The WIYN One Degree Imager: An Overview

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for the ODI Team

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Finding Answers to Some Key Questions in Astronomy

- Large Scale structure in the Universe (many degrees).
- Structure of Galaxy Clusters (a few degrees)
- Weak and strong lensing (a few degrees)
- Structure of galaxies (sub-arcsecond for large z, but large samples)
- Structure of the Galactic halo (entire sky)
- Very rare objects (Extremely metal-poor stars, interacting binaries, ...)

- The astronomical community is building a plethora of new wide field imagers:
  - Skymapper, VST, VISTA, DECam, **ODI**, PanSTARRS, LSST, Hyper-SuprimeCam, ...

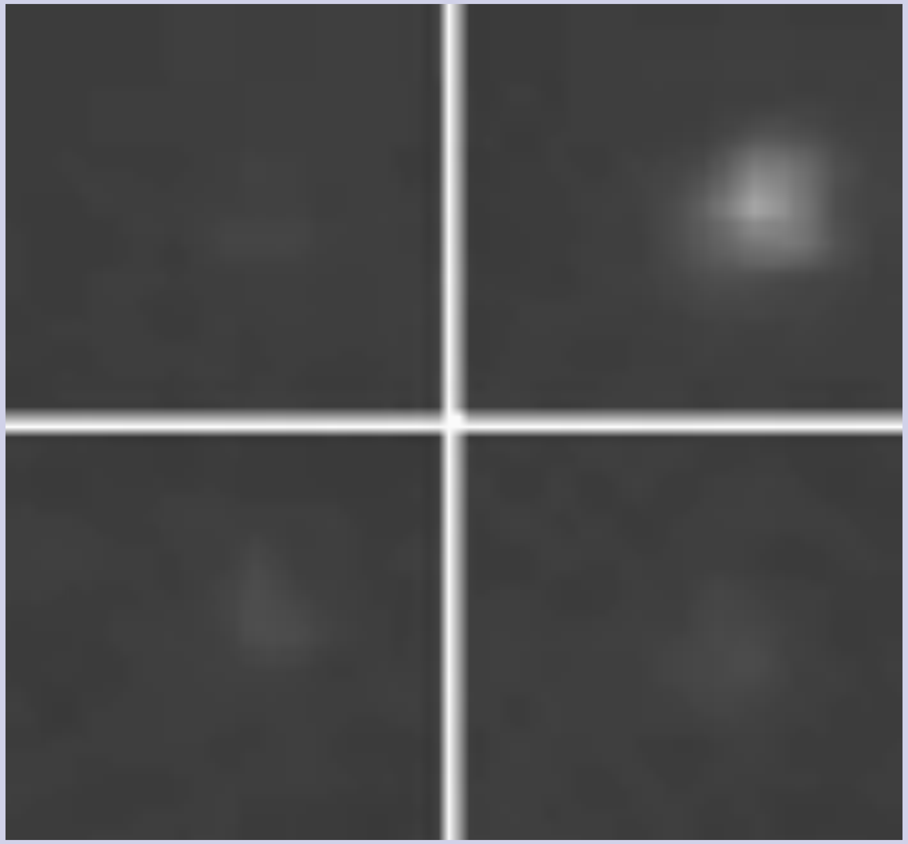
A One Degree Imager for WIYN

- Use WIYN’s 1º field of view.
- Utilize the excellent seeing of site & telescope.

- Further enhance image quality by active tip/tilt image motion compensation.
  - 20 Hz guide loop speed required, 50Hz goal.
  - Shown to improve median seeing in R by 0.15”.
- Median DIQ of ~0.55” in r’, capability of DIQ < 0.3” design goals.

- Sample the focal plane with 0.11” pixels -> 1GPixel camera.
- High observing efficiency, automated cadences:
  - shutter close to open <<20 sec in snapshot mode
- Provide on-site basic data reduction
  - Instrumental detrending, meta data, WCS...

Effect of Tip/Tilt motion on image quality



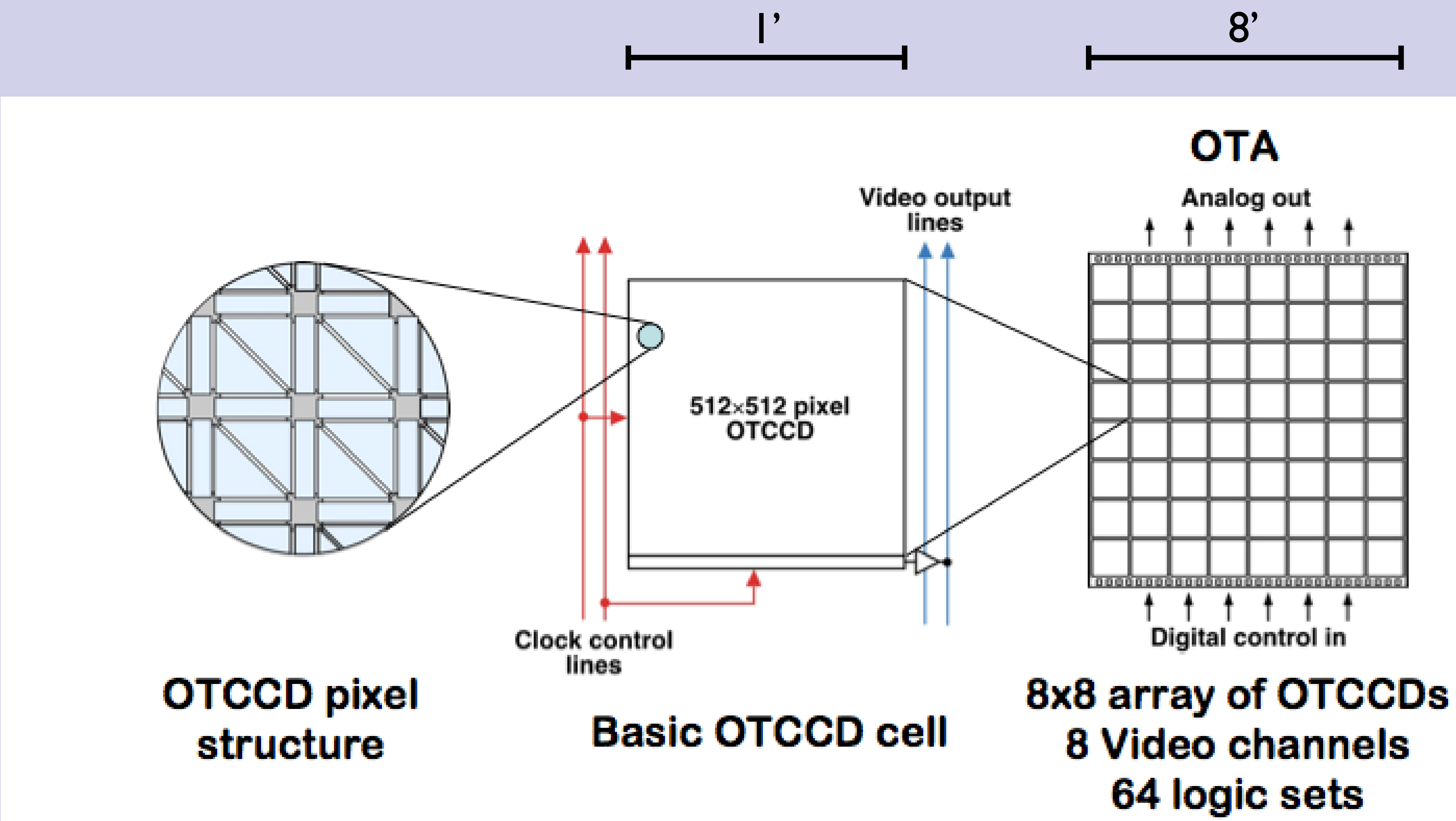
- Atmospheric turbulence, wind-shake cause image motion.

- Some image motion is correlated, e.g., due to telescope shake
- Uncorrelated image motion due to atmospheric turbulence

- (Not too new) Idea:
  sense motion from a bright guide star
  and compensate for it
  - Active secondary mirror (common in AO systems)
  - Move detector (consumer digital cameras)
  - Move electrons in detector (Orthogonal Transfer CCD)

- **New Idea: do it over 1º FoV**

Orthogonal Transfer Array CCD



each cell is an independent CCD ~1’ on sky

each cell can be read out in video mode

each cell is either imaging or obtaining guiding information at up to 30Hz

tip/tilt correction can be applied to each individual cell

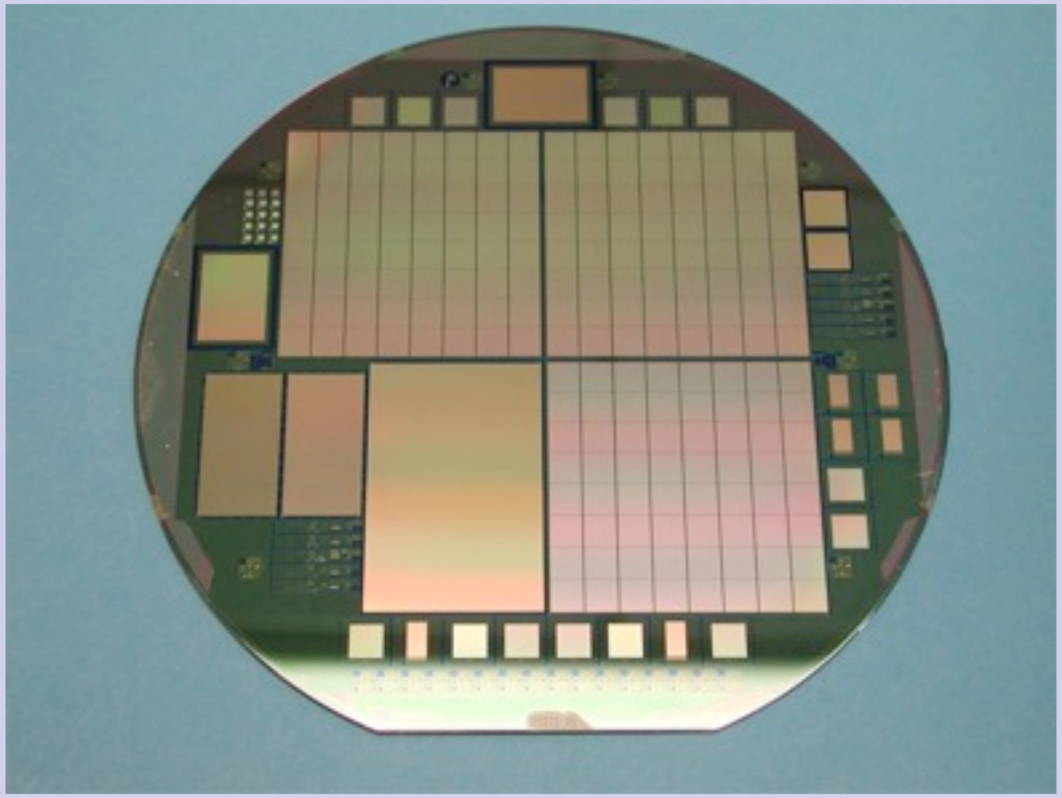
OTA Detector Development

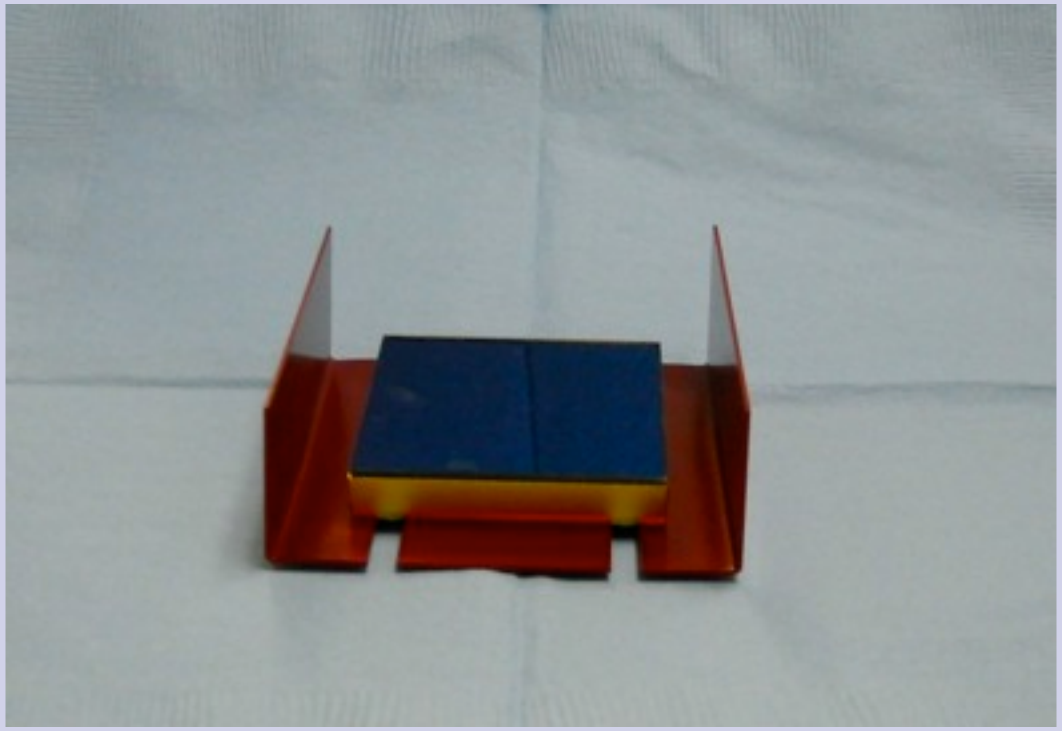
- OT(A) concept invented by John Tonry (IfA)
- Collaborative development of OTAs w/ PanSTARRS project

- ODI works with STA/DALSA
- Wafer production complete.

- Processing of wafers done by ITL (University of Arizona)
  - Thinning, packaging, and testing.
  - Mounting detectors on SiC focal plane.

- Delivery of 64 detectors in May 2010.

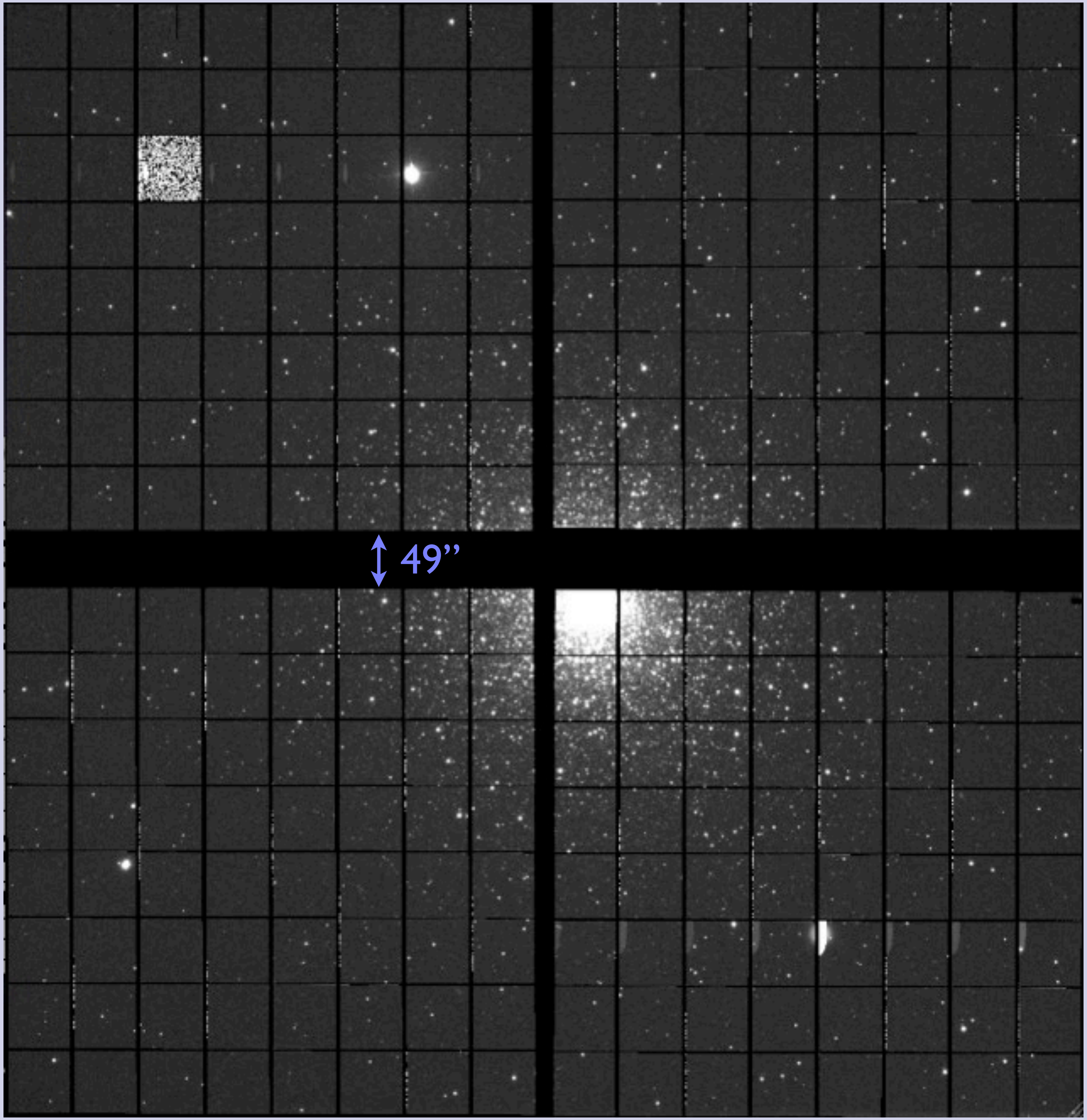




OTA Imaging w/ QUOTA

- 4 Detectors

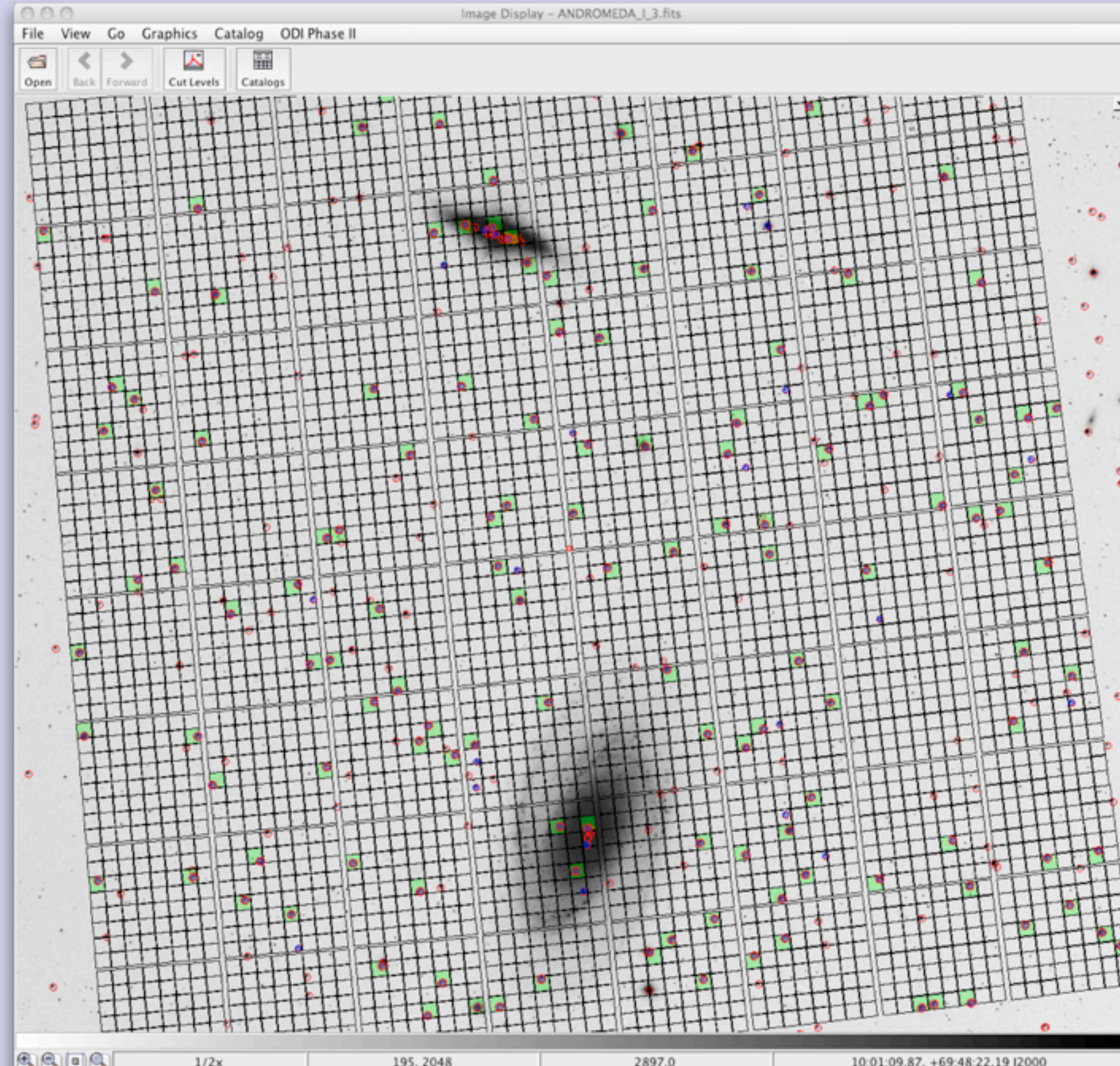
- M 15
- SDSS r'
- 120 sec



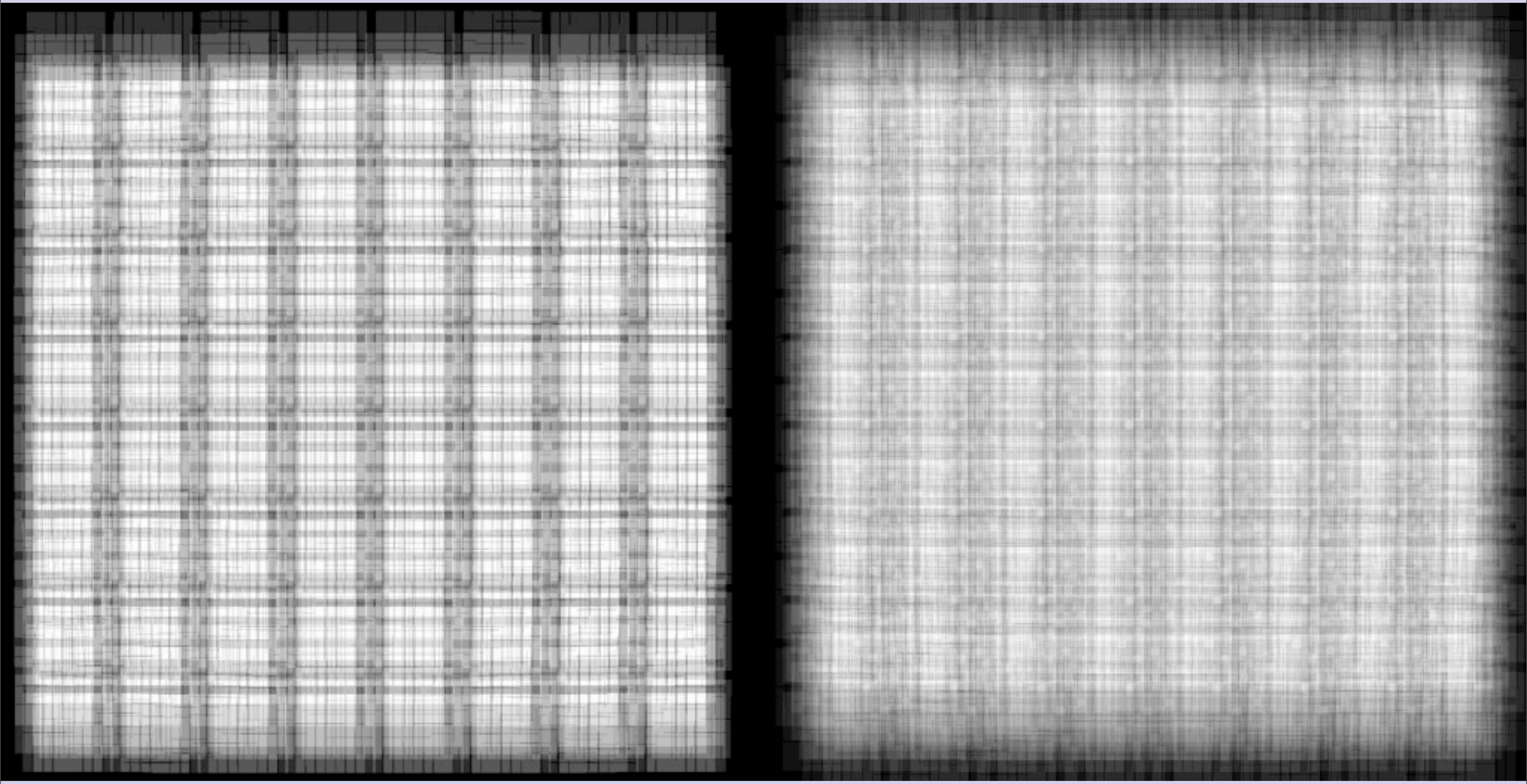
M51 seen by QUOTA:

- 50 min in U, 0.4" seeing
- 15 min in Y (red end of z')
- demonstration of sensitivity and image quality
- also demonstration of fringe behaviour

... on a 1º Field of View



Think about dithering!



- No dither - live with incompleteness.
- Small dither - cover the gaps between OTA cells.
- Large dither - cover gaps between OTA cells AND detectors
- Huge dither - potentially best flat fielding.

OTA Operational Modes

- Static Imaging
  - Use focal plane as conventional imager.
  - *Snapshot programs, photometric standards*

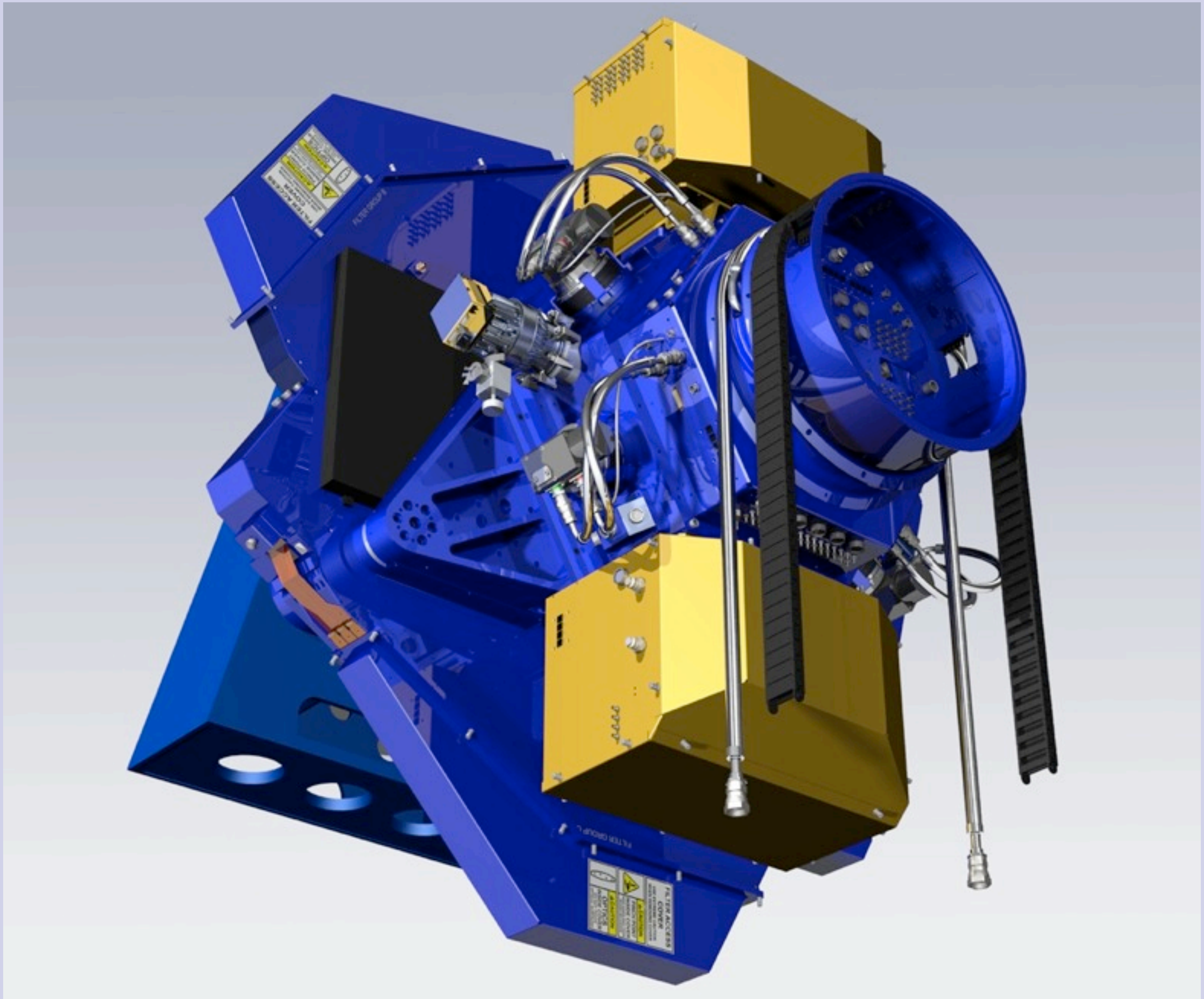
- Coherent Correction
  - Sample only a few guide stars (e.g., one in each corner).
  - Correct 1° field for common-mode image motion.
  - Removes guide error, wind shake.

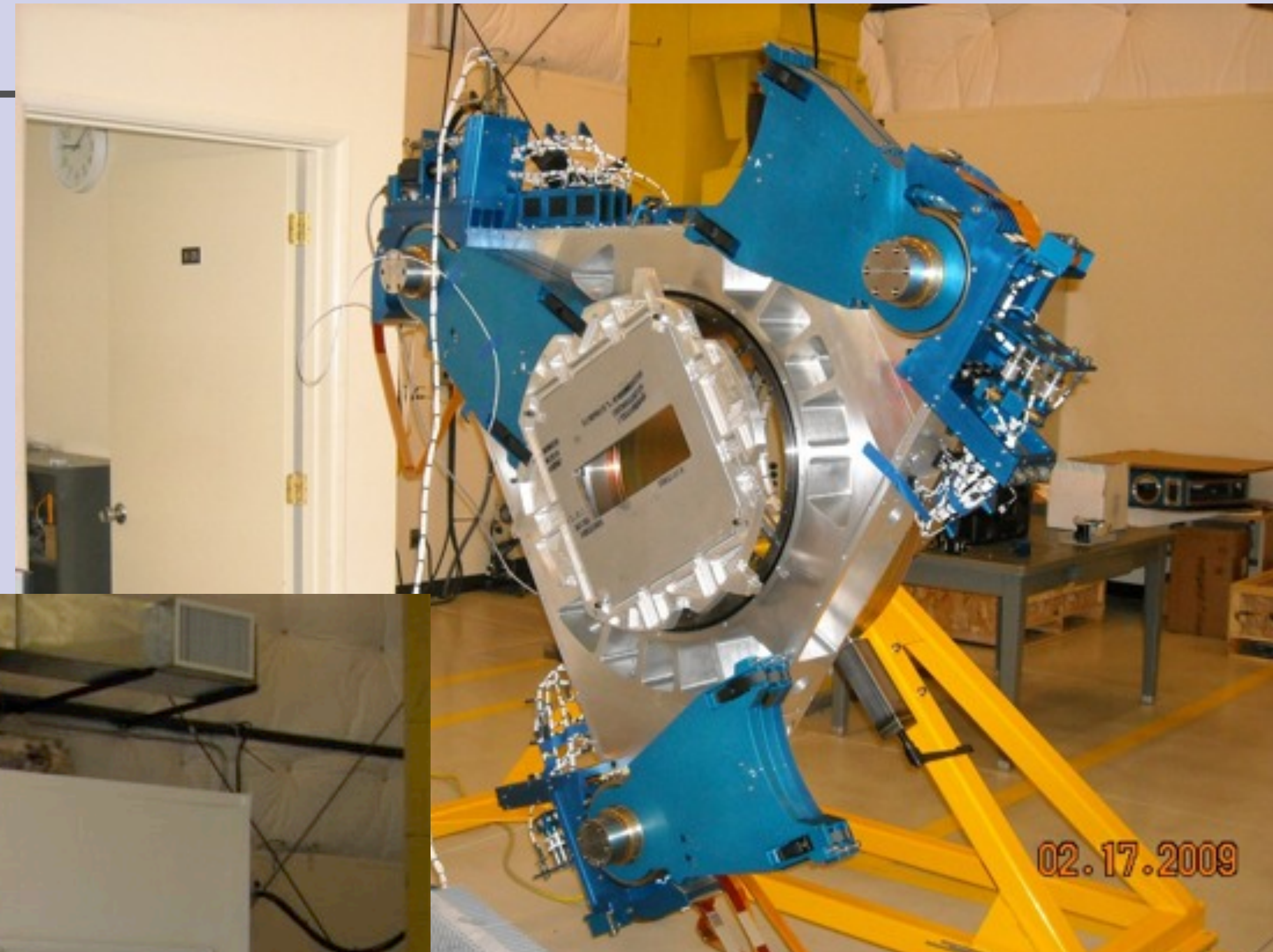
First commissioning phase

- Local Correction (default mode)
  - One guide star every 4 arcminutes; ~200 over 1°!!
  - Correct for atmospheric turbulence (tip/tilt only).
  - Correct in ~4'x4' cells only.
  - Not fully possible everywhere on sky.

- Targeted Photometry
  - Use guide star for shutterless photometry.
  - Select guide star for science goals (vs. to optimise guiding).
  - up to 512 guide stars.

Construction Status

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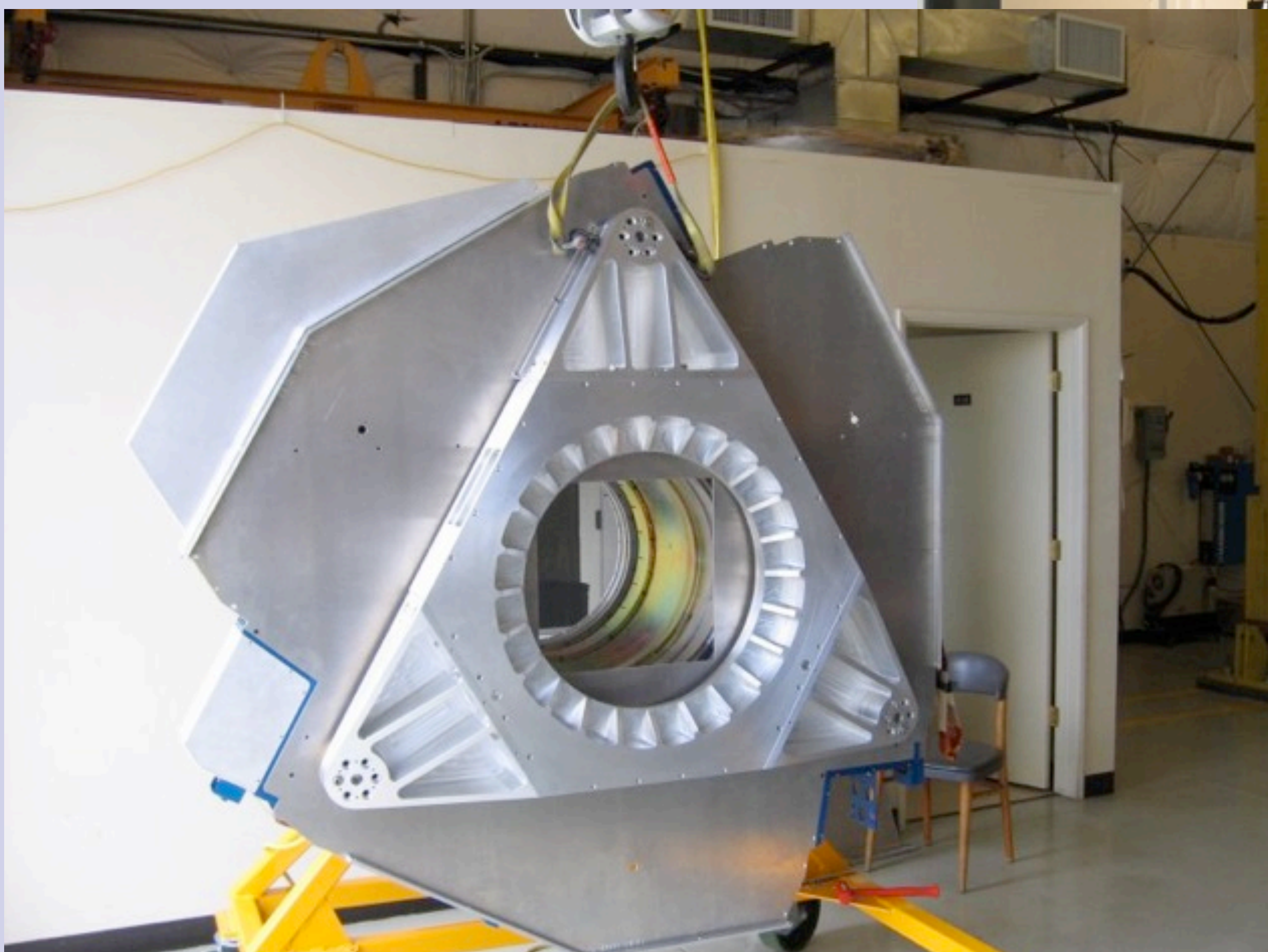
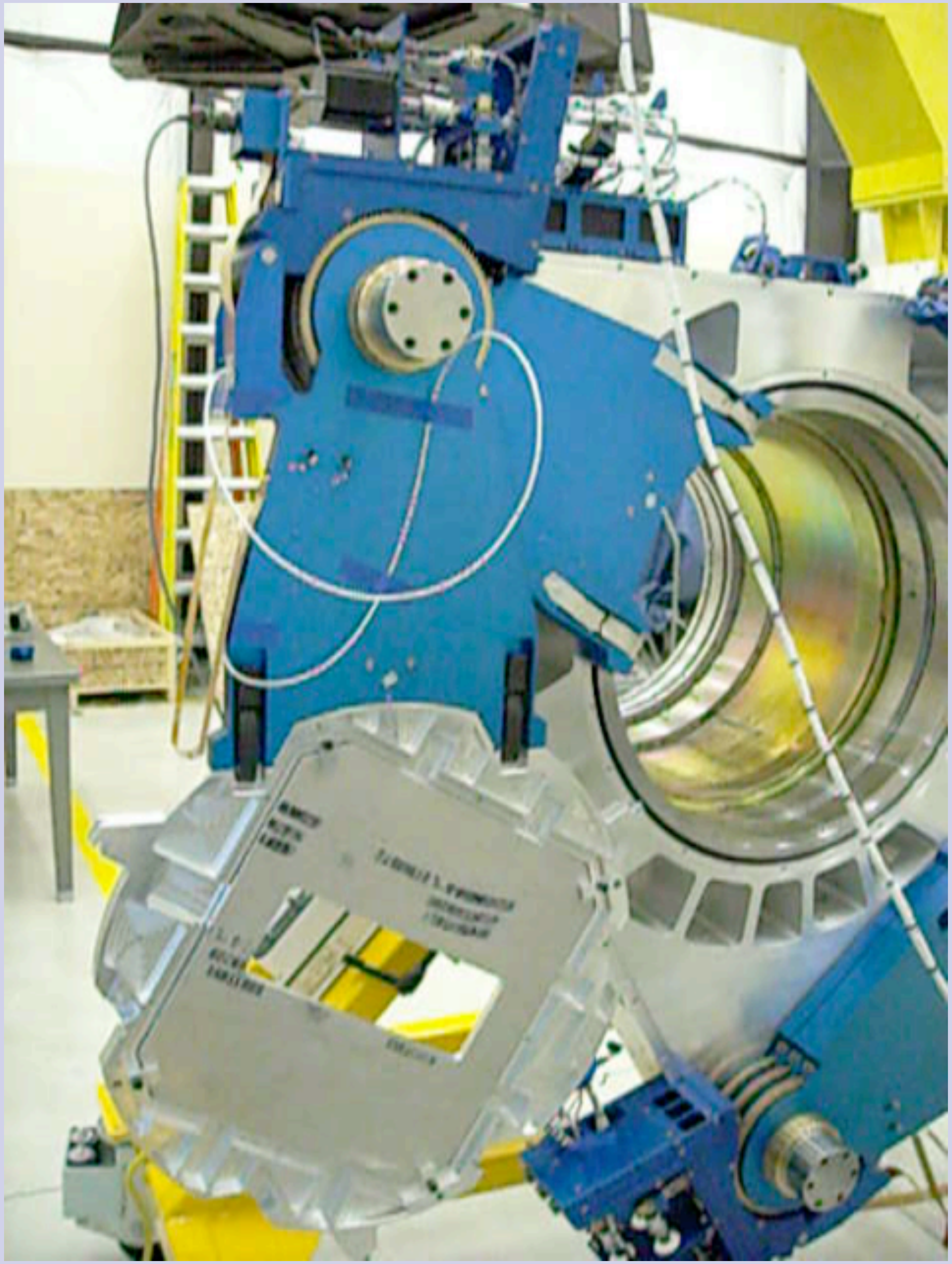


Filter Mechanism

- Design challenge: filter size (42cm)
- **Filter cost ($65k-$100k est.)**
- Filter weight
- Safe handling
- Minimum of 8 live filters as requirements

- ~30 seconds filter change time



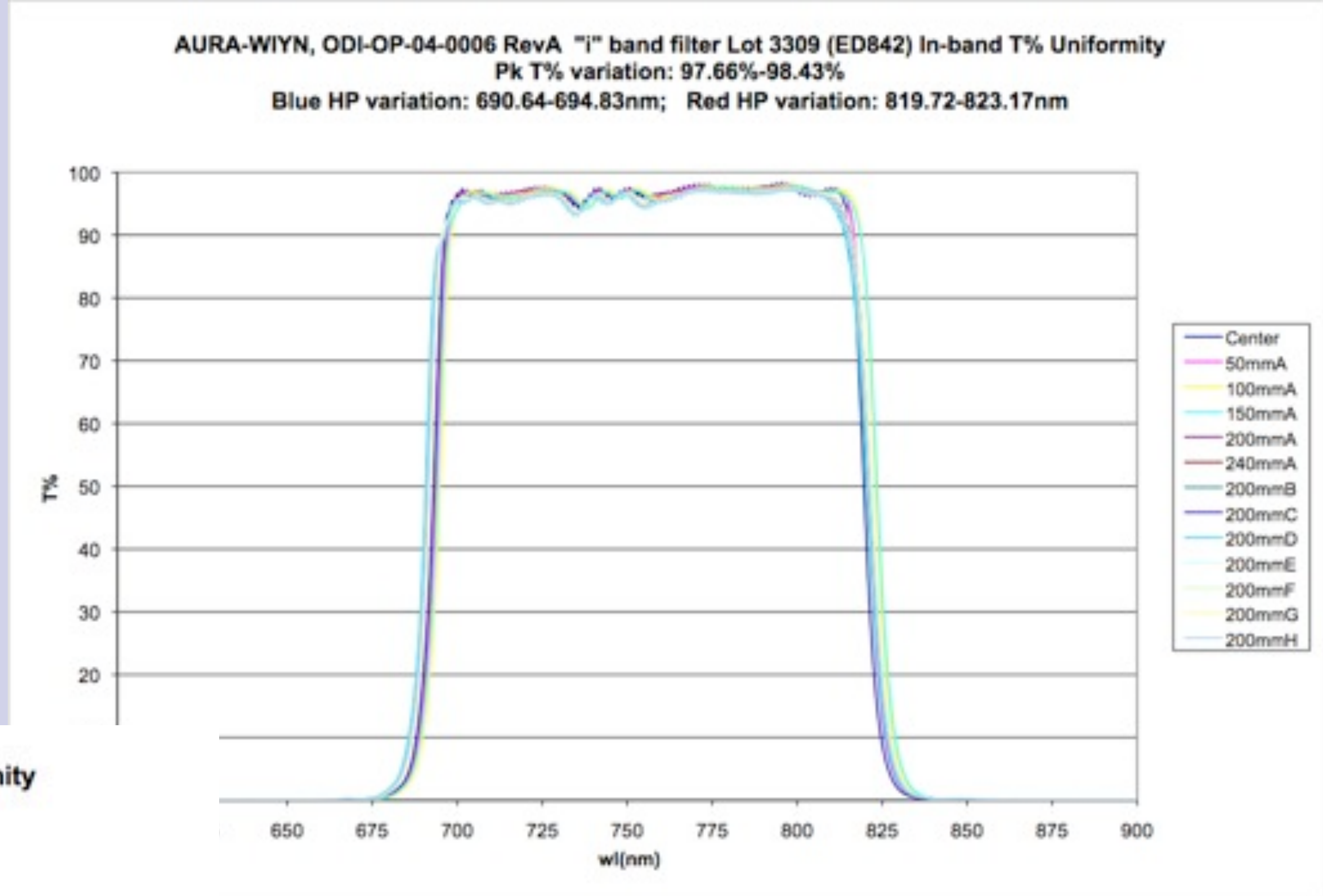
ODI Filters

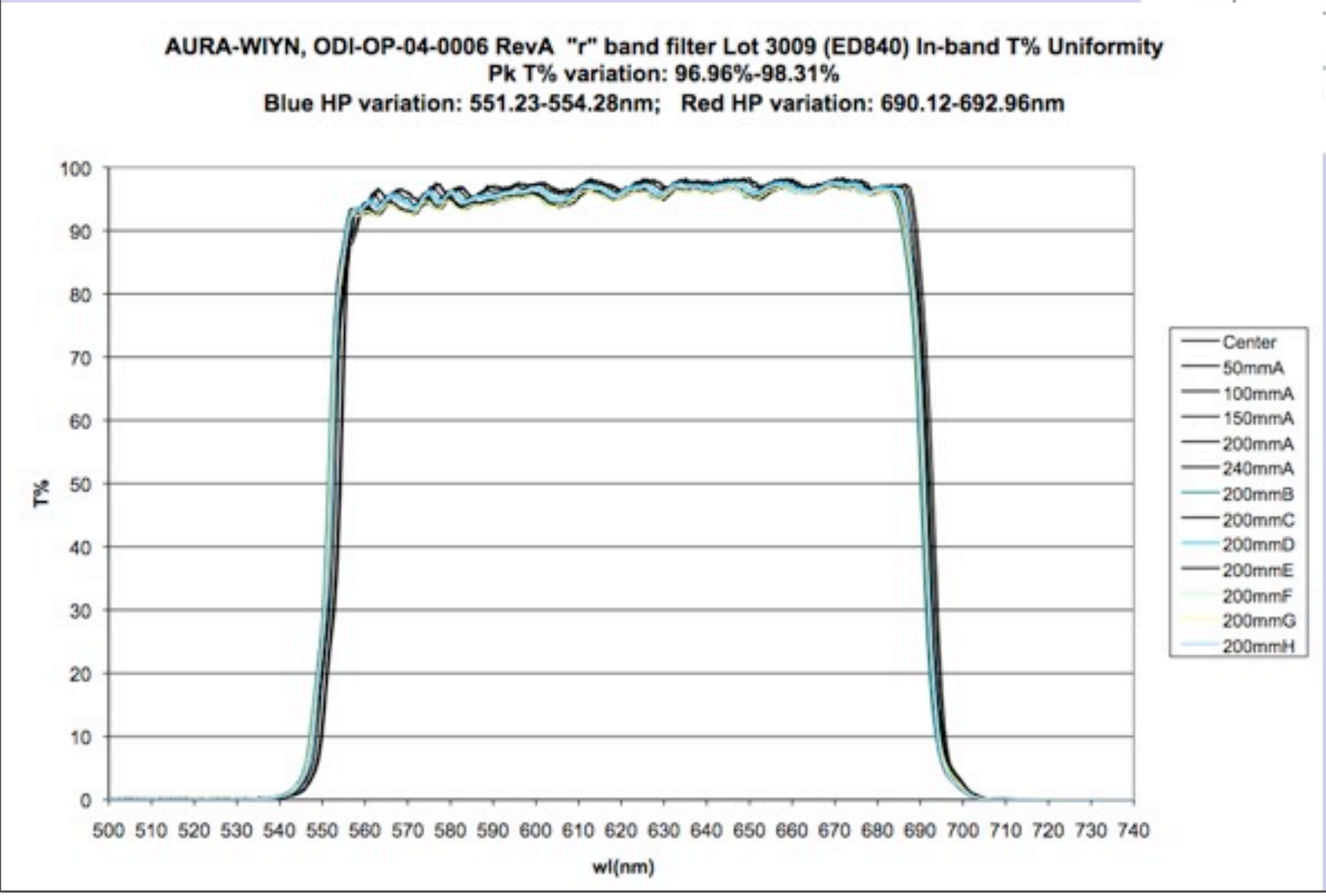
- 3 Filters delivered to WIYN:
- SDSS g' r' i'
- Additional filters to be acquired:
  - SDSS u' i'
  - Narrow-band filter?

ODI i'

ODI r'

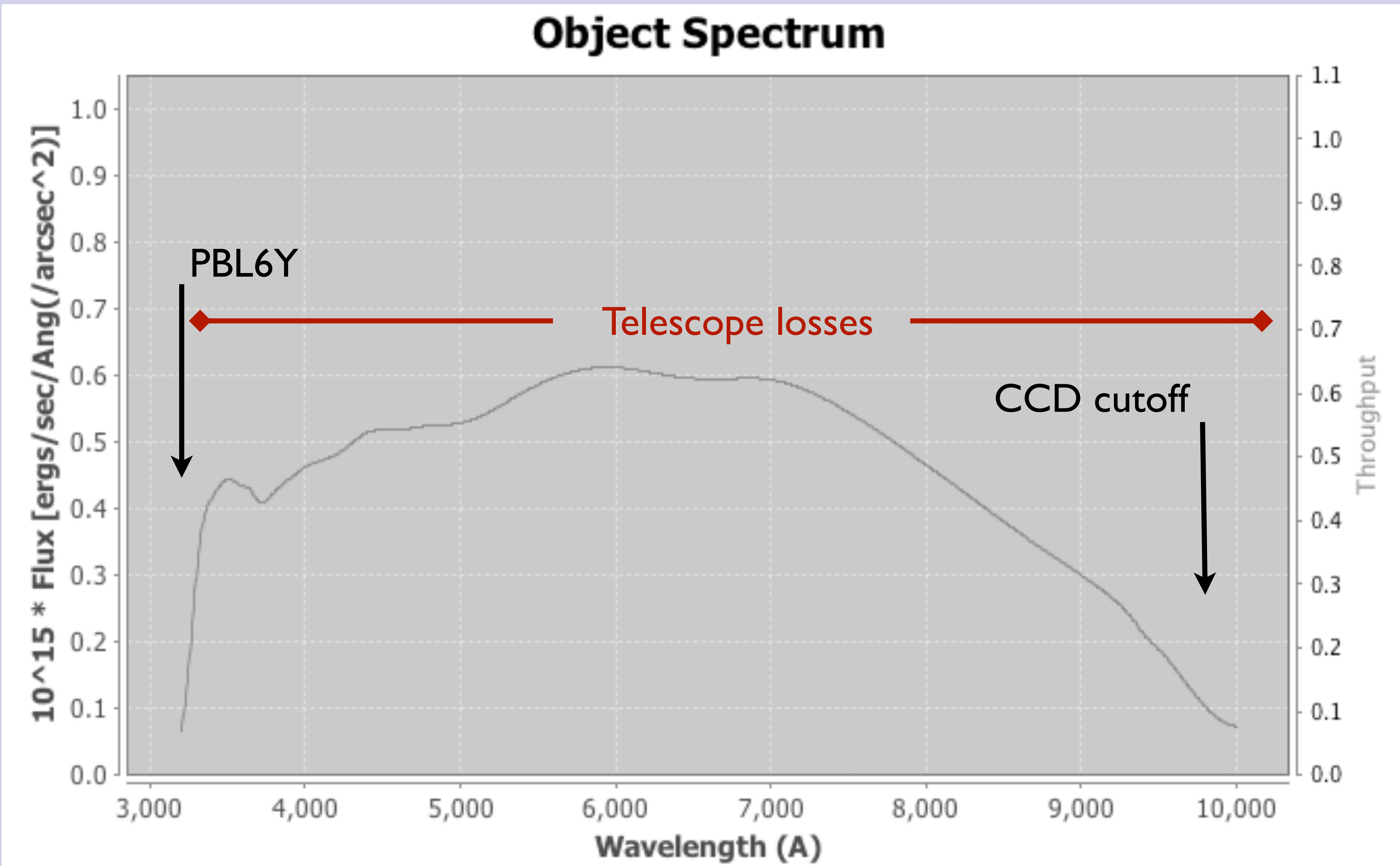
ODI Filter Performance





Expected Throughput

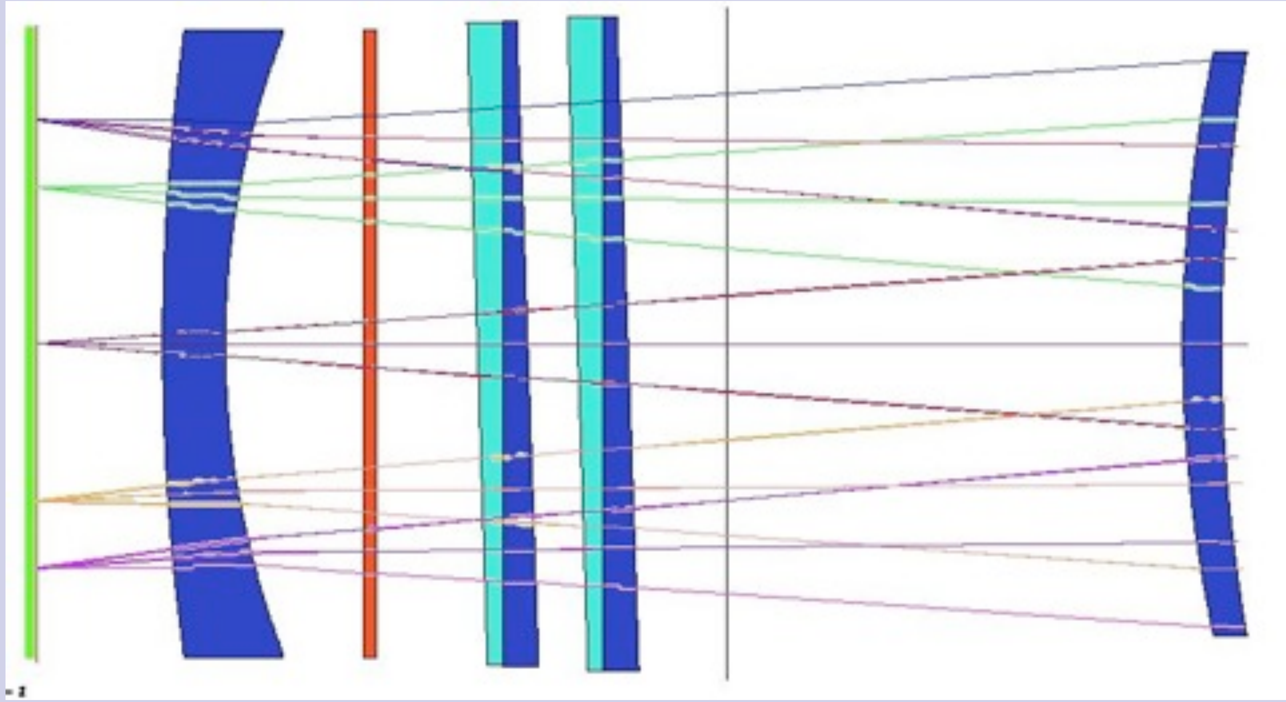
- 3x mirror reflections (Al coating)
- 8x reflection losses at optical surfaces (coatings, as built)
- PBL6Y, Fuse Silica
- CCD sensitivity



Corrector Optics Design...

- Atmospheric Dispersion Compensator (ADC)
- less than 2% distortion over 1° FoV

- 2-element Design
- One aspheric surface



All optics received
Lenses coated or at coating.
Prisms under evaluation for quality.

Shutter

- 2-blade design for accurate timing & short exposure times
- Designed and fabricated by the University of Bonn (Germany)
- Delivered and accepted.

Focal Plane Module


DoALL

Stargrasp CCD Controller

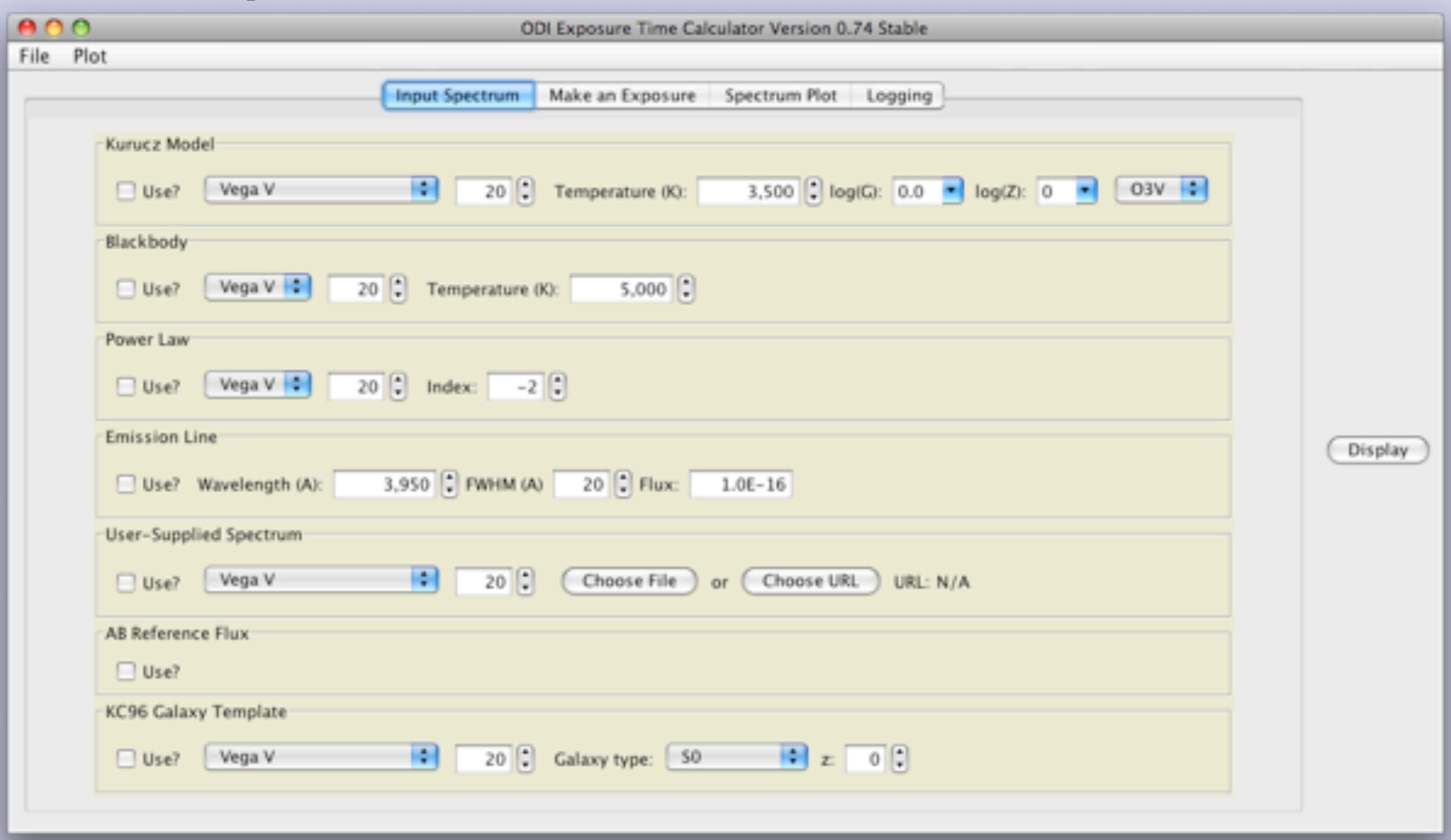
Resources

- ODI Web Page
  http://www.wiyn.org/ODI

- Guide Star Prediction Tool
  Experimental tool for guide star prediction.
  Not linked in ODI web page yet, preview at:

  http://www.wiyn.org/quota/Software/odip2/

- Exposure Time Calculator
  In the *Observing* section, follow the link to **Exposure Time Calculator**



User Interface

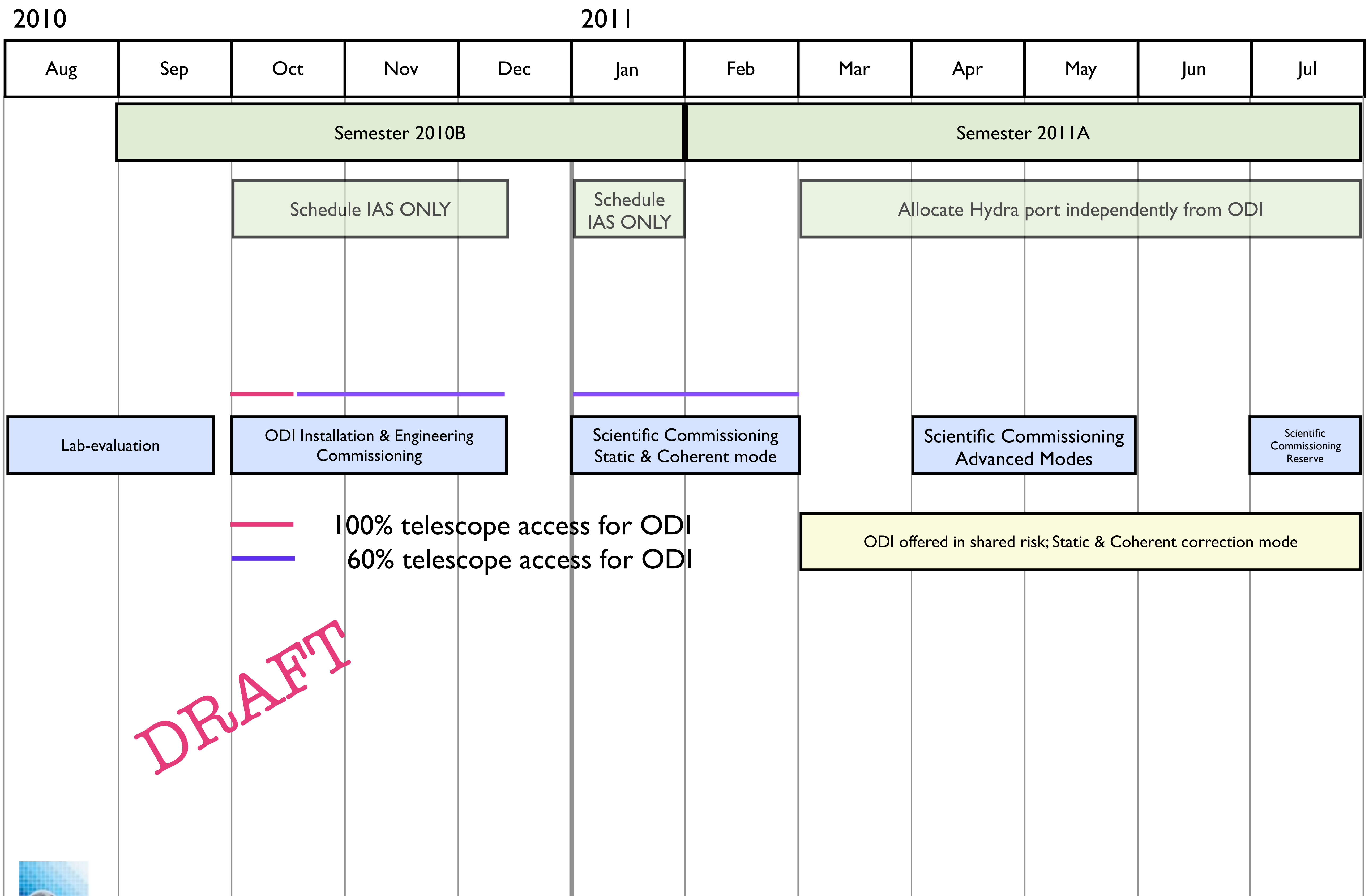
- Queue-like user interface
  - Define observing sequence (e.g., 9x 100 sec in g'; 1200s Ha + 300s r').
  - Define pointing (coordinates).
  - Define boundary conditions.
  - Combine pointing & sequence to define visits.

  - Designed to enable book keeping for extended programs.
  - Designed to be expandable into a queue system.

- Baseline for observations: visitor mode. See Pierre's talk for broader vision.

- Data handling:
  - 0.5-4TB / night
  - Data archive & calibration pipeline to be offered by WIYN.
  - Integrated calibration process, standard calibration plan.
  - **Project seeded; more details in Pierre's talk.**

ODI Time Line



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Implications for Yale Survey

- Expect start of data acquisition earliest in Spring 2011. For **first semester**:
  - Only Static and coherently corrected imaging (everywhere on sky!).
  - Expect inefficiencies, larger overhead.
  - Automatic dithering not working perfectly yet.
  - Remote scripting ("Phase II") used for the first time for production.
  - **Keep first semester observations simple!**
- Data pipeline ramping up
  - Calibration not perfect yet - need to gain experience in Tier I.
  - Limited "Tier II" support only (e.g., stacking of dithered exposures).
- Advanced ("Standard") modes to be enabled Fall 2011
  - Local image motion correction
  - **Check availability of guide stars!**
  - Data pipeline should be functional.


www.wiyn.org/ODI


www.wiyn.org/ODI

Bonus Tracks

Availability of guide stars

- At least one guide star available per chip on whole sky.
- Pointing needs optimization!
- If very few guide stars are available, correct for correlated image motion only