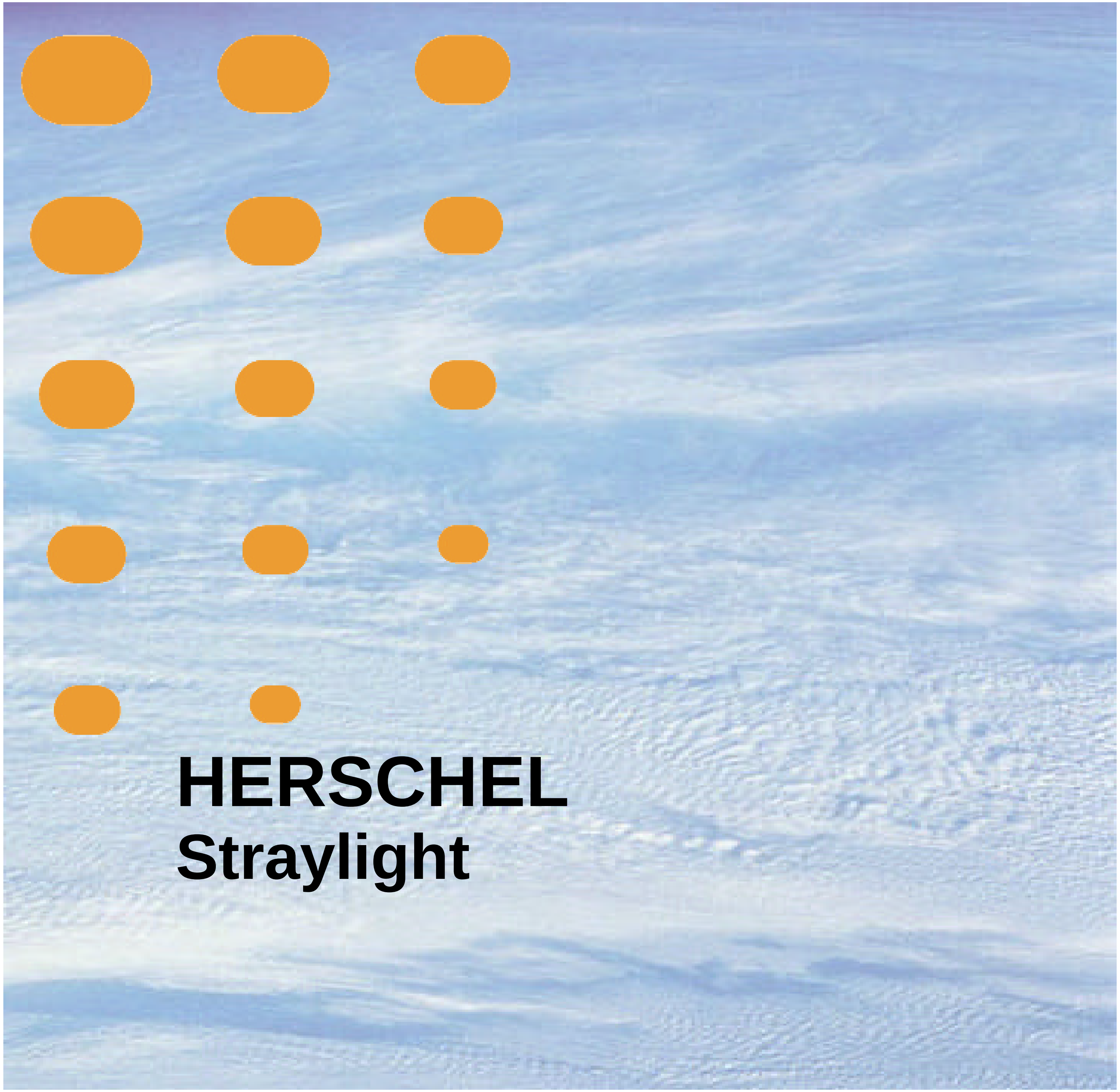

HERSCHEL
Straylight

Quarterly Progress
Meeting 16
15.-18. July 2003

HP-2-ASED-HO-0050

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ASAP models: Changes in large model since OSWG October 2002

sunshade model:

- enlarged sunshade introduced

telescope model:

- new mirror scattering function
- new hexapod barrel inclinations (support by V.Kirschner)

cryostat model:

- some minor dimensional changes due to consistent recalculations
  warm⇔cold   ambient pressure⇔vacuum
- some dimensional changes due to thermal optimizations, e.g. shorter instrument shield tube

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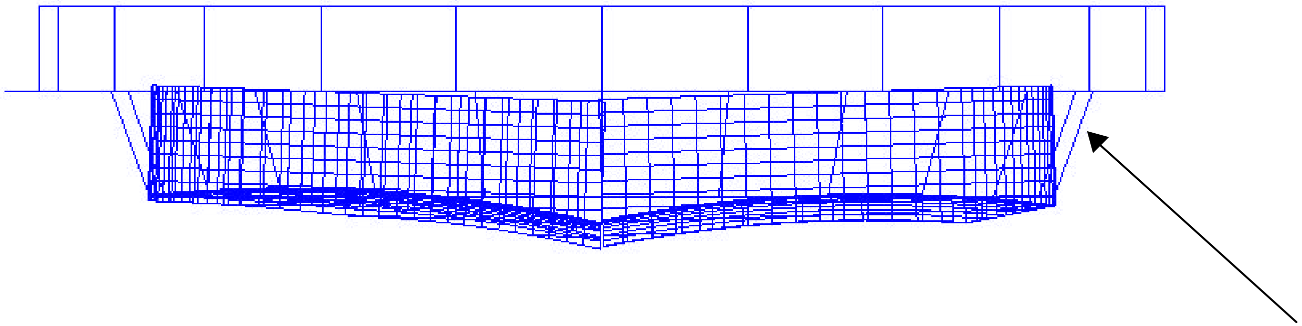
ASAP models: Changes in large model since OSWG October 2002 (cont'd)



- some emissivity changes due to thermal optimizations, short cone of cryocover closure now is black (probably black anodized, emissivity at scientific wavelengths ≈0.5), instrument shield is reflective

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ASAP models: Changes in large model since OSWG October 2002 (cont’d)

SPIRE model:

- new reflectivities and scattering functions for FP unit (i.e. entrance box, now being more absorbing than before)
- new scattering function for thermal filter 1 (very recently, only a fraction of results obtained so far are based on the new scattering function), the new scattering function resembles that of a rough mirror.

PACS model:

- N. Geis suggested the inclusion of new commands for all PACS Mirrors in the model, also the calibration mirrors are included now (ASAP commands set by ASED based on data tables from N. Geis).

Two auxiliary models created (not included in the large model)

- model for objects below the gap between sunshade and M1
- model for thermal shields from LOU windows to the cryostat opening.

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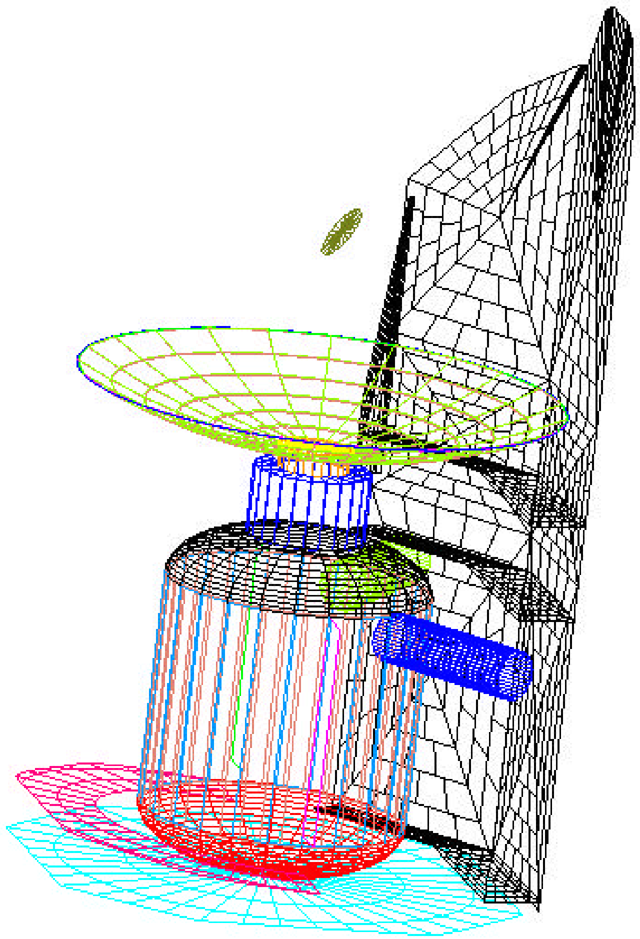

Separate model for objects below the gap between sunshade and M1

result: the gap has a radiation with an apparent emissivity of 0.10 at T=204 K, i.e. grey instead of black

reasons:

- open directions to cold space
- some temperatures below 204 K

⇒ results for straylight from the gap (of october 2002) are reduced considerably (by 0.1/0.9),
both scatter and diffraction results are reduced to below 1%

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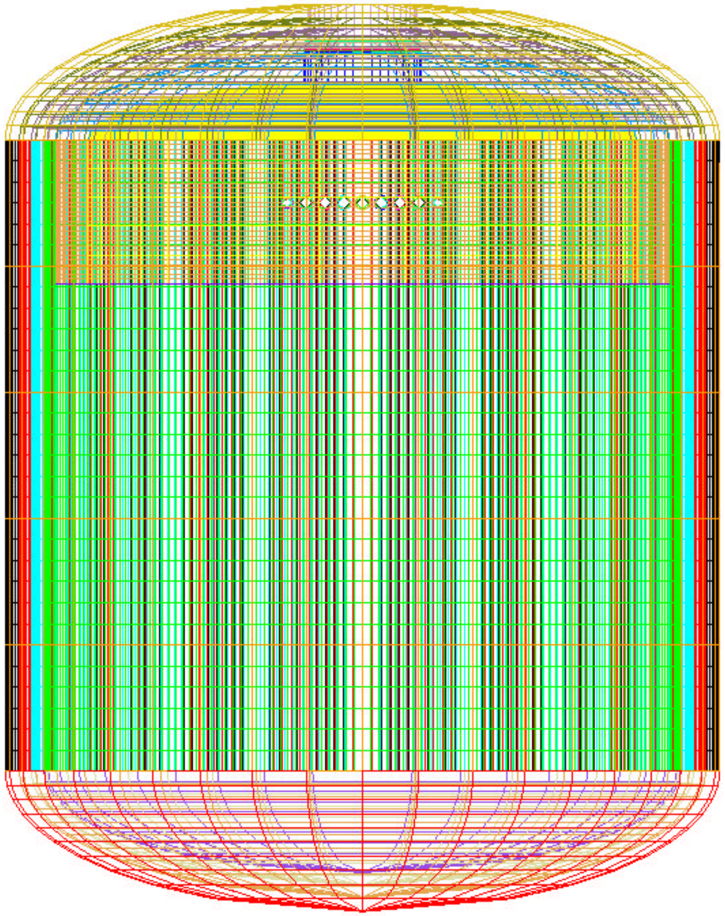

Separate model for thermal shields from LOU windows to the cryostat opening

Simulation of ray transport by a roughness random parameter of size 0.02 radian
(for tubes and top spheres only, not for bottom spheres and for LOU baffles).
This parameter slightly changes the ray direction from pure specular reflection

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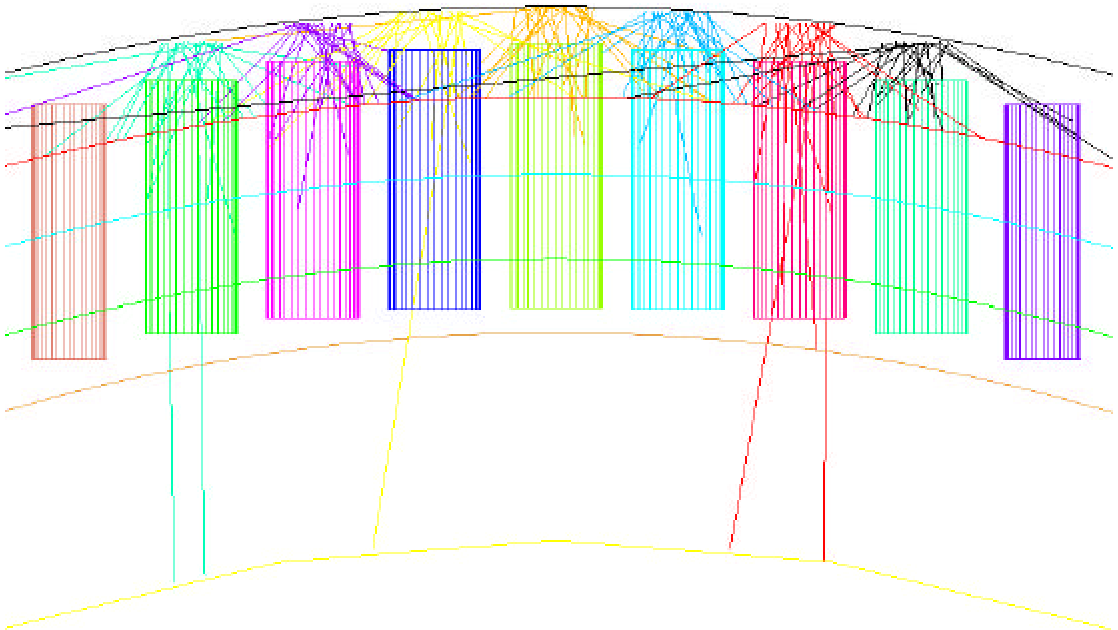

Details around the LOU windows for the preceeding model.
The different spheres from top to bottom are CVV, thermal shields 3, 2, 1, instrument shield and instruments (in a curved approximation)

Results for the radiation transport through the shields: negligible

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Requirements

a) Requirement on sources inside the FOV: compliant according to ASEF analysis.

b) Requirement on straylight from external sources (outside FOV):

Emitting Object	PACS	SPIRE	COMPLIANCE [2)]
Moon at 13 degrees	8.7E-04	5.0E-04	yes/no
Earth at 23 degrees	4.1E-03	1.8E-03	yes/no

[2)] Requirement: <1% of thermal self emission of both reflectors

Non-compliance – Moon within allowed solid angle at some specific directions:
factor 17 above requirement due to reflections on hexapod structure
(worst case – Moon bright zone, 80µ)

c) Requirement on self emission: <10% of thermal self emission of both reflectors, see next slides.

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Diffraction calculations

---Diffraction at a rim within a pupil plane

expected distribution on detector planes: fairly homogeneous

most important case:

- source is the gap near the sunshade.
- diffraction at the rim of the secondary mirror.

---Diffraction at a rim within an image plane

expected distribution on detector planes: steep increase from center to rim

most important case:

- sources are the warm objects during ground testing (CVV, gap etc.)
- diffraction at the rim of rectangular opening/filter in the telescope focal surface.

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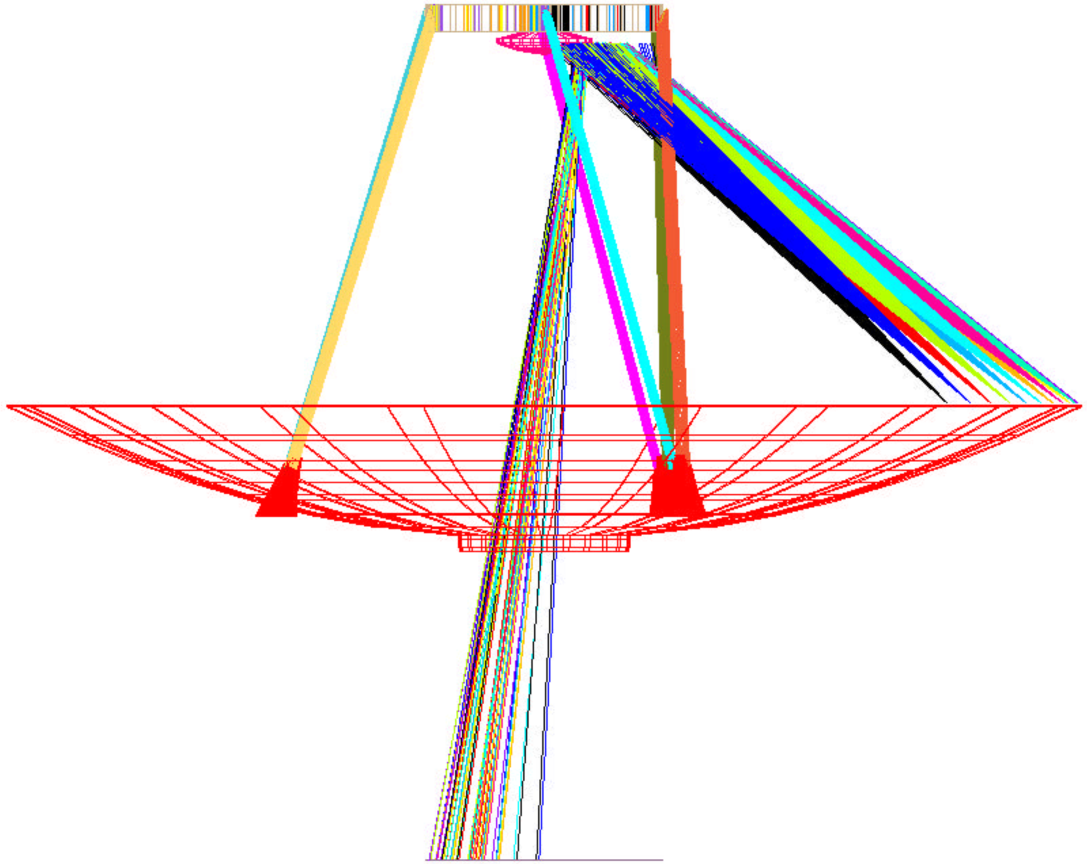

Diffraction at the rim of the secondary mirror.

Beams used for the calculation are shown.

Source is the gap near the sunshade

Calculation of irradiance in the telescope focal surface with ASAP's coherent module

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Results for diffraction at the rim of the secondary mirror,
source is the gap near the sunshade (orbit case).

The diffraction is somewhat higher for the long wavelength end of SPIRE.

	SPIRE	PACS
	at Z=-90 mm	at Z=+80 mm
earlier results october 2002 (ε=0.9)	5%	4%
corrected with emissivity reduction 0.9→0.1 from auxiliary model	0.55%	0.44%

Data for PACS and SPIRE are in %
with 100%= telescope irradiation (70 K, total ε=0.03)

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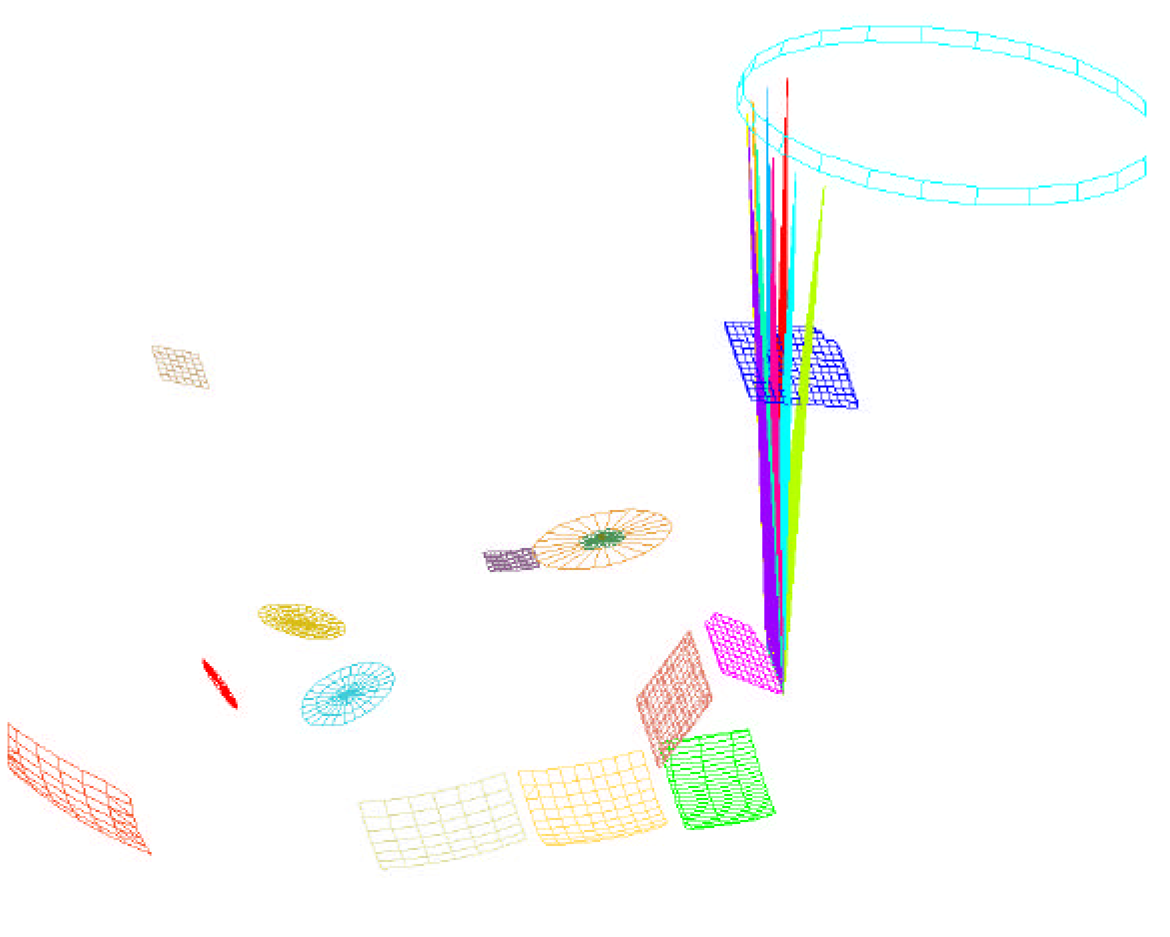

Diffraction on rim of thermal filter 1 of SPIRE (within telescope focal surface),
sources are CVV and objects nearby during ground testing, i.e. with warm rings = worst case

STEP 1:
--calculation of irradiance onto thermal filter 1 (shown schematically on the left)

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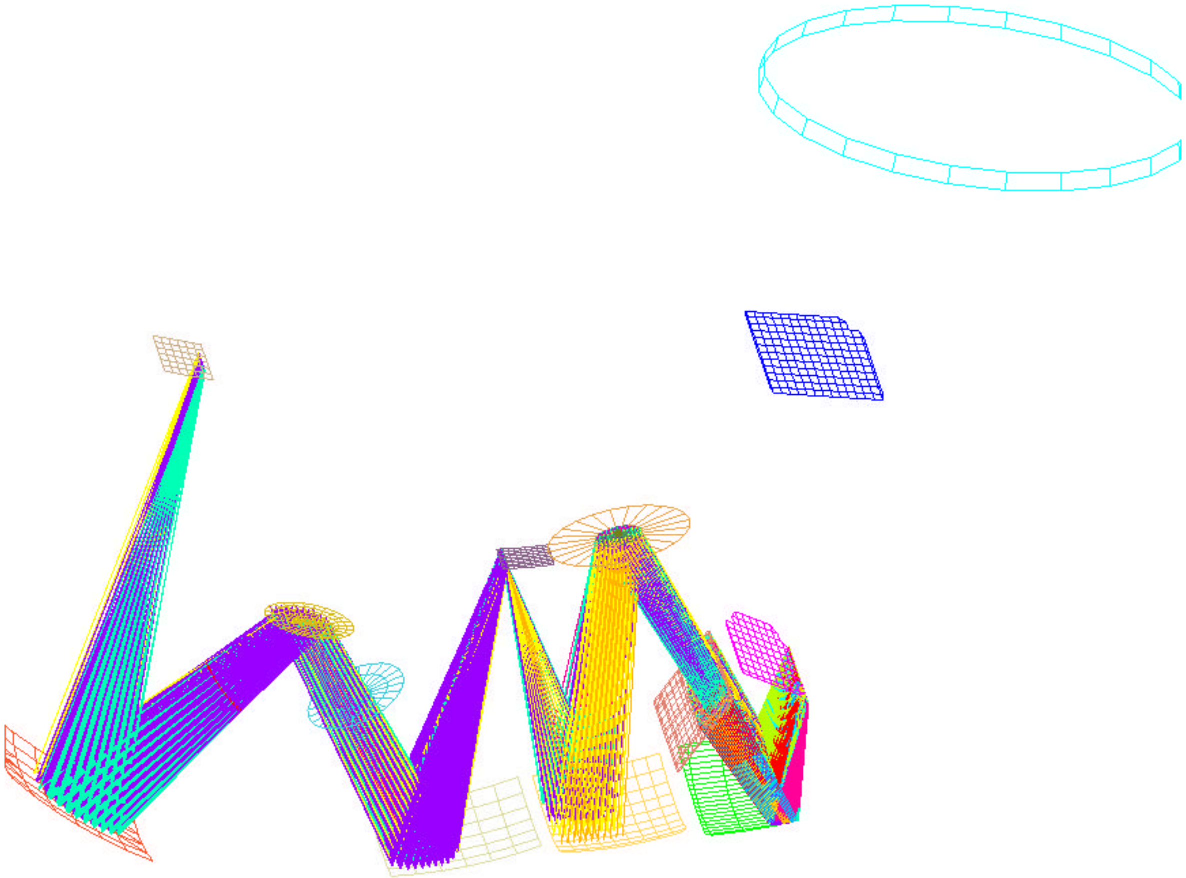

STEP 2:
--diffracted rays created at the rim of thermal filter 1
-- ray directions and fluxes as from method of stationary phase
-- flux of diffracted rays collected on detector

calculational problem:
rays converge outside rims of M6 and detector (by design)
⇨M6 and detector enlarged, the collected flux is an overestimation
⇨step 3

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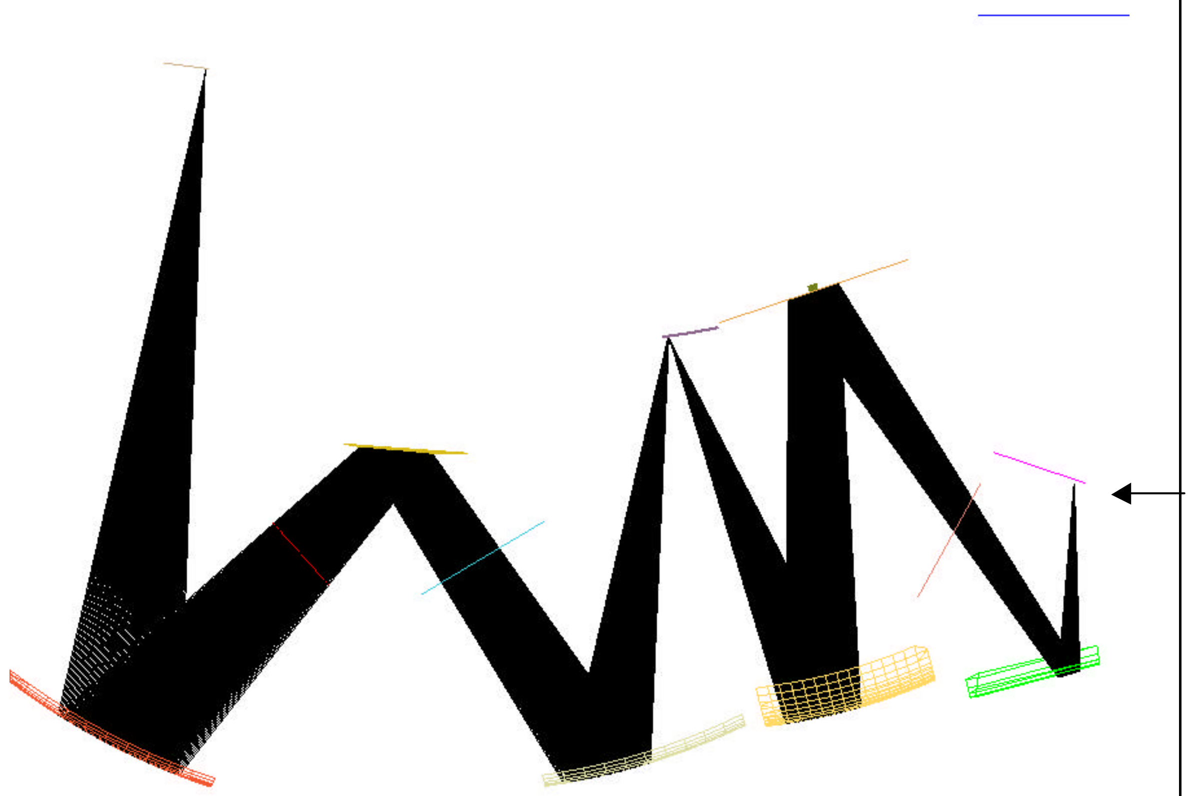

	STEP 3: -- point sources created within rim of thermal filter 1 with an offset value -- ASAP's coherent module used for finding the diffraction spread for the imaging from filter 1 to the detector offset the rays on the detector are shifted by a scaled offset value ⇨spreaded image on the detector with correction for the offset

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Results for diffraction at a rim within an image plane, ground testing

emitting object	CVV (293K, ε=0.05)		gap (293K, ε=0.5)		black cone (70K, ε=0.5)	
diffraction at a single rim of thermal filter 1 of SPIRE						
irradiance onto detector	230 µm	670 µm	230 µm	670 µm	230 µm	670 µm
maximum	0.0926	0.7949	0.0211	0.1812	0.1934	2.1276
average	0.0033	0.0379	0.0008	0.0086	0.0069	0.1015
minimum	0.0000	0.0003	0.0000	0.0001	0.0000	0.0008
diffraction at a single rim of PACS input (plane of rearview mirrors)						
irradiance onto detector	80 µm	230 µm	80 µm	230 µm	80 µm	230 µm
maximum	smaller than for 230 µm	0.0070	smaller than for 230 µm	0.0875	smaller than for 230 µm	0.0208
average		0.0003		0.0042		0.0010
minimum		0.0000		0.0000		0.0000

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03)

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Summary for diffraction at a rim within an image plane

The irradiances listed in the preceeding table actually occur at 4 sides of the detector (not only the one shown in the graph). The corresponding average values still are negligibly small.

This is also true, if another diffracting edge is taken into account (e.g. the input edge of SPIRE, the input edge of PACS). Although the diffraction effect varies from edge to edge, there is enough margin for that statement. Not all edges contribute appreciably to diffraction, since not all are irradiated by strong sources.

So, in general, the diffraction at edges close to the experiment openings are considered to have no appreciable effect.

Exception: For SPIRE the increase of irradiance towards the detector rim is not negligible at the longest wavelengths, there an appreciable rim of 3…10% has to be expected.

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Summary for diffraction at a rim within an image plane (cont'd)

The irradiances for the orbit case are reduced (compared to those shown for the ground testing), since the sources are colder.

All statements above rely on the condition that the detectors do not have a view onto those edges which are irradiated appreciably (near experiment openings). Misalignments (also within experiments) must not destroy this avoidance.

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Self emission onto PACS/SPIRE detectors, small scattercone, pessimistic case

emitting object	temperat.	emiss.	PACS	SPIRE
sunshade	204 K	0.05	1.863	0.801
gap between sunshade and M1, scattered	204 K	0.10	0.189	0.091
gap betw. sunsh. and M1, diffracted on M2 rim	204 K	0.10	0.444	0.556
hexapod (ASEF analysis)	70 K	0.02	4.34	4.34
M1+M2 via hexapod (ASEF analysis)	70 K	0.015	7.54	7.54
scattercone (ASEF analysis)	70 K	0.015	0.62	0.62
M1 baffle flat + cone / cylinder	75 K	0.05	4.821	1.570
M1 baffle gap (12 mm) between cone / cylinder	75 K	0.90	1.511	0.324
cryocover mirrors	75 K	0.05	0.663	0.025
other reflecting parts of cryocover	75 K	0.05	0.067	0.020
short black cone of cryocover	75 K	0.80	1.714	0.242
reflecting objects near cryocover	75 K	0.05	0.454	0.068
black slits around and below cryocover and M1-baffle	75 K	0.90	2.436	0.362

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03)

Herschel Straylight

Self emission onto PACS/SPIRE detectors, small scattercone, pessimistic case (continued)

emitting object	temperat.	emiss.	PACS	SPIRE
CVV plate top	75 K	0.05	1.212	0.076
gap between CVV and thermal shield 2 baffle	60 K	0.90	0.290	0.080
thermal shield 2 baffle	43 K	0.80	1.775	2.247
instrument shield baffle	12 K	0.05	0.002	0.002
gap betw. instr. shield baffle and instruments	12 K	0.90	0.075	0.033
LOU windows via HiFi	150 K	0.90	0.05	0.04
LOU windows via gaps between CVV and thermal shield 2 baffle instrument shield and instruments	150 K	0.90	0.226	0.020
SUM			**30.3**	**19.1**

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03).
Requirement is 10%

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Self emission onto PACS/SPIRE detectors, small scattercone, optimistic case

emitting object	temperat.	emiss.	PACS	SPIRE
sunshade	155 K	0.015	0.361	0.174
gap between sunshade and M1, scattered	204 K	0.08	0.151	0.073
gap betw. Sunsh. and M1, diffracted on M2 rim	204 K	0.08	0.356	0.444
hexapod (ASEF analysis)	70 K	0.015	3.25	3.25
M1+M2 via hexapod (ASEF analysis)	70 K	0.015	7.54	7.54
scattercone (ASEF analysis)	70 K	0.015	0.62	0.62
M1 baffle flat + cone / cylinder	64 K	0.015	1.138	0.391
M1 baffle gap (5 mm) between cone / cylinder	64 K	0.90	0.495	0.112
cryocover mirrors	64 K	0.015	0.209	0.008
other reflecting parts of cryocover	64 K	0.015	0.016	0.005
short black cone of cryocover	64 K	0.50	0.843	0.126
reflecting objects near cryocover	64 K	0.015	0.107	0.017
black slits around and below cryocover and M1-baffle	64 K	0.90	1.917	0.301

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03)

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Self emission onto PACS/SPIRE detectors, small scattercone, optimistic case (continued)

emitting object	temperat.	emiss.	PACS	SPIRE
CVV plate top	64 K	0.015	0.286	0.019
gap between CVV and thermal shield 2 baffle	55 K	0.90	0.251	0.072
thermal shield 2 baffle	40 K	0.50	0.965	1.280
instrument shield baffle	12 K	0.015	0.001	0.001
gap between instr. shield baffle and instruments	12 K	0.90	0.075	0.033
LOU windows via HiFi	136 K	0.90	0.05	0.04
LOU windows via gaps between CVV and thermal shield 2 baffle instrument shield and instruments	136 K	0.90	0.191	0.017
SUM			**18.8**	**14.5**

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03).
Requirement is 10%

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Self emission onto PACS/SPIRE detectors with closed cryocover, without diffraction

emitting object	temperat.	emiss.	PACS	SPIRE
CVV	295 K	0.05	0.007	0.759
gap between CVV and thermal shield 2 baffle	295 K	0.50	0.042	0.484
short black cone of cryocover	75 K	0.50	0.134	5.748
thermal shield 2 baffle	50 K	0.80	0.137	0.695
gap betw. instrument shield and instruments	12 K	0.90	0.014	0.084
LOU/CVV via space below instrument shield	295 K	0.90	0.173	0.048
SUM			**0.51**	**7.8**

Data for PACS and SPIRE are in % with 100%= telescope irradiation (70 K, total ε=0.03)

Remarks: The short black cone of cryocover recently changed from reflecting to black anodized due to thermal reasons.

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Trade-off for emissivity of short cone of cryocover

Predicted Interface Temperatures for Ground Test

.	SPIRE L1	PACS L1	HIFI L1	SPIRE L3
temperature with black short cone of cryocover	6.7 K	6.6 K	4.8 K	8.1 K
temperature increase with reflecting short cone of cryocover	+1.5 K	+0.9 K	+0.3 K	+0.4 K

(L0 does not change appreciably)

	orbit		ground test	
	SPIRE	PACS	SPIRE	PACS
straylight with black short cone of cryocover	19.1%	30.3%	7.8%	0.51%
straylight decrease with reflecting short cone of cryocover	-0.2%	-1.5%	-5.1%	-0.12%

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Waivers to be raised on:

- Requirement on straylight from external sources (outside FOV)
- Requirement on self emission.

Straylight requirement values are relative to telescope emission.

Proposal (agreed on OSWG meeting in June) :

Adherence to 'reference telescope' used earlier in the analyses, i.e. temperature 70 K, emissivity 0.015 for a single reflector (total 0.03).

Advantage:

Easy comparison with earlier analyses

Waiver has a fixed basis

Avoidance of apparent straylight 'changes' parallel to actual telescope changes.

The analysis will present multiplication factors for varying temperatures and emissivities of the telescope, i.e. supply the reader with data allowing for different telescope properties.

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Request from HIFI for a conical baffle shape within the center of M1 (instead of a plane ring)

--- not included in the calculations since raised very late

--- discussion with straylight specialists (ESTEC, Alcatel) on next actions only just started.