

European Low Frequency Survey

Collaboration Slides

ELFS Working Group on behalf of the
European Ground-Based CMB Coordination
wiki.e-cmb.org

Goals & Concepts (Slides for Mike in Milan)

...



Defining Scientific Requirements for ELFS

- **Organization**
- **Definition Phase**
- **Initial conditions for Specifications**
- **Groups, Methods & Forecasts**
- **Testing Schedule**
- **Timescale to Definition of Science Case, HW Proposal**



Organization

- HW reference persons
 - Jose' Alberto Rubino Martins (SP), Mike Jones (UK), Daniele Mennella (IT)
 - Carlo Baccigalupi (secretary), Marco Bersanelli, Nicoletta Krachmalnicoff, Enrique Martinez-Gonzalez, Jose Alberto Rubino-Martin (HW resp., Spain), Daniele Mennella (HW resp., Italy), Angela Taylor
- People participating to discussions so far: Carlo Baccigalupi, Marco Bersanelli, Nicoletta Krachmalnicoff, Enrique Martinez-Gonzalez, Davide Poletti, Angela Taylor
- Three telecons so far, going bi-weekly since February 21st, 2019
- Constant Coordination and Reporting to e-cmb, COSMOS
- ACTIONS in progress:
 - **Write a short "Manifesto" of the proposal (Mike)**
 - **Prepare a wiki page and mailing list (Daniele)**
 - **Setup living document for presentation (Carlo, this one)**
 - **gather collaborators (all groups)**
 - ...





Definition Phase: Methodology & Purpose

- **Recovery of Foregrounds & CMB via Parametric Component Separation**
- **Amplitude of Foregrounds and Generalized Frequency Dependence**
- **Reconstruction of CMB**
- **Optimization**
- **Assessment of the Performance of SO, CMB-S4 & LiteBIRD with Synchrotron Priors from ELFS**



Methodology & Purpose

- **Recovery of Foregrounds & CMB via Parametric Component Separation**
- **Amplitudes of Foregrounds and Generalized Frequency Dependence**
 - Varying spectral index on all scales indicated by radio and microwave observations (S-PASS, C-BASS * Planck, WMAP),
 - Spatially varying curvature,
 - Limitations due to Polarized Anomalous Microwave Emission
- **Reconstruction of CMB**
 - B-modes
 - Statistical Description of Foreground Residuals
- **Optimization**
 - Recovery of Synchrotron
 - Principal Components of the Tensor Power Spectrum (Campeti et al., to appear)
- **Assessment of the Performance of SO, CMB-S4 & LiteBIRD with Synchrotron Priors from ELFS**





Initial Specifications: Sensitivity & Angular Resolution

Normalize S/N to a value comparable to LiteBIRD/CMB-S4 at CMB frequencies, keep it constant with frequency following Synchrotron scaling, normalizing

$$0.5 \mu\text{K} \cdot \text{arcminutes} \cdot (\text{frequency}/100 \text{ GHz})^{\Sigma}$$

Assume simple power law for FWHM

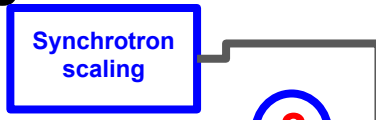
$$20 \text{ arcminutes} \cdot (\text{frequency}/10 \text{ GHz})^{\text{B}}$$



Initial Specifications: Sensitivity & Angular Resolution

Normalize S/N to a value comparable to LiteBIRD/CMB-S4 at CMB frequencies, keep it constant with frequency following Synchrotron scaling, normalizing

$$0.5 \mu\text{K} \cdot \text{arcminutes} \cdot (\text{frequency}/100 \text{ GHz})^{-3}$$



Assume simple power law for FWHM

$$20 \text{ arcminutes} \cdot (\text{frequency}/10 \text{ GHz})^{-1}$$



Specifications: frequency coverage, FWHM & Sensitivity

- **Very Low Frequency Array (VLFA, GHz):**

- Frequency [GHz]: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- FWHM [arcminutes]: 20, 18, 17, 15, 14, 13, 12.5, 12, 11, 10.5, 10
- Sensitivity [$\mu\text{K} \cdot \text{arcminutes}$]: 5000, 3800, 2900, 2300, 1800, 1500, 1200, 1000, 850, 730, 630
- Bandwidth: 1 GHz

- **Low Frequency Array (LFA)**

- Frequency [GHz]: 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46
- FWHM [arcminutes]: 7.7, 7.1, 6.7, 6.3, 5.9, 5.6, 5.3, 5, 4.8, 4.6, 4.3
- Sensitivity [$\mu\text{K} \cdot \text{arcminutes}$]: 280., 230, 190, 150, 130, 110, 90, 78, 67, 59, 51
- Bandwidth: 2 GHz

- **Middle Frequency Array (MFA, GHz, arcminutes, $\mu\text{K} \cdot \text{arcminutes}$):**

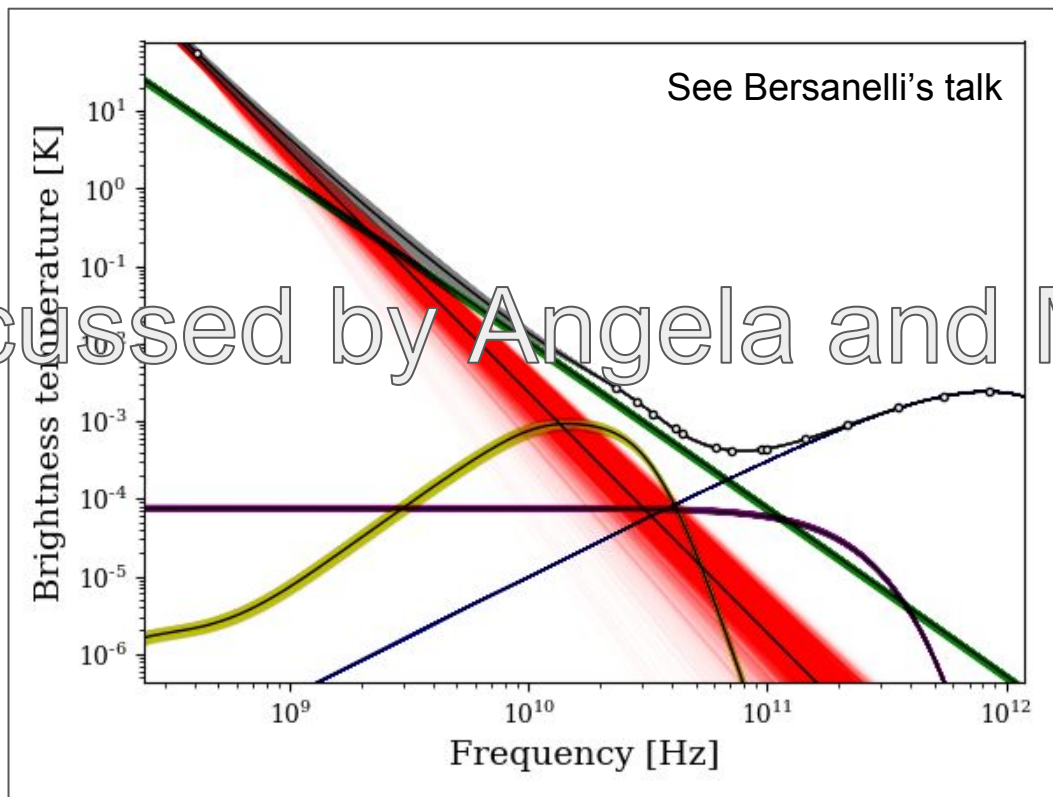
- 75, 78, 81, 84, 87, 90, 93, 96, 99, 102, 105, 108, 111, 114, 117, 120
- 2.7, 2.6, 2.5, 2.4, 2.3, 2.2, 2.1, 2.1, 2, 2, 1.9, 1.9, 1.8, 1.8, 1.7, 1,7
- 11.9, 10.5, 9.4, 8.4, 7.6, 6.9, 6.2, 5.7, 5.2, 4.7, 4.3, 4.0, 3.7, 3.4, 3.1, 2,9
- Bandwidth: 3 GHz



Groups, Methods & Present Results of Forecasts

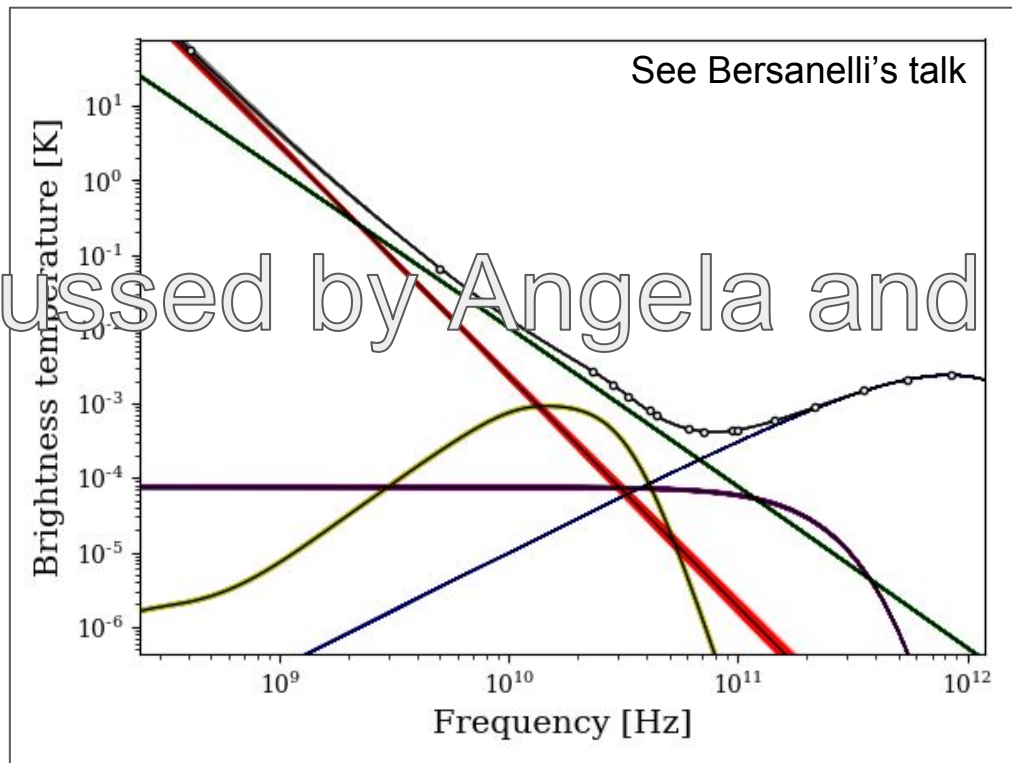
- Area Parametric Fitting @ Oxford
- FGBuster @ SISSA
- Parametric Fitting @ Santander

Area Parametric Fitting @ Oxford



As discussed by Angela and Mike

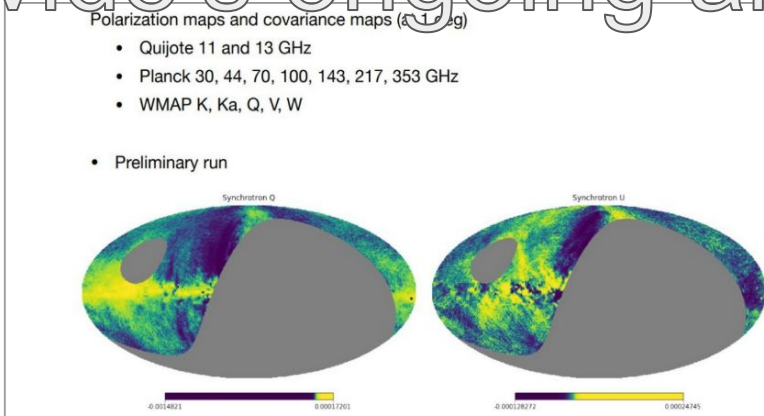
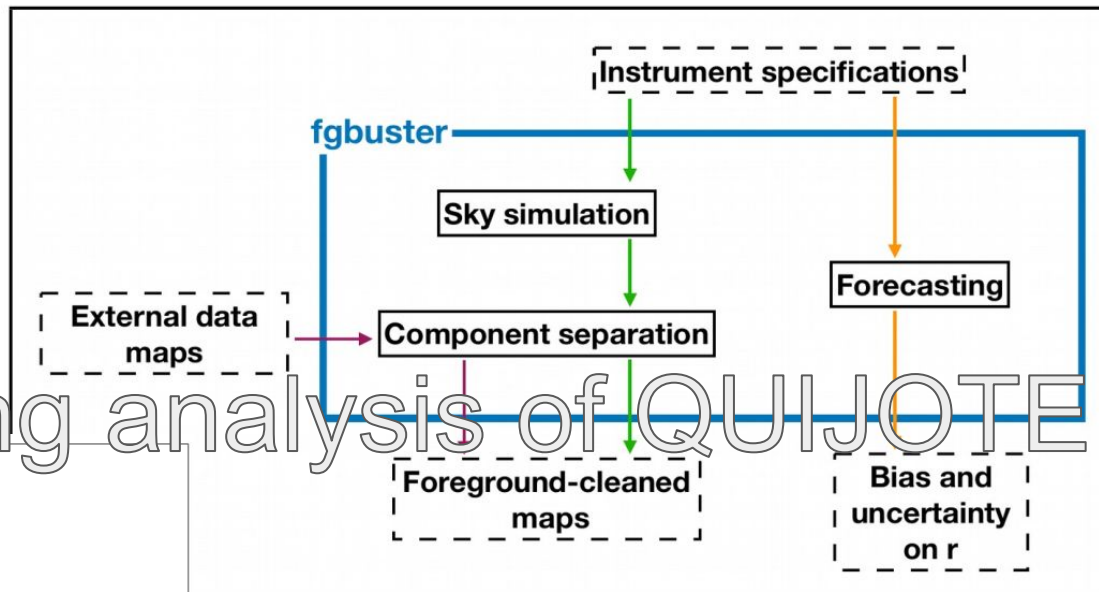
Area Parametric Fitting @ Oxford



As discussed by Angela and Mike

FGBuster @ SISSA

Daivide's ongoing analysis of QUIJOTE



Parametric Fitting @ Santander

Initial Considerations 1_of_2

Starting with the instrumental description given above, we performed an analysis to check how important is to keep a large number of narrow band detectors, considering two sky models:

- **5 parameters per pixel:** CMB + Synchrotron (Amplitud+index) + Thermal Dust (Amplitud+index, RJ region)
- **6 parameters per pixel:** CMB + Synchrotron (Amplitud+index+curvature) + Thermal Dust (Amplitud+index, RJ region)

When playing around with the number of channels and bandwidth, we impose to **keep always the same sensitivity**. The **whole frequency range** of a given atmospheric window **is always covered**.

Parametric Fitting @ Santander

Initial Considerations 2_of_2

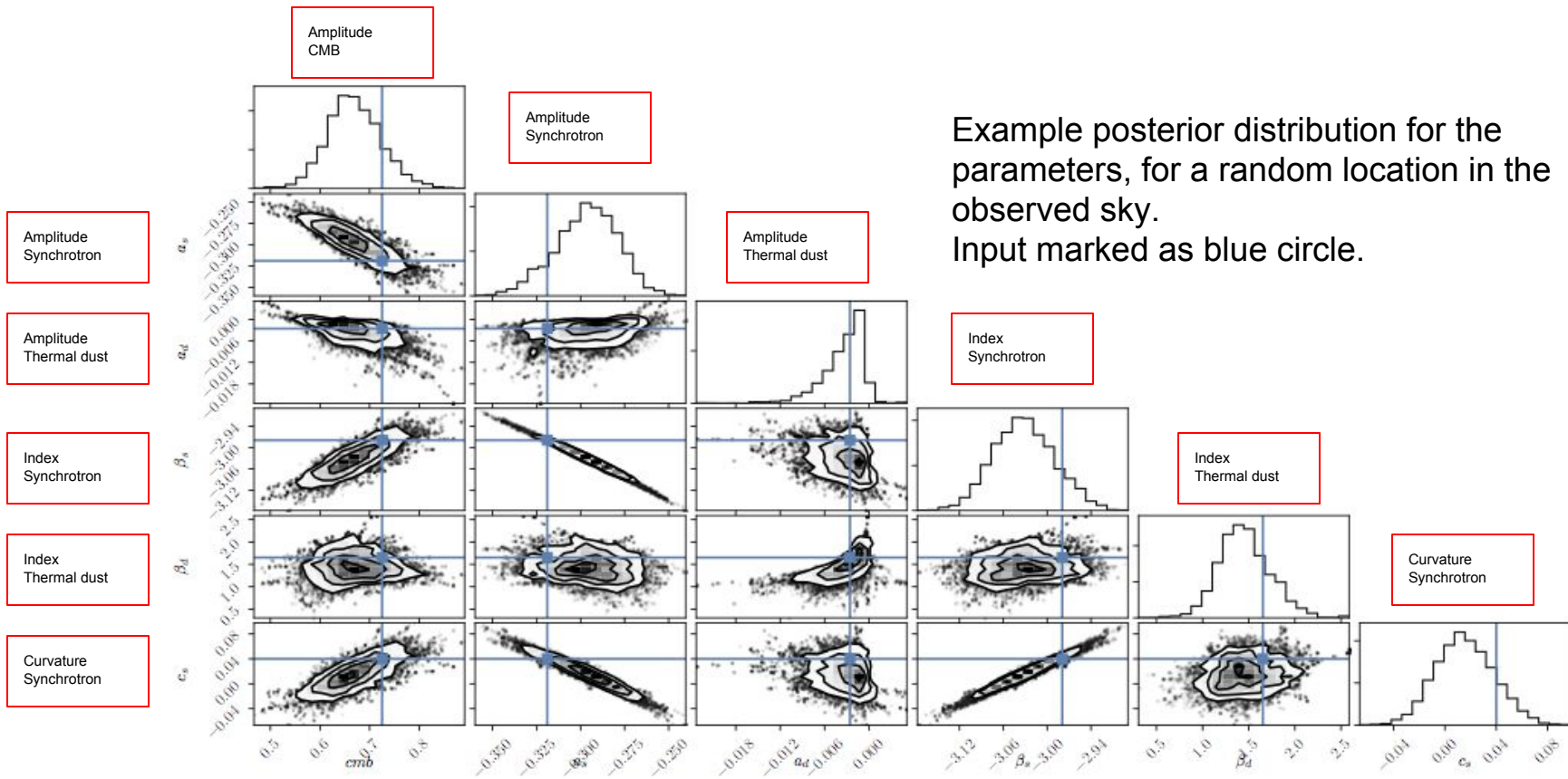
We started to look to a **sky coverage as the Cosmological Fields from QUIJOTE** experiment (approx. $f_{\text{sky}}=0.084$).

We assumed **all the sensitivity is concentrated on this sky region**.

Parametric fitting is performed in Q and U maps, independently, **at nside=64** (all the maps at the same resolution, and directly simulated to it).

Wide priors adopted to maximize the posterior (Gaussian priors, three times wider than simulated).

Parametric Fitting @ Santander



Parametric Fitting @ Santander

Residuals for the 5 parameters case

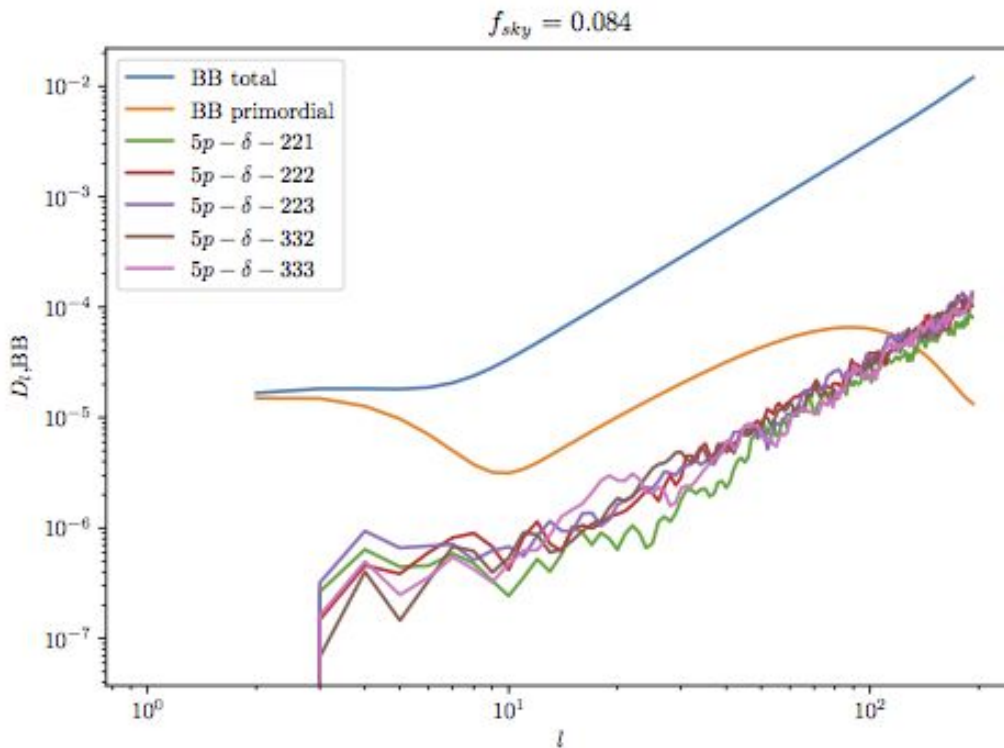
5 frequency schemes are considered

In the legend, first number correspond to the number of channels in the VLFA, second to the number of channels in LFA, and third to the number of channels in the MFA. Example:

332 \Rightarrow 3 channels @ VLFA, 2 channels @ LFA, 2 channels @ MFA

As expected, **no huge differences**, as soon as **there is enough number of channels for the sky complexity**.

Noise characteristics is low enough to provide residuals well below primordial BB.



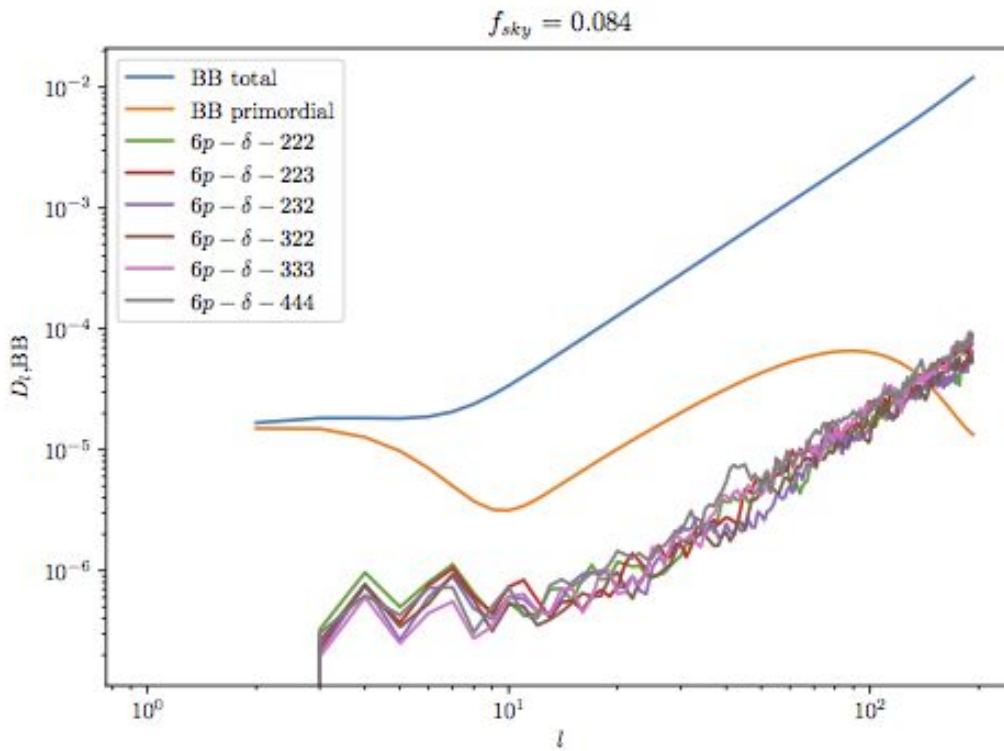
Parametric Fitting @ Santander

Residuals for the 6 parameters case

As before, **no huge differences**, as soon as there is enough number of channels for the sky complexity.

Noise characteristics is low enough to provide residuals well below primordial BB, even increasing the sky complexity.

These are **good news**.





Testing Schedule

- **March: check recovery of Synchrotron and CMB from VLFA, LFA, MFA**
- **April: Comparisons of Methods, optimization, impact of polarized AME**
- **May: evaluate performance when combining with CMB-S4, LiteBIRD**



Timescale

- **Platform for Proposals to be defined, options:**
 - Synergy
 - ESFRI
- **Forecasting has to end by May with a baseline**
- **Proposal Writing over Summer**
- **Strong Scientific Case:** the community has to design a low frequency CMB probe
- **Issues:** impact on the timescale by limitation from human resources, parallel ongoing activities

