The Navy Precision Optical Interferometer

Current Status, Future Upgrades

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September 20th, 2013

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Tour: Navy Precision Optical Interferometer

Flagstaff, AZ (~7,200’ / 2,200 m)
79-m baseline
Six 12-cm apertures

[432-m baseline]
[Four 1.8-m apertures]

Basics

- NPOI = **N**avy **P**recision **O**ptical **I**nterferometer
  - Major funding by Oceanographer of the Navy and Office of Naval Research
  - Additional instrument funding from National Science Foundation
- NPOI is collaboration b/w USNO, NRL & Lowell Observatory
- Lowell is both a science partner, and a contractor to USNO (infrastructure & ops) & NRL (site projects)

NPOI Current Capabilities


NPOI Imaging Siderostat

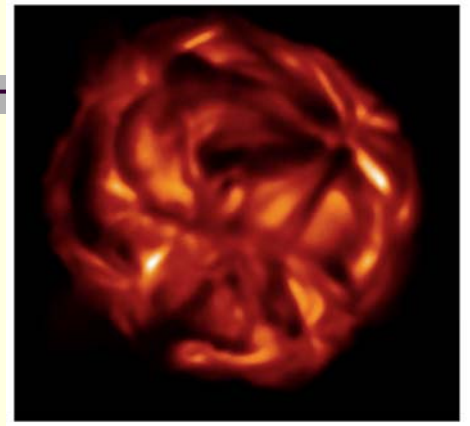
- Simultaneous, group-delay fringe tracking on multiple baselines (6 stations)
- Bandpass 550-850nm in 16 channels (R ~ 30-50)
- Single-baseline fringe tracking to m_V = 6.7
- Multi-baseline fringe tracking w/closure phase to m_V ~ 6.0
- Wide-angle astrometry with 5-10mas accuracy on bright stars
- Operated by one observer, scheduled ~355 nights/year

Facility Upgrades in Progress

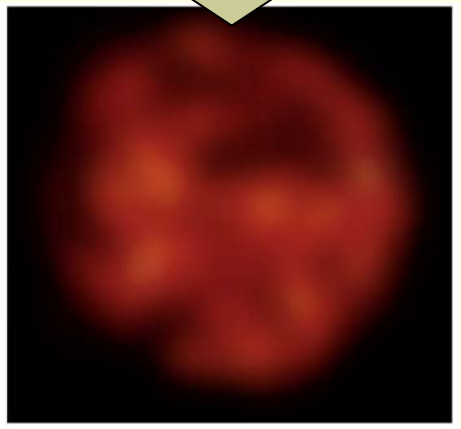
- Completion of 6-station “imaging” (portable) siderostat array:
  - New enclosures for star acquisition & tip-tilt optics installed for 5 of 6 stations
  - New domes installed for 5 of 6 imaging siderostats
  - 2 more imaging stations to be commissioned in 2013
  - Long baselines to 432 m & ‘compact’ configurations
  - To complete: integration of Long Delay Lines
- Control systems upgrades:
  - PC-based siderostat controllers for astrometric & imaging stations (4 installed; 5 more this year)
  - PC-based Fast Delay Line (FDL) control system:
    - Delivered to site & tested with 2 FDLs thus far
    - Significant performance improvement

‘Classic’ Instrument Upgrade in Progress

- New Fringe Engine read-out electronics
  - FPGA hardware finished; firmware & software under development
  - 32 → 96 channels, 30^{sec} → unlimited integration time
  - Flexible FTK algorithms
- Baseline bootstrapping, coherent integration
- Recently approved as a 3-year NSF-funded upgrade program



Freytag simulation (Chiavassa+ 2010)

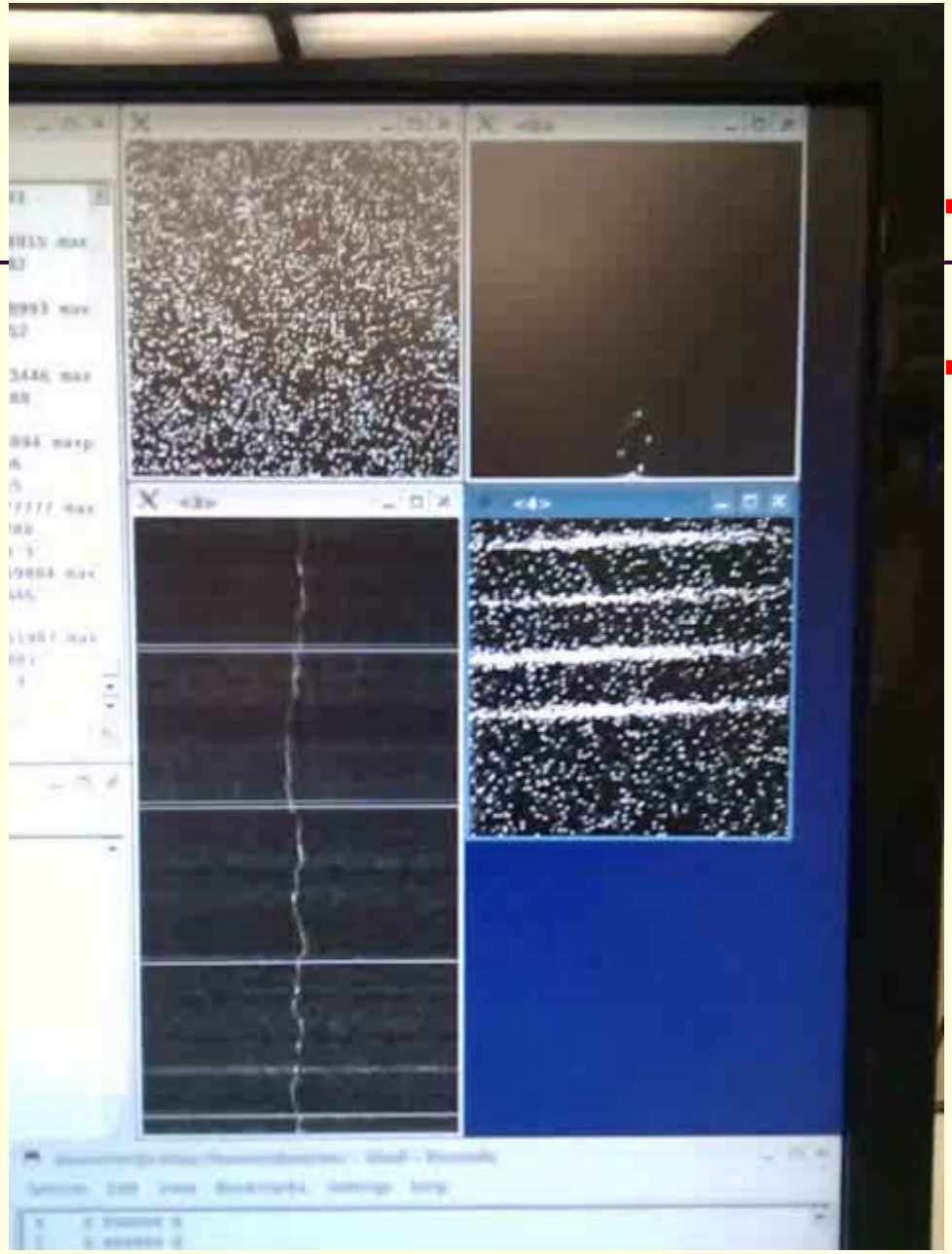


6×6 pixel imaging (NPOI 2014?)

VISION Instrument Commissioning in Progress

- VISION NSF project: PI Matthew Muterspaugh (TSU)
  - Visible “MIRC++” combiner for NPOI
- Improvement
  - Visibility precision ~10×
  - No delay nonlinearities, APD afterpulsing
  - Full 6-way combination, flexible spectral resolution (R~50, 2000)
  - Modern equipment, CCD
- Commissioning ongoing
  - First fringes: Oct 2012
  - Four-way combination: Jan 2013
  - Grad student (V. Garcia) now on-site for full-time commissioning work

Fringes in Image Plane
(barely seen above the noise)



‘Waterfall’ plot for single tracking baseline
(left-right motion due to residual atmospheric piston)

FFT of Fringes

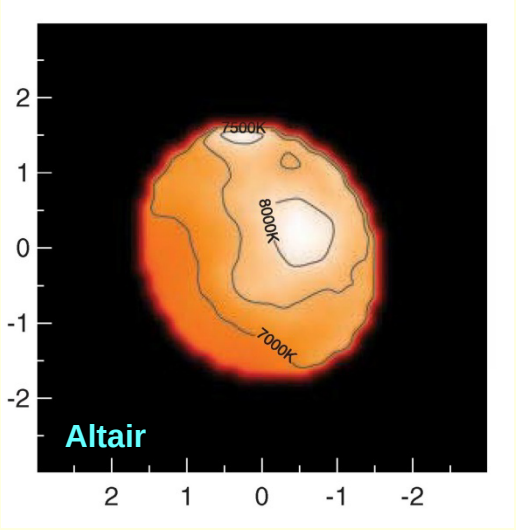
Spatial Frequency versus Delay
- Each ‘Hot Pixel’ row is one baseline of six
- Bottom pixel is DC term
- Some baselines very hard to see because fringe contrast is low (for long baselines)
- Left-right motion due to atmospheric piston
- Pixels should line up in a single vertical line but don’t due to uncorrected static piston offsets

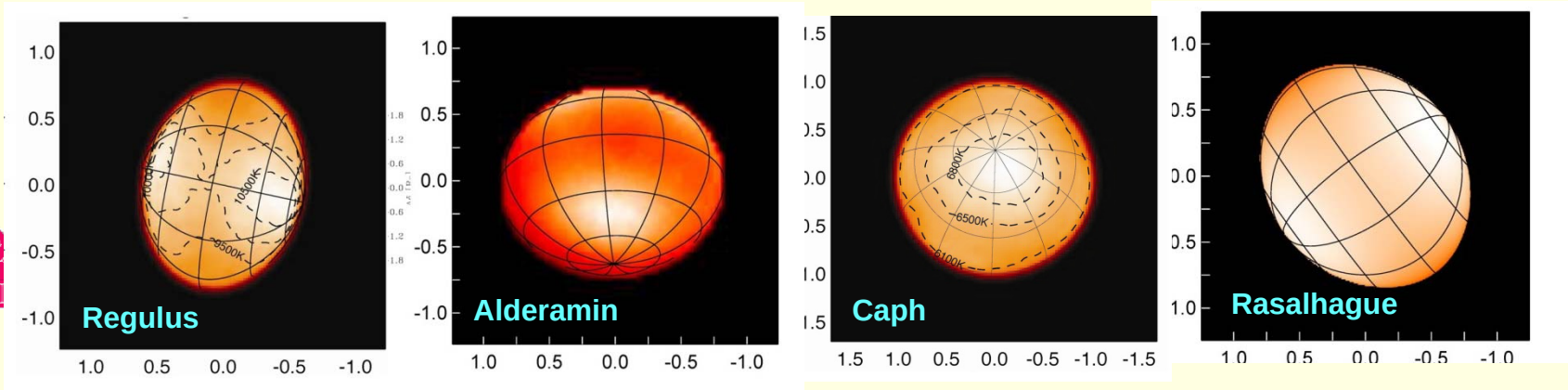
Photometry for each of 4 telescopes

Four simultaneous telescopes
=
Six baselines
(and 3 independent closure phases)

NPOI Targets: Stars are Photogenic

- Progression over the past 10 years
  1. Simple modeling
  2. Detection of surface features
  3. Direct imaging
- Already starting to see some surprises
  - Stellar structure not as expected from simple models
- Next step: time-series images → movies

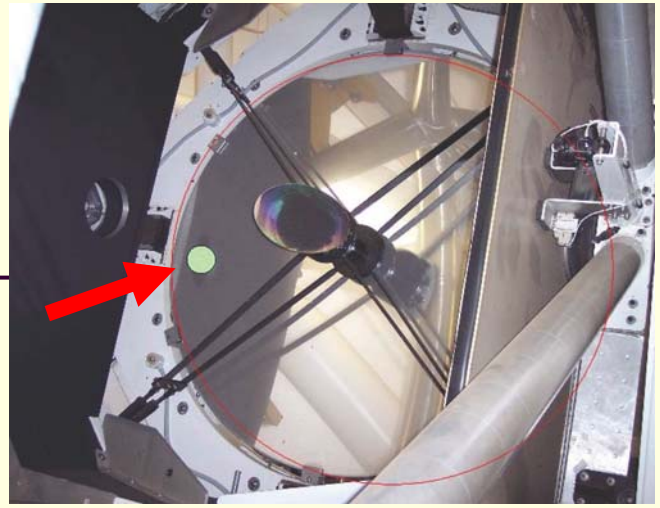




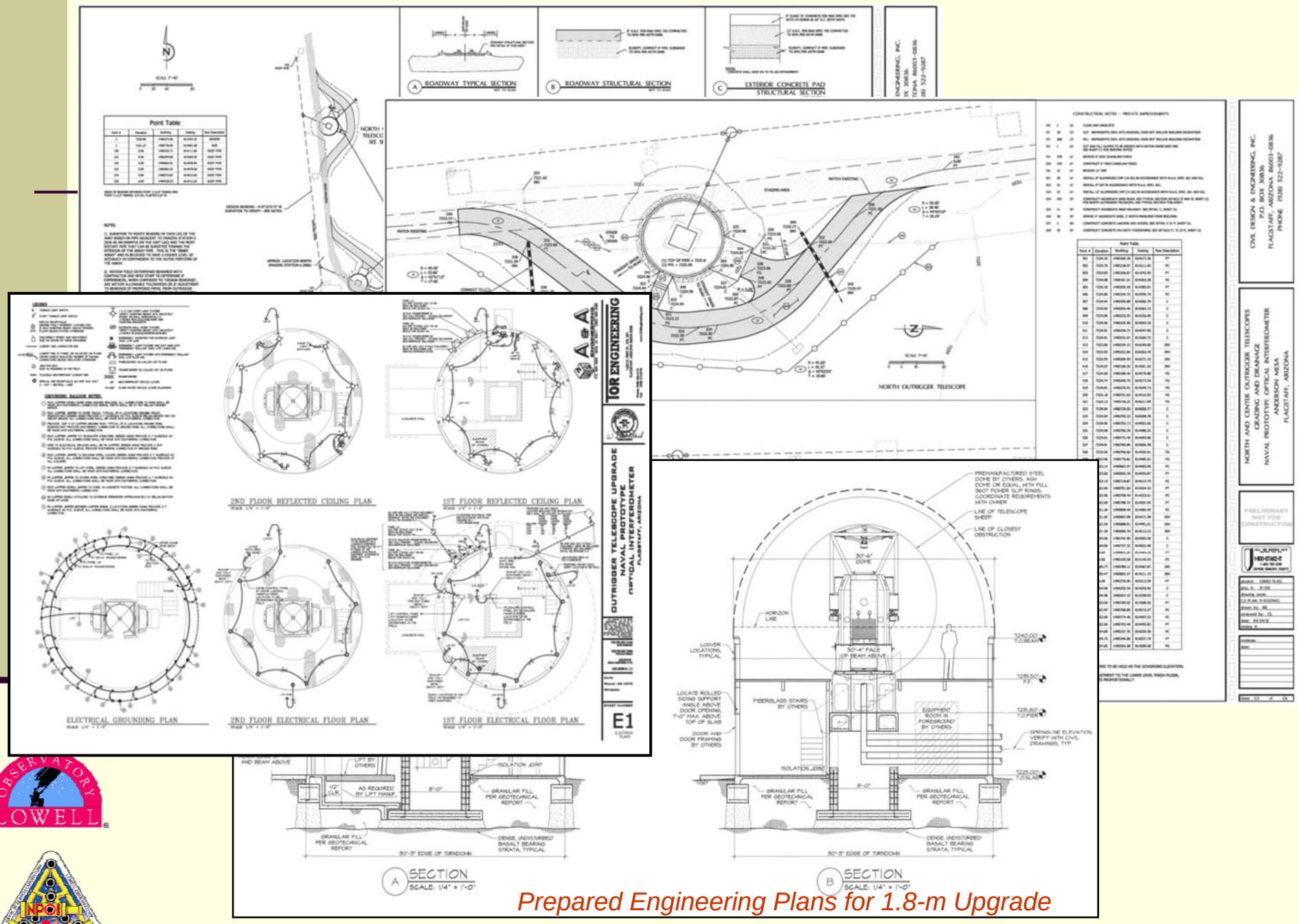
Monnier+ 2007, Zhao+ 2009, Che+ 2011: 4-way CHARA-MIRC Images

1.8-m Upgrade

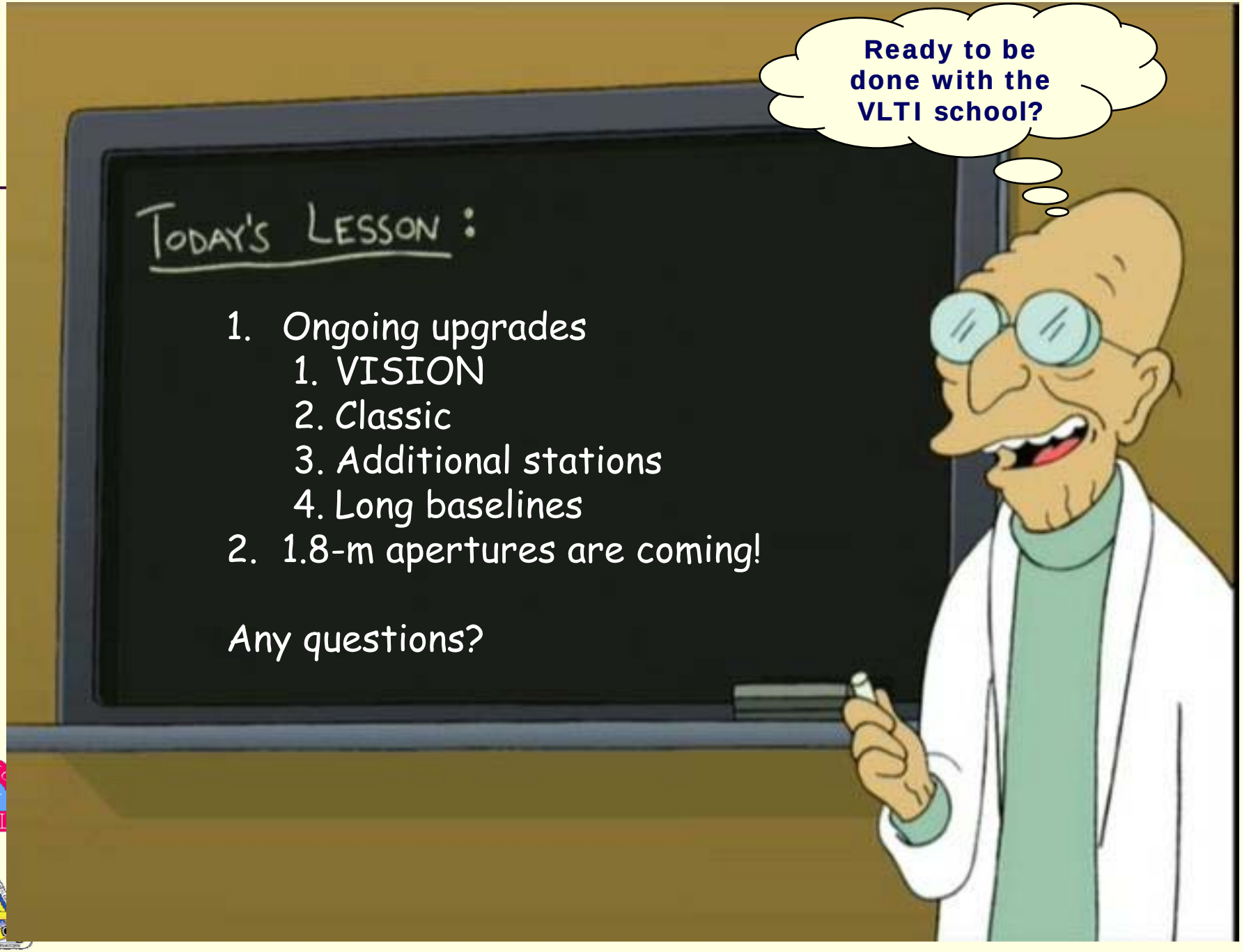
- Four 1.8-m telescope were built by NASA for the Keck Interferometer
  - Not installed for non-technical reasons
  - ‘Over-engineered’ for narrow-angle astrometry
  - Good for NPOI wide-angle astrometry mission
  - [One on loan to Mt. Stromlo]
- ‘Gifted’ to USNO from CARA in 2010
- Final engineering plan in 2011
- USFS site permit in 2012



Relative size of current 5” siderostats and 1.8-m telescope



Prepared Engineering Plans for 1.8-m Upgrade


Ready to be done with the VLTI school?
TODAY'S LESSON :
1. Ongoing upgrades
1. VISION
2. Classic
3. Additional stations
4. Long baselines
2. 1.8-m apertures are coming!
Any questions?