



PBO LabTM 3.0

(Particle Beam Optics Laboratory 3.0)

**User Manual Supplement:
PSI-TURTLE Module**

**A PBO Lab Module Created with the
OASIS Module Builder Technology**

Distributed by

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PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module

PBO Lab™ 3.0 User Manual Supplement: PSI-TURTLE Module,
A PBO Lab Module Created with the OASIS Module Builder Technology
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PBO Lab™

1. Getting Started

**User Manual:
Supplement:
PSI-TURTLE
Module**



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1. Getting Started

The PSI Code Modules for PBO Lab are based upon the Open Architecture Software Integration System (OASIS™) Module Builder. The OASIS Module Builder is used to create Application Modules for the Particle Beam Optics Laboratory (PBO Lab™) software. This User Manual Supplement describes the use of the PSI-TURTLE Module within the PBO Lab framework. Refer to the PBO Lab User Manual (Basic Package) for general information on the PBO Lab user interface.

This PBO Lab 3.0 User Manual Supplement describes the PSI-TURTLE Module. Features specific to the Module are discussed here. The main (Basic Package) PBO Lab User Manual provides general information on the PBO Lab user interface.

Overview

The PSI Code Modules are available commercially as PBO Lab Modules. The PSI executable physics programs may be downloaded from the Paul Scherrer Institute website (www.psi.ch) and include the PSI versions of TRANSPORT, TURTLE and associated programs. This Section of the User Manual Supplement provides an overview and introduction to the PBO Lab PSI-TURTLE Module. The installation of the PSI-TURTLE Module is described, a summary of the PSI-TURTLE Module command structure is presented, and the PBO Lab Pieces supported by the PSI-TURTLE Module are listed. For information on the physics and other features of the PSI version of TURTLE, also known as "Graphic TURTLE," please refer the documentation provided by the Paul Scherrer Institute website (see Section 6).

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 Module for PBO Lab. The PSI Code Modules were created with the OASIS Module Builder.

Section 2 of the User Manual Supplement describes the Commands submenus for the PSI-TURTLE Module. Section 3 describes the Optics and Command Pieces. Section 4 summarizes the Auxiliary Input, List Windows and Options available to the user. Section 5 presents selected examples.

The PSI-TURTLE Module utilizes executable programs (.exe) and dynamic linked libraries (.dll) that are part of the PSI Graphic Turtle Framework by U. Rohrer based on a CERN-SLAC-FERMILAB version by K.L. Brown et al. This User Manual Supplement describes how to use the PSI "Graphic TURTLE" program within the PBO Lab framework. For information on using the FNAL/SLAC versions of TURTLE please see the PBO Lab User Manual Supplement for the TURTLE and DECAY-TURTLE Modules.



Installing the PSI-TURTLE Module

The PSI-TURTLE Module requires two components:

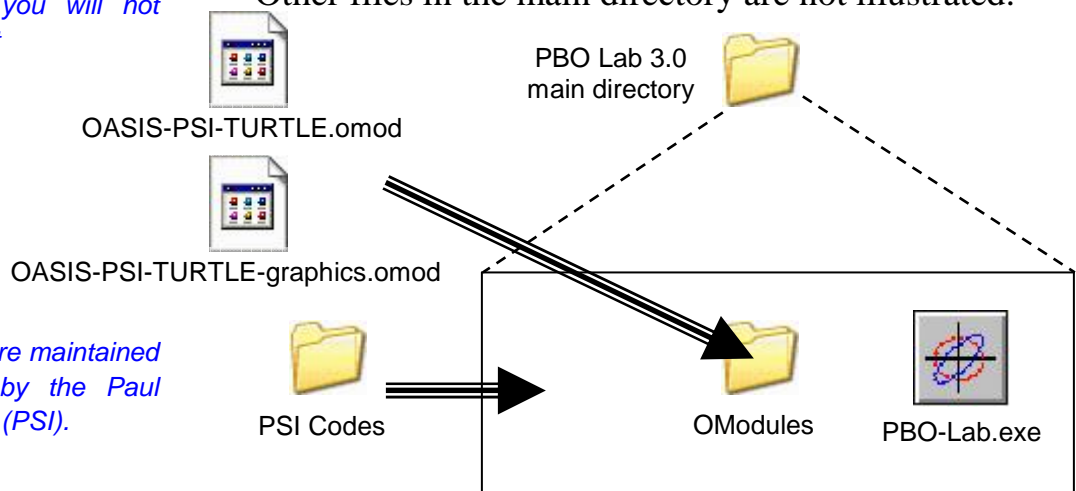
1. The OASIS Module Specification Documents, and
2. The PSI physics and related programs.

The OASIS Module Specification Documents are files with extension .omod, The PSI-TURTLE Module includes two: OASIS-PSI-TURTLE.omod and OASIS-PSI-TURTLE-graphics.omod. The PSI physics programs that will be needed include the files "turtle32.dll", "gratur32.exe" and "ix_higz.dll". To install the PSI-TURTLE Module these files need to be in specific locations on your computer's hard drive.

1. Move (or copy) the *files* with extension ".omod" to the folder (directory) named "OModules" inside the folder containing the PBO Lab 3.0 (or later) executable.
2. Set up a folder named "PSI Codes" in the folder containing PBO Lab 3.0 (or later).

You will need to have PBO Lab 3.0 (or later) in order to utilize the PSI Code Modules. If you do not already have PBO Lab 3.0 installed on your computer, you will need to install it first. Follow the installation instructions that accompanied your PBO Lab 3.0 software. If you already have PBO Lab 3.0 installed on your computer, you will not need to reinstall it

Figure 1 illustrates the locations for the components. Other files in the main directory are not illustrated.



The PSI Codes are maintained and distributed by the Paul Scherrer Institute (PSI).

There will be many files and folders (directories) appearing in the main PBO Lab directory. These are not illustrated in Figure 1.

Figure 1. Copy the ".omod" *files* to the OModules folder and create a new *folder* (directory) in the main PBO Lab folder named PSI Codes. The exact name "PSI Codes" is important.

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Copy the PSI physics programs "turtle32.dll", "gratur32.exe" and "ix_higz.dll" into the folder named PSI Codes. To access the PSI-TURTLE Module you will need to have a user license number for PBO Lab 3.0 (or later) and a CD-Key *enabled for OASIS Modules*. The user license number and CD-Key are included in the documentation shipped with the PBO Lab software or Module upgrade. The license number and CD-Key need to 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 PSI Code Modules to an existing PBO Lab 3.0 installation, you will need to update your CD Key. To do this, start PBO Lab in the (default) Single Model Mode. You will see a PBO Lab Document Window like that illustrated in Figure 2. Under the Tutorial menu 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 PSI-TURTLE Module. (OASIS Modules will not work with PBO Lab 2 or earlier.)

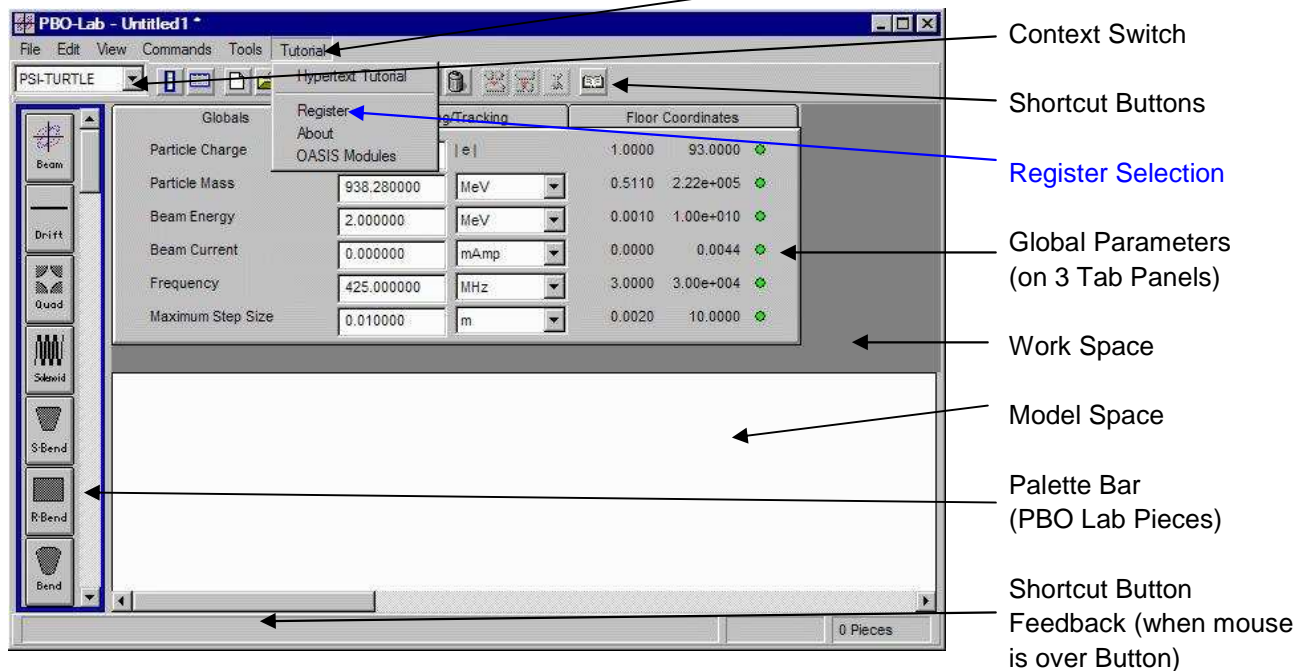


Figure 2. The Tutorial menu of the PBO-Lab Document window contains a Register selection.



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After entering the PBO Lab license number and required CD-Key for the OASIS PSI-TURTLE Module, the PBO Lab application needs to be closed and then re-opened in order to access the PSI-TURTLE Module.

The PSI OModules folder on the CD contains the following Module files for the PSI-TURTLE Module:

- PSI-TURTLE.omod
- PSI-TURTLE-graphics.omod

Close PBO Lab by choosing Quit from the File menu. When you re-open the PBO Lab application the PSI-TURTLE Module will be installed. You may wish to install certain optional items from the installation CD. A PDF version of this user manual may be contained in the Manuals folder on the CD. A PSI Examples folder may also be on the installation CD with PBO Lab model files (.pbo) extension) for the PSI-TURTLE Module. If desired, copy these folders from the CD to the hard drive folder where PBO Lab is installed.

Summary of Command Structure

A brief summary of the PSI-TURTLE Module command structure is presented here. Individual commands are described in more detail in later Sections of this Supplement. Figure 3 illustrates a PBO Lab Document window with the PSI-TURTLE Commands submenu selected in the PBO Lab Command Menu.

Command submenus for installed Application Modules are accessed from the PBO Lab Commands Menu in the Document Window

Commands submenu for the PSI-TURTLE Module

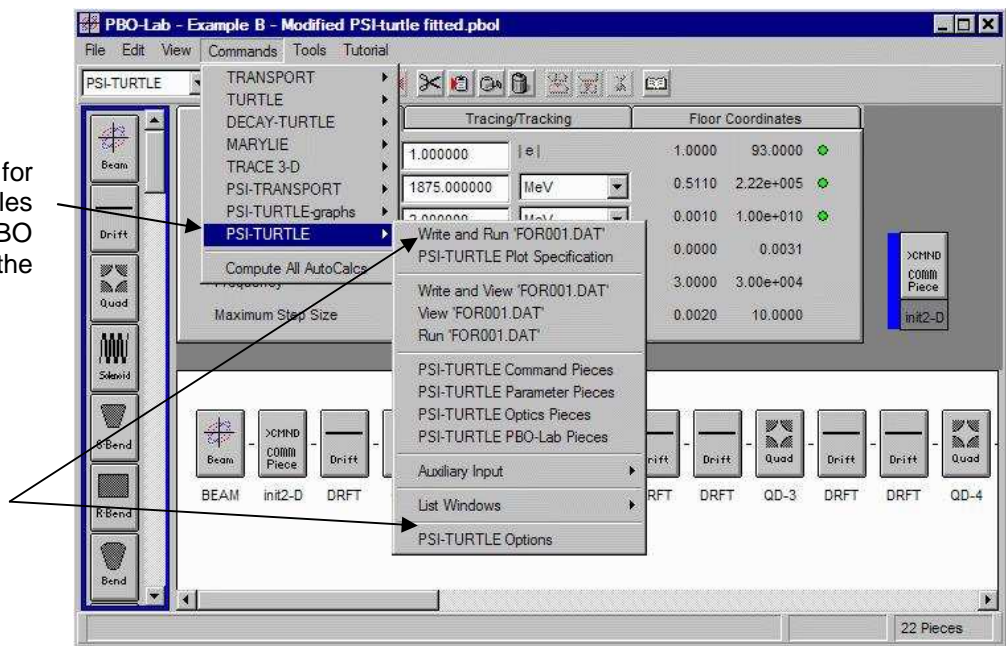


Figure 3. PBO Lab Document Window showing the PSI-TURTLE Module Commands submenu.

PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module



The PBO Lab Document window illustrated in Figure 3 also shows an entry on the Commands menu for another component of the PSI-TURTLE Module:

PSI-TURTLE-graphs

The Command Menu in the PBO Lab Document Window contains submenus for any installed Simulations and Application Modules. The Command Menu shown in Figure 3 includes six other installed PBO Lab Application Modules: TRANSPORT, TURTLE, DECAY-TURTLE, MARYLIE, TRACE 3-D, and PSI-TRANSPORT.

The PSI-TURTLE Commands submenu is shown in the side-bar with the corresponding Manual Sections that describe the entries in more detail. The command structure for the PSI-TURTLE-graphs is simple and only contains one item.

The PSI-TURTLE Commands submenu is separated into six groups. The first two groups contain commands for generating I/O for the PSI-TURTLE Module and for running the computation engine. The Main Input File for the PSI-TURTLE Module is named "FOR001.DAT" and most of the commands operate via that file. These commands are described in Section 2 of this Supplement.

The PSI-TURTLE Plot Specification Command is also described in Section 2. Those commands are used to display PBO Lab Plot Tool Windows. The PBO Lab Plot Tool Windows can be used to quickly view various displays of the final beam distribution, without the need to set up specific PSI-TURTLE distribution plot (histogram) requests.

PSI-TURTLE Module
Commands submenu.

Manual Section:

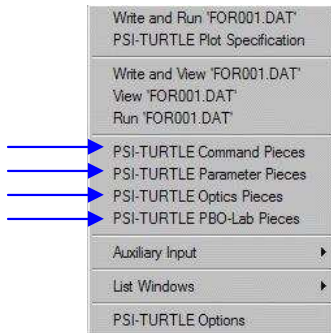
Write and Run 'FOR001.DAT'	
PSI-TURTLE Plot Specification	2
Write and View 'FOR001.DAT'	
View 'FOR001.DAT'	2
Run 'FOR001.DAT'	
PSI-TURTLE Command Pieces	
PSI-TURTLE Parameter Pieces	3
PSI-TURTLE Optics Pieces	
PSI-TURTLE PBO-Lab Pieces	
Auxiliary Input	4
List Windows	4
PSI-TURTLE Options	4

Write and Run Input

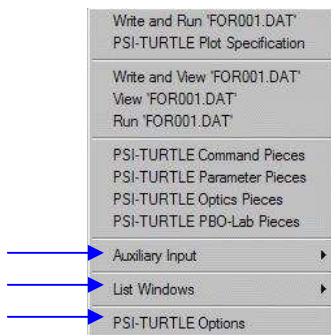
PSI-TURTLE-graphs Commands submenu contains only one item.



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PSI-TURTLE Module Commands submenu has four (4) Piece creation commands.



Auxiliary Input, List Windows and Options for the PSI-TURTLE Module are also accessed from the Commands submenu.

The next group of commands in the PSI-TURTLE Commands submenu focuses on the different types of beamline elements (Pieces) that are supported by the PSI-TURTLE Module. PSI-TURTLE Module 1.0 utilizes only three of the four Piece types listed in the menu: there are no PSI-TURTLE Parameter Pieces. This may change with future versions of the PSI-TURTLE Module. The Piece creation commands are discussed in Section 3 of this Supplement.

The next command group contains a submenu for PSI-TURTLE Auxiliary Input. There are two items in the Auxiliary Input submenu that can be used to add additional text directly to the PSI-TURTLE Main Input File (FOR001.DAT). One is for "Header Instructions" to follow the Header Section of the Main Input File, and the other is for "Footer Instructions" to precede the Footer Section of the Main Input File. These are described in Section 4 of this Supplement.

The List Windows commands are used to display results from different types of parameter and labeling searches over a beamline model. These commands are also described in Section 4 of this Supplement. Although these commands are not utilized directly by the PSI-TURTLE Module, they provide information on parameters utilized by other PBO Lab Modules.

The final entry on the Commands submenu is used to open the PSI-TURTLE Options window. Section 4 of this Supplement illustrates the Options window and describes the PSI-TURTLE Options available.



Summary of Supported Pieces

A summary of the Pieces supported by the PSI-TURTLE Module is given here. The different types of Pieces include (a) PBO Lab "Palette Bar" optics elements that are supported by PSI-TURTLE and by most other PBO Lab Application Modules, as well as (b) custom Command, Parameter and Optics Pieces developed specifically for the PSI-TURTLE Module. The PSI-TURTLE Module does have any custom *Palette Bar* Pieces although this may change in a future release. Of course, as described in Section 3, there are several custom PSI-TURTLE Pieces that are accessed using the Commands submenu items for various Pieces.

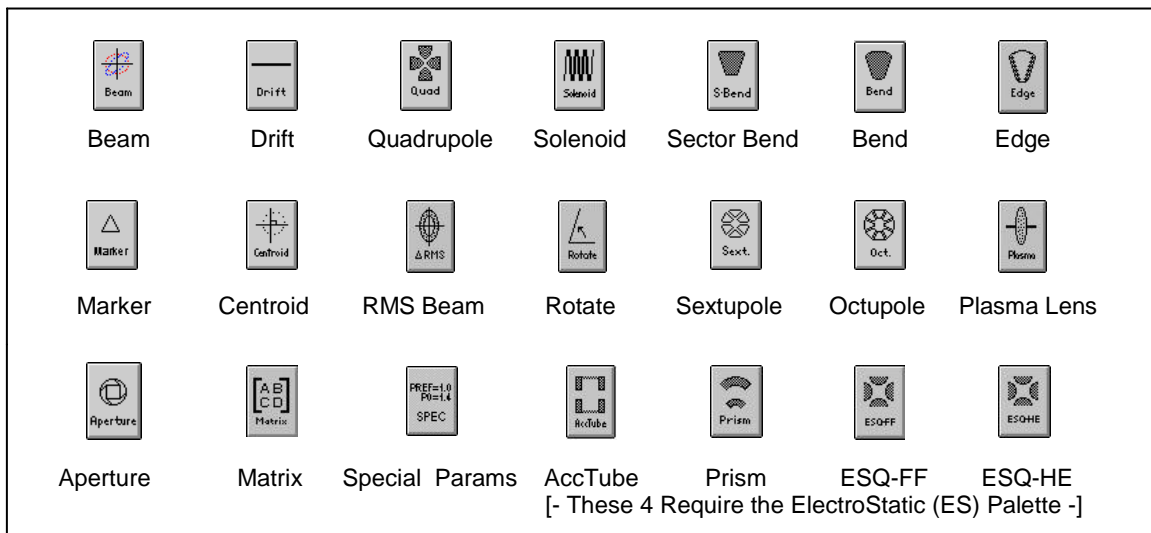


Figure 4. PBO Lab Palette Bar Pieces supported by the PSI-TURTLE Module. Note that the electrostatic elements also require the PBO Lab ElectroStatic Palette.



PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module

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PBO Lab™

2. PSI-TURTLE Commands Menu

**User Manual:
Supplement:
PSI-TURTLE
Application
Module**



PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module

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Principal PSI-TURTLE Commands

A summary of the PSI-TURTLE Module command structure was given in Section 1 and illustrated in Figure 3. This Section describes the first five (5) commands in the PSI-TURTLE Module submenu shown in the side-bar. Sections 3 and 4 describe the remaining Commands.

The first command provides a general command to execute the PSI-TURTLE Module computation engine. When selected, the “Write and Run 'FOR001.DAT'” Command will write a Main Input File for the beamline in the Document Window, then run the computation engine (turtle32.dll) with that input, and finally open a window to display the output text file FOR002.DAT. The Main Input File (FOR001.DAT) is written but not displayed by this Command. Instead the Main Output File (FOR002.DAT) is opened and displayed as soon as the computations are completed. Figure 5 shows an example of the result for the “Write and Run 'FOR001.DAT'” Command.

Manual Section:

Write and Run 'FOR001.DAT'	←	2
PSI-TURTLE Plot Specification		2
Write and View 'FOR001.DAT'		2
View 'FOR001.DAT'		2
Run 'FOR001.DAT'		2
PSI-TURTLE Command Pieces		3
PSI-TURTLE Parameter Pieces		3
PSI-TURTLE Optics Pieces		3
PSI-TURTLE PBO-Lab Pieces		3
Auxiliary Input	▶	4
List Windows	▶	4
PSI-TURTLE Options		4

[PSI-TURTLE Module Commands submenu](#)

```

Turtle32.DLL computational part for Turtle Framework, compiled by U. Rohrer (PSI), 5-May-2004

EXAMPLE B - MODIFIED PSI RUN MONDAY, JUNE 06 2016
(*** OASIS PBO-LAB MODULE FOR PSI-TURTLE VERSION 0.9.3.0 *** )
10000
Next label truncated to 4 characters.
17. /ORDE/ 1.000000;
** 1st order **
Next label truncated to 4 characters.
16.00 /MASS/ 3.000000 3669.283203;
Next label truncated to 4 characters.
16.00 /CHAR/ 29.000000 1.000000;
16.00 /SEED/ 30.000000 1.000000;
15. / / 11.000000 /MEVC/ 0.001000 =
15. / / 12.000000 /MEV / 0.001000 =
16.00 /F100/ 190.000000 0.000000 100.000000;
(*** BEAM UNITS ARE CM, MRAD, CM, MRAD, CM, %DP/P, MEV/C *** )
(*** CURRENT VALUE OF PSI-TURTLE MODULE OPTION RMSTOBOUNDARY = 1.118034 *** )
Next label truncated to 4 characters.
16.00 /6-DU/ 24.000000 0.000000;
(** USE OPTION RMSTOBOUNDARY OF 1.118034 FOR PBO-LAB END EMIT = 5X RMS EMIT ** )
1.000000 /BEAM/ 0.601438 26.102430 0.527136 25.537601 1.024674 0.945052 86.626007;
(** CORRELATIONS: C21 C31 C32 C41 C42 C43 C51 C52 C53 C54 C61 C62 C63 C64 C65 ** )
12. /COOR/ -0.952111 0.000000 0.000000 0.000000 0.000000 0.000000 0.934271 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 -0.121000;

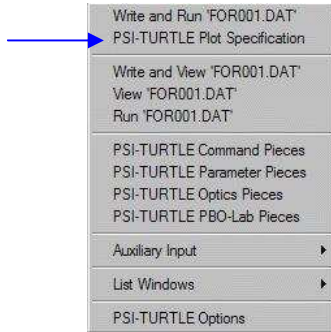
Next label truncated to 4 characters
51.0 /IN/ 1.000000 -0.800000 0.800000 0.029630;
52.0 / / 2.000000 -35.000000 35.000000 2.413793;

Next label truncated to 4 characters
51.0 /IN/ 3.000000 -0.800000 0.800000 0.029630;
52.0 / / 4.000000 -35.000000 35.000000 2.413793;
3.0 /DRFT/ 0.173000;
5.00 /QD1/ 0.096000 -2.244760 1.000000;
3.0 /DRFT/ 0.039750;
    
```

Figure 5. Main Output File after a “Write and Run 'FOR001.DAT'” Command.



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The Command PSI-TURTLE Plot Specification is used to provide quick views of the beam distribution at the end of the beam line.

After a Write and Run 'FOR001.DAT' command has been executed, for a beamline with a least one PSI-TURTLE Command (COMM) Piece requesting a histogram, then selecting any plot option from the list will open a PBO Lab Graph Tool Window displaying data for the output beam.



The beamline on the Model Space must contain at least one COMM Piece requesting a histogram for data to be written to the file FOR111.dat. See Figure 14 for a list of PSI-TURTLE COMM Pieces including those that are used to request histograms.

The example FOR002.DAT file illustrated in Figure 5 is for the PBO Lab model file "Example B - Modified-fitted PSI-TURTLE.pbol". This example is described in more detail in Section 5, PSI-TURTLE Module Examples.

The "PSI-TURTLE Plot Specification" command is also found in the first group of commands for the Module. This command provides a listing of commonly used PBO Lab Plot Specifications defined for the PSI-TURTLE Module. Figure 6 illustrates the PBO Lab Plot Option window that is opened by this Command. The list window provides for each plot option: (a) the Type, (Scatter Plot or Histogram), (b) a Description of the plot specification, (c) the Data File Name that provides the distribution data and (d) an Open descriptor (which is always "Manual" for the PSI-TURTLE Module).



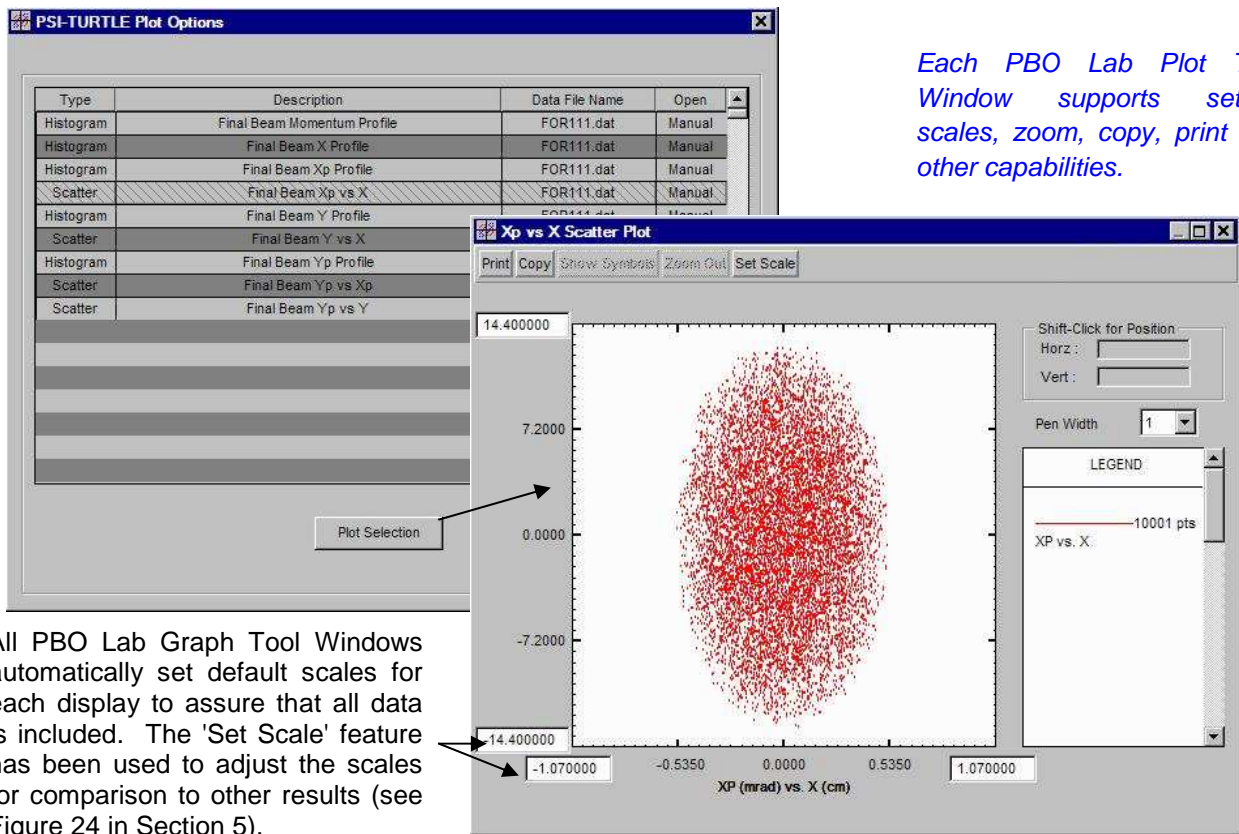
Figure 6. PSI-TURTLE Plot Options window.

Making a selection from the list and pressing the "Plot Selection" button will process that Plot Option selection and display the data in a PBO Lab Plot Tool Window, not a Graphic TURTLE "HIGZ_01" window.

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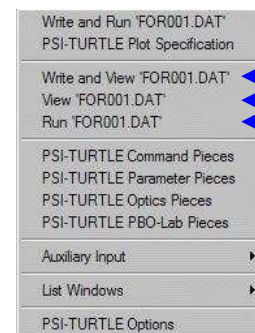
After a “Write and Run 'FOR001.DAT'” Command as been executed, resulting in the display of a FOR002.DAT output file such as that shown in Figure 5, then a plot option may be selected from the list illustrated in Figure 6 and the Plot Selection button used to open a display of the final beam distribution data for that option. Figure 7 illustrates this for the “Final Beam Xp vs x” scatter plot of the PBO Lab model “Example B - Modified-fitted PSI-TURTLE.pbol”.



All PBO Lab Graph Tool Windows automatically set default scales for each display to assure that all data is included. The 'Set Scale' feature has been used to adjust the scales for comparison to other results (see Figure 24 in Section 5),

Figure 7. Selecting a PBO Lab Plot Option for the PSI-TURTLE Module.

The second group of commands in the Commands Menu provides individual commands to Write and View, View, or Run the FOR001.DAT Main Input File. This separates the steps that are encapsulated into the combined “Write and Run 'FOR001.DAT'” Command. Examples of using “Write and View 'FOR001.DAT'” are given in Section 5.





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The “Write and View...” Command will cause a new Main Input File to be written and opened for viewing, but will not execute a computation. The “View...” command will open an existing FOR001.DAT Main Input File, but again will not cause any computation. The “Run...” command will use the existing Main Input File (FOR001.DAT) to execute the PSI-TURTLE computation engine (turtle32.dll). These Commands are useful for debugging purposes.

The Main Input File is organized into four sections:

Header

Lattice

Lines

Footer

The PSI-TURTLE Module uses the Header, Lattice, and Footer Sections, but not the Lines Section. Figure 23 in Section 5 illustrates these sections of the Main Input File.

The Main Input File is grouped into four logical sections: Header, Lattice, Lines and Footer. When writing the Main Input File, the Header section is written first, followed by the Lattice section. The Lines section is not used by the PSI-TURTLE Module. The Footer section is written at the bottom of the Main Input File. Additional lines may be written between these primary sections utilizing Auxiliary Input. See Section 4 for additional information.

PSI-TURTLE Module I/O

The PSI-TURTLE Module utilizes several other input/output files. These I/O files are the same as those defined for the PSI computation codes "turtle32.dll", "gratur32.exe" and "ix_higz.dll". Table 1 gives a summary of the main I/O files used by the PSI-TURTLE Module and the supporting PSI-TURTLE-graphs Module.

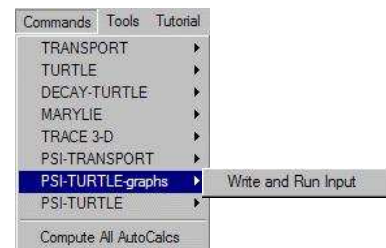


Table 1. Summary of main I/O files used by the PBO Lab PSI-TURTLE Module.

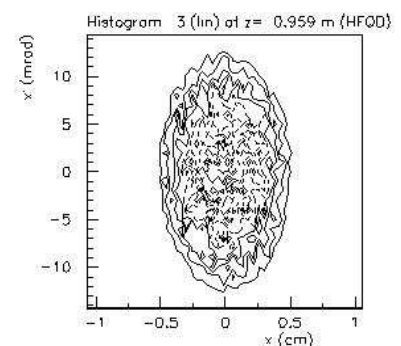
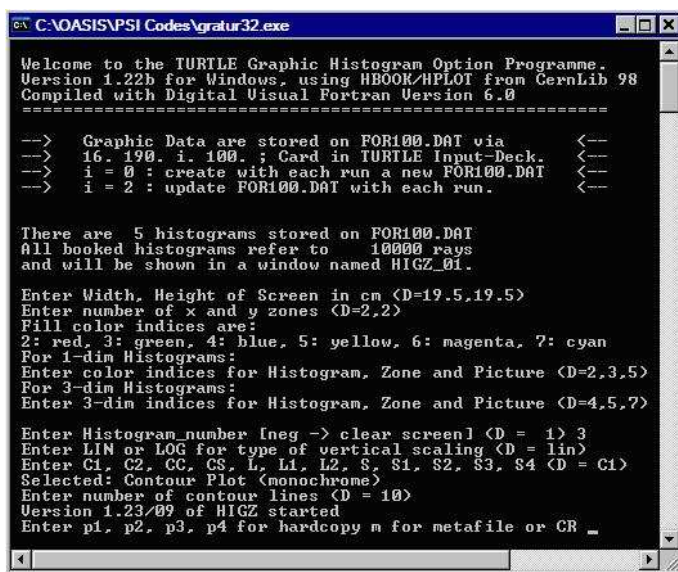
File Name	Description	Written By	Used By
FOR001.DAT	PSI-TURTLE Main Input File	PBO-Lab PSI-TURTLE Module	turtle32.dll
FOR002.DAT	PSI-TURTLE Main Output File	turtle32.dll	PBO-Lab View Menu
FOR111.DAT	particle distribution data	turtle32.dll	PBO-Lab PSI-TURTLE Plots
"	"	"	gatur32.exe
FOR100.DAT	histogram parameter data	turtle32.dll	gatur32.exe
FOR222.DAT	histogram parameter data	turtle32.dll	gatur32.exe
FOR011.DAT	histogram graphics parameters	gatur32.exe	ix_higz.dll
hist.ps	postscript file	ix_higz.dll	any postscript viewer/editor

PSI-TURTLE-graphs Commands

The PSI-TURTLE Module also includes a specialized supporting Module named "PSI-TURTLE-graphs" that supports the Graphic TURTLE capabilities. The PSI-TURTLE-graphs Module has only one Command "Write and Run Input". (Execution should follow a run of the main PSI-TURTLE Module by using the "Write and Run Input Command, or equivalent.) The Write and Run Input Command will open a gratur32.exe console window similar to that in Figure 8.



PSI-TURTLE-graphs Module Commands submenu contains only one item which opens a console window similar to that shown in Figure 8.



After entering the requested data in the gratur32.exe console window (see Figure 8) the requested plot(s) will appear in a HIGZ_01 window. The above shows Histogram 3 of the Example B - Modified-fitted PSI-TURTLE.pbol model.

Figure 8. Window opened by PSI-TURTLE-graphs Module with gratur32.exe request for Histogram 3.



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PBO Lab™

3. PSI-TURTLE Supported Pieces

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PSI-TURTLE Palette Bar Pieces

Standard beamline elements (PBO Lab Pieces) are located on the scrolling Palette Bar of the Document Window. Dragging a Piece icon from the Palette Bar to the Model Space of the Document Window adds that element to the beamline model and snaps it in at the location at which it is dropped. Pieces may also be dropped on the Work Space of the Document Window by dragging a piece icon from the Palette Bar.

Not all of the PBO Lab Palette Bar Pieces are supported by the PSI-TURTLE Module. A summary of the Pieces appearing on the PBO Lab Palette Bar that are supported by the PSI-TURTLE Module was presented in Section 1, Getting Started. All of the PSI-TURTLE Pieces, including Pieces unique to the Module, may be accessed using three of the four items appearing on the PSI-TURTLE Commands submenu:

- PSI-TURTLE Command Pieces
- PSI-TURTLE Parameter Pieces (not used)
- PSI-TURTLE Optics Pieces
- PSI-TURTLE PBO-Lab Pieces

Selecting the menu item "PSI-TURTLE PBO-Lab Pieces" opens the window illustrated in Figure 9.

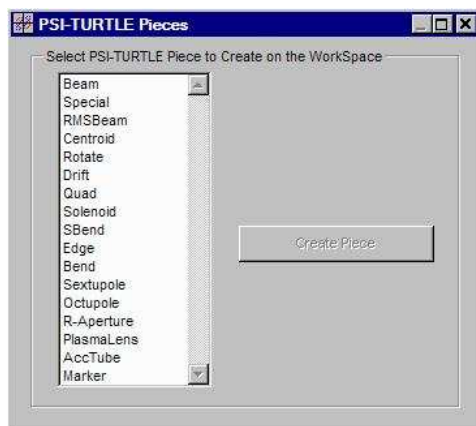
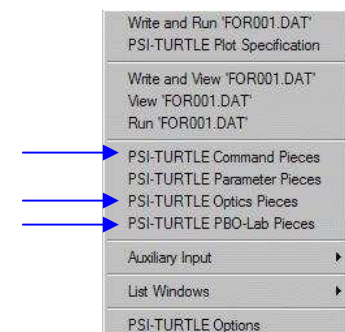


Figure 9. PBO Lab Palette Bar Pieces Supported by the PSI-TURTLE Module.



Standard optics elements (PBO Lab Pieces) are located on the scrolling Palette Bar of the Document Window.



The PSI-TURTLE Commands submenu utilizes three (3) Piece creation commands.



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Selecting one of the items from the list on the left side of the PSI-TURTLE Pieces window illustrated in Figure 9 will activate the "Create Piece" button. A corresponding Piece is created on Work Space of the Document Window when the "Create Piece" button is used.

Any Piece created using the PSI-TURTLE Pieces window will be identical to one created from the Palette Bar. The window simply provides a list of Palette Bar Pieces supported by the PSI-TURTLE Module. The list in the PSI-TURTLE Pieces window may include more items than shown in Figure 9 as the number of supported Palette Bar Pieces is increased.

Many of the PBO Lab Pieces for describing transport lines (drifts, quadrupoles, bends, etc.) are supported by the PSI-TURTLE Module. The set up of transfer lines, and the selection of parameters for the individual Pieces in a transfer line, follow the standard PBO Lab procedures used for any PBO Lab Optics Application Module.

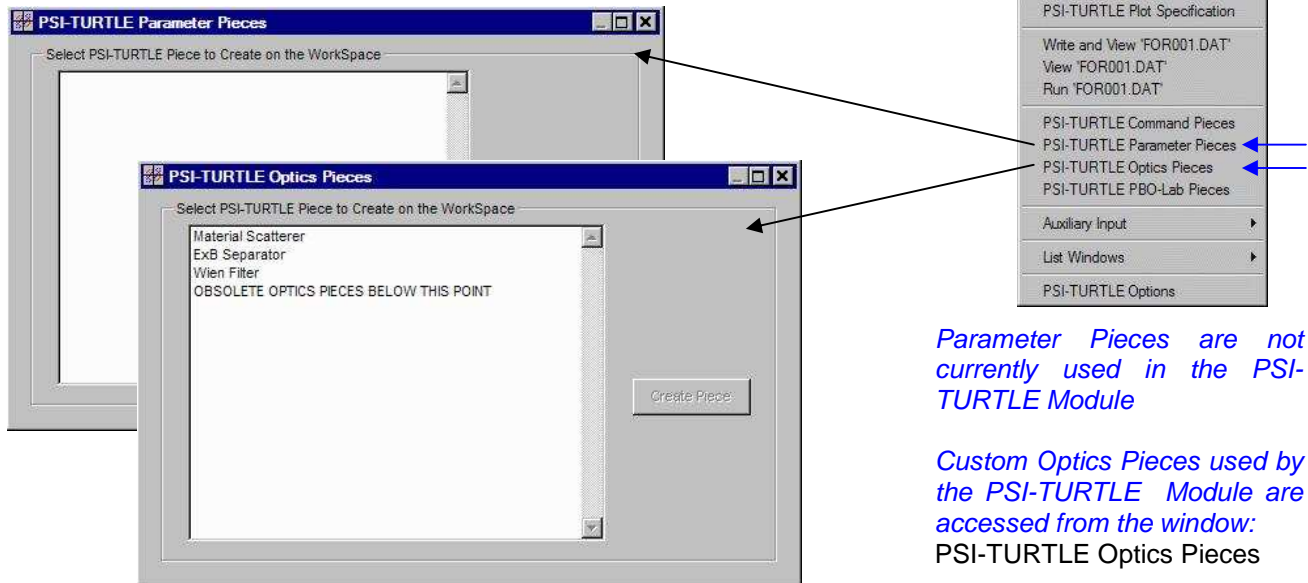


PSI-TURTLE Parameter & Optics Pieces

There are no Parameter Pieces in PSI-TURTLE Module 1.0. This may change in a future release.

One custom Optics Piece has been defined for the PSI-TURTLE Module, and it is listed in the “PSI-TURTLE Optics Pieces” window illustrated in Figure 10.

Windows showing the available Parameter or Optics Pieces are accessed from the PSI-TURTLE Commands menu



Parameter Pieces are not currently used in the PSI-TURTLE Module

Custom Optics Pieces used by the PSI-TURTLE Module are accessed from the window: PSI-TURTLE Optics Pieces

Figure 10. Parameter Pieces (none) and Optics Pieces defined specifically for the PSI-TURTLE Module

The "Material Scatterer" Optics Piece is an important feature of the PSI-TURTLE Module. The capabilities of the "Material Scatterer" is one of the main features that distinguish the PSI-TURTLE Module from the standard PBO Lab TURTLE and DECAY-TURTLE Modules. The "Material Scatterer" Piece encapsulates the combined effects of multiple scattering, nuclear elastic scattering, and absorption that are modeled in the PSI-TURTLE physics code. The use of the "Material Scatterer" Optics Piece is illustrated on the next few pages, with additional material in the PSI-TURTLE Examples, Section 5.

PBO Lab Palette Bar Pieces that supported by the PSI-TURTLE Module are listed in the PSI-TURTLE Pieces window shown in Figure 9.

If a custom Optics Piece becomes "obsolete", e.g. if it is replaced by a PBO Lab Palette Bar Piece, then it will be moved below the line in Figure 10 starting with OBSOLETE. The discussion near Figure 15 in regards to OBSOLETE Command Pieces applies here as well.



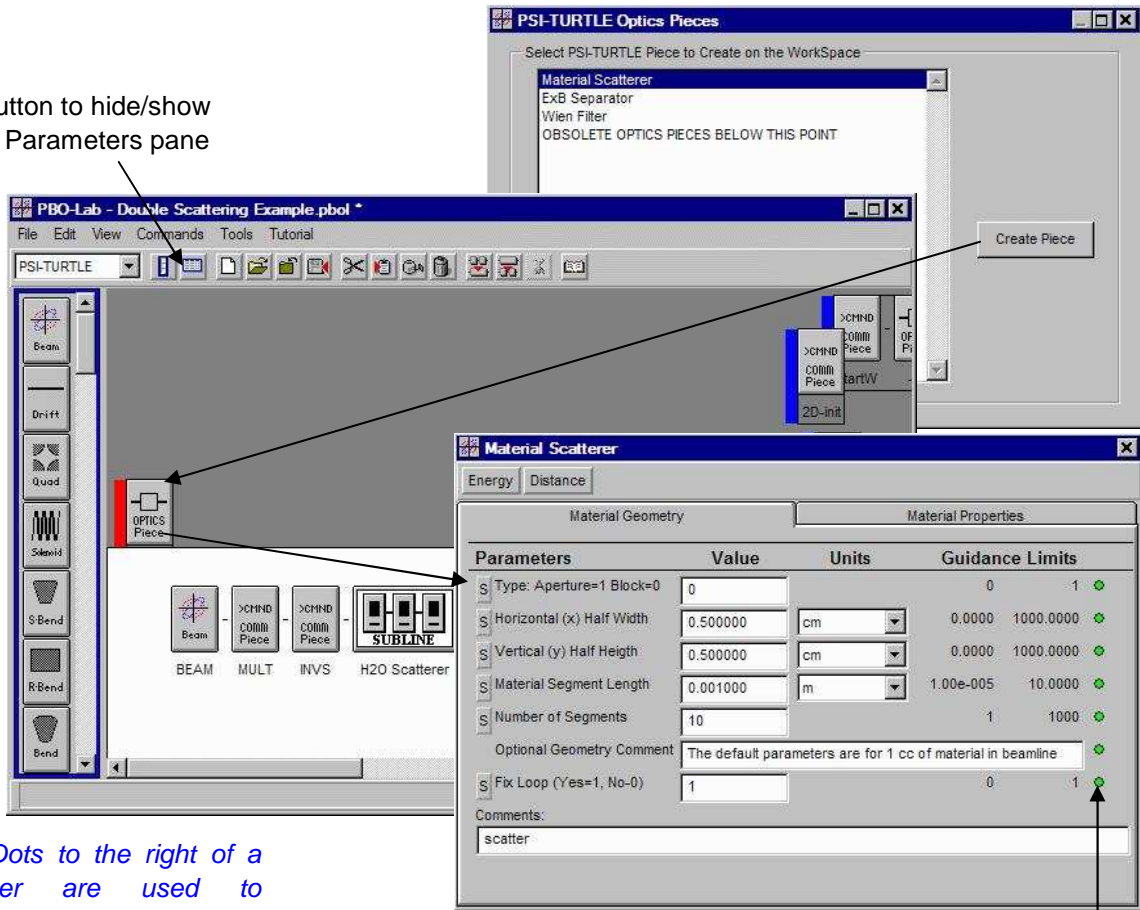
PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module



Unique Optics Pieces defined for the PSI-TURTLE Module are created using the PSI-TURTLE Optics Pieces window.

The PSI-TURTLE Optics Piece named "Material Scatterer" is used to simulate the effects on a beam due to matter in the beam line. The "Create Piece" button in the Parameter Pieces window is used to create the selected Piece on the Work Space of the Document window. This is illustrated in Figure 11.

Use this button to hide/show the Global Parameters pane



Green Dots to the right of a parameter are used to indicate that the parameter will be used by the PBO Lab Module identified by the Context Switch in the upper left of the Document Window.



Green Dots will appear if the PBO-Lab Context Switch is set to PSI-TURTLE

Figure 11. PSI-TURTLE Module "Material Scatterer" Piece Example.



The PBO Lab PSI-TURTLE Optics Piece "Material Scatterer" contains two tab pages. The front tab page is for inputting the "Material Geometry" of the scatterer. The "Material Geometry" tab page is illustrated in Figure 11 with the default values of all parameters. The second tab page is for the "Material Properties" of the scattering element. The "Material Properties" tab page is shown in Figure 12.

The PSI-TURTLE Optics Piece Material Scatterer has tab pages for inputting material geometry and material properties..

The Material Properties tab of the PSI-TURTLE Module "Material Scatterer" Piece has parameters that correspond to those of the multiple scattering, nuclear elastic scattering, and absorption model defined by Urs Rohrer of PSI. Refer to Urs Rohrer's documentation for further information.

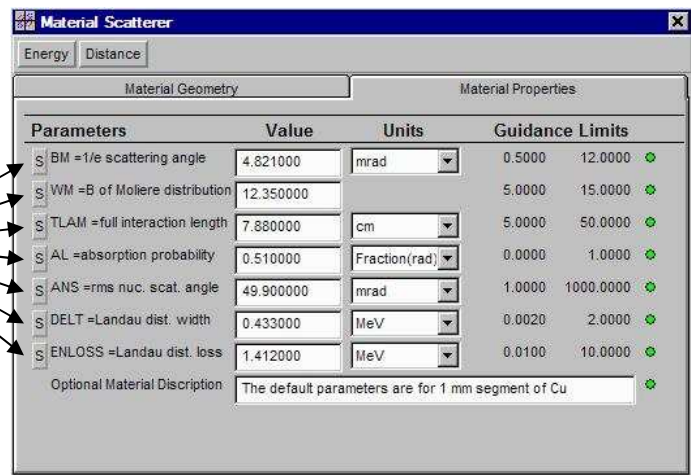


Figure 12. The "Material Properties" of the PSI-TURTLE Module "Material Scatterer" Optics Piece.

The "Material Geometry" tab (Figure 11) is used to define (a) the physical dimensions of the scatterer, (b) whether the scatterer is of the aperture type or "inverse" aperture type (i.e. a block of material), and a specification of the whether or not the "repeat loop" over the "Number of Segments" parameter (Figure 11) is to be "fixed" to include *only* the elements of the scatterer. If the "Fix Loop (Yes=1, No=0)" parameter is set to Yes (=1) then no PBO Lab Pieces appearing after the "Material Scatterer" Piece will be included in the repeat loop. The required PSI-TURTLE "Repeat" lines in the FOR001.DAT Main Input File will be included automatically.



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In contrast, if it is desired to include additional optics elements within the repeat loop, then the "Fix Loop (Yes=1, No=0)" parameter should be set to No (=0). In this case the user must specify the beginning and end of the repeat loop. The PSI-TURTLE Command Piece "Procedure Loop - Code 9" is used to specify these locations in the beamline on the Model Space. (The "Code 9" refers to the *type code* used by the PSI-TURTLE computation engine turtle32.dll.) The PSI-TURTLE Command Pieces are discussed further in the next subsection. The "Double Scattering Example.pbol" model discussed in Section 5 illustrates the use of both types of repeat loops.

Another Optics Piece unique to the PSI-TURTLE Module is the "ExB Separator" Piece appearing second in the list of Figure 10. Figure 13 illustrates the Piece window for the ExB Separator Piece.

Each ExB Separator Optics Piece supports up to seven (7) longitudinal segments, with varying length and fields, but having fixed transverse dimensions. Multiple ExB Separator Pieces are used to model more segmented separators, or separators with changing transverse apertures.

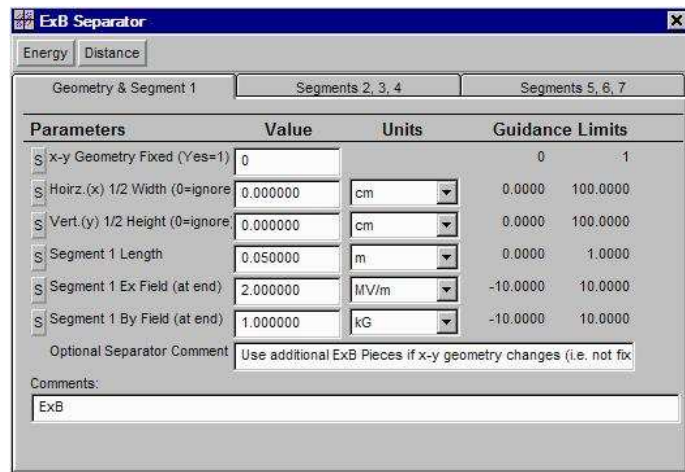


Figure 13. PSI-TURTLE Module "ExB Separator" Piece.

The ExB separator element in the PSI-TURTLE Module is a Wien-type filter that is divided into "segments" longitudinally. The electric and magnetic fields are constants in each segment, but the segments can be of varying length and unlimited in number.



The ExB Separator Piece window has 3 tab pages. The first tab page, shown in Figure 13, is used to set up the first "segment" of the separator, as well as providing additional information for the segments of the Piece. The first parameter on tab 1, named "x-y Geometry Fixed (Yes=1)", is used to specify whether or not the transverse geometry of the separate is changing along its length. For long separators, to which the ExB Separator Piece is typically applied, the transverse apertures often change so the default is set to "0". *The value of "1" should only be used* if the ExB Separator Piece is the last one in a multiple ExB Separator Piece model, or if the device model uses only one ExB Separator Piece. Changing apertures requires multiple ExB Separator Pieces.

The next two parameters are optional and are used on the *first* ExB Separator Piece to specify the initial horizontal and vertical apertures, "Horiz.(x) 1/2 Width (0=ignore)" and "Vert.(y) 1/2 Height (0=ignore)" respectively. As indicated, these parameters are ignored if equal to zero. Both parameters can be non-zero on the *first* ExB Separator Piece. For *subsequent* ExB Separator Pieces only one of the two aperture parameters can be non-zero. If the "0" default is left on a *subsequent* ExB Separator Piece, then the apertures remain unchanged. Use a non-zero value for *one of the apertures* to change that aperture. If two non-zero apertures are encountered on the same *subsequent* ExB Separator Piece, an error message will appear in the output file FOR002.DAT.

The next three parameters on tab 1 of the ExB Separator Piece window are used to specify the length, horizontal E-field, and vertical B-field, for the first segment of that Piece. The length of the first segment must be non-zero. Tab pages 2 and 3 provided similar input fields, for the length, horizontal E-field, and vertical B-field, of segments 2 through 7. Zero length for any of the segments will cause those segments to be ignored.

The parameter named:

x-y Geometry Fixed (Yes=1) is used as a flag to indicated if more than one ExB Separator Piece will be used consecutively to model the complete separator. The Yes ("1") choice is only used if:

(a) the complete separator can be modeled with 7, or fewer, longitudinal segments all having the same transverse apertures, or (b) the ExB Separator Piece is the last ExB Separator Piece modeling the device..

Multiple ExB Separator Pieces are often used to model a single physical separator. The first tab page of the [first](#) ExB Separator Piece has special significance. The transverse aperture dimensions of the first ExB Separator Piece will be applied to all subsequent ExB Separator Pieces. Only one transverse aperture can be changed (non-zero) on each subsequent ExB Separator Pieces. The other transverse dimension must keep the zero default value.

Not all segments of a ExB Separator Piece need to be used. To use only a few of the 7 segments Leave the "0" default for the "Segment N Length" to ignore that segment



PSI-TURTLE Command Pieces



Command (COMM) Pieces that have been defined for the PSI-TURTLE Module are listed in the PSI-TURTLE Command Pieces window.

Each COMM Piece will initially appear on the Work Space of the Document when created, similar to that illustrated in Figure 14.

The PSI-TURTLE computation engine uses a unique set of “commands” or “operators” that provide instructions for the physics code. These code-specific commands are implemented using a set of PSI-TURTLE Command Pieces, or "COMM" Pieces. The Command Pieces defined for the PSI-TURTLE Module are listed in the “PSI-TURTLE Command Pieces” window shown in Figure 14. A COMM Piece is created on the Work Space using the “Create Piece” button. Double-clicking on the COMM Piece icon opens the COMM Piece window, also illustrated in Figure 14.

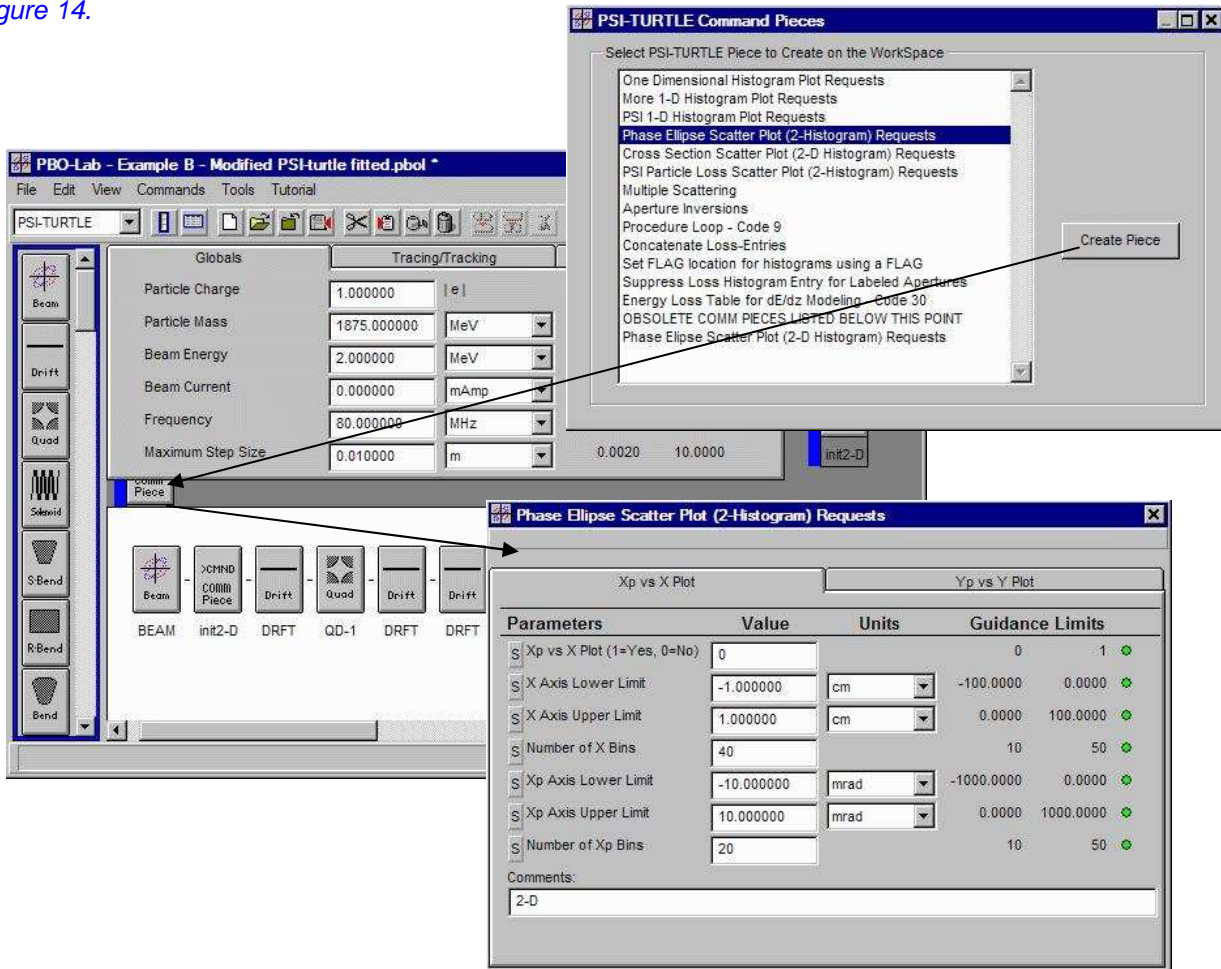


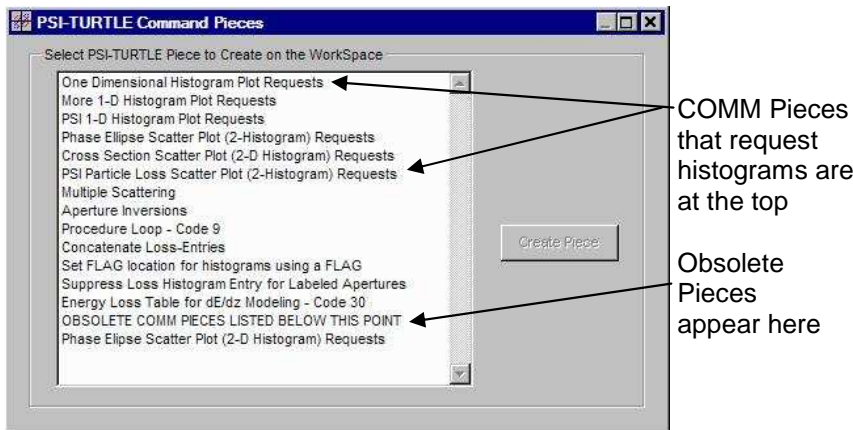
Figure 14. PSI-TURTLE Command Piece Example.



Beamline models constructed with PBO Lab should have at least one PSI-TURTLE COMM Piece that requests histogram plots. Without a histogram plot request COMM Piece, in the beamline on the Model Space, there will be no graphic output.

The PSI-TURTLE COMM Pieces that request histogram plots, either 1-D or 2-D plots, appear at the top of the list in the “PSI-TURTLE Command Pieces” window. Figure 15 shows the histogram plot request COMM Pieces. The other PSI-TURTLE Command Pieces shown in the list in Figure 15 correspond to specific operations that the PSI-TURTLE computation engine supports. The COMM Pieces have appropriate key words and comments to aid in their use. Embedded within the PBO Lab object for each Piece are the necessary methods, for input syntax and format, to support their use with the turtle32.dll computation engine.

Certain COMM Pieces may become "obsolete" when enhancements to the Module are developed. The functionality of obsolete Pieces will be replaced by the enhancements. Obsolete Pieces will continue to be supported in future PSI-TURTLE Modules, but their continued use is discouraged. Any obsolete PSI-TURTLE Module Pieces created on the Work Space will be identified by a new comment field that says OBSOLETE followed by a recommendation on what should be used instead. .



At least one COMM Piece requesting a histogram plot should always be used with PSI-TURTLE. If not, the data files

FOR100.DAT,
FOR111.DAT,
FOR222.DAT,

will not be written and no graphic output will be available.

Figure 15. Always use at least one Command Piece requesting a histogram with the PSI-TURTLE Module.



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The location within the beamline (on the Model Space) of the PSI-TURTLE COMM Pieces is important. In addition, the relative order of COMM Pieces can be important.

COMM Pieces are used to implement Application Module commands or instructions in the Main Input File. Unlike the Optics Pieces, the Command Pieces are not treated as physical beamline elements, although they are evaluated sequentially to produce the appropriate command instruction at the correct location in the Main Input File. The PSI-TURTLE Module Options also contain a number of instructions and commands that are not location specific. See Section 4 for a description of the PSI-TURTLE Module Options.



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4. PSI-TURTLE Module Tools

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4. PSI-TURTLE Module Tools

Auxiliary Input

The PSI-TURTLE computation engine (turtle32.dll) will access input and write output using the Main Input and Output Files. These files are described in Section 2 of this Supplement with examples given in Section 5. Auxiliary Input may also be used to produce additional commands or instructions to be written at specific locations in the Main Input File. The “Auxiliary Input” submenu in the PSI-TURTLE Commands menu has two commands which provide an interface for entering auxiliary input that will appear in the Header Section or the Footer Section of the Main Input File (see Figure 23 or Figures 34A and 34B). Figure 9 illustrates these Header and Footer Instruction Windows. For the PSI-TURTLE Module, there are no auxiliary inputs required, so the windows do not contain any additional instructions to be written to the Main Input File. Each window contains a check box to activate or deactivate the instructions from being written, without deleting the text of the instruction.

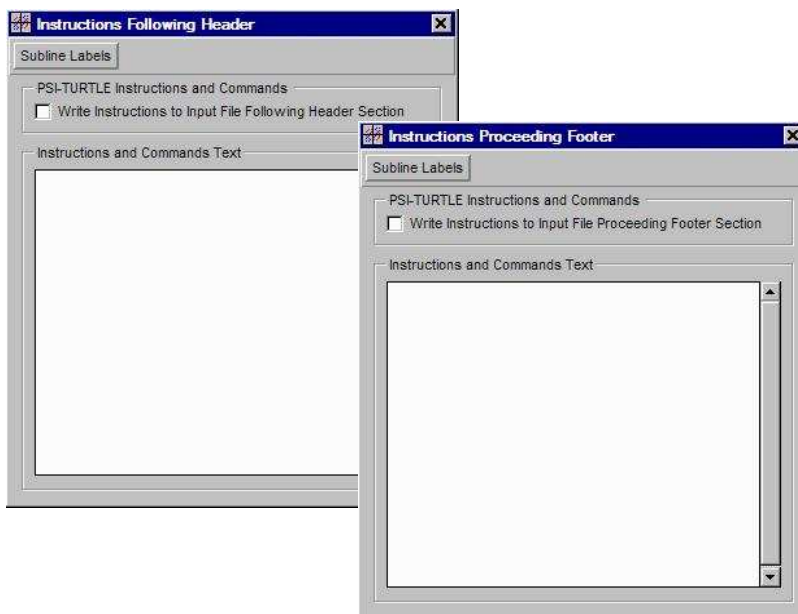
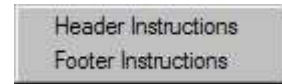


Figure 16. Header and Footer Instruction Windows



PSI-TURTLE Auxiliary Inputs

Auxiliary Input can be used to generate literal commands or instructions to be written at specific locations in the Main Input File. The Header Instructions and Footer Instructions write auxiliary input to fixed locations in the Main Input File FOR001.DAT,

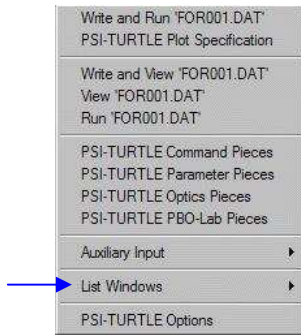
The Auxiliary Inputs are a “catch all” method to support some capability of the computation engine turtle32.dll that is not implemented with the Application Module. These may be “undocumented” features. AccelSoft is interested in learning about auxiliary input found useful by users. Please let AccelSoft know about your use of Auxiliary Input and support for them may be implemented in the future.



The Marker Piece can also be used to insert auxiliary input at specific locations in a beamline. However, this should be done with care as the location and order of such “in-line” commands can be important.



List Windows



The *PSI-TURTLE Commands* menu item named *List Windows* contains a submenu with access to information related to various *Special Parameter Settings (SPS)*.

The “List Windows” section of the Commands Menu for PBO Lab Modules generally provides access to lists of various types of PBO Lab Special Parameter Settings (“SPS” parameters). SPS parameters can be parameters varied during fitting or optimization, related by formulas to other parameters, or assigned other attributes. Many PBO Lab Modules utilize SPS parameters, but the PSI-TURTLE Module does not. Nevertheless it is often useful to see which parameters have SPS attributes assigned to them by other PBO Lab Modules. The PSI-TURTLE List Windows submenu has one item for this purpose “Other Module Named Parameters”. Figure 17 illustrates the Named Parameter List Window for the PBO Lab “Example B - Modified-fitted PSI-TURTLE.pbol” model.

Other Module Named Parameters

Label	Parameter Name	Parameter Variable	Fit	Value	Unit
QD-1	Magnetic-Field Gradient	VARY1		-2.244760	kG/cm
QD-1	Magnetic Field at Pole Tip	PSIVARY1	X	-2.244760	kG
QD-2	Magnetic-Field Gradient	VARY2		3.668180	kG/cm
QD-2	Magnetic Field at Pole Tip	PSIVARY2	X	3.668180	kG
QD-3	Magnetic-Field Gradient	VARY3		-2.268570	kG/cm
QD-3	Magnetic Field at Pole Tip	PSIVARY3	X	-2.268570	kG
QD-4	Magnetic-Field Gradient	VARY4		2.617440	kG/cm
QD-4	Magnetic Field at Pole Tip	PSIVARY4	X	2.617440	kG

List Windows are used to display search results for PBO Lab SPS parameters. While the PSI-TURTLE Module does not use SPS parameters, a list of such parameters used by other PBO Lab Modules can be viewed. Double-clicking a selection in the list opens the Piece Window with the Named Parameter.

Figure 17. PSI-TURTLE Module Named Parameters List Window example.

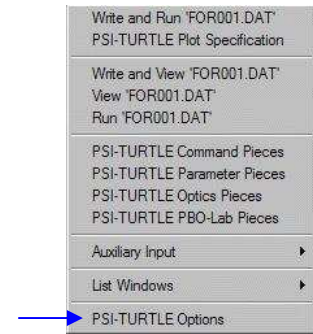
The *Piece Comment (Label)*, *Parameter Name*, *Symbolic Parameter Name (Parameter Variable)*, *Value*, *Unit* and whether or not the parameter is assigned as a fitting (*Fit*) variable in another PBO Lab Module.

The Named Parameters List Window (Figure 17) shows information for each Piece that contains Named Parameters. Double clicking an entry opens the corresponding Piece Window.



PSI-TURTLE Module Options

PSI-TURTLE Module Options are accessed with the last command in the PSI-TURTLE Commands Menu. Options are used to set Module specific conditions and assign specific values to certain Module parameters. Figure 18 illustrates the PSI-TURTLE Options Window. These option parameters, called "Numeric Constants", are shown in Figure 18. The number of PSI-TURTLE Module Options may increase in the future as additional features are added to the Module.



PSI-TURTLE Options is the last entry on the PSI-TURTLE Commands submenu



Selecting an item in the list activates edit fields for that item. Use the Accept button to update the selection.

The Reset button can be used to restore default values for all entries.

Use the Reset Defaults button following the installation of a Module update that adds new PSI-TURTLE Options.

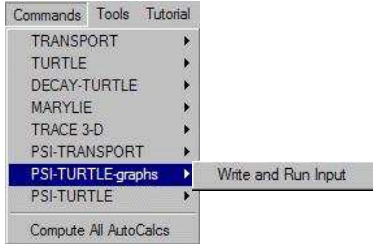
Figure 18. PSI-TURTLE Module Options window showing Numeric Constants

The first parameter in the list of Numeric Constants used as PSI-TURTLE Module Options is named "RMStoBoundary". This parameter is used to convert the Beam Piece Semi-Axis parameters from their "boundary" values (PBO Lab assumed) to the RMS values assumed by the PSI-TURTLE Module. The default value (1.118034) corresponds to $(1.25)^{1/2}$. The upper Guidance Limit (2.236068) corresponds to $(5)^{1/2}$. Option Parameters are stored with the model (.pbo) file.

The RMStoBoundary Option parameter is used to make Beam Piece parameters more readily compatible with other PBO Lab Modules. The Semi-Axes - Beam 1 parameters in the Beam Piece are divided by this parameter, prior to writing them to the FOR001.DAT Main Input File.



PSI-TURTLE-graphs support Module



The PSI-TURTLE-graphs Module is a supporting module for the gratur32.exe program. It allows that program to be run directly from PBO Lab.

The PSI-TURTLE-graphs Module makes displaying results using the gratur32.exe program easy, but data is only available to the gratur32.exe program for those histograms that were requested during a run of the main PSI-TURTLE Module. .

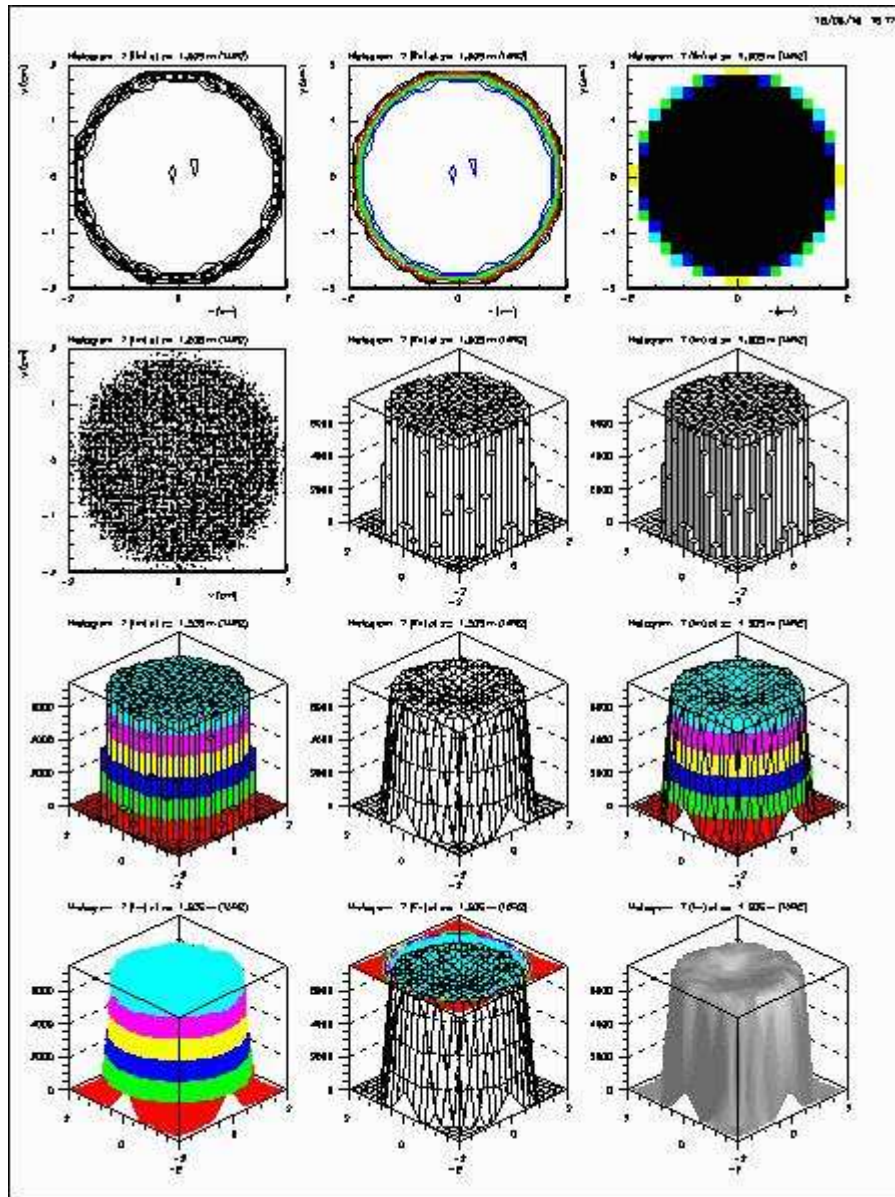
The PBO Lab PSI-TURTLE Module includes a supporting Module named PSI-TURTLE-graphs. The Module has only one Command (Write and Run Input) which should be used *after* an execution of the “Write and Run 'FOR001.DAT'” Command for the main PSI-TURTLE Module. The Write and Run Input Command will open a gratur32.exe console window for inputting plot specifications. Examples of the gratur32.exe console window are shown Figure 8, Figure 26 and Figure 38.

There a variety of options for input to the gratur32.exe console window. It is beyond the scope of this PBO Lab User Manual Supplement to detail all of them here, and the user is referred to the PSI-TURTLE Documentation (see Section 6) for further information. However, a short visual summary of the main options for the display of 2-D histogram data may be helpful.

When a histogram number is specified in the gratur32.exe console window that references 2-D histogram data, the gratur32.exe console window then asks for whether a linear or log plot is desired, followed by a request for the user to input the type of display. There are twelve (12) types of 2-D histogram plots available. The request for the type is a little vague, just giving a list of one or two character codes. The request in the gratur32.exe console window to enter the plot type looks like this:

```
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 (D = C1)
```

The default is "C1" which corresponds to a particular type of contour plot. Figure 19 shows examples for the twelve types of 2-D histogram plots available.



The 12 types of histograms shown in Figure 19 correspond to the following one or two digit codes entered into the gratur32.exe console window:

C1	C2	CC
CS	L	L1
L2	S	S1
S2	S3	S4

The arrangement of the codes above corresponds to the arrangement of the images in Figure 19.

Certain types of plots (e.g. CC) are less useful when large numbers of macro-particles are involved.

Figure 19. Examples of the 12 types of 2-D histogram plots available to the gratur32.exe computation engine.

The images of Figure 19 are for the beam cross section (i.e. y vs x) of the final distribution of particles for the "Double Scattering Example.pbo1" model discussed in the Section 5. Figure 40 in Section 5 shows a larger image of a gratur32.exe "S1" type of plot for the Double Scattering Example.

There are other options available to the gratur32.exe computation engine besides the type of 2-D histogram types illustrated in Figure 19.



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5. PSI-TURTLE Module Examples

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5. PSI-TURTLE Module Examples

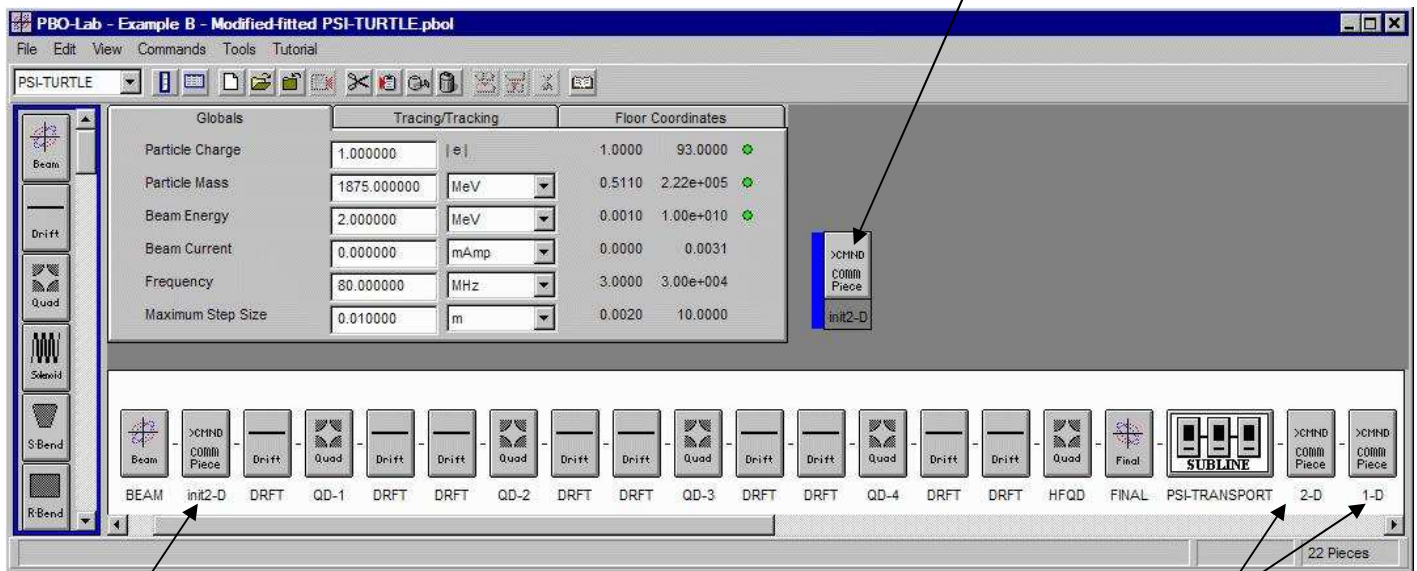
This section provides an overview of examples using the PSI-TURTLE Module. The examples are based on information from the public literature and are intended to both illustrate the use of the PSI-TURTLE Module and to provide benchmarks that users can utilize with their installed PBO Lab software. Additional examples may be added to this section in future releases of the PSI-TURTLE Module.

PBO Lab model files (.pbol extension) for the examples in this Section may be found on the installation CD for the PBO Lab PSI-TURTLE Module, or by contacting AccelSoft Inc. directly: accelsoft@ghga.com. Key output files for comparison purposes are also available.

Example B - Modified-fitted

The “Example B - Modified-fitted PSI-TURTLE.pbol” model file provides a simple example of a four quadrupole transfer line. The Document Window for the model is illustrated in Figure 20 below.

A 2-D Phase Space Plot Comm Piece stored on the Work Space



Phase Space Plot requests for the initial Beam

Phase Space and Momentum Plot requests for output beam

Figure 20. PBO Lab Document Window for “Example B - Modified-fitted PSI-TURTLE.pbol”

The example illustrated in Figure 20 contains 3 Pieces on the Model Space unique to the PSI-TURTLE Module. They are labeled init2-D, 2-D, 1-D and are identified with arrows along the bottom of the Figure.

The PBO Lab Subline labeled "PSI-TRANSPORT" near the end of the beamline is ignored by the PSI-TURTLE Module.



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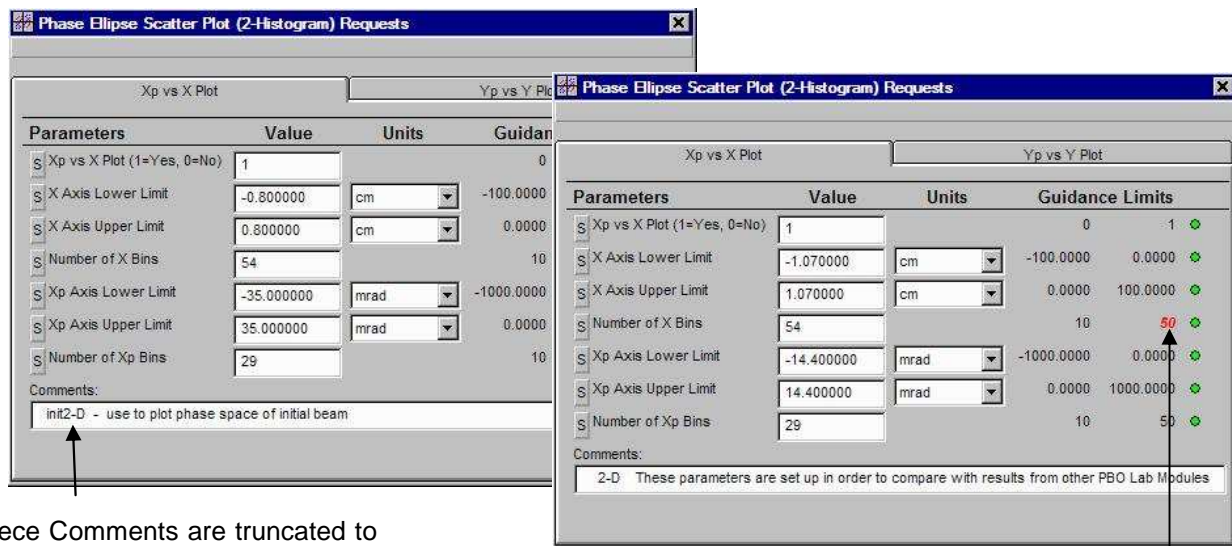
Standard PBO Lab Pieces, that is, Pieces that appear on the Palette Bar, are supported by the PSI-TURTLE Module if they are included in the list of the PSI-TURTLE Pieces window (see Figure 9). Other Palette Bar Pieces are ignored by the PSI-TURTLE Module.

At least one COMM Piece requesting PSI-TURTLE plots is required in the beamline on the Model Space for any graphic TURTLE output to be produced.

2-D plots in the PSI-TURTLE text output file FOR002.DAT will be approximately "square" in shape if the ratio of the number of bins is about 2:1.

The majority of the Pieces appearing on the Model Space of the example in Figure 20 are standard PBO Lab Pieces corresponding to drifts and quadrupoles. The Beam and Final Pieces are also standard PBO Lab Pieces. All of these standard Pieces and, with the exception of the Final Piece, are supported and used by the PSI-TURTLE Module (see Table 1). The Final Piece is ignored by PSI-TURTLE Module 1.0 but may be utilized in a future version. The PBO Lab Subline labeled PSI-TRANSPORT in Figure 20 contains Pieces unique to the PBO Lab PSI-TRANSPORT Module. They are ignored by the PSI-TURTLE Module and all other PBO Lab Modules.

There are four (4) PSI-TURTLE Command (COMM) Pieces shown in Figure 20: three (3) on the Model Space and one (1) on the Work Space. Figure 21 illustrates Piece windows for two of the COMM Pieces in the beamline on the Model Space.



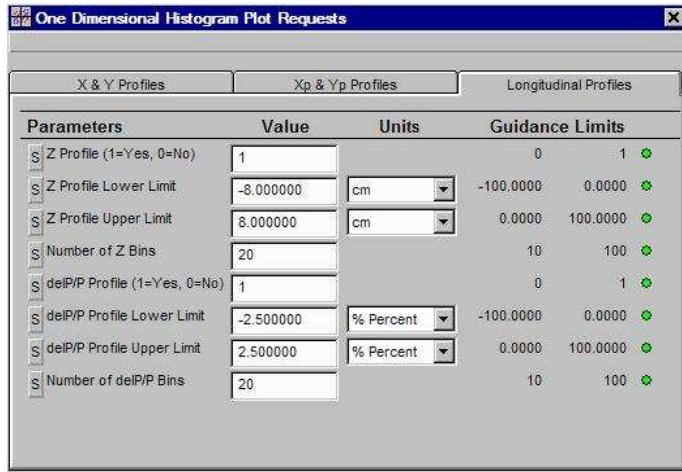
Piece Comments are truncated to 8 characters for the Main Input File FOR001.DAT. These are further truncated to 4 characters in the output file FOR002.DAT.

All Guidance Limits are "soft" and do not restrict input

Figure 21. PSI-TURTLE Module Phase Space Scatter Plot (2-D) Requests



Figure 22 illustrates the Piece window for the COMM Piece labeled 1-D located near the end of the beamline on the Model Space.

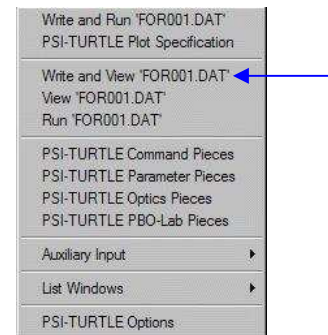


There are several PSI-TURTLE COMM Pieces that can be used to request various plots. These are accessed from the PSI-TURTLE Command Pieces window (see Figure 14).

Figure 22. Histogram Plot Request Piece window showing requests for 1-D histograms (Profiles) of path length differences (Z) and momentum spread (deI/P).

The PSI-TURTLE Module Main Input File is named FOR001.DAT. The input file produced by the PBO Lab PSI-TURTLE Module for the “Example B - Modified-fitted PSI-TURTLE.pbol” model is illustrated in Figure 23. The window in Figure 23 is displayed by using the Command "Write and View 'FOR001.DAT'" from the PSI-Commands menu.

The Header, Lattice and Footer Sections for the FOR001.DAT file are indicated in Figure 23. The Header Section utilizes certain of the PBO Lab Global Parameters and provides unit specifications, certain file I/O specifications, and some PSI-TURTLE Option settings. The Lattice Section generally forms the majority of the FOR001.DAT file content and reflects the beamline constructed by the user on the Model Space. This includes any Palette Bar Pieces supported by the PSI-TURTLE Module as well as any Pieces unique to the PSI-TURTLE Module.



The PSI-TURTLE Command: Write and View 'FOR001.DAT' will create and open the Main Input File.

The FOR001.DAT file is organized into four sections:

- Header
- Lattice
- Lines
- Footer

Figure 23 illustrates the Header, Lattice and Footer sections. PSI-TURTLE Module 1.0 does not have a Lines Section in FOR001.DAT.



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```
FOR001.DAT
File Edit Font
/EXAMPLE B - MODIFIED PSI RUN THURSDAY, JUNE 02 2016/
(***) OASIS PBO-LAB MODULE FOR PSI-TURTLE VERSION 0.9.3.0 (***)
10000
17.0 1. /ORDER/ ;
16.0 3.0 3.669283E+003 /MASS_EMASS/ ;
16.0 29.0 1.000000E+000 /CHARGE/ ;
16.0 30.0 1 /SEED/ ;
15. 11.0 /MEVC/ 0.001 ;
15. 12.0 /MEV/ 0.001 ;
16.0 190. 0.0000 100.000 /F100/ ;
(***) BEAM UNITS ARE CM, MRAD, CM, MRAD, CM, MRAD, CM, %DP/P, MEV/C (***)
(***) CURRENT VALUE OF PSI-TURTLE MODULE OPTION RMSTOBOUNDARY = 1.118034 (***)
16. 24.0 /6-D UNIFORM/ ; (** USE OPTION RMSTOBOUNDARY OF 1.118034 FOR PBO-LAB BND EMIT = 5X RMS EMIT **)
1.0 6.014379E-001 2.610243E+001 5.271360E-001
2.553760E+001 1.024674E+000 9.450518E-001 8.662600E+001 /BEAM/ ;
(** CORRELATIONS: C21 C31 C32 C41 C42 C43 C51 C52 C53 C54 C61 C62 C63 C64 C65 **)
12.0 -9.521110E-001 0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000 9.342710E-001
0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000
0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000 -1.210000E-001 /COORD/ ;

51. 1. -8.000000E-001 8.000000E-001 2.962963E-002 /__INIT2D__ / ;
52. 2. -3.500000E+001 3.500000E+001 2.413793E+000 ;
51. 3. -8.000000E-001 8.000000E-001 2.962963E-002 /__INIT2D__ / ;
52. 4. -3.500000E+001 3.500000E+001 2.413793E+000 ;
3.0 1.730000E-001 /DRFT/ ;
5.0 9.600000E-002 -2.244760E+000 1.000000E+000 /QD1/ ;
3.0 3.975000E-002 /DRFT/ ;
3.0 3.975000E-002 /DRFT/ ;
5.0 9.600000E-002 3.668180E+000 1.000000E+000 /QD2/ ;
3.0 4.274000E-002 /DRFT/ ;
3.0 4.274000E-002 /DRFT/ ;
5.0 9.600000E-002 -2.268570E+000 1.000000E+000 /QD3/ ;
3.0 4.574000E-002 /DRFT/ ;
3.0 4.574000E-002 /DRFT/ ;
5.0 9.600000E-002 2.617440E+000 1.000000E+000 /QD4/ ;
3.0 4.873000E-002 /DRFT/ ;
3.0 4.873000E-002 /DRFT/ ;
5.0 4.800000E-002 -2.650000E+000 1.000000E+000 /HFQD/ ;
51. 1. -1.070000E+000 1.070000E+000 3.962963E-002 /__2D__ TH/ ;
52. 2. -1.440000E+001 1.440000E+001 9.931034E-001 ;
51. 3. -1.070000E+000 1.070000E+000 3.962963E-002 /__2D__ TH/ ;
52. 4. -1.440000E+001 1.440000E+001 9.931034E-001 ;
-50. 1. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 3. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 2. -1.000000E+001 1.000000E+001 1.000000E+000 ;
-50. 4. -1.000000E+001 1.000000E+001 1.000000E+000 ;
50. 5. -8.000000E+000 8.000000E+000 8.000000E-001 ;
50. 6. -2.500000E+000 2.500000E+000 2.500000E-001 ;
16. 180. 111. 0. ;
16. 190. 0. 222. ;
SENTINEL
SENTINEL
```

Header
Section

Lattice
Section

Footer
Section

Figure 23. Main Input File FOR001.DAT generated for the “Example B - Modified-fitted PSI-TURTLE.pbol” model

Users may wish to examine Figure 23 in detail to identify the lines in the Main Input File FOR001.DAT that are generated by specific PBO Lab Pieces. In general this is not necessary, and it is recommended that users not edit the FOR001.DAT file directly as this may cause conflicts with the PBO Lab model.

The most common method of running the PBO Lab PSI-Module is to use the Command "Write and Run 'FOR001.DAT'" from the PSI-TURTLE Commands menu. This will create the Main Input File FOR001.DAT (but *not* open it to view), call the Module computation engine (turtle32.dll) and then open the output file FOR002.DAT. The result of using the "Write and Run 'FOR001.DAT'" Command, for the “Example B - Modified-fitted PSI-TURTLE.pbol” model, is shown in Figure 24. This run utilized 10,000 macroparticles, specified on the Tracing/Tracking tab of the Global Parameters.



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This example illustrates one of the limitations of the PBO Lab PSI-TURTLE Module, compared to the standard PBO Lab TURTLE Module. The standard PBO Lab TURTLE Module utilizes the FNAL/SLAC version of the TURTLE computation engine:

TurtleFort.dll.

That computation engine supports plots of 1-D and 2-D histograms that involve the path length variable, often denoted as l , which is the 5th element of the general particle coordinates. The PBO Lab PSI-TURTLE Module uses the PSI computation engine:

turtle32.dll.

That computation engine does not support plots that involve the 5th element of the general particle coordinates.

An examination of the Main Input File FOR001.DAT for the “Example B - Modified-fitted PSI-TURTLE.pbol” model (Figure 23) shows that, just prior to the Header Section, there are two (2) requested 1-D histograms:

```
50. 5. -8.000000E+000 8.000000E+000 8.000000E-001 ;
50. 6. -2.500000E+000 2.500000E+000 2.500000E-001 ;
```

The first 1-D histogram request, beginning with "50. 5.", is asking for a plot of the *path length spread* of the final beam, while the second 1-D histogram request, beginning with "50. 6.", is asking for a plot of the *momentum spread* of the final beam. The PSI-TURTLE computation engine (turtle32.dll) supports the latter (momentum spread) but not the former (path length spread). Any PSI-TURTLE Module histogram request that involves a *variable that is not supported* will result in a line in the Main Output File FOR002.DAT indicating that the request will be ignored. This line will appear in the upper part of the FOR002.DAT file, where the data from the Main Input File are being reiterated. Figure 25 illustrates this.

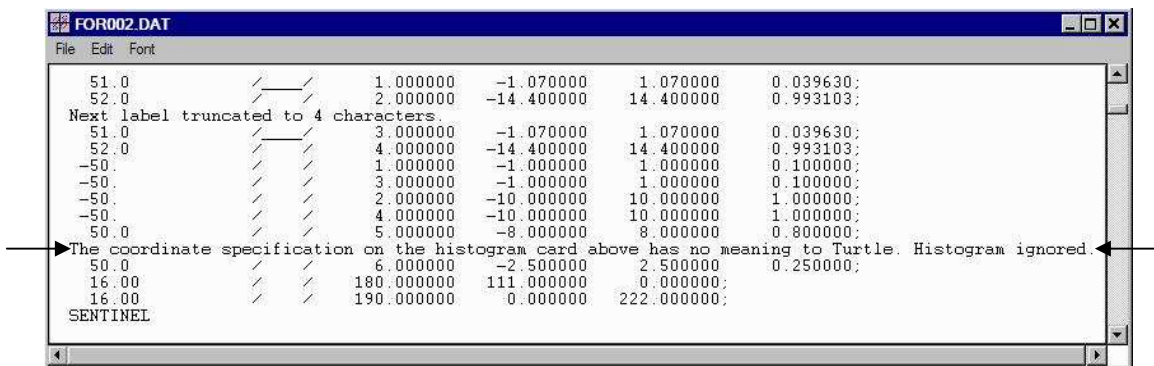


Figure 25. 'FOR002.DAT' file alert indicating a histogram request is being ignored.

The alert illustrated in Figure 25 will not appear if the parameter:

Z Profile (1=Yes, 0=No)

shown in the COMM Piece window of Figure 23 is set to "0" as that plot will not be requested.

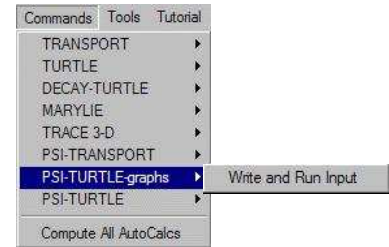
Information regarding the *path length spread* of beam particles may be important for systems where beam bunching (or debunching) is involved. Users may need to use other macro-particle PBO Lab Modules for such systems (e.g. TURTLE, MARYLIE, or PARMILA-2).

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Once the Command Write and Run 'FOR001.DAT' has been executed, and the Main Output File (FOR001.DAT) window has been opened (e.g. Figures 24 or 25) the unique capabilities of the PSI Graphic TURTLE software can be invoked. This is accomplished in PBO Lab by executing the single Command (Write and Run Input) of the supporting PSI-TURTLE-graphs Module. This was described at the end of the Section 2 (on page 17), and illustrated with a single plot, which is extended to 4 plots here.

Executing the Command (Write and Run Input) of the PSI-TURTLE-graphs Commands submenu opens a gratur32.exe console window. The defaults for the gratur32.exe code are set up to produce plots in a 19.5 cm by 19.5 cm graph window. Accepting all defaults for the first 4 histograms is illustrated in Figure 26.



The Write and Run Input Command of the PSI-TURTLE-graphs Module will open a gratur32.exe console window. Various plots can be produced entering appropriate data into the console window.

```
C:\OASIS\PSI Codes\gratur32.exe
Welcome to the TURTLE Graphic Histogram Option Programme.
Version 1.22b for Windows, using HBOOK/HPILOT from CernLib 98
Compiled with Digital Visual Fortran Version 6.0
=====
--> Graphic Data are stored on FOR100.DAT via      <--
--> 16. 190. i. 100. ; Card in TURTLE Input-Deck. <--
--> i = 0 : create with each run a new FOR100.DAT <--
--> i = 2 : update FOR100.DAT with each run.      <--

There are 5 histograms stored on FOR100.DAT
All booked histograms refer to 100000 rays
and will be shown in a window named HIGZ_01.

Enter Width, Height of Screen in cm (D=19.5,19.5)
Enter number of x and y zones (D=2,2)
Fill color indices are:
2: red, 3: green, 4: blue, 5: yellow, 6: magenta, 7: cyan
For 1-dim Histograms:
Enter color indices for Histogram, Zone and Picture (D=2,3,5)
For 3-dim Histograms:
Enter 3-dim indices for Histogram, Zone and Picture (D=4,5,7)

Enter Histogram_number [neg -> clear screen] (D = 1) 1
Enter LIN or LOG for type of vertical scaling (D = lin)
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 (D = C1)
Selected: Contour Plot (monochrome)
Enter number of contour lines (D = 10)
Version 1.23/09 of HIGZ started
Enter p1, p2, p3, p4 for hardcopy n for metafile or CR

Enter Histogram_number [neg -> clear screen] (D = 2) 2
Enter LIN or LOG for type of vertical scaling (D = lin)
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 (D = C1)
Selected: Contour Plot (monochrome)
Enter number of contour lines (D = 10)
Enter p1, p2, p3, p4 for hardcopy n for metafile or CR

Enter Histogram_number [neg -> clear screen] (D = 3) 3
Enter LIN or LOG for type of vertical scaling (D = lin)
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 (D = C1)
Selected: Contour Plot (monochrome)
Enter number of contour lines (D = 10)
Enter p1, p2, p3, p4 for hardcopy n for metafile or CR

Enter Histogram_number [neg -> clear screen] (D = 4) 4
Enter LIN or LOG for type of vertical scaling (D = lin)
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 (D = C1)
Selected: Contour Plot (monochrome)
Enter number of contour lines (D = 10)
Enter p1, p2, p3, p4 for hardcopy n for metafile or CR
```

Figure 26. Accepting all defaults in the gratur32.exe console window for the first 4 histograms.

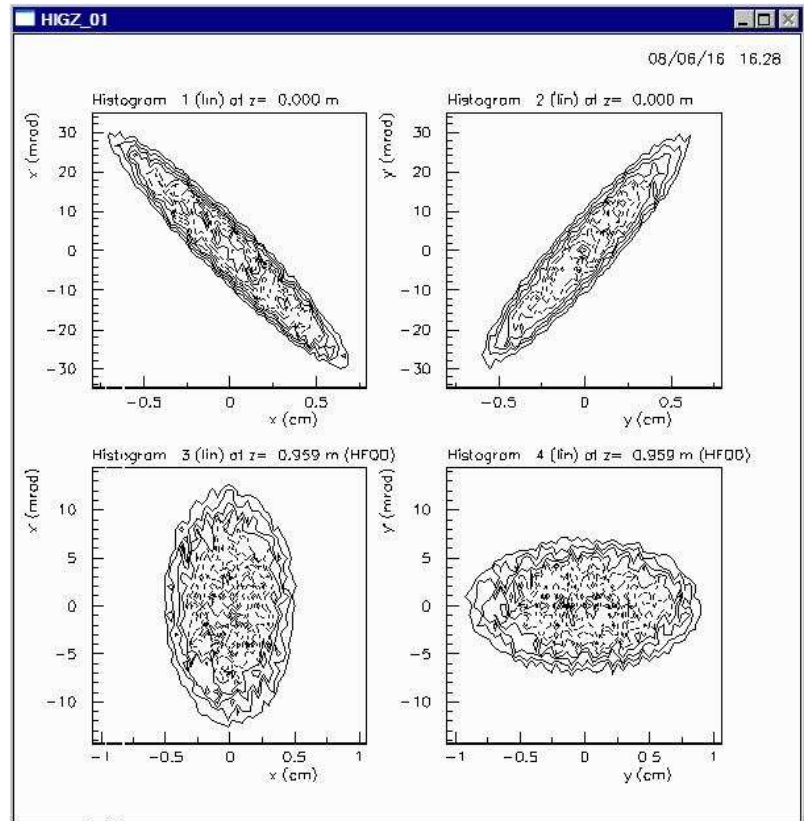


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If one continues to the next (5th histogram) plot request in the gratur32.exe console window, which corresponds to the 1-D momentum histogram, the HIGZ_01 window will erase the first four plots and start a new display.

Figure 27. The first 4 histograms of the “Example B - Modified-fitted PSI-TURTLE.pbol” model.

As the data for each histogram is completed, which are indicated by the line breaks following the lines reading "Enter p1, p2, p3, p4 for hardcopy m for metafile or CR", then a plot is created in the HIGZ_01 window. Figure 27 shows the HIGZ_01 window after 4 plots are created.



The two top plots in Figure 27 are the initial beam transverse phase spaces and the two bottom plots are the final beam transverse phase spaces. The “Example B - Modified-fitted PSI-TURTLE.pbol” model is a matching line in which 4 quadrupoles have been adjusted to transform the initial phase space ellipses into "upright" ellipses in the center of the quadrupole labeled "HFQD". (For the reasons discussed on page 46, it is not possible to plot the longitudinal phase space using the PSI-TURTLE Module.)

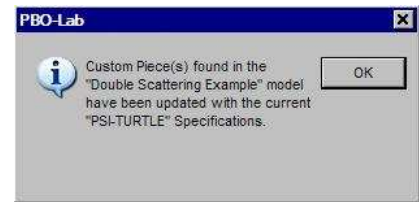
The Double Scattering Example described next illustrates an example that creates 8 plots in the HIGZ_01 graph window.

Figure 7 in Section 2 illustrates the creation of a *PBO Lab Graph Tool Window* for this example.



Double Scattering Example

The “Double Scattering Example.pbol” model file illustrates the set up and running of one of the examples documented by Uhrs Rohrer using PSI Graphic TURTLE. A PBO Lab Document Window for this model is illustrated in Figure 28 below. The Piece contents of the Sublines are also shown.



Opening PBO Lab model (.pbol) files created by earlier PSI-TURTLE Module versions may result in an alert dialog: click OK.

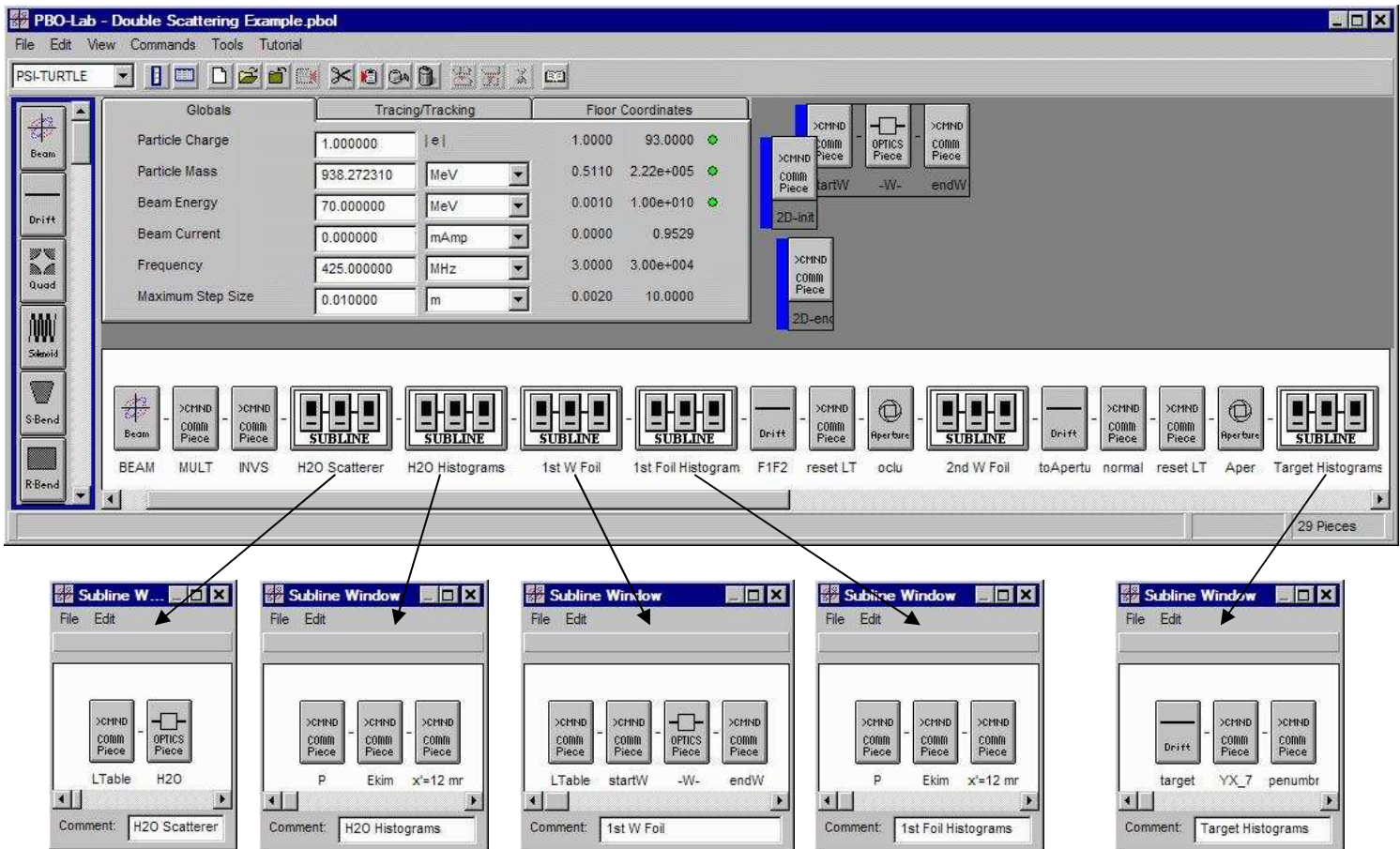


Figure 28. Document & Sublines for the “Double Scattering Example.pbol” beamline.

The PBO Lab model illustrated in Figure 28 utilizes six Sublines to collect and organize various Pieces into logical groups. Each of these Sublines will be described further on the following pages. The model also contains several PSI-TURTLE specific Command (COMM) Pieces as well as a few standard PBO Lab Pieces (Beam, Drifts and Apertures).

The Double Scattering Example represents a unique modeling capability of the PSI-TURTLE Module. It utilizes only a few traditional optics elements, but makes extensive use of PSI-TURTLE specific elements.



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The first two PSI-TURTLE Command (COMM) Pieces shown in Figure 28, immediately following the Beam Piece, are used to invoke multiple scattering and to "invert" apertures into solid material. Each of these COMM Pieces only have one parameter, which turns on (or off) the specific attribute. Figure 29 shows the Piece windows for these two COMM Pieces.

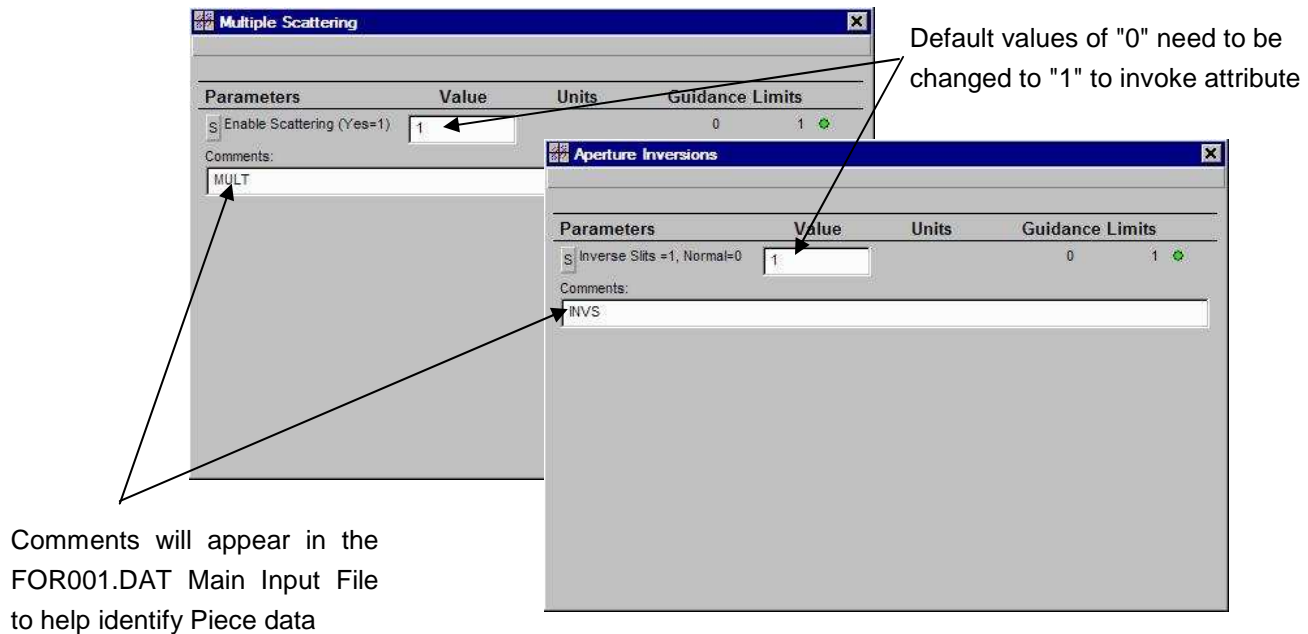


Figure 29. Multiple Scattering and Aperture Inversions Piece Windows

Figure 34A displays the first part of the Main Input File FOR001.DAT for the Double Scattering Example. The lines in that file, corresponding to the Pieces illustrated in Figure 29, can be identified by the Comment fields which appear between forward slashes for those elements.

The text description of the parameters shown in Figure 29 is intended to describe the primary function of each parameter. The user does not need to know the type codes, format, or syntax of how these attributes are described in the PSI-TURTLE Module Main Input File (FOR001.DAT). Note that the default values for the parameters are "0" meaning that the attributes will only be invoked if the user changes the parameter values to "1", as is the case in Figure 29. The same Pieces may be used (i.e. later in the beamline) to turn the attributes "off" by using the default "0" values. An example is the COMM Piece with comment "normal" which returns the Aperture Inversions setting back to normal.



The first Subline on the Model Space of the Double Scattering Example, commented as "H2O Scatterer", contains two Pieces that are used to describe the water degrader: one COMM Piece and one OPTICS Piece, both unique to the PSI-TURTLE Module. The COMM Piece is used to Concatenate Loss-Entries into the particle loss table and the OPTICS Piece is for a Material Scatterer element. Figure 30 illustrates the Piece windows for the "H2O Scatterer" Subline.

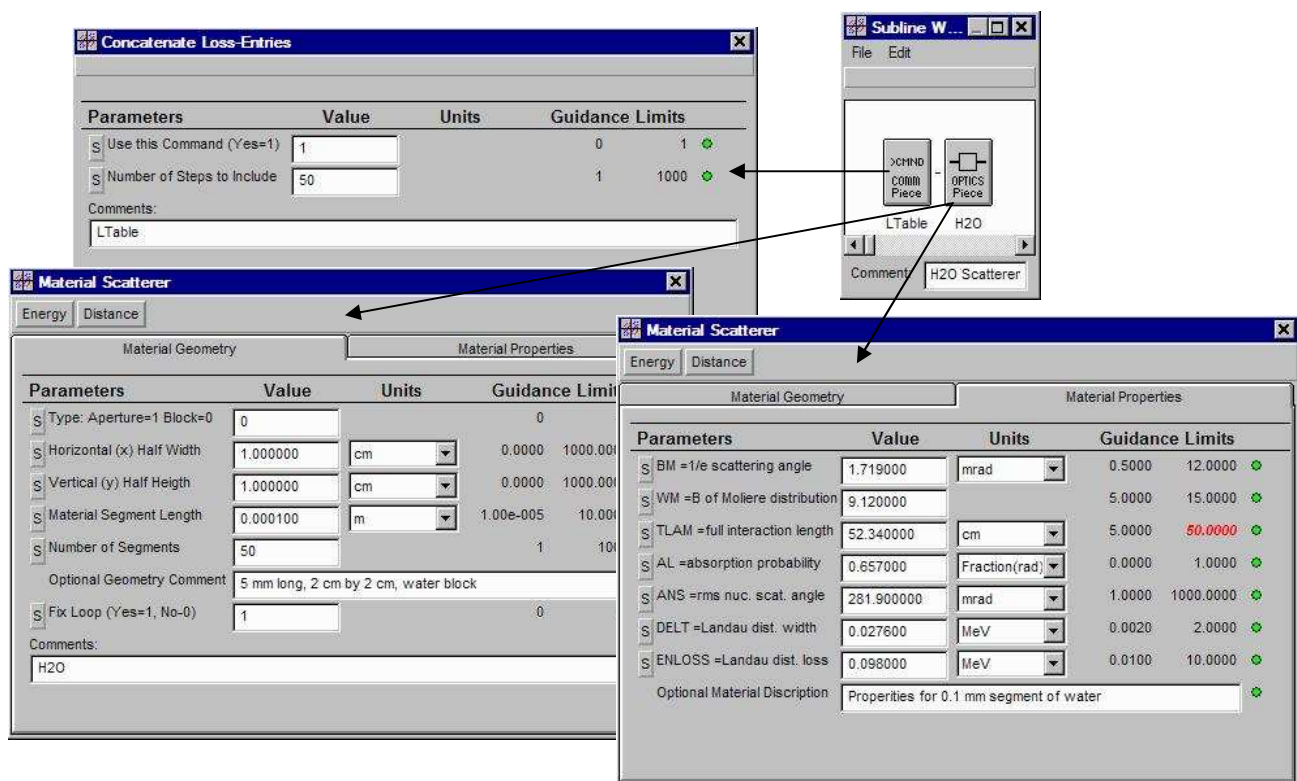


Figure 30. Water Degradation Subline Details

The first parameter of the Concatenate Loss-Entries COMM Piece is a logical input used to invoke (or not) the data concatenation attribute. Its function is similar to that of the Pieces shown in Figure 29. The second entry establishes how many segments of data will be included. In this example, data from 50 (water) segments will be concatenated.

Figure 34A displays the first part of the Main Input File FOR001.DAT for the Double Scattering Example. The lines in that file associated with the Figure 30 Pieces can be identified by the Optional description fields which appear between parentheses.



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The Material Scatterer OPTICS Piece contains two groups of parameters which can be classified generally as Material Geometry or Material Properties parameters. These two parameter groups appear on separate tab pages of the Material Scatterer Piece Window, as shown in Figure 30.

The Material Scatterer parameters encompass data that typically appear on *several individual element lines* in the Main Input File (FOR001.DAT). The element lines are associated with PSI Graphic TURTLE "type codes" 1, 3, 6, and 9, which require a degree of self-consistency among their parameters to be meaningful. Some comments on the Material Geometry tab parameters are in order. The longitudinal size (length along the beamline) of each PBO Lab Material Scatterer Piece is determined by two parameters:

Material Segment Length
Number of Segments

For the parameters shown in Figure 30, the length of the H₂O Material Scatterer Piece is 50×0.0001 m or 5 mm. This information has been included by the user in the Optional Geometry Comment field, which will appear in the Main Input File (** within parentheses **) at the location of the elements from the Piece in the Main Input File. Similarly, information on the transverse dimensions of the Material Scatterer, given by the Horizontal (x) Half Width and Vertical (y) Half Height parameters, have been included in the Optional Geometry Comment field. Since the default shape of PSI-TURTLE apertures is elliptical, the use of equal transverse dimensions results in a circular aperture. Taken with the Aperture Inversions Piece setting (Figure 29) this "circular aperture" becomes a 1 cm radius circular cylinder of 5 mm length.

The Material Scatterer OPTICS Piece of the PBO Lab PSI-TURTLE Module may include additional parameters in a future release of the Module. For example, the option to concatenate loss-entries may be added directly to the Piece.

Note that the Number of Steps to Include parameter of the Concatenate Loss-Entries COMM Piece should be consistent with the Number of Segments parameter of the Material Scatterer OPTICS Piece (see Figure 30).



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The last parameter on the Material Geometry tab is called: Fix Loop (1=Yes, 0=No). This parameter is used to specify whether or not of the data of the PBO Lab Material Scatterer Piece provides a complete description of the situation. The PSI-TURTLE Module computation engine (turtle32.dll) computes over a "loop" of material segments. Each segment is identical and the "loop" computation is repeated according to the Number of Segments parameter. Typically all of the elements necessary for computing this loop are provided by the PBO Lab Material Scatterer Piece, in which case the Fix Loop (1=Yes, 0=No) parameter can be set to "1" (the default) as is done in Figure 30. (If this is not the case, then the parameter should be set to "0" and separate "Procedure Loop - Code 9" COMM Pieces should be used. Their use is described in connection with the Subline "1st W Foil" discussion.)

The parameters appearing on the Materials Properties tab panel are also linked with the Materials Geometry tab parameters. Specifically the values of the Materials Properties parameters are specified for a length of material given by the Material Segment Length parameter. The parameter names on the Materials Properties use the abbreviations of the PSI Graphic TURTLE documentation (see Section 6) followed by a brief description of the parameter. The Materials Properties tab also contains an Optional Material Description text field parameter.

For the Material Scatterer Piece illustrated in Figure 30, the following lines will be written by the PBO Lab PSI-TURTLE Module to the FOR001.DAT Main Input File at the appropriate location:

```
9.0 0050 /H2O/ ; (** START OF FIXED LOOP **)
6.0 1.0 1.000000E+000 3.0 1.000000E+000 /H2O/ ; (** 5 MM LONG, 2 CM BY 2 CM, WATER BLOCK **)
1.0 1.719000E+000 9.120000E+000 5.234000E+001 6.570000E-001 2.819000E+002
2.760000E-002 9.800000E-002 0.0 /H2O/ ; (** PROPERTIES FOR 0.1 MM SEGMENT OF WATER **)
3.0 1.000000E-004 /H2O/ ;
9.0 0 /H2O/ ; (** END OF FIXED LOOP **)
```

It is perhaps worth noting that the following parameters are generally independent of the Material Segment Length value:

TLAM, AL, ASN

The following parameters can be scaled linearly with the Material Segment Length value:

DELT, ENLOSS

The following parameters do not have a simple scaling with the Material Segment Length:

BM, WM

However, within a sufficiently narrow range the value of BM appears to approximately scale with the square root of the Material Segment Length value, and the value of WM changes only slightly.



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The second Subline on the Model Space of the Double Scattering Example, commented as "H2O Histograms", contains COMM Pieces that are used to request histograms of the beam following the water degrader (H2O Scatterer). Figure 31 illustrates selected Piece window tab pages for the "H2O Histograms" Subline.

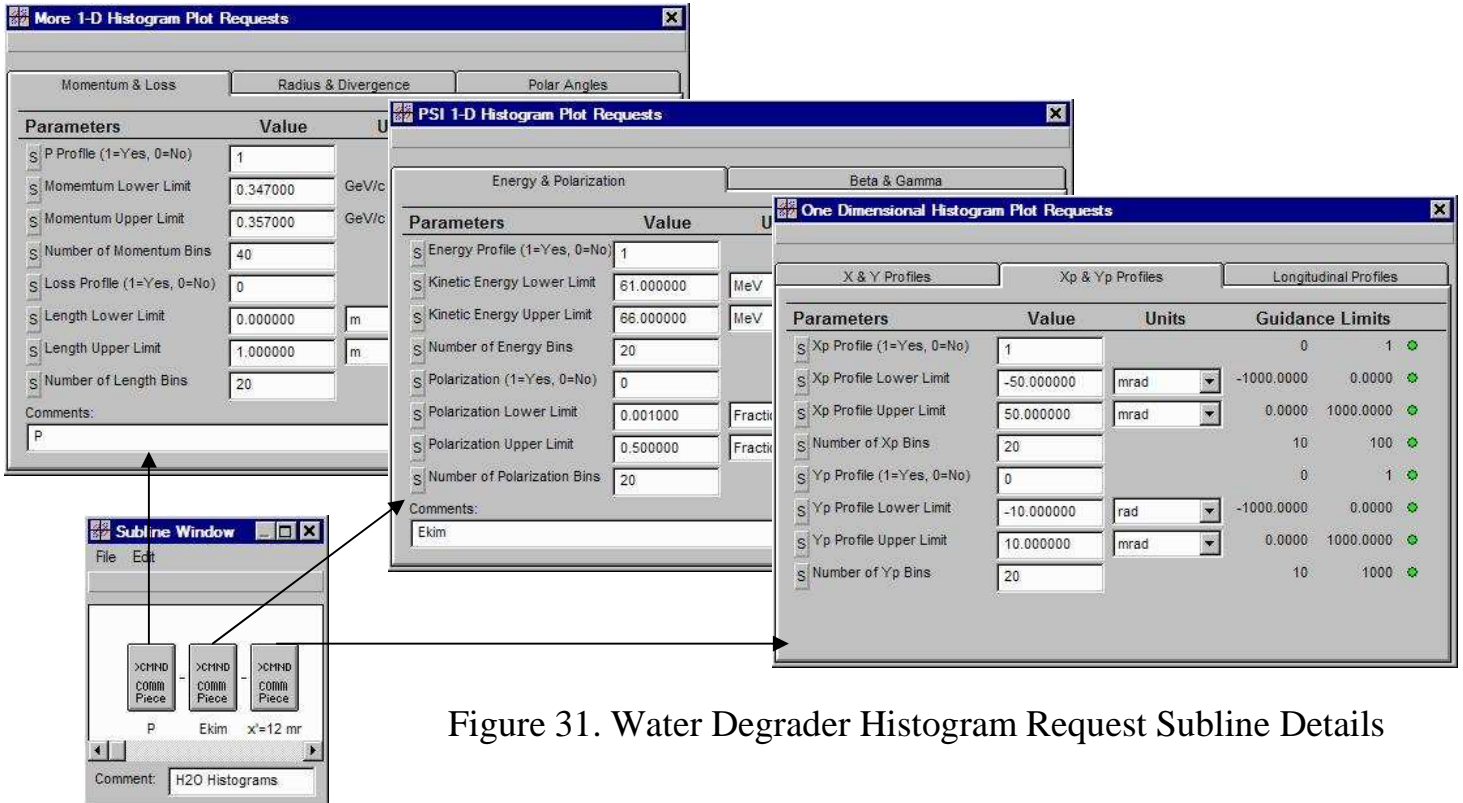


Figure 31. Water Degrader Histogram Request Subline Details

Recall from the discussion on page 46 that the PSI-TURTLE physics engine turtle32.dll does not support plots that involve the 5th element of the general particle coordinates.

Each COMM Piece shown in Figure 31 is requesting a single 1-D histogram for a particular parameter. The COMM Piece entitled "One Dimensional Histogram Plot Requests" is used for any of the standard 6-D particle coordinates, with limitations on the longitudinal coordinate. The COMM Piece entitled "More 1-D Histogram Plot Requests" is used for other particle distribution parameters that most TURTLE versions support. The COMM Piece entitled "PSI 1-D Histogram Plot Requests" can be used for those specialized particle distribution parameters that are only supported by the PSI-TURTLE computation engine turtle32.dll.



The third Subline on the Model Space of the Double Scattering Example, commented as "1st W Foil", contains COMM Pieces that model the first Tungsten scattering foil (-w-). Figure 32 illustrates selected tab pages for the Piece windows of the "1st W Foil" Subline.

Use units pop up options to view parameters that may be small in the default units

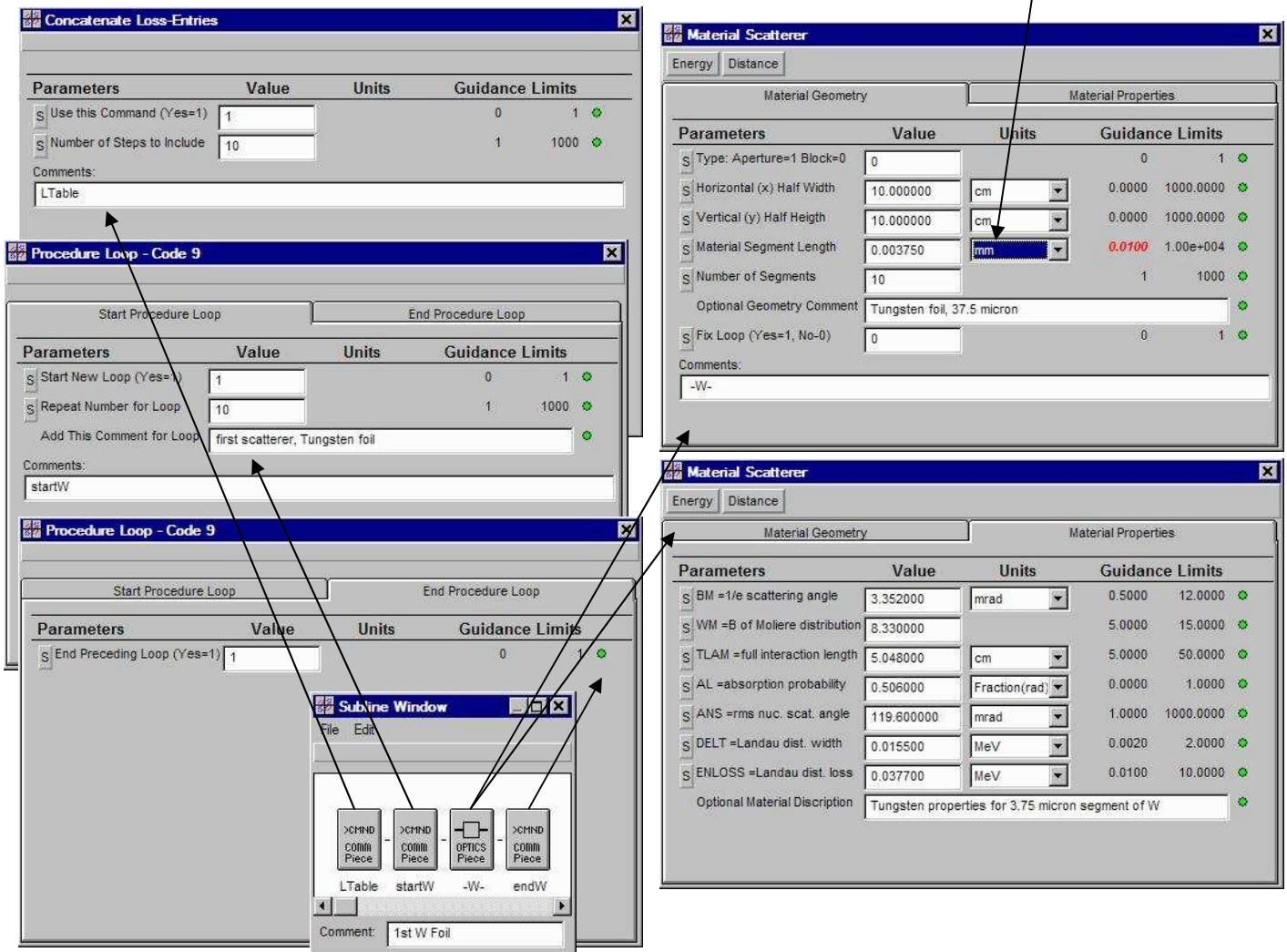


Figure 32. First Tungsten Foil Subline Details

The Concatenate Loss-Entries COMM Piece and the Material Scatterer OPTICS Piece are similar to those discussed in connection with the "H2O Scatterer" Subline (Figure 30) except the parameters are now for a 37.5 μm Tungsten foil divided into 10 segments. Another difference is the value of the "Fix Loop" parameter: "0".



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When the value of the parameter Fix Loop (Yes=1, No=0) is set to "0", a separate set of Loop Procedure - Code 9 Pieces need to be utilized to create a loop for the PSI-TURTLE computation engine (turtle32.dll). The Loop Procedure - Code 9 Piece window has two tabs: one to Start Procedure Loop and another to End Procedure Loop. Each tab starts with a logical parameter that has a default of "0", one of which must be set to "1" in order for the desired procedure loop attribute to be invoked.

Note that Loop Procedure - Code 9 Pieces always need to be paired. Whenever a procedure loop is started, using a Loop Procedure - Code 9 Piece, it must be followed a some point later in the beam with a procedure loop ending point, using another Loop Procedure - Code 9 Piece. These two "extra" Pieces for the "1st W Foil" Subline are shown in Figure 32.

The Repeat Number for Loop parameter on the Start Procedure Loop tab, of the first Loop Procedure - Code 9 Piece, will effectively override the Number of Segments parameter appearing on the Material Scatterer Piece. (The Number of Segments parameter will not be utilized when the Fix Loop (Yes=1, No=0) parameter is set to 0.) Consequently care must be taken to assure that the "Repeat Number for Loop" parameter is consistent with the Material Segment Length parameter, so that the full length of the scattering material is correct.

The Material Scatterer Piece shown in Figure 32 will result in the following lines being written to the FOR001.DAT Main Input File at the appropriate location:

A minus sign (-) at the start of a line in the FOR001.DAT input file effectively removes the line. The PSI-TURTLE physics engine turtle32.dll takes lines beginning with a negative type code (e.g. -9.0) to be a "commented out" line.

```
9.0 0010. /STARTW/ ; (** FIRST SCATTERER, TUNGSTEN FOIL **)
-9.0 0010 /_W/ ; (** START OF FIXED LOOP **)
  6.0 1.0 1.000000E+001 3.0 1.000000E+001 /_W/ ; (** TUNGSTEN FOIL, 37.5 MICRON **)
  1.0 3.352000E+000 8.330000E+000 5.048000E+000 5.060000E-001 1.196000E+002
  1.550000E-002 3.770000E-002 0.0 /_W/ ; (** TUNGSTEN PROPERTIES FOR 3.75 MICRON SEGMENT OF W **)
  3.0 3.750000E-006 /_W/ ;
-9.0 0 /_W/ ; (** END OF FIXED LOOP **)
-9.0 0001. /_ENDW/ ; (** END FIRST SCATTERER, TUNGSTEN FOIL **)
9. 0. ;
```



It would have been simpler to model the "1st W Foil" Subline without using the Loop Procedure - Code 9 Pieces, by following the pattern for the "H2O Scatterer" Subline (Figure 30). The method presented here for the "1st W Foil" Subline is intended to illustrate an alternate approach for implementing the multiple scattering capability for situations in which the modeling cannot be done with a single Material Scatterer OPTICS Piece. Perhaps other PBO Lab Pieces need to be included in the scattering region, or additional Material Scatterer OPTICS Pieces need to be used in order to model sandwiched layers of different thin materials. The use of 2 Loop Procedure - Code 9 Pieces provides a means to achieve such models. Pairs of Loop Procedure - Code 9 Pieces can also be used to loop over other types of PBO Lab Pieces.

Note that two methods have been described for the Double Scattering Example for setting up procedure (or repeat) loops for the Material Scatterer Piece. Either method can be used for the Material Scatterer, and users may wish to explore both approaches further.

The fourth Subline on the Model Space of the Double Scattering Example, commented as "1st Foil Histograms", is essentially identical to the "H2O Histograms" Subline (Figure 31) and contains the same COMM Pieces. Similarly the fifth Subline on the Model Space of the Double Scattering Example, commented as "2nd W Foil", is identical to the "1st W Foil" Subline (Figure 32). The previous discussions are equally applicable to the fourth and fifth Sublines and will not be repeated.

Intervening between the fourth and fifth Sublines are three Pieces labeled by comments "F1F2", "reset LT" and "oclu". The F1F2 and oclu Pieces are standard PBO Lab Drift and Aperture Pieces, respectively. The Aperture Piece is set to be a circular type with radius of 2.5 mm. Note, however, that the Aperture Inversions Piece INVS setting (Figure 29) is still applicable, so that the oclu Aperture Piece is *inverted* to be a solid cylinder *which stops all beam particles within the 2.5 mm radius*. This results in substantial beam loss, but is a critical element for achieving a uniform beam.

Once an Aperture Inversions Piece is invoked, the inversion remains in affect through the beamline that follows until another Aperture Inversions Piece is encountered which can revoke the inversion.



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The PSI-TURTLE COMM Piece labeled "reset LT" is another Concatenate Loss-Entries Piece (see Figure 30) used to reset the loss table. Since there is only one "segment" for the standard PBO Lab Aperture Piece that follows this COMM Piece, the value for the parameter Number of Steps to Include is simply "1" (rather than the "50" of Figure 30).

The Aperture Inversions Piece labeled INVS, near the beginning of the beamline (Figure), is revoked by the settings of the second Aperture Inversions Piece labeled normal. PBO Lab Aperture Pieces after this will be normal apertures and not "inverted."

Following the fifth Subline ("2nd W Foil") are four Pieces labeled by comments "toAperture", "normal", "reset LT" and "Aper". The toAperture and Aper Pieces are again standard PBO Lab Drift and Aperture Pieces, respectively. The PSI-TURTLE COMM Piece labeled "reset LT" is identical to the Concatenate Loss-Entries Piece discussed in the preceding paragraph. Just before this reset LT Piece is the PSI-TURTLE COMM Piece labeled "normal". This an Aperture Inversions Piece (see Figure 29) and the only parameter for this Piece is set to "0" which makes all PBO Aperture Pieces after this "normal" apertures, rather than the solid cylinder that was labeled by "oclu".

The last Subline labeled "Target Histograms" includes a drift (labeled target) from the Aper Aperture Piece to the "target" plane together with 2 PSI-TURTLE COMM Piece labeled "YX_7" and "penumbra". Key "Target Histograms" Subline details are shown in Figure 33.

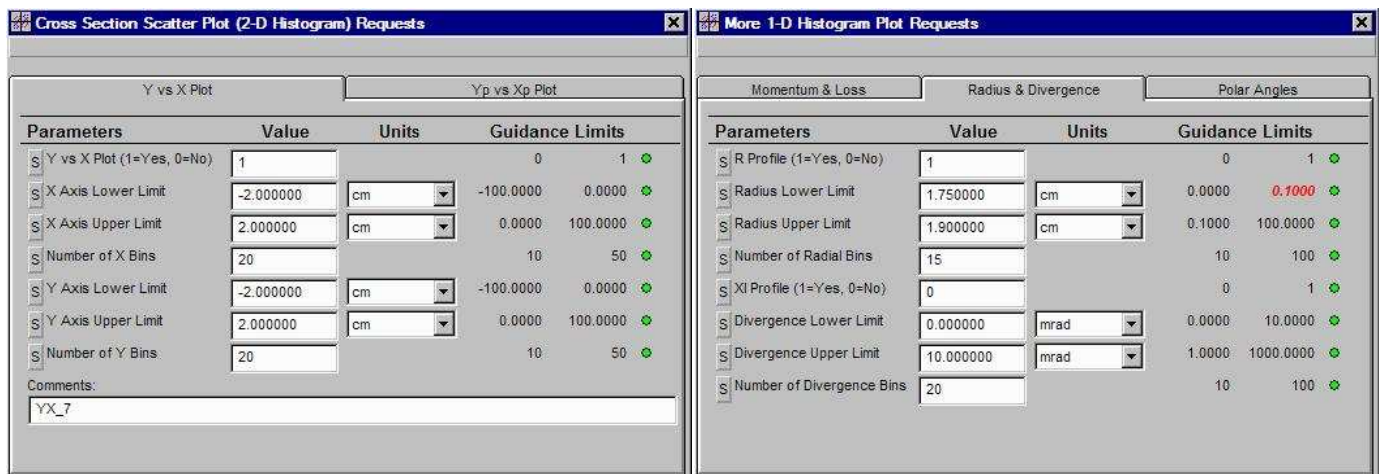


Figure 33. Histogram request Pieces in the target Subline

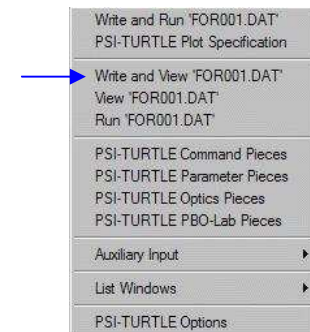


The PSI-TURTLE COMM Piece labeled "YX_7" in Figure 33 specifies the parameters for a beam cross section plot (y vs x). This is a 2-D histogram, often referred to as a scatter plot. The PSI-TURTLE COMM Piece labeled "penumbra" in Figure 33 specifies the parameters for a radial plot of the beam distribution. This is a 1-D histogram and provides the particle count as a function of $R=(x^2+y^2)^{1/2}$. These 2 histogram requests provide the data for the primary visualizations of the beam distribution at the target plane, and are used by the PSI-TURTLE-graphs Module.

Any histogram request at the end of the beamline will generate distribution data for the final beam in the FOR111.DAT file. The PBO Lab Command PSI-TURTLE Plot Specification can then be used to display a variety of 1-D and 2-D plots of that data, not just the histogram requested. This capability is useful for examination of the distribution in order to refine plot limits, select new histogram requests, or prepare similar visualization enhancements.

The file written by PBO Lab to run the PSI-TURTLE computation engine is the Main Input File FOR001.DAT. It is common to never examine the Main Input File for PBO Lab Application Modules - the output alone usually provides any desired information. However, for testing or purposes, it can be instructive to examine the Main Input File. Figure 34A shows the first half of the FOR001.DAT Main Input File for Double Scattering Example, and Figure 34B shows the second half. Several features of the file are noted in the Figures.

There are a significant number of lines in the FOR001.DAT Main Input File that begin with a minus sign "-". The minus sign effectively acts as a comment character for the PSI-TURTLE computation engine (turtle32.dll) and those lines do not have executable instructions. The lines that begin with a minus sign are processed by the input reading part of turtle32.dll, and reiterated in the output file FOR002.DAT, but are not used in the calculations. However, syntax errors in lines that begin with a minus sign can cause read errors, so caution is urged for users modifying the FOR001.DAT text file directly (e.g. to use the PSI-TURTLE Command Run 'FOR001.DAT' for special situations).



The PSI-TURTLE Command Write and View 'FOR001.DAT' will create a display the Main Input File.



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Header Section Includes:

- PBO Lab Model Name and Date of Run
- PSI-TURTLE Module Version Number
- Number of Macro-Particles (PBO Lab Global Parameter)
- Calculation Order (PBO Lab PSI-TURTLE Option Parameter)
- Particle Mass (PBO Lab Global Parameter)
- Particle Charge (PBO Lab Global Parameter)
- Random Number Seed (PBO Lab PSI-TURTLE Option Parameter)
- Energy & Momentum Units (fixed for PBO Lab PSI-TURTLE Module)

Lattice Section Includes:

- Comments on Beam Units & Feedback on Beam Piece Settings
- ... all remaining input from the Model Space of the Document Window

```
FOR001.DAT
File Edit Font
/DOUBLE SCATTERING EXAMPLE RUN WEDNESDAY, JUNE 08 2016/
(** OASIS PBO-LAB MODULE FOR PSI-TURTLE VERSION 0.9.3.2 **)
100000
17.0 1. /ORDER/ ;
16.0 3.0 1.836153E+003 /MASS_EMASS/ ;
16.0 29.0 1.000000E+000 /CHARGE/ ;
16.0 30.0 1. /SEED/ ;
15. 11.0 /MEVC/ 0.001 ;
15. 12.0 /MEV/ 0.001 ;
16.0 190. 0.0000 100.000 /F100/ ;
(** BEAM UNITS ARE CM, MRAD, CM, MRAD, CM, %DP/P, MEV/C **)
(** CURRENT VALUE OF PSI-TURTLE MODULE OPTION RMSTOBOUNDARY = 1.118034 **)
(** GAUSSIAN BEAM ** DIVIDES BY OPTION PARAMETER 1.118034 TO CONVERT TO 2-SIGMA)
1.0 1.000005E-001 5.000000E+000 1.000005E-001
5.000000E+000 1.120000E+000 1.000005E-001 3.691320E+002 /BEAM/ ;
(** CORRELATIONS: C21 C31 C32 C41 C42 C43 C51 C52 C53 C54 C61 C62 C63 C64 C65 **)
12.0 0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000
0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000
0.000000E+000 0.000000E+000 0.000000E+000 0.000000E+000 /COOR/ ;

16.0 165.0 /MULT/ ;
16.0 160.0 /INVS/ ; (** SLITS INVERTED **)
16.0 198. 0050 /LTABLE/ ;
9.0 0050 /H2O/ ; (** START OF FIXED LOOP **)
6.0 1.0 1.000000E+000 3.0 1.000000E+000 /H2O/ ; (** 5 MM LONG, 2 CM BY 2 CM, WATER BLOCK **)
1.0 1.719000E+000 9.120000E+000 5.234000E+001 6.570000E-001 2.819000E+002
2.760000E-002 9.800000E-002 0.0 /H2O/ ; (** PROPERTIES FOR 0.1 MM SEGMENT OF WATER **)
3.0 1.000000E-004 /H2O/ ;
9.0 0 /H2O/ ; (** END OF FIXED LOOP **)
50. 11. 3.470000E+002 3.570000E+002 2.500000E-001 ;
-50. 8. 0.000000E+000 1.000000E+000 5.000000E-002 ;
-50. 21. 0.000000E+000 1.000000E+000 5.000000E-002 ;
-50. 22. 0.000000E+000 1.000000E+001 5.000000E-001 ;
-50. 23. -9.000000E+001 9.000000E+001 9.000000E+000 ;
-50. 24. -9.000000E+001 9.000000E+001 9.000000E+000 ;
50. 12. 6.100000E+001 6.600000E+001 2.500000E-001 ;
-50. 13. 1.000000E-003 5.000000E-001 2.495000E-002 ;
-50. 14. 1.000000E-003 2.000000E-001 9.950000E-003 ;
-50. 15. 1.000001E+000 2.000000E+000 1.000000E-001 ;
-50. 1. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 3. -1.000000E+000 1.000000E+000 1.000000E-001 ;
50. 2. -5.000000E+001 5.000000E+001 5.000000E+000 ;
-50. 4. -1.000000E+001 1.000000E+001 1.000000E+000 ;
-50. 5. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 6. -1.000000E+000 1.000000E+000 1.000000E-001 ;
16.0 198. 0010 /LTABLE/ ;
9.0 0010 /STARTW/ ; (** FIRST SCATTERER, TUNGSTEN FOIL **)
-9.0 0010 /W/ ; (** START OF FIXED LOOP **)
6.0 1.0 1.000000E+001 3.0 1.000000E+001 /W/ ; (** TUNGSTEN FOIL, 37.5 MICRON **)
1.0 3.352000E+000 8.330000E+000 5.048000E+000 5.060000E-001 1.196000E+002
1.550000E-002 3.770000E-002 0.0 /W/ ; (** TUNGSTEN PROPERTIES FOR 3.75 MICRON SEGMENT OF W **)
3.0 3.750000E-006 /W/ ;
-9.0 0 /W/ ; (** END OF FIXED LOOP **)
-9.0 0001. /_ENDW/ ; (** END FIRST SCATTERER, TUNGSTEN FOIL **)
9. 0. ;
50. 11. 3.470000E+002 3.570000E+002 2.500000E-001 ;
```

Figure 34A. First part of the Double Scattering Example Main Input File FOR001.DAT.

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Lattice Section Includes:

... all input from the Model Space of the Document Window, including
Any supported PBO Lab Palette Bar Pieces on the Model Space
Unique PSI-TURTLE Module COMM Pieces (e.g. Histograms)
Unique PSI-TURTLE Module OPTICS Pieces (e.g. Material Scatterer)
User Entered Piece /COMMENTS/ (abbreviated if necessary)
PSI-TURTLE Module (** EXTENDED COMMENT FIELDS **) remarks

Footer Section Includes:

File Specs for Distribution Data (fixed for PBO Lab PSI-TURTLE Module)
Required Sentinel Lines for turtle32.dll

```
FOR001.DAT
File Edit Font
-50. 8. 0.000000E+000 1.000000E+000 5.000000E-002 ;
-50. 21. 0.000000E+000 1.000000E+000 5.000000E-002 ;
-50. 22. 0.000000E+000 1.000000E+001 5.000000E-001 ;
-50. 23. -9.000000E+001 9.000000E+001 9.000000E+000 ;
-50. 24. -9.000000E+001 9.000000E+001 9.000000E+000 ;
50. 12. 6.100000E+001 6.600000E+001 2.500000E-001 ;
-50. 13. 1.000000E-003 5.000000E-001 2.495000E-002 ;
-50. 14. 1.000000E-003 2.000000E-001 9.950000E-003 ;
-50. 15. 1.000001E+000 2.000000E+000 1.000000E-001 ;
-50. 1. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 3. -1.000000E+000 1.000000E+000 1.000000E-001 ;
50. 2. -5.000000E+001 5.000000E+001 5.000000E+000 ;
-50. 4. -1.000000E+001 1.000000E+001 1.000000E+000 ;
-50. 5. -1.000000E+000 1.000000E+000 1.000000E-001 ;
-50. 6. -1.000000E+000 1.000000E+000 1.000000E-001 ;
3.0 4.500000E-001 /F1F2/ ;
16.0 198.0001 /RESET_LT/ ;
6.0 1.0 2.500000E-001 3.0 2.500000E-001 ; (** CIRCULAR APERTURE OR DISC **)
(6.0 1.0 1.000000E+005 ; )
(6.0 2.0 1.000000E+006 ; )
(6.0 3.0 1.000000E+005 ; )
(6.0 4.0 1.000000E+006 ; )
(6.0 5.0 1.000000E+005 ; )
(6.0 6.0 1.000000E+005 ; )
16.0 198.0010 /LTABLE/ ;
9.0 0010. /STARTW/ ; (** SECOND SCATTERER, TUNGSTEN FOIL **)
-9.0 0010 /W/ ; (** START OF FIXED LOOP **)
6.0 1.0 1.000000E+001 3.0 1.000000E+001 /W/ ; (** TUNGSTEN FOIL, 37.5 MICRON **)
1.0 3.352000E+000 8.330000E+000 5.048000E+000 5.060000E-001 1.196000E+002
1.550000E-002 3.770000E-002 0.0 /W/ ; (** TUNGSTEN PROPERTIES FOR 3.75 MICRON SEGMENT OF W **)
3.0 3.750000E-006 /W/ ;
-9.0 0 /W/ ; (** END OF FIXED LOOP **)
-9.0 0001. /ENDW/ ; (** END SECPMD SCATTERER, TUNGSTEN FOIL **)
9.0 0 ;
3.0 9.800000E-001 /TOAPERTURE/ ;
16.0 161.0 /NORMAL/ ; (** SLITS NORMAL **)
16.0 198.0001 /RESET_LT/ ;
6.0 1.0 1.750000E+000 3.0 1.750000E+000 ; (** CIRCULAR APERTURE OR DISC **)
(6.0 1.0 1.000000E+005 ; )
(6.0 2.0 1.000000E+006 ; )
(6.0 3.0 1.000000E+005 ; )
(6.0 4.0 1.000000E+006 ; )
(6.0 5.0 1.000000E+005 ; )
(6.0 6.0 1.000000E+005 ; )
3.0 7.000000E-002 /TARGET/ ;
51. 1. -2.000000E+000 2.000000E+000 2.000000E-001 /YX_7/ ;
52. 3. -2.000000E+000 2.000000E+000 2.000000E-001 ;
-51. 2. -1.000000E+001 1.000000E+001 5.000000E-001 /YX_7/ ;
-52. 4. -1.000000E+001 1.000000E+001 1.000000E+000 ;
-50. 11. 0.000000E+000 1.000000E+002 5.000000E+000 ;
-50. 8. 0.000000E+000 1.000000E+000 5.000000E-002 ;
50. 21. 1.750000E+000 1.900000E+000 1.000000E-002 ;
-50. 22. 0.000000E+000 1.000000E+001 5.000000E-001 ;
-50. 23. -9.000000E+001 9.000000E+001 9.000000E+000 ;
-50. 24. -9.000000E+001 9.000000E+001 9.000000E+000 ;
16. 180. 111. 0. ;
16. 190. 0. 222. ;
SENTINEL
SFNTTINPT
```

Figure 34B. Second part of the Double Scattering Example Main Input File FOR001.DAT.



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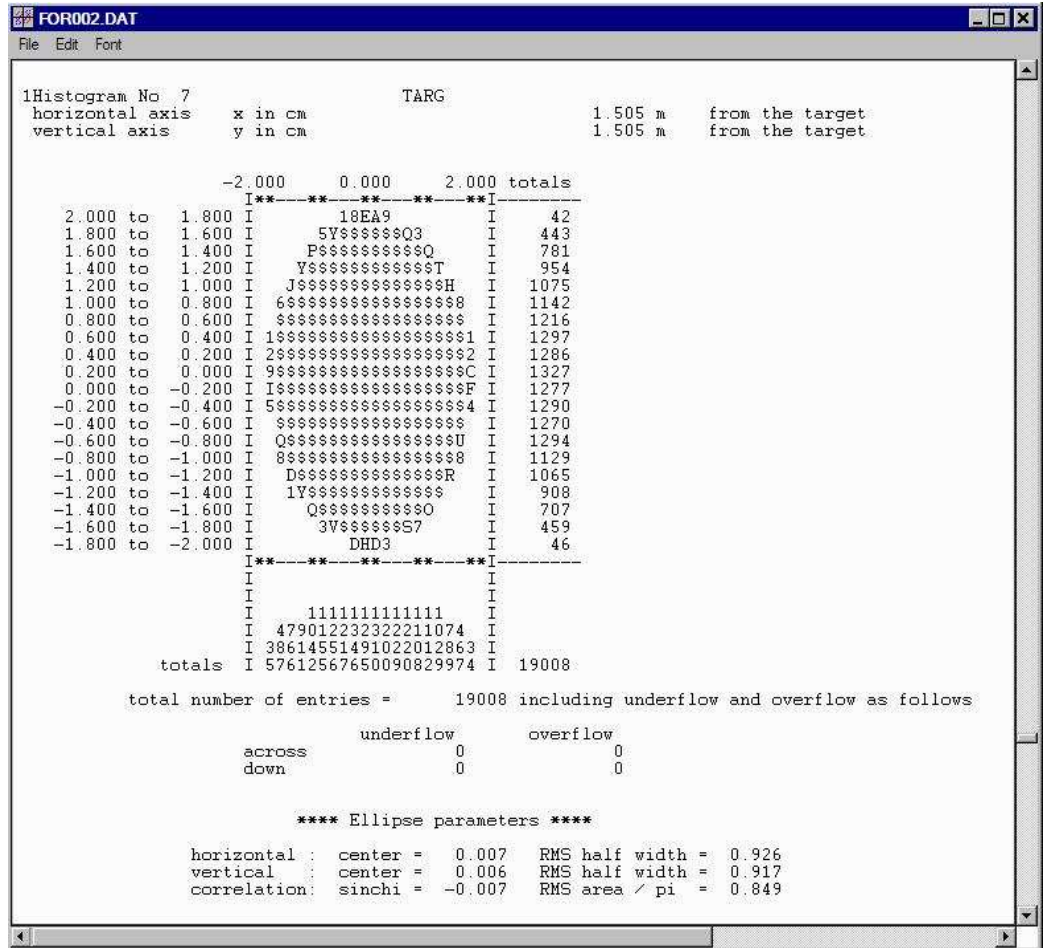


The PSI-TURTLE Command Write and Run 'FOR001.DAT' will write the Main Input File (but not display it), run the PSI-TURTLE Module computation engine turtle32.dll, and when the calculations are completed open and display the Main Output File FOR002.DAT.

Note that the Number of Macro-Particles Global Parameter used for the "Double Scattering Example.pbol" is 100,000. That number is used for the output results shown on the next few pages.

Using the PBO Lab PSI-TURTLE Command to "Write and Run 'FOR001.DAT' " for the "Double Scattering Example.pbol" model will carry out the calculations specified and then display the text output file FOR002.DAT. The FOR002.DAT file is considerably longer than the input file (FOR001.DAT) because it contains the requested alphanumeric TURTLE histogram plots. A small section of the output file, containing the cross section 2-D scatter plot requested using the COMM Piece labeled "YX_7" (see Figure 33), is shown in Figure 35.

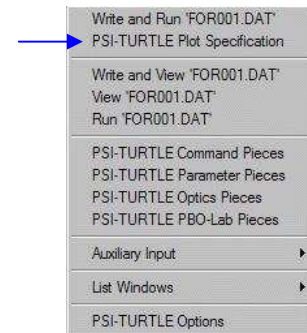
Figure 35. Double Scattering Example Output FOR002.DAT



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From the results in Figure 35 it can be seen that just over 19,000 particles have survived to the target. This represents a transmission efficiency of 19%. The 2-D cross section plot shown in Figure 35 for the surviving beam *suggests* a uniform central region. The \$ symbols in the plot just indicate that particle count is largely saturated: each \$ represents more than 1000 particles. The PBO Lab PSI-TURTLE Module has another method to view the final beam distribution: PBO Lab Graph Tool Windows. The PSI-TURTLE Module Command "PSI-TURTLE Plot Specification" will open a list window (Figure 6 in Section 2) that includes the PSI-TURTLE Plot Options available. Figure 36 shows the results of selecting "Final Beam Y vs X".



The PSI-TURTLE Command PSI-TURTLE Plot Specifications can be used to access PBO Lab Graph Tool Windows for the final beam distribution. The options include displays that might not have been requested as a histogram plot.

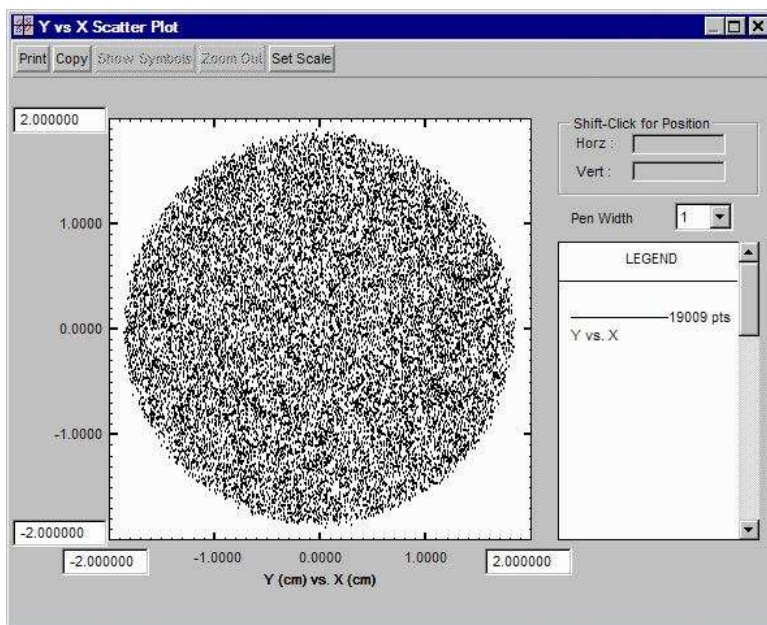


Figure 36. PBO Lab Graph Tool Window for the "Final Beam Y vs X" Distribution Scatter Plot.

The cross section scatter plot shown in Figure 36 reconfirms that the beam is distributed quite uniformly within a circle of approximately 1 cm radius. As might be expected the divergence of the beam at the target plane is not uniform. Figure 37 shows the results of selecting "Final Beam Y_p vs X_p" for the PSI-TURTLE Plot Option.



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*The PSI-TURTLE Command
PSI-TURTLE Plot Specifications
provides options for displays not
requested as histogram plots.
Figure 37 illustrates one for the
Double Scattering Example.*

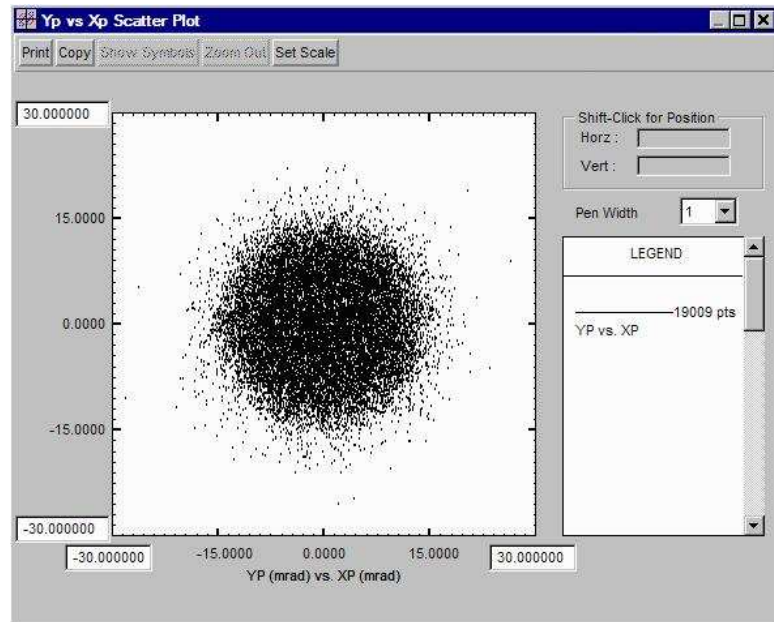
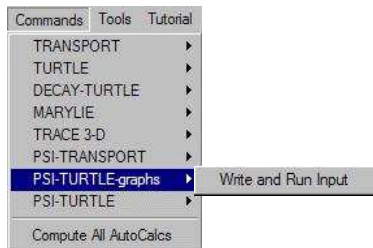


Figure 37. PBO Lab Graph Tool Window for the "Final Beam Yp vs Xp" Distribution Scatter Plot.



*The Write and Run Input
Command of the PSI-
TURTLE-graphics Module will
open a gratur32.exe console
window. Various plots can be
produced entering appropriate
data into the console window.*

The displays of the PSI-TURTLE `gratur32.exe` program are needed to accurately quantify the results of the double scattering system. The PBO Lab supporting PSI-TURTLE-graphs Module is used for this purpose. Selecting the single Command available (Write and Run Input) opens a `gratur32.exe` console window. Data entered into the console window is used to create *displays of the data originally requested as histograms*. Each time a set of data input is completed in the console window, the corresponding display is added to an window entitled HIGZ_01. Figure 38 shows the `gratur32.exe` console window completed for all 8 of the requested histograms, while Figure 39 illustrates the resulting HIGZ_01 window, for the Double Scattering Example starting with 100,000 particles.



```

C:\OASIS\PSI Codes\gratur32.exe
Welcome to the TURTLE Graphic Histogram Option Programme.
Version 1.22b for Windows, using HBOOK/HPLLOT from CernLib 98
Compiled with Digital Visual Fortran Version 6.0
-----
--> Graphic Data are stored on FOR100.DAT via <--
--> 16, 190, i, 100, ; Card in TURTLE Input-Deck. <--
--> i = 0 : create with each run a new FOR100.DAT <--
--> i = 2 : update FOR100.DAT with each run. <--

There are 8 histograms stored on FOR100.DAT
All booked histograms refer to 100000 rays
and will be shown in a window named HIGZ_01.

Enter Width, Height of Screen in cm <D=19.5,19.5> 30.0,30.0
Enter number of x and y zones <D=2,2> 3,3
Fill color indices are:
2: red, 3: green, 4: blue, 5: yellow, 6: magenta, 7: cyan
For 1-dim Histograms:
Enter color indices for Histogram, Zone and Picture <D=2,3,5>
For 3-dim Histograms:
Enter 3-dim indices for Histogram, Zone and Picture <D=4,5,7>

Enter Histogram_number Ineg -> clear screen! <D = 1>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Version 1.23/09 of HIGZ started
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 2>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 3>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 4>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 5>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 6>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 7>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter C1, C2, CC, CS, L, L1, L2, S, S1, S2, S3, S4 <D = C1>
Selected: Contour Plot <monochrome>
Enter number of contour lines <D = 10>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR

Enter Histogram_number Ineg -> clear screen! <D = 8>
Enter LIN or LOG for type of vertical scaling <D = lin>
Enter M<monochrome> or C<colored> <D = M>
Enter p1, p2, p3, p4 for hardcopy m for metafile or CR
    
```

The Figure 38 example uses most of the default parameters for the gratur32.exe console window. The exceptions include the Width and Height for the Screen (30.0, 30.0) and the number of x and y zones (3,3). The results of these gratur32.exe console window inputs are shown in Figure 39.

Figure 38. Completed gratur32.exe console window for all 8 histograms of the Double Scattering Example.

The gratur32.exe console window shown in Figure 38 uses nearly all default settings, with the exception of the "screen" (i.e. window) width and height parameters and the plot arrangement (number of x and y zones) for the HIGZ_01 window. Users should refer to the PIS Graphic TURTLE documentation (see Section 6) for more information on the gratur32.exe console window options.



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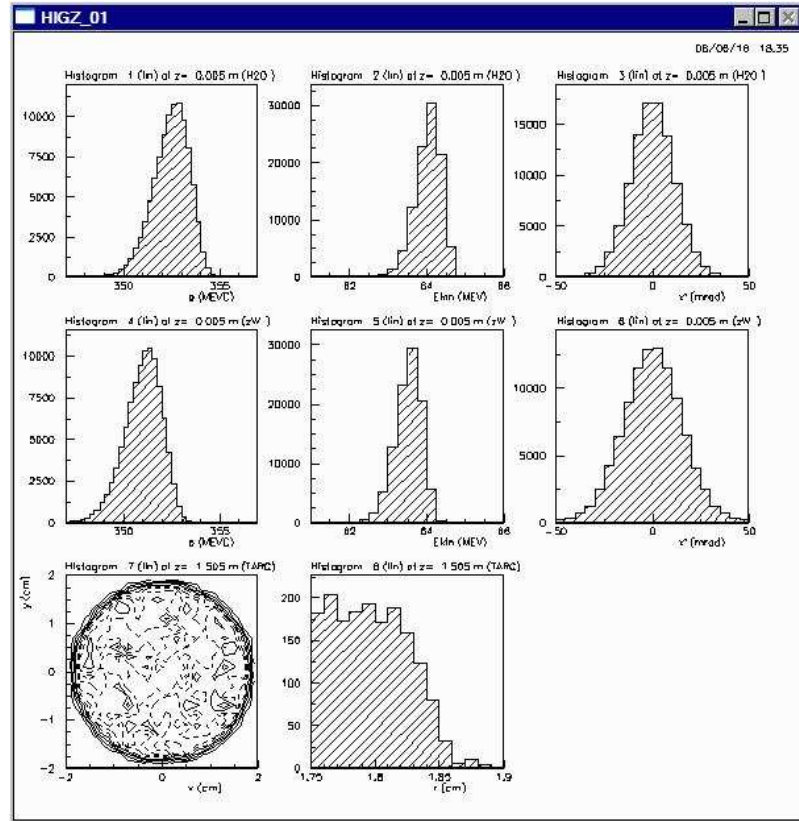
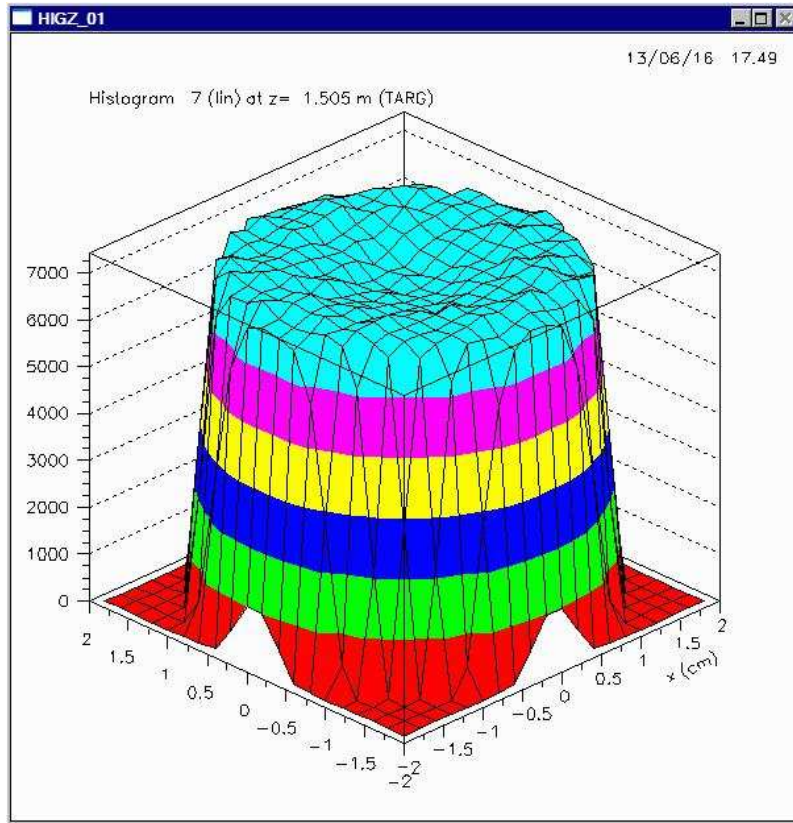


Figure 39. Results of the gratur32.exe computations for the 8 histograms of the Double Scattering Example.

The last histogram (#8) in Figure 39 (penumbra) for the Double Scattering Example shows that the radial fall off is somewhat "jagged" for the 100,000 particle simulation. Similarly the beam cross section plot in the next to last histogram (#7) shows some quantitative variation in the uniformity of the distribution at the target plane. This variation was not so discernible in the results shown in Figure 35 and Figure 36. To improve the fidelity of the gratur32.exe plots the number of particles in the simulation needs to be increased. Figure 40 shows a result for the final beam cross section, using a 10 million macro-particle simulation with the PSI-TURTLE Module.



See Figure 19 for images of the 12 basic types of 2-D histogram displays available to the `gratur32.exe` program.

Figure 40. Results of 10 million particle simulation of the Double Scattering Example, displayed with a "S1" type `gratur32.exe` plot.

Figure 40 displays the final beam cross of the Double Scattering Example using a `gratur32.exe` type "S1" display. Figure 19 provides an overview of the `gratur32.exe` plot types available for displaying 2-D histogram data. The use of ten million macro-particles significantly improves the fidelity of the results and the "smoothness" of images created from the data.

Table 2 gives some approximate run times for the Double Scattering Example for different numbers of macro-particles. Times are given for two representative laptop computers of different configurations.



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Table 2. PSI-TURTLE Module Simulation Times for Double Scattering Example.
All results used PBO Lab 3.1.0.0 but the PSI-TURTLE Module versions differ.

Version	No. of Particles	Computer Information / Operating System	Time (min:sec)
0.9.4.6	100,000	Intel T2400, 1.8 GHz, 987 MHz, 2.00 GB RAM / Win XP, SP 3	00:07
0.9.3.2	1,000,000	Intel T2400, 1.8 GHz, 987 MHz, 2.00 GB RAM / Win XP, SP 3	01:19
0.9.5.2	3,000,000	Intel T2400, 1.8 GHz, 987 MHz, 2.00 GB RAM / Win XP, SP 3	03:08
0.9.5.9	10,000,000	Intel T2400, 1.8 GHz, 987 MHz, 2.00 GB RAM / Win XP, SP 3	14:13
0.9.4.2	100,000	Intel i7-4702MQ, 2.80 GHz, 2.80 GHz, 16.00 GB RAM / Win 8.1	00:02
0.9.4.2	1,000,000	Intel i7-4702MQ, 2.80 GHz, 2.80 GHz, 16.00 GB RAM / Win 8.1	00:21
0.9.4.2	3,000,000	Intel i7-4702MQ, 2.80 GHz, 2.80 GHz, 16.00 GB RAM / Win 8.1	01:03
0.9.4.2	10,000,000	Intel i7-4702MQ, 2.80 GHz, 2.80 GHz, 16.00 GB RAM / Win 8.1	03:29
0.9.5.9	30,000,000	Intel i7-4702MQ, 2.80 GHz, 2.80 GHz, 16.00 GB RAM / Win 8.1	12:25

Run times are also dependent upon other applications that may be running simultaneously. No other applications, other than required operating system and security routines, were running for the Table 2 times.

Results for different PSI-TURTLE Module versions are given in Table 2 although little difference (<4%) was seen using different versions for the same number of macro-particles. However, for the first machine listed it was observed that the *first* execution of a “Write and Run 'FOR001.DAT'” command results in a *faster* run time than subsequent “Write and Run 'FOR001.DAT'” executions. The data shown in Table 2 are for the first execution. For the second machine listed in Table 2, the times of the first and subsequent executions were the same.



PBO Lab™

6. PSI-TURTLE Documentation

**User Manual:
Supplement:
PSI-TURTLE
Application
Module**



PBO Lab 3.0 User Manual Supplement: PSI-TURTLE Module

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6. PSI-TURTLE Documentation

PSI-TURTLE Information and Links

The PSI-TURTLE Module utilizes selected executable programs (.exe) and dynamic linked libraries (.dll) that form part of the PSI Graphic Turtle Framework by U. Rohrer based on a CERN-SLAC-FERMILAB version by K.L. Brown et al. AccelSoft does not distribute documentation authored by U. Rohrer of the Paul Scherrer Institute (PSI), but documentation for the PSI Graphic Turtle program may be downloaded from the PSI website: http://aea.web.psi.ch/Urs_Rohrer/MyWeb/turtle.htm

Documentation for the PSI physics codes may be obtained from the website of the Paul Scherrer Institute.

Documentation for the SLAC-FERMILAB version of TURTLE and DECAY-TURTLE are distributed by AccelSoft as part of the PBO Lab TURTLE Module and DECAY-TURTLE Module under written agreement with SLAC and FNAL. Please refer to the PBO Lab User Manual Supplement: TURTLE and DECAY-TURTLE Modules. (The PBO Lab PSI-TURTLE Module requires the PBO Lab TURTLE Module, or the PBO-Lab DECAY-TURTLE Module.)

PSI-TURTLE Troubleshooting

Difficulties can be encountered with the PSI-TURTLE Module, just as with any other software. AccelSoft provides technical support to all PBO Lab users whose Technical Support & Product Update Service (TS&PUS) is current. Users encountering a problem should email their model (.pbo) file to AccelSoft with a brief summary of the problem. However, there are a few things users can look for on their own to possibly diagnosis and correct problems. These are summarized on the next few pages.



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The PBO Lab PSI-TURTLE Module relies on the turtle32.dll "computation engine" for physics calculations. As a dynamically linked library, any "crash" in the turtle32.dll library will generally result in a crash in PBO Lab itself. A "hard crash" of this type may result in the display of a run-time error window similar to that shown in Figure 41.

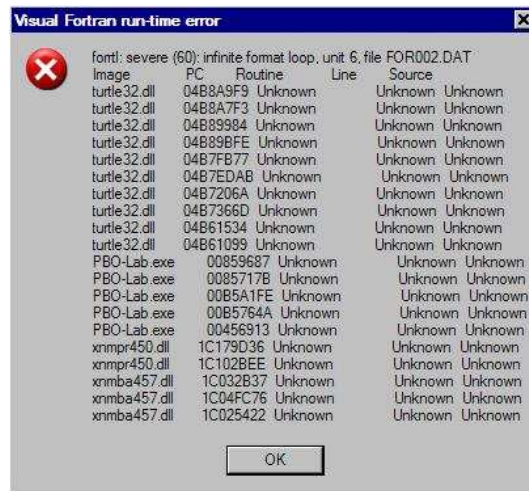
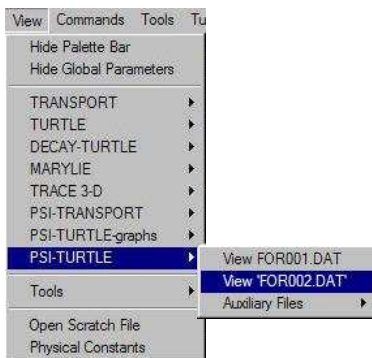


Figure 41. Example of a run time error dialog resulting from a "hard crash" in the turtle32.dll library.



Restart PBO Lab after a hard crash and use the View menu to look at the Main Output File FOR002.DAT. It can give an indication of where a problem may be in the Main Input File.

The actual dialog display will depend upon the configuration of the Windows software and compiler applications that may be installed. Frequently, the information displayed is much less than shown in Figure 41, but the first line will usually appear.

Any problem causing difficulty for the turtle32.dll library is *almost always a problem with the Main Input File* FOR001.DAT. If you restart PBO Lab, and use the View menu to open the Main *Output* File FOR002.DAT, there may be information near the bottom of the file that points to the problem. (If the crash occurs before any data is written to FOR002.DAT a dialog will appear saying "FOR002.DAT file does not exist".)



A more common problem is that the turtle32.dll library completes its execution, and the Main Output File FOR002.DAT successfully opens, yet there are no histograms appearing at the end of FOR002.DAT. Figure 42 shows an example of the type of information that may appear at the bottom of the FOR002.DAT file instead of histograms.

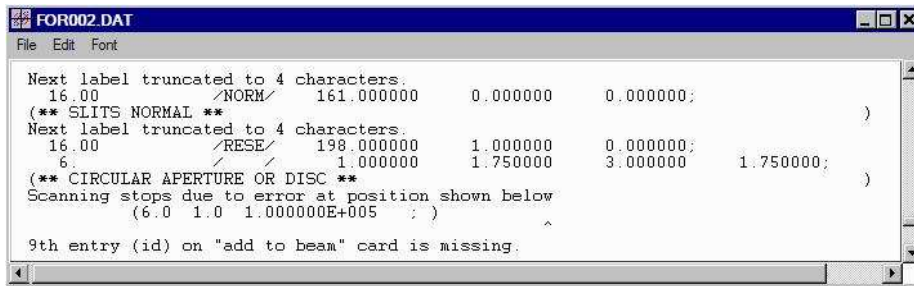


Figure 42. Example of error reporting in FOR002.DAT.

Errors reported at the bottom of the FOR002.DAT output file are often the result of a problem in the Main Input File FOR001.DAT, but not always. The turtle32.dll library is loaded at the start up of the PBO Lab software. The library remains "open" as long as PBO Lab is open, and in particular, any initializations executed at the first use of the turtle32.dll library are not automatically repeated. It may be necessary to close and reopen PBO Lab before re-attempting the computation.

PBO Lab may crash under certain circumstances. The resulting dialog will reference PBO-Lab, but the details in the dialog will depend upon the operating system. A typical example is shown in Figure 43. This may occur shortly after opening a model (.pbol) file and reflect an error in loading the PSI-TURTLE Module for that model. The problem can often be solved by restarting PBO Lab, using the File→Open menu to open the model, *and continuing to leave the start-up "Untitled1" document open.*

Users encountering the types of problems shown in Figure 42 are requested to email their model (.pbol) file to AccelSoft. It may be possible to find a solution that does not require restarting PBO Lab.

Encountering a PBO-Lab crash shortly after start up, that displays a dialog similar to that shown in Figure 43, can reflect an error in loading the PSI-TURTLE Module. Avoid double-clicking a model file to open it, or using the File→Recent Files menu, until the problem is resolved.

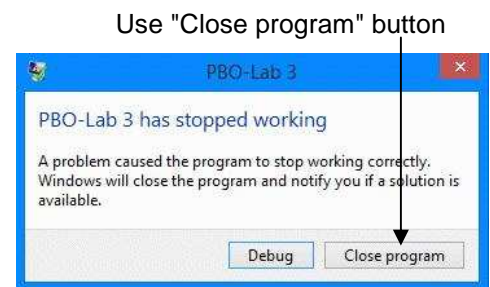


Figure 43. Example of a PBO Lab crash dialog.



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