MINUTES OF MEETING

Herschel / Planck Project

date	4 July 2003	reference	SCI-PT/18857	page	1/15 + 7 annexes
meeting date	24 June 2003	meeting place	Astrium-EF – Toulouse - France		
chairman	D. de Chambure (ESA /ESTEC)				

participants
J. Fischer (Naval Research Laboratory – Washington D.C. - USA)
A. Marti Polegre (ESA /ESTEC– Noordwijk - NL)
G. Pilbratt (ESA/ESTEC – Noordwijk - NL)
V. Kirchner (ESA /ESTEC– Noordwijk - NL)
D. Beintema (SRON- Groningen -NL)
M. Ferlet (RAL – Chilton - UK)
A. Frey (ASED – Friedrishafen - D)
E. Hoelzle (ASED - Friedrishafen - D)
P. Martin (Alcatel – Cannes – F)
Y. Toulemont (ASEF – Toulouse – F)

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subject **MoM of Herschel Optical System Working Group No. 8**
ASEF– 24 June 2003

description	action	due date
A. **Agenda** – see annex 1		
B. **Herschel Telescope Status** See ASEF presentation in annex 2 Major event coming soon is the brazing of the Primary Mirror (M1) due to take place end of this week → in the mean time carried out. Results will be available by July 5, 03. Polishing is under qualification at Opteon. Herschel telescope is on-time for delivery before March 2005, as requested by the Project.		

Work has been initiated with CSL for the cryo-optical testing (with Focal XXL development).

M2 mirror is also under production at Boostec. It will be then delivered to Zeiss for polishing. Zeiss has developed since 6 months a polishing process for this mirror.

C. Review of actions of previous meeting

None = all closed

D. Herschel standing waves

See A. Marti Polegre presentation in annex 3

The analysis work presented is a summary of the technical note released two weeks ago by A.M.P. The content of his presentation was as follows:

- Reminder of problem
- Input used (HIFI band 1 (lowest frequency)) with
  - Gaussian taper feed horn (theoretical) or with side lobes (realistic)
  - on-axis or off-axis feed
- Analysis results for first elements (cavities; instrument baffle and heat shield 2; scattering cone; barrel radial bars).

The model has been simplified with just one horn to the satisfaction of all specialists.

The coupling factor of the feed with the entrance baffle cavity is very low for all cases (on-axis or off-axis feed - Gaussian or realistic feed) i.e. below –100 dB → no concern. .Since the calculated coupling factors are *very* sensitive to the feed patterns used, 'Gaussian' or 'realistic' (180 dB higher for 'realistic' feed for on-axis and 50 dB higher for off-axis), GP asked for reassurance from DB that the 'realistic' pattern was 'realistic enough': DB felt it was.

The coupling effect of instrument baffle with the feed is also very low i.e. below –100 dB → no concern.

description	action	due date

Coupling due to sub-reflector surface (M2): the analysis shows that the scattering cone surface (spherical) is the best compromise with respect to a design with no scattering cone or a parabolic shaped scattering cone: -76 dB compared to –50 dB for on-axis feed. The difference is mainly explained by the fact there is a better cancellation of overall coupling when the coupling of the scattercone and that of M2 are comparable in magnitude (which is the case for the baseline cone, and not for the parabolic cone.

NB: Parabolic shape of scattercone is better than spherical as standalone element i.e. without including M2. But, on a stray light point of view, a parabolic scatter cone would be extremely poor, as paths from the hot sunshade to the instruments would be opened.

For the coupling with the hexapod structure, AMP didn't have time to complete the analysis. Therefore, for the barrel of the hexapod structure, only the case with radial horizontal bars (i.e. not tangential bars) has been analysed for the moment (with realistic feed case → no theoretical case taken into account).

Two coupling paths have been analysed:

- path1 : feed → barrel → feed
- path 2 : feed → M2 → M1 → barrel → M1→ M2 → Feed

Path 2 is much worse then path 1 :

- for path 1, the computed coupling of one horizontal barrel is –123.7 dB for on-axis feed
- for path 2 (with no scatter cone), the computed coupling for on-axis feed is –62 dB (not the case for Herschel) and is in the range of [–88 -93 dB] for the off-axis feed (for 6 barrels)
- for path 2 (with scatter cone), the computed coupling for off-axis feed increases and is now in the range [–65 –83 dB], due to rays missing previously M1 but reaching it now via the scatter cone.

This result is at the limit of the recommended value of –65 dB but will definitely be improved (less coupling) when doing the analysis with tilted radial bars.

The work remaining to be done by AMP is listed below:

- coupling through path: feed → M1 central cone → M2 → feed or feed→ → M2 → M1 central baffle→ feed
- frequency dependence of the scattering cone + sub-reflector in band 1
- complete analysis of barrel structure with tilted bars (radial + tangential) in band 6-L (feed on-axis).

description	action	due date
As conclusion, the coupling between the HIFI signal to the CVV elements (baffles) and to the M2 mirror with scattercone is not a problem. For the M2 hexapod structure (barrels), the coupling looks "compliant" with the HIFI recommended values but this should be confirmed with the final analysis (incl the critical on-axis band 6-L feed) to be carried out in the summer period with the comments provided below by D.Beintema.		
HIFI presentation (D. Beintema) - see annex 4		
D.B. reminds that there is still no formal requirement agreed on standing wave in the IID-B.		
In general, D.B. claims that his results are in agreement with the ones of Estec (AMP): some minor comments have been sent to A.M.P directly.		
DB has looked in detail to the following sources of coupling: scattercone and M2 rim edge→ both effect are strongly frequency dependant (band 6 is on-axis - all other feeds are off-axis).		
The scatter cone coupling is found to be at –70 dB at 400 GHz and –100 dB at 1800 GHz. (drop 12 dB per octave)		
The coupling with M2 rim (assumed to be a 45 degree chamfer with a width of 0.2 mm) is found to be at –70 dB for all frequencies (slight drop 6 dB per octave). The M2 rim design assumptions of HIFI are correct according to ASEF and their documentation (see ASEF document referenced HER.NT.0286.T.ASTR).		
In total, the coupling level due to M2 sub-reflector is found to be in a [–65-85 dB] range at 480 GHz (worst case frequency) → NB: strong frequency dependence.		
HIFI is also raising a newly discovered concern with the M1 central baffle (i.e. more exactly gap between M1 mirror and central baffle upper flat part, the inner edge at a diameter of 500 mm and the flatness and orientation of the upper part → discontinuities), which is in view of HIFI detectors. Coupling resulting from this baffle could go from –65 dB at 480 GHz to –75 dB at 1800 GHz, assuming perfectly geometric and optical surface.		
Some discussion occur on the flat (upper) surface of the M1 central baffle closed to the optical beam, which could create large amount of standing waves: a conical shape (5 deg +/- 1 deg inwards from horizontal – center higher than edge) of this flat part will drastically improve the situation according to specialists but the improvement couldn't be quantified exactly. This would correspond to an increase of 2.5 mm at center.	A1 – ASED to confirm that new design is acceptable wrt stray light	Closed by ASED and HIFI e-mail in the mean time
NB: At that position (radius 250 mm), the M1 parabola slope angle is about 4 degree (inverse direction).		
With this slight modification, no impact on stray light expected: ASED will		

description	action	due date
check that no opening path is created to sunshield-sunshade. In an e-mail sent after the meeting by ASED (AF) -see extract below-, the hypothesis has been confirmed:		
If I set a cone angle of 6 degrees (zero degree is a 'cone' identical to the flat ring planned up to now), then there are some marginal view directions from SPIRE leading to views approaching (but not touching) the sunshade. So I suggest that a cone angle of 6 degrees be an absolute upper limit, which must not be exceeded. ASEF should lower this cone angle as much as they expect for the angular inaccuracies of their Kapton foil, thus a lower nominal value should be set.		
Therefore, in view of the above, it is decided by the H/P Project to give an upwards angle of 3.5 deg +/- 2 deg for the upper flat part of the M1 central baffle. In a later e-mail from DB (attached below), the above assumptions have been found to be correct:		
• 0 degrees tilt: single baffle rim: 6 dB less than the M1 rim reflection worst-case total of M1 + 2 baffle rims: 6dB more than M1 alone • (0-2) degrees tilt: single rim -3.5 dB, worst case total. +7.3 dB • (3.5-2) degrees tilt: single rim -7.5 dB, worst case total. +5.3 dB • 3.5 degrees tilt: single rim -8.7 dB, worst case total. +4.9 dB • (3.5+2) degrees tilt: single rim -10.6 dB, worst case total + 4.0 dB.		
<u>Conclusion</u>: the tilt helps, 3.5 degree nominal is a reasonable improvement, the effect is not too sensitive to the actual tilt angle.		
With respect to the hexapod design, according to HIFI, the total horizontal surface of 8 % (out of the total hexapod area facing M1 corresponding to 495 cm2) would be unacceptable, corresponding to a coupling of -22 dB. For HIFI, horizontal surface equivalent to 50 cm2 with a 0.5 dB taper will create standing waves in the order of –61 dB level. The amount of standing wave is going with the root square of the horizontal surface: if the amount of horizontal surface is reduced down by a factor 2, the standing waves level will be decreased by a factor of –6 dB. ASEF will do their best effort to have this values reduced to 20-30 cm2.		
Some discussions occur on the fact that the HIFI measurements need stability for a certain minimum duration (few minutes tbc) and therefore the coupling phenomena should be compared with the stability of the telescope and the CVV (predicted to be in hours and even days) in operation conditions. Optical path length change will be created if temperature changes in the order of 1 Kelvin will be observed. At the date of today, only mKelvin	A2 – HIFI Check standing wave budget requirement including chopper (with time duration)	15/7/03

description	action	due date
changes are expected in this timeframe.		
J. Fisher indicates that the chopping should be taken into account into the calculation of the standing wave budget.		

ASEF presentation – see annex 2

ASEF is presenting detailed design principle for the design of the hexapod structure holding the M2 mirror with Invar shims to create tilting of surfaces (radial/ tangential bars facing M1 mirror) and possibly to break the slopes of the horizontal surfaces.

ASEF mentions one additional difficulty since the previous meeting: the hexapod structure will be illuminated in the launch phase for ½-1 hour. Indeed, the mounting of the Al Kapton thermal protection foils on the hexapod barrel bars will require using non-obvious adhesive tape solution working both at cryo and high temperatures or if not possible sewing solution.

E. **Coating emissivity measurements**

Far-IR laser Absorptivity Measurements (carried out at TU-Delft-NL)
See annex 5 presentation of J. Fisher

Principle: The emissivity of a sample is measured by recording sample temperature change when illuminated. The principle is based on the assumption that the absorptivity and the emissivity are equivalent at given temperature and wavelength and that the power incident on the sample is well known.

The samples are small and thin to record temperature changes (less thermal inertia): 14 x 14 x 0.5 mm.

The delta temperature is recorded via sensor glued on the back side of the coated sample. This test has been carried out for various frequencies (70, 118, 186 and 496 microns).

Lot of calibration work was done prior to real test (sample illumination (homogeneity) by laser; laser power; S/N ratio). S/N ratio was improved by using a Wheatstone bridge.

Preliminary results on two Herschel and one Planck samples show results very closed to theory (see table below).

description

Wavelength (microns)	Emissivity
70	0.35% +/- 0.09%
118	0.26% +/- 0.07%
186	0.31% +/- 0.08%
496	0.21% +/- 0.08%

One sample measurement campaign was disturbed by presence of humidity detected on the window of the test set-up.

Next week, complete error analysis and result comparison from different samples will be done, including re-evaluation of the sample whose measurements have been disturbed by humidity. Also, a sample contaminated with clean room contamination (5000 ppm) assumed to be also representative of fairing fall-off will be tested (emissivity).

<u>ASEF presentation – see annex 2</u>

Intermediate results of the coating validation campaign are presented by ASEF:

- Reflectivity measurements have been carried out at LEMTA (CNRS-Nancy-F) laboratory at room temperature and at 77 K on various SiC polished samples coated during the coating qualification run of the CAHA facility in March 2003. For the time being, only samples which have not yet passed the qualification environmental tests (humidity and thermal tests) have been measured. The reflectivity measurements of samples, which have seen the environmental tests, have not yet been completed
- Reflectivity tests have been carried out fully covering the Herschel 80-670 micron range, more exactly in the 30-670 micron range.
- The reflectivity measurement accuracy is claimed to be around +/- 1%.
- Results show good homogeneity for all sample locations (mirror center, edge etc..)
- The measurement method with a spectrometer shall be clarified: Total Integrated Scatter (TIS) or specular.

It is recommended to recover all the measurements in the 30-80 micron range with the spectrometer for evaluating PACS lower range and telescope thermal aspects (the eventual telescope operational temperature will depend on the emissivity at around 30-40 micron).

action	due date
AI 3- ASEF to collect 30-80 micron reflectivity data and to forward to HOWG members and to clarify measurement method	30/7/03

description	action	due date

<u>(Preliminary) conclusions</u>:

ASEF and TU-Delft emissivity measurements of the coating are in good agreement.

Emissivity values appear to be in the lower range and closer to the theory, than it was expected. Therefore, stray light levels inside the Herschel optical system will be relatively high wrt to telescope background, which will be lower by a factor 3-6 (assumptions 70 K for telescope and emissivity of 1.5 %).

See some additional explanations below (to be looked in light of section F):

The following table illustrates the relative benefit of maintaining the stray light spec of 10% of the nominal thermal telescope emission corresponding to T=70 K and emissivity of 1.5% per mirror.

Straylight levels, optical surfaces, and resulting effective emissivities, Eeff:

For the straylight level we have today, ie 30% of E=1.5% mirrors at 70 K:

- 30% wrt 70 K and 1.5% optical surfaces => 1.3x3.0% => Eeff ~ 4% - (but straylight calculations uncertain x2)
- 90% wrt 70 K and 0.5% optical surfaces => 1.9x1.0% => Eeff ~ 2%
- 180% wrt 70 K and 0.25% optical surfaces => 2.8x0.5% => Eeff ~ 1.5%

For the straylight specification, ie 10% of E= 1.5% mirros at 70 K:

- 10% wrt 70 K and 1.5% optical surfaces => 1.1x3.0% => Eeff ~ 3%
- 30% wrt 70 K and 0.5% optical surfaces => 1.3x1.0% => Eeff ~ 1.5%
- 90% wrt 70 K and 0.25% optical surfaces => 1.9x0.5% => Eeff ~ 1%

So if we hold to the stray light specification wrt nominal, we can expect a factor of 33 - 50% (for 0.5% and 0.25% emissivity mirrors) improvement in the effective emissivity and therefore the effective amount time it takes for a given set of background limited observations compared with the stray light situation as it stands today, (remembering that this level is considered accurate to within a factor of 2).
All SPIRE observations of faint sources are expected to be background limited. For PACS, broadband observations of faint sources are expected to be background limited, but probably not spectroscopic ones.

In conclusion, it is clear that being able to reduce the straylight contribution to the background seen by SPIRE and PACS would offer significant gains in scientific return of the Herschel mission.

description	action	due date

F. **Herschel stray light status**– see ASED presentation in annex 6

The work presented ASED is at an intermediate status, as the final results will be presented at the H/P QPM in the July15-18, 2003 period.

Major changes since last meeting in October 2002 are listed below:

- enlarged sunshade
- telescope model with new hexapod bars
- cryo-cover with 2 mirrors for ground testing of instruments; side of short cone of cryocover is made black
    - in favour of lower temperatures for the experiments during ground testing
    - this is a disadvantage for stray light both in orbit and during ground testing
- SPIRE ASAP model (new scattering functions introduced for the thermal filter N 1)
- PACS ASAP model (introduction of new commands in the model for all mirrors as suggested by PACS).

Additional models have been created for assessing the gap effect between the M1 mirror and the sunshade and for checking the influence of LOU windows on straylight levels on SPIRE and PACS instruments.

The gap between the M1 and sunshade has proven to have values lower than 0.5% compared to the few percent found before (reminder 100% = telescope background transmission).

For the LOU windows, the stray light levels are also found to negligible below 0.16% worst case for SPIRE at 230 microns.

Diffraction calculations:

- Diffraction at rim within a pupil plane→ fairly homogeneous distribution on the detector plane --> worst source: gap with sunshade and diffraction at M2 mirror
- Diffraction at rim within an image plane→ steep increase from center to rim on the detector plane --> worst source: warm object during ground testing and diffraction at rim of opening or filters in the instruments

SPIRE is mentioning that the apodisation factor is wavelength dependant. The results for diffraction at the rim of M2 with source being the gap near

description	action	due date

the sunshade has been decreased by a factor 10: 5% down to 0.5% (due to new detailed model -see above).

Diffraction on rim of thermal filter 1 of SPIRE (the thermal filter is in the image plane) with source being the warm CVV rim in ground testing.

Correction for offset: M6 and detector have been artificially increased in order to collect more rays for the purpose of the computation: for the calculation, this is also corrected.

For details of the calculation: see the presentation.

At 80 micron, no results obtained due to numerical problem→ no problem due to extremely low levels.

<u>Conclusion on diffraction:</u>

The opinion of the people present today is that the diffraction cases analyzed by ASED are worst case and have low contribution to the overall stray light budget with the exception of the one mentioned in the presentation (longest wavelength of SPIRE and the possible misalignment within SPIRE and PACS). In conclusion, neither the fears of PACS (N.Geiss) nor its calculation are fully understood by the stray light specialists present today. One diffraction contributor mentioned by PACS is the cryostat opening rim. It is estimated to be less detrimental to PACS than to SPIRE : the PACS beam is more "further away" from the cryostat rim than the SPIRE beam.

It is reminded that the experiment-internal alignment should ensure that illuminated rims near the experiment input are not seen by the detector, especially for illumination by hot sources (ground testing).). In case of visibility of the rims due to misalignment, a dramatic increase of straylight is to be expected.

The illuminated rims of the M2+hexapod are considered to be visible by the detector (in the straylight analysis) since it is not possible/foreseen that they are invisible by the detectors. The resulting straylight was found not important

On this subject, SPIRE (MF) is mentioning that they have currently problems manufacturing the CM3 mirror for the STM creating alignment problems, which could give stray light problems at the end.

<u>Scattered radiations</u>

Latest data with revised temperature shows no dramatic change since October 02 for the in-orbit case:

- 31.85% for PACS
- 19.36% for SPIRE.

description	action	due date
Data for PACS and SPIRE are in % with 100% for the total telescope irradiation (70 K, emissivity of 0.03). NB: Error bars on the scattering results are factors (may be 2) not percent.		
The 7.68% of structure and slits around cryocover for PACS should be clarified : the seems to be driven from on-ground testing and thermal (instrument temperature) considerations. Can it be corrected ? What is the design driver?	AI 4- ASED to clarify stray light budget for cryo-cover in-orbit conditions	15/7/03
The 12.5% is coming from stray light analysis carried out by ASEF. Results look quite high but this inherent to the telescope design with an aperture in the middle of the Primary Mirror (M1). Likely, a more complex telescope design with an off-axis design would have given better results !! It should be clarified whether this 12.5% do not take into account obscuration from hexapod structure and scattercone.	AI 5- ASEF-ASED to clarify stray light budget for telescope in-orbit conditions	15/7/03
Recommendation: The Herschel OSWG recommends that all stray light results and analysis be revisited in order to make new budgets with • optimum and nominal cases from real emissivity data of aluminized Kapton, preferably measurements • and eventually temperatures (less influencing factor). This work is strongly encouraged to identify drivers (given the importance of straylight, see conclusions section E), and for the justification of the waiver, which is intended to be presented by ASED for the straylight requirement.		
The above work shall be supported by the following actions: • check emissivity values of aluminized Kapton (from Sheldahl) used for the hexapod, including Al thickness. If possible, choose aluminized Kapton foil with the highest Al thickness in order to decrease emissivity at longest Herschel wavelength	AI 6- ASEF to check emissivity values of Kapton in Herschel range	15/9/03
• If needed, measurement of emissivity of thermal aluminized Kapton used on hexapod and M1 central baffle at Herschel wavelength (LEMTA). To be done at same time as mirror sample. • ASED to send aluminized Kapton sample to ASEF urgently for test campaign.	AI 7- ASEF to measure emissivity of Al Kapton thermal foil in Herschel range	30/7/03
Warning on result interpretation: The self-emission on PACS/SPIRE detectors with closed cryo-cover during ground testing shall be understood as follows: PACS stray light ratio will be 0.375 % extra of background		

description	action	due date
radiation instead of 30% extra for in-orbit case, if the cryocover is correctly designed i.e the cryocover is designed to match the in-orbit telescope background.		
H. **Interfaces**		
The definition of the M1 central baffle is confirmed to be the one indicated in the ASEF presentation (annex 2 p23).		
I. **Herschel alignment (reminder)**		
Latest updated results is presented by ASED. See annex 7.		
Instruments will come pre-aligned: no external alignment on instruments is possible for axial and lateral directions on the optical bench. Therefore, in the alignment budget, the bias is set to zero.		
The telescope can be axially adjusted on telescope side : 2-12 mm shims will be provided by ASEF. No lateral alignment of the telescope is foreseen. Following last interface meeting, ASEF has to check that the agreed 1 mm relaxation on the interface holes is included in the Herschel telescope budget.	Reminder of AI of last interface meeting	
LOS budgets are still being worked out by ASED: results will be presented at next QPM on July 15-18, 2003.		
Alcatel is working on the system alignment verification by videogrametry for measuring the CVV shrinkage wrt Herschel telescope during cool-down.		
J. **Thermal aspects of Herschel telescope**		
Sun illumination case - ASEF		
Work is on-going at ASEF to study the illumination case during launch phase.		
Answers to actions of Herschel telescope thermal meeting – 25/7/03 (ASEF)		
• M1-M2 max temperature gradient will be less than 1 Kelvin in operational case. A 10C axial gradient through the whole telescope		

description	action	due date
will have a defocus of 1.15 mm defocus coupled with a WFE degradation of 0.02 micron. • Transverse gradient across M1 is less than 0.1 K in steady operational case. • Time constant for going from one steady state to another as calculated by ASEF: • RT → cold cas : 10 days (S/C cool-down phase or cool-down phase after decontamination) • Cold→ hot case (in operational conditions): 50 days.	AI 8- ASEF to retrieve thermal analysis data on telescope thermal gradient during operation	15/7/03
More detailed calculations will be carried out by ASED with refined data on the thermal environment of the telescope including introduction of emissivity curve function of temperature. Results shall be presented at the QPM in July 2003. ASEF to retrieve and distribute transverse gradient data from the hot to cold case. ASEF to check that the implementation of the new electrical design is implemented in the thermal design (more harnesses) and modify the model if necessary. **- End of meeting -**	AI 9- ASEF to verify that thermal harnesses are included in their thermal analyses	15/7/03

Annex 1: Agenda of meeting

Dear all,

After some reiteration, please find the agenda for the next Herschel Telescope Optical Working Group N 8 to be held in Astrium-Toulouse on 24 June between 9:15 and 17:00 onwards. Please let me know ASAPwhether you have further agenda points.

9:15-9:30 Introduction
9:30-10:00 Herschel telescope Project status (Y.Toulemont-ASEF)
10:00-11:30 Herschel stray light status (ASED) with emphasis on:
- results with mixed cases (i.e. SPIRE old and new scattering function for the thermal filter)
- stray light LOU towards PACS and SPIRE
- status on diffraction (V. Kirschner and A. Frey)
- reminder of configuration for the analysis (with dimensions; temperature and emissivity) with confirmation of M1 central baffle interface
- NB: Please note that the objective will be to have a complete stray light analysis for the quarterly progress meeting (QPM) which will take place in July 14-18, 03. Therefore, ASED presentation of June 24 will be at sort of "intermediate" status.

11:30-12:30 Emissivity measurements of coating
- TU-Delft results with reminder on test set-up (J.Fisher)
- results obtained by ASEF

13:45-15:30 Herschel standing waves
- reminder of latest hexapod and M2 design (ASEF)
- presentation of Estec work (AMP)
- presentation (reminder) of HIFI study (D.Beintema)
- conclusions

15:30-16:30 Alignment update
- alignment budget
- alignment principle
- ITT status

16:30-17:00 Thermal aspects (ASED & ASEF)
- refinement of telescope thermal environment (ASED)
- long term transient case (cool-down after launch and decontamination) (ASED)
- influence of temperature gradient between M1 and M2 on telescope performance (ASEF)
- latest thermal design change (ASEF)

17:00-17:30 AOB and conclusions

For the time being, known participants are:

ESA	G. Pilbratt; A. Matin Polegre; V. Kirchner; G. Crone (tbc) and myself
ASEF	Y.Toulemont + support (with exception of D. Pierrot)
ASED	E.Hoelzle; A.Frey and more ??
RAL	M. Ferlet
HIFI	D. Beintema
NRL	J. Fisher.

For ESA, due to the heavy agenda, the intention is to take late plane on 23 June 03 (KL 1313) and early one (6:45) on 25 June 03 (K:1300 ?).
Foreseen hotel for ESA and others is Albert 1er (centre of Toulouse). This morning, there were still a few rooms left....

Waiting for your confirmation of participation to Yves and myself,

Kind regards,

Daniel de Chambure.

Kind regards,

Daniel de Chambure.
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Corrections suggested by ASED to the minutes

The corrections are inserted by bold characters, the text with normal characters is unchanged. Please remove the bold format before copying/inserting (the bold format shall only indicate where changes have been done).

F. Herschel stray light status– see ASED presentation in annex 6

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    - **in favour of lower temperatures for the experiments during ground testing**
    - **this is a disadvantage for stray light both in orbit and during ground testing**
- SPIRE ASAP model (new scattering function introduced for the thermal filter **no. 1**)
- PACS ASAP model (introduction of new commands in the model **for all mirrors as suggested by PACS**).

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The gap between the M1 and sunshade has proven to have values lower than 0.5% compared to the few percent found before (reminder 100% = telescope background transmission).

For the LOU windows, the stray light levels are also found to negligible below 0.16% worst case for SPIRE at 230 microns.

Diffraction calculations:

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SPIRE is mentioning that the apodisation factor is wavelength dependant. The results for diffraction at the rim of M2 with source being the gap near the sunshade has been decreased by a factor 10: 5% down to 0.5% (**due to the new detailed model,** see above).

Diffraction on rim of thermal filter 1 of SPIRE (the thermal filter is in the image plane) with source being the warm CVV rim in ground testing.

For details of the calculation: see the presentation.

At 80 micron **(PACS)**, no results obtained due to numerical problem→ no problem due to extremely low levels.

Conclusion on diffraction:

The opinion of the people present today is that the diffraction cases analyzed by ASED are worst case and have low contribution to the overall stray light budget with the exception of the ones mentioned in the presentation (longest wavelength of SPIRE and the possible misalignment ***within SPIRE and PACS****). In conclusion, neither the fears of PACS (N.Geiss) nor its calculation are fully understood by the stray light specialists present today. One diffraction contributor mentioned by PACS is the cryostat opening rim: it is estimated to be less detrimental* ***to PACS than to SPIRE, the PACS beam is more "far away" from the cryostat rim than the SPIRE beam****.*

It is reminded that the ***experiment-****internal alignment should ensure that illuminated rims* ***near the expriment input*** *are not seen by the detector, especially* ***for illumination by*** *hot sources (ground testing).* ***In case of visibility of the rims due to misalignment, a dramatic increase of straylight is to be expected.***

The illuminated rims of the M2+hexapod are considered to be visible by the detector (in the straylight analysis) since it is not possible/foreseen that they are invisible by the detectors. The resulting straylight was found not important.

On this subject, SPIRE (MF) is mentioning that they have currently problems manufacturing the CM3 mirror for the STM creating alignment problems, which could give stray light problems at the end.

Scattered radiations

Latest data with revised temperature shows no dramatic change since October 02 for the in-orbit case:

- 31.85% for PACS
- 19.36% for SPIRE.

Data for PACS and SPIRE are in % with 100% for the total telescope irradiation (70 K, emissivity of 0.03).

NB: Error bars on the scattering results are factors (may be 2) not percent.

The 7.68% of structure and slits around cryocover for PACS should be clarified : the seems to be driven from on-ground testing and thermal (instrument temperature) considerations. Can it be corrected ? What is the design driver?

The 12.5% is coming from stray light analysis carried out by ASEF.

Results look quite high but this inherent to the telescope design with an aperture in the middle of the Primary Mirror (M1). Likely, a more complex telescope design with an off-axis design would have given better results !! It should be clarified whether this 12.5% do not take into account obscuration from hexapod structure and scattercone.

Recommendation:

The Herschel OWG recommends that all stray light results and analysis be revisited in order to make new budgets with

- optimum and nominal cases from real emissivity data of aluminized Kapton, preferably measurements
- and eventually temperatures (less influencing factor).

This work is strongly encouraged for the justification of the waiver, which is intended to be presented by ASED for the straylight requirement.

The above work shall be supported by the following actions:

- check emissivity values of aluminized Kapton (from Sheldahl) used for the hexapod, including Al thickness. If possible, choose aluminized Kapton foil with the highest Al thickness in order to decrease emissivity at longest Herschel wavelength
- If needed, measurement of emissivity of thermal aluminized Kapton used on hexapod and M1 central baffle at Herschel wavelength (LEMTA). To be done at same time as mirror sample.
- ASED to send aluminized Kapton sample to ASEF urgently for test campaign.

Warning on result interpretation: The self-emission on PACS/SPIRE detectors with closed cryo-cover during ground testing shall be understood as follows: PACS stray light ratio will be 0.375 % extra of background radiation instead of 30% extra for in-orbit case, if the cryocover is correctly designed i.e the cryocover is designed to match the in-orbit telescope background.

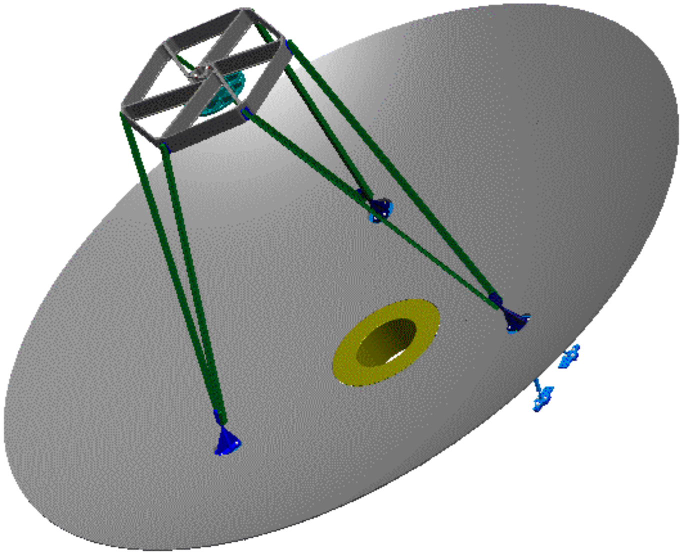
Alignment Overview

The following table summarises the achievable alignment results (based on FEM analysis) and compares the results with the requirement.

Instruments w.r.t. Telescope (95% Confidence Level)

	PACS	SPIRE	HIFI	Telescope	Remarks
Achievable X Direction System Level	5.1mm	5.0mm	7.4mm		w/o margin
Requirement					
• H-EPLM Requirement Specification	7.0mm	7.7mm	8.5mm		
• HIFI			8.5mm		2)
Instruments / Telescope Contribution					
• Uncertainty	1.0mm	0.5mm	2.7mm	4.3mm	
• Bias	0mm	0mm	2.0mm	3)	
• Thermoelastic	0.1mm	0.1mm	0.1mm	3)	
Achievable Lateral System Level	3.8mm	4.2mm	16.3mm		1)
Requirement					
• H-EPLM Requirement Specification	7.0mm	9.5mm	24mm		
• HIFI			24mm		2)
Instruments / Telescope Contribution					
• Uncertainty	0.5mm	1.3mm	10mm	1.14mm	
• Bias	0.5mm	0mm	1mm	3)	
• Thermoelastic	0.1mm	0.1mm	0.1mm	3)	

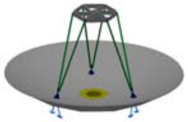
1) Pupil mismatch in M2 Plane
2) Proposed by HIFI
3) Uncertainty value includes bias and thermoelastics as agreed during HOWG Meeting, dated 11./12.06.02



HERSCHEL TELESCOPE
OPTICAL WORKING GROUP MEETING

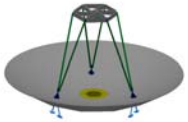
24/06/2003

ASEF presentation: Project status



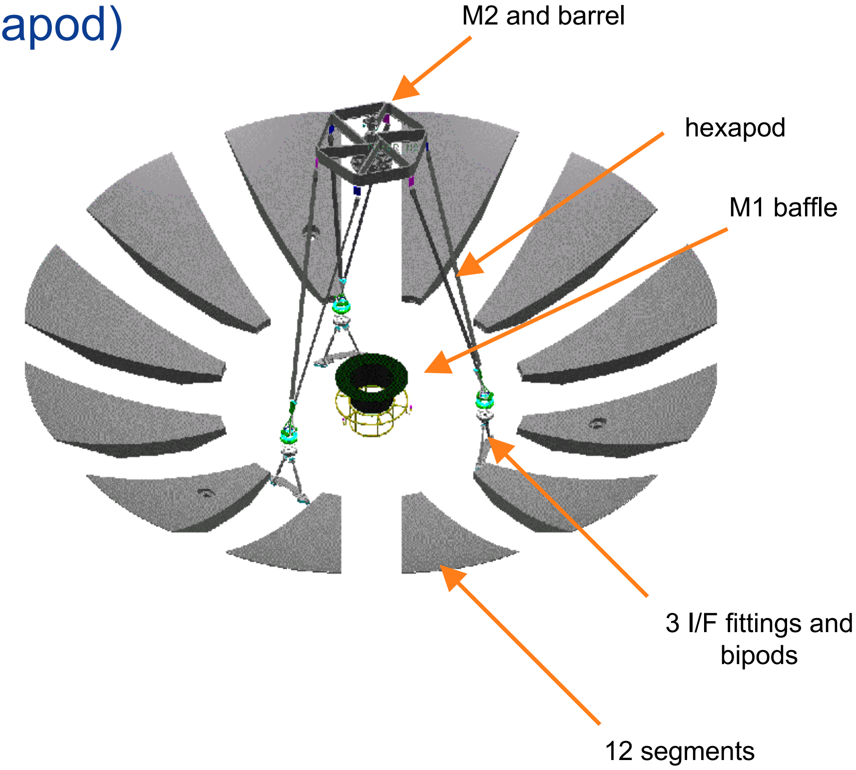
- ❑ **Project status**
- ❑ **Emissivity measurements**
- ❑ **Hexapod and M2 designs wrt stading waves**
- ❑ **Thermal aspects**
  - temperature gradient between M1 and M2
  - Design evolutions following new requirements on Sun illumination
- ❑ **Mechanical aspects**
  - M1 baffle definition

Herschel Telescope main figures

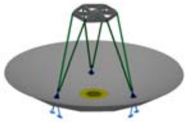


- **Main characteristics:**
  - SiC made telescope (M1, M2, barrel, hexapod)
  - Ø 3,5m primary mirror F/0,5
  - Cassegrain Telescope F= 28,5m
- **Environment:**
  - Operational temperature: 70K at L2
- **Performances:**
  - WFE < 6μ rms @ 70K
  - M= 300Kg/ F lat: 45Hz, F longi: 87Hz
- **M1 process:**
  - Assembling and brazing of 12 segments
  - Circular grinding of the whole reflector
  - Polishing, roughness= 30nm rms
  - Aluminium Coating

We are here



Herschel Telescope development status



- **Schedule:**
  - FM delivery: March 2005

- **Up to now status:**

→ M1 segments assembled, ready for brazing
→ M1 coating under qualification tests
→ M1 polishing under qualification with the Ø1,35m demonstrator

- **2003/ beginning of 2004 Events:**

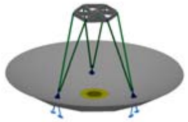
→ FM M1 brazing and grinding
→ FS M1 brazing
→ Vibrations proof-tests on M1, and hexapod/ M2

- **2004/ beginning of 2005 Events:**

→ Vibration qualification at ITS
→ Vacuum cycling and performances tests at CSL

FM segments assembling

Industrial status



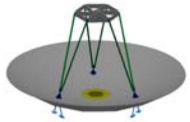
- **Technos qualifications:**
  - Mechanical technos: qualified
  - Thermal technos: in 4Q 2003
  - Electrical technos: qualified

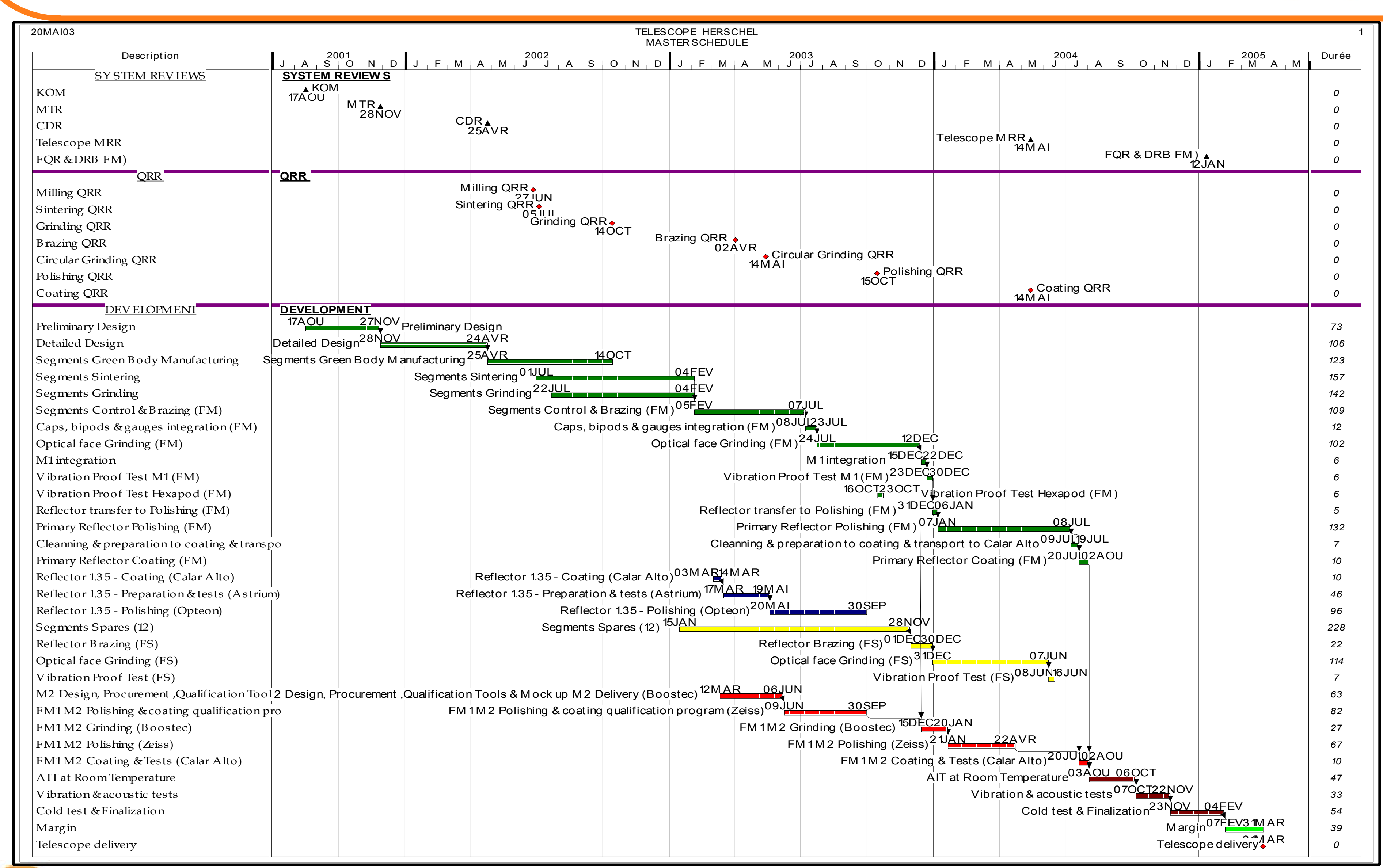
- **Process qualifications:**
  - SiC parts: qualified
  - M1 Polishing: in 3Q 2003
  - Coating: in 3Q 2003

- **Procurement:**
  - EEE parts done
  - Mechanical parts done

- **Under development:**
  - Vibration tools 3Q 2003
  - Vacuum test tools 3Q 2004

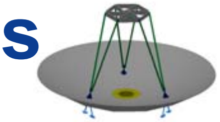
Planning - Master Schedule -





Description			Durée
SYSTEM REVIEWS			
KOM	17AOU		0
MTR	28NOV		0
CDR	25AVR		0
Telescope MRR	14MAI		0
FQR & DRB FM)	12JAN		0
QRR			
Milling QRR	27JUN		0
Sintering QRR	05JUL		0
Grinding QRR	14OCT		0
Brazing QRR	02AVR		0
Circular Grinding QRR	14MAI		0
Polishing QRR	15OCT		0
Coating QRR	14MAI		0
DEVELOPMENT			
Preliminary Design	17AOU	27NOV	73
Detailed Design	28NOV	24AVR	106
Segments Green Body Manufacturing	25AVR	14OCT	123
Segments Sintering	01JUL	04FEV	157
Segments Grinding	22JUL	04FEV	142
Segments Control & Brazing (FM)	05FEV	07JUL	109
Caps, bipods & gauges integration (FM)	08JUL	23JUL	12
Optical face Grinding (FM)	24JUL	12DEC	102
M1 integration	15DEC	22DEC	6
Vibration Proof Test M1 (FM)	23DEC	30DEC	6
Vibration Proof Test Hexapod (FM)	16OCT	23OCT	6
Reflector transfer to Polishing (FM)	31DEC	06JAN	5
Primary Reflector Polishing (FM)	07JAN	08JUL	132
Cleanning & preparation to coating & transpo	09JUL	19JUL	7
Primary Reflector Coating (FM)	20JUL	02AOU	10
Reflector 1.35 - Coating (Calar Alto)	03MAR	14MAR	10
Reflector 1.35 - Preparation & tests (Astrium)	17MAR	19MAI	46
Reflector 1.35 - Polishing (Opteon)	20MAI	30SEP	96
Segments Spares (12)	15JAN	28NOV	228
Reflector Brazing (FS)	01DEC	30DEC	22
Optical face Grinding (FS)	31DEC	07JUN	114
Vibration Proof Test (FS)	08JUN	16JUN	7
M2 Design, Procurement ,Qualification Tool	12MAR	06JUN	63
FM1 M2 Polishing & coating qualification pro	09JUN	30SEP	82
FM1 M2 Grinding (Boostec)	15DEC	20JAN	27
FM1 M2 Polishing (Zeiss)	21JAN	22AVR	67
FM1 M2 Coating & Tests (Calar Alto)	20JUL	02AOU	10
AIT at Room Temperature	03AOU	06OCT	47
Vibration & acoustic tests	07OCT	22NOV	33
Cold test & Finalization	23NOV	04FEV	54
Margin	07FEV	31MAR	39
Telescope delivery	31MAR		0

ASEF presentation: Emissivity measurements



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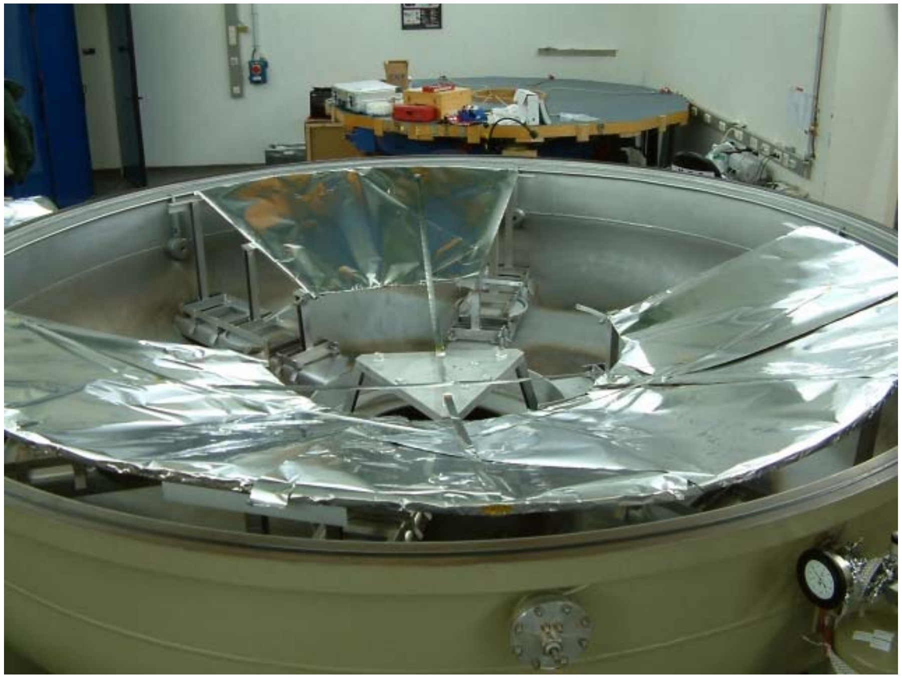
Coating Validation Campain

- CALAR ALTO

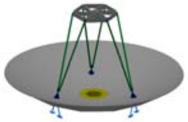
3/03/03 – 14/03/03

- Qualification run
- 1.35m Mirror Coating

1,35m and samples configuration



COATING SAMPLES : delivery status



- Coating qualification campaign performed on 03 march to 14 march
- 3 samples have been delivered to Max Plank Institute on 19/03/03:

- Q21 : located at 1750 mm in radius in the chamber. Thickness estimated to 300 nm Al + 7 nm plasil
- Q22 : located at 1250 mm in radius in the chamber. Thickness estimated to 350 nm Al + 16 nm plasil
- Q23 : located at 300 mm in radius in the chamber. Thickness estimated to 400 nm Al + 25 nm plasil

- (3 samples were also coated together in Plank run in december 2002)

COATING REFLECTIVITY MEASUREMENT

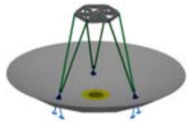
- ☐ **Lemta laboratory (University of Nancy)**
- ☐ **Spectrometer BRUCKER 66V**
- ☐ **Ambient reflectivity**
  - ✓ over [30-670 µm]
  - ✓ relative to a reference alu coated mirror

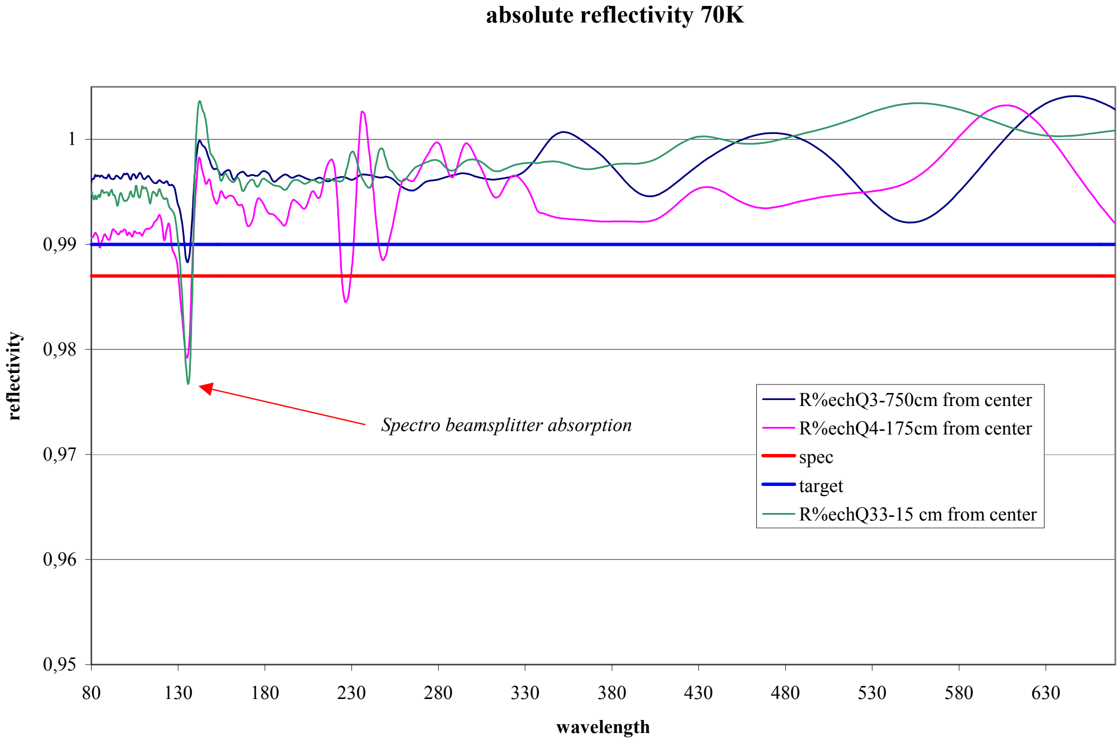
- ☐ **At 70K**
  - ✓ Liquid He Cryostat
  - ✓ Measurement of signal ratio : 70K relative to 300K reference signal inside cyostat
  - ✓ over [30-670 µm]

Alu + plasil ambient reflectivity results before environments

- Absolute reflectivity = [10 averaged measurements] x Al theoretical reflectivity
- Very good spatial uniformity of reflectivity: < 0.2% (spec 1%)
- Very good process repeatability from one campaign to the other (sample 3305 coated on september 2002).

Alu + plasil cold reflectivity results before environments





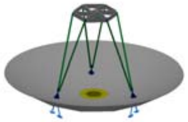
Spectro beamsplitter absorption

Absolute reflectivity 70K curve = Ambient reflectivity curves multiplied by measured signal ratio 70K/300K

Compliance to specification

Measurement Accuracy ± 0.05 on signal ratio : explains values greater than 1.

ASEF presentation: standing waves



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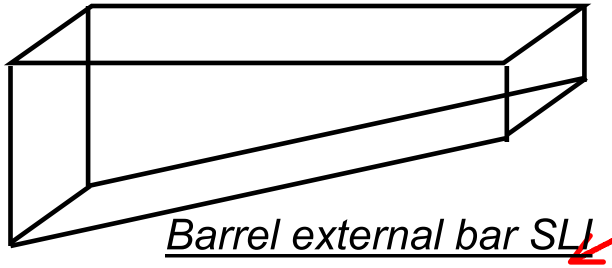
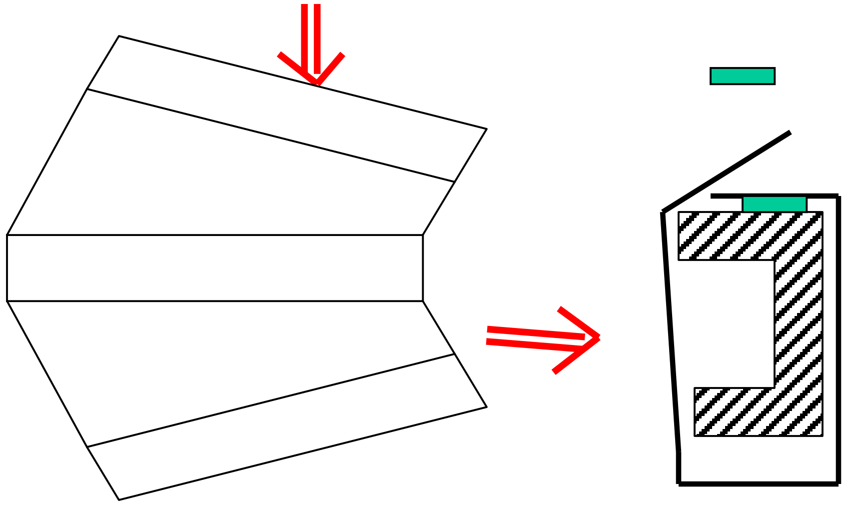
definitive barrel SLI profile

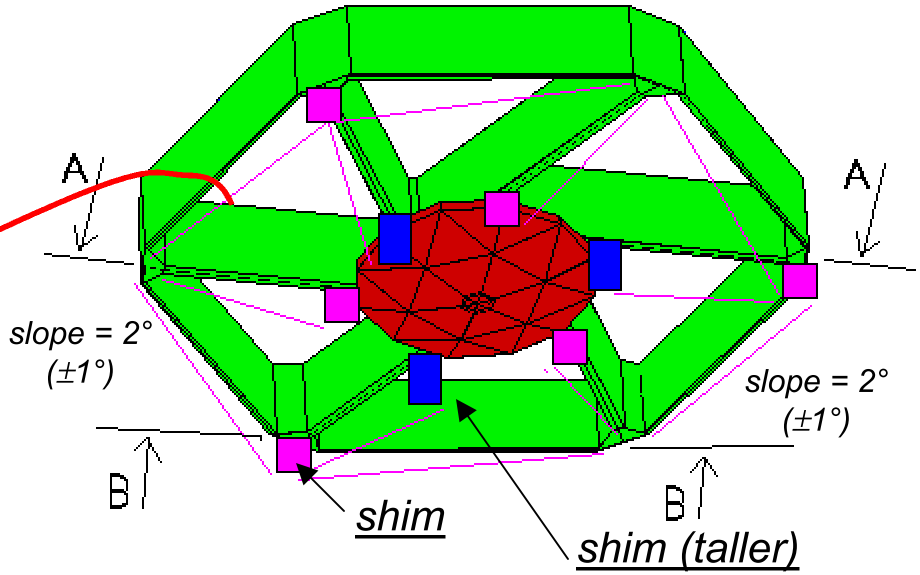
<u>This proposition</u> leads to simpler shapes of SLI foils and allows to glue the adhesive tapes directly on the SiC structure (reduced risk of over-heating during the Sun illumination).

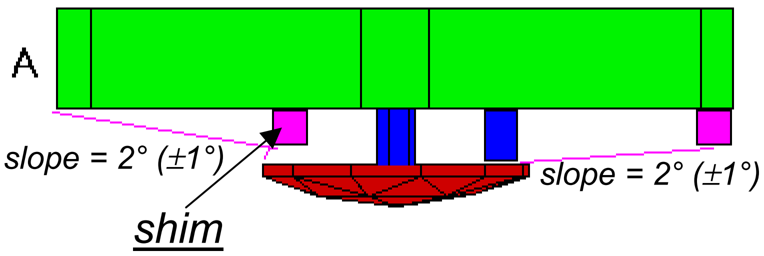


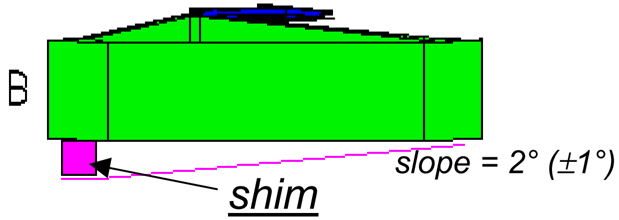
<u>Barrel external bar SLI</u>



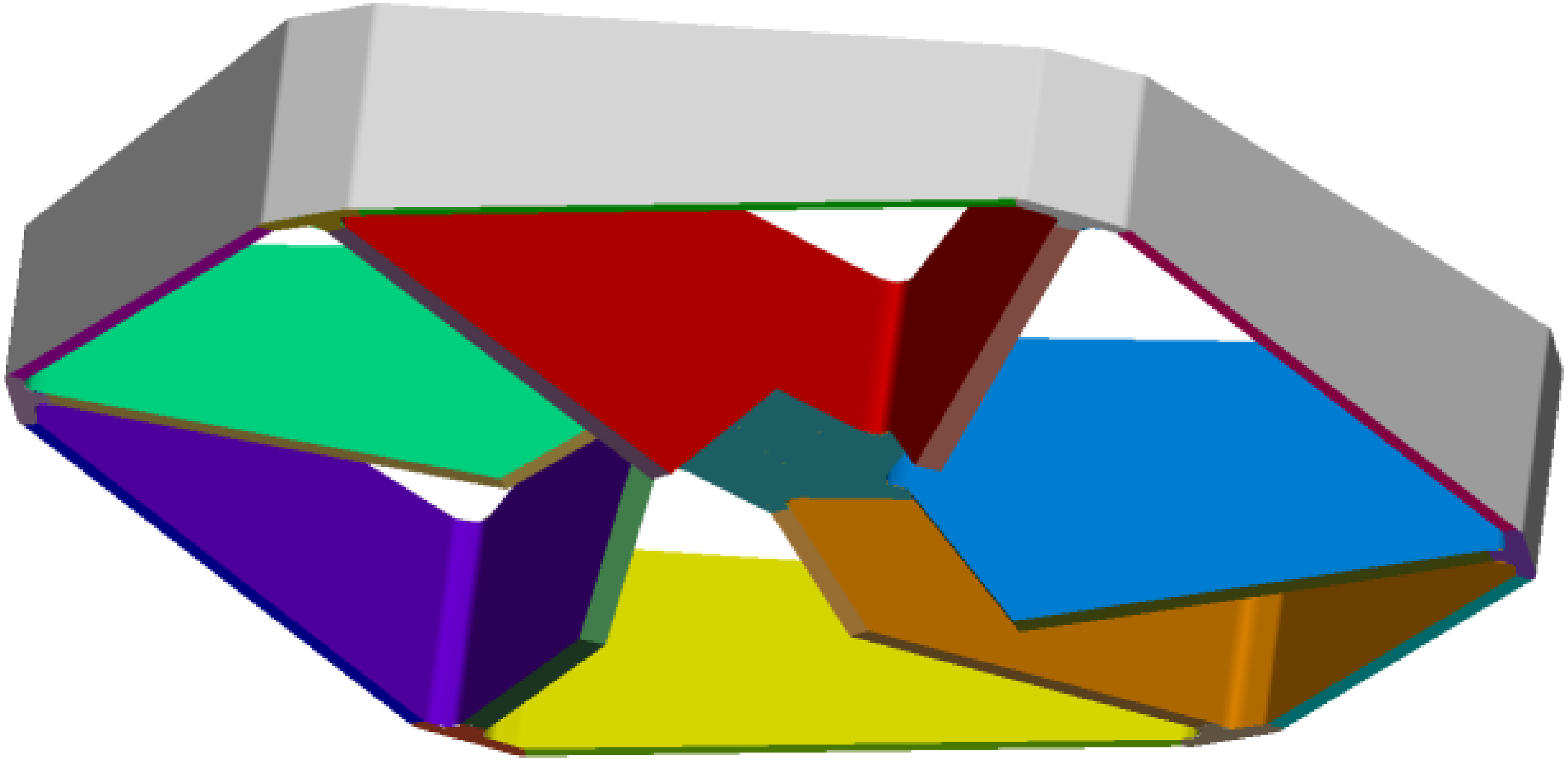
<u>Developed shape of the SLI</u>







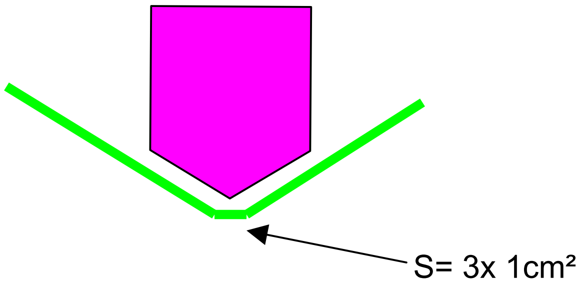
Definitive barrel (artistic view)



Horizontal surfaces estimation

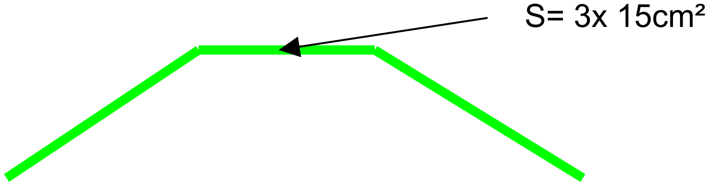
Conf 1: Horizontal surface with shim:

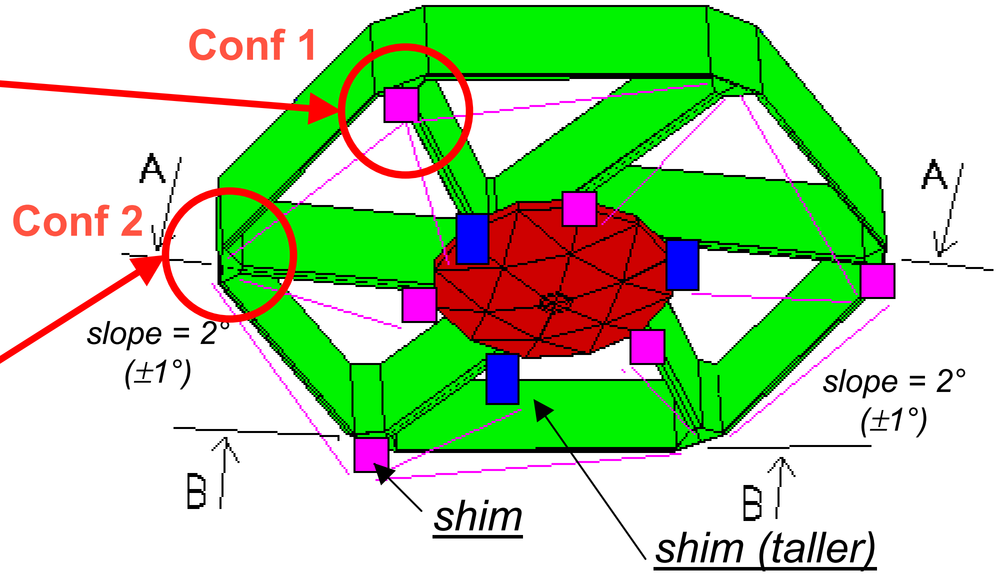
The surface can be limited by « angular » shims (in 1 direction)

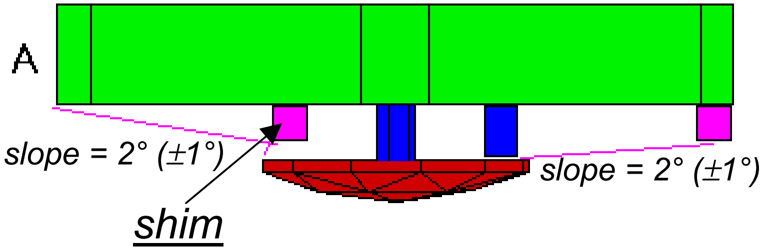


Conf 2: Horizontal surface without shim:

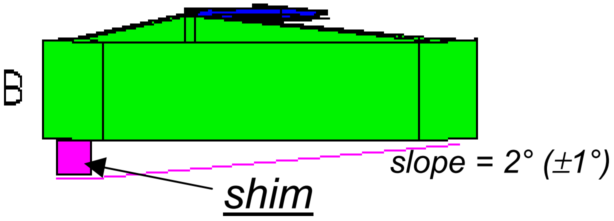
The surface is only limited by the beginnings of the sloped radial bars. The flat area still remains.



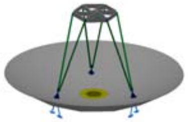




Estimated S tot= 50cm²



ASEF presentation: thermal aspects



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Sun illumination cases

- **Origin:**

Fairing operation during launch and shadowing limitation from the sunshield induces thermal illumination cases for the Telescope.

- **design modifications (to be analysed)**

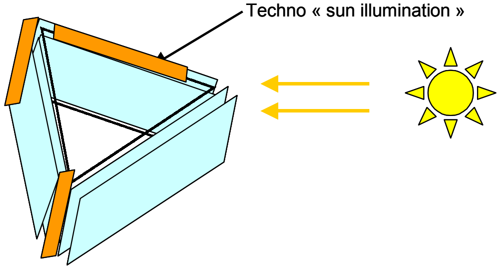
- high temperature adhesive tapes, use of « cold coating » adhesive tapes (SSM, kapton…)
- other material for screen (outside the optical field of view),
- replacement or supplementary screen
- Other technologies for MLI (sewing)

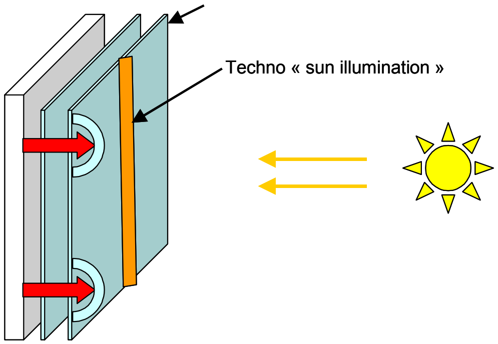
- **Constraints:**

- No modification of straylight environment (emissivities, areas)

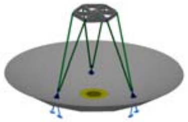
- **Qualification:**

- On representative samples, in solar- vacuum, with LN2 shrouds





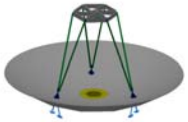
Influence of temperature gradient M1/ M2



- **Flight predictions:**
  - M1/ M2 gradient is very low:<1°C

- **Sensitivity study:**
  - 10°C axial gradient through the whole telescope gives:
    - WFE: 0,02µ rms
    - Defocus: 1,15mm

ASEF presentation: mechanical aspects



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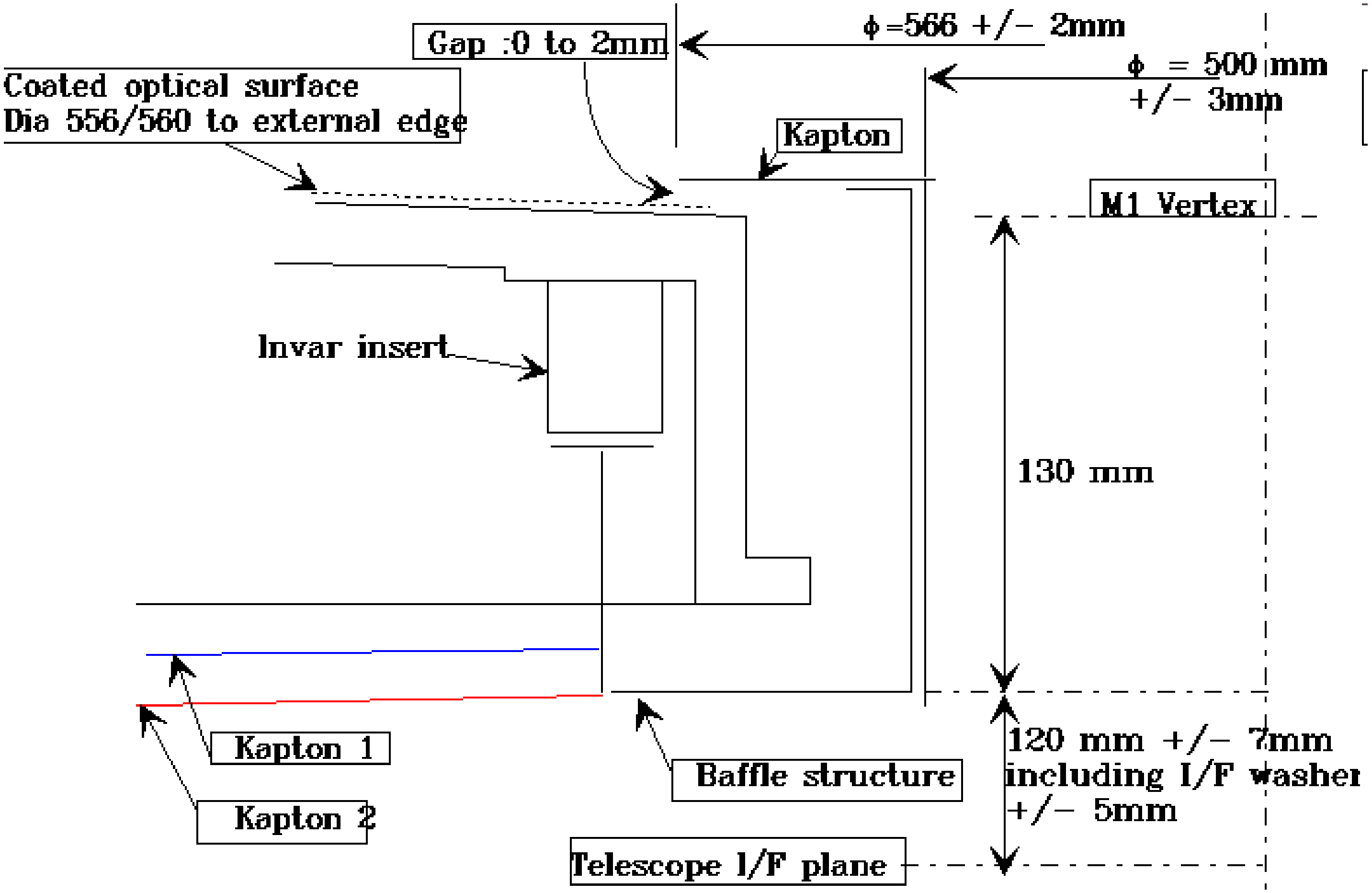
M1 baffle: interfaces proposal



In addition to these uncertainties, **+/-2mm in longitudinal, and +/4mm in lateral have to be considered for the dynamic effects.**

HERSCHEL HIFI

Standing Wave Analysis

Peter de Maagt

Maarten van der Vorst

Arturo Martín Polegre

Antenna and Sub-mm Wave Section

Electromagnetics Division

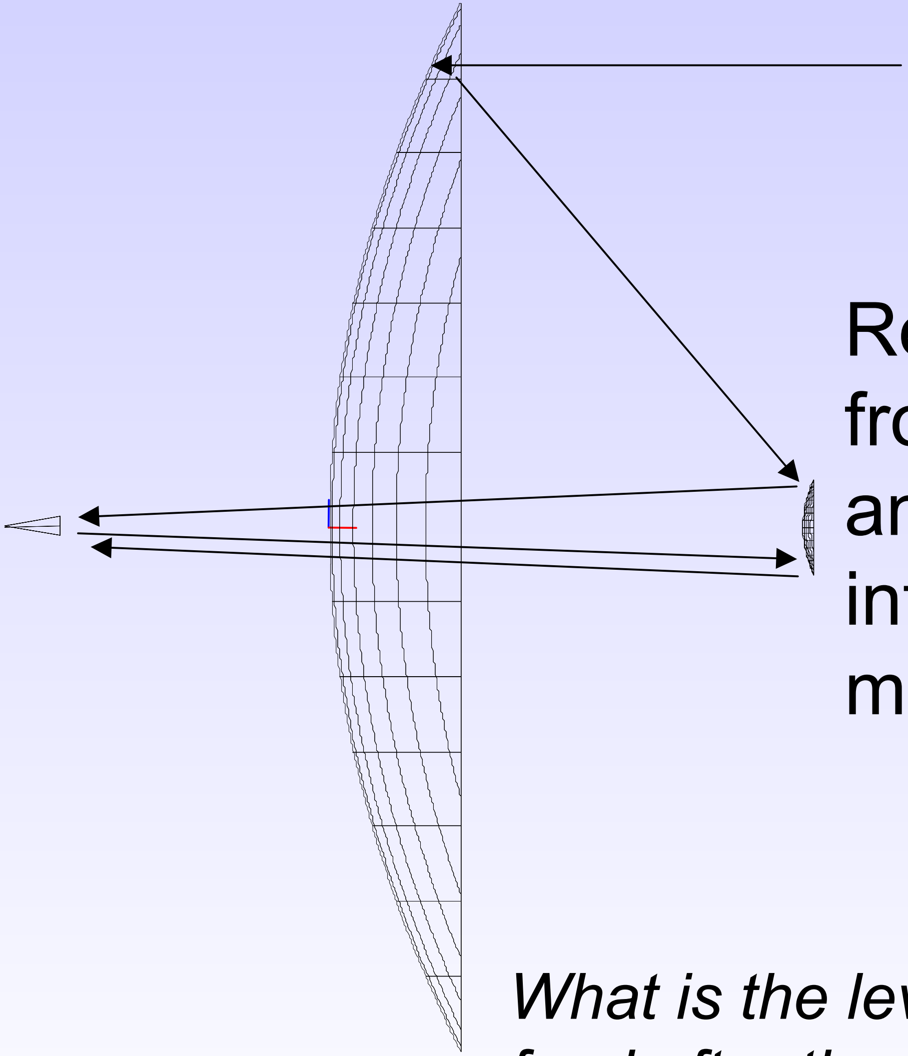
ESA-ESTEC

Toulouse, 24 June 2003

Summary

- Inputs
- Analysis method
- Results
  - Rings and cavities
  - Barrels
  - Scattering cone
- Conclusions

The problem



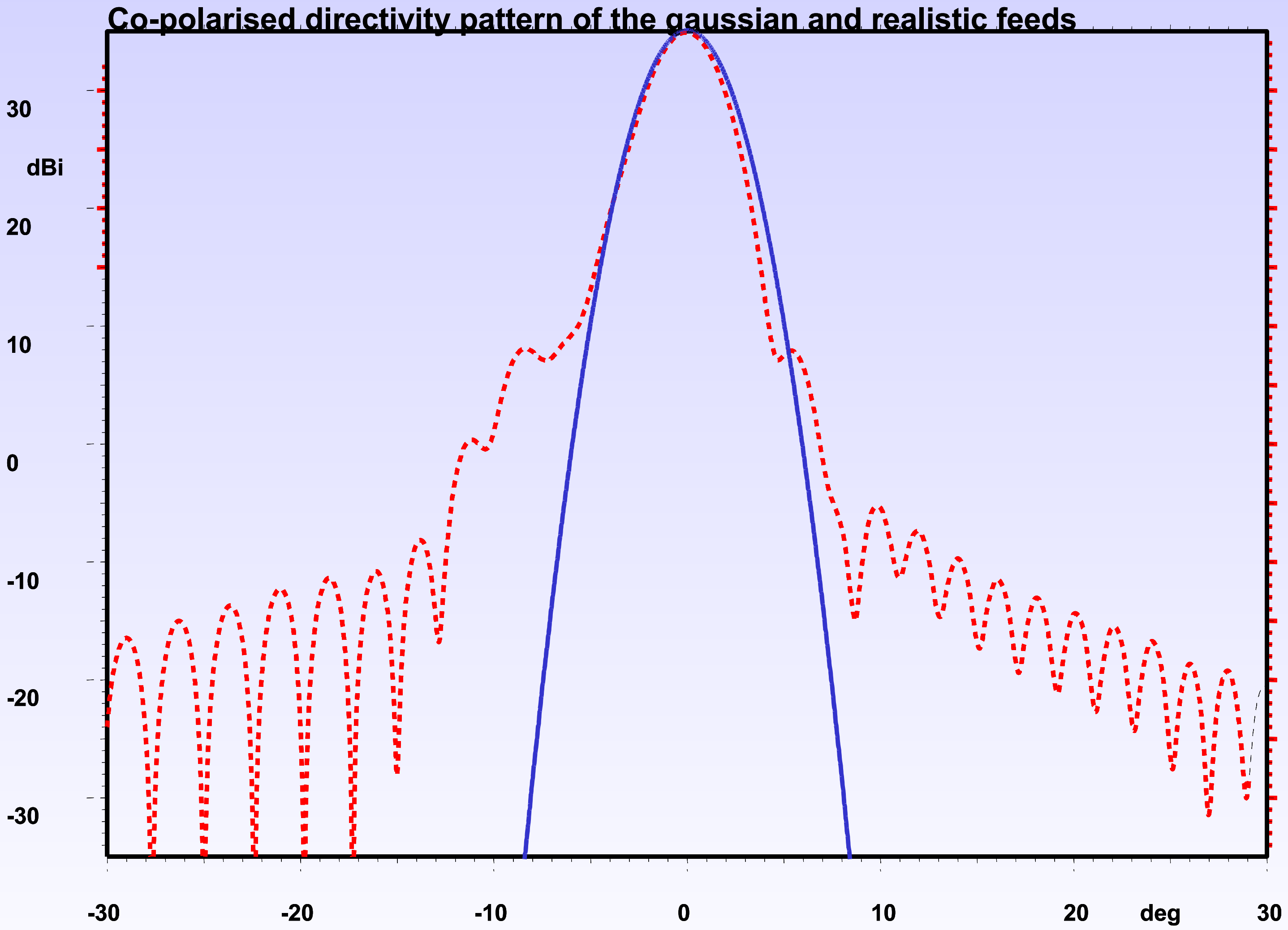
Reflections and coupling from telescope elements and surrounding structure interfere with signal to be measured

What is the level of power coupled to the feed after these reflections ?

Inputs

- Dual reflector geometry
- Frequency: 480 GHz
- Gaussian feed with a taper of –11 dB at 3.3 degrees
- Off-axis feed position for HIFI band 1, as provided by SRON

Feeds used


Co-polarised directivity pattern of the gaussian and realistic feeds
30
dBi
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
deg
30

Analysis

The sources, receivers or transmitters are expressed by a number of radiating elements (currents elements) and the complex coupling ratio for each of these elements is calculated as:

$$C_{ij}=-jkr\ e^{jkr}\ ½(E_{1i,near} \bullet E_{2j,near})$$

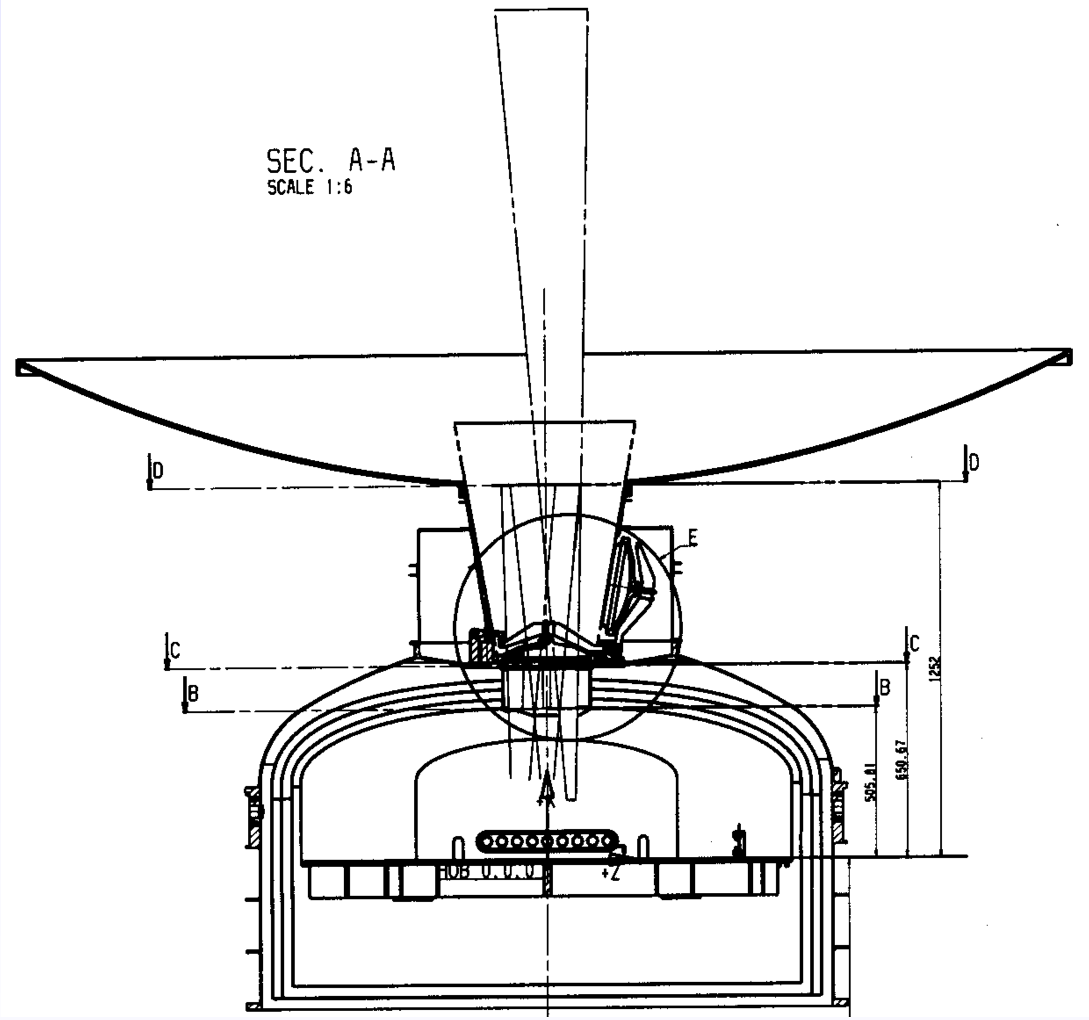
The total coupling ratio is:

$$C= \Sigma C_{ij}$$

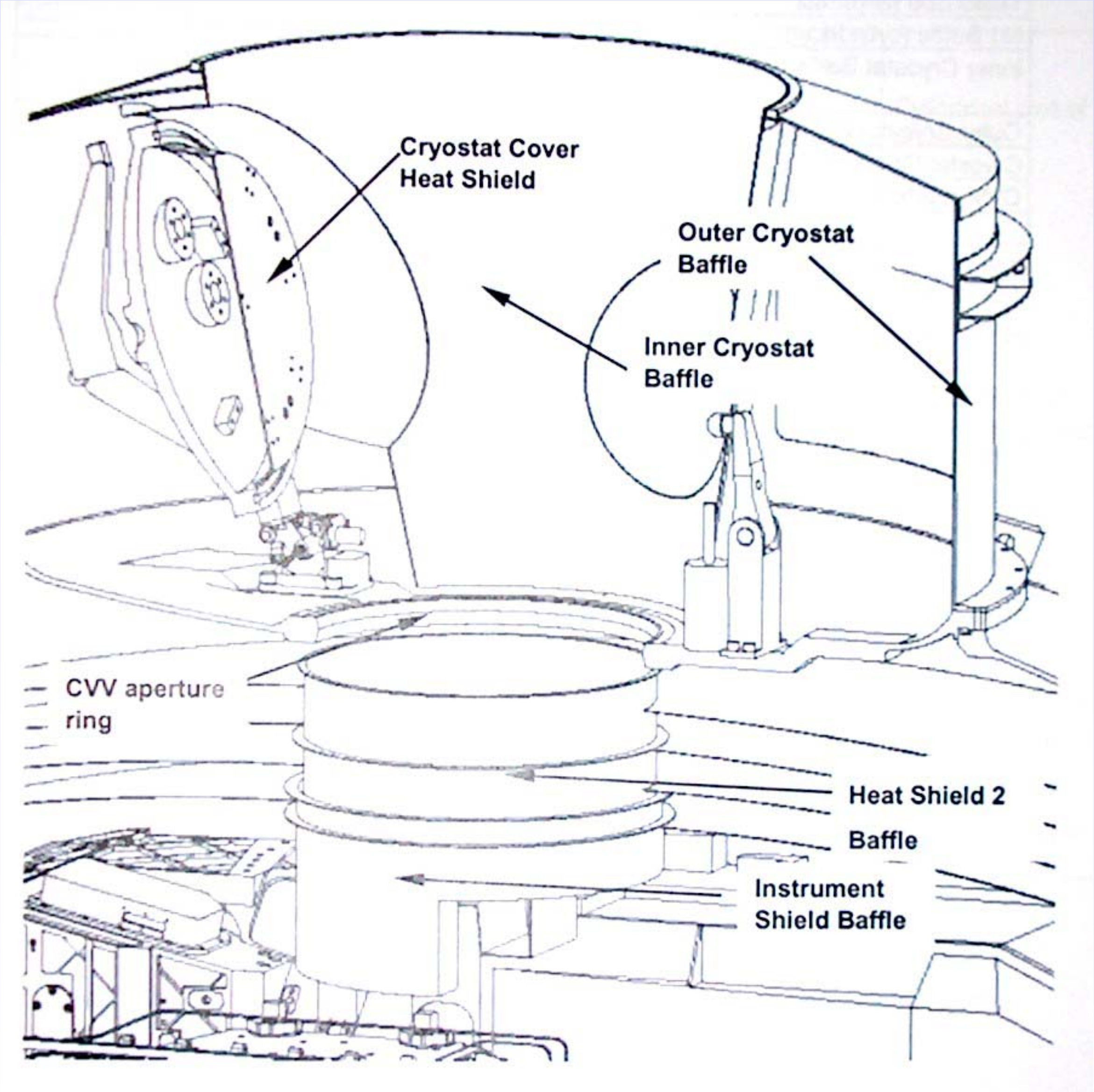
where the summation is done all the source elements combinations

The method has been validated (see TICRA's "Manual for Coupling" S-894004)

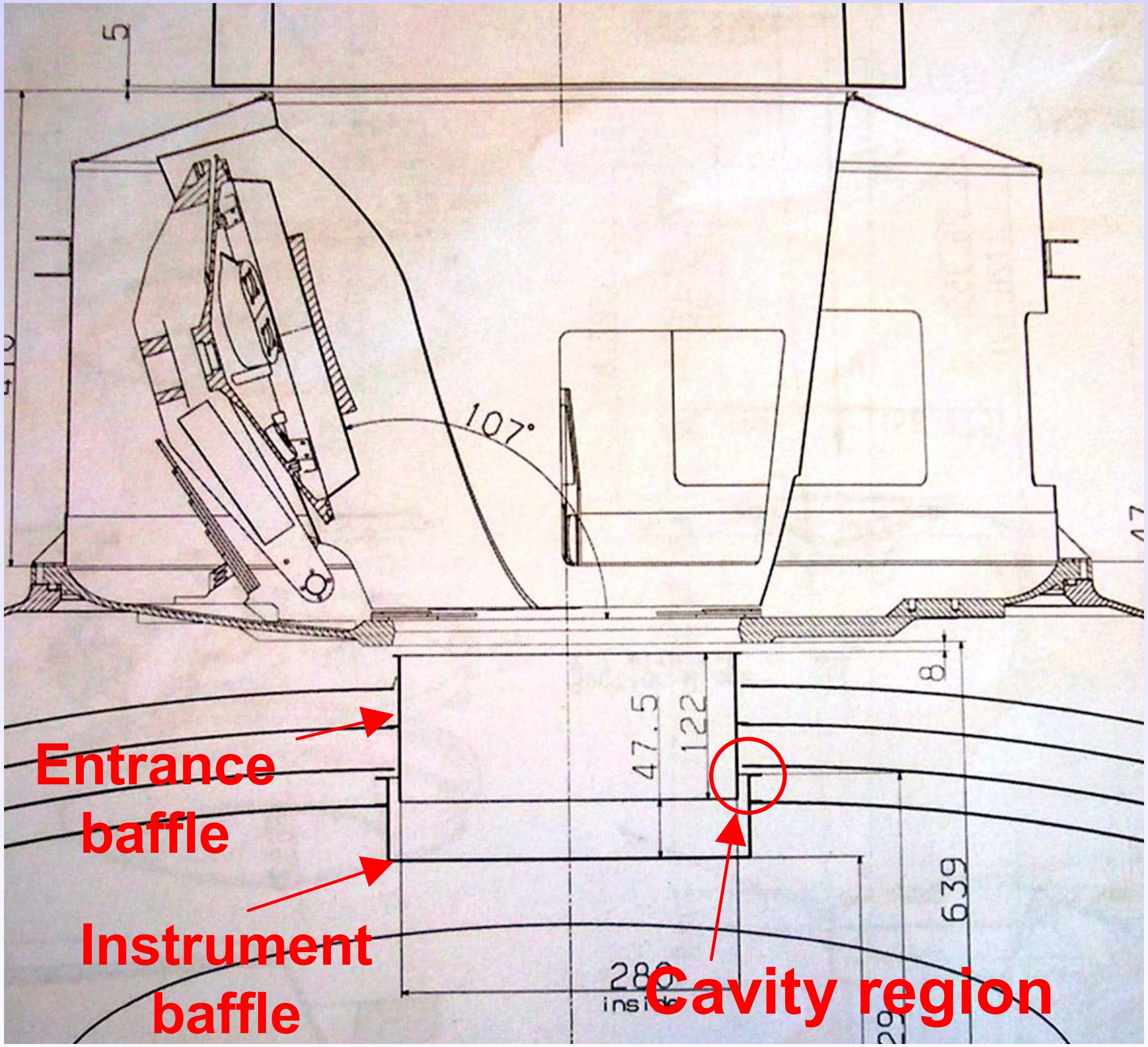
Rings and cavities



Rings and cavities



Cavity



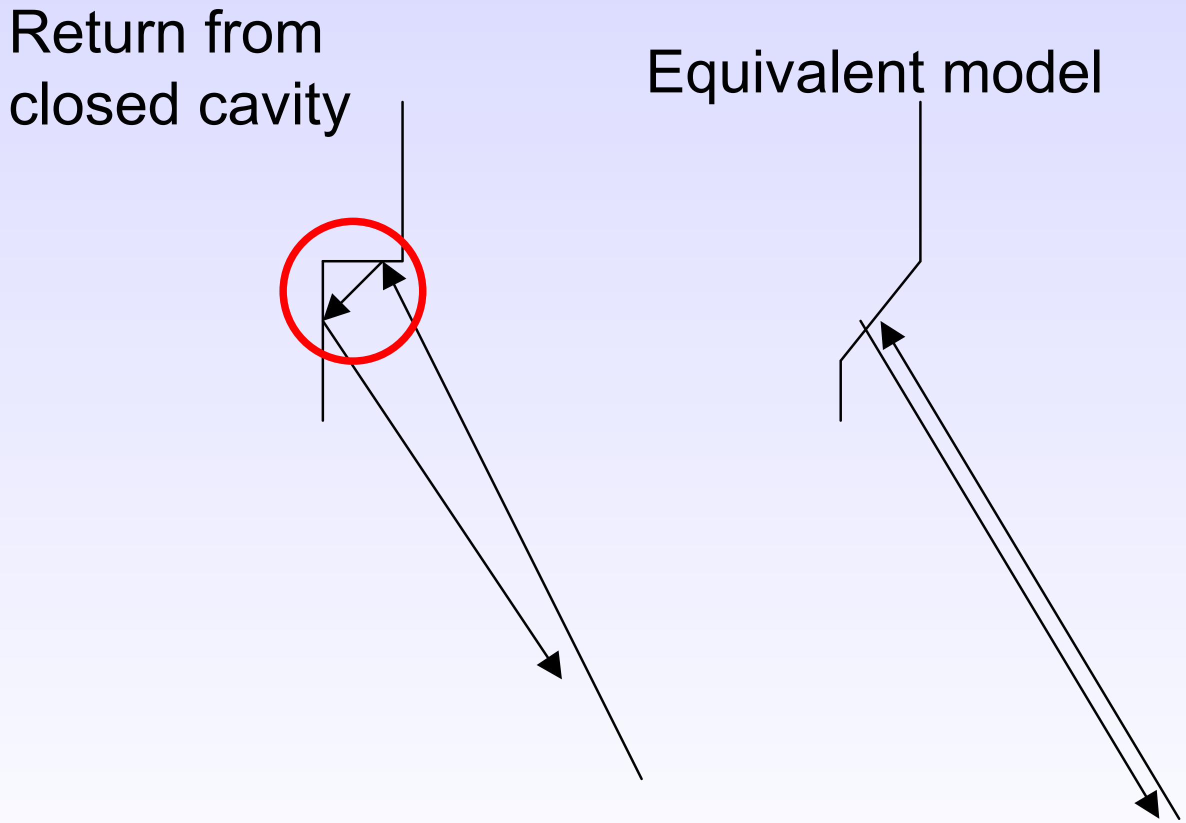
Entrance baffle

Instrument baffle

Cavity region

Cavity

Model used for the analysis of the Cavity

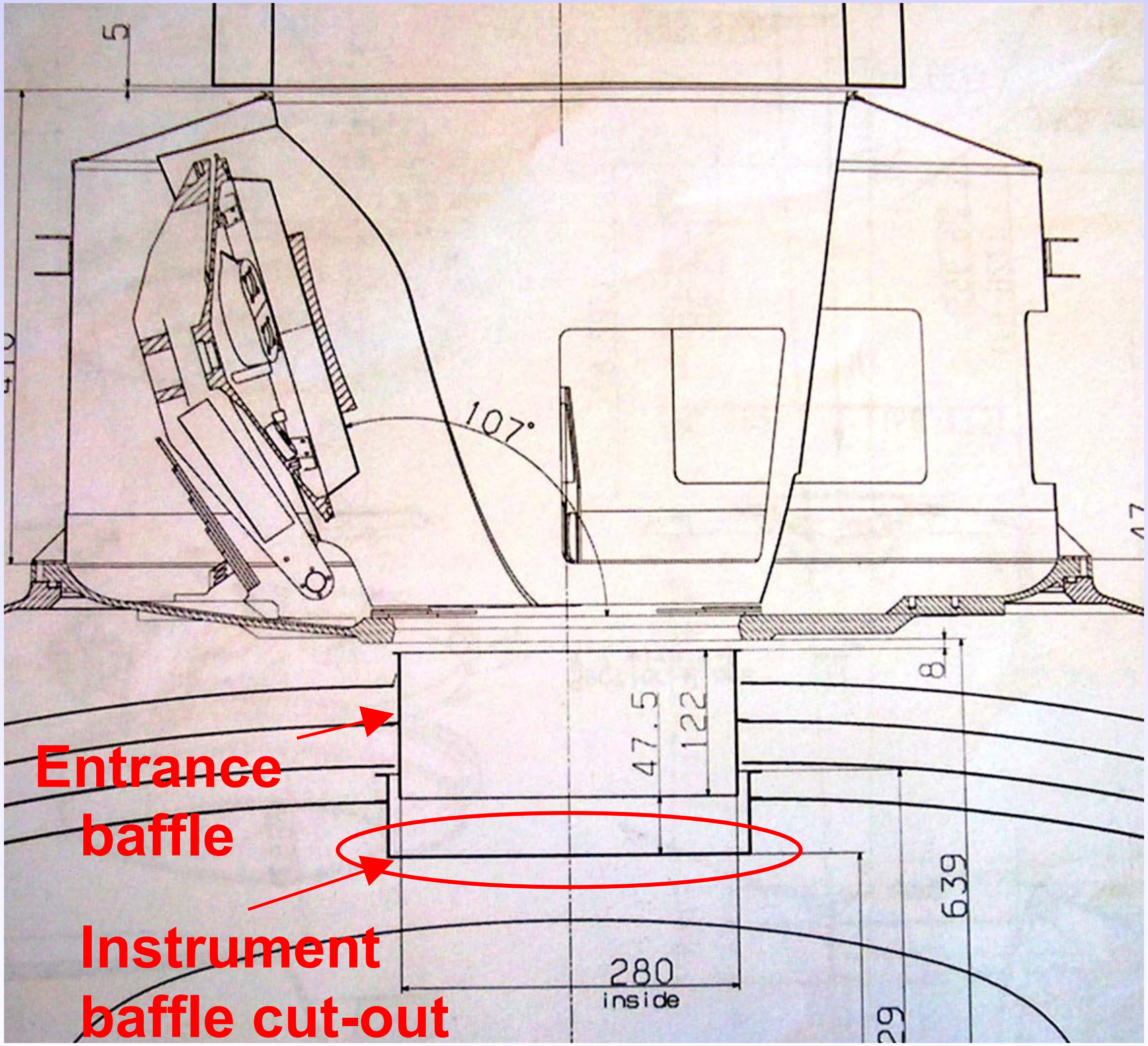


Cavity

Results

Coupling factor of the feed with the entrance baffle cavity (dB)	
On-axis gaussian feed	< -300
On-axis realistic feed	< -120
Off-axis gaussian feed	< -150
Off-axis realistic feed	< -100

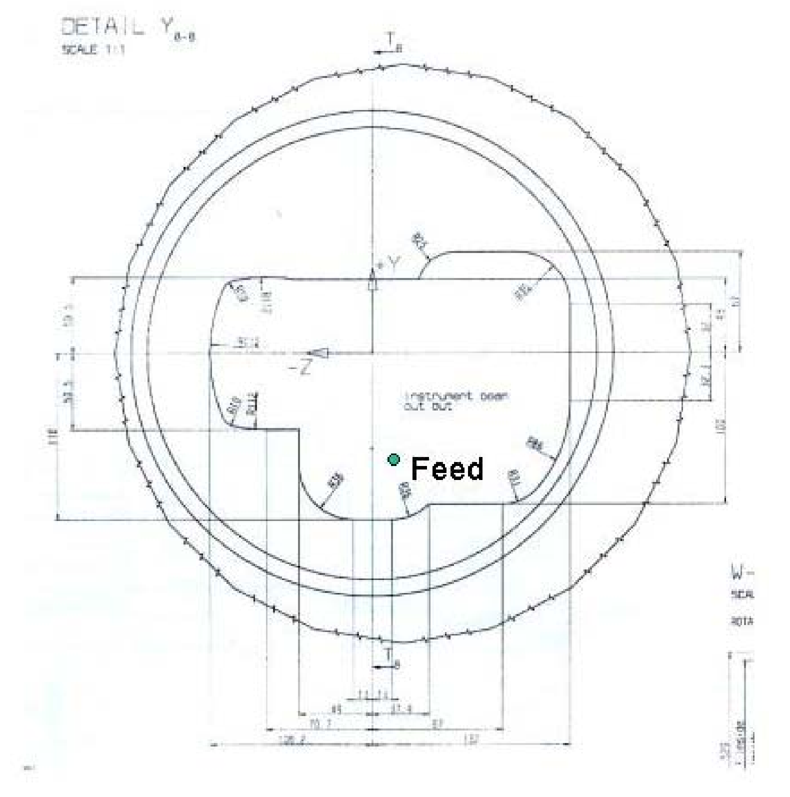
Instrument baffle cut-out

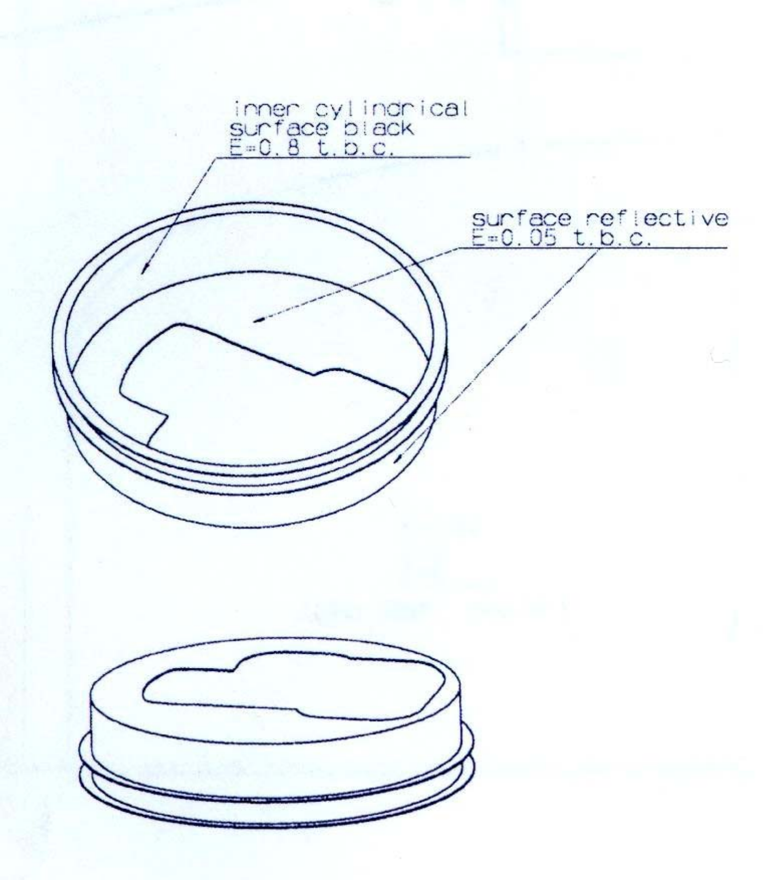


Entrance baffle

Instrument baffle cut-out

Instrument baffle cut-out





Instrument baffle cut-out

TOS-EEA

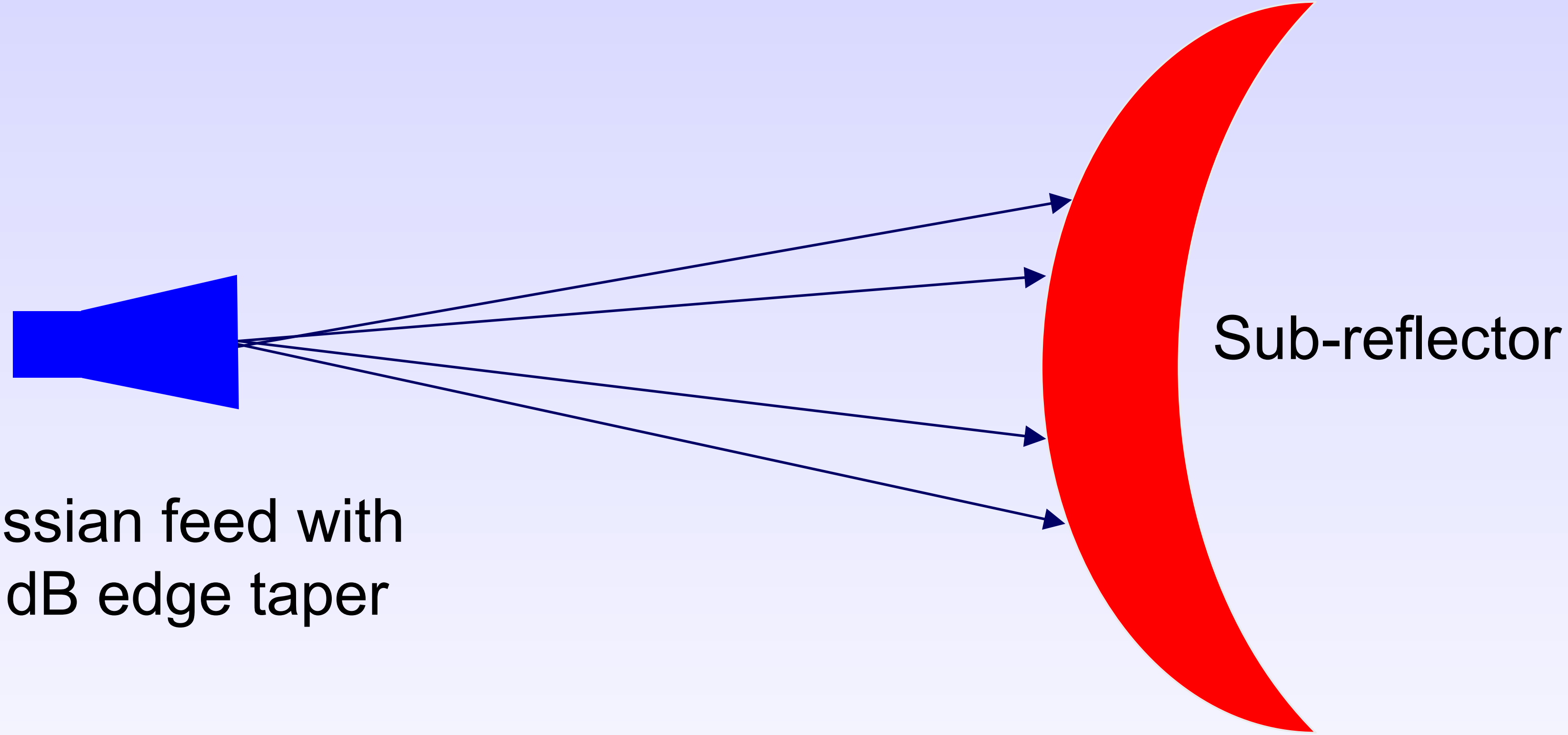
Results

Coupling factor of the feed with the cut-out of the instrument baffle (dB)	
On-axis gaussian feed	-176
On-axis realistic feed	-138
Off-axis gaussian feed	-329
Off-axis realistic feed	-104

of the feed with the cut-out
of the instrument baffle (dB)

Sub-reflector coupling

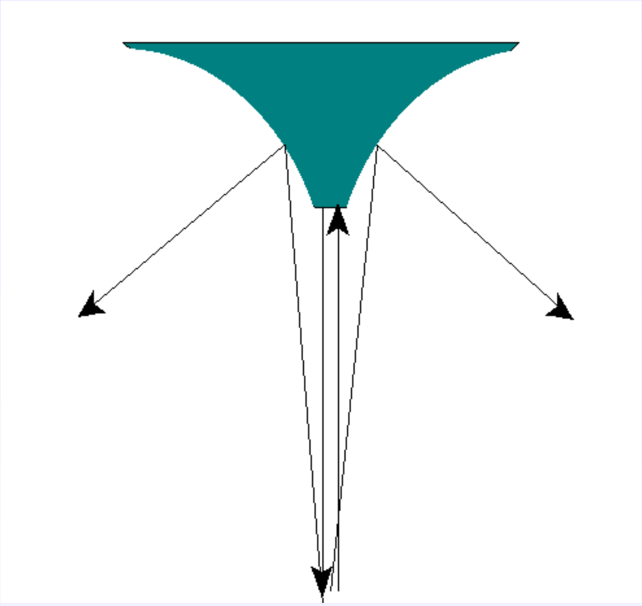
The coupling from the complete sub-reflector is –48.5 dB



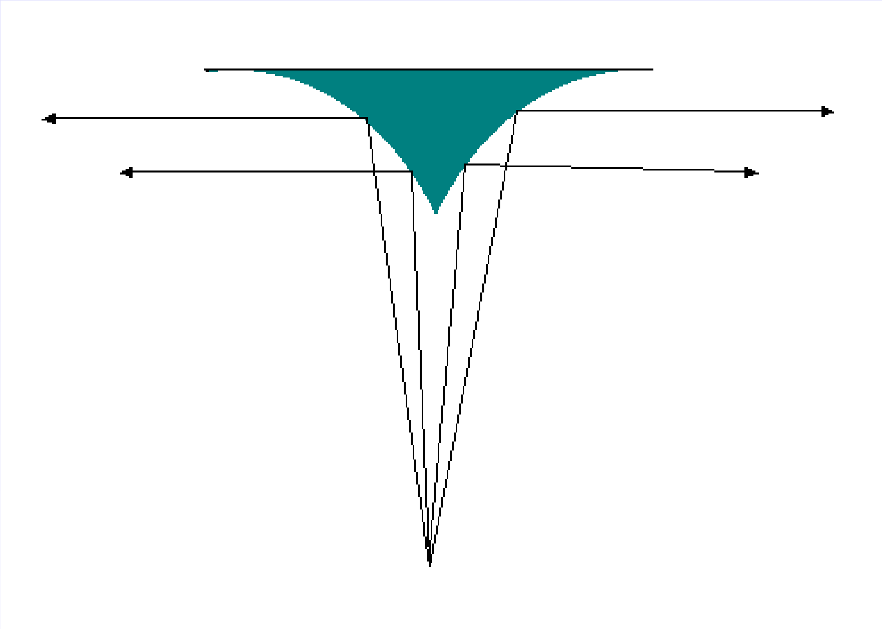
Gaussian feed with
–11 dB edge taper

Scattering cone

Baseline: Circular arc profile

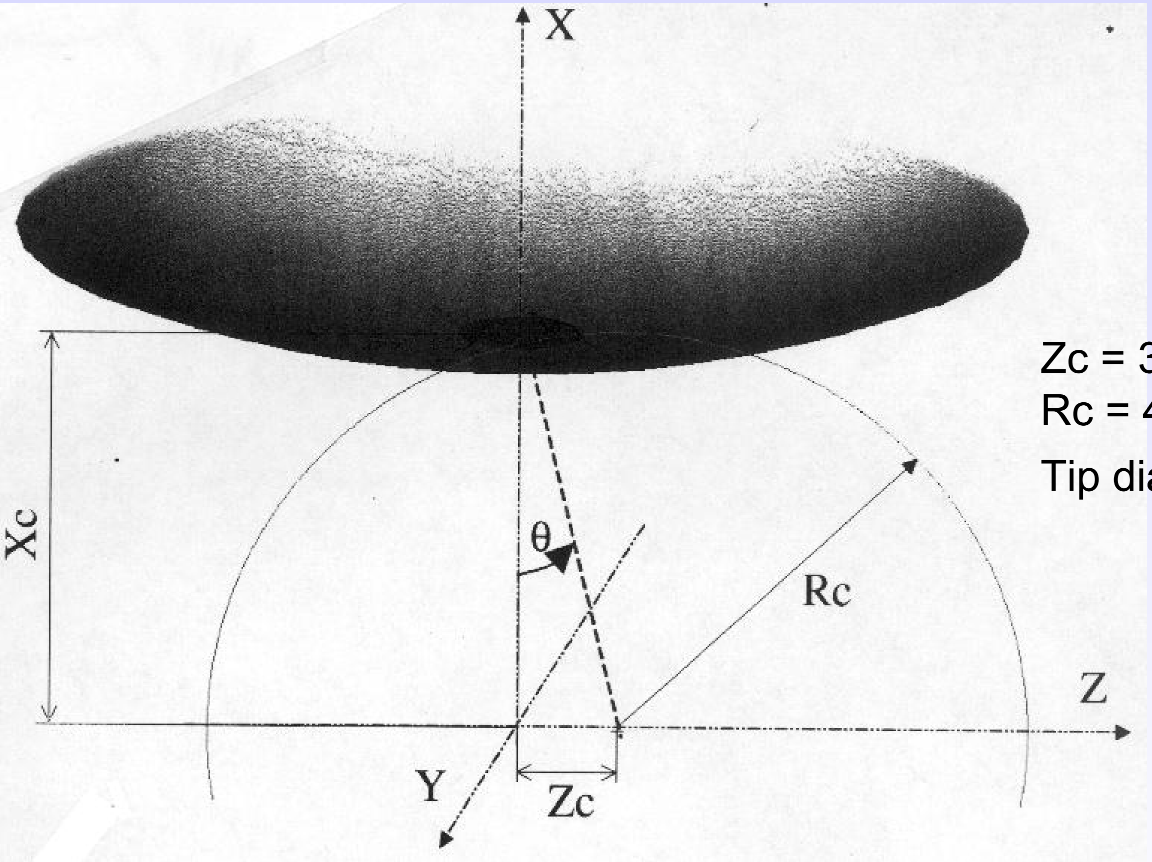


Alternative: parabolic arc profile



Scattering cone definition

Circular arc profile

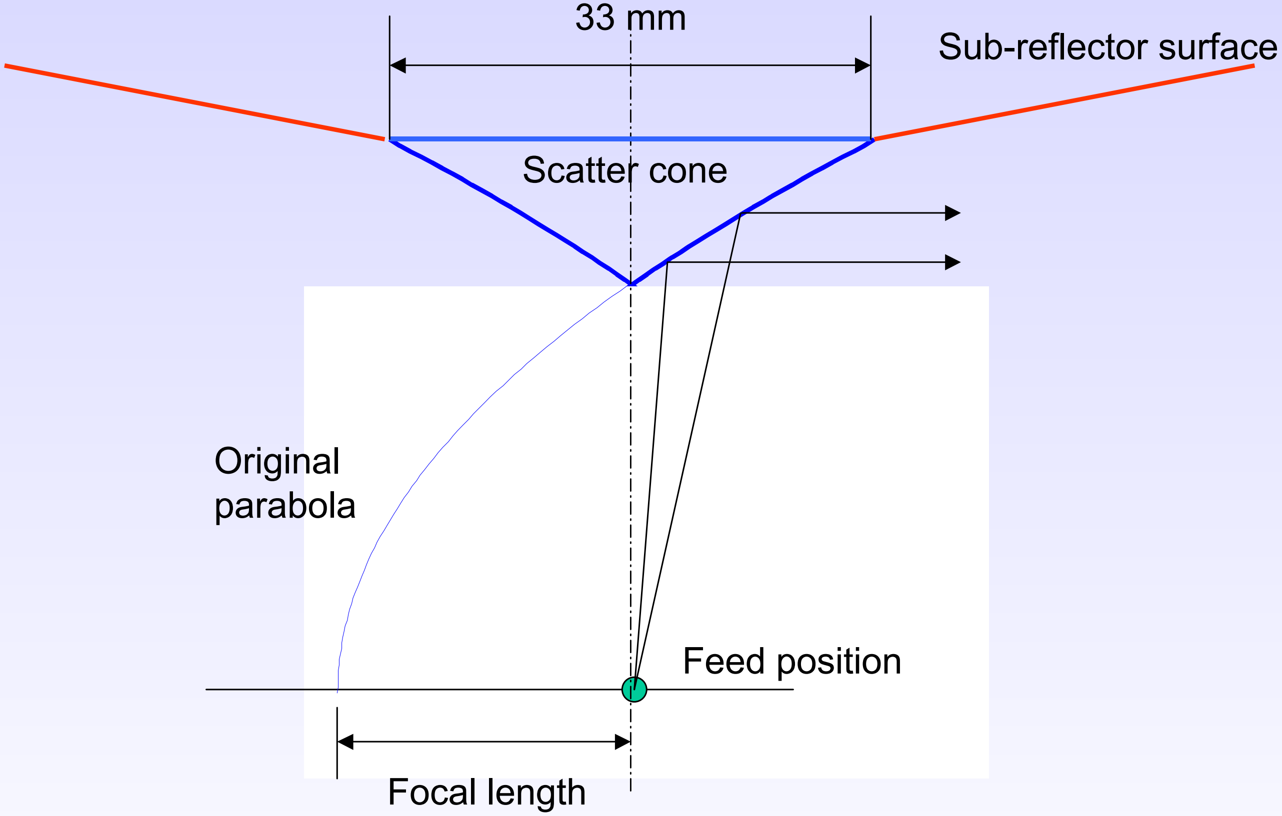


Zc = 37.978 mm
Rc = 449.093 mm

Tip diameter = 1 mm

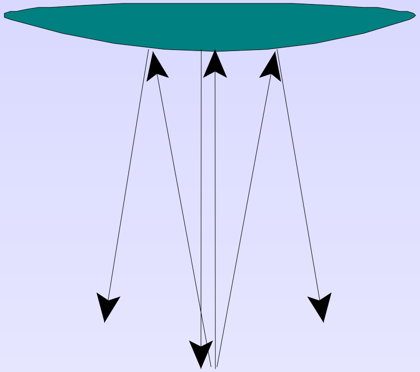
Scattering cone definition

Parabolic arc profile



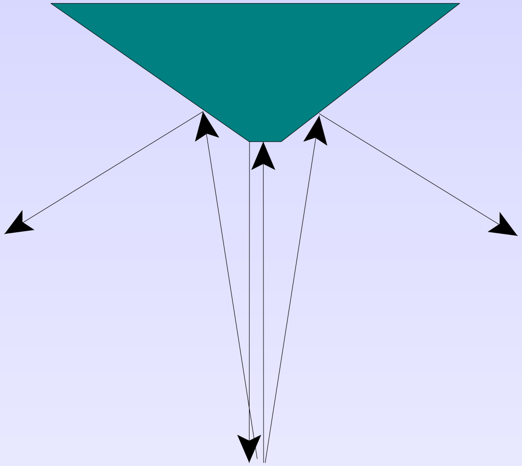
Coupling from scattering cone isolated (with feed at focus)

No scatter cone (only hyperbolic profile) D=33mm



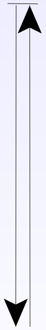
-45.2 dB

Scatter cone with circular profile + flat top D=33mm



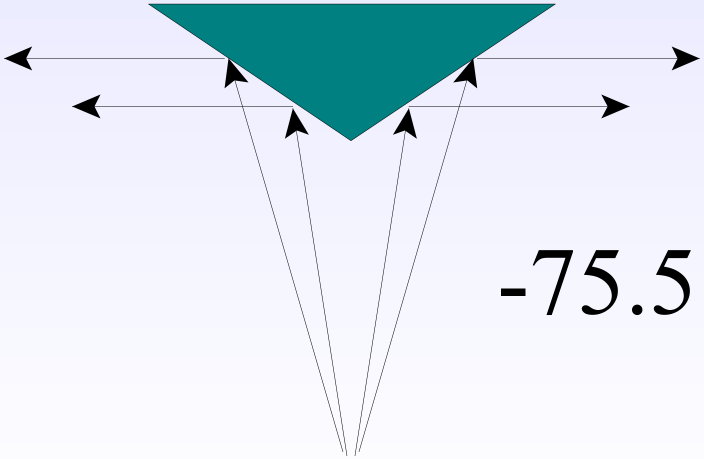
-50 dB

Flat top of 1 mm in diameter



-91 dB

Scatter cone with parabolic profile D=33mm



-75.5 dB

Coupling from scattering cone isolated (with feed at focus)

Coupling factor of scatter cones with various profiles in self-standing configuration (dB)		
	Circular profile	Parabolic profile
On-axis feed	-50.0	-75.5
Off-axis feed	-59.8	-87.7

Coupling from scattering cone + sub-reflector

Coupling factor of scatter cones with various profiles together with the sub-reflector (dB)		
	Circular profile	Parabolic profile
On-axis feed	-76.0	-50.0
Off-axis feed	-67.8	Not calculated

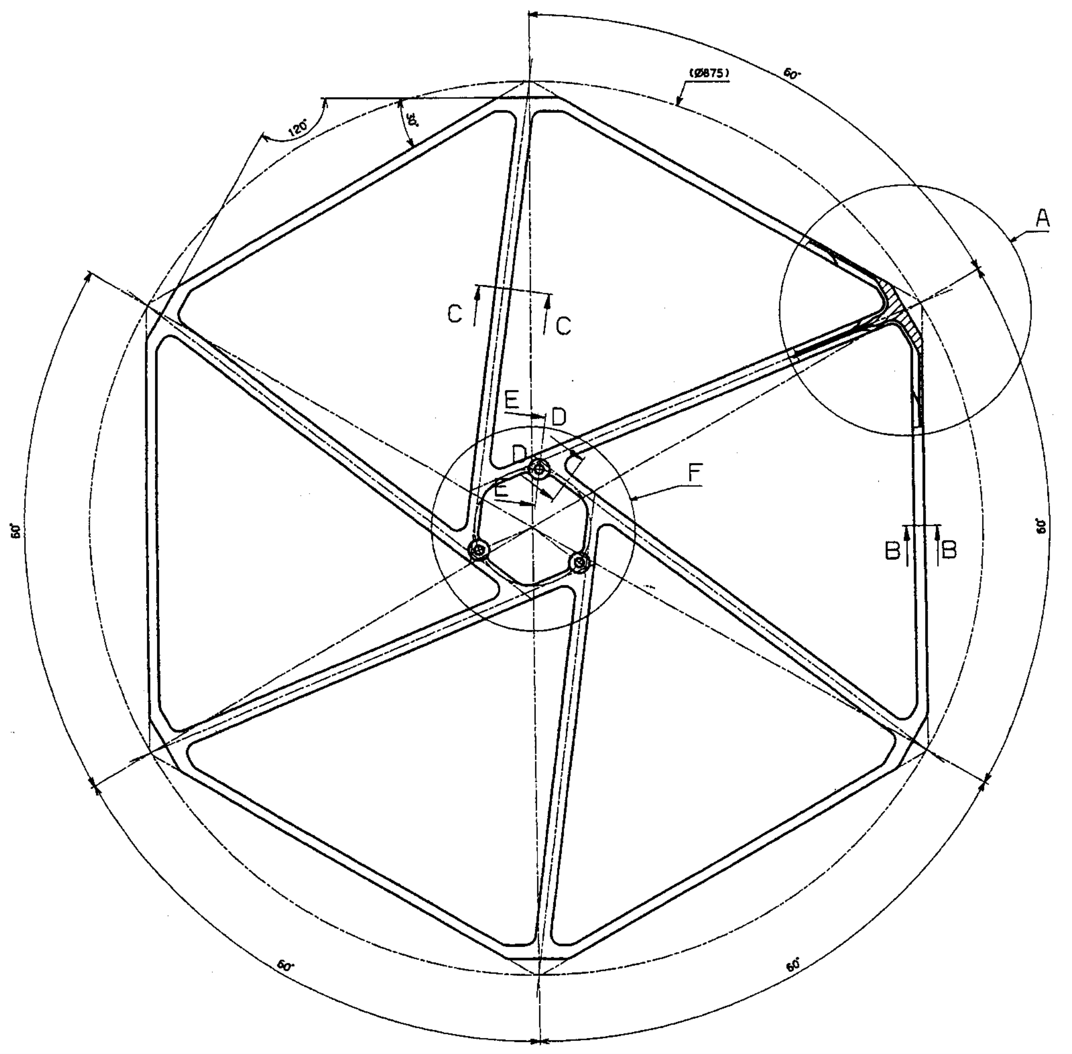
Conclusions on scattering cone

Baseline scattering cone (circular arc profile) is better than that with parabolic profile because of:

- Lower straylight problems
- Lower coupling when sub-reflector contribution is considered

Barrel structure top view

The bottom face of barrel is flat and horizontal

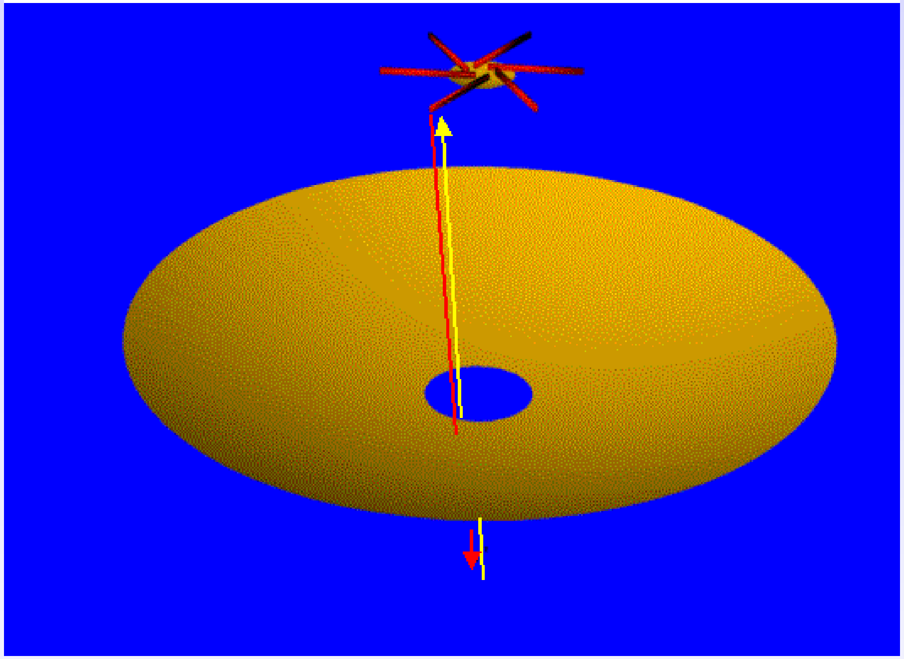


Barrels

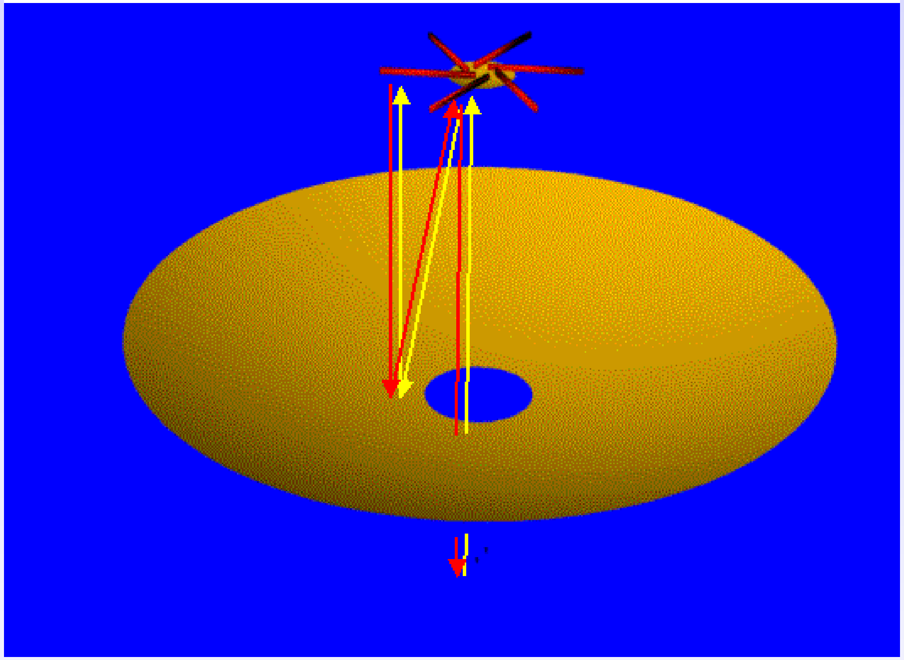
Two possible coupling paths were analysed

Path 1

Path 2

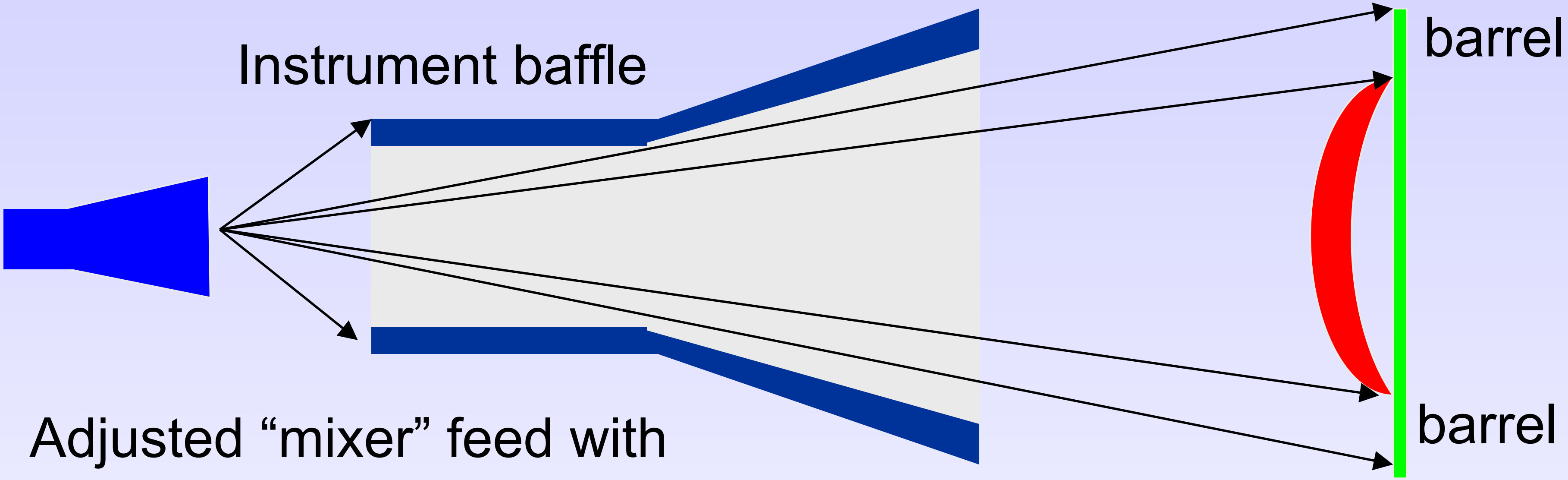


Feed-Barrel-Feed



Feed-Secondary-Primary
-Barrel-Primary-Secondary
-Feed

Direct reflection on barrels (path 1)



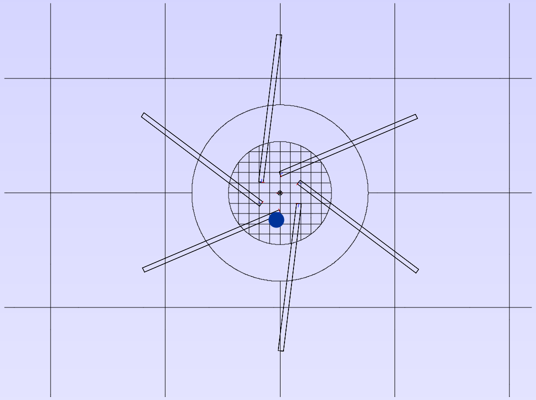
Adjusted “mixer” feed with
–11 dB edge taper

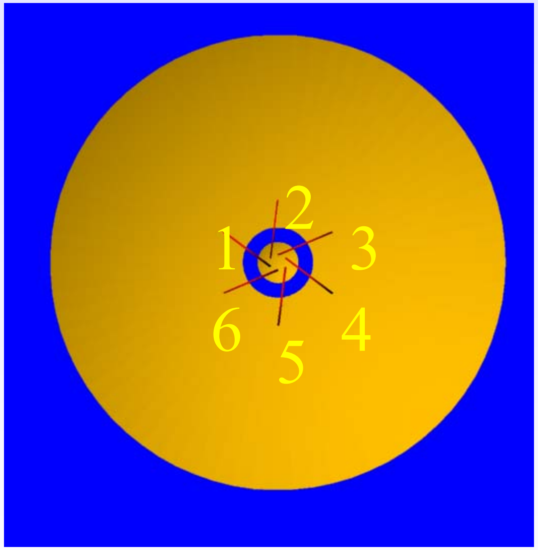
Computed Coupling from one barrel is **–123.7 dB**
(*on-focus feed*)

Barrel coupling through path 2

(Coupling with <u>off-axis</u> feed)

Barrel	**Coupling (dB)**
1	-89.90
2	-99.04
3	-93.86
4	-90.87
5	-89.87
6	-88.53





Coupling of one barrel

with <u>on-axis</u> feed = -62 dB

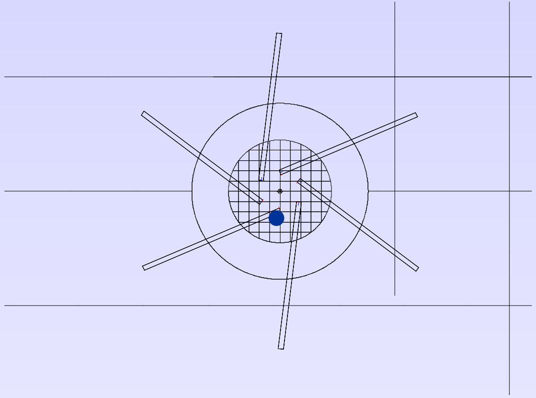
Barrel coupling through path 2

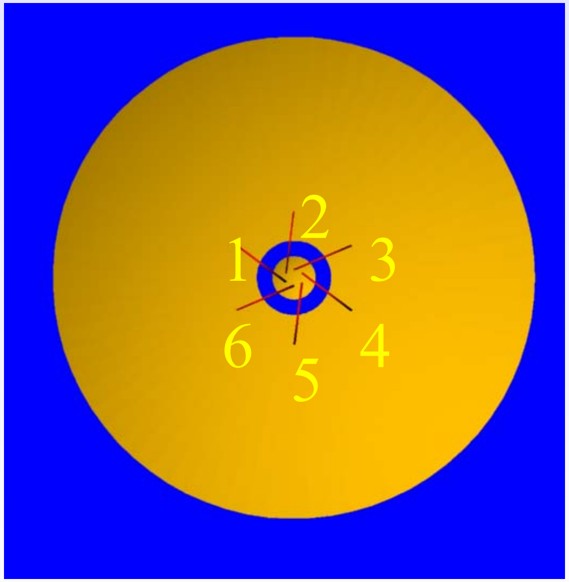
but when the baseline scattering cone is present …

the coupling with the barrels increases

(Coupling with ***off-axis*** *feed)*

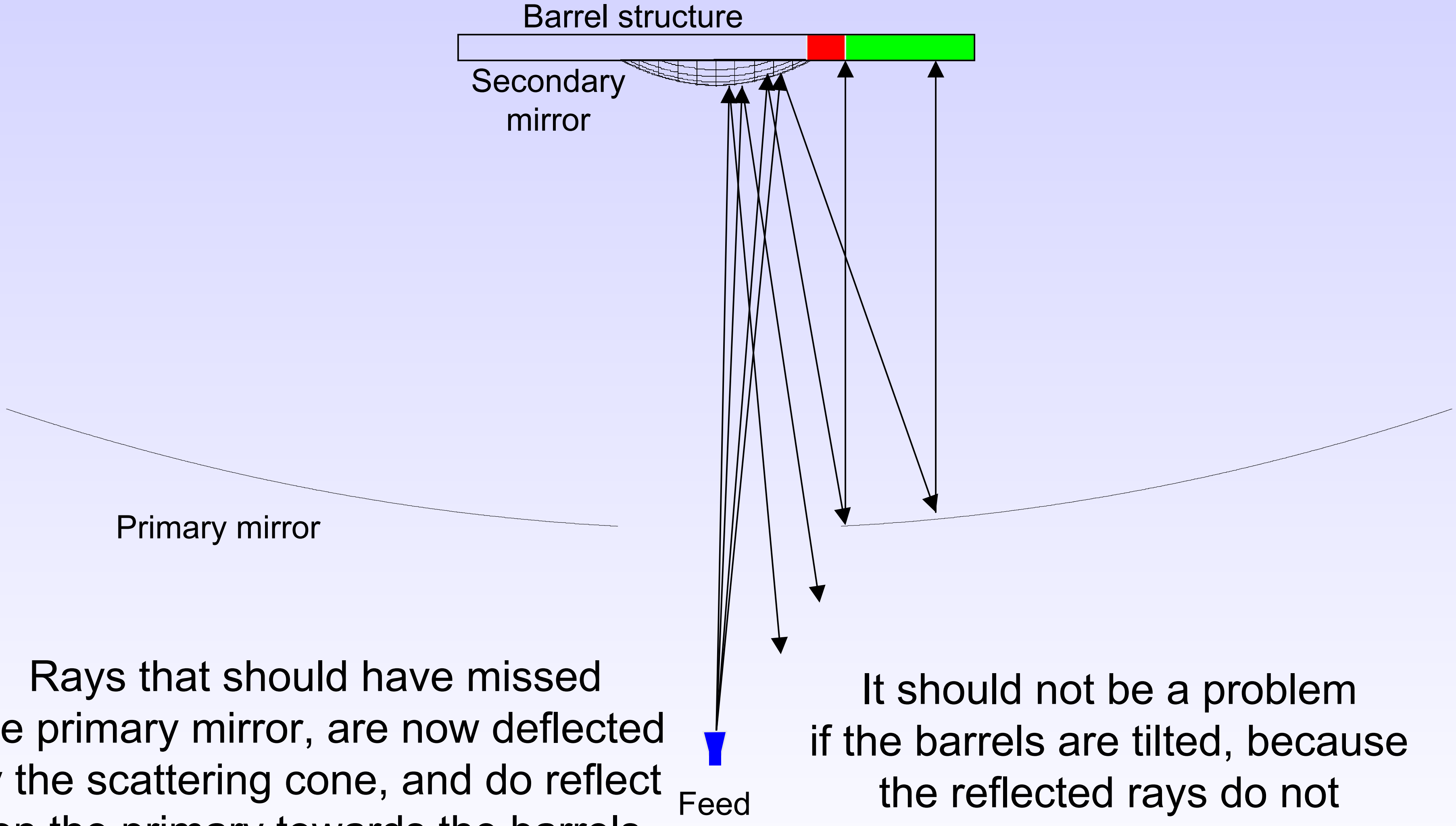
Barrel	***Coupling (dB)***
1	-65.8
2	-83.7
3	-65.2
4	-64.9
5	-65.1
6	-66.5





Barrel coupling through path 2

(without scattering cone)

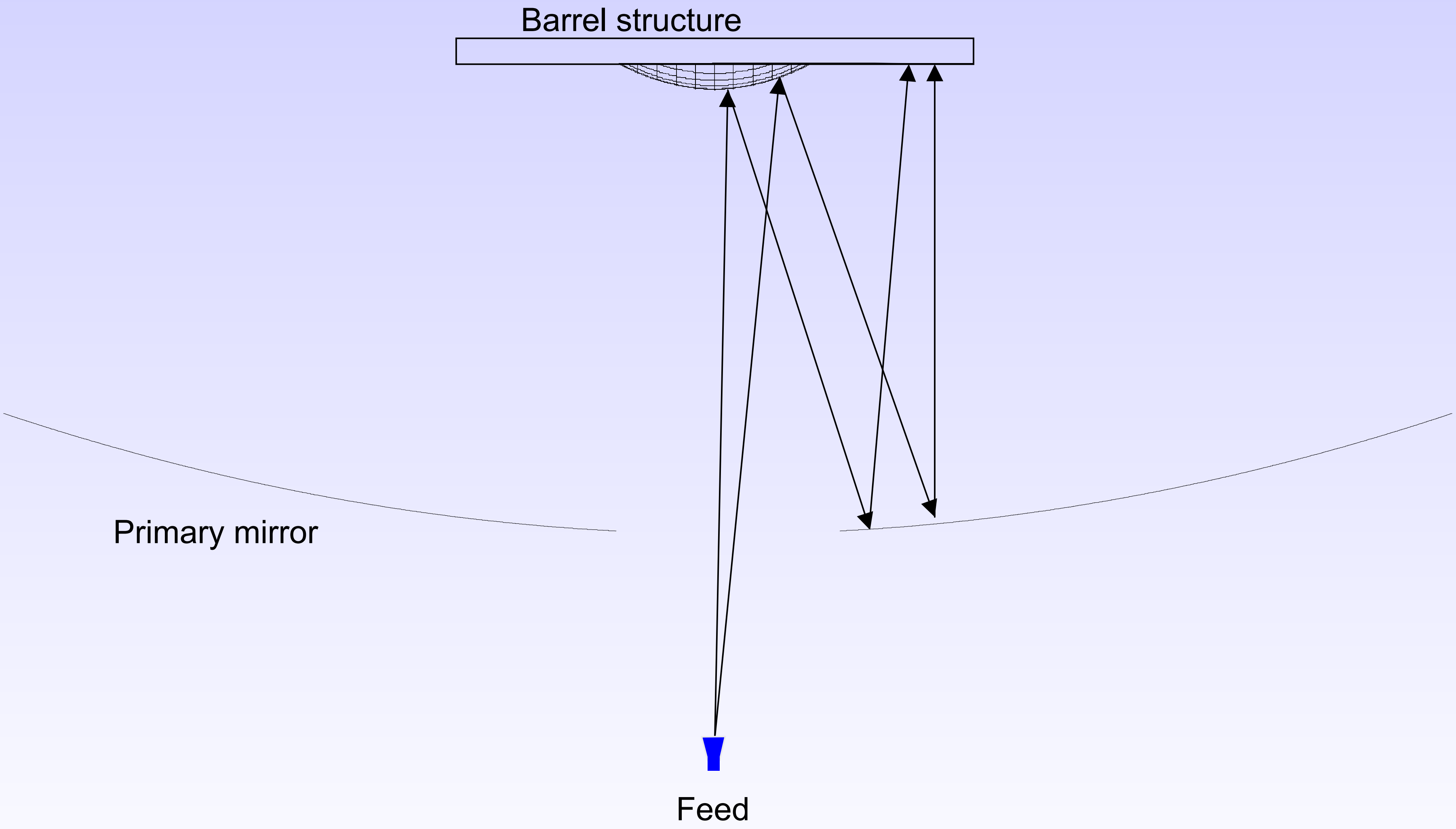


Rays that should have missed the primary mirror, are now deflected by the scattering cone, and do reflect on the primary towards the barrels

It should not be a problem if the barrels are tilted, because the reflected rays do not return to the feed

Barrel coupling through path 2

(with scattering cone)



Conclusions

- ✓ Cryostat is not a problem (cavities and cut-out openings)
- ✓ Baseline scattering cone is better than that with parabolic profile
- ✓ Horizontal barrels + baseline scattering cone are not compliant, but the tilted barrels should improve the situation (under analysis)

Currently under analysis:

- ➢ Frequency dependence of coupling from scattering cone + sub-reflector
- ➢ Coupling through path
  feed -> sub-reflector -> inner baffle cone ->feed

HIFI Standing-wave report

Analysis progress

Reflections off the internal baffle

Reflections off M2

Reflections via M2 from M1 and from the M1 baffle

Reflections via M1 and M2 from the barrel (M2 support)

Reflections via the scatter cone off the barrel

Overview of the reflection modes

Conclusions on the ESTEC assessment

Conclusions on the telescope design

HIFI progress

Did not yet manage to get standing-wave specifications in the IID-B!

Learned to explore on-axis reflections in the frequency domain,
useful for a physical understanding of the analysis results

Attacked one more reflection mode, off the hole in the primary mirror

Expect to be able to do off-axis frequency analysis on the M2 before next meeting

Found consistency with results from Bob Lucke (NRL) and with the ESTEC standing-wave report

SRON

The internal baffle

The ESTEC report explored reflections from the internal cryostat baffle and from the instrument baffle cut-out.

The report concludes that reflections from these objects remain below –150 dB for clean gaussian beams and below –100 dB for beams with representative side-lobe levels.

HIFI agrees with the conclusion that the cryostat baffle and the cut-out should not cause significant standing waves

M2

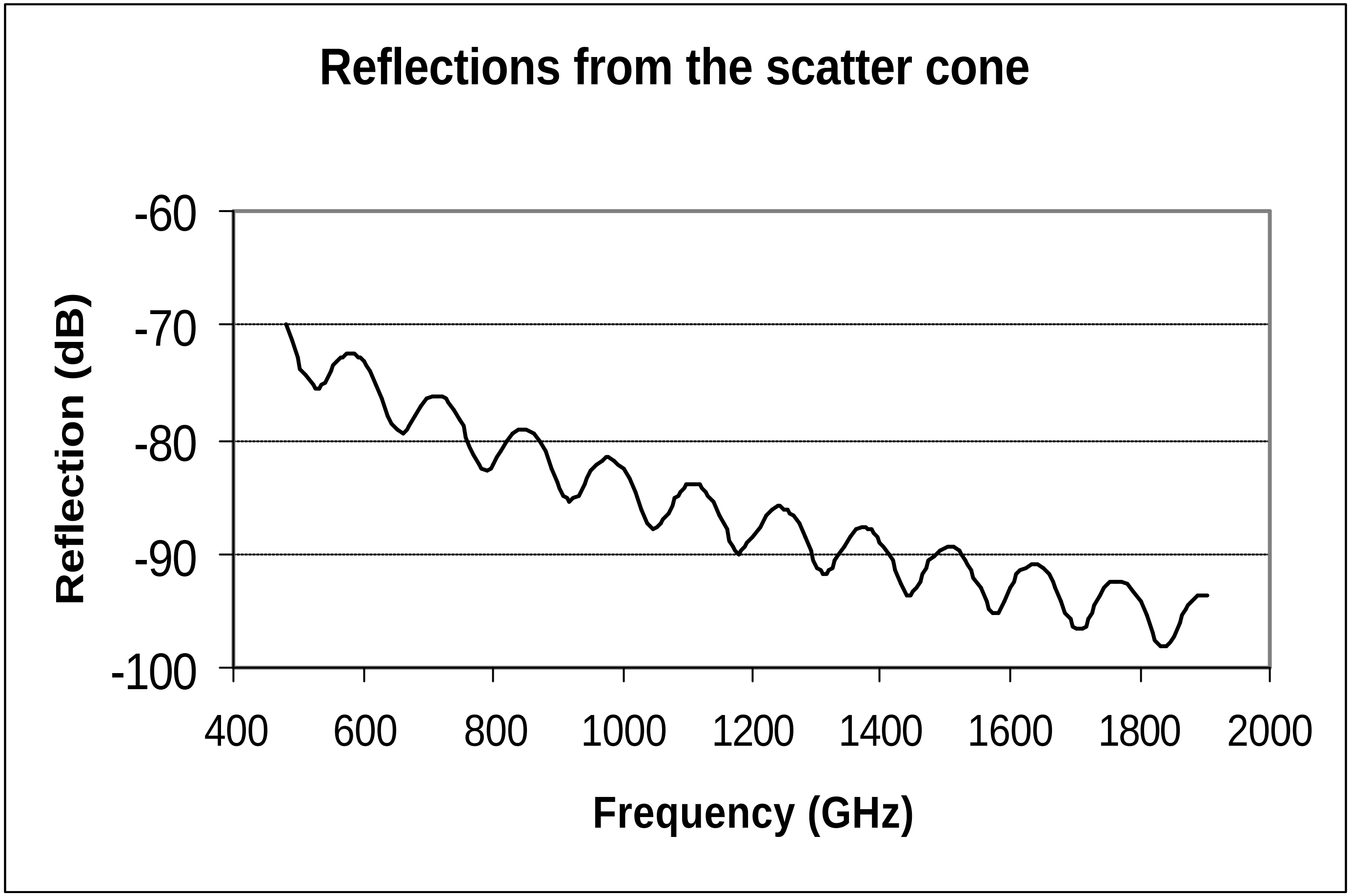
M2 has two sources of reflections: the scatter cone and the rim of the secondary.

The scatter cone reflections are dominated by diffraction from the vertex and by diffraction from the abrupt change in curvature at the scatter cone base. The scatter cone reflection is around –70 dB at 480 GHz and drops off to higher frequencies with 12 dB/octave. The scatter-cone reflection should not be very different at off-axis angles.

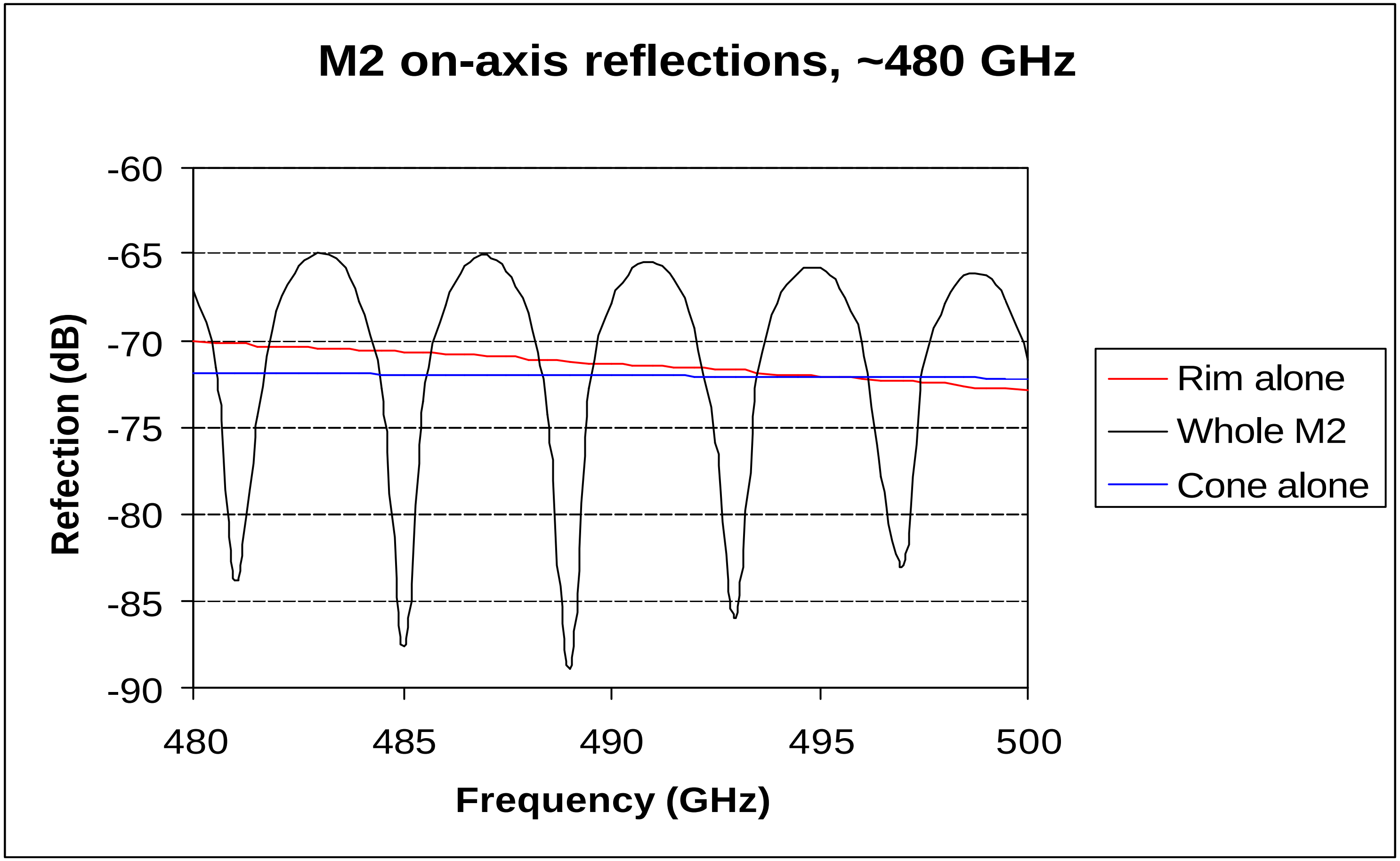
The rim reflection is significant only close to the optical axis. It drops with 6 dB/octave.

The combined effect on-axis is strongly frequency dependant.

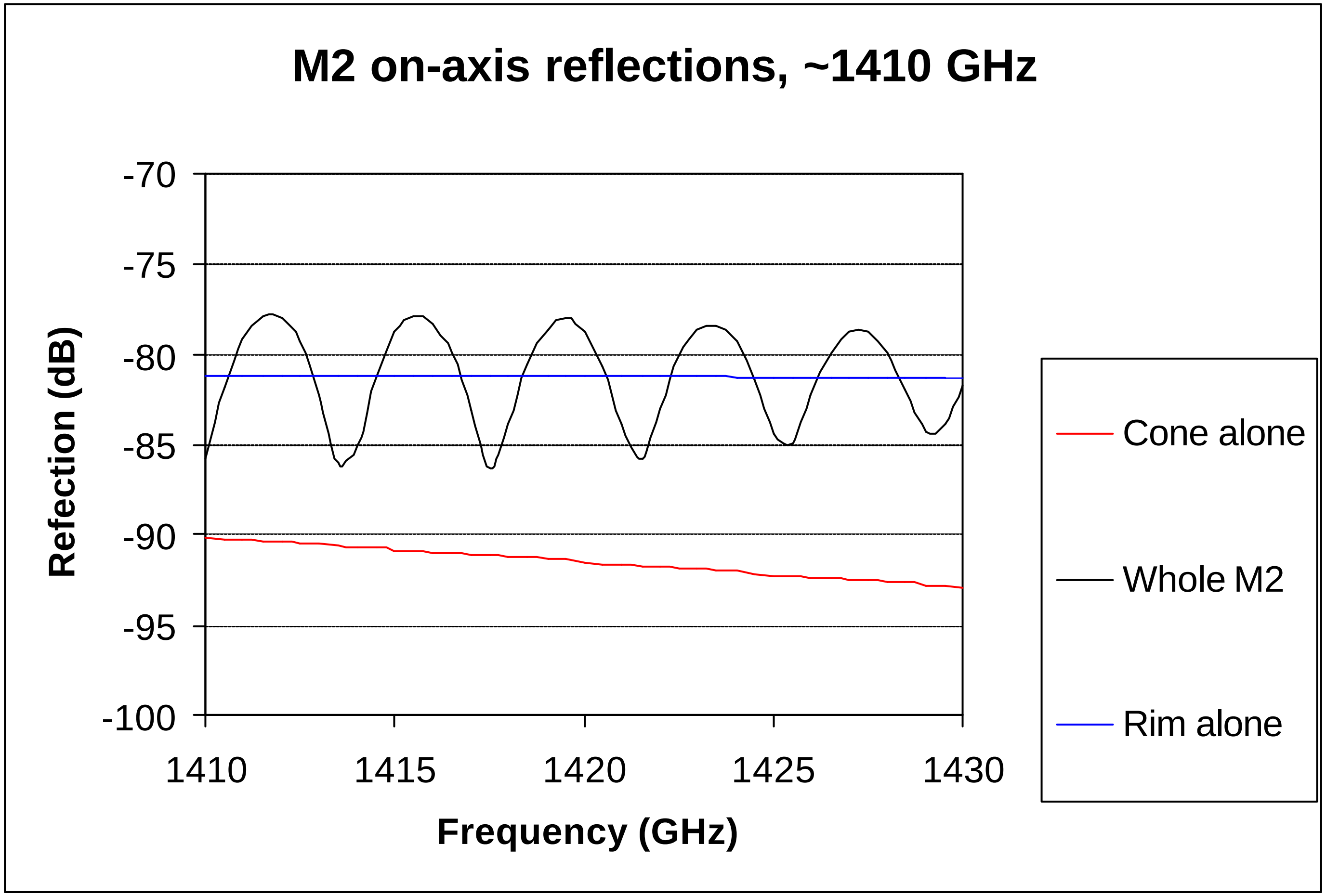
The scatter cone alone, on-axis



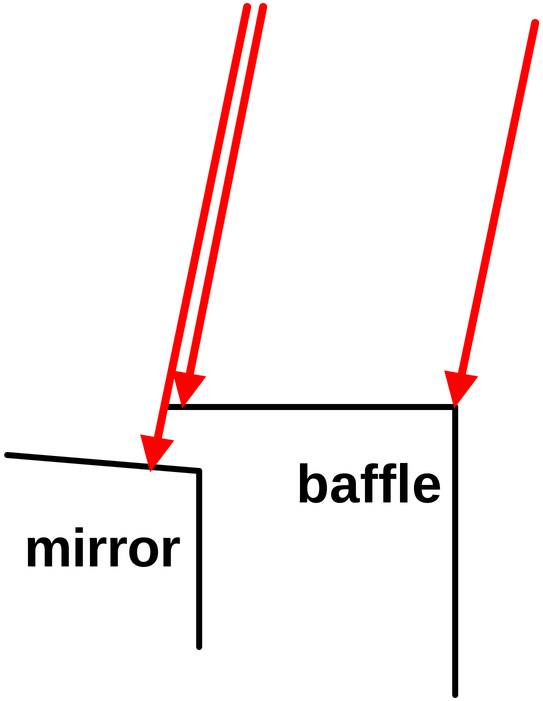
M2 on-axis near 480 GHz



M2 on-axis, near 1410 GHz



M1 and M1 baffle



With the small scatter cone, the inner rim of M1 and the top edge of the baffle are in full view of the HIFI feeds, in the central portion of the beam, with a high risk of strong reflections by diffraction.

Potentially, M1 and the baffle rim provide 3 cut-offs of reflecting surfaces. There will be only one cut-off if the transition between mirror surface and baffle edge is smooth enough (step of order 20 microns or less).

Additional risks: further rims down the barrel and still in view via the M2 surface around the scatter cone. Detailed design info needed!

The barrel, direct(via M1 and M2, in the parallel beam)

The original barrel design causes a frequency-independent on-axis reflection of –42 dB (3 dB stronger than presented presented earlier by HIFI, consistent with the ESTEC report)

The new barrel design still has flat areas left, at the connection points between radial bars, tangential bars and the legs. My estimate is that this area amounts to about 8% of the original flat surface area, so that the expected reflection drops by about 22 dB.

This is still far too high to be acceptable

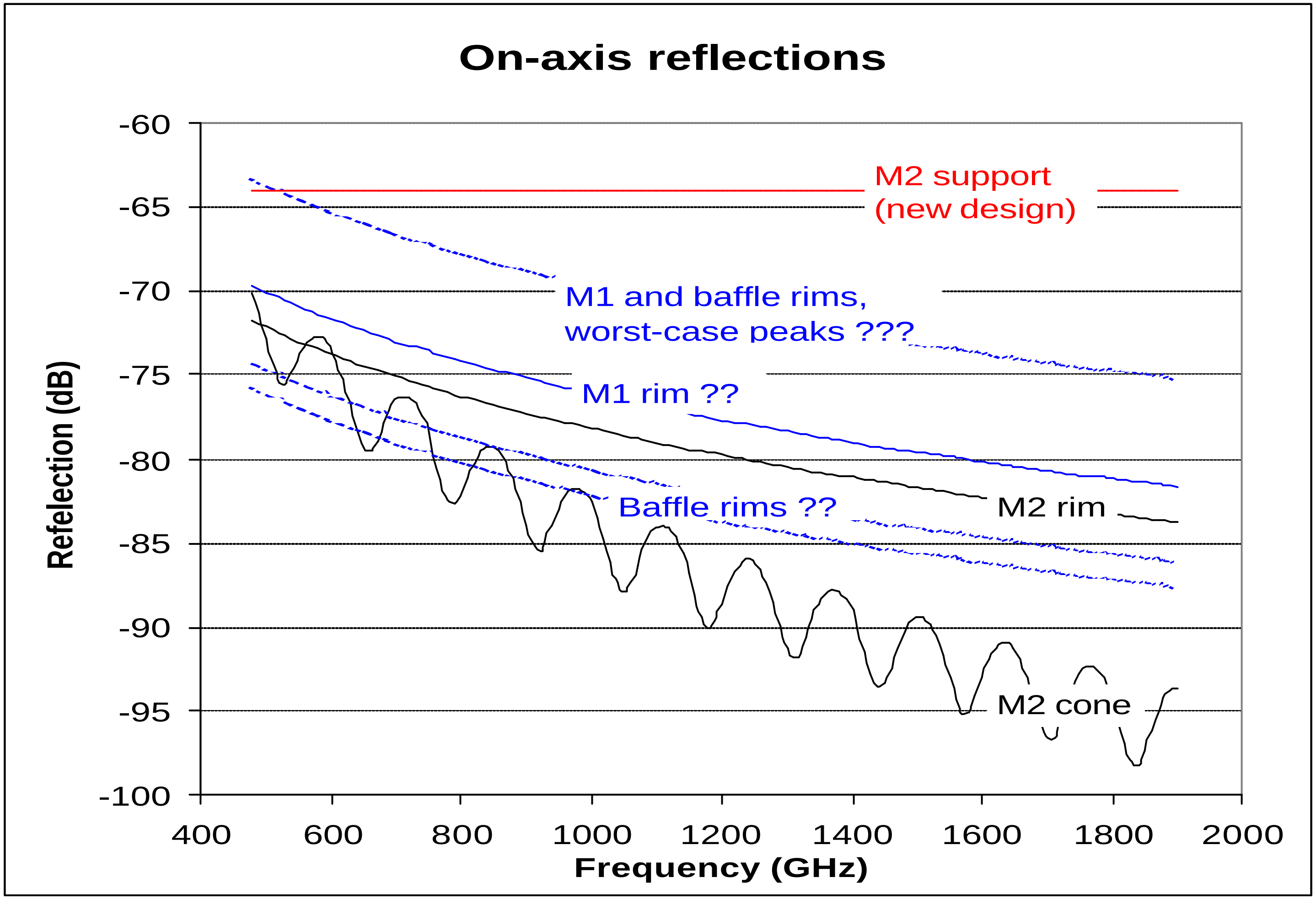
The barrel, via the scatter cone

This parasitic standing-wave path is a nice discovery in the ESTEC standing-wave report. The report notes that this standing-wave mode should disappear with the present tilted-bar approach.

We agree, the more since the original effect appears to be barely significant (although this should be verified at higher frequencies).

SRON

Overview of on-axis modes



Conclusions on the ESTEC assessment

Where direct comparisons are possible (on-axis M2 reflection at 480 GHz, on-axis reflection off the flat barrel structure) the report matches our analysis.

Thanks for the standing-wave investigation on the cryostat innards.

We found two errors in section 6.1: a slight one where the 6 barrel sections were taken into account by a multiplication factor of 5 instead of 6, and a large one, where the report states that the huge on-axis reflection is no real concern because HIFI has no detectors on axis. Band 6 is nominally on-axis and adjacent bands may easily end up on axis through an otherwise insignificant telescope misalignment.

A serious weakness of the report is that it limits itself to one frequency.

Attention must be given to the design around the hole in M1.

Conclusions on the telescope design

The barrel design is still unacceptable: the reflections off the remaining flat surfaces will dominate at all frequencies and are too high by at least 15 dBs at the higher frequencies.

A proper barrel design should have **no** horizontal surfaces. Only then will it be worthwhile to look into the remaining reflection properties of the barrel.

The design around the hole in M1 has been overlooked up to now for its standing-waves properties. Further inspection of the design details is necessary.

M2 is about as good as we might hope. The cone design appears to be almost optimal (for people who like small scatter cones).

Far-IR Laser Absorptivity Measurements of the Herschel Space Observatory Telescope Mirror Coatings:

Status and Preliminary Results

Jacqueline Fischer	Naval Research Laboratory
Tjeerd Klaassen	Delft University of Technology
Niels Hovenier	Delft University of Technology
Gerd Jakob	Max-Planck-Institute für Extraterrestrische Physik
Albrecht Poglitsch	Max-Planck-Institute für Extraterrestrische Physik

HOSWG #8, 24 June 2003

Experiment Concept

According to Kirchhoff’s law, for equilibrium conditions, the fraction of blackbody radiation emitted by the surface of an object at a given temperature and wavelength, its emissivity, ε, is equal to the fraction it absorbs at the same temperature and wavelength, its absorptivity, α.

This applies to total, spectral, directional, and polarization quantities. Thus one can indirectly measure the emissivity of a surface by calorimetrically measuring the fraction of radiation that it absorbs at that wavelength.

- A Herschel telescope mirror sample is weakly coupled to a 77 K thermal bath and then illuminated by FIR-radiation of known wavelength and power P_0 until a stable sample temperature is reached.

- The resulting small temperature increase ΔT is recorded through a temperature sensor, which is glued to the backside of the sample.

- Subsequently, the far-IR radiation is blocked and the sample is electrically heated via a resistor, which is also glued to the backside of the sample.

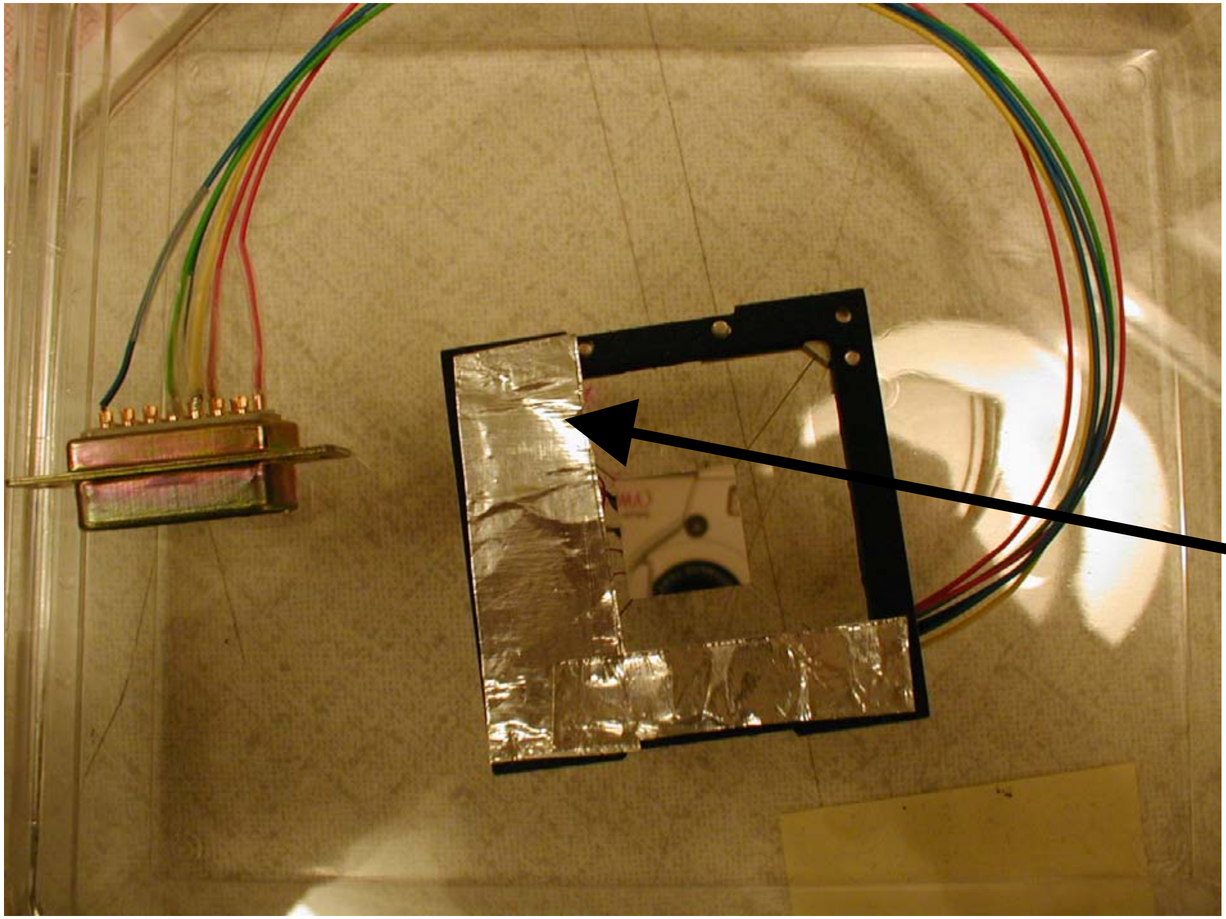
- The heating current is then adjusted until the sample reaches equilibrium at the same temperature that was recorded during laser illumination, heating the sample with power $P_H=I_H V_H$, where I_H and V_H are the heater current and voltage respectively.

- The incoming laser power P_0 is measured so that the absorptivity, α, and thus the emissivity, ε, at a given laser wavelength can be ascertained:

$$\boxed{\varepsilon = \alpha = P_{abs}/P_0 = P_H/P_0}$$

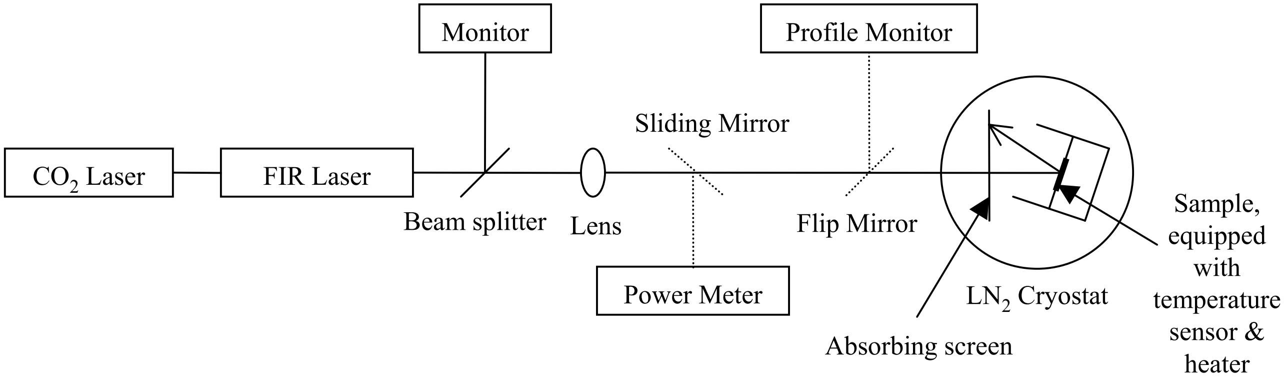
Sample and sample carrier, mounted in the sample housing

Sample size 14 x 14 x 0.5 mm



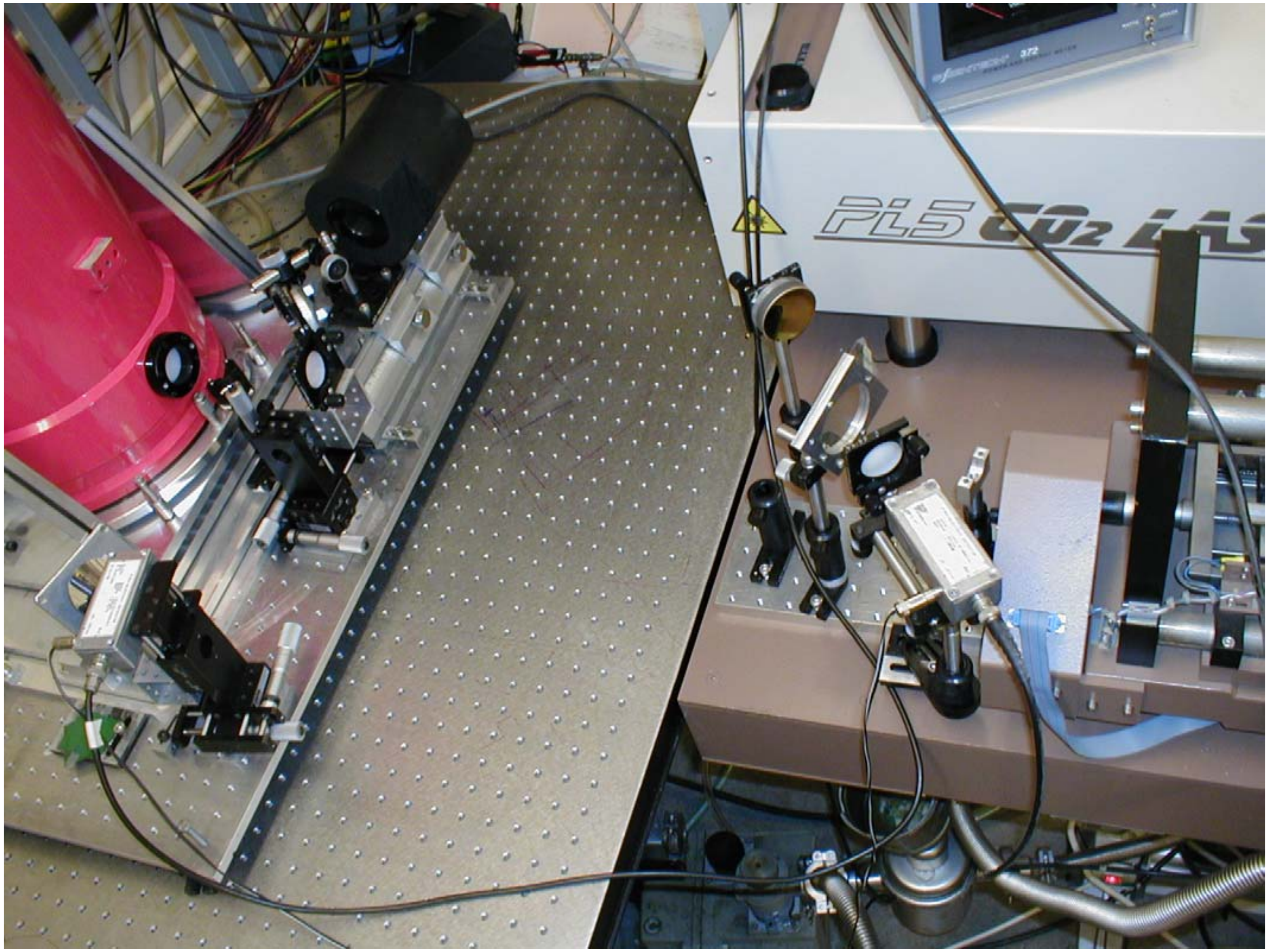
Light baffle in front of wire connections

Optical Configuration

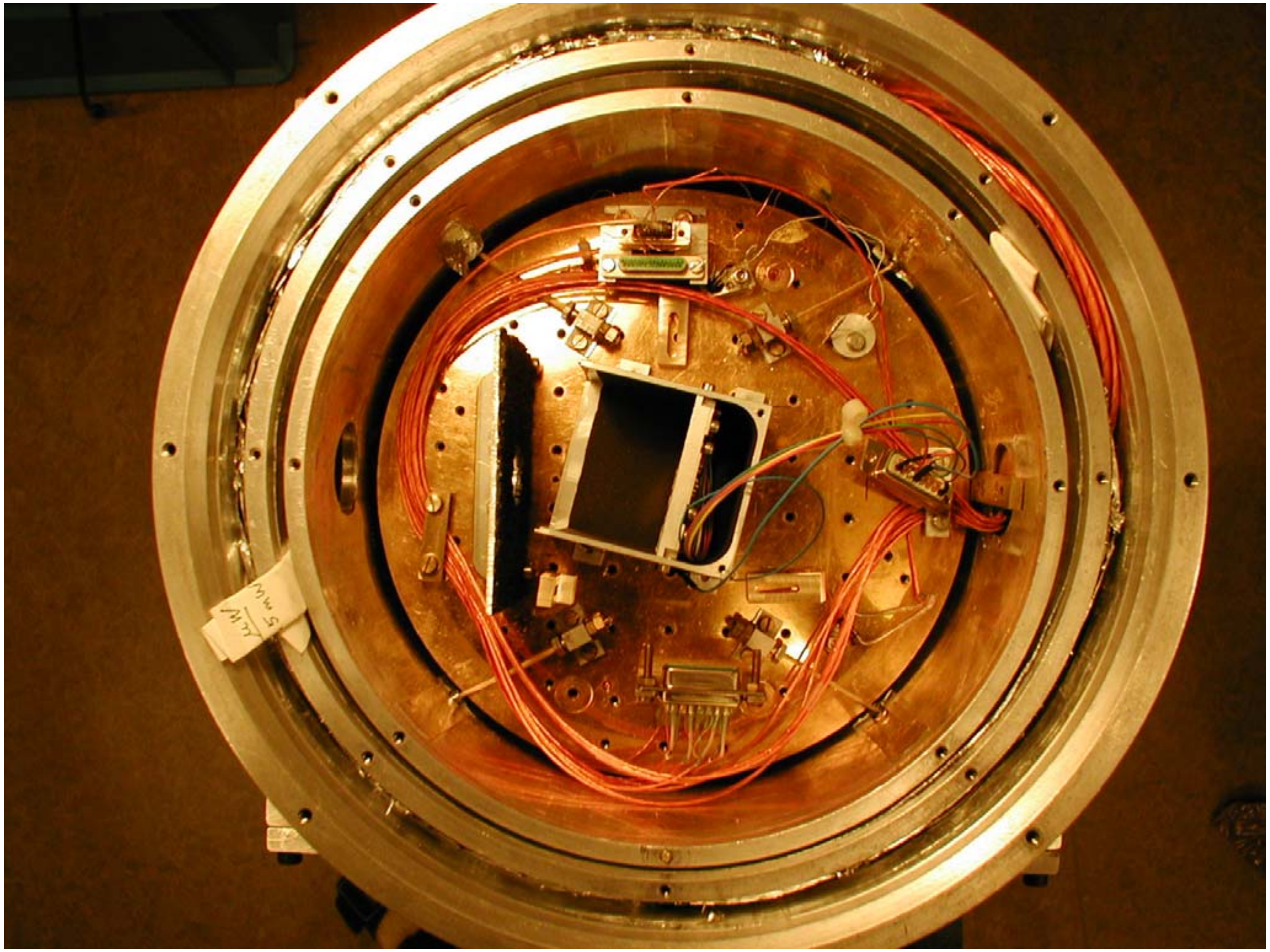


Sliding and flip mirrors are inserted into the beam for power calibration and beam profile measurement, as shown.

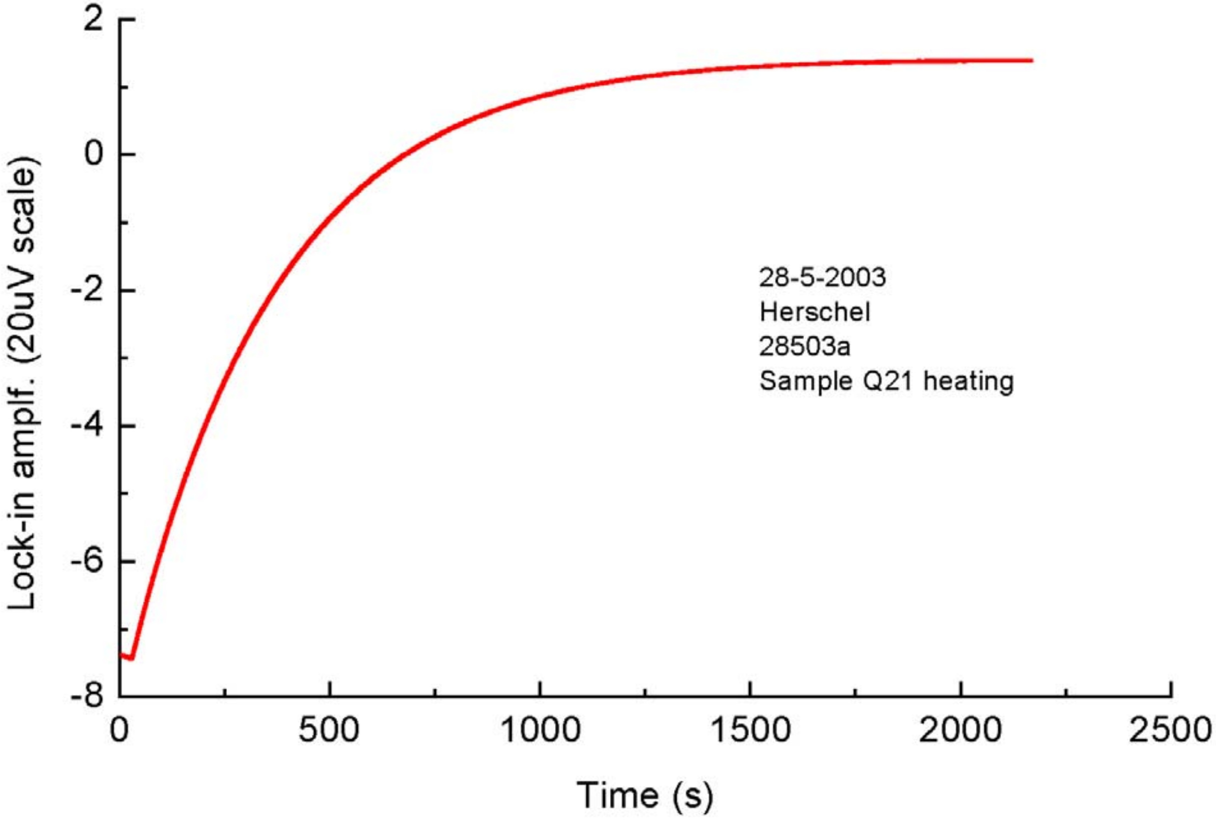
Optical Layout



Cryostat Cold Plate
(with top of sample housing removed)



Sample heating curve



Experimental Challenges

- To ensure that the full power of the laser beam is intercepted by the sample, mapping the central region of the sample and aperture checks were carried out.

- To ensure that high signal to noise was obtained, synchronous detection across a Wheatstone bridge was adopted.

- To ensure that the calibration of the laser power impinging on the sample is correct, a calorimetric power meter was newly developed for this purpose using a highly absorptive sample in a configuration similar to that of the absorptivity measurement.

- To ensure that the reflected laser power did not affect the output laser power, the sample was tilted at a 14 degree angle and an absorptive dump was used.

Sample properties*

Sample	Alumnum Thickness (nm)	Plasil Thickness (nm)
Planck	600	20
Herschel Q21	300	7
Herschel Q23	400	25

*Sample size was 14 x 14 x 0.5 mm

Preliminary Results for Q21

Wavelength (μm)	Absorptivity* (%)
70	0.35 ± 0.09
118	0.26 ± 0.07
186	0.31 ± 0.08
496	0.21 ± 0.05

*On the last day of experiments while measuring Q23, high humidity was present in the lab and moisture condensed on the window. Although a heater was used, absorptivity values twice as large as those in the table were measured. However all other indications are that there are no significant differences between the samples.

Dust contamination of Sample Q21

by M. van Eesbeek, O. Schmeitzky (ESTEC)

- Sample has been contaminated with 5000 ± 500 ppm dust

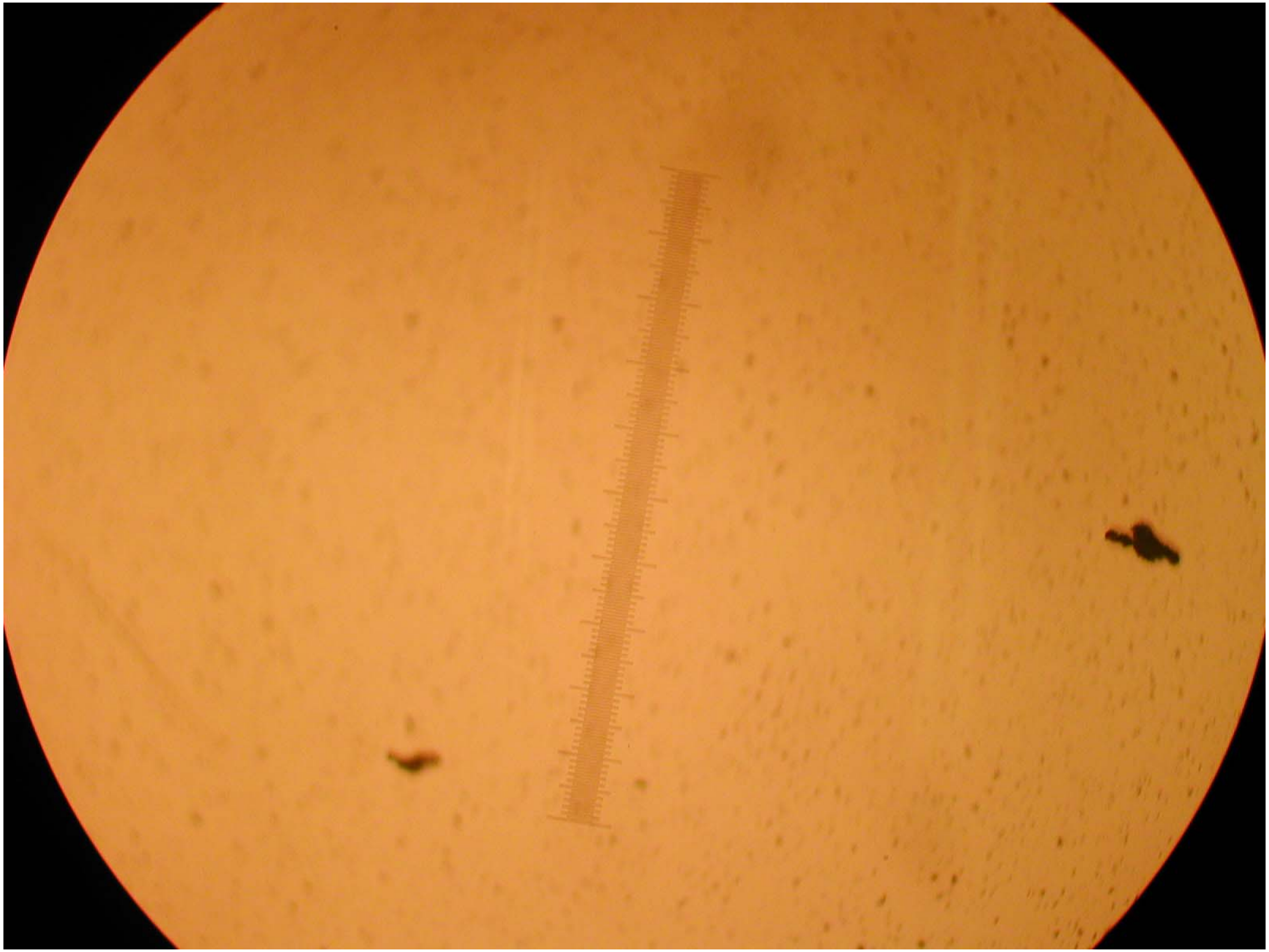
- Dust comes from class 100,000 clean room at ESTEC Test Center

- This type of dust was chosen to represent what might fall on Herschel telescope from Ariane rocket fairing

- Vertical placement in vacuum chamber did not affect the contamination level

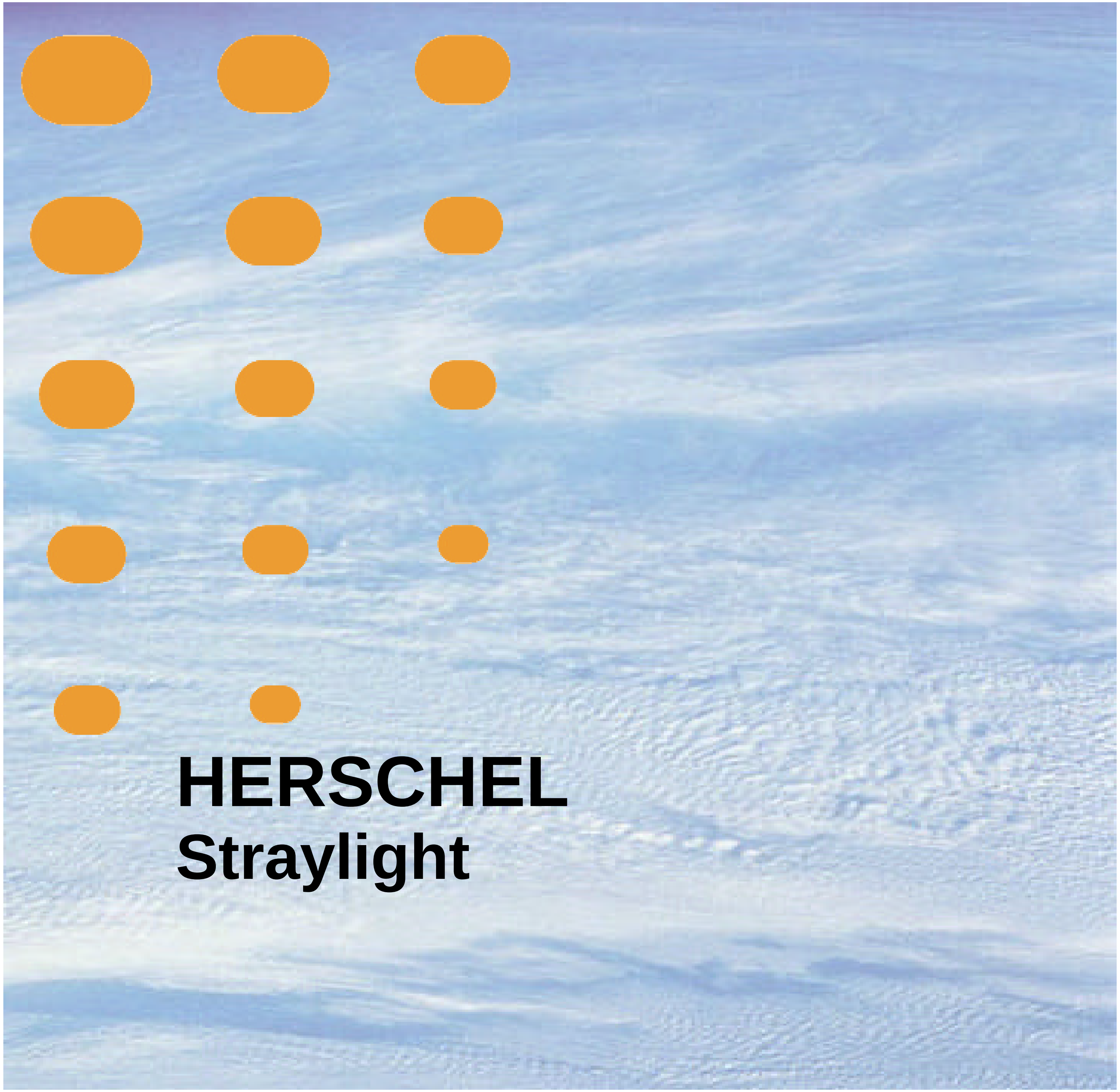
- Laser measurements are planned for week of 30 June 2003

SiC holes on sample (25 micron/line scale)



Current Status

- Complete error analysis and comparison of results from different samples will be done
- Test and model the effects of water vapor and condensation
- Transport dust contaminated sample to TU Delft and carry out absorptivity measurement
- End of campaign: July 8, 2003



HERSCHEL

Straylight

Quarterly Progress
Meeting 16
15.-18. July 2003

HP-2-ASED-HO-0050

Herschel Straylight

ASAP models: Changes in large model since OSWG October 2002

sunshade model:

- enlarged sunshade introduced

telescope model:

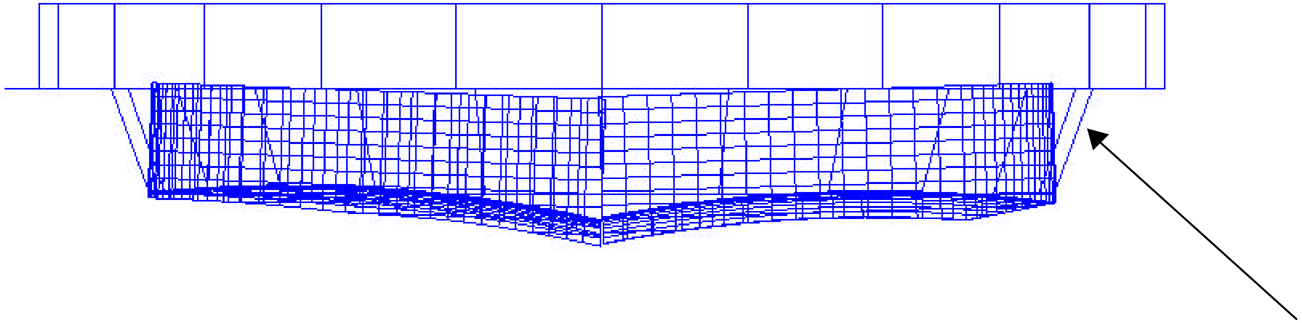
- new mirror scattering function
- new hexapod barrel inclinations (support by V.Kirschner)

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

Herschel Straylight

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

Herschel Straylight

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.

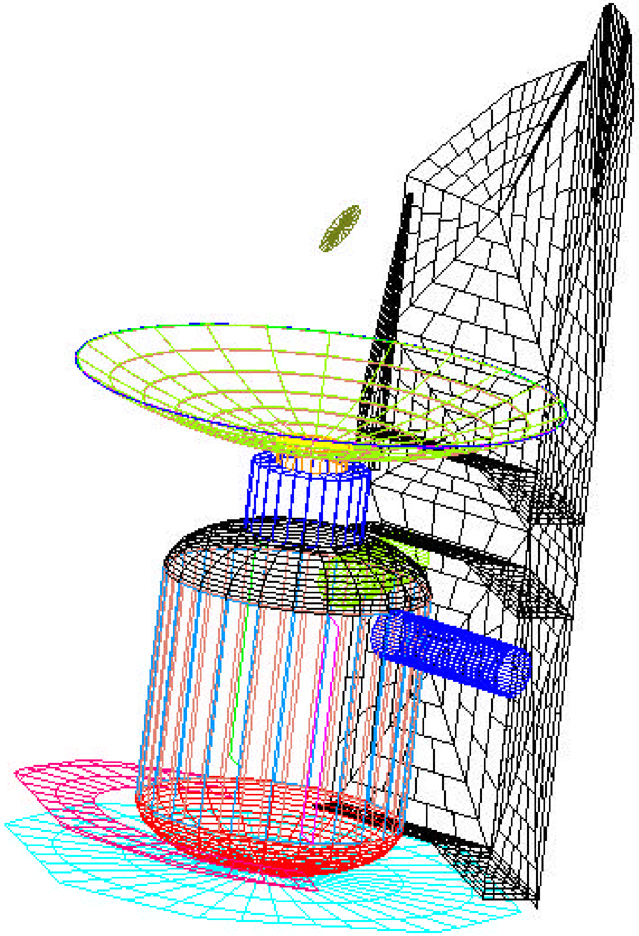
PACS model:

- 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.

Herschel Straylight



Separate model for objects below the gap between sunshade and M1

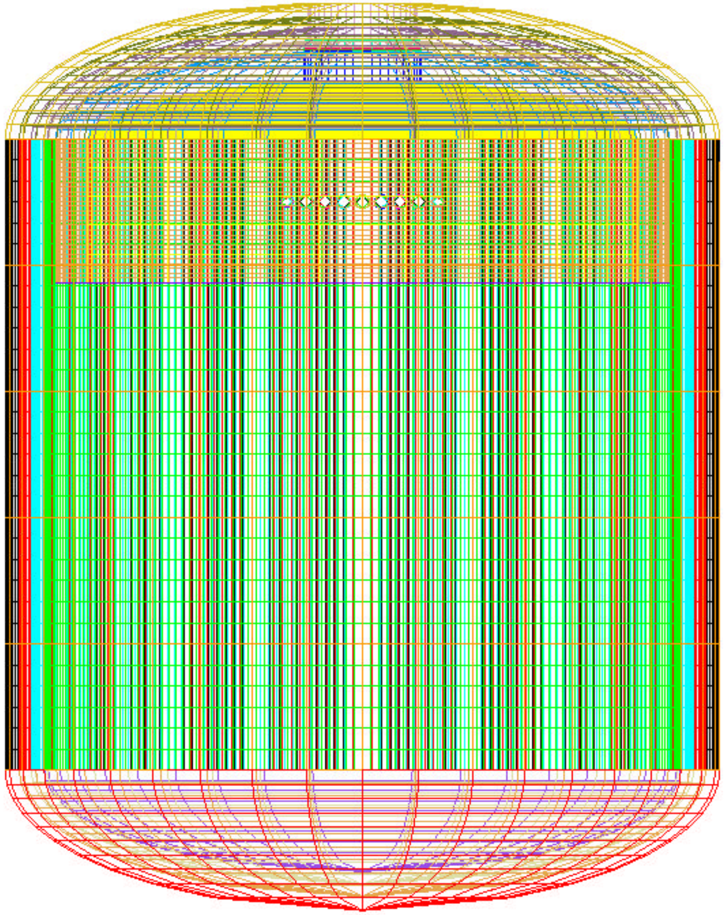
result: the gap has a radiation with an apparent emissivity of 0.10 at T=204 K, i.e. grey instead of black

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%

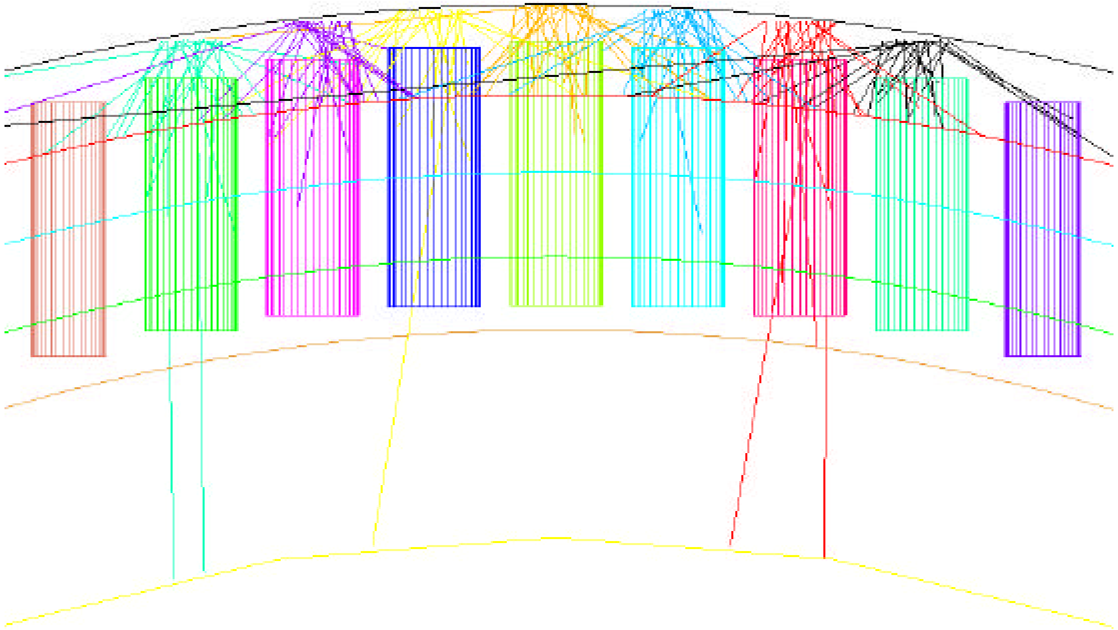
Herschel Straylight



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

Herschel Straylight



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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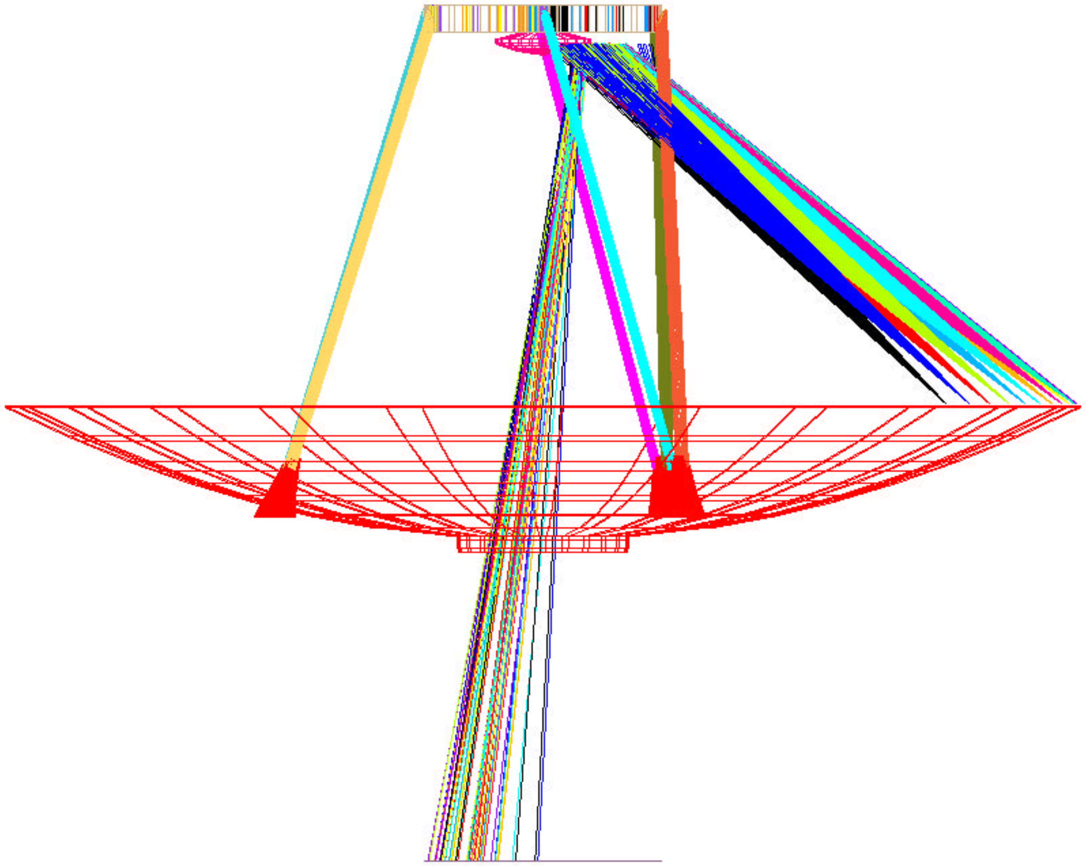

Diffraction at the rim of the secondary mirror.

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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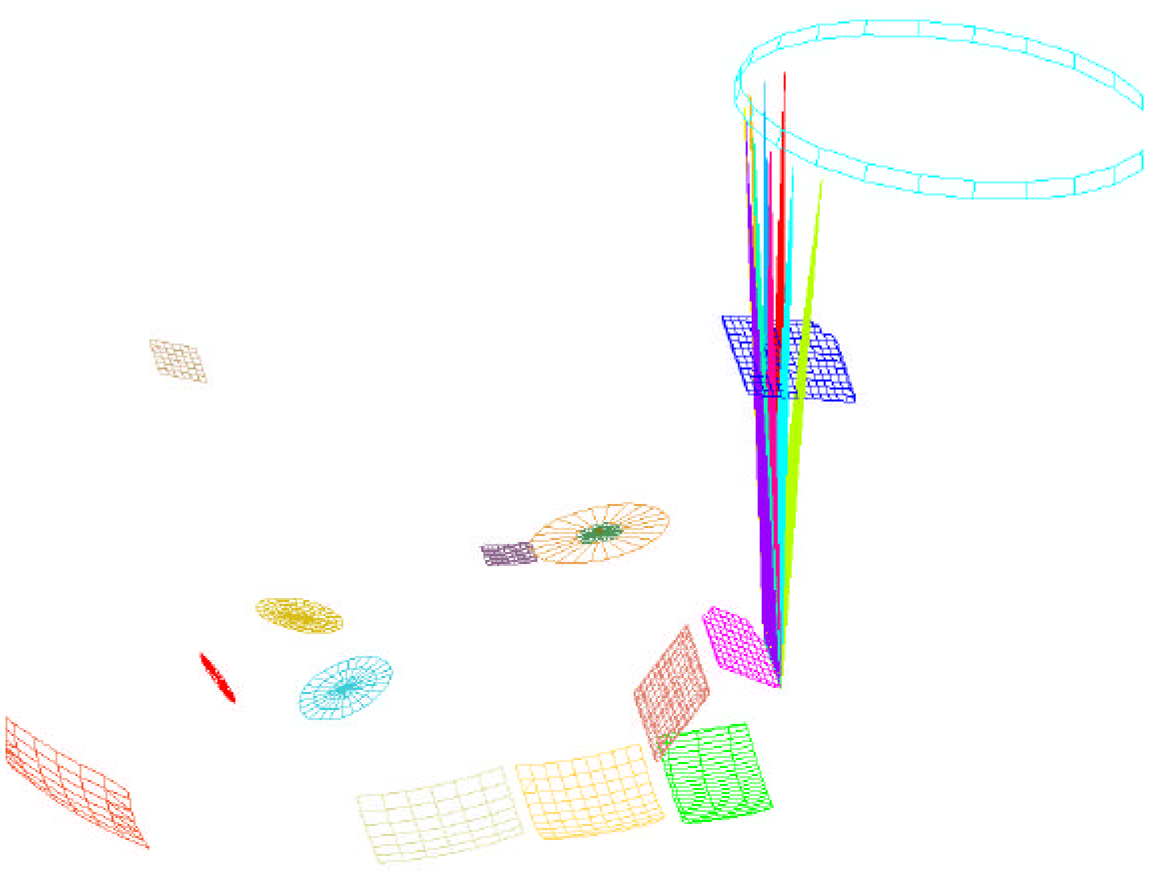

Diffraction on rim of thermal filter 1 of SPIRE (within telescope focal surface),
sources are CVV and objects nearby during ground testing, i.e. with warm rings = worst case

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

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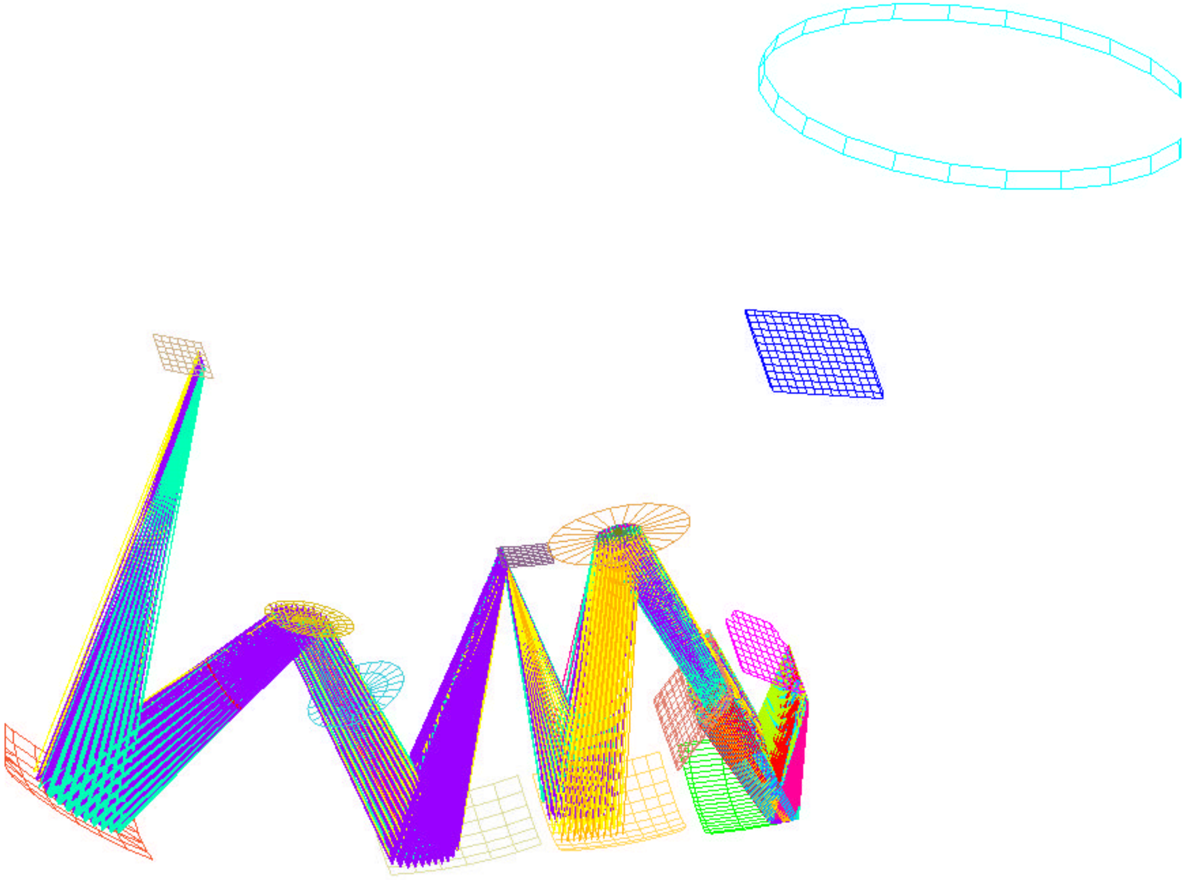

STEP 2:
--diffracted rays created at the rim of thermal filter 1
-- ray directions and fluxes as from method of stationary phase
-- flux of diffracted rays collected on detector

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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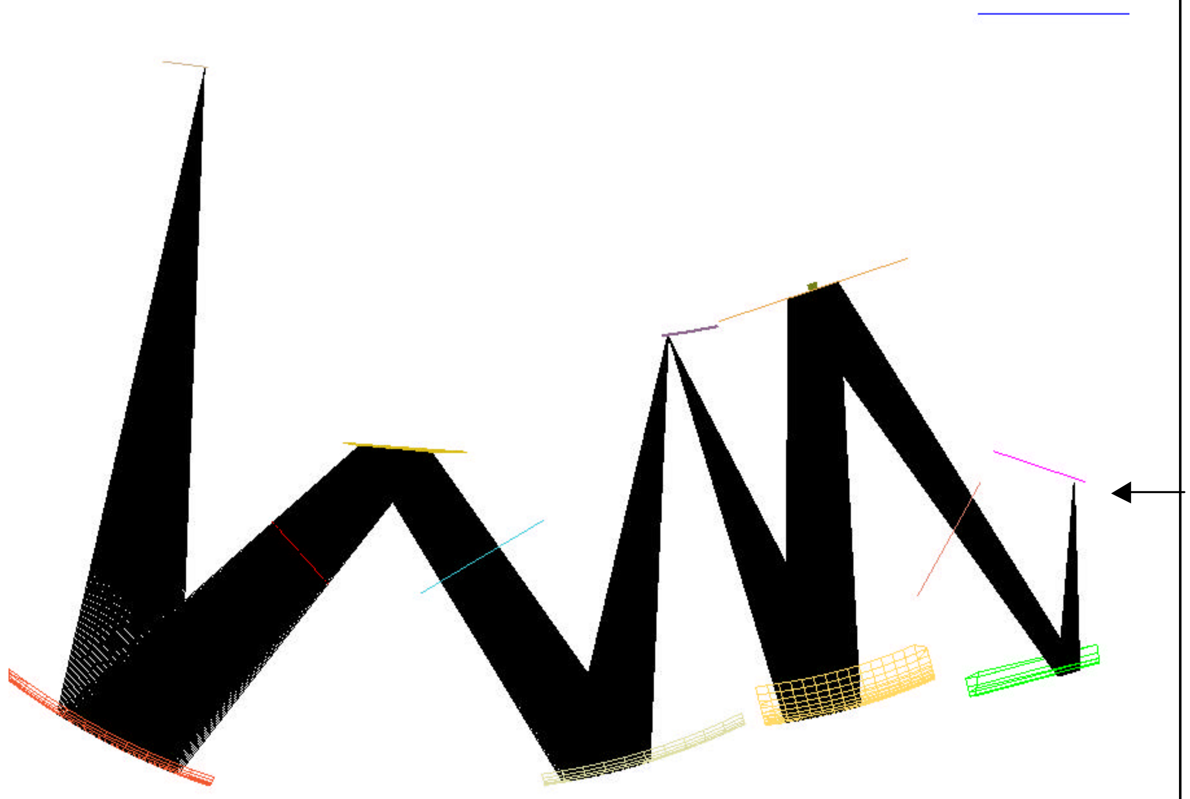

STEP 3:

-- 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%

Herschel Straylight

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.