Title: Frontiers of Modern Cosmology

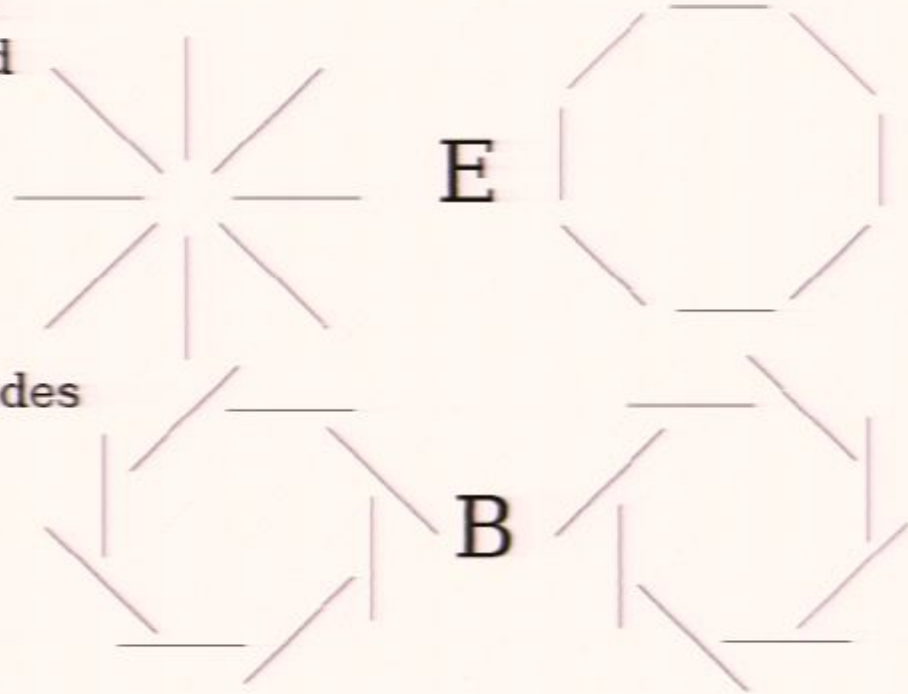
Date: Sep 12, 2007 04:00 PM

URL: http://pirsa.org/07090042

Abstract:

Polarization: E modes and B modes

E Modes:
- Gradient of the polarization
- Produced by both scalar and tensor modes
- Have been detected



B Modes:
- Curl of the polarization
- Produced only by tensor modes

...or gravitational lensing

...or foregrounds

...or systematics

- Expected from inflation
- Have not been detected

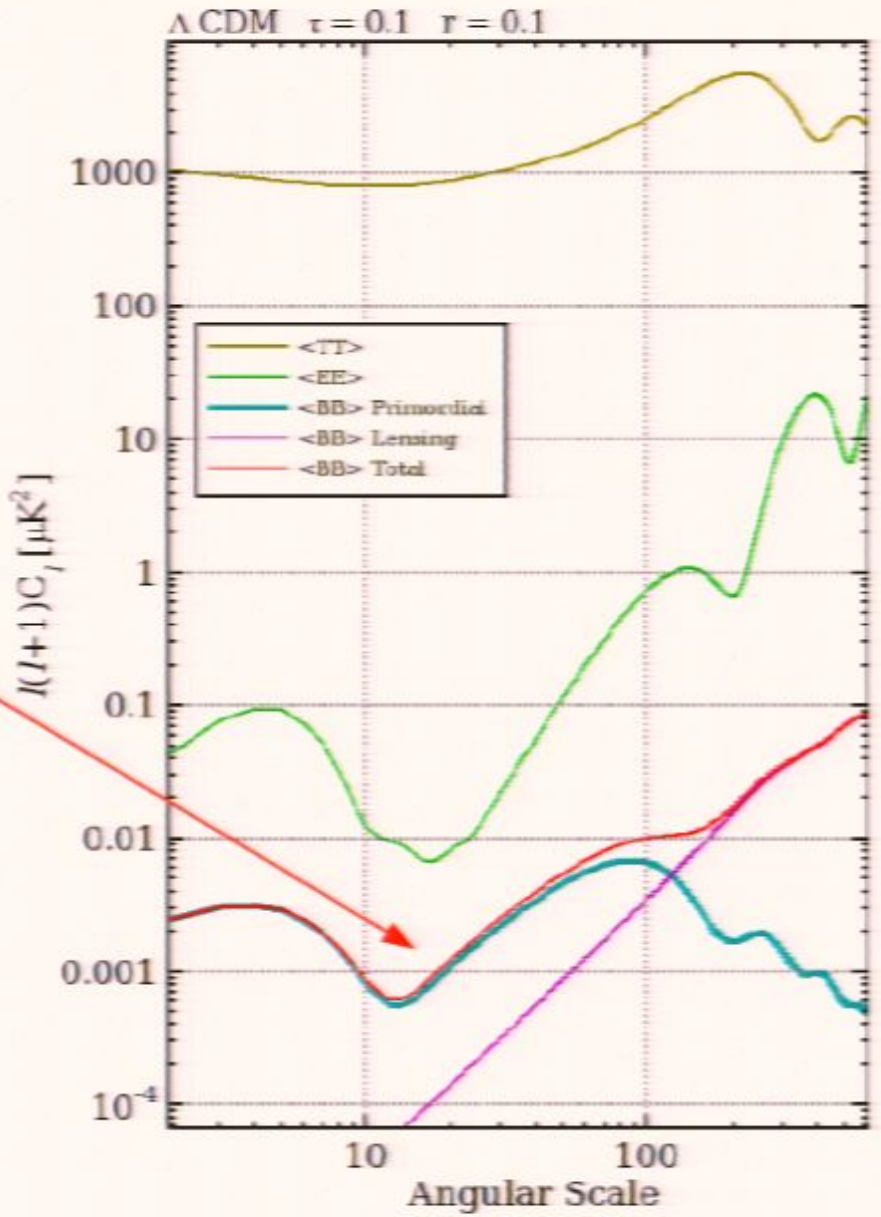
A detection of primordial sourced B modes would provide important evidence for, and determine the energy scale of

Inflation

Challenges

Signal is very small

Need unprecedented sensitivity

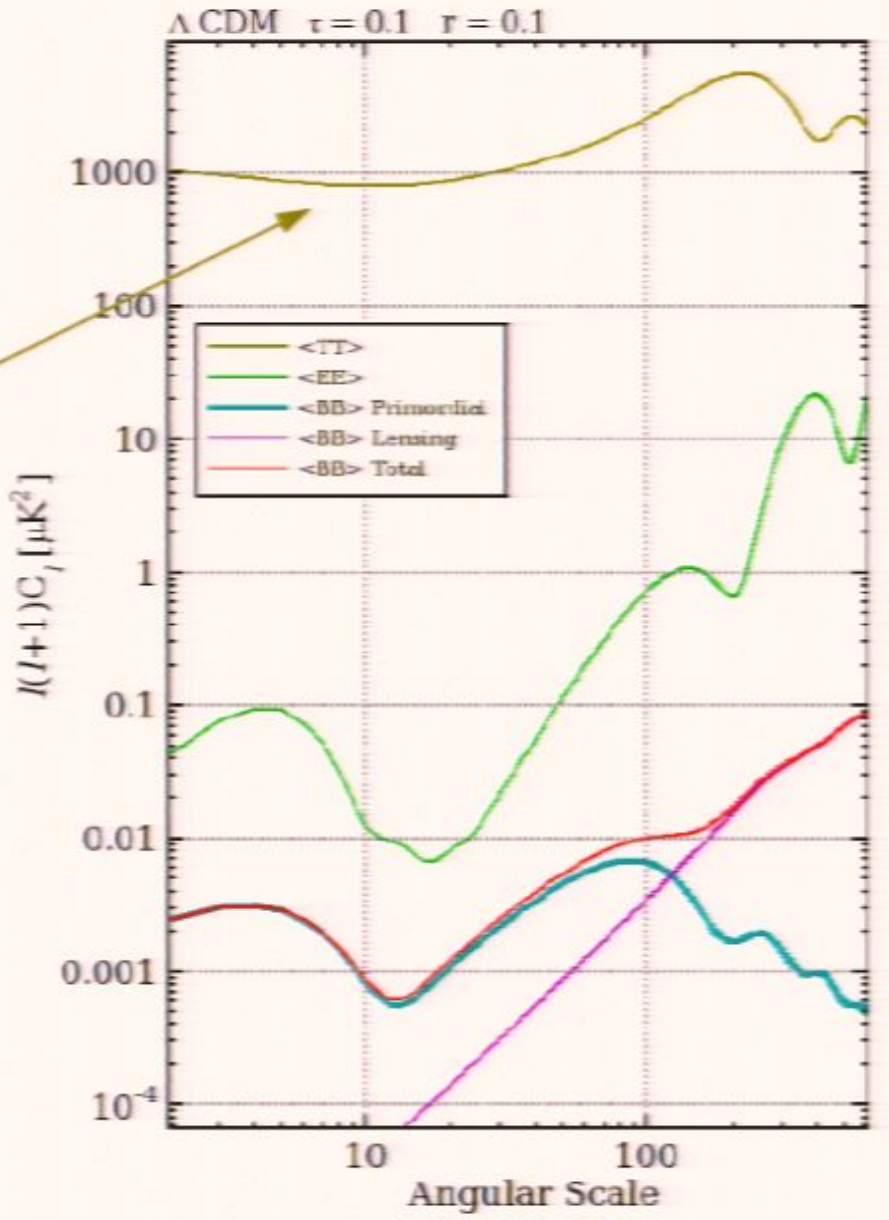


Challenges

<TT> greater than <BB>

Must minimize

I-QU Mixing



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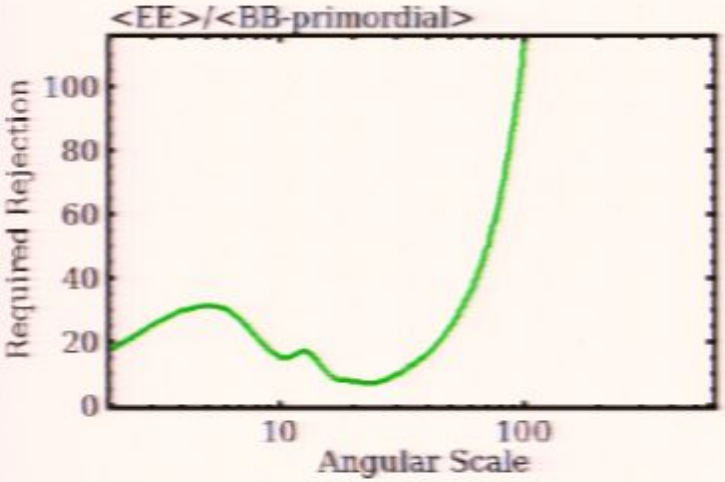
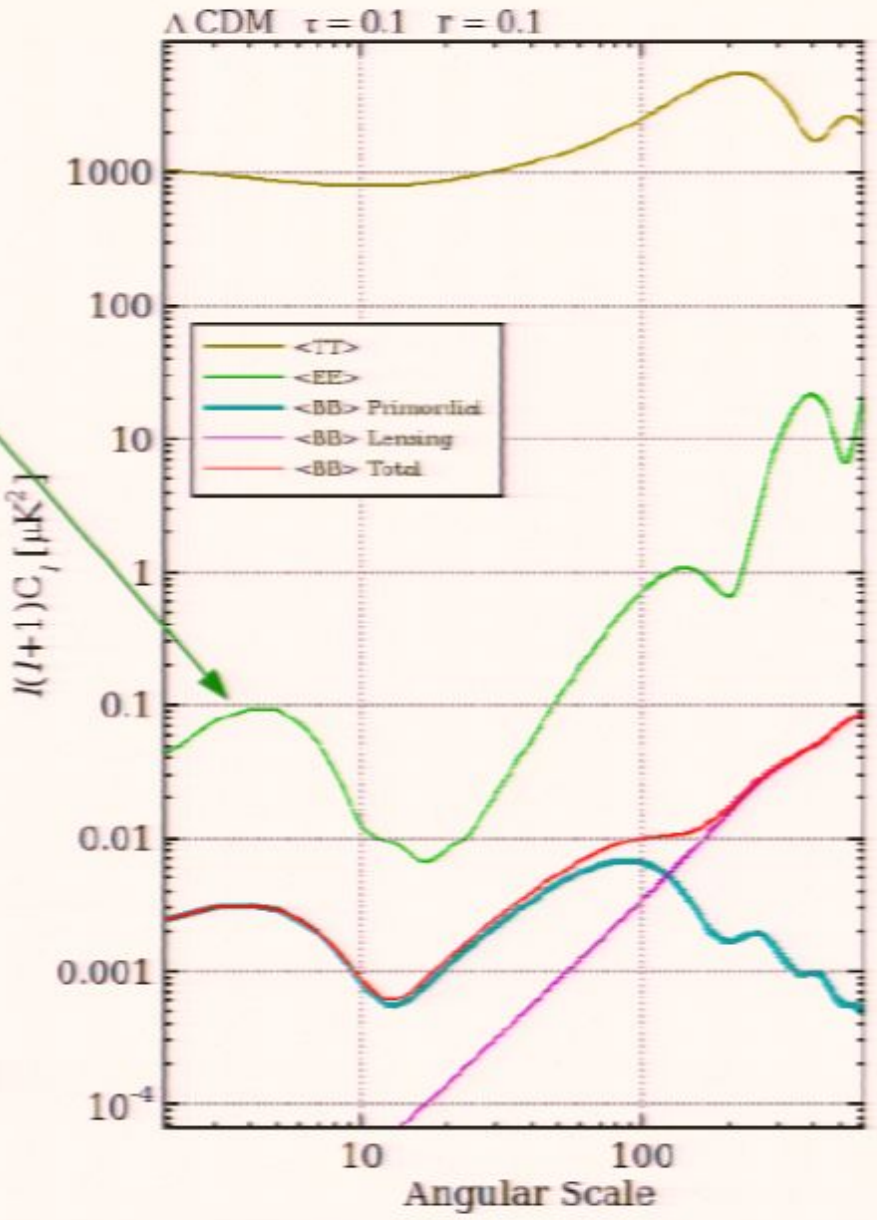
Must minimize

E-B Mixing



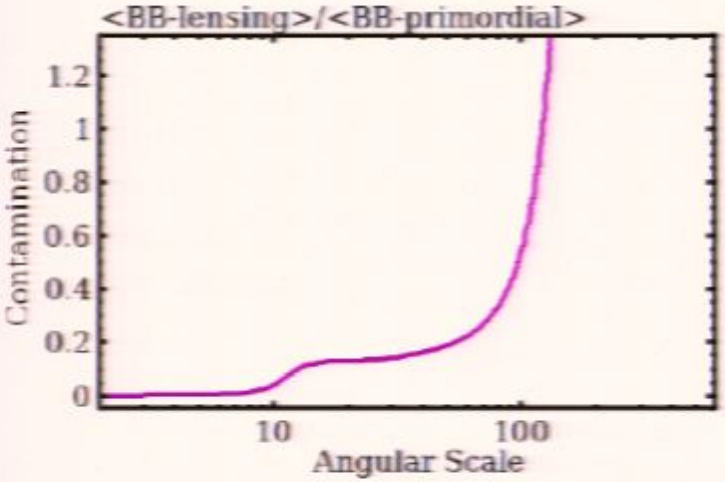
Becomes harder above l~100



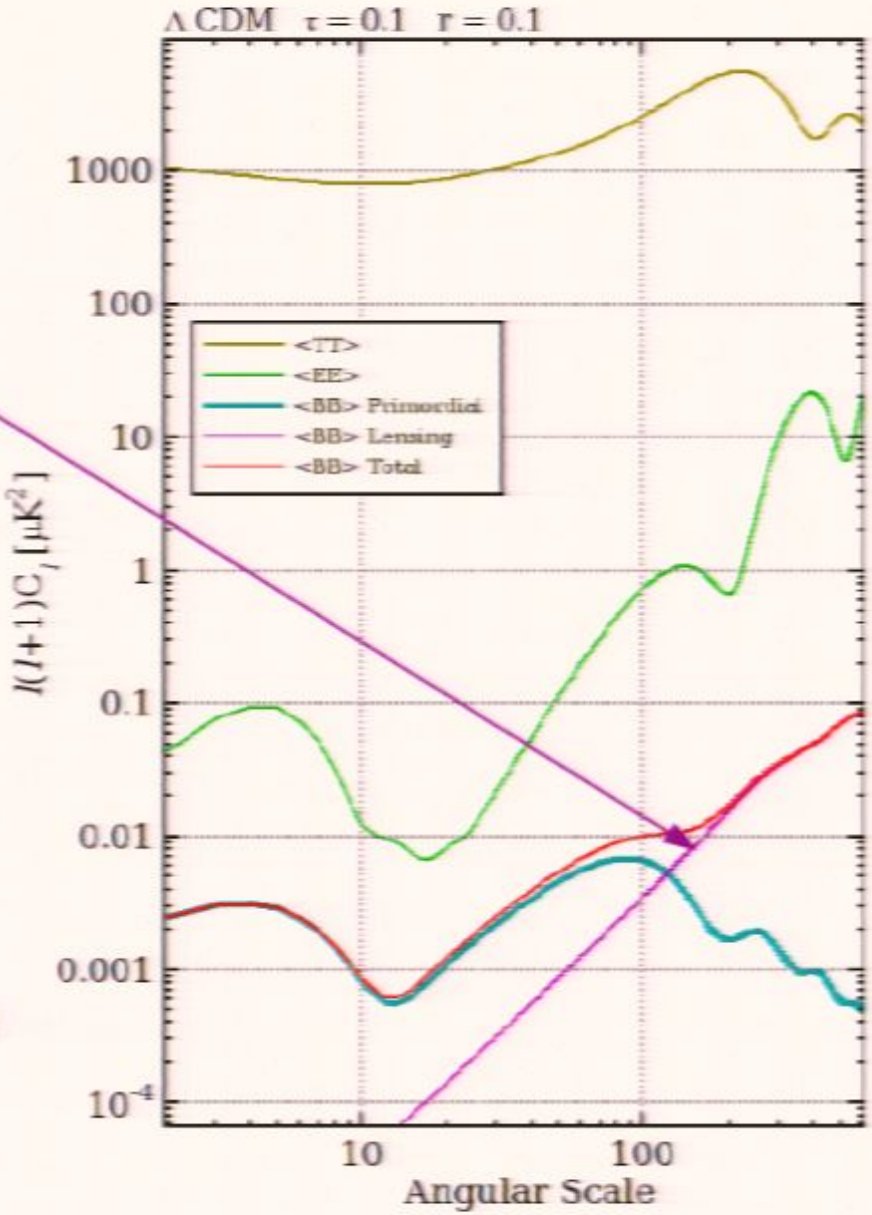
Challenges

Avoid Lensing <BB>

Must observe
large angular scales



Minimum contamination l<10
For r~0.1, l<80 OK



Challenges

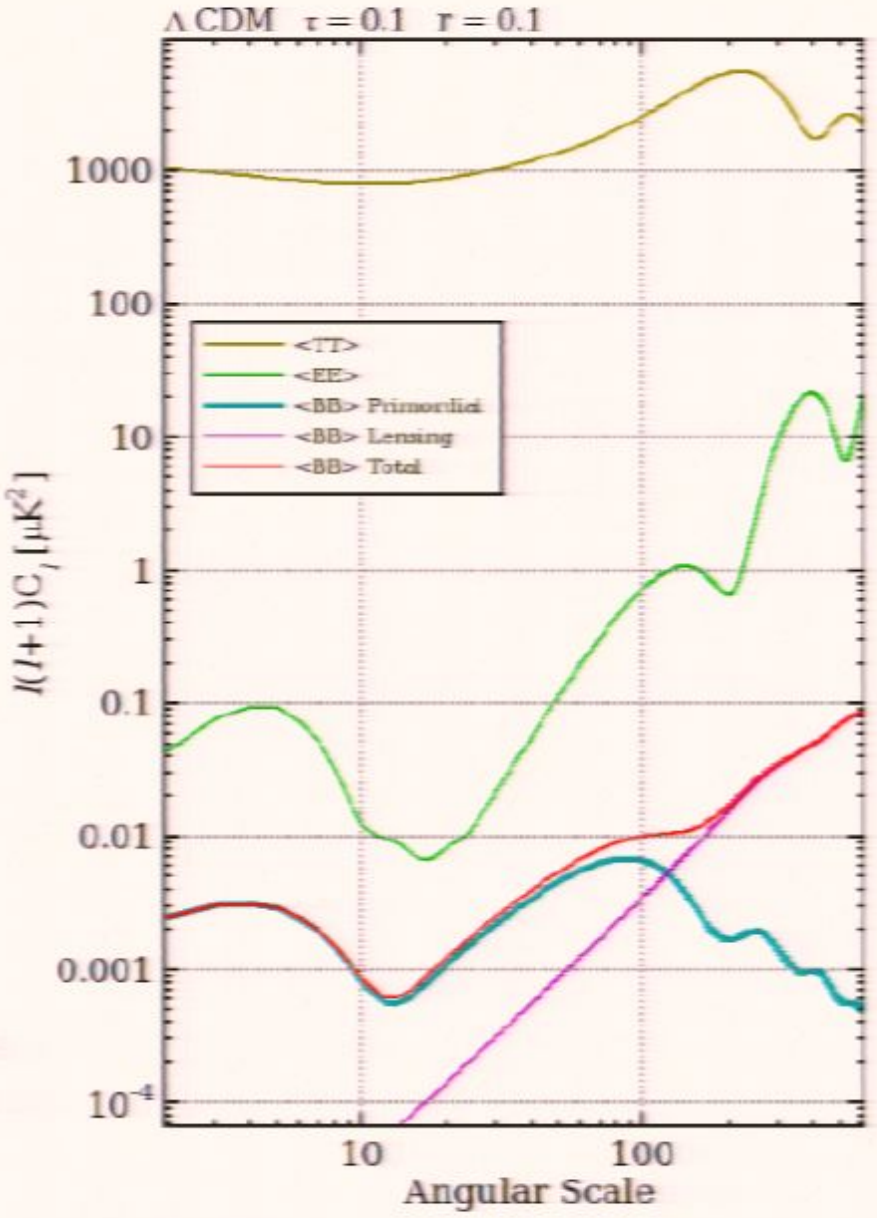
Avoid Lensing <BB>
- Must observe
- large angular scales

<TT> greater than <BB>
- Must minimize
- I to Q&U Mixing

<EE> greater than <BB>
- Must minimize
- E to B mode mixing

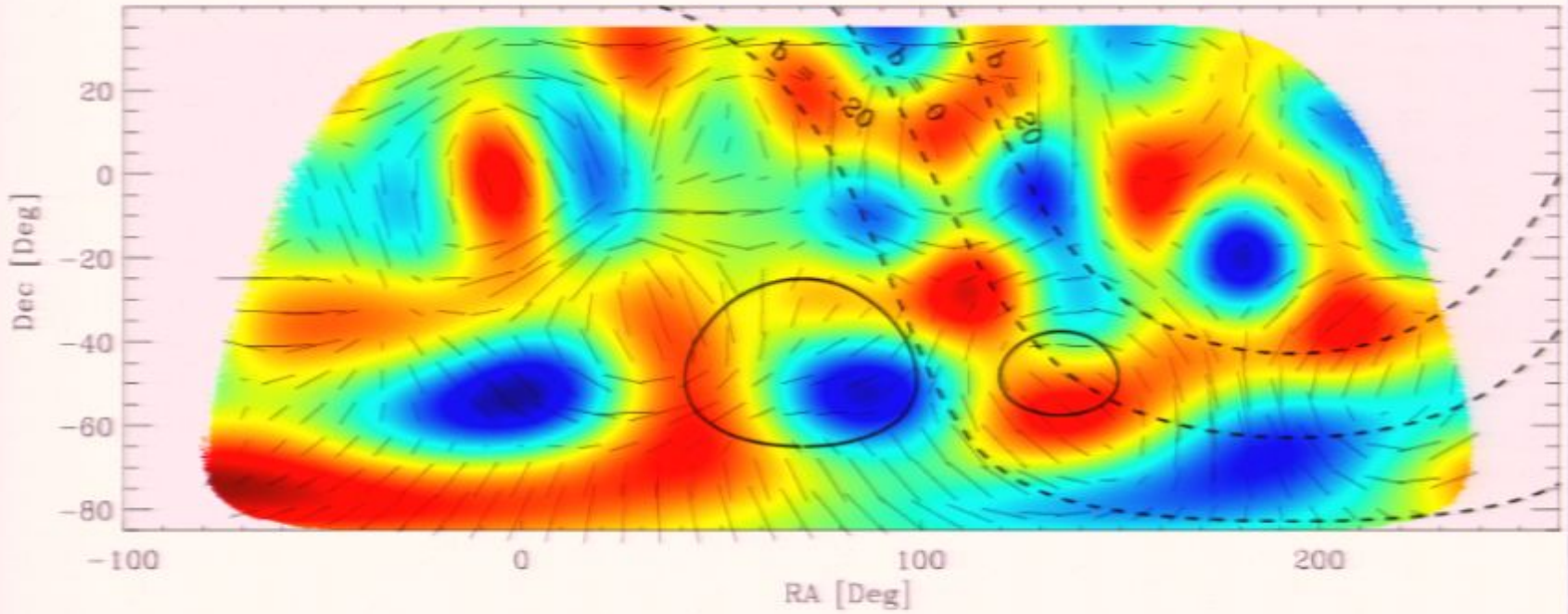
Signal is very small
- Need unprecedented
- sensitivity

Spider will observe Large Angular Scales with more than 2000 Bolometers behind a post-optics half wave plate.



Simulated Spider Polarization Map

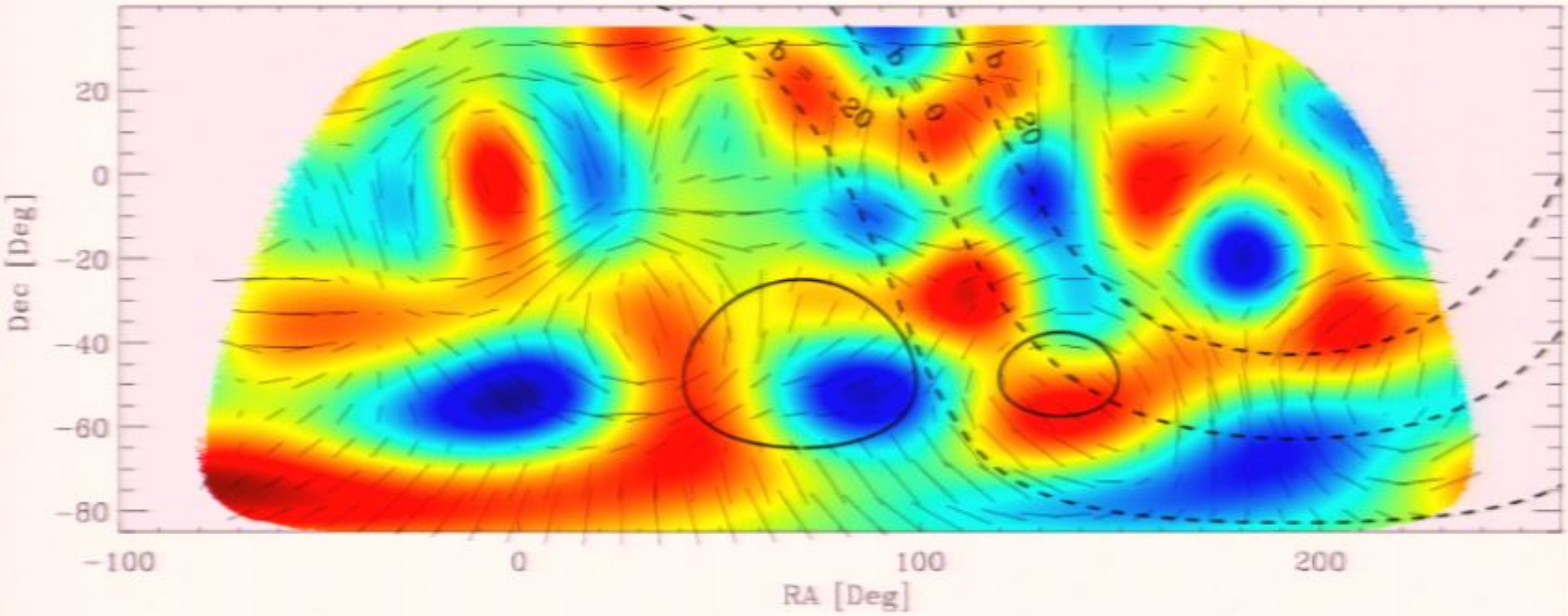
Without B-modes



[Contaldi]

Simulated Spider Polarization Map

With B-modes, r=0.1



[Contaldi]

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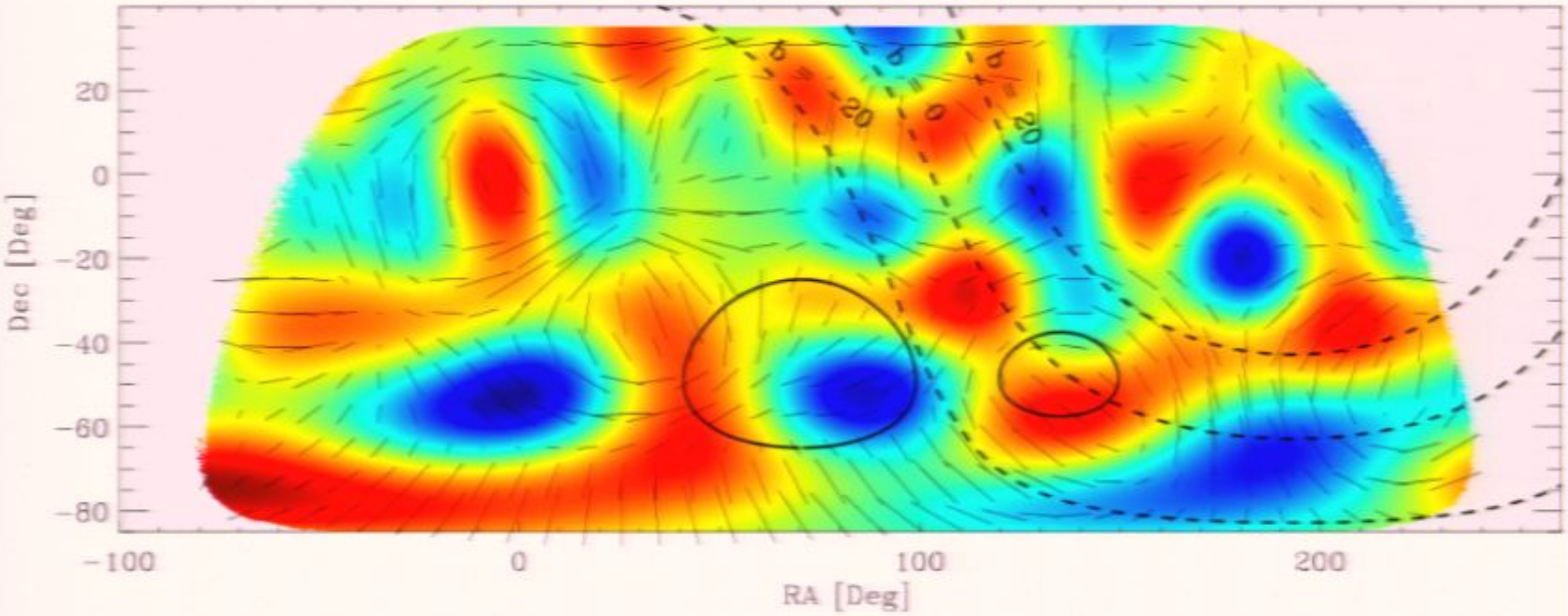

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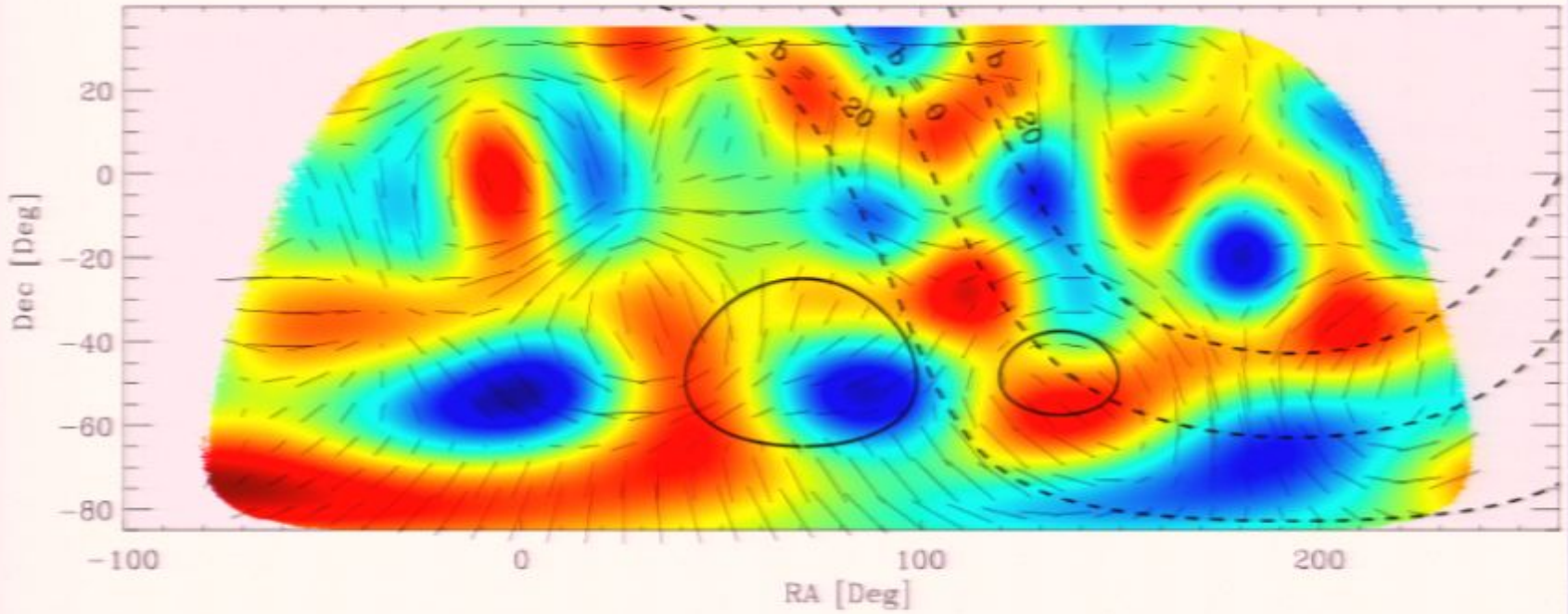

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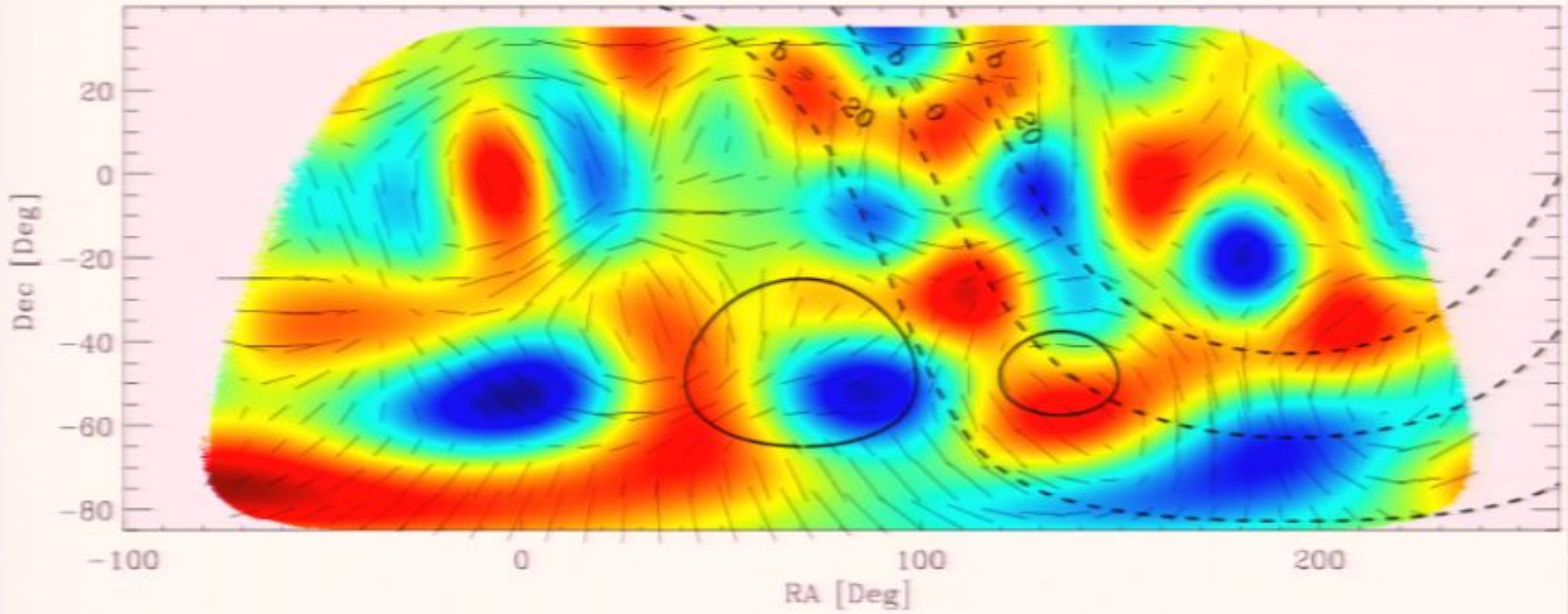

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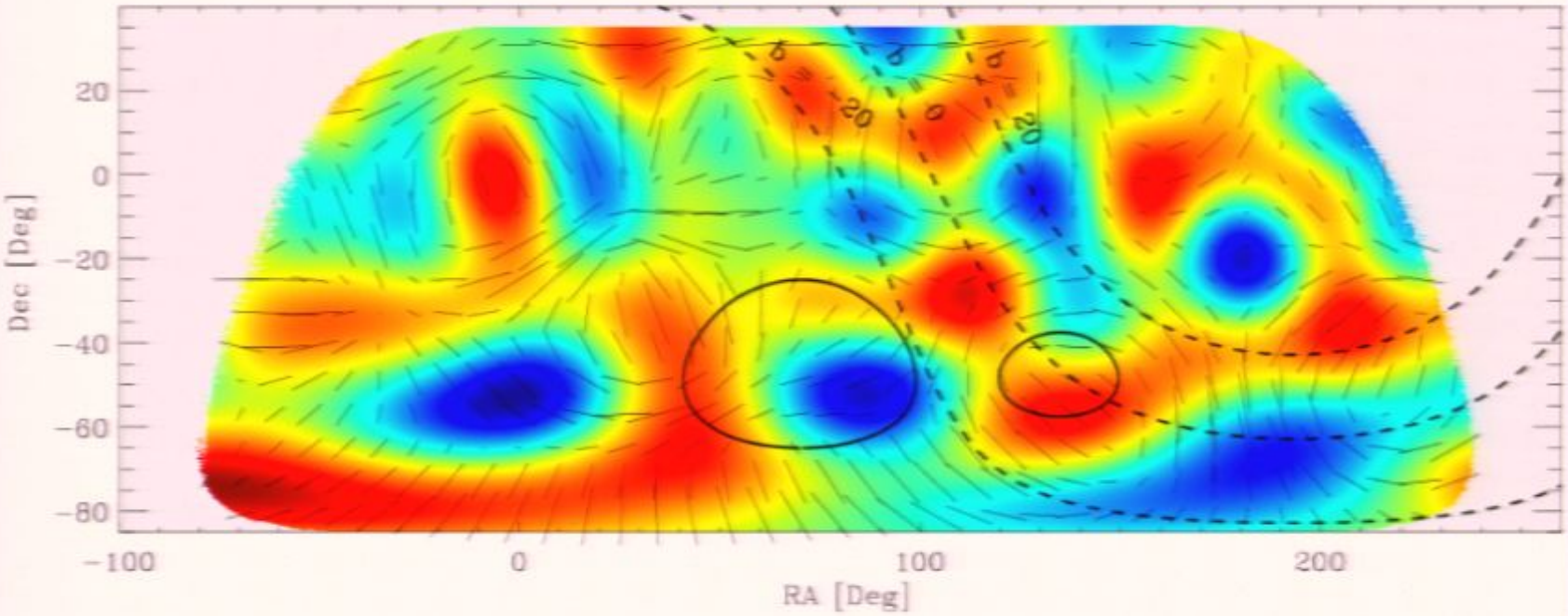

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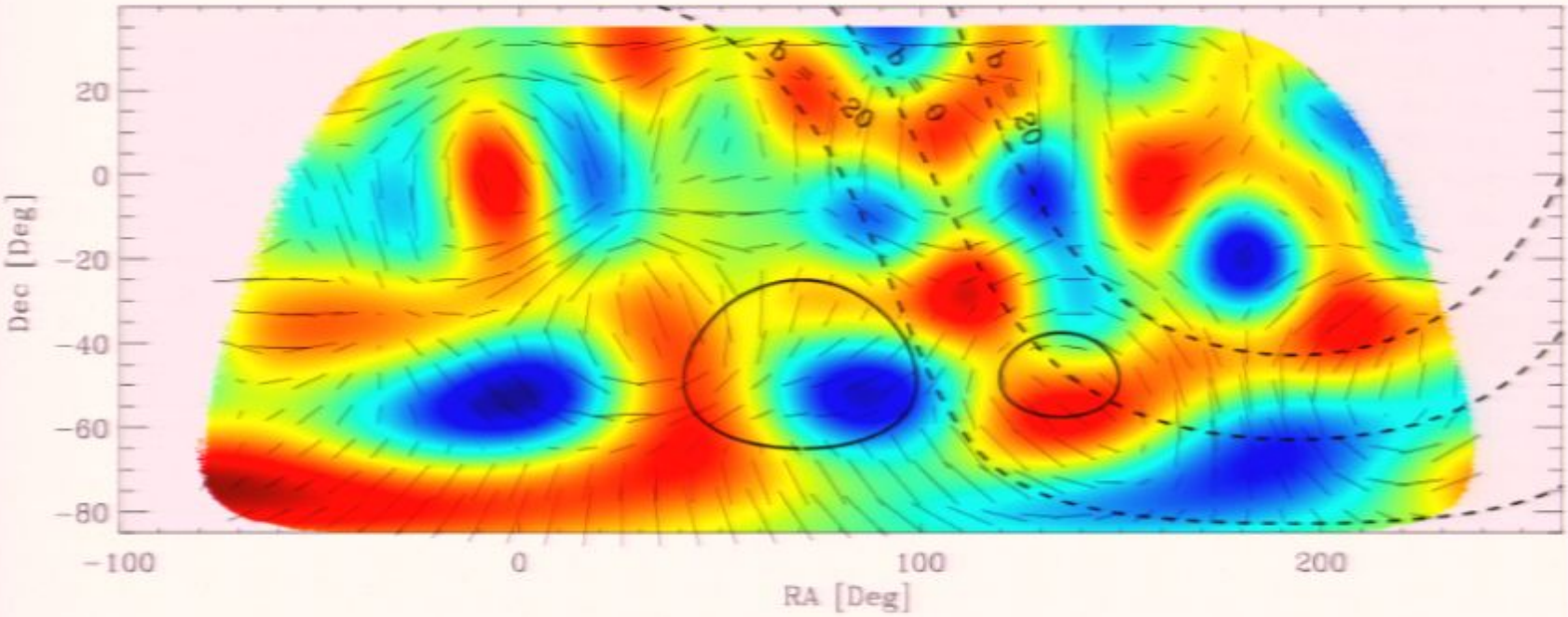

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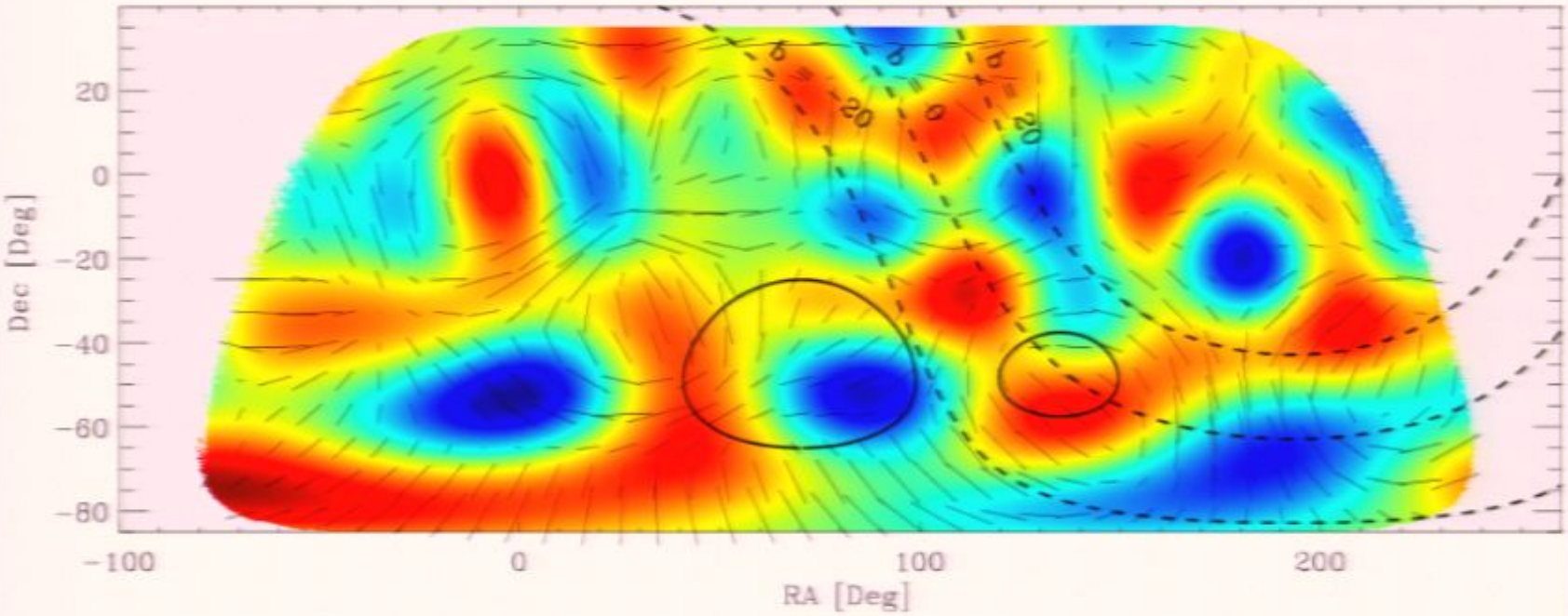

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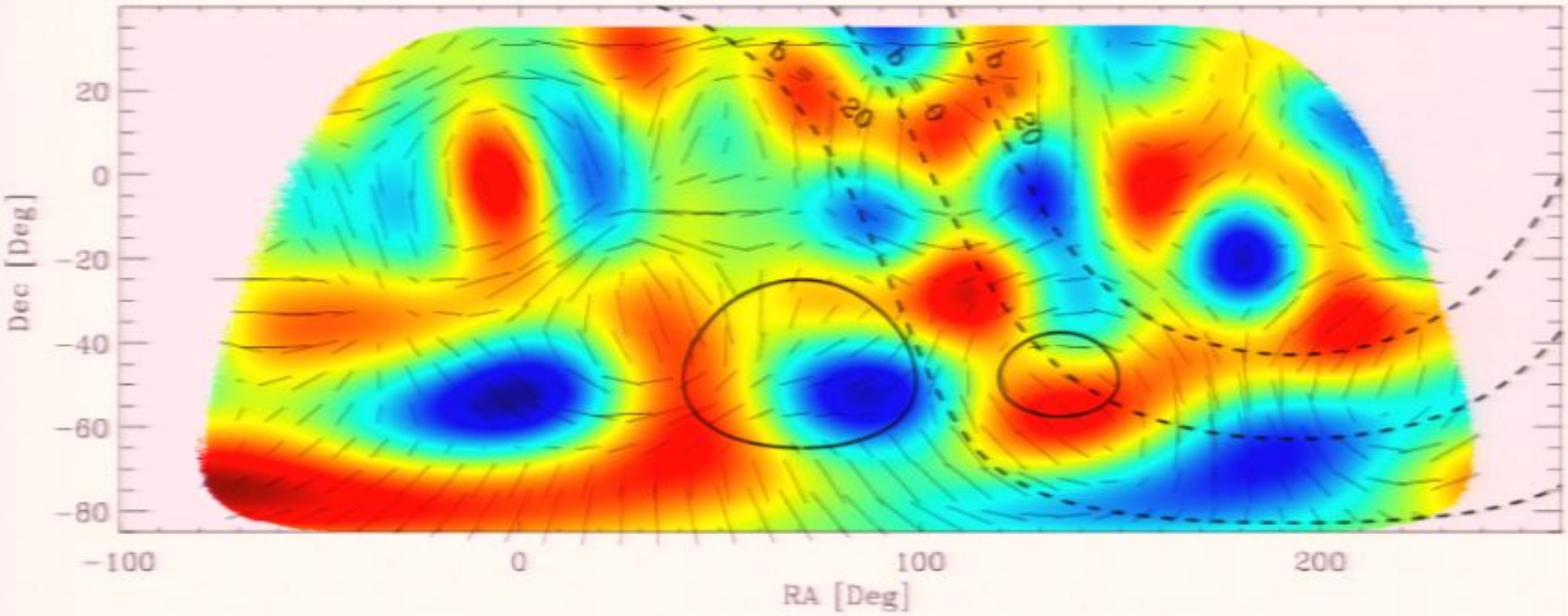

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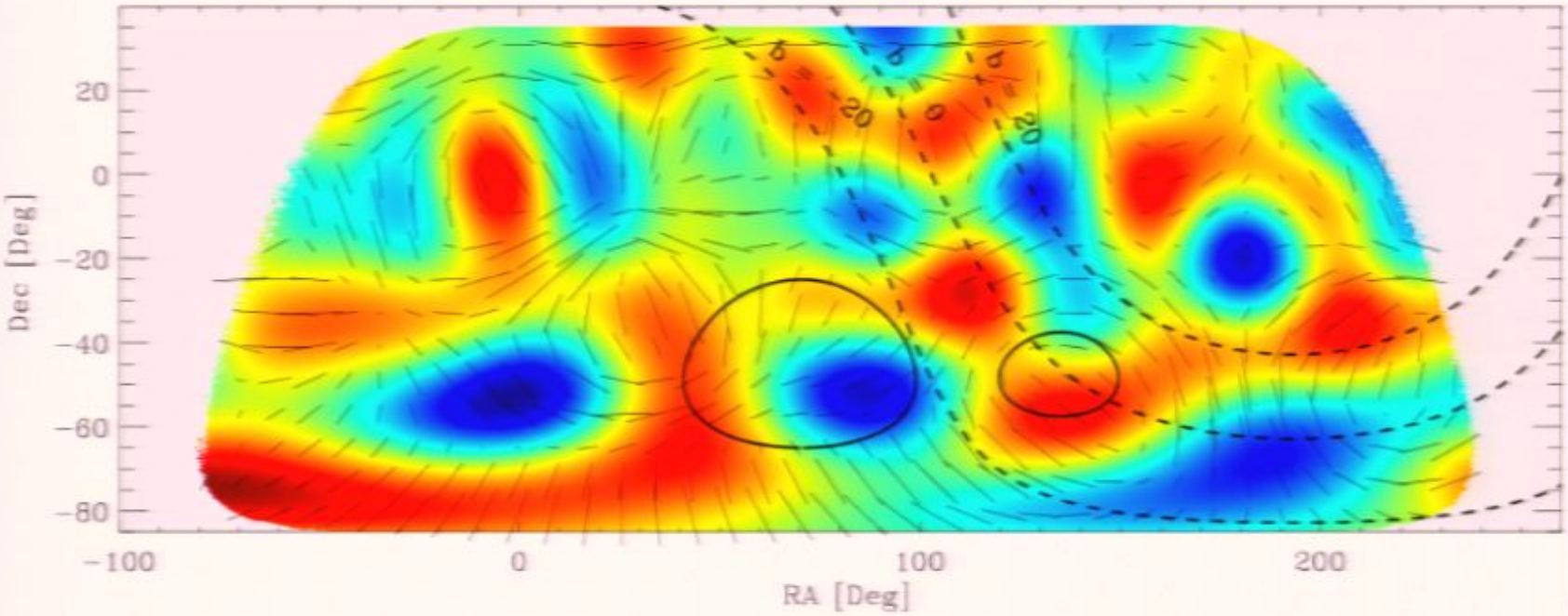


[Contaldi]

More Challenges

Polarized Synchrotron radiation dominates at low frequencies

It must be removed

Polarized dust emission dominates at high frequencies

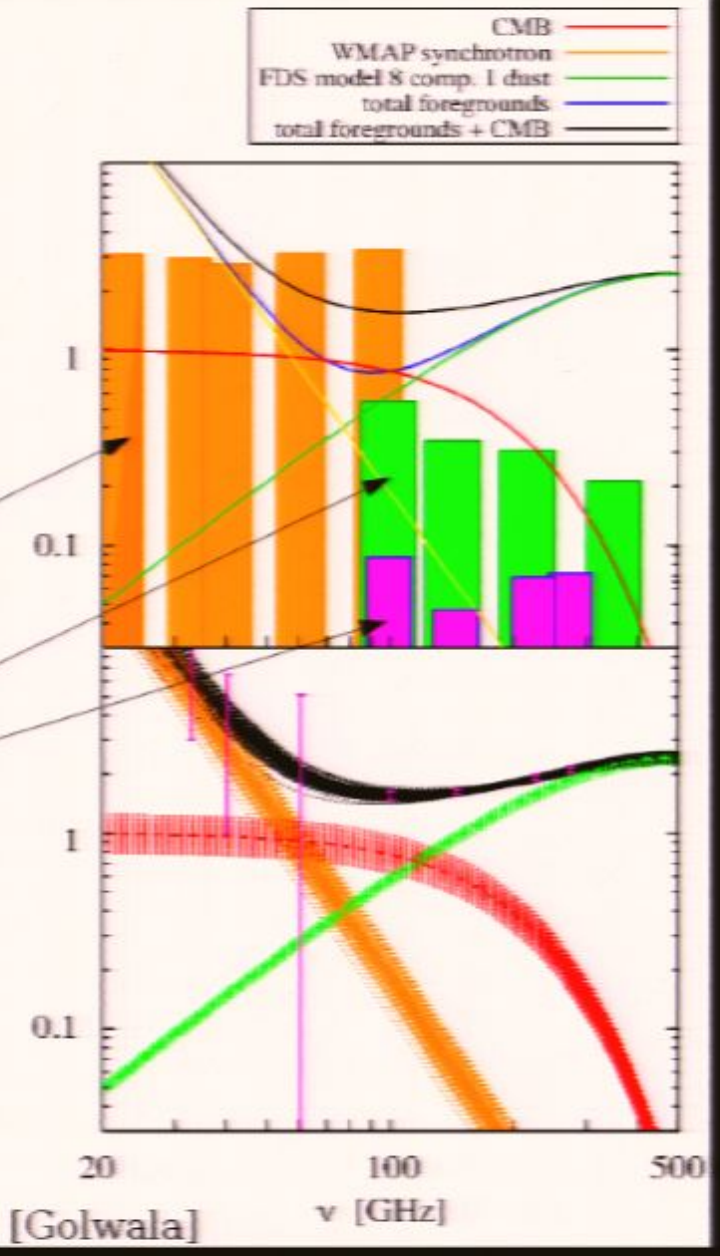
It must be removed

WMAP 8 year sensitivity

Planck HFI sensitivity

Spider Sensitivity

Spider will observe the sky in 4 close spaced frequency bins between 90 GHz and 300 GHz



[Golwala]

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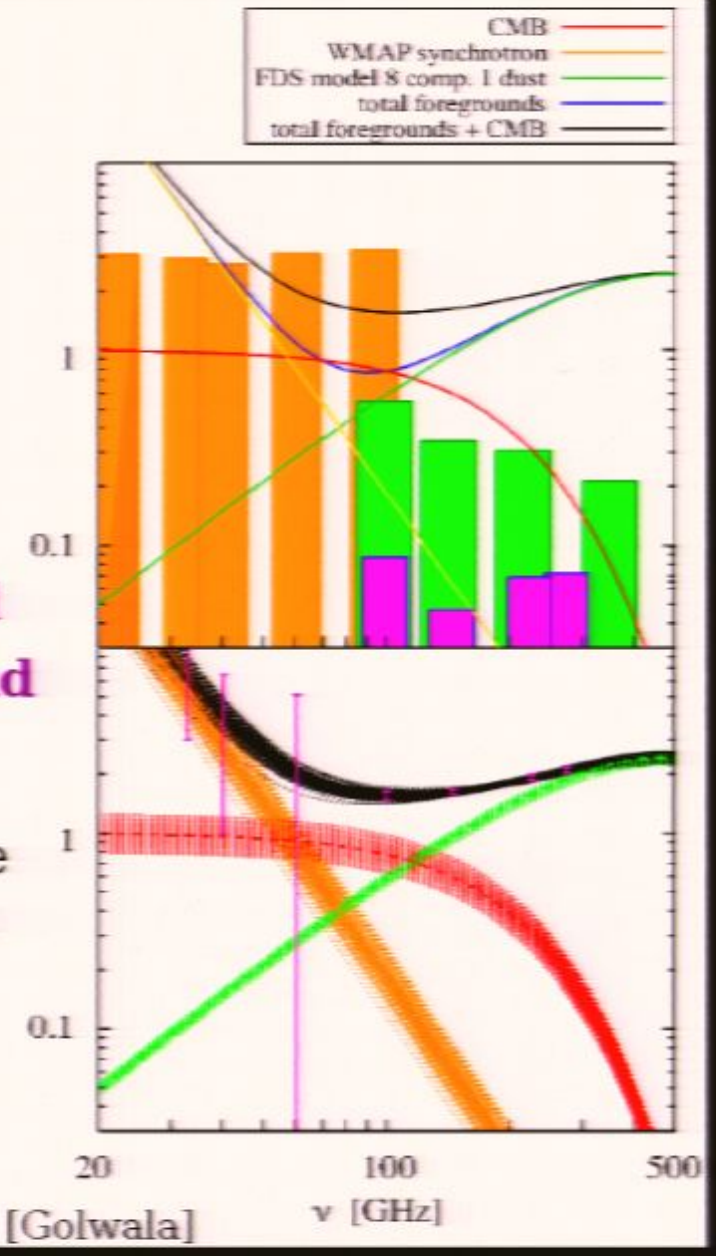
Monte Carlo analysis:

at r ~ 0.1, T_{cmb} can be recovered even with pessimistic foreground estimates!

By choosing a cleaner than average part of the sky, Spider will do even better!

Spider will observe the sky in 4 close spaced frequency bins between 90 GHz and 300 GHz



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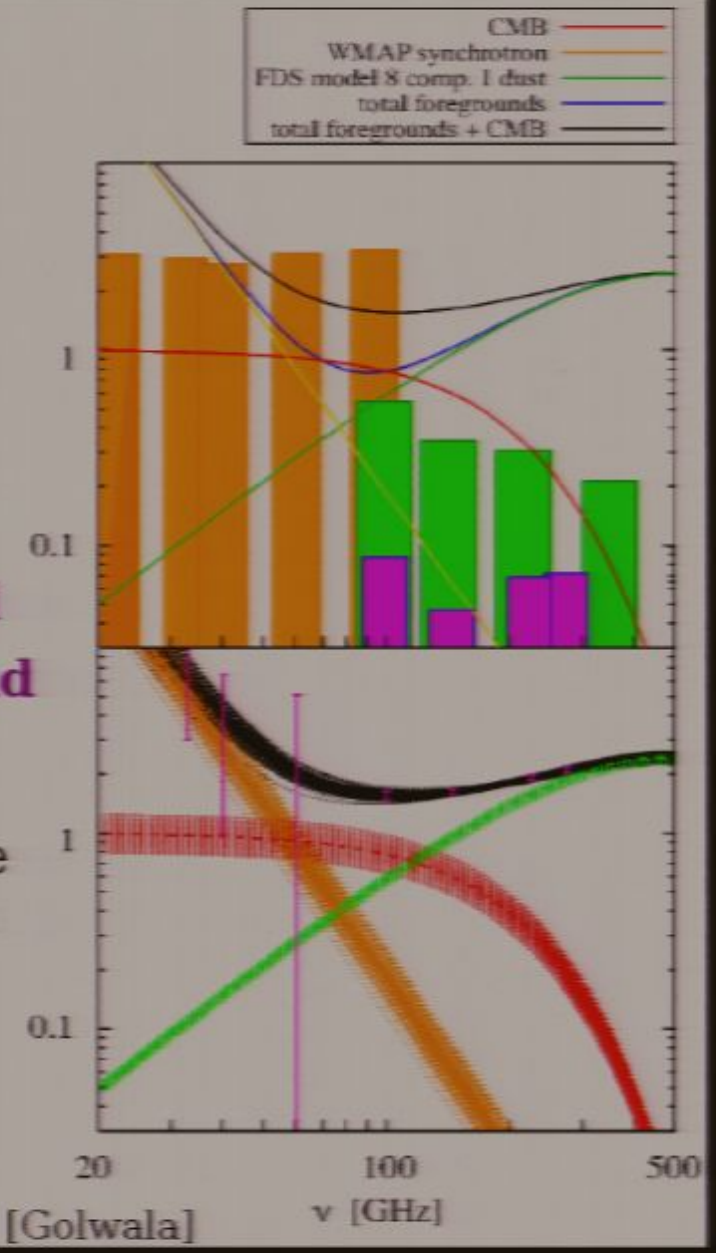

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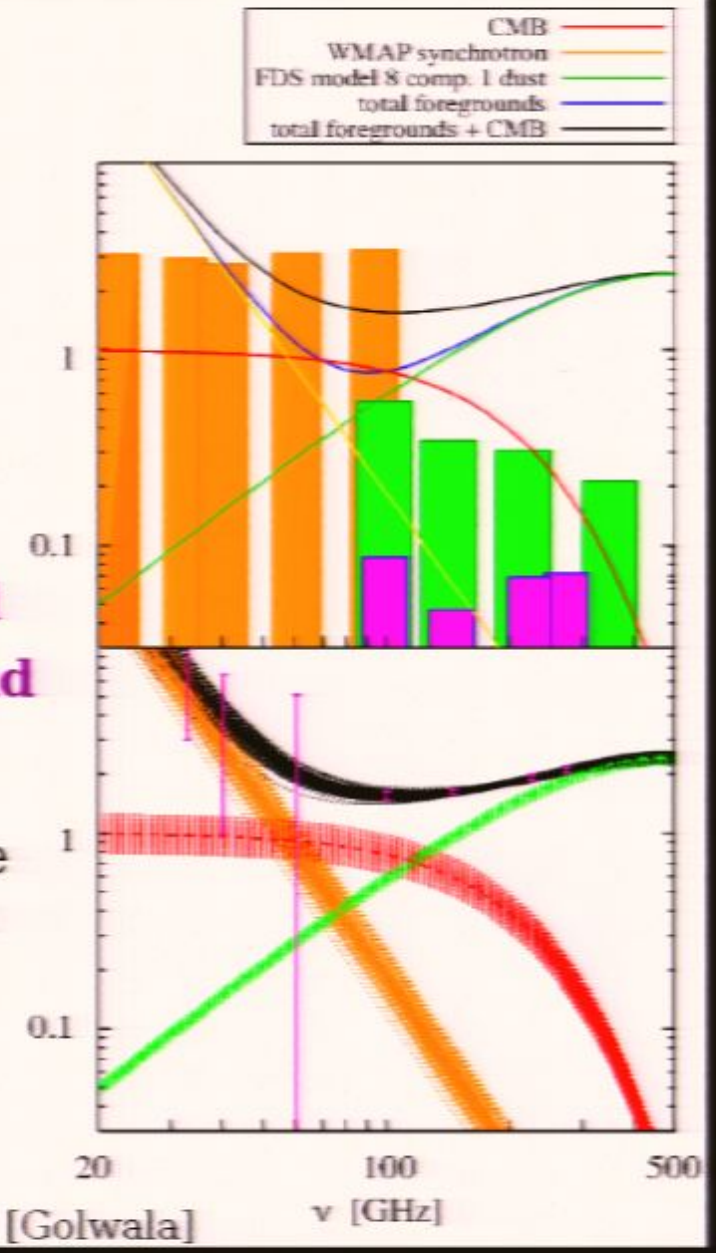


[Golwala]

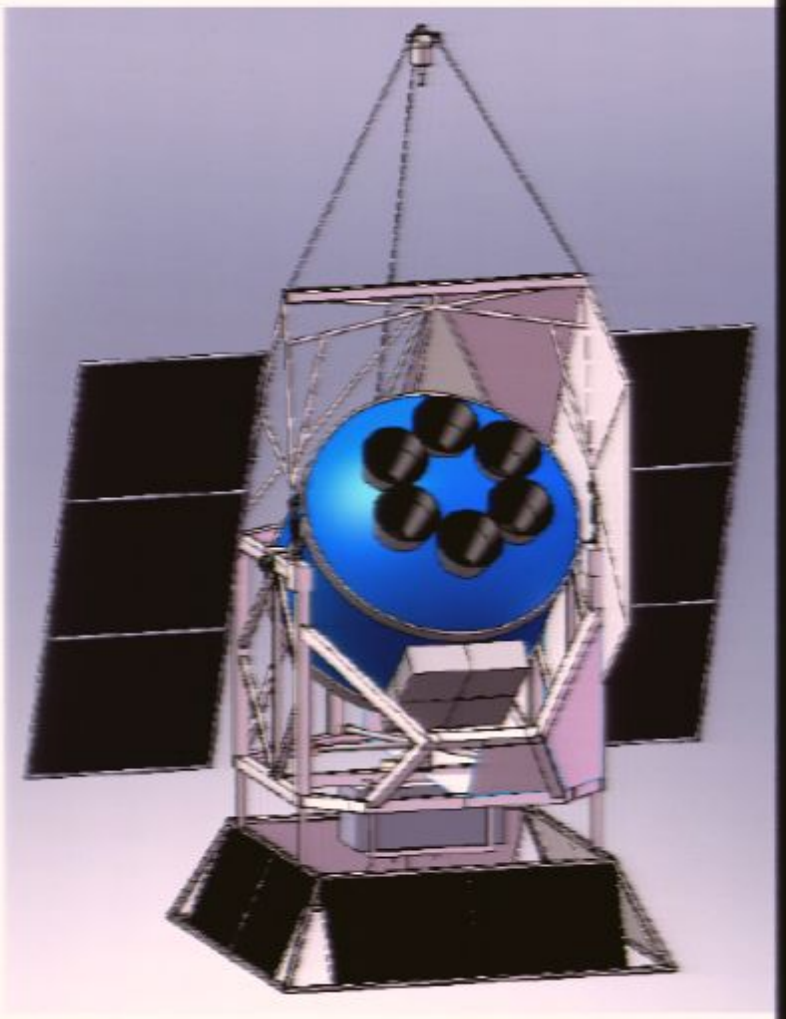
Spider Architecture

Balloon Borne
30 day balloon flights

Six single frequency telescopes
each with its own half wave plate

Each focal plane uses polarization sensitive **antenna coupled bolometers**

Two Scan modes:
Rotate in azimuth, mapping ~50% of the sky each night from Australia
or
Scan in Azimuth
mapping 8% of the sky each day from Antarctica



[T. Martin]

Stratospheric Balloons

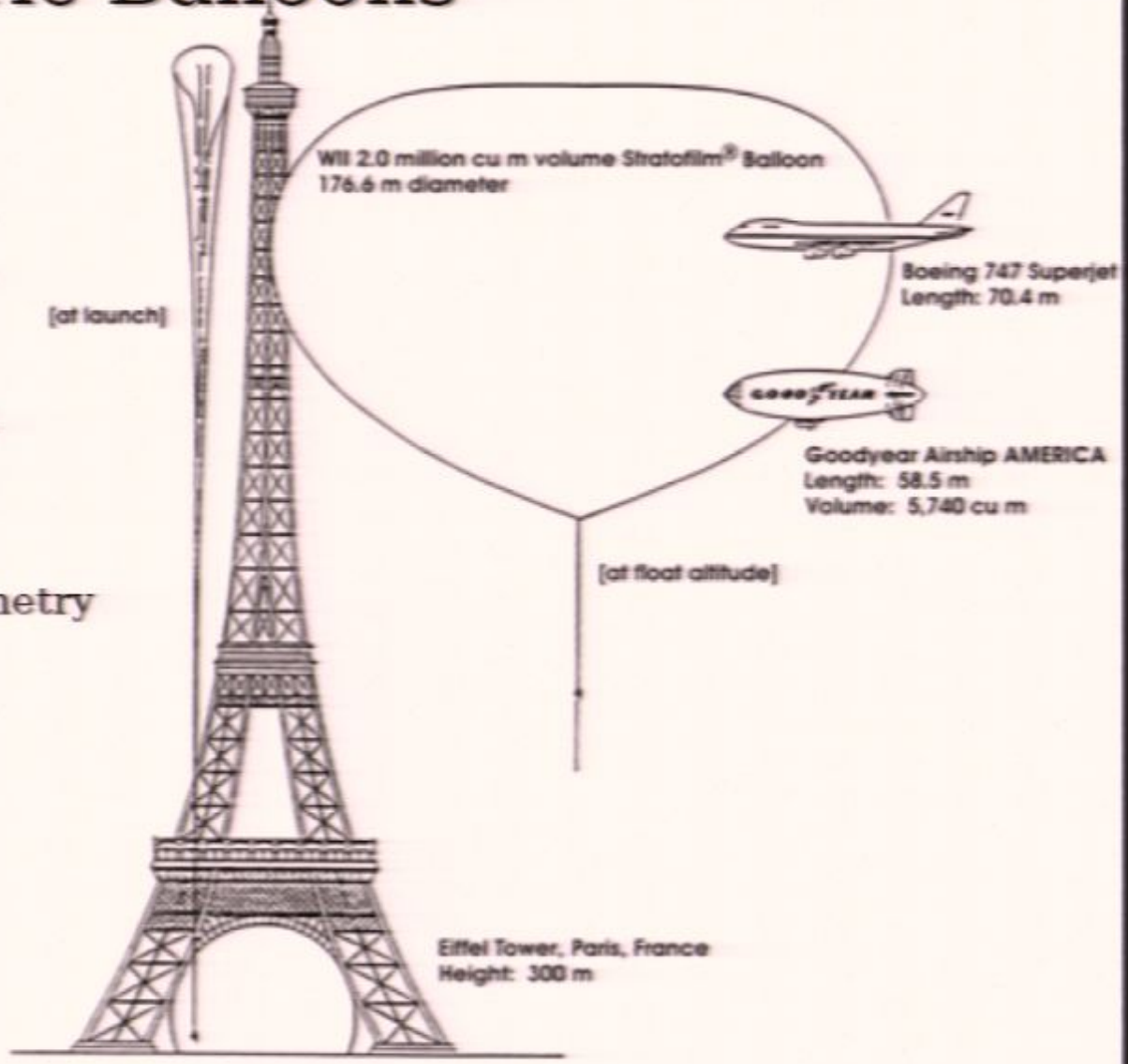
38km altitude

1800kg payloads

Flights up to 42 days

Launches from
McMurdo, Antarctica,
Alice Springs, NM,
Kiruna, Sweden.

Near continuous telemetry

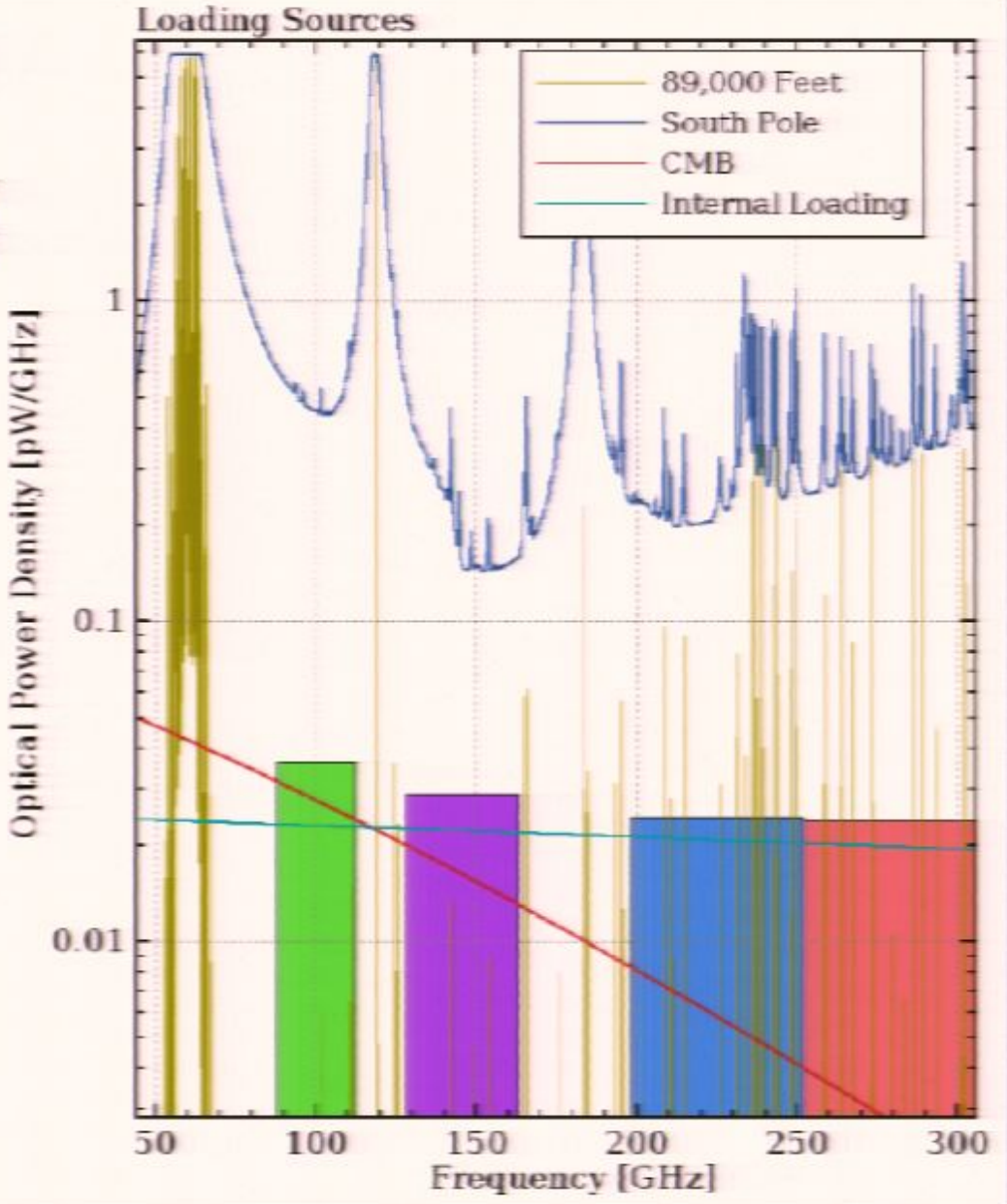


The Ballooning

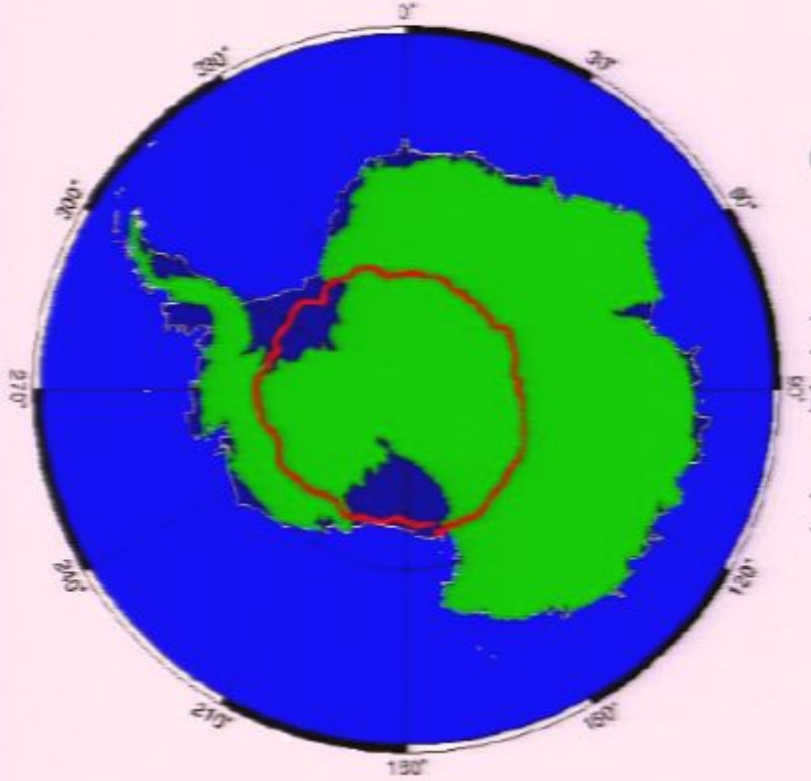
Atmospheric loading below 0.1% in all Spider bands at balloon altitudes.

Provides

- Lower noise
- Greater stability
- More frequency coverage



Antarctic flights

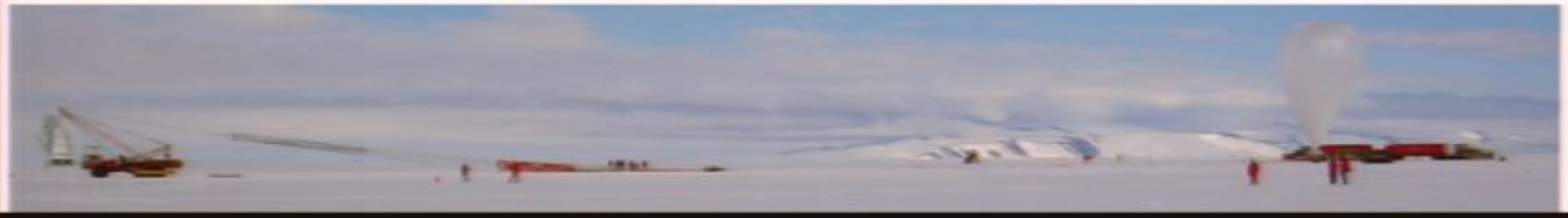


Continuous solar illumination
Minimizes diurnal variations

Flights of 10 to 15 days for one revolution.

Launch window: Dec 10 – Jan 10

BOOMERANG flight: 1998/1999



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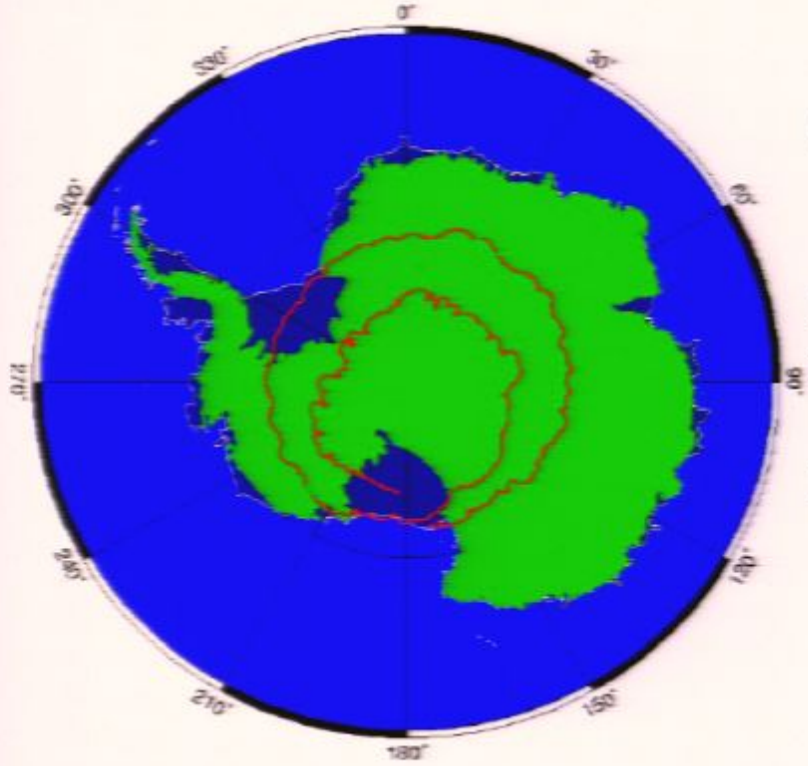


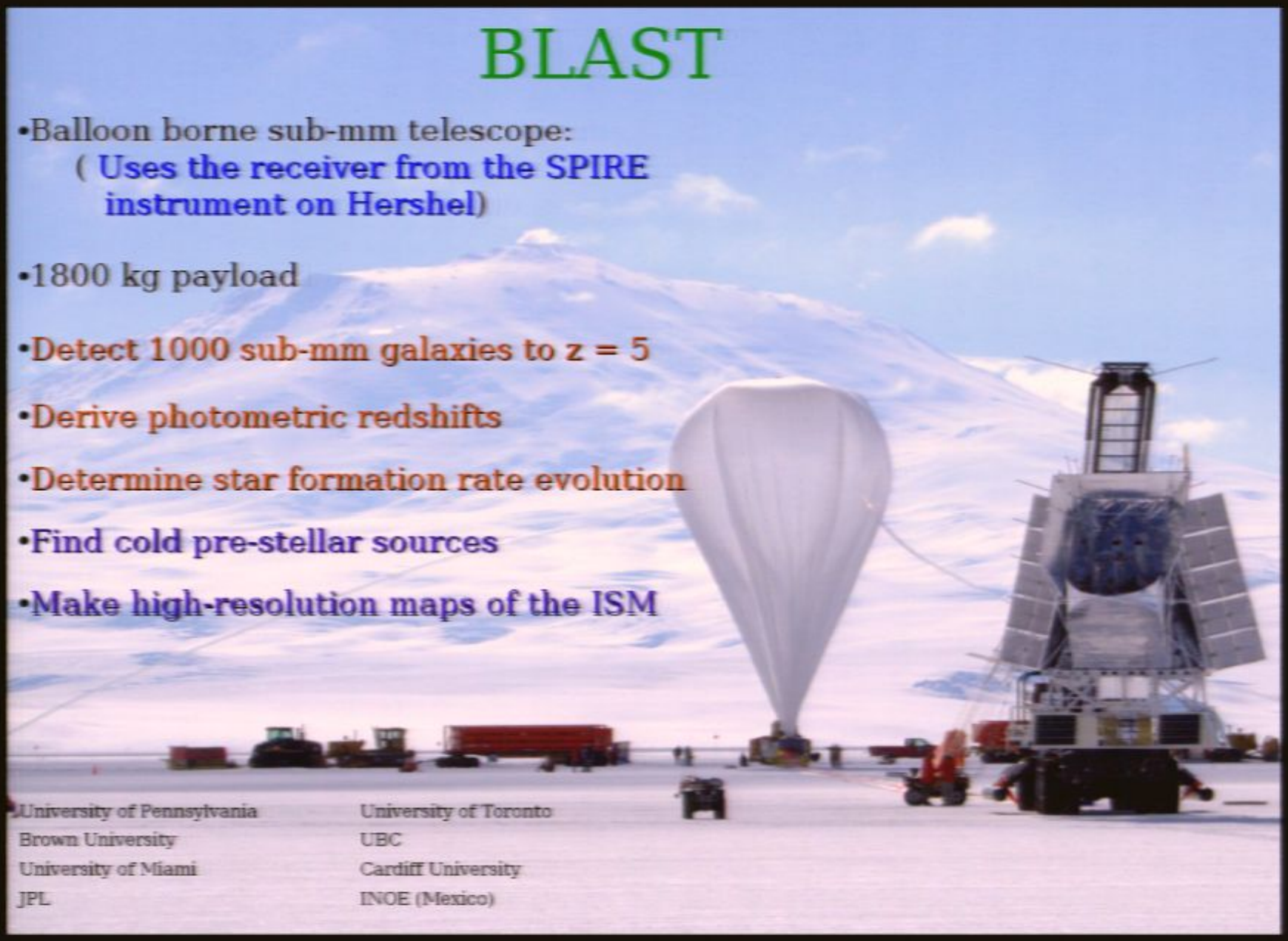
Continuous solar illumination
Minimizes diurnal variations

Flights over 30 days with multiple revolutions now typical.

Launch window: Dec 10 – Jan 10

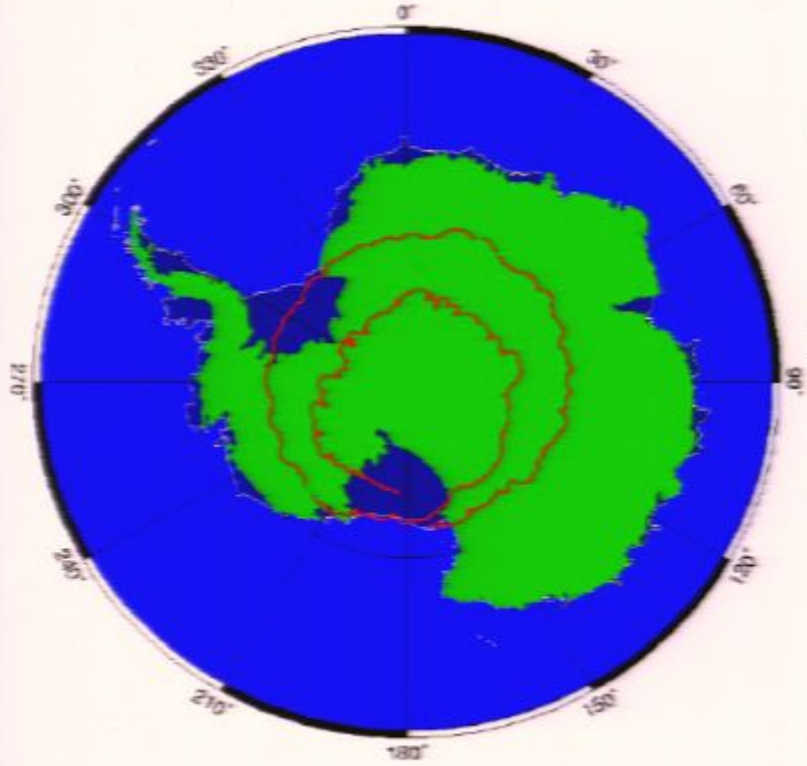
BLAST

- Balloon borne sub-mm telescope:
  (**Uses the receiver from the SPIRE instrument on Hershel**)
- 1800 kg payload
- **Detect 1000 sub-mm galaxies to z = 5**
- **Derive photometric redshifts**
- **Determine star formation rate evolution**
- **Find cold pre-stellar sources**
- **Make high-resolution maps of the ISM**



University of Pennsylvania
Brown University
University of Miami
JPL
University of Toronto
UBC
Cardiff University
INOE (Mexico)

Antarctic flights



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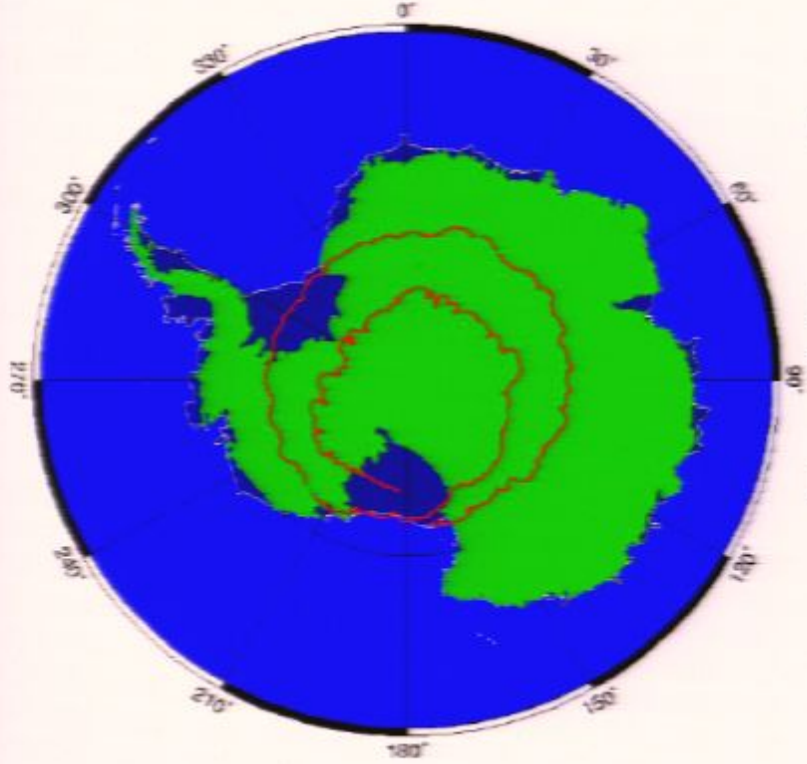

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University of Pennsylvania
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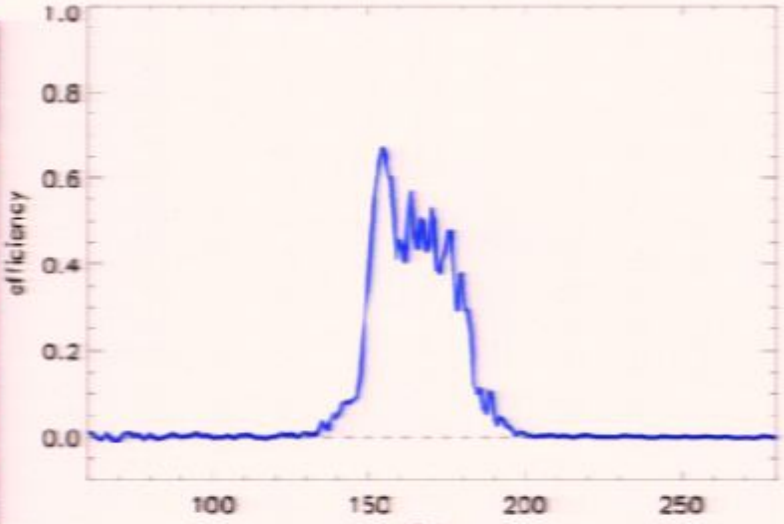
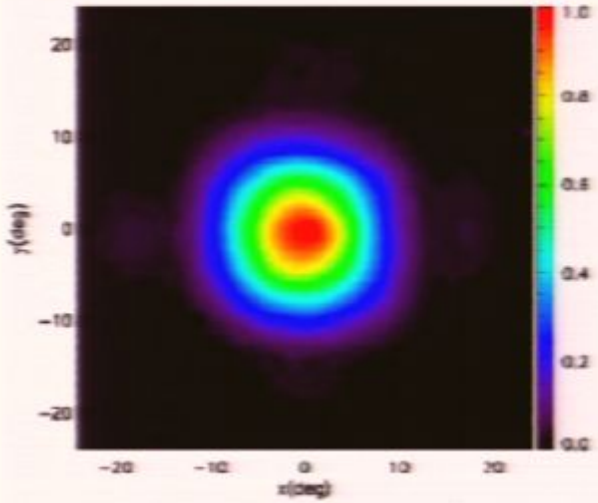
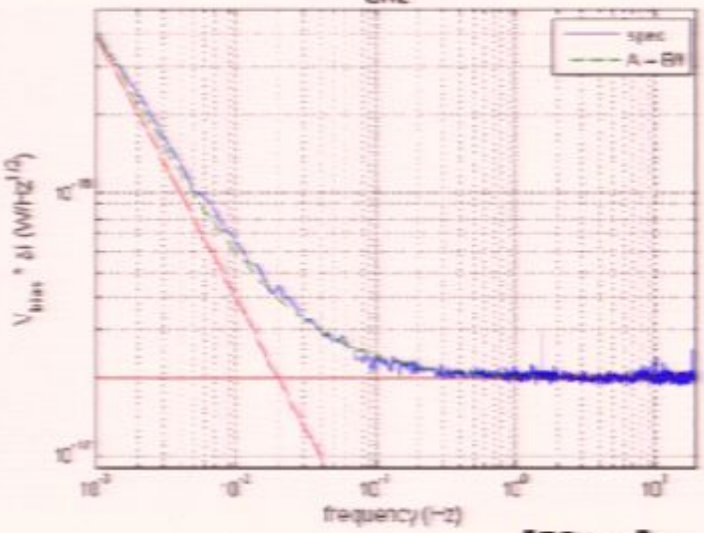
JPL
University of Toronto
UBC
Cardiff University
INOE (Mexico)

Antenna Coupled Bolometers







[Kuo]

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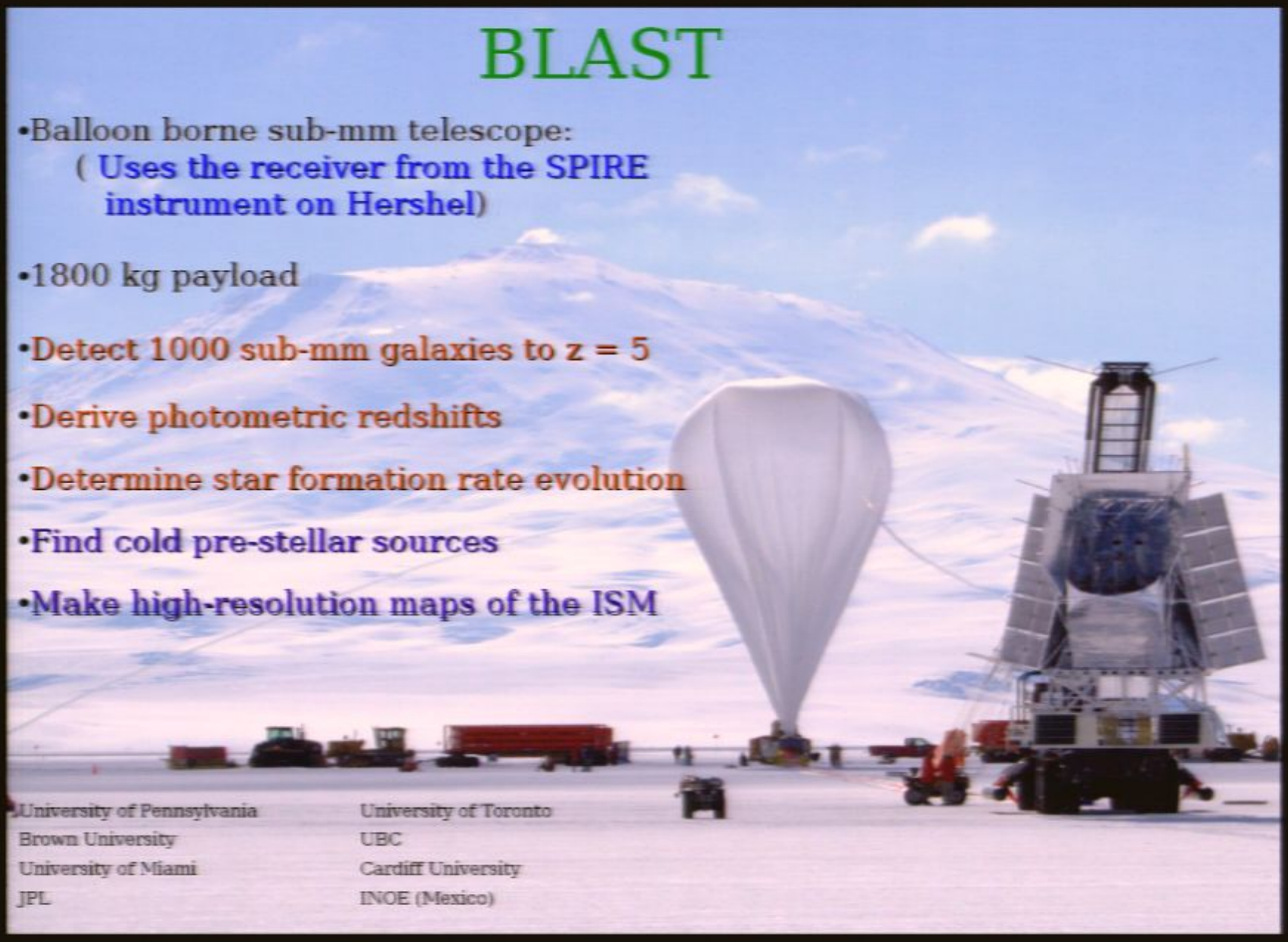

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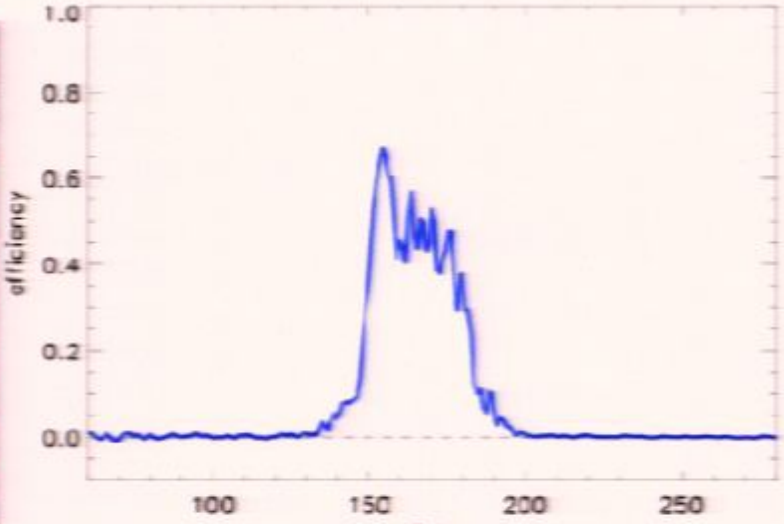
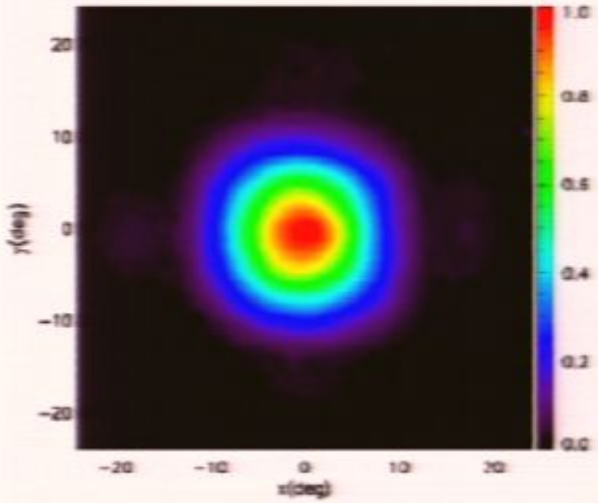
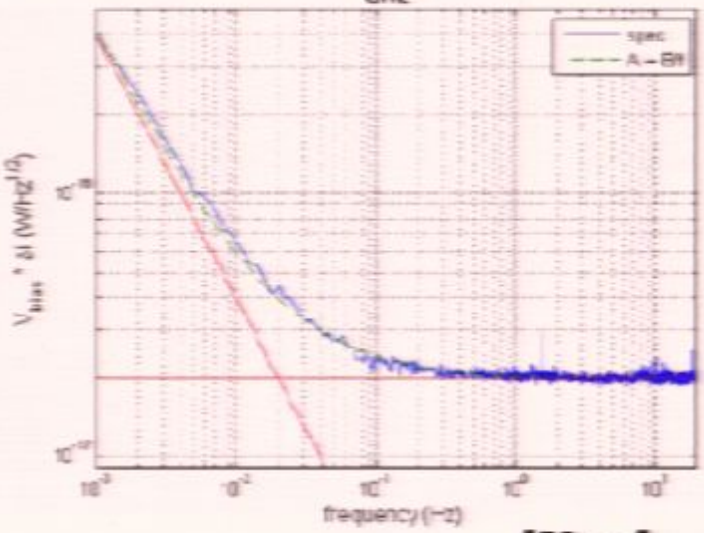


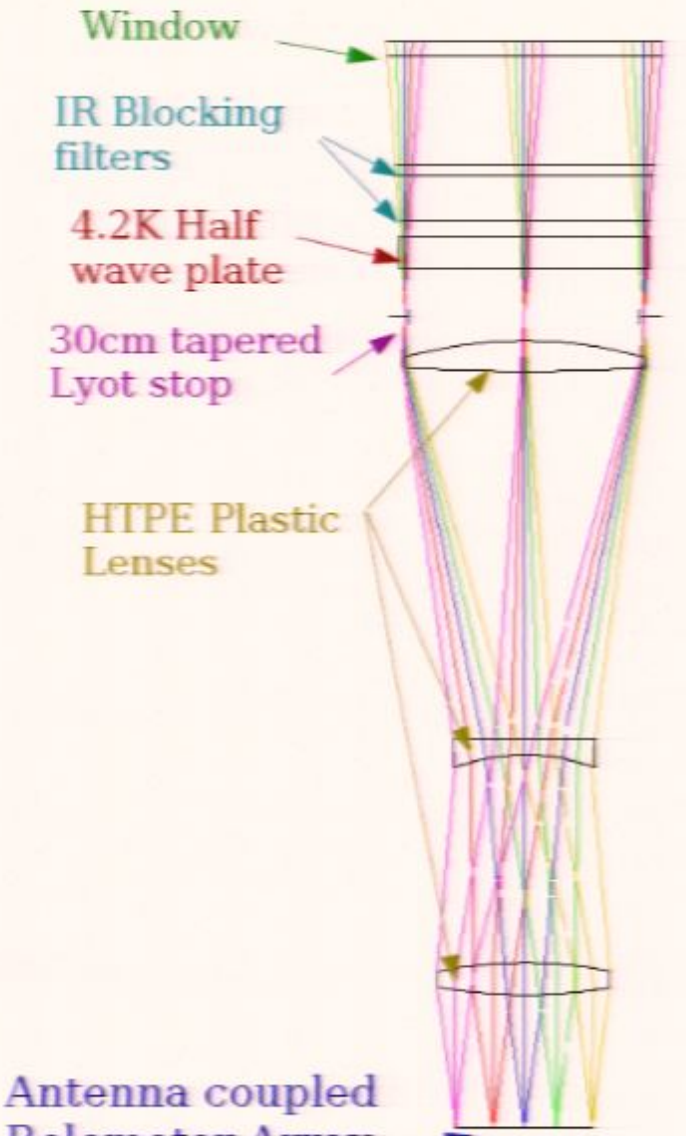




[Kuo]

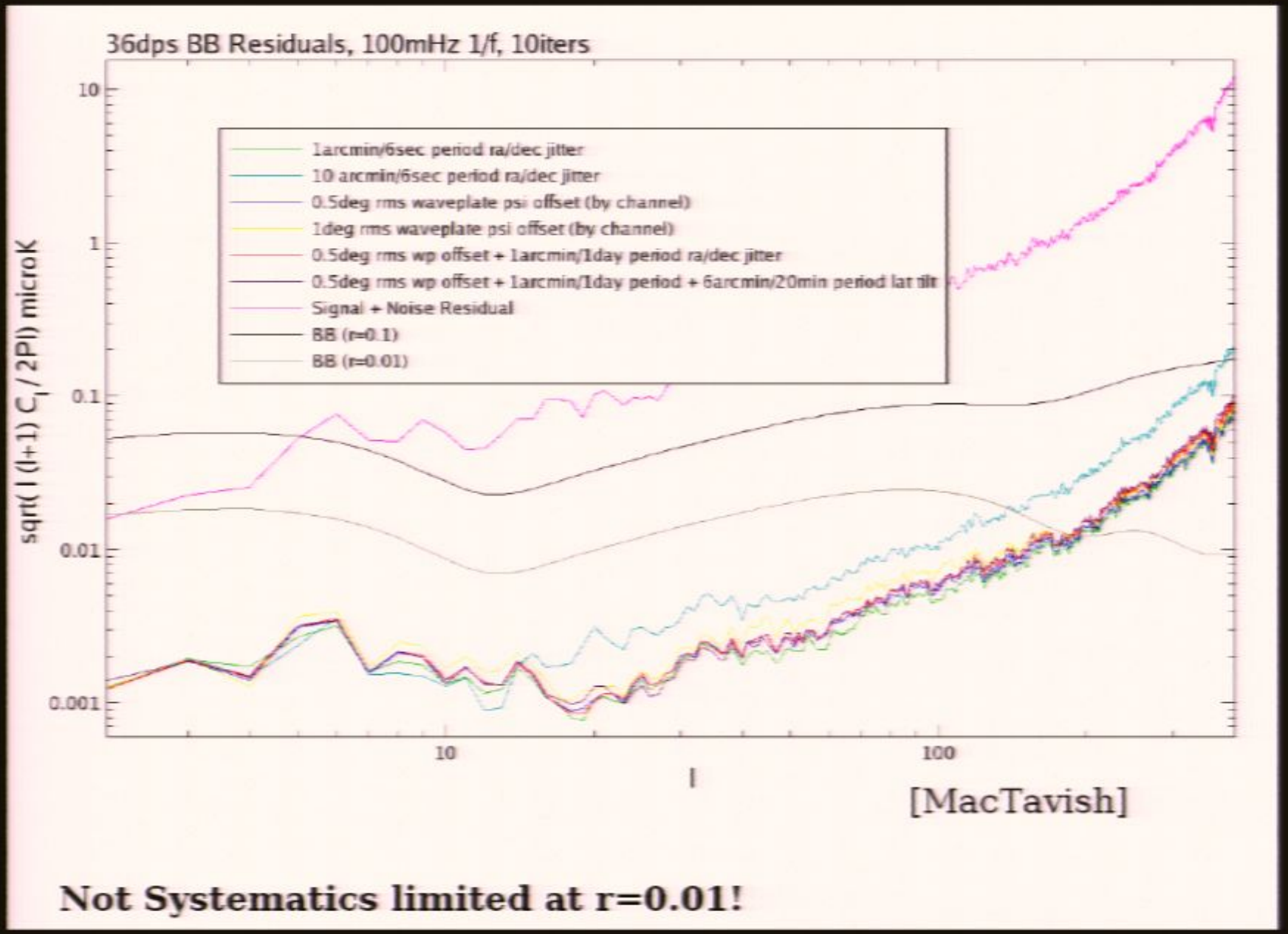
Optics:

- Approach inherited from BICEP
- Un-obstructed optics with minimal loading – CMB photon limited!
- Cold half wave plate location minimizes rotation synchronous systematics
- Optimally symmetric beams
- Baffleable for excellent control of far side lobes
- All optics cold: excellent stability!



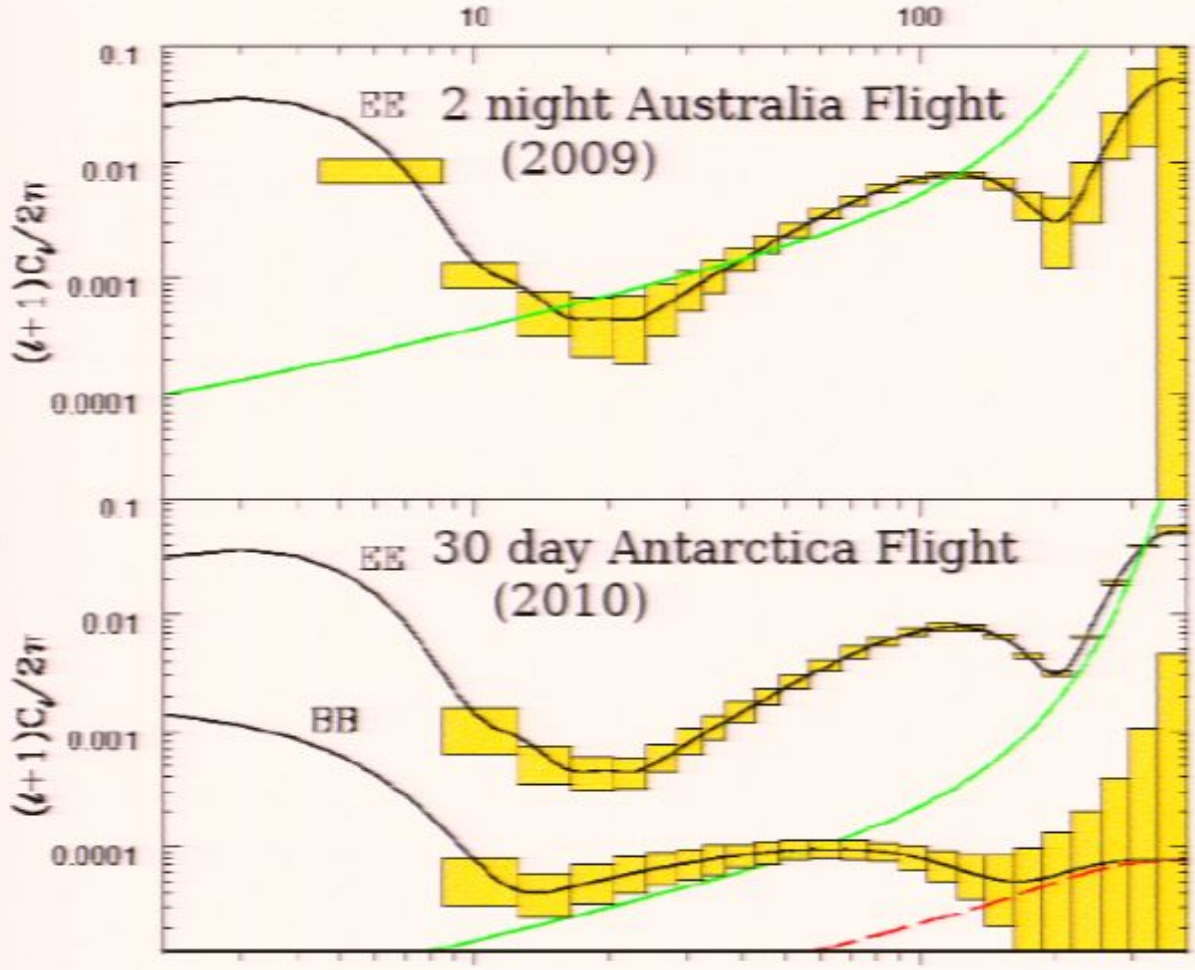
Control of Systematics

Source	Effect	Mitigation
Beam Uncertainty	Spectral distortion	Small aperture telescope allows exquisite pre-flight measurement
Pointing Uncertainty	*I to QU and Q to U mixing*	*Pointing to 10"*
Beam Variation with Polarization angle	I to QU and Q to U mixing	Placement of HWP
Gain Drifts	*I to QU and Q to U mixing*	*Cold transfer calibrator in Lyot stop Measure to 0.1%.*
Gain Variation with polarization (stable)	I to QU mixing	Relative HWP gain varies by <1% Will be measured in flight from CMB
Optics temperature drifts	*1/f noise, contamination*	*Cold optics.*
Finite Sky Coverage	E to B mixing	50% Sky Coverage, tuned weight mask



Not Systematics limited at r=0.01!

Spider Forecasts:



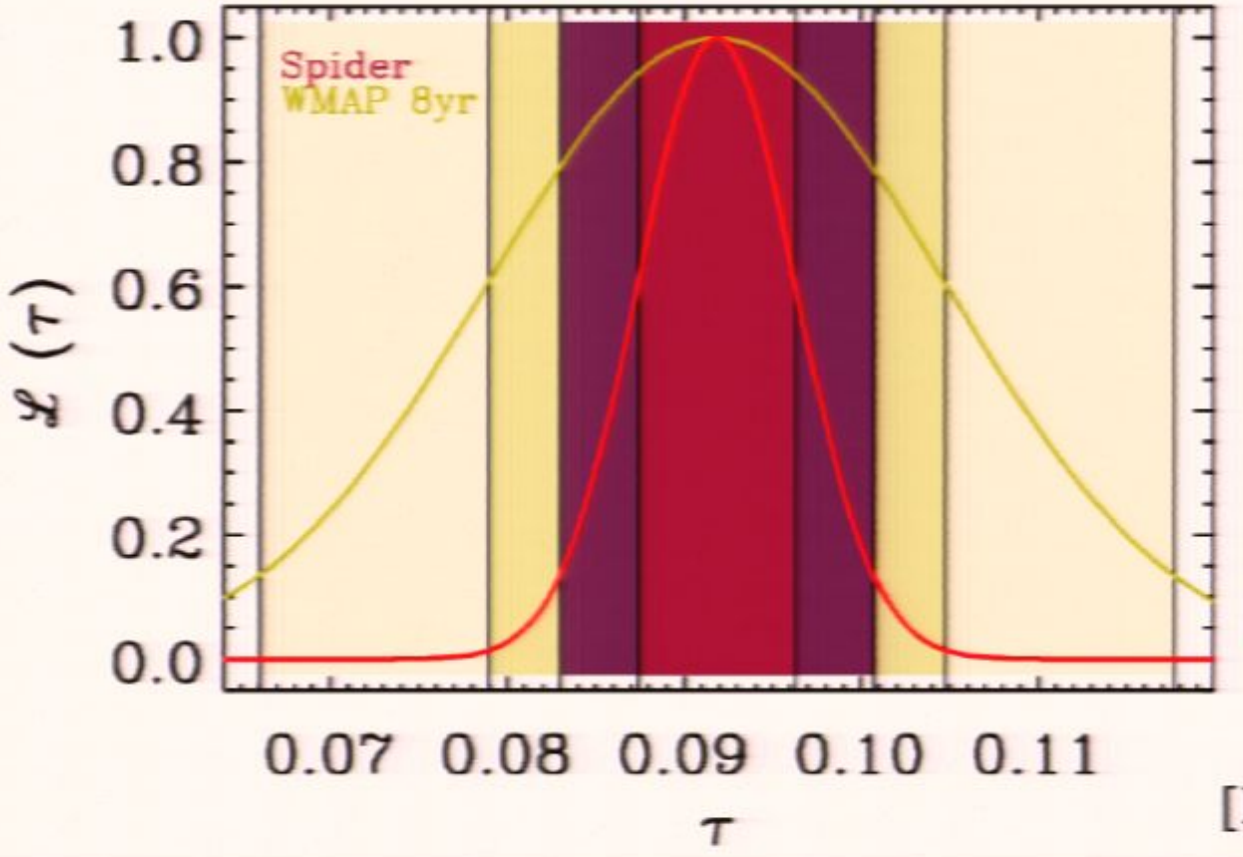
First Flight Targets Large Angular scale E modes.

Map of Foregrounds

[Contaldi]

Reionization

Spider's excellent determination of low l E modes permits excellent determination of τ, the optical depth to reionization, and improves determination of n_s.



[Dore]

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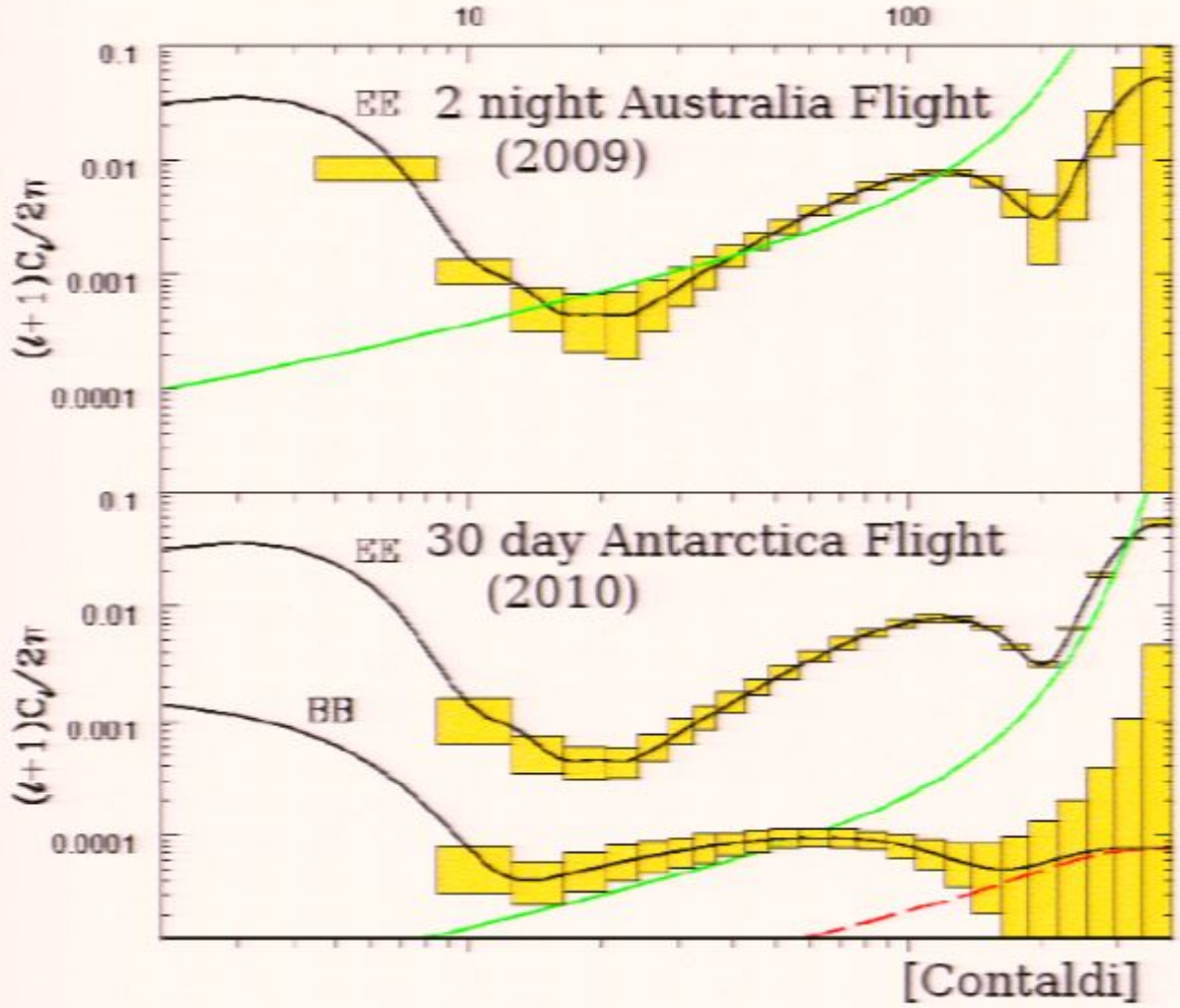

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Map of Foregrounds

Second Flight Targets Cosmological B modes.

r detection threshold: <~0.03 (several sigma)