Herschel Calibration Workshop #2, February 6-8, 2008

CONFUSION NOISE AND BACKGROUND

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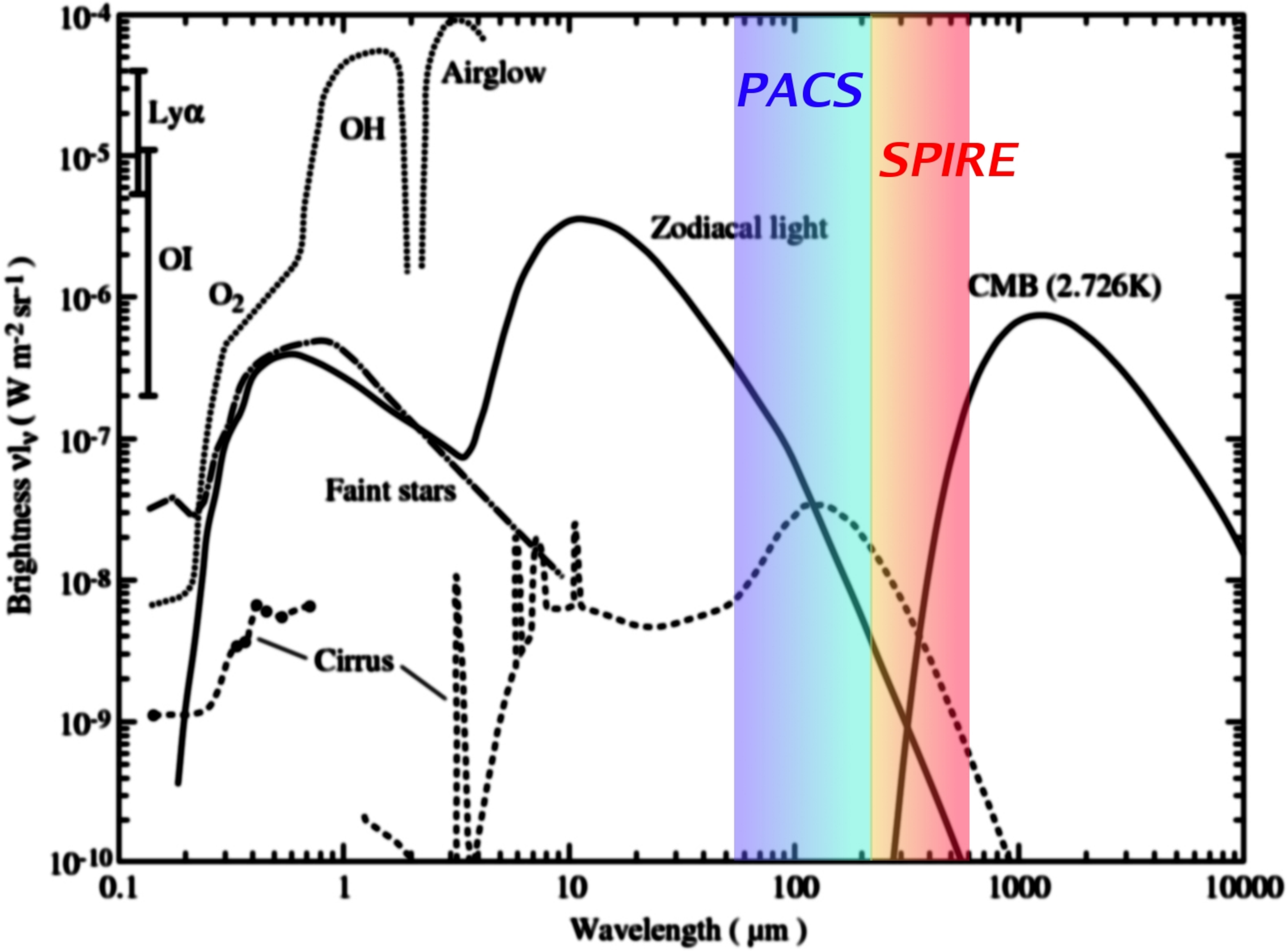
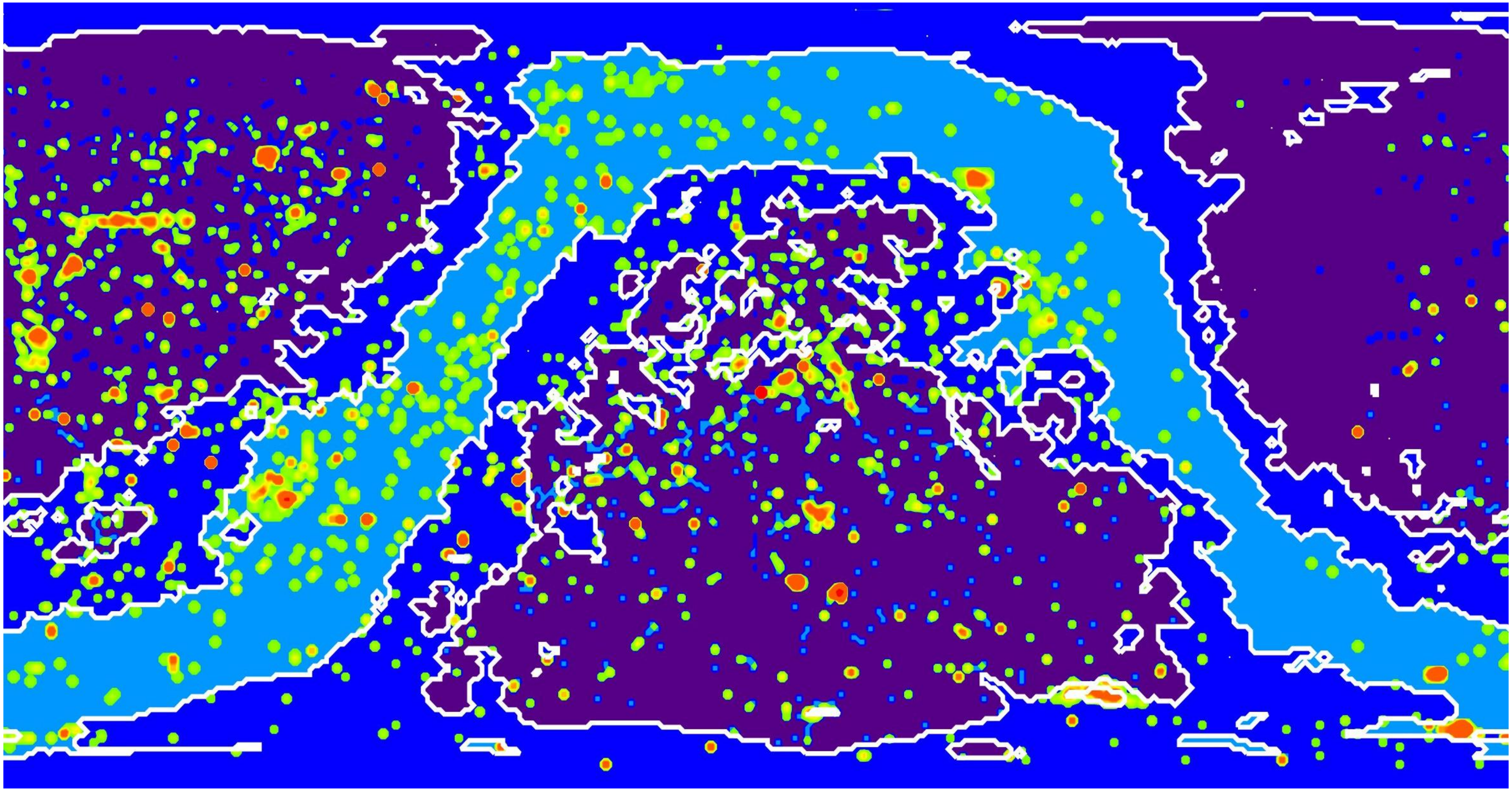
Introduction

- Confusion noise was very important for the recent infrared space instruments (e.g. those of IRAS, ISO and Spitzer), especially for the long wavelength filters, where these instruments were heavily confusion noise limited.
- Confusion noise – whatever the source – is known to scale with the resolving power of the telescope ($\propto\lambda/D$). The actual relationship depends on the sky background component considered.
- These telescopes had <1m diameter primary mirrors, while Herschel will have a ~3.5m mirror. This fact alone should decrease the confusion noise significantly.
- **Question: Is confusion noise important for Herschel at all?**

Introduction



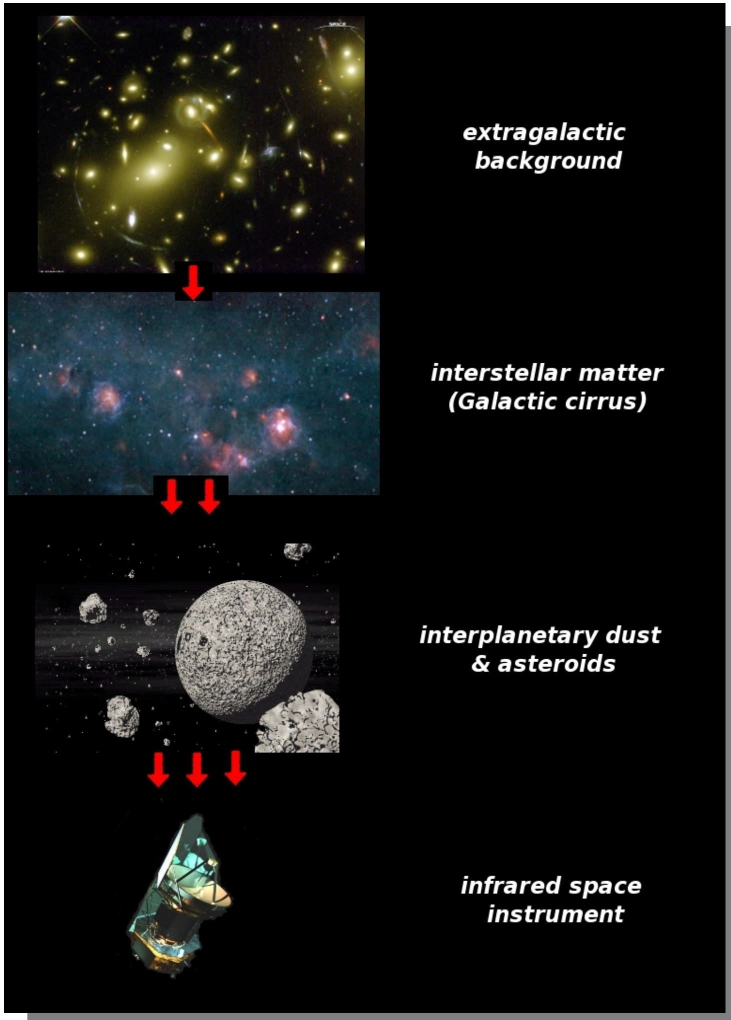
Introduction



The relative strength of the expected cirrus and CIB confusion noise for the PACS 160μm filter, with ISO pointing density overlaid

Introduction

- First steps for confusion noise estimates for Herschel: the Herschel Calibration Workshop #1 (December 2004, Leiden).
- Early 2005: decision to include a confusion noise estimator tool in HSpot.
- Main sky background components for Herschel:
  - Distant galaxies (extragalactic background / CIB)
  - Dust in the Galactic interstellar medium (cirrus confusion noise)
  - Dust in the Solar System (zodiacal emission and asteroids)
- Preliminary calculations show the importance of the CIB and cirrus as confusion noise components, **but what about the zodiacal emission and asteroids?**



Asteroids -- model

- There has been no reliable model for the contribution of asteroids to the sky background and confusion noise for infrared wavelengths.
- A complete model of the asteroid component of the infrared sky has been developed, based on Statistical Asteroid Model (SAM) by Tedesco et al. (2005):
  - Ephemerids of 1.9 M asteroids, including different dynamical families in the main belt, with a given albedo and size distribution
  - Extension of the SAM model (with describes the asteroids as seen in the scattered sunlight) to 5...1000μm, where the thermal emission is dominant
  - The spatial and apparent coordinates of each asteroid have been calculated for the period 2000-01-01 – 2012-12-31, with a 5-day temporal resolution.
  - Based on the solar and geocentric distances, and the mean albedo of the SAM minor planets the temperature distribution was determined on the surface of the asteroid, using the Standard Thermal Model (Lebofsky et al., 1986), and an SED was assigned to each asteroid, at each times step.

Asteroids -- model

- **Outputs of the model (α,δ,λ,t):**
  - Full fluctuation power: $\delta F(\lambda) = (1/\Omega)\sum S_i^2(\lambda)$ [$Jy^2 sr^{-1}$]; confusion noise can be calculated directly from as $\sigma^2(\lambda) = \Omega_p \cdot \delta F(\lambda)$ (contribution to the photometric accuracy, [Jy])
  - Fluctuation power and confusion noise due to asteroids below the detection limit ($\delta F_{lim}(\lambda)$ and $\sigma^2_{lim}(\lambda)$)
  - The total count of asteroids, and the count of asteroids above the detection limit, per unit area (N_{tot} and N_{lim} [sr^{-1}])
  - Average contribution of SAM-I asteroids to the infrared background (zodiacal emission) at the specific sky area (B_0, [$MJy\ sr^{-1}$])
  - These parameters are calculated for geocentric conditions (Akari, Herschel and ground based instrument), but can also be calculated for an arbitrary place in the solar system – e.g. for the orbit of the Spitzer Space Telescope.

KISAG - Asteroid confusion noise & number count estimates - Mozilla Firefox

http://pc100.konkoly.hu/~apal/sam/

from the KISAG homepage...

Auxiliary output data:

- λ_{sun}: The ecliptical longitude of the Sun, at the given date at 0^h00 UT, in degrees.
- *E*: The solar elongation of the specified position, in degrees (followed by either 'E' or 'W' for Eastern or Western elongation, respectively).

Request Form

Coordinate types: (•) Equatorial (R.A., Dec) ( ) Ecliptical (Ecl. longitude, Ecl. latitude)

Observing location: (•) Geocentric (between 2000 - 2012) ( ) Spitzer Space Telescope (between 2004 - 2009)

	R.A. *(deg)*	Dec *(deg)*	Date *(YYYY-MM-DD)*	λ *(μm)*	S_{lim} *(Jy)*
Pos. #1	0	0	2007-01-01	9	0.001
Pos. #2	0	0	2007-01-01	18	0.001
Pos. #3	0	0	2007-01-01	60	0.001
Pos. #4	0	0	2007-01-10	90	0.001
Pos. #5	0	0	2007-01-01	140	0.001+

Continue Reset

Mozilla Firefox

Fájl Szerkesztés Nézet Ugrás Könyvjelzők Eszközök Súgó

http://pc100.konkoly.hu/~apal/sam/sam.php?userc Ugrás

News | Időjárás | MyOwnPages | Konkoly-OWM | EngHun | Google | Astro | HERSCHEL | Paperwork

Google | http://pc100...im4=0.001%2B

Query (geocentric)							Result					Other	
R.A. (deg)	Dec (deg)	Ecl.lon. (deg)	Ecl.lat. (deg)	Date	lambda (um)	Slim (Jy)	dF0	dFlim (Jy^2/sr)	Ntot	Nlim	B0 (MJy/sr)	Solar long. (deg)	Elong. (deg)
0.000	0.000	0.000	0.000	2007-01-01	9.0	1.00e-3	5.680e+0	3.800e-1	693	77	1.682e-3	280.172	79.828 E
0.000	0.000	0.000	0.000	2007-01-01	18.0	1.00e-3	5.537e+1	5.794e-1	693	398	5.817e-3	280.172	79.828 E
0.000	0.000	0.000	0.000	2007-01-01	60.0	1.00e-3	1.230e+1	7.292e-1	693	144	2.876e-3	280.172	79.828 E
0.000	0.000	0.000	0.000	2007-01-10	90.0	1.00e-3	5.579e+0	3.633e-1	756	63	1.623e-3	289.342	70.658 E
0.000	0.000	0.000	0.000	2007-01-01	140.0	1.00e-3	1.055e+0	1.849e-1	693	28	8.501e-4	280.172	79.828 E

SAM output, generated at 2007.04.19 23:04:05 CEST (GMT+0200)

References:

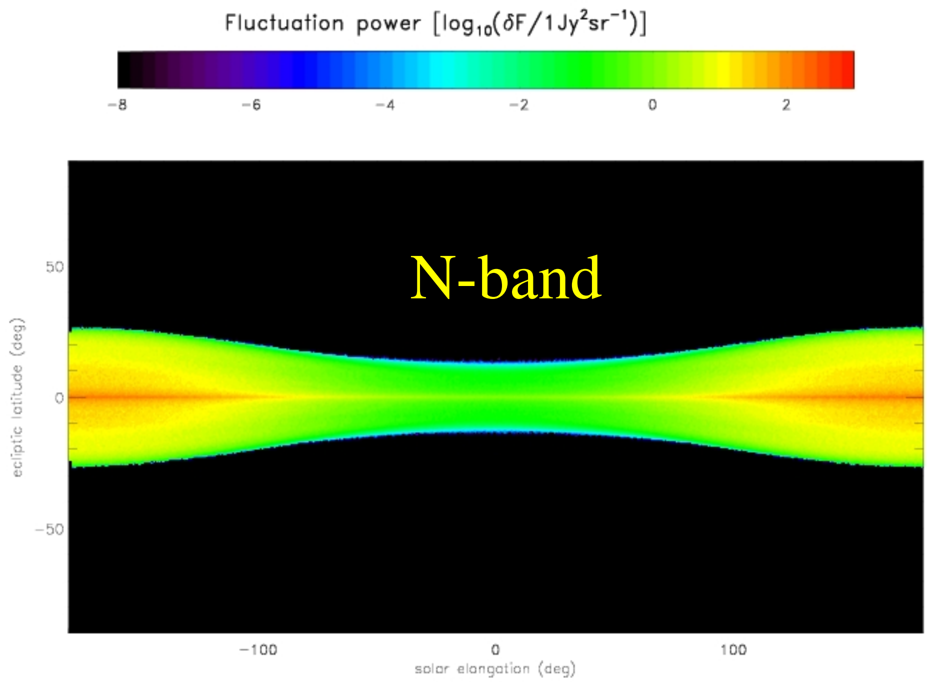
- Kiss, Cs.; Pál, A.; Müller, Th.; Ábrahám, P.: An asteroid model of the mid- and far-infrared sky, PADEU, 17, p135., 2006

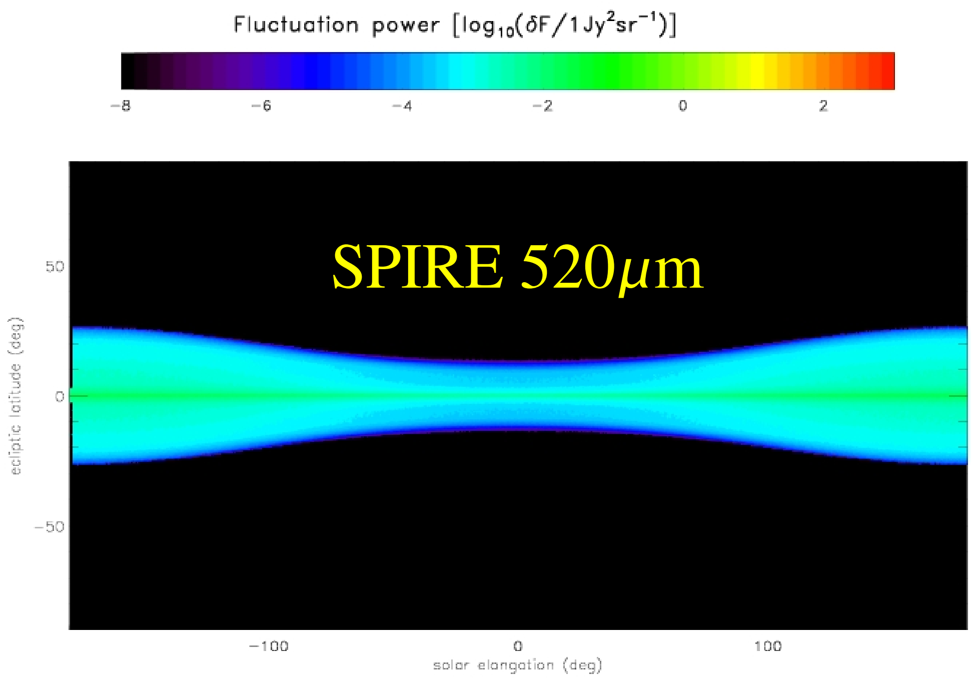
KISAG - Aster... | sam.php

http://kisag.konkoly.hu/solarsystem/irsam.html

Asteroid results

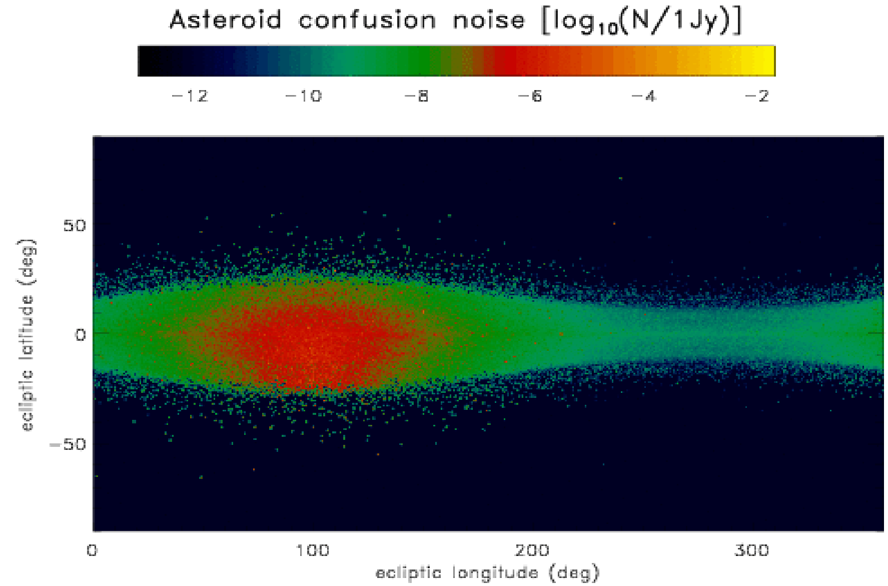
- <u>"Mission average" maps</u>: most of the temporal changes in the fluctuation power can be very well described by a constant celestial distribution, if it is transformed to a coordinate system co-moving with Earth around the Sun (Helioecliptic coord. sys.).

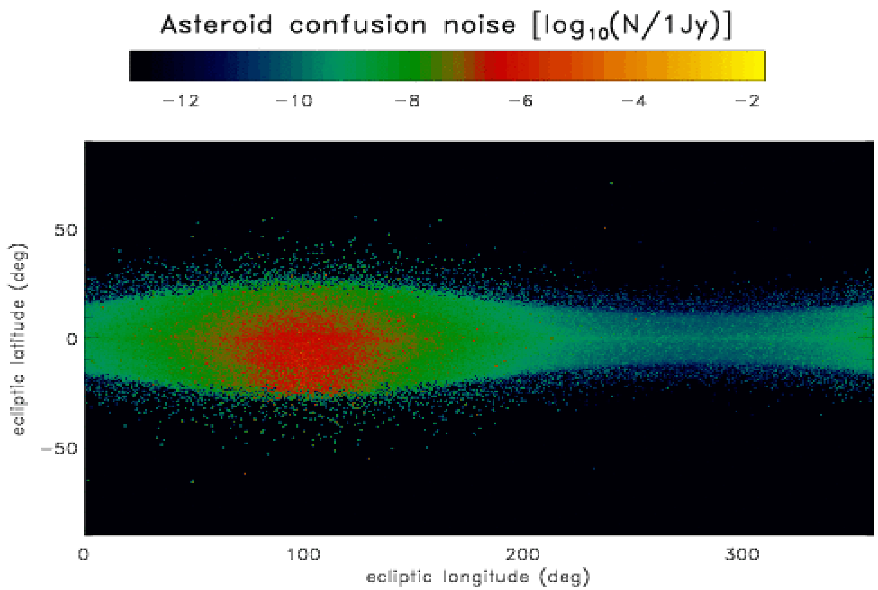


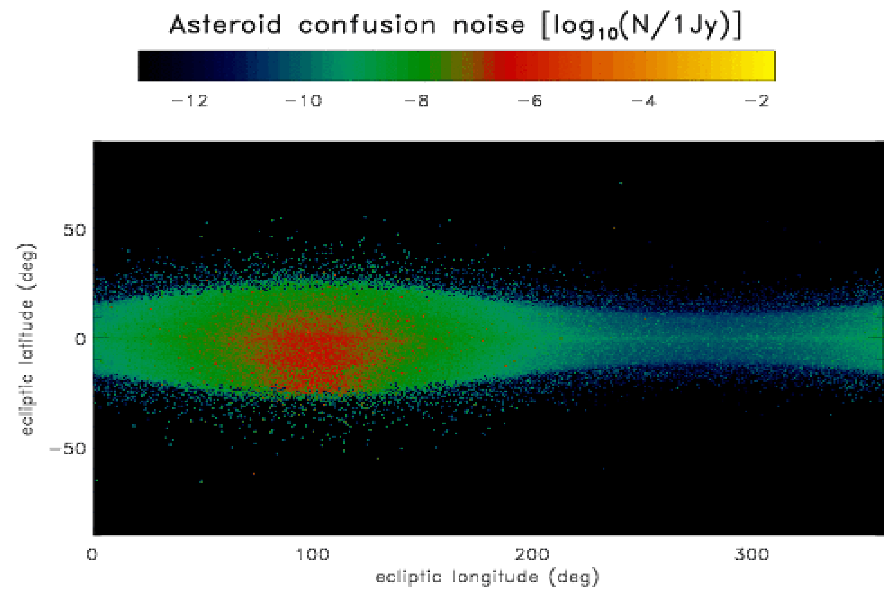


Asteroid results

- Example: Confusion noise due to main belt asteroids for the Herschel/PACS photometric bands







Asteroid results

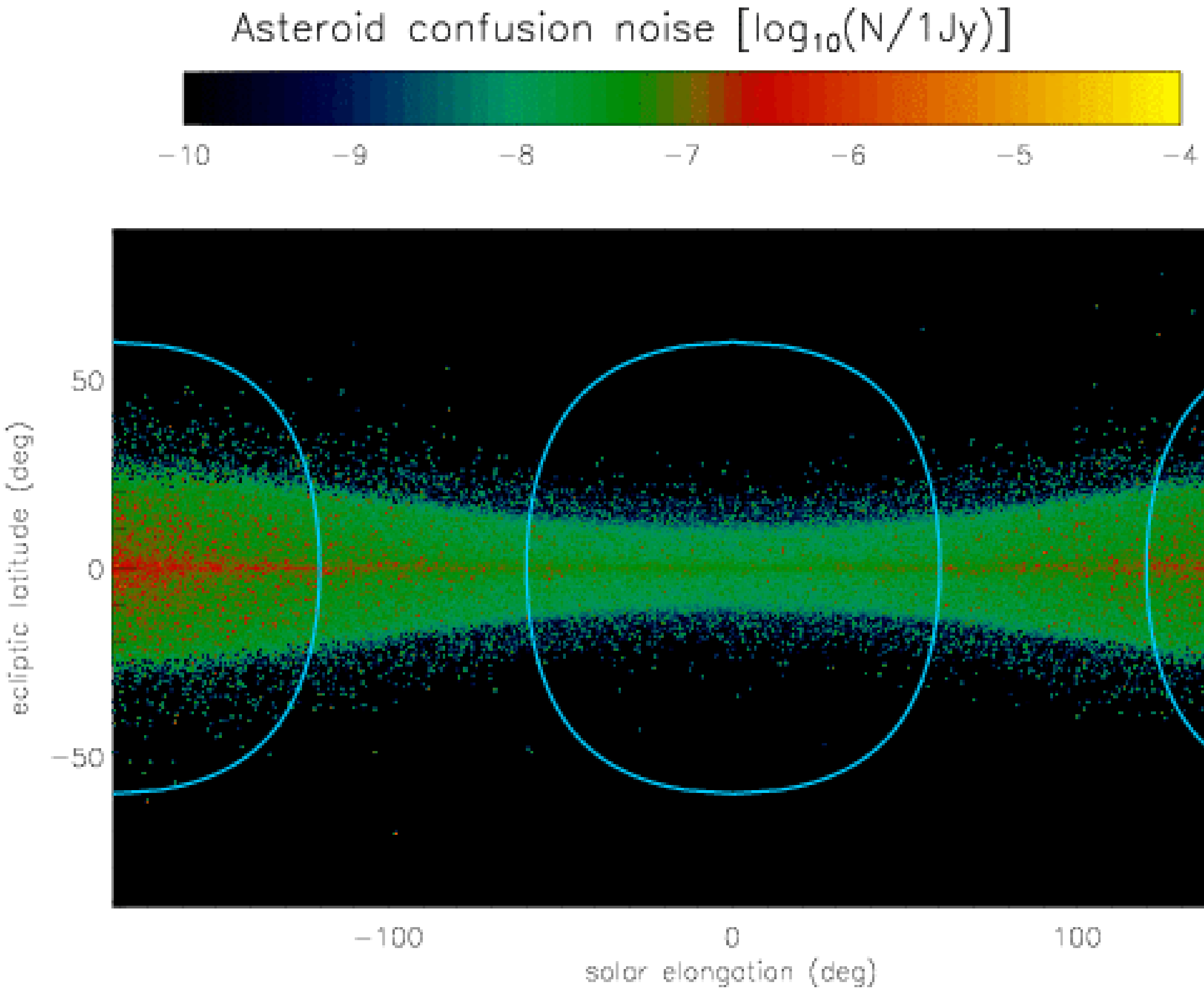
- **Which instruments are affected the most?**

  - Mid-infrared wavelengths (5...70μm): Asteroid confusion at or close to the ecliptic plane cannot be neglected; in some cases this is the dominant confusion noise component (e.g. for the 9 and 18μm bands of Akari). These sensitivities are only available from space, ground based M, N and Q instruments are far above these limits.

  - Far-infrared wavelengths (λ>70μm): at the current instrument sensitivities asteroid confusion is negligible for the instruments in operation or set to work in the near future (e.g. the long-wavelengths detectors of Spitzer and those of Herschel). However, the present results can serve as reference values for future space IR missions, like SPICA.

  - The count of asteroids above a certain flux limit can be an important question at any wavelength

Asteroid results



Asteroid confusion noise and visibility constraints for the PACS 100μm photometric band

Zodiacal emission fluctuations

- Zodiacal emission (ZE) peaks at ~20μm, which is far from the Herschel photometric bands
- Relative amplitude of fluctuations:
  - Ábrahám et al. (1997) found an upper limit of 0.2% for the amplitude of ZE fluctuations relative to the ZE background level at medium and high ecliptic latitudes, based on 25μm ISO/ISOPHOT data.
  - This ratio may be higher close to the ecliptic, but the ZE is rather smooth, except for the regions of cometary trails.
  - This can most likely be neglected for confusion noise purposes
  - The comparison with the IR asteroid model indicate, that majority of the ZE fluctuations are caused by the asteroid distribution, at least close to the ecliptic plane

Confusion noise in HSPOT:

The Herschel Confusion Noise Estimator

- Main characteristics:
  - Confusion noise is calculated at the pixel scale – this allows us to handle instrument noise and confusion noise together
  - Photometric uncertainties are calculated for the 'per pixel' noise using a noise model – this assumes a certain way of point source flux determination
  - Confusion noise is provided for the 6 photometric bands (3 PACS and 3 SPIRE)
  - Cirrus confusion noise is calculated via the surface brightness dependence of this confusion noise component (Helou & Beichman 1990; Gautier et al., 1992; Kiss et al,, 2001, 2003, 2005). There are other ways to do it...see e.g. Jeong et al., (2005, 2006).
  - The cirrus (interstellar matter) surface brightness is provided by the IPAC background server
  - Consideration of measurement configurations / AOTs (from v016 on)

Current Status of HCNE

- Current version: v015 (released on 28 March, 2007), for the Herschel Open Time Key Program AoO
- The main characteristics are summarized in the release note:
  http://herschel.esac.esa.int/Docs/HCNE/pdf/HCNE_releaseNote_v015_1.pdf
- Extragalactic background: Calculated according to Lagache et al. (2003, 2004), model version as of December 2006
- Cirrus confusion noise: Calculated according to Kiss et al. (2005), using a surface brightness dependent spectral index
- No other confusion noise (sky background) components are considered

HCNE: (near) future developments

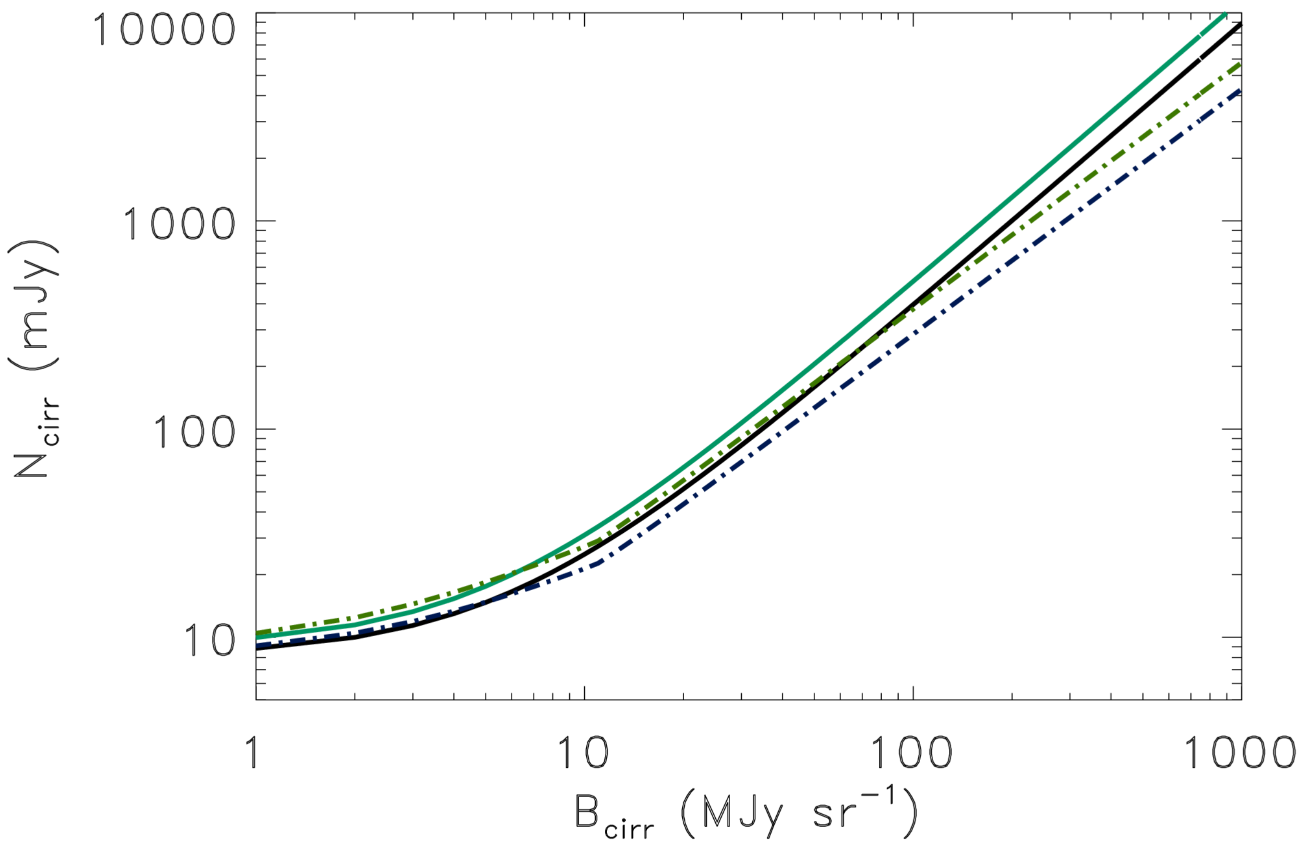
- **1.) Application of improved cirrus confusion noise estimates:**
  - The current cirrus confusion noise estimates (Kiss et al., 2005; K05) are based on the ISOPHOT C100_90, C100_100, C200_170 and C200_200 filter measurements (Kiss et al., 2005), that cover only a limited surface brightness range, and are based on relatively few "independent" sky areas.
  - The extrapolation of the surface brightness dependent spectral index in Kiss et al. (2003) [$\alpha = -1.57 \cdot \log_{10}(\langle B \rangle / 1\ \mathrm{MJysr^{-1}}) - 1.67$] would result in extremely high confusion noise values for high surface brightness.
  - Alternative estimates by Miville-Deschenes et al., 2007:
    - based on the 100μm spatial structure of IRAS/IRIS maps
    - brightness dependent spectral index: $\alpha = -1.57 \cdot \log_{10}(\langle B \rangle / 1\ \mathrm{MJysr^{-1}}) - 1.67$ for B<10MJysr-1, and $\alpha = -1.57 \cdot \log_{10}(\langle B \rangle / 1\ \mathrm{MJysr^{-1}}) - 1.67$ for

HCNE: (near) future developments

- **1.) Application of improved cirrus confusion noise estimates:**
  - Alternative estimates by Miville-Deschenes et al., 2007 (MD07):
    - based on the 100μm spatial structure of IRAS/IRIS maps (Miville-Deschenes et al., 2005)
    - brightness dependence: $\alpha = -0.26 \cdot \log_{10}(\langle B \rangle / 1\ \mathrm{MJysr^{-1}}) - 2.77$
    - The "per beam" confusion noise is estimated as (b' is the "beam parameter"):
      - $N\ [\mathrm{mJy}] = 3.3 \cdot 10^6 \cdot \langle B_{100} \rangle \cdot \left(B_\lambda / B_{100}\right) \cdot \left(b'\right)^{-\alpha/2+1}$ for $\langle B_{100} \rangle < 10\ \mathrm{MJysr^{-1}}$
      - $N\ [\mathrm{mJy}] = 1.0 \cdot 10^6 \cdot \langle B_{100} \rangle^{3/2} \cdot \left(B_\lambda / B_{100}\right) \cdot \left(b'\right)^{-\alpha/2+1}$ for $\langle B_{100} \rangle \geq 10\ \mathrm{MJysr^{-1}}$
    - Is this good for another instrument? Validation of the MD07 model:
      - Comparison of the MD07 predictions with the K05 measurements

HCNE: (near) future developments

- Comparison of the MD07 predictions with the K05 measurements:



ISOPHOT C100_90 and C100_100 fitted confusion noise (K05, continuous curves) and the MD07 "predictions" (dashed curves)

HCNE: (near) future developments

- **2.) IPAC background server "interstellar medium issue":**
  - At some sky areas the interstellar medium component in the IPAC background estimator is over/underestimated, due to the constant dust temperature (18K) used for the calculations.
  - The presence of this "feature" was confirmed by W. Reach, at the same time suggesting the necessary changes in the code (2006).
  - A recent test (end of 2007) have confirmed, that the background server was still using the "old" code (CK & AM)
  - A correction has been developed and implemented as a new version of HCNE lookup tables (February 3, 2008, CK); it is ready for delivery as a simple lookup table update (HCNE v016)