

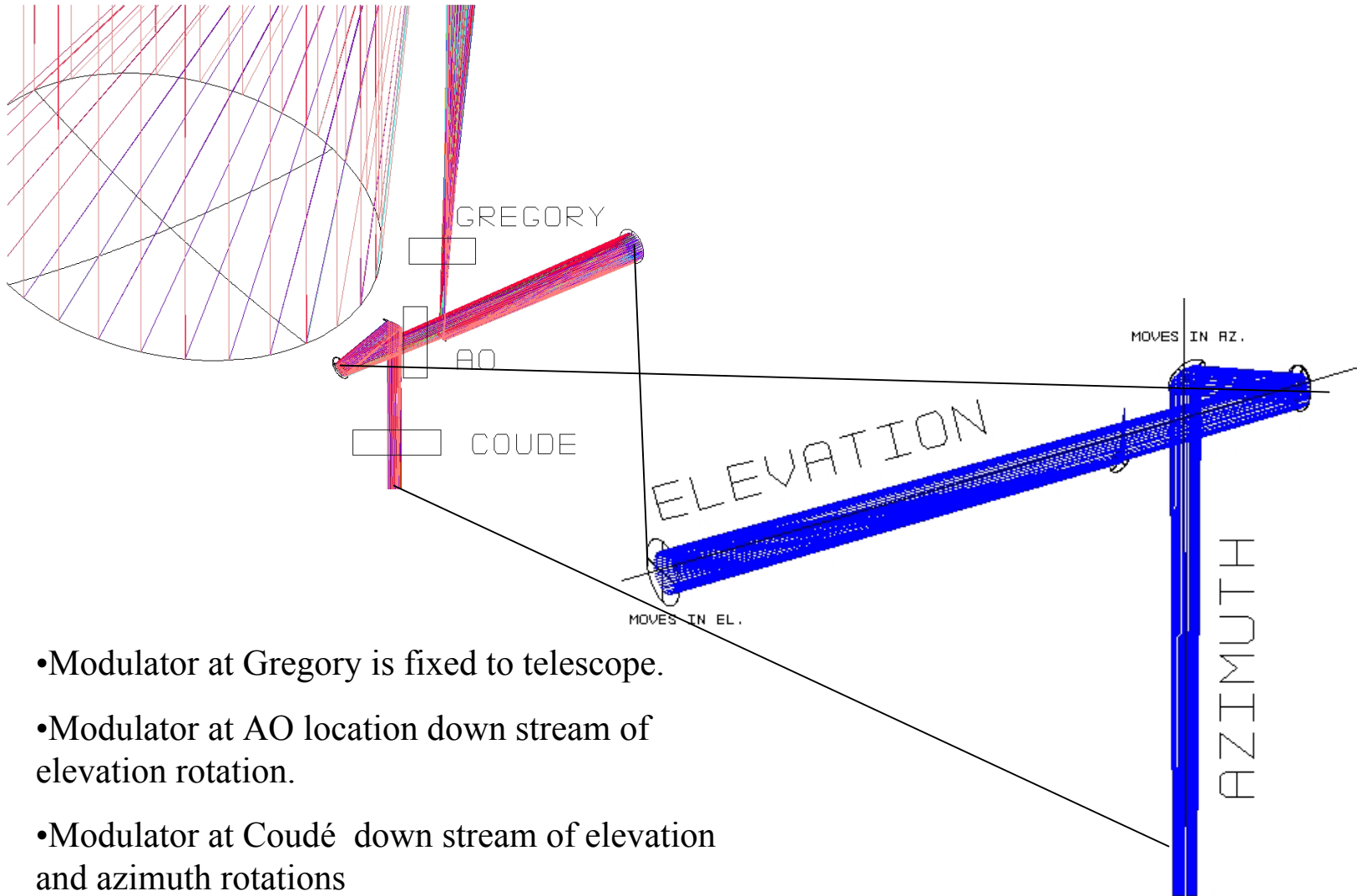
Modulator and Analyzer Location

David Elmore
HAO/NCAR
303 497 1580
elmore.ucar.edu

Overview

- Use 'current' telescope design
- Insert coordinate transformations
- Use ZEMAX for Al coating properties
- Calculate single point polarimeter response, X, matrices
 - Modulator at Gregory, AO, or Coudé
 - Analyzer at Gregory, AO, or Coudé
- Calculate single point telescope, T, matrix for optics up to modulator
- Evaluate results

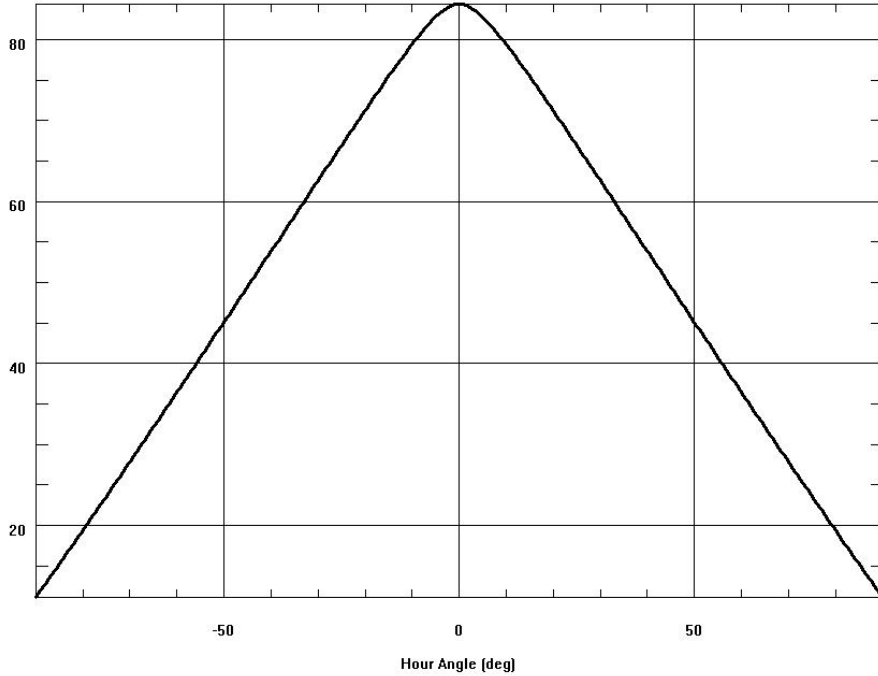
Modulator Locations



- Modulator at Gregory is fixed to telescope.
- Modulator at AO location down stream of elevation rotation.
- Modulator at Coude down stream of elevation and azimuth rotations

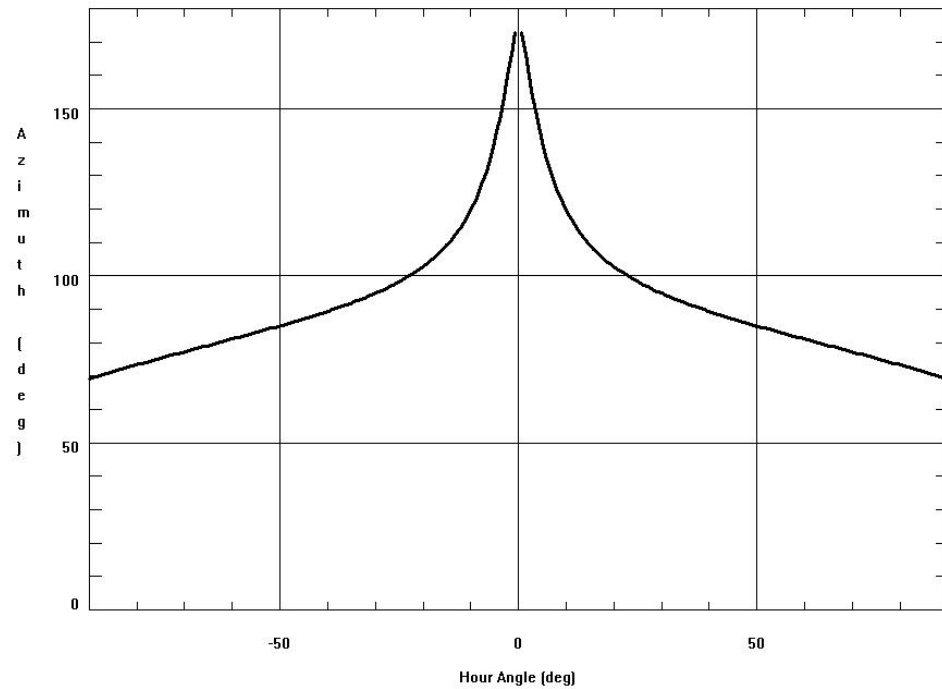
Elevation and Azimuth

Elevation vs. Hour Angle

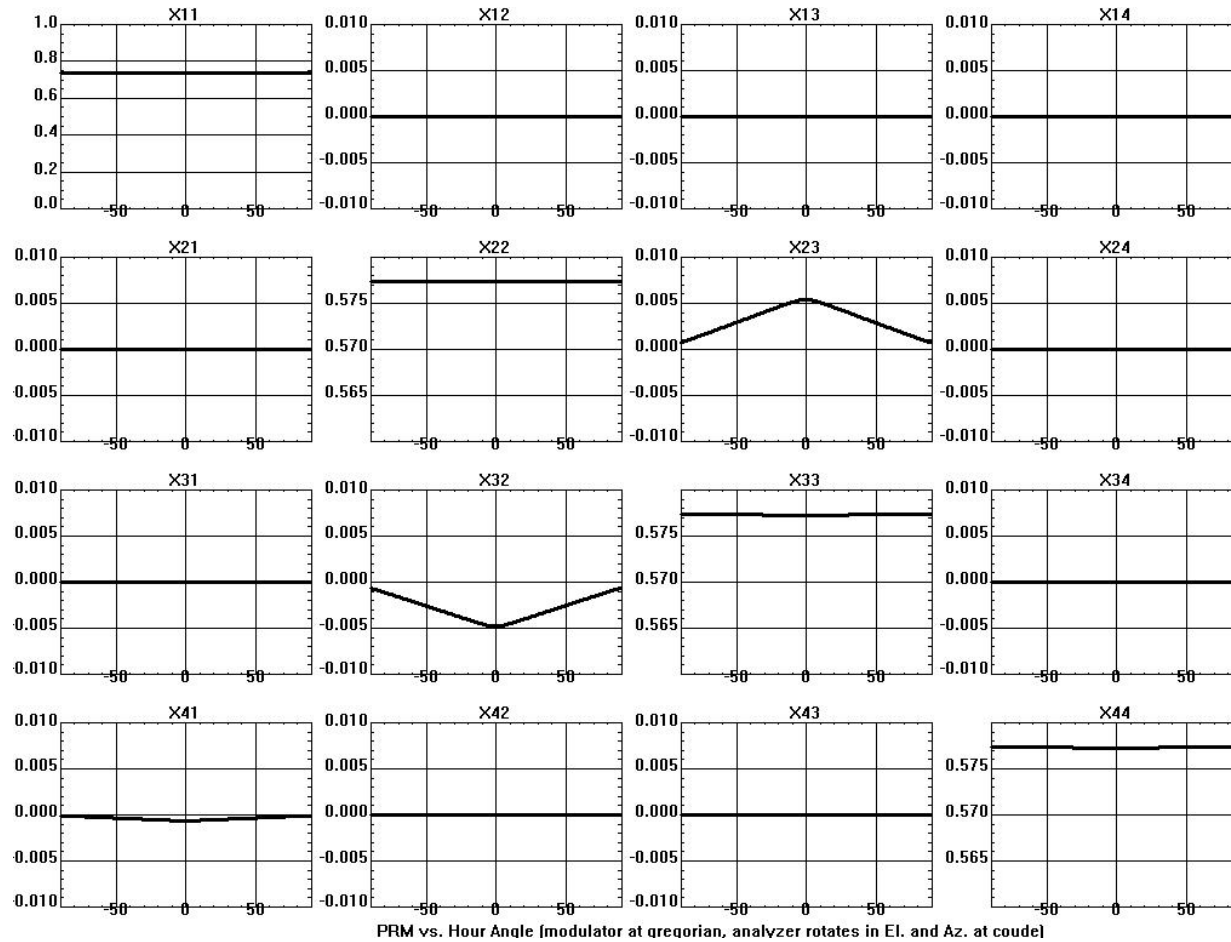


Sun approaches zenith at some time of year for most sites. This calculation is for 29° latitude and summer solstice.

Azimuth vs. Hour Angle

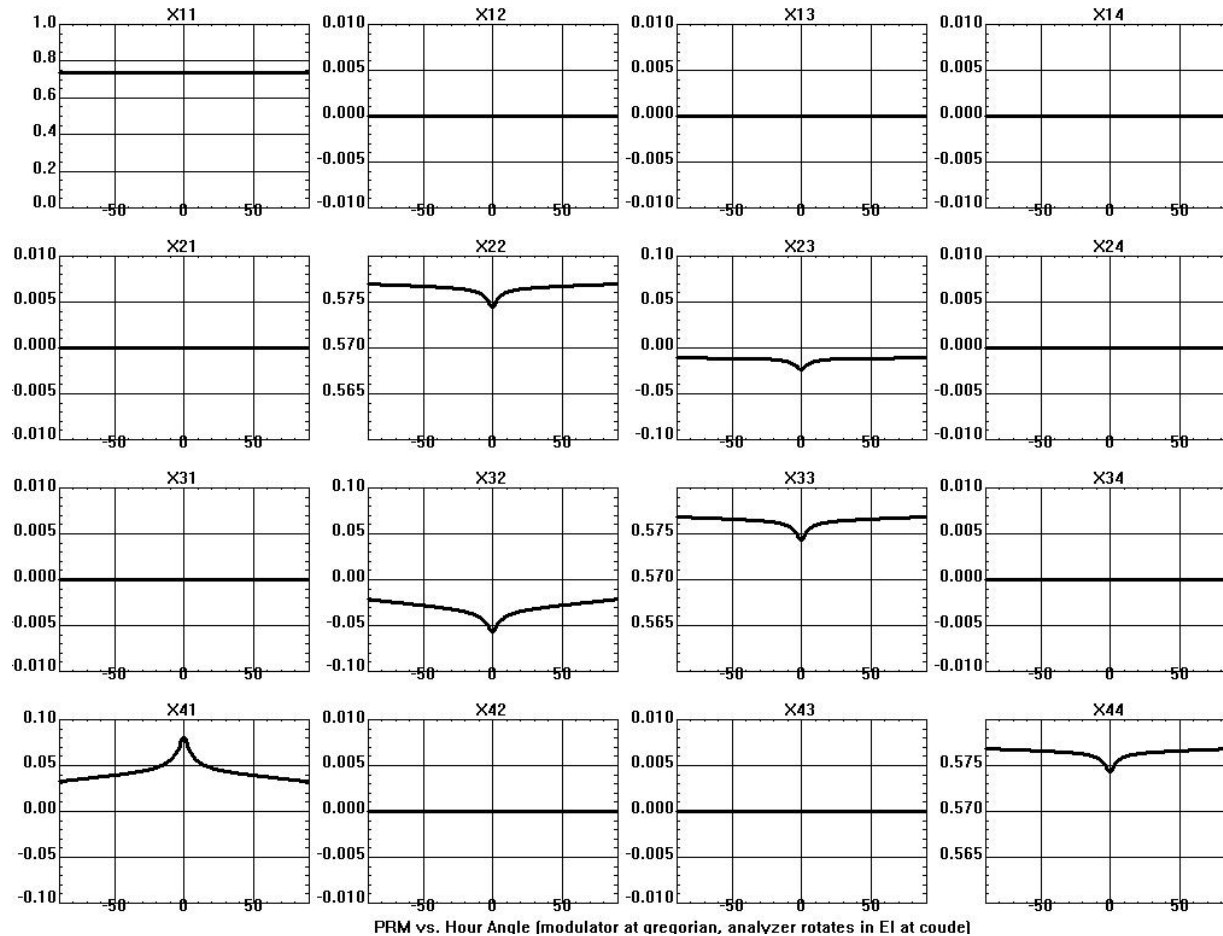


X: Modulator at Gregory, Rotating Analyzer (Az+El) at Coudé



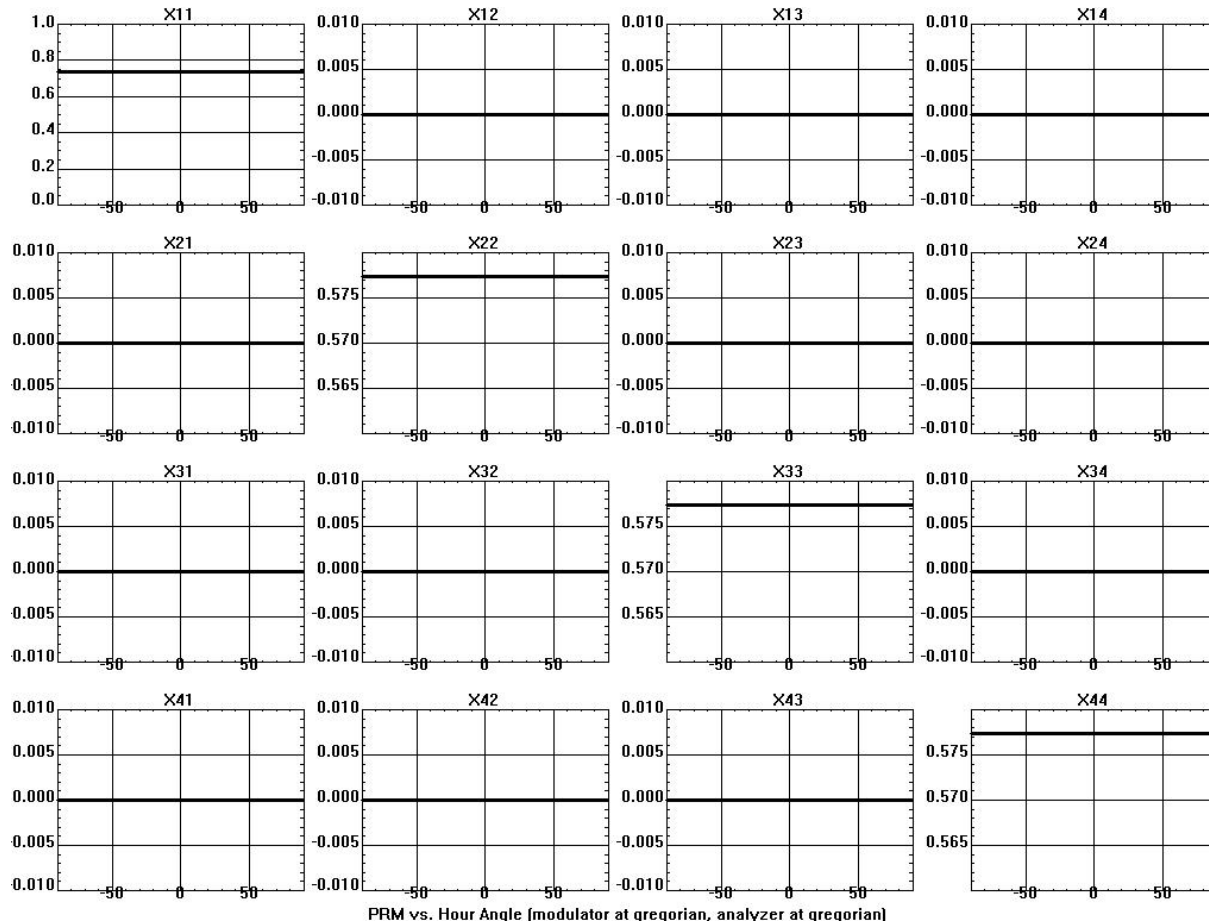
This is the baseline design. Analyzer must rotate to compensate for elevation and azimuth rotations. Note significant X_{23} and X_{32} variations with hour angle. These are about 0.01 of diagonal elements. Rotation to correct X matrix is not the same needed to compensate image rotation. Calibration vs. elevation could be used to model this effect at all elevations.

X: Modulator at Gregory, Image rotation correction at Coudé



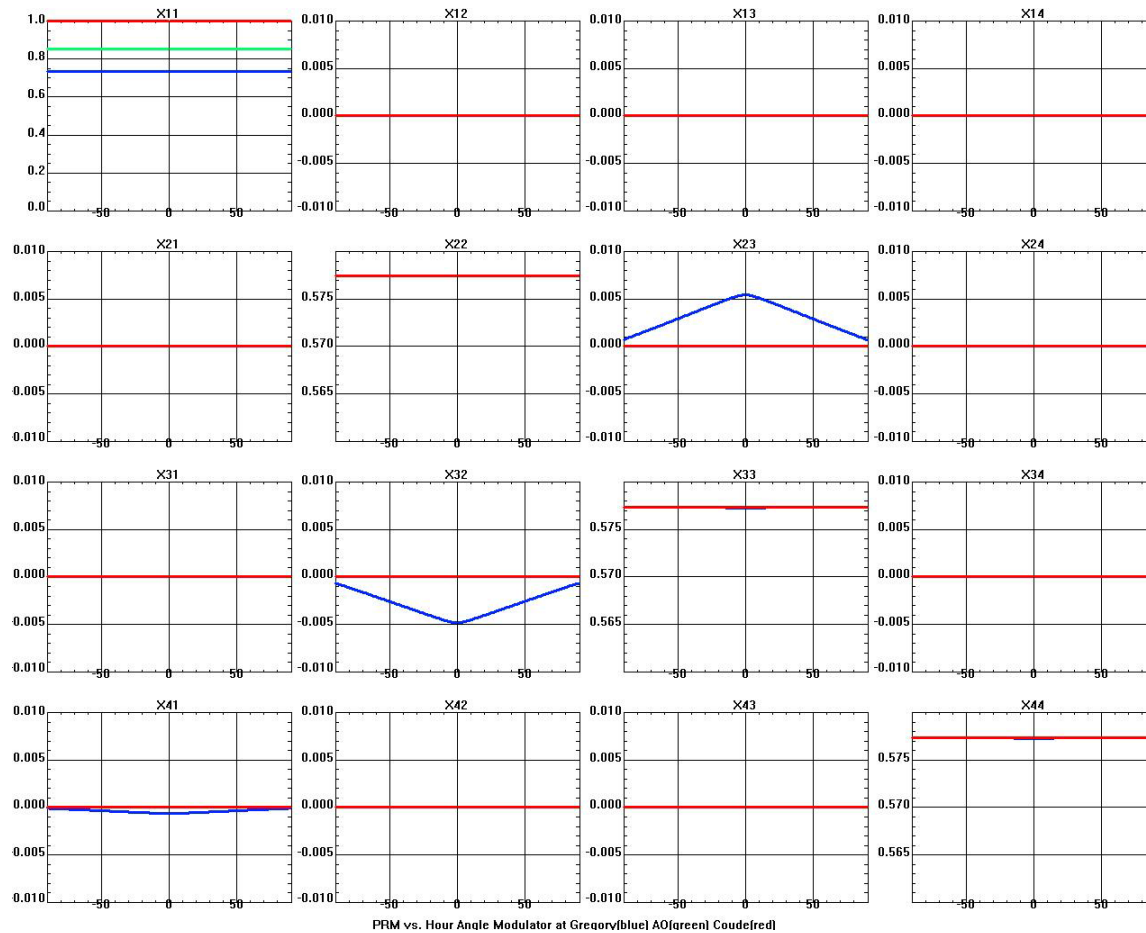
Analyzer rotates along with coudé to correct for image rotation (elevation). Note significant X_{41} variations with hour angle. These are about 0.1 of intensity. Calibration vs. azimuth could be used to model this effect at all azimuths.

X: Modulator at Gregory, Analyzer at Gregory



With modulator immediately followed by analyzer, there is no change in the X matrix due to azimuth and elevation changes. Image rotation can be corrected at Coudé. Dual beam analyzer at Gregory, upstream of AO system, will probably not work.

X Matrix: Modulator @ Gregory/AO/Coude, Analyzer @ Coudé

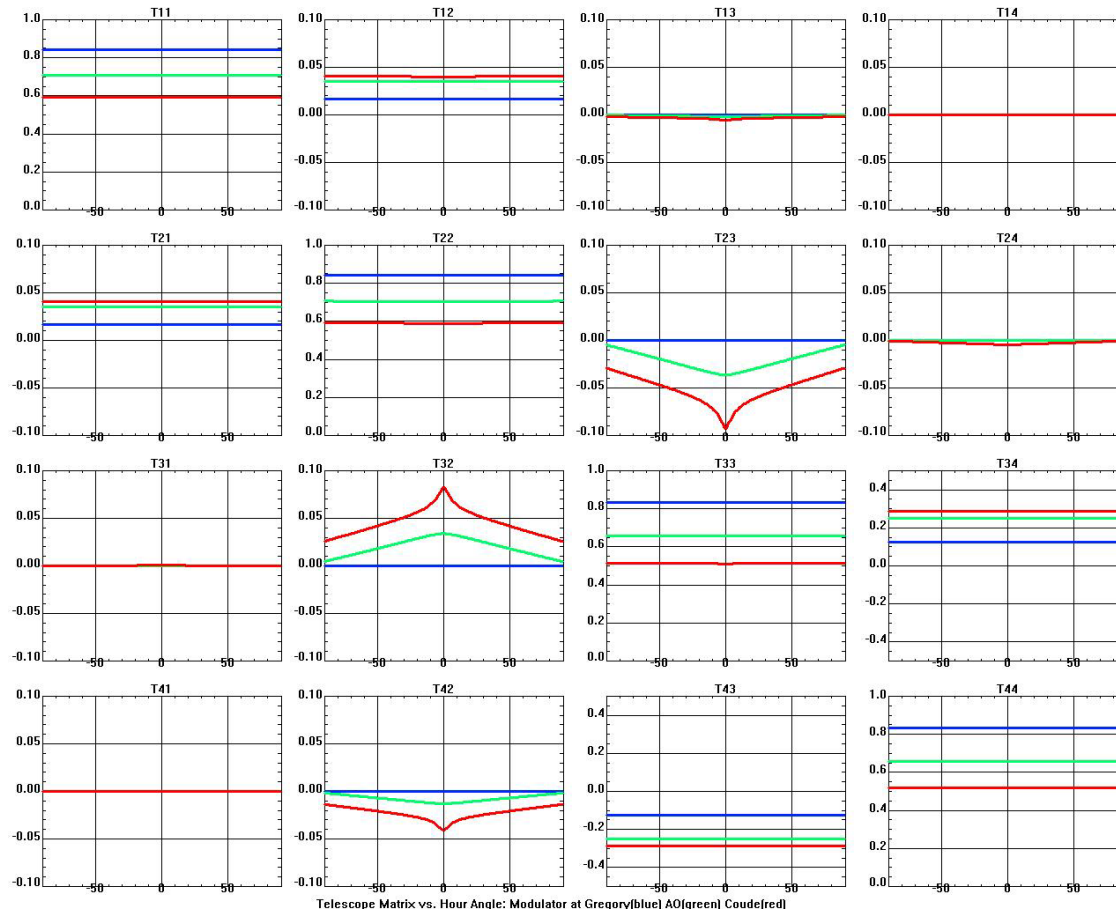


X matrix vs hour angle for modulator at **Gregory**, **AO**, and **Coudé** and analyzer (rotating to correct Az and El) at Coudé. X_{11} shows transmission following modulator. All other elements normalized to X_{11} . Only modulator at **Gregory** changes significantly over the day.

X: Modulator conclusions

- Coordinate transformations between modulator and analyzer introduce cross talk
 - With modulator at Gregory and analyzer at Coudé, X_{23}/X_{22} varies by 0.01 over a day. X matrix could be calibrated vs. elevation.
 - Very small changes in X over a day with modulator at AO or Coudé and analyzer at Coudé.
 - Very small changes in X over a day with modulator *and* analyzer at Gregory.

T: Telescope plus optics before modulator



Telescope matrix vs hour angle for optics preceding modulator at **Gregory**, **AO (middle curves)**, and **Coudé**. X_{11} shows transmission preceding modulator. All other elements normalized to X_{11} . Only modulator at **Gregory** location (top blue curve) is constant over the day.

Telescope Matrix Conclusions

- To reduce magnitude and eliminate diurnal variations, locate modulator as close to the front of the telescope as possible
 - Telescope polarization ‘constant’ if modulator is at Gregory
 - Diurnal variation in telescope polarization is added if modulator is moved to AO.
0.05 for T_{23}/T_{22}
 - Diurnal variation in telescope polarization is even larger with modulator at Coudé.
0.15 T_{23}/T_{22}

Dual Beam Issues

- For an **Az/EI** mount, rotation required for the analyzer is not the same rotation required to correct image rotation thus complicating dual beam polarimetry
 - Use equatorial mount
 - Place modulator and analyzer after image rotation
 - Correct before analyzer with half wave plate
 - Allow X matrix to vary over the day
- Dual beams cannot be sent to the AO, therefore only single beam polarimetry is possible with the modulator ahead of AO.

What options are left?

- *High Polarimetric Precision*: Build a fast C3Po (Charge Caching CMOS Photodetector). Operate in single beam mode with a rapid modulation and fixed analyzer at Gregory. At Gregory, telescope matrix magnitude is minimized and elements are constant. (think ZIMPOL)
- *High Versatility*: Use conventional detectors. Locate modulator and dual beam analyzer after image rotation correction (at Coudé). Calibrate M3 through M6 vs. Elevation and Azimuth, using calibration unit at Gregory, leaving only fixed M1 and M2 to model (much better than DST). (think DLSP)

Summary

Modulator Location	Analyzer Location	T(t)	X(t)	Dual beam + AO OK?	Analyzer rot. = Image rot.	Special Detector?
Gregory	Gregory	0.00	0.00	No	Yes	C3Po
Gregory	Coudé	0.00	0.01	Yes	No	Any
AO	AO	0.05	0.00	No	Yes	C3Po
AO	Coudé	0.05	0.00	Yes	No	Any
Coudé	Coudé	0.15	0.00	Yes	Yes	Any

Matrix of options. *High polarimetric precision* (second row) highlighted in lemon. *High versatility* configuration (bottom row) highlighted in lavender.