CMB polarization observations with the POLAR and COMPASS experiments

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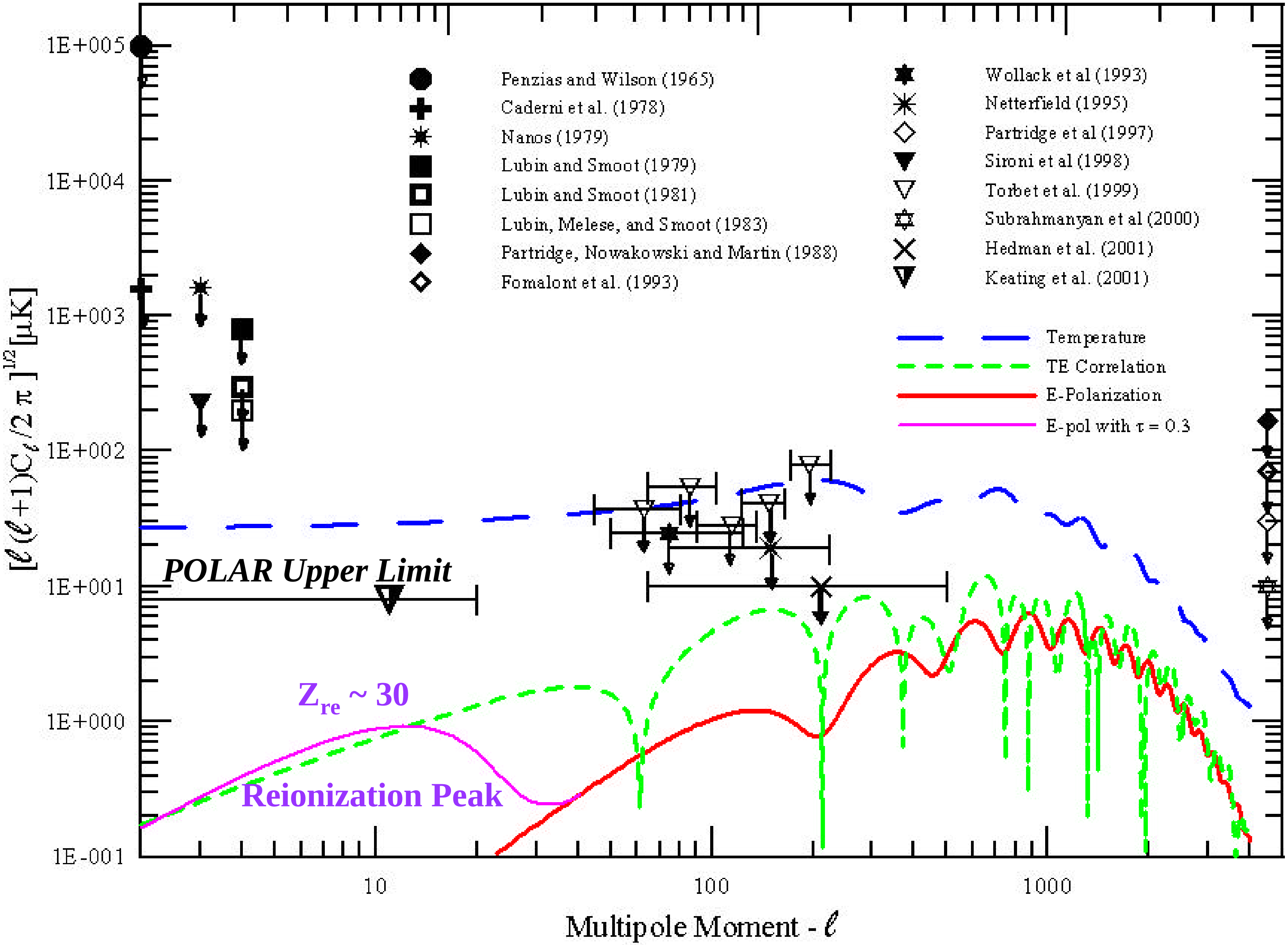
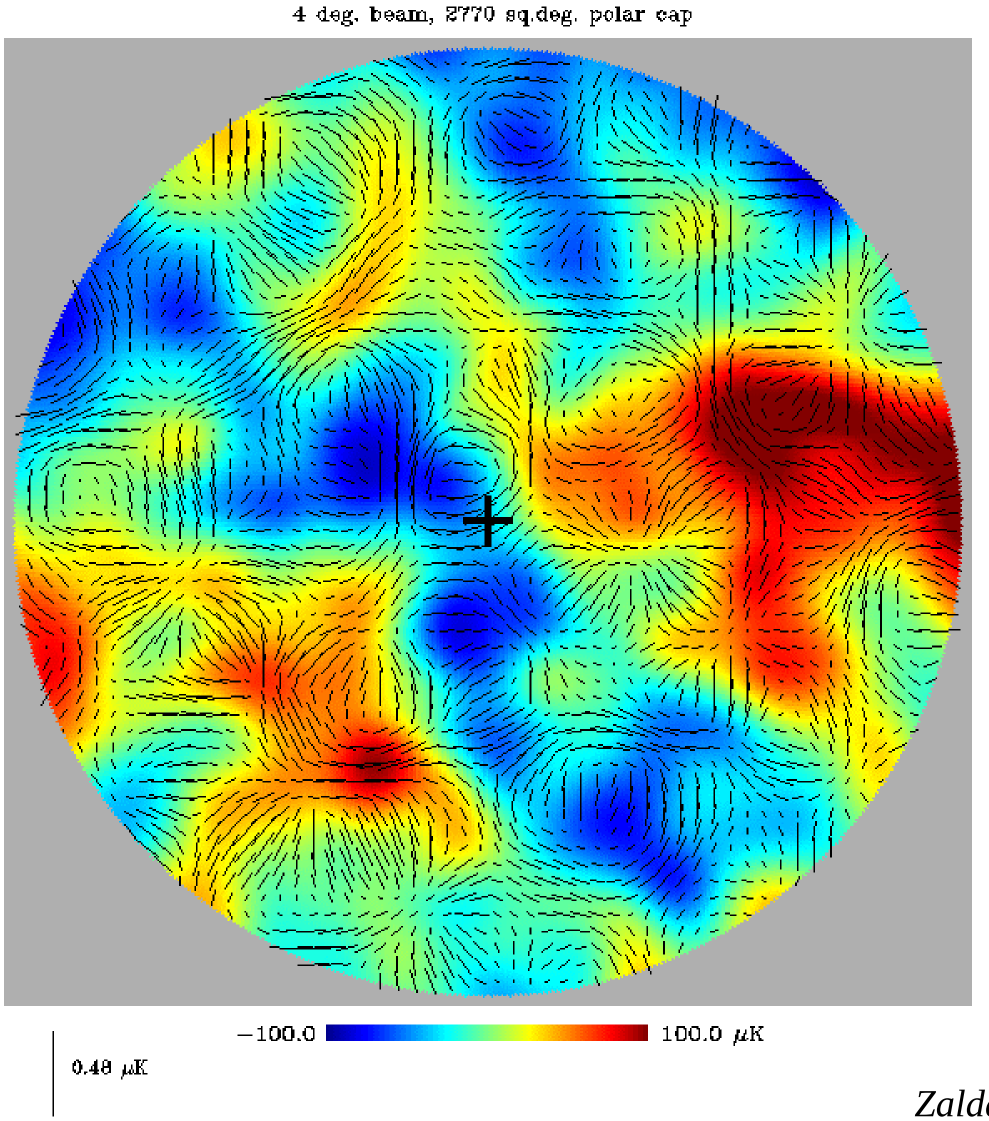


Josh Gundersen, 2001

No Reionization.

$P_{rms} \sim 0.5\ \mu K$

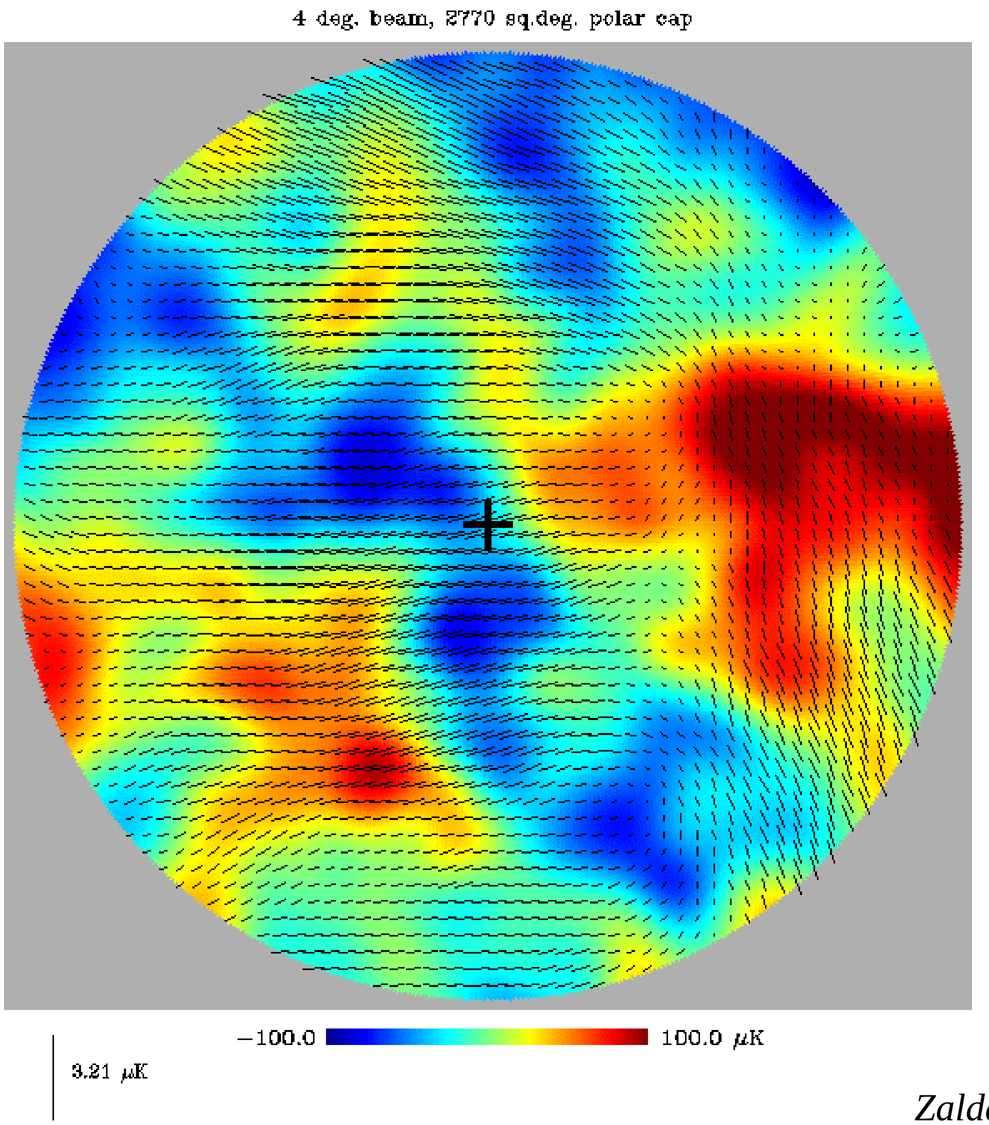


Zaldarriaga, 2001

Reionization at z ~ 30

$t = 0.3$, $Z_{re} \sim 30$

$P_{\mathbf{rms}} \sim 3.2\ \mu K$

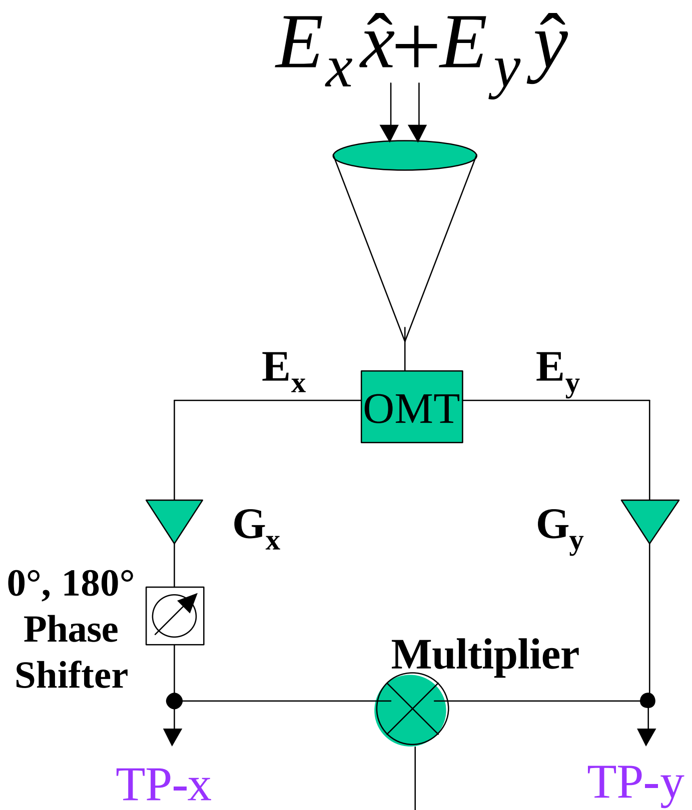


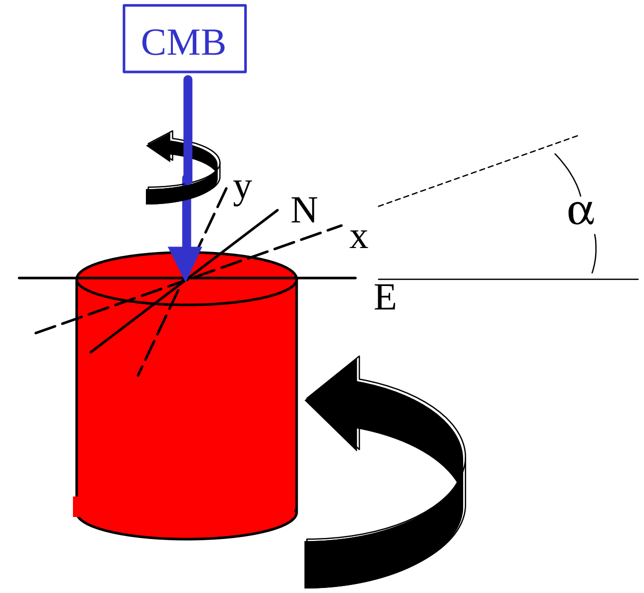
Zaldarriaga, 2001

Polarization Observations of Large Angular Regions (POLAR)

A. de Oliveira-Costa (UPenn)
J. Gundersen (Miami)
B. Keating (Caltech)
S. Klawikowski (UW-Madison)
C. O'Dell (UW-Madison)
L. Piccirillo (Cardiff)
N. Stebor (UW-Madison)
D. Swetz (UW-Madison)
M. Tegmark (UPenn)
P. Timbie (UW-Madison)

The Spinning Correlation Polarimeter





$$Signal = Q \cdot (\cos 2a) + U \cdot (\sin 2a)$$

$$Output \propto E_x \times E_y$$

$$\propto \pm E_{x0} E_{y0} G_x G_y U$$

POLAR Main Features

- Clean, simple design: no lenses or mirrors
  no magnetic or moving parts
  (excepting overall rotation)

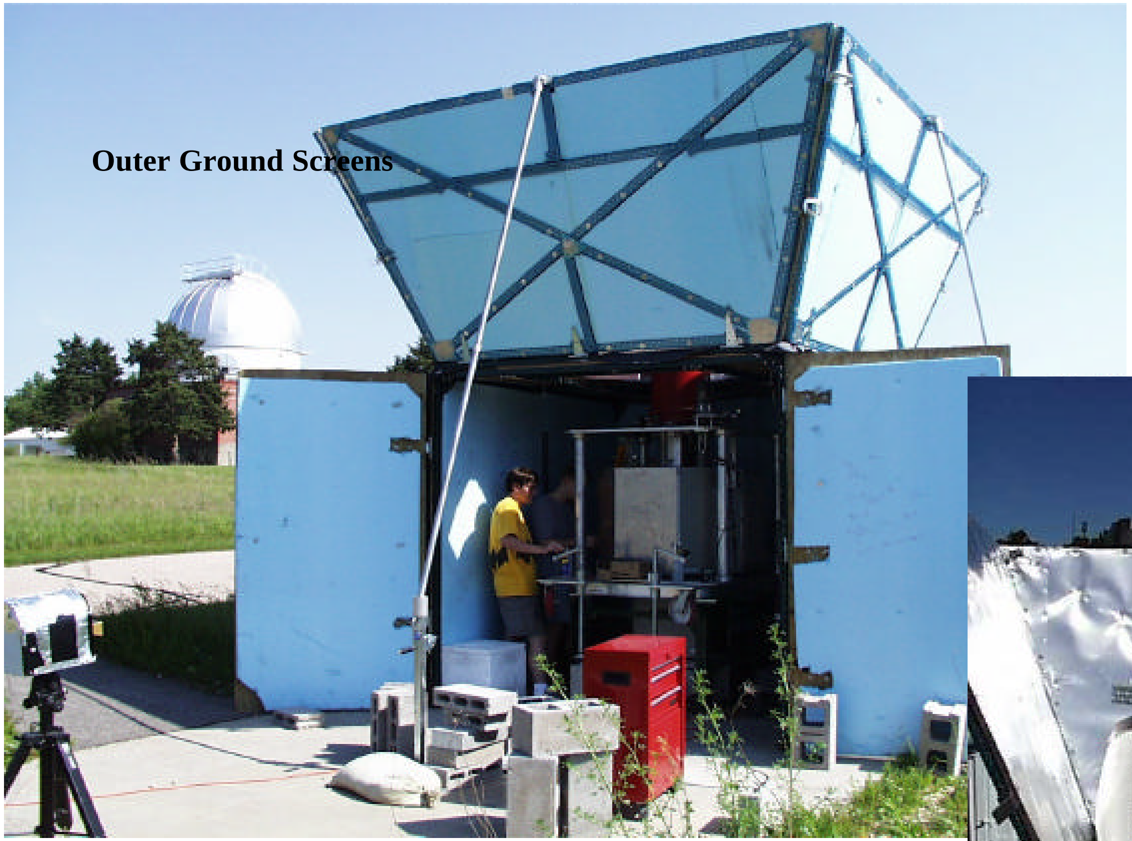
- Corrugated conical feed horn achieves 7° beam with very low sidelobes.

- HEMT amplifiers (25 K noise temperature, NET ~ 800 mK • sec$^{-1/2}$)

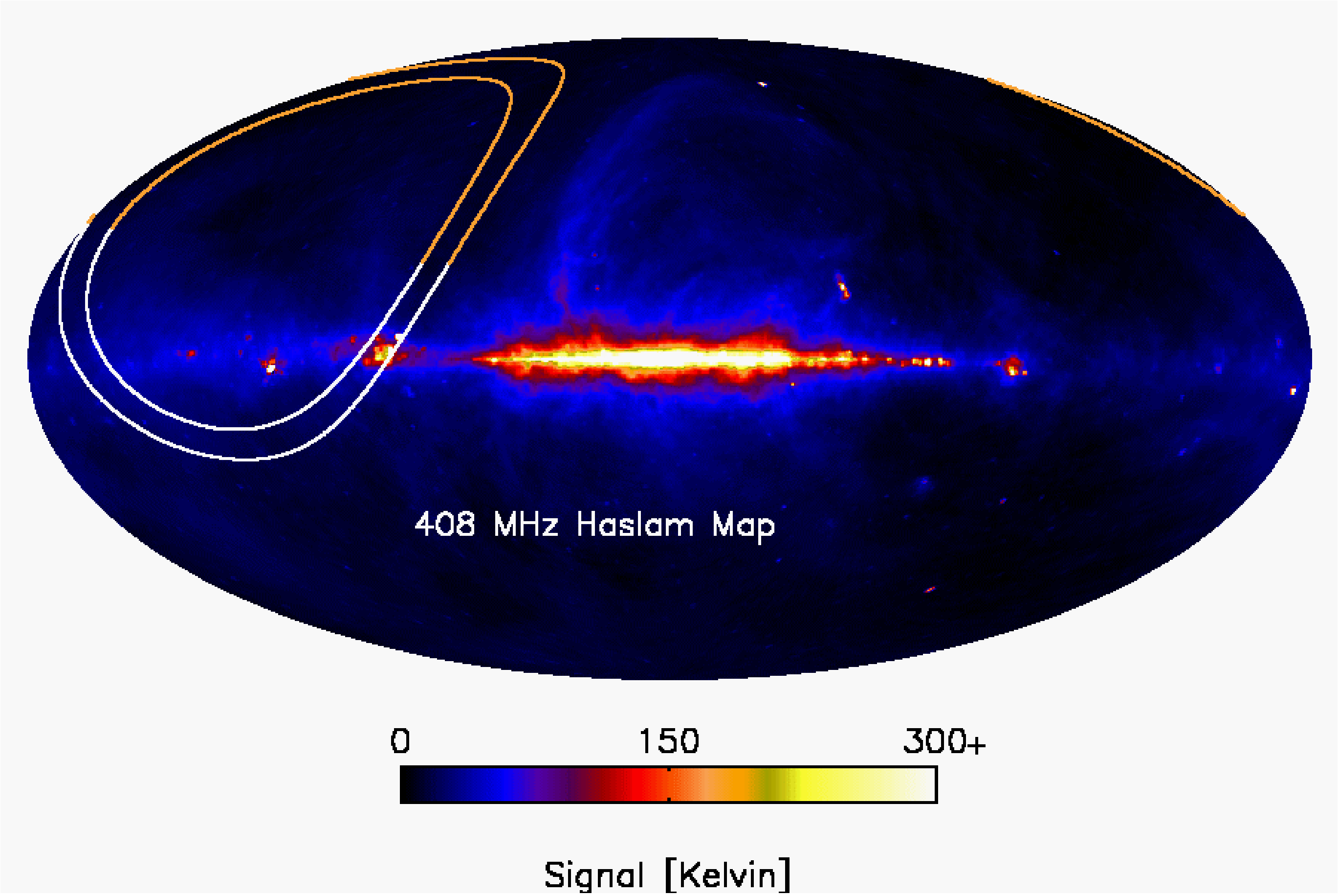
- Commercial Cryocooler (no liquid cryogens).

- Frequency bands: 26-36 GHz, 3 sub-bands.

POLAR Site: Pine Bluff, WI

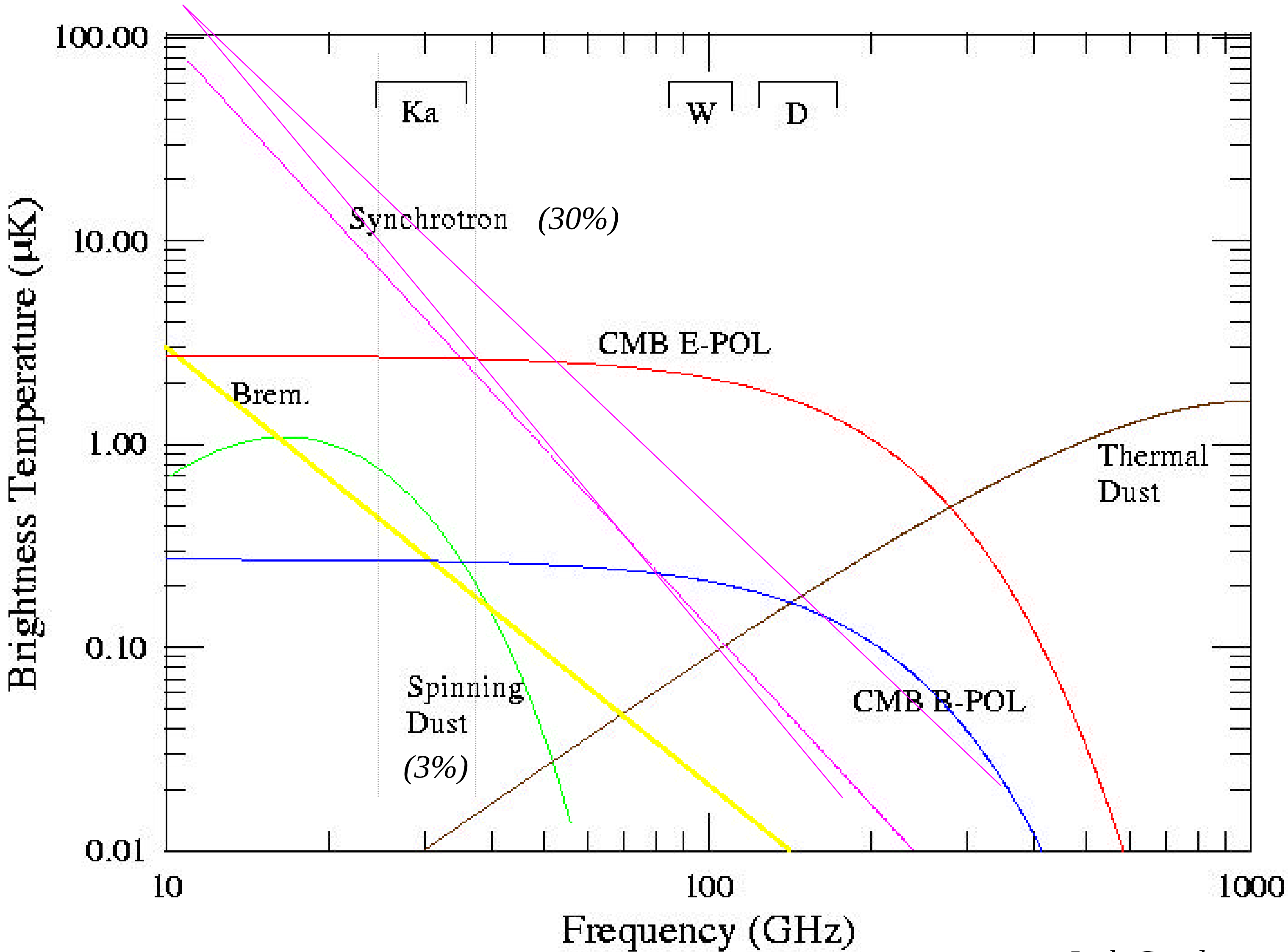


POLAR Scan Strategy



Q and U at ~ 20 pixels on the sky, on a 7° ring at declination 43°

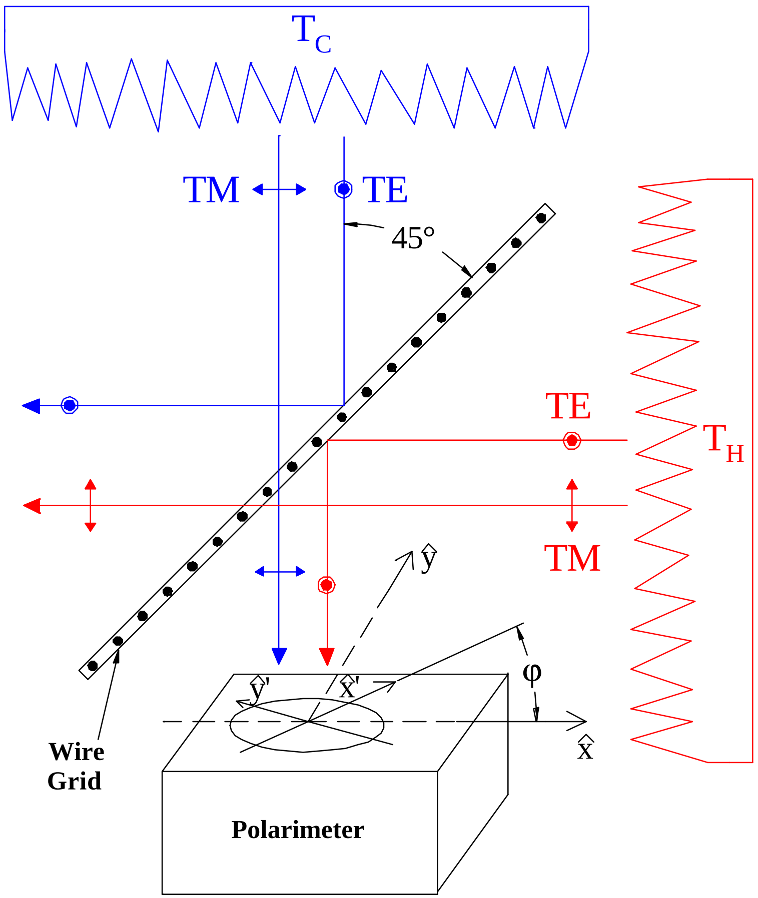
Polarized Foregrounds Power Spectra



Josh Gundersen, 1999

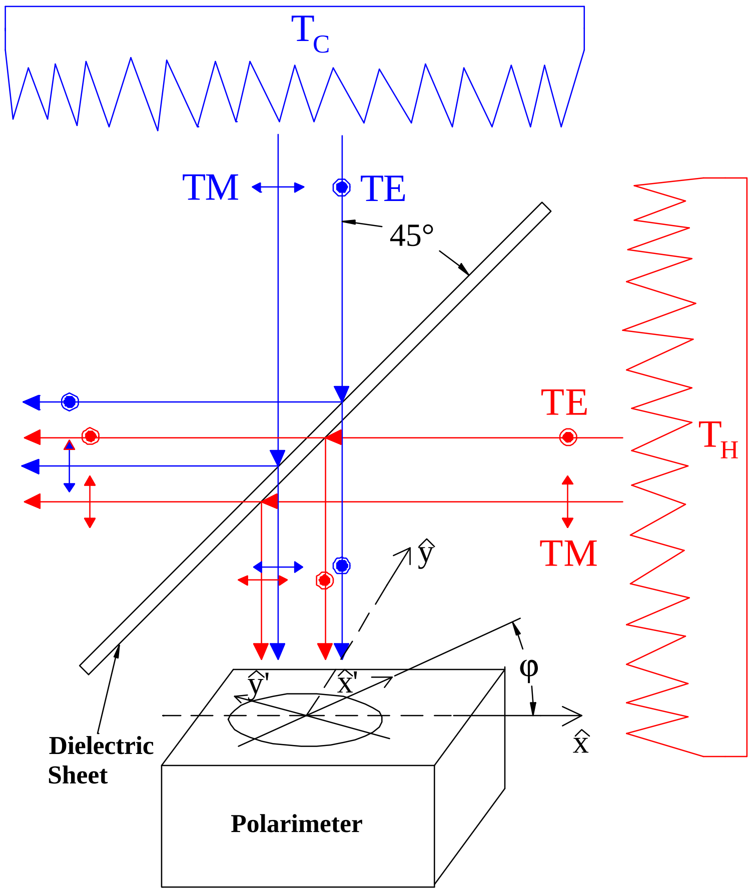
Calibration

- Typically calibrate with **wire grid**, giving a signal = T_{hot} - T_{cold} ~ 250 K (90% pol)
- We needed a much smaller signal (both in power and fractional polarization).



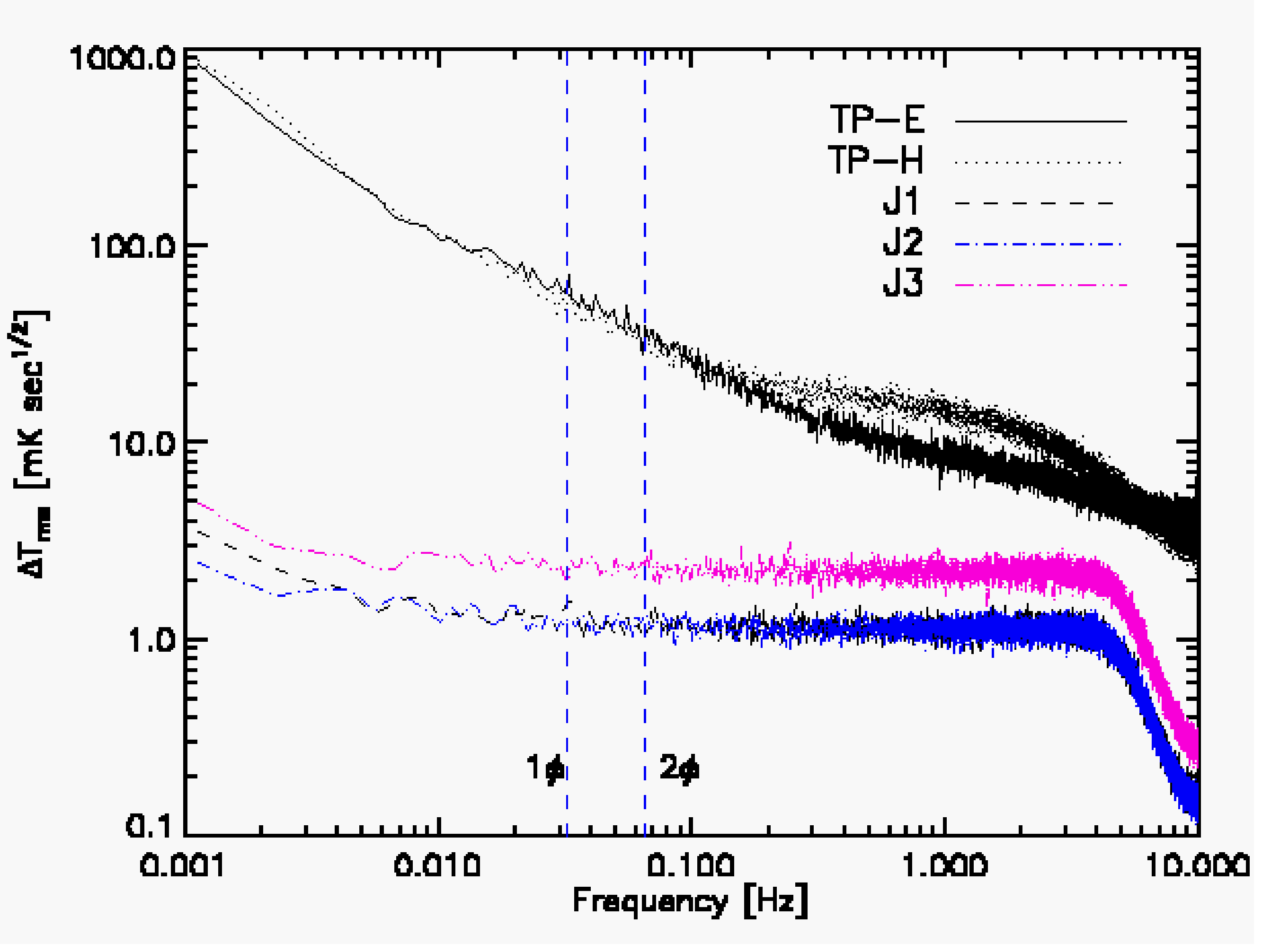
Calibration

- Typically calibrate with **wire grid**, giving a signal = T_{hot} - T_{cold} ~ 250 K (90% pol)
- We needed a much smaller signal (both in power and fractional polarization).
- Solution: Replace Grid with Thin Dielectric Sheet, calculate reflection properties using simple Fresnel equations.
- Calibration Signal ~ 12 K (5% pol)

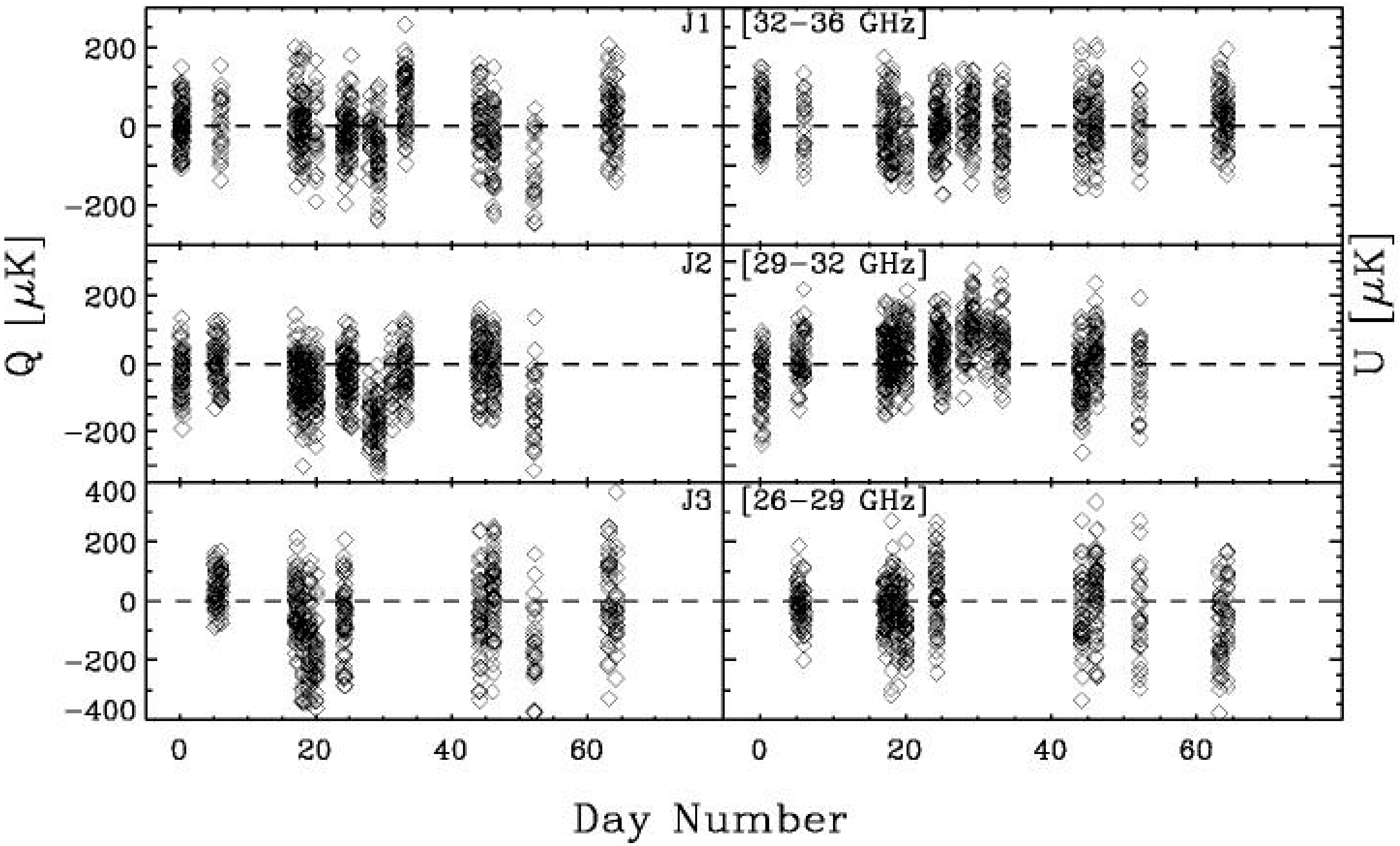


O'Dell, Swetz, & Timbie, accepted in IEEE Trans. Mic. Th. Tech., 2002

Stability and Sensitivity



Q and U Time Stream for Entire Season



Offset Removal

- Certain matrix operations can remove sensitivity to specific "modes" in a map.
- There exist several formalisms for removing unwanted modes.
- We apply this formalism to each channel and "submap" in our cleaned data set.
- Then combine these "de-offsetted" submaps into final channel maps.

For Each Submap/Channel:

Simply add ***Constraint Matrix*** to Σ :

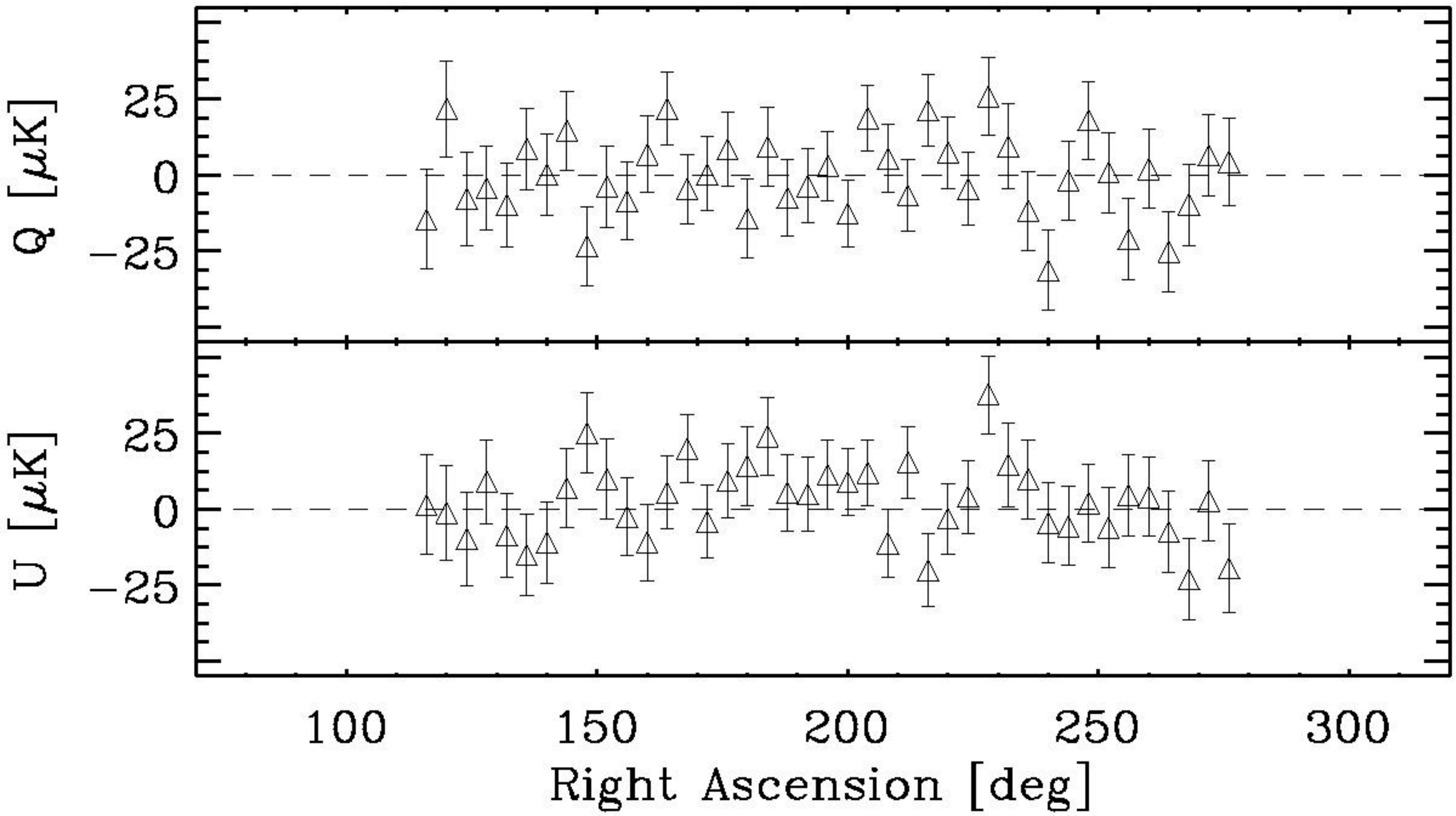
$$\Sigma \xrightarrow[s \to \infty]{} \Sigma + s^2 \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

(simple offset removal)

Bond, Jaffe, Knox 1998

Tegmark, 1998

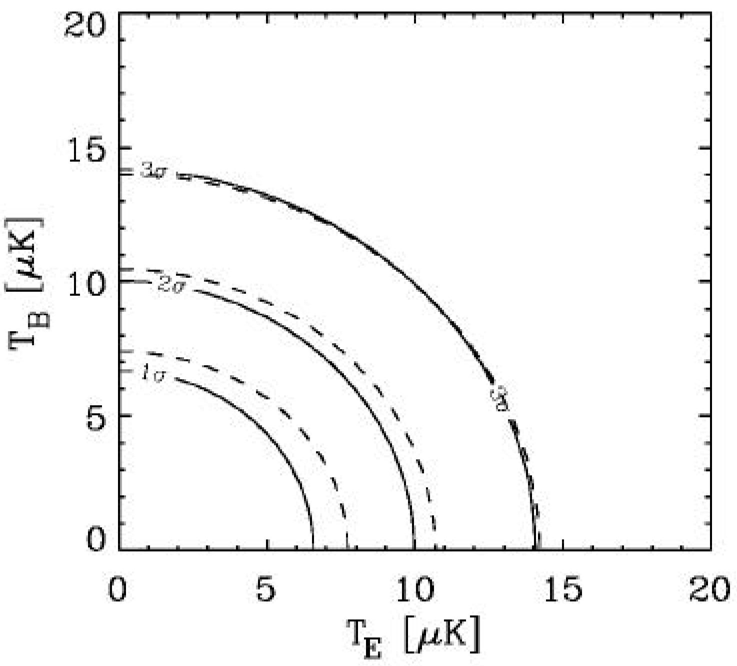
Final Combined Q, U Maps



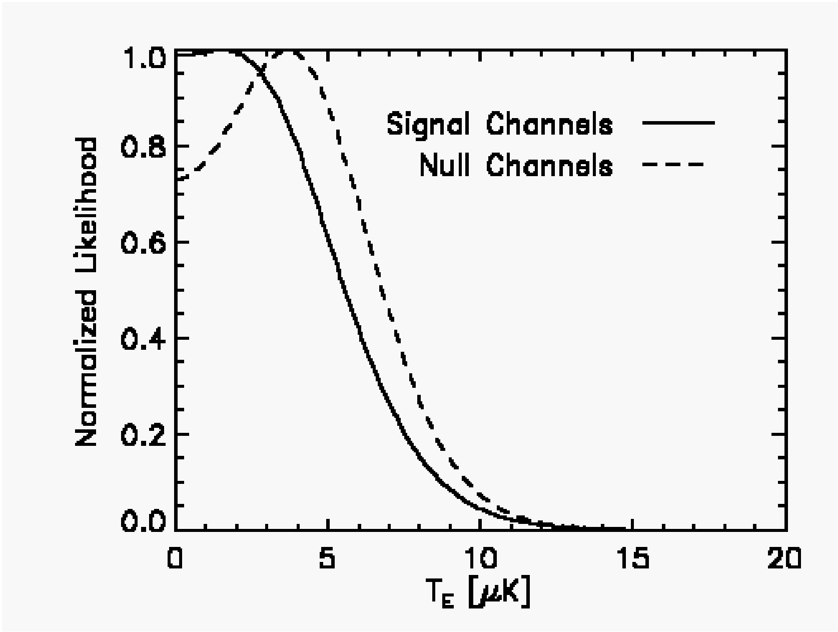
Flat Band-Power Model :

E, B Spectra have constant power at all scales, characterized by variances (T_E^2 , T_B^2)

Full 2D Likelihood:

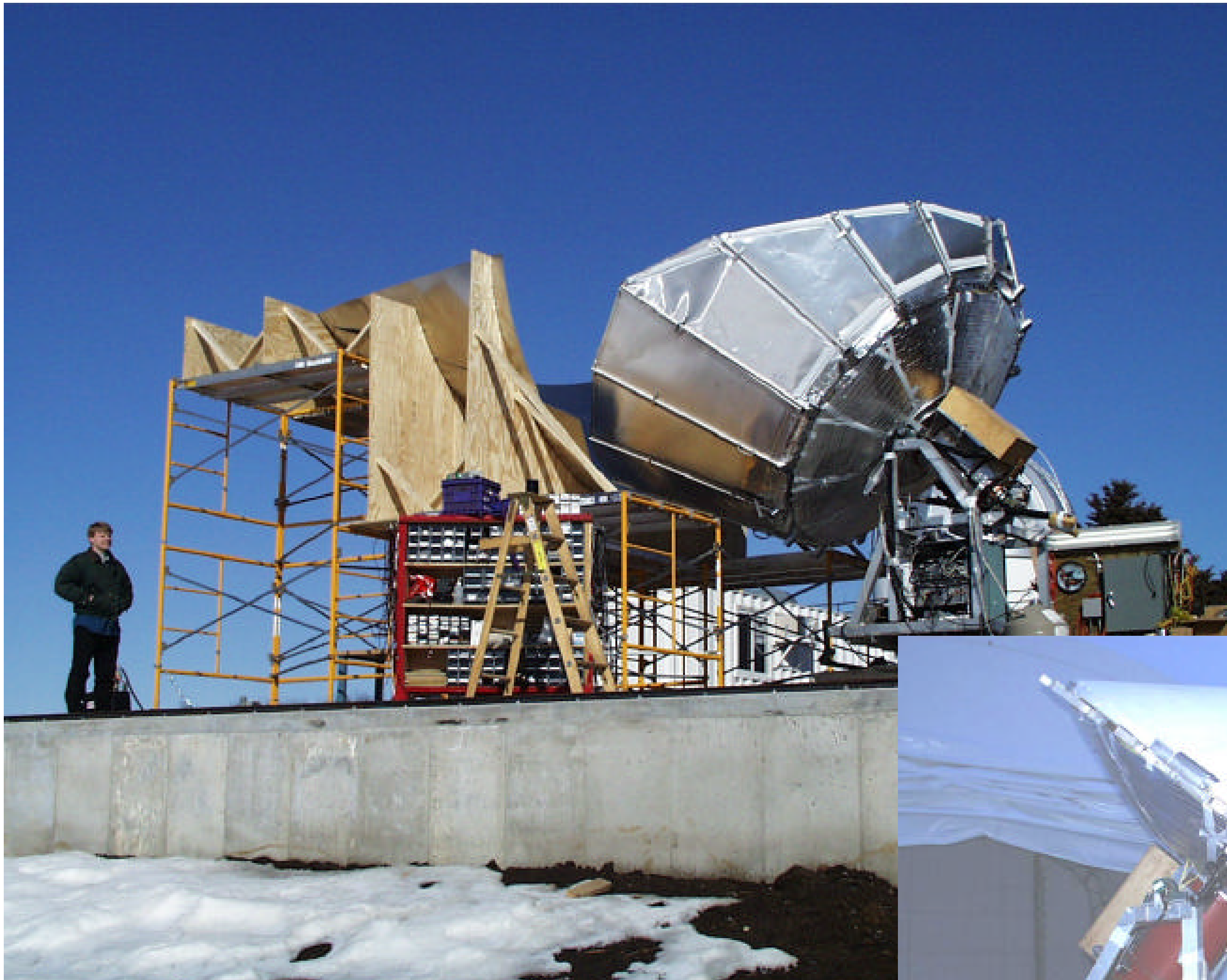


Prior Constraint that $T_B = 0$



Cosmic Microwave Polarization at Small Scales (COMPASS)

G. Dall'Oglio	Rome III
P. Farese	***UCSB***
J. Gundersen	U. Miami
B. Keating	CalTech
S. Klawikowski	***UW***
L. Knox	UC-Davis
A. Levy	UCSB
P. Lubin	UCSB
C. O'Dell	UW
A. Peel	UC-Davis
L. Piccirillo	Cardiff
J. Ruhl	UCSB
Z. Staniszewski	***UW***
P. Timbie	UW



COMPASS Facts

• Same radiometer as POLAR (26-36 GHz)

• 2.6 meter on-axis reflector, 20’ beam

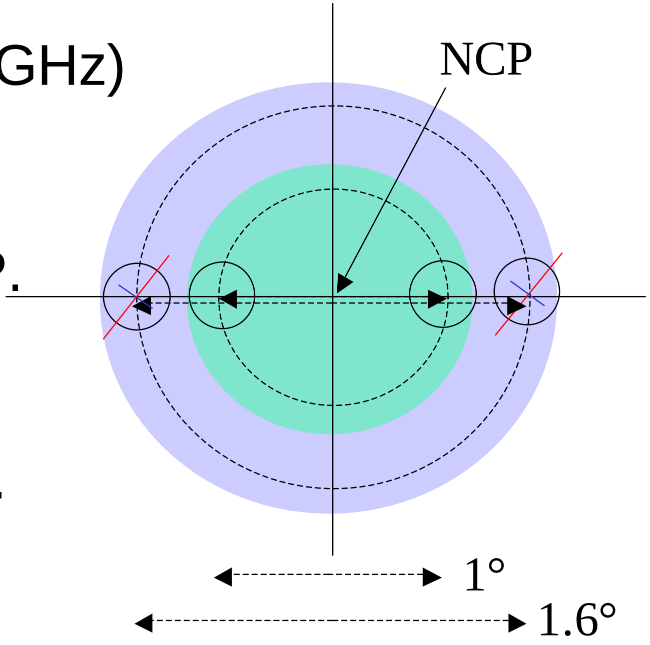
• Scanned 1° and 1.6° dia disk at NCP.

• ~ 30 pixels (20’ ea) at 1.6° scan.

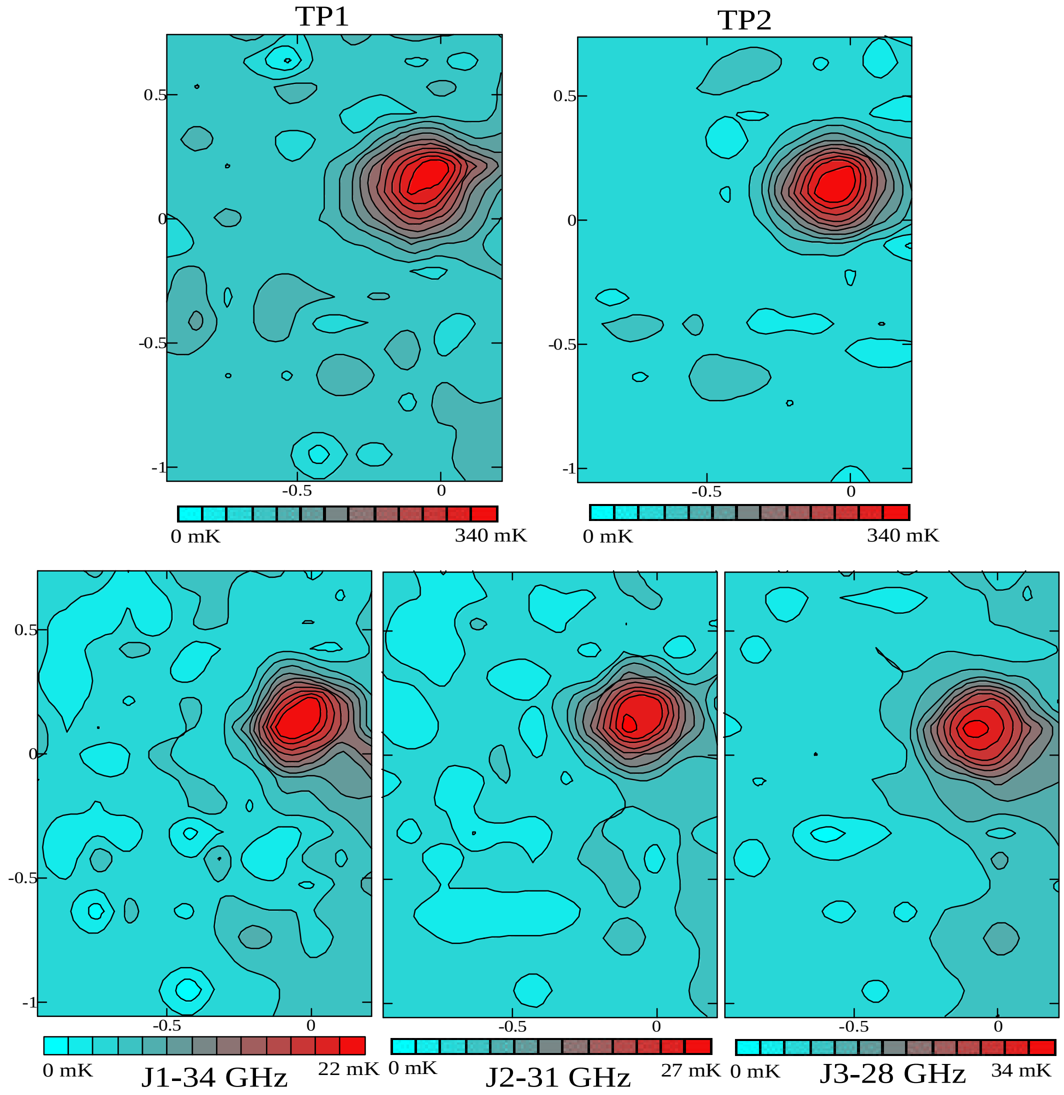
• Season 2001 ~180 usable hours (U).
Season 2002: currently observing Q.

• Calibration on Tau A (6.6% pol’d)

• Effelsberg 100m companion survey at 32 GHz



Polarized Calibration on the Tau A radio source:



COMPASS Current Status

- Pointing is known with good accuracy, ± 4.3’ Az, ± 1.6’ El.
- Noise is well behaved, with N.E.T. ~ 600 $\mu K \cdot sec^{1/2}$
- Analysis of 2001 data (U) nearing completion. Jack-knife tests show map consistency, calibration well-understood. Addition of 2002 data (Q) will help nail down systematics, foregrounds, etc.
- Addition of 90 GHz (W-band) system will allow us to probe different frequency as well as smaller angular scales (7’ beam).
- Proposal in for HEMT array with ~ 20 pixels, will drastically increase sensitivity.