



SCUBA-2 FTS Project Office

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Change Record

Issue	Date	Section(s) Affected	Description of Change / Change Request Reference / Remarks
0.1	17/08/06	All	First draft
1.0	2/11/06	All	CDR version. Output coordinates for corner cube design are TBD

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1. Summary

The FTS-2 optical model is built on the main SCUBA-2 Zemax model developed by the ATC, and uses the same coordinate system. The original SCUBA-2 model did not conform to the ZEMAX thickness conventions, as the beam from the object travelled in the negative Z direction. The workaround solution was to place a plane mirror immediately after the object surface in order to satisfy the convention that all thicknesses should be negative after an odd number of mirrors. The SCUBA-2 model was then modified to include the sub-array footprint at the image location, in order to ensure the FTS input and output ports are properly aligned with the SCUBA-2 feed optics. Since Zemax uses normalized field coordinates for operations such as ray aiming, we must calculate the field coordinates for image locations corresponding to the FTS-2 FOV.

2. SCUBA-2 Array Footprint

The SCUBA-2 pixels are spaced at $0.5F\lambda$ for the $850\text{ }\mu\text{m}$ band. Both arrays have the same pixel geometry, as described in the Pixel Interfaces document (SC2/i100/INT/01). The pixels themselves are 1.055 mm in diameter, and spaced on a 1.135 mm grid as described in (SC2/MOD/WP200/02). The subarrays are separated from each other by a gap due to mounting and wiring requirements, as described in the Array ICD drawings. Figure 1 shows the SCUBA-2 array geometry with the proposed FTS-2 port locations superimposed in red. At the image plane, $1'$ corresponds to 11.84 mm .

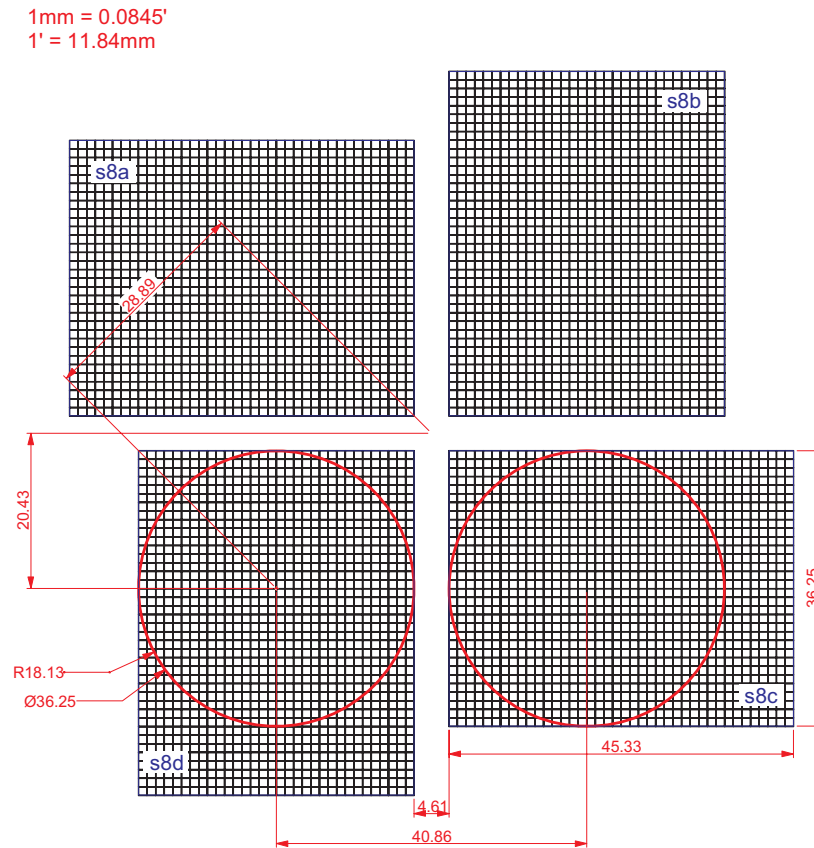


Figure 1. SCUBA-2 pixel layout showing subarray spacing and FTS-2 output port orientation.

SCUBA-2 has a nominal 8'x8' FOV, as shown in Figure 2. Each port of FTS-2 will have a roughly 9 arcmin² FOV, indicated by the red circles in the figure.

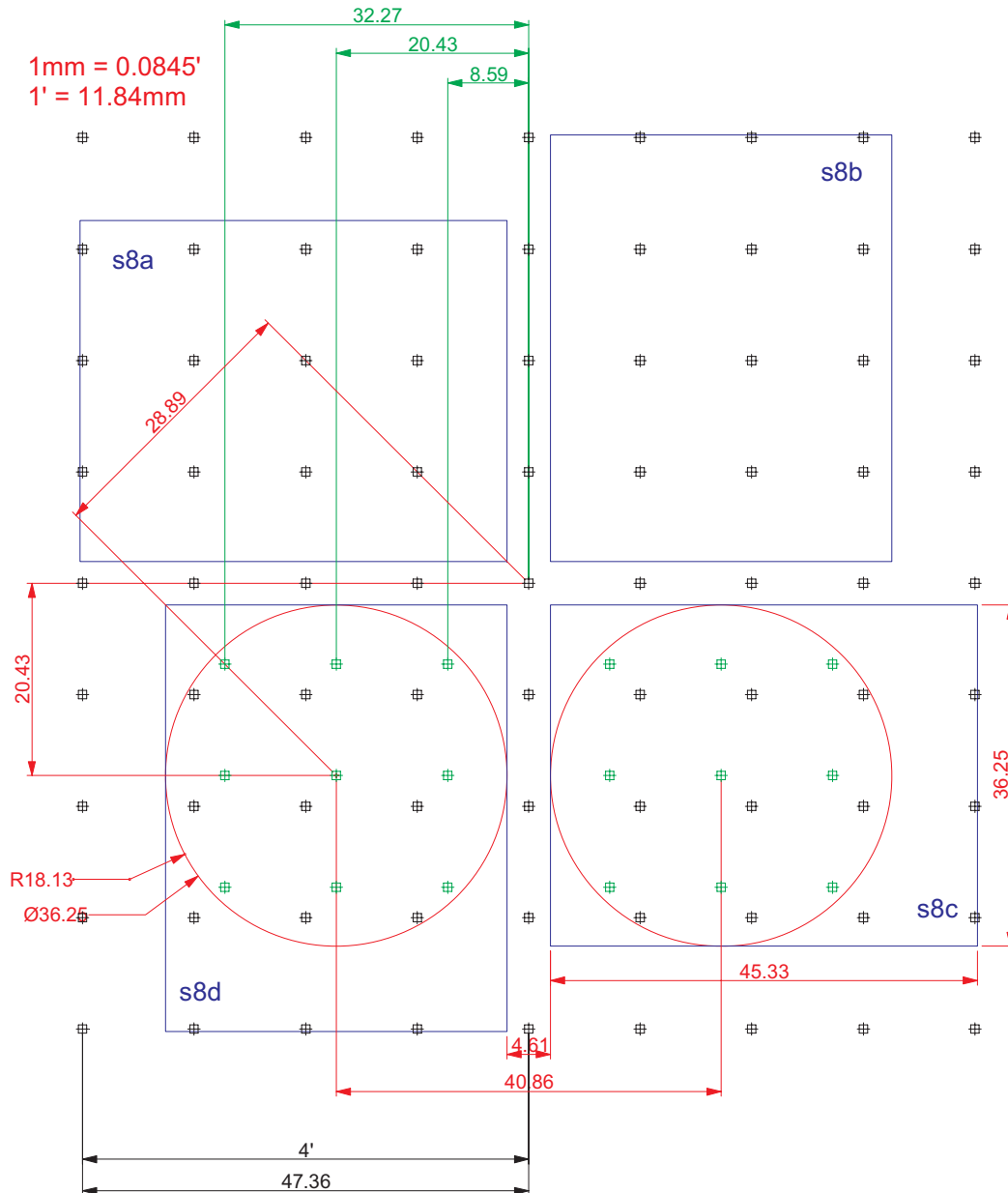


Figure 2. SCUBA-2 and FTS-2 field points. Subarray outlines shown in blue, FTS-2 field points shown in green. Port 1 falls on subarray s8d, Port 2 falls on subarray s8c.

3. FTS-2 Field Coordinates

3.1. Input Field Coordinates

The locations of the FTS-2 field points from Figure 2 in spatial dimensions must be converted to angular units for use in Zemax. The relation of $1' = 11.84 \text{ mm}$ at the image plane is used, and the resulting field point angular coordinates characterizing one port of the FTS are given in the following table. (Note that the signs of the X and Y coordinates are negative relative to the original SCUBA-2 model which did not obey the ZEMAX thickness convention.)

Table 1. Port 1 Angular Field Coordinates

Field Point	Field Number	X (degrees)	Y (degrees)
Optical axis	1	0	0
Port centre	3	0.02876	0.02876
Corners of 2' square around centre	2	0.01209	0.01209
	4	0.01209	0.04543
	5	0.04543	0.01209
	6	0.04543	0.04543

Table 2. Port 2 Angular Field Coordinates

Field Point	Field Number	X (degrees)	Y (degrees)
Optical axis	1	0	0
Port centre	3	-0.02876	0.02876
Corners of 2' square around centre	2	-0.01209	0.01209
	4	-0.01209	0.04543
	5	-0.04543	0.01209
	6	-0.04543	0.04543

According to the coordinate conventions in the Zemax model, the upper left quadrant of the beam is negative in X and positive in Y coordinates, as seen when looking into the elevation bearing from the FTS-2 location, or when looking at the $850 \mu\text{m}$ array from the back.

3.2. Normalized Field Coordinates

Zemax uses rectangular normalized field coordinates (Hx and Hy) to represent points on a unit circle. The radial size of the field of view as defined by the field points entered in the Field Data editor is used to scale the normalized field coordinates. All of the FTS field points lie within a circle with $4'$ radius centered on the optical axis, so if we include one field point in the model with coordinates $[4', 4']$ then the field coordinates for the FTS-2 ports can be changed during modeling without affecting the normalization factors.

Table 3. Port 1 Normalized Field Coordinates

Field Point	Field Number	Hx	Hy
Optical axis	1	0	0

Port centre	3	0.4314	0.4314
Corners of 2' square around centre	2	0.1814	0.1814
	4	0.1814	0.6814
	5	0.6814	0.1814
	6	0.6814	0.6814

Table 4. Port 2 Normalized Field Coordinates

Field Point	Field Number	Hx	Hy
Optical axis	1	0	0
Port centre	3	-0.4314	0.4314
Corners of 2' square around centre	2	-0.1814	0.1814
	4	-0.1814	0.6814
	5	-0.6814	0.1814
	6	-0.6814	0.6814

4. Output Field Coordinates

NOTE- This section is valid only for the rooftop model, which has been replaced with the new corner-cube design. The output field coordinates for the corner-cube design are not yet available.

Due to the parity of the FTS internal mirrors, there is a 180° field rotation introduced at the output ports about the center of each port ([0.02876°, 0.02876°] and [-0.02876°, 0.02876°]). In order to optimize the image quality, the coordinates at the array for the rotated field points must be determined. Assuming that there is no image magnification, the FTS-2 field points can be entered into the original SCUBA-2 model and raytraced to determine the coordinates at the array surface. Table 5 shows the image coordinates for the FTS-2 fields and the corresponding SCUBA-2 field numbers.

Table 5. Field Coordinates at the Array

Field Point	FTS-2 Field #	SCUBA-2 Field #	X (mm)	Y (mm)
Optical axis	1	1	0	0
Port centre	3	3	-20.0322947	-20.03077623
Corners of 2' square around centre	2	6	-31.7105090	-32.0245799
	4	5	-31.7309996	-8.35864783
	5	4	-8.37725999	-32.2411558
	6	2	-8.42407491	-8.5458825