Update on the Magdalena Ridge Observatory Interferometer

M. J. Creech-Eakman
New Mexico Tech – MROI Proj. Scientist
On behalf of the NMT and Cambridge Teams
Magdalena Ridge Observatory

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

- MROI is 10 1.4m movable afocal telescopes in equilateral Y configuration
- Optical and near-IR operation
- Baselines from 7.8 to 340m
- Design optimized for imaging mission
MROI Key Science Mission

- **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 and mass loss:**
  - Convection, mass loss and mass transfer in single and multi-star systems.
  - Bipolarity and collimation of circumstellar material, wind and shock geometries.
  - Pulsations in Cepheids, Miras, RV Tauris, etc.
Technical Requirements Flowdown

- Telescope diameter of 1.4 m
  - H magnitude = 14th for group delay tracking limit
- Spatial scales of 0.3 to 30 mas
  - Baselines from 7.8 to 340 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
Walk through the Optical Path

1.4m Unit Telescope and enclosure

Beam Transport Lines
Enhanced silver, 30 deg incidence in air

Vacuum Delay Lines
"Cat's-Eye" retro-reflecting telescope carried on moving cart in vacuum

Beam Turning Area
Enhanced silver, 30 deg incidence in vacuum
2 mirrors comprising Menzene 6.66 x Beam reducing telescope
10cm beam dia

Beam Combining Area
15 deg incidence, dichroic mirrors for selective reflection of different wavelengths
Alignment Laser for back propagating alignment beam
Metal Film Mirror

Visible
IR FT
IR Sci
Visitor

These outputs to switchyard and beam Combiner

Beam Combiner

Low Noise Detector
Unit Telescopes

- Designed/built by AMOS
  - 1.4m aperture
  - afocal alt-alt design
  - polarization preserving
  - 44 nm WFE rms after three mirrors
  - UT1 expected to arrive late this year
  - UT2-3 long-lead items ordered and being assembled
Optics & UT Enclosures

- Enclosures Designed by EIE
- Houses and transports UTs
- Allows close-packed configuration to 30 deg elevation without vignetting for 6 hour tracks
- 6 full sets of optics in house
  - All M2’s and M3’s completed
  - First 3 M1’s in various states of completion – none done yet

48 nm RMS when contract closed
Fast Tip-tilt & Acquisition System

- At an advanced stage of construction in Cambridge:
  - Full-scale prototype under test
  - Majority of software complete
- Uses Andor EM CCD head
- Transmissive optics
  - High throughput and relaxed tolerances
- Fully passive opto-mechanical design:
  - No actuation to meet stability requirements
- V-band sensitivity of 16\textsuperscript{th} mag:
  - Good match to reddest targets
Foundations and Beam Relay System

- Recently completely redesigned by M3 and built by MRO
- Meets stringent thermal, wind stability and subsidence requirements
- Supports 3 UTs per beamline with 0.5 mbarr vacuum from UT to BCA
- Install for piers for inner array began 2010
- Houses all components of automated alignment system
Inner Array Install

Today 7 piers installed with infrastructure being added as funds become available.
Automated Alignment System

- Designed and built by MRO
- End-to-end alignment of tilt and shear
- Enclosed in a “Magical Optical Box”
- Custom quad cell and beam injection via fibers
- Ongoing CLFE -- part of a thesis and dissertation

03/18/2013
Beam Combining Facilities

- Thermal & vibrational stability
  - 1.0deg diurnally DL
  - 0.1 deg diurnally BCA
- Supports full 10 DL array
- Single-pass DL section 190 m long
Delay Lines

- Designed/built Cambridge
- Innovative approach
- Inductive pick-up & wireless communications
- DL1 install to about 100m
  - <0.5mm subsidence over 1 year
  - <0.5” metrology pointing stability over weeks
Fringe Tracker - ICoNN

- Designed/built by MRO
- Operates H or Ks
- Coatings designed in-house
- Uses nearest-neighbors combination to bootstrap
- Dewar from Univ. Cryogenics
Science Instrument - SIRCUS

- MRO design at conceptual phase
- J,H,K with R~30 and 300; studying higher R
- Potential design: 4-way image plane combination with fast-switching to combine 6 beams in ~100 sec

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**Performance:**
SNR per spectral channel in 100 sec at R~30 with 0.7” seeing and RN=5e-
Software infrastructure

- **Architecture and Framework:**
  - Centralized Supervisory System controls distributed systems
  - Automatic Interface code generation based on sub-system descriptions
  - Sub-system s/w developed in Java or C
  - Standalone testing of sub-system s/w
  - Comprehensive simulation framework

- **Status of major sub-system software:**
  - UT mount complete (via simulator)
  - WAS complete
  - Environmental Monitoring System complete
  - FTT in development
  - Fringe Tracker system in development/test
  - Enclosure software designed, not yet implemented
Funding & Schedule Issues

- Need $45M over next 6 years to get 4 telescope facility operational – mix of Federal, State, institutional, philanthropic and partner funding
- Have DOT fund to build a visitor center and maintenance facility on Ridge → allow testing of UT#1 later this year
- Looking for university or potential consortium partners for telescopes, instruments and operations.

New Video made for Sen. Heinrich’s visit:
http://www.youtube.com/watch?v=yqtJJxMh04o
Thank you for your attention!

- **PI:** Van Romero
- **Deputy PI:** R. Cervantes
- **Prog. Director:** I. Payne
- **System Architects:** C. Haniff, D. Buscher
- **Proj. Scientist:** M. Creech-Eakman
- **Proj. Manager:** R. Selina

- **NMT Team:** M. Edwards, A. Farris, D. Klinglesmith, T. McCracken, A. Olivares, C. Salcido, A. Shtromberg, a few student assistants
- **Cam. Team:** R. Boysen, J. Coyne, M. Fisher, B. Seneta, D. Sun, D. Wilson, J. Young