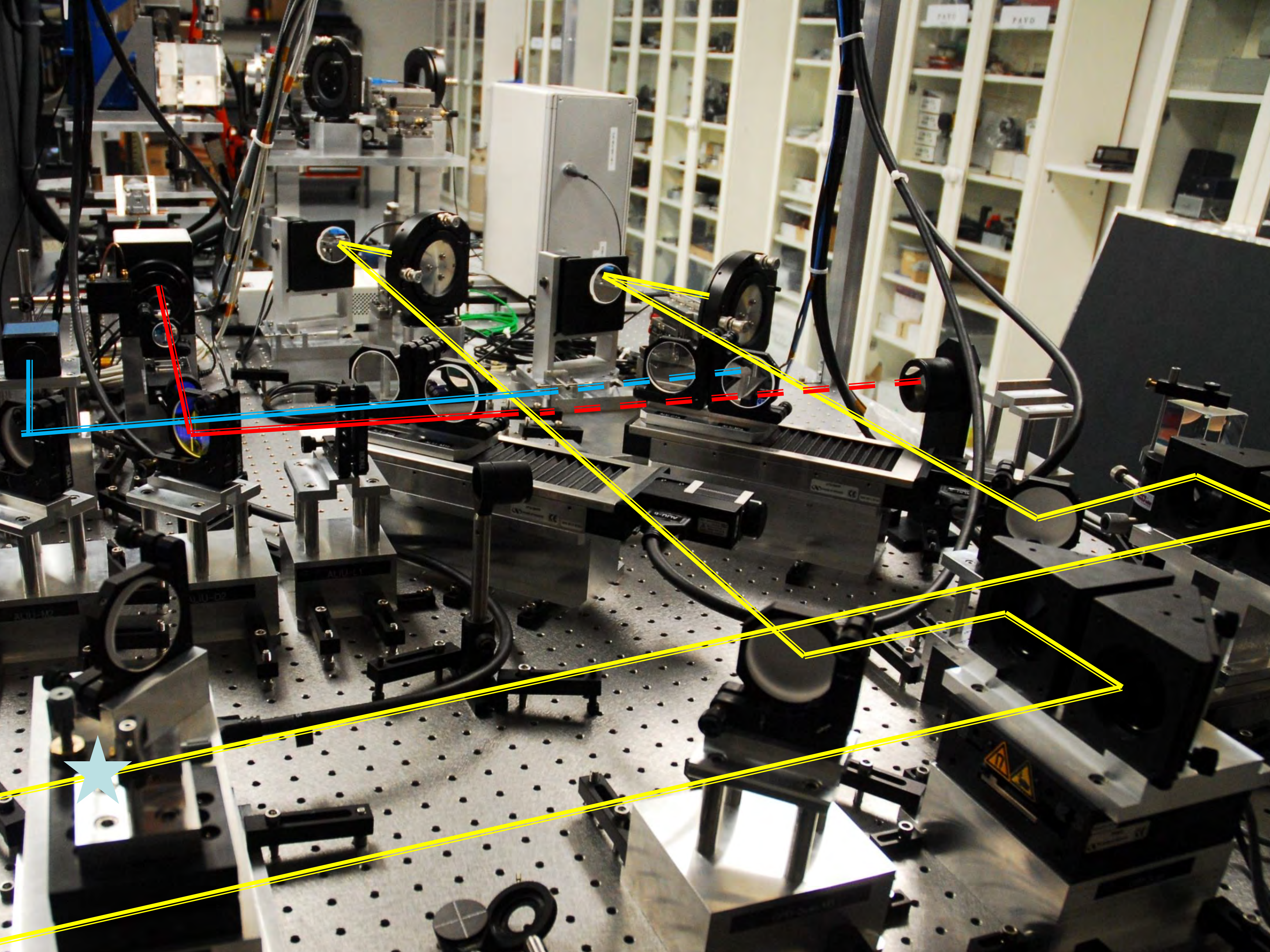
Observations with JouFLU

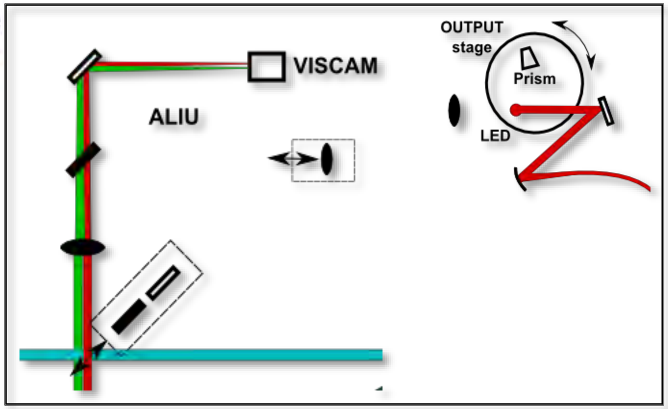
Update and First Results

Nicholas J Scott

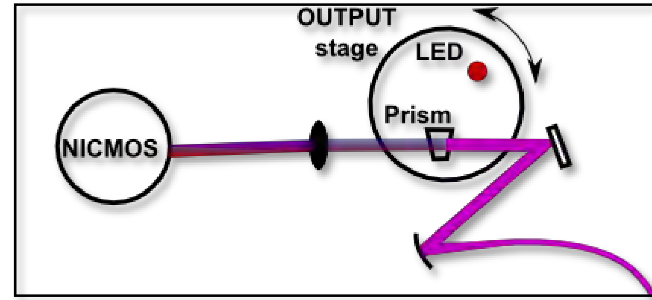
March 2014

- Intro
- Current status
- 2013 observing
- Polarization issues
- Spectral dispersion mode
- Future

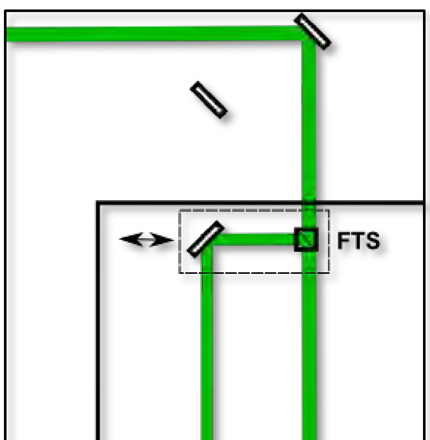




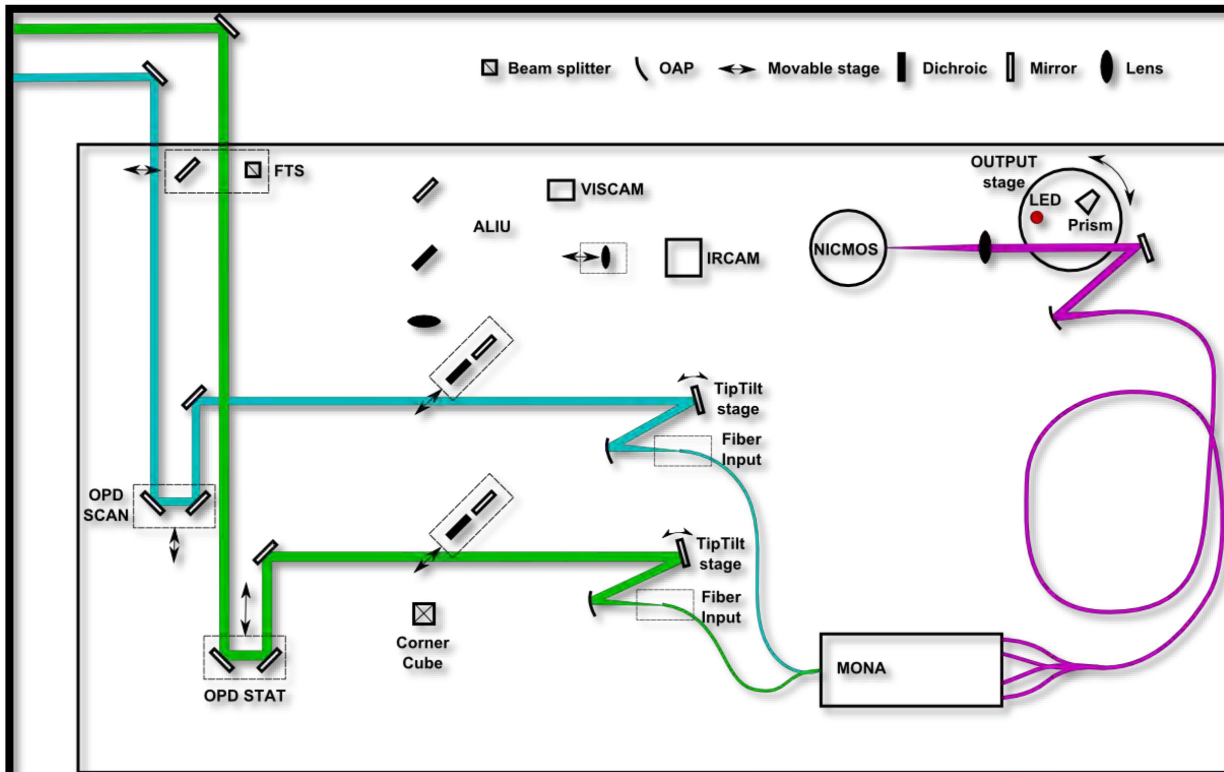
VISCAM
OUTPUT
stage
Prism
ALIU
LED



OUTPUT
stage
LED
Prism
NICMOS



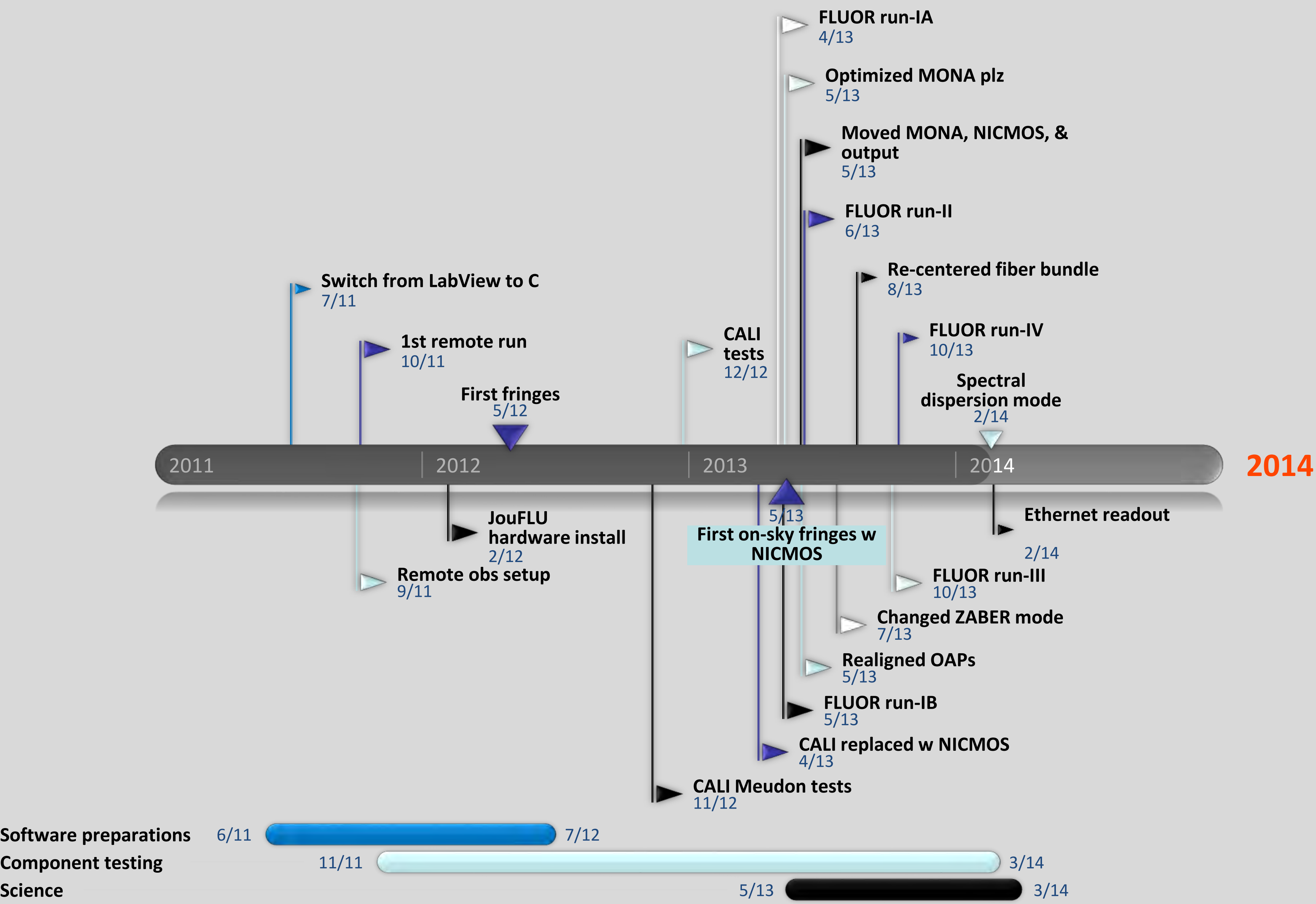
FTS



Beam splitter
OAP
Movable stage
Dichroic
Mirror
Lens
FTS
VISCAM
ALIU
IRCAM
OUTPUT
stage
LED
Prism
NICMOS
TipTilt
stage
Fiber
Input
OPD
SCAN
TipTilt
stage
Fiber
Input
Corner
Cube
OPD STAT
MONA

Differences

- Remote operations
- Software & hardware integrated with CHARA environment
- Pupil imaging
- Improved fiber injection
- Improved alignment procedure
- Spectral dispersion mode
- FTS

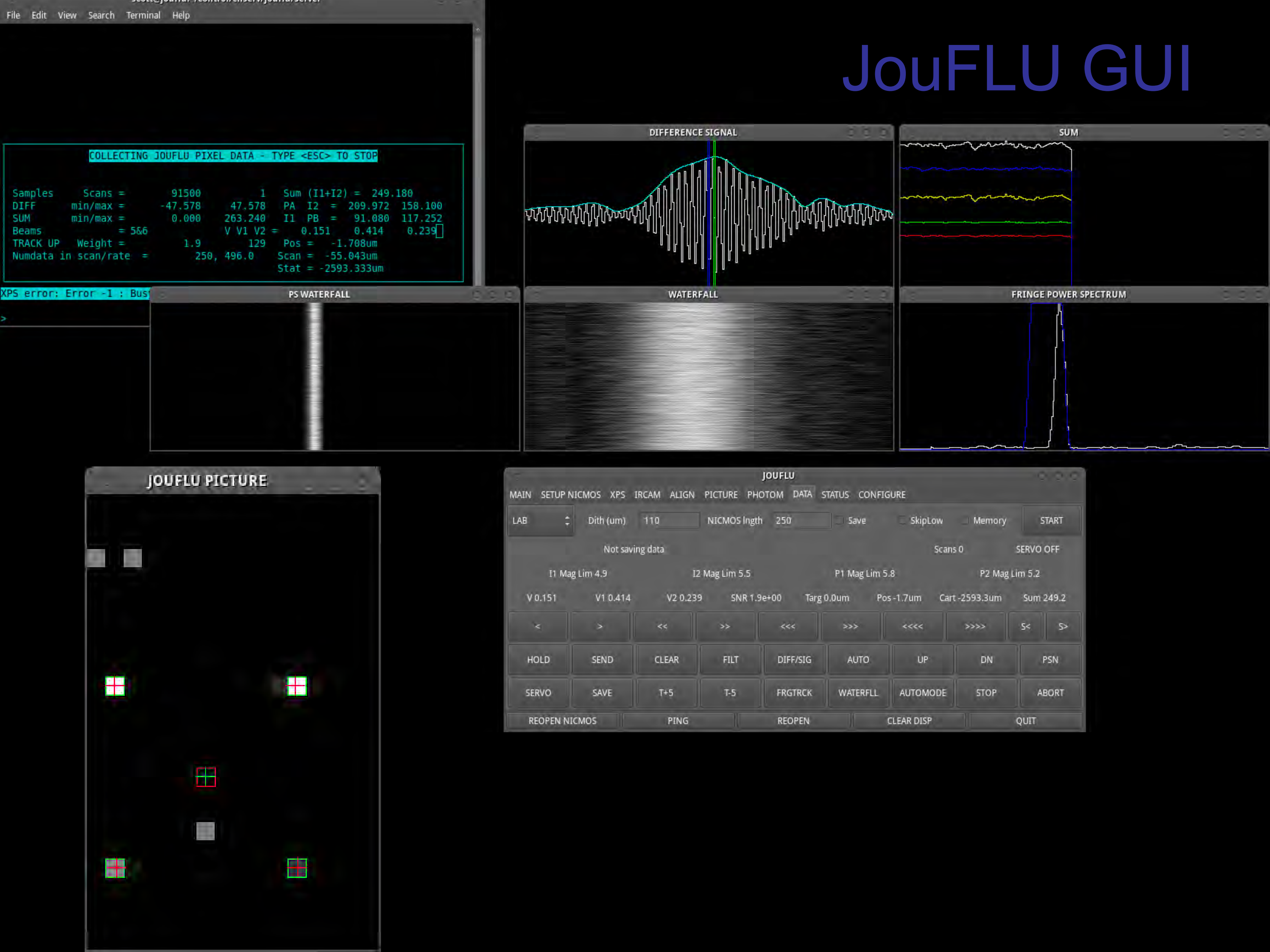

FLUOR run-IA
4/13
Optimized MONA plz
5/13
Moved MONA, NICMOS, & output
5/13
FLUOR run-II
6/13
Switch from LabView to C
7/11
Re-centered fiber bundle
8/13
1st remote run
10/11
CALI tests
12/12
FLUOR run-IV
10/13
First fringes
5/12
Spectral dispersion mode
2/14
2011
2012
2013
2014
2014
JouFLU hardware install
2/12
5/13
First on-sky fringes w NICMOS
Ethernet readout
2/14
Remote obs setup
9/11
FLUOR run-III
10/13
Changed ZABER mode
7/13
Realigned OAPs
5/13
FLUOR run-IB
5/13
CALI replaced w NICMOS
4/13
CALI Meudon tests
11/12
Software preparations
6/11
7/12
Component testing
11/11
3/14
Science
5/13
3/14

Current status report

- First science data taken
- Preliminary data reductions done
  - Initial science data reduced
  - More testing of reduction code planned
- New alignment procedures being documented
- Remote ops tested and working
  - Barring network issues
- Polarization issues investigated
- OAP improvement planned

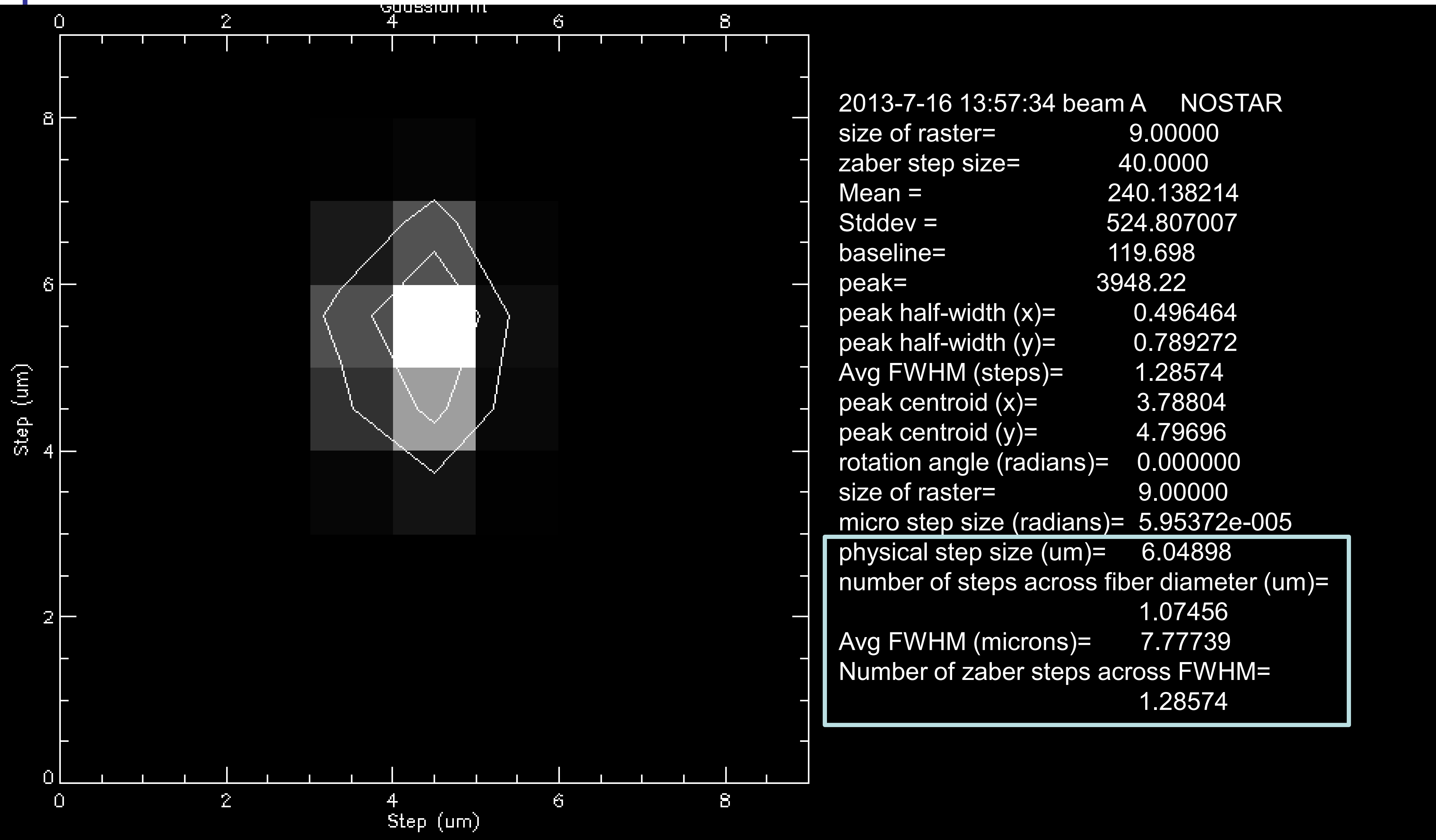
Better throughput

JouFLU GUI


File Edit View Search Terminal Help
COLLECTING JOUFLU PIXEL DATA - TYPE <ESC> TO STOP
Samples Scans = 91500 1 Sum (I1+I2) = 249.180
DIFF min/max = -47.578 47.578 PA I2 = 209.972 158.100
SUM min/max = 0.000 263.240 I1 PB = 91.080 117.252
Beams = 5&6 V V1 V2 = 0.151 0.414 0.239
TRACK UP Weight = 1.9 129 Pos = -1.708um
Numdata in scan/rate = 250, 496.0 Scan = -55.043um
Stat = -2593.333um
XPS error: Error -1 : Bus
DIFFERENCE SIGNAL
SUM
PS WATERFALL
WATERFALL
FRINGE POWER SPECTRUM
JOUFLU PICTURE
JOUFLU
MAIN SETUP NICMOS XPS IRCAM ALIGN PICTURE PHOTOM DATA STATUS CONFIGURE
LAB Dith (um) 110 NICMOS lngth 250 Save SkipLow Memory START
Not saving data Scans 0 SERVO OFF
I1 Mag Lim 4.9 I2 Mag Lim 5.5 P1 Mag Lim 5.8 P2 Mag Lim 5.2
V 0.151 V1 0.414 V2 0.239 SNR 1.9e+00 Targ 0.0um Pos -1.7um Cart -2593.3um Sum 249.2
< > << >> <<< >>> <<<< >>>> S< S>
HOLD SEND CLEAR FILT DIFF/SIG AUTO UP DN PSN
SERVO SAVE T+5 T-5 FRGTRCK WATERFLL AUTOMODE STOP ABORT
REOPEN NICMOS PING REOPEN CLEAR DISP QUIT

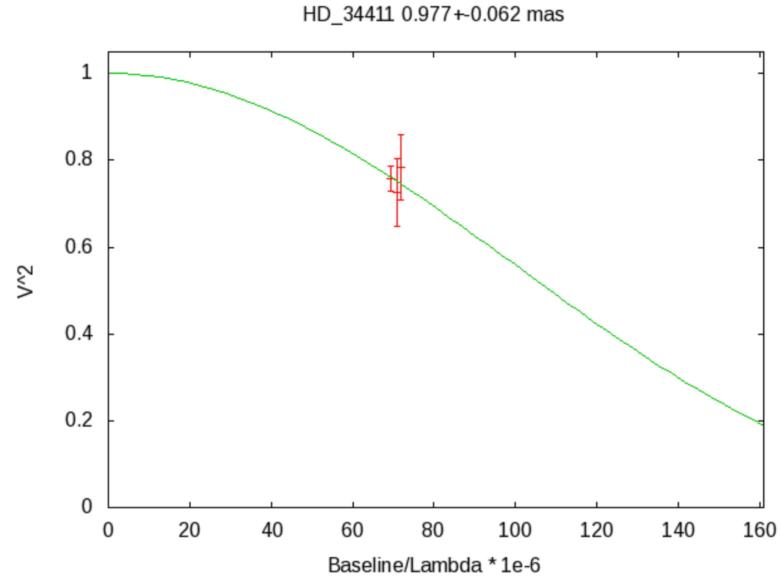
Fiber injection raster scan

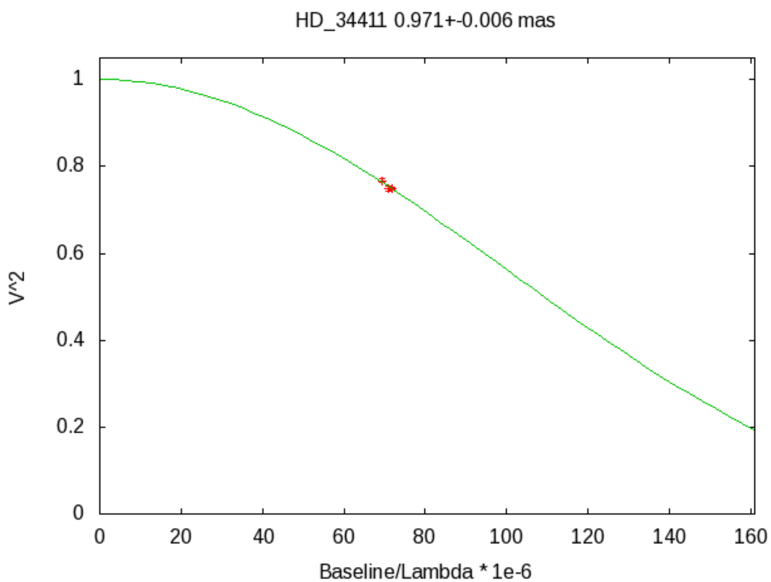
Configuration and log data saved with each alignment

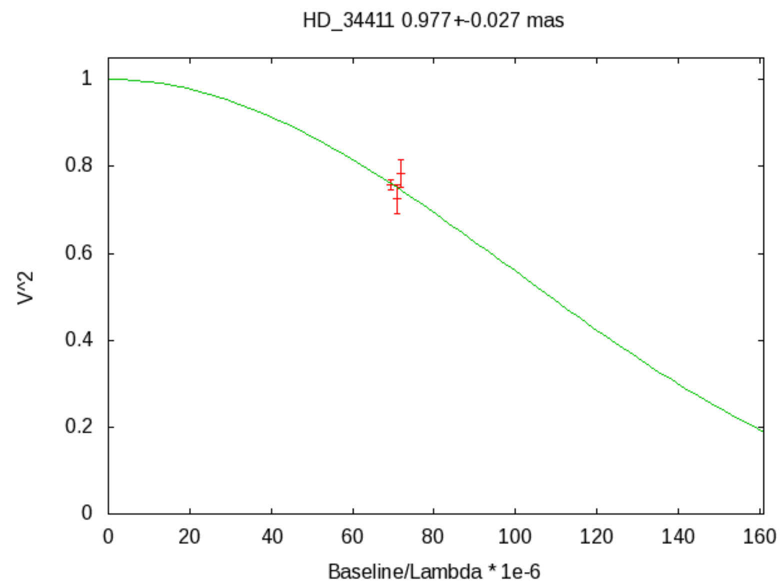


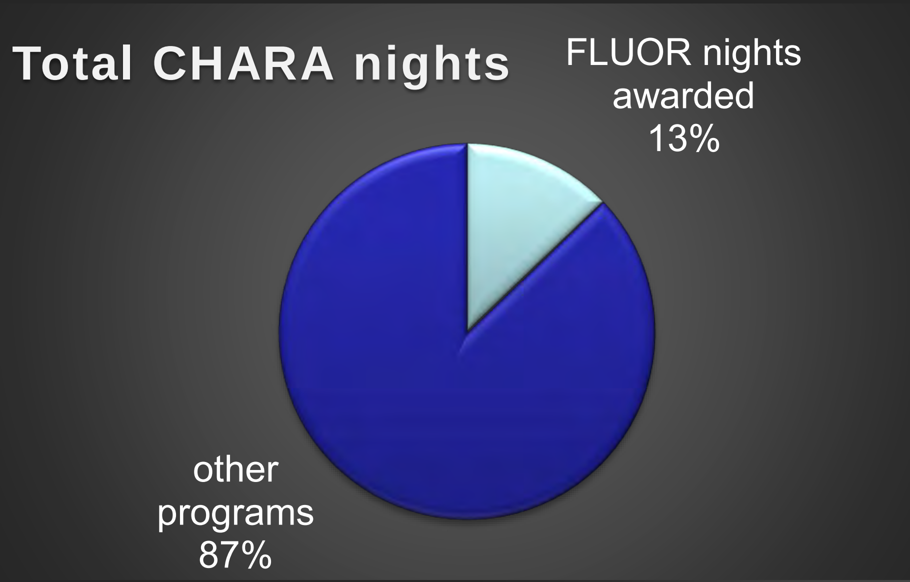
Comparison to known diameter

- Tabby 0.981 0.015
- One bracket, more obs planned

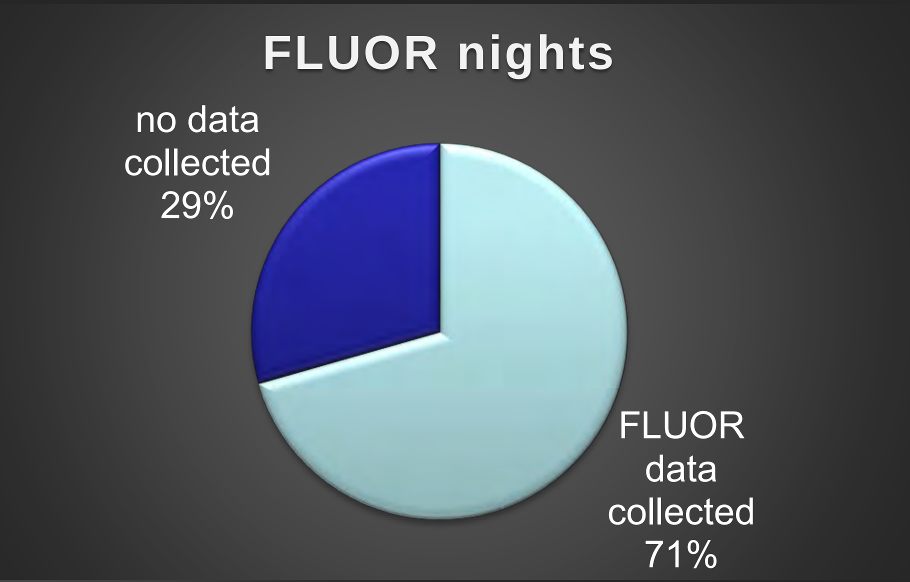




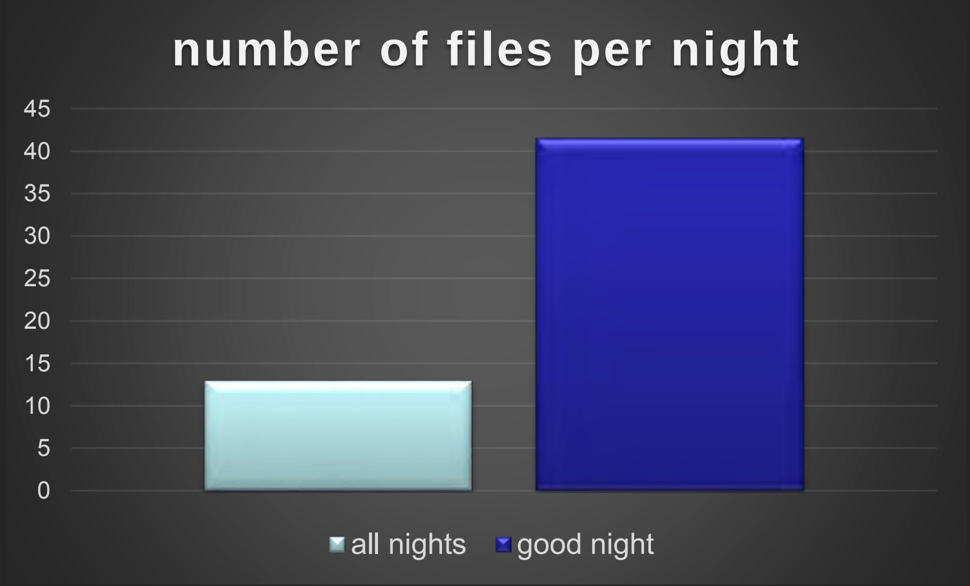




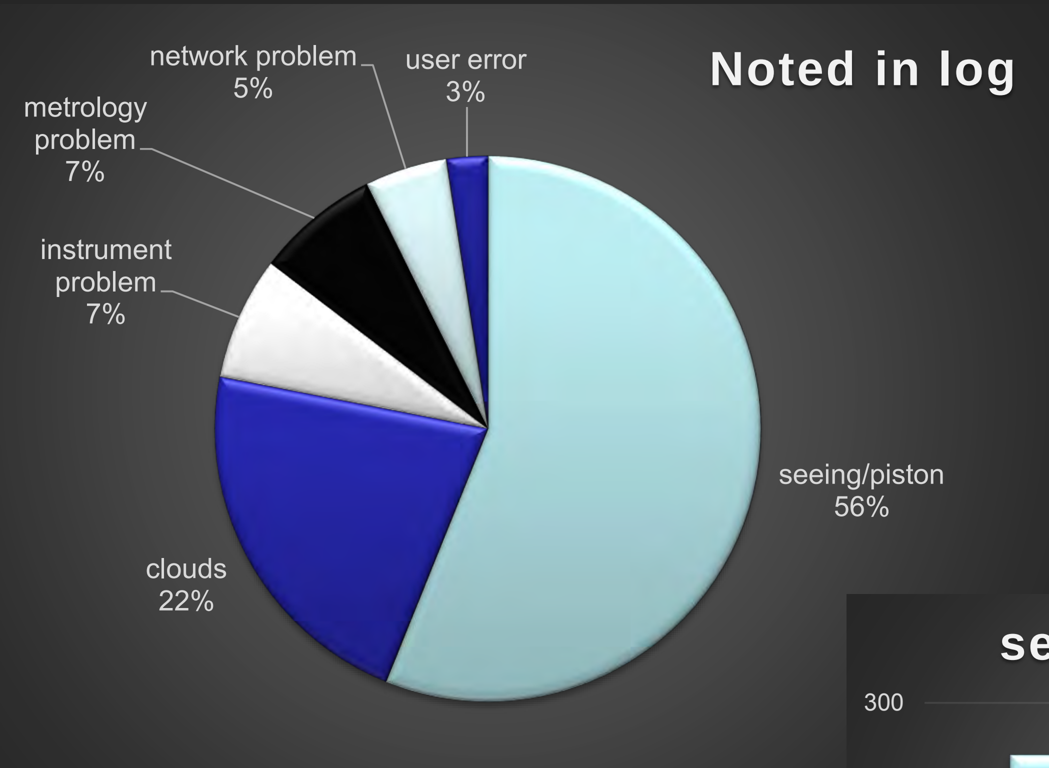
Total CHARA nights
FLUOR nights awarded 13%
other programs 87%

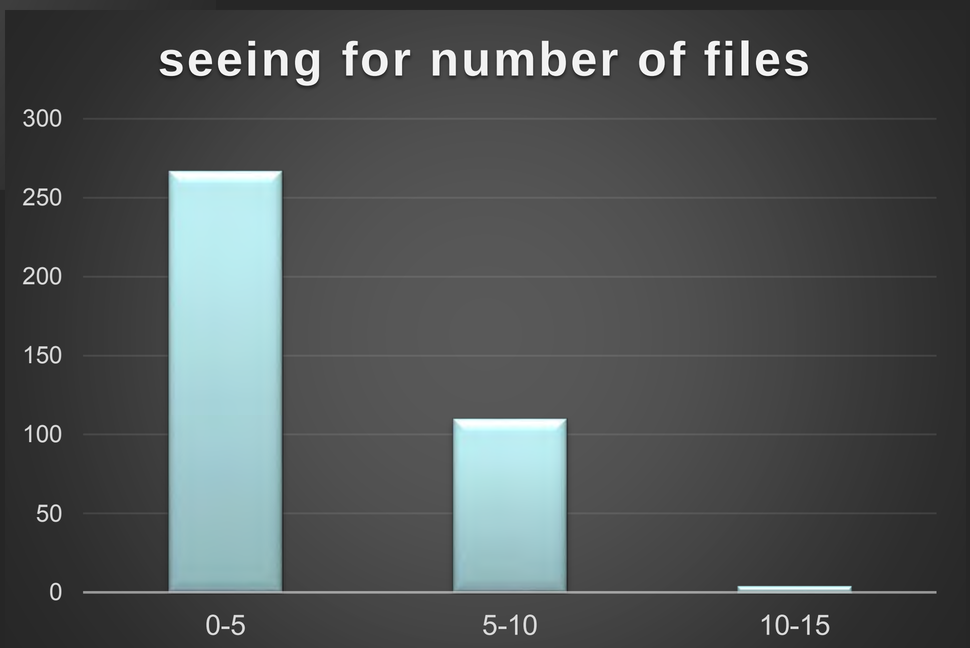


FLUOR nights
no data collected 29%
FLUOR data collected 71%



number of files per night
45
40
35
30
25
20
15
10
5
0
all nights
good night


Noted in log
network problem 5%
user error 3%
metrology problem 7%
instrument problem 7%
seeing/piston 56%
clouds 22%


seeing for number of files
300
250
200
150
100
50
0
0-5
5-10
10-15

Number of brackets (1o2o3o1)

0.5 Per hour

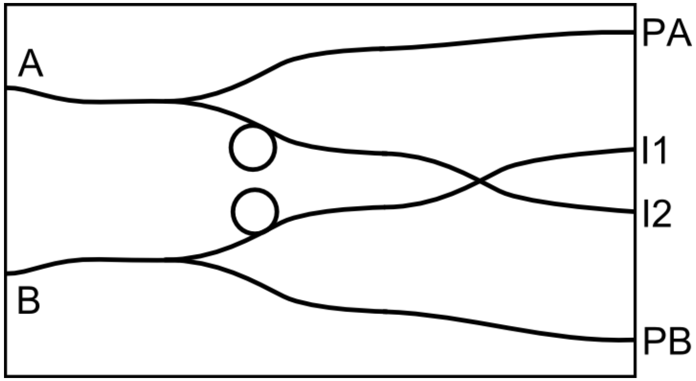
4.6 Per night

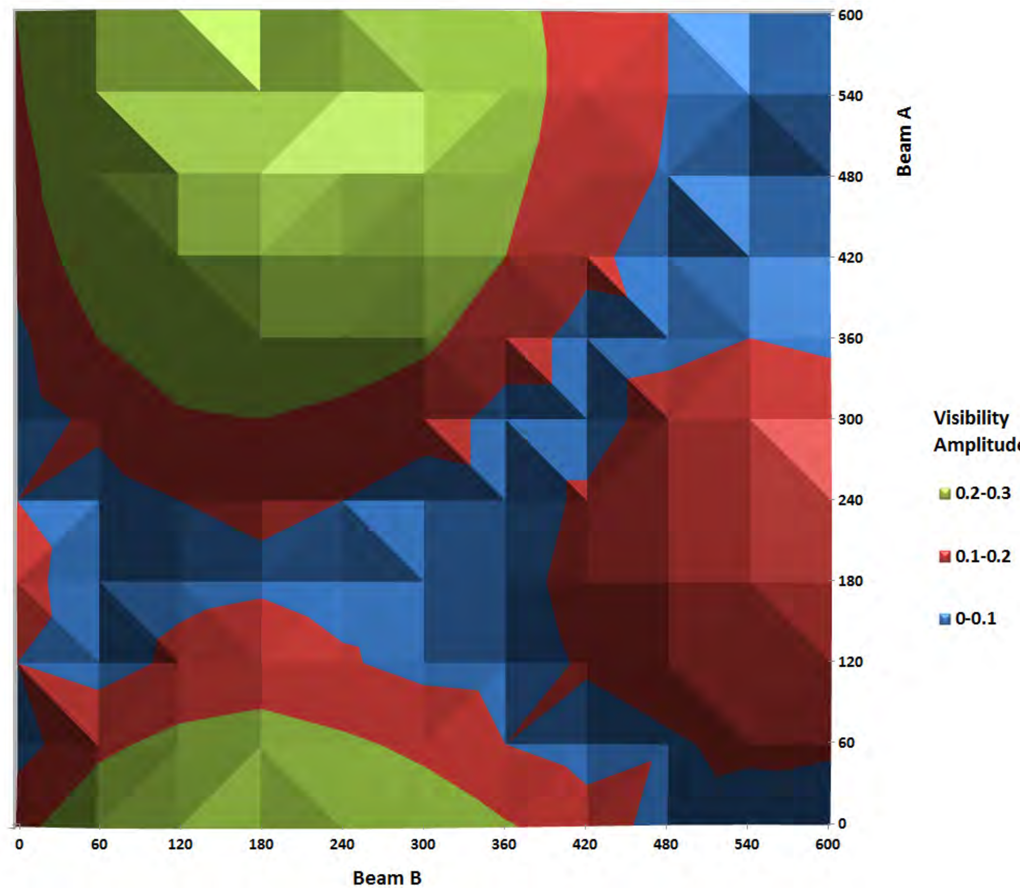
mK magnitude limit

4.86 HD 27789

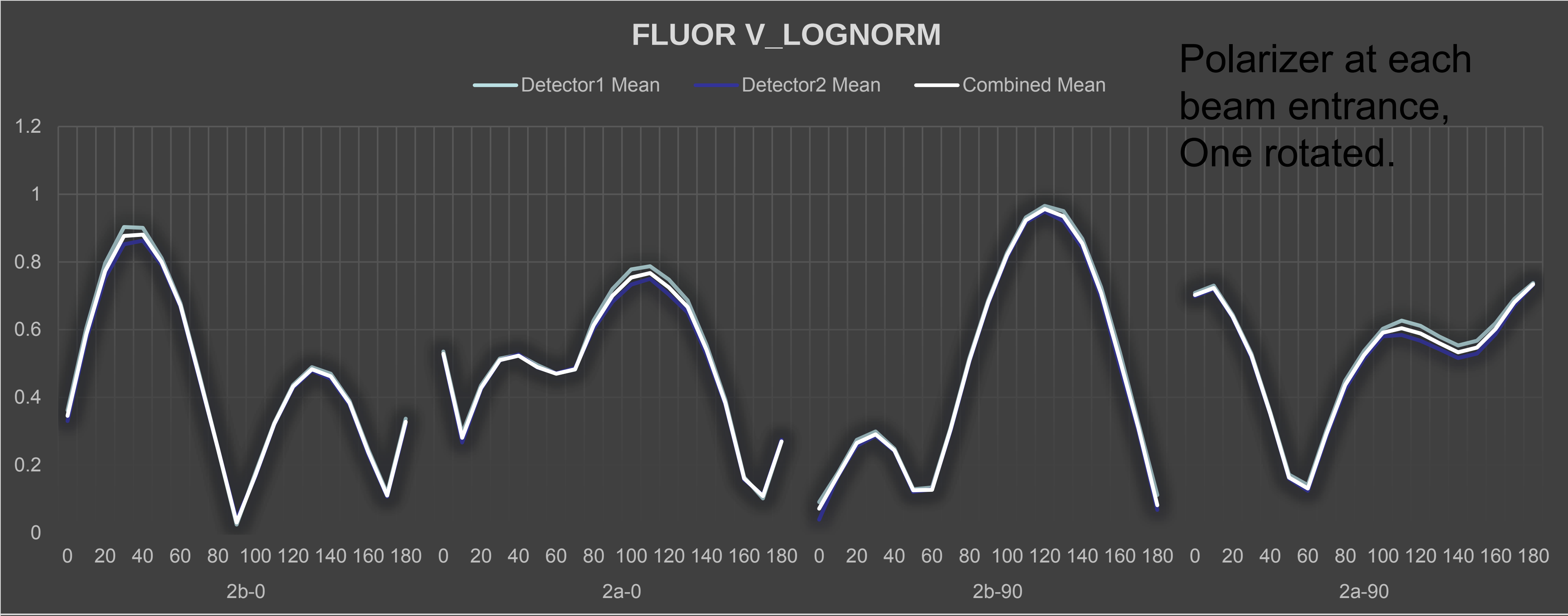
5.17 FU Ori

Polarization

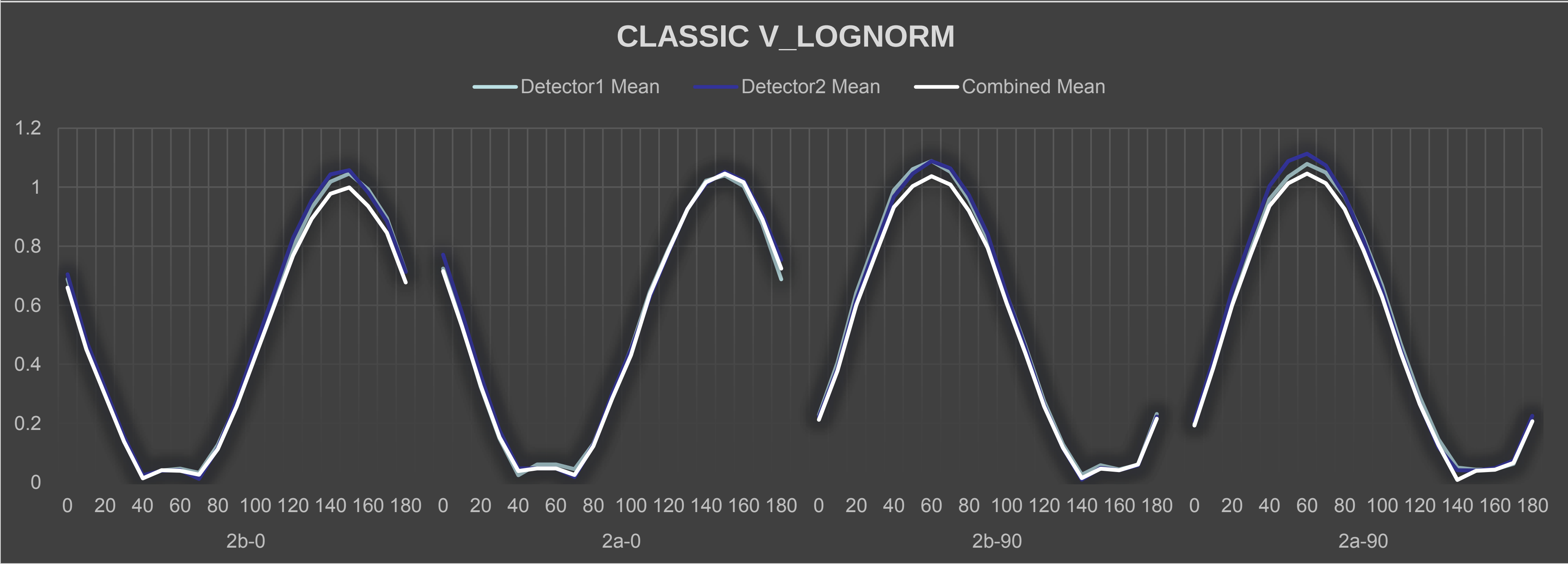


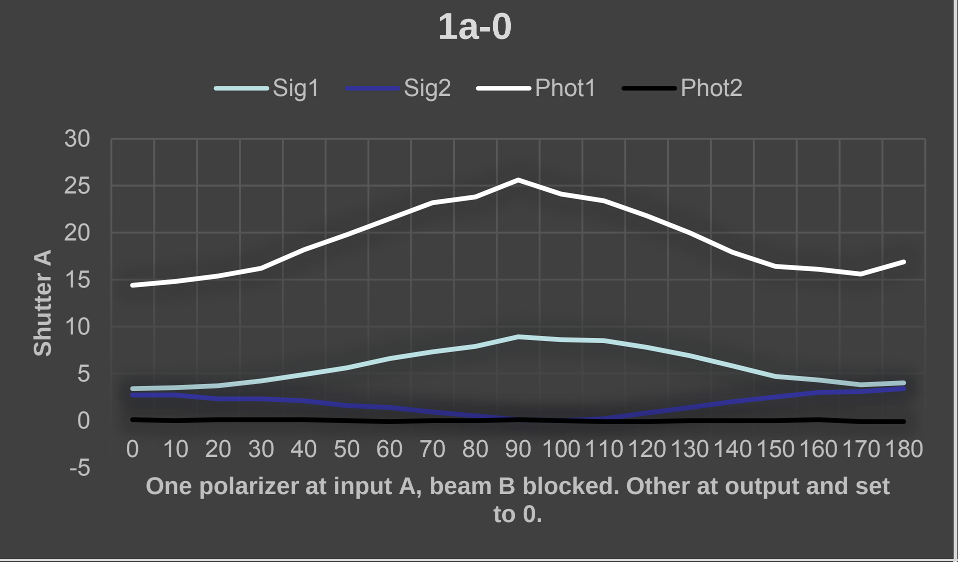


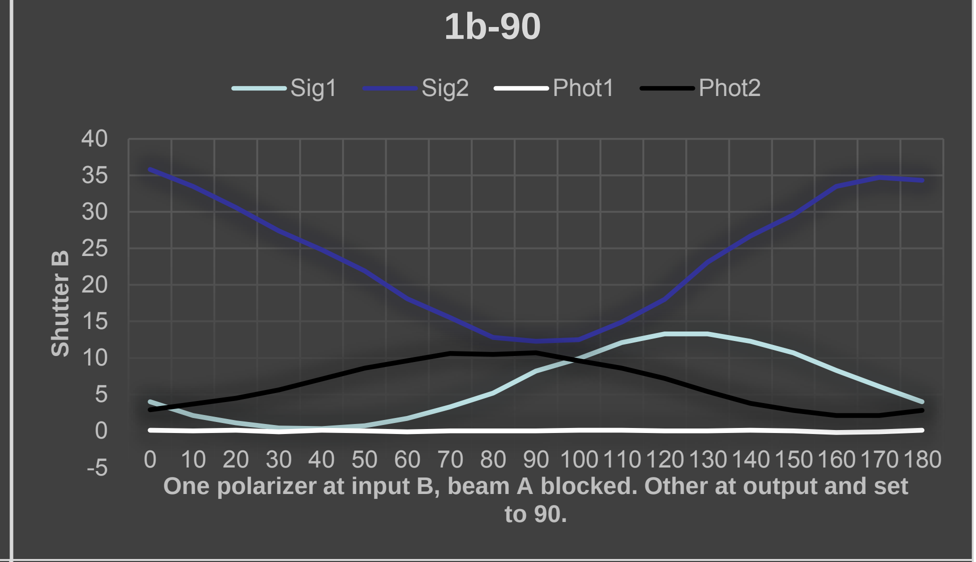
Why can we only get a maximum V of ~0.3+?

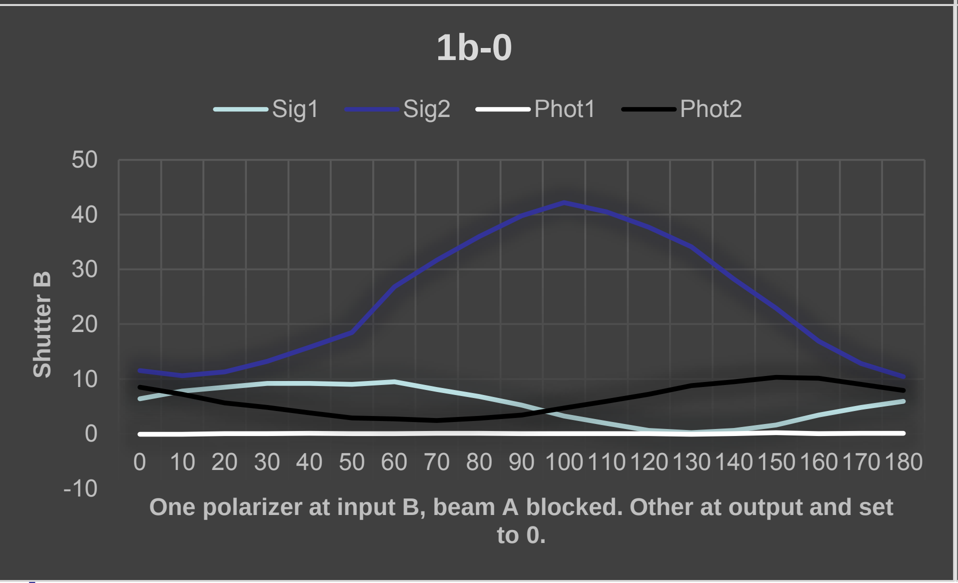


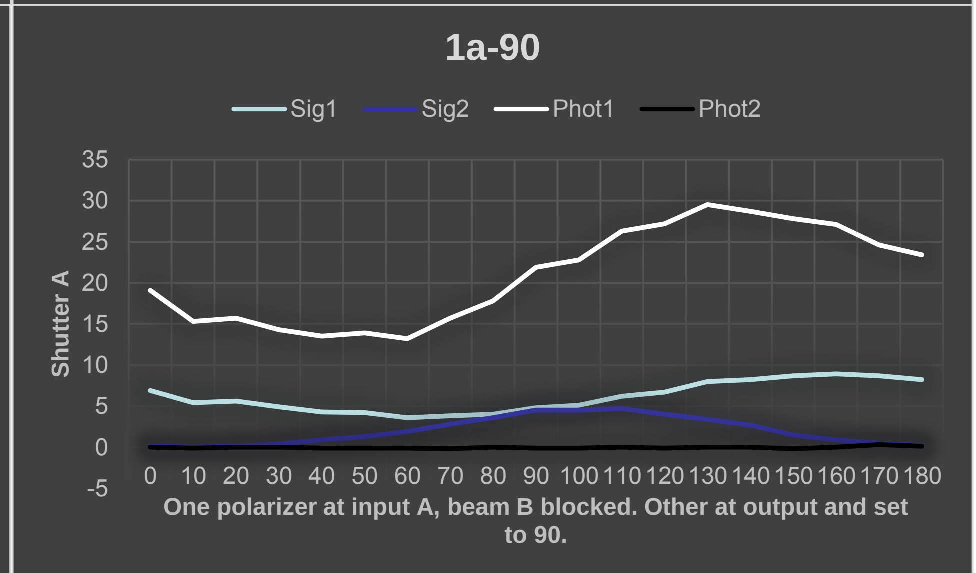
Polarizer at each beam entrance, One rotated.







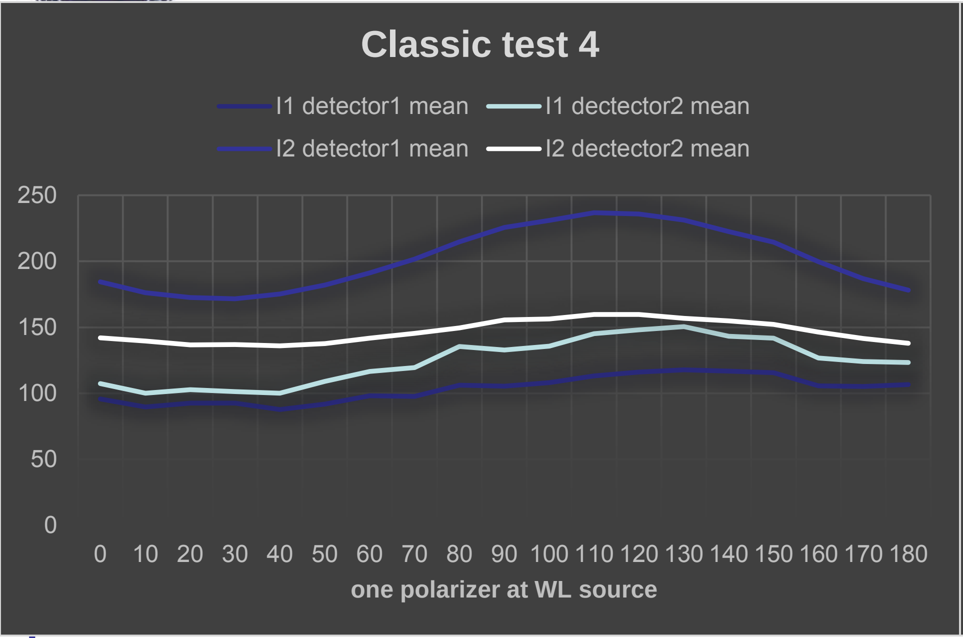


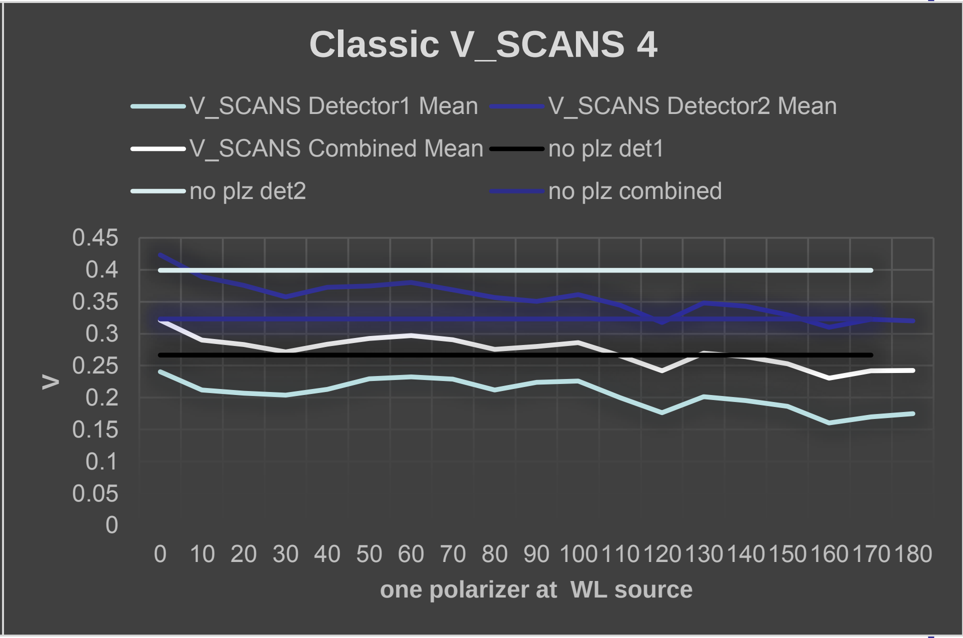


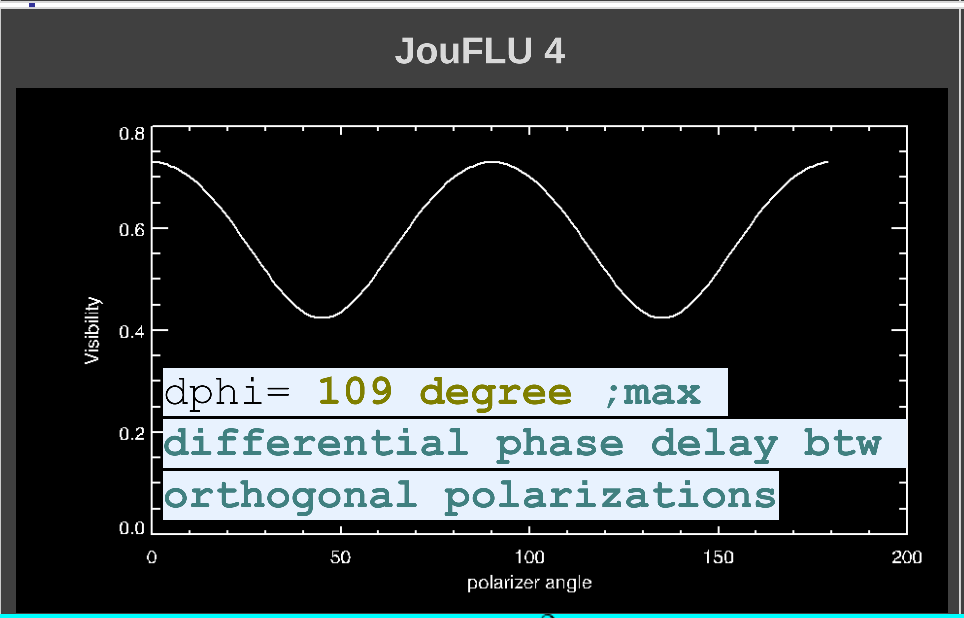
Polarization rotation

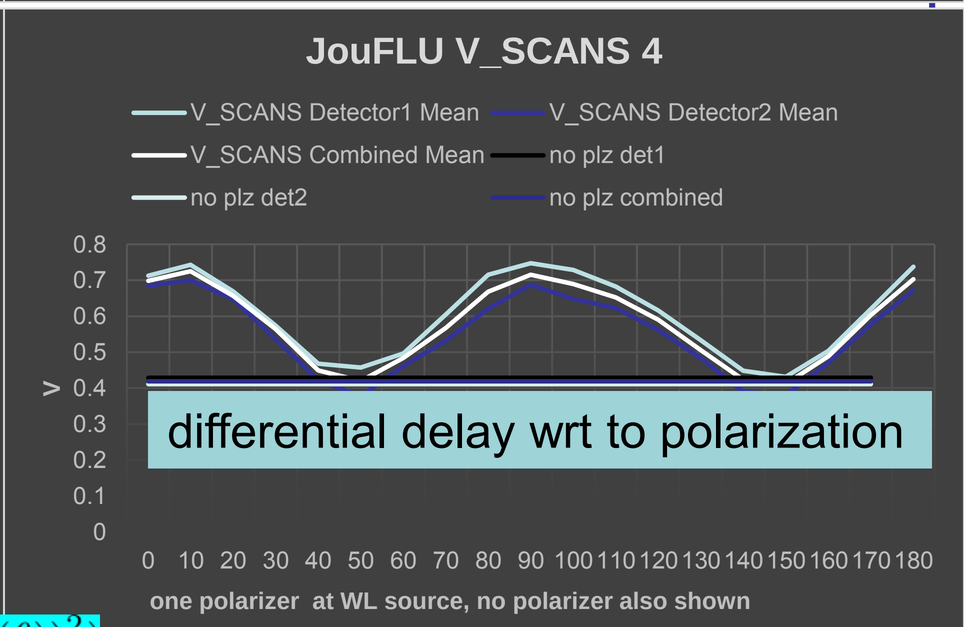
	Sig1	Sig2
Test1-0	30	80
Test1-90	40	110

differential polarization rotation=
50˚
70˚









$$I = 2 * (1 + \cos(\phi) * (\cos(\theta))^2 + \cos(\phi + d\phi) * (\sin(\theta))^2)$$

Polarization Summary

- Found differential polarization rotation and differential phase delay
- Modelling differential phase delay gives dphi = 109° and 90° periodicity
- Max V ~ 0.73
  - bandwidth smearing / dispersion
  - beam intensity imbalance
  - fringe sampling & finite integration effects
  - AND differential polarization rotation.

Differential rotation:

- V loss is analogous to beam intensity mismatch

$$V_{obs} = V \frac{2\cos(\alpha)}{1+\cos^2(\alpha)}$$

50° → 90%V

70° → 60%V

Additionally,

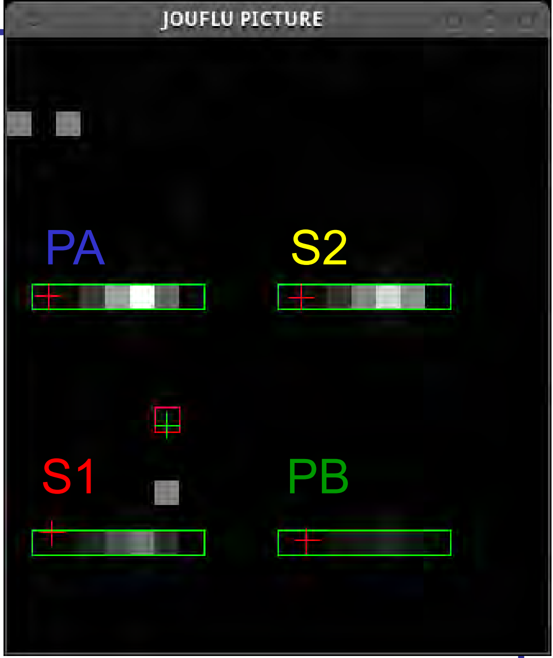
- WL is probably not circularly polarized.
- We observe average V~0.42 instead of expected 0.59.
- WL is elliptically polarized (close to 50 or 150°).

Beam Balance

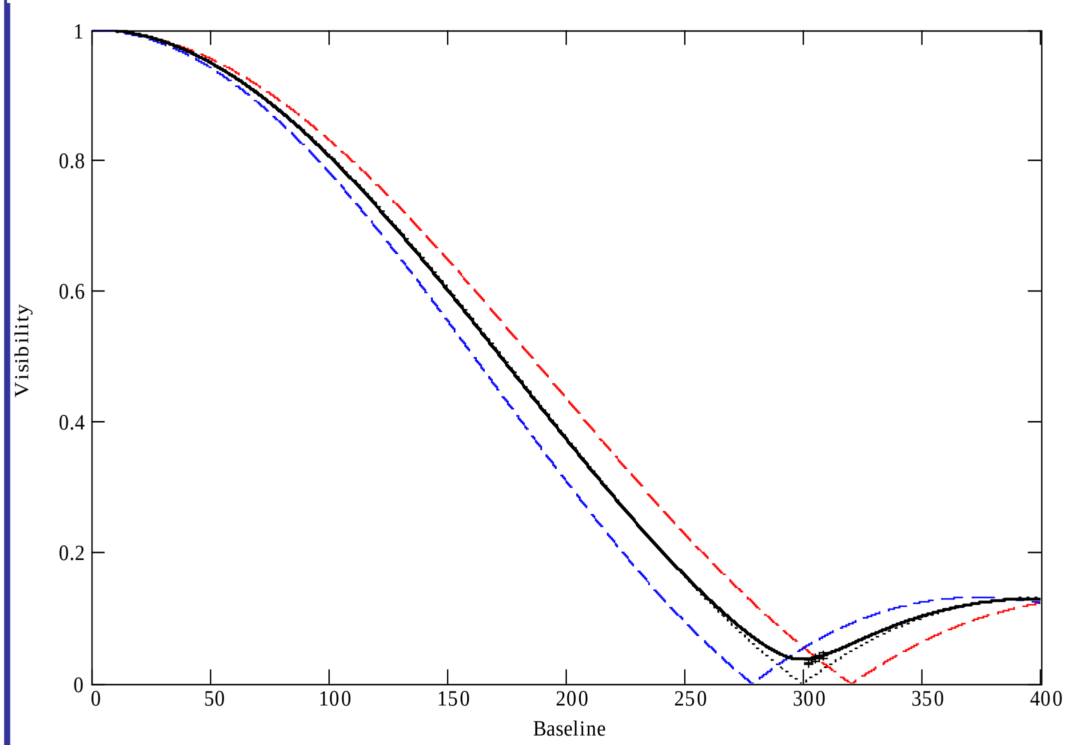
- Factor of 2-3 diff between FLUOR beams
  - Beam A weak
- 15% difference between CLASSIC beams
- Reduces maximum visibility

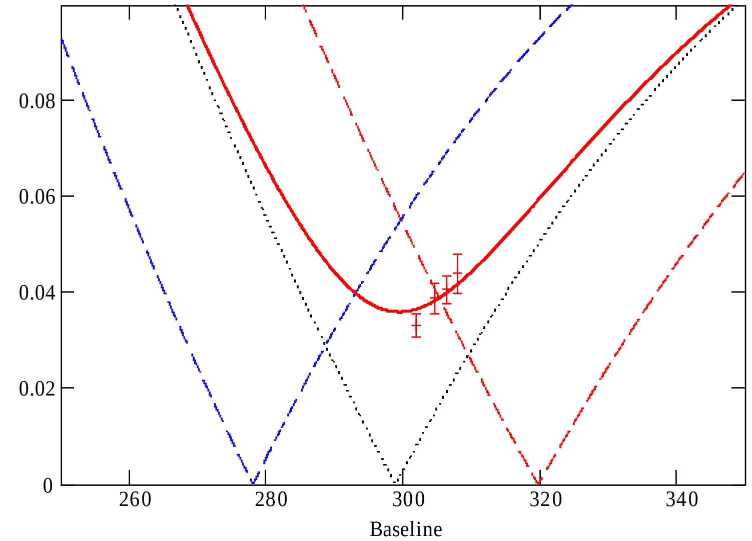
- Replace OAPs

Spectral dispersion

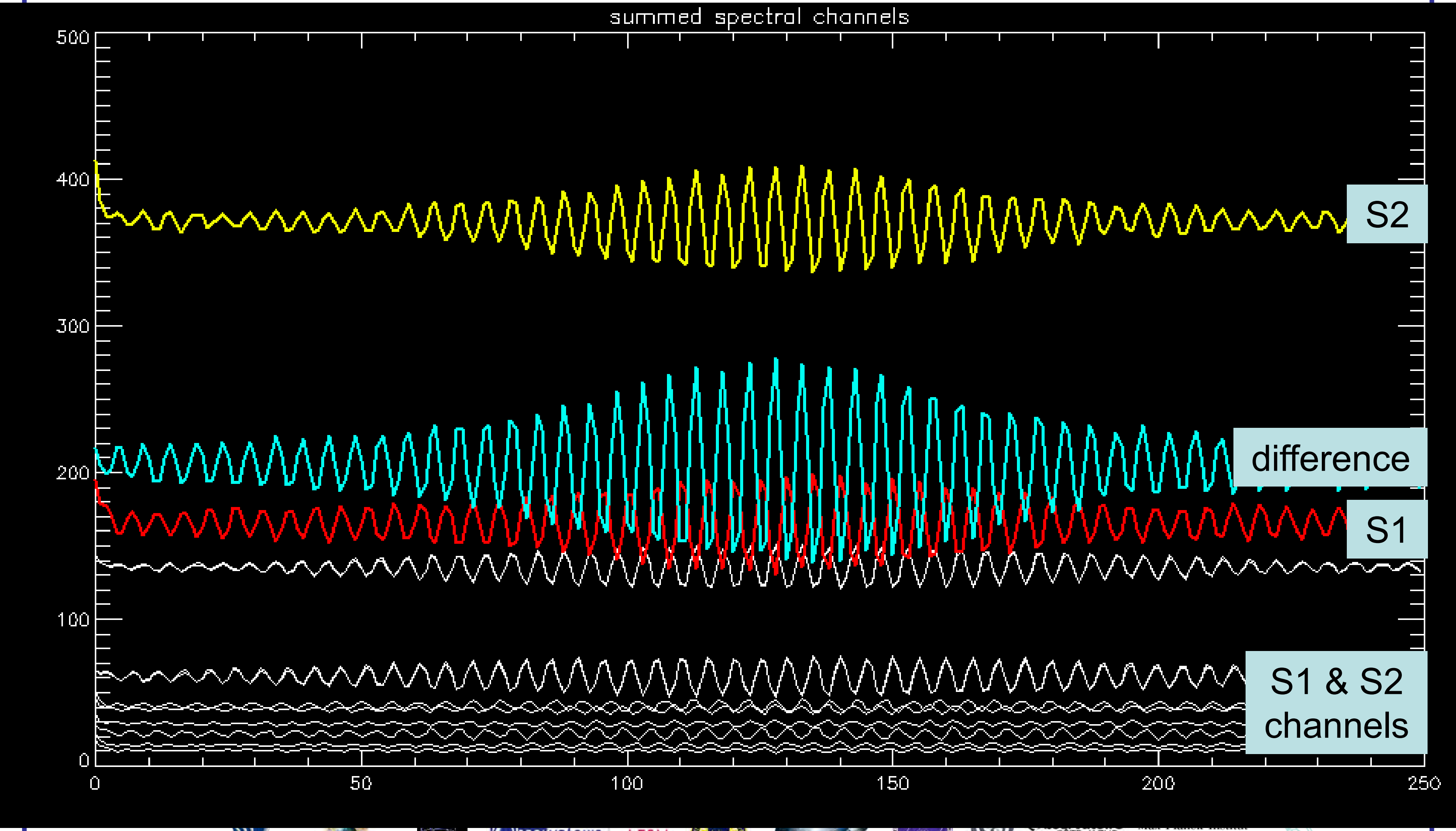


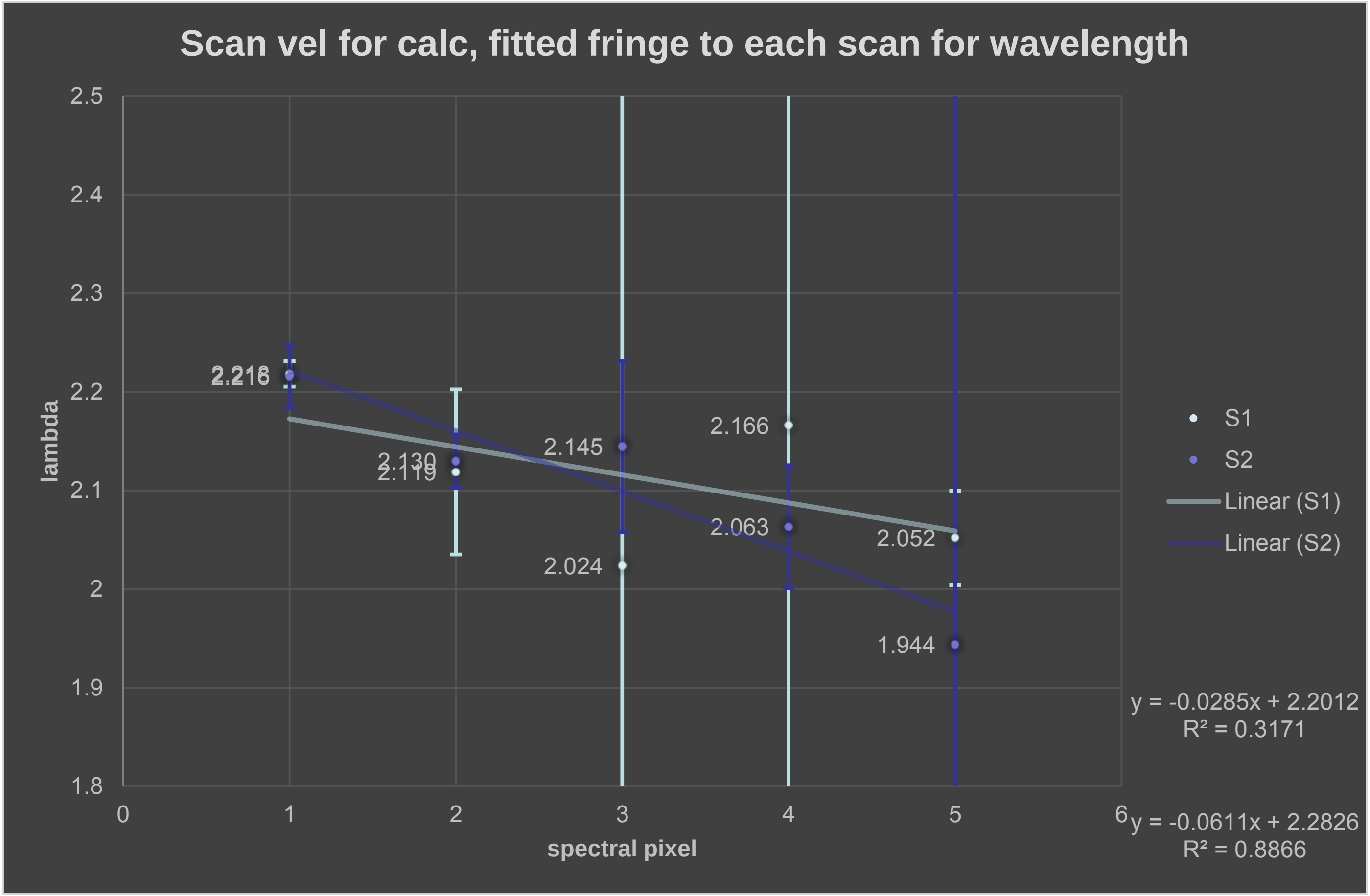
- K band
- Up to 10 spectral channels
- 500 Hz fastest rate possible with 5 spectral channels
- Remove chromatic biases / bandwidth smearing
- Expect factor of 100 improvement when science star and calibrator are of different types





Spectrally dispersed lab fringes

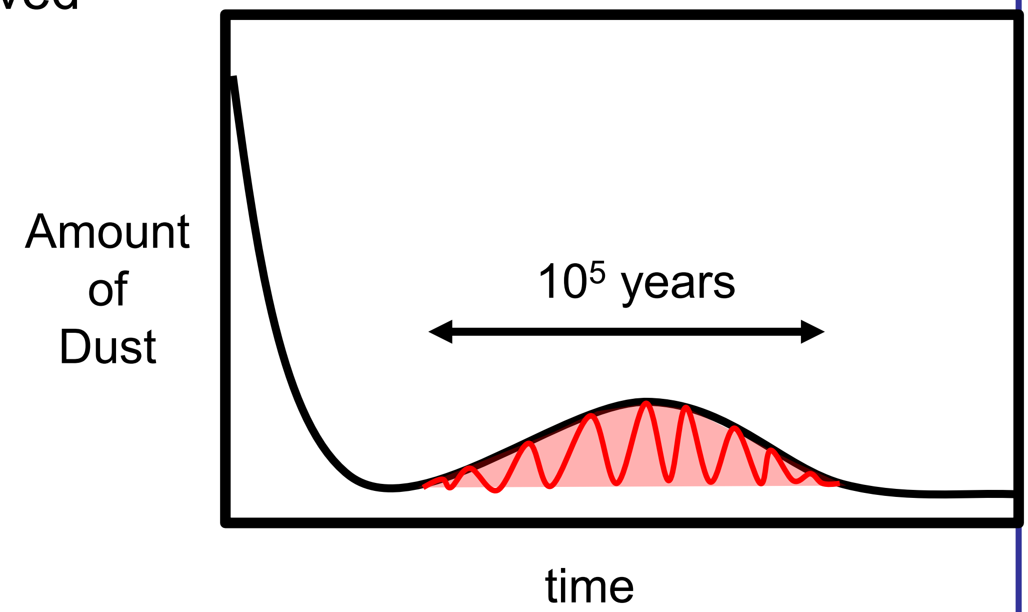




	S1	S2	avg
total bandwidth	0.17	0.27	0.22
R	12.94	7.90	9.81

Evolution / dynamics

- Dust production mechanism poorly understood
- Close-in dust extremely short lived
  - ≈ few yrs
  - ≈ 10^{-8} $M_{\oplus}$/yr to replenish
    (10 Hale-Bopps per day)



- Destruction factors:
  - Sublimation
  - Radiation Pressure
  - Poynting-Robertson (P-R) drag

- Models:
  - ~~Steady state/continuous replenishment~~
  - Steady state/trapped nano-grains [Su et al. (2013), Lebreton et al. (2013)]
  - LHB & outgassing

Statistics, origin, and evolution

Absil et al. Disk Survey

42 stars A-K (mag limited)

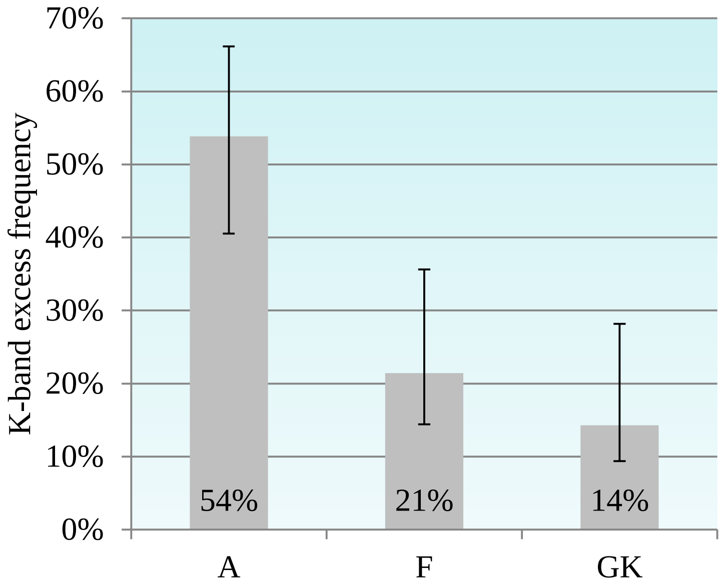
	A	F	G-K	Total
Cold disk	8	6	6	20
No outer disk	4	7	9	19
Unknown	0	2	0	2
Total	12	15	15	42

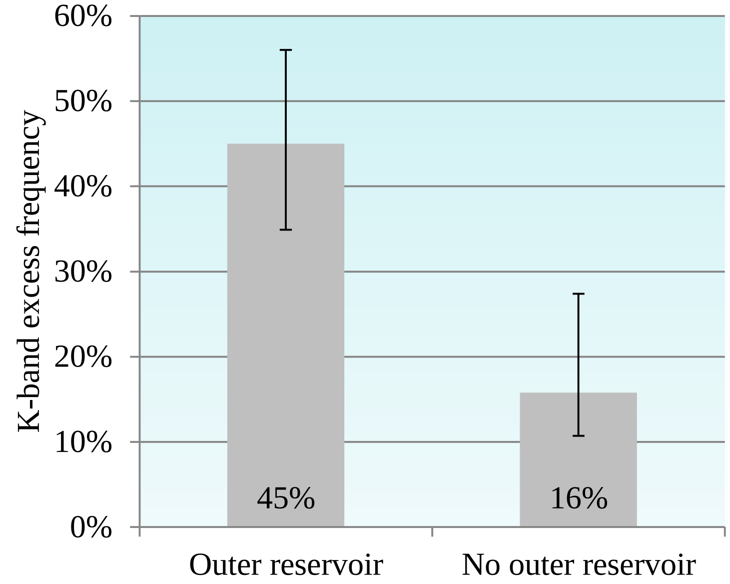
Spectral type, age, metallicity, presence of cold dust

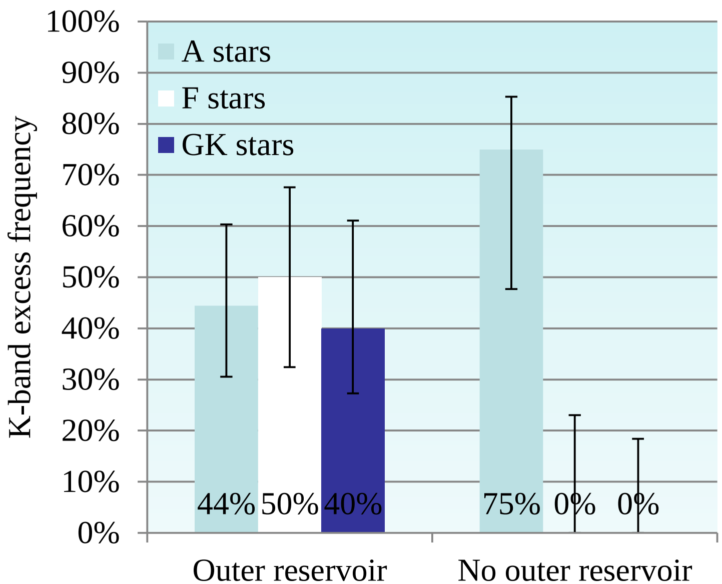
Absil et al. 2013 (submitted)

- Most common around A stars

	# MS (K < 4)	# MS w. debris (K < 4)	# MS (K < 5)	# MS w. debris (K < 5)
All	303	45	1158	103
North	156	16	536	42
South	147	29	622	61
-10° < dec < +20°	73	8	256	21







Age or amount of available material?

- A stars: not clear if correlation with metallicity
- FGK stars lack warm dust due to ages > 1 Gyr

Absil et al. 2013 (submitted)

Georgia State University

Max-Planck-Institut für Radioastronomie

NASA Origins Program with Betrand Mennesson

- 3 year program: exozodi disk survey
  - ≈ 100 nearby MS stars
  - 20% long/short, rest only short baselines
  - – hot dust (1000-1500K), expected in 25-30% of MS systems
- Goal: excesses at 0.5% level (5σ) for m_K=5
  - – Determine grain properties, disk morphology, correlations b/t stellar properties
- Visibility precision to <0.1%

IRTF

- SpeX
  - 2-5 μm spectra
  - Followup to survey
  - Photosphere-subtracted SED slope
  - Cross-correlate with Interferometric data
  - Add constraints to dust disk models
    - temperature, size of the dust grains, age estimate, composition, mass, albedo
  - Look for spectroscopic debris disk markers

Future plans

- CHARA AO
  - Increased sensitivity
  - Fainter magnitude limit
  - More targets
  - On axis, small field of view AO systems for each telescope.
- CHAMP
  - Full fringe tracking and locking capability on all baselines.

for FLUOR

- Spectral dispersion mode observations
- Integration with CHAMP
- Further camera and software improvements

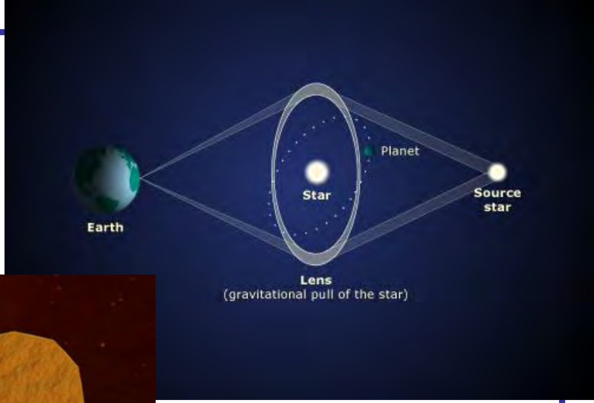
Complementary studies

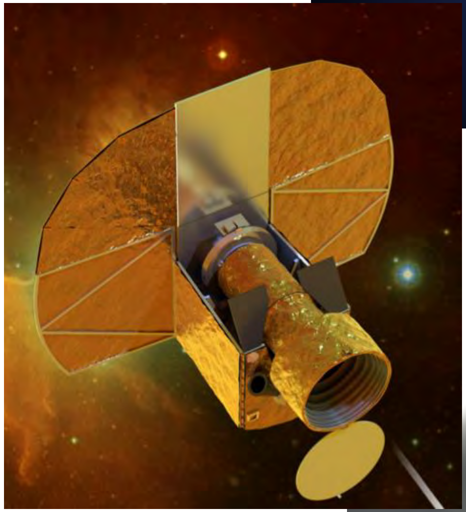
- Follow-up of gravitational microlensing survey
  - Faint, 7th mag
  - Targets of opportunity
  - Alert network?

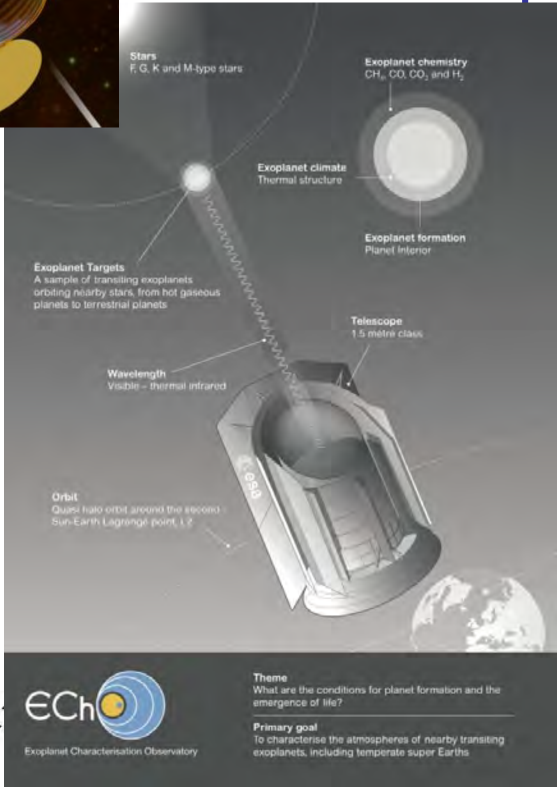
(Cassan 2012)

- CHEOPS
  (CHaracterizing ExOPlanet Satellite)
  - Photometry of known exoplanet host stars
    - Bright, low activity stars
  - Determine radii, dynamics, and atmospheric properties
- Investigate potential targets of EChO transit space mission
  - 2022 launch
  - Feasibility study, full program requires CHARA AO

≈ 100 planetary spectra







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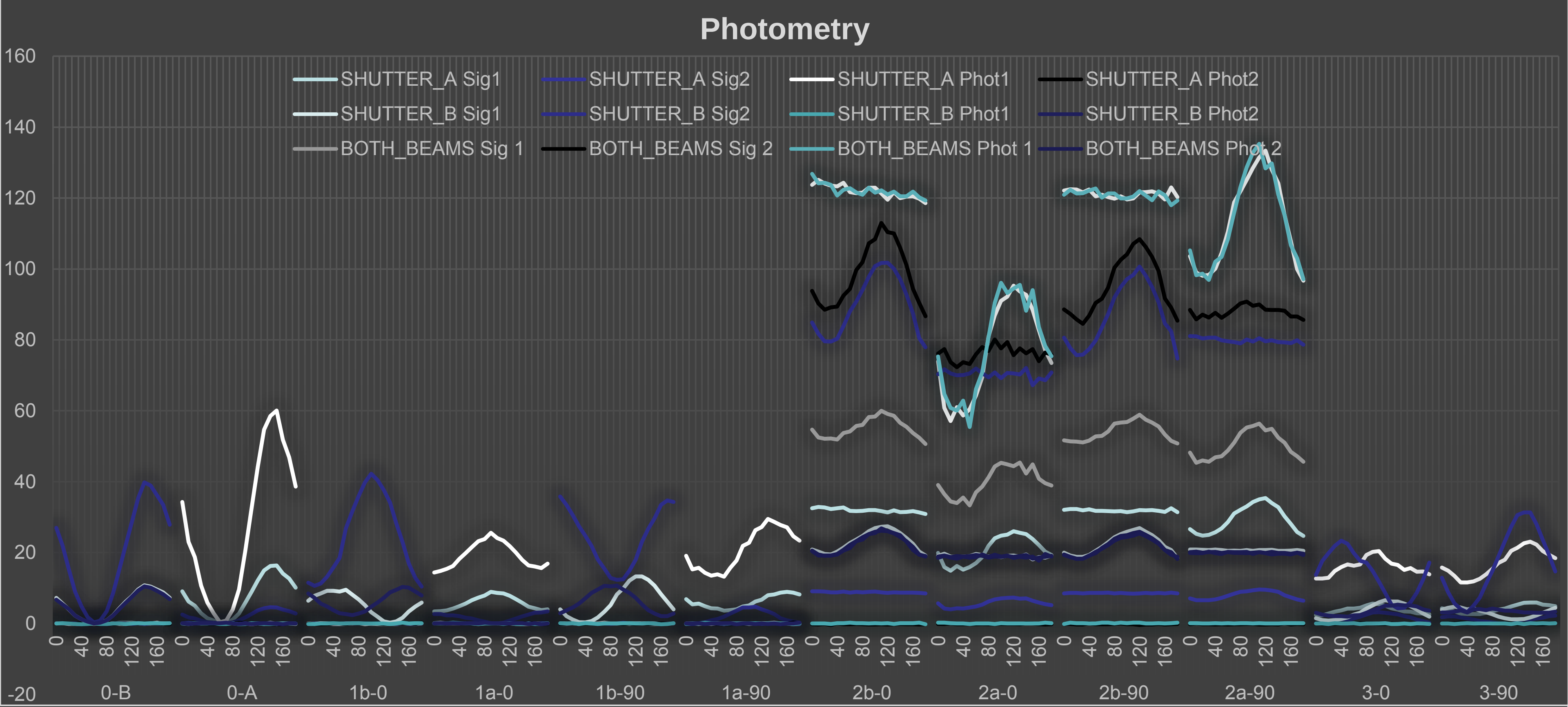
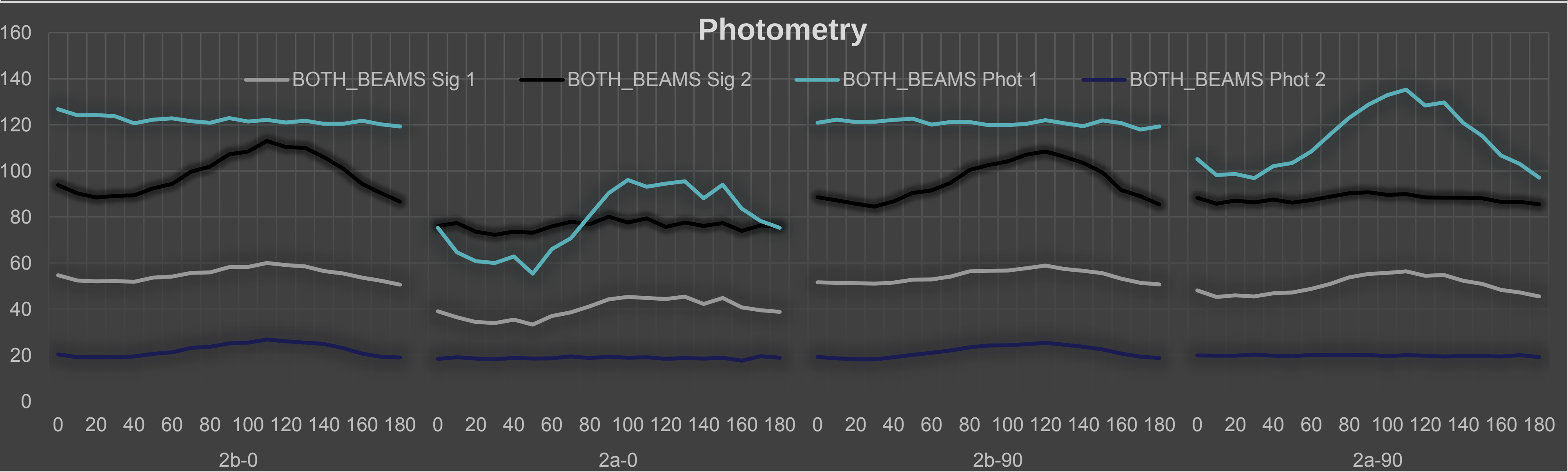
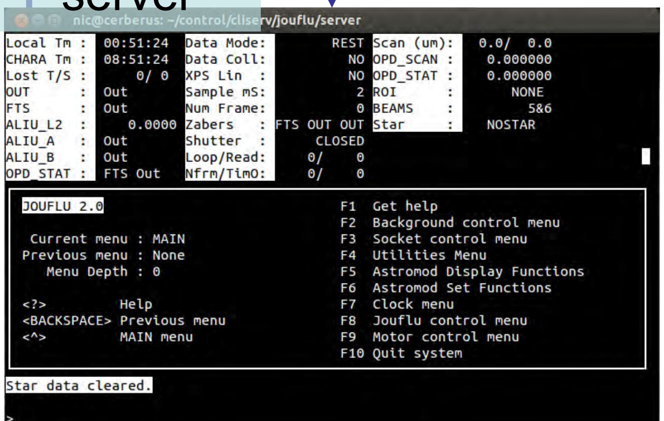


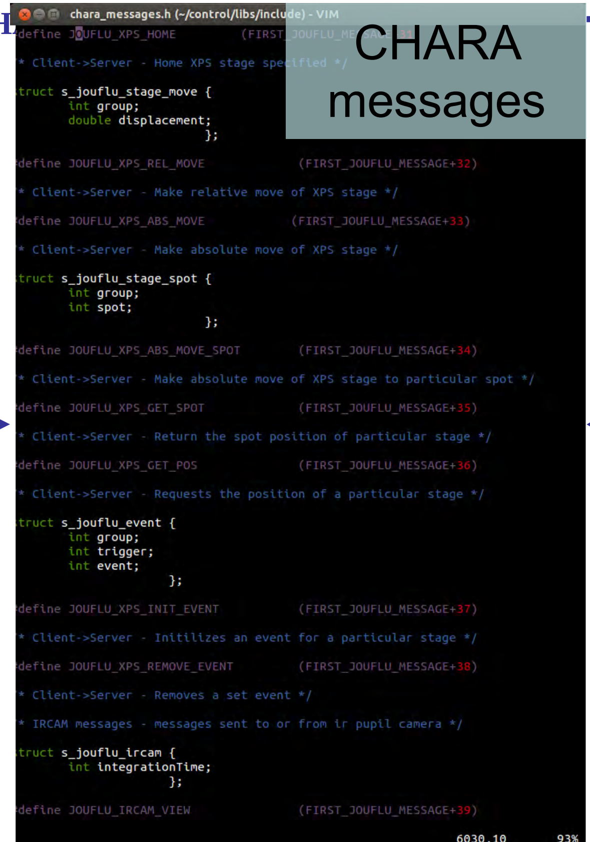
Photometry
SHUTTER_A Sig1
SHUTTER_A Sig2
SHUTTER_A Phot1
SHUTTER_A Phot2
SHUTTER_B Sig1
SHUTTER_B Sig2
SHUTTER_B Phot1
SHUTTER_B Phot2
BOTH_BEAMS Sig 1
BOTH_BEAMS Sig 2
BOTH_BEAMS Phot 1
BOTH_BEAMS Phot 2
0-B
0-A
1b-0
1a-0
1b-90
1a-90
2b-0
2a-0
2b-90
2a-90
3-0
3-90

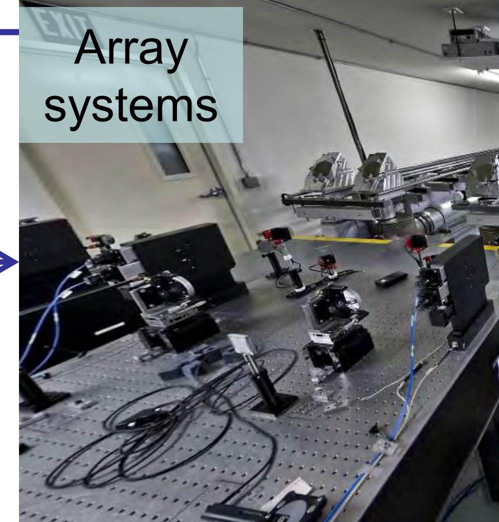


Photometry
BOTH_BEAMS Sig 1
BOTH_BEAMS Sig 2
BOTH_BEAMS Phot 1
BOTH_BEAMS Phot 2
2b-0
2a-0
2b-90
2a-90

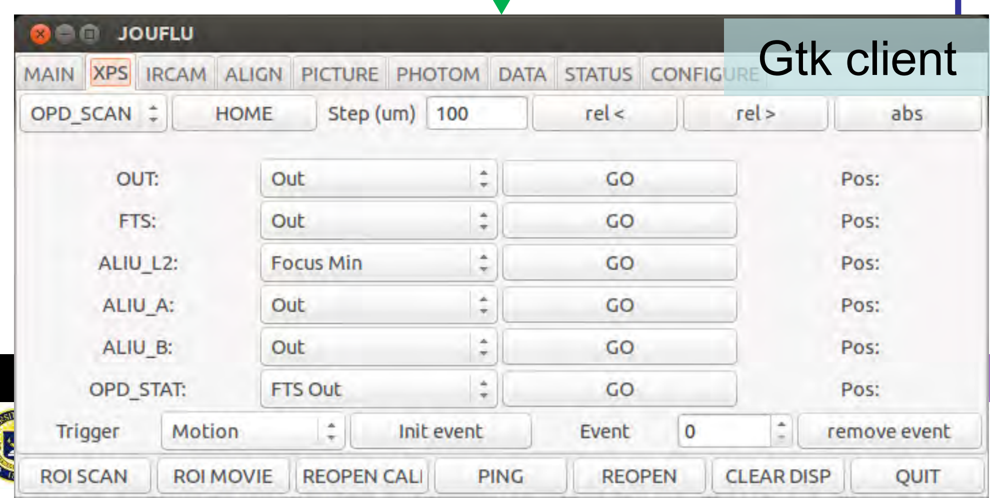
CHARA systems interface



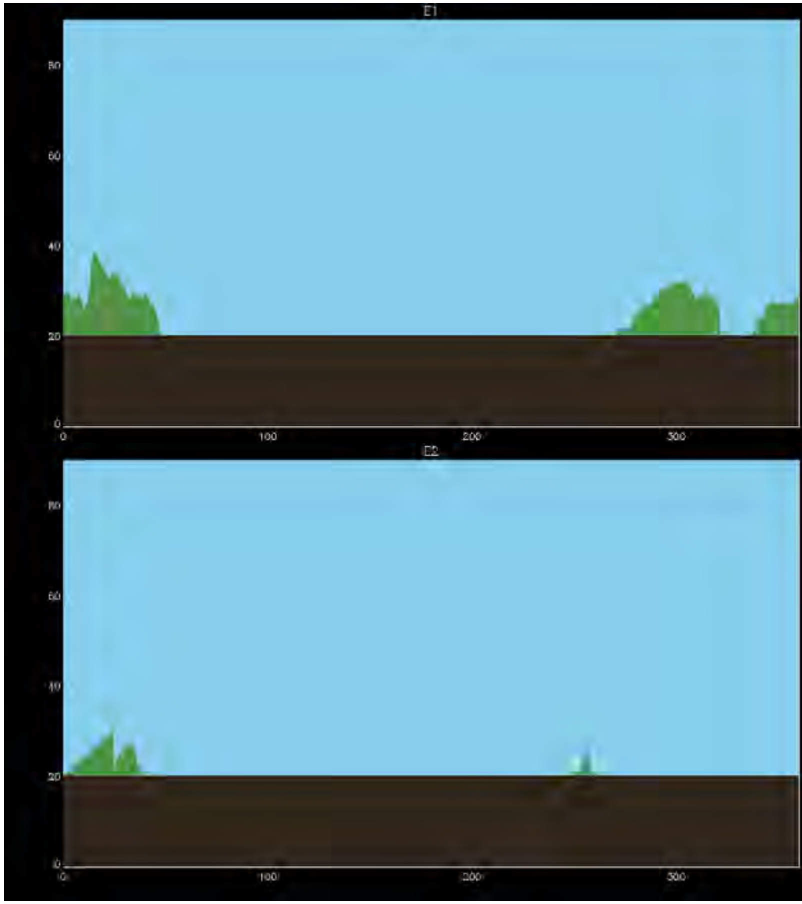


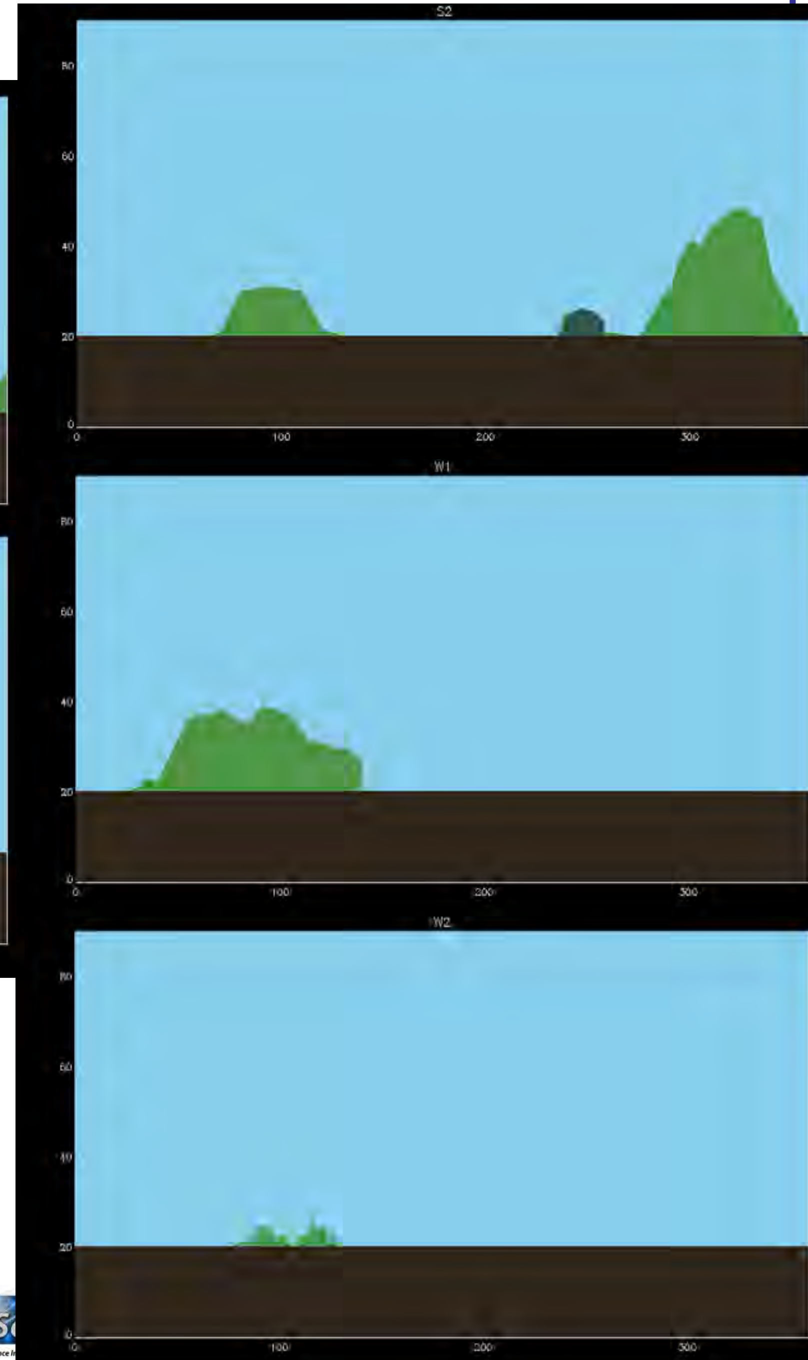


vpn



horizons





11.8963 % S2 obstruction
8.83448 % W1 obstruction
0.862847 % W2 obstruction
6.49262 % E1 obstruction
1.40250 % E2 obstruction

(solid angle above 20.0000 degrees)

Milestone(s)

Timeline: 7/1/2011 - 2/18/2014

Date	Description
7/1/2011	Switch from LabView to C
9/29/2011	Remote obs setup
10/4/2011	1st remote run
2/1/2012	JouFLU hardware install
5/1/2012	First fringes
11/7/2012	CALI Meudon tests
12/19/2012	CALI CHARA tests
4/1/2013	CALI replaced w NICMOS
4/28/2013	FLUOR run-IA
5/5/2013	FLUOR run-IB
5/7/2013	Optimized MONA plz
5/14/2013	First on-sky fringes w NICMOS
5/29/2013	Moved MONA, NICMOS, & output
5/30/2013	Realigned OAPs
6/3/2013	FLUOR run-II
7/17/2013	Changed ZABER mode
8/14/2013	Re-centered fiber bundle
10/1/2013	FLUOR run-III
10/10/2013	FLUOR run-IV
2/17/2014	Switched to ethernet readout
2/18/2014	Spectral dispersion mode added