Chile r forecasting: How to improve & validate *r*-forecasts

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S4 Collab Meeting summer 2024

Bullet Points Handed to Us:

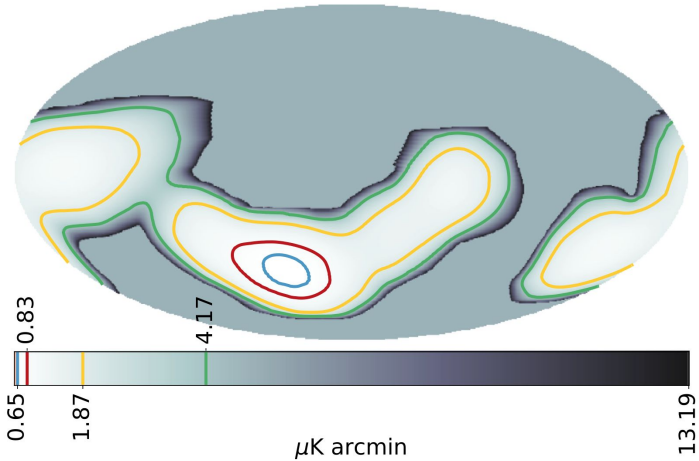
1. De-lensing validation
2. Map based validation
3. Optimizing band allocation on SATs and delensing LATs

4. Inclusion of potential systematics

Question / comment: validation (of Alt 3) vs. optimization (of Chilean survey) ?

Current Status: 1) Delensing validation (map based)

- As Raphael said yesterday we have seen recovery of lensing B-mode templates from Julien Carron and Sebastian Belkner that match predictions pretty well.
- The current DC11 round of sims includes all-Chile alt3.
  - Lensing reconstruction of that is still in progress.
  - How to include the extended alt3 field with its highly variable delensing level into re-analyses will take some work but is probably not a huge issue…
  - FG cleaning of LAT maps complete (Shamik)



Current Status: 2) Map-based validation

- Fisher calcs yield sigma(r) only - map based sims can give bias on r as well
- To back the AoA Fisher studies we have done latest DC10/11 map based runs which include alt1, alt2 and alt3 (all-Chile)
- Colin gave a good summary of the current results yesterday - there is significant bias for the medium and complex models - very strong for alt3 (all-Chile) if one just uses the less good sky regions blindly.

Question: Should we worry about method-based variations?

Question: Should we take (more) seriously high complexity FG?

3) (Re)Optimizing band allocation on SATs and delensing LATs

- The SAT/LAT split and band-allocations within each were (supposed to have been) optimized in the past - see published paper
- This should maybe be revisited - particularly for the all-Chile configs…

Question: Specifically, do we need HF and LF bands for the delensing survey? How does the answer depend on sky complexity?

Question: Do current FG models span the right range of complexity for delensing?

Question: Do extragalactic FG matter for delensing?

Other questions ?

Big unknowns

- Polarized atmosphere?
- Foreground bias?
- Systematics?

Anything else (before we discuss systematics at length)?

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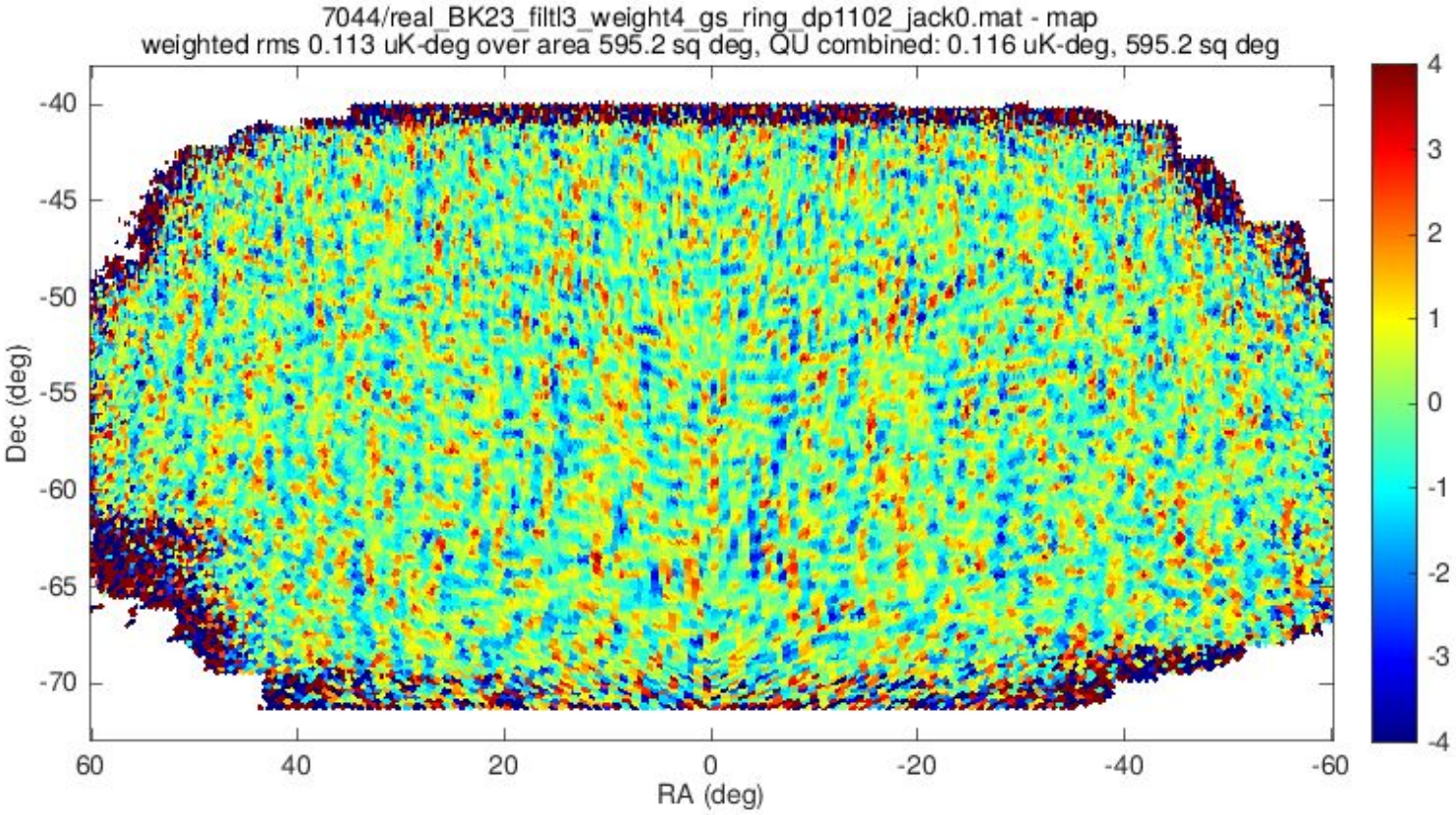
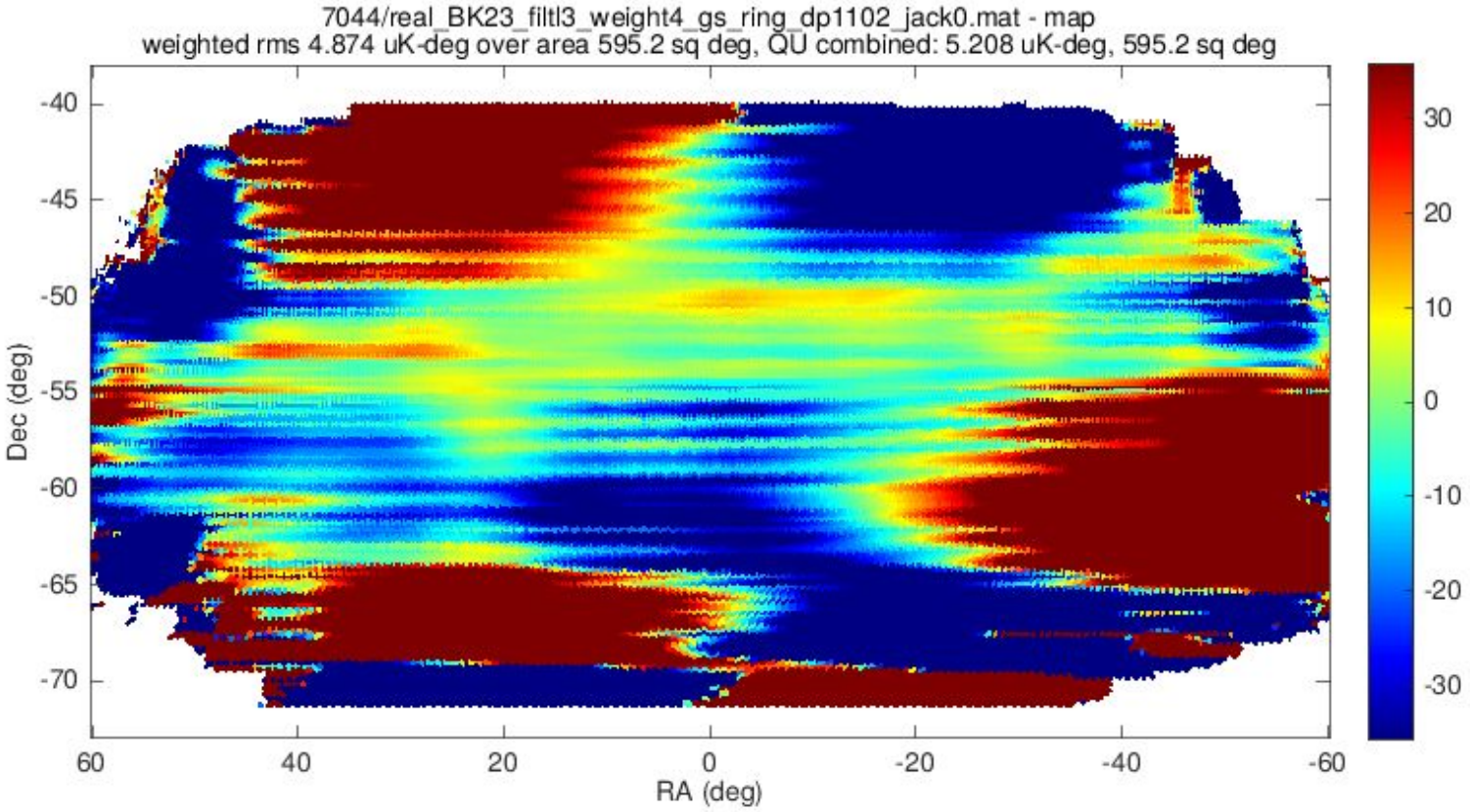
4) Inclusion of potential systematics: Switching to “aggressive optics”

- In the existing calcs the SAT map sensitivity is scaled from BK achieved performance using the relative number of detectors and calculated NET ratios.
  - ➢ This is simple to change for an “aggressive optics” version.
- Way more uncertain is whether “aggressive optics” will be OK from a bias on *r* point of view
  - ➢ All we know for sure is that such bias has been controlled to a level of a few times the noise down to current BK noise levels. (i.e. map null tests pass)
  - ➢ And as we see below the systematic effects already being removed like scan-sync are very large compared to the signal we are after (r=0.001)
  - ➢ Knowingly making such systematics bigger seems a brave move…

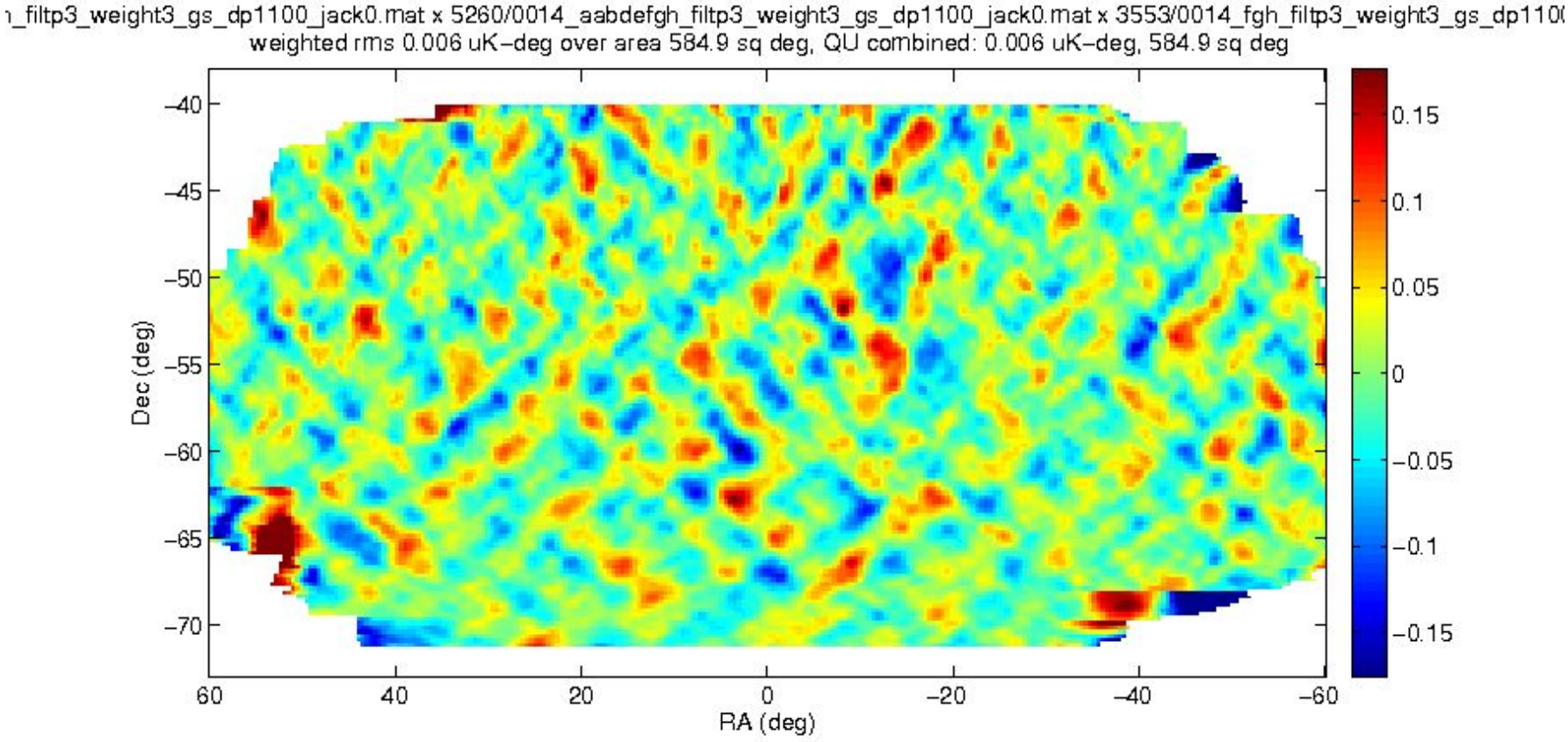
The BICEP3 8-year Q map
The remaining map after filtering (LCDM E-mode dominated)



The BICEP3 8-year Q map
The part removed by scan-sync filter (note change in color scale)



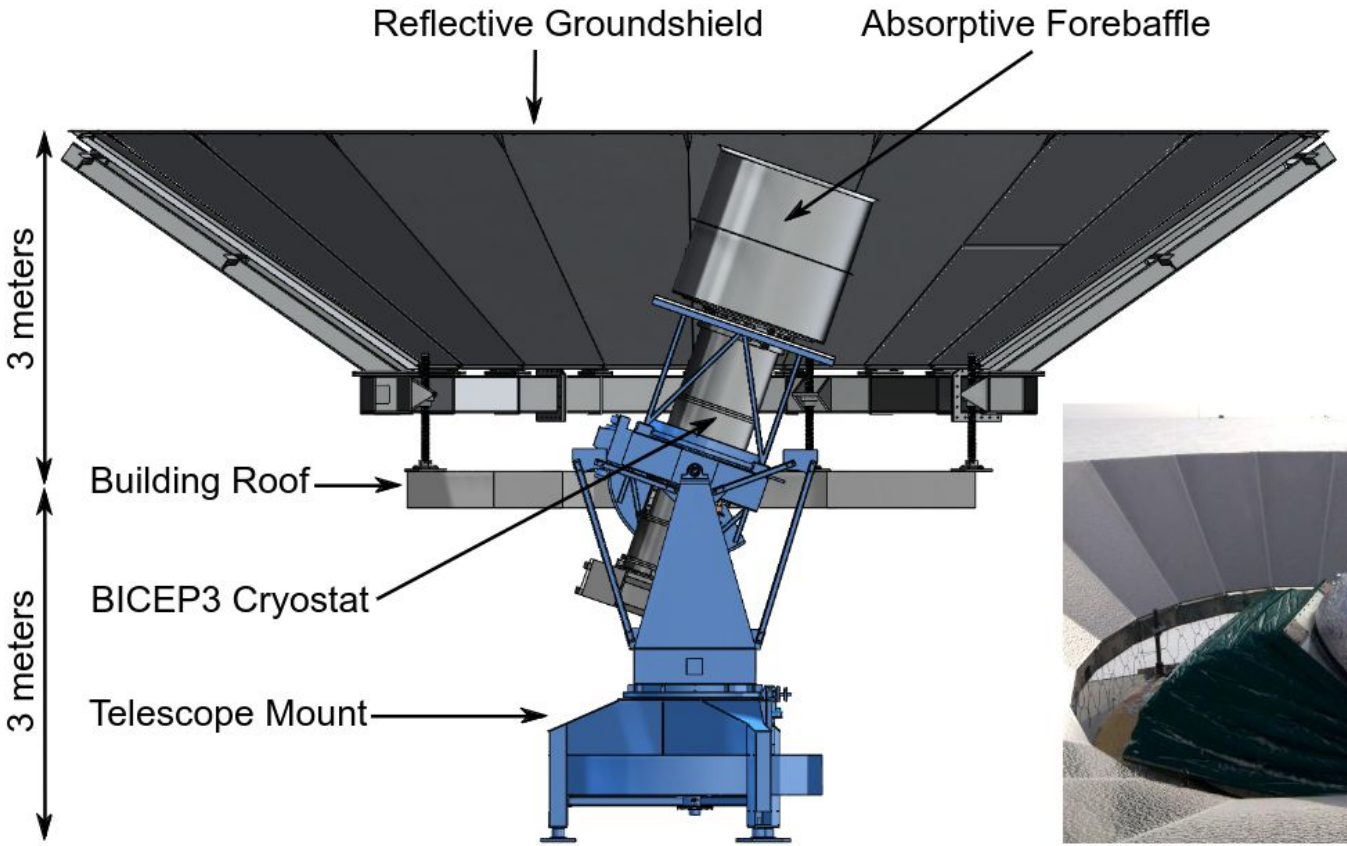
The BICEP3 8-year Q map
An *r*=0.1 signal (note change in color scale)



So where does the scan-sync signal come from? - why would it time evolve?

- In standard BICEP CMB scanning the azimuth range is held fixed for ~50 minutes while the sky drifts past (by ~12.5 degrees)
- We subtract the mean of all scans from each scan
  - This will perfectly remove any scan-sync signal which is constant in time
  - (done separately for left and right scans)
- Scan-sync signal is very large compared to the signal of interest
  - How time stable can we expect it to be? Where does it come from?

BICEP3 is very well shielded - but not perfectly!



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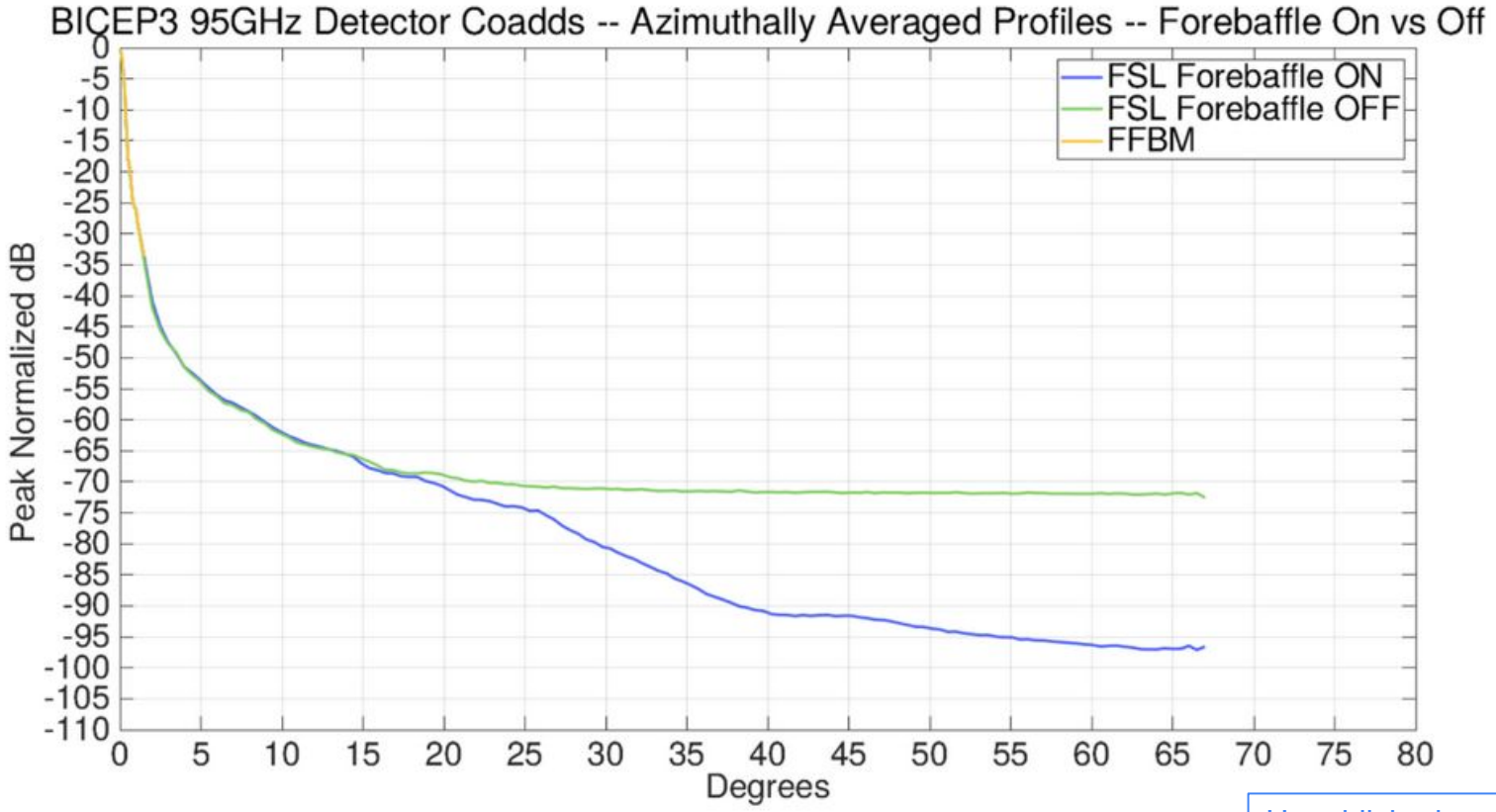
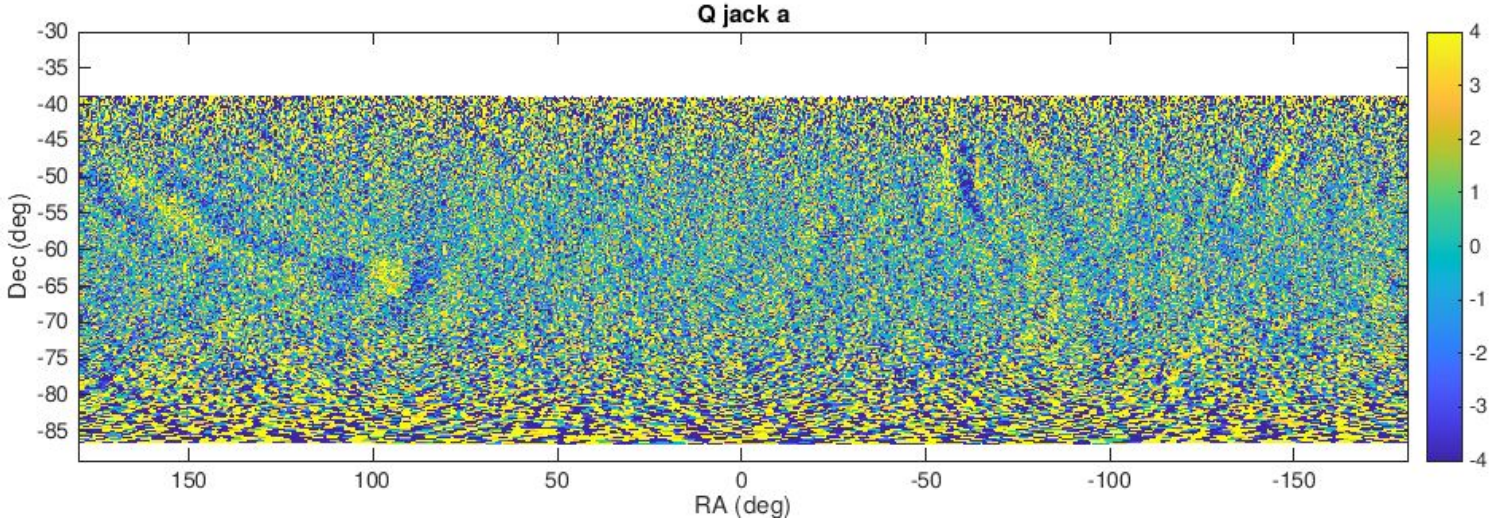


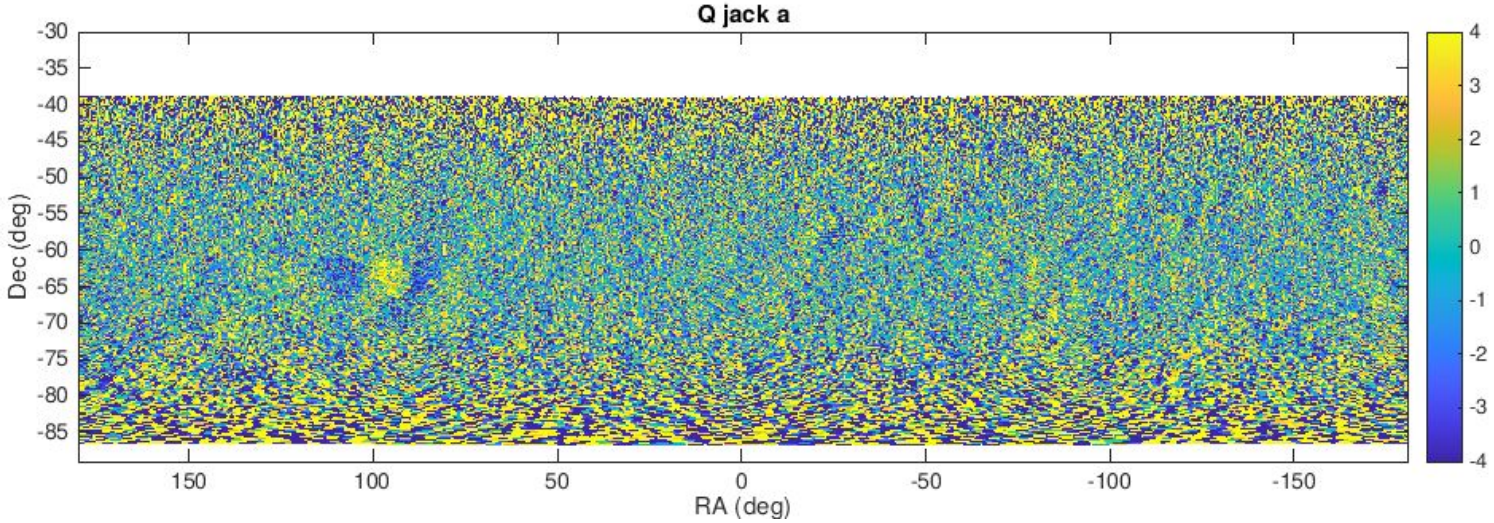
Unpublished work by
Christos Giannakopoulos

An example of a time evolving scan-sync signal: the Sun
Map: BICEP3 wide field, focal plane inner/outer split difference Q map
Case: Include all data



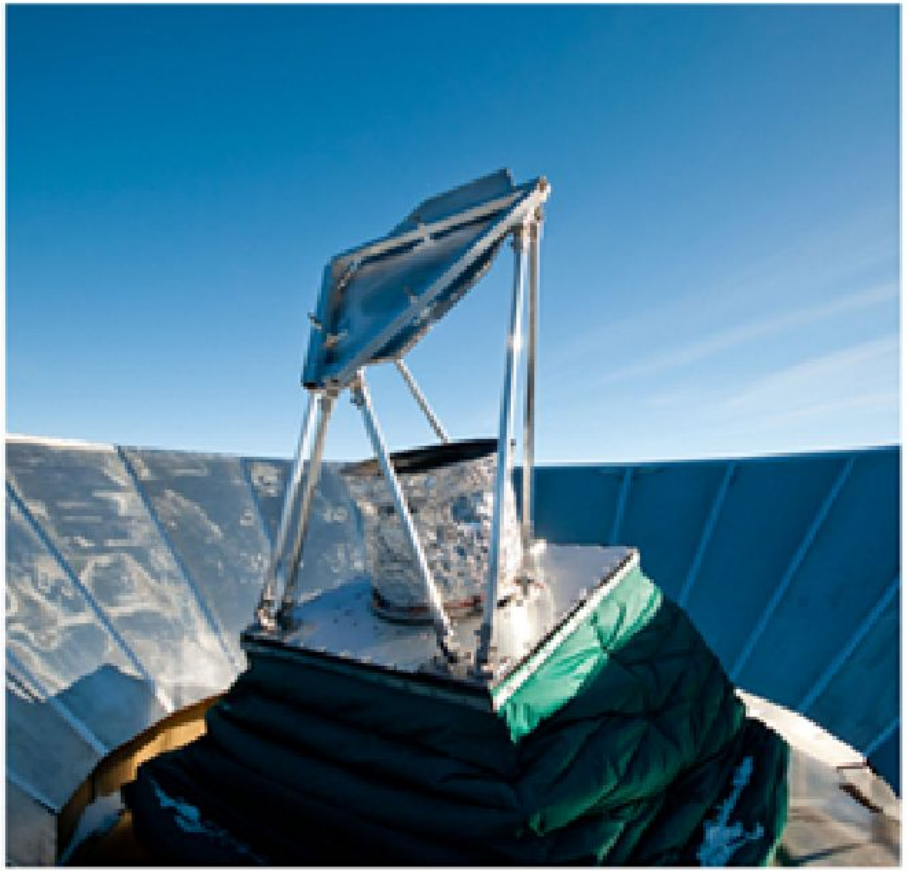
Unpublished work
by Cyndia Yu

An example of a time evolving scan-sync signal: the Sun
Map: BICEP3 wide field, focal plane inner/outer split difference Q map
Case: Exclude when boresight <38 degrees from Sun



Unpublished work
by Cyndia Yu

Put 45 degree flat mirror on and directly map the ground emission



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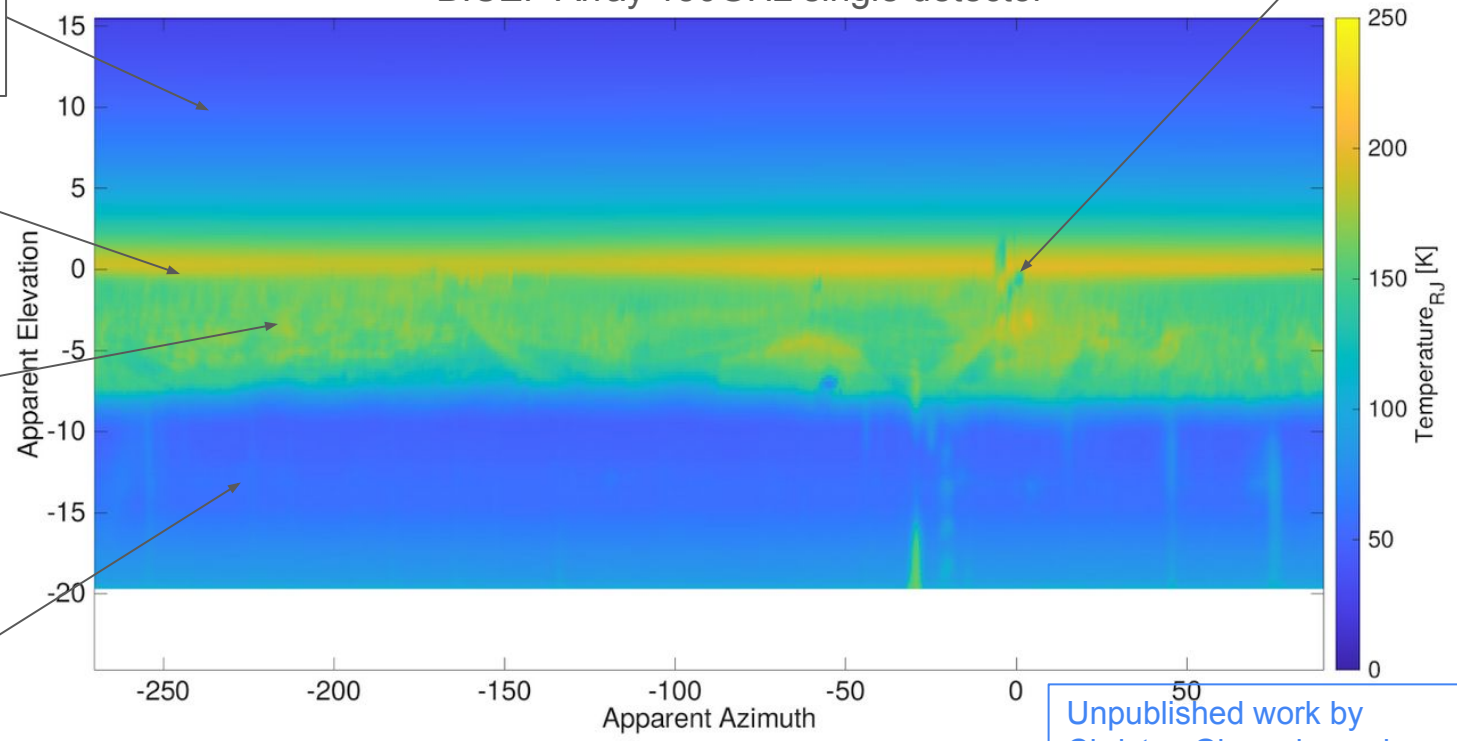


Calibrate on atmospheric gradient

SPT and DSL building

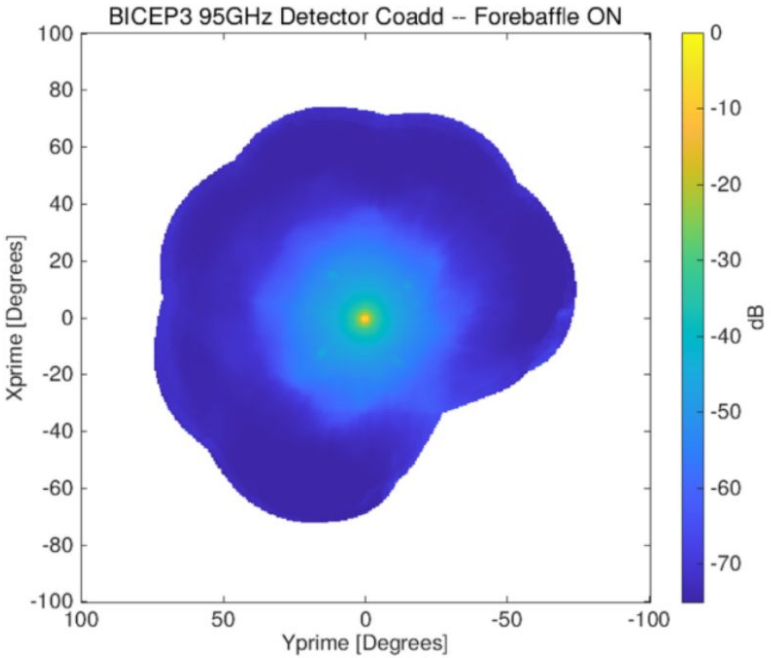
The horizon

Snow not completely featureless - and semi polarized

Inside of the ground shield reflecting the cold sky

Unpublished work by Christos Giannakopoulos

Try to predict scan-sync?! Convolve environment map with 4pi beam?



- Left is measured coadd - would need per-detector
- Full physical optics calculation (per detector) plus anechoic chamber measurements? (Planck did this)
- How to get environment map for Chile? SO could measure? S4 test telescope in Chile?
- How to add time-evolution of environment map? Again SO could measure. Could also try to model diurnal heating of mountains etc?

Unpublished work by Christos Giannakopoulos

How to quantify systematics and risk therefrom?

- John Ruhl and Colin Bischoff showed yesterday that it is simple enough to make an “aggressive optics” all-Chile S4 config which nominally meets the charge from Jim Strait’s presentation (slide 9).
- There may be noise-like effects like polarized atmosphere which slow things down versus such existing forecasts…
- But how to quantify the risk that such a plan will never pass null tests - i.e. will contain demonstrable bias much larger than r=0.0005?
- It seems hard to argue that paper studies alone can ever reduce the risk to “acceptable” levels…
- It seems like we need a design development phase including actual hardware, both in the lab (antenna range tests) and in the field. This would be a big effort but still small compared to S4 total cost.

Discussion…

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Questions:

- Path for survey optimization (sky coverage, scan strategy, LAT-SAT sensitivity balance)?
- More generally: Chilean alternatives, i.e. “A - forecast for a pre-defined Chilean survey” vs. “B - optimization and forecasts for a Chilean survey”?
- Can we do a suite of simulated systematics (simple, medium, high complexity) + get the mitigation / analysis pipeline ready in the allocated time? Or just have a plan?
- Can we trust a simulation? How to decide the level of systematics to put in?