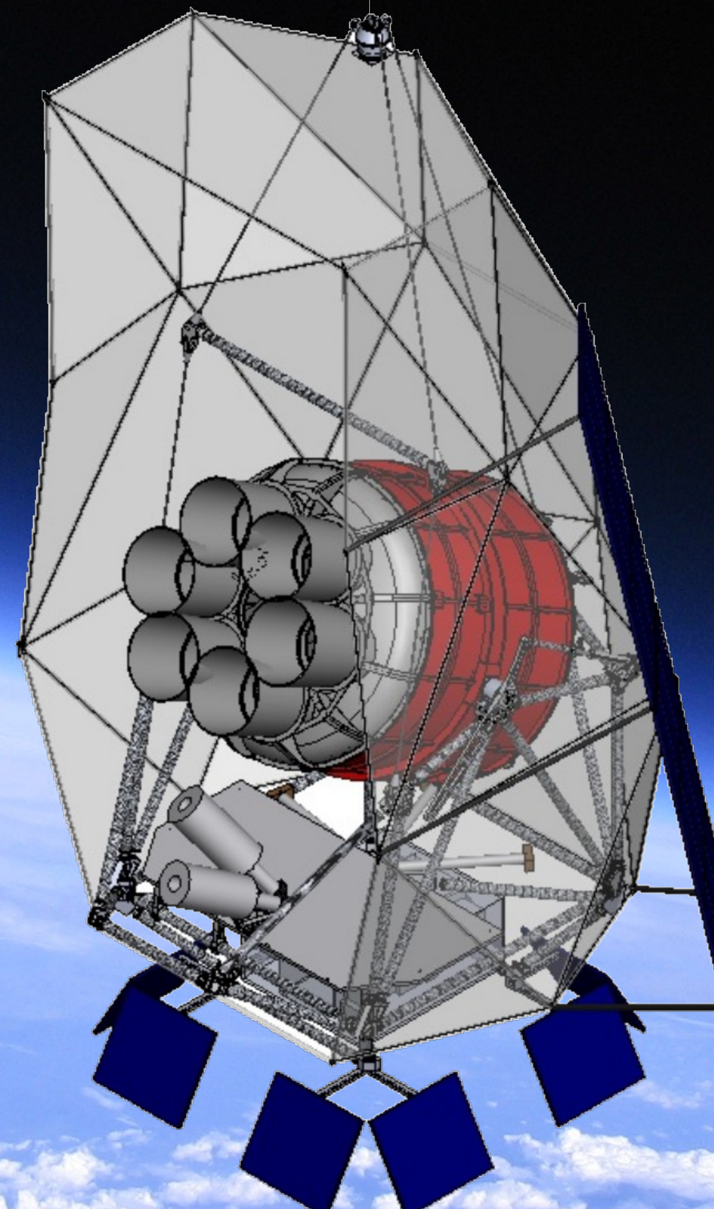
SPIDER

Probing Inflation with a Balloon-Borne Polarimetric Survey of the Southern Sky



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University of KwaZulu-Natal

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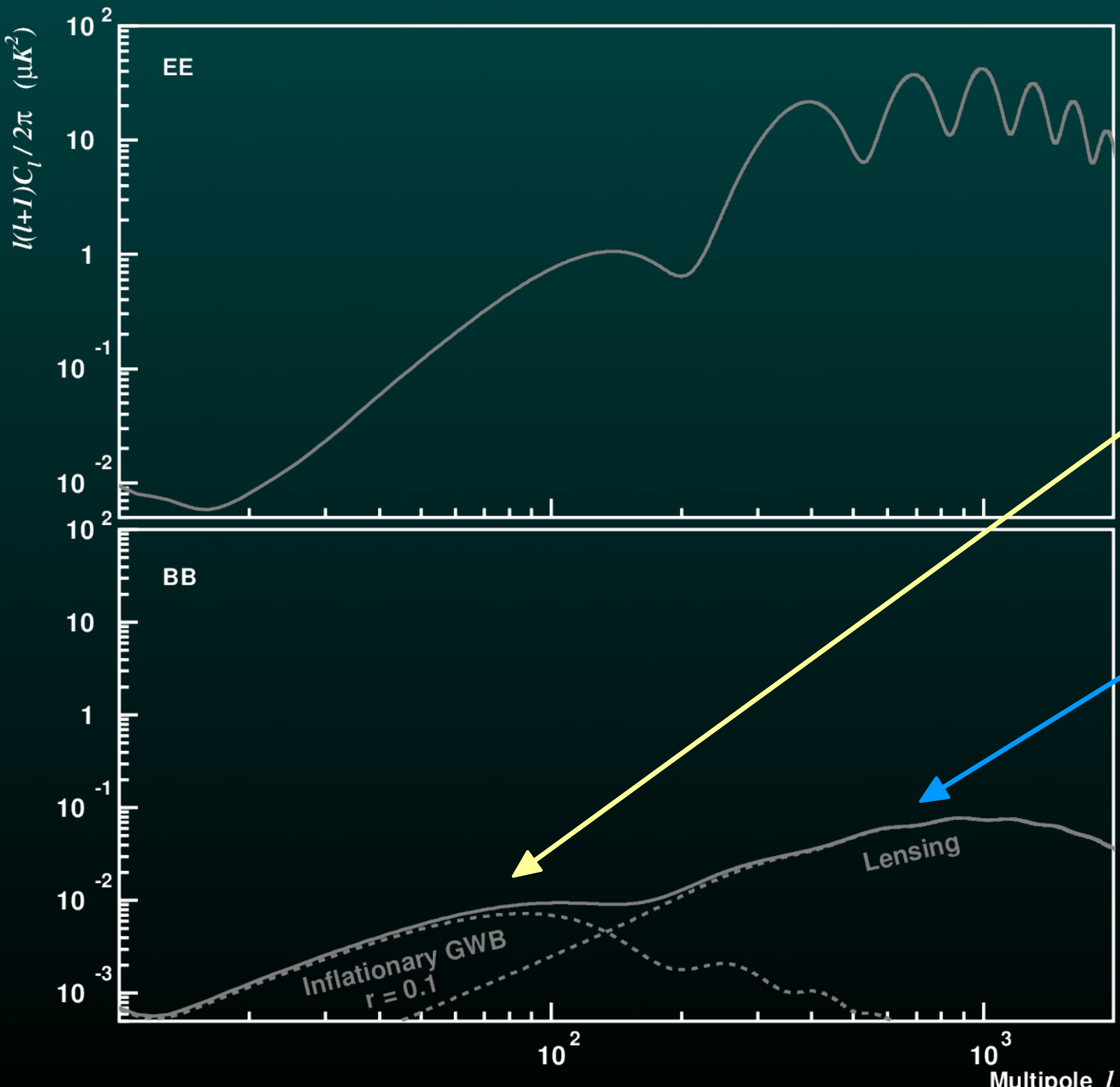
April 4, 2013

CMB polarization power spectra

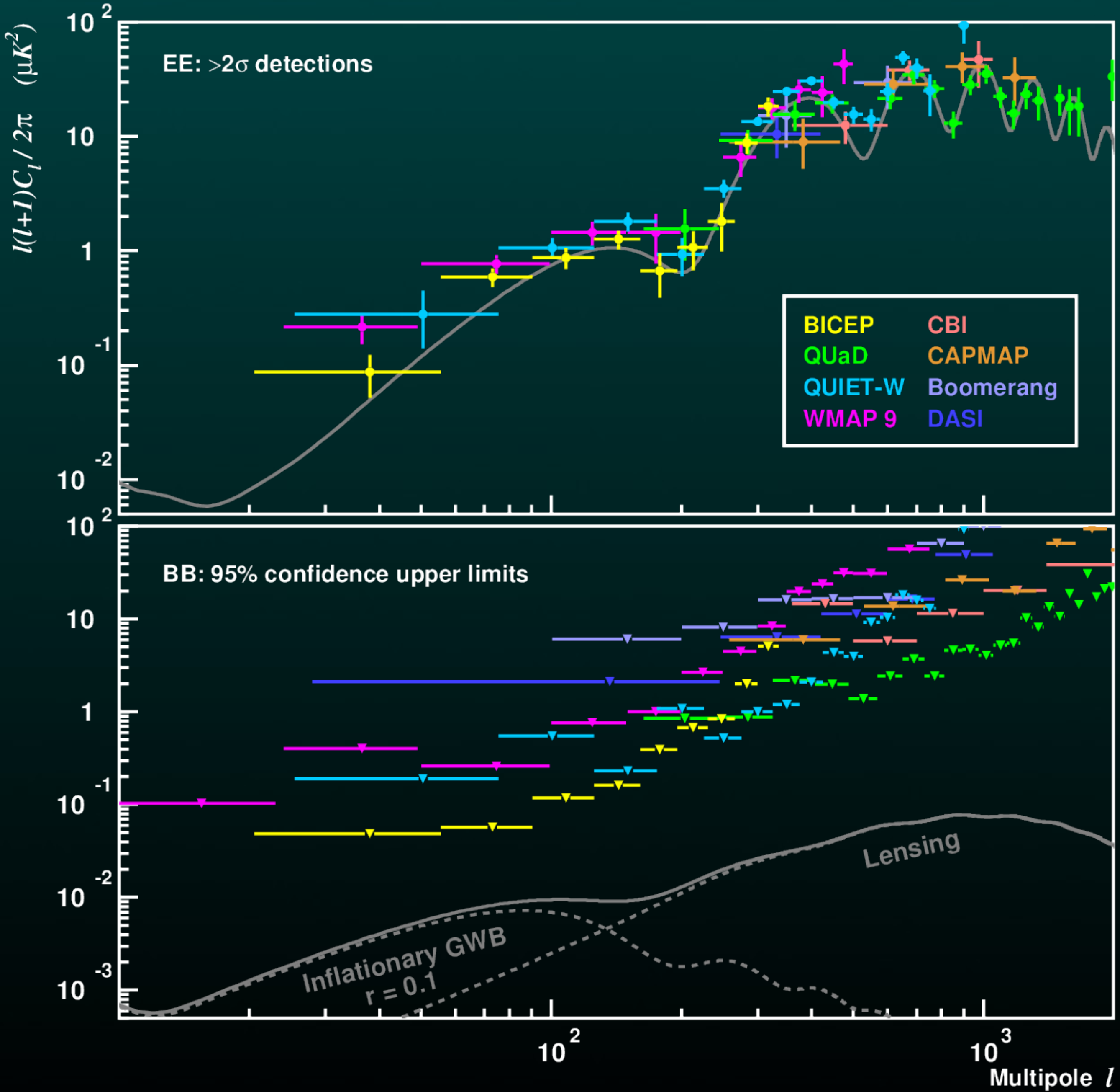


B-mode polarization from gravitational waves, amplitude ~ tensor-to-scalar ratio *r*. Current upper limit is *r* < 0.1, set mainly by TT data.

B-mode polarization from weak gravitational lensing by large-scale structure, partial conversion of E-modes

Both flavors of B-mode polarization are much fainter than E-mode, no detections yet.

Current CMB polarization measurements



E-mode polarization measured with high precision: acoustic peaks have been detected and are consistent with LCDM

B-mode polarization: most stringent upper limits correspond to $r < 0.72$, no lensing detection yet

SPIDER is optimized to target the inflationary BB bump at ell ~ 100

SPIDER: a new instrument for CMB polarimetry

SPIDER science goals

Constrain inflationary B-modes to $r < 0.03$ at 3σ, or measure lensing BB

Characterize polarized foregrounds

Instrumental approach

Long duration balloon platform (2 flights, 20+ days each)

0.5 deg resolution over 8% of the sky, target $10 < ell < 300$

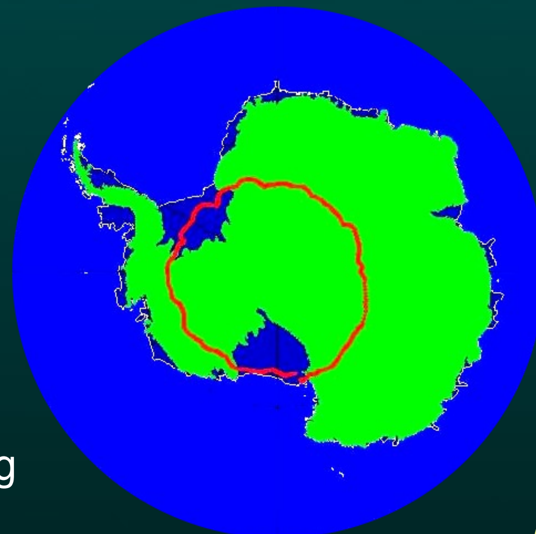
6 compact, monochromatic refractors in LHe cryostat

Polarization modulation: HWPs

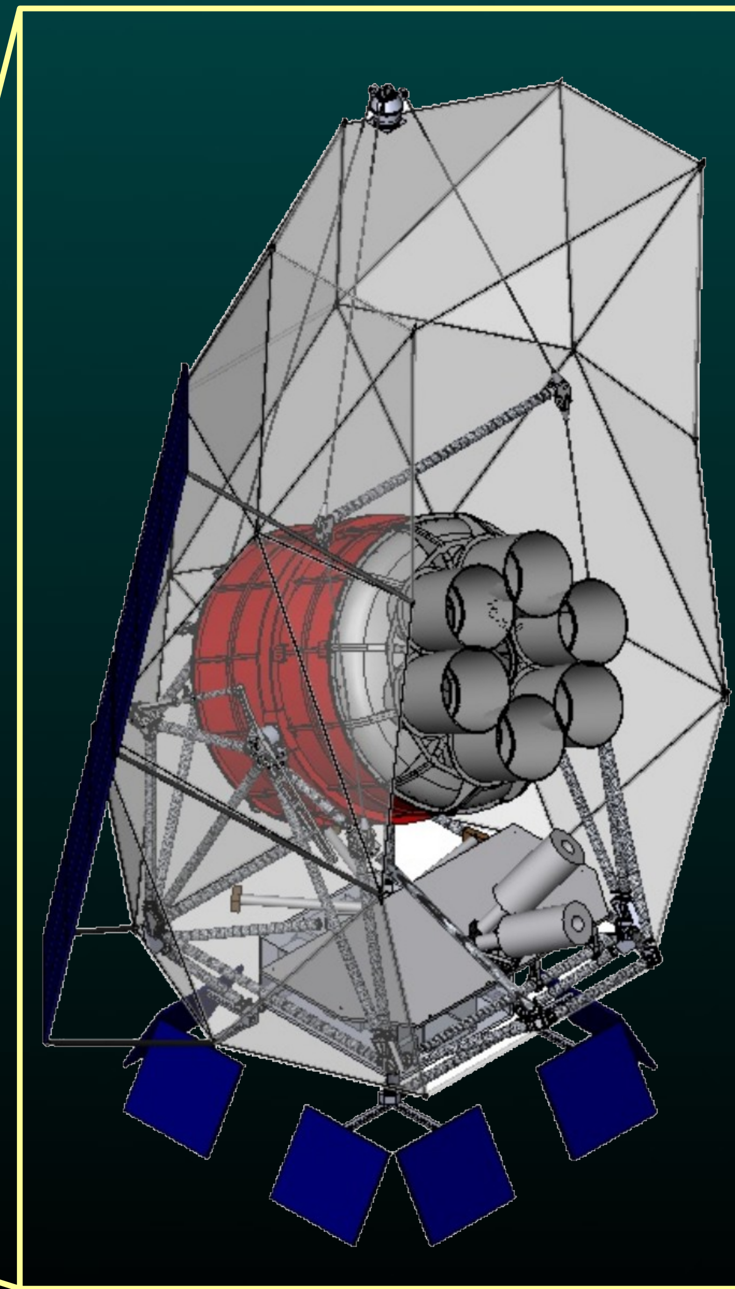
2600 detectors split between 90,150, 280 GHz

Antarctic long-duration ballooning

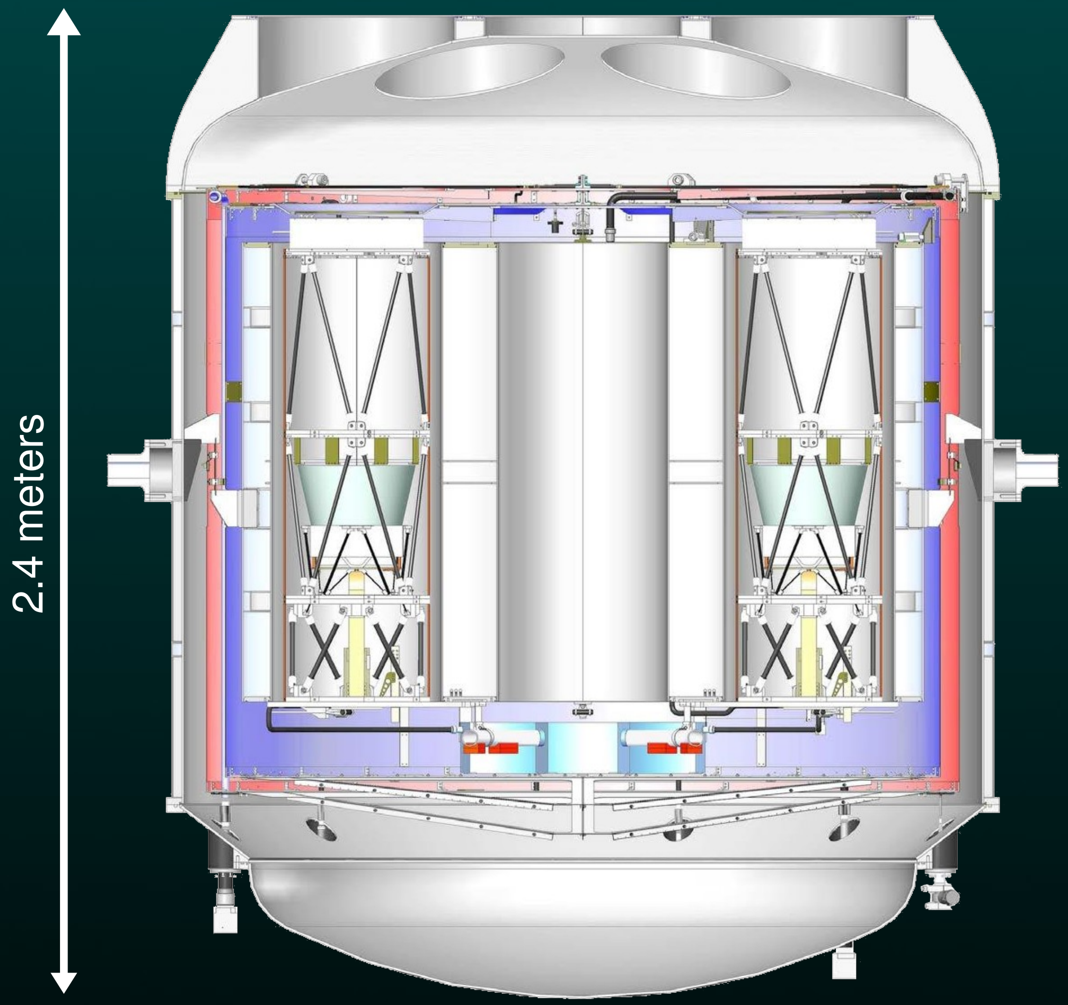
Launch from McMurdo station, circumnavigate continent in ~2 weeks

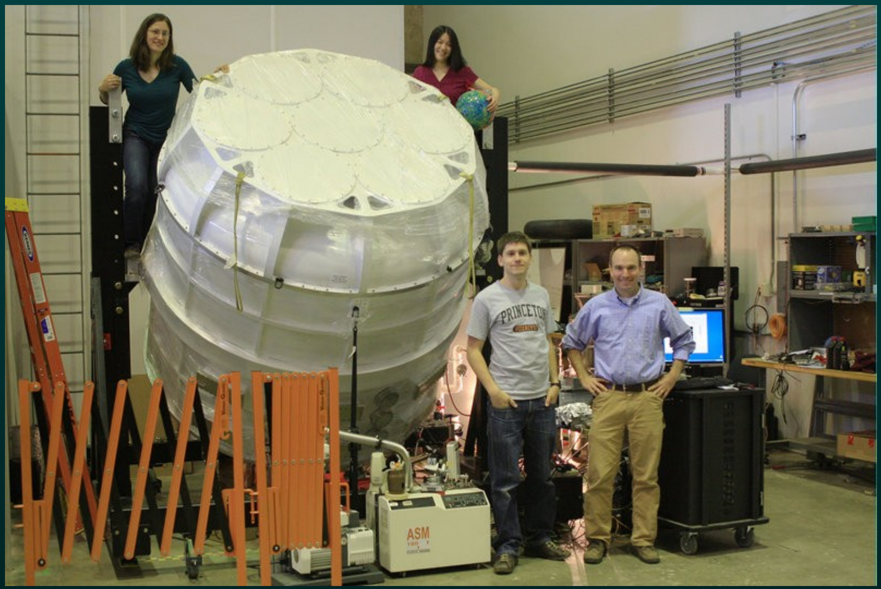


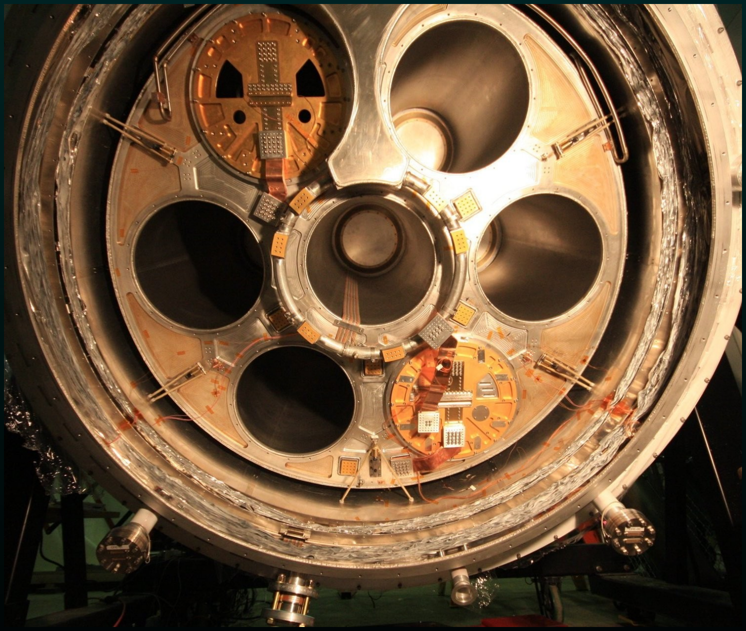
Float altitude: 40 km
Volume: 1 million m^3
Max payload weight: 3600 kg



SPIDER cryostat

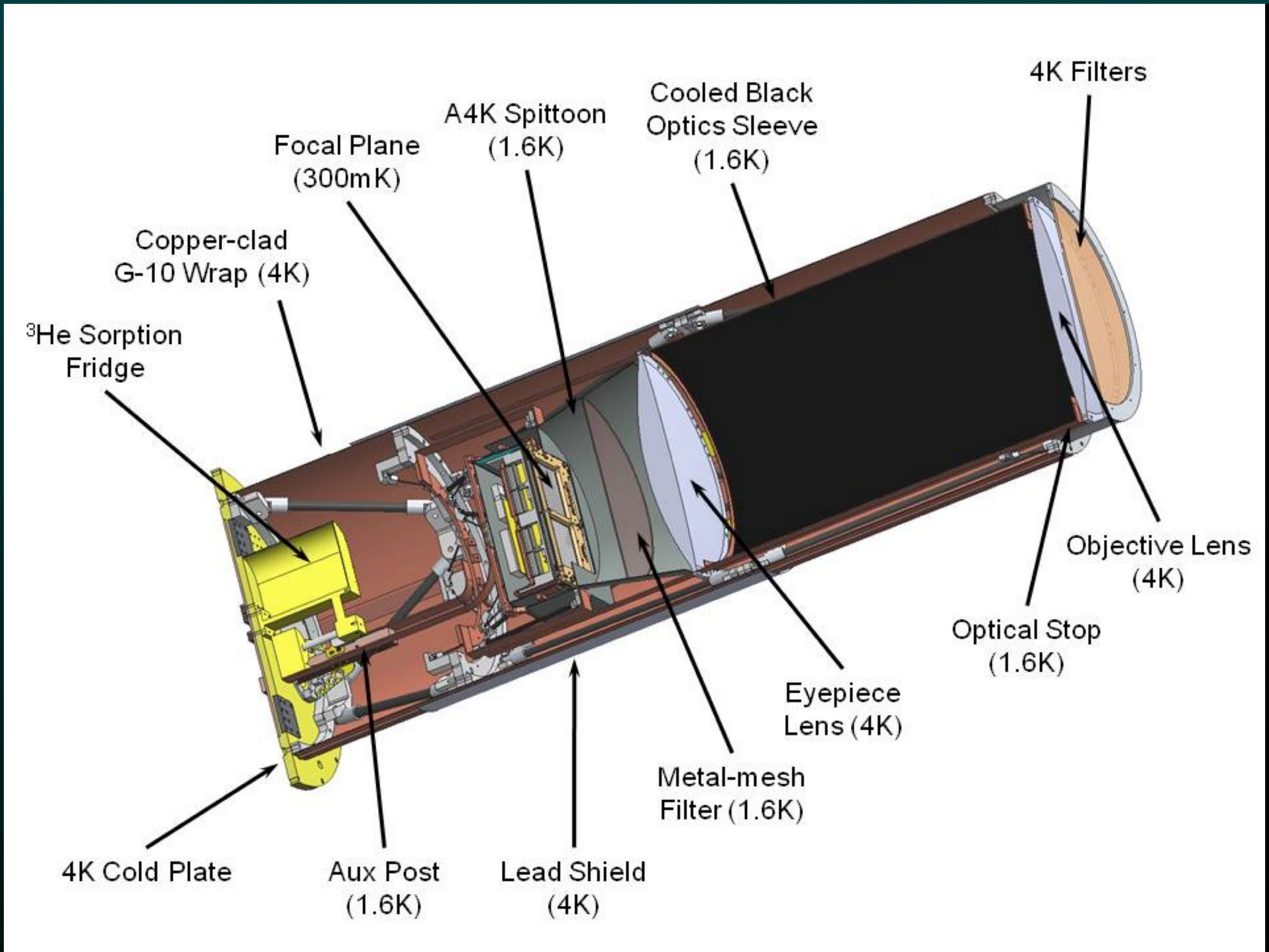


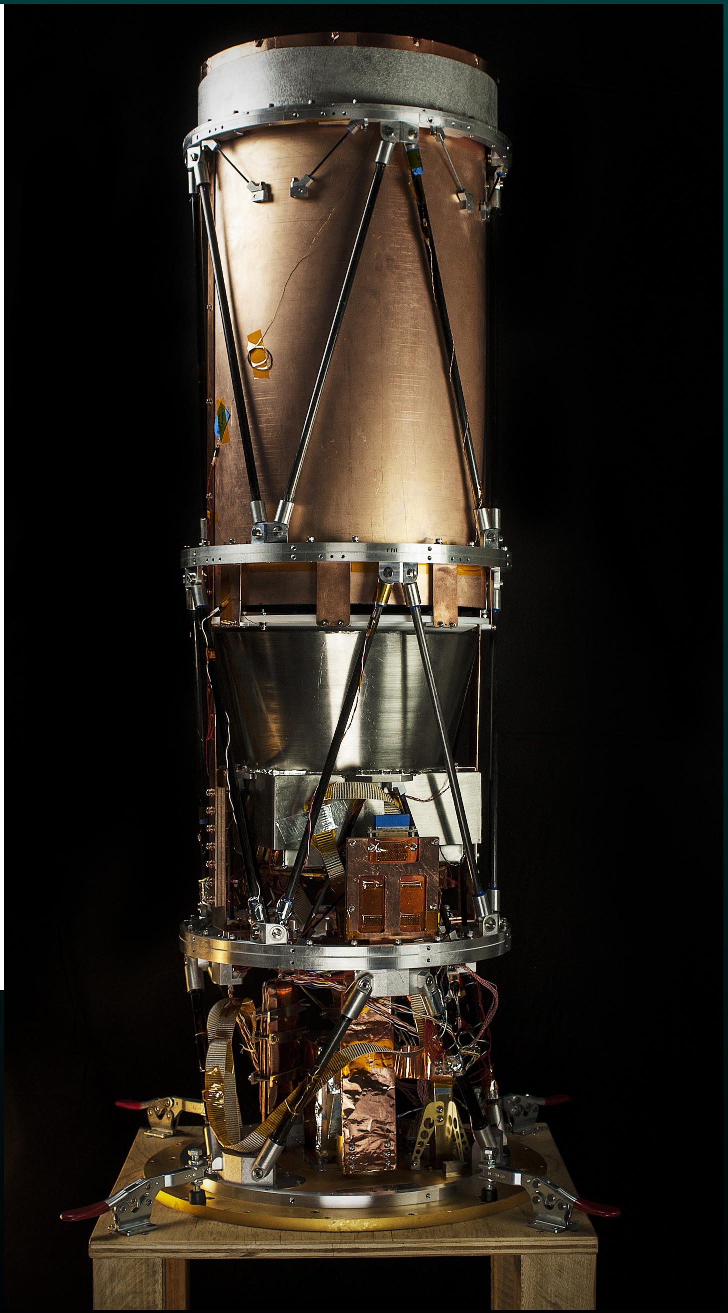




- Dry weight: 850 kg
- Main tank: 1200 liters LHe, 4K
- Capillary-fed superfluid tank: 16 liters LHe, 1.4K
- Two vapor cooled shields, 30K and 150K
- Hold time: 20+ days

Instrument insert

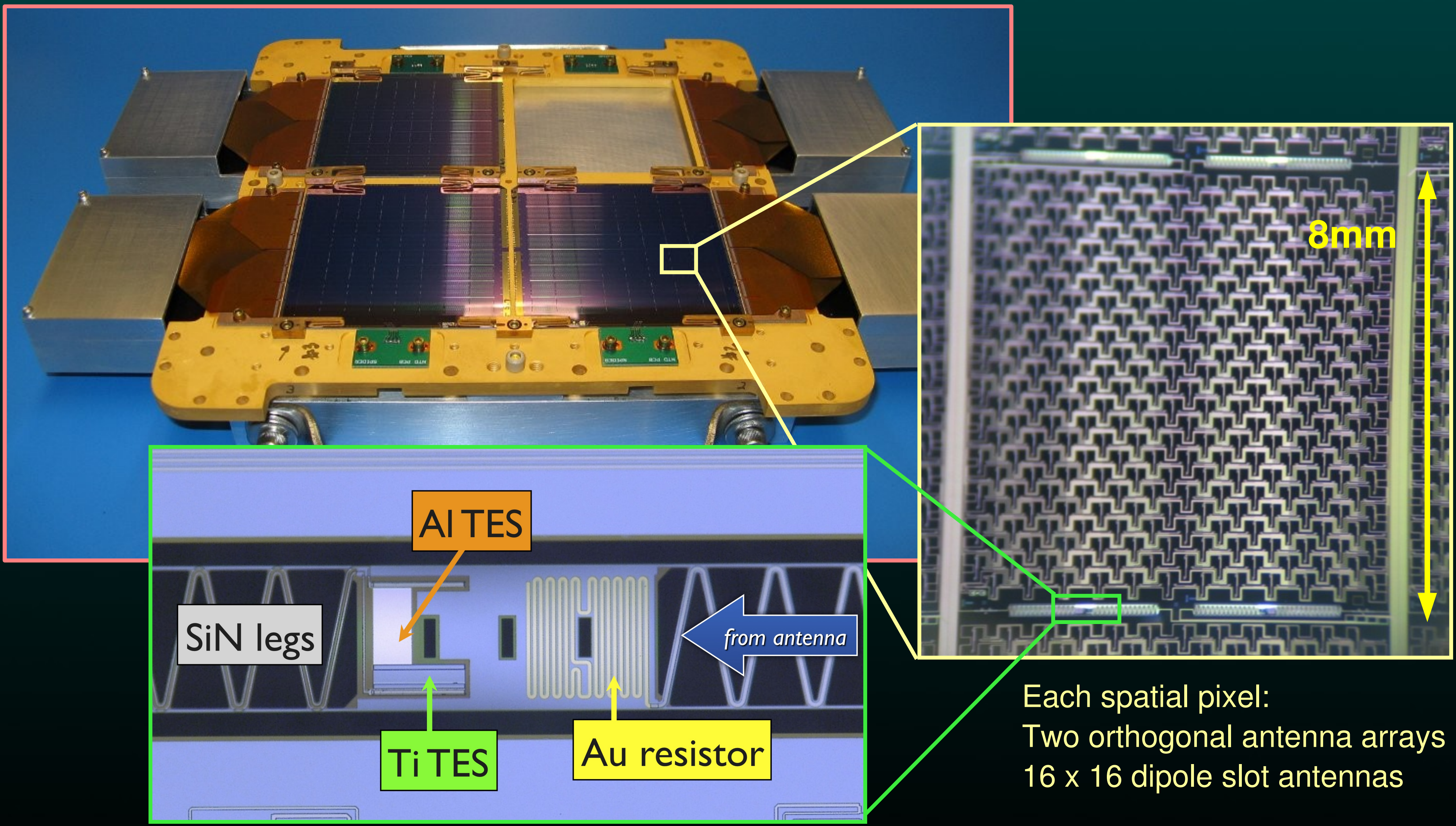




- Each insert tuned for a single frequency band
- 90 lbs each: lightweighting + stiff carbon fiber truss
- Two-lens optical design (based on BICEP)
- Extensive efforts to optimize magnetic shielding

Focal plane: antenna-coupled TES bolometers

Each focal plane: 4 tiles x 64 pixels x 2 polarizations = 512 detectors

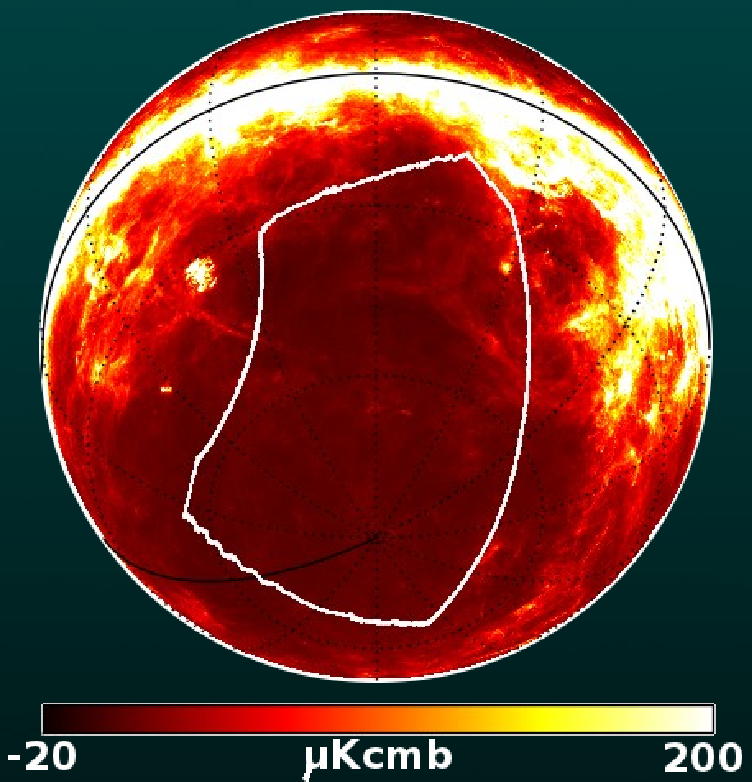


Each spatial pixel:
Two orthogonal antenna arrays
16 x 16 dipole slot antennas

Detectors: Al / Ti TES bolometers

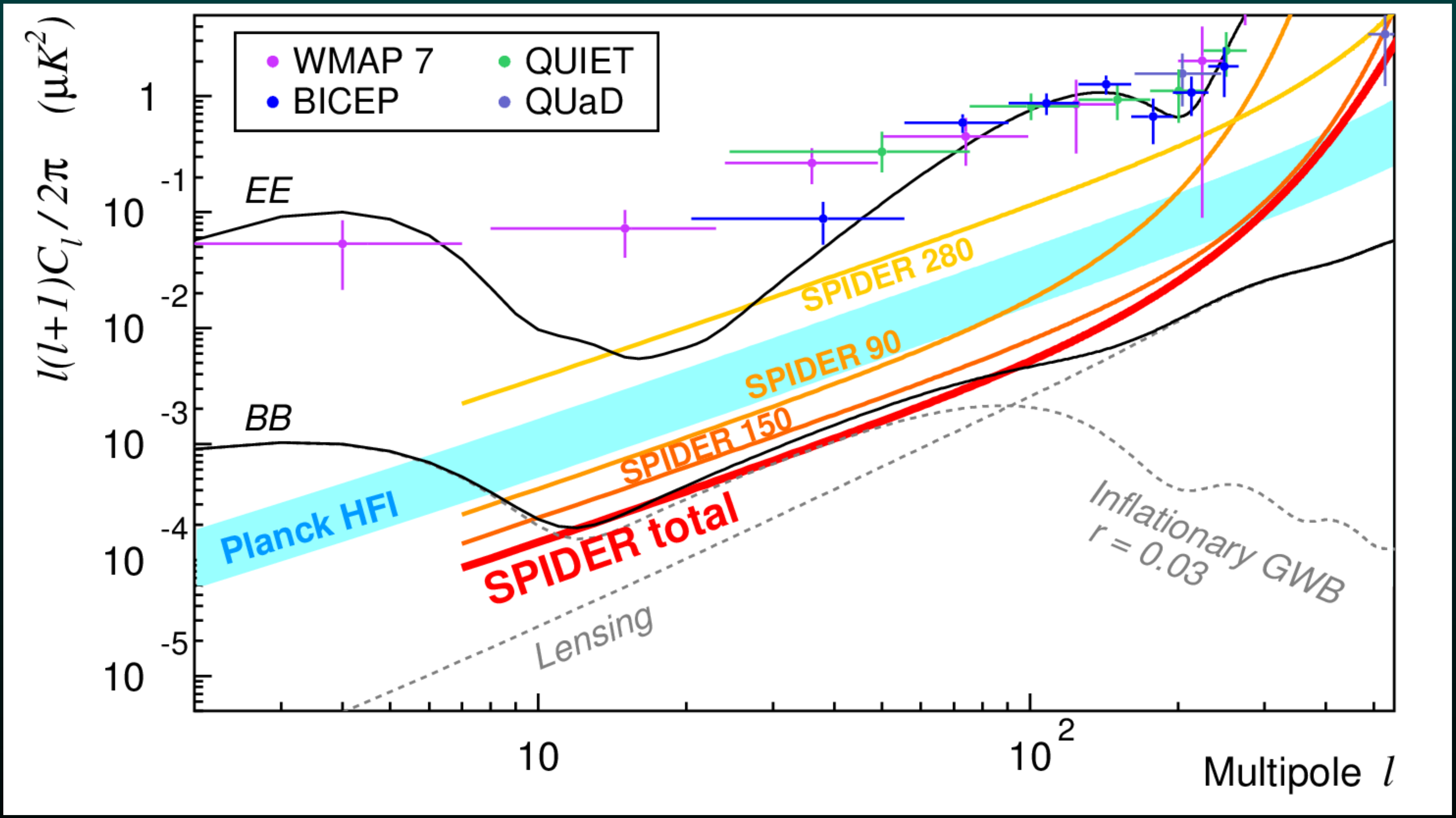
SPIDER flight plan

- SPIDER will map 8% of the sky in an exceptionally clean region (encompasses the “southern hole”)
- First flight: 90 GHz and 150 GHz to maximize sensitivity for a B-mode detection
- Second flight: assuming that we see something in the first flight (could be foregrounds), expand frequency coverage to characterize the signal

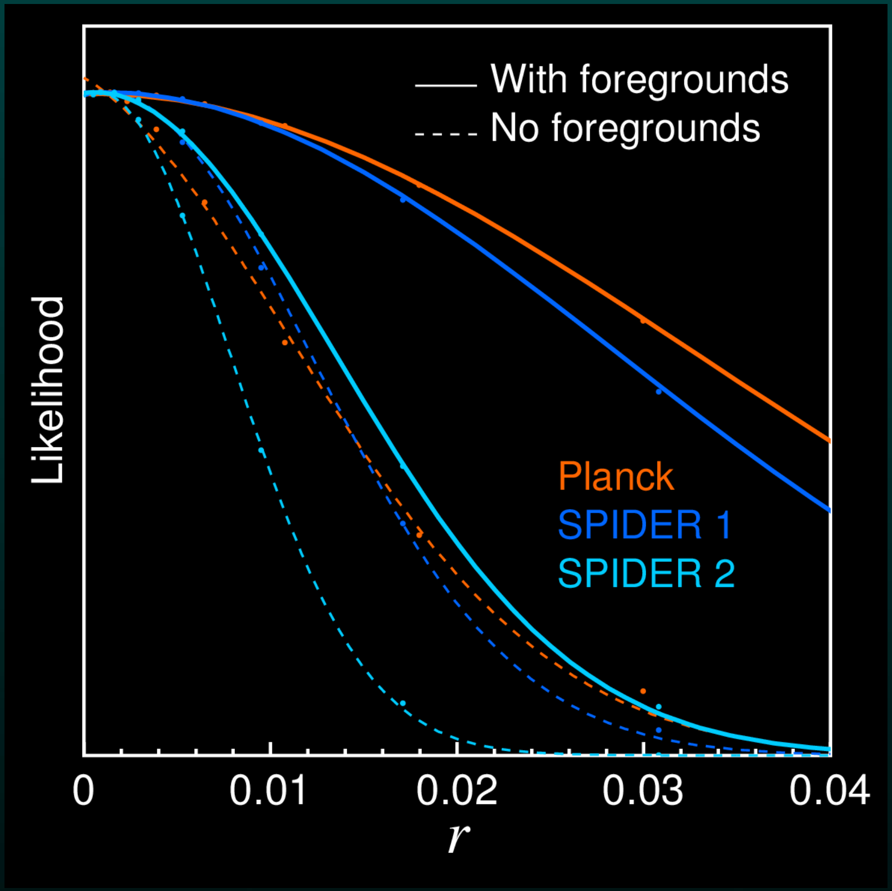


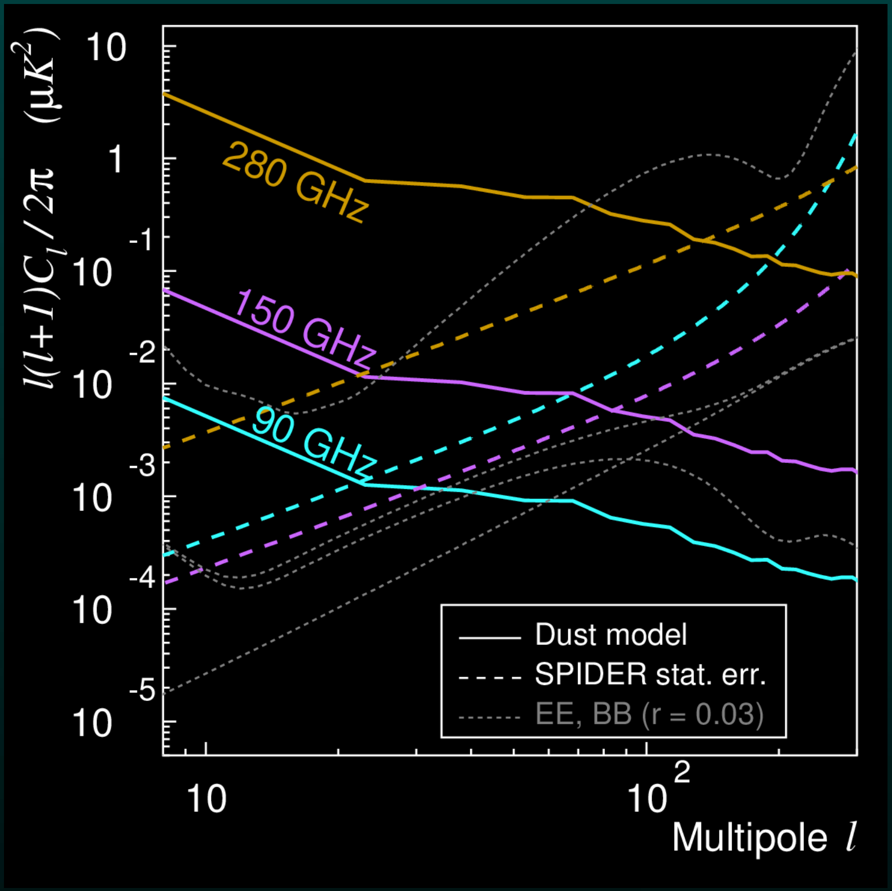
Flight date	Focal plane and detector distribution			Cumulative noise, μK/deg²		
	90 GHz	150 GHz	280 GHz	90 GHz	150 GHz	280 GHz
Dec 2013	3 x FPs = 864	3 x FPs = 1536	–	0.27	0.20	–
Dec 2014?	2 x FPs = 576	2 x FPs = 1024	2 x FPs = 1024	0.21	0.16	0.62

SPIDER noise projections



What will Spider do for you?

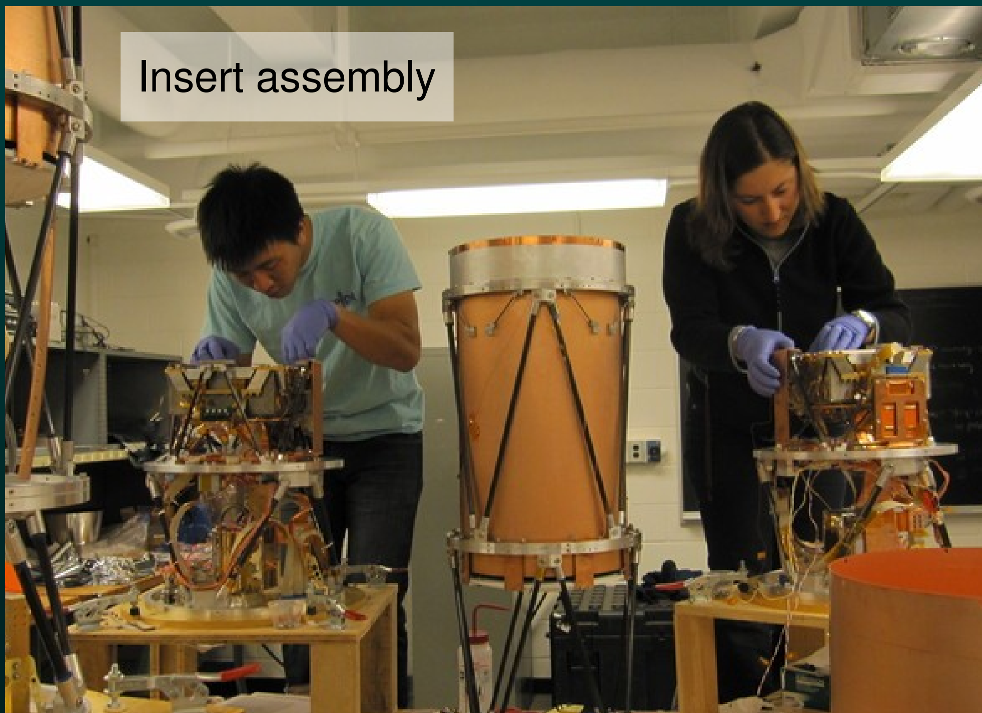


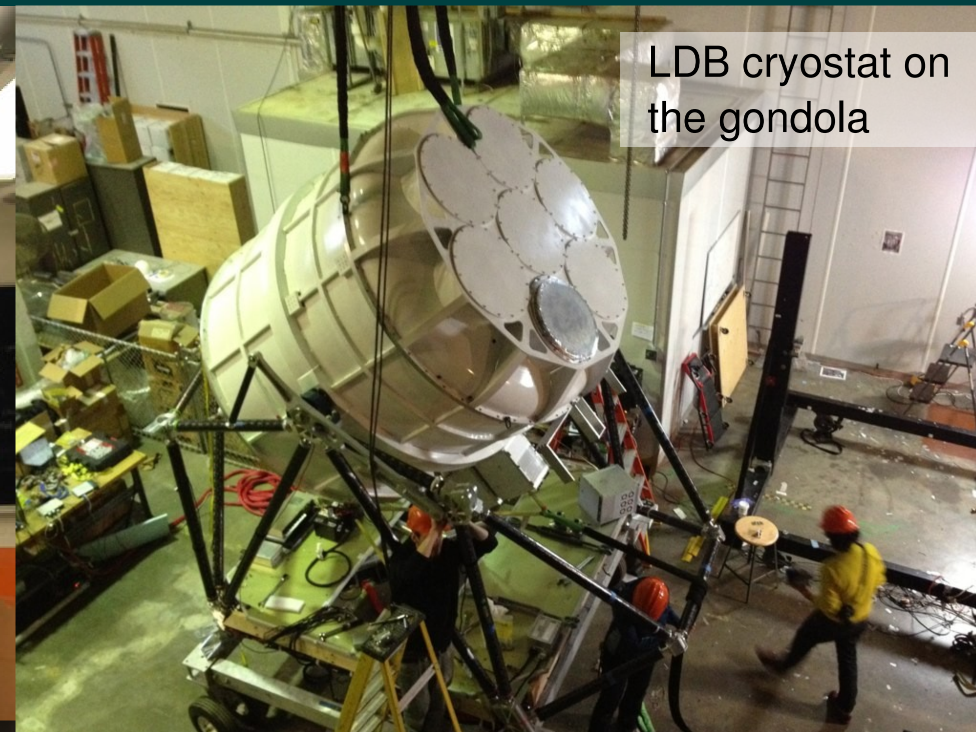


Without foregrounds: $r < 0.03$ at 3σ in 1 flight
With foregrounds: need 2 flights, add 280 GHz

Despite low foregrounds in the observing region, models predict that we'll see dust. Spider will characterize and subtract the dust emission.

SPIDER status: counting down to a December flight!


Insert assembly


LDB cryostat on the gondola


Team SPIDER owns the machine shop!


Preparing for cooldown