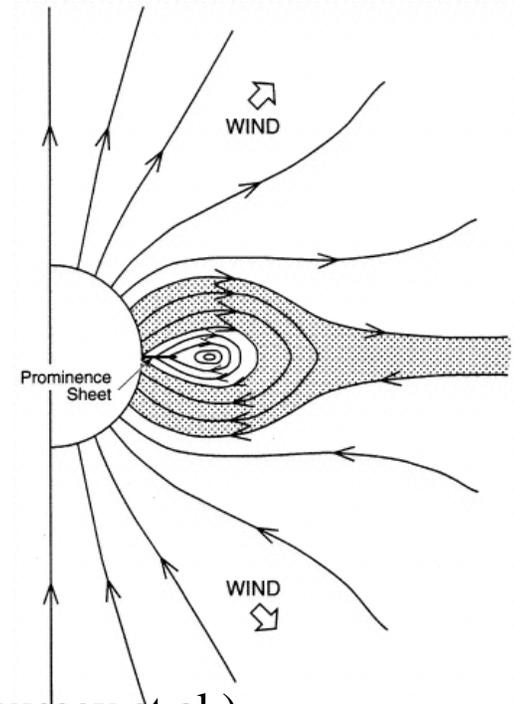
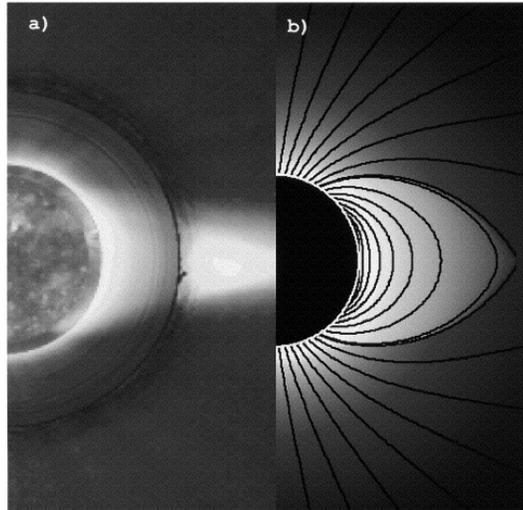


# Coronal magnetic field observations

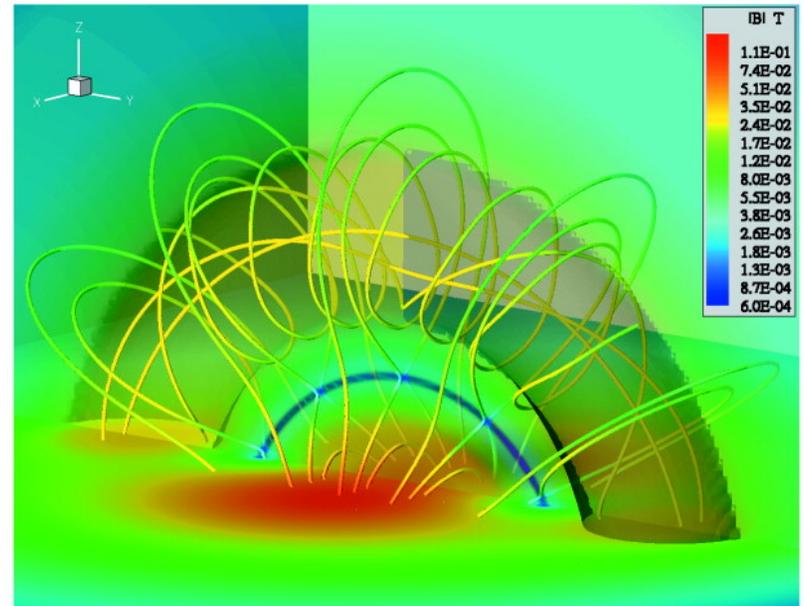
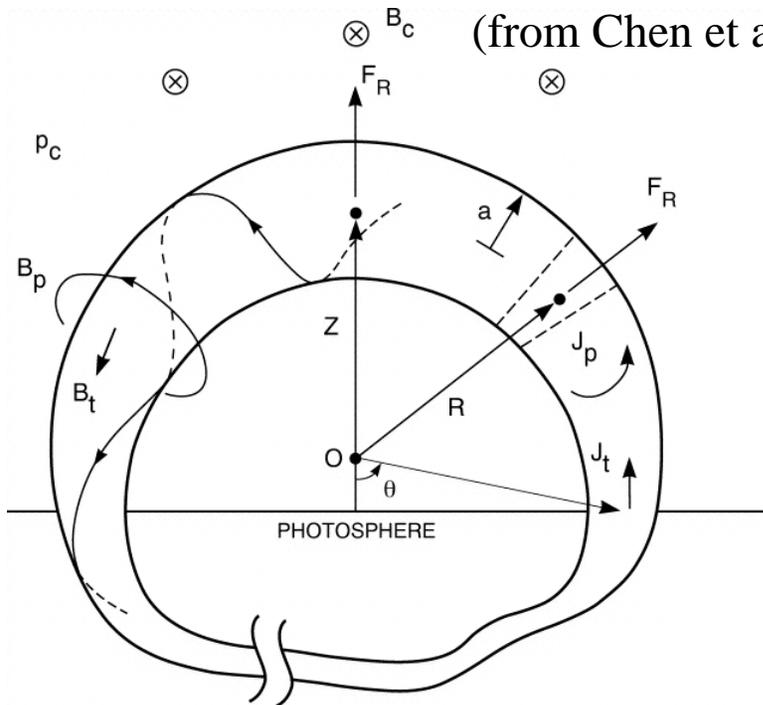
J.R. Kuhn, R. Coulter, H. Lin, D. Mickey

- Useful coronal field model constraints can be obtained from IR observations
- This is a vigorous activity, with three serious ongoing efforts (plus important solar radio measurements proposed)

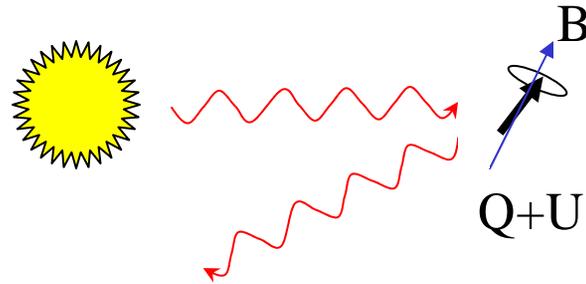
# Are images enough?



(from Chen et al., Low, Gibson, Roussev et al.)



# Magnetic linear polarization sensitivity

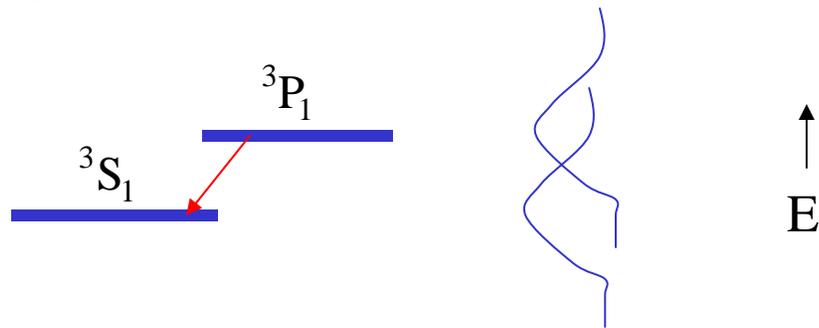


$$\omega_L \approx \frac{eB}{mc} \quad (1\text{G} \rightarrow \omega_L = 1.8 \times 10^7 \text{ s}^{-1})$$

$$\frac{1}{\Gamma} = A \quad (10^2 - 10^7 \text{ s}^{-1})$$

Permitted ( $A \approx \omega_L$ ) – Hanle

(eg. HeI 1083nm,  $A = 10^7 \text{ s}^{-1}$ )



$Q, U \propto B$  (almost with I profile)

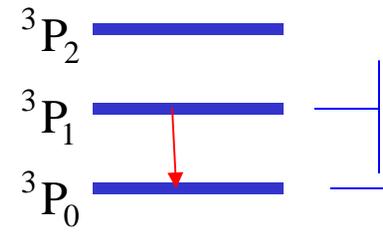
$V \propto B$  (almost  $dI/d\lambda$  profile)

$|Q, U| \geq |V|$

polarization is  $\parallel$  or  $\perp$  to B

Forbidden ( $A \ll \omega_L$ )

(eg. FeXIII 1075nm,  $A = 10^2 \text{ s}^{-1}$ )



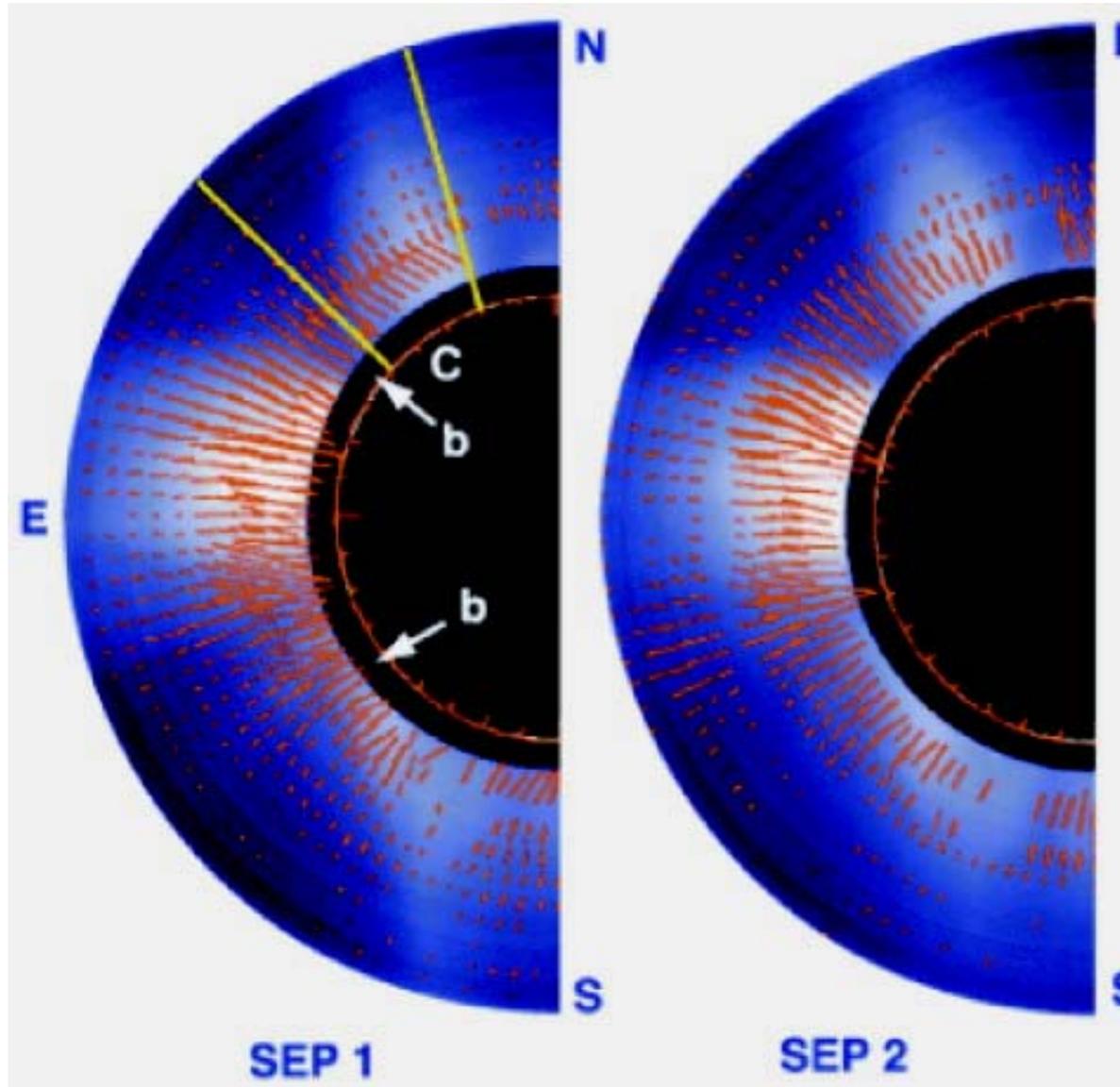
$Q, U$  independent of  $|B|$

$V \propto B_{\text{los}} (\propto \lambda)$

# Coronal Hanle measurements

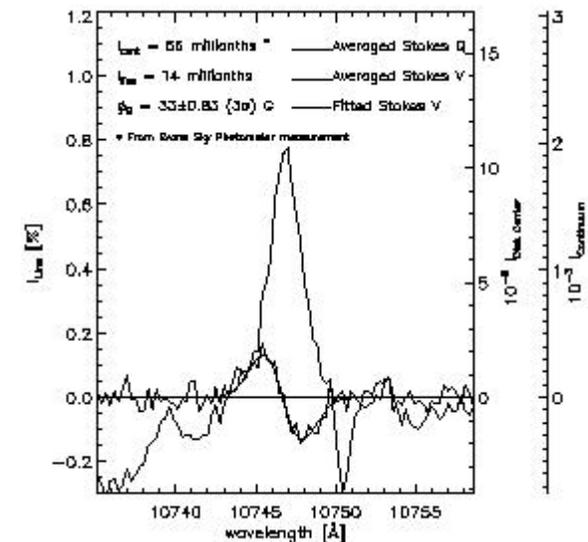
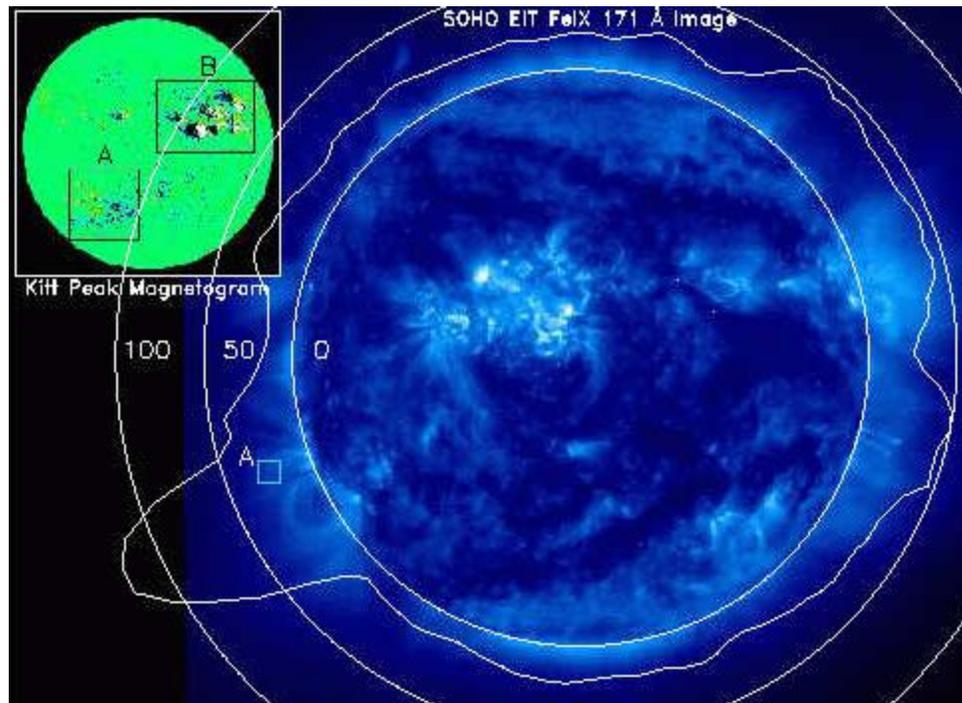
- Raouafi, Sahal-Bréchet, Lemaire, A&A 396, 1019, 2002.
  - OVI 103.2nm polarization measurement using CDS in a coronal hole (9%, 9 degree from limb tangent)
  - Analysis: non-unique solution requires both B of a “few gauss” and velocity of “few 10’s km/s”

# QU forbidden line observations

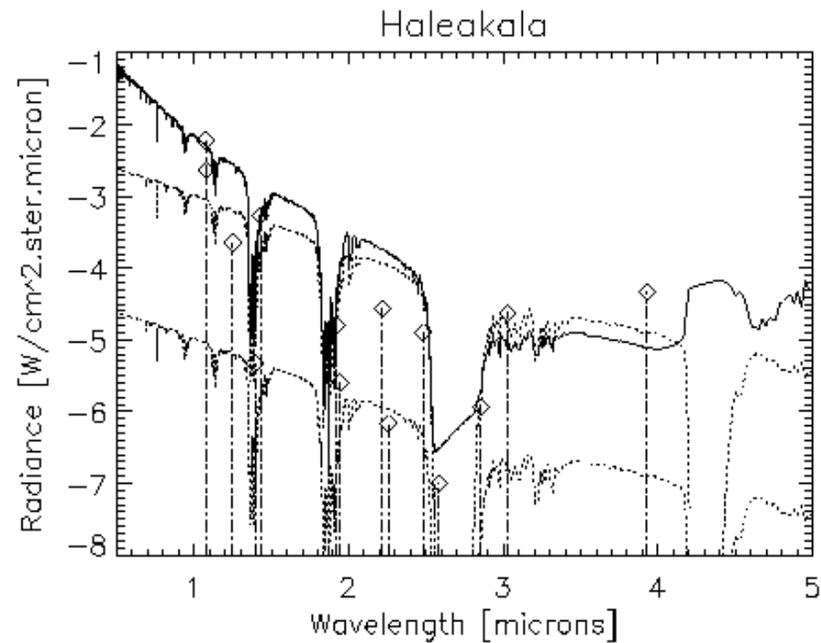


# Coronal forbidden line Zeeman Observations

- Lin, Penn, Tomczyk, ApJ, 541, L83 (2000)
  - FeXIII V polarimetry



# Why IR: Atmospheric backgrounds

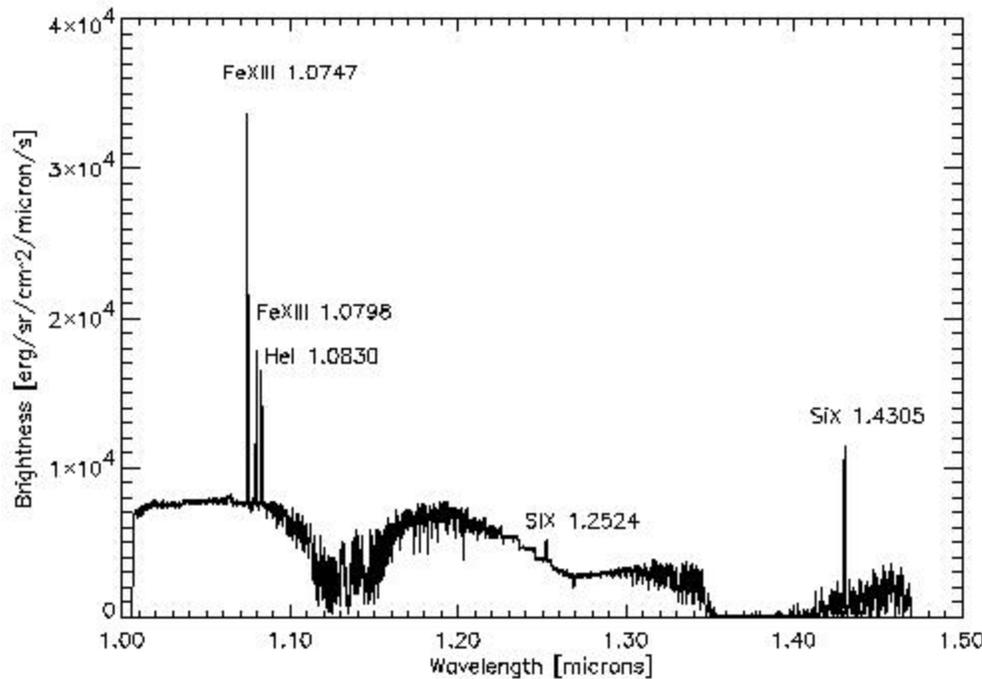


# IR expectations

- Judge, Casini, Tomczyk, Burkepile...  
(<http://comp.hao.ucar.edu/how.html>)\*

Ion	Wavelength	Temperature	Prospects
Fe XIV	530.3nm	2MK	ok
FeXIII	1075nm	1.7MK	excellent
Si X	1430nm	1.3MK	ok
Mg VIII	3027nm	0.8MK	?
Si IX	3932nm	1.1MK	good
Mg VII	9031nm	0.6MK	?

# The IR corona



Infrared imaging spectroscopy, using fixed and tunable ( $\lambda/\delta\lambda = 200-400$ ) filter elements, reveals evidence of a new Si IX emission line. This line is far into the infrared and may allow direct measurements of coronal magnetic fields (heretofore impossible). This experiment was conducted from an open C130 aircraft (operated by NCAR). Scientists from NSO/SP, Rhodes College, MSU, Max Planck (Lindau) and HAO participated in a broad range of IR experiments. A new Rockwell HgCdTe high dynamic range infrared array camera (sensitive between 1-5  $\mu$  and developed at MSU in collaboration with NSO/SP) was used to obtain these results. [This slide was prepared by J. R. Kuhn]

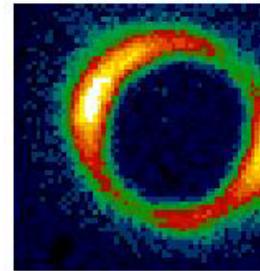


Fig. 1.— Inner corona at  $\lambda = 1.10\mu$

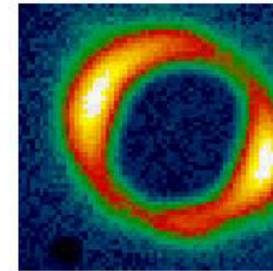


Fig. 2.— Inner corona at  $\lambda = 1.45\mu$

The upper figures show the K corona (continuum only) brightness at 1.1  $\mu$  and 1.458  $\mu$  in a 7nm bandpass. A tunable liquid crystal Lyot filter was used to obtain these images

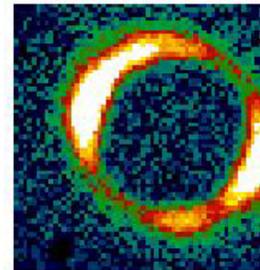


Fig. 3.— Continuum + FeXIII  $\lambda = 1.075\mu$

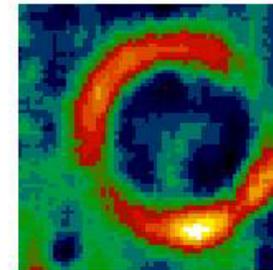


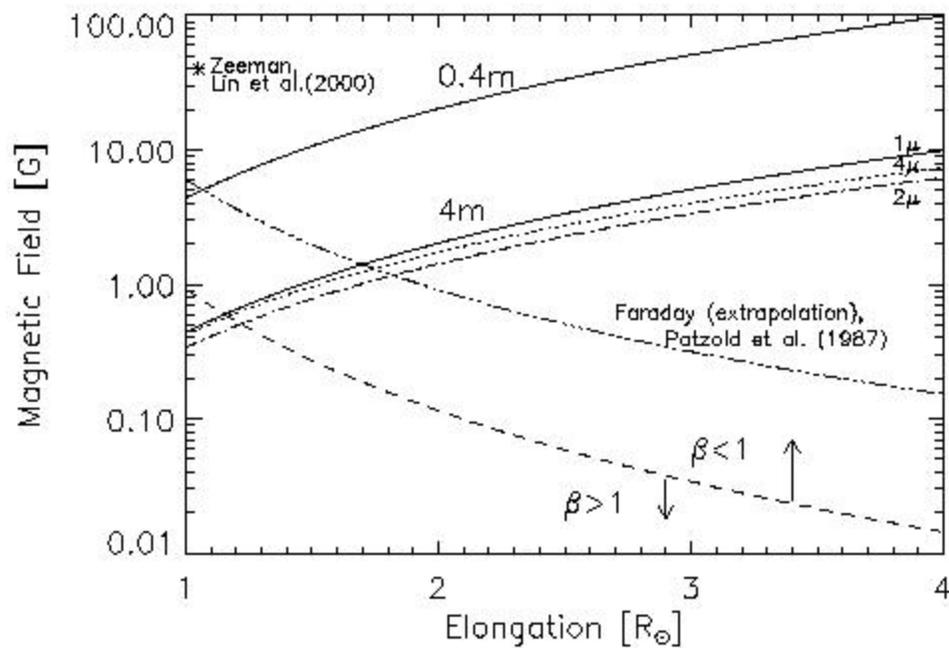
Fig. 4.— Continuum + Si IX  $\lambda = 3.932\mu$

These figures show the continuum + line emission near Fe XIII and the predicted Si IX wavelengths. The bright region on the lower (west) limb of figure 4 is likely evidence of Si IX emission. Tentative intensity calibration suggests that this may be one of the brightest coronal emission lines visible. The long wave observations were obtained with a 10nm bandwidth interference filter centered at 3.932 $\mu$ .

Kuhn et al. 1995, 1999

Also Judge et al., 2002

# Ideal B measurement sensitivity



5 min observation, 10'' pixel

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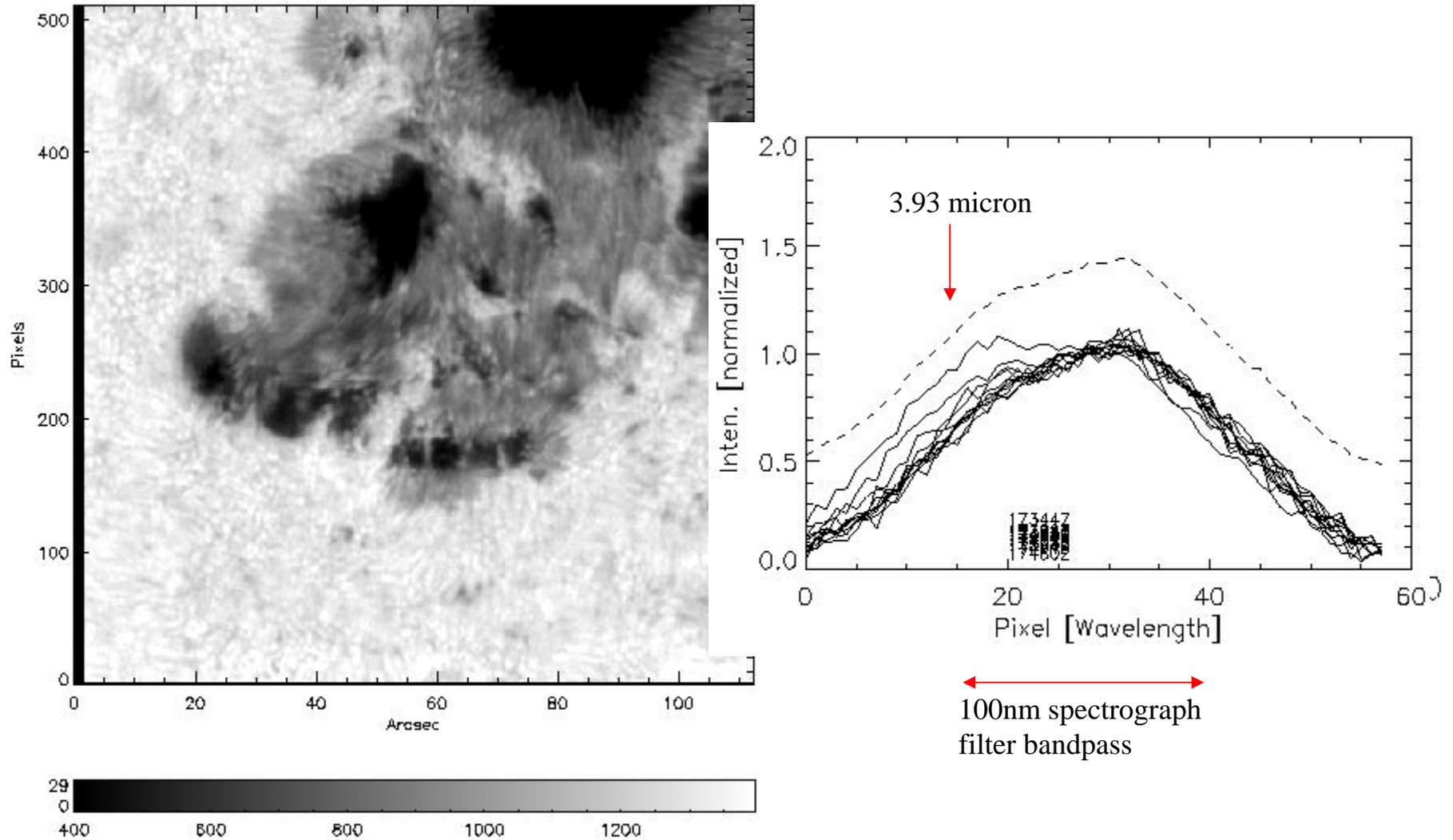


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ADVANCED TECHNOLOGY SOLAR TELESCOPE

# SOLARC

Roy Coulter, Jeff Kuhn, Haosheng Lin, Don Mickey



# Magnetic field measurements...

- ...will be achieved in the quiet corona with a sensitivity of better than 1 G
- ...from IR coronal observations obtained by several research groups using sensitive polarimetry techniques
- ...on a timescale of one year

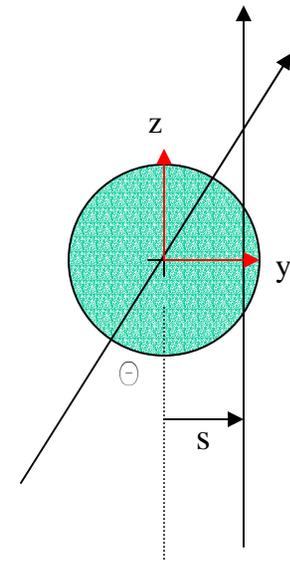
# Vector Inversions

- FF and potential model from Low (1993)
  - External potential field+FF at  $r < R$  + dipole

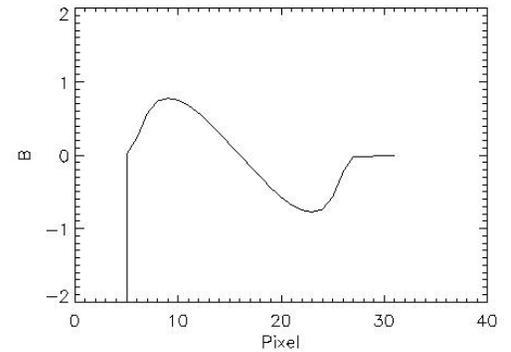
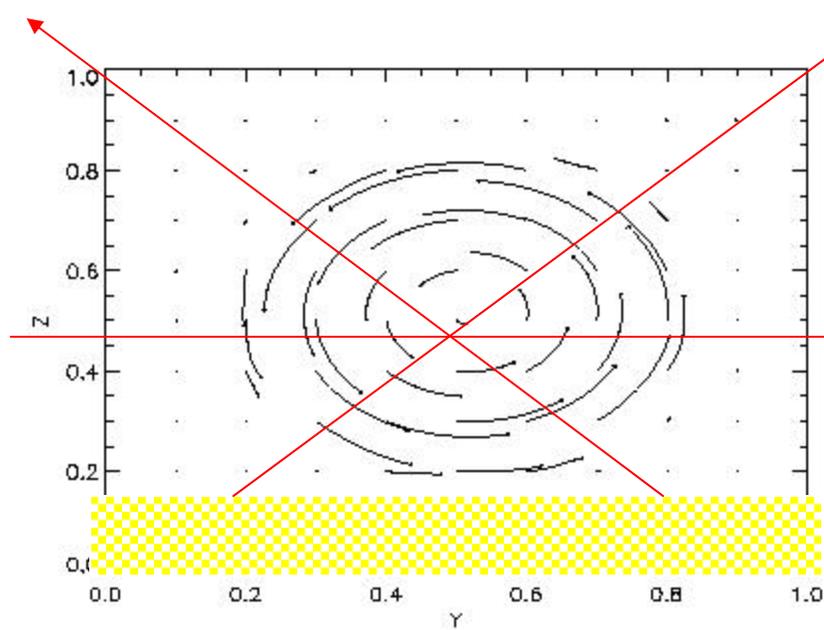
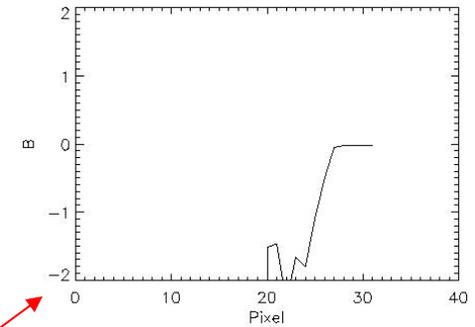
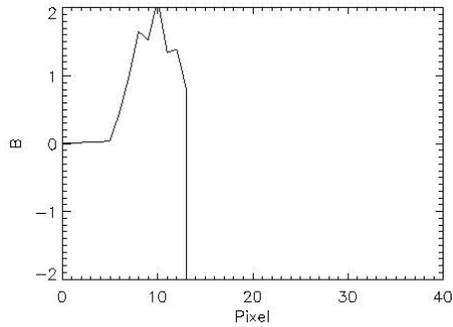
- Radon transform using Algebraic Reconstruction Technique

$$B(y, z) = \mathfrak{R}^{-1}(B_y(s, \theta) \cos \theta + B_z(s, \theta) \sin \theta)$$

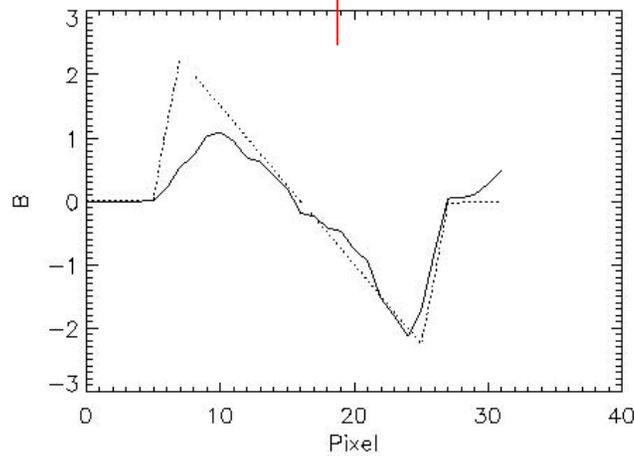
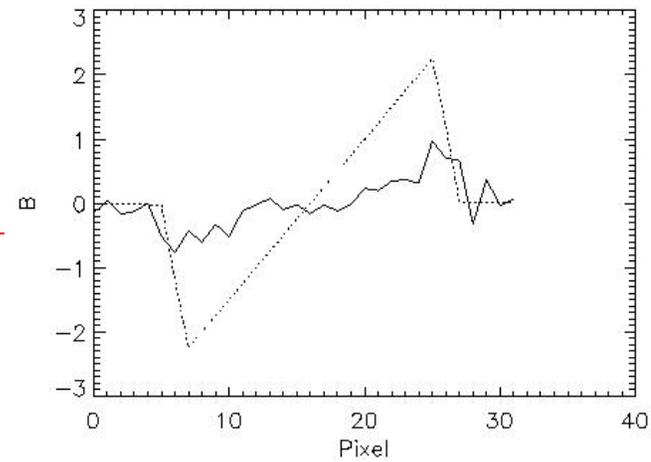
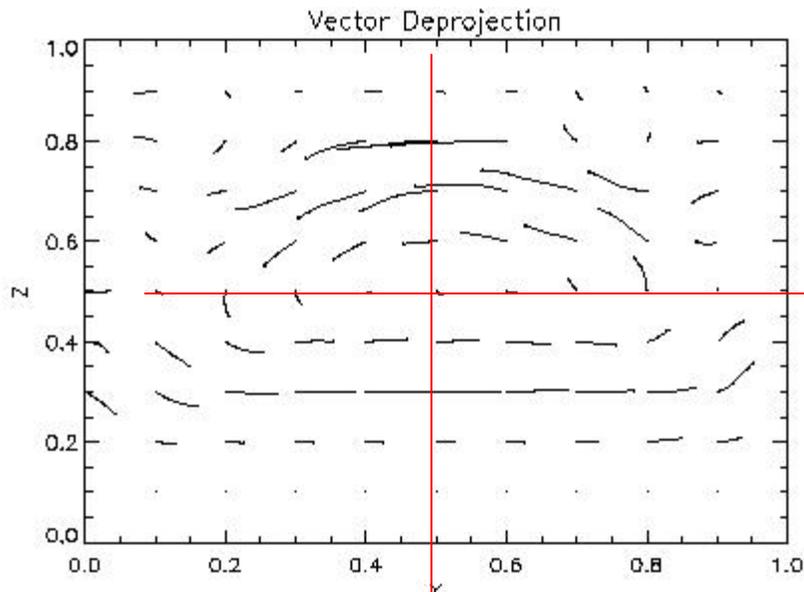
$$\mathfrak{R}^{-1}(\cos \theta \sin \theta) = 0 \quad B_y \approx \mathfrak{R}^{-1}(B_{los} \cos \theta) \quad B_z \approx \mathfrak{R}^{-1}(B_{los} \sin \theta)$$



# The projection problem

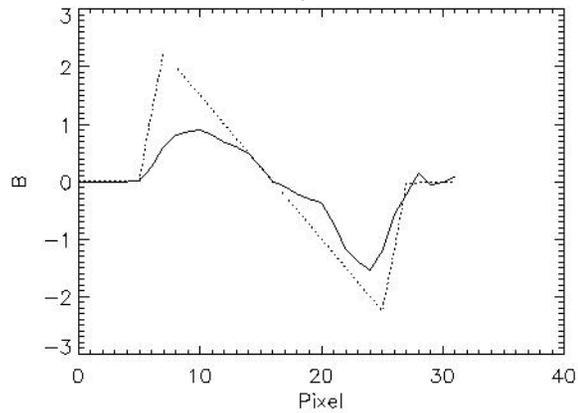
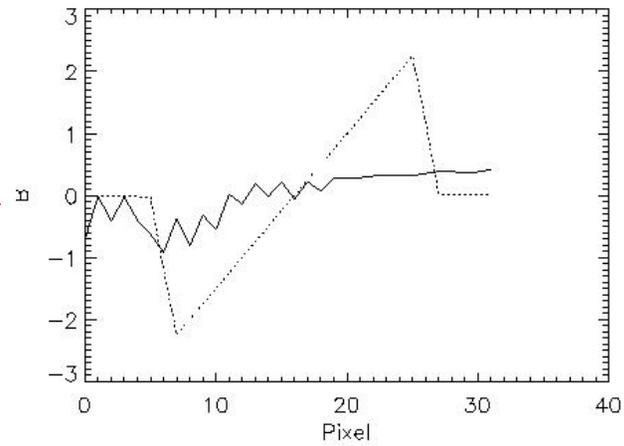
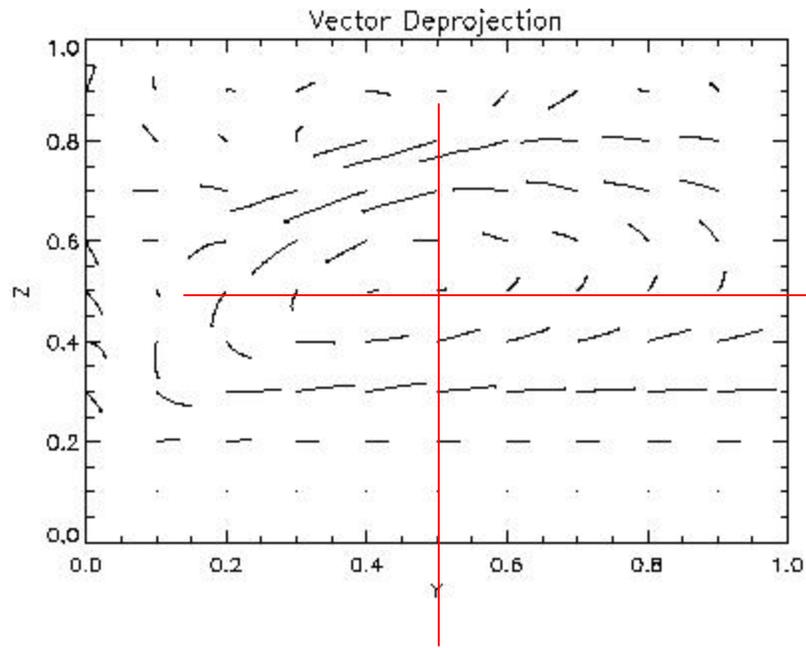


# The inversion



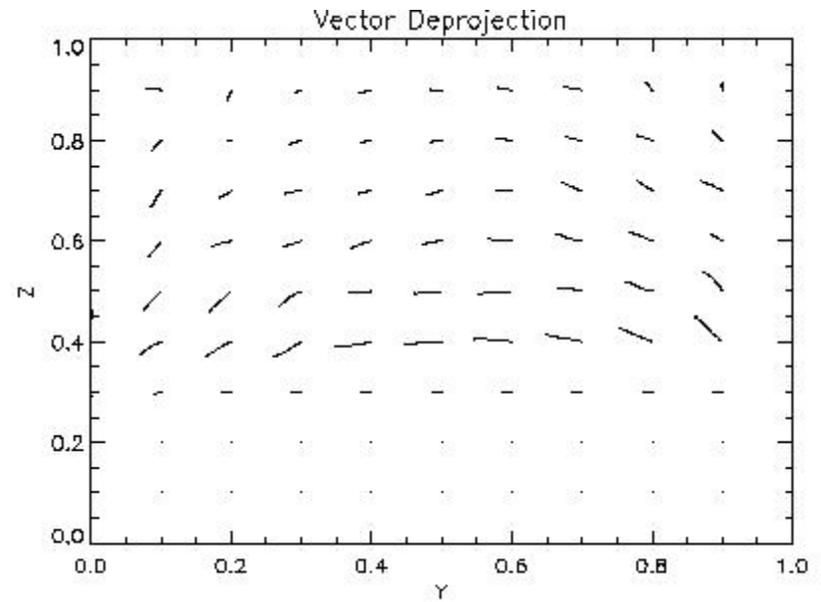
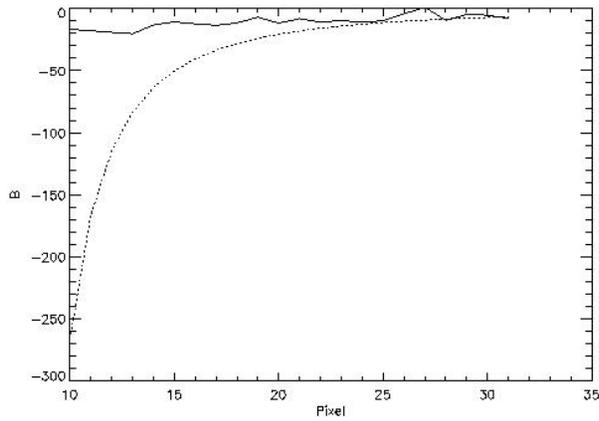
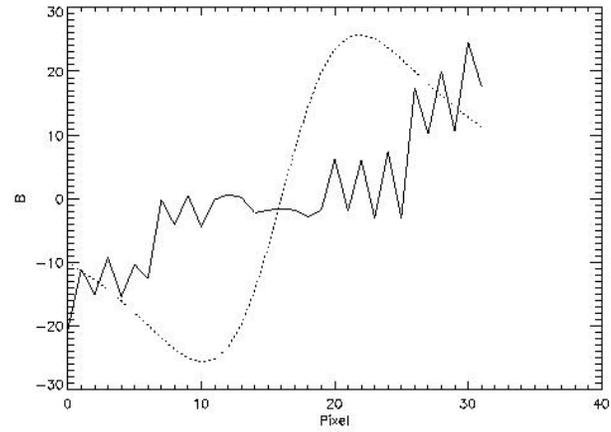
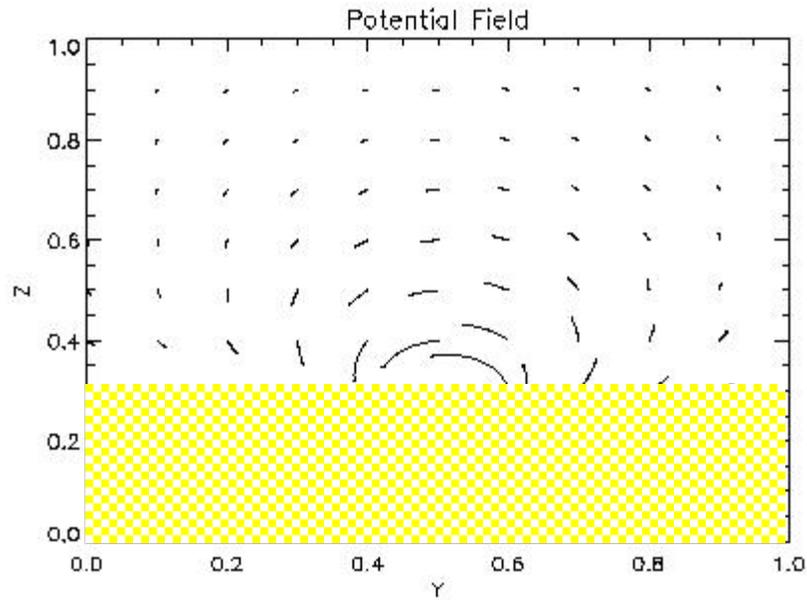
10 iterations over 12 projections  
spaced 15 degrees...

# Another inversion



6 projections, 0-90 degrees...

# Potential field...





# Long Wavelengths

