Status Update and Near-term Plans for the

MAGDALENA RIDGE OBSERVATORY INTERFEROMETER

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Overview of the Observatory

- Magdalena Ridge about 1 hour west of Socorro, NM overlooking VLA
- Altitude 10,500 ft
- Env. Impact Survey completed in 2003
- Two facilities at MRO
  - Fast-tracking 2.4m
  - NIR/Optical 10-element interferometer
  - Third site available

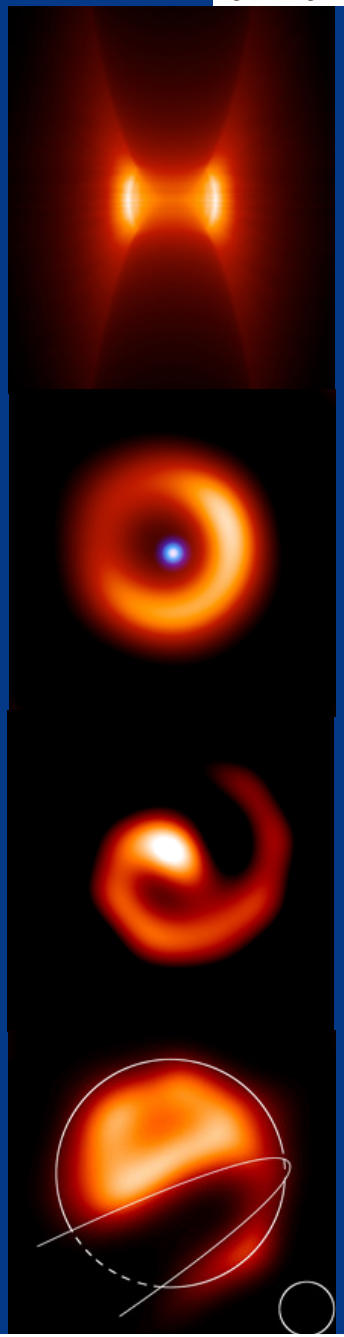
- MROI is *10* 1.4m *movable* afocal telescopes in equilateral Y configuration (28 stations)
- Optical and near-IR operation, near-IR fringe tracking
- Baselines from 7.8 to 347m (58 to 0.3 mas)
- Design optimized for imaging mission

MROI Science Case

- AGN:
  - Verification of the unified model.
  - Determination of nature of nuclear/extra-nuclear starbursts.
  - H =14 gives >100 targets.

- Star and planet formation:
  - Protostellar accretion, imaging of dust disks, disk clearing as evidence for planet formation.
  - Emission line imaging of jets, outflows and magnetically channeled accretion.
  - Detection of sub-stellar companions.

- Stellar accretion, mass loss and B fields/circulation:
  - Convection, mass loss and mass transfer in single and multi-star systems.
  - Bipolarity and collimation of circumstellar material, wind and shock geometries, interacting binary systems
  - Pulsations in Cepheids, Miras, RV Tauris, etc.
  - Star spots, oblateness, asymmetric properties



Flow Down for Requirements

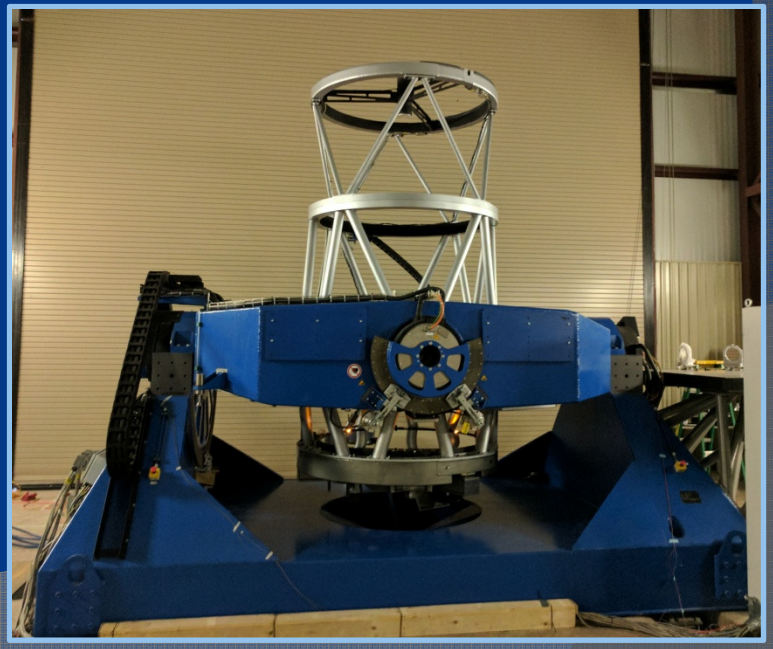
- Telescope diameter of 1.4 m
  - H magnitude = 14th for group delay tracking limit
- Spatial scales of 0.3 to 58 mas
  - Baselines from 7.8 to 347 m (for 0.6-2.4 microns)
- Moderate-to-high spectral resolutions
  - Separate fringe tracking and science cameras
- High throughput to achieve sensitivity limit
  - Fifteen reflections from primary to detectors
  - Optimized coatings for 0.6-2.4 microns
- Large number of telescopes rapidly combined
  - Optimized for model-independent imaging

The Take-Away: H_{mag} (FT) = 14, R_{mag} = 15; Closure phase prec. = 0.5º; Δ-mag image = 5.5; efficiency (6-beam combiner) = 10 min (bright source + calib) {2X longer for fainter targets}

MROI Walkthrough – Queue Film!

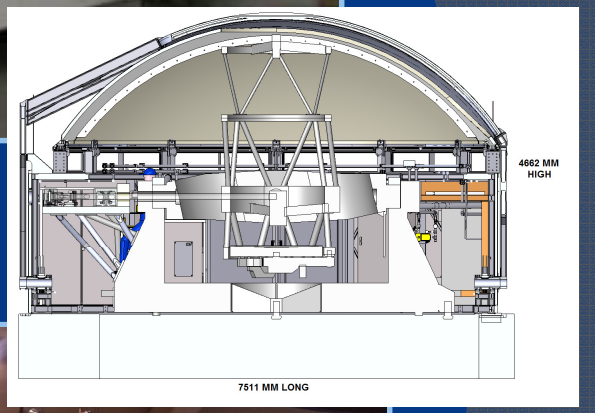
First Telescope had First Light!

- AMOS 1.4m diameter alt-alt telescopes
  - 62nm rms wavefront after 3 reflections
  - Polarization preserving design
  - Tip-tilt secondary on PI hexapod to reduce number of reflections in system but still achieve low-order AO correction
  - First light in VCMF in Nov ‘16



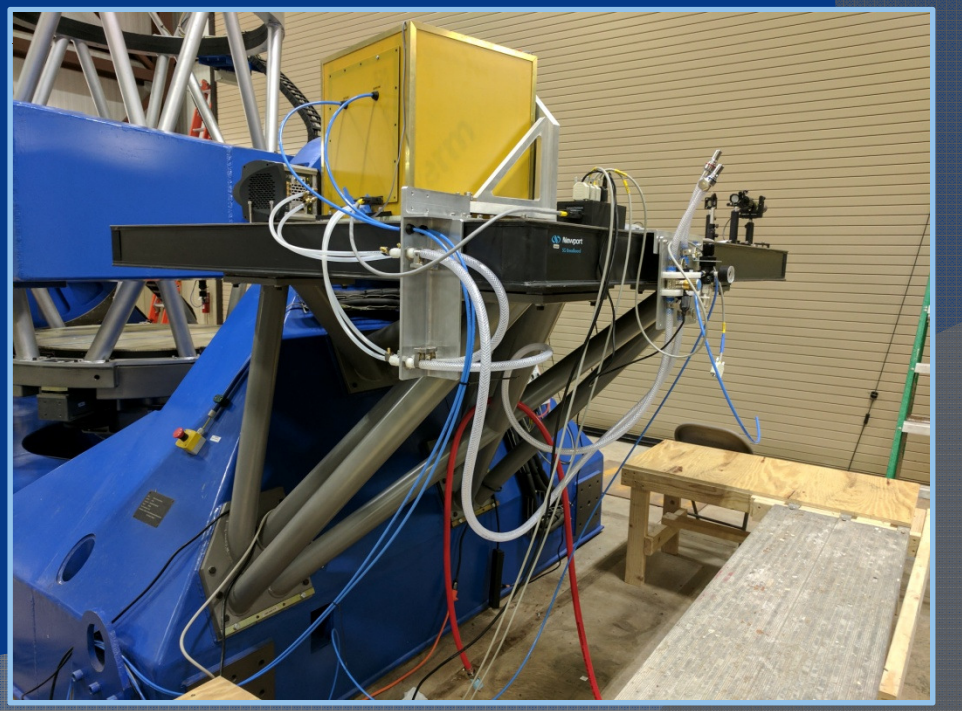
First Enclosure

- EIE enclosures house and transport telescope
  - Squat design allows for 6 hours continuous tracking even in close-packed configuration (7.8m on centers)
  - Louvered design for venting to equilibrate rapidly
  - Metal mesh for lightning protection
  - Lifting with crane or reach stacker
  - Factory Testing completed in Jan; Site Testing at the array in May of this year



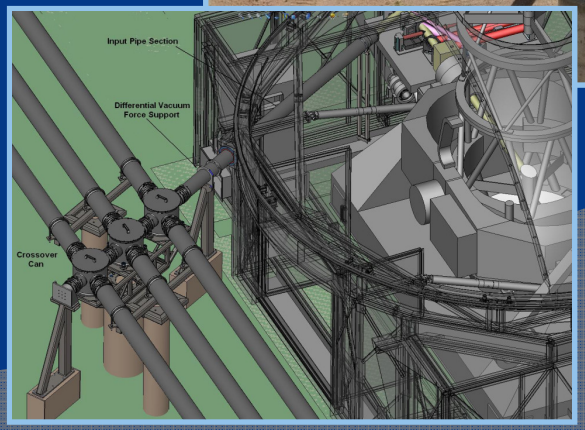
Fast Tip-Tilt System

- Designed and built by Cambridge
  - Passive design to minimize moving parts
  - Sensing in “blue” end of spectrum to at least V=16
  - Fast tip-tilt deployed on Nasmyth table controls telescope secondary
  - Final Site Testing once telescope is on array



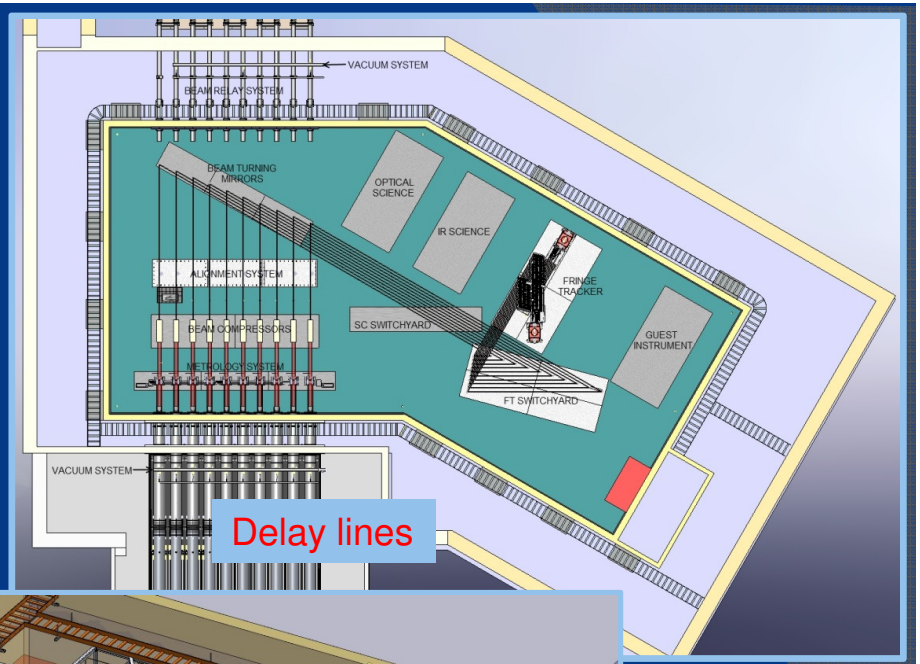
Beam Relay System

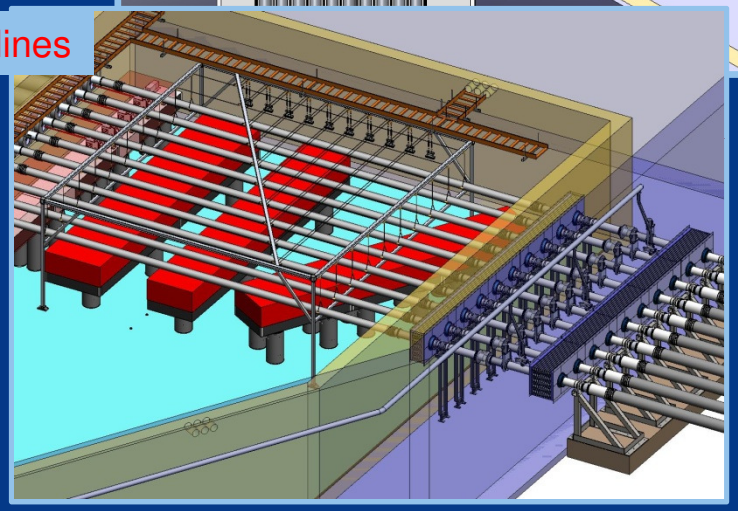
- All designed and built at NMT
- Array infrastructure includes 28 telescope locations – 7 are partially completed
- Continuous light transport via vacuum from telescope to beam combining room
- Designed to minimize subsidence and prevent lightning strikes from getting “into” the building



Beam Combining Facility

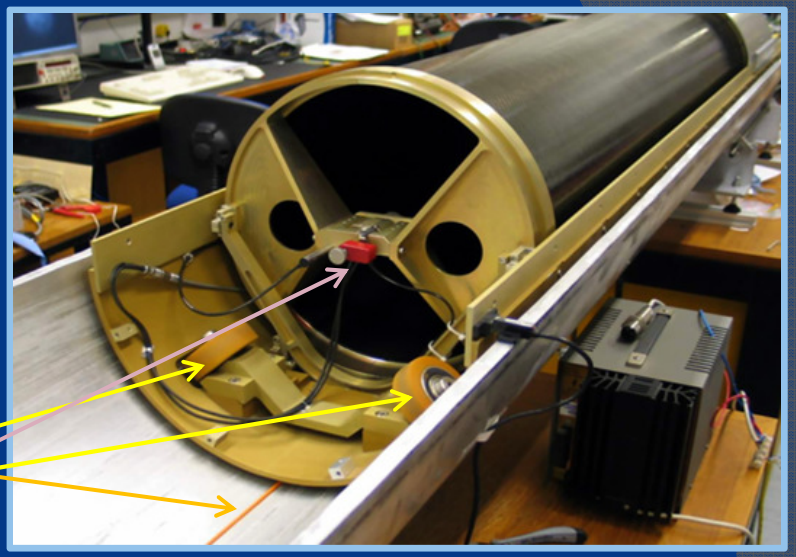
- Completed in 2008 to support full facility including 10 delay lines and 4 instrument tables
- Continuous delay
- “Dead air” in beam combining room
- Tested for thermal/vibrational stability



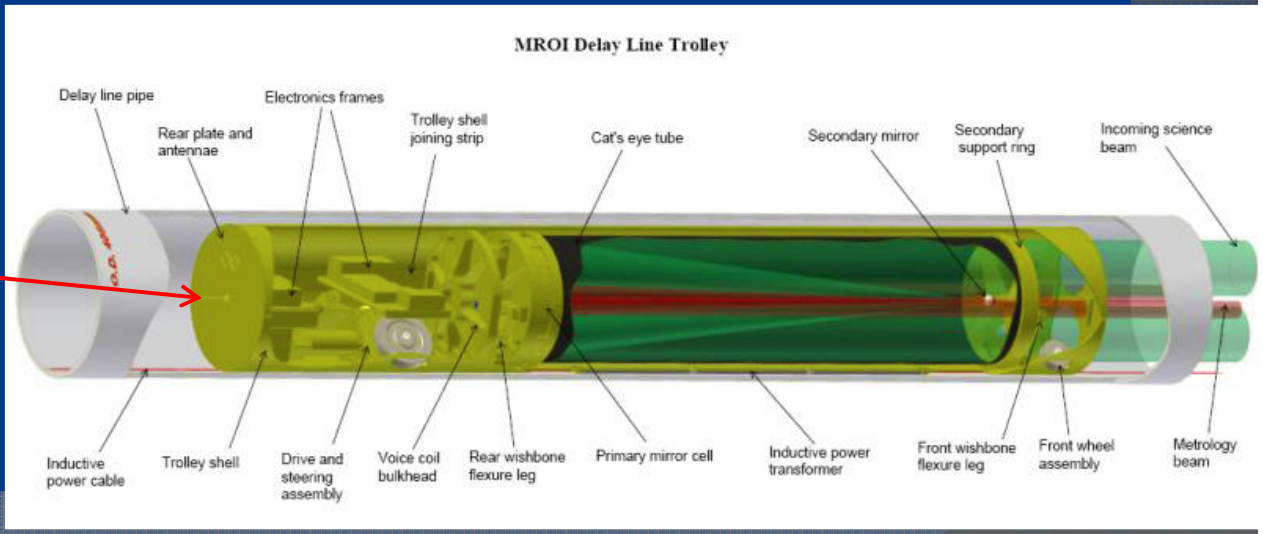


Delay Lines

- Delay line carts/trolleys – cat's eye vacuum system designed by Cambridge
- Inductive pick-up
- Compliant wheels
- Tip-tilt secondary



- Wire-less communication to computer

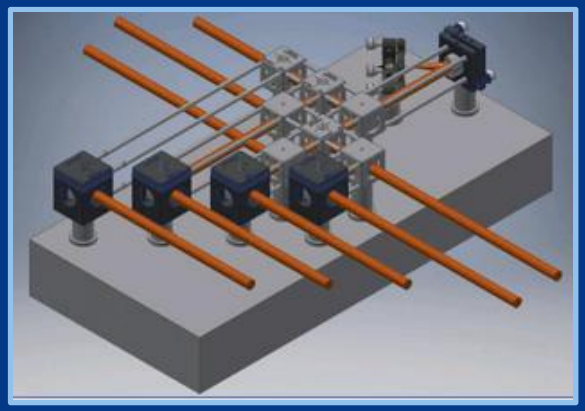


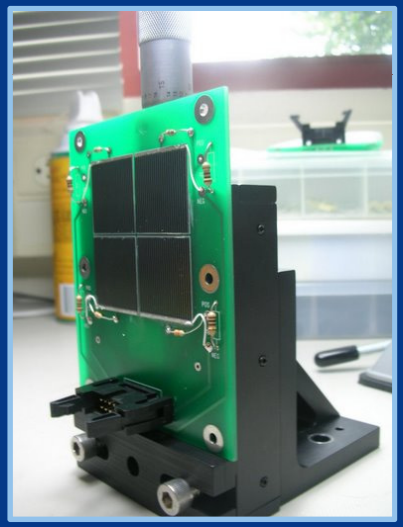
Delay Line Pipes

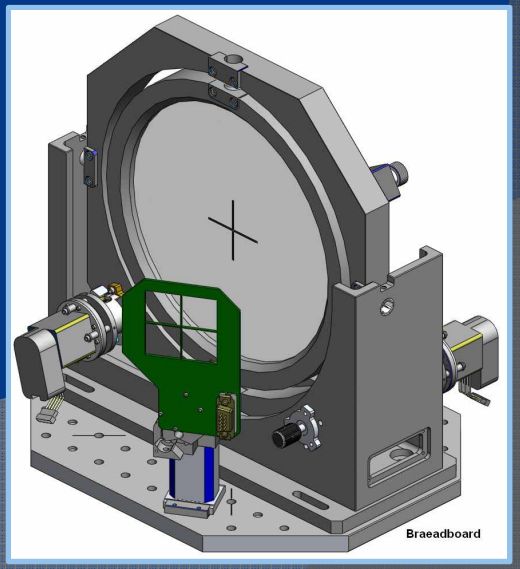
- 190m continuous vacuum delay using off-the-shelf pipe
- Resting on a technical slab separated from outer building footings/walls
- Compensates for sidereal positions as well as atmospheric turbulence
- Installed from center outward due to spacing
- Holds vacuum (~1 mbar) for weeks without issue

Automated Alignment System

- End-to-end alignment of interferometer as needed during day/night
- Capacitive sensors on mirrors for sensing motions
- Quad-cell photovoltaic “pop-ups” for beam location
- Optical/infrared beam launchers for “fake stars”
- Making more efficient use of system under computer control

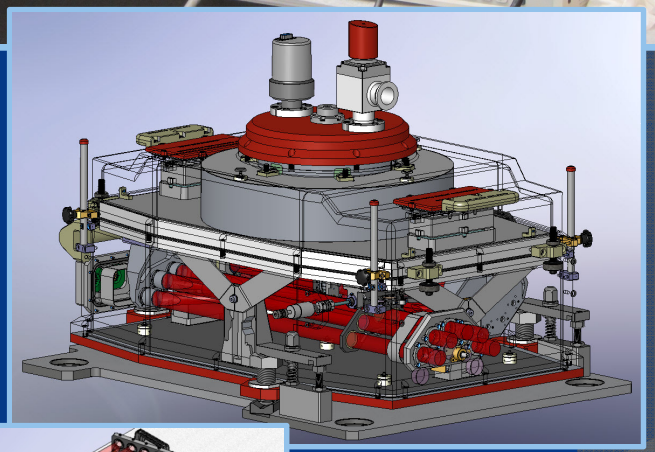


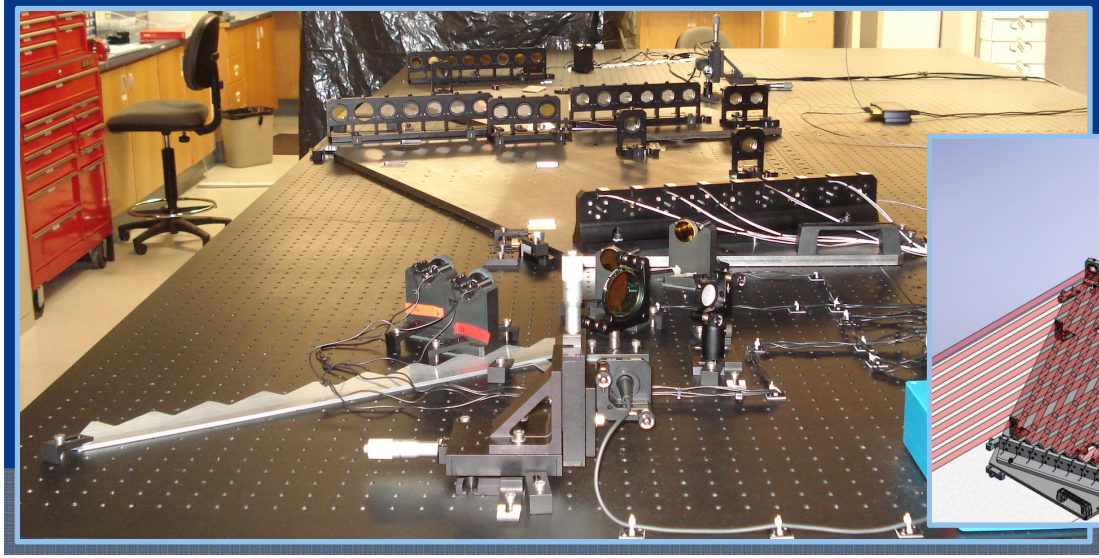


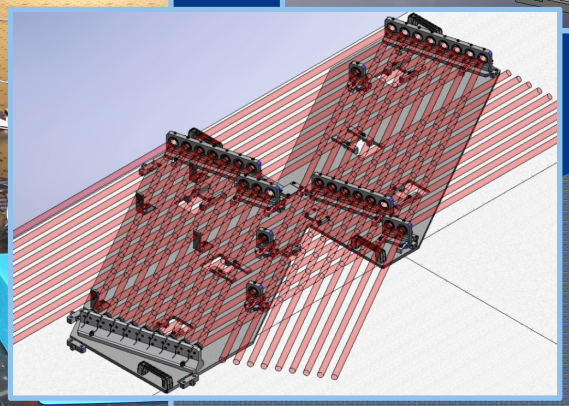


Beam Combiner and Fringe Tracker (ICoNN)

- Infrared fringe-tracker (ICoNN) using SELEX Saphira detector to achieve 14th mag at H band tracking limit
- Inner 6 beam trains tested and populated with optics







Telescope Integration Summer 2018

Funding and Fringes Timeline

- Funding via AFRL under CA with university for $25M through 2021
  - Realize 3-telescope system to do GEO risk reduction demos
- Future funding after 3 telescopes is TBD – *looking for partners or philanthropic support*
- Cost ~$8M/beamline for hardware
- Initial science after first fringes with deeper magnitudes than possible today
- Anticipate first light on the array with UT1 in May this year
- Schedule is funding dependent
- Delivery time for telescope+enclosure is 15-18 months
- Anticipate making time available to astronomical community via NOAO around deployment of UT4

Simulated image Direct-TV Satellite 9 accomplished in 2 hours using 10-element MROI plus 2.4m scope with aperture masking

Thank you for your attention!

For more information see: www.mro.nmt.edu

My TedX-ABQ talk on YouTube.

Listen to stories about MROI on StarDate.

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