ASTROPHYSICS FROM
THE RADIO TO THE
SUBMILLIMETRE
BOLOGNA

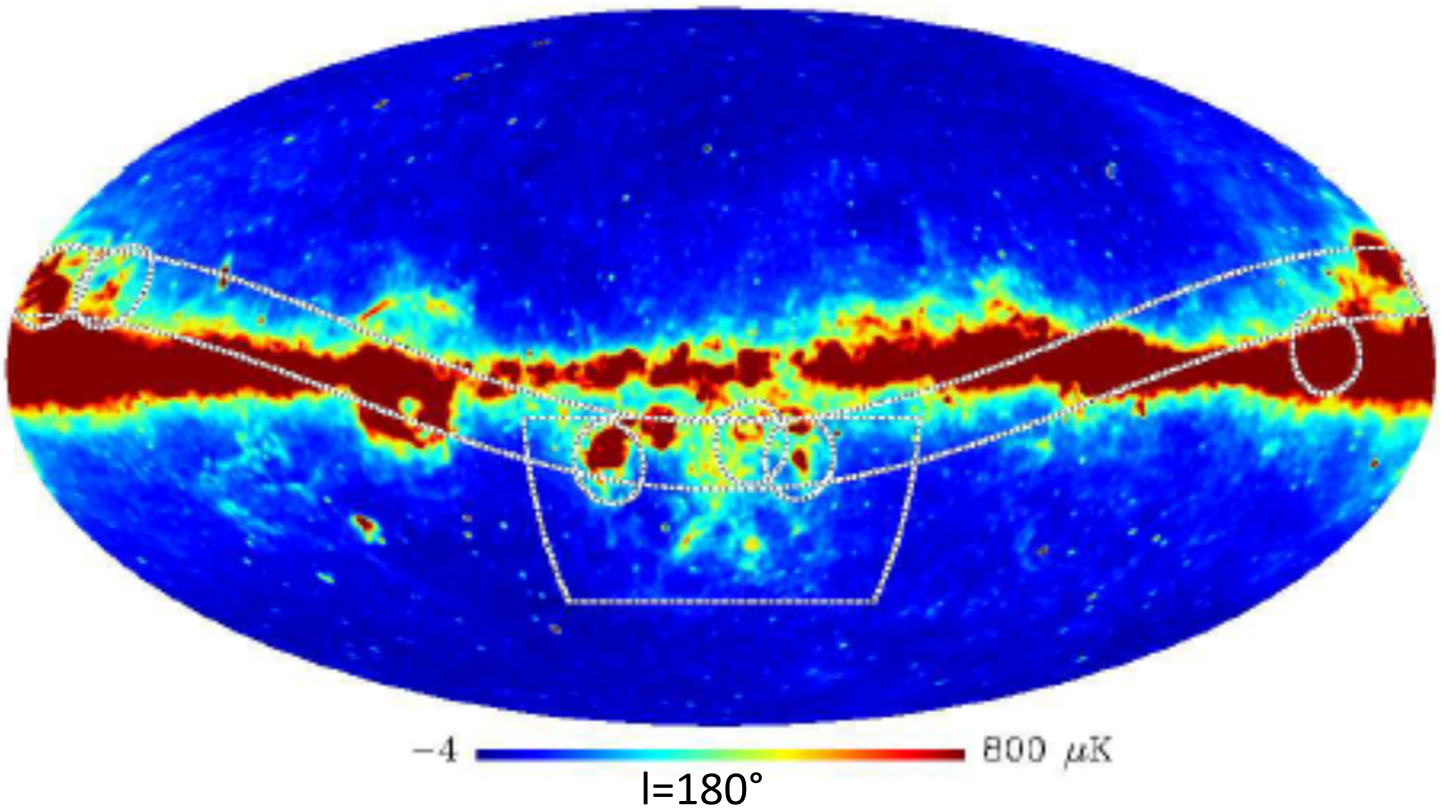
Planck intermediate results: component separation in the Gould Belt system

Planck Collaboration

Presented by Anna Bonaldi, JBCA

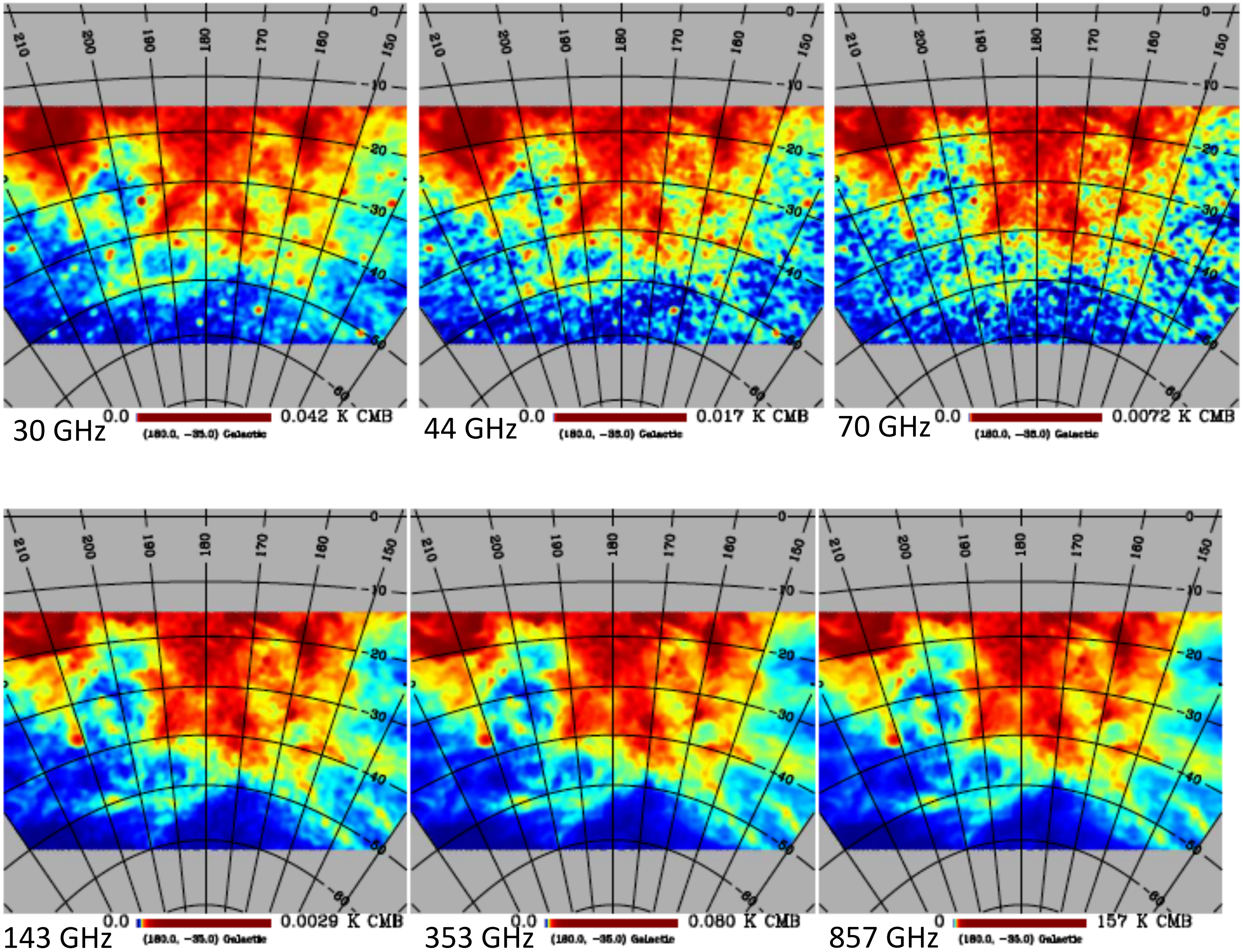
The scientific results that we present today are the product of the Planck Collaboration, including individuals from more than 50 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA) and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.



We consider the Gould Belt South, l=130°-230°, b=-10°-50°

Fainter Galactic Plane -> cleaner view of the Gould Belt


30 GHz
0.0
0.042 K CMB
44 GHz
0.0
0.017 K CMB
70 GHz
0.0
0.0072 K CMB
143 GHz
0.0
0.0029 K CMB
353 GHz
0.0
0.080 K CMB
857 GHz
0
157 K CMB

Scientific objectives

- Separation of diffuse synchrotron, free-free, thermal dust and AME
  - Flux, morphology, spatial correlations
- Diffuse free-free:
  - Comparison with Hα emission: dust absorption fraction, electron temperature
- Diffuse AME:
  - Frequency spectrum
  - Comparison with spinning-dust models

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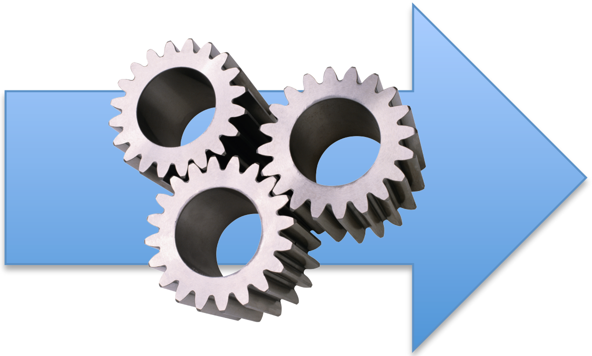
Component separation

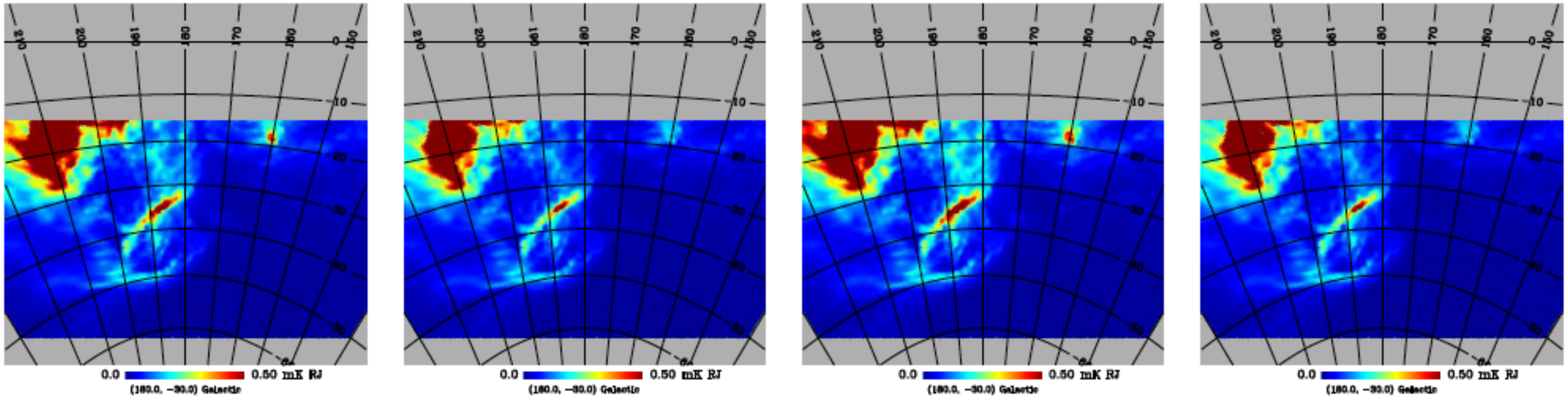
- Planck
  - 30 GHz
  - 44 GHz
  - 70 GHz
  - 143 GHz
  - 353 GHz
- WMAP K band (23 GHz)
- Haslam 408 MHz map
- 23 GHz free-free template



- CMB
- Synchrotron
- Free-free
- Thermal dust
- AME

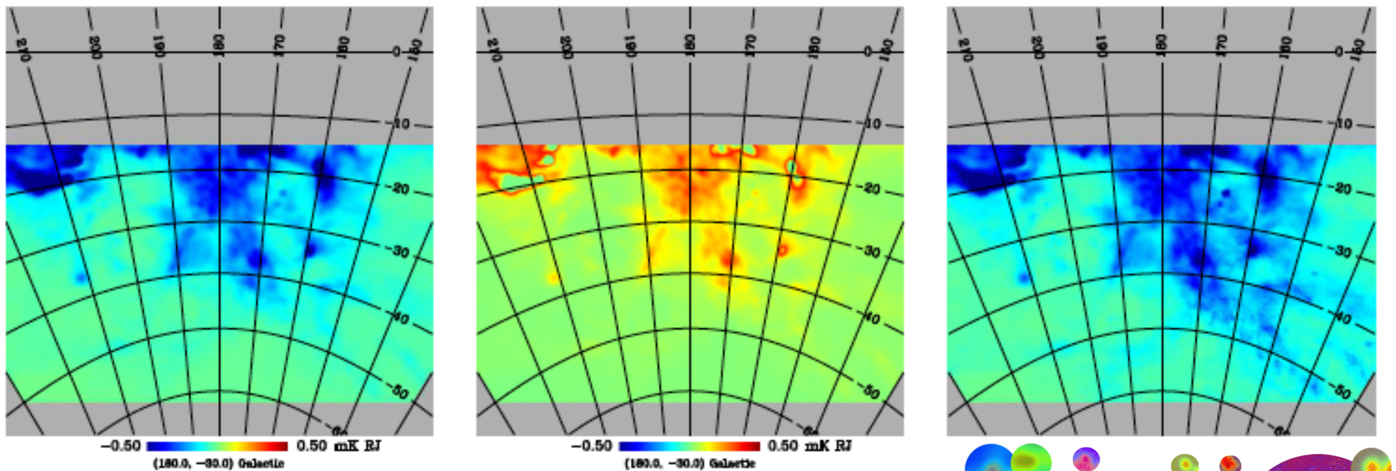
Free-free templates

Reference FF1 FF2 FF3



(FF#-Ref)/Ref

up to 60%,
dust-correlated



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Simulated dataset

- CMB realization for WMAP7 best-fit model
- Synchrotron template: Haslam et al. (1995); spectrum: power law, Giardino et al. (2002) spectral indices
- Dust template: Schlegel et al. (1995) 100mm, spectrum: grey-body Td=18, <βd>=1.8 spatially-varying
- Free-free template: Dickinson et al. (2003) (fd=0.33); spectrum: Te=7000 K
- AME template: Schlegel et al. (1995) E(B-V); normalization: Ghosh et al. (2011); spectrum: Spdust
- Instrument noise: Gaussian spatially-varying; beams: Gaussian nominal; bandpasses: monochromatic

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1) AME frequency spectrum

- Method: Correlated Component Analysis (CCA)
  Bonaldi et al. (2006), Ricciardi et al. (2010)
- Use 2nd order statistics of data to estimate parameterised spectra of the components
- Model:
  - AME: parameterised in terms of peak frequency and slope at 60 GHz (Bonaldi et al. 2007)
  - CMB (blackbody), synchrotron (βs=-2.9), thermal dust (Td=18 K, βd=1.8), free-free (Te=7000 K)

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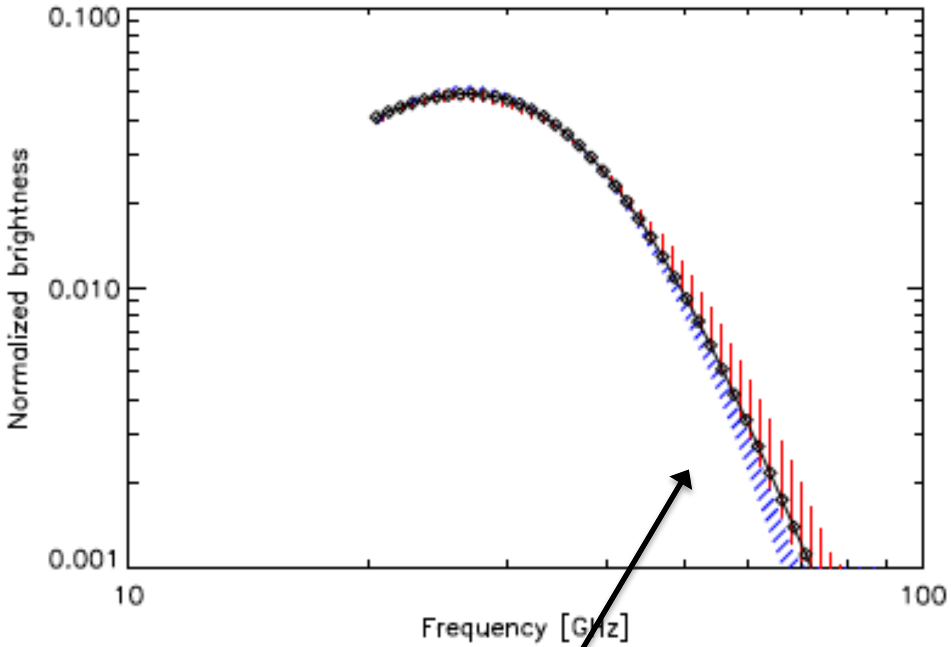

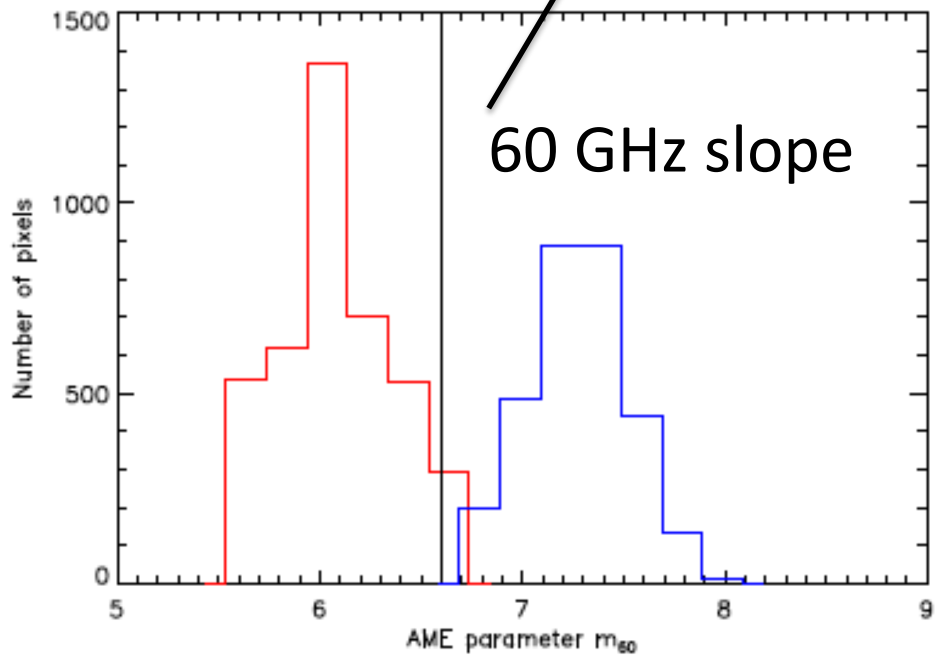

60 GHz slope

SIMULATIONS

"True" free-free= Ref
use for the estimation:
FF1 FF2

- CCA does a good job!
- AME peak frequency recovered with few GHz errors
- Possible biases on AME high-frequency slope

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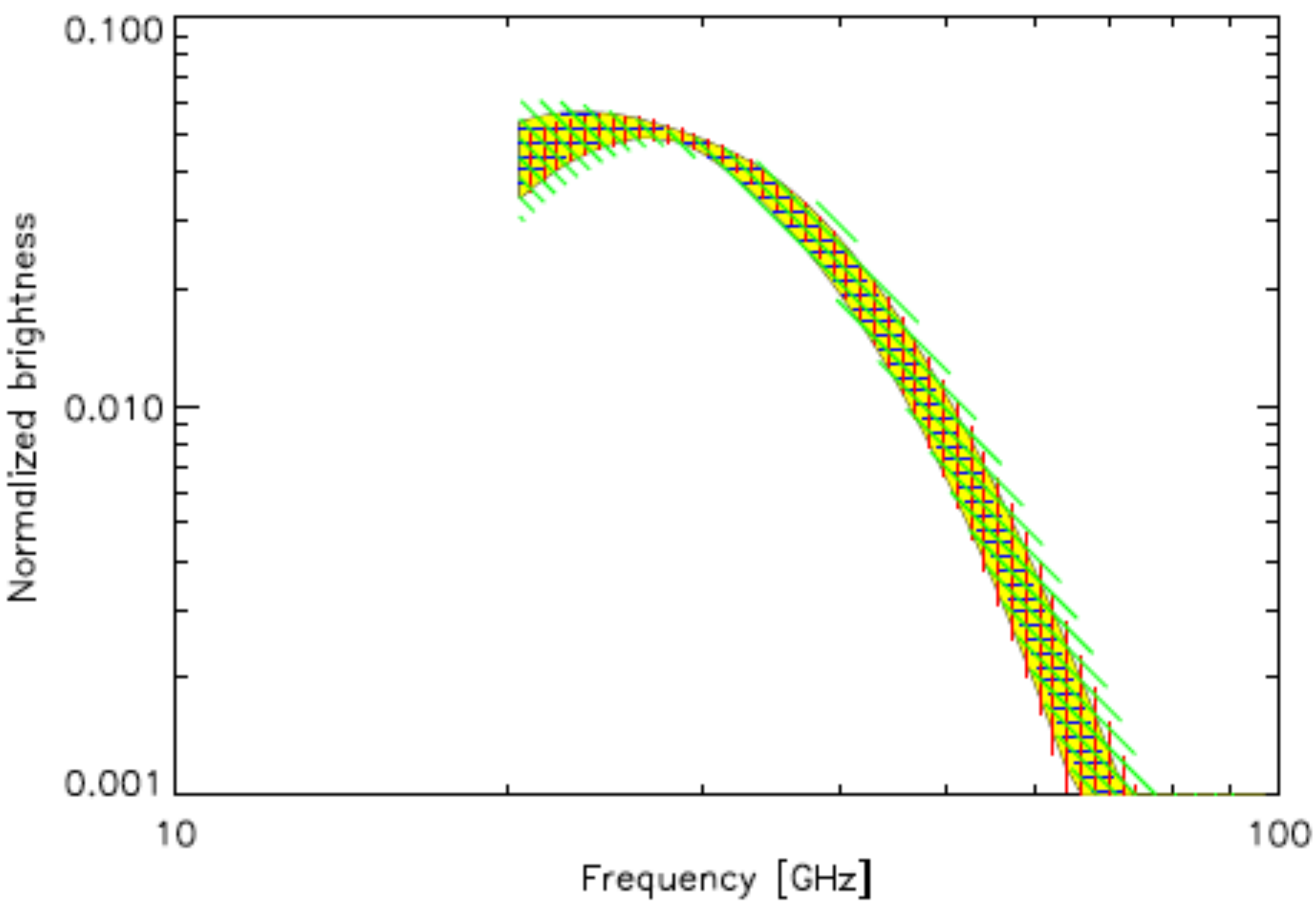
DATA



FF ref
FF1
FF2
FF3

Peak ~ 26 GHz
mild spatial variations compatible with errors

2) Reconstruction of amplitudes

- Generalised Least Square (GLS) solution: linear combination of data depending on noise and component spectra
- We combine equalized-resolution (1deg) data
  - WMAP K band (23 GHz)
  - Planck 30, 44 70, 143, 353 GHz
  - Haslam 408 MHz map
  - ~~23 GHz free-free template~~

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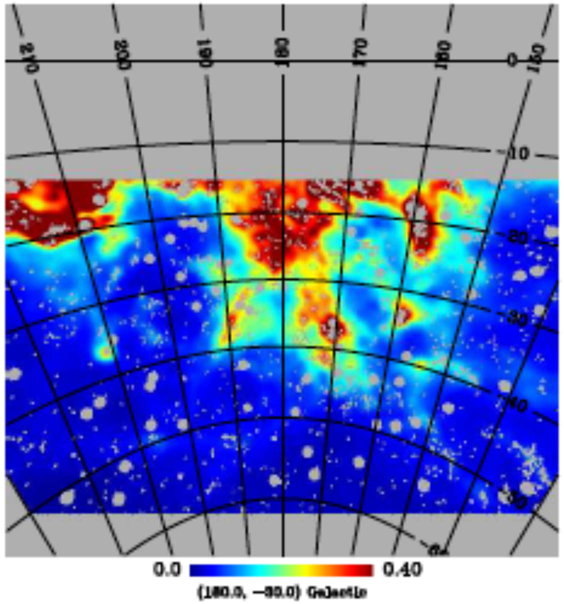
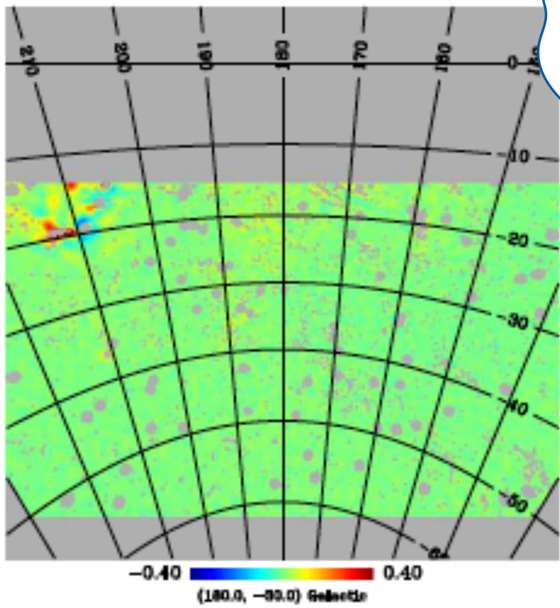
SIMULATIONS

AME

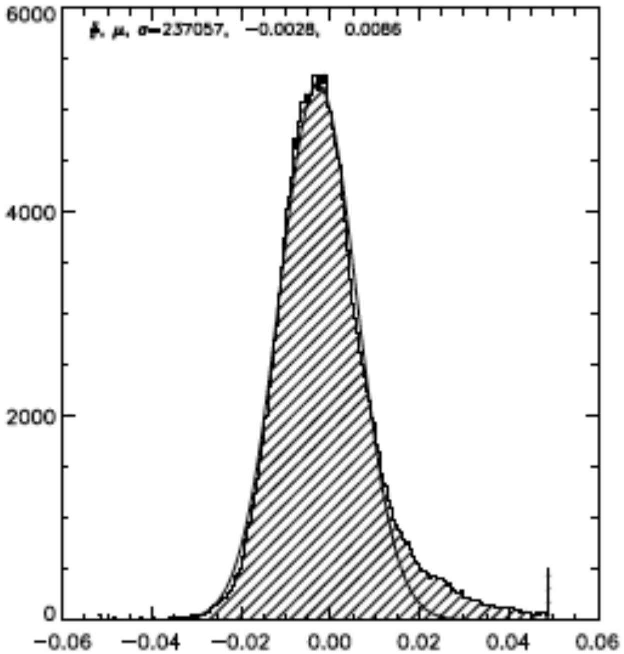
true component



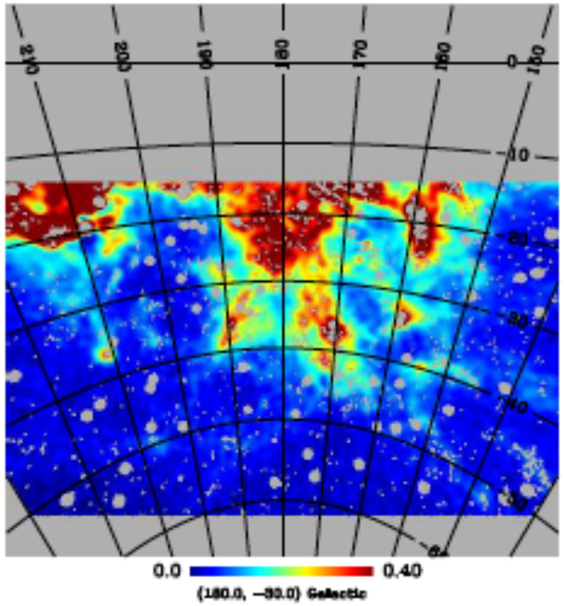
dif = true - rec



dif distribution



reconstruction



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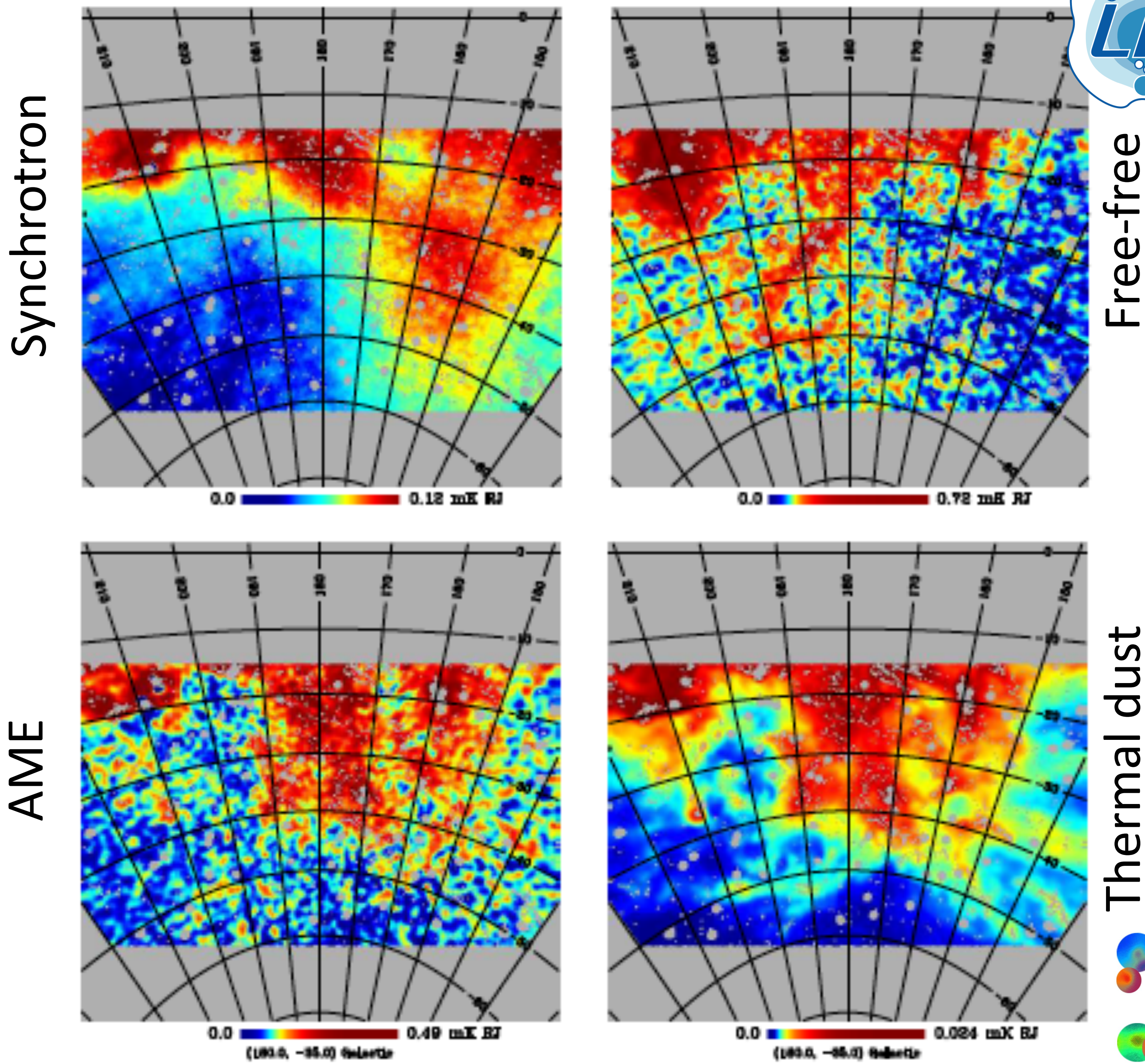
DATA



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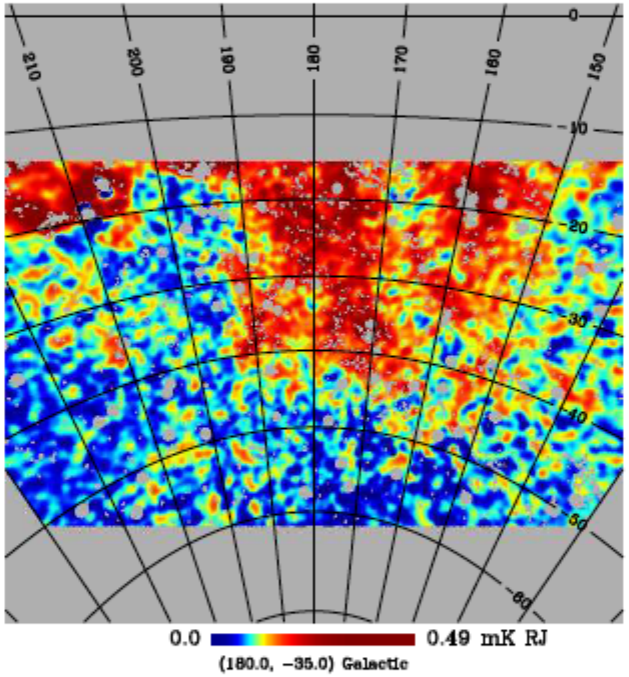
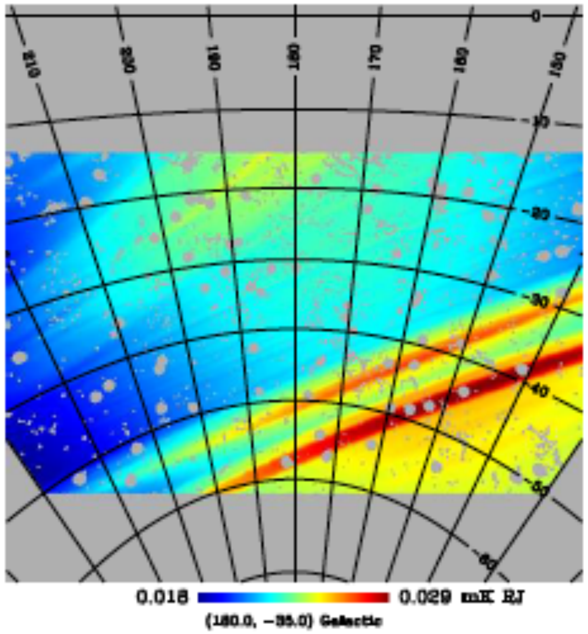
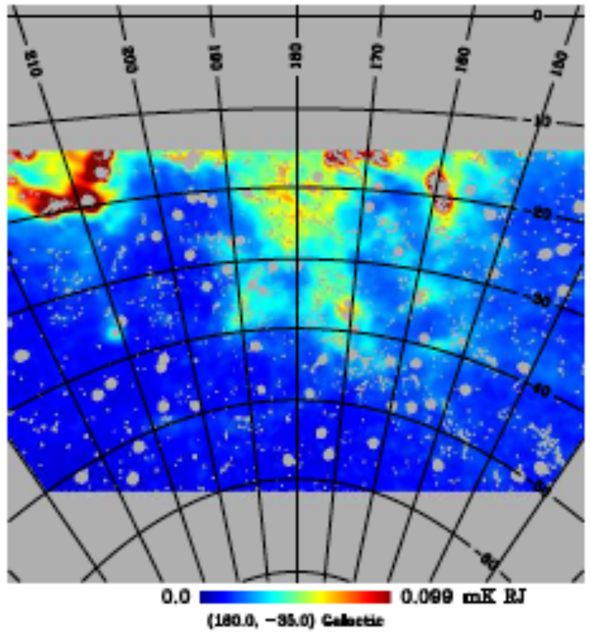


Component



Noise RMS



Separation RMS

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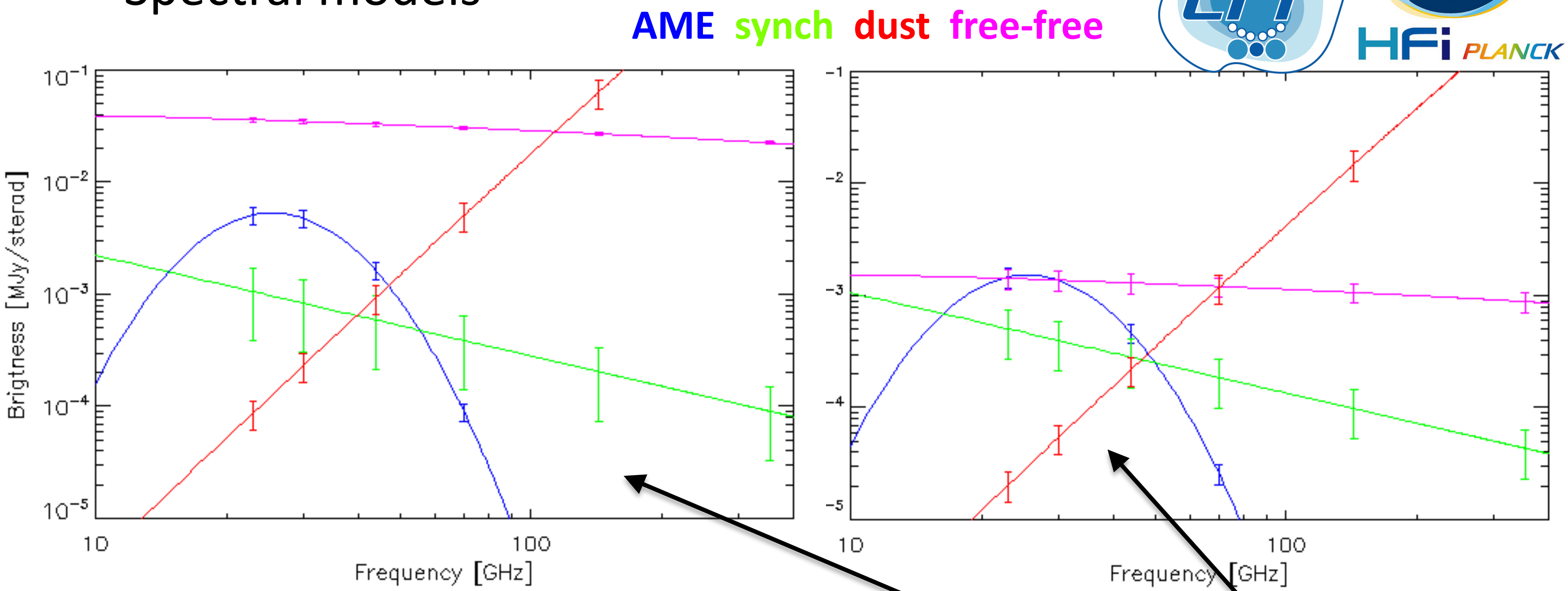
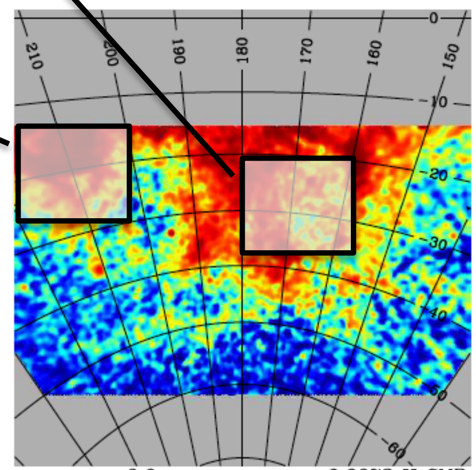
Spectral models





CORRELATIONS:

	H_α	Haslam	100 μm	E(B-V)
Free-free	0.61	0.11	0.40	0.39
AME	0.22	0.41	0.38	0.71
Synchrotron	0.18	0.98	0.31	0.52
Thermal dust	0.47	0.47	0.73	0.96

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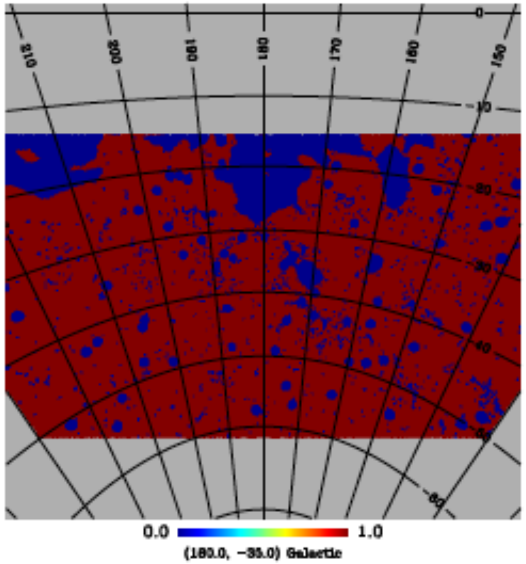
Free-free electron temperature

$$\frac{T_{ff}(\nu)[\mu K\, RJ]}{H_\alpha[\text{Rayleighs}]} = 14.0\, T_4^{0.517} \cdot 10^{0.029/T_4} \cdot 1.08\, F(\nu)$$

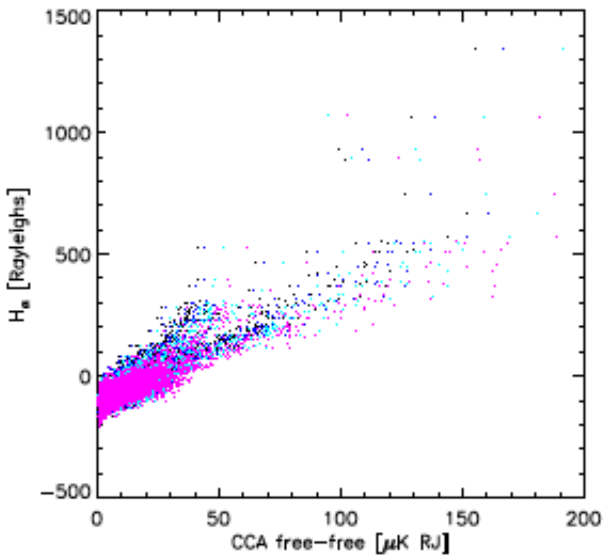
In progress

Te=T4 * 10^4 K ; fd = dust absorp. fraction



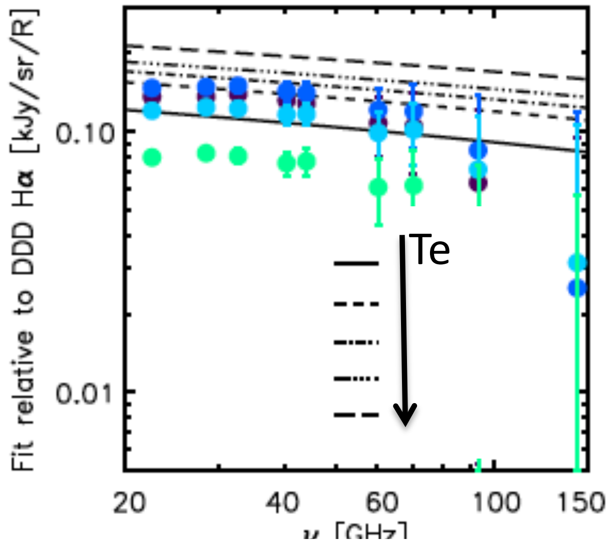
Mask to reduce Te-fd degeneracy

fd * * * *



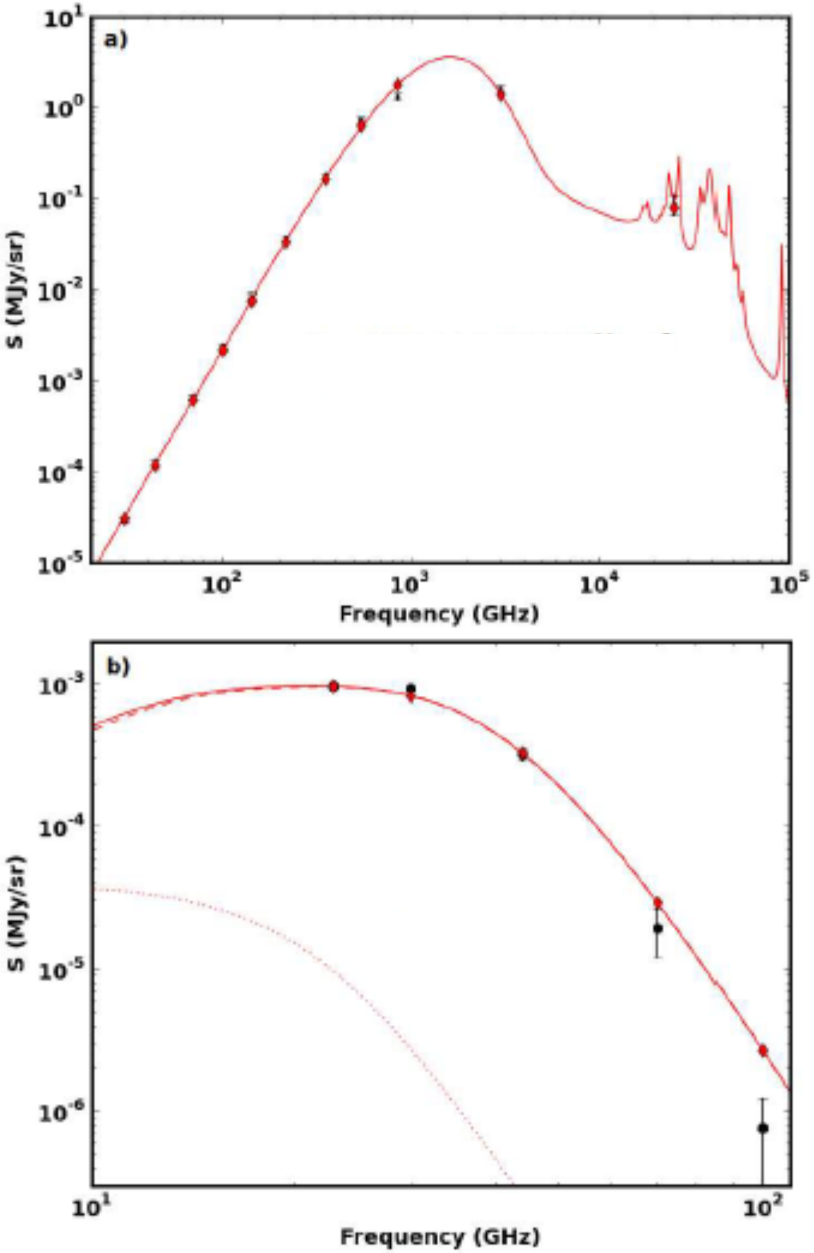
TT plot: free-free vs Ha

fd * * * *



CC analysis (Ghosh et al. 2011)

Joint modelling of dust & AME



In progress

- Ysard et al. (2011): Spdust + dustEM
- IR (Planck + IRIS) -> G_0, N_H
- Low freq (WMAP, Planck) + G_0, N_H -> n_H hydrogen density
- Results for different regions in the Gould Belt

Conclusions

- Robust separation of diffuse foregrounds in the Gould Belt South region with *Planck* + ancillary data
- Free-free vs Hα
  - dust absorption and electron temperature
- Significant diffuse AME:
  - Highly correlated with thermal dust
  - Convex spectrum peaking ~26 GHz
  - Joint modelling of AME and dust from 20 to 3000 GHz
- Paper to come out soon!