

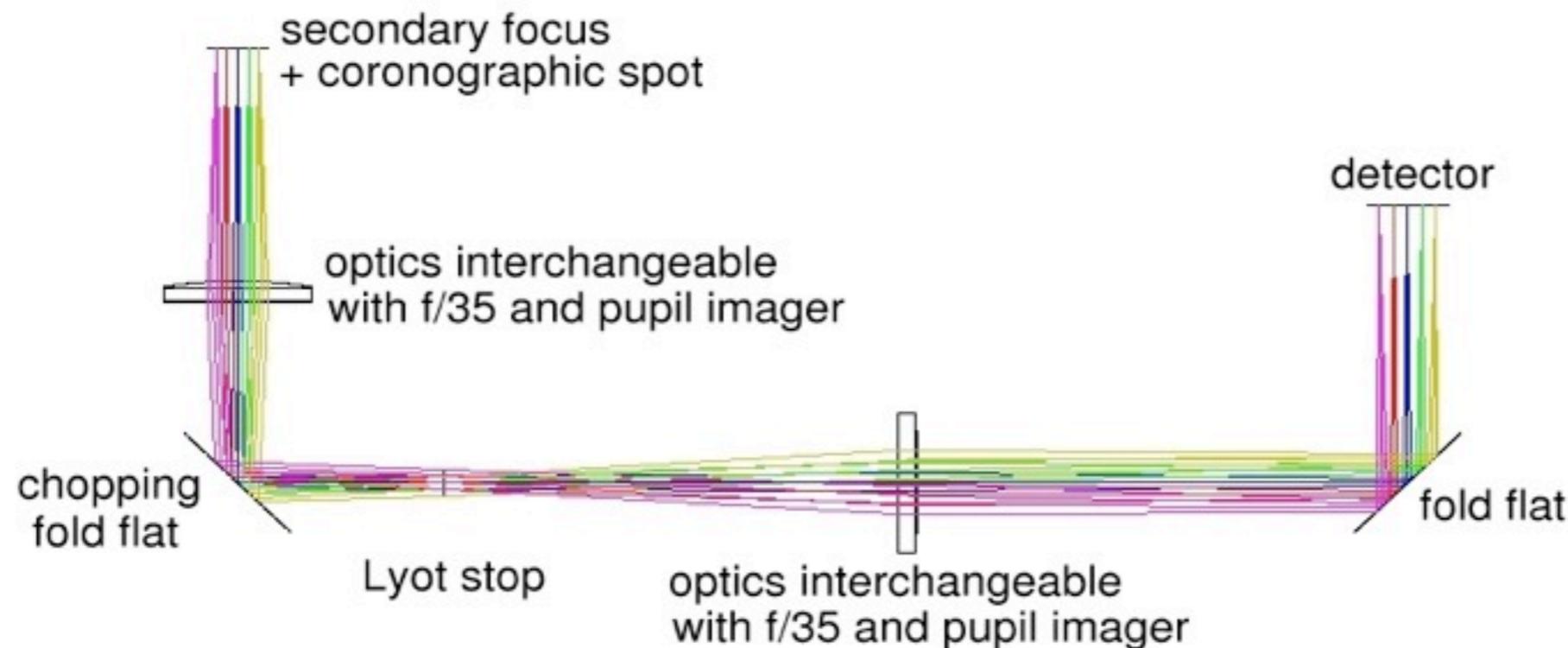
Introduction to the Clio Camera

Phil Hinz
July 4, 2012

Pre-presentation version: June 17, 2012



Optical Parameters

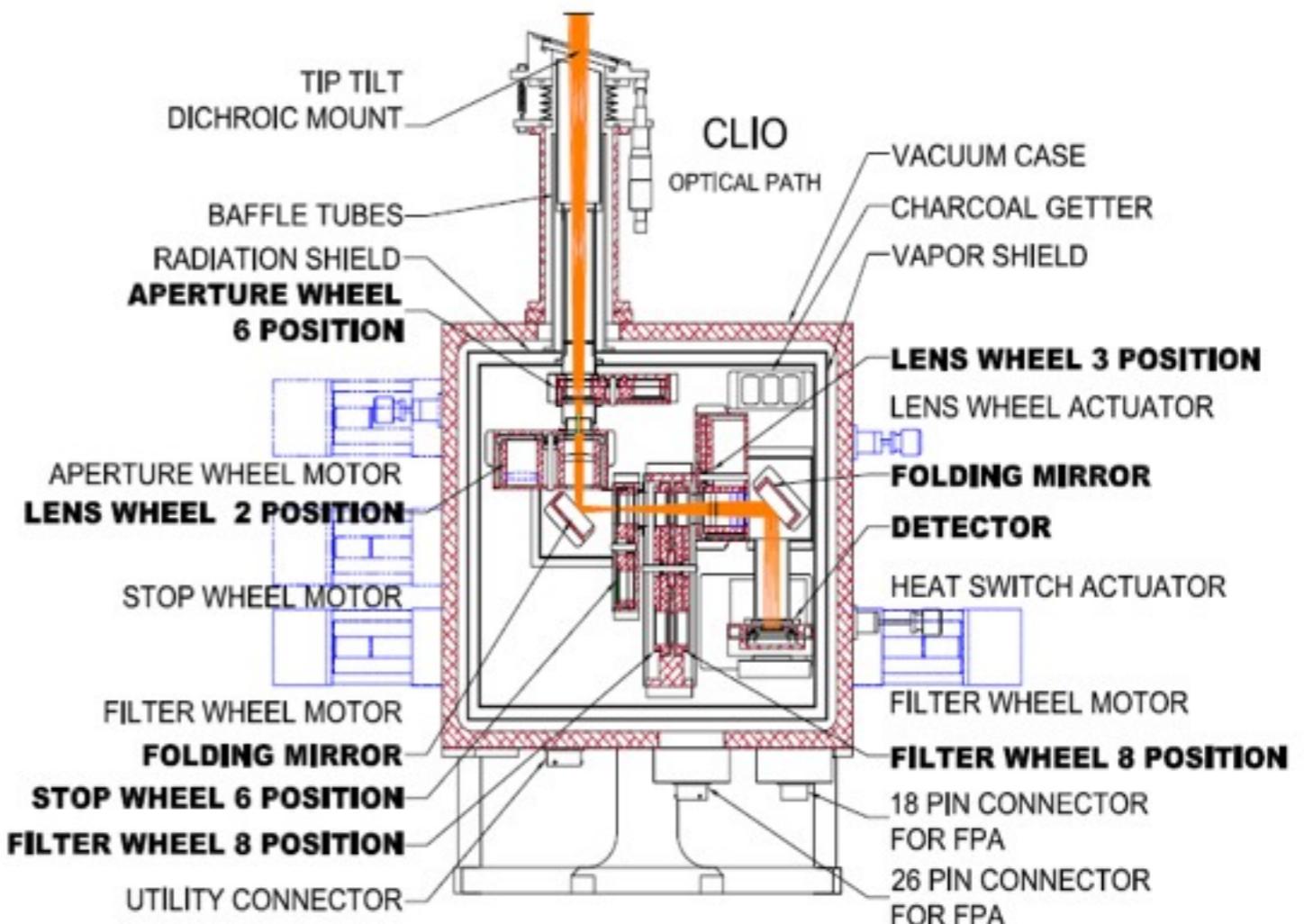


- Diffraction-limited imaging from **H through M-bands**
- 3 imaging modes: **f/37.7** (H and K-bands), **f/21.5** (L and M-bands), and **pupil imaging** (for alignment of cold-stops) modes
- HAWAII-1 HgCdTe array with a 5.3 μm cutoff (Teledyne)
- **Cooled optics** (77K), **baffling**, and **cold stops** to minimize instrument thermal background
- **Coronagraphic option** built in (have ability to add field and pupil stops and PSF shaping wave plates)

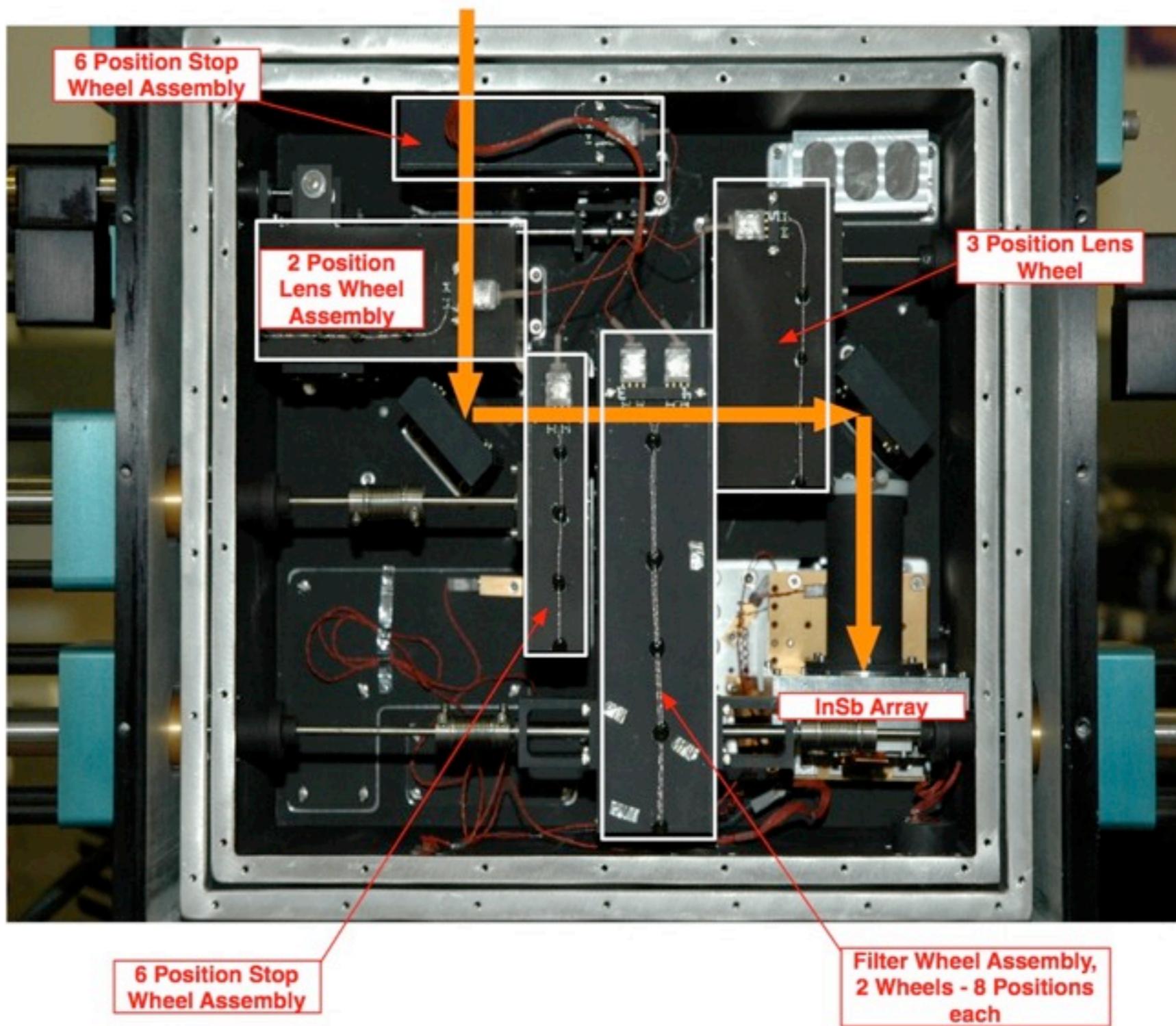


Mechanical Design

- Optics, filters and cold stops are selectable with stepper motors.
- Entrance window is dichroic to reflect the WFS light ($< 1 \mu\text{m}$).



Mechanical Design



Thermal Design

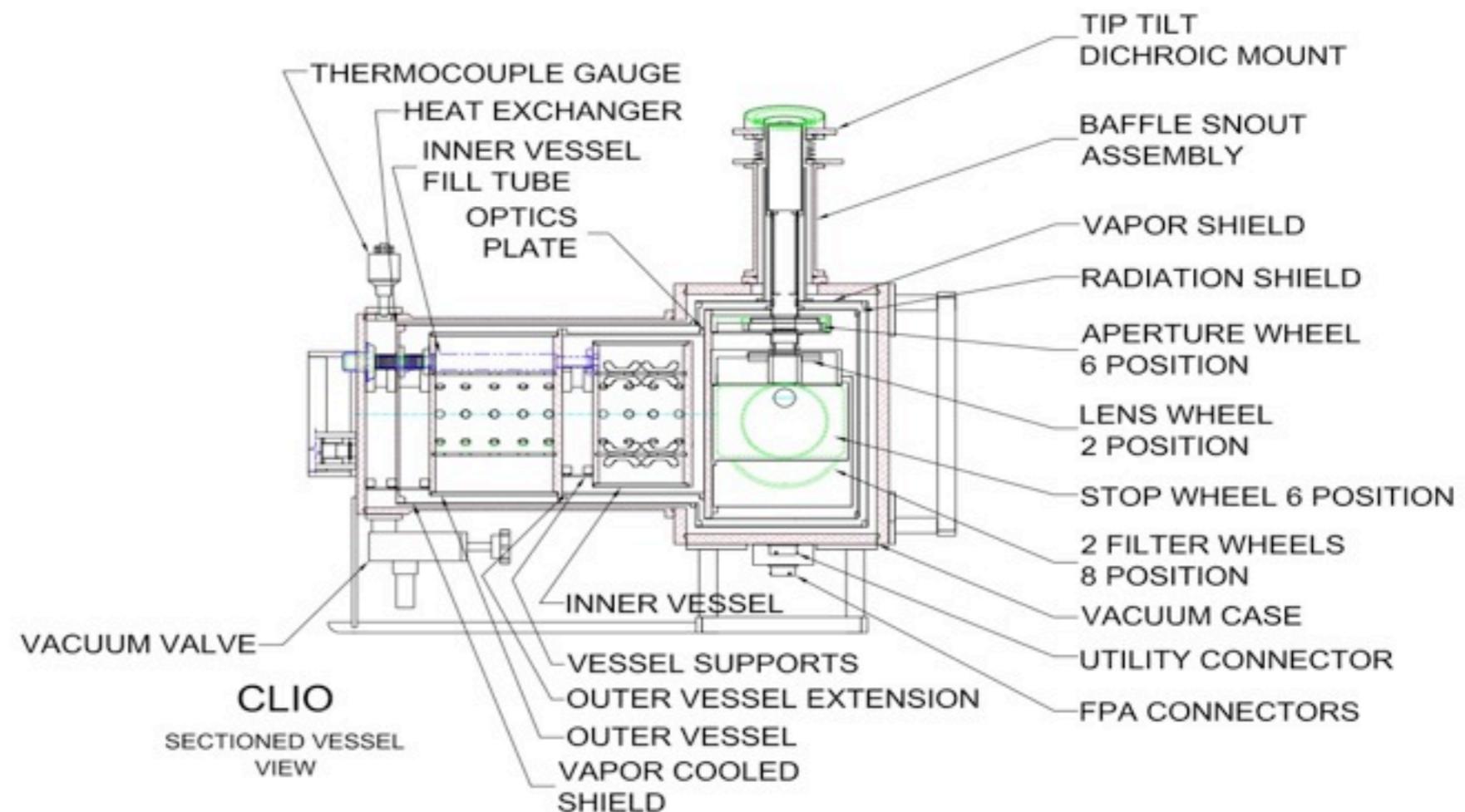
- Two stage cryostat:
 - First stage: Optics
(LN₂: 77 K)
 - Second stage: Detector
(Solid N₂: 60 K)



Thermal Design

- Two stage cryostat:

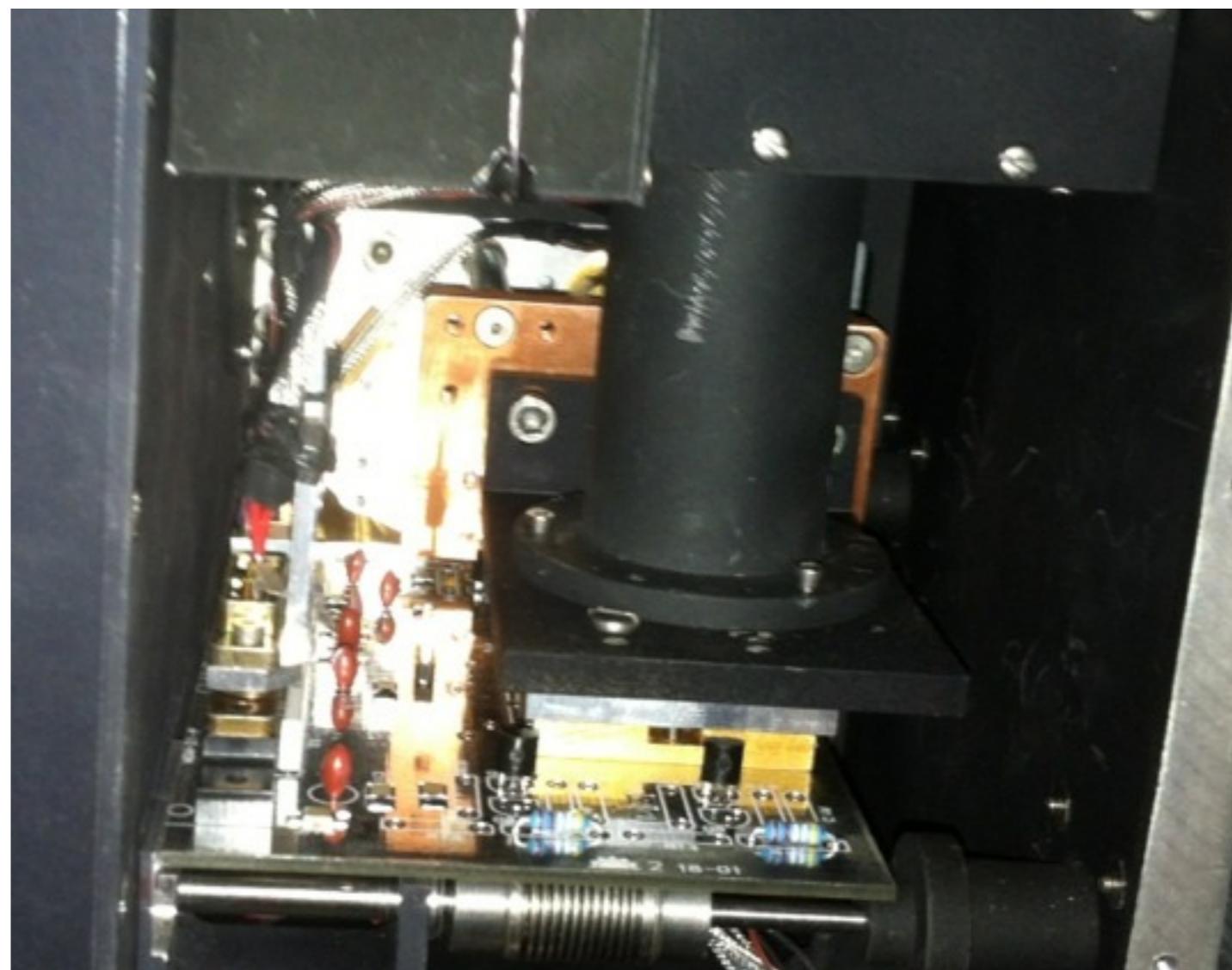
- First stage: Optics
(LN₂: 77 K)
- Second stage: Detector
(Solid N₂: 60 K)



Clio Detector

- Uses two quadrants of an engineering grade HAWAII-I MBE long wavelength detector.
- SDSU Gen. II electronics

Temperature	60 K
Pixel Rate	1 MHz
Readouts	1 per quadrant
Duty Cycle	~ 90%
Frame Rate	\leq 3.8 Hz full frame
QE _{3-5 μm}	0.6
Well Depth	$2.5 \times 10^5 e^-$
Dark Current	<3 e ⁻ /s
Read Noise	100 e ⁻ single read 20e ⁻ CDS
Gain	5 e ⁻ /DN

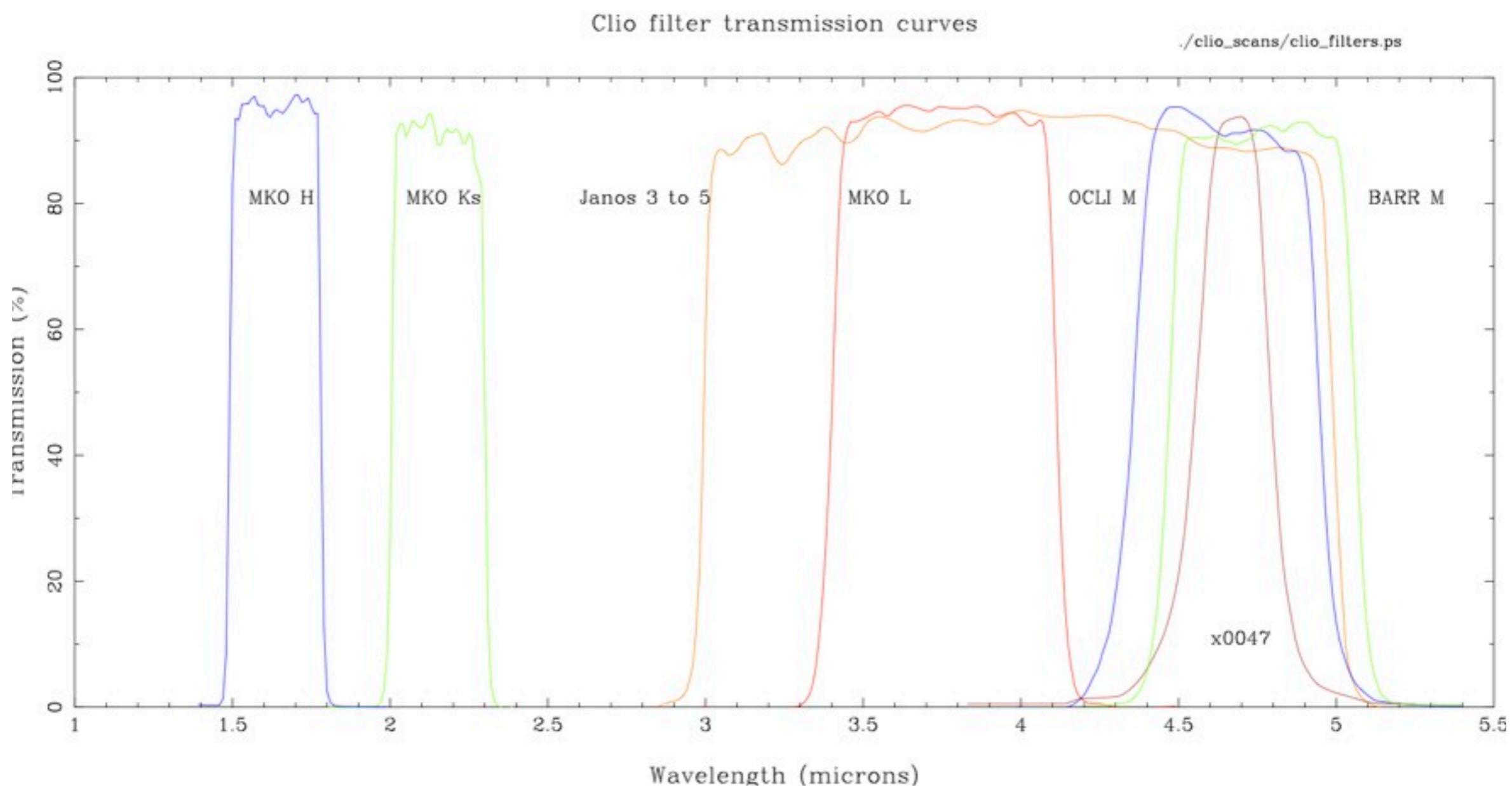


Clio Readout Modes

- Full Reset-Read mode used for fast imaging.
 - Overhead of 1 read time (262 ms) is incurred for any readout.
- “Strip” mode used for higher efficiency in L' band
 - 183 ms overhead
- “Stamp” mode used for M band imaging
 - 43 ms overhead.



Filter Complement

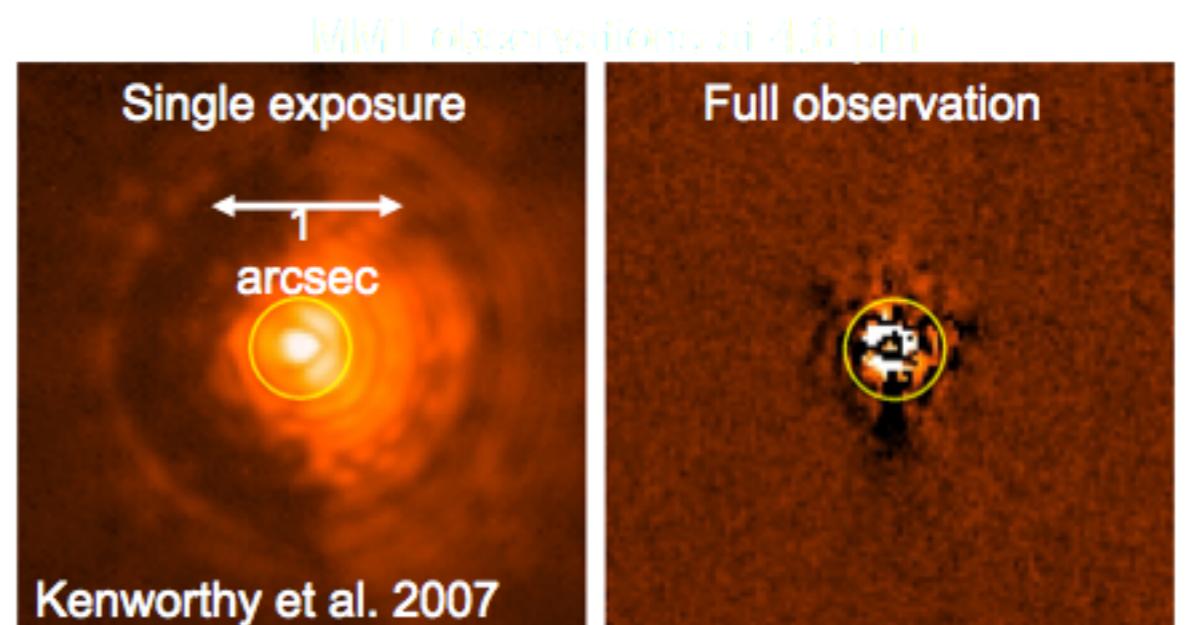


- 3.1, 3.3, 3.4, and 3.9 μm filters also available.



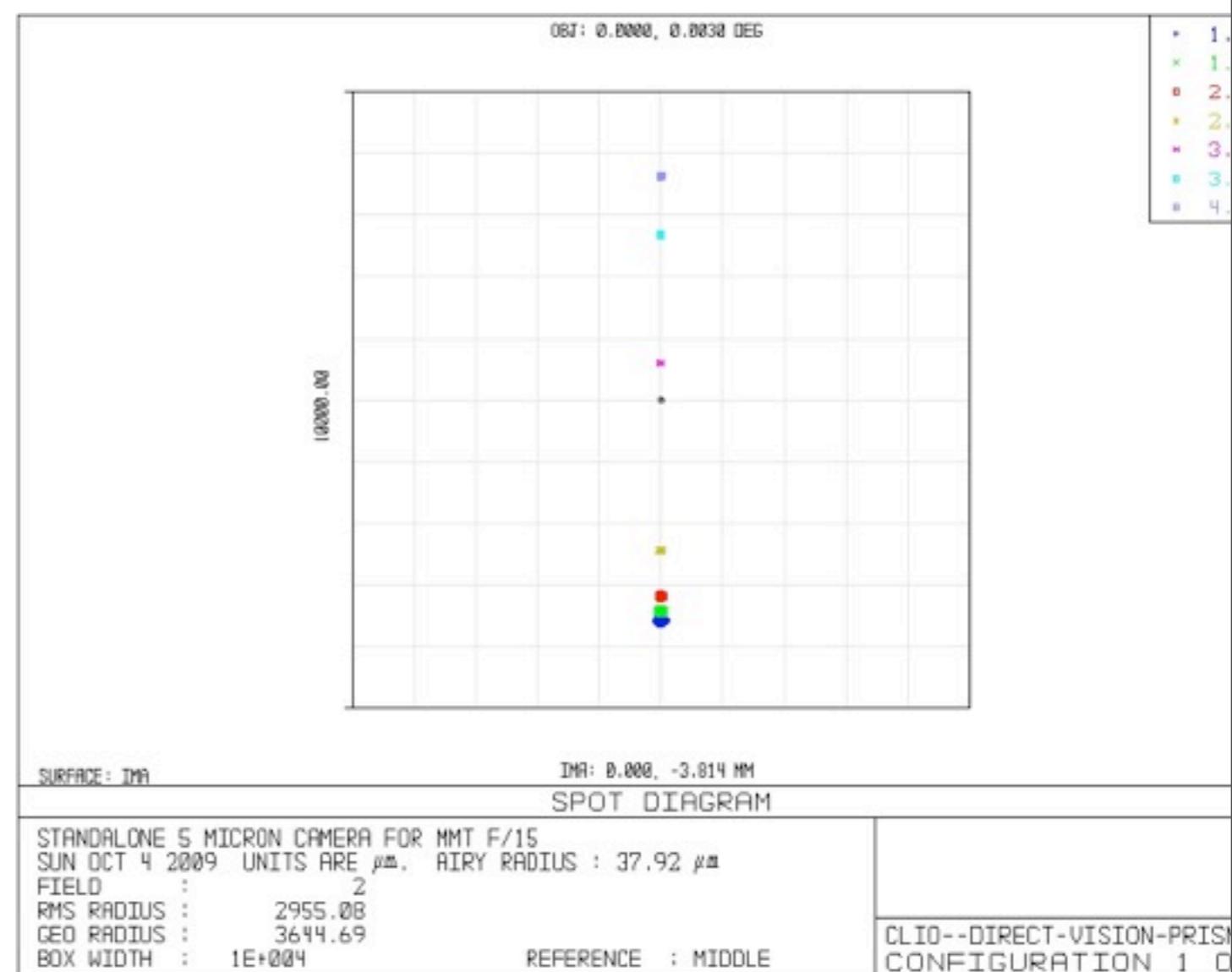
Other Modes

- Apodizing Phase Plates are available in the cold stop wheel to provide a “dark hole” at L' and M band for high contrast imaging.
- 3 hole and 6 hole nonredundant masks are available for NRM data acquisition.

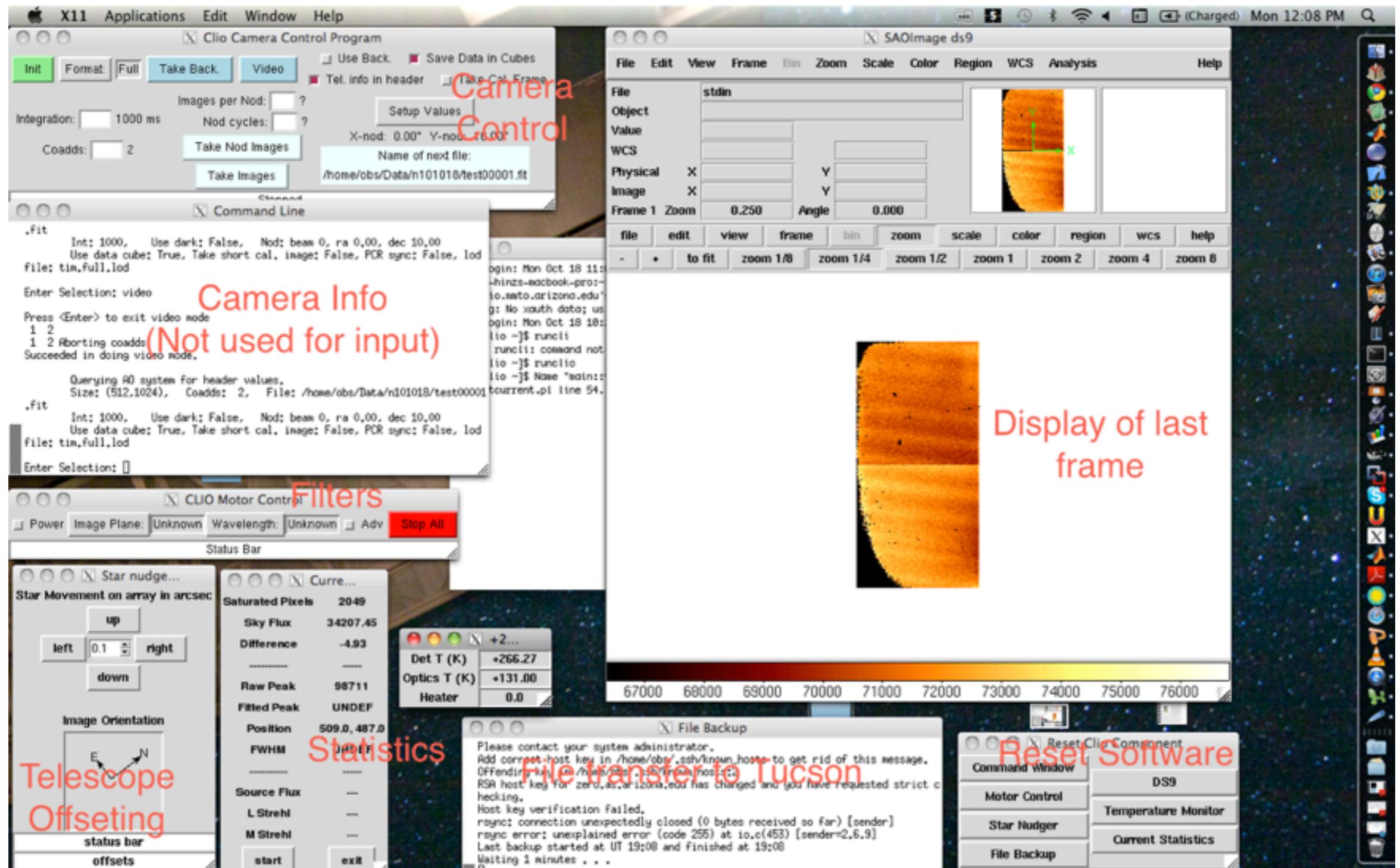


Prism spectroscopy

- A direct vision prism is available.
 - R @ 2 μm is ~30
 - R @ 3.5 μm is 130



Clio Software



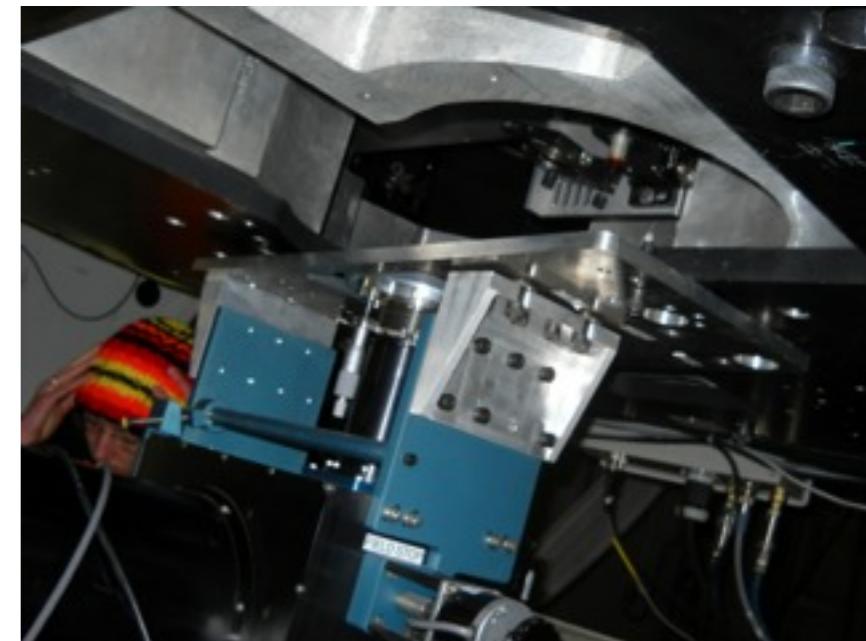
Clio in Operation

- Clio communicates with the AO system to carry out automated nods and dithers.
- FITS header information is retrieved from the AO system to provide all relevant instrument and telescope information.
- Remote operation is achieved via remote X display.

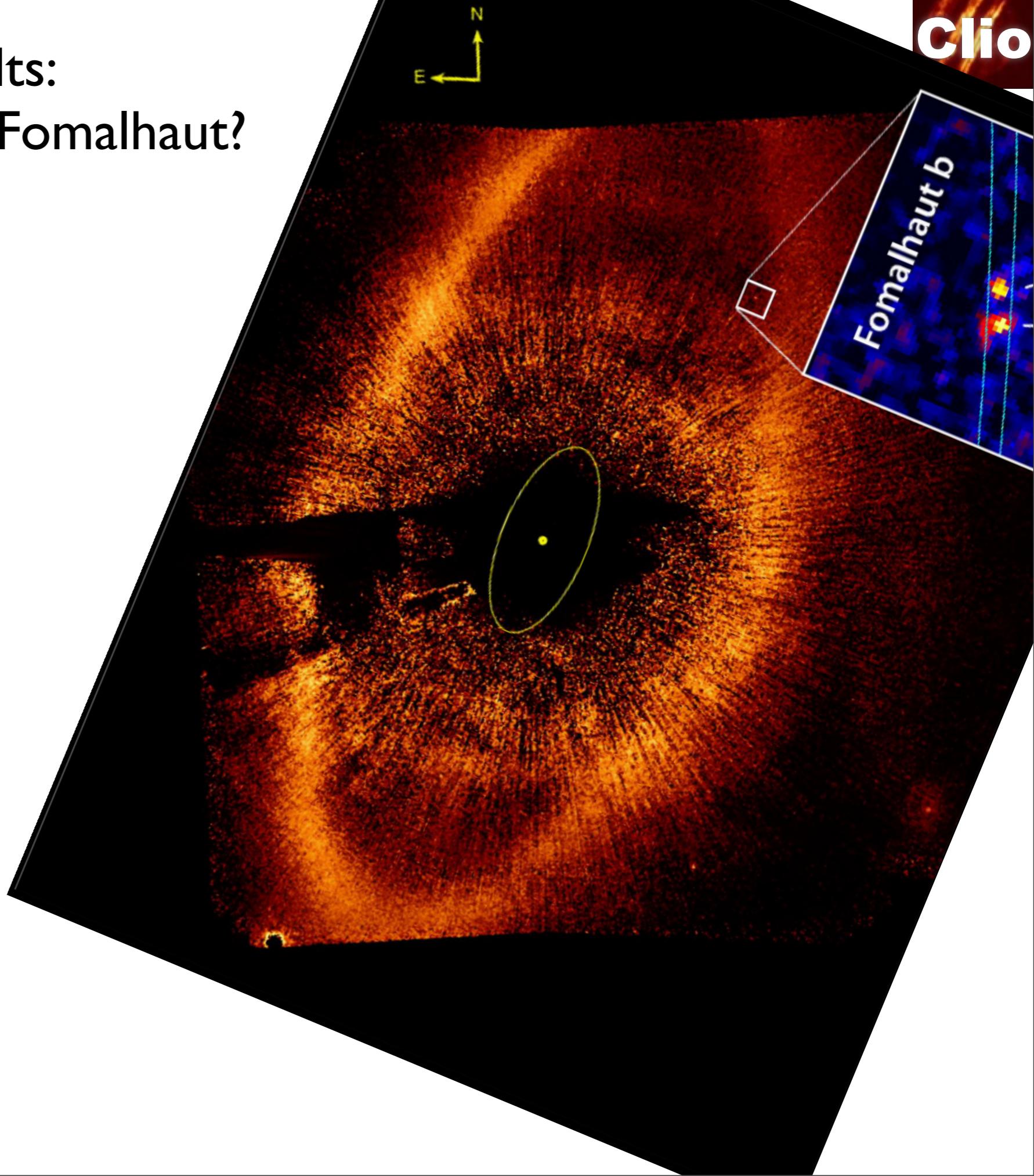


Clio at the MMT

- Clio has been used at the MMT since 2006.
- Clio2 started operation in 2010.
- Simple camera operation has allowed use by a range of observers.

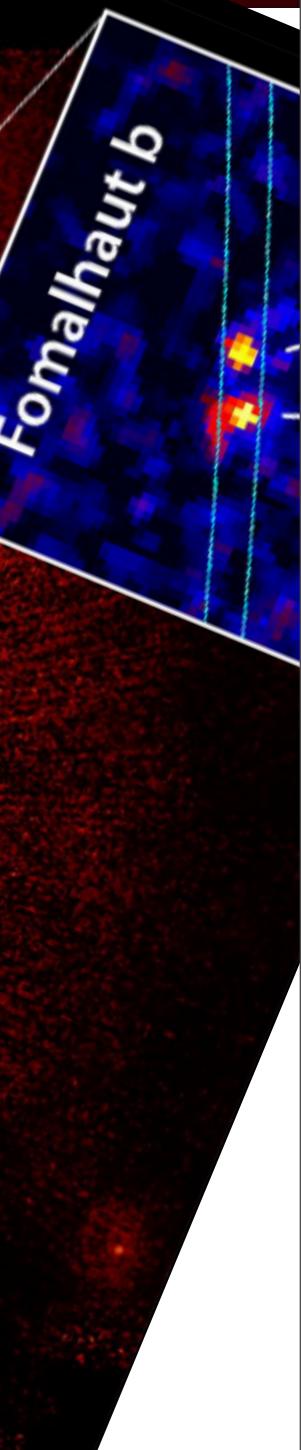
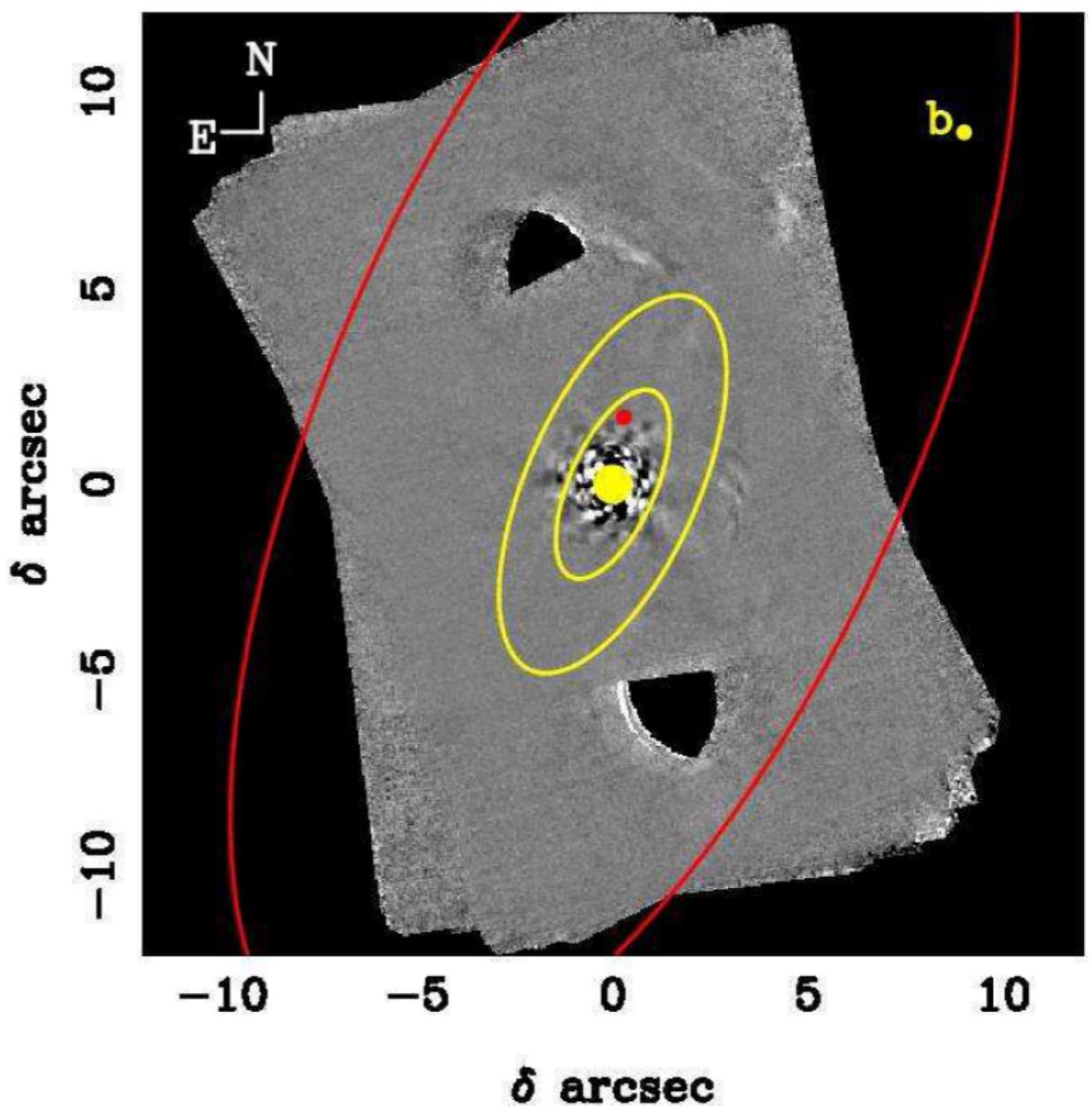


Selected Results: Other planets around Fomalhaut?



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- Clio used at M band
to eliminate existence
of inner companions
to Fomalhaut of > 3
 M_J

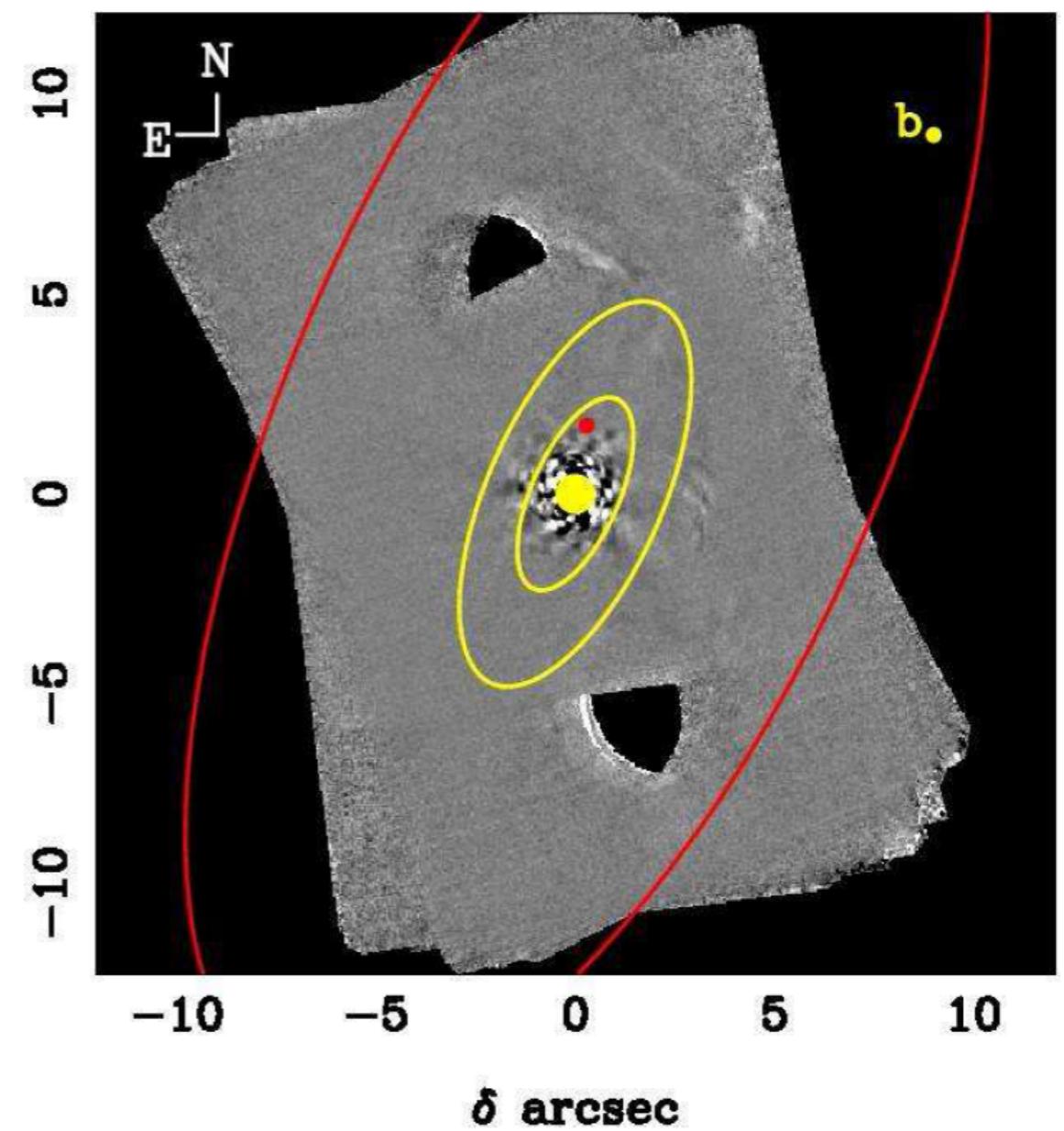
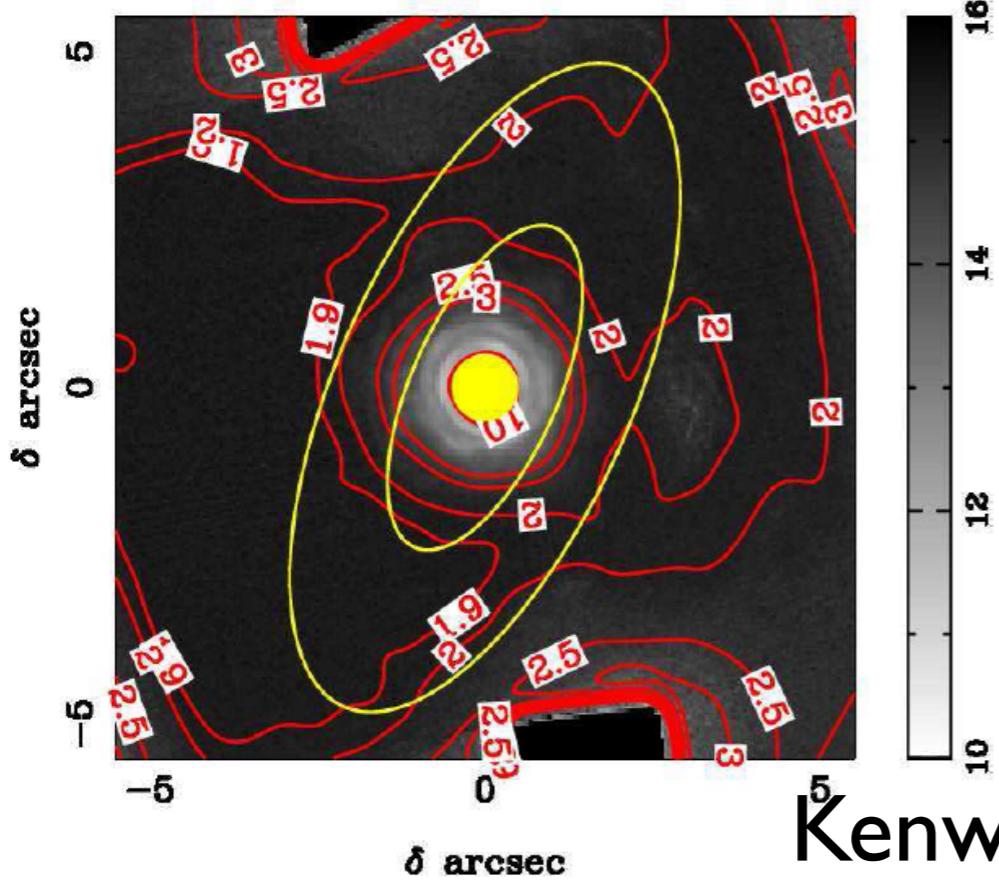


Kenworthy et al. 2009



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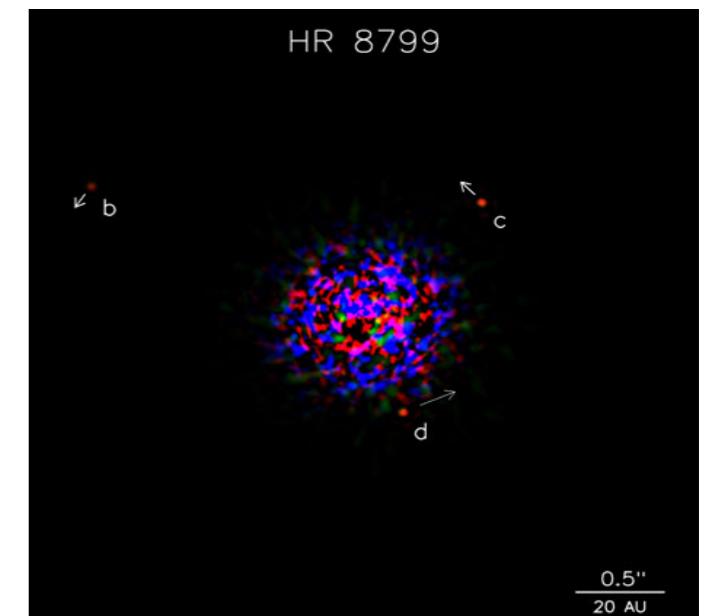
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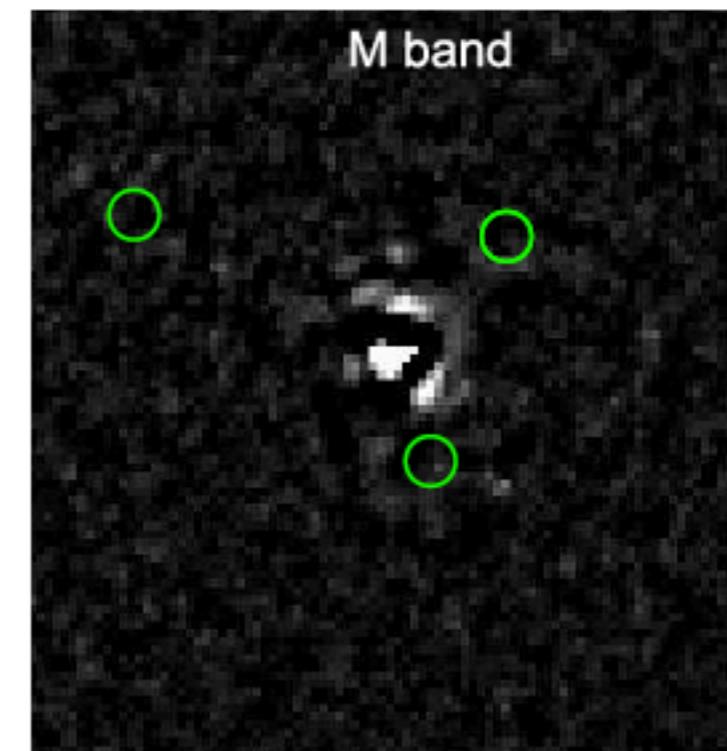
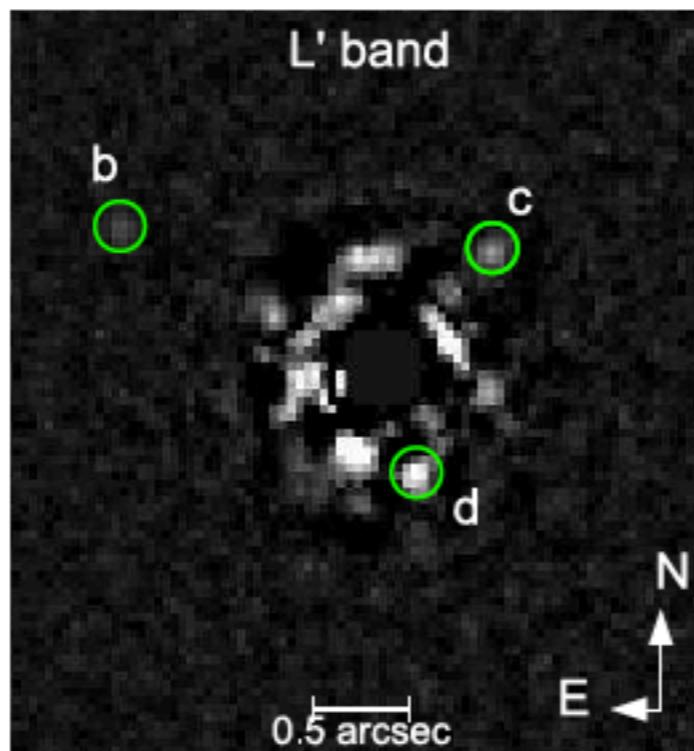
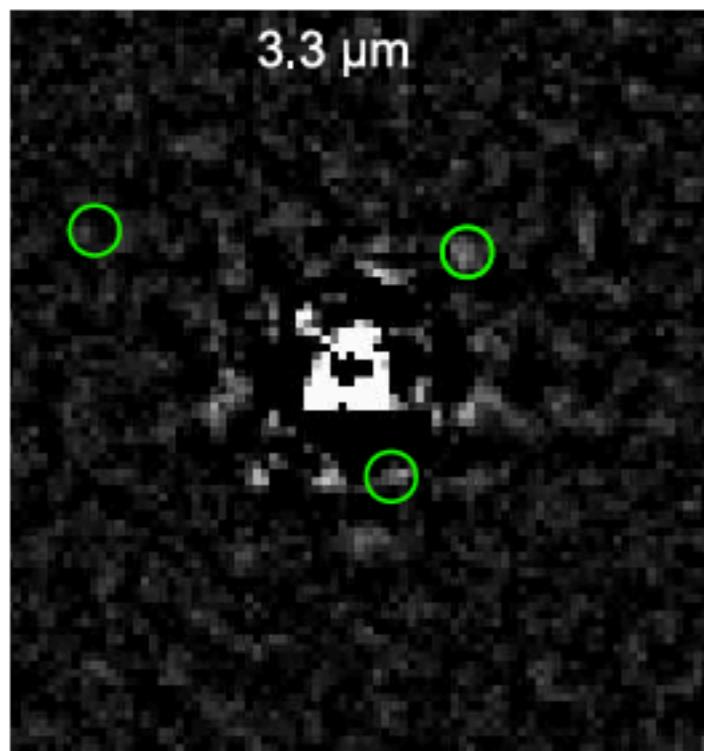
Selected Results: Imaging the Planets around HR 8799

- Clio used to probe lack of methane absorption in HR 8799b,c,d



Discovery by Marois
et al. 2008

Clio Imaging of HR 8799



Hinz et al. 2010



Changes for Clio at Magellan

Motorized Optics Mode
Change



Modified Clio to
operate inverted

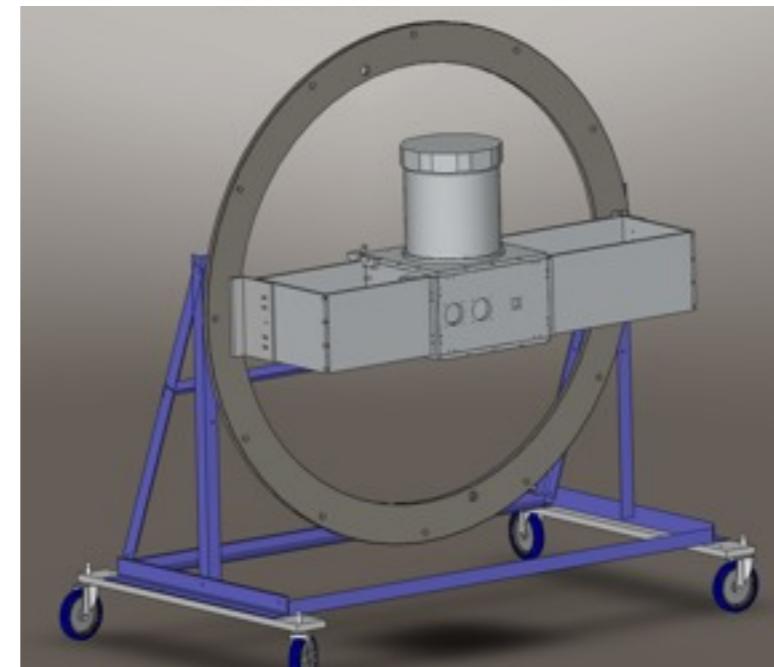
Changed Dichroic for
MagAO WFS



Added
super-insulation

Thermalized E-rack

New Mount and Cart



Clio ready to mount on Magellan



Clio Shipping Plan

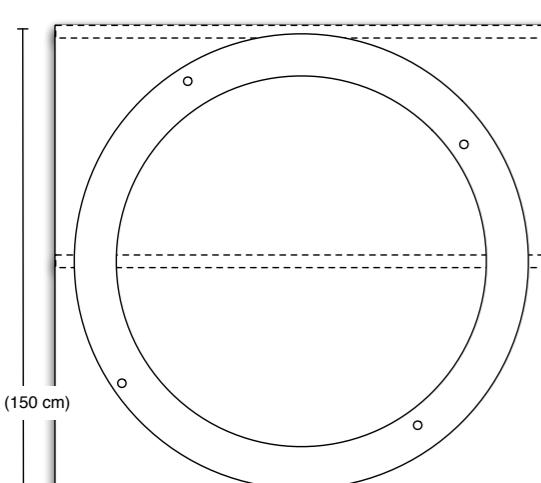
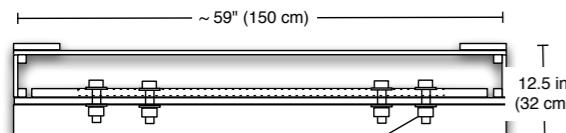


Clio Shipping Plan

- Items to be shipped
 - Clio Instrument
 - Electronics Support Rack
 - Cables (umbilical)
 - NAS Interface Ring
 - Service/Storage cart
- We request from Carnegie:
 - Shipping from Pasadena to LCO
 - Airride transport
 - Pilot car



Shipping



- The instrument and support equipment will be shipped together in four (4) packages:
 - (1) Clio will be packaged in an existing Hardigg shipping case together with the umbilical.
 - (2) The NAS Mounting ring will be shipped in a custom 58"x58" wooden box with forklift skids.
 - (3) The electronics rack will be package on a standard 48"x40" lightweight export pallet. The pallets may be recycled or stored after shipping is complete.
 - (4) The service cart will be broken down and along with the Clio interface elements will be palletized on a standard 48"x40" pallet.

48 x 40" Lightweight Export Pallet

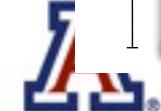
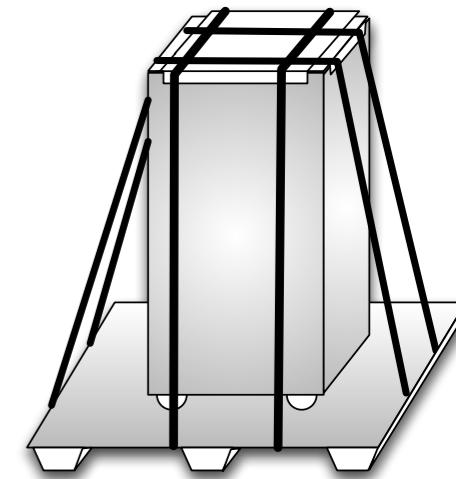


[Enlarge](#)

ECONOMICAL

Sturdy, cost-effective pallet - Ideal for one-way shipping.

- Stack 45 pallets in 6 feet.
- ISPM 15 exempt for export shipping.
- Weather resistant, won't rot, split or mildew.
- 4-way forklift access and 9-legged support.
- Larger quantity quotes available.

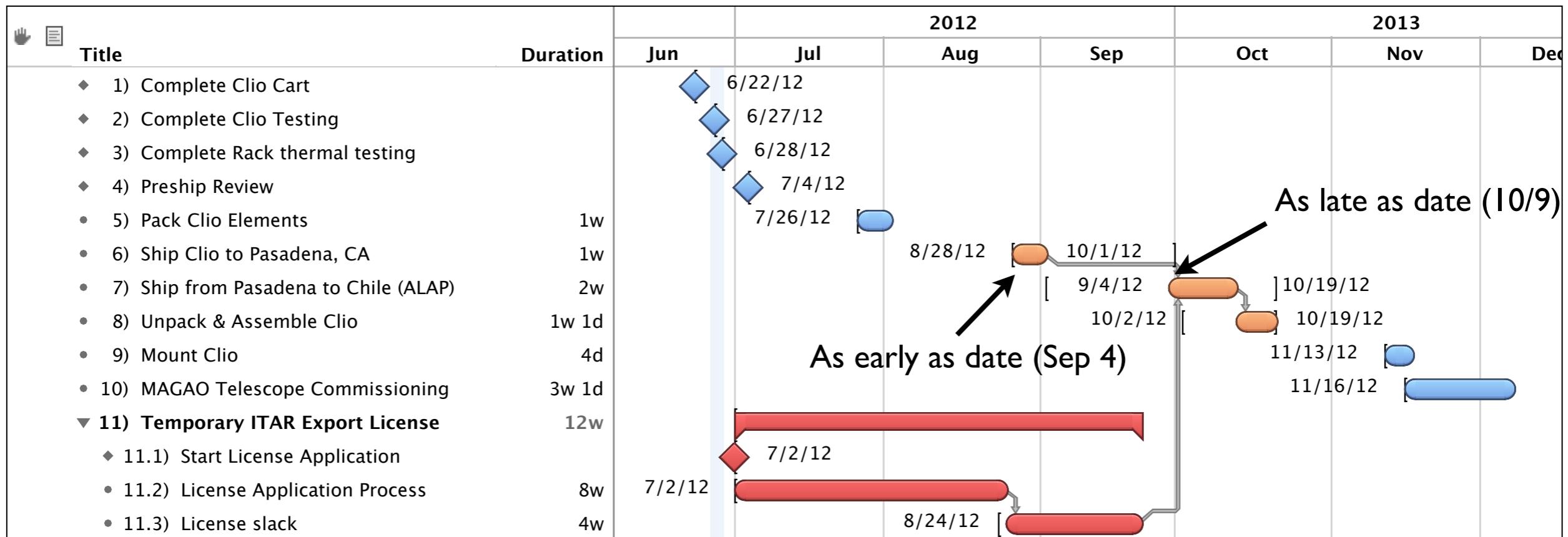


Export License

- Clio requires ITAR Export License from the State Department
- Process commenced on June 27 with the information transmitted to the UA “Person of Authority”. Tom McMahon will be overseeing the licensing process.
- We will request a permanent export license with the expectation of Clio residing permanently in Chile.
- Clio will remain the property of UA, under the care and management of the UA PI.
- We are scheduling 2 months for the licensing process with 4 weeks margin.



Shipping Schedule



- Export License is the critical path.
- We will be packed and ready to ship by early August.
- We can ship to Carnegie by late August for arrival in Pasadena by Tuesday, Sept 4 (set by holiday schedules)
- We can ship to meet an “as late as possible” (ALAP) delivery of Oct 19. This late date will be used only if excessive delays in receiving export license.
- Clio would be unpacked by instrument team as late as Oct 19.

