Konkoly Infrared & Space Astronomy Group

Herschel related activities at Konkoly Observatory

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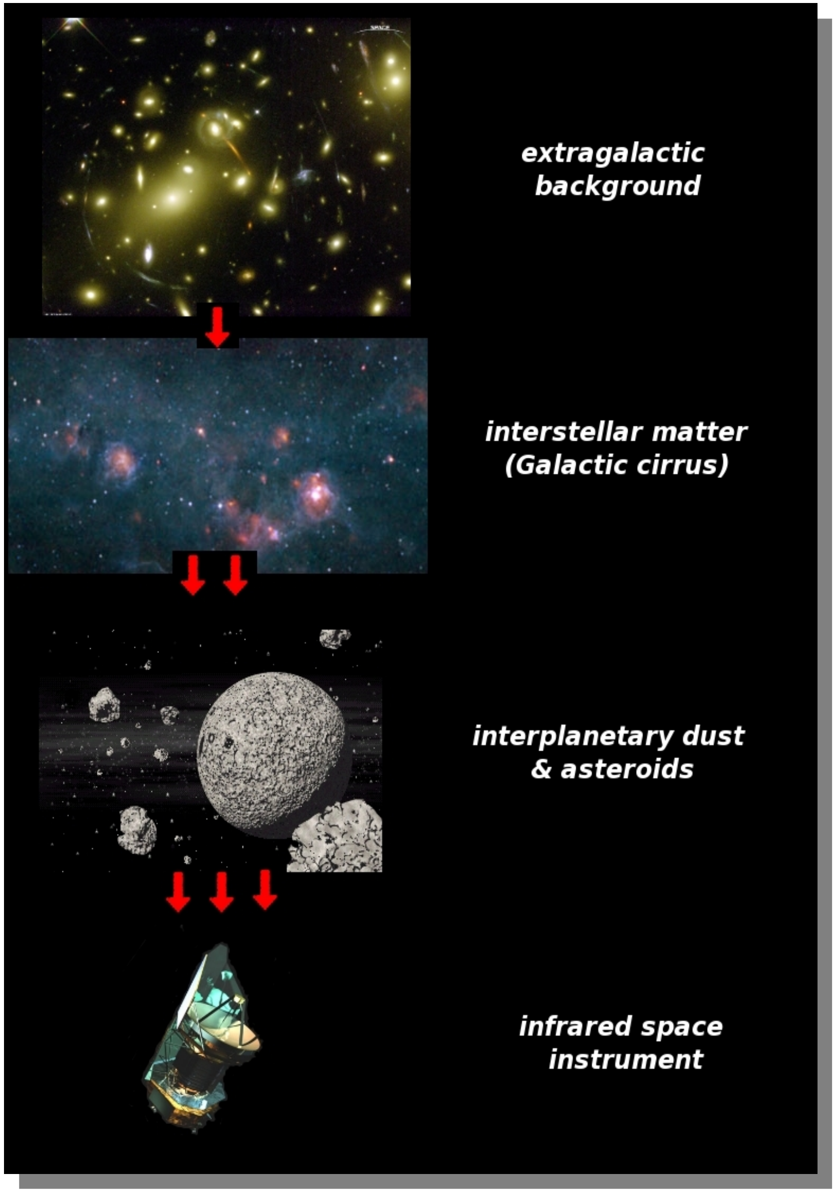
Participation in the Herschel mission

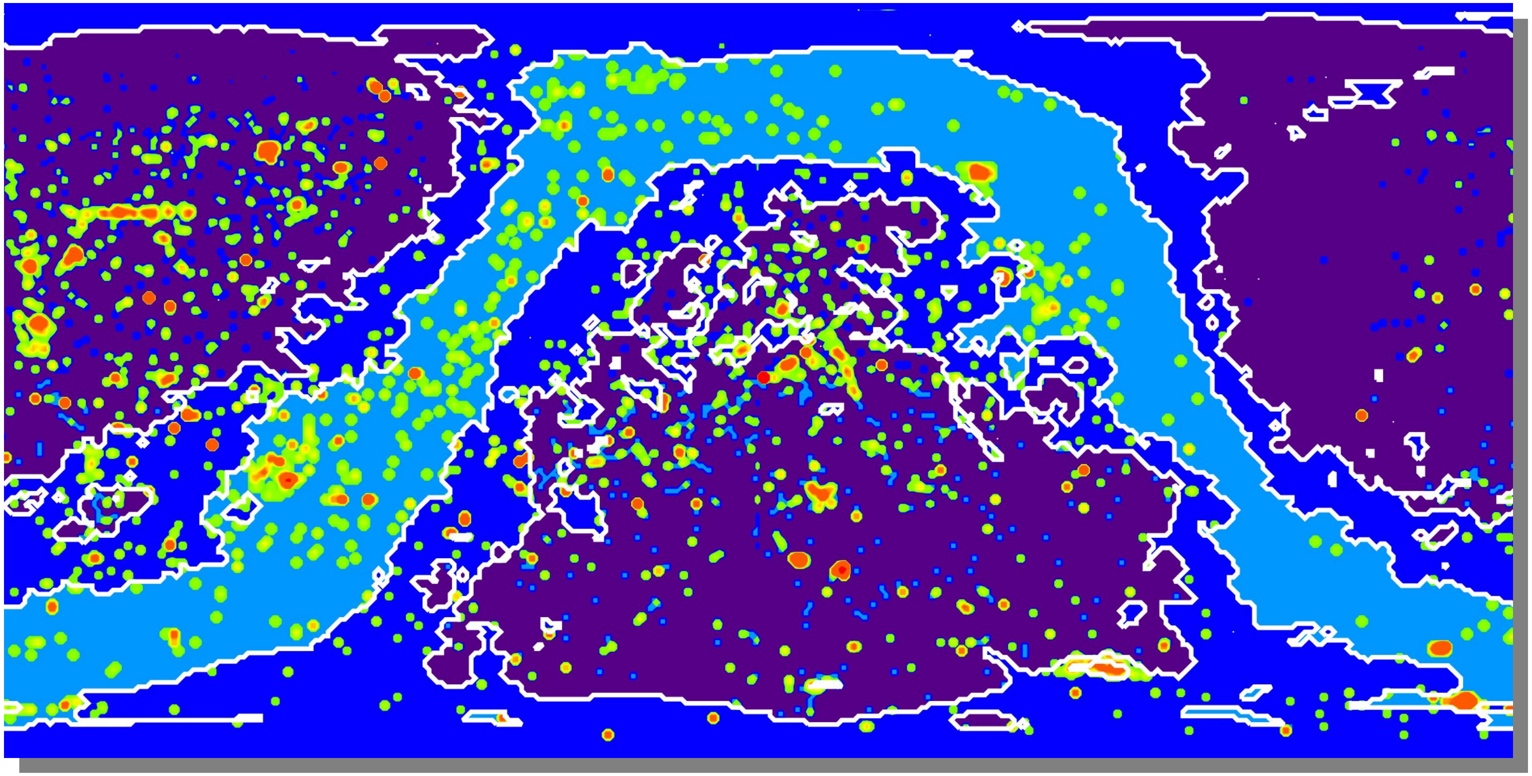
- Financial basis: ESA's PECS programme (#98011)
- Covered period: September 1, 2004 – December 31, 2007
- 8 man-years; Cs. Kiss, Sz. Csizmaida, L.V. Tóth and A. Moór
- Main fields:
  - Development of the Herschel Confusion Noise Estimator module for HSPOT (coordinated by the Herschel Science Centre, scientific coordination by Konkoly Observatory)
  - PACS calibration (coordinated by MPE, Garching):
    - AOT tests
    - Calibration tests
    - Other calibration issues (e.g. celestial standards)

Confusion noise in the infrared

- Confusion noise: uncertainty in the point source flux determination due to the fluctuations of the sky background
- Confusion noise is absolute limit, the signal-to-noise ratio cannot be improved by longer integration times.
- Confusion noise is closely related to the structure of the sky background:
  - Interstellar matter (Galactic cirrus): fractal
  - Extragalactic bakcground (cosmic infrared background, CIB) : Poissonian distribution
  - Minor planets: local Poissonian distribution, but – unlike the CIB – varies in the sky



Significance of confusion noise for Herschel



- PACS blue detectors are confusion noise limited around the Galactic plane and regions with high cirrus strength
- PACS deep surveys at 175μm are confusion noise limited everywhere (CIB)
- Figure: relative strength of expected cirrus and extragalactic background confusion noise for PACS 175μm, with ISOPHOT pointing density overlaid

Asteroid model of the infrared sky

- Co-workers: A. Pál (Eötvös University), Th. Müller (MPE, Garching)
- Input for our model: Statistical Asteroid Model (SAM—I): Tedesco, E., Cellino, A, Zappala, V., 2005, AJ, 129, 2869 [NASA]
- Main features of the SAM: Main belt, 15 asteroid families, simulated ephemerids for ~1.9 million asteroids with a specific albedo- and diameter distribution down to a size of ~1km, + ~10000 known minor planets
- Validity of the SAM-I: -- Meadows et al. (2004): First Look Survey (ecliptic plane) results at 8 and 24μm: observed asteroid counts agrees well with the SAM-I predictions (including the so far unknown asteroids)

Asteroid model of the infrared sky

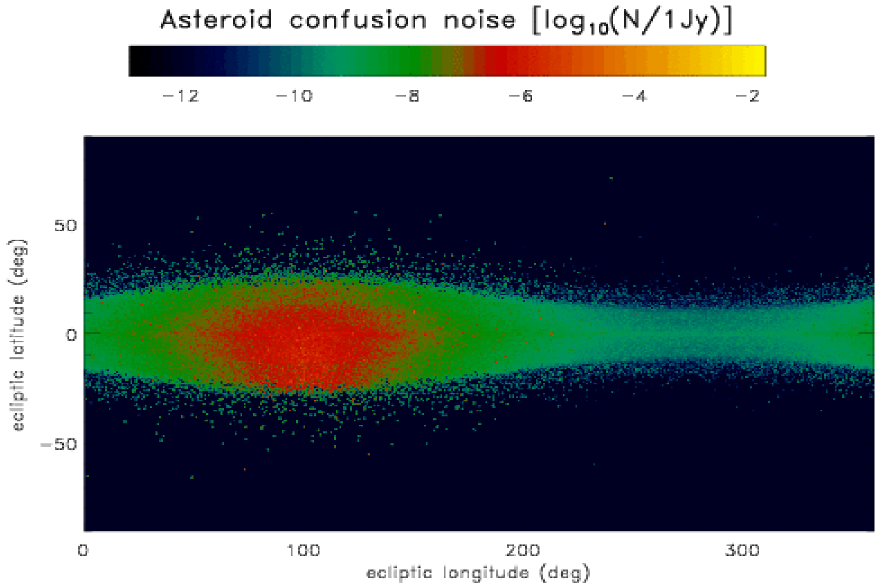
- Position calculation: orbital elements of all SAM-I asteroids are calculated for the period January 1, 2000 – December 31, 2012, with 5 day temporal resolution; accurate numerical integration including the effect of all inner and outer planets (expect Pluto); real spatial and apparent sky coordinates are calculated

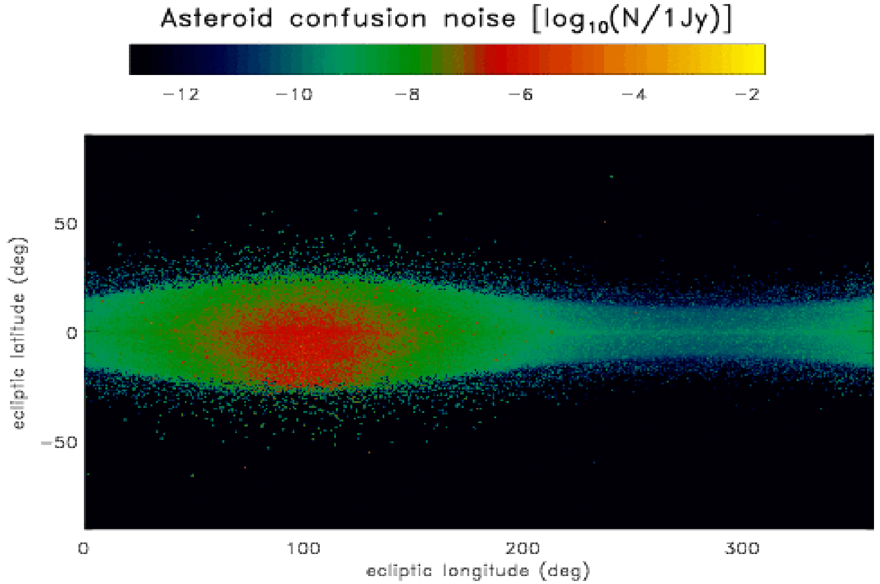
- Thermal brightness calculation: Standard Thermal Model (Lebofsky et al., 1986); true observing geometry for a given epoch; asteroids: smooth, spherical and non-rotating bodies; correction for beaming, shape and conductivity effects via the η parameter

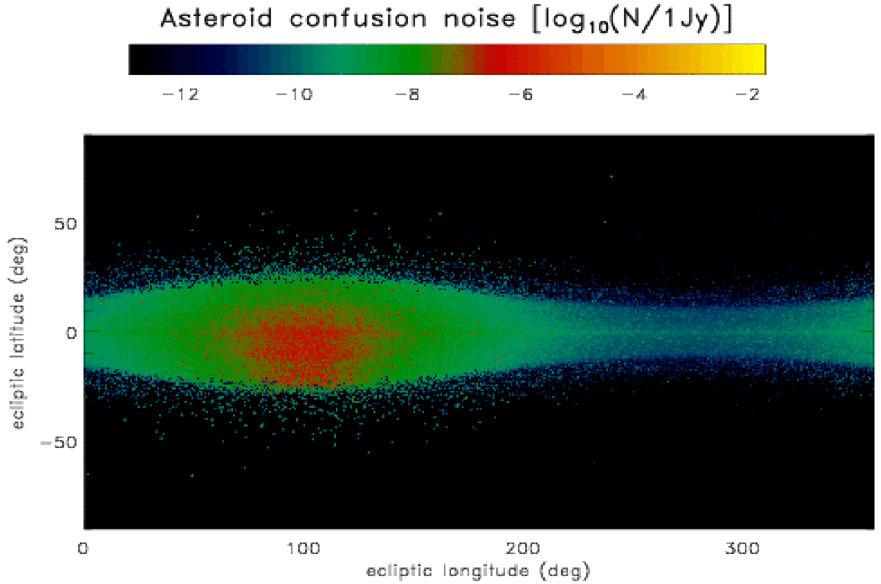
- Confusion noise and asteroid count calculations: outputs: expected counts above detection limits and "per pixel" confusion noise for specific filters/instruments; grid of $0.5^\circ \times 0.5^\circ$ cells in ecliptic coordinates; $\sigma_a^2(\lambda) = (\Omega/\Omega_p)\sum S_i^2(\lambda)$; these confusion noise values are lower limits due to unknown contribution of small (<1km) asteroids.

Asteroid confusion noise results

- <u>Example:</u> all-sky asteroid confusion noise maps for the Herschel/PACS photometers (75, 110 and 175μm)







PACS calibration

- Analysis of CQM and EQM test measurements:
  - CQM cooler recycling
  - Comparison of nominal and PACS/SPIRE parallel mode cooler recycling, EQM/IMT
  - Cooler holdtimes for EQM/IMT
  - Emissivity of PACS internal calibration sources (EQM/IMT)
  - Dynamic range per selected integration capacitor
- Preparation for FM tests: working out CUS and IA scripts
  - FM tests
- Analysis of wavelength switching mode AOT measurements
- ISOPHOT based list of standard stars for PACS photometry

PACS calibration – Cooler recycling

- The bolometer focal plane has to be kept at T<0.3K during operation (^{3}He is necessary, super-conductive below 1mK)
- Cooler recycling brings the system to this 'cold' state
- Requirement: this temperature (T<0.3K) should be kept at least for 46-48 hours
- We have investigated: general behavior of temperatures (red/blue bolometers, evaporator, thermal straps, timescales, etc.), cooler holdtimes, evaporator temperatures reached in different CR procedures, transient features, variations of temperatures at commad-issue times

PACS calibration – Cooler recycling

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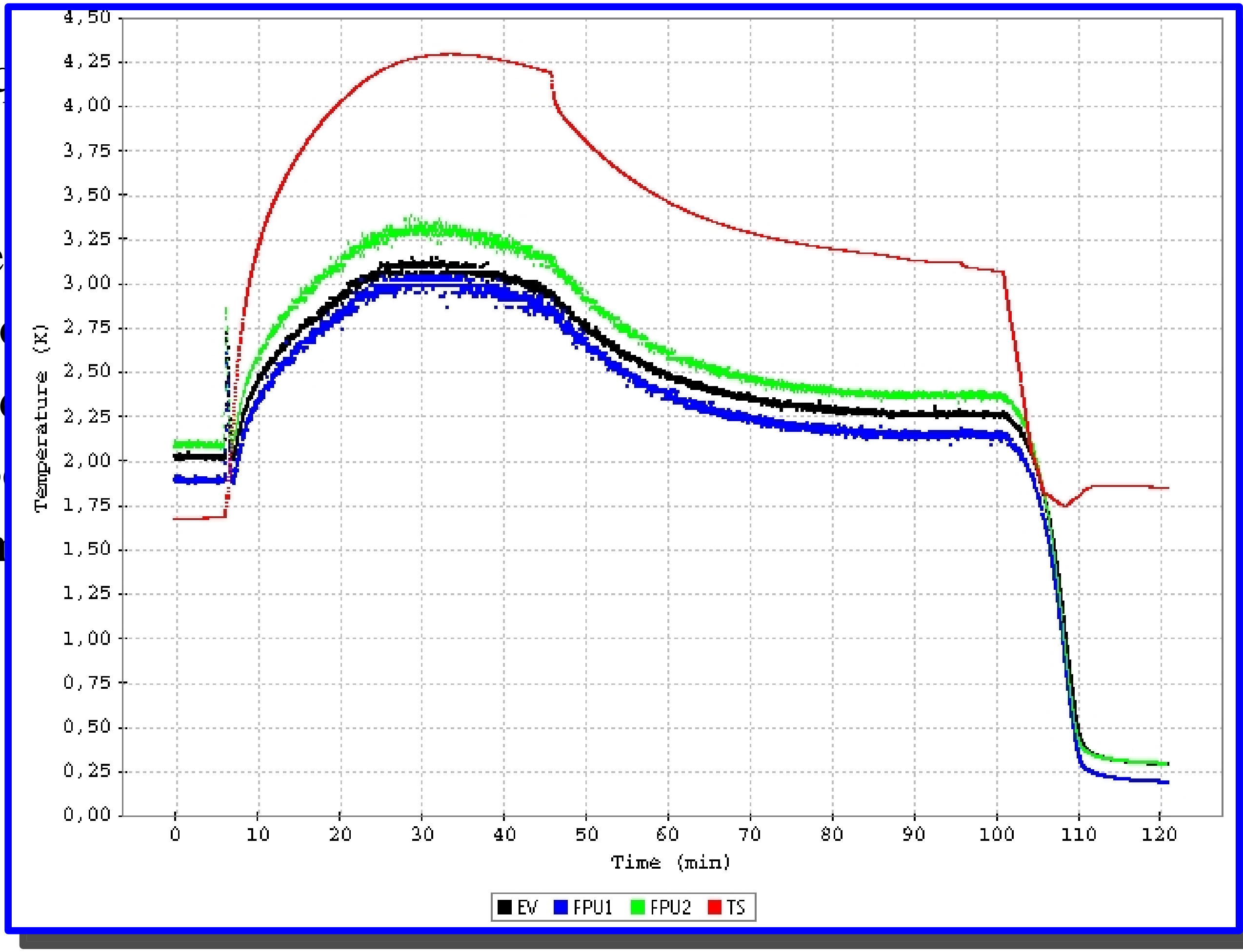
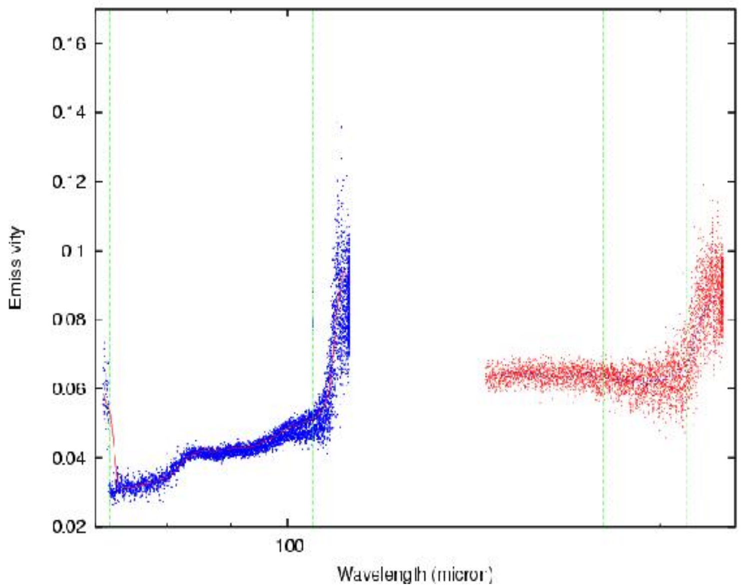
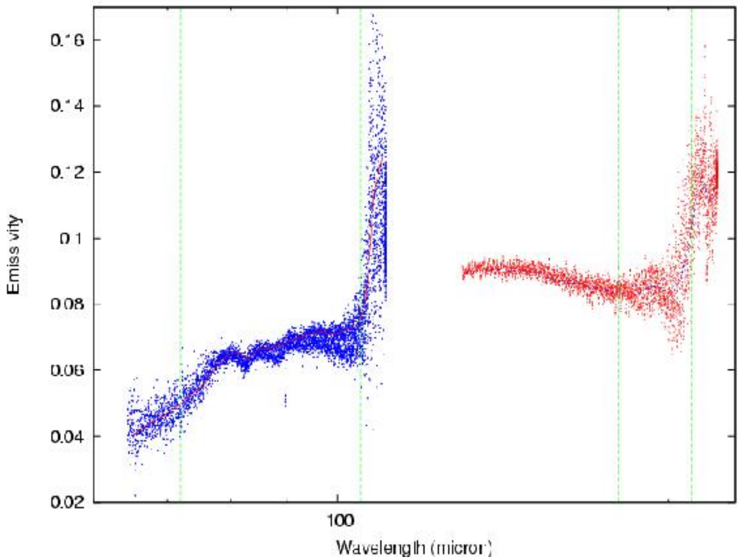


PACS calibration – Emissivity of calibration sources

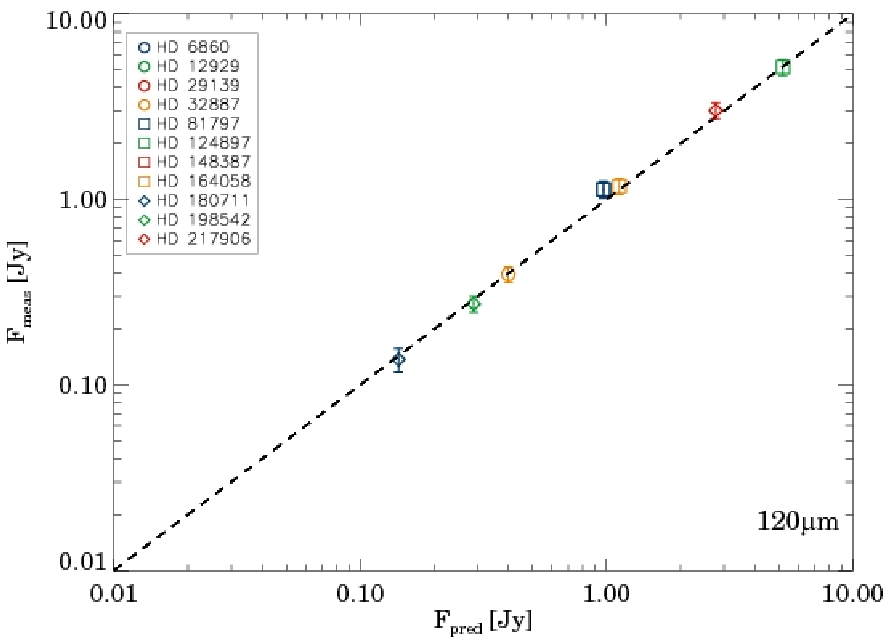
- There are two independent calibration sources in Herschel/PACS (CS1 and CS2)
- They are measured at least at the beginning and at the end of the observations, to calibrate the scientific measurement to flux density
- Emissivity values were determined by comparing the CSs fluxes to some standard black body radiators
- The emissivities was found to be quite low and highly wavelength dependent
- Emissivity values were calculated for all the pixels of the blue and red spectrometer arrays.

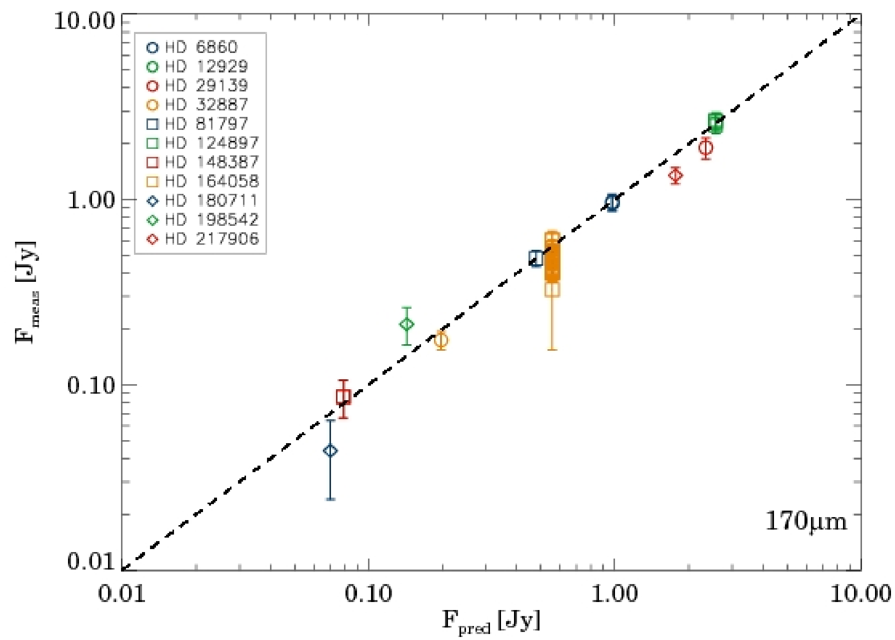




Photometric standard stars for PACS

- Far-IR observations of current stellar photometric standards:
  - Spitzer/MIPS is going to provide accurate fluxes of standards at 24 and 70μm, but the 160μm calibration has serious problems (filter leak).
  - $\lambda \geqslant 100\mu$m ISOPHOT measurements are still unique to constrain the flux of celestial standards
  - No stars show excess at $\lambda \geqslant 100\mu$m, but the fluxes of γDra and δDra are relatively uncertain (below the prediction). These stars are situated in Draco, which has a high cirrus confusion background despite the relatively low surface brightness.





Photometric standard stars for PACS

- Proposed list of additional photometric standards:
  - Based on ISOPHOT and MIPS measurements a list of potential secondary standard stars has been compiled; 15 stars have been recommended as standards.
  - The analysis included:
    - Inspection of all available IR measurements (especially at $\lambda \geqslant 24 \mu m$)
    - Expected impact of confusion noise on PACS photometry
    - Inspection of individual properties of the stars (binary/multiple system; bright, nearby background object, etc...)
  - Recommended stars: ν And, ι Per, DY Eri, λ Aur, γ Lep, α Men, θ Boo, χ Her, γ Ser, 110 Her, σ Dra, ψ Cap, γ Pav, ι Psc, ω Psc

Future work

- Further development of the Herschel Confusion Noise Estimator
  - Implementation of the existing code in Java, and integration to HSPOT (TDB by HSC/NHSC)
  - Refinement of calibration tables (cirrus and extragalactic components)
  - Investigation of cirrus structure at small angular scales (through the relationship of visual scattered light and far-infrared emission)
  - Investigation/inclusion of the effect of galaxy clustering
- Participation in FM test
  - Calibration (commanding, CUS scripts, analysis): Cooler recycling, Dynamic range per selected integration capacitor, Time constants, Linearity of CRE readout, Signal dependence on chopper frequency, Emissivity of PACS calibration sources
  - Frequency (wavelength) switching AOT tests (commanding, CUS scripts, analysis)