Correlation Polarimetry at the 30m Telescope

Calibration and Data Reduction

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Workshop “Polarization Measurements at Effelsberg”
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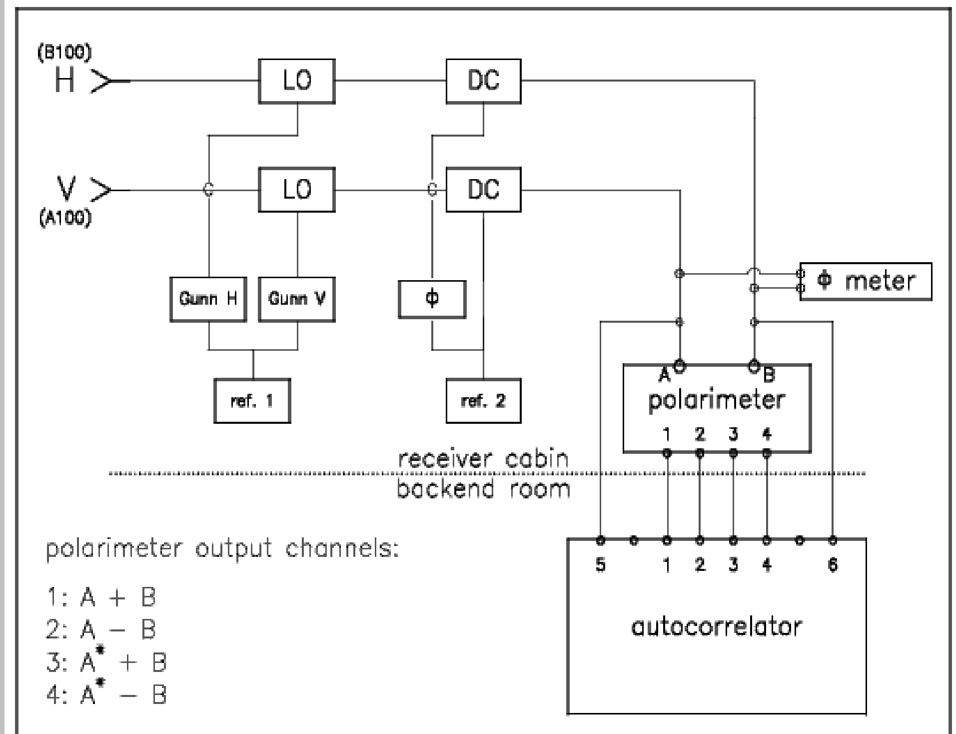
Heterodyne Polarimetry at the MRT

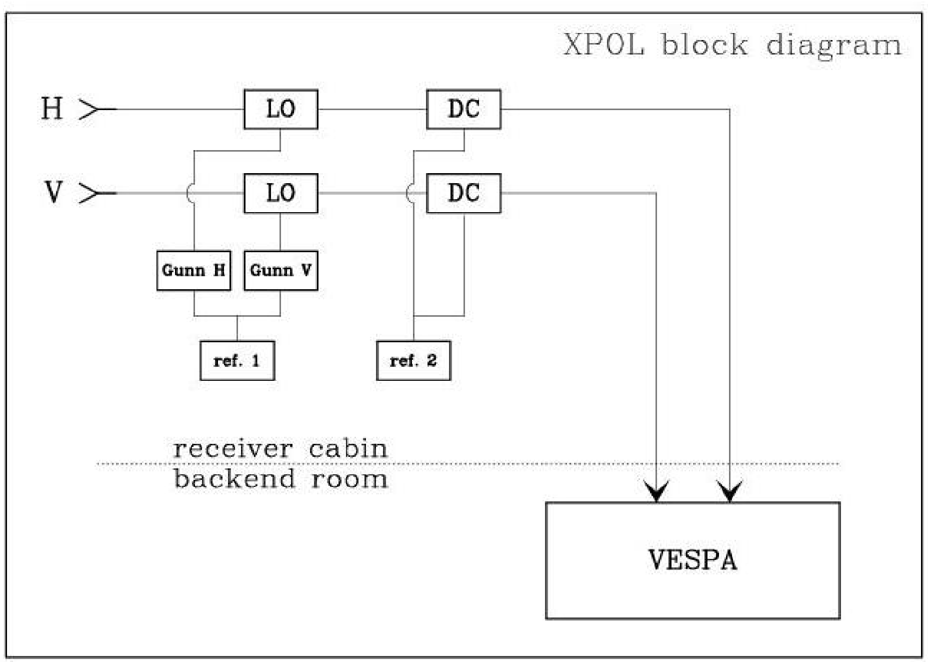
IF Polarimeter:

$$\langle (e_x+e_y)\overline{(e_x+e_y)}\rangle = \langle E_x^2\rangle + \langle E_y^2\rangle + 2\langle E_x E_y \cos(\theta)\rangle$$

+ Uses existing backend.

– total power term



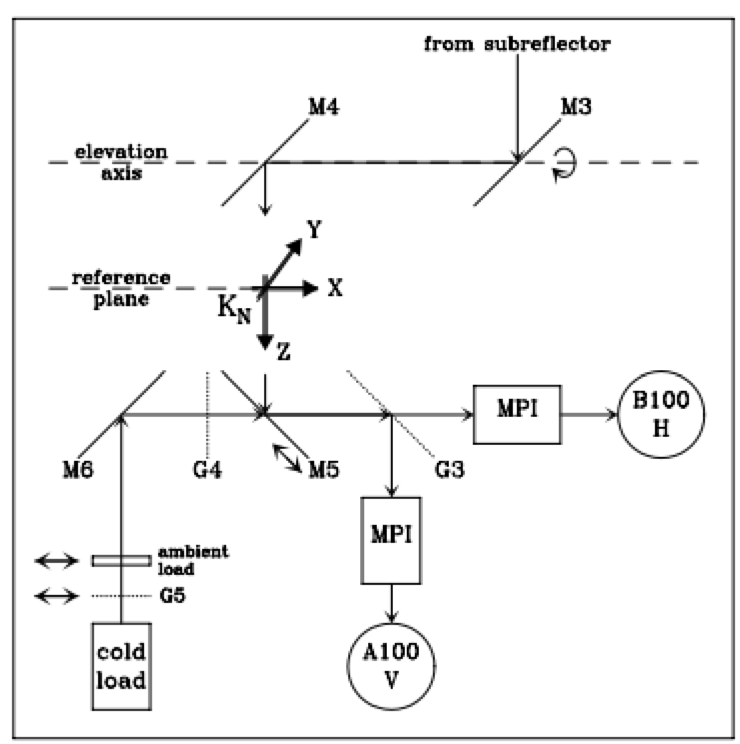


XPOL:

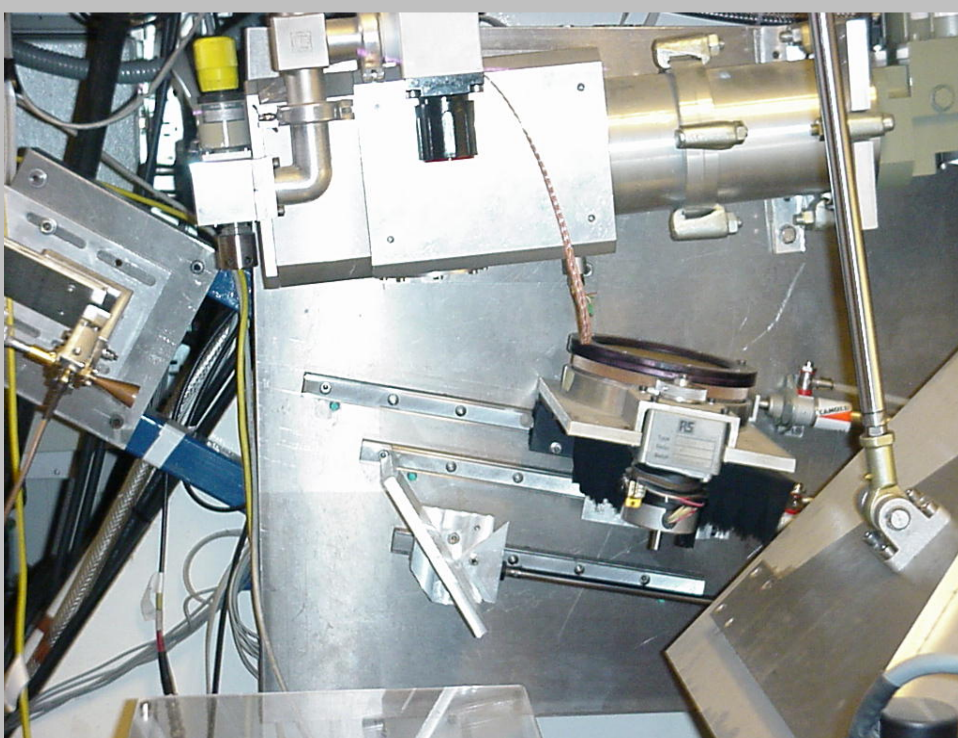
Direct cross-band correlation yields:

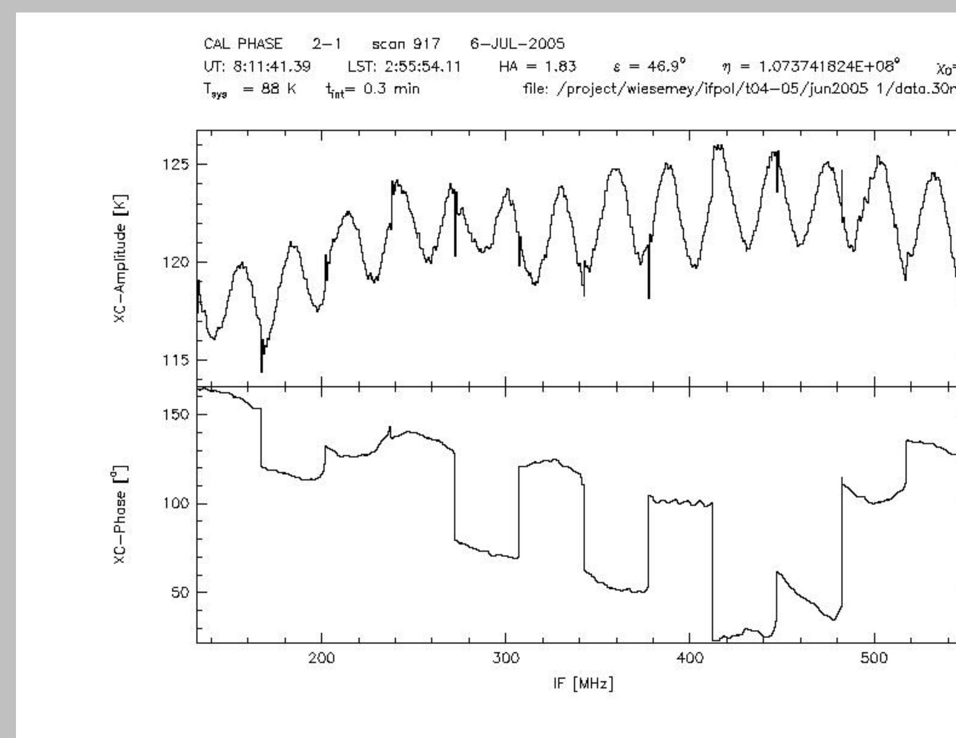
$$\langle E_x^2\rangle, \langle E_y^2\rangle, \Re\langle E_x \overline{E_y}\rangle, \Im\langle E_x \overline{E_y}\rangle$$

Phase Calibration

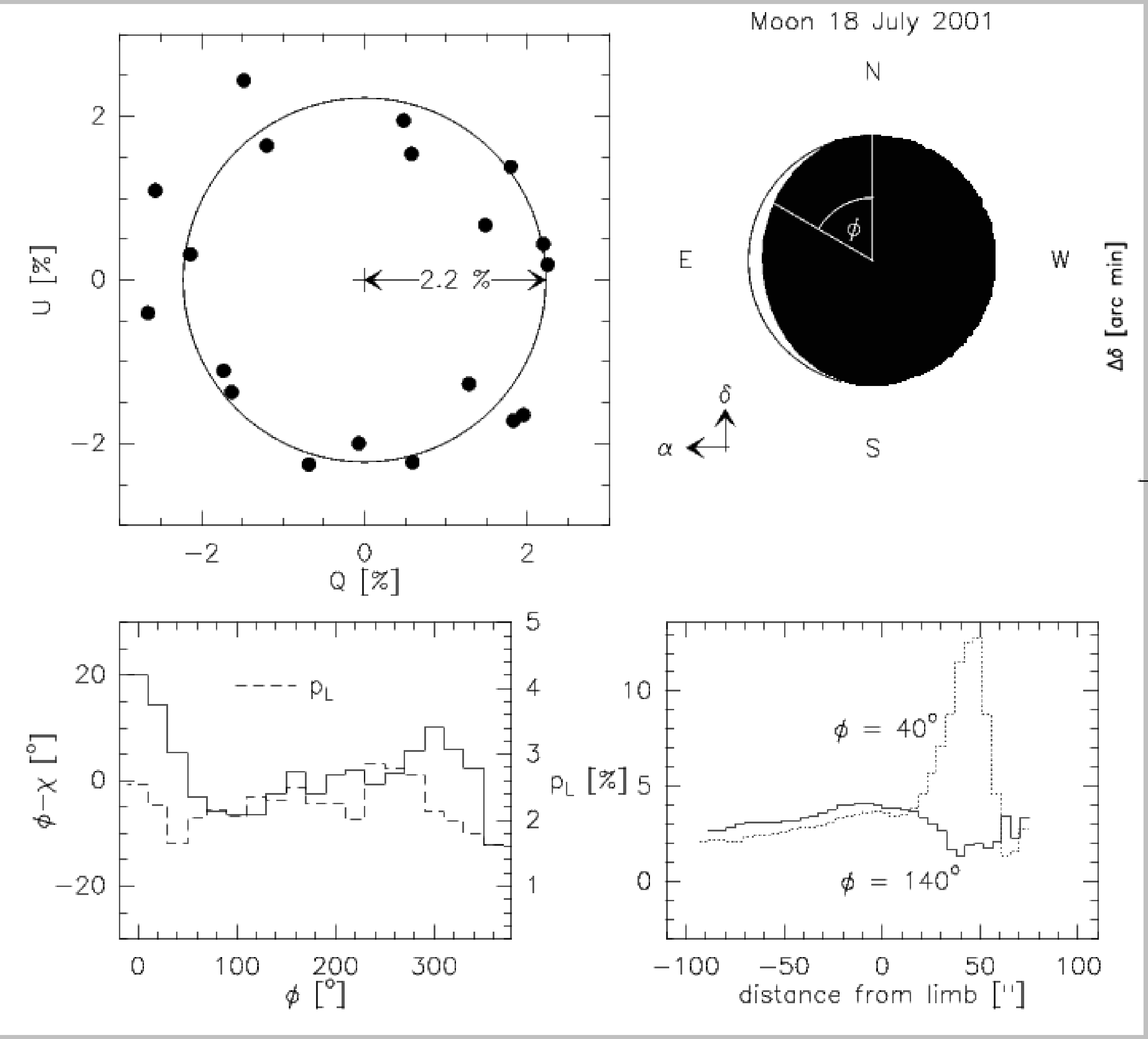


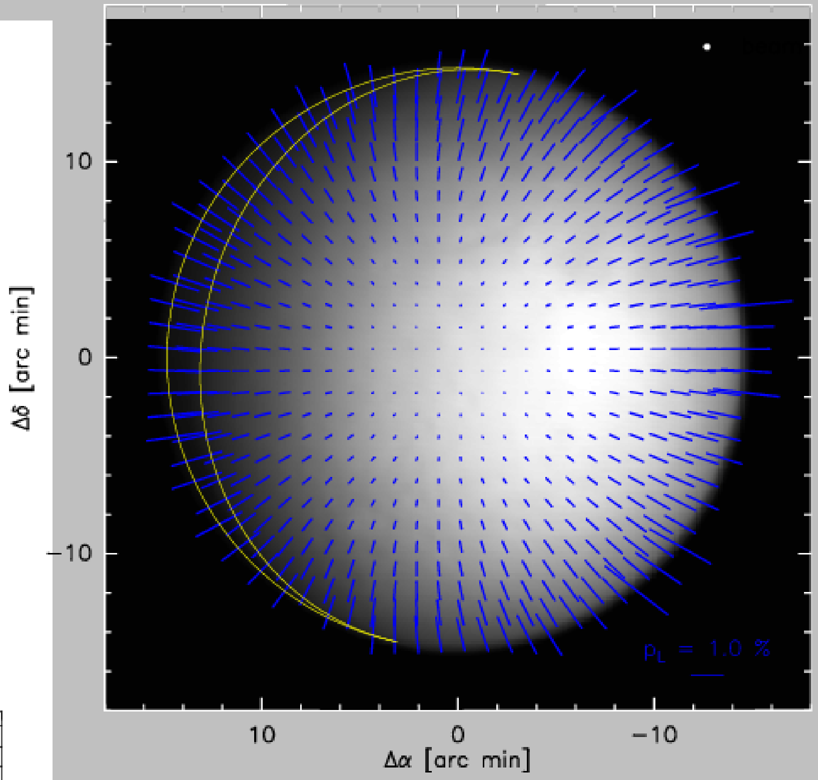
$$\begin{pmatrix} U \\ V \end{pmatrix} = \begin{pmatrix} +\cos(\varphi) & +\sin(\varphi) \\ -\sin(\varphi) & +\cos(\varphi) \end{pmatrix} \begin{pmatrix} \Re(X) \\ \Im(X) \end{pmatrix}$$





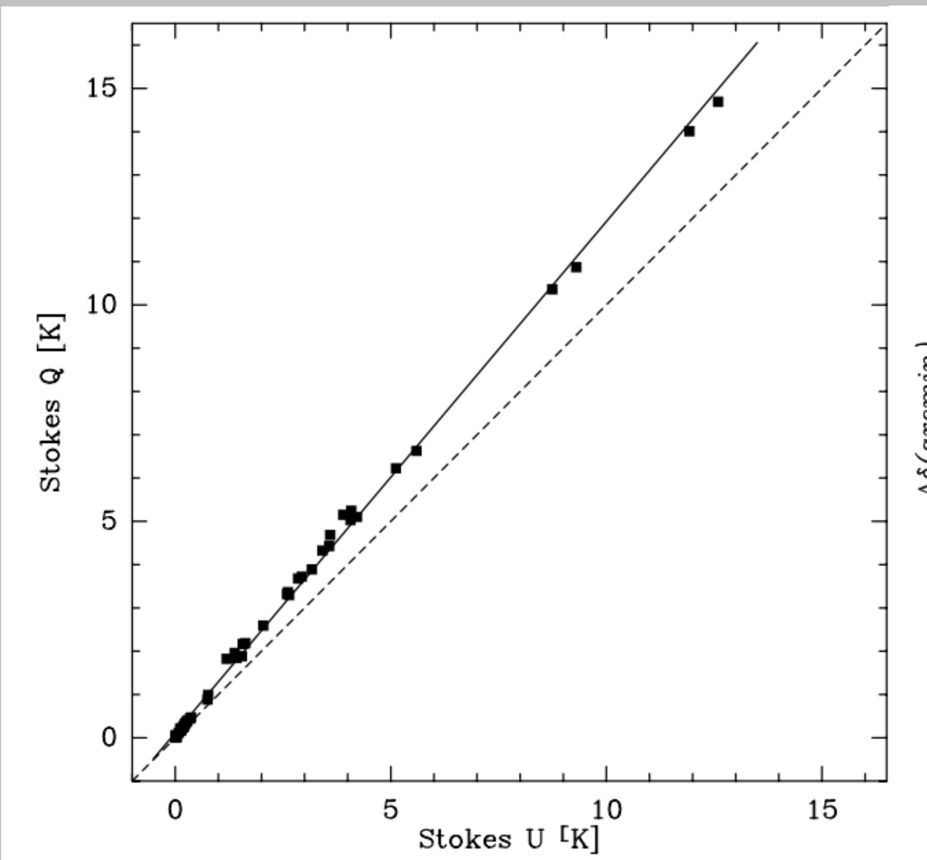
Polarization angle calibration (1)



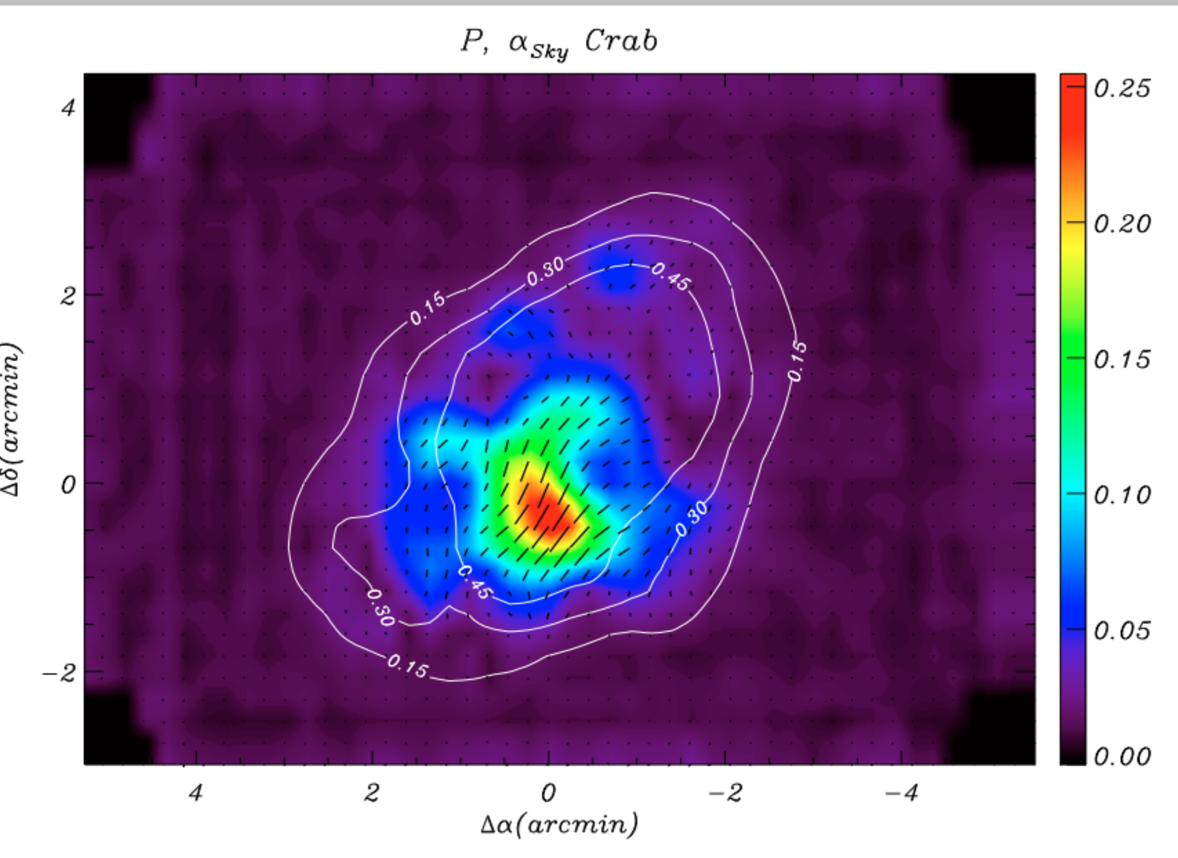


Moon at 345 GHz
PolKa @ APEX

Polarization angle calibration (2)

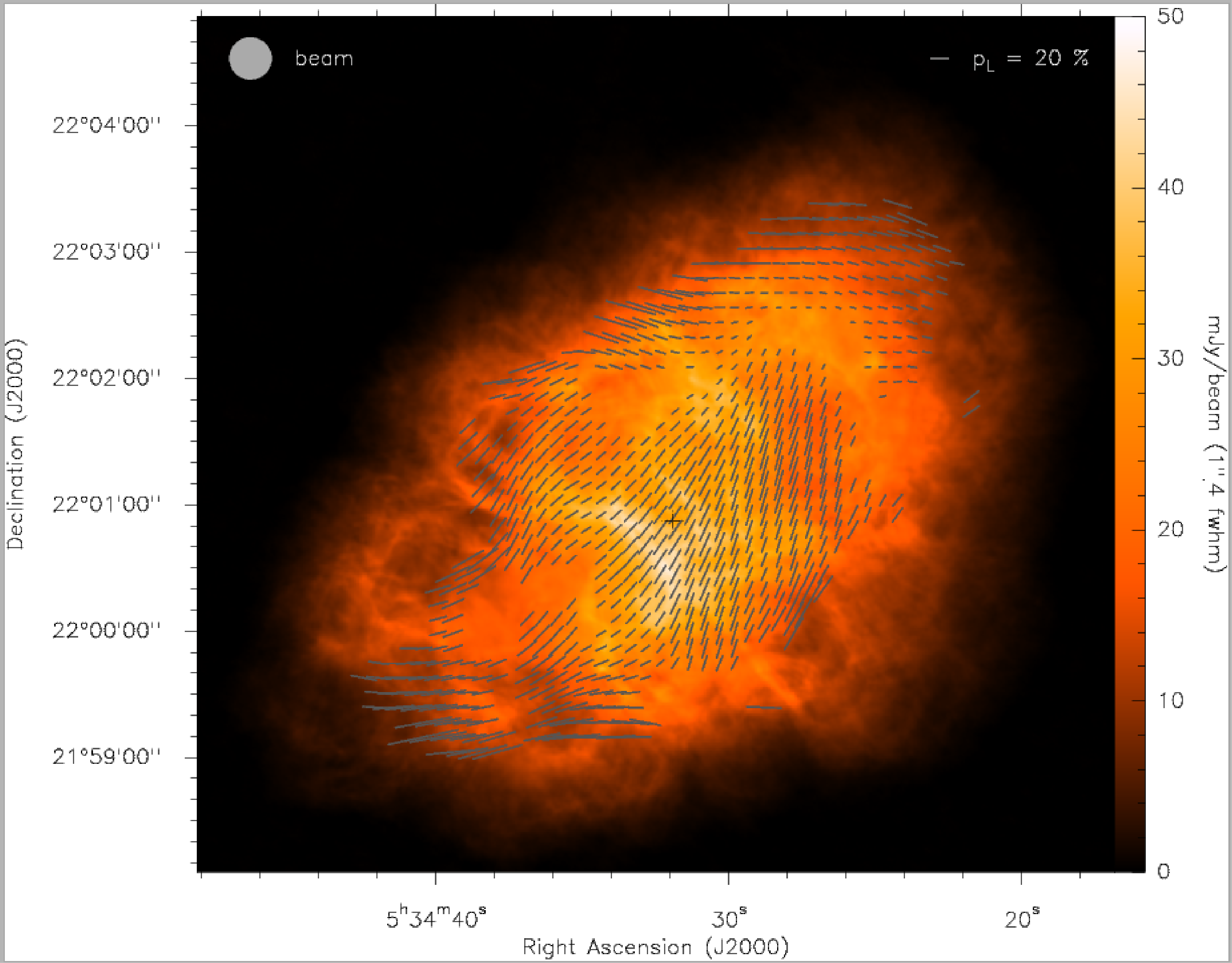


χ Cyg, SiO v=1,J=2-1 maser (Thum et al. 2008)



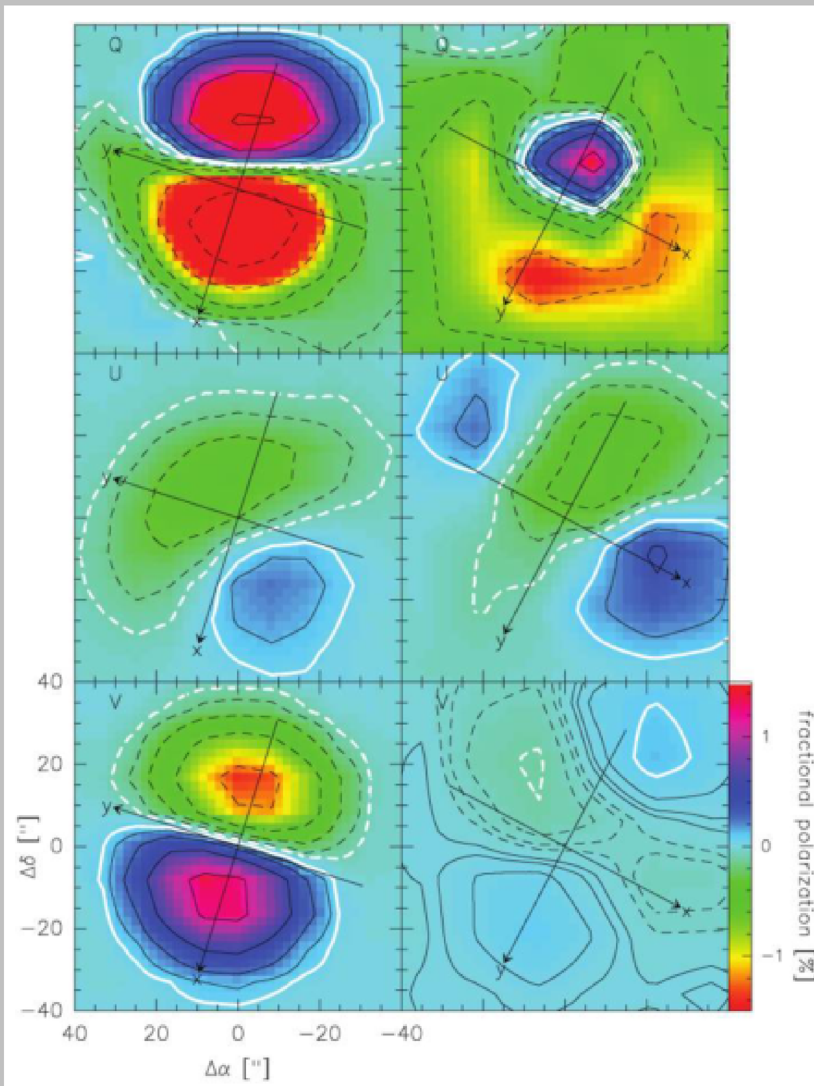
Polarization of Tau A (90 GHz, Aumont et al. 2010)

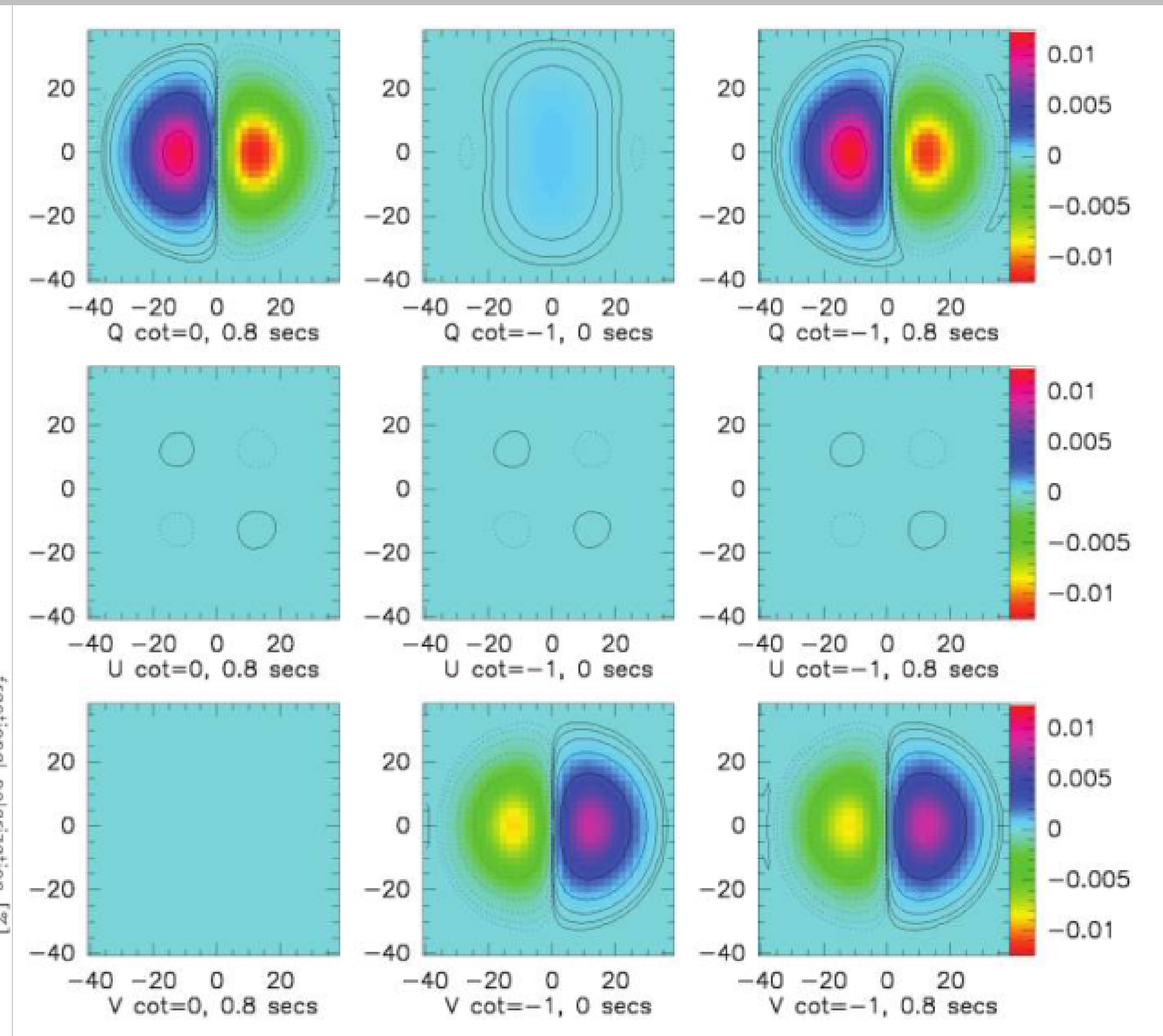
Commissioning of PolKa @ APEX



345 GHz polarization map (Wiesemeyer et al. 2014) with VLA 5 GHz emission underneath (Bietenholz et al. 2001, FWHM 1.4“)

Instrumental Polarization



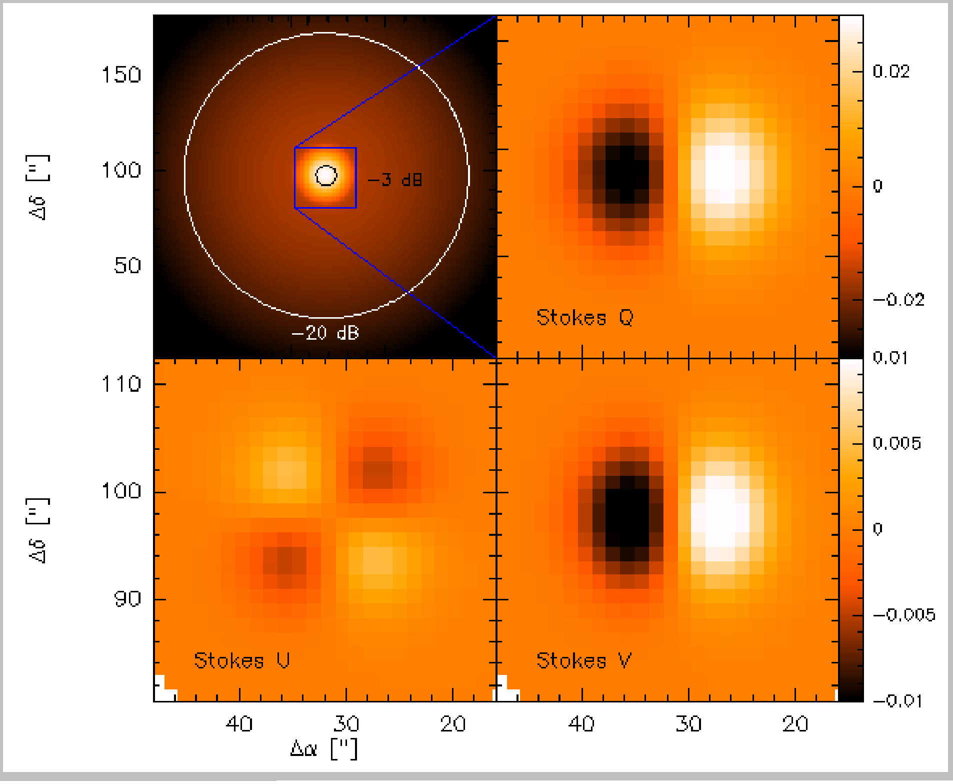


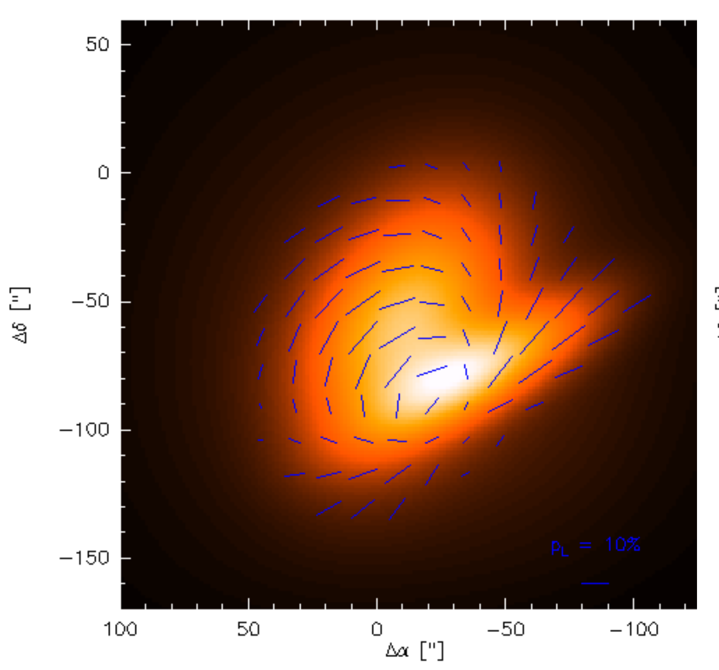
↑ Stokes beams before and after realignment

↑ Modeled Stokes beams

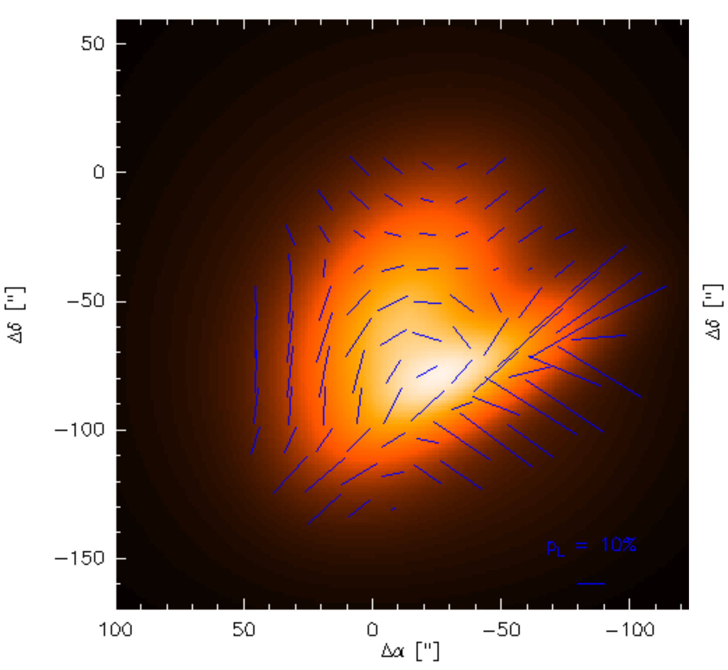
Thum et al. 2008, PASP 120, 777

Removal of instrumental polarization

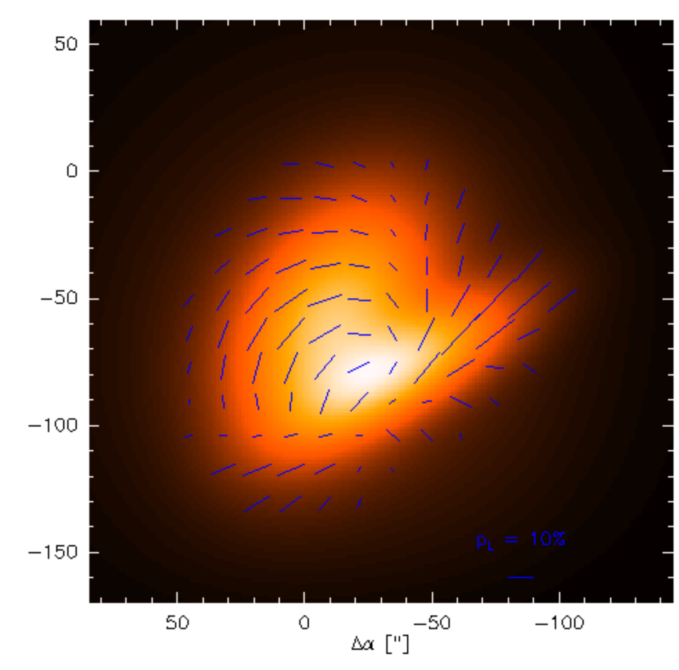




Model



with IP



after correction

Statistical description of polarization

Two probabilities:

- For a single photon, to be in a given polarization state.
- For this polarization state, to be represented in an ensemble of photons.

Measurement equation: S = tr(ρ·A), with

$\rho = \frac{1}{2}\begin{pmatrix} I+Q & U-iV \\ U+iV & I-Q \end{pmatrix}$ coherency matrix, Born & Wolf 1999

and e.g., $A = \begin{pmatrix} 1 \\ 0 \end{pmatrix}(1,0) = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$, so $S = \frac{1}{2}(I+Q) = \langle E_x^2 \rangle$

or, e.g., $A = \begin{pmatrix} 1 \\ D_{x1} \end{pmatrix} g_{x1} \left(D_{y2} \quad ,1 \right) \bar{g}_{y2}$ → Hamaker et al. 1996

$$S = \frac{1}{2} g_{x1} \bar{g}_{y2} \left(U_{12} + i\,V_{12} + I_{12}\left(\bar{D}_{y2} + D_{x1}\right) + Q_{12}\left(\bar{D}_{y2} - D_{x1}\right)\right)$$