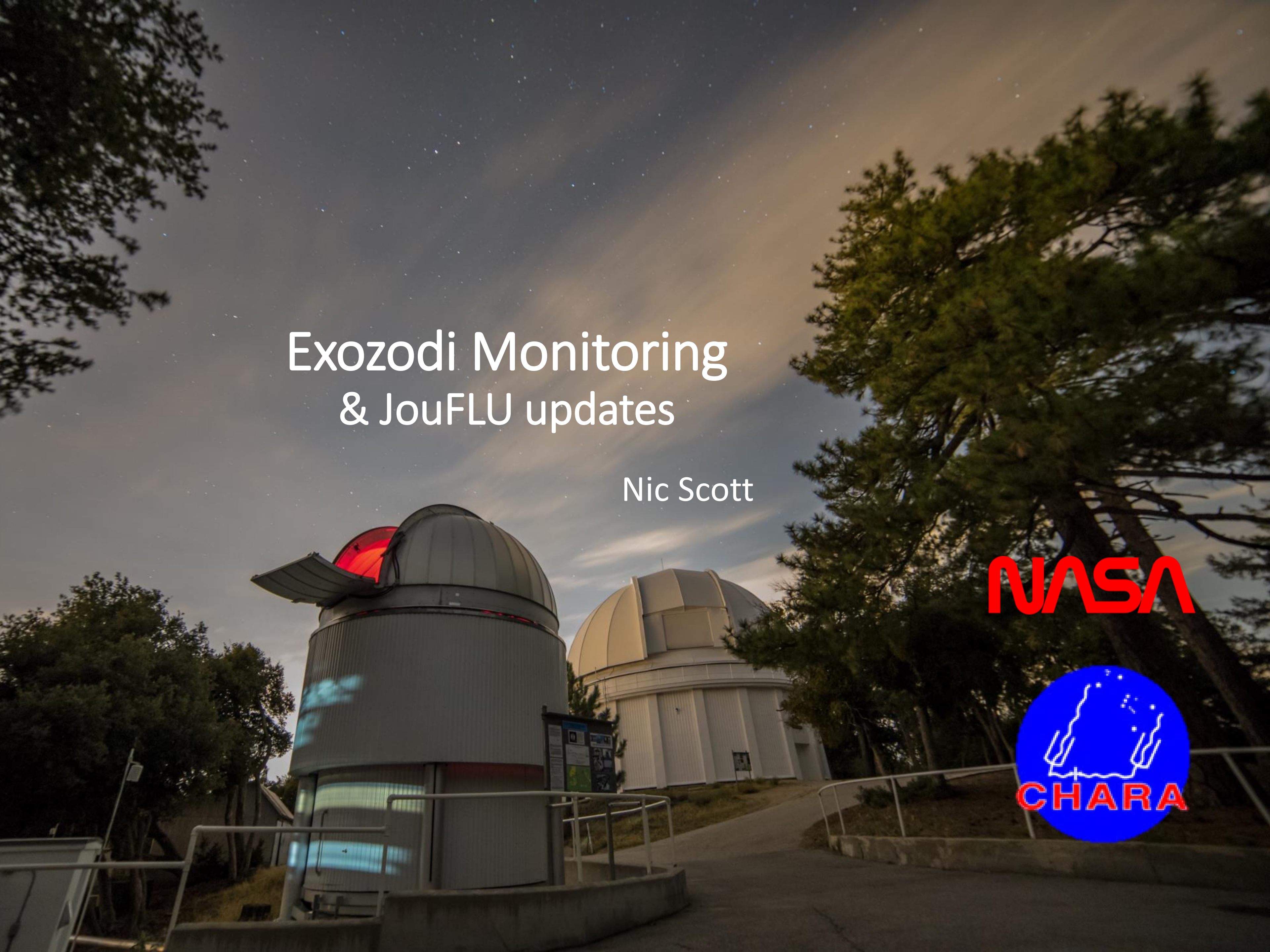
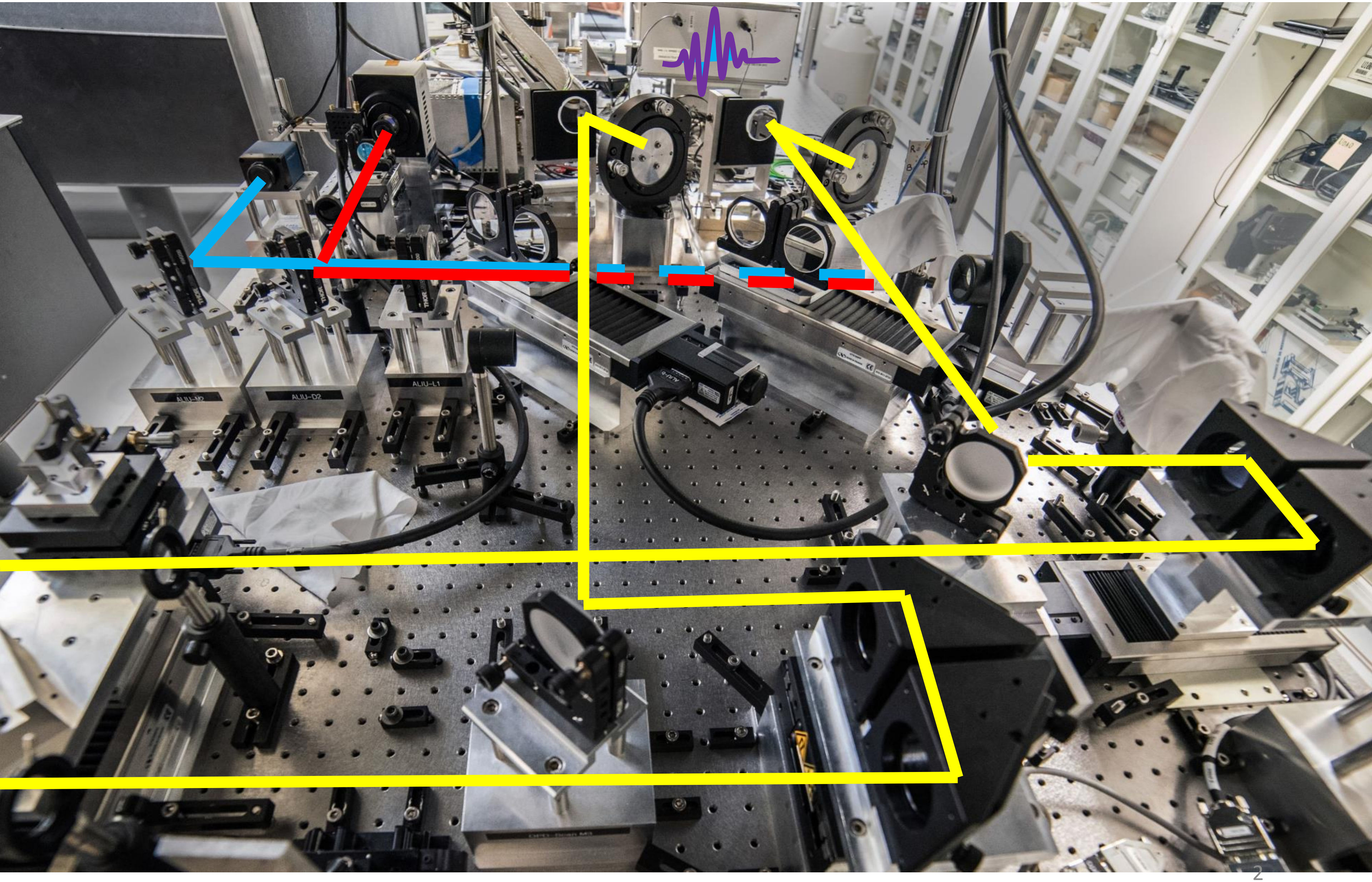
Exozodi Monitoring
& JouFLU updates

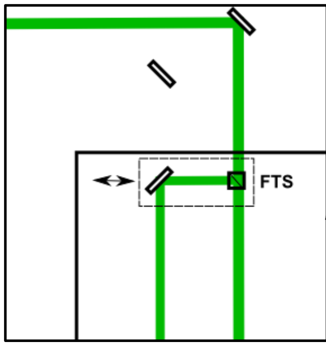
Nic Scott



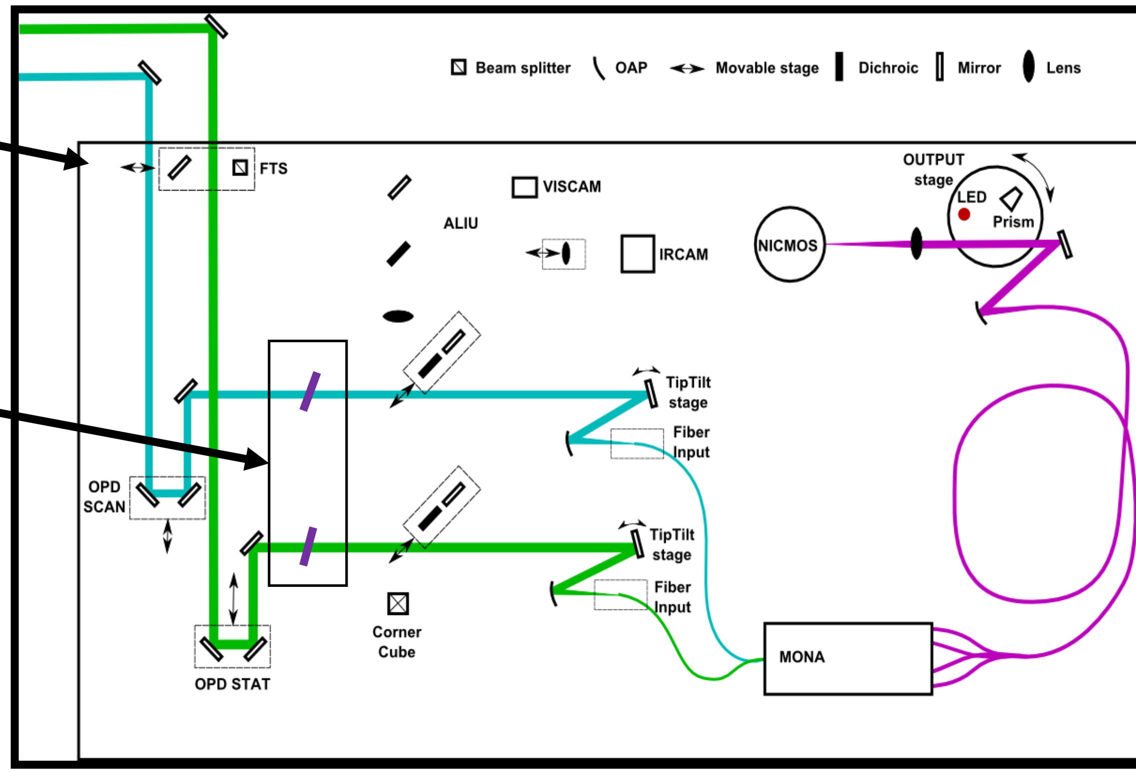


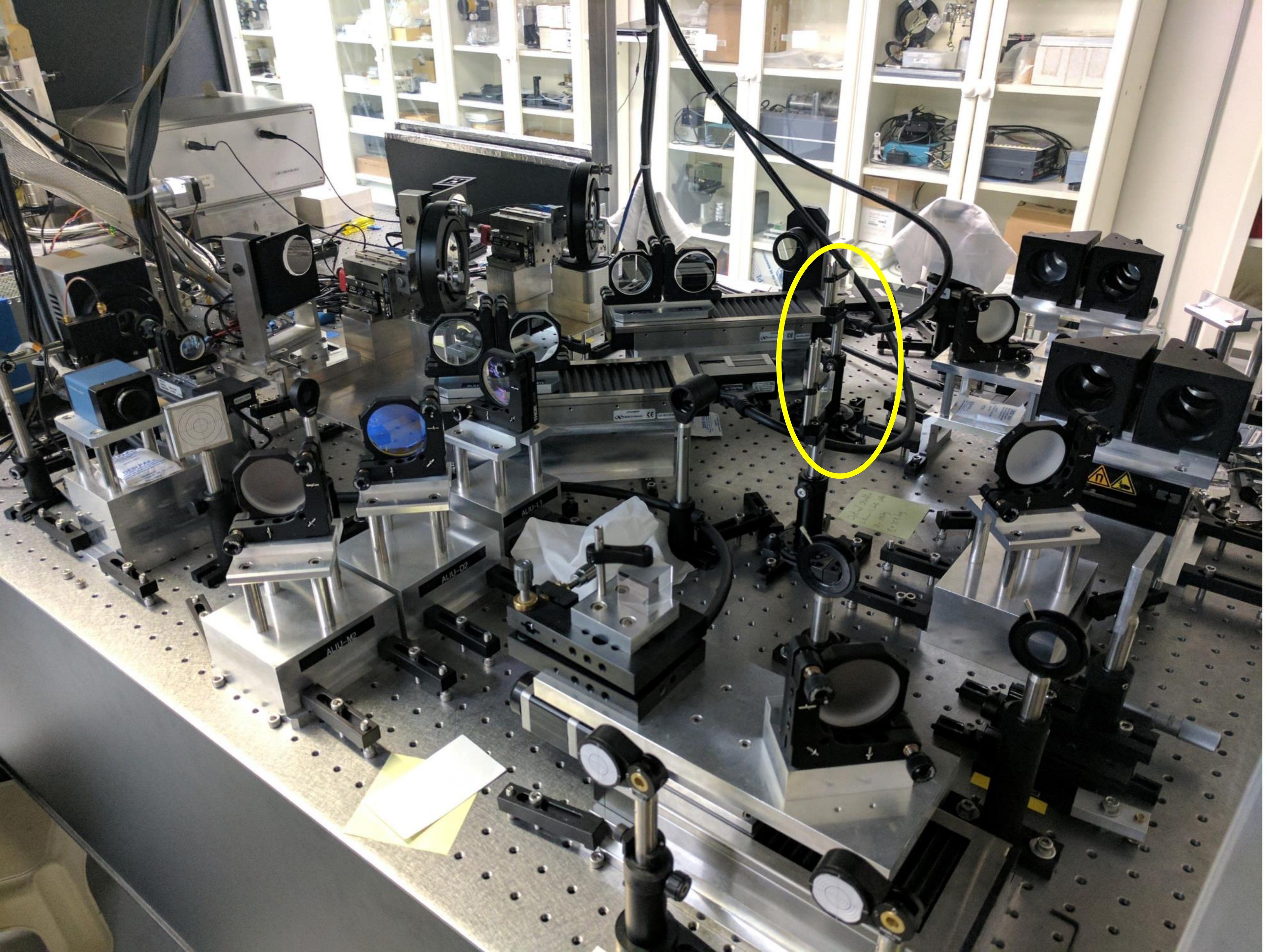
Update on JouFLU - Hardware

- FTS

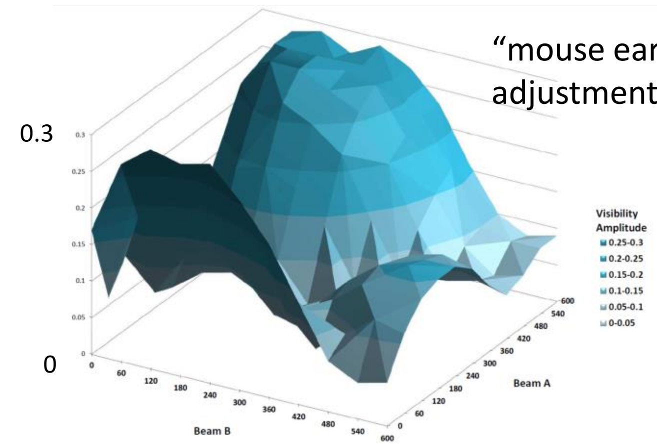


- Lithium plates
  - Instrument visibility up from ≈ 0.3 to ≈ 0.7



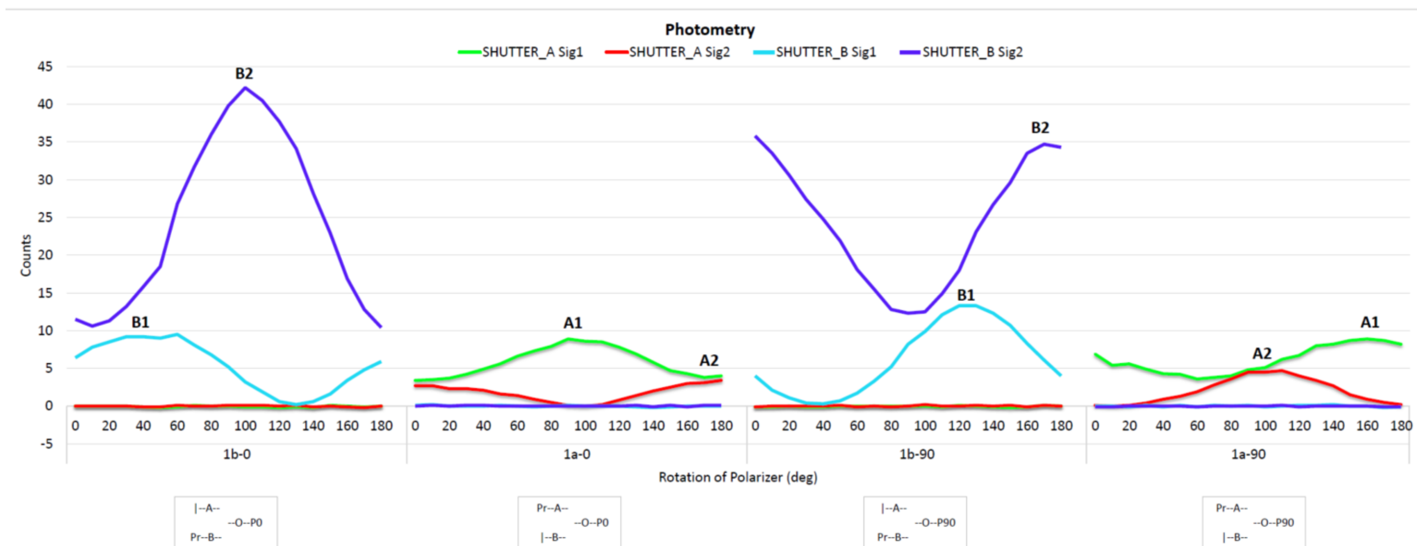

ALIU-M2
ALIU-D2
ALIU-L1

Differential Polarization Rotation



"mouse ear" adjustments

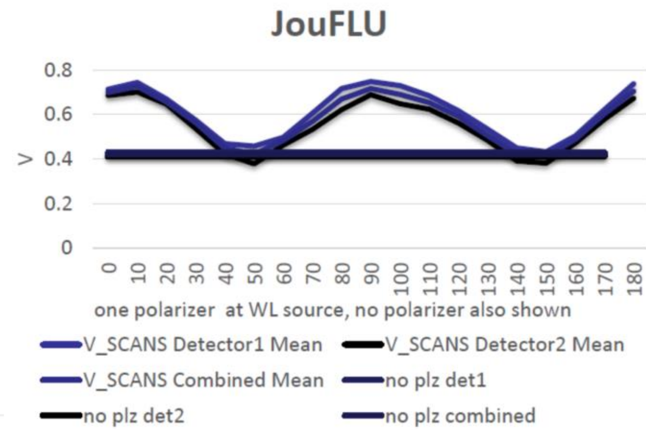
Name	Signal 1 (°)	Signal 2 (°)	Difference (°)
Test1-0	50	80	30
Test1-90	35	110	75



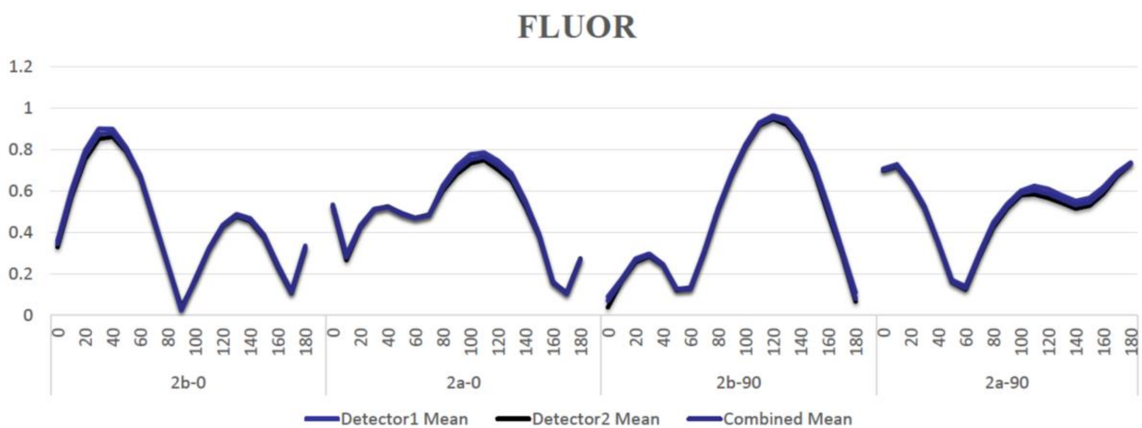
Polarizer adjustments

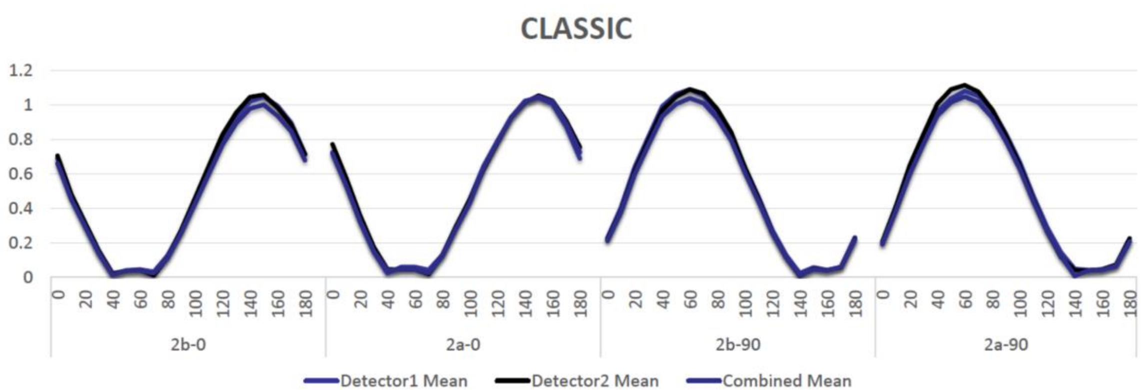
1 polarizer at input and rotated, 1 at output held fixed

Differential Polarization Phase Delay

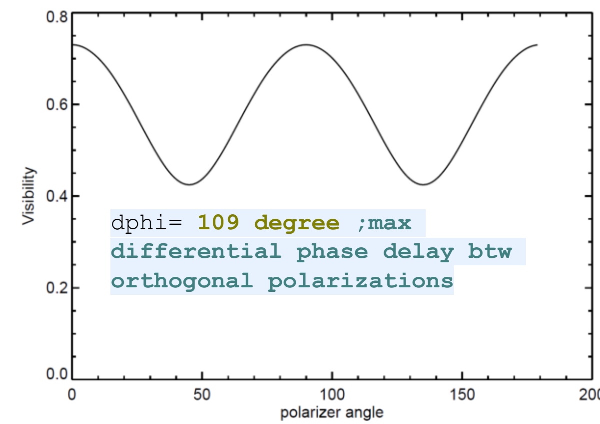


$$V_{\text{max}} \approx 0.73$$





$$I = 2\left[1 + \cos\phi\cos^2\theta + \cos\left(\phi + \Delta\phi\right)\sin^2\theta\right]$$



$$50^\circ \rightarrow V_{max} \approx 90\%$$

$$70^\circ \rightarrow V_{max} \approx 60\%$$

1 polarizer at each input, 1 rotated

Effect of Lithium Niobate Plates

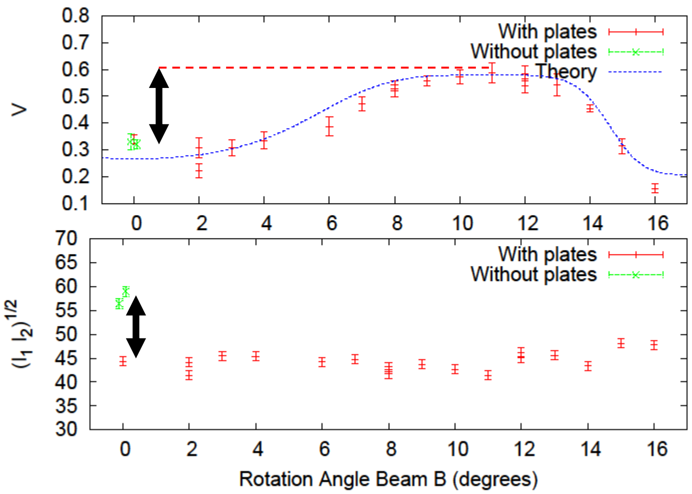
- System visibility has improved, at cost of some throughput

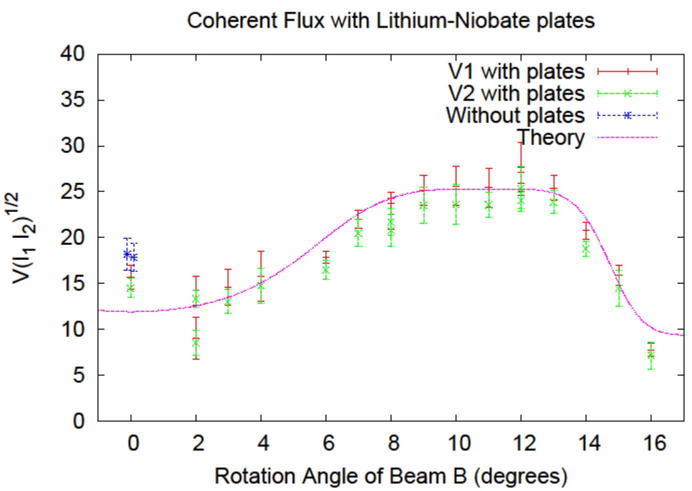
estimated visibility (difference signal)
along with the photometric outputs

200% percent increase in V

≈25% percent reflection loss

no AR coating yet



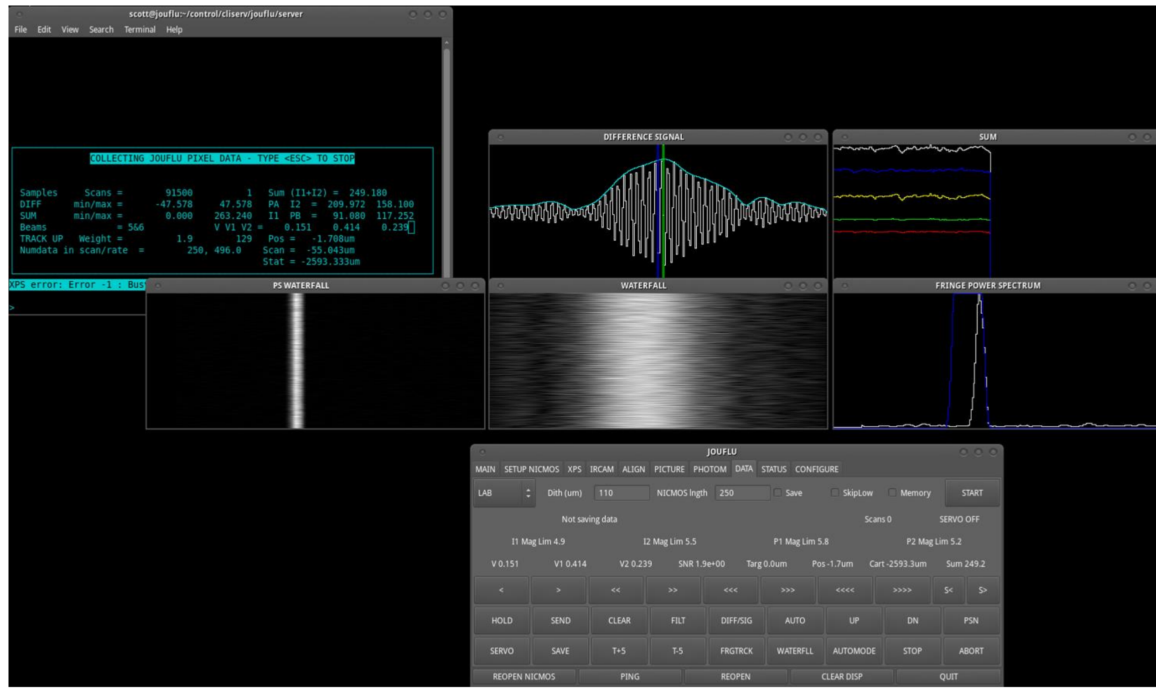


fringe contrast limited by a polarization delay rather than polarization rotation

247+-8 degrees of delay between the two polarization states (diff from before....aging?)

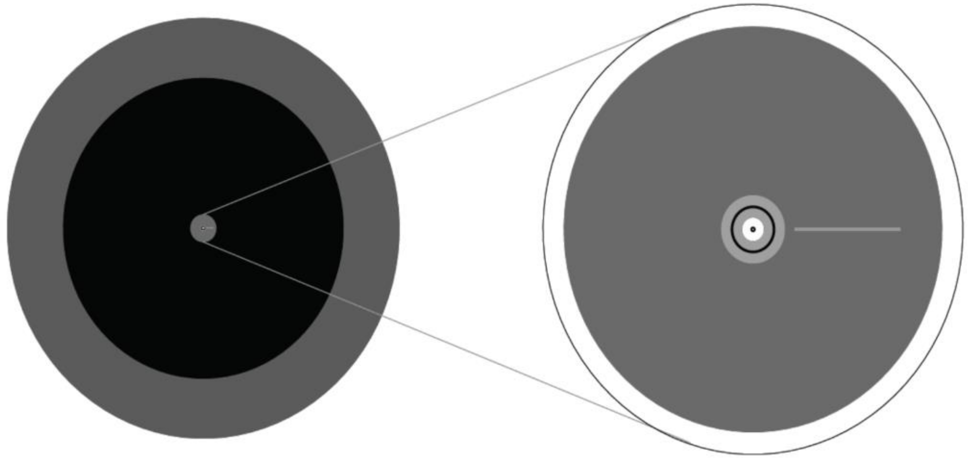
Update on JouFLU - Software

- Now in git
- FTS software working
- fpa – four pixel align
- External trigger - ALOHA

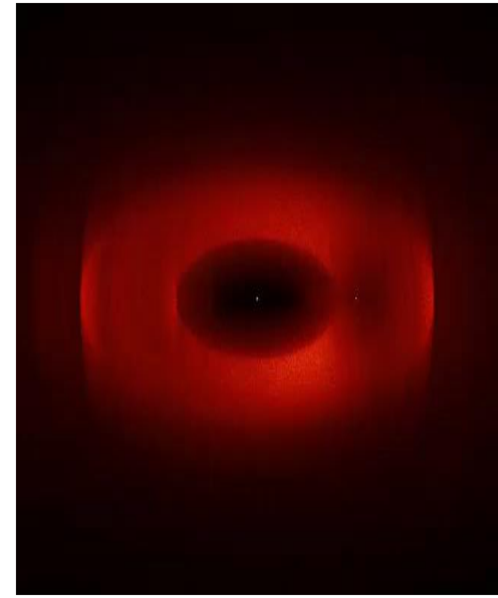


Zodiacal light

- Exozodiacal analogs
- Tenuous but huge in surface area
- Circumstellar dust
- < 1 AU – 10AU
- Warm (300K)
- < 1-100 μm dust in the inner SS
- Debris from comets, asteroids, collisions and outgassing
- 90% from comets (Nesvorný et al. 2010)
- Not smooth, bands & clumps



	Conventional detection level [Spitzer, Herschel]		Interferometric field-of-view
>100 AU	cold debris disk (<100K)	<10 AU	exozodiacal dust (100-1400K)
10 AU	giant planet	2 - 7 AU	habitable zone (line)
<10 AU	exozodiacal dust (100-1400K)	1 AU	terrestrial planet with gap
		0.5 - 1.5 AU	warm dust disk (500K)
		0.1 - 0.5 AU	hot dust disk (>1000K)
		center	A0 star



animation by Chris Stark

Debris disks – left over from planetary formation, late heavy bombardment period (LHB)

- 20% of MS systems are thought to harbor DD (Trilling et al. 2008, Carpenter et al. 2009, Eiroa et al. 2013)
- Space missions: IRAS, HST, ISO, Spitzer, Herschel
- Far-IR excess, Sub-mm imaging, Visible imaging

Exozodiacal analogs

- Tenuous but huge in surface area
- Grains < 1-100 µm in diameter
- Debris from comets, asteroids, collisions and outgassing

Short Baseline

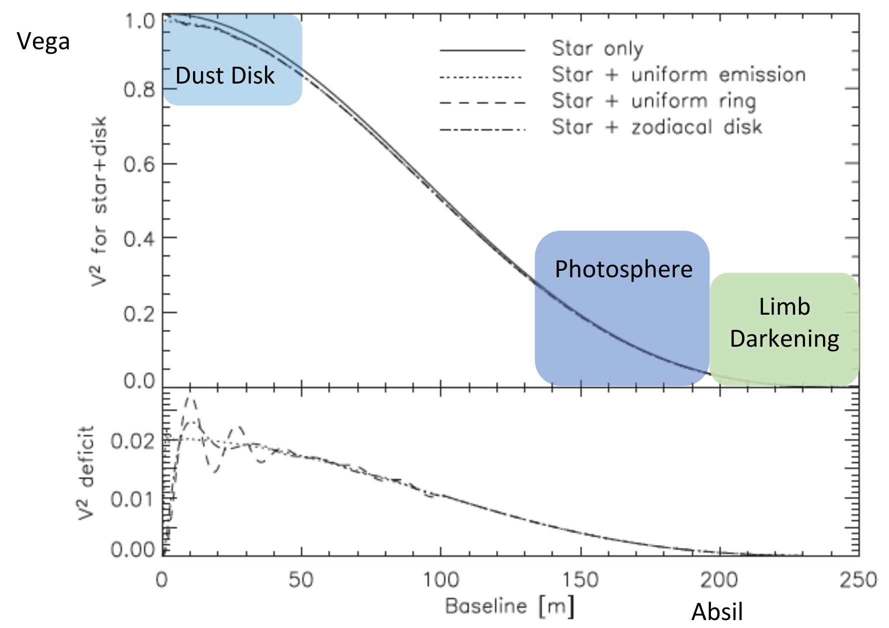
Disk unresolved (> λ/b)

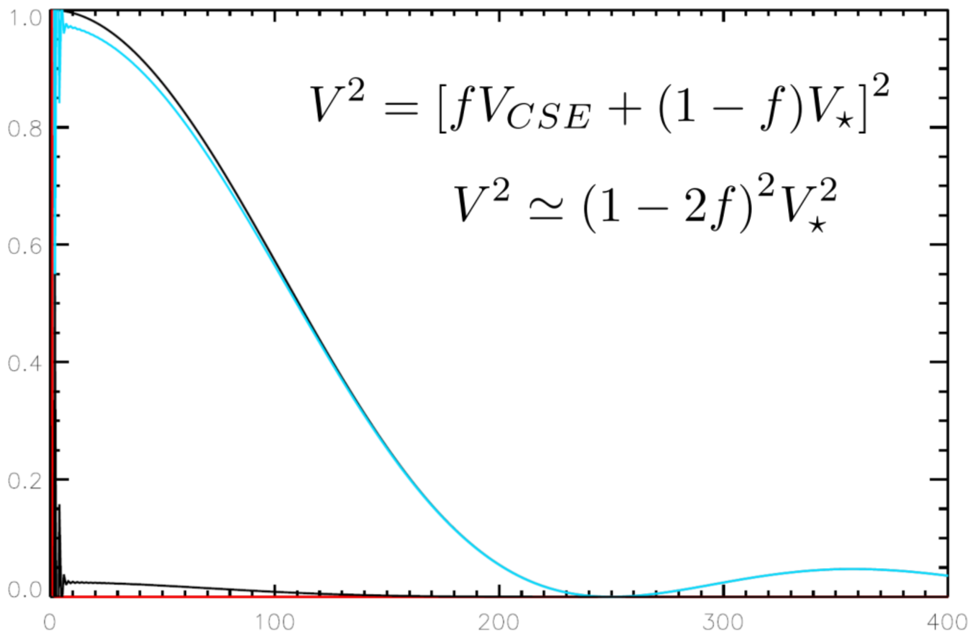
⇒ Incoherent flux

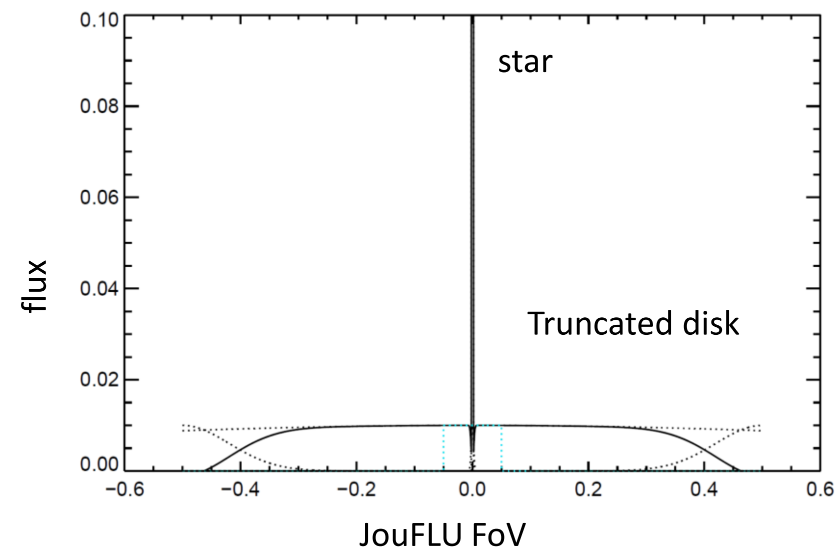
⇒ Visibility deficit on all baselines

⇒ Easiest to detect at short baselines

⇒ Need <1% precision







Exozodis

NIR results → large populations of hot small grains close in to nearby MS stars

- Possibly Mg-rich forsterite (peridot, Mg_2SiO_4) (Lisse 2015, Su 2015)
- Sub-micron grains should be short lived in this region (Wyatt 2008)

Trapped or replenished by catastrophes

Highly variable on short time-scales due to short orbital period

- Meng et al. (2014) reports quasi-periodic (P≈70 days) disk flux modulation in MIR spectra
- Giant impact resulted in a thick cloud of silicate spherules that were then ground into dust ‘panel’ by collisions
- Mass loss rate ≈ 180 km diameter asteroid every < 10 yrs,
- Not uncommon, 4 other similar systems

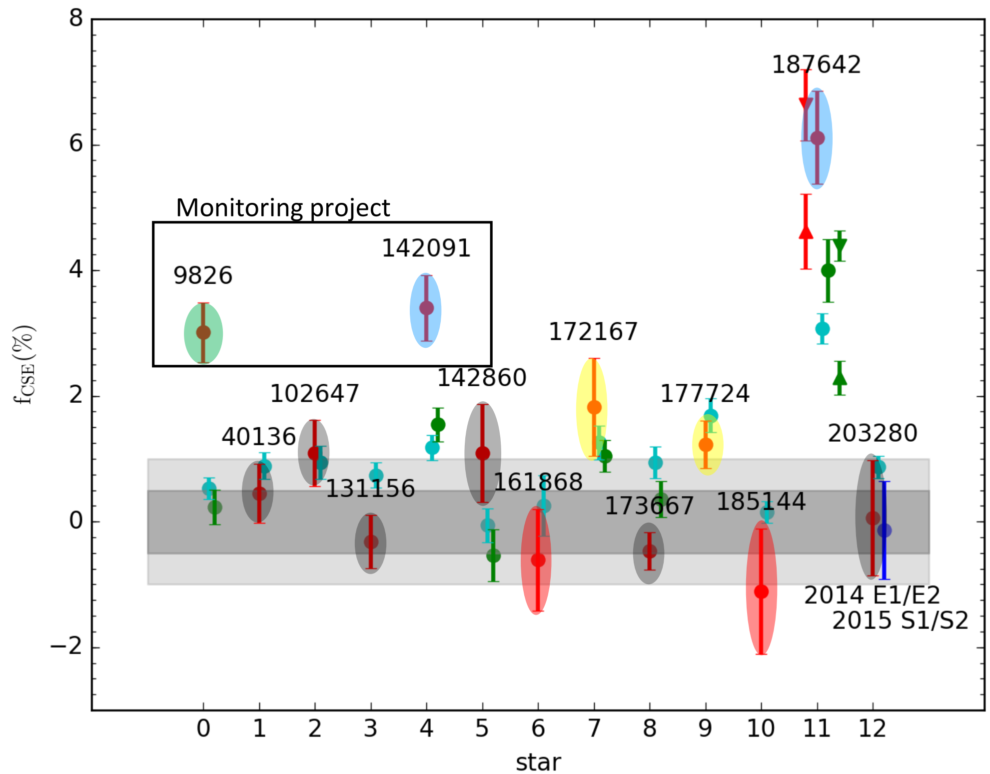
Exozodi Program description

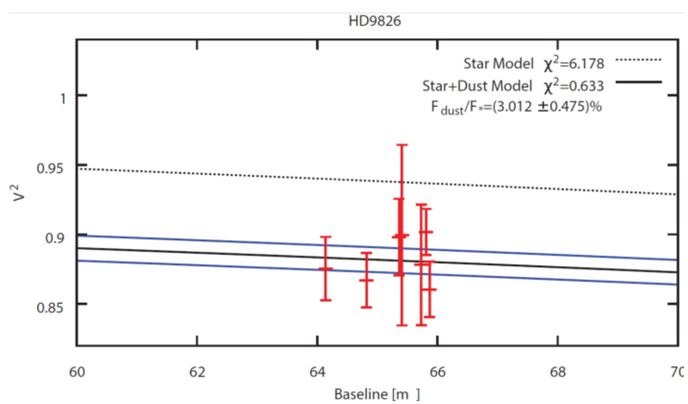
- **Near Infrared Exozodi Variability Study** (complete) Revisit 12 of the bright A-K stars with previously detected excesses from the Absil et al. 42 star FLUOR survey.
- **Near Infrared Exozodi Survey Extension** (complete) 3 year program observing ≈100 MS A-K stars. Hot dust expected in 30% of systems. Goal is 1% excess detection at 5σ to $m_K < 5$.
- **IRTF/SpeX Spectrophotometric Survey** (on hold) Provide confirmation of dust from NIR excesses, obtain spectra, and develop survey campaign.
- **Monitoring of Known Variable Exozodiacal Disks** (in progress) Revisit three stars from the Exozodiacal Variability survey that exhibit a strong near infrared excess. These stars will be observed at least three times during the season.
- **Exozodi confirmation** (in progress) Utilize speckle interferometry to confirm hosts of exozodis are point sources. Rule out stellar companion from 25 mas to 2.3”.

Near Infrared Exozodi Variability Study

Threshold for detection changed to 1% instead of 0.5%

- Excesses not considered significant: eta Lep, bet Leo, ksi Boo, gam Ser, 110 Her, alf Cep
- New excess: ups And
- Two excesses remain unchanged: zet Aql, Vega
- Two non-detections remain unchanged: gam Oph, sig Dra
- Two excesses increased: kap CrB, alf Aql





2013 Absil

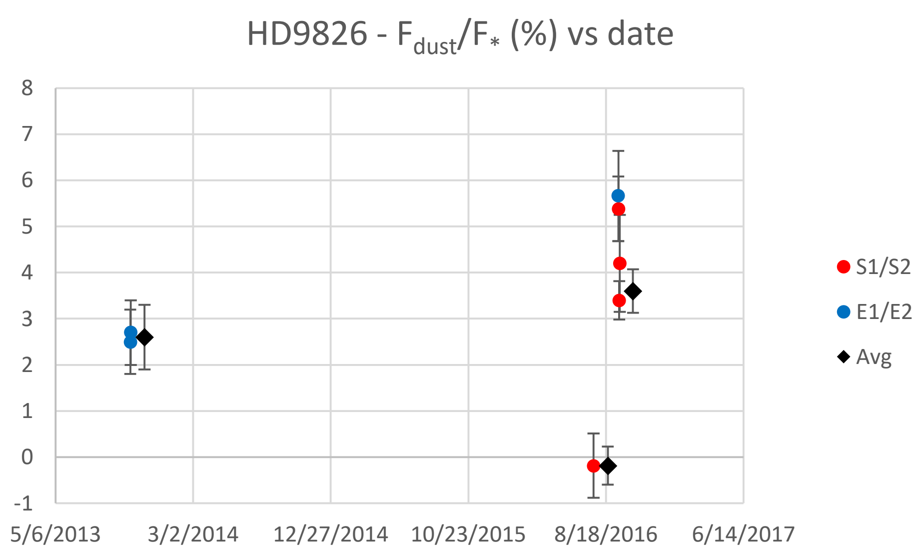
Absil data – new DRS

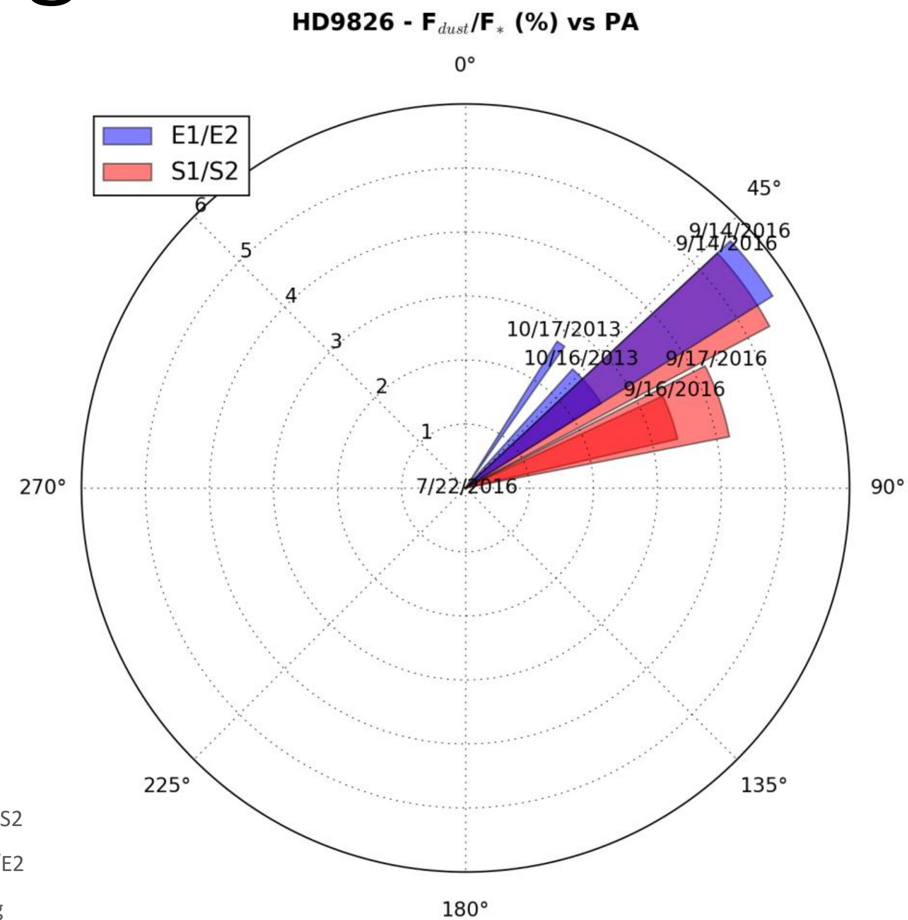
New data

Exozodi monitoring

HD9826, HD142091, HD142860 – from Absil survey, multiple times since.

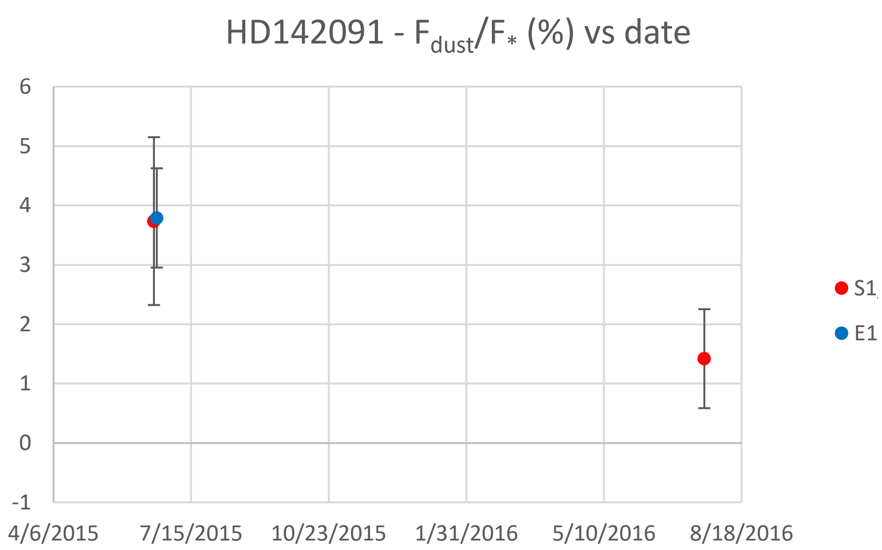
- HD9826 – F9V, 4 planets, 3 companions in WDS (but 55,114,287”), spec binary (M4.5V 55” away)

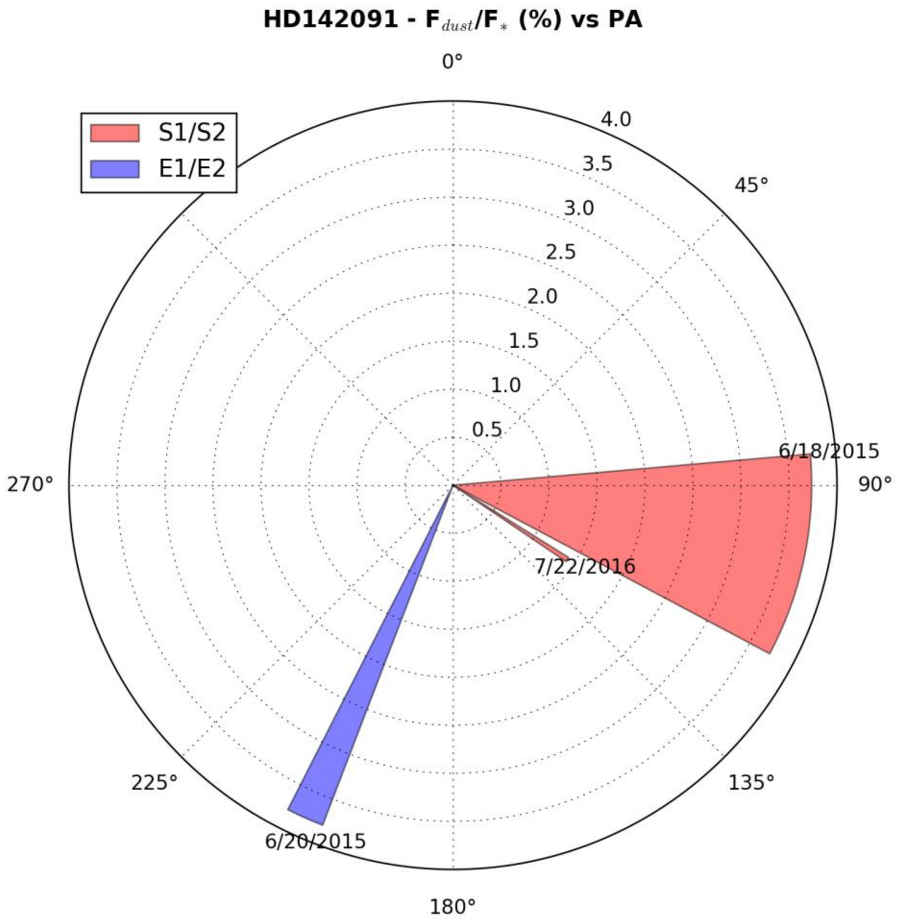




0.53 ±0.17% FLUOR

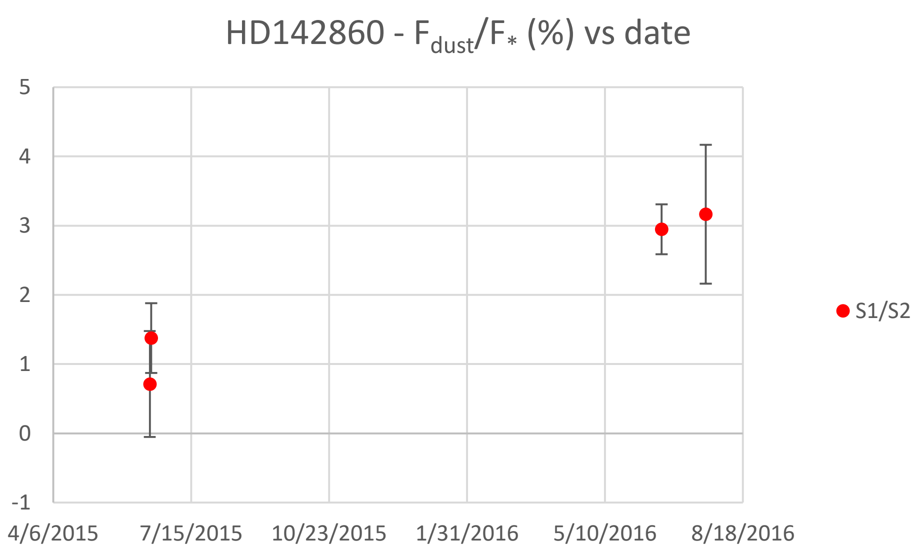
- HD142091
  - Variability of F_{CSE} seems independent of PA

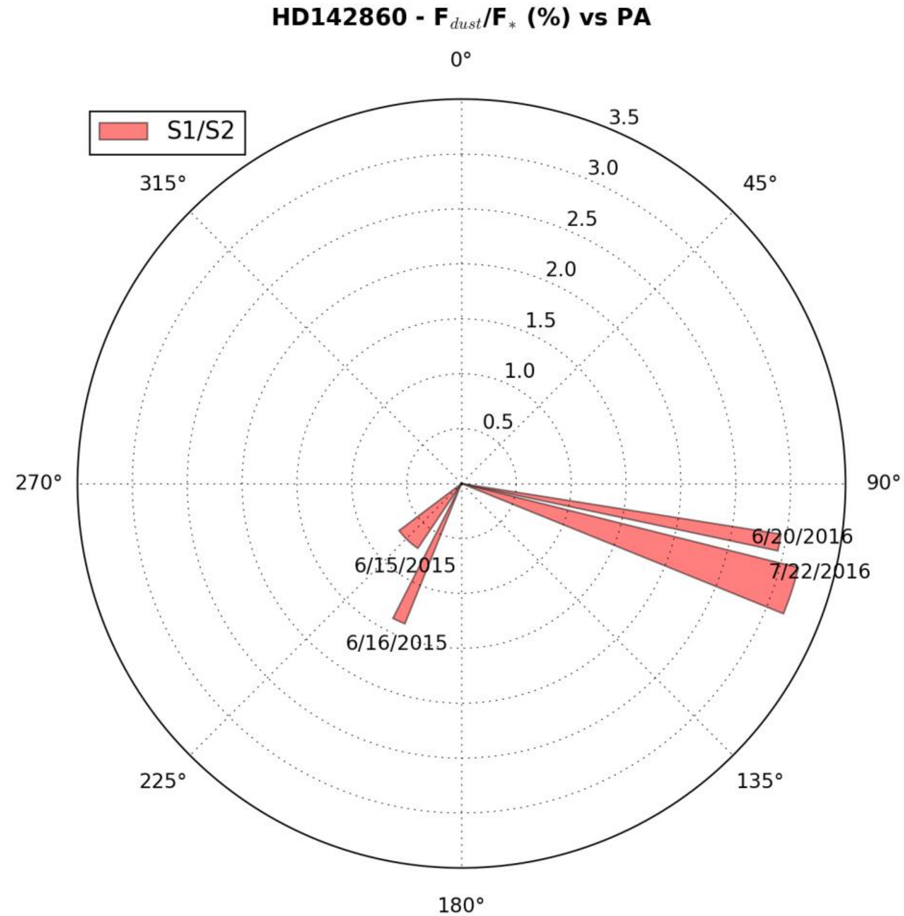




1.18 ±0.2% FLUOR

- HD142860
  - F_{CSE} changes with PA
  - Could be variability of dust
  - Could be evidence of inclined disk





-0.06 ±0.27% FLUOR

New Exozodi Monitoring targets

- HD98058
  - Phi Leo spectra shows signs of exocomet infall and evaporation (Eiroa et al. 2016, A&A 594, Oct 2016)
- HD210418
  - A-type with 1.7 ± 0.5% excess from 2013
- HD222368
  - F-type with 1.3 ± 0.3% excess from 2013

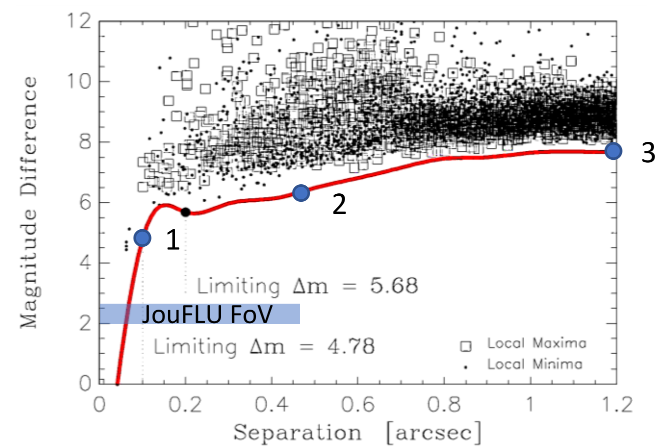
Speckle observations

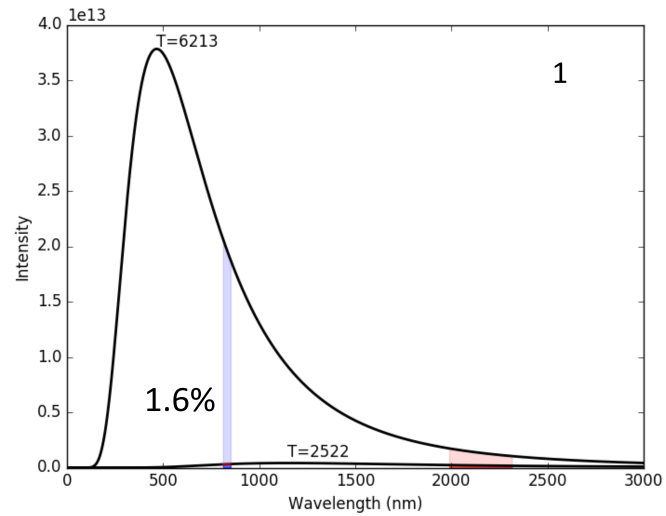
- NESSI (NN-Explore Exoplanet and Stellar Speckle Imager)
  - Observations of HD9826 –Oct 2016 at WIYN, <1 min of data
- Constrains the possibility of a faint companion at wide FoV

1 • An upper limit of the flux ratio at 832nm of a companion located 0.1'' away was found to be 1.6%, excludes earlier spectral type than M8V/M9V (T > 2500K).

2 • 0.4% (T=2100K) at the extent of the JouFLU FoV

3 • 0.06% (T=1700K) at the extent of the speckle FoV.



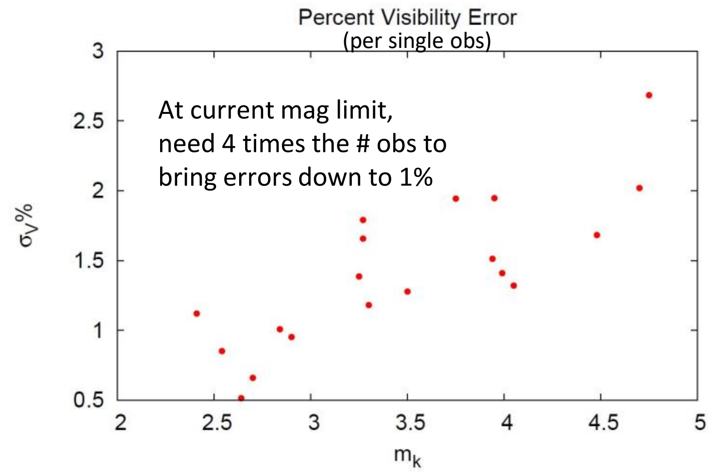


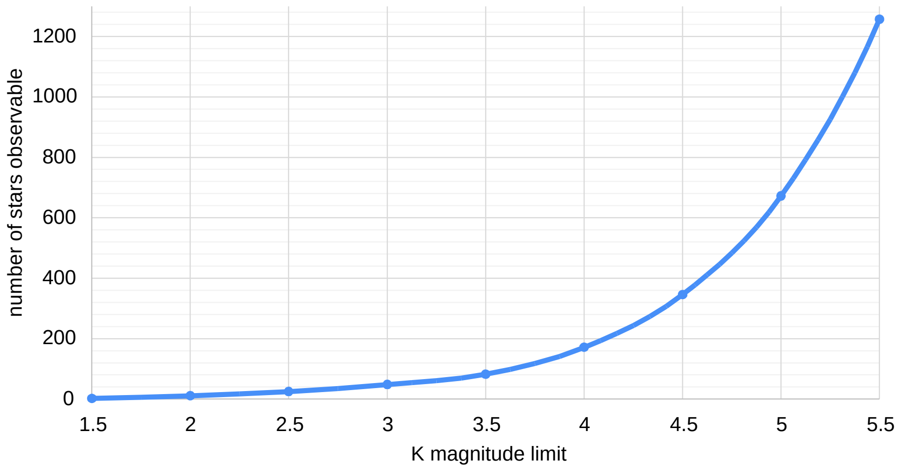
JouFLU upgrade paths

Goal is to access more exozodi targets

- AR coat LiNbO3 plates
- Replace MONA
  - New fibers or IO (GRAVITY)
- Replace NICMOS
  - SAPHIRA? PICNIC?
- Add Fringe-tracker

Getting to 5th mag could more than double the number of targets observable





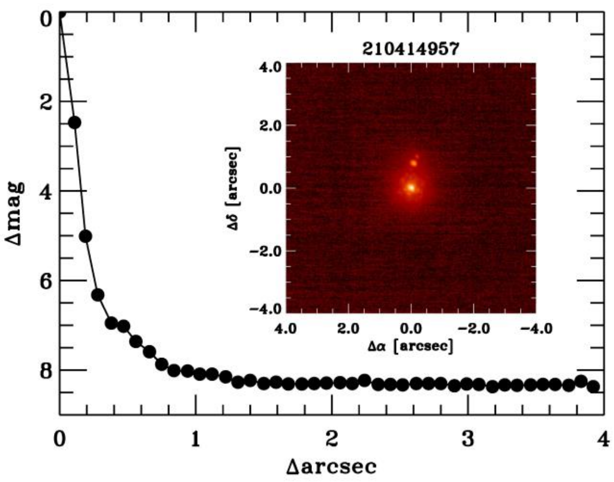
Other possibilities:

- Observe with MYSTIC, MIRCx?
- Observe with SPICA?
- Aperture mask on 8+ m telescope

Get closure phase, rule out companions, determine if scattered or thermal emission

Know Thy Star - Know Thy Planet
Assessing the Relevance of Ground-based High Resolution Imaging and Spectroscopy of Exoplanet Host Stars

October 9-12, 2017 — Hilton Pasadena in Pasadena, CA



http://nexsci.caltech.edu/conferences/2017/knowthystar/

- April 14, 2017: Registration and Abstract Submission Sites Available
- August 18, 2017: Early Registration and Abstract Submission Deadline
- September 7, 2017: Hotel Reservation Deadline for Conference Room Block at the Hilton Pasadena
- September 29, 2017: Late Registration Deadline

This meeting will gather experts in the field to understand community needs for follow-up observations in the era of *K2* and *TESS* and leading into *JWST, PLATO,* and *WFIRST.*

The three and a half day meeting will focus on the needs for stellar characterization, bound (and unbound) companions, false positive assessment, and planetary characterization with an emphasis on the techniques necessary to accomplish these goals. The follow-up needs for radial velocity, transit, direct imaging, and microlensing detections of planets are similar but also different in detail.