SUBJECT: **SPIRE instrument beam sections in the cryostat space**

PREPARED BY: **A G Richards**

KEYWORDS: **beams, cross-sections**

COMMENTS: **This document presents data on the expected size of the SPIRE instrument beams at various distances forwards of the instrument within the space presently occupied by the cryostat.**

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1. INTRODUCTION

In order to help the cryostat contractors tailor the cryostat apertures to fit around the beams defining the active views out of the FIRST focal plane instruments, this note presents some of the relevant data obtained for the SPIRE photometer and spectrometer. We present 2-D plots showing beam cross-sections at three places between SPIRE and the front of the space allotted to the cryostat. This graphical data can be supplemented on request with the original data that allows reconstruction of the beam boundaries at any plane in the beam path. IGES files can also be produced showing representations of the beam boundaries in 3 dimensions in any convenient co-ordinate reference frame.

2. OPTICAL GEOMETRY AND RAYTRACING

The CODEV representations of the SPIRE instruments, which are presently in use at RAL, are versions identified as PH126B (photometer) and SP460C (spectrometer). These permit reverse ray tracing from the respective detectors (rectangular 4' x 8'for the photometer, circular 1.3' radius for the spectrometer) outwards to the telescope space. The present telescope model places the pole of the primary mirror surface 975 mm forwards of the telescope's axial back focus and the pole of the secondary 1720.3 mm further forwards of the primary. Therefore the model does NOT yet include the proposed 'thick' primary telescope model.

In order to be able to define each detector's active view, several points uniformly spaced around the edge of each detector (24 photometer, 8 spectrometer), together with one point in the centre of eachd detector, were taken as sources of 37 rays. One ray from each source point, the chief ray, was traced through the centre of the chosen entrance pupil-defining aperture (pupil stop), the other 36 from each source point being traced through points uniformly distributed around the boundary of the pupil stop. The (x,y,z) intersections of each ray with all relevant surfaces was output in a global co-ordinate system to an ASCII text file. The global co-ordinate system chosen was that centred on the location of the axial back focus of the telescope, 975 mm behind the pole of the primary mirror surface on the axis of symmetry of the telescope with +Z towards the focal plane instruments. The Z co-ordinate of the primary in this system is therefore Z= -975mm. The +Y direction is in the fold plane of the SPIRE photometer pointing towards the SPIRE entrance aperture.

The photometer has a two-axis steering mirror, M4, which is intended to displace the detector field of view by +- 2 arcminutes on the sky in a direction orthogonal to the fold plane (X direction) and by about +- 0.5 arc minutes on the sky parallel to the fold plane (Y direction). The rays were therefore traced through the photometer for several combinations of two-axis tilts that covered the extremes of each range, producing one data set for each combination of the two tilt angles. The photometer therefore has a range of active views that have eventually to be combined into a composite instrument view through the cryostat and telescope.

3. OUTPUT DATA AND PROCESSING

The data files containing ray intercept co-ordinates were used as input to MATHCAD analysis documents. Two parallel planes were selected in a relevant space between two of the surfaces at which intercepts were evaluated and listed and the boundaries of the beams from all object points were displayed so that a single boundary curve could be estimated and parameterised. Figure 3-1 is an example. This shows the boundaries of the 'views' from all 25 object points on the photometer detector for one combination of M4 tilts, together with an outer dashed line boundary, flagged with diamond symbols. This composite boundary has been sizeded to clear the overlapping boundaries by a positive margin of about 1 mm all round. It has been found possible to parameterise the beam between any two suitably chosen analysis planes by determining just two sets of composite boundary points, one in each of the planes, and just interpolating between ordered pairs of points (one from each plane) to any intervening plane. Thus boundary for the photometer beam at any plane located between axial locations approximately 100 and 1175 mm from the focal surface can be accurately determined using two suitably chosen sets of 41 points in each of these planes. This Z-range covers the space occupied by the cryostat and centre of the primary mirror.

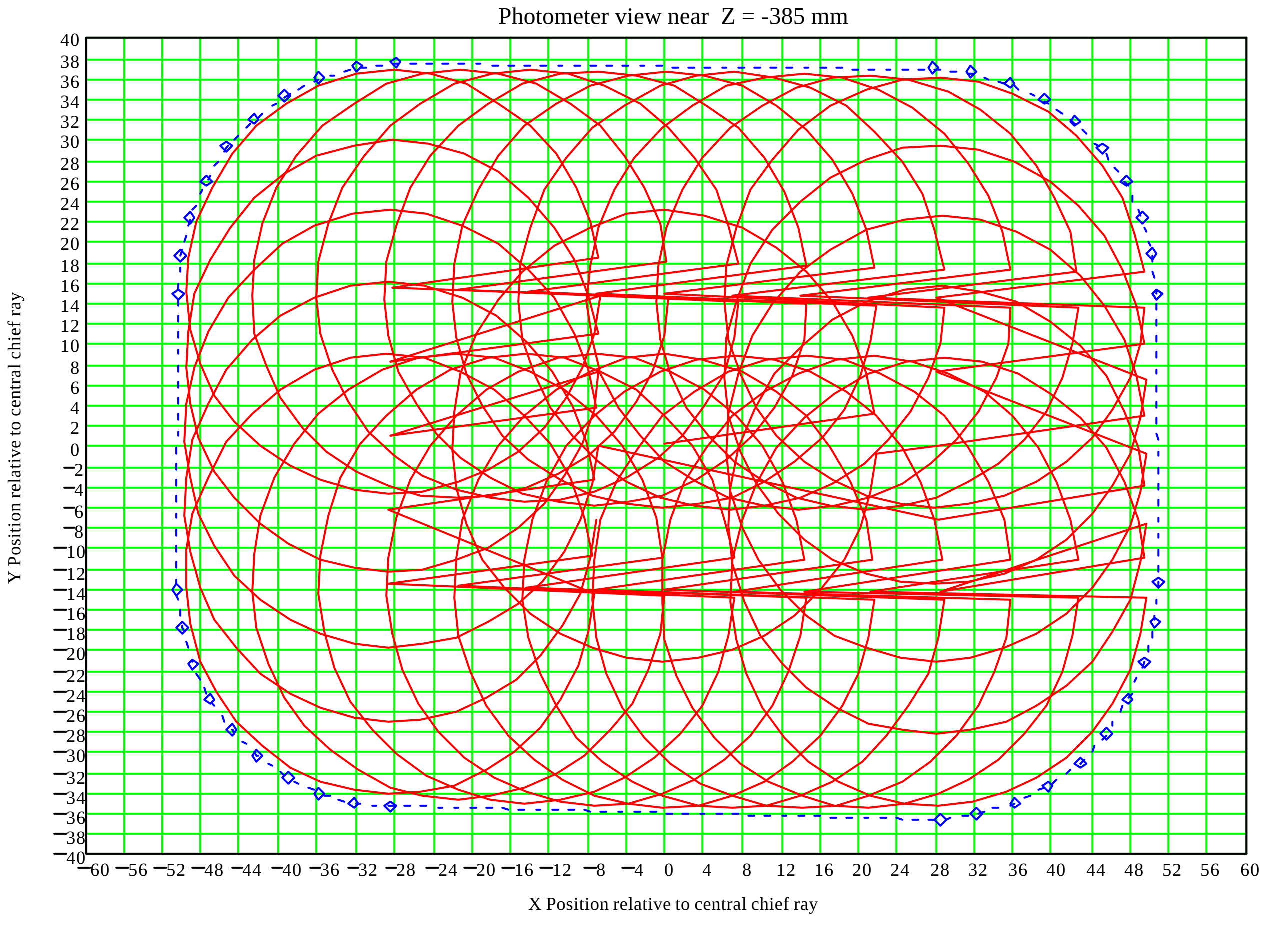

Figure 3-1 Photometer view approximately 385 mm forwards of telescope focal surface

As well as the two sets of 41 points used to define beam boundaries in two parallel planes, the MATHCAD analysis uses them to generate beam boundaries at intervening planes by interpolation. This data is converted to a convenient co-ordinate reference frame and then output in a suitable format to 3-D vector plot files. These plot files enable the beam to be visualised and they can also be converted into IGES files suitable for importing into a CAD system. Figure 3-2 shows such a visualisation of the beam, a section of which is represented by the dashed line in figure 3-1.

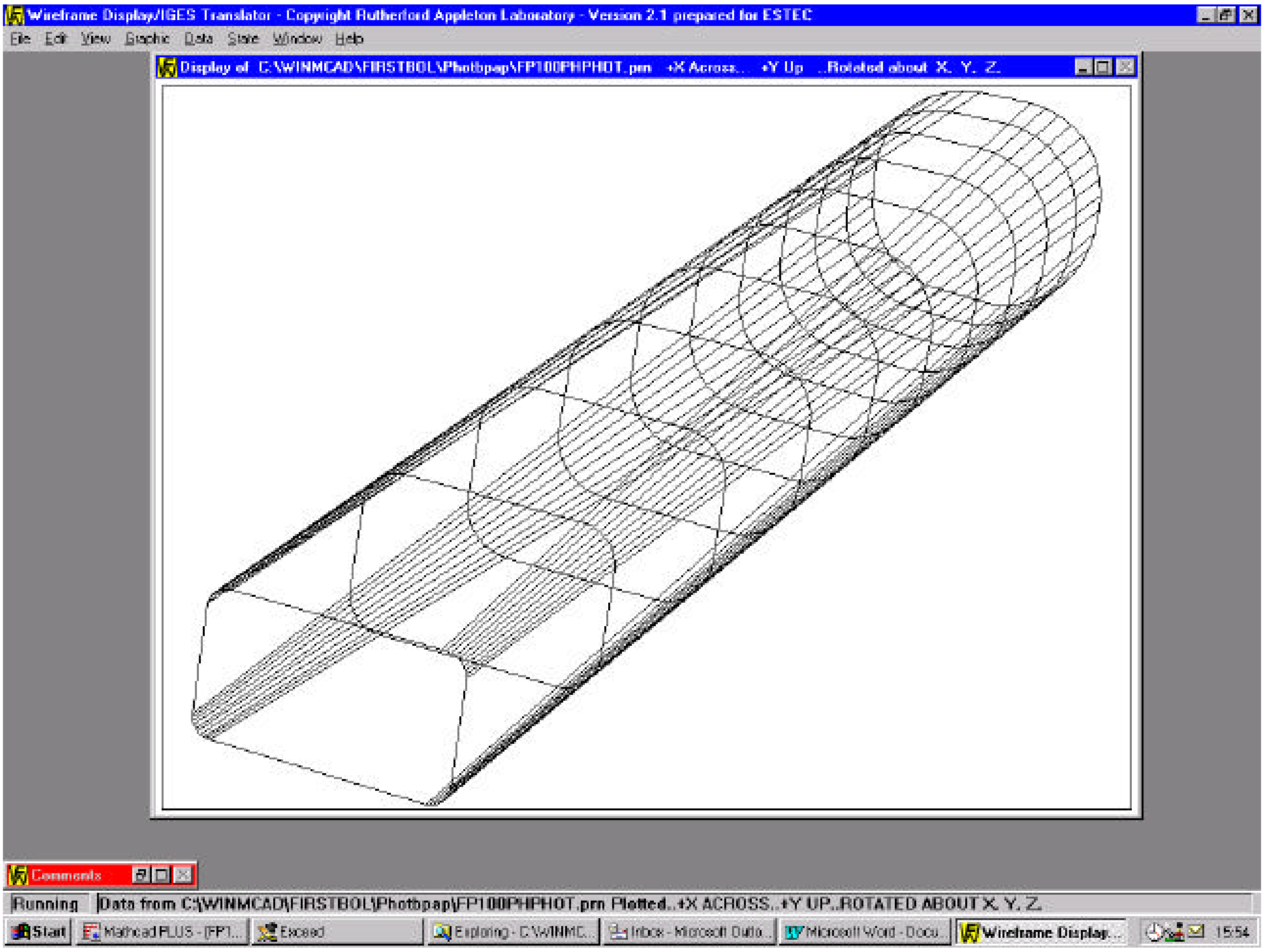

Figure 3-2 View of a 3-D representation of a composite photometer beam boundary

4. COMBINED BEAM SECTIONS

Figures 4-1, 4-2 and 4-3 show the combined boundaries of beams from both SPIRE instruments. The spectrometer beam is the roughly circular one to the left. This was produced for a single setting for the M4 mirror, in the centre of its range of tilts in both axes. Several overlapping boundaries are shown for the photometer, one for each of the four extreme pairs of tilt angles and two for the two extreme Y tilt values at the central 'zero' X tilt position. For the case where M4 tilts the photometer view away from the spectrometer FOV (X tilt), the beam representing the rightmost 2 arc minutes of the detector has been excluded. This reflects the fact that M3 will not be extended in that direction enough to cover more than the central 4 arc minute square when it is given a 2 arc minute tilt offset in this direction.

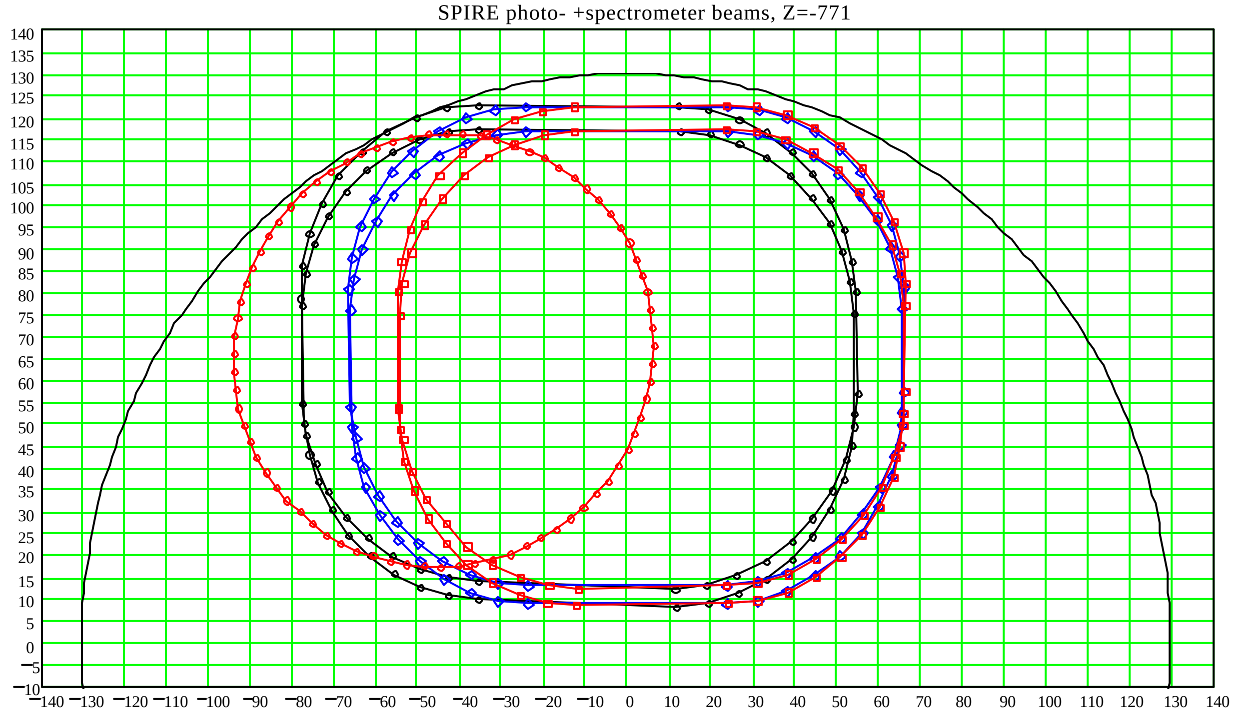

Figure 4-1 Composite beam boundaries at 771 mm forwards of the telescope axial focus

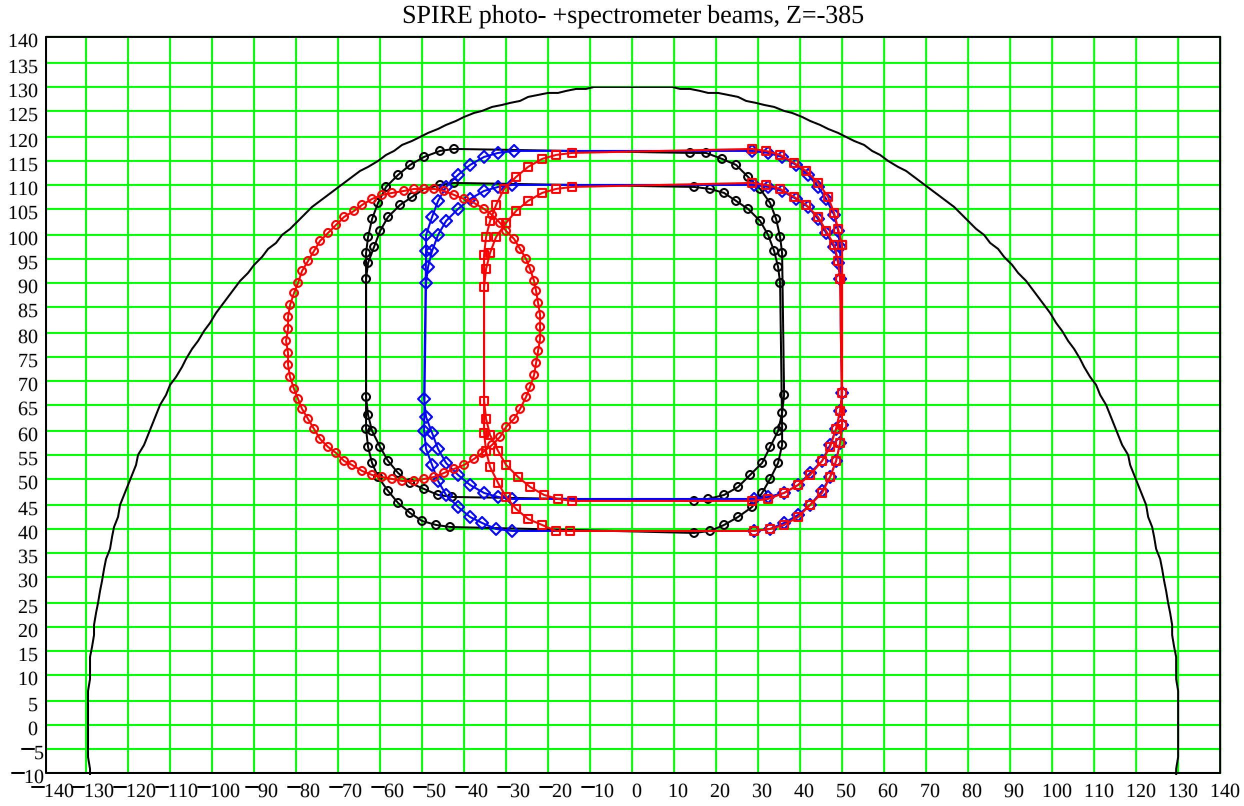

Figure 4-2 Composite beam boundaries at 385 mm forwards of the telescope axial focus

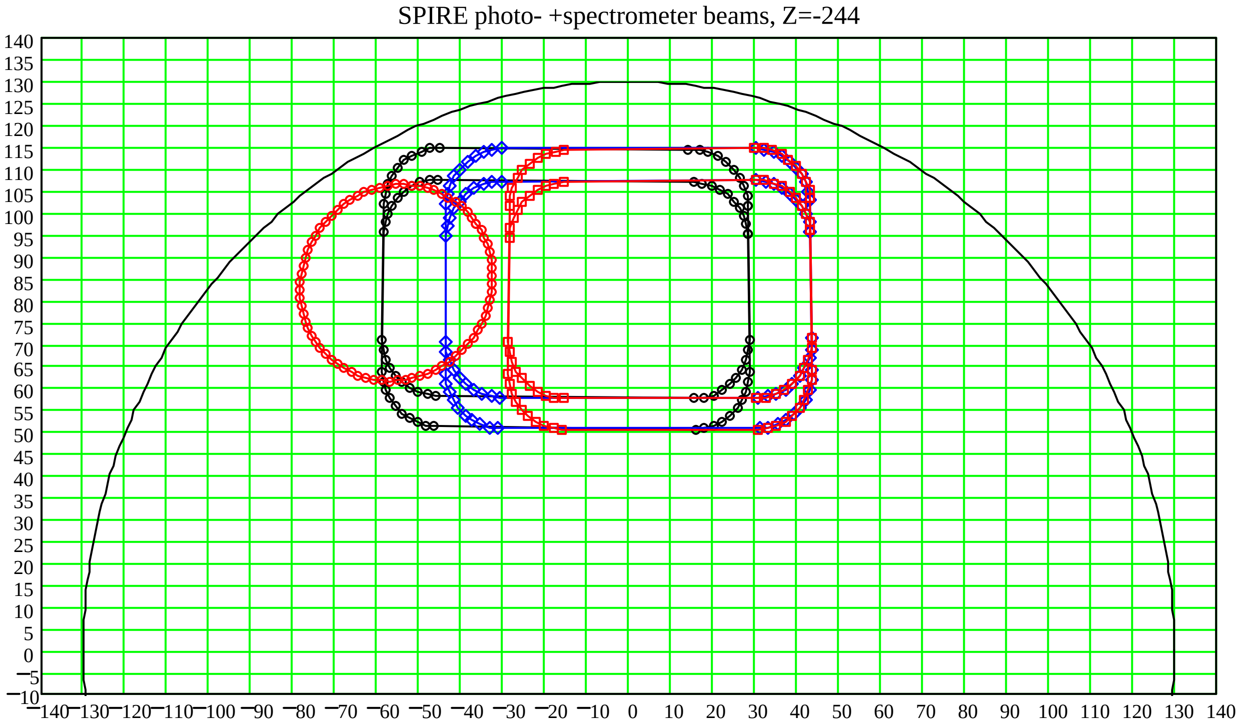

Figure 4-3 Composite beam boundaries at 244 mm forwards of the telescope axial focus

The Z co-ordinates chosen for the illustrated sectional planes (-771, -385 and –244 mm) represent respectively the approximate locations of the front opening to the cryostat, the cryostat vent closure plate and the rearmost heat shield nearest the focal plane instruments. These dimensions reflect the cryostat design that existed at the time of the original FIRST payload module study. The 130 mm radius semi-circular boundary drawn on each figure represents the size of the openings in all the cryostat shields that are included in the cryostat model presently used for straylight analysis. All dimensions shown in the figures are in millimetres.

5. REQUESTS FOR FURTHER DATA

Please e-mail me at A.G.Richards@RL.AC.UK if the text data files referred to above are needed and I will endeavour to satisfy your requirements.