

**Analysis Of Survey Data Taken In June 1999**

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The secondary reflector was adjusted and surveyed in June 1999. Most of the targets on the secondary were adjusted except for the perimeter panels. The adjustments were based on two data sets. The first data set was a survey done in May, 1999 which measured one target per collection plate. Some of the collection plates around the perimeter were not measured during this survey. This data gave the global shape of the reflector. The second data set was the videogrammetry done to check to shape of the reflector immediately after its assembly on the ground. This data was processed to give the differentials between the target measured in the May survey and the other targets on a given collection plate. This combination provided adjustment tables for most of the secondary. After the adjustments were complete every target on the entire reflector (except five) was surveyed on four successive nights, a total of 1624 points. This report provides the analysis of this data.

The targets surveyed are shown in three views in Figures 1,2,3. The different colors indicate the targets surveyed on different nights. The survey proceeded from the center of the reflector to the perimeter. The yellow targets are the first nights work, the blue targets the second night, the green targets the third night and the purple targets are the fourth night. Figure 3 shows five red targets which were not surveyed. These targets are not measurable from any of the existing theodolite stands because of either obscuration, oblique angles, or very short range. For future surveys a new theodolite stand to measure these targets would be a useful addition.

The survey data is initially in the coordinate system provided by the theodolite software. This coordinate system is defined by surveying a set of targets on the secondary and back fitting to the nominal values of these targets. The nominal values were obtained from older surveys of the secondary. The secondary has been adjusted significantly since these nominal values were obtained. It is not surprising that the coordinate system they define is not the optimal system. Figure 4 shows a scatter plot of the normal errors in the secondary surface. The order of the points is the order in which they were measured. Two things are noticeable, the first being the large outliers. These will be seen to be mostly the panels around the perimeter which were not adjusted. The second significant feature is the relatively large mean in the data set. Figure 5 is a histogram of the same data set. The large outliers are obvious and so is the offset of the center of the distribution. Figure 6 is a parametric representation of the target locations in ray direction parameters. Figure 7 shows the normal errors plotted in the parametric representation. The vertical scale clips the largest of the errors. The viewpoint in Figure 7 is on the symmetry

plane of the reflector. There is a clear trend in the data when moving across the reflector perpendicular to the symmetry plane. The next step is to refit the data to reduce the errors.

The new best fit was performed using the points inside the 75% integral power circle, equally weighted. This set has 688 points out of the total of 1624 points. Other weighting schemes are possible but this one works very well so more elaborate techniques were not utilized. The fitting technique optimized only normal errors, tangential errors were ignored.

Figure 8 shows the scatter plot of the new error set on the same scale as Figure 4. The mean has been almost eliminated and the scatter has been significantly reduced. There are still large outliers present. Figure 9 shows the histogram of the data on the same scale as Figure 5. The improvement is obvious, the plot is narrower and centered on zero.

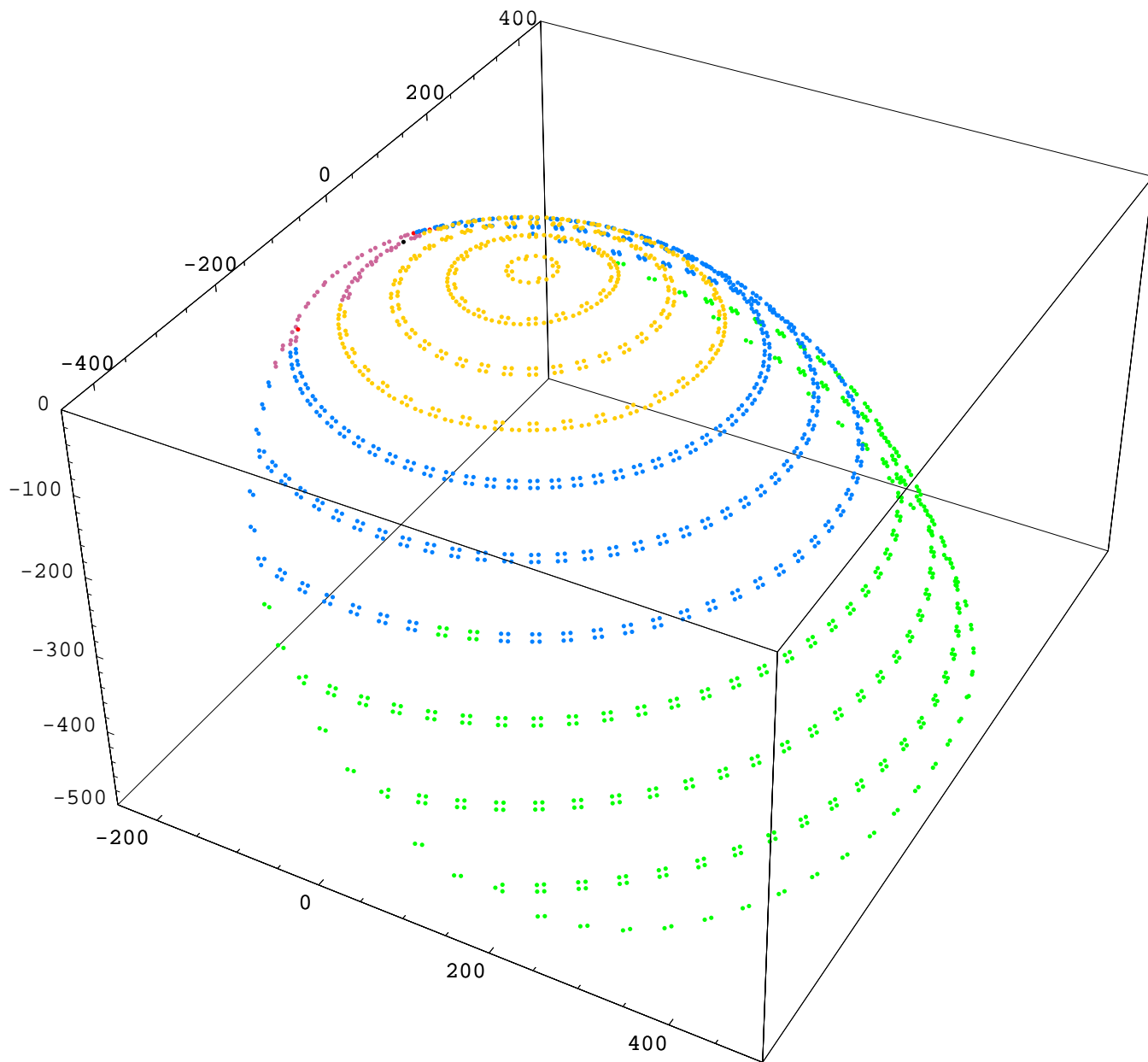
Having found the optimal coordinate system to represent the measured data, the key question is what is the effective RMS of the secondary. To calculate the RMS, the reflector was divided into bands of integral power and the measured targets divided into corresponding groups. The RMS of each group was calculated using equal weighting and then the groups were combined using the power weighting of the groups. Figure 10 shows the subdivision of the targets on the parametric disk. The gray circles are disks at .2, .4, .6, .8, .9, .975, and 1.0 integral power. The targets are colored coded for each group. Figure 11 shows the same target groups on the reflector shape itself. Table 1 gives the statistics for each group and the combined RMS which is .0458 inches or 1.2 mm RMS. This number is heavily influenced by the few very large errors around the perimeter, even though these points are very lightly weighted. If the perimeter was adjusted to the same accuracy as the rest of the reflector, the RMS would be about .032 inches or .8 mm. There are a few outliers in each power band which could be adjusted to reduce the RMS. An RMS of .6 to .7 mm. RMS is not an unreasonable goal.

The next step is to adjust the worst errors and resurvey the secondary (at least partially). Figure 12 shows the worst errors on the secondary plotted on the parametric disk. The 170 worst errors are greater than 2 mm. and are shown in red. Almost all of these are the targets around the perimeter which were never adjusted. The 95 blue targets are between 1.5 and 2.0 mm. These are more uniformly scattered with some emphasis around the rim. The next category of 1.0 to 1.5 mm. is not shown on this plot. There are 242 points in this group and they are distributed fairly evenly over the reflector surface. Certainly the red and blue targets shown need adjusting and perhaps some of the targets

under 1.5 mm. should be adjusted as well. With these adjustments performed and verified, the secondary RMS will be well below the original target of 1 mm. RMS.

There are reassuring conclusions to be drawn from this and the previous survey. Adjustments to the reflector produce the intended results without complicating interactions. Corner fairing on a single collection plate is very stable. The data used for the corner fairing in this adjustment was obtained more than two years ago on the ground. In the interim the dome was hoisted, hurricane George occurred and the dome was realigned on the elevation rails. Despite all this the data produced very good fairing even though the global shape of the reflector had shifted significantly.

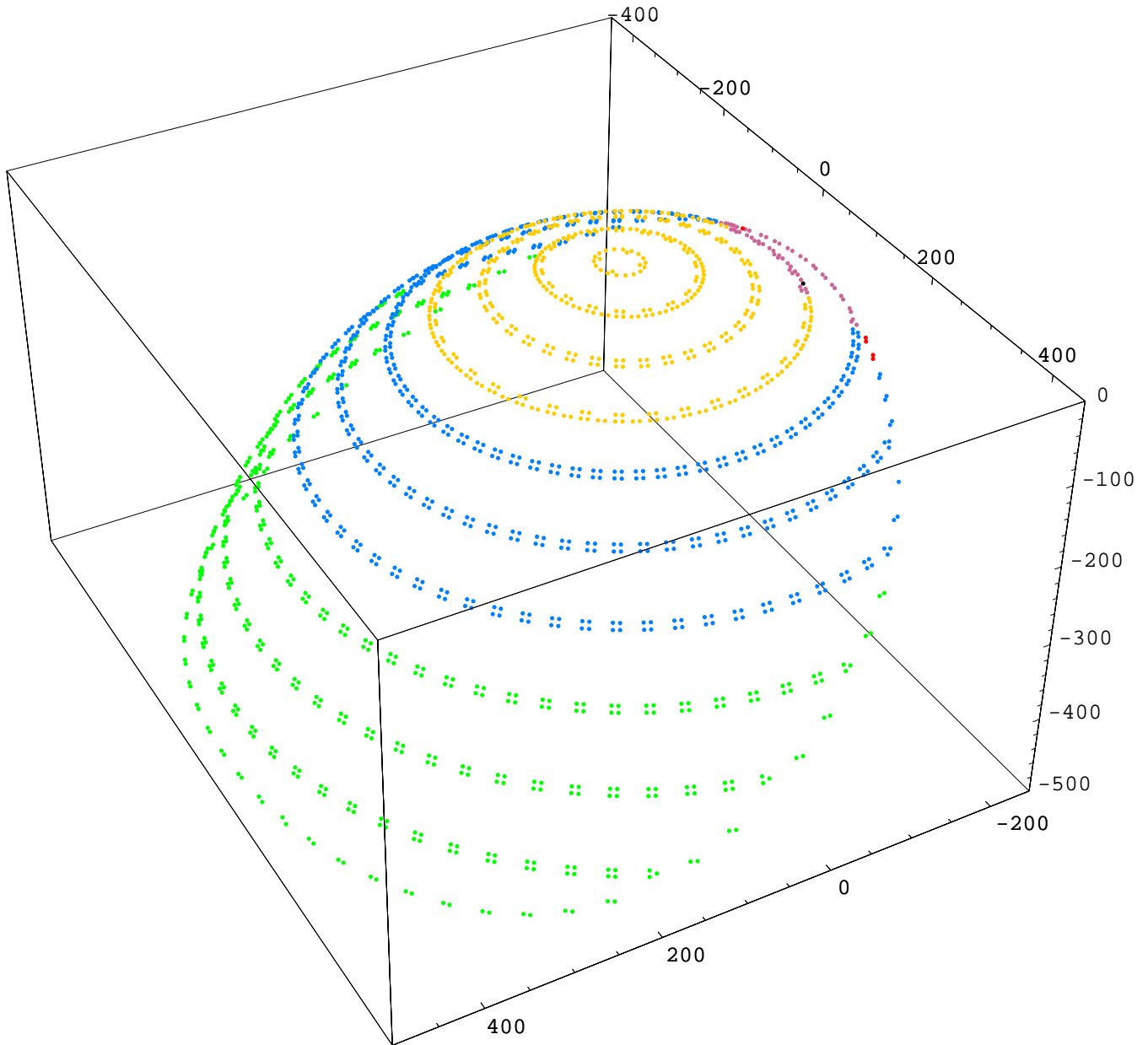
# Secondary Targets Surveyed In June 1999



Different Colors Indicate Targets  
Surveyed On Different Nights

**Figure 1**

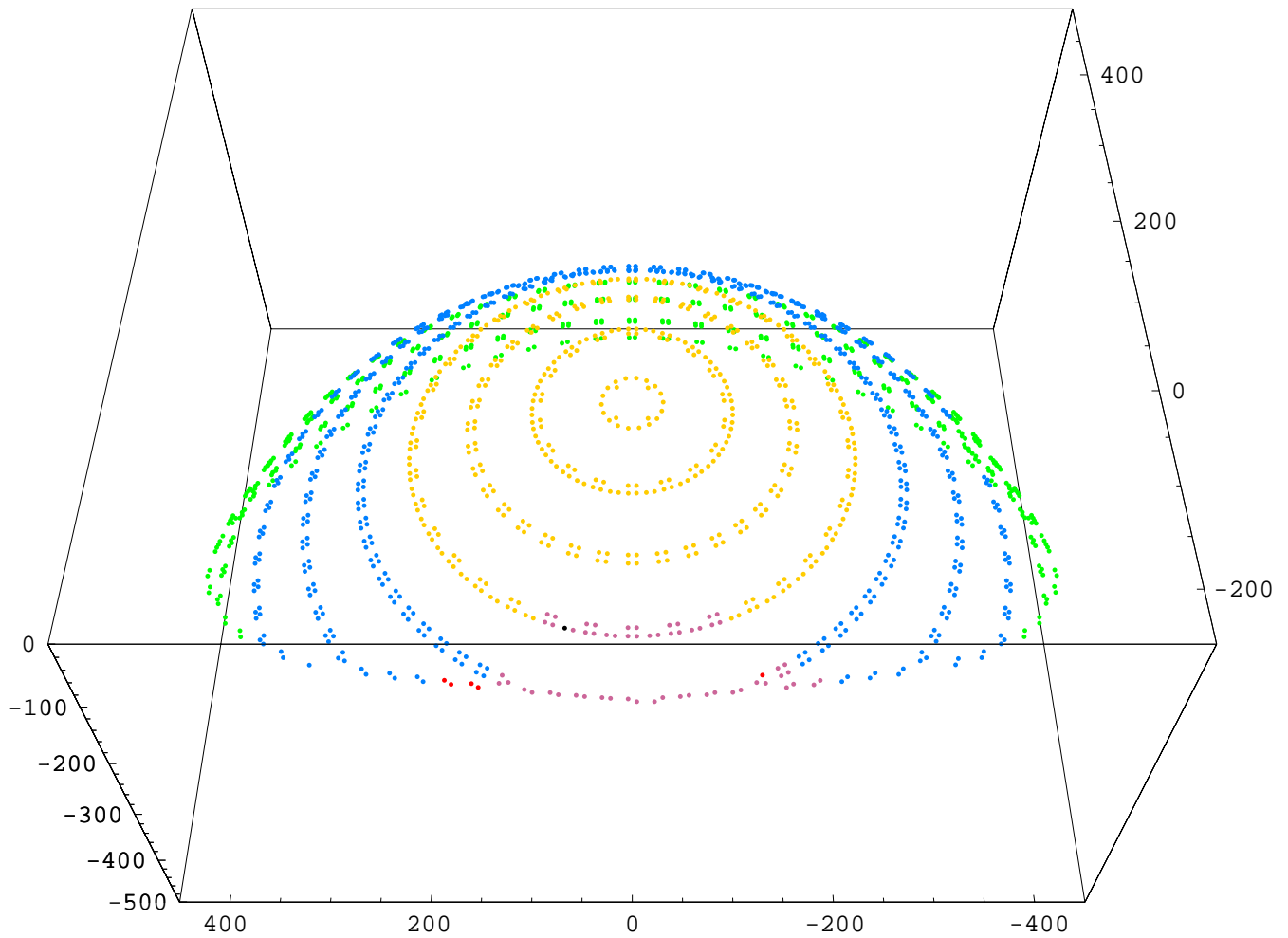
# Secondary Targets Surveyed In June 1999



Different Colors Indicate Targets  
Surveyed On Different Nights

**Figure 2**

# Secondary Targets Surveyed In June 1999



Different Colors Indicate Targets  
Surveyed On Different Nights

**Figure 3**

Scatter Plot Of Normal Errors  
Initial Coordinate System

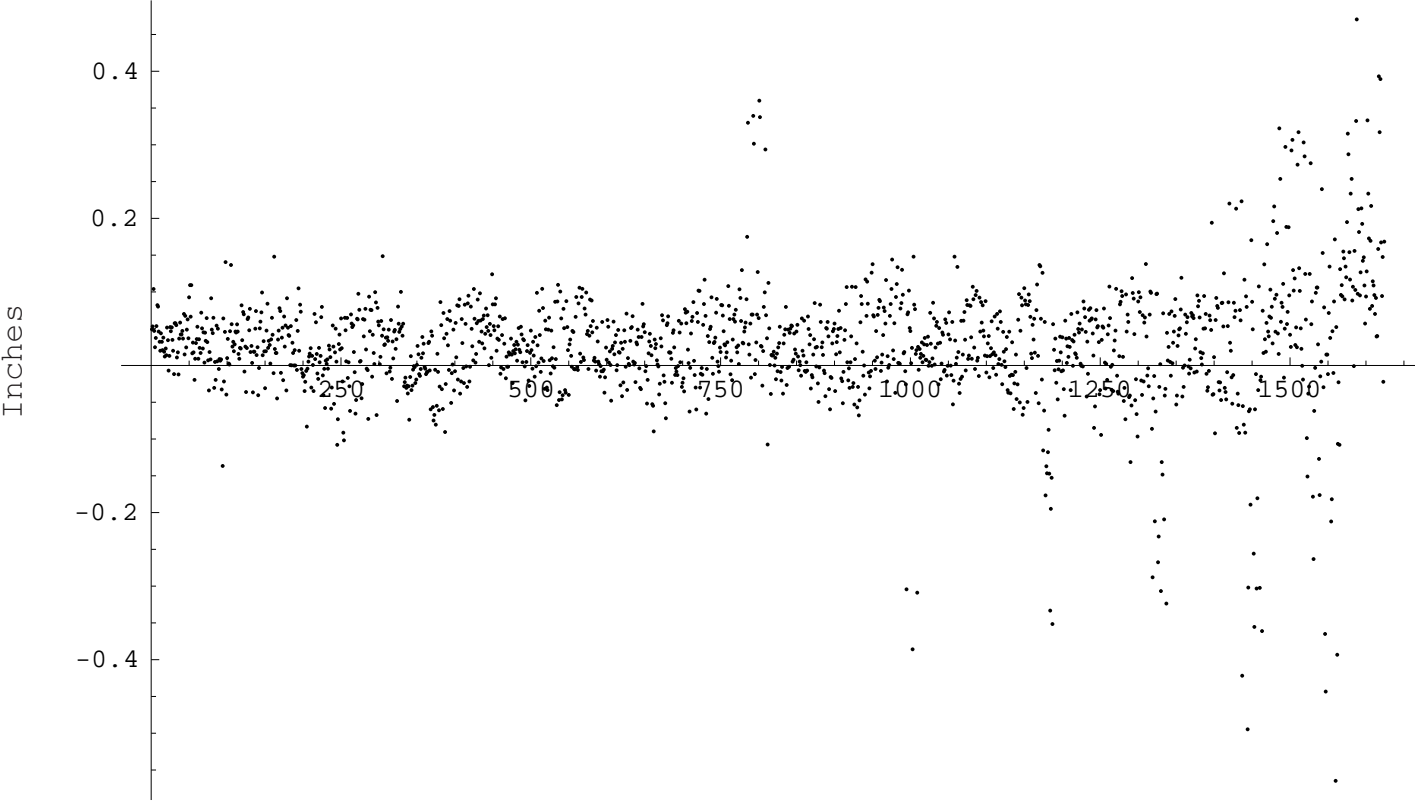


Figure 4

# Histogram Of Normal Errors Initial Coordinate System

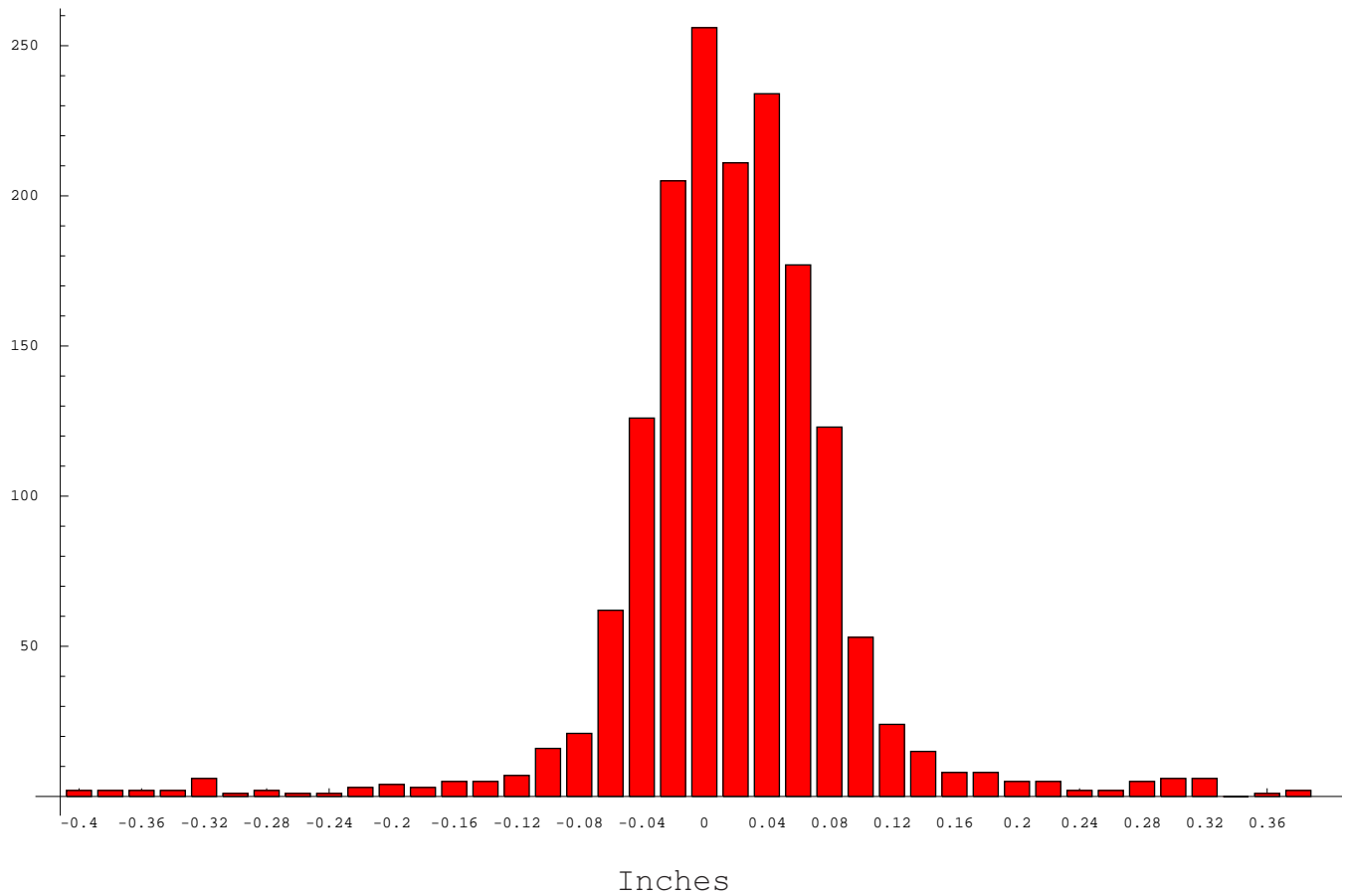


Figure 5

# Target Locations On The Ray Parametric Disk

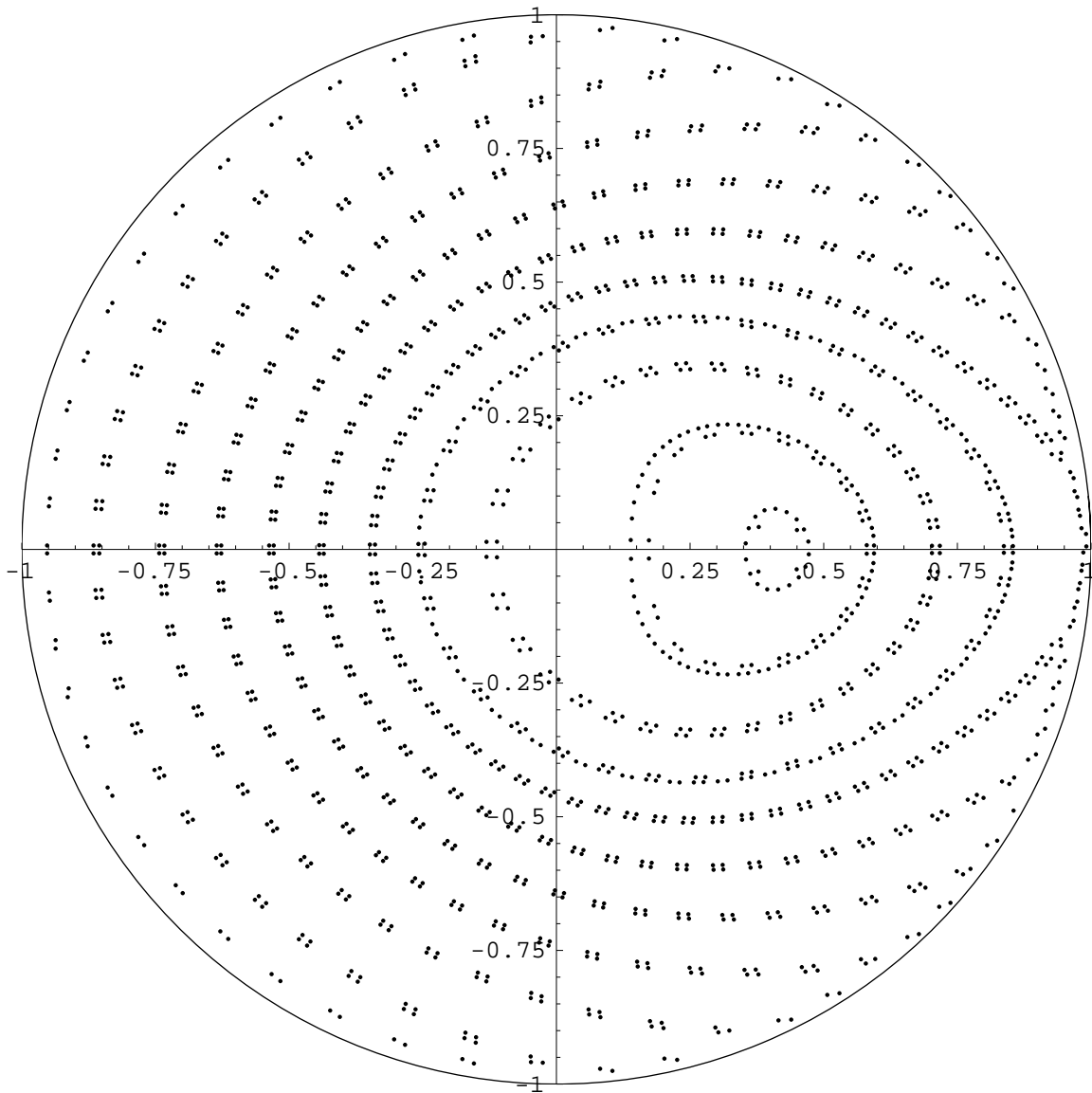
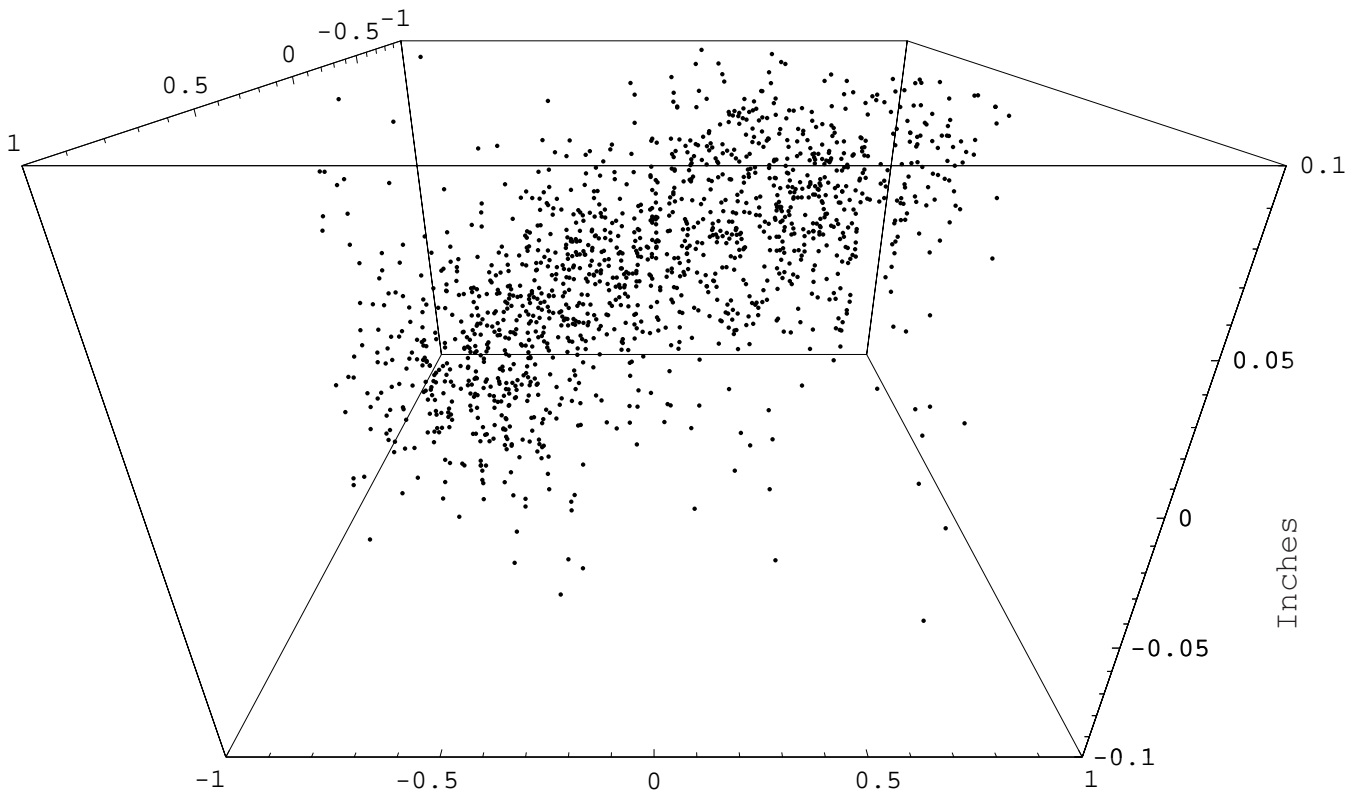


Figure 6

# Normal Errors Plotted Over The Parametric Disk Initial Coordinate System



Viewpoint On Symmetry Plane Of Reflector

**Figure 7**

Scatter Plot Of Normal Errors  
Transformed Coordinate System

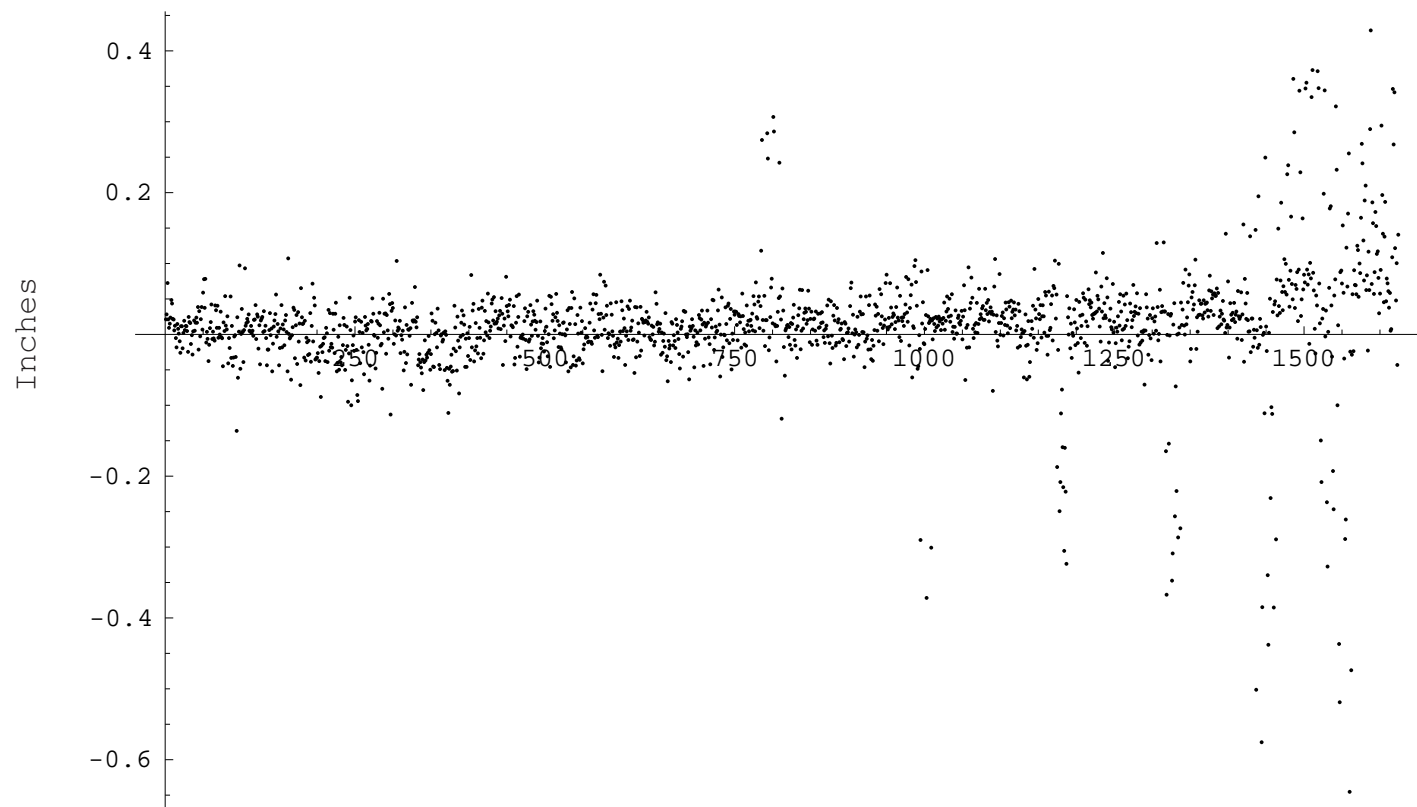


Figure 8

# Histogram Of Normal Errors Transformed Coordinate System

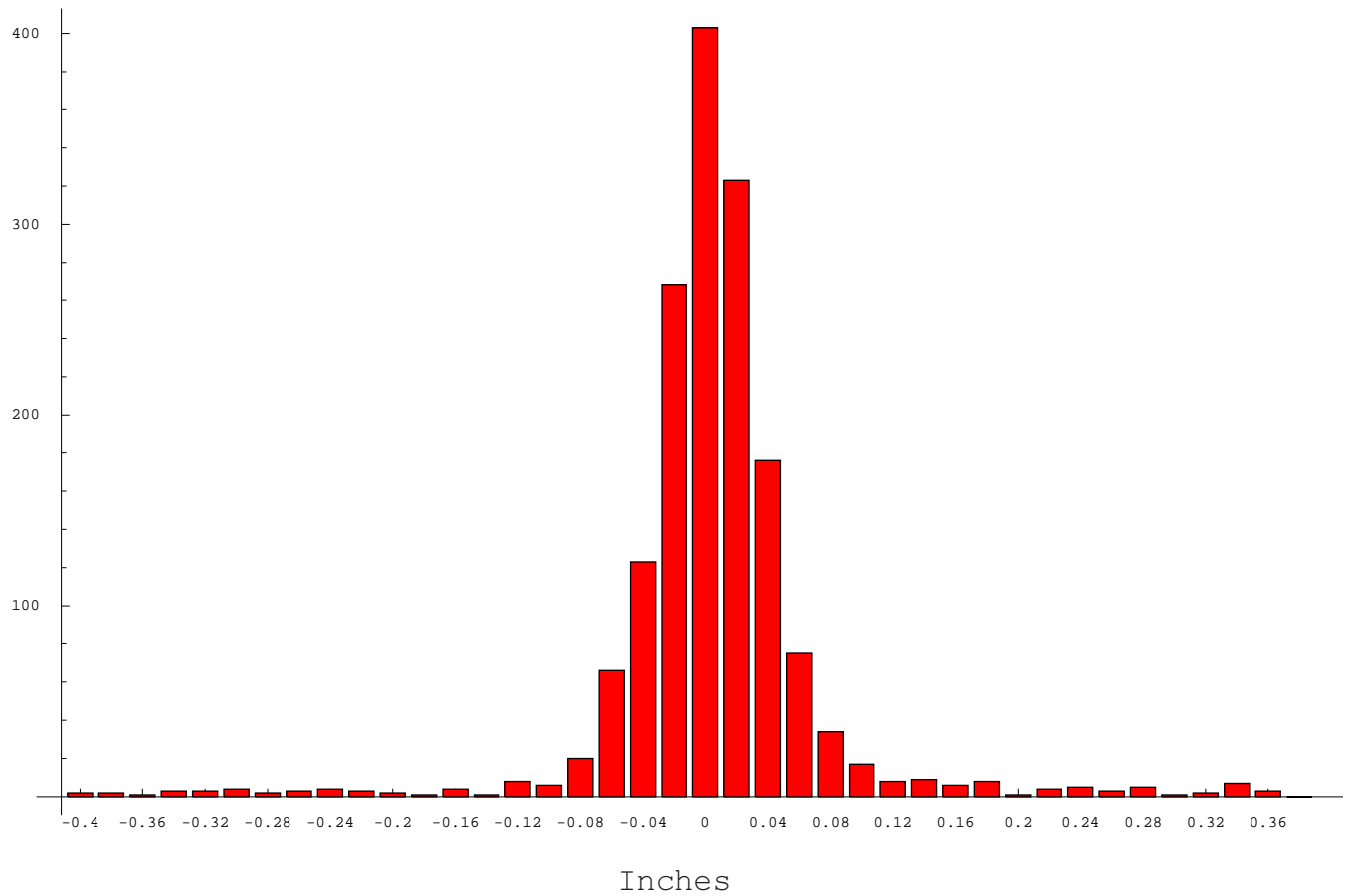


Figure 9

# Targets Grouped By Bands Of Integral Power On The Parametric Disk

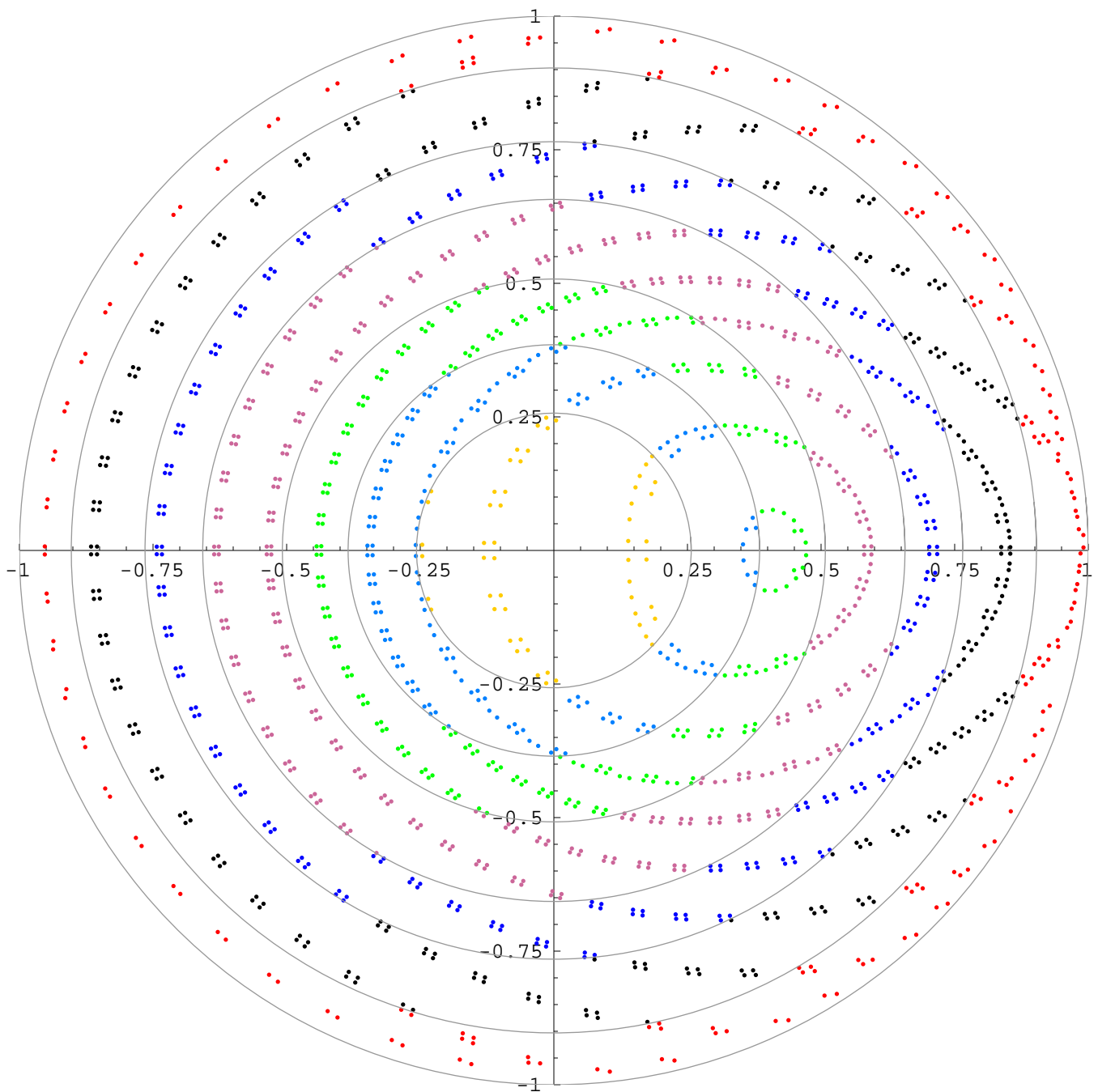
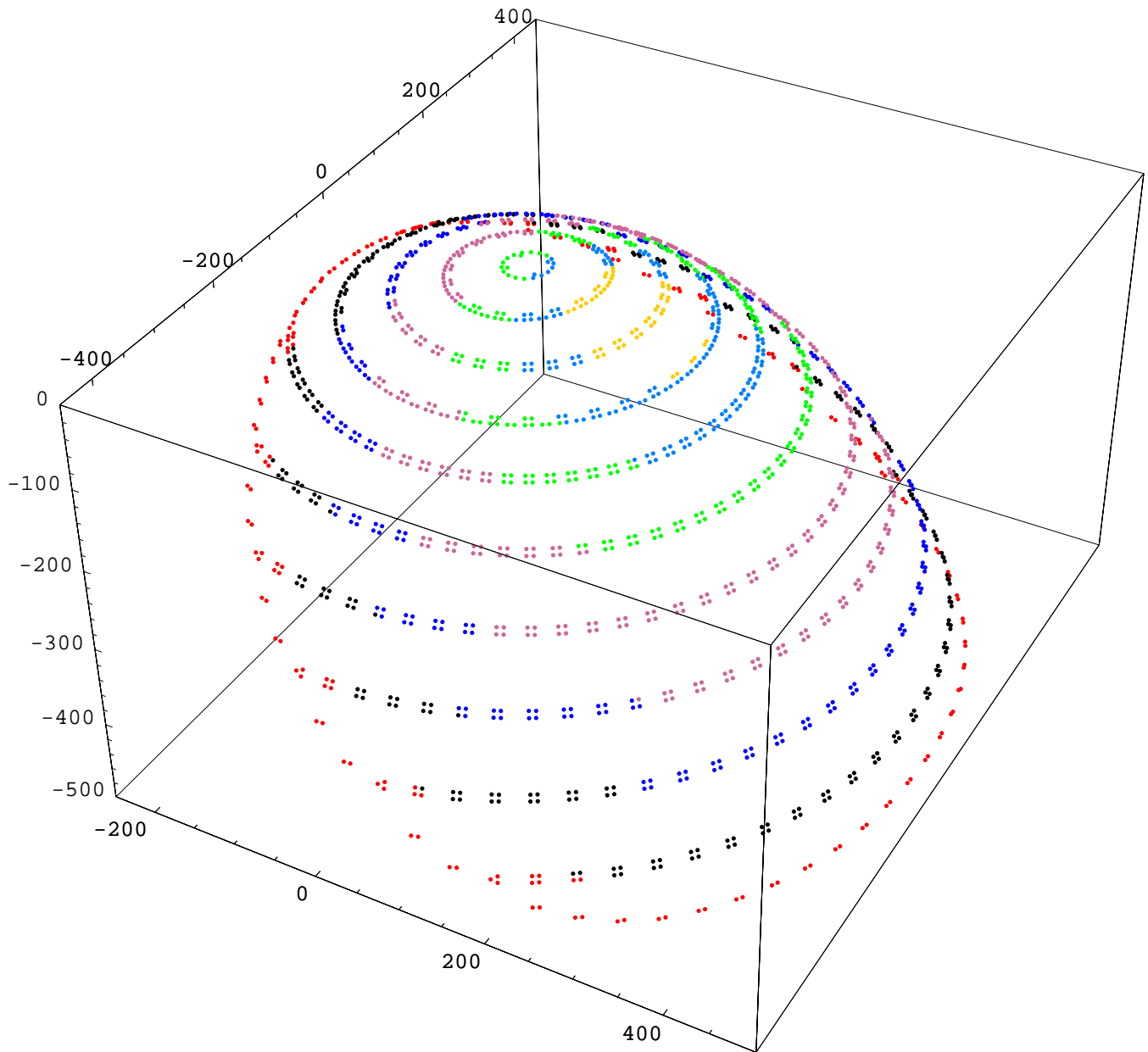


Figure 10

# Targets Grouped By Bands Of Integral Power On The Reflector Surface



Target Color Colding Same As Figure 10

**Figure 11**

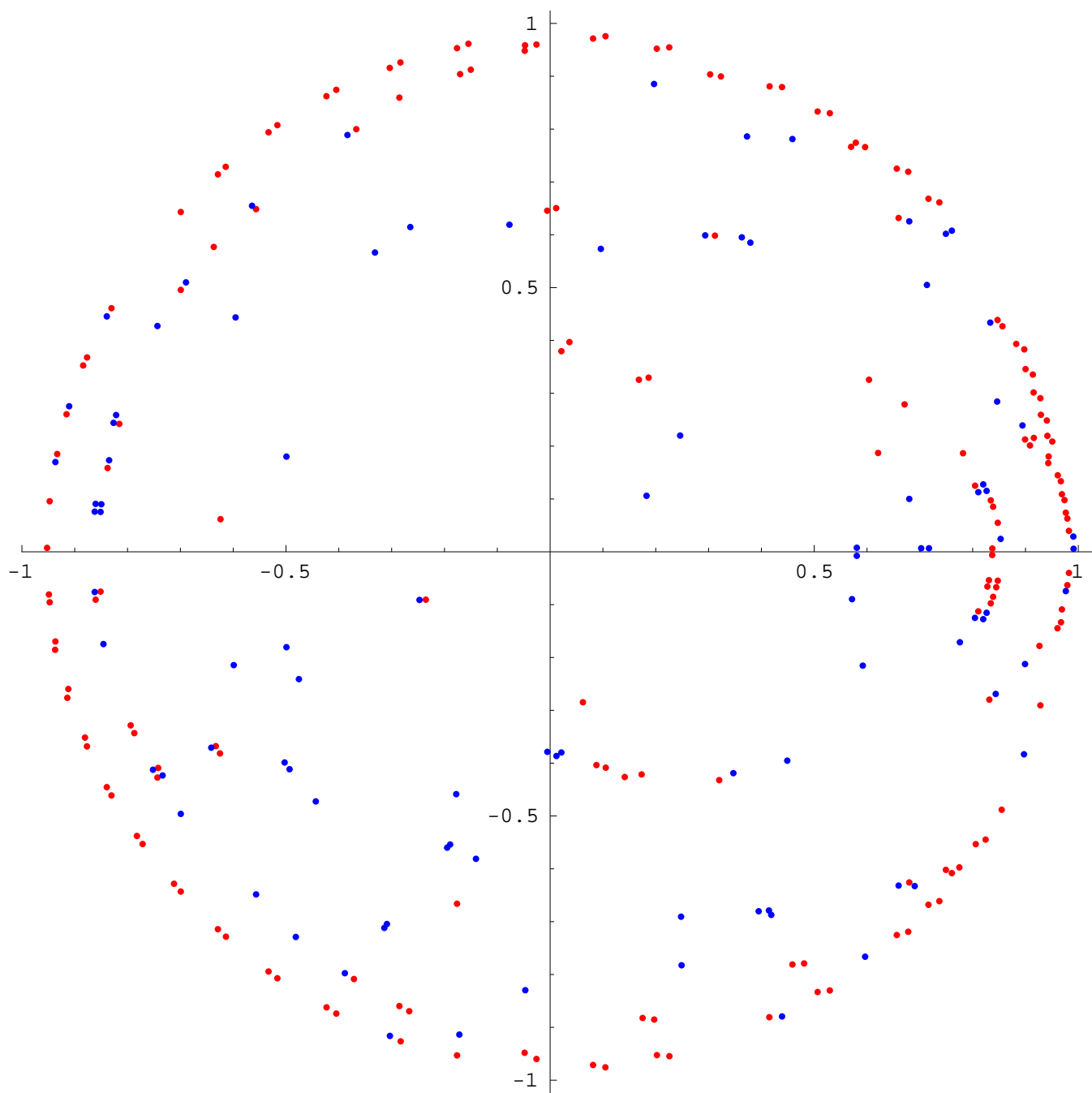
# Table 1

## Error Statistics For Bands Of Integral Power

Integral Power Band	Number of Points	Mean (inches)	RMS (inches)	Std. Dev. (inches)
.0 .2	54	-0.002	0.030	0.031
.2 .4	164	-0.004	0.033	0.033
.4 .6	232	0.000	0.028	0.028
.6 .8	394	0.012	0.032	0.030
.8 .9	276	0.015	0.033	0.030
.9 .975	300	0.034	0.050	0.038
.975 1.0	204	0.017	0.203	0.202

Weighted RSS combining the above RMS values = .0458"

# Largest Remaining Errors On Secondary



RED: Error > 2 mm. (170 points)  
BLUE: 1.5 mm. < Error < 2 mm. (95 points)

**Figure 12**