Design Optimization Considerations for MROI

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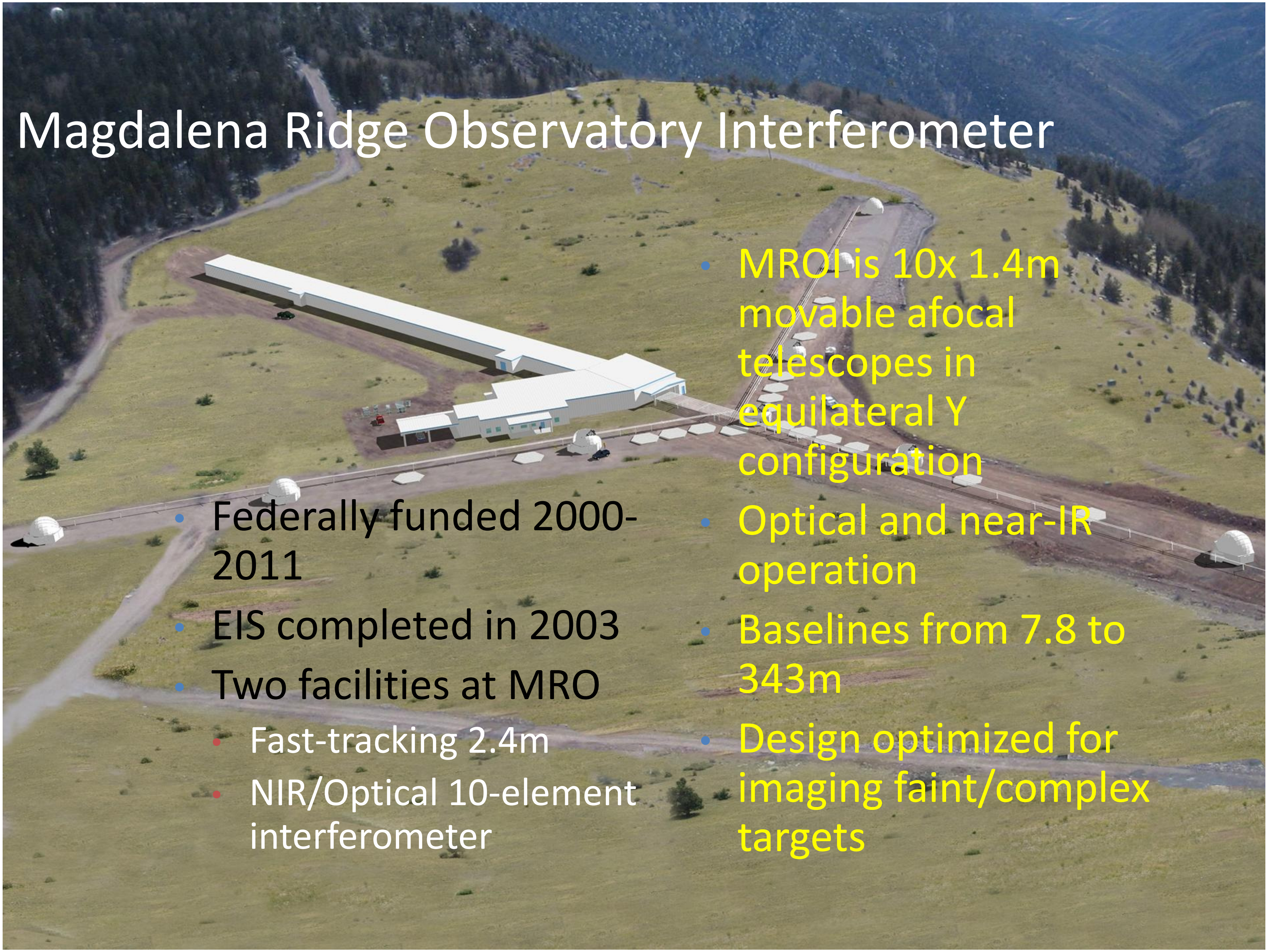
On behalf of MROI team in NM, USA and Cambridge, UK

Overview of Talk

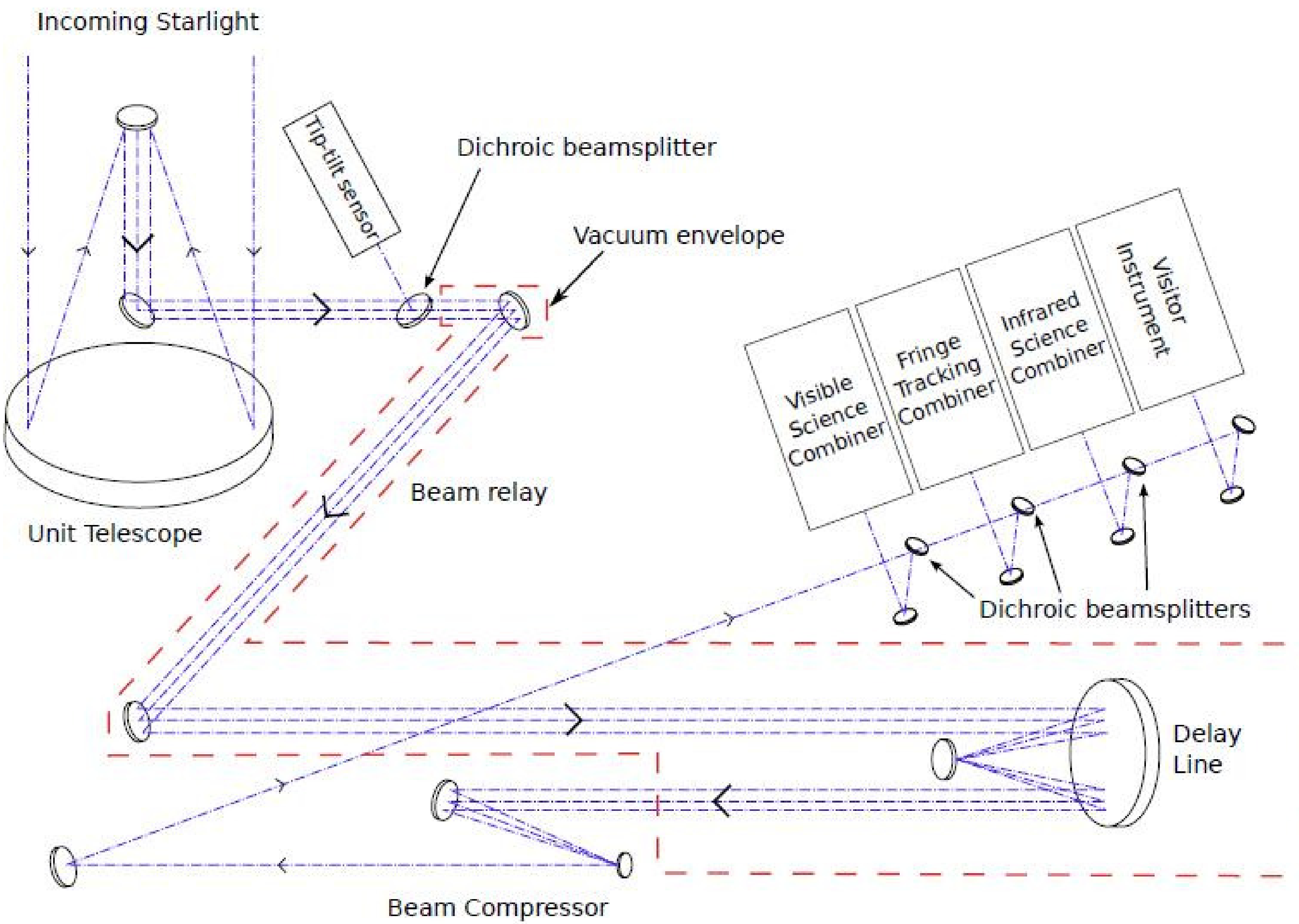
- Quick Introduction to MROI
- Design Philosophy
- Error Budget
- Subsystem Examples
- Recent Updates
- Quick Movie
- Conclusions



Magdalena Ridge Observatory Interferometer

- Federally funded 2000-2011
- EIS completed in 2003
- Two facilities at MRO
  - Fast-tracking 2.4m
  - NIR/Optical 10-element interferometer

- MROI is 10x 1.4m movable afocal telescopes in equilateral Y configuration
- Optical and near-IR operation
- Baselines from 7.8 to 343m
- Design optimized for imaging faint/complex targets



Buscher et al. 2013 JAI in press

Interferometric Considerations

- Sensitivity
- Speed of Data Collection
- Accuracy
- Precision
- Scalability
- Mobility
- Polarization Purity
- Expert/Novice User Base
- Astrometry
- Imaging
- High Resolution Spectra
- Nulling
- Costs

MROI Considerations

- Sensitivity
- Speed of Data Collection
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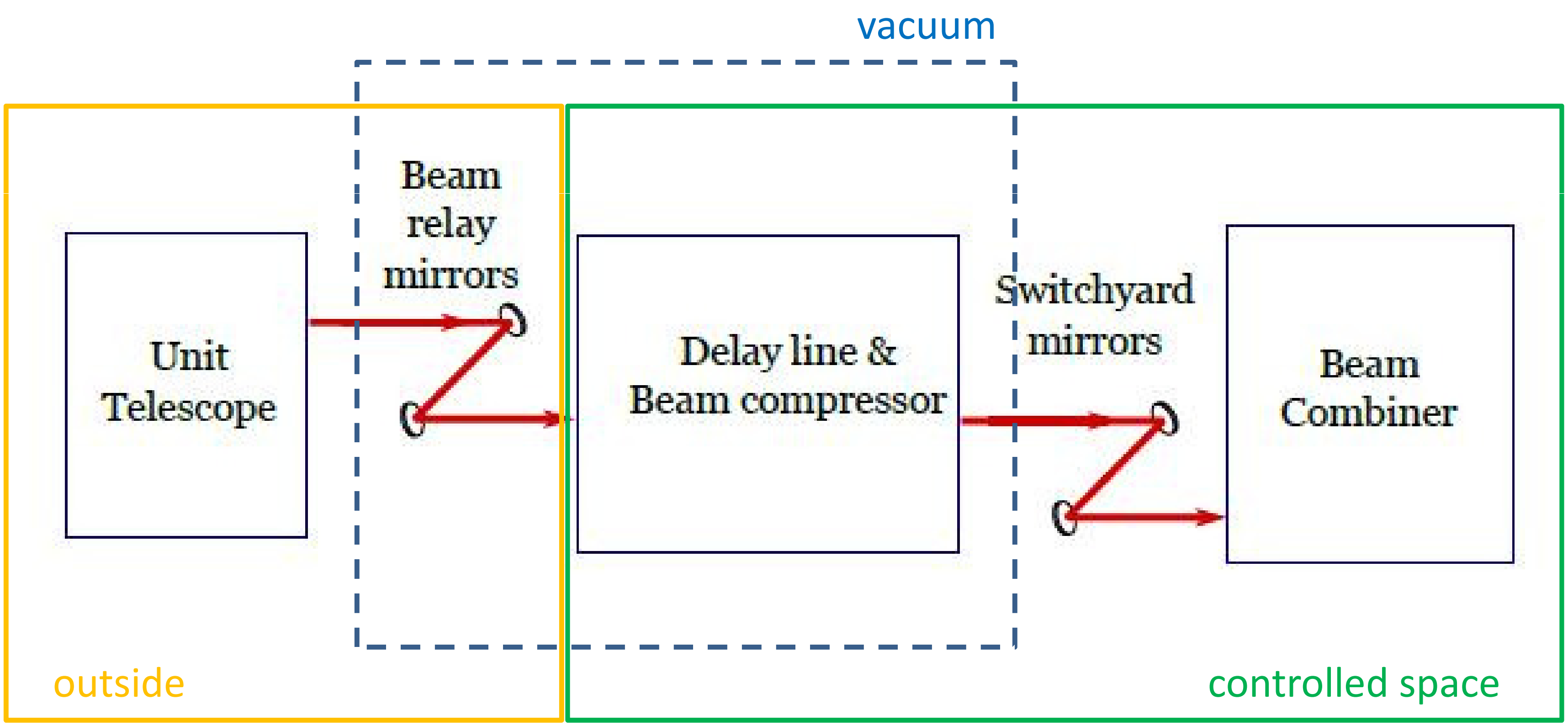
MROI Innovations

- Sensitivity = many components in overall design – factor of a few in most cases
- Speed of data collection = simple architecture with very few moving components
- Scalability/mobility = site location & design of building/infrastructure
- Polarization purity = telescopes & beam train
- Imaging = number of telescopes, FT architecture, separated FT/science

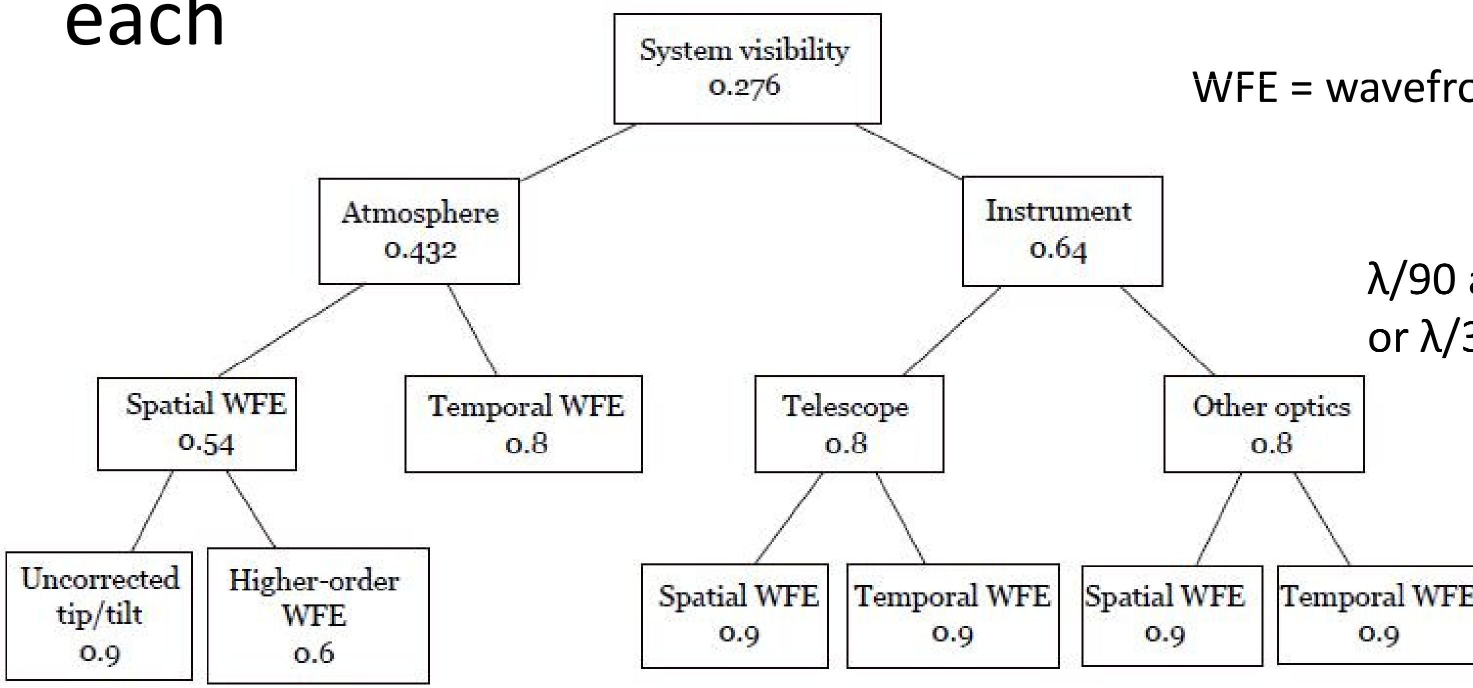
Conceptually

Three subsystems – very few mirrors to adjust



Start with an Error Budget

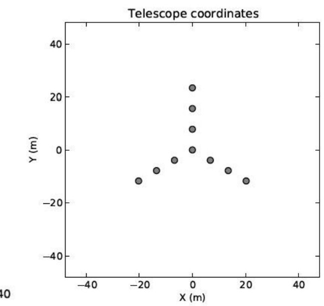
Assign *achievable* errors (factors of a few improvement) to each component of the overall system, and then "hold the line" on each



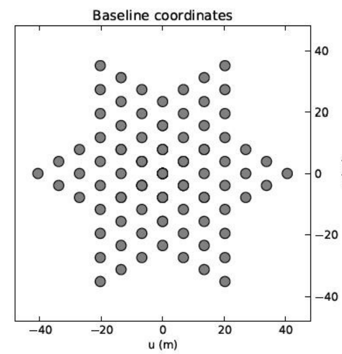
WFE = wavefront errors

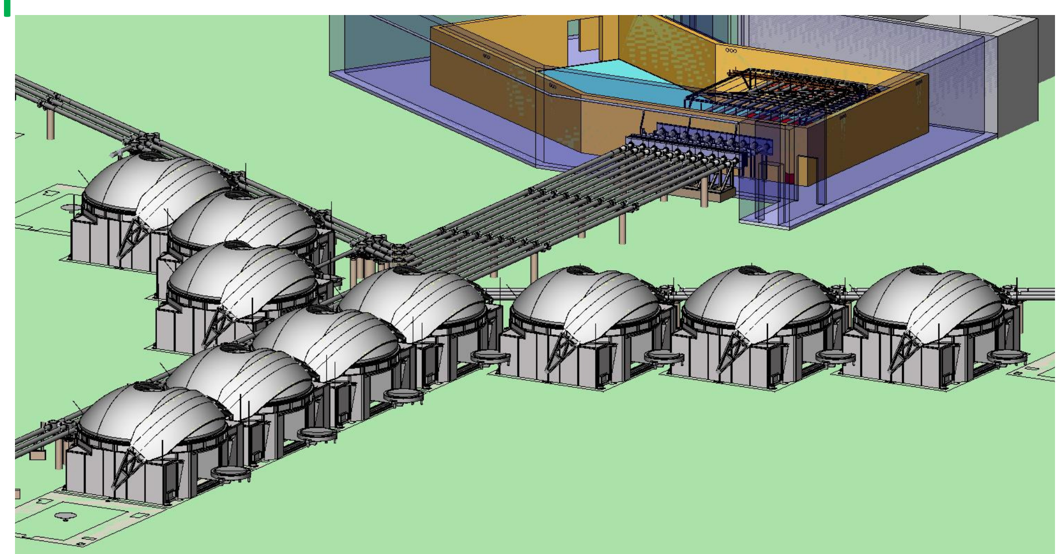
λ/90 at 1.6um
or λ/35 at HeNe

Array Layout



- Equilateral Y Configuration
  - 5:1 within a configuration
  - 44:1 overall angular scaling
- Multiple Telescopes
  - UV points & CP triangles
- Speed data collection
- Scalability
- Imaging
- Cost - infrastructure





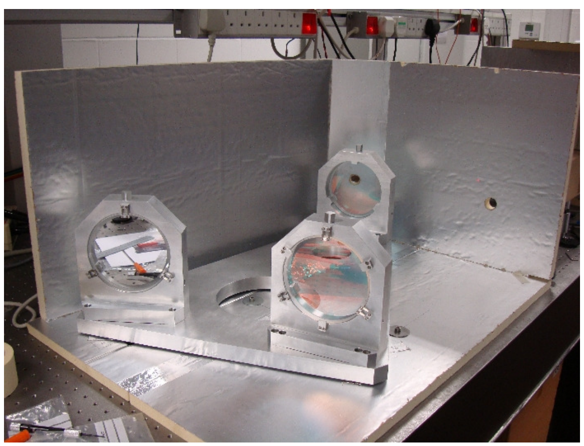
Telescopes

- Alt-alt design
  - 3 mirrors
  - 1 reflection > 30^{o}
  - OPD vibrations <40nm RMS *tested*
  - <350um radial pupil motion *tested*
- Sensitivity, Scalability, Mobility, Polarization Purity, Imaging
- Cost – specifications

Pirnay et al. 2008 SPIE

FTT and Beam Relay Systems

- Transmissive design
- Located on Nasmyth platform – commands 2^{ndary}
- EM CCD
- TT error of 60.8mas RMS at m_v = 16 in 0.7” seeing
- Sensitivity, Speed of Data Collection
- Cost



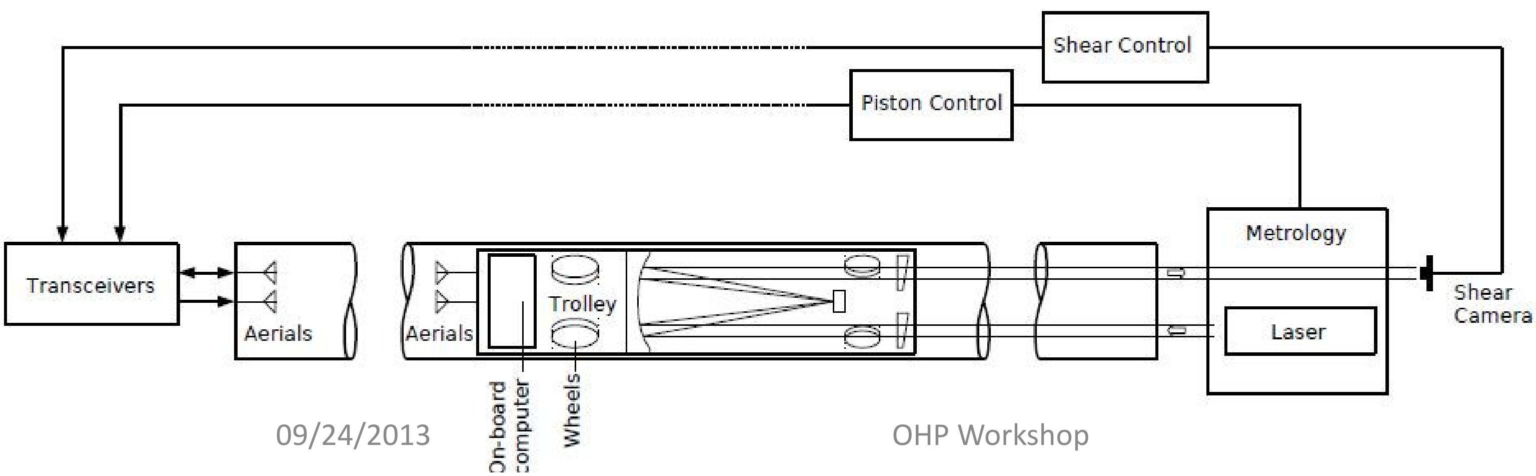
Young et al. 2012 SPIE

- Vacuum transport large beams (cheap)
- No longitudinal dispersion correction needed
- Multiple wavelengths simultaneously
- Sensitivity
- Cost

Santoro et al. 2012 SPIE

Delay Lines

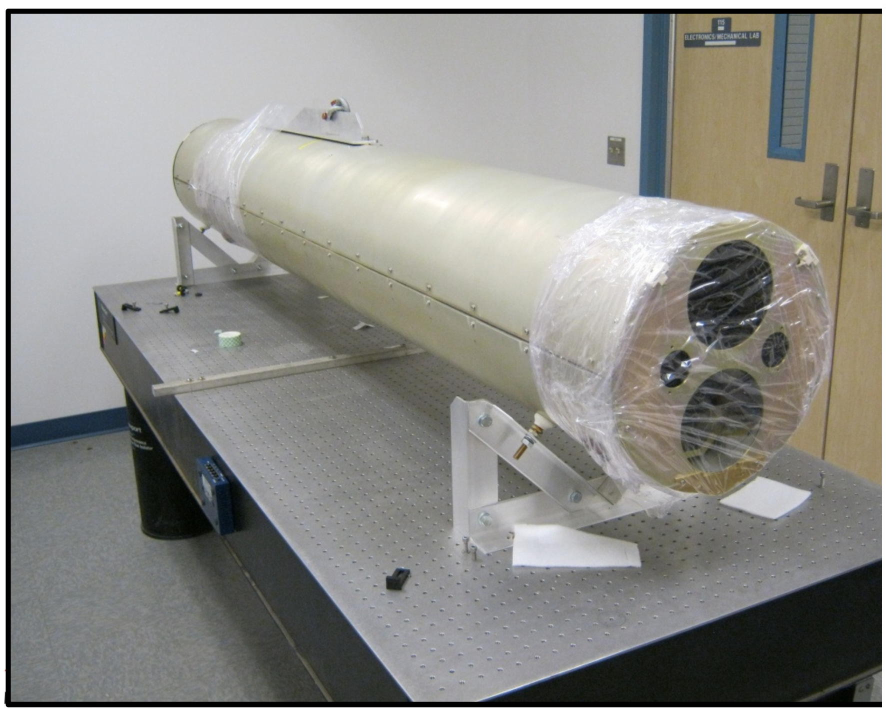
- Single stroke system with novel features
  - 380m continuous delay compensation
  - Vacuum vessel and track are same component
  - No “on-board” cabling
  - COTS laser metrology
  - $\lambda/40$ RMS DL jitter over $2t_o$ *tested* on 25m

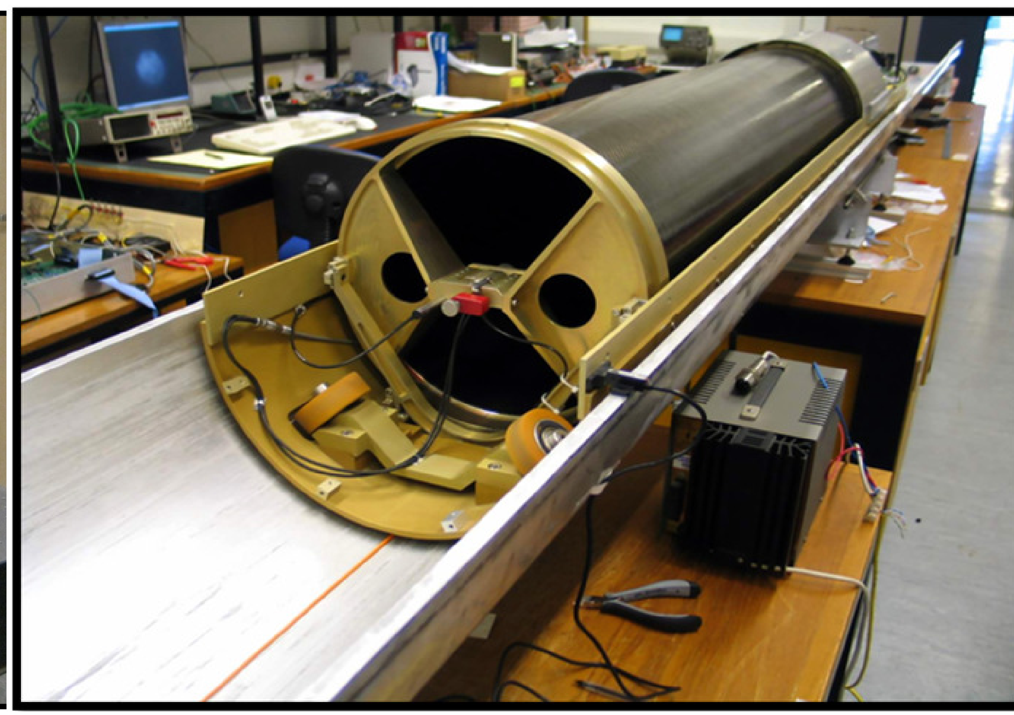


Haniff et al. 2008 SPIE
Fischer et al. 2010 SPIE

Delay Lines

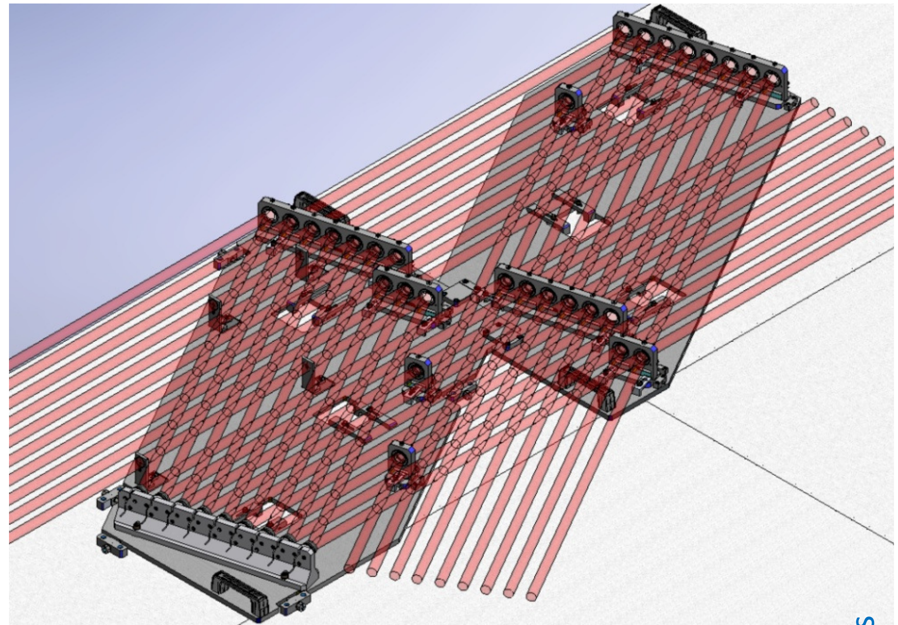
- Sensitivity, Speed of Data Collection, Polarization Purity, Imaging
- Cost ($275K after NRE)





FT - ICoNN

- Nearest-Neighbors for all 10 beams
  - Maximizes per baseline SNR
  - Accepts 5 beams per dewar
- No adjustments, precision plates
- Reflective outside, refl/trans inside
- Stays aligned for days in campus lab
- Sensitivity, Scalability, Speed of Data Collection
- Cost



Jurgenson et al. 2008 SPIE & 2013 JAI paper in press

Recent MROI Updates

- UTM1 shipped last week
- DL1 cart delivered few months back and lab tested; will be installed on Ridge in 2 months
- Visitor/maintenance building on Ridge under construction
- First BR system installed outside building
- University searching for more $$ - Fed & State

Last full talk at Flagstaff meeting in Feb 2013 if you want more MROI details.

MOVIE HERE!!

Conclusions

- Sensitivity = 14^{th} mag at H for FT
- Polarization purity = 1 reflection >30^{o} AOI
- Scalability = Entire design for 10 telescope array – add on components as $ comes
- Mobility = 28 pads, 4 "intrinsic" configurations
- Speed of imaging = 10 min/calibrated UV snapshot

Snapshot Imaging Machine!

See Ifan Payne if you are interested in joining.

Thank you for your attention!