Note on Apertures

Although this is not very relevant to the topic of coma-correction, I did need to find the sizes of the mirrors in order to make sure I was using sensible values for the normalization radius of the Zernike polynomials, since those are expressed in terms of radius of a point on the surface divided by the nominal radius of the aperture. This note is just to record the results and to show where on the surfaces the bundles of rays fall.

To give a little margin, even with the wider field of 30 by 15 degrees that I now plan to try, the sizes were set using points at +/- 16 degrees in X and +/-8 deg in Y. Additional points on the diagonals were added. The input beams, in terms of angle on the sky, therefore looked like this. Note the colouring of rays by point in the sky, which is the same as that used in subsequent plots.



As before I have run the model with an artificial stop which is applied to the input beam before it reaches M1, even though it is physically located behind M1. See layout plot on next page.

The reason for this is to avoid the complication of having the stop in the model located between the two active mirrors, which causes the input pupil to be non-circular. I don’t think this is a significant approximation at this point. The stop is 1552mm behind M1 (along the principal ray) and is tilted at an angle of 15 deg. These values were chosen so that is approximately at the image of the “real” stop formed by M1.

I went through the system setting elliptical apertures that were just large enough to pass all the rays (rounding up for convenience). For each of the mirrors I had two surfaces, one being the classical conic and the other a tilted surface roughly fitted to match the conic. The point of the latter is to show the physical dimensions and what the patterns look like when viewed face-on to the mirror.

I have done this with the classical paraboloid-ellipsoid design using the parameters for V3D. The changes required due to the coma-correction should be small compared to the margins which will anyway be required for diffraction, etc.

Here is the side view of the system. The artificial stop is on the upper right.



The fit of the rays into the apertures can best be seen in what Zemax calls the “footprint diagram”. Here is the plot for M1. The rings correspond to the outer edges of the rays for each field point.



This is the view along the axis of the paraboloid, i.e. looking into the aperture. The dimensions are 2500 by 2000mm (as given in the plot) and centre of the ellipse is offset by 6450mm in Y from the axis of the paraboloid. (Note that it is not centred on the principal ray, which is at Y = 6241.68mm.)



This is the plot for the same mirror, but now viewed normal to its tilted surface. Naturally the width in X stays the same, whereas in Y it has to be ~ root(2) bigger. The surface is tilted by 45 deg and the centre of the ellipse is offset from the chief ray by 300mm in the plane of the surface.



This is the plot for the artificial stop. By definition the rings all lie on top of each other on this surface. The aperture is slightly elliptical to allow for the 15 degree tilt of the stop: it corresponds to a circular aperture normal to the central beam with the desired diameter of 1.4m.



This is the plot at the physical stop. The fact that the rings do not lie perfectly on top of each other is due to the distortion introduced by M1. This aperture is circular but tilted by 12 degrees. There is an offset of 20mm in Y. Clearly putting a circular physical aperture of ~580mm radius here will give a very nearly circular effective aperture at the input with a diameter of close to 1.4m.



This is the plot for M2 looking along the axis of the ellipsoid. The aperture is offset by -760mm in Y from the axis of the ellipsoid.



This is the plot for M2 face on. This aperture is tilted by 25 deg w.r.t the direction of the chief ray going to the focal plane and the ellipse is centred on the chief ray.

Finally here is a plot for the focal plane just to give a rough idea of the physical size implied by this very large field of view – remember that we started with 32 by 16 degrees.



Richard Hills 10th Nov 2017