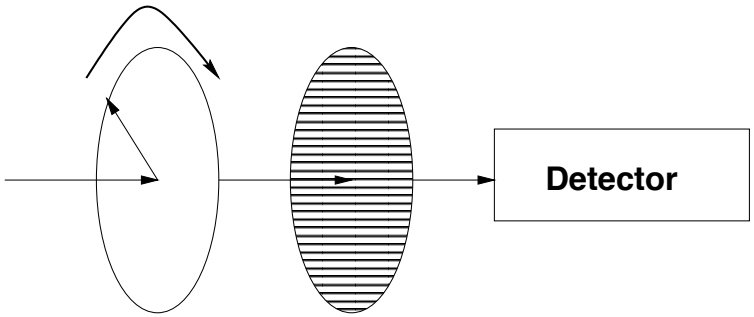
Lecture 12: Rotating Retarder Polarimeters

Outline

1. Rotating Waveplate Polarimeters
2. HARPSpol

Rotating Waveplate Polarimeter

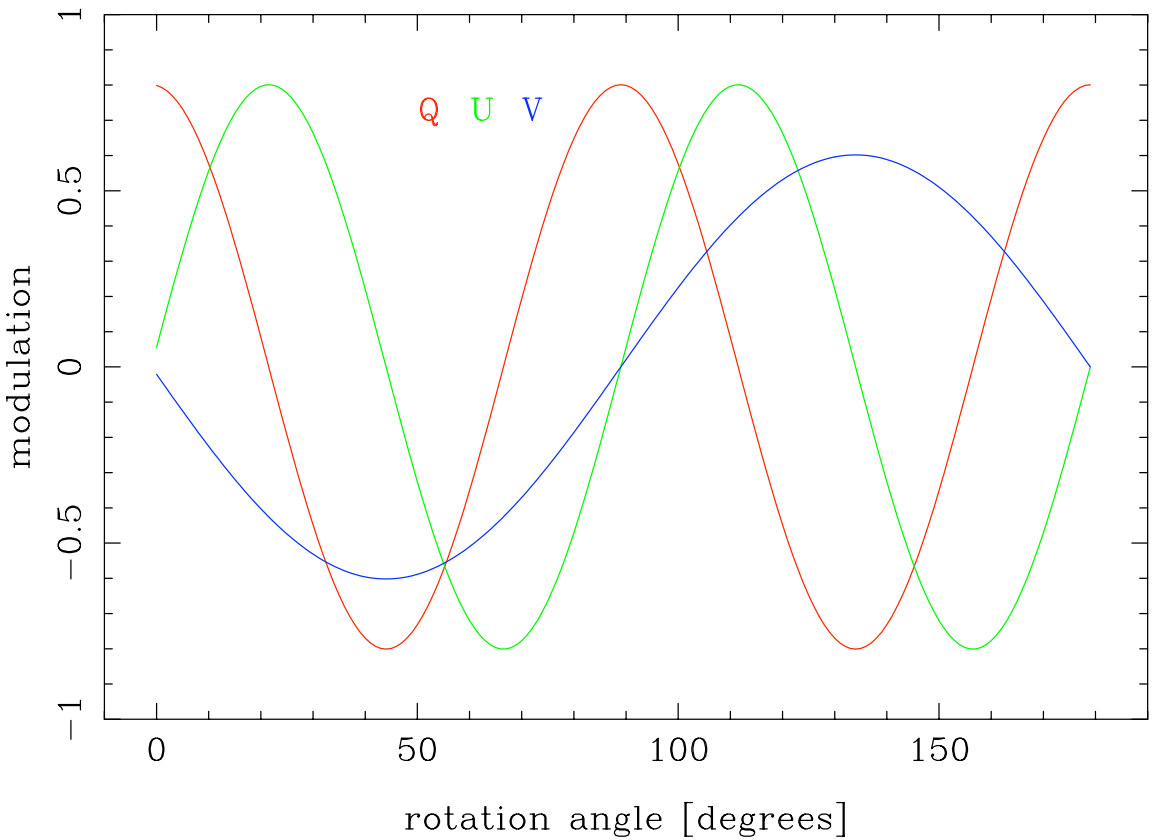


- rotating retarder, fixed linear polarizer
- measured intensity as function of retardance δ, position angle θ

$$I' = \frac{1}{2}\left(I + \frac{Q}{2}\left((1+\cos\delta) + (1-\cos\delta)\cos 4\theta\right) + \frac{U}{2}(1-\cos\delta)\sin 4\theta - V\sin\delta\sin 2\theta\right)$$

- only terms in θ lead to modulated signal
- equal modulation amplitudes in Q, U, and V for δ=127°
- polarizing beamsplitter makes use of all photons and provides dual-ratio capabilities

Continuously Rotating Waveplate



- Q, U modulated at twice the frequency of V
- phase shift in modulation between Q and U is 90°$\Rightarrow$ measurements at 8 angles to determine all 4 Stokes parameters

Issues with Rotating Waveplate Polarimeters

- polarimetric efficiency not optimum for continuously rotating waveplate due to sinusoidal modulation
- beam wobble due to slight wedge in waveplate
- limited modulation speed
- need frame-transfer detectors for continuously rotating plate

HARPS Polarimeter

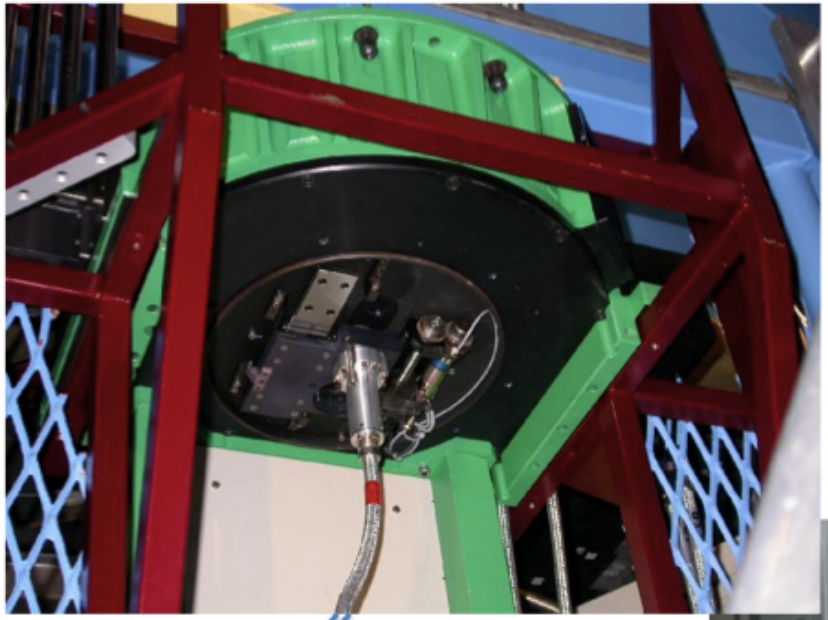
Introduction

- HARPS: Most successful exoplanet finder
- measures magnetic fields of planet-hosting stars
- only publicly accessible high-resolution spectropolarimeter in southern hemisphere

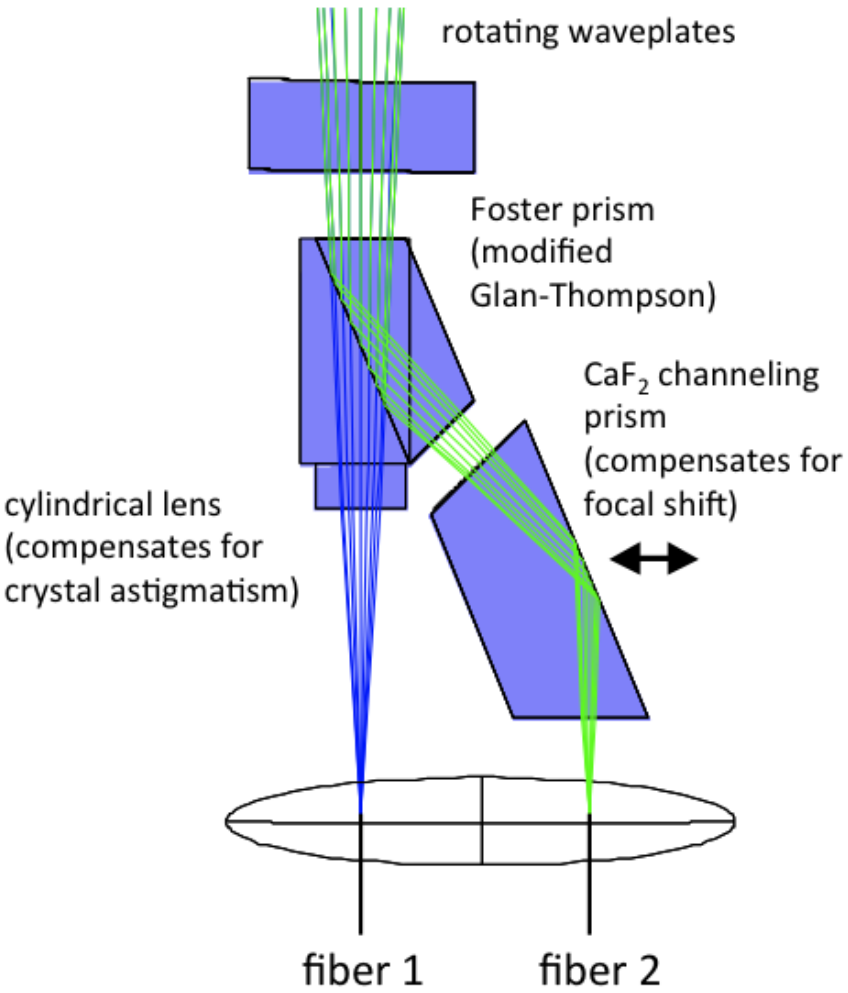
Requirements

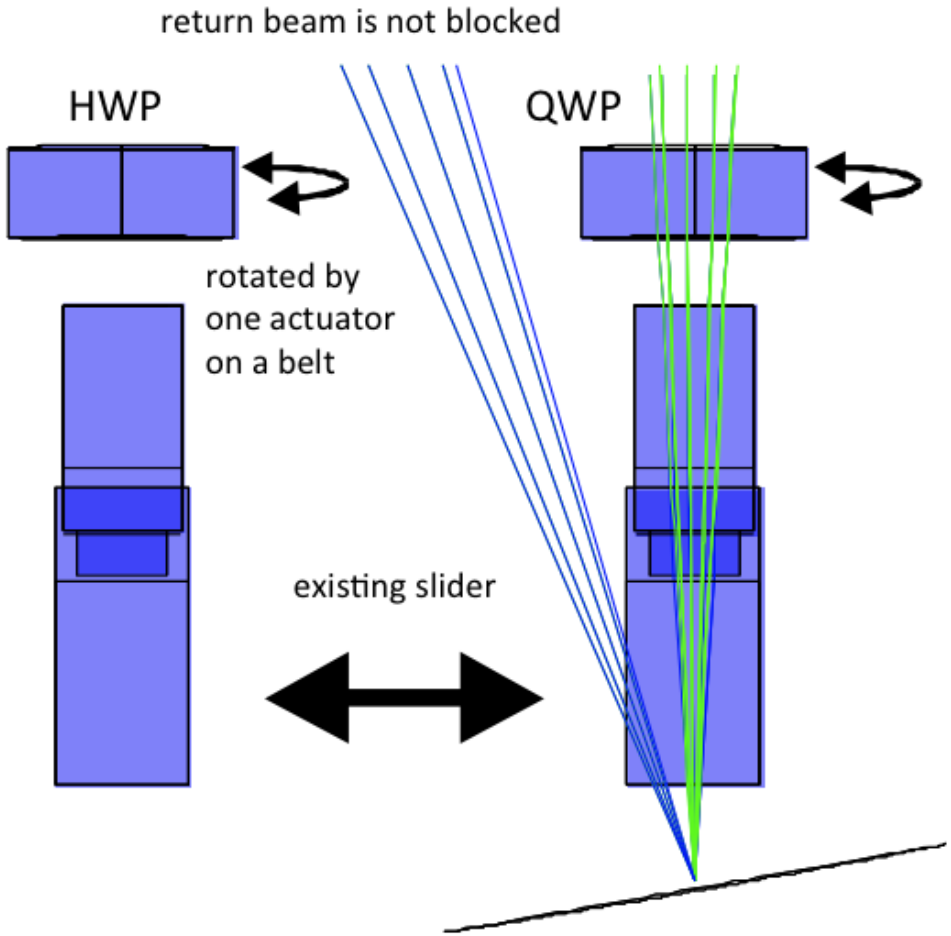
- Use slider and volume of Iodine cell
- Do not compromise performance and operations of HARPS
- Full Stokes
- Polarimetric sensitivity 10^{-4} for one night on a bright star
- 380-690 nm
- Minimal instrumental polarization
- Minimal (polarized) fringes

HARPS



optical design



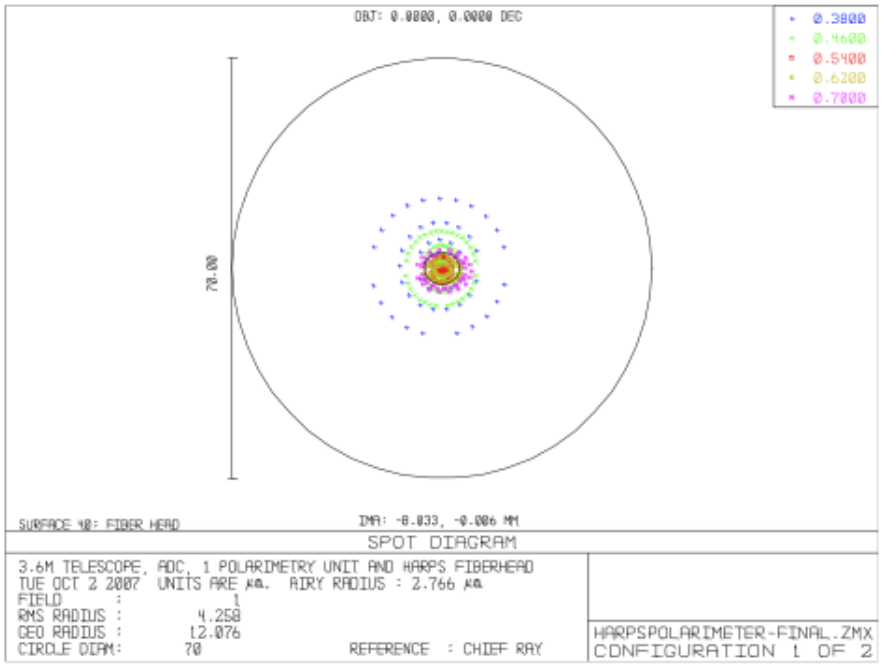


Waveplates

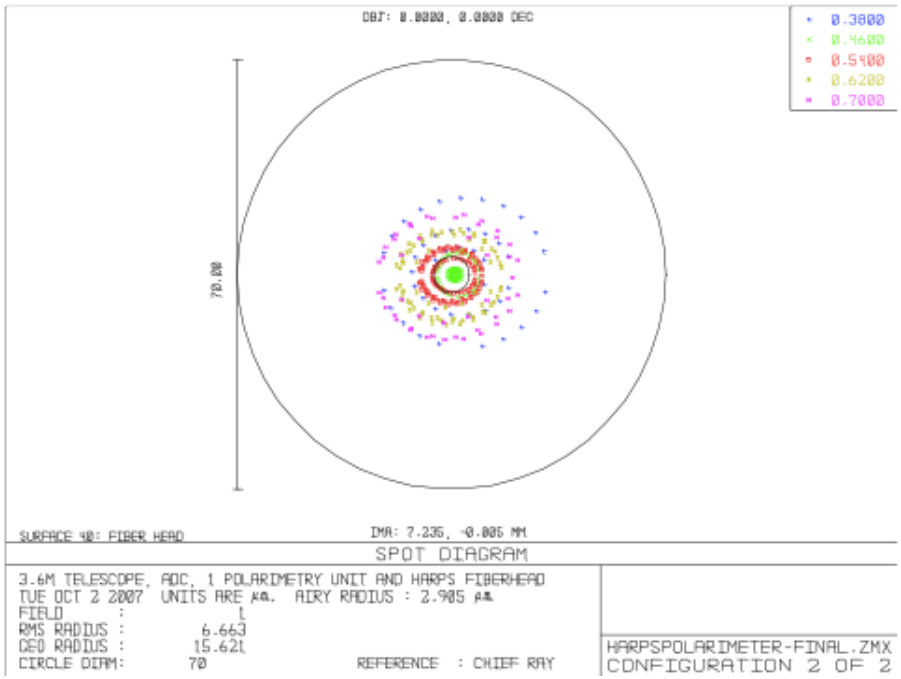
- zero-order polymer superachromatic waveplates
  - minimal temperature effects
  - minimal beam angle effects
- minimal fringing due to
  - thin polymer layers in superachomatic waveplates (Samoylov et al. 2004, Ikeda et al. 2003)
  - tilting of waveplates
  - wedge on parallel surfaces between prisms

Optical Performance

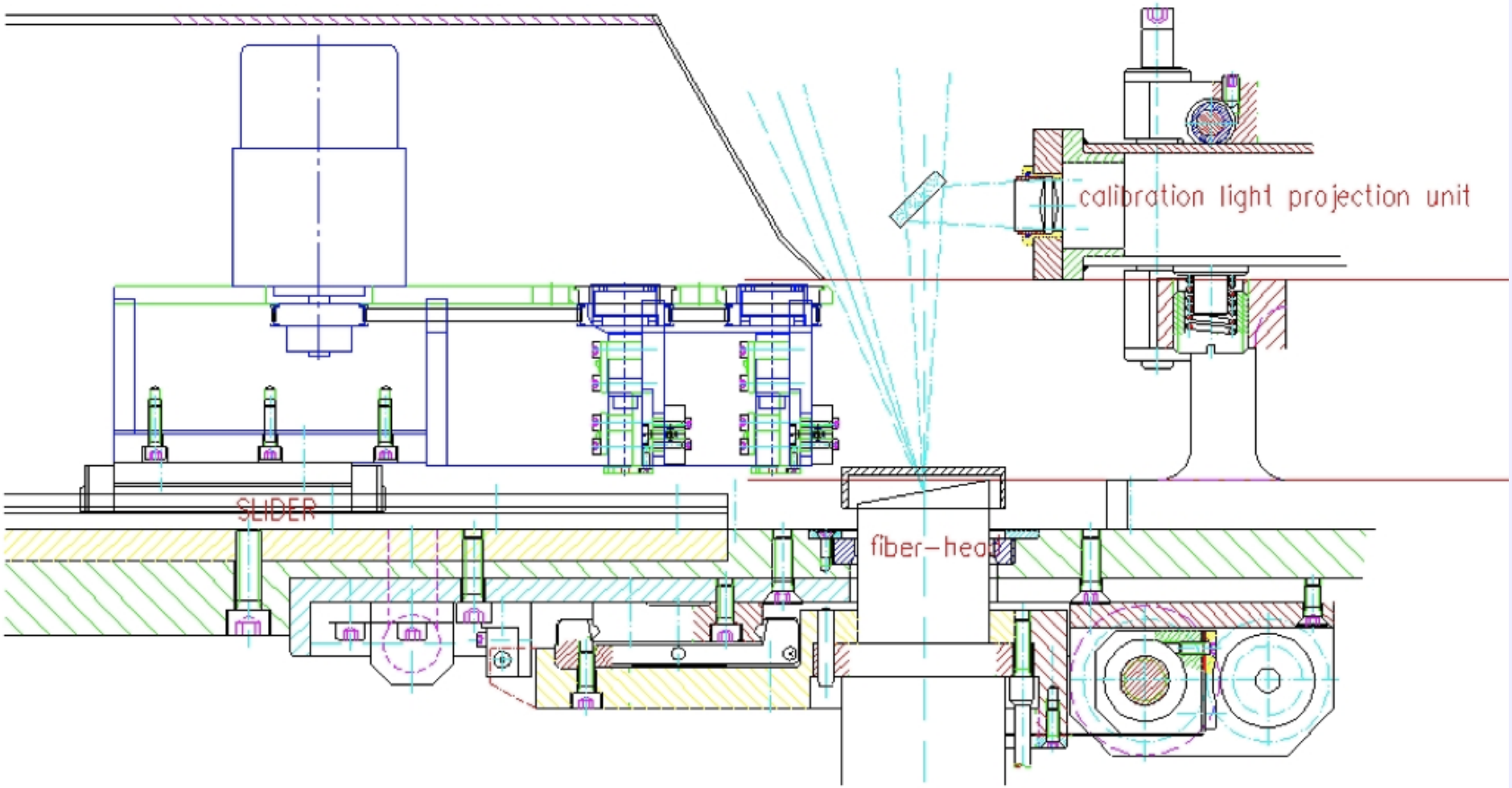
fiber 1

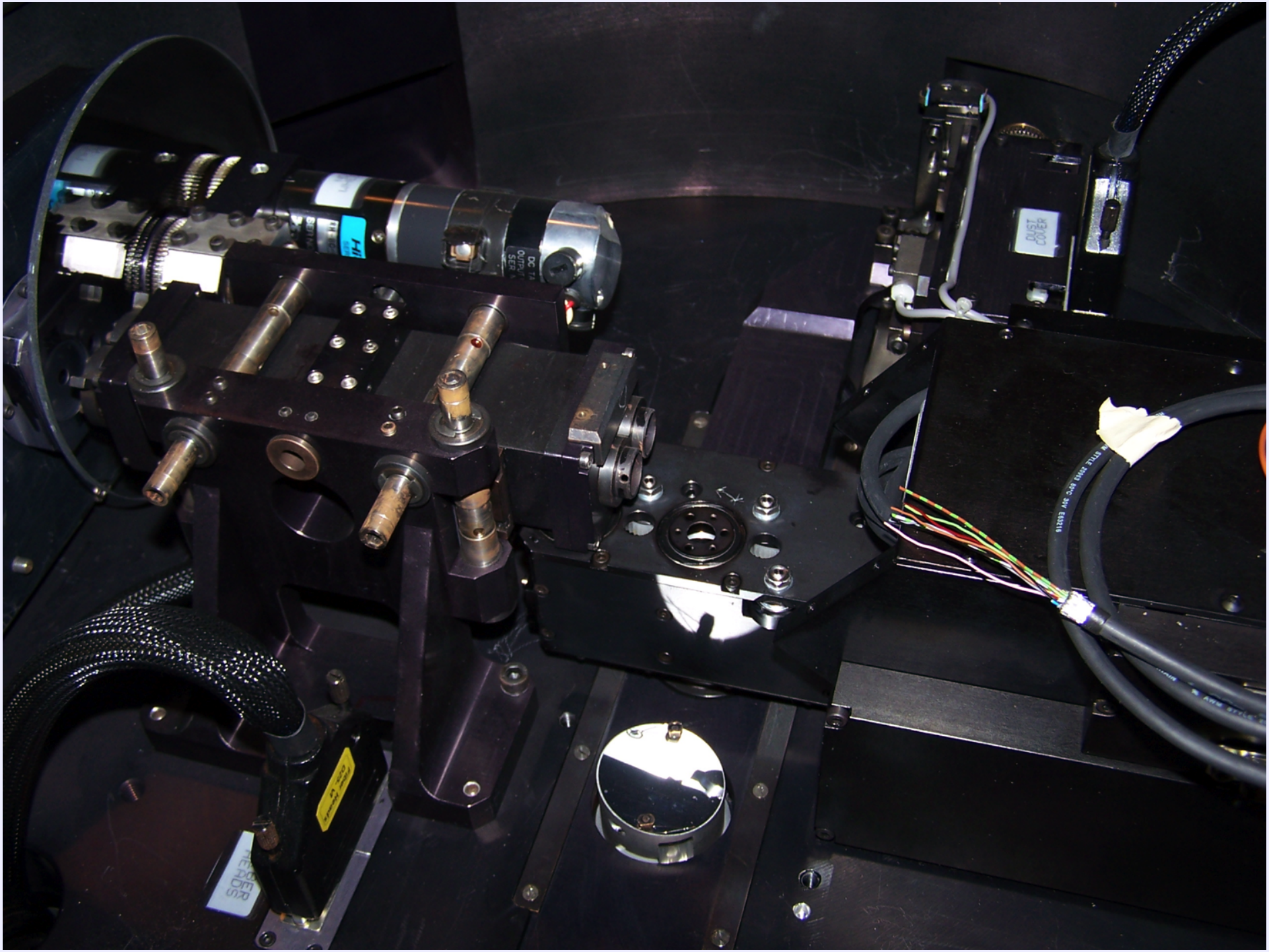


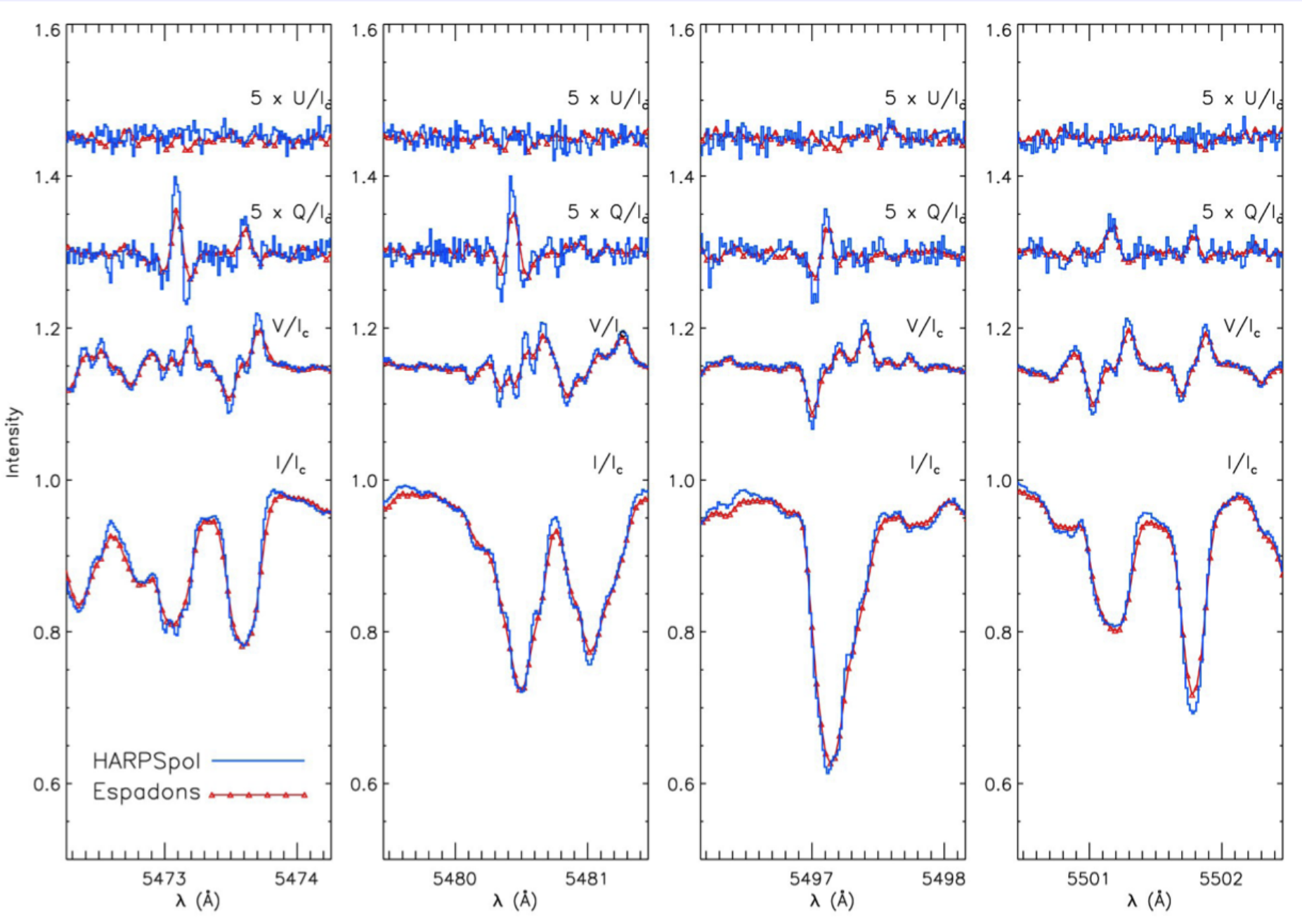
fiber 2



mechanical design






1.6
1.4
1.2
1.0
0.8
0.6
Intensity
5 x U/I$_c$
5 x Q/I$_c$
V/I$_c$
I/I$_c$
HARPSpol
Espadons
5473
5474
5480
5481
5497
5498
5501
5502
λ (Å)