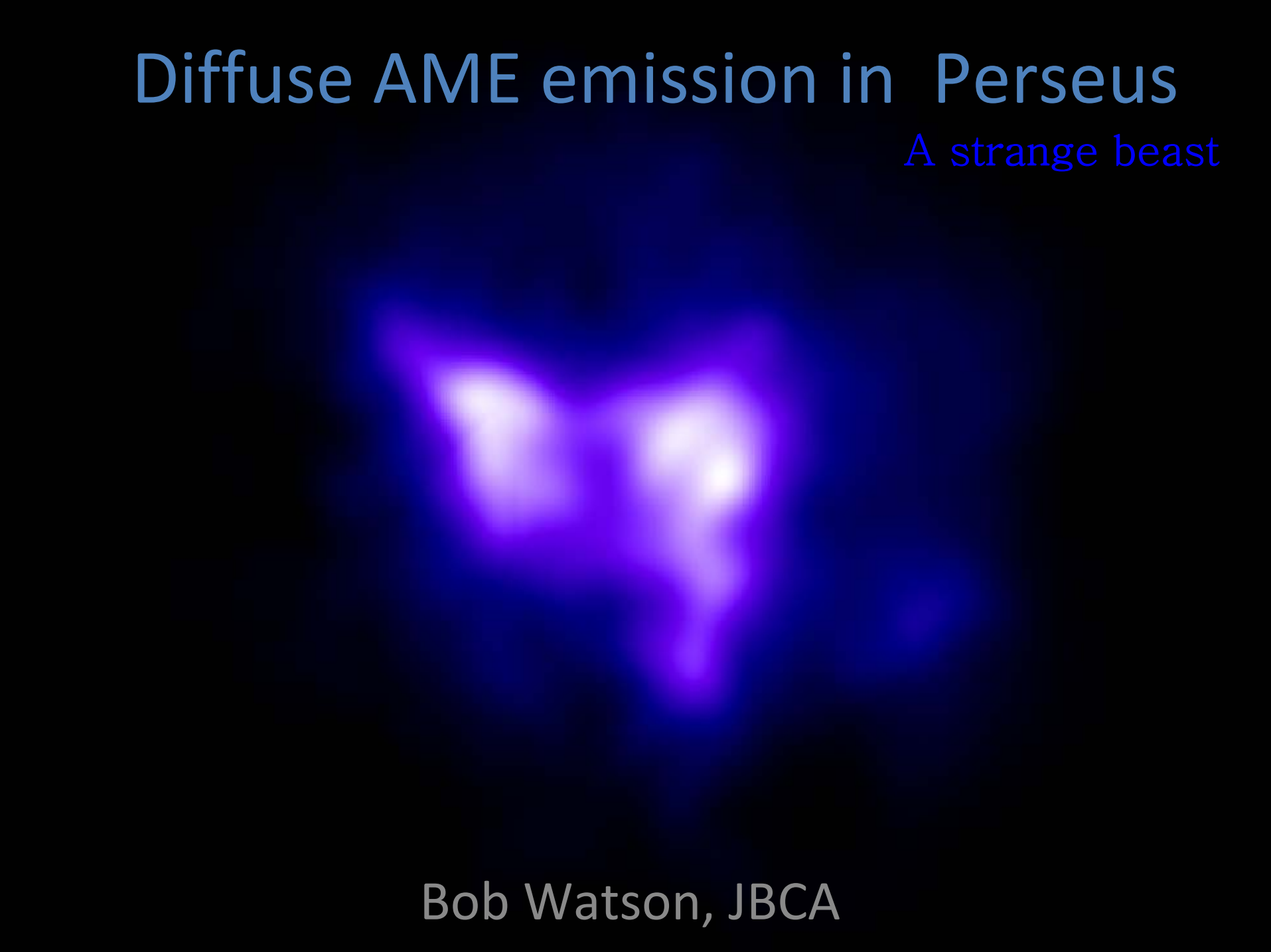
Diffuse AME emission in Perseus

A strange beast



Bob Watson, JBCA

Summary

- Tenerife experiment – first hint
- COSMOSOMAS
  - Leading to Perseus SED
  - Less filtered data (1 harmonic removal)
  - Component separation
- VSA
  - The map
  - Combined with WMAP
  - Compared with NICER/2MASS & CO maps
- Planck

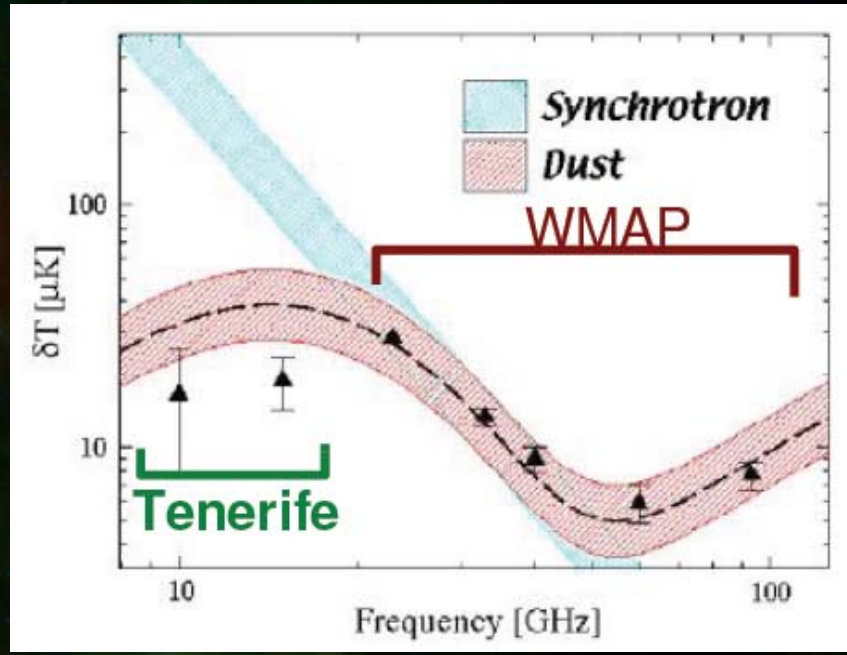
First hints in the Tenerife Experiment

5° switch beam radiometer survey at 10 & 15 GHz [27.5° < δ < 47.5°]

Showed a turnover <20 GHz when comparing with WMAP channels (de OliveraCosta et al 1997,1999 & 2004).

Couldn't be synchrotron as suggested by WMAP K-Ka spectral index

Tenerife – WMAP synchrotron template show most emission near California nebula region

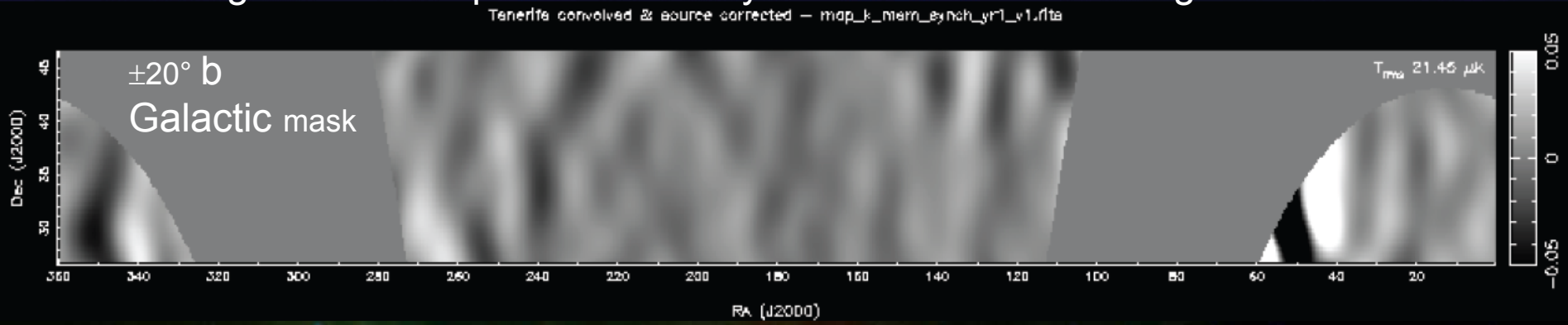


The analysis was a bit of a "black box" and assumed signal was over most of the sky in similar way to CMB.

I had look inside the box and found ….

Looking at the maps

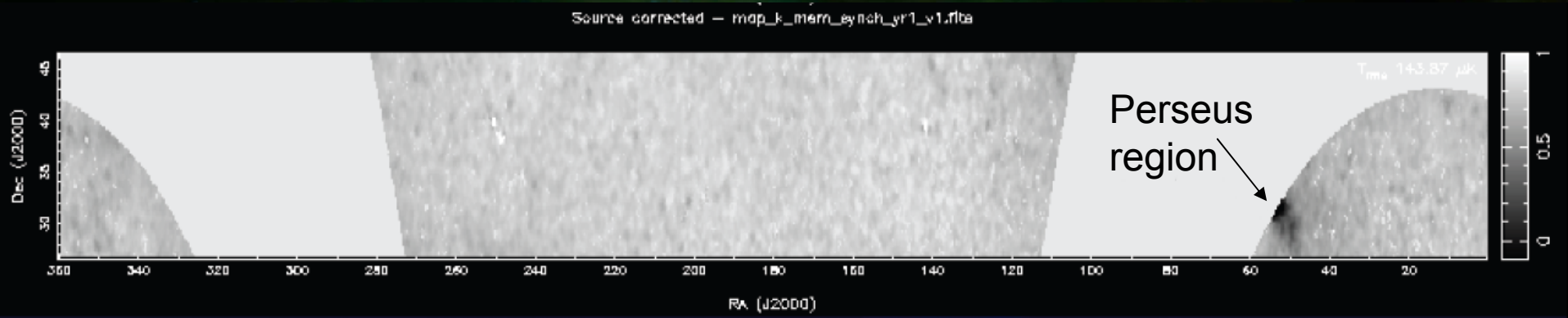
Correcting Tenerife map with WMAP synchrotron reveals the signal is localized.



Looking at original WMAP synchrotron map unfiltered by Tenerife beams and switching shows filamentary blob near Perseus.

Since region of bright California nebula HII region I was sceptical

Yet bet Rafa Rebolo if AME did exist it would have to be in this area



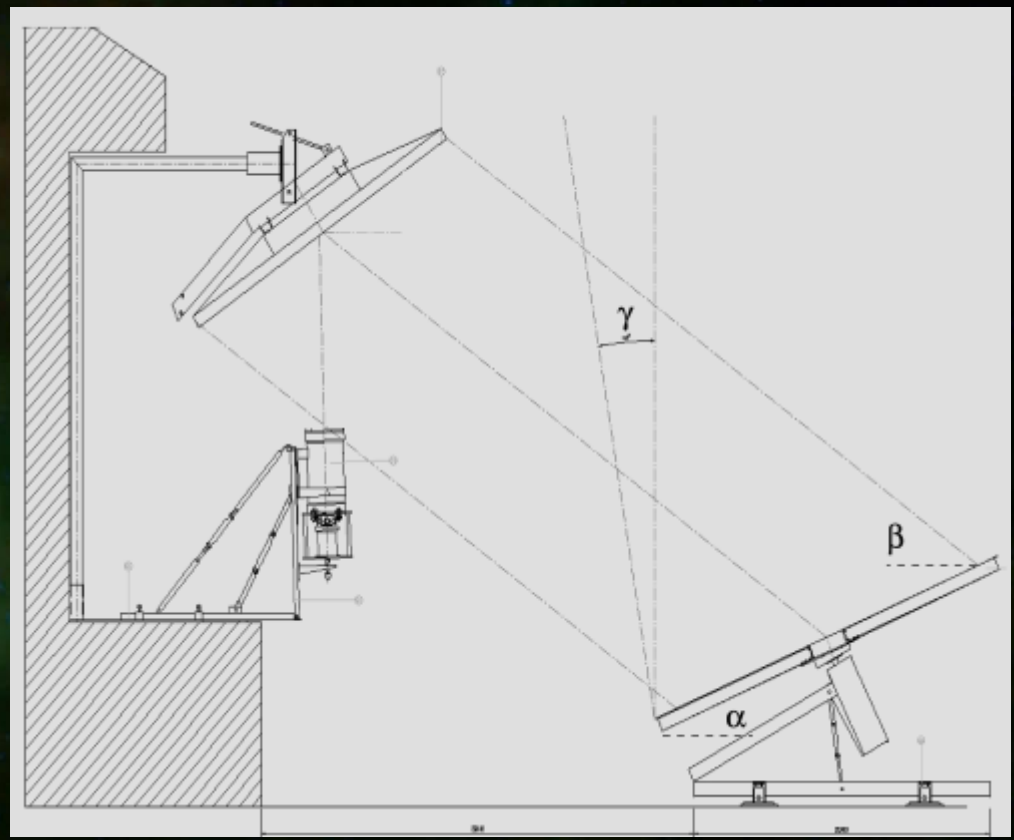
COSMOSOMAS experiment

Cosomosomas was a Spanish CMB/forground experiment which ran in Tenerife from 1998 to 2006

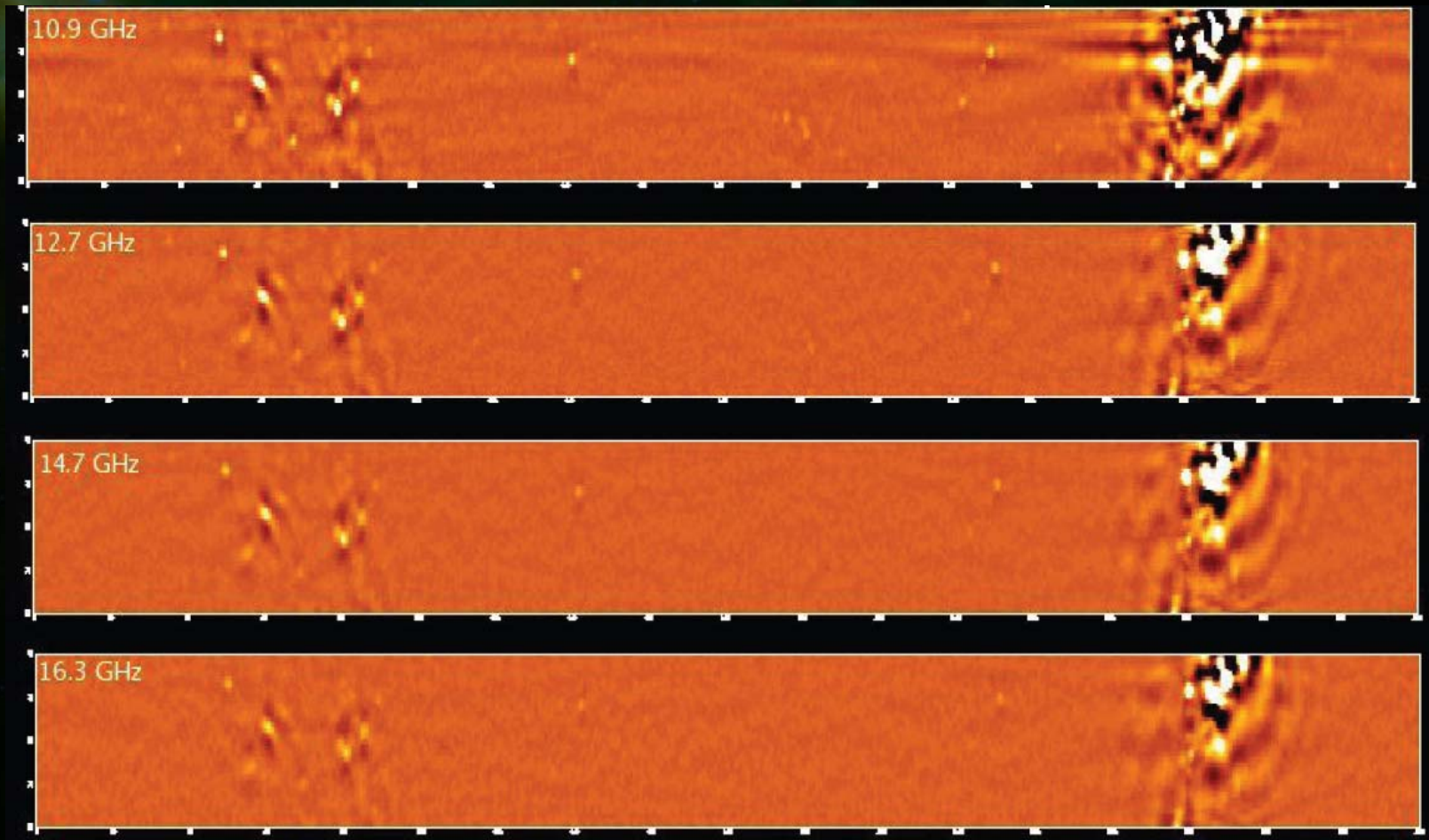
Two telescopes Cosmo11 (2x11GHz channels) and Cosmo15 (13, 15 & 17 GHz channels)

Used flat rotating mirrors with their normal offset ~5^{o} from the spin axis to make nearly circular scans.

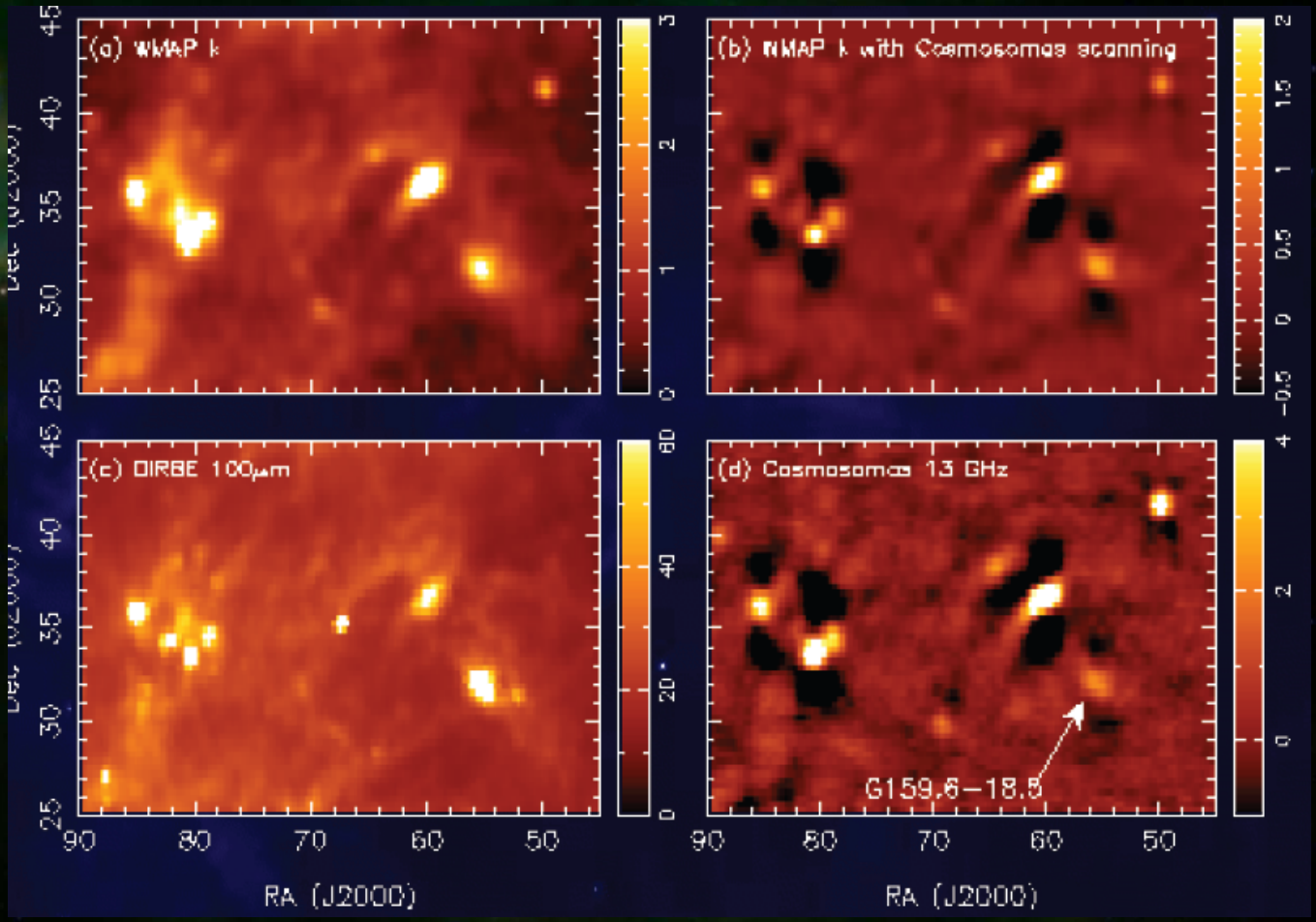
Earth rotation would scan out this 20^{o} diameter circle along RA to produce a map covering ~10% sky each day.



The COSMOSOMAS maps



Auriga-Perseus region



WMAP K band is highly correlated 100μm DIRBE map in this area.

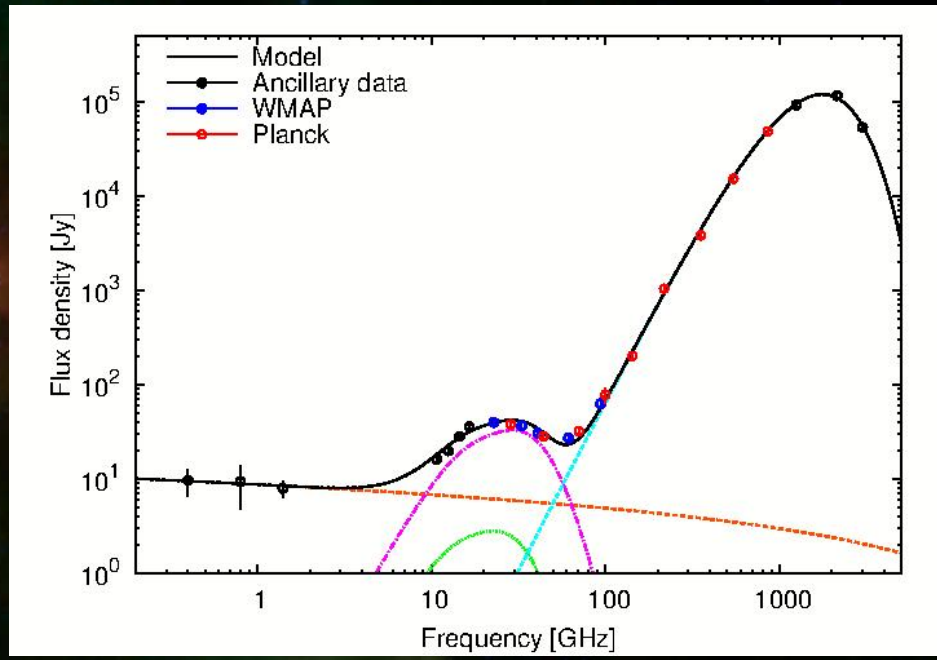
COSMOSOMAS filtering unfortunately removes the diffuse components.

Producing the SED

The circular scans data use harmonic ‘lock-in’ with mirror phase.

Cosmo15 first 5 harmonics are too noisy due to atmospheric 1/f so are set to zero, which leads to a nature filtering.

Unfortunately all data must be smoothed to same 1.12° FWHM and filtered the same way.

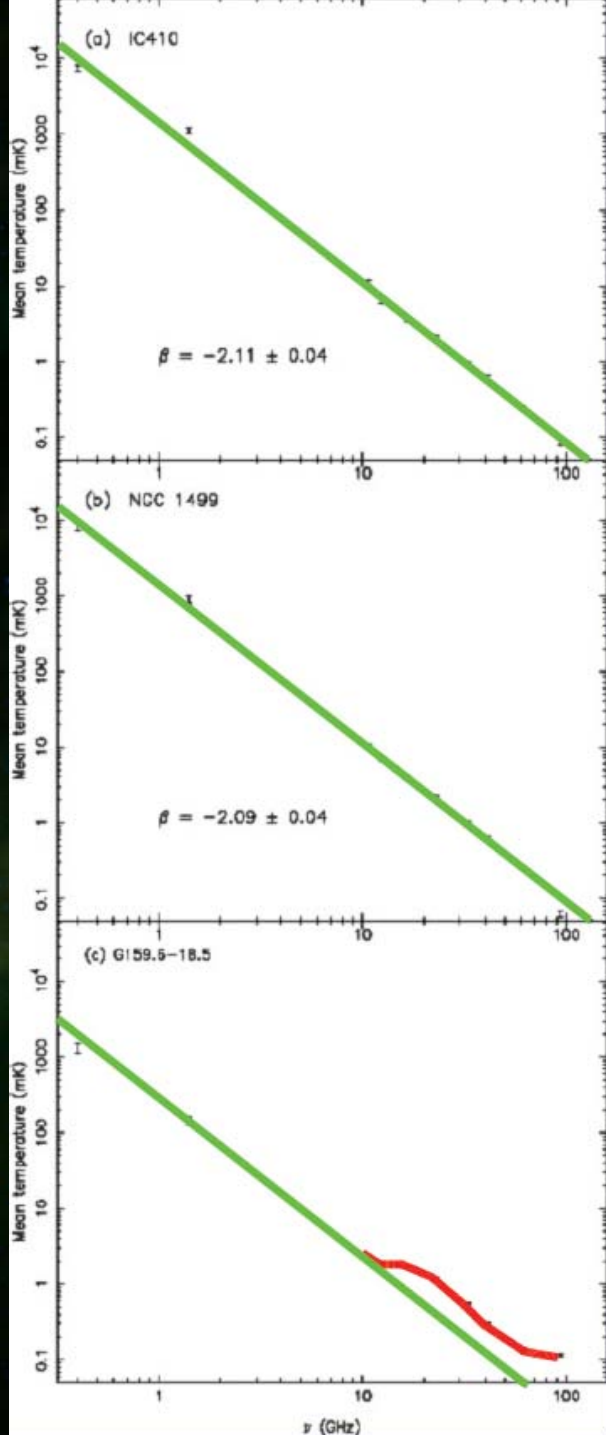


Then a boost factor is required to restore the lost power. Requires a model of the source. Point sources are easy but extended sources are a problem.
Best solution is a model fit to unfiltered data – in this case WMAP K band

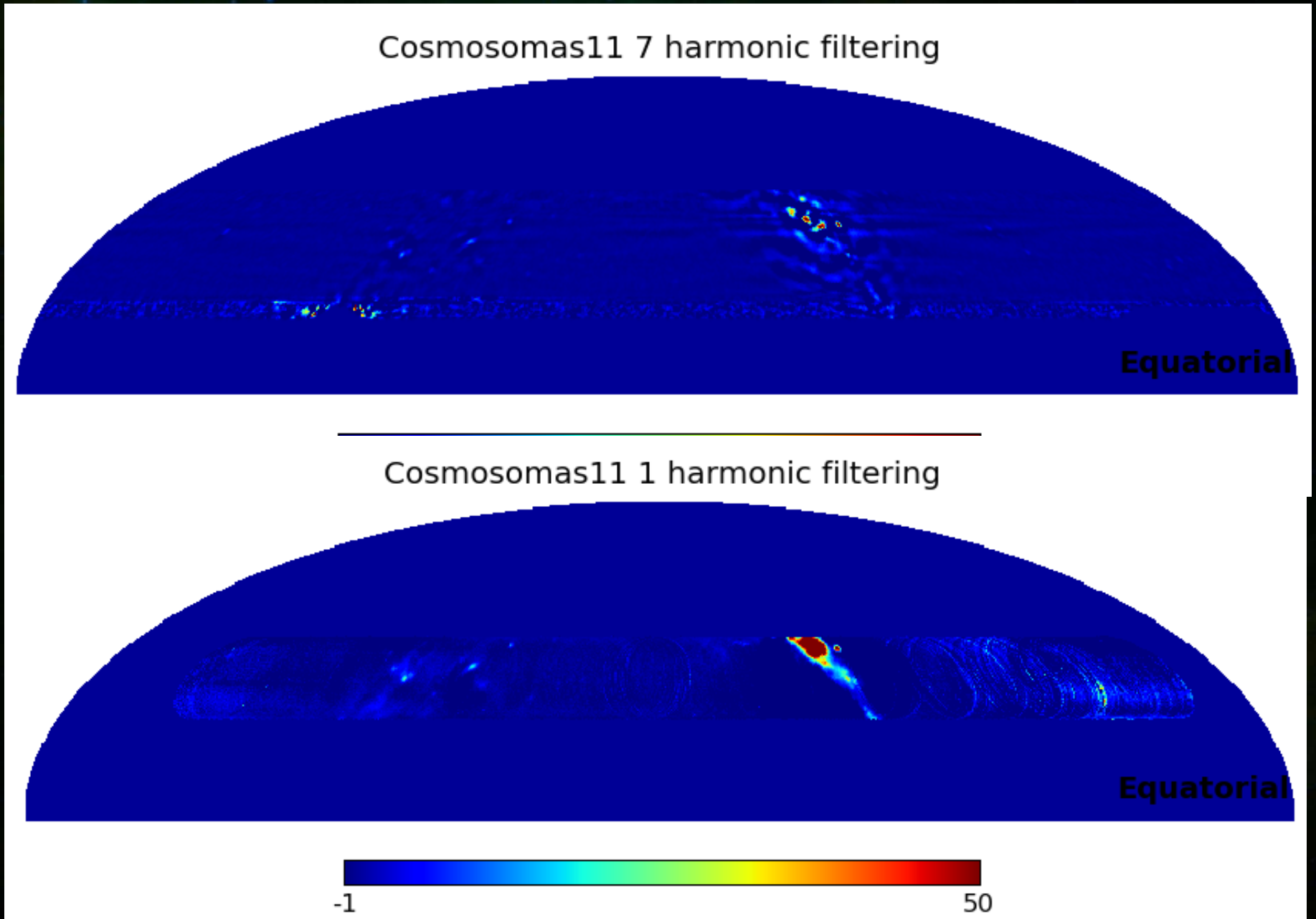
Relative calibration is fine so long as model is still valid (ie morphology is stable).

Calibration Check

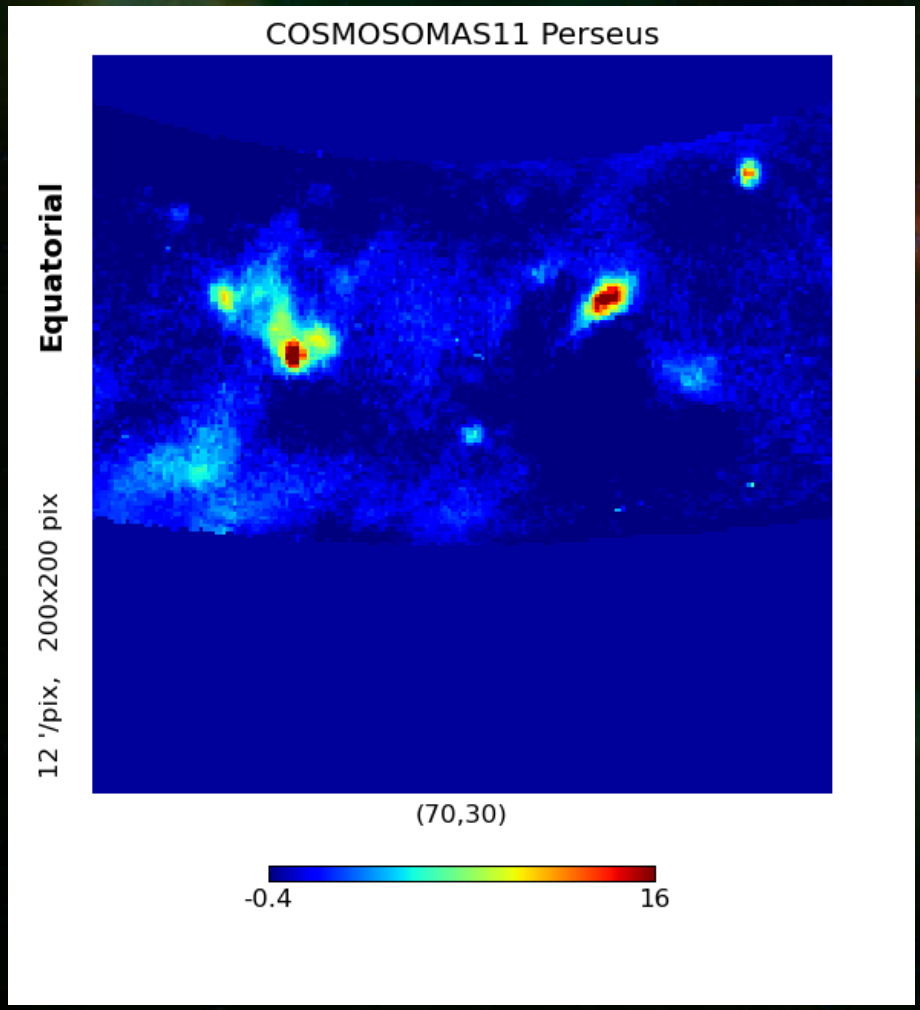
- As a check on diffuse calibration can use HII regions ‘California’ NGC1499 and IC410.
- Expect pure free-free with index -2.1 (in temperature).
- IC410 gave -2.11 ± .04
- NGC1499 gave -2.09 ± .04
- Assumed 10% absolute calibration
- Still tricky to define flux density for a diffuse source.

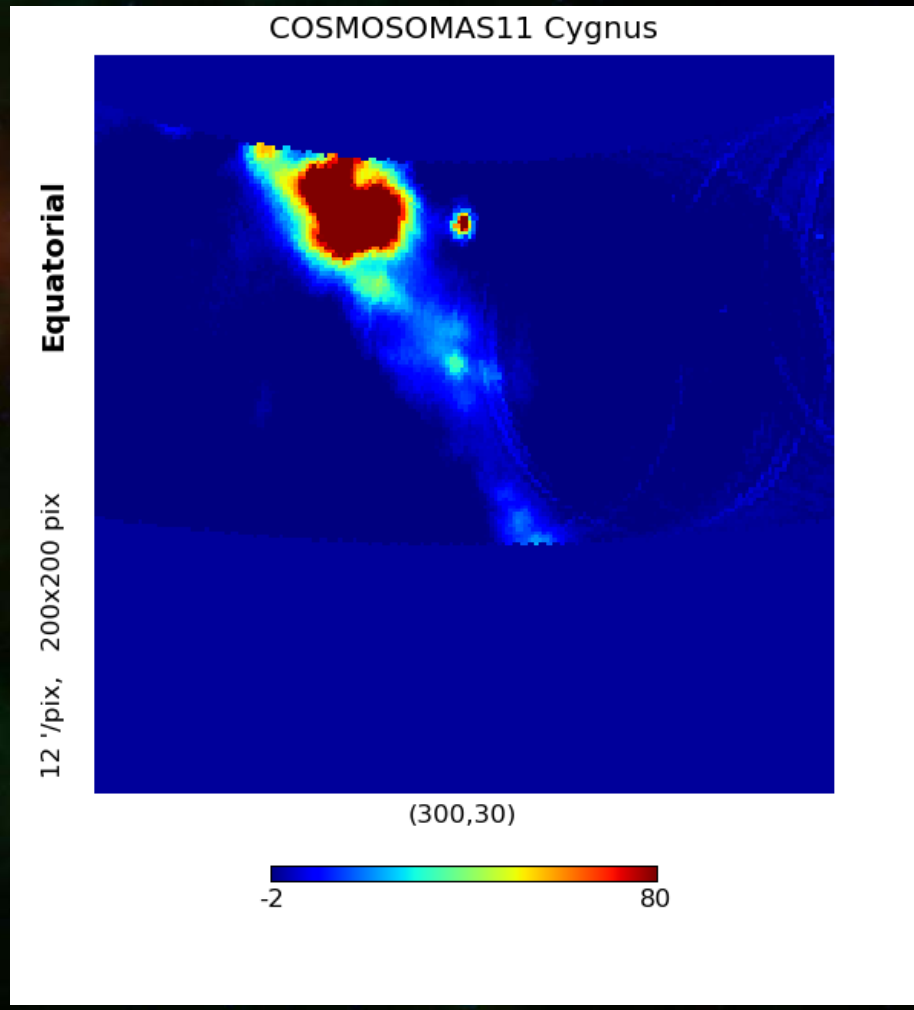


Filtering less – Cosmo10 suffered less 1/f

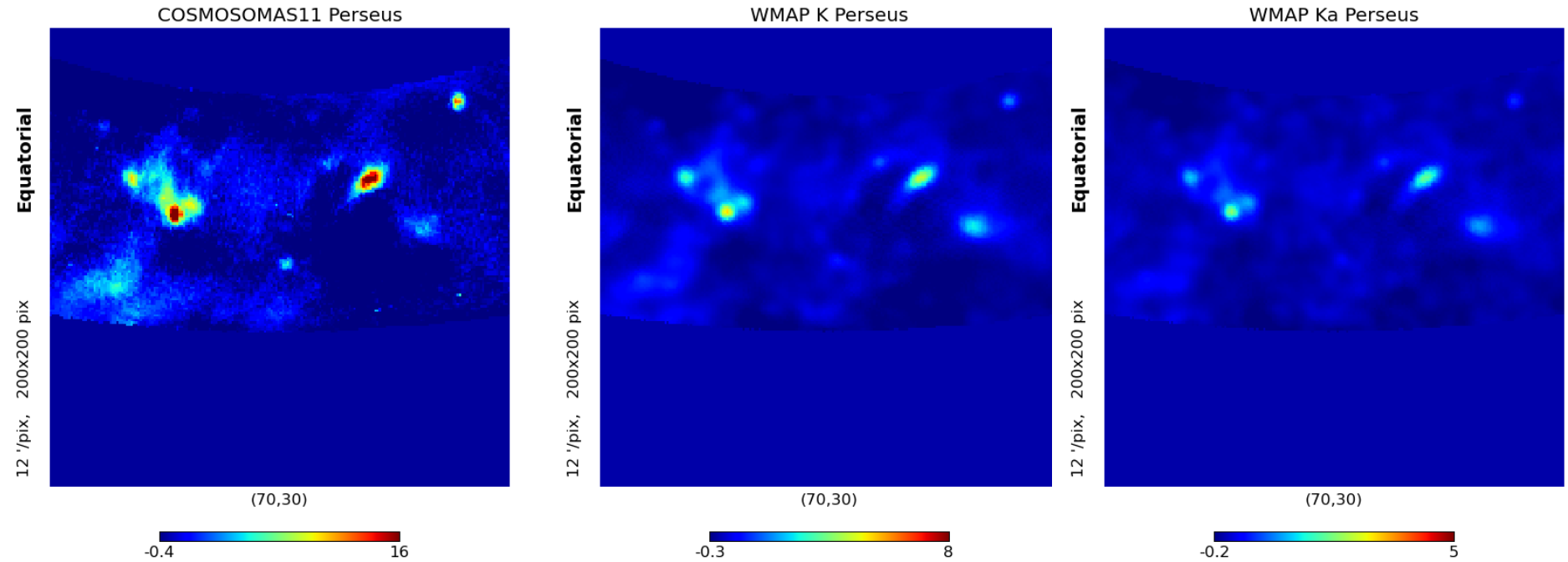


New COSMO10 maps





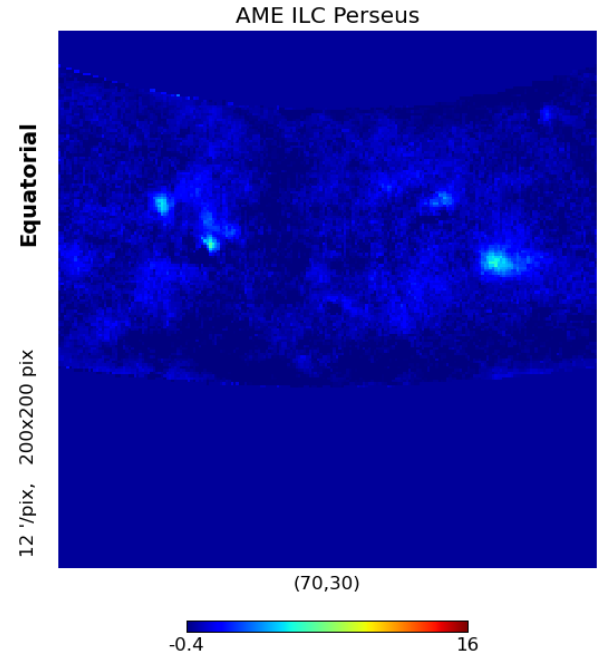
Compare to WMAP K & Ka

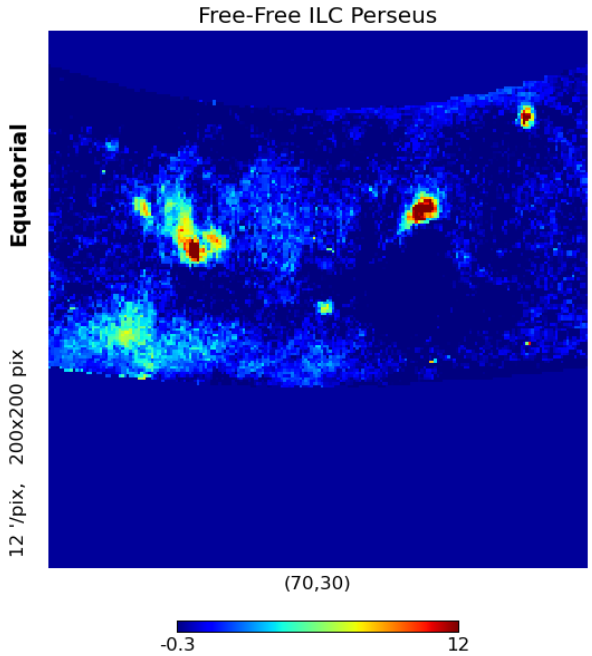


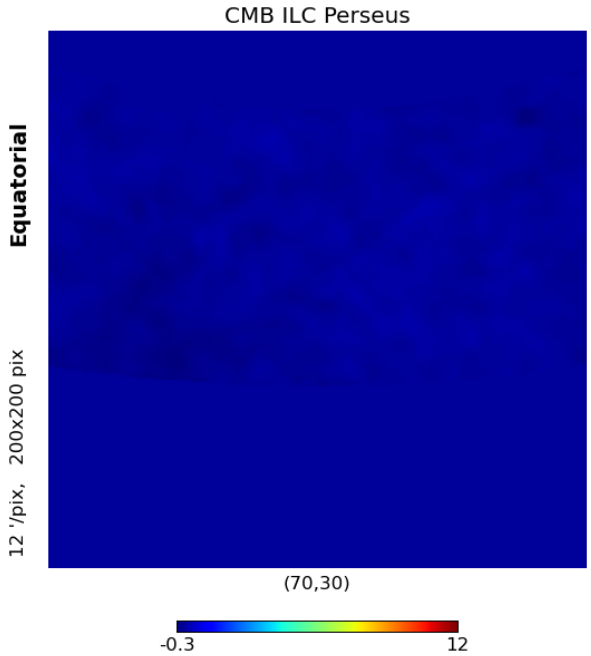
Carry out same 1 harmonic remove filtering on WMAP K and Ka channels

Can do an ILC separation!

AME | Free-Free | CMB



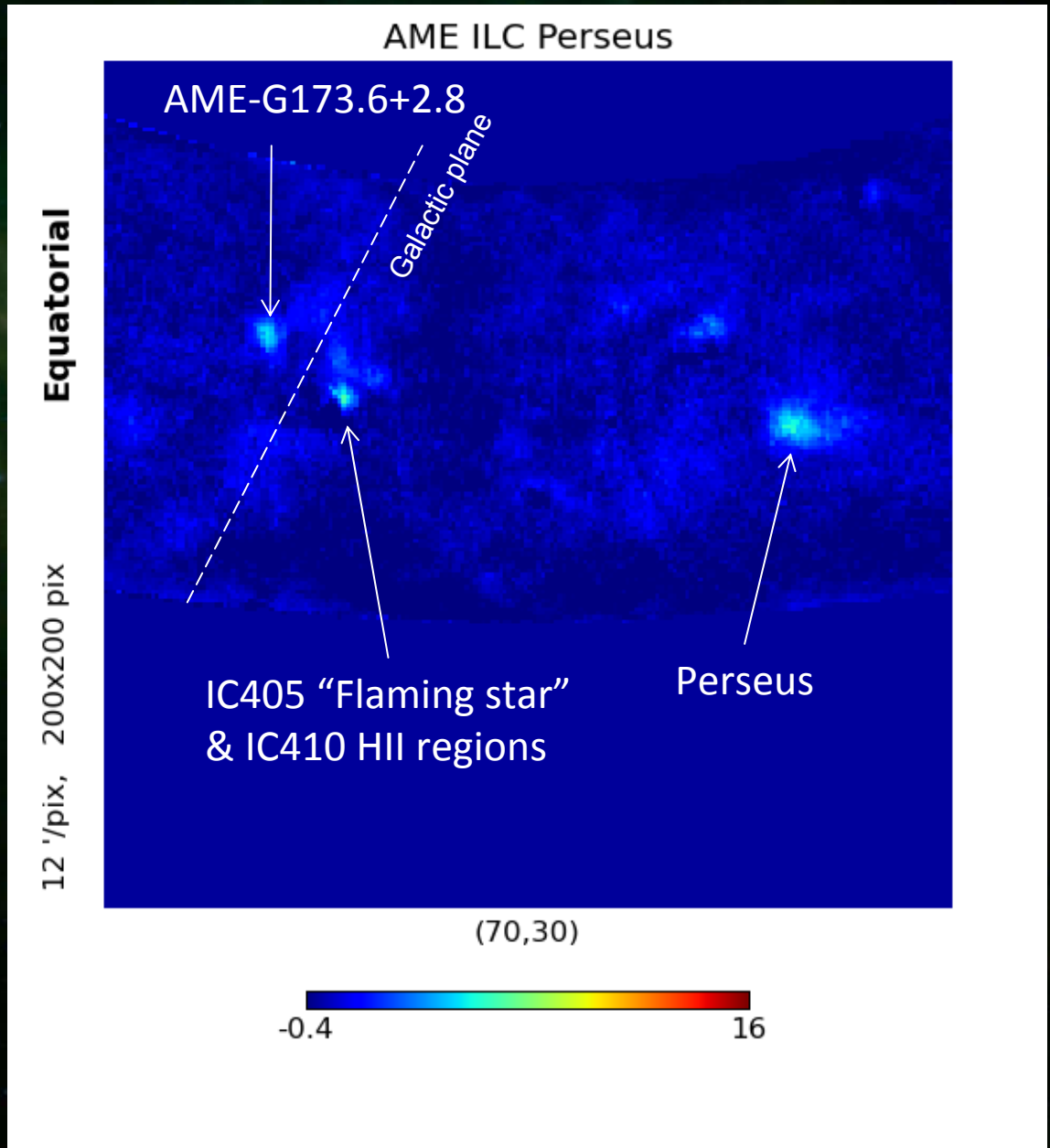




Works surprisingly well.

Might even be some diffuse AME.

AME ILC in detail



The Perseus molecular cloud

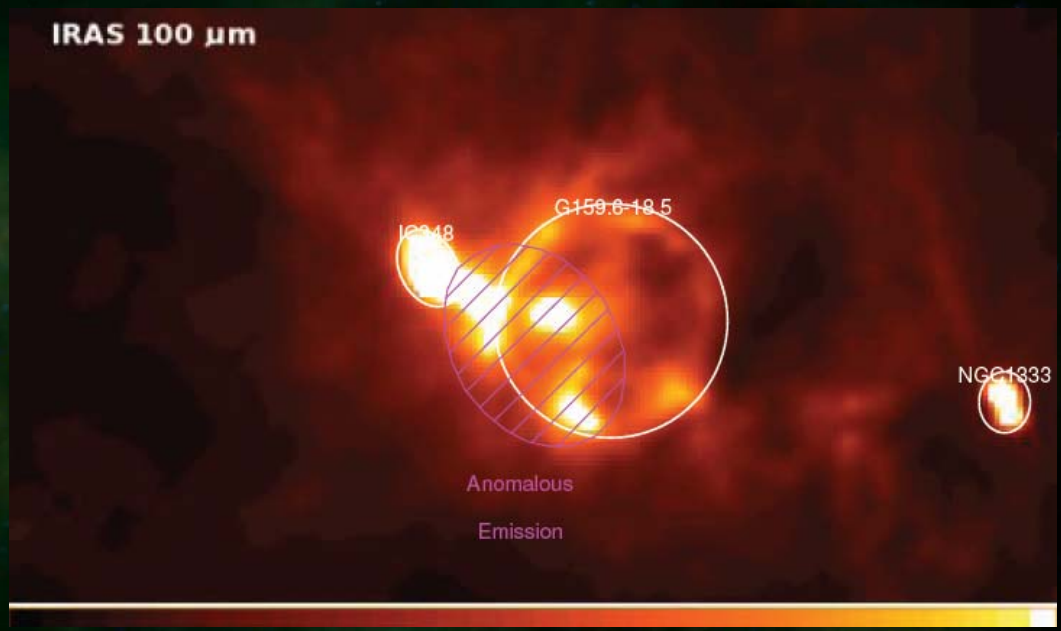
Chain cold molecular clouds

Two sites of low mass formation IC348 & NGC1333

Weak HII region

Couple of Barnard dark clouds

Perseus in IRAS



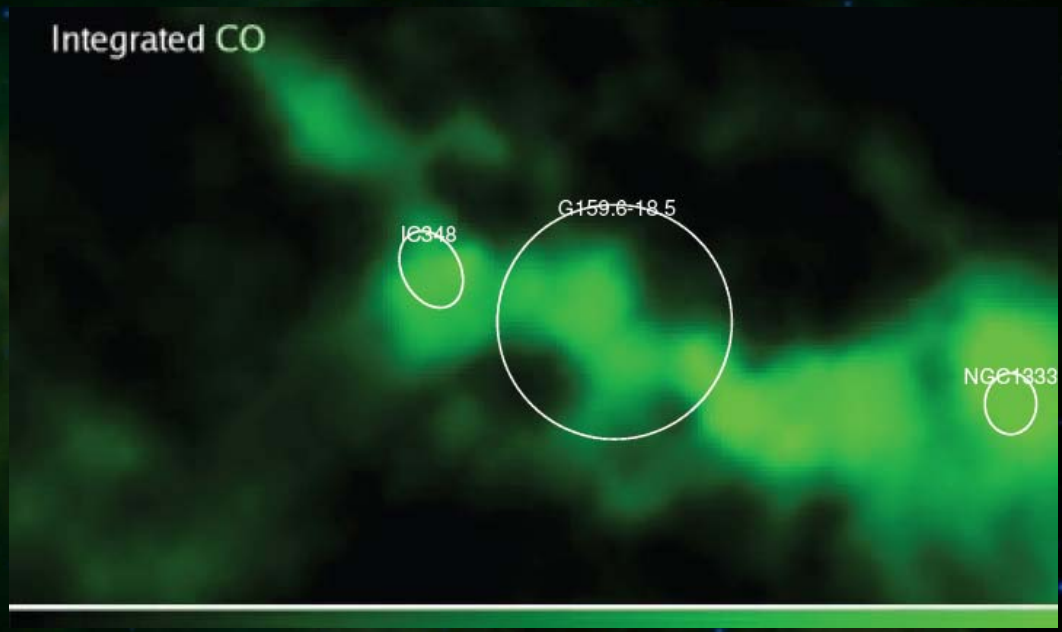
See a chain of ‘knots’ of emission 100-200 MJy/sr and a ring of warmer dust surrounding HII region. The brightest feature (~600MJy/sr) is the star forming region IC348

Hα & HII

Hα emission (~40R) seems to come from inside the HII region drive by the B0 star HD 278942. The dust cloud and a small filament obscure half of it.

Only expect <5Jy from HII region assuming 120R over whole ring.

CO



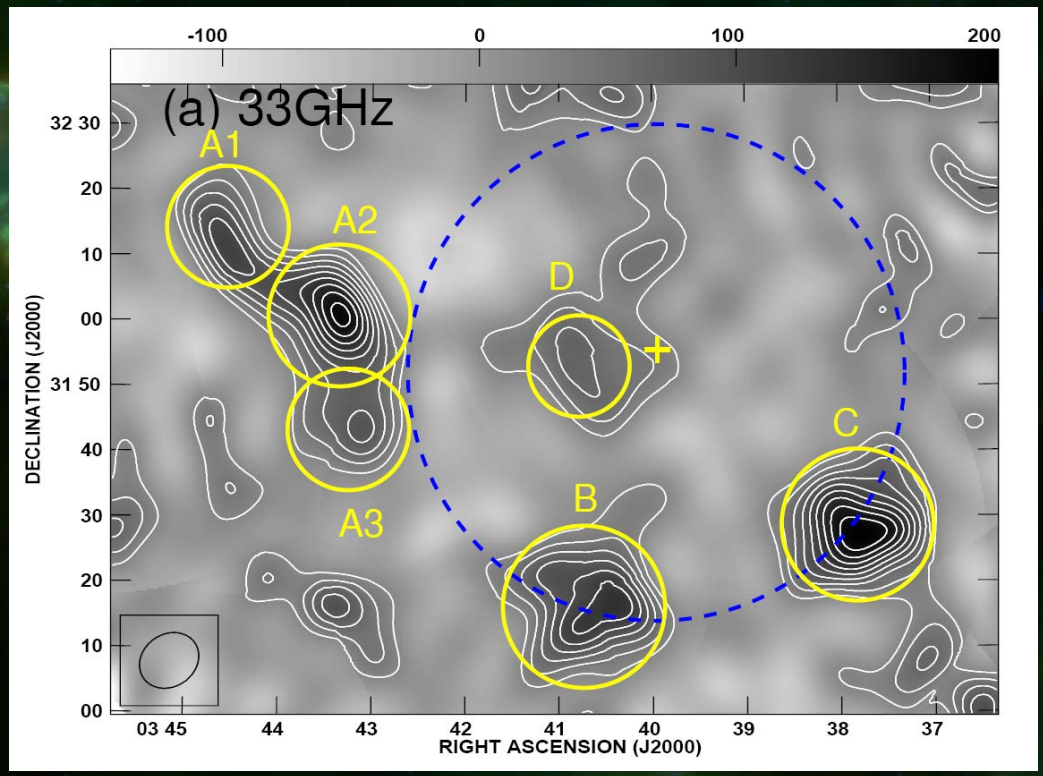
Shows up very well the gas associated with the dust in the molecular cloud. Can easily see the chain of clouds.

Radio Sources

No bright radio sources and most are steep spectrum apart from the brightness 4C+32.14 (~2Jy) which is flat spectrum quasar.

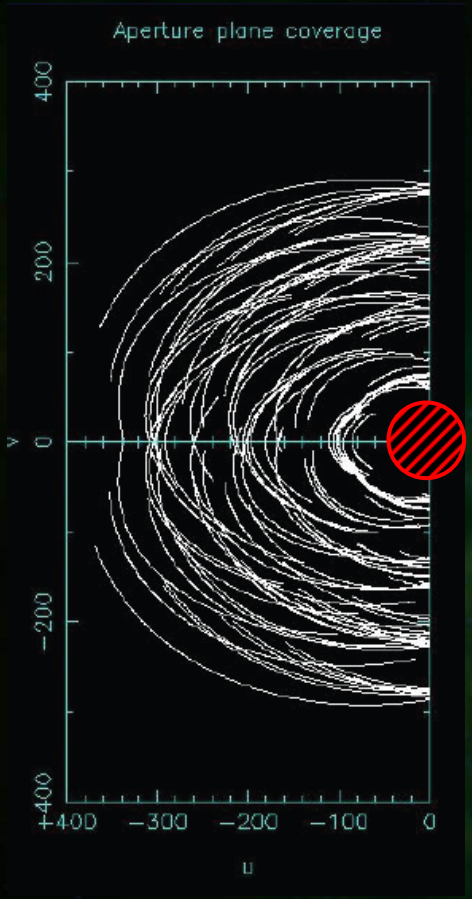
Green Bank postage stamp just shows the weak free-free in the centre of the HII region.

VSA follow up



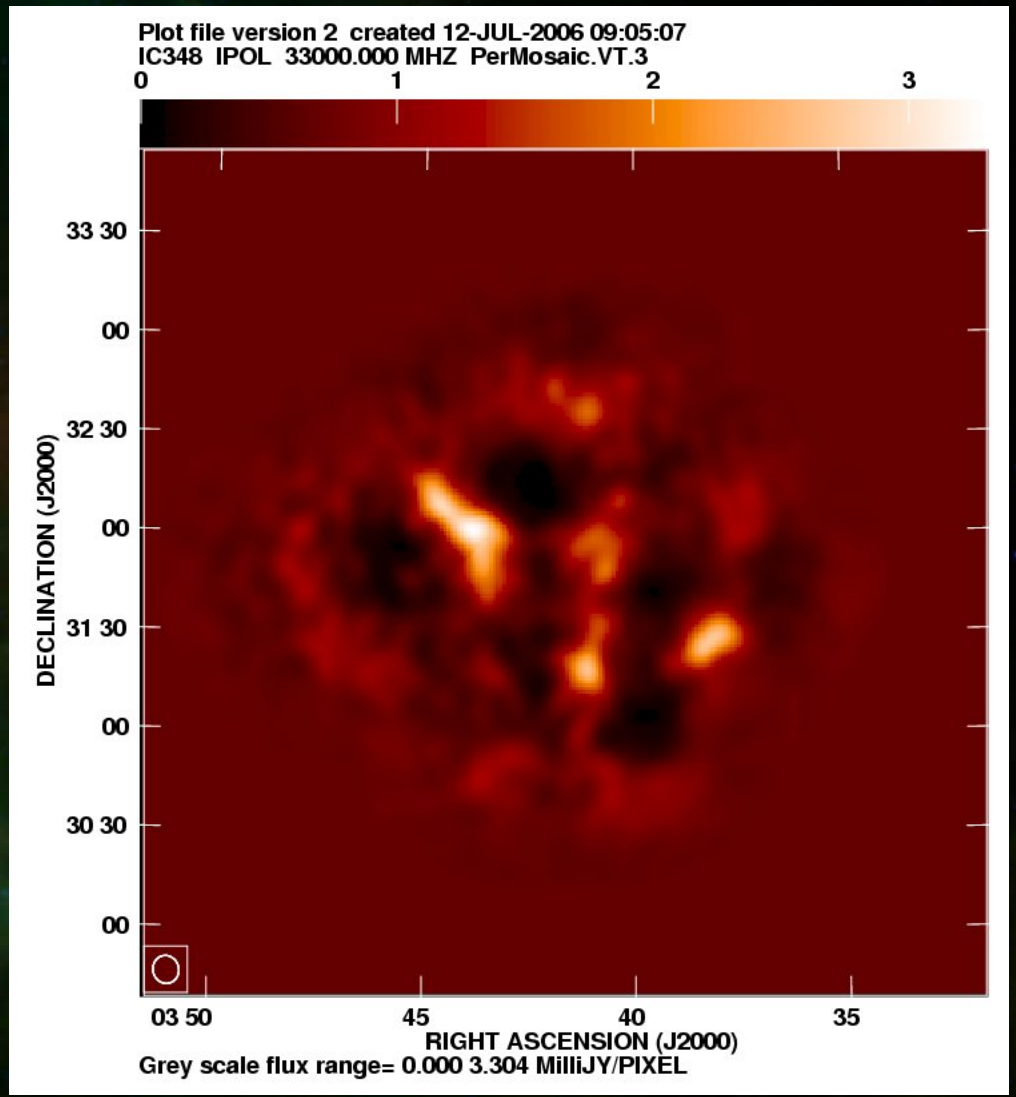
VSA made interferometeric observations at 33GHz with a resolution of 9' described in Tibbs *et al* 2010. A mosaic of 11 pointings with the super-extended array.

VSA Missing flux



UV hole

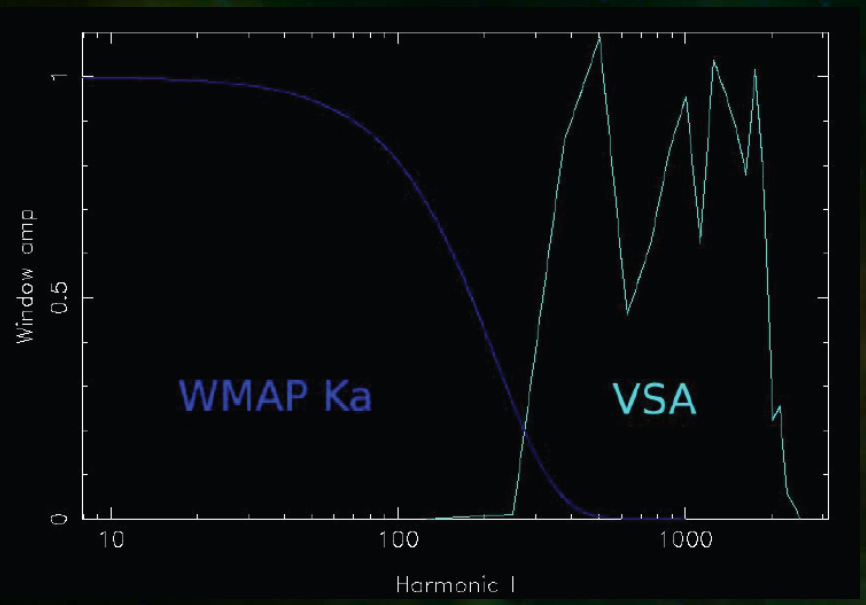
For 30’ and larger scales

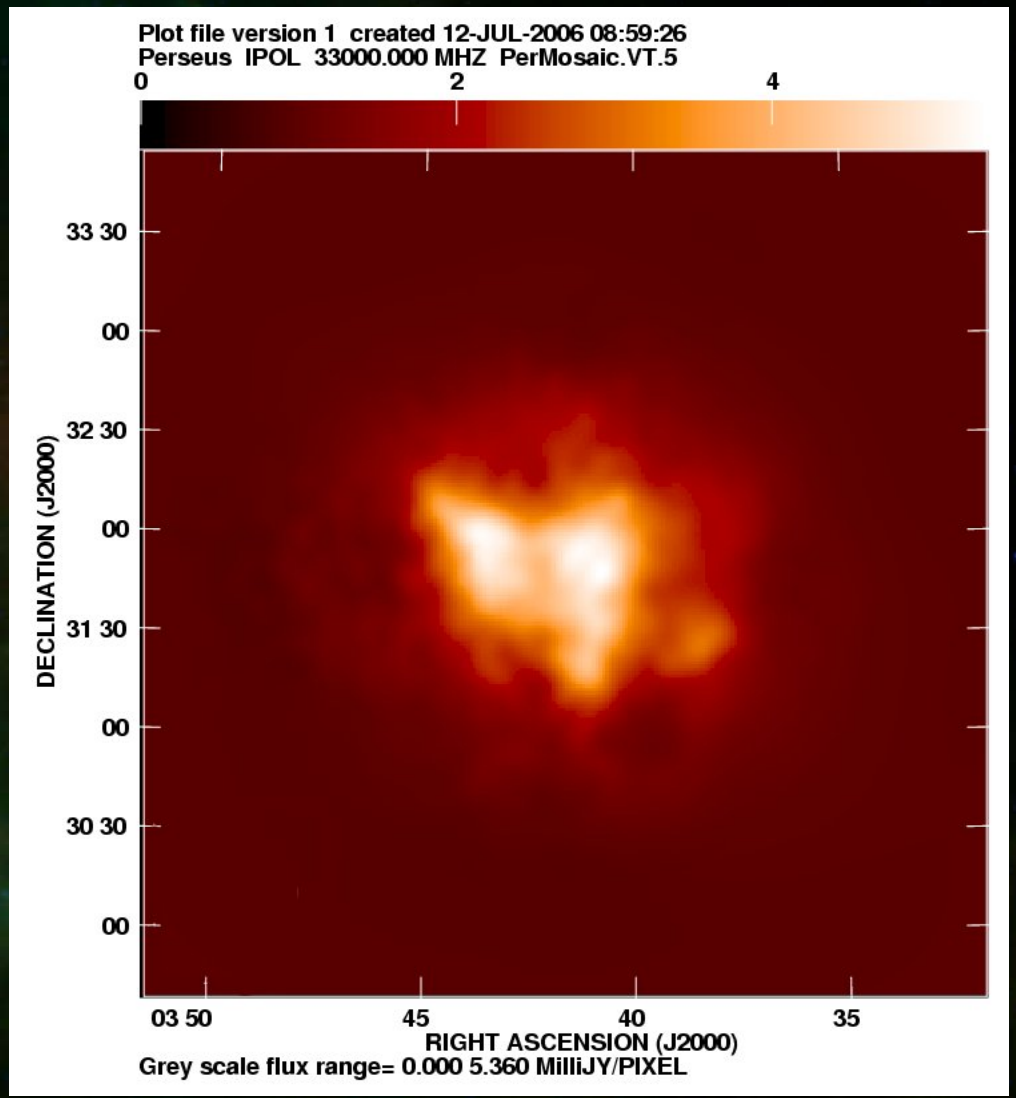


UV hole problem of interferometers WMAP and COSMOSOMAS data fall through it.

Leads to characteristic negative structure in data.

Filling the UV hole





VTESS allows for short spacing information which was generated from the WMAP K channel

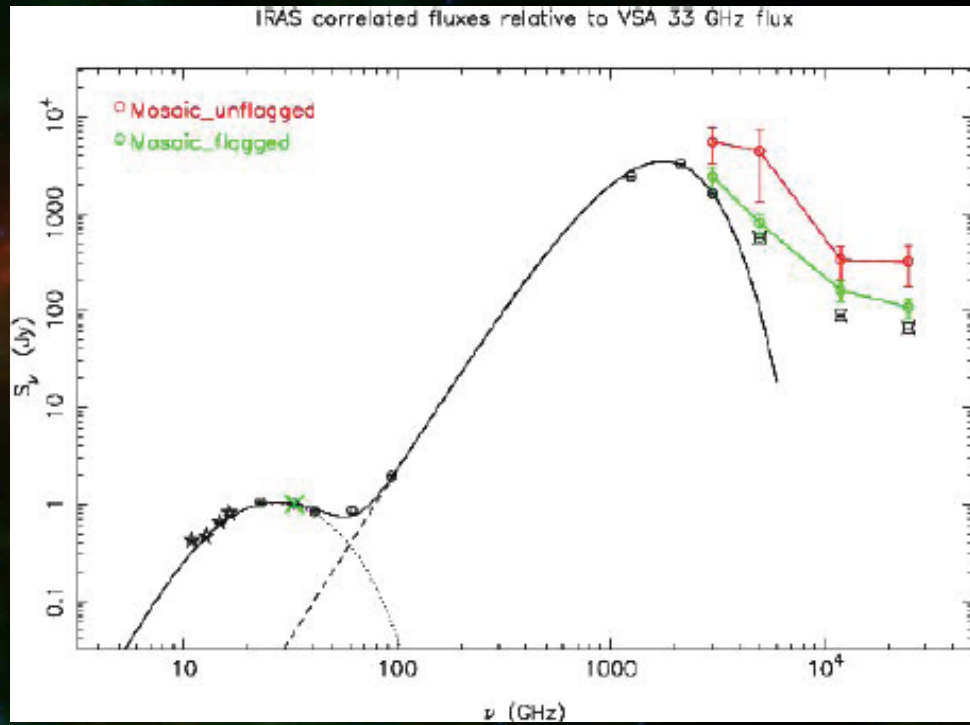
Cookie model of Perseus

Can easily have 90% more cookie dough than chocolate chips.

Question is are Perseus VSA chips made of the same stuff as the COSMOSOMAS/WMAP filler?

Is large AME same as small scale

- Flagging the warm dust in IC348 and the VSA D spot and passing IRAS data through VSA UV sampling

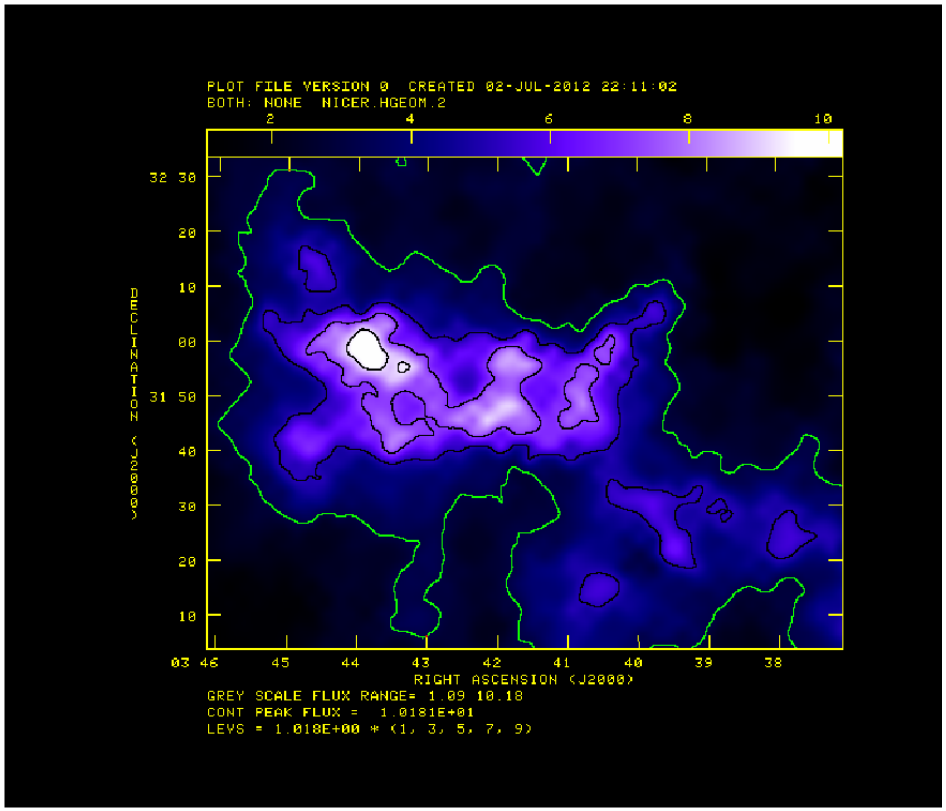


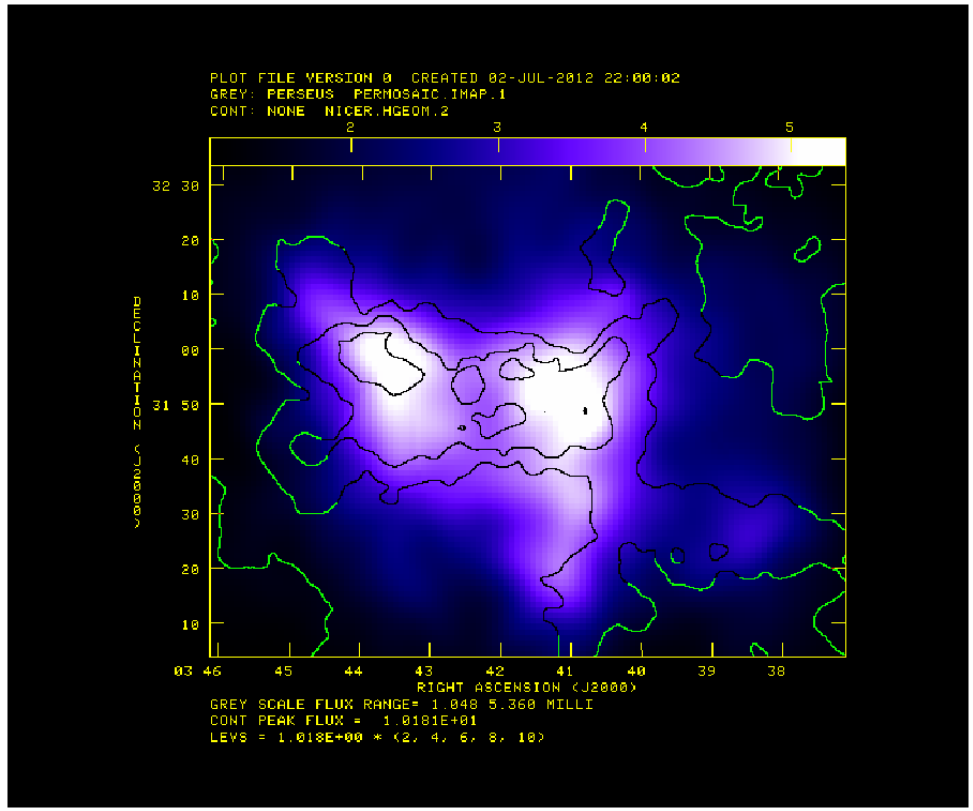
We get the same emissivity suggesting VSA hot-spots are same as the COSMOSOMAS AME and other diffuse AME ~10-15μK/(MJy/sr).

VSA spot A1 which sits on IC348 has an emissivity ~3 μK/(MJy/sr) more typical of HII regions.

Need temperature independent estimates of dust and get away from emissivities.

Comparing to NICER/2MASS extinction

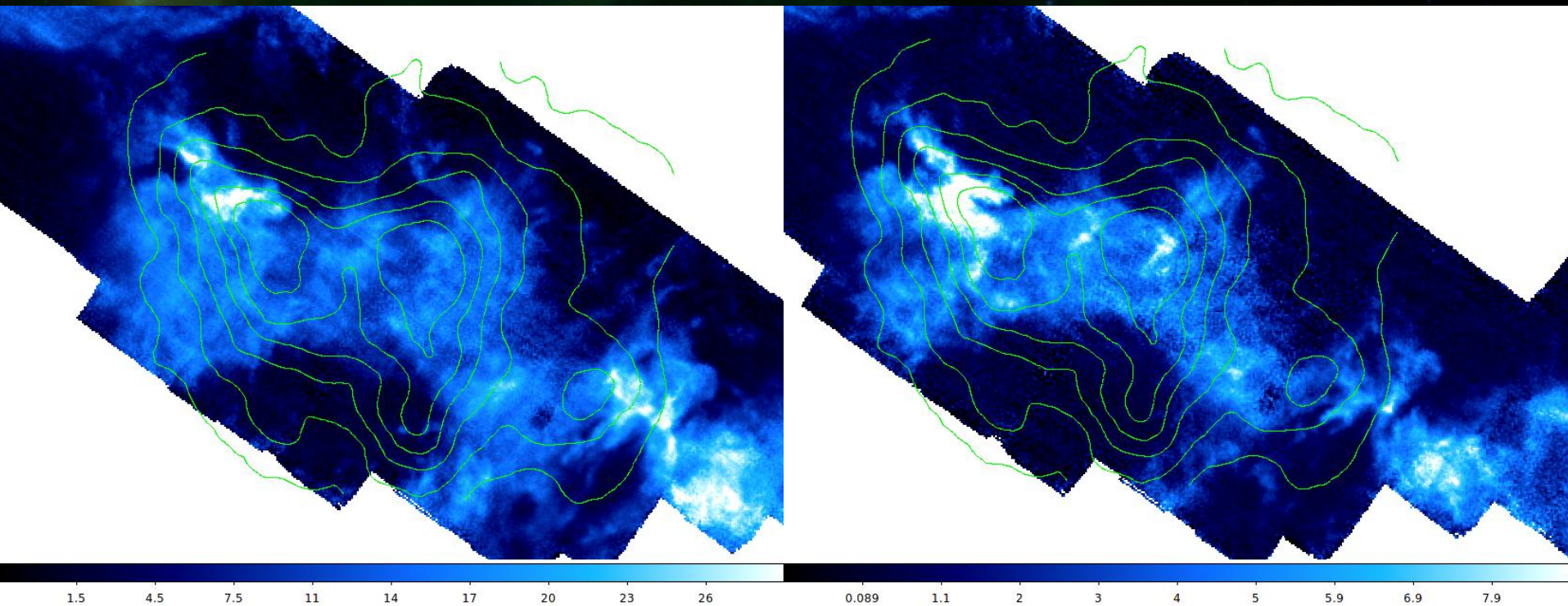




Similar but noticeable differences

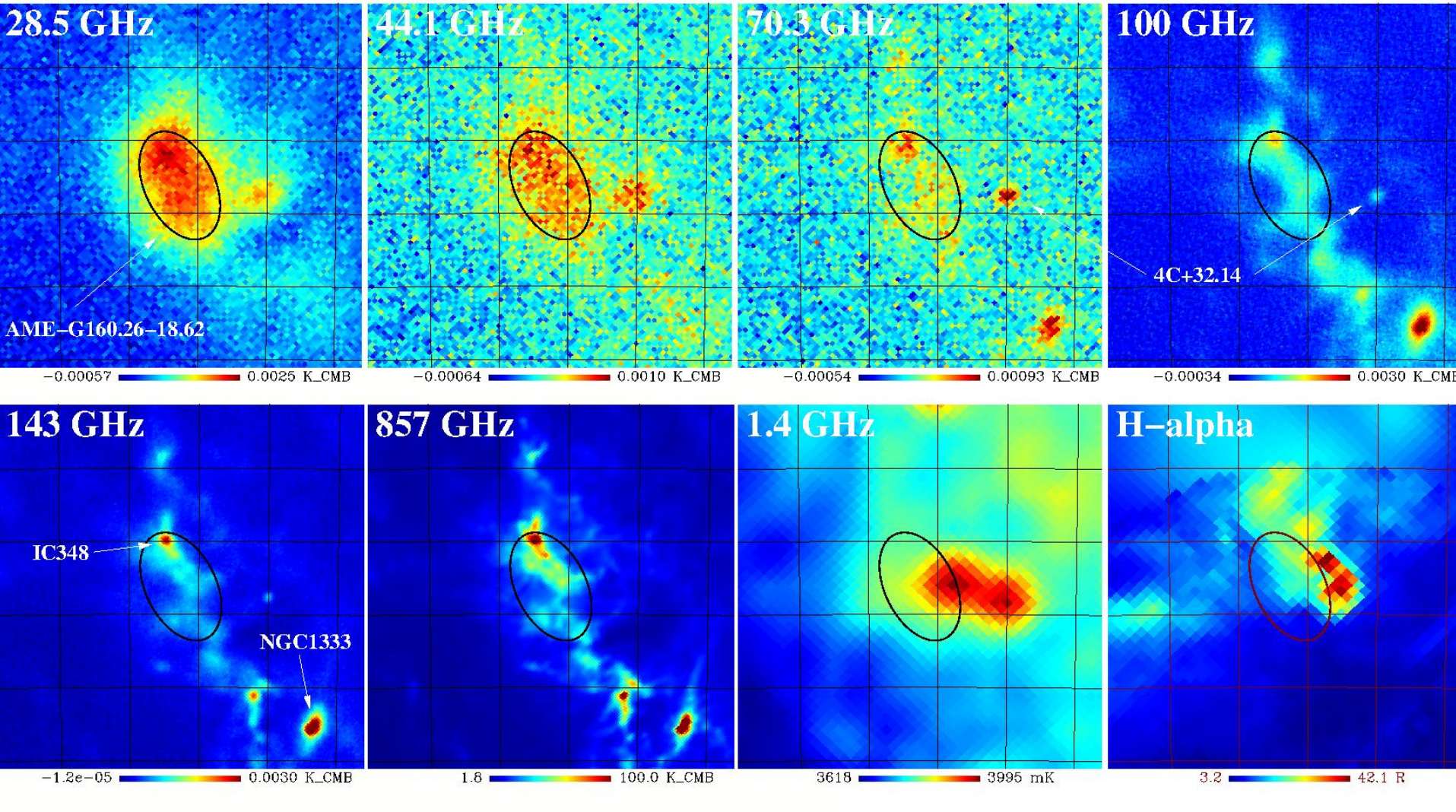
"Horns and a tail!"

And with CO



Again similar shape, but not quiet the same

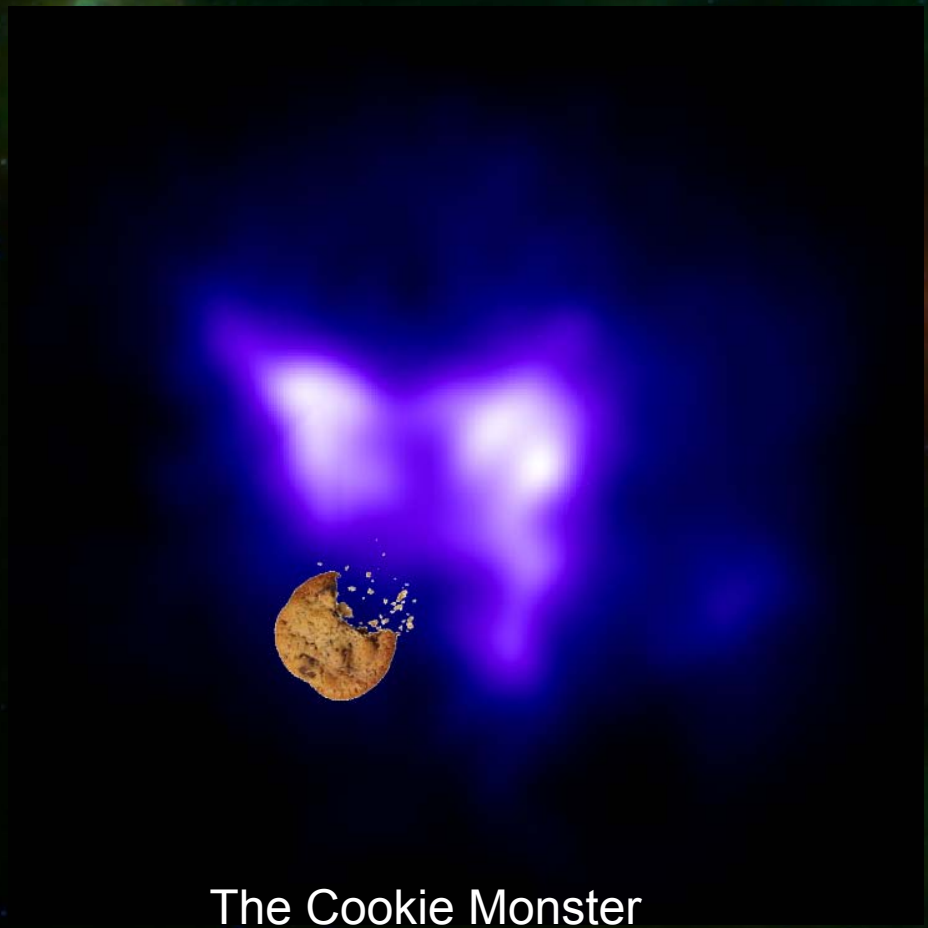
Planck


28.5 GHz
AME–G160.26–18.62
−0.00057
0.0025 K_CMB
44.1 GHz
−0.00064
0.0010 K_CMB
70.3 GHz
−0.00054
0.00093 K_CMB
100 GHz
4C+32.14
−0.00034
0.0030 K_CME
143 GHz
IC348
NGC1333
−1.2e−05
0.0030 K_CMB
857 GHz
1.8
100.0 K_CMB
1.4 GHz
3618
3995 mK
H–alpha
3.2
42.1 R

Conclusions

- Need to push and combine data to cover more angular scales to make sense of the emission.
- 5-15 GHz data going to be very useful for look for diffuse AME (C-BASS, QUIJOTE, AMI and others).
- VSA missing flux probably not missing and just low level and covering whole region.

Thank you,
questions please!



The Cookie Monster

The Perseus Molecular cloud