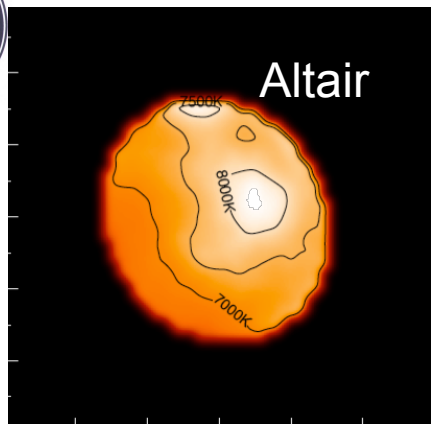
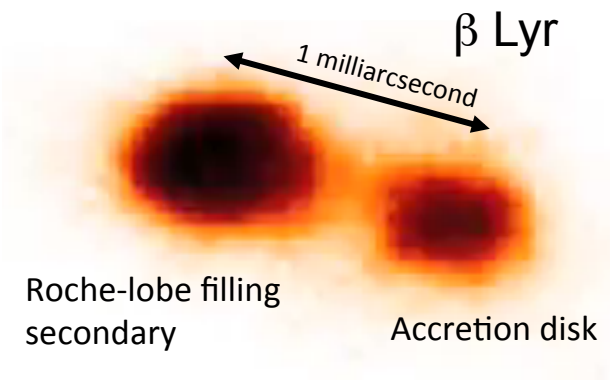
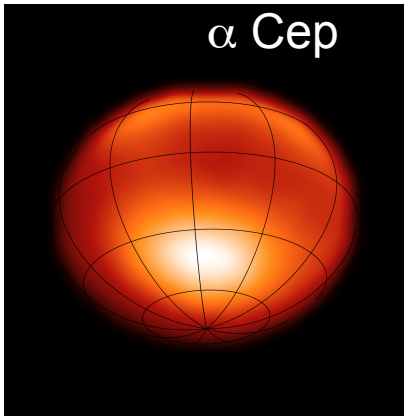
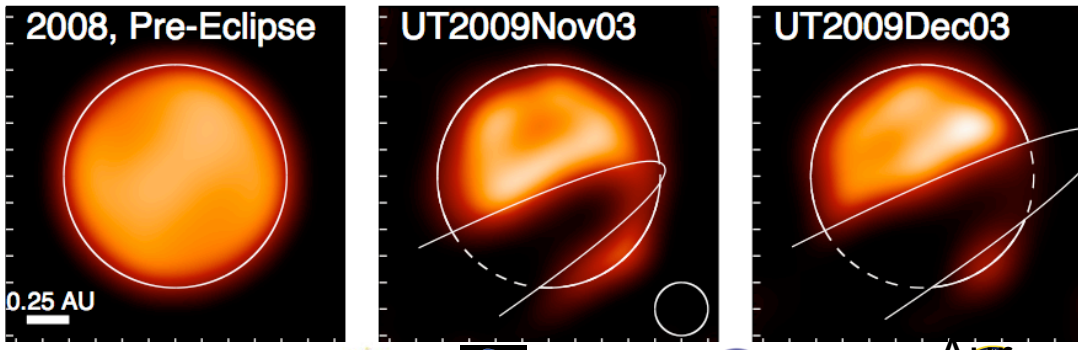


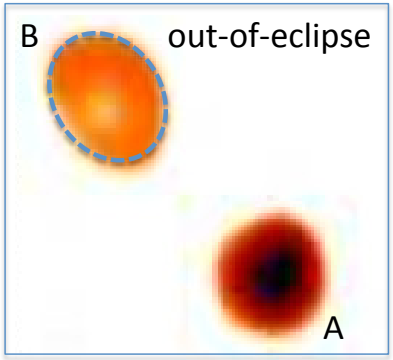



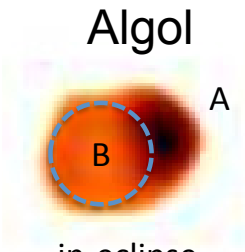




# MIRC & CHAMP
# Status, Updates, Reflections

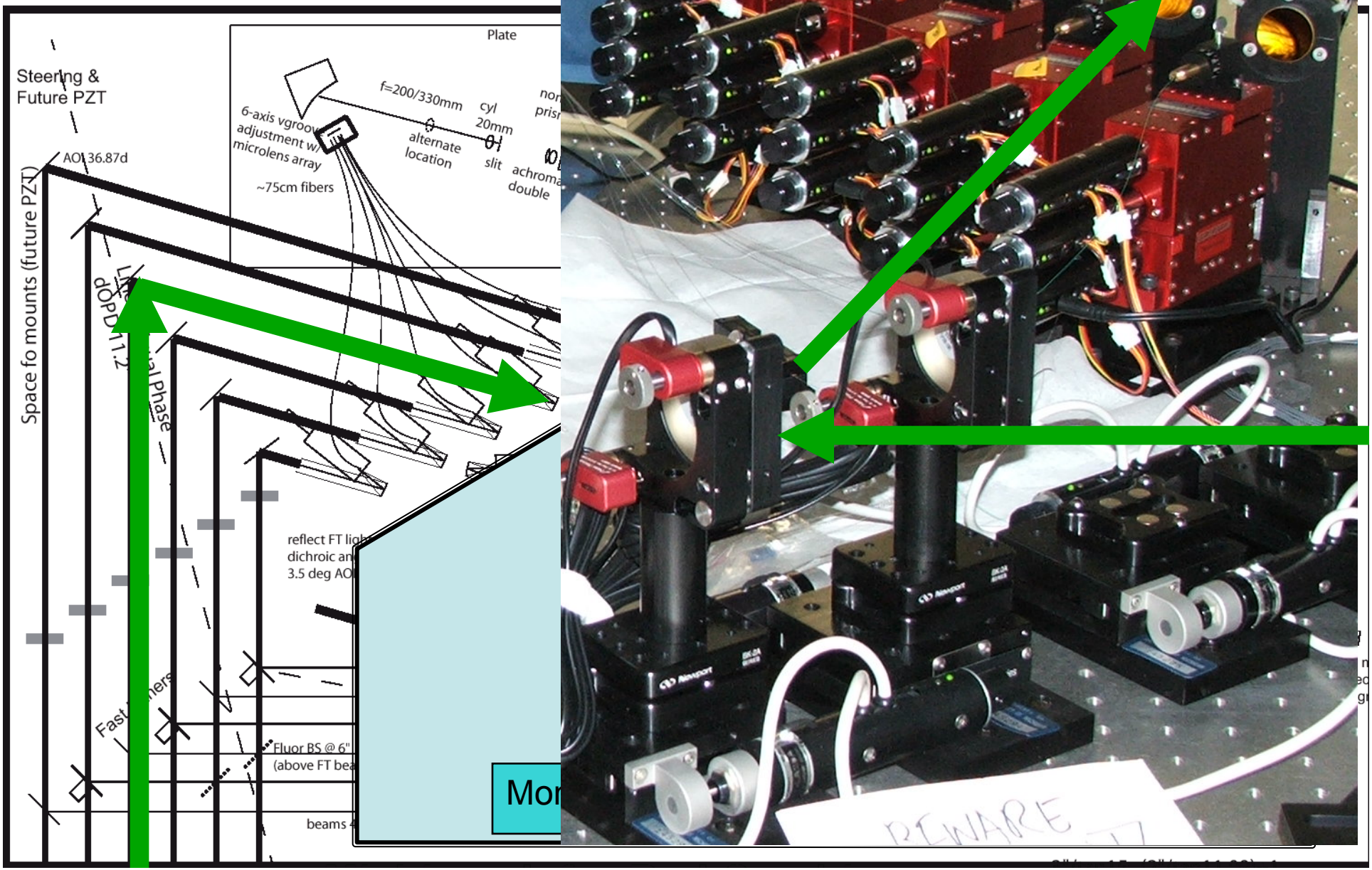
John Monnier, Fabien Baron, Xiao Che, Rachael Roettenbacher,
Nate England, Matt Anderson, Stefan Kraus (UM),
Rafael Millan-Gabet, Ming Zhao, Ettore Pedretti

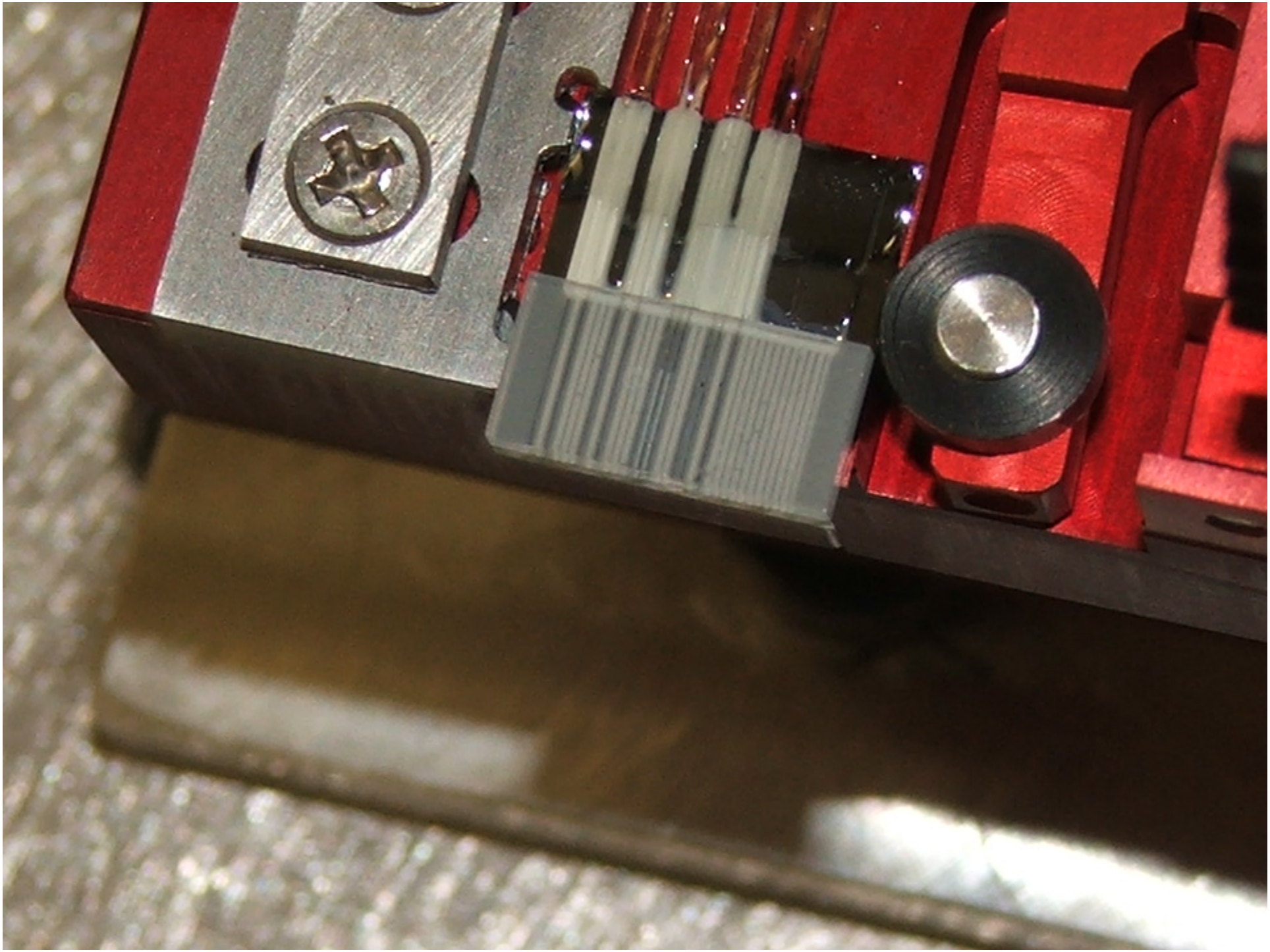


# MIRC


Steering &
Future PZT
Space fo mounts (future PZT)
AOI 36.87d
Plate
6-axis vgroov
adjustment w/
microlens array
~75cm fibers
f=200/330mm
cyl
20mm
alternate
location
slit
achroma
double
dOPD 11.2
reflect FT ligh
dichroic an
3.5 deg AO
Fluor BS @ 6"
(above FT bea
beams 4
Mor
REWARE



# 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)
  - No one has tried K band since upgrade (any takers?)
- Demonstrated sensitivity: H~5.5 (MWC 361, 2012), K~3.5
- Spectral resolution: R~ 44 (best!), 150, or 400
- $V^2$ error ~ 3-8%; CP error ~ 2º-5º (for 6min obs.)
  - Absolute CP error.. Some problems < 0.5 degrees
- Updated some CHARA/MIRC server communication protocols
- U. Michigan Remote MIRC Observing commissioned
  - GUI speed ups

# MIRC: Year 7 (2012) Summary

- MIRC Observing (and engineering)
  - 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

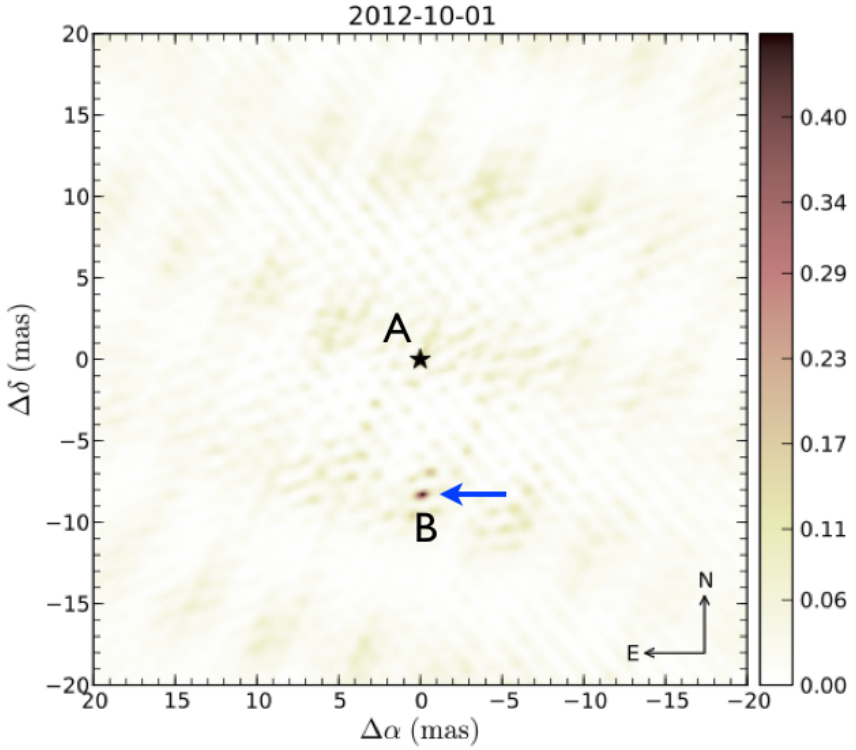
- Historically, ~40% of scheduled MIRC time has PI not from Michigan (including all MIRC/CHAMP engineering time)
  - e.g., 5 of the last 9 MIRC papers have first-author not from Michigan

# MIRC: Year 7 (2012) Summary

## Projects in 2012:

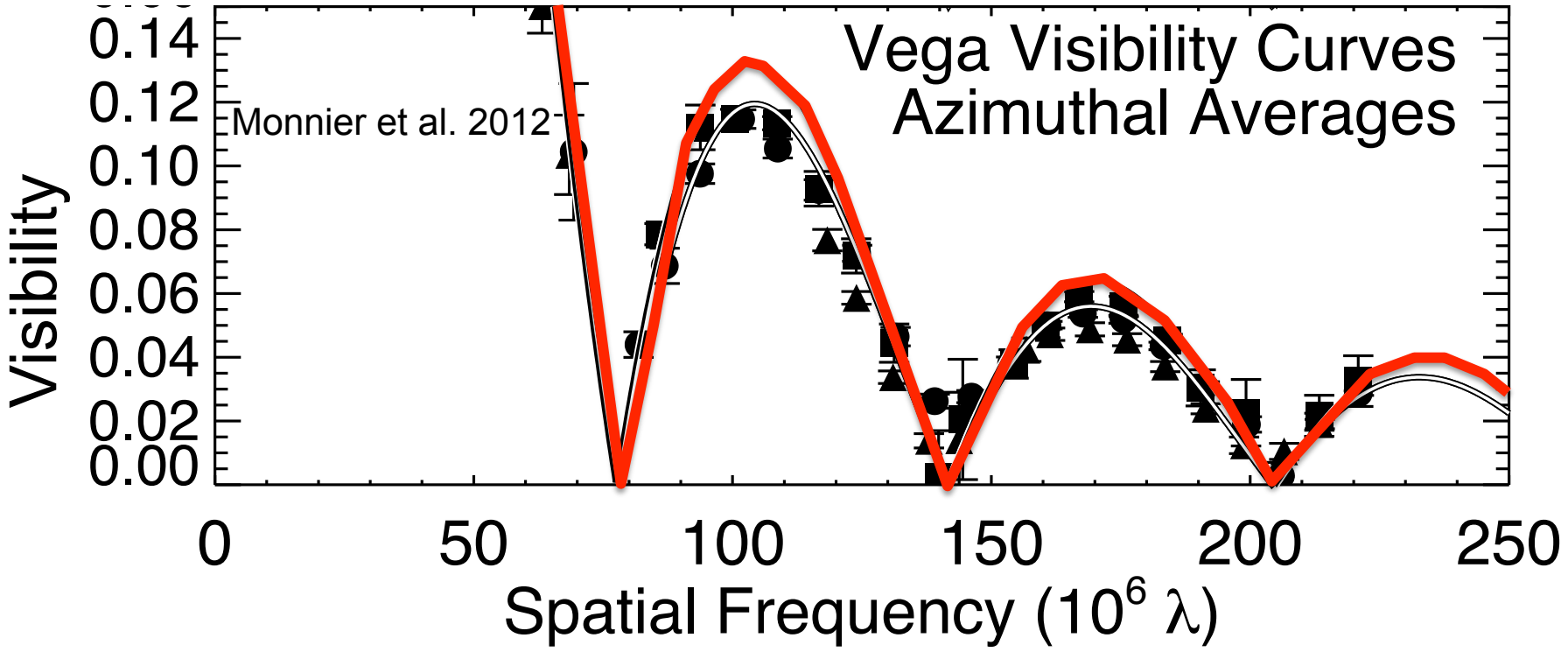
- Young Stellar Objects w/ CHAMP: Monnier, Baron, Kraus, Millan-Gabet
- Cepheid Binaries: Gallenne, Kervella
- Be stars: Che, Schaefer, Gies
- Exoplanets: Zhao, von Braun
- Multiples: Schaefer, Kraus, Che
- Betelgeuse: Kervella
- Spotted stars: Roettenbacher

Cepheid Masses



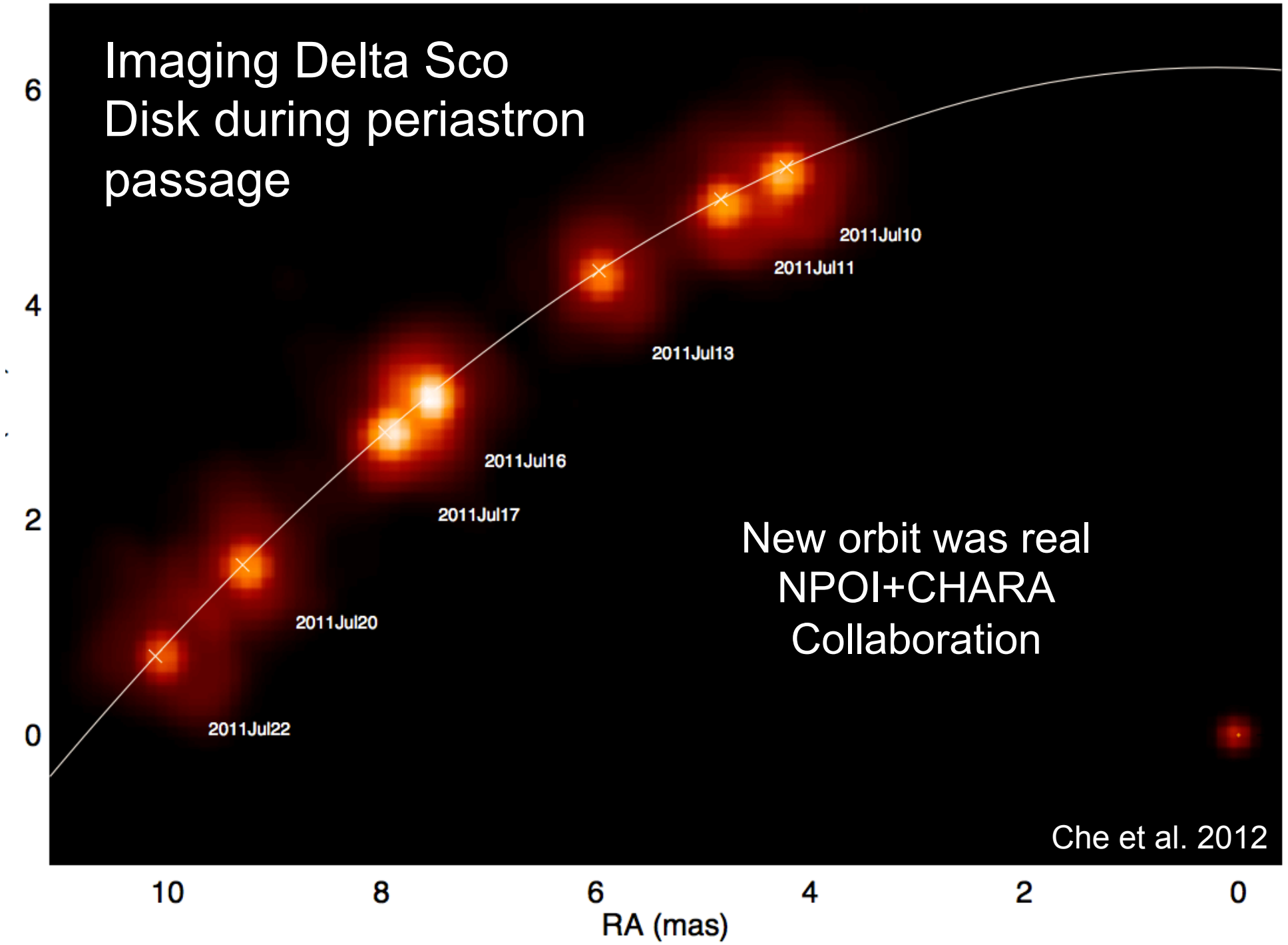

Gallenne et al. 2013

# MIRC's view of Vega

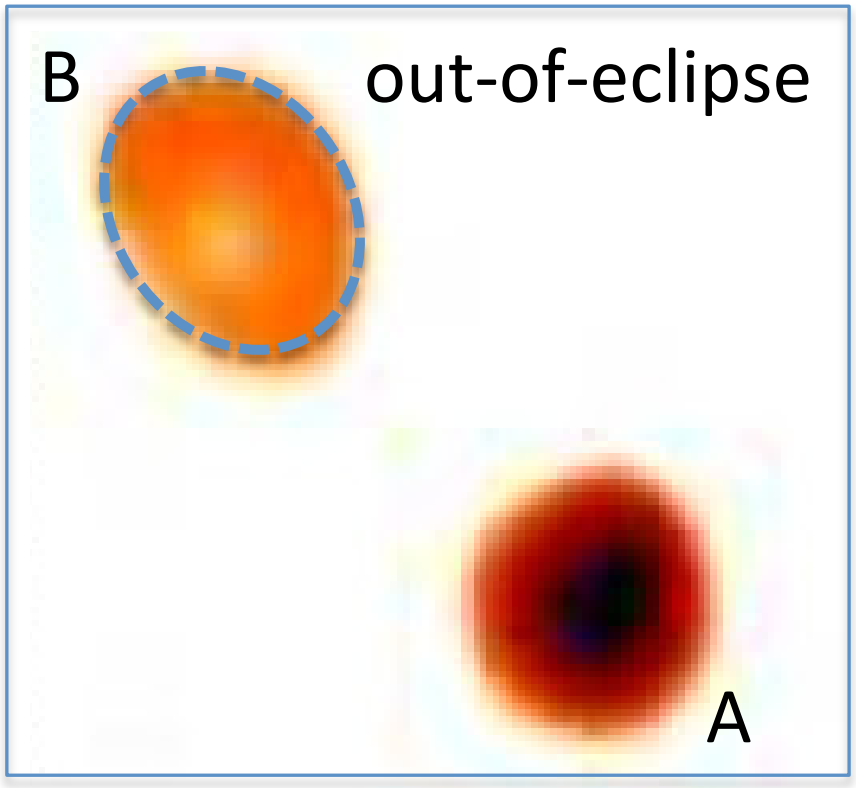



We confirm strong limb-darkening on Vega
and rule out slow rotation models

(although we find a slower rotation speed and higher inclination than previous workers)

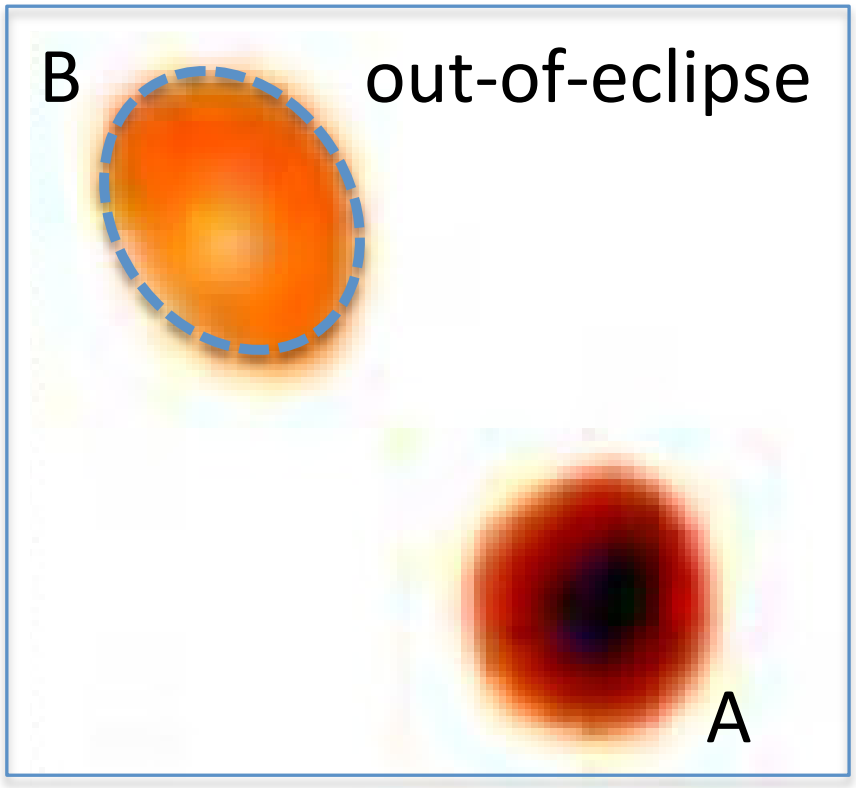

Imaging Delta Sco
Disk during periastron passage
2011Jul10
2011Jul11
2011Jul13
2011Jul16
2011Jul17
2011Jul20
2011Jul22
New orbit was real
NPOI+CHARA
Collaboration
Che et al. 2012
6
4
2
0
10
8
6
4
2
0
RA (mas)

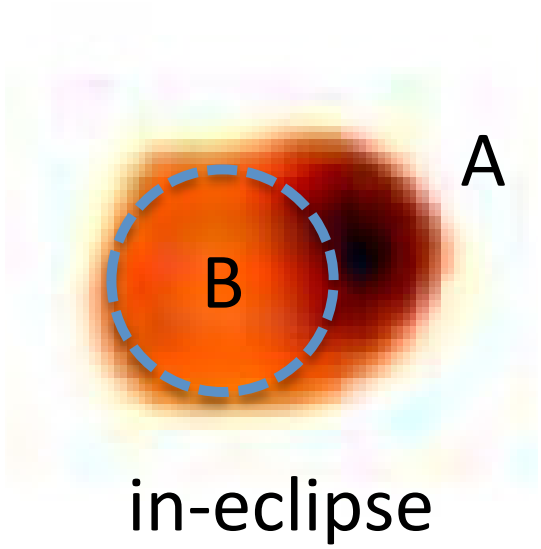
# Algol Snapshots




Baron et al. 2012

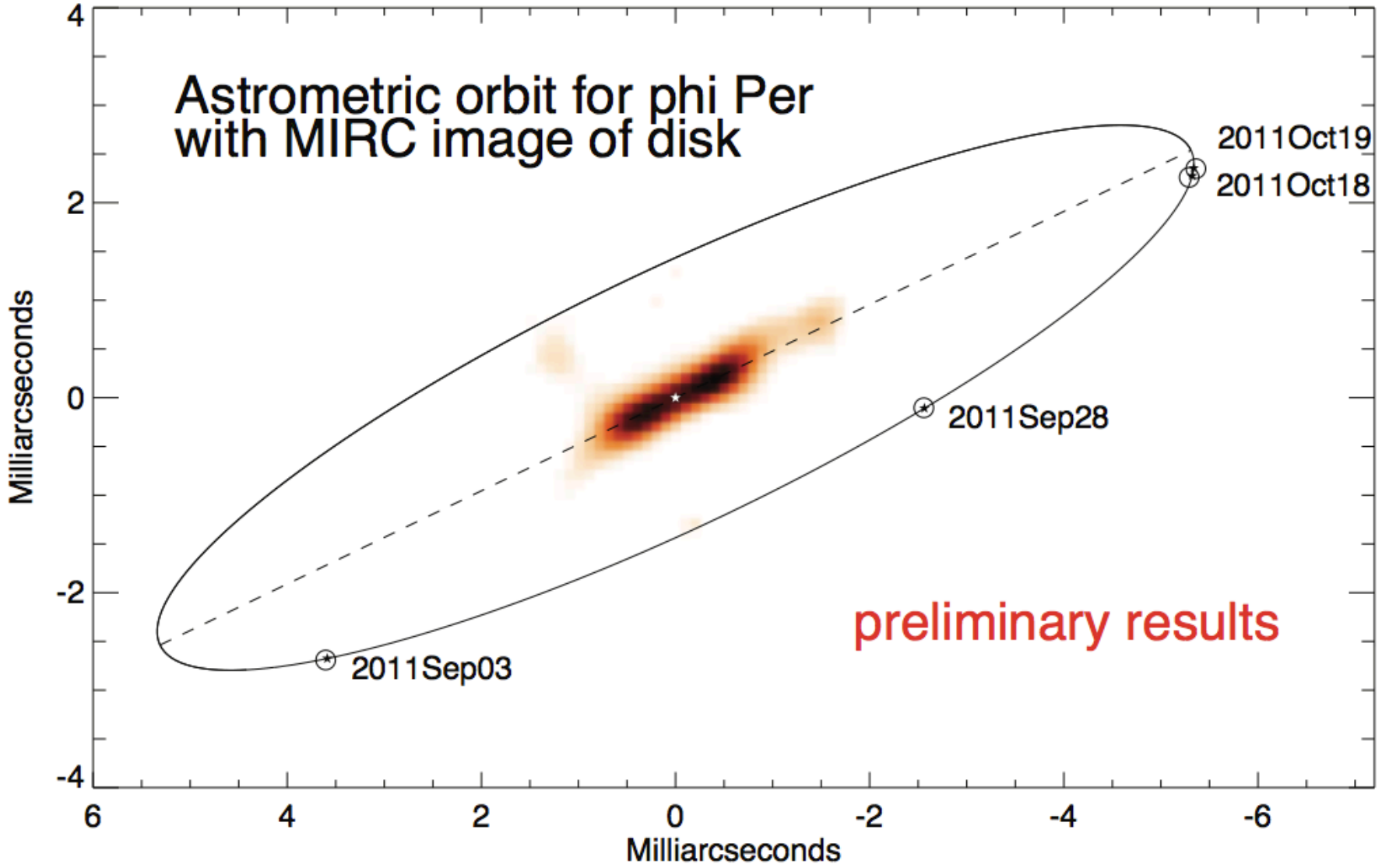
# Algol Snapshots




Baron et al. 2012

# Edge-on Be disk Phi Per



# MIRC: Year 7 (2012) Paper Summary

Publications:

1. Kraus et al. 2012. Beta CMi
2. Smith et al. 2012, Gam Cas I
3. Baron et al. 2012, ALGOL imaging
4. Stee et al. 2012, Gam Cas II
5. Che et al., 2012, Delta Sco
6. Monnier et al. 2012, Vega
7. Gallenne et al. 2013, Binary Cepheids
8. Delaa et al. 2013, Alp Cep
9. Richardson et al. 2013 (submitted), P Cygni

Coming soon…. (we hope)

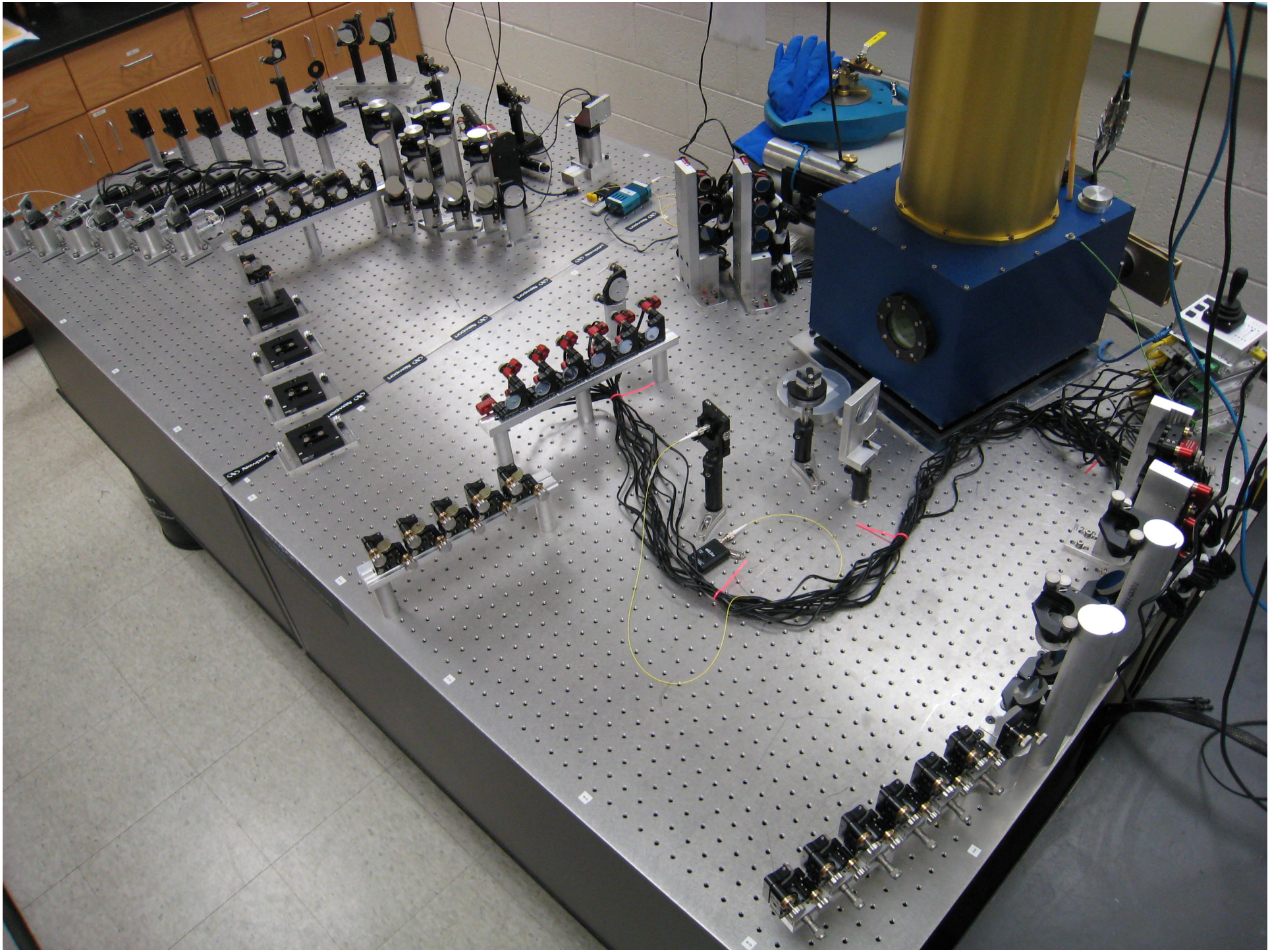
1. MIRC/CHAMP Instrument paper
2. First imaging of YSO with MIRC+CHAMP
3. *Theta Cyg w/ PAVO+MIRC (White)*
4. *Debris disks (Absil)*
5. *Imaging Red Supergiants (Baron)*
6. Imaging Spots (Roettenbacher; *Parks*)
7. Epsilon Aurigae Followup (Kloppenborg)
8. Phi Per with MIRC and Vega (Mourard)

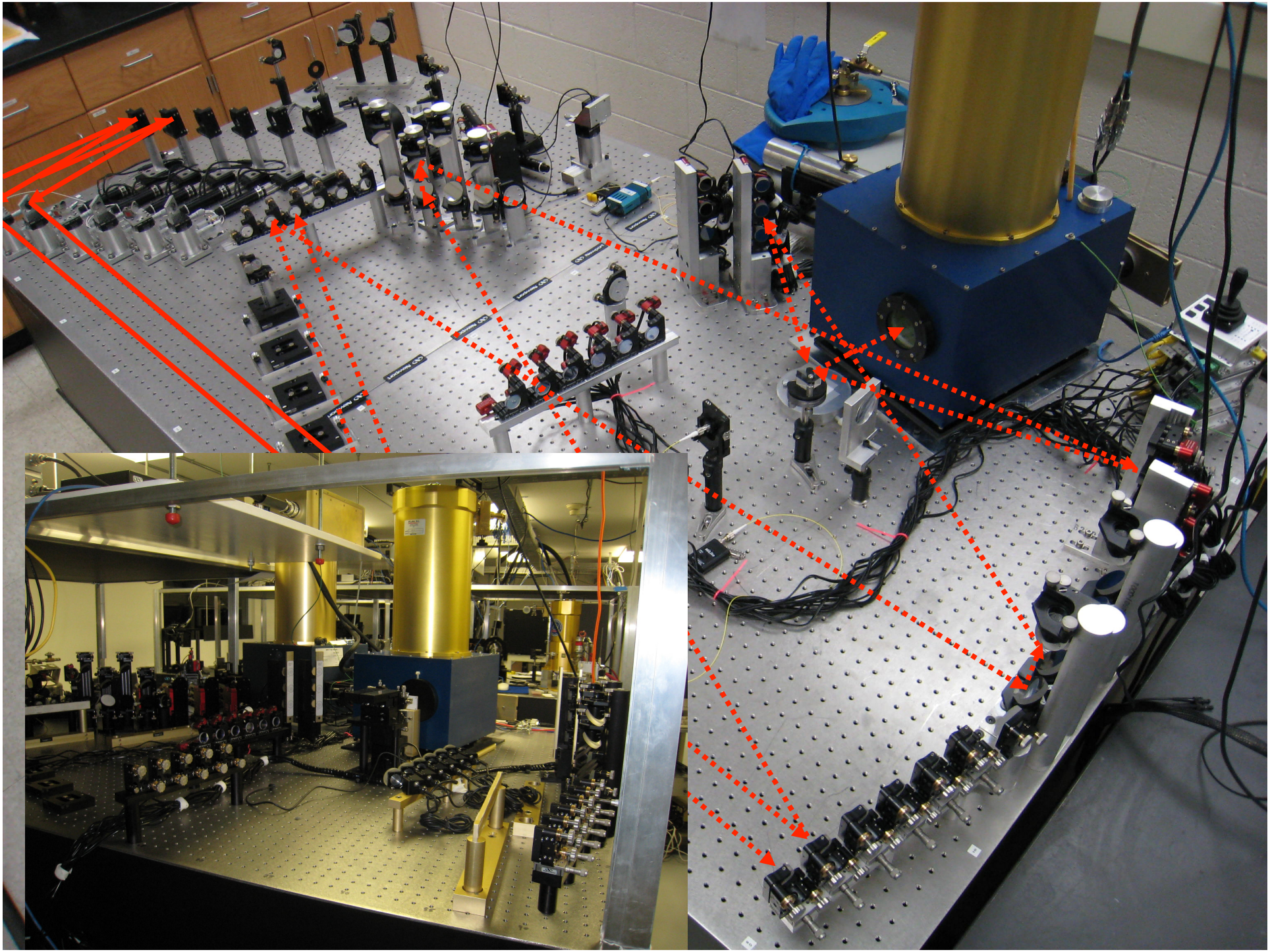
# CHAMP: Status

Guiding Principles:

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

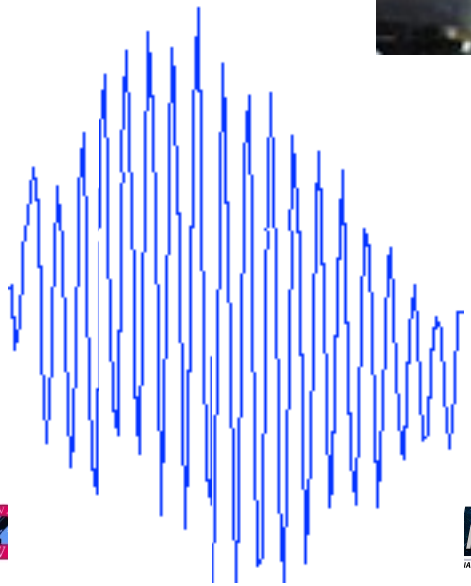
- Combines all 6 CHARA telescopes (1-2,2-3,3-4,4-5,5-6,6-1)
  - Operated successfully with MIRC in June 2012
- Works at J (1.25 micron), H (1.65 micron) and K (2.2 micron)
  - New J band laser blocking filters
- Demonstrated sensitivity: K~5 (goal K~7-8)
  - Long stroke piezos improve coherencing
- Spectral resolution: R~ 5 (i.e., none)
- Computer upgrade planned in 2013





# CHAMP v2.0

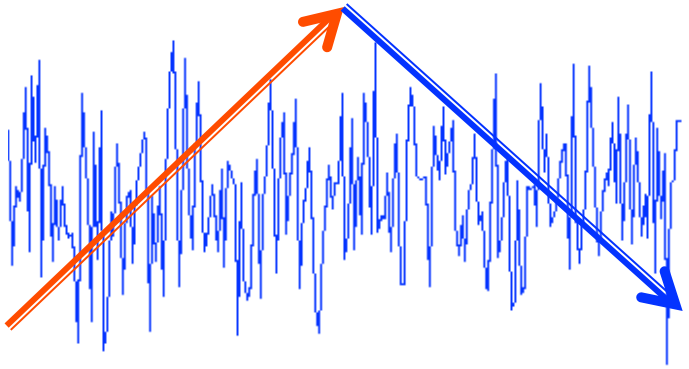
- New PZTs
  - Longer stroke 8->100 mu
  - Closed loop
- Envelope tracking
- J band mode



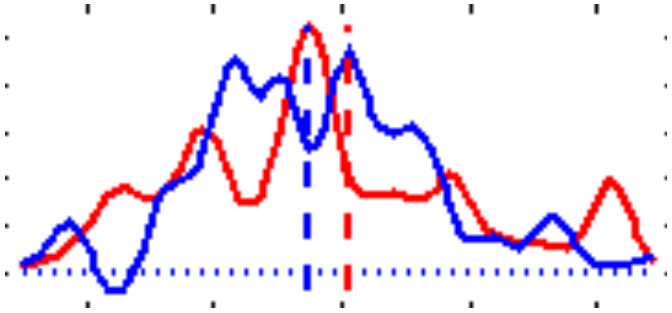
# Tracking Faint Fringes

## Current Method

- ABCD across scan
  - acts as Fourier filter
- Correlate amplitude^2 with matched filter
- Control of fringe drop-outs, intelligent reacquisition, careful thresholding
  - Not so easy

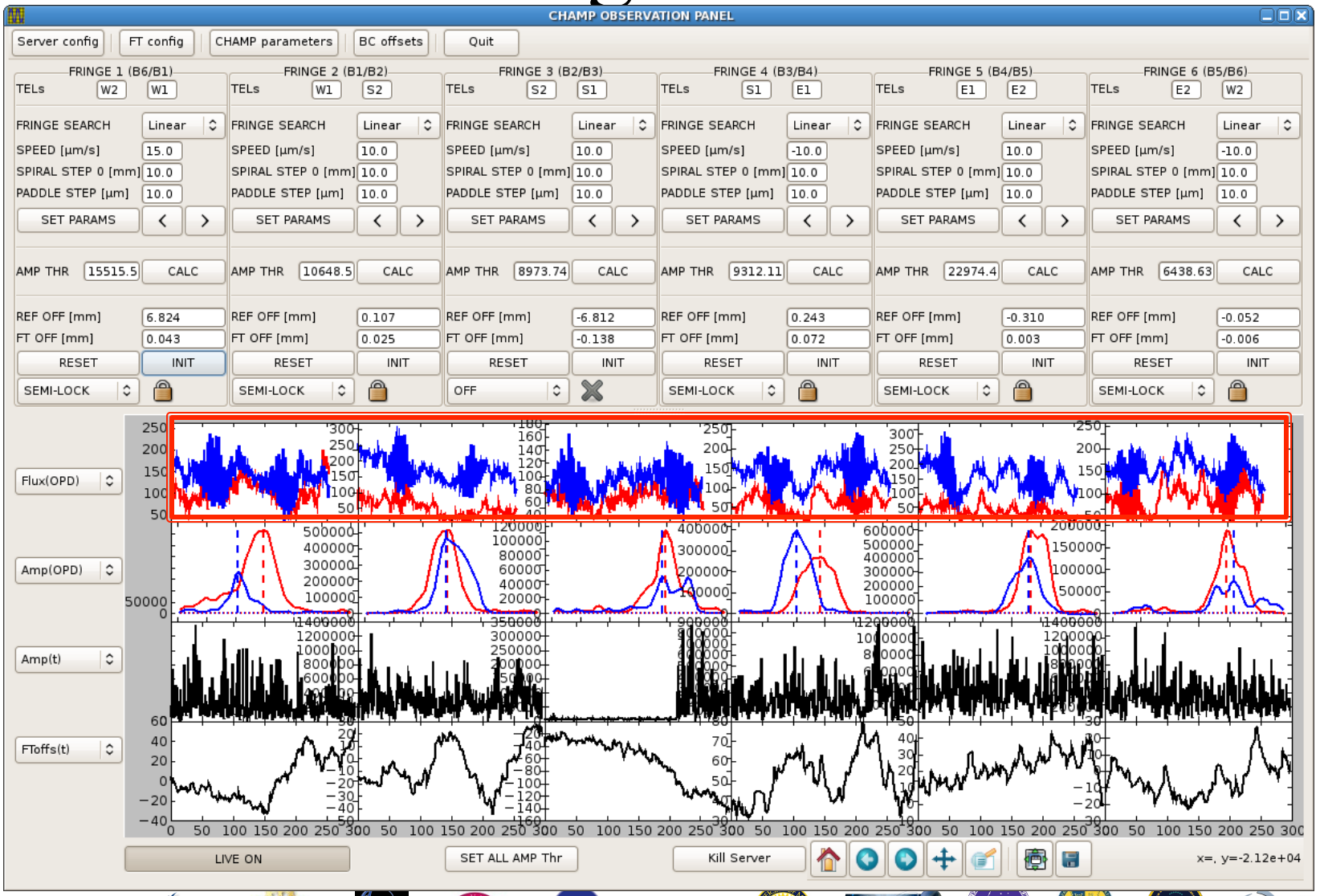


Big Triangle Scan



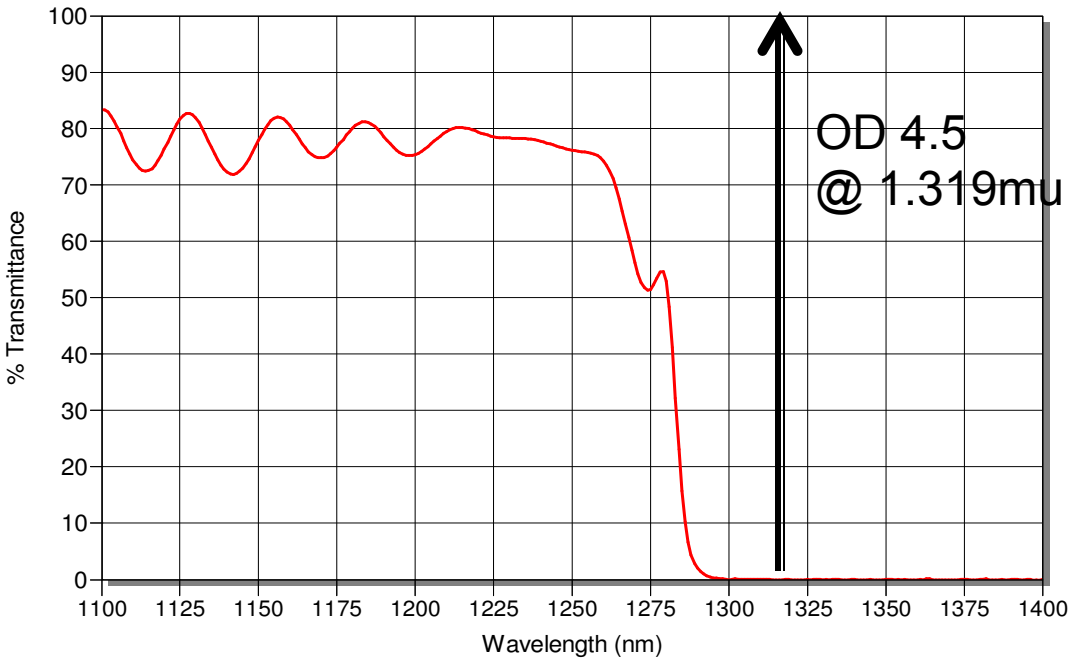
Fringe Envelope
Matched Filter

# Six Fringes in New Mode

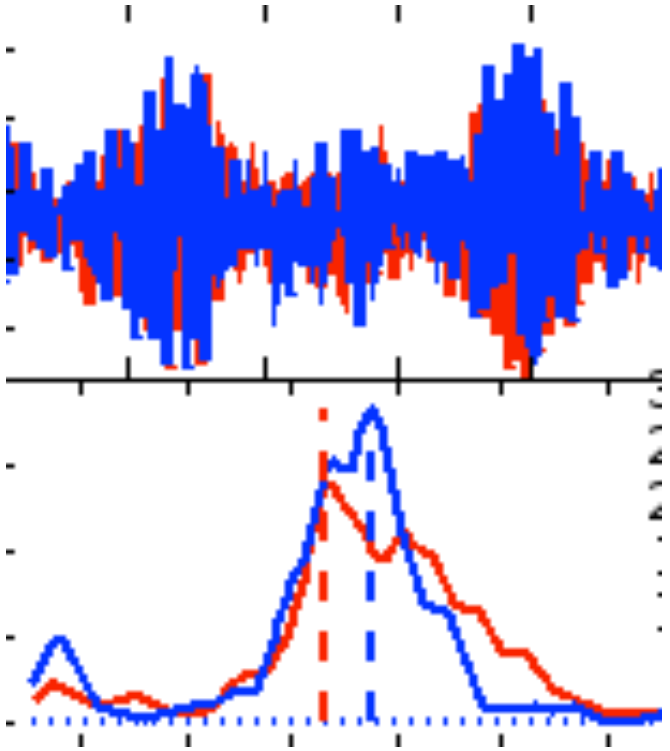


# New J band mode

New Brinnell Vision
Metrology-suppression filter




On-sky tracking at J



This filter is superceded thanks to Judit's improvements to metrology supression!!

# MIRC/CHAMP Issues

- Discovered a 1.0-0.5% cross talk ($V^2$) between neighboring fringes
  - Rarely a problem – but will likely motivate a re-write of pipeline.
- MIRC hard drive chassis continues to cause problems
  - No one should ever touch MIRC computer or hard drives
- MIRC camera communication problem causing data loss
  - Used to be rare but is getting more common (reboot not always successful)
- MIRC Photometric channels seem to need regular realignment
  - We need to test Xiao's instructions on this. Could be a maintenance problem
- MIRC calibration is still sometimes surprising poor, 10-20%
  - Vibrations? Can we save metrology/TT statistics with time stamps in easy form?
- CHAMP PZT/Camera sync strategy not good for long-stroke PZTs
  - Need to re-do voltage drivers and camera trigger synchronization (not small job)
- Alignment lasers at CHARA have gotten very weak again
  - Can barely use for MIRC and impossible for CHAMP

# MIRC & CHAMP Improvements planned for 2013

- 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

- Personnel
  - Stefan Kraus (Sagan Fellow) left for faculty job at Exeter (UK)
  - Fabien Baron (UM) leaving 4/1 for faculty job at GSU
    - Including new postdoc to help do imaging with MIRC
  - Rachael Roettenbacher should start full-time graduate research 2013
  - Xiao Che will graduate by early 2014
  - Undergrad Matt Anderson accepted to GSU for grad school
- Data Analysis Pipelines
  - Improved IDL-based CLASSIC and MIRC pipelines
  - Complete IDL libraries distributed via svn
  - IDL pipeline for CLIMB not quite there yet (later this year)
  - Google + Community for MIRC users
  - Undergrad Sam Swihart learning pipeline in order to crunch through MIRC archive

# UM News (more)

- Starting to lab test CHARA coatings for polarization properties with Nate England
- We hosted an excellent Imaging Workshop in 2012 August
  - Organized mostly by Fabien Baron
- Xiao Che is building CHARA AO upgrade wavefront sensors and software
- Applying to NSF and NASA for new SELEX Saphira detector
  - 1-2 e- read noise
- Work on near-infrared fiber link

# MIRC Reflections

- Contrary to many theoretical papers, practical experience shows a 4T combiner is superior to serial 3T observations – and 6T even better!
  - Flexible baseline bootstrapping for resolved objects
  - 4T-bootstrapping allows triangles with 2 weak arms
  - Snapshots important for time-variable objects
  - Astronomers can do science faster
  - Complex imaging soon in the visible at CHARA or NPOI?
- Multi-combiner projects not successful yet
  - Labor shortage? Data too complex? Collaboration difficulties?
- Emerging trends with MIRC
  - Big Imaging campaigns (next year: beta lyra, zet and)
  - More smaller collaborations with new PIs (usually binary stars)

# CHAMP Reflections

- Still difficult to observe YSOs due to
  - Challenges with bootstrapping (there is no central CHARA station)
  - YSO K band visibilities are low (V<20%)
  - Success on MWC 361, MWC 275, but requires good seeing
- If I get a chance to re-do this someday:
  - Integrated optics or MIRC-style combiner to get ALL baselines and to ease the alignment burden of free-space beam combiner
  - Combined H and K band system (two cameras for simultaneous work)
    - Fringe tracking might be using some fringes at H and others at K
  - New detector with lower readnoise (would make H and J band modes more practical)

- Looking forward to more discussion at this meeting on:
  - Data pipelines
  - User feedback on instrument performance and pipelines
    - Please complain more (with evidence)
  - Unified web resources for CHARA and instruments?
    - Software, documentation, best practices, updates, cookbooks, user feedback, archives, calibration files
  - Public archives and Data Rights
  - New instrument ideas
  - Future directions for CHARA