



# MIRC/CHAMP Status and Updates

Ming Zhao

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Ettore Pedretti, Nathalie Thureau, Xiao Che

Nice, France, 2009 March







# Outline

- Current Status of MIRC
  - Sensitivity, Calibration, Modes
  - Planning, Observing, and Data Reduction
  - Personnel
- Summary of MIRC Observations
- MIRC Improvements
- CHAMP Overview
- Problems



# MIRC: Status

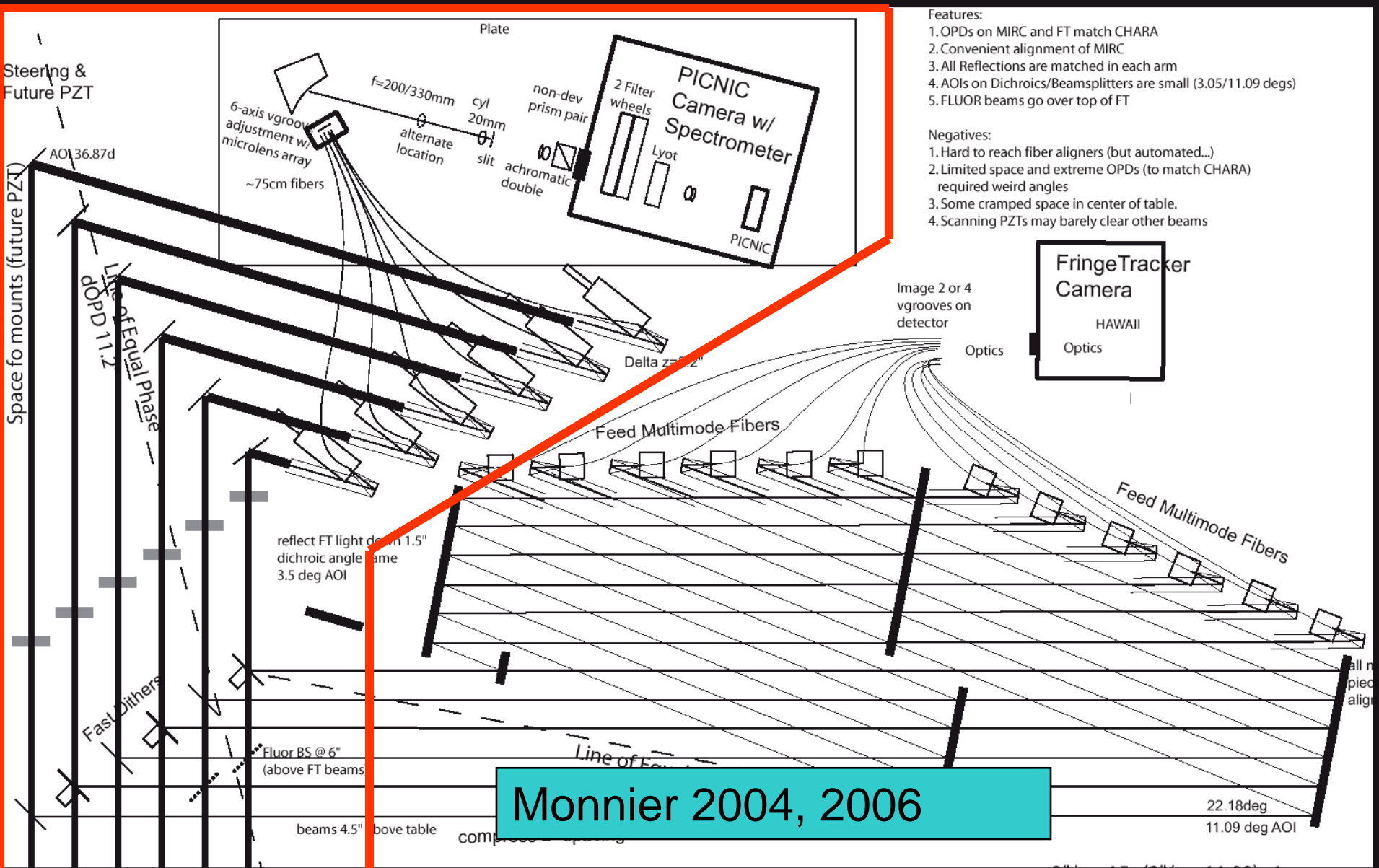
## Guiding Principles:

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

- Combines 4 telescopes at present
- Works at H (1.65 micron) and K (2.2 micron)
- Demonstrated sensitivity: H~ 4.0, K~3.5
- Spectral resolution:  $R \sim 44, 150, \text{ or } 400$ 
  - we successfully observed with  $R \sim 150$  Grism at H band and  $R \sim 400$  Grism at Ks band
- Calibration:  $V^2$  error  $\sim 10\% - 20\%$ ; CP error  $\sim 2^\circ - 5^\circ$  (for 6min obs.)
- Photometric Channel on the way, expecting  $V^2$  error  $\sim 1\%$
- Fringe tracker CHAMP expected this summer



# Optical Layout



Features:

- 1. OPDs on MIRC and FT match CHARA
- 2. Convenient alignment of MIRC
- 3. All Reflections are matched in each arm
- 4. AOIs on Dichroics/Beamsplitters are small (3.05/11.09 degs)
- 5. FLUOR beams go over top of FT

Negatives:

- 1. Hard to reach fiber aligners (but automated...)
- 2. Limited space and extreme OPDs (to match CHARA) required weird angles
- 3. Some cramped space in center of table.
- 4. Scanning PZTs may barely clear other beams

Monnier 2004, 2006

22.18deg  
11.09 deg AOI





# MIRC: Observing

- Acquire Star [5min]
- Fiber Explorer Tool [~15-20 min for 4 tels]
  - Will be much faster with the photometric channel
- Find all Fringes and Lock [~10 min 4 tels]
  - Will be much faster with the fringe tracker
- Fringe data [5 minutes]
- Shutter Matrix [5 minutes]
- More fringes [5 minutes]
- Shutter matrix [5 minutes]

Total Time if lucky: ~50-55 minutes      Total time will be less

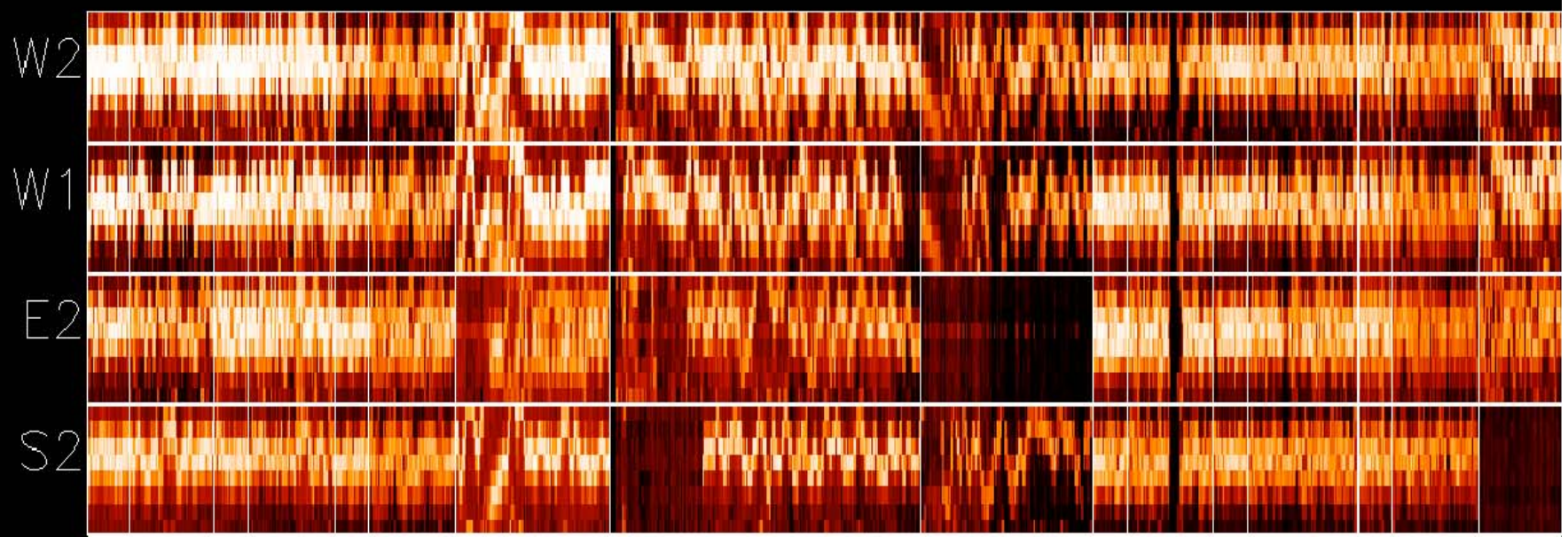
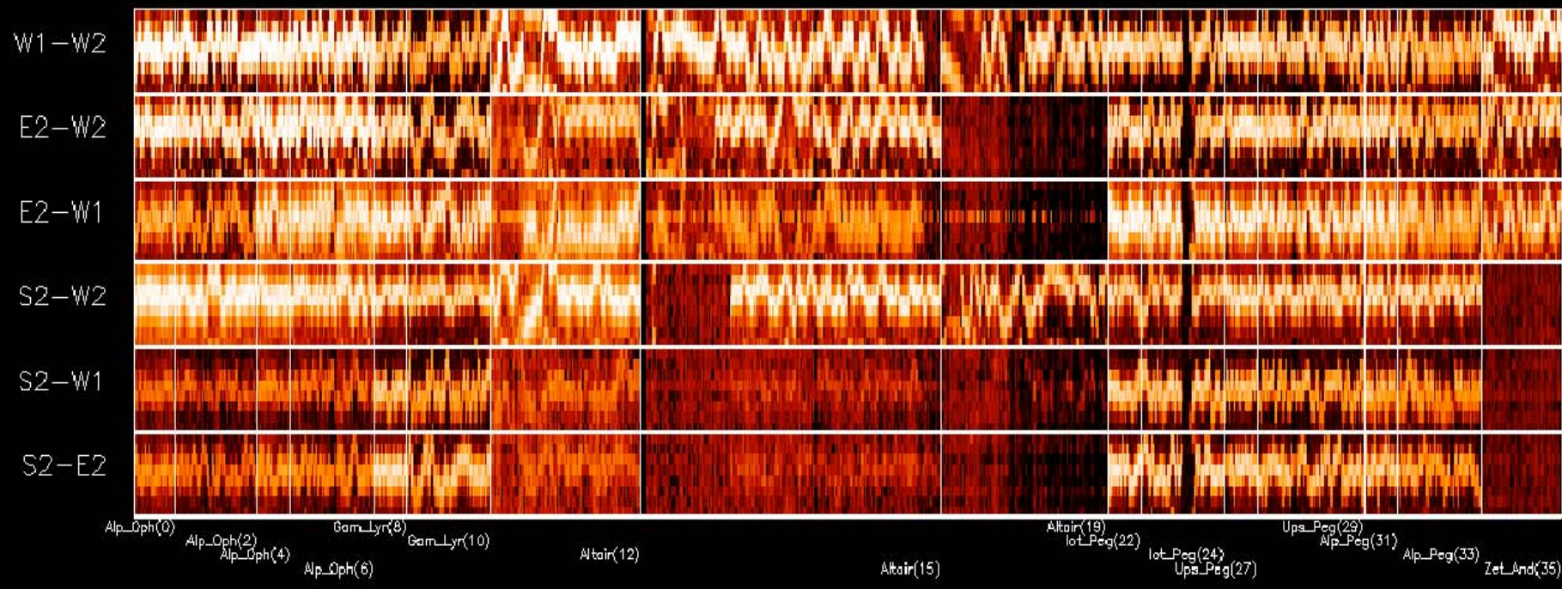
On best night we could average 1 hr per object

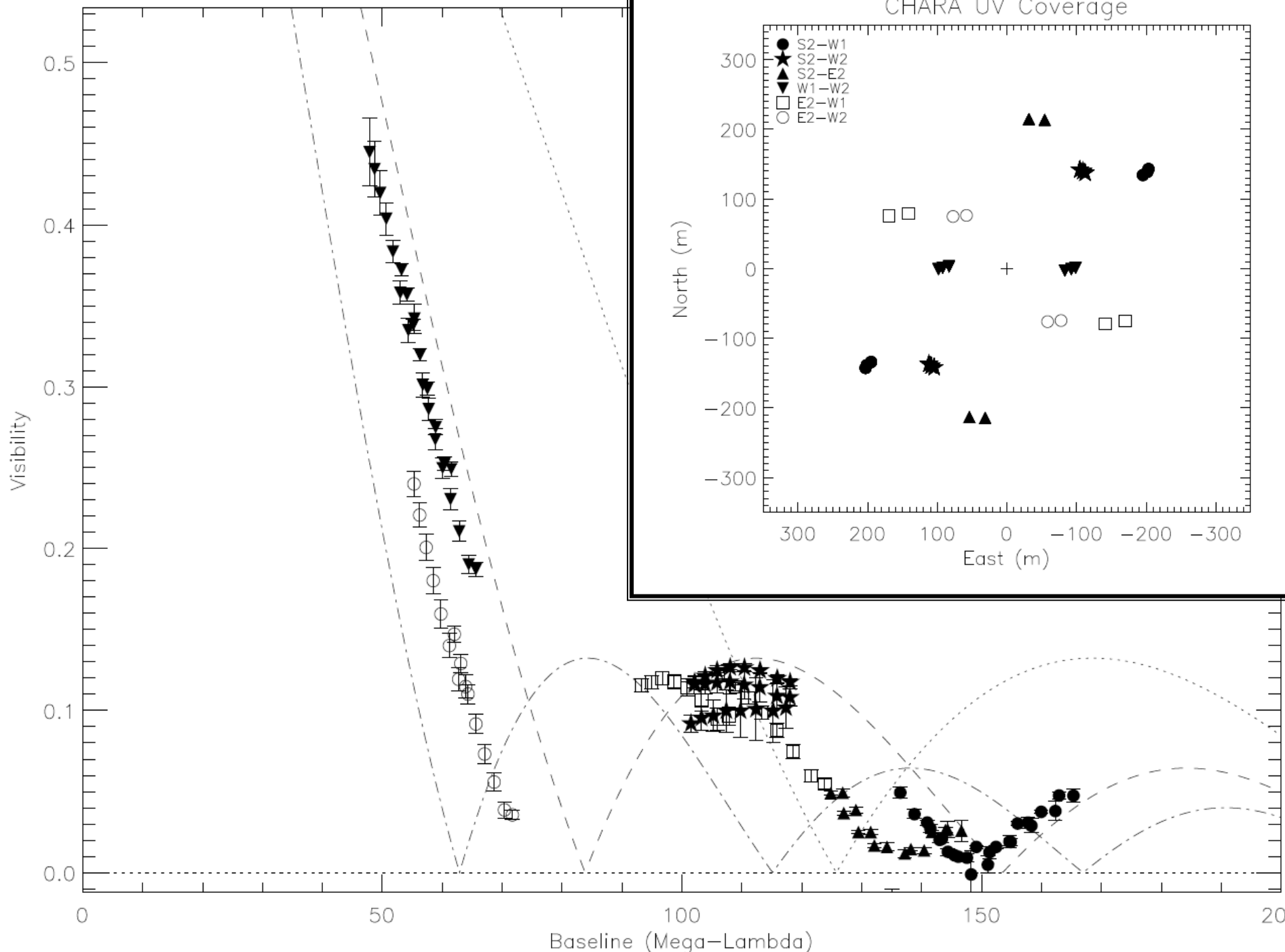


# MIRC Data Pipeline

- Most of the steps are automatic, need few interactions.
- Interactive in the last step (calibration) - very flexible
  - Choose target cal's w/ diameters
  - Choose averaging method (split data up into chunks)
  - Edit data to find lost fringes
  - Inspect data in detail
  - Save reduced data in a FULL OI-FITS data format
- Create summary plots for inspecting full richness of data
- Modeling and Imaging

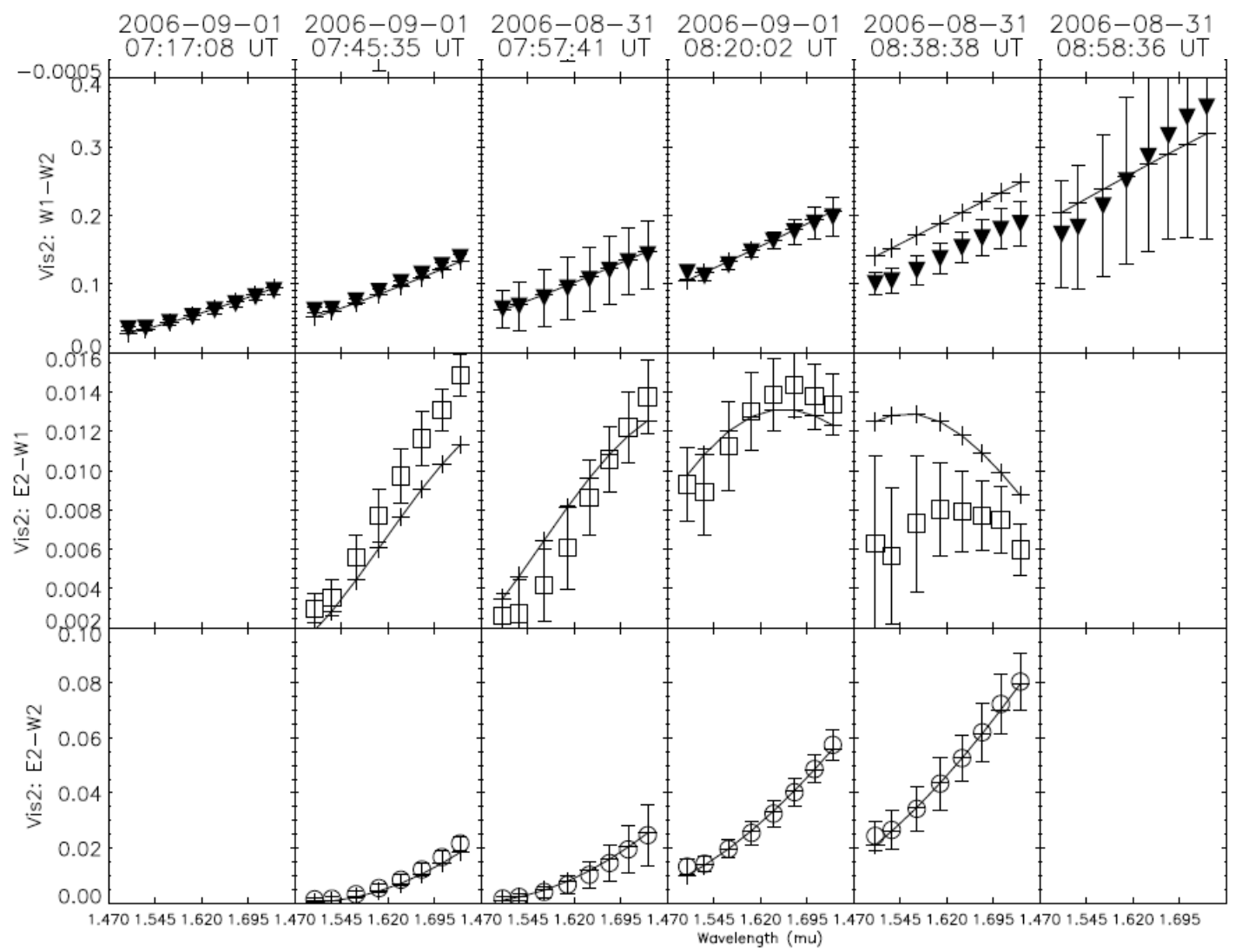








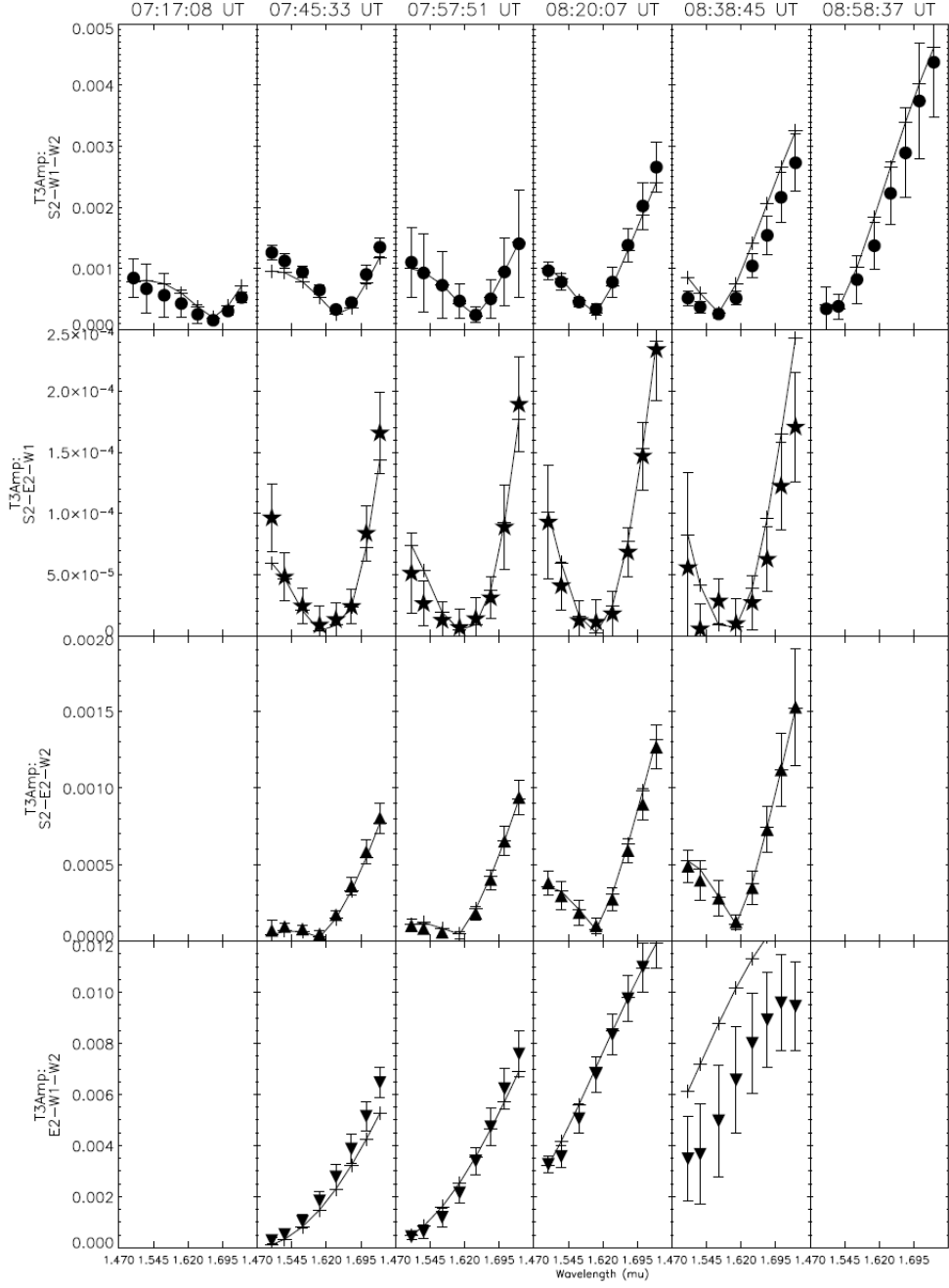
# CHARA Collaboration Year-Five Science Review



LESIA

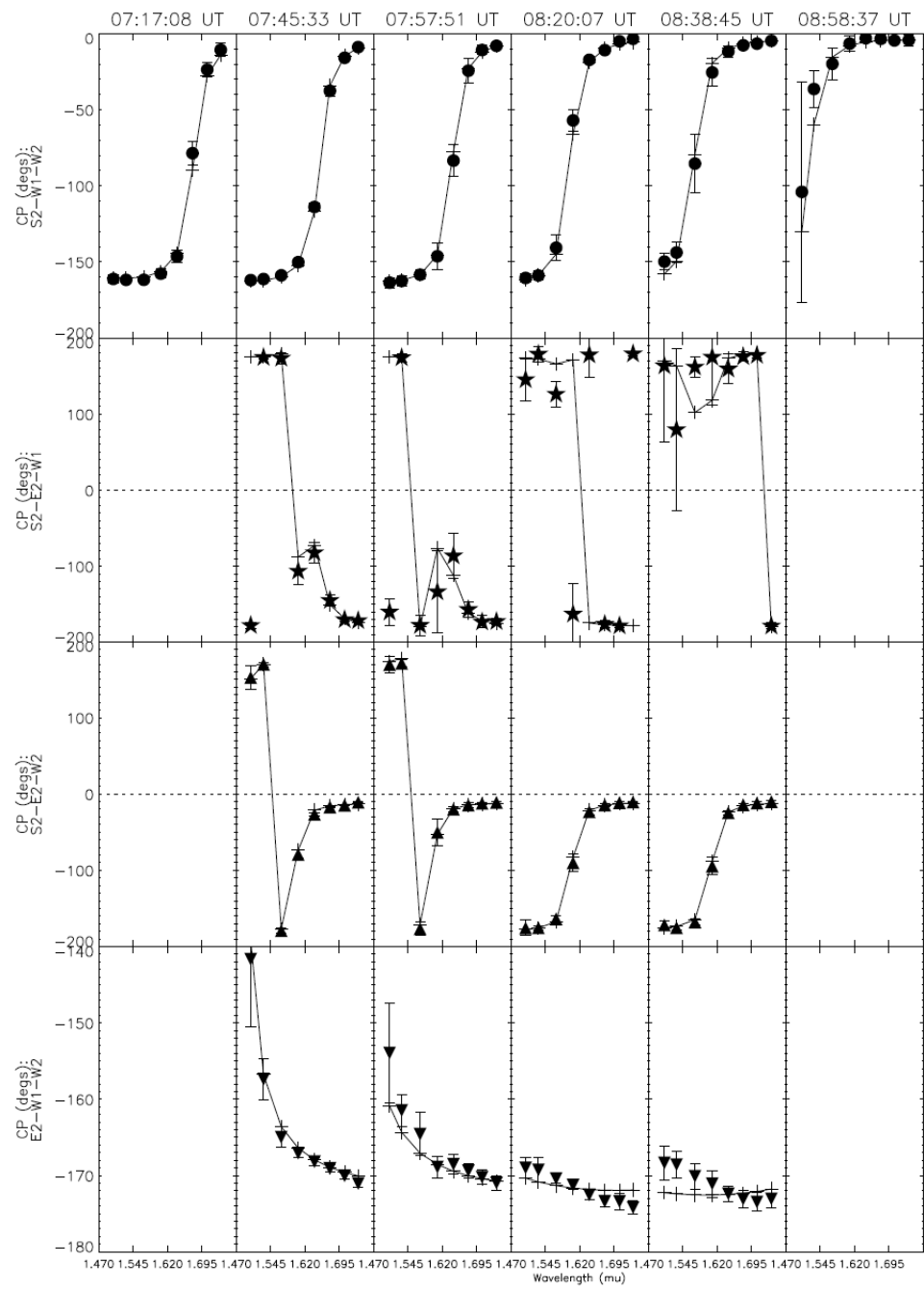


Observatoire de la CÔTE d'AZUR





# CHARA Collaboration Year-Five Science Review



Observatoire de la CÔTE d'AZUR



# MIRC: Progress towards becoming a “Facility Instrument”

- MIRC can now be observed by non-Michigan teams
  - Well documented start-up and alignment procedures
  - But one still needs to be trained to run MIRC (mostly for fringe locking and fiber exploring)
- This year the Michigan team decided to focus on CHAMP and thesis.
- There are more MIRC experts: Gail, Yamina, Rob
- Data pipeline is better documented
  - Distribution of software through Subversion
  - New step-by-step data reduction manual
  - Visit to Michigan is still highly recommended



# Personnel

- Ettore Pedretti and Nathalie Thureau are at St. Andrews
- Dave Berger is in a company near DC
- Ajay Tannirkulam graduated and is now in a company in India
- Ming Zhao is graduating and will be a postdoc at Wesleyan
- Gail Schaefer is now an expert of MIRC
- New graduate student, Xiao Che, is working on MIRC data and building the photometric channel
- Two new postdocs this Fall: Stefan Kraus (Sagan Fellow), Fabien Baron (CHAMP science)



# MIRC: Year 2&3 (2007, 2008)

## Summary

- Observing
  - 2008: 42 nights in total with 30 nights of data (66%)
  - 2007: 57 nights in total with 24 nights of data (42%)
  - Causes of downtime: weather, delaylines, power failure, fire
- Projects:
  - Rapid rotators: Monnier, Merand
  - Hot Jupiters: Zhao
  - Be stars: Monnier, Gies, Schaefer
  - Binaries: Zhao, Pedretti, Merand, Kotani, Stencel
  - Spotty stars: Parks, Pedretti
  - Supergiants: Kiss
  - Debris Disks: Akeson
  - Miras: Ridgway





# MIRC: Year 3 (2008) Summary

- Publications:

1. Monnier et al. 2007, Science, “Imaging Altair”
2. Zhao et al. 2008, ApJL, “Imaging Beta Lyr”
3. Zhao et al. 2008, Proceedings of SPIE, “Ups And”
4. Kiss et al. 2008, Conference Proceeding, “Red Supergiants”
5. Zhao et al. 2009, ApJ, “Alderamin and Rasalhague”, submitted

## Expecting:

1. Aufdenberg et al. 2009, ApJ, “Spica”, submit soon
2. Schaefer et al. 2009, “Zet Tau”
3. Zhao et al. 2009, “Hot Jupiter”
4. Pedretti et al. 2009, “Zet And”
5. Kotani et al. 2009, “Theta Dra”
6. Ridgway et al. “Miras”
7. Che et al. “Altair and Vega”
8. Stencel et al, “Eps Aur”



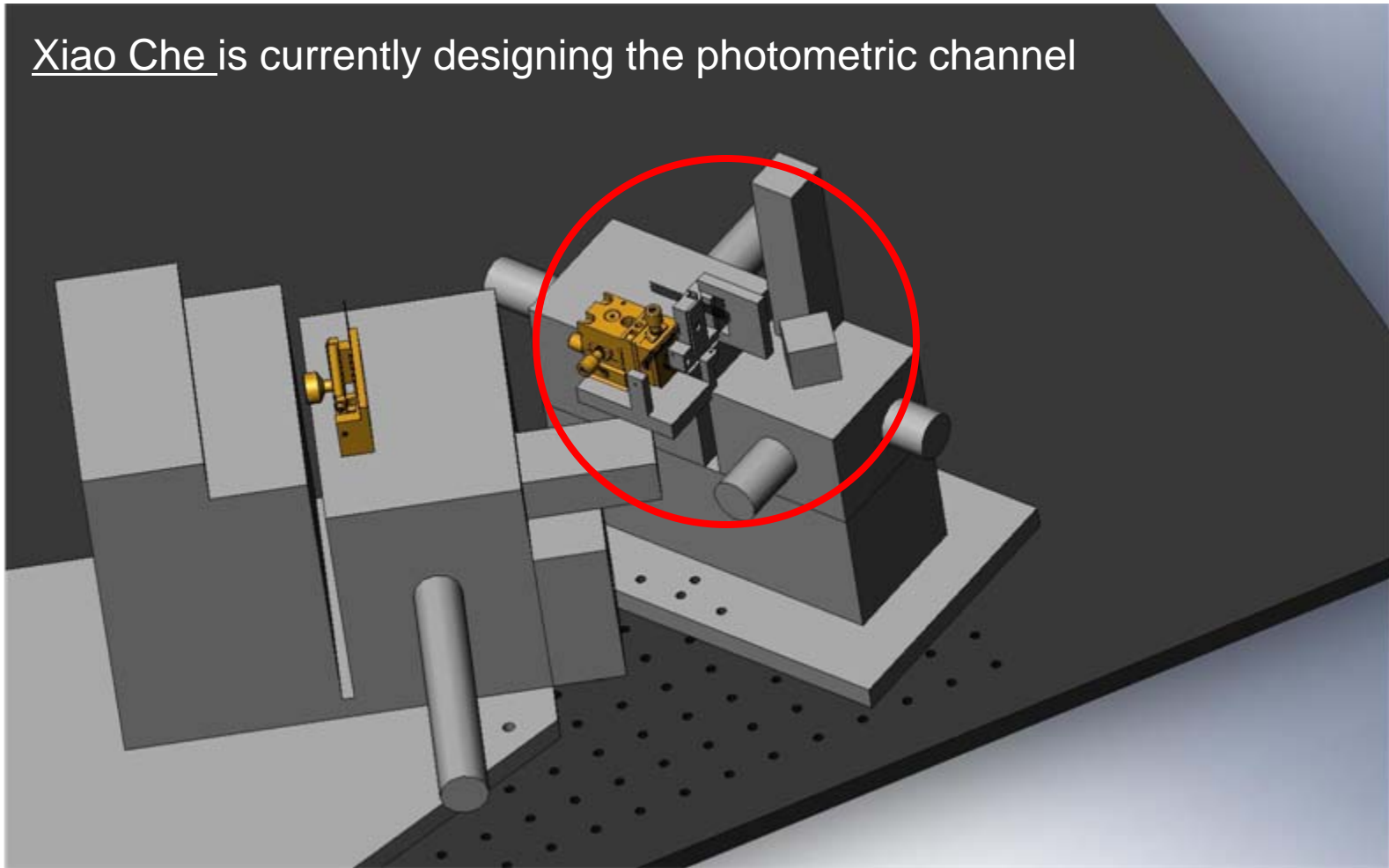
# MIRC Improvements

- Digital chopper signals
- New vacuum pump: much faster
- New fiber mount cabling
- Fixed three broken stepper motors
- Automated starting sequence: all-in-one start-up
- Better data spooling scheme: less glitch when taking data
- MIRC Planning Tool now supports 3, 4, 5 or 6 -Telescope planning
- Data reduction manual
- Photometric Channel
- CHAMP



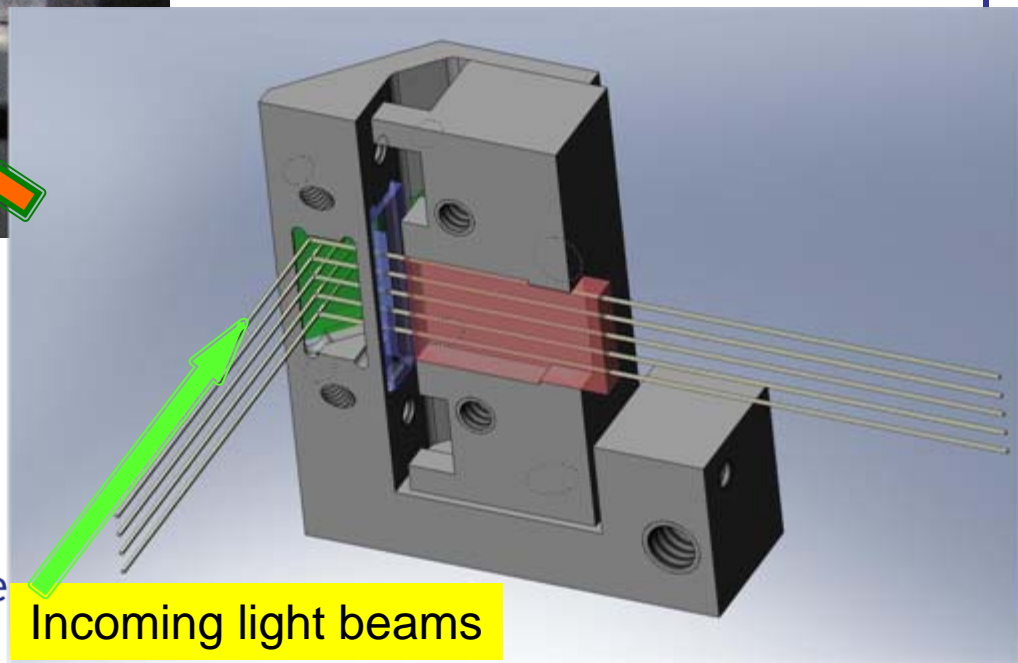
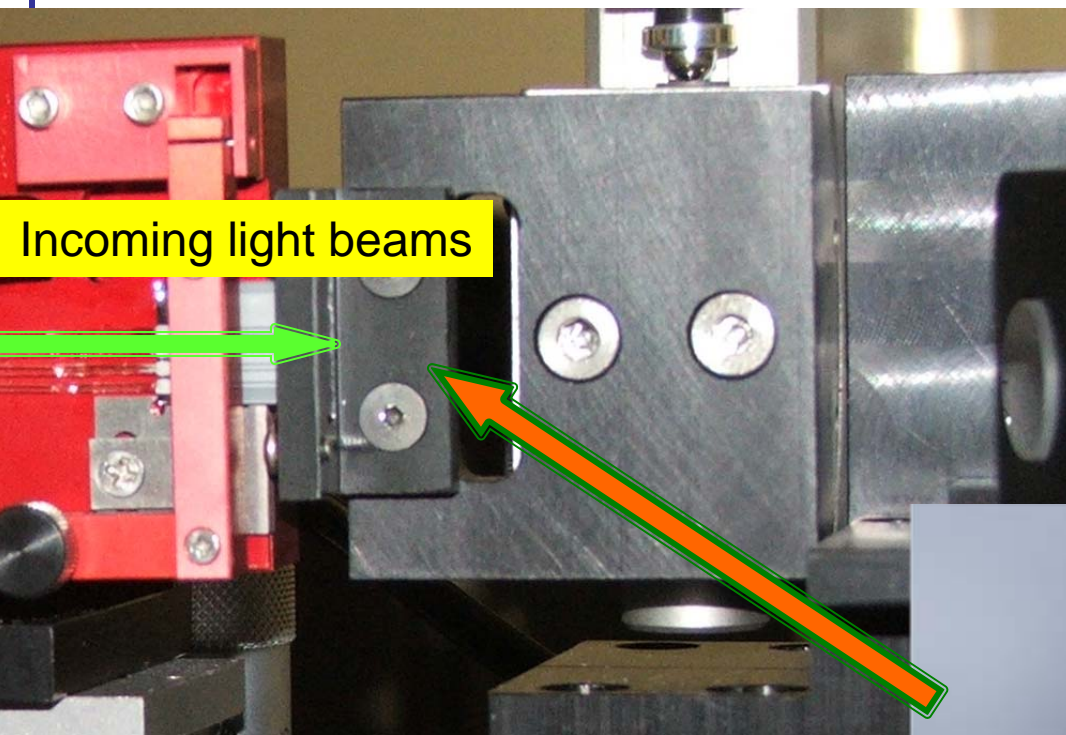
# Photometric Channels

Xiao Che is currently designing the photometric channel





# Photometric Channels



Xiao Che 2009



Incoming light beams



# CHAMP: CHARA Michigan Phase-tracker

Dave Berger, John Monnier

Rafael Millan-Gabet, Ettore Pedretti,  
Toby Eckhause, Theo ten Brummelaar,  
Phil Iriwin





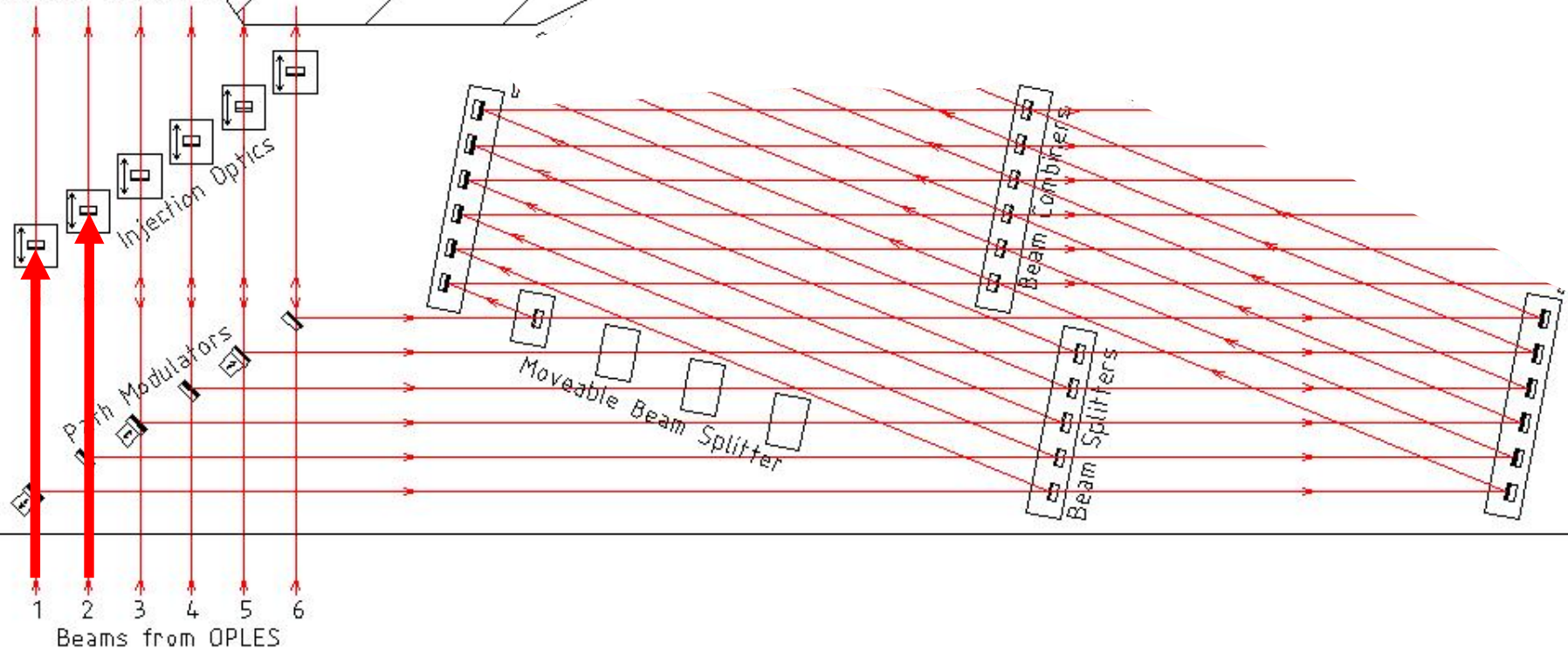
# CHAMP: Design Overview

- Operate in J, H, or K (1 to 2.4 microns)
- Separate fringe tracker from science combiners
- Optimized for sensitivity: H=7-8
- Fringe phase measured simultaneously on 6 baselines up to 500Hz

MIRC

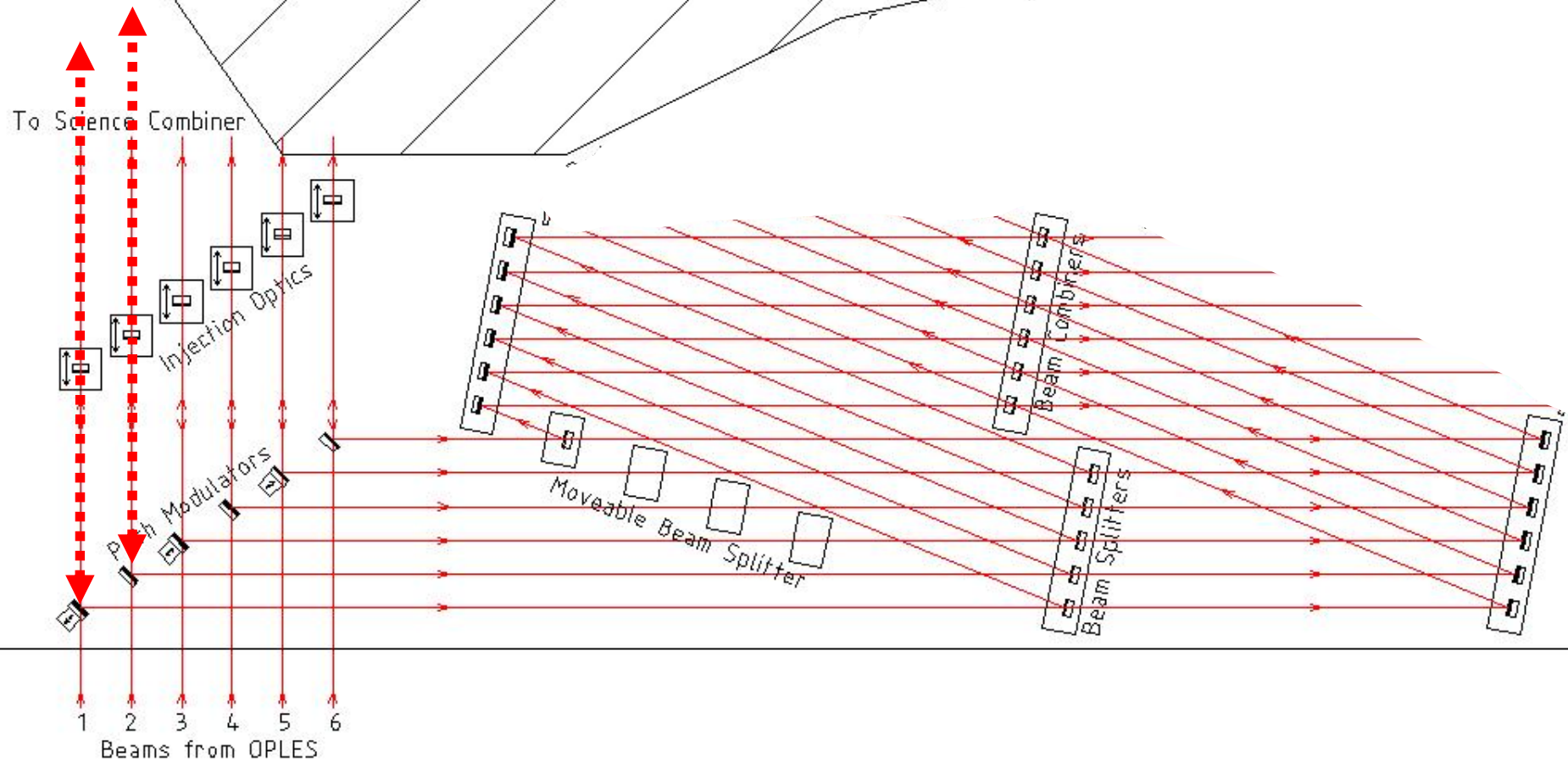
CHAMP

To Science Combiner



MIRC

CHAMP



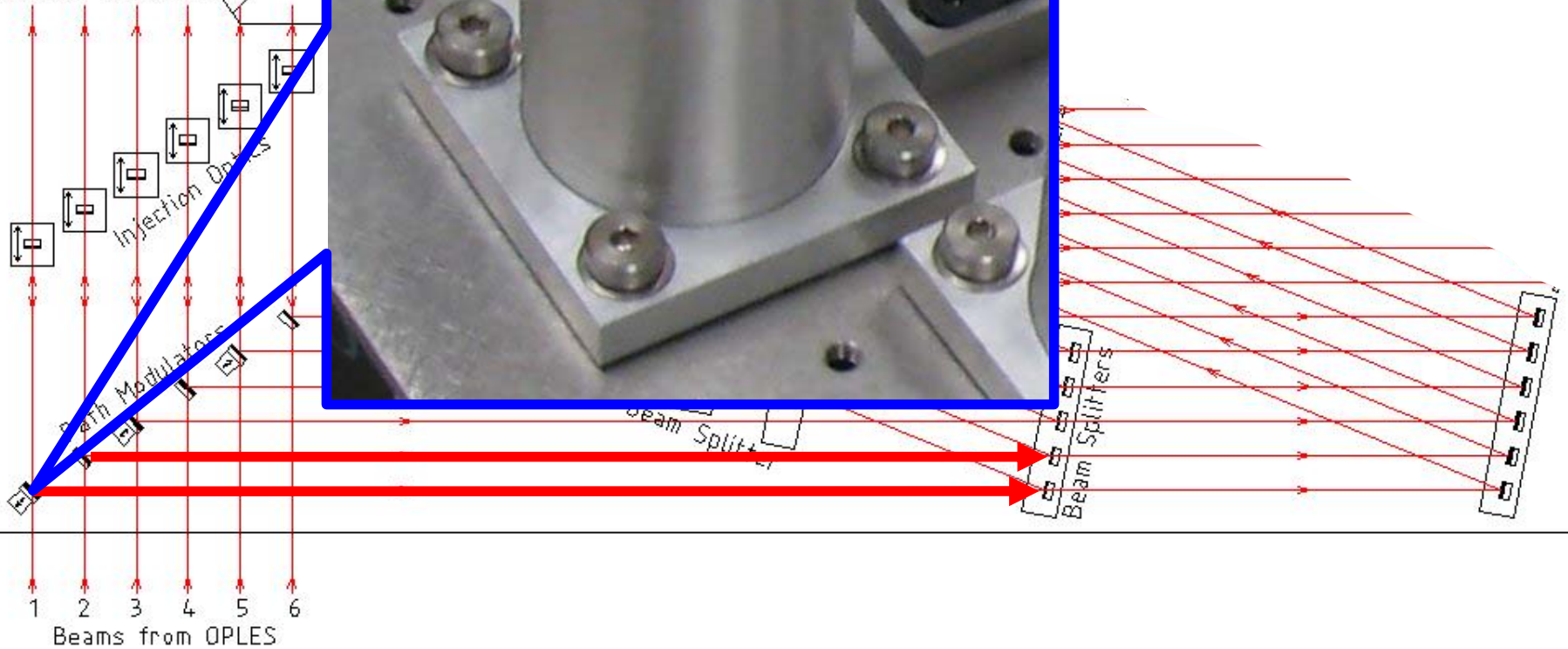


MIRC

CHAMP



To Science Combiner

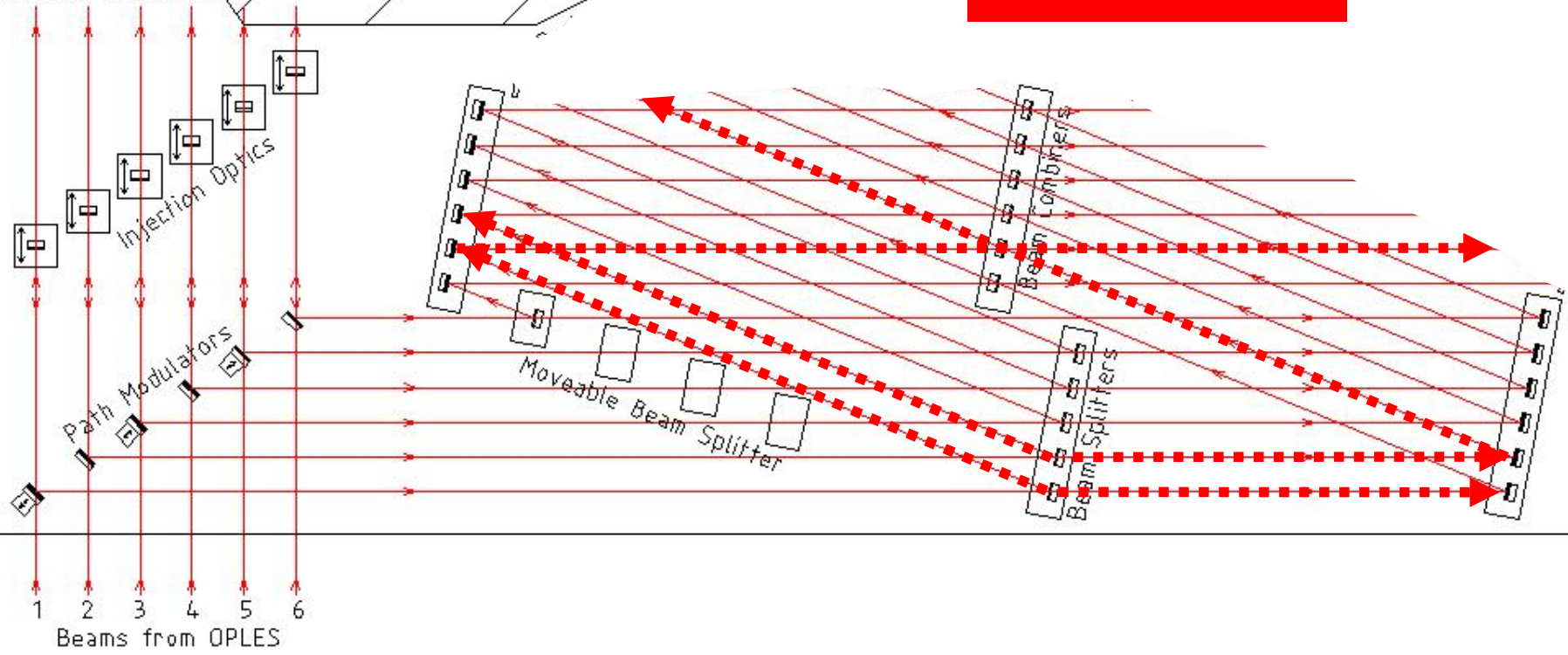


MIRC

CHAMP

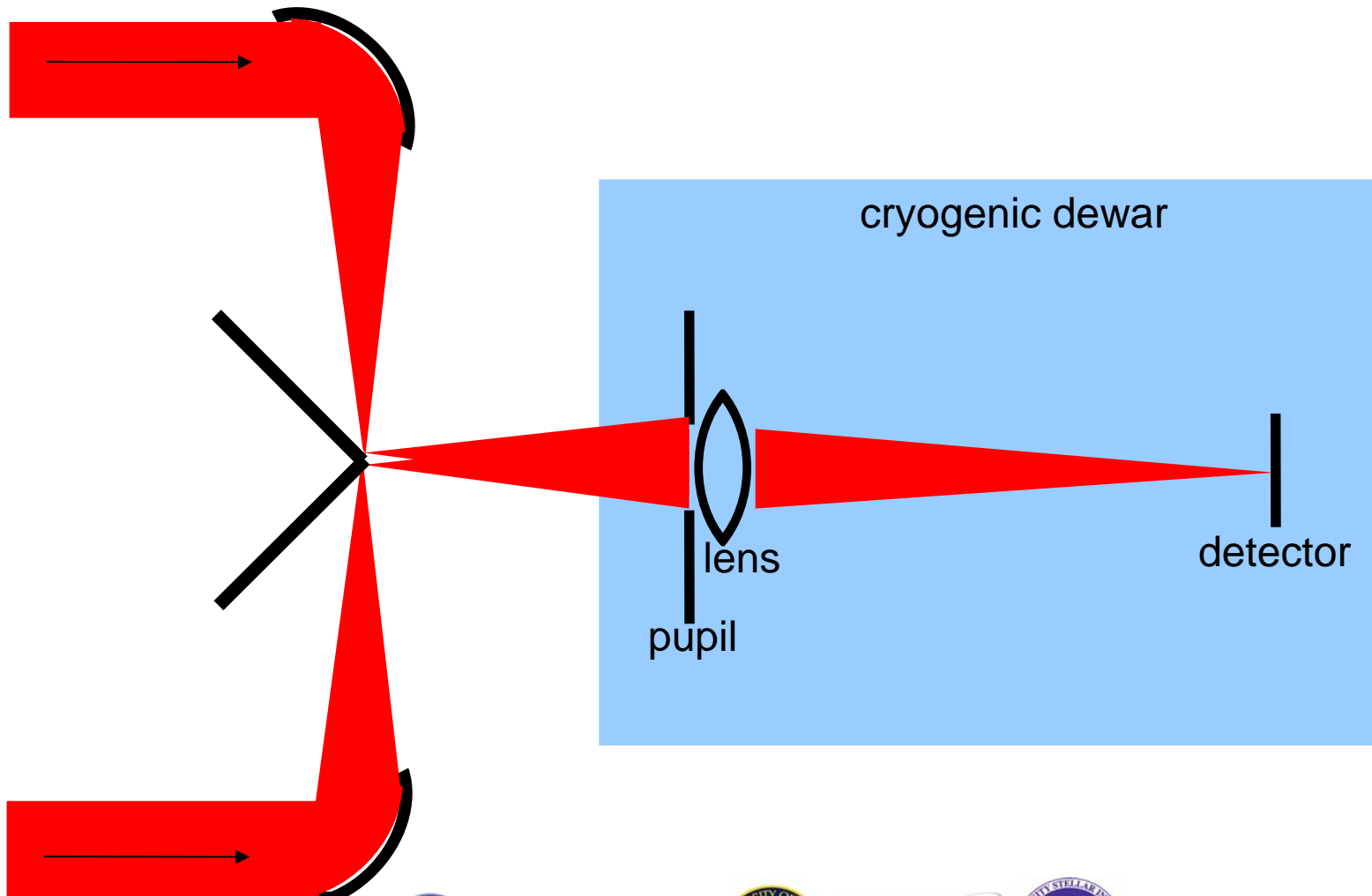
Now What?

To Science Combiner





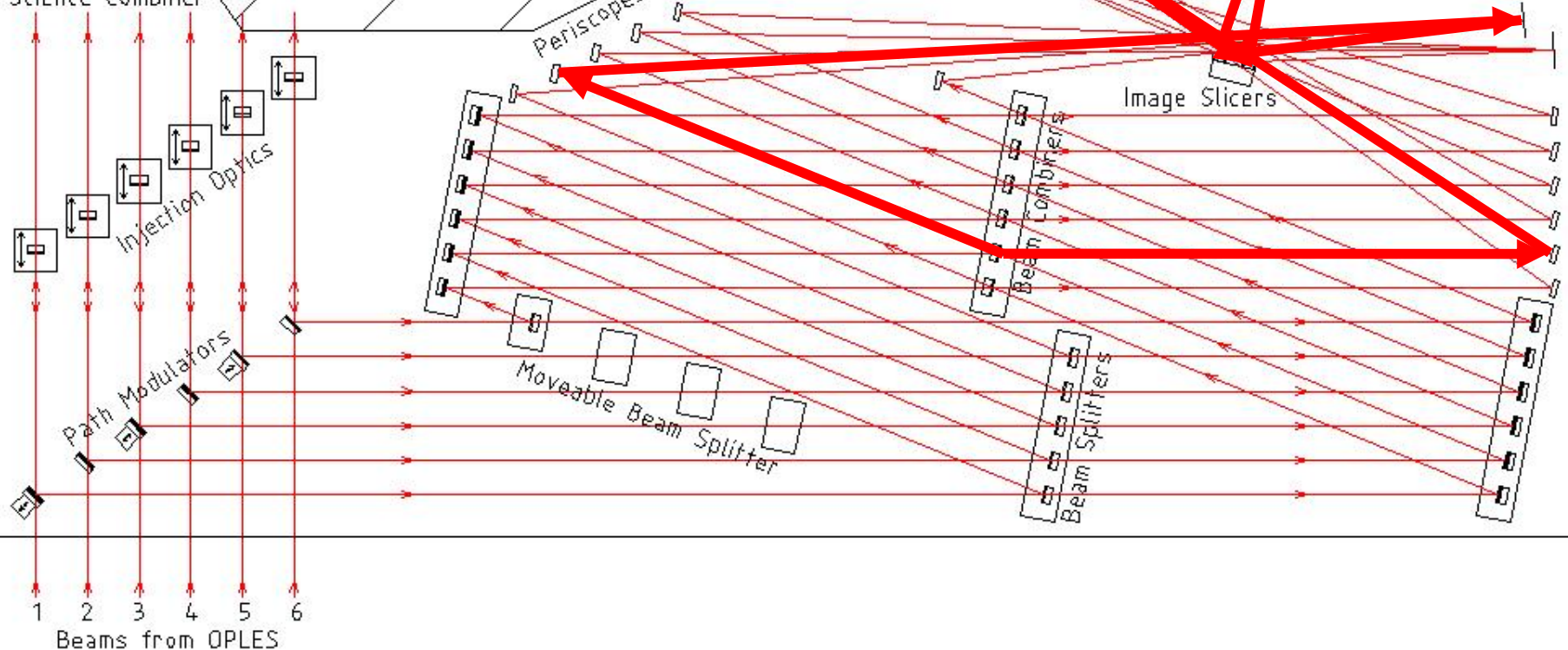
# Post-Combo Beam Transport



# MIRC

# CHAMP

To Science Combiner



Cryogenic Dewar

FPA

Triplet

Spherical Mirrors

Periscopes

Image Slicers

Beam Combiners

Moveable Beam Splitter

Beam Splitters

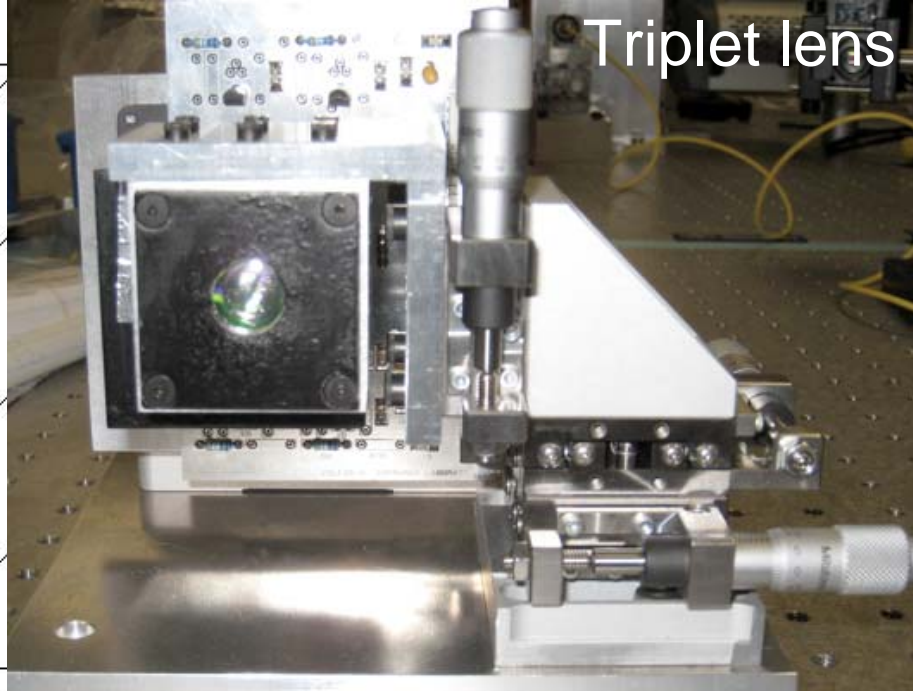
1 2 3 4 5 6

Beams from OPLES

MIRC

Triplet lens

CHAMP



To Science Combiner

Cryogenic Dewar

FPA

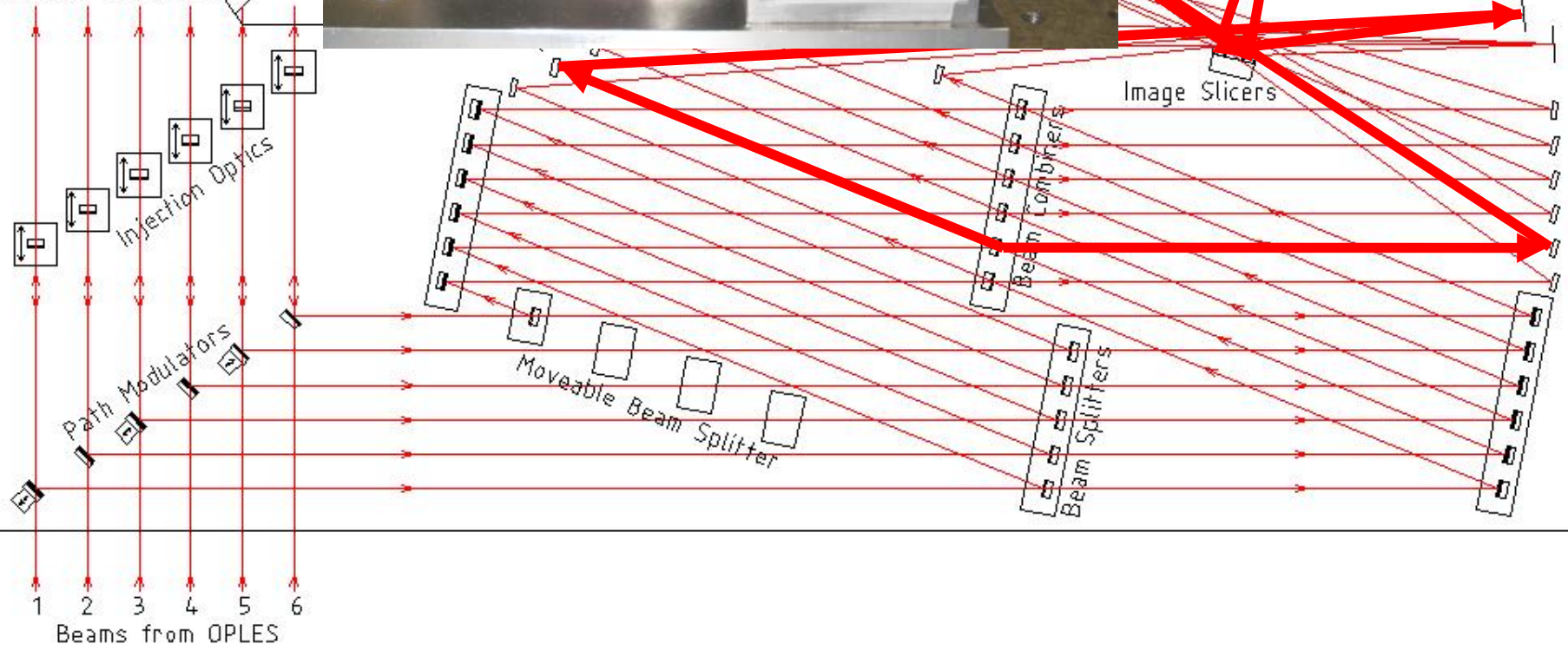
Triplet

Image Slicers

Beam Combiners

Moveable Beam Splitter

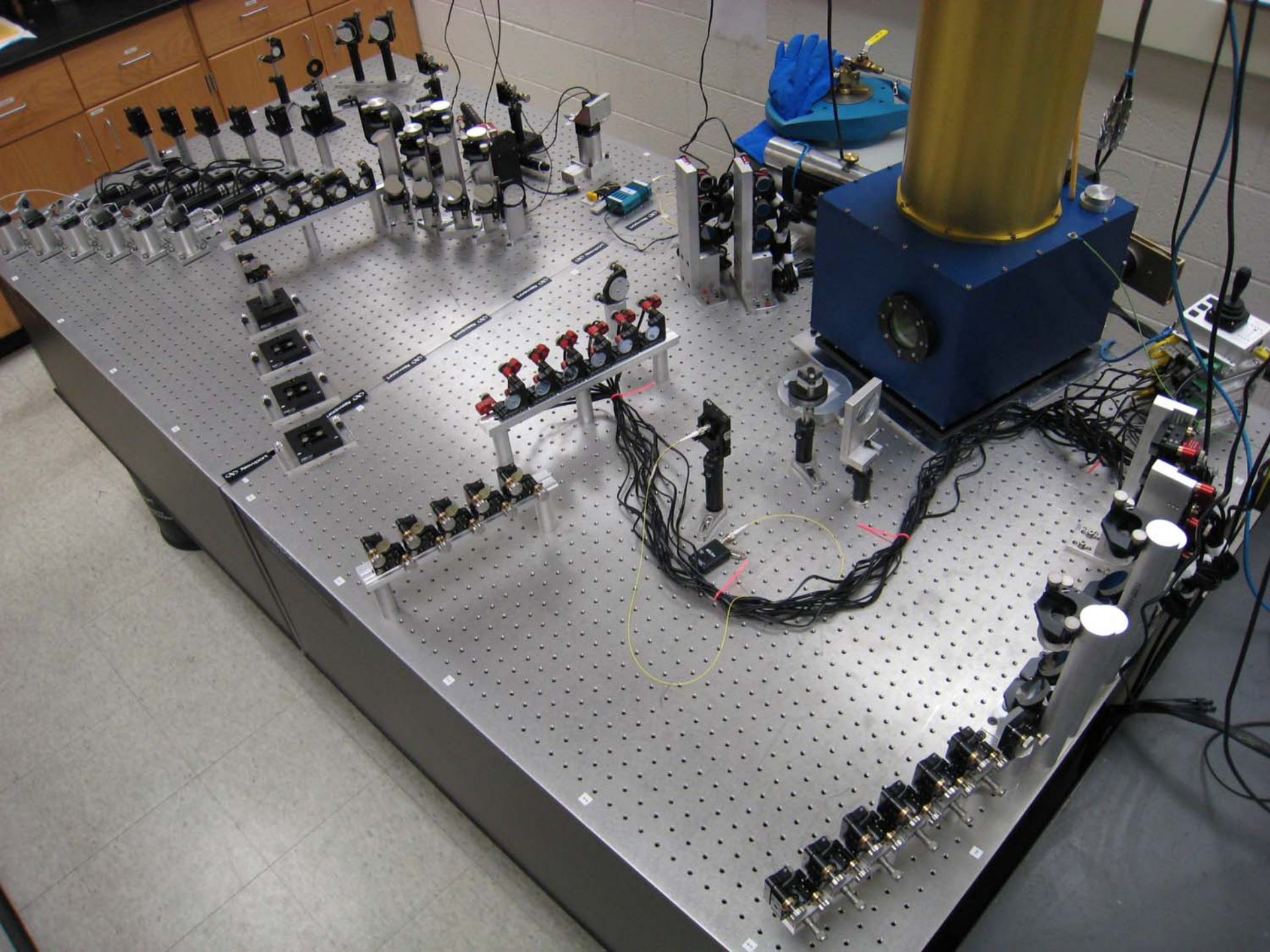
Beam Splitters

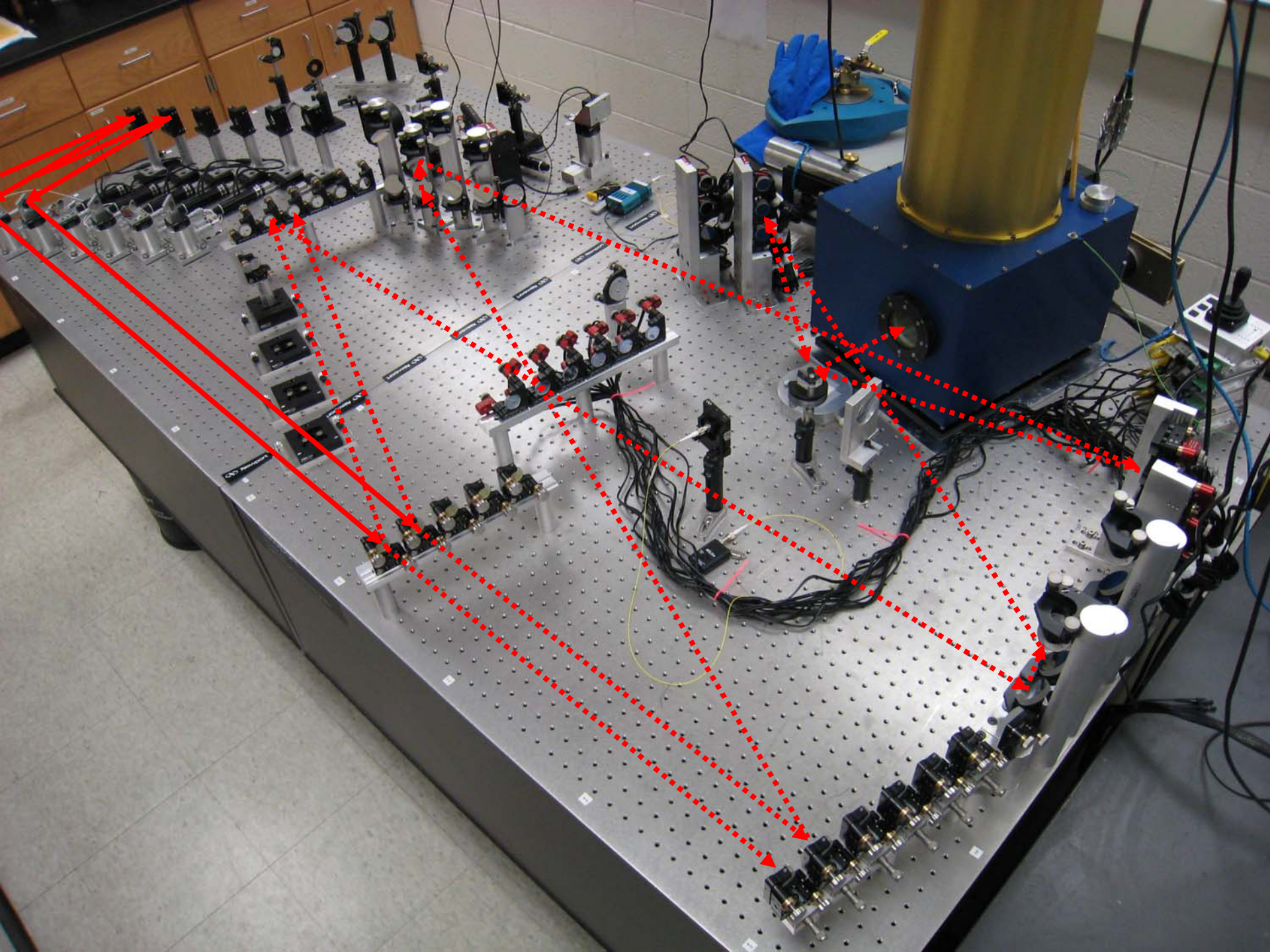




# Image Slicers





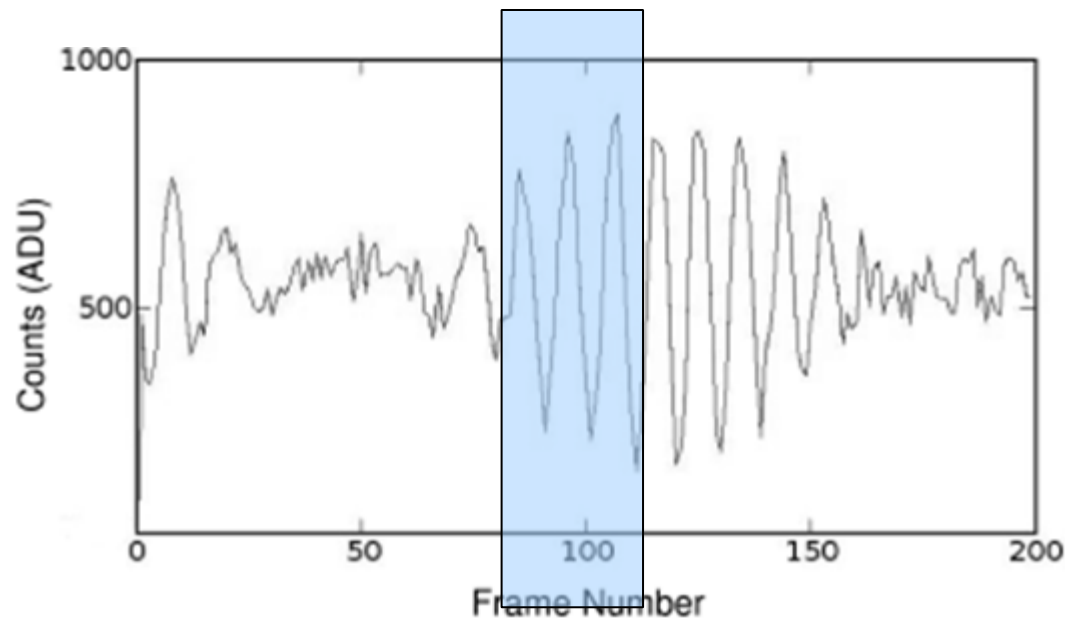






# CHAMP's First White Light Fringe

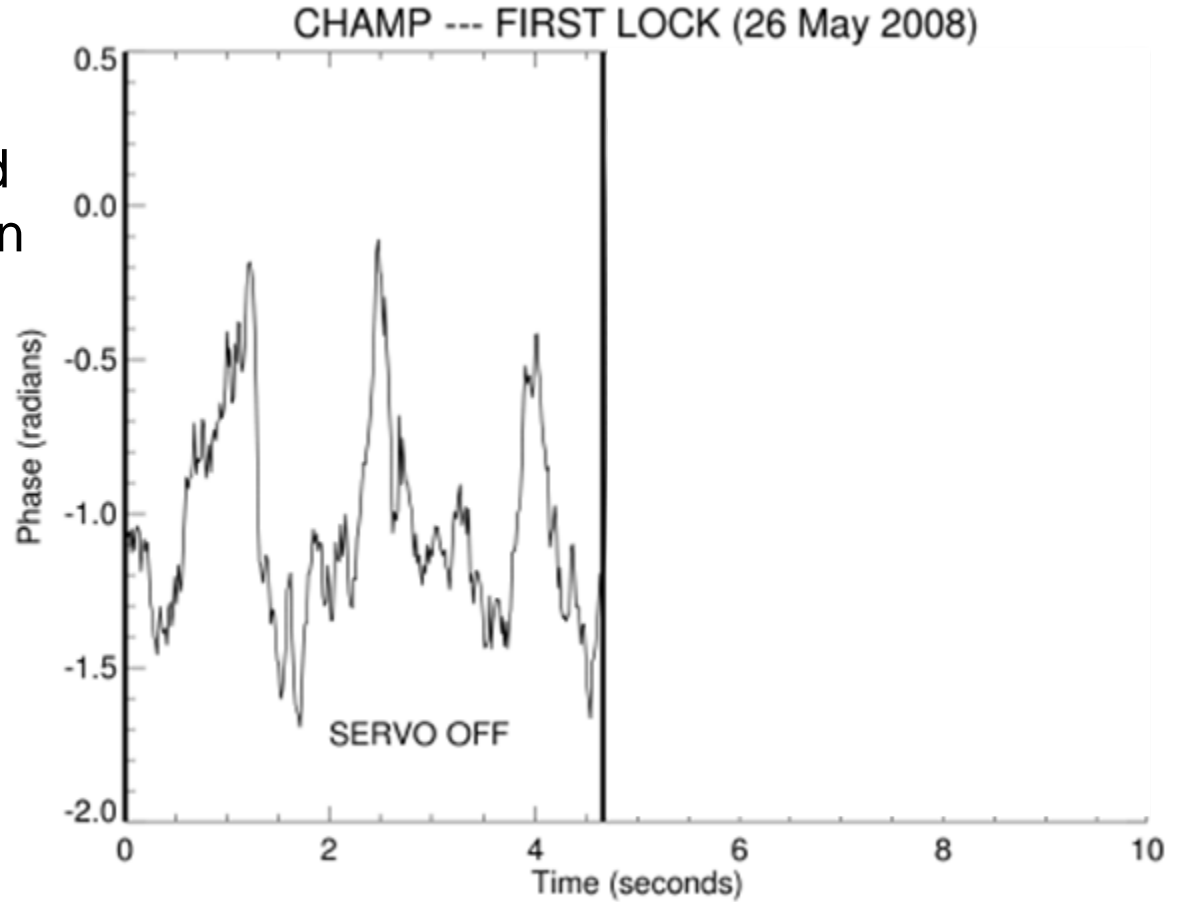
- measure phases of 3 fringes using ABCD
- track on the middle one
- use others for group delay
- no need for group delay from science combiner





# CHAMP's First Lock

- 3 fringe scanning, H-band
- ABCD phase estimates on middle fringe





# CHAMP Update Since Last Summer

- Pyramid image slicers mounted and tested
  - 3 worked, 1 failed (being re-fabricated now)
- Triplet lens mounted
- Dewar plate
  - mount holds dewar card and lens assembly
  - focused in lab using HeNe reference
  - will be installed this week (during Nice conference)
- Detector tests
  - Careful tests (Rafael)
  - Excess 1/f noise due probably to detector problem
  - investigating possibility of new detector but will continue on (no impact for K band, only for H band)
- VME upgrade



# CHAMP Schedule

- 2009 March-May:
  - Validate performance of pyramid image slicers and triplet for image quality
  - Test alignment procedures
- June:
  - Software in Michigan (close loop with optimized control loop)
- July:
  - Ship to CHARA, initial integration
- August:
  - on-sky integration (two-week run scheduled)
  - also install new photometric channels on MIRC, if ready
- September-November
  - New postdocs arrive, just in time!



# Problems

- Image quality
- Delay carts get stuck at various positions
- Closure phase calibration is worse than before
  - Seems consistent from night to night for a given cal-target pair
  - Maybe due to polarization
  - Study underway