HStrayWG mtg#1 - MOM

Herschel/HSC/MOM/1304

Göran Pilbratt, 4 December 2008

The first meeting of the Herschel Straylight Characterisation Working Group (HStrayWG#1) took place in ESTEC room Dj124y on 26 Nov 2008, starting at 09:30 hours and finishing at 17:00 hours. The draft minutes were circulated on 30 Nov 2008, comments incorporated in the final minutes issued on 4 Dec 2008.

Attendance

Bruno Altieri (BA)

Dominic Doyle (DD) - from 11:00 hours

Marc Ferlet (MF)

Ulrich Klaas (UK)

Koryo Okumura (KO) - could not attend

Göran Pilbratt (GLP)

1. Welcome and Agenda

- GLP acting as meeting chair welcomed BA, MF, and UK to the meeting, and explained that DD will join around 11:00. KO was unable to attend this meeting.
- GLP asked for comments on the circulated draft agenda *(attached as Appendix 1)*. UK and MF confirmed that they have short presentations to be provided under point 4.
- The agenda was adopted for the meeting.

2. Introduction to the task

- In the ongoing preparations of the early mission phases the SciOpsWG needs input whether, and if so what, straylight characterisation activities need to be executed during the PV phase. The HStrayWG has been set up to generate and provide this input.
- GLP provided the System Requirements Specification (SRS) requirements wrt straylight *(relevant pages attached as Appendix 2)*, and explained that they have been 'inherited' from the Telescope Specification (TelSpec) which precedes the SRS. The straylight requirements were originally captured in the TelSpec *(relevant pages (note p.25 is blank) attached as Appendix 3)*.
- GLP gave an overview of the straylight documentation collected in Feb 2008 in response to an action from the SciOpsWG, see README_v3 doc from this folder *(attached as Appendix 4)*.
- The relevant EQM straylight documents were requested - what was the 'solution' to the excess straylight initially observed? GLP will add the relevant documents into Livelink *(Action_1-1 on GLP)*, he also pointed out that we now know from actual measurements under He-II conditions that the FM cryostat is as 'dark' as can be expected.
- An ISOPHOT straylight document provided by UK will be added into Livelink *(Action_1-2 on GLP)*.
- The HStrayWG Terms of Reference (TOR) summarises the scope, task, membership, communication, output, and reporting of the HStrayWG. The draft TOR circulated by GLP was discussed and approved without changes. GLP will issue the TOR *(Action_1-3 GLP)*.

4. Instrument presentation

- Since DD had not yet arrived, it was decided to proceed to agenda point 4, before dealing with agenda point 3. DD arrived shortly after starting with point 4.

- UK gave a presentation initially prepared by H. Feuchtgruber and N. Geis for the SciOpsWG mtg held in Feb 2008 *(attached as Appendix 5).*
  - Deficiencies in the available models were listed. DD pointed out that Philippe Martin, TAS-F, (PM) now have an as built model - we might consider requesting particular analysis/information from PM.
  - Norbert Geis (NG) 'transformation' - how have the 'attenuations' been computed? *(Action_1-4 on UK).*
  - Can the model of PM be used to calculate 'attenuations'? *(Action_1-5 on DD).*
  - A very important issue is whether, and if so how, confident can we be that the 'locations' of outside-FOV sources have been computed correctly? In other words how large maps would we need to make in order to characterise the actual straylight performance.
- UK pointed out that in the PACS calibration document (PCD - PACS-MA-GS-001) there is a section 7.3 on straylight suppression. There are also observations related to photometer and spectrometer straylight requirements *(relevant PCD pages attached as Appendix 6).*
- UK summarised the ISOPHOT straylight characterisation.
  - This work took advantage of solar eclipses as seen from ISO (in Sep 1997). Herschel does not have eclipses, but partial ones?
  - ISO straylight performance was very good, and predictions generally appeared accurate - to the extent verification was possible. The Saturn 'ring' and 'finger' discovered during the serendipitous observations were surprises though.
- MF presented *(attached as Appendix 7)* the Pcal illumination issue.
  - Some Pcal power will be reflected out of SPIRE towards the cryocover (ground) / telescope (in-flight), from where it can be reflected back into the focal plane and possibly affect PACS during parallel mode observations - in-flight the M2 scattercone will possibly suppress any effect.
  - MF would like to check the suppression of the narcissus effect by running PM's in-flight Code-V model. DD will interact with Philippe Martin, TAS-F, and deliver the model to MF/SPIRE and also to N.Geis /PACS. *(Action_1-6 on DD).*
  - The SPIRE spectrometer also has a calibration source, Scal. As opposed to Pcal, Scal is used continuously during spectrometer operation to null the telescope signal, but it is in a different place in the optical path and will not 'leak' power into the focal plane.

3. Analysis performed

- Discussion of existing 'old' ASED, ASEF, and Alcatel straylight analysis documents made available in the Livelink 'Straylight folder'. It was pointed out by GLP that none of them accurately reflect the as-built and as-aligned flight spacecraft, importantly the implications of this are not clear.
- It was pointed out by DD that the SPIE paper by PM which was presented in the SPIE meeting held in Marseille in Jun 2008 reported on the in-flight straylight analysis performed. It will be added in Livelink *(Action_1-7 on GLP).*
- In connection with a discussion on the cross-section shape of the hexapod legs MF pointed out that reflective coatings (e.g. MLI etc.) are not necessarily always reflective at long wavelengths corresponding to low temperatures (lesson learned from JWST/MIRI work). Do we know for sure that the kapton covering the hexapod legs is highly reflective at Herschel operating wavelengths? Is the Al layer thick enough? The multi-reflection paths may have higher attenuation because of lower than expected reflectivity (but self-emission contribution would then be higher than currently computed). DD will provide the Al thickness (*Action_1-8 on DD*).

5. General discussion/brainstorming

- The first question to answer is whether there is a need to characterise straylight performance in-flight at all. The HStrayWG concluded we do need to perform straylight characterisation in-flight.
- Having concluded on this; what exactly do we need to determine, why, and how?
- Straylight for sources inside and close to the instrument FOV.
  - UK clarified that for PACS sources inside its FOV and up to 10-15 arcmin outside PACS is covered by existing instrument PV phase observations.
  - MF clarified that for SPIRE existing PV phase observations cover inside the SPIRE FOV 'only'.

- Straylight from sources (far) outside the instrument FOVs.
    - The main issue UK sees is Sun, Earth, and Moon straylight, and possibly issues reminiscent of the ISOPHOT 'Saturn ring' (see section 4 above). MF agrees for SPIRE.
    - The hope is that using the in-flight Code-V model from PM the locations of 'sore spots' on the sky can be predicted, can they? We want to know whether Fig.6 in PM's SPIE paper has been produced by using the in-flight Code-V model. *(Action_1-9 on DD).*
- Self-emission.
    - MF pointed out that if the total optical background is composed of telescope optics background and straylight in approx equal parts then the spectrum is no longer a Planck spectrum for a single temperature. GLP confirmed that this is the current expectation, at least for SPIRE wavelengths.
    - It was agreed that during routine observing, what is important to know is the total power, spectrum, and temporal stability of the optical background power. If - which can be the case at least for SPIRE - the optical background is dominated by straylight, then it will be the cumulative power from a number of contributors of different temperatures and emissivities.
    - UK pointed out that in order to use the PACS spectrometer to observe the telescope background changing during telescope cooldown - at least in a reproducible fashion - several instrument parameters need to have been determined.
    - MF will investigate what practical constraints could be important in the operation of SPIRE early in the mission, in the context of using the SPIRE spectrometer to observe the telescope background changing during telescope cooldown. *(Action_1-10 on MF).*
    - UK pointed out that - although not necessarily an issue - that we should check for a possible straylight contribution from the PACS internal calibration sources while they are cooling down (timescale hours) when SPIRE is operational.

6. Tools

- We want predictions as to where the 'sore spots' are. Which tool can provide this? In particular can PM's in-flight Code-V code do the job? (Cf. Action_1-9 on DD).
- The construction of AORs is not likely a problem, but mission planning will be crucial in providing the desired orientation on the sky between telescope boresight and straylight source positions. Is this a problem? Check with Jon Brumfitt. *(Action_1-11 on GLP).*

7. Next meeting

- Next meeting will take place on 18 Dec 2008 in ESTEC, TBC depending on Philippe Martin being available *(Action_1-12 on DD).*

8. Action review

- To be performed by commenting on the draft MOM. *(Action_1-13 on all).*

9. AOB

- None.

GLP thanked everyone and closed the meeting.

List of Actions - HStrayWG1-Action#

1. Add relevant EQM straylight documents into Livelink. Actionee: GLP. Deadline: 8 Dec 2008.
2. Add the ISOPHOT straylight document provided by UK into Livelink. Actionee: GLP. Deadline: 8 Dec 2008.
3. Issue and circulate the HStrayWG TOR. Actionee: GLP. Deadline: 8 Dec 2008.
4. Provide explanation for how N.Geis has computed the ‘attenuations’ presented in App.5. Actionee: UK. Deadline: 15 Dec 2008.
5. Provide information whether the in-flight model of PM can be used to calculated ‘attenuations’. Actionee: DD. Deadline: 15 Dec 2008.
6. Deliver the in-flight Code-V straylight model of PM to MF/SPIRE and N.Geis /PACS. Actionee: DD. Deadline: 15 Dec 2008.
7. Add PM’s SPIE straylight paper into Livelink. Actionee: GLP. Deadline: 8 Dec 2008.
8. Provide the Al thickness of the kapton used to cover the hexapod legs. Actionee: DD. Deadline: 15 Dec 2008.
9. Check whether locations of ‘sore spots’ can be predicted and whether Fig.6 in PM’s SPIE paper has been produced by using the in-flight Code-V model. Actionee: DD. Deadline: 15 Dec 2008.
10. Identify what practical constraints are important for the operation of SPIRE early in the mission. Actionee: MF. Deadline: 15 Dec 2008.
11. Can the MPS system handle desired source (in particular Sun, Earth, Moon) relative positional arrangements for the scheduling of straylight characterisation observations. Actionee: GLP. Deadline: 15 Dec 2008.
12. Check and confirm that PM can attend the meeting TBC on 18 Dec 2008. Actionee: DD. Deadline: 8 Dec 2008.
13. Review the list of actions in the draft MOM. Actionee: all. Deadline: 2 Dec 2008.

List of Appendices - HStrayWG1-Appendix#

1. Draft agenda
2. SRS_v3.3 straylight requirements
3. TelSpec_v7.0 straylight requirements
4. README_v3 document from Livelink straylight folder
5. PACS input to straylight discussion in SciOpsWG presentation
6. PACS PCD sections relevant wrt to straylight
7. SPIRE Pcal illumination implications presentation

Appendix 1

DRAFT agenda for HStrayWG#1

ESTEC room Dj124y, 26 Nov 2008, 09:30-17:00

1. Welcome and agenda - GLP

2. Introduction to the task - GLP
   - SciOPsWG actions
   - Task and output
   - Approval of the TOR

3. Analysis performed - DD/GLP

4. Instrument ideas/presentations - TBC

5. General discussion/brainstorming - all
   - what do we want to determine
   - possible measurements
   - further analysis

6. Tools
   - do we have the tools we need for
     * defining and producing required observations
     * any required further analysis

7. Next meetings

8. Action review

9. AOB

HERSCHEL / PLANCK

SYSTEM REQUIREMENTS SPECIFICATION [SRS]

SCI-PT-RS-05991

Issue 3 / 3 - 27 July 2004

Prepared by ESA Herschel / Planck Project Team
Responsible A. Elfving – S/C Systems Engineering Manager

Approved by ESA Herschel / Planck Project Manager SCI-PT

T. Passvogel

5.3.3 Straylight

For the Herschel mission

The straylight coming into the focal plane can have three distinct origins:

- Sources outside telescope field of view
- Sources inside field of view
- Thermal self emission

The definition of the optical components and properties of the Herschel scientific instruments, as far as relevant for the stray light verification are defined in the IID's parts A and B (AD4-1, AD4-2, AD4-3, AD4-4). The requirements are the following :

a. Sources outside telescope field of view

The far infra-red and sub-millimetre sky is dominated by four extremely bright objects: the Sun, the Earth, the Moon and Jupiter. Off-axis rejection is determined mainly by the quality of the baffling system at small angular distances from these bright sources.

SPER-050 H *The parasitic light in the focal plane shall be below 1% of the background induced by self emission of the optical system for Sun, Earth, Moon at worst case locations corresponding to the aspect angle limits as specified in Section 4.2.7 for the Herschel observation mission phase.*

Note: The limit angle for Jupiter shall not be a design driver but shall be specified by the Contractor based on the actual design.

b. Sources inside field of view

The diffraction theory shows, that for a telescope of limited size, the energy coming from a monochromatic point source, even if it has a very strong maximum, is distributed across the whole focal plane. Imperfections in the mirror qualities, mainly dirt and small scale irregularities, will amplify this spill-over.

For information, it will be noted that:

Over the entire field of view at an angular distance of 3 arcmin or more from the peak of the Point Spread Function (PSF) the irradiance shall be less than 10^{-4} of the PSF peak irradiance (in addition to the level given by diffraction).

c. Thermal self emission

The optical subsystem of Herschel being at a finite temperature will emit far infra-red and sub-millimetre radiation that will fall onto the detectors, introducing spurious signals which are difficult to eliminate.

SPER-055 H	*The straylight level received at the detector element location of the PLM/Focal Plane Unit Straylight Models by self emission, not including the self-emission of the telescope reflectors alone, shall be less than 10% of the background induced by the self emission of the telescope reflectors.*

This requirement includes the self-emission of the PLM / Focal Plane Unit Straylight Model, which will be delivered by ESA.

For the PLANCK Mission

The contractor is invited to consult Reference Document RD-6 as a guide to the approach to be followed.

The straylight coming into the focal planes can have two distinct origins:

- Sources external to the spacecraft in the far-field of the telescope
- Spacecraft Self emission sources .

The definition of the optical components and properties of the Planck scientific instruments, as far as relevant for the straylight verification are below. The requirements are the following :

a. Sources external to the spacecraft in the far-field of the telescope

External straylight in the millimetre and sub-millimetre wave range is dominated by four extremely bright sources: the Sun, the Earth, the Moon and the Milky Way. Large angle off-axis rejection is determined mainly by the telescope shield's shape and size.

SPER-060 P	*The system rejection at the detectors for Sun, Earth, Moon at worst case locations shall be , at least :* ***30 GHz :*** *-91 dB , -78 dB and -71 dB respectively.* ***100 GHz (HFI) :*** *-91.5 dB (-99 dB), -78.5 dB (-86 dB) and -71.5 dB (-73 db) respectively* ***353 GHz :*** *-92 dB (-108 dB), -79 dB (-95 dB) and -72 dB (-81 dB) respectively.* ***857 GHz :*** *-98 dB (-122 dB), -85 dB (-109 dB) and -78 dB (-95 dB) respectively.*

H E R S C H E L

T E L E S C O P E

S P E C I F I C A T I O N

Prepared by: D. de Chambure
ESA Herschel/Planck Telescope Engineer

Approved by: G. Crone
ESA Herschel/Planck Payload Manager

T. Paβvogel
ESA Herschel/Planck Project Manager

ESA Herschel/Planck Project

reference: SCI-PT-RS-04671

issue: 7

revision: 0

date of issue: 26 July 2004

E S T E C

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TEPE-095 Non-uniformity of relative spectral transmission ^{d} £ ± 0.01.

<u>Notes and definitions for TEPE-090 and 095</u>:

a. The relative spectral transmission $t(l)$ of the telescope is defined by

$$t\,(l) = f\,(l)\,/\,f_{0}\,(l)$$

with

$f\,(l)$ integrated flux [W] leaving the telescope in image space

$f_{0}\,(l)$ integrated flux [W] entering the telescope through its entrance pupil within the unobstructed areas.

b. At acceptance and delivery of the telescope.

c. The design life is specified in paragraph 5.1

d. The non-uniformity of the relative spectral transmission is defined as the maximum deviation between the relative spectral transmission values for any 100 mm diameter area within the entrance pupil (EP) and the average relative spectral transmission determined for the full EP area of the telescope, excluding the gaps between the segments.

4.2.2 Straylight

The Straylight requirement for the telescope including the sunshield, is defined w.r.t. the straylight level obtained at a specified detector element location. The definition of the optical components and properties between the Primary reflector and the detector element, as far as relevant for the straylight verification will be provided by ESA.

The following straylight requirements apply over the full operational wavelength range:

- Scattered light

TEPE-100 Sources outside telescope FOV:
Taking into account the worst combination of the Moon and the Earth positions w.r.t. the LOS of the telescope with maximal:
- *Sun - S/C - Earth angle of 37º*
- *Sun - S/C - Moon angle of 47º*
- *Sun - S/C - LOS angle of 60º to 120º,*

the straylight shall be: < 1.0% of background radiation induced by self-emission of the telescope.

TEPE-105 Sources inside FOV:
over the entire FOV at angular distances ³ 3' from the peak of the point-spread-function (PSF), the straylight shall be:

< 1 x 10^{-4} of PSF peak irradiance (in addition to level given by diffraction).

- Self-emission

TEPE-110 *The straylight level, received at the defined detector element location of the PLM/Focal Plane Unit Straylight model by self emission (with "cold" stops in front of PACS and SPIRE instrument detectors), not including the self emission of the telescope reflectors alone, shall be £ 10 % (tbc) of the background induced by self-emission of the telescope reflectors.*

4.2.3 Coating

The optical coating of the telescope reflectors shall be designed for the operating wavelength defined in 4.2.1.

TEPE-115 *The coating shall comply with the durability requirements defined in AD-7.*

TEPE-120 *The durability requirements of the optical coating shall be verified with representative samples from the same coating batch/material as the reflectors.*

TEPE-125 *The optical coating shall be grounded via the telescope grounding system.*

4.3 Physical Requirements

4.3.1 Dimensions of the Telescope

TEPE-130 *The telescope and its interfaces shall not exceed the size of the dynamic envelope defined in Figure 4.3-1.*

4.3.2 Mass properties

TEPE-135 *The total mass of the Telescope (including the thermal H/W and the alignment cubes) shall not exceed 315 kg.*

TEPE-140 *The knowledge accuracy of the position of the centre of gravity (CoG) shall be better than ±3 mm: it shall be verified by test (Y and Z axes) and by analysis (X axis). The knowledge accuracy of the moments of inertia wrt CoG shall be better than ± 5% (analysis).*

Herschel SciOpsWG Straylight Documentation - README v_3

Göran Pilbratt, 20 February 2008

Herschel/HSC/MEM/1116

1. Introduction and Scope

The present note intends to provide a listing of - and some comments on - available documentation relating to straylight and straylight analysis for Herschel.

This is document_00 in the Straylight folder in the Livelink SciOpsWG folder. I have put the changes notes last in order to be unobtrusive.

2. Available Documentation

There is not a lot of documentation available for the actual in-flight Herschel optical configuration.

In the Herschel/Planck DMS there exists some outdated documentation - remember the current telescope and suite of instrument is but the last in a sequence - which is not included here. Also not included here is documentation related to the straylight situation in various ground tests.

The document numbers below refer to the numbers given in the Straylight folder in the Livelink SciOpsWG folder.

2.1 Specification

10. Herschel Telescope Specification v_7.0 - 26 Jul 2004

Straylight performance is a system level requirement. However, due to historical reasons it was captured in the telescope specification (section 4.2.2), and then copied-and-pasted into the SRS.

2.2 EPLM QR level

20. Herschel Straylight Calculation Results v_4 - 27 Sep 2004

This document in v_3 was the straylight document in the Extended PLM (EPLM) QR (Qualification Review) held in spring 2004. After the review, incorporating enhancements due to QR RIDs it was issued as v_4. It has been produced by the person - Albrecht Frey - who actually performed most of the straylight analysis. In practice it supersedes document_30_v3 which is RD1 - dated 2002 but supplied for the FQR/DRB with a new cover page.

21. Radiometric Environment Hypotheses for Straylight Assessments v_1 - 14 Feb 2002

This RD2 in document_20.

22. Herschel Straylight Expertise v_1 - 27 Sep 2002

This RD3 in document_20.

2.3 Telescope delivery

30. Herschel Telescope Straylight Analysis v_4.0 - 12 Dec 2006

The telescope FQR/DRB (Flight Qualification Review/Delivery Review Board) took place in Oct-Nov 2006. This document in v_3 (RD1 of document_20) is the straylight document in the FQR/DRB data package, it was updated and reissued as v_4 on the basis of the DRB RIDs. (Actually, the change record in v_4 is incorrect, wrt v_3 pp.16-18 have been added after old p.15, old p.17 has become new pp.20-21, and pp.48-49 are old pp.44-45 updated.) Beware, filesize 38 Mb.

3. Change notes

Version 1, 19 Feb 2008. New document.

Version 2, 19 Feb 2008. Document numbering system introduced. Doc_20 v_3 replaced by v_4 (thanks Helmut). Doc_21 and doc_22 added. Descriptive text updates.

Version 3, 20 Feb 2008. Doc_30 v_3 replaced by v_4 (thanks Dominic). Descriptive text updates. Change notes added.

PACS Input to Straylight Discussion

H. Feuchtgruber, N. Geis

Available Straylight Documents

- Herschel SciopsWG Straylight Documentation README V3
- No real as-built calculations for straylight available
- HER.NT.0017.T.ASTR, issue 3 recommends:

> Nota: Rectangular bars offer a less complicated diagram as only some specific directions have to be avoided during image integrating time, mainly 6 critical directions for bright object, but two for the Moon and two for the Earth.

- No document says that actually the rectangular hexapod bars have been implemented
- Thermal self-emission:
  Are there any operational rules to keep it minimized ?
  Will measure it during IST early PV...

Telescope Straylight Specification (SCI-PT-RS-04671)

The following straylight requirements apply over the full operational wavelength range:

- Scattered light

TEPE-100 *Sources outside telescope FOV:*
Taking into account the worst combination of the Moon and the Earth positions w.r.t. the LOS of the telescope with maximal:

- *Sun - S/C - Earth angle of 37°*
- *Sun - S/C - Moon angle of 47°*
- *Sun - S/C - LOS angle of 60° to 120°,*

the straylight shall be: < 1.0% of background radiation induced by self-emission of the telescope.

TEPE-105 *Sources inside FOV:*
over the entire FOV at angular distances ≥ 3' from the peak of the point-spread-function (PSF), the straylight shall be:

$< 1 \cdot 10^{-4}$ of PSF peak irradiance (in addition to level given by diffraction).

- Self-emission

TEPE-110 *The straylight level, received at the defined detector element location of the PLM/Focal Plane Unit Straylight model by self emission (with "cold" stops in front of PACS and SPIRE instrument detectors), not including the self emission of the telescope reflectors alone, shall be ≤ 10 % (tbc) of the background induced by self-emission of the telescope reflectors.*

Deficiencies in Model Calculations

- Cryostat apertures on instrument and heat shield are missing
- Conical shape of cryostat baffle is not in the model
- Final design of barrel assembly not in the model
- Any final calculations/conclusions at the time the design has been finalized ?

Straylight PSF from Hexapod Legs

From H-P-ASPI-TN-0379, sec. 8.4.2:

The PSF is very spread along one direction, and its normalised irradiance as found by ASAP is around 2,03.10-6.

Peak vs. Integrated Power ?
mm-units ?
10000Jy source at wrong place cause a 20mJy peak add on

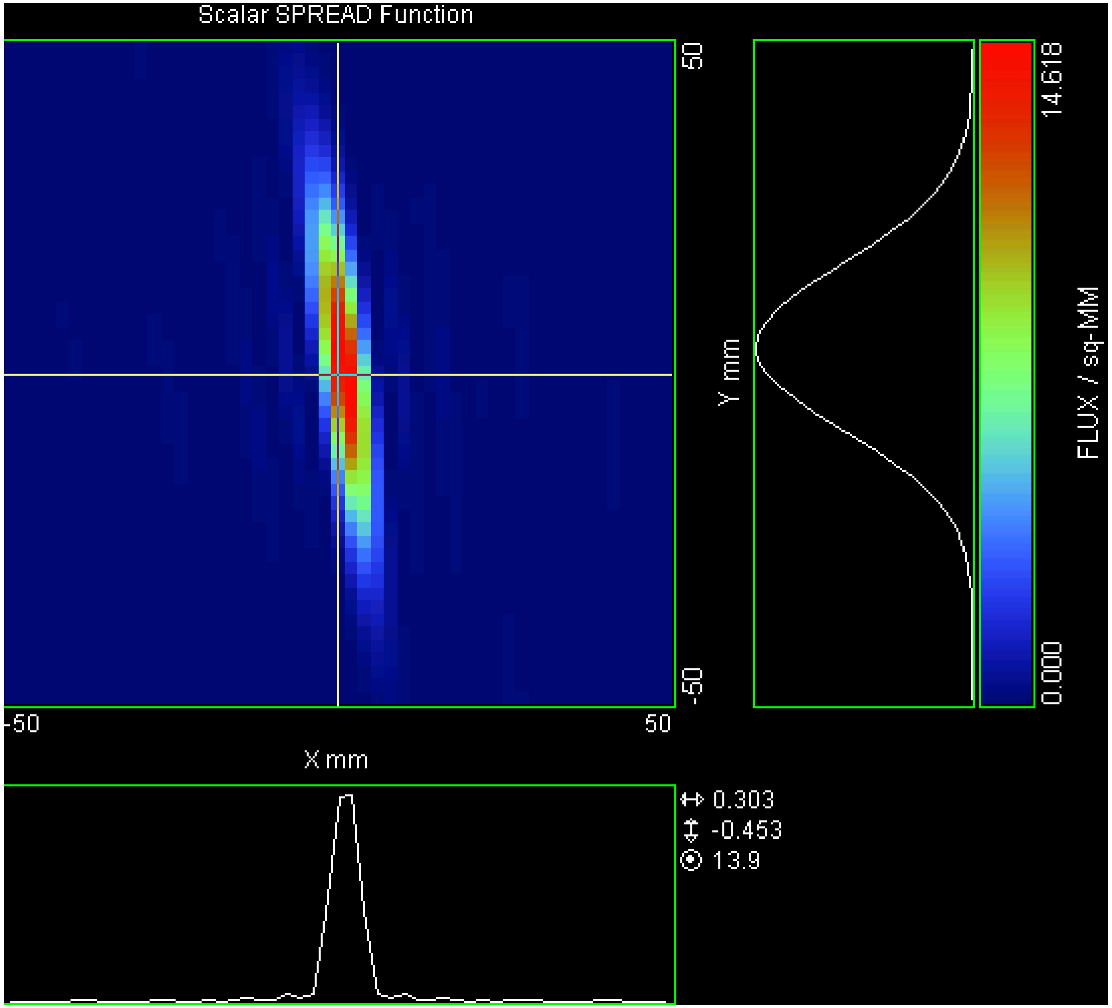
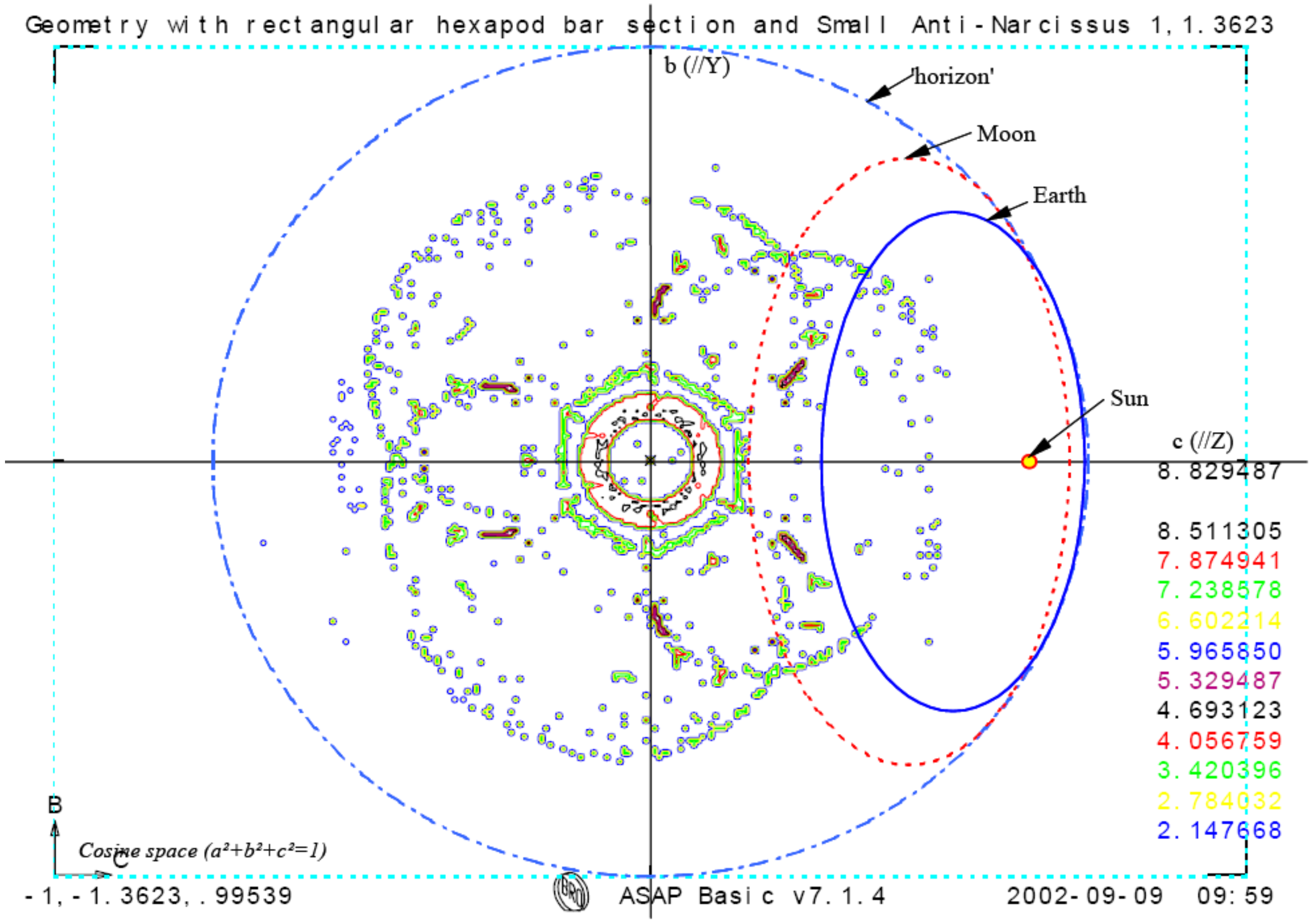


Figure 15 : PSF of IMP1 source on PACS detector, caused by specular reflection on an hexapod leg

Direct Image due to multiple Reflections

From HER.NT.0017.T.ASTR Section 9.3.4:

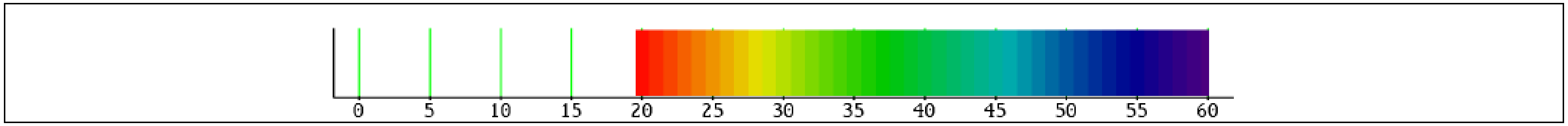
Cosine space !

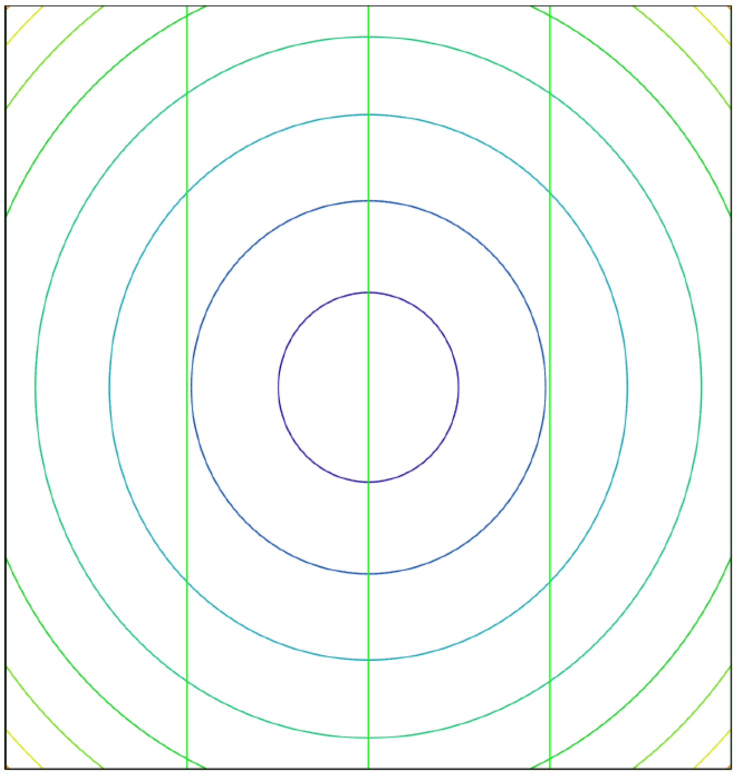


Small Scatter Cone, Rectangular Cross Section, FOV (X,Y)=0.0 0.0

Transformation by N. Geis

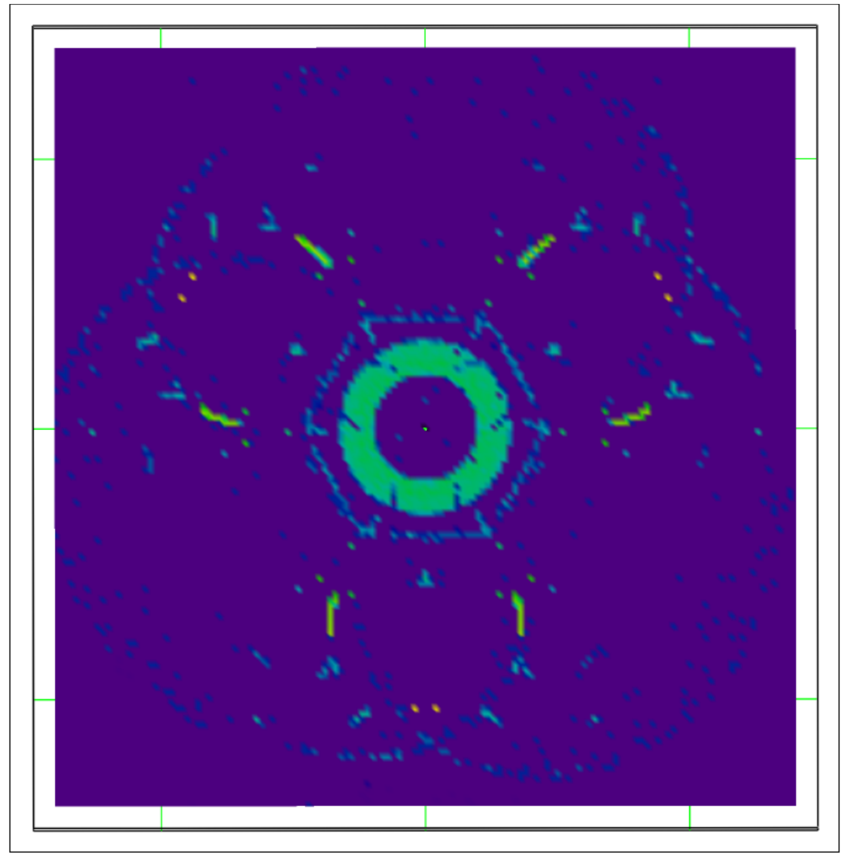
Color Map for the following Plots: color "37" corresponds to value $10^{-3.7}$ etc.: $\mathbf{Colors_i} := -\mathbf{i} \div 10$





Ang

10 degree contour lines



logArray

Definition of Straylight characterization Programme

- Observing strategy: Line scans ? How much sq. deg ?
- Check against the Moon ?

- “Very bright” target list ?

- Which visibility constraints to implement in MPS or to foresee ?

- Observer tool to check-out risks ?

PACS Calibration Document

PACS ICC Calibration Working Group:
Babar Ali (IPAC), Bruno Altieri (ESAC), Joris Blommaert (KUL),
Jeroen Bouwman (MPIA), Alessandra Contursi (MPE), Helmut Dannerbauer (MPIA),
Helmut Feuchtgruber (MPE), Martin Groenewegen (KUL), Ulrich Klaas (MPIA),
Dieter Lutz (MPE), Thomas Müller (MPE), Markus Nielbock (MPIA),
Koryo Okumura (CEA Saclay), Marc Sauvage (CEA Saclay) and Roland Vavrek (ESAC)

Custodian: Ulrich Klaas

Req. 3.1.6 Photometer Straylight

Objectives

Determine or put limits on signals detected by the PACS photometer that are due to bright sources of radiation outside the field of view. Note that such radiation of significant strength may remain undetected in chopped observations if it is only weakly dependent on chop position, and that the bolometers give relative fluxes subject to drifts rather than absolute fluxes. Sources of straylight to be considered include

- Very bright compact sources (late type stars, Planets) within a few arcmin of the bolometer FOV. Note also the possibility of compact reflections - see also 3.1.5
- Very bright sources at large angles from the FOV, with reflections off the secondary mirror support (see e.g. the various scenarios in the Herschel Telescope Straylight Analysis HER.NT.0017.T.ASTR Issue 3.0). The assumption previously made was that these are non-specular reflections and spread over a large area, thus being more of an addition to the background rather than an image with structure on the scale of the FOV or less. This may not be true given the as-built Herschel telescope where the secondary supports are covered with a fairly specular and flat foil. The issue was discussed in the Sciops WG in spring 2008 but is on hold until better predictions allow to guide the positions for possible searches. No specific measurements to trace this effect are described below for the time being, this may need to be revisited if improved input on expected straylight becomes available.

A signal that could be called 'straylight' is caused by chopping in the presence of telescope temperature gradients, and is being fought by nodding or position switching. Trend analysis of this signal is covered in requirement 3.2.x????

There is a certain semantic ambiguity between what is called 'straylight' here and the 'ghosts' as discussed in 3.1.5., for the moment we consider 'straylight' an additional illumination that is more diffuse over the FOV compared to a more compact ghost.

Fulfilling or fulfilled by

Specific observations discussed in 3.1.5 are relevant here as well. Also inspection of science data.

Priority

B

When performed / frequency

PV and later, pre-tests in ILT.

Required accuracy

Inputs, prerequisites

Modelling of Herschel straylight properties to guide search.

Sources

Very bright $>$100Jy sources: Mars, Jupiter, late type stars...

ILT: External blackbody and single hole on xy stage. Because of the limited contrast and background structures, only very strong straylight of the type considered here would be detectable with the real OGSE setup.

In orbit: An exploratory 2deg$\times$2deg fast scan AOR around a bright isolated source should be done. If a bright planet is available in PV and in a low background region, use this one and revisit the region later after planet has moved, to better discriminate straylight from real structure. If no planet is available in PV, use a bright isolated source from PICC-ME-TN-023 in PV and do the planet exercise later.

If better predictions for the straylight reflected off secondary supports or baffles become available, the basic scheme would be: (1) Do a fast scan map or cross of elongated scan maps over the spot where the straylight from a very bright SSO source (e.g. moon) is expected at a specific time. (2) Redo the observation days or weeks later at the same sky position but with the straylight moved away together with its cause.

Calibration Implementation Procedure (CIP)

There are two basic possibilities to probe for straylight:
(a) chopped observations at various positions relative to the bright source. Probably suggested for a range of positions where radiation is still near the PACS aperture.
(b) unchopped fast line scan or raster passing over or near the bright source, aiming to detect a temporary signal excess at a level that can be discriminated from background/sensitivity drifts and from real structure of the sky.

ILT: The external blackbody and single hole on XY stage was used to try out possibility b). The only clear detection was the compact 'blue streak' ghost, see also 3.1.5. Note that the OGSE test optics setup is complex and different from telescope.

In orbit: Fast scan, optimal coverage scan maps at an angle filling the matrix gaps should be a good approach.

Estimated time needed

In orbit: A 2deg$\times$2deg fast scanmap, optimum coverage, map orientation angle 20deg in array coordinates takes 1.9h. One or two such maps in PV, zero to two later according to the plan outlined above.

Calibration Analysis Procedure (CAP)

In the specific observations described in 3.1.5 or archival calibration and science data, search for excess signals that are not plausibly due to structures in the real sky.

In orbit: Reduce map in the standard way and look for conspicuous signals that are not associated with known sources. For the planet, subtract the two maps with planet on and off to improve discrimination.

Output, products

Limits on straylight or quantification under which conditions it occurs.

Status/version

More detail on possible large angle reflections

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$Revision: 1.7 $
$Date: 2008/07/07 15:12:54 $
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Req. 3.1.7 Background Structure in the Photometer Field-of-View over the Full Chopper Angle Range

Objectives

Assess the background homogeneity and structures over the full field-of-view accessible to the photometer by moving the chopper within its maximum angle range. This comprises the FOVs of the two calibration source and the sky sections as well as the two boundaries inbetween. It verifies the dynamic range for typical observing conditions for the given bias settings for low and high gain. It is an efficient way to check for saturation (for both gain settings, both filters, and in bright sky regions). It is an important addition to flat-field determination and also serves for straylight assessment induced from one section onto the other, i.e. additive emission by the sky to the internal calibration source emission and straylight of the internal calibration sources into the sky-field-of-view. Furthermore it is a good data source for cross-talk investigations.

Fulfilling or fulfilled by

Related to req. 3.2.8 Measure the photometer full system flat-field,
req. 3.2.9 Telescope background and its stability,
(req. 3.2.10 (TBW) Straylight onto the internal calibation sources),
req. 1.1.17 Measure the level of optical cross-talk in the detector and
req. 1.1.18 Measure the level of electrical cross-talk

Priority

A

When performed / frequency

- [1] During ILT tests
- [2] During IST tests
- [3] In-flight during Performance Verification

Required accuracy

Localize features and emission gradients down to 1% level of the actual sky and CS background (may vary with CSs on/off and cooling-down telescope in PV Phase)

Inputs, prerequisites

1 Optimum detector biases (Reqs. 1.1.1 and 1.1.1bis)

2 Chopper angular calibration (Req. 2.3.1)

Sources

1 ILT and IMT/IST tests: internal calibration sources (IMT/IST) and OGSE BBs (ILT).

2 In-flight:

- dark sky field to have maximum contribution by the telescope background and internal calibration sources on various temperature levels.
- very bright sky field in galactic plane for additional straylight checks

Calibration Implementation Procedure (CIP)

For ILT/IST:

- Perform chopper multi-step scan with fine step sizes in the order of the pixel scale between maximum allowed negative and positive chopper deflections.
- Consider all possible sky field backgrounds when looking from the instrument along the various OGSE paths to the different stimulators.
- Consider detector operation in direct and DDCS mode.
- Consider ow and high gain detector operation
- Consider internal calibration sources on various temperature levels.

The following illumination combinations have been probed during FM-ILT, for both blue filters

- detector DDCS mode
  - cold CS1 (<8 K), cold FOV, cold CS2 (<8 K)
  - warm CS1 (71 K), cold FOV, warm CS2 (76 K)
  - warm CS1 (71 K), BB1 at 22 K, warm CS2 (76 K)
  - warm CS1 (71 K), window 1, warm CS2 (76 K)
  - warm CS1 (71 K), window 2, warm CS2 (76 K)
  - warm CS1 (55 K), BB1 at 17.89 K, warm CS2 (60 K)
  - warm CS1 (55 K), cold BB1, warm CS2 (60 K)
  - warm CS1 (55 K), warming up BB1, warm CS2 (60 K)
  - warm CS2 (60K) restricted to +13000 . . . +23000 chopper deflection (sharp feature investigation)
- detector DDCS mode
  - warm CS1 (55 K), cold integrating sphere + laser line at 70.5 μm, warm CS2 (60 K)
  - warm CS1 (55 K), cold IS + laser line at 170 μm, warm CS2 (60 K)
  - cold CS1 (<8 K), BB1 at 40 K, cold CS2 (<8 K)
  - cold CS1 (<8 K), cold FOV (BB1 at 6 K), cold CS2 (<8 K)
  - FM-IST reference scan
  - warm CS1 (55 K), BB1 at 10.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB2 at 15.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB1 at 20.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB2 at 22.5 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB1 at 25.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB2 at 30.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB1 at 35.0 K, warm CS2 (60 K)
  - warm CS1 (55 K), BB2 at 40.0 K, warm CS2 (60 K)
  - warm CS1 (40 K), BB1 at 21.815 K, warm CS2 (50 K)
  - warm CS1 (40 K), BB2 at 23.496 K, warm CS2 (50 K)
  - warm CS1 (45 K), BB2 at 23.496 K, warm CS2 (65 K)

- warm CS1 (45 K), BB1 at 21.815 K, warm CS2 (65 K)

For additional information, cf. PICC-ME-TR-005, OGSE characterization during CQM/FM-ILT.

For PV:

- Perform chopper multi-step scan with fine step sizes in the order of the pixel scale between maximum allowed negative and positive chopper deflections.
  225 steps up and down between chopper positions $\pm$23000;
  both blue filters (wavelength dependence of straylight)
  80 read-outs per chopper position.
- Consider low gain (foreseen in Commissioning Phase) and high gain detector settings.
- Consider the cool-down of the telescope which provides different absolute illumination levels of the sky section allowing to scale the relative contribution to the neighboring sections.
  Mid and end of PV.
- Consider internal calibration sources on various temperature levels.
  CS1/CS2 off, CS1/CS2 at nominal temperatures, CS1/CS2 at higher than nominal temperatures.

Estimated time needed

For ILT: About 25 FOV scans, 0.5 h each during the 3 FM-ILT campaigns.
For PV: 0.5 h per chopper up- and down scan in two blue filters for each illumination combination
$\Rightarrow$ 3 (CS illumination levels) $\times$ 2 (telescope background levels) $\times$ 0.5 h = 3 h + 2 $\times$ 0.3 h (CS stabilization to higher T) = 3.6 h
0.4 h for 2 low gain FOV scans during Commissioning Phase.

Calibration Analysis Procedure (CAP)

- Use data reduction techniques as e.g. outlined in PICC-NHSC-TR-002, Bolometer FOV chopper scans
- Construct flat-fields for different illumination conditions and detector settings
- Quantitatively characterize level and gradient of sky/telescope straylight into the CS sections as e.g. outlined in SAp-PACS-KO-0675-08, Straylight on the internal calibration sources
- Quantitatively characterize level and gradient of CS straylight into the sky section
- Identify cross-talk features and the originating area as e.g. outlined in SAp-PACS-KO-0676-08, transient electrical cross-talk

Output, products

1) FOV maps of the bolometer for the various illumination combinations
   for FM-ILT, cf. PICC-NHSC-TR-002, PICC-NHSC-TR-010
2) Scalable straylight maps for CS and sky sections; for FM-ILT, cf. SAp-PACS-KO-0675-08
3) Saturation limits for the PACS photometer;
   for FM-ILT, cf. SAp-PACS-MS-0680-08
4) Description of cross-talk phenomena;
   for FM-ILT, cf. SAp-PACS-KO-0676-08

5) Chopper and bolometer pixel angular scale verification for FM-ILT, cf. PICC-MA-TR-009

Status/version

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$Revision: 1.1 $
$Date: 2008/08/07 18:16:15 $
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Req. 4.1.5 Spectrometer Straylight

Objectives

Determine signals measured by the PACS spectrometer that are due to bright sources of radiation outside the field of view. Note that such radiation of significant strength may remain undetected in chopped observations if it is only weakly dependent on chop position. Spectral structure in the source that causes straylight may help discriminating straylight from other backgrounds.

Sources to be considered include

- Very bright compact sources (late type stars, Planets) within a few arcmin of the FOV (possibility of compact reflections?)
- Very bright sources at large angles from the FOV, with reflections off the secondary mirror support. The assumption is that these are non-specular and diffused over a larger area.

A signal that could be called 'straylight' is caused by chopping in the presence of telescope temperature gradients, and is being fought by nodding or position switching. Trend analysis of this signal is covered in requirement 4.3.4 (TBC). See also req. 4.3.11 for the investigation of the telescope background structure.

Fulfilling or fulfilled by

Self-standing

Priority

B.
Pre-test in ILT: C

When performed / frequency

Pre-tests in ILT, PV and later

Required accuracy

Scattered light from outside the telescope FOV should be $<1\%$ of the background radiation level induced by the self-emission of the telescope.

Inputs, prerequisites

Modelling of Herschel straylight properties to guide search

Sources

Mars, Jupiter, very bright >500 Jy late type stars. Sources should be located in a clean region of the sky (Mars and Jupiter cross the galactic plane).

ILT: External blackbody and single hole on xy-stage. Because of the limited contrast, only very strong straylight of the type considered here is detectable with the real OGSE setup.

Calibration Implementation Procedure (CIP)

- [1] ILT:
  Note that the test optics set-up is complex and different from the telescope, results have to be interpreted with caution.
  Using a staring observation and a large (at least 5 – 10 arcsec) hole in front of the external blackbody, do a finely sampled cross scan over the full x- and the full y-range, centered on the FOV, and a more coarse raster over the full

range of the xy-stage. Choose a wavelength giving simultaneous data in both channels. Because of the limitations of the OGSE set-up (low source contrast, background structures), such a measurement is considered low priority. ⇒ Such a measurement was not done in FM-ILT due to lack of time.

- [2] In orbit:
  Chopped scan maps around extremely bright source. Source should not be in the map FOV, but boarder of maps should stay away by about 1 arcmin. Chop with frequency of 1 Hz and chopper throw of 1.5 arcmin in scan direction. 15 arcmin leg, 31 legs, 30” separation. Use a slow scan speed of 3”/sec so that the smearing within a single chopper on-off cycle is negligible. Repeat maps twice to disentangle glitch effects and increase S/N (second map in orthogonal orientation). Before and after the scan map, point to a clean off-position while chopping. Do 4 maps on each side of the source.
  If e.g.. Jupiter is selected fix grating at prominent line so that instantaneous spectrum of any intensity feature could support origin by Jupiter. Since Jupiter moves with about 3’ per day the maps with suspicious “straylight” features could be repeated when Jupiter is off the area further constraining the nature of the feature.

Estimated time needed

- [1] ILT:
  About one hour
- [2] In orbit:
  - Required time for 1 scan map:
    15×15 arcmin^2, i.e. 900 arcsec leg length, with 30 arcsec distance among the legs, i.e. 31 legs and 3 arcsec/s scan speed:
    $(900/3\,\mathrm{s} \times 31)_{chop} + (31 \times 20\,\mathrm{s})_{slew} = 9920\,\mathrm{s} = 2.8\,\mathrm{h}$
    This time has to be multiplied by 2 scan repetitions and 4 maps on each side of the source, yielding a total duration of 22.4 h.
    If the whole map comprising all 4 parts is repeated a second time with the source off this adds another 22.4 h.

Calibration Analysis Procedure (CAP)

- [1] ILT:
  - Subtract running median background for each pixel
  - Apply flatfield
  - Look for unusual signals.
- [2] In orbit:
  - Subtract chopper on-off thus defining and subtracting running background.
  - Alternatively check background subtraction making use of the signals from the clean off-position.
  - Apply flatfield.
  - Average spectral pixels, produce a map and look for unusual features that do not correspond to faint real sources.
  - If those are present, make use of the spectral information at the location of the feature and check for spectral signatures of the central straylight source.
  - Compare maps with straylight source in and out.

Output, products

Limits for straylight, or quantification of its strength and the conditions under which it occurs.

Status/version

PV Preparation

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$Revision: 1.7 $
$Date: 2008/06/09 16:26:14 $
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Req. 7.3.1 Verification of solar straylight rejection

Objectives

Determine whether the straylight specification for the Herschel focal plane is met when the Sun is between 60 and 120^o of the telescope line-of-sight. Any significant non-homogeneous straylight contribution would have an impact on the final photometric accuracy.

Fulfilling or fulfilled by

Priority

A

When performed / frequency

- [1] PV Phase would be ideal, however, the occurrence of a solar eclipse facilitates the straylight assessment (cf. Lemke et al. 2001, The Calibration Legacy of the ISO Mission, ESA SP-481, 219).

Required accuracy

In order to assess the straylight level quantitatively the measurement accuracy must be much better than 1% of the telescope background level.

Inputs, prerequisites

Information on occurrence of solar eclipses. The S/C pointing should be as close as possible to the minimum constraint of 60^o.

Sources

A relatively blank sky field

Calibration Implementation Procedure (CIP)

The measurement should be done with the most sensitive photometric channel of the PACS bolometer camera (100 μm (TBC); consider also color temperature of Sun straylight spectrum). The blank sky field, located as close as possible to the minimum constraint of 60^o, should be monitored with the PACS bolometer camera starting before a solar eclipse and then observing all the time through the eclipse until the eclipse is over. Since a chopped measurement must be done, chopping should be between the sky and one internal calibration source providing a stable reference background.

An alternative is to observe the blank sky field at different solar elongation angles (e.g. 90^o, 75^o, 65^o, and 60^o and to search for any systematic background changes with angle. However, this method requires a much higher sensitivity for relative straylight gradients beyond 60^o and a high relative stability in order to get quantitative results from measurements distributed over the period of several weeks.

In case a straylight level exceeding the specification were found, more measurements for characterising its spectral shape would have to be defined.

Estimated time needed

In the order of $<$1 h.

Calibration Analysis Procedure (CAP)

The difference signal blank sky field - reference source divided by the signal of the reference source shall be monitored with time. If there were measurable Sun straylight, there should be a variation when entering and exiting the eclipse and the normalised difference should alter inside and outside the eclipse. Improvement of the S/N can be achieved by averaging over several pixels.

Output, products

Confirmation of the solar straylight level.

Status/version

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$Revision: 1.1 $
$Date: 2007/10/31 19:28:45 $
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Req. 7.3.2 Verification of Earth straylight rejection

Objectives

Determine whether the straylight specification for the Herschel focal plane is met when the Earth comes as close as 23^o to the telescope line-of-sight. Also a search for specular reflections by the hexapod should be done, although the simulations predict them to occur at a relative angle of around 20^o to the line-of-sight, which is just inside the Earth constraint and therefore they should not occur. Any significant non-homogeneous straylight contribution would have an impact on the final photometric accuracy.

Fulfilling or fulfilled by

Related to Req. 7.3.3 with regard to specular reflection measurements of Moon straylight.

Priority

A

When performed / frequency

- [1] PV Phase would be ideal, however, the measurement is driven by the requirement to have a constellation with Sun – S/C – Earth angle equal to 37^o.

Required accuracy

In order to assess the straylight level quantitatively the measurement accuracy must be much better than 1% of the telescope background level.

Inputs, prerequisites

One S/C pointing should be as close as possible to the minimum constraint of 23^o.

Sources

A relatively blank sky field

Calibration Implementation Procedure (CIP)

The measurement should be done with the most sensitive photometric channel of the PACS bolometer camera (100 μm (TBC); consider also color temperature of Earth straylight spectrum).

For a check of diffuse straylight emission the blank sky field should be observed at different angular distances from the Earth (e.g. 60^o, 45^o, 30^o, and 23^o) and the measurements searched for any systematic background changes with angle. Since a chopped measurement must be done, chopping should be between the sky and one internal calibration source providing a stable reference background.

For a check of specular straylight line scan maps of fields seen under an angular distance to the Earth of $\geq 23^o$ should be performed. The map size should be several degrees (application of SPIRE-PACS parallel mode?).

Estimated time needed

4 h for diffuse straylight assessment.
18 h for parallel mode map $10^o \times 3^o$ with fast scan speed for specular reflection assessment (combined with Moon reflection assessment).

Calibration Analysis Procedure (CAP)

The difference signal blank sky field - reference source divided by the signal of the reference source shall be compared four the 4 different angular distances from the Earth. If there were measurable Earth straylight, there should be a variation with an increase towards the smaller angle. Improvement of the S/N can be achieved by averaging over several pixels. The specular reflections are expected to be at a relatively high level of the telescope background (e.g. 15% for bright Moon (400 K)). This pattern should become visible in the raw scans.

Output, products

Confirmation of the Earth straylight level.

Status/version

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$Revision: 1.1 $
$Date: 2007/10/31 19:28:45 $
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Req. 7.3.3 Verification of Moon straylight rejection

Objectives

Determine whether the straylight specification for the Herschel focal plane is met when the Moon comes as close as 13^o to the telescope line-of-sight. Also a search for specular reflections by the hexapod should be done, which simulations predict to occur at a relative angle of around 20^o to the line-of-sight. Any significant non-homogeneous straylight contribution would have an impact on the final photometric accuracy.

Fulfilling or fulfilled by

Related to Req. 7.3.2 with regard to specular reflection measurements of Earth straylight.

Priority

A

When performed / frequency

- [1] PV Phase would be ideal, however, the measurement is driven by the requirement to have a constellation with Sun – S/C – Moon angle equal to 47^o, implying Sun – S/C – Earth angle close to 37^o.

Required accuracy

In order to assess the straylight level quantitatively the measurement accuracy must be much better than 1% of the telescope background level.

Inputs, prerequisites

One S/C pointing should be as close as possible to the minimum constraint of 13^o.

Sources

A relatively blank sky field (free of bright sources)

Calibration Implementation Procedure (CIP)

The measurement should be done with the most sensitive photometric channel of the PACS bolometer camera (100 μm (TBC); consider also color temperature of Moon straylight spectrum).

For a check of diffuse straylight emission the blank sky field should be observed at different angular distances from the Moon (e.g. 20^o, 16^o, and 13^o) with the Earth under nearly constant angle and the measurements searched for any systematic background changes with angle. Since a chopped measurement must be done, chopping should be between the sky and one internal calibration source providing a stable reference background.

For a check of specular straylight line scan maps of fields seen under an angular distance to the Moon of $\approx 20^o$ should be performed. The map size should be several degrees (application of SPIRE-PACS parallel mode?). Depending on the S/C z-axis orientation during maps it may be better to perform several narrow maps along the S/C y-axis under different elongation angles to the Moon from 13 to 27^o (TBD).

Estimated time needed

3 h for diffuse straylight assessment.
18 h for parallel mode map $10^o \times 3^o$ with fast scan speed for specular reflection assessment (combined with Earth reflection assessment).

Calibration Analysis Procedure (CAP)

The difference signal blank sky field - reference source divided by the signal of the reference source shall be compared four the 3 different angular distances from the Moon. If there were measurable Moon straylight, there should be a variation with an increase towards the smaller angle. Improvement of the S/N can be achieved by averaging over several pixels.

According to the straylight calculations, the specular reflections are expected to be at a relatively high level of the telescope background (e.g. 15% for bright Moon (400 K)). This pattern should become visible in the scan maps. The pattern has to be checked for the location of celestial sources along the scan path, but such bright sources should be rare.

Output, products

Confirmation of the Moon straylight level.

Status/version

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$Revision: 1.1 $
$Date: 2007/10/31 19:28:45 $
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Req. 7.3.4 Sensitivity to bright out-of-field sources in or near the Herschel focal plane

Objectives

The Herschel telescope FOV has a diameter of 30'. The PACS FOV is offset from the centre by about 10' in positive Z-direction. The spatial sensitivity of the PACS instrument within or near the Herschel FOV due to scattering, diffraction effects and/or stray reflections shall be investigated. ISO TDT 58200903 proves a straylight feature by Saturn with Saturn $\approx$20' off from the CFOV, not really predicted by straylight simulations before launch.

Fulfilling or fulfilled by

This Req. should be fulfilled by Reqs. 3.1.6 for PACS photometer and 4.1.5 for PACS spectrometer. This Req. is related to Req. 7.3.3 investigating specular reflections of bright sources by the hexapod at relative angles to the line-of-sight of 20^o. Should such reflections be found for the Moon a scaling to other bright sources like Jupiter, Saturn or bright FIR galactic sources should be possible.

Priority

A

When performed / frequency

- [1] In PV Phase, when bright isolated sources like Jupiter and Saturn are visible.

Required accuracy

In general telescope straylight levels should be below 1% of the telescope background level.

Inputs, prerequisites

Modelling of Herschel straylight properties provides some guidance under which angles straylight features may occur.

Sources

A bright isolated compact source. The planets Jupiter (maximum diameter from Earth = 49") and Saturn (maximu diameter from Erath = 20") on a relatively low sky background appear to be well suited for this investigation.

Calibration Implementation Procedure (CIP)

Scan maps around these bright sources without including them (from 1' distance out to 30' distance).

Estimated time needed

A single 30' $\times$ 30' scan map in slow mode reaching 1σ levels of 4-5 mJy costs $\approx$ 3 h.

Calibration Analysis Procedure (CAP)

Search for extended straylight spikes in the maps.

Output, products

Confirmation/Non-confirmation of straylight spikes. Avoid angular distances to bright sources under which these straylight peaks occur.

Status/version

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$Revision: 1.1 $
$Date: 2007/10/31 19:28:45 $
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HERSCHEL / SPIRE: About PCAL illumination on Photometer

(extract for HStrayWG)

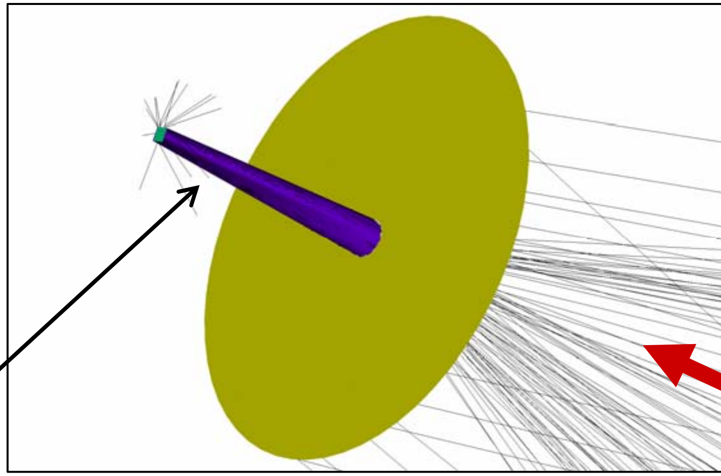
Marc Ferlet (STFC-RAL/SSTD, 03/09/08)

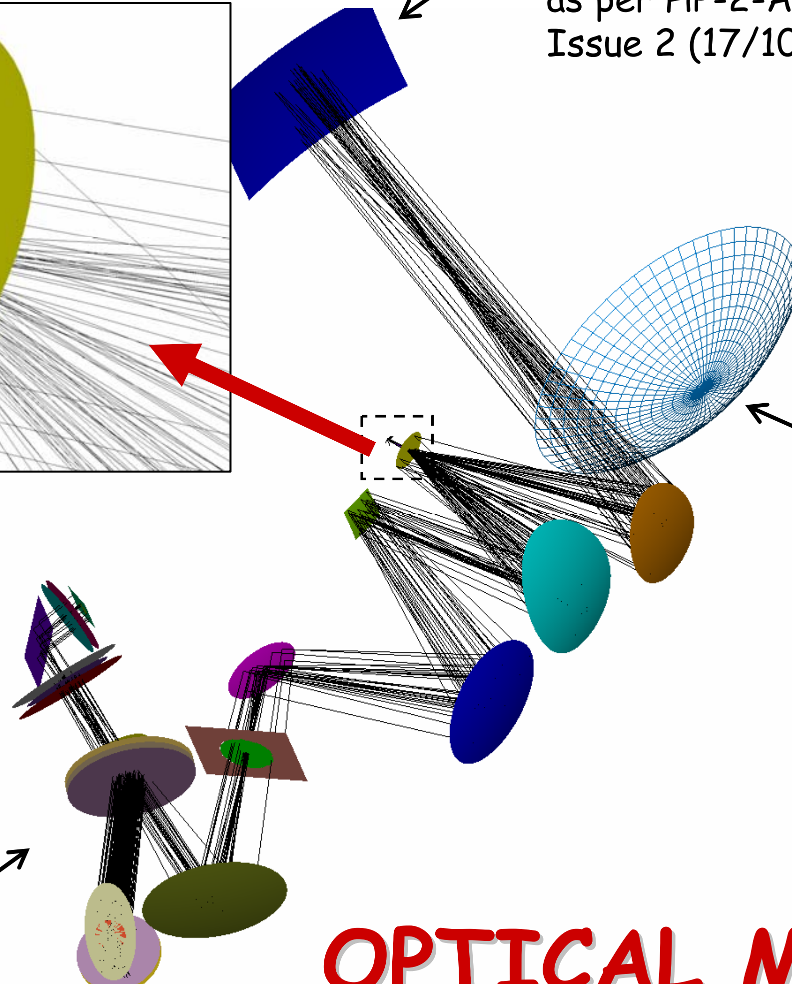
Science & Technology Facilities Council

OPTICAL MODEL (Photometer)

Cryocover mirror (SPIRE side):

Toric (=biconic in the model) with RoCs and position & orientation along chief ray set as per HP-2-ASED-TN-0076 Issue 2 (17/10/03) section 2.3





PCAL:

1mmx1mm emitter feeding CM4 hole (~3mm diameter) via ~20mm long light pipe, based on SPIRE DDD & PCal ICD & Applied Optics 44-16 (2005); initially on-axis then sequentially tilted to represent prime and redundant

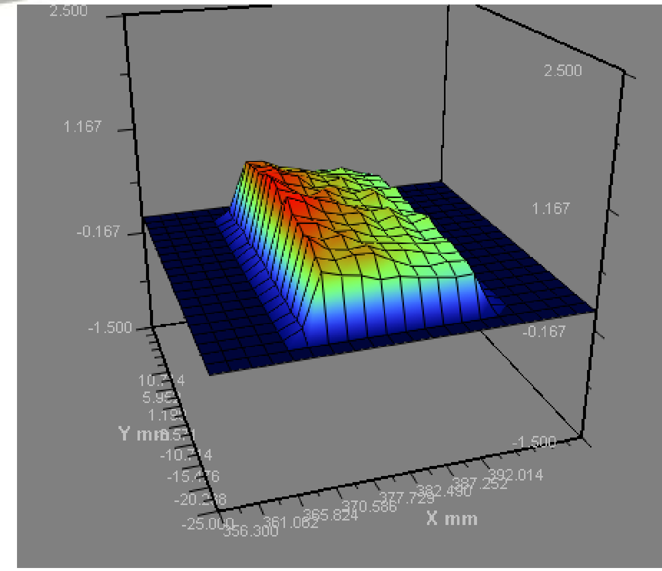
Telescope focal surface:

Virtual surface shared by all instruments

SPIRE Photometer:

ASAP optical model from design prescription BOLPHOT155

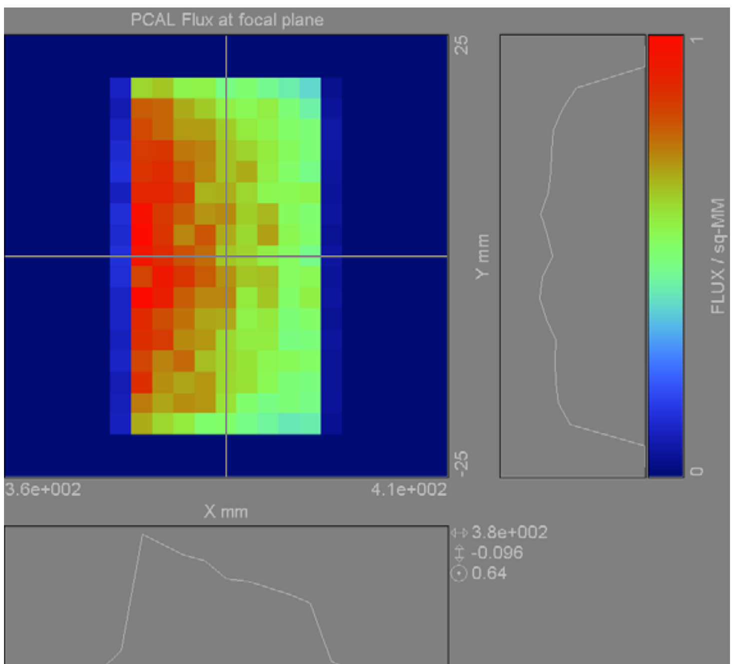
RESULTS (without cryo-cover mirror)



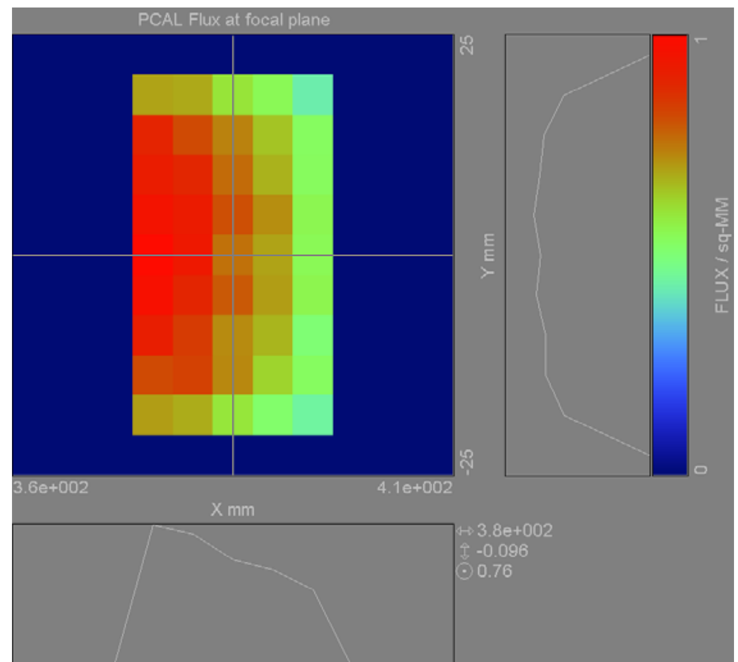
3D distribution of PCAL illumination at focal plane

Only direct path between PCAL and detector arrays considered here (in flight: addition of M2 effect ?)

Apparition of a full-field diffuse background illumination but not flat: gradient with magnitude ~x2 max between level at respective Z edges



PSW sampling



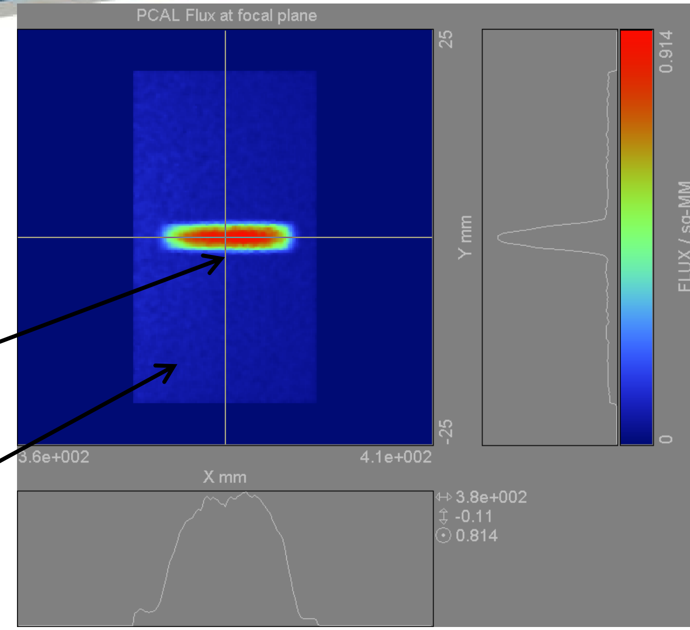
PLW sampling

Science & Technology Facilities Council

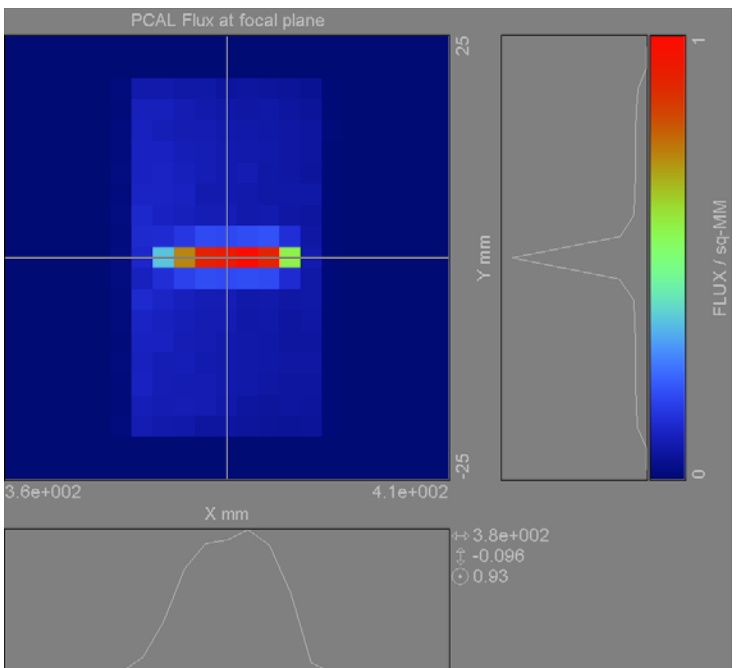
RESULTS (with cryo-cover mirror)

Effect of PCAL reflection on cryo-cover: central Z-direction elongated feature; ~ x5-x10 brighter than the diffuse surrounding background

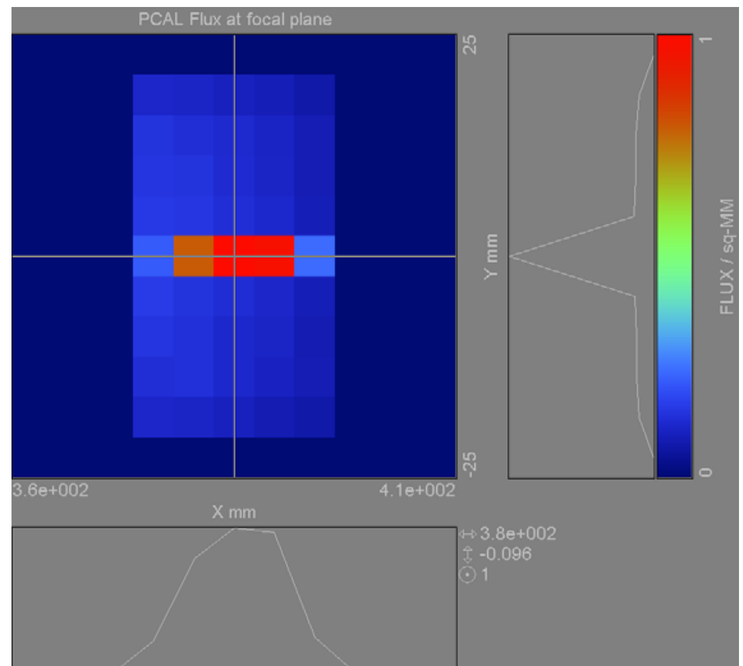
Diffuse background over full field from direct path PCAL illumination



Detailed focal plane image



PSW sampling



PLW sampling

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• PCAL illumination can exit SPIRE aperture, only filtered by CFIL1 (=100cm^{-1} low freq pass filter)

• When lid closed (e.g. ground test), PCAL light is returned in-field for SPIRE Photometer => such structured focal plane illumination have been detected by Phot arrays in agreement with model

• When lid open (e.g. flight operations), PCAL illumination is therefore expected to reach central region of telescope M2

• M2 is common to all instruments so need to check in case reflection on M2 towards PACS aperture can exist (PACS/SPIRE parallel mode)

•Simple check but need definition of M2 i.e. including the anti-narcissus cone (not in the SPIRE-maintained optical model) and PACS entrance aperture feature as minimum + old ASAP model delivered by ASED to SPIRE ("SPIRE_tel4.inr", 10/12/2004) only contains SPIRE & telescope models and does not run under recent version of ASAP

• Is there an equivalent source/path from PACS towards SPIRE ?