MAGDALENA RIDGE OBSERVATORY

NEW MEXICO TECH

UNIVERSITY OF CAMBRIDGE

Final Mechanical and Opto-Mechanical Design of the Magdalena Ridge Observatory Interferometer

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ABSTRACT

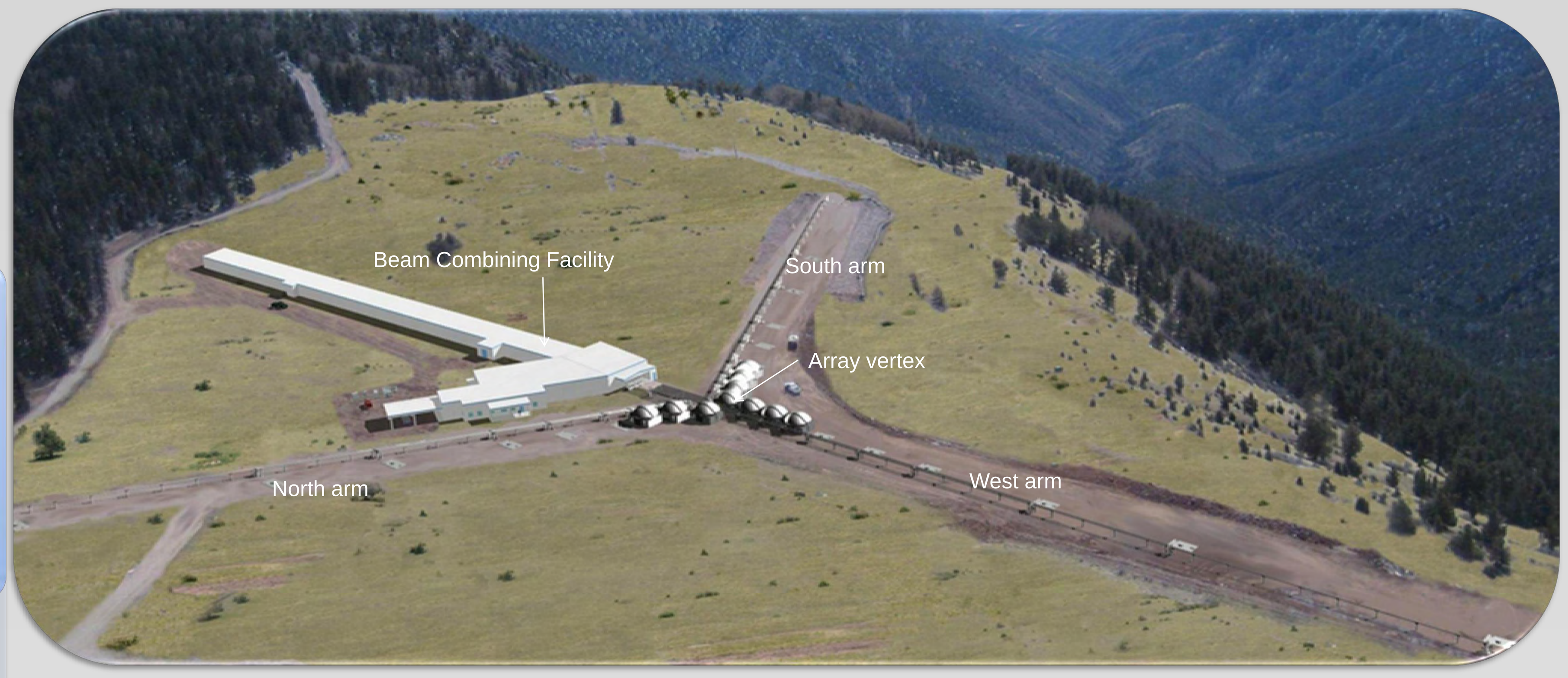
Most subsystems of the Magdalena Ridge Observatory Interferometer (MROI) have progressed towards final mechanical design, construction and testing since the last SPIE meeting in San Diego - CA. The first 1.4-meter telescope has successfully passed factory acceptance test, and construction of telescopes #2 and #3 has started. The beam relay system has been prototyped on site, and full construction is awaiting funding. A complete 100-meter length delay line system, which includes its laser metrology unit, has been installed and tested on site, and the first delay line trolley has successfully passed factory acceptance testing. A fully operational fringe tracker is integrated with a prototyped version of the automated alignment system for a closed looping fringe tracking experiment. In this paper, we present details of the final mechanical and opto-mechanical design for these MROI subsystems and report their status on fabrication, assembly, integration and testing.

BACKGROUND

The MROI project is an international consortium between New Mexico Institute of Mining and Technology (NMT) and the Astrophysics Group of the Cavendish Laboratory at the University of Cambridge in the UK. The MROI offices are located in Socorro-NM and the observatory site is located on the Magdalena Mountains, about 48 km (30 miles) west of Socorro, at an elevation of 3230 meters (10600 ft) above sea level. The observatory is primarily intended for astronomical research and will comprise an array of up to ten 1.4-meters Mersenne afocal unit telescopes (UT) arranged in an equilateral "Y" configuration. Each of these UTs will send a collimated beam of starlight to a laboratory facility located close to the center of the array, the Beam Combining Facility (BCF). The UTs will be re-locatable amongst a discrete set of 28 foundation pads, giving baseline lengths (inter-telescope spacing) from approximately 7.8 meters to 380 meters.

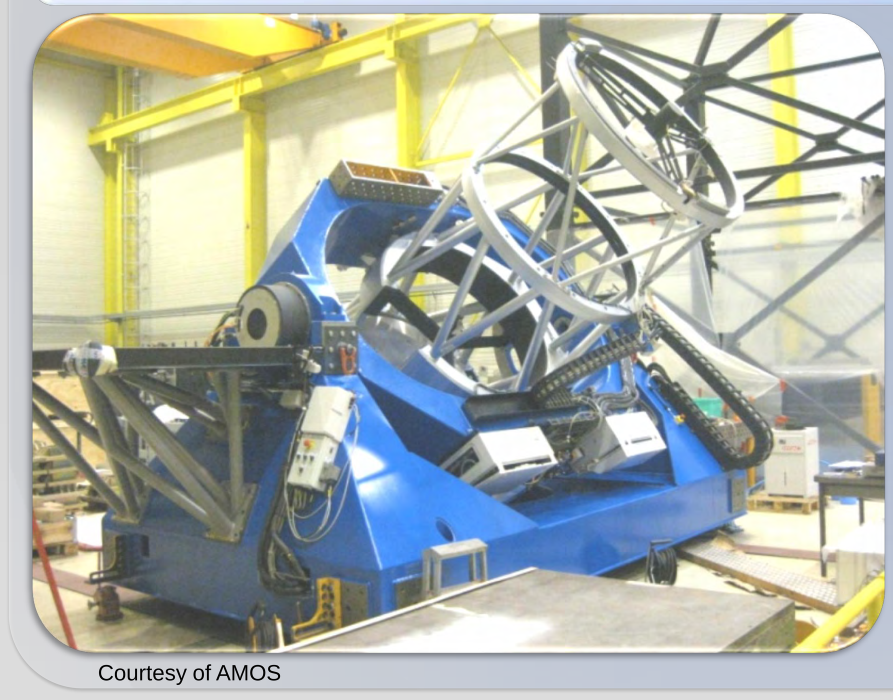
With limited funding, the project has progressed adequately towards final mechanical design, prototyping, construction, and testing. In this paper, we present details of the final mechanical and opto-mechanical design of MROI subsystems and report their status on fabrication, assembly, integration and testing. We specially emphasize the mechanical stability of some of these subsystems as one of the most targeted design characteristics of MROI, such as in the beam relay system, delay line pipes, delay line laser metrology system and fringe tracker beam combiner. First light is scheduled to happen in 2015 and commissioning phase from then on.

The mechanical design of MROI is broken down into eight major sub-systems. Following the order that they appear to the incoming beam of light these subsystems are the Unit Telescope Mount/Optics (UTM/O), Fast Tip-Tilt System (FTTS), Beam Relay System (BRS), Delay Line System (DLS), Beam Compressing Telescope (BCR), Automated Alignment System (AAS), M10 and Infrared Coherencing Nearest Neighbor tracker (ICoNN). The Unit Telescope Enclosure (UTE), Unit Telescope Transporter (UTT) and Vacuum System (VS) are also added as major subsystems.



Unit Telescope Mount

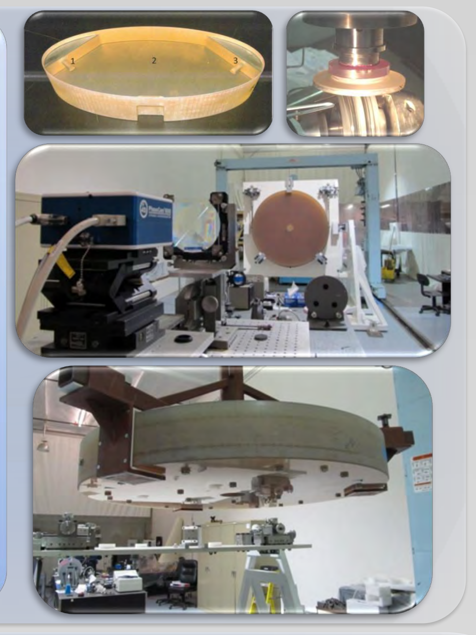
The MROI unit telescope (UT) is a 1.4m Mersenne optics design assembled on an elevation over elevation gimbal configuration. It takes an input beam of light from the night sky and delivers a collimated beam of 95mm in diameter. The optical train is composed of an f/2.25 concave parabolic primary mirror (M1) with 1.4m in diameter, a convex parabolic secondary mirror (M2) with 115 mm in diameter and a flat elliptical tertiary mirror (M3) that is articulated to allow light to be directed to a fixed horizontal position out of the telescope (nominally at 1.6m above the BCF grade). The UT is designed and constructed under contract with Advanced Mechanical and Optical Systems (AMOS) in Belgium. The first mount (UTM#1) successfully passed FAT and is ready to be shipped to MRO. Integration with the UT optics and SAT will be carried out at the integration facility on Magdalena Ridge. Manufacturing of the long lead items (fork, gimbal and tube) for UTM#2 and UTM#3 has been completed.



Courtesy of AMOS

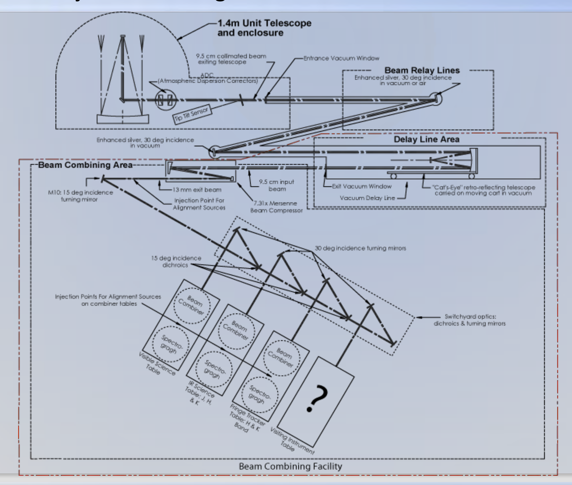
Unit Telescope Optics

The UTO consist of a f/2.25 concave parabolic M1 1.4m in diameter, a convex parabolic M2 115 mm in diameter and a flat elliptical M3. Fabrication has started on the first six sets of UTO (Figure 4). All six secondary and tertiary mirrors are polished to specification and awaiting coating. The six primary mirrors are at various levels of polishing with the first primary (SN1) at approximately 50nm RMS (still higher than the specification), SN2 at approximately 1-wave (600nm RMS) and SN3-6 have been ground and are awaiting polishing. Final polishing and coating are expected to resume in 2013.



Optical Train

The MROI optical train consists of a total of 10 mirrors, going from the UT up to the switchyard optics located in the instrument area of the inner portion of the Beam Combining Area (Inner-BCA). During operation, starlight from each UT will be transported in up to ten evacuated Beam Relay System (BRS) pipes to the BCF. Part of the BCF is the Delay Line Area (DLA) where up to ten evacuated single path traverse Delay Line (DL) pipes and cat's eye Trolleys are placed. These will be used to match light paths from a star, via a pair of UTs, to within the coherence length of the light being measured in any spectral channel of the detector being used. Upon exiting the DLA, light is directed to the Inner-BCA where will be optically compressed and directed to the Infrared Coherencing Nearest Neighbor tracker (ICoNN) via M10. The Inner-BCA is temperature controlled to ±0.1ºC by controlling the temperature in the adjacent building.

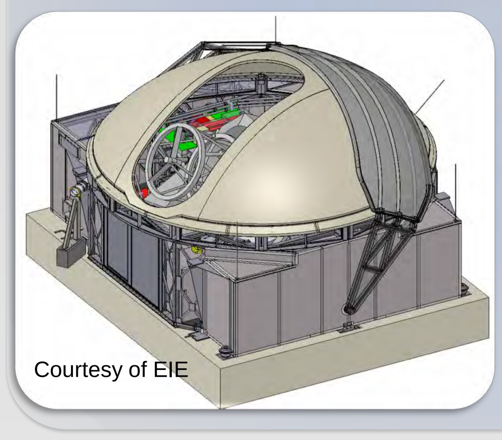


Unit Telescope Enclosure

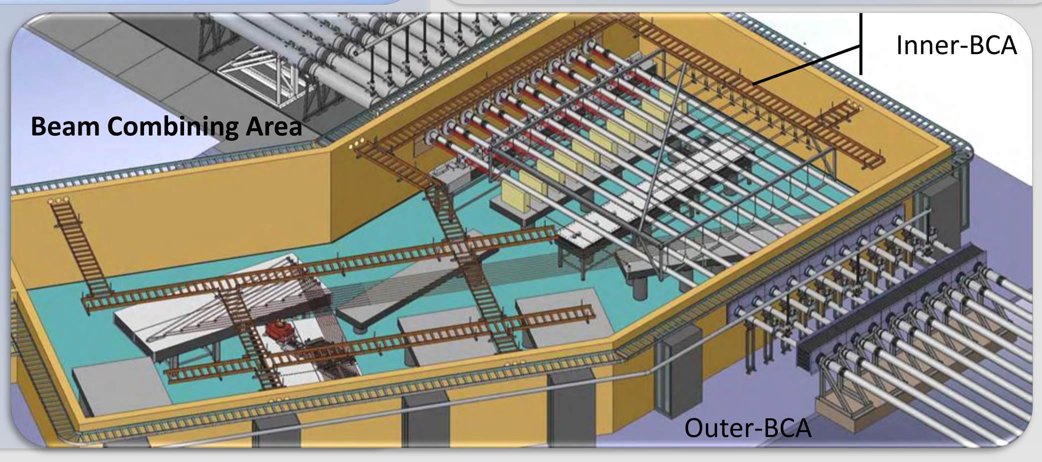
Each UT will be housed within an enclosure (UTE) that has been designed to operate under three different modes: Observation Mode: UT is completely disconnected from the UTE and operates for science or engineering on-sky observation under optimum observing environment or reduced performance observing environment; Shut-down Mode: UT is parked and protected by the UTE; and Relocation Mode: UTE and housed UT are being transported from one station to another within the array. The UT is designed under contract with European Industrial Engineering (EIE) in Italy. Berengo-Galbiati of Italy has been selected via a competitive Request For Proposal for the fabrication, testing and delivery of the UTE. Fabrication of the first enclosure is anticipated to start in 2013.

FTTS/NAS

The functions of the FTTS/NAS are twofold. One is to provide fast tip-tilt correction signals to the second stage hexapod actuators that allow fast tip-tilt motion of M2. The other is to operate under narrow acquisition mode which allows a telescope operator to find an object in the full field of view of the telescope. The design of the FTTS/NAS is being developed under contract with the University of Cambridge - UK. The University of Cambridge has successfully passed PDR in June/2011.



Courtesy of EIE

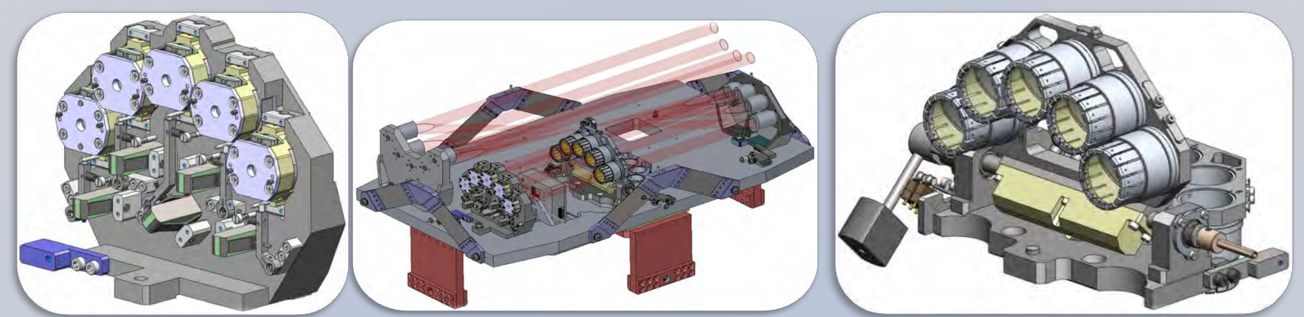


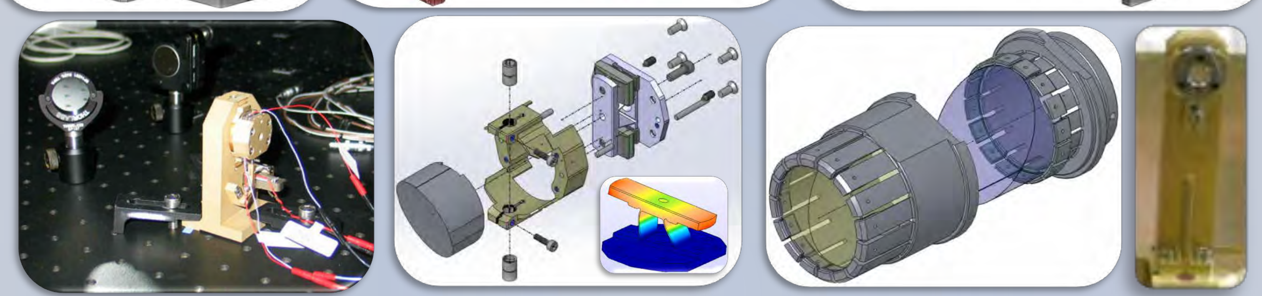
Automated Alignment System

A beam of light from a UT will travel distances ranging from 460m to 660m before reaching a spectrograph at the Inner-BCA. Considering that MROI is comprised of three major optical axes, i.e. UT, DLS and beam combiner, a suitable method for co-aligning these axes in a nightly basis is provided by the Automated Alignment System (AAS). Automated alignment is performed via M4/M5 and switchyard. The AAS is an in-house development.

ICoNN

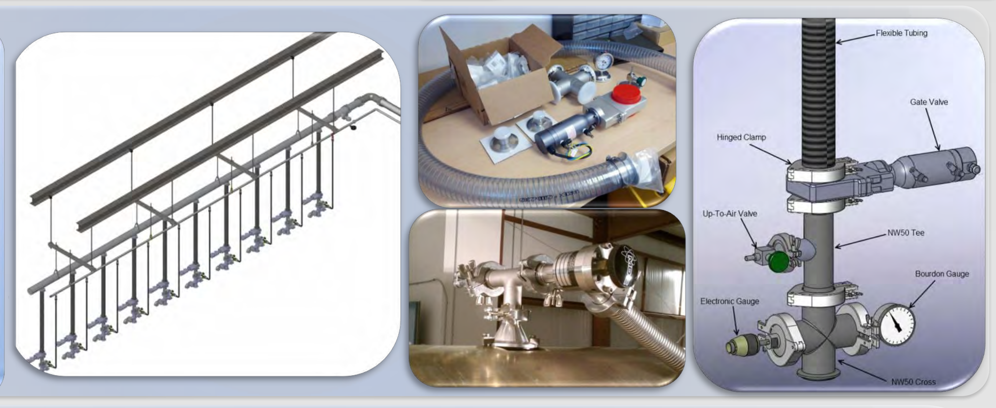
The major role of the Infrared Coherencing Nearest Neighbor tracker (ICoNN) is to measure the group delay between all nearest neighbor UTs in the array and to send closed feedback signal to the corresponding DL trolleys for correction of atmospheric perturbations. The FT is an in-house development in which the mechanical design is broken down into four major subsystems named as switchyard, beam combiner (BC), periscope optics (PO) and spectrograph. The FT is an in-house development. Much of the fabrication has been completed excepting the PO and some optical mounts for the spectrograph. Alignment and stability testing of the BC has been completed successfully and testing has begun on the spectrograph. Prototype testing of several components, such as the focus-OAP tip-tilt cell, has been completed or is underway.





Vacuum System

The Vacuum System (VS) is an in-house development used to evacuate the BRS and DLS. It is required to hold a vacuum level of 0.5mbar (3.75x10-1 Torr) over the night and has to evacuate a volume of approximately 320m^3. Final design for the system has been completed. Testing of individual components has begun.



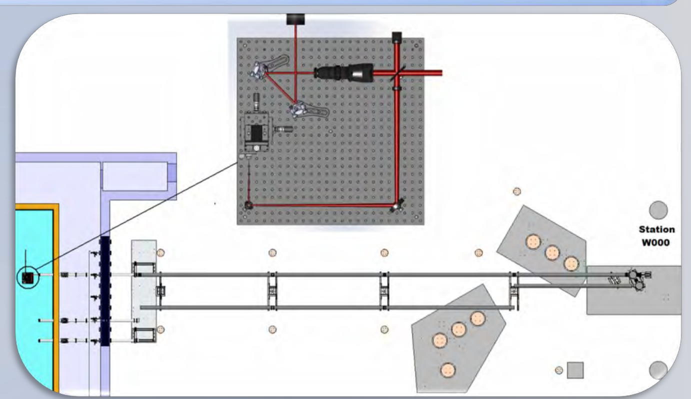
Delay Line System

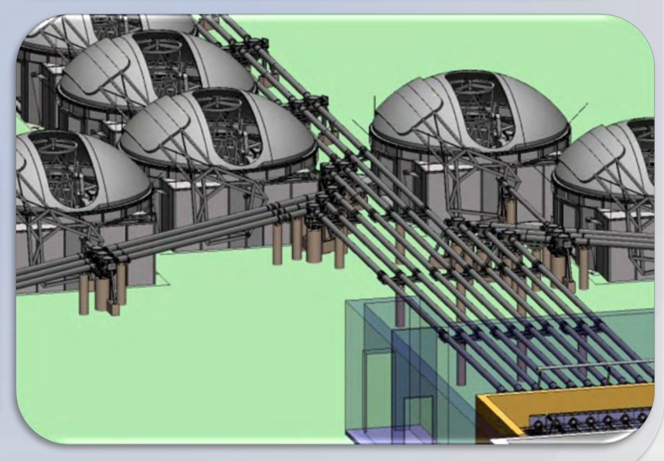
The major function of the Delay Line System (DLS) is to control the position of each cat's eye along its corresponding evacuated single path traverse DL pipe so as to match light paths from a star, via a pair of UTs, to within the coherence length of the light being measured. The DLS is assembled inside the DLA, Inner-BCA and Outer-BCA. When MROI is completed: - the DLA will be equipped with up to ten 190m DL pipes/supports and Trolleys; - the Inner-BCA will be equipped with a laser metrology system with associated hardware and optics to feed up to ten DLs; and - the Outer-BCA will be equipped with electronics racks and computers. The DLS is being designed under contract with the University of Cambridge in the UK. The first 100m DL has been installed along with a laser metrology system. The system has undergone stability and vacuum integrity testing and performed well. The first production DL trolley has completed FAT at the University of Cambridge in the UK and ready to be shipped to MRO.

Courtesy of University of Cambridge

Beam Relay System

The major function of the Beam Relay System (BRS) is to transport light exiting M3 to the BCF in vacuum using two flat mirrors (M4 & M5). When MROI is completed, a net of evacuated pipes will be available to feed all 28 stations and at any UT configuration in the "Y" array. A second function of the BRS is to allow tilt and shear errors between the UT and DLS axes to be minimized. The BRS is currently in the final design phase and fabrication of a prototype is underway. Testing of resolution and thermal stability of the capacitor sensor (used to measure tip/tilt position) is currently in progress. The prototype will be installed on-site and be used to test stability due to temperature changes and wind loading. A diagram of the prototype setup is shown below (top-left).





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