



Herschel Calibration Workshop, Madrid, Spain 6-8 Feb 2008



Planck/HFI vs. Herschel/SPIRE Cross-Calibration

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The Planck/Herschel X-Calibration Working Group



- Talk by J.M. Lamarre at first Herschel calibration workshop
- One meeting and 3 telecons in 2005/2006
- Members:
 - Ken Ganga, Ana Heras, Pedro Garcia Lario, Guilaine Lagache, Rene Laureijs, Sarah Leeks, Tanya Lim, Ramon Nartallo, Bernhard Schulz (chair) , Jan Tauber
- Science Team Support:
 - Martin Harwit
- New Members:
 - Andrea Catalano, Francesco Piacentini





Introduction

- Blackbody in space is absolute radiometric standard
- Filter overlap at 350 and 500/550 μm between Herschel-SPIRE and Planck-HFI
- CMB dipole:
 - Predicted HFI 550 μm uncertainty ~10%
- On-board Blackbodies on COBE-FIRAS:
 - abs. uncertainty 3%
- Unique Opportunity to establish accurate absolute flux standards at FIR/Submm wavelengths





SPIRE and HFI Details

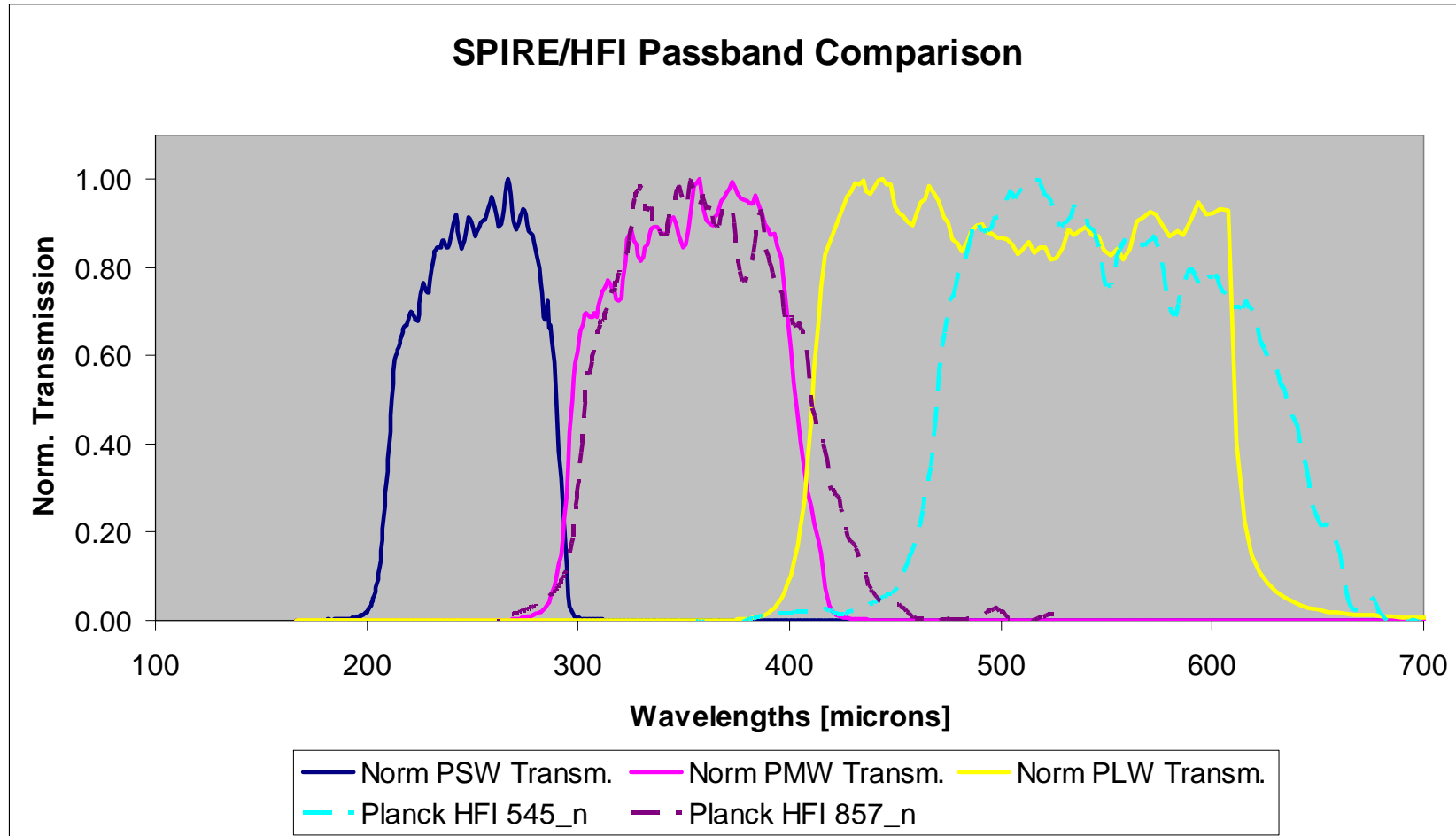
- SPIRE
- Spiderweb Bolometers
- 3 filterbands
- 350 μm filter (full overlap)
- 500 μm filter (part. overlap)
- SPIRE beam 25", 36" at 350 and 500 μm (88, 43 det.)
- jiggle maps and scan maps

- HFI
- Spiderweb Bolometers
- 6 filterbands
- 857GHz ($\sim 350 \mu\text{m}$) filter (overlap)
- 545 GHz ($\sim 550 \mu\text{m}$) filter (part. overlap)
- beam 5' (4 det.)
- 1/60 Hz great circles on sky
- 2' steps at average speed of 2.5'/min





Filter Comparison





FIRAS Details

- Band 1: 100-500 μm
- Band 2: 0.5-10 mm
- FTS compares sky with on-board BB
- Beam 7° FOV
- 5% spectral resolution.
- Error on CMB 0.02 MJy/sr
- Gain uncertainty $<3\%$ in high frequency channels
- Primary calibrator on-board Blackbody
(Fixsen et al. 1994, Mather et al. 1998)

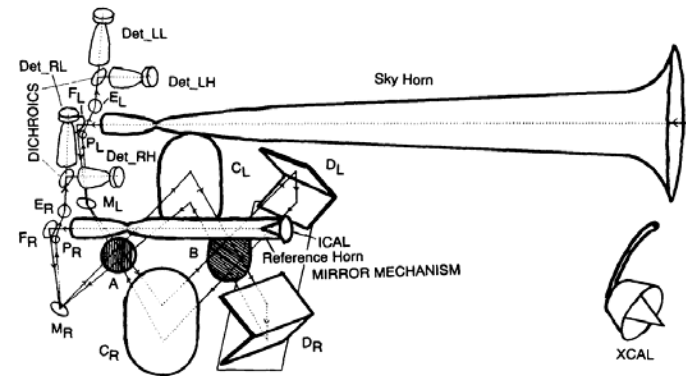
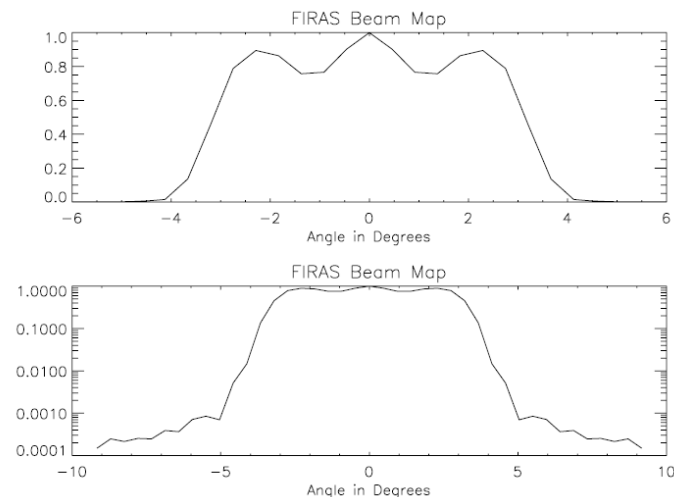
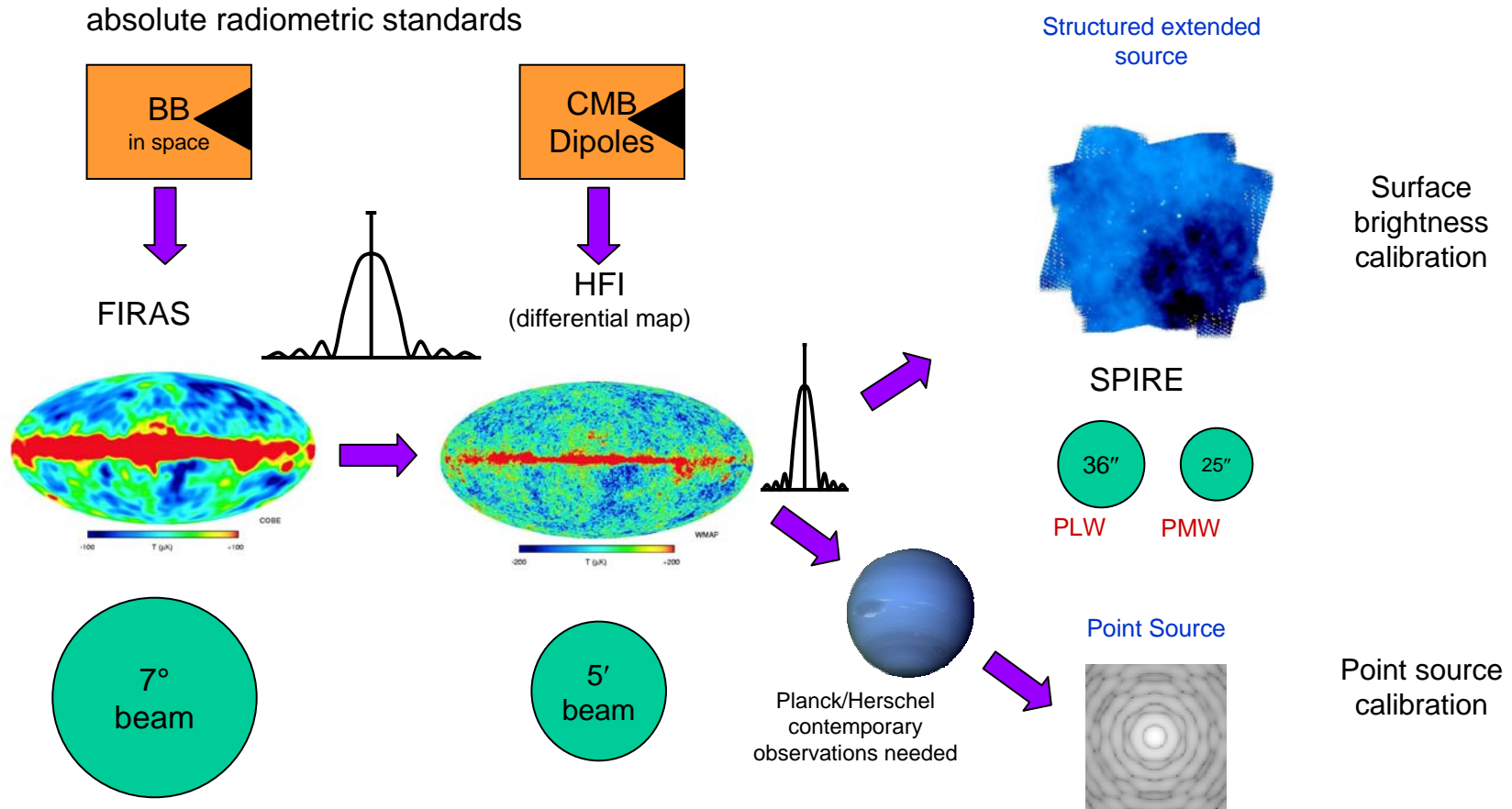


FIG. 1.—Simplified optical layout of FIRAS, showing the positions of the horns, Xcal, Ical, mirrors, grids, MTM, and detectors. The drawing is not to scale; the sky horn is 2 m long and the other parts fit in a box ~ 50 cm on a side.





X-Calibration Scheme





X-Calibration Steps

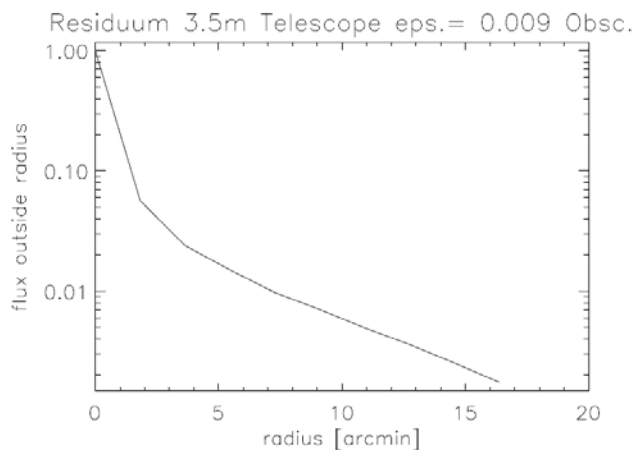
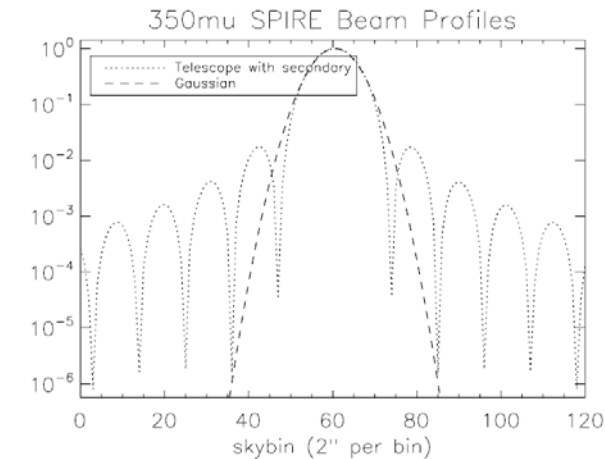
- Blackbody calibration transfer to FIRAS map
- Convolve HFI map with **FIRAS beam profile**
- Derive calibration factor from ratio of convolved HFI map and FIRAS map
- Convolve SPIRE map with **HFI beam profile**
- Derive calibration factor from ratio of convolved SPIRE map and calibrated HFI map

- Convert HFI surface brightness to point source flux with **HFI beam profile**
- Calibrate SPIRE point source flux with HFI point source flux





Check Beam Profile Convolution



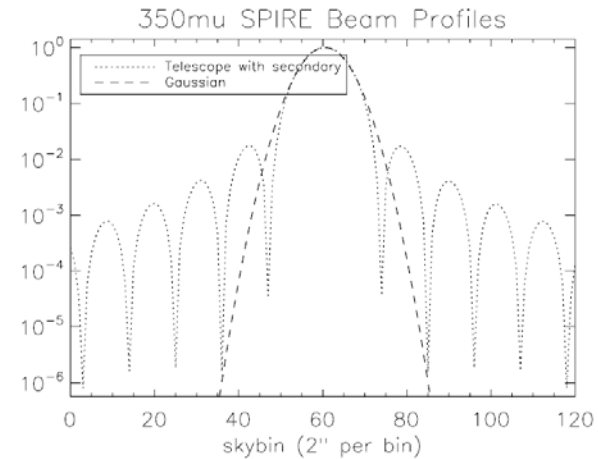
- Generated test PSFs
 - 3.283 m telescope mirror
 - secondary 0.308 m
- 99% flux within 8' radius
- need Planck telescope dimensions
 - *work in progress*
 - *what are the systematic errors introduced by the convolution?*



Systematics from Beam Profile Shape

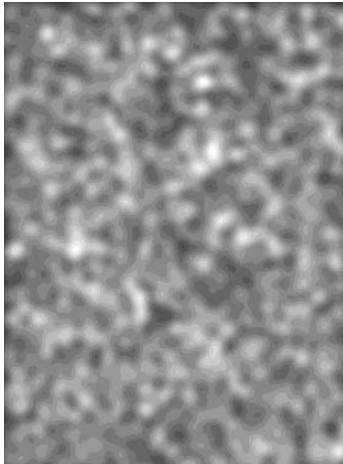


- Model sky 9.3' x 12.7'
- Model PSFs
 - Model w. obscuration
 - Gaussian
- used 8000 point sources <30Jy
- beam profile: 4'x4' array at 350μm
- average ratio different by ~0.5%



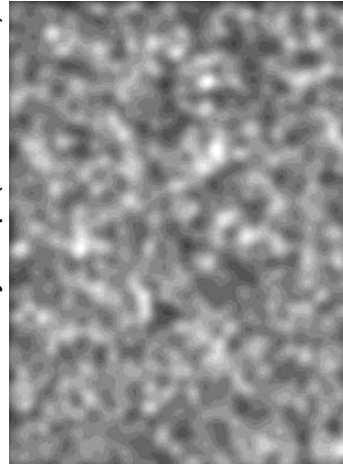
9.3' x 12.7'

simulated sky map (obsc. mirror)



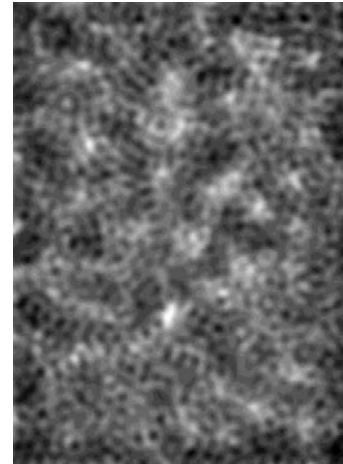
9.3' x 12.7'

simulated sky map (Gauss PSF)



avg = 0.5%

ratio of two maps



Systematic error from
beam profile shape
small



Some X-Calibration Options

- Comparison of large SPIRE maps of strongly varying extended emission (Galactic Plane) to HFI maps.
 - Data will be available from science programs
- Simultaneous observations of a bright planet
 - Uranus/Neptune for a few hours
 - 50-200Jy @ 350-500mm
- SPIRE observations of PN NGC 6543
 - >50Jy @ 100 μ m
- SPIRE follow-up observation program of bright point sources detected with HFI.
 - 9.7min per source





Coordinated Observations of Planets

- Coordinated observations of Uranus and Neptune
- Short term variability not significant
- Need to map sufficient background to cover several HFI beam diameters
- Planck 5' HFI beam, choose 15 beam diameters field for cross calibration (75' x 75' field)
 - in standard mode for HFI takes 30h (avg. speed 2.5'/ h)
 - accuracy 43/49 mJy (857/545 GHz)
 - corresponding cross scanned SPIRE map 1.8h
 - accuracy ~13.2/11.2 mJy





Comparison of Galactic Plane Maps

- Final exp. accuracy 43/49 mJy for HFI maps @ 857/545 GHz
- Beam profile accuracy for Planck-HFI $\sim 1\%$ (integral)
- Beam profile accuracy for COBE-FIRAS ?
- However, influence of inaccuracies in beam profile shape very small. Integral matters most.
- FIRAS-Map accuracy 3%
- Very high S/N on calibration factor
- Map reconstruction with $1/f$ noise removal necessary, systematic uncertainties yet unknown





Summary

- Cross calibration between COBE-FIRAS, Planck-HFI and Herschel-SPIRE can lead to absolute accuracies well below 10%, but not better than 3%.
- Cross calibration with extended emission using large maps from the science program will not need additional time.
- Cross calibration using point sources will need additional observations but the time needed is estimated to be moderate.

