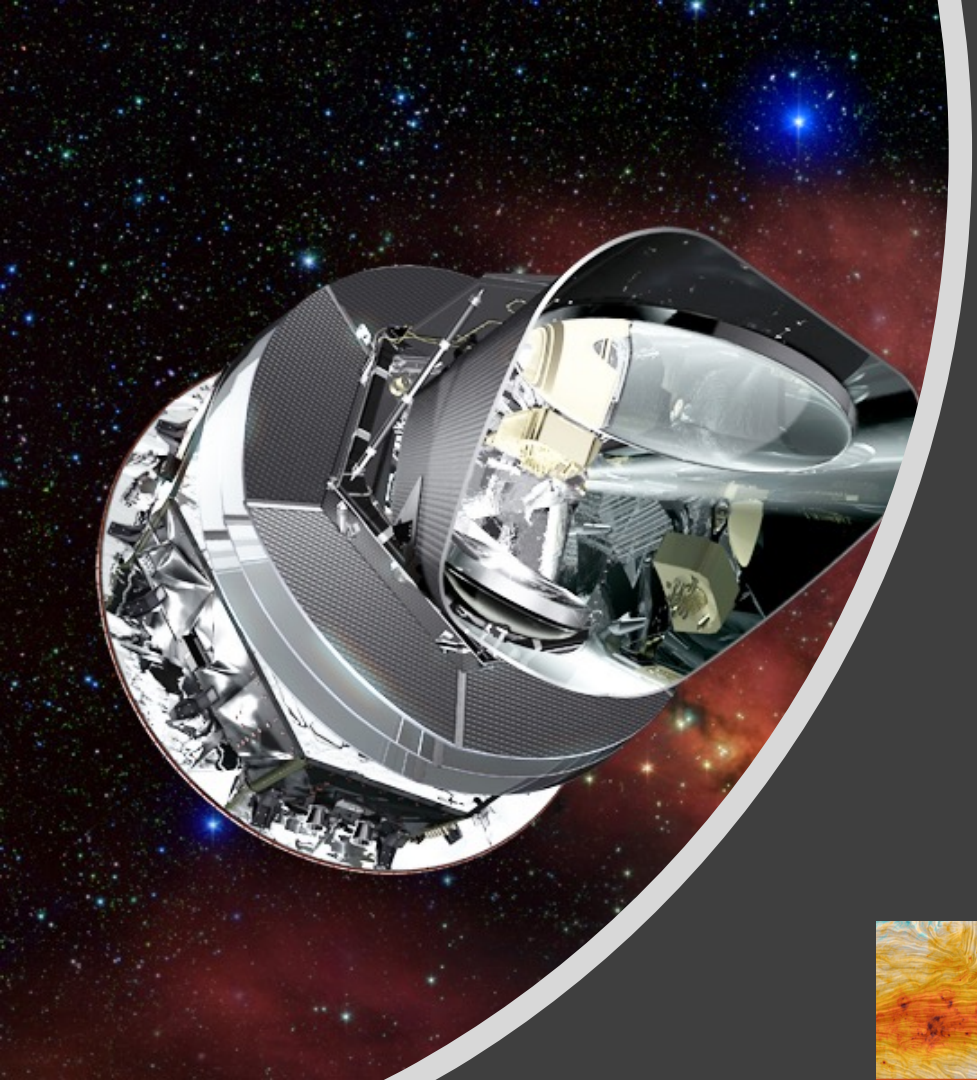

Extragalactic point sources in total intensity and polarisation: lessons from Planck

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Universidad de Oviedo

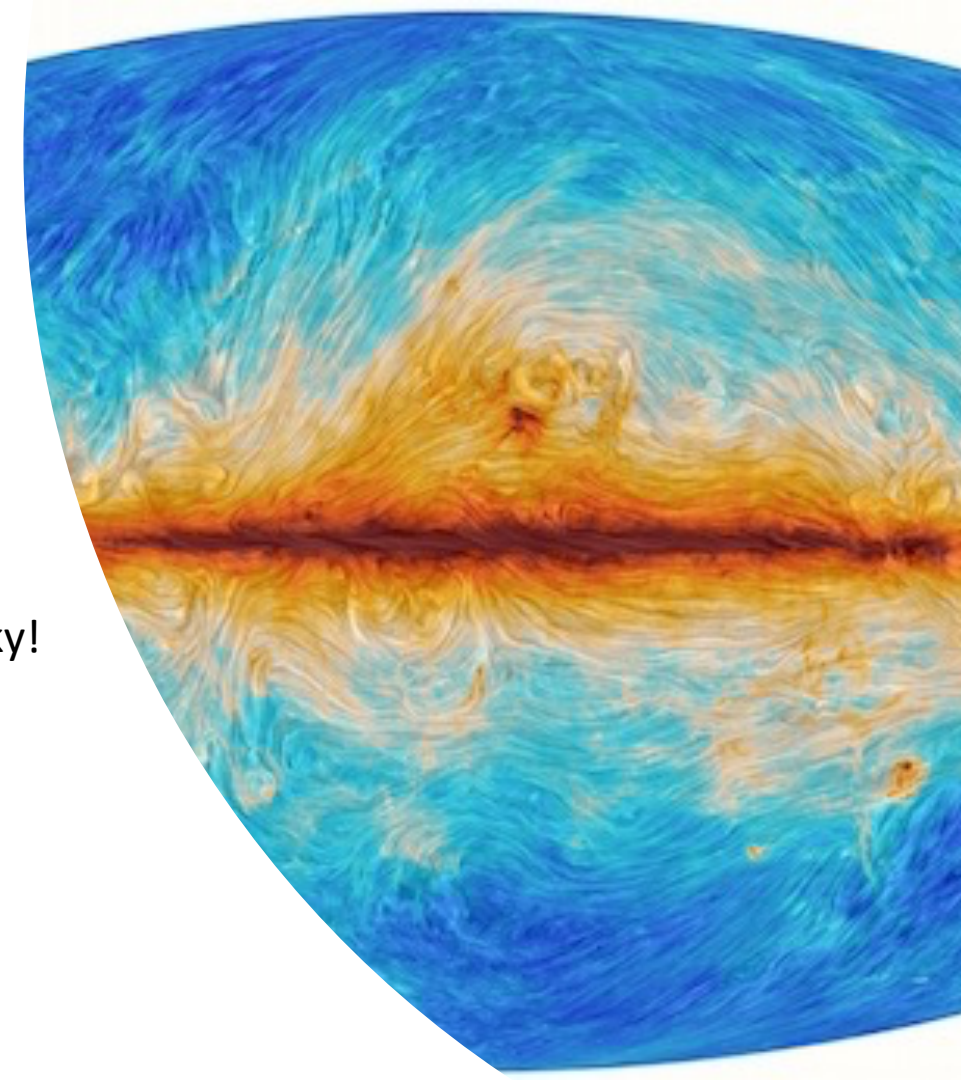
CMB foregrounds for B-mode studies

Tenerife, Spain, October 15-18, 2018

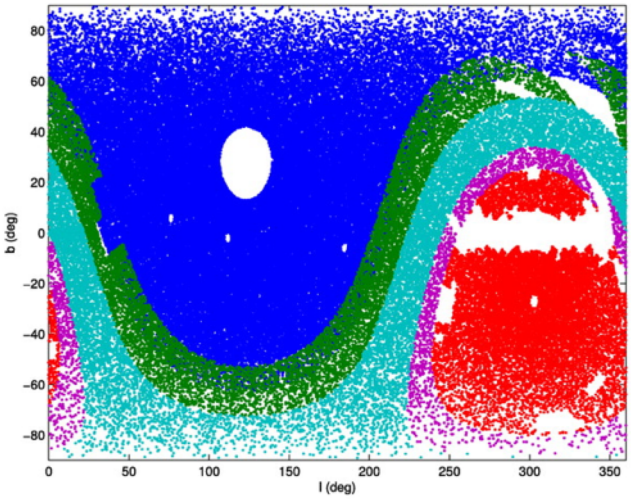
Outline

Point Sources lessons learnt from Planck:

- Lesson 1: You can NOT make them disappeared!
- Lesson 2: You can NOT mask the entire sky!
- Lesson 3: Get ready to make your hands dirty!
- Lesson 4: Expect the unexpected!
- Lesson 5: Know your enemy!
- Conclusions



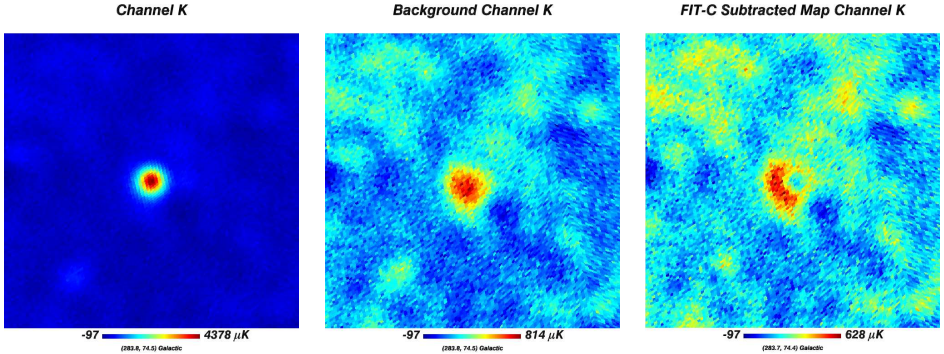
Lesson 1: PS removal



Sky coverage of 5 GHz surveys in equatorial coordinates: GB6 (Gregory et al. 1996) (*blue*), PMNE (Griffith et al. 1995) (*dark green*), PMNS (Wright et al. 1994) (*red*), PMNT (Griffith et al. 1994) (*light blue*), and PMNZ (Wright et al. 1996) (*magenta*). The white regions are "holes" in these surveys that have been covered exploiting the NVSS and the SUMSS.

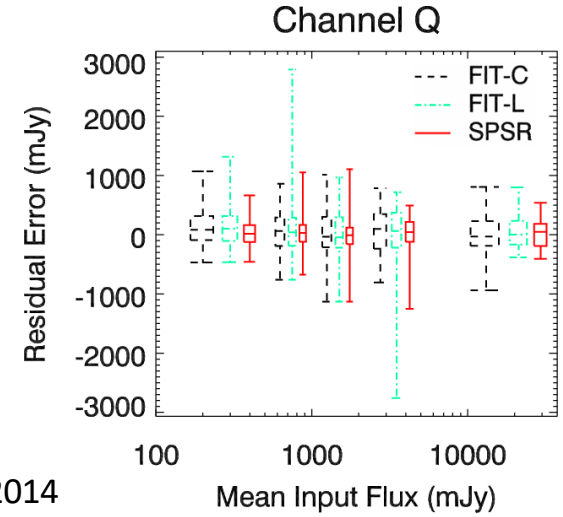
BEST IDEA! Using known radiosources at lower frequencies … (e.g. PIC)

Pro	Cons
Known positions	Baricentre with more than one source?
Known flux at lower frequencies	Spectral index?
	Variability?



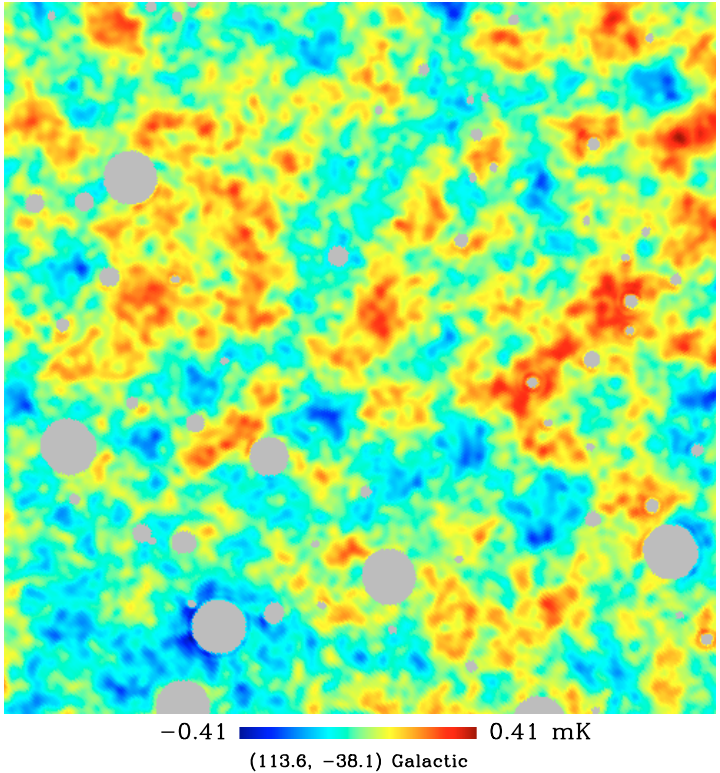
Lesson 1: PS removal

SECOND BEST IDEA! Detect and substract!



Sureau et al. 2014

- In real life PS removal is never perfect!
- Residuals bias due to positional, shape and intensity uncertainties.
- To determine residuals bias accurate simulations or additional precise statistical analyses are required. (Scodeller & Hansen, 2013)

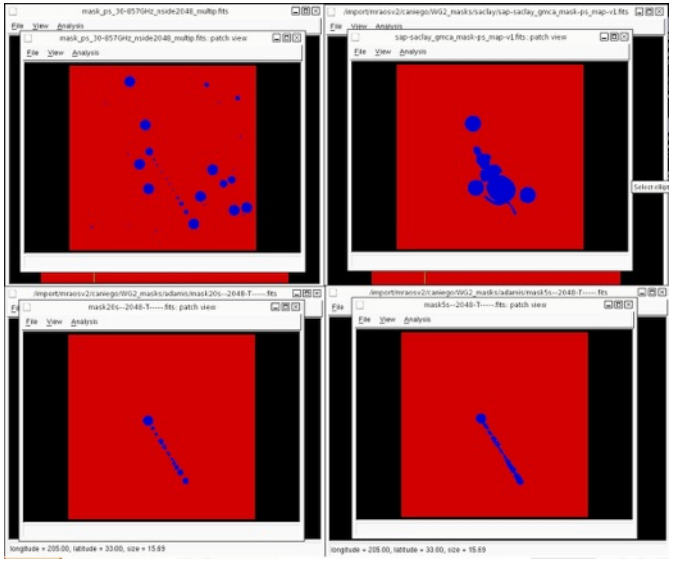


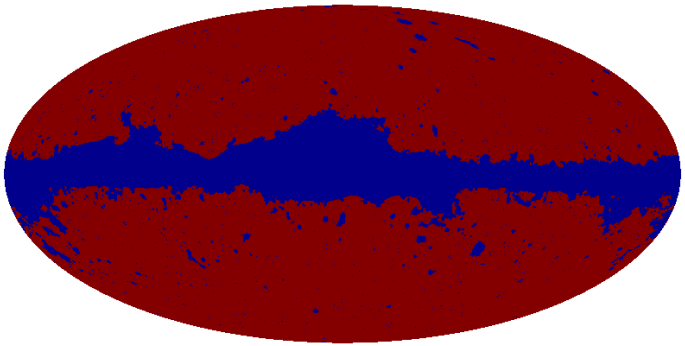
Leach et al. 2008

Lesson 2: PS masking

BEST IDEA! Mask the known sources!

- How many? Which ones? (stat info)
- How much area to mask? (intensity info)
- In all channels? (spectral information)
- Same issues in Polarization!



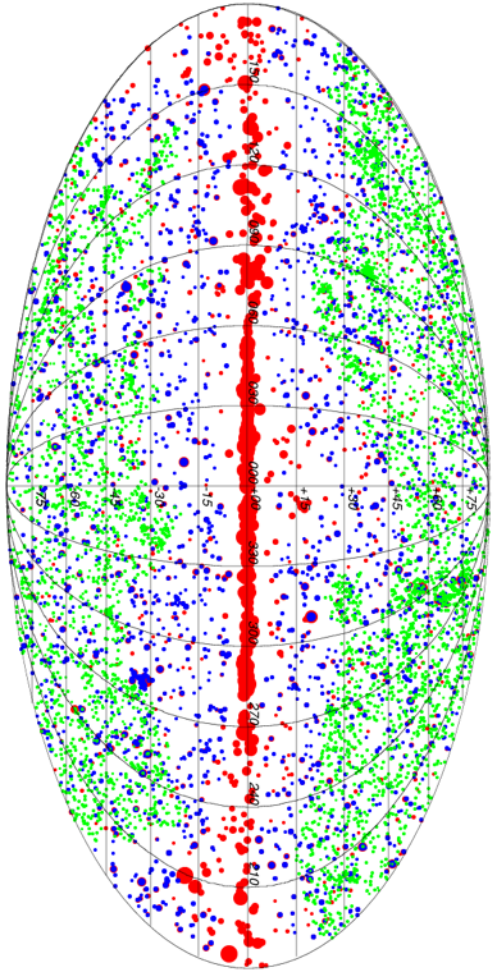


PLA (ESA)

Lesson 2: PS masking

SECOND BEST IDEA! Mask detected sources!

- Detection pipeline needed
- Different CompSep methods require different masks!
- Number of masks grow exponentially!
  - Single/multiple channels, CS methods, detection pipelines, …
- Compromise: **Common Mask**



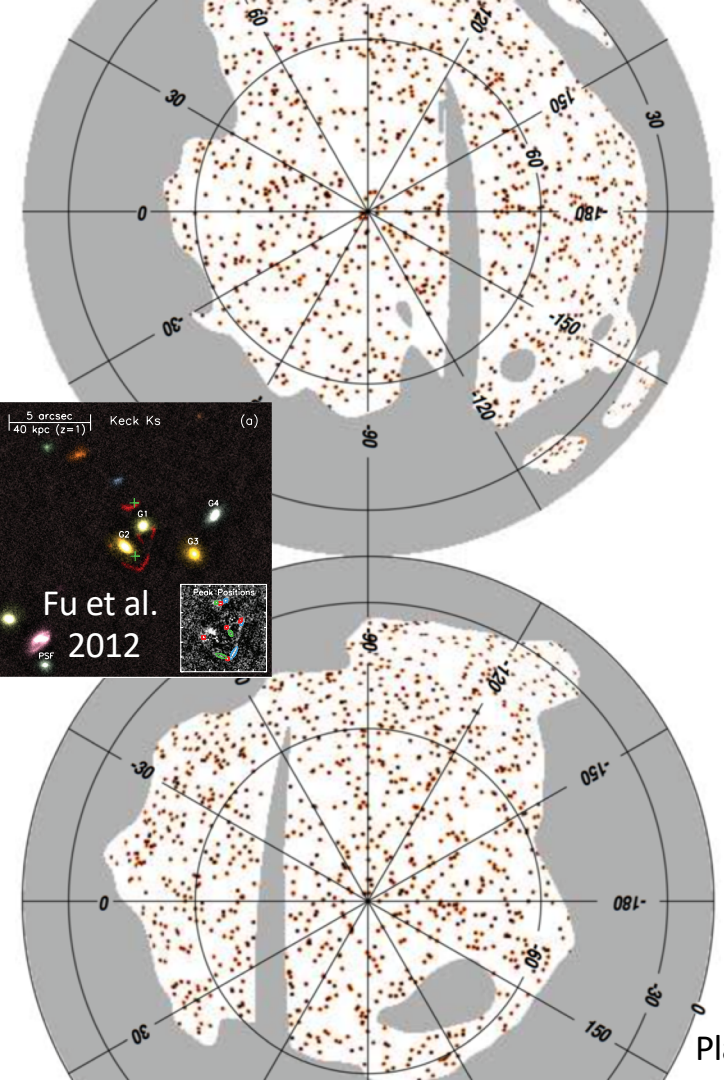
PCCS2,
Planck 2015 results. XXVI

Lesson 3: PS detection

Even from the cosmological point of view you can not avoid to detect the point sources.

- Planck delivered 4 incremental PS catalogues
  - ERCSC, PCCS, PCCS2(+pol), PCNT (multi-frequency)
- Better to maintain 2-3 methods
  - Be ready for internal fighting to choose these methods!
  - Optimal for internal validations
  - Should be reliable and well tested.
  - Different methods for different tasks! (single/multi freq., polarization, …)
- Completeness vs. Reliability
- See Lopez-Caniego's talk tomorrow!

Lesson 4: Unexpected results

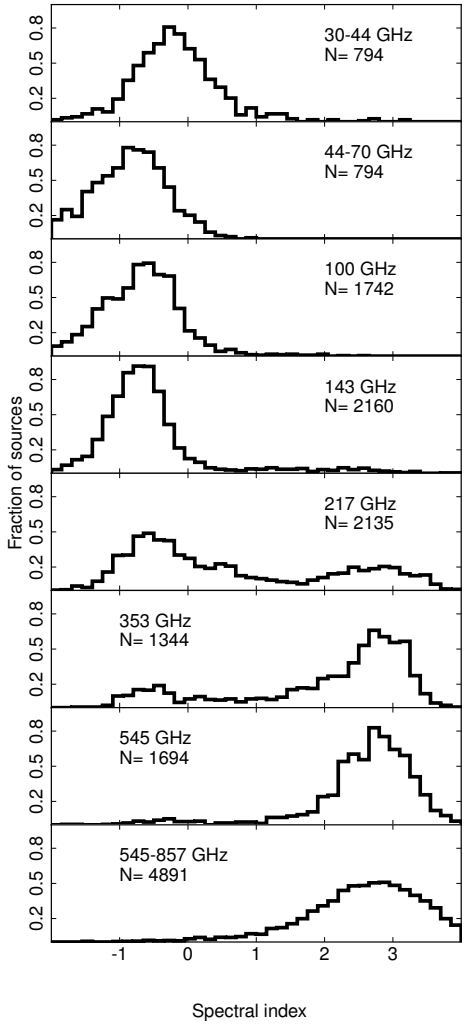


The Planck list of high-redshift source candidates (PHZ)

(anticipated by Negrello et al. 2007,
preliminary results Herranz et al. 2012)

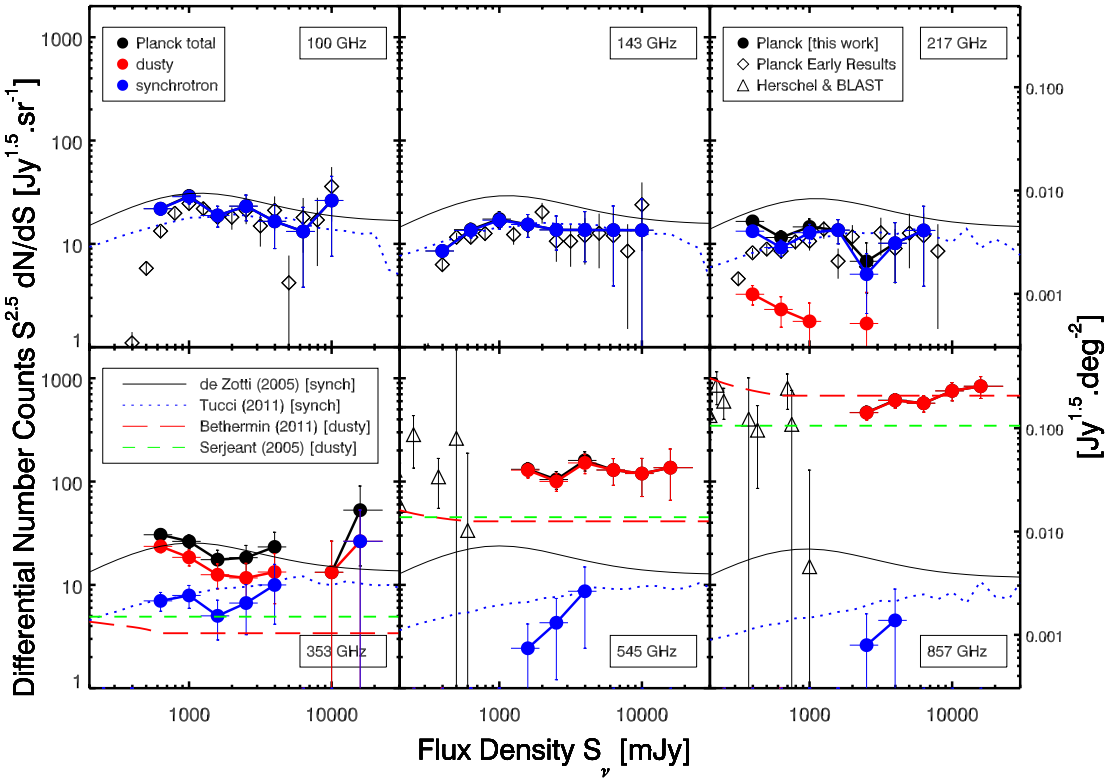
- 2151 PS located in the cleanest 26% of the sky exhibiting an excess in the submillimeter compared to their environment.
- These sources are considered as high-z source candidates (z>1.5-2).
- Followed-up with Herschel: proto-clusters (93%) and strongly lensed galaxies (3%)

PHZ,
Planck Intermediate results. XXXIX

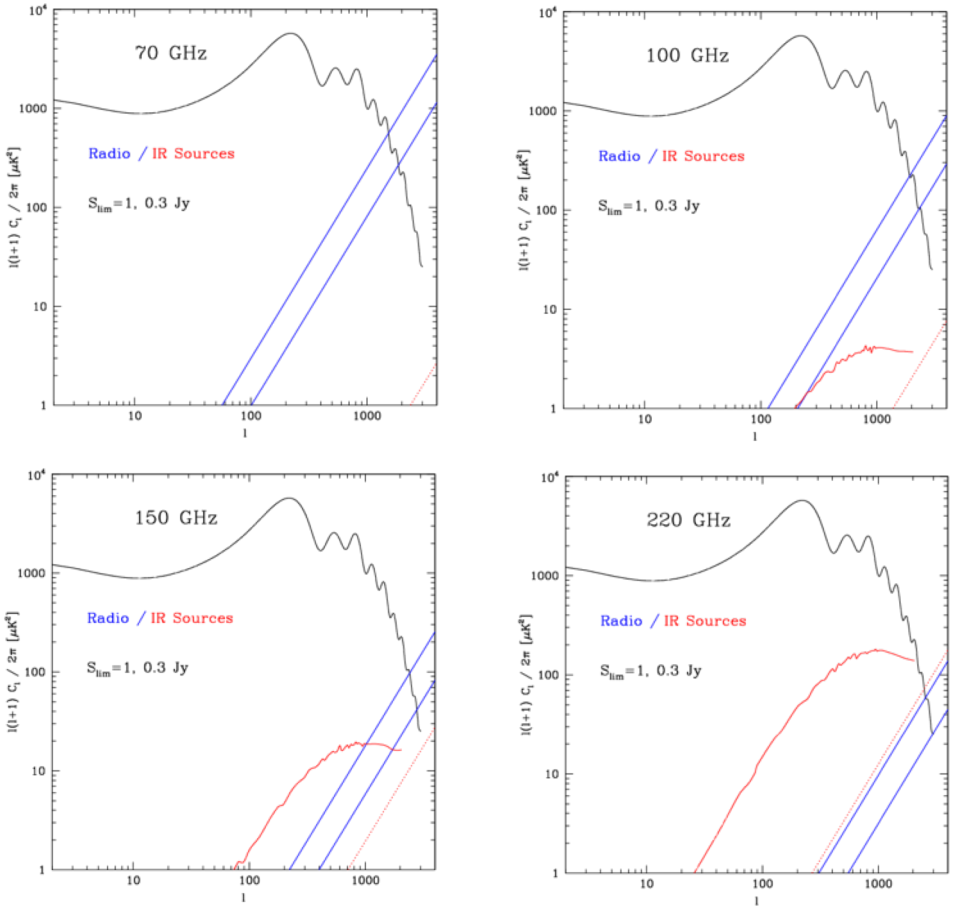


Planck 2015 results. XXVI
Planck Intermediate results. VII 2013
Planck Early results. XIII 2011

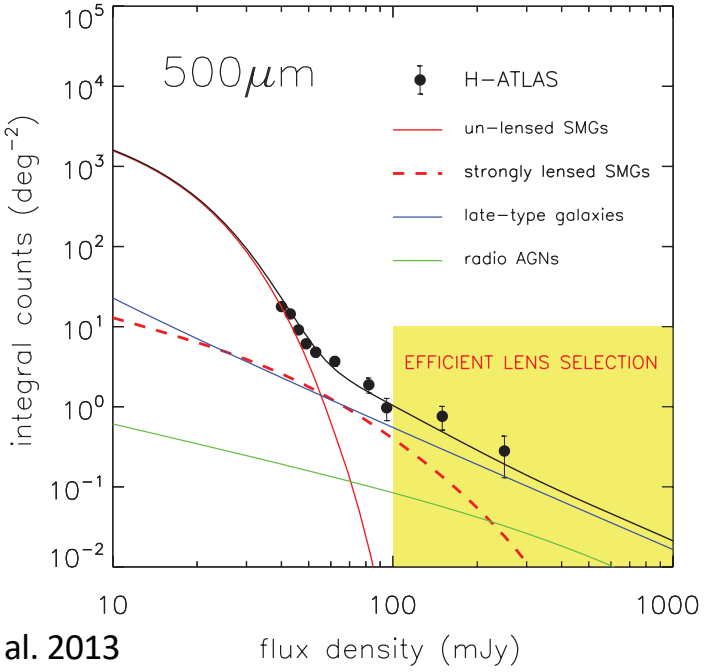
Lesson 5: PS statistical properties



Lesson 5: PS statistical properties



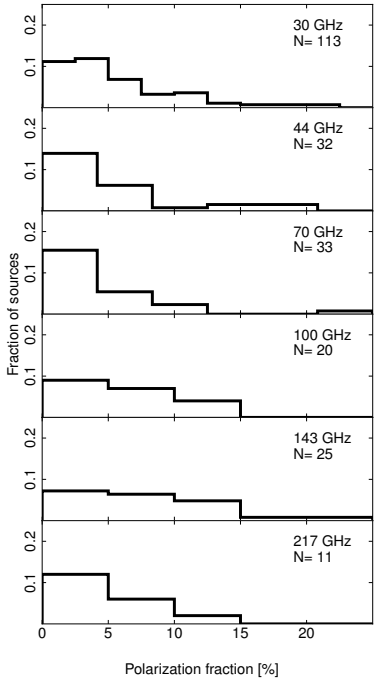
Sub-mm galaxies, the unexpected barrier!

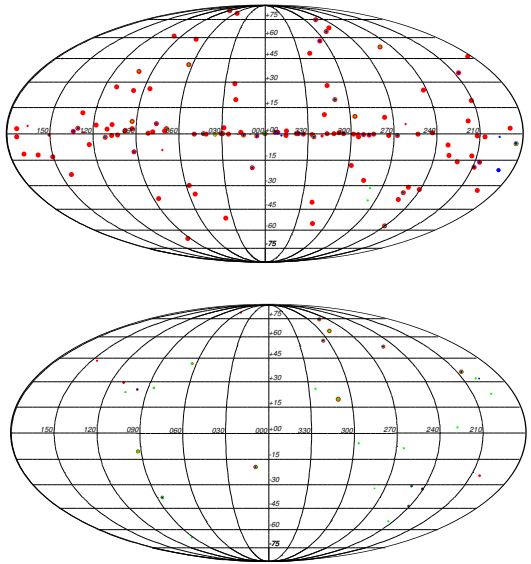


Curto et al. 2013
Negrello et al. 2010

Lesson 5: PS statistical properties. Polarization

Just a few detections!





Planck 2015 results. XXVI
Curto et al. 2013

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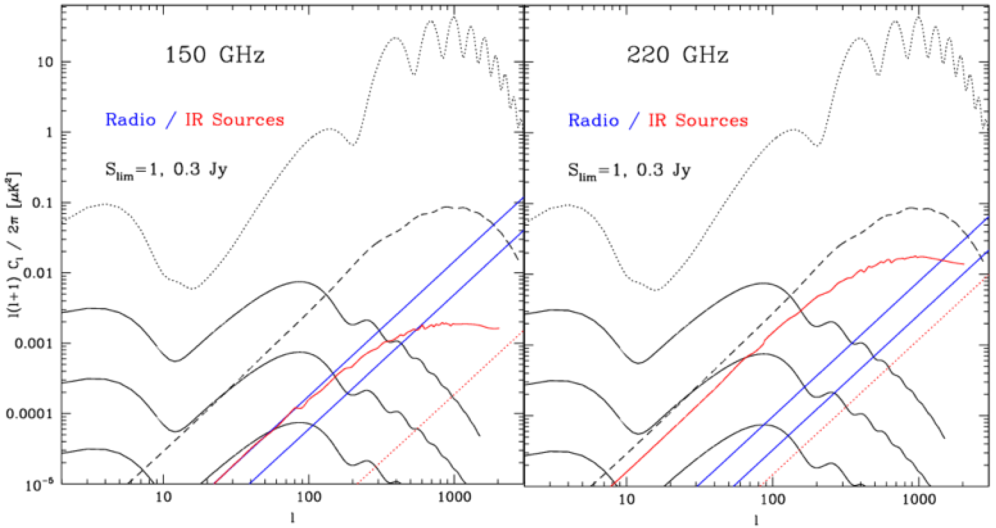
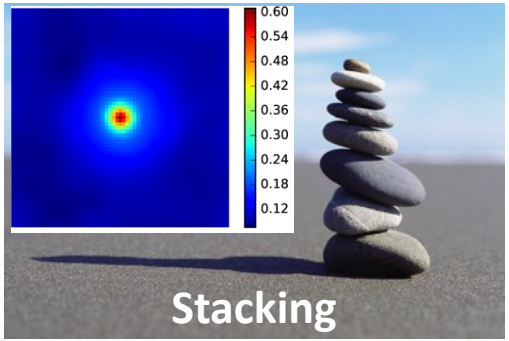
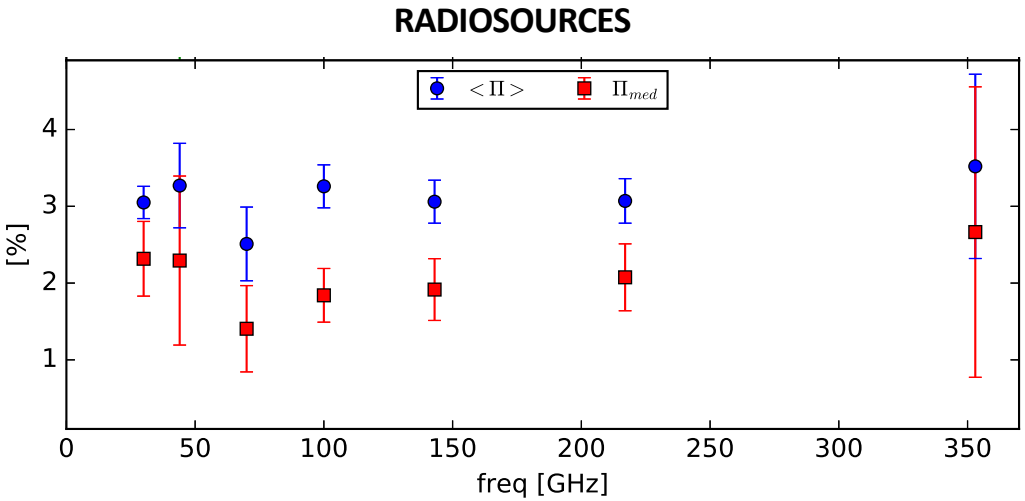
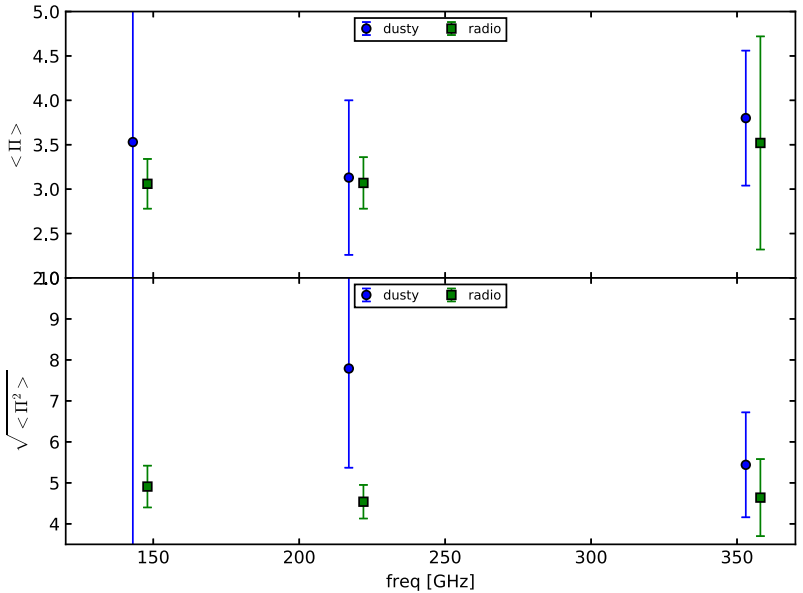


Assumed IR pol. ~1%

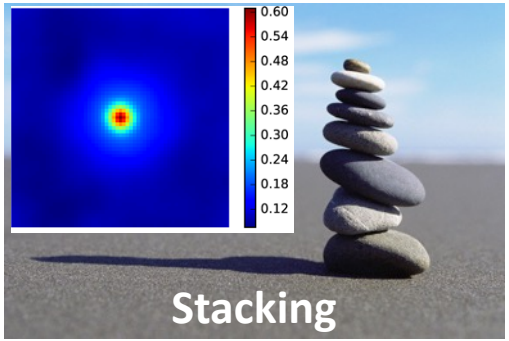


Lesson 5: PS statistical properties. Polarization



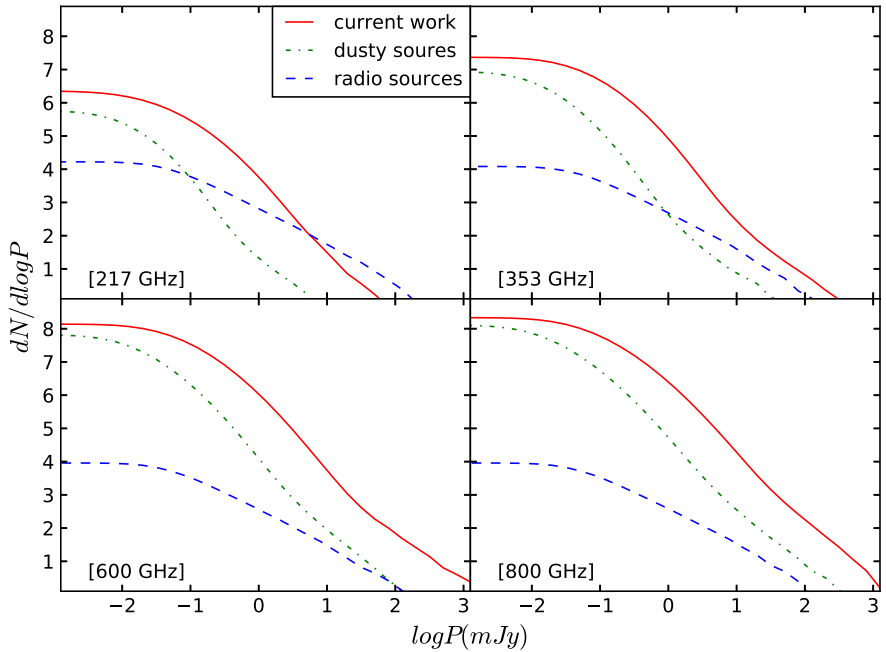


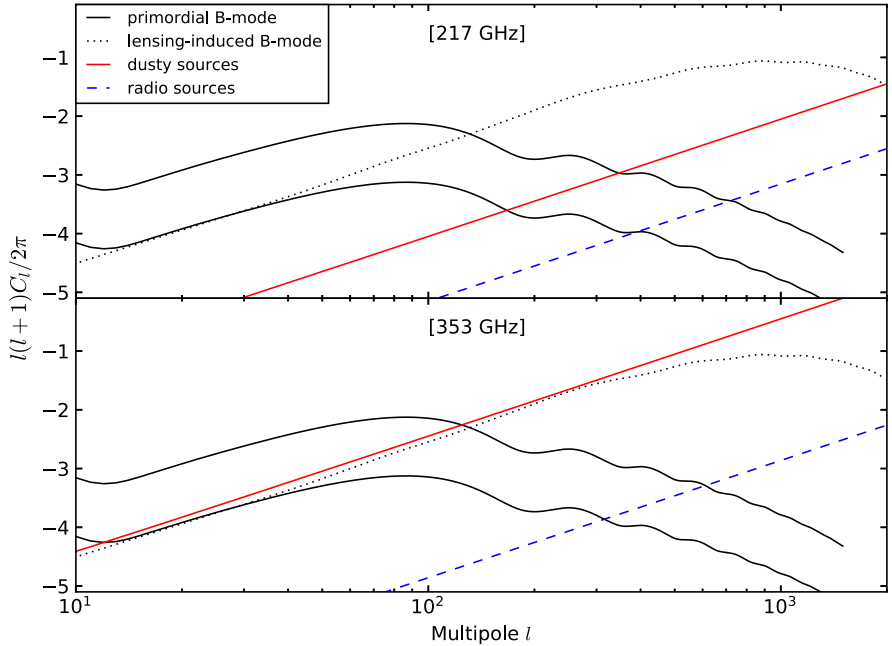
Bonavera et al. 2017a,b



Lesson 5: PS statistical properties. Polarization

Sub-mm galaxies, the unexpected barrier!!!





Bonavera et al. 2017a,b

See Puglisi's talk!

Conclusions

- PS removal vs PS masking: choosing the least worst option
  - PS removal uncertainties introduce unknown residuals bias, to be determine.
  - **New opportunities with surveys in the same bands: ALMA, Herschel, SPT, …**
  - PS masking reduce the available sky and complicate the power spectrum estimations.
- You can NOT avoid PS detection (see Lopez-Caniego's talk)
  - Very important from the astrophysical point of view, of course!
- Knowing the PS statistical properties allows us to anticipate future issues: (see Puglisi's talk)
  - Sub-mm galaxies, the unexpected barrier!!!