

<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	1 of 12

**SUBJECT:** SPIRE cover and shutter aperture dimensions

**PREPARED BY:** A G Richards

**KEYWORDS:** apertures, cover, shutter

**COMMENTS:** This document presents data on the dimensional requirements of the apertures required in both the SPIRE instrument cover and the proposed shutter assembly located on top of the cover. A 6-mm clearance requirement round the optical beams is applied.

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<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	2 of 12

## 0. CHANGES

Issue	Changes
1.0	First issue: 3-mm beam clearance applied. Rectangular aperture specified.
2.0	Beam clearance increased to 6-mm. Apertures now conform to the beam envelope within an overall rectangular limit box.
2.01	Warning concerning priority of tabulated dimensions over IGES models added. Error in pocket edge coordinate label in Figures 4-1 and 4-4 corrected. Error describing the angular intervals of points shown in figures 4-2 and 4-5 corrected.

<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	3 of 12

## Contents

0. Changes.....	2
1. Introduction .....	4
2. Optical BEAM Geometry.....	5
3. Co-ordinate system and dimensions .....	5
4. Aperture locations and dimensions.....	6
4.1. SPIRE cover aperture .....	6
4.1.1. Rectangular limit box.....	6
4.1.2. Conformal Aperture.....	7
4.2. Shutter aperture.....	9
4.2.1. Rectangular limit box.....	9
4.2.2. Conformal Aperture.....	10
5. File retrieval.....	12
6. Requests for further data .....	12

## Figures and Tables

Figure 1-1 Combined beam envelopes and SPIRE structure surfaces	4
Figure 2-1 Combined beams surrounded by a rectangular aperture.	5
Figure 4-1 Clear rectangle dimensions at X=+445.52	6
Figure 4-2 Six aperture corner centres and radii for 6 mm clearance	7
Figure 4-3 SPIRE Cover aperture added to beam envelopes and structure surfaces	8
Figure 4-4 Clearance rectangle dimensions at X=+445.52+12	9
Figure 4-5 Six aperture corner centres and radii for 6 mm clearance - Shutter space	10
Figure 4-6 Shutter 'plate' aperture added to beam envelopes and structure surfaces.	11
Figure 5-1 Where to find the IGES data at the 'JACKAL' anonymous FTP site	12
Table 4-1 Conformal aperture specification data (see figure 4-2)	8
Table 4-2 Clearance rectangle dimensions and changes for the two aperture planes	10
Table 4-3 Shutter space conformal aperture specification data (see figure 4-5)	11
Table 5-1 List of relevant IGES-formatted files	12

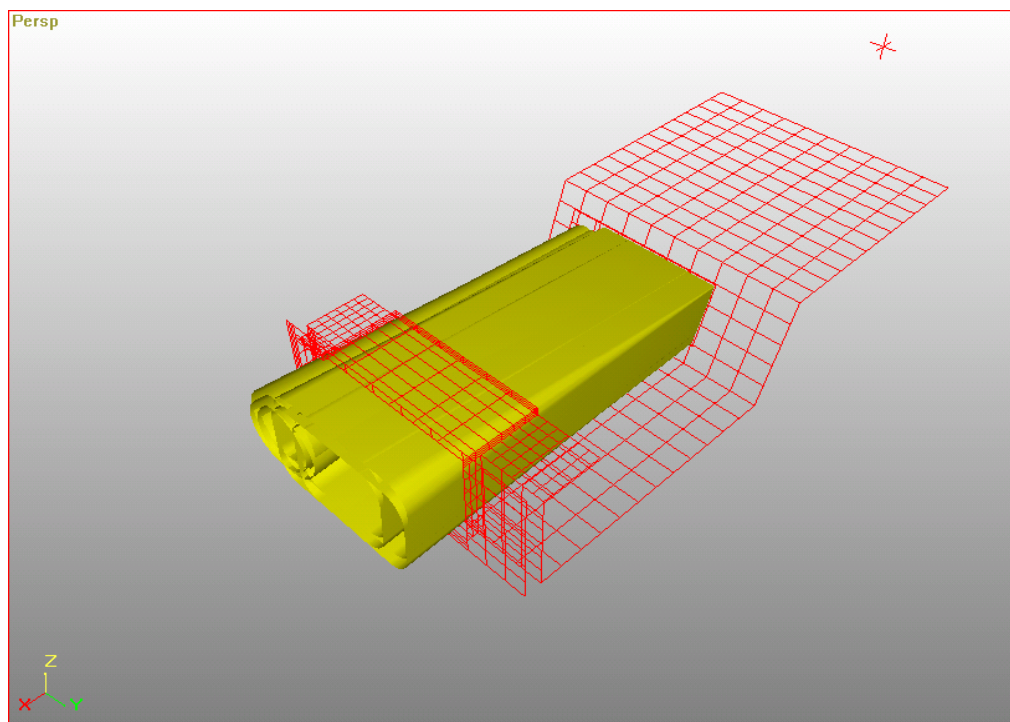
<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	4 of 12

## 1. INTRODUCTION

This note summarises the data required to size and design apertures in the SPIRE cover and in the shutter assembly so that their edges will clear the beams that define the active views out of the FIRST focal plane instruments by 6-mm all round. Note that the previous issue of this note used a margin of 3-mm, which is now considered inadequate, given that 20% clearance demands 6 mm and 20% has been the guiding value for sizing components inside SPIRE. Another change from the first issue is that the aperture shape is now no longer a pure rectangle. The aperture boundary is now made to conform to the shape of the envelope of the composite beams by introducing radiused corners.

Several IGES-formatted files have been produced to model these conformal apertures in 12-mm thick rectangular volumes meeting at the outer surface of the SPIRE cover. An IGES file showing a 3-D representation of the optical beams that must be kept clear of aperture boundaries accompanies these aperture files, as does a file showing some of the structural surfaces included in the straylight model. All of these files are available on the SPIRE anonymous FTP site (see section 5), both individually and as a ZIPped archive.

**The IGES files are intended as an aid to the CAD modelling, and to show the clearances required between the optical beams and each aperture's edges. They are not to be taken as the primary reference data for beam clearances. The data in tables 4-1, 4-2 and 4-3 is the primary reference data that must be used to construct the required apertures.**



**Figure 1-1 Combined beam envelopes and SPIRE structure surfaces**

<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	5 of 12

## 2. OPTICAL BEAM GEOMETRY

Figure 1-1 shows the combined envelope of the optical beams that define the instruments' combined views through the focal plane aperture plate and out towards the telescope. The envelope is shown together with wireframe representations of surfaces such as the focal plane plate and some other SPIRE box surfaces that are being included in the instrument straylight model. Other surfaces have been omitted for clarity.

The beam envelope is a composite of four beams from each of the two instruments, each beam representing the instantaneous view of an instrument as the beam steering mirror is tilted to the four combinations of two extreme values for each of the 'chop' and the 'jiggle' tilts. The way that the focal plane plate is sized to pass these extreme views is fully described in SPIRE-RAL-NOT-000581. Note that **no oversizing** of the beam envelopes is applied in this case.

The format of the combined beam envelope is shown more clearly in figure 2-1, where it is shown surrounded by a rectangular aperture boundary (the apparent lack of clearance at the bottom is an effect of perspective due to the beam envelopes extending beyond the plane of the aperture).

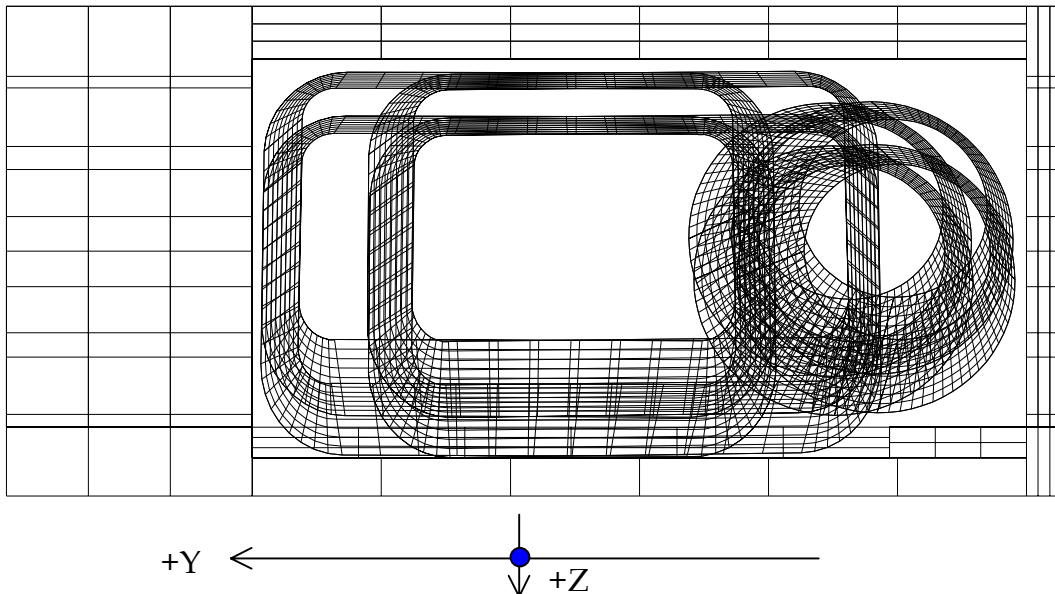


Figure 2-1 Combined beams surrounded by a rectangular aperture.

## 3. CO-ORDINATE SYSTEM AND DIMENSIONS

The directions of the X-, Y- and Z-axes in the ESA co-ordinate system are indicated in the bottom left-hand corner of figure 2-1. The origin of co-ordinates is indicated by a small axis-triple near the top right-hand corner figure 1-1. The axes' directions are also shown superimposed on figure 2-1. The view in figure 2-1 is obtained by looking IN through the aperture in the -X direction. Figures 4-1 and 4-4 use this co-ordinate system. Figures 4-2 and 4-5 use a 'local' co-ordinate frame with local +X corresponding to ESA +Y and local +Y corresponding to ESA +Z.

<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	6 of 12

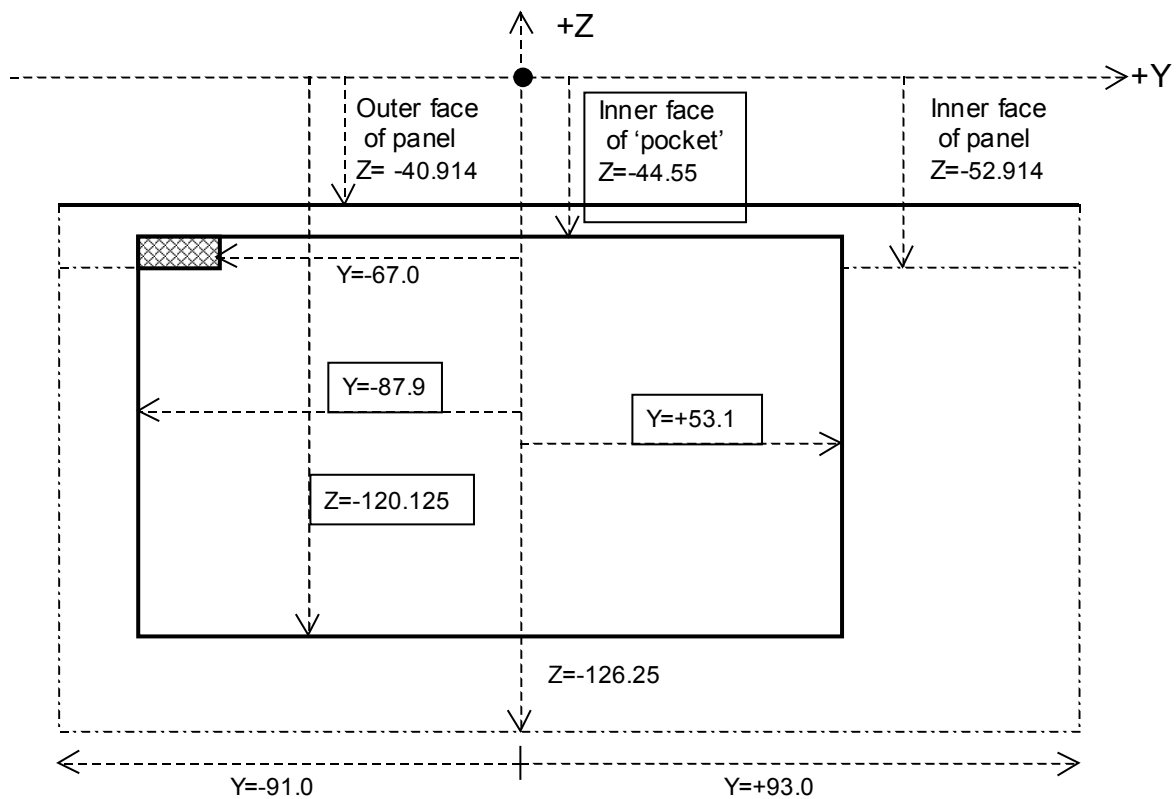
In the aperture figures that follow, all dimensions are shown in millimetres. A signed dimension indicates a distance measured parallel to one of the three co-ordinate axes and at 90 degrees to one of the three reference planes that cross at the co-ordinate origin. All dimensions shown are assumed to be the 'COLD' values i.e. as they should be with the instrument cooled to its operating temperature.

#### 4. APERTURE LOCATIONS AND DIMENSIONS

##### 4.1. SPIRE cover aperture

##### 4.1.1. Rectangular limit box

The SPIRE cover is stated to be 12 mm thick with its outermost surface being located in the  $X=+445.52$  plane<sup>1</sup>. Thus the inner surface will be at  $X=+433.52$ . The cross-section through the composite beam envelope was analysed in this plane and an aperture with the dimensions shown in rectangular text boxes in figure 4-1 will clear the nearest points on the envelope by 6 mm.



**Figure 4-1 Clear rectangle dimensions at  $X=+445.52$**

In figure 4-1, the three edges of the outer rectangle shown as dashed lines represent internal cover and optical bench surfaces. The solid line at  $Z = -40.914$  represents the

<sup>1</sup> E-mail from John Coker, MSSL, 02-05-2001

<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	7 of 12

exposed edge of the outer face of the panel nearest to the telescope axis where it meets the  $X=445.52$  plane. This panel is 12 mm thick, so a small pocket has to be machined in it in order to accommodate the aperture boundary on that side. The length of the pocket in the  $-Y$  direction need not extend the full width of the aperture and it is shown terminating at  $Y=-67.0$  in the figure. This would leave a small rectangular area of the side panel visible in one corner as shown. The depth of the pocket into the panel is 8.4 mm. The pocket needs to extend down to  $X=445.52-100$  i.e. 100 mm below the top surface of the panel. The pocket depth could taper linearly from 8.4 mm to zero at this level and still achieve the required 6-mm clearance from the beam envelope. The dimensions shown in figure 4-1 also apply to an aperture required in the inner face of the cover, located 12-mm back along the X-axis.

#### 4.1.2. Conformal Aperture

Figure 4-2 shows the parameters that define a conformal aperture i.e. one that follows the shape of the composite beam envelope and clears it by 6-mm all round whilst just fitting within the limiting rectangle of figure 4-1. It is to be understood that the gaps between corners are to be covered by straight lines, except the two small gaps between each 40-degree arc and its nearest-neighbour 28.2-mm radius arc. This gap was eventually bridged using cubic spline interpolation. A boundary that closely fits the actual beam envelope is constructed by using the same co-ordinates for each corner but by reducing all radii by 6 mm. In figure 4-2, each point shown on the 90-degree arcs labelled #1 and #2 are at 9-degree intervals. Points on the other arcs are at 10-degree intervals. The dimensional data are summarised in table 4-1.

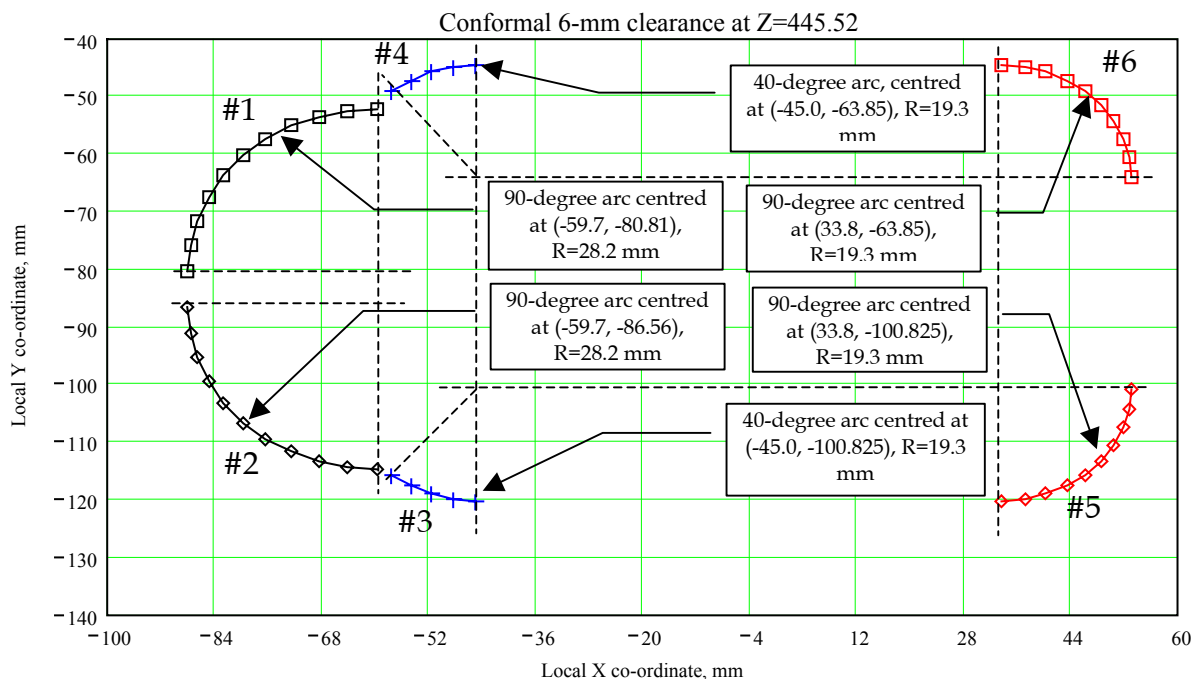


Figure 4-2 Six aperture corner centres and radii for 6-mm clearance

<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	8 of 12

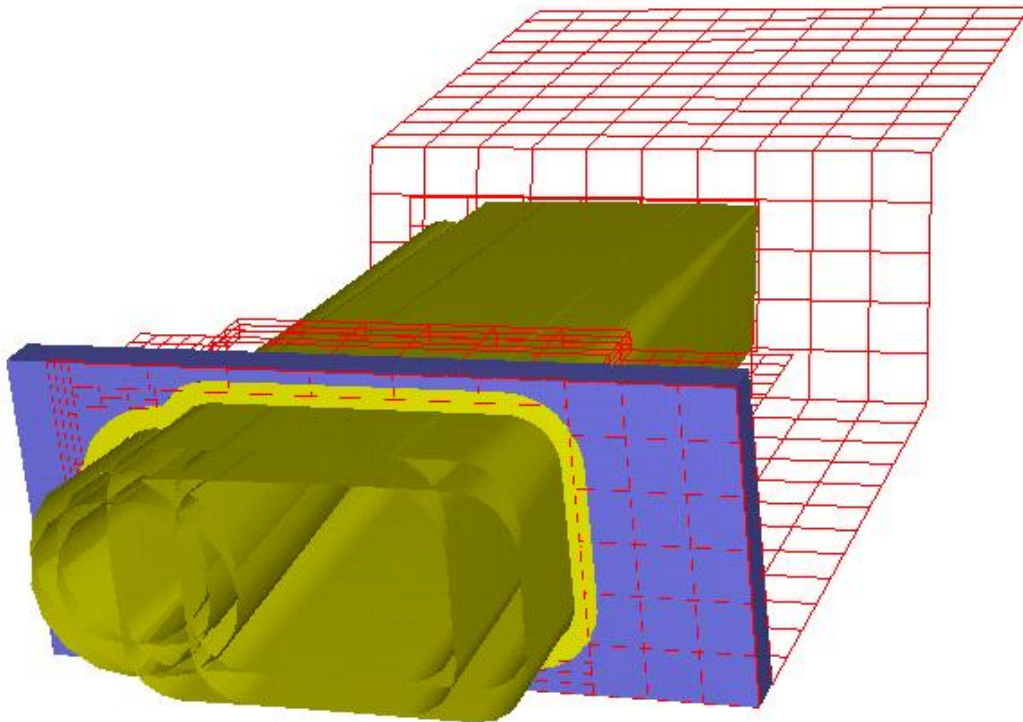
Arc	Centre, local X	Centre, local Y	Radius	Angular extent (deg.)
#1	-59.7	-80.81	28.2	90
#2	-59.7	-86.56	28.2	90
#3	-45.0	-100.825	19.3	40
#4	-45.0	-63.85	19.3	40
#5	33.80	-100.825	19.3	90.0
#6	33.80	-63.85	19.3	90.0

**Table 4-1 Conformal aperture specification data (see figure 4-2)**

Cubic spline curves were then fitted to the data shown and they were used to generate:

- (a) An IGES model of a 12 mm thick, parallel-faced volume having an outer boundary having the shape shown in figure 4-2 and a conformal inner boundary 6-mm inside it. This represents the actual 6-mm wide clearance space required between the composite beam envelope and the aperture boundary.
- (b) An IGES model of a 12 mm thick, rectangular, parallel-faced plate containing a conformal aperture with the dimensions shown in figure 4-2 and having an outer rectangular boundary with dimensions shown in figure 4-1.

The 12 mm thickness extends inwards from the outermost X=445.52 mm plane of the SPIRE cover. The items are shown in figure 4-3 added to the structures shown in figure 2-1. Item (b) is shown blue; item (a) is shown yellow. The optical beams are shown green.



**Figure 4-3 SPIRE Cover aperture added to beam envelopes and structure surfaces**



<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	9 of 12

## 4.2. Shutter aperture

### 4.2.1. Rectangular limit box

The shutter interface plane was taken to be the outer face of the SPIRE cover at  $X=+445.52$ . A volume having a nominal thickness of 12 mm was assumed for the shutter extent along  $+X$  from this plane, in the region of the beam boundaries. The beam envelope extends in a so-called 'outer shutter plane' located at  $X=445.52+12$  mm were then determined as before and aperture limiting rectangle in this plane was determined. The dimensions required for the rectangle are shown in figure 4-4 in rectangular boxes. All four dimensions show small changes from the corresponding dimensions of the aperture in a plane 12-mm lower, and these changes are summarised in table 4-2. The biggest change is 0.76 mm in the location of the edge nearest the telescope axis (the 'pocket' side). The tabulated data can be used to determine clearance rectangle edge locations in any plane within a reasonably small distance from the one used here, if the shutter assembly requires greater depth along the  $+X$  direction than that assumed here.

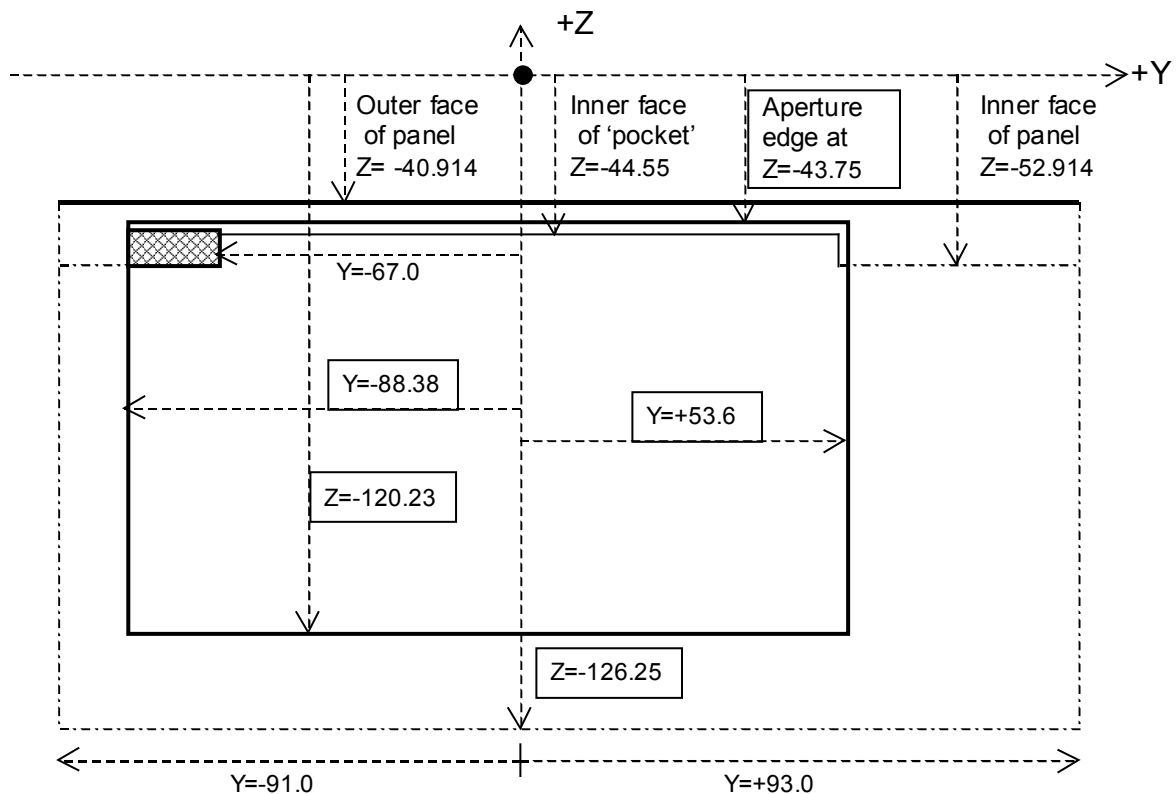


Figure 4-4 Clearance rectangle dimensions at  $X=+445.52+12$

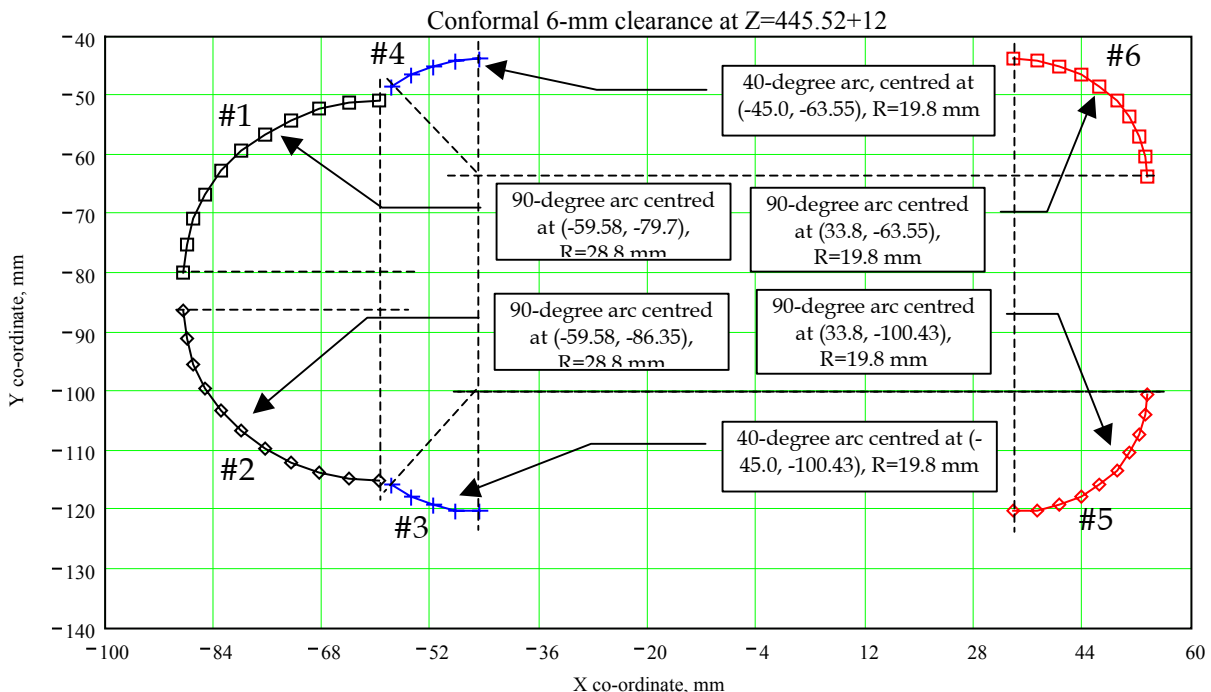
<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	10 of 12

		locations of aperture edges in ESA co-ordinates in MM			
aperture level with	aperture plane X location	MAX Z	MIN Z	MIN Y	MAX Y
SPIRE Cover top	+445.52	-44.51	-120.125	-87.9	+53.1
Shutter plate top	457.52	-43.75	-120.23	-88.38	+53.6
Change in value	+12.0	+0.76	-0.105	-0.48	+0.5

**Table 4-2 Clearance rectangle dimensions and changes for the two aperture planes**

#### 4.2.2. Conformal Aperture

Figure 4-5 shows the parameters that define a conformal aperture i.e. one that follows the shape of the composite beam envelopes and clears it by 6-mm all round whilst just fitting within the limiting rectangle of figure 4-4. It is to be understood that the gaps between corners are to be covered by straight lines, except the two small gaps between each 40-degree arc and its nearest neighbour 28.8-mm radius arc. This gap was eventually bridged using cubic spline interpolation. A boundary that closely fits the actual beam envelope is constructed by using the same co-ordinates for each corner but reducing all radii by 6 mm.



**Figure 4-5 Six aperture corner centres and radii for 6-mm clearance - Shutter space**

In figure 4-5, each point shown on the 90-degree arcs labelled #1 and #2 are at 9-degree intervals. Points on the other arcs are at 10-degree intervals. The dimensional data are summarised in table 4-3.

<b>SPIRE</b>	<b>Technical Note</b>	Ref:	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	Issue:	2.01
		Date:	29 June 2001
		Page:	11 of 12

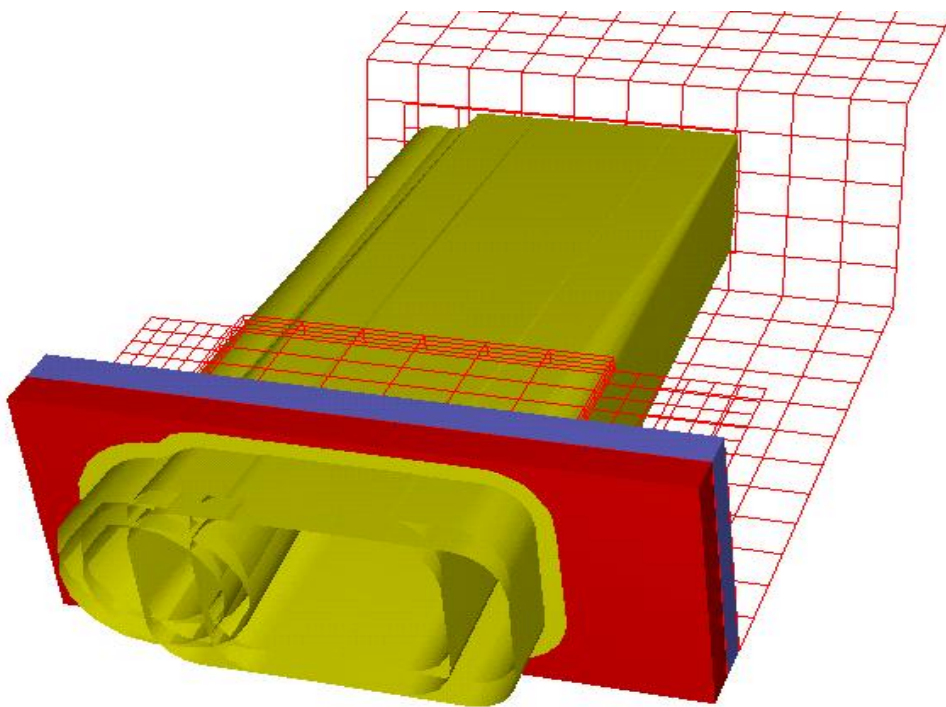
Arc	Centre, local X	Centre, local Y	Radius	Angular extent (deg.)
#1	-59.58	-79.70	28.8	90
#2	-59.58	-86.35	28.8	90
#3	-45.0	-100.43	19.8	40
#4	-45.0	-63.55	19.8	40
#5	33.80	-100.43	19.8	90.0
#6	33.80	-63.55	19.8	90.0

**Table 4-3 Shutter space conformal aperture specification data (see figure 4-5)**

Cubic spline curves were then fitted to the data shown and they were used to generate:

- (a) An IGES model of a 12 mm thick, parallel-faced volume having an outer boundary with the shape shown in figure 4-5 and a conformal boundary 6-mm inside it. This represents the actual 6-mm wide clearance space required between the composite beam envelope and the aperture boundary in the shutter space.
- (b) An IGES model of a 12 mm thick, rectangular, parallel-faced plate containing a conformal aperture with the dimensions shown in figure 4-5 and having an outer rectangular boundary with dimensions shown in figure 4-4.

For both of these items, the 12 mm thickness extends outwards from the outermost X=445.52 mm plane of the SPIRE cover. The items are shown in figure 4-6 added to the structures shown in figure 2-1. Item (b) is shown red; item (a) is shown yellow. The optical beams are shown green. The 12-mm thick SPIRE aperture plate is shown in blue.



**Figure 4-6 Shutter 'plate' aperture added to beam envelopes and structure surfaces.**

<b>SPIRE</b>	<b>Technical Note</b>	<b>Ref:</b>	SPIRE-RAL-NOT-000694
	SPIRE cover and shutter aperture dimensions	<b>Issue:</b>	2.01
		<b>Date:</b>	29 June 2001
		<b>Page:</b>	12 of 12

## 5. FILE RETRIEVAL

All the IGES files listed in the table below are available via anonymous FTP from JACKAL.BNSC.RL.AC.UK. When logging-on use 'anonymous' as the username and the files can be found in the following sub-folders (see figure 5-1)

.../pub/spire/APERTURES/IGES

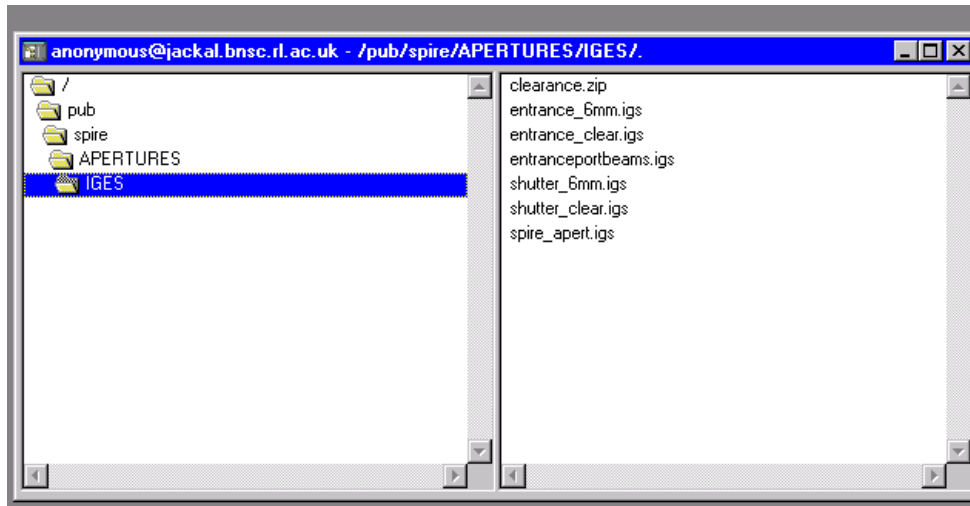


Figure 5-1 Where to find the IGES data at the 'JACKAL' anonymous FTP site

Filename	Content
SPIRE_APERT.IGS	Representations of SPIRE structural surfaces
ENTRANCEPORTBEAMS.IGS	Representations of the geometrical beams from both SPIRE instruments for all extremes of tilt and chop.
ENTRANCE_6MM.IGS	Representation of a 12-mm thick cover containing a conformal aperture that clears the optical beams by 6-mm.
ENTRANCE_CLEAR.IGS	Representation of the 6-mm wide clear space sought around the optical beams inside a 12-mm thick volume extending back from the SPIRE entrance port.
SHUTTER_6MM.IGS	Representation of a 12-mm thick space containing a conformal aperture that clears the optical beams by 6-mm.
SHUTTER_CLEAR.IGS	Representation of the 6-mm wide clear space sought around the optical beams in the space containing the shutter aperture.
CLEARANCE.ZIP	WinZip archive of the above 6 files

Table 5-1 List of relevant IGES-formatted files

## 6. REQUESTS FOR FURTHER DATA

If for any reason the text data files referred to above cannot be obtained, please e-mail me at [A.G.Richards@RL.AC.UK](mailto:A.G.Richards@RL.AC.UK) and I will endeavour to satisfy your requirements.