Polarized point sources in the QUIJOTE Wide Survey

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CMB foregrounds for B-mode studies
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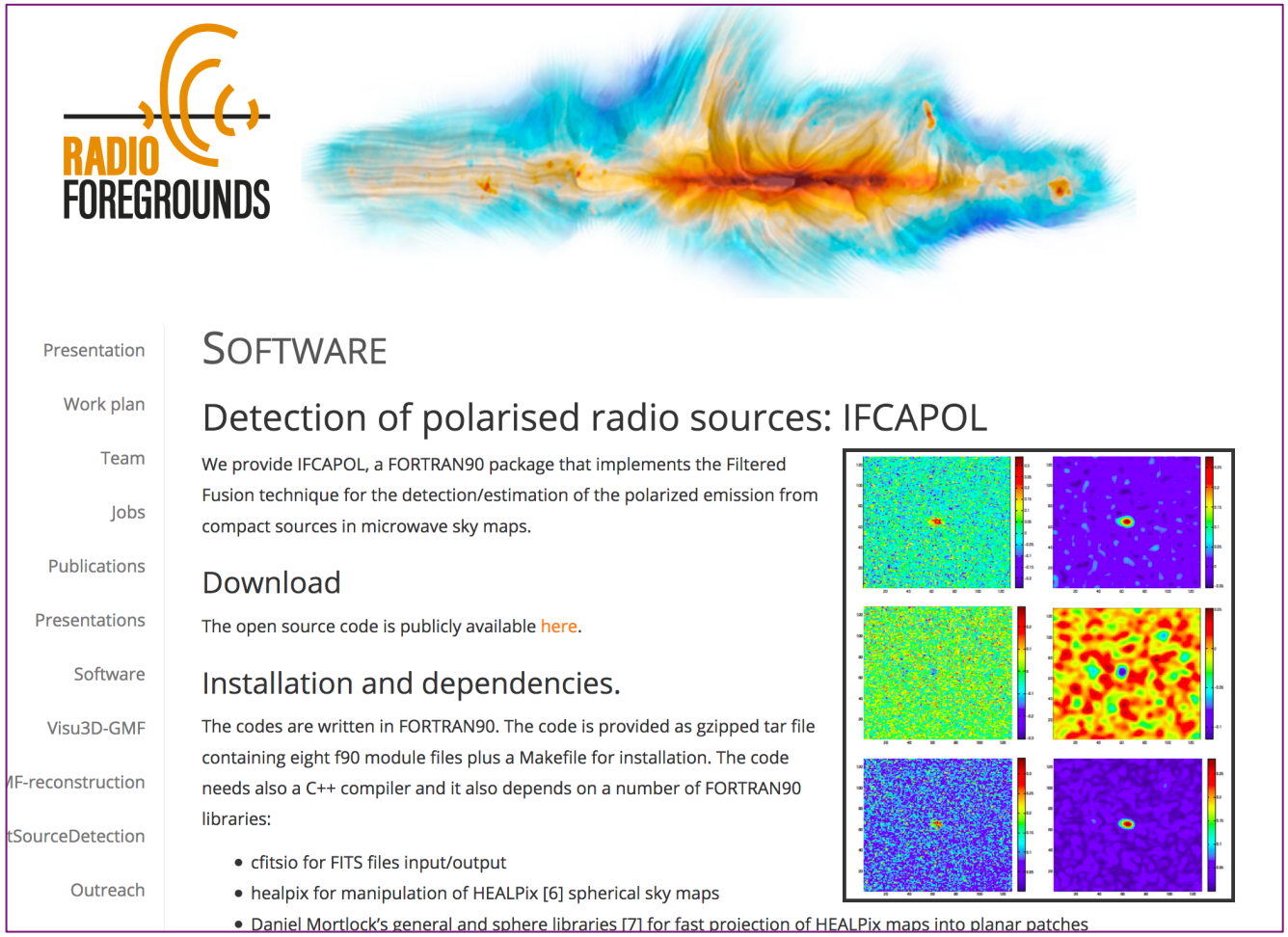
Overview

- Method
- Sample
- The RADIOFOREGROUNDS point source catalogue, v1.0
  - Consistency checks
  - Validation
  - Statistical properties
- Conclusions

Method: Filtered Fusion (FF)

A Python 3 version of IFCAPOL



1. F. Argüeso, J. L. Sanz, D. Herranz, M. Lopez-Caniego, and J. González-Nuevo, *"Detection/estimation of the modulus of a vector. Application to point-source detection in polarization data,"* MNRAS, vol. 395, no. 2, pp. 649–656, 2009.

2. M. López-Caniego, M. Massardi, J. González-Nuevo, L. F. Lanz, D. Herranz, G. de Zotti, J. L. Sanz, and F. Argüeso, "*Polarization of the WMAP Point Sources,*" ApJ, vol. 705, no. 1, pp. 868–876, Nov. 2009

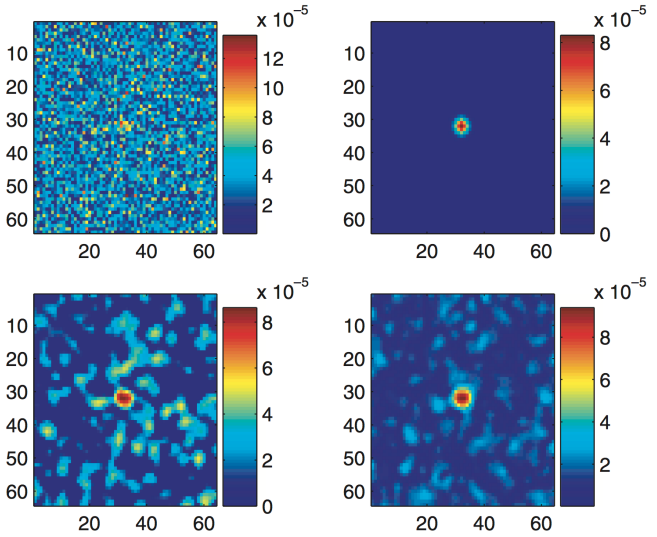
Method: Filtered Fusion (FF)

- Small flat patches
- **Matched filter** for Q and U maps

$$Q_{MF}, U_{MF} = \psi_{Q,U} \otimes Q, U$$

$$\psi_{Q,U}(k) \propto \frac{\tau_b(k)}{P_{Q,U}(k)}$$

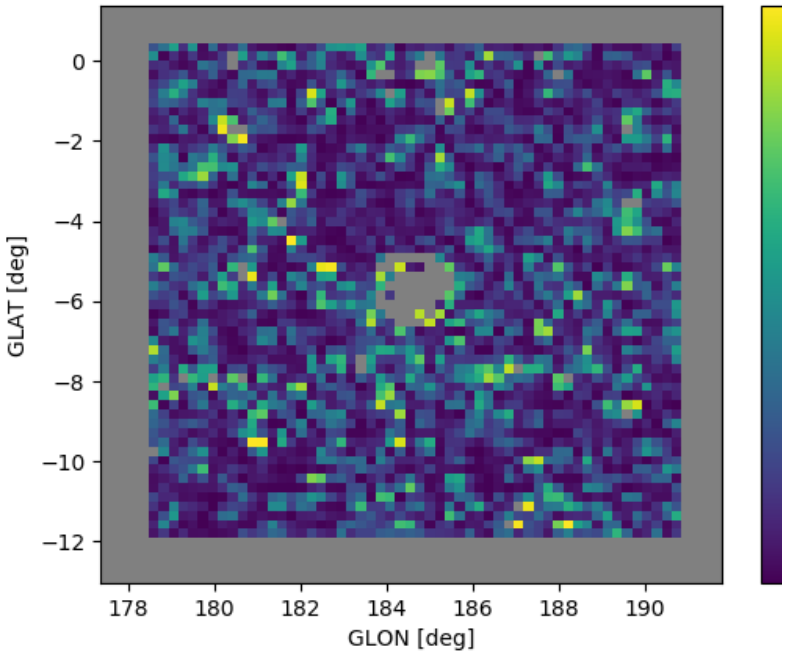
  - Unbiased
  - Maximum efficiency
  - Optimal for Gaussian color noise

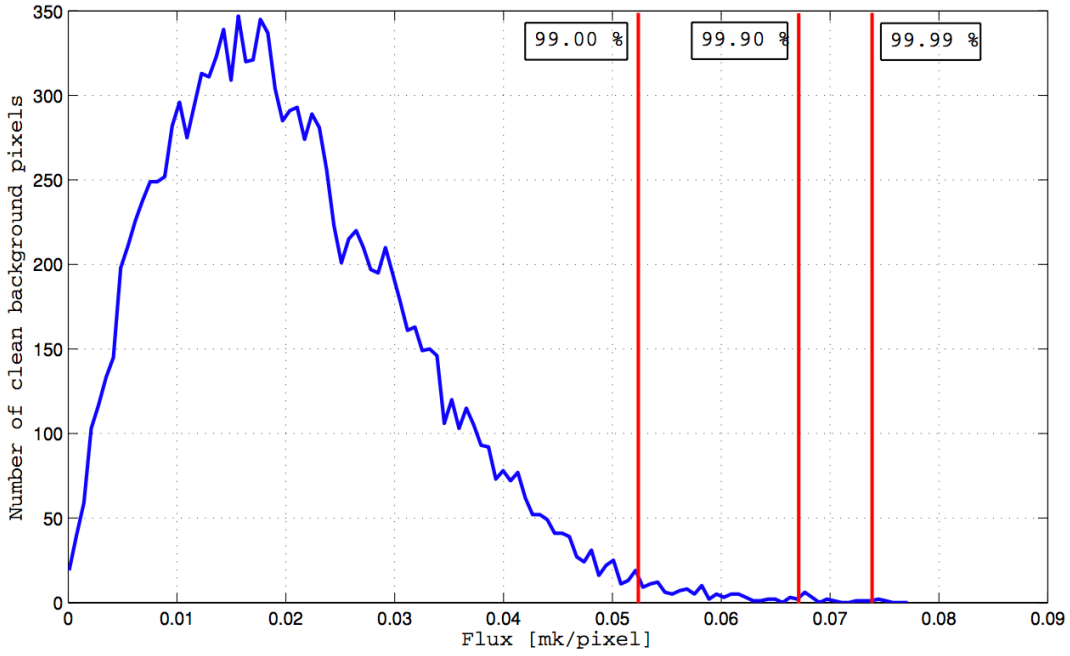


- $P = (Q_{MF}^2 + U_{MF}^2)^{1/2}$ ➔ non-Gaussian residual noise!
  - Detection significance instead of SNR (although SNR is still useful)

Method: Filtered Fusion (FF)

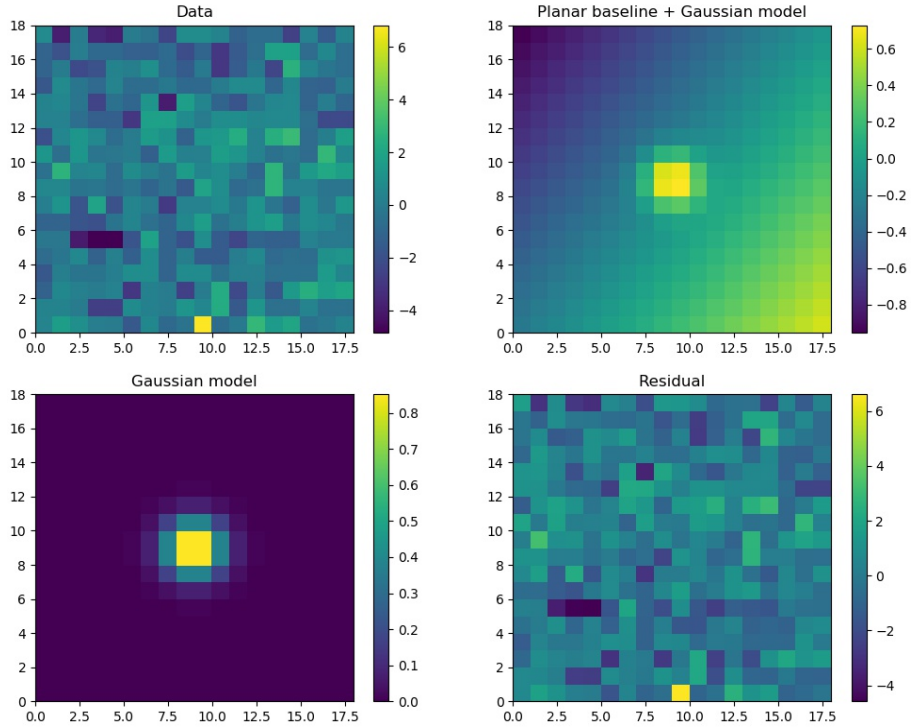
- Significance of the detections
  - Mask borders and source (5% brightest pixels)





Additional method: *Q*,*U* Gaussian fitting

- Fit to a Gaussian profile + planar baseline
- For white noise, equivalent to FF



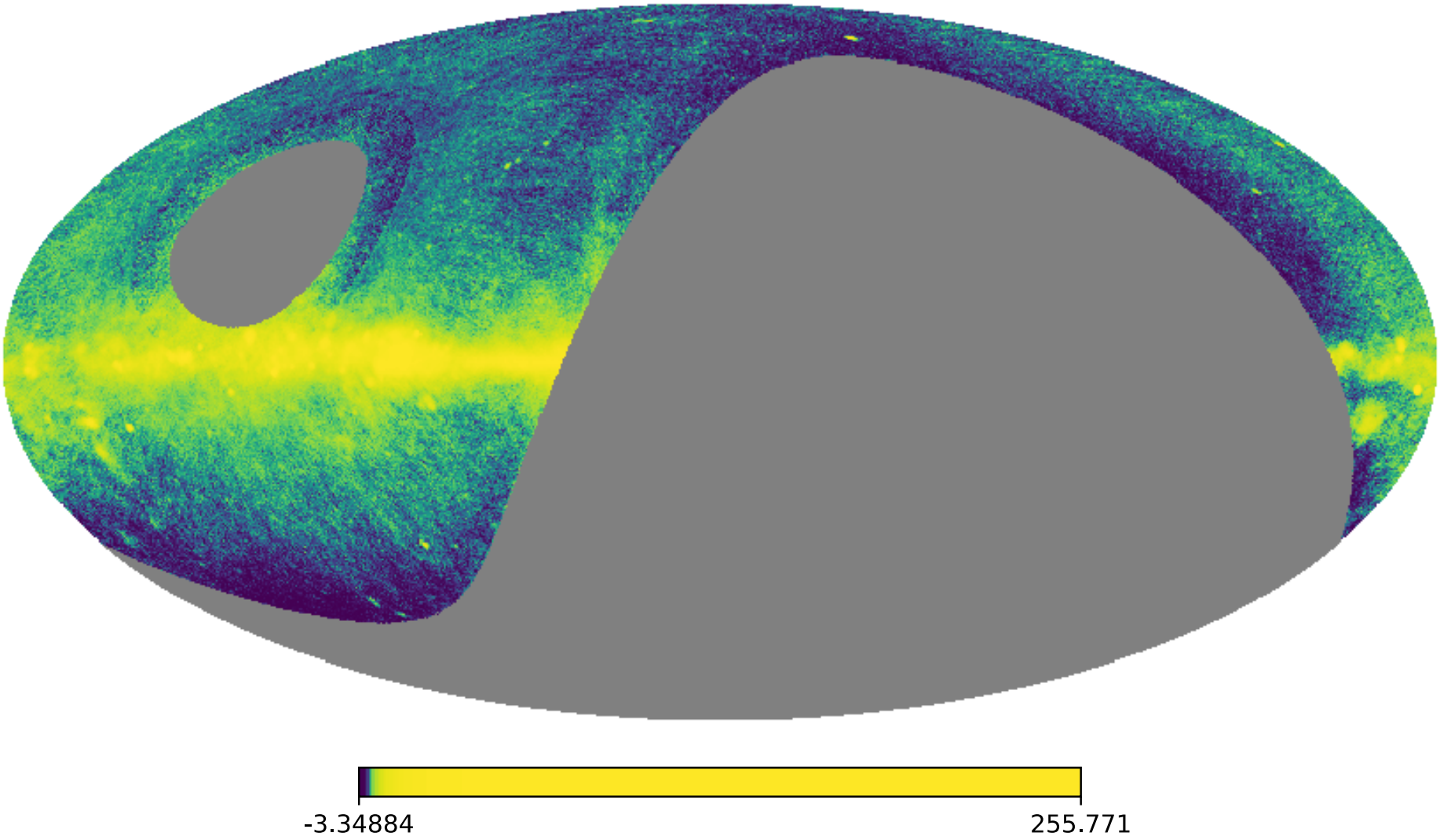
- Extra consistency check
- Particular sources

The sample: Planck PCCS2 polarized sample at 30 GHz

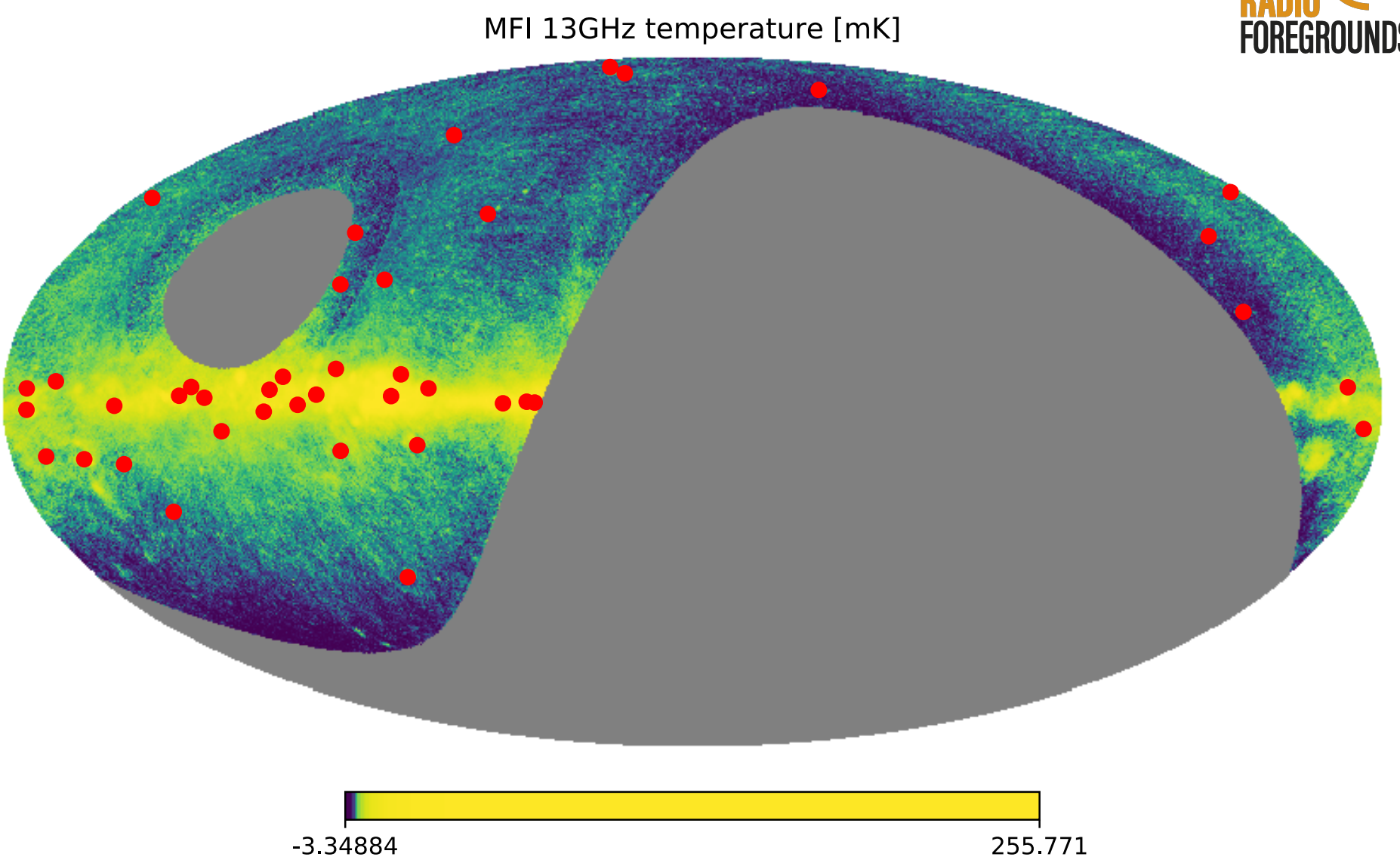
- Non blind search
- P. Collaboration, "*Planck 2015 results. XXVI. The Second Planck Catalogue of Compact Sources*," Astronomy & Astrophysics, 594, A26, 2016.
- 114 sources detected with significance >99.99% or, at least, as 99% upper limits
- Providing *I*, *P*, ϕ values at 30 GHz as reference
- 41 sources in the Wide Survey area
  - Most of them in the Galactic Plane
  - A few near the mask border

RADIO FOREGROUNDS

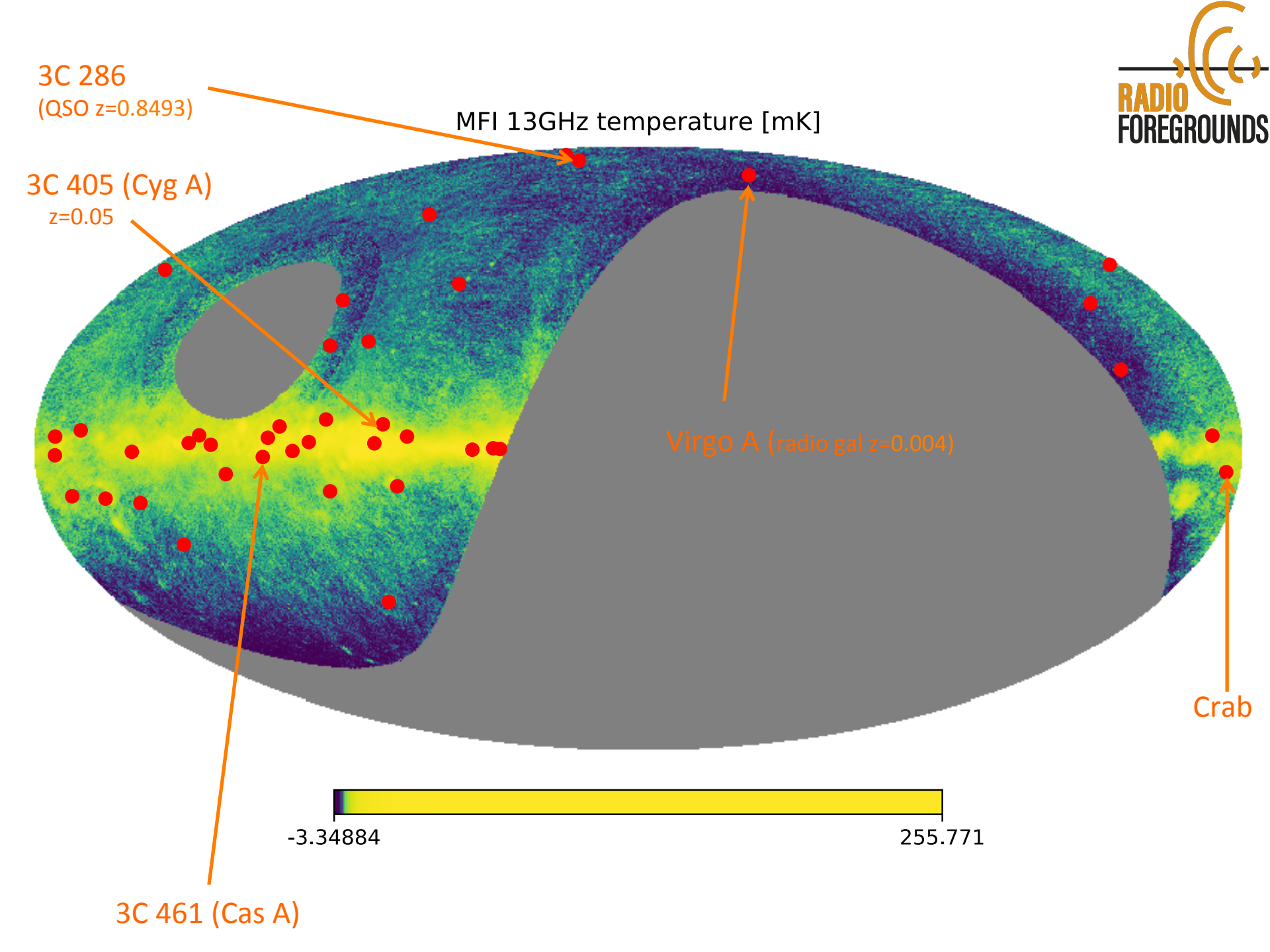
MFI 13GHz temperature [mK]



RADIO FOREGROUNDS



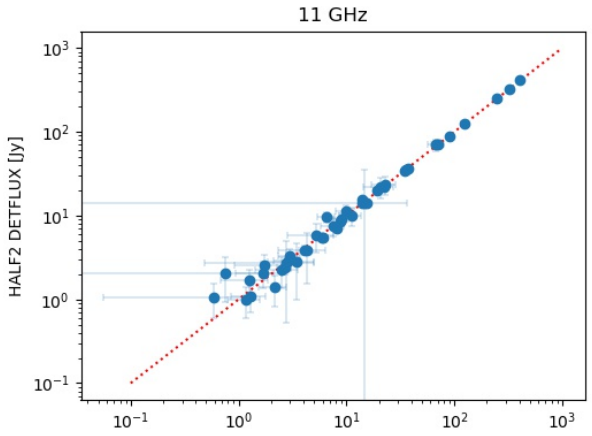
41 sources

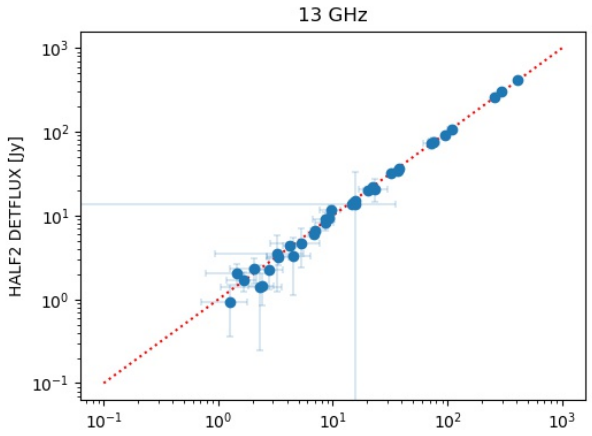

3C 286
(QSO z=0.8493)
MFI 13GHz temperature [mK]
3C 405 (Cyg A)
z=0.05
Virgo A (radio gal z=0.004)
Crab
-3.34884
255.771
3C 461 (Cas A)
RADIO
FOREGROUNDS

Results: consistency checks

- Half survey vs. half survey: intensity

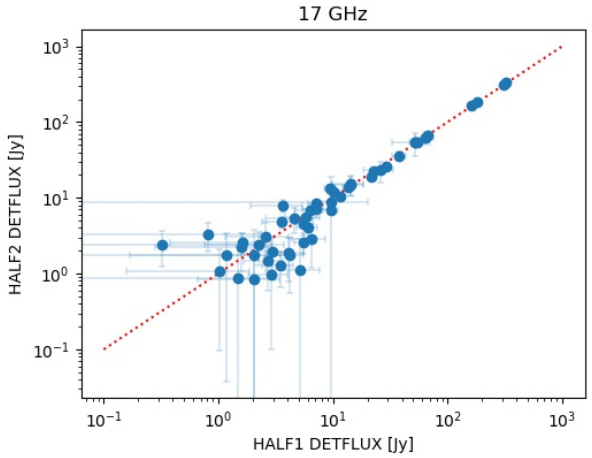
$y = 1.002\,x - 0.066$

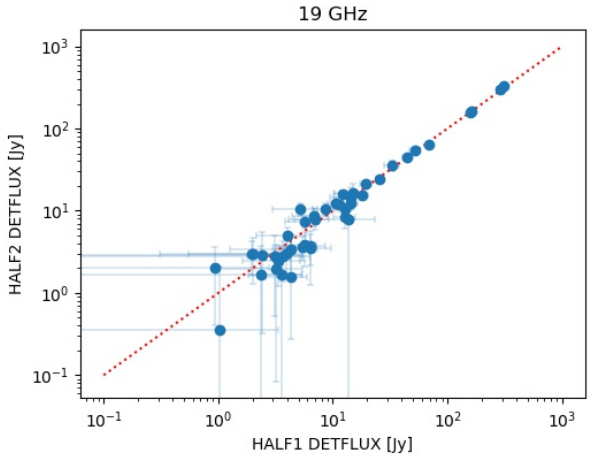




$y = 1.001\,x - 0.32$

$y = 1.024\,x - 0.723$



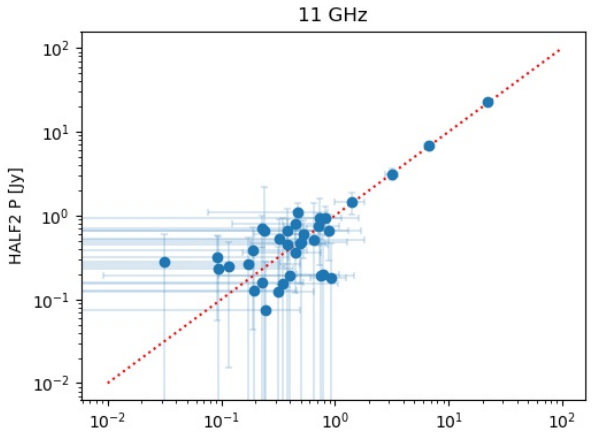


$y = 1.024\,x - 0.501$

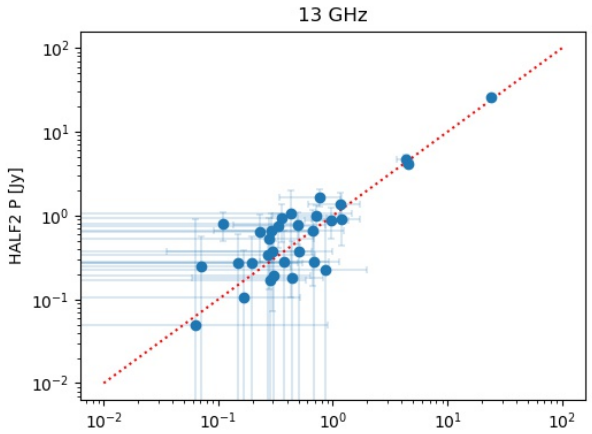
Results: consistency checks

- Half survey vs. half survey: polarization

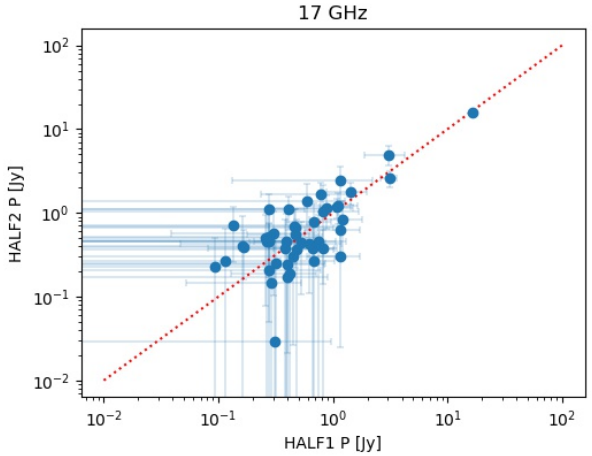
$y = 1.039\,x - 0.016$



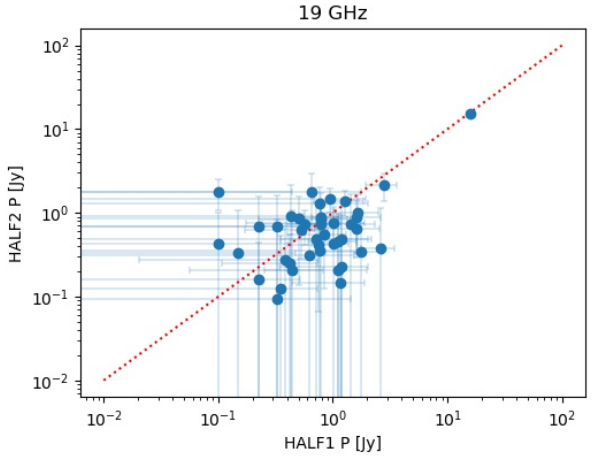
$y = 1.062\,x + 0.860$



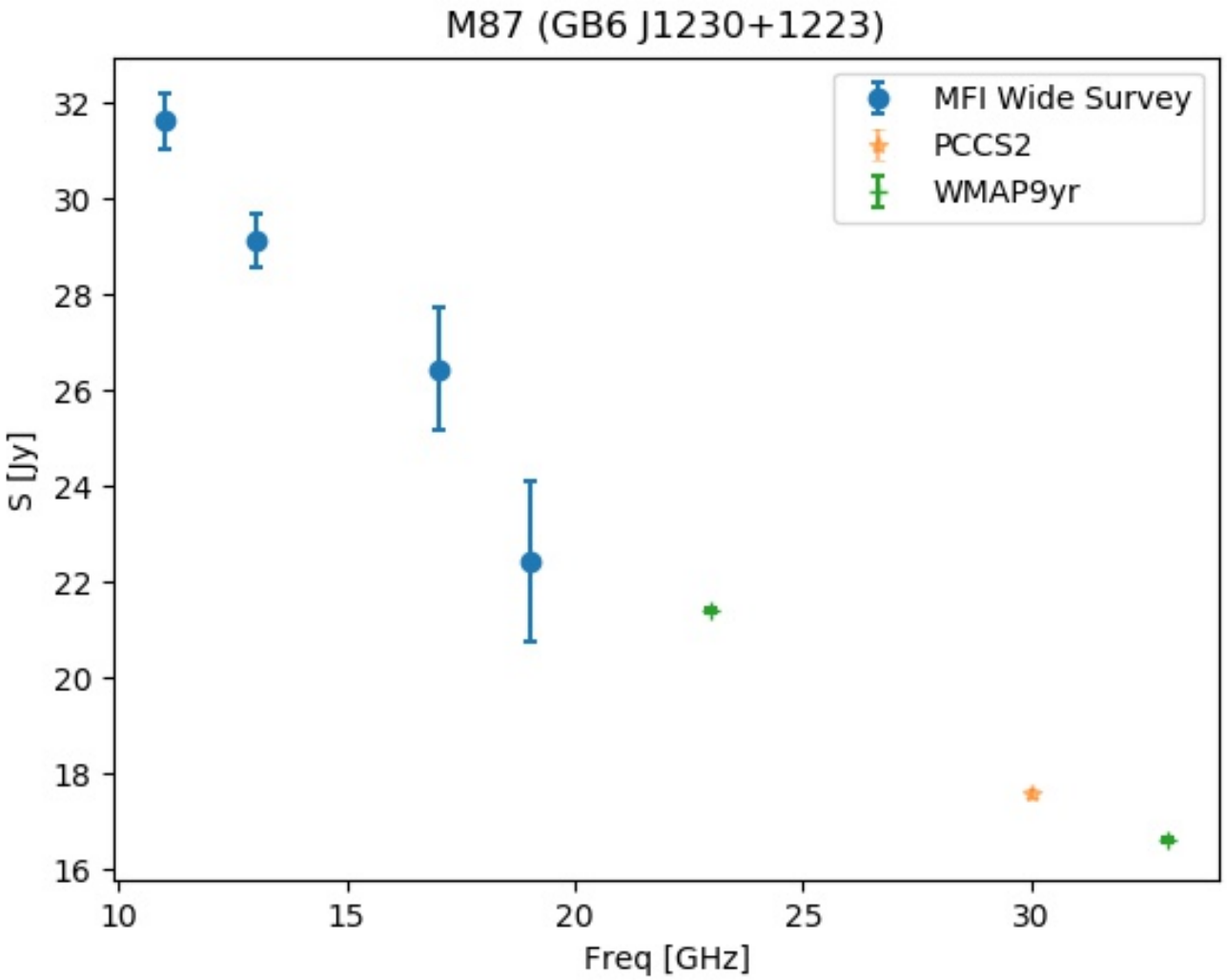
$y = 0.045\,x + 0.040$



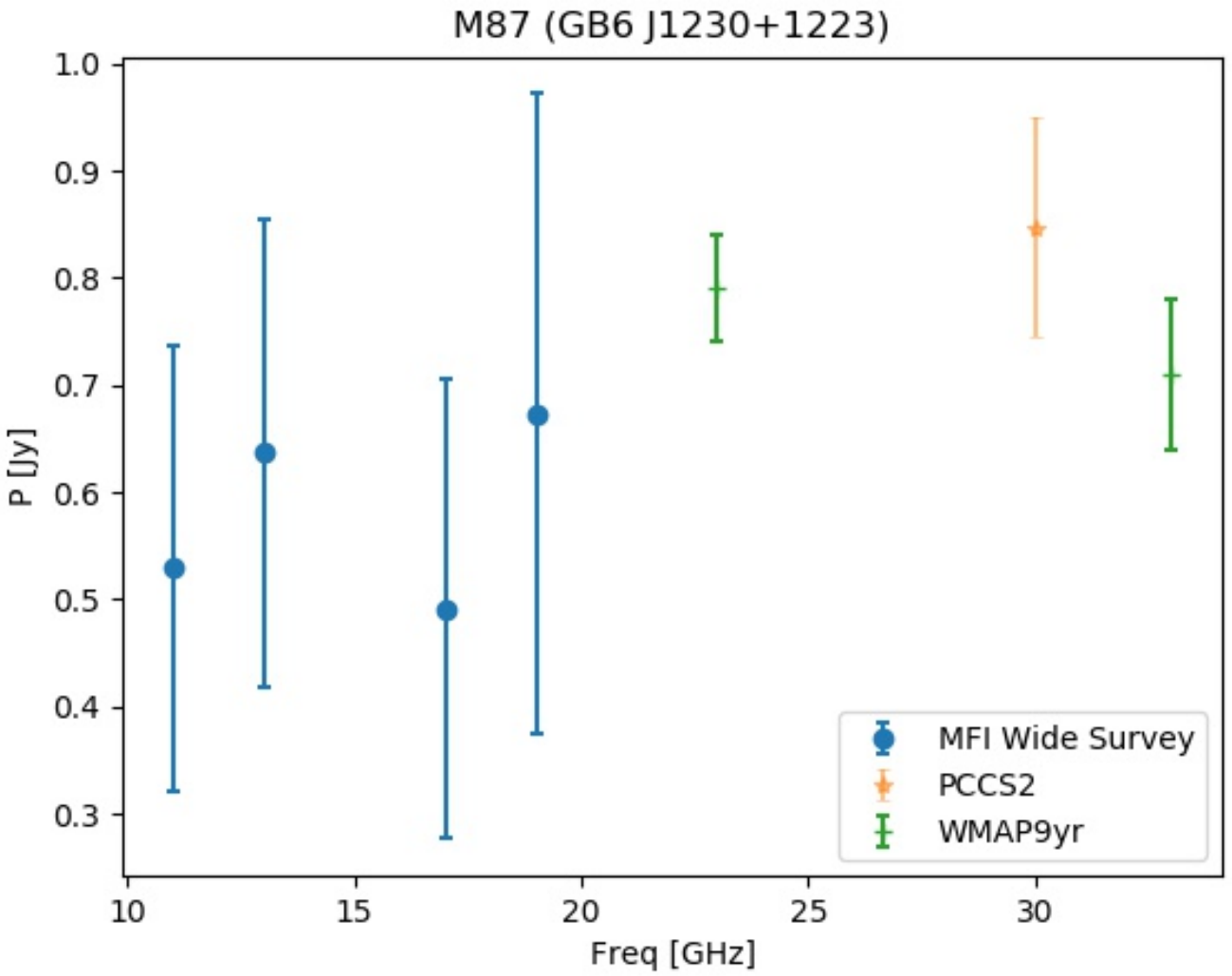
$y = 0.958\,x - 0.112$



Results: validation

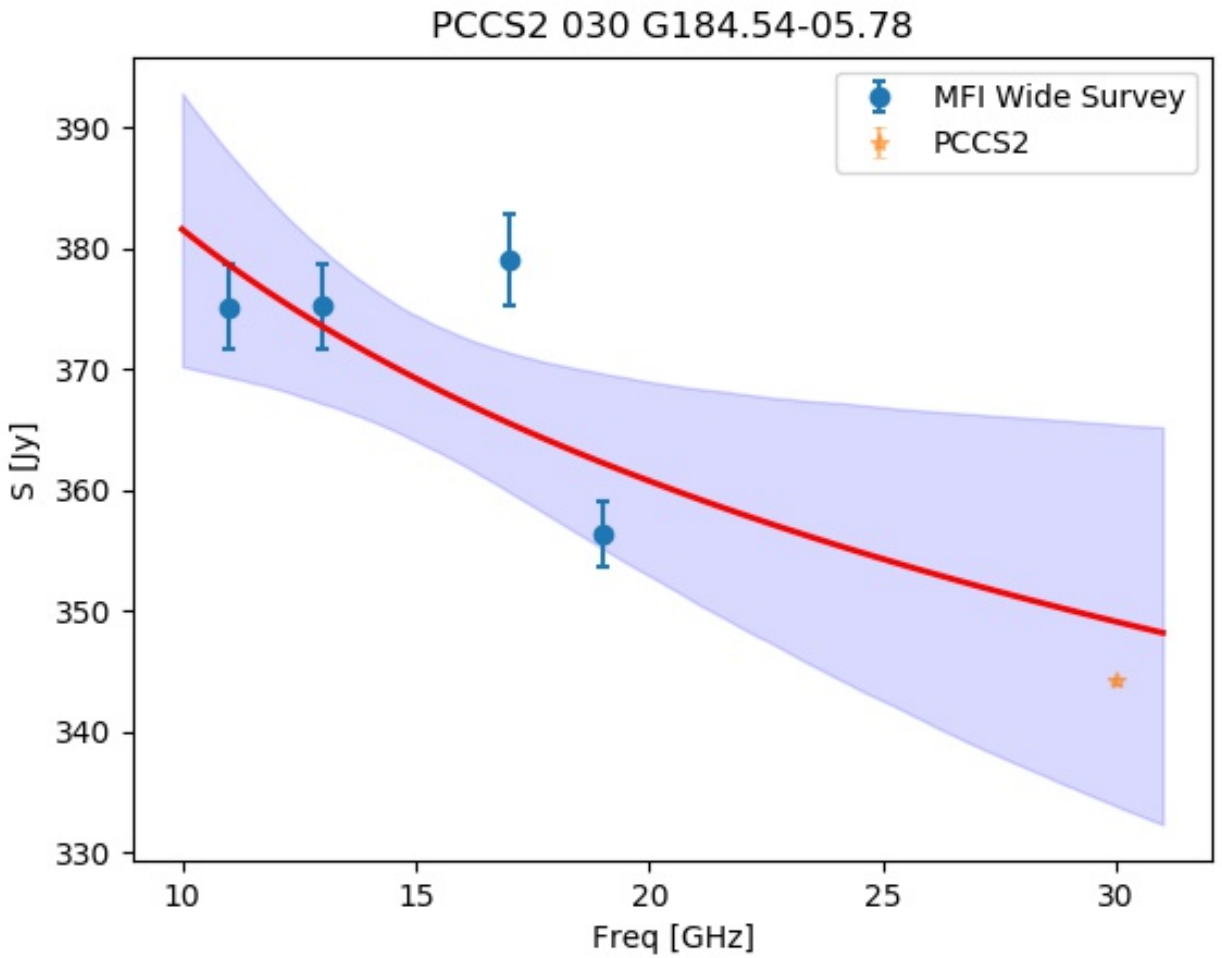


Results: validation

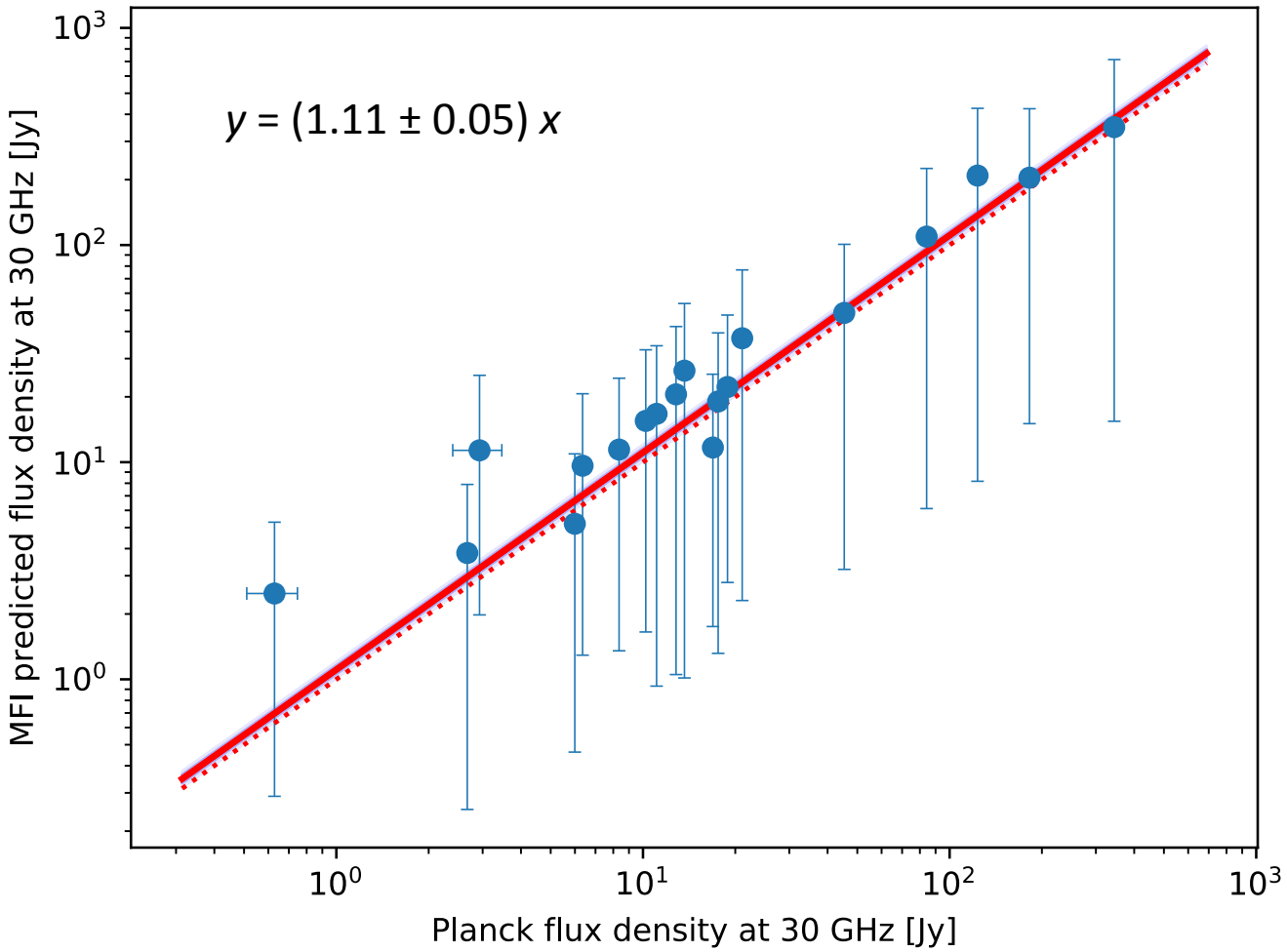


Results: validation (*Planck*)

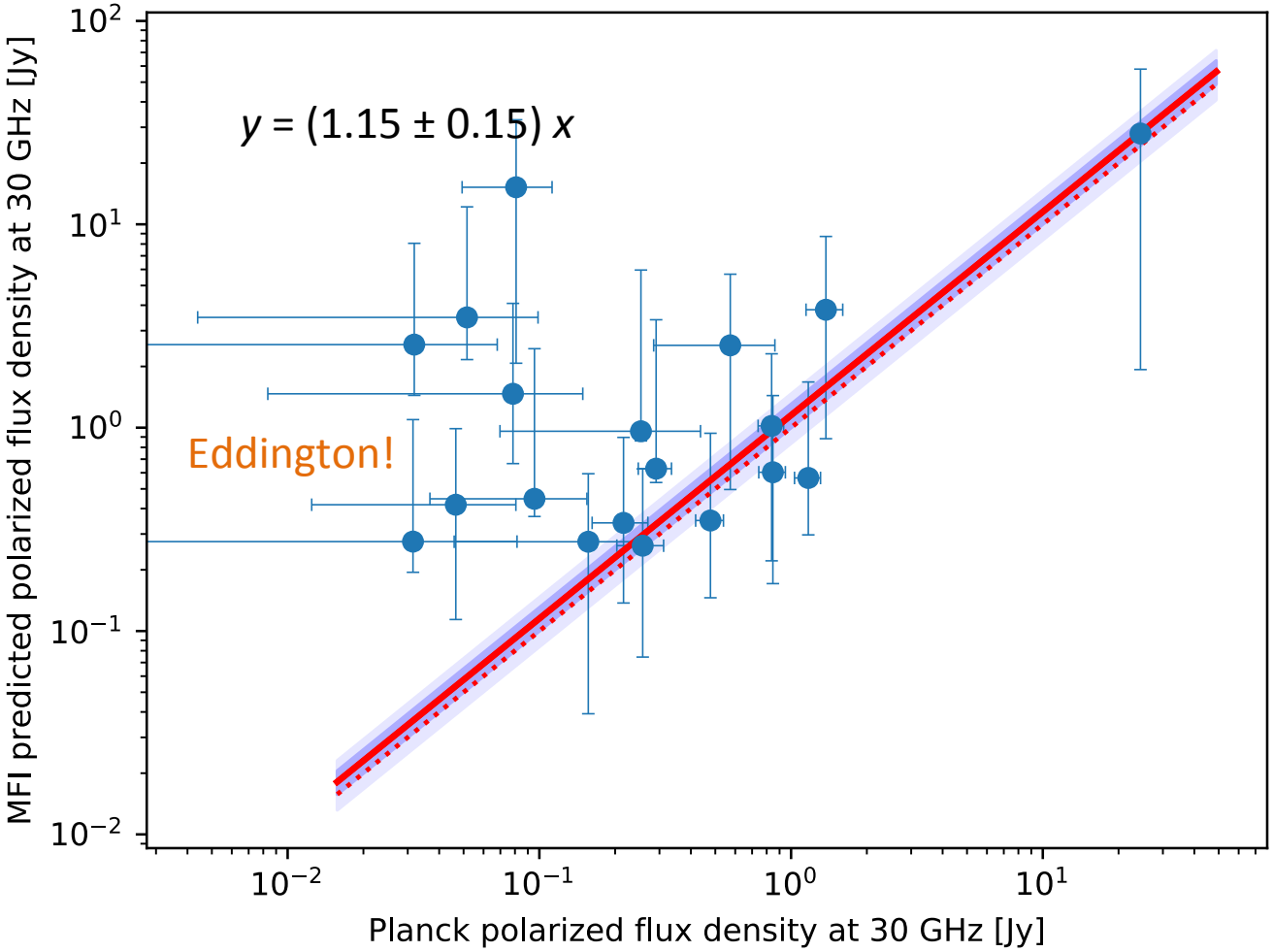
Fit a spectral index to QUIJOTE data and extrapolate to 30 GHz



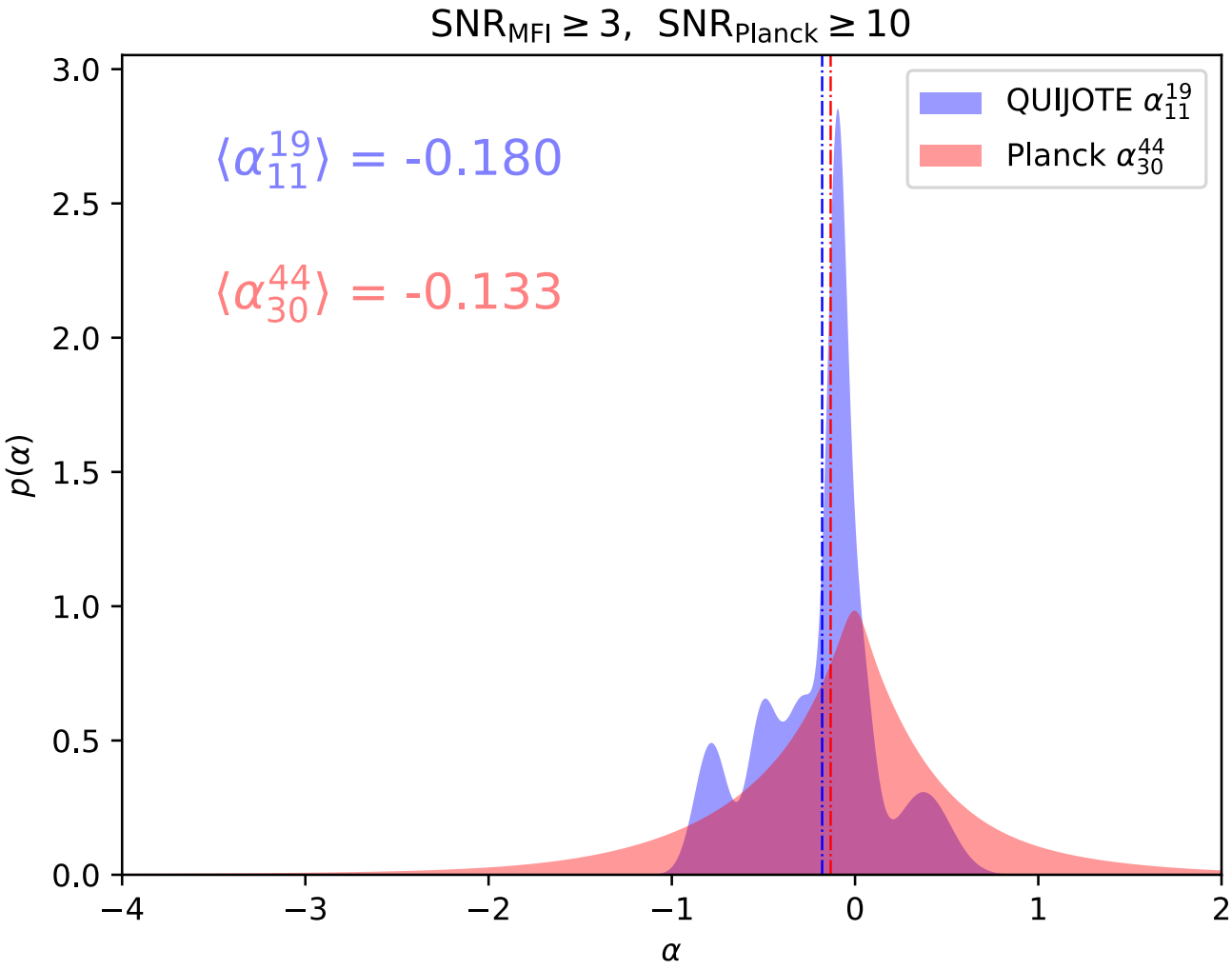
Results: validation (Planck)



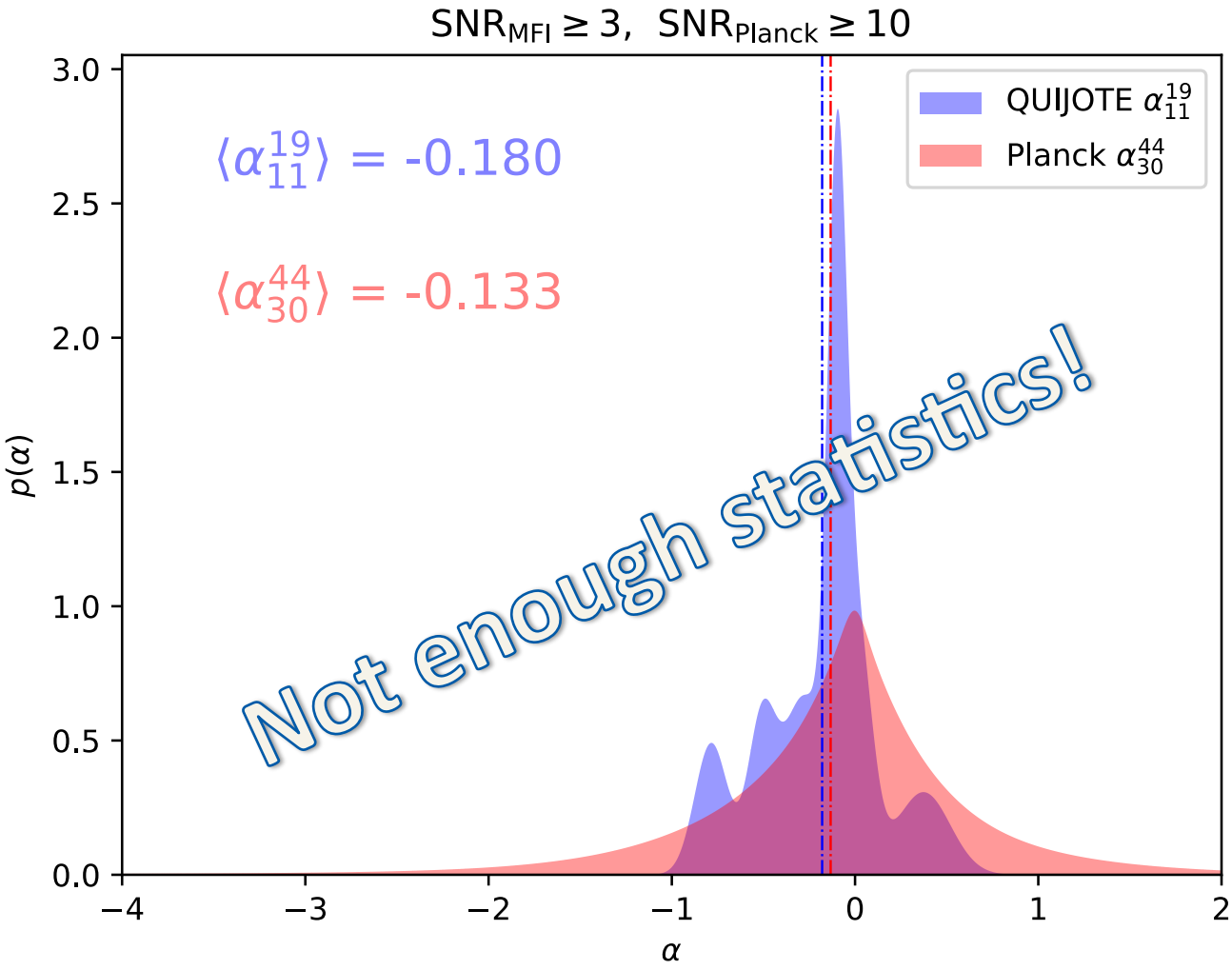
Results: validation (Planck)



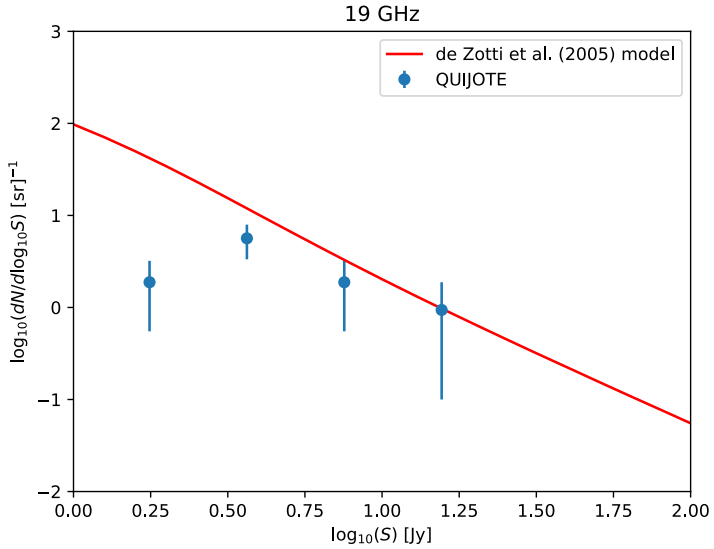
Results: statistical analysis

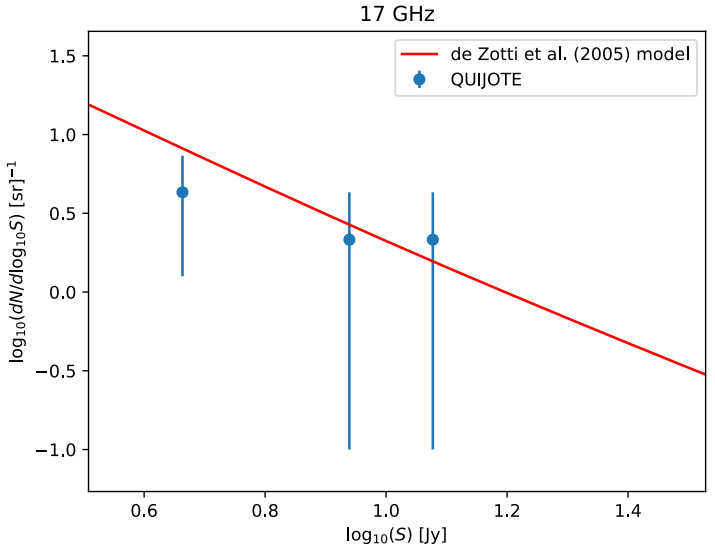


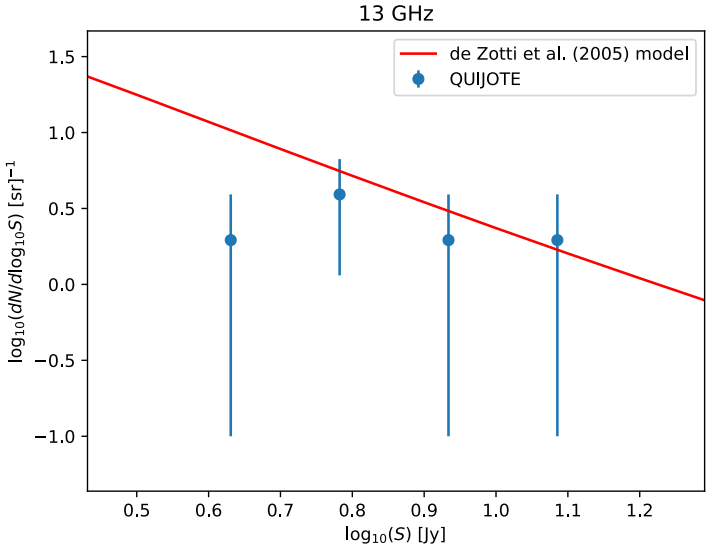
Results: statistical analysis

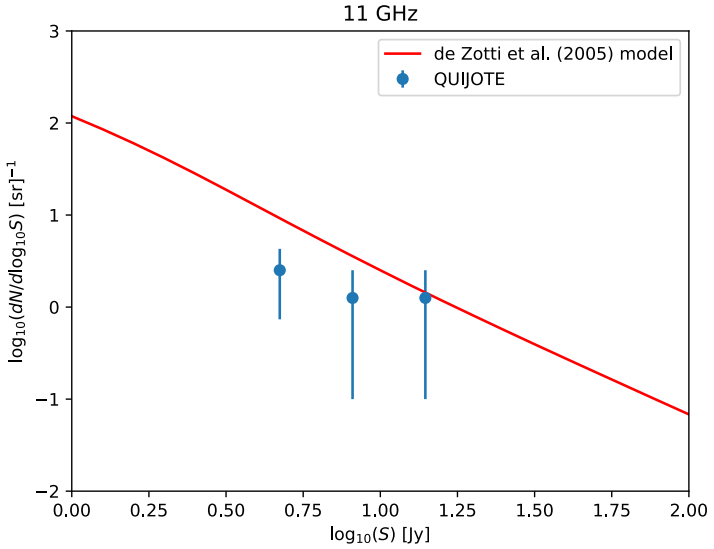


Results: statistical analysis

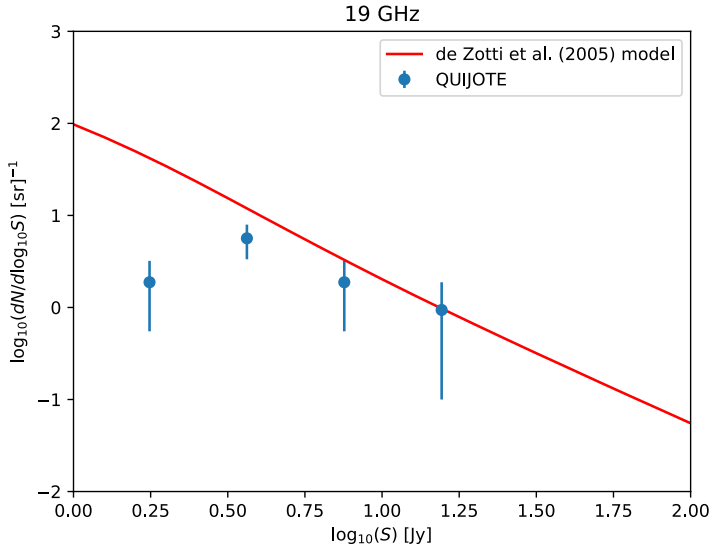


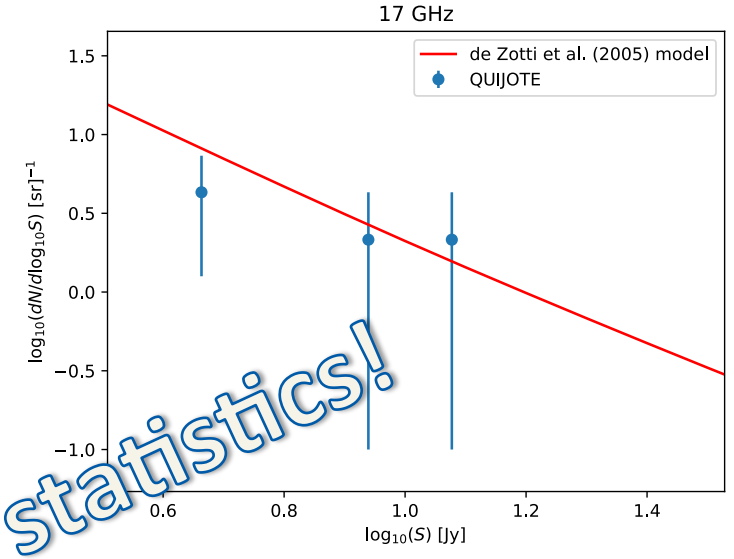




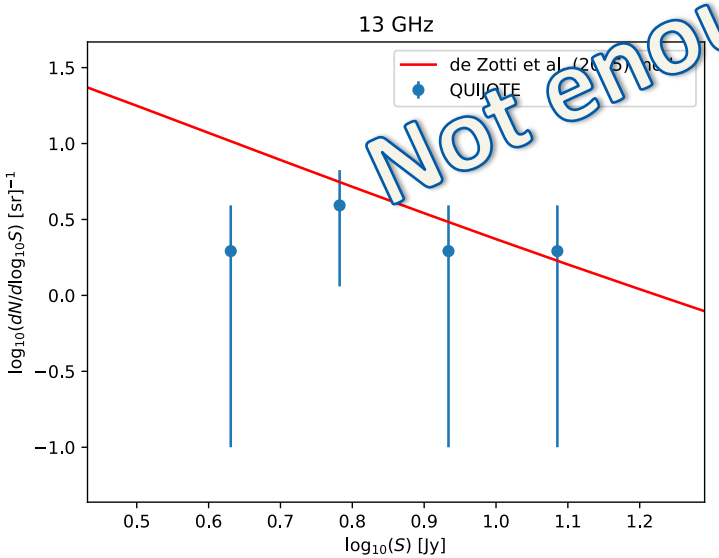


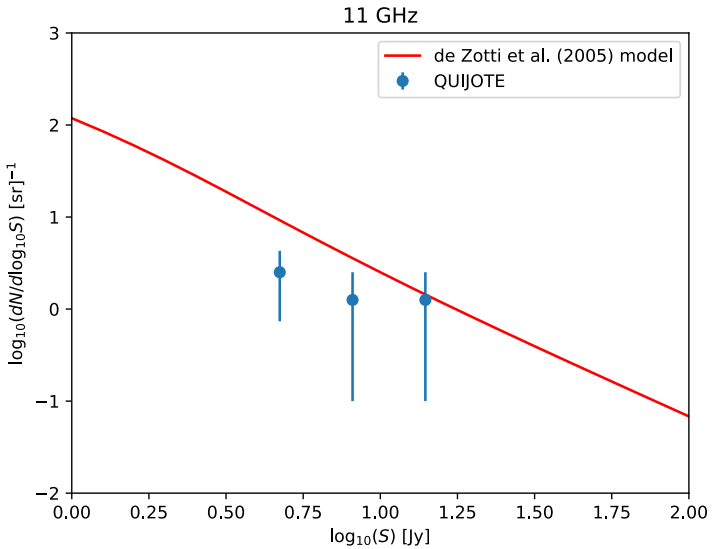
Results: statistical analysis





Not enough statistics!





Results: statistical analysis

Freq [GHz]	$\langle \Pi \rangle$ [%]	Π_{median} [%]	**N**samp [SNRΠ>3]
11	2.82	2.34	5
13	2.94	2.59	4
17	2.39	1.57	4
19	2.86	1.78	4

Results: statistical analysis

Freq [GHz]	$\langle \Pi \rangle$ [%]	Π_{median} [%]	**N**samp [SNRΠ>3]
11	2.82	2.34	5
13	2.61	2.59	4
17	2.39	1.57	4
19	2.86	1.78	4

Not enough statistics!

Summary

- First version of the QUIJOTE compact source catalogue
- NON BLIND: 41 targets with known polarization signal from *Planck*
- Preliminary work:
  - High noise levels
  - Early map version
  - Low number of objects / low SNR
  - **Main purpose:** additional QUIJOTE map validation/consistency check
- Future version(s) (ongoing work):
  - Widen the non-blind search to all the PCNT catalogue
  - Non-blind search
  - Multifrequency detection