

# Cassegrain Telescope Builder

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## INTRODUCTION

A while ago, I was reading through Joe Geary's excellent book, "Introduction to Lens Design"<sup>1</sup>, and it occurred to me that his first order construction of a Cassegrain telescope could be very easily written up as a BASIC script in FRED.

The example file that accompanies this document contains three embedded scripts.

[makeCassegrain](#) – Implement's Joe Geary's method of constructing a Cassegrain telescope with some basic input construction parameters. Also creates a default plane wave source, sequential paths, and some simple baffle geometry.

[makeImportanceSamples](#) – Implements a paraxial approach to automating the construction of importance samples for scattering calculation.

[assignScatterProperties](#) – Automates the assignment of scatter models and raytrace controls to geometry that is created by the makeCassegrain script.

After running the automated scripts, the user will have a simple Cassegrain telescope system with baffle geometry, importance sample specifications applied to the optical surfaces which target the telescope focal plane, and scatter models and raytrace controls assigned to the geometry in preparation for scatter calculations.

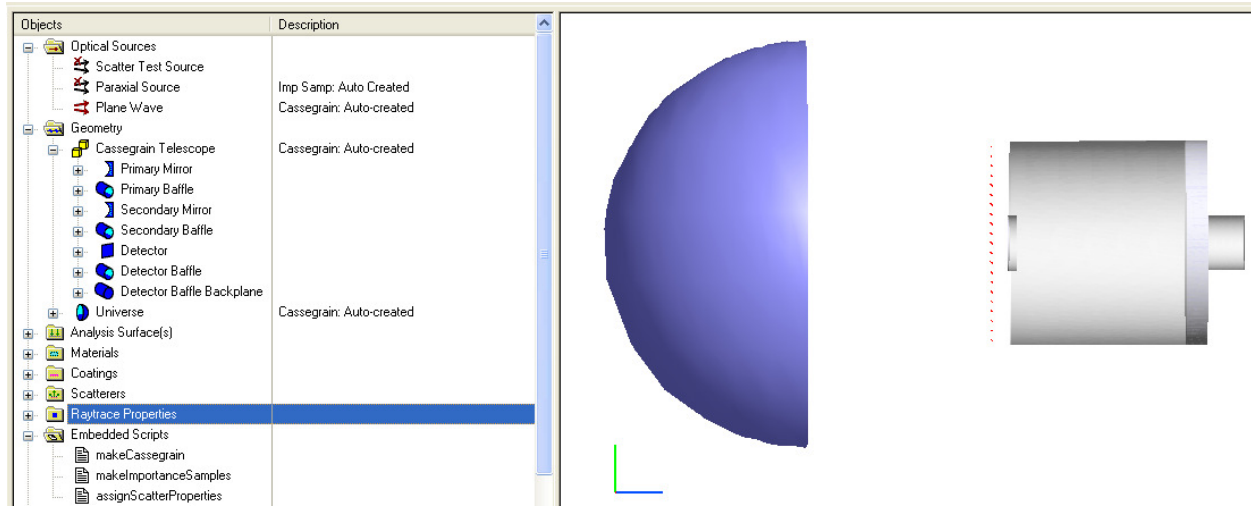
I find that this set of scripts is particularly useful for quickly generating a meaningful (but simple) opto-mechanical system on which I can test various modeling scenarios.

1. Geary, Joseph M. *Introduction to Lens Design: With Practical Zemax Examples*. Willmann-Bell: Richmond, 2007. [\(Amazon Link\)](#)

## Running the Scripts

### **makeCassegrain**

The makeCassegrain embedded script is responsible for constructing the geometry of the telescope (mirrors, detector, baffles), the "universe" object and a plane wave source. These components are shown in the image below. Additionally, the components created by the script are flagged with the description "Cassegrain: Auto-created", as seen in the tree view on the left of the image.



If you open the script in the editor, you will see a section of user-inputs on lines 29-36 that control the construction of the system. These variables are:

<u>Variable name</u>	<u>Variable purpose</u>
dPrimAp	Primary mirror full aperture
dPrimSpeed	F/# of the primary mirror
dFracSecHeight	Secondary mirror full aperture as a fraction of the primary mirror aperture
dBflFrac	Back focal length of the system as a fraction of the mirror spacing
dSourceWL	Source wavelength in microns

When the script is run, the system construction information and derived parameters are reported to the output window. Additionally, the script checks the entity's description to see if the "Cassegrain: Auto-created" tag is present. Every entity with this tag is deleted, which makes it easy for the user to re-build a new telescope system without worrying about manually cleaning up the document.

One other item to note is that the script will create two default user-defined raytrace paths for the system; "Forward Sequential" and "Reverse Sequential". These paths are used by the makeImportanceSamples embedded script.

## makeImportanceSamples

There are many ways of constructing importance samples in FRED so that scatter calculations can be performed with maximum efficiency. This embedded script demonstrates one method of automating the setup of importance samples. For more information on importance samples please read the Help documentation or search our online knowledge base.

The fundamental algorithm that this embedded script implements is to raytrace a point source from the detector back through the optical system out to object space in order to find the image of the detector in each optical space. When the rays are stopped at each optical surface, the best focus position of the rays is computed to determine the image location and the image size is computed from the optical invariant and the NA of the beam in the current optical space.

Although not explicitly required, this script works best when combined with a user-defined sequential path that lays out the explicit surface intersections moving from the detector out to object space through the optical system. The default sequential paths are added by the makeCassegrain script and should be present in this example system.

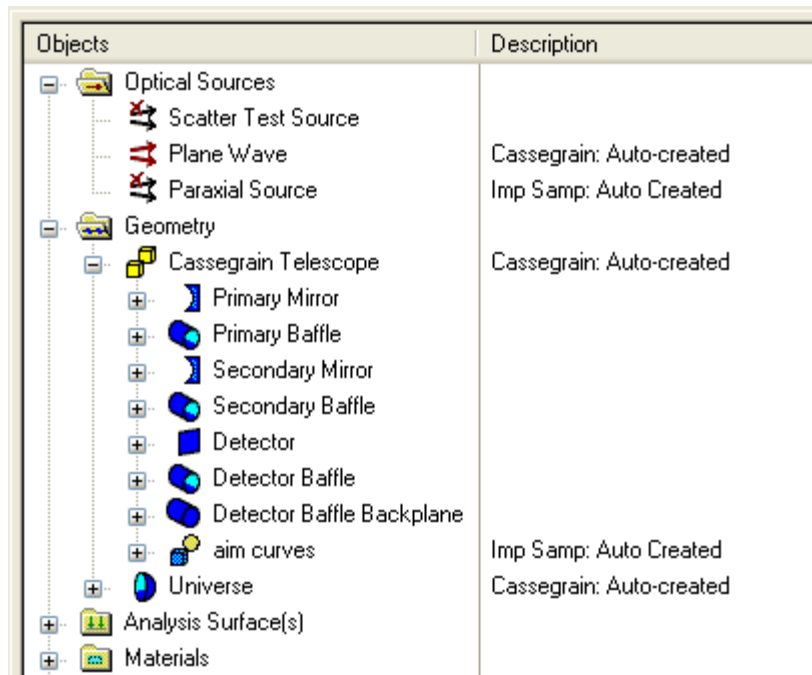
At the end of the script's execution, each optical surface along the sequential path will have an importance sample specification setup that targets the image of the detector in its optical space. There will be a custom element added to the Cassegrain Telescope subassembly called "aim curves" which contains the segmented curves that serve as the importance sample targets.

If you edit the embedded script, you will see a user-setup section on lines 69-86 with the following variables:

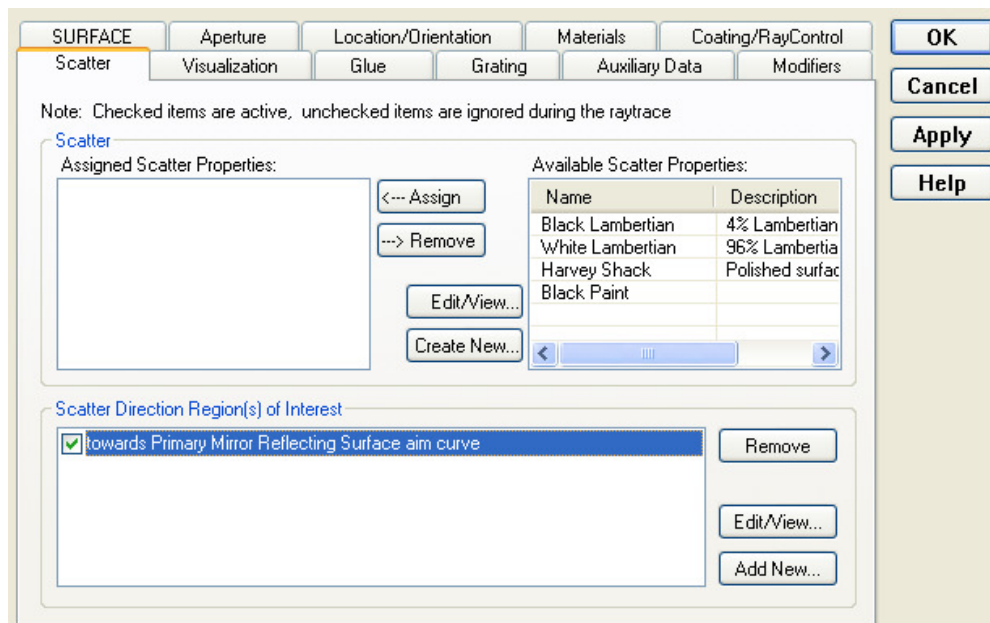
<u>Variable name</u>	<u>Variable purpose</u>
bModifyImpSampSpec	If True, we overwrite the existing importance sample specifications for each surface. If False, we append new importance sample specifications.
maxDist	If the image of the detector happens to be in a collimated optical space, the distance between the object and the detector image can be very large. This variable specifies a maximum distance beyond which a detector image is treated as an angular importance sample specification.

drawCurves	True if you want to draw the importance sample curves in the 3D view after creation. False if you don't want to visualize the curves.
nSub	Parent node underneath which the importance sample curves should be created.
nObj	Detector surface at which the importance sample source should start.
nHaltSrf	If rays hit this object, the calculation finishes.
isReversed	True if the source's propagation direction is pointing away from the optical system. False if the source's propagation direction is pointing towards the optical system.
wfno	The working F/# of the optical system. This is part of the calculation that determines the size of the importance samples.
wavelen	Wavelength of the source in microns.
rayCount	Number of rays that are traced from the source.
SetUserDefinedRayPathMode	This is a FRED script command, not a variable. However, the argument passed to the subroutine indicates whether you want to trace along a sequential path or use FRED's default intersection algorithm.
pathID	If the user has chosen to trace along a sequential path, the string name supplied to the PathFind command designates the sequential path that should be traced.

After the script has been run a custom element node called "aim curves" will be added to the parent object designated by the setup variable nSub, as shown in the image below. In this case, nSub was designated to be the subassembly "Cassegrain Telescope".



If you open up one of the optical surfaces (“Geometry.Primary Mirror.Reflecting Surface” shown below) and move to the Scatter tab, you will see that the corresponding importance sample has been assigned.



## **assignScatterProperties**

This script simply assigns scatter models and raytrace properties to various surfaces in the system. It is designed to be run on an unmodified version of a Cassegrain Telescope after the makeCassegrain script has been executed.