Use of SM12 mirrors as spectrometer stop

KD, 19/7/01

Introduction
The spectrometer optical system was designed before selection of the detector technology. In preparation for the possible choice of non-feed-horn array detectors, it was found necessary to have a cold stop located near the focal plane. Following the choice of feed-horn detectors, this design choice was less advantageous since the feed-horns limit themselves the extent of the beam.

Ideally the horns should be located on a spherical surface such as to point towards the exit pupil of the instrument, located 112.57 mm in front of the focal plane. This has not been found practical from a fabrication point of view; the feed-horn array is therefore telecentric, all horns pointing in a direction parallel to the axis. The off-axis beams will therefore be heavily clipped during their passage through the instrument.

Although it was earlier felt not to be necessary to implement the cold stop, it is now thought safer to implement the clipping as early as possible. The advanced state of the mechanical design does not easily allow implementation of a stop in the actual exit pupil position (image of the telescope secondary when the FTS mechanism is in its zero position). It is therefore proposed to reduce the size of the SM12 fold mirrors, located between the focal plane and the pupil, 80 mm in from the focal plane, such as to perform most if not all of the clipping at that mirror.

In ray tracing figures, the spectrometer is traced backwards from the detectors. The pupil is placed at infinity and oversized by a factor of two (F/2.5). Vignetting is enabled so that only unclipped rays are shown. Ray-fans containing 20 rays equally distributed across a pupil diameter are traced (plotted black) plus the "gut" ray, (plotted red). The effective focal ratio is approximately equal to the number of rays transmitted multiplied by 0.5. The goal of the exercise was to study clipping at mirrors other than the SM12 mirrors. To avoid confusion by the inevitable clipping at the spectrometer cold stop (located between SM6 and SM7), this stop was therefore not implemented.

Sizing M12 for F/5 central beam
The calculations have been made using a SM12 size calculated to produce a F/5 beam for the central detector, giving an ellipse of 16 x 23 mm. This effectively places the spectrometer pupil in this position. From a geometrical point of view, the axial beam is not affected by this and will pass unclipped through the whole system (fig. 2). This is true for any position of the scan mechanism (figs 3, 4).

At other field positions, the beam will be reduced to F/5 but using a non-optimal part of the Gaussian beam, whose maximum lies on the red gut ray. However, the beam suffers minimal, if any, clipping at other components than SM12 (figs 5 - 8). This appears to hold for all scan positions (figs 9 - 12).

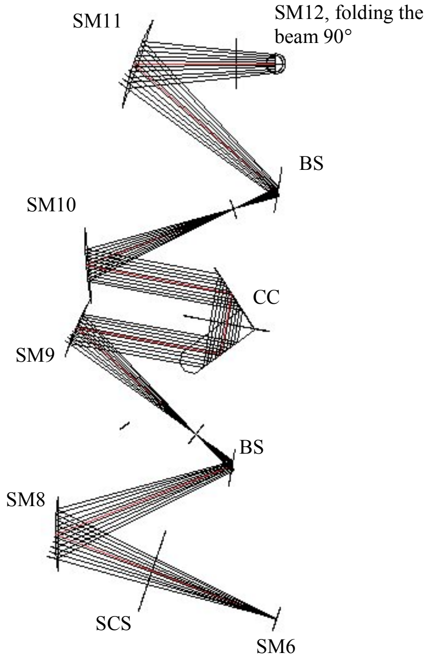

Fig 1.
Raytraces are made on a model containing only spectrometer optics. The beam is limited by the SM12 mirror, implemented at an angle of 45° to the plane of the system as in SPIRE. Beams are traced outwards from the detector. The cold stop is not implemented (but its position is indicated). The fold mirror SM7 is not implemented.

The red beam represents the line of sight (gut ray) for each detector.

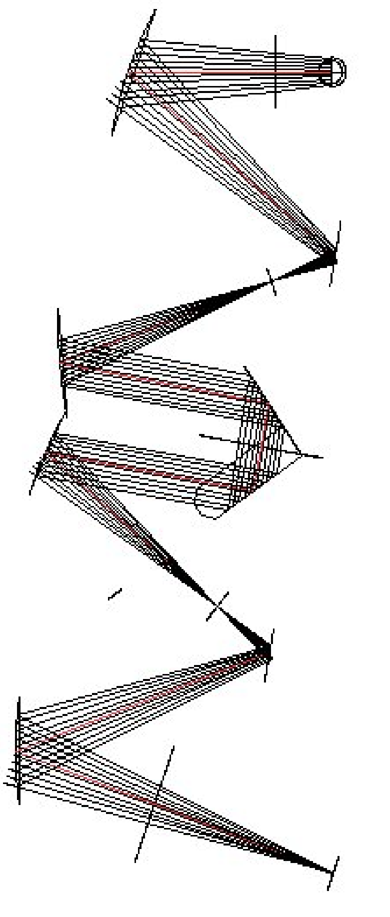

Fig. 2. Central detector, ZPD

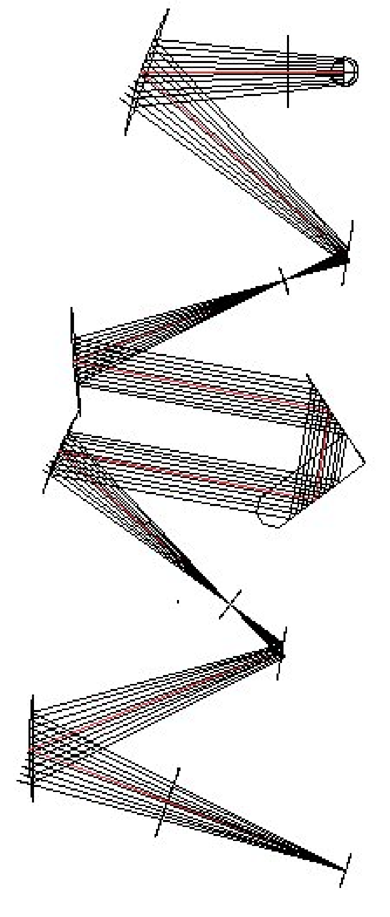

Fig. 3. Central detector, long stroke

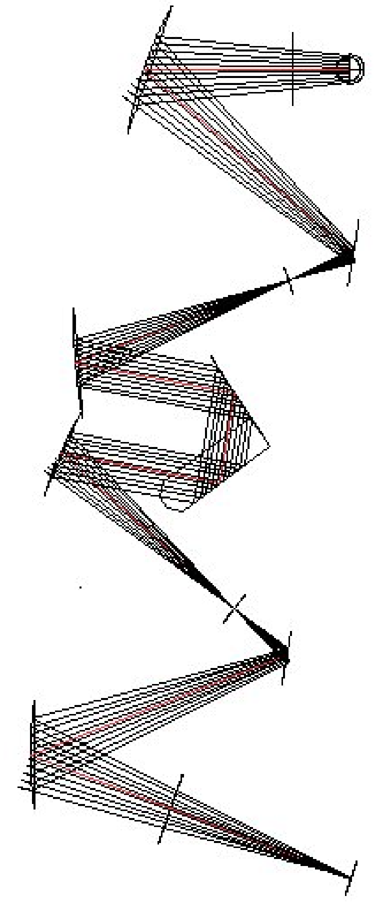

Fig. 4. Central detector, short stroke

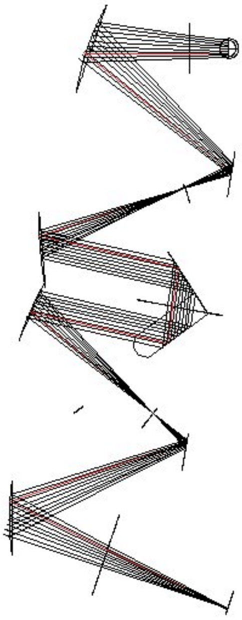
Fig. 5. Lower edge detector, ZPD

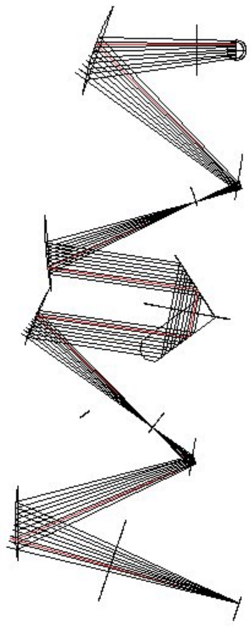
Fig. 6. Upper edge detector, ZPD

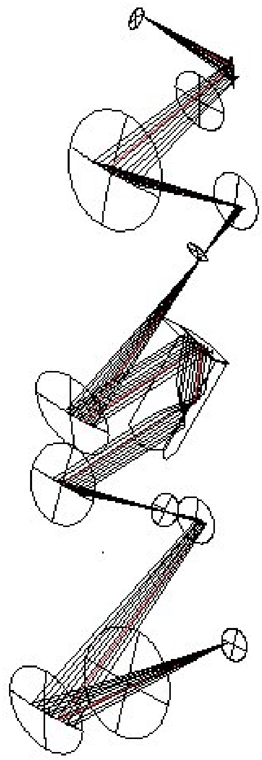
Fig. 7. Inner edge detector, ZPD

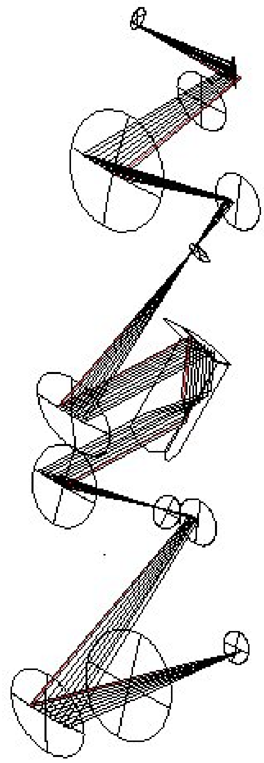
Fig. 8. Outer edge detector, ZPD

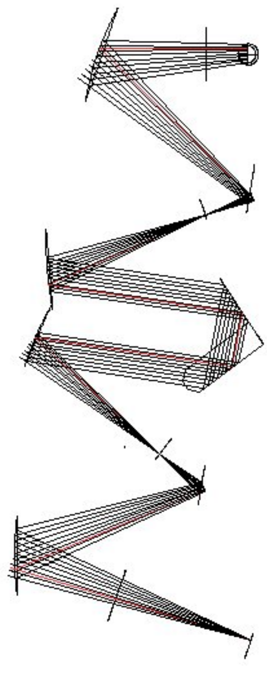
Fig. 9. Upper edge detector, long stroke

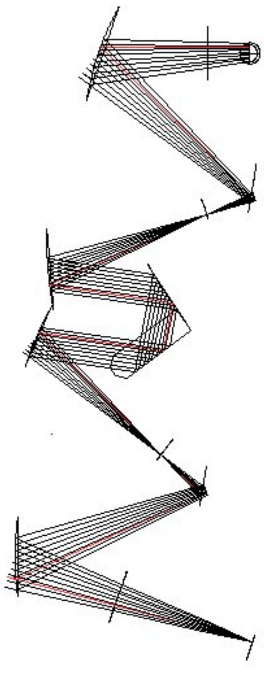
Fig. 10. Upper edge detector, short stroke

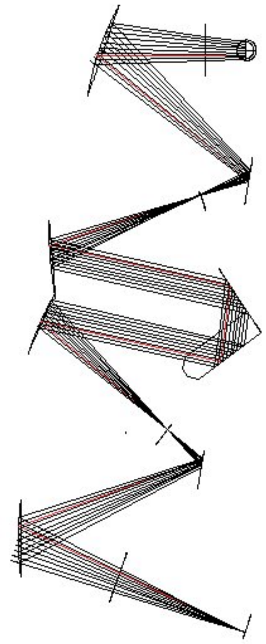
Fig. 11. Lower edge detector, long stroke

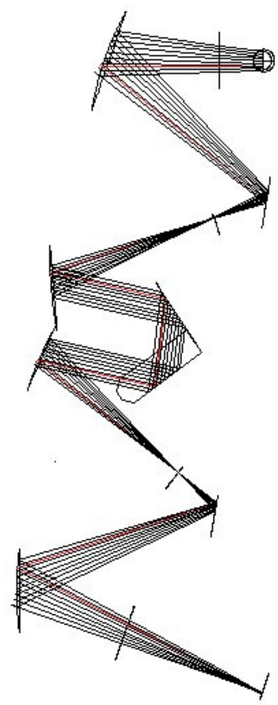
Fig. 12. Lower edge detector, short stroke

Sizing M12 for F/5 edge beams

An alternative sizing policy would be to make SM12 sufficiently large to pass all the F/5 beams traced through the instrument in the forward direction. This would require a size of 18 x 25 mm, ie about 10% larger. The case has not been raytraced, but from the figures it is seems that some spillover may occur within the corner cube, at SM9, and at SM8. It was originally thought that this spillover would concern only the beam wing furthest from the gut ray of each beam, where the Gaussian beam intensity is low. At SM8 this is not the case, however, the clipping will affect a part of the beam close to the gut ray, see in particular Figs. 6, 7, 10.

Conclusion.
A geometrical raytrace study indicates that using SM12 as stop for the spectrometer, sized for F/5 at the central detector, gives minimal clipping at other mirrors in the system. It can be seen that increasing the size of SM12 sufficiently to fill the instrument pupil at all field points will introduce clipping in some situations, and that this clipping will occur in the strongest part of the beam.