

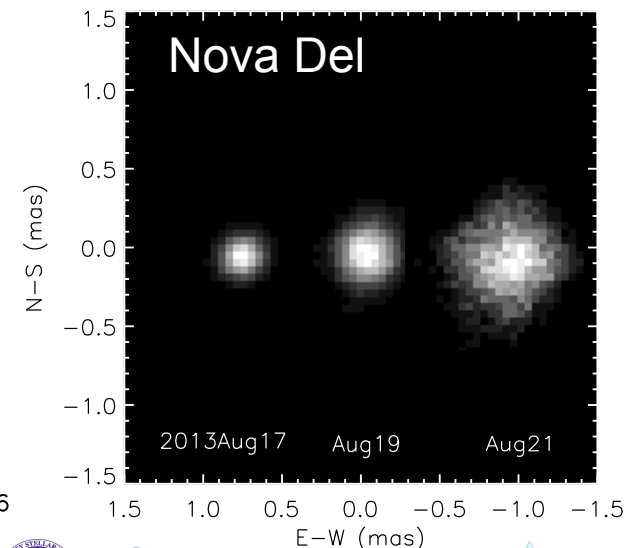
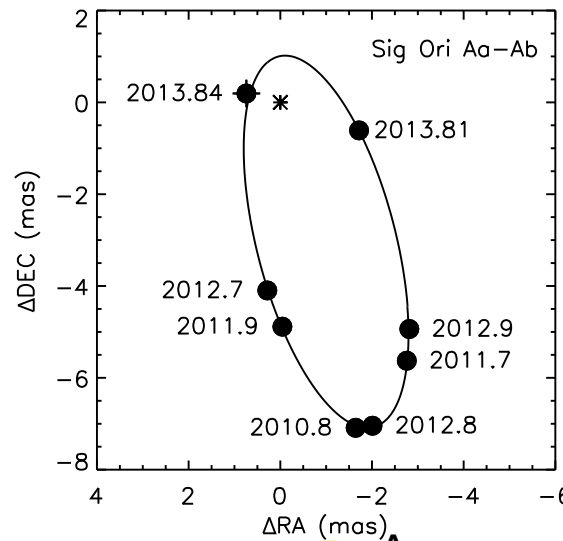
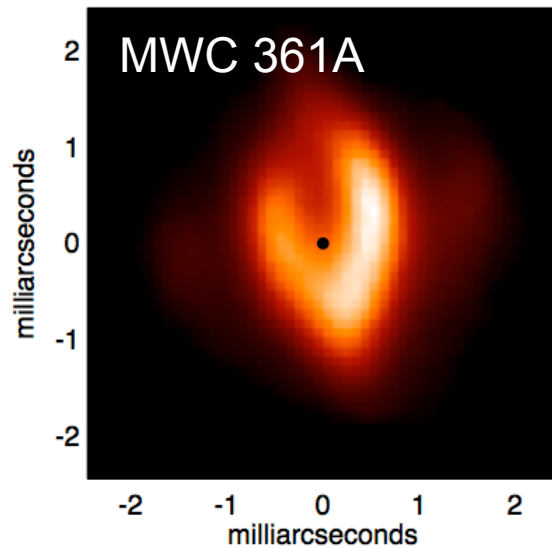


MIRC & CHAMP

Update and Future Plans

John Monnier, Xiao Che, Rachael Roettenbacher,
Sam Swihart, Keith Jackson (UM)

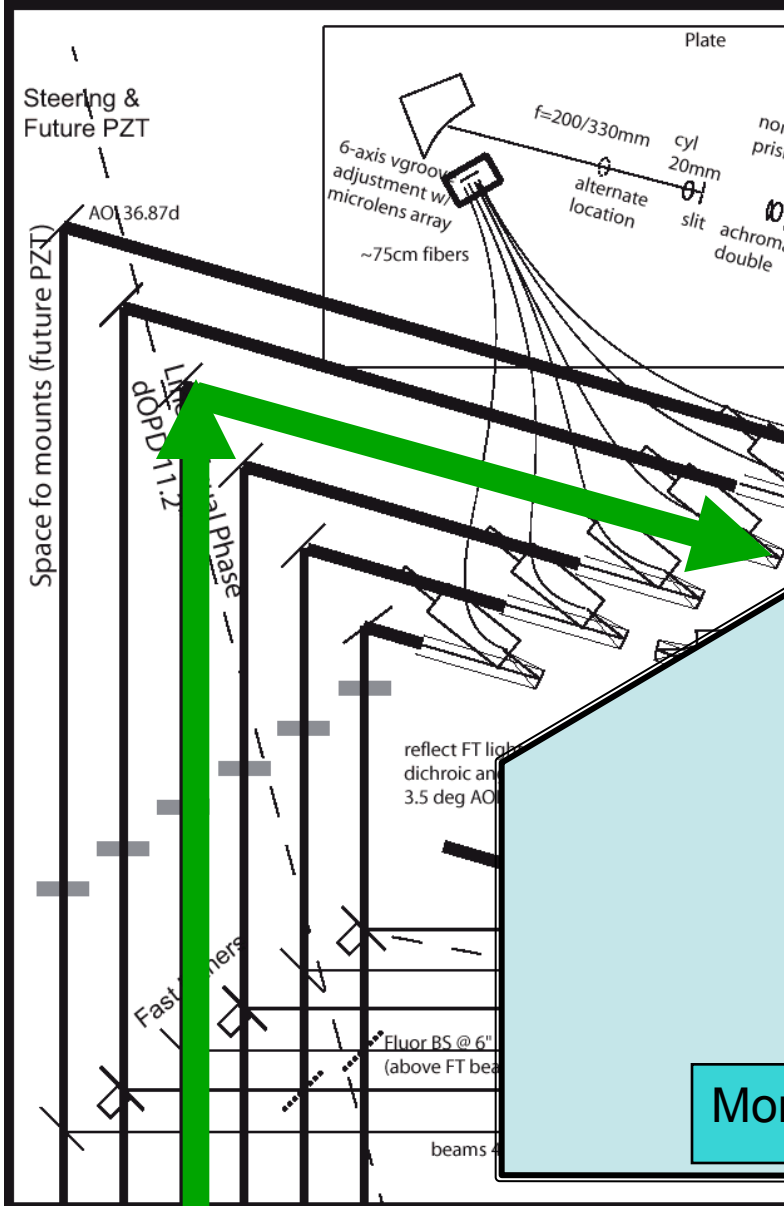
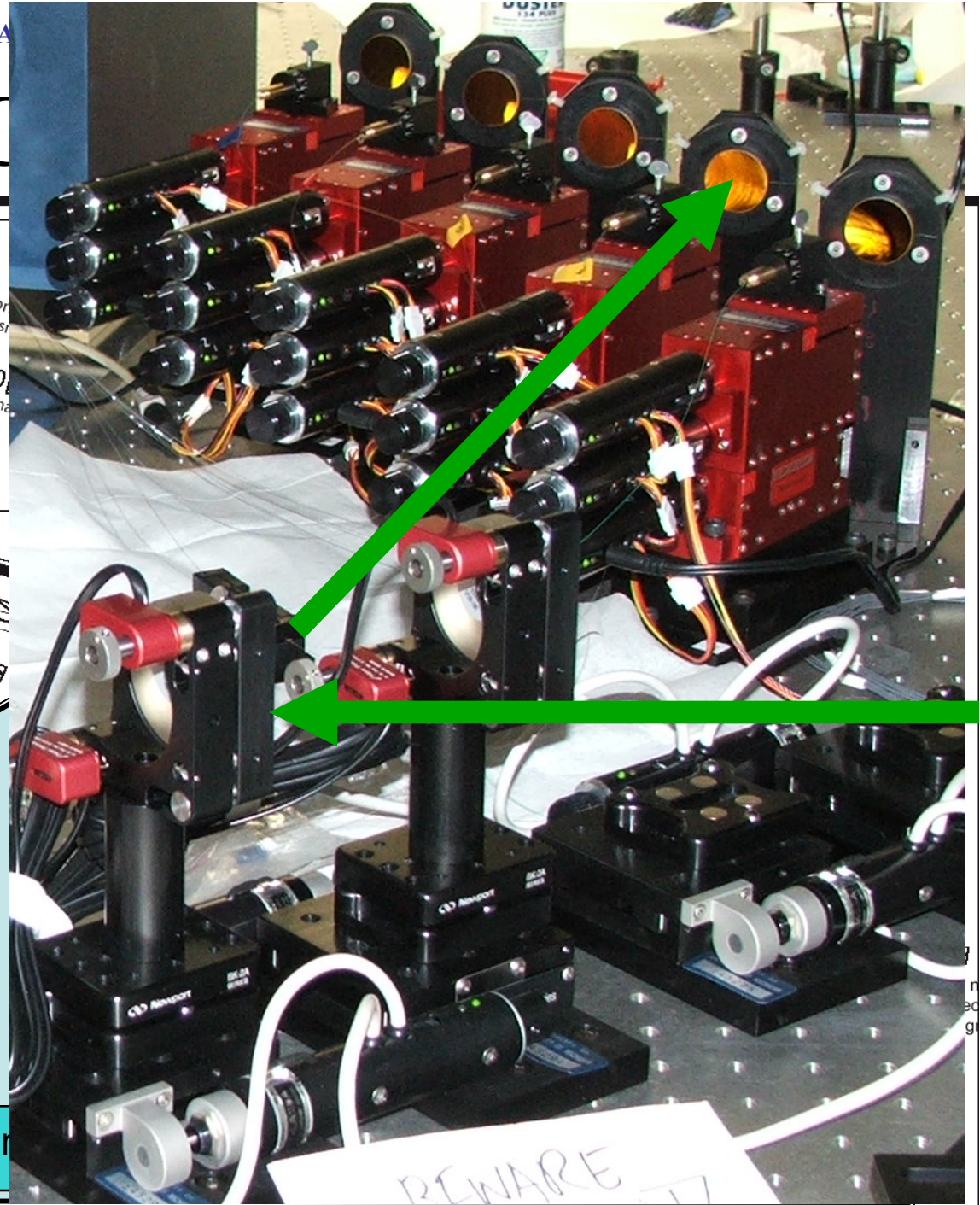
Fabien Baron, Matt Anderson (GSU), Stefan Kraus (UM->Exeter),
Rafael Millan-Gabet, Gail Schaefer, Ming Zhao, Ettore Pedretti





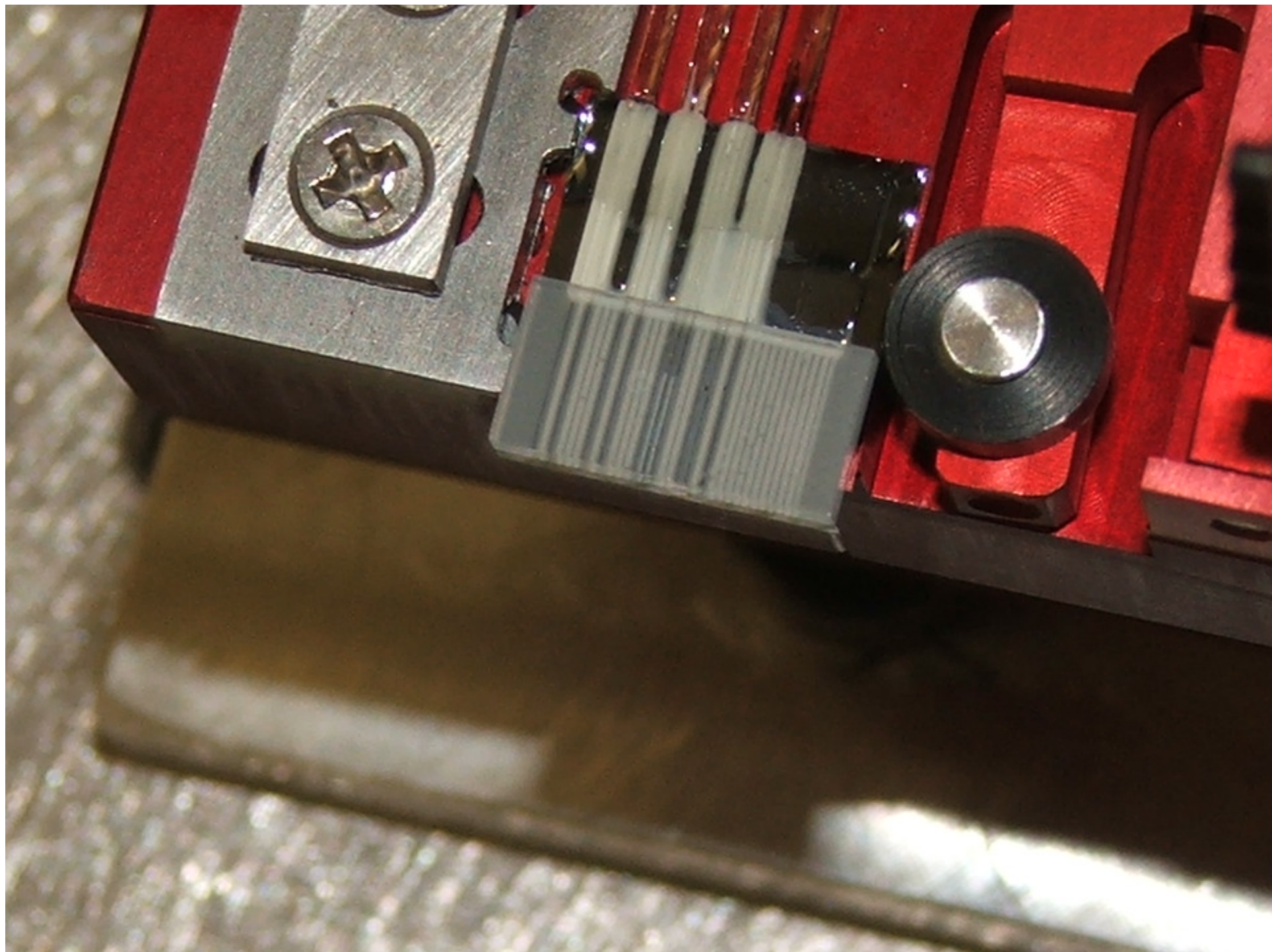
CHARA

MIRCO



Monitor

BEWARE





MIRC: Status

Guiding Principles:

- 1) Maximum Calibration Precision for Closure Phases
- 2) Imaging

- Combines all 6 CHARA telescopes
 - Following Che upgrade in 2011, includes improved photo-channels
- Works at H (1.65 micron) and K (2.2 micron)
- Demonstrated sensitivity: H~5.5 (MWC 361, 2012), K~3.5
- Spectral resolution: $R \sim 44$ (most common), 150, or 450
- V^2 error $\sim 3-8\%$; CP error $\sim 2^\circ-5^\circ$ (for 6min obs.)
 - Absolute CP error.. Some problems < 0.5 degrees
- No Major Changes in 2013



MIRC: Year 8 (2013) Summary

- MIRC Observing
 - 2013: 77 nights, including Rachael's record-breaking 20 consecutive night run in September
 - 2012: 79 nights (mirc6 in full force, more small programs)
 - 2011: 51 nights (champ installation downtime)
 - 2010: 62 nights
 - 2009: 51 nights
 - 2008: 42 nights
 - 2007: 57 nights
 - 2006: 34 nights

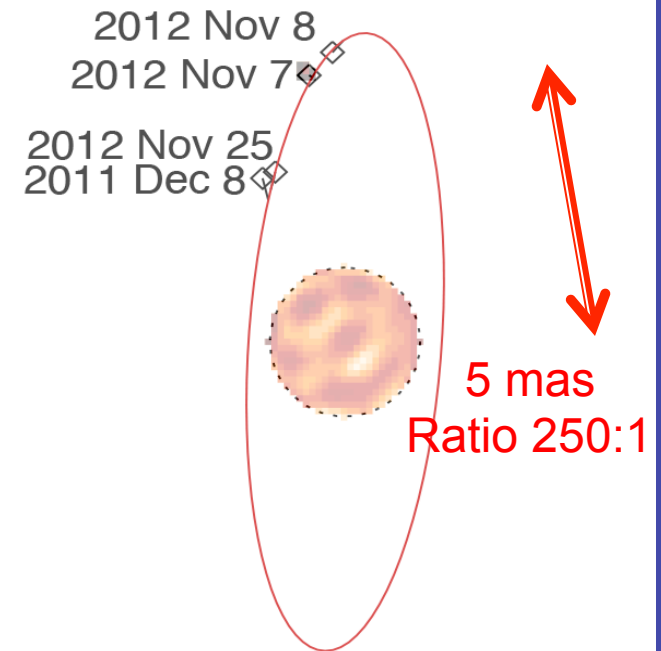


MIRC: Year 8 (2013) Summary

Projects in 2013:

- Young Stellar Objects w/ CHAMP: Monnier, Baron, Kraus, Millan-Gabet
- Cepheid Binaries: Gallenne, Kervella
w/ new joint HST program
- Be stars: Schaefer, Gies
- Exoplanets: Zhao, von Braun
- Multiples: Schaefer, Kraus, Boyajian
- Betelgeuse: Kervella
- Spotted stars: Roettenbacher, Kloppenborg
- X-ray Binaries: Baron, Reynolds
- Beta Lyrae Campaign: Baron, Mourard
- Nova Del: Schaefer+

Direct Detection of RS CVn companions



Roettenbacher et al., in prep



MIRC: Year 8 (2013) Paper Summary

Publications:

1. Gallenne et al. 2013, Binary Cepheids
2. Delaa et al. 2013, Alp Cep
3. Richardson et al. 2013, P Cygni
4. Absil et al. 2013, Debris Disks
5. White et al. 2013, Kepler Stars
6. Maestro et al. 2013, Hot stars
7. Baron et al. 2014, Red Supergiants

Coming soon.... (we hope)

1. MIRC/CHAMP Instrument paper
2. First imaging of YSO with MIRC+CHAMP
3. Imaging Spots (Roettenbacher; *Parks*)
4. Epsilon Aurigae Followup (Kloppenborg)
5. Phi Per with MIRC and Vega (Mourard)

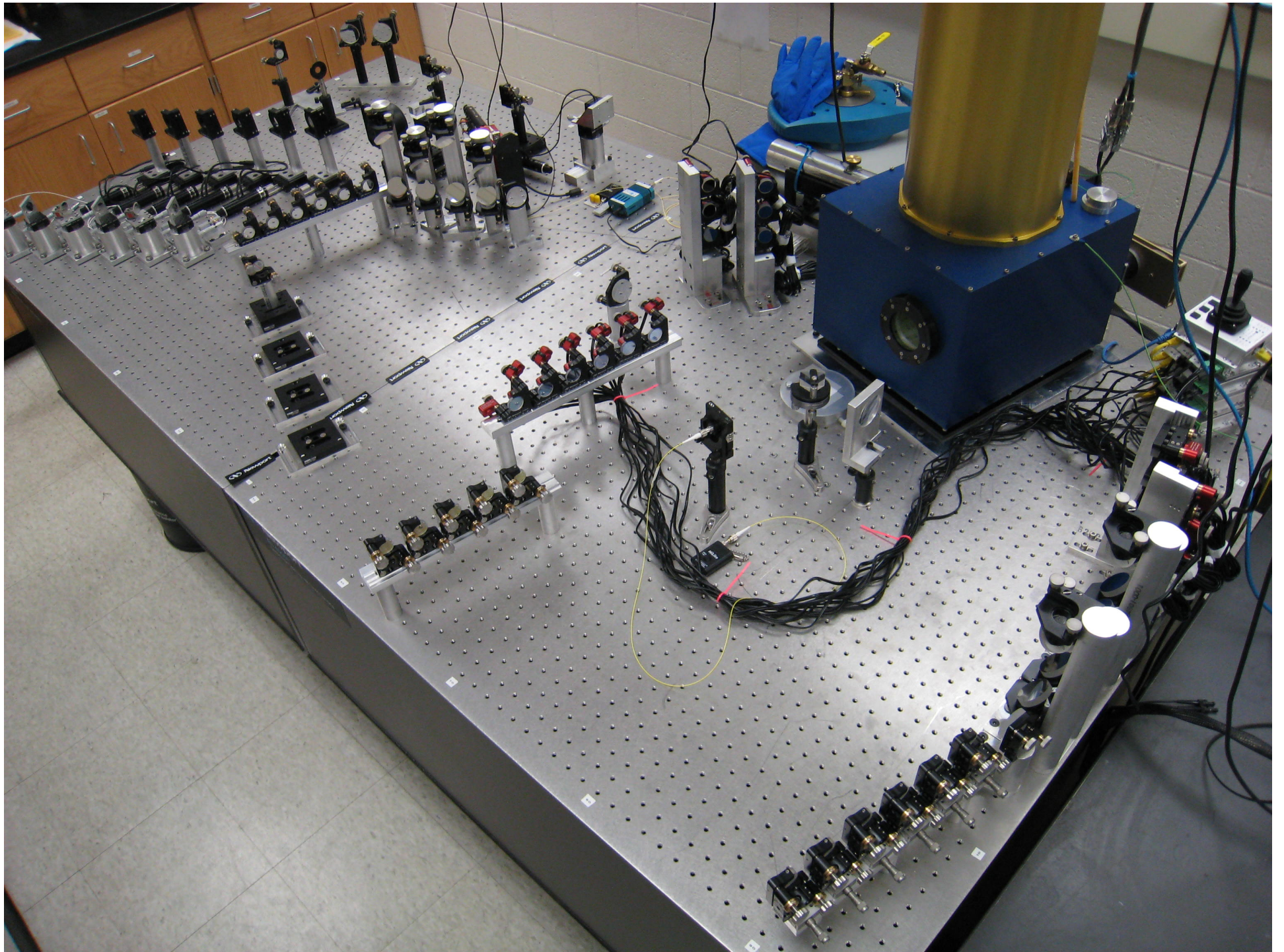


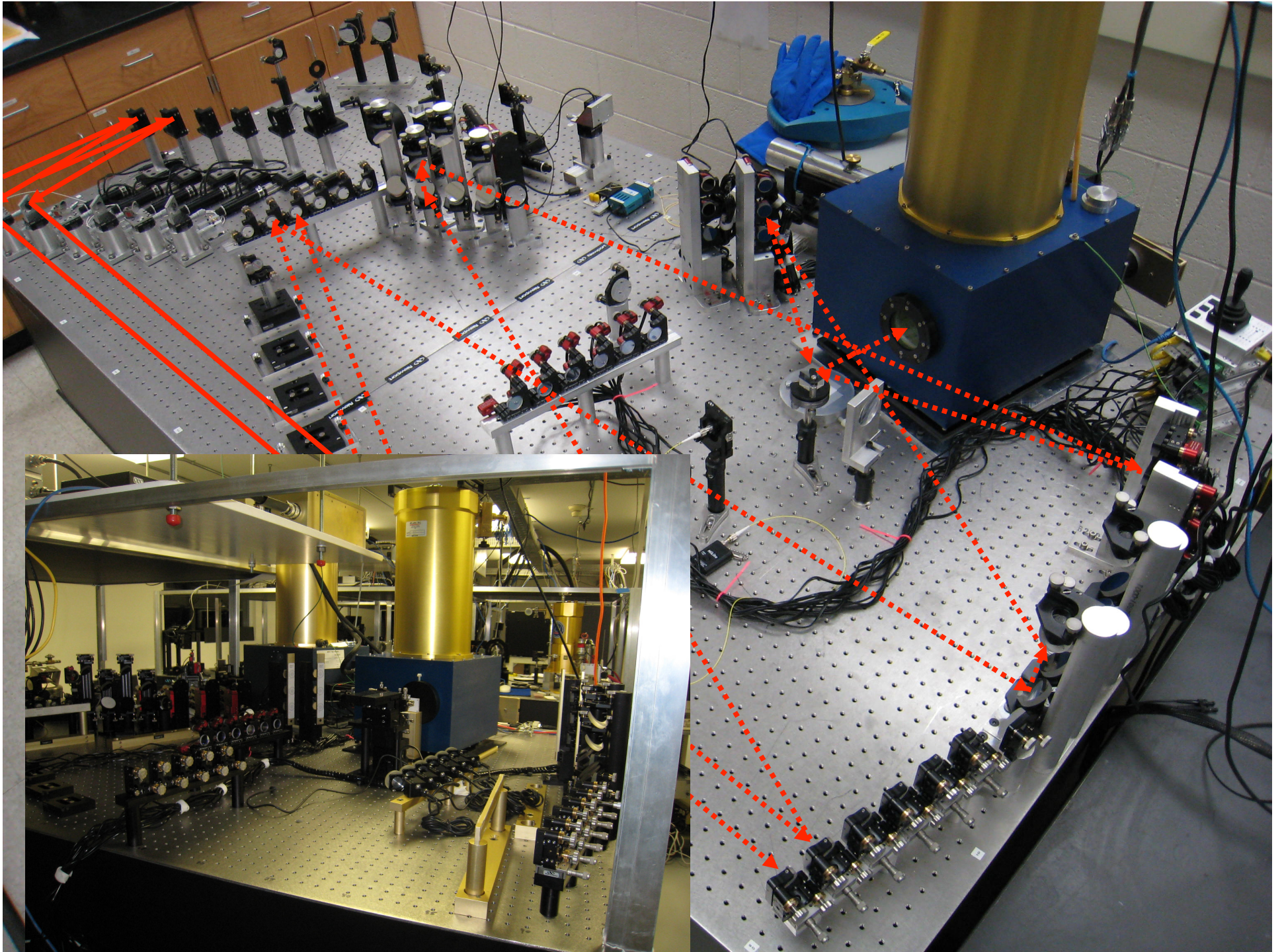
CHAMP: Status

Guiding Principles:

- 1) Allows fringe tracking with all 6 telescopes
- 2) Maximum Sensitivity for fringe tracking

- Combines all 6 CHARA telescopes (1-2,2-3,3-4,4-5,5-6,6-1)
- Works at J (1.25 micron), H (1.65 micron) and K (2.2 micron)
- Demonstrated sensitivity: $K \sim 5$ (goal $K \sim 7-8$)
- Spectral resolution: $R \sim 5$ (i.e., none)
- Routine operation in 2013 July to observe YSOs with MIRC:
 - MWC 275, MWC 297, MWC 361
- No major changes 2013







MIRC-CHAMP Status

- We had a very successful run in July 2013, tracking on MWC 297, MWC 361, MWC 275 fringes.
- Although we were tracking fringes with CHAMP, MIRC data was marginal in most cases
 - Highlights SNR problem for cphases
 - Camera systematics, e.g. $1/f$ noise
- Only way to do this right is to get better SNR on



How to get better SNR on MIRC?

1. Continue with AO upgrade. In principle, 10-20X more flux possible with diffraction-limited telescope

2. New Detector for MIRC- TOP PRIORITY

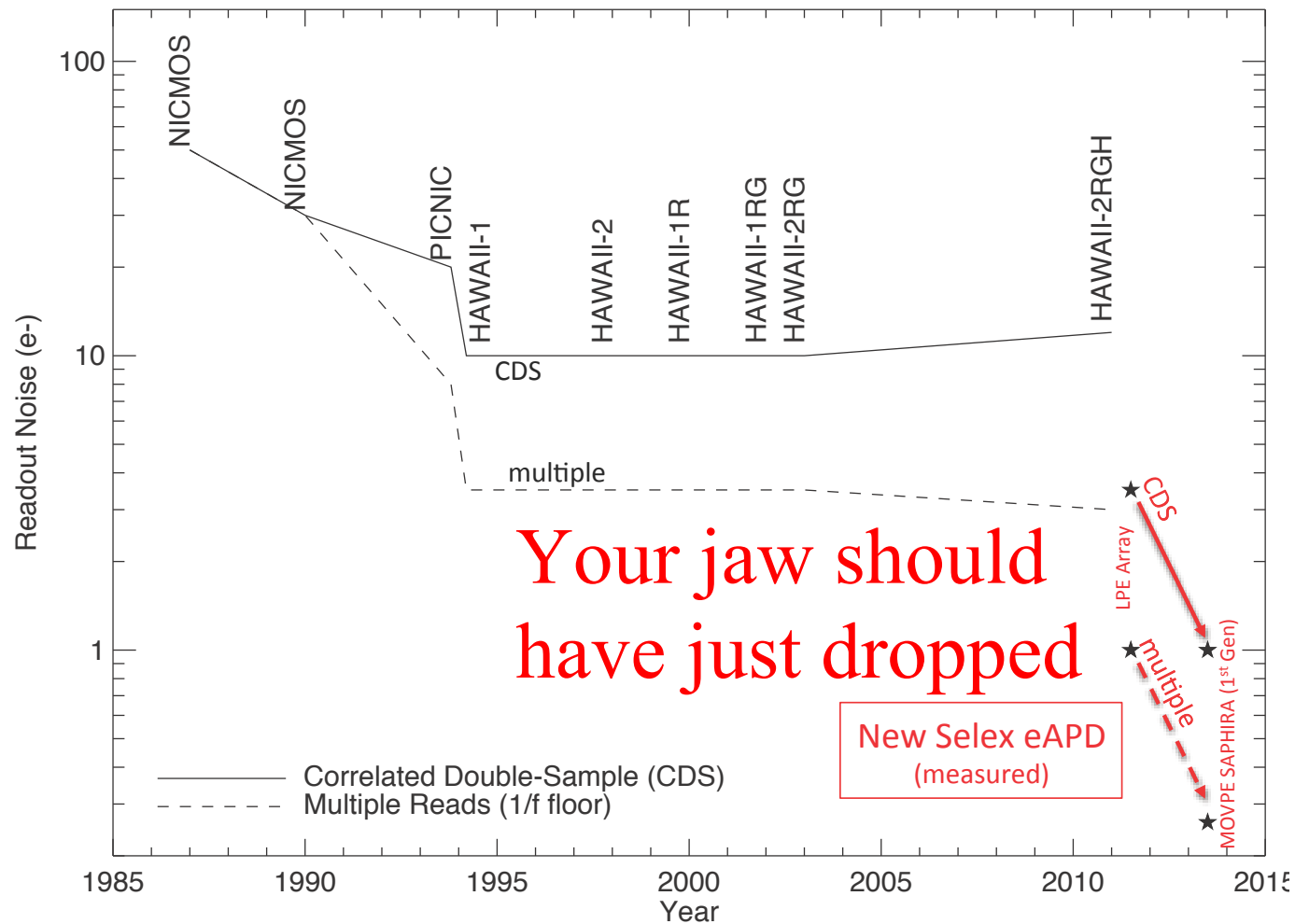
JDM applied for NSF-ATI \$\$ to fund new development cycle for SELEX eAPD arrays with 20X better read noise than our MIRC detector (Stefan Kraus also applying for EU \$\$)

3. New MIRC/CHAMP beam combiner? Won't help much without AO And new detector

First things first.



Historical progress in reducing readnoise had stalled until eAPD breakthrough





MIRC & CHAMP Improvements planned for 2014

RIP: Wolverine1

- New MIRC computer (USB3 for data xfer) (priority 1)
 - Upgrade to standard linux + RT patch (drop Xenoami)
 - Might try new DSP code for MIRC to possible improve stability 1/f noise
- New CHAMP computer (priority 2)
 - Ideally need to upgrade to new standard linux + RT patch, but issue with drivers for National Instruments Board
- New interface computer with larger screens
- Mostly software issues left to improve..
Hardware is about as upgraded as can be without a major refresh



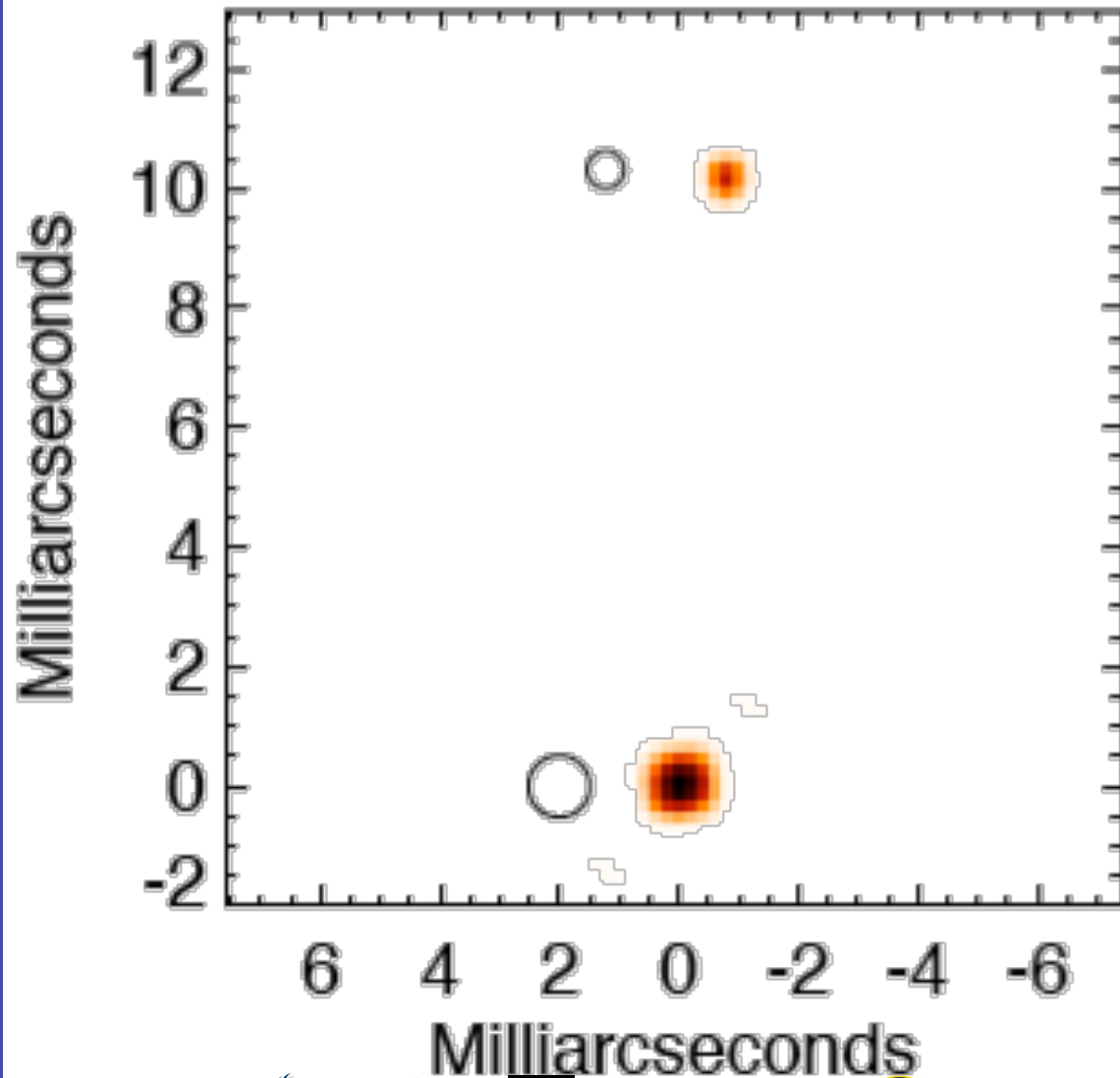


UM News

- People
 - Stefan Kraus (Sagan Fellow) left for faculty job at Exeter (UK)
 - Fabien Baron (UM) left UM for faculty job at GSU
 - Hired Brian Kloppenborg at GSU
 - Xiao Che will graduate April 2014 → Heading to Manhattan (Bloomberg)
 - Rachael Roettenbacher passed prelim exams – full time research now
 - UM Undergrad Matt Anderson joined GSU for grad school
 - Alicia Aarnio (UM) got new NSF grant – involved in MIRC YSO work
- Data Analysis
 - Improved IDL-based MIRC pipelines
 - Still some “cross-talk” problems in special cases.
 - [Google + Community](#) for MIRC users
 - UM Undergrad Sam Swihart setup new online Target/Observing History
 - I am interested in contributing to public archive



New Project: “Ultra-Orbits”



Imaging
Demonstration:

Iota Peg
(period 10.2 days)

Monnier et al. 2007

MACIM: Ireland et al. 2006

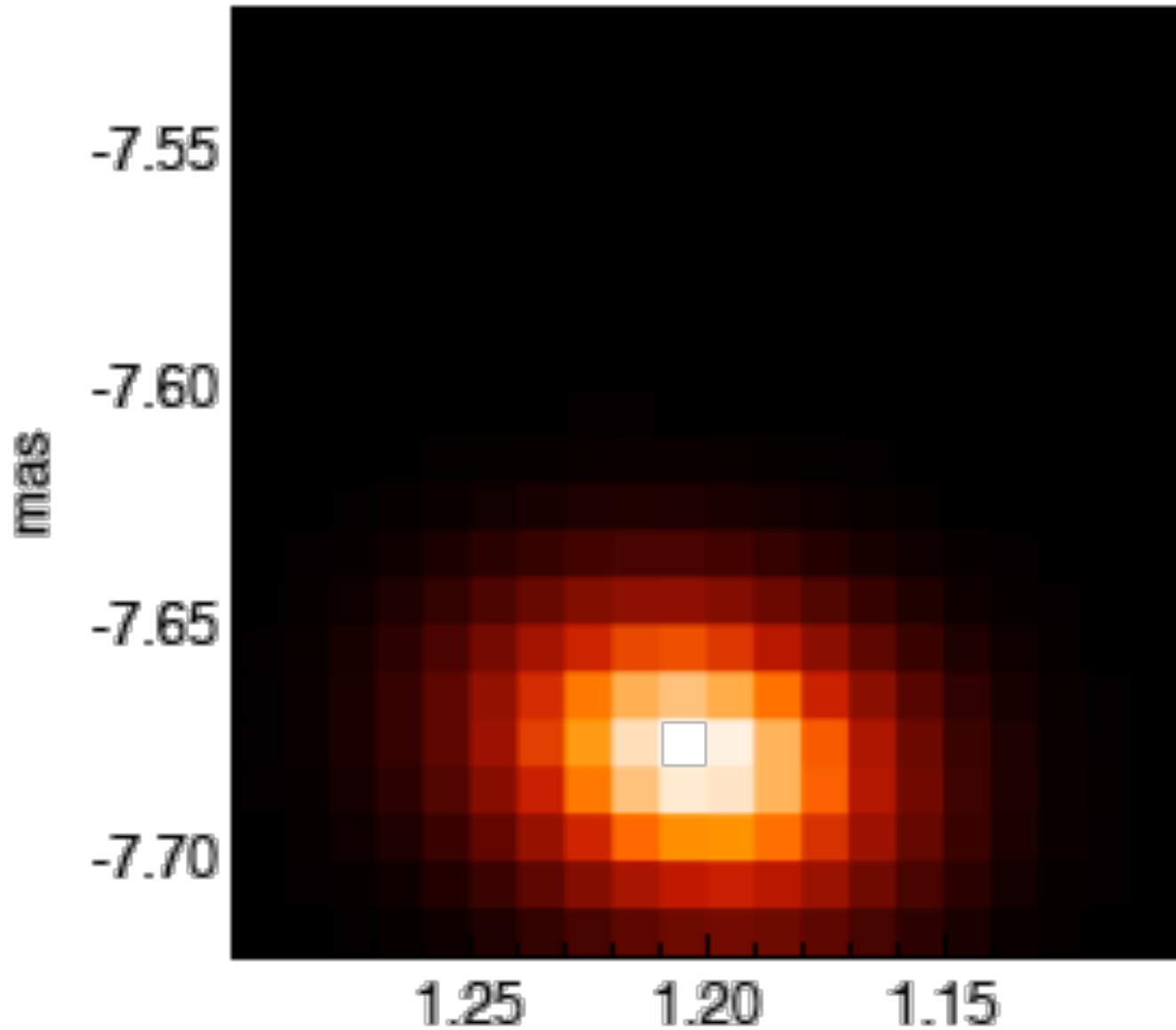


Max-Planck-Institut für Radioastronomie



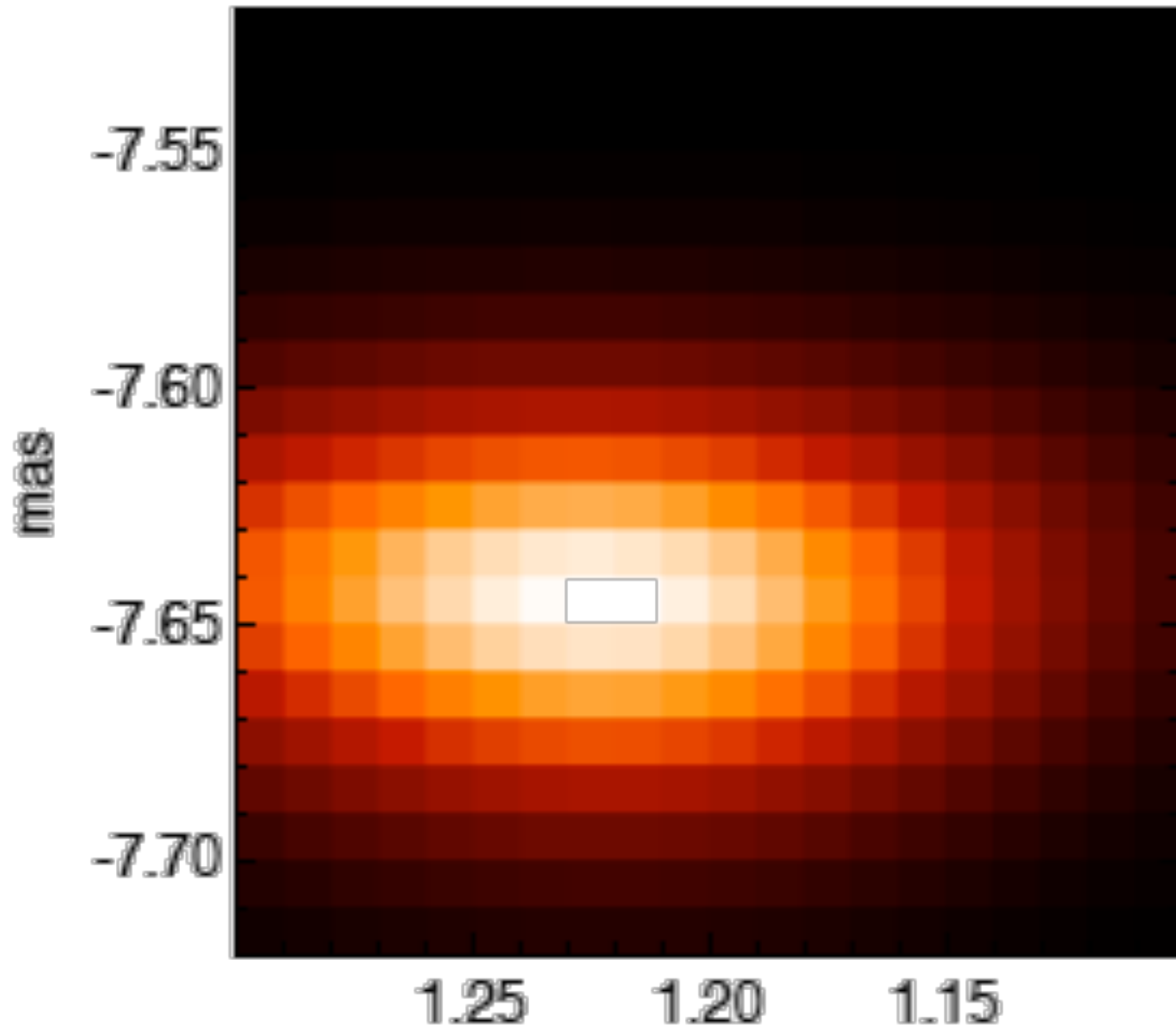


Time: 0 minutes



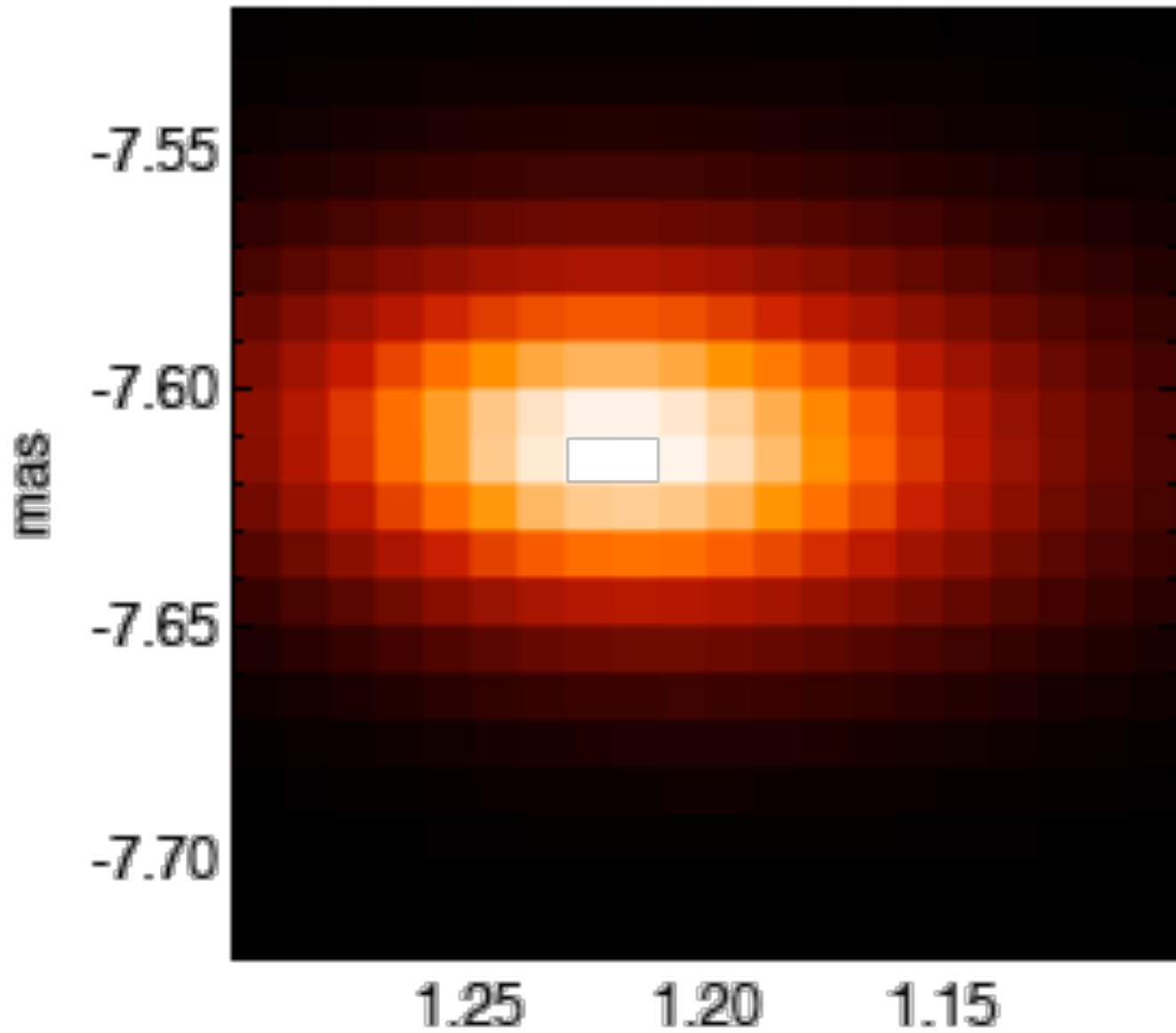


Time: 11 minutes



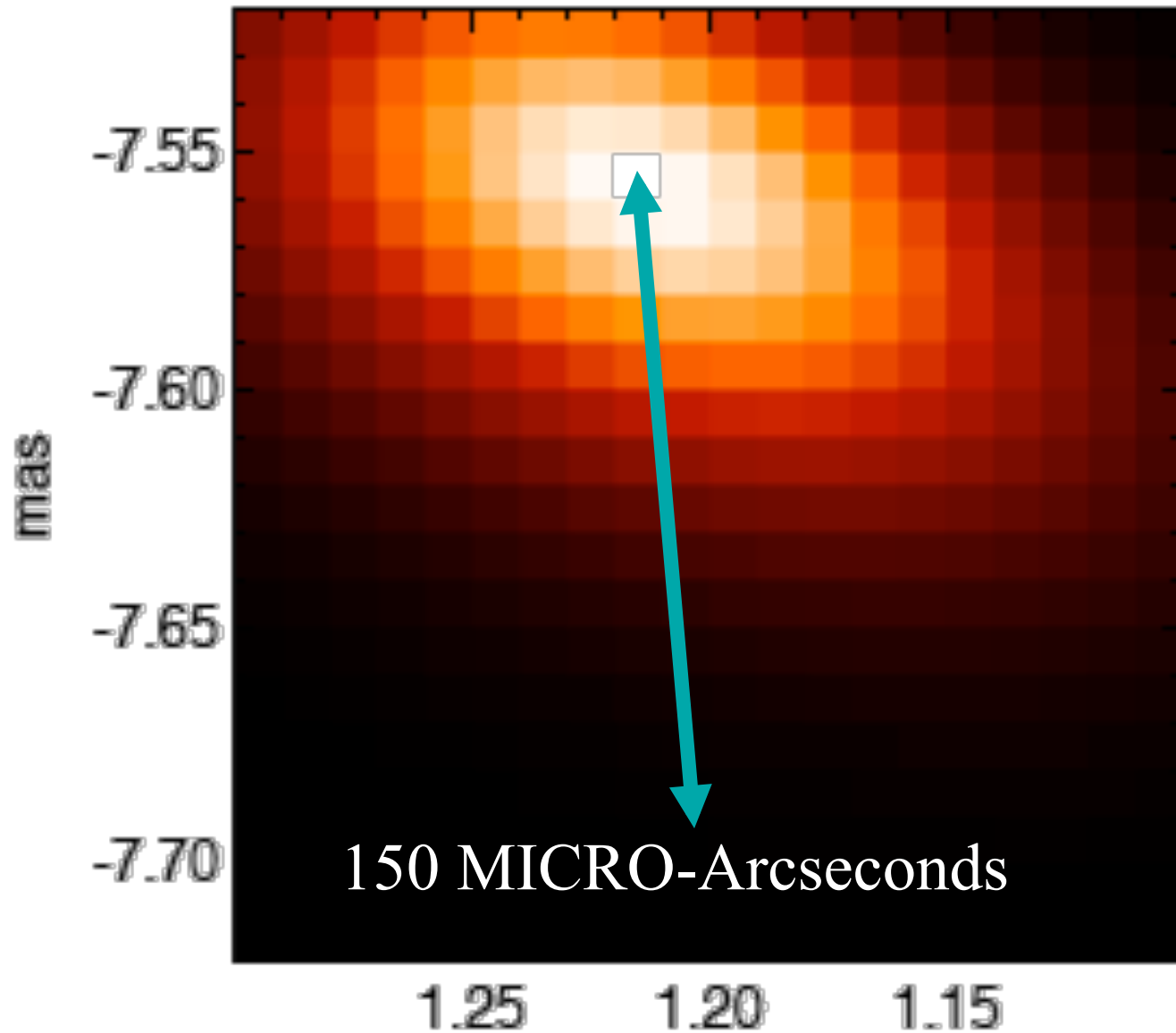


Time: 25 minutes



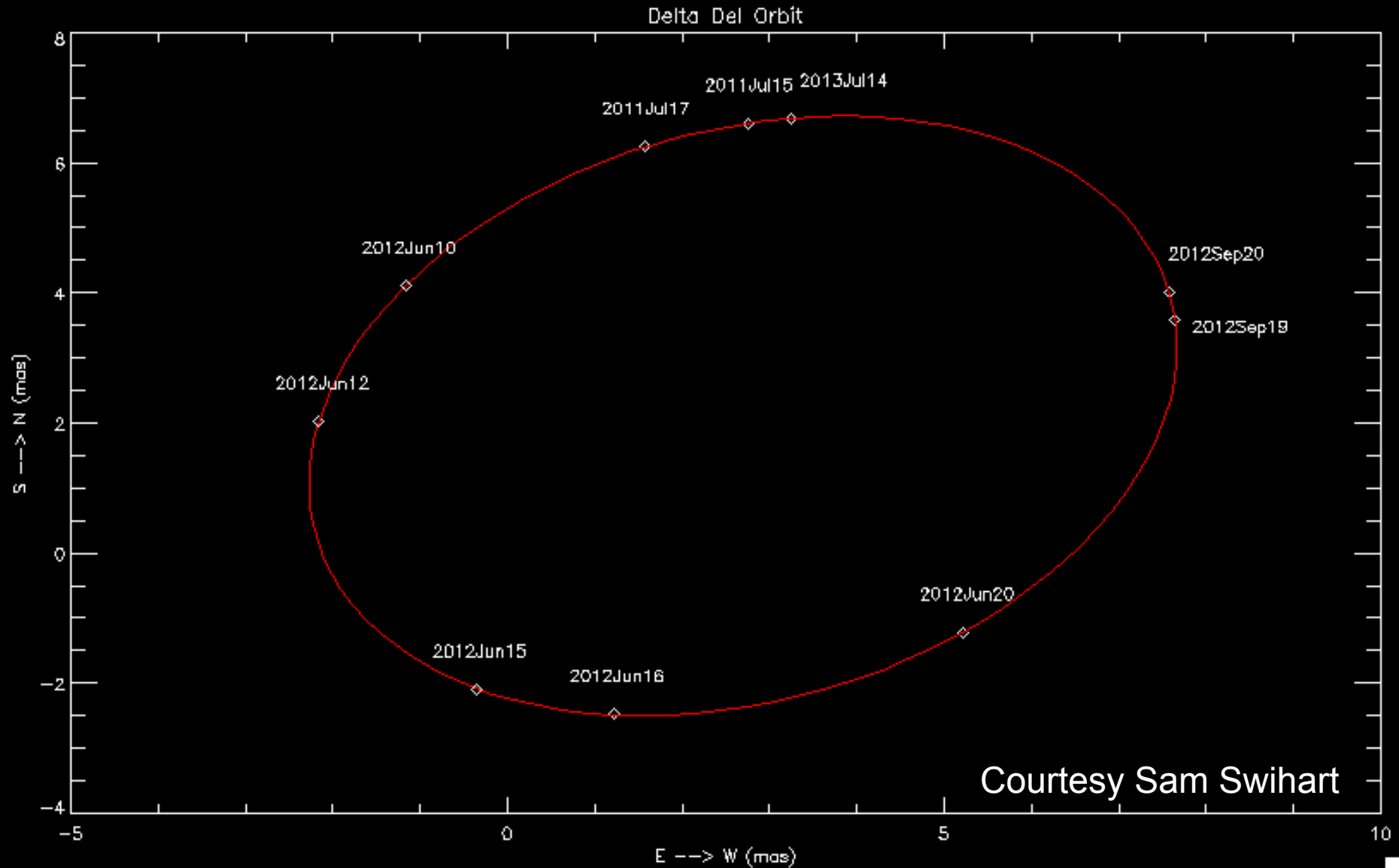


Time: 45 minutes





Also, Delta Del over longer period of time

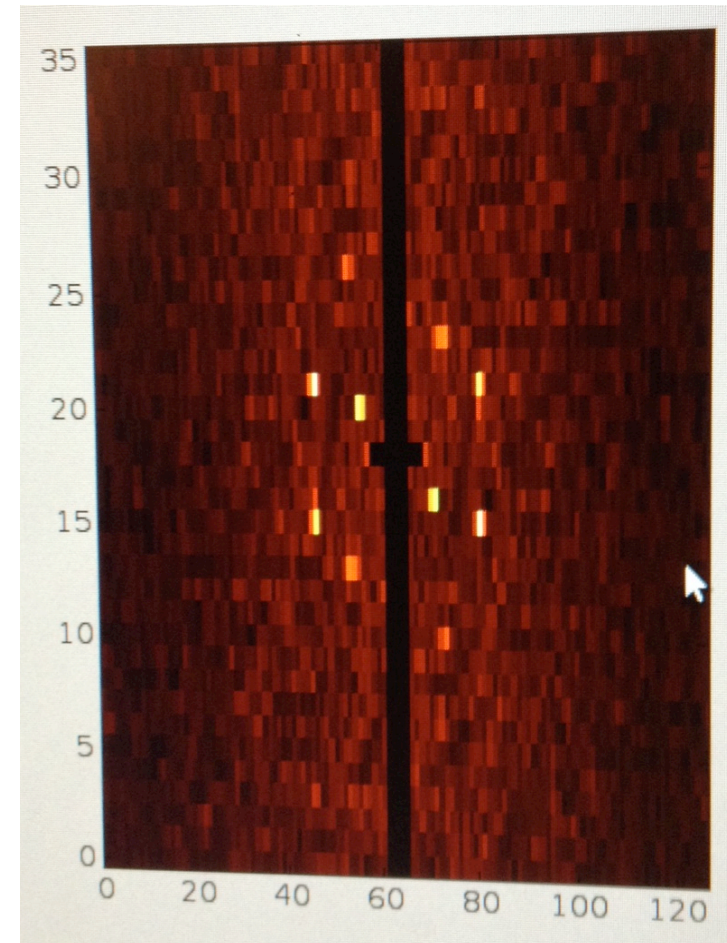


Courtesy Sam Swihart



Exoplanets in binaries

- Binaries with 10-30 days orbits are very unlikely to harbor a massive exoplanet due to disk truncation in planet formation epoch
- We need to target “wide” binaries but must be within diffraction-limit of one telescope
 - 50-200 mas separation is ok.
- Must use grism with $R > 100$ in order for packets to overlap

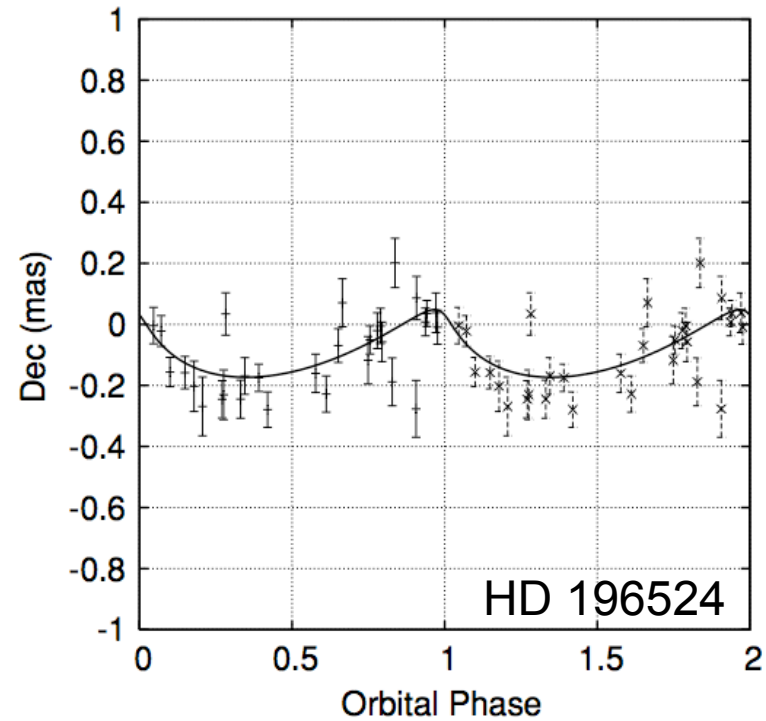
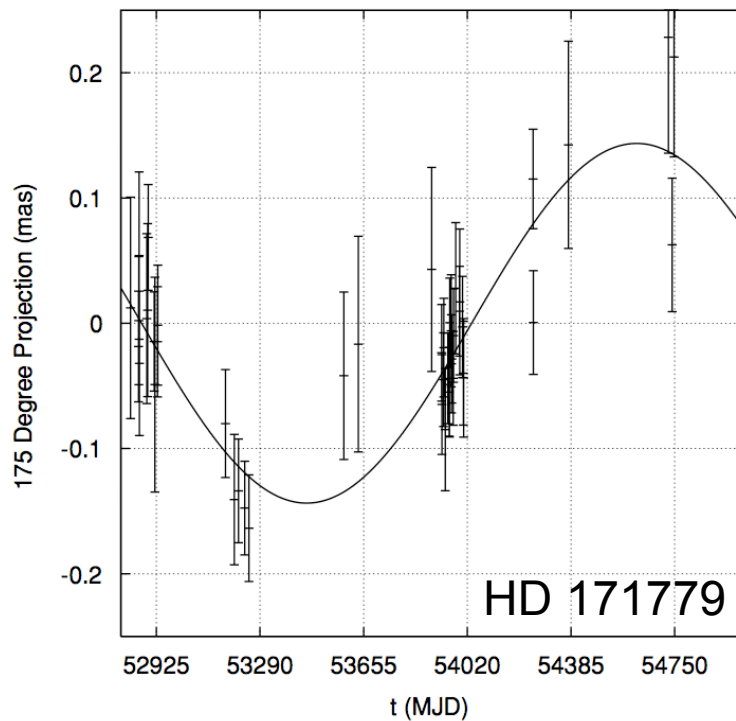


R~450 grism experiment in 2012



Astrometry Goals

The PTI-PHASES survey found some candidates sub-stellar companions, **requiring 10-20 micro-arcsecond astrometry**



Muterspaugh et al. 2010



Requirements

Accuracy of binary separation depends on:

- Current Baseline Precision:

$5\text{mm}/330\text{m} = 1.5 \times 10^{-5}$ (best case, w/AO+pupil control)

$10\text{ cm}/330\text{m} = 3 \times 10^{-4}$ (worse case, pupil wander)

- Wavelength Precision (absolute):

MIRC: $0.1\% = 1 \times 10^{-3}$ (current methods)

Conclusion: we need to measure wavelength accurately!

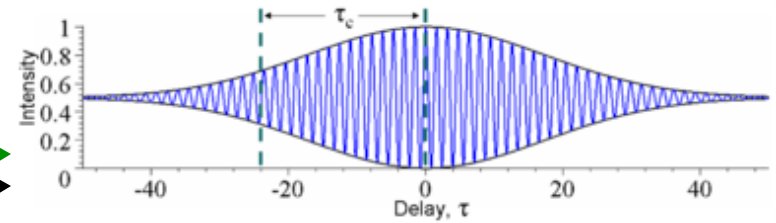
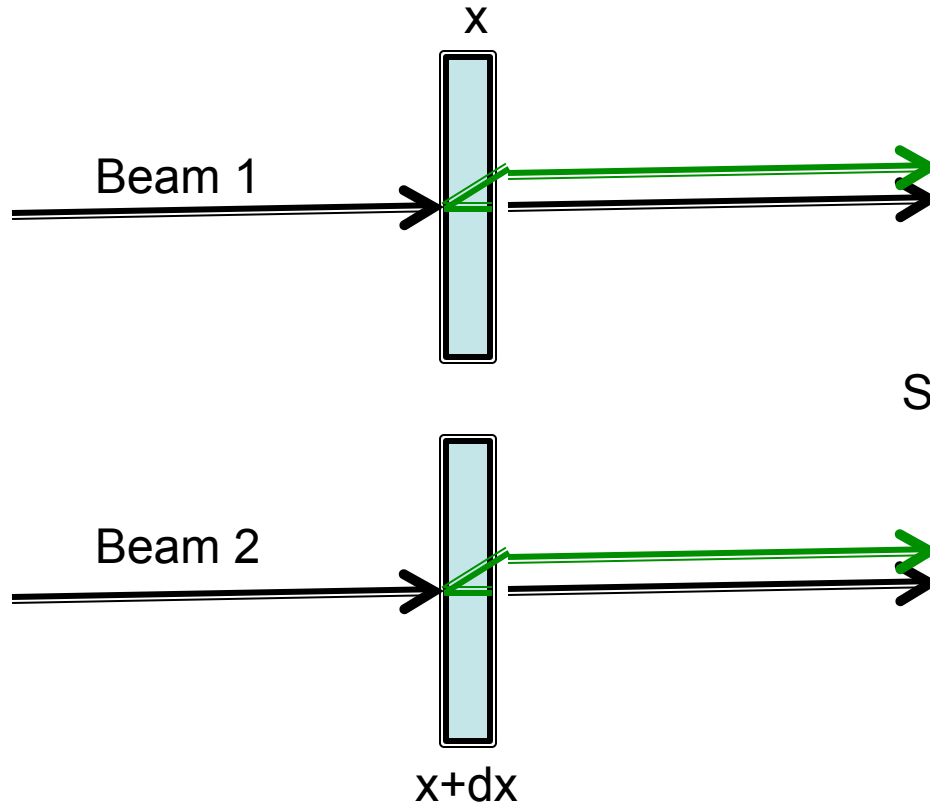


How to measure wavelength to 1×10^{-5}

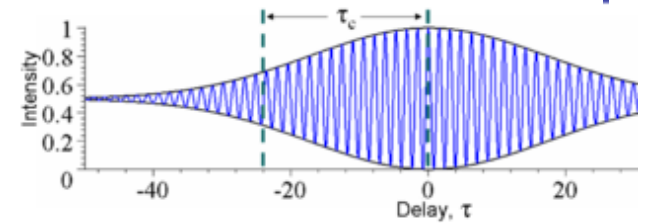
- FTS method
 - in 2012 we tried FTS experiment. It FAILED due to ~5 meters of un-sensed air path that introduced phase >> radian turbulence
- Use Laser source or comb
 - Difficult to back out with low-resolution system
- Etalons?



Etalons

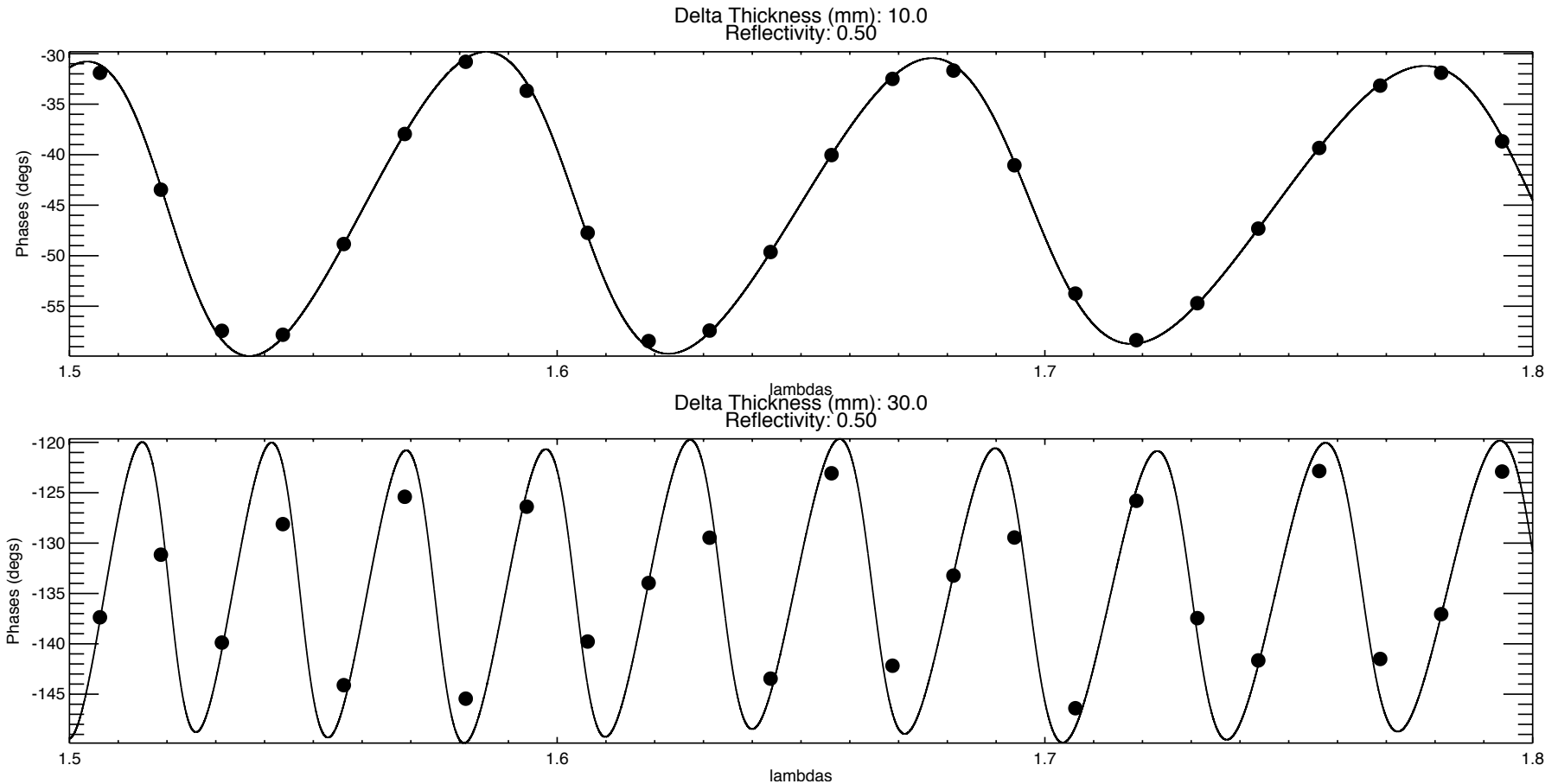


Primary Fringe packet at $OPD=0$
Secondary Fringe with $OPD=2n dx$
+ other weak ones





Looks like binary to MIRC !





Etalon Stability

- For OPD to be stable to 1×10^{-5} , then the individual etalons must have $\pm 0.01\text{K}$ thermal stability relative to each other
 - Impossible using active sensing and control
- Mount all optics in common mount for passive control
 - Reduced stability requirement to $\pm 1\text{K}$ knowledge
- Also angle of incidence tolerance met by common mount

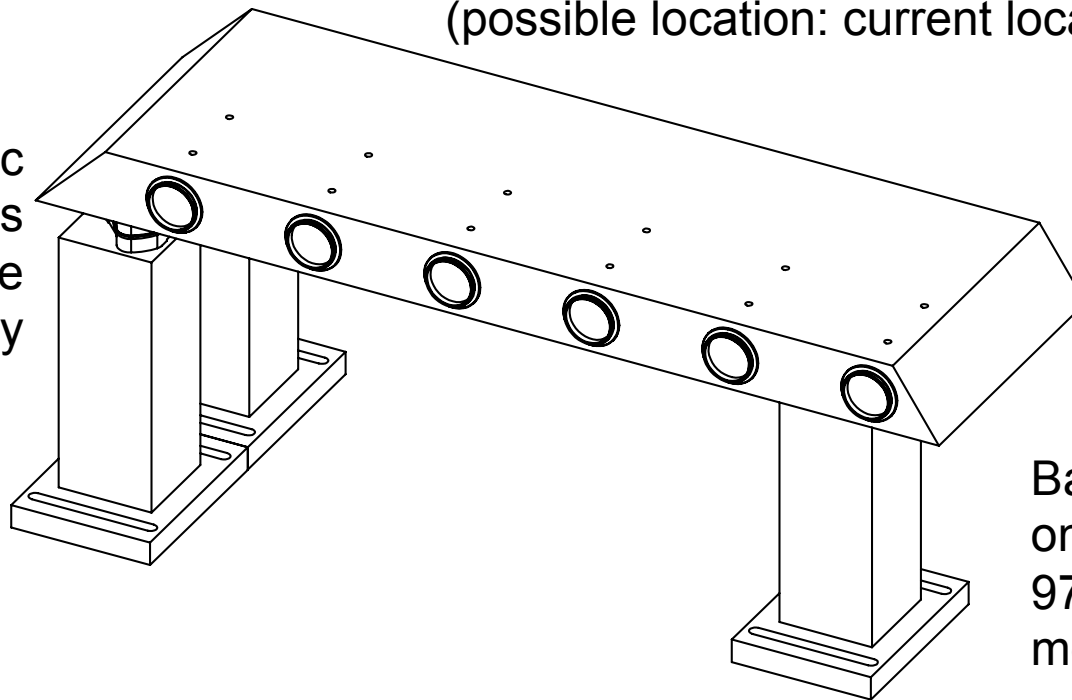


Etalon Mount Design

w/ Keith Jackson, Mike Ireland

16 pound plate with etalons is removable
(possible location: current location of IR shutters)

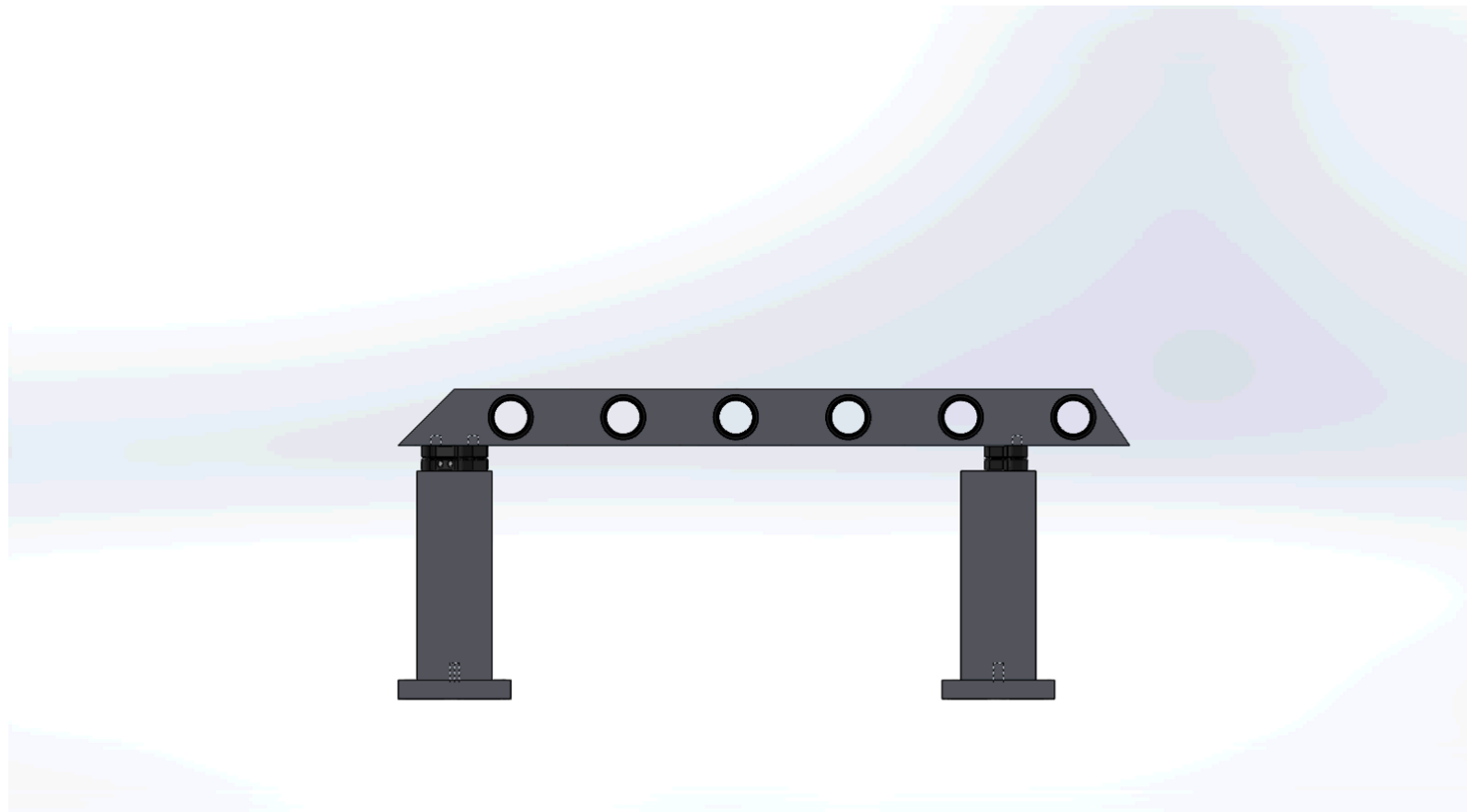
Kinematic
bases
For angle
reproducibility



Baffled by 3" tubes
on both ends means
97% solid angle see A1
mount



Assembly





Etalon Schedule

- 2013 Aug-Sep: Etalons Specified
- 2013 Sep 27: Order with Light Machiner
- 2014 Jan 30: Received etalons (with 1 spare)
- 2014 Spring: Finalize passive mount
- 2014 May: Submit NASA proposal to fund student project
- 2014 June 13-16: First sky time with etalons



MIRC+CHAMP

- No major changes for MIRC + CHAMP
- New SELEX detector top priority for MIRC
 - Also Adaptive Optics Phase 2 Upgrade!!
- Interesting faint companion science emerging
 - Cepheids, RS CVn stars, Be stars
- Imaging complex objects made difficult by small (but important) cross-talk issues
 - Working on some new ideas but may require pair-wise combination down the road
- Etalon upgrade may allow for “Ultra-orbits”



Backup

