Pressure profiles of galaxy cluster from SPT and Planck observations.

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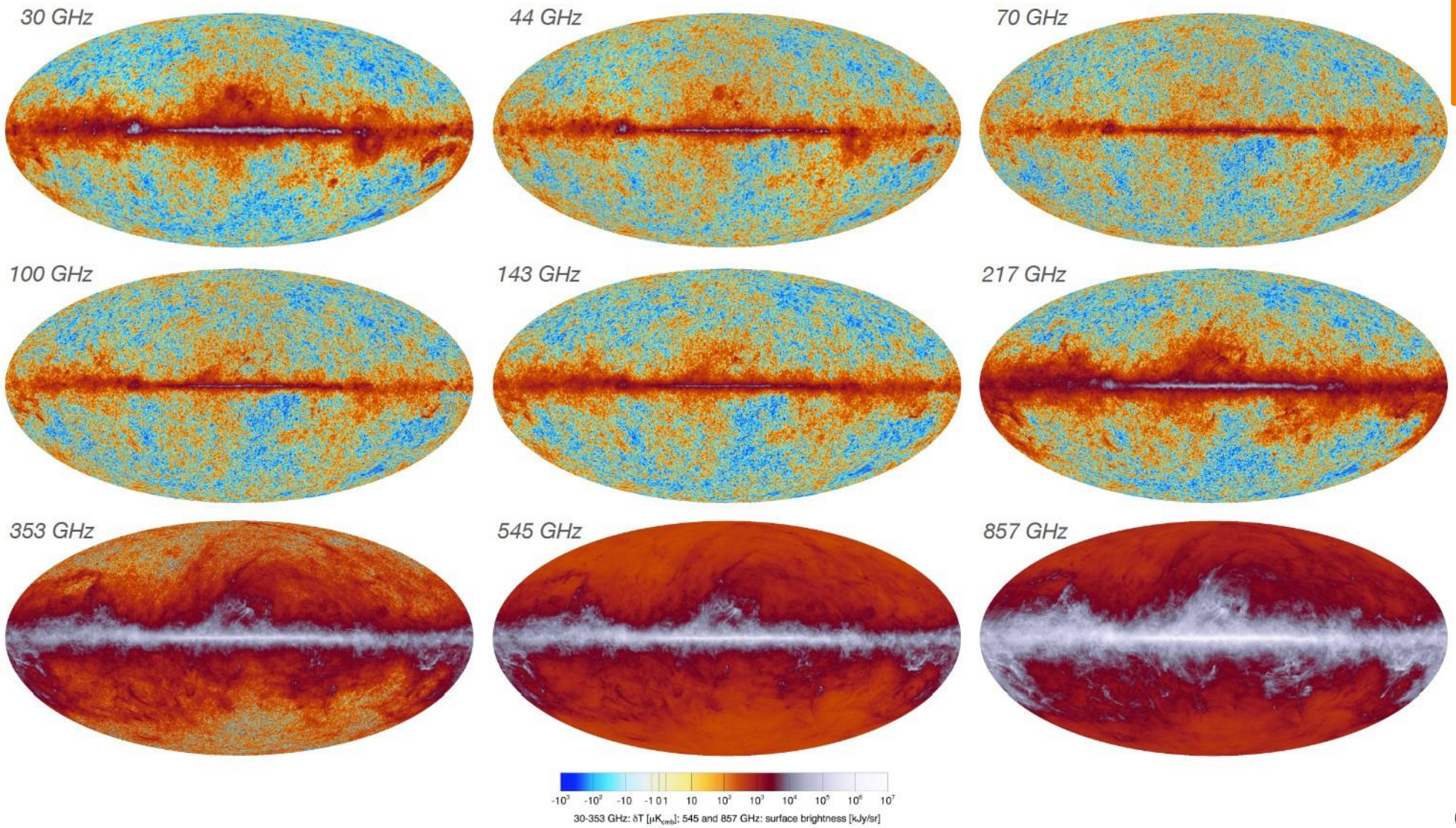
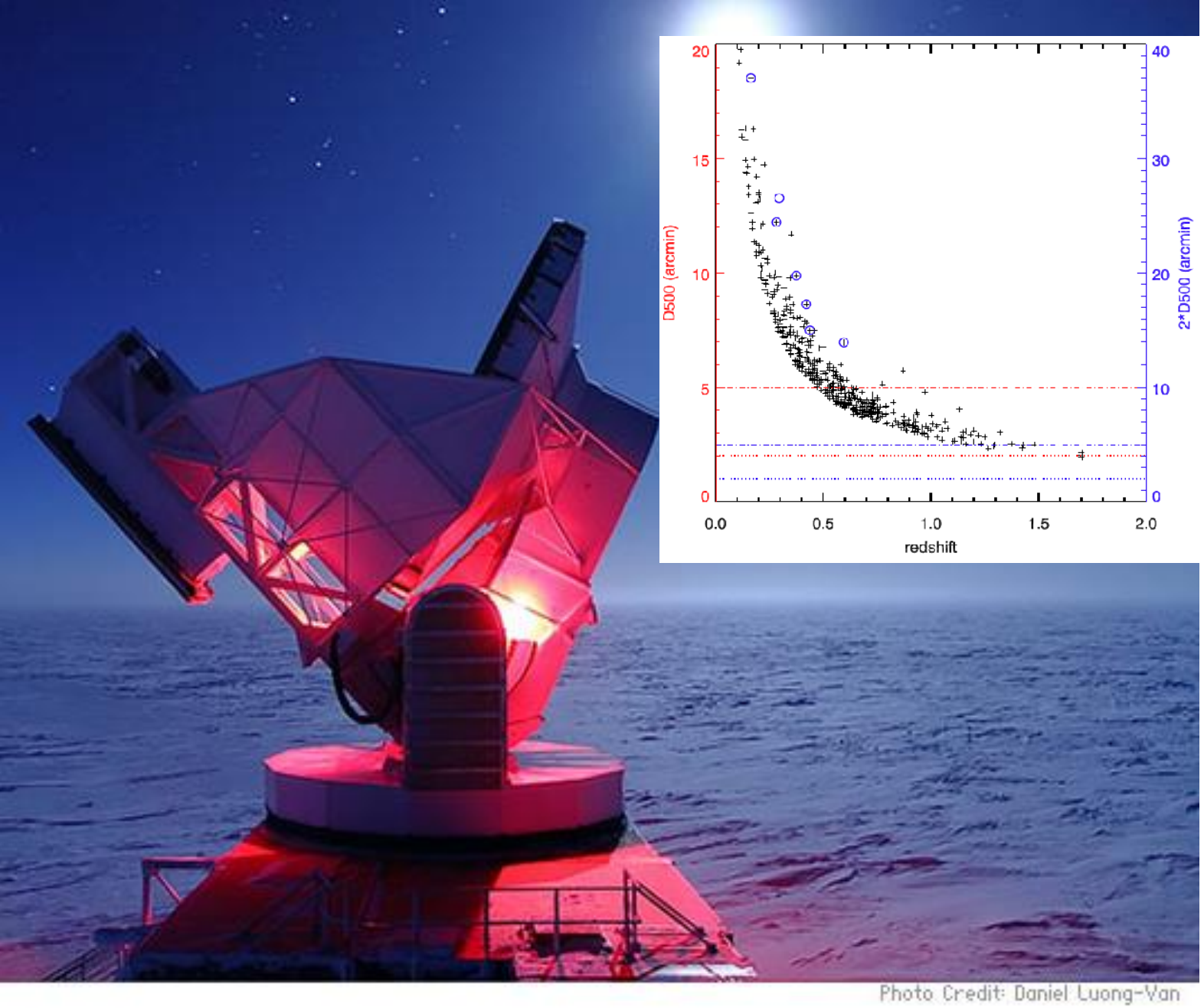


PLANCK

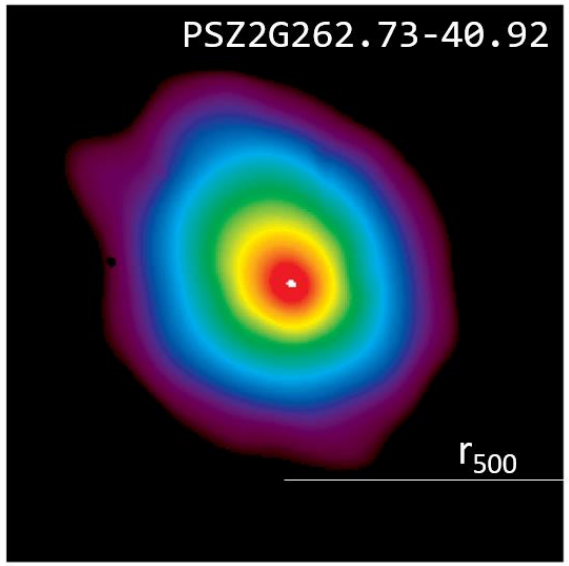
- ESA satellite mission launched in 2009.
- Full sky maps of temperature and polarization with sub-Jansky sensitivity.
- 9 frequency bands from 30 to 857 GHz.
- Resolution <10 arcmin.
- 1000+ cluster detected via the Sunyaev-Zeldovich effect (SZ).

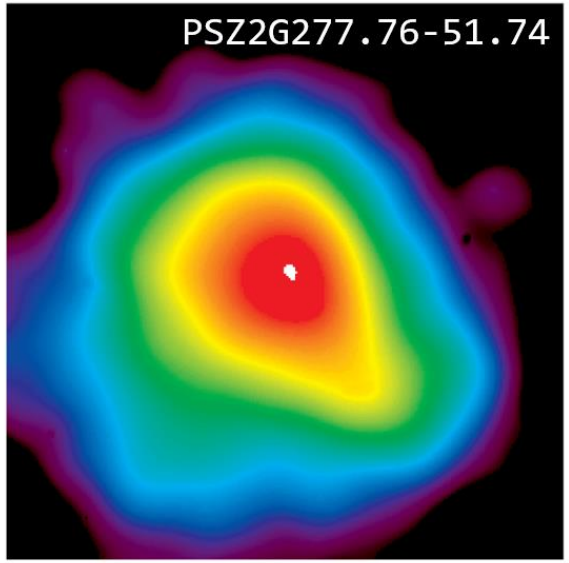
(Planck Collaboration 2020, A&A,641,A1, arXiv:1807.06205)

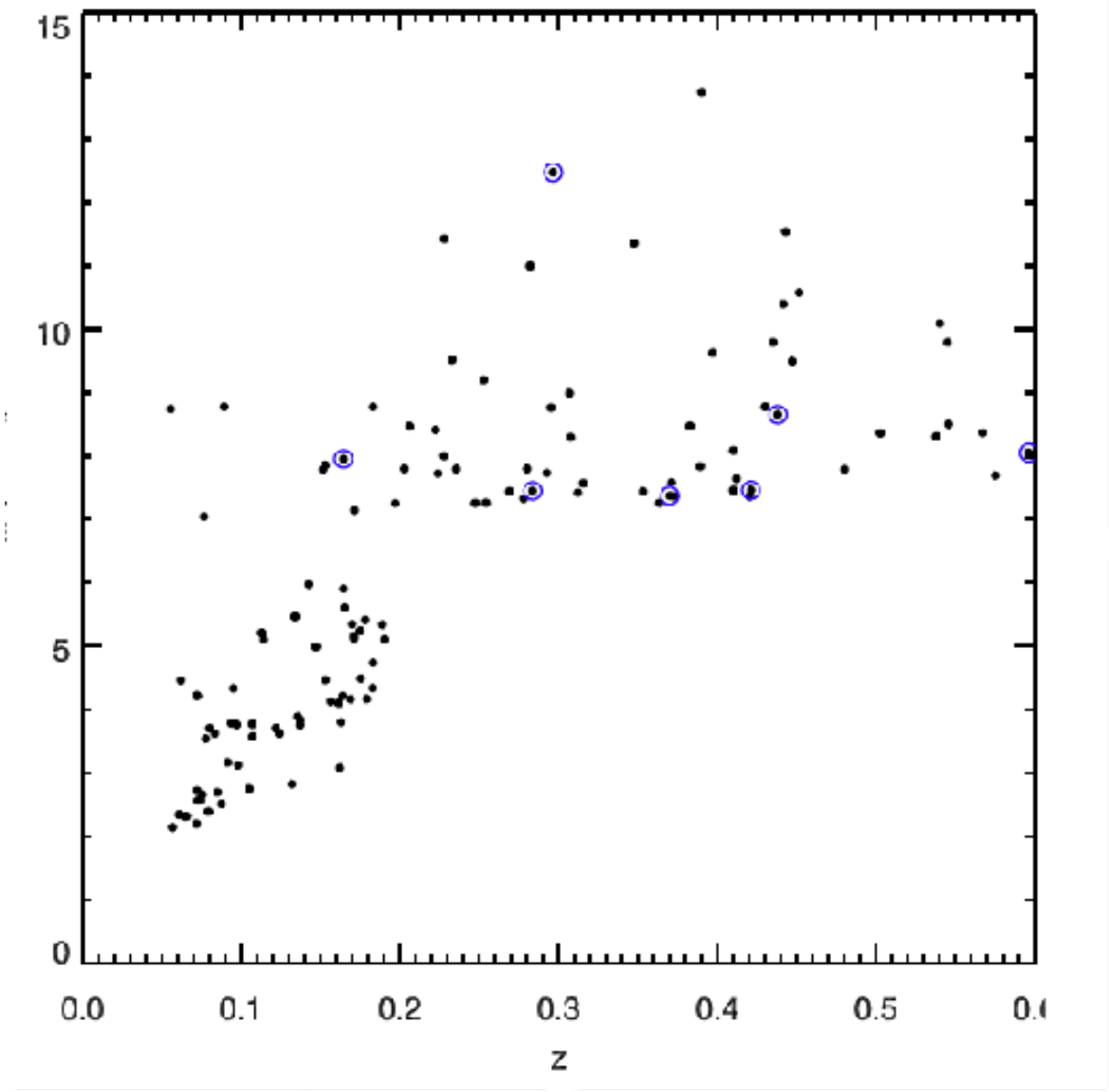


South Pole Telescope

- 3 channels: 95, 150, 220 GHz , resolution 1.75 arcmin.
- 2500 square-degree survey at high galactic latitude.
- 677 clusters candidates:
  - Nearly mass limited (M_{500} > $2x10^{14}M_{\odot}$).
  - Maximum redshift: 1.7.
- It allows to probe the redshift evolution of the cluster structure.
- SPT is sensitive to inner regions, Planck to the peripheries.

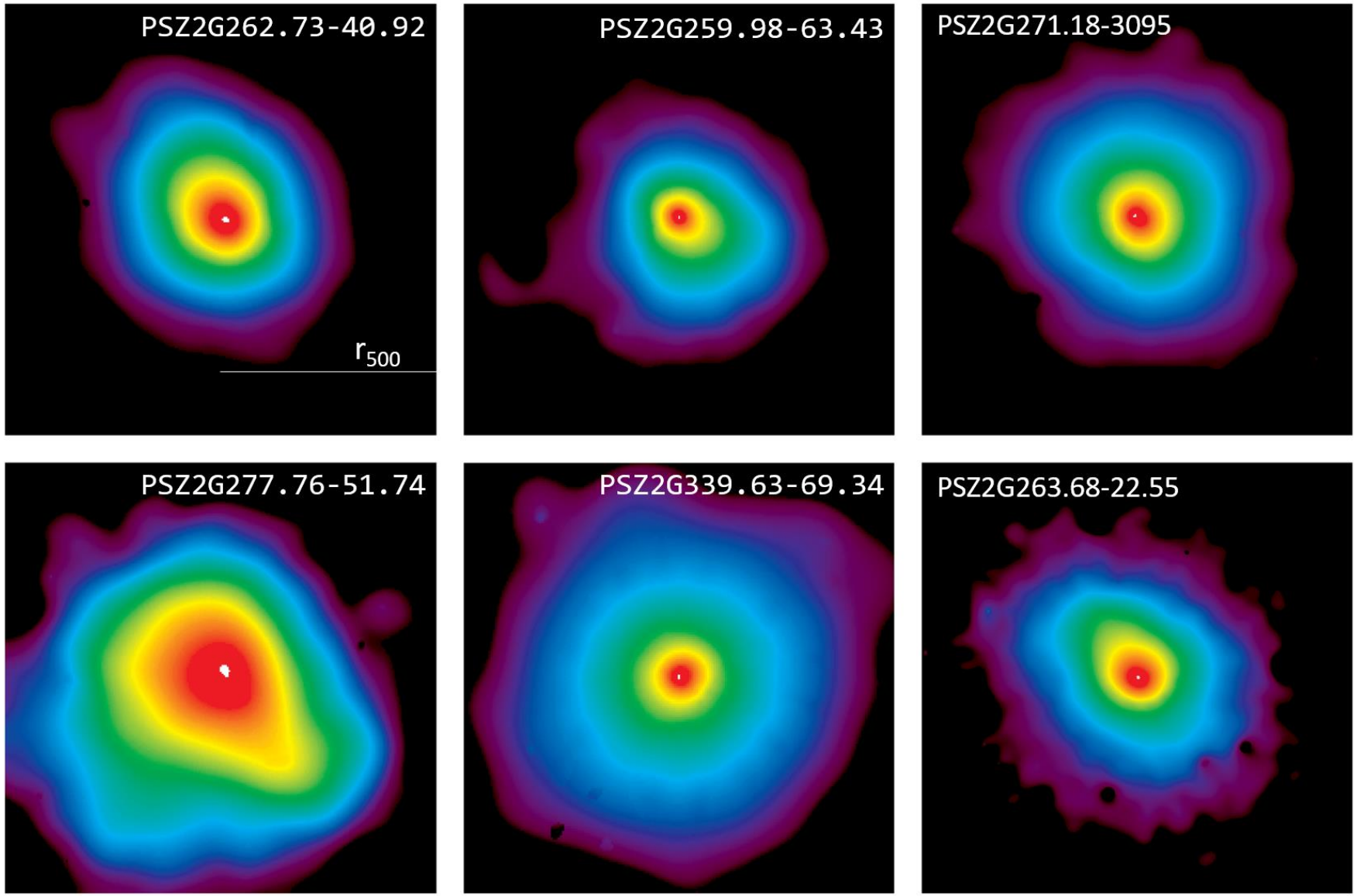






The Sample

- We analyse a sub-sample of 6 clusters common to the SPT and CHEX-MATE catalogue. (arXiv:2010.11972)
- We exploit the XMM data to validate our SZ pressure profile extraction algorithm.
- The comparison with X-ray spectroscopic data provides a powerful benchmark.
- We study the impact of sub-structure on the relation between SZ and X-ray profiles.



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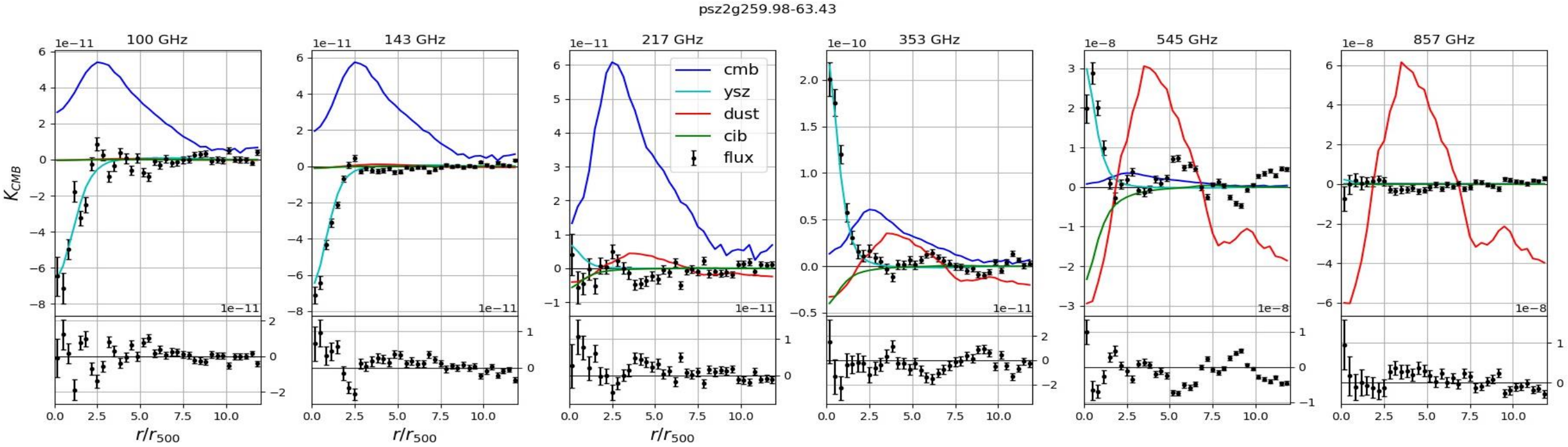
Component separation: Planck

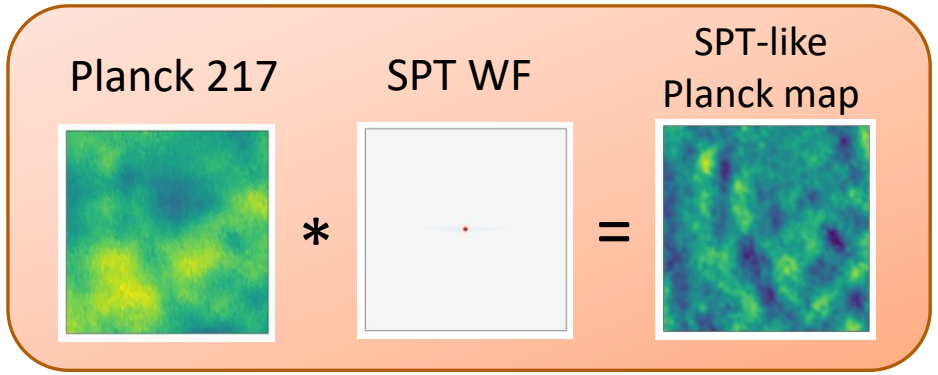
(Bourdin et al. 2017, ApJ 843:72)

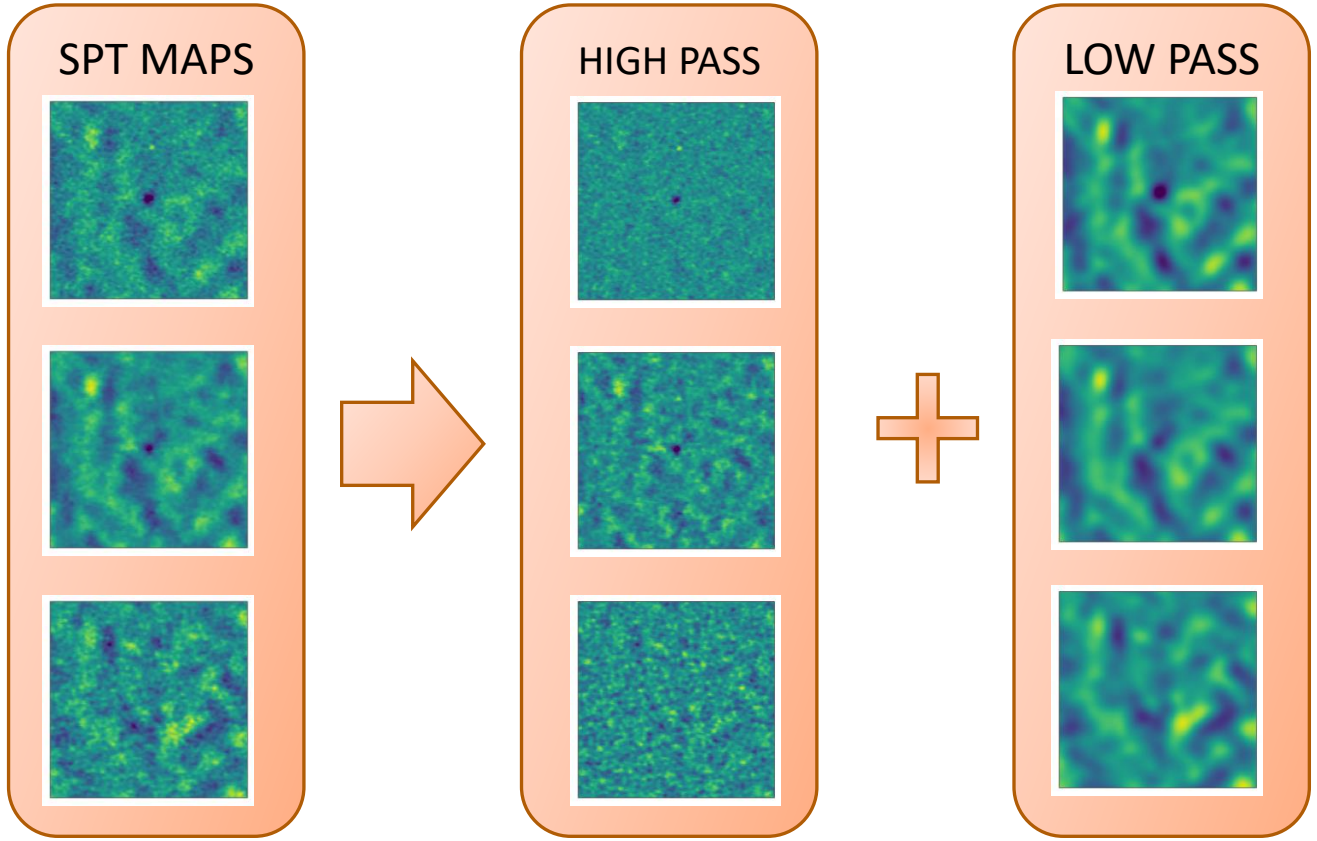
- Maps are high-pass filtered to removes large scale modes.
- 4 components fit:
  - cluster SZ signal.
  - Primary CMB anisotropies.
  - Galactic Thermal Dust (Meisner & Finkbeiner, 2005, ApJ, 798:88).
  - Intracluster Dust Correction.
- Cluster template gNFW profile (Nagai et al 2007) projected and convolved with the instrumental beams.
- The diffuse Components are recovered from the wavelets reconstruction of the 857Ghz (Dust) and the 217GHz (CMB) channels.



Component separation: SPT

- SPT maps are high-pass filtered due to the Filter Transfer Function.
- 220 GHz noise is very high.
- No significant dust contamination.
- To recover the background (CMB) in SPT we resort to a *Multiscale Internal Linear Combination*, including also the Planck 217GHz Channel.
- The weights minimize the CMB variance nulling the SZ component





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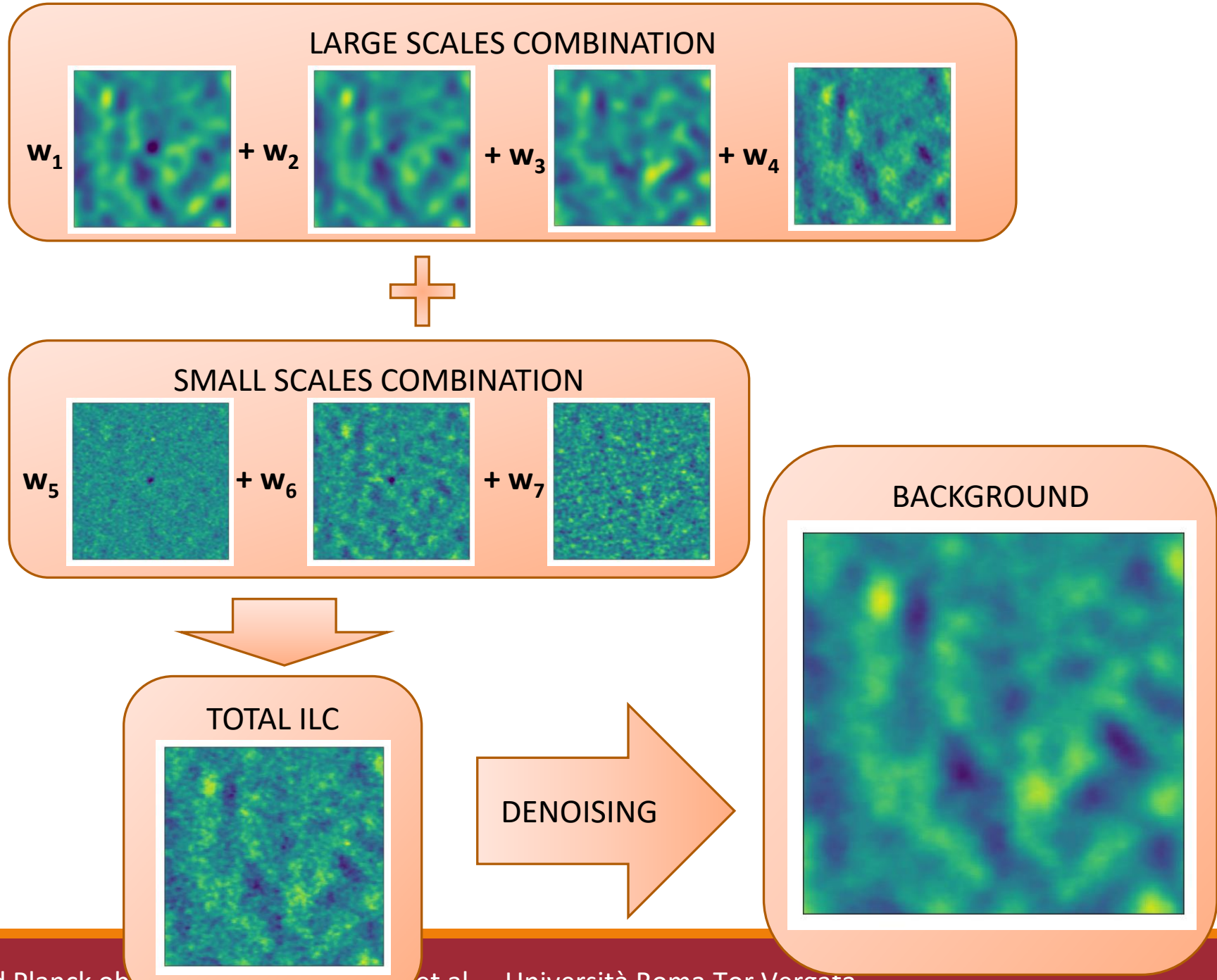
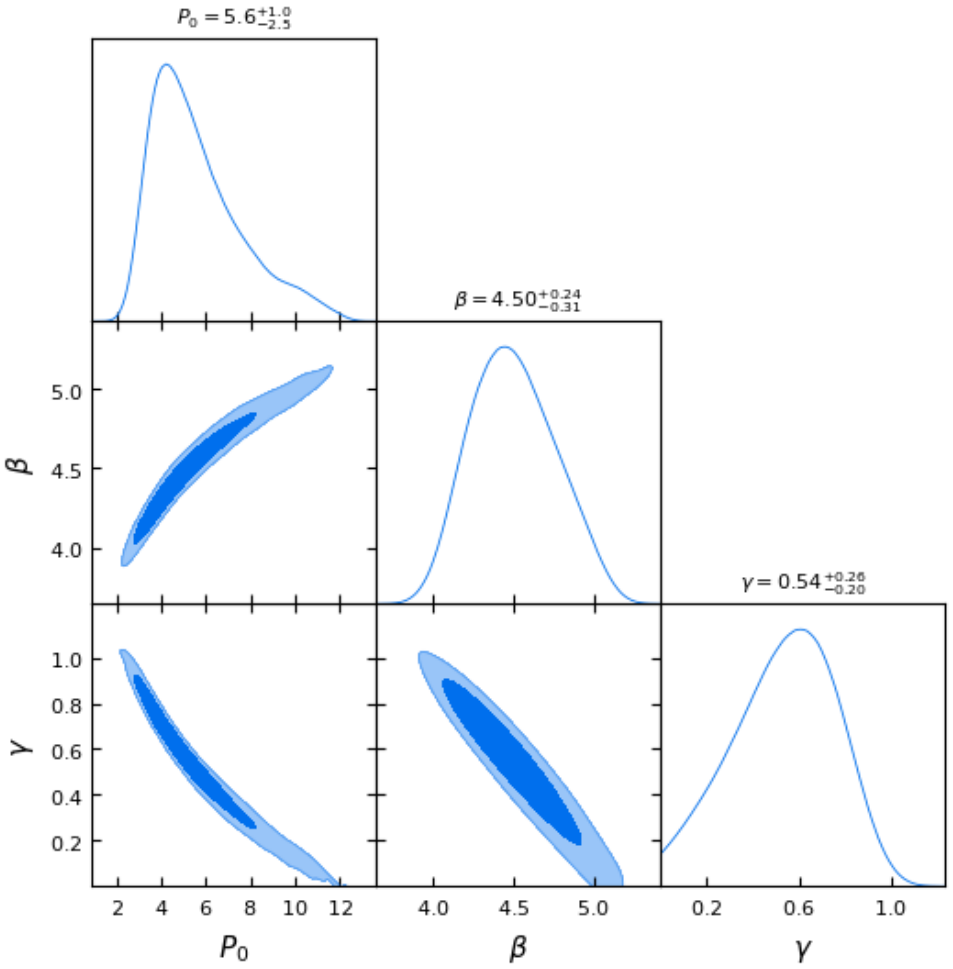
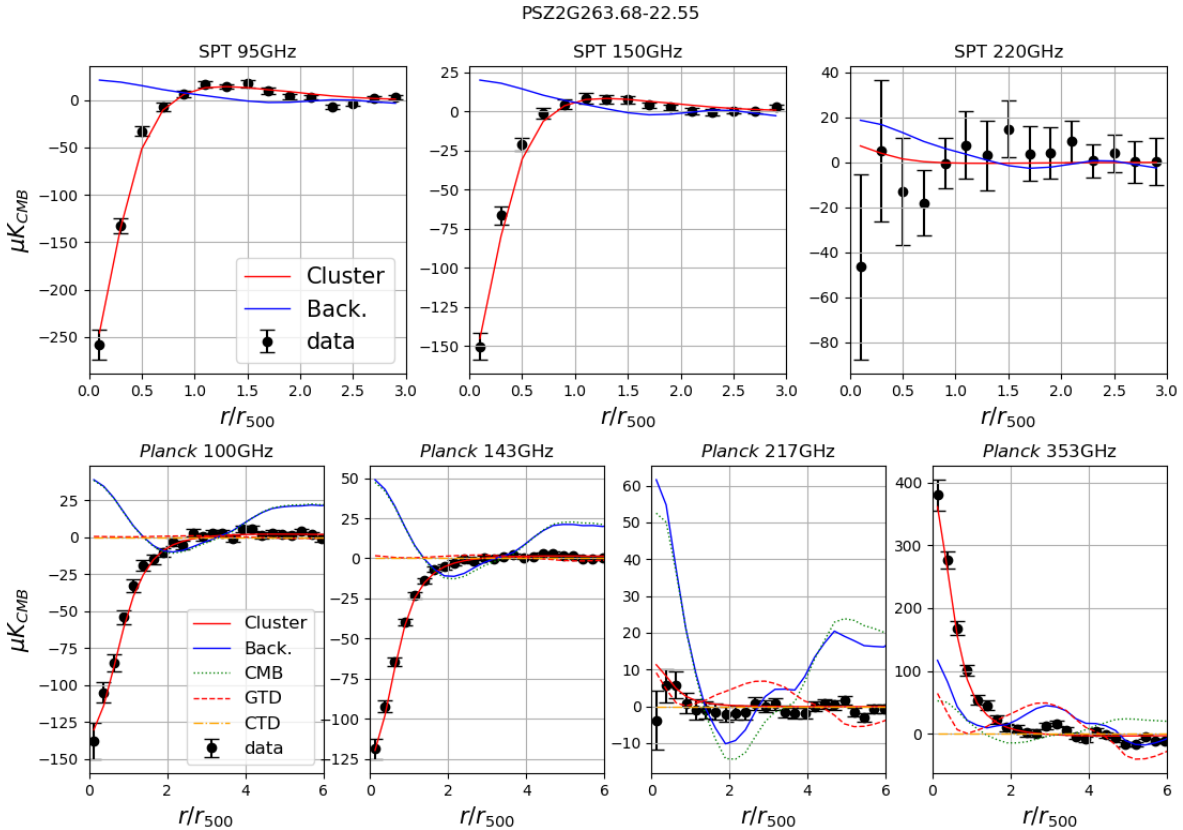


SPT-Planck Joint fit





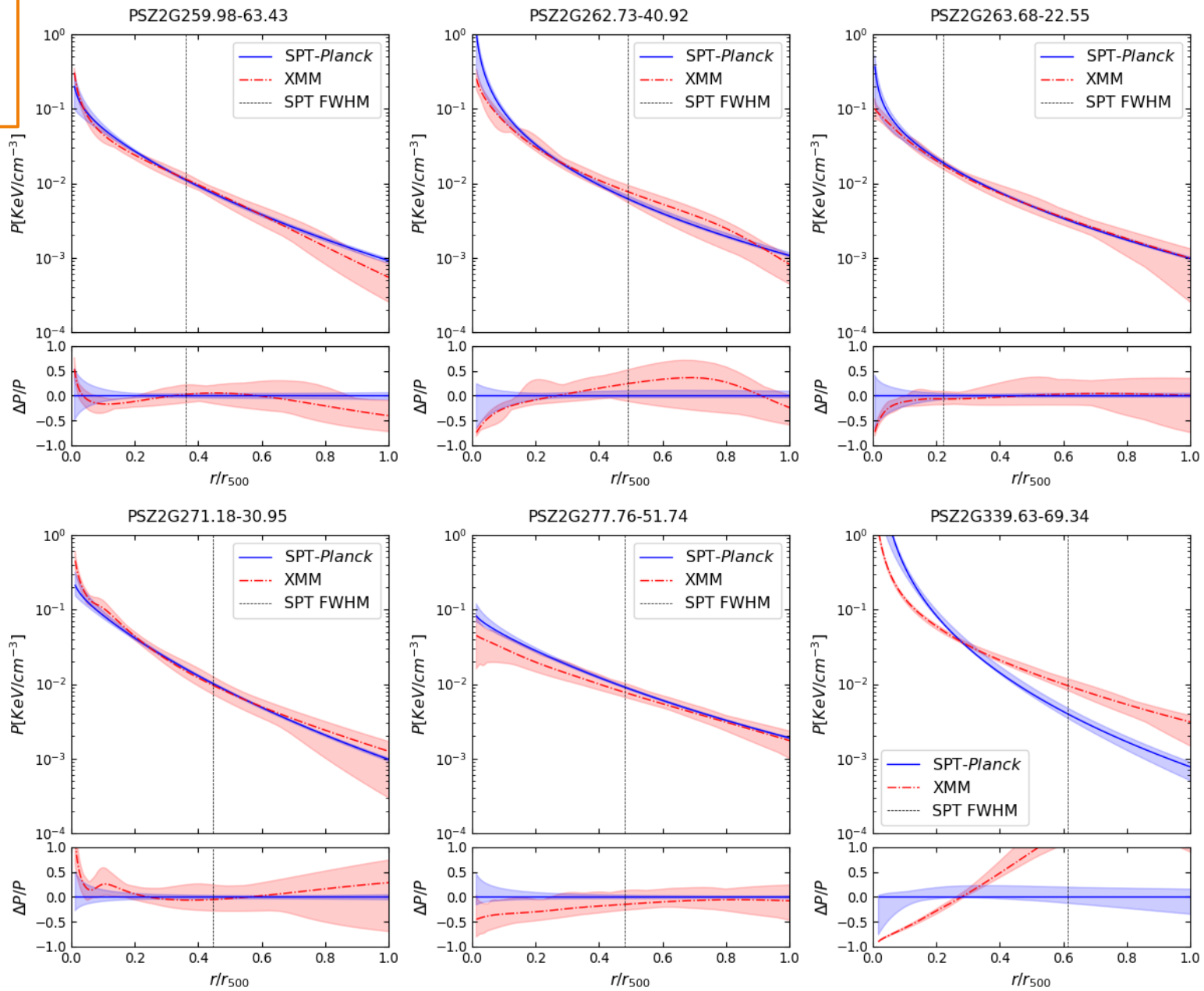
- We combine the cleaned maps in a joint fit of a gNFW profile.
- We use the 95, 150 GHz SPT channels and the 100, 143, 353 GHz from Planck HFI.
- Nagai profile with 3 free parameters:
  1. Amplitude P_0 .
  2. 2 slopes: β for $r \gg r_{500}$, γ for $r \ll r_{500}$.
  3. Intermediate slope and concentration fixed α =1.051, c_{500}=1.177 (Arnaud et al., 2010).

$$P(r) = P_0 \frac{P_{500}}{x^{\gamma}(1+x^{\alpha})^{\frac{\beta-\gamma}{\alpha}}}$$
$$x = rc_{500}/r_{500}$$

Profiles comparison

X-ray pipeline in Federico De Luca's talk

- The comparison with XMM profiles shows good agreement in the innermost regions.
- The agreement is higher in the cluster with regular shape.
- PSZ2G259.98-63.43 presents a slight deviation around r_{500} probably explained by the irregular shape.
- The Phoenix cluster (PSZ2G339.63-69.34) is contaminated by a strong AGN X-ray emission.



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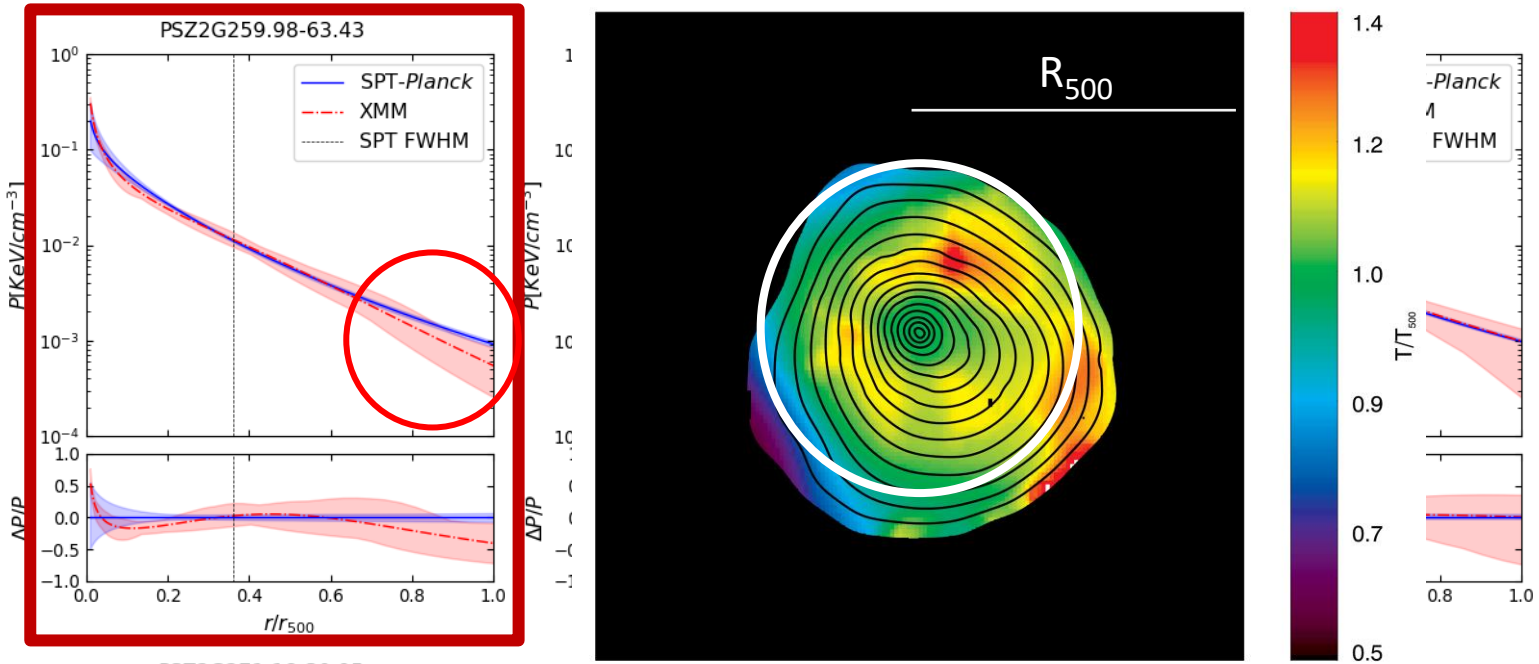

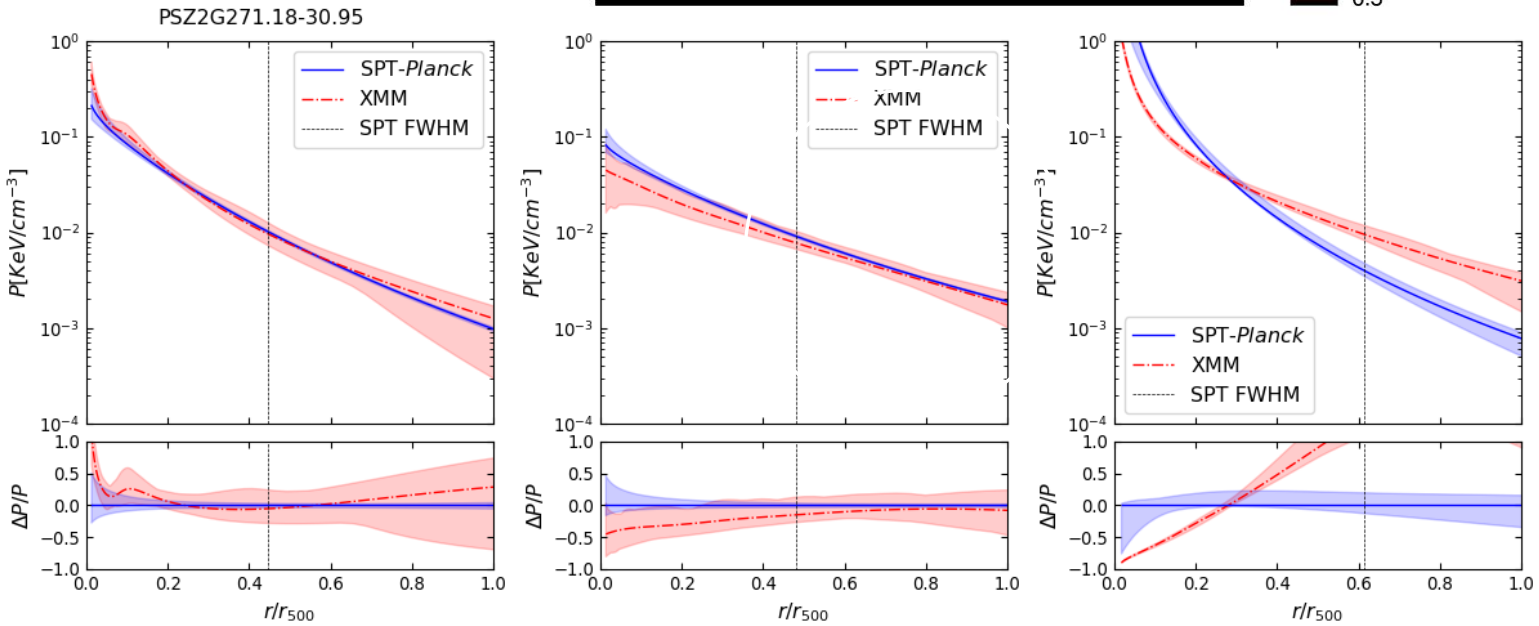

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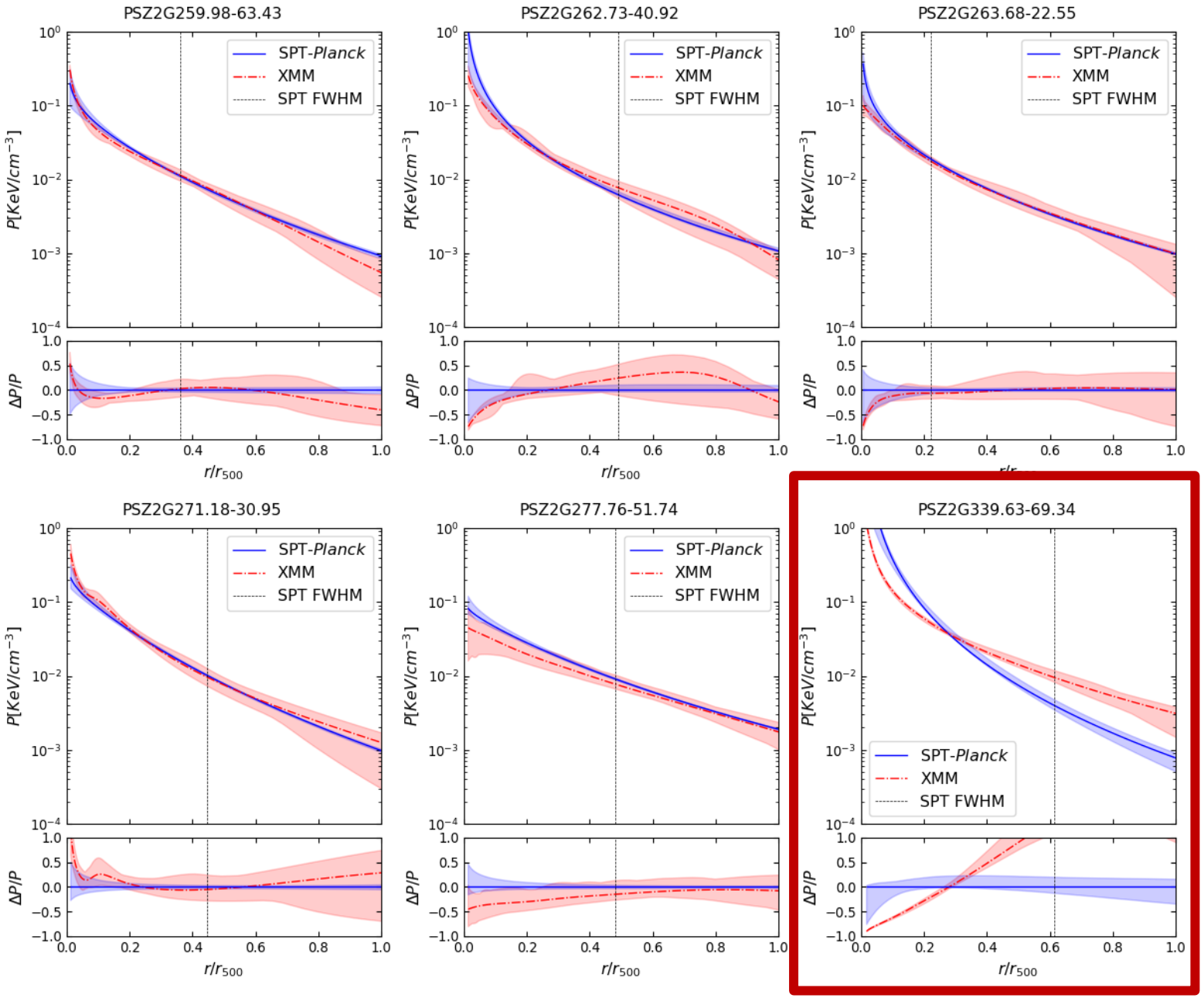
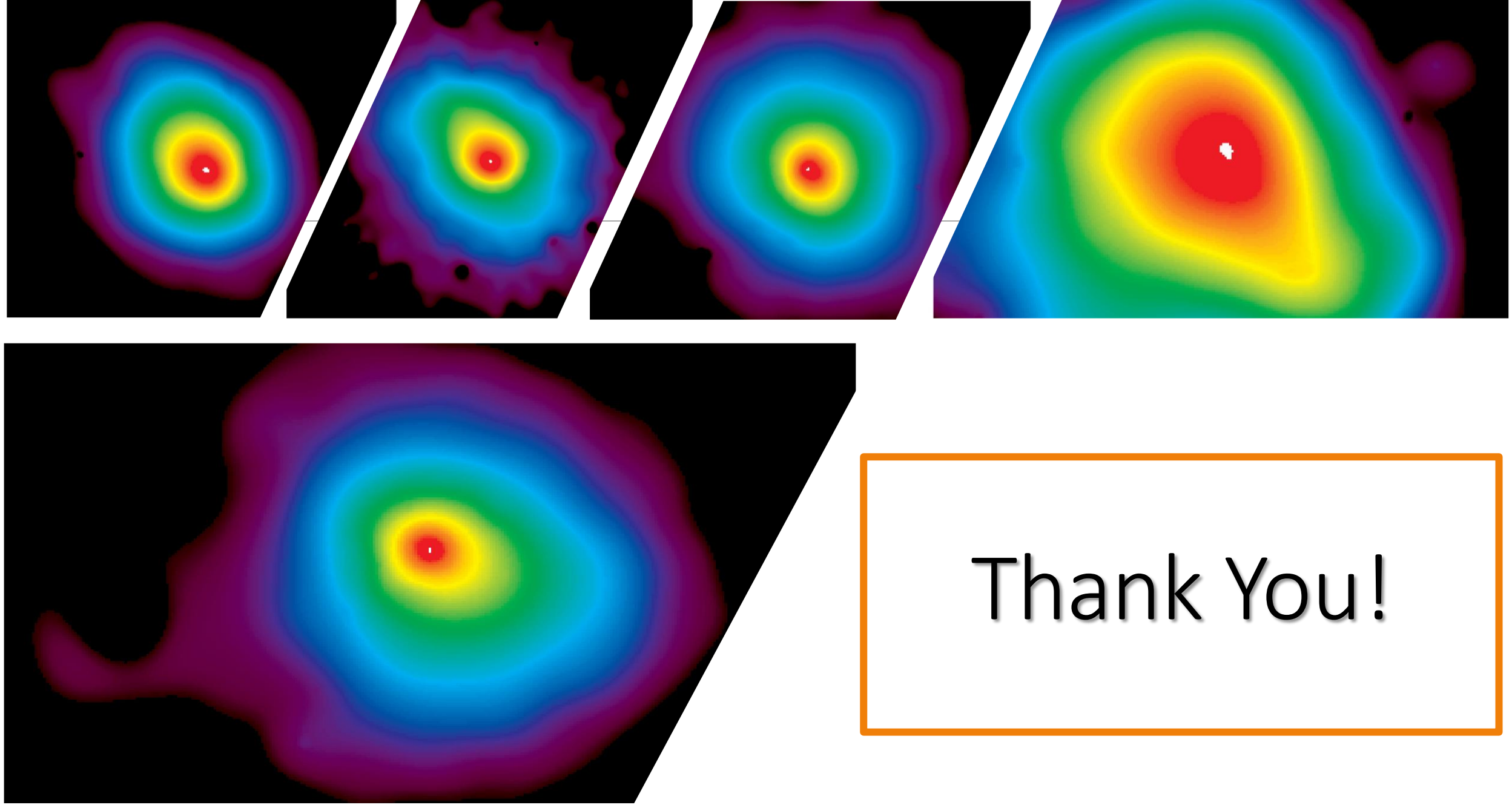


Conclusion and future works

- We develop a complete set of tools to extract cluster pressure profiles from the joint analysis of Planck and SPT data.
- Combining the datasets allows us to fit the profile from the inner to the outermost regions of the clusters.
- We implemented two specific pipelines for the component separation on SPT and Planck.
- The comparison with XMM data on a pilot sample overlapping the CHEX-MATE catalogue shows good agreement between the X-ray and millimetre data.
- We investigate the impact of irregularities in the cluster shape to explain potential discrepancies.
- We will extend the analysis to a larger part of the SPT catalogue.



Thank You!