QUIJOTE view on Fan region

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Outline

- Fan region description.
- QUIJOTE observations.
- Results:
  - Correlation plots in I, Q.
  - Fluxes and SED in intensity.
- Conclusions.

Fan region

- Located in the Galactic plane, in the outer part of the Perseus arm.
- Extended around 25º (gl) x 30º (gb)
- Distance ~ 500 pc
- It contains diffuse emission and some sources.

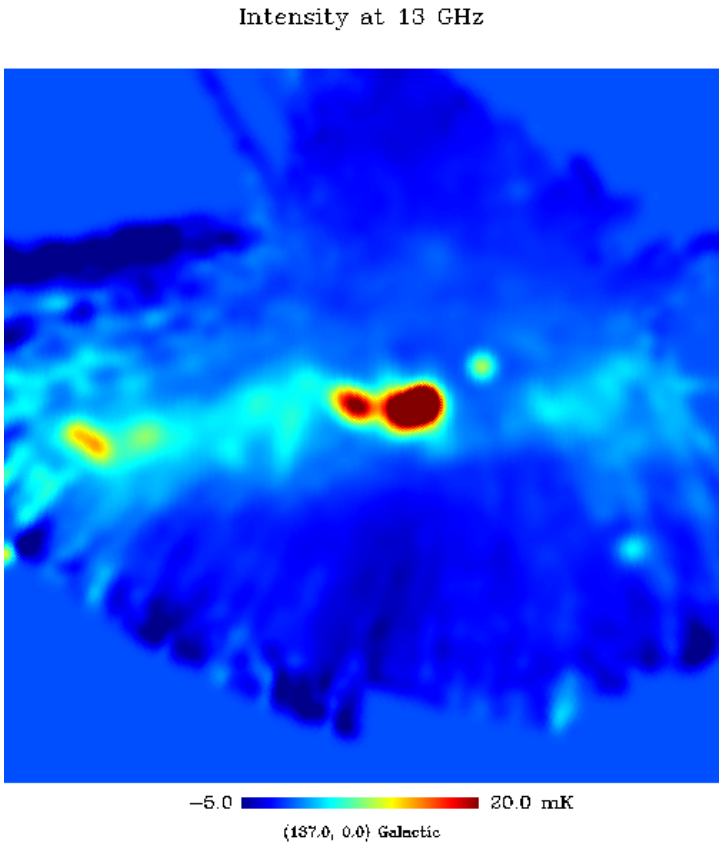


Table 1. Sources in the Fan region

Name	l (deg)	b (deg)	Description
SNR3C58	130.75	3.12	SN remnant
W3	133.8	1.2	Molec. cloud
W5	137.5	1.1	Molec. cloud
W4	134.7	0.9	Molec. cloud
LBN0679	141.0	-1.7	Molec. cloud
LBN0679	140.7	2.0	Molec. cloud
Bckgr1	138.65	11.5	
Bckgr2	135.5	-7.9	

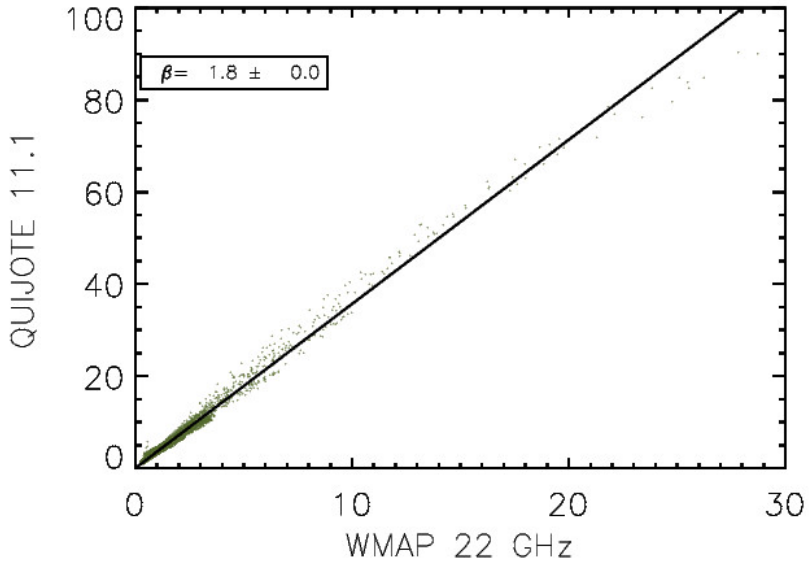
QUIJOTE observations

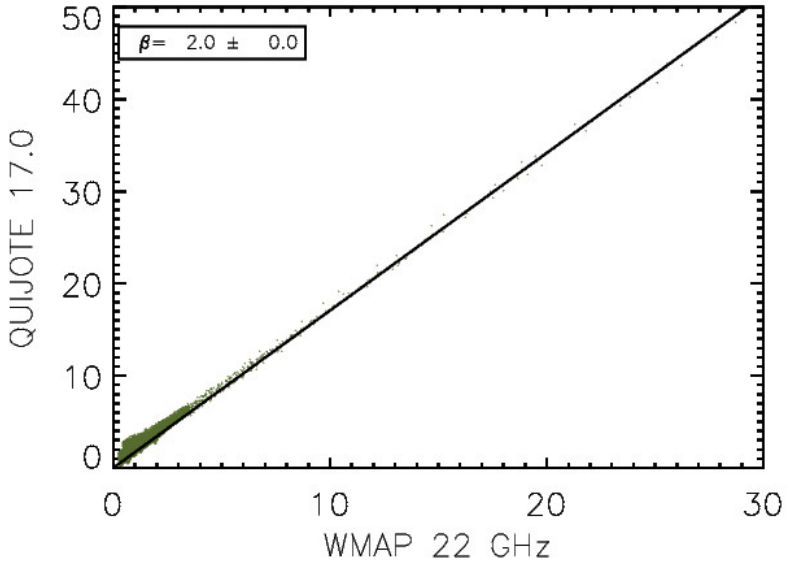
- **Nominal observations:** diffuse emission.
- **Raster observations**: sources.
  - Period of observations: 02/April/2013 – 16/Nov/2015.
  - Number of observations = 258, total time ~ 450 hours.
  - Null-tests:
    - Dividing in two periods.
    - Dividing in two halves.
    - RMS is computed in a radius of 2º centered in (l=133.4 deg., b=7.19 deg.).

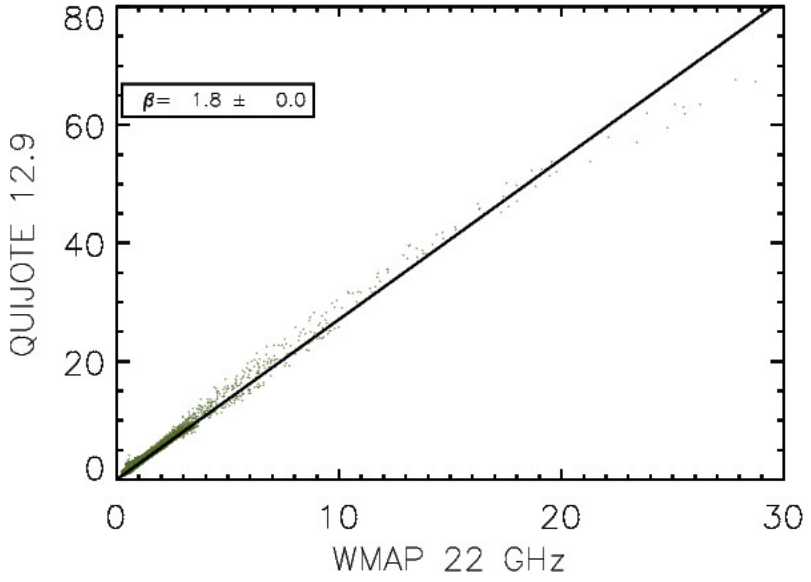
Results:
1. Correlation plots

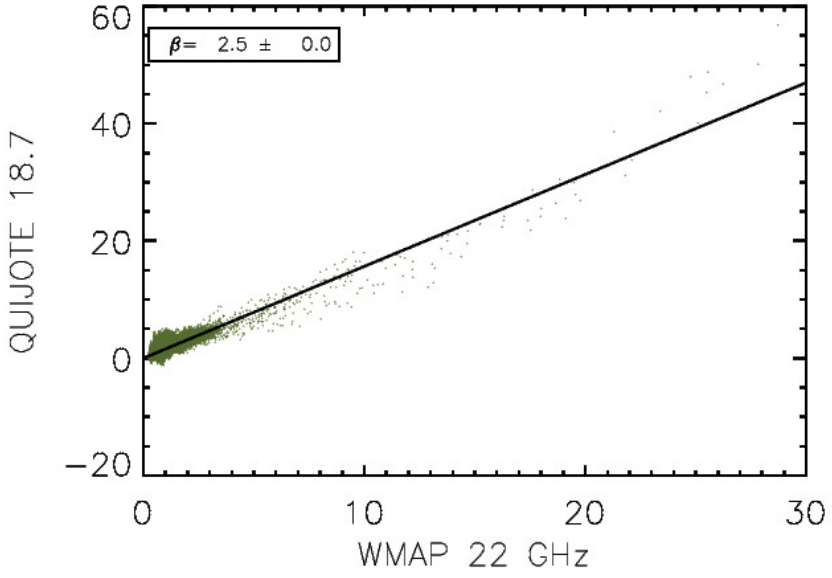
- The wide survey is used for computing correlation plots in intensity and in polarization and thus, for characterizing the diffuse emission.
- Correlation plots allow us to infer the spectral index of the whole emission in the region.
- Correlations between WMAP 23, 33 GHz and QUIJOTE 11, 13, 17 and 19 GHz are computed in Stokes' I and Q.
- To this purpose, we consider a extended region:
  - With gl in [122,155] deg., gb in [-12,12] deg.

Correlation plots in intensity





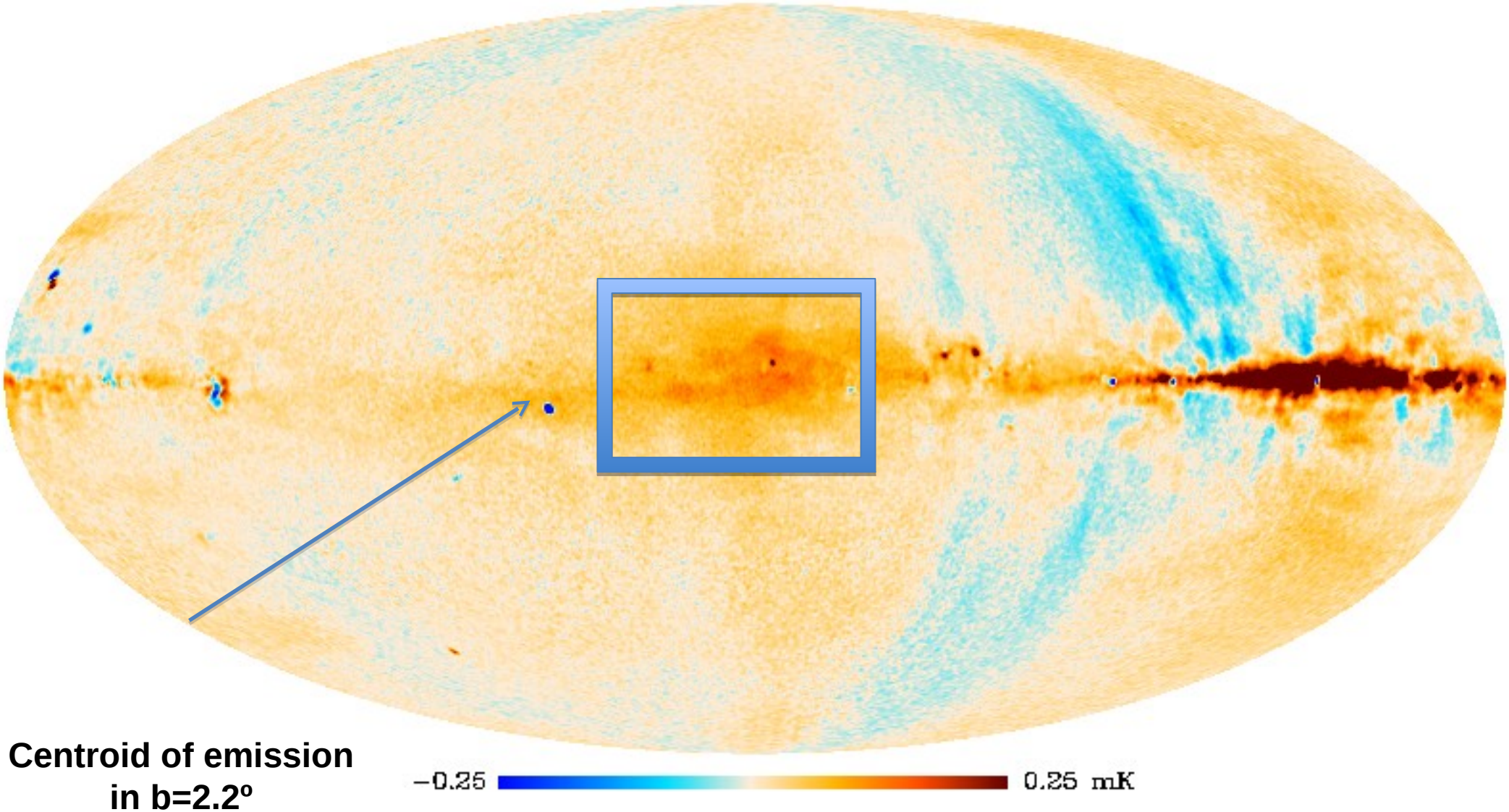




Spectral index derived from correlation plots in intensity

- Spectral index for WMAP **(22 – 33 GHz) : -2.09±0.02**
- Spectral index **(11 – 22 GHz): -1.96 ± 0.11 (11 – 33 GHz): -1.99±0.07**
- Spectral index **(13 – 22 GHz): -1.94 ±-0.24 (13 – 33 GHz): -2.00±0.15**
- Spectral index **(17 – 22 GHz) : -2.16± 0.34 (17 – 33 GHz): -2.11± 0.17**
- Spectral index **(19 – 22 GHz): -2.11± 0.28 (19 – 33 GHz): -2.08±0.19**

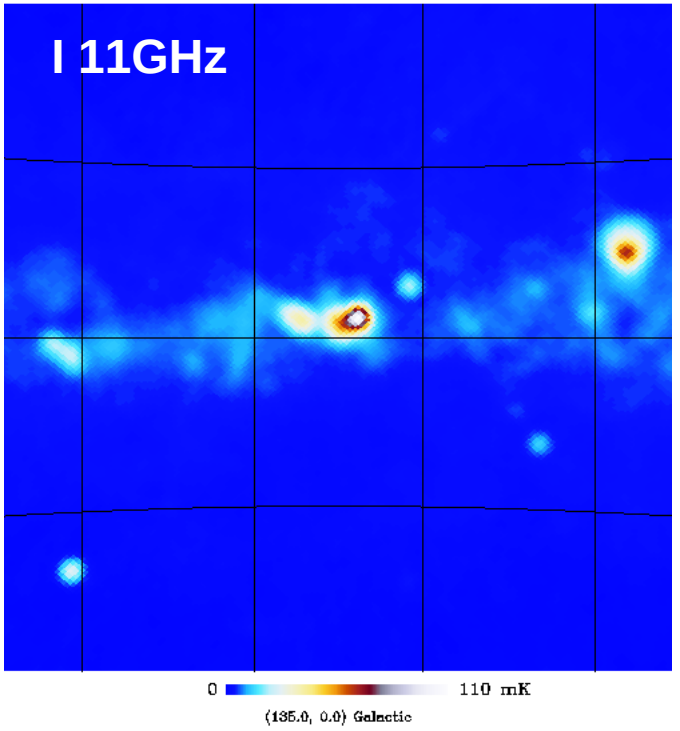
The FAN region in polarization Stokes Q 22GHz

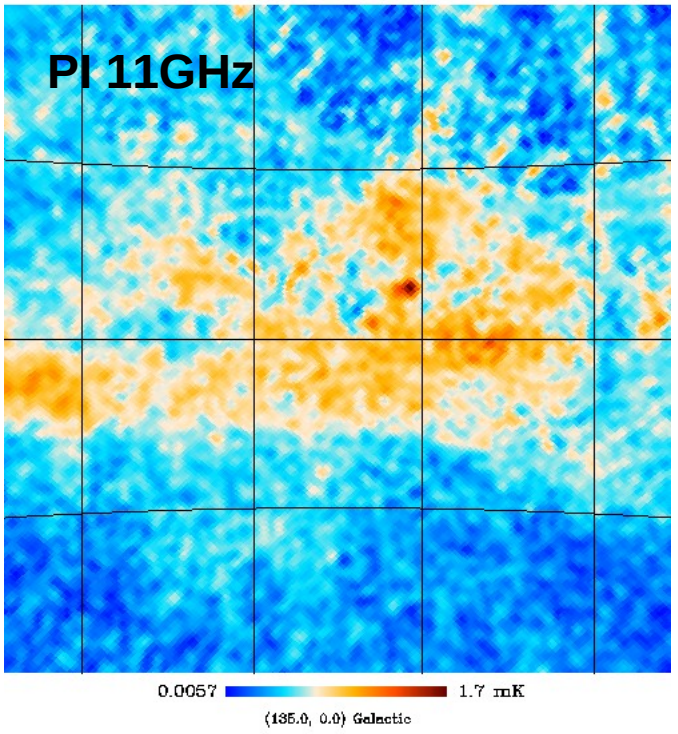


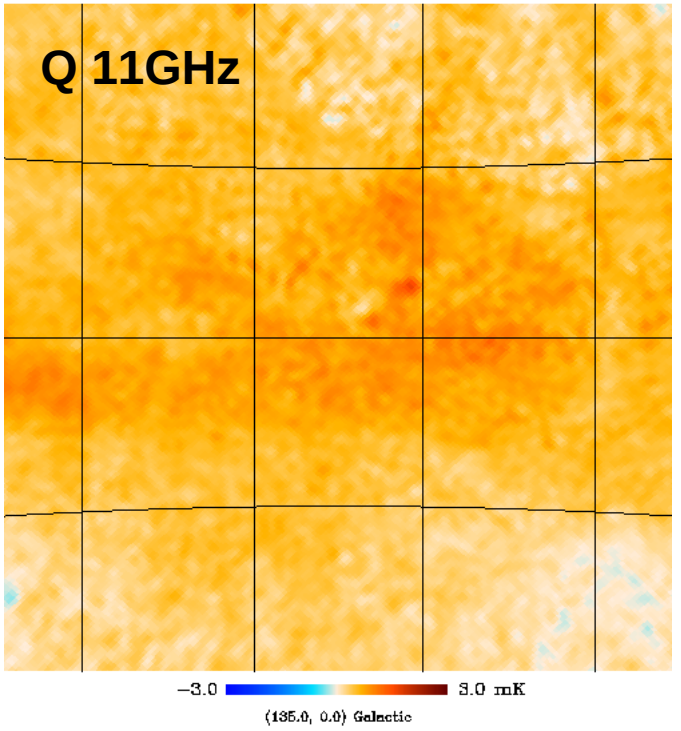
Centroid of emission in b=2.2º

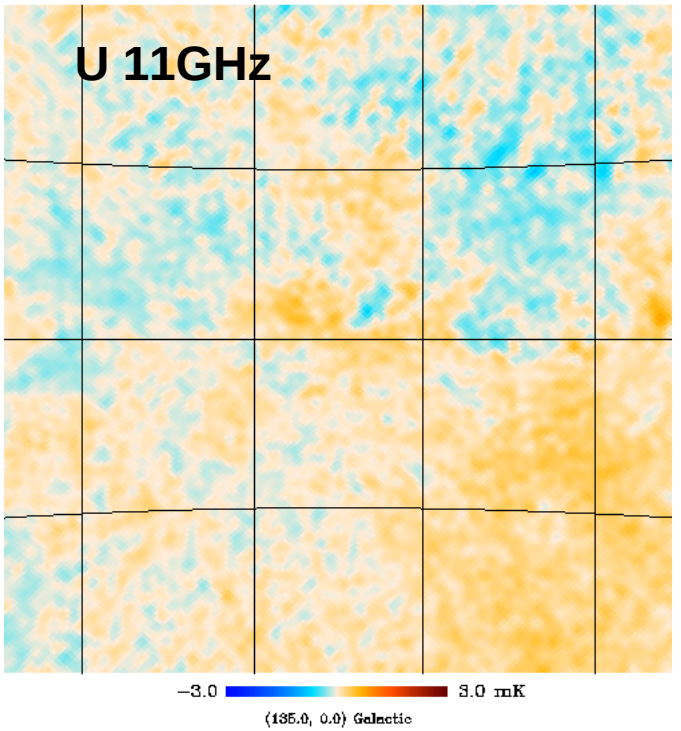
QUIJOTE observations at 11GHz.

All maps show a 40ºx40º region, centered around (l,b)=(135º,0º).









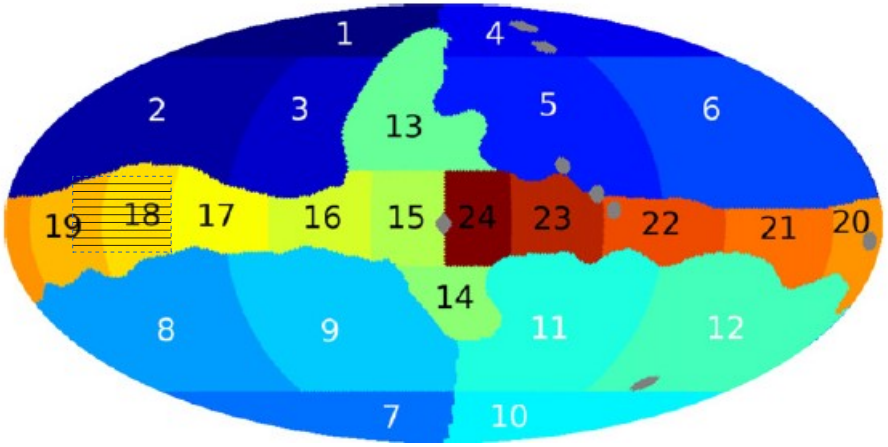
FAN in the wide survey

We mask the polarized sources in the region.

Spectral index in the region l=[122º, 155º], and b=[-12º, 12º], computed using **TTplots for Q (or P)**:

- 22-33GHz: -2.65 ± 0.13
- 11-22GHz: -2.89 ± 0.03
- 11-33GHz: -2.87 ± 0.06

Flattening between 22 and 33GHz!

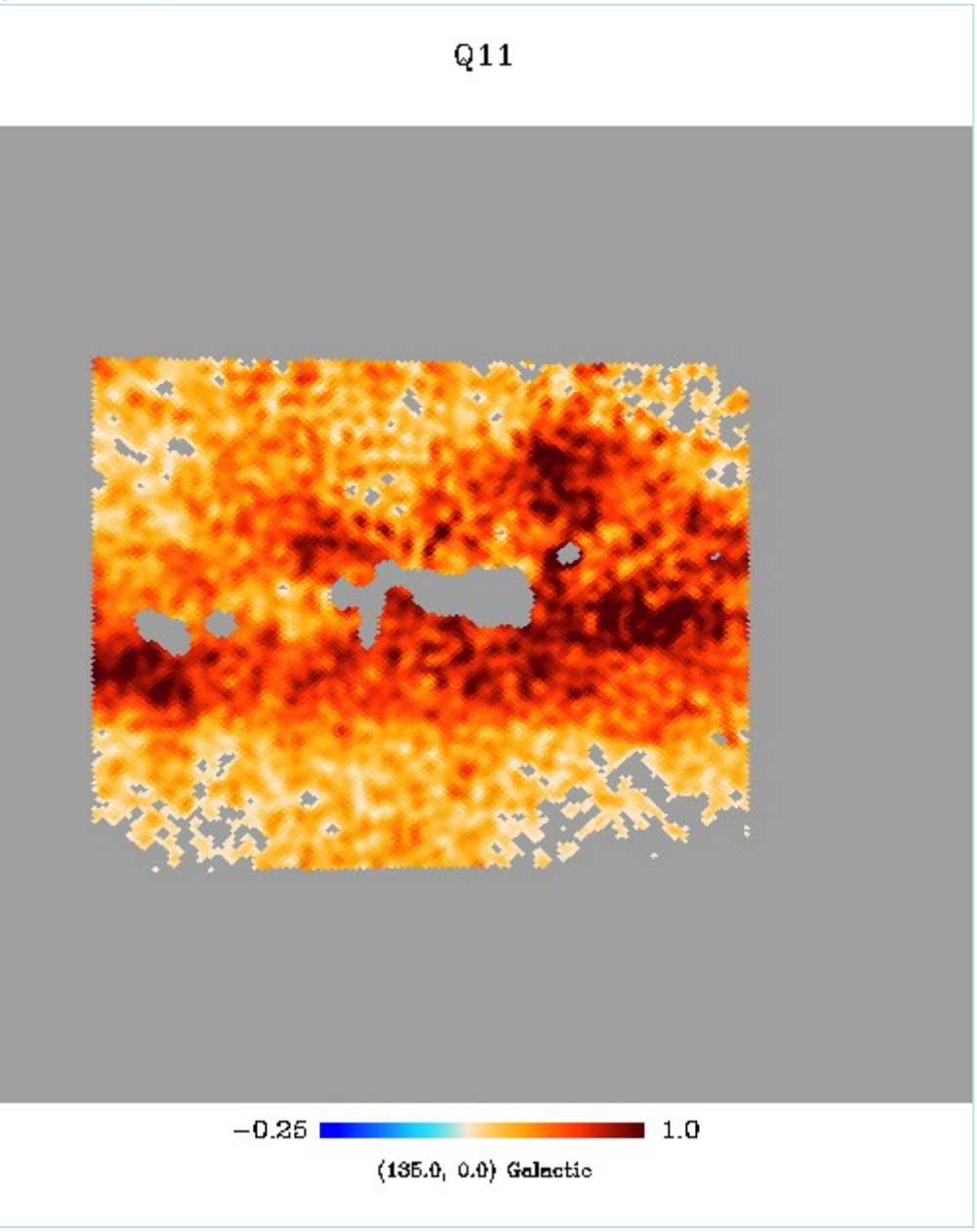


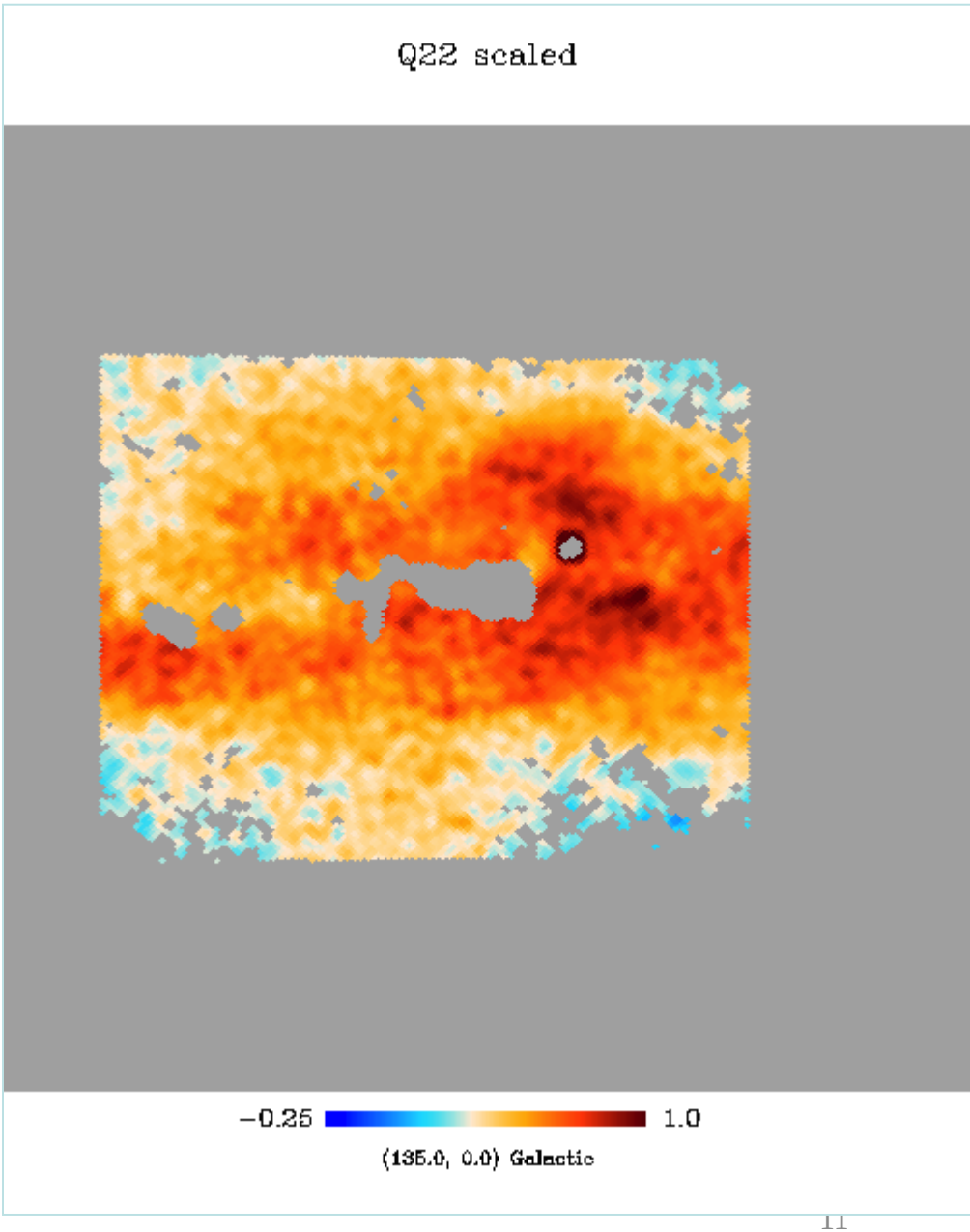
Fuskeland et al. (2014). Regions 18 and 19 cover the FAN region. Using WMAP data only they found (no source emission masked):

$$18 \quad -2.82 \pm 0.11$$
$$19 \quad -2.93 \pm 0.11$$

FAN in the wide survey

Scaling the Q 22GHz emission to 11GHz assuming beta=-2.6

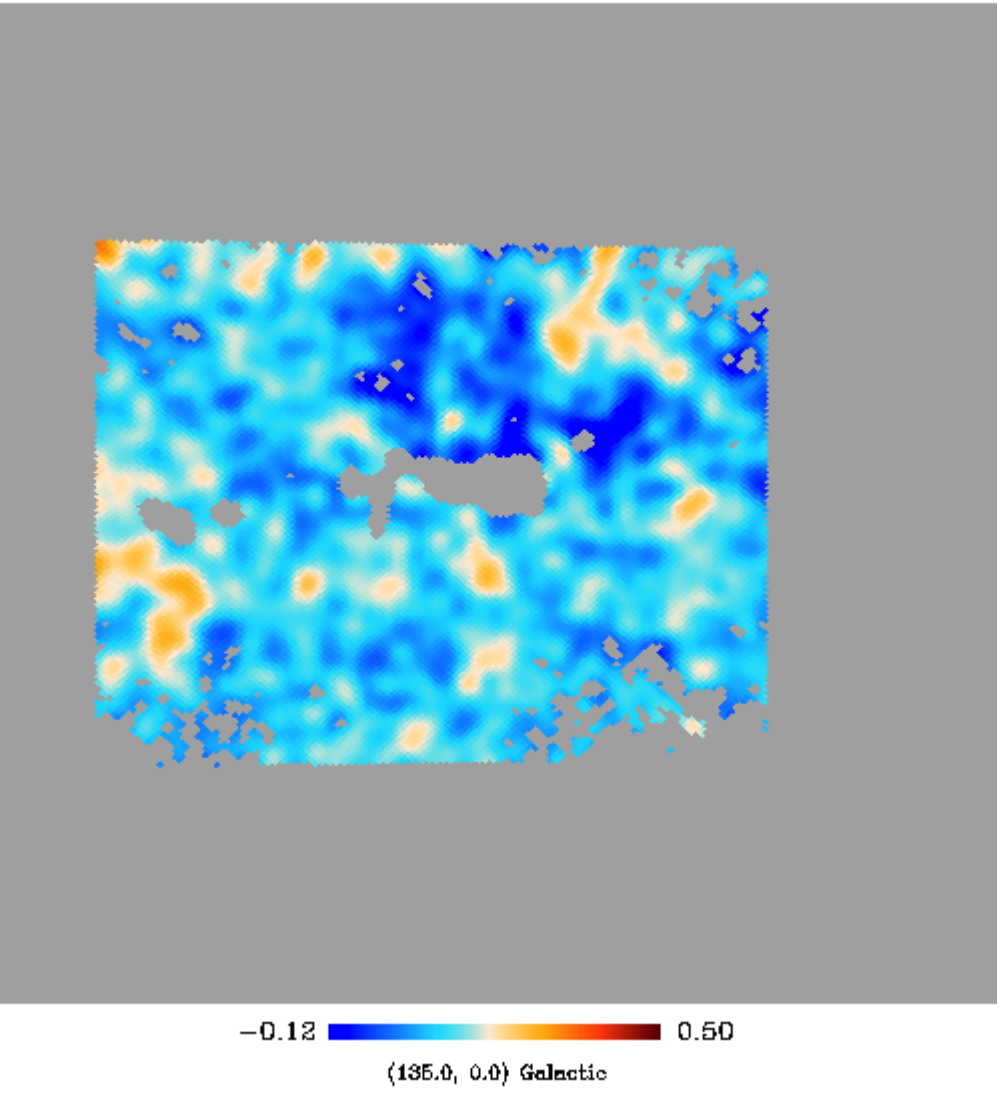




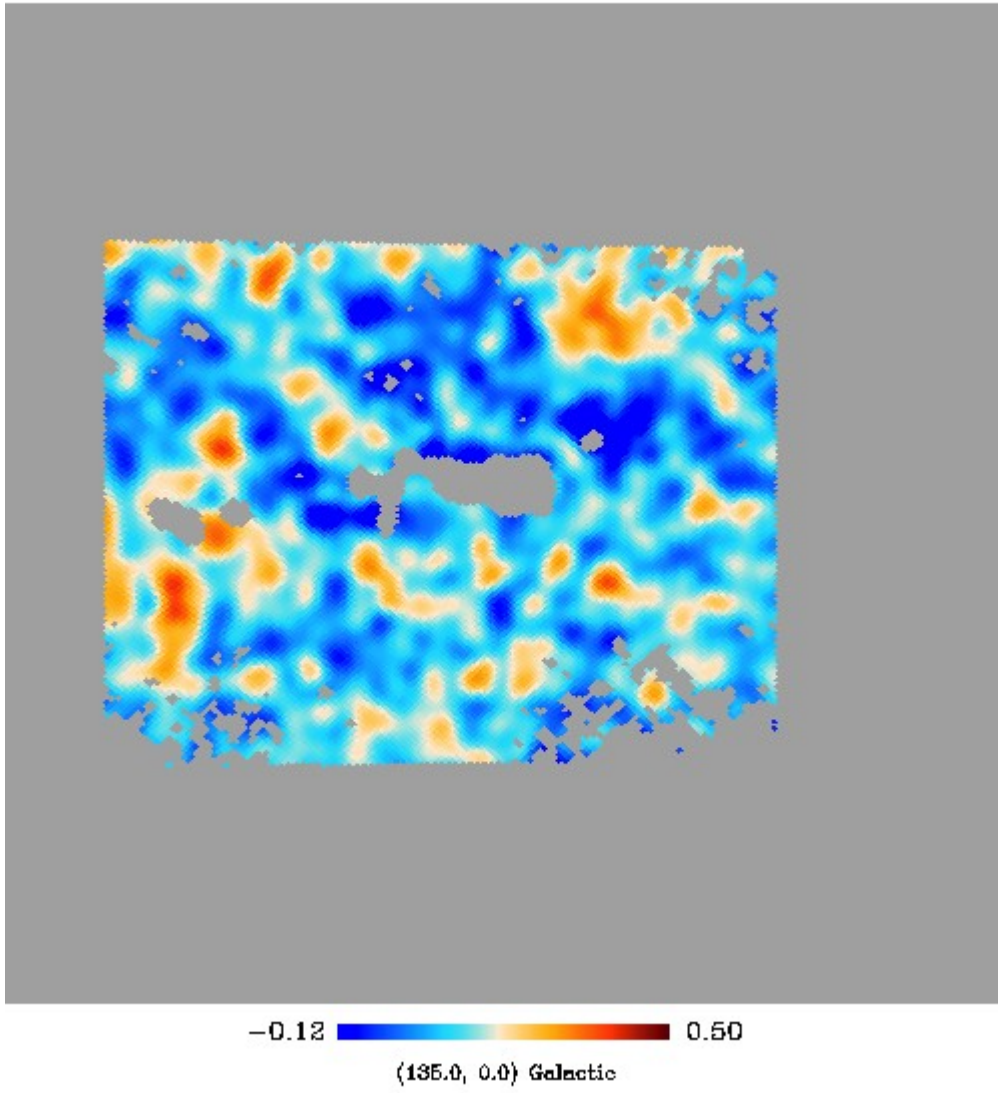
FAN in the wide survey

Residuals at Q 11GHz after correcting for the scaled emission (beta=-2.6)

Residual at 11GHz from 22GHz



Residual at 11GHz from 33GHz



FAN in the wide survey

* Conclusions on diffuse emission:

- Centroid of the emission seems to be shifted to positive values (above the plane). Hill et al. (2017) atribute this to positive warp of the disc in the Perseus arm (+1º).

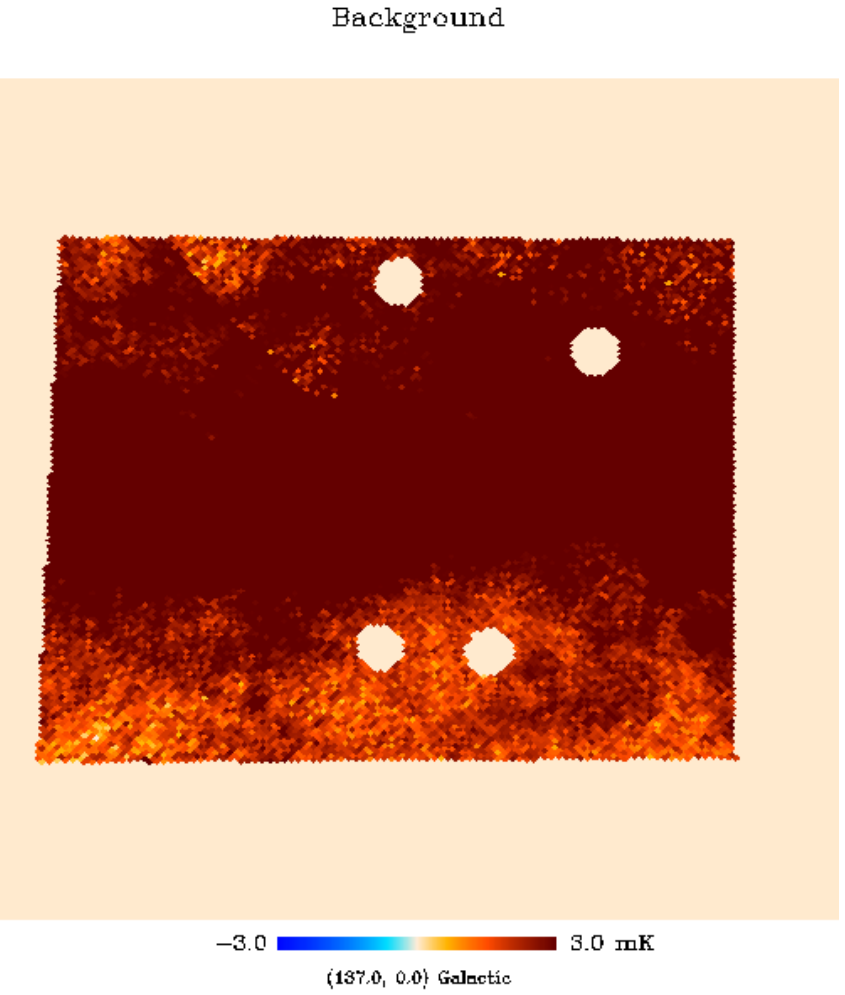
- Flattening of the spectral index of the polarised emission between 22 and 33GHz. Two populations of electrons?

- Residuals at 11GHz show diffuse emission in the region. Possible explanation: extragalactic cosmic ray contribution?

- In intensity the emission is compatible with mainly free-free emission.

2. Fluxes and SED

- Raster observations are used for computing the flux in the sources by doing aperture photometry. Flux is computing by considering the pixels of the source and masking everything else.
- Four different regions are considered for computing the background.



Fluxes

- Ancillary data used: Haslam, Reich, HartRAO, Urumqi, WMAP, Planck and DIRBE.
- The SED is fitting to several components: free-free, synchrotron, thermal dust, AME, CMB (see Poidevin's talk).
- Commander simulations and Finkbainer are used to infer some information about EM, electron temperature, etc.

SED in intensity: W3

- **Fit models:**

  dash-blue: sync

  purple: free-free

  red: AME

  orange: dust

- **Data points:**

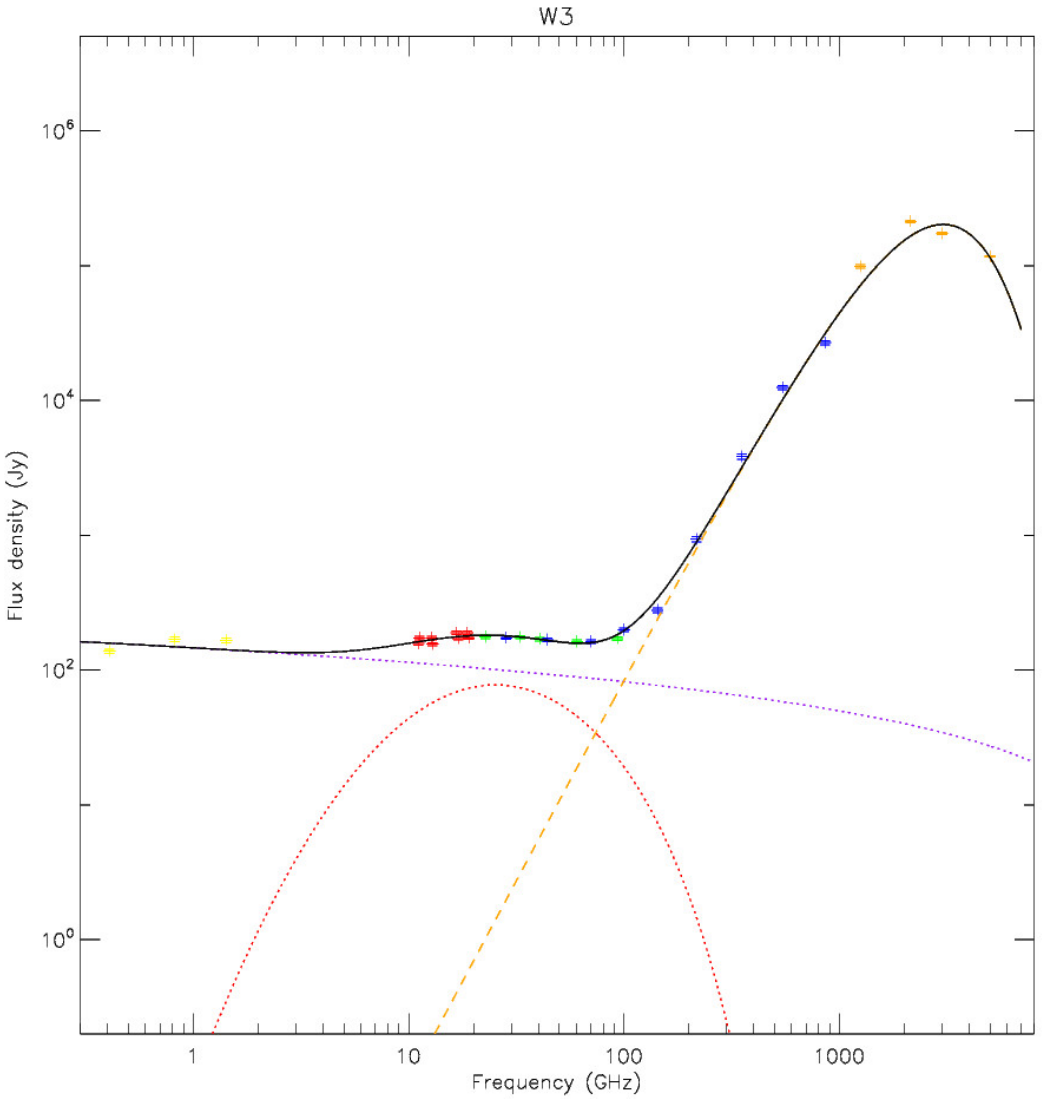
  yellow: Has, Rei, Har

  red: QUIJOTE

  green: WMAP

  blue: Planck

  orange: DIRBE



SED in intensity: W4

- **Fit models:**

  dash-blue: sync

  purple: free-free

  red: AME

  orange: dust

- **Data points:**

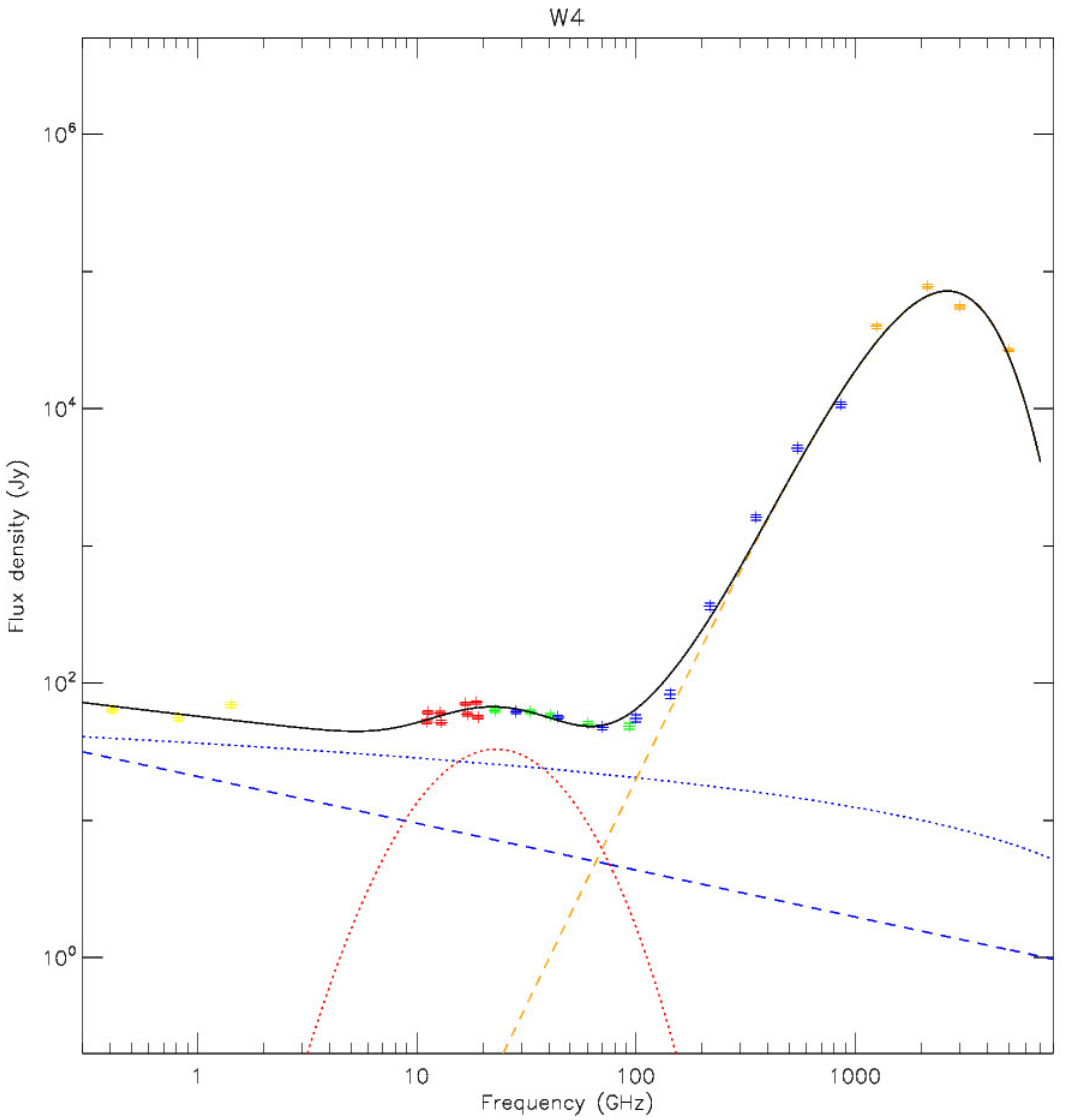
  yellow: Has, Rei, Har

  red: QUIJOTE

  green: WMAP

  blue: Planck

  orange: DIRBE



SED in intensity: W5

- **Fit models:**

  dash-blue: sync

  red: AME

  orange: dust

- **Data points:**

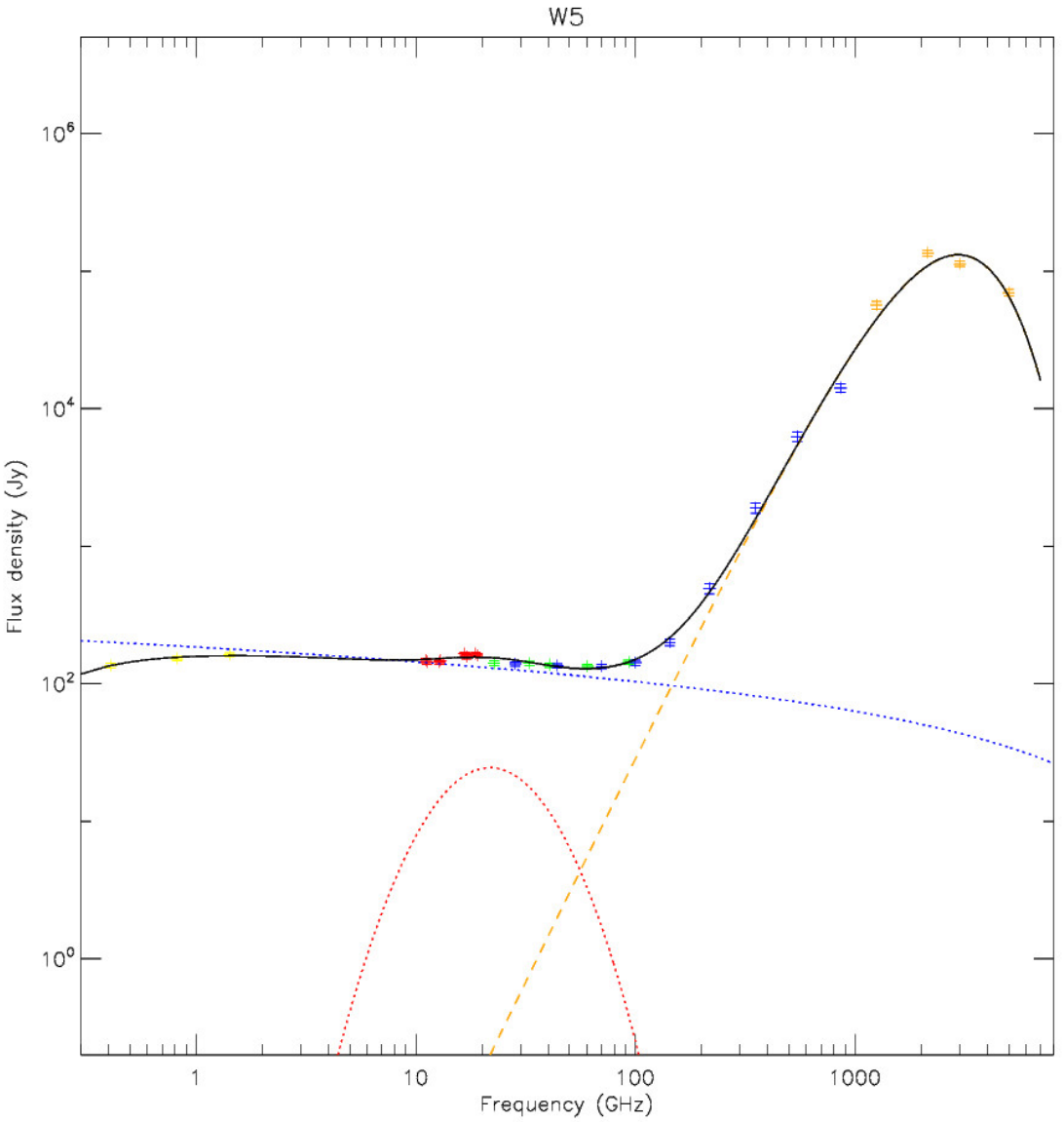
  yellow: Has, Rei, Har

  red: QUIJOTE

  green: WMAP

  blue: Planck

  orange: DIRBE



Conclusions

- First analysis of the spectral energy distribution of the sources of the Fan: W3, W4, W5:

  - We found evidences for AME in molecular clouds W3, W4 and W5 when QUIJOTE frequencies are included (in I).

- Diffuse emission is dominated by free-free emission in intensity while in polarization, we find evidence for a turn-off in the spectral index of the synchrotron:

  -This could be interpreted as two populations of cosmic rays.

THANK YOU FOR YOUR ATTENTION.