OASIS™ 1.0

(Open Architecture Software Integration System - SBIR Phase II Development Version)

User Manual: Building Application Modules for the Particle Beam Optics Laboratory (PBO Lab™)

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OASIS™

1. Introduction

OASIS User Manual:
Building Application Modules
for PBO Lab™

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1. Introduction

The Open Architecture Software Integration System (OASIS™) Module Builder is used to create Application Modules for the Particle Beam Optics Laboratory (PBO Lab™) software. OASIS Module Builder users should be familiar with the PBO Lab graphic user interface. Refer to the PBO Lab User Manual (Basic Package) for general information on the PBO Lab user interface. This Section provides an overview and describes the installation and initial set up for the OASIS Module Builder.

This Manual describes the use of the OASIS Module Builder to create interface features specific to an Application Module for the PBO Lab software. The main (Basic Package) PBO Lab User Manual provides more general information on the user interface.

Overview

There are two basic parts to using the OASIS Module Builder to create a new Application Module for PBO Lab. The first part is to use the OASIS Module Builder to define the graphic interface elements, the inputs, the outputs, and other features of the desired Application Module to be run with PBO Lab. This manual describes how to accomplish that part. The second part is to compile a library for the optics code that provides the computation engine for the Application Module. That part depends upon the computer operating system environment in which the PBO Lab software is running. For a Microsoft Windows based operating system, the library may be either (A) a dynamic-link library (.dll file) or (B) an executable application (.exe file). The Application Module computation engine library is referred to in this manual as either (A) a DLL or (B) an EXE. This refers to a Windows platform, with the understanding that different types of libraries or applications are to be used on other systems.

Figure 1 illustrates the basic steps for using the OASIS Module Builder to create a PBO Lab Application Module.

There are two parts to creating a new Application Module for PBO Lab:
1. Defining and building the graphic interface components for the Application Module, and
2. Creating the computation engine library for the optics code to be used by the Application Module.

This Manual describes how to accomplish part 1 using the OASIS Module Builder.

The OASIS Module Builder supports different configurations, called "libraries" in this Manual, for the beam optics computation engines. In many cases it may be possible to use an existing library or executable for the computation engine library.

This manual uses "computation engine," "physics code," "optics program," and similar terms to refer to the underlying particle beam optics program of an OASIS Module.

PBO Lab provides an intuitive, interactive, user friendly, graphic interface customized to the needs of the accelerator community. A number of Application Modules have been developed for PBO Lab. The OASIS Module Builder extends the utility of the PBO Lab software by allowing researchers to create their own Application Modules for PBO Lab.

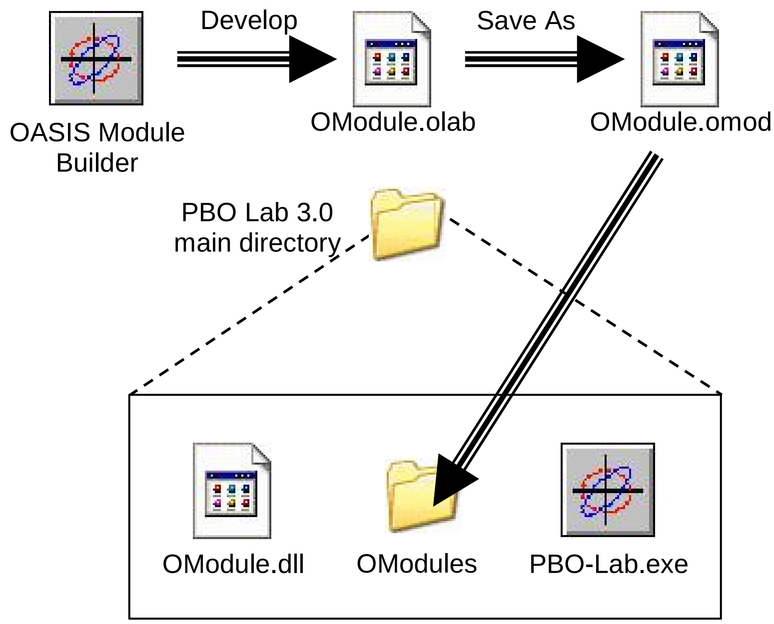


Figure 1. The OASIS Module Builder is used to create Application Modules for the Particle Beam Optics Laboratory (PBO Lab).

Installing the OASIS Module Builder

The OASIS Module Builder is itself an Application Module of the PBO Lab software framework -- a rather special Application Module -- but an Application Module nonetheless. The OASIS Module Builder is shipped on CD-ROM with version PBO Lab 3.0 and later, and is automatically installed when PBO Lab is installed. The procedure for installing PBO Lab is described in the *Getting Started* section of the PBO Lab User Manual (Basic Package). The manual (PBO-Lab Basic.pdf) may be found inside the folder named “Manual” on the PBO Lab CD-ROM. The PBO Lab User Manual may also be downloaded (in PDF format) from the AccelSoft website (www.ghga.com/accelsoft).

To access the OASIS Module Builder you will need to have a user license and CD-Key for the Module. This information should be entered into the PBO Lab Registration window after installation of the PBO Lab software. If you are installing PBO Lab for the first time, follow the instructions in the PBO Lab User Manual (Basic Package). If you are adding the OASIS Module Builder to an existing PBO Lab installation, you will need to update your CD Key. To do this, start PBO Lab in the (default) Single Model Mode. You should see a PBO Lab Document Window like that illustrated in Figure 2. Under the Tutorial menu of the Document Window select the Register choice. A PBO Lab Registration window will open. Enter your CD Key and/or other data as necessary.

You will need to have PBO Lab 3.0 or later in order to utilize the OASIS Module Builder. If you already have PBO Lab 3 installed on your computer, you will not need to reinstall it. However, you will need to have a user license and CD-Key to use the OASIS Module Builder. (OASIS will not work properly with PBO Lab 2 or earlier.)

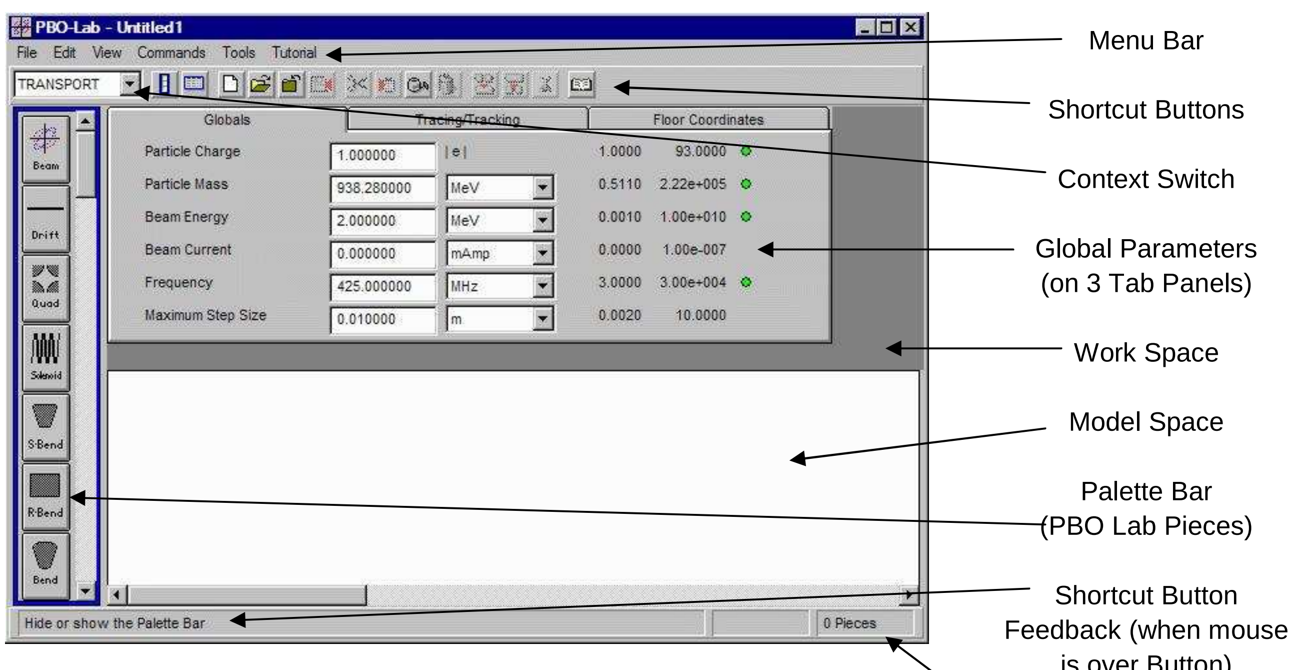


Figure 2. PBO-Lab Document Window with selected features identified. The Tutorial menu contains a Register selection.

Initial Set Up

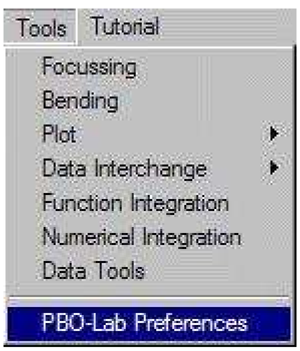
After installation of the PBO Lab software has been accomplished, the OASIS software is ready to run. You may wish to install certain optional items from the installation CD. A PDF version of this user manual is contained in the Manuals folder on the CD. In addition, some sample Application Modules built with the OASIS Module Builder are also on the CD. The sample OModules and corresponding computation engines are contained in the folders Sample OModules and Sample Computation Engines, respectively. Drag these folders from the CD to the same directory (folder) on your hard drive where PBO Lab is installed.

The PBO Lab installation CD contains sample OModules that were developed with the OASIS Module Builder. These are located in the folder named Sample OModules. OModules are contained in single files and have names like:

"DIMAD-sample.omod".

The corresponding libraries of the computation engines are located in the folder named Sample Computation Engines. Some of these samples are used for illustrations in this Manual.

To set up and initialize the OASIS Module Builder double-click (launch or start) the PBO-Lab.exe icon located in the PBO Lab installation folder on your computer. If PBO Lab has been launched from a fresh installation, the software will open a Document Window such as that illustrated in Figure 2. This is referred to as the PBO-Lab Single Model mode. The mode will need to be changed to the OASIS Module Builder mode. To do this, mouse on the Tools menu in the Document Window (Figure 2) and select the PBO Lab Preferences item in the menu. This will open the window shown in Figure 3. Select the choice OASIS Module Builder for PBO Lab.



You may use the OASIS Module Builder immediately after installation of PBO Lab and entering the license number and CD Key. Modify the PBO Lab Preferences in order to access the OASIS Module Builder.

To initialize OASIS for creating a PBO Lab Module, select the radio button option: OASIS Module Builder.

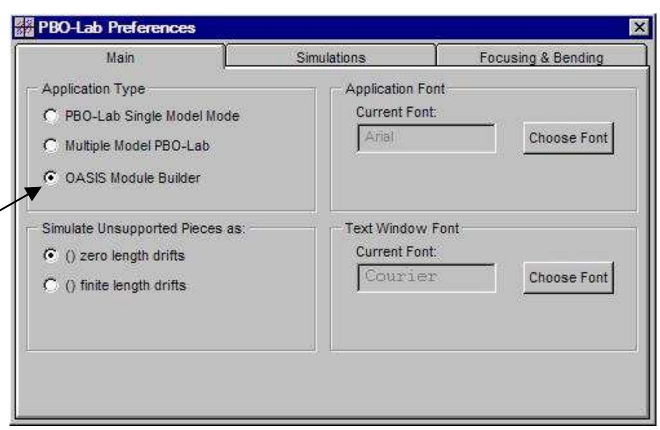
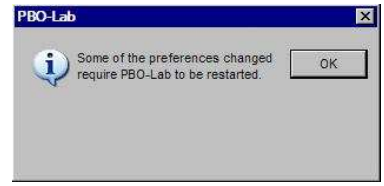


Figure 3. PBO-Lab Preferences window.

After selecting the OASIS Module Builder for PBO-Lab radio button, close the PBO-Lab Preferences window. A dialog will appear indicating you will need to restart PBO Lab in order for some Preferences to take effect. Close the OASIS Document Window, and restart (double click the icon of) the PBO Lab application. The OASIS Module Builder window illustrated in Figure 4 will now open (instead of the PBO Lab Document Window shown in Figure 2).



Close and Restart PBO Lab after changing the Preferences

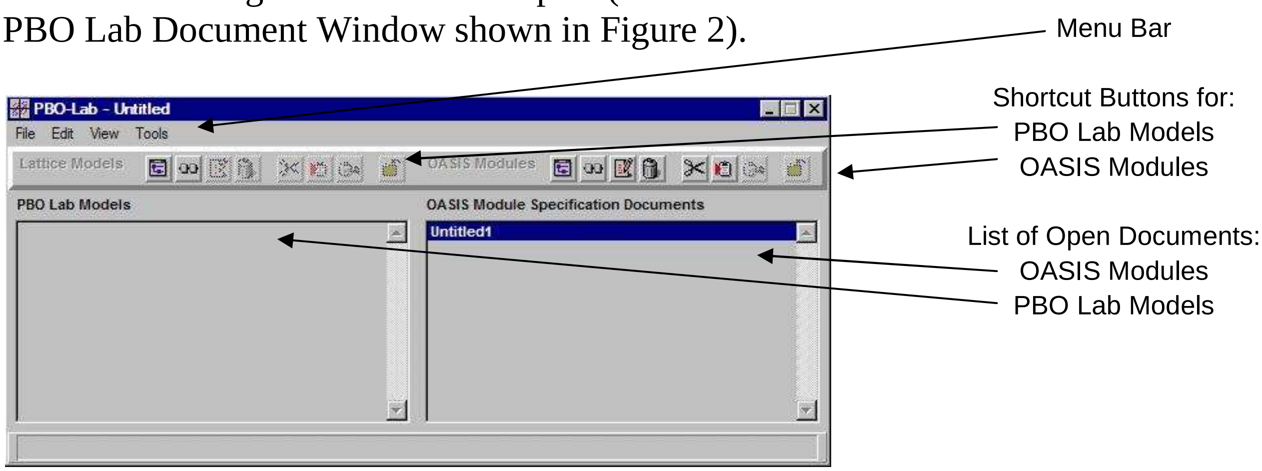


Figure 4. The OASIS Module Builder window.

The Untitled1 document, highlighted in the right hand pane of the window shown in Figure 4, is used to create an Application Module. Double clicking the Untitled1 item will open a Document Window. This is an OASIS Module Specification Document and is illustrated in Figure 5. It is similar to the PBO Lab Document Window shown in Figure 3, but has special features and capabilities that are the focus of this Manual.

The Module Specification Document is used to define nearly all aspects of the graphic interface for an Application Module. When a Module Specification Document is completed, it will be saved as an OASIS Module file, or simply OModule file (file extension .omod). A completed OModule file contains all of the information needed by PBO Lab for an Application Module.

Context Switch of an OASIS Module Specification Document Will Show "OASIS" as the First Item

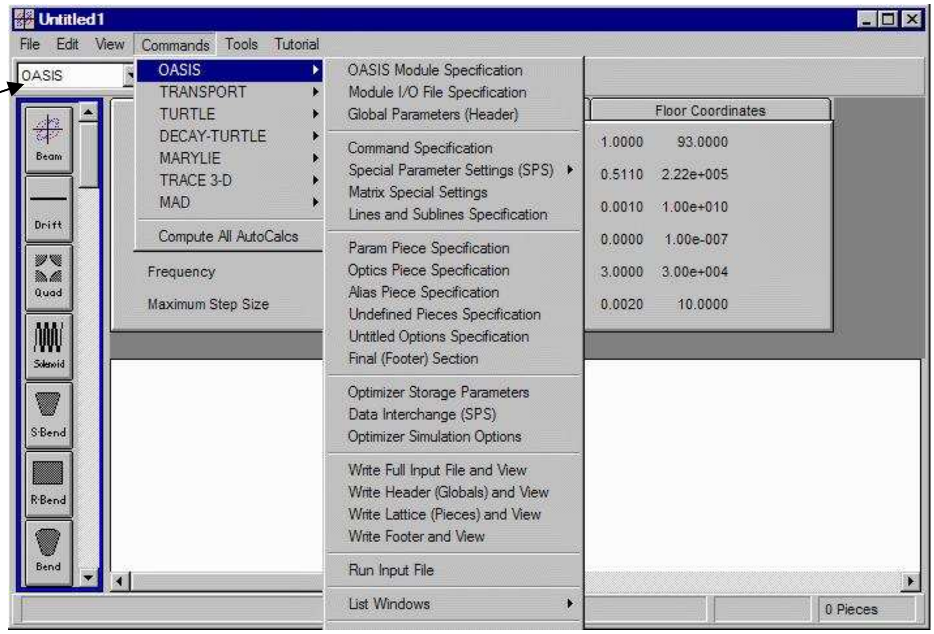
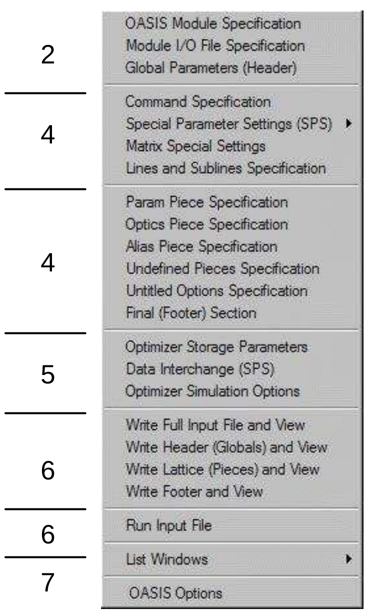


Figure 5. OASIS Module Specification Document window showing the OASIS items of the Commands menu.

An OASIS Module Specification Document, with the OASIS item on the Commands menu selected, is illustrated in Figure 5. Sections 2 and 4-7 of this Manual correspond to the various dividing blocks on the Commands menu. Section 3 of this Manual discusses the specification of the beamline parameters and their syntax, which is also referred to as the lattice specification. Section 8 describes how to test an OModule within the OASIS Module Builder. Of course the final testing of an OModule should use the standalone .omod file generated as the last step in the creation of a PBO Lab OModule (see Figure 1). Section 9 describes how the Module Specification Document is used to define a standalone (.omod file) PBO Lab Application Module.

Manual Section



The next Section (Section 2) includes discussions of the OASIS Module Specification, the Module I/O Specification and the selection of Global Parameters.

OASIS™

2. Defining an Application Module

OASIS User Manual:
Building Application Modules for PBO Lab™

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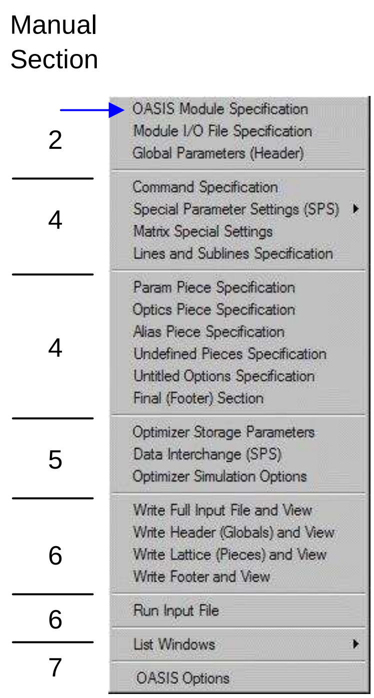
2. Defining an Application Module (OModule) Using OASIS

The first step in creating an Application Module for PBO Lab using OASIS is to define the basic parameters of the Module. A generic Application Module created using OASIS will be referred to as an OASIS Module, or simply OModule. This Section describes how to start the creation of an OModule, and summarizes the minimum required parameters needed for defining an OModule. Required parameters must be specified in order for other parts of the OASIS Module Builder to be active.

The OASIS Commands menu is used to access many of the Module Builder windows. Section 2 discusses the first 3 items of the menu.



OASIS Module Specification

The creation of an OModule is started by double clicking (opening) the Untitled1 object highlighted in the right hand pane of the window illustrated previously in Figure 4. This will open a Document Window like that shown in Figure 5. Use the Commands menu to select the first item: OASIS Module Information. This will open a window like that illustrated in Figure 6.

Select the OASIS Module Specification item of the OASIS Commands menu to open the OASIS Module Information window.

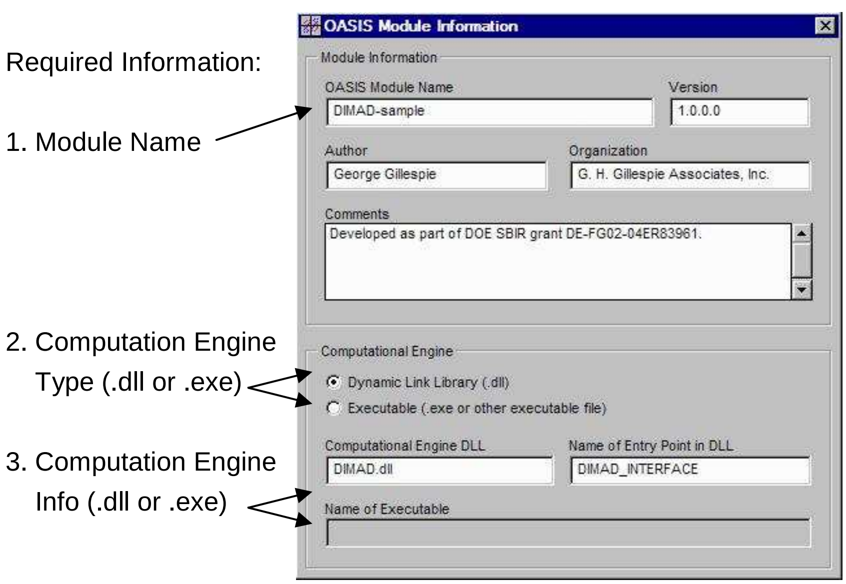


Figure 6. OASIS Module Information window.

The data used to illustrate the Module Information Window is for the DIMAD-sample Module created with OASIS. The DIMAD-sample Module is one of several new PBO Lab Application Modules created with the OASIS software.

Several pieces of required data need to be entered into the OASIS Module Information window. The required data include the OASIS Module Name, the Computational Engine radio selection, and the name of the computational engine. There are two options for the Computational Engine, as determined by the radio button selection.

- If the Dynamic Link Library (DLL) radio button is selected, then both the name of the Computational Engine DLL and the Name of Entry Point into that DLL need to be specified.
- If the Executable radio button is selected, then only the Name of Executable for the computational engine needs to be specified.

The other text fields of the OASIS Module Information window are optional, but strongly recommended. The data in the Version, Author, Organization, and Comments fields are used to provide users of the OModule with information about the Module. For example, the data will be displayed in a tab panel of an "About" window when a user requests information on OModules accessible with his/her PBO Lab configuration. Figure 7 shows how the Module Information illustrated in Figure 6 will appear in the About window for this Module.

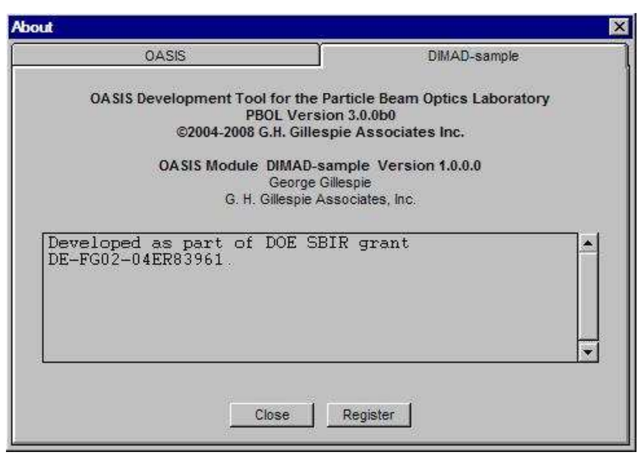
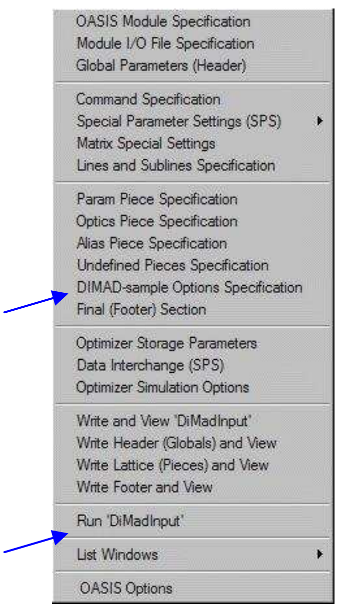


Figure 7. An OASIS Module About window.

The OASIS Module Name will appear in the Context Switch of each PBO Lab Document Window (Figure 2) when the OModule is loaded. This name will NOT appear in the context of the OModule Specification Document (Figure 5).

Once entered, the OASIS Module Name will appear in other places in the OModule Specification Document. Below is an example of how the Commands menu appears for the DIMAD-sample OModule as specified in Figure 6.



Other items in the OModule Specification Document will also change as the OModule is further defined. For example, the Run entry on the Commands menu for the DIMAD-sample OModule has the specified Main Input File name (see the Module File I/O Specification discussion on the next page).

Module File I/O Specification

An OModule computation engine will access input and write output using various files. These files are identified using the File I/O Specification window. Use the Commands menu to select the second item: File I/O Specification. This will open a window like that illustrated in Figure 8.

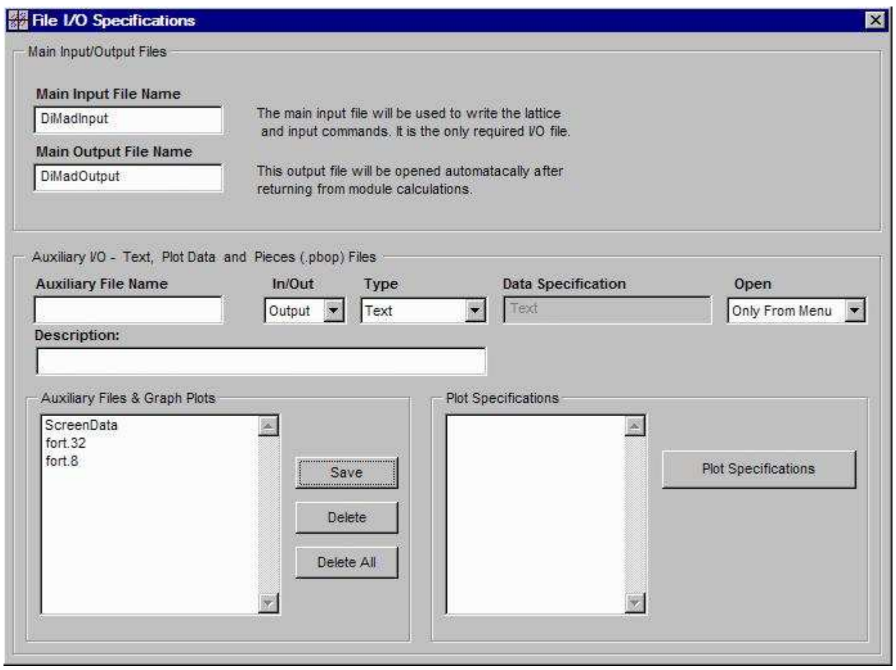
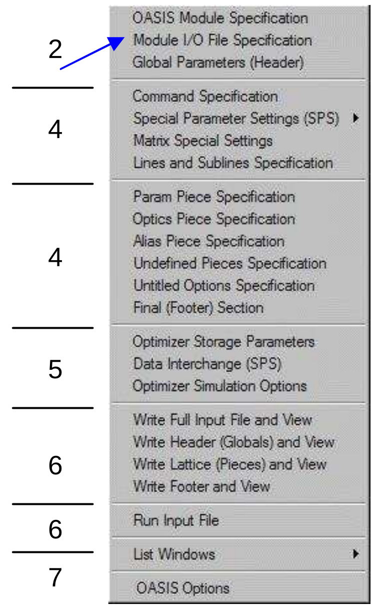


Figure 8. File I/O Specification window.

The specification of the Main Input File Name is required. When the completed OModule is installed in PBO Lab, the PBO Lab software will open and write data to the Main Input File for use by the OModule. It is also good practice to specify the Main Output File if the OModule routinely generates text output. The main input file and main output file are text files. The other optional specifications are used for additional files, including other input text files, output text files, and graphics files. These are referred to as Auxiliary I/O files. The specifications for handling various Auxiliary I/O files are described in later sections.

Manual Section



The File I/O Specification window is accessed by selecting the second item on the OASIS Commands.

When an OModule is used in PBO Lab, the software will write the input data, in the format needed by the Module's computation engine, to the file specified by the Main Input File Name. How the required format is specified with the OASIS Module Builder forms a major part of remainder of this User Manual. After the computation engine has completed execution, the primary text outputs from the calculation are written by the computation engine to the file specified by the Main Output File Name. This Main Output File will then be automatically opened by PBO Lab and displayed to the user of the OModule.

OASIS divides the Main Input File into several primary sections. These primary sections are designed to support the input requirements for a large group of particle optics codes. OASIS uses the following names for the four primary sections:

Header
Lattice
Lines
Footer

The Main Input File is divided into parts or sections for discussion purposes in this User Manual. There are four primary parts of the Main Input File referred to the as the Header, Lattice, Lines and Footer sections. The OASIS Module Builder writes data to the Main Input File in a prescribed order that follows these parts. The data content of the various parts of the Main Input File are flexible, but the OModule developer should be aware of the parts, and the order in which their data will appear in the Main Input File.

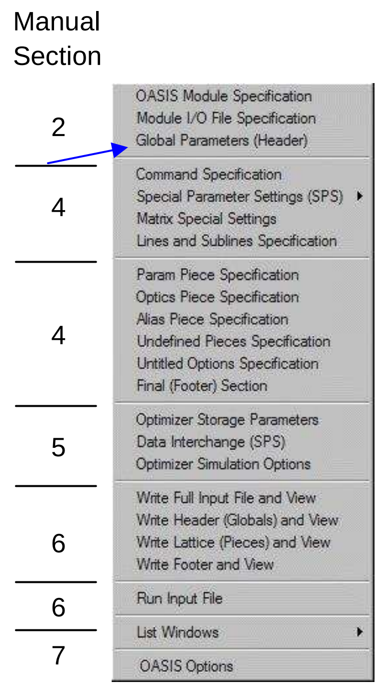
Note that not all of the primary sections of the Main Input File need to be used for a given OModule. Examples of Main Input Files for various optics codes are illustrated in Section 8 of this manual.

The remainder of this Section of the User Manual describes the selection of Global Parameters for the OModule, as well as the way the data format for the Header part of the Main Input File is defined. The data format is defined by prescribing a syntax for text and numbers that will appear in the Header. The procedures used for specifying the syntax are the same as those to be used for defining the format of the data for individual optics elements and other inputs to a computation engine.

When writing the Main Input File, an OModule first writes the Header section, followed by the Lattice section, the Lines section, and concluded with the Footer section. Additional lines may be written to the Main Input File between these primary sections by the use of OASIS Comm Pieces. Comm Pieces are discussed in Section 4.

Global Parameter Selection

The OASIS Module Information and File I/O Specifications are required for all OModules created using the OASIS software. The next step in creating an OModule is to begin the specification of the Main Input File. Many optics computation engines will utilize some of the PBO Lab Global Parameters. These Global Parameters (Figure 2) can be used throughout the Main Input File, and are also available to other parts of the OModule. The particular use of Global Parameters will be unique to each OModule created, and their use is perhaps best explained by way of illustration via specific OModule examples. The first step in making Global Parameters available to the OModule is to select them as OModule parameters. This is described next. Then the procedures used to place some of these parameters in the Header section of a Main Input File will be described.



The Globals window is opened by selecting the third item on the OASIS Commands.

Use the OASIS Commands menu to select the item: Global Parameters (Header). This will open the Globals parameter selection window illustrated in Figure 9.

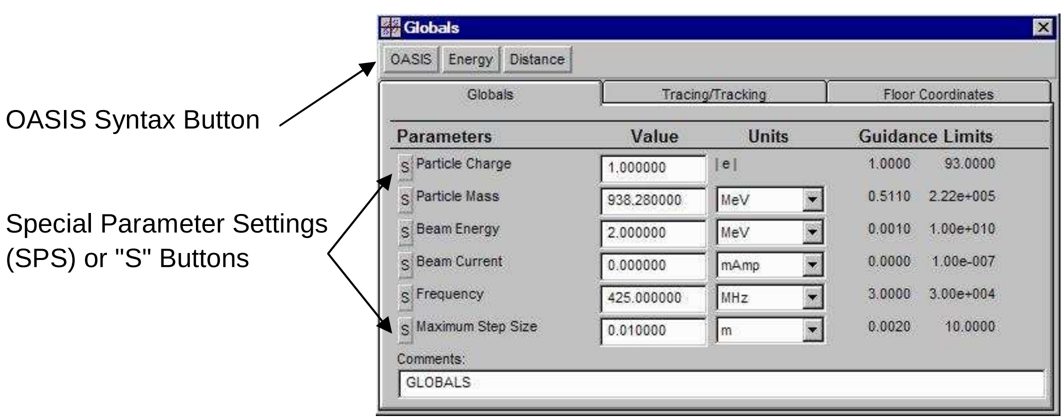


Figure 9. The Globals parameter selection window.

The Globals parameter selection window contains all of the PBO Lab Global Parameters (Figure 2).

All existing PBO Lab Global Parameters are available for use as Global Parameters in the creation of an OASIS Module. Global Parameters may be utilized throughout the OASIS Module Builder.

Click on a Special Parameter Setting ("S") button to open a new window that is used to assign attributes to that parameter. The parameter can then be used by other parts of OASIS and by the OModule itself. Figure 10 illustrates the Special Parameter Setting (SPS) window for the Global Parameter: Beam Energy.

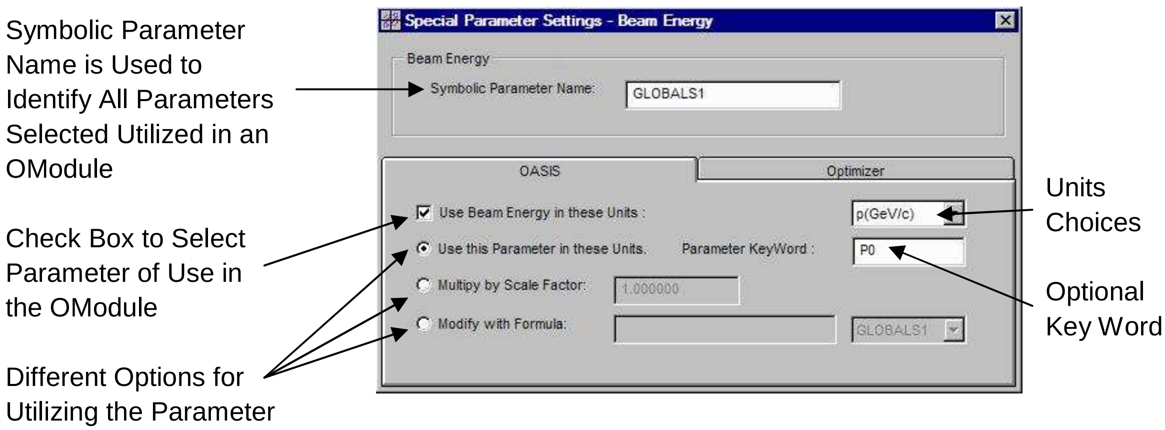


Figure 10. Special Parameter Settings (SPS) window for the Beam Energy Global Parameter.

There are a number of useful and important features of the Special Parameter Settings window that should be noted.

An OModule developer can also define and utilize additional custom parameters throughout the OASIS Module Builder. These form part of the OModule Options and are described in Section 4 of this User Manual.

First, a parameter is only selected for use elsewhere in OASIS, or in the OModule being created, when the box "Use this [Parameter Name] Parameter in these Units" has been checked. Checking the box will create a (default) Symbolic Parameter Name that appears in the upper pane of the window. The default name (GLOBALS1 in the example shown in Figure 10) consists of two parts: a word identifier and a number. The default word identifier is useful for locating that Symbolic Parameter Name later during the OModule definition. The attached number is generated sequentially during the OModule definition; this assures that the default Symbolic Parameter Name will always be unique.

The user may change the Symbolic Parameter Name, but it is important to remember that all Symbolic Parameter Names throughout the entire OModule Specification Document must be unique.

Second, each parameter has a number of attributes that may be associated with it. Several different Units selections are available, which are displayed by a pop-up menu. The Units for a parameter are selected by the OModule creator using that pop-up menu. The specification to "Use this Parameter in these Units" tells OASIS what units to use for the parameter later in the OModule definition. For example, when preparing the syntax for writing to the OModule Main Input File, the parameter will be written to the file in the selected units. For the illustration shown in Figure 10, the GLOBALS1 (Beam Energy) parameter value will be written as the equivalent momentum for that Beam Energy and Particle Mass.

The Special Parameter Settings provide a variety of options for each parameter's attributes. For example, several Units options are available. In the Beam Energy parameter specification shown in Figure 10, the Units selection has been used to specify that the equivalent momentum, p, in GeV/c is to be used for this OModule, rather than the (default) kinetic energy. Scaling by constants, as well as modification of the parameter using a formula, provide more options.

Third, a parameter (in the Units specified) may also be modified further for use. Two primary options are available. One is to Modify by Scale Factor, that is, multiply the parameter (in the Units specified) by a constant. For the example shown in Figure 10, if the equivalent momentum is desired in MeV/c, select the second radio button (Multiply by Scale Factor) and then enter the constant 1000. The GLOBALS1 (Beam Energy) parameter will then be available in MeV/c (rather than GeV/c) to the OModule. This type of modification of the Beam Energy parameter will be global throughout the OModule. Whenever the Symbolic Parameter GLOBALS1 is used it would then be evaluated in MeV/c. There are other ways to accomplish this same modification locally, rather than globally. This will be described later when the format for the data is defined with the syntax specification.

The set of numerical operands available for use in formulas is the same as those shown in Figure 14. A Formula may be used to redefine a Global Parameter. The redefined Global Parameter will then be available for use in the OASIS Module, utilizing the same name.

The alternate method for implementing formula based calculations uses the {Math} features available for the Input Syntax specification where the Global Parameters are used. In most cases, this alternative method is the preferred method for implementing formulas. See Section 3 for a discussion and examples.

Another option available for modifying the value of a parameter is to Modify with Formula. When the Modify with Formula button is selected a formula can be entered. Other Global Parameters may be used in the formula, and a number of operands (+, -, *, /, sin(), cos(), etc.) are available. Consider the case where the beam total energy (kinetic energy + rest mass) is desired. For this case, the Beam Energy could be specified in Units MeV (GLOBALS1), and the Particle Mass (another Global Parameter, see Figure 9) specified in Units MeV (e.g. GLOBALS2). The formula to be entered would then be GLOBALS1 + GLOBALS2. Whenever the Beam Energy (GLOBALS1) is specified elsewhere in constructing the OModule, it will be interpreted as the total energy, and the numerical sum GLOBALS1 + GLOBALS2 will be provided. This type of modification of the Beam Energy parameter will also be global throughout the OModule. Whenever GLOBALS1 is used it would then be interpreted as the total energy in MeV. This result can also be achieved locally, rather than globally, with a corresponding syntax specification.

Parameter keywords, or parameter type codes, are used by certain computation engines. For example, the keywords might be used for parameter fitting.

Finally, a keyword (or type code) may be assigned to each parameter. The keyword (or type code) is a representation for that parameter that can be recognized by the computation engine for the OModule being created. For the example illustrated in Figure 10, the GLOBALS1 (Beam Energy) parameter value in equivalent momentum p(GeV/c) has been assigned the keyword “P0” which is typical of TRANSPORT-like computation engines.

Not all codes use keywords or type codes. Even for computation engines that do use keywords or type codes for some parameters, not every available PBO Lab parameter may have such a keyword or type code for that computation engine. In other cases an optics code may have been modified and improved at one laboratory, so that new keywords (or type codes) not in the original optics code are now used. OASIS makes keyword (or type code) support available for all parameters. This facilitates the OASIS Module creator in maintaining and updating OModules as the underlying optics code evolves.

Support for different versions of a computation engine is relatively easy to maintain and control with OASIS. OASIS provides for multiple OModules that can be loaded at the same time, or loaded individually. Different OModules can be used to support different versions of a computation engine.

Close the SPS window (Figure 10) when the input is completed for the Beam Energy. The "S" button will turn red, indicating that the Beam Energy parameter has been given a Symbolic Parameter Name and has SPS attributes assigned for use in the OModule. A green dot will also then appear to right of the Beam Energy parameter field of the Globals parameter selection window. The green dot will also appear in the Global Parameters pane of a PBO Lab Document Window (Figure 2) when the context switch is set to OModule name (e.g. DIMAD-sample), signifying that the Beam Energy parameter is utilized by the OModule for writing the Main Input File.

Other Global Parameters are selected for use by the OModule, as needed, following the same procedures as described for the Beam Energy. Figure 11 illustrates how the Globals parameter selection window might look after selection of a number of Global Parameters. In the example illustrated, for the DIMAD-sample OModule, all of the Global Parameters except for the Beam Current and Minimum Step Size have red "S" buttons and green dots, signifying that all but these 2 Global Parameters have been selected for use in the OModule.

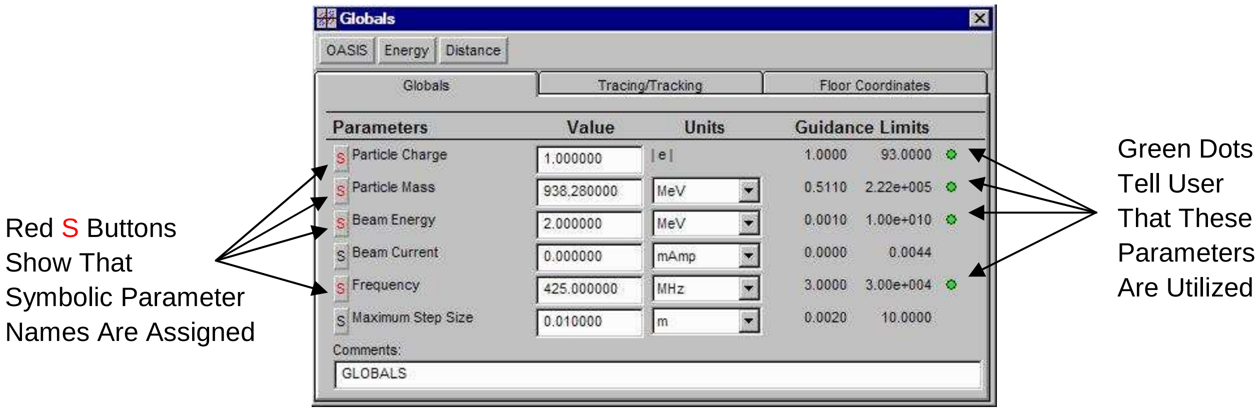
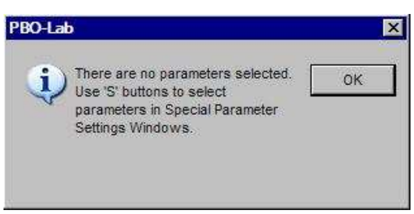


Figure 11. The Globals parameter selection window for the example OModule: DIMAD-sample.

It is worth noting that the numerical values of the Global Parameters in the OModule Specification Document will not be used, except for certain testing purposes as discussed later in this Section. When the completed OModule is used for a beamline calculation, the Global Parameters for the PBO Lab Model used in the beamline calculation are utilized. The OASIS parser is responsible for making these substitutions at runtime. The format for the use of the substituted parameters is defined by a syntax that the OModule developer specifies.



A warning dialog will appear if the OASIS button is used before any parameters are selected.

When the Global Parameters to be used by the OModule have been selected they can be utilized throughout the OModule. Examples of their use will be illustrated in various Sections of this User Manual.

Header Syntax for the Main Input File: Example of the DIMAD-sample OModule

Frequently the first use of the Global Parameters will be in specifying the format for the Header section of the Main Input File. This is described here. The OASIS Module Builder provides for a variety of capability in specifying the syntax for all parts of the Main Input File. Only a few are discussed in this Section, others are described in other Sections of the User Manual. The reader may want to look at a simpler example by skipping ahead to Section 3 and reading the portion entitled "Example Using a Drift Piece."

Select the OASIS syntax button on the Globals parameter selection window (Figure 9) to open the Input Syntax for Globals window. An example of this window is shown in Figure 12 before any syntax has been entered.

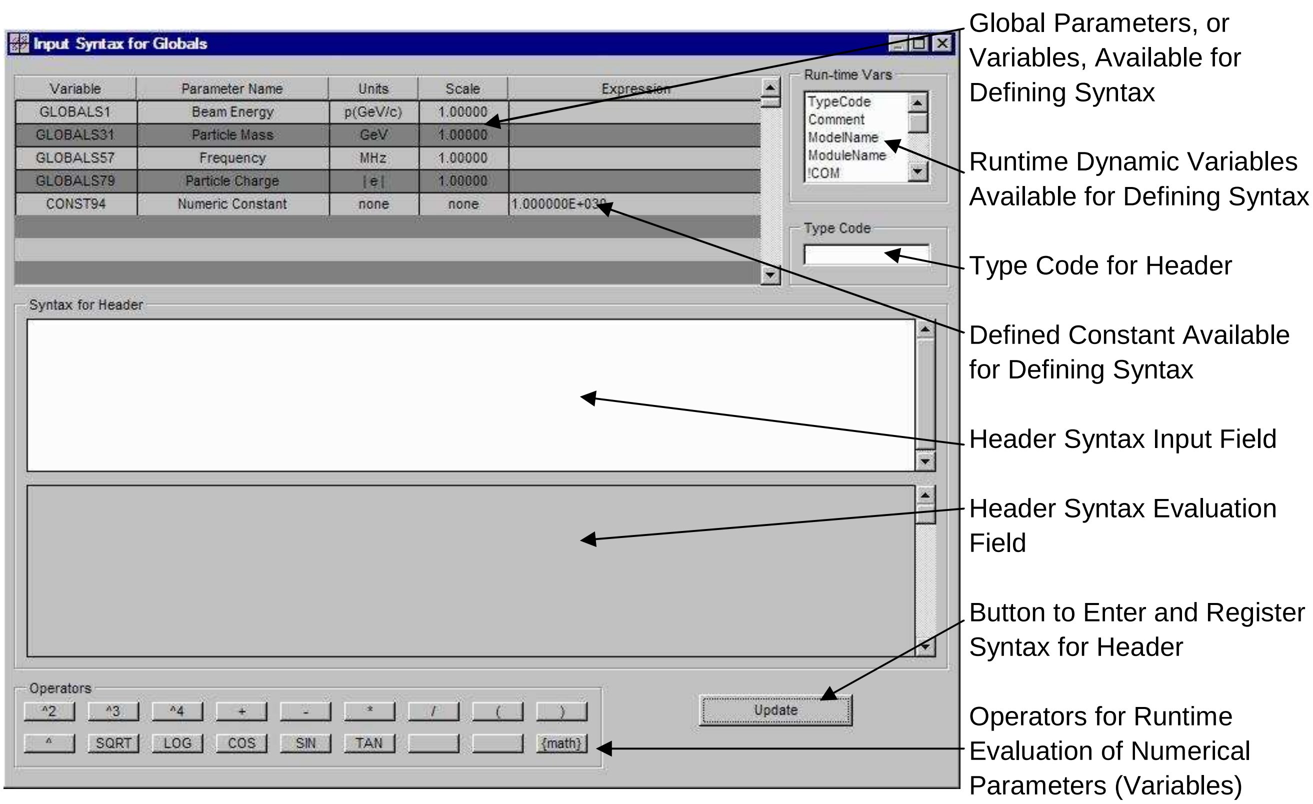


Figure 12. Input Syntax for Globals window.

The field labeled "Syntax for Header" is used to enter specifications for writing the Header section of the Main Input File in the desired format. Most of the input to this field can be obtained from other items shown in the menu: Variables, Run-time Vars, Type Code, and Operators. An example of a completed Syntax for Header field is given in Figure 13, but we first summarize some information on important items.

The Variables list at the top of the window gives the Symbolic Parameter Name for all of the Global Parameters which have been selected as OModule parameters (Figures 9 and 10). The Variables shown in Figure 12 correspond to the DIMAD-sample OModule. The first four Symbolic Parameter Names correspond to the 4 selected Global Parameters for the DIMAD-sample OModule (Figure 11).

Note that the GLOBALSXX *parameters need not all be selected for use at the same time. The numbers* XX *attached to the* GLOBALS *default Symbolic Parameter Names are not consecutive, and reflect the order in which these particular parameters were selected for use in the DIMAD-sample OModule. The intervening numbers are associated with the selection of parameters for the Drift, Quad, and other elements, assigned in the order in which the parameters were selected for use in the OModule*

The Variables list also contains an additional Symbolic Parameter Name: CONST94. This is an example of a Numeric Constant option for an OModule. The specification of OModule options is discussed in detail in Section 4. This example is included here to illustrate how additional user-editable data can be incorporated into the Header by use of OModule options.

Run-time Vars provide access to dynamic runtime variables useful for defining various OModules. The Run-time Vars include:

- *TypeCode*
- *Comment*
- *ModelName*
- *ModuleName*
- *!COM*
- *Include*
- *If*
- *IfNot*
- *Endif*
- *Date*
- *Date-Time*
- *Version*

The DIMAD-sample OModule uses 4 of these Run-time Vars in the Header syntax:

- *!COM*
- *Date-Time*
- *ModelName*
- *Version*

The Run-time Vars are variables evaluated at run time when the OModule is used to operate on a PBO Lab model file. The runtime variables provide dynamic data that is different from the user-editable PBO Lab Parameters such as the Global Parameters. Not all runtime variables are appropriate for the Header section and only four are discussed here: !COM, DateTime, ModelName, Version. Other Run-time Vars are discussed is Section 3.

The Type Code field is used to store an alphanumeric string for the Header section that will be evaluated at runtime wherever the Run-time Var 'TypeCode' appears in the syntax. The Type Code field is most typically used in connection with specifying the Main Input File syntax for individual optics elements (PBO Lab Pieces) and examples are discussed in Section 3.

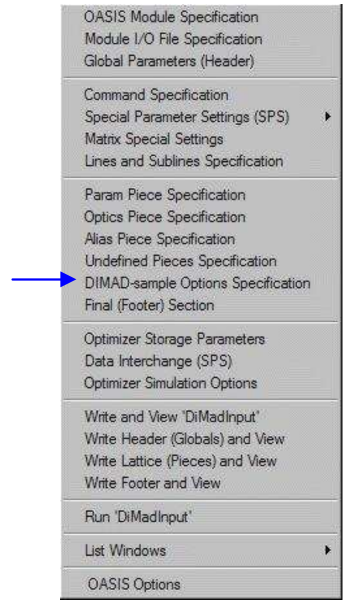
The Operators provide a selection of mathematical functions that can operate on the Variables at runtime. The Operators may be used in the Header section, but the discussion of their use is deferred until Section 3.

Both Variables and Run-time Vars always need to be enclosed in single quotes for the OASIS syntax parser to correctly evaluate them at runtime.

Variables and Run-time Vars can be entered into the Header Syntax by clicking on the desired item in the appropriate list. The selected item will appear in the Syntax in single quotes. For example, clicking on the !COM item in the Run-time Vars list will result in an entry '!COM' appearing in the Syntax specification field at the location where the cursor was last placed.

Variables and Run-time Vars are always identified in Syntax fields by single quotes. Variables and Run-time Vars may also be typed directly into the Syntax specification field, but the single quotes must be included for the OASIS syntax parser to properly evaluate the entries at runtime.

The !COM item in the Run-time Vars list is a comment delimiter for adding text comments to the Main Input File. The comment delimiter tells the computation engine to "ignore" the associated text. Computation engines generally have only a few allowed comment delimiters and many have only one. Comment delimiter selections for an OModule are made using the OModule Options Specification and are discussed in Section 4. The comment delimiter for the DIMAD-sample OModule is the exclamation point (!). The entry '!COM' will be evaluated at runtime as ! wherever it appears in a Syntax specification field.



Both the !COM Run-time Var and the CONST94 Variable are defined by the DIMAD-sample Options Specification. The OModule Options Specifications are discussed in Section 4.

Likewise, wherever the Variables entry 'GLOBALS1' appears in a syntax specification it will be evaluated at runtime, when the Main Input File is written, to the Beam Energy Global Parameter of the PBO Lab Model. Similar comments apply for any Variables entries 'GLOBALS31', 'GLOBALS57' and 'GLOBALS79' - these evaluate to the PBO Lab Model values for the Particle Mass, Frequency and Particle Charge, respectively.

Figure 13 illustrates the Header syntax specification for the DIMAD-sample OModule. The five '!COM' entries are used to start the Main Input File with 5 comment lines. These comment lines include ordinary text (simply typed in) as well as three Run-time Vars: 'Date-Time', 'ModelName' and 'Version'.

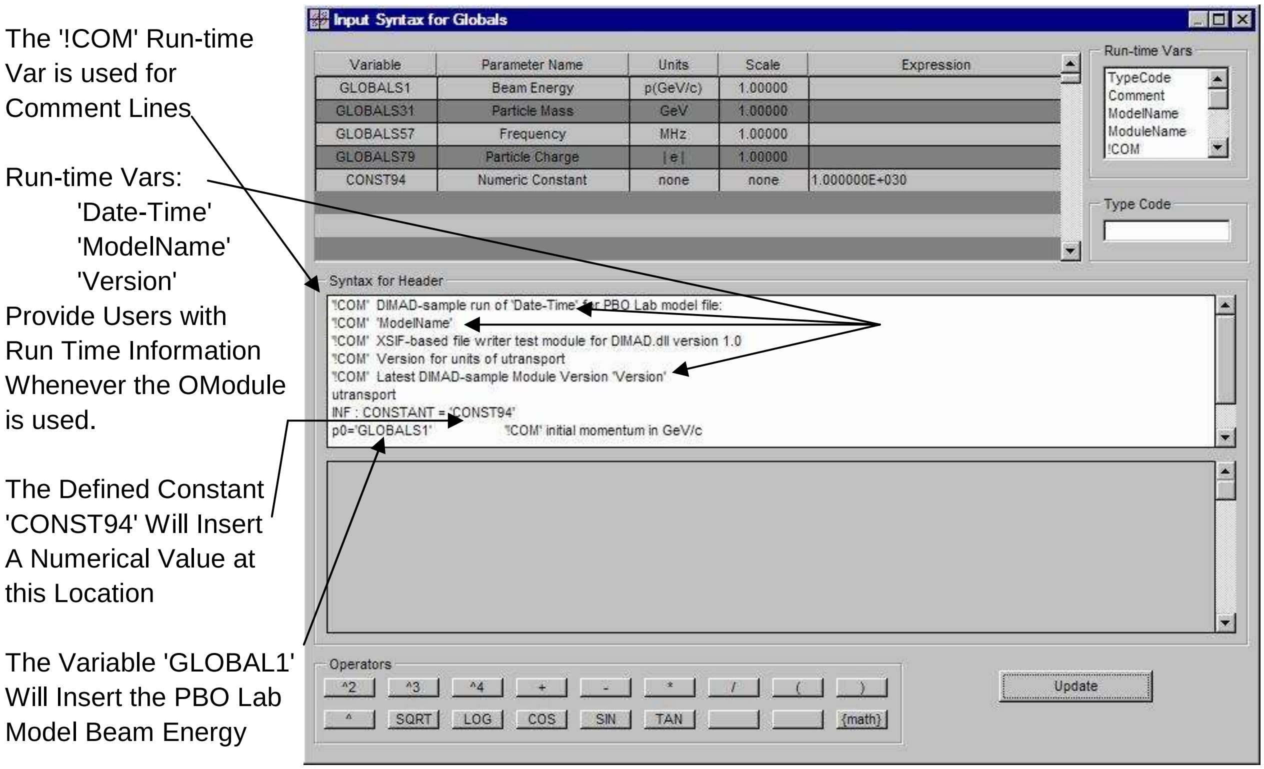
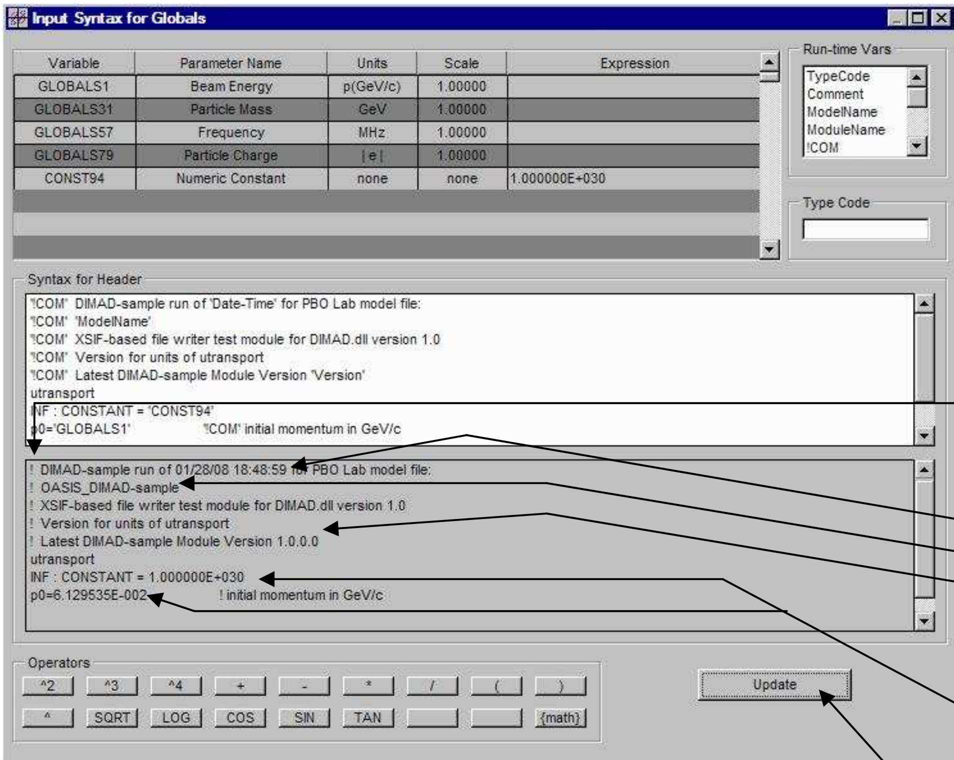


Figure 13. Input Syntax for Globals window with the Syntax for Header as specified for the DIMAD-sample OModule.

The Header syntax illustrated in Figure 13 also includes other ordinary text items. Any item that is *not* an operator, or *not* enclosed by single quotes, is interpreted by the OASIS parser as ordinary text. Ordinary text items will be written to the Main Input File exactly as they appear in the syntax specification.

The Update button triggers the OASIS syntax parser to evaluate the Variables, Run-time Vars, and Operators. The Update button also "records" the syntax in the OModule Specification Document, which can then be saved.

Text and other items entered into the Syntax for Header field need to be recorded and updated. To do this, use the Update button in the lower right of the Input Syntax for Globals window. The Update button will evaluate the syntax specifications for the current OASIS Module Specification Document and then display the results in the lower pane (gray in color) of the Syntax for Header field. Figure 14 illustrates the result for the DIMAD-sample OModule.



Variables and Run-time Vars are evaluated for the OASIS Module Builder Document when the Update button is selected.

'!COM' Run-time Var is Evaluated to ! (Comment Delimiter for DIMAD)

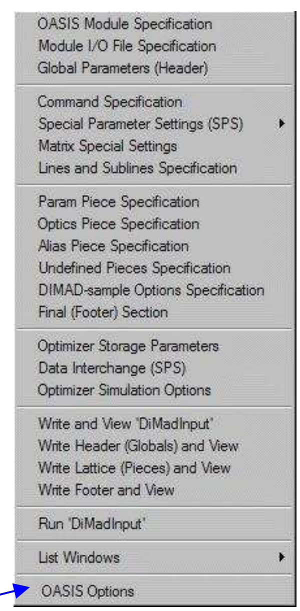
Run-time Vars:
'Date-Time'
'ModelName'
'Version'
are Evaluated.

Numerical Values Substituted for 'CONST94' & 'GLOBALS1'

Update Button Both Updates and Records the Syntax

Figure 14. Input Syntax for Globals window after the Update button has been used.

The numerical values of the Variables 'CONST94' and 'GLOBALS1' are displayed in a format that can be specified by the OModule developer. Real numbers and integers can be specified in a variety of formats. The OASIS Options are used to specify the formats needed by the computation engine. (The OASIS Options should not be confused with the DIMAD-sample Options Specifications.)

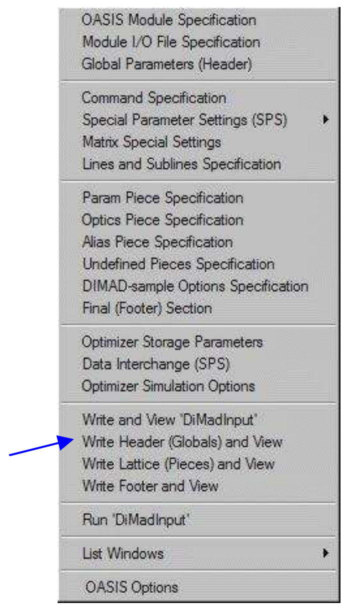


Numerical format is specified with OASIS Options and is described in Section 7.

Other text entered into the Syntax for Header field will appear unaltered in the Header syntax evaluation field following an Update. During the running of a PBO Lab Model with the DIMAD-sample OModule, the Header section of the Main Input File will appear in the same form as illustrated in Figure 14, only the Variables and Run-time Vars will be evaluated for the specific PBO Lab Model.

The Update button "records" the syntax for the OModule Specification Document. If the Update button is NOT used, the syntax will be lost if the Input for Globals Syntax window is closed.

The Header can be written to the Main Input File and viewed for test purposes using the Write Header (Globals) and View item on the commands menu. This command is described further in Section 6.



When writing the Main Input File, an OModule first writes the Header section, followed by the Lattice section, optional Lines section, and concludes with the Footer section. Additional lines may be written to the Main Input File between these primary sections by the use of OASIS Comm Pieces.

The Update button also records the data of the syntax items into persistent software objects of the OModule Specification Document. The software object model for OASIS is an extension of the software object model for PBO Lab and persistent data will be saved to file when the OModule Specification Document is saved. Saving different document types (.olab and .omod extensions) is described in Section 7.

OASIS provides for dynamic user testing of the OModule Specification Document as it is being developed. There are several levels of testing available, and the simplest tests are made using the Write… entries of the OASIS Commands menu. The Write Header (Globals) and View command produces the DiMadInput file illustrated in Figure 15.

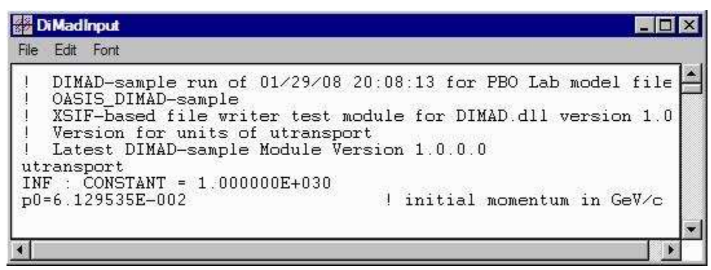


Figure 15. Header Section of the Main Input File for the DIMAD-sample OModule.

The discussion of the selection of Global Parameters, and the specification of the format and syntax for the Header section of the Main Input File, gives a brief introduction to these topics. The examples for the DIMAD-sample OModule illustrate representative features. The DIMAD-sample OModule is included with the OASIS Module Developer for further study.

The next Section of this User Manual describes the development of the principal components of the Lattice section of the Main Input File. Procedures similar to those presented above are utilized there to select parameters and define syntax for beamline elements.

OASIS™

3. Beamline Parameters & Syntax

OASIS User Manual:
Building Application Modules
for PBO Lab™

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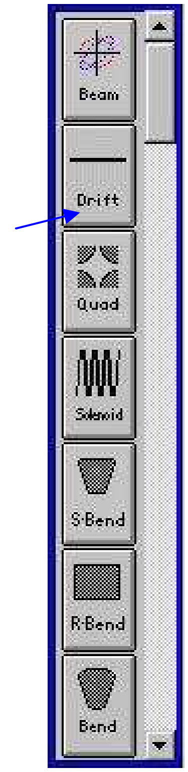
3. Beamline Parameters and Syntax

This Section describes one of the more important parts of defining a PBO Lab Application Module using the OASIS Module Builder: selection of beamline element parameters for the Main Input File. This Section also describes how to specify the syntax for writing the selected parameters to the Lattice section of the Main Input File. The detailed format of the Main Input File is developed using the procedures summarized here. The procedures are similar to those described in Section 2 for the Global Parameters and are discussed here initially by way of example for the case of a Drift Piece.

To begin, make sure that the OASIS Module Specification Document window is open on the computer screen, similar to that shown in Figure 5. The required information needed to specify an OModule (Section 2) should also be completed.



Individual optics elements (PBO Lab Pieces) are located on the scrolling Palette Bar of the OModule Specification Document.

Optical Components

Example Using a Drift Piece

From the Palette Bar appearing on the left side of the OASIS Module Specification Document window, select a Drift Piece icon and drag it to the Model Space of the window. Figure 16 illustrates how the OModule Specification Document window should appear with the Drift Piece on the Model Space.

The Drift Piece offers a simple example to illustrate creating the element syntax of the Main Input File for several computation engines.

Note that the example used in Figure 16 illustrates how the DIMAD-sample OModule Specification Document would appear *during this stage* of the Module development. The DIMAD-sample OModule distributed with the OASIS Module Builder will actually have more Pieces on the Model Space since that is a more fully developed OModule.

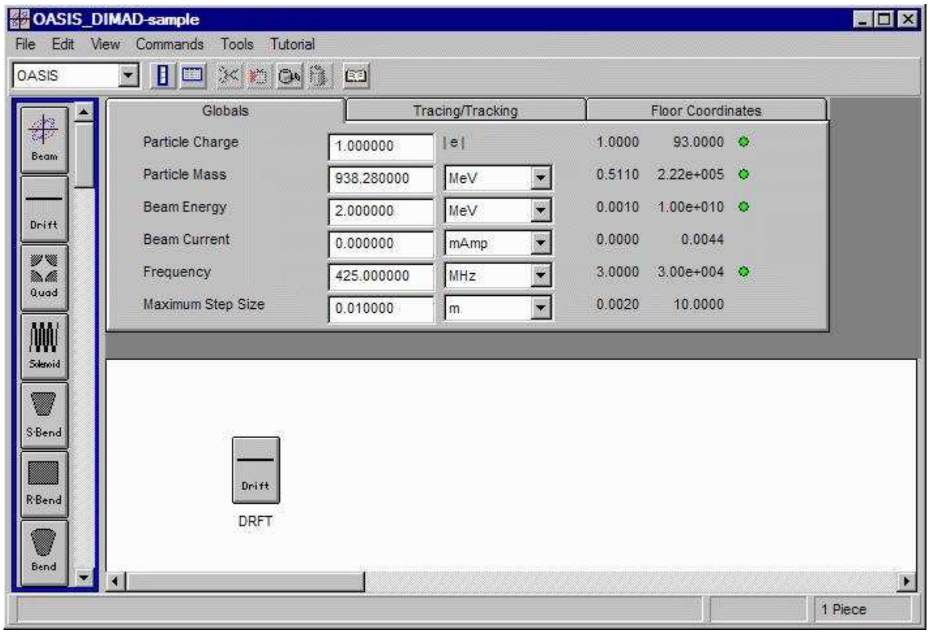


Figure 16. OASIS Module Specification Document with Drift Piece on the Model Space.

Double click the Drift Piece icon on the Model Space to open the Drift Piece window. The Drift Piece window is shown in Figure 17. Several features of the Piece window are indicated.

OASIS Syntax Button

Special Parameter Selection ("S") Buttons

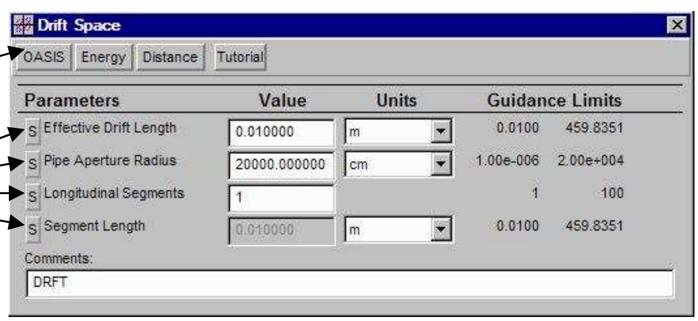
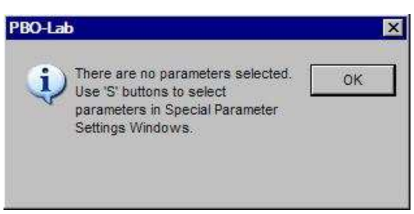


Figure 17. Drift Piece window with selected features identified.



The OASIS Syntax Button cannot be used to define syntax before any parameters have been selected.

The procedures for the selection of parameters for use by an OModule, together with the syntax specification for writing data to the Main Input File, are very similar to the procedures described for the Global Parameters.

Selecting the "S" button will open the Special Parameter Settings (SPS) window for the parameter. The SPS window for the Effective Drift Length is illustrated in Figure 18. Figure 18 also identifies several features of the SPS window for the OASIS Module Builder.

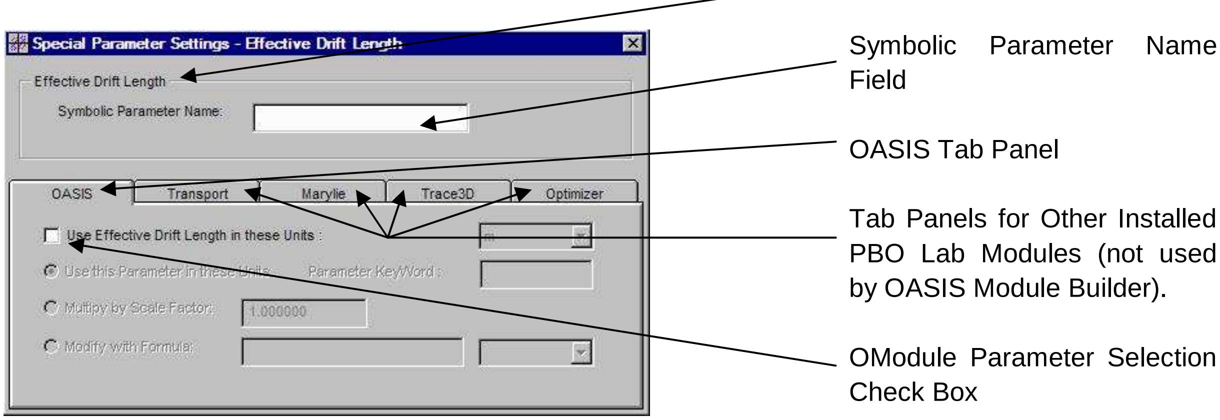


Figure 18. Special Parameter Settings (SPS) window for Effective Drift Length.

Clicking the OModule parameter selection check box, appearing in the upper left of the OASIS tab panel, will select the Effective Drift Length as a parameter that will be used by the OModule under construction. When the box is checked, a default name will appear in the Symbolic Parameter Name field, and other parts of the window will become active. Figure 19 illustrates a typical appearance for the SPS window when the Effective Drift Length parameter check box is selected.

The example used for Figure 19 is from the OModule DIMAD-sample. Selecting the check box activates: the units selection popup menu, the Parameter Keyword field, and sets the radio button to the default: Use this Parameter in these Units. Other radio button choices offer different options for the numerical value of the parameter to be used in the OModule. These other options are the same as those described in Section 2 for the Global Parameters.

Different options in the SPS window are used to specify how the selected parameter will be made available to the OModule. Units, keywords, and other attributes can be assigned.

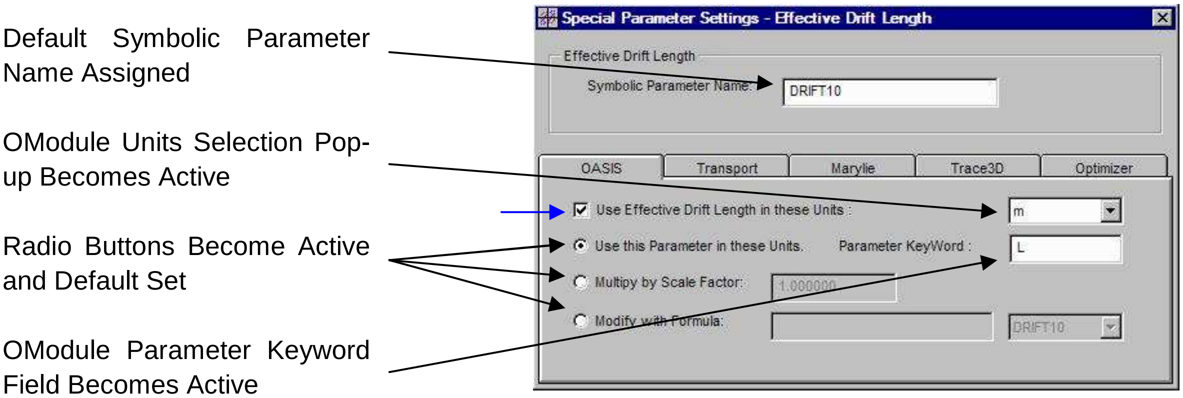


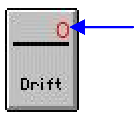
Figure 19. Special Parameter Settings (SPS) window when the OModule parameter selection box is checked. Elements activated by checking this box are indicated.

To complete the selection of the Effective Drift Length for use in the OModule:

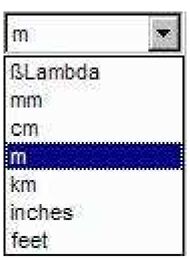
- Select the OModule units for this parameter
- Enter any OModule keyword for the parameter
- Choose the appropriate radio button option and enter additional information if needed.

In Figure 19 the units option for meters (m) has been selected, the DIMAD key word L has been entered, and the default setting for the parameter usage has been set.

It should be noted that the data appearing in the OASIS Piece Window is not used directly by an OModule. The particular values of the Effective Drift Length, Pipe Aperture Radius, etc., in the OModule Specification Document will not be used for any calculations (other than OASIS Module Builder internal testing). When the OModule is utilized by a user for a particular PBO Lab Model that contains Drift Pieces, the values for the parameters will obtained from the Drift Pieces of that PBO Lab Model.



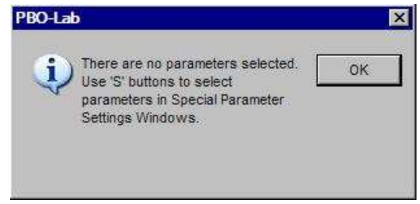
A red O will appear on the Piece icon for which a parameter selection has been made. This designates the Piece as an OASIS Piece and indicates that at least one parameter has been selected for use in an OModule.



Length Units Popup

PBO Lab supports the input of parameters in a variety of units, including "smart units" such as $\beta\lambda$ (βLambda) for length. The OASIS Module Builder supports the same units.

With the completion of the parameter settings, the SPS window may be closed. The Drift Piece Window (Figure 11) should still be open. The next step is to define the OModule specific syntax for how a Drift Piece and its parameters (e.g. Effective Drift Length) will be written to the Main Input File which will be read by the computation engine. Use the OASIS syntax button appearing in the upper left of the Drift Piece Window (Figure 17) to open the Input Syntax window. An example of the Input Syntax Window for a Drift Piece is illustrated in Figure 20.



Parameters must be selected for use by the OModule before defining the Input Card Syntax for the Piece. Otherwise a dialog window will appear advising the developer to select parameters.

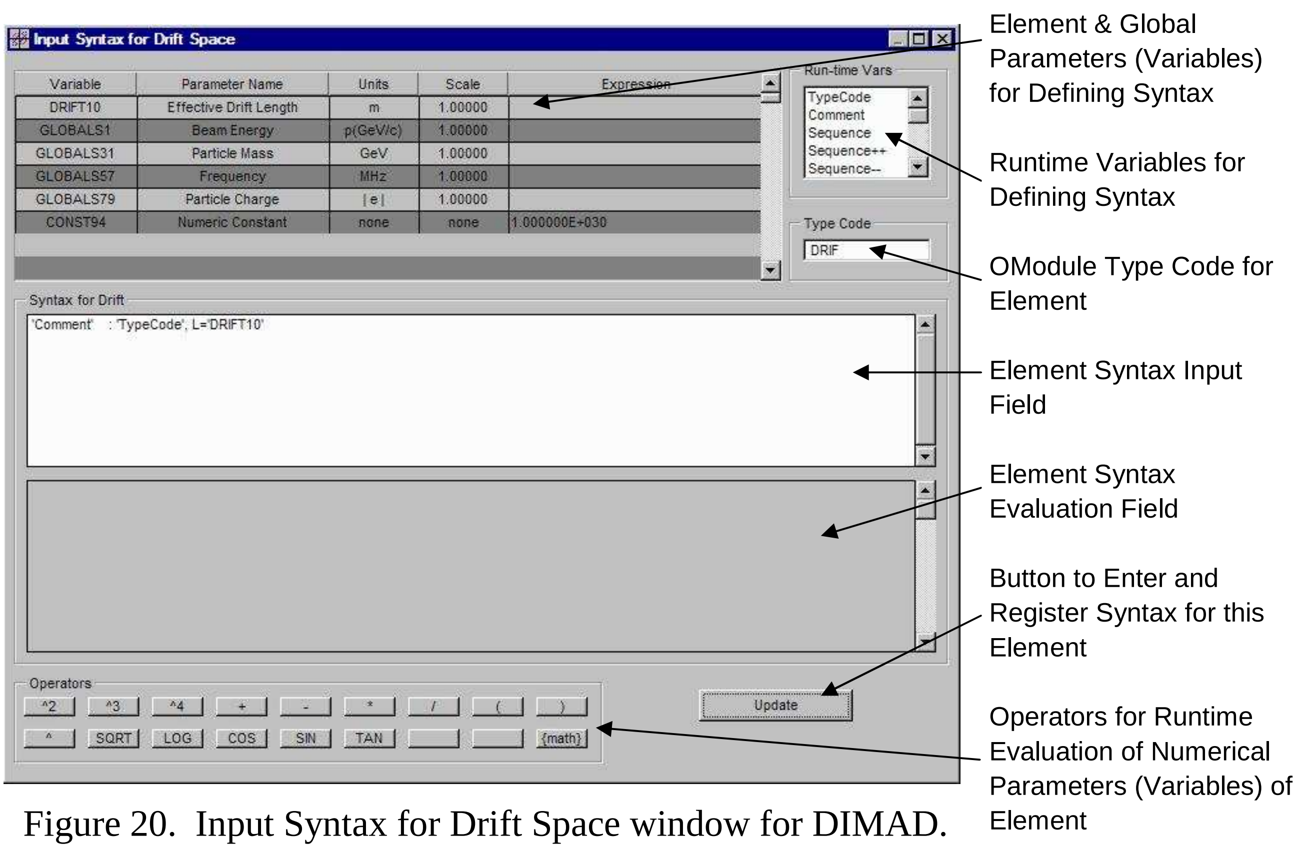


Figure 20. Input Syntax for Drift Space window for DIMAD.

The Input Syntax window is used to specify the detailed alphanumeric text line(s) that will be written to the Main Input File for any optical Piece. Items and text entered into the Syntax for Drift field provide the specification of the format and syntax for the alphanumeric text line(s). Figure 20 shows an example with 'Comment' : 'TypeCode', L= 'DRIFT10' entered.

There are several features of the Input Syntax window that should be noted. First, the parameters available for use in writing to the Main Input File are given in the Variables list at the top of the window. This list includes all parameters of the Piece selected for use (see Figure 19) in the OModule, together with any Global Parameters also selected for use (see Figure 12) in the OModule. Second, a list of runtime variables (Run-time Vars) available for use in defining the syntax is shown in the upper right part of the window. Third, a field is available for specifying any Type Code that is used by the OModule for the Drift. Fourth, a variety of numerical operators are available for use in defining the syntax.

The Input Syntax refers to the text line (or lines) that will be written to the Main Input File for the OModule computation engine. The example shown in Figure 20 corresponds to the Drift Piece syntax defined for use by the DIMAD computation engine. The first item in the Input Card Syntax is the Comment ('Comment') runtime variable. The Comment is followed by a colon (:) and a second runtime variable, the Type Code ('TypeCode'). The Type Code is followed by a comma and parameter assignment string (, L=). The parameter value is given by the DRIFT10 Variable ('DRIFT10'). The DIMAD Type Code for a drift is entered into the Type Code field (DRFT). *Note that all Variables and Run-time Vars must be enclosed in single quotes*. How is this Input Syntax used? When PBO Lab has the OModule installed, the Input Syntax is used for each Drift Piece in any beamline model to write the appropriate card to the Main Input File. The Variables and Run-time Vars ('Comment', 'TypeCode', and 'DRIFT10') are evaluated for each drift, and the appropriate text and numerical data are then written to the Main Input File.

The Input Syntax window offers a number of features for use in defining how an optics component is written to the Main Input File for an OModule computation engine. Only a few of these capabilities are needed to specify the text line (Input Syntax) for the Drift Piece of the DIMAD-sample OModule.

The Update button, located in the lower right part of the Input Syntax window (Figure 20) is used to register and record the syntax specification. The Input Syntax becomes what is referred to as "persistent data" when the Update button is selected. <u>The Input Card Syntax will not be retained or saved if the Update button is not used.</u> The Update button also evaluates Variables and Run-time Vars for the current Drift Piece (i.e. the Drift Piece being used to define the syntax). The result is displayed in the syntax evaluation field. Figure 21 illustrates the Input Syntax window after using the Update button for the DIMAD-sample Drift syntax illustrated in Figure 20.

The Update button in the lower right of the Input Syntax window operates like an "accept" button, registering and retaining the Input Card Syntax. The Update button also evaluates the syntax for the Drift Piece being used to define the OModule syntax, and displays the results in the syntax evaluation pane. This permits some preliminary testing of the Input Card Syntax for the OModule under construction

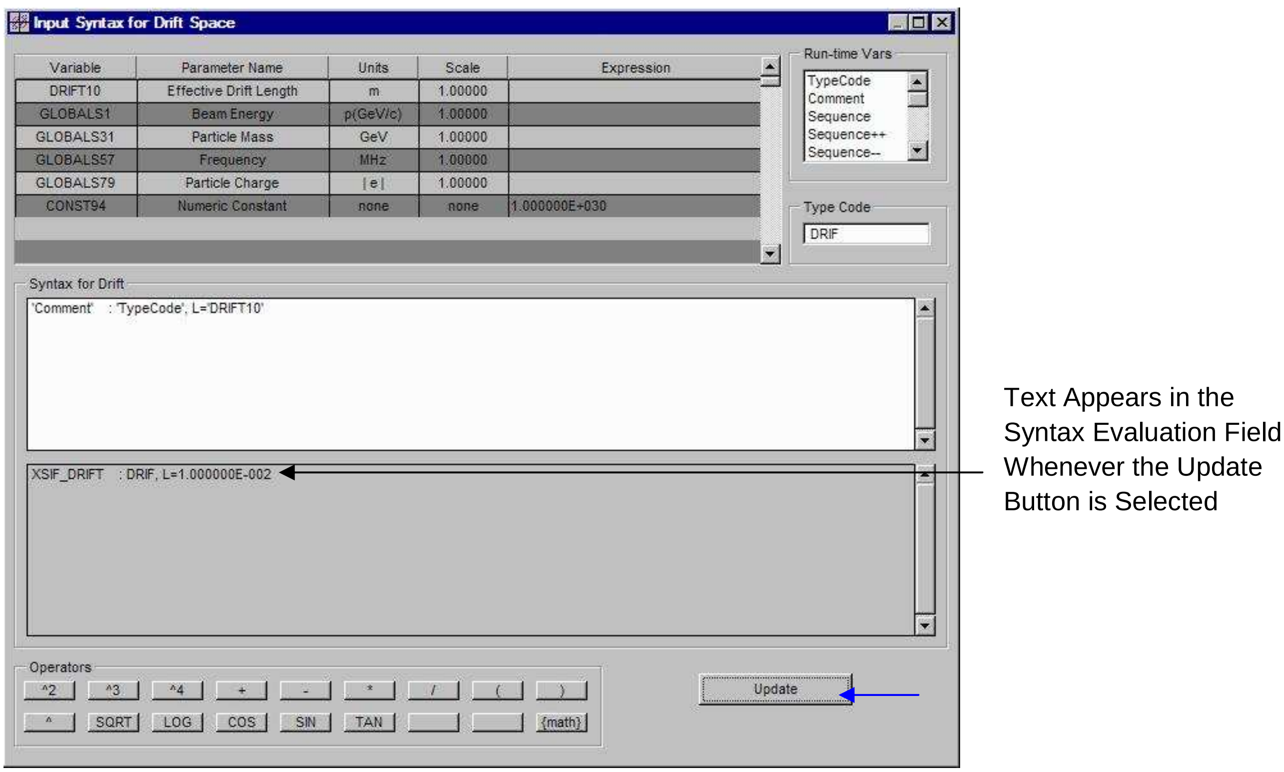


Figure 21. Example of an Input Syntax for Drift Space window after the Update button is used.

The Update button calls on the OASIS parser to first evaluate the syntax in the specification field and then to display the results in the evaluation field.

Make sure that text appears in the syntax evaluation field before closing an Input Syntax window. If no text appears in the syntax evaluation field, the syntax specification will not be saved!

.
The Drift Piece Comments field (see Figure 17) for the DIMAD-sample OModule shown in Figure 21 has XSIF-DRIFT *entered (rather than the Drift Piece default:* DRIFT*). This comment refers to the eXtended Standard Input Format utilized by a number of particle beam optics codes. The Standard Input Format (SIF) and Methodical Accelerator Description (MAD) formats can be considered simpler versions of XSIF. The DIMAD-sample OModule can be used as a starting point in developing OModules that use the XSIF, SIF or MAD input file descriptions.*

Whenever the Update button is used, the OASIS parser utilizes data for the syntax evaluation that is obtained from the (OASIS) Piece itself. This provides an internal test of the syntax which the OModule developer can examine for accuracy and completeness. The data in the OASIS Piece can be modified by the developer in order to test different aspects of the syntax. This is particularly useful if the syntax contains mathematical expressions. Sometimes there may be a specific set of Piece parameters that is particularly useful for testing syntax that contains mathematical formulas. That data may be entered in the OASIS Piece and it will be saved when the OModule Specification Document is saved. Data entered into an OASIS Piece and saved with the OModule Specification Document will not impact the operation of the OModule in PBO Lab. When an OModule is instantiated in PBO Lab by a user, the OASIS parser will act upon the data present in the PBO Lab model under investigation, regardless of what data is present in the corresponding OASIS Piece. The Update button is one of the few times that the specific numerical data in an OASIS Piece is used. However, it provides a quick and interactive capability to test each Piece's syntax as it is specified by an OModule developer.

The OASIS parser provides some feedback in the event that syntax and/or variables are improperly defined. For example, suppose the syntax refers to a Variable named BAD22, e.g. the single-quoted string 'BAD22' *appears in the syntax, but BAD22 has not been defined. The OASIS parser will display the following for BAD22 in the evaluation field:*

Variable can not be found

Drift Syntax for Different Computation Engines

Figure 22 shows some Input Syntax for Drift Space windows with syntax developed for three (3) different computation engines. From top to bottom these computation engines are: (a) PARMILA-1, (b) PARMILA-2 and (c) the "old" style TRANSPORT. PARMILA-1 corresponds to the version of PARMILA that was in common use prior to ~1998. PARMILA-2 corresponds to the version that has been in prominent use since that time. One difference between these PARMILA versions is how transport elements (e.g. drifts) are described in their respective input files. The old style TRANSPORT refers to versions of TRANSPORT that still use the original positional notation input file.

Although the syntax for drift elements does not use any Global Parameters, it is worth noting the different uses shown in Figures 22 and 23: The examples show various Global Parameters for each computation engine: Particle Charge, Particle Mass, Beam Energy, Beam Current, etc. Different units have been specified for some of the Global Parameters. For example, the Beam Energy is specified to be expressed in terms of the beam momentum (GeV/c) for the TRANSPORT examples. Also note that the Particle Mass is multiplied by a factor for the PARMILA examples in order to comply with the conventions of those codes.

Figure 23 shows some Input Syntax for Drift Space windows with syntax developed for three (3) additional computation engines. From top to bottom these computation engines are: (a) "MAD" style TRANSPORT, (b) TRACE 3-D and (c) MARLYIE. The MAD style TRANSPORT version uses descriptions of beamline elements that are similar to those in the DIMAD-sample OModule.

The Input Syntax windows shown in Figures 22 and 23 are typical of the spectrum of input formats for different computation engines. Note that the PARMILA-1 and TRACE 3-D use the Run-time Vars 'Sequence'. The 'Sequence' runtime variable is discussed further in the quadrupole example section. For the Comments field of the Drift Pieces (see Figure 21) used for Figures 22 and 23, the name of the underlying computation engine has been entered. The runtime variable 'Comment' as evaluated in the Syntax Evaluation Field reflects this name.

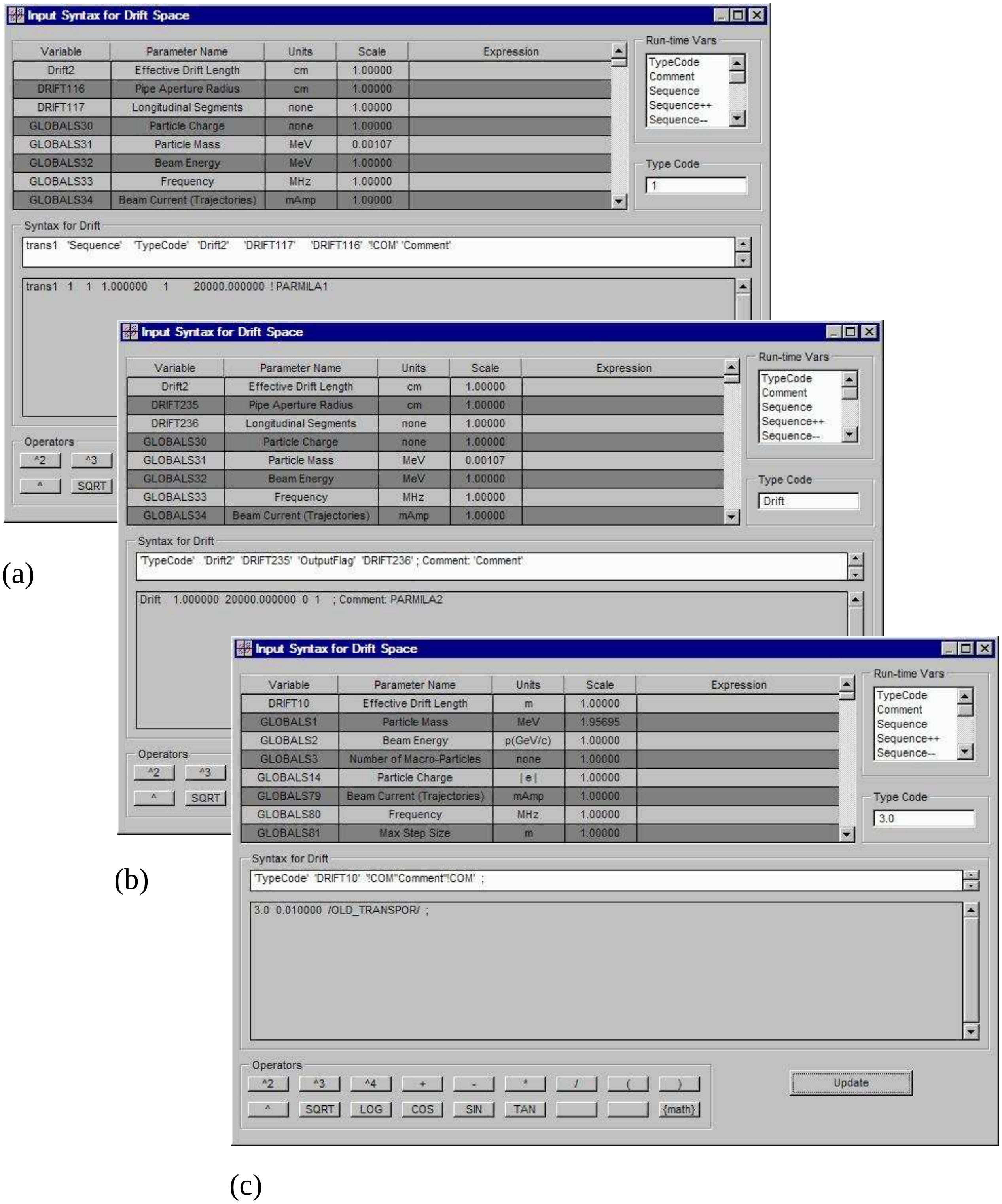


Figure 22. Input Syntax for Drift Space windows for three (3) different computation engines: (a) PARMILA-1, (b) PARMILA-2 and (c) "old" style TRANSPORT.

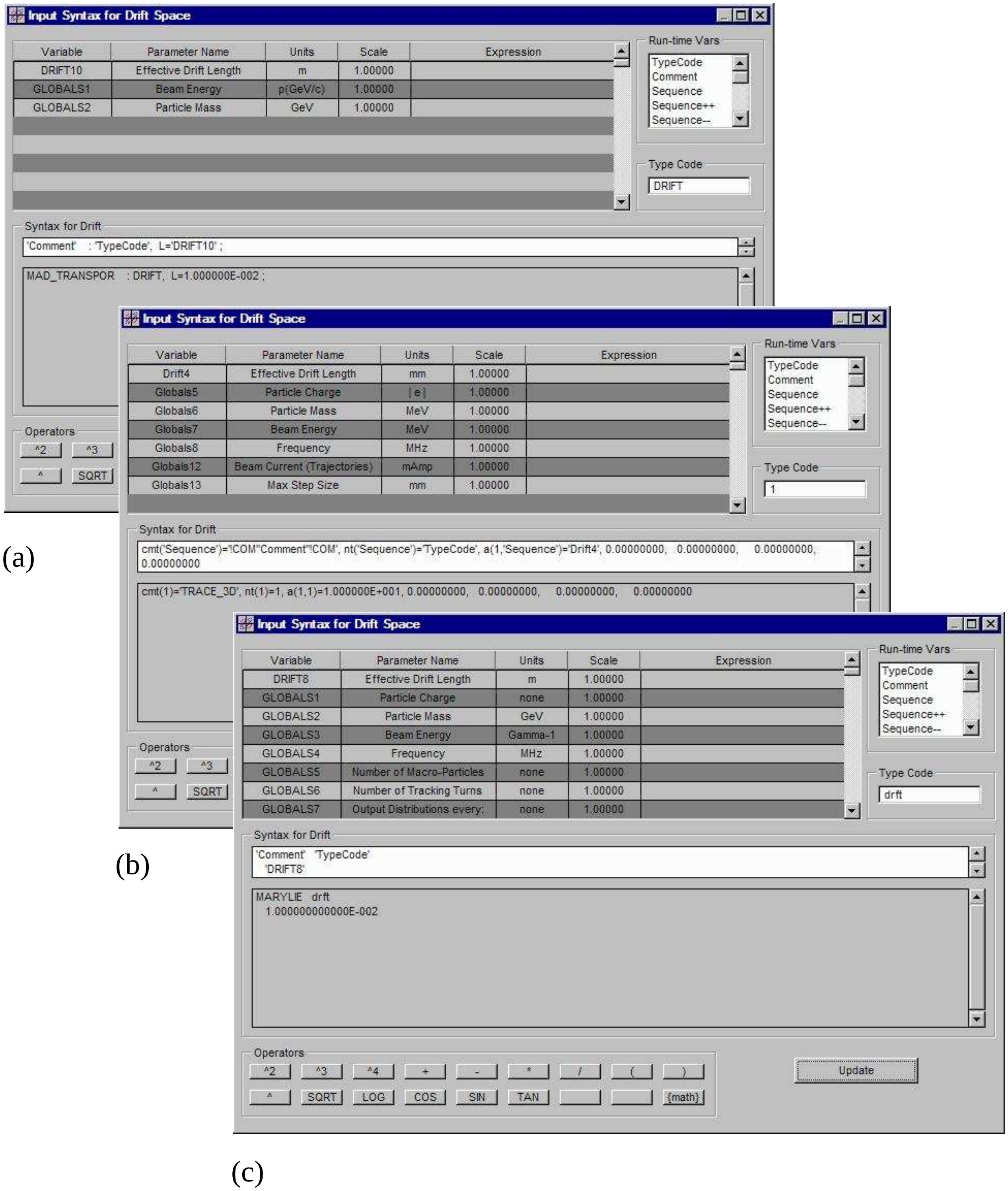
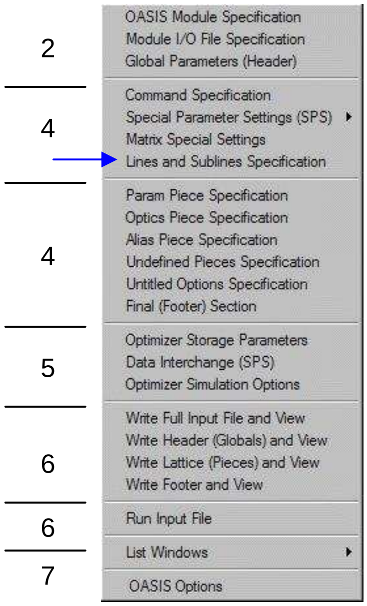


Figure 23. Input Syntax for Drift Space windows for three (3) different computation engines: (a) "MAD" style TRANSPORT, (b) TRACE 3-D and (c) MARYLIE.

Manual Section



The Lines and Sublines Specification can be used to define the labeling scheme for hierarchical beamline lattice descriptions. The 'Comment' *Run-time Vars can be evaluated to a unique dynamic label in support of hierarchical lattice descriptions.*

As mentioned, the comments for the Drift Pieces used in Figures 22 and 23 have the name of the underlying computation engine entered into the Comments field. The OASIS parser evaluates the runtime variable 'Comment' and puts this name in the syntax evaluation field when the Update button is selected. However, it is worth noting here that the 'Comment' runtime variable can also take on different values for hierarchical lattice descriptions. How this is accomplished is discussed in Section 4. When certain hierarchical lattice descriptions are specified, the OASIS parser can substitute a dynamic labeling for each 'Comment' runtime variable when the OModule is used in calculations for a PBO Lab Model.

Example for a Quadrupole Piece

The Quadrupole Piece offers an example that is modestly more complicated than the Drift Piece. Figure 24 shows the Piece window for a quadrupole, illustrating several features of the window that are not present for the Drift. The example illustrated in Figure 24 is for the DIMAD-example, and shows 4 parameters on the Element pane that have been selected for use.

The Quad Piece has multiple tab panels, each of which provides parameters that can be used to describe a magnetic quadrupole lens.

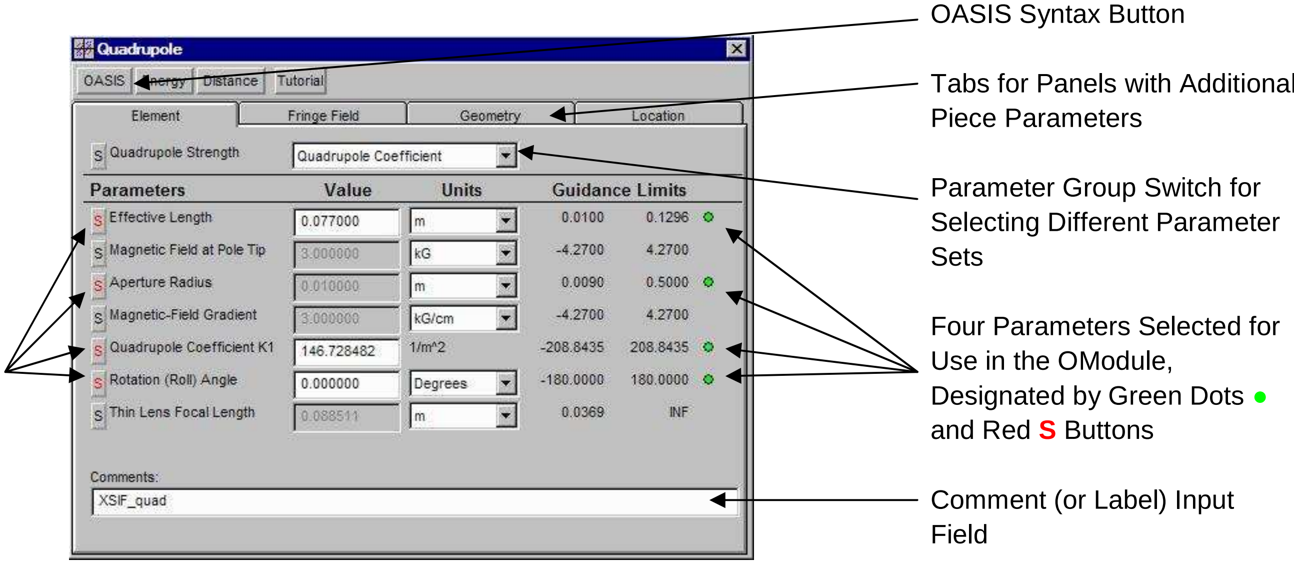


Figure 24. Quadrupole Piece window for the DIMAD-sample OModule with selected features identified.

The selection of individual Quadrupole Piece parameters for use in an OModule follows the same procedure as described for the Drift Piece. For a quadrupole there are more parameters to be selected. Some of the parameters may appear on the Fringe Field, Geometry or Location tab panels, in addition to those on the Element tab panel illustrated in Figure 24.

The Quad Piece example is used to illustrate creating the element syntax of the Main Input File for several computation engines.

Quadrupole Strength Parameter-Group Switch

Parameter-group switches are used to select between different sets of dependent parameters for a PBO Lab Piece. Parameter-group switches can be used to define different alphanumeric strings for each switch setting. The different strings will be written to the Main Input File, depending upon the OModule user's switch selection. In addition, parameter-group switches can be used to define a different syntax for each switch setting. An entire group of parameters can be utilized within each syntax specification. This is described later and is illustrated for the Beam Piece.

A logical-parameter switch is similar to a parameter-group switch and can also be used to define alphanumeric strings for Piece syntax. An example of the use of a logical-group switch is described later in this quadrupole section.

The example in Figure 24 indicates that four (4) parameters have been selected on the Element tab panel for use by the OModule: the Effective Length, Aperture Radius, Quadrupole Coefficient K1, and Rotation (Roll) Angle. These four parameters have a red "S" appearing on their corresponding Special Parameter Selection buttons.

The Quad Piece window (Figure 24) contains a parameter-group switch (Quadrupole Strength) on the Element tab. This switch has been set to the Quadrupole Coefficient option in order to select the Quadrupole Coefficient K1 parameter for use in the OModule. Note also that there is an "S" button to the left of the Quadrupole Strength parameter-group switch, indicating that the switch setting can be used by the OModule. For the example shown in Figure 24 the button is not red, indicating that the switch is not used for the particular OModule used for the illustration (DIMAD-example). An example of the use of a parameter-group switch will be described later for the Beam Piece. Another type of switch, referred to as a logical-parameter switch, also appears in certain windows. An example of the use of a logical-parameter switch will be described later in this Quad Piece discussion.

The syntax and format for writing Quadrupole Piece data to the Lattice Section of the Main Input File is specified following procedures similar to those described for the Header Section and for the Drift Piece. The OASIS syntax button (Figure 24) is used to open the window. Figure 25 illustrates the Syntax Window used to define the quadrupole text line for the DIMAD-sample OModule example. Note that the Update button has been used so that the syntax evaluation field (lower pane of the Input Syntax window) displays the OASIS parser results for the syntax evaluation for this (OASIS) Quadrupole Piece.

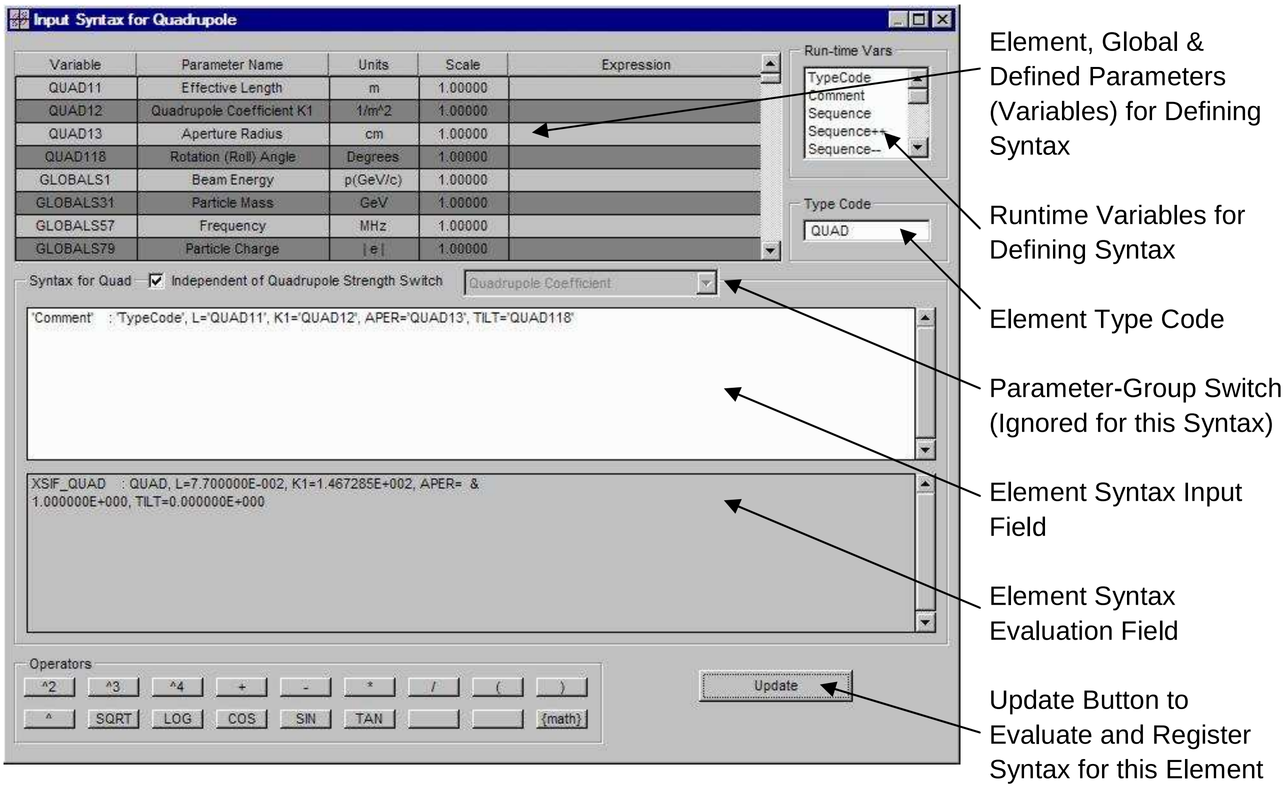
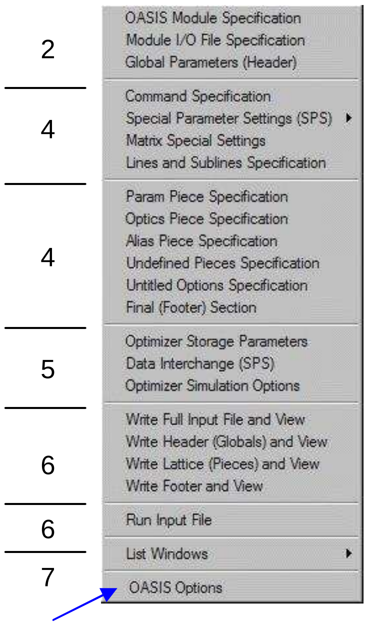


Figure 25. Input Syntax for Quadrupole window for the DIMAD-sample OModule.

Remember that the Update button in the lower right of the Input Syntax window also operates like an "accept" button. Selecting the button will register and store the Input Syntax, as well as display the result (for the particular parameter values of the OASIS Piece) in the syntax evaluation box in the lower part of the Input Syntax window. <u>If no text appears in the syntax evaluation box, the syntax specification will not be saved.</u>

The OASIS parser for the Quadrupole Piece syntax illustrated in Figure 25 utilizes additional formatting information that is not specified in the Input Syntax window. The scientific format for the real numbers is governed by the OASIS Options. The OASIS Options window contains a Numerical Formatting tab for specifying this type of formatting information and is described in Section 7.

Manual Section



The OASIS Options provide additional formatting capability for specifying the text lines of the Main Input File. The maximum number of characters per line (e.g. 68), the character to be used to signify line continuation (e.g. &), and similar formatting items are provided on the Input File Options tab of the OASIS Options window. These are discussed in Section 7.

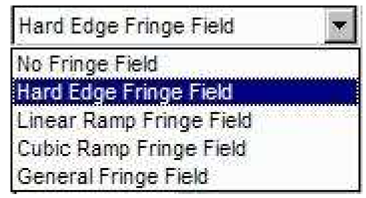
The OASIS Options window also provides an Input File Options tab to support additional formatting capability. This was used to specify that the maximum number of characters be limited to 68 for any one line of the Main Input File for the DIMAD-sample OModule. The ampersand (&) character was also specified there to be used as a line continuation character whenever the 68 character line limit is encountered. This condition was encountered for the Quadrupole Piece syntax illustrated in Figure 25. The result is that 2 lines appear in the syntax evaluation field, linked together with the ampersand (&) character.

Line continuation character specification, numerical formatting, and other OASIS Options are discussed in Section 7.

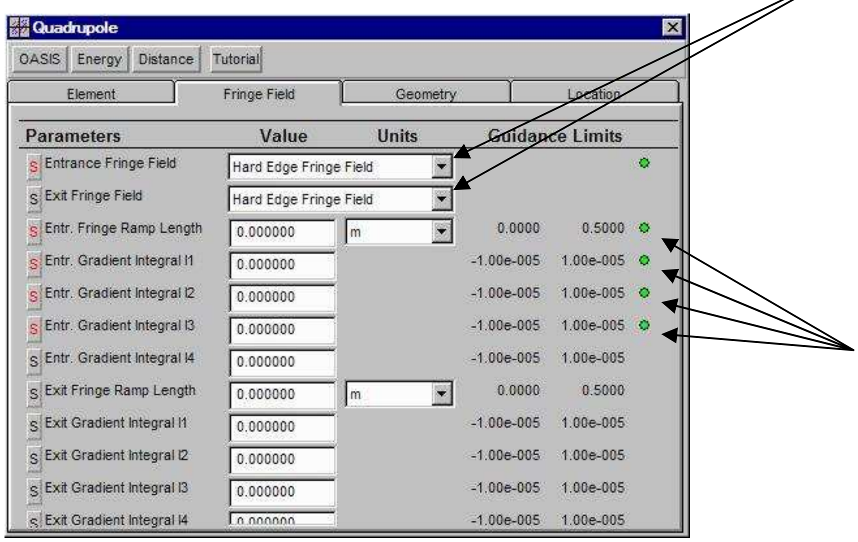
The next several pages describe the use of a logical-parameter switch. The Quad Piece has two logical-parameter switches on the Fringe Field tab of the Quadrupole Piece window. The discussion shifts away from the DIMAD-sample example and describes the use of a quadrupole logical-parameter switch in the context of a version of TRANSPORT that has been developed at the Paul Scherrer Institute (PSI). The underlying computation engine is referred to as PSI-TRANSPORT and the associated OASIS Module as the PSI-TRANSPORT OModule. PSI-TRANSPORT uses the "old" style TRANSPORT positional notation for the input file. Figure 22(c) gave an example of how the Drift Piece syntax is specified for the "old" style TRANSPORT positional notation.

Example for Logical-Parameter Switch

Logical-parameter switches are popup controls that offer different text descriptions for various ways in which the parameters in the window may be used. Unlike parameter-group switches, logical-parameter switches do not alter the user's ability to edit any parameter value. Logical-parameter switches simply offer a convenient way to select different methods for using parameters, utilizing an intuitive word description of the choices available. Figure 26 illustrates a Piece Window tab panel that contains two logical-parameter switches.



Quadrupole Fringe Field Logical--Parameter Switch



2 Logical Parameter Switches: One ("Entrance Fringe Field") Is Selected for Use in the OModule, as Designated by the Green Dot ● and Red **S** Button

The Other ("Exit Fringe Field") is Not Selected for Use (No Green ● or Red **S**).

Four Numerical Parameters Selected for Use in the OModule, as Designated by the Green Dots ● and Red **S** Buttons

Figure 26. Fringe Field tab panel of the Quadrupole Piece window with two logical-parameter switches.

Logical-parameter switches can be selected for use in an OModule by choosing the Special Parameter Selection ("S") button that appears to the left of the parameter name. Figure 26 illustrates two examples of logical-parameter switches, named Entrance Fringe Field and Exit Fringe Field, appearing on the Fringe Field tab panel of the Quadrupole Piece window. The Entrance Fringe Field has already been selected for use in the OModule, while the Exit Fringe Field has not.

Logical-parameter switches can be used to define different alphanumeric strings for each switch setting.

The PSI-TRANSPORT code supports soft-edge quadrupole modeling through 2nd order. This involves the use of the gradient integrals I1, I2 and I3. For a hard-edge quadrupole these integrals are all zero. A PSI-TRANSPORT OModule has been developed that illustrates how to support this fringe field modeling capability.

The PSI-TRANSPORT code models soft-edge quadrupoles through the use of the gradient integrals I1, I2 and I3. For hard-edge quadrupoles these integrals are zero. A logical-parameter switch will be used to distinguish these cases.

The "S" button to the left of each logical-parameter switch opens a Special Parameter Settings (SPS) window that is different from the SPS window used for numerical Piece Parameters (see Figure 19). The SPS window for the first logical-parameter switch (Entrance Fringe Field) of Figure 26 is illustrated in Figure 27.

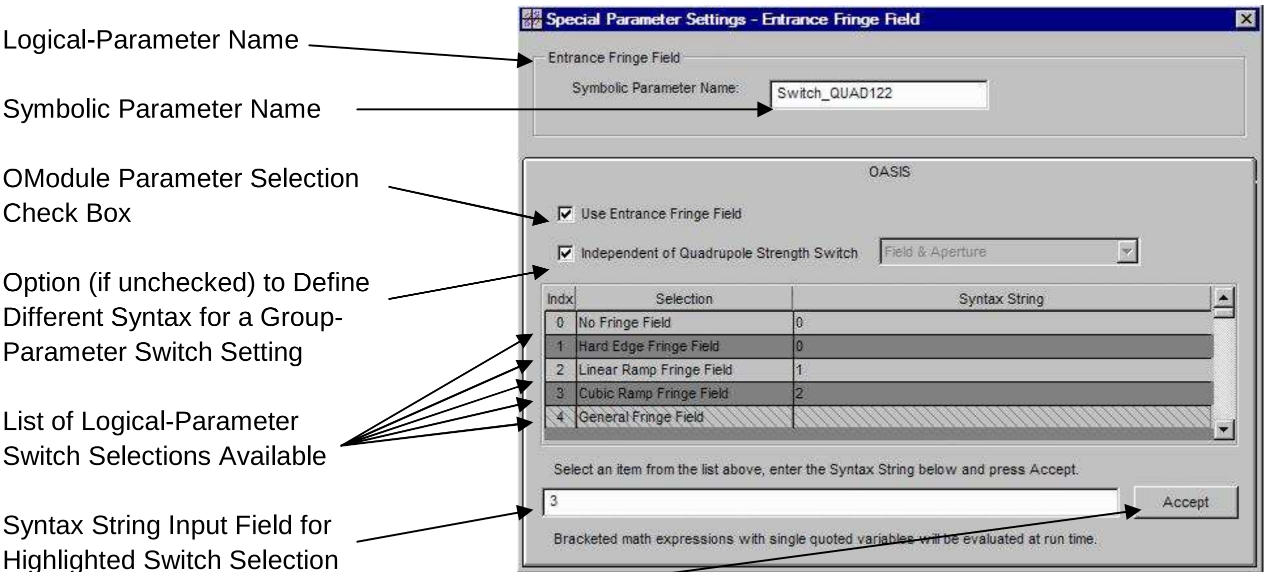


Figure 27. Example of a Special Parameter Settings (SPS) window for a logical-parameter switch.

Different strings will be written to the Main Input File, depending upon the OModule user's switch selection, according to the alphanumeric string assigned to each switch position. The alphanumeric string is substituted whenever the logical-parameter switch name is encountered in the Piece Syntax.

The Entrance Fringe Field logical parameter is selected for use as an OModule parameter by checking the OModule parameter selection check box "Use Entrance Fringe Field." A (default) Symbolic Parameter Name will then automatically appear in the text box in the upper part of the window. Figure 27 shows an example where the Entrance Fringe Field has been selected for use as an OModule parameter, and the Symbolic Parameter Name "Switch_QUAD122" has been assigned.

A list table appears in the bottom part of the SPS Window for a logical-parameter switch with entries for each selection available for the switch. For each available selection, the list table provides the Index, the Selection, and the Syntax String for the selection. There are five selections available for the Entrance Fringe Field switch illustrated in Figure 27: No Fringe Field, Hard Edge Fringe Field, Linear Ramp Fringe Field, Cubic Ramp Fringe Field, and General Fringe Field, with indices 0 through 4, respectively. The Syntax String fields in the list table are initially empty (blank). For the example shown in Figure 27, a Syntax String of 0, 0, 1 and 2 has been assigned to the first four entries in the table.

Clicking on a list table entry highlights that entry, causing a cross-hatch pattern to appear in the table for that entry. An alphanumeric string may then be typed into the Syntax String input field at the bottom of the window. For the example of Figure 27, the last entry in the list table (General Fringe Field) has been selected, and the number 3 has been typed into the Syntax String input field. This Syntax String is recorded when the "Accept" button in the lower left part of the window is pushed. The number 3 would then appear in the Syntax String list table for the General Fringe Field switch Selection.

A logical-parameter switch can also use Variables, or algebraic expressions of Variables, in the Syntax String that will be evaluated at runtime. To use Variables in the Syntax String the Variables must appear inside single quotes (e.g. 'Globals1'*) and the Variables or algebraic expressions must also be enclosed with one pair of OASIS math brackets (e.g.* {…}*). For example, to just use the Variable QUAD11, the following should be entered into the Syntax String input field for the desired switch Selection:*

{'QUAD11'}

Logical-parameter switches can be used in defining the syntax for a Piece in a manner similar to that used for numerical parameters. The Symbolic Parameter Name for the switch (Switch_QUAD122 in Figure 27) is entered into the element syntax input field for the Piece (see Figure 25) using single quotes, the same as for all other Variables (e.g. 'Switch_QUAD122'). At run time, the OASIS parser will evaluate the logical-parameter switch Variable to the appropriate alphanumeric string.

If-EndIf and IfNot-EndIf Runtime Variables

The use of a logical-parameter switch in the syntax for a Piece will be illustrated in conjunction with the use of two runtime variables: IfNot and EndIf. OASIS includes three Run-time Vars (If, IfNot, EndIf) that can be used to construct logical expression similar to a Boolean "IF" statement in Fortran or C. The Run-time Vars are always used in pairs: If and EndIf, or IfNot and EndIf. The format for using either of these pairs is as follows:

Run-time Vars provide access to dynamic runtime variables useful for defining various OModules. The Run-time Vars include:

- *TypeCode*
- *Comment*
- *ModelName*
- *ModuleName*
- *!COM*
- *Include*
- *If*
- *IfNot*
- *Endif*
- *Date*
- *Date-Time*
- *Version*

The Quad Piece of the PSI-TRANSPORT OModule uses 5 of these Run-time Vars in the Quad syntax:

- *TypeCode*
- *Comment*
- *!COM*
- *IfNot*
- *Endif*

'If' 'SymbolicParameterName' AlphanumericText 'EndIf'

The OASIS parser will examine the Variable SymbolicParameterName in the above structure. If the Variable is non-zero ("true") the AlphanumericText will be written at the location of this structure. The 'EndIf' indicates to the OASIS parser that the AlphanumericText string has ended. If the SymbolicParameterName Variable evaluates to zero ("false") in the above structure, then nothing will be written.

'IfNot' may replace 'If' in the above format. In that case the logic is reversed. If the Variable SymbolicParameterName is non-zero ("true") nothing will be written. If the SymbolicParameterName Variable evaluates to zero ("false") in the above structure, then the AlphanumericText will be written at the location of this structure.

Note that the If (or IfNot), SymbolicParameterName, and EndIf must be in single quotes (the OASIS "rule" for Variables and Run-time Vars). An If (or IfNot) must always be accompanied by an EndIf after the 'SymbolicParameterName' and AlphanumericText entries.

Figure 28 illustrates an example of a Input Syntax for Quad window for a version of TRANSPORT developed at the Paul Scherrer Institute (PSI) that incorporates quadrupole fringe fields through 2nd order. The OModule created for that version of TRANSPORT is named PSI-TRANSPORT. The PSI-TRANSPORT computation engine utilizes the "old" style TRANSPORT positional notation in the Main Input File. Figure 22(c) illustrated the Input Syntax for Drift Space for this computation engine.

The "old" style TRANSPORT positional notation, utilized by the PSI-TRANSPORT code, uses a minus sign ("-") in front of a type code to turn that element "off." This is used in a PSI-TRANSPORT OModule, in conjunction with a logical-parameter switch and the IfNot-EndIf logic structure, to turn the fringe fields either "on" or "off."

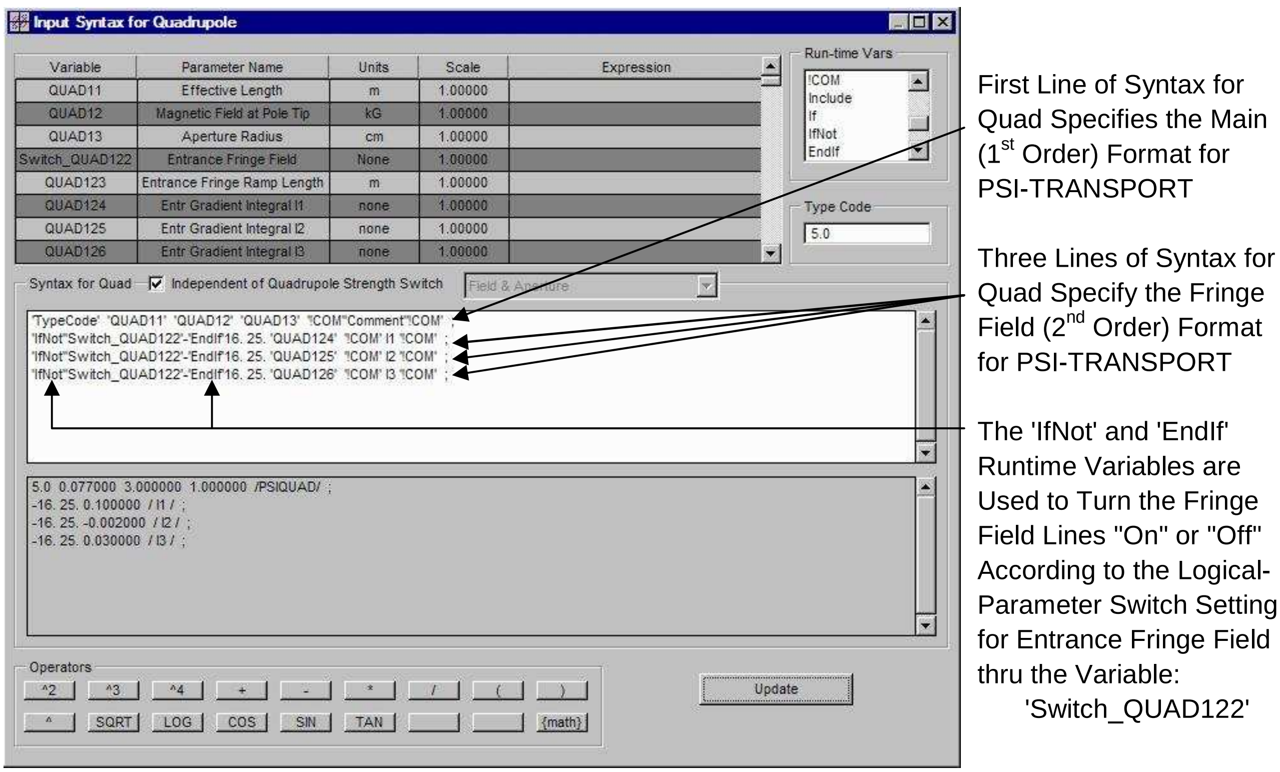


Figure 28. Input Syntax for Quadrupole window for the PSI-TRANSPORT OModule.

The Syntax for Quad input field contains one line for the basic quadrupole parameters that will evaluate to the "old" style positional notation of TRANSPORT. This is followed by three lines which utilize IfNot-EndIf structures, all of the form:

'IfNot' 'Switch_QUAD122' - 'EndIf'

The Update button in the lower right of the Input Syntax window registers and stores the Input Syntax, as well as displaying the syntax evaluation result for the current parameter values of the Piece.

"Hard Edge Fringe Field" is the Default Setting for the Entrance Fringe Field Logical--Parameter

A PSI-TRANSPORT OModule is described that supports the modeling of soft-edge quad fringe fields. In this simple example, the soft-edge fringe fields are either "on" or "off" for a particular quad, depending upon the OModule user's setting for the Entrance Fringe Field switch on each quad.

The minus sign (-) that appears after the IfNot conditional Variable (Switch_QUAD122) will either be ignored, or written in line, depending on whether 'Switch_QUAD122' evaluates to a non-zero (true) or zero (false) value, respectively. The remainder of the syntax, after the EndIf entry, will evaluate to the same results, independent of the 'Switch_QUAD122' value.

The Update button is used to see how the syntax will evaluate for the current parameters of the Quad Piece. For the example of Figure 28, the logical-parameter switch named Entrance Fringe Field is set to the default value (Hard Edge Fringe Field). As illustrated in Figure 27, the Syntax String "0" has been assigned to the Symbolic Parameter (Switch_QUAD122) for this switch setting. Hence the Variable 'Switch_QUAD122' will evaluate to 0 (false). The IfNot-EndIf structure then puts a minus sign (-) at the start of each of the three lines specifying the fringe field parameters for this Quad. The minus (-) instructs PSI-TRANSPORT to ignore those lines, i.e. the fringe fields are "off." Figure 29 illustrates an example with fringe fields "on."

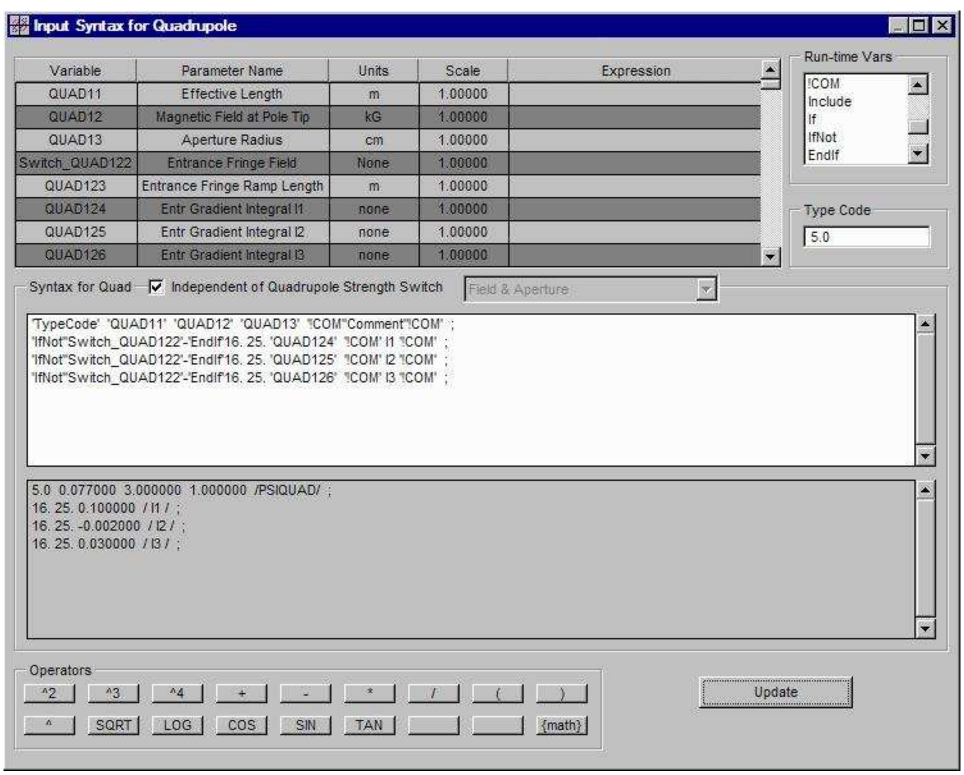


Figure 29. Input Syntax for Quadrupole window for PSI-TRANSPORT OModule for the case where General Fringe Field is selected.

Quadrupole Examples for Different Computation Engines

Figure 30 shows some Input Syntax for Quadrupole windows with syntax developed for three (3) different computation engines. From top to bottom these computation engines are: (a) PARMILA-1, (b) PARMILA-2 and (c) TRACE 3-D. PARMILA-1 corresponds to the version of PARMILA that was in common use prior to ~1998. PARMILA-2 corresponds to the version that has been in prominent use since that time. One difference between these PARMILA versions is how transport elements (e.g. quadrupoles) are described in their respective input files. The PARMILA-1 and TRACE 3-D Input Syntax for Quadrupole use the Run-time Vars ‘Sequence’. The ‘Sequence’ runtime variable is discussed further below.

The Quad Piece is used here to illustrate the element syntax for a quadrupole for several different computation engines. The OASIS parser interprets the syntax and will write the results of the evaluation to the corresponding Main Input File.

The PARMILA-2 Input Syntax for Quadrupole consists of the three lines. The first and third lines of the syntax utilize IfNot-EndIf structures, similar to those discussed in the preceding section for including (or excluding) the 2nd order quadrupole fringe integrals for the PSI-TRANSPORT computation engine. For PARMILA-2 the IfNot-EndIf structures are used to turn "off" and "on" the Rotation (Roll) Angle for the Quadrupole. The Rotation (Roll) Angle input is implemented by using a particular version of the PARMILA-2 "Displace" line. The IfNot-EndIf structures turn the corresponding Displace lines "on" or "off." In Figure 30(b) the Rotation (Roll) Angle is turned "off." It should be noted that the "off" cannot be accomplished by simply using Displace lines with an effective Rotation (Roll) Angle of zero (0.0). PARMILA-2 interprets such lines as a skew quad (45 degree Roll). Note also that the "ignore" character for PARMILA-2 is the semicolon (;) rather than the minus sign (-) used for PSI-TRANSPORT.

Remember that the Update button in the lower right of the Input Syntax window also operates like an “accept” button. Selecting the button will register and store the Input Syntax, as well as display the OASIS parser evaluation result for the particular parameter values of the OASIS Piece. Once the syntax has been saved, using the Update button, it is not necessary to repeat this if the Input Syntax window is opened simply for viewing. However, if the syntax specification is <u>changed</u>, the Update button must be used again in order to save the changes.

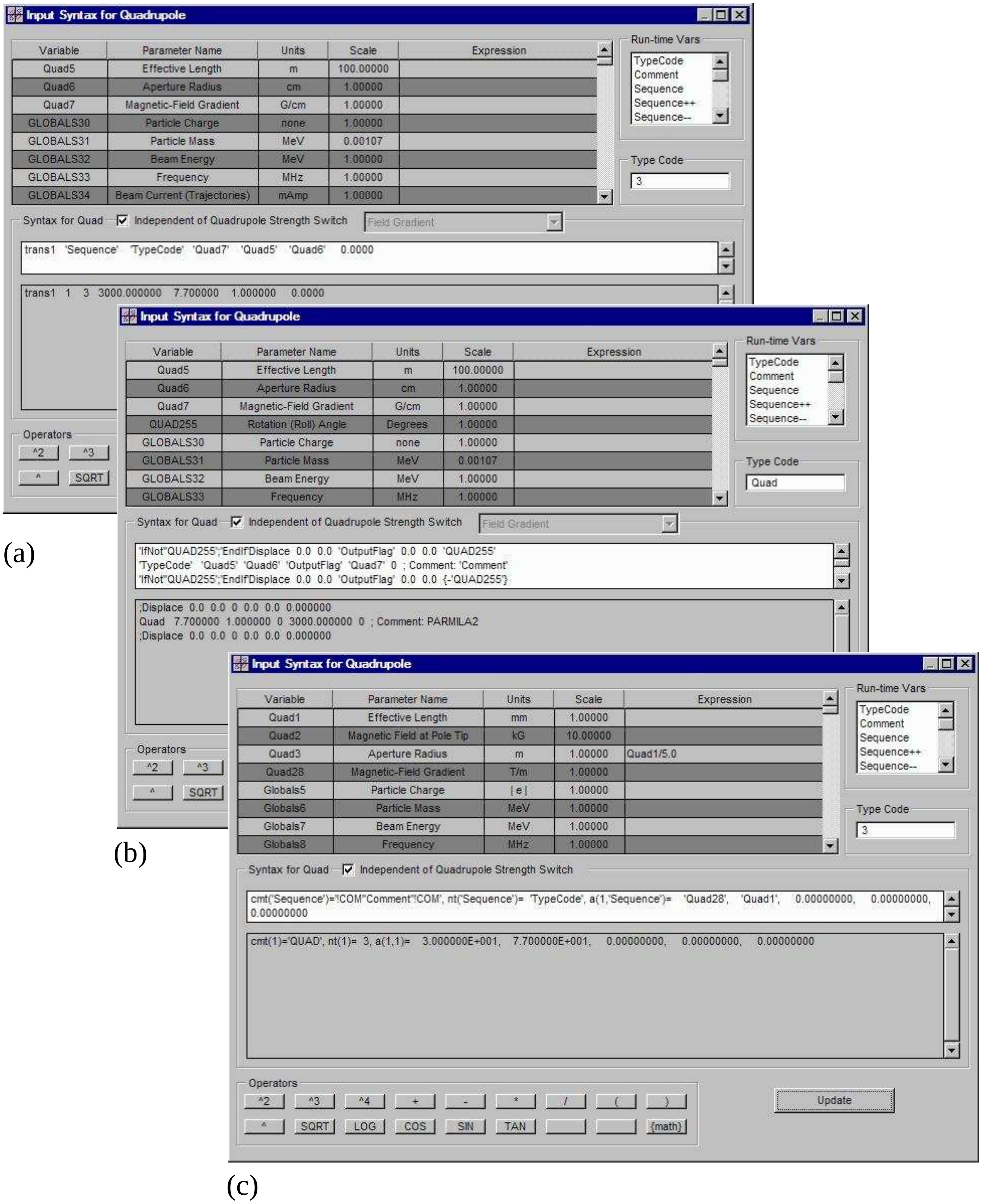


Figure 30. Input Syntax for Quadrupole windows for three (3) different computation engines: (a) PARMILA-1, (b) PARMILA-2 and (c) TRACE 3-D.

Sequence Runtime Variable

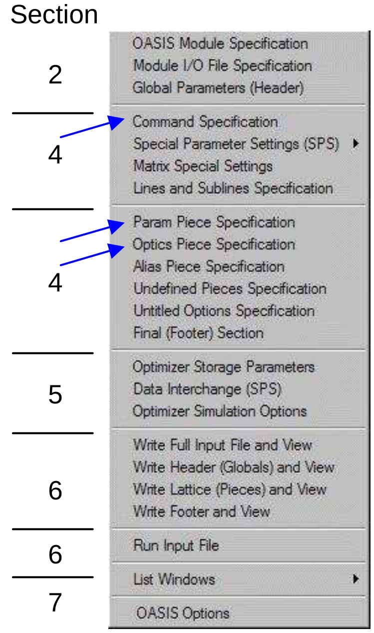
The PARMILA-1 and TRACE 3-D examples shown in Figure 30 use the runtime variable 'Sequence'. The PARMILA-1 and TRACE 3-D computation engines are examples of codes that utilize a sequential index, or counter, that defines the order in which the transport elements are to be utilized. The OASIS Sequence runtime variable can be used for that counter. Sequence provides a counter that starts from 1 at the first "physical" Piece on the beamline and increments by 1 for each subsequent "physical" Piece. A physical Piece is any Piece that represents a physical beamline element, such as a drift or a quadrupole, or any Piece that presents a psuedo-physical element that can modify certain computed beam characteristics, such as coordinate rotation or matrix element Pieces. The majority of the PBO Lab Pieces are physical Pieces. Figure 31 summarizes the PBO Lab physical Pieces that will increment the Sequence runtime variable. Figure 31 also shows the "unphysical" PBO-Lab Pieces that do NOT increment the Sequence runtime variable.

The OASIS Module Builder can be used to define new PBO Lab Pieces for a given computation engine. This is discussed in Section 4 of the user manual. Figure 32 shows the physical and unphysical OASIS Piece types that can be used for defining new PBO Lab Pieces. Physical OASIS Piece types will increment the Sequence runtime variable, while unphysical OASIS Piece types will not.

There are additional sequencing Run-time Vars available for use in an OASIS Module. These include Sequence++, Sequence-- and Max Sequence. Each of these is described next.

All physical Pieces appearing in the beamline on the Model Space Pane of a PBO Lab Document Window (Figure 2) will increment the Sequence *runtime variable for that beamline model. Nearly all PBO-Lab and OASIS Pieces are physical Pieces. The notable exceptions are the Beam, Marker, and Final Pieces. In addition, certain code-specific Pieces such as the MARYLIE Map Operations, Map Analysis, and Map Math Pieces, are not physical Pieces for the purpose of the* Sequence *runtime variable.*

Manual Section



The OASIS Module Builder can be used to define new PBO Lab Pieces for a given computation engine OModule. Examples are discussed in Section 4 of this user manual.

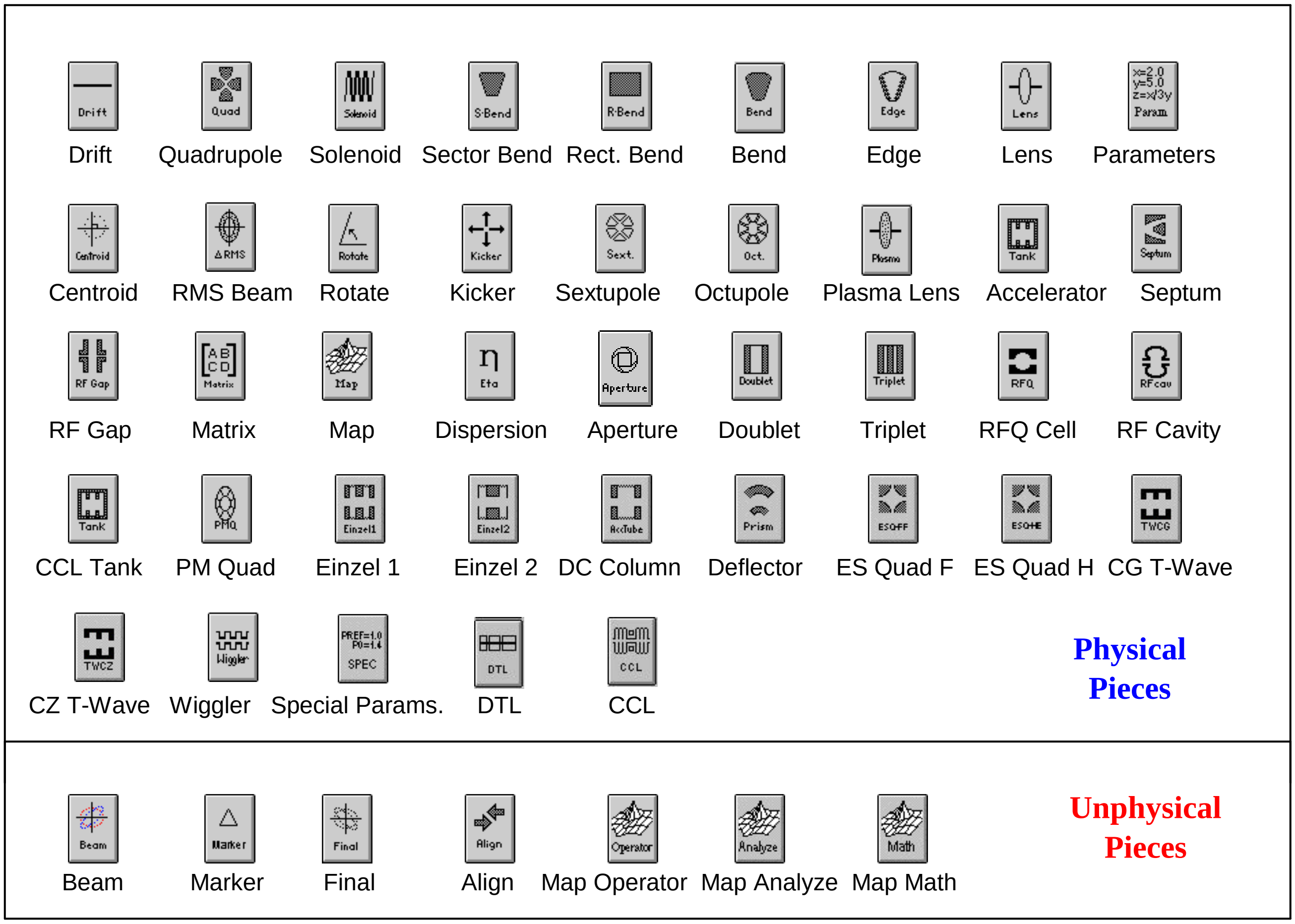
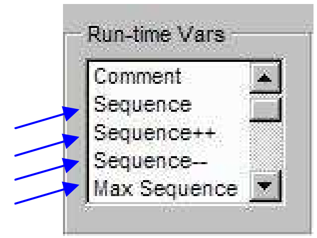


Figure 31. PBO Lab physical and pseudo-physical Pieces (top) and unphysical Pieces (bottom). The OASIS parser increments the 'Sequence' runtime variable for physical Pieces only. The 'Sequence' runtime variable is not incremented for unphysical Pieces.

Figure 32. Physical (top) and unphysical Pieces (bottom) OASIS Piece types that can define new PBO Lab Pieces using the OASIS Module Builder.

The Sequence++ runtime variable increments the sequence counter by adding one, each time a 'Sequence++' variable appears in the syntax of any Piece. Sequence++ can be useful when a single PBO-Lab Piece represents more than one basic optics element (requiring a unique sequence number) for a particular computation engine. Figure 33 illustrates an example how one could use the Sequence and Sequence++ runtime variables, in combination, to incorporate the Rotation (Roll) Angle in the Quad Piece for TRACE 3-D.



There are four Run-time Vars available for sequencing the PBO Lab and OASIS Physical Pieces in a PBO Lab Model.

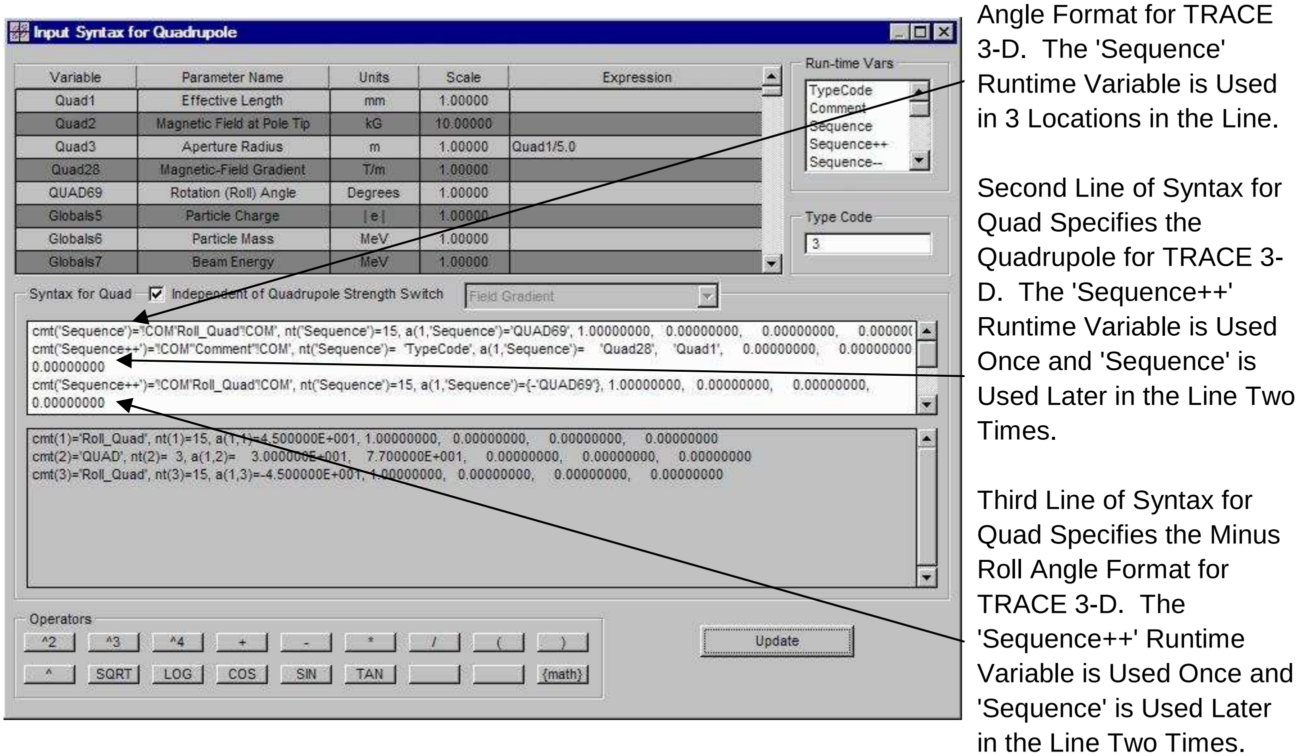
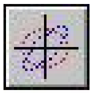


Figure 33. Input Syntax for Quadrupole window using Sequence and Sequence++ runtime variables for a TRACE 3-D OModule.

Run-time Vars such as Sequence++ *(or* Sequence--*) when used in a Piece Syntax string serve to increment (or decrement) the internal sequence count of physical Pieces.*

The example illustrated in Figure 33 effectively breaks the quadrupole data into three separate elements: an initial coordinate rotation, the quadrupole itself, and final coordinate rotation opposite in sign to the first.



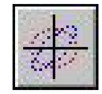
During execution of an OModule, the OASIS parser operating on the Run-time Vars such as Sequence, Sequence++, *will output the sequence value for each physical Piece in the beamline on the Model Space of the PBO Lab Document Window (Figure 2). However, within an OASIS Module Specification Document (Figure 5) the sequence index is initialized to unity (1) for each OASIS Piece. Consequently, within the context of a single OASIS Piece the first* 'Sequence' *variable of the Piece syntax will evaluate to* 1 *and each subsequent entry of* 'Sequence++' *will increment the sequence counter.*

The Sequence runtime variable is used in the first line which begins the element indexing for the quadrupole syntax illustrated in Figure 33. Note that 'Sequence' is used three times in the first line. The first line implements an axial TRACE 3-D coordinate rotation through the Rotation (Roll) Angle. The second line utilizes the 'Sequence++' runtime variable for the first instance where the element index needs to be incremented. However, the next two occurrences for this line utilize 'Sequence'. The index has already been incremented by the 'Sequence++' entry, so subsequent entries on that line that need the same index value are implemented with 'Sequence' alone. The second line provides the basic TRACE 3-D quadrupole parameters (Field Gradient, Effective Length). The third line of the syntax illustrated in Figure 33 follows a similar sequencing pattern to that utilized in the second line: the 'Sequence++' runtime variable is used initially, followed by two uses of 'Sequence'. The syntax evaluation field (activated via Update button) shown in Figure 33 illustrates results for a 45 degree quad roll.

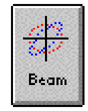
The TRACE 3-D example used here to illustrate the use of the Run-time Vars Sequence *&* Sequence++ *to implement the Rotation (Roll) Angle for quad would be appropriate for older versions of TRACE 3-D before 1996. An enhanced version of TRACE 3-D was introduced in 1996 that includes the roll angle as an input directly on the quad syntax line.*

The type of multiple element implementation illustrated in Figure 33 is referred to as a <u>compound element</u> for the particular computation engine (e.g. TRACE 3-D) under consideration. PBO Lab Pieces contain more data than any one computation engine generally uses - indeed the PBO Lab object model for each Piece represents a superset of all the data that may be associated with the underlying optical element (e.g. quadrupole). The OASIS sequencing runtime variables provide one method of utilizing the full power of the PBO Lab object model for computation engines that require the data to be separated into distinct, indexed, elements in their Main Input File.

The 'Sequence--' runtime variable decrements the counter, while 'Max Sequence' provides the highest (last) value for the counter in a PBO Lab Model.



Other Components



Beam Piece

The PBO Lab Beam Piece provides two different sets of 6-D phase space specification parameters, as well as several other parameters associated with centroid location, particle distribution type, etc. Selecting the necessary beam parameters and defining the appropriate beam syntax is somewhat different than for optics components such as the Drift Piece and Quadrupole Piece. The manner in which beams are specified for different computation engines (beam syntax) also tends to vary more in detail than the syntax for optics components, such as the drift and quadrupole. Figure 34 shows the Beam Piece window with the Beam Parameters switch set to the selection: Semi-Axes - Beam 1.

Each Beam Piece in PBO Lab stores two (2) separate beams: one in the Semi-Axis parameter representation and the other in the Courant-Synder (Twiss) parameter representation. These two sets of parameters are displayed according the setting of the parameter-group switch named Beam Parameters. Parameters from both of these representations may be used to define OModule syntax, but their independence should be understood.

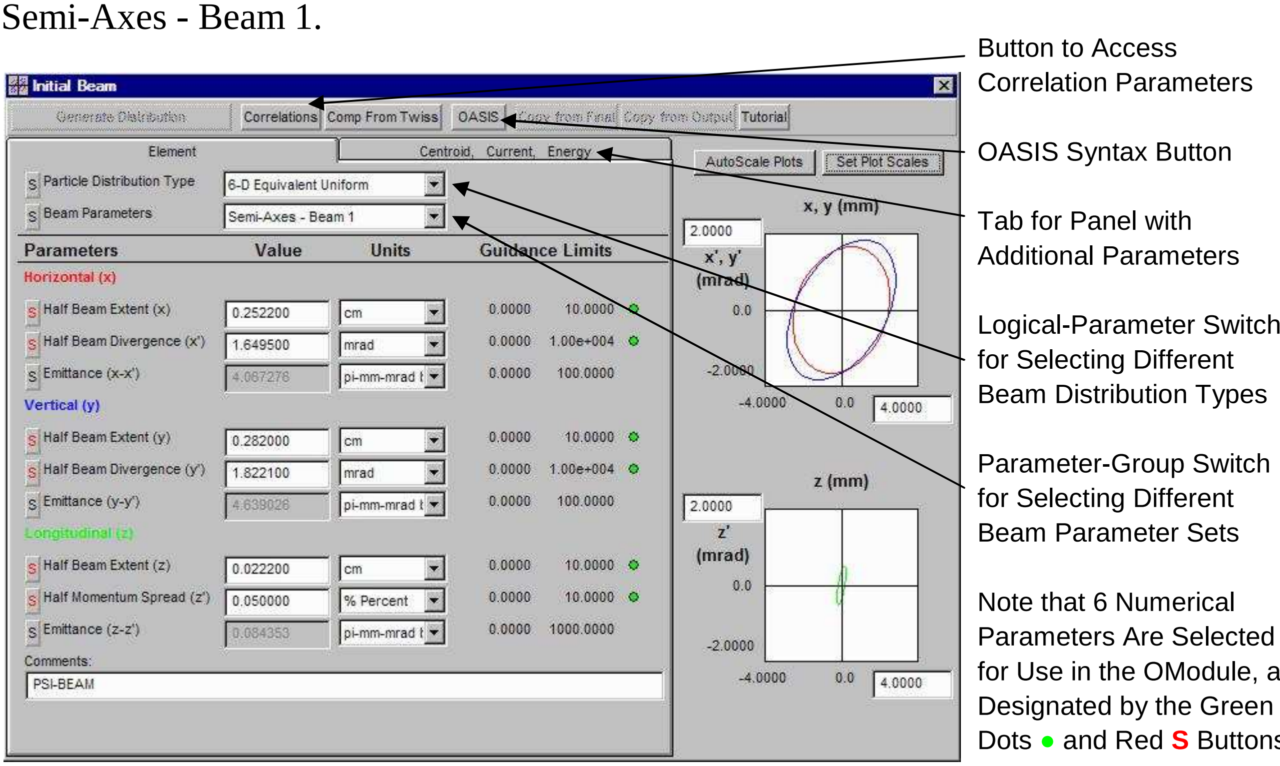


Figure 34. Beam Piece window with parameter-group switch Beam Parameters set to Semi-Axes.

Beam Parameters Parameter-Group Switch

The Beam Parameters switch in the Beam Piece window (Figure 34) is an example of a parameter-group switch. When a group-parameter switch is moved to a new position, the parameter display in the window is changed. The Beam Piece window where the parameter-group switch has been set to the second selection, Courant-Synder (Twiss) - Beam 2, is illustrated later in this Section (see Figure 39).

The selection of parameters in the Beam Piece window for use with an OModule, and the specification of the input file syntax of the OModule, follow the same basic procedures described for the Global Parameters, the Drift Piece, and the Quadrupole Piece. For each parameter to be utilized in the OModule, the Special Parameter Setting ("S") button is selected, which opens an SPS (Special Parameter Settings) window for that parameter. Each SPS window for most of the Beam Piece numerical parameters have the same characteristics as the SPS windows previously illustrated in Figures 10, 18 and 19. Similarly, the SPS windows for the logical-parameter switch "Particle Distribution Type" has the same features as shown for the Quadrupole logical-parameter switch illustrated in Figure 27. The selection and specification of the corresponding beam parameters are not shown here, but instead we illustrate the steps to select and specify two new types of parameters: (a) beam correlation parameters and (b) parameter-group switch Beam Parameters.

To illustrate the use of the Beam Piece correlations in an OModule, an example developed for the "old" style TRANSPORT positional notation will be used. Previous syntax examples for this type of Main Input File were shown in Figures 22(c), 28 and 29.

Beam Correlations

When the Beam Parameters switch in the Beam Piece Window (Figure 34) is set to the Semi-Axis - Beam 1 position, there is a button named “Correlations” that appears in the button bar at the top of the Beam Piece Window. This button is used to access the beam correlation parameters, sometimes referred to as the correlation cosines, or the reduced sigma matrix. Figure 35 illustrates an example of the Correlation Matrix window that is opened.

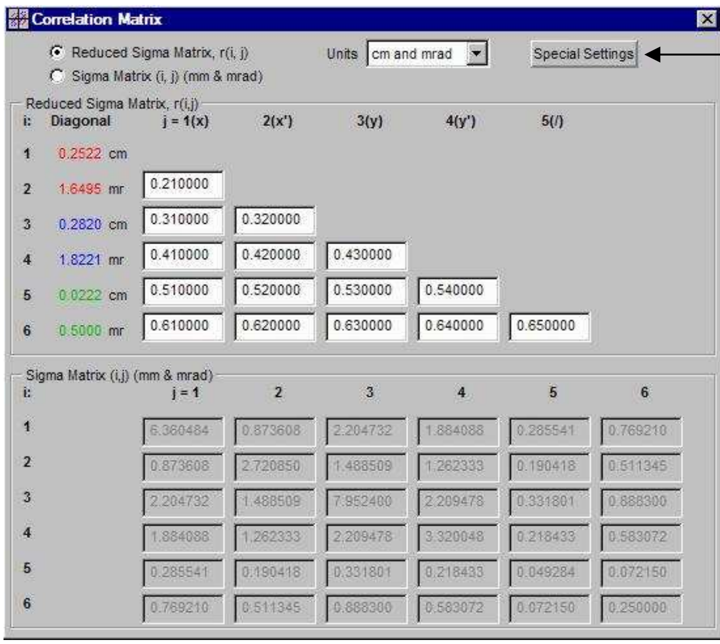


Figure 35. Correlation Matrix window opened from the Beam Piece window via the “Correlelations” button.

Button to Access the Special Parameter Settings (SPS) for Correlation Matrix Elements

The Correlation Matrix data for the Reduced Sigma Matrix r(i,j) shown in Figure 35 are values that identify the particular matrix element for each entry. For example, the r(3,2) element has a value of 0.32 entered. This can be useful in debugging the Beam Piece syntax for OModules that use correlation parameters as input.

The button labeled “Special Settings” in the upper right corner of the Correlation Matrix window is used to access the Special Parameter Settings (“S”) buttons for each of the correlation elements. Selecting the Special Settings button opens the Special Settings window shown in Figure 36. This Special Settings window displays the “S” buttons for the Reduced Sigma Matrix, r(i,j), with each button labeled by the corresponding i,j indices.

The lower part of the Correlation Matrix window displays the full Sigma Matrix for the beam. These matrix elements are computed from Semi-Axes and Reduced Sigma Matrix elements. The off-diagonal elements of the full Sigma Matrix may be edited directly by changing the radio button selection in the upper left of the Correlation Matrix window. However, the full Sigma Matrix elements can not be selected for Special Settings.

Special Parameter Settings ("S") Buttons for Each Element

The Red **S** Buttons Indicate that All 15 Independent Elements of the Reduced Sigma Matrix Have Been Selected for Use in the OModule.

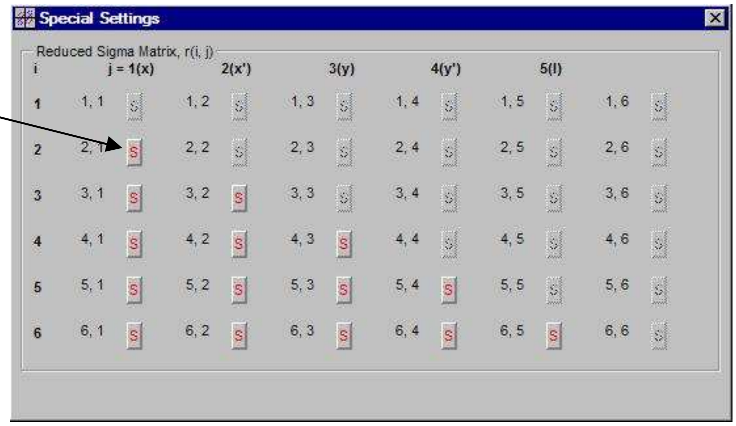


Figure 36. Special Settings window used to select individual correlation matrix elements for an OModule.

The Special Settings window displays the full correlation ("reduced sigma") matrix, although the symmetry requirement, r(i,j)=r(j,i), means that only half of the off-diagonal elements need be used. The diagonal elements correspond to the semi-axes parameters, selected for use in an OModule directly in the Beam Piece window (Figure 34).

Note that only the lower half-diagonal of the Reduced Sigma Matrix elements are accessible, reflecting the matrix symmetry. There are 15 independent elements of the correlation matrix. Selecting an "S" button in the Special Settings window (Figure 35) opens an SPS (Special Parameter Settings) window for that particular matrix element. An example for the r(2,1) element is illustrated in Figure 37.

Parameter Name

Symbolic Parameter Name Input Field

OModule Parameter Selection Check Box

Options for Parameter Attributes

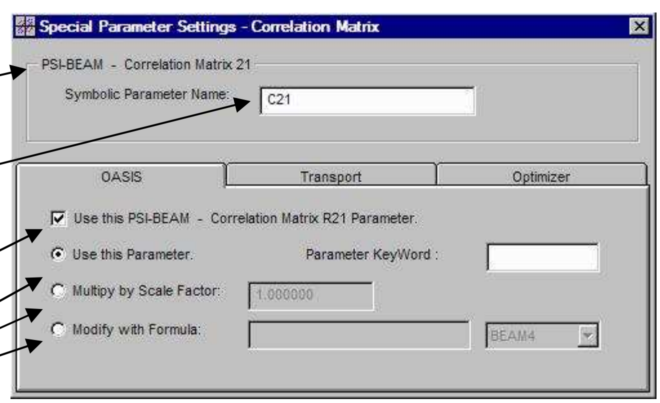


Figure 37. SPS window for the correlation matrix element r(2,1).

It is important to remember that all Symbolic Parameter Names throughout the entire OASIS Module Specification Document must be unique.

The default Symbolic Parameter Name for the example shown in Figure 37 has been replaced with "C21" for clarity. Symbolic Parameter Names may be changed by an OModule developer, but they must all be unique.

The SPS (Special Parameter Selection) window for each correlation matrix element is similar to that used for other numerical parameters, such as those illustrated in Figures 9 and 23. Some differences worth noting are (1) that the parameter name includes the comment (appearing in the Comment field of the Beam Piece Window) and the indices (i,j) of the element under consideration, and (2) that no units options are displayed for the reduced correlation matrix elements. The r(i,j) elements are unitless parameters by definition.

Once the parameters needed to specify a beam for a particular OModule have been selected, the syntax needs to be defined that will be used to write the beam parameters to the Main Input File for that OModule. Figure 38 illustrates the Input Syntax for Initial Beam window for a TRANSPORT computation engine that uses the OLD-TRANSPORT positional notation.

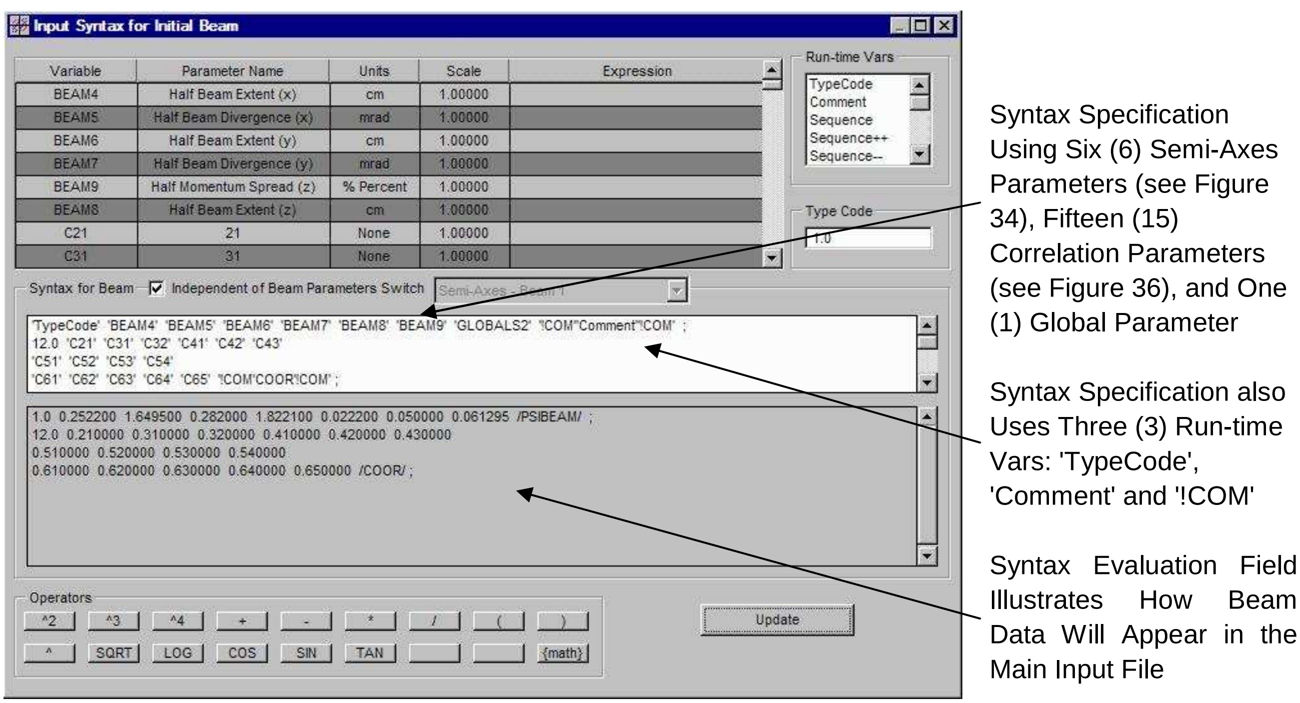
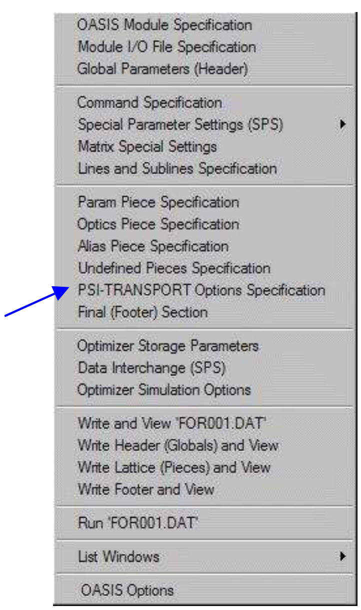


Figure 38. Input Syntax for Initial Beam window illustrating an example for the “old" style TRANSPORT positional notation.

Remember to always use the Update button after entering details into the Syntax for Beam specification pane.

The Syntax for Beam specification shown in Figure 38 consists of four lines. The first line specifies the syntax for the Semi-Axes parameters of the Beam, in the positional notation of TRANSPORT. That line also includes the Beam Energy Global Parameter ('GLOBALS2') specified in momentum units GeV/c (not in the visible portion of the Variables table shown in Figure 38). The next three lines provide the correlation parameter syntax. In the TRANSPORT positional notation, the type code for correlations is 12. The first of these three lines thus starts with 12, simply typed into the syntax field. The correlation parameters then appear in the order required by TRANSPORT. The syntax represents another type of compound element implementation, similar to the TRACE 3-D quadrupole example shown in Figure 33 (although no sequencing runtime variables are needed here).

The example syntax illustrated in Figure 38 was developed specifically to support the PSI-TRANSPORT computation engine. It utilizes three variables from the Run-time Vars list: 'TypeCode', 'Comment' and '!COM'. The 'Comment' and 'TypeCode' runtime variables were described in the discussion of the Drift Piece syntax within the context of the DIMAD computation engine. For positional notation style TRANSPORT computation engines the 'TypeCode' for a beam is 1. The 'Comment' variable will evaluate to the text that appears in the Comment field of the Beam Piece. The '!COM' is a runtime variable that evaluates to a specified comment character or *comment delimiter*. The comment delimiter in this example has been specified to be a forward slash (/) as utilized by the PSI versions of TRANSPORT and TURTLE. The forward slash would not be appropriate for MAD-type versions of TRANSPORT since that character (/) is interpreted by those computation engines as a division symbol. The comment delimiter is discussed further in Section 4.

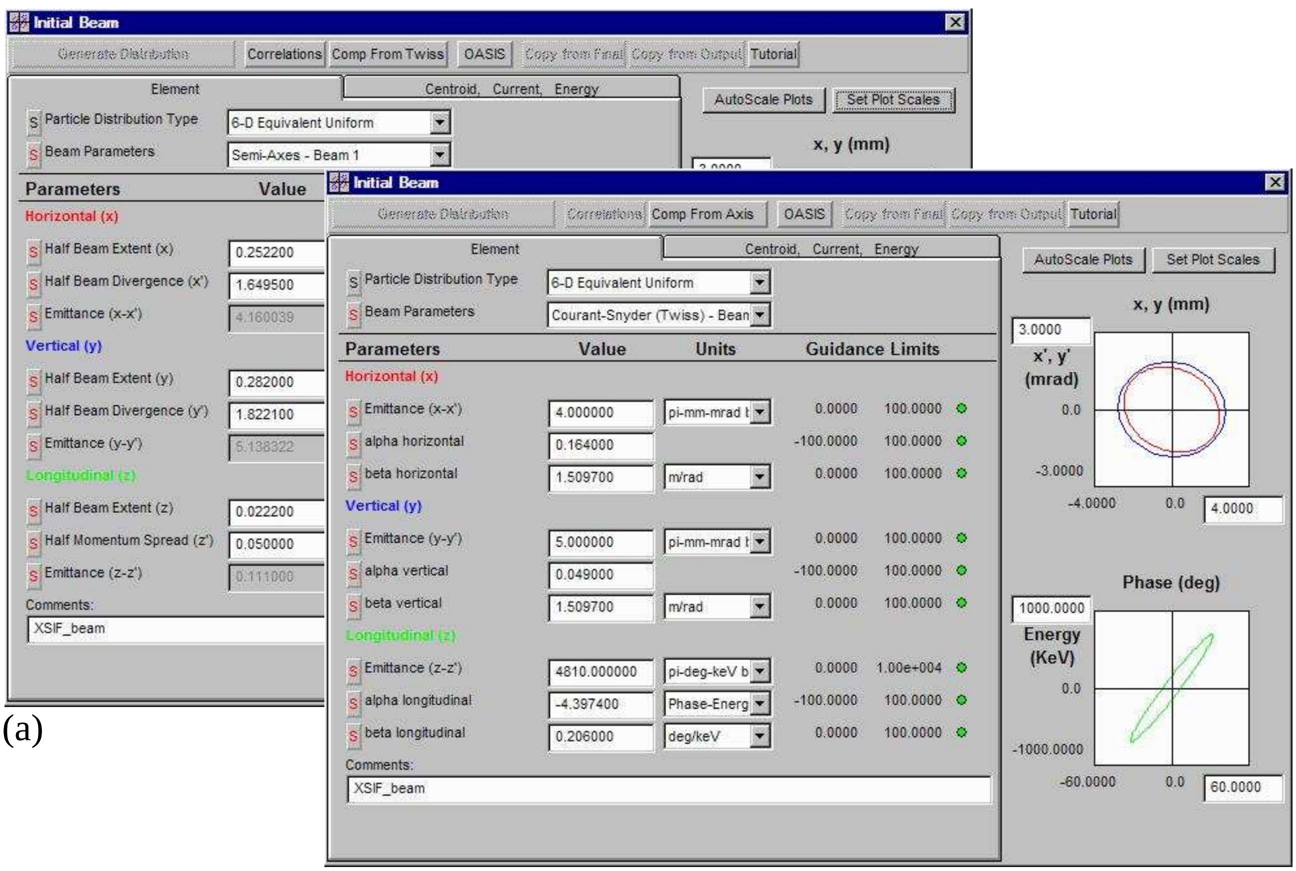


The !COM runtime variable is a comment delimiter that is defined in the OModule Options Specification and is discussed in Section 4.

Example for Parameter-Group Switch

Parameter-group switches may also be used to define the syntax for any Piece that has a parameter-group switch. Examples of parameter-group switches include the Quadrupole Strength switch (Figure 24) and the Beam Parameters switch (Figure 34). A parameter-group switch can be assigned the same functionality as that of a logical-parameter switch, but it also supports additional capability. A different syntax may be assigned to each switch setting. Figure 39 illustrates the different Beam Windows associated with the two settings for the Beam Parameters switch.

Beam Parameters Parameter-Group Switch



(a)

(b)

Figure 39. Beam Piece window with parameter-group switch set to (a) Semi-Axes - Beam 1 and (b) Courant-Snyder (Twiss) - Beam 2.

The PBO Lab Beam Piece has a number of useful features to assist users. For example, buttons will automatically compute the parameters for one beam representation, e.g. Semi-Axes, from the other, i.e. Courant-Snyder. The PBO Lab (Basic Package) User Manual describe these features.

To use the Beam Parameters parameter-group switch select the "S" button appearing to the left of the switch name Beam Parameters (see Figure 34). This will open a Special Parameter Setting (SPS) window for the switch. Figure 40 shows an SPS window set up of the Beam Parameters switch for use with the DIMAD-sample OModule.

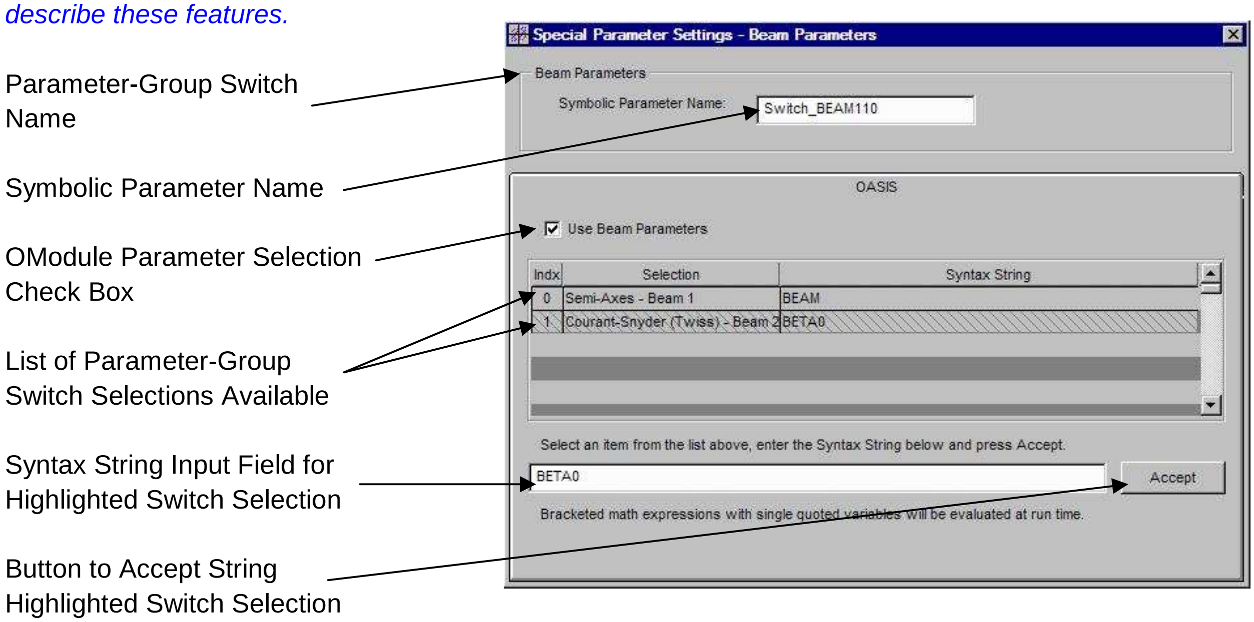


Figure 40. SPS window for assigning syntax strings for the Beam Parameters parameter-group switch.

The procedure for entering a Syntax String for each Selection of a parameter-group switch is essentially the same as that used for logical-parameter switches. See the Example for Logical-Parameter Switch for more information.

The Symbolic Parameter Name assigned to a parameter-group switch can be used to provide a switch-dependent text string for the syntax. One string has been assigned to each of the two switch positions in Figure 39. The string BEAM has been assigned to the Semi-Axes - Beam 1 switch selection, and BETA0 has been assigned to the Courant-Synder (Twiss) - Beam 2 switch position. These two strings will be used in writing to the Main Input File whenever the (single quoted) variable 'Switch_BEAM110' is to be evaluated in the beam syntax. The appropriate string will be evaluated for the variable 'Switch_BEAM110' according to the OModule user's current switch setting.

Once the parameter-group switch has been selected for use, it can then be used to specify a different syntax for each switch position. The syntax specification window is opened using the OASIS button on the Beam Piece window. Figure 41 shows a syntax specification window developed for the DIMAD-sample OModule for the Semi-Axes parameter-group switch setting.

*The syntax strings (*BEAM *and* BETA0*) assigned to the parameter-group switch in Figure 40 correspond to two key words used by the XSIF (eXtended Standard Input Format) description of beam parameters.*

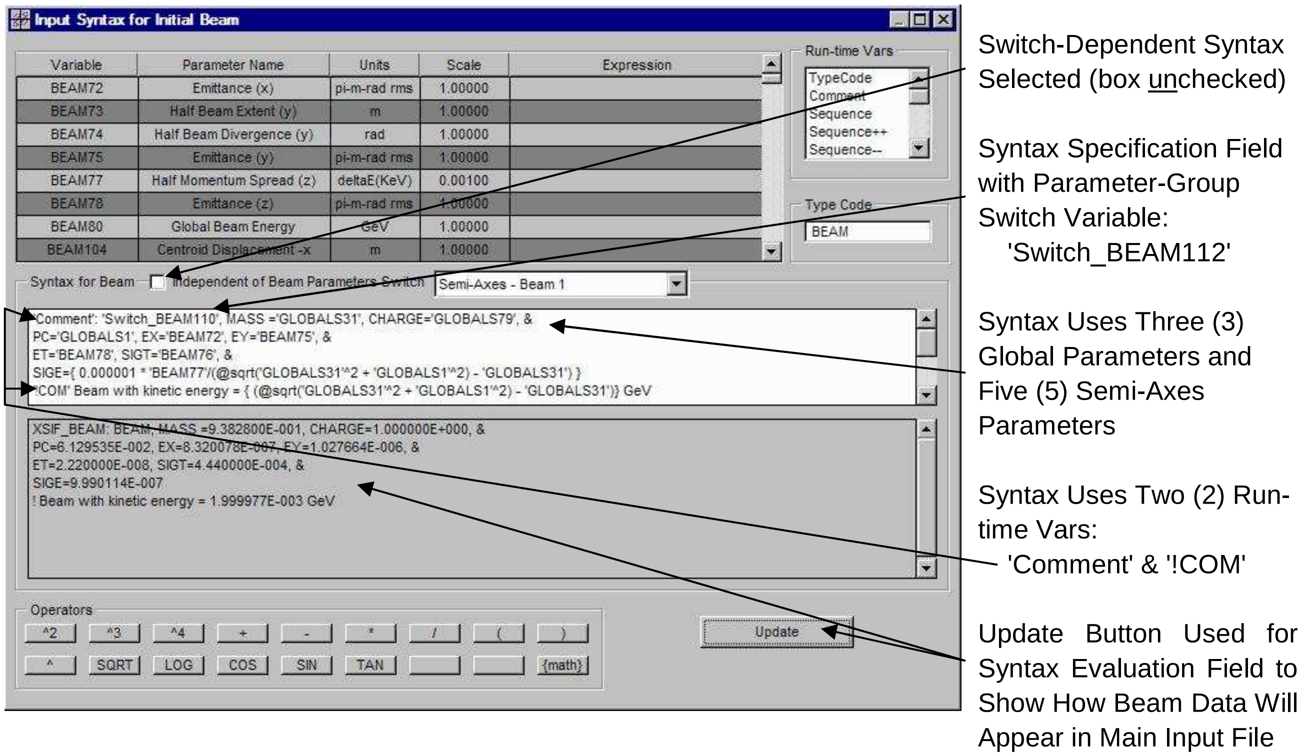


Figure 41. Input Syntax for Beam window for the Semi-Axes - Beam 1 representation of the DIMAD-sample OModule.

The Input Syntax illustrated in Figure 41 is dependent upon the parameter-group switch setting. To create a switch-dependent syntax, first *uncheck* (default is checked) the “Independent of Beam Parameters Switch” box that appears immediately to the right of the "Syntax for Beam" title of the syntax specification field. Next, *select the switch position* that corresponds to the syntax that will be entered.

The syntax illustrated for the DIMAD BEAM *specification utilizes the {math} capability of the OASIS syntax evaluator. Mathematical formulas may be utilized in syntax specification, which will be evaluated during runtime for the parameters and variables used in the formulas.*

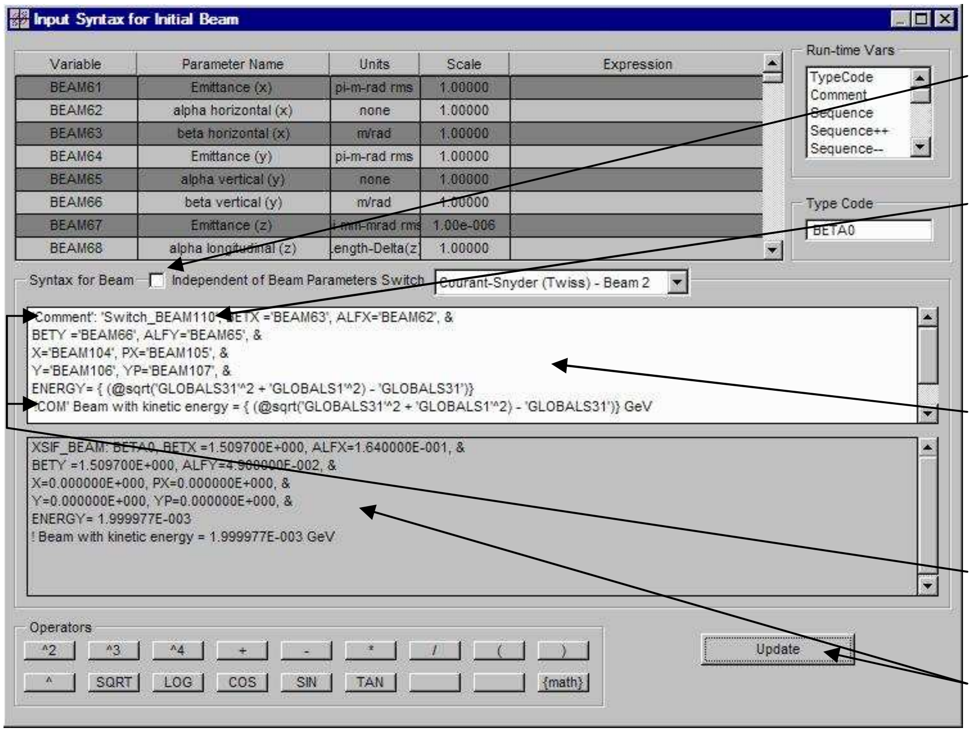
In the example illustrated in Figure 41, the first switch position has been selected (Semi-Axes - Beam 1). The detailed syntax is then entered for the DIMAD BEAM element, using the appropriate Variables and Run-time Vars. When the Update button is selected, the syntax is evaluated for the current values of the variables and switch position. The DIMAD keyword BEAM is written for the evaluated 'Switch_BEAM110' switch variable.

The OASIS Module Builder generally supports more than one way to meet specific formats for the Main Input File of a computation engine.

The {math} structure provides a method for introducing quantities derived from Global or Piece Parameters into the syntax for a Piece. The {math} construct is generally preferred over the use of the parameter expressions option (the Modify with Formula selection in an SPS window).

Note that BEAM has also been entered into the Type Code field of the Input Syntax window shown in Figure 41. The TypeCode runtime variable is not used in the syntax specification illustrated, so this field is not actually utilized in this example. It has been entered simply as a reminder that this switch position is for a XSIF BEAM keyword element. However, different Type Codes can be assigned to different parameter-group switch positions. The TypeCode runtime variable then could be utilized (rather than the 'Switch_BEAM110' switch variable) for setting the key word in a switch dependent manner. This illustrates an example of how the OASIS Module Builder typically offers more than one approach to addressing a particular requirement.

To set up the syntax for the second position of the Beam Parameters parameter-group switch, change the switch to the Courant-Synder (Twiss) - Beam 2 selection. The switch position can be changed on either the Beam Piece window (Figure 39) or on the Input Syntax for Beam window (Figure 41). Enter the syntax to be used for this switch setting. Figure 42 illustrates an example for the DIMAD-sample OModule.



Switch-Dependent Syntax Selected (box unchecked)

Syntax Specification Field with Parameter-Group Switch Variable: 'Switch_BEAM112'

Syntax Uses Three (3) Global Parameters, Four (4) Twiss Parameters and Four (4) Centroid Parameters

Syntax Uses Two (2) Run-time Vars: 'Comment' & '!COM'

Update Button Used for Syntax Evaluation Field to Show How Beam Data Will Appear in Main Input File

Figure 42. Input Syntax for Beam window for the Courant-Synder (Twiss) - Beam 2 representation of the DIMAD-sample OModule.

In the example illustrated in Figure 42, the second switch position, Courant-Synder (Twiss) - Beam 2, has been used to create a XSIF BETA0 type element for DIMAD. The syntax has been evaluated by the OASIS parser using the Update button. The DIMAD keyword BETA0 has been written for the evaluation of the 'Switch_BEAM110' variable.

The syntax illustrated for the DIMAD BETA0 *specification utilizes the {math} capabilities of the OASIS syntax evaluator to compute the beam kinetic energy. The* '!COM' *runtime variable is used to display the result as a comment line.*

When a DIMAD-sample OModule user switches between the two Beam Parameter representations on a Beam Piece, the Piece effectively switches between a XSIF BEAM type element and a XSIF BETA0 type element. It should be noted that the XSIF BEAM and XSIF BETA0 elements do not correspond to the DIMAD operation, or command, keyword BEAM. The DIMAD BEAM command is used for tracking and can be defined using an OASIS Command Piece.

The DIMAD-sample OModule examples illustrated here show how the Beam Parameters parameter-group switch can be used to implement either a XSIF BEAM type element or a XSIF BETA0 type element.

An OASIS Command Piece (Section 4 of this user manual) can be used to specify DIMAD BEAM operations.

Centroid, Current, Energy Tab Panel

The Beam Piece has a tab panel named Centroid, Current, Energy which provides additional parameters that may be useful in specifying a beam for some optics codes. Figure 43 illustrates the Beam Piece window with this tab panel selected. Any of the parameters shown on this window that have a Special Parameter Settings (“S”) button on their left may be used for OModules. The procedure for selecting these parameters is identical to that for similar OASIS numerical variables or logical-parameter switches.

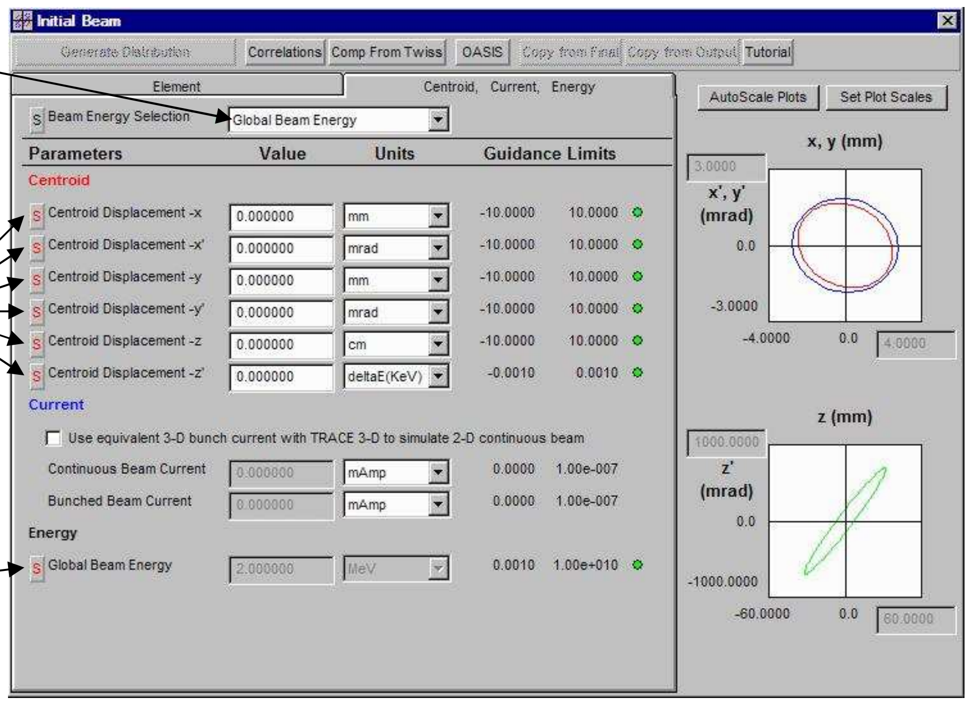


Figure 43. Centroid, Current, Energy tab panel of the Beam Piece window.

Parameters from the Centroid, Current, Energy tab panel, selected for use in an OModule, may be used to define the Beam Piece syntax. In Figure 43, the Global Beam Energy parameter and six (6) beam centroid parameters have been selected. Figure 42 shows the use of four of these (BEAM104 thru BEAM107) in the beam syntax for the XSIF BETA0 element.

Marker Piece

The Marker Piece provides a general method for adding comments and other location specific content to be written to the Main Input File. It may also be set up for inserting commands, plotting specifications, and similar input data that might not be supported directly by a particular OModule. The basic structure of the Marker Piece is different from that of most other elements. This is apparent when the Marker Piece is opened. An example of the Marker Piece window is illustrated in Figure 44.

The Marker Piece in PBO Lab is used in various ways dependent upon the underlying PBO Lab computation engine. An OASIS Marker Piece is created automatically with a red **O** *indicating that it has certain immediate OModule functionality without the need for any further specification.*

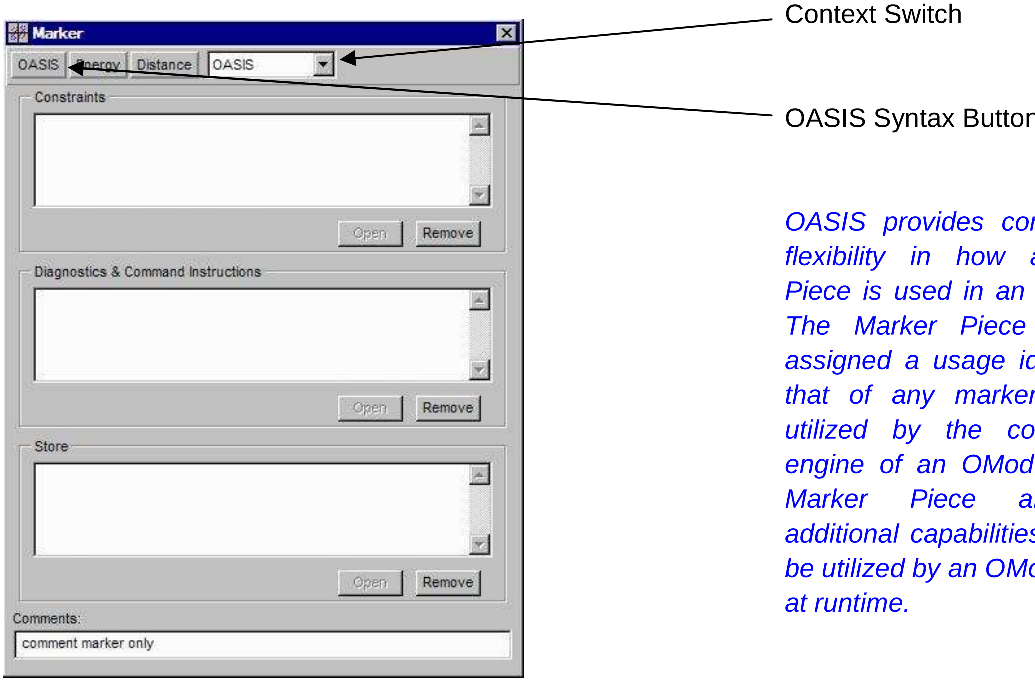


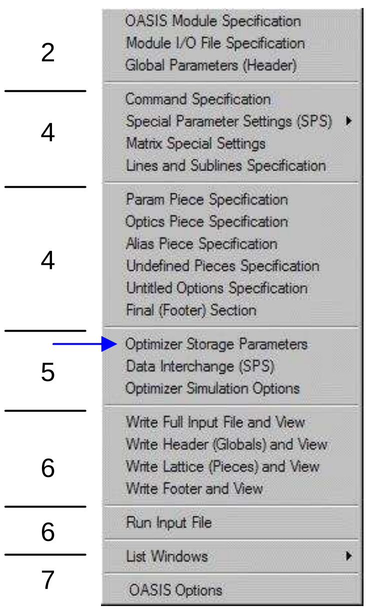
Figure 44. Marker Piece window.

OASIS provides considerable flexibility in how a Marker Piece is used in an OModule. The Marker Piece may be assigned a usage identical to that of any marker element utilized by the computation engine of an OModule. The Marker Piece also has additional capabilities that can be utilized by an OModule user at runtime.

The Marker Piece window has a Context Switch in the button bar at the top of the window. The Context Switch on the Marker Piece window is a duplicate control for the Context Switch that appears in the upper left of a PBO Lab Document window (Figure 2), or an OASIS Module Specification Document window (Figure 5), for the Document window in which the Marker Piece is located. Changing the switch in one location will change it in all locations.

The three fields of the Marker Piece may be utilized by an OModule, but have no functionality in the OASIS Module Builder mode.

Manual Section



Section 5 of this User Manual describes the specification of Optimizer Storage Parameters

The functionality of a Marker Piece depends upon the setting of the Context Switch. There are three fields in the Marker Piece window:

(1) Constraints
(2) Diagnostics and Command Instructions
(3) Store

These three fields are used to display summary information from other windows that are accessed with the Open button below each of these fields. The Open buttons become active for certain settings of the Context Switch, for example if TRANSPORT is selected. The Open buttons are *not* active for the OASIS switch setting, which corresponds to an OASIS Module Specification Document (see Figure 5). However, some of the Open buttons *become* active for an OModule switch setting when a user is utilizing the OModule in PBO Lab. The Open button for the (2) Diagnostics and Command Instructions field will *always* be active for any OModule. This is the automatic functionality created whenever a Marker Piece is added to an OASIS Module Specification Document. The Open buttons associated with (1) Constraints and (3) Store are only active for an OModule if Optimizer Storage Parameters have been specified. That is discussed in Section 5 of this User Manual.

The automatic functionality of the Marker Piece is illustrated in Figure 45. When a Marker Piece in a PBO Lab Model is opened, the Context Switch is initially set to the then current Context Switch setting of that PBO Lab Document. The Context Switch may be changed to any available OModule. For the example illustrated in Figure 45 the Context Switch is set to DIMAD-sample. The Open button for the Diagnostics & Command Instructions field is active and can be used to open the Marker Instruction window, also shown in Figure 45.

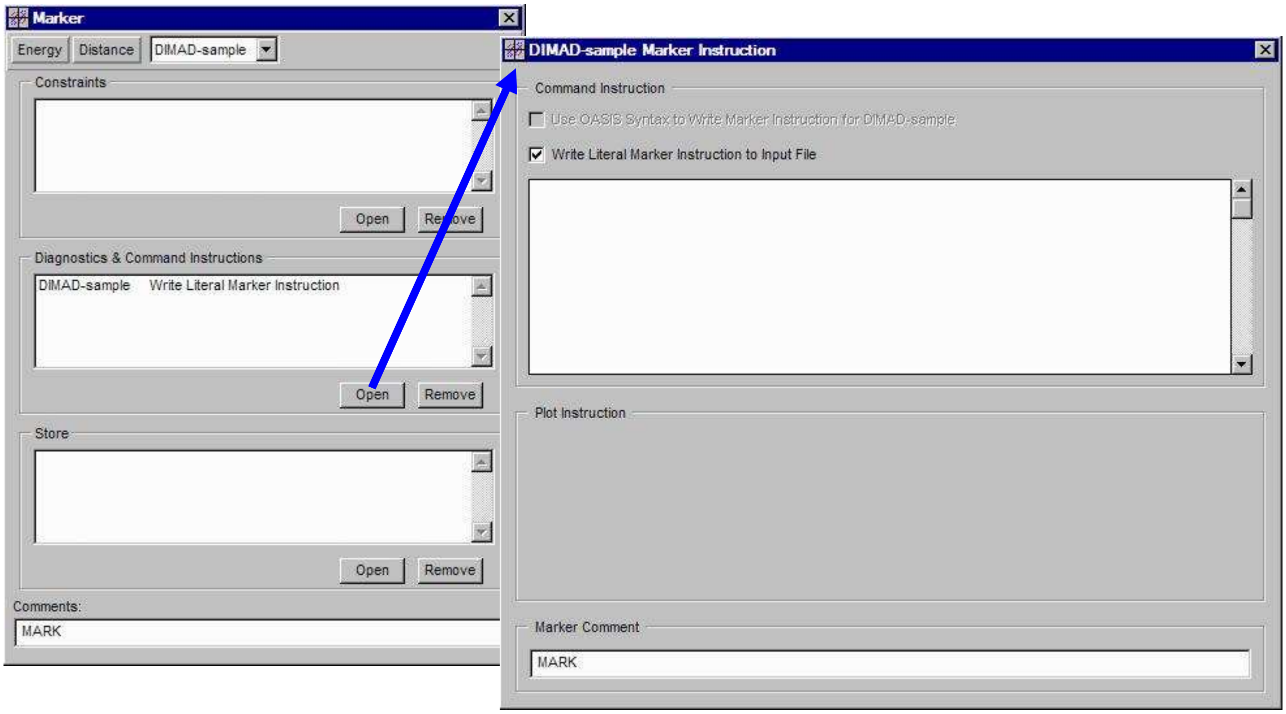


Figure 45. The automatic functionality of a default Marker Piece in an OModule provides the ability to enter alphanumeric text that will be written literally (no OASIS parsing) in the Lattice Section of the Main Input File at the location corresponding to the Marker Piece.

The default functionality of a Marker Piece for an OModule provides the ability to write a literal text instruction inline at the lattice location of the Marker Piece. The Diagnostics & Command Instructions Open button provides a Marker Instruction window where the user can enter a text block. The text block will be written, literally as it appears in the Marker Instruction window, to the Lattice Section of the Main Input File.

OModule users can add any text instruction to the Main Input File with the use of a Marker Piece. The OModule developer must provide this support by adding a Marker Piece to the OASIS Module Specification Document.

For the default functionality of the Marker Piece to be active, the OModule developer must add a Marker Piece to the Model Space of the OASIS Module Specification Document (e.g. similar to Figure 16). Otherwise the Marker Piece will be treated as an undefined Piece by the OModule. (An undefined Piece is ignored, or handled according to the OModule's Undefined Pieces Specification - see Section 4.)

The Marker Piece may also be used in the same manner that a marker element is utilized by the computation engine of an OModule. The setup of this usage begins with selecting the OASIS syntax button on the Marker Piece window.

The function of the Marker Piece can also be defined by an instruction syntax that the OModule developer assigns. The syntax is defined similar to that for other Pieces, and the Input Syntax for Marker window is accessed by using the OASIS syntax button located in the upper left corner of the Marker Piece window (Figure 43). An example of the Input Syntax window for a Marker Piece is shown in Figure 46.

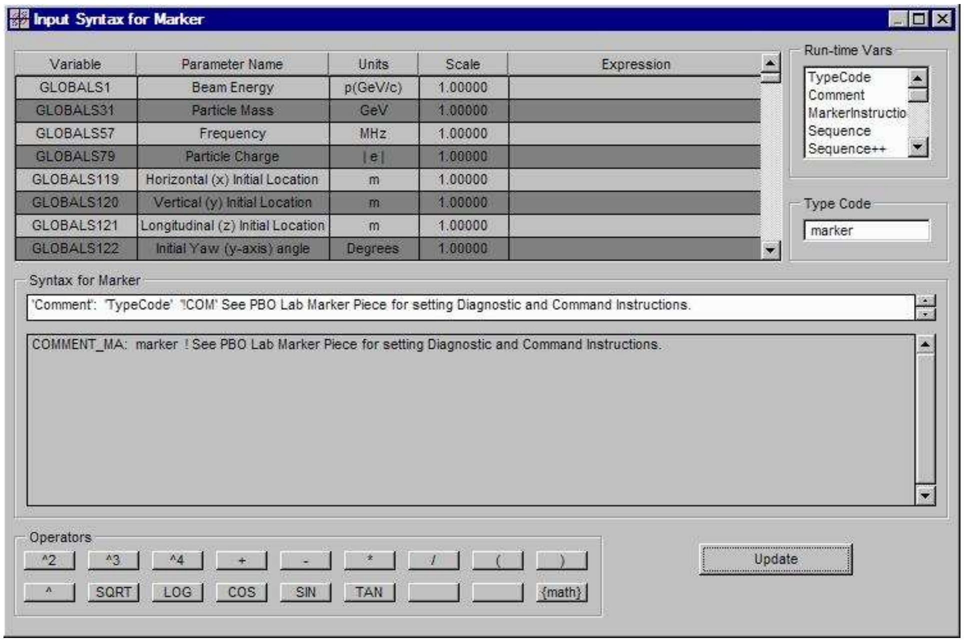


Figure 46. Input Syntax for Marker window.

The syntax for a marker element has essentially all of the features that are available for any other Piece. The main difference is that the Marker Piece has no inherent parameters. Consequently, only Global Parameters, Numerical Constants, String Constants or Run-time Vars that have been specified for use in the OModule are available for defining the marker syntax. In Figure 46, the Syntax for Marker has been setup to model a normal DIMAD marker element. In addition, a comment string will be displayed alerting the DIMAD-sample user that additional capabilities for the Marker Piece are available (as illustrated in Figure 45).

PBO Lab Parameter Piece

The PBO Lab Parameter Piece provides an element that can be used to input up to eight (8) parameters (per Piece) which may be assigned basically the same attributes as the parameters of any other optical component. The selection and syntax specification of parameters for use in an OModule follows the same steps as that involved for a drift (Figures 17-21), but the Parameter Piece offers up to 8 unitless parameters than can be selected for use. Figure 47 illustrates the Parameter Piece window.

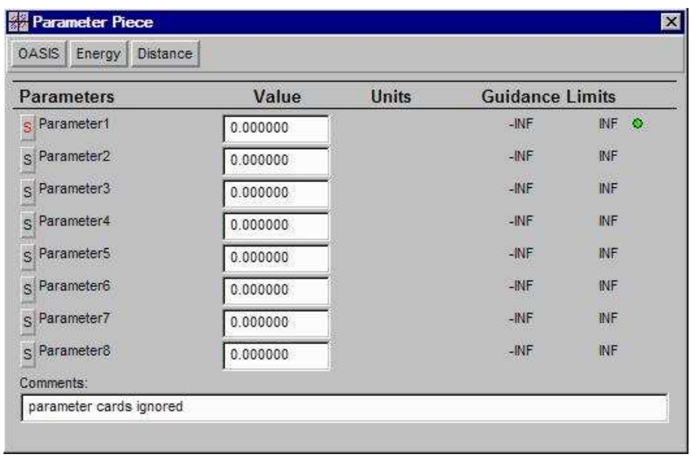
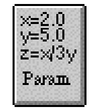


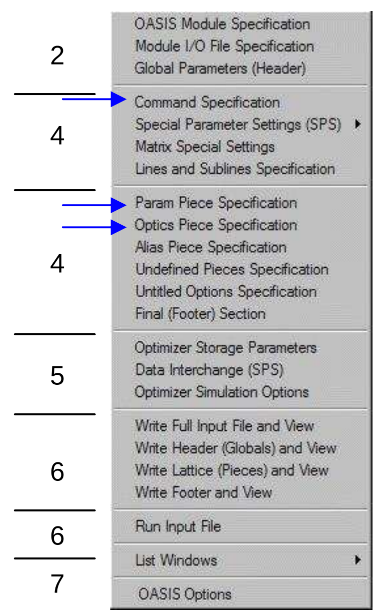
Figure 47. PBO Lab Parameter Piece window.

Several computation engines support the use of parameter elements directly, and the Parameter Piece can be used to provide that support. The PBO Lab Parameter Piece is patterned after the use of PARAM lines in MAD style input files. The PBO Parameter Piece does not utilize units for any of the parameters. For defining a custom Piece for an OModule, including parameters with units and other attributes, the OModule developer should utilize either the customizable OASIS Param Piece or the OASIS Optics Piece. Those are discussed in Section 4.



The PBO Lab Parameter Piece can be used to provide support for codes such as MAD that utilize parameter elements. In order to maintain compatibility with other PBO Lab and OASIS Modules, the Parameter Piece should not be "overloaded" to mimic custom elements, commands, or other functions provided by various OASIS features. The OASIS Comm Piece, Param Piece, and Optics Piece should be used for such functionality.

Manual Section



Section 4 of this User Manual describes the setup of:
Command Specifications
Param Piece Specifications
Optics Piece Specifications

The example illustrated in Figure 47 shows only one parameter selected for use. The corresponding Special Parameter Settings (SPS) window for this parameter is very similar to that illustrated in Figures 18 and 19 and is not illustrated here. The only notable difference is the absence of any units selection for the selected parameter (Parameter1). The specification of the syntax for selected parameters follows the same procedures as outlined for other Pieces. Figure 48 illustrates DIMAD-sample syntax specification for the Parameter Piece shown in Figure 47.

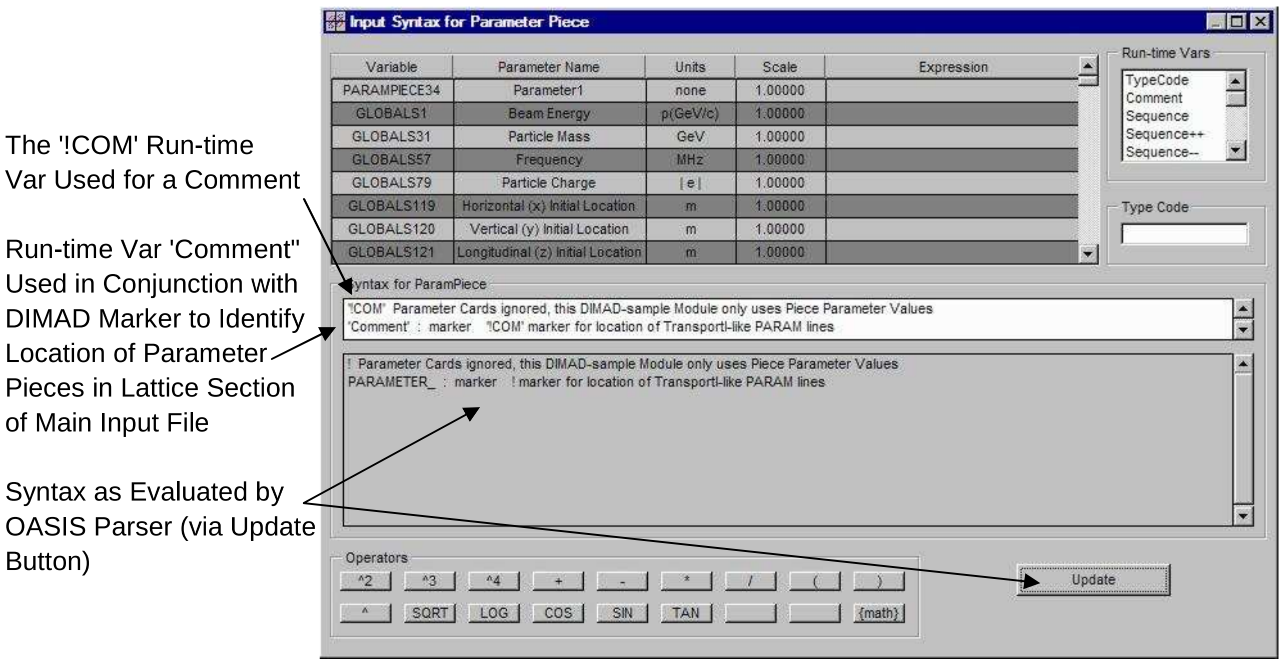


Figure 48. Input Syntax for Parameter Piece window.

Note that the DIMAD-sample syntax for the Parameter Piece shown in Figure 47 does not actually use the parameter selected for the OModule (PARAMPIECE34). Instead, the syntax simply specifies a comment line and XSIF Marker line that will appear in the Main Input File at the location of any PBO Lab Parameter Pieces in the model. This is a convenient method for temporarily supporting any PBO Lab Piece during the on-going process of developing an OModule.

Special (SPEC) Parameter Piece

The Special Parameter Piece supports TRANSPORT and TURTLE SPEC parameters.

The Special (SPEC) Parameter Piece in PBO Lab is modeled after the use of SPEC parameters in TRANSPORT and TURTLE. The SPEC Piece provides input for a number of specially defined parameters. One of the uses of a SPEC Piece is to update (or replace) certain Global Parameters at the location of the SPEC Piece in the beamline on the Model Space of the Document Window.

It is recommended that OModule developers consider incorporating the Special Parameter Piece in order to maintain compatibility of existing PBO Lab Models that may include a SPEC Piece in their beamline. However, there are some special considerations of which the developer should be aware. Some of these are discussed below.

The Special (SPEC) Parameter Piece is a multiple tab PBO Lab Piece. Figure 49 illustrates the SPEC Piece with the first tab (System) in front. Two parameters have been selected for use in the OModule, as indicated by the red S buttons to the left of the parameters (and the green dots to the right of the parameters).

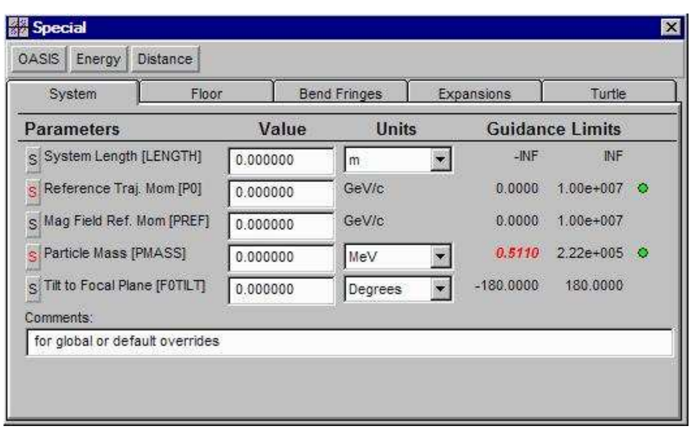


Figure 49. Special (SPEC) Piece window.

The selection of parameters, and the specification of the syntax, for the Special (SPEC) Parameter Piece is similar to that described for other PBO Lab Pieces. Figure 50 illustrates an example of the Input Syntax for Special window for the DIMAD-sample OModule. Only one of the selected parameters ('SPECIAL33') has actually been used in the syntax.

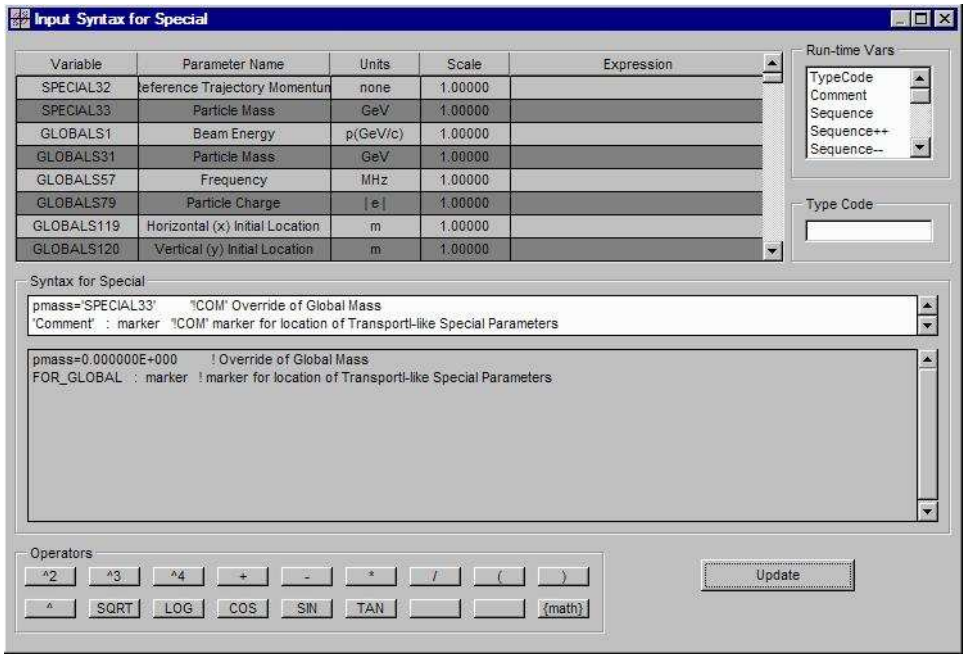


Figure 50. An Input Syntax for Special (SPEC) window.

An IfNot-EndIf logic structure can be used to either turn "on" or "off" SPEC Piece parameters depending upon whether they are zero or not.

There is a practical limitation on the use of the SPEC Piece that should be understood. The default values for all parameters on the SPEC Piece are zero (0.0). Consequently whenever a SPEC is utilized in a PBO Lab model any parameters utilized by an OModule will have a zero value. This may not be desirable, for example, if the OModule user wants to use only one SPEC Piece parameter, but the syntax for several have been defined. The OASIS parser for the OModule will effectively write all SPEC Piece parameters according to the specified syntax, using the default zero values, unless the OModule user specifically changes all parameters to their desired values. This can be tedious and error prone. To avoid this problem an IfNot-EndIf type of structure can be used to comment out lines for parameters which have a zero value.

The approach will be illustrated for a positional notation version of TRANSPORT. Figure 51 illustrates the Bend Fringes tab panel of the Special Piece with 4 parameters selected.

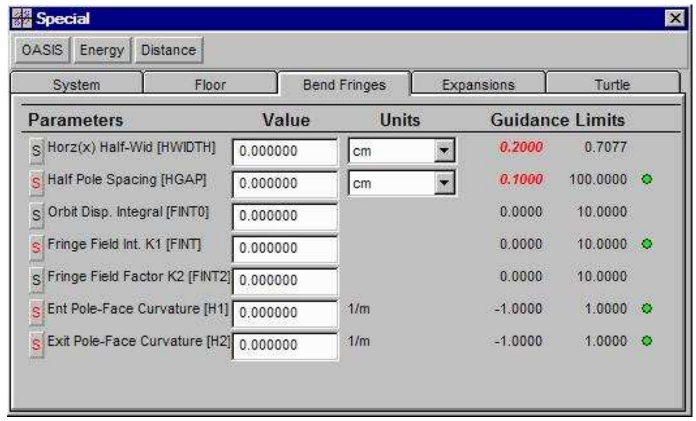
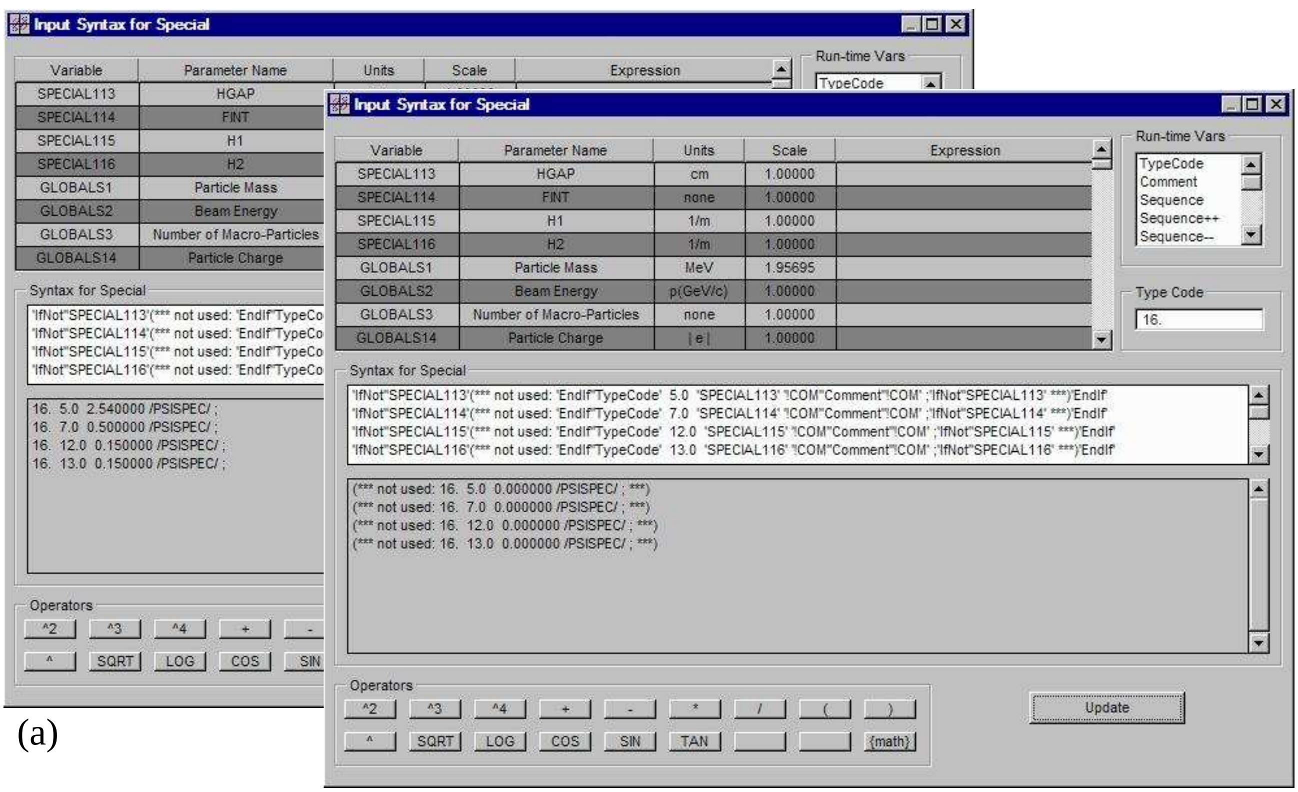


Figure 51. Bend Fringes tab panel of SPEC Piece with four parameters selected for PSI-TRANSPORT.

Figure 52 illustrates a syntax that avoids the "zero value" problem. The IfNot-EndIf syntax is used in 2 places in each line in order to provide a comment to the user for the case of zero value parameters. Compare to Figure 28 for an alternative syntax.



(a)

(b)

Figure 52. Input Syntax for Special window for four selected parameters. The evaluated syntax is shown for (a) the case where the parameter values are non-zero and (b) the case where the values are zero. The same syntax accomplishes both.

Summary of Pieces Supported by OASIS

In addition to the standard PBO Lab Pieces, OASIS can be used to create custom Pieces for any Module. The OASIS Param Piece and the OASIS Optics Piece are examples, and are described in Section 4 of this manual.

All physical optical components available on the PBO Lab palette can be used for defining OModules with the OASIS Module Builder. In addition, most of the other (non-optical) components are also available to use in constructing OModules. Figure 53 summarizes the status of all PBO Lab Pieces regarding their use in creating an OModule with OASIS. Only certain Pieces unique to a particular Module (e.g. MARYLIE) cannot be used by the OASIS Module Builder.

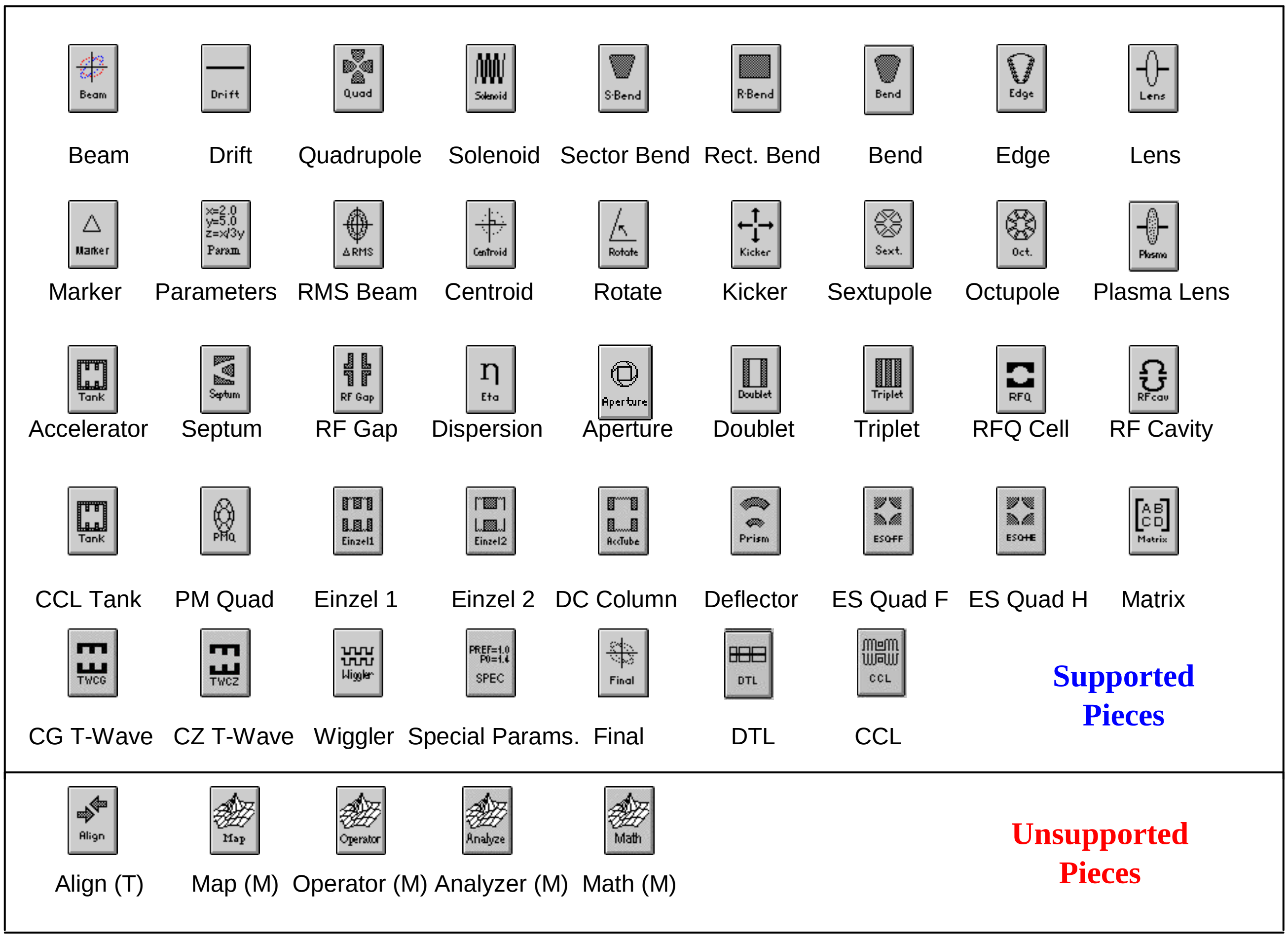


Figure 53. PBO Lab Pieces supported (top) or unsupported (bottom) by the OASIS Module Builder. Unsupported Pieces are specific to the TRANSPORT (T) or MARYLIE (M) codes.

OASIS™

4. Other Input Parameters & Syntax

OASIS User Manual:
Building Application Modules
for PBO Lab™

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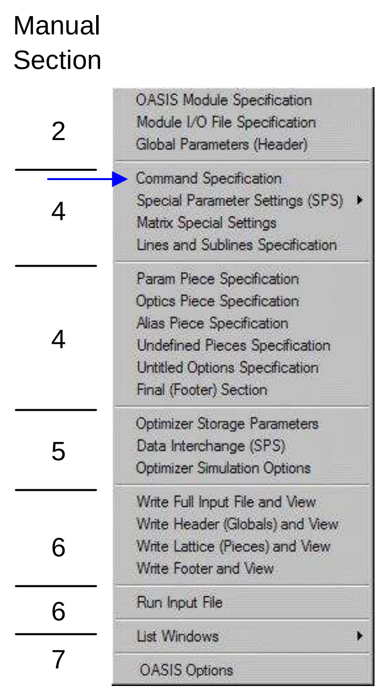
4. Other Input Parameters & Syntax

OASIS provides a number of capabilities for supporting a spectrum of computation engines. This Section of the User Manual describes additional features of the OASIS Module Builder. Not all of the features described here will utilized for every computation engine, but nearly every computation engine will need some of these features.

Command Piece Specification

The OASIS Command Piece is used for specifying a custom command or operation.

Each OModule created with OASIS will automatically have a number of predefined “commands” that will appear on the Commands menu for that OASIS Module. Section 8 (Testing an OModule within OASIS) of this user manual describes the predefined commands and illustrates their usages. In addition, each optics code will often have its own unique “commands” or “operators” that encapsulate the computation capability for the code. These code-specific commands are implemented using a set of OASIS Command Pieces. This section provides an introduction to the use of the Command Piece.



To initiate the creation of an OASIS Command Piece, select the menu item “Command Specification” on the OASIS Commands menu. This will open an OASIS Command Piece Specification window. This window is illustrated in Figure 54. The OASIS Command Piece Specification window is used to begin the setup of an optics command or operation and requires one entry: a name for the command. The name assigned will later appear (for the OModule user) in a list of commands available to the underlying computation engine. A descriptive string is recommended for clarity, rather than a single key word or acronym. Of course the string may contain relevant key words.

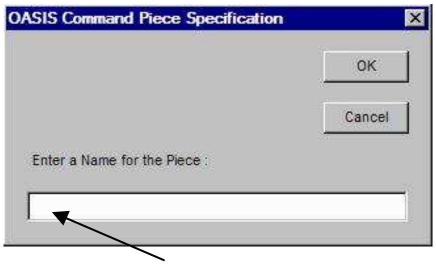


Figure 54. OASIS Command Piece Specification name window.

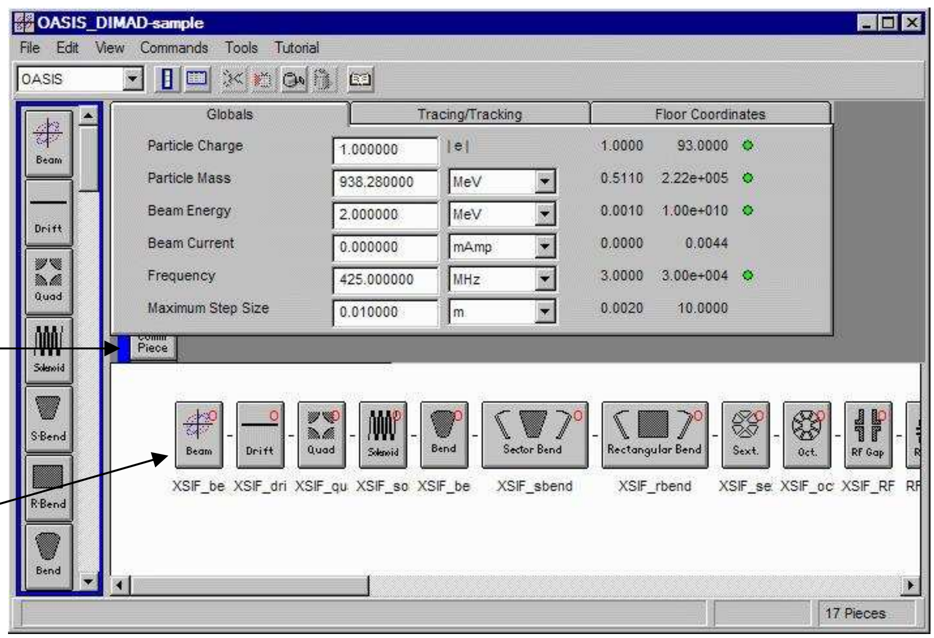
Enter Descriptive Name for the OModule Command

A descriptive name for each Comm Piece should prove helpful to OModule users.

Entering a name for the Command (or "Comm") Piece and selecting the OK button will create an "OASIS Comm" Piece on the Work Space of the OASIS Module Specification Document window. The newly created OASIS Comm Piece will appear near the left edge of the Work Space and may be located partially under the Global Parameters pane. The OASIS Module Specification Document window with the new OASIS Comm Piece should look similar to that shown in Figure 55.

Newly Created OASIS Comm Piece Located on Work Space

Typical Set of Pieces Previously Selected for Use, as Designated by Red O's, Located on Model Space



In addition to the standard PBO Lab Pieces and Comm Pieces, OASIS can be used to create other custom Pieces. The OASIS Param Piece and the OASIS Optics Piece are examples, and are described later in this Section of the User Manual.

Figure 55. Example of an OASIS Module Specification Document with a newly created OASIS Comm Piece on the Work Space.

Once an OASIS Comm Piece is created it will need to be moved from the Work Space to the Model Space. *Only Pieces located on the Model Space are used during runtime of an OASIS Module.*

To *move* an OASIS Comm Piece, that initially appears on the Work Space, to the Model Space of the OASIS Document Window hold down the Shift key and drag ("Shift-drag") the Piece to the Model Space. The Comm Piece may be located anywhere within the beamline appearing on the Model Space. The location of commands within the Main Input File will be determined by attributes to be assigned to the Comm Piece. Double click the OASIS Comm Piece to open the command Specification window. The *name* for the command (Figure 54) will appear as the *title* of the command Specification window. An example is illustrated in Figure 56.

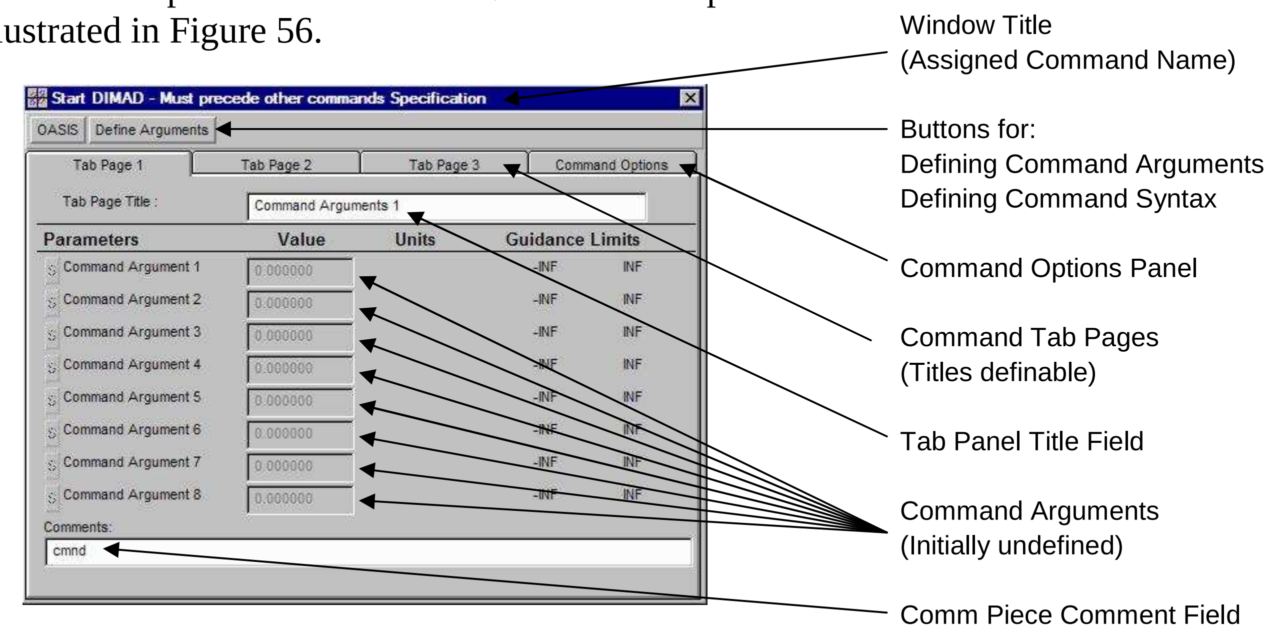


Figure 56. Command Specification window used for defining the details for the named command. The name of the command appears in the window title.

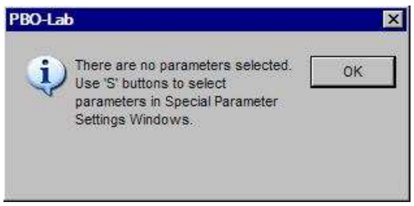
The Command Name will appear in the title of the Specification window of the OASIS Module Builder. The Command Name will also appear in PBO Lab in a list of all commands available for the OModule user.

The command name illustrated in Figure 56 is:

Start DIMAD - Must precede other commands

This name is descriptive of how the command is to be used. Other Comm Pieces should follow this Comm Piece in the PBO Lab Model being studied, when utilizing the DIMAD-sample OModule.

The Command Specification window has a number of features which are summarized here. Examples of the use of each feature are also described below. As with other parts of the OASIS Module Builder, not all features may be needed by a given OModule, but certain default settings should be recognized.



A warning dialog will appear if the OASIS button is used before Command Arguments are specified.

There are two buttons near the top of the Command Specification window. The OASIS button is used to define the syntax for the Comm Piece. This button works similar to the OASIS buttons on other windows and is used after the Command Arguments have been specified. The Define Arguments button is used to open a window for assigning Command Argument names and other attributes. The "S" button for a Command Argument is not active until that Command Argument has been assigned a name.

Commands may be written to specified locations in the Main Input File. The Main Input File has four principal sections:

Header
Lattice
Lines
Footer

The location of command lines in the Main Input File is specified using a popup menu on the Command Options tab. Note that the ***default*** *is the first choice:*

In Line at Location in Lattice

The Command Options provide a popup menu that is used to specify *where* in the Main Input File the command is to be written. The *default* setting for this popup is "In Line at Location in Lattice" so that it acts like any other Piece appearing in the beamline on the Model Space of a PBO Lab Document window. If the command is to appear at another location, as would be the case for the DIMAD-sample OModule, then this default setting needs to be changed. For the DIMAD-sample OModule the required setting would be:

After Lines - Before Footer

Different Comm Pieces may have different settings for the location choice. For all commands for which the default setting (In Line at Location in Lattice) is *not* appropriate, the popup switch on the Command Options tab page will need to be changed.

Tab pages are available to group related Command Arguments. The tab pages will appear in the finished OModule only if a Tab Page Name is assigned.

An OASIS Comm Piece must have at least one Command Argument defined. The Define Arguments button (Figure 56) is used to open a Define Arguments window. The Define Arguments window is illustrated in Figure 57.

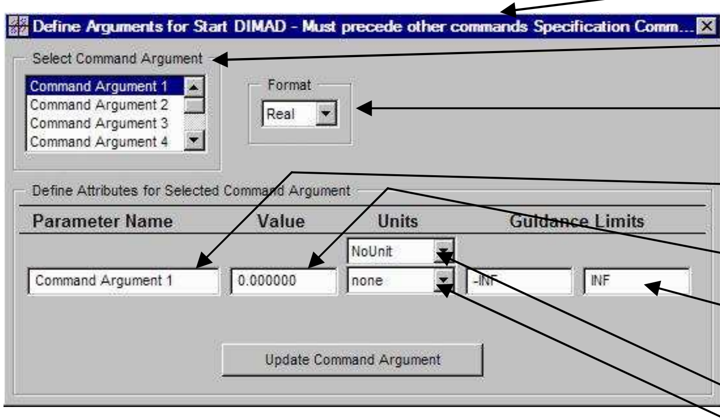


Figure 57. Define Arguments window with first item chosen in the Select Command Argument list.

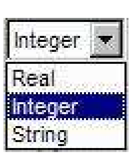
The various fields appearing in the Define Arguments window become active when one of the entries in the Select Command Argument list is selected. These fields are used to assign attributes to a command argument. Each command argument has its own set of attributes. The items appearing in the Select Command Argument list refer to the command arguments that will appear on the *tab page that is located in front* on the Command Specification window (Figure 56).

There are eight (8) command arguments on tab page 1, and ten (10) command arguments on the other tab pages. Each command argument has a unique name internal to OASIS. The items in the Select Command Argument display the internal OASIS names. Tab page 1 includes Command Argument 1 through Command Argument 8, tab page 2 includes Command Argument 9 through Command Argument 18, etc. The internal OASIS names (Command Argument 1, etc.) will not be visible to the OModule user (unless the OModule developer has used identical names).

If no Tab Page Names have been assigned then the Comm Piece will not have any tab panels for an OModule. All command arguments will also appear together (in order) in the Comm Piece window, regardless of the tab page to which they were originally assigned by the OModule developer.

A simple command needs only four (4) parts for its definition. First, the Comm Piece must have a name. The second part is comprised of parameters, or Command Arguments, needed by the command. The third part is the specific format, or Syntax, of the command line(s) that will be written to the Main Input File. The last part specifies where in the Main Input File the command is to be written.

A command name is required in order to create a Comm Piece, so the first part is completed automatically. The Define Arguments button in the command definition window is used for the second part. The OASIS button is then used for the third part. The Syntax will generally involve Command Arguments, so these two parts are usually completed in the order described. The third part uses the Command Options tab of the command definition window. (Simple commands often do not use the Tab Panel Title Field.)



Format Selection Choices for Command Arguments

The Comment field can be used to assign a default comment for each Comm Piece. The default comment will appear to an OModule user any time a Comm Piece is utilized. Although default comment may be a long string (up to 256 characters) only a few characters will appear below the Comm Piece on the Model Space of a PBO Lab Document. A key word, or other brief one word description of the command, will generally prove helpful to an OModule user. A few examples of the use of OASIS Command Pieces will be illustrated.

A Simple Comm Piece Specification

The first example for the Comm Piece named "Start DIMAD - Must precede other commands" is illustrated in Figures 56 and 57. Use the Define Arguments button (Figure 56) to open the Define Arguments window (Figure 57). Select the first item (Command Argument 1) in the Select Command Argument list appearing in the upper left of the Define Arguments window. The input fields become active for Command Argument 1 and data may be entered.

After an item in the Select Command Argument list is chosen, then choose the Format for the argument. The default is Real, but either Integer or String may be selected. Next enter a name for the argument. The name needs to be short and should be descriptive of the parameter. Finally enter a default value, guidance limits, and (if appropriate) select a units type and default unit for the argument. Figure 58 illustrates an example of a completed command argument definition. When the input for the argument definition is complete, the Update Command Argument button is used to store the definition. The assigned name to the command argument (i.e. All Beamline (0=No,1=Yes)) will then appear in the Comm Piece window, instead of the OASIS internal name (e.g. Command Argument 1), together with the default value, guidance limits and units (if applicable) assigned.

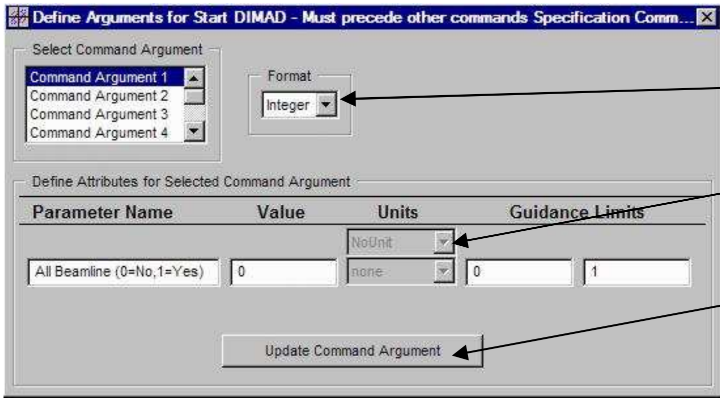
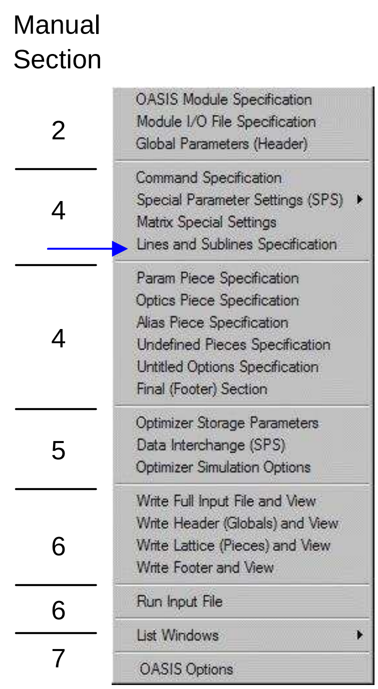


Figure 58. Define Arguments window completed for the first command argument.

Guidance Limits are simply for guidance. The Guidance Limits do not restrict the user's ability to input values for an argument that lie outside the Guidance Limits.

The first command argument defined in Figure 58 will be utilized to tell the DIMAD code which *LINE statement* of the Lattice section in the Main Input File is to be used. It is set up with an Integer format, with no units assigned, and Guidance Limits of 0 and 1. This represents a Boolean argument, and the argument name reflects this. Either all of the beamline is to be used, or not. The Lines and Sublines Specification of the OASIS Module Builder can be used to provide a DIMAD *LINE designator* that automatically identifies the entire beamline on the PBO Lab Model Space. This is discussed later in this User Manual.



The Lines and Sublines Specification is described later in this Section 4.

The default value for command argument "All Beamline (0=No,1=Yes)" shown in Figure 58 is set to no ("0"). Additional input is required in order to specify which *LINE* is to be used. The second command argument will be used to provide the OModule user with a string field where a *LINE* designation is to be entered. Figure 59 shows a specification for Command Argument 2 that achieves this objective.

The example shown in Figure 59 uses the String choice for the command argument format. The value field is elongated, and no units or guidance limit fields appear. The value contains the default string: LINE_0001.

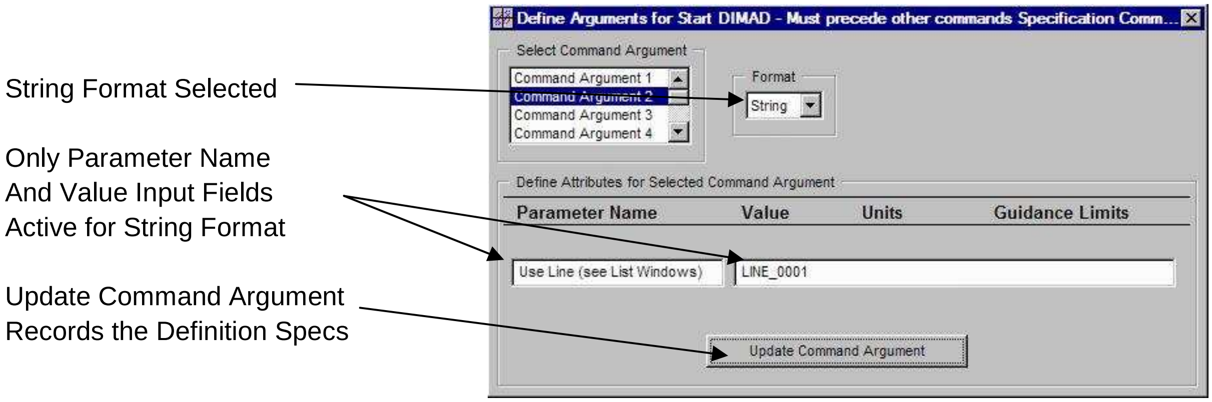


Figure 59. Define Arguments window completed for the second command argument.

Figure 60 shows the appearance of the Command Specification window, for the command named "Start DIMAD - Must precede other commands," after the two command arguments illustrated in Figures 58 and 59 have been completed. Note that the first tab page has also been assigned a name (Use Line Specs) and a default comment (dimat) has been entered.

The data appearing in a completed Comm Specification window will also appear in the corresponding Comm Piece in a PBO Lab Model. The Value fields for command arguments will be editable by the OModule user, and the entries displayed in the Specification window will be the default settings for the OModule.

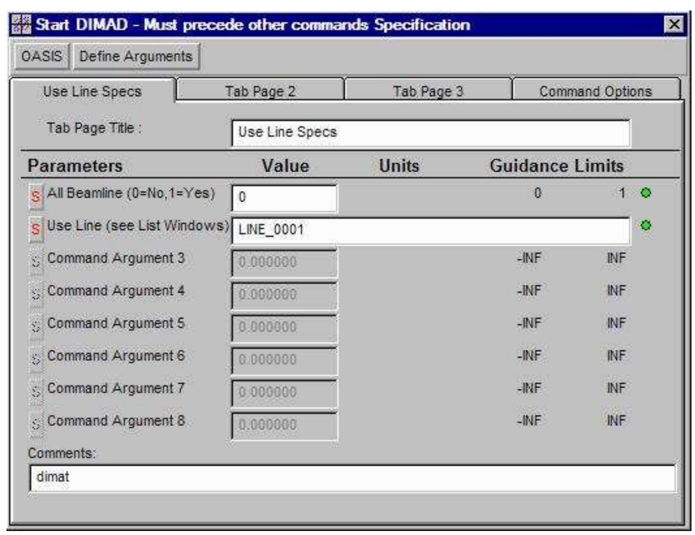


Figure 60. Command Specification window with two command arguments defined. Compare to Figure 56.

Once the Command Arguments have been defined, the syntax for the command needs to be specified. The OASIS button located on the button bar of the Command Definition window is used to open the Input Syntax for Command specification window. Figure 61 illustrates the window used to set up the syntax for the command name:

Start DIMAD - Must precede other commands

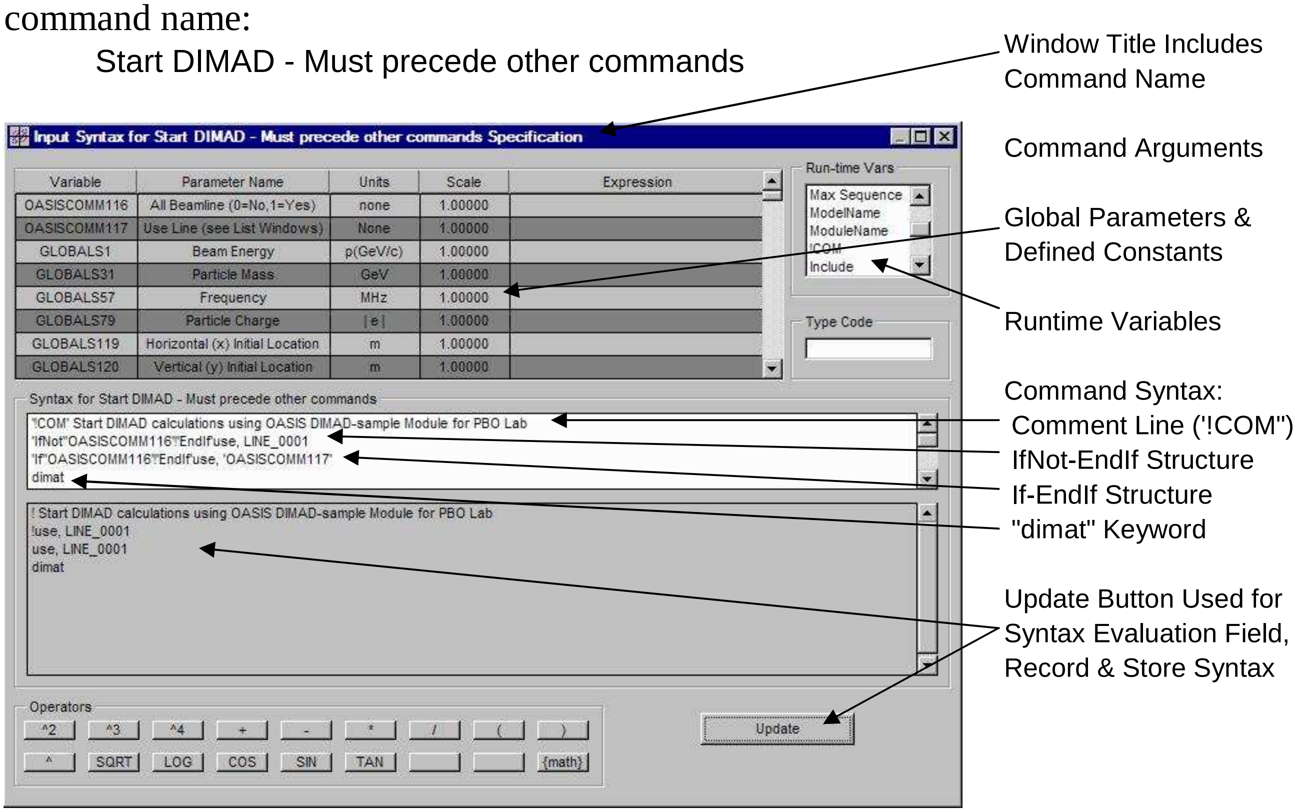


Figure 61. Input Syntax for (Command Name) Specification window.

The syntax illustrated in Figure 61 is for the DIMAD-sample OModule. The syntax provides one information line, which will appear in the DiMadInput and DiMadOutput files. This is followed by If-EndIf type structures used to either write or omit a DIMAD comment character (!) in front of 1 of the 2 lines that specify which LINE *statement to use for computations. The* dimat *line is a keyword that tells DIMAD to look for more commands and then start the optics calculations.*

OASIS Input Syntax specification windows have a large suite of capabilities which makes it possible for the OASIS Module Builder to support a wide spectrum of particle optics codes. These capabilities have been discussed in detail in Sections 2 and 3 of this User Manual. The Input Syntax for Command window provides the same set of capabilities, and utilizes the same basic procedures for the syntax specification, as previously described for the Global Parameters and the Drift, Quad and Beam Pieces.

OASIS divides the Main Input File into several primary sections. These primary sections are designed to support the input requirements for a large group of particle optics codes. OASIS uses the following names for the four primary sections:

Header
Lattice
Lines
Footer

One final item is needed to complete the definition of a DIMAD command: the specification of the *location* in the Main Input File where the command data is to be written. This specification is made using the Command Options tab panel of the Command Specification window (Figure 56). Figure 62 illustrates the selection for the location in the Main Input File where the example DIMAD command will be placed.

Command Location Selector
Set to:
After Lines - Before Footer
For DIMAD-sample OModule

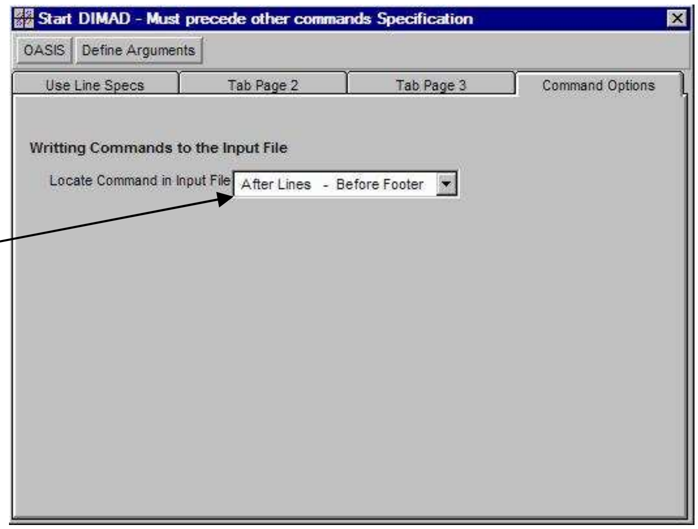


Figure 62. Command Options tab panel of the Command Specification window.

Comm Pieces can be written "in-line" as they are encountered in a beamline on the Model Space, or may be written at locations between any of the primary sections of the Main Input File.

DIMAD operations are placed in an input file immediately after the lines section. The location specification "After Lattice - Before Footer" is thus selected in the popup menu shown in Figure 62. Other commands have also been specified for the DIMAD-sample Module, allowing the user to utilize multiple commands, arranging their order to accomplish specific tasks.

Some Other Comm Piece Specifications

Figure 63 shows several Input Syntax specification windows for the DIMAD-sample OModule.

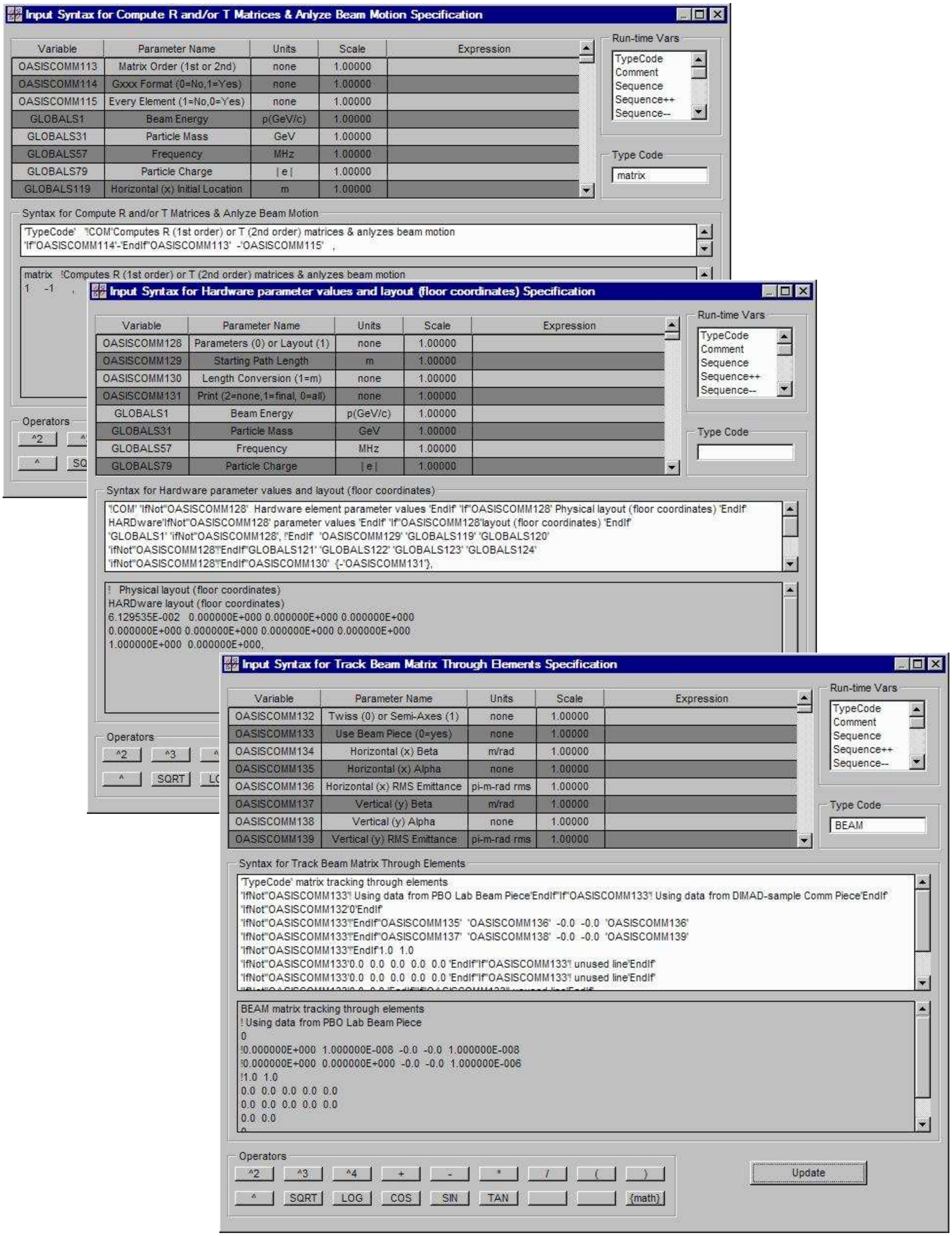


Figure 63. Some command syntax specifications for the DIMAD-sample OModule.

Descriptive text is permissible (up to 80 characters) following four-letter operation key words in the Main Input File for DIMAD. Similar descriptive entries for other codes would most likely require a leading comment character. See the OASIS Module Options in Section 4 for a description of the '!COM' comment delimiter runtime variable.

The Input Syntax specification windows illustrated in Figure 63 are additional examples from the DIMAD-sample OModule. The Comm Pieces for these specifications implement the DIMAD operations generally referred to as: MATRix, HARDware, and BEAM. The first four letters of these operations constitute the key words for these DIMAD operations. Although these four letters must appear at the beginning of the first line of the DIMAD operation statement, up to 80 additional characters may be included to further describe the operation. The Input Syntax specification windows illustrated in Figure 63 take advantage of this feature.

When writing the Main Input File, an OModule first writes the Header section, followed by the Lattice section, optional Lines section, and concluded with the Footer section. Additional lines may be written to the Main Input File between these primary sections by the use of OASIS Comm Pieces.

The last four groups on the OASIS Commands Menu are discussed in Sections 6 and 7 of this User Manual. Please refer to those sections for more information.

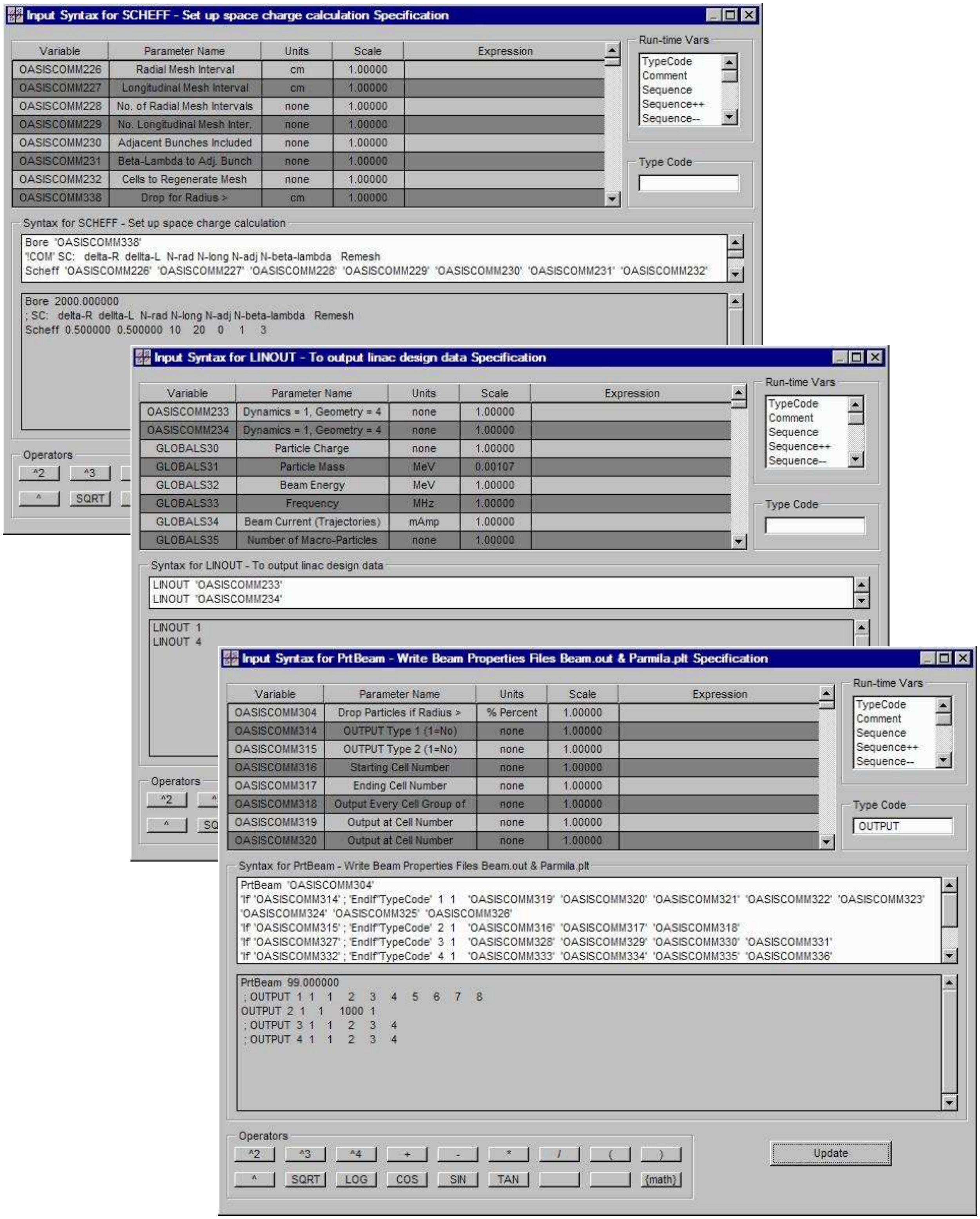


Figure 64. Some command syntax specifications for the PARMILA-2 OModule.

Special Parameter Settings (SPS)

Many computation engines support certain attributes for individual parameters of optical components. One of the most common is the ability to vary individual parameters as part of a fitting or matching procedure. Some computation engines also support the ability to define individual parameters by a formula, rather than a fixed number. Support for these capabilities in an OModule is defined using the Special Parameter Settings (SPS) item on the OASIS Module Builder Commands menu. Different types of attributes may be assigned using different submenu items of the SPS item. The submenu items include:

- Parameter Variable Spec,
- Parameter Expression Spec.

Selecting the Parameter Variable Spec choice opens the window shown in Figure 65. The window provides options for use of variable parameters and symbolic parameter names, as well as for syntax specification.

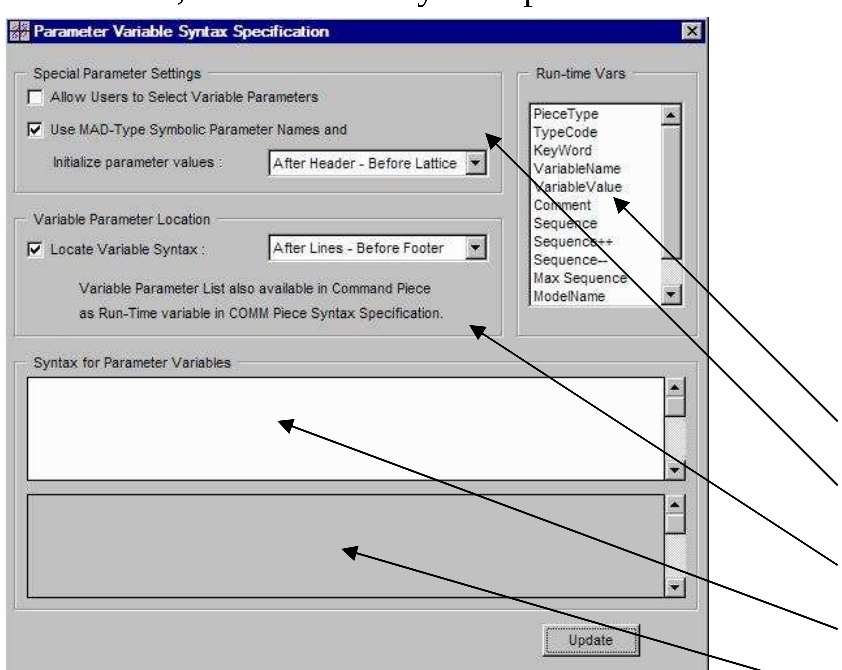
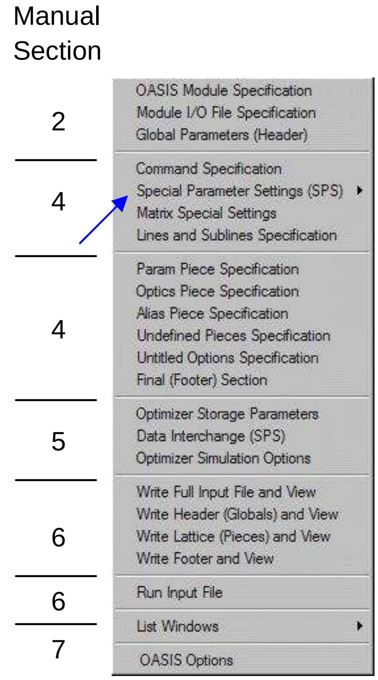
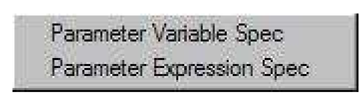


Figure 65. Parameter Variable Syntax Specification window.



Special Parameter Settings (SPS) are used to assign additional attributes to Piece Parameters of an OModule.



Different types of attributes may be assigned using the submenu of the Special Parameter Settings (SPS) Commands menu item.

With certain noted exceptions, all Piece parameters selected for use in an OModule will have the assigned attributes available to them. In particular, Piece parameters selected for use in the OModule, as described in Section 3, can be utilized with the SPS capabilities specified by the Special Parameter Settings (SPS) attributes. Exceptions to this rule include:

- *Global Parameters*
- *Piece Parameters that use Modify by Scale Factor*
- *Piece Parameters that use Modify by Formula*

A Piece parameter not included in the exceptions list above may still be removed from the set of parameters with capabilities specified by the Special Parameter Settings (SPS) attributes. For example, in the Piece parameter SPS Window (see Figure 19) select different units for use than ultimately desired, and then choose the Modify by Scale Factor option with appropriate multiplier that will return the parameter to the correct units. This effectively creates the second exception above.

An OModule can also be interfaced to the PBO Lab Optimization Module. That Module utilizes the nonlinear, constrained, many-parameter, MINOS and NPSOL optimization codes. Interfacing an OModule to the Optimization Module is also described in Section 5.

The example in Figure 66 illustrates the assignment of variable parameter attributes for DIMAD. The syntax to be used for the vary parameters is also shown.

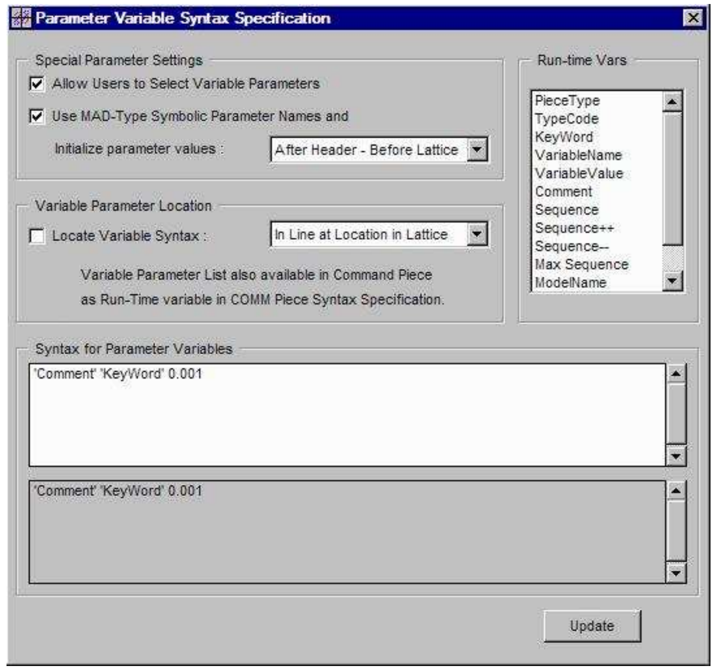


Figure 66. Parameter Variable Syntax Specification window for DIMAD.

MAD-like parameter expressions can also be utilized with OASIS created modules. Selecting the Parameter Expression Spec item on the Special Parameter Settings (SPS) submenu opens the window illustrated in Figure 67.

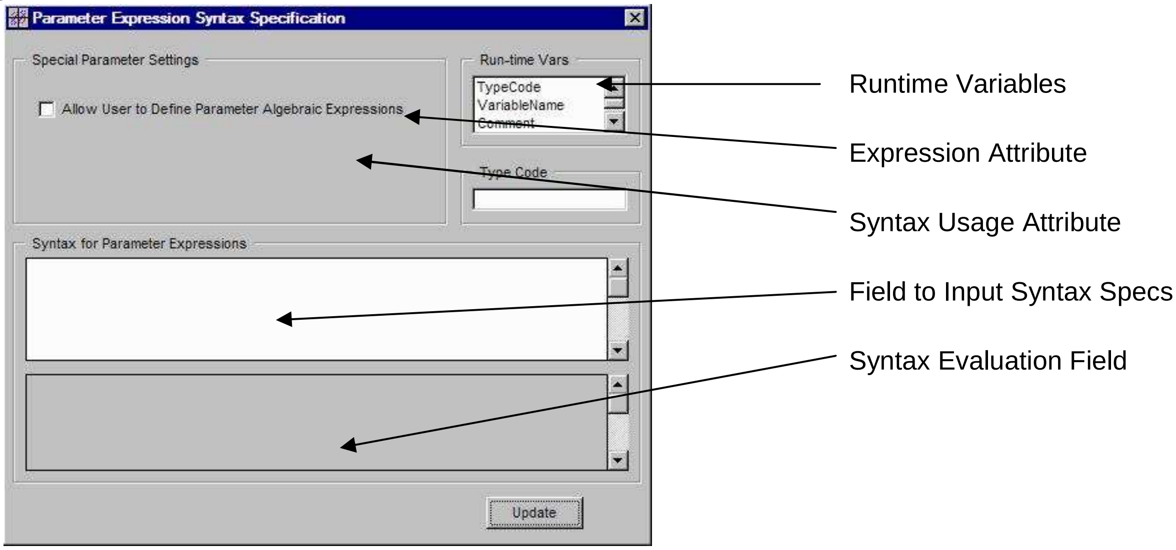
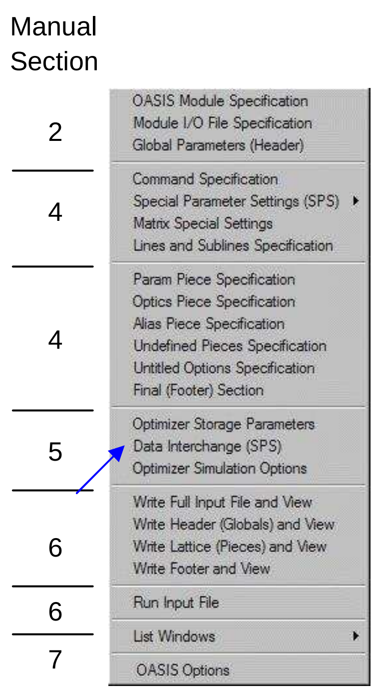


Figure 67. Parameter Expression Syntax Specification window.

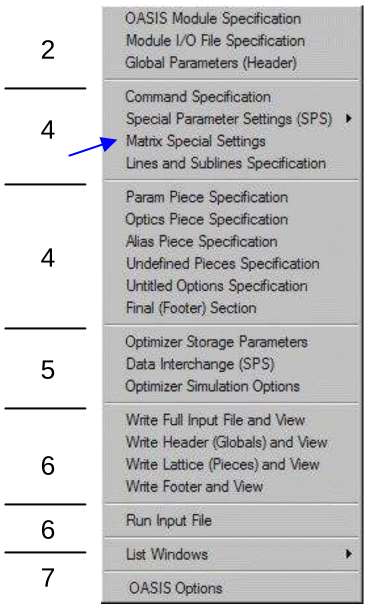
Another attribute for individual parameters available within the PBO Lab software framework is the ability to assign parameters as Import Parameters. Such parameters can be updated from an external file, or from a dynamic data interface to other software, such as MatLab™ or control systems using EPICS Channel Access. Section 5 discusses the assignment of special parameter setting attributes for this type of Data Interchange.



Data Interchange special parameter settings (SPS) are discussed in Section 5.

Matrix Special Settings

Manual Section



Matrix Special Settings are used to assign attributes to those available to Piece parameters using the Special Parameter Settings (SPS) command.

Matrix Special Settings are utilized to assign attributes to matrices that are similar to the attributes that can be assigned to Piece parameters using the Special Parameter Settings (SPS) command. The Matrix Special Settings command opens a window similar to that illustrated in Figure 65.

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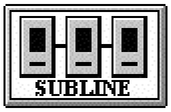
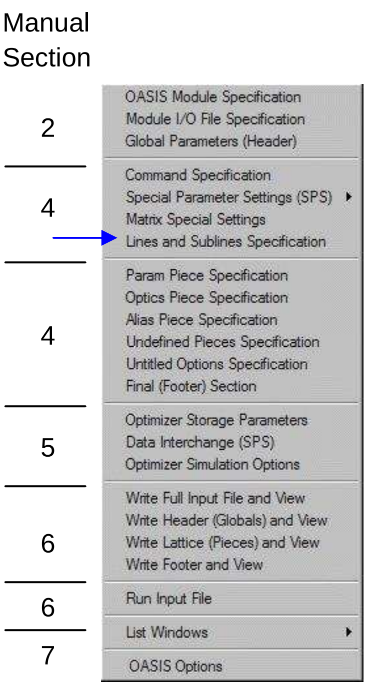


Sublines are powerful PBO Lab objects that allow users to visually construct, edit and manipulate hierarchical lattice beamline structures. This facilitates easy organization and identification of various parts of a beamline, in addition to providing the underlying framework for using optics codes that require hierarchical beamline descriptions.



The Lines and Sublines Specification is used to define the type of beamline lattice architecture that will be used in the Main Input File. This specification is important for any codes that use MAD, SIF, XSIF, or a similar hierarchical lattice description.

Lines and Sublines Specification

Several particle optics codes support, or even require, the use of hierarchical descriptions of beamlines. Hierarchical beamline descriptions permit selections of optical elements to be grouped together, and those groups to be further grouped, at the desire of the user. Computation engines which utilize hierarchical descriptions generally also support the analysis and simulation of individual groups. This significantly improves the flexibility and capability of computational procedures. Examples of hierarchical beamline lattice descriptions include:

- Methodical Accelerator Description (MAD),
- Standard Input Format (SIF),
- eXtended Standard Input Format (XSIF), and
- MARYLIE input format

The PBO Lab software fully supports hierarchical beamline descriptions, providing tools for graphically constructing and manipulating lattice groups called Sublines. The underlying software object model in PBO Lab provides a number of recursive methods that implement the visual display of Sublines, ready access to Pieces or Sublines inside of Sublines, aliasing of Sublines, importing hierarchical lattices, and a number of other capabilities useful for the manipulation of hierarchical beamline descriptions.

The Lines and Sublines Specification item on the OASIS Commands menu is used to integrate these capabilities with OModule computation engines. This menu item opens a window like that illustrated in Figure 68. The default settings for this window are shown in Figure 68, which correspond to a *non-hierarchical* description of beamline lattices.

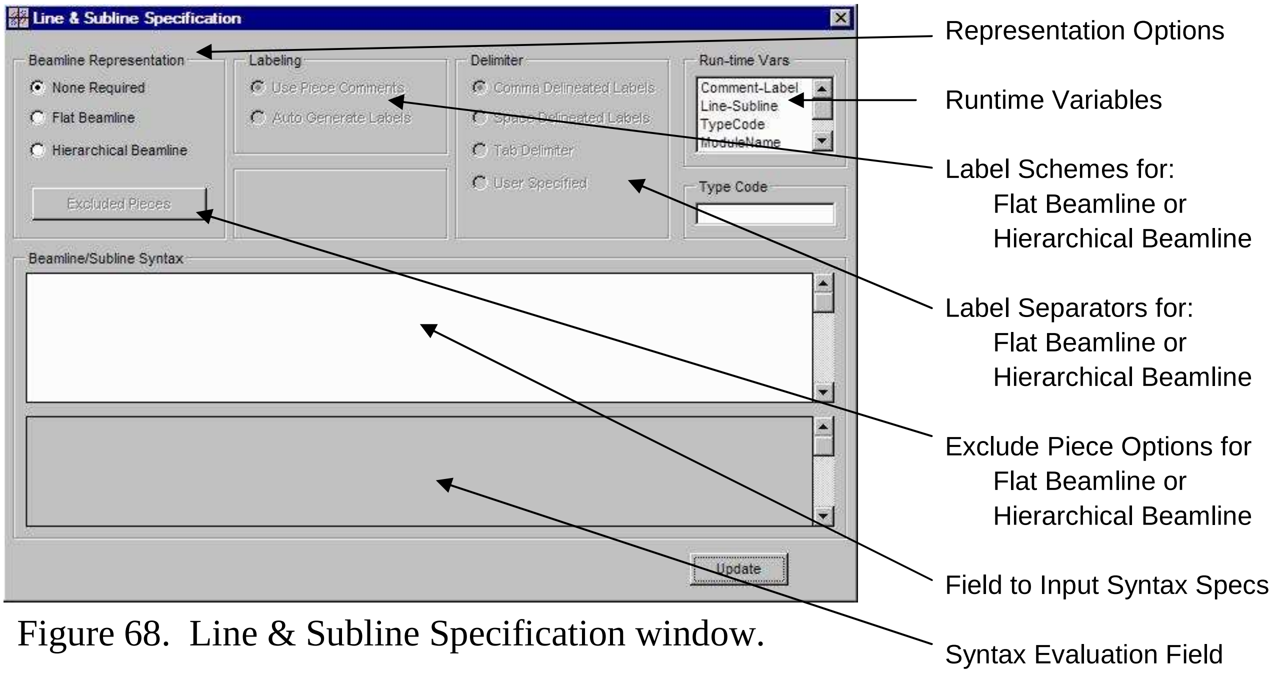


Figure 68. Line & Subline Specification window.

The first panel (upper left) is used to select one of three basic Beamline Representation specifications. The default is None Required, which is used for computation engines which do not use a hierarchical beamline description. Most other parts of the window are inactive when the None Required specification is selected. The example shown in Figure 68 corresponds to this case.

The Line and Subline Specification window has two other panels at the top which provide for selecting different options when the Beam Representation is selected to be either Flat Beamline or Hierarchical Beamline. These two panels are discussed further below. For Flat Beamline or Hierarchical Beamline representations it is possible to exclude any PBO Lab Pieces, OASIS Comm Pieces, and OASIS Optics Pieces from the lattice description by using the Exclude Pieces button. The other parts of the window, providing for Run-time Vars, a Type Code, and the Beamline/Subline Syntax specification and evaluation fields, are similar to those of other OASIS syntax windows.

The None Required selection for Beamline Representation is used for optics codes which do not utilize lines or sublines in their input files. Examples of such codes include:

- *TRACE 3-D*
- *TRACE*
- *PARMILA*
- *PARMELA*
- *RAYTRACE*
- *OPTIC*
- *TRANSOPTR*

Note that a PBO Lab beamline can have a hierarchical construction on the Model Space of the PBO Lab Document Window, yet still be written in a no-lines (None Required) representation, if that is the specification for the OModule.

The Flat Beamline selection is useful for comparing and testing results for optics codes that use lines or sublines. It offers an independent way to simulate the full beamline on the PBO Lab Model Space, which can be compared to results obtained with using Hierarchical Representation.

Two runtime variables are available for constructing the syntax for Flat or Hierarchical Representations:

- *Comment-Label*
- *Line-Subline*

The selection Flat Beamline, for the Beamline Representation, may be used for codes which require that the beamline or lattice to be used must be identified or named, but for which the creator of the OModule does not wish to provide a complete hierarchical description to the input file. When Flat Beamline is selected, the PBO Lab beamline on the Model Space of the Document window will be "flattened" for writing to the Main Input File, that is, the PBO Lab subline hierarchy will be ignored. However, an entry for the full beamline will be written to the Main Input File, according to the entry in the Beamline/Subline Syntax box. For the Flat Beamline selection, the runtime variable 'Comment-Label' takes on the value "LINE_0001" for the entire beamline. It can be written to the Main Input File according to the specification entered into the Line/Subline Syntax box. No other line or subline entries will be written to the Main Input File, regardless of whether any PBO Lab sublines appear on the Model Space. All elements appearing on the Model Space of the PBO Lab Document Window will be included in "LINE_0001" list.

A Hierarchical Representation selection is used for optics codes that require line or subline definitions in their input files. Examples of such codes include:

- *MARYLIE*
- *MAD*
- *DIMAD*
- *LIAR*
- *TEAPOT*
- *LEGO*

The last option for the Beamline Representation selection is for a fully Hierarchical Beamline. When Hierarchical Beamline is selected, the full Subline structure of the beamline on the Model Space of a Document Window will be written to the Main Input File. The format is specified in the Line/Subline Syntax box.

No lines or sublines are utilized for the None Required selection of the Beamline Representation. Consequently no labeling scheme is required, although the Piece Comments can be utilized for OModule user labeling purposes in individual Piece syntax.

For either Flat (or Hierarchical Beamline) selections, the labeling scheme for individual Pieces (and Sublines) is determined by options in the upper center panel called Labeling. Labeling provides for two different schemes for labeling Pieces and Sublines. The first selection in the Labeling panel is to Use Piece Comments, which is the default selection.

For Flat and Hierarchical Beamlines the labels utilized to identify individual Pieces must be unique. The Labeling option titled Use Piece Comments places the burden of assuring unique labels upon the OModule user. The labels in a PBO Lab Model will be assembled into a list, and the list will then be used to evaluate the Run-time Var 'Line-Subline' at runtime. If the user assigned labels are not unique, then the list will contain multiple entries for the same label, even when the associated Pieces are physically distinct. An alternative, and in many ways preferable, approach to assuring unique labels is to utilize the Auto Generate Labels selection.

The OASIS runtime variable Comment *in Piece syntax, as well as the Beamline/Subline syntax* Comment-Label *runtime variable, take on unique values for Flat or Hierarchical Representations when Auto Generate Labels is selected. The value for each Piece (or Subline) is composed of the first four characters of the Comment appearing on the Piece (or Subline) plus an integer counter that is incremented by one for each Piece (or Subline).*

The selection Auto Generate Labels becomes active in the Labeling panel when either of the two selections Flat Beamline or Hierarchical Representation is made in the Beam Representation panel. If unique labeling is required for physically different Pieces, then it is recommended that the Auto Generate Labels choice be utilized. The OASIS parser will generate unique labels at runtime. The runtime variable 'Comment' in any Piece syntax (e.g. Figures 20, 25) will then evaluate to the auto generated label for that Piece. This "overrides" any text (label, comment, etc.) that an OModule user may have placed in the Piece Comment field, assuring that all lattice identification labels will be unique. The same auto generated labels will then be used to create a list of labels for the 'Line-Subline' runtime variable. Individual labels in the list will be separated according to the Delimiter panel selection.

OASIS divides the Main Input File into several primary sections. These primary sections are designed to support the input requirements for a large group of particle optics codes. OASIS uses the following names for the four primary sections:

Header
Lattice
Lines
Footer

The Lines section is only used if the Beamline Representation selection is: (a) Flat Beamline or (b) Hierarchical Beamline.

Figure 69 illustrates the Line and Subline Specification window using a Hierarchical Beamline representation suitable for the MAD computation engine, or any other computation engine that utilizes SIF or XSIF lattice descriptions, such as DIMAD.

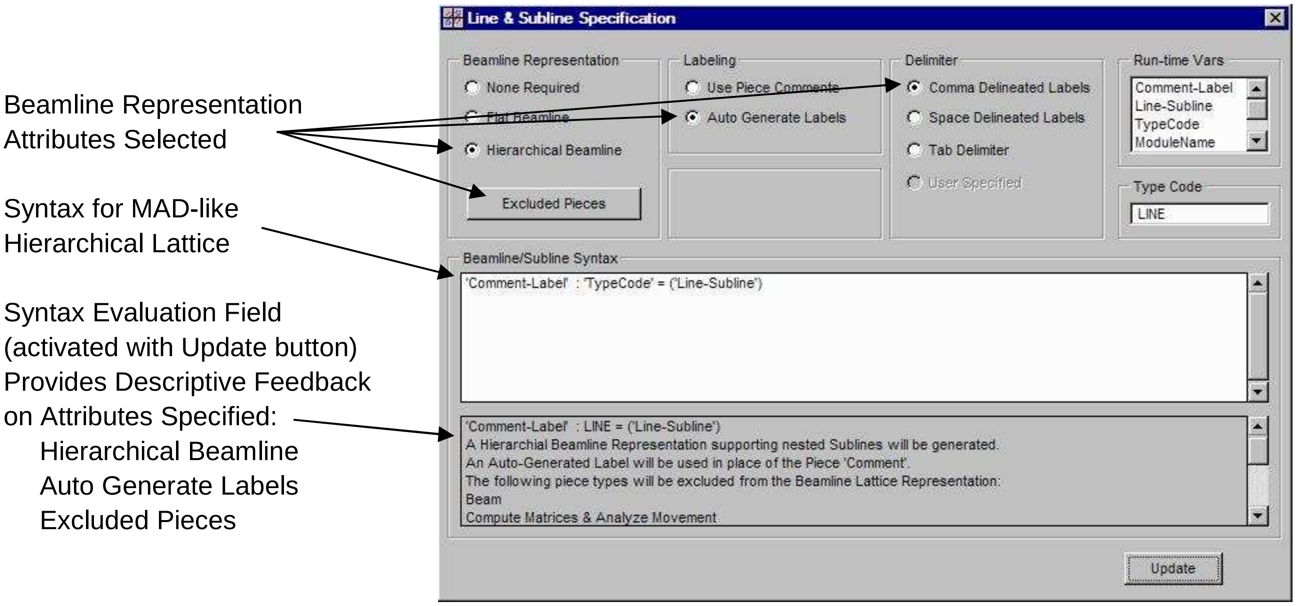


Figure 69. Line & Subline Specification window for Hierarchical Beamline representation of DIMAD.

Figure 69 illustrates an example of the Line & Subline Specification window for the DIMAD-sample OModule. The various blocks appearing in the window are described in this section of the User Manual. Note that the Update button provides specific information on the syntax, rather than the literal syntax evaluation as is done for the Piece Syntax that is described in Section 3.

The Beamline/Subline Syntax input field shown in Figure 69 is relatively simple:

'Comment-Label' : 'TypeCode' = ('Line-Subline')

This syntax, together with the attributes as selected in Figure 69, will result in a hierarchical lattice description appropriate for a MAD-type beamline representation. The syntax supports nested PBO Lab sublines, with corresponding LINE definitions in the Lines section of the Main Input File.

The Beamline/Subline Syntax evaluation field does not provide the typical OASIS parser evaluation result. The runtime variables 'Comment-Label' and 'Line-Subline' are not well-defined outside the context of a PBO Lab Model on which the OASIS parser will operate. Consequently, the syntax evaluation provides a summary of how the beamline will be represented in the Lattice and Lines sections of the Main Input File. Part of this summary includes a list of Excluded Pieces which will not appear in the Lines section.

All Pieces for which OASIS Syntax has been defined are automatically included in the lattice description whenever the Flat Beamline or Hierarchical Beamline choice is selected for the Beamline Representation. It may be appropriate to exclude certain Pieces from the lattice description for some codes. The Excluded Pieces button is used to incorporate this type of information into the Beamline Representation. Figure 70 shows the window that opens when the Excluded Pieces button is used.

All Pieces with OASIS Module specifications defined, as described in Section 3, will appear initially in the Include (left) column. Pieces moved to the Exclude (right) column will not be utilized in the Lines section of the Main Input File. The individual Pieces may still be written in the Lattice section (depending upon their syntax), but will not have an Auto Generated Label.

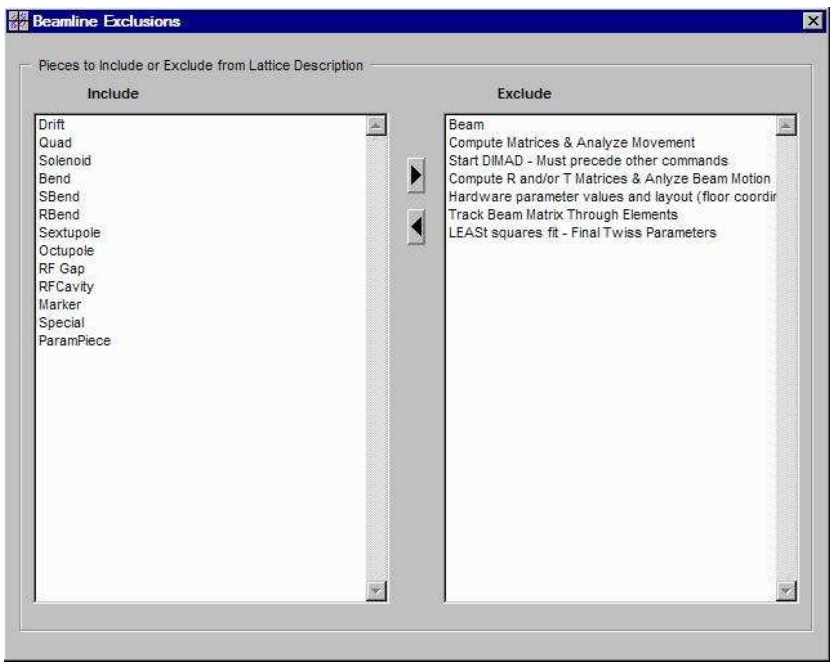


Figure 70. Beamline Exclusions window for selecting Pieces to be excluded from the Lines sections of the Main Input File when using a Flat or Hierarchical Beamline representation.

Note in Figure 70 that the DIMAD Comm Pieces have been excluded. DIMAD commands appear after the Lines section of the Main Input File and so have been moved from the (default) Include column to the Exclude column.

Excluding a Piece from the lattice description means that the Piece will *not* be assigned an Auto Generated Label (if that attribute is selected) and *no entry* will appear in the Lines section for that Piece. The Piece may still have an inline entry in the Lattice section of the Main Input File, if the Piece has a syntax specified, but it will not be used in the hierarchical description.

An example of a hierarchical beamline in the Main Input File is discussed on the next three pages of this User Manual.

Pieces that are to be excluded from beamline lattice descriptions are moved from the Include (right) to the Exclude (left) column. Select (with the mouse) any Piece appearing in the Include column that is to be excluded from beamline lattice description. The selected Piece will become highlighted. Then use the top arrow button in the middle of the window to move the selected Piece to the Exclude column. Reverse the procedure to move a Piece back to the Include column.

The Small Static Storage Ring example is an 800 MeV proton ring that illustrates a multi-level hierarchical beamline.

It is instructive to illustrate an example of how a PBO Lab beamline with nested sublines will appear in the Lattice and Lines section of the Main Input File when using the DIMAD-sample OModule. Figure 71 shows a PBO Lab Model ("2.5 Small Static Storage Ring") together with a view of the nested sublines.

Alias Pieces & Alias Sublines form a part of the PBO Lab graphical beamline object model. Any Alias is identified visually by the red **A** *which appears in the upper left part of the icon for the Piece or Subline. An Alias points to an original (often unique) Piece or Subline. (The Alias does not contain a copy of the original's data, but contains a pointer to that data as well as possible deviations.)*

The storage ring PBO Lab model illustrated in Figure 17 has two sublines at the "top level" or first level of hierarchy. The first subline has the Comment "half" and describes one-half of the ring. The second subline in the first hierarchical level is an Alias subline, as indicated by the red **A** in the upper left corner of the subline icon. This Alias subline represents an identical duplicate of the original "half" subline, and has the identical Comment "half". The "half" subline, representing the second level of the hierarchy, is itself composed of five other sublines. These include three "unique" sublines labeled "nsex", "tsex" and "lsex" which are named after the type of sextupole corrector element in each. There are two "nsex" Alias sublines in the "half" subline as well. The third level of hierarchy is where the individual optics elements are located. These include drifts, quadrupoles, bends, sextupoles and Aliases to the various unique elements.

Figure 72 shows the Lattice and Lines sections of the DIMAD Module Main Input File ("DiMadInput) that corresponds to the example storage ring.

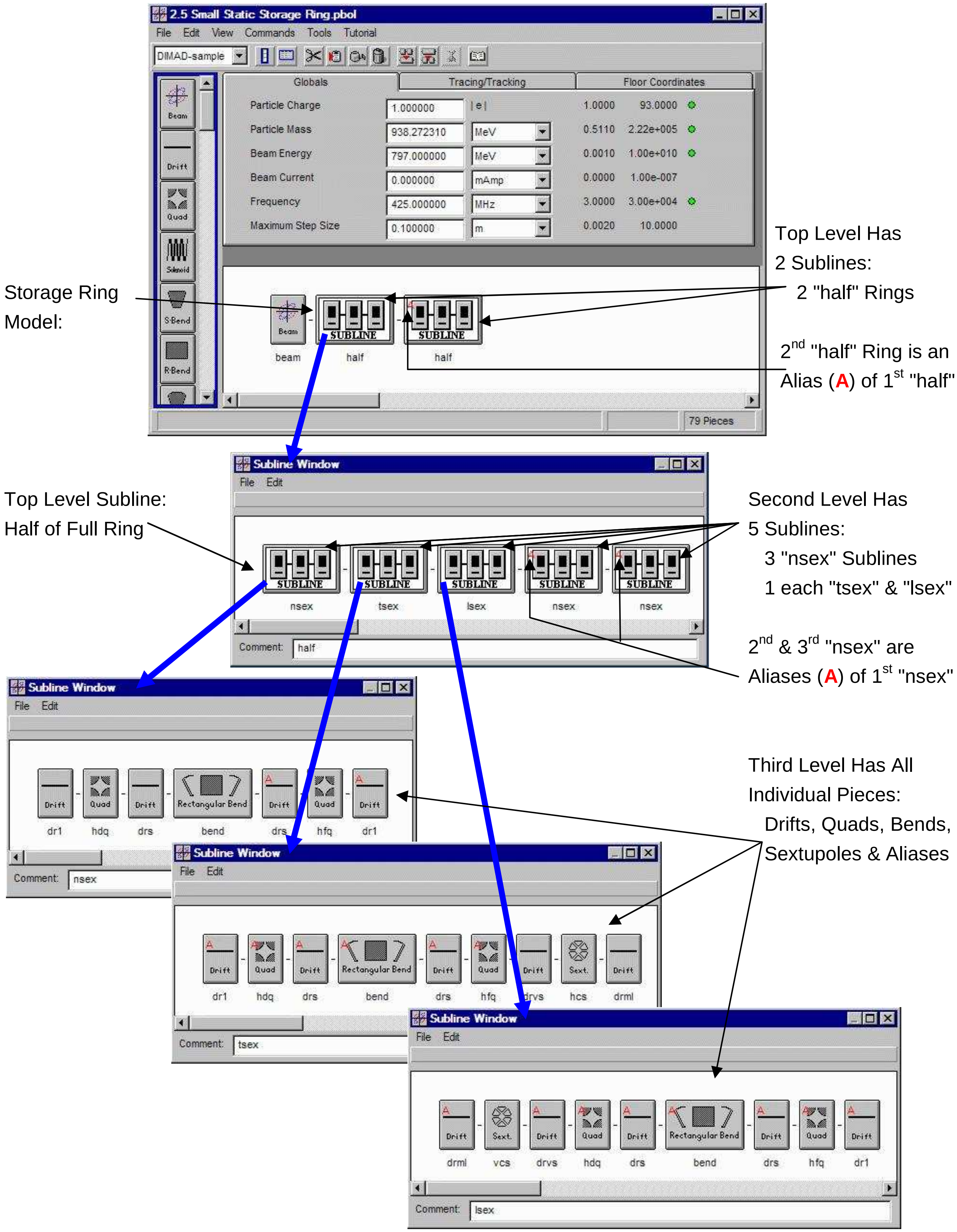
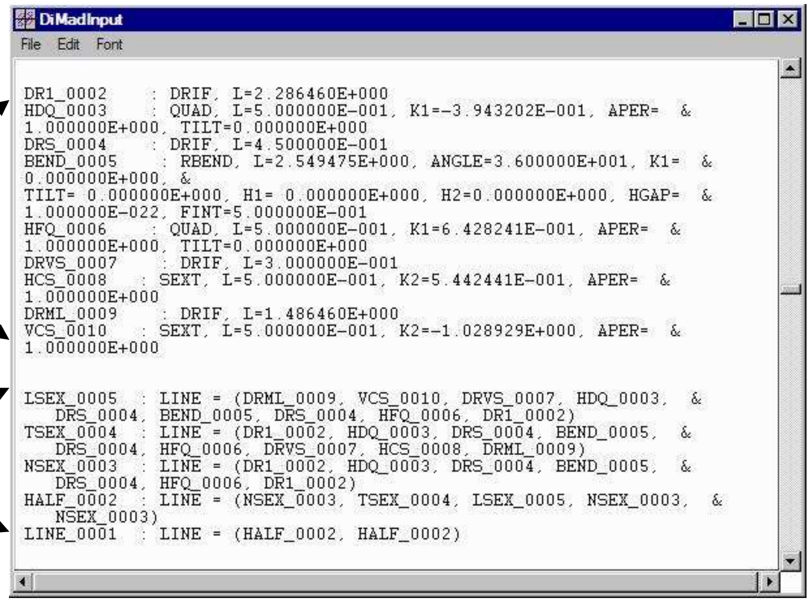


Figure 71. PBO Lab storage ring model with nested sublines.

Lattice Section Includes All Unique (non-Alias) Pieces

Lines Section Includes All Nested Sublines and Full Beamline (LINE_0001)



Manual Section

2

4

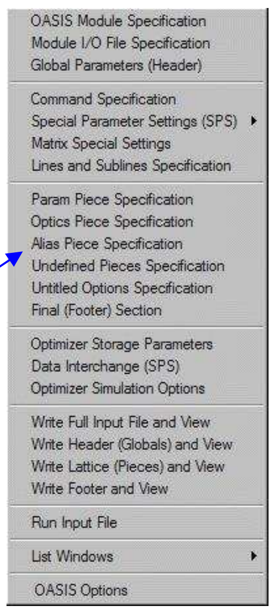
4

5

6

6

7



The Alias Piece Specification is used to define how Aliases will be written to Lattice section in the Main Input File. This is described later in this Section of the User Manual. The DIMAD OModule uses default specifications for Aliases.

Figure 72. Lattice and Lines sections of the DIMAD-sample Main Input File (DiMadInput) for the storage ring model with nested sublines shown in Figure 71.

The Beamline/Subline Syntax shown in Figure 69 was used to create the DiMadInput file illustrated in Figure 72. This simple storage ring consists of nine (9) unique optics elements (4 drifts, 2 quadrupoles, 1 rectangular bend, and 2 sextupoles). The Auto Generate Labels attribute (Figure 69) creates the unique labels for these Pieces: DR1_0002, HQD_0003, DRS_0005, BEND_0005, HFQ_0006, DRVS_0007, HCS_0008, DRNL_0009, VCS_0010. These labels appear in the Lattice section of the DiMadInput file.

Each of the sublines appearing in Figure 71 is represented by a MAD-type LINE statement in the DiMadInput file. As with unique Pieces, the Auto Generate Labels attribute results in unique labels for each of the four (4) non-Alias sublines: LSEX_0005, TSEX_0004, NSEX_0003, HALF_0002. These, together with the full beamline label LINE_0001, are used in the Lines section of the DiMadInput file, per the syntax specification shown in Figure 69.

Custom Parameter Piece

An OASIS Param Piece is available to create a customized parameter-like Piece for an OModule. The custom Param Piece can be used to create simple beamline elements which use no more than eight (8) parameters. However, the Param Piece will be specific to the OModule. Unlike the standard (built-in) PBO Lab Parameter Piece (discussed in Section 3 of this User Manual) a custom Param Piece will not be supported by other PBO Lab Modules (except as an *undefined* Piece).

The procedure for creating a custom Param Piece is similar to that described for the creation of Comm Pieces (discussed at the beginning of Section 4). To initiate the creation of an OASIS Param Piece, select the menu item "Param Piece Specification" on the OASIS Commands menu. This will open an OASIS Param Piece Specification window which is illustrated in Figure 73.

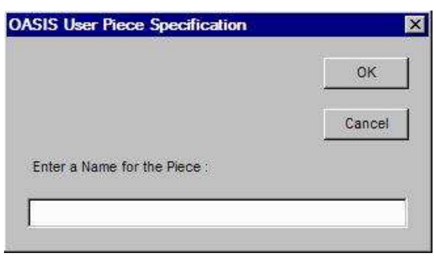
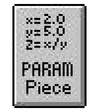


Figure 73. Param Piece Specification window.

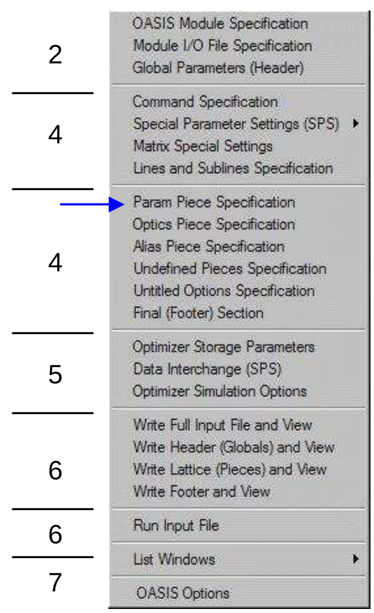
Like the Command Piece Specification window, the Param Piece Specification window requires only one entry: a name for the Param Piece. The name assigned will later appear (for the OModule user) in a list of Param Pieces available to the underlying computation engine. Figure 74 illustrates an example for DIMAD with the name:

Horizontal or Vertical Kick



The OASIS Param Piece can be used to mimic custom elements, commands, or other functions appropriate to a particular OModule.

Manual Section



The OASIS custom Param Piece is different from the standard PBO Lab Parameter Piece.

The standard (built-in) PBO Lab Parameter Piece can be used to provide support for codes such as MAD that utilize parameter elements. In order to maintain compatibility with other PBO Lab and OASIS Modules, the built-in PBO Lab Parameter Piece should be used for that functionality. (See Section 3 of this User Manual.)

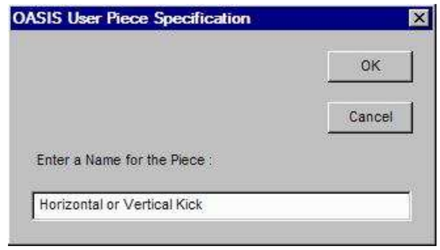


Figure 74. Param Piece Specification window with name assigned for the Piece.

The standard (built-in) PBO Lab Parameter Piece is patterned after the use of PARAM lines in MAD-style input files. The built-in PBO Lab Parameter Piece, rather than the OASIS custom Param Piece, should be used to provide similar support for an OModule. See Section 3.

Once a name for the Param Piece has been entered, the OK button is used to create a Param Piece with this name. The newly created Piece will appear in the lower left region of the Work Space of the Module Specification Document. This is the same location where newly created Comm Pieces appear (see Figure 55). Move (Shift-drag) the new Param Piece to the Model Space of the Module Specification Document. Remember, *only Pieces located on the Model Space are used during runtime of an OASIS Module*. Double click the Param Piece icon to open the [Piece Name] Parameters Specification window, illustrated in Figure 75.

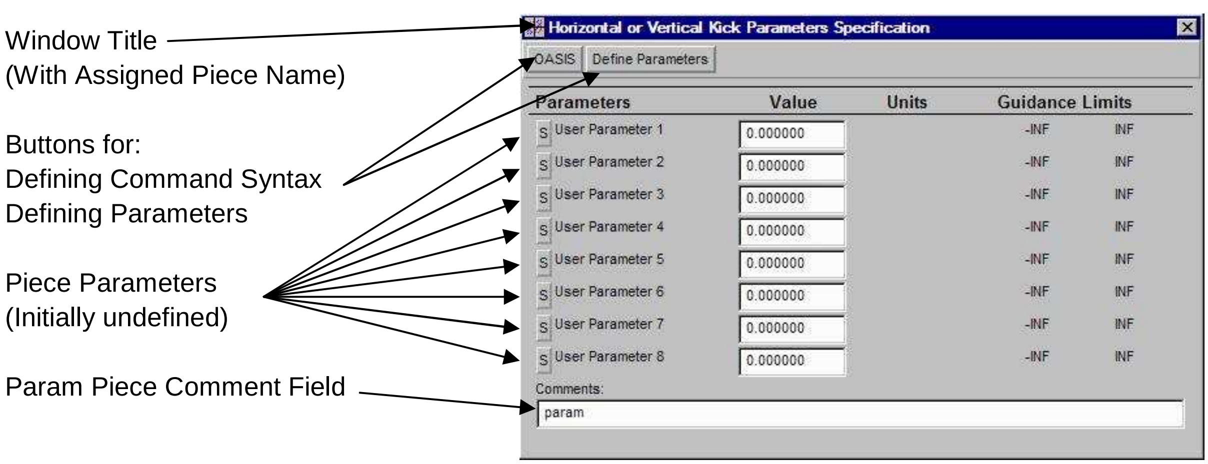


Figure 75. Horizontal and Vertical Kick Parameters Specification window.

The main features of the Parameters Specification window have similar functionality to the corresponding features of a Comm Piece Spec window (Figure 56).

There are a few differences between an OASIS Comm Piece and an OASIS Param Piece. First, the OASIS Param Piece has no tab panels comparable to those available on a Comm Piece (Figure 56). Consequently the Parameter Specification window (Figure 75) has no tab pages and no field for entering names for tab panels. This limits the number of parameters to eight (8), rather than the twenty-eight (28) available to a Comm Piece. Second, only real parameters are utilized with the OASIS Param Piece. This is apparent in Figure 76 which illustrates the Define Parameters window for the Param Piece. In contrast, the OASIS Comm Piece supports integer, real and string (text) parameters (Figure 57).

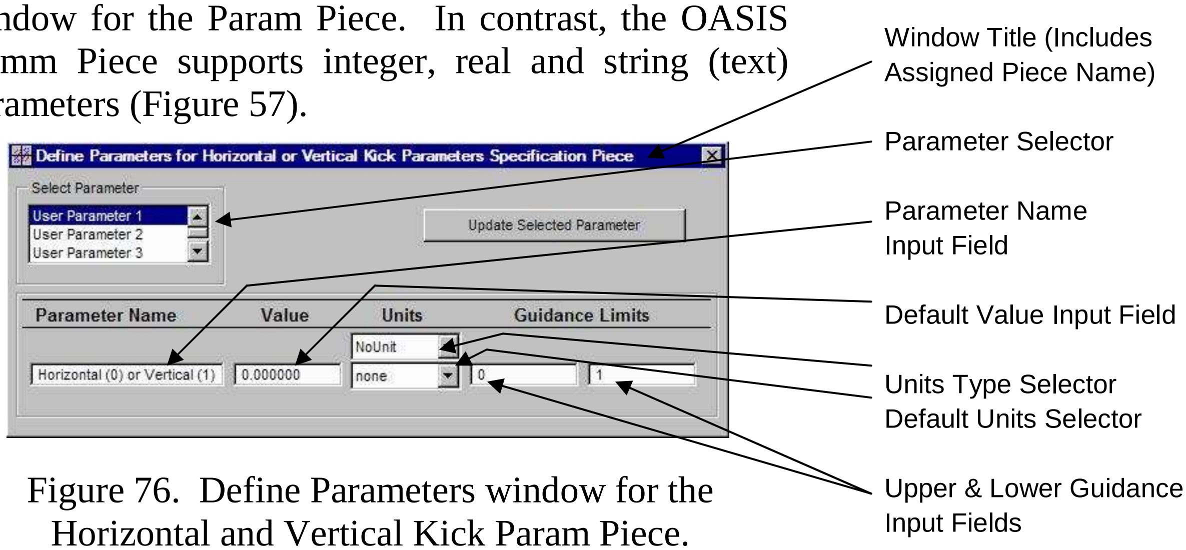


Figure 76. Define Parameters window for the Horizontal and Vertical Kick Param Piece.

Parameters are defined following the same procedures as described for defining arguments of a Comm Piece. The Select Parameters list is used to choose a parameter associated with a given internal name (e.g. User Parameter 1). The parameter internal name will then be highlighted, and a parameter name, default value, units type, default unit, and guidance limits can be entered. The Update Selected Parameter button is used to record and store the parameter attributes.

When the Update Selected Parameter button is selected, the parameter name, default value, default unit, and guidance limits will appear in the [Piece Name] Parameters Specification window.

Figure 77 shows the Horizontal and Vertical Kick Parameters Specification window with three parameters defined for the DIMAD-sample OModule.

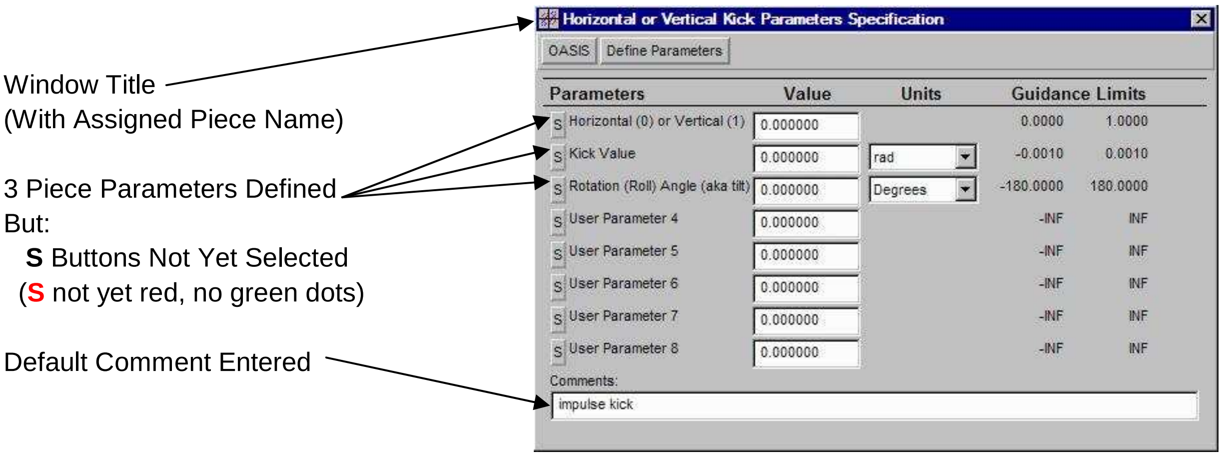


Figure 77. Horizontal and Vertical Kick Parameters Specification window with three parameters defined.

Unlike the OASIS Comm Piece discussed at the beginning of Section 4, and the OASIS Optics Piece discussed next, the parameters of the OASIS custom Param Piece are not automatically assigned a Symbolic Parameter Name. The OModule developer needs to select the **S** *button, to the left of each defined parameter, in order to make the Symbolic Parameter Name assignment.*

Note: If a Symbolic Parameter Name is not assigned to a parameter, that parameter will still appear in the Param Piece window of the OModule. However, the parameter will effectively have no impact since such a parameter cannot be used in constructing the Piece syntax.

The Special Parameter Settings (S) buttons need to be selected for each parameter in order for the parameters to be used in the syntax specification. The S button opens a Special Parameter Settings window similar to that illustrated in Figure 78.

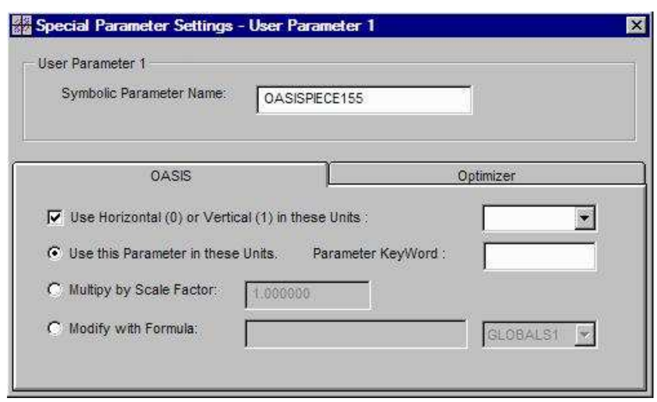


Figure 78. Special Parameter Settings - User Parameter 1 window for a Param Piece.

Once Symbolic Parameter Names are assigned for the desired parameters, the OASIS button on the parameter specification window (Figure 77) opens the syntax window for the Param Piece.

Figure 79 illustrates a completed syntax specification window for the Horizontal or Vertical Kick Param Piece utilized in the DIMAD-sample OModule.

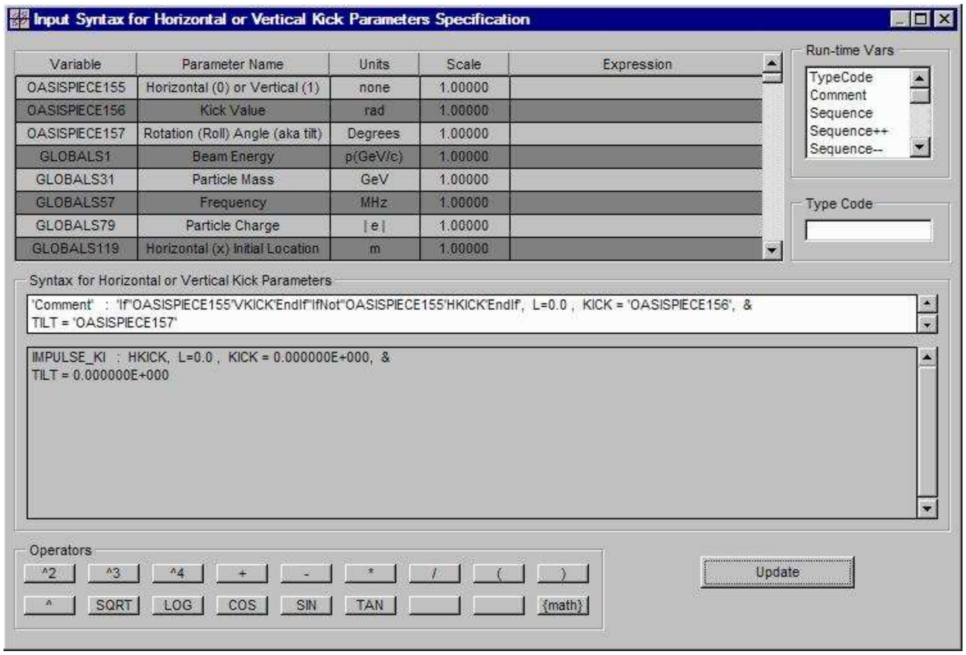
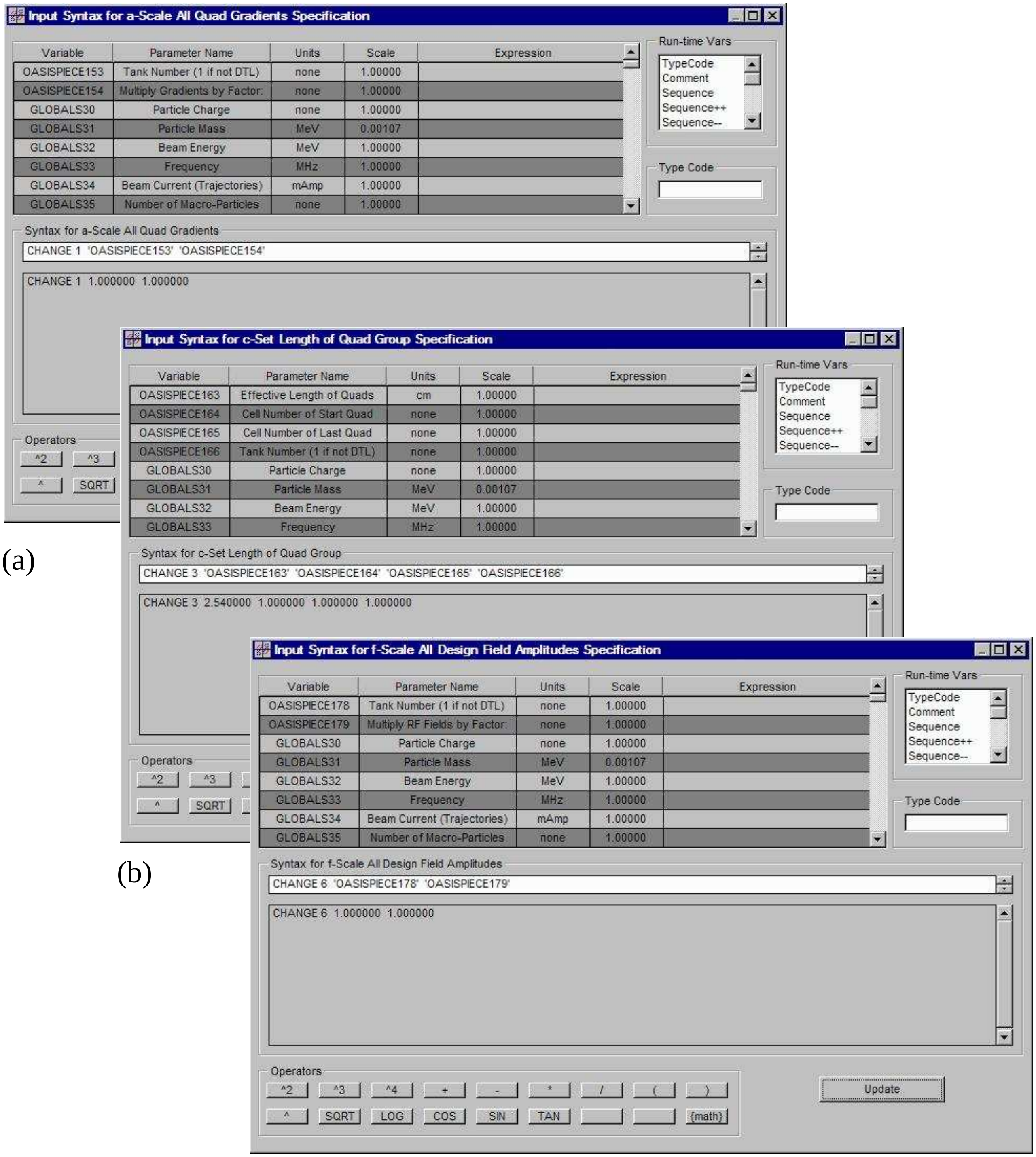


Figure 79. Input Syntax for Horizontal or Vertical Kick Parameters Specification window.

The example syntax illustrated in Figure 79 corresponds to an XSIF kicker element of zero length. The length is fixed to zero by the L=0.0 entry in the syntax field. The assigned default comment for this Piece is "impulse kick" (Figure 77), reflecting the zero length. An extra length parameter could have been added to the Defined Parameters in order to provide support for a finite length kicker. However, for finite length elements it is recommended that an OASIS Optics Piece be used. The OASIS Optics Piece has more functionality than the OASIS Param Piece, which can be useful for other parts of the PBO Lab graphical framework. The OASIS Optics Piece is described next, but first Figure 80 is presented that includes other examples of OASIS Comm Piece usage. The examples in Figure 80 are for the PARMILA-2 Module.



(a)

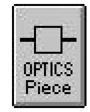
(b)

(c)

Figure 80. Input Syntax for some PARMILA-2 custom Param Pieces:
(a) Change Type 1, (b) Change Type 3 and (c) Change Type 6.

Custom Optics Piece Specification

OASIS provides for the definition and specification of additional optics elements that are not included in the standard set of PBO Lab Pieces. Whenever possible the PBO Lab standard Pieces should be used for defining optics components, as described in Section 3 of this manual. Because all other optics codes available as PBO Lab Modules utilize the standard Pieces as well, comparison of results between optics codes is easy. However, in some cases an additional Piece is needed to fully support the capabilities of a particular optics code. The OASIS Custom Piece can be used to create such a new Piece for use with a given OASIS Module. The procedure for creating a Custom Piece is similar to that used for creating Comm Pieces as described at the beginning of Section 4. This discussion will illustrate the procedure by stepping through a specific example



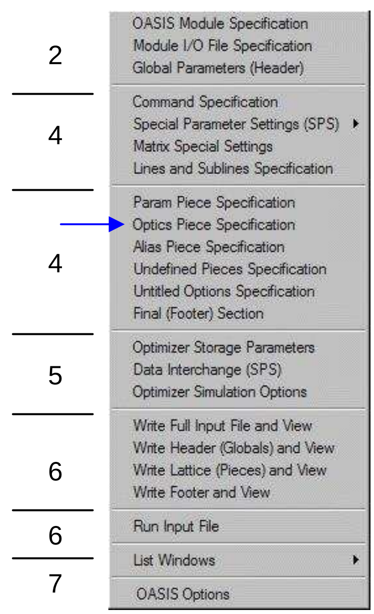
The OASIS custom Optics Piece provides the mechanism for adding a customized optics element to an OASIS Module.

When available, an existing PBO Lab Piece should always be used for standard particle optics elements in order to maintain compatibility with other PBO Lab and OASIS Modules. See Figure 53 for a summary of existing Pieces on the PBO Lab Palette. The OASIS Optics Piece can be used for adding specialized optics elements unique to the OModule being developed.

Wien Filter Example for PSI-TRANSPORT

The first step in defining a User Piece is to assign a Name to the new Piece being created. Using the OASIS Commands menu select the item: Optics Piece Specification. An OASIS Piece Specification name assignment window will open. Type in the name for the Optics Piece being defined. Figure 81 shows an example with the name for the new Piece: Wien Filter.

Manual Section



The OASIS custom Optics Piece setup starts with the Optics Piece Specification menu item

Figure 81. OASIS Piece Specification name window for a Piece to be called Wien Filter.

The named OASIS Piece must be dragged to the Model Space in order for it to be recognized as a valid piece in the OASIS Module. It is not necessary to keep the original copy of the piece on the Work Space.

After the name for the new Piece has been entered, select the OK button. The window shown in Figure 81 will close and an Optics Piece icon will appear on the Work Space. Move (shift-drag) the Optics Piece to the Model Space. Double clicking on the Optics Piece icon opens a Piece specification window that is used to define parameters, specify syntax for the Main Input File, and complete other steps similar to those described at the beginning of Section 4 for OASIS Comm Pieces. Figure 82 shows the Piece specification window for the “Wien Filter” Piece created as illustrated in Figure 81. Descriptive text has been entered into the Comment field. This default comment will appear to users of the OModule whenever a Wien Filter Piece is placed on the Work Space or Model Space.

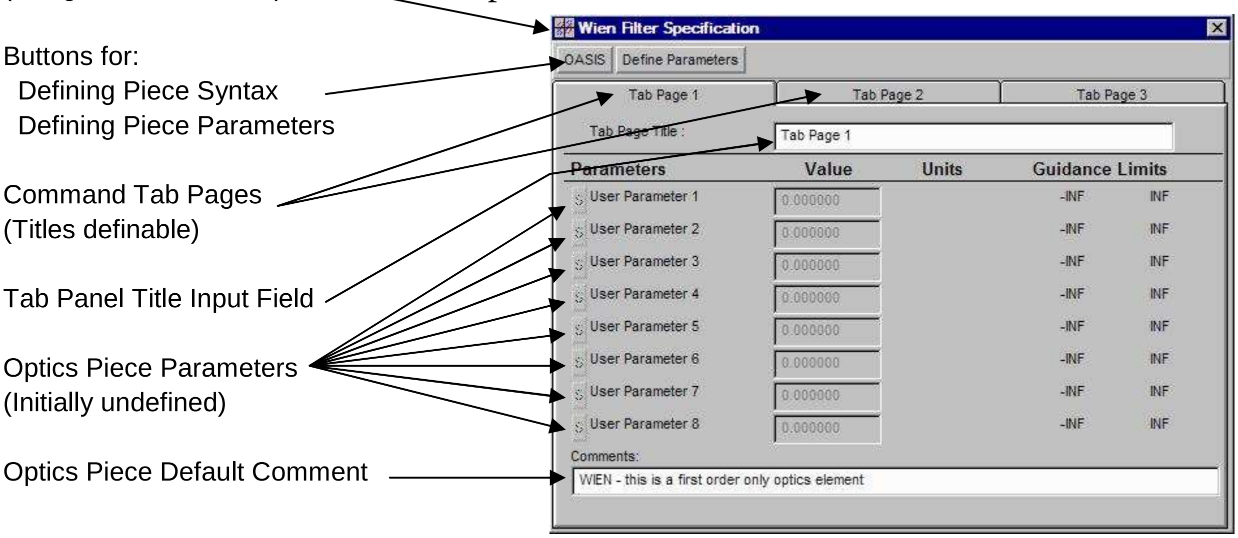


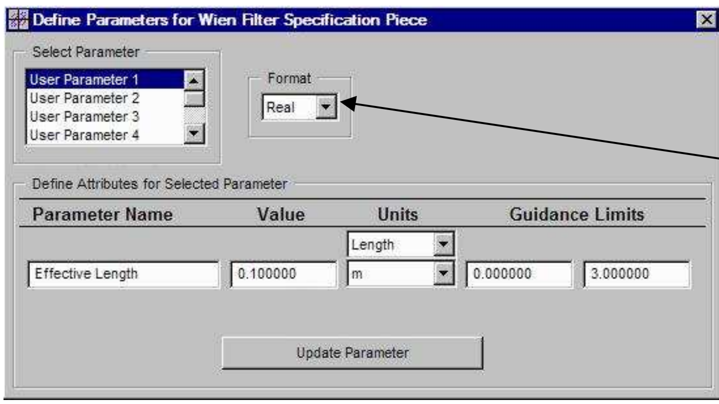
Figure 82. Wien Filter Specification window for defining parameters and syntax.

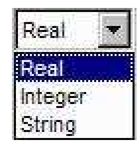
The Define Parameters button in the button bar at the top of the Optics Piece specification window is used to open the Parameter Definition window for the Optics Piece.

To start the specification of the Wien Filter parameters, select the Define Parameters button located in the button bar along the top of the Piece specification window. This will open the Parameter Definition window for the parameters appearing on the front Tab Page.

There are eight (8) parameters available for definition on Tab Page 1, and ten (10) each for the other tab pages. The Wien Filter described here is being defined for the PSI-TRANSPORT OModule, and only two parameters are needed: the Effective Length and the Magnetic Field Strength. Figure 83 shows Define Parameters window with the input, or attribute assignments, completed for the first parameter.

Initially, each custom Optics Piece contains generic parameters that can be configured as required. This includes formatting and naming the parameters, specifying default values, selecting a units type and default units, as well as specification of lower and upper guidance limits.





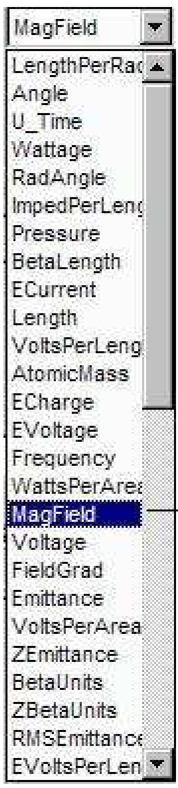
Format selection choices for Optics Piece parameters

Figure 83. Define Parameters window for specifying the Wien Filter first parameter, Effective Length.

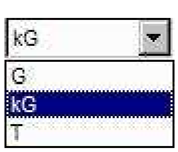
Parameter attributes that need to be assigned are the Format, Parameter Name, the default Value, the Units type and default units, as well as Guidance Limits (optional). Three Format types are available: Real, Integer, String. The Units type is selected through the upper pop-up under the Units heading. The selection "Length" has been made in the Window illustrated in Figure 83. (A view of Units types available is illustrated on the following page.) Once the Units type is selected, then the default units are selected from the choices in the lower pop-up. The default Value of the parameter, and the optional Guidance Limits, must have numerical values appropriate to the selected default units. PBO Lab Users of the OModule will be able to select different units for their input, just as for any other PBO Lab Piece. For the Wien Filter example shown in Figure 83, the default units for the Effective Length are meters (m).

The Parameter Definition window allows individual parameters to be selected and provides input fields for the specification of the parameter attributes: name, default value, units type, units choice and limits. Once accepted, the selected parameter is updated directly in the named Optics Piece Specification window.

At least one parameter must be specified, and up to twenty-eight (28) parameters total may be specified, for each custom Optics Piece. The Update Parameter button in the Define Parameters window is used to accept the parameter attribute inputs.



Units type menu, for use in specifying any real (non-integer) parameter units, with the MagField choice selected.



Individual units available for Units Type: MagField

The second parameter for the Wien Filter example described here is the Magnetic Field Strength. Figure 84 shows the assignment of the attributes for the magnetic field strength parameter named: "Vertical (y) Magnet Field". For this magnetic field parameter, the Units type is "MagField" and the default Units are kilogauss (kG).

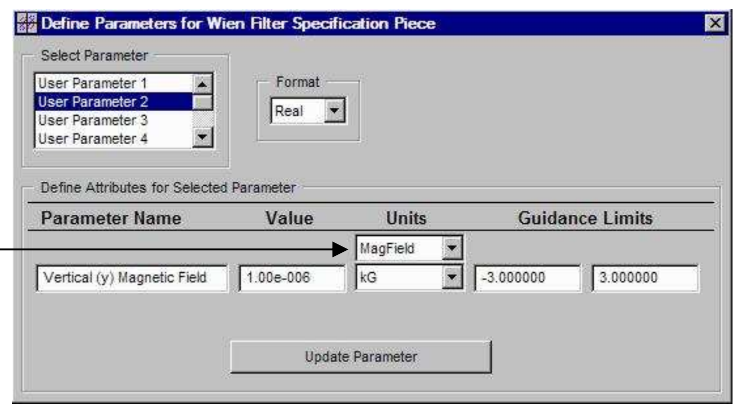


Figure 84. Define Parameters window for specifying the second parameter, Vertical (y) Magnetic Field.

When the Update Parameter button is selected, the attributes for the currently displayed parameter are added to the Optics Piece definition. The parameters are automatically updated in the Piece specification window each time the Update Parameters button is used. Default Symbolic Parameter Names, for use in the Optics Piece syntax, are also assigned when the Update Parameter button is pushed. Figure 85 illustrates the Wien Filter Piece specification window after the two parameter definitions, Effective Length and Vertical (y) Magnetic Field, are completed.

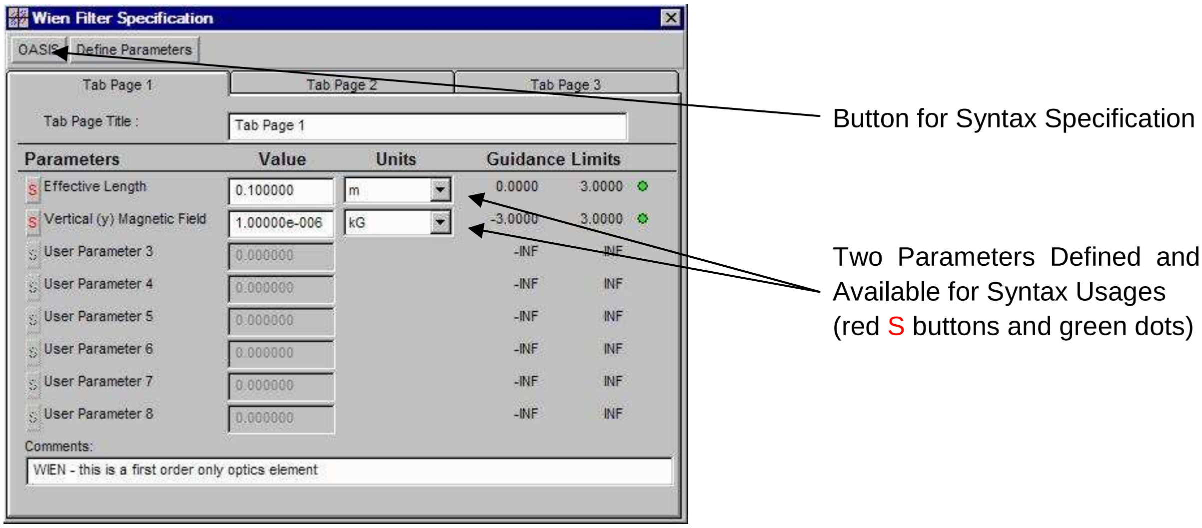


Figure 85. Wien Filter Specification window showing two defined parameters, ready for syntax specification.

Similar to the Comm Piece functionality, default Special Parameter Settings (SPS) including the Symbolic Parameter Name are automatically assigned when the Update Parameter button is used (Figure 83 or 84). This is clear in Figure 85 by the red "**S**" buttons to the left of each parameter. If the default SPS attributes need to be modified for a parameter, simply select the "S" button appearing to the left of the parameter to open the Special Parameter Settings (SPS) window. Figure 86 shows the SPS window, with default settings, for the Effective Length parameter.

As with all PBO Lab Piece specifications, there must be at least one Optics Piece parameter assigned a Symbolic Parameter Name. Default assignments for Symbolic Parameter Names are made in the SPS window for each parameter selected. Any parameter with a Symbolic Parameter Name may be used in the Piece syntax.

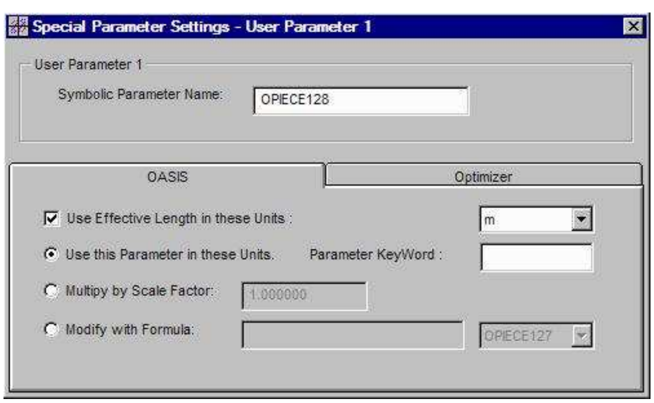
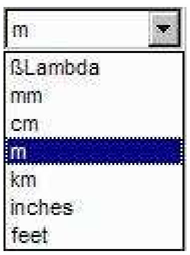


Figure 86. Special Parameter Settings (SPS) window for the Effective Length of the Wien Filter Piece.

The parameter name (User Parameter 1) appearing in the SPS window is what is used internally by OASIS for storing and manipulating the parameter's attributes, including the parameter's name. The “Effective Length” parameter is the name attribute that was assigned to User Parameter 1 of the OASIS Piece named “Wien Filter.”



Individual units available for Units Type: Length

For the Effective Length parameter of the Wien Filter, the SPS window shown in Figure 86 provides a choice of units for use when retrieving this parameter (e.g. for the syntax used to write the Wien Filter lines to the Main Input File). Figure 86 shows the selection of “m” -- the same as that used for the default units. However, these need not be the same, when for example the optics code needs the parameter in meters in the Main Input File, but a more convenient choice for users of the OModule, such as centimeters (cm) or inches (in), is more appropriate.

It is sometimes useful to get a parameter in different units (e.g. cm) and then scale by a factor (e.g. 0.01) to utilize the parameter in certain units (e.g. m), even though those units are available directly. This will exclude the Special Parameter Setting (SPS) attributes from that particular parameter.

The same Special Parameter Settings (SPS) attributes selected for the standard PBO Lab Pieces (Figure 65) are also available for Optics Pieces. However, just like regular PBO Lab Pieces, if the Modify by Scale Factor or the Modify by Formula option is used, those attributes will not be available to that Optics Piece parameter.

Once the Optics Piece parameters have been specified, the Optics Piece parameters are used, like the parameters in any other PBO Lab Piece, in a syntax specification to define the native instructions that will be generated when a Piece of this named type is encountered in a PBO Lab beamline model.

The final step in defining the Wien Filter is to specify the Piece syntax needed by the PSI-TRANSPORT code. The OASIS button in the Wien Filter Piece specification window (Figure 85) is used to open an Input Syntax window. The procedure for specifying the syntax is the same as that used for any other Piece used by the OASIS Module. The procedure is described in detail, with several examples illustrated, in Section 3 of this manual. Figure 87 shows the Input Syntax for Wien Filter window.

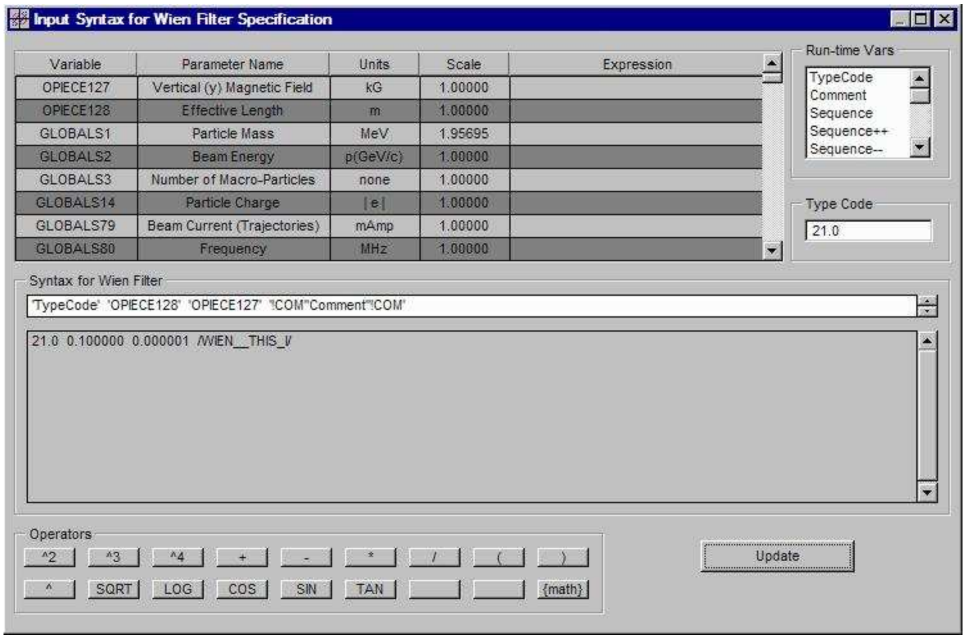
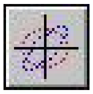


Figure 87. Input Syntax for Wien Filter Specification window used for specifying how the Wien Filter parameter data is to be written to the Main Input File (FOR001.dat) for the PSI-TRANSPORT code

The PSI-TRANSPORT type code for the Wien Filter is 21. This Type Code is entered into the Input Syntax window. The Type Code, the two parameters Vertical (y) Magnetic Field and Effective Length, and Piece Comment are included in the Syntax for Wien Filter Piece. The Update button must be selected to accept (and store) the syntax. Selecting the button will also display the syntax evaluation results in the lower pane, for the parameter values appearing in the Wien Filter Specification window (Figure 85). See Section 3 for further information on specifying syntax.

A syntax specification must be defined for an OASIS custom Optics Piece. Otherwise, nothing will be done with the defined parameters when users utilize the Piece in an OModule.

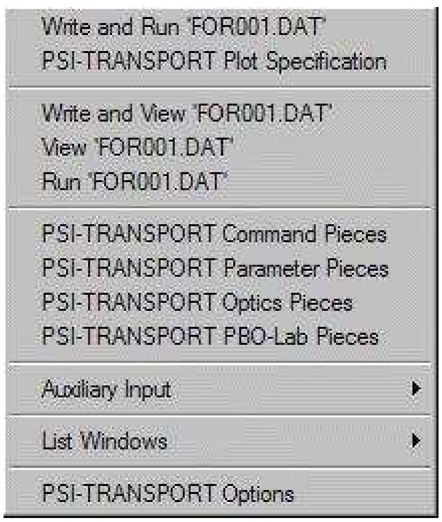
Note: A Wien Filter Piece may be added to the PBO Lab Palette in a future release.



What the PSI-TRANSPORT OModule User Sees for the Wien Filter Piece

This short section provides a summary of how a user will utilize an OASIS Optics Piece, specifically the Wien Filter described in the preceding section, as he or she interacts with the OModule developed for the PSI-TRANSPORT code. It is the type of material that might appear in a user manual for the PSI-TRANSPORT OModule, but should prove illustrative of the Optics Piece capabilities to developers of OASIS Modules.

When a PBO Lab user opens a new (or existing) beamline model file (.pbol extension) the file will open in a Document Window similar to those illustrated in the PBO-Lab User Manual or this OASIS User Manual. If the PSI-TRANSPORT OModule is installed, an entry named PSI-TRANSPORT will appear in the Context Switch (upper left corner of the Document Window), on the Commands menu, on the View menu, and elsewhere in the PBO Lab Document Window, similar to that for any other PBO Lab Module. The PSI-TRANSPORT submenu of the Commands menu will have an entry "PSI-TRANSPORT Optics Pieces." Selecting the PSI-TRANSPORT Optics Pieces item opens a window that provides a list of all User Pieces defined for the OModule. Figure 88 shows the PSI-TRANSPORT Optics Pieces list window.



Items appearing on the Commands submenu for an OModule can depend upon an OModule's specifications, as developed in the OASIS Module Builder. They may be different than those illustrated above.

Defined OASIS custom Optics Pieces do not appear on the PBO Lab Palette Bar. Instead, they appear in a window that lists all custom Optics Pieces that have been defined for use with that OASIS Module.

The PSI-TRANSPORT Optics Pieces window illustrated in Figure 88 shows only one entry: Wien Filter. If other custom Optics Pieces have been defined, they will also appear in the window. A user selects the Wien Filter entry in the list, and then uses the "Create Piece" button to make a Wien Filter Piece. The Wien Filter Piece icon will appear on the lower left part of the Work Space.

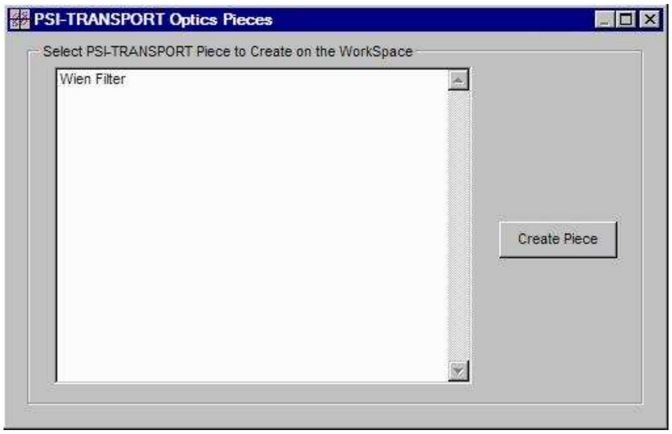
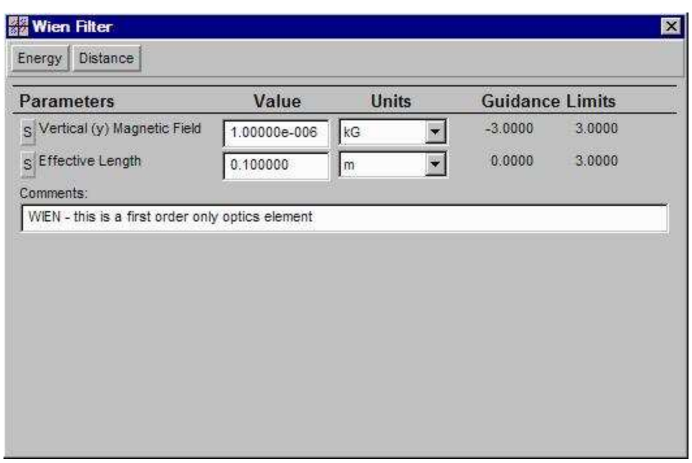


Figure 88. The PSI-TRANSPORT Optics Pieces list window showing custom Pieces for this Module

Once a Wien Filter Piece has been created, it can be used just as any other PBO Lab Piece is used. To use the Piece in a beamline, move (shift-drag) or copy (drag) the Piece to the desired location in the beamline on the Model Space of the PBO Lab Document Window. Double clicking the Piece icon for the Wien Filter will open the Wien Filter Piece window. The custom Wien Filter Piece window is illustrated in Figure 89 and shows the Piece parameters whose specification was developed in the preceding pages. Only the two parameters selected and defined for the Wien Filter appear in the Piece window.



The Wien Filter Piece window functions the same as any other Piece window. Parameters may be edited, in the units desired by the user. Any Special Parameter Settings (SPS) attributes defined for the OModule are accessed by the “S” button.

Figure 89. Piece Window for the Wien Filter developed for the PSI-TRANSPORT OModule.

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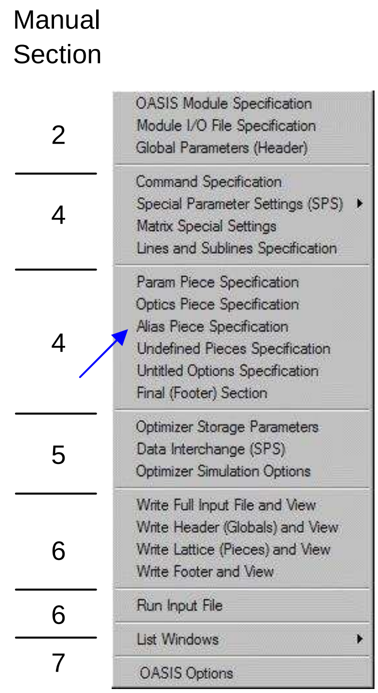
Alias Piece & Alias Subline Specification

The Alias Piece in PBO Lab can be used for any individual optical component (Piece) which is to be replicated. An Alias Piece represents an individual optical component with parameters identical to those of another component, referred to as the Original Piece. The parameter data are set in the Piece window of the Original Piece and any subsequent use of the same component is accomplished with the use of an Alias Piece. Similar comments apply to Alias Sublines. An Alias Subline represents a subline whose data is identical to that of another subline, or Original Subline. In this discussion, the term Alias refers to either an Alias Piece or an Alias Subline.



Select the Alias Piece Specification item of the OASIS Commands menu to open the Alias Syntax Specification window

The OASIS Commands menu contains an item named Alias Piece Specification. Selecting this item opens a window similar to that illustrated in Figure 90. The Alias Syntax Specification window has these primary parts: an Alias Representation pane, a specialized Run-time Vars list, and Alias Syntax input and evaluation fields.

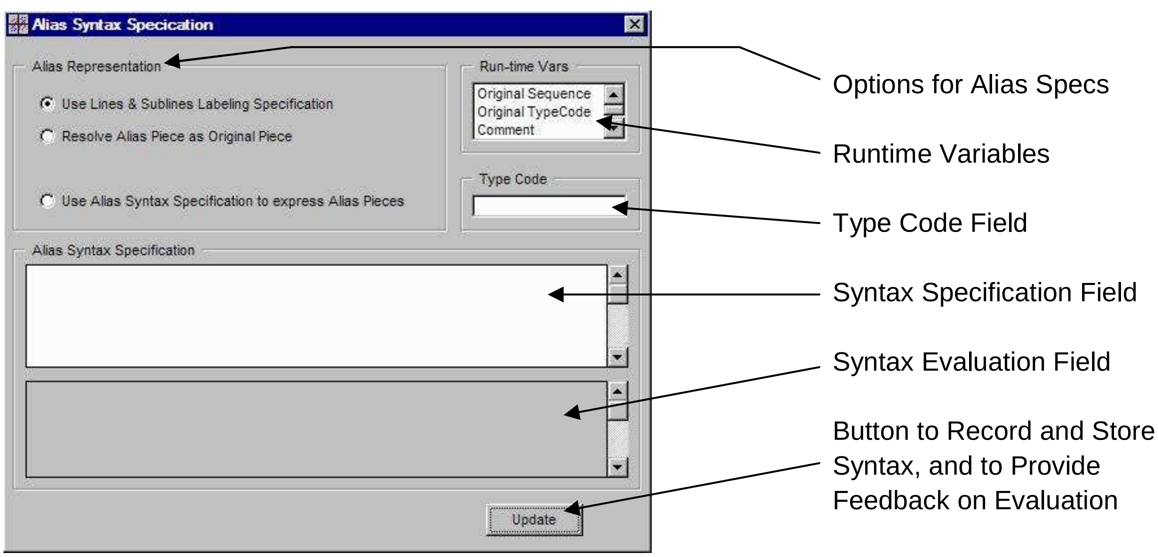


Figure 90. Alias Syntax Specification window used for defining the syntax of Alias Pieces and Alias Sublines.

The default setting for the Alias Representation is: Use Lines & Sublines Labeling Specification. For this selection no other input is required. This default setting is useful for computation engines that support hierarchical beamline lattice descriptions. The Aliases will be written using the same specifications as defined for writing lines and sublines (see Figure 69). This facilitates the representation of hierarchical beamline structures in which an Alias's Original Piece or Subline *is referenced by label*. The DIMAD-sample OModule utilizes the default setting for the Alias Representation.

The second choice for Alias Representation is: Resolve Alias Piece as Original Piece. This selection is appropriate for computation engines that do not support the concept of an identical or alias element. Each Alias Piece will be written as a copy using the syntax specified for the appropriate Original Piece. Versions of TRANSPORT that use the "old" style positional notation input file are examples that would use this selection, and the PSI-TRANSPORT OModule utilizes Resolve Alias Piece as Original Piece.

The Alias Syntax Specification is useful for computation engines that support an alias concept, but do not use a naming or labeling scheme. For example, the identical element in TRACE 3-D is represented by an Alias Piece. A TRACE 3-D Alias Piece references its original element by the Runtime Variable 'Original Sequence'

The last choice for Alias Representation is: Use Alias Syntax Specification to express Alias Pieces. Figure 91 illustrates an example of this type for TRACE 3-D.

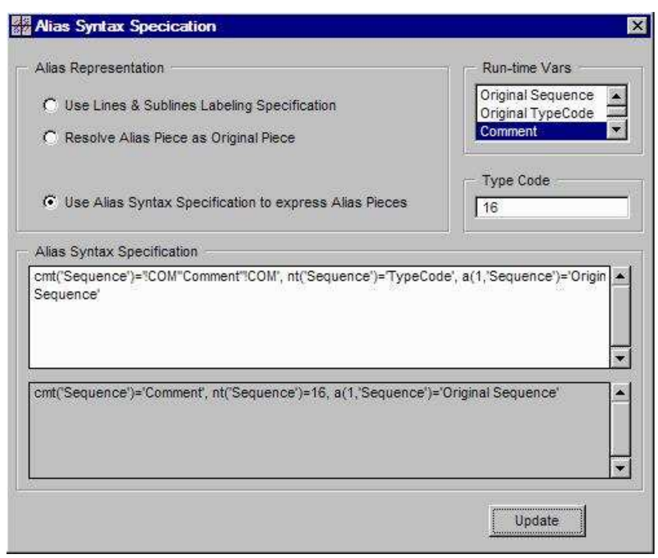
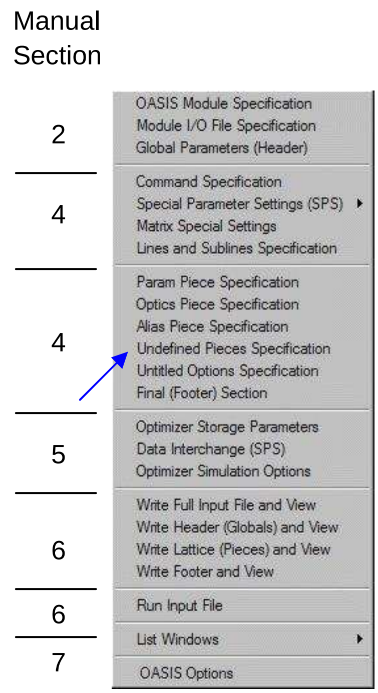


Figure 91. Alias Syntax Specification window used for TRACE 3-D.

Undefined Piece Specification

The PBO Lab environment offers a large spectrum of Pieces, both those representing beamline optical components, and those representing other location specific data that does not correspond to a physical element. No computation engine uses all of the PBO Lab Pieces -- the Piece set in PBO Lab is a superset of all possible location specific data structures that can appear in any of a large set of computation engines (see Figure 53). Consequently, it is almost certain that there will be some Pieces which cannot be meaningfully specified for any particular optics code. In addition, during the development of an OModule, not all applicable Pieces may have been specified initially, resulting in some undefined Pieces for that OModule. The Undefined Piece Specification is used by an OModule to process any PBO Lab Pieces encountered that have not been defined for use by the computation engine of that OModule.



Use the Undefined Pieces Specification item of the OASIS Commands menu to specify how to handle PBO Lab Pieces not yet defined for an OModule.

The Undefined Pieces Specification item on the OASIS Commands menu opens the Undefined Pieces window illustrated in Figure 92.

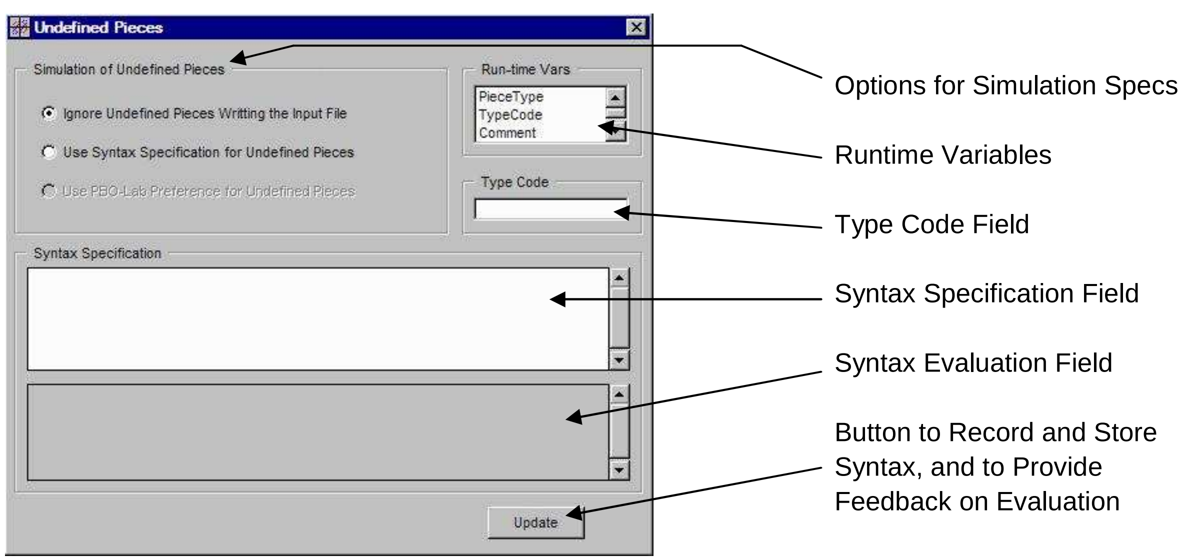


Figure 92. Undefined Pieces specification window

The Run-time Vars for the Undefined Pieces specification include items internal to PBO Lab Pieces as well as standard OASIS runtime variables. Items internal to all PBO Lab Pieces include:

PieceType (text string)
Length (in meters)

There are three options for the Simulation of Undefined Pieces. The first choice is to simply ignore any undefined Pieces when writing to the Main Input File. This is the default setting (Figure 92) and is useful during the early development of an OASIS Module Specification Document. The use of the second option, to utilize a specified syntax, is recommended for most cases. Examples are illustrated below. The third option is to utilize the PBO Lab Preferences setting for how to Simulate Unsupported Pieces (see Figure 3 for an illustration of the PBO-Lab Preferences window). This option may be useful for completed OModules.

One consideration in utilizing the second choice for the Simulation of Undefined Pieces is to provide users of the OModule with information that can be utilized to adjust their lattice or beamline to eliminate undefined Pieces. If the computation engine supports comment lines in the Main Input File, then adding a comment to identify specific undefined Pieces can be useful. Figure 93 illustrates a completed Undefined Pieces specification window for the DIMAD-sample OModule that includes this information.

Any Piece Not Explicitly Defined in the Module Specification Document Will Utilize the Syntax Specification Given in This Window

Syntax Will Write 2 Lines and Includes 3 Runtime Variables:
Comment
Length
PieceType

Syntax Evaluation Field Can Not Display Evaluate Runtime Variables Since They Are Only Meaningful in Context of a PBO Lab Model

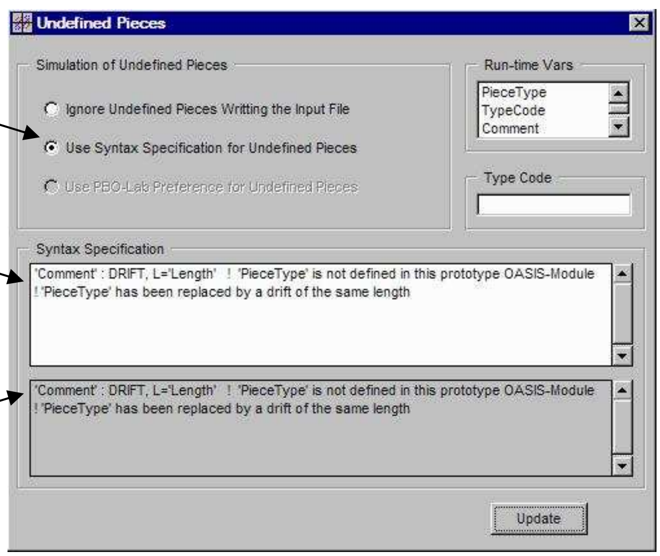
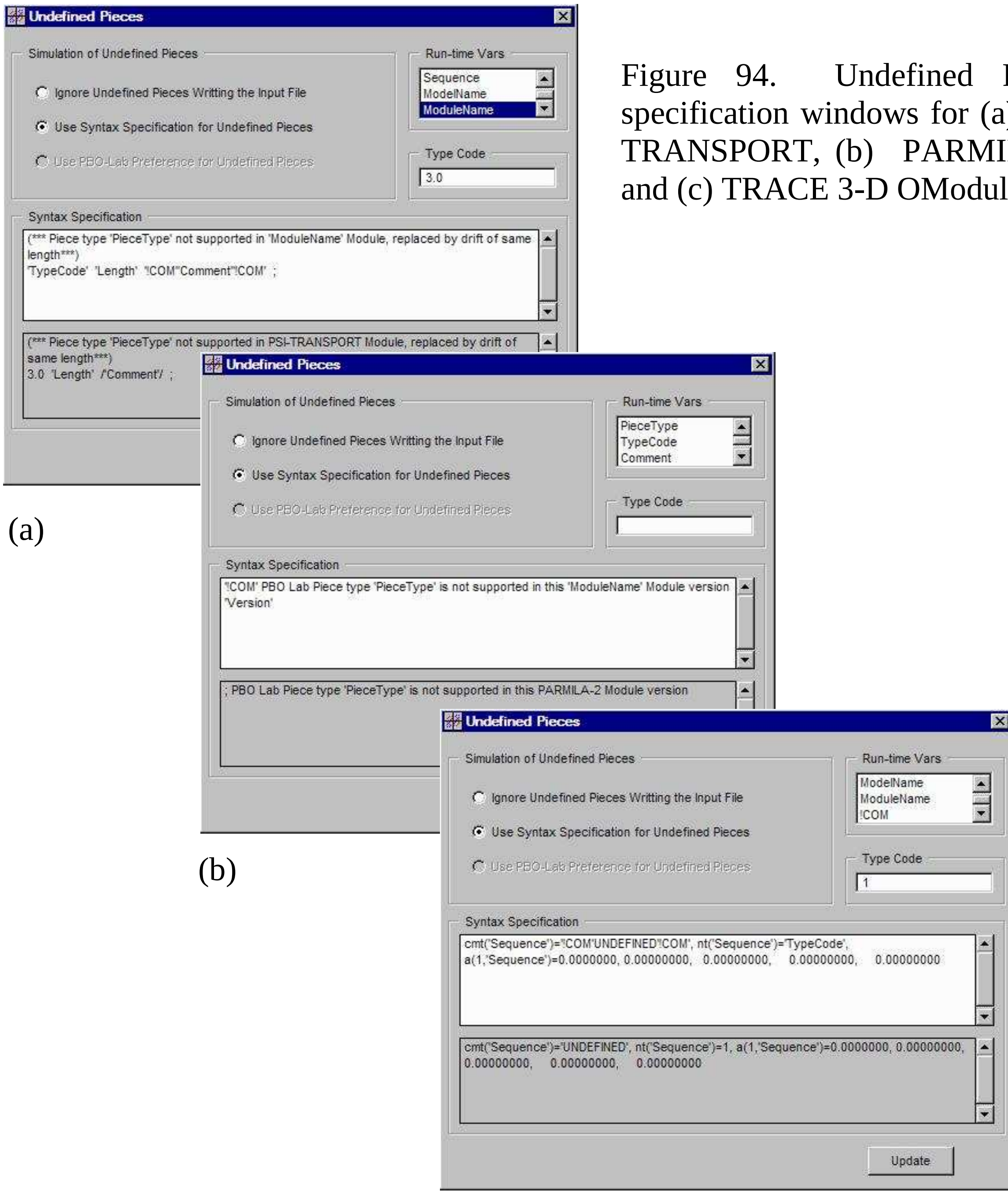


Figure 93. Undefined Pieces specification window for the DIMAD-sample OModule.

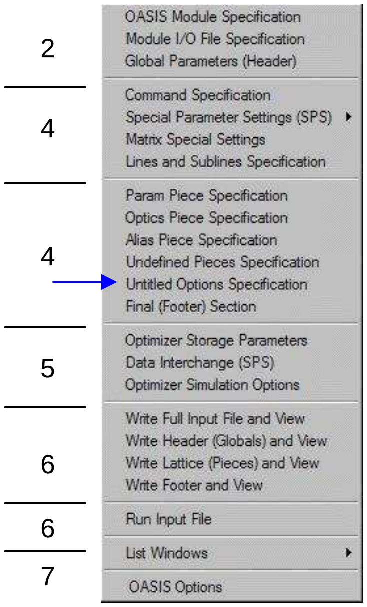
Figure 94 shows examples of other Undefined Pieces specification windows for OModules developed for different computation engines. Different "diagnostic" information will be written to the Main Input File in each case, working within the capabilities and limitations of the corresponding optics code.



(a) (b) (c)

Figure 94. Undefined Pieces specification windows for (a) PSI-TRANSPORT, (b) PARMILA-2, and (c) TRACE 3-D OModules.

Manual Section



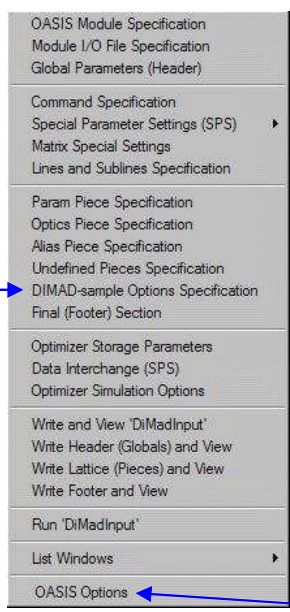
The name of the Untitled Options Specification item on the OASIS Commands menu will change to reflect the Module Name when assigned.

OASIS Module (OModule) Options

Most particle optics codes have a number of ways in which they can be used. Some of these capabilities are implemented for an OModule using the Command Piece specifications described earlier in this Section the User Manual. Other capabilites may be implemented through the use of OModule Options. The OASIS Module (OModule) Options provide a method for specifying options that are available to the user of the computation engine. The Options may also be used as a "catch all" location for implementing certain OModule capabilities not readily implemented elsewhere using the OASIS Module Builder. Figure 70 illustrates an example of the multi-tab panel OASIS Module Option Specifications window.

Once a Module Name has been assigned (see Figure 6) there will be an entry on the OASIS Commands Menu with the Module Name followed by Options Specification. Selecting this menu item opens an OModule Options Specification window. Figure 95 illustrates how this window would appear for the DIMAD-sample OModule, prior to setting any options.

There are several tab pages on the DIMAD-sample Options Specification window. The first three are described here: Numerical Constants, String Constants, and Comment Delimiters. OModule options provide *global type* parameters and runtime variable specifications that are specific to a given OModule. Access to OModule options can also be made available to users of an OModule for modification.



OASIS Options are used to specify features of an OModule that cannot be altered or edited by an OModule user. OASIS Options can be utilized to fix number formats, provide PBO Lab constants, and specify similar features that may be required by the underlying computation engine. OASIS Options are discussed in Section 7.

The DIMAD-sample Options Specification opens the DIMAD-sample Options Specification window.

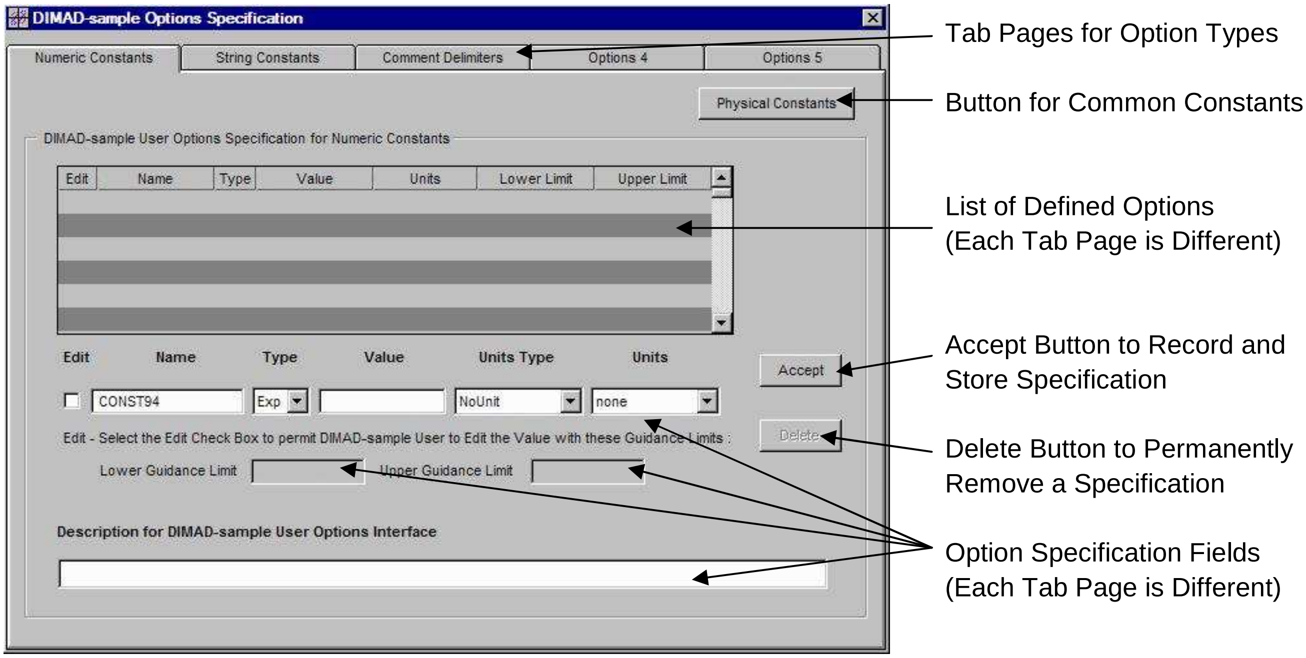


Figure 95. DIMAD-sample Options Specification window prior to setting any options.

The Options window shown in Figure 95 is for an OModule that has the assigned name DIMAD-sample, as illustrated in Figure 6. The OModule name (DIMAD-sample) appears in the title of the Options Specification window. The Numeric Constants panel is the front-most tab panel and illustrated in Figure 95.

The Numeric Constants tab is used to define constant names, type, assign default values, specify units, and guidance limits. In addition, checking the Edit box appearing to the left of the parameter specification Name field will make the numerical value of the parameter editable by an OModule user. If the Edit box is not checked, OModule users will be able to view the parameter but not change its value. In either case, the parameter (referenced by 'Name') can be utilized for syntax specification throughout the OASIS Module Specification Document.

Numeric Constants may be used to define specific constants, or global-like parameters, that can be used throughout the various syntax fields of an OASIS Module Specification Document. Any Numeric Constants defined in the OModule Options Specification window may be made available as editable parameters to users of the OModule.

The Name field will initially be filled with an automatically generated default value created by the OASIS Module Builder software that will assure a unique Name for the parameter. This is similar to the default names generated for other parameters throughout the OASIS Module Builder. A newly generated, unique, default Name will appear whenever an empty row in the list of defined options (Figure 95) is selected.

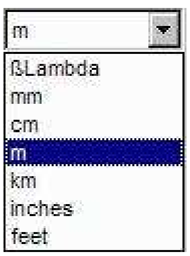
A variety of units choices are available for use with the Numeric Constant parameters. There are two popup menus (combo boxes) that are used to define the units for Numeric Constant parameters (see Figure 95). The Units Type menu is used to select the type of units from among the extensive list of unit types available for use in OModules. Once a Units Type has been selected for a given Numeric Constant parameter, several choices are available for assignment to the numerical default value of that Numeric Constant parameter. This selection is made using the second Units popup menu. The specific choices available depend upon the units type selected. The choices available for both the Units Type and the Units selections are the same as those available to Real formatted parameters of OASIS Comm Pieces and OASIS Optics Pieces.

The beta-lambda unit (βLambda) is a "smart unit" available in PBO Lab Modules, including OModules developed for PBO Lab, to express length parameters in terms of the wavelength of the Global Parameter Radiofrequency (RF) times the relativistic velocity parameter beta = v/c. The beta-lambda unit is useful for systems which have radiofrequency accelerator components. Additional smart units are available for certain other Unit Type selections.

Numerical Constants may be of three Types:

Int = Integer Format
Real = Fixed Decimal
Exp = Scientific Exponential

These Types indicate how the parameter will appear to an OModule user in the graphic interface, not the format that will be used to write the parameter to the Main Input File of the OModule (see Section 7).



Several Units Types, such as Length*, offer "smart unit" options in addition to standard (fixed) units. For* Length*, the available units include the smart units choice beta-lambda (*βLambda*) as well as millimeters (*mm*), centimeters (*cm*), meters (*m*), kilometers (*km*), inches (*in*), and feet (*ft*). While smart units are often useful to OModule users, it is recommended that only* *<u>fixed</u>* *units be utilized for default settings. Otherwise the default value (associated with the default units) could depend upon Global Parameter values.*

.

In assigning default units to Numeric Constants it is recommended that a fixed unit choice, rather than a "smart unit" choice, be used. For example, if a smart unit choice is used for a length parameter default unit, the default value would then be dependent upon certain Global Parameters assigned by the user in a PBO Lab Model, such as the Beam Energy, Particle Mass, or Radiofrequency. This could result in unintended consequences. Users of an OModule will still be able to use a smart unit for any Numeric Constants that has a Unit Type with a smart unit choice, but the default value for the OModule will be stored in fixed units.

The Edit check box is used to make the Numeric Constant available for modification by the OModule user. If the Edit box is not checked, the OModule user will be able to view the Numeric Constant, but not change the value from the default.

Figure 96 illustrates how the Options Specification window appears for the DIMAD-sample OModule with the option specification fields filled in, but where the data has not yet been recorded or stored.

The Lower Guidance Limit and the Upper Guidance Limit specification fields become activated for input only if the Edit check box is selected. These limits are used only to provide the OModule user with guidance, they do not limit any numerical value from being entered.

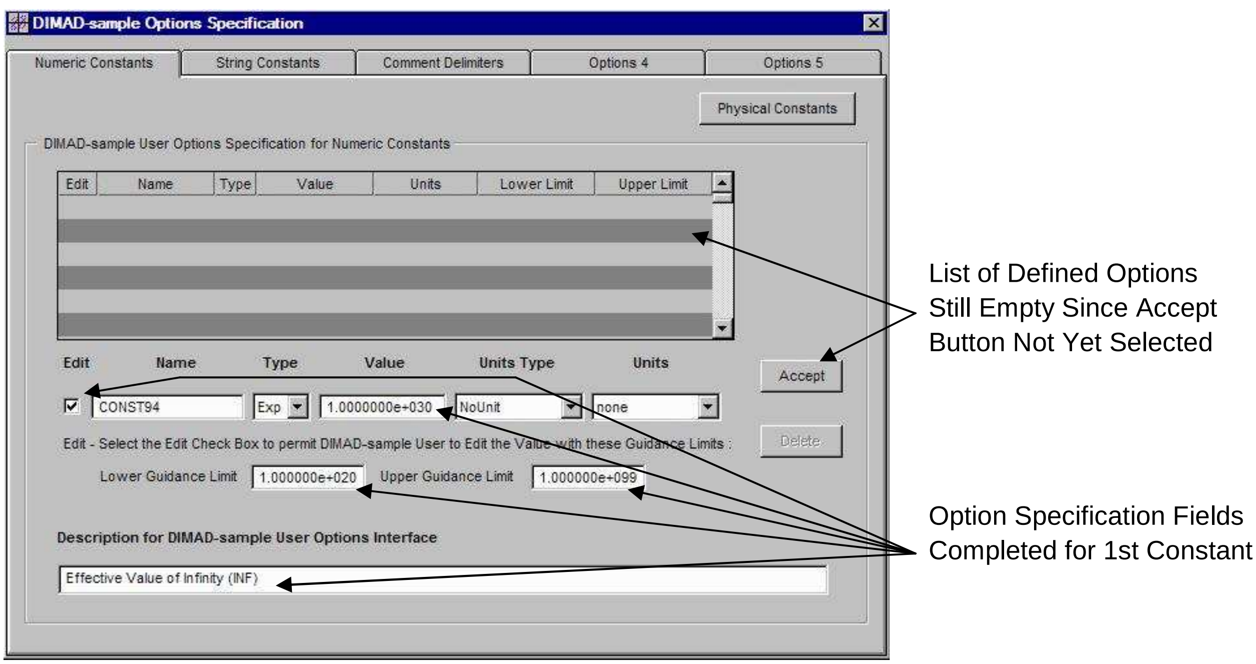


Figure 96. DIMAD-sample Options Specification window with specification fields completed for first Numeric Constant.

The example shown in Figures 95-97 retains the default name CONST94 *that was generated by OASIS for this Numeric Constant. This name will appear to an OModule user. Here is a case where the OModule developer may want to utilize his/her own name, for example by changing the item* CONST94 *to* INFINITY *or something similar. The name must be different from any other name used in a Module Specification Document.*

Once a Numeric Constant has been specified, the Accept button is used to record and store the information in the specification fields for that constant. This will result in a line appearing in the list. There will be one line for each Numeric Constant specified (and the Accept button selected). Once an entry appears in the list, it may be selected and the details for that item will appear in the specification fields. Both the Accept and Delete buttons will become active. The entry may then be edited or deleted. Figure 97 illustrates the appearance of the DIMAD-sample OModule Options Specification window after the Accept button for CONST94 has been used and the list entry then selected.

List Updated when the Accept Button is Selected

When Entry in List is Selected the Specification Fields Give the Entry's Details and the Accept & Delete Buttons are Activated

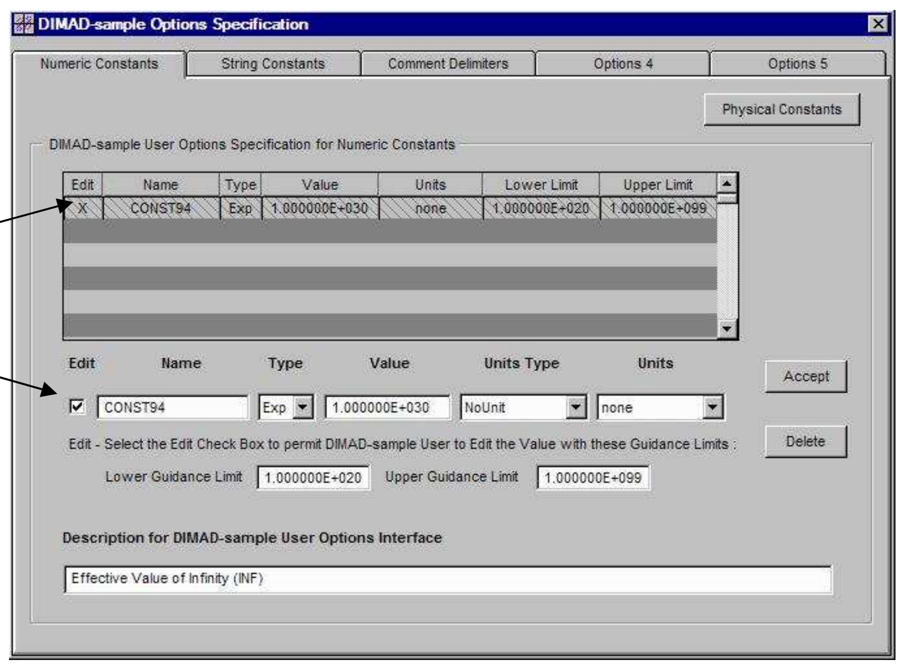


Figure 97. DIMAD-sample Options Specification window with CONST94 data recorded and stored.

In addition to Numeric Constants, text String Constants can be specified. The specification and recording procedures for String Constants are very similar to those used for Numeric Constants. Figure 98 illustrates an example of this type of option, set up for the DIMAD-sample OModule.

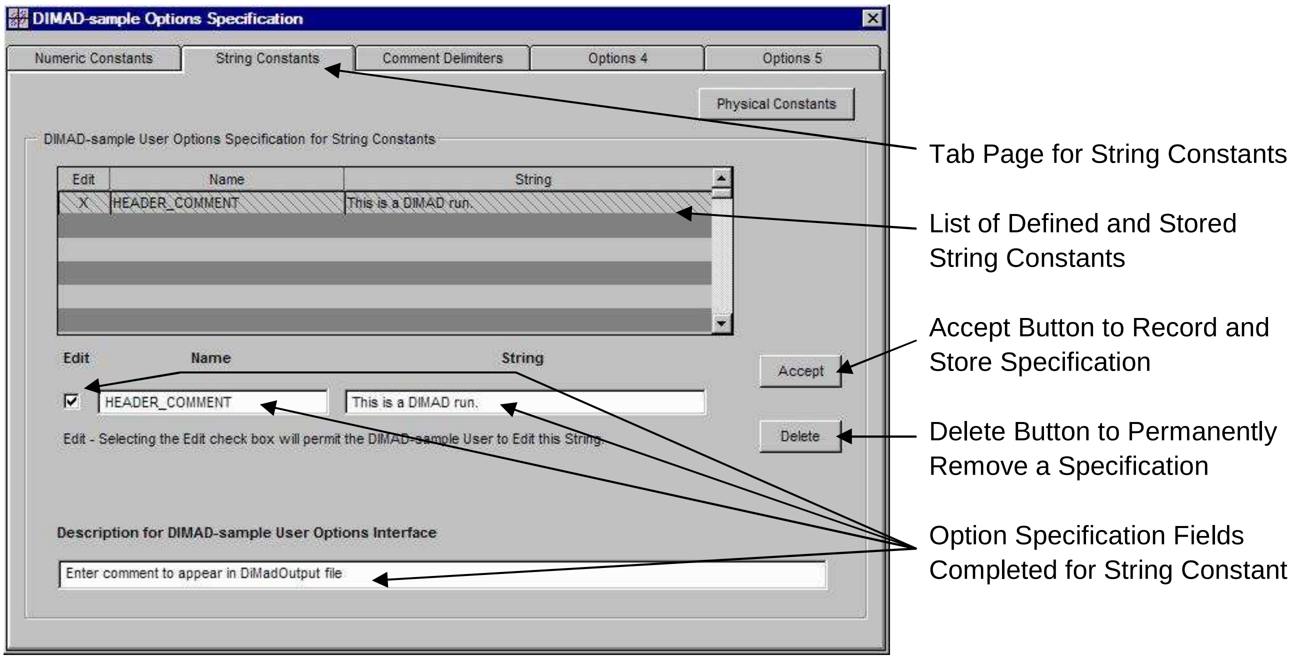


Figure 98. DIMAD-sample Options Specification window for a user editable String Constant.

In the example shown in Figure 98 the default name that was generated by OASIS for this String Constant has been changed to:

HEADER_COMMENT

Any name entered must differ from all other names in an OASIS Module Specification Document and the name <u>must not contain any spaces</u>.

The specification fields for String Constants include an Edit check box, Name, default String and Description entry fields. Once the specification is entered, the information is stored using the Accept button. Figure 98 illustrates an example where the OASIS Module Builder generated default name for this String Constant (STRING159) has been changed. The new name for the String Constant is HEADER_COMMENT. This name will be global to the OASIS Module Specification Document, and can be used anywhere an OModule syntax can be defined. For the DIMAD-sample OModule it would make sense to add something like

'!COM' 'HEADER_COMMENT'

to the Header syntax specification (see Figure 13).

Another type of OModule option is the character to be used for the evaluation of the comment delimiter !COM runtime variable. An Options Specification window with the Comment Delimiter tab page in front is illustrated in Figure 99.

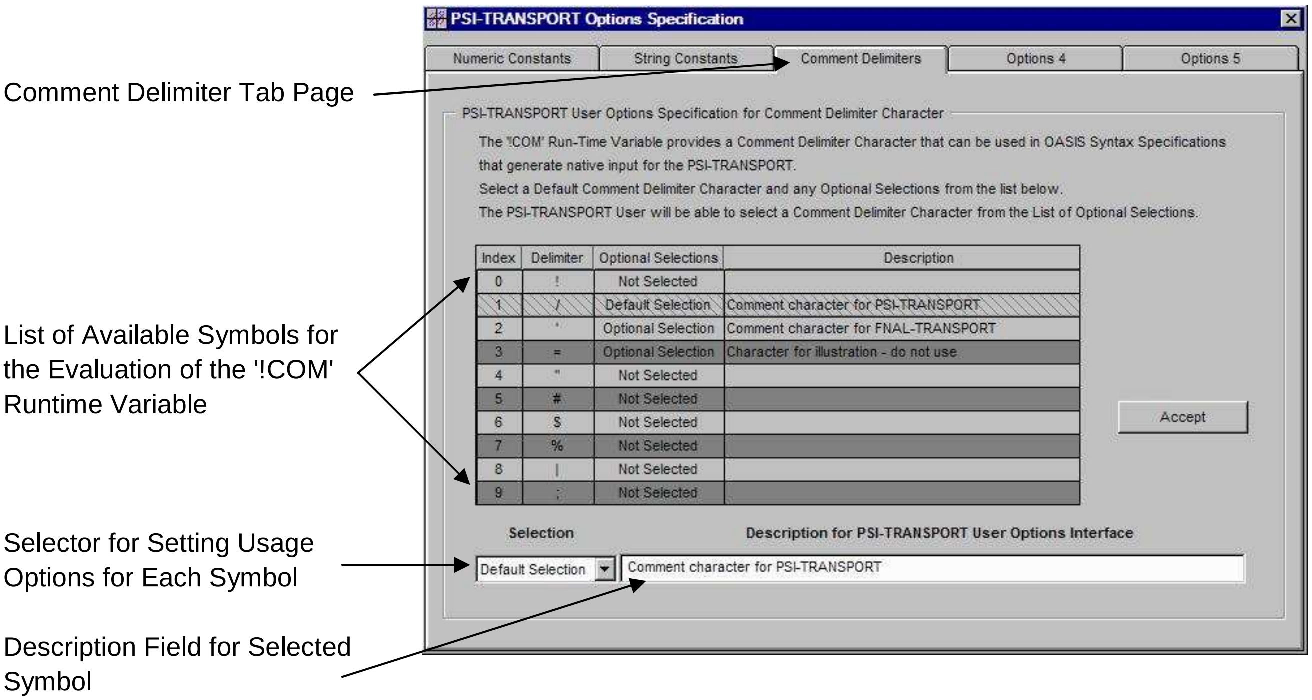
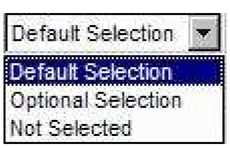


Figure 99. PSI-TRANSPORT Options Specification window for a user modifiable Comment Delimiter.



There are three selection choices for each symbol to be used in the evaluation of '!COM' *whenever it appears in a syntax specification.*

The Comment Delimiter tab page of the Options Specification window provides different symbol options for specifying how the '!COM' runtime variable will be evaluated in any syntax that uses it. When a symbol is selected in the list, the Selection and Description fields become active. The Selection popup menu is used to specify how a given symbol can be used. All symbols are initially set to the Not Selected choice, meaning that no symbol is initially assigned to '!COM' evaluation. One symbol must be set to the Default Selection choice for '!COM' to be evaluated at runtime. (If no default selection is made, '!COM' will return nothing at runtime.) Other symbols may be added with the Optional Selection choice.

The Description field can be used to provide an OModule user with a text summary regarding the usage of any Optional Selection symbols made available. The example shown in Figure 99 illustrates how this might be used in constructing an OModule for the TRANSPORT code. There are several versions of TRANSPORT utilized around the world, but the input files are often incompatible for the different versions. How element labels are denoted is one notable difference. The default symbol selection (/) in Figure 99 would be for use with the PSI-TRANSPORT version, while an optional selection (') would be used for the FNAL version of TRANSPORT.

Many optics codes provide for the inclusion of comments, labels, and similar annotations in the input files, which are identified by particular symbols in the input file to the optics computation engine. Some of the symbols used for this purpose conflict with OASIS syntax requirements, and thus cannot be used directly in a syntax specification. Examples include the forward slash (/), which is reserved for the OASIS parser as the operator to denote numerical division, and single quote ('), which is utilized in OASIS syntax to denote the start and end of a parameter for evaluation by the OASIS parser. OASIS provides for a comment delimiter (!COM) that is a runtime variable which can evaluate to symbols not otherwise permitted in the syntax.

Even for symbols that may be used directly in an OASIS syntax specification, the use of the comment delimiter runtime variable may still offer advantages. For example, the comment delimiter may be readily changed throughout an entire input file, by selecting a different choice from the available list. This can be especially useful for certain computation engines which have several different versions with incompatible comment delimiter requirements. The symbols selected for use in the PSI-TRANSPORT OModule illustrated in Figure 99 are an example of such an application.

Final (Footer) Specification

The last element of defining the Main Input File format and syntax for an OModule is to specify the content of the closing lines, or footer section. Figure 100 illustrates the Input File Footer Specification window, opened using the Final (Footer) Section item of the Commands menu.

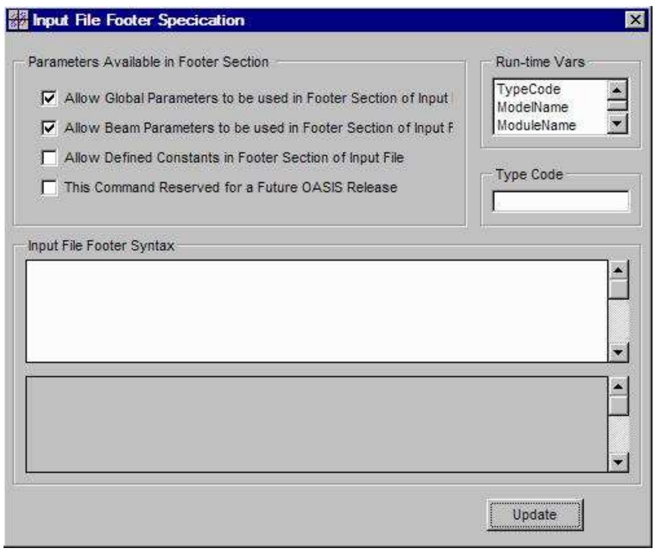


Figure 100. Input File Footer Specification window

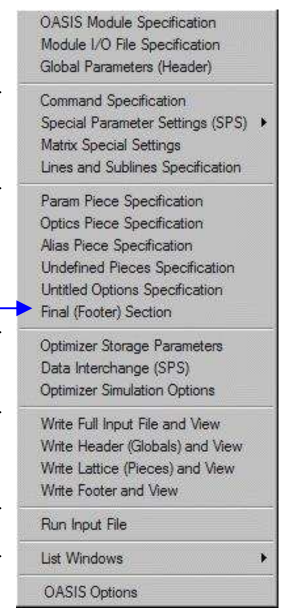
The field for specifying the syntax of the footer section is where any concluding lines, commands, or other requirements of the computation engine for the end of the Main Input File, are entered. Check boxes in the upper part of the window indicate the types of global OModule data (Global Parameters, Defined Constants, etc.) that can be utilized in the footer section. In many cases the footer section is relatively short and the syntax simply tells the computation engine that it has reached the end of the Main Input File. Figure 101 illustrates some examples of footer syntax for a few optics codes.

OASIS divides the Main Input File into several primary sections. These primary sections are designed to support the input requirements for a large group of particle optics codes. OASIS uses the following names for the four primary sections:

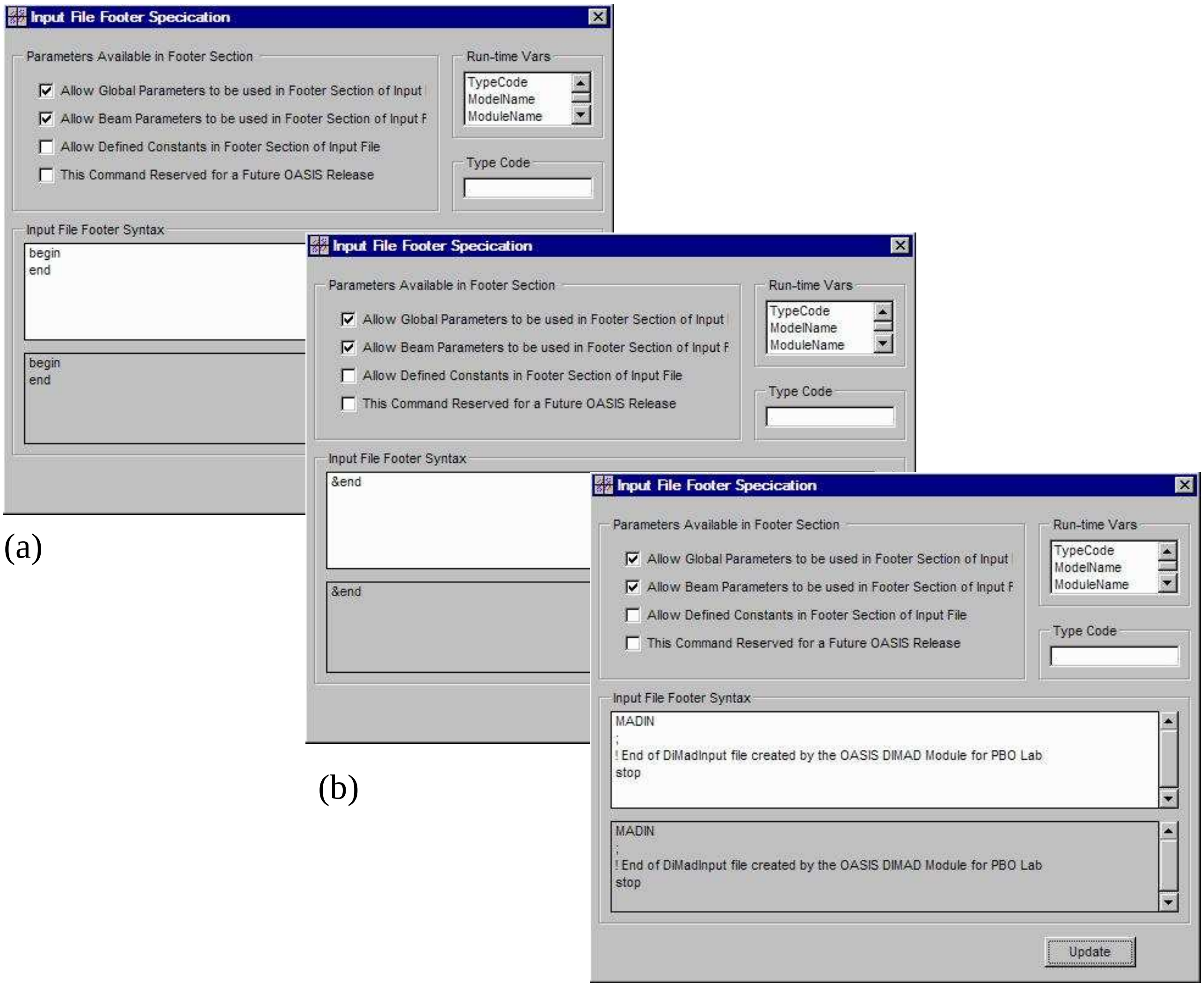
Header
Lattice
Lines
Footer

Manual Section

2
4
4
5
6
6
7



The Final (Footer) Section item of the OASIS Commands menu will open the Input File Footer Specification window.



(a) (b) (c)

Figure 101. Input File Footer Specification for three computation engines: (a) PARMILA-2, (b) TRACE 3-D and (c) DIMAD.

Additional text can be added to the beginning of the Footer Section of the Main Input File by an OModule user, utilizing one of the items of the Auxiliary Input menu for the OModule.

This completes the discussion of the primary OModule specifications, for writing data to the Main Input File. The next Section discusses the integration of the OModule with certain PBO Lab Tools.

OASIS™

5. Utilizing PBO Lab Tools

OASIS User Manual:
Building Application Modules
for PBO Lab™

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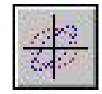
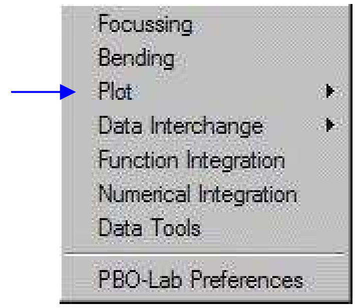


5. Using PBO Lab Tool Capabilities

Overview of PBO Lab Tools

The PBO Lab framework has a number of tools available that can significantly enhance any optics code that is integrated with PBO Lab. Several of the tools are described in the PBO Lab Basic Package User Manual. This Section of the OASIS Module Builder User Manual describes how certain of the tools can be integrated to work with OModules. Integrating OModules with the following tools is discussed here:

Plot
Optimization Module
Tutorial



The Tools menu shows the PBO Lab tools that are available in an OASIS Module Specification Document. The Plot item provides a submenu with a Plot Data Specification entry that can be utilized for OModule development.

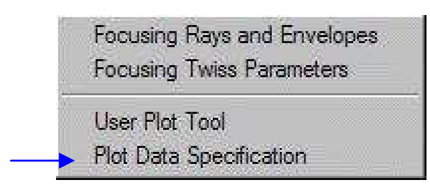
Several PBO Lab Tools will also work seamlessly with developed OModules without any further work by the OModule developer. Those tools are not discussed further here and include:

Focusing
Bending
Data Interchange
Function Integration
Numerical Integration
Data Tools

In addition to the items on the Tools menu, the Optimization Module tool can be used with OModules.

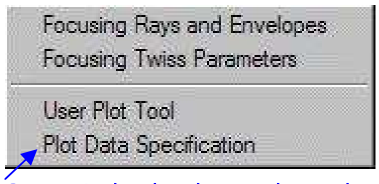
The Optimization Module is an advanced tool that is described in a separate document, PBO Lab User Manual Supplement: Optimization Module.

The Plot item on the Tools menu opens a submenu with several choices. The first two items (Focusing Rays and Envelopes, Focusing Twiss Parameters) are utilized by PBO Lab for displaying Focusing tool data in standard PBO Lab Plot tools. The next two items (User Plot Tool, Plot Data Specification) can be used with PBO Lab to create and display customized plots of data. The Plot Data Specification is utilized in the OASIS Module Builder to set up plot specifications for an OModule.

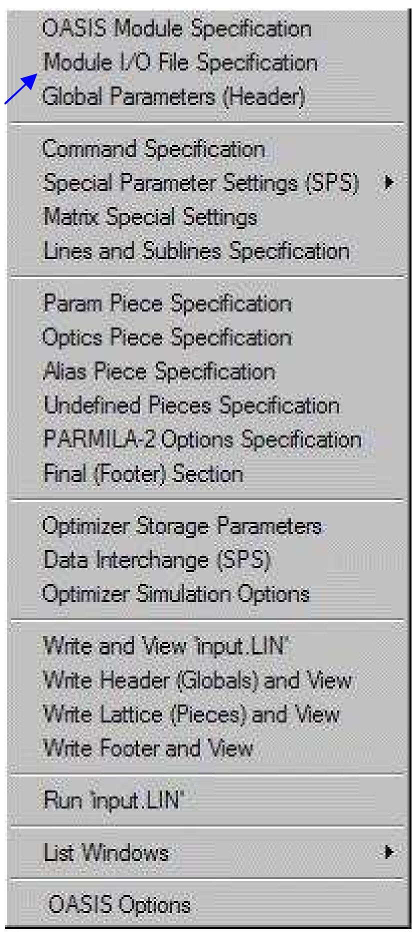


The Plot Data Specification item of the Plot submenu is used to set up OModule plot specifications.

Step 1 - Plot Data Specification



Step 1 in implementing plot specifications uses the Plot Data Specification item of the Tools→Plot submenu.



Step 2 in implementing plot specifications uses the Module I/O File Specification of the OASIS Commands menu.

The specification of plot windows and displays for an OModule involves two primary steps. The first is the specification of the data types and formats which can be used by PBO Lab Plot tools. Files that contain the necessary data types and formats, produced by the computation engine underlying the OModule, are also identified as part of the first step. The first step utilizes the (PBO Lab) Plot Data Specification. The second step involves defining a list of plot specifications that will populate the OModule plot list available for selection by an OModule user. This second step utilizes the OASIS Module Builder item Module I/O File Specification on the OASIS Commands menu. These two steps are described below for the example of the PARMILA-2 OModule.

The Plot Data Specification item on the Plot submenu of the Tools menu opens the User Plot Data Specification window illustrated in Figure 102. The User Plot Data Specification window has three tab panels, one for each of the types of plot styles available: line, scatter, and histogram. The content of each tab is customized to the type of plot. The plot specifications developed with this User Plot Data Specification window define how the data in an output file, generated by a particular computation engine, is to be read and manipulated for creating a display in a PBO Lab Plot tool window.

The window shown in Figure 102 illustrates the Length Plot Data Specification tab page in front. This tab page is used for specifying *line plots*. The Scatter Plot Data Specification and Histogram Data Specification tab pages are used for specifying *scatter plots* and *histogram plots*, respectively. The examples for the PARMILA-2 OModule discussed here illustrate the specification of scatter and histogram plots.

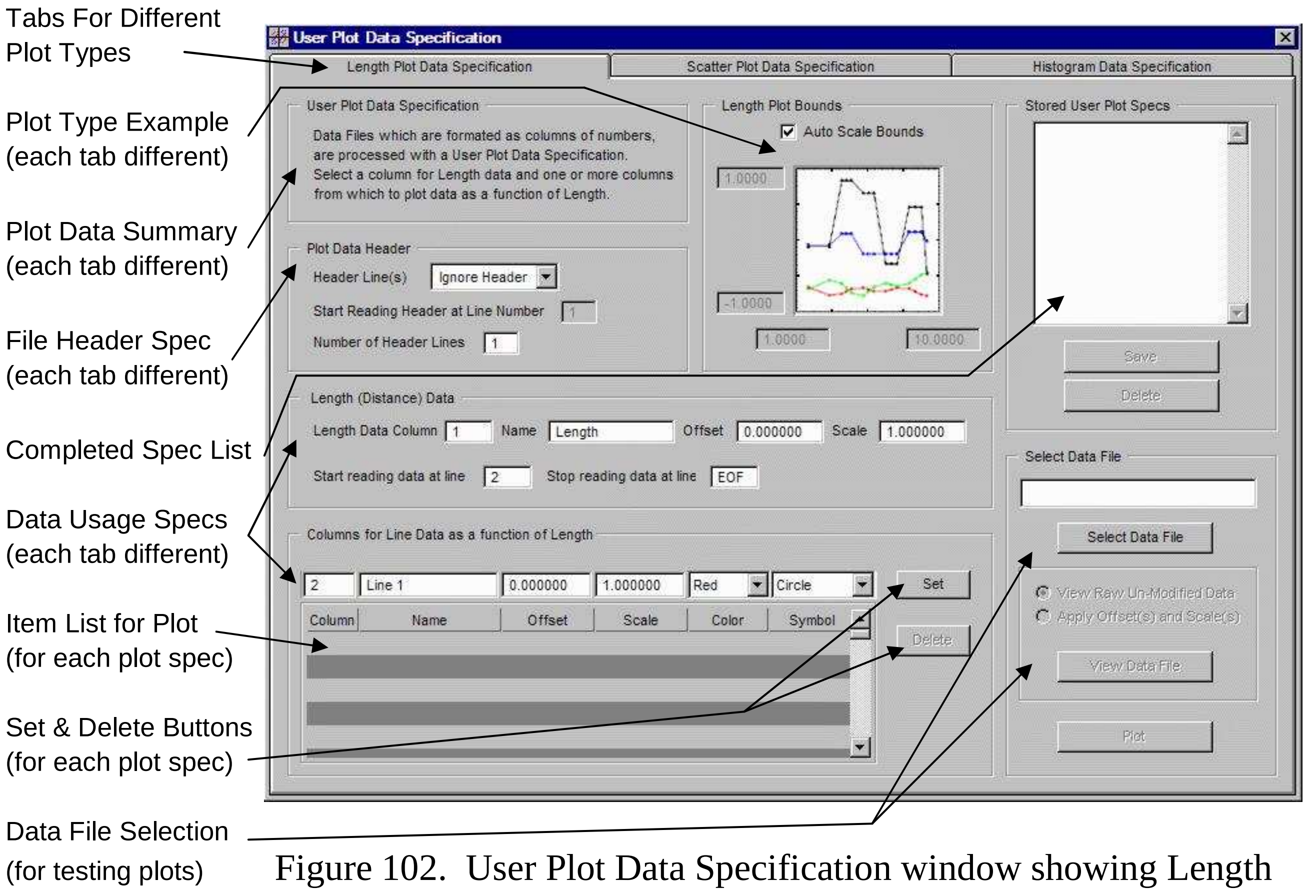


Figure 102. User Plot Data Specification window showing Length Plot Data Specification tab page used for defining line plots.

The second tab of the User Plot Data Specification window, Scatter Plot Data Specification, is illustrated in Figure 103. Optics codes that track particles can typically be used to produce data files of the particles' coordinates and momenta. Beam cross sections and phase space plots are representative of the types of scatter plots that can be created from this data.

The set up of a plot specification begins with items in the left side of the User Plot Data Specification window, and proceeds from top to bottom. However, some information on the data file produced by the computation engine is required. This information can be obtained by examination of the data file using the Open Scratch File submenu of the View menu.

Use the View menu of the OASIS Module Specification Document to access the Open Scratch File submenu.

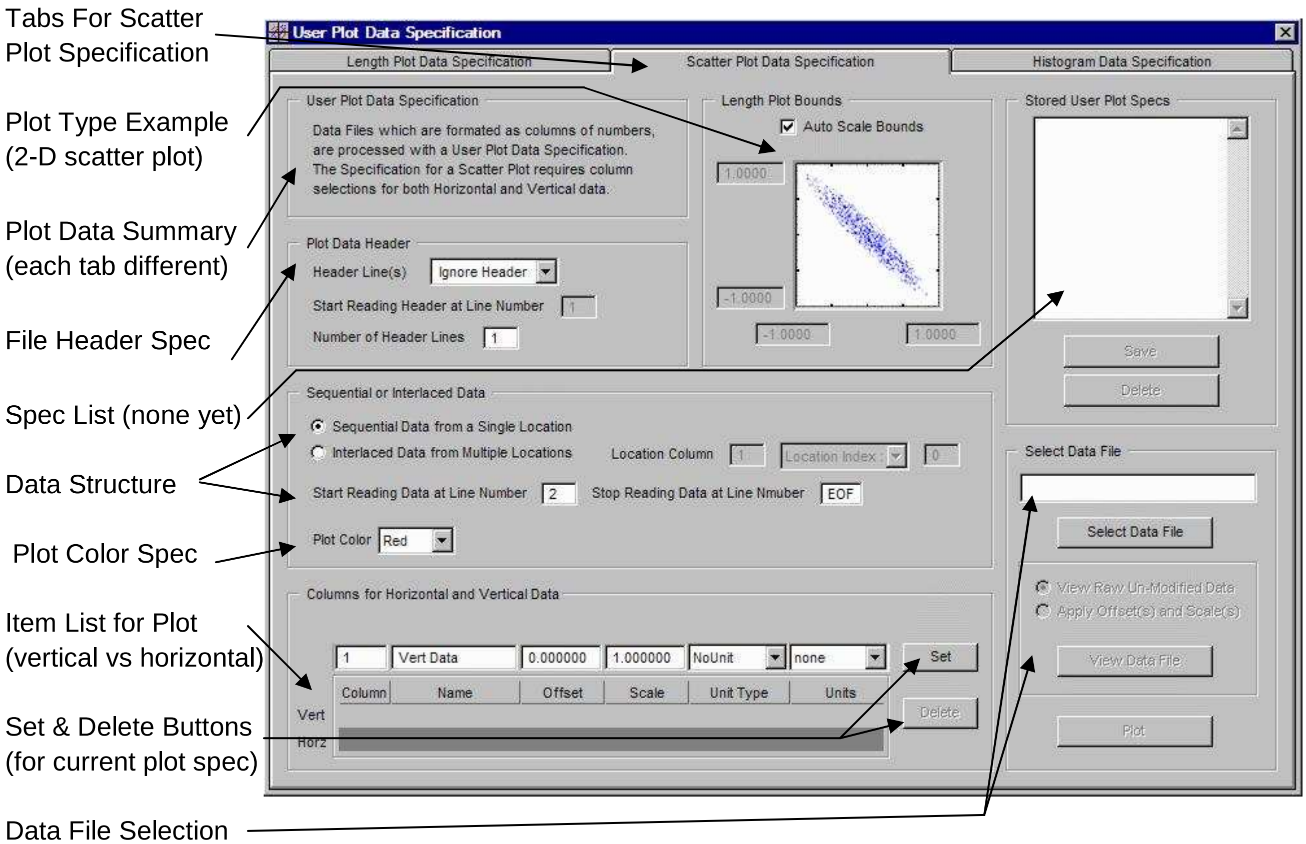
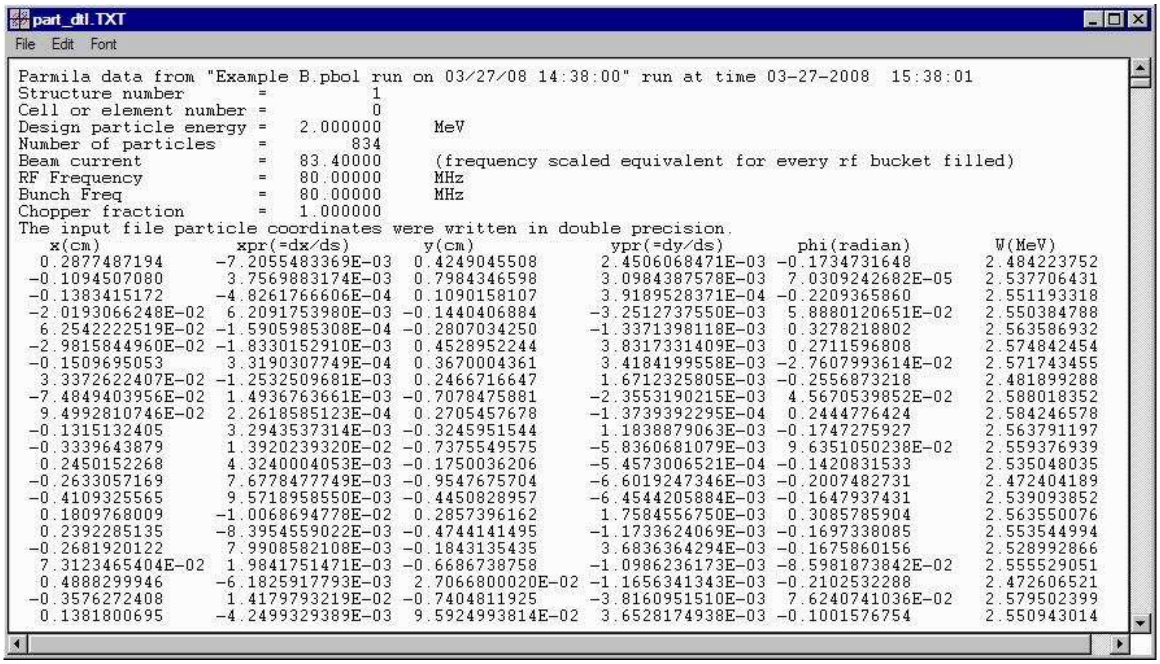


Figure 103. User Plot Data Specification window showing Scatter Plot Data Specification tab page used for defining scatter plots.

Header Line(s) in a file can be either ignored or used. Only one line of a header may be used to obtain labels for the data columns in the file.

PARMILA-2 produces a *binary* output file named "part_dtl.dst" which contains particle 6-D coordinate data at the exit of the beamline. This file is converted into a *text* file named "part_dtl.TXT" using the program ReadDst.exe. Figure 104 illustrates the window opened for a typical "part_dtl.TXT" file using the Open Scratch File selection from the View menu.

The file illustrated in Figure 104 has eleven (11) "header" lines -- the first header line begins with the words "Parmila data …" and the last (11th) header line starts with " x(cm) …" In this example, the header lines will be ignored. The entry for the field Number of Header Lines in the User Plot Data Specification window will be "11".



part_dtl.TXT

File Edit Font

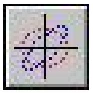
```
Parmila data from "Example B.pbol run on 03/27/08 14:38:00" run at time 03-27-2008  15:38:01
Structure number        =          1
Cell or element number =          0
Design particle energy =   2.000000     MeV
Number of particles     =        834
Beam current            =   83.40000     (frequency scaled equivalent for every rf bucket filled)
RF Frequency            =   80.00000     MHz
Bunch Freq              =   80.00000     MHz
Chopper fraction        =   1.000000
The input file particle coordinates were written in double precision.
   x(cm)             xpr(=dx/ds)        y(cm)              ypr(=dy/ds)        phi(radian)          W(MeV)
  0.2877487194      -7.2055483369E-03  0.4249045508       2.4506068471E-03 -0.1734731648        2.484223752
 -0.1094507080       3.7569883174E-03  0.7984346598       3.0984387578E-03  7.0309242682E-05    2.537706431
 -0.1383415172      -4.8261766606E-04  0.1090158107       3.9189528371E-04 -0.2209365860        2.551193318
 -2.0193066248E-02  6.2091753980E-03 -0.1440406884      -3.2512737550E-03  5.8880120651E-02    2.550384788
  6.2542222519E-02 -1.5905985308E-04 -0.2807034250      -1.3371398118E-03  0.3278218802        2.563586932
 -2.9815844960E-02 -1.8330152910E-03  0.4528952244       3.8317331409E-03  0.2711596808        2.574842454
 -0.1509695053       3.3190307749E-04  0.3670004361       3.4184199558E-03 -2.7607993614E-02    2.571743455
  3.3372622407E-02 -1.2532509681E-03  0.2466716647       1.6712325805E-03 -0.2556873218        2.481899288
 -7.4849403956E-02  1.4936763661E-03 -0.7078475881      -2.3553190215E-03  4.5670539852E-02    2.588018352
  9.4992810746E-02  2.2618585123E-04  0.2705457678      -1.3739392295E-04  0.2444776424        2.584246578
 -0.1315132405       3.2943537314E-03 -0.3245951544       1.1838879063E-03 -0.1747275927        2.563791197
 -0.3339643879       1.3920239320E-02 -0.7375549575      -5.8360681079E-03  9.6351050238E-02    2.559376939
  0.2450152268       4.3240004053E-03 -0.1750036206      -5.4573006521E-04 -0.1420831533        2.535048035
 -0.2633057169       7.6778477749E-03 -0.9547675704      -6.6019247346E-03 -0.2007482731        2.472404189
 -0.4109325565       9.5718958550E-03 -0.4450828957      -6.4544205884E-03 -0.1647937431        2.539093852
  0.1809768009      -1.0068694778E-02  0.2857396162       1.7584556750E-03  0.3085785904        2.563550076
  0.2392285135      -8.3954559022E-03 -0.4744141495      -1.1733624069E-03 -0.1697338085        2.553544994
 -0.2681920122       7.9908582108E-03 -0.1843135435       3.6836364294E-03 -0.1675860156        2.528992866
  7.3123465404E-02  1.9841751471E-03 -0.6686738758      -1.0986236173E-03 -8.5981873842E-02    2.555529051
  0.4888299946      -6.1825917793E-03  2.7066800020E-02 -1.1656341343E-03 -0.2102532288        2.472606521
 -0.3576272408       1.4179793219E-02 -0.7404811925      -3.8160951510E-03  7.6240741036E-02    2.579502399
  0.1381800695      -4.2499329389E-03  9.5924993814E-02  3.6528174938E-03 -0.1001576754        2.550943014
```

Figure 104. Top part of a typical "part_dlt.TXT" file generated by PARMILA-2. The file has eleven (11) head lines, followed by six (6) columns of numerical data.

In this PARMILA-2 example, the Plot Data Header pane of the User Plot Data Specification window (Figure 103) has two pieces of information obtained from the data file (Figure 104): (a) Ignore Header and (b) use 11 in the Number of Header Lines field.

The Sequential or Interlaced Data pane of the User Plot Data Specification window (Figure 103) is utilized to specify how lines in the data file are grouped. The term "Sequential" is used to describe files where the data from one beamline location are grouped together. Several locations may appear sequentially in the file. The "part_dlt.TXT" file data is "Sequential." The term "Interlaced" refers to files in which a given row of data has an indicator that identifies a particular location in the beamline. The particle data for a particular beamline location maybe mixed, or interlaced, with particle data from other locations. TURTLE produces data files typically "Interlaced."

Sequential or Interlaced Data refer to two common types of data layout used with particle coordinate and momenta. Interlaced data will generally have an extra column that has a Location Index that indicates the particle's location along the beamline.



The 6-D particle coordinate and momenta data begin on live twelve (12) in the "part_dlt.TXT" file of Figure 104. The entry for the field Start Reading Data at Line Number is thus "12". The field Stop Reading Data at Line Number is left at the default setting "EOF" which stands for "end of file."

Four choices are available for the point color in scatter plots using the Plot Color popup.

The selection for Plot Color is arbitrary. For built-in graphics displays, such as those appearing in the Focusing tool window or the Beam Piece window (Figure 34), PBO Lab utilizes a color coding system. Similar selections may be useful for comparison purposes. The PBO Lab color coding for phase space data plots is:

Transverse Horizontal (x) Phase Plane:	**Red**
Transverse Vertical (y) Phase Plane:	**Blue**
Longitudinal (z) Phase Plane:	**Green**
Mixed (e.g. y vs x) Phase Plane:	**Black**

*Offset and scale data may also be entered for each entry in the list (Vert or Horz). For example, if the y' (*YP*) scale is desired to be in milliradians rather that radians, a scale factor 1000 could entered into the Scale column of the Vert specification. It would be preferable, however, to use the* Angle *unit choice* mrad *to accomplish this scaling, since that unit will then be reflected in the PBO Lab interface.*

This example will illustrate the set up of a phase space scatter plot of y' versus y, so the Blue choice for the Plot Color will be selected. The 11th (header) line (Figure 104) identifies the data columns in the file. The y data is in the 3rd column and the y' data, labeled as ypr(=dy/ds) is in the 4th column. The units of y are centimeters (cm) according to the 11th (header) line. The units of y' are not explicitly given in the 11th line, but can be inferred to be radians. For a y' vs y plot, the horizontal axis would be y and the vertical axis would be y'. This information is used for completing the Horizontal and Vertical Data fields, starting with the "Vert" (top) entries first. The Set button is used to register and store the data. The entries will appear to the right of the Vert list item. Selecting the item in the list will highlight it for editing; both the Set and Delete buttons will be active. Figure 105 illustrates how the User Plot Data Specification window might appear at this point in the specification of the y' vs y scatter plot.

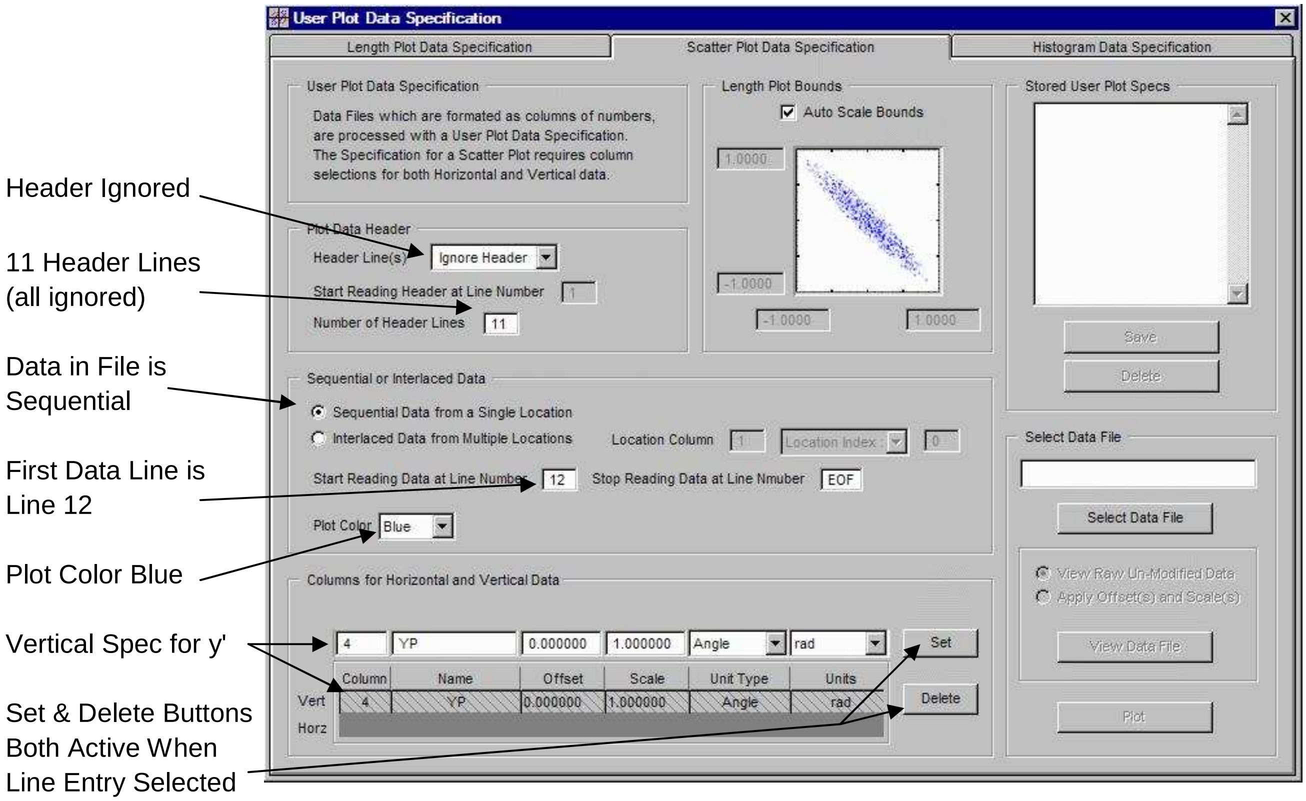


Figure 105. User Plot Data Specification window illustrating set up of y' (YP) "Vert" axes specification for y' vs y scatter plot.

To enter the "Horz" axes specifications, first *deselect* (click the Horz entry) the Vert entry in the lines list. Then enter the information for the y data. Once the necessary data is entered into the input fields, the Set button is used to record and store the data in the Horz line entry. When both the Vert and Horz lines are populated the specification for the scatter plot is complete, and the Save button in the Store User Plot Specs pane (upper right) will become active. Figure 106 shows how the User Plot Data Specification window might appear at this point in the specification of the y' vs y scatter plot.

The example illustrated in Figure 105 utilizes the default setting for the Scatter Plot Bounds: Auto Scale Bounds. Fixed bounds can also be specified. The fixed bounds are useful in PBO Lab Models where the same (or similar) plot will be created each time calculations are done for that model. For OModules, the Auto Scale Bounds is generally more appropriate, since the range of data is unlikely to be known in advance. In either case, the OModule user can set the scales after the plot is created (see Figure 108).

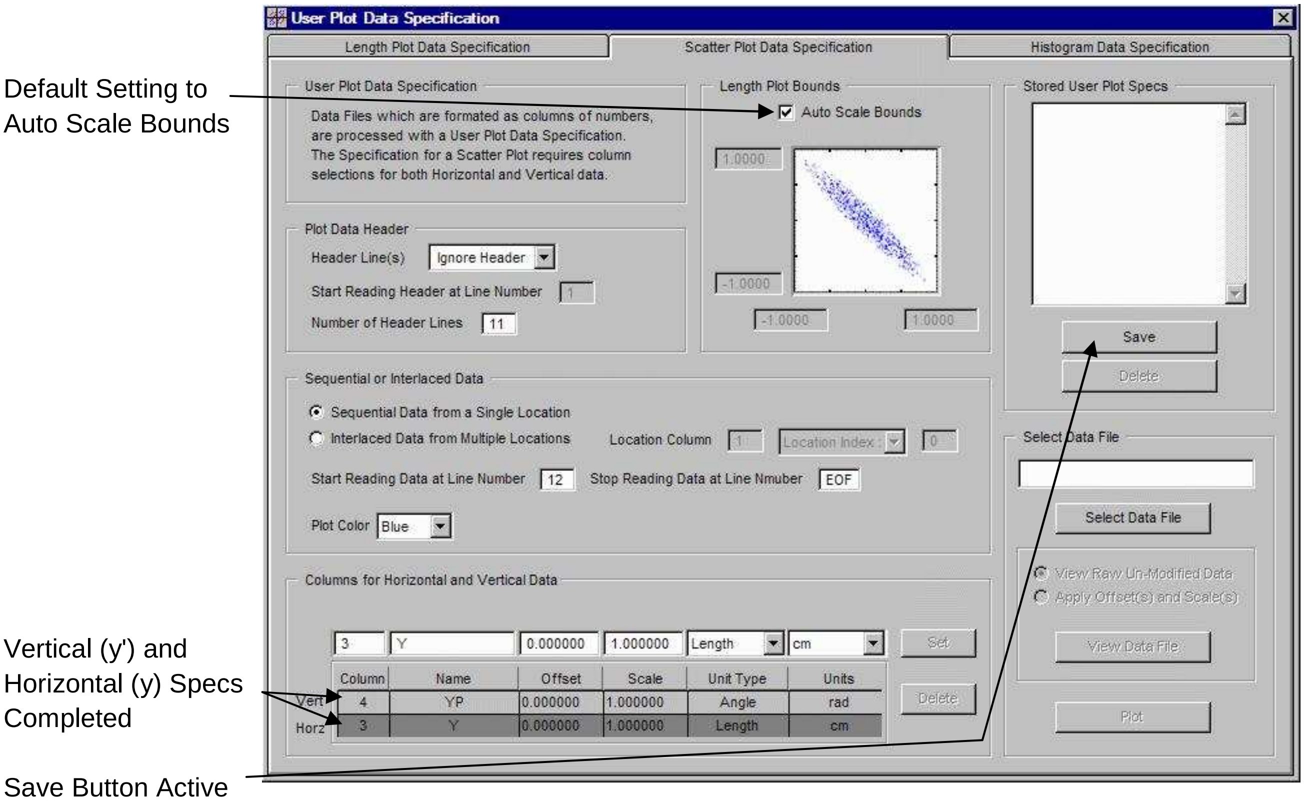
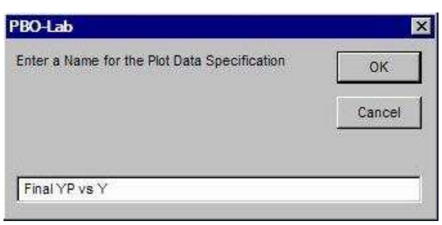


Figure 106. User Plot Data Specification window showing the completed specification for a y' vs y scatter plot, ready to save.



Plot specification name dialog with the name Final YP vs Y *entered. When the OK button is selected, the name will appear in the Stored User Plot Specs list.*

The Save button in the upper right portion of the User Plot Data Specification is used to record and store the plot specification. Selecting the Save button will open a dialog window for assigning a name to the specification. Entering a name and selecting OK will store the data as a persistent object of the PBO Lab / OASIS software. The name will appear in the Stored User Plot Specs list. The Stored User Plot Specs pane provides a list of all plot specifications stored with the OASIS Module Specification Document. Figure 107 shows an example of the User Plot Data Specification window with a series of plot specifications stored for the PARMILA-2 OModule.

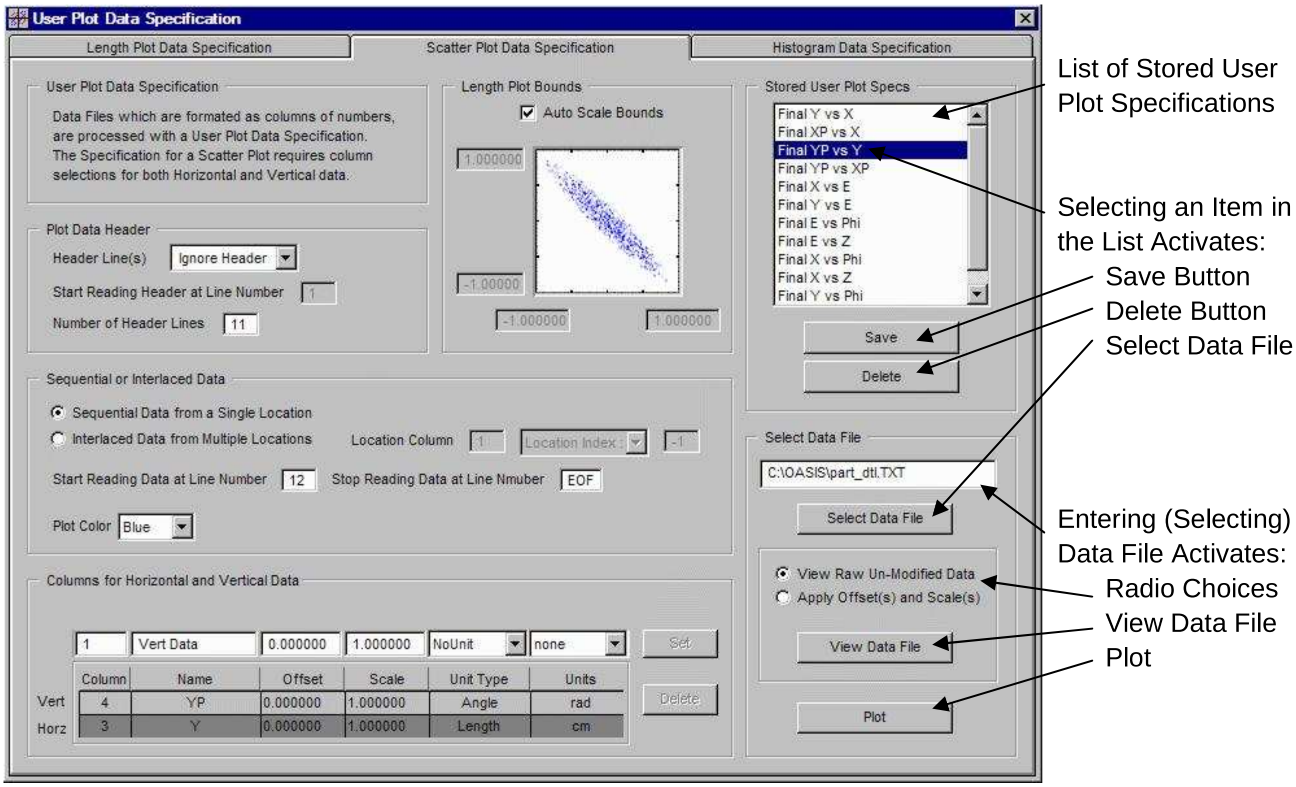
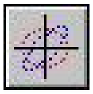


Figure 107. User Plot Data Specification window illustrating a list of stored plot specifications for the PARMILA-2 OModule.

The Stored User Plot Specs list in Figure 107 shows a number of stored plot specifications for scatter plots. The selected item in the list corresponds to the plot y' vs y specification discussed in this manual. When an item in the list is selected, the features in the lower right pane of the User Plot Data Specification window may be used to apply that specification to a data file. To examine the data file, enter the file name in the Select Data File field, or use the Select Data File button to access a file opening dialog. When a file name appears in the Select Data File field, the other items in the lower right part of the User Plot Data Specification window become active. Selecting the button View Data File will open a window similar to that illustrated in Figure 104 which displays the content of the selected file.

The Select Data File pane of the User Plot Data Specification window is useful for testing or verifying plot specifications. The Plot button will display the data in the selected file, using the highlighted item in the Stored User Plot Specs list. The window will be essentially identical to the one that will appear to OModule users, when the Module File I/O Specification is used to link the plot specification to the same file.



A file name entered into the Select Data File field of the User Plot Data Specification window is not persistent. That is, the link to the file is not retained or stored, and the file name is removed when the window is closed.

The Plot button at the bottom right of the User Plot Data Specification window will open a PBO Lab plot window. The plot specification selected (highlighted) in the list of Stored User Plot Specifications will be applied to the data in the file named in the Select Data File field (edit box). Figure 108 illustrates an example of the PBO Lab plot window created using the PARMILA-2 specification for y' vs y scatter plot at the end of a beamline.

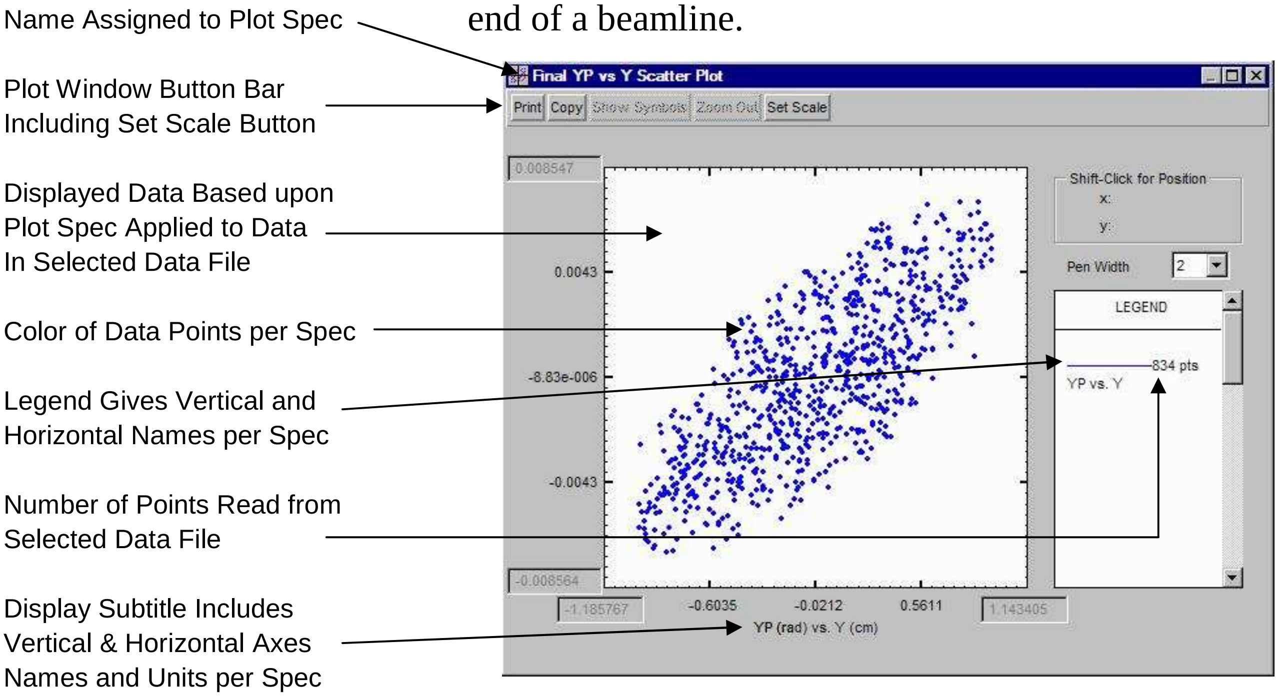


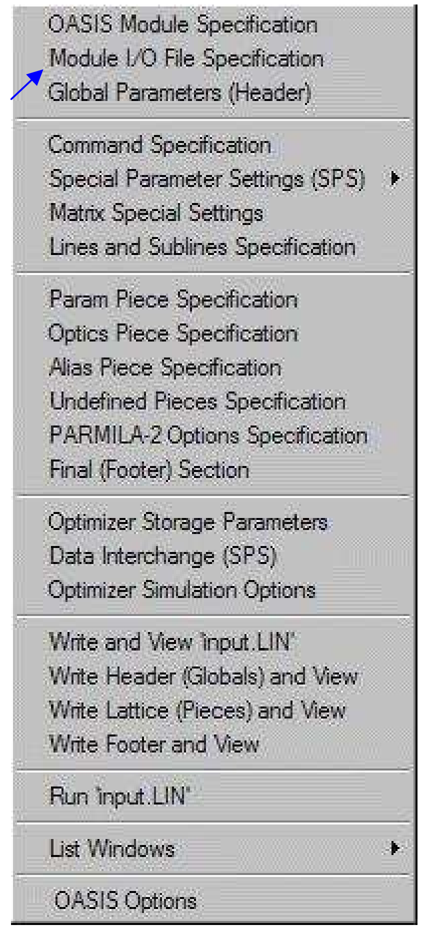
Figure 108. Final YP vs Y Scatter Plot window of PARMILA-2 OModule for an Example B beamline.

The algorithm used for the Auto Scale Bounds routine determines the minimum and maximum values of the data. The data range is computed as the difference between these. Then 10% of the range is added to the minimum and maximum data values to determine the minimum and maximum scale settings.

PBO Lab plot windows have several capabilities for manipulating the display presented. Some of these are indicated in Figure 108. The PBO Lab User Manual discusses the capabilities in detail. The use of the default setting to Auto Scale Bounds in the plot specification (Figure 106) assures that the displayed data will be on scale. Of course, the scales may be changed at anytime by using the Set Scale button in the button bar at the top of the window. The Legend for the plot displays the assigned names for the data as well as the number of data points read from the file.

Step 2 - Linking Plot Specs to Data Files

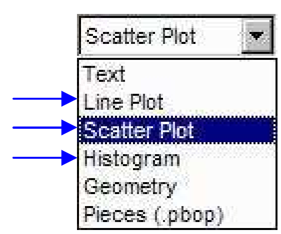
Step 1 of the process for specifying of plot windows for an OModule developed the plot data specifications. Step 2 involves linking those data specifications to OModule data files, and assigning other attributes for the handling of the data files. The Module I/O File Specification item on the OASIS Commands menu is used to begin Step 2. Selecting this item opens a File I/O Specification window similar to that shown previously in Figure 8. Figure 109 illustrates the File I/O Specification for the PARMILA-2 OModule when the Stored User Plot Specs shown in Figure 107 have been defined.



Step 2 in implementing plot specifications uses the Module I/O File Specification of the OASIS Commands menu to link data files to the plot specs.

Stored User Plot Specs are linked to data files using the lower part of the File I/O Specification window - the region that handles Auxiliary I/O files. In Figure 109 the auxiliary file Type selection has been set to Scatter Plot. This selection populates the Stored User Plot Specs with the same entries completed for Scatter Plot Data Specifications (Figure 107).

Other choices for the auxiliary file Type that can populate the Stored User Plot Specs list include Line Plot and Histogram, provided that Stored User Plot Specs have been created with the Length Plot Data Specification tab page and the Histogram Data Specification tab page, respectively, of the User Plot Data Specification window (Figure 102).



The Auxiliary I/O File Type selection has 3 plot data file types: Line Plot, Scatter Plot, and Histogram.

Items appearing in the Auxiliary Files & Graph Plots list of the File I/O Specification window are accessible to users of the OModule. Each item has an Auxiliary File Name, an associated Type, and may or may not have an associated Description. Files of type Text will appear to the OModule user in the Auxiliary Files submenu of the PBO Lab View menu for the OModule. Files of other types are handled differently.

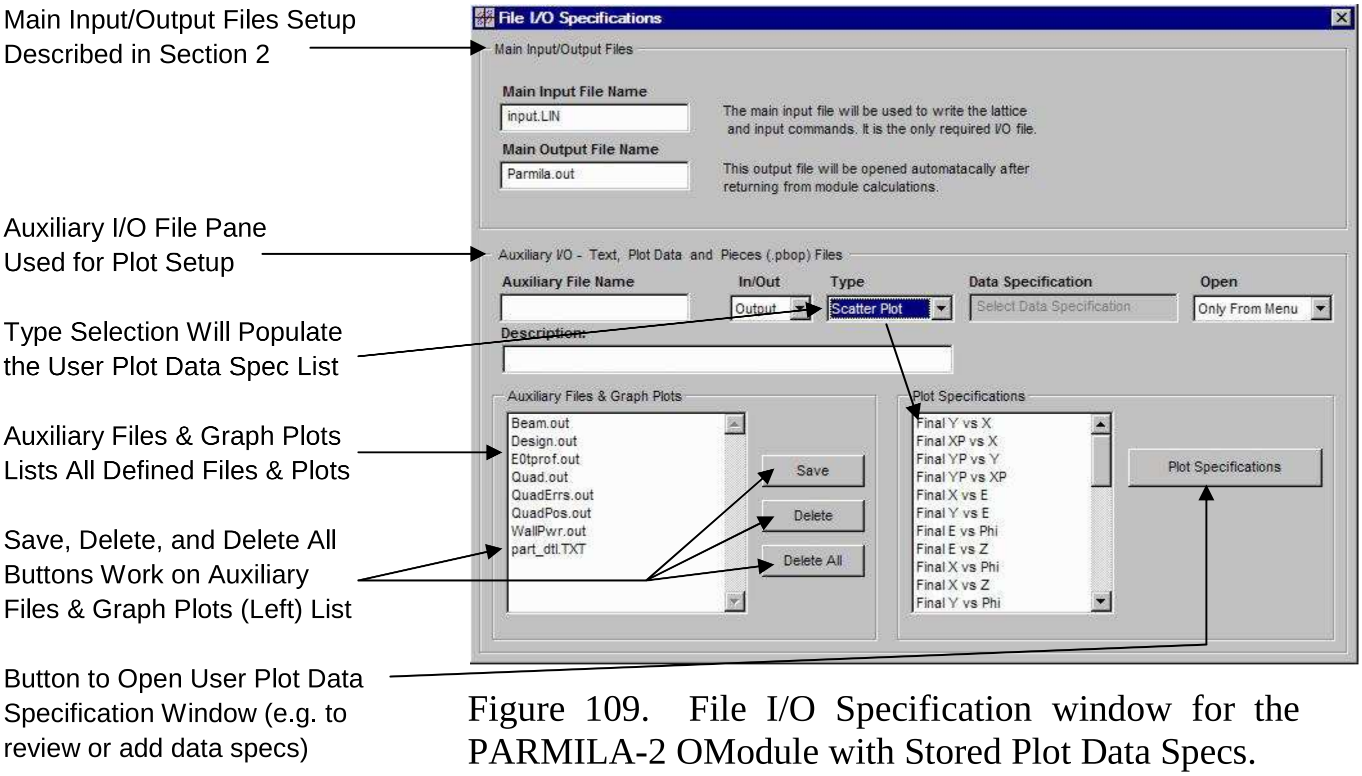


Figure 109. File I/O Specification window for the PARMILA-2 OModule with Stored Plot Data Specs.

The PARMILA-2 file which contains the particle coordinate data, and has been used to define the scatter plot data specifications, is named part_dtl.TXT. The contents of this file were illustrated in Figure 103. This file has already been entered as an Auxiliary File of type Text, and it appears at the bottom of the Auxiliary File & Graph Plot list. This file will also be used for linking to the Stored Plot Data Specs.

Clicking on an item in the Stored Plot Data Specs list will load the item name into the Data Specification field immediately to the right of the Type selection popup menu, which is set to Scatter Plot in Figure 109. The name of the data file to be linked to this plot data specification is entered into the Auxiliary File Name field. This name should be *typed* into the Auxiliary File Name field, even if the same name appears in the Auxiliary File & Graph Plot list. (Selecting an item from the list will populate the associated fields with previously entered data.)

A short phrase that summarizes the plot should be entered into the Description field. The Description field entry will appear to an OModule user in a list of Plot Specifications for the OModule. Figure 110 illustrates how the File I/O Specification would appear at this point in the scatter plot setup.

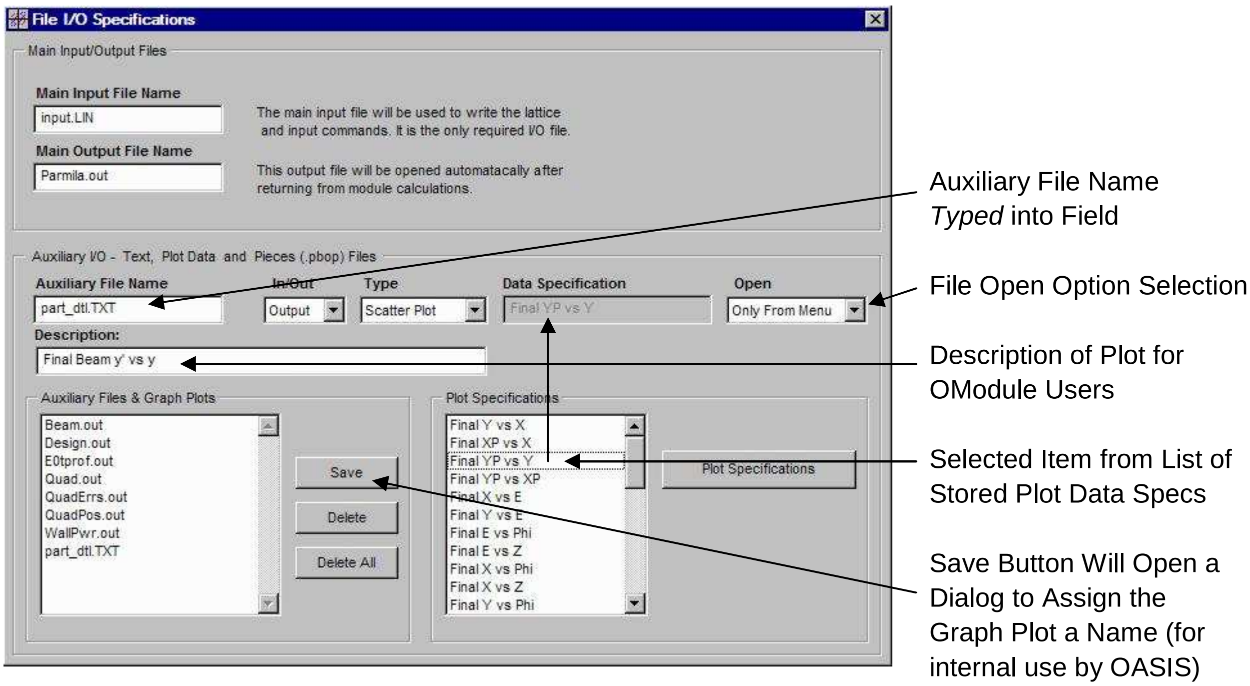
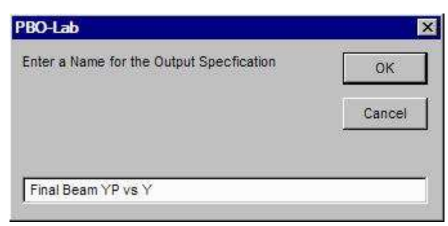


Figure 110. File I/O Specification window with the PARMILA-2 scatter plot setup ready to Save.

The Save button is used to store the plot setup. This button opens a dialog window that is used to assign a name to the plot setup. The assigned name will appear in the Auxiliary Files & Graph Plots list when the OK button on the dialog is selected. This name is an internal name used for OASIS purposes, and does not appear to an OModule user. The dialog will show a default name entered that corresponds to the Auxiliary File Name specified for this setup. Since the same auxiliary file may be used for multiple purposes, as in this PARMILA-2 OModule example, another name should be assigned in the dialog. The name "Final Beam YP vs Y" has been assigned to this scatter plot.



Dialog used to assign an internal name to a graph plot set up. The internal name will appear in the Auxiliary Files & Graph Plots list for later selection or editing.

Figure 111 illustrates a File I/O Specification window for the PARMILA-2 OModule with a number of Graph Plots set up. Both scatter plots and histograms are set up, all using the same data file.

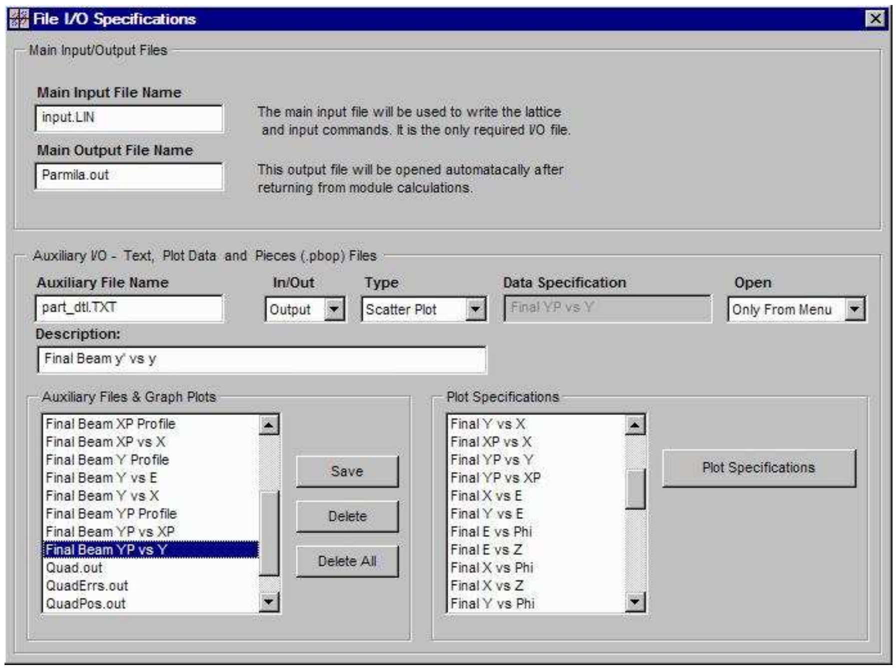
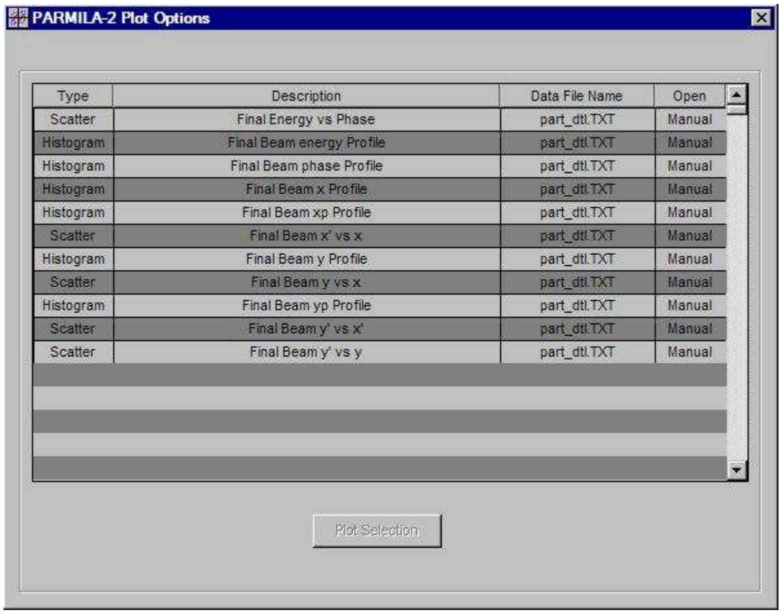


Figure 111. File I/O Specification window with several Graph Plots for a PARMILA-2 OModule.

The file Open option selection box (Figure 110) has two choices. The choice Automatically *can be used to specify that a given Graph Plot be opened automatically at the completion of a calculation by the computation engine underlying an OModule. This may be useful if there is a file of graphic output data routinely produced by the computation engine that is always plotted following a computation.*

When a user is working with the PARMILA-2 OModule in PBO Lab, the Commands menu for PARMILA-2 has an entry titled "PARMILA-2 Plot Specification." Selecting this entry opens a list window, called PARMILA-2 Plot Options, with all of the available Graph Plots specified for the OModule. Figure 112 illustrates an example of the PARMILA-2 Plot Options.

The OModule Plot Options window provides the plot Type, Description, Auxiliary File Name and Open selection for each of the Graph Plots defined for the OModule. When an OModule user selects an item in the list, the Plot Selection button becomes active. Selecting the button opens the plot window.



Type	Description	Data File Name	Open
Scatter	Final Energy vs Phase	part_dtl.TXT	Manual
Histogram	Final Beam energy Profile	part_dtl.TXT	Manual
Histogram	Final Beam phase Profile	part_dtl.TXT	Manual
Histogram	Final Beam x Profile	part_dtl.TXT	Manual
Histogram	Final Beam xp Profile	part_dtl.TXT	Manual
Scatter	Final Beam x' vs x	part_dtl.TXT	Manual
Histogram	Final Beam y Profile	part_dtl.TXT	Manual
Scatter	Final Beam y vs x	part_dtl.TXT	Manual
Histogram	Final Beam yp Profile	part_dtl.TXT	Manual
Scatter	Final Beam y' vs x'	part_dtl.TXT	Manual
Scatter	Final Beam y' vs y	part_dtl.TXT	Manual

Figure 112. A PARMILA-2 OModule user selects graphs from the PARMILA-2 Plot Options list.

A PARMILA-2 OModule user can select an entry in the PARMILA-2 Plot Options list, and the Plot Selection button will become active, which is used to display the desired plot. For example, selecting the entry Final Beam y' vs y *in the list and then pushing the Plot Selection button will open a window identical to that shown in Figure 108.*

The PBO Lab Plot Tools provide a standard set of features that make the creation of useful, interactive, graphics displays for most types of data amendable to plotting. The PBO Lab (Basic Package) User Manual describes the features of the PBO Lab Plot Tools. The OASIS Module Builder supports the integration of the Plot Tools, customized to the requirements of each OModule.

All Stored Plot Data Specs (Part 1) developed for an OModule will also be available to an OModule user through the PBO Lab Tools menu. OModule users can readily create their own Plot Tools utilizing these User Plot Data Specs.

Specialized graphic displays, which fall outside the scope of the PBO Lab Plot Tools, can also be integrated with OModules. For example, the PARMILA-2 code has a separate program named "Lingraf.exe" that is used to display graphs that are unique to PARMILA-2. A very simple OModule has been constructed to execute the Lingraf.exe program following a PARMILA-2 run. That OModule can be used to automatically display the native PARMILA-2 graphs for that run.

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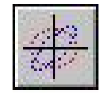


Optimizer Integration

The PBO Lab Optimization Module provides two nonlinear, constrained optimization programs that can be utilized with other PBO Lab Modules. The optimization programs NPSOL and MINOS were developed in the Systems Engineering Department of Stanford University and provide two different, multi-algorithm programs capable of optimizing many (~100) variables to minimize an objection function, while simultaneously satisfying many (~100) nonlinear constraint conditions. OASIS Modules can also utilize these optimizers. The integration of these optimizers with an OModule is discussed here.

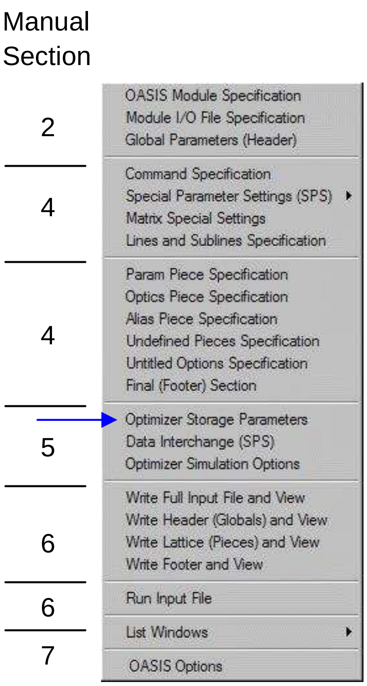
Optimizer Variable Parameters

The set up of a problem in the PBO Lab Optimization Module has three parts: (1) selection of the parameters to be varied, (2) specification of the objective (or merit) function to be optimized (minimized) and (3) the (optional) specification of nonlinear constraints that must be simultaneously satisfied. The selection of the (1) Optimizer Variables is straightforward using the PBO Lab Special Parameter Settings ("S" buttons) when the Optimization Module is installed. There are *no* OModule specifications that need to be developed. Any Piece parameter in PBO Lab is automatically available as an Optimizer Variable. Parameters selected for use in an OModule will thus automatically be selectable as Optimizer Variables.

The selection of OModule variables to be used by the NPSOL or MINOS packages of the PBO Lab Optimization Module requires no special setup. All parameters of PBO Lab Piece Windows are available for use as Optimizer Variables, and their selection for that purpose is the same as for any other PBO Lab Module.

To make an OModule work with the Optimization Module, the computation engine outputs from the OModule need to be identified and made available to PBO Lab. Those outputs can then be used by the Optimization Module for computing (2) the merit function and / or (3) the nonlinear constraints.

Optimizer Storage Parameters



The Commands menu item Optimizer Storage Parameters is used to access the Storage Parameter set up window.

The merit function and nonlinear constraints are constructed in the Optimization Module as functions of Storage Parameters (and also Optimizer Variables if desired). Storage Parameters are used to store specified outputs from the computation engine of a PBO Lab Module. The specification of the outputs that the computation engine will provide, and the assignment of OModule names to the corresponding Storage Parameter for each specified output, is the first step in setting up Storage Parameters for an OModule. Figure 113 illustrates a setup window for selecting and specifying Storage Parameters. Storage Parameters are always associated with a particular OModule and its underlying computation engine, so the OModule name appears in the window title. The example shown in Figure 113 is for the DIMAD-sample OModule.

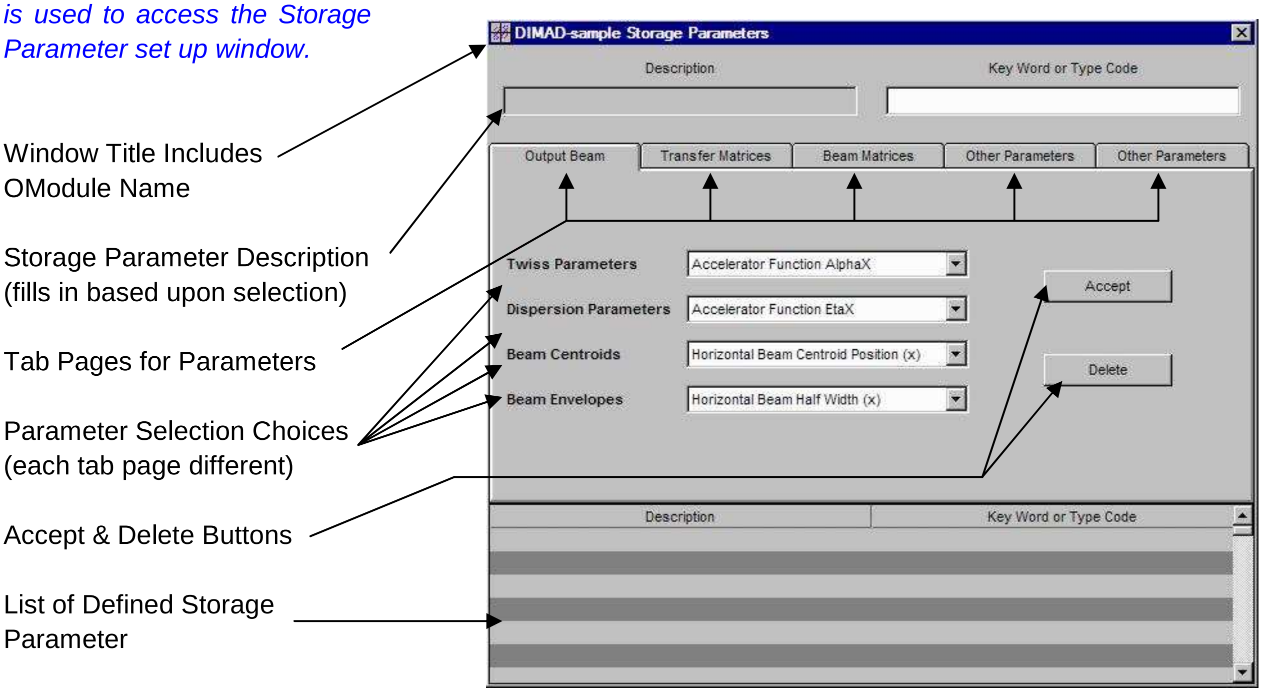


Figure 113. DIMAD-sample Storage Parameter set up window