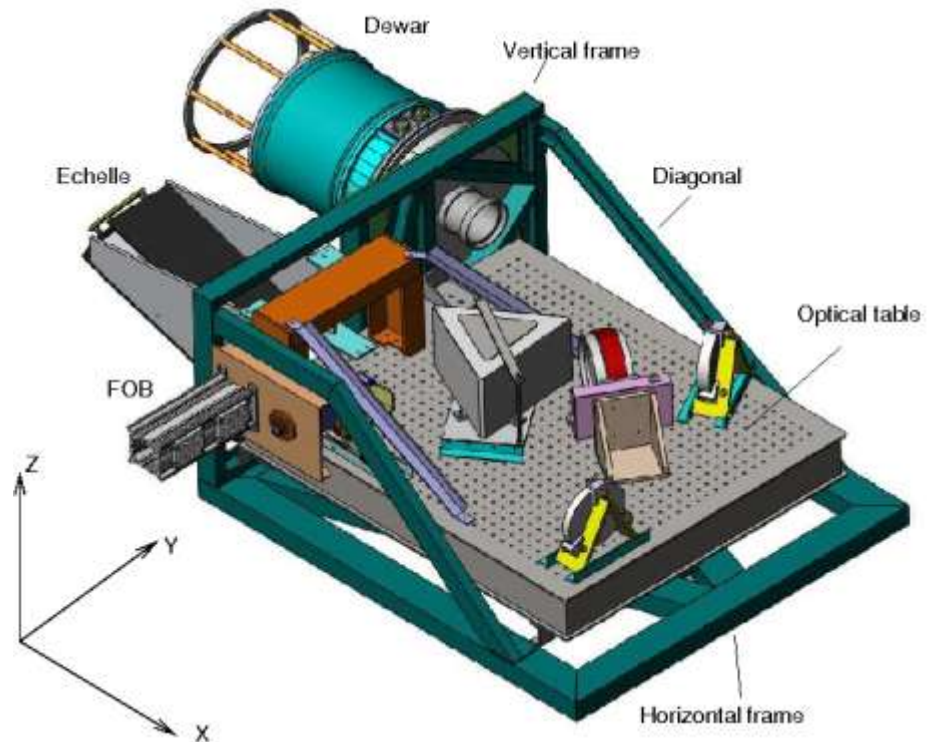
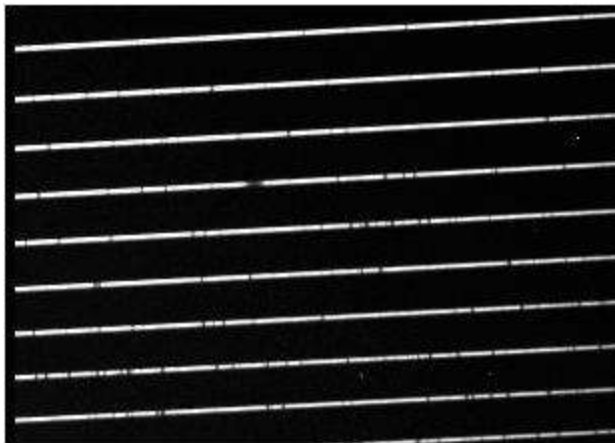


CHIRON – a new planet-finding spectrometer

A. Tokovinin, D.Fischer, Ch. Schwab, J.F.P. Spronck



Summary

- Context
 - Fiber feed
 - Optics
 - Mechanics
 - Detector
 - Challenges
- 2007: start of the α Cen project at CTIO
2008: Fiber feed + Blanco echelle, data
2009: MRI proposal to build CHIRON
2010: Instrument design & procurement
2011+ Operation

<http://www.ctio.noao.edu/~atokovin/echelle/>

Why another spectrometer?

- Science driver: detection of terrestrial planets
- Ideal target: α Cen is bright and provides A-B reference, visible most of the year
- Dense time coverage \rightarrow 10 cm/s precision?
- CTIO 1.5-m has service observing, time can be purchased from SMARTS in needed quantity
- Photons are not critical (beat HARPS/PFS by cadence?)

Can we really reach a 10 cm/s precision with iodine cell and high-cadence observations?

Blanco echelle (2008-2010) @ CTIO 1.5m

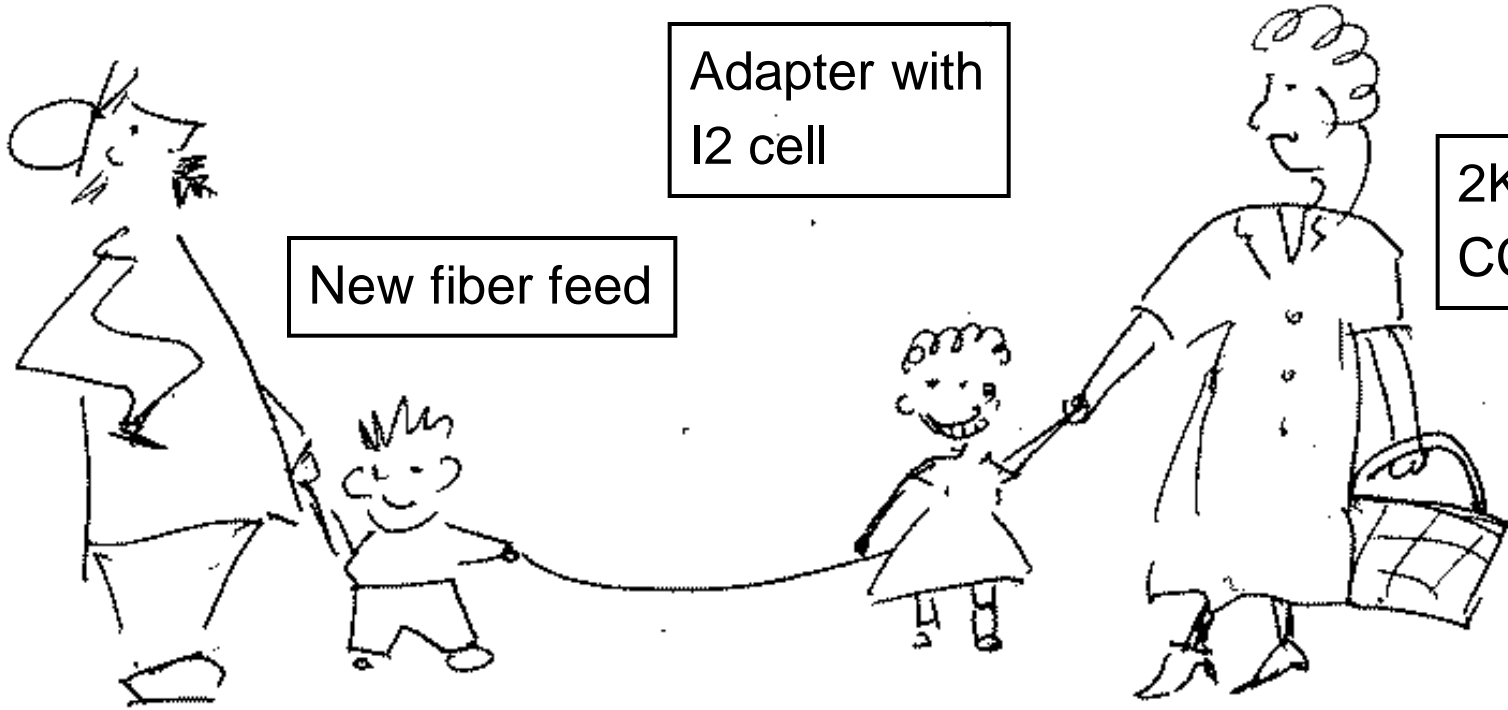


Blanco echelle:
R=43000 410-730nm

Adapter with
I2 cell

New fiber feed

2Kx2K SIT
CCD



Telescope

FEM

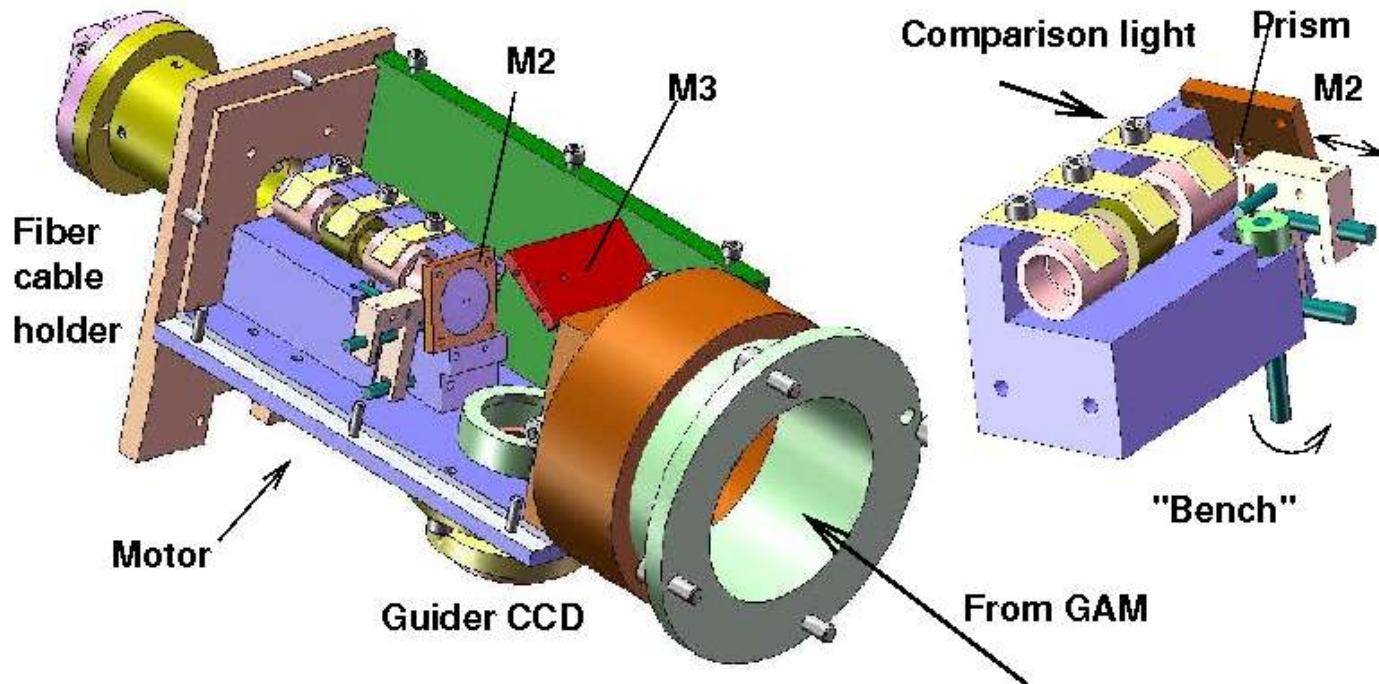
Fiber

BEM

Spectrograph CCD

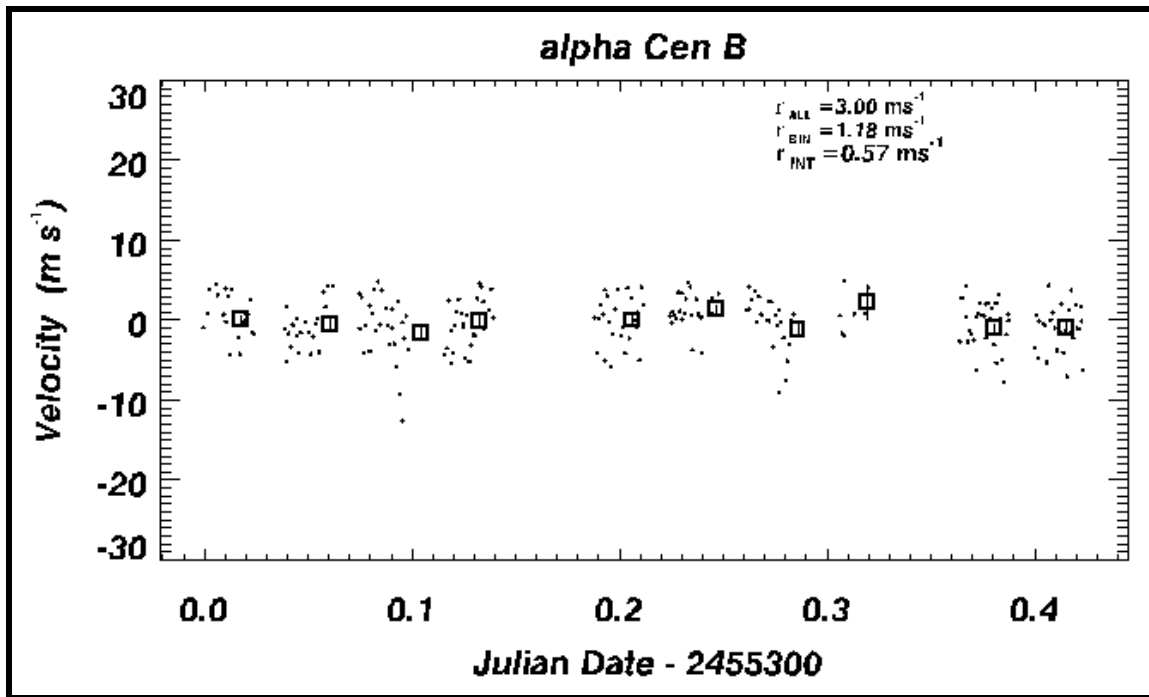
The fiber feed

- Existing fiber cable, 100 μm core, $L=14\text{m}$
- New optics, use guider arm to pick-up the beam
- Calibration light by fiber

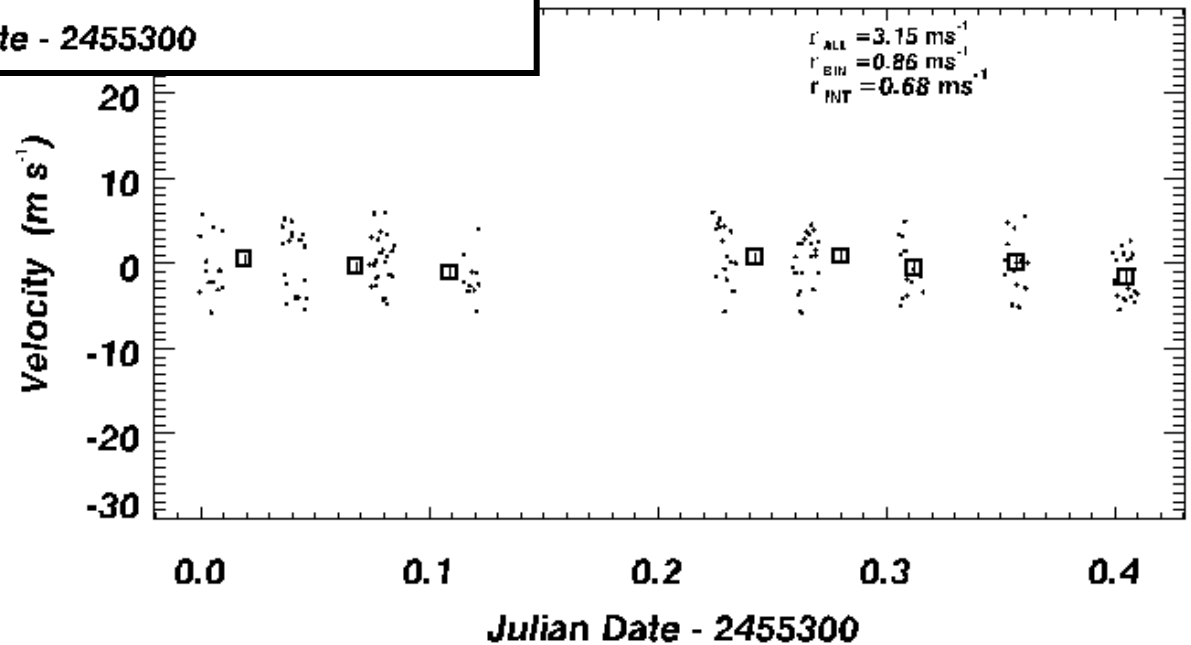


Some results

First time?
Iodine+fiber



Alpha Cen A

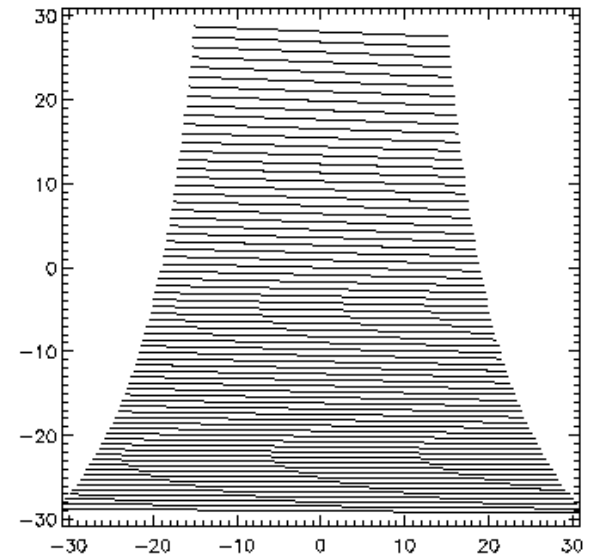


- 3 m/s per spectrum
- 0.6 m/s in 1h
- 0.2 m/s in 1 night (B-A)

CHIRON: a step forward

- R~80000, image slicer, $\lambda = 420..870\text{nm}$
- Goal 15% efficiency (prism cross-disperser)
- Stable PSF, <1pixel shifts on detector
- Exposure meter (get to fainter stars!)
- Stabilize temperature & pressure

Use >50% of pixels for starlight!

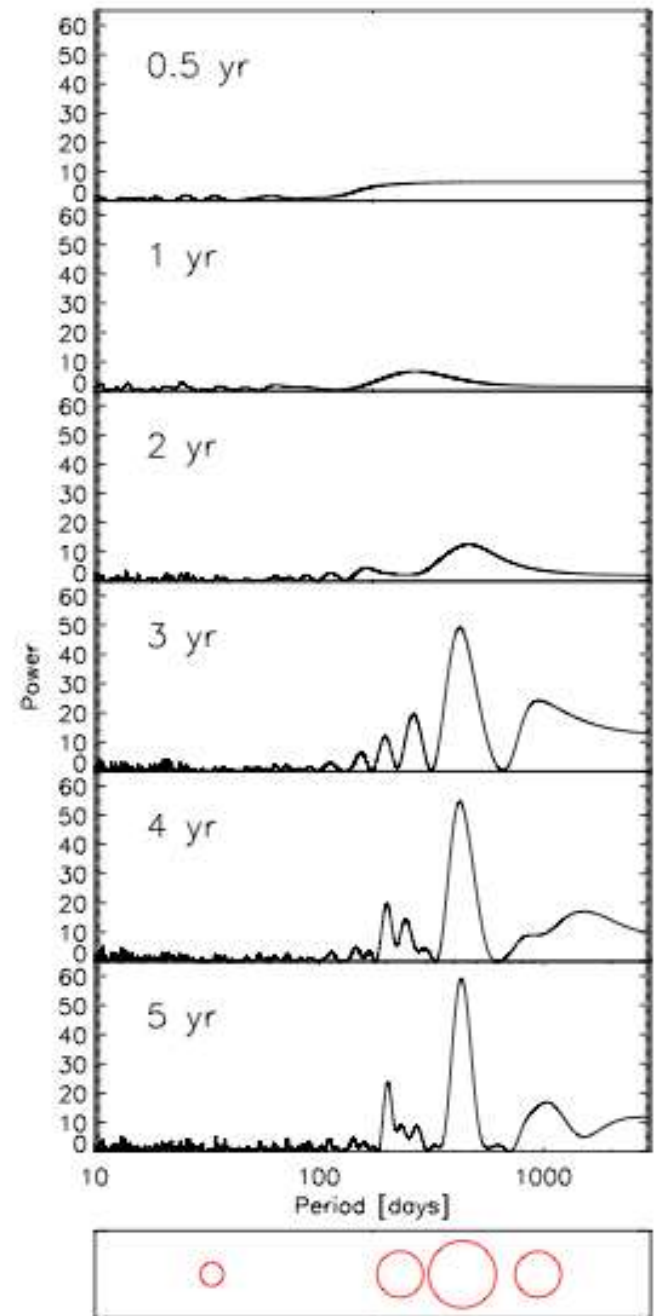
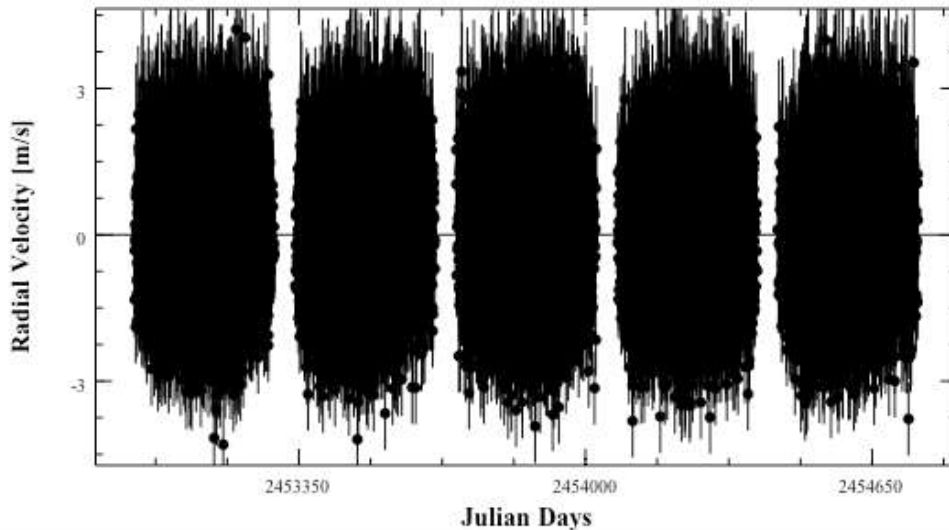


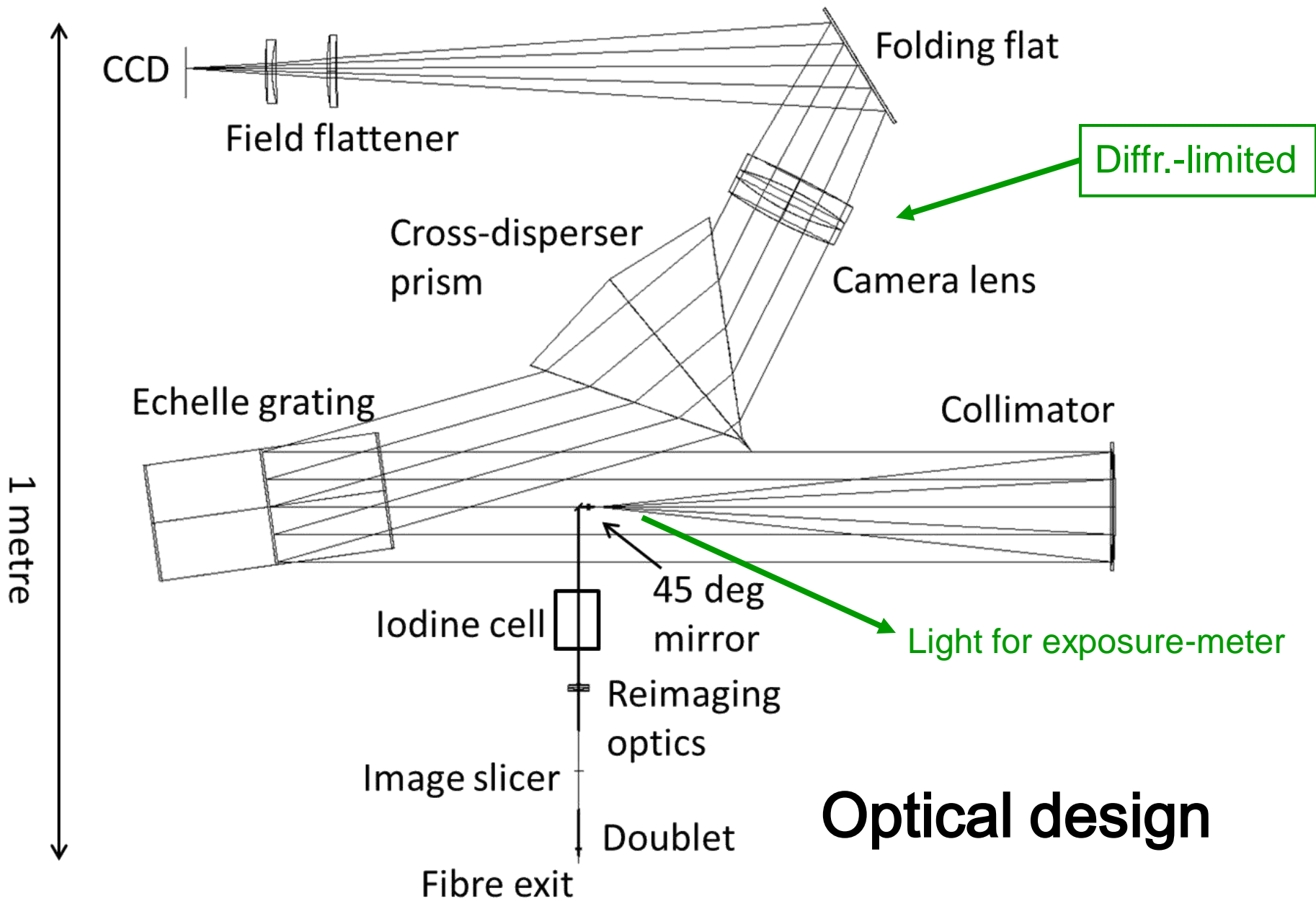
Limits of instrumental RV precision with I2

- Photon noise: white, averages out but dominates χ^2
- Detector defects (intra-pixel sensitivity, CTE)
- Imperfect model (PSF, template, iodine)
- Software (extraction, PSF modeling, flat field)
- Contamination (sky, echelle ghosts, binary companions)
- What else? (timing, telluric lines, modal noise,...)

Expectations

Individual precision 3m/s, 75obs/night
Simulated 4-planet system 32d..943d
Masses 0.07...1.8 M_Earth
5 years of data





Optical design

Pseudo-Littrow: pros and cons

- Avoids double pass through the lens (better PSF)
- Single pass through the prism → constant line tilt
- $\gamma=6^\circ \rightarrow$ line tilt $24^\circ \rightarrow$ loss of resolution
- Beam on the camera lens is elliptical

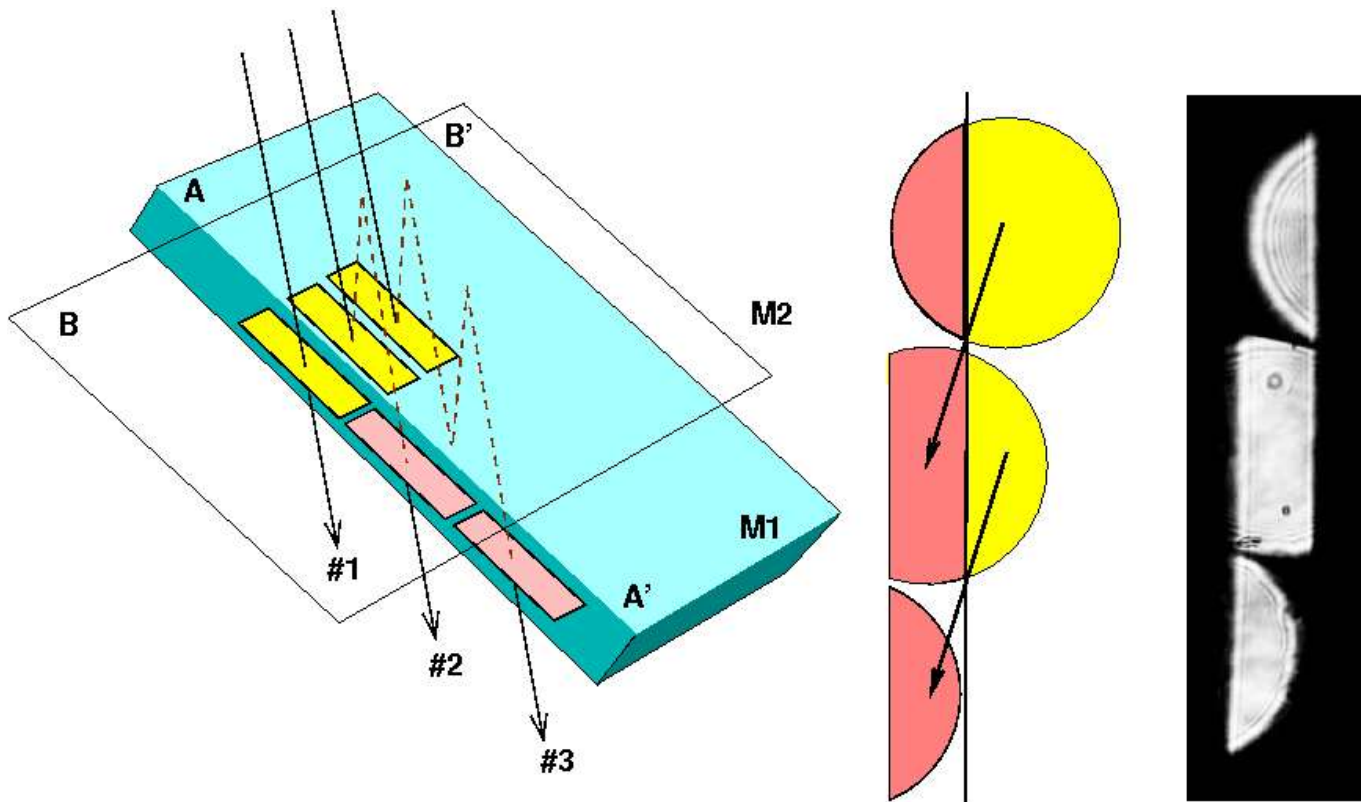
Folded camera gives an easy way to shift the spectrum (stabilize or scan).

Table of elements

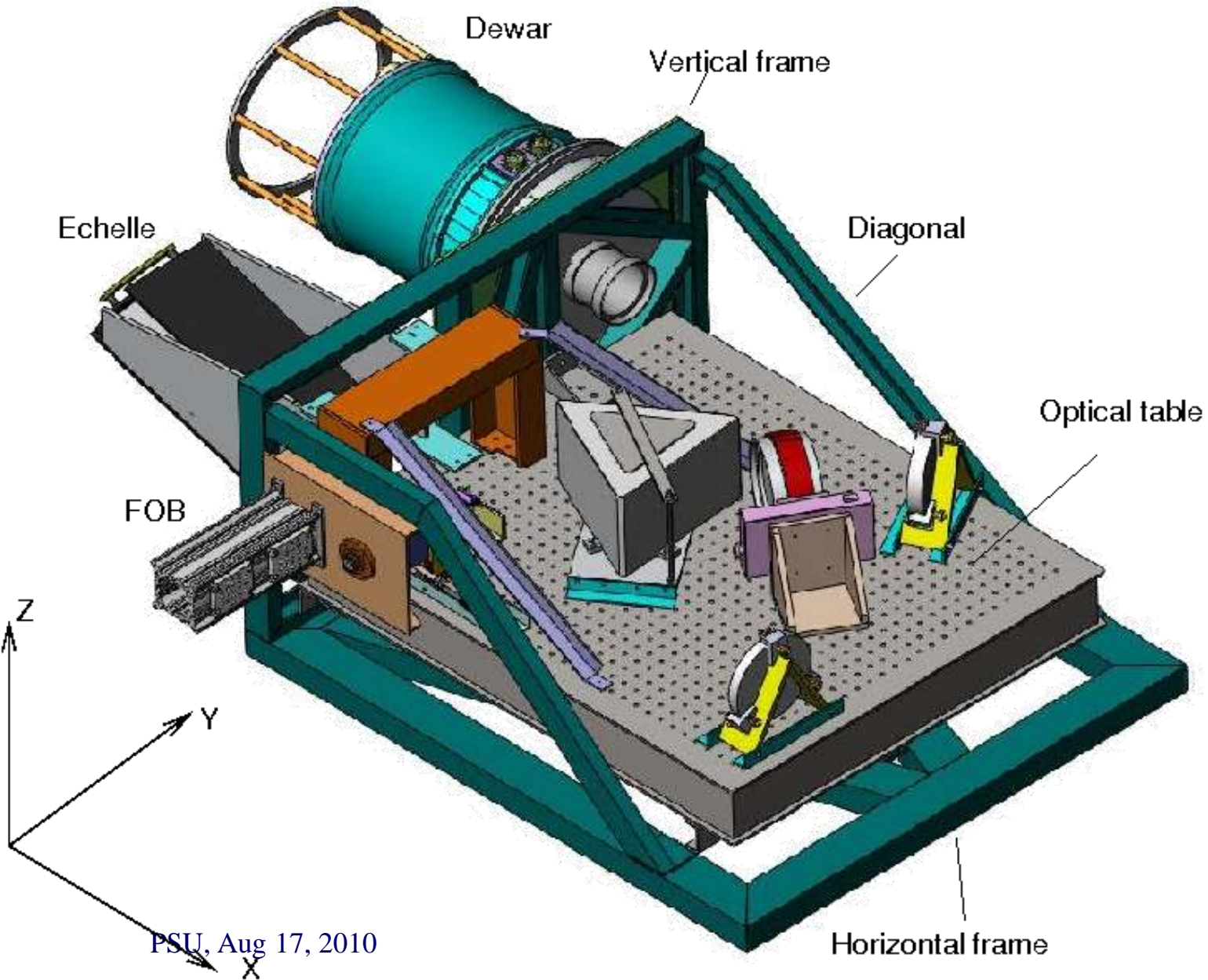
Fiber	100 μ m, Polymicro, L=15m, FC-connector
Image slicer	3x in F/28 beam. 600 μ m \rightarrow 200x1200 μ m
Iodine cell	D=40-50mm L=100mm t=+55C
Collimator	D=150mm, Beam 140mm, F/4
Echelle grating	31.6 gr/mm, R2, 375x200mm
Prism	LF7, 62deg, side 260mm h=160mm
Camera	APO-140 D=140mm, F=1m, flattener
Detector	4Kx4K, 15 μ m, e2v
Exposure meter	Hamamatsu PMT H9319-01, RS-232

Image slicer

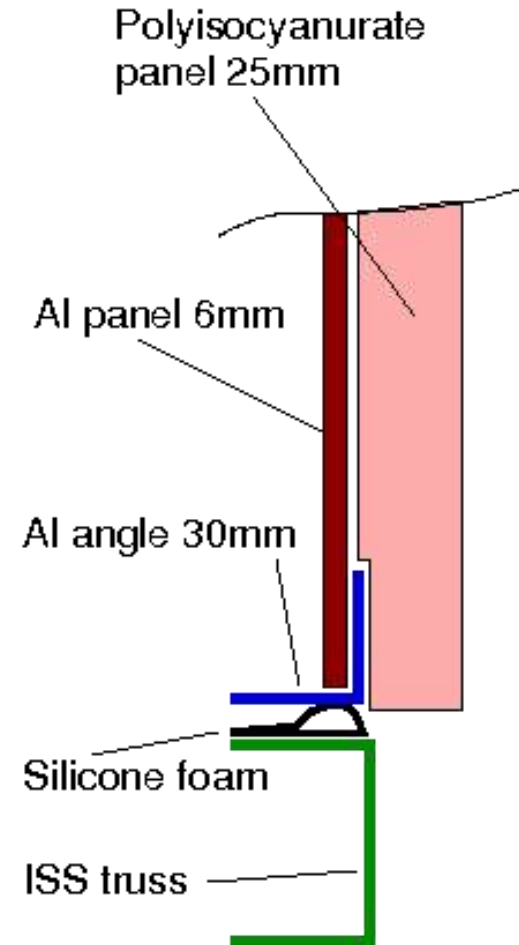
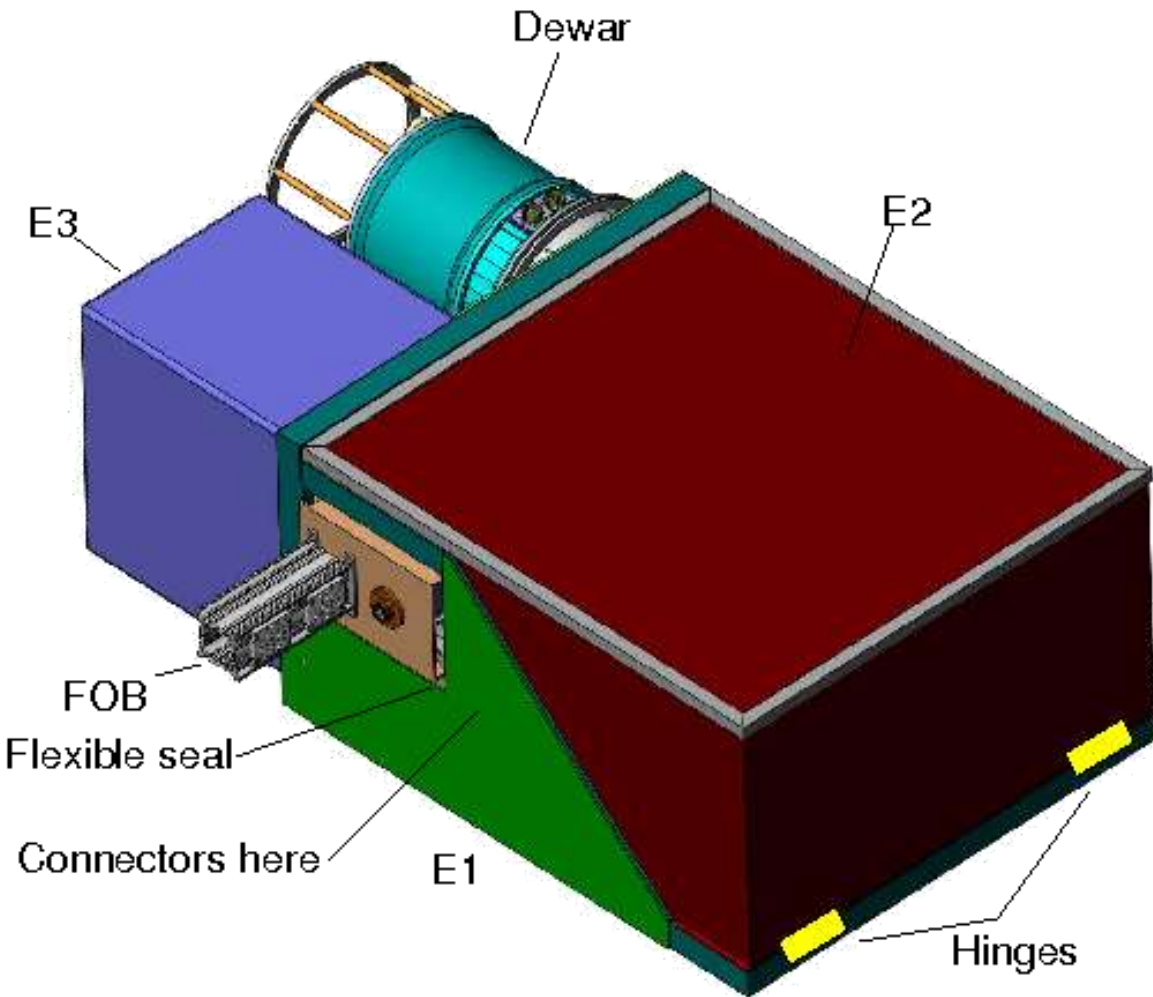
- Bowen-Walraven, 3 slices, 2 mirrors at F/30
- Moves out of the beam \rightarrow bare fiber or slit



Mechanical design



Enclosure



The CCD camera

- 4Kx4K CCD231 from e2v, 15 μm pixels
- Optimized spectral coating
- Excellent noise ($2e^-$ @50kHz), CTE 0.999996
- Dewar: LN2, NOAO design
- Controller: Monsoon Orange (NOAO)
- Software: ArcView (NOAO)

The current system works with Orange+Arcview
Two identical dewars with same 4K e2v chips exist

Electronics

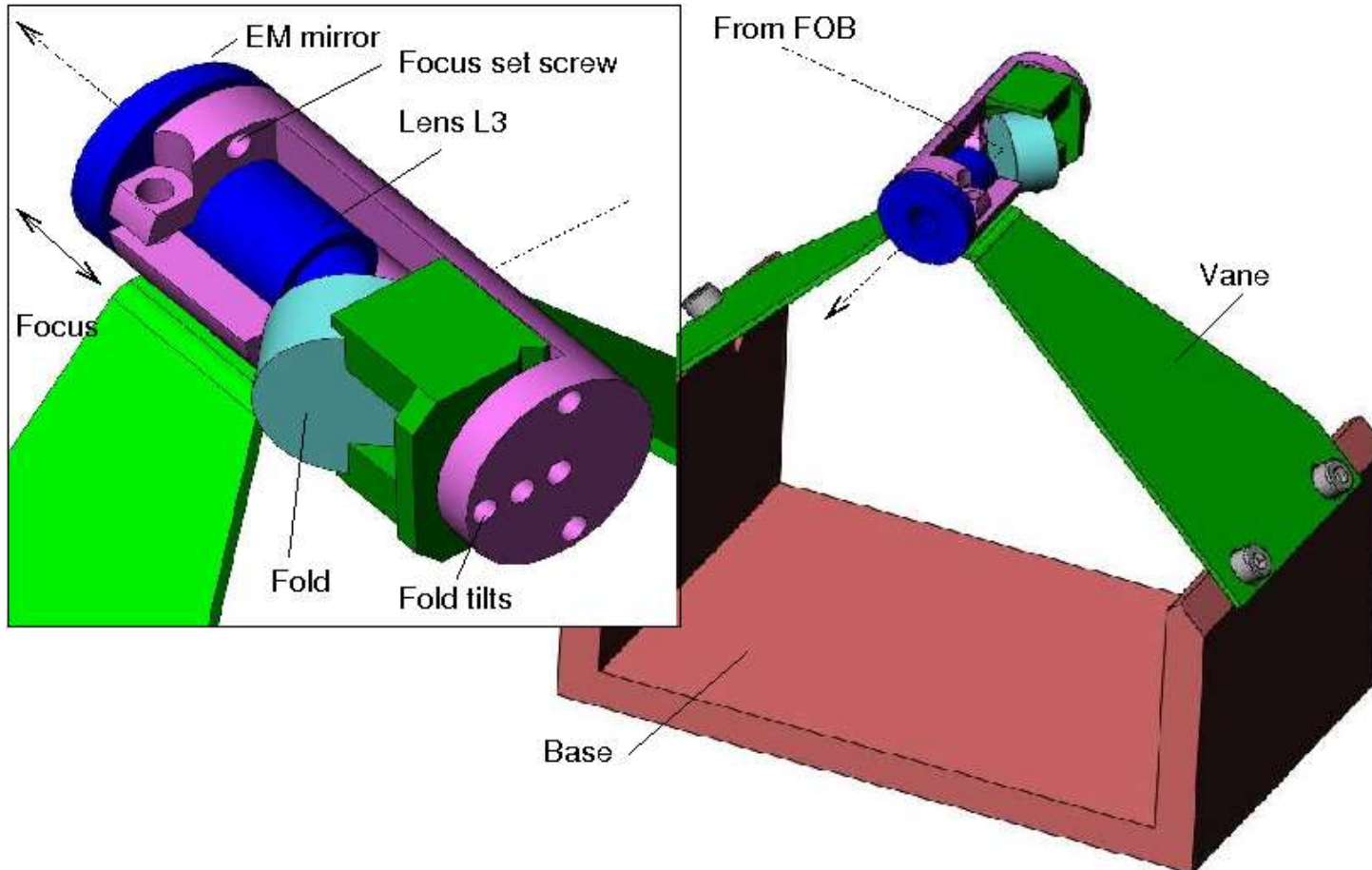
- Two translation stages (PI) – focus, slicer
- Shutter (TS6B, Uniblitz)
- Iodine cell: temperature controller, in/out
- Enclosure: temperature stabilization
- Enclosure: [over]-pressure stabilization (TBD)
- Exposure meter (Hamamatsu PMT, RS-232)

Status & schedule (August 2010)

- Prism: retouching, to be AR-coated
- Collimator/fold: received
- APO-140 camera: received & tested
- CCD: chip received, dewar fabricated
- Mechanical design: finished, start fabrication
- FOB & EM developed at Yale
- First integration starts October 20
- Move to telescope: January 20, 2011

Thank you!

Design details (1)



Obstructed 15-mm beam used in the exposure meter

Design details (2)

