Constraining cosmology with the summer fields of the South Pole Telescope

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on behalf of the NEUCosmoS team
and the SPT-3G collaboration

CMB France #4
Nov 2022 – Paris

Corpse and Mirror II | The Art Institute of Chicago

The South Pole Telescope (SPT)

- **10 m** primary mirror telescope
- Off-axis Gregorian optics design
- Location:
  Amundsen-Scott station,
  South Pole
- Dedicated to CMB observations with high angular resolution (~1 arcmin)
- Funded by

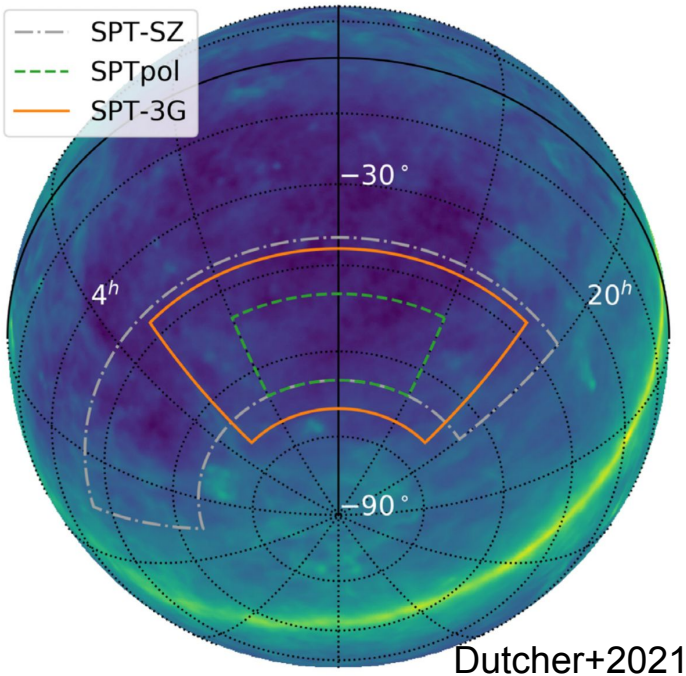
The South Pole Telescope (SPT)

- Frequency bands:
  95, 150, 220 GHz
- FWHM : **1.6, 1.2, 1.0 arcmin**
  (at 95, 150, 220 GHz)
- SPT-3G: third generation camera,
  deployed in 2017,
  currently observing
  with ~ 16 000 TES bolometers
  (see Sobrin et al. 2022)

SPT-3G baseline (winter) survey

- ~ **1700 deg2** (fsky ~ 4.1%) covered with stepping constant elevation rasters
  - 1 deg/s, ~100 s per scan
  - −42° to −70° declination
  - 20h 40m to 3h 20m right ascension

- Overlap with the BICEP/Keck field for delensing



Dutcher+2021

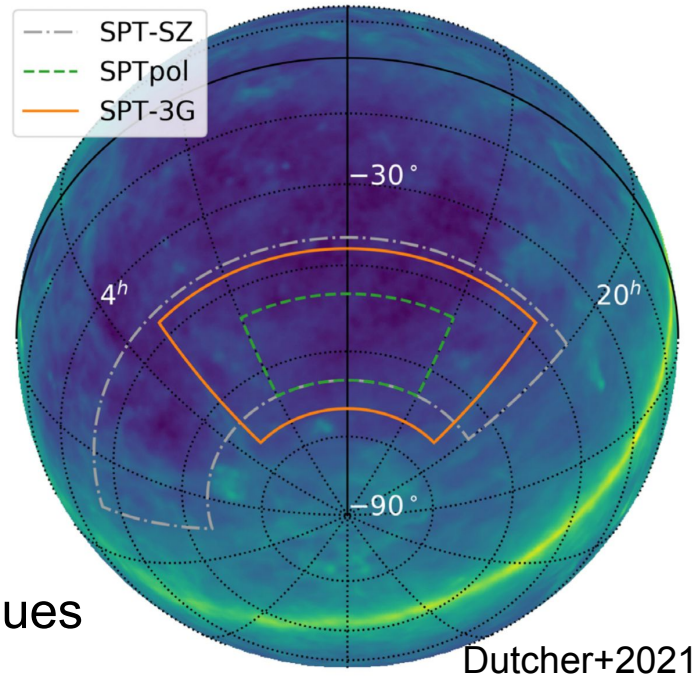
SPT-3G baseline (winter) survey

2018 data: first SPT-3G results (EE/TE)

- First survey with ~ half of the focal plane
- **Four months**
- **6600** active detectors in average

  → Dutcher et al. 2021
  (arXiv:2101.01684, maps, bandpowers, ΛCDM)

  → Balkenhol et al. 2021
  (arXiv:2103.13618, ΛCDM extensions)



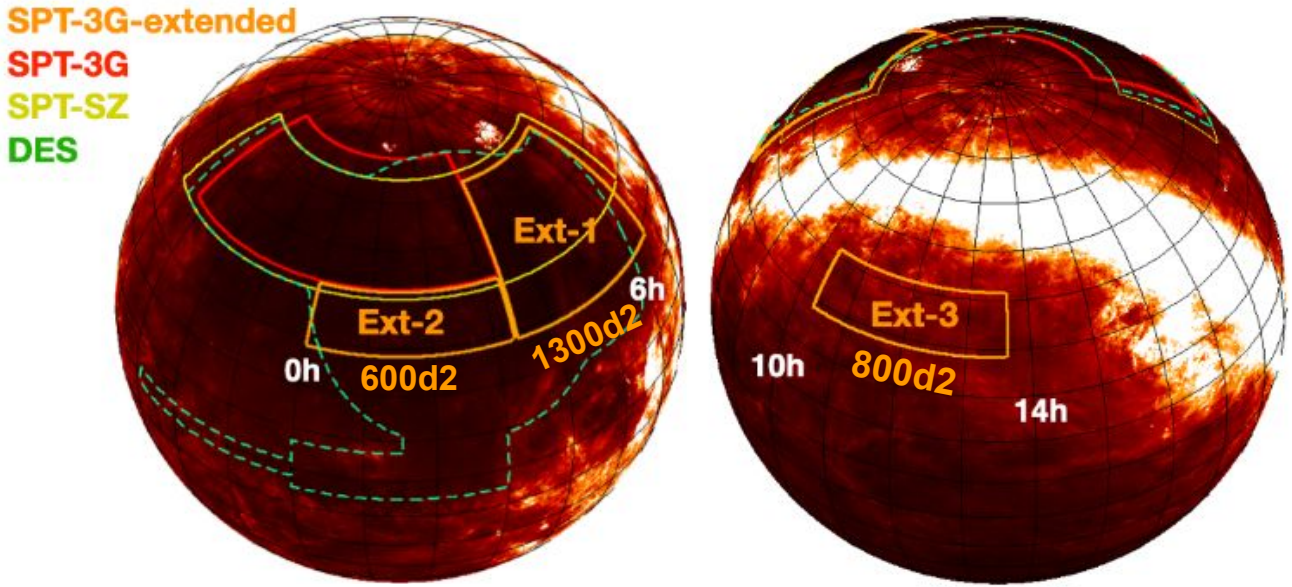
Dutcher+2021

2019–2023: the integration on the winter field continues

- **Full focal plane** operative
- **Eight months** of observations per year (April–November)
- 5y ΛCDM constraints from SPT-3G TT/EE/TE winter alone comparable with Planck
- **Analysis of 2019+20 data is ongoing** → See E. Camphuis' talk

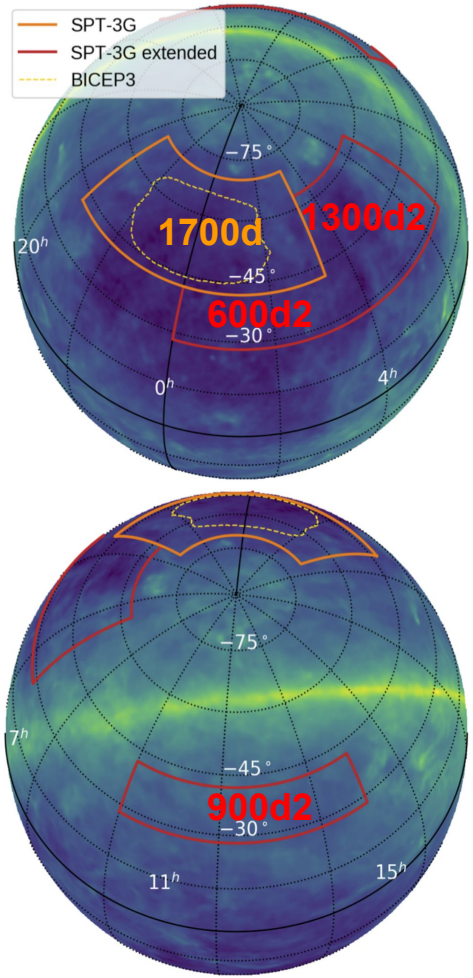
Extended survey or “summer fields”

- 3 extra patches in addition to the (baseline) winter fields:
  2800 deg2 (6.6%) = 1300 (3.1%) + 600 (1.4%) + 900 (2.1%)
- Observed during **~4 months** per year (December–March)



Extended survey or “summer fields”

- The analysis of the first two summer surveys is ongoing (19/20 + 20/21)
- Noise levels at 95/150/220 GHz:
  ~ **12, 12, 43** μK-arcmin (T)
  ~ **17, 17, 58** μK-arcmin (pol)
- White noise summer (2 years) ~ 3 times larger than white noise winter (2019+20)
- Summer+Winter ~ 3 times larger sky fraction than the winter fields → reduce sample variance

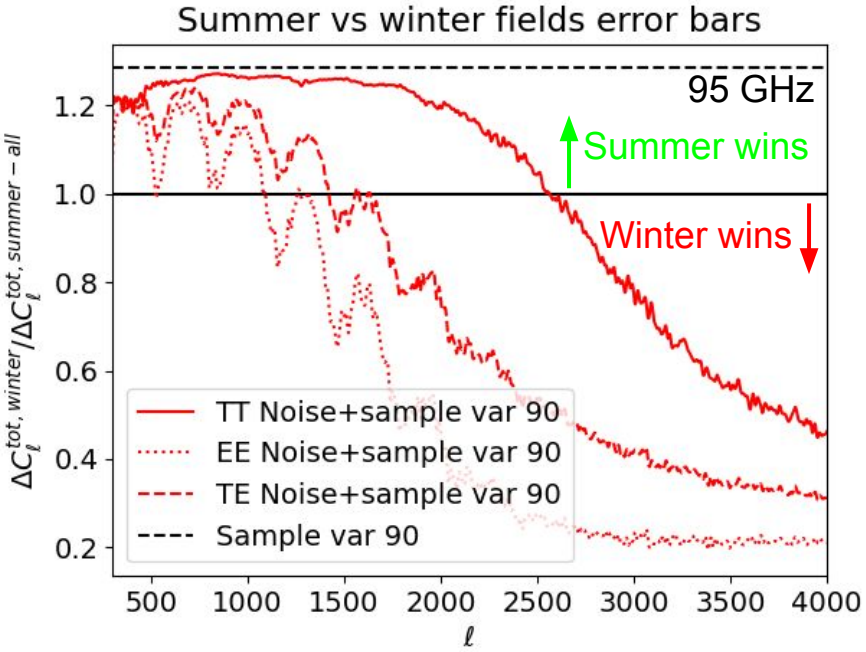


Impact of the summer fields for SPT-3G cosmo

- Comparison of expected error bars of the summer (2y) and winter (19+20) angular power spectra

$$\Delta C_\ell^{XX} = \sqrt{\frac{2}{(2\ell+1)\Delta\ell \frac{w_2^2}{w_4} f_{sky}}} \left(C_\ell^{sky,XX} + N_\ell^{XX} \right)$$

  - Sample variance (f_{sky})
  - Noise variance (N_ℓ)



- Above 1: information added by the summer fields
  - Improvement in the sample variance limited regime of the SPT-3G spectra: at $\ell \lesssim$ 2600/1500/1100 in TT/TE/EE (at 95 GHz)

Forecasts including SPT-3G summer fields

1. **ΛCDM** constraints with SPT-3G TT/TE/EE* improve by **~15–20%** when including summer:
   - **$\sigma(H_0)$** = 0.66 (winter) → 0.52 (winter+summer, ~16%)
   - **$\sigma(S_8)$** = 0.018 (winter) → 0.015 (winter+summer, ~20%)

2. Summer fields will help to test extensions:
   ΛCDM+N_{eff} constraints with SPT-3G TT/TE/EE are expected to improve by up to **~40%** when including summer

(To be checked the impact of summer fields including CMB lensing)

Preliminary

Credit: Silvia Galli

*For a 3100 deg2 summer fields and 5 years of integration on the winter fields.

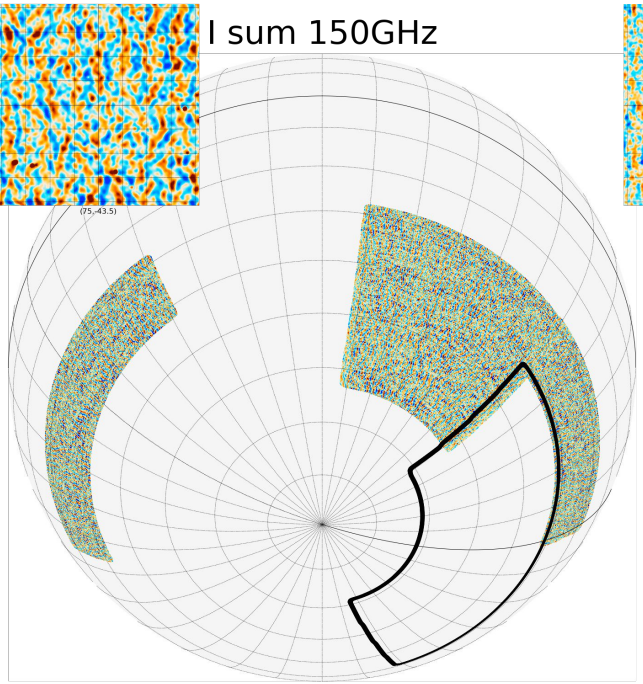
SPT-3G Summer Maps

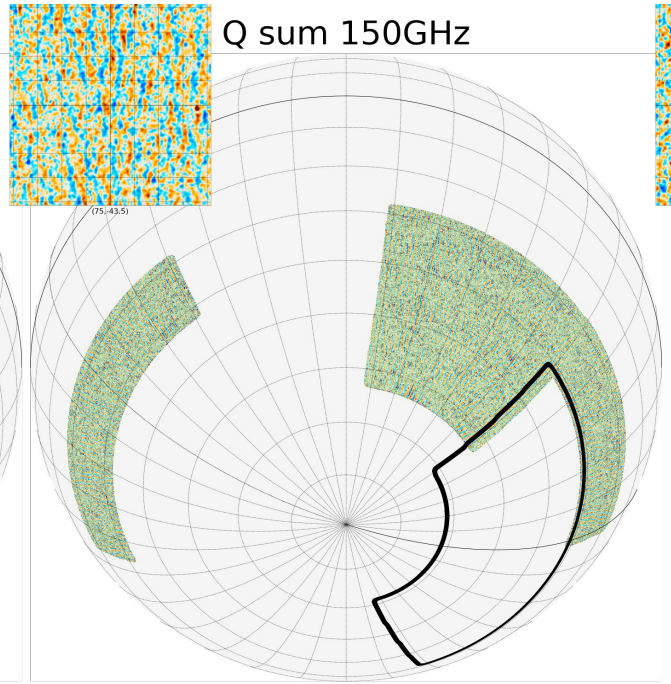
Only 2 summer seasons, 2 more to come

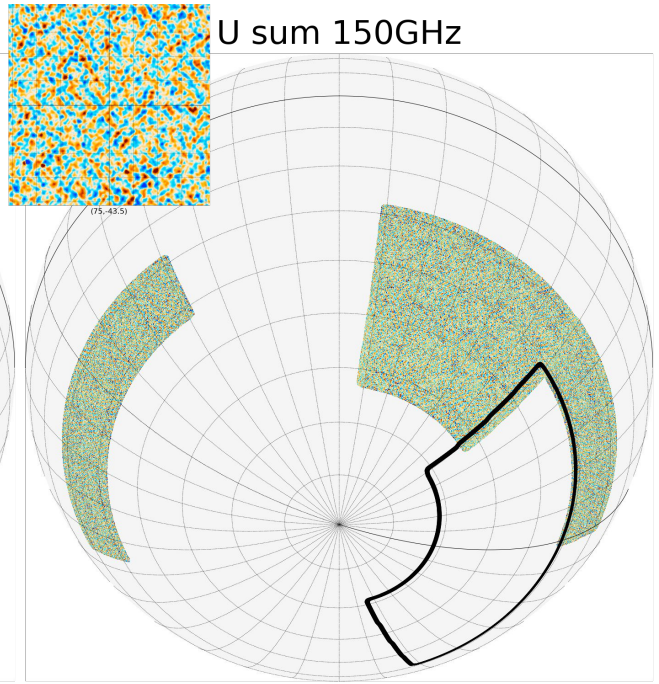
Preliminary

Gaussian smoothed

6 arcmin

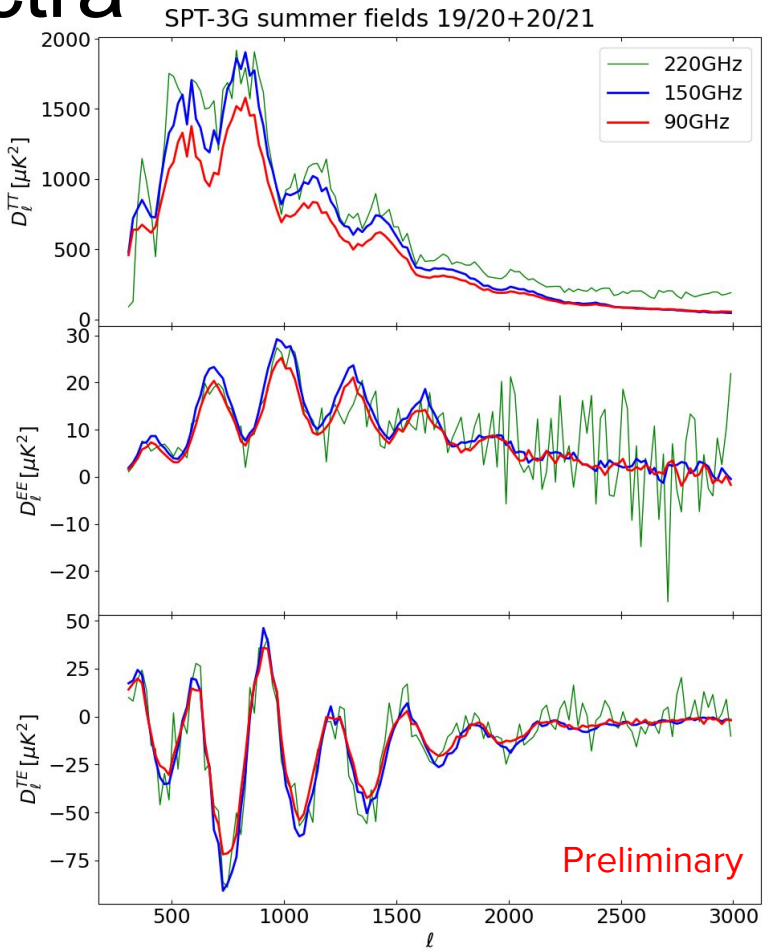






SPT-3G Summer power spectra

- Left-cross-Right-going spectra
  - Uncorrected data stream filtering (no transfer function correction)
  - Uncorrected by global re-calibration
  - Beam and pixel window function corrected
- High signal to noise at 95 and 150 GHz at $300 \lesssim \ell \lesssim 1500$ (EE) or larger ℓ for TT and TE
- This is from only 2 summer seasons (19/20+20/21)
  - 2 more to come, of which:
    - one already on disk (21/22)
    - and the last one planned for 22/23
- Now running null-tests

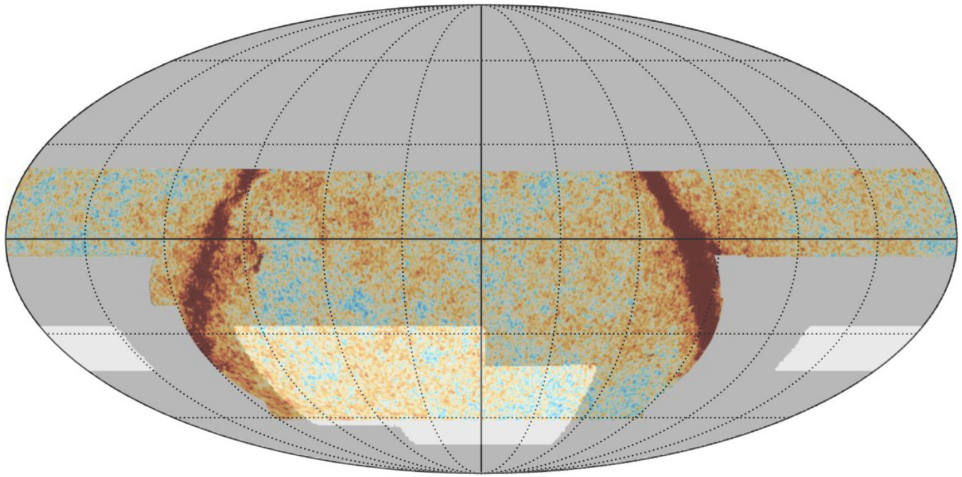


SPT-3G and ACT sky footprints

- **ACT** (Mallaby-Kay+21)
  - 18 000 deg2 (~44%)
  - DR4 (2013-2016):
    ≤ 20 μK-arcmin over ~ 2,600 deg2
    - Cosmology from 5400 deg2 (Aiola+20, Choi+20)
  - DR5 (2013-2018):
    ≤ 10 μK-arcmin over ~ 2,500 deg2
  - DR6 to come

- **SPT-3G**
  - 2018 (Dutcher+21)
    - ~1500 deg2
    - ~20 μK-arcmin at 150 GHz
  - 2019+2020
    - 4500 deg2 (1700d2 winter+ 2800d2 summer)
      - Winter: ~4 μK-arcmin at 150 GHz
      - Summer: ~12 μK-arcmin at 150 GHz

Coadded temperature map of ACT with Planck and SPT-3G sky footprint

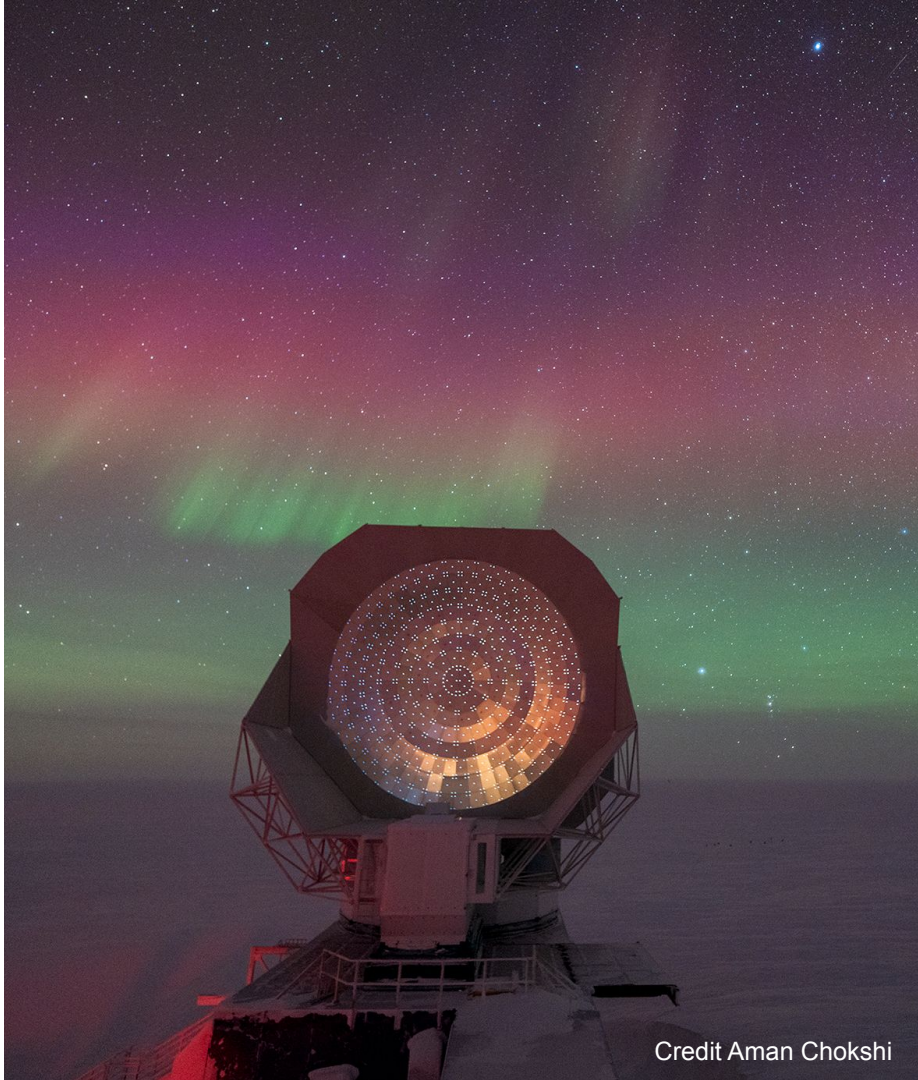


Adapted from Mallaby-Kay+21

Conclusions

- SPT-3G is providing a powerful dataset to test cosmology almost independently from Planck
  - Testing a complementary range of multipoles (low:Planck, intermediate–high: SPT)
  - Small region of the sky
- Winter fields of SPT will constrain ΛCDM as good as Planck
- Summer fields will further improve the baseline SPT-3G constraints, and will help to test ΛCDM extensions
- Comparisons with Planck and ACT will be very interesting

Thank you!



Backup