WP 7-6X1
Astroparticle and Fundamental Physics
Status of activities

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Name	Role	Institution	Note
Paolo Natoli	PA	UniFe	WP manager
Alessandro Gruppuso	Researcher	IASF/BO	Task leader
Gianluca Polenta	Researcher	ASI	Task Leader
Massimiliano Lattanzi	Researcher	INFN	Task leader
Vladimir Lukovic	PostDoc	Tor Vergata	Task leader
Luca Pagano	PostDoc	IAS Orsay	Task leader
Reno Mandolesi	Professor	UniFE	I/F to WP 4-6X1
Nicola Bartolo	PA	UniPD	I/F to WP 8-6X1
Alessandro Melchiorri	PA	Sapienza	Participant
Andrea Zacchei	Researcher	INAF/OAT	I/F to WP 4-6X2
Carlo Baccigalupi	PO	Sissa	I/F to WP 9-6X1/X2
Raffaele Tripiccione	PO	UniFE	Participant
Giuseppe Iacobellis	PostDoc	UniFE	Participant
Diego Molinari	PostDoc	UniFE	Participant
Linda Polastri	PhD Student	UniFe	Participant
Francesco Forastieri	PhD Student	UniFe	Participant
TDA Researcher	Researcher	UNife	To be recruited

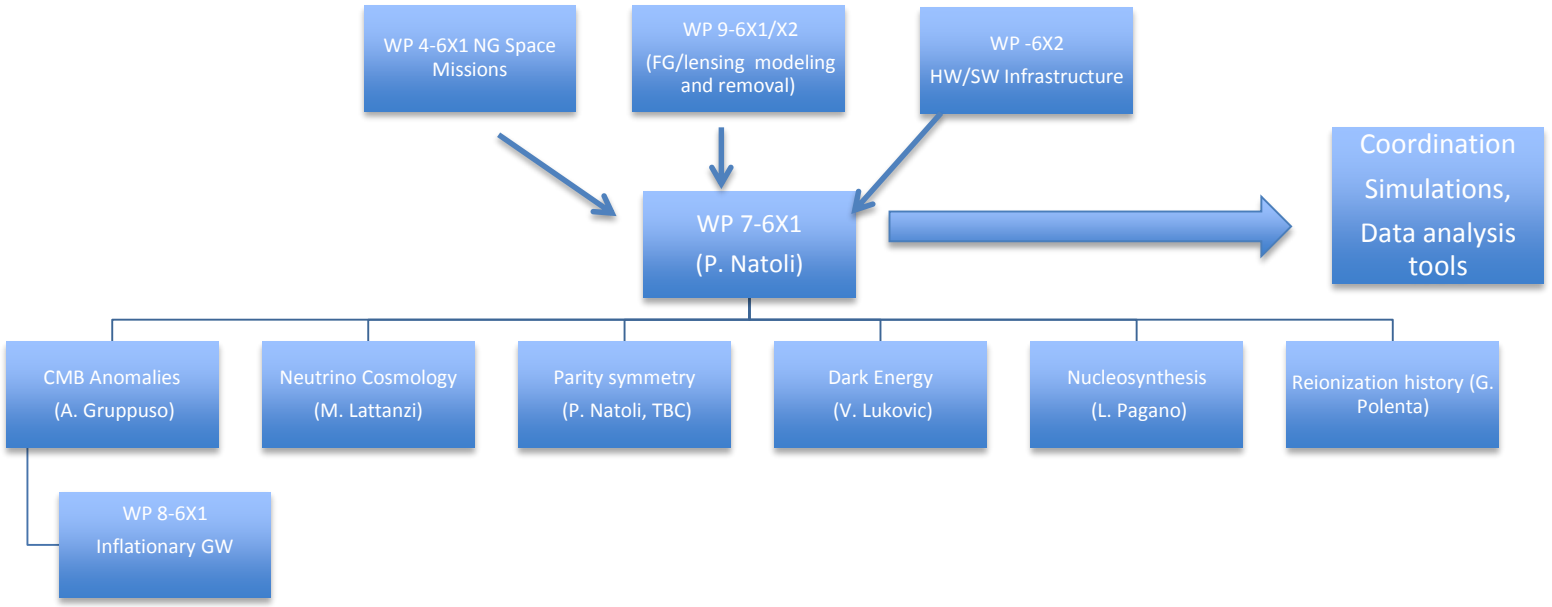
Scope of WP 7-6X1

- In the context of COSMOS, provide support, forecasts and constraints for astroparticle and fundamental physics:
  - Neutrino physics, fundamental symmetries, new avenues for CMB research (anomalies, etc.), dark energy, baryonic and dark matter content, reionization as a probe for new physics.
  - Based on public sources (e.g. Planck legacy data) and contributions from other COSMOS WP.
- Identify and case-study interesting science targets to build our “roadmap”
- Set-up science-extractions tools and make them available to the COSMO micro-world
  - Forecast/likelihood packages for “specific” experimental scenarios/targets.
  - This requires close coordination with other working groups

Organizational Setup

- There are several science targets in this WP. A division in tasks is desirable. We have agreed on a breakdown:
  - **Task 7-6X1.1: CMB Anomalies (A. Gruppuso)**
  - **Task 7-6X1.2 Neutrino Cosmology (M. Lattanzi)**
  - **Task 7-6X1.3: Parity Symmetry (P. Natoli)**
  - **Task 7-6X1.4: Dark Energy (V. Lukovic)**
  - **Task 7-6X1.5: Nucleosynthesis (L. Pagano)**
  - **Task 7-6X1.6: Reionization history (G. Polenta)**

Breakdown structure



Status of Activities

- Large topic, need to “grease joints”
  - First aim is to organize production of deliverable document on COSMOS Roadmap
  - DRAFT Texts provided to “Scientific Motivations” for “CMB Anomalies” (A. Gruppuso), “Cosmological birefringence” (P. Natoli), “Neutrino cosmology” (M. Lattanzi), “Impact of B modes on cosmological parameters” (G. Polenta)
  - Contributing to the “Data Analysis” part of the COSMOS roadmap.
- Specific activities planned

First Year, t0+6months

• Set up, structure, Review of theoretical model, assess parameters, planning of activities

=> Status is advanced: No problem foreseen in providing things in time

First Year, t0+12months

• Set up simulation pipeline for theoretical signal and realistic sky model.

=> Rather ambitious, needs an early start and close interaction with other WP

• Set up data analyses on Planck legacy, validation checks

=> Can be considered already in progress

• Set up of relevant tools for likelihood modeling and other forms of parameter constraints

=> Important also to feed other working groups.

Two examples of results:

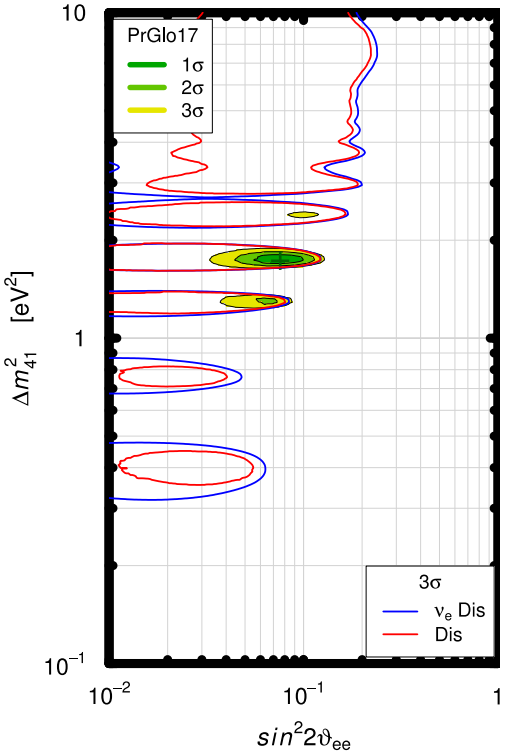
- Neutrino constraints
- CMB Anomalies

Other than constraining the mass (M_ν) and abundance (N_{eff}) of neutrinos, the CMB can also probe their interactions
(i.e. deviations from the `standard' free-streaming behaviour)

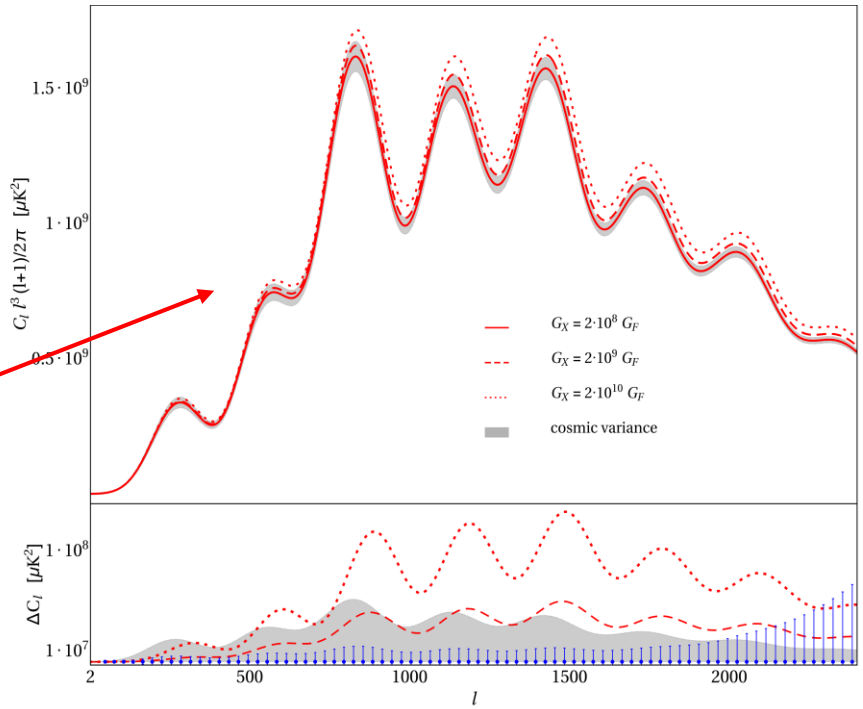
Sensitivity to different mediators: e.g. scalar, vector…..

Example: 3 active + 1 sterile neutrino ($m_s \sim 1$eV) with *Fermi-like non-standard interactions*:

$$\mathcal{L}_s = g_X \bar{\nu}_s \gamma_\mu \frac{1}{2} (1 - \gamma_5) \nu_s X^\mu$$



Such an interaction has been proposed to reconcile long-standing anomalies in short baseline oscillation experiments and cosmological observations



Collisions lead to an increase in density and pressure fluctuations below a critical scale

CMB can probe this scenario, that is mostly unconstrained by laboratory observations!

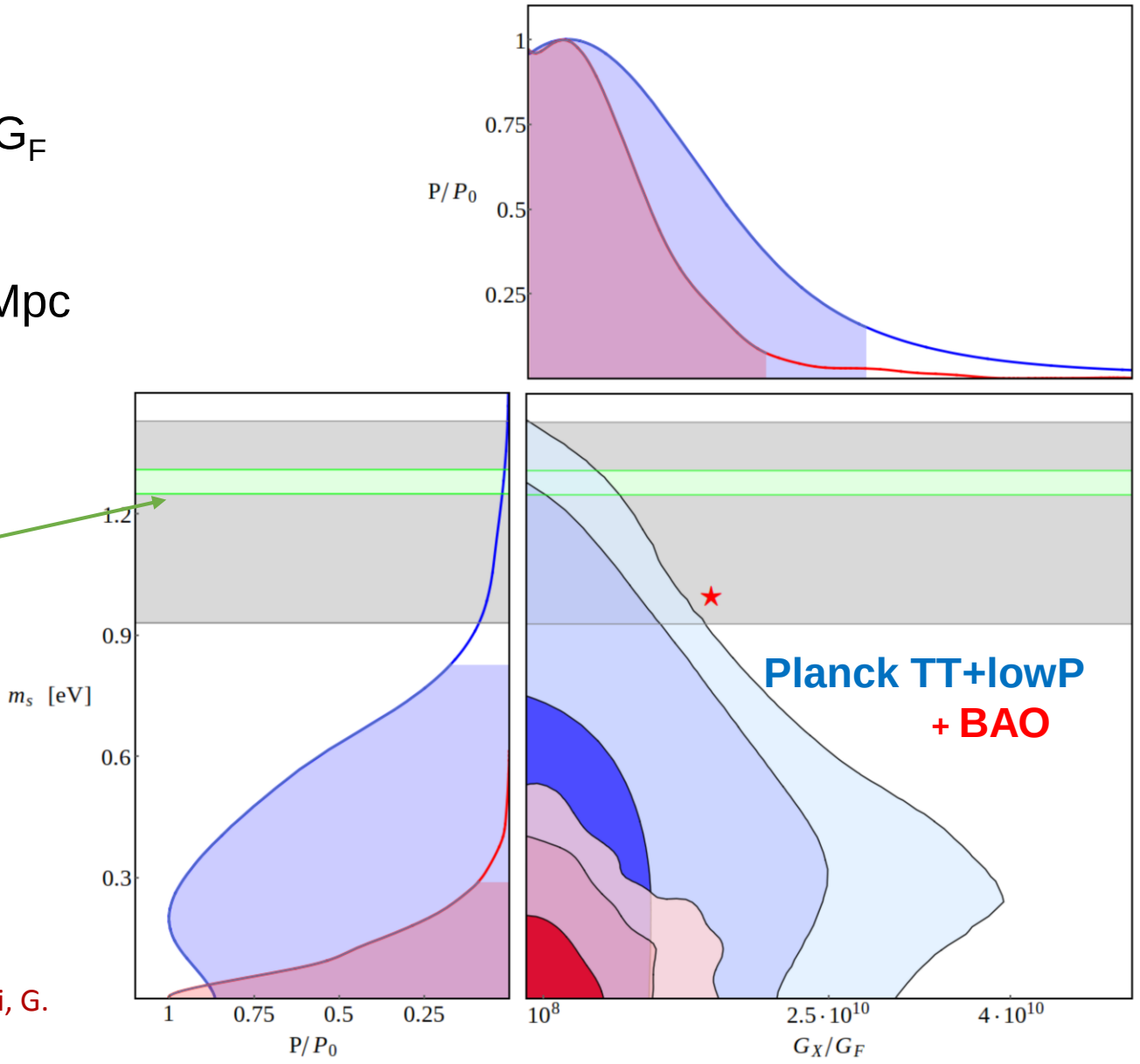
ΛCDM + m_s + G_X

G_X < 2.8 (1.97) x 10^{10} G_F
m_s < 0.82 (0.29) eV

H_0 =62.6 +/- 1.8 km/s/Mpc
(65.3 +/- 0.7)

Mass range singled out by SBL anomalies

CMB + BAO observations exclude the model with a high statistical significance!



F. Forastieri, M. Lattanzi, A. Mirizzi, G. Mangano, P. Natoli, N. Saviano, arXiv:1704.00626

Lack of power

At large angular scale of the temperature CMB pattern shows less power wrt what expected in the ΛCDM scenario. The significance is around 2.5-3σ CL.

Of course this might be a **statistical fluke**. If not, there are two reasons to consider seriously this anomaly since it is not natural to ascribe this effect to

1. **foreground emissions not fully removed**: any residuals should *increase* rather than reduce the power since they are not expected to correlated with CMB.

2. **instrumental systematics**: two independent experiments (WMAP and Planck) observe the same features with similar significance

Lack of power

Moreover there is a particular behaviour which has to be taken into account:

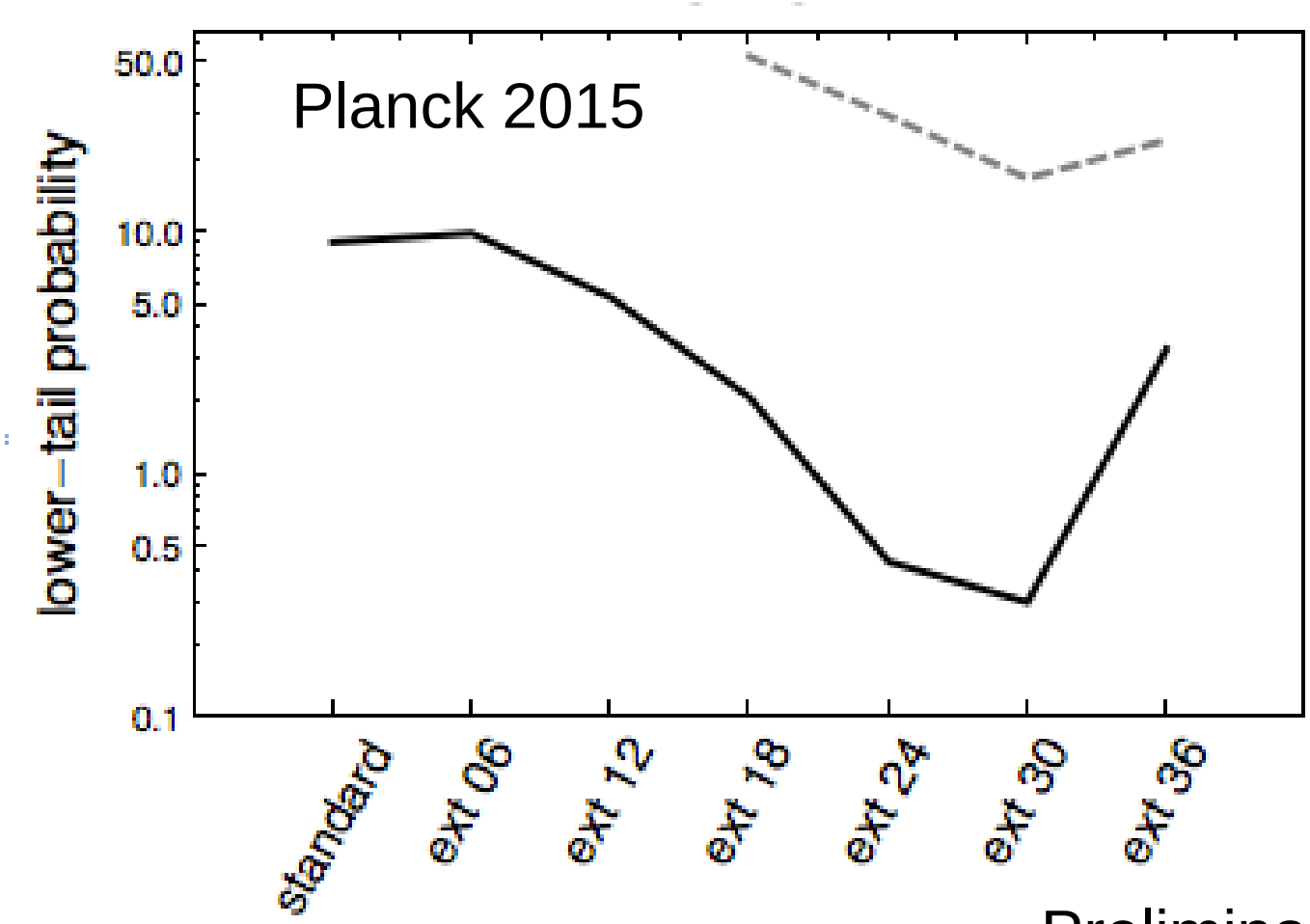
The significance of this anomaly gets stronger when the Galactic mask is increased.

This is really a remarkable fact since the exclusion of regions close to the Galactic plane is in principle a very conservative choice.

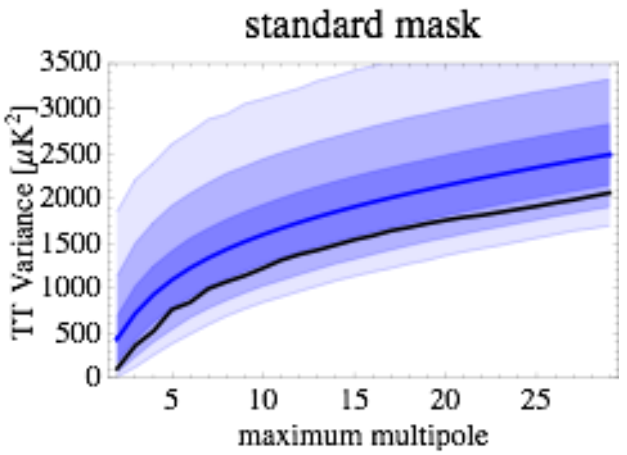
Lack of power

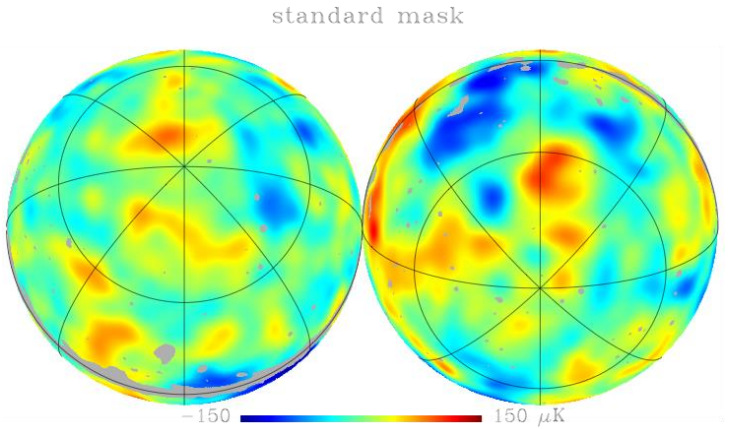
variance in harmonic space

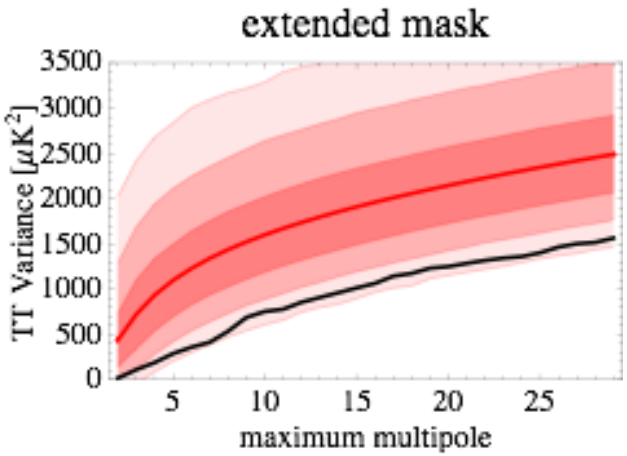
Gruppuso et al. (in prep.)

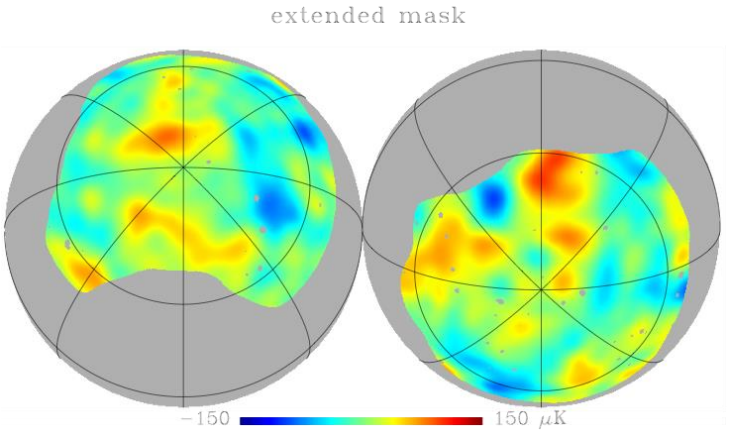


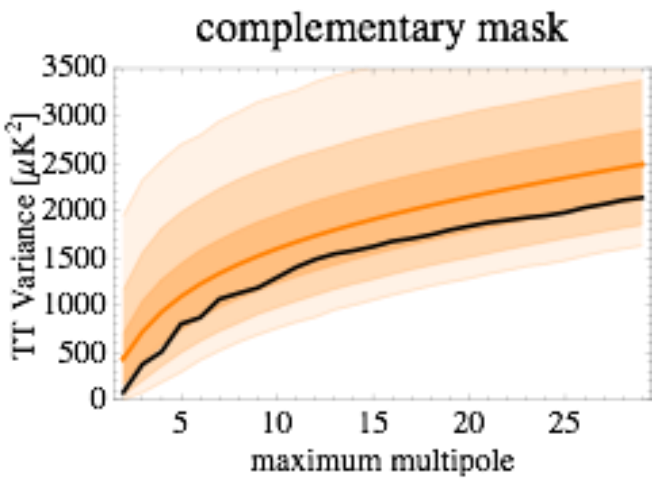
Preliminary results

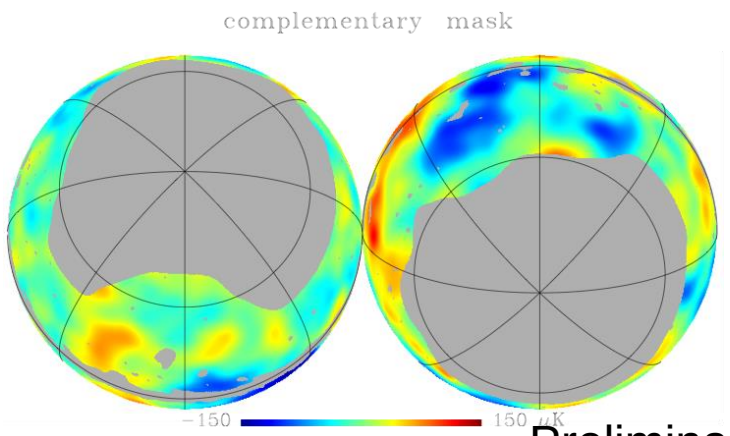












Preliminary results