The WALOPNorth Instrument

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The PASIPHAE Survey - Background

- Problem: B-modes in the CMB
  - Distorted by dust and magnetic field
  - Depends on the number and characteristics of dust clouds in the line-of-sight
- Solution: Similar distortions in the polarization of optical sources (stars)
- Stars:
  1. (usually) intrinsically unpolarized
  2. known distances (Gaia)
- 1,2 → 3D structure of dust clouds →
  A way to clear our picture of the CMB polarization

The PASIPHAE Survey - Numbers

- 2 Wide-Area Linear Optical Polarimeters (WALOPs)
  - Skinakas 1.3m telescope
  - SAAO 1m Elizabeth telescope
- $10000\ {}^{\circ 2}$ at the galactic poles
- 360 stars per ${}^{\circ 2} \rightarrow 3.5 MStars \rightarrow 1000$ times the state of the art

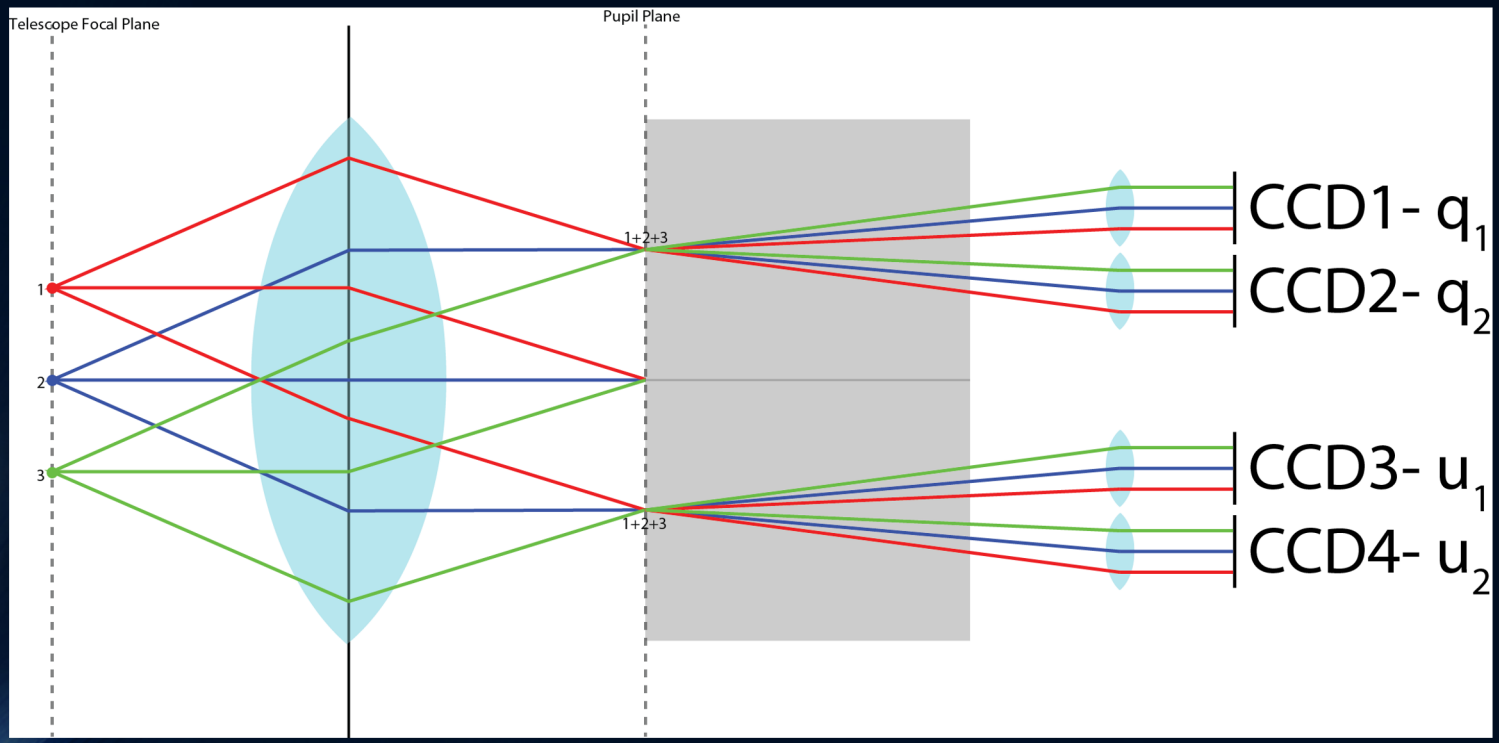
The PASIPHAE Survey - Deliverables

- High Galactic Latitude Survey
  - polarization measurements (p, EVPA)
  - 0.2% accuracy in p
  - over 360 stars per $^{\circ 2}$
  - over 1500 $^{\circ 2}$ per year
- Tomographic map and CMB foreground subtraction
  - Sky mask
  - Foreground removal
- Astrophysical Applications
  - structure and magnetic field properties of translucent molecular clouds
  - stellar astrophysics of intrinsically polarized stars
  - high-energy astrophysical sources of cyclotron and/or synchrotron emission

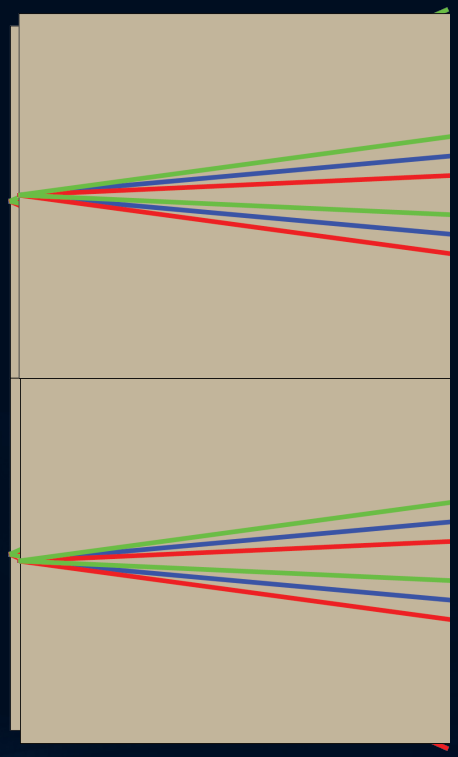
WALOP - Requirements

- One shot
- No moving parts
- 30'x30' field-of-view
- Every polarization state in proprietary detector
- $\sigma_p \leq 0.1\%$

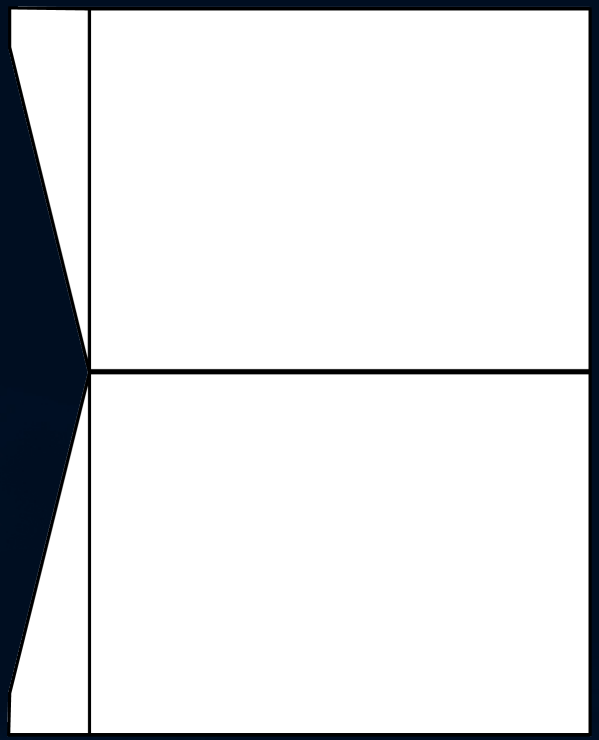
Base Design


Telescope Focal Plane
Pupil Plane
1
2
3
1+2+3
1+2+3
CCD1- q_1
CCD2- q_2
CCD3- u_1
CCD4- u_2

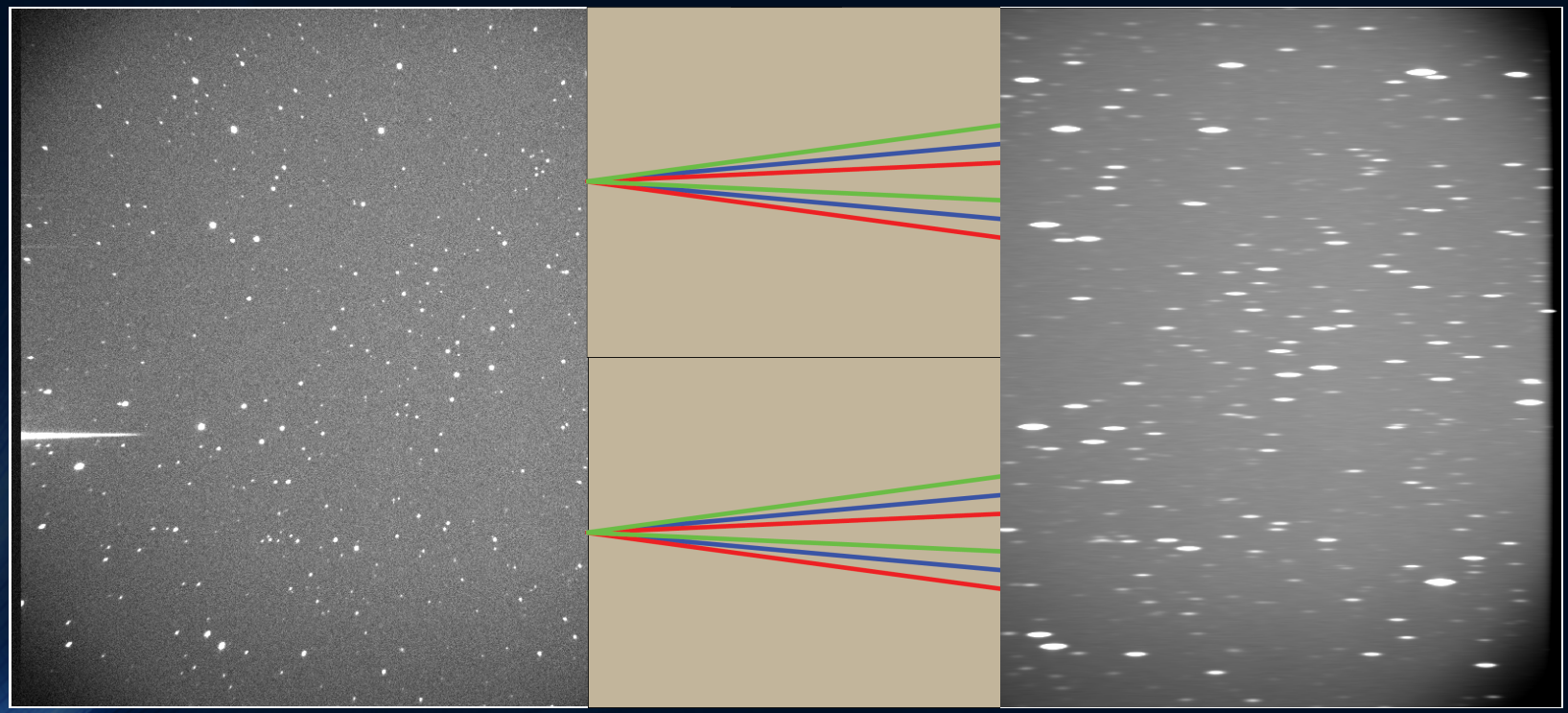
Problem – Prism Interface



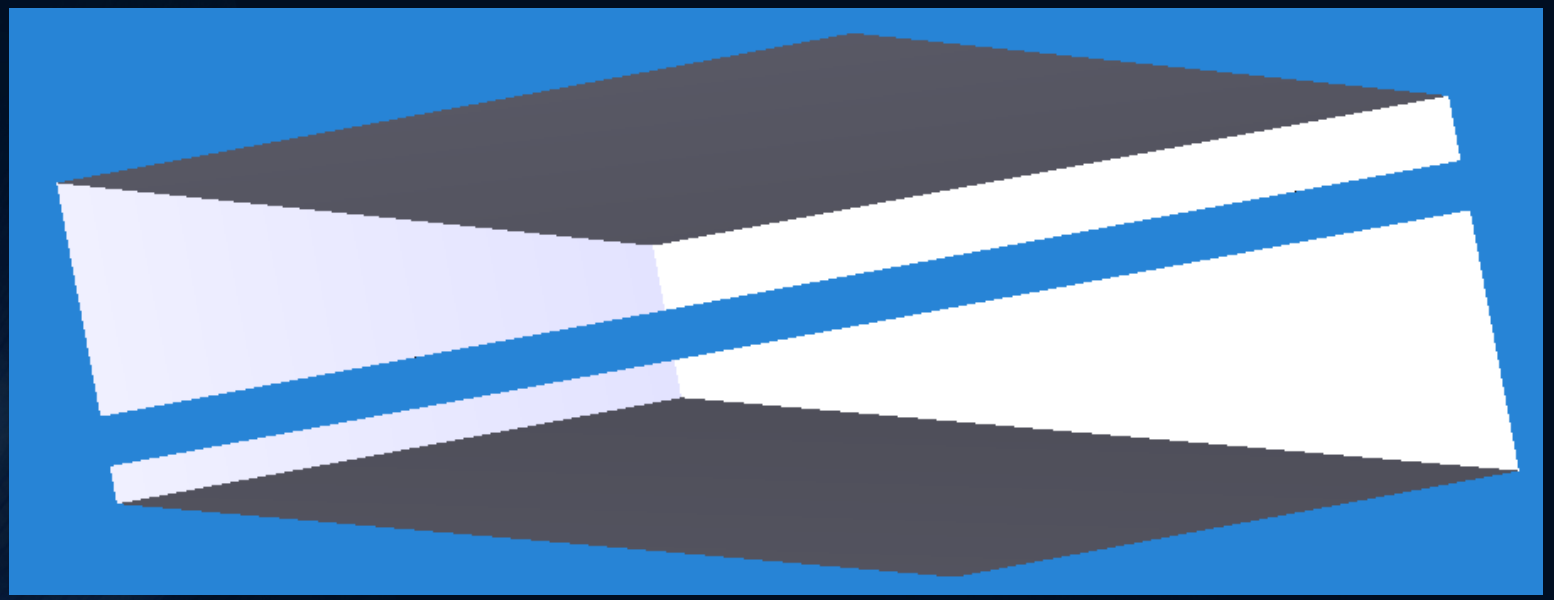
Solution – Prism Interface



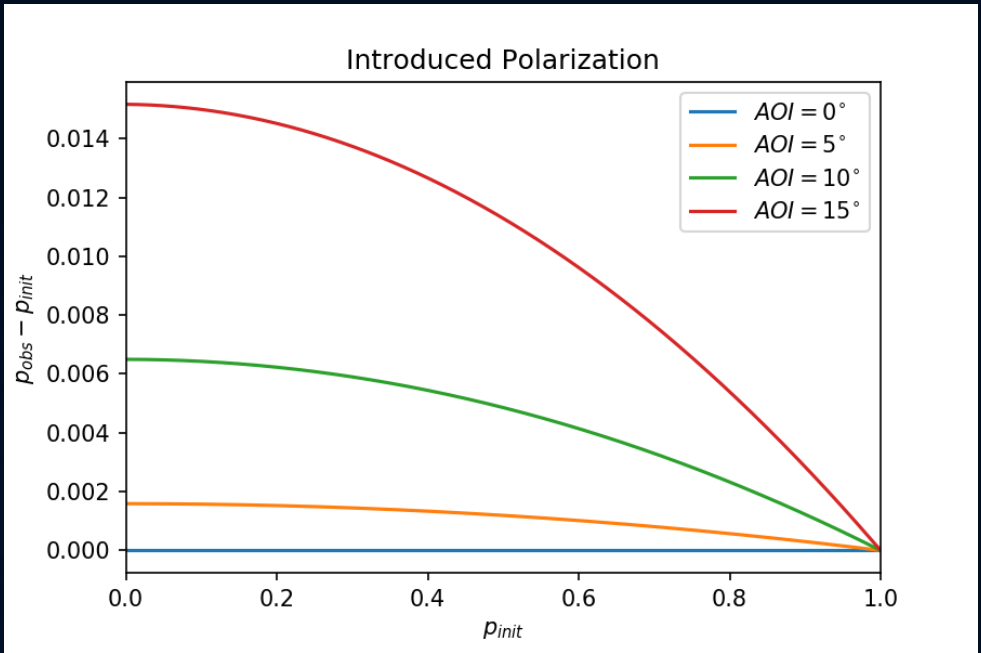
Problem – Wavelength Dependent Split



Solution – Wavelength Dependent Split



Problem – Filter Polarization



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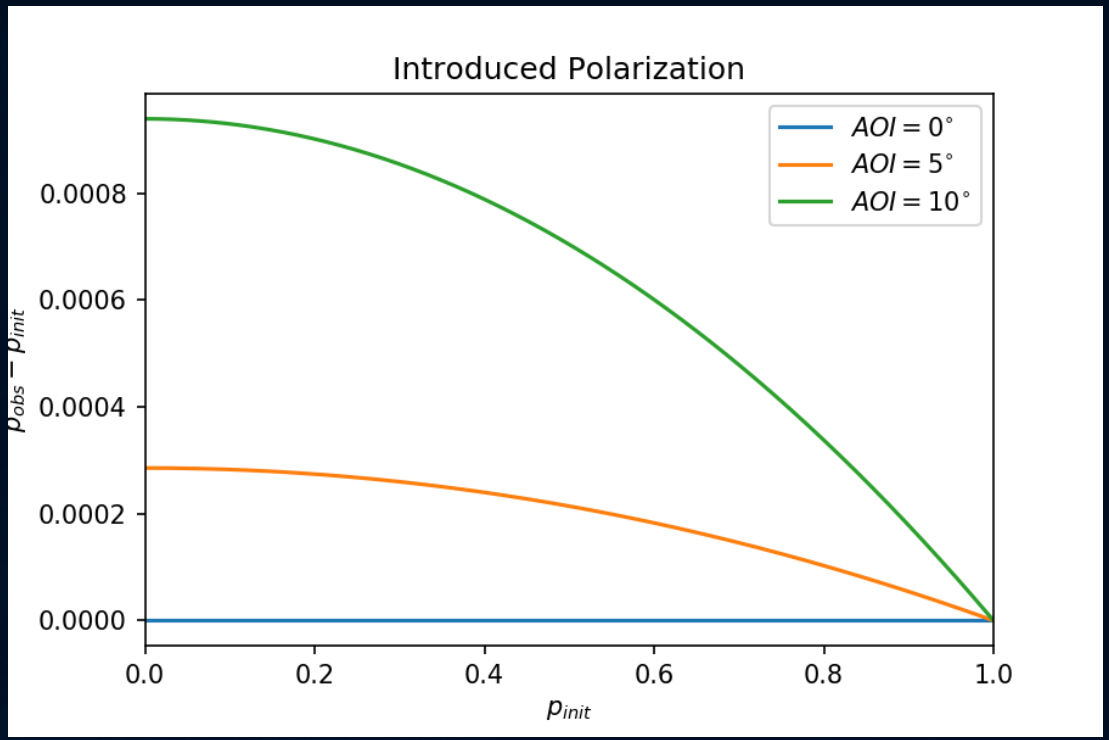
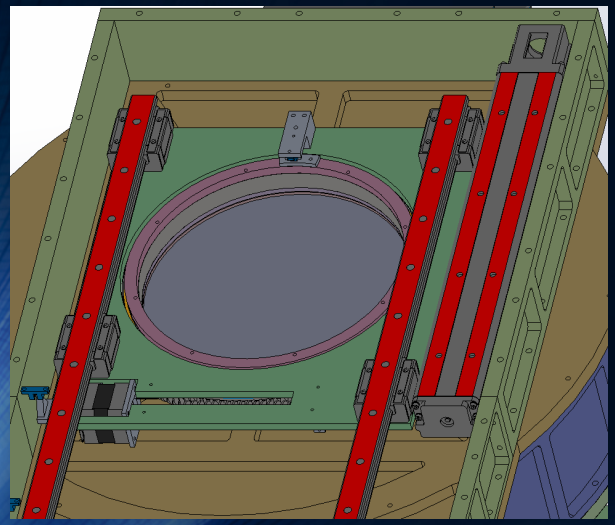
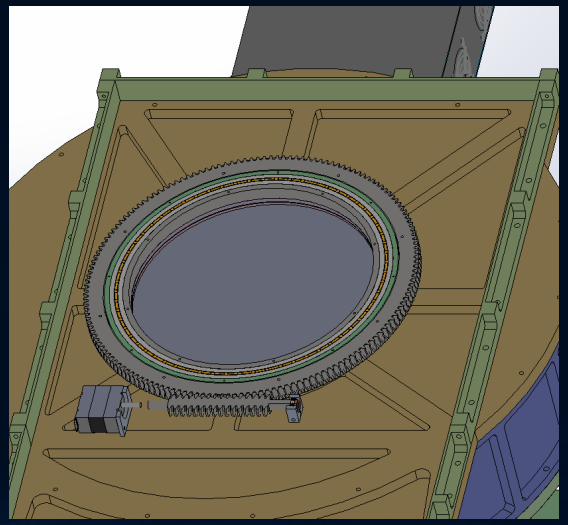
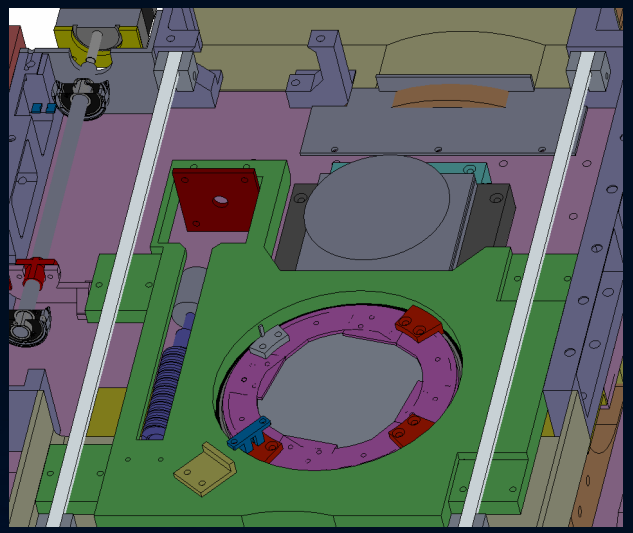


Problem/Solution – Calibration

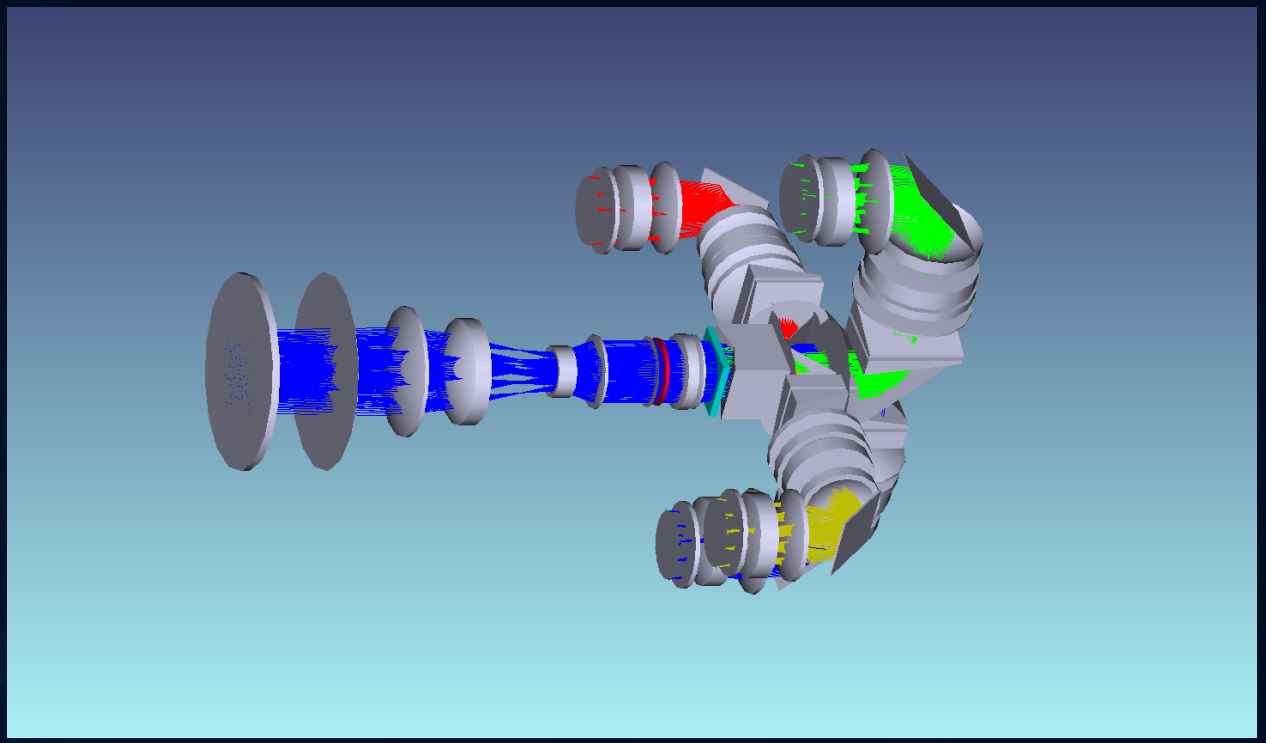
- Polarizer (rotatable in steps/continuously) at the instrument entry
- HWP (rotatable in steps/continuously) before the prism







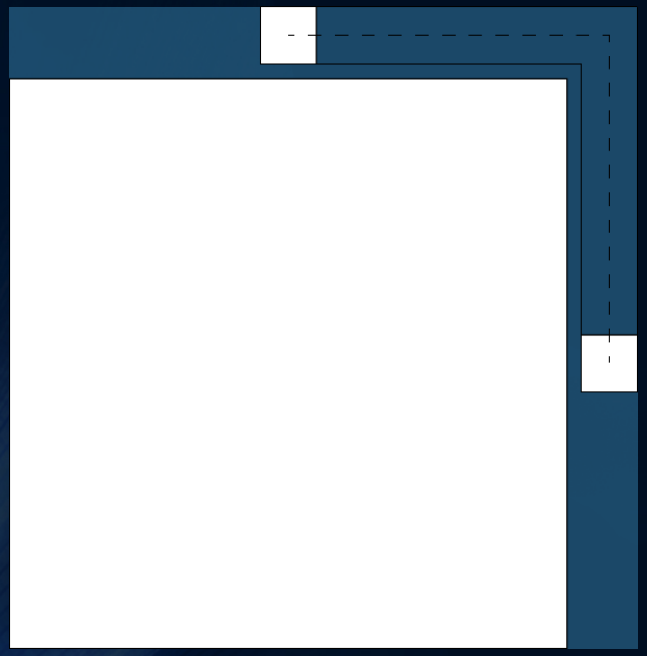
Optics



Problem – Guider Field

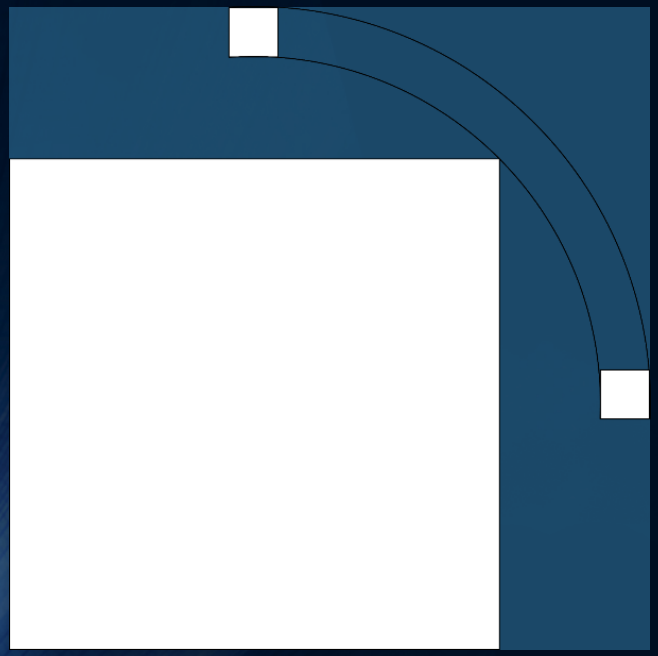
- Limiting Magnitude: 17 (without filter)
- Guiding Time: $9s$
- Guiding Accuracy: $\frac{1}{3}''$
- Limiting Field (min. 3 stars brighter than limit): 10'x10'

Solution I – Guider Field



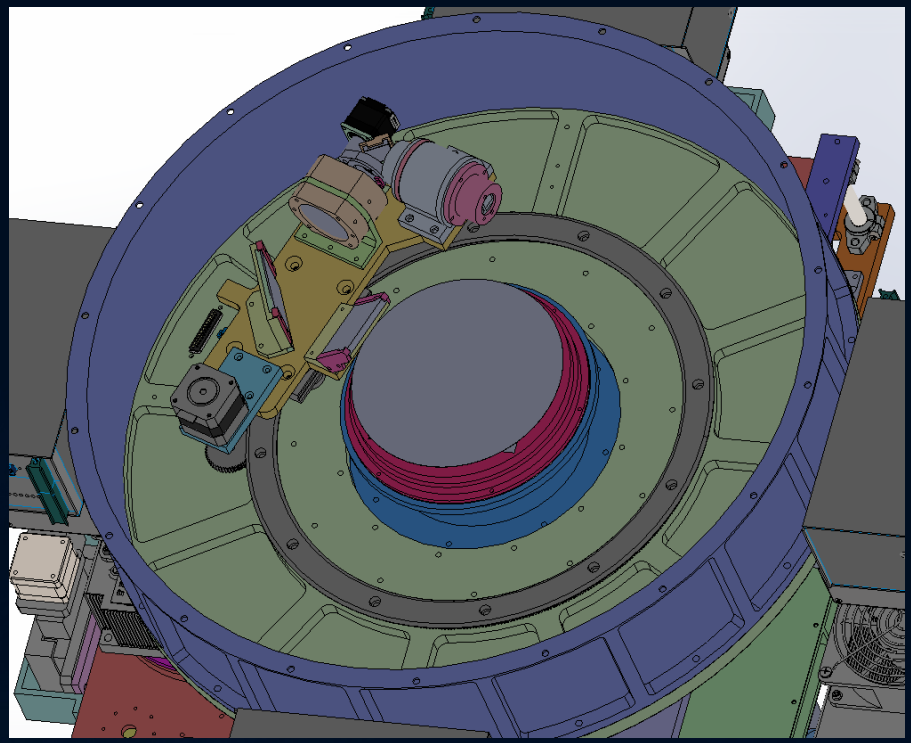
- 2’x2’
- Requires 2 linear motors
- Simple optics
- Simple Mechanics
- More space

Solution II – Guider Field

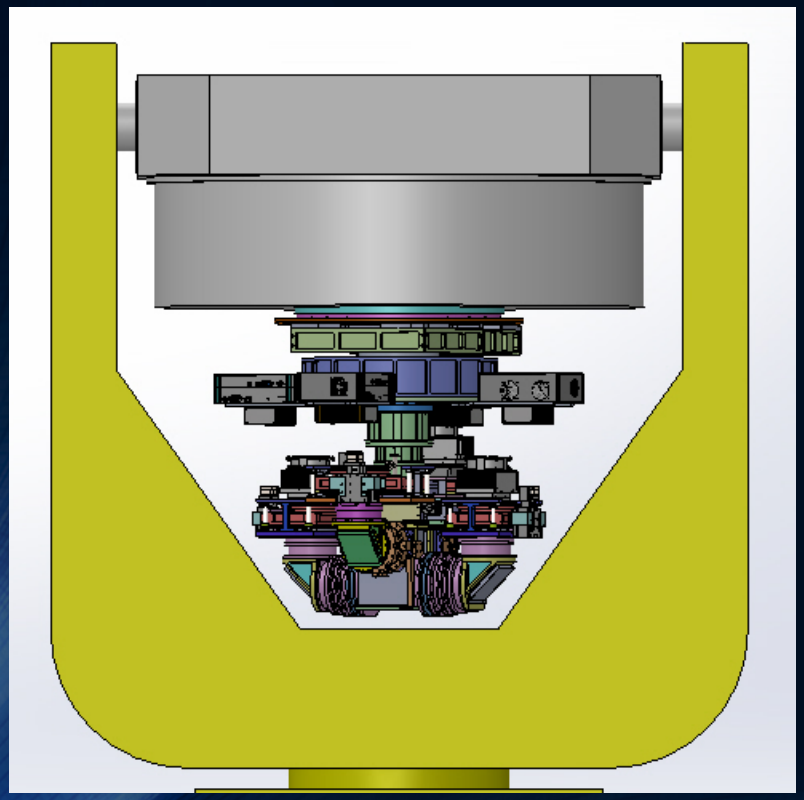


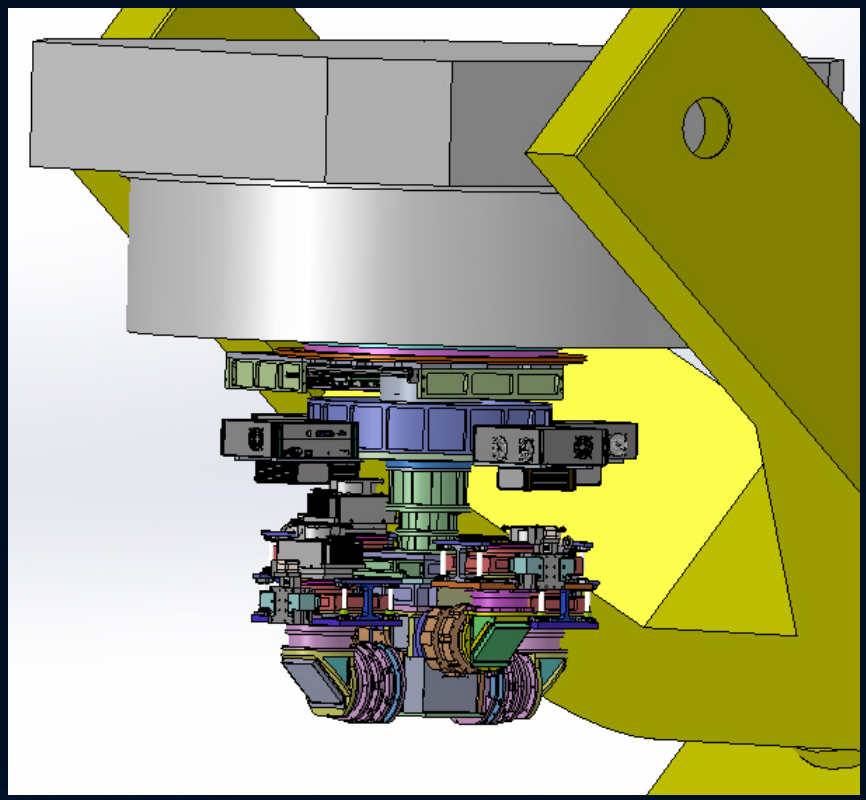
- 1’x1’
- Requires 1 rotary motor
- Simple optics
- Tougher Mechanics
- Less space

Solution II – Guider Field



Looks





Software Snap (no time for the flowchart, this is the control interface)