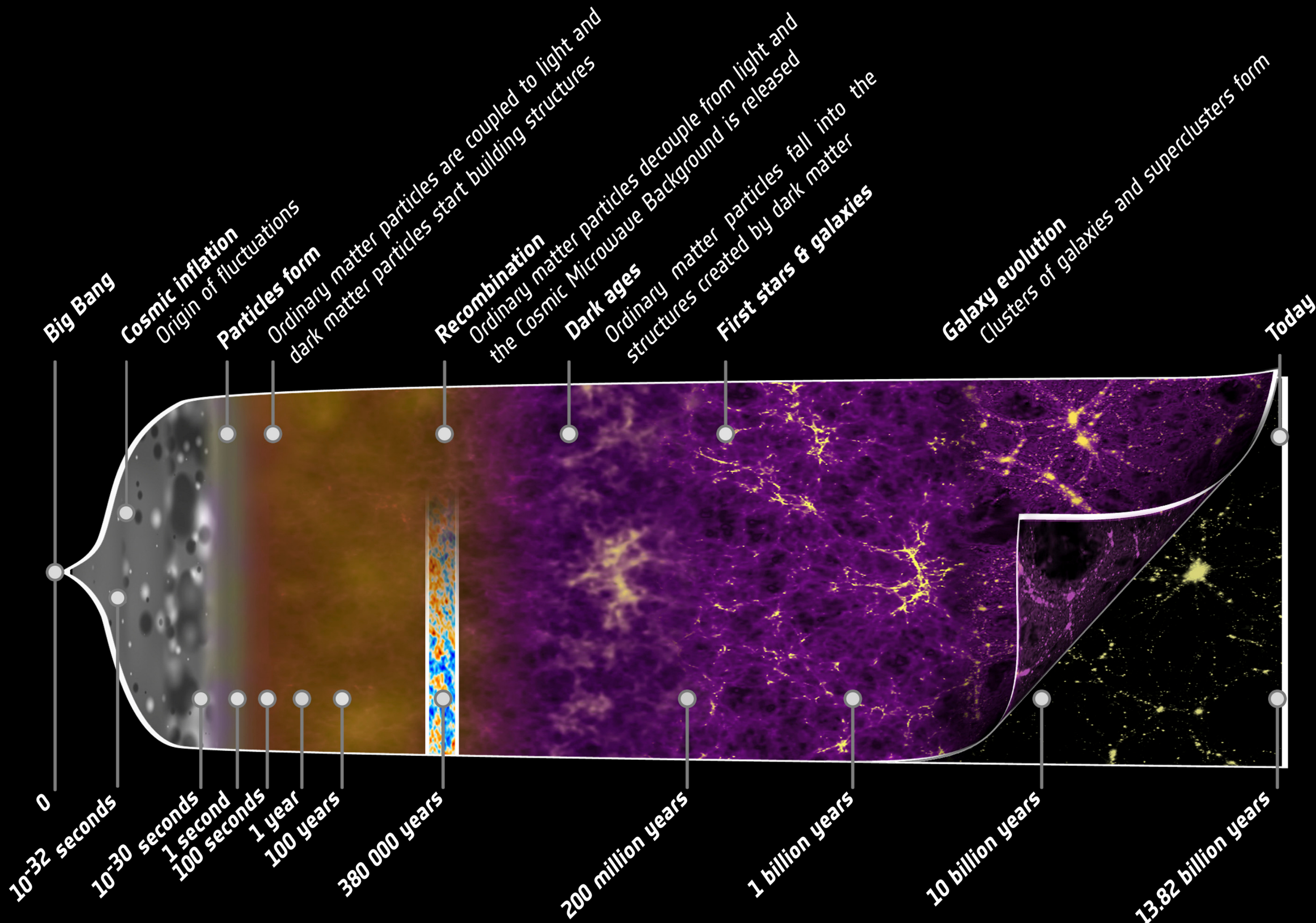
OBSERVING THE POLARIZATION OF THE CMB WITH SPIDER

Aug 7, 2017

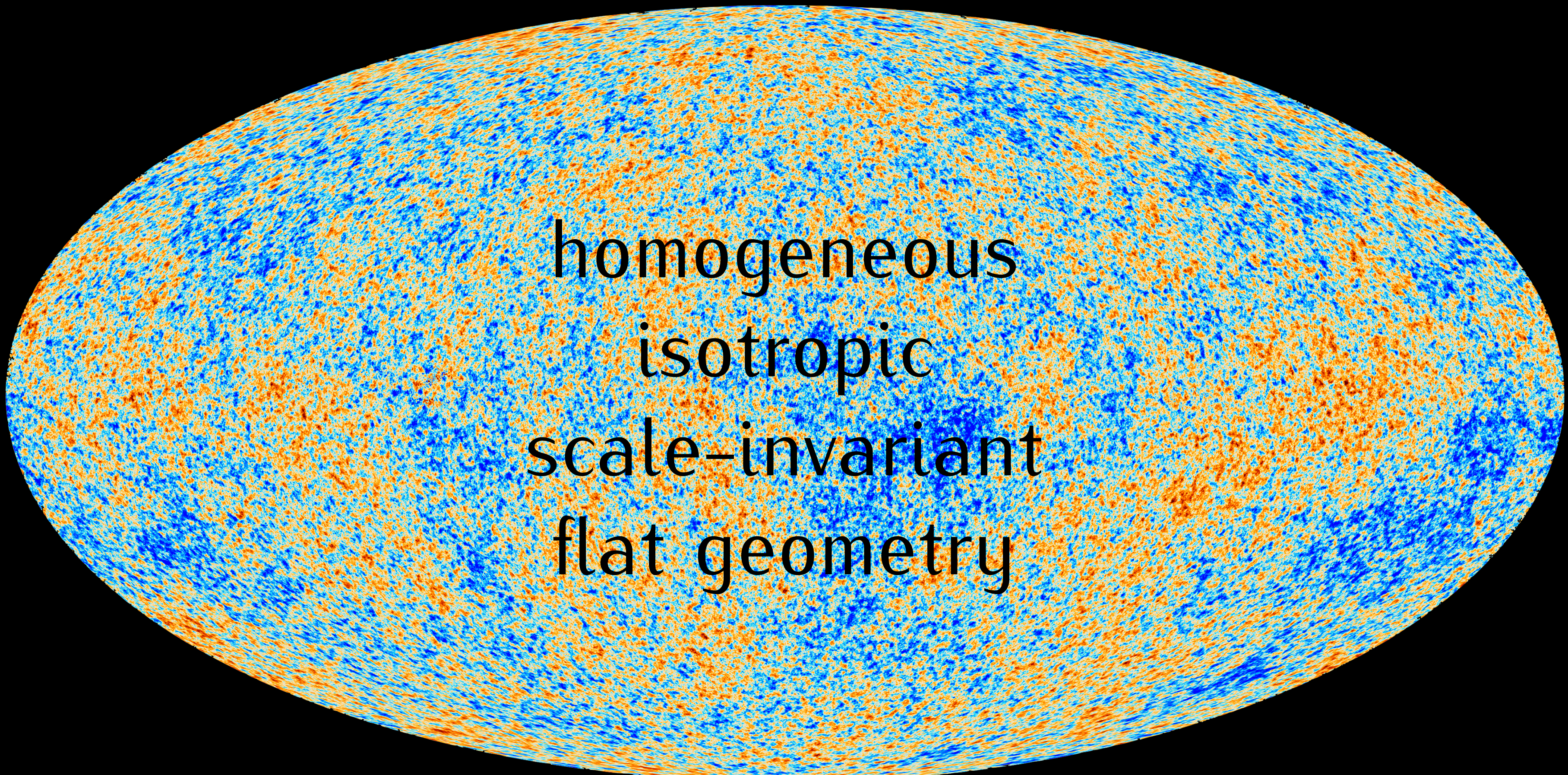
Alexandra Rahlin, Fermilab

The History of the Universe



http://sci.esa.int/planck/

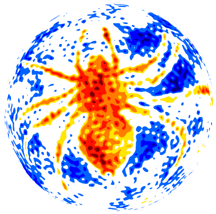
The History of the Universe

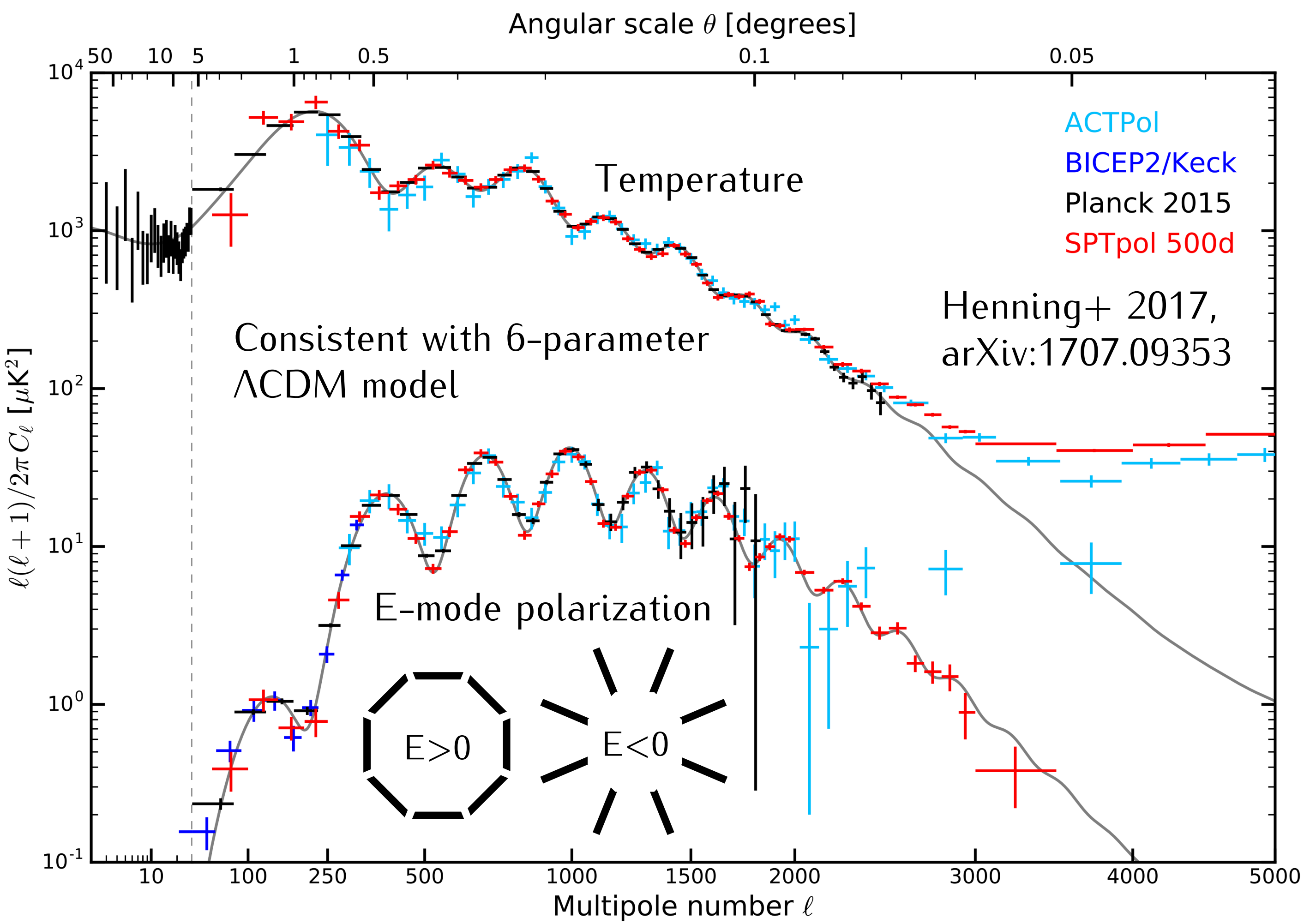


30 μK RMS fluctuations
on a 3 K background

http://www.cosmos.esa.int/web/planck/picture-gallery

State of the Field



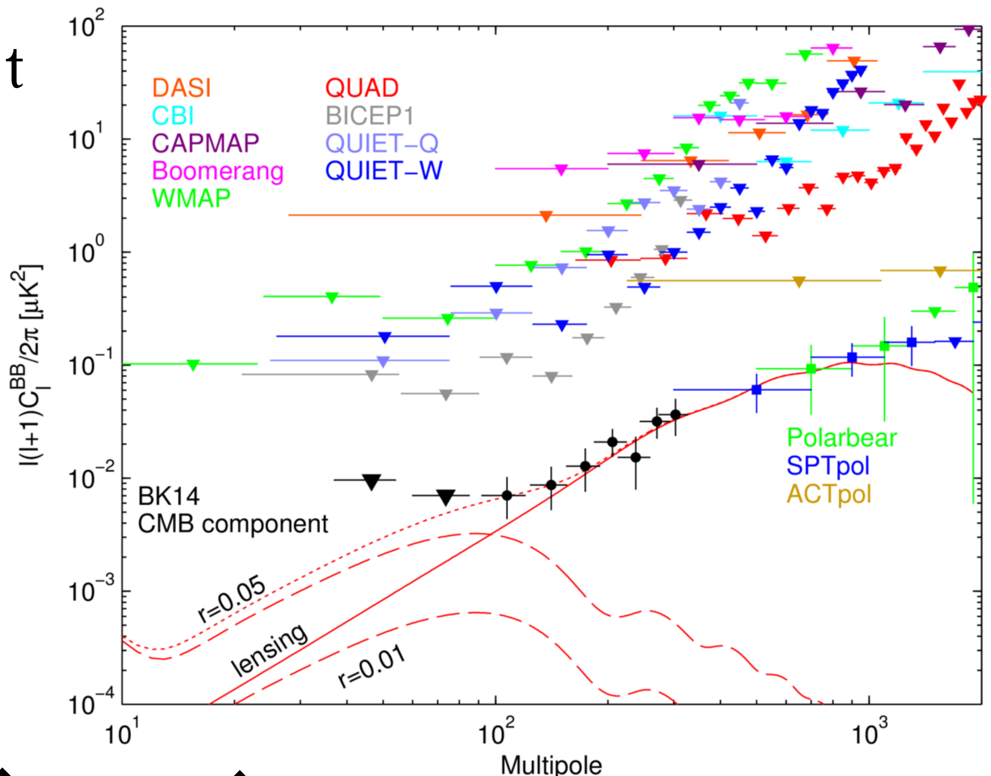


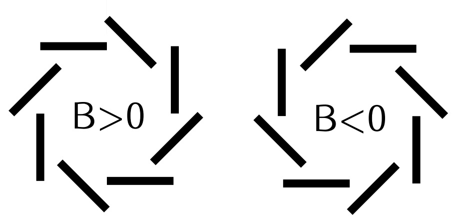
State of the Field

Lensing B-mode consistent with expectations

Primordial B-mode limited to $r<0.09$ by BICEP2/Keck/Planck

Need high-fidelity measurements at large scales

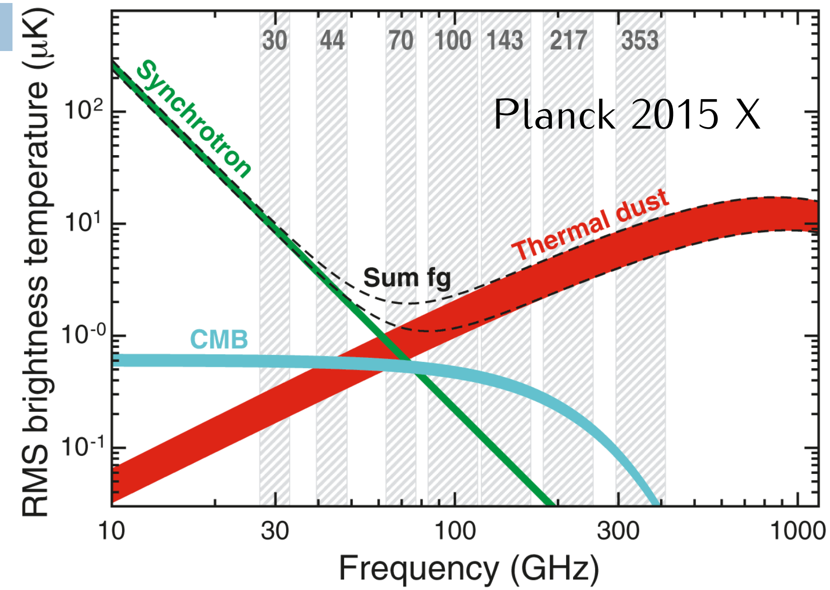


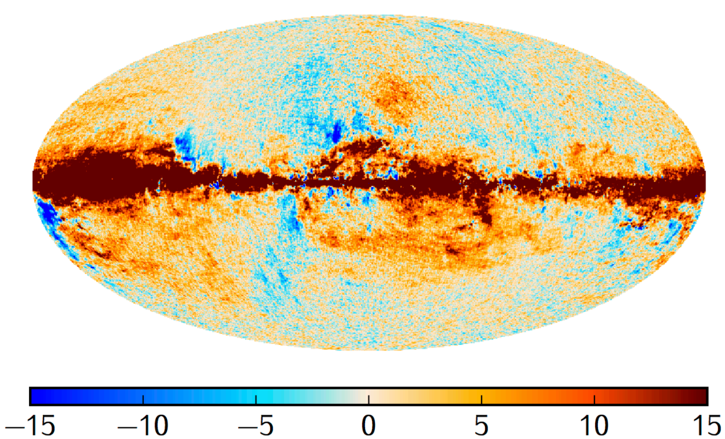


BK-VI, PRL 116, 2016

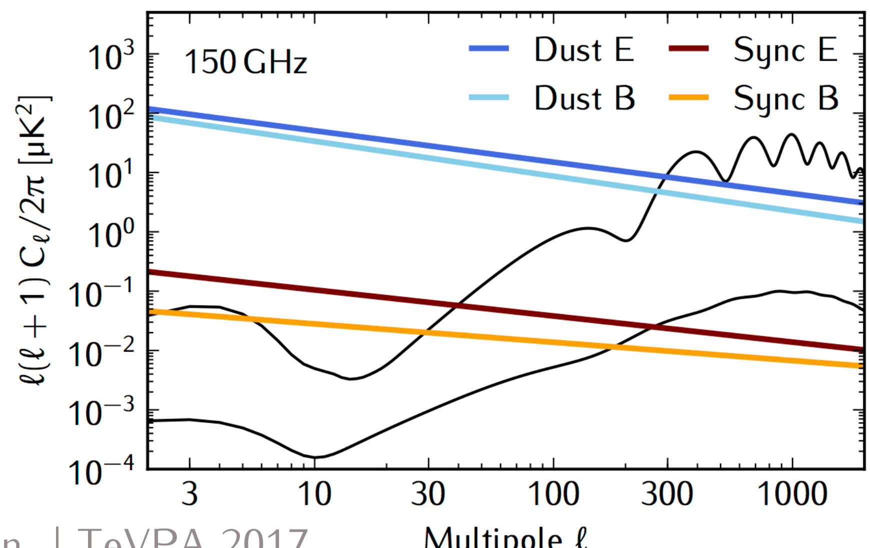
Galactic Foregrounds

- Significant spatial variation
- Characteristic frequency spectrum
- Power law angular spectrum
- High-fidelity multi-frequency maps to disambiguate from CMB





Planck HFI 143 GHz Q Polarization [μK]




Ross Ice Shelf, Antarctica
December 2014

The SPIDER Instrument

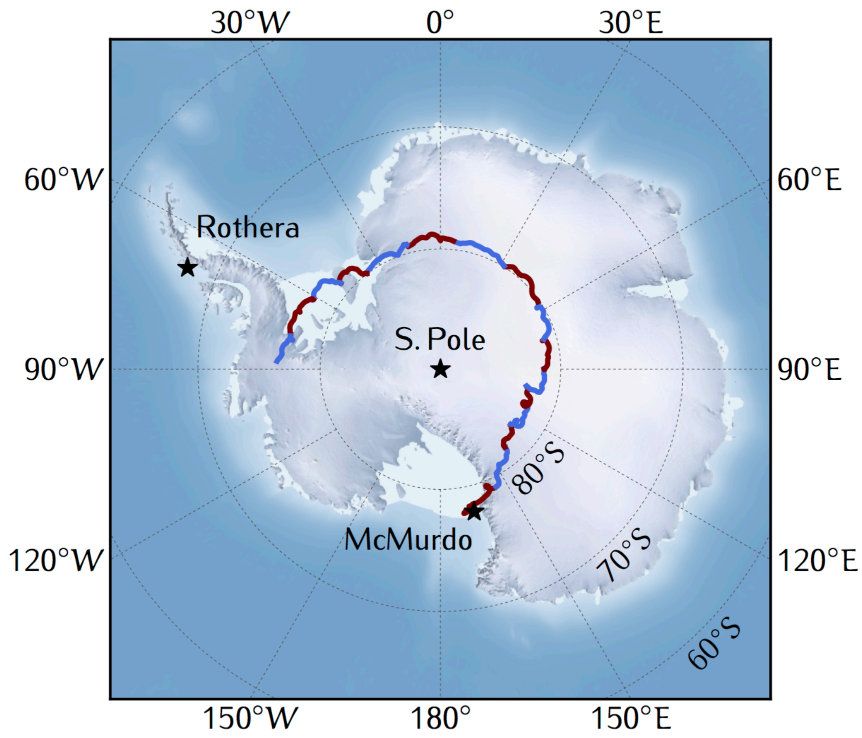
Balloon-borne polarimeter designed to:

- Measure the angular power spectrum of the sky over a large area and a wide range of angular scales
- Separate the frequency and angular spectra of Galactic foregrounds
- Verify the statistical isotropy of the CMB component

Goal: Limit or detect primordial B-modes

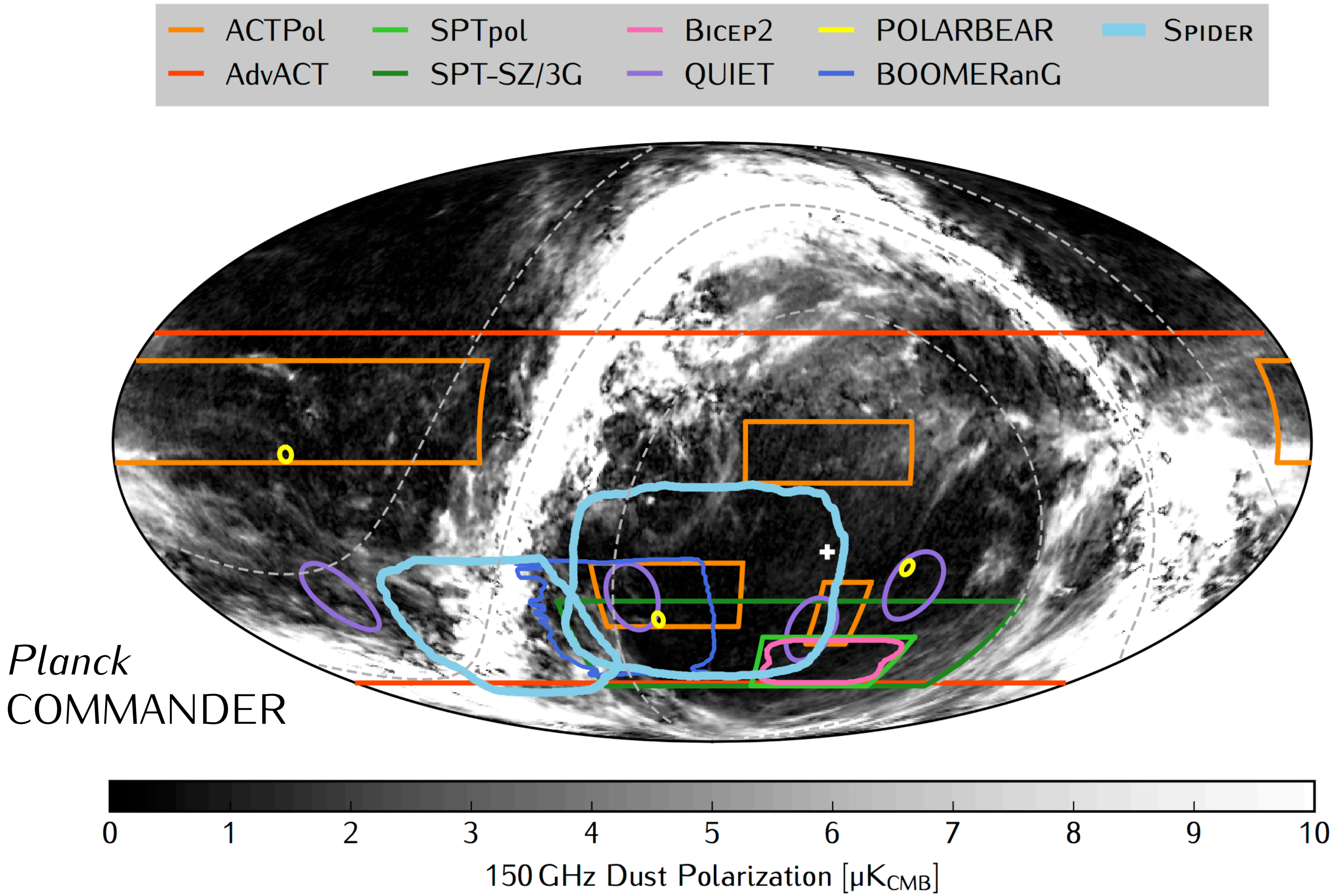
Flight Summary

- Launched January 1, 2015
- 16 days at float
- 1.6 TB data
- Data recovered, February 2015
- Hardware recovered November 2015
- Next flight December 2018



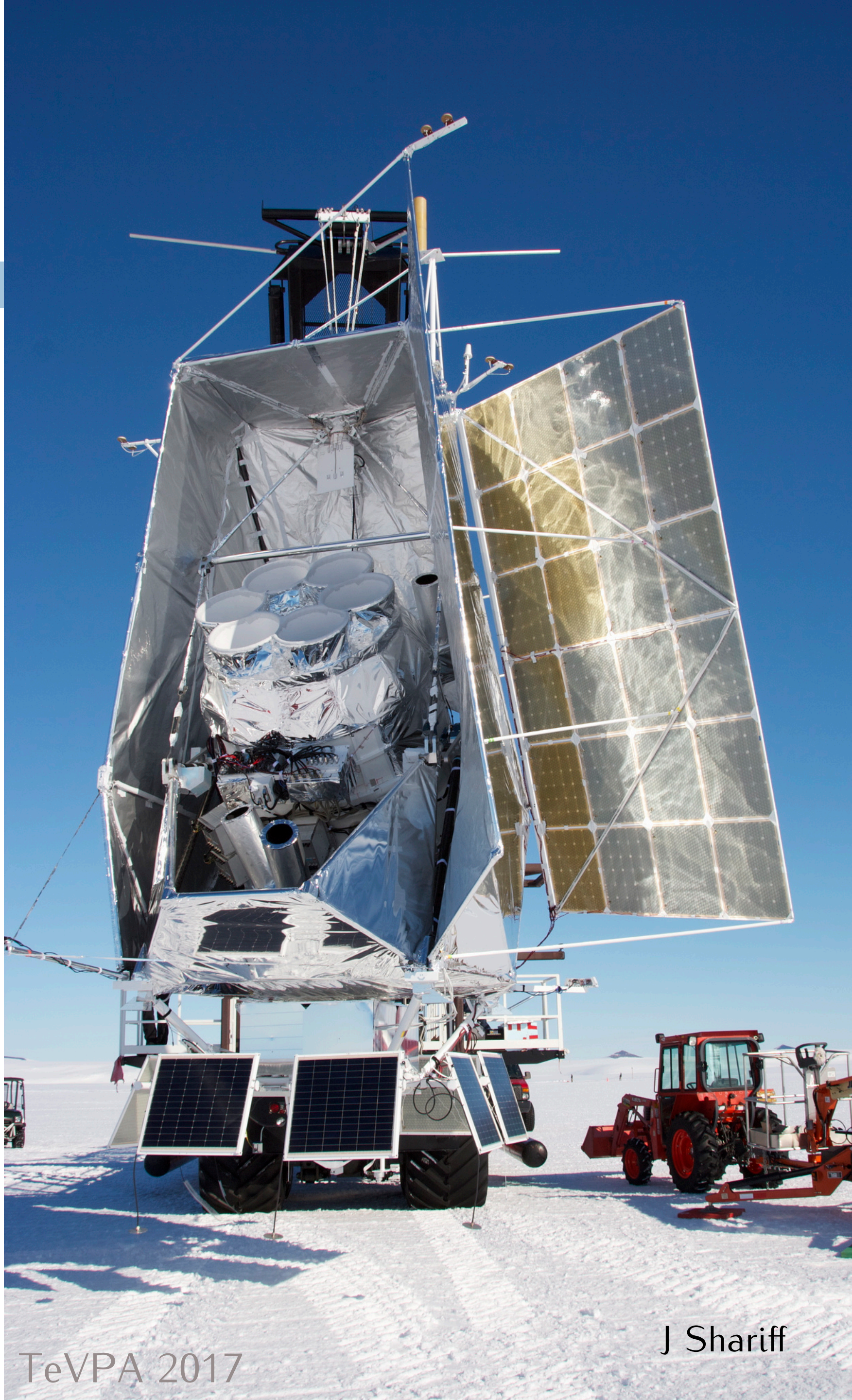
HC Chiang

Sky Coverage



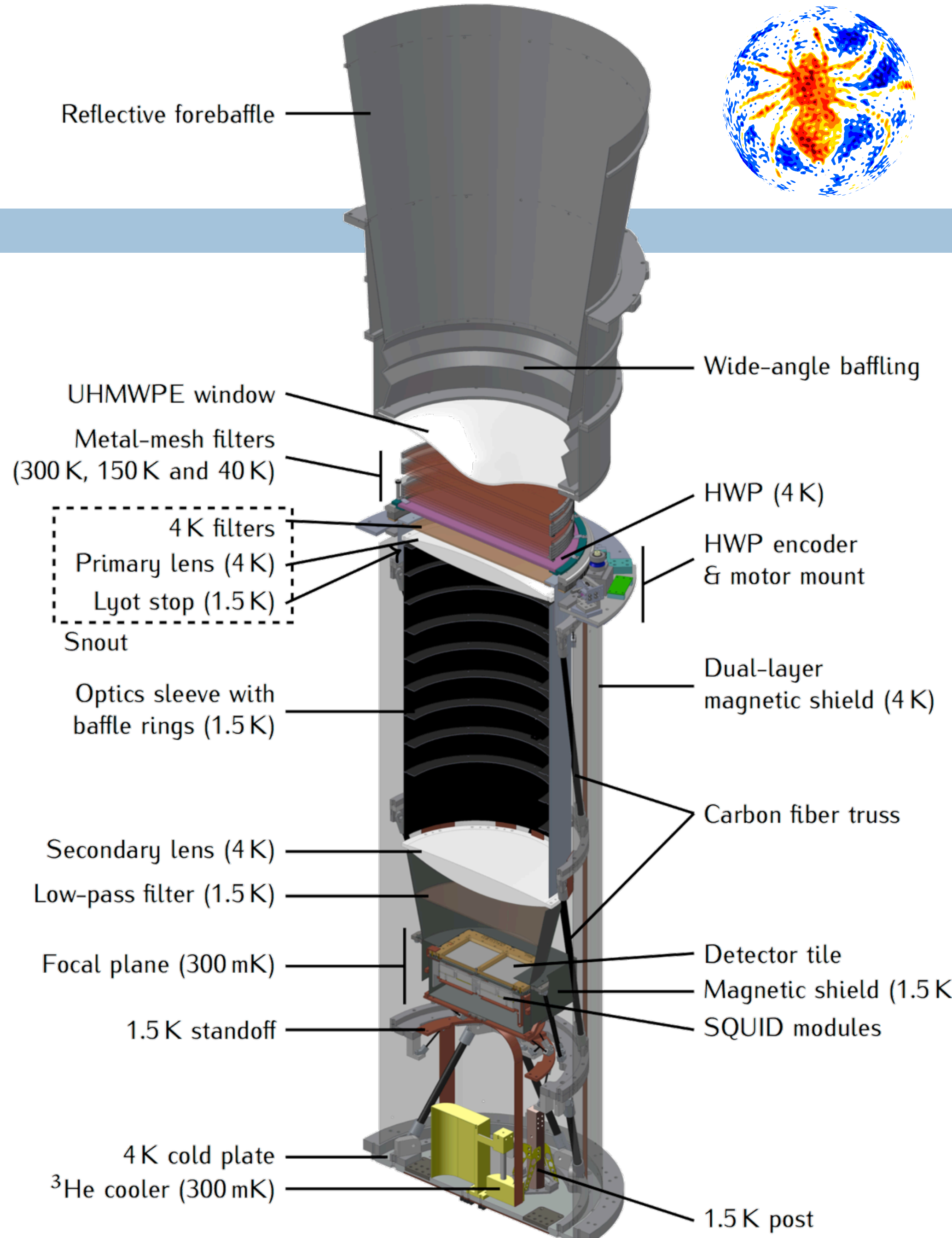
System Overview

- 6 independent receivers
  - 3x 150 GHz, 3x 95 GHz
- A single cryogenic/vacuum environment
- Lightweight carbon fiber gondola
- Multi-axis pointing control and reconstruction
- Custom control electronics
- Lots of heritage from the BLAST program



Receiver

- Cold refractive telecentric optics
- Well-controlled radiative loading:
  - External and internal baffling
  - Metal mesh filters
- Cold stepped HWP
- 300 mK focal plane
  - TES bolometers
  - Time-division multiplexed SQUIDs



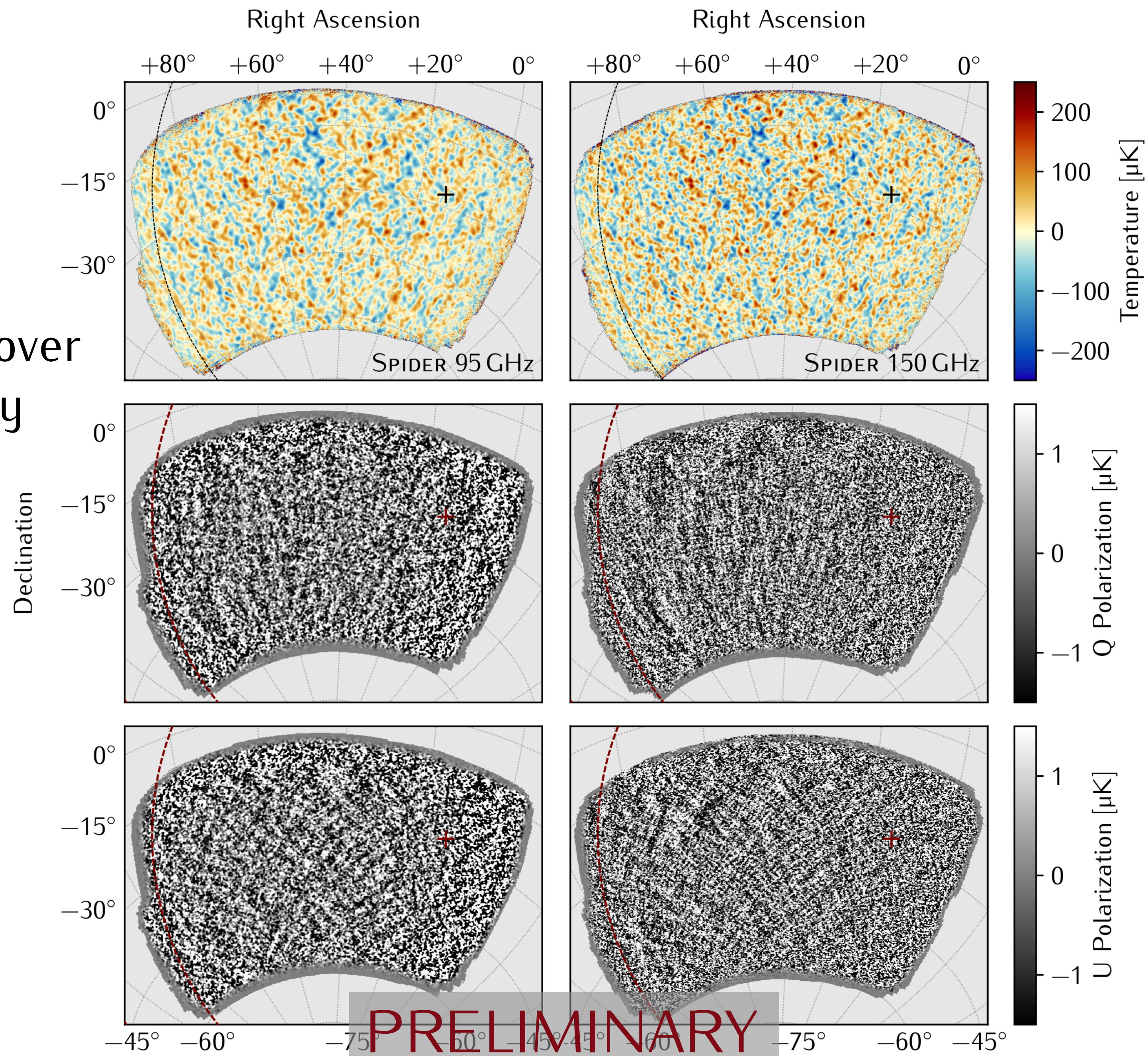
Performance Summary

	95 GHz	150 GHz
Bandwidth	22 GHz	36 GHz
Optical efficiency	30-45%	30-50%
Angular Resolution	41.1 arcmin	28.2 arcmin
Optical loading	< 0.25 pW	< 0.35 pW
# detectors (w/ cuts)	675	1188
Total NET	7.1 μK-s$^{1/2}$	5.3 μK-s$^{1/2}$

- Instantaneous NET near predictions
- Very conservative flagging for initial analysis
  - Flagging substantial due to thermal duty cycle, radio-frequency interference
- Observed < 0.3 pW loading, space-like conditions

Maps

Stokes T/Q/U over ~12% of the sky



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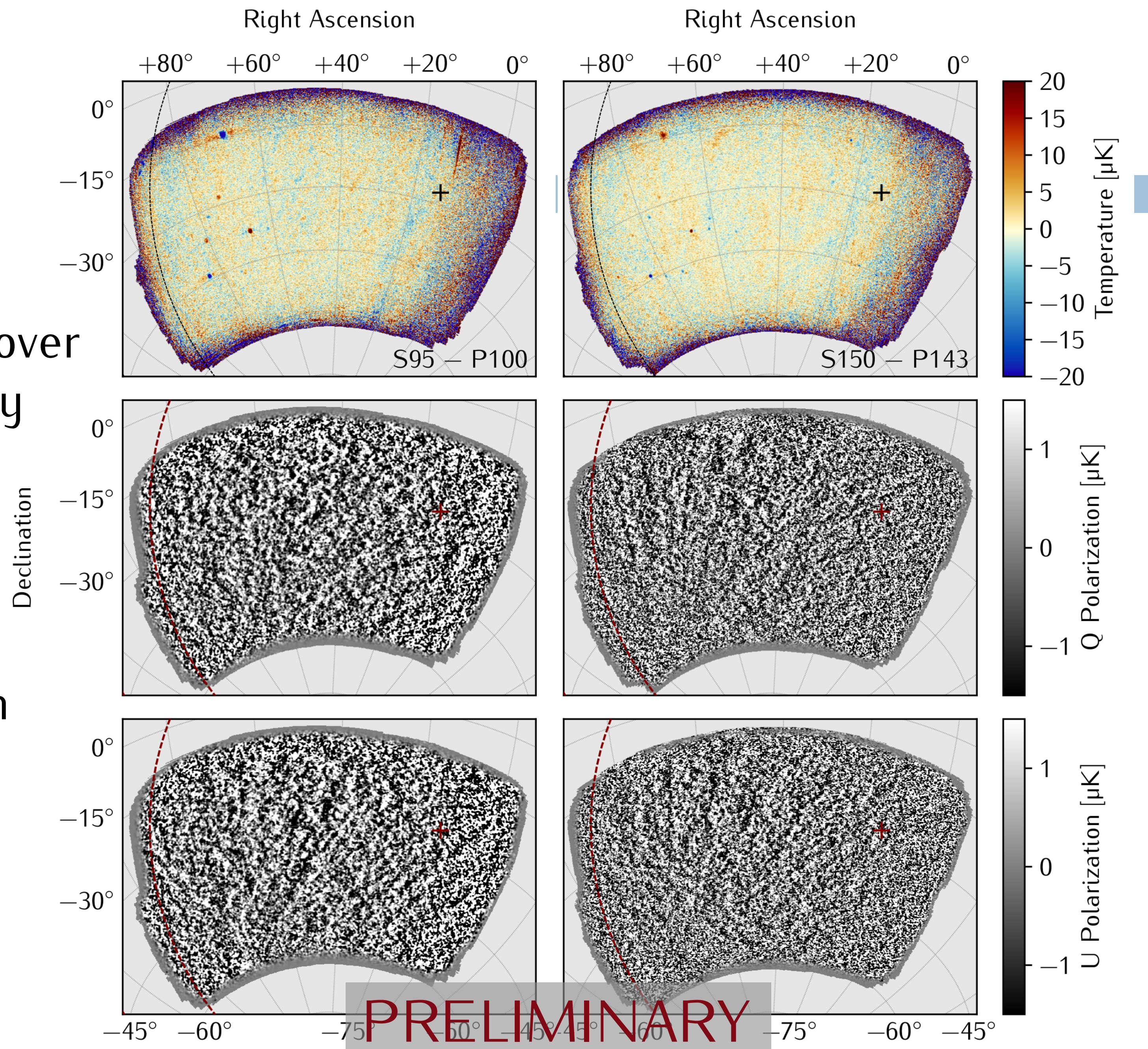
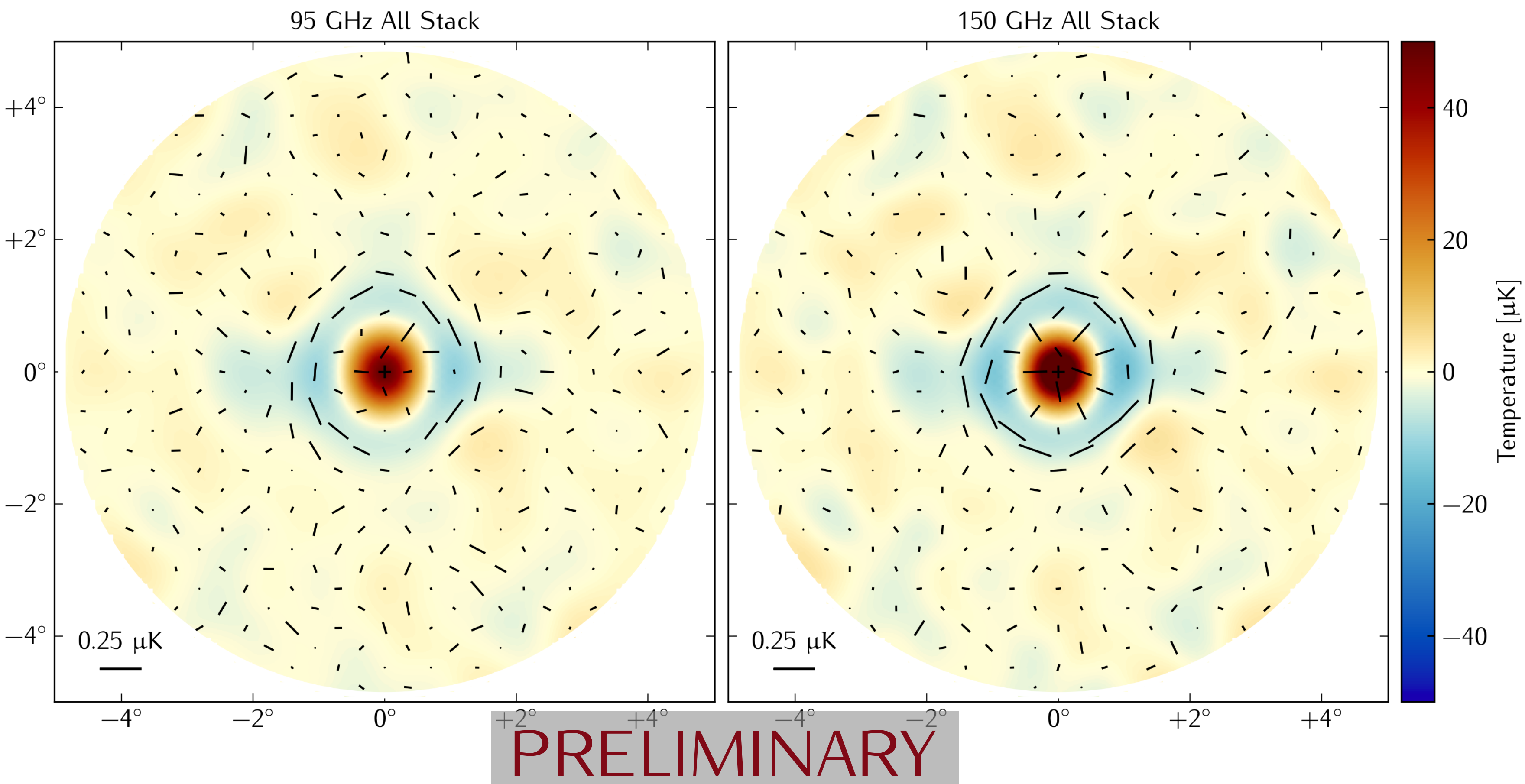
Consistent with Planck HFI



Peak Stacking

Characteristic correlation structure



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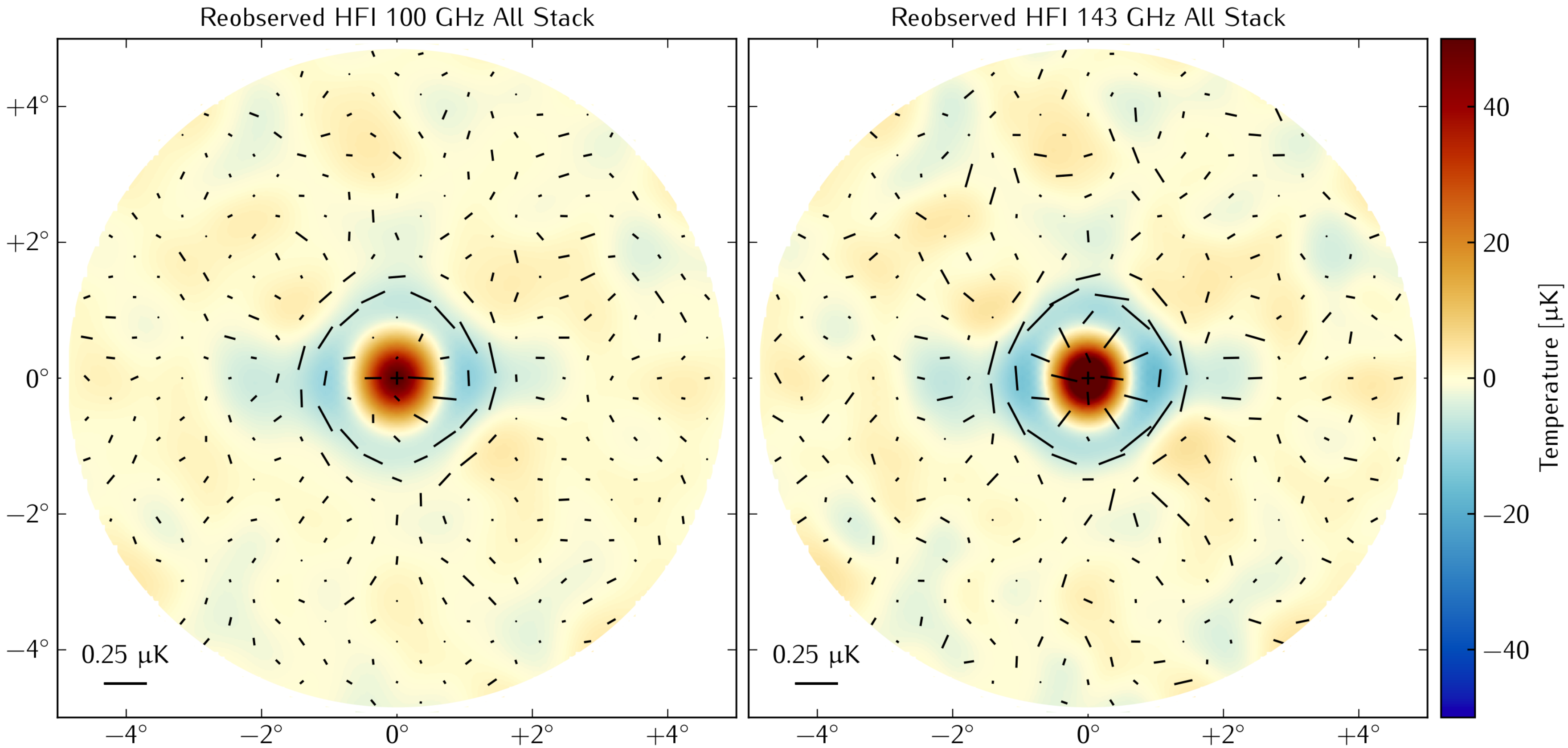
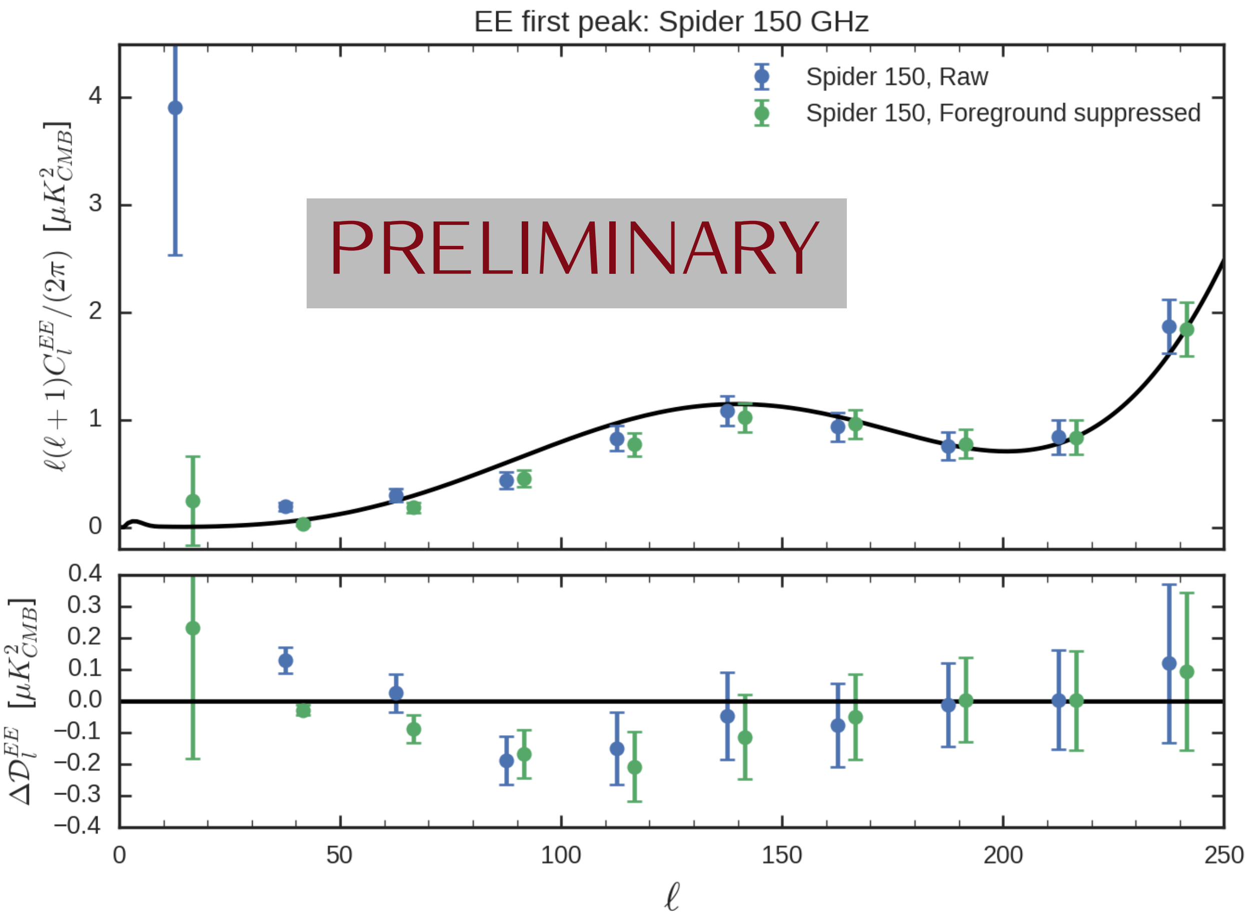


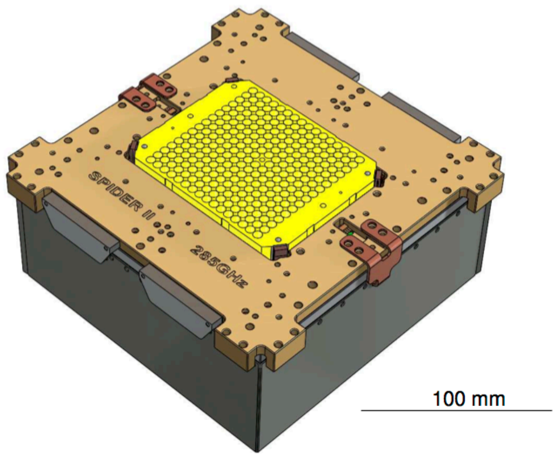
E-mode Power Spectrum

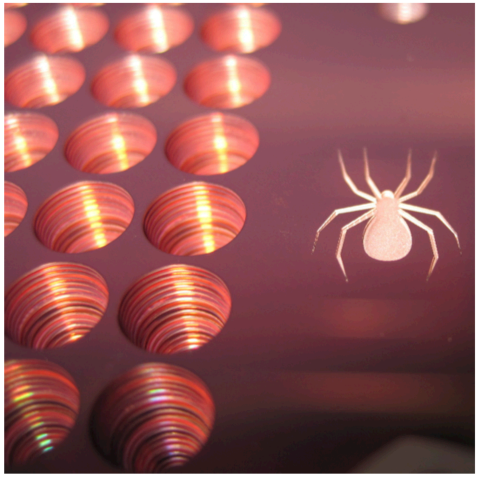
Evidence of foregrounds at large scales

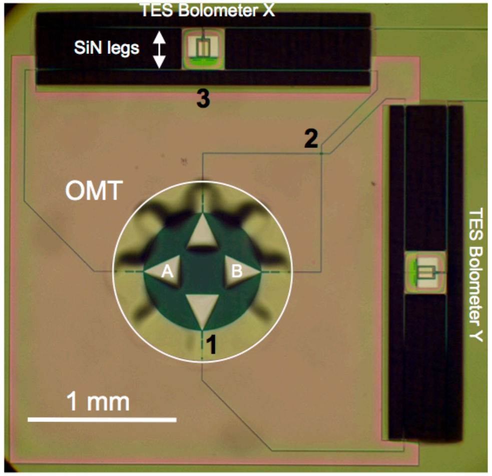


SPIDER-2: December 2018

- 280 GHz receivers to characterize Galactic dust







Hubmayr et al, SPIE 2016

- Feedhorn-coupled OMTs, NET ~335 μK-rts
- Designed to fit into existing receiver and electronics architecture

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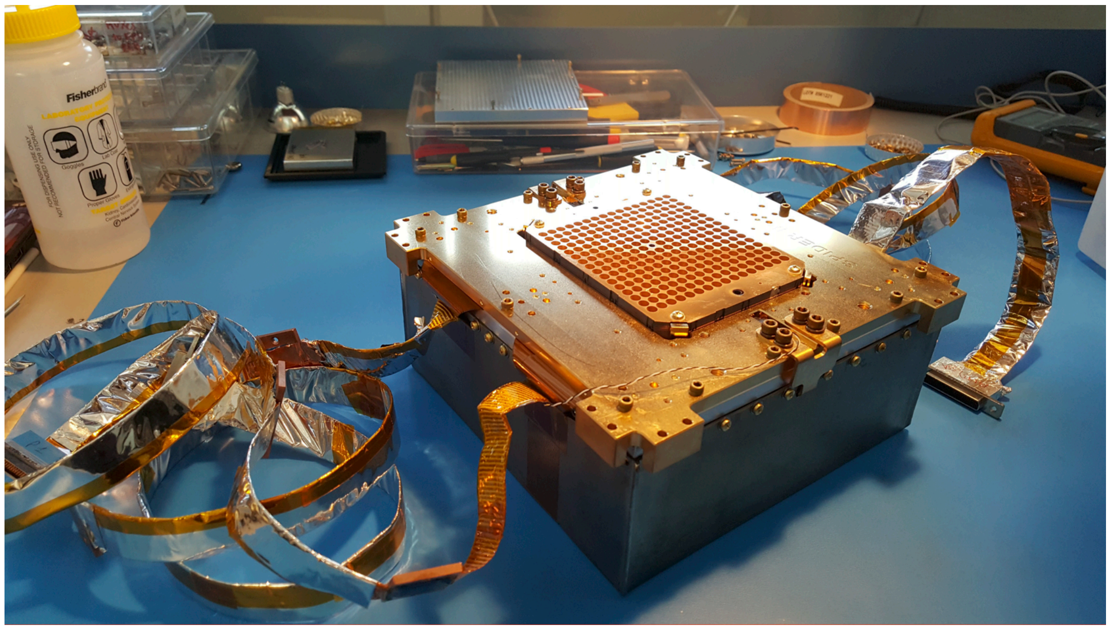

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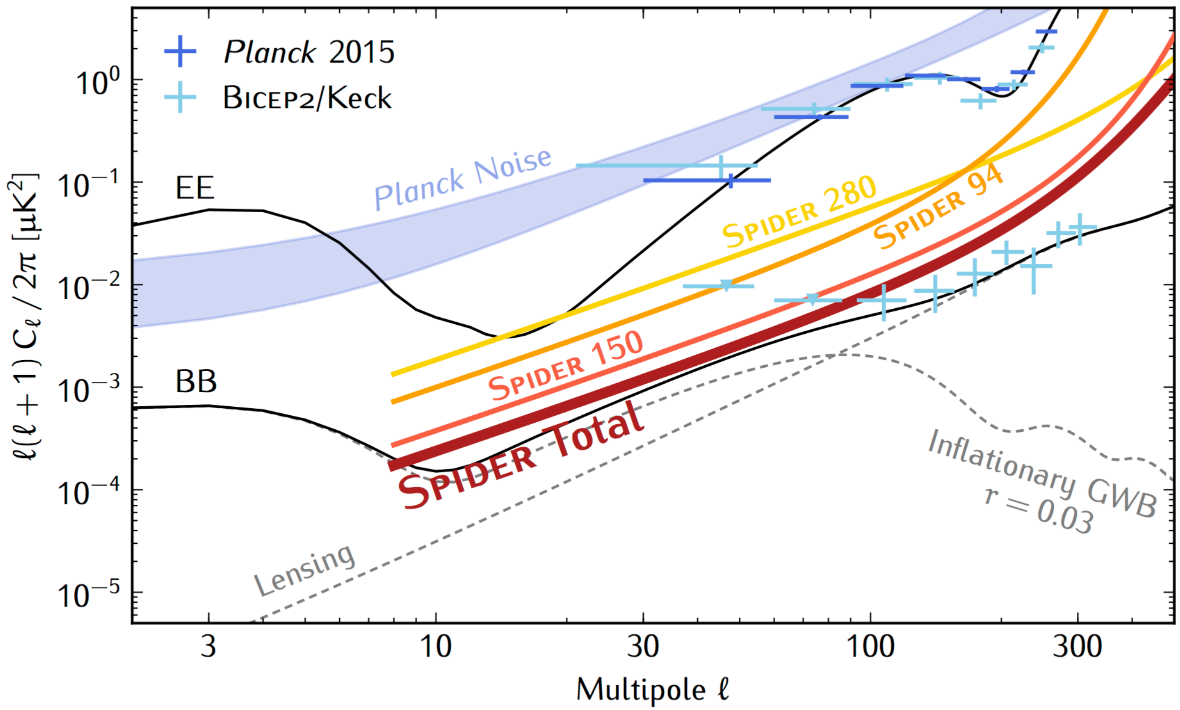
SPIDER-2 Development

- 280 GHz receivers to characterize Galactic dust
- Expected sensitivity after two flights:



- SPIDER-1 successful
  - Space-like optical loading
  - Analysis in progress
- SPIDER-2 build underway
  - High frequency for dust
  - December 2018 launch

Thank you!