MIRCx: Enabling 6-telescope imaging of protoplanetary disks

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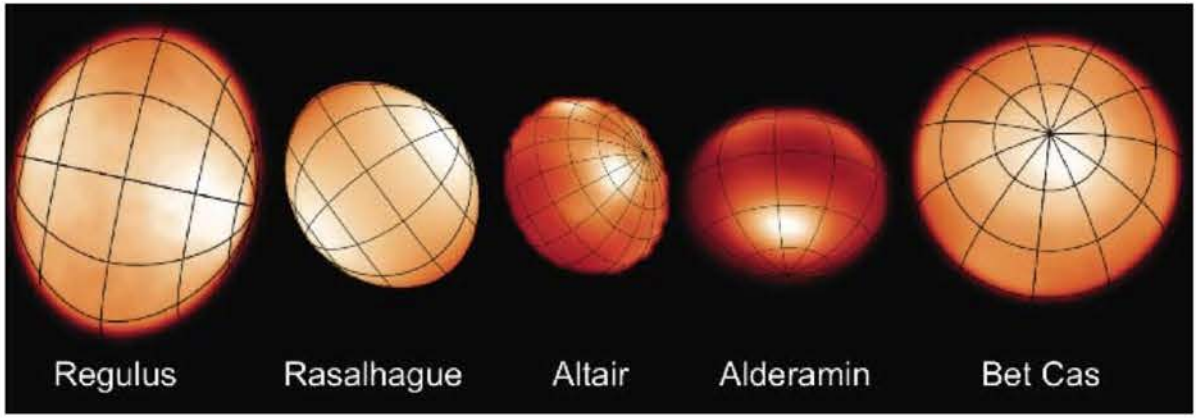
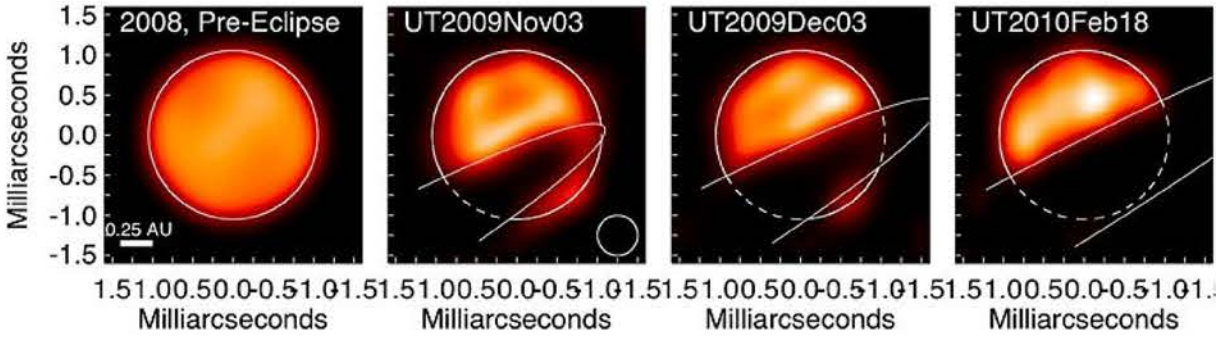
John Monnier (UMich)

Landmark results achieved with MIRC

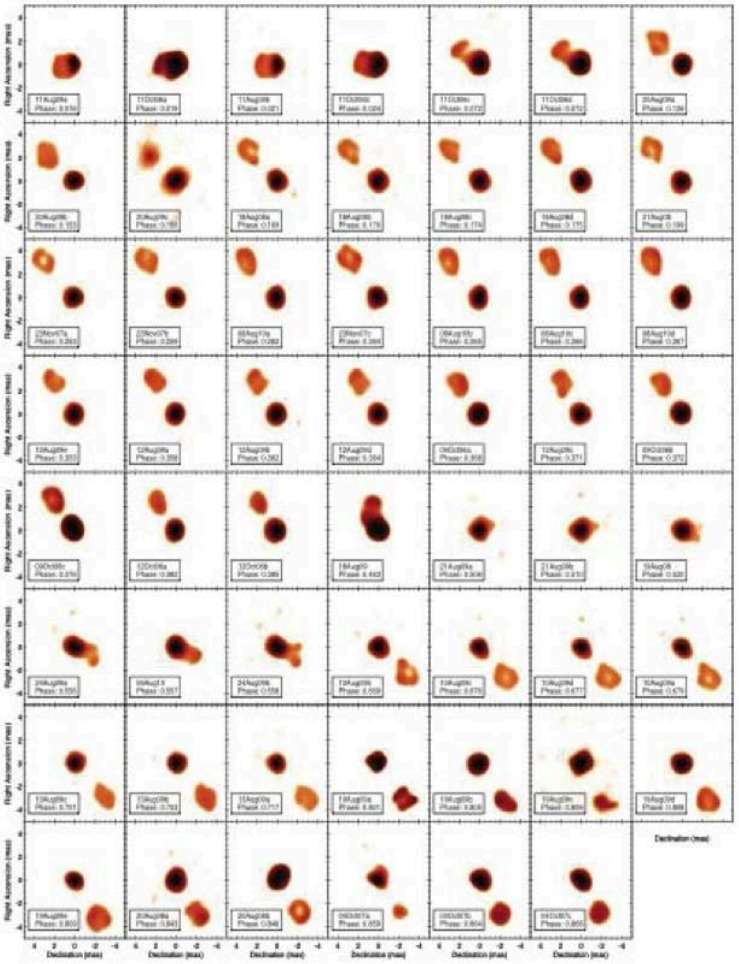
Gravity-darking in rapid rotators (Monnier et al. 2007, 2012; Che et al. 2011)



Images of ε Aur eclipsing system (Kloppenburg et al. 2010)



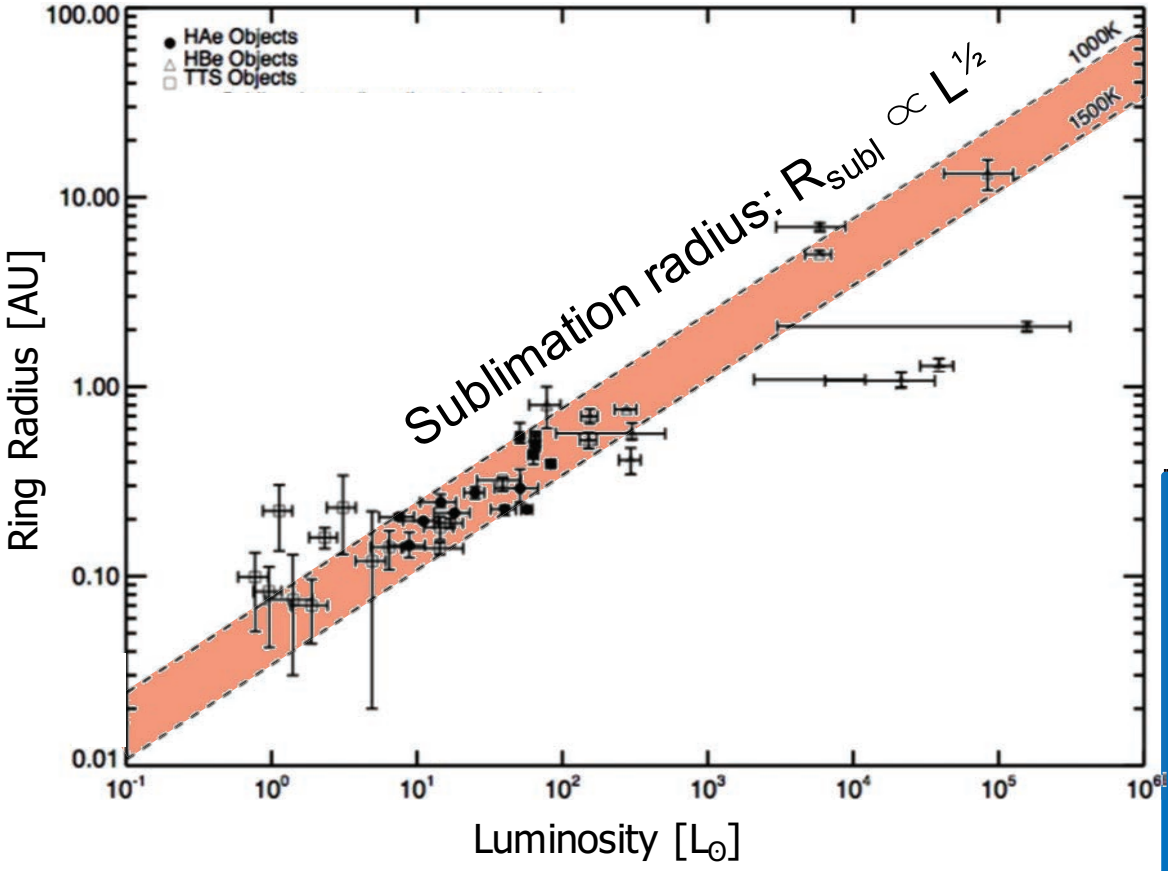
Interacting binary system Algol (Baron et al. 2012)



➜ CHARA/MIRC is the most efficient IR interferometric imager worldwide

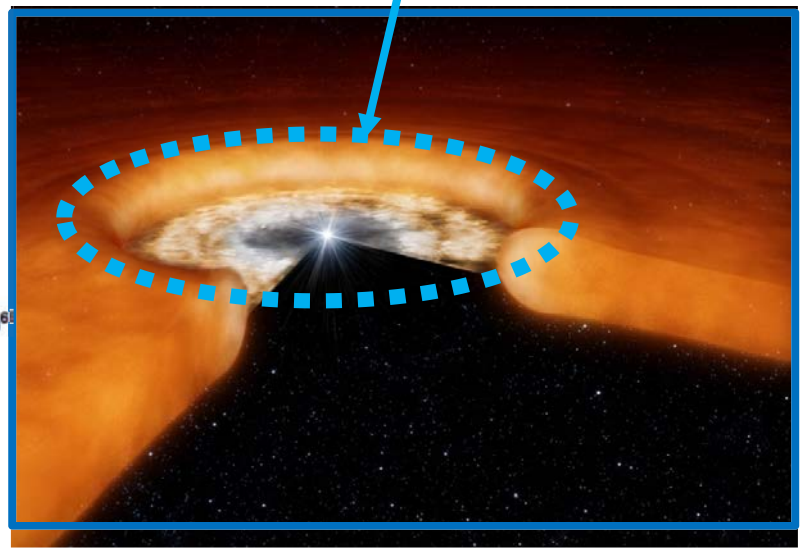
➜ We would like to apply it for imaging protoplanetary disks

Our Key Science: Protoplanetary Disks



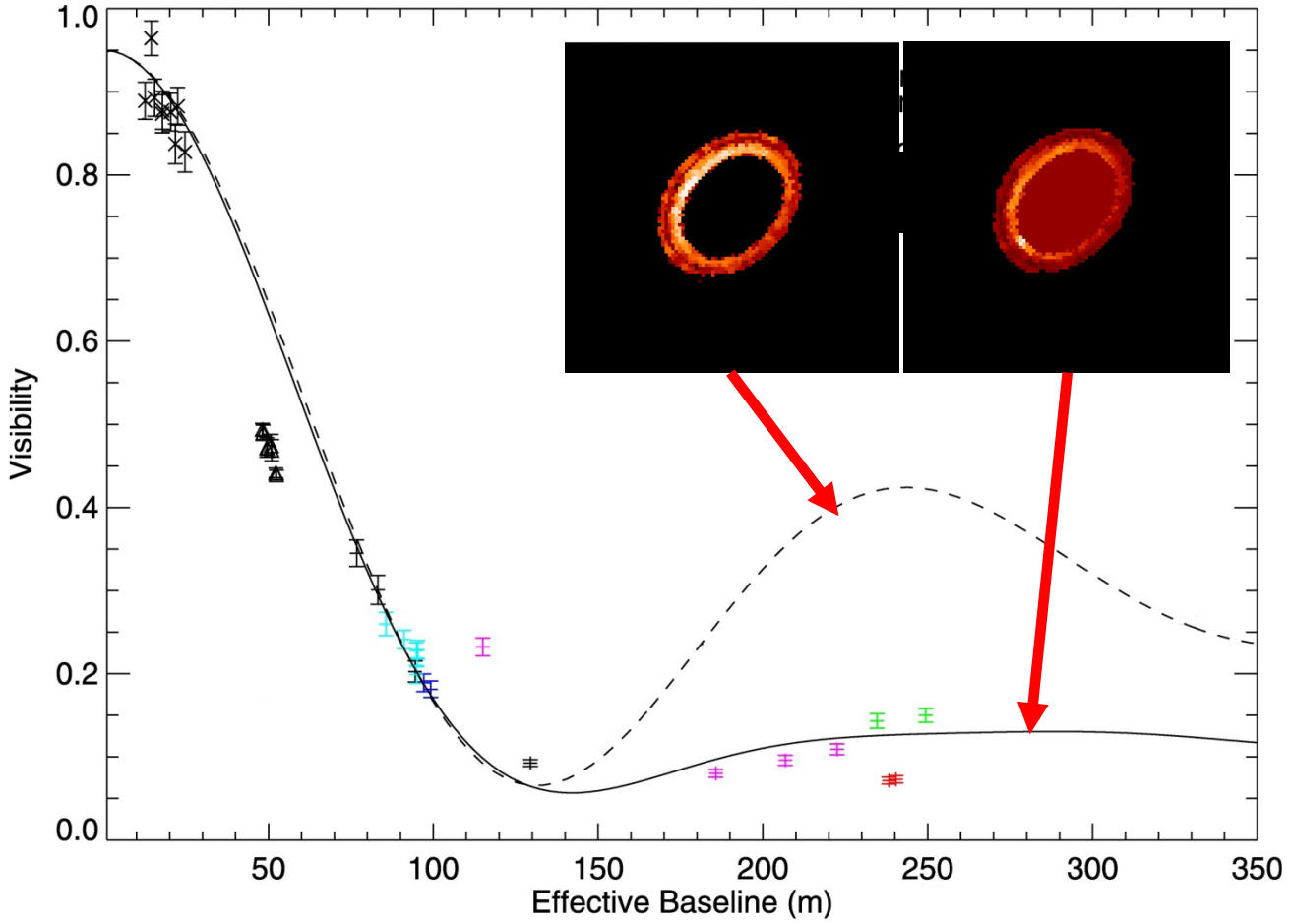
The measured NIR disk sizes scale roughly with the squared stellar luminosity ($L^{1/2}$)

➜ Consistent with emission from the dust sublimation rim



Millan-Gabet 2001, 2007 PPV; Monnier et al. 2002, 2005
also: Akeson et al. 2000; Eisner et al. 2003, 2004

Our Key Science: Protoplanetary Disks



➜ Baselines ≥200m are essential to properly resolve the innermost regions of the most nearby protoplanetary disks

HD163296
Tannirkulam et al. 2008

Our Key Science: Protoplanetary Disks

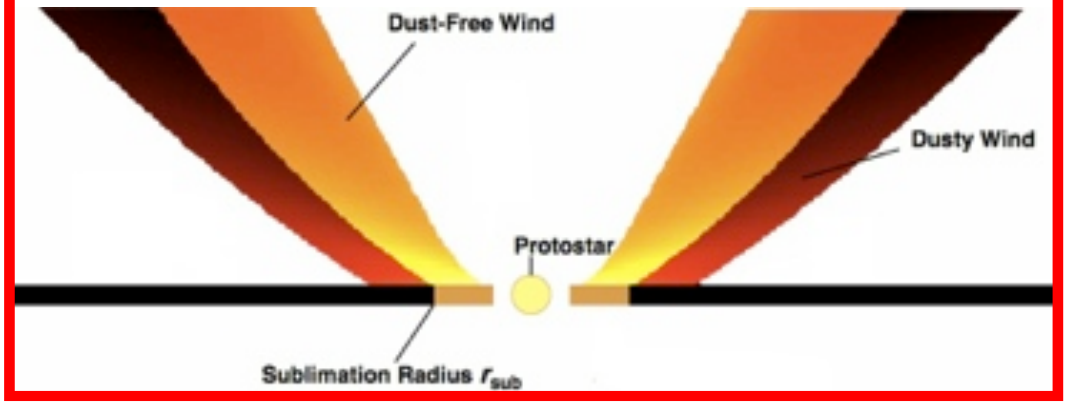
Evidence for a highly complex inner disc environment:

- Quasi-periodic photometric/spectroscopic variability
- NIR/MIR interferometry revealed asymmetries and AU-scale structural changes

Multi-epoch imaging could reveals origin of photometric variability and trace dynamical processes in inner AU

Disc warps

Disc-related structural changes



Credit: Bans & Königl 2012

MIRC upgrade programme

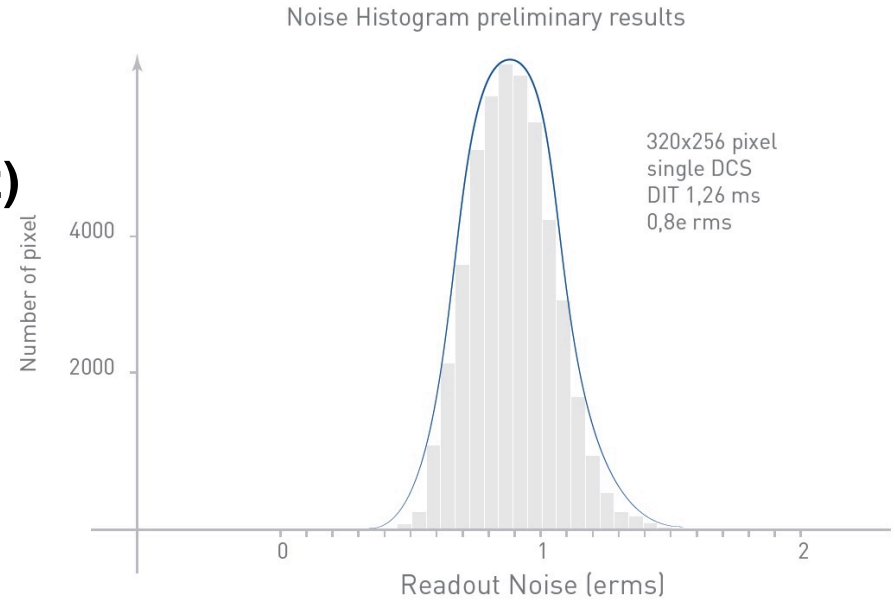
- Plan to increase sensitivity of MIRC to achieve YSO Key Science
- ERC Starting Grant to equip MIRC with SELEX/SAPHIRA-based detector (hardware & postdoc) and to purchase observing time

SELEX/SAPHIRA detector

Current PICNIC detector:
Read-noise 17.7e$^-$ (single read, 300 Hz)

➜ SAPHIRA: read-noise (0.8 e$^-$, 3507 Hz)

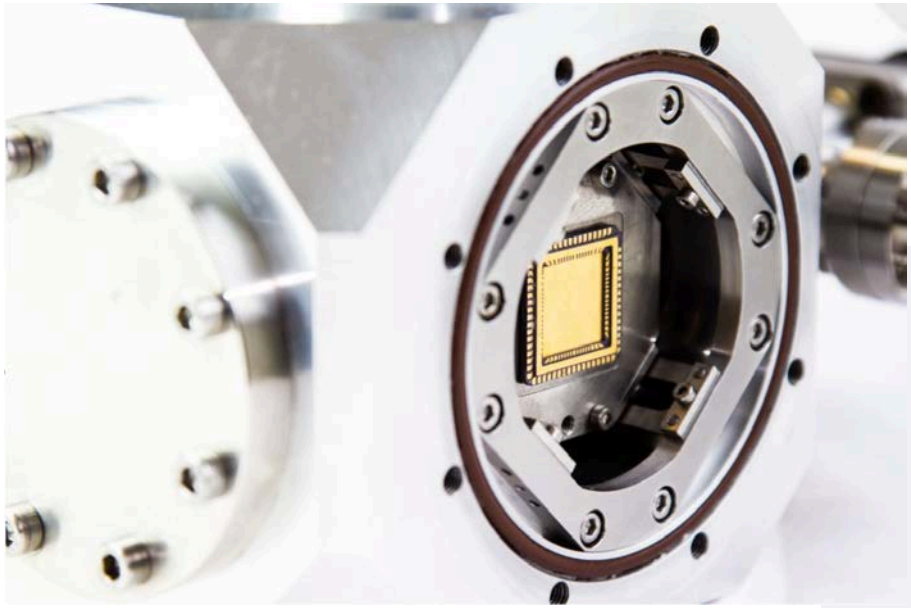
➜ Read-noise reduction by factor ~20

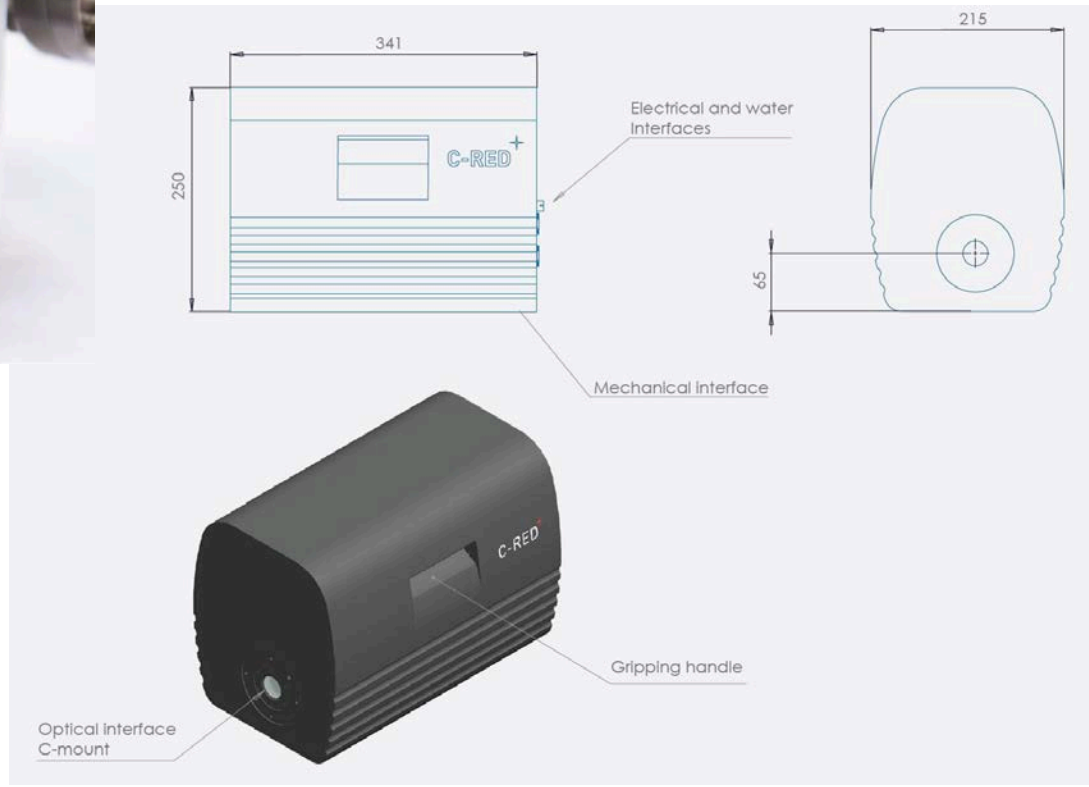


Test measurement	Result	Unit
Maximum speed	3507	FPS
Mean Dark + Readout Noise at 3500 fps and gain ~ 30	<1	e-
Quantization	16	bit
Detector Operating Temperature	80	K
Peak Quantum Efficiency from 1.3 µm to 2.5 µm	>70	%
Operability ± 30%	99.3	%
Image Full well capacity at gain X1, 3500 fps	200 000	e-
Excess noise Factor F	1.25	n/a

Credit: First Light Imaging

SELEX/SAPHIRA detector





- Pulse tube cooling (vibration-free)
- 1 cold filter possible

Credit: First Light Imaging

Upgrades to the hardware / optics

- New instrument computer (rack, connected via fiber CameraLink)
- Spectral range: **H → J+H**
  (select fibers accordingly; need to add filter to remove metrology laser line)
- New fibers and V-groove
  (glued to simplify alignment; optimize spacing to minimise cross-talk)
- Warm filter wheels
- Option for future high spectral resolution mode
  (slidable unit)
- Polarisation control
  (observe both polarisation modes; rotatable half-wave plates)

"MIRCx"

Overall, we expect sensitivity improvement "x10", "x20"

→ "MIRCx10", "MIRCx20", … ?

→ "MIRCExeter" ?

→ MIRCx !

Will be set up to work well with its "sibling" instrument **MYSTIC** (K-band) and with the CHARA infrastructure in general (e.g. for fringe tracking).

Software modifications to real-time code & MIRC data reduction pipeline to exploit new capabilities

Personnel & Timeline

- John Monnier & Stefan Kraus
- Narsireddy Anugu
  (PostDoc MIRC upgrade; starting July 2016 in Exeter)
- Claire Davies (PostDoc data analysis & science interpretation)
- Jean-Baptiste LeBouquin (Advisor)

Timeline:

CDR optical design: summer 2016

Assembly & testing at Michigan: mid-2016 to early-2017

Integration at CHARA: 2017