Magdalena Ridge Observatory Interferometer

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Overview of Talk

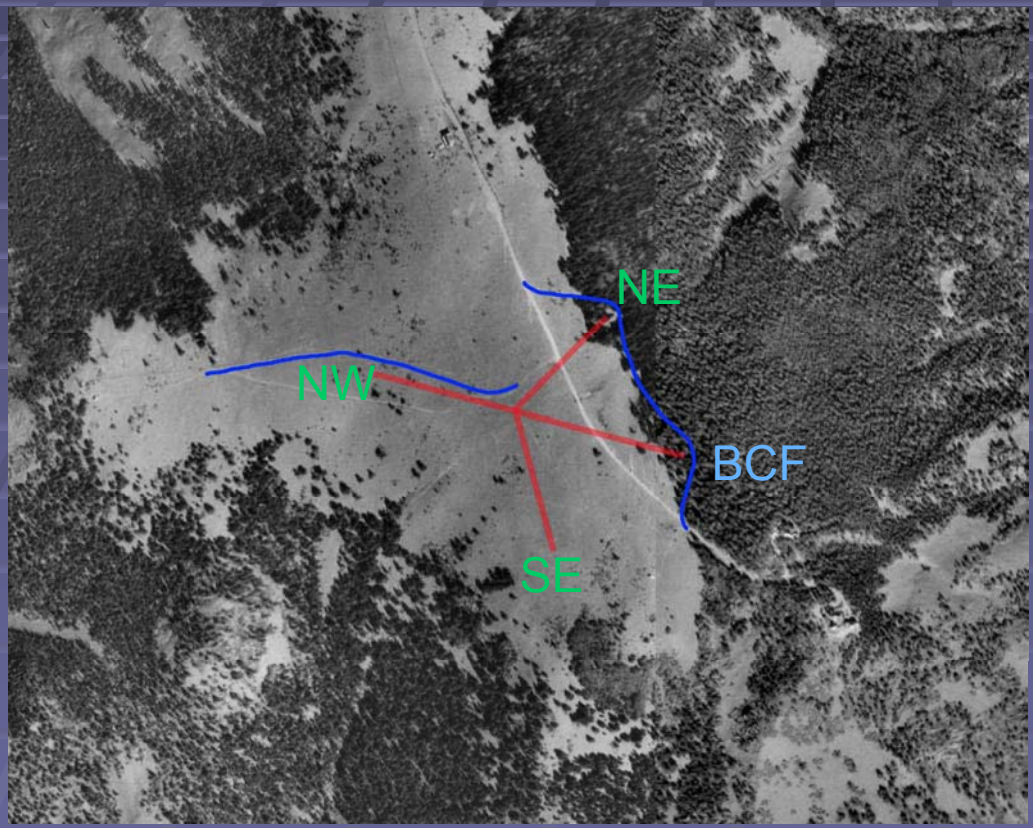
- Instrument/Site Description
- Science Reference Mission
- Technical Progress
- Personnel/Staffing
- Schedule
- Conclusions

Magdalena Ridge Observatory Site

- Altitude 10,500 ft -- outside Socorro, NM
- US Fed. Funding
- Completed EIS
- Construction permit in place
- Site infrastructure being implemented 2004

- Ongoing site testing – median r_0 = 8.5 cm @ 500 nm

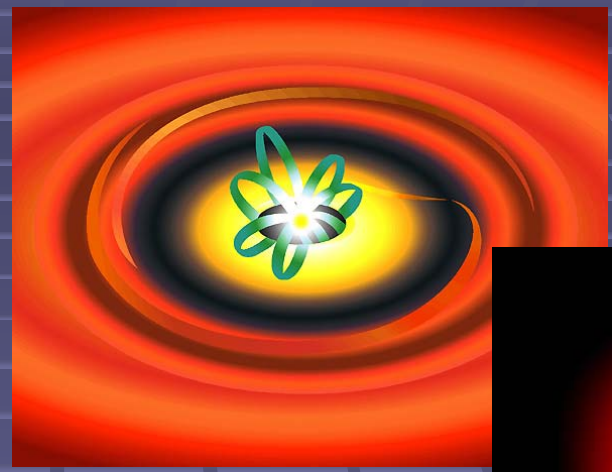
MRO Interferometer

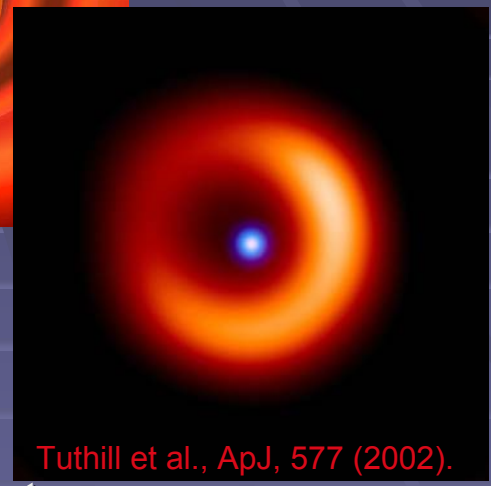


- 10 1.4 m alt-alt telescopes
- Tip-tilt, no higher AO
- Baselines from 8-400 meters
- 34 “kinematic” pads
- 0.6-2.4 micron operation
- Vacuum transport and DL
- Parallel FT and science combiners
- Fixed, moderate spectral resolution backends
- Visitor instrument port

Science Reference Mission (i)

- YSOs and Planetary Companions:
  - Protostellar accretion:
    - Imaging of thermal dust and scattered emission on sub-AU scales.
    - Disk clearing as evidence for the epoch of planet formation.
    - Emission line imaging of jets, outflows, and magnetically channelled accretion.
  - Companions:
    - Frequency of occurrence.
    - Physical and compositional characterisation.
    - Direct detection of sub-stellar companions.



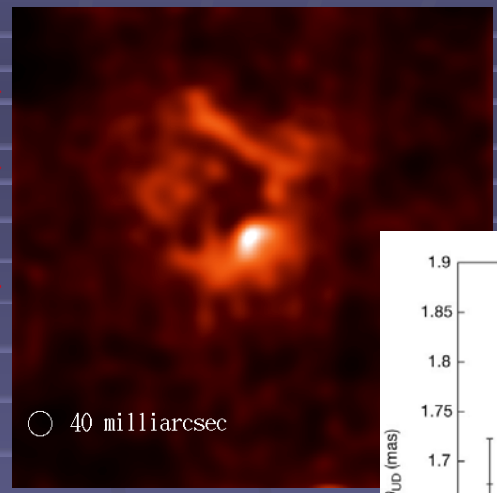


Tuthill et al., ApJ, 577 (2002).

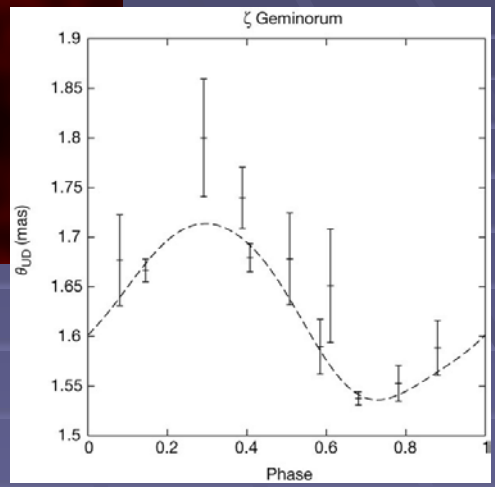
- Requirements:
  - <1mas for disks out to 500 pc
  - 1-10mas for hot dust
  - Recombination line imaging and spectroscopy R ~ 250

Science Reference Mission (ii)

- Stellar Astrophysics:
  - Mass loss in single stars:
    - Convection: latitudinal or longitudinal?
    - Distribution of circumstellar material, the onset of bipolarity, shocks and wind geometries.
  - Mass loss in binaries:
    - Recurrent novae and symbiotics. Orbit, wind and accretion geometry.
    - Eclipsing binaries. Clumpiness in mass transfer.
  - Dynamical studies:
    - Pulsational models for Cepheids, Miras, RV Tauris etc.



Tuthill et al, ApJ, 543 (2000)

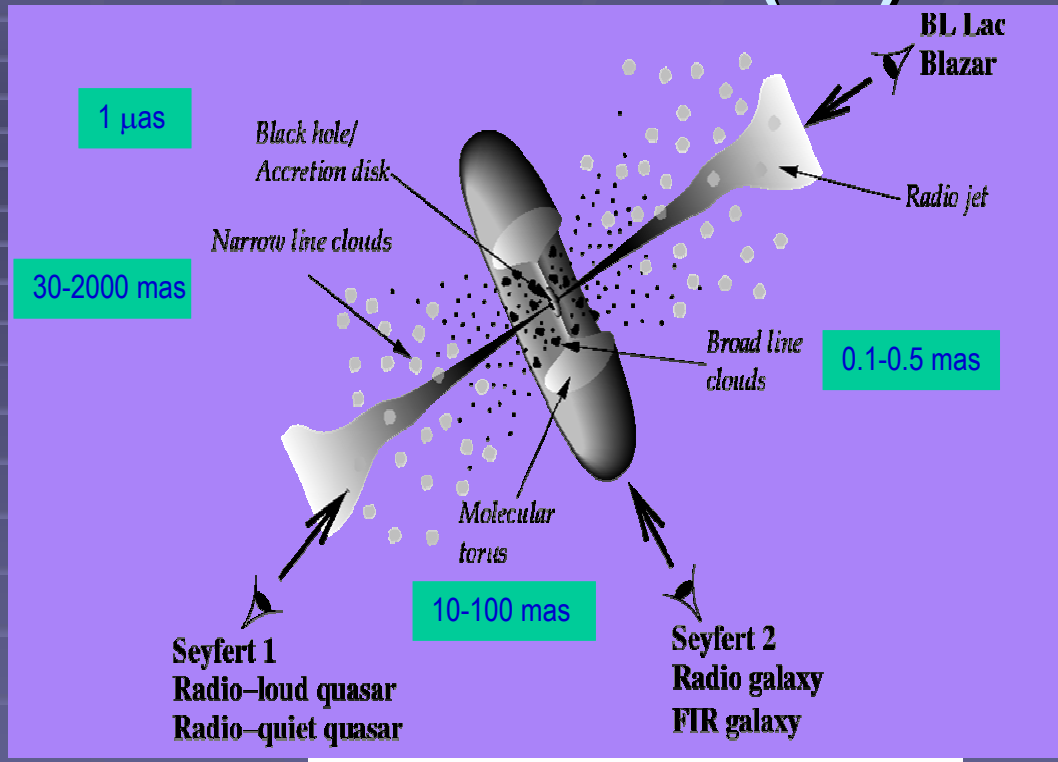


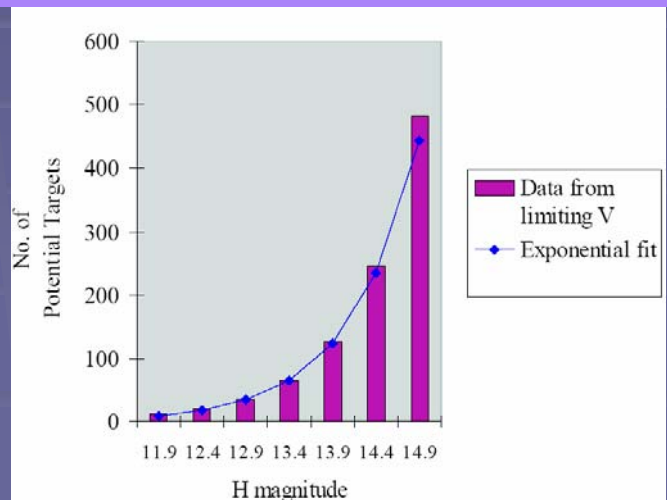
Lane et al, AJ, 573, 330 (2002)

- Requirements:
  - 0.3-20mas dust shells, emission nebulae and pulsations
  - <1mas for eclipsing binaries
  - Moderate spectral resolutions for continuum and line imaging

Science Reference Mission (iii)

- AGN science:
  - Verification of the unified model:
    - Direct detection of the obscuring tori.
    - Geometry and orientation of tori.
    - Correlations with other observables.
  - Nature and contribution of nuclear and extra-nuclear starbursts.
  - Imaging and dynamics of the broad line region.
  - Detection and characterization of optical and IR counterparts of synchrotron jets.

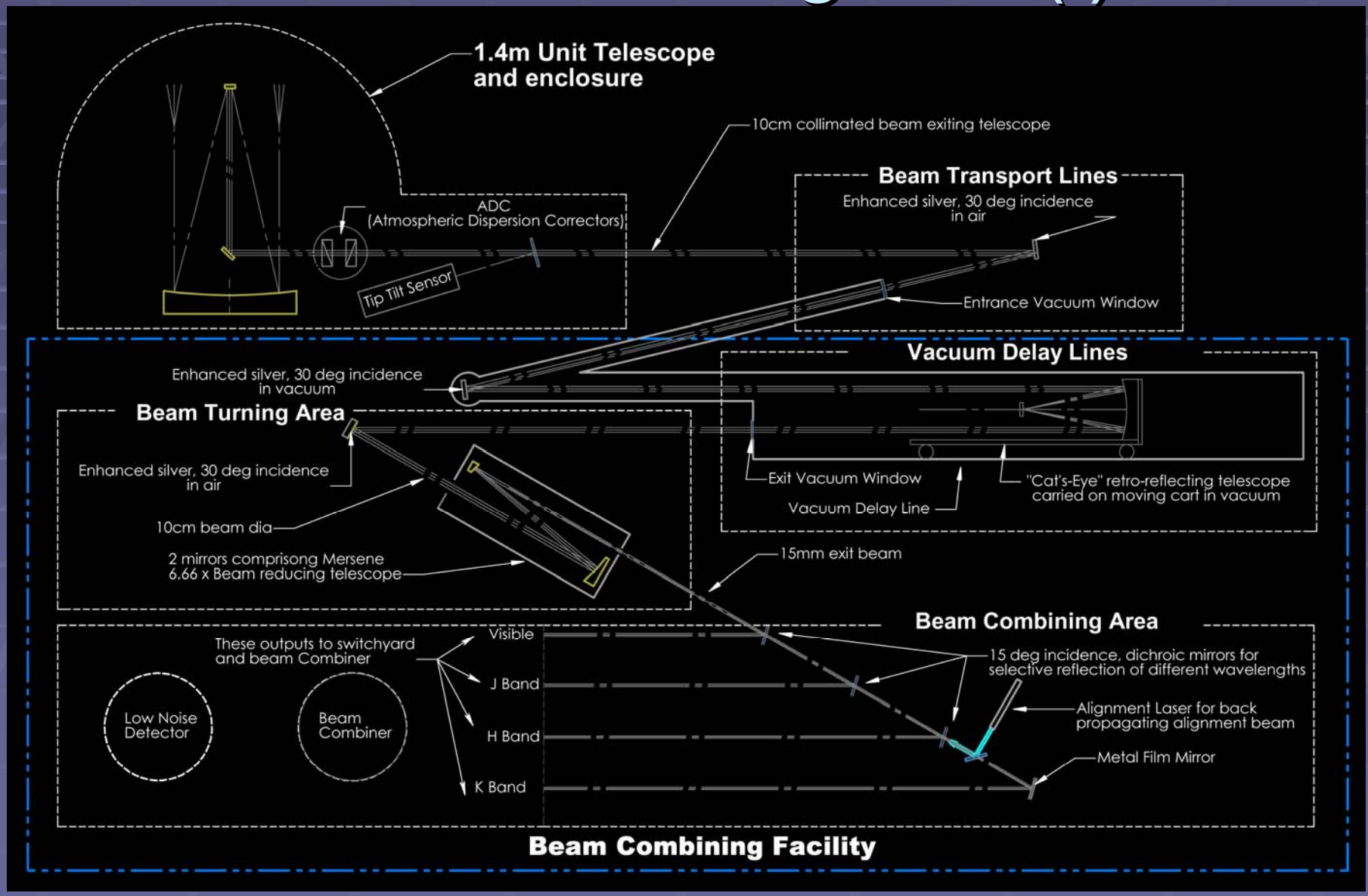




Science Reference Mission (iv)

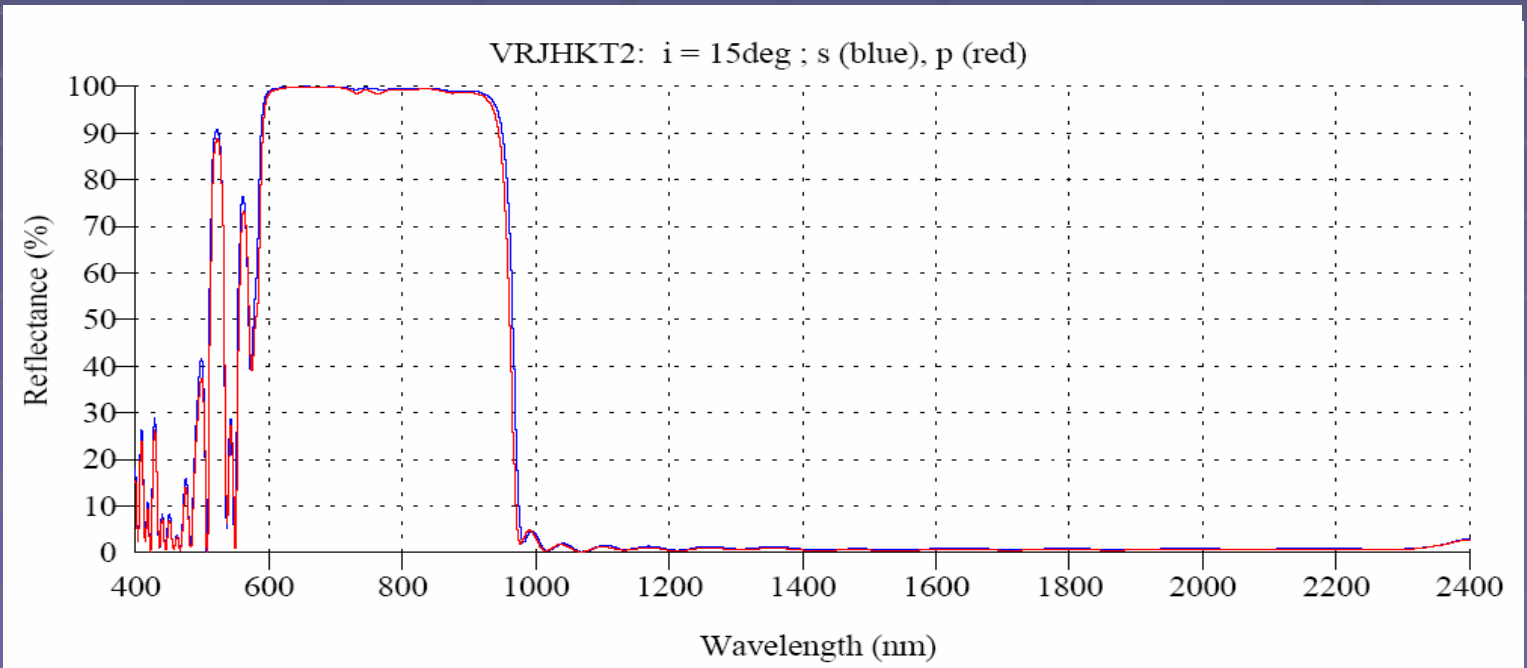
- Requirements
  - Telescope size of 1.4 m
    - H magnitude = 14 for group delay tracking limit
  - Spatial scales of 0.3 to 30 mas
    - Baselines from 8 to 400 m
  - High throughput to achieve sensitivity limit
    - Fifteen reflections from primary to detectors
    - Optimized coatings for 0.6-2.4 microns
  - Large number of telescopes
    - Optimized for model-independent imaging

Technical Progress (i)



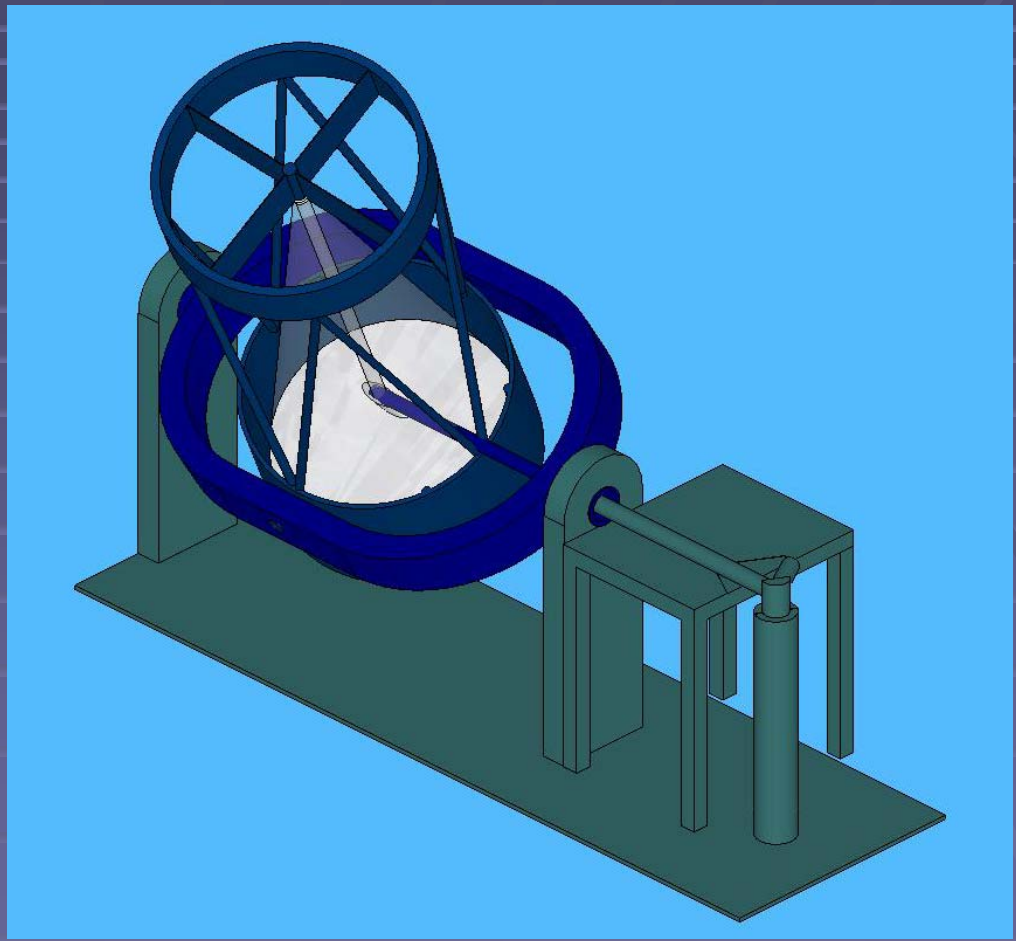
Technical Progress (ii)

- Coatings
  - COAST dichroic <0.5% losses over 0.6-2.4 microns
- Designed coating (Baldwin et al. 2004)
  - <0.1% losses over optical; 99% throughput in NIR



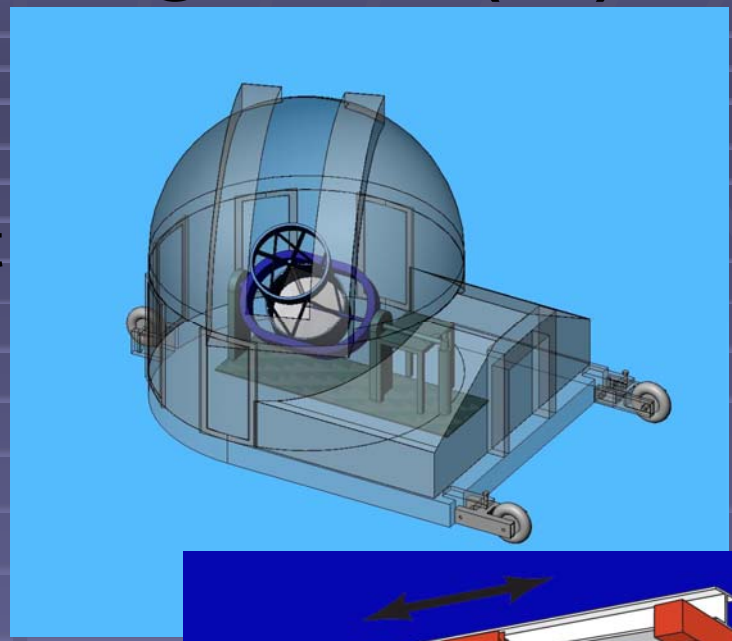
Technical Progress (iii)

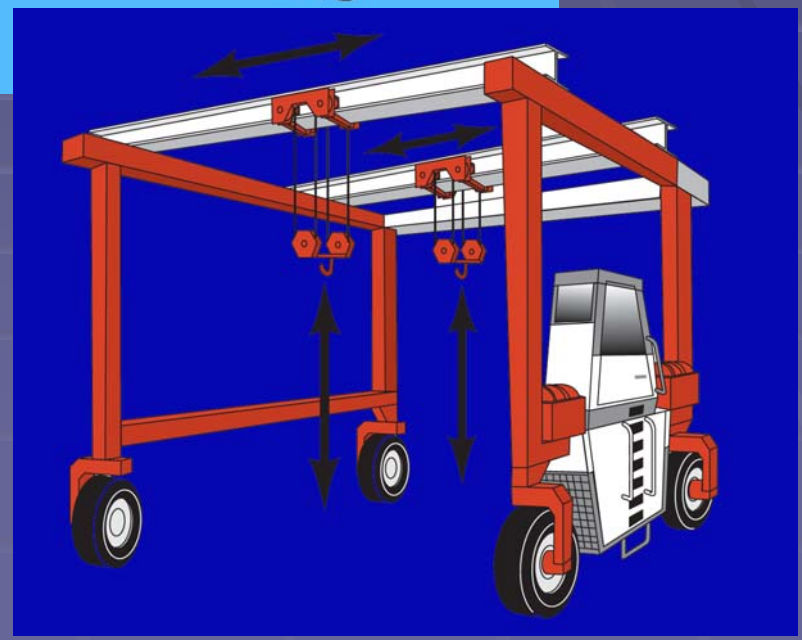
- Telescopes
  - 1.4m aperture
  - Alt-alt mount
  - Articulated tertiary
  - Optics table – T/T & ADC
  - Feeds into vacuum transport
  - 7 responses to ROM



Technical Progress (iv)

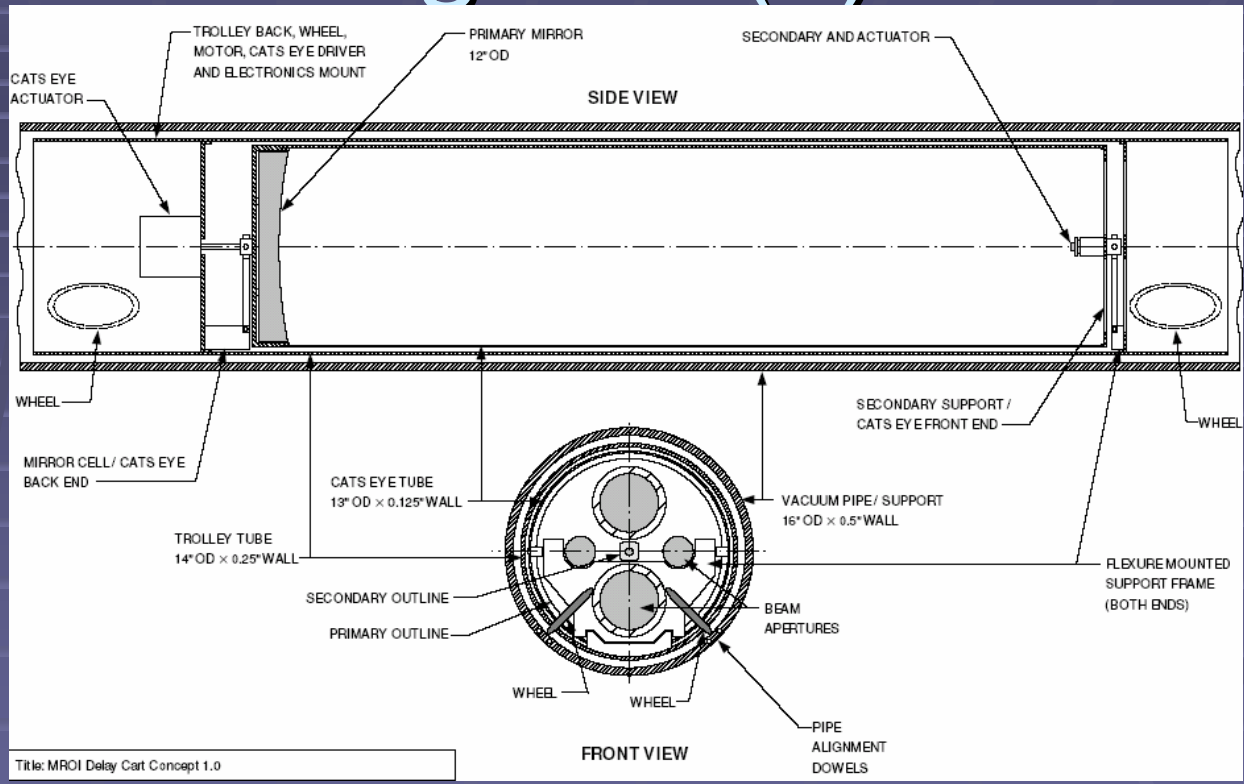
- Transporter concepts
  - Independent consultant – rails too expensive
  - Wheeled dome
    - 6 m shown
  - Boat-lifter
  - Studying g loading requirements and repeatability





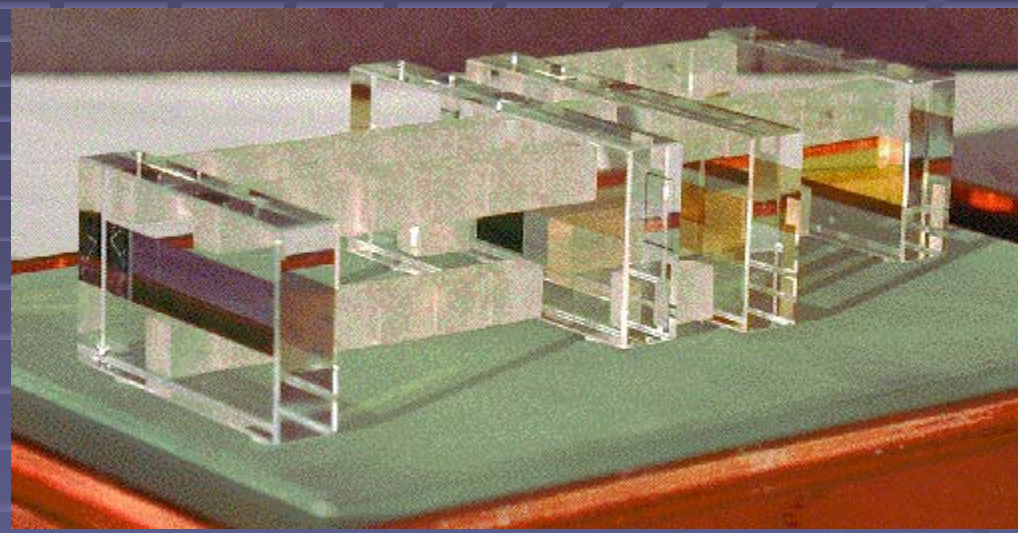
Technical Progress (v)

- Delay lines concept
  - No rails
  - Rotational control
  - Active secondary
  - Inductive power transmission and RF communication
  - Prototype under test at Cavendish Lab



Technical Progress (vi)

- Beam combiners
  - 15 mm beams
  - Optically contacted devices
  - Limited degrees of freedom
    - Ease of alignment and calibration
    - Long-term stability

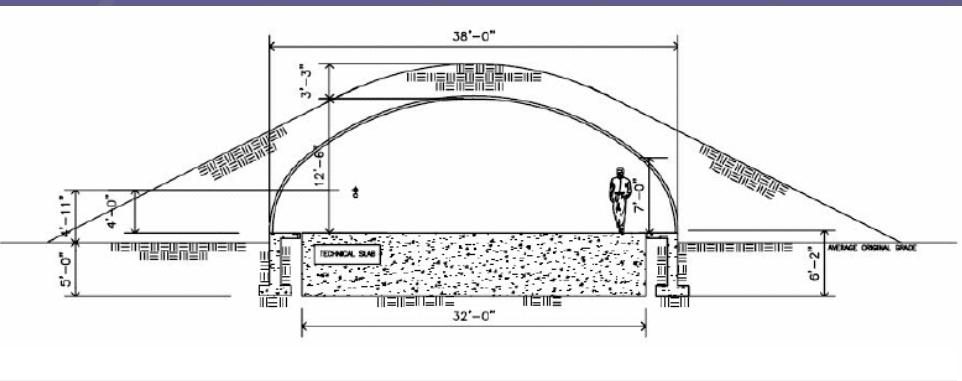


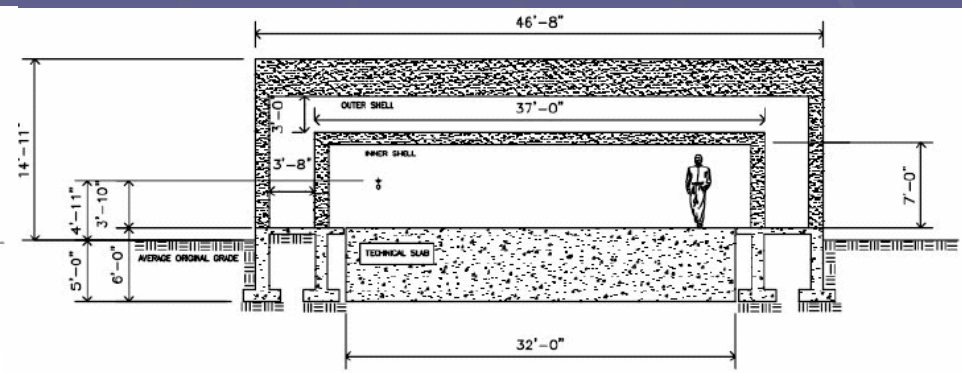
Technical Progress (vii)

- Detectors
  - Optical (T/T & science)
    - E2V back-illuminated CCD87
    - On-chip gain – zero read-noise
    - Pixel rates > 1MHz per beam
    - Available off-the-shelf
  - Infrared (FT & science)
    - Rockwell Calico AO
    - $1e^-$ at 500 kHz pixel rate
    - 8 on-chip amp designs under study at Caltech/ESO

Technical Progress (viii)

- BCF/DL buildings
  - Initial designs concentrating on:
    - Berm building
    - Room-within-a-room
  - Design contract to be let Q3 `04
  - Build contract to be let Q2 `05





Personnel/Staffing

- PI – V. Romero/Deputy PI – D. Westpfahl
  - Proj Manager – M. Sirota
  - Proj Architects – D. Buscher and C. Haniff
  - Proj Scientist – M. Creech-Eakman
  - Lead Optomechanical Eng. – J. Kern
  - Lead Control Software Eng. – T. Coleman
  - Total Personnel: 15 FTE – hiring 8 more positions over next year (mechanical, camera systems, electrical, software, postdocs and technicians)

  - Partner – COAST group from Cambridge
  - Spending Oversight - NRL

Phased Build

- Phase A:
  - 6 telescopes, 225 m baselines, NIR science ➔ $40M
- Final Instrument:
  - 10 telescopes, 400 m baselines, NIR & optical science ➔ $70M

Proposed Schedule

- Let RFP for telescopes - 4th Q, ’04
- Design Review – 1st Q, ‘05
- Begin building BCF & piers – 3rd Q, ’05
- Telescopes arrive – 1st Q, ’07
- First fringes – 4th Q, ’07
- First closure phase – 2nd Q, ’08
- First Nature paper shortly thereafter

Conclusions

MROI first facility class interferometer with a design which is optimized for *model-independent imaging* over a large range of spatial scales.

More information?

- Jobs postings: Michelle Creech-Eakman, Mark Sirota, Chris Haniff or David Buscher

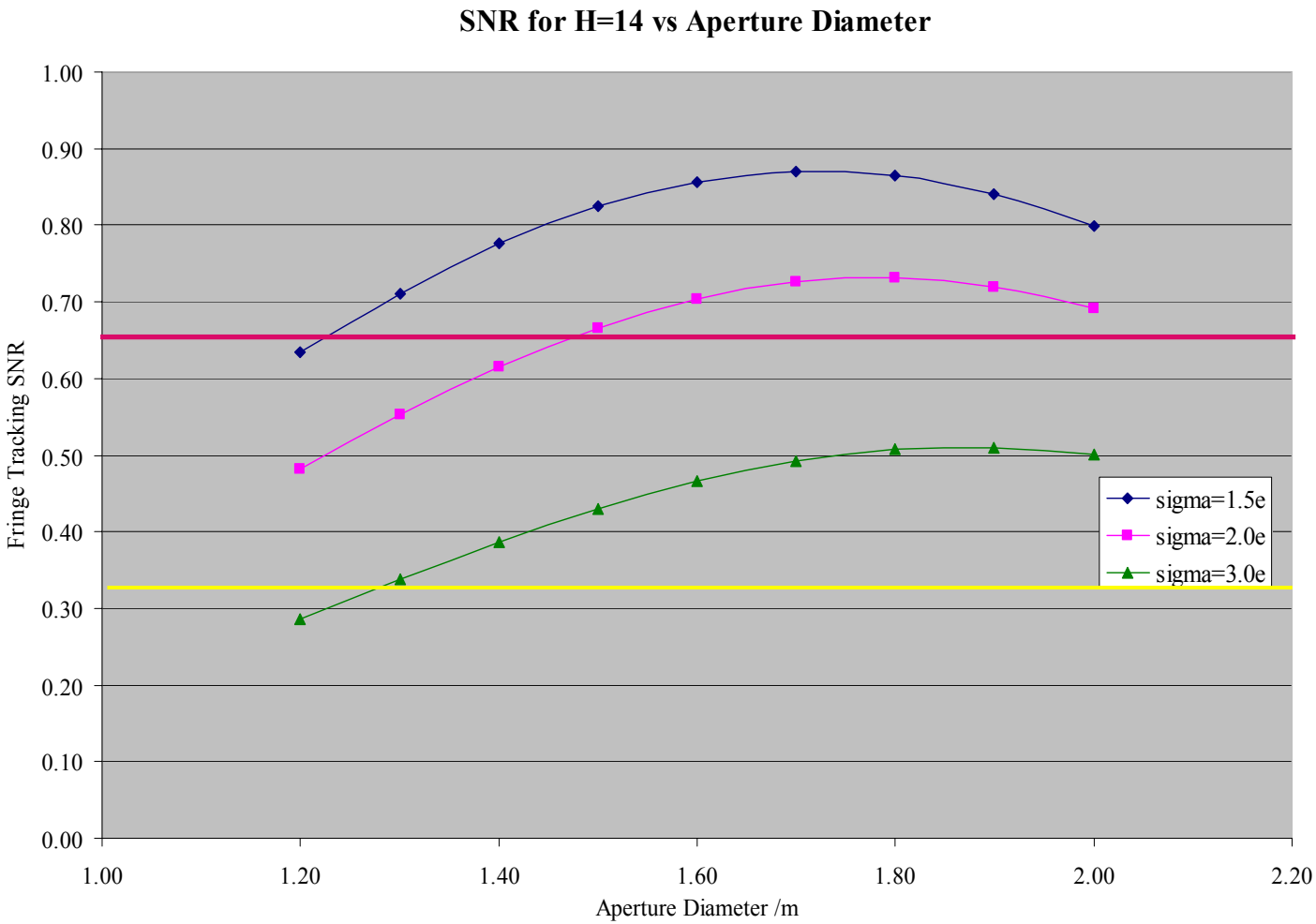
  (*Camera Systems Engineer, Mechanical Engineer, Electronics Engineer, Postdoc*)
- NMT Physics Dept: expect 3-4 faculty retires in next 6 years
- Posters: 5491:144-147,183, 5489:83
- Papers: 5491:59, 78, 98

Backup Slides

SNR Calculation

- Assumptions:
  - r_0 = 14 cm, T/T 10 Hz, windspeed 10m/s, 1.4m aperture, errors/vibrations λ/10 rms, 1.5e^- readnoise, pairwise combination, H band, unresolved source
- Results:
  - N = 80 photons at H, $N_{background}$ <10 photons, n_{pixels} = 20 = 5 channels X 4 bins
- SNR Calculation:
  - SNR ≈ $V^2 N^2 / (N + N_{background} + n_{pixels}\sigma^2)$ = 0.77
  - Buscher (1988) showed SNR = 0.33 is all that is required for group delay (fringe envelope) tracking

Why 1.4 m apertures?



Throughput Calculation

- Telescope primary - Al
- All other mirrors – overcoated Ag
- Infrasil windows and substrates
- Custom dichroic & AR coatings
- Extra 1% losses at each exposed surface