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**QUICK START GUIDE 3.0**  
**Configuring and Outputting Results with E x H reTORT Ray Tracer**  
**Estimated Time to Invest: 15 minutes**

**Purpose:** Explain the results available from reTORT, where they are accessed, and teach how to configure and view results including user-defined results not included in the expansive list already provided by reTORT.

**Scope:** We'll use the final file from Quick Start Guide 2.0 – Design of a Tessar-style lens.

First we'll show you around the UI to gain familiarity with accessing the built in result values available, where you can configure and view those results, and how to filter and configure result formats to suit your precise needs.

Next, we'll step through the various classes of results, demonstrate navigating to each and provide some representative examples.

Lastly, we'll review formatting of several types of output formats.

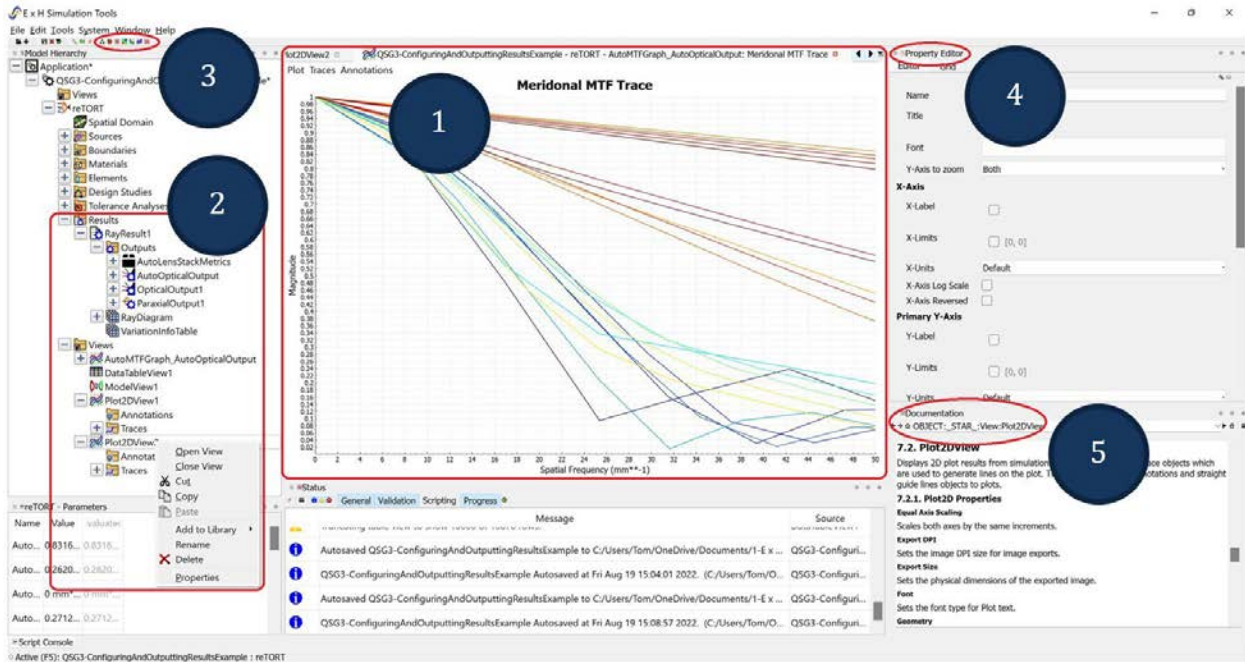
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## 1.0 Intro – Finding Your Way Around the User Interface

First let's take a look at the major docks in the UI, each dock resizable at any time to suit your need.



1. The Workspace is where model views and results, plots and tabular data, appear. You can have multiple model views and an unlimited number of windows, split the windows or drag and place where you wish. You can also configure and filter the data for any of these views, as well as export tables for further analysis outside of reTORT or export of data to another application.
2. In the Model Hierarchy dock, the Results section contains all the current and typical result values that, if enabled by you, will be calculated with each individual simulation run, whether updated with a single manual simulation, or run as one of 30,000 simulations during an optimization. Those typically evaluated in most optical designs are enabled by default, others are easily enabled in the Property Editor. Should you wish to configure other types of results not available, you can easily create an additional Optical Output section of Ray Results and add your new metrics.

Each result for which a plot, table or model view is generated is listed in the Views section of the Model Hierarchy, at the very bottom of the model hierarchy dock. This allows easy access for operations on the views, chief of all, opening the property editor to further filter data or modify the view.

3. Plotting Wizards can be found in the last group of Icons below the main menu, immediately after the optimization and tolerancing wizard icons. Wizards are designed



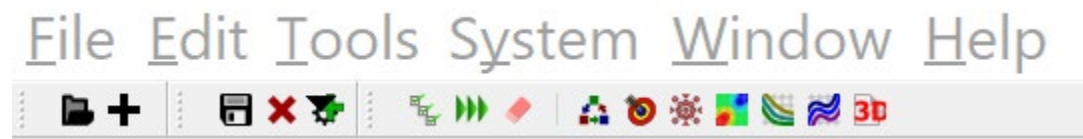
for the most frequent tasks and offer quick configuration drop down menus. Plotting Wizards are available for spot, MTF, wavefront error, and TRA plots as well as quick export of the design to a CAD format.

4. For every item in the Results and View sections of the Model Hierarchy, by right-clicking on the item to reveal the contextual menu, you can click on Properties to go to the Property Editor for that item. Here, for Results, you can alter some key global parameters and enable or disable focal plane, imaging, and aberration metrics for any of the optical outputs. For Views, you can reformat the table or plot and filter data.
5. Wherever you click, if you have any questions or wish to learn more about the item on which you clicked, any information available in the contextual help will appear in the Documentation dock.

For more information, contact E x H through <https://exhsw.com/exh-support/#Contact-exh>.

## 2.0 The Plotting Wizards

Simply mouse over the icons to identify each plotting wizard.



The final five are the plotting wizards:



Spot diagram



Wavefront error



MTF diagram



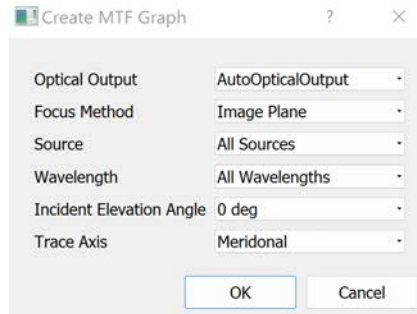
TRA trace



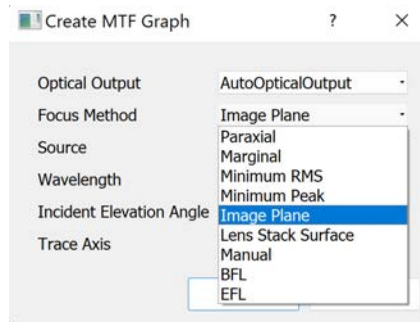
Export to CAD



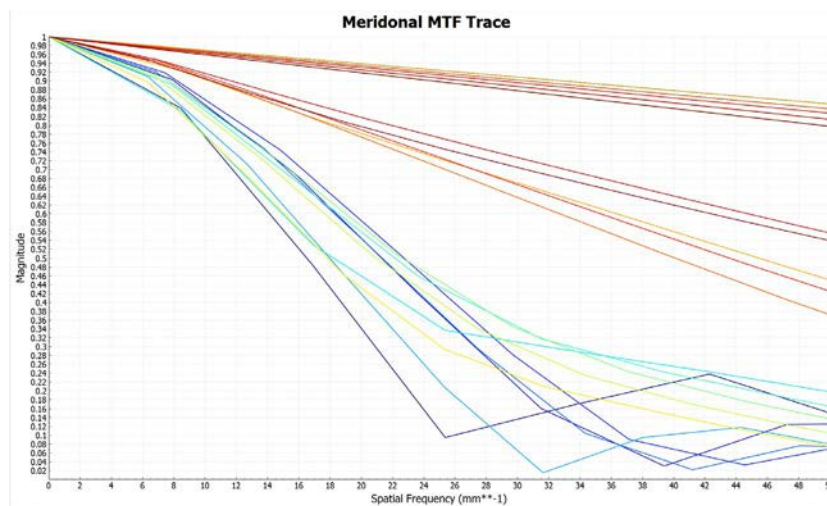
A left-click on either will reveal the quick configuration options, for example, for MTF,



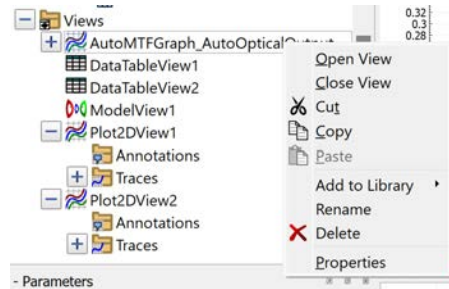
Most options are self-explanatory but for clarity, let's expand the focus method, which we'll also get into again shortly when we go over Optical Outputs,



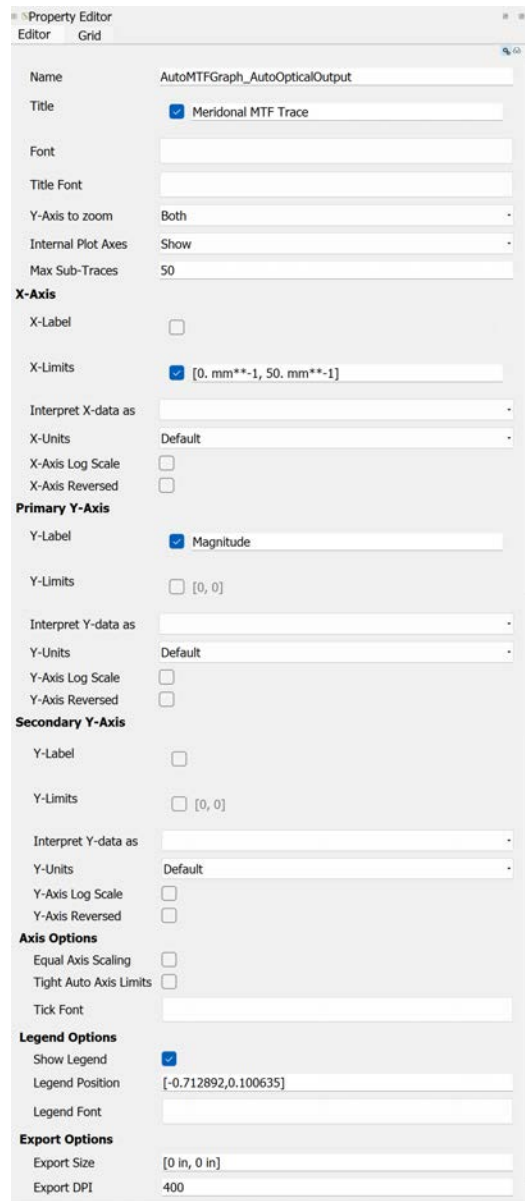
Leaving all the defaults but changing the incident angle to include all angles, we simply click OK and the MTF diagram is instantly plotted.



To reconfigure our chart, we go to Views where this particular plot is found under AutoMTFGraph\_AutoOpticalOutput, right click to see the options and select properties.



Here, we've selected advance options and we can make any changes to our plot formatting.





This is typical of all the plotting wizards with the exception of CAD where you will simply be prompted to save to your choice of CAD format.

### 3.0 Ray Result Outputs – Auto Lens Stack Metrics

This is not something you are likely to need but contains reference data for reTORT's reference. Remember, reTORT is by default non-sequential, with a sequential ray tracing option, even if we are using lens stacks in a sequential order for these examples. For more complex examples, reTORT has the flexibility of specifying the order of ray tracing.

You will find the data you typically need in the lens stack itself, which can be exported, and in the parameters dock and the optimization and tolerancing wizard parameters tabs. You don't need to reference all of these. reTORT simply makes the data you need available wherever you happen to be.

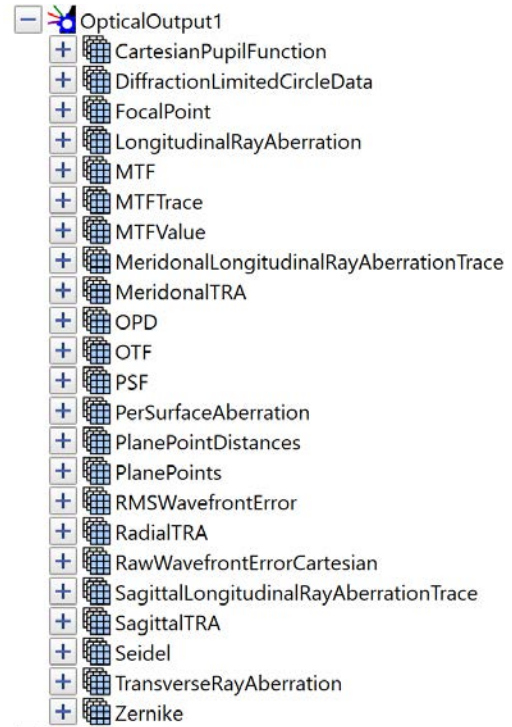
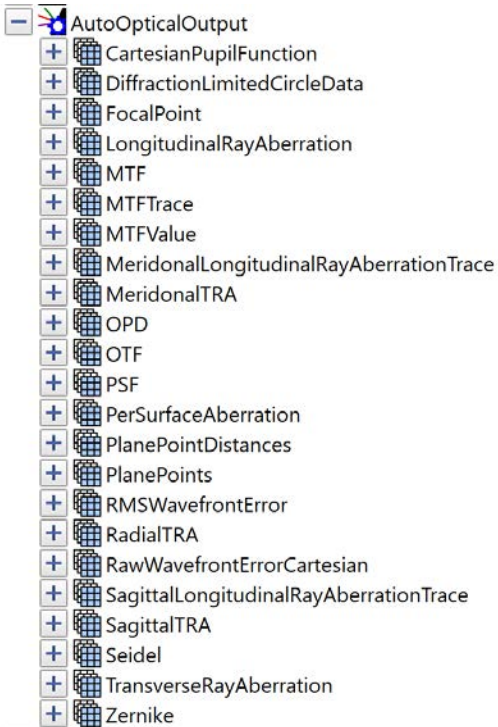
But for example, here is the table generated for this current item.

Table View

	SourceUID	Wavelength (m)	Theta (deg)	Phi (deg)	Trace Order	Surface Index	Is Airgap	Middle Thickness (m)	Edge Thickness (m)
1	192	4.80E-07	0.000000000000...	0.000000000000...	1	1	0.000000000000...	0.006654989	1.000100530036712E-03
2	192	4.80E-07	0.000000000000...	0.000000000000...	1	2	1.000000000000...	0.006888774	NAN
3	192	4.80E-07	0.000000000000...	0.000000000000...	1	3	0.000000000000...	0.001016833	4.805054432500622E-03
4	192	4.80E-07	0.000000000000...	0.000000000000...	1	4	1.000000000000...	0.004576925	NAN
5	192	4.80E-07	0.000000000000...	0.000000000000...	1	5	1.000000000000...	0.003349482	NAN
6	192	4.80E-07	0.000000000000...	0.000000000000...	1	6	0.000000000000...	0.001017026	4.316403402745595E-03
7	192	4.80E-07	0.000000000000...	0.000000000000...	1	7	0.000000000000...	0.007282341	1.627369246470504E-03
8	192	4.80E-07	0.000000000000...	0.000000000000...	1	8	1.000000000000...	0.078000000	NAN
9	192	4.80E-07	0.000000000000...	0.000000000000...	1	1	0.000000000000...	0.006654989	1.000100530036712E-03
10	192	4.80E-07	0.000000000000...	0.000000000000...	1	2	1.000000000000...	0.006888774	NAN
11	192	4.80E-07	0.000000000000...	0.000000000000...	1	3	0.000000000000...	0.001016833	4.805054432500622E-03
12	192	4.80E-07	0.000000000000...	0.000000000000...	1	4	1.000000000000...	0.004576925	NAN
13	192	4.80E-07	0.000000000000...	0.000000000000...	1	5	1.000000000000...	0.003349482	NAN
14	192	4.80E-07	0.000000000000...	0.000000000000...	1	6	0.000000000000...	0.001017026	4.316403402745595E-03
15	192	4.80E-07	0.000000000000...	0.000000000000...	1	7	0.000000000000...	0.007282341	1.627369246470504E-03
16	192	4.80E-07	0.000000000000...	0.000000000000...	1	8	1.000000000000...	0.078000000	NAN

### 4.0 Ray Result Outputs – AutoOpticalOutput and OpticalOutput1

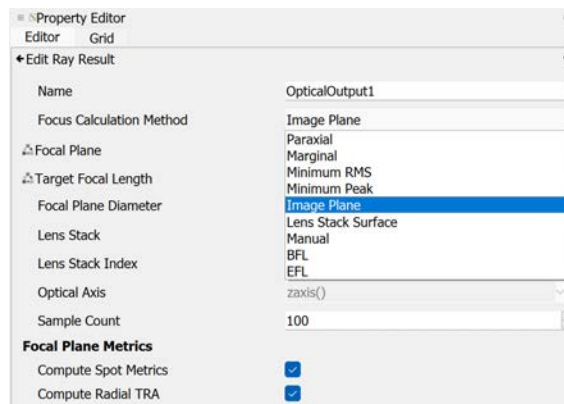
The only difference between these two are that the AutoOpticalOutput is pulled by the wizards – optimization, tolerancing and plotting wizards. In practical terms, these two groups of outputs are currently identical. Nevertheless, my practice is to configure them identically which involves only small changes from the defaults. Below are the standard values available and reevaluated with each individual simulation run. You can see they are the same optical metrics. If you happen to miss one at the start of an optimization, simply enable it later, rerun at least one simulation, and the new results you want will be populated.



So, for this section, we'll use only the OpticalOutput1 as an example as it is typical for both.

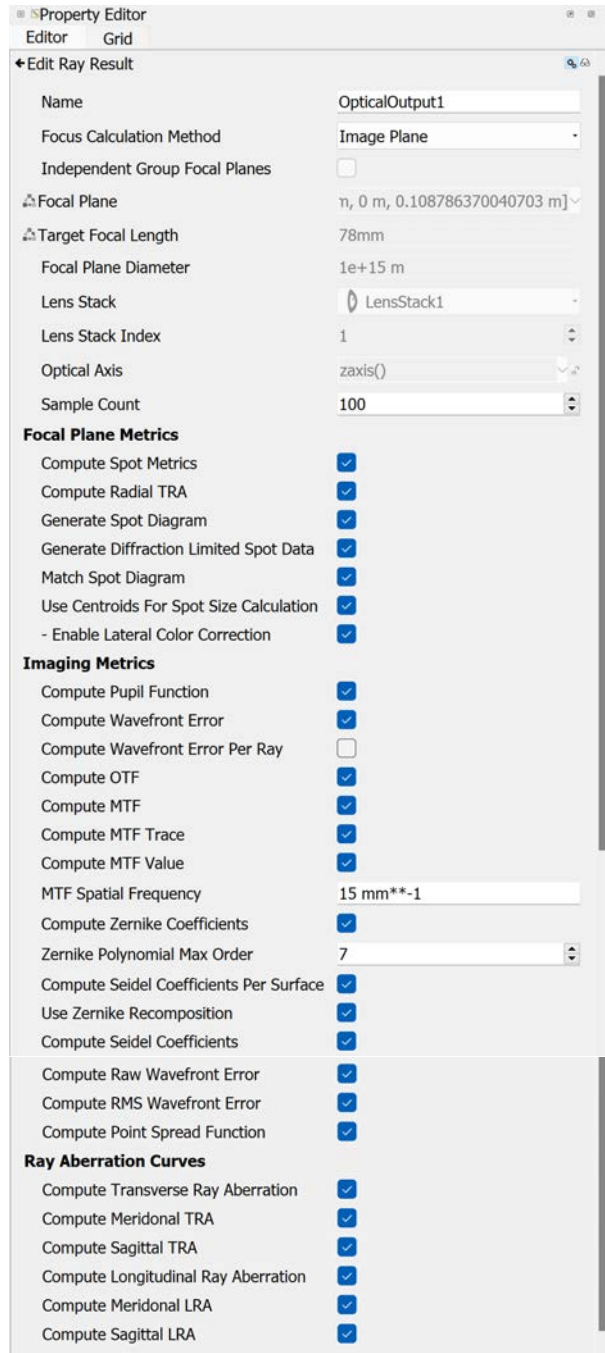
Of utmost importance is defining the Focus Calculation Method in the Property Editor for the Optical Output. Of the choices below, we've chosen the Image Plane. We also have the opportunity to enter a target focal length. This only comes into play in the computations for BFL or EFL but, in practice, I will normally enter this for the image plane as well just as a matter of record in the data file. In this case, I switch to BFL, change the target focal length, and then switch back to image plane.

These metrics will be available on any surface including any dummy surface.





Note if we right click on OpticalOutput1 and click properties, select the double-gear advanced option, we'll see the entire list of metrics.

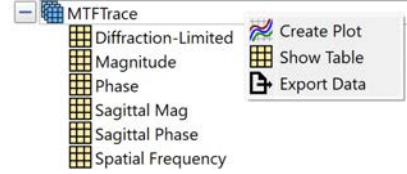
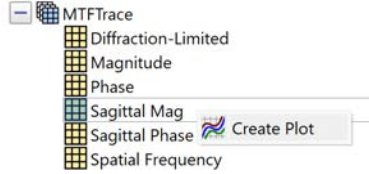


All of the metrics enabled will be reevaluated with every single simulation. If we already have plots or tables of these metrics in our workspace, we can update them at any time by simply clicking Run All, running a single simulation.





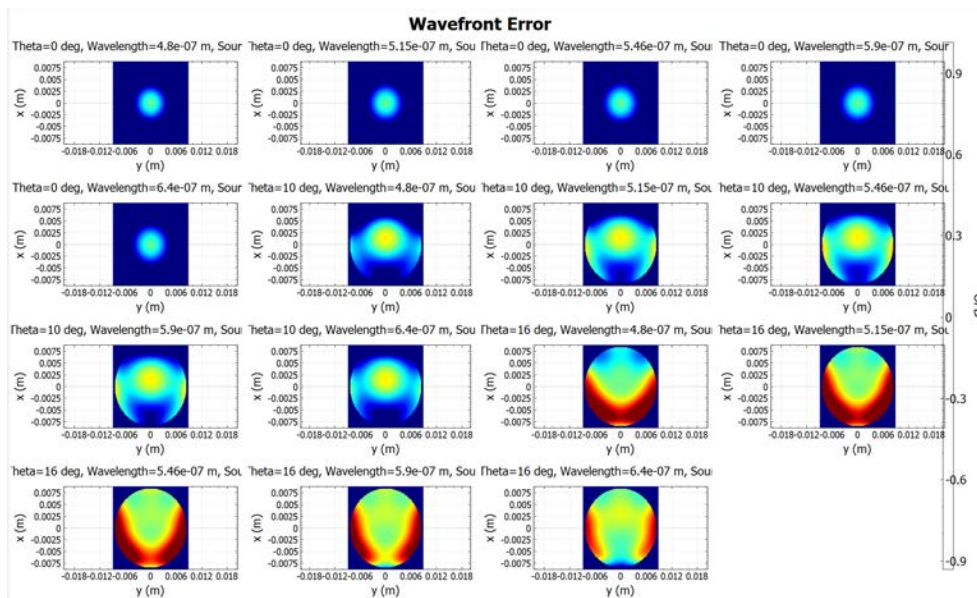
We also have complete control from Results in the model hierarchy. For example, for any component of the MTFTrace, right click and instantly create a plot. Right click on MTFTrace to reveal options to view the plot, view the table of data, or export the data:



Typical Focal Point table:

Table View										
	SourceUID	Wavelength (m)	Theta (deg)	Phi (deg)	MS Diameter (um)	Peak Diameter (um)	RMS Radius (um)	Meridional Radius (um)	Sagittal Radius (um)	Missing Rays
1	192	4.8000000E-07	0.000000000000...	0.000000000000...	29.859435	36.20991	14.929717	14.929717	14.929717	0.000000000000...
2	192	4.8000000E-07	10.000000000000...	0.000000000000...	27.241531	64.69684	13.620765	17.568398	7.899487	0.000000000000...
3	192	4.8000000E-07	16.000000000000...	0.000000000000...	26.054285	115.11254	13.027143	16.106270	8.944326	0.000000000000...
4	192	5.1500000E-07	0.000000000000...	0.000000000000...	23.821259	31.83320	11.910629	11.910629	11.910629	0.000000000000...
5	192	5.1500000E-07	10.000000000000...	0.000000000000...	24.796161	54.54107	12.398080	15.029731	9.029507	0.000000000000...
6	192	5.1500000E-07	16.000000000000...	0.000000000000...	27.274289	103.42832	13.637145	14.907019	12.236184	0.000000000000...
7	192	5.4600000E-07	0.000000000000...	0.000000000000...	22.689106	31.31194	11.344553	11.344553	11.344553	0.000000000000...
8	192	5.4600000E-07	10.000000000000...	0.000000000000...	25.091854	51.93507	12.545927	14.696529	9.940453	0.000000000000...
9	192	5.4600000E-07	16.000000000000...	0.000000000000...	27.851368	100.24149	13.925684	14.316429	13.523654	0.000000000000...
10	192	5.9000000E-07	0.000000000000...	0.000000000000...	24.218981	33.52383	12.109491	12.109491	12.109491	0.000000000000...
11	192	5.9000000E-07	10.000000000000...	0.000000000000...	26.441632	53.96423	13.220816	15.635771	10.251957	0.000000000000...
12	192	5.9000000E-07	16.000000000000...	0.000000000000...	27.656787	102.17896	13.828393	14.130427	13.519613	0.000000000000...
13	192	6.4000000E-07	0.000000000000...	0.000000000000...	28.400820	38.35796	14.200410	14.200410	14.200410	0.000000000000...
14	192	6.4000000E-07	10.000000000000...	0.000000000000...	28.984302	60.88214	14.492151	17.862509	10.048664	0.000000000000...
15	192	6.4000000E-07	16.000000000000...	0.000000000000...	27.608556	109.63836	13.804278	15.330798	12.086472	0.000000000000...

A good example of a colormap chart is the wavefront error plotting wizard. Selecting all angles and all wavelengths, this chart is produced easily with a few clicks.

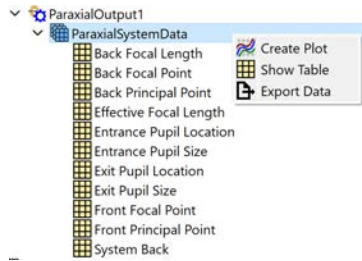




## 5.0 Ray Result Outputs – Paraxial Output

The paraxial output comprises the first order optical parameter results. This is derived from the same rigorous application of Snell's law as all other output and is not to be confused with the results of simplified paraxial ray tracing.

The parameters computed with each simulation can again be found in the model hierarchy.

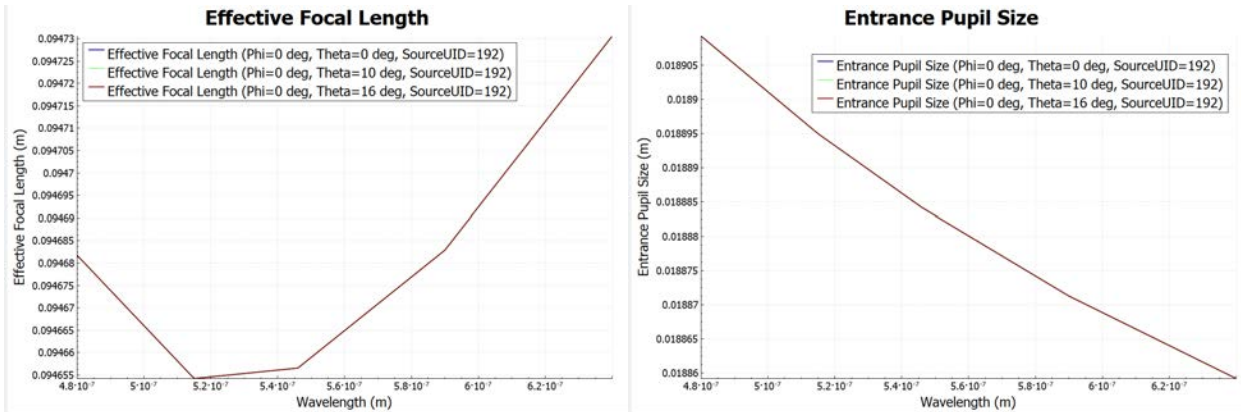


The full paraxial outputs can be viewed or further processed in tabular form by right clicking ParaxialOutput1 and choosing whether to view the table in the workspace or to export the table.

Source UID	Wavelength (m)	Theta (deg)	Phi (deg)	System Back (m)	Front Principal Point (m)	Back Principal Point (m)	Front Focal Point (m)	Back Focal Point (m)	Effective Focal Length (m)	Back Focal Length (m)	Entrance Pupil Location (m)	Entrance Pupil Size (m)	Exit Pupil Location (m)	Exit Pupil Size (m)
192	4.80E-07	0	0.00E+00	0.108786	0.0161	0.014645	-7.86E-02	0.109327	0.094682	5.40E-04	0.052769	0.018909	0.050875	0.017665
192	4.80E-07	10	0.00E+00	0.108786	0.0161	0.014645	-7.86E-02	0.109327	0.094682	5.40E-04	0.052769	0.018909	0.050875	0.017665
192	4.80E-07	16	0.00E+00	0.108786	0.0161	0.014645	-7.86E-02	0.109327	0.094682	5.40E-04	0.052769	0.018909	0.050875	0.017665
192	5.15E-07	0	0.00E+00	0.108786	0.016087	0.014648	-7.86E-02	0.109302	0.094654	5.16E-04	0.052746	0.018895	0.05087	0.017653
192	5.15E-07	10	0.00E+00	0.108786	0.016087	0.014648	-7.86E-02	0.109302	0.094654	5.16E-04	0.052746	0.018895	0.05087	0.017653
192	5.15E-07	16	0.00E+00	0.108786	0.016087	0.014648	-7.86E-02	0.109302	0.094654	5.16E-04	0.052746	0.018895	0.05087	0.017653
192	5.46E-07	0	0.00E+00	0.108786	0.016077	0.01465	-7.86E-02	0.109307	0.094657	5.20E-04	0.05273	0.018884	0.050866	0.017644
192	5.46E-07	10	0.00E+00	0.108786	0.016077	0.01465	-7.86E-02	0.109307	0.094657	5.20E-04	0.05273	0.018884	0.050866	0.017644
192	5.46E-07	16	0.00E+00	0.108786	0.016077	0.01465	-7.86E-02	0.109307	0.094657	5.20E-04	0.05273	0.018884	0.050866	0.017644
192	5.90E-07	0	0.00E+00	0.108786	0.016066	0.014653	-7.86E-02	0.109336	0.094683	5.50E-04	0.052711	0.018871	0.050862	0.017634
192	5.90E-07	10	0.00E+00	0.108786	0.016066	0.014653	-7.86E-02	0.109336	0.094683	5.50E-04	0.052711	0.018871	0.050862	0.017634
192	5.90E-07	16	0.00E+00	0.108786	0.016066	0.014653	-7.86E-02	0.109336	0.094683	5.50E-04	0.052711	0.018871	0.050862	0.017634
192	6.40E-07	0	0.00E+00	0.108786	0.016057	0.014656	-7.87E-02	0.109387	0.094731	6.00E-04	0.052693	0.018859	0.050858	0.017625
192	6.40E-07	10	0.00E+00	0.108786	0.016057	0.014656	-7.87E-02	0.109387	0.094731	6.00E-04	0.052693	0.018859	0.050858	0.017625
192	6.40E-07	16	0.00E+00	0.108786	0.016057	0.014656	-7.87E-02	0.109387	0.094731	6.00E-04	0.052693	0.018859	0.050858	0.017625

Instant plots can be configured and obtained for any of the values listed. As the ParaxialOutput1 name implies, like OpticalOutput1, you can easily define a ParaxialOutput2 and so on to add your own custom parameters.

Two common plots we view are the EFL and the entrance pupil diameter.



## 6.0 Ray Result Output - Ray Diagram

The Ray Diagram is best viewed in tabular form and contains all of the data – for our simple Tessar-style example, over 5000 sets of data – used to create the model view.

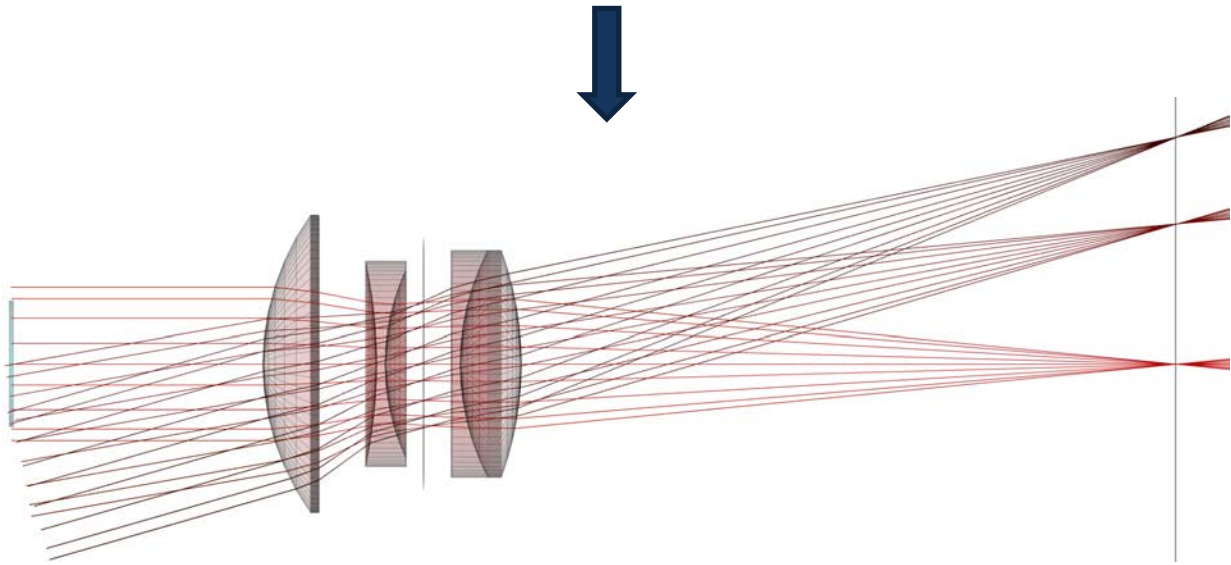
RayDiagram

- Generation
- Ind
- L
- M
- Px
- Py
- Pz
- Ray ID

Create Plot  
Show Table  
Export Data

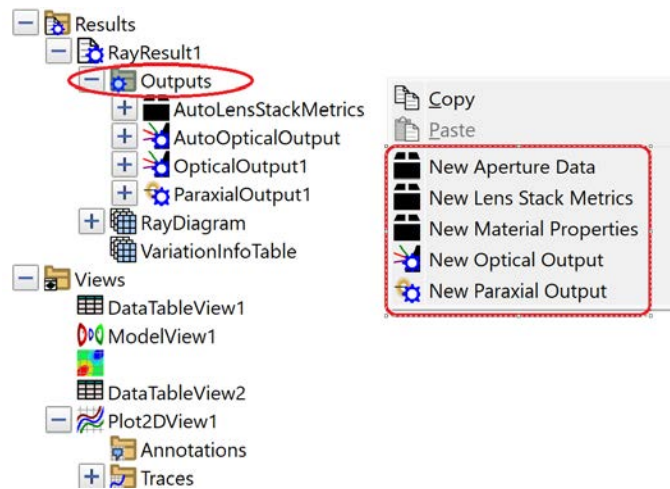


Source UID	Wavelength (m)	Theta (deg)	Phi (deg)	Ind	Px (m)	Py (m)	Pz (m)	M (V m** <sup>-1</sup> )	L (m)	Ray ID	Generation
192	4.80E-07	0	0.00E+00	1.61E+19	0	0	-0.03	1	0.03	0	0
192	4.80E-07	0	0.00E+00	0.00E+00	0	0	0	1.2771257	0.010855	0	1
192	4.80E-07	0	0.00E+00	1.00E+00	0	0	0.006655	1	0.006889	0	2
192	4.80E-07	0	0.00E+00	2.00E+00	0	0	0.013544	1.2779277	0.001661	0	3
192	4.80E-07	0	0.00E+00	3.00E+00	0	0	0.014561	1	0.004577	0	4
192	4.80E-07	0	0.00E+00	4.00E+00	0	0	0.019138	1	0.003349	0	5
192	4.80E-07	0	0.00E+00	5.00E+00	0	0	0.022487	1.228034	0.001534	0	6
192	4.80E-07	0	0.00E+00	6.00E+00	0	0	0.023504	1.2771257	0.011878	0	7
192	4.80E-07	0	0.00E+00	7.00E+00	0	0	0.030786	1	0.078	0	8
192	4.80E-07	0	0.00E+00	8.00E+00	0	0	0.108786	1	0.341214	0	9
192	4.80E-07	0	0.00E+00	9.00E+00	0	0	0.45	1	0.489956	0	9
192	4.80E-07	0	0.00E+00	2.31E+18	-0.001762	-0.001762	-0.03	1	0.030102	1	0
192	4.80E-07	0	0.00E+00	1.10E+01	-0.001762	-0.001762	0.000102	1.2771257	0.010694	1	1
192	6.40E-07	16	0.00E+00	3.56E+02	-0.006669	0	0.02248	1.2244342	0.002618	32	5
192	6.40E-07	16	0.00E+00	3.57E+02	-0.006361	0	0.0242	1.2729585	0.010276	32	6
192	6.40E-07	16	0.00E+00	3.58E+02	-0.005226	0	0.030439	1	0.084681	32	7
192	6.40E-07	16	0.00E+00	3.59E+02	0.0269079	0	0.108786	1	0.153088	32	8
192	6.40E-07	16	0.00E+00	3.60E+02	0.085	0	0.250424	1	0.305658	32	8



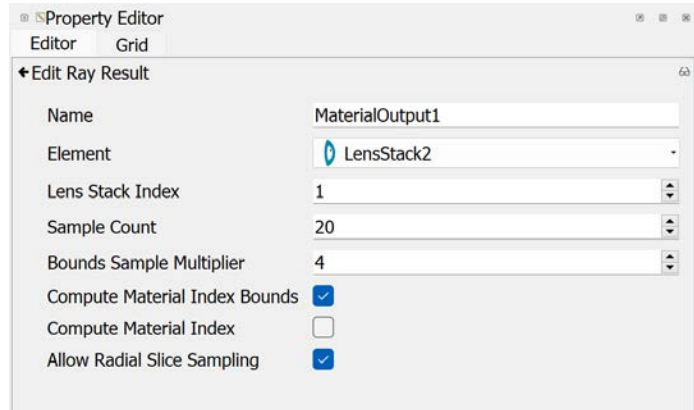
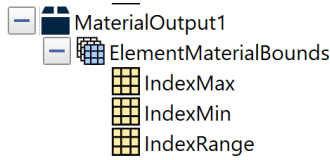
## 7.0 Ray Result Output – Adding Additional Outputs

Right click on Outputs to select classes of additional outputs to define, tabulate or plot.





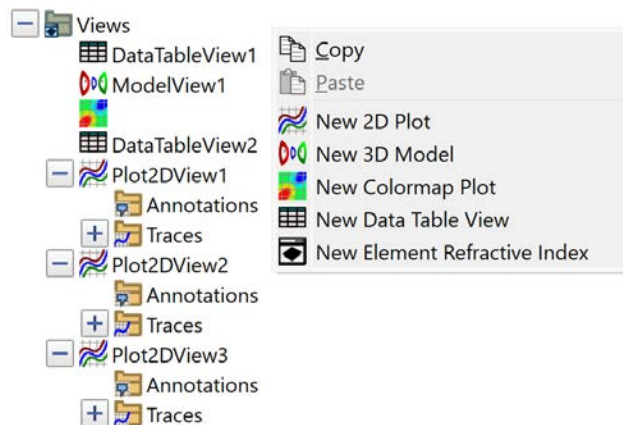
Creating a new Material Output, and clicking on that header, will open its property editor. Here we're using this for a second LensStack2 we've defined under elements. We also could use this for bounded elements.



Creating an OpticalOutput2 and opening its properties displays a list of metrics to be enabled or disabled identical to OpticalOutput1 for you to configure uniquely.


## 8.0 Views – Tables, Plots and other Output Formatting

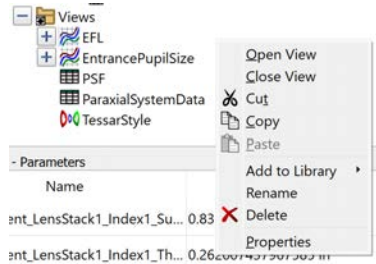
As a minimum, Views will always at least include the model view for the optical system you're designing. Upon originating any form of output, it will appear simultaneously in the workspace and a reference entry will appear under views. You may delete any item in the workspace without deleting its entry in Views. In that way, from that item in Views, you can regenerate any table or plot previously displayed in the workspace.





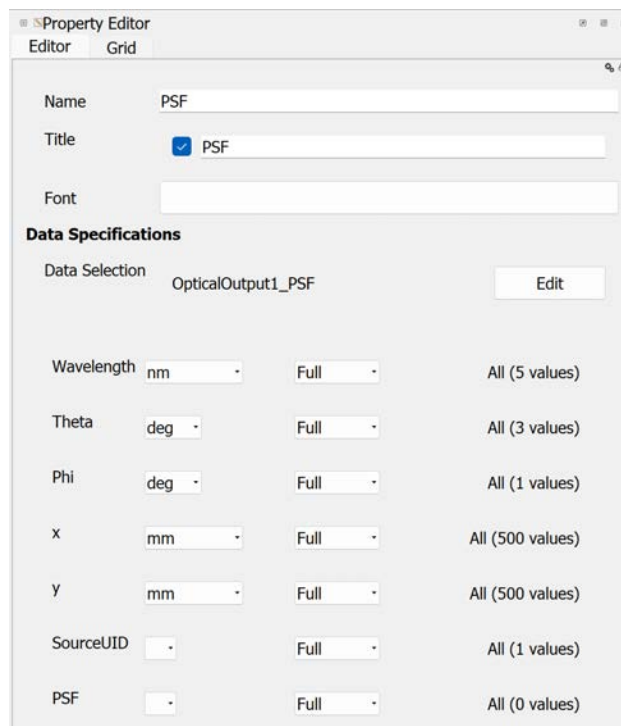
In Views, tables are depicted by the icon  , plots by  , the model views by 

and colormaps by  . Each of these has a property editor page accessed by right-clicking on the line or icon and clicking “properties”. Noting the icons is especially useful when, in the property editor for each, you replace a default name such as DataTable1 by its actual name, using no spaces or special characters, such as the table below of ParaxialSystemData or the Plot of EntrancePupilSize.



For plots, the property editor allows formatting of the plot itself, as already shown on page 5.

Tables can at times be very large and, at times, you may want to only view the data for a certain wavelength, or a certain beam source angle, or any parameter or section of the system of your choice. The property editor for plots allows easy filtering of data, as shown below for PSF.

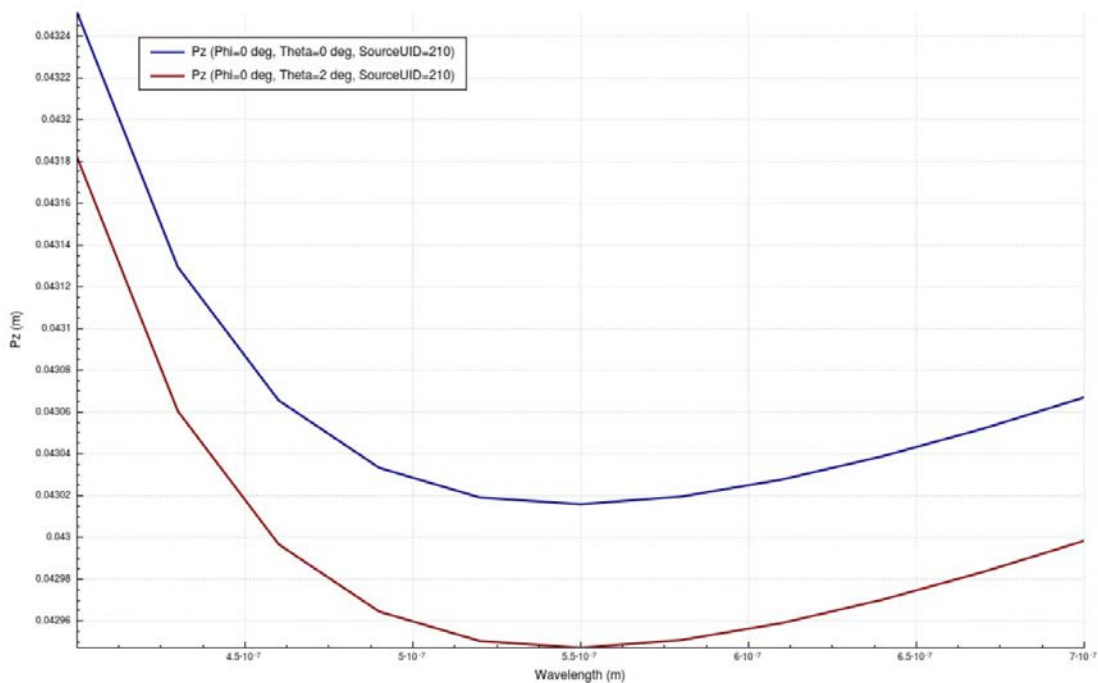




With regard to filtering settings, please note the following options and tips:

1. If a column's filtering settings are set to Full or Ignore, all values for that column will be displayed.
2. If a column's filtering settings are set to Current, only the first value for that column will be displayed.
3. If a column's filtering settings are set to Single, then a slider and textbox appears, and an individual value of that column from the table can be selected. Only the rows whose column value matches the entered value will be displayed in the table.
4. Similar result-filtering settings can be used to control which rows of a result are included in an optimization goal, or can be used to filter results from a plot view as well.
5. If not all columns of the table are listed in the Property Editor, make sure the result has been computed by running the simulation, and make sure the Property Editor is updated by selecting a different item in the Model Hierarchy before clicking back to the table view.

An example of another special plot is the Focal Drift Plot. For detailed instructions, please see [Section B - Creation of the Focal Drift Plot and Manual Plot Creation](#), starting at the bottom of page 12 of the SWaP reduction tutorial which can be found at <https://exhsw.com/download/SwapReductionUseCaseDLSV3.pdf>. This tutorial is scheduled to be reviewed, updated and expanded upon in the near future at which time we'll also move the Focal Drift Plot to this Guide.





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## 9.0 Conclusions

reTORT offers a wide variety of metrics in assorted formats. These formats can be modified easily by the user as well. Other outputs can also be created by the user. We hope this Guide has demonstrated those points and serves you well in navigating the results specifications and output menus.

If you have any questions, contact E x H through <https://exhsw.com/exh-support/#Contact-exh>.