Behind the ACTPol map
Some aspects of data processing

Loïc Maurin

ACTPol collaboration
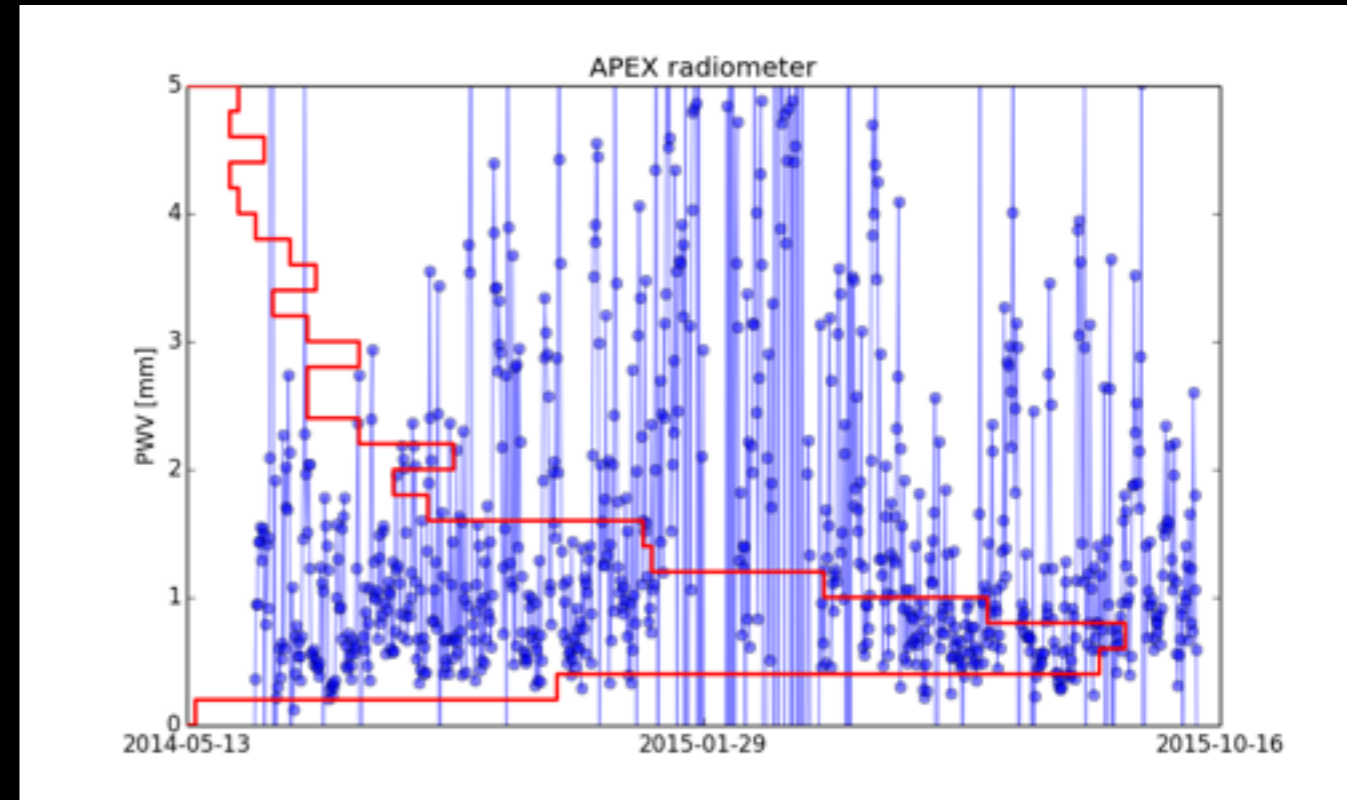
Pontificia Universidad Católica
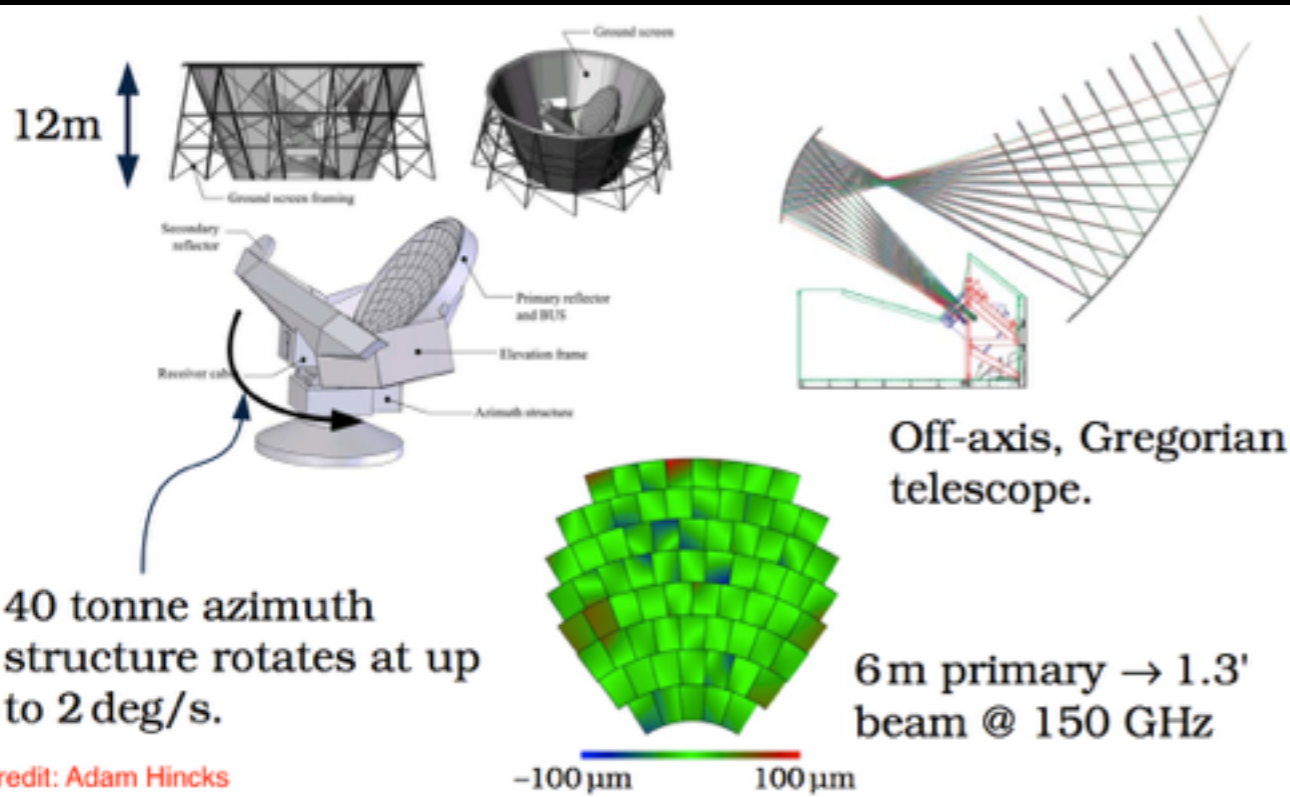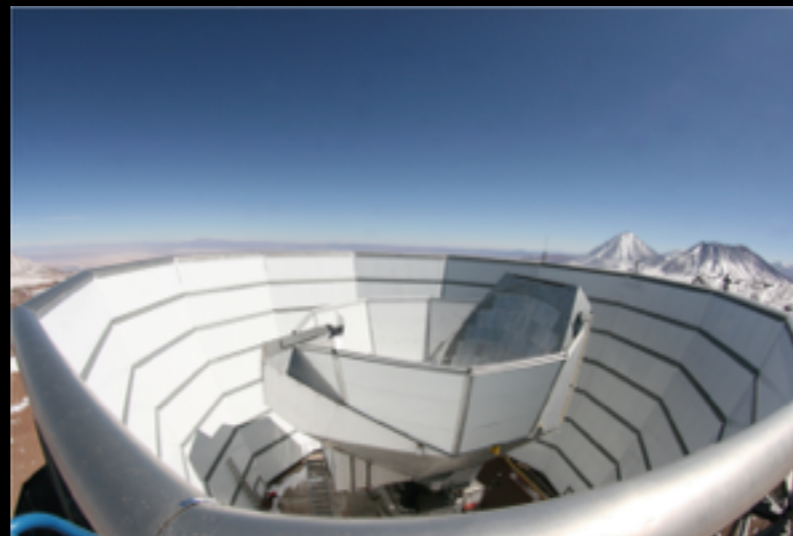
Collaboration

Location

- Chajnantor plateau, Atacama desert (Chile)

- 5190m

- Low PWV

- Good transmission at 90 and 150 GHz

- Great neighborhood (POLARBEAR, CLASS, APEX, ALMA, Simons Observatory coming soon…)

Telescope

ACT Telescope

Credit: G. Ercolani/A. Schillaci

Credit: Rolando Dünner

12m

Ground screen

Ground screen framing

Secondary reflector

Primary reflector and BUS

Elevation frame

Receiver cal

Azimuth structure

Off-axis, Gregorian telescope.

40 tonne azimuth structure rotates at up to 2 deg/s.

Credit: Adam Hincks

6 m primary → 1.3' beam @ 150 GHz

−100 μm   100 μm

Instrument

- 3 optics tubes:
  - ‣ 2013: 1 array at 150GHz
  - ‣ 2014: 2 arrays at 150GHz
  - ‣ 2015: 2 arrays at 150GHz, 1 at 90/150GHz
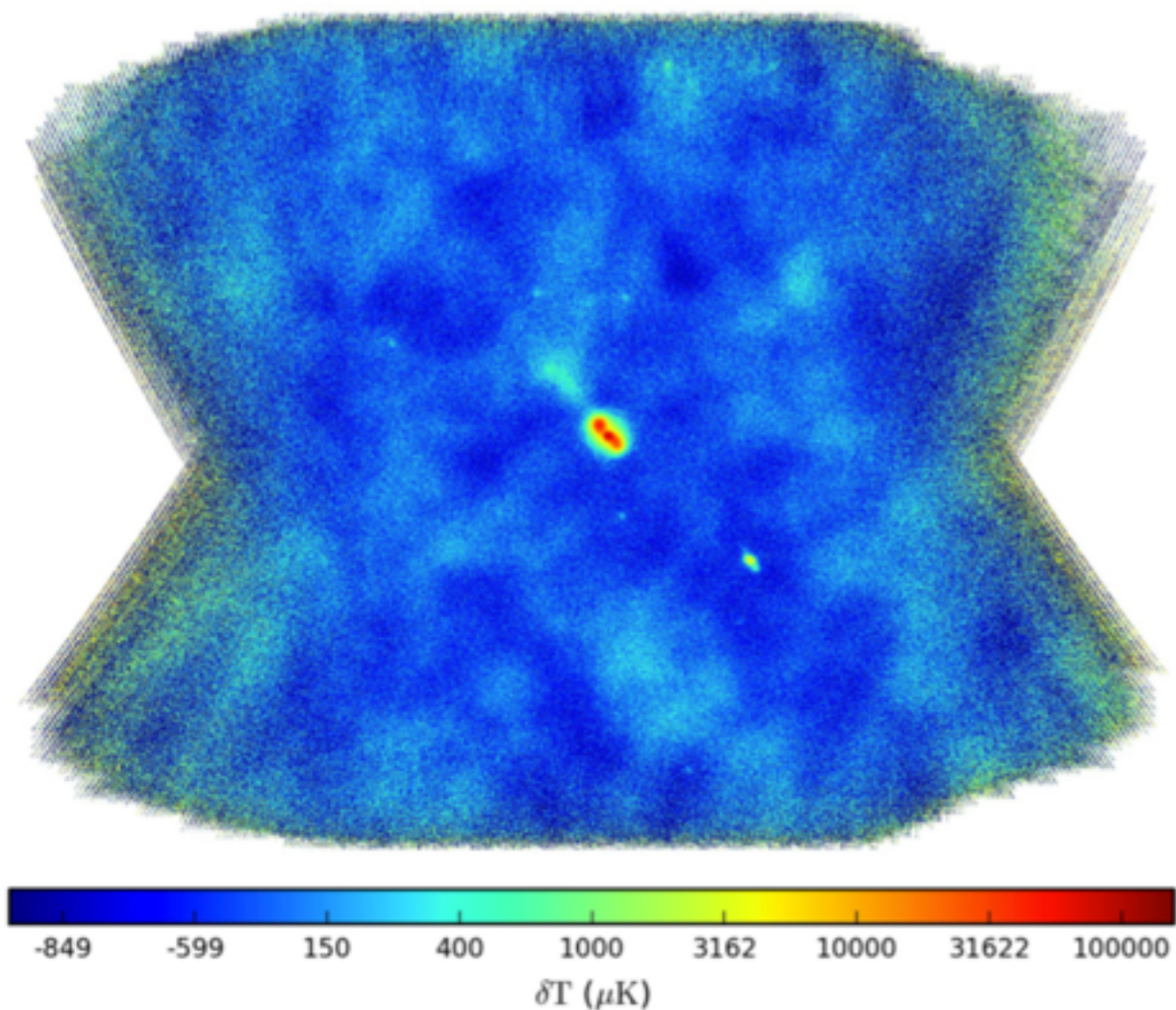
- Each array: ~1000 detectors
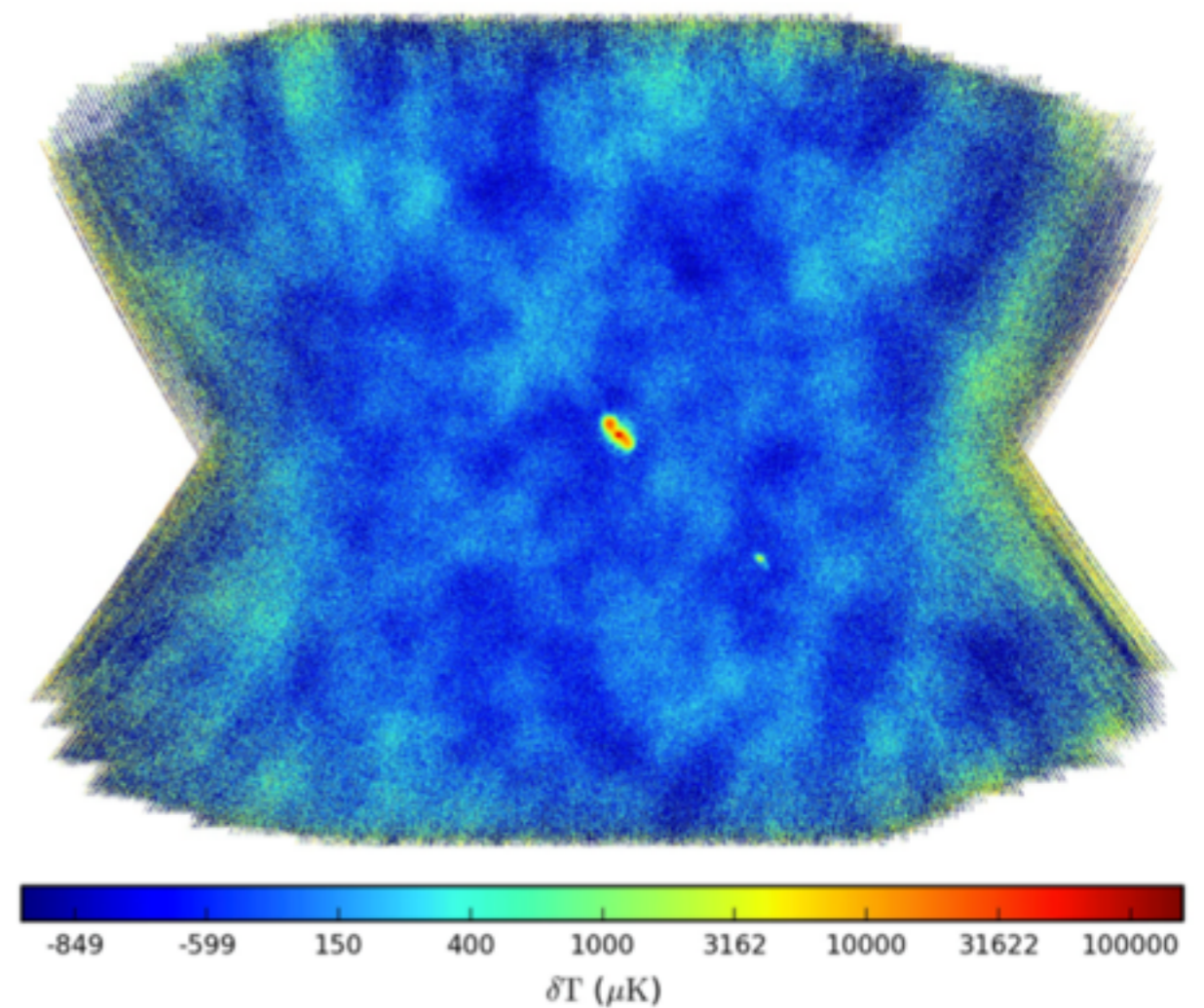
- 2015: HWP
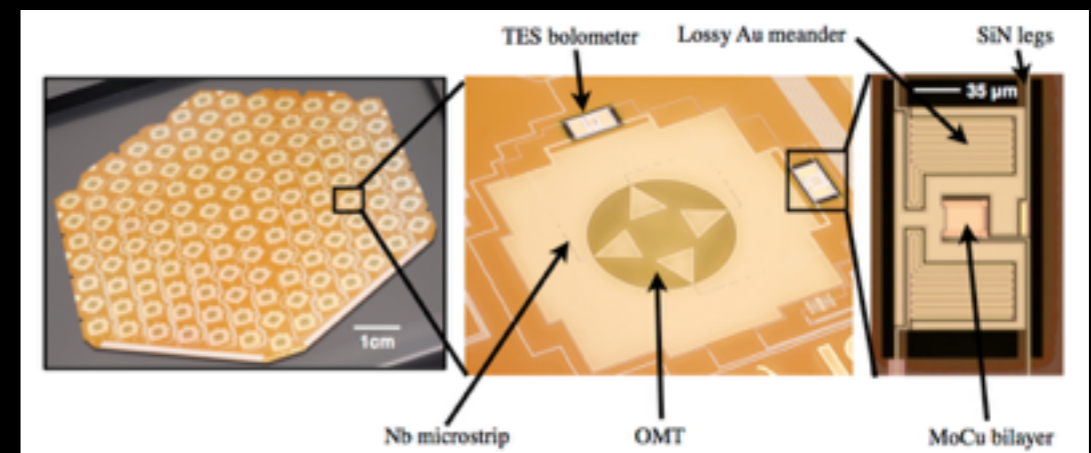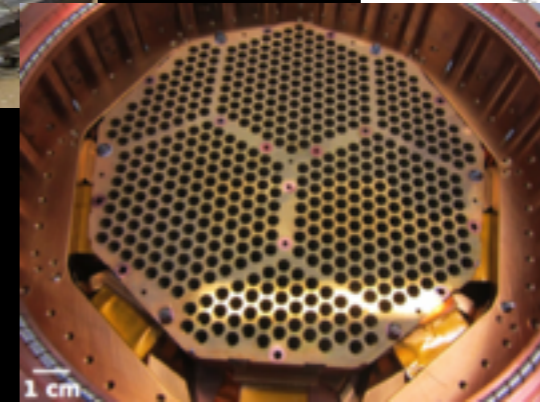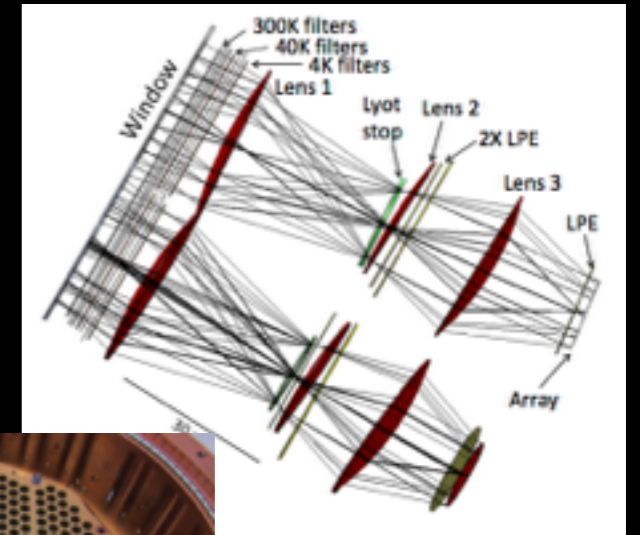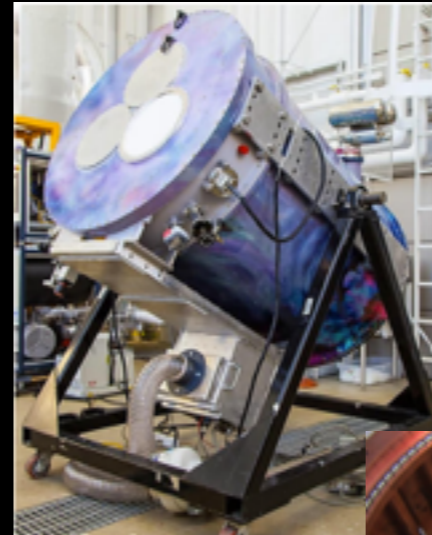
Thornton et al. 2016
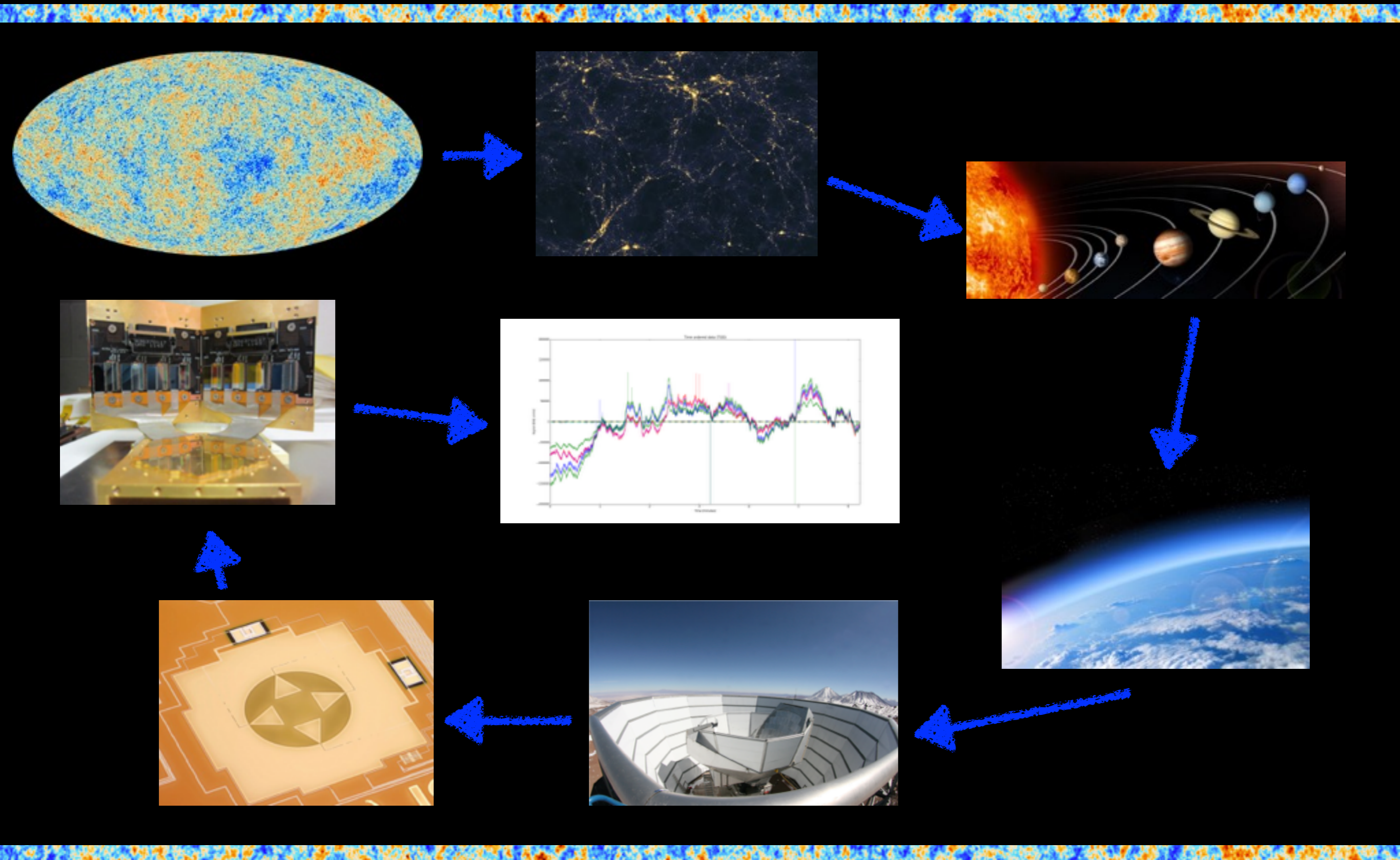
Dichroic array

Centaurus A
~10 hours of data

Credit: Marius Lungu

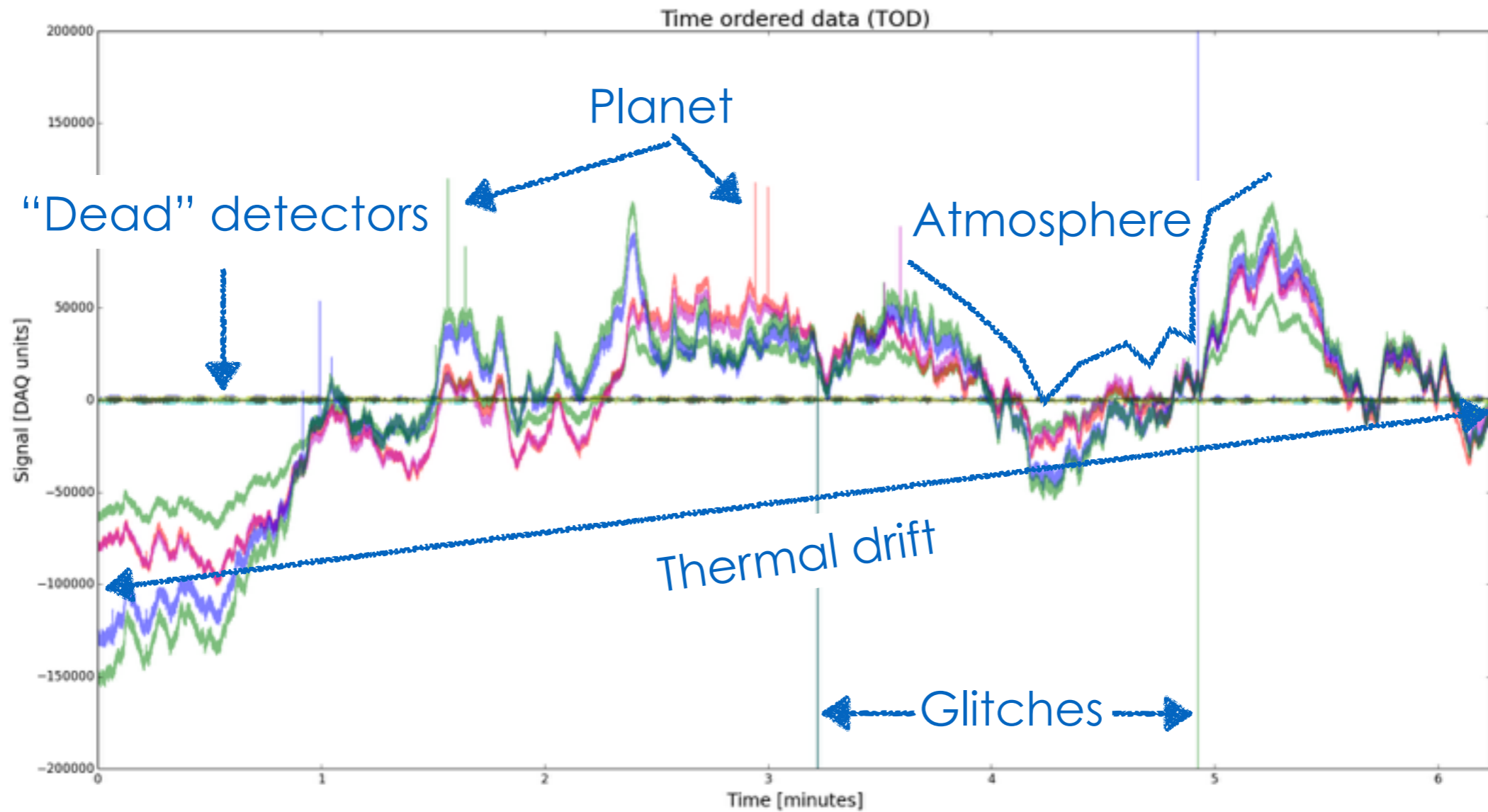# From the sky to the data
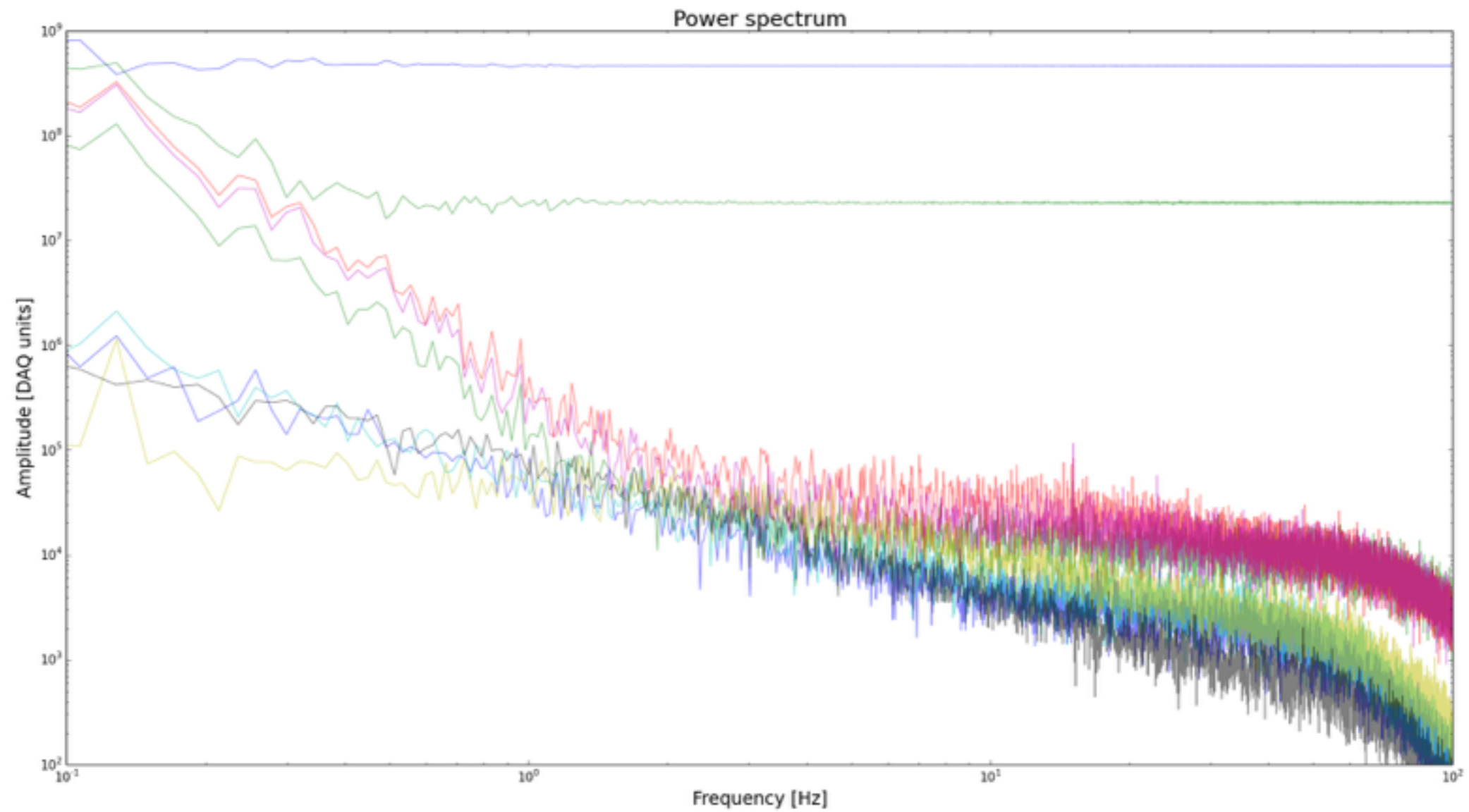
Raw data

- 3 x 1056 detectors sampled at 400Hz

- Scanning information

- Housekeeping information
  - ‣ thermometers
  - ‣ HWP
  - ‣ flags
  - ‣ IV curves, Bias Steps
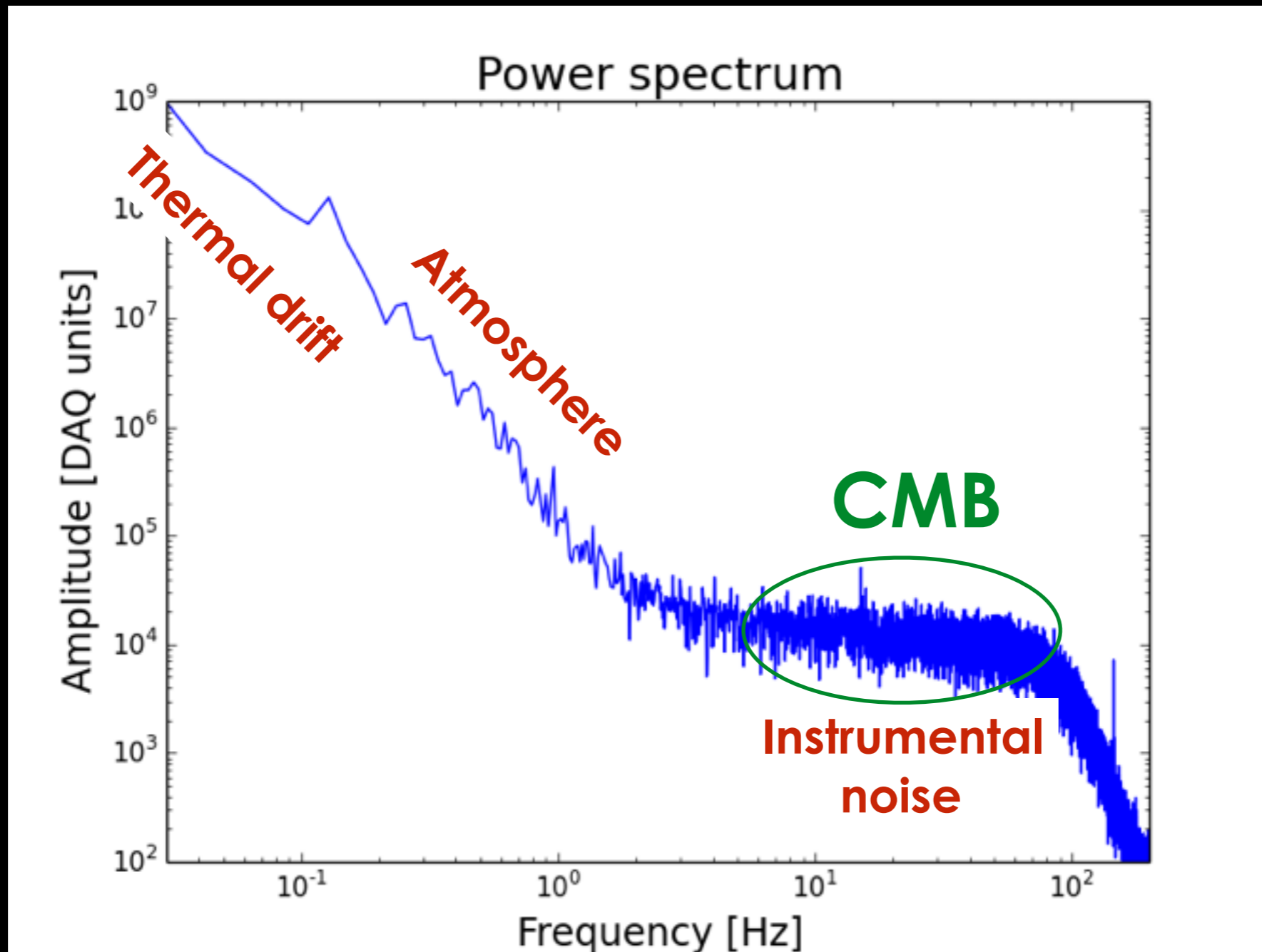
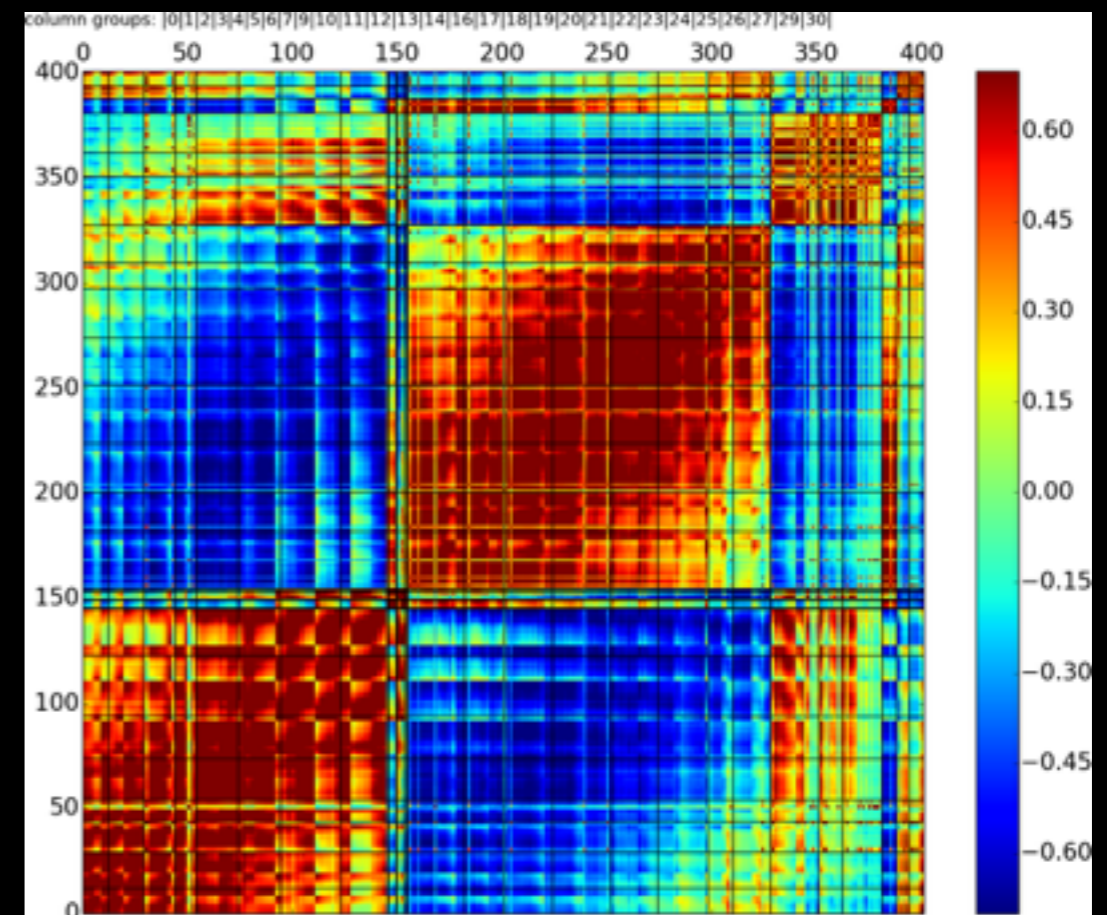- Stored in 10 minutes chunks (TOD)
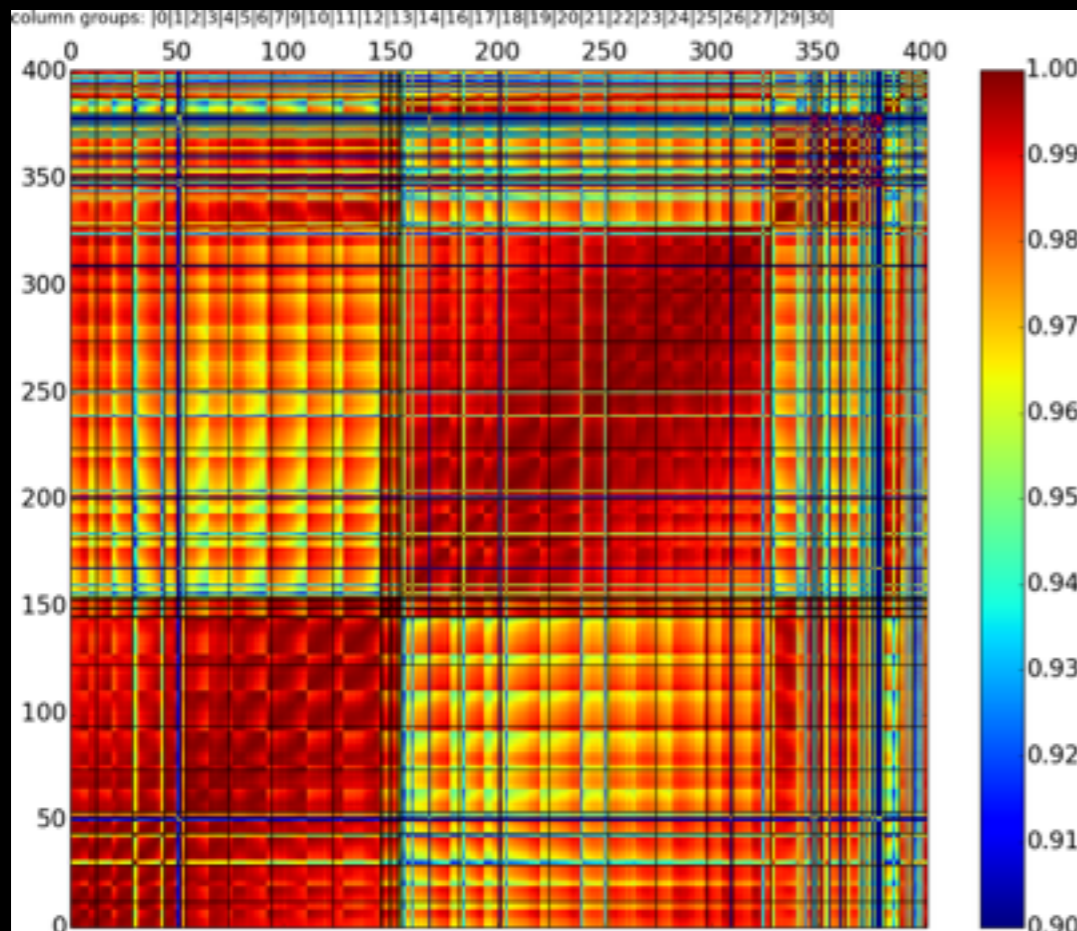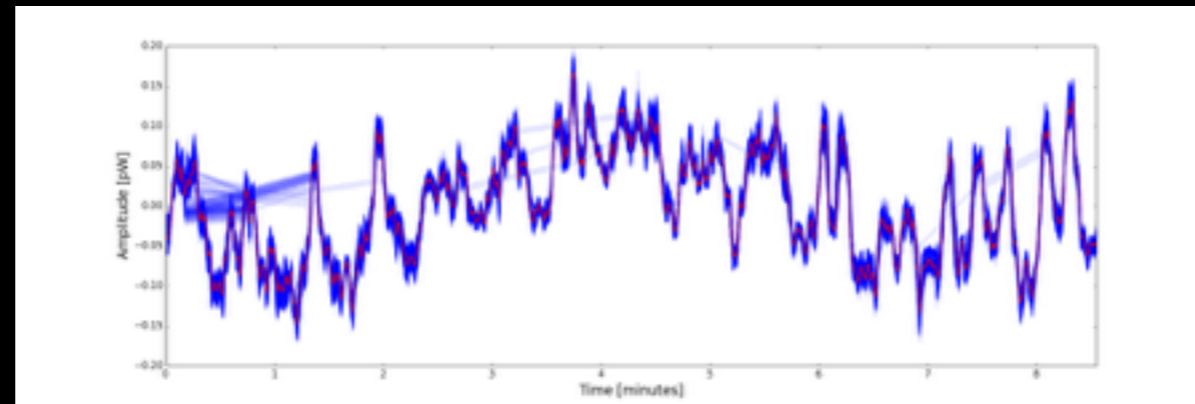
2016: ~ 25 TB !

Raw data

Raw data

Where is the signal?

Atmosphere

What is good data?

- What are the properties of good data?
  - ▸ should correlate well to the atmosphere (dominant signal)
  - ▸ atmosphere contamination shouldn't be too large (PWV > 3mm)
  - ▸ high frequency noise should "look good"
    - ✓ noise level in expected range
    - ✓ statistics should be close enough to gaussianity
  - ▸ glitches and jumps should be flagged

- According to these criteria, we flag:
  - ▸ chunks of a TOD for individual detector
  - ▸ whole TOD for individual detector
  - ▸ whole TOD for all detectors

What is good data?
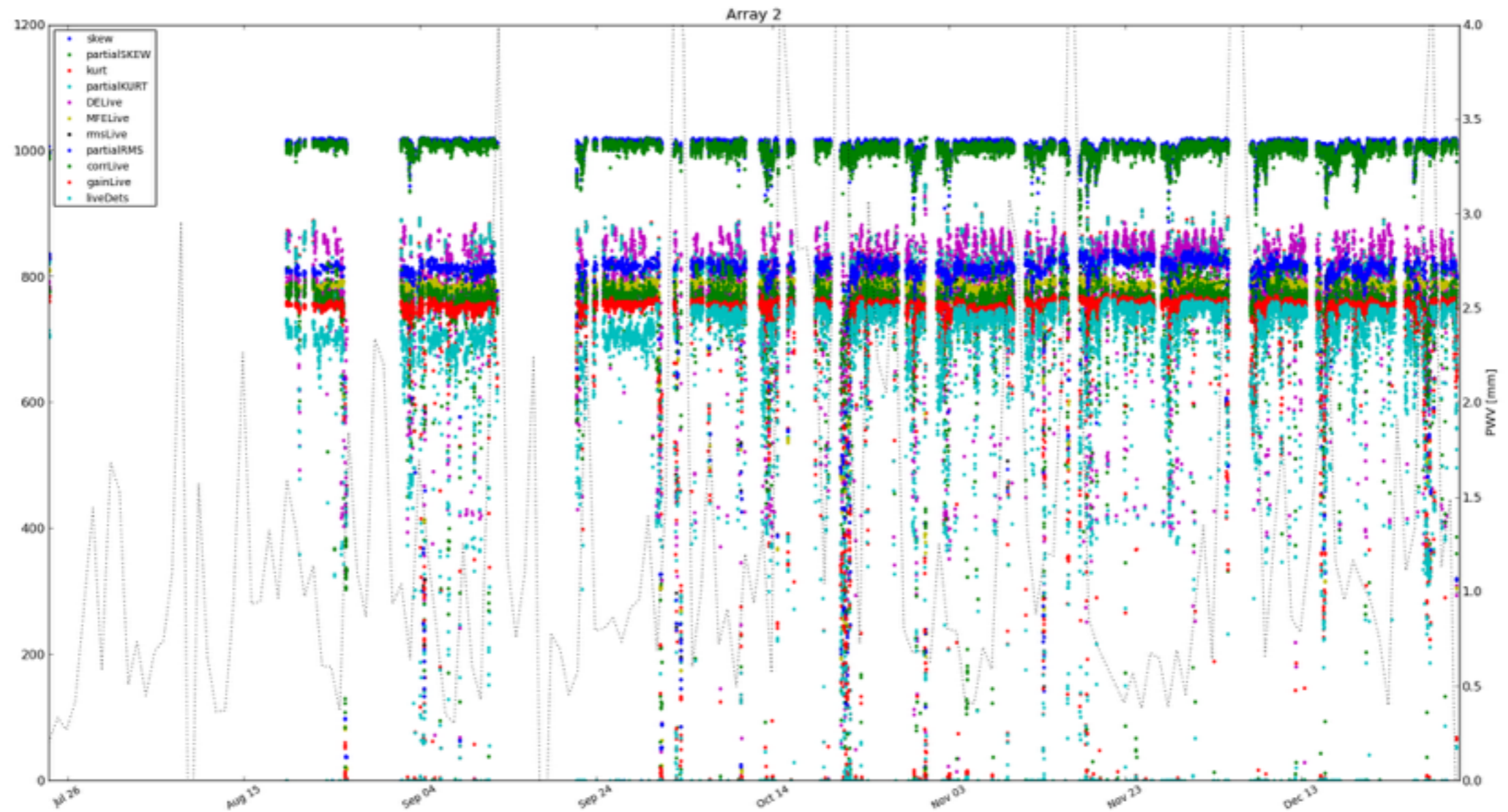
Calibration

- What do we have to calibrate our data?
  - ▸ detector responsivity measurements
    - ✓ IV curves
    - ✓ Bias steps
  - ▸ observations
    - ✓ atmospheric signal
    - ✓ planet observations

Calibration

IV Curve
Bias Step

Atmosphere

Planet

DAQ Units → **« Detector » Power** → **« Sky » Power** → **CMB temperature**

Flat-fielding

Do not include optics

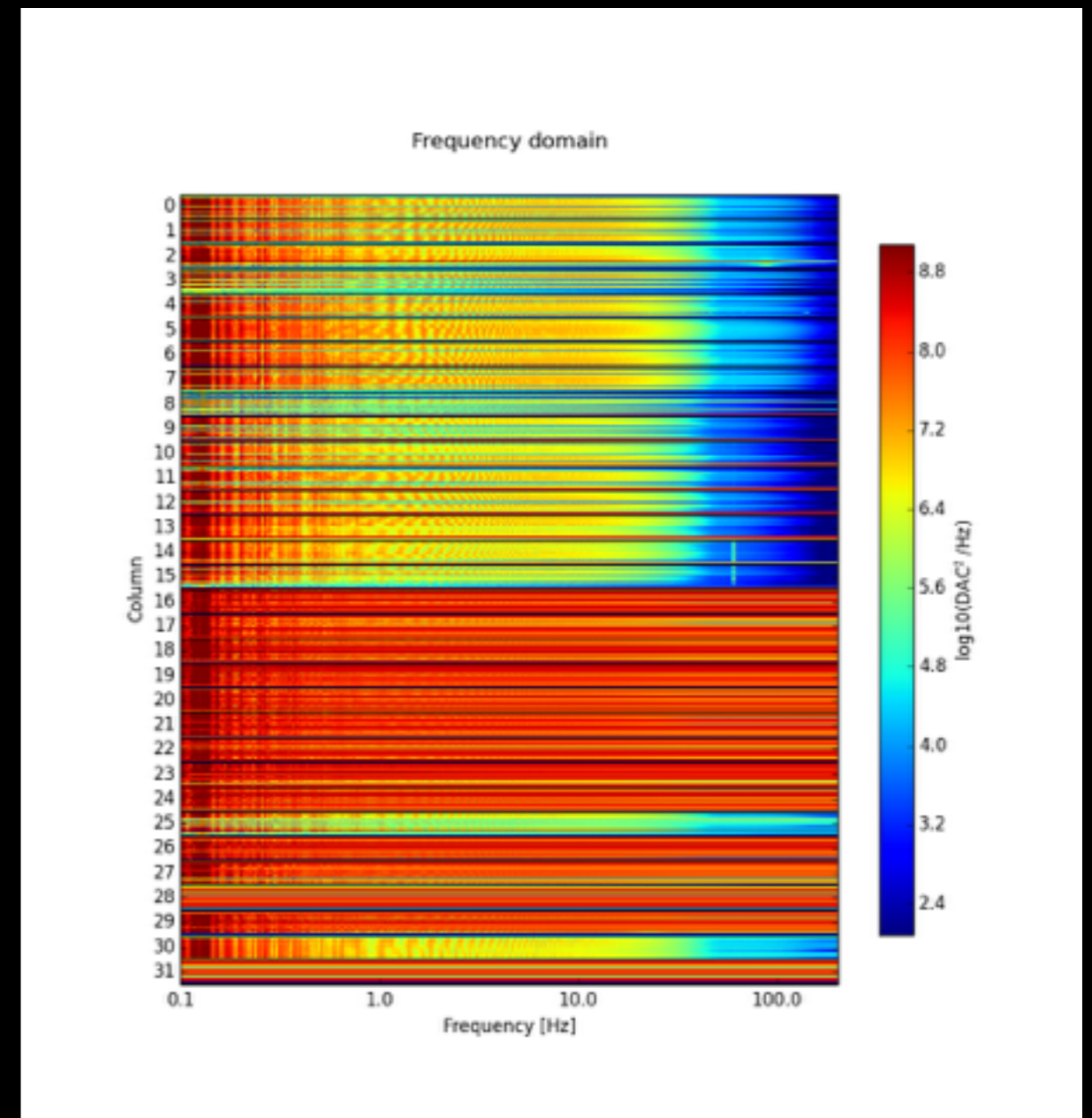Account for atmosphere emission

Planet model + Atmosphere transmission model

Depends on detector loading

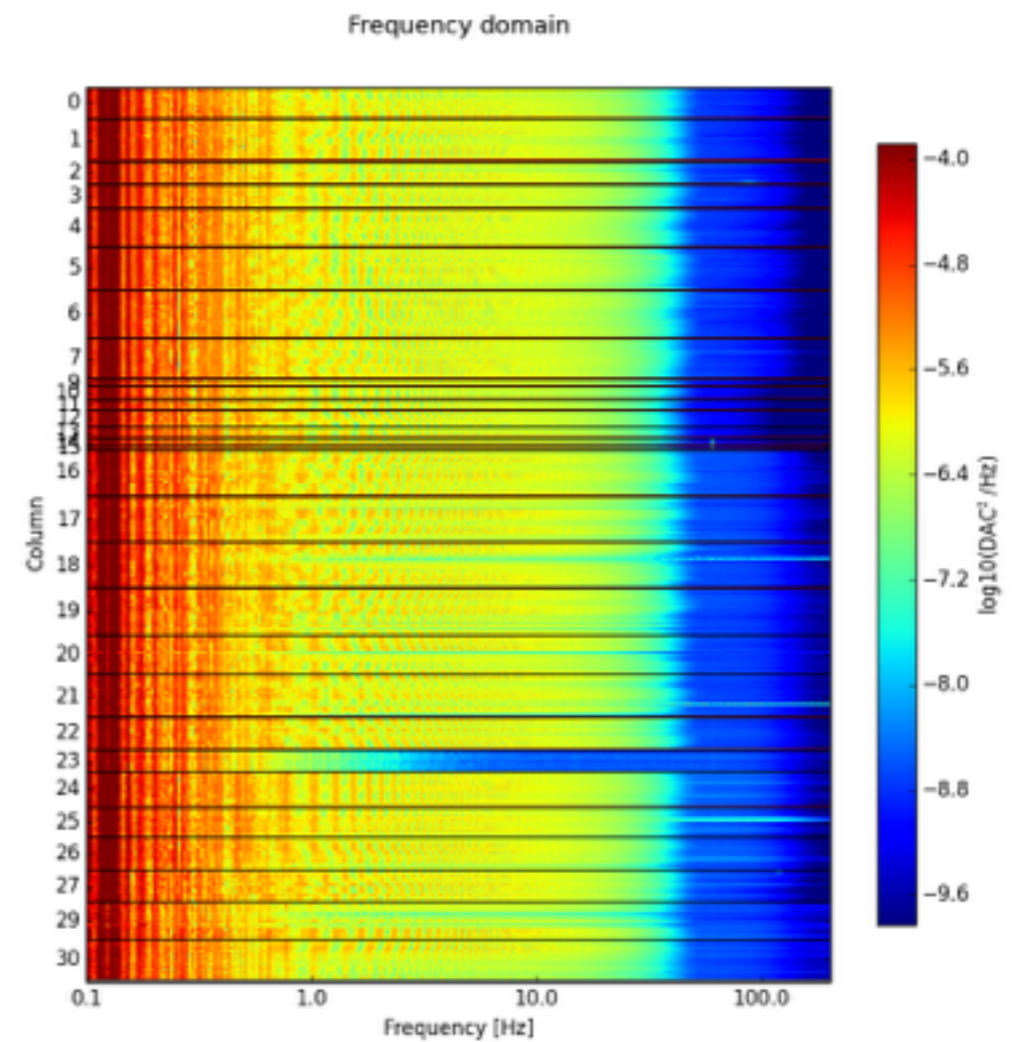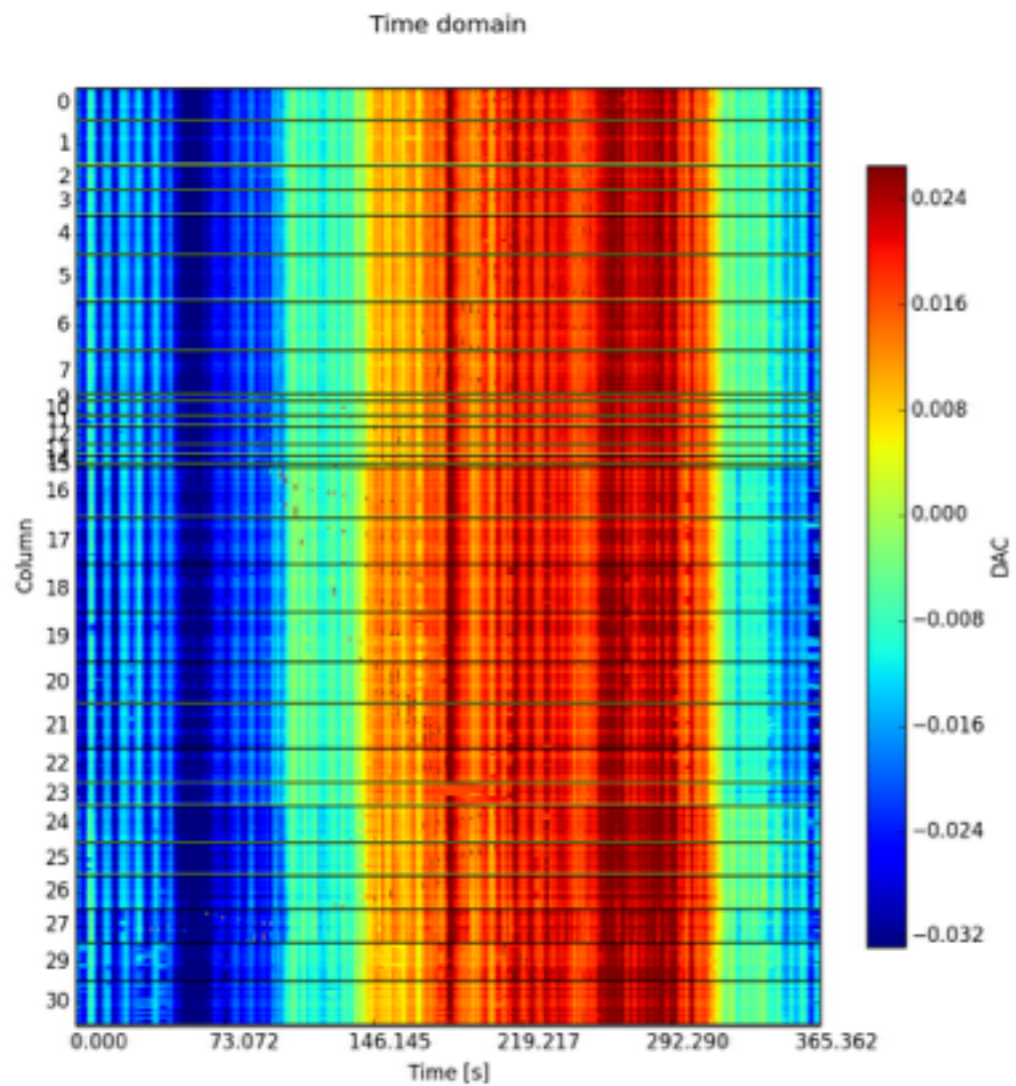Do not account for atmosphere transmission

Fit to observations

Before
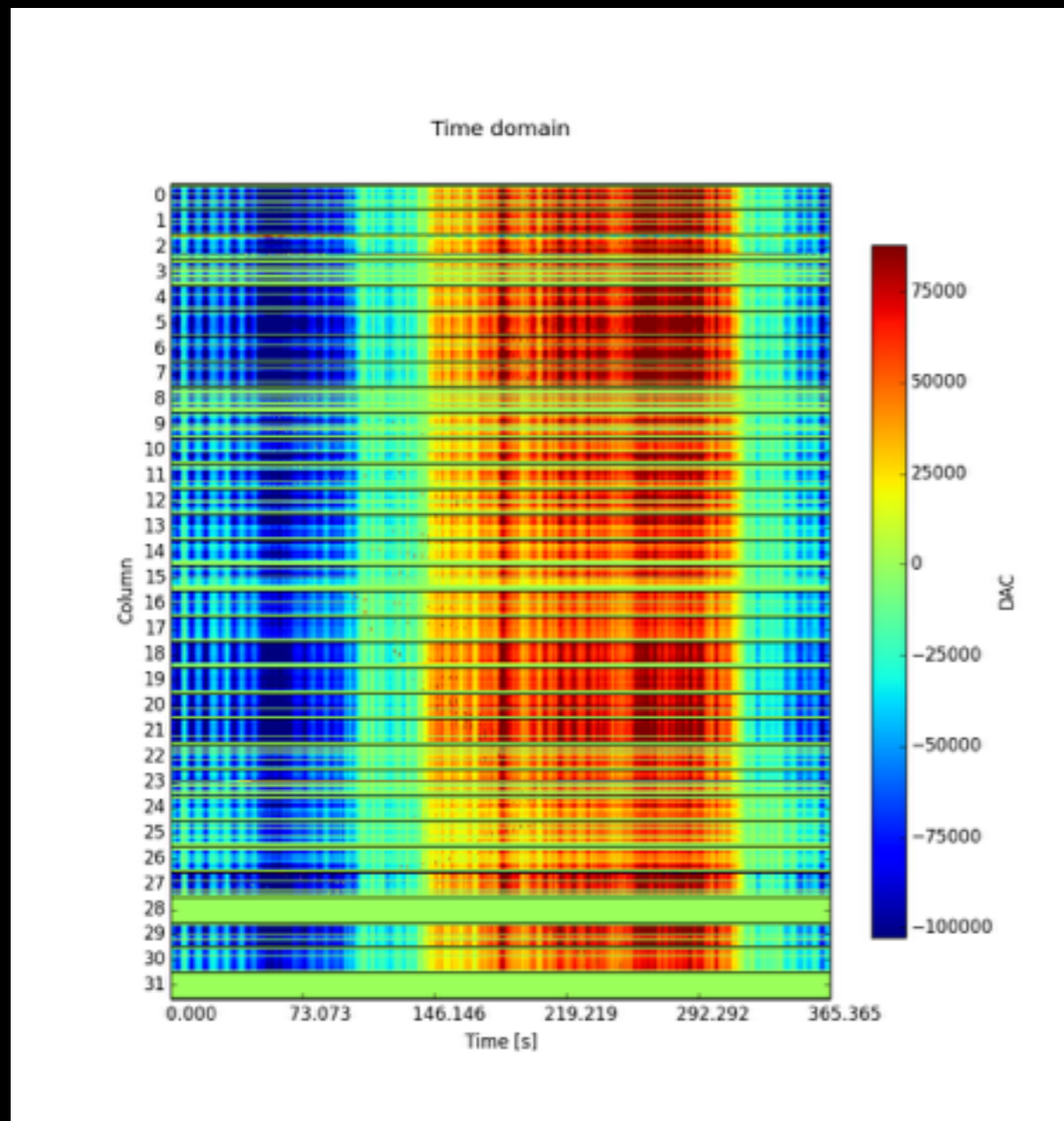
After

Can we make a map now?

- Not yet!
  - ‣ Time constants
    - ✓ from IV curves
   - ✓ from planets
  - ‣ Pointing
    - ✓ relative detector offsets from all planets observations
    - ✓ absolute boresight pointing per TOD from model fitted on planets (and possibly point sources)
  - ‣ Noise model
    - ✓ compute TOD correlation matrix
    - ✓ remove dominant modes
    - ✓ estimate residual (uncorrelated) per detector noise
  - ‣ Beam
    - ✓ from planets
    - ✓ from simulations (GRASP)

Grace et al. (2014)

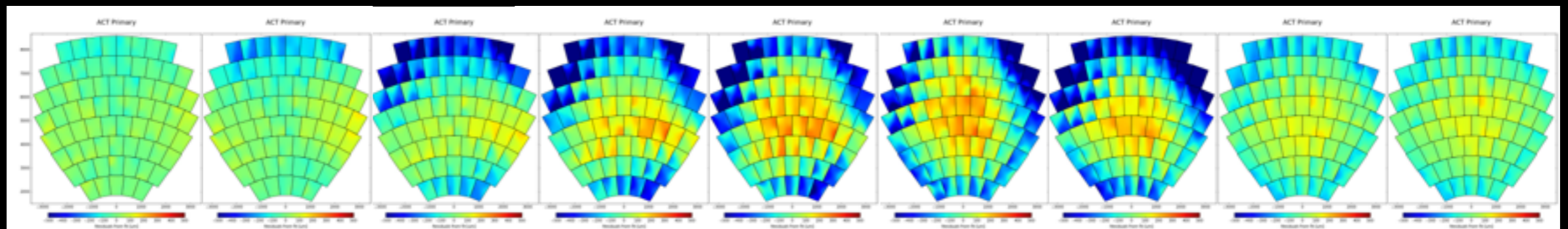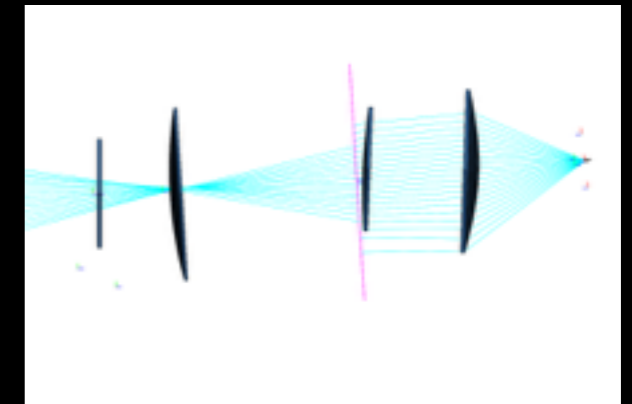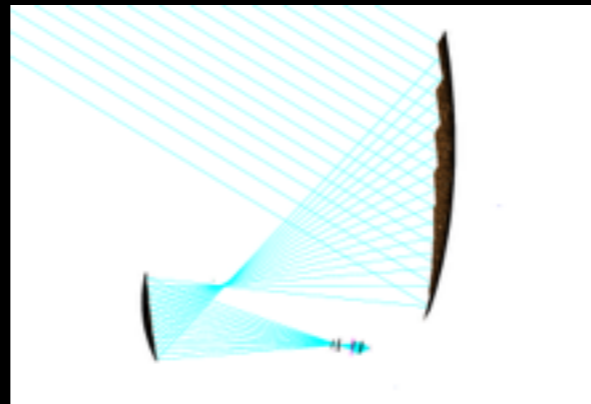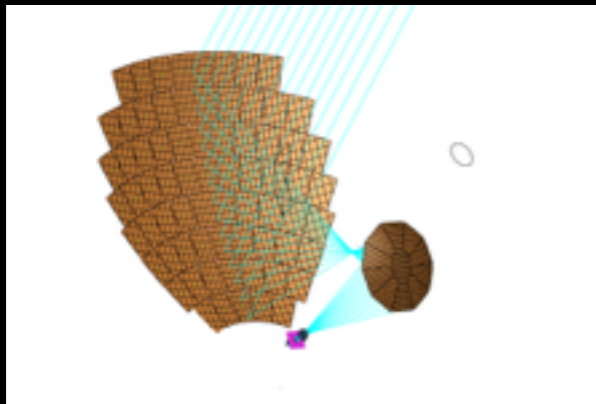*Thornton et al. (2016)*
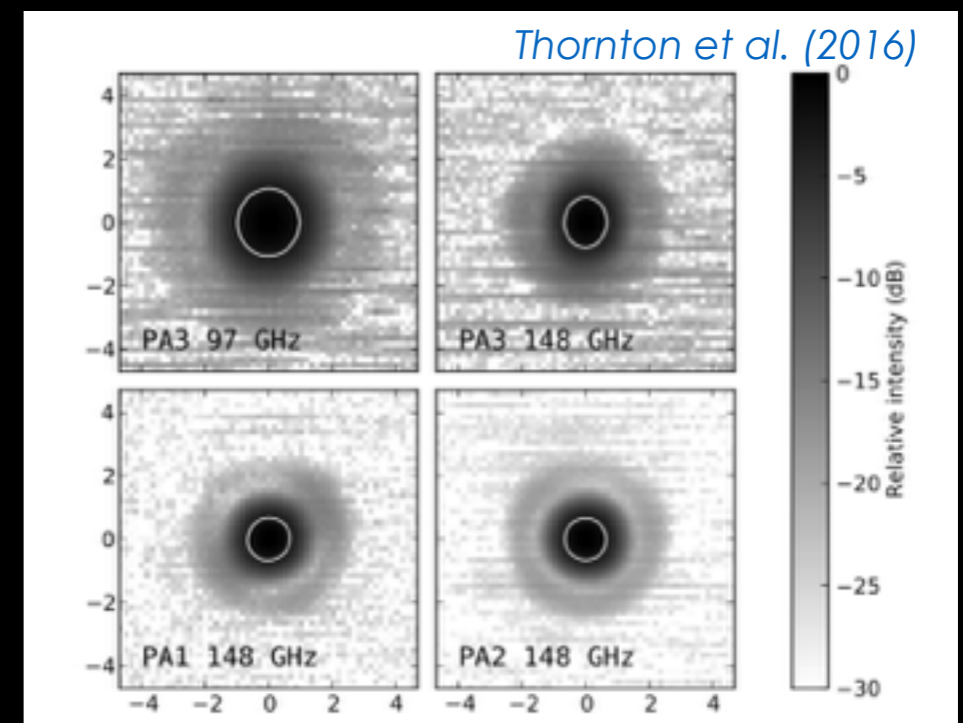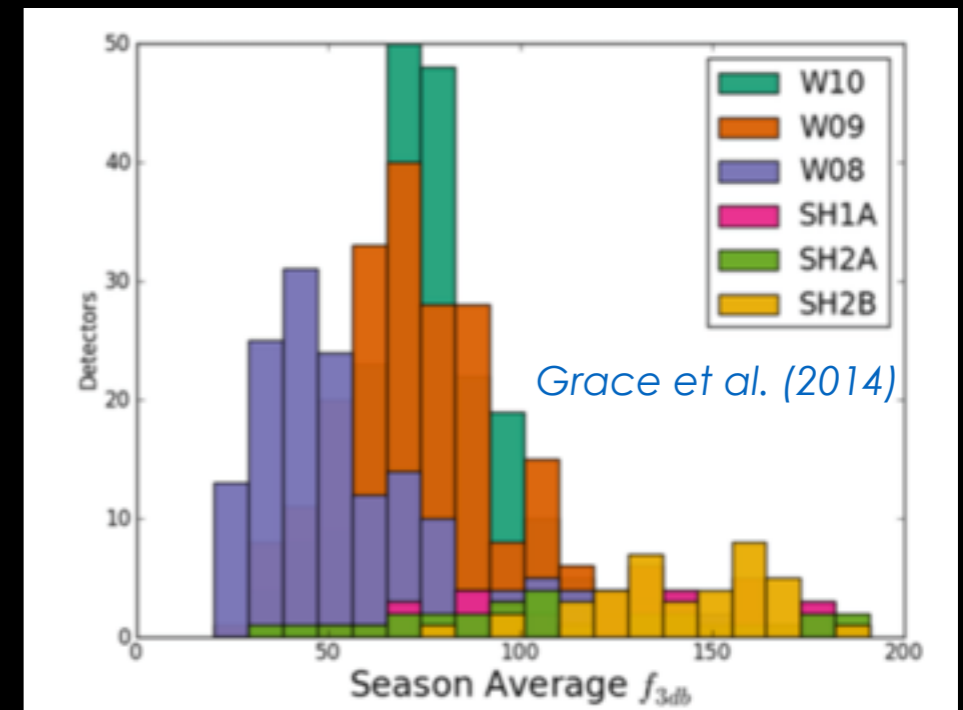
Optics characterization

*PUC Team: R. Dünner, P. Fluxa, A. Schillacci, C. Béchet
(postdoc position available, contact: rdunner@astro.puc.cl)*

- **Goals:**
  - ‣ Mirror alignment
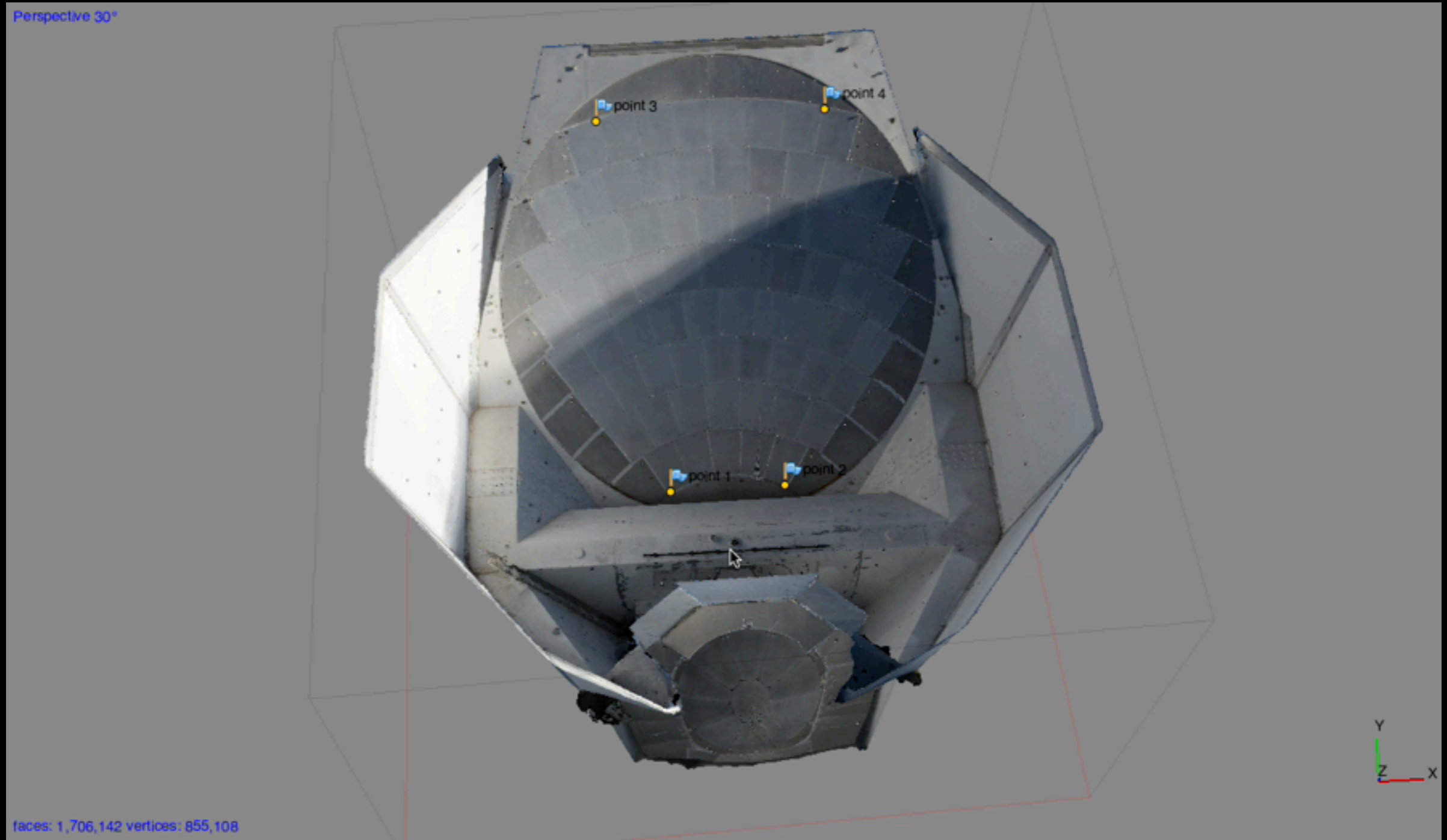 - ‣ Telescope modeling
  - ‣ Beam simulation

- **Techniques:**
  - ‣ photogrammetry
  - ‣ Solidworks/Agisoft-Photoscan
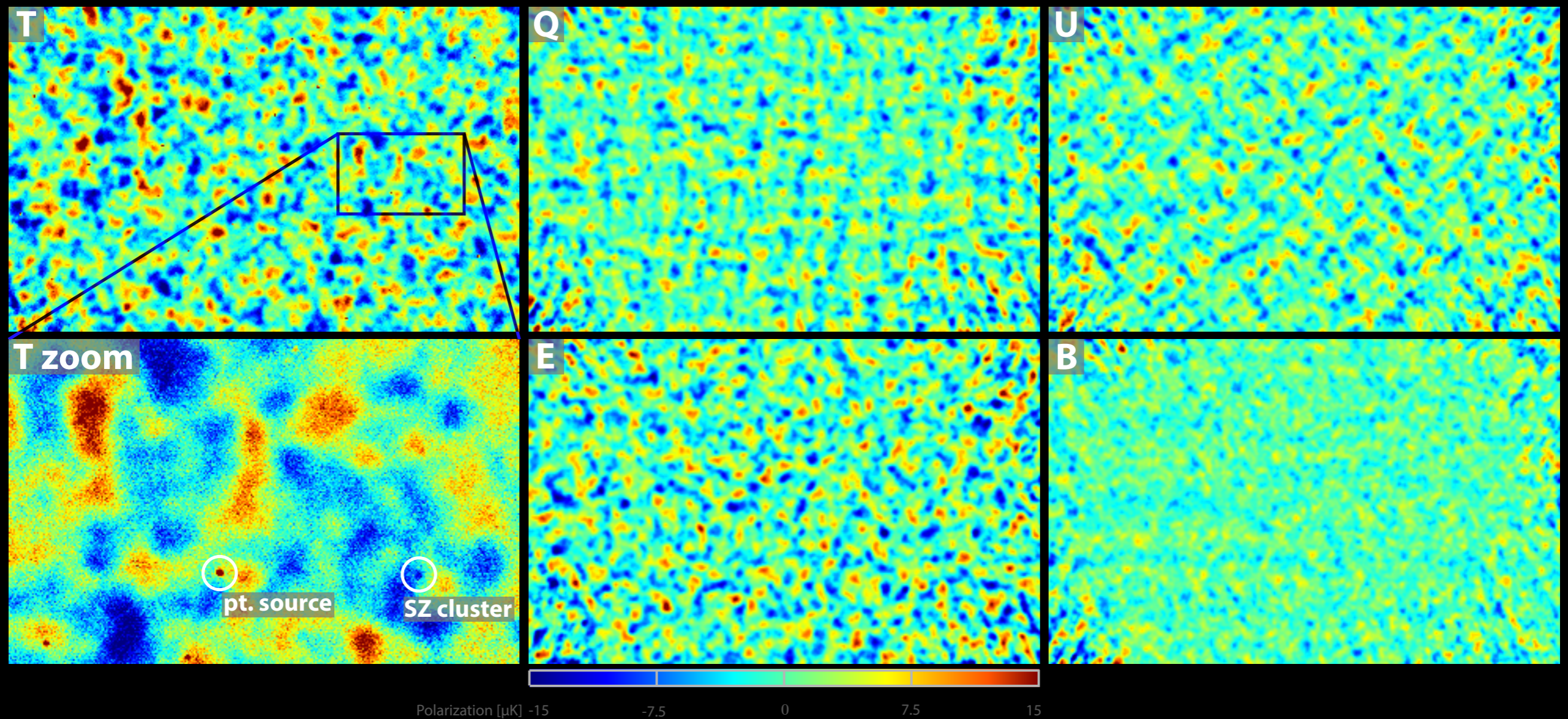 - ‣ GRASP simulation

3D reconstruction

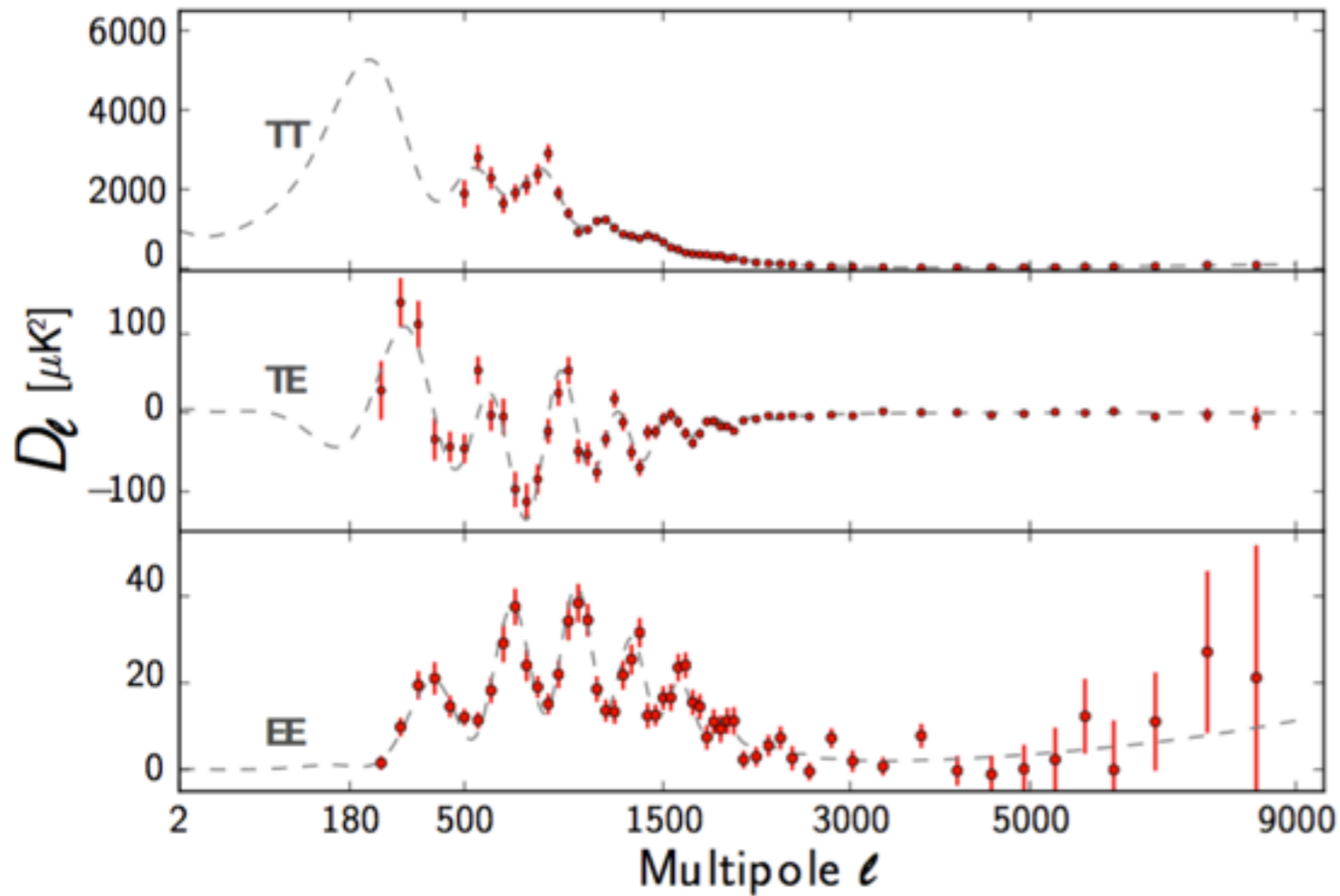# Maps 2013

T

Q

U

T zoom

pt. source

SZ cluster
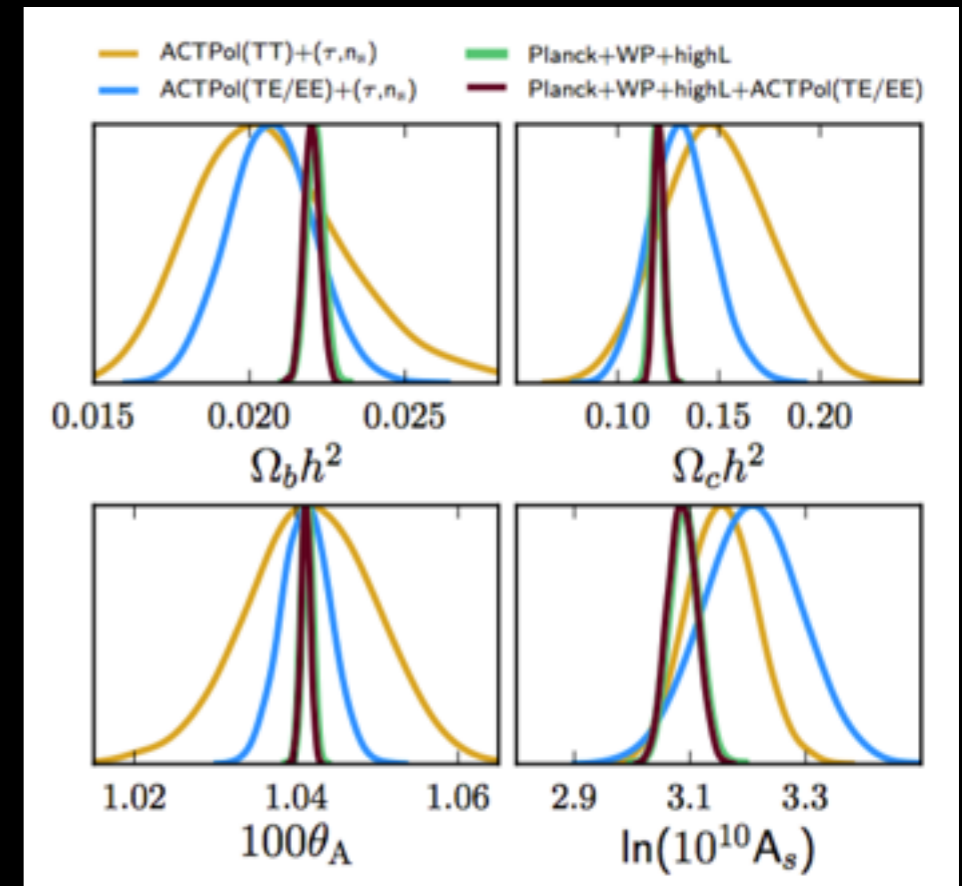
E

B

Polarization [µK] -15   -7.5   0   7.5   15

Naess et al (2014)

CMB

Naess et al (2014)

CIB lensing

ACTPol Lensing x Planck CIB
All Estimators
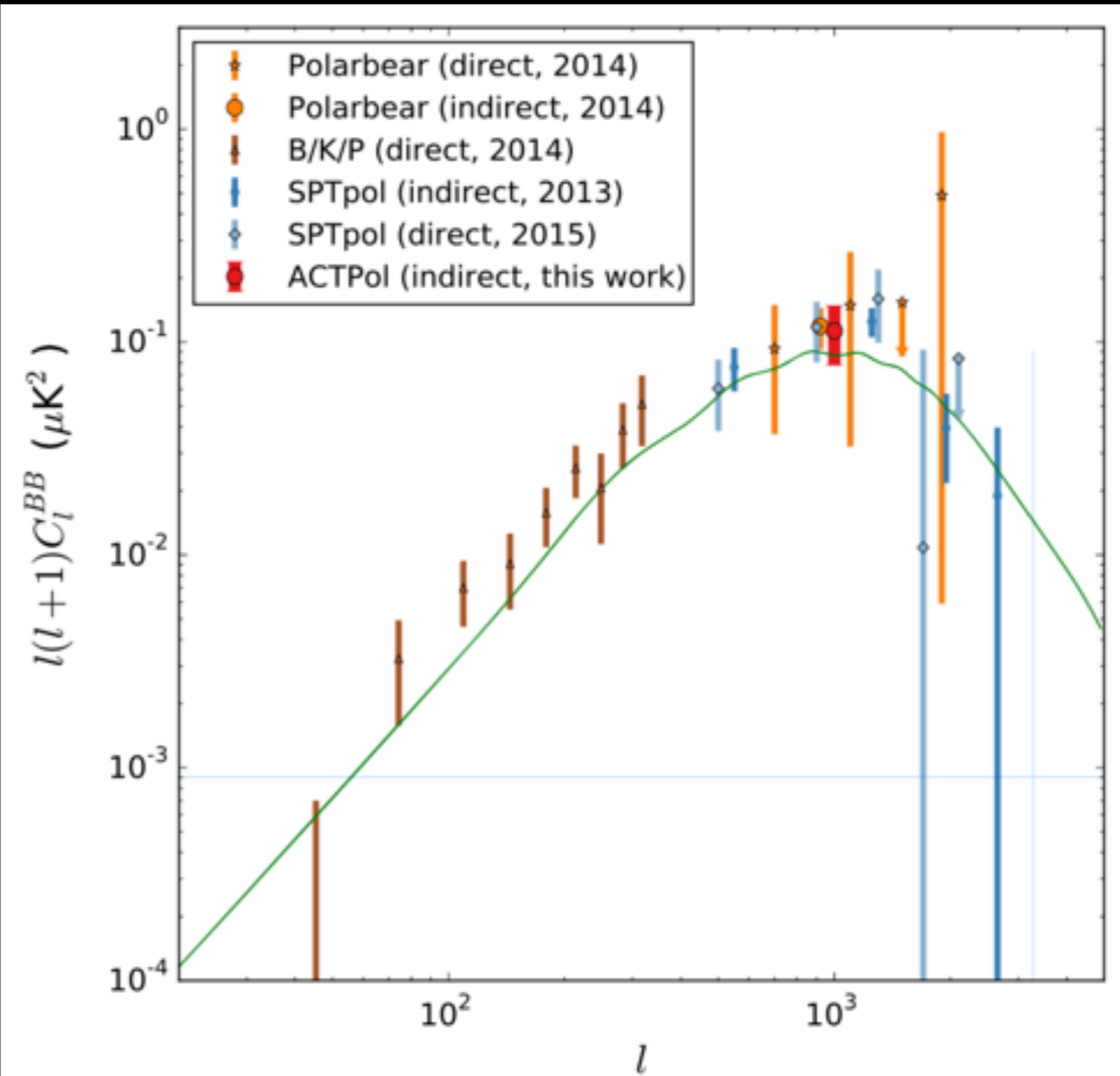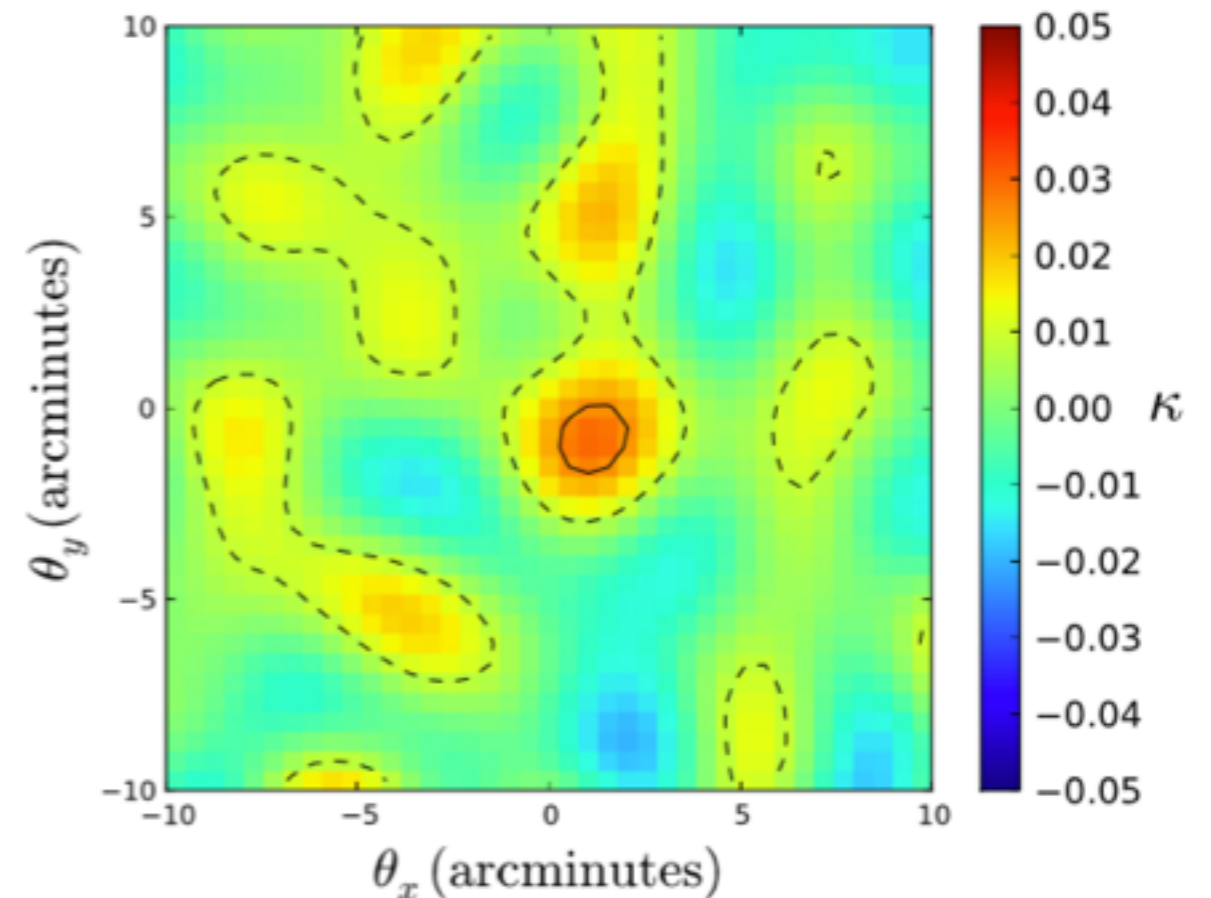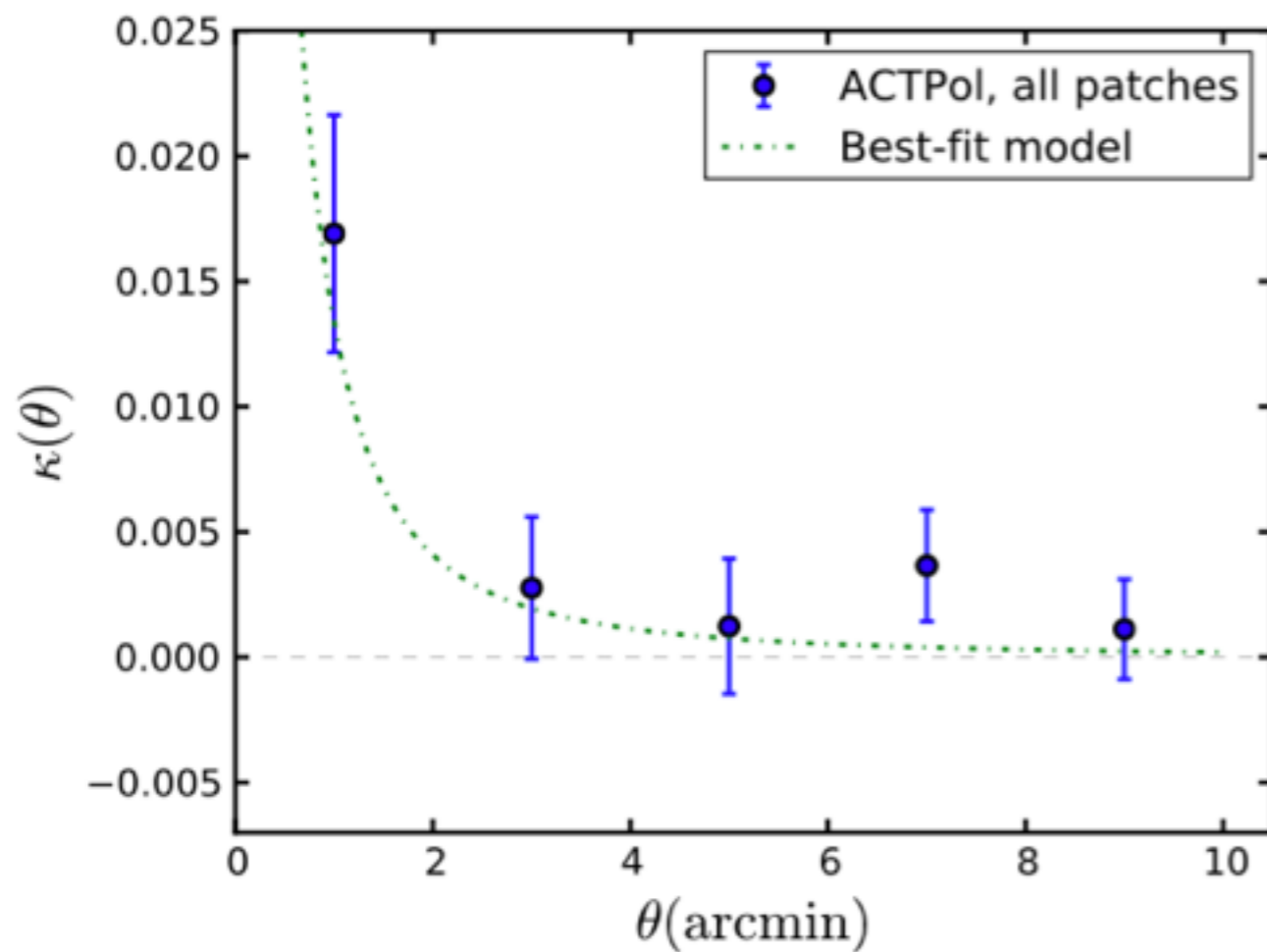
9.1σ
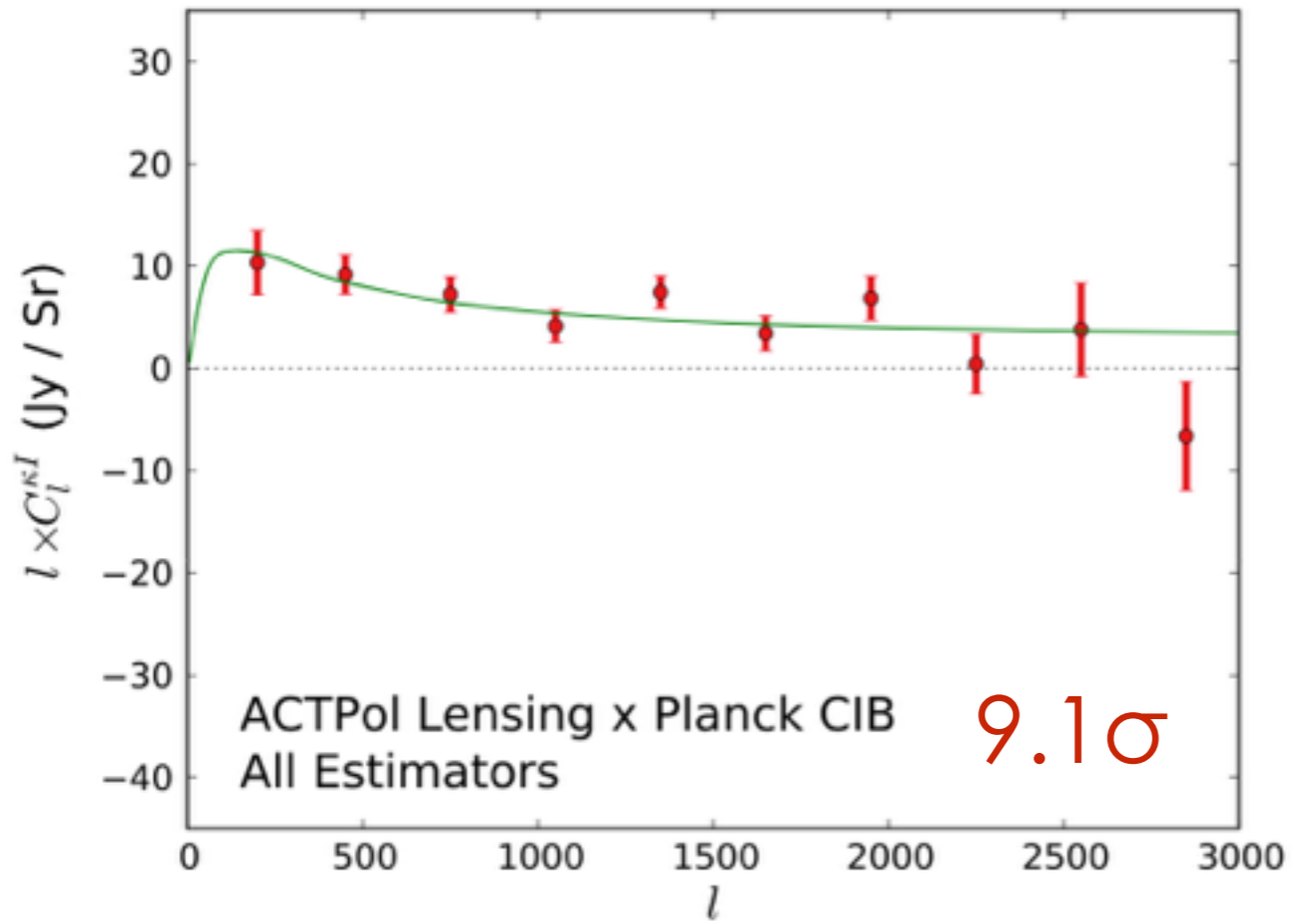
van Engelen et al (2015)

DM haloes lensing

- Convergence field stacked around galaxies from BOSS

Madhavacheril et al (2014)

Coming soon…

- 2013+2014 data

- First CMB multichroic array on the sky (since 2015)

- AdvACT is being deployed

- Simons Observatory on the way

Thank you