MIRC/CHAMP Status and Updates

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Pasadena, CA, 2010 March

John not sleeping

Nora sleeping

Outline

- MIRC
  - Current status
  - Science Summary
  - Future
- CHAMP
  - Current status
  - Future plans

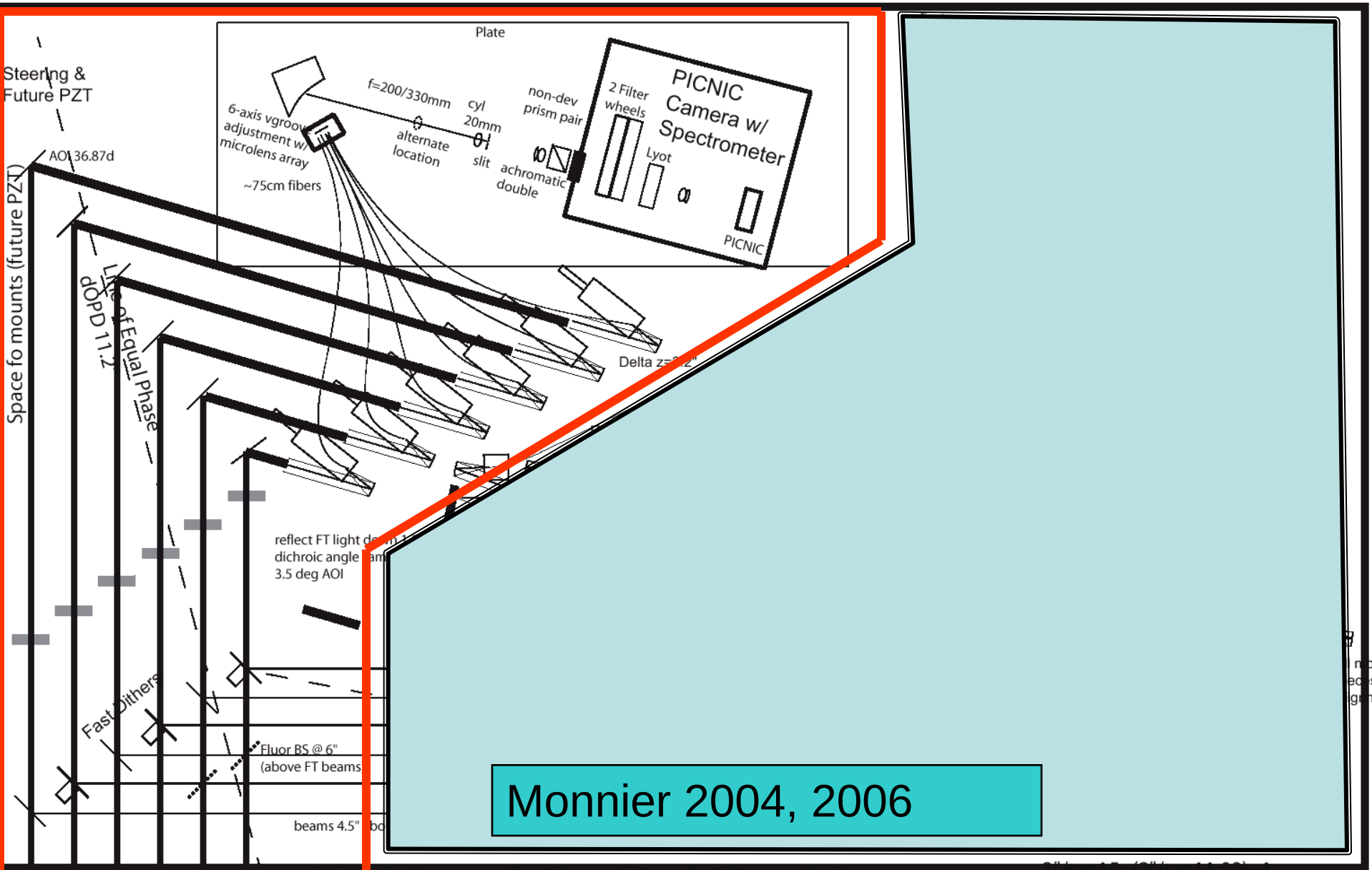
MIRC: Status

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~ 44, 150, or 400
- Calibration: V^2 error ~ 10%-20%; CP error ~ 2º-5º (for 6min obs.)
  - New Photometric Channels seems to improve V^2 error: ~ 5%
- Fringe tracker CHAMP expected to finish September 2010
- MIRC 6-telescope upgrade in 2010-2011

Optical Layout



Monnier 2004, 2006

Personnel Changes

- Xiao Che (UM grad student) will focus on MIRC 6-tel upgrade following his completion of coursework in April 2010
- Fabien Baron started his CHAMP postdoc, expertise in image reconstruction and fringe tracking
- Stefan Kraus arrived at UM as Sagan Fellow; he plans to observe YSOs and help with CHAMP commissioning
- Ming Zhao graduated and is now a NPP postdoc at JPL with Mark Swain – will continue collaborations on hot Jupiters
- Ettore Pedretti and Nathalie Thureau are still at St. Andrews

MIRC: Progress towards becoming a "Facility Instrument"

- MIRC can now be observed by non-Michigan teams
  - Only 17 of the 50 observing nights with MIRC were UM nights
  - Well documented start-up and alignment procedures
  - But one still needs to be trained to run MIRC
- There are more MIRC experts: Gail, Yamina, Rob, Brian
- Fringe tracker and photometric channels will make observing even easier in 2010

- Data pipeline is better documented
  - Distribution of software through Subversion
  - New step-by-step data reduction manual
  - Visit to Michigan is still highly recommended

MIRC: Year 4 (2009) Summary

- Observing
  - 2009: 51 nights in total with 34 nights of data (66%)
    - Only 17/51 nights were “Michigan” time, the rest from other CHARA collaborations
  - 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, delay lines, power failure, fire

- Projects in 2009:
  - Rapid rotators: Monnier, Che
  - Hot Jupiters: Zhao, Malbet
  - Be stars: Monnier, Gies, Schaefer, Che
  - Multiples: Zhao, Baron, Stencel, Gies, Schaefer
  - Spotty stars: Parks

MIRC: Year 4 (2009) Summary

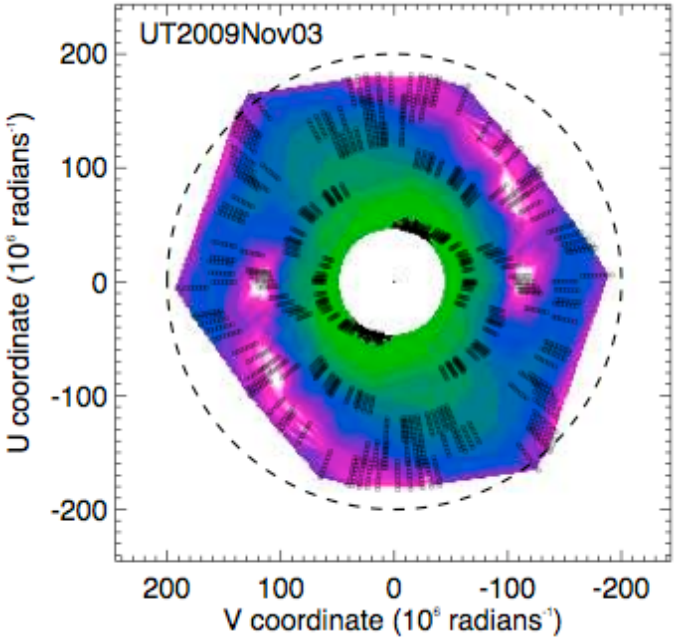
- Publications:
  1. Zhao et al. 2009, ApJ, “Imaging and Modeling Rapidly Rotating Stars: Alpha Cep and Alpha Oph” [+ invited talk to hot stars liege meeting]
  2. Kloppenborg et al. 2010, Nature, “Imaging eclipse of epsilon aurigae”, in press

Expecting in 2010:

1. Aufdenberg et al. 2010, ApJ, “Spica”
2. Schaefer et al. 2010, “Zet Tau”
3. Zhao et al. 2010, “Hot Jupiters”
4. Pedretti et al. 2010, “Zet And”
5. Che et al. 2010, ”Beta Cas and Regulus”
6. Monnier et al. 2010, “Deneb”
7. Baron et al. 2010, “Algol”

MIRC Improvements in 2009

- Newly implemented imaging mode – "**Schaefer configuration**"
  - S1-E1-W1-W2 for one half of night and S2-E2-W1-W2 for second half without changing POPs (or swapped)
  - This is great for imaging: 11/15 baselines, 8/20 closure phases

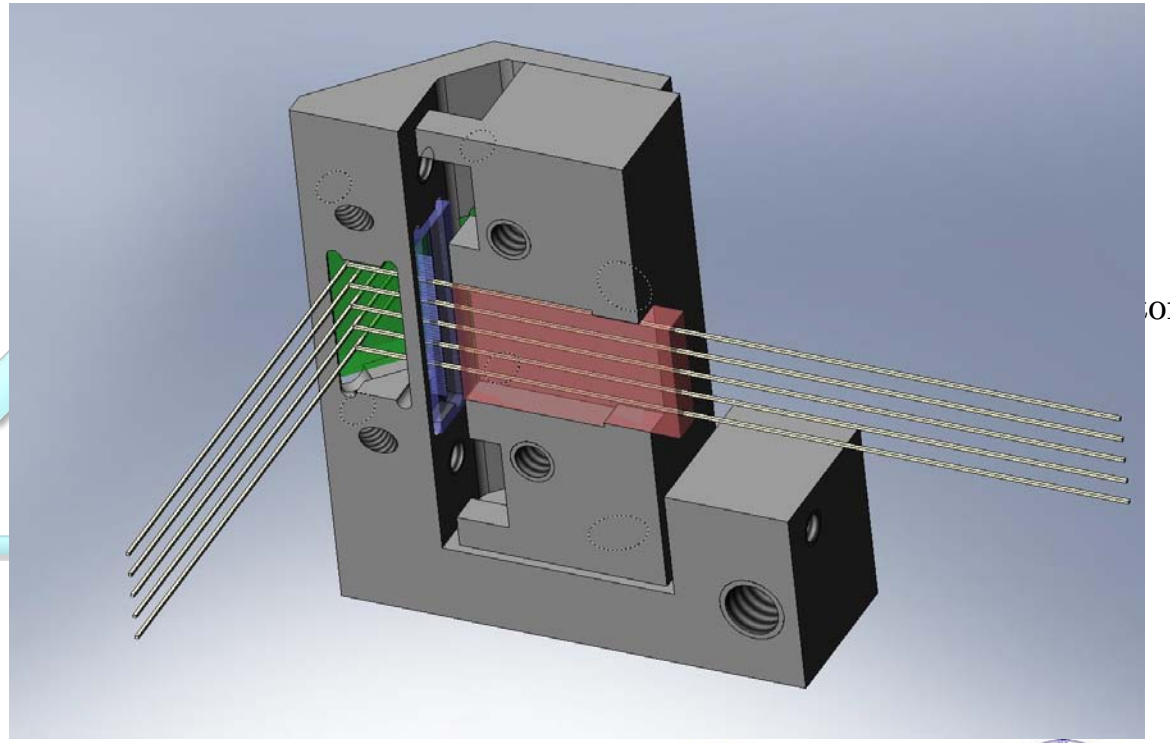


Only
3 nights of
Observations

This really helps with imaging

MIRC Improvements in 2009

- Xiao Che commissioned photometric channels: “X-Channels”
  - Simplies observing (no more choppers ! Yay!)
  - Better calibration

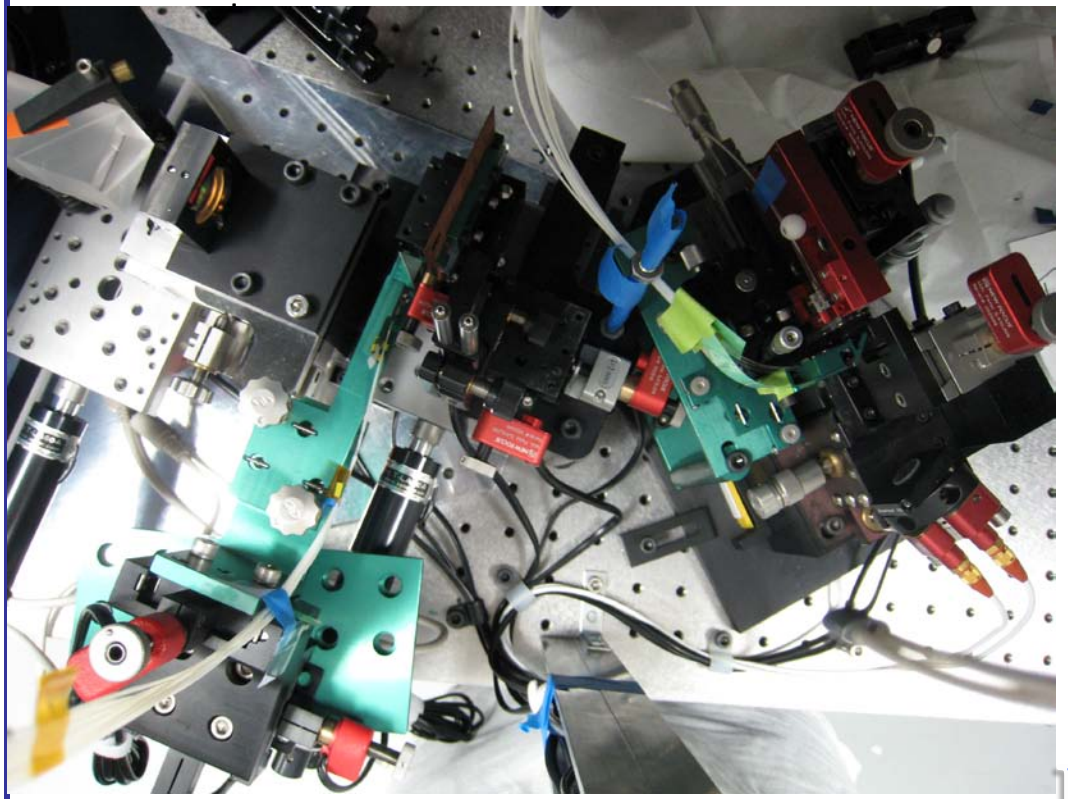


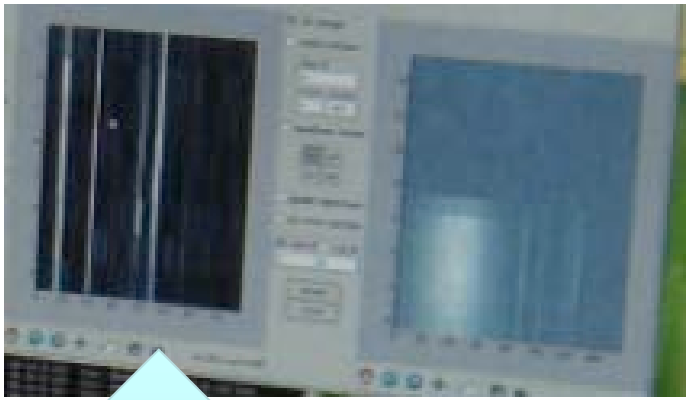
Photometric Channels

QuickTime™ and a
Microsoft Video 1 decompressor
are needed to see this picture.

Photometric Channels @ MIRC

Upgraded MIRC with Photometric Channels during Aug. 7th-

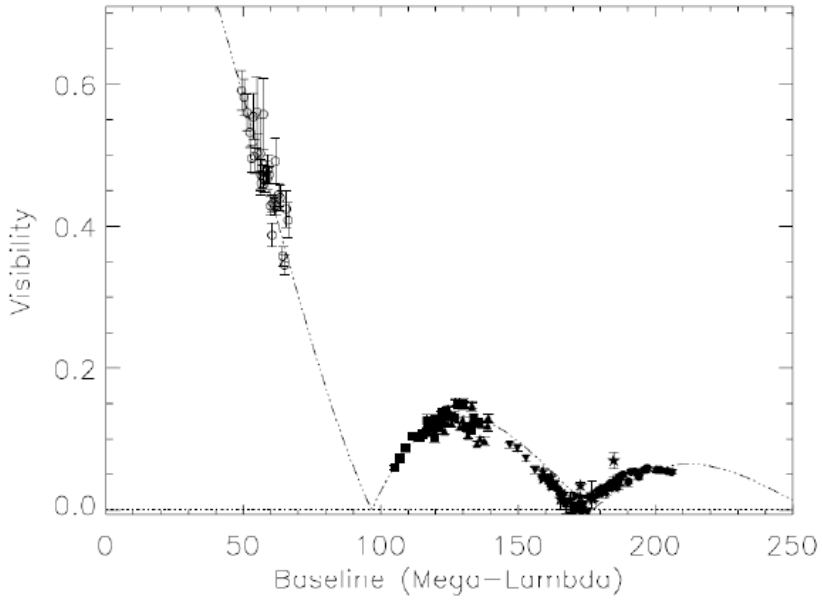


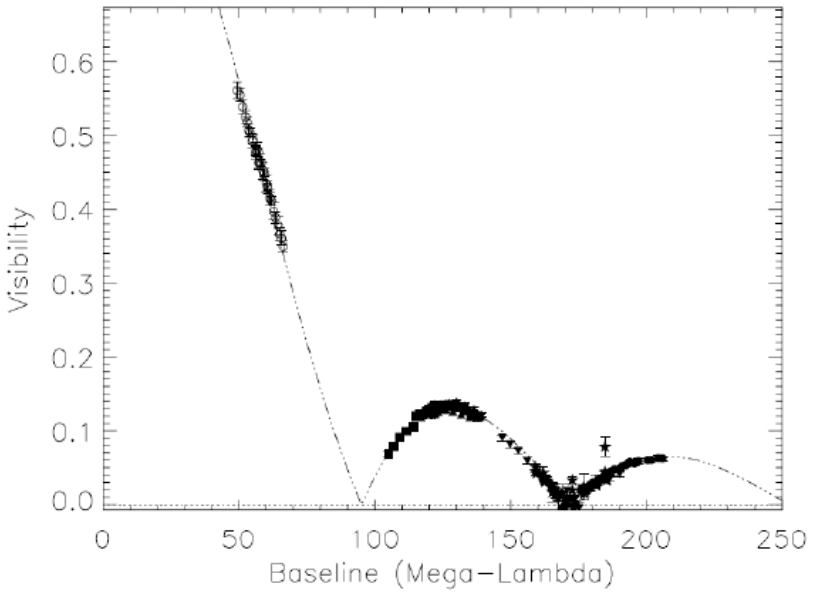


First sky light for Photometric Channel

Photometric Channels

- Big improvement in calibrating visibilities





Problems affecting MIRC

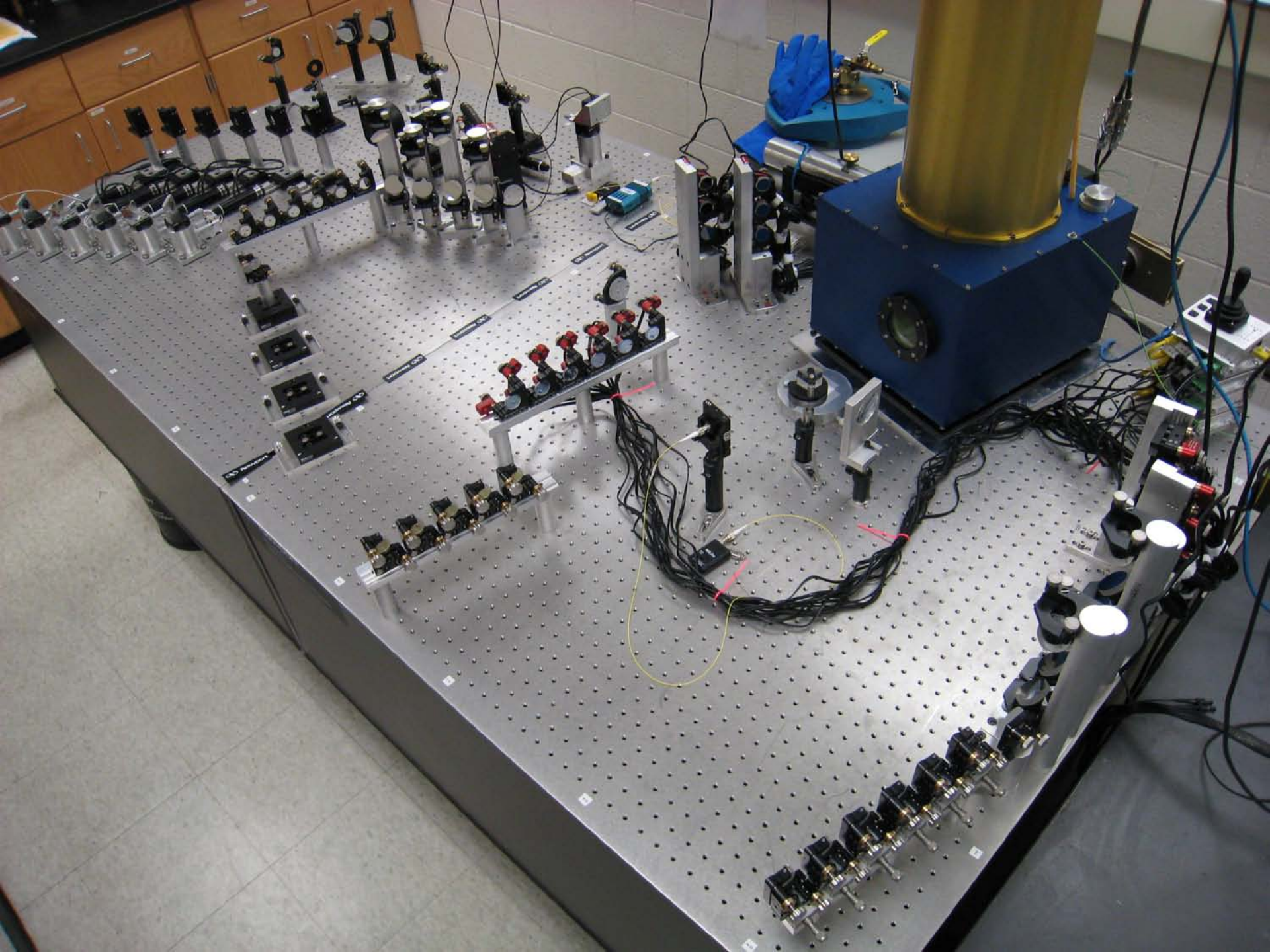
- Delay line performance was noticeably worse this Fall
- Did not see any improvement in telescope image quality
  - We strongly support continued work on this
  - Also continued vigilance to keep the delay lines and BRTs aligned
- We see strong closure phase variations with telescope pointing
  - Possibly due to mismatched polarizations (lets get rid of the silver coatings in the Coude train!)
  - CHARA beams are HIGHLY polarized (20-30%) at H band
    - This seems higher than expected if the Aluminum coatings are as thick as they should be – but could be due to aluminum coatings being sub-optimal
    - Interesting: the birefringence could be WORSE in the IR, not visible, due to thin-layer effects
  - Closure phase drifts could be due to air dispersion [not sure yet we want to try to use the dispersion compensators to find out in 2010]
- Photometric channels are poorly aligned
  - we about 5X less throughput than expected

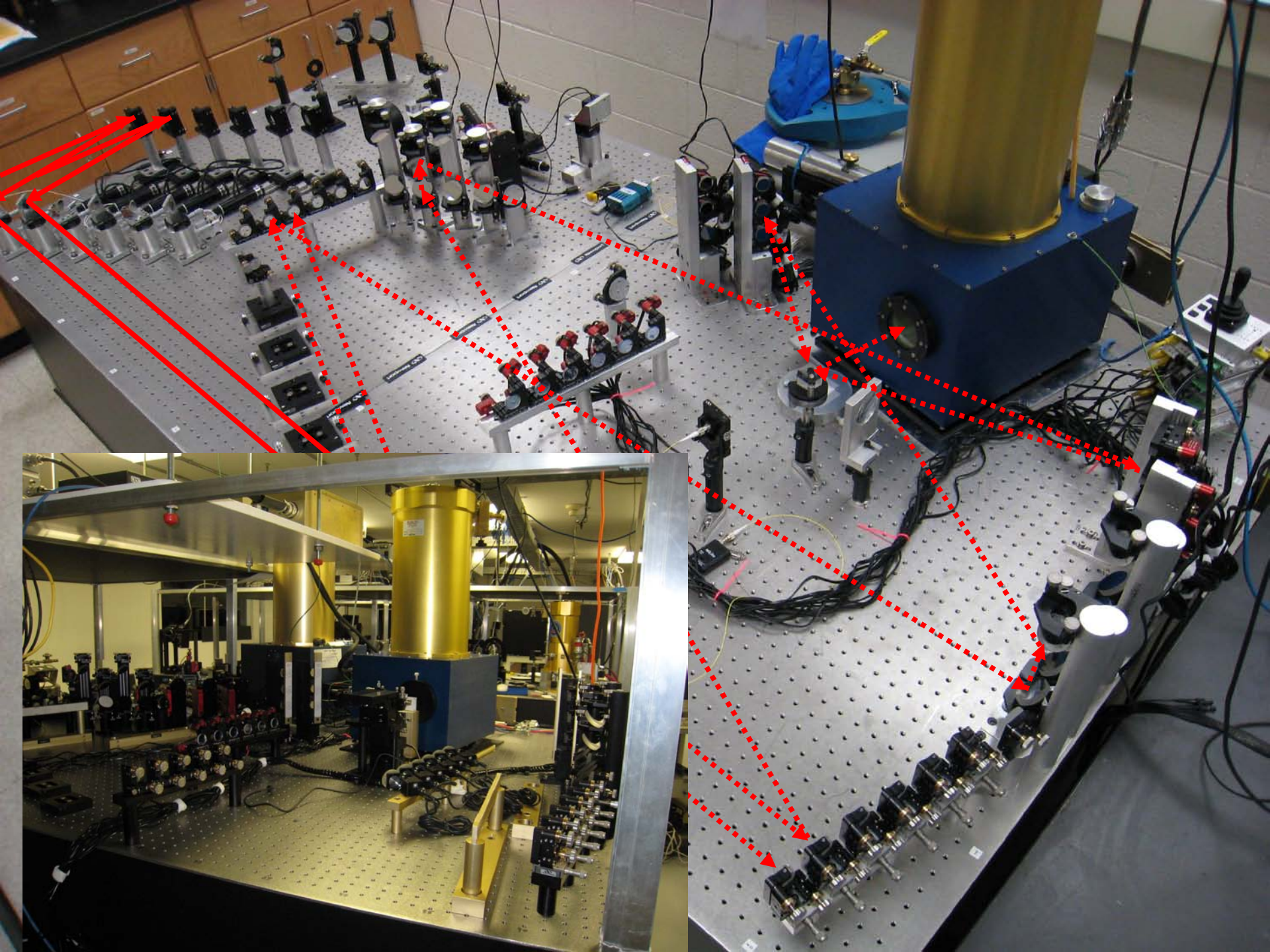
CHARA-Michigan Phasetracker (CHAMP)

- Will detect and correct pathlength fluctuations
  - "adaptive optics" for an interferometer
  - "freezes" the fringes to allow long integrations
- New instrument will improve sensitivity x10
  - enable imaging at visible wavelengths
  - extend sensitivity to image Young Stellar Objects
- Commissioned one baseline in August 2009
  - all 6 to be commissioned in summer 2010

CHAMP: Design Overview

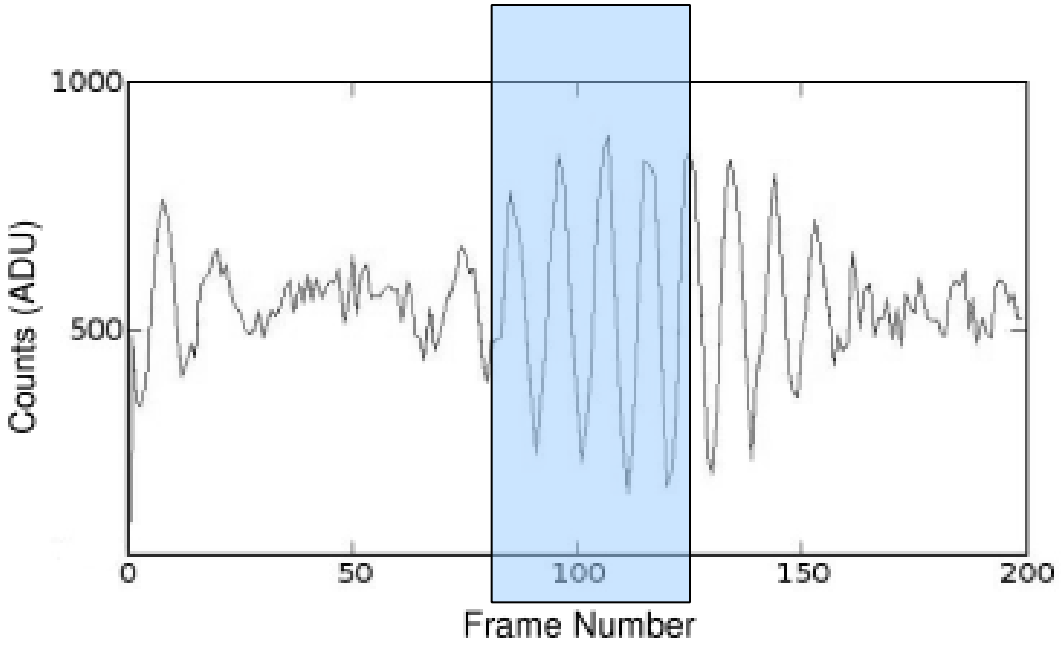
- Operate in J, H, or K (1 to 2.4 microns)
- Separate fringe tracker from science combiners
- Optimized for sensitivity: H=7-8
- Fringe phase measured simultaneously on 6 baselines up to 500Hz





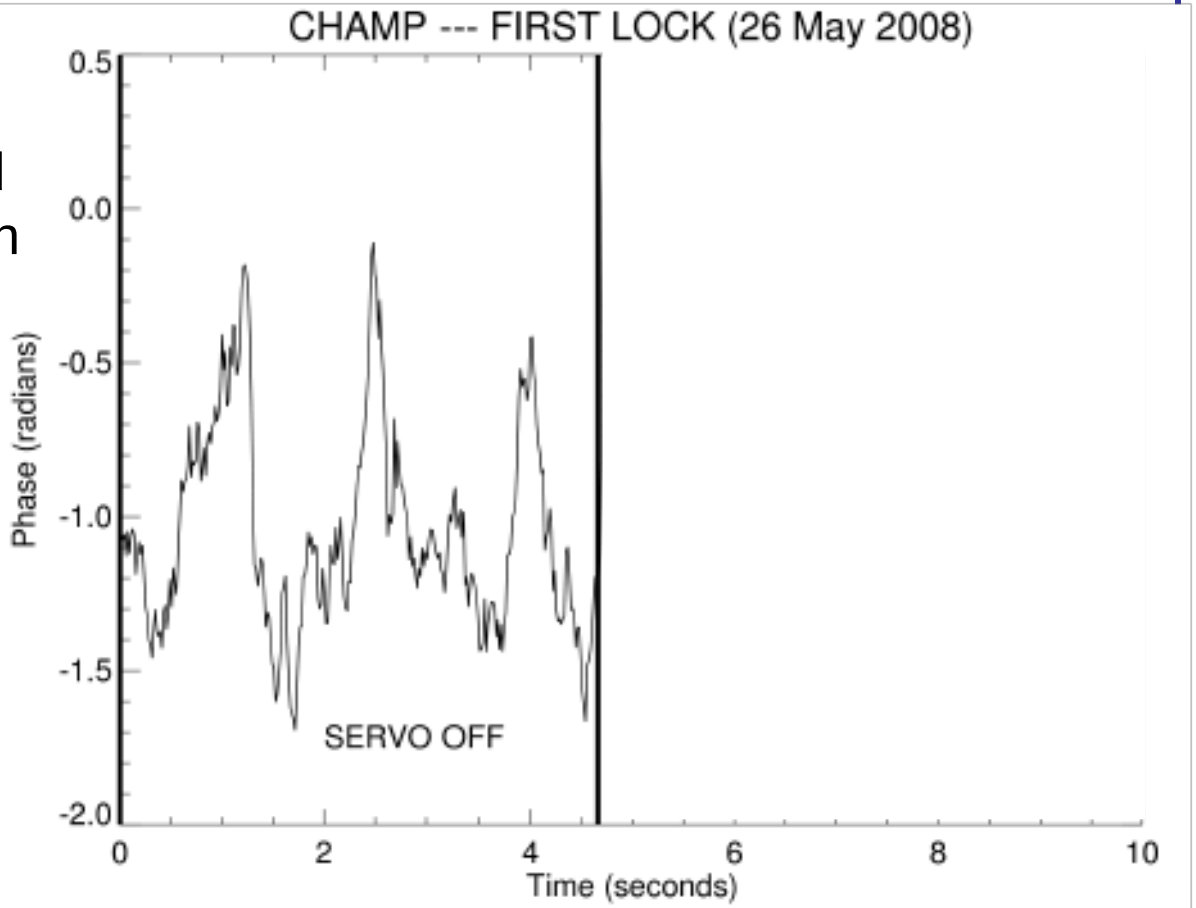
CHAMP's First White Light Fringe

- measure phases of ~5 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 in Lab

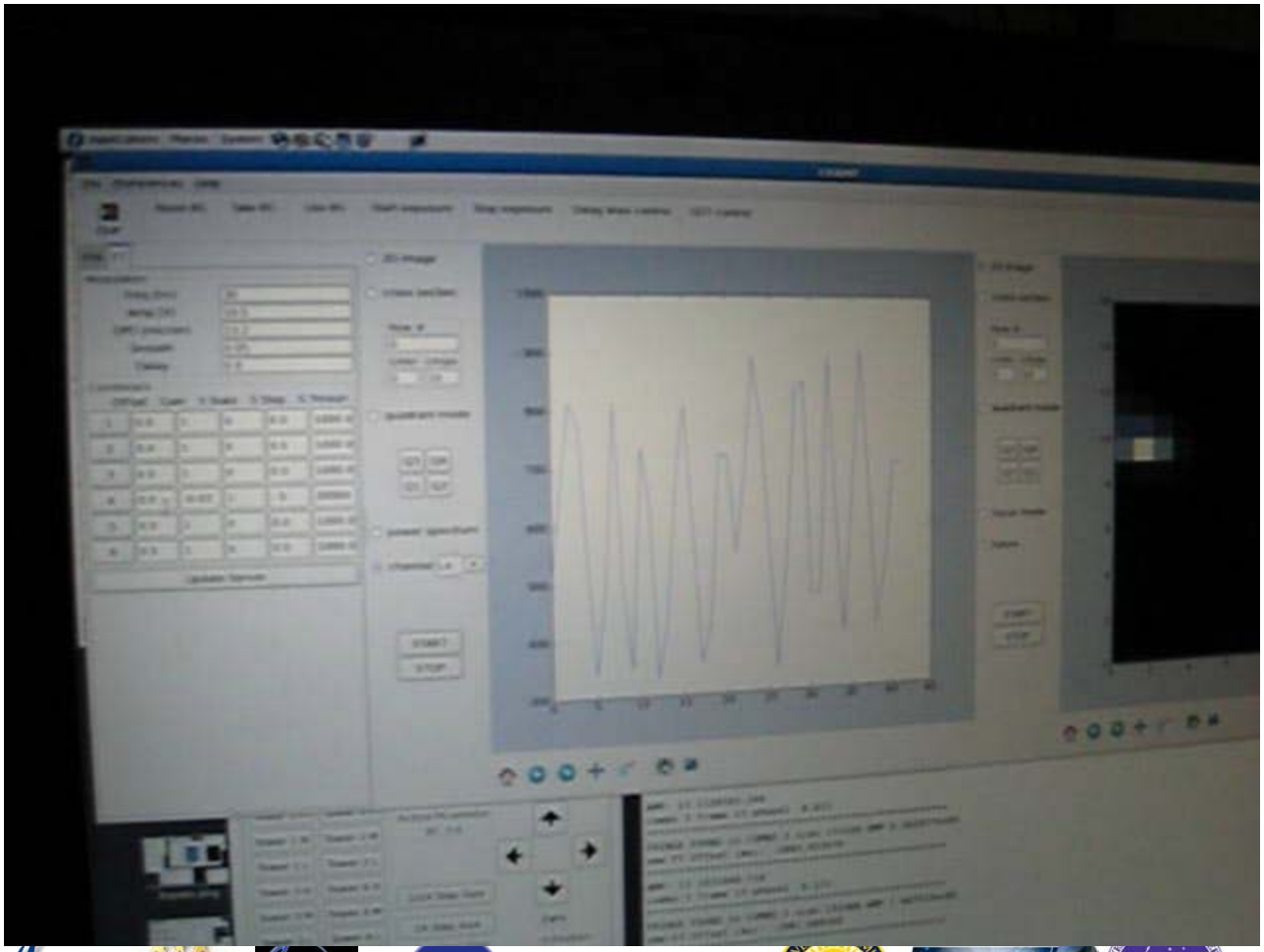
- 3 fringe scanning, H-band
- ABCD phase estimates on middle fringe

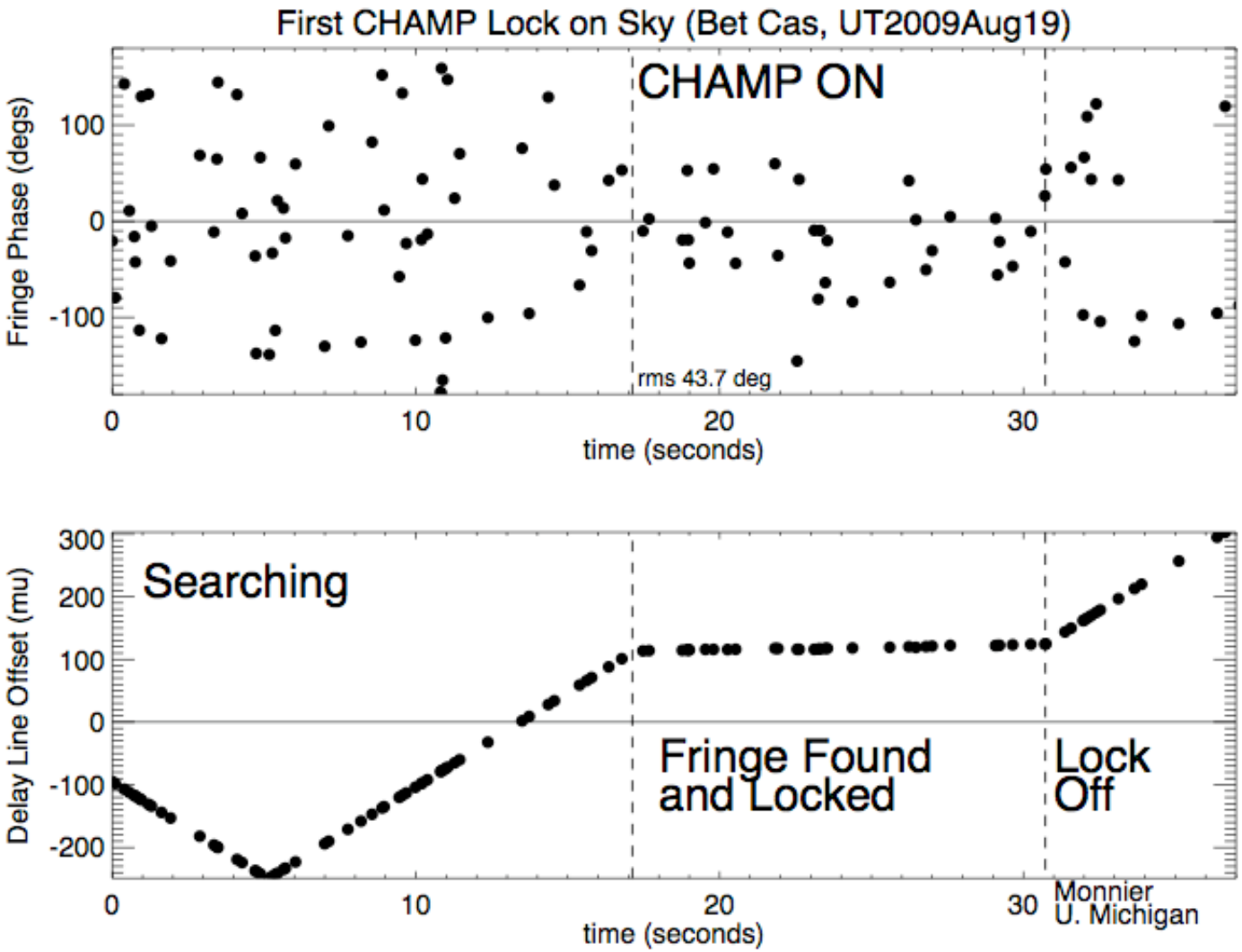


CHAMP Update

- Shipped everything from UM to CHARA
  - Everything made it ok except one box of dichroics were damaged; being replaced now
- Fringe tracking successful

First White Light Fringe (sky) UT2009Aug19




First CHAMP Lock on Sky (Bet Cas, UT2009Aug19)
CHAMP ON
Fringe Phase (degs)
100
0
-100
rms 43.7 deg
0
10
20
30
time (seconds)
Searching
Fringe Found
and Locked
Lock
Off
Delay Line Offset (mu)
300
200
100
0
-200
0
10
20
30
time (seconds)
Monnier
U. Michigan

CHAMP Plans

- Lots still to do:
  - Group delay estimator
  - Sequencer for 6 telescope fringe acquisition
  - Optimize for sensitivity
  - Finish interface GUIs
  - Document alignment procedures

CHAMP Problems

- Red laser is too weak to align CHAMP
  - We need to buy a strong green laser
  - Should help multiple combiners
- Lost engineering run in January due to weather
  - Behind on software development
  - Will catch up this summer

Summary for 2010-2011 plans

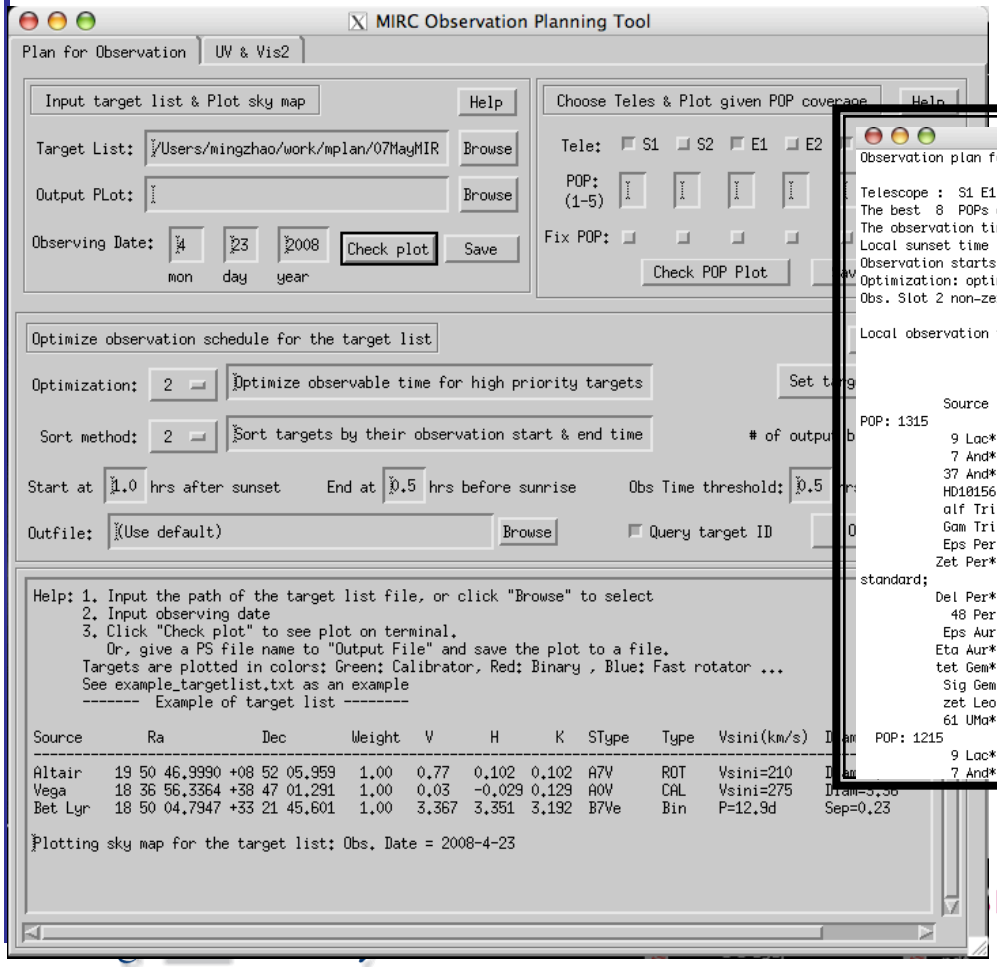
- Lots of Papers to be published
- MIRC:
  - Use new interface computer *wolverine* [retiring *lothlorien*]
  - Update realtime system to Xenomai in 2010 (Pedretti)
  - Photometric channels control software improvements in 2010
    - Speed up fiber explorer by x4
  - Upgrade mirc realtime control and GUIs to work for 6 –telescopes
  - Upgrade and re-align MIRC optics for 6 Telescopes
    - Goals for Xiao: Summer 2011
- CHAMP
  - Demonstrate 4-telescope fringe tracking with MIRC in August 2010
    - Will speed up MIRC observing, avoid having to use CLASSIC for offsets

A toast to another great year in 2010

Backup

MIRC: Planning and Observing

- MIRC Planning tool available in GUI



Output: detailed observing schedule

MircPlan_S1E1W1W2_2008_11_5.txt

```
Observation plan for 11/5/2008 CHARA Run

Telescope :  S1 E1 W1 W2
The best  8  POPs are :  1515 1415 2515 1315 2415 1215 1125 1225
The observation time thredshold for each avaliable source is : 0.50 hours
Local sunset time : 16.9  sunrise time :  6.3
Observation starts  1.0 hour after sunset, ends  0.1 hour before sunrise
Optimization: optimizes the observation time of sources according to their weights.
Obs. Slot 2 non-zero means there are two avaliable observation time slots

Local observation time for these POPs:  (in Hours,      sorted by starting time )


                        Obs. Slot 1
          Source     ID     Start  End   Duration  Weight    V      H      K     Comment
POP: 1315
             9 Lac*  HR8613   17.9  19.1   1.2       1.0     4.654  3.693          A8IV      CAL    Vsini=90   Diam=0.65+-0.08
             7 And*  HR8830   17.9  19.7   1.8       1.0     4.540  3.760  3.791           CAL    Vsini=65   0.67+-0.03
            37 And*   HR269   18.2  21.2   3.0       1.0     3.867  3.652  3.636           CAL    Vsini=80   0.72+-0.03
          HD10156 HD10156   18.9  22.0   3.1       1.0     7.62   6.639  6.576  F5       Bin    Pedretti
           alf Tri   HR544   19.3  21.7   2.4       5.0     3.41   2.182  2.274  F6IV     Bin    P=1.767                  High contrast
           Gam Tri   HR664   19.7  22.5   2.8       1.0     4.00   3.862  3.958  A1Vnn    CAL    Vsini=254  Diam=0.38+-0.08
           Eps Per  HR1220   21.2   0.3   3.1       5.0     2.9    -      -      B0.5V    Bin    P2.483     Diam=0.5      High contrast
          Zet Per*  HR1203   21.3   0.1   2.8       1.0     2.883  2.621  2.603  B1Ib     CAL    Vsini=55   Diam=0.7          Calib : B
standard;
          Del Per*  HR1122   21.3   0.2   2.9       1.0     2.99   3.392  3.256           CAL    Vsini=190  0.6
            48 Per  HR1273   21.7   0.6   2.9       1.0     4.003  3.899  3.796  B3Ve     Be        Vsini=155  Diam=0.59     Be star; M
           Eps Aur  HR1605   22.3   1.4   3.2       5.0     3.039  1.702  1.533  A8Iab    Bin    Rob Stencel
          Eta Aur*  HR1641   22.3   1.4   3.1       1.0     3.152  3.761  3.857           CAL       Vsini=125  Diam=0.5          Calib
          tet Gem*  HR2540    0.3   3.1   2.8       1.0     3.60   3.229  3.163  A3III    CAL    Vsini=130  Diam=0.82+-0.03   Calib : B
           Sig Gem  HR2973    1.2   3.5   2.3       5.0     4.28   1.799  1.736  K1III    Bin    Pedretti, RS CVN binary with spots
           zet Leo  HR4031    4.1   5.5   1.4       1.0     3.443  2.628  2.631  F0III    ROT    Vsini=79   Diam=1.1      Rotator
           61 UMa*     ---    5.1   6.2   1.2       1.0     5.3    3.648  3.588  G8V      CAL       Vsini=8    Diam=0.88+-0.06   G8V
 POP: 1215
             9 Lac*  HR8613   17.9  19.1   1.2       1.0     4.654  3.693          A8IV      CAL    Vsini=90   Diam=0.65+-0.08
             7 And*  HR8830   17.9  19.9   2.0       1.0     4.540  3.760  3.791           CAL    Vsini=65   0.67+-0.03
```

NASA Exoplanet Science Institute

MIRC: Observing

- Acquire Star [5min]
- Fiber Explorer Tool [~15-20 min for 4 tels]

  - With Photometric channels, reduce time to 5 minutes by August 2010

- Find all Fringes and Lock [~10 min 4 tels]

  - Will CHAMP, reduce time to 3 minutes by September 2010

- Fringe data [5 minutes]
- Shutter Matrix [5 minutes]
- More fringes [5 minutes]
- Shutter matrix [5 minutes]

Total Time if lucky: ~50-55 minutes

On best night we could average 1 hr per object

MIRC Data Pipeline

- Most of the steps are automatic, need few interactions.
- Photometric channels calibration is now included in pipeline
- Interactive in the last step (calibration) - very flexible
  - Choose target cals 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