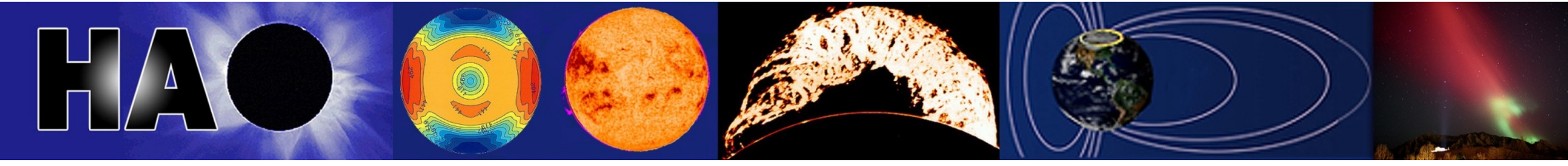

The Chromosphere Magnetometer

ChroMag

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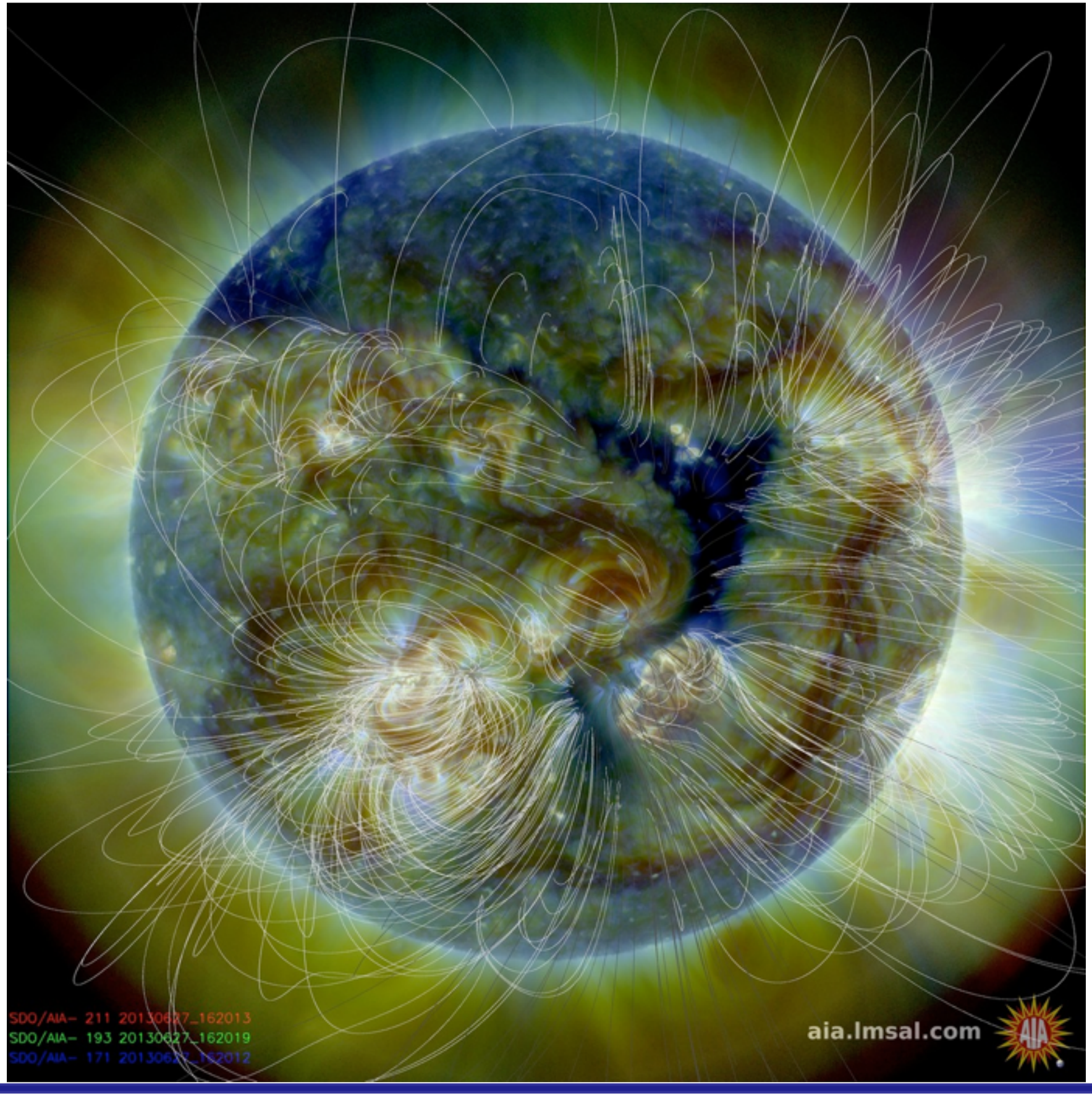
NCAR

Motivation

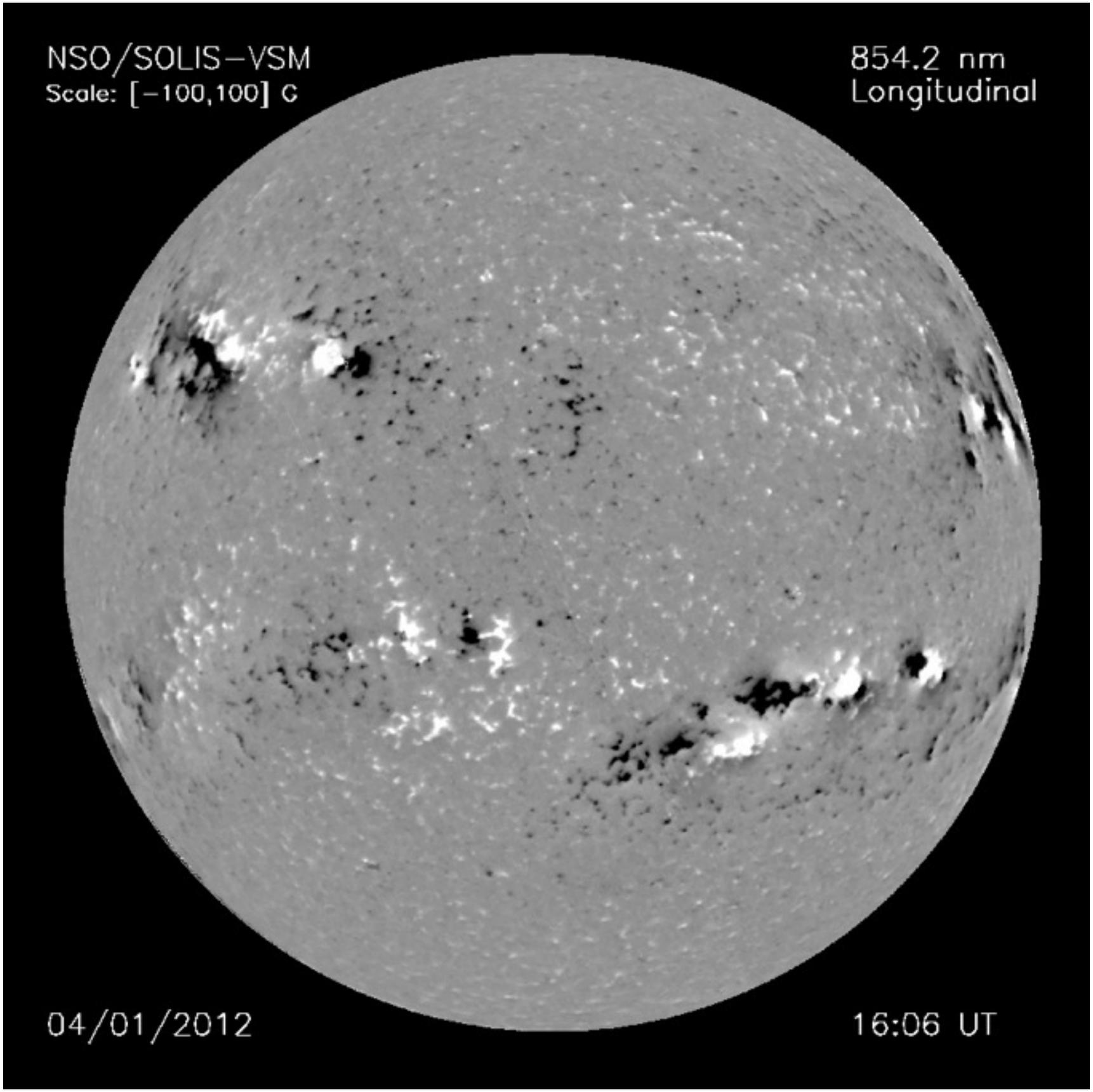
- Robertus: measure **B** at several heights.
- Markus: future networks should provide V_{Dop} and **B** at cadence < 60 s at a spatial resolution of 1” in a variety of wavelengths.
- Michal: full-Stokes polarimetry in Hα 656.3 nm, Ca II 854.2 nm, and He I 1083.0 nm.

- What determines the magnetic structure of the Sun?
- What is the role of the chromosphere in the mass and energy balance of the corona?
- What magnetic configurations lead to flares and CMEs?
- How are prominences formed, and how are they related to CMEs?
- Where does the solar wind originate and how is it accelerated?

- Chromospheric and coronal structure is dominated by magnetic field.
- We must know the magnetic field at the force-free bottom boundary in order to understand solar activity in the heliosphere: flares, CMEs, etc.
- Extrapolating from photospheric (vector) field does not work.


SDO/AIA- 211 20130627_162013
SDO/AIA- 193 20130627_162019
SDO/AIA- 171 20130627_162012
aia.lmsal.com
AIA

- We need spectral lines with a chromospheric contribution of which the formation is understood that are sensitive to magnetic field.
- We would prefer lines in the optical or near-infrared.
- We're in luck: He 1083.0 nm and the Ca IR triplet 849.8/854.2/866.2 nm.


NSO/SOLIS–VSM
Scale: [–100,100] G
854.2 nm
Longitudinal
04/01/2012
16:06 UT

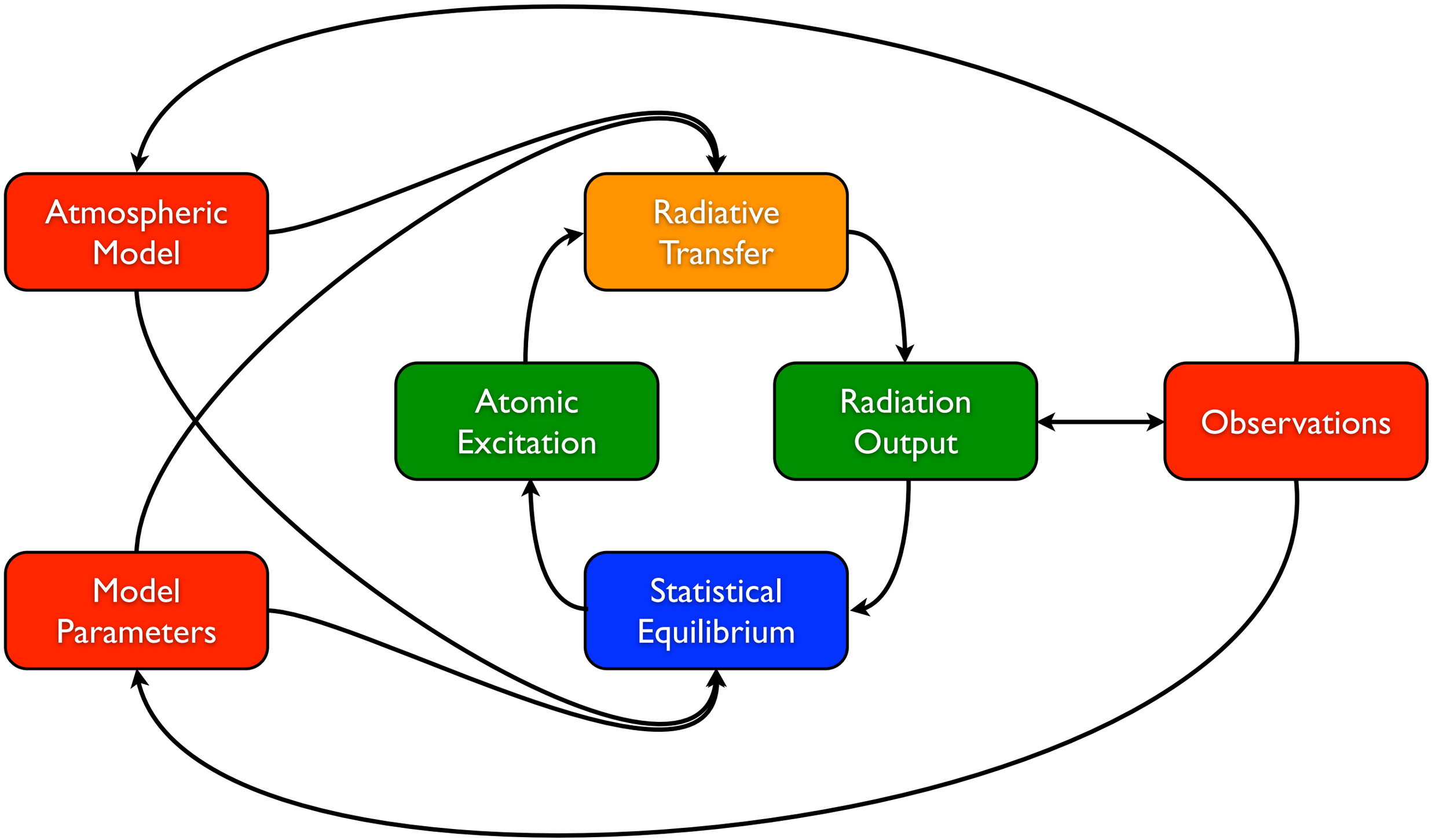
- How can we make quantitative measurements?
- We can infer plasma parameters from full-Stokes spectral line profiles.
- Actual inversion of the profile is not tractable, so we solve the forward problem: synthesize a line, compare with the observation, and repeat until a match is found.

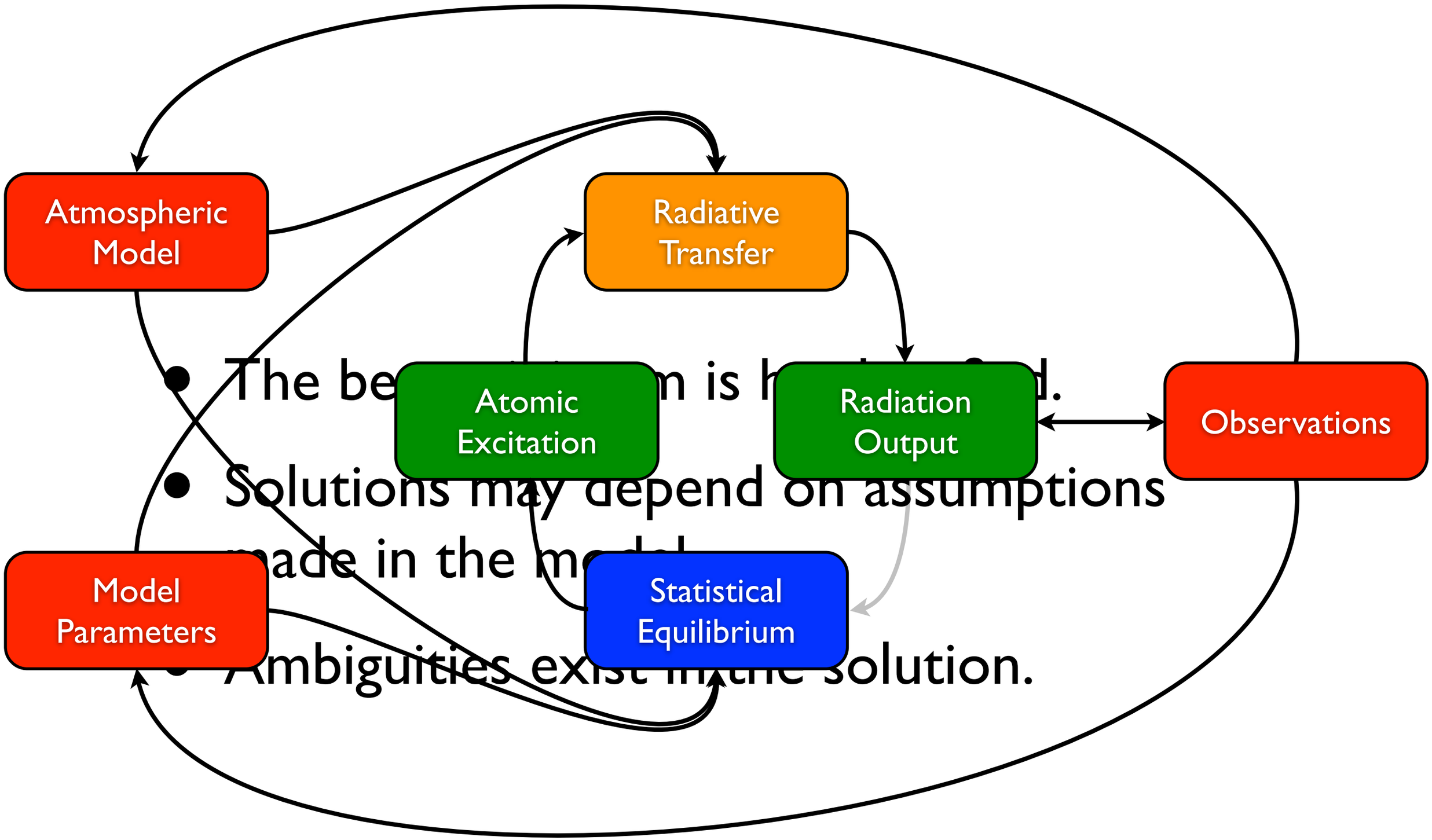
- Both He and Ca are promising diagnostics, and several inversion codes already exist. But:
- Radiative transfer of the Ca IR triplet is difficult and 2 of the lines suffer from blends.
- He 1083.0 nm is very weak outside of active regions.

- We need a spectrograph or a wavelength-tunable imager to measure the line profiles.
- Detectors are 2D, but observation space is 3D: 2 spatial, 1 spectral dimension.
- We have to slice the cube somehow.
- And observing is never easy anyway.

- Why is quantitative polarimetry difficult?
- Detectors are sensitive to intensity.
- We must encode the Stokes 4-vector into intensity measurements, and decode it from the observations. Polarimetry is by necessity a difference measurement.
- Polarization signals are small compared to intensity.

- How do we analyze the data?
- Remember the “inversion” process: synthesize, compare, repeat.
- We need a model atmosphere, and calculate polarized radiative transfer.
- So why is that so difficult?


Atmospheric Model
Radiative Transfer
Atomic Excitation
Radiation Output
Observations
Model Parameters
Statistical Equilibrium

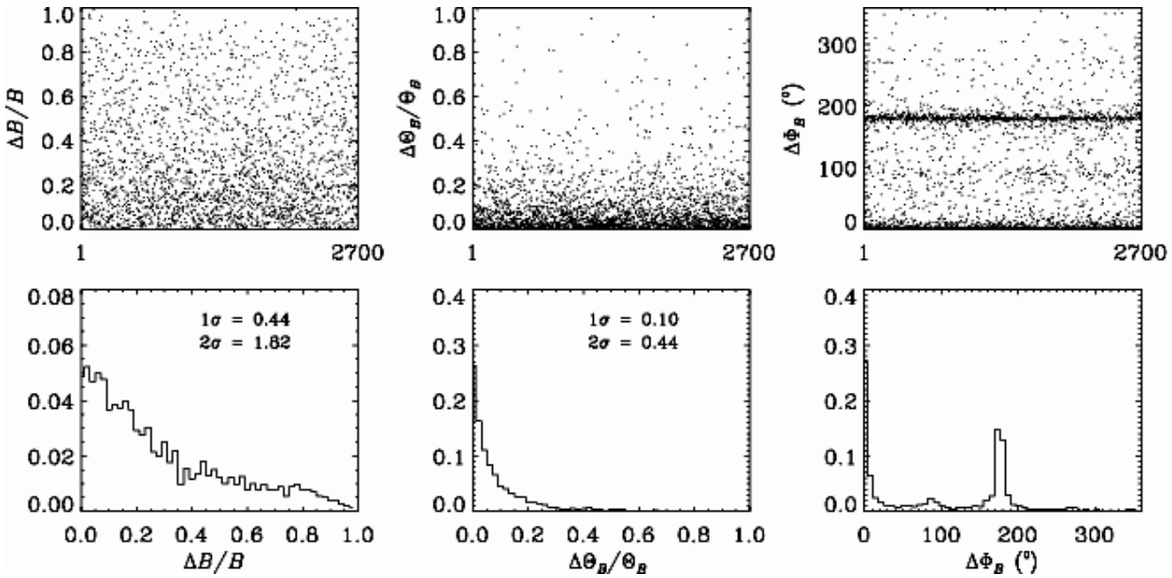


- The be m is h d.
- Solutions may depend on assumptions made in the mo
- Ambiguities exist in the solution.

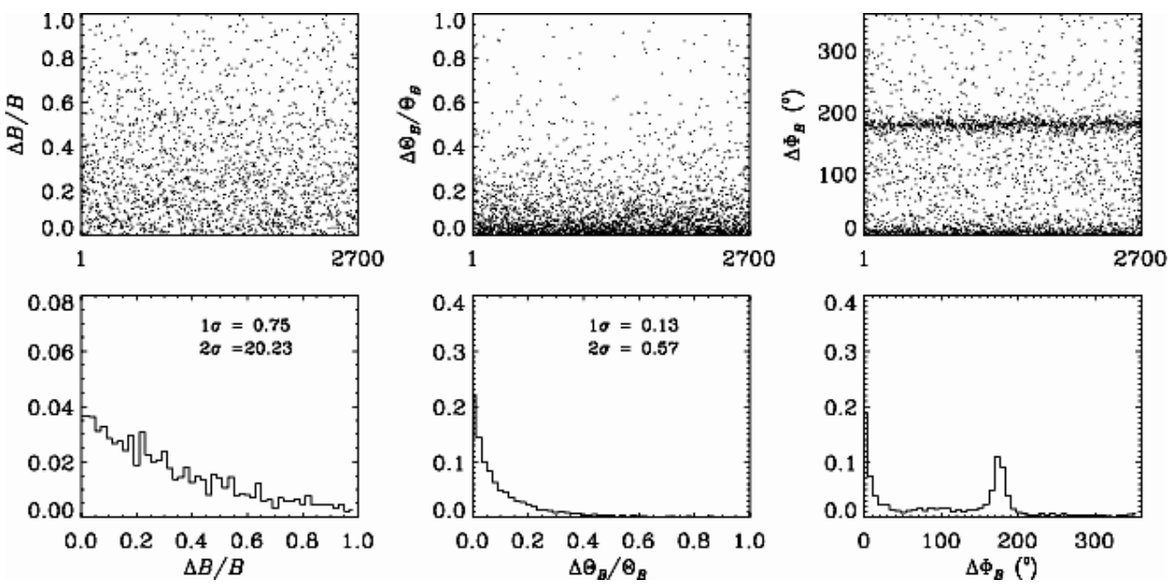
Spectro-polarimeter

R = 180000 (0.048 Å sampling)

No noise



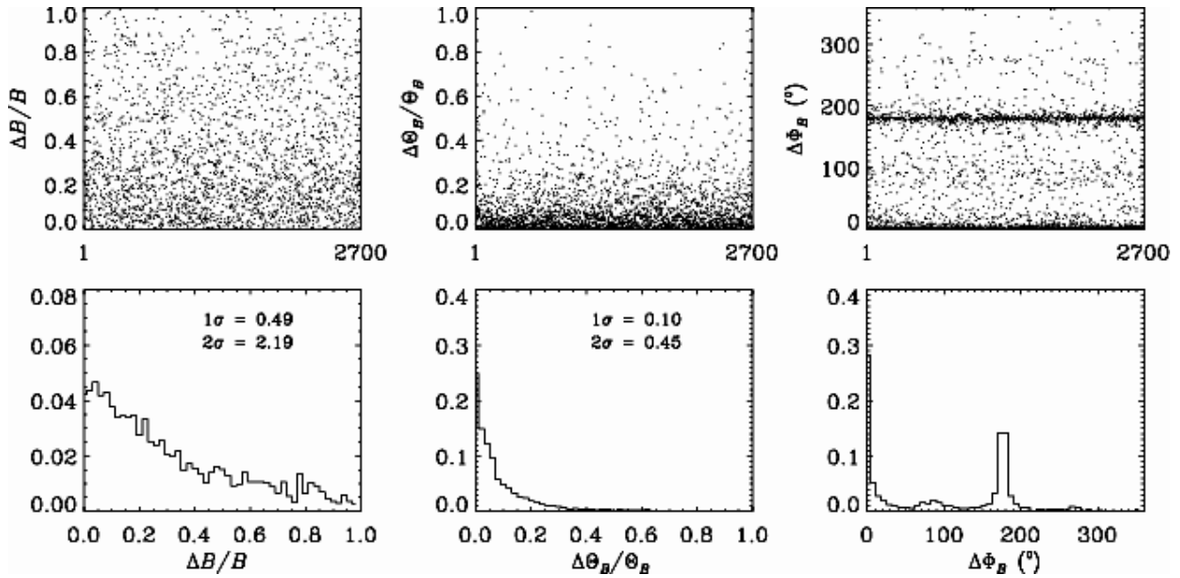
S/N = 10^3



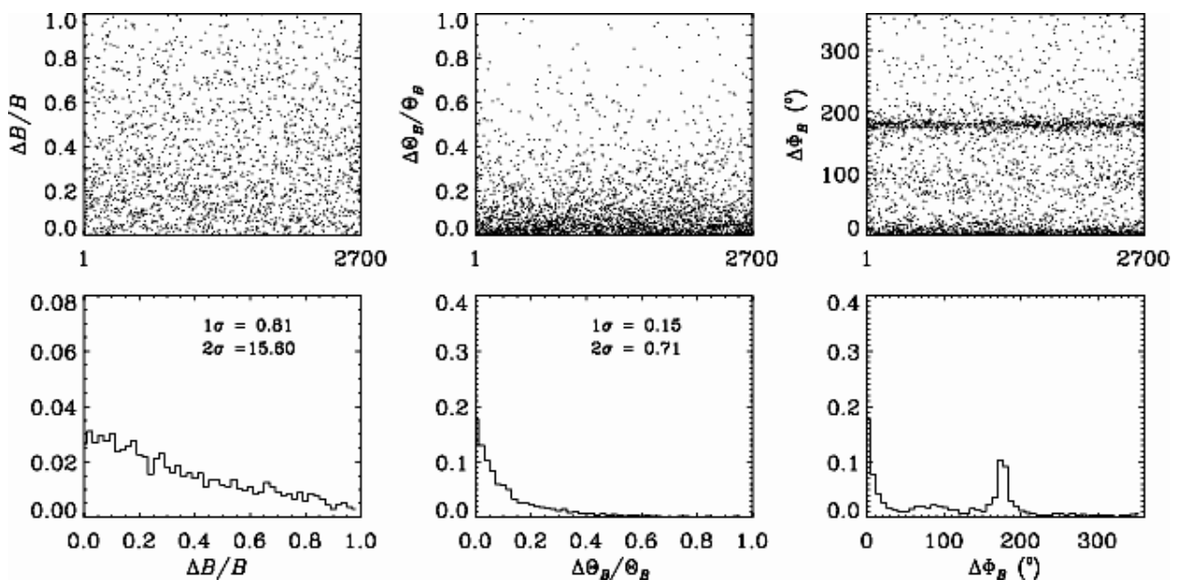
Lyot filter (ChroMag)

FWHM = 0.2 Å, 0.1 Å sampling

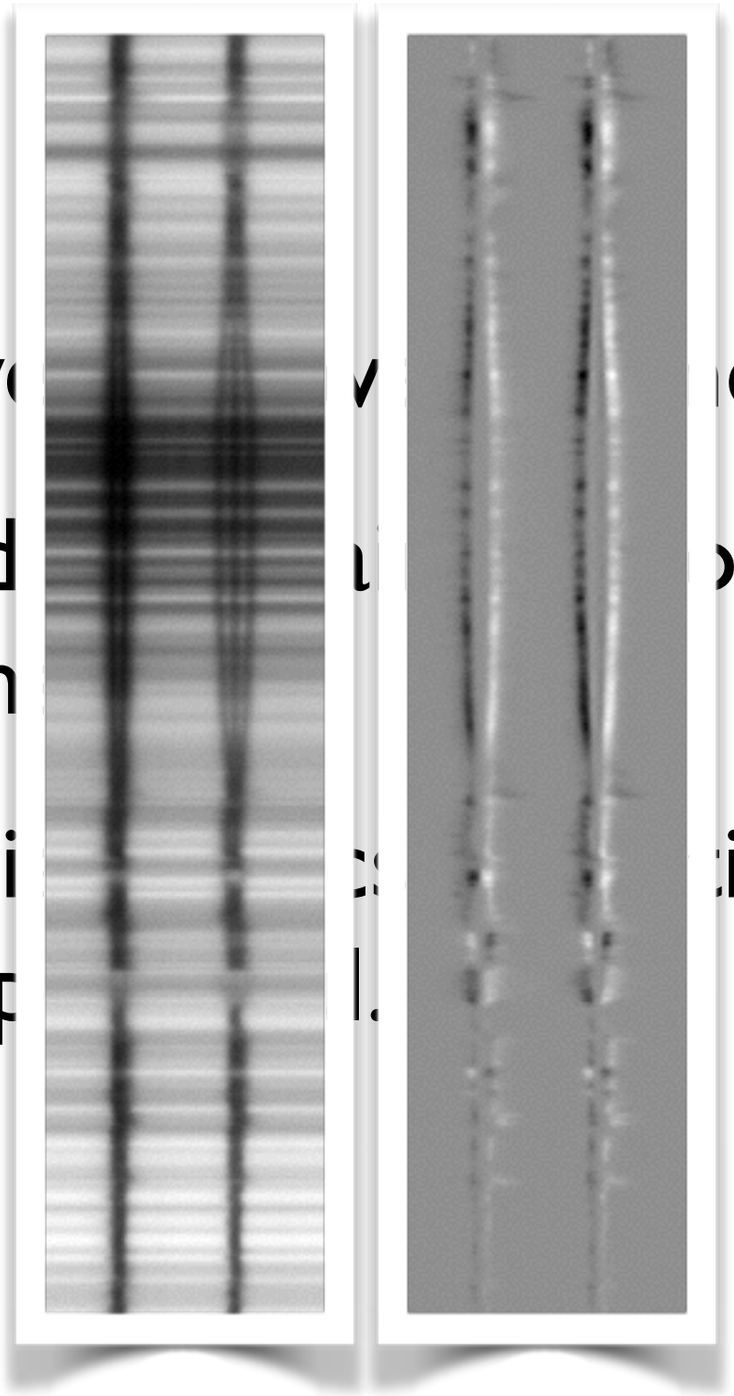
No noise



S/N = 10^3



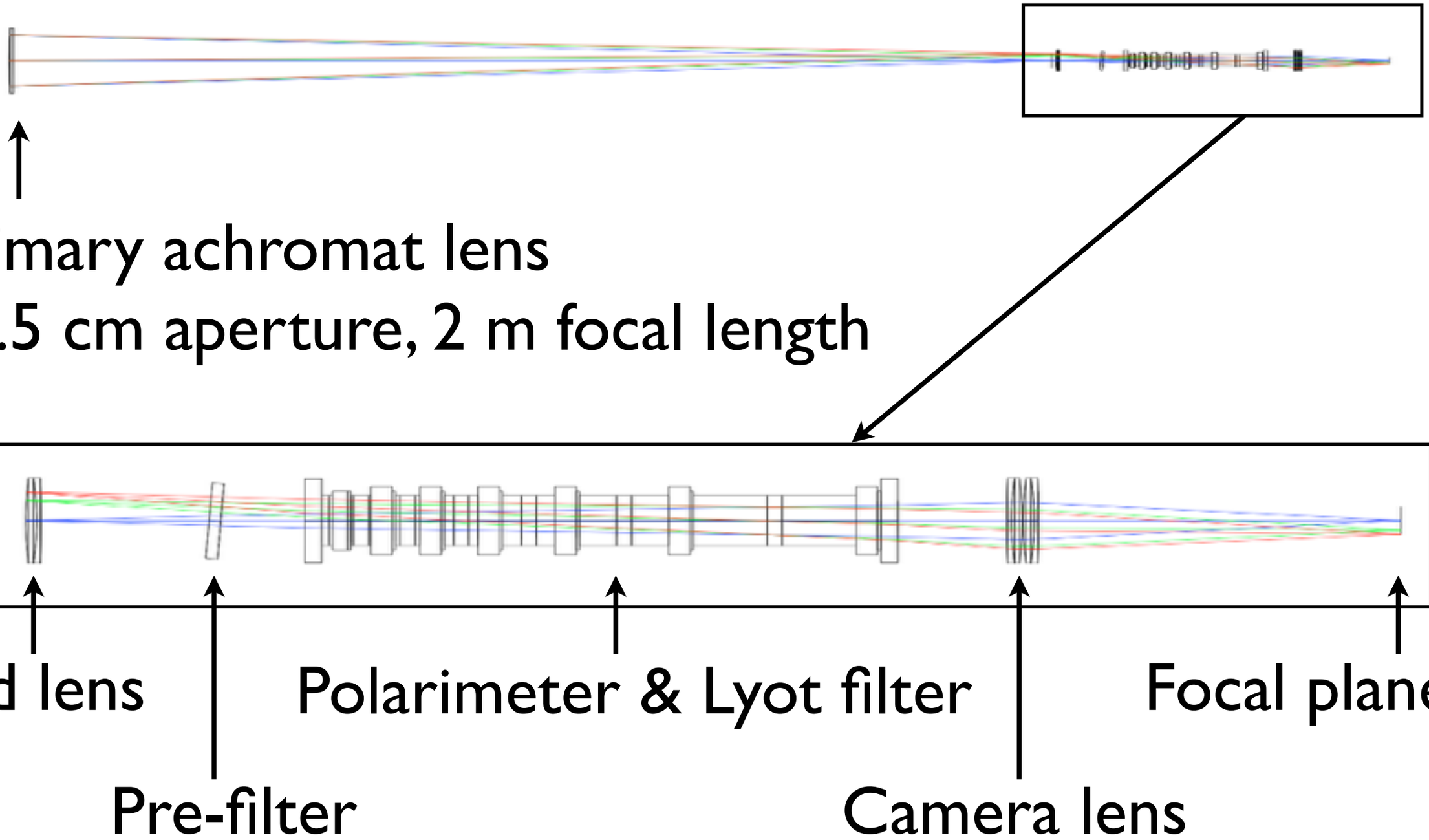
- How can w easurements?
- We can add ough more observation
- Multi-line di icular turn out to be very p l.



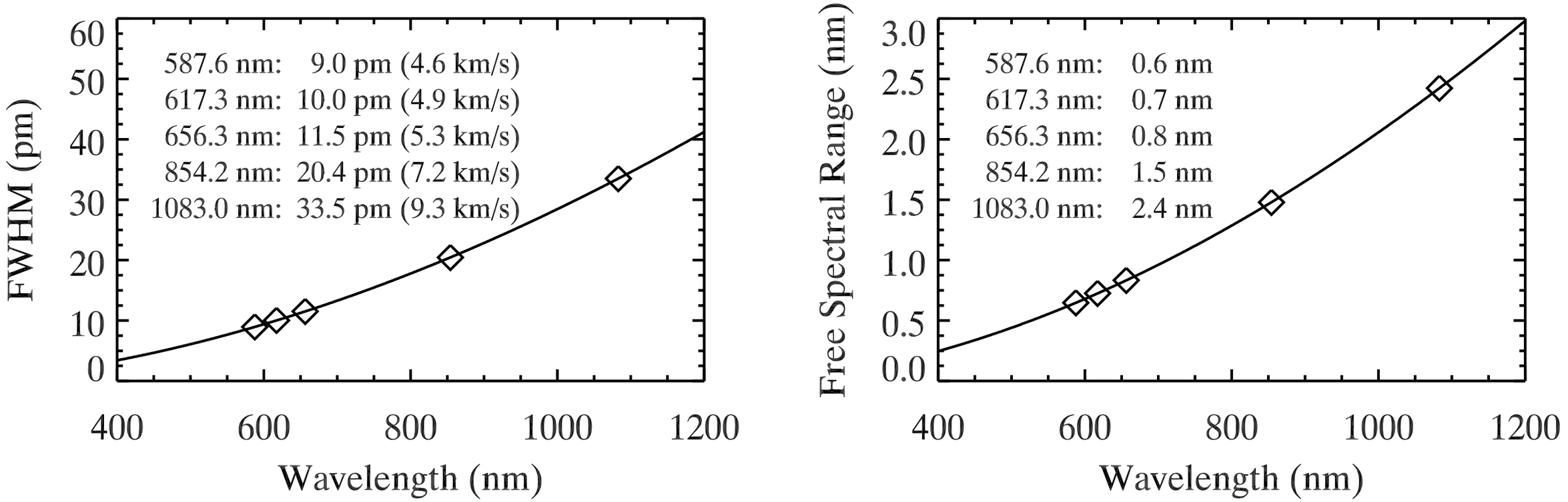
ChroMag

- Provides synoptic imaging spectro-polarimetry in:
  - He I 587.6 & 1083.0 nm: chromospheric magnetograms
  - Hα 656.3 nm: chromospheric structure and dynamics
  - Ca II 854.2 nm: chromospheric magnetograms
  - Fe I 617.3 nm: photospheric magnetograms
- High cadence: < 1 minute for all lines
- Moderate spatial resolution: 2.6 arcsec (1.3 arcsec pixels)
- Field of view: 3×3.5 R_{sun}
- High polarimetric sensitivity: < 10^{-3}

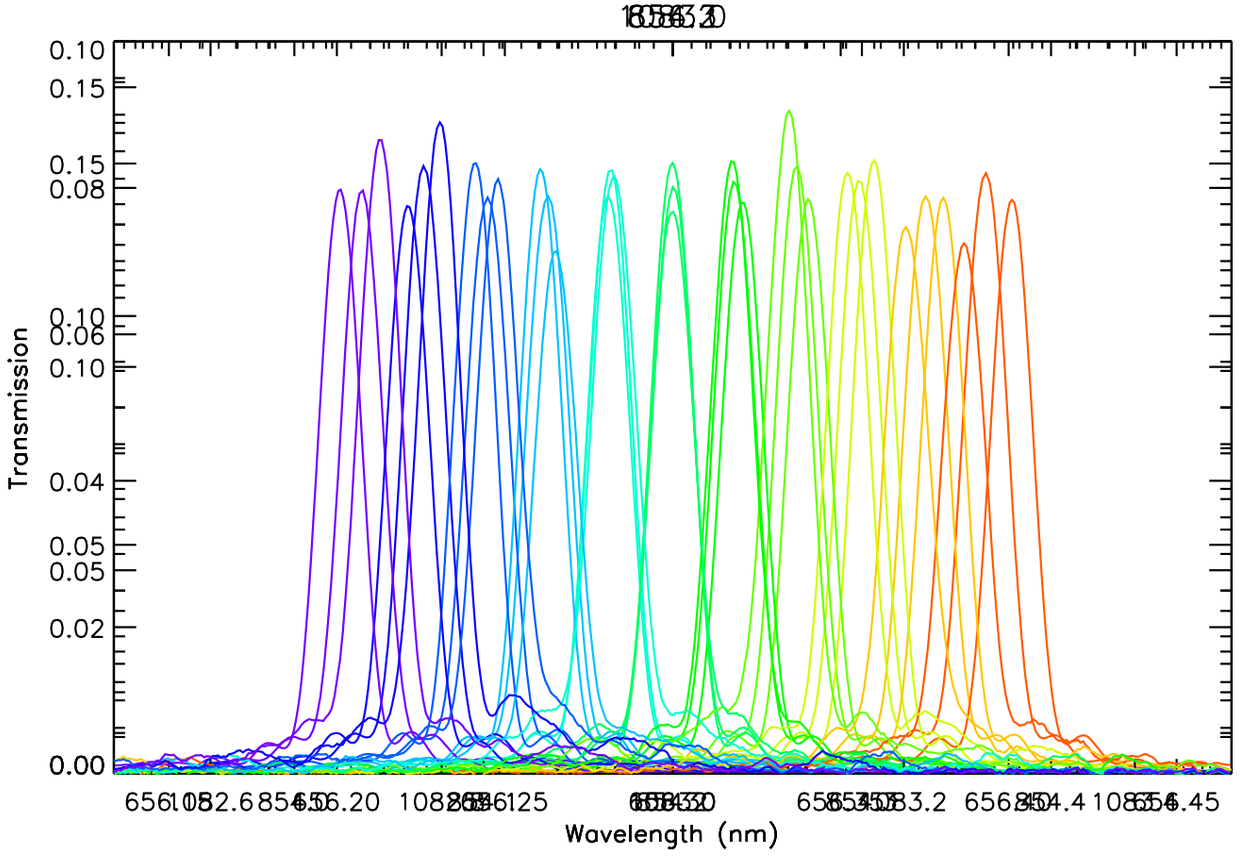
Prototype Overview

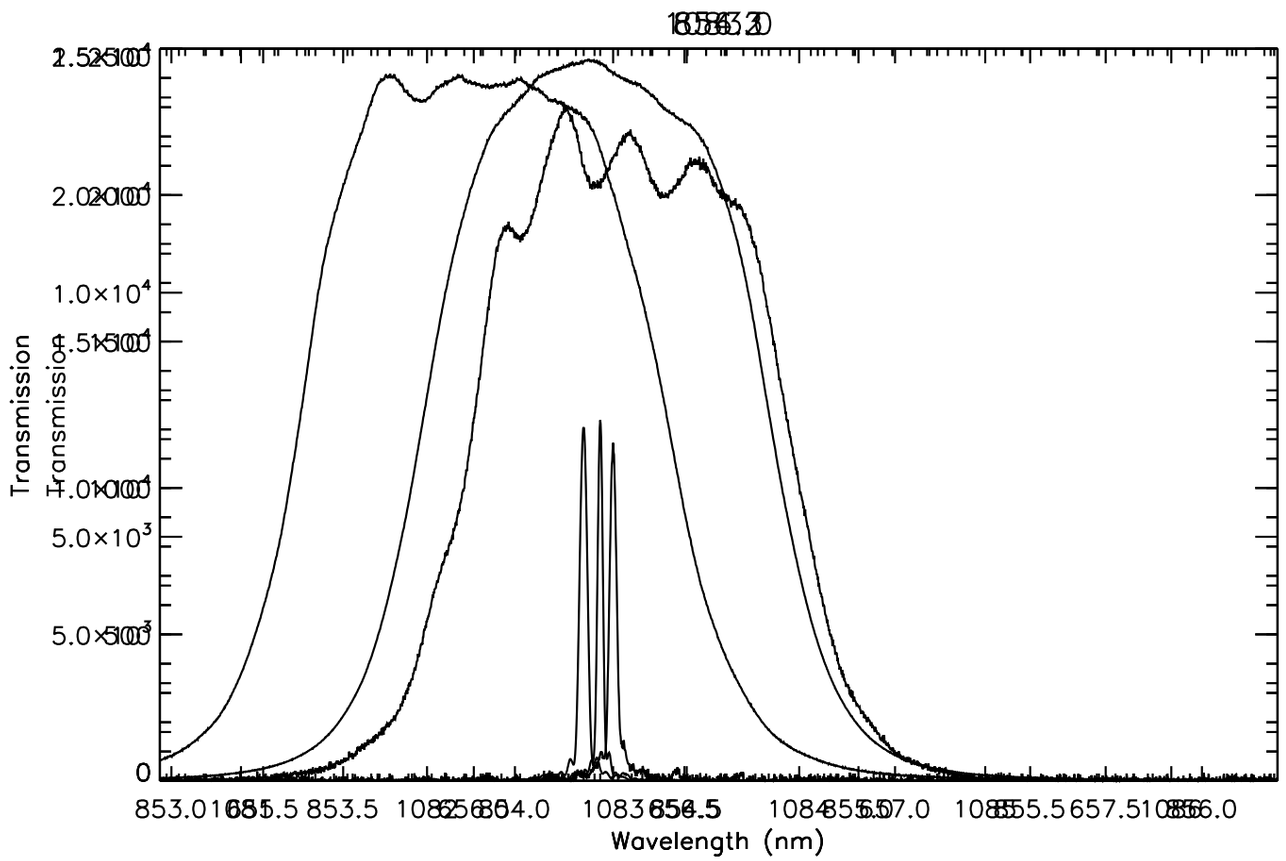


Lyot filter overview



- Electro-optically tunable with LCVRs (0.2s)
- Usable range: 587–1085 nm
- 6 stages, thickest stage has 88mm of calcite


Transmission
Wavelength (nm)


Transmission
Wavelength (nm)

Where are we now?

- Last year: thermal stability problems
- Re-design effort, completely rebuilt back-end solves thermal issues
- Recently re-deployed to the NCAR Mesa Lab spar facility
- Testing and Commissioning underway