PHOC | ESA | R | 0008.1

MASTER

FIRST Payload Module/

Focal Plane Unit Straylight Model

Photoconductor Instrument (PHOC)

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FIRST	PT-04348									
JAS	MA	MVH	HS	FE	HO	TP				FILE
X	X					X				X
JC	GP	OD	CJ	MB	EG	DC	PU	AS ✓ DASA ✓		
X	X									
DATE 21.5.'97										

1. Introduction

The Far Infrared and Submillimeter Telescope (FIRST) mission is the fourth cornerstone of the ESA long term space science programm. It will perform astronomical observations in the wavelength band between 85 µm and 900 µm.

The FIRST Payload Module/ Focal Plane Unit Straylight Model is the third and last step in the development of the FIRST straylight model. The three particular models are:

- The Telescope Straylight Model, mainly consisting of the telescope mirrors, the struts, the sunshade and the ringshield (if applicable)
- The Cryostat Straylight Model, mainly consisting of the space between the primary mirror and the focal plane
- The FIRST Payload Module/ Focal Plane Unit Straylight Model, mainly consisting of the space between the focal plane and the instrument detectors

The FIRST Payload Module/ Focal Plane Unit Straylight Model is dedicated to one single instrument (HET, PHOC, Bolometer) each. In the first step, the Photoconductor instrument (PHOC), is modeled.

The PHOC consists of an imaging Fabry-Pérot interferometer, operating in the band between 85 and 210 µm.

2. References

AD-1 FIRST - Far Infrared and Submillimeter Space Telescope
Payload Definition Document (PDD). "common model payload"
Version 3, 25. January 1996

AD-2 FIRST Telescope Assembly Specification, ESA PT-RQ-03832, 01.02.97

RD-1 Telefax from A. Poglitsch to T. Passvogel, 21.01.97 (no ref)
RD-2 Telefax from A. Poglitsch to T. Passvogel, 16.12.96 (no ref)

3.2. Software Model

The FIRST Payload Module/ Focal PlaneUnit Straylight Model is initially implemented as an APART script (SMI.IN1), like the other two models. From this model, a secondary model for the ASAP software is derived. This secondary model is obtained by

1. Converting the binary system file TAPE10.DAT (the BASICA.SMI file) to an ASAP script (SMI.INR).
2. Translating the ASAP script to an ASAP binary system file (SMI.SYS)
3. Application of a modification script for corrections, additional properties etc.

A common macro file (SMI.LIB) complements the model. It contains routines for formatted print, ray tracing and plotting (ASAP only).

There exists also an ASAP file IDEAL.INR which contains an optics chain made of ideal lenses, for checking focal lengths, magnification etc.

There is no way for a reverse model development with an ASAP script as the primary implementation.

The APART model will be used for the analysis of thermal radiation, edge diffraction and diffuse scattering. The ASAP script will be used for the check of the optical system (image position, apertures etc.) and for near angle diffraction at the beam. The ASAP model is also needed for the functional check of the Lyot stop(s).

The primary model follows a standard coordinate break system with clearly defined optical spaces. In order to have a working model, the telescope mirrors and the focal plane are included as optical surfaces. The actual instrument starts in space 4.

The imaging mirrors (M3, M5, M7, M12, M15) are modeled as symmetric, non-off-axis spherical mirrors. The radius of curvature is twice the focal length given in RD-1.
Only M3 has a rectangular aperture, all others do have circular apertures. The detector is a square with a certain curvature (TBD).

The position of one mirror is only determined by it's z-coordinate and the x- and y-rotations applied to the previous optical surface (similar to a polar coordinate system). No lateral shifts are applied to optical surfaces. Note that the z-coordinate is not identical to the OPL, because the z-axis always changes the sign after a mirror.

The Fabry-Pérot optics is not included.

3.3. Coordinate System

APART makes use of a standard coordinate break system. The Z-axis falls always together with the optical axis. The Y-Z plane is than the meridional plane, X-Z is the sagittal plane. The sign of Z always changes after a mirror. If the mirror is rotated, also the orientation of Z and either X or Y (or both, if two rotations are applied) changes.
Because of this coordinate break system, there is no way to follow the ESA specification (AD-2), that the positive X-Axis shall point from the interface plane towards the target

3.4. Optical Datasheet

Surf	RD[8]	CC[9]	TH[10]	OPL[11]	CA[1]	x[2]	y[2]	z[2]	rot x[2,3]	rot y[2,3]
			500.00000	0		0	0	-500.00000	0	0
M1	-3000.008	-1.00057	-1372.88	500.00000	3000	0	0	0.00000	0	0
M2	-269.20641	-1.25719	2287.88000	1872.88000	242.446	0	0	-1372.88	0	0
TFP	INF	0	200.00000	4160.76000	7.32856[5]	0	0	915	0	0
M3	-400	0	-220.56518	4360.76000	155×70	0	0	1115	12.46921383	0
M4	INF	0	202.60553	4581.32518	40	0	0	894.43482	-26.13115948	0
M5	-400	0	-338.37849	4783.93071	60	0	0	1097.04034	13.07780450	-10.01835018
M6	INF	0	452.54833	5122.30910	70	0	0	758.66186	-1.04636541	-12.97338864
M7	-1181.85366	0	-204.26698	5574.85754	90	0	0	1211.21020	0.944549911	11.69195008
M8	INF	0	125.60255	5779.12452	90	0	0	1006.94322	19.52994341	7.92499053
M9	INF	0	-250.00000	5904.72707	90	0	0	1132.54576	25.76477399	-5.88061775
STOP	INF	0	-150.00000	6154.72707	70	0	0	882.54576	0	0
M10	INF	0	190.39433	6304.72707	90	0	0	732.54576	35.30501889	-29.95015208
M11	INF	0	-335.26109	6495.12139	90	0	0	922.94009	-13.94483786	-20.62295143
M12	1695.21498	0	318.94357	6830.38249	90	0	0	587.67900	0.73386016	-10.93499641
M13	INF	0	-325.72995	7149.32606	70	0	0	906.62257	-0.57925208	11.14935136
M14	INF	0	130.00000	7475.05600	50	0	0	580.89262	-14.26614801	0.28886672
M15	229.59398	0	-200[4]	7605.05600	50	0	0	710.89262	8.78524717	-7.15092949
IM				7805.056[4]	57.6×57.6	0	0	510.89262[4]	0	0

[1] Diameter or rect size
[2] Local coordinates
[3] degrees
[4] TBC
[5] 112" FOV
[6] ~~rotates first~~
[7] ~~Re-orientation of X and Y~~
[8] Radius of Curvature
[9] Conical Constant
[10] "Thickness, distance to next surface
[11] Optical Path Length

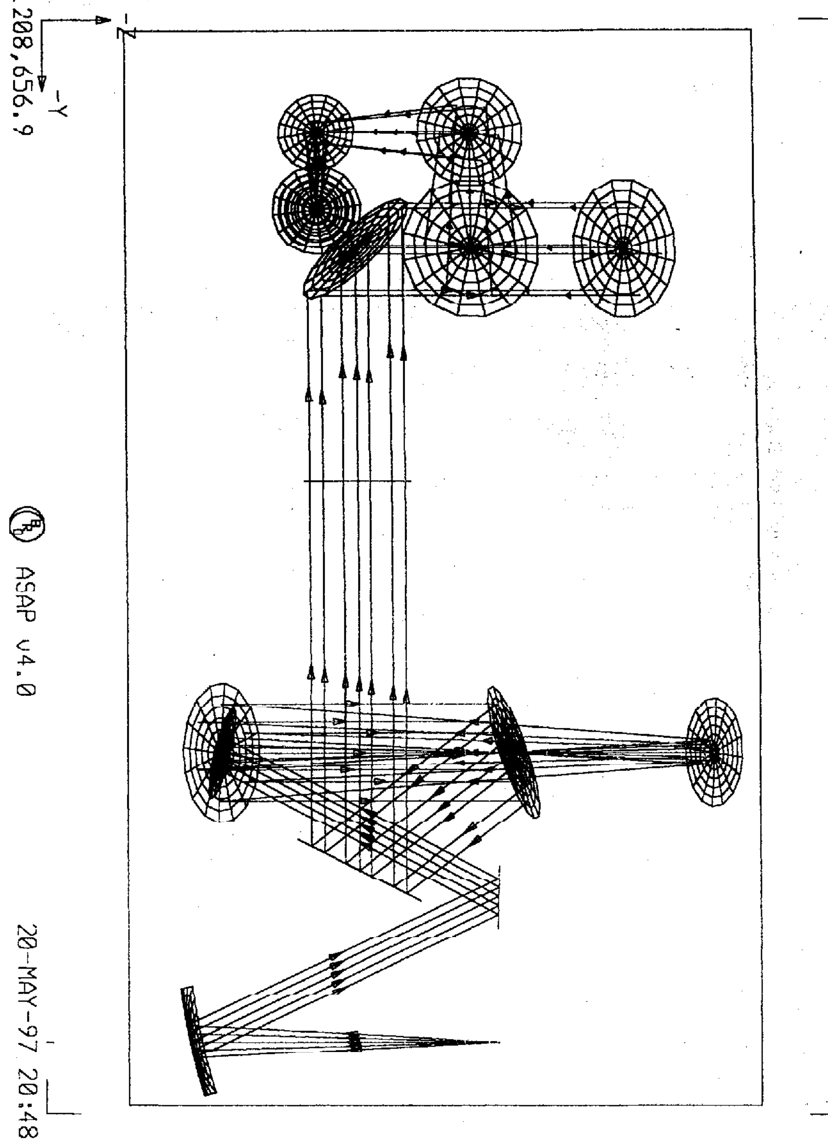


Figure 3.6.1: Slice in Z-Y

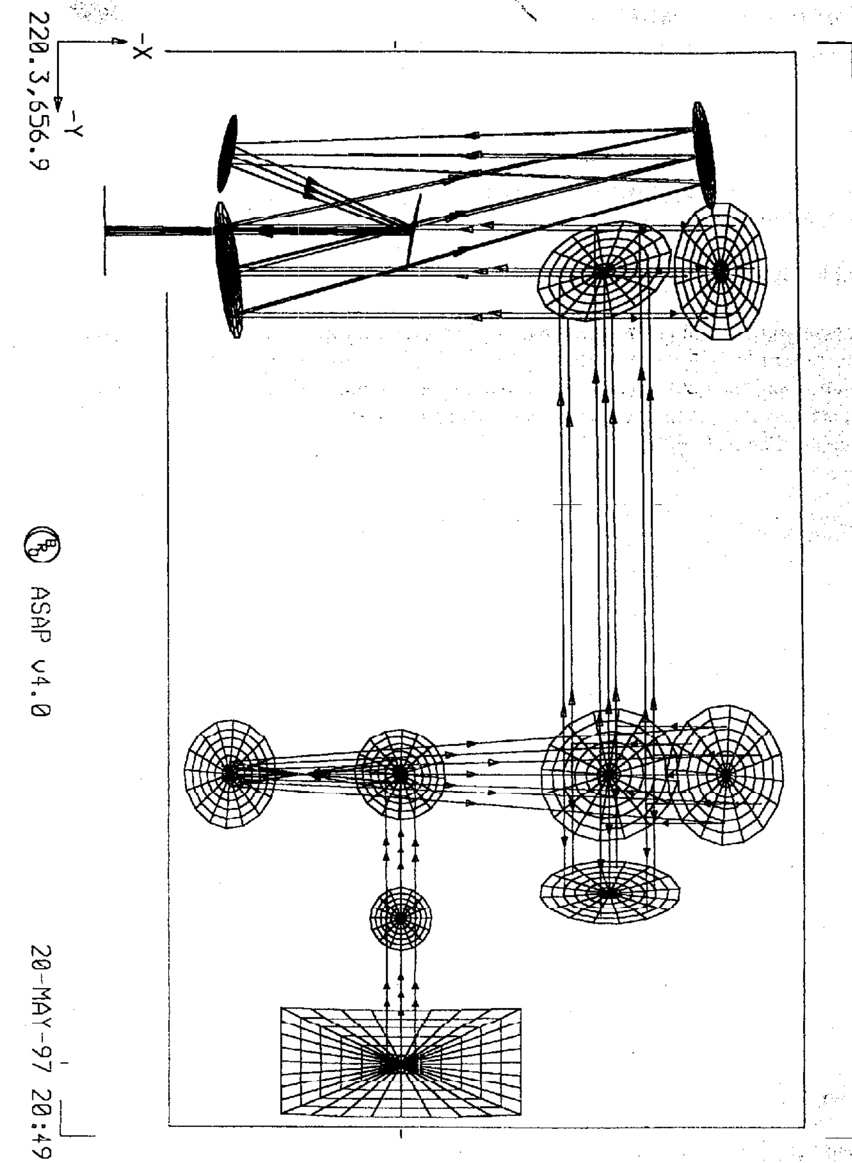
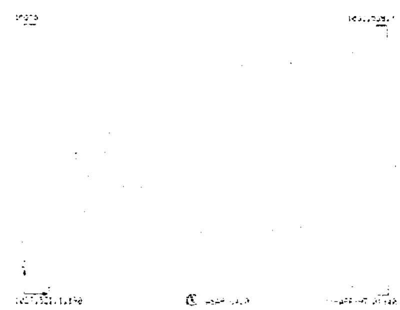


Figure 3.6.3: Slice in X-Y

4.3. Real Model Check

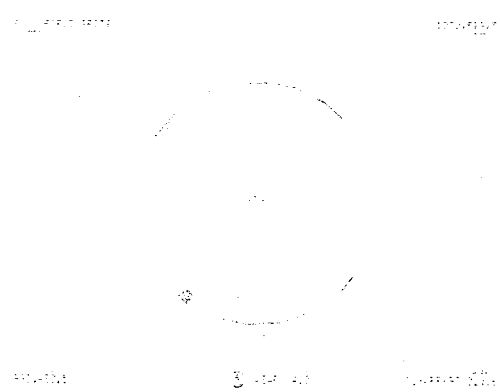
This check includes the Telescope Mirrors

Spots Diagramm:



RMS Blur Radius: 1.47 mm
max Blur Radius: 2.82 mm

Field of View



Summary:

- The focus is not optimal, but may satisfy to the pixel size
- The field position is correct, however a part of the rays is clipped

Estec IID mtg 4 Jul 97

PHOC Model Results

MASTER

Retocon GmbH

20.05.97

Technical Note:

FIRST	PT-04349								
JAS	MA	MvH	HS	PE	RO				FILE
X	X				X				X
JC	GP	OB	CJ	MS	BG	EC	PU	AS ✓ DASA ✓	
X	X								
DATE 21.05.'97									

Performance Results Part 1, Comparison with DSS model

Contents:

The PHOC straylight model has been appended to the DSS straylight model from August 96. This was done by replacing the transfers to the Detector in the Telescope Focal Plane (Object 110) with the transfers into the PHOC. The transfers from within the PHOC to the PHOC detector are appended. The DSS model has intentionally not been changed for reasons of easy comparison.

The transfers from the DSS model to the PHOC detector (object 300) via the PHOC objects are all made by diffraction at the edges of the apertures. The surfaces of the mirrors are assumed to be optical perfect for this wavelength range. They contribute only by their own thermal self emission.

Because of the changed mission specification, only the calculations of the internal thermal self emission are compared. The external straylight sources were not considered so far.

In the first part, the results are given for the assumption that there is a mask in the Telescope Focal Plane according to the size of the PHOC Field of View.

In the second part, the results are given for the assumption that there is a mask in the Telescope Focal Plane according to the size of the Telescope Field of View.

Conclusions:

1. The impact at the PHOC detector is about 3 orders of magnitude less than in the Telescope Focal Plane.

2. The PHOC detector is only radiated from the optical surfaces and from surfaces which are placed within the clear Aperture (the tripod legs 10, 20 and 30).

3. An additional mask in the focal plane (equivalent to object 110) gives only small improvements.

Notes:

1. In the DSS Model, the Secondary Mirror (object 130) makes no impact at Level 0. This was kept for comparison, although M2 should be included at Level 0.

2. The following objects (pieces of the tripod legs) do have transfers to tho PHOC detector, but were not included in the script for the thermal analysis: 12, 13, 16, 17, 22, 23, 24, 25, 26, 27, 32, 33, 35, 36, 37. This was kept for comparison.

WAVELENGTH 190µm

RUN DSSMODEL (original, Detector 110 at Telescope FP)

OBJECTS/	LEVEL 0	1	2
10 LEG 1 PART 1	3.4E-12	0.0E+00	0.0E+00
20 LEG 2 PART 1	1.2E-12	0.0E+00	0.0E+00
30 LEG 3 PART 1	1.2E-12	0.0E+00	0.0E+00
119 PM INNER CONE	5.0E-09	3.8E-10	0.0E+00
123 PRIMARY MIRROR	2.5E-09	1.0E-10	0.0E+00
130 SECONDARY MIRROR	0.0E+00	2.3E-13	0.0E+00
141 SHIELD 0 EDGE	1.2E-12	1.8E-09	0.0E+00
143 SHIELD 1 EDGE	7.2E-11	8.5E-11	0.0E+00
145 SHIELD 2 EDGE	2.1E-10	8.9E-10	0.0E+00
147 SHIELD 3 EDGE	3.0E-10	1.4E-09	0.0E+00
149 CVV LOWER CONE	1.4E-08	1.3E-09	3.0E-11
150 SHIELD 0 TO DET	5.4E-11	0.0E+00	0.0E+00
153 SHIELD 1 TO DET	4.4E-09	1.5E-10	0.0E+00
156 SHIELD 2 TO DET	1.6E-08	1.5E-09	0.0E+00
159 SHIELD 3 TO DET	2.6E-08	2.9E-10	0.0E+00
165 CVV INNER SURFAC	1.2E-08	1.1E-10	0.0E+00
166 CVV INNER EDGE	2.3E-09	2.1E-09	0.0E+00
172 CAVITY CAP INNER	6.6E-08	1.7E-07	3.2E-07
174 CRYO COVER CAP I	3.6E-10	4.7E-09	0.0E+00
TOTAL POWER	1.5E-07	1.8E-07	3.2E-07

Run DSSModel with PHOC

OBJECTS/	LEVEL 0	1	2
10 LEG 1 PART 1	1.3E-12	[illegible]	[illegible]
20 LEG 2 PART 1	6.2E-13	0.0E+00	0.0E+00
30 LEG 3 PART 1	6.2E-13	0.0E+00	0.0E+00
123 PRIMARY MIRROR	2.6E-10	1.9E-12	0.0E+00
130 SECONDARY MIRROR	[illegible]	[illegible]	[illegible]
210 M3	1.4E-11	0.0E+00	0.0E+00
213 S3_M3	[illegible]	[illegible]	[illegible]
215 M4	1.4E-11	0.0E+00	0.0E+00
[illegible] M5	[illegible]	[illegible]	[illegible]
225 M6	1.7E-11	0.0E+00	[illegible]
230 M7	1.4E-11	0.0E+00	0.0E+00
231 E_M7	0.0E+00	7.2E-25	0.0E+00
[illegible] M8	1.4E-11	[illegible]	[illegible]
[illegible] M9	1.4E-11	[illegible]	[illegible]
[illegible] M10	[illegible]	[illegible]	0.0E+00
255 M11	9.6E-18	0.0E+00	0.0E+00
[illegible] M12	1.1E-17	[illegible]	[illegible]
261 E_M12	0.0E+00	4.7E-20	0.0E+00
265 M13	1.7E-17	0.0E+00	0.0E+00
266 E_M13	0.0E+00	2.7E-15	0.0E+00
[illegible] M14	[illegible]	[illegible]	[illegible]
271 E_M14	0.0E+00	2.5E-18	0.0E+00
275 M15	1.6E-14	0.0E+00	0.0E+00
276 E_M15	0.0E+00	1.7E-14	0.0E+00
TOTAL POWER	[illegible]	1.8E-12	[illegible]