

The South Pole Telescope (SPT): Current Status and Future Plans



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U.S. DEPARTMENT
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October 7, 2025



The South Pole Telescope (SPT)

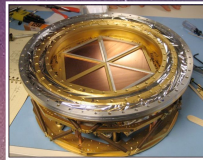


10-meter diameter telescope

95, 150, 220 GHz frequency
1.6, 1.2, 1.0 arcmin resolution

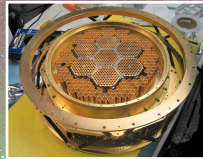
2007: SPT-SZ

960 detectors
100,150,220 GHz



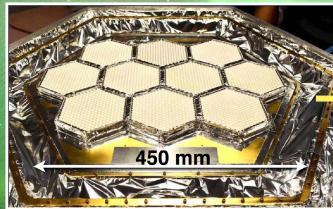
2012: SPTpol

1600 detectors
100,150 GHz
+Polarization



2017: SPT-3G

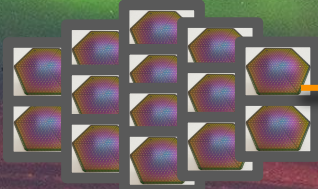
~16,200 detectors
100,150,220 GHz
+Polarization



SPT-3G has ~7x larger mapping speed relative to Planck!

2029: SPT-3G+

~24,000 detectors
100,150 GHz
+Polarization



SPT-3G+ will have ~50x larger mapping speed relative to Planck!

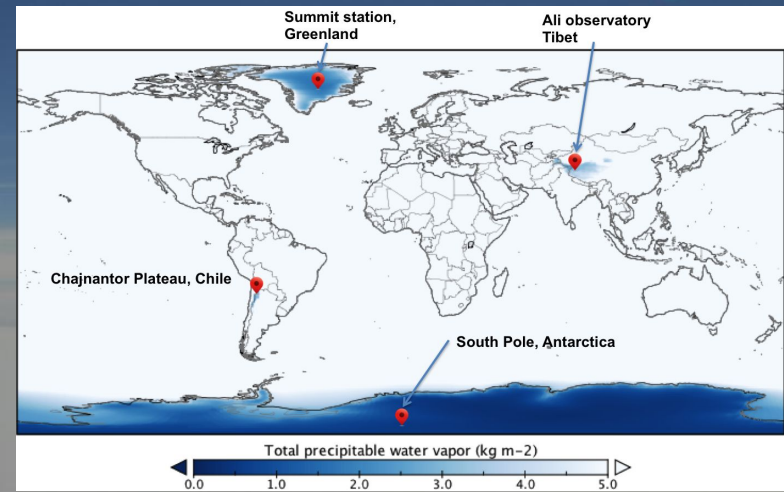


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The South Pole is a unique window to the CMB... like being in space!



South Pole Environment

- High Altitude (~10,000 ft) with unique Polar Vortex
- Driest desert on Earth with most stable atmosphere
- Featureless horizon
- 24/7 year-round access to Southern Sky
- Excellent logistics for power, data, cargo



SPT Science Breadth

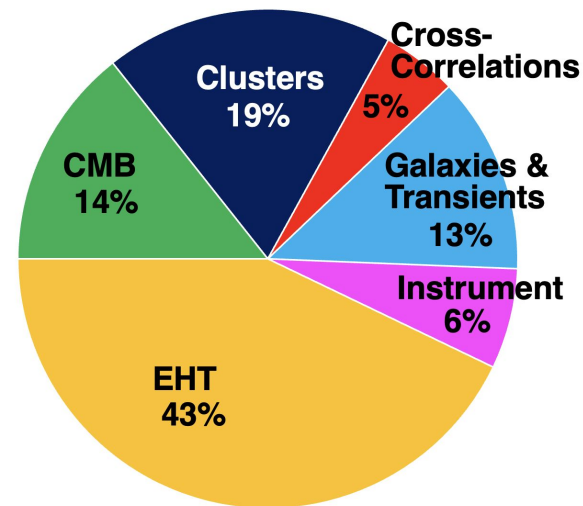


- **SPT data used by community of >500 scientists.**
 - SPT collaboration and working groups consists of approximately 200 scientists.
 - SPT part of Event Horizon Telescope (EHT) network and collaboration, consisting of over 300 scientists.

SPT has over 360 science or technical publications with more than 37,500 citations

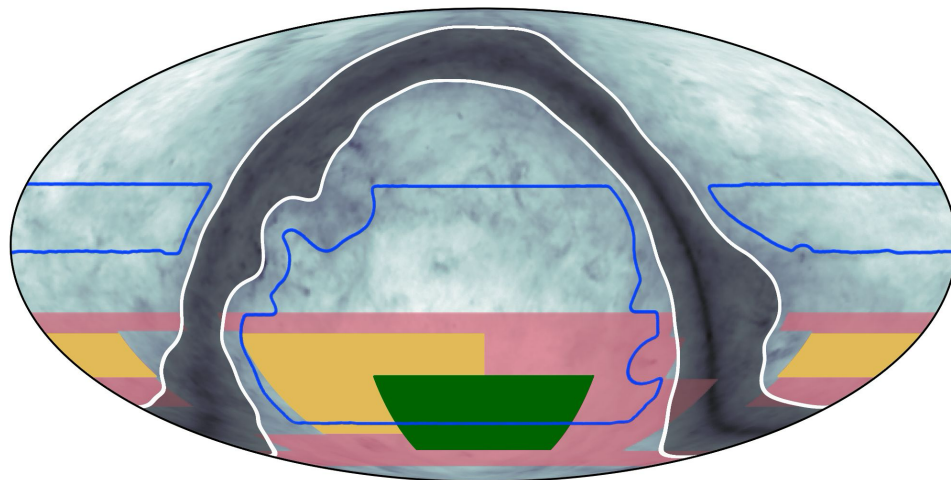
- **Broad science reach across cosmology, astronomy, and high-energy physics:**

- World-leading constraints on cosmic Inflation and the origin of the Universe (with **BICEP** and **South Pole Observatory, SPO**).
- From the **CMB** and **galaxy clusters**, new cosmological constraints, including on **dark energy** and **neutrinos**.
- Discovering the earliest formed **galaxies** and **galaxy clusters** in the Universe, and new classes of **astrophysical transients**.
- Joint science and observations with many of the biggest facilities in Astronomy (e.g., JWST, Hubble, Chandra, ALMA).
- Physics of **Black Holes** and general relativity (with **EHT**).



*Citation fraction by topic, for full list see pole.uchicago.edu

SPT-3G Surveys



■ SPT-3G Main (this work) ■ SPT-3G Summer ■ SPT-3G Wide
■ Planck galactic mask — ACT DR6

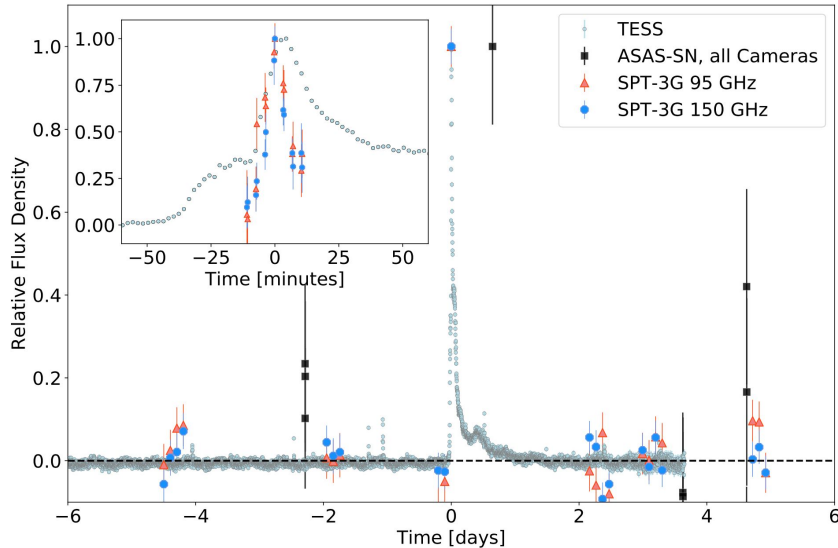
- SPT-3G started a **1500 deg² Main survey** in 2019, funded to continue observations thru 2028.
 - Coordinated overlap with BICEP Array survey, where deep SPT-3G data “delenses” BICEP to improve Inflationary B-mode constraints.
 - Transient catalog of 111 events from first four years (2019-2023) presented in [Tandoi et al. \(2025\), arXiv: 2401.13525](#)
 - CMB power spectra from first two years (2019-2020) of data recently released: [Camphuis et al. \(2025\), arXiv: 2506.20707](#)
- SPT-3G **Summer** and **Wide surveys** total 10,000 deg² (~25% of the sky).
 - First results expected in 2026, I will preview some results at end of this talk.

Transients and the Time-VARIABLE Sky



Astro2020: “An important requirement for our strong endorsement is that the project broadly engage astronomers beyond the traditional CMB community... It is essential that CMB-S4 produce transient alerts...”.

Stellar flare light-curves from Guns et al. 2021 (SPT-3G)



SPT-3G has made pioneering measurements of the time-variable mm-wave sky;

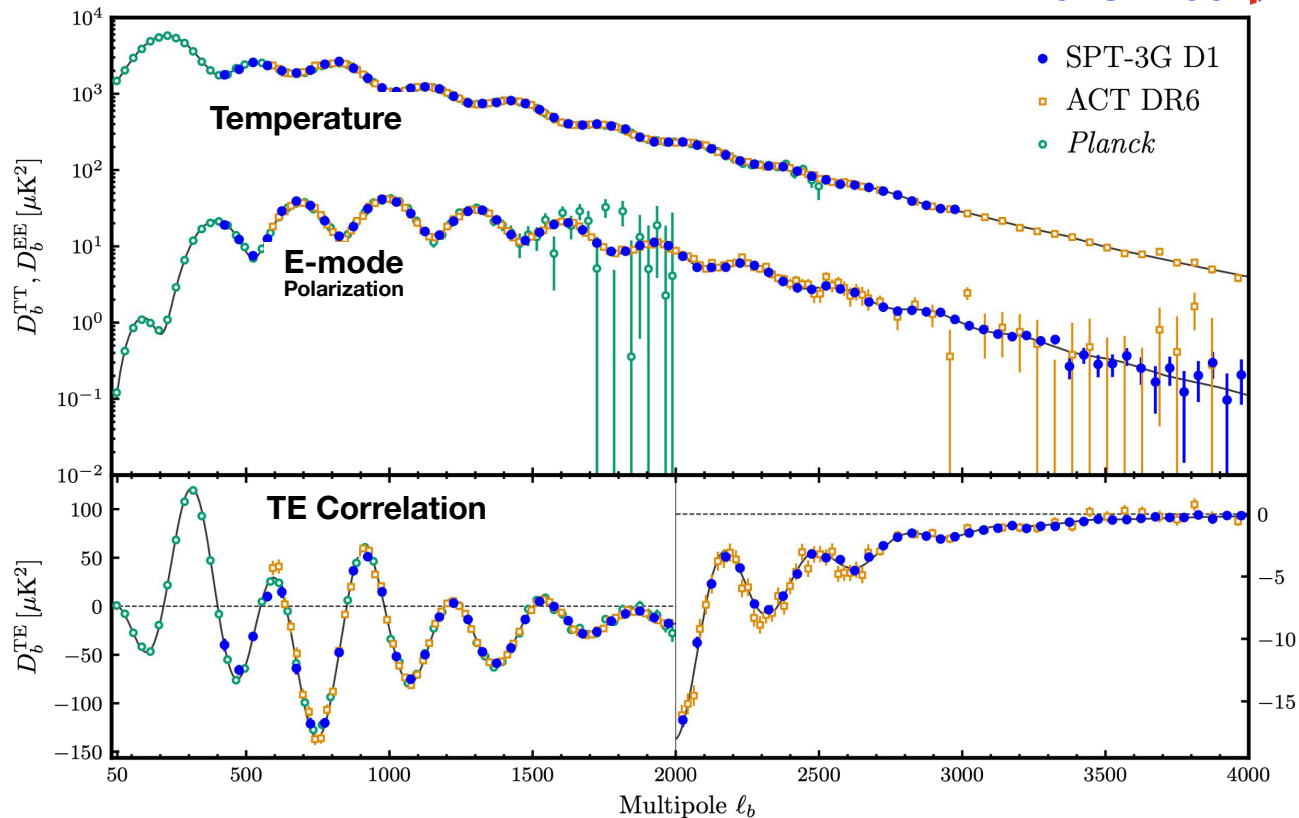
- [Guns et al. \(2021\)](#): **First catalog of 15 events**, a combination of new stellar and extragalactic sources.
- [Tandoi et al. \(2024\)](#): **Catalog of 111 short-duration (<10-day) events** from 4-years of SPT-3G data
- Several recent SPT-3G measurements of mm-wave time-variable sky including:
 - [Asteroids](#); [Low-Earth Orbit Satellites](#); [AGN variability and flaring](#); [Discovery of flaring white dwarves in Galactic plane](#)
- Transient alerts are produced internally within hours after SPT-3G observations.
 - We’ve released some quasi-realtime public alerts, however this could be expanded with further support.

SPT-3G: CMB Power Spectra



With SPT-3G

- SPT-3G provides the most precise measurement of polarization power spectra at multipoles, $\ell > \sim 1800$ for EE, and $\ell > \sim 2200$ for TE

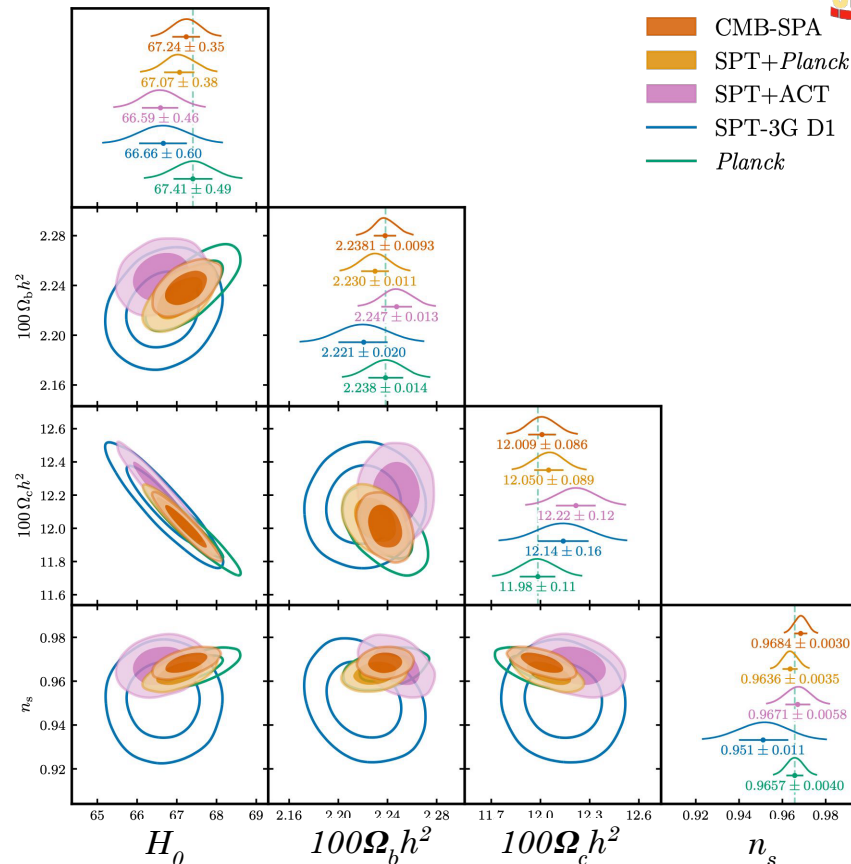


Λ CDM Cosmology fits to CMB Data



- The **SPT**, **Planck**, & **ACT** CMB measurements give statistically consistent constraints.
- For the first time, the combined constraining power of SPT & ACT **exceeds** the precision from the Planck satellite on many cosmo parameters.
- For example, Hubble constant (H_0):

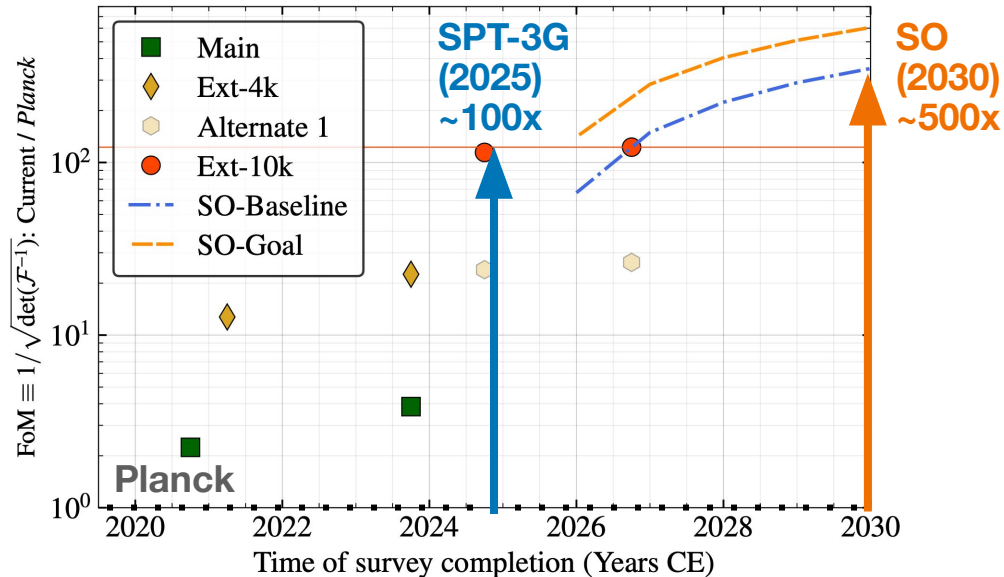
<i>Planck</i>
$H_0 = 67.41 \pm 0.49$ km/s/Mpc
SPT-3G D1
$H_0 = 66.66 \pm 0.60$ km/s/Mpc
SPT+ACT
$H_0 = 66.59 \pm 0.46$ km/s/Mpc
CMB-SPA
$H_0 = 67.24 \pm 0.35$ km/s/Mpc



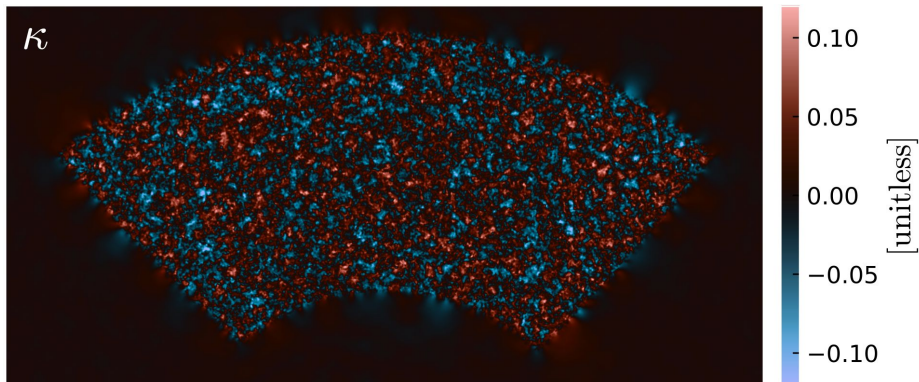
Cosmology from SPT-3G Wide & SO Surveys



- Large area (~25-50% of sky) surveys from **SPT-3G** and **Simons Observatory (SO)** will soon significantly improve Λ CDM cosmological constraints over Planck
- The “Figure-of-merit” (FOM) comparing allowed Λ CDM likelihood volume to Planck, SPT-3G and SO will improve by factors of ~100 and ~500, respectively



SPT-3G: CMB Lensing



SPT-3G data provides high-fidelity maps of CMB lensing due to its depth ($<2 \mu\text{K}\text{-arcmin}$, $\sim 20\times$ deeper than Planck);

- [Ge et al. \(2024\)](#): CMB lensing map and cosmology from 2-years of SPT-3G data.
 - $38\text{-}\sigma$ measurement of CMB lensing, nearly equal to Planck detection significance, but only using CMB polarization.
- [Qu et al. \(2025\)](#): Joint ACT+SPT collaboration paper with combined lensing power spectrum and cosmology constraints.
- SPT-3G data is being used to “delens” BICEP data and improve constraints on cosmic Inflation and the tensor-to-scalar, r , ratio:
 - SPT-3G measurement of lensing B-modes can be separated from Inflationary B-modes.
 - **See C.L. Kuo’s talk for South Pole Observatory (SPO) science forecast!**

SPT-3G) Ge et al. (2024), arXiv: 2411.06000
(ACT & SPT) Qu et al. (2025), arXiv: 2504.20038

The South Pole Observatory (SPO)



SPO is a collaboration of the South Pole Telescope (SPT) and the BICEP Array (BA) experiments dedicated to conducting a coordinated program to search for the imprint of **Inflationary Gravitational Waves** on the Cosmic Microwave Background.



Astro2020: *“Recommendation: The NSF and the DOE should jointly pursue the design and implementation of the next generation ground-based cosmic microwave background experiment (CMB-S4).”*

DOE & NSF are coordinating with SPO to explore pursuing camera upgrades (SPT-3G+, BA+).

SPT-3G+ plans to deploy ahead of 2029 Austral winter, with two awarded NSF MRI proposals fully supporting NSF scope.



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Extras



SPO Collaboration Members

SPO collaboration consists of over 150 members across 25 institutions.



The SPT-3G Collaboration

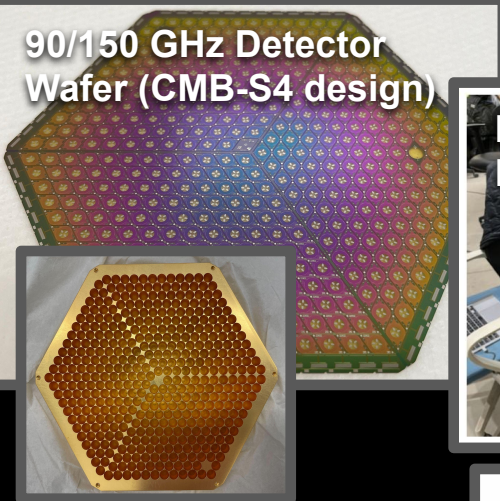
~100 members (~60 students and postdocs) from 33 institutions



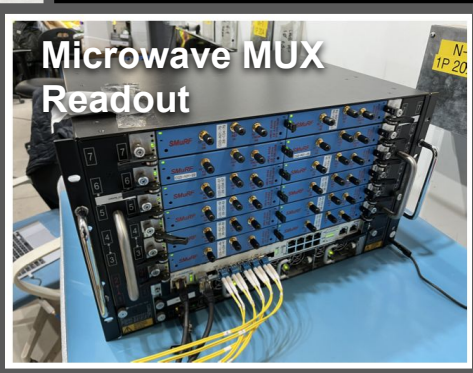
SPT-3G+: Instrument



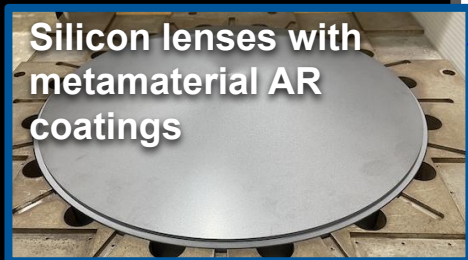
90/150 GHz Detector Wafer (CMB-S4 design)



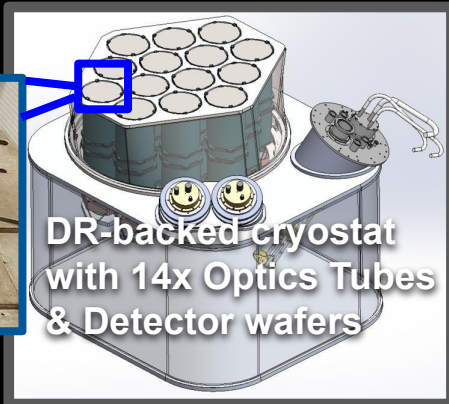
Microwave MUX Readout



Silicon lenses with metamaterial AR coatings



DR-backed cryostat with 14x Optics Tubes & Detector wafers



SPT-3G+ Camera Specifications

- **Detectors:** 24,000 transition edge sensors (TES) detectors with 90/150 GHz dichroic horn-coupled pixels
- **Optics:** 14x 25-cm diameter optics tubes, with cryogenic silicon lenses, each with its own individual detector wafer
- **Readout electronics:** μ MUX SQUID readout with SMuRF warm electronics

SPT-3G+ mapping speed goal is to be >7x larger than SPT-3G

- SPT-3G+ projections scale from achieved SPT-3G performance and map-depths (i.e., incorporating achieved SPT-3G observing efficiency, data / detectors cuts, etc.)

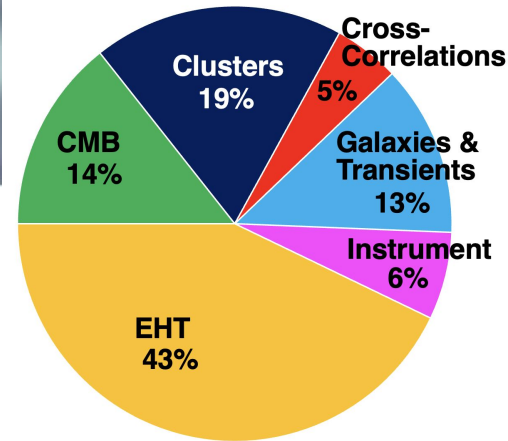
SPT

Planck

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