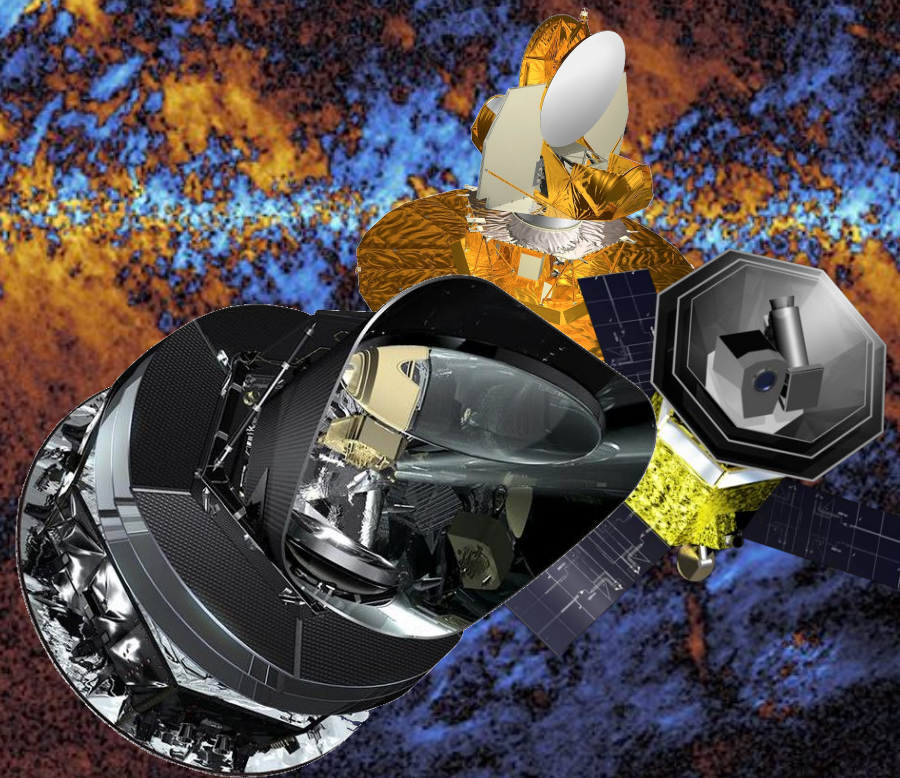


BeyondPlanck products

Anna-Stiina Suur-Uski

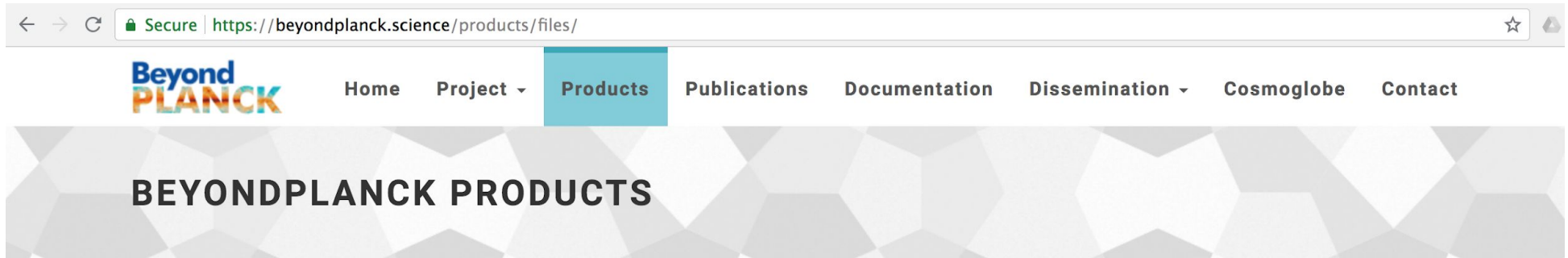


BeyondPlanck online release conference, November 18-20, 2020



BeyondPlanck products

⇒ <https://beyondplanck.science/products/files/>



BeyondPlanck Parameter Files

Filename	Content	Filesize	Format specification
BP_param_full_v1.txt	Main Commander parameter file	69 kB	Commander parameter file documentation
BP_param_Tresamp_v1.txt	Commander parameter file for high-resolution CMB TT resampling	69 kB	Commander parameter file documentation
BP_param_Presamp_v1.txt	Commander parameter file for low-resolution CMB polarization resampling	x kB	Commander parameter file documentation

BeyondPlanck Chain Files

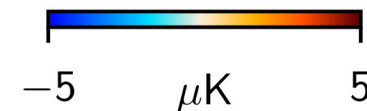
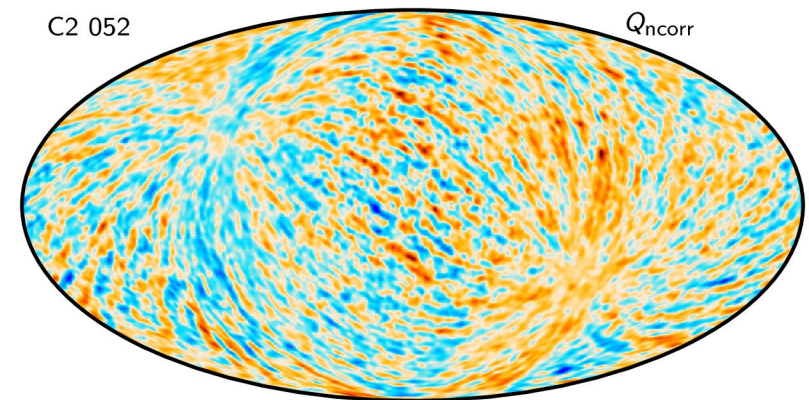
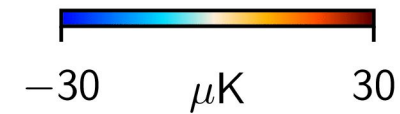
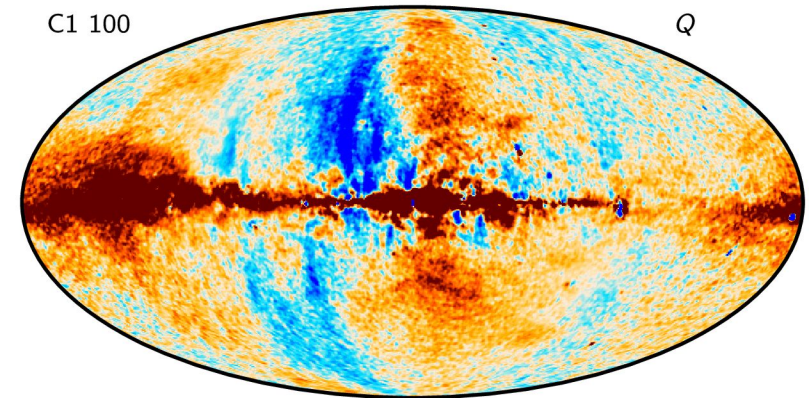
Filename	Content	Filesize	Format specification
BP_c000x_v1.h5 (1, 2, 3, 4, 5, 6)	Main chain files	329 GB each	File Formats
BP_c000x_Tresamp_v1.h5 (1, 2, 3, 4, 5, 6)	High-res CMB T resamp chain files	(2.3, 1.5, 1.7, 1.6, 1.5, 1.7) GB	File Formats
BP_c000x_Presamp_v1.h5 (1, 2, 3, 4, 5, 6)	Low-res CMB P resamp chain files	(437, 437, 437, 376, 397, 392) MB	File Formats



What are the BeyondPlanck products?

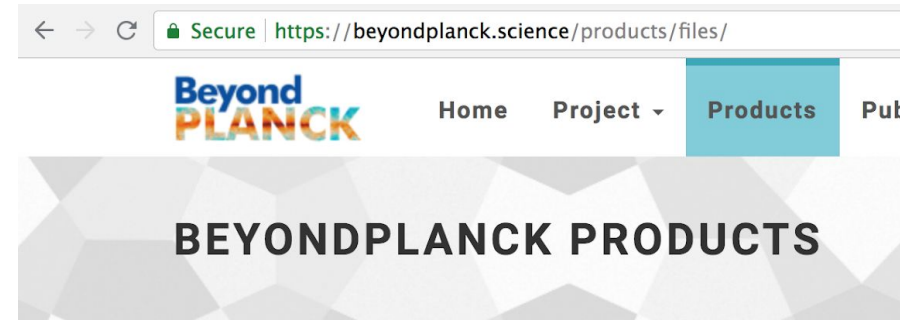


- Samples!
- 6 chains
 - 200 samples in each chain
 - first 50 samples in each chain discarded for burn-in
 - 900 samples for science



⇒ <https://beyondplanck.science/products/files/>

- BeyondPlanck Parameter Files
- BeyondPlanck Chain Files
- BeyondPlanck Frequency Maps
- BeyondPlanck Astrophysical Component Maps
- BeyondPlanck CMB Maps



BeyondPlanck Parameter Files

Filename	Content
BP_param_full_v1.txt	Main Commander parameter file
BP_param_Tresamp_v1.txt	Commander parameter file for high-resc
BP_param_Presamp_v1.txt	Commander parameter file for low-resol resampling

BeyondPlanck Chain Files

Filename	Content
BP_c000x_v1.h5 (1, 2, 3, 4, 5, 6)	Main chain files
BP_c000x_Tresamp_v1.h5 (1, 2, 3, 4, 5, 6)	High-res CMB T res
BP_c000x_Presamp_v1.h5 (1, 2, 3, 4, 5, 6)	Low-res CMB P res

- Posterior means

$$\hat{m}_\nu = \langle m_\nu^i \rangle$$

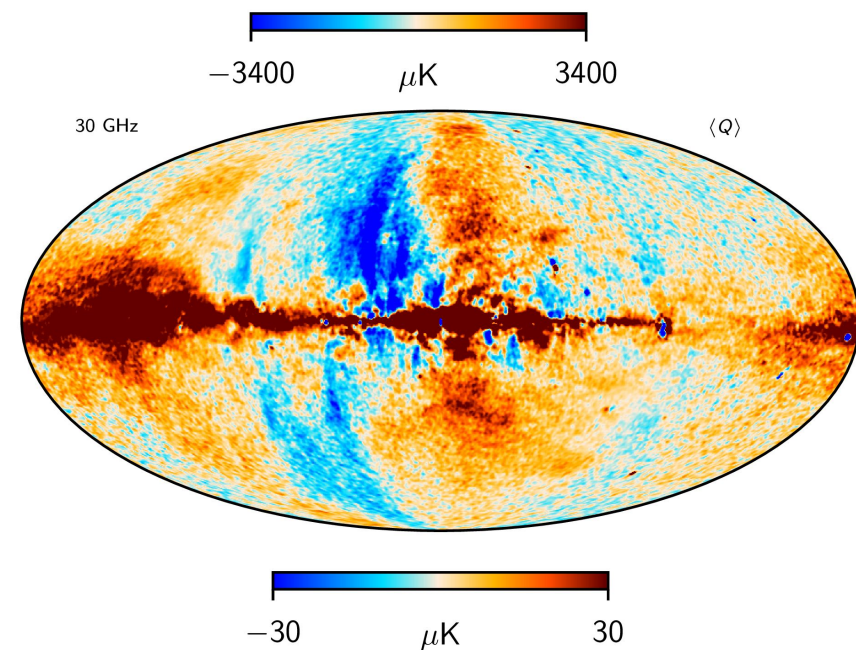
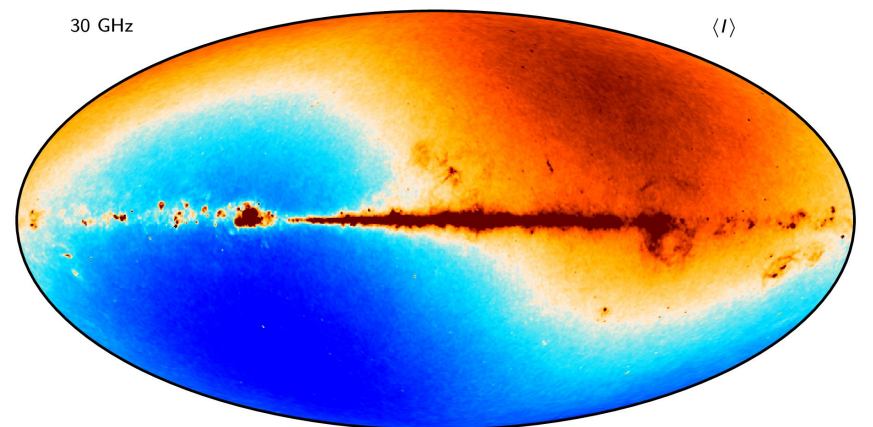
- Files:

[BP_030_IQU_n0512_v1.fits](#) LFI 30 GHz frequency map

[BP_044_IQU_n0512_v1.fits](#) LFI 44 GHz frequency map

[BP_070_IQU_n1024_v1.fits](#) LFI 70 GHz frequency map

- Used in the BeyondPlanck analysis:
 - to illustrate BP maps
 - to compare BP maps with other pipelines

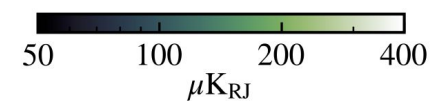
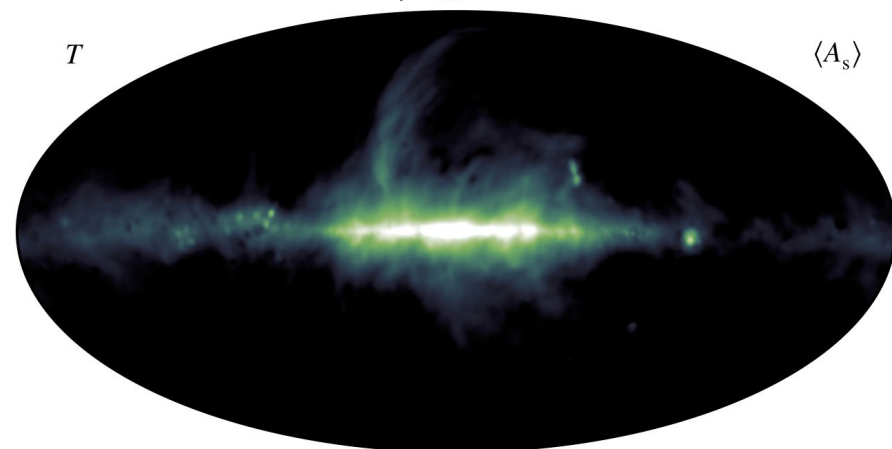
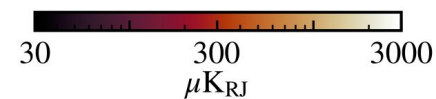
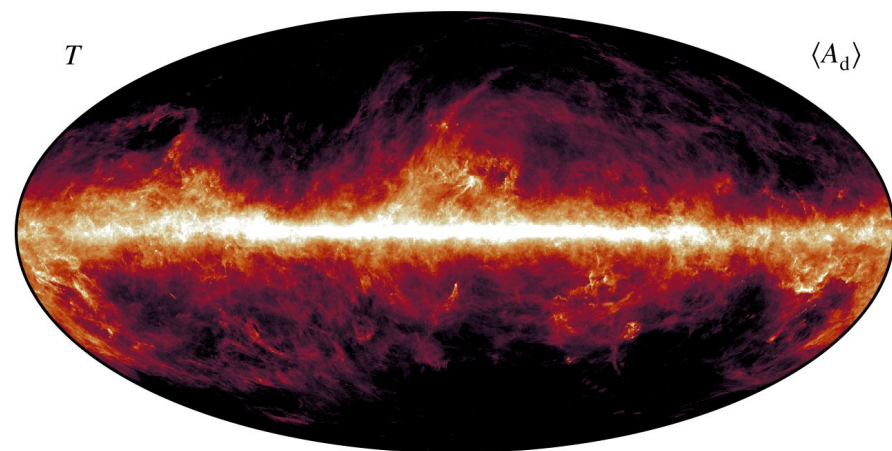


- Posterior means

$$\hat{m}_\nu = \langle m_\nu^i \rangle$$

- Files:

Filename	Content
BP_ame_I_n1024_v1.fits	AME (spinning dust) map
BP_dust_IQU_n1024_v1.fits	Thermal dust emission map
BP_freefree_I_n1024_v1.fits	Free-free emission map
BP_synch_IQU_n1024_v1.fits	Synchrotron map



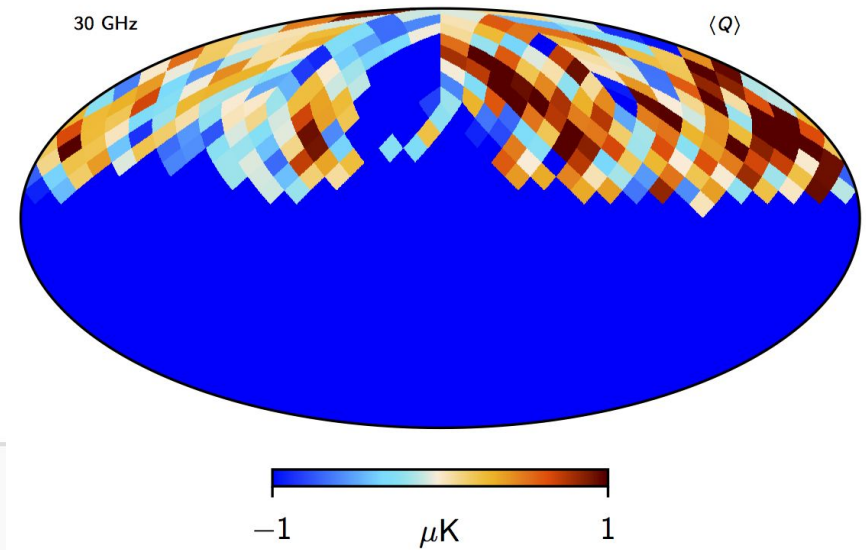
- Posterior means

$$\hat{m}_\nu = \langle m_\nu^i \rangle$$

- Files:

BP_CMB_I_full_n1024_v1.fits CMB posterior mean temperature map

BP_CMB_QU_map_n8_v1.fits CMB posterior mean polarization map



- Files:

Filename	Content
BP_c000x_v1.h5 (1, 2, 3, 4, 5, 6)	Main chain files
BP_c000x_Tresamp_v1.h5 (1, 2, 3, 4, 5, 6)	High-res CMB T resamp chain files
BP_c000x_Presamp_v1.h5 (1, 2, 3, 4, 5, 6)	Low-res CMB P resamp chain files

- Main chain files contain samples for
 - frequency maps, astrophysical components, correlated noise, noise parameters, gains, bandpasses, ...
- Are stored as HDF5 files
 - a portable data format designed to store and organize large amounts of data
 - <https://www.hdfgroup.org/solutions/hdf5/>

- HDF5 file structure contains two major types of objects:
 - **Dataset** = multidimensional arrays of a homogeneous type
 - **Group** = container structures which can hold datasets and other groups
- Objects can be accessed by their full paths

```
dataset /000000/synch/beta_pixreg_val
dataset /000000/synch/sigma_1
group /000000/tod
group /000000/tod/030
dataset /000000/tod/030/accept
dataset /000000/tod/030/alpha
dataset /000000/tod/030/bp_delta
dataset /000000/tod/030/chisq
dataset /000000/tod/030/fknee
dataset /000000/tod/030/gain
dataset /000000/tod/030/gain0
dataset /000000/tod/030/map
dataset /000000/tod/030/mono
dataset /000000/tod/030/polang
dataset /000000/tod/030/rms
dataset /000000/tod/030/sigma0
group /000000/tod/044
dataset /000000/tod/044/accept
dataset /000000/tod/044/alpha
dataset /000000/tod/044/bp_delta
dataset /000000/tod/044/chisq
dataset /000000/tod/044/fknee
dataset /000000/tod/044/gain
dataset /000000/tod/044/gain0
```

Chain file contents



```
FILE_CONTENTS {
group /
group /000000
group /000000/ame
dataset /000000/ame/D1_amp
dataset /000000/ame/D1_beta
dataset /000000/ame/alpha_map
dataset /000000/ame/alpha_pixreg_nprop
dataset /000000/ame/alpha_pixreg_proplen
dataset /000000/ame/alpha_pixreg_val
dataset /000000/ame/amp_alm
dataset /000000/ame/amp_lmax
dataset /000000/ame/amp_nmaps
dataset /000000/ame/nu_p_map
dataset /000000/ame/nu_p_pixreg_nprop
dataset /000000/ame/nu_p_pixreg_proplen
dataset /000000/ame/nu_p_pixreg_val
dataset /000000/ame/sigma_l
group /000000/bandpass
dataset /000000/bandpass/0.4-Haslam
dataset /000000/bandpass/030
dataset /000000/bandpass/030-WMAP_Ka
dataset /000000/bandpass/033-WMAP_Ka_P
dataset /000000/bandpass/040-WMAP_Q1
dataset /000000/bandpass/040-WMAP_Q2
dataset /000000/bandpass/041-WMAP_Q_P
dataset /000000/bandpass/044
dataset /000000/bandpass/060-WMAP_V1
dataset /000000/bandpass/060-WMAP_V2
dataset /000000/bandpass/061-WMAP_V_P
dataset /000000/bandpass/070
dataset /000000/bandpass/353
dataset /000000/bandpass/857
group /000000/cmb
dataset /000000/cmb/D1_amp
dataset /000000/cmb/D1_beta
dataset /000000/cmb/amp_alm
dataset /000000/cmb/amp_lmax
dataset /000000/cmb/amp_nmaps
dataset /000000/cmb/sigma_l
group /000000/dust
dataset /000000/dust/T_alm
dataset /000000/dust/T_lmax
dataset /000000/dust/T_map
dataset /000000/dust/T_nmaps
dataset /000000/dust/T_pixreg_nprop
dataset /000000/dust/T_pixreg_proplen
dataset /000000/dust/T_pixreg_val
```

```
dataset /000000/dust/amp_alm
dataset /000000/dust/amp_lmax
dataset /000000/dust/amp_nmaps
dataset /000000/dust/beta_alm
dataset /000000/dust/beta_lmax
dataset /000000/dust/beta_map
dataset /000000/dust/beta_nmaps
dataset /000000/dust/beta_pixreg_nprop
dataset /000000/dust/beta_pixreg_proplen
dataset /000000/dust/beta_pixreg_val
dataset /000000/dust/sigma_l
group /000000/ff
dataset /000000/ff/D1_amp
dataset /000000/ff/D1_beta
dataset /000000/ff/Te_map
dataset /000000/ff/Te_pixreg_nprop
dataset /000000/ff/Te_pixreg_proplen
dataset /000000/ff/Te_pixreg_val
dataset /000000/ff/amp_alm
dataset /000000/ff/amp_lmax
dataset /000000/ff/amp_nmaps
dataset /000000/ff/sigma_l
group /000000/gain
dataset /000000/gain/0.4-Haslam
dataset /000000/gain/030
dataset /000000/gain/030-WMAP_Ka
dataset /000000/gain/033-WMAP_Ka_P
dataset /000000/gain/040-WMAP_Q1
dataset /000000/gain/040-WMAP_Q2
dataset /000000/gain/041-WMAP_Q_P
dataset /000000/gain/044
dataset /000000/gain/060-WMAP_V1
dataset /000000/gain/060-WMAP_V2
dataset /000000/gain/061-WMAP_V_P
dataset /000000/gain/070
dataset /000000/gain/353
dataset /000000/gain/857
group /000000/md
dataset /000000/md/0.4-Haslam
dataset /000000/md/030
dataset /000000/md/030-WMAP_Ka
dataset /000000/md/040-WMAP_Q1
dataset /000000/md/040-WMAP_Q2
dataset /000000/md/044
dataset /000000/md/060-WMAP_V1
dataset /000000/md/060-WMAP_V2
dataset /000000/md/070
dataset /000000/md/857
group /000000/radio
```

```
dataset /000000/radio/amp
dataset /000000/radio/specind
group /000000/synch
dataset /000000/synch/amp_alm
dataset /000000/synch/amp_lmax
dataset /000000/synch/amp_nmaps
dataset /000000/synch/beta_alm
dataset /000000/synch/beta_lmax
dataset /000000/synch/beta_map
dataset /000000/synch/beta_nmaps
dataset /000000/synch/beta_pixreg_nprop
dataset /000000/synch/beta_pixreg_proplen
dataset /000000/synch/beta_pixreg_val
dataset /000000/synch/sigma_l
group /000000/tod
group /000000/tod/030
dataset /000000/tod/030/accept
dataset /000000/tod/030/alpha
dataset /000000/tod/030/bp_delta
dataset /000000/tod/030/chisq
dataset /000000/tod/030/fknee
dataset /000000/tod/030/gain
dataset /000000/tod/030/gain0
dataset /000000/tod/030/map
dataset /000000/tod/030/mono
dataset /000000/tod/030/polang
dataset /000000/tod/030/rms
dataset /000000/tod/030/sigma0
group /000000/tod/044
dataset /000000/tod/044/accept
dataset /000000/tod/044/alpha
dataset /000000/tod/044/bp_delta
dataset /000000/tod/044/chisq
dataset /000000/tod/044/fknee
dataset /000000/tod/044/gain
dataset /000000/tod/044/gain0
dataset /000000/tod/044/map
dataset /000000/tod/044/mono
dataset /000000/tod/044/polang
dataset /000000/tod/044/rms
dataset /000000/tod/044/sigma0
group /000000/tod/070
dataset /000000/tod/070/accept
dataset /000000/tod/070/alpha
dataset /000000/tod/070/bp_delta
dataset /000000/tod/070/chisq
dataset /000000/tod/070/fknee
dataset /000000/tod/070/gain
dataset /000000/tod/070/gain0
```

```
dataset /000000/tod/070/map
dataset /000000/tod/070/mono
dataset /000000/tod/070/polang
dataset /000000/tod/070/rms
dataset /000000/tod/070/sigma0
```

- h5ls

- Lists specified features of HDF5 file contents
- <https://portal.hdfgroup.org/display/HDF5/h5ls>
- Simple example:
 - **h5ls <file_name>.h5** [displays root group]

```
> h5ls chain_c0001.h5 | less
```

```
000000          Group
000001          Group
000002          Group
000003          Group
000004          Group
000005          Group
000006          Group
000007          Group
000008          Group
000009          Group
```

```
> h5ls chain_c0001.h5/000000/tod/030
```

```
accept          Dataset {4, 45860}
alpha           Dataset {4, 45860}
bp_delta        Dataset {1, 5}
chisq           Dataset {4, 45860}
fknee           Dataset {4, 45860}
gain            Dataset {4, 45860}
gain0           Dataset {5}
map             Dataset {3, 3145728}
mono            Dataset {4}
polang          Dataset {4}
rms             Dataset {3, 3145728}
sigma0          Dataset {4, 45860}
```

- h5dump

- Examines the contents of an HDF5 file and dumps the contents into an ASCII file
- <https://portal.hdfgroup.org/display/HDF5/h5dump>
- Simple examples:
 - **h5dump -n <file_name>.h5** [displays list of objects in a file]
 - **h5dump -d "dataset" <file_name>.h5** [displays dataset]
 - **h5dump -H <file_name>.h5** [displays header]
 - **h5dump -a "attribute" <file_name>.h5** [displays given attribute]

```
> h5dump -n chain_c0001.h5

FILE_CONTENTS {
group      /
group      /000000
group      /000000/ame
dataset    /000000/ame/DI_amp
dataset    /000000/ame/DI_beta
dataset    /000000/ame/alpha_map
dataset    /000000/ame/alpha_pixreg_nprop
dataset    /000000/ame/alpha_pixreg_proplen
dataset    /000000/ame/alpha_pixreg_val
```

- The h5py package is a Pythonic interface to the HDF5 data
- <https://www.h5py.org/>

```
> cat ReadMap.py

import h5py
import numpy as np

filename = 'chain_c0001.h5'
sample = '000071'
freq = '030'

with h5py.File(filename, 'r') as f:

    map = np.array(f[sample+'/tod/'+freq+'/map'])
    print("Read "+freq+"GHz map sample "+sample)
    print("Map dimensios:", np.shape(map))
```

```
> python ReadMap.py

Read 030GHz map sample 000071
Map dimensios: (3, 3145728)
```

- BeyondPlanck products are available through the BeyondPlanck website!
 - Not a static release: products are bound to change as the pipeline evolves
 - Main products are the chain files
 - Chain files are in HDF5 format
 - Can be operated for example with command-line tools, like h5ls and h5dump, or with python h5py package

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776282



- “*BeyondPlanck*”
 - COMPET-4 program
 - PI: Hans Kristian Eriksen
 - Grant no.: 776282
 - Period: Mar 2018 to Nov 2020

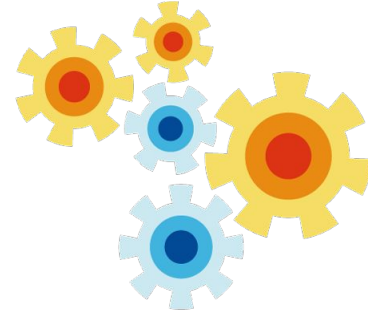
Collaborating projects:

- “*bits2cosmology*”
 - ERC Consolidator Grant
 - PI: Hans Kristian Eriksen
 - Grant no: 772 253
 - Period: April 2018 to March 2023
- “*Cosmoglobe*”
 - ERC Consolidator Grant
 - PI: Ingunn Wehus
 - Grant no: 819 478
 - Period: June 2019 to May 2024

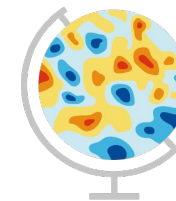


Questions?

Beyond PLANCK



Commander



Cosmoglobe Beyond PLANCK