Observational summary of AME

In search of the extended anomalous microwave emission

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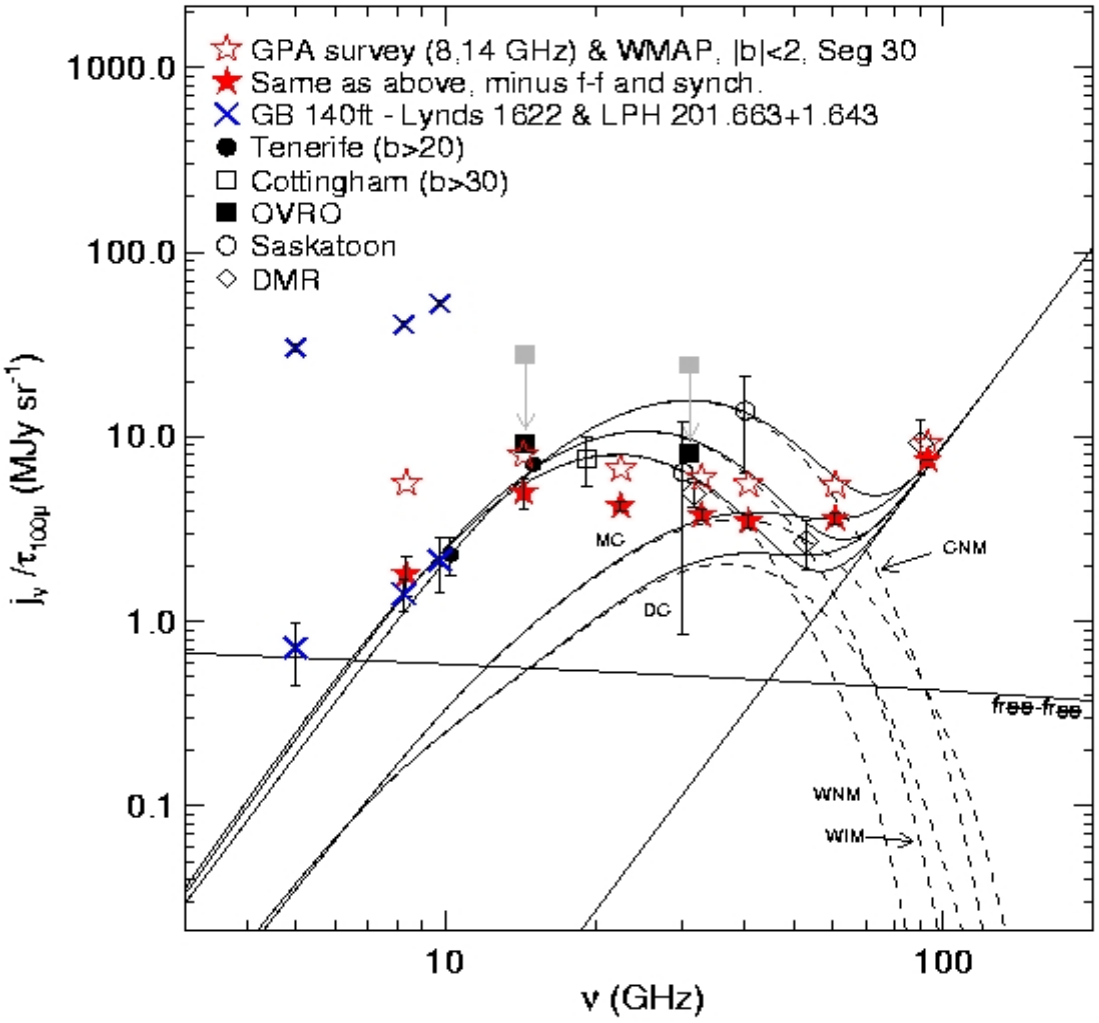
This talk will focus on the current knowledge about the extended AME in the Galaxy.

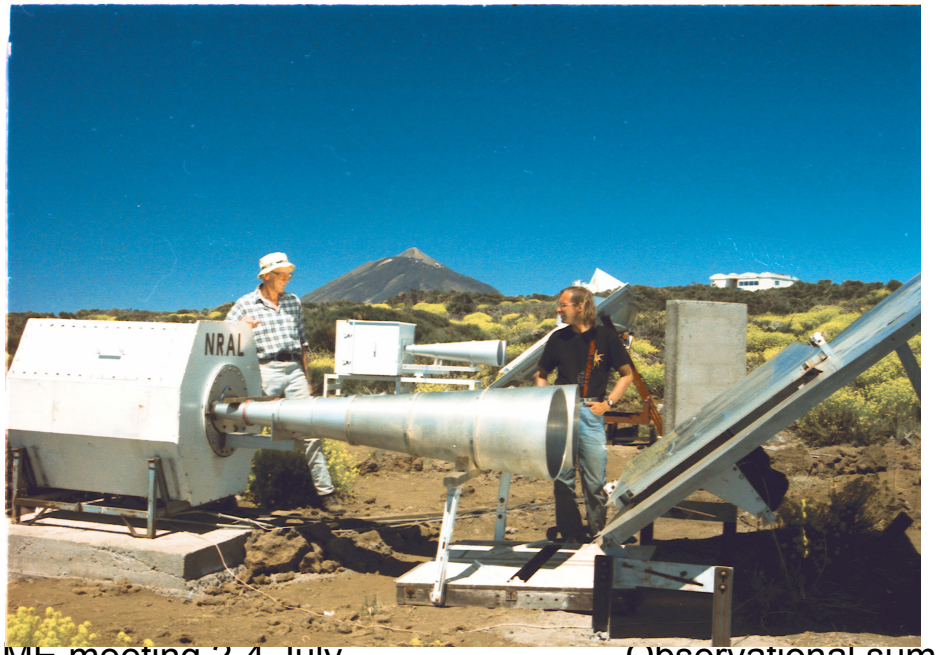
- **Early work concentrated on the study from the ground of individual FIR dust clouds. These were best observed with interferometers**
- **Observations from space gave the opportunity to obtain full-beam data, although at somewhat poorer resolution. More extended AME was identified.**
- **This extended emission was found within and around the previously known AME sources but more widely in the Galactic plane.**
- **A challenge is posed to detect AME polarization in the presence of synchrotron emission at the frequencies where AME is its strongest..**

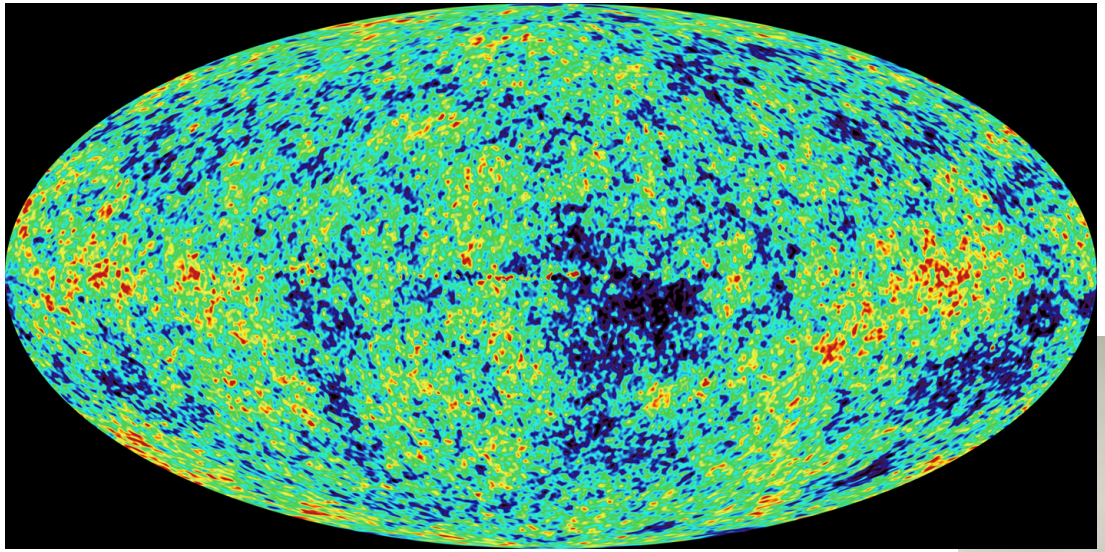
Where we start (Draine & Lazarian 1998)



Beam-switching and interferometry from the ground

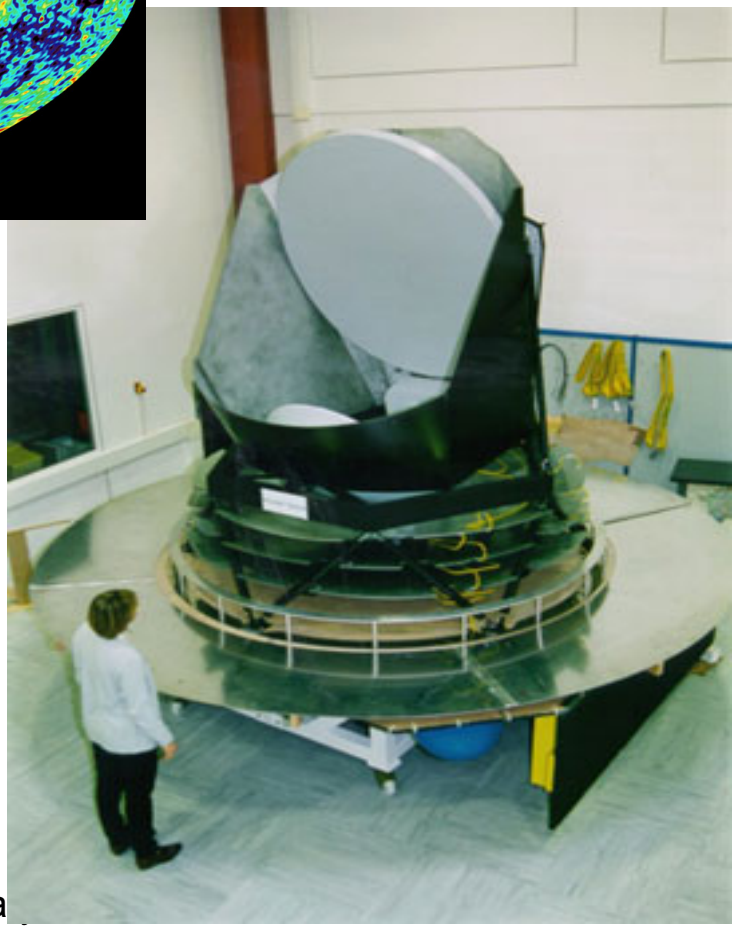
CBI, Izana, VSA



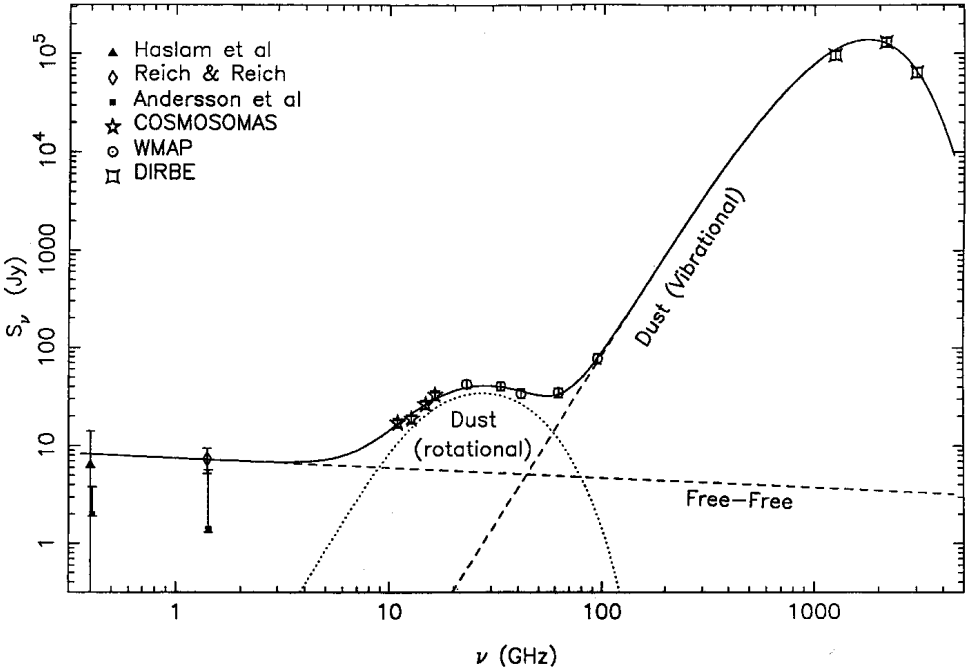


WMAP

COBE-DMR



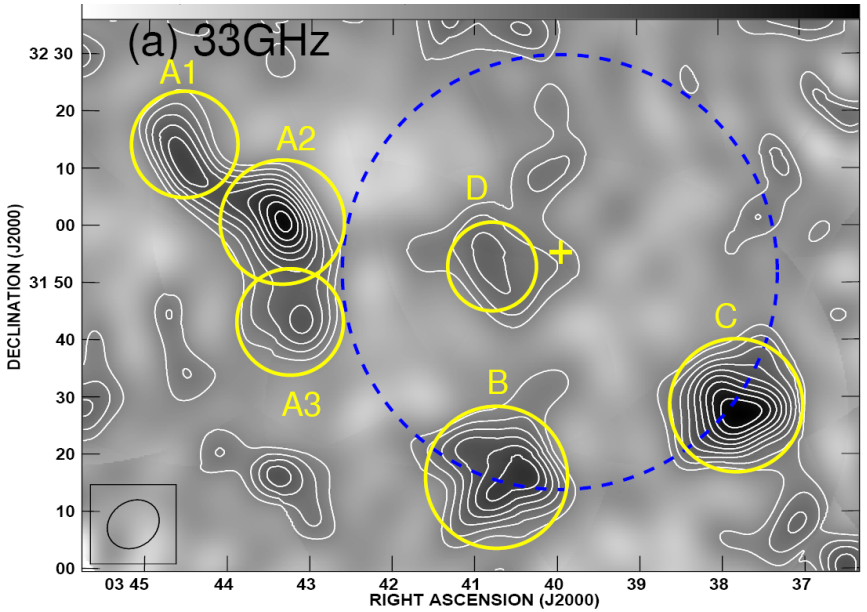
Perseus Molecular Cloud



Cosmosmas

Watson et al. 2005

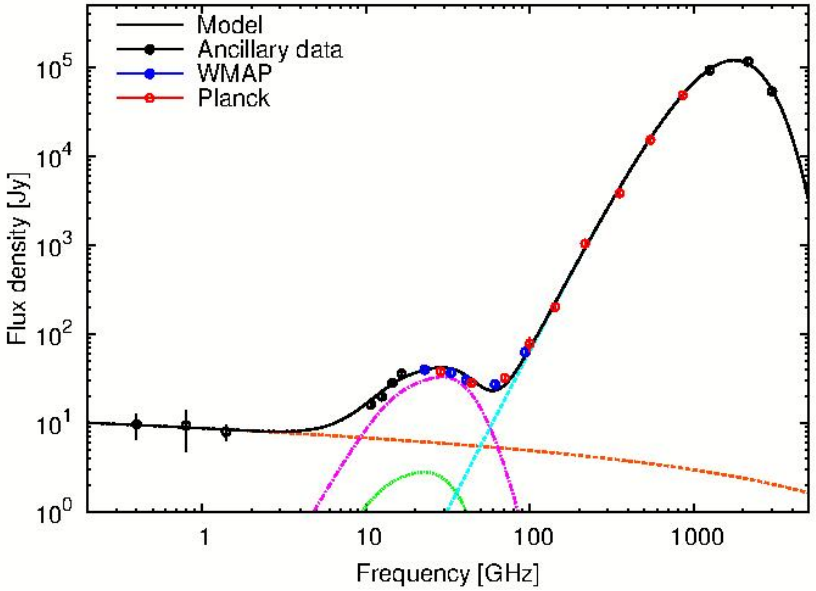
40.3 +/- 0.4 Jy

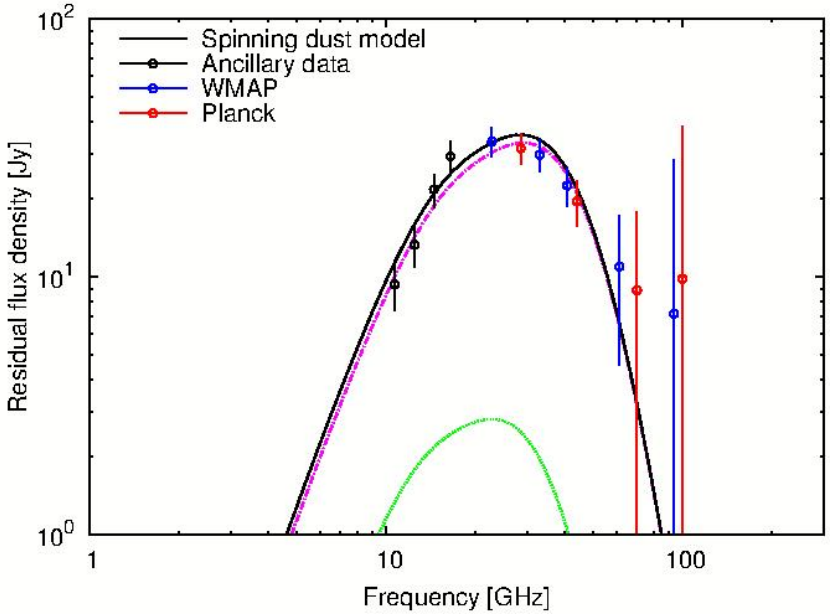


The VSA

Tibbs et al. 2010

4.4 +/- 0.4 Jy





Perseus Molecular cloud

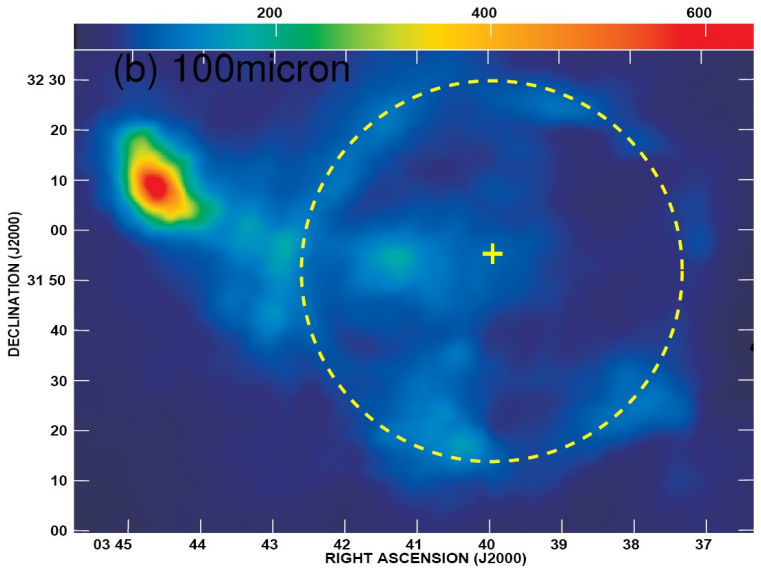
Planck Early Paper

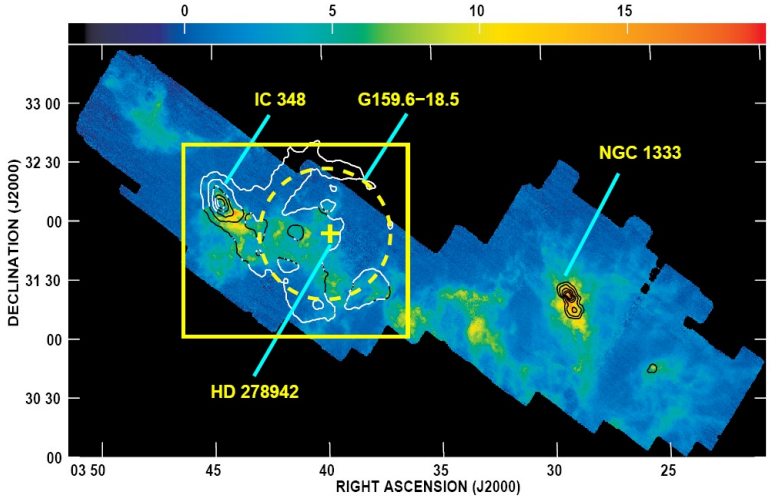
Planck Collaboration (d) A20

Area covered = 1.5^o x 1.0^o

The AME flux density in this area is ~ 35 Jy,

Similar to that found with COSMOSOMAS in its 1.3^o beam.





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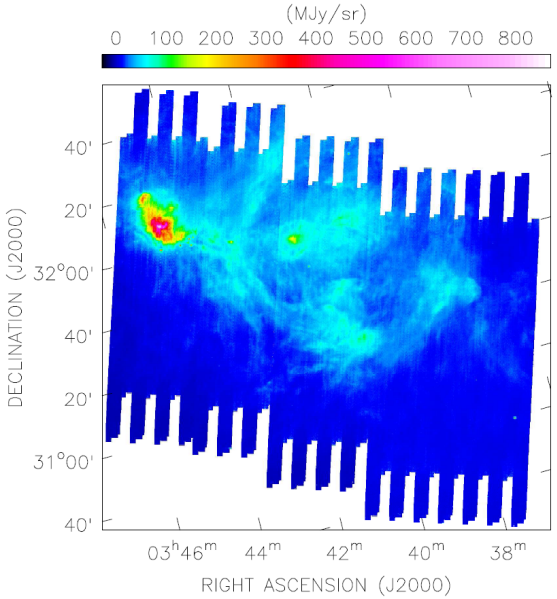
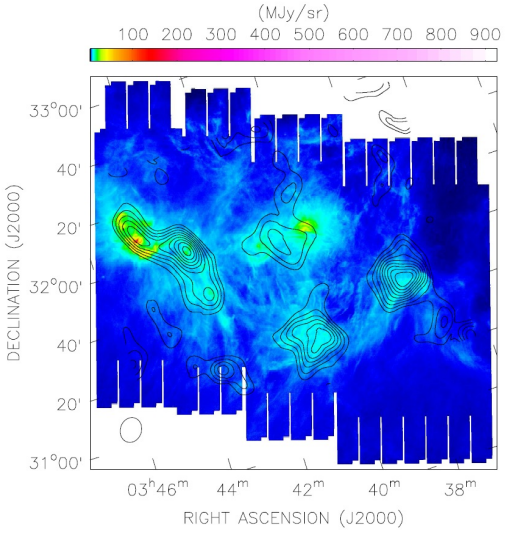


70u



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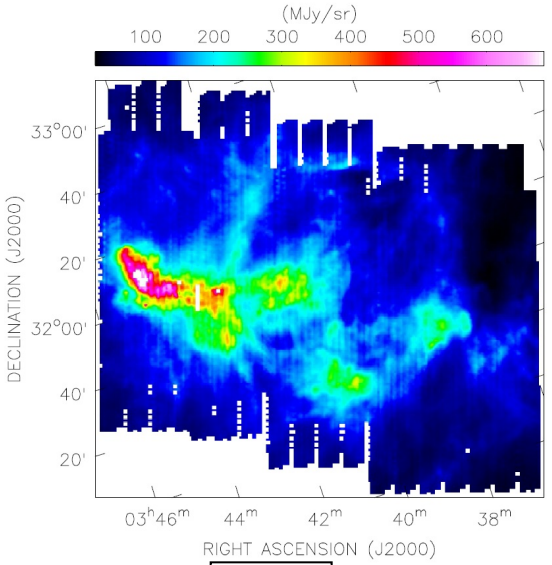
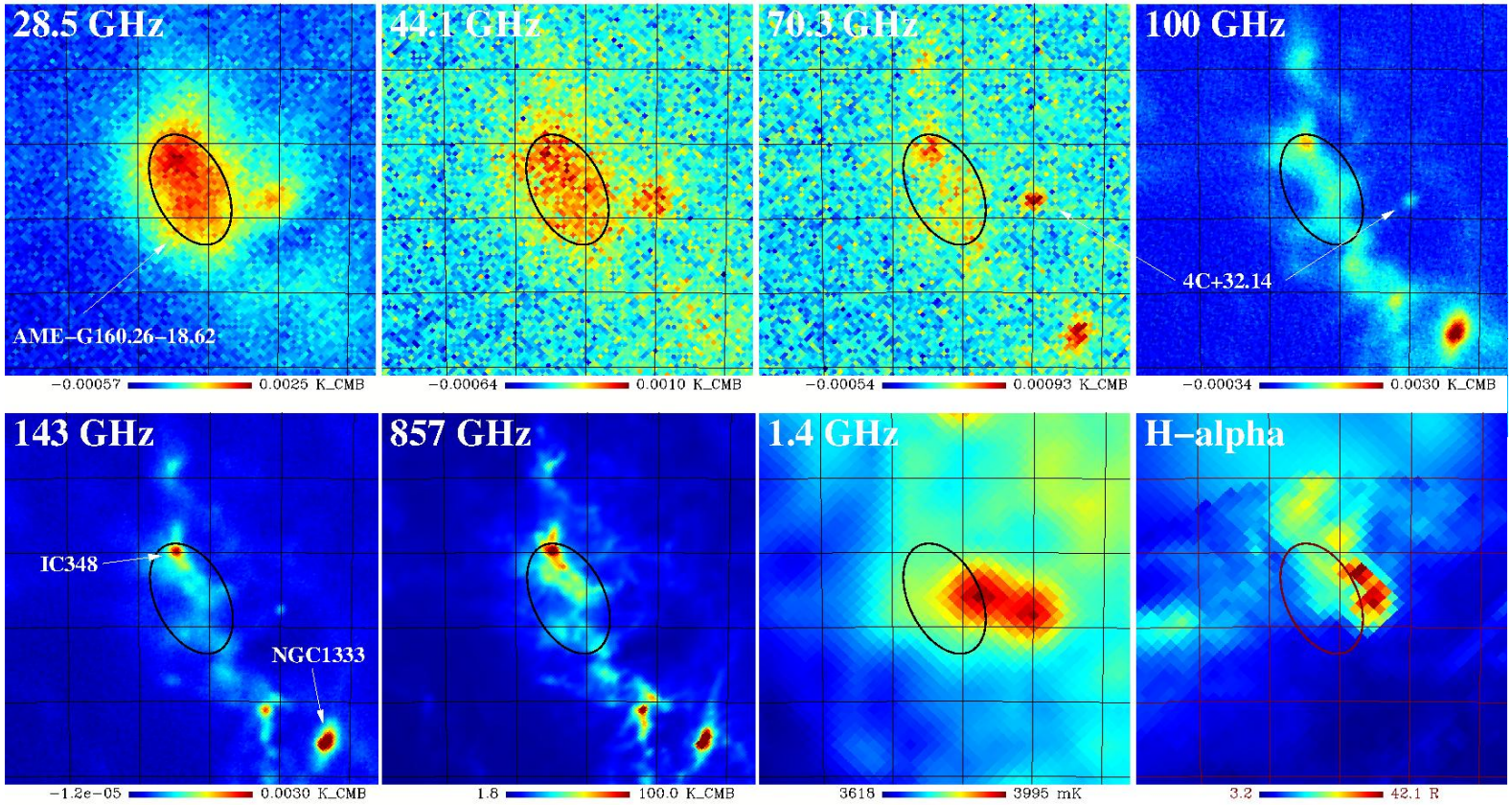
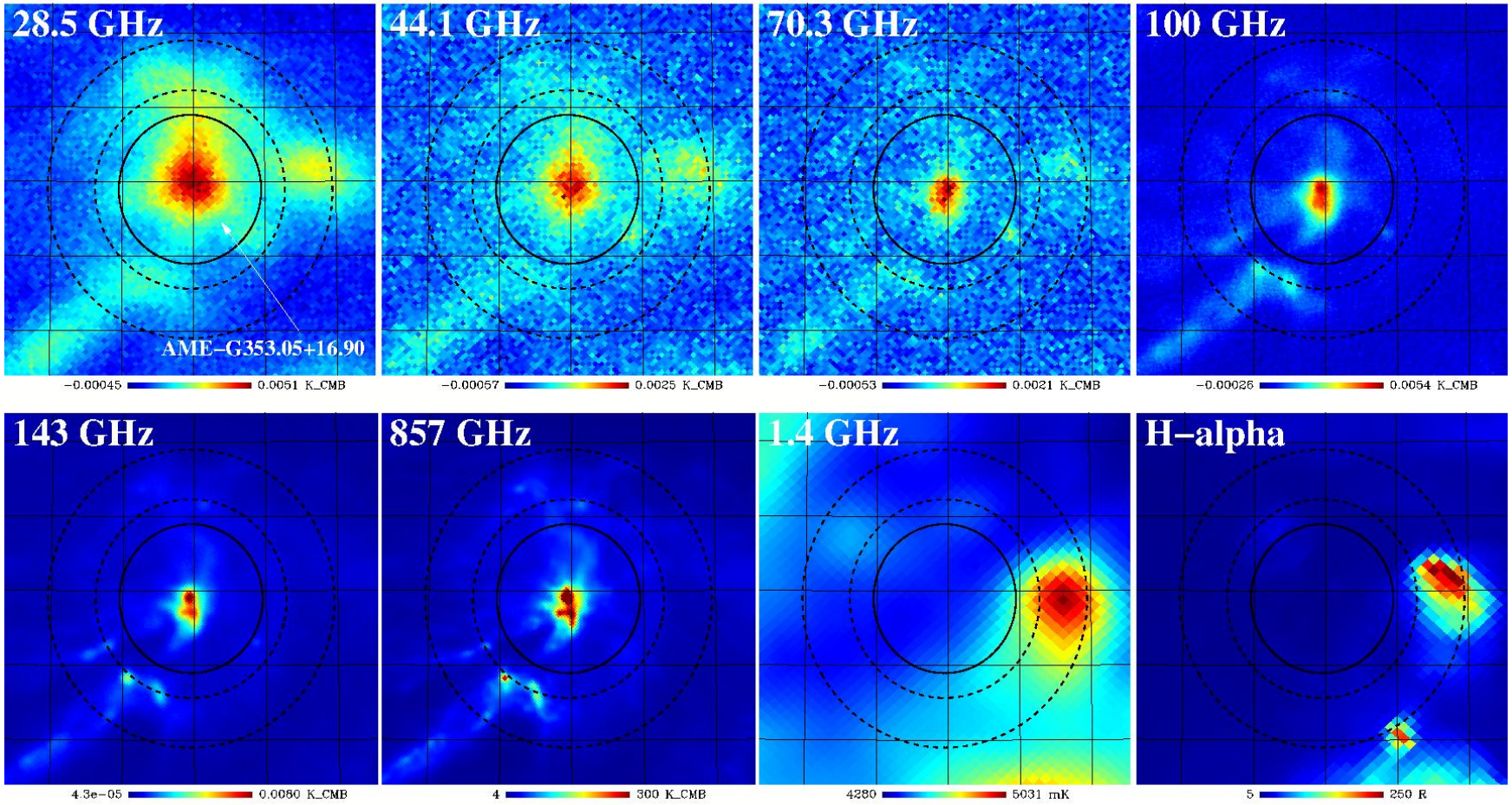


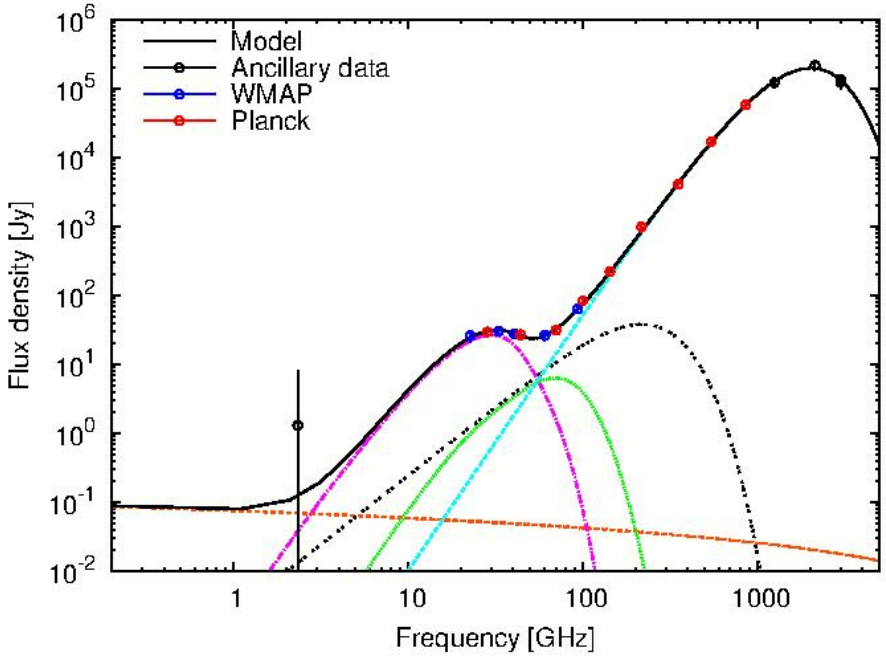
160u

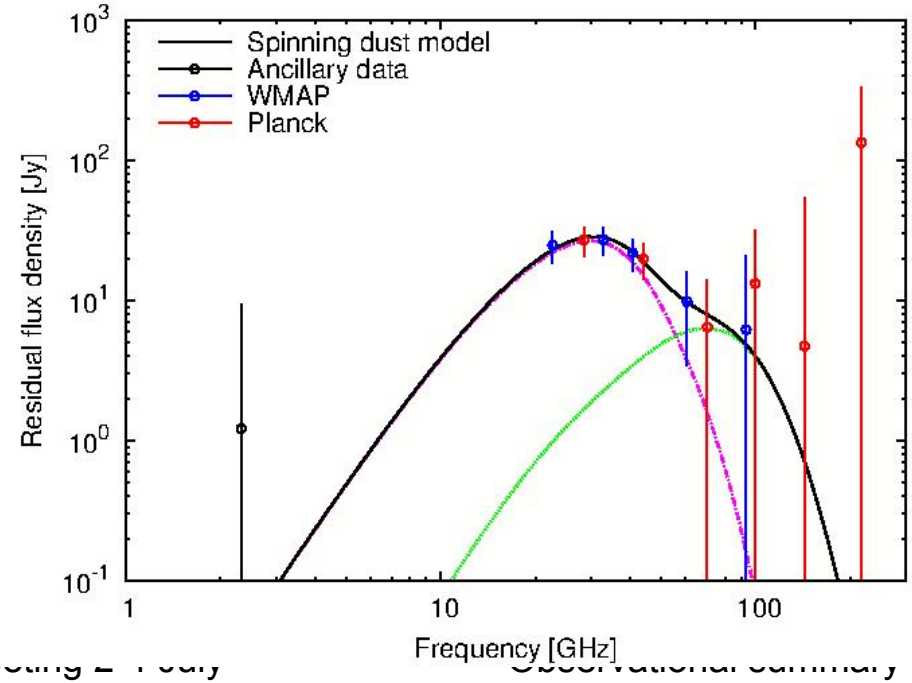
Perseus – more data



Rho-Oph cloud.

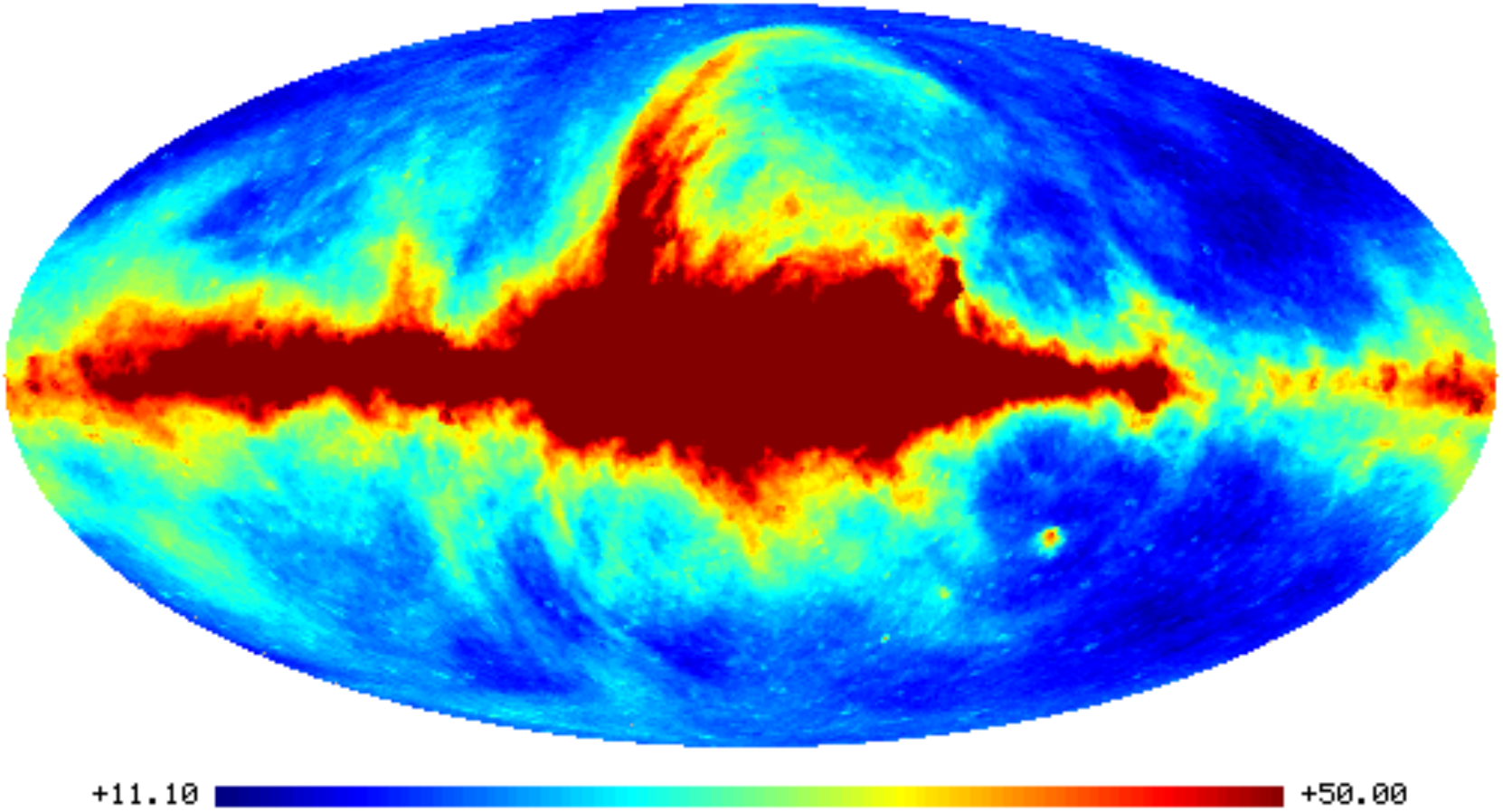




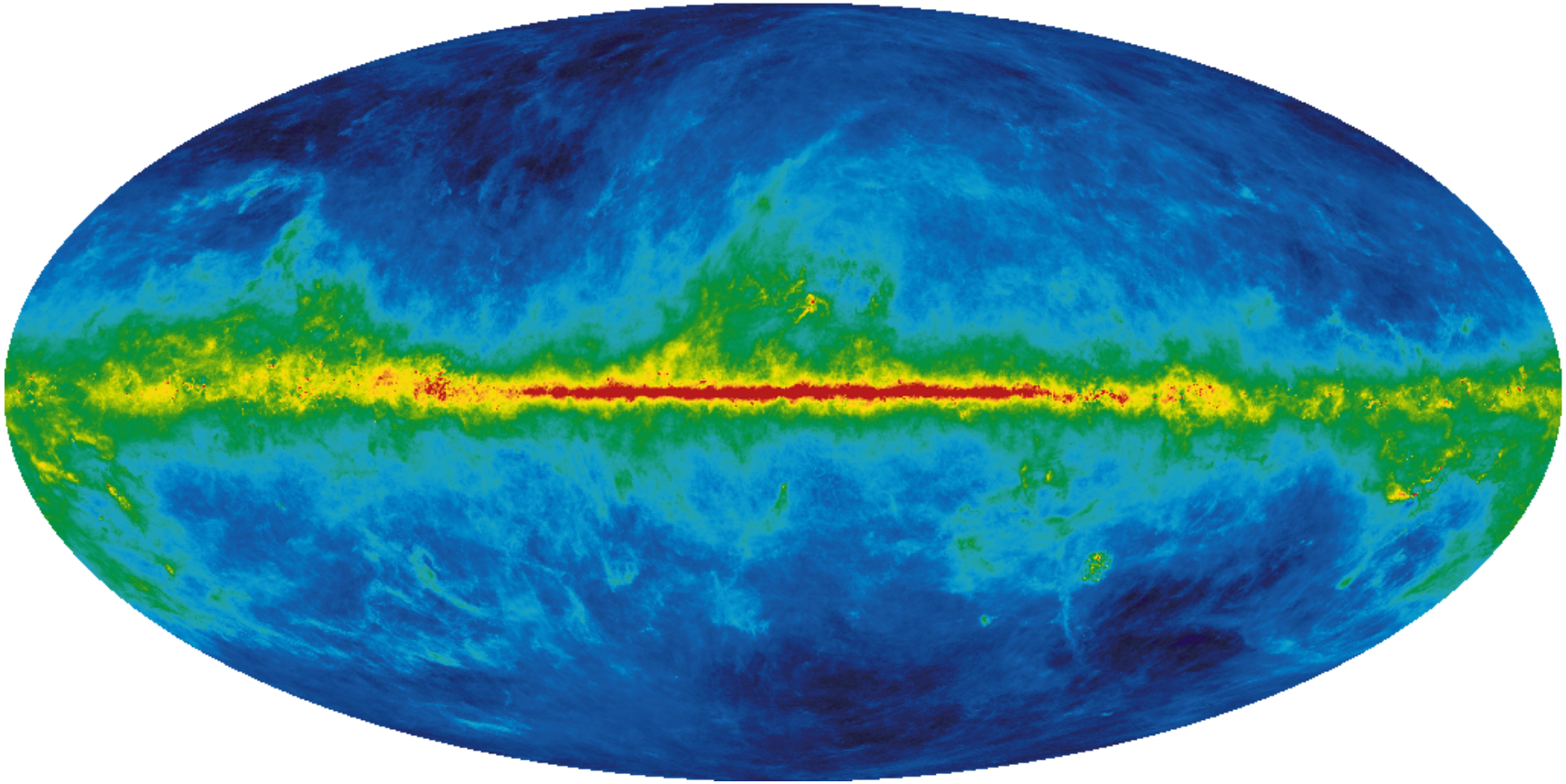


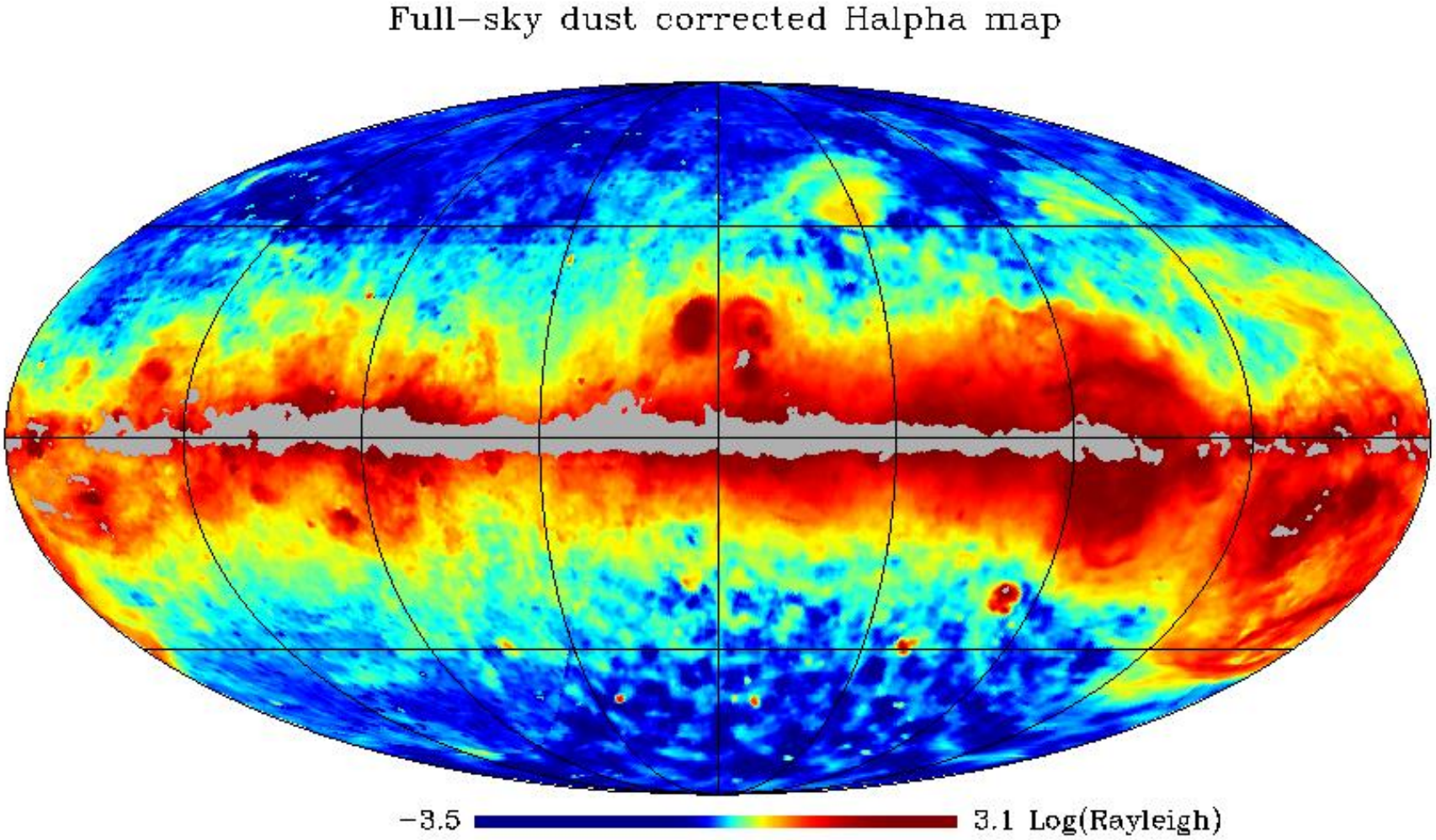
Rho Ophiuchi SEDs

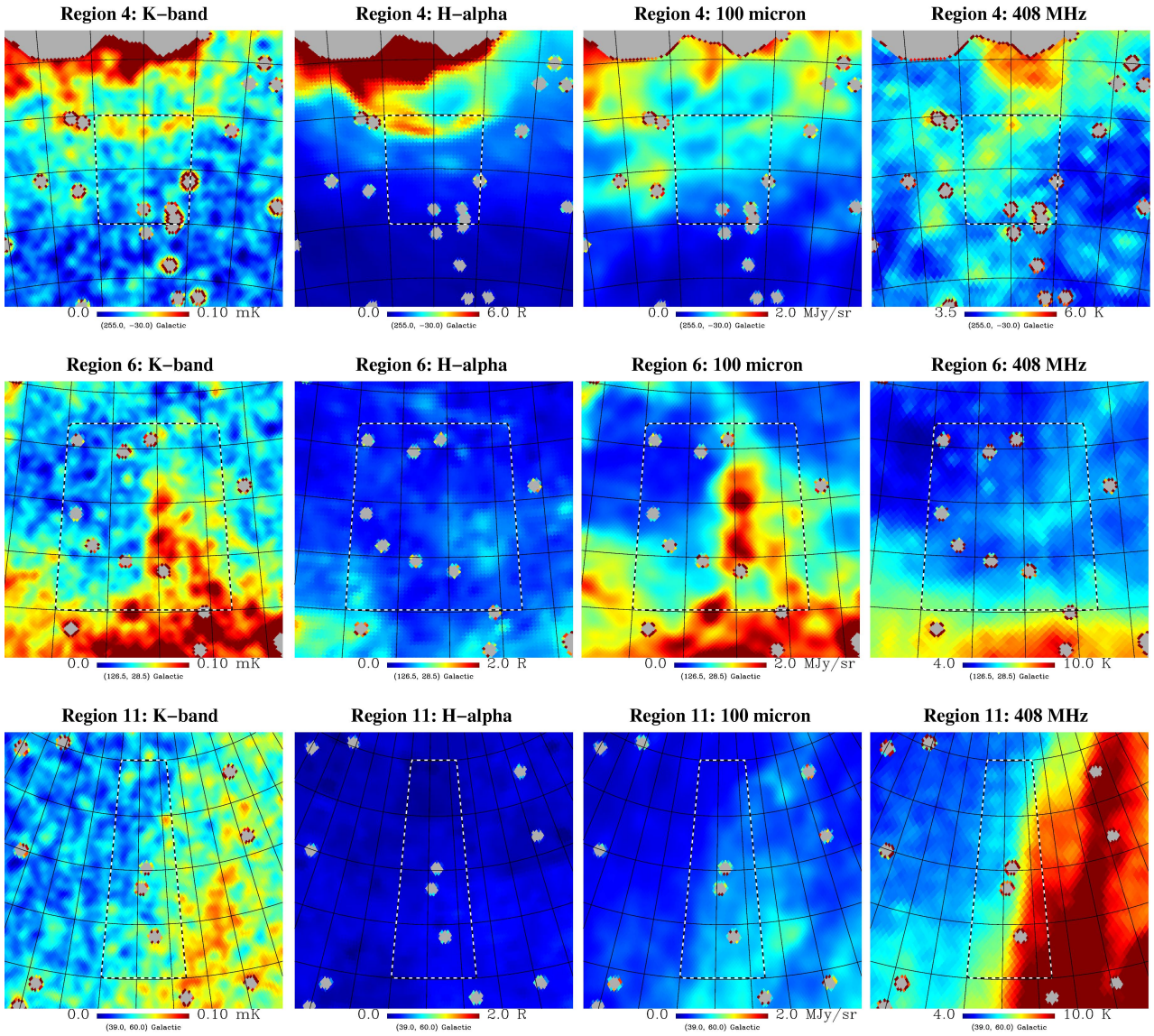
The extended emission in the Galaxy as determined from space observations plus auxiliary data, typically at 1^{o} resolution

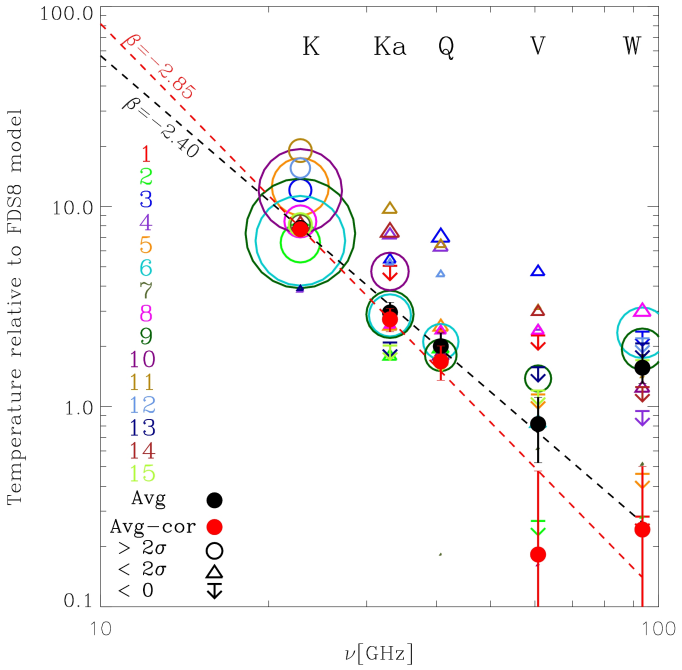


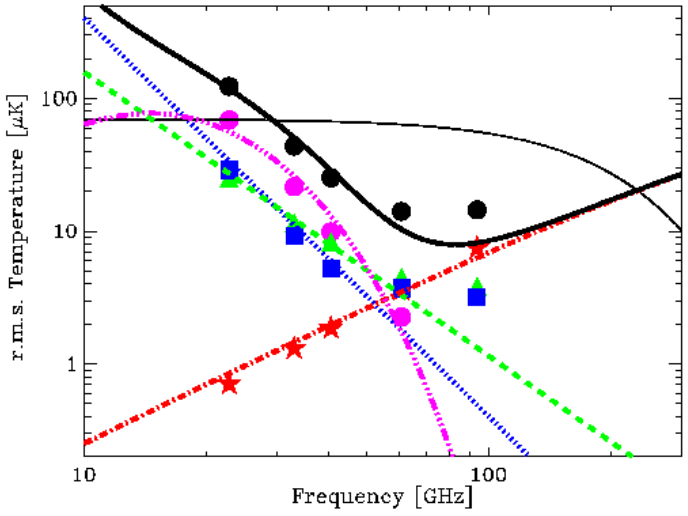
100 microns




Full−sky dust corrected Halpha map
−3.5
3.1 Log(Rayleigh)


Region 4: K–band
Region 4: H–alpha
Region 4: 100 micron
Region 4: 408 MHz
0.0 0.10 mK
0.0 6.0 R
0.0 2.0 MJy/sr
3.5 6.0 K
(255.0, −30.0) Galactic
Region 6: K–band
Region 6: H–alpha
Region 6: 100 micron
Region 6: 408 MHz
0.0 0.10 mK
0.0 2.0 R
0.0 2.0 MJy/sr
4.0 10.0 K
(126.5, 28.5) Galactic
Region 11: K–band
Region 11: H–alpha
Region 11: 100 micron
Region 11: 408 MHz
0.0 0.10 mK
0.0 2.0 R
0.0 2.0 MJy/sr
4.0 10.0 K
(39.0, 60.0) Galactic





AME at intermediate latitudes from WMAP and ancillary data

A cross-correlation analysis of 15 regions selected to be relatively clean in one component Davies et al. 2006).

The slope of the AME is intermediate between that of the synchrotron and free-free at the lower WMAP frequencies.

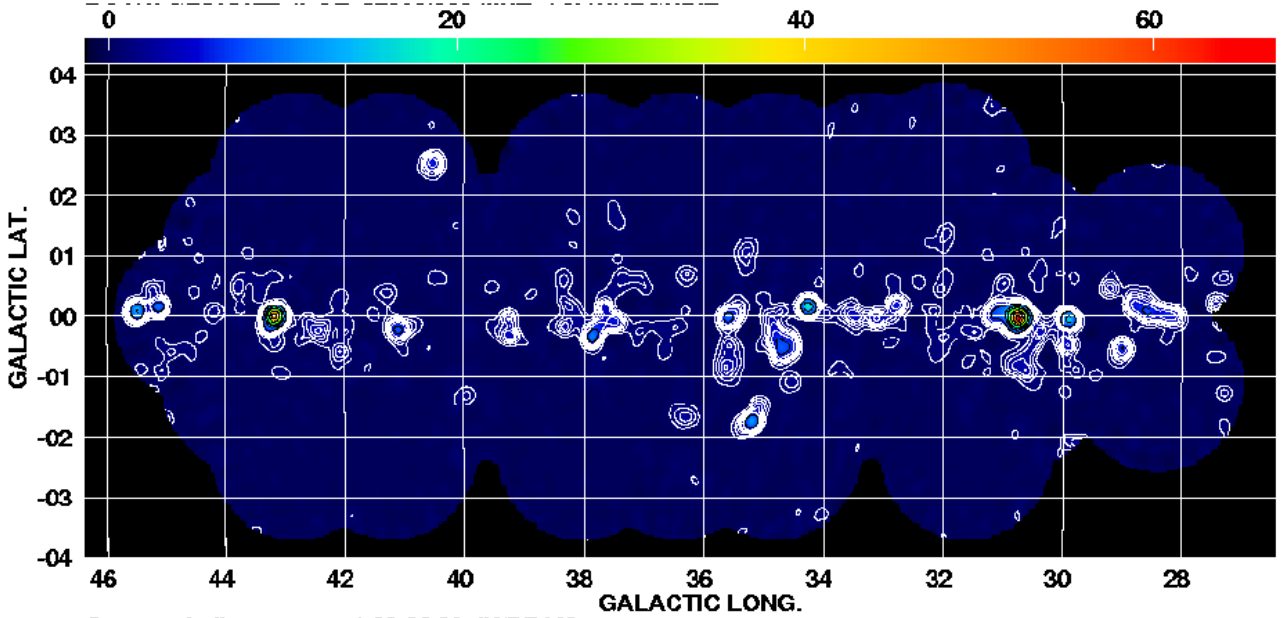
The Planck HFI data help define the low frequency thermal dust spectrum.

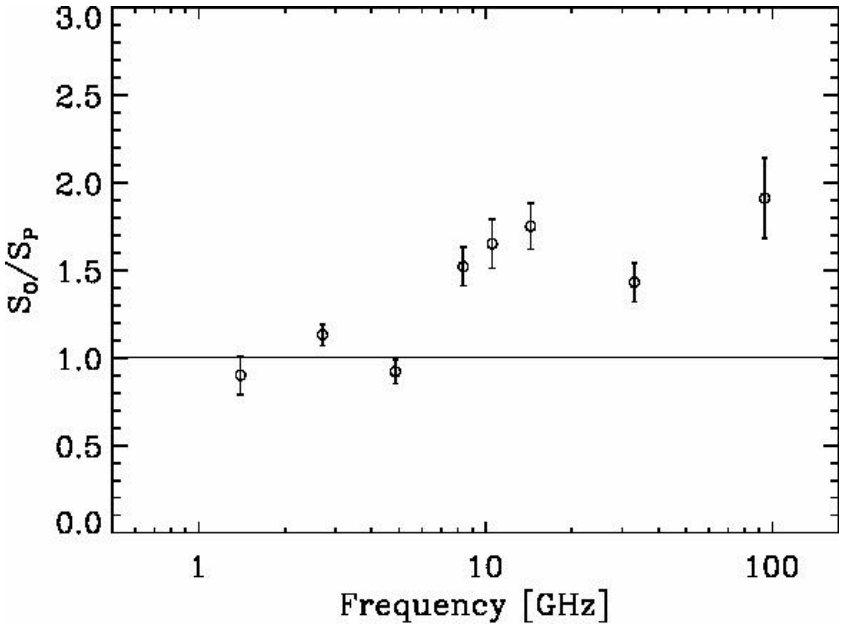
See the AME Planck Early Paper.

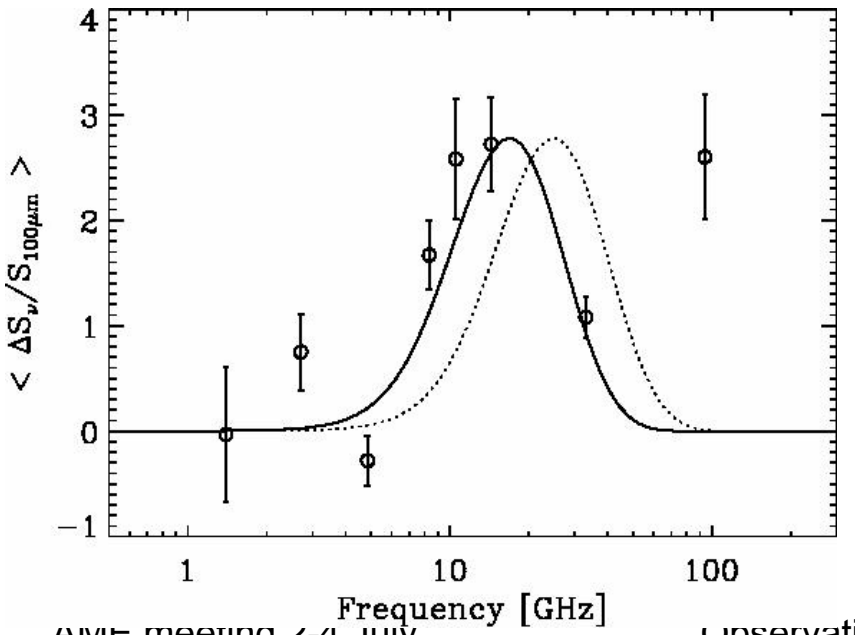
See Ghosh et al. 2012 for more extended analysis.

THE FRACTION ON FOREGROUND EMISSION IN STRUCTURE

- The VSA 33 GHz field (l = 27° – 45°) shows structure on scales of 15' (Todorovic et al. 2010). This emission is mainly free-free. On the plane this contributes ~25% of the total emission seen by WMAP (Todorovic et al. 2012 in prep.) A similar situation is found for the clumpiness at this resolution of free-free (Alves et al. 2010 and 2012).







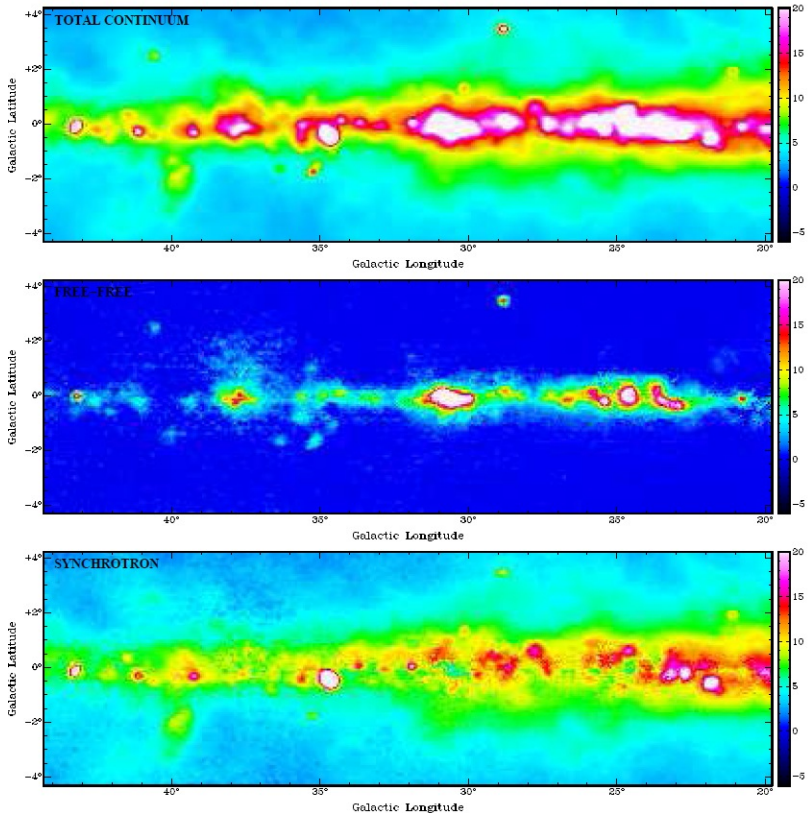
The 9 brightest HII regions in the VSA field show a mean AME component which is 40 +/_10% of the total emission from these HII regions (Todorovic et al. 2010.)

Their emissivity relative to 100 micron FIR brightness is similar to that in other AME sources lying mainly off the plane.

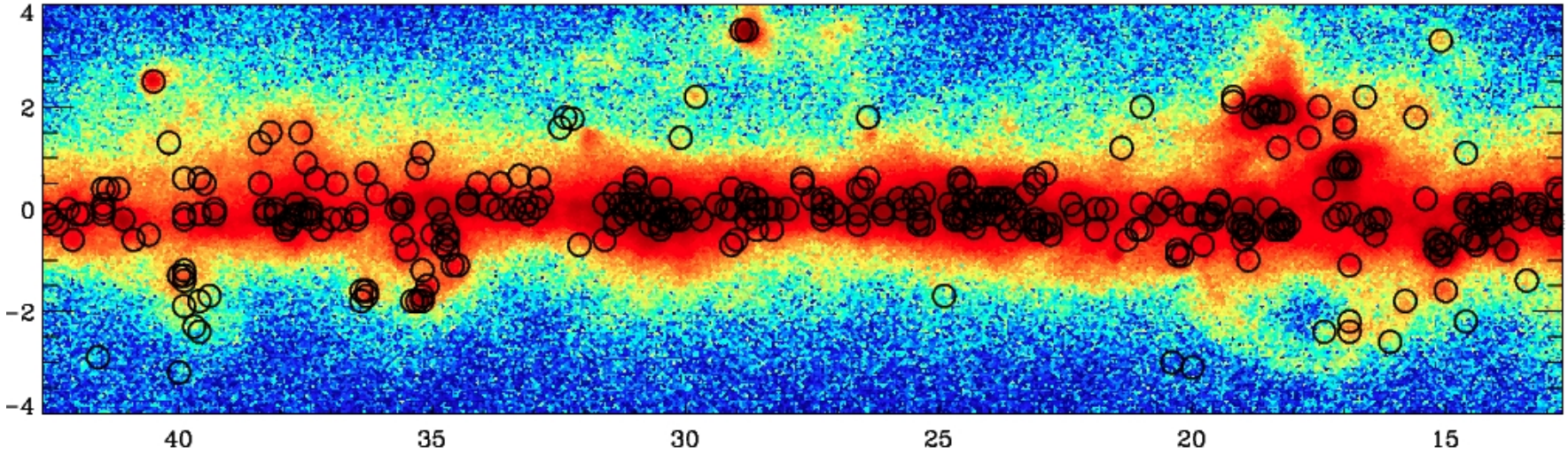
Distribution of AME across the Galactic plane.

The Parkes HIPASS survey includes RRL data which can be used to determine the free=free distribution.

In turn this gives the (corrected synchrotron and ultimately the AME (Alves et al. 2010).

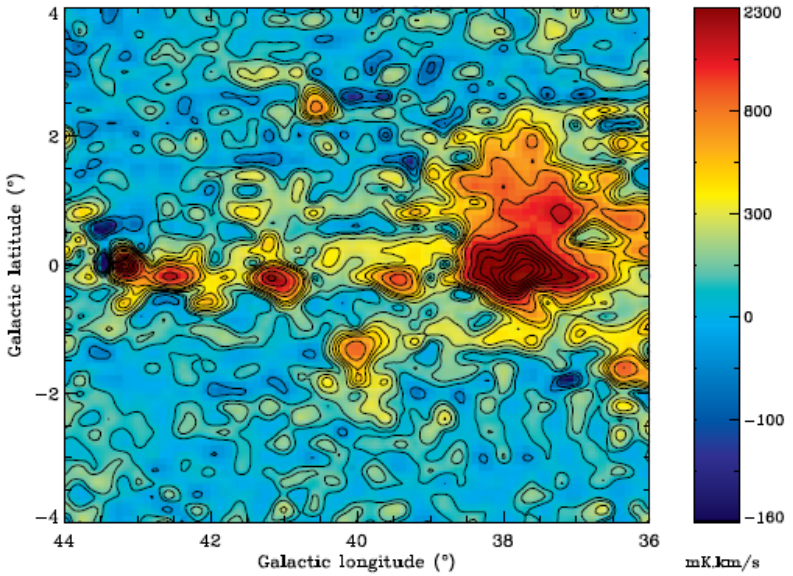


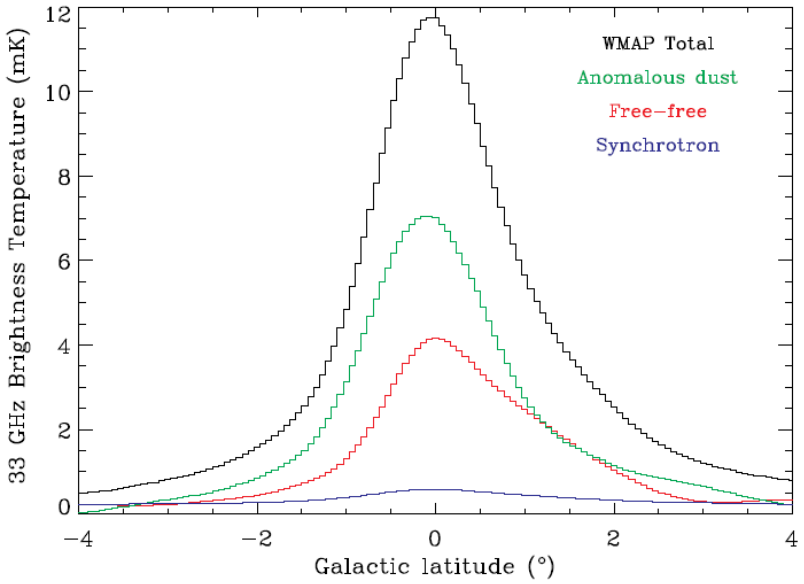
HII regions account for ~20% of total free-free in the 33GHz map.



The separation of free-free, synchrotron and AME at l = 36° – 39°.

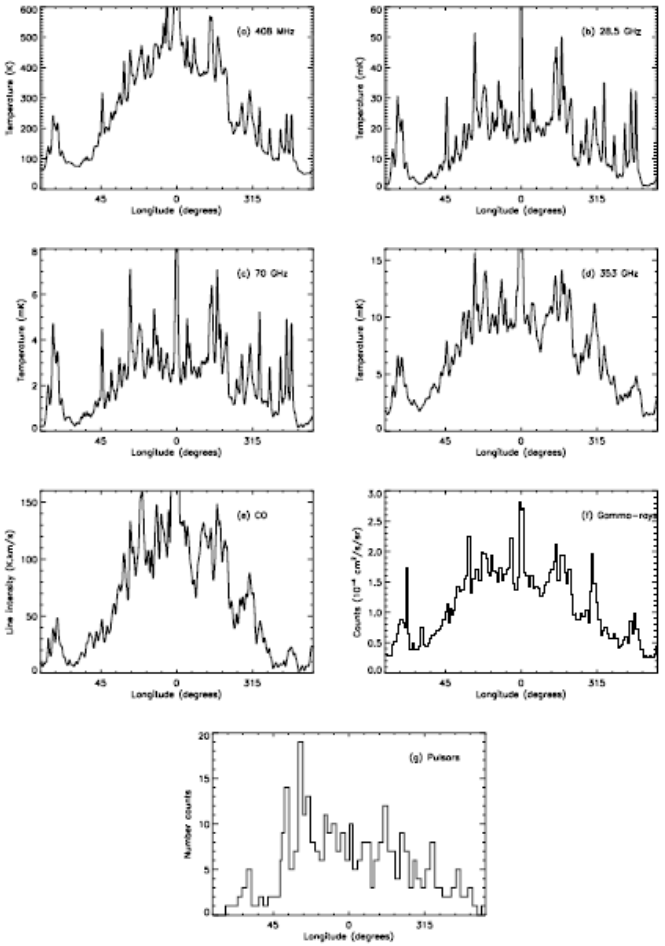
1. Correct 408 MHz map for free-free.
2. Convert each to 23GHz and subtract from total to obtain AME.
3. Derive free-free from RRL map at 1.4 GHz.
4. AME is comparable to free-free at 23 GHz ie. each is ~50% of total emission.



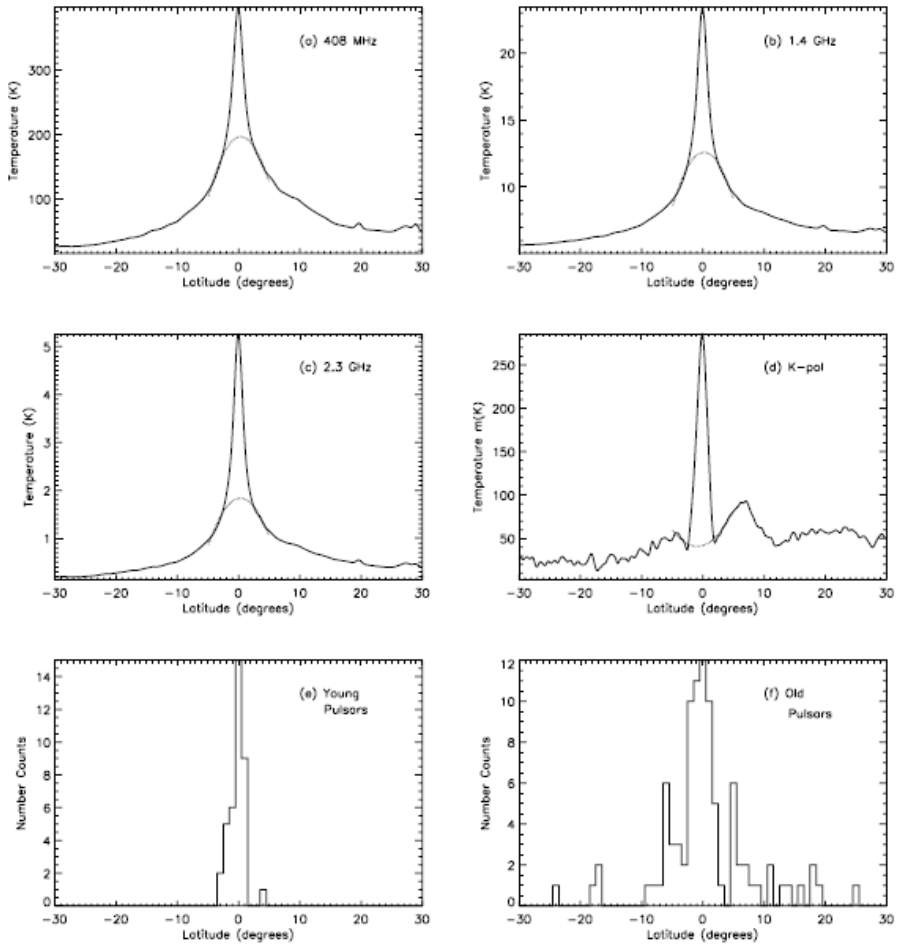


The longitude distribution of the emission components (b = 0^{o}).

Demonstrates tar formation in the inner Galaxy.

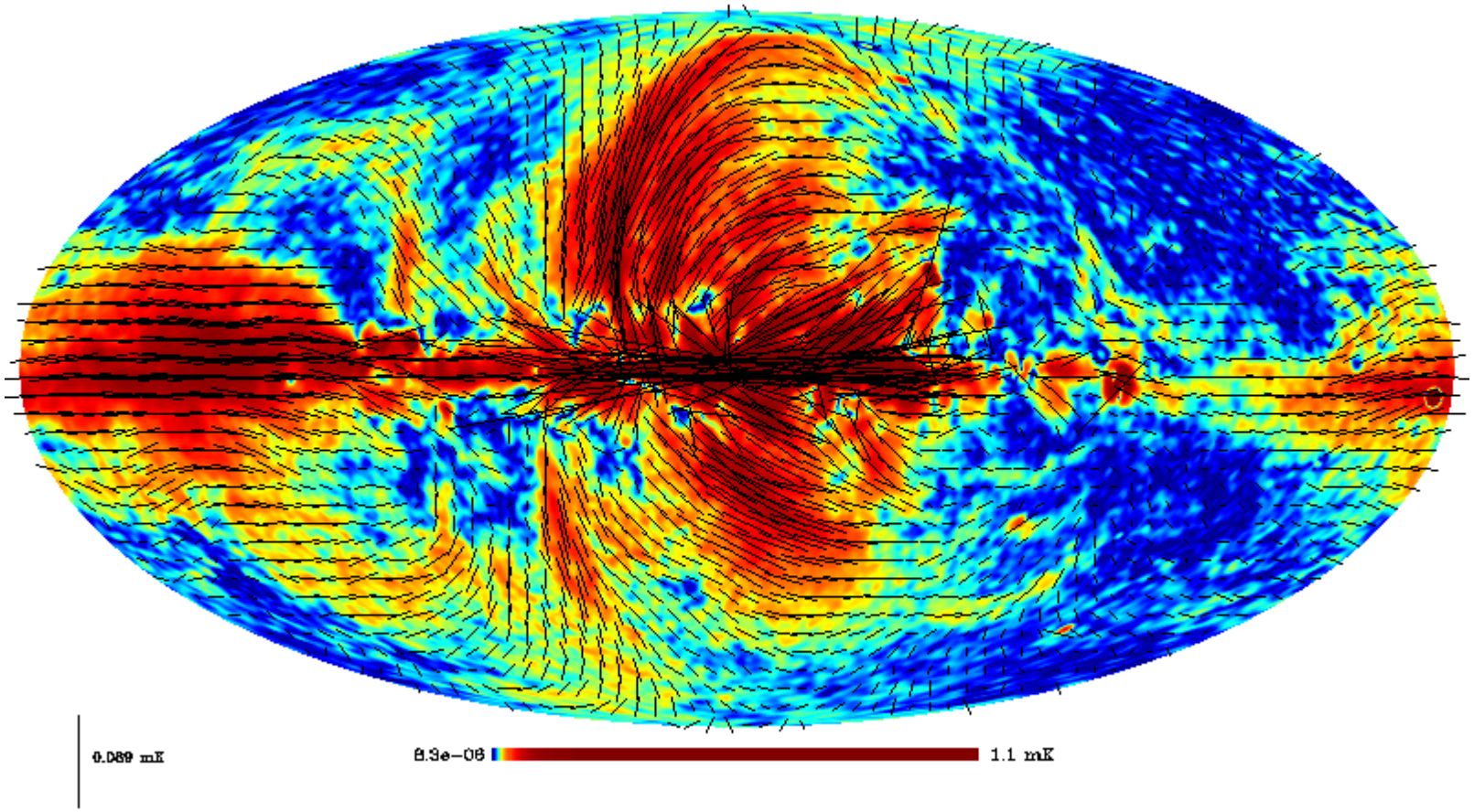


The latitude distribution of components related to synchrotron emission.



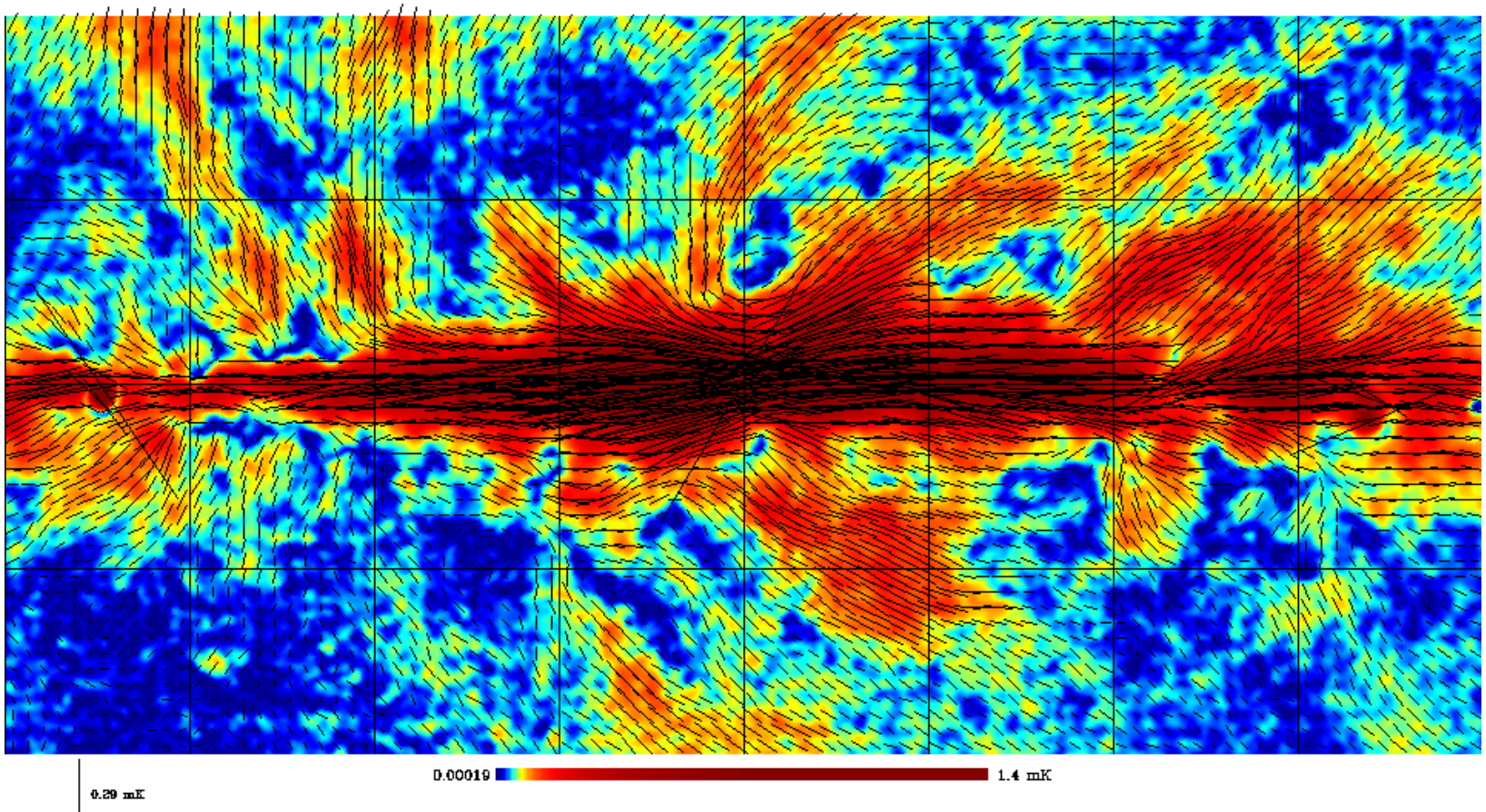
Challenges in measuring polarization in the diffuse AME.

WMAP synchrotron polarization at 23 GHz. The magnetic field direction is shown. A wide range of angular scales is found.



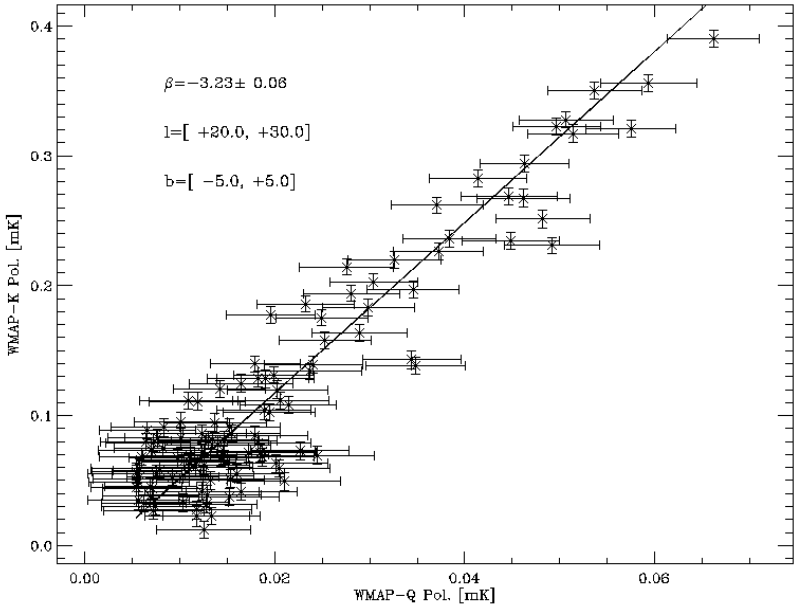
The magnetic field structure over the range l = 300^{o} -0o -60^{o}, b = -20^{o} - +20^{o}.

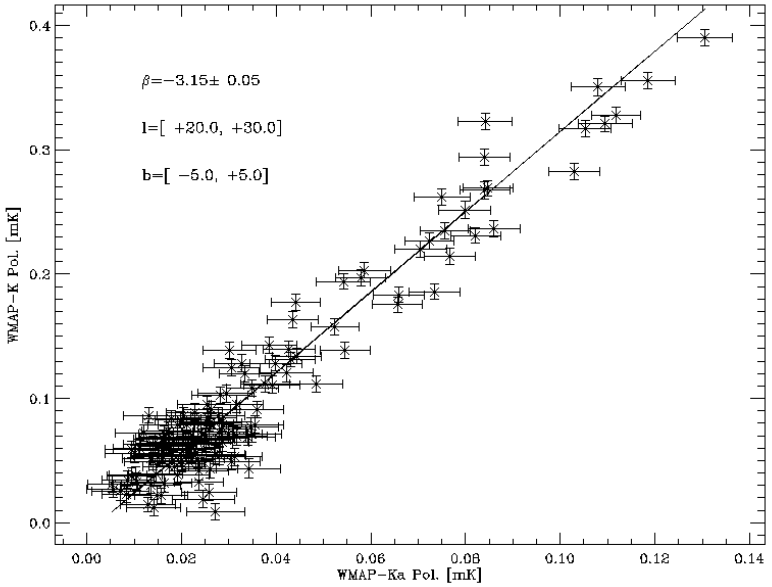
(Vidal et al. in prep.)



The spectral index of the polarized emission at WMAP frequencies of 23, 33 and 41 GHz for l = 20^o +/-3^o b = +/-5^o

Polarization-bias corrected





Latitude cuts at 23, 33 and 41 GHz

- Latitude width is similar to 408 MHz synchrotron.
- Note the angular structure off-plane.