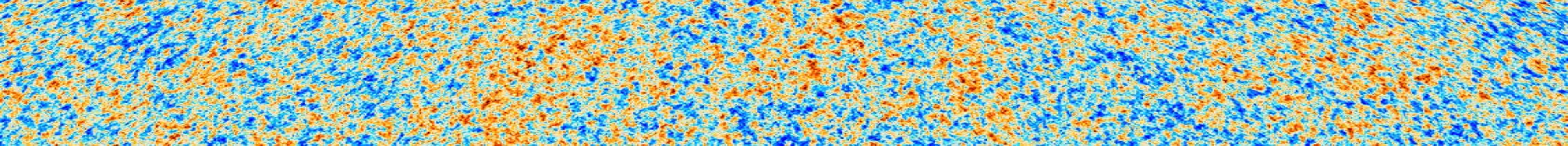

WP3 6X2:
support to data analysis for LSPE-SWIPE

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Bologna, May 26, 2017

WP objectives (from the proposal)

- Prepare **quantitative simulations** of SWIPE datasets including:
  - optimized scan strategy
  - known systematic effects
- Data analysis pipeline development:
  - Coordinate
  - Contribute
  - Test the performance of the pipeline by means of simulated datasets
  - Devise strategies to mitigate systematics.
- Perform the LSPE SWIPE data analysis

- **Tasks RA1:**
  - **Instrument model development**
  - **Simulations development**

WP Participants

- Univ Roma1
  - F. Piacentini, P. de Bernardis, S. Masi, L. Lamagna, E. Battistelli, A. Paiella (Post-Doc), F. Columbro (PhD)
- Univ Roma2
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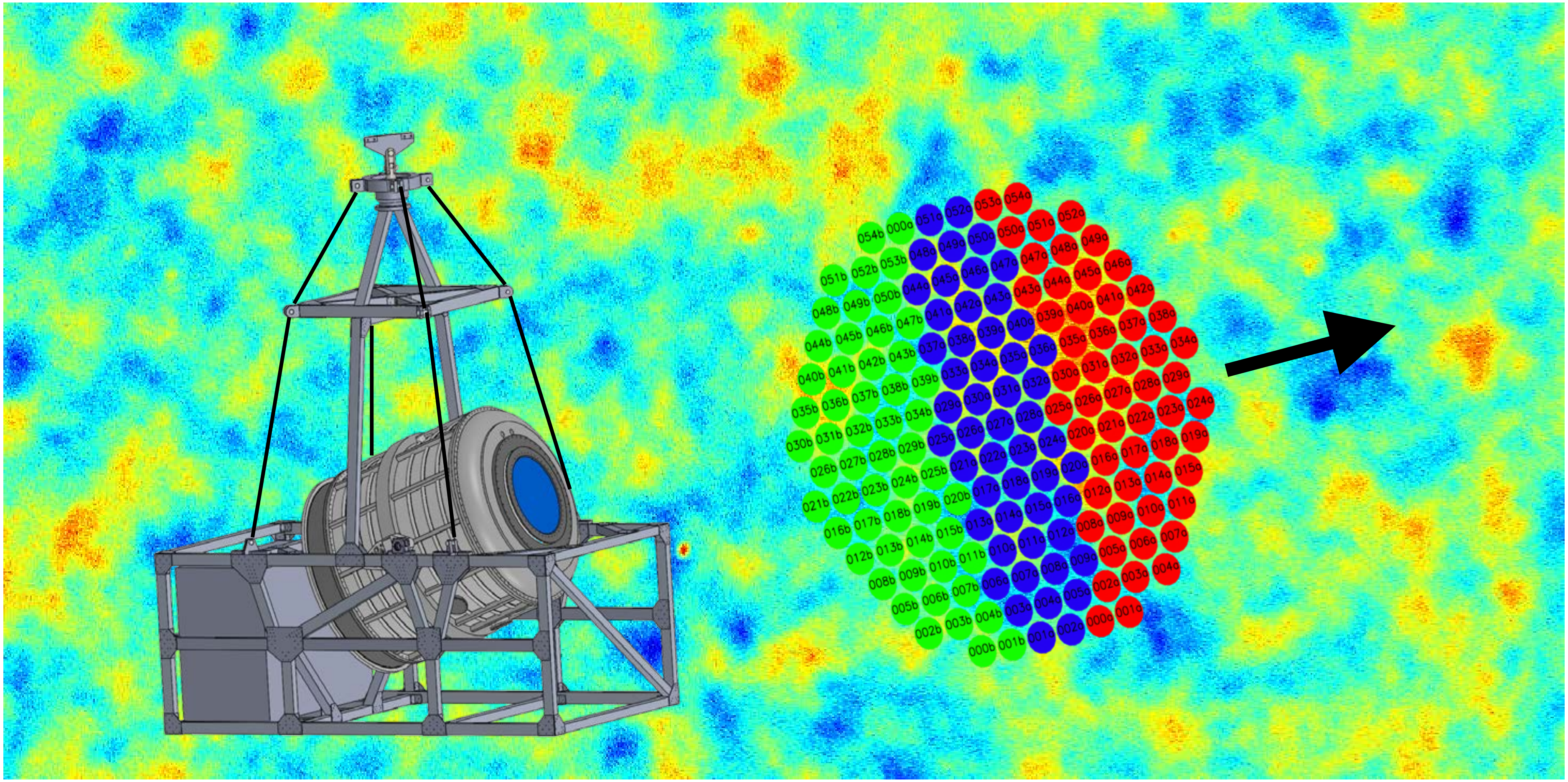
- IASF-BO
  - A. Gruppuso
- Univ Pisa
  - G. Signorelli, D. Vaccaro, F. Cei
- External:
  - L. Pagano (IAS – Orsay), G. Polenta (ASI), M. Migliaccio (ASI)

LSPE-SWIPE Instrument model development



LSPE-SWIPE Instrument model development

- Running at NERSC on Cori or Edison
  - Parallel Fortran code

- Settings:
  - Launch site coordinates
  - Sampling rate
  - Spin rate
  - Elevation
  - Elevation range
  - Mission duration
  - Half Wave Plate (step/spin)
  - cutoff radius for Real-Space Convolution

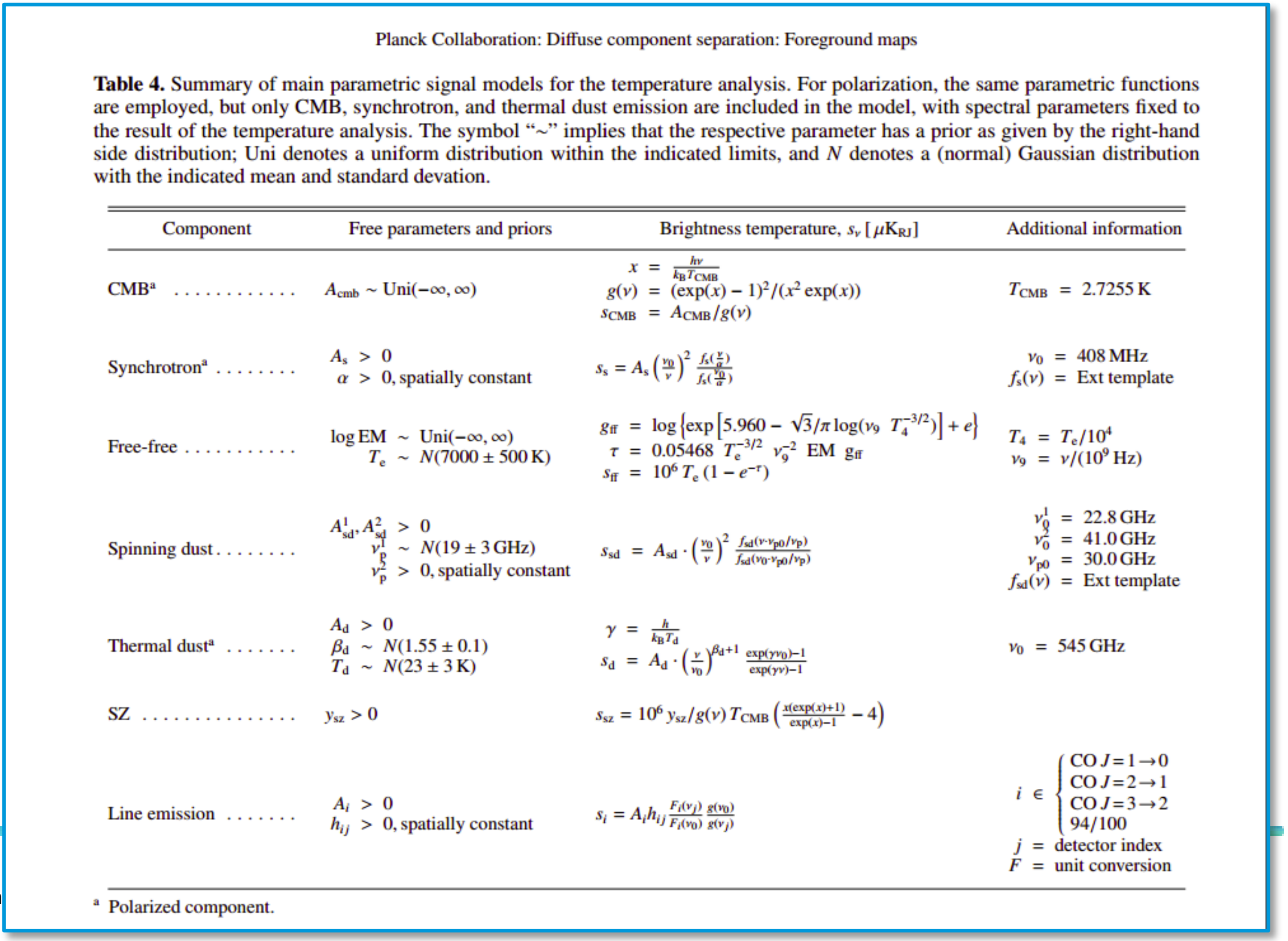
- Inputs:
  - High resolution map
  - Detector List
  - Instrument Database:
    - Detector position
    - Noise NET
    - Noise slope
    - Noise knee frequency
    - Real space beam (<5deg)

LSPE-SWIPE Instrument model development

- Outputs
    - Time Ordered Data (TOD)
    - Attitude
    - Reconstructed Map
        - Naïve or de-striped map-making
    - Noise Map (with intra-pixel covariance)
    - Total coverage
    - Single detector maps
    - Single detector coverage
    - Noise Montecarlo
    - Real-space convolved map (slow)
    - Real-space convolved single detector maps (slow)
    - intermediate products available

Sky Model – Intensity

- from **Planck** 1 degree resolution commander component separation products
  https://wiki.cosmos.esa.int/planckpla2015/index.php/CMB_and_astrophysical_component_maps



Planck Collaboration: Diffuse component separation: Foreground maps

Table 4. Summary of main parametric signal models for the temperature analysis. For polarization, the same parametric functions are employed, but only CMB, synchrotron, and thermal dust emission are included in the model, with spectral parameters fixed to the result of the temperature analysis. The symbol "∼" implies that the respective parameter has a prior as given by the right-hand side distribution; Uni denotes a uniform distribution within the indicated limits, and N denotes a (normal) Gaussian distribution with the indicated mean and standard devation.

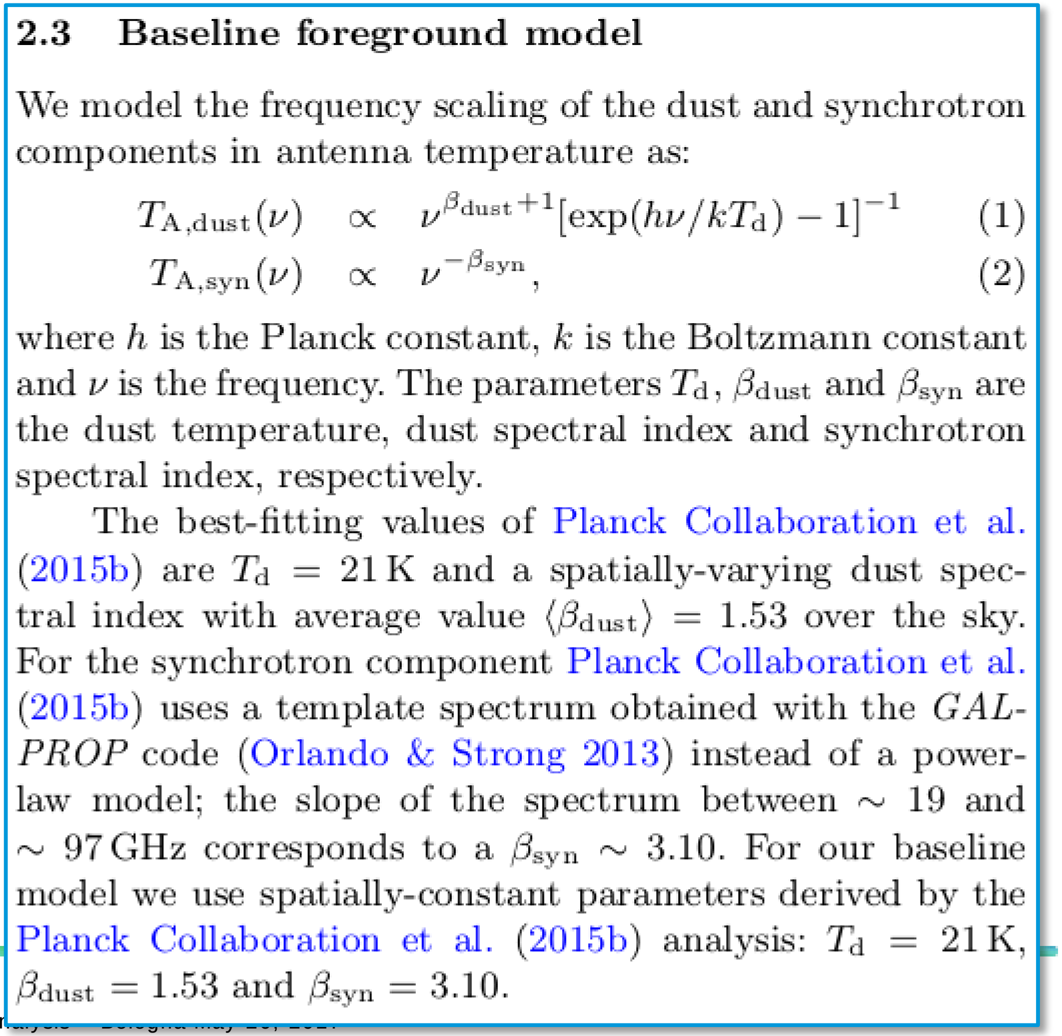
Component	Free parameters and priors	Brightness temperature, s_ν [$\mu\mathrm{K_{RJ}}$]	Additional information
CMB[a]	$A_\mathrm{cmb} \sim \mathrm{Uni}(-\infty, \infty)$	$x = \frac{h\nu}{k_\mathrm{B} T_\mathrm{CMB}}$ $g(\nu) = (\exp(x)-1)^2/(x^2\exp(x))$ $s_\mathrm{CMB} = A_\mathrm{CMB}/g(\nu)$	$T_\mathrm{CMB} = 2.7255\,\mathrm{K}$
Synchrotron[a]	$A_\mathrm{s} > 0$ $\alpha > 0$, spatially constant	$s_\mathrm{s} = A_\mathrm{s}\left(\frac{\nu_0}{\nu}\right)^2 \frac{f_\mathrm{s}(\frac{\nu}{\alpha})}{f_\mathrm{s}(\frac{\nu_0}{\alpha})}$	$\nu_0 = 408\,\mathrm{MHz}$ $f_\mathrm{s}(\nu) =$ Ext template
Free-free	$\log \mathrm{EM} \sim \mathrm{Uni}(-\infty, \infty)$ $T_\mathrm{e} \sim N(7000 \pm 500\,\mathrm{K})$	$g_\mathrm{ff} = \log\left\{\exp\left[5.960 - \sqrt{3}/\pi \log(\nu_9 \ T_4^{-3/2})\right] + e\right\}$ $\tau = 0.05468 \ T_\mathrm{e}^{-3/2} \ \nu_9^{-2} \ \mathrm{EM} \ g_\mathrm{ff}$ $s_\mathrm{ff} = 10^6\, T_\mathrm{e}\, (1 - e^{-\tau})$	$T_4 = T_\mathrm{e}/10^4$ $\nu_9 = \nu/(10^9\,\mathrm{Hz})$
Spinning dust	$A_\mathrm{sd}^1, A_\mathrm{sd}^2 > 0$ $\nu_\mathrm{p}^1 \sim N(19 \pm 3\,\mathrm{GHz})$ $\nu_\mathrm{p}^2 > 0$, spatially constant	$s_\mathrm{sd} = A_\mathrm{sd} \cdot \left(\frac{\nu_0}{\nu}\right)^2 \frac{f_\mathrm{sd}(\nu \cdot \nu_\mathrm{p0}/\nu_\mathrm{p})}{f_\mathrm{sd}(\nu_0 \cdot \nu_\mathrm{p0}/\nu_\mathrm{p})}$	$\nu_0^1 = 22.8\,\mathrm{GHz}$ $\nu_0^2 = 41.0\,\mathrm{GHz}$ $\nu_\mathrm{p0} = 30.0\,\mathrm{GHz}$ $f_\mathrm{sd}(\nu) =$ Ext template
Thermal dust[a]	$A_\mathrm{d} > 0$ $\beta_\mathrm{d} \sim N(1.55 \pm 0.1)$ $T_\mathrm{d} \sim N(23 \pm 3\,\mathrm{K})$	$\gamma = \frac{h}{k_\mathrm{B} T_\mathrm{d}}$ $s_\mathrm{d} = A_\mathrm{d} \cdot \left(\frac{\nu}{\nu_0}\right)^{\beta_\mathrm{d}+1} \frac{\exp(\gamma\nu_0)-1}{\exp(\gamma\nu)-1}$	$\nu_0 = 545\,\mathrm{GHz}$
SZ	$y_\mathrm{sz} > 0$	$s_\mathrm{sz} = 10^6\, y_\mathrm{sz}/g(\nu)\, T_\mathrm{CMB}\left(\frac{x(\exp(x)+1)}{\exp(x)-1} - 4\right)$	
Line emission	$A_i > 0$ $h_{ij} > 0$, spatially constant	$s_i = A_i h_{ij} \frac{F_i(\nu_j)}{F_i(\nu_0)} \frac{g(\nu_0)}{g(\nu_j)}$	$i \in \begin{cases} \mathrm{CO}\ J=1\rightarrow 0 \\ \mathrm{CO}\ J=2\rightarrow 1 \\ \mathrm{CO}\ J=3\rightarrow 2 \\ 94/100 \end{cases}$ $j =$ detector index $F =$ unit conversion

---

[a] Polarized component.

Sky model – Polarization

- from Carlos Hervías-Caimapo, Anna Bonaldi, Michael L. Brown, *A new model of the microwave polarized sky for CMB experiments,* MNRAS (http://arxiv.org/abs/1602.01313)
- We included;
  - dust
  - synchrotron
- Model available: http://www.jb.man.ac.uk/chervias



2.3 Baseline foreground model

We model the frequency scaling of the dust and synchrotron components in antenna temperature as:

$$T_{\mathrm{A,dust}}(\nu) \propto \nu^{\beta_{\mathrm{dust}}+1}[\exp(h\nu/kT_{\mathrm{d}})-1]^{-1} \qquad (1)$$

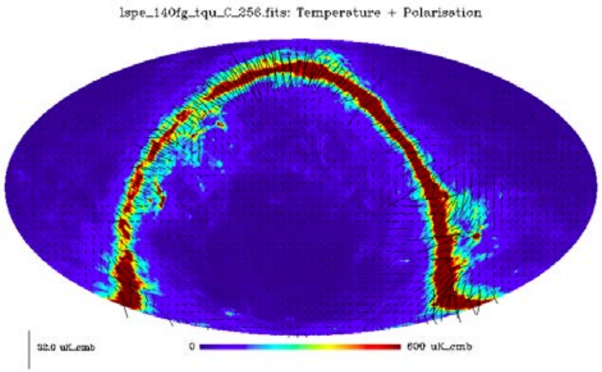
$$T_{\mathrm{A,syn}}(\nu) \propto \nu^{-\beta_{\mathrm{syn}}}, \qquad (2)$$

where h is the Planck constant, k is the Boltzmann constant and ν is the frequency. The parameters T_{d}, β_{dust} and β_{syn} are the dust temperature, dust spectral index and synchrotron spectral index, respectively.

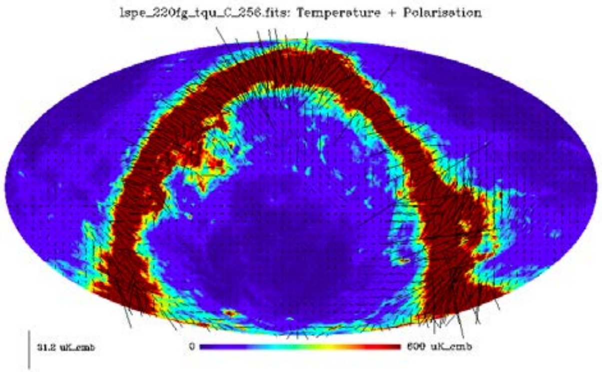
The best-fitting values of Planck Collaboration et al. (2015b) are $T_{\mathrm{d}} = 21\,\mathrm{K}$ and a spatially-varying dust spectral index with average value $\langle\beta_{\mathrm{dust}}\rangle = 1.53$ over the sky. For the synchrotron component Planck Collaboration et al. (2015b) uses a template spectrum obtained with the *GALPROP* code (Orlando & Strong 2013) instead of a power-law model; the slope of the spectrum between ~ 19 and $\sim 97\,\mathrm{GHz}$ corresponds to a $\beta_{\mathrm{syn}} \sim 3.10$. For our baseline model we use spatially-constant parameters derived by the Planck Collaboration et al. (2015b) analysis: $T_{\mathrm{d}} = 21\,\mathrm{K}$, $\beta_{\mathrm{dust}} = 1.53$ and $\beta_{\mathrm{syn}} = 3.10$.

Simulated SWIPE maps

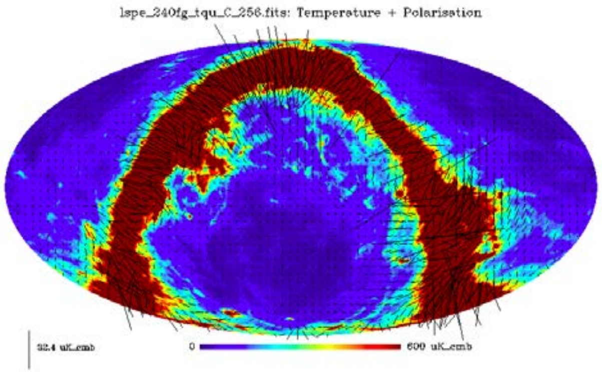
125-155 GHZ



220 GHz



240 GHz



Instrument model

The instrument model is build according to the following scheme:

```
n detectors
name        x          y       FP angle (0 or 90)    eta       net         knee          slope
```

example:

```
1
140_0a     0.0000000   0.00000   0.00000       1.00000   50.00000   0.0200000    -1.0000000
```

Beam definition procedure:

```
;;;;;;;;;;
  Nx = 2000l
  Ny = 2000l
  Centrex =          1000l
  Centrey =          1000l
  Deltax  =    0.000349066 ;rad
  Deltay  =    0.000349066 ;rad
  map=fltarr(Nx,Ny)
  sxaddpar, hdr, 'Centrex', Centrex,'centre location (1-based Y index)'
  sxaddpar, hdr, 'Centrey', Centrey,'centre location (1-based X index)'
  sxaddpar, hdr, 'Ny', Ny,'grid Y size'
  sxaddpar, hdr, 'Nx', Nx,'grid X size'
  sxaddpar, hdr, 'Deltay', Deltay,'grid Y step [radians]'
  sxaddpar, hdr, 'Deltax', Deltax,'grid X step [radians]'
  mwrfits, map, 'beam.fits', hdr
  ;;;;;;;;;;
```

Simulator: list of parameters

feedback -> livello di feedback del codice

year,month,day -> giorno del lancio

input_map -> mappa input

write_tod -> scrive il tod,theta,phi

output_tod_dir -> directory in cui scrive il dirfile con il tod

do_map -> fa il mapmaking su tutti i detector

do_flag -> flagga i dati non utilizzabili

do_map_single -> fa il mapmaking per single detector

do_coverage -> calcola la mappa con la copertura

nside_out -> risoluzione in uscita

out_map_dir -> directory con le mappe in uscita

out_map_root -> nome delle mappe in uscita

out_coverage_root -> nome delle mappe di copertura in uscita

do_iterations -> fai il mapmaking filtrando e iterando la soluzione

iterations -> numero di iterazioni

iterative_mapmaking_baseline_in_sec -> lunghezza della baseline per l'iterative map-making

doconvolution -> fa la convoluzione in real space

cutoff_radius -> raggio del disco in gradi in cui fa la convoluzione

instrumentDB -> file txt con l'istrument database

beam_list -> file txt con i beam da convolvere

ndet -> numero di detectors

detectors -> lista di detectors

add_noise -> mette il noise

latitude -> latitudine iniziale

longitude -> longitudine iniziale

elevation_start -> elevazione iniziale

elevation_range -> range di variazione dell'elevazione

mission_lenght_in_days -> numero di giorni della missione

sampling_rate -> sampling rate

undersampling -> undersampling per calcolo posizione del sole

rotation_speed -> velocità di rotazione del telescopio

remove_mean -> rimuove la media per ogni posizione stabile del hwp

apply_filter -> filtra il tod

wiregrid_angle -> angolo della wiregrid

do_spinning_hwp -> hwp spinnante o a step

spin_hwp -> velocita' di rotazione hwp

hwp_step_per_hour -> step della hwp per ora

hwp_deg_per_step -> gradi per ogni step

alpha_wiregrid -> angolo della wire grid

include_hwp_angle_error -> include una sistmatica nella posizione della hwp

hwp_angle_error -> errore sulla posizione della hwp

hwp_angle_offset -> offset sulla posizione della hwp

donoiseMC -> genera un montecarlo di noise

noiseMCroot -> path delle mappe di noise generate

numbernoiseMC -> numero di mappe generate

Conclusion

- **Tasks RA1:**
    - **Instrument model development**
        - Sky simulator developed
        - Instrument model developed
    - **Simulations development**
        - Mission simulator developed
        - Including scanning strategy, HWP, beam, noise, map-making
        - **Simulation runs ongoing** with different instrumental configurations