New results from the *Planck*-ATCA Co-eval Observations (PACO) project

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On behalf of:
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Based on:
Massardi et al., 2011
Bonavera et al., 2011
Bonaldi et al., in prep.
Massardi et al., in prep.
Burke-Spolaor et al., in prep.

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Outline

- **Motivation of simultaneous observations**
- **Sample selection & Observing strategy**
- **Description of results**
- **Conclusions**

Motivation of simultaneous observations

Minimizing the effect due to variability

Planck provides unique information on wavelength range hardly accessible from the ground

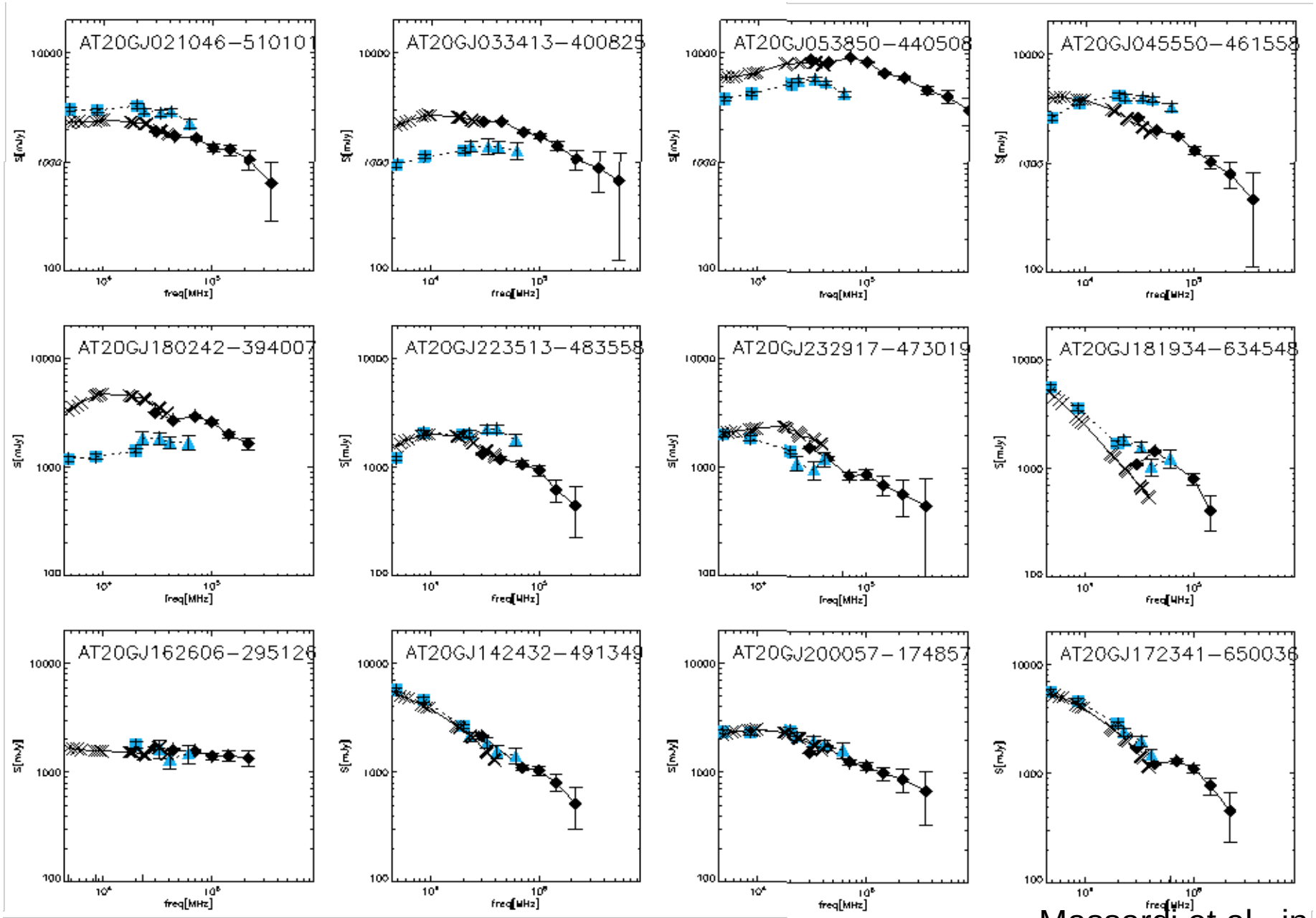
Multifrequency simultaneous (within a week) ground-based observations will allow us:

- **To help Planck** with the validation of detected sources (reliability & completeness)

- **To help ground-based radio telescopes** by transferring the Planck flux density calibration, which at frequencies up to 353 GHz is based on the cosmic microwave background (CMB) dipole, to the primary calibrators used by the telescopes

- To help investigating the spectral properties of radio sources in a wide frequency range

SEDs



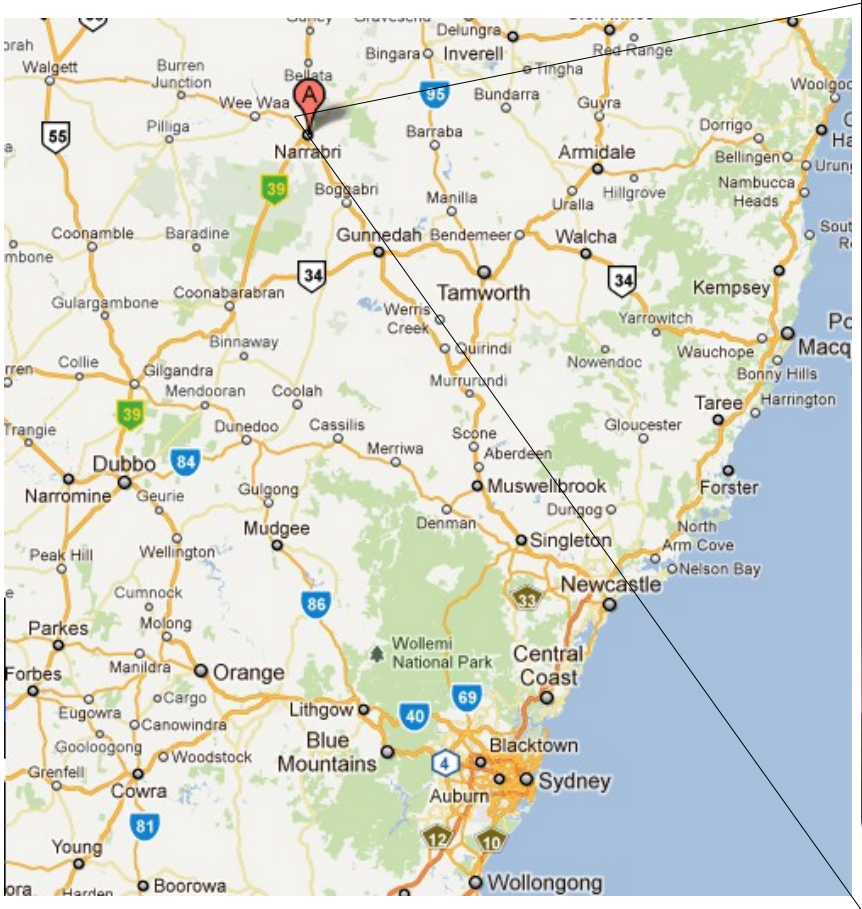
Massardi et al., in prep

Complex spectra and variability

→ no extrapolation from low frequency catalogues

PACO

Planck-ATCA Co-eval Observations



The Australia Telescope Compact Array (ATCA) is an array of six 22-m antennas, located about 25 km west of the town of Narrabri in rural NSW (about 500 km north-west of Sydney). It is perated by CSIRO's Astronomy and Space Science division.

Sample selection

The selection was done starting from the AT20G catalogue

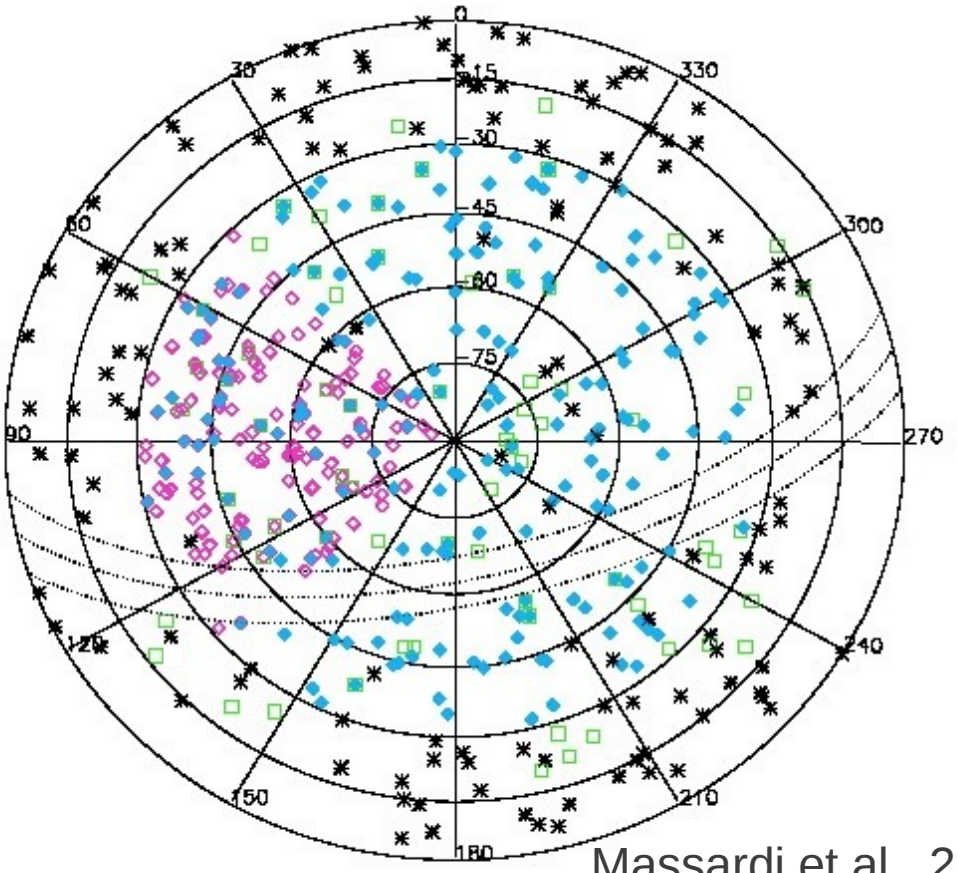
1) Bright Sample: 189 sources

2) Faint Sample: 162 sources

3) Spectrally-Selected Sample: 69 sources

4) Blazars Sample: 63 sources

5) ~100 ATCA phase calibrators



Massardi et al., 2011

→ **Total number of sources: 480 +PicA (core+western lobe)**

Observing strategy

~460 hours allocated (July 2009 - August 2010)

Priority:
- simultaneity with Planck
- observations of the largest number of sources

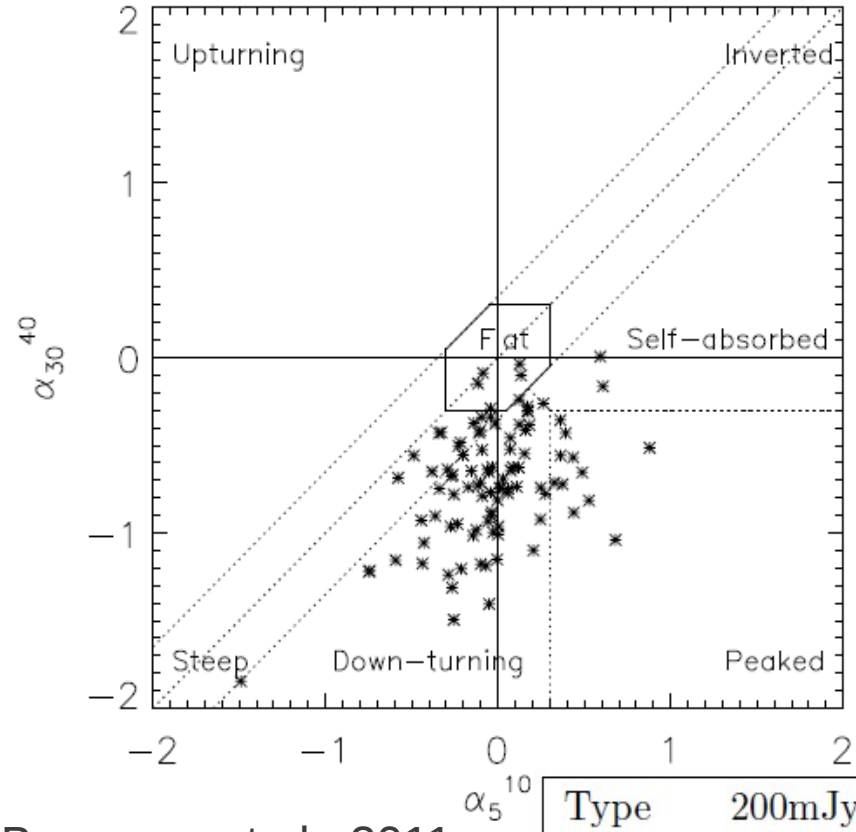
Frequency channels: **33 – 39 GHz** (overlap with Planck)
18 – 24 GHz (selection freq.)
5.5 – 9 GHz (increase freq. coverage)

1.5 min on source for each freq (to have at least ½ time on source and ½ time slewing or calibrating) → Theoretical RMS noise <1mJy

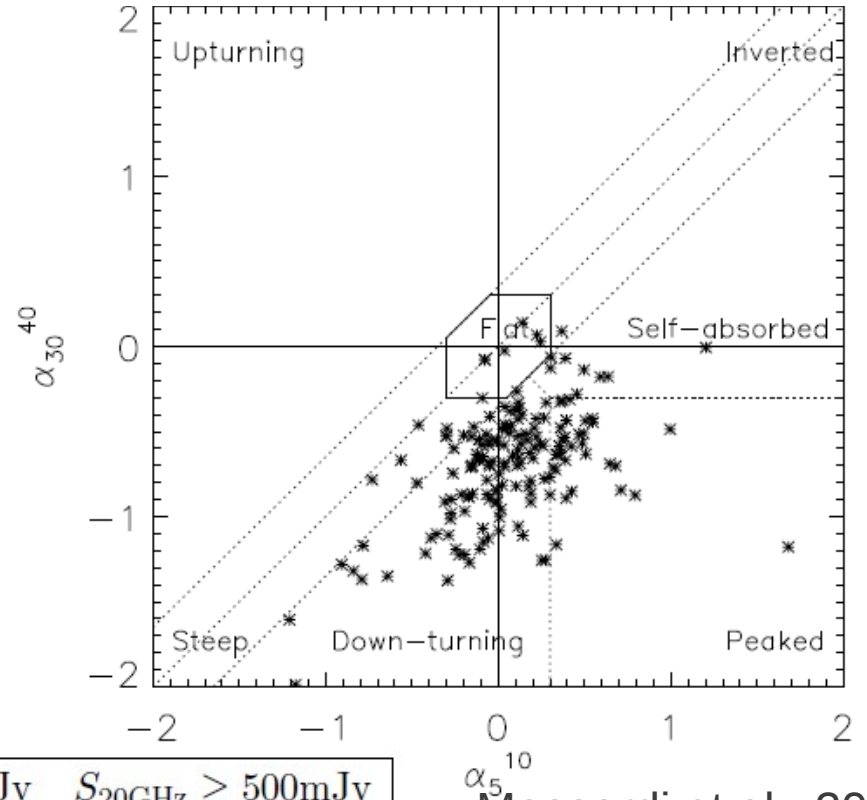
In 4h of observation:
about 1h for setup & **20-30 sources** at all the frequencies

Spectral Types

Color-color plot of PACO faint (left) and PACO bright (right) sources



Bonavera at al., 2011

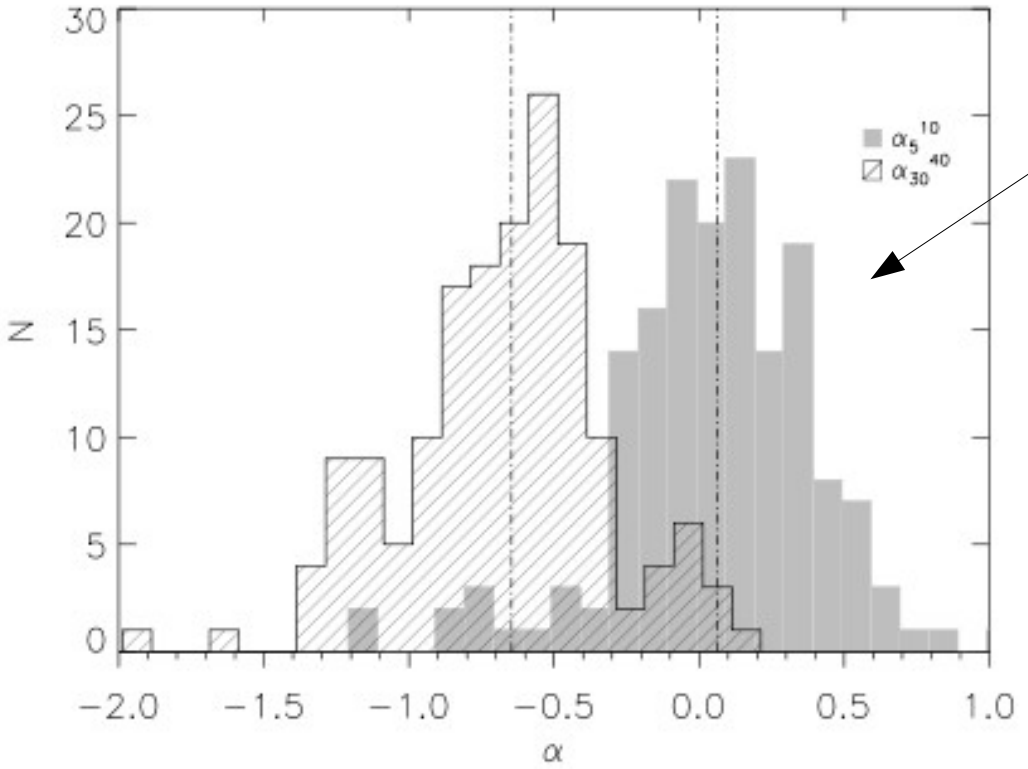


Massardi et al., 2011

Type	$200\text{mJy} \leq S_{20\text{GHz}} < 500\text{mJy}$ per cent	$S_{20\text{GHz}} \geq 500\text{mJy}$ per cent
flat	5.1	10.3
steep	13.3	3.6
inverted	0	0.6
peaked	11.2	14.5
down turning	65.3	66
self absorbed	5.1	4.8
upturning	0	0

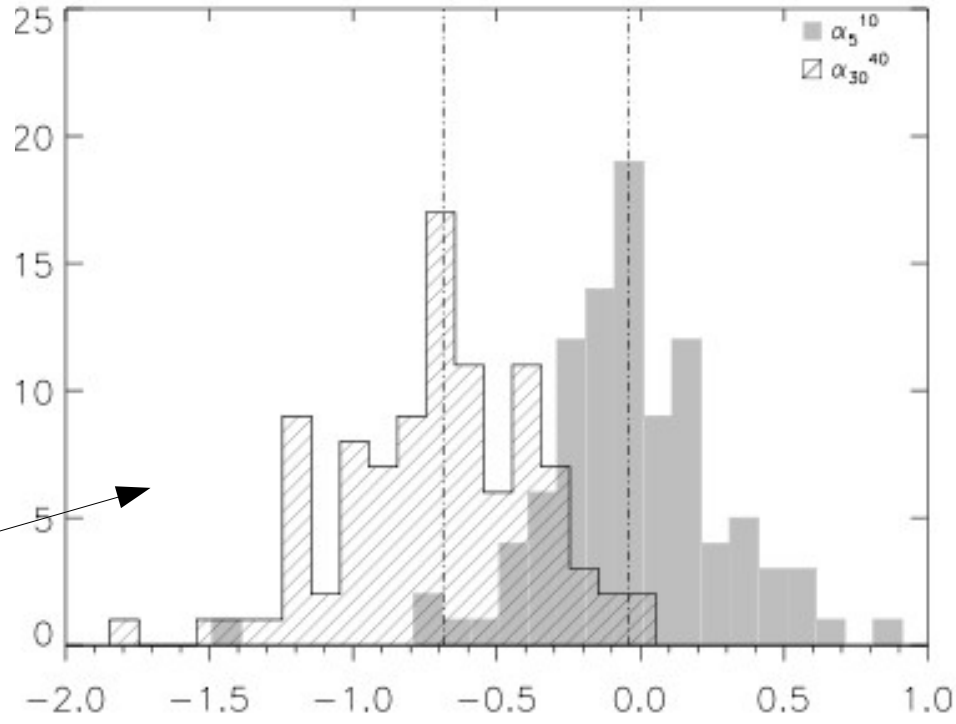
$S \propto \nu^{\alpha}$

Steepening



Bright sample:
Median α_5^{10} =0.064
Median α_{30}^{40} =-0.65

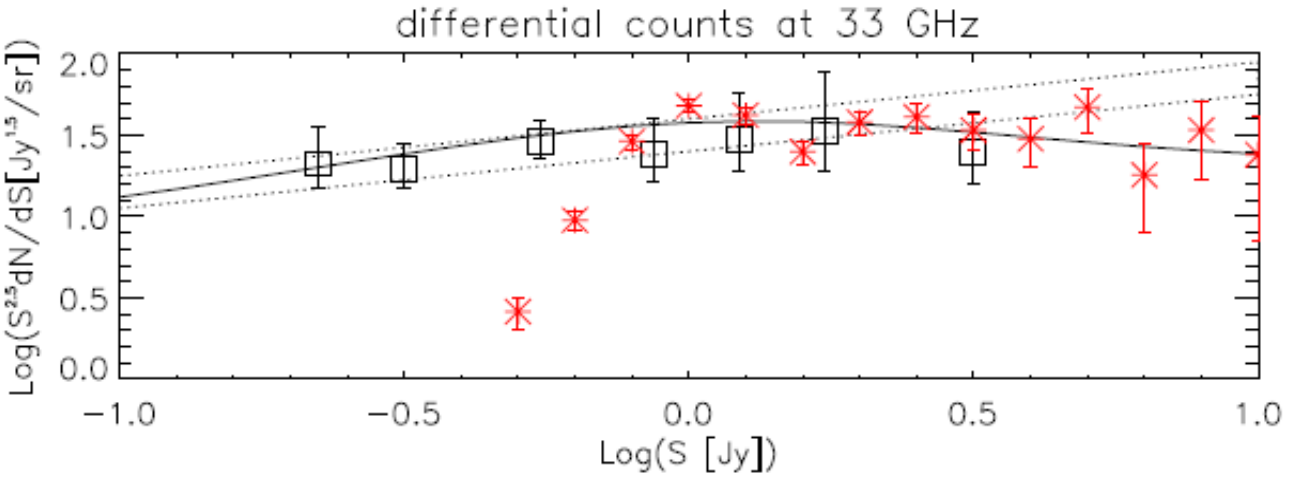
Faint sample:
Median α_5^{10} =-0.04
Median α_{30}^{40} =-0.69

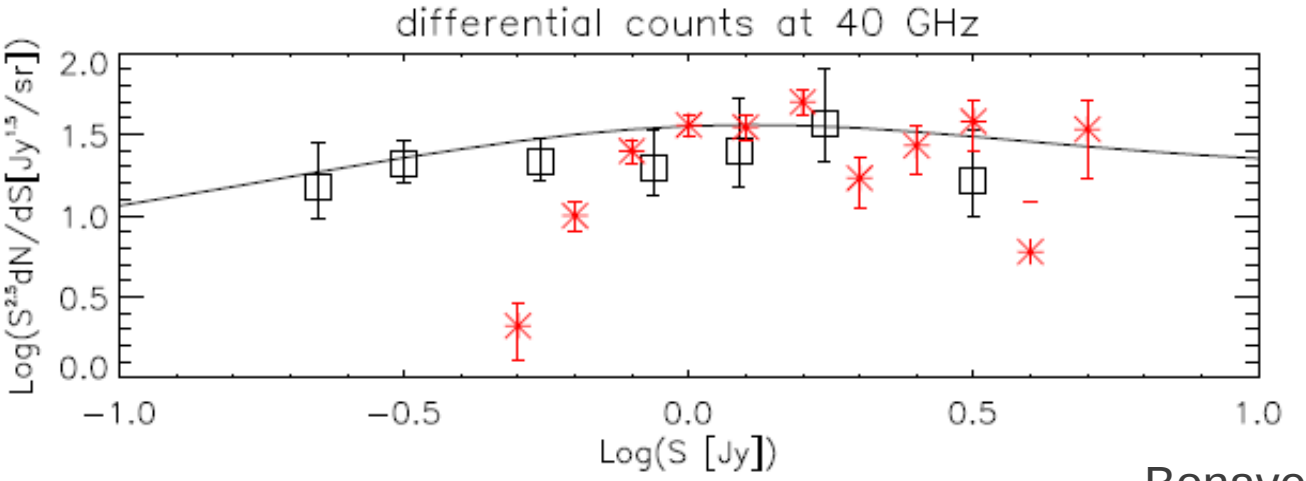


α Bonavera et al., 2011

The source spectra tend to steepens at higher frequencies

Number Counts





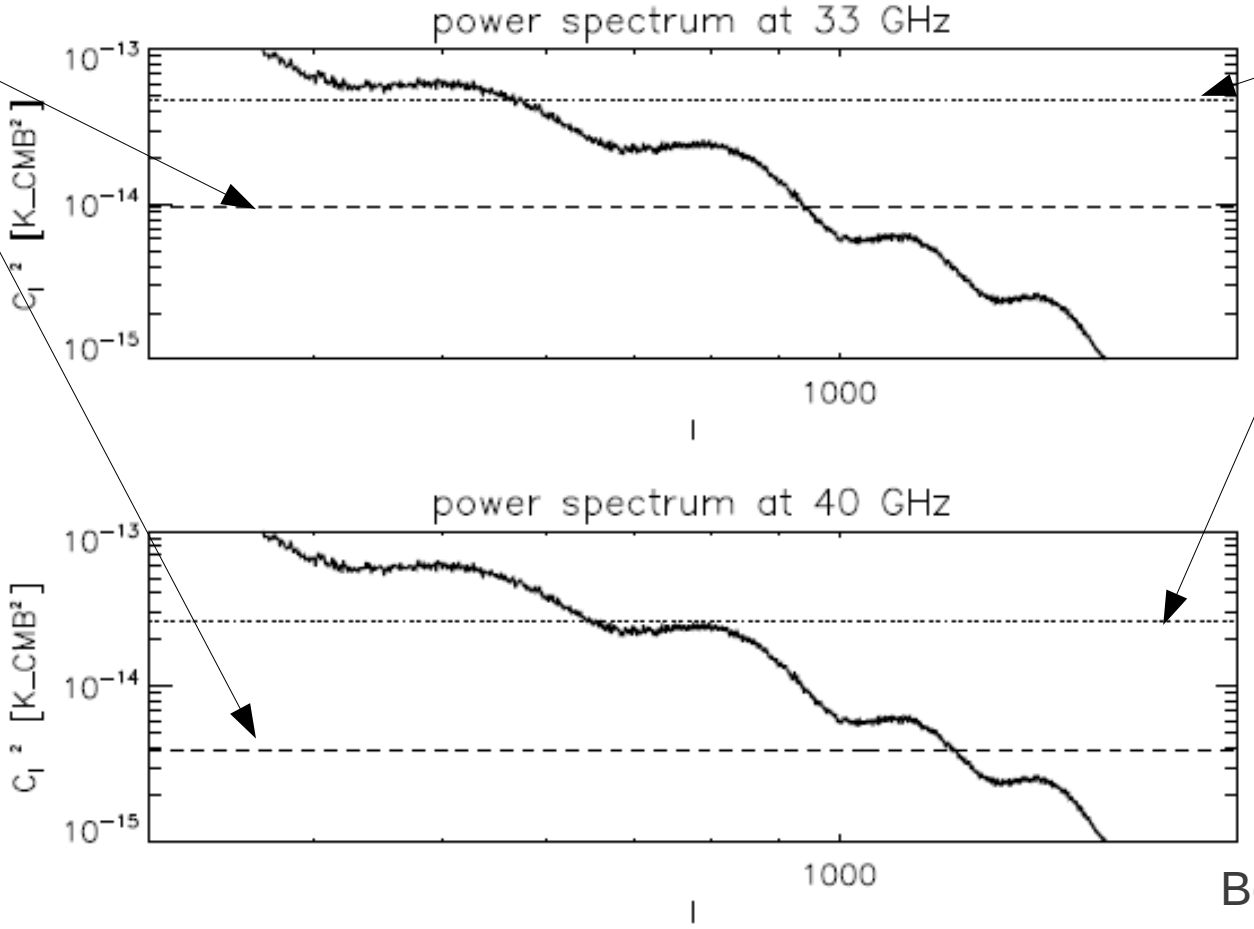
Bonavera et al., 2011

Extrapolate the 20 GHz source counts to 33 and 40 GHz → a factor 5 below current estimates from Planck

Power Spectrum

'PACO faint' flux density limit

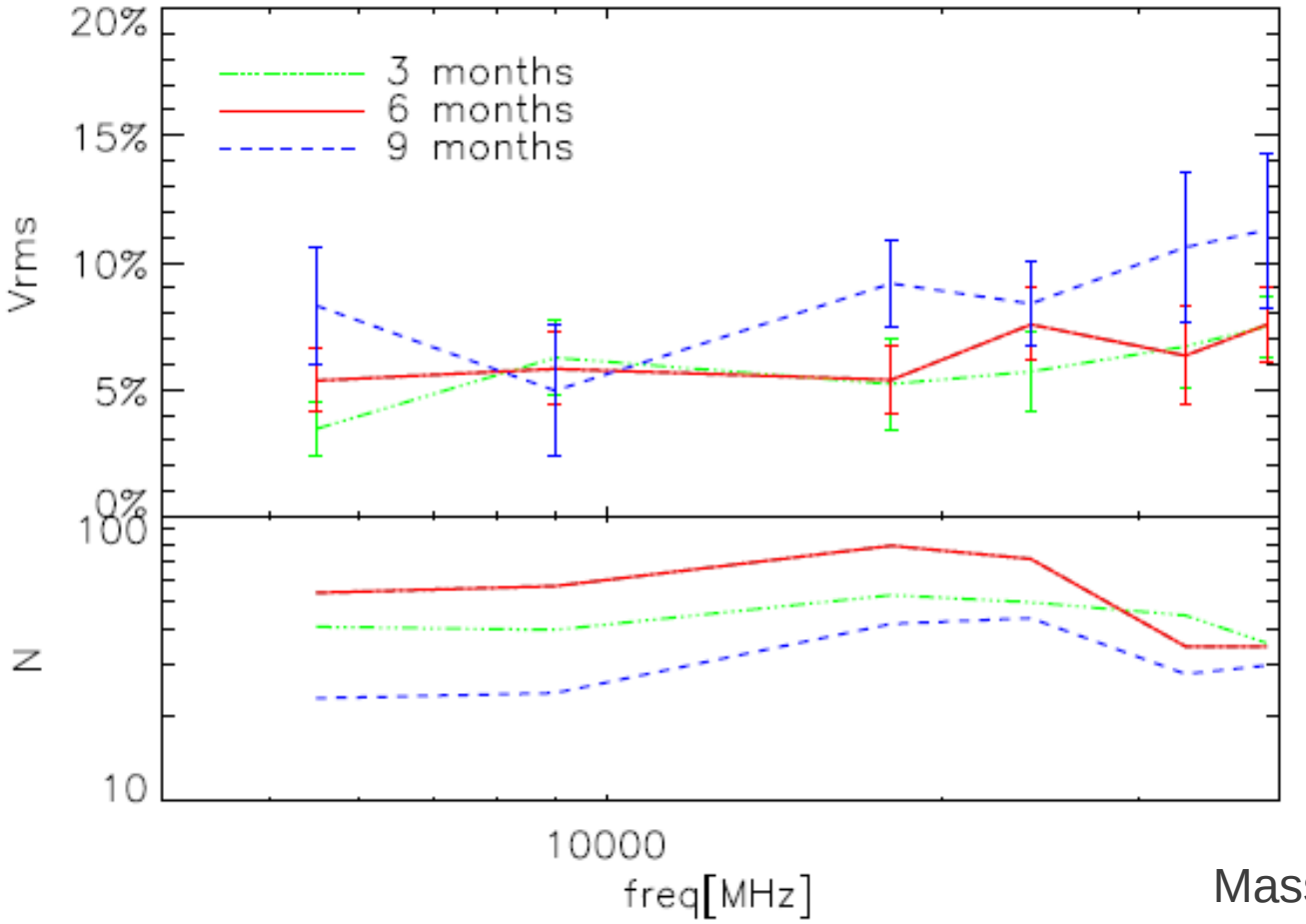
ERCSC completeness limit



Bonavera et al., 2011

Improves the control of fluctuations due to unresolved sources in Planck maps

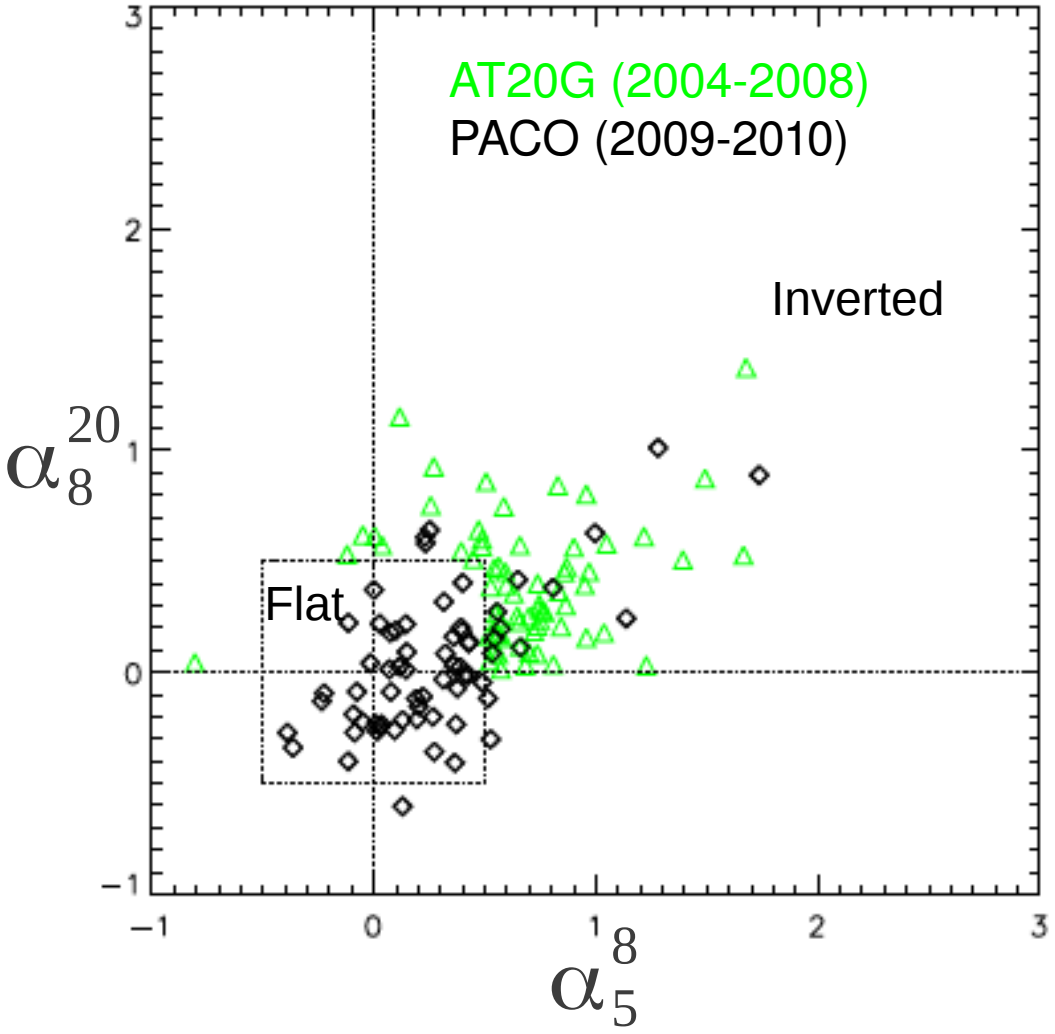
Variability



Massardi et al., 2011

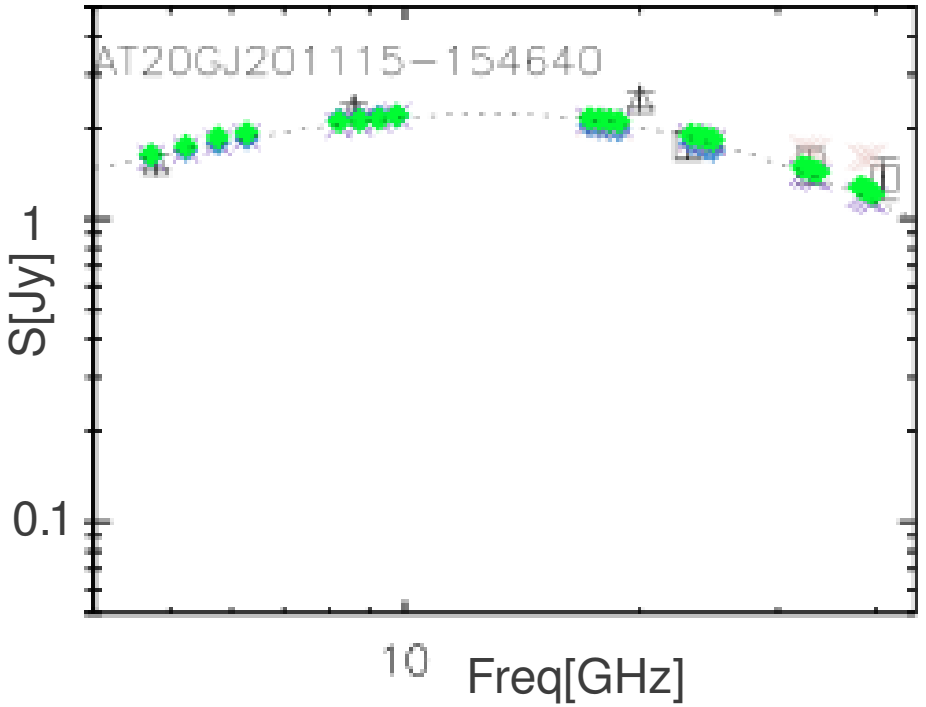
→ increase of the variability amplitude with time lag and frequency

Spectrally-Selected sample



Color-color (5-8 and 8-20 GHz):

→ Mostly Blazars selected while flaring



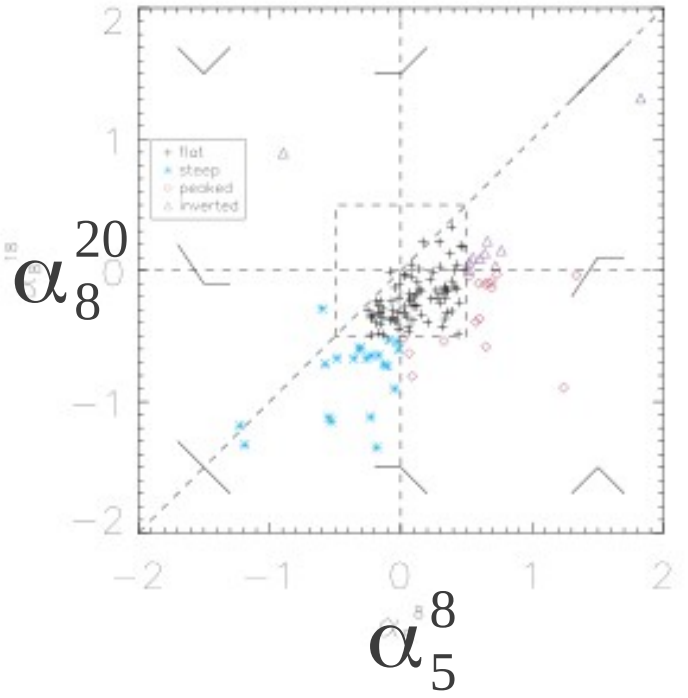
Bonaldi at al., in prep.

From PACO-AT20G variability:

→ 87% blazars (~40% of which are in Roma-BZCAT)

→ 13% GPS candidates

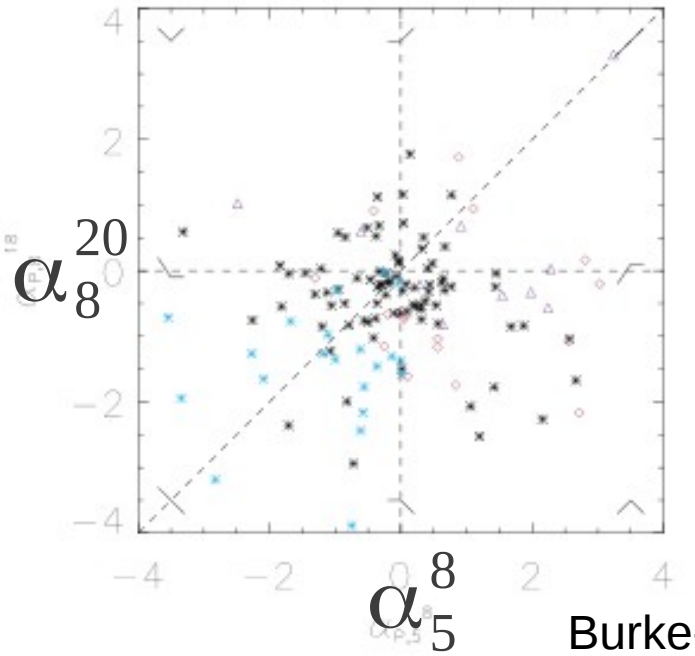
Polarization of extragalactic AT20G sources



186 sources DEC<-30deg, 135 with pol detection at 4.8, 8.6 and 18 GHz

Median fractional polarization

	Full Sample	Flat	Steep	Peaked	Inverted
# sources	130	21	83	10	16
4.80 GHz	1.80	1.82	1.25	2.54	1.80
8.64 GHz	1.78	1.90	1.52	2.18	1.38
18.0 GHz	2.08	1.99	2.69	2.47	1.37



Preliminary findings:
- broadening of spectral index distributions
- steep spectrum remains steep also in pol
-fractional polarization increasing with frequency
- different behavior for different spectral classes (being investigated)

Burke-Spolaor et al., in prep.

Conclusions

- **Similar overall phenomenology in the PACO bright and faint samples, main difference in the fraction of flat and steep sources**
- **Source spectra tend to steepens at higher frequencies**
- **Extrapolatation of source counts to 33 and 40 GHz, down to ≃ 200 mJy**
- **Short term variability analysis shows increase of variability amplitude with frequency and time lag**
- **Spectrally selected sample: looking for GPS**

THANKS