MAGDALENA RIDGE OBSERVATORY

NEW MEXICO TECH

Mechanical design of NESSI: New Mexico Tech Extrasolar Spectroscopic Survey Instrument

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ABSTRACT

NESSI: the **N**ew Mexico Tech **E**xtrasolar **S**pectroscopic **S**urvey **I**nstrument is a ground-based multi-object spectrograph that operates in the near-infrared. It will be installed on one of the Nasmyth ports of the Magdalena Ridge Observatory (MRO) 2.4-meter Telescope. NESSI operates stationary to the telescope fork so as not to produce differential flexure between internal opto-mechanical components during or between observations. In this paper we report on NESSI's detailed mechanical and opto-mechanical design, and the planning for mechanical construction, assembly, integration and verification.

BACKGROUND

Spectroscopy of extrasolar planets (or exoplanets) is a relatively new field in astronomy and so far has been most successfully accomplished using space-based platforms. However, there are a number of factors such as the lower cost, the ease of access, operation ability, and maintenance that makes ground-based observations more attractive. For these reasons, NESSI: the **N**ew Mexico Tech **E**xtrasolar **S**pectroscopic **S**urvey **I**nstrument was born as a collaboration between the Magdalena Ridge Observatory and the NASA Jet Propulsion Laboratory to build a ground-based multi-object spectrograph that operates in the near-infrared (J, H, and K bands). NESSI's design is characterized by its modularity, compactness, stability of alignment, and low cost.

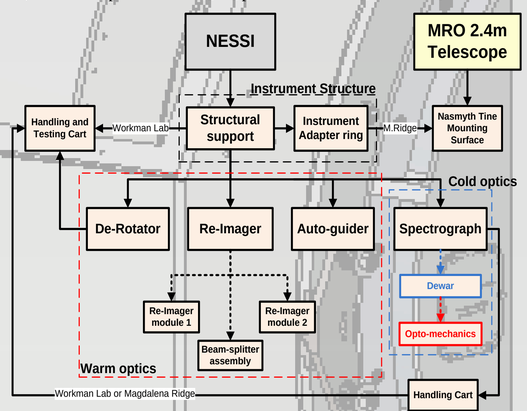
NESSI is broken down into three major mechanical sub-systems: instrument structure, warm optics, and cold optics. The warm optics consists of a field lens and field de-rotator, a re-imaging unit which includes a dichroic beamsplitter, and an

auto-guider. The cold optics portion is composed of a multi-object mask wheel, collimator assembly, filter wheel, Lyot stop, grism wheel, camera assembly, field flattener, and a detector.

The requirements that alignment of these optical components be highly repeatable and stable over short and long observation timescales have dictated the mechanical engineering requirements:

- An extremely stiff and lightweight instrument platform
- Linear and angular stability for the temperature range expected
- Stability of the mechanical subsystems

NESSI Mechanical Subsystems (right): Desiging NESSI to be modular facilitated the design process and will be key during the procurement for fabrication, pre-alignment, and performance testing in the lab, as well as installation and alignment at the telescope site.

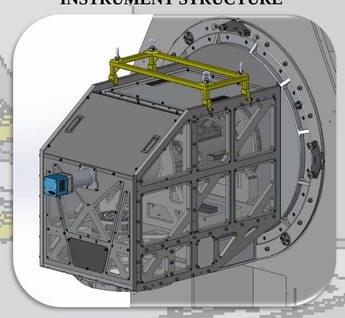


The MRO 2.4-meter Telescope (left)**:** NESSI will be installed on the Nasmyth 'tine mounting surface' port of the MRO 2.4-meter telescope sited in the Magdalena Mountains at an altitude of 3230m, about 48km west of Socorro – New Mexico. The telescope is a modified Ritchy-Chrétien alt-azimuth design, capable of tracking targets up to rates of 10 degree/second along both elevation and azimuth axes.

INSTRUMENT STRUCTURE

NESSI operates stationary to the telescope fork so as not to introduce differential flexure between internal optical elements during or between observations. This means that after NESSI is aligned it is feasible to maintain the registration between the telescope and instrument optics to the required accuracy by using a very stiff overall structure.

NESSI Instrument Structure: A substantial aluminum structure composed of an interface mounting ring and six structural plates is designed to support the NESSI opto-mechanical components and Dewar spectrograph.

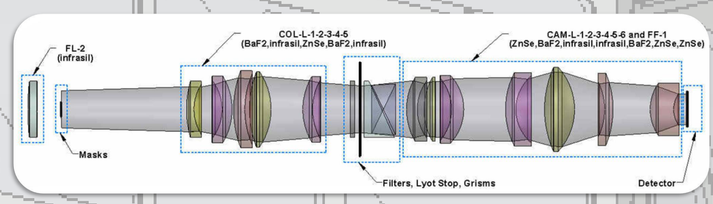


NESSI Handling and Testing Cart (right): This general purpose handling and testing cart will enable instruments to be mounted, integrated, aligned, and extensively tested in the lab, as well as facilitate assembly, handling, and servicing subassemblies at the telescope site.

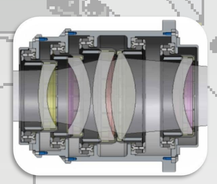
COLD-NESSI OPTO-MECHANICAL COMPONENTS

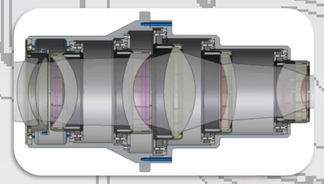
The main purpose of the NESSI spectrograph is to select a target and calibrator objects in the field, spectrally disperse light, and sense the dispersed spots on the detector.

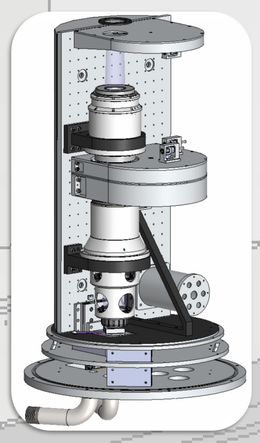
NESSI Spectrograph Optics: The major purpose of the NESSI cold optics is to select a target and calibrator object in the field, spectrally disperse light and sense the dispersed spots on the detector. Each lens is supported by a cell assembly similar to the warm opto-mechanical supports. Individual lens cells are mounted on precision machined barrels for spacing and centering. The barrels include baffling where space is available. The spectrograph optics as fabricated are shown below; the top row is the collimator optics and the bottom row is the camera optics. Also shown is the optical layout of the cold optical components, far left; a cut away view of the optics in their cells and barrels, near left.

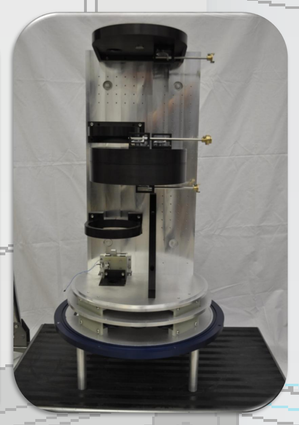


Global view of the NESSI Dewar Spectrograph (left): The optics and detector must be enclosed inside a cryogenic environment, i.e. a Dewar, with vacuum and temperature provided by LN2 at 77K. Outer dimensions are 508mm by 970mm length. The total weight is 140kg, including optics and about 11.8 liters of LN2. Driving motors for the internal wheels are placed outside for ease of maintenance. Required hold time is 36 hours.





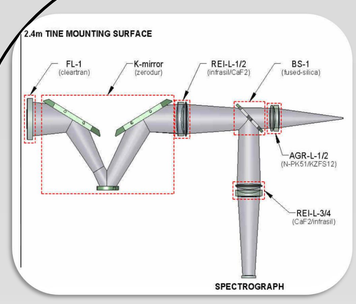




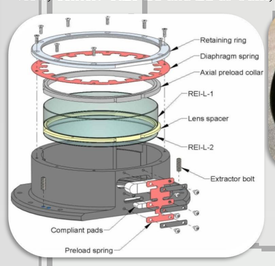
NESSI Dewar Spectrograph: The NESSI Dewar during various stages of fabrication; left, fabricated components; center, assembled vapor shield; right, assembled radiation shield. Design, construction and testing of the Dewar, multi-object mask wheel, filter wheel, Lyot stop, grism wheel, and detector mount was outsourced to Universal Cryogenics in Tucson. Design and construction of the collimator assembly, camera assembly, interface plate used to connect the spectrograph to the NESSI structural support, and handling/integrating cart is the responsibility of the MRO engineers.

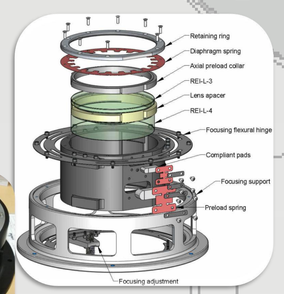
NESSI Dewar Spectrograph with Shields Removed Model (far left) **and As Fabricated** (near left): The collimator and camera barrels are assembled on angle brackets precisely mounted on the cold plate of the spectrograph.

WARM-NESSI OPTO-MECHANICAL COMPONENTS



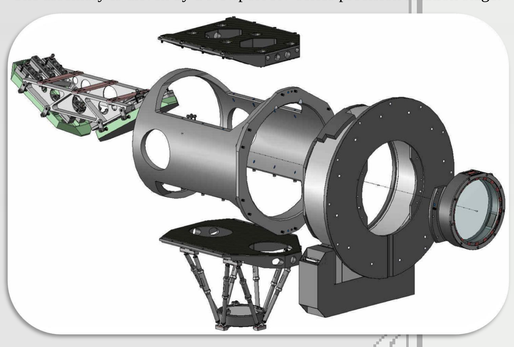
Re-imaging Optics Assemblies: Each lens mount is composed of a mounting cell, a G10 spacer, an axial preload collar, a diaphragm spring, a retaining ring, a compliant pad, and a preload spring; The assembly for RE-L3 and L4 also includes a focusing flexure hinge, with support, and adjustment (left: REI-L1 and L2 exploded view, center: REI-L1 and L2 as-built, right: REI-L3 and L4 exploded view).



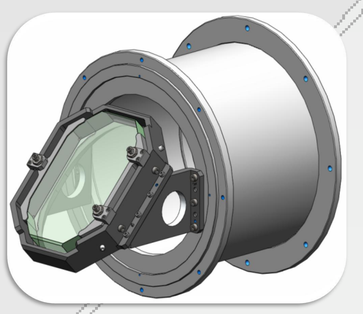


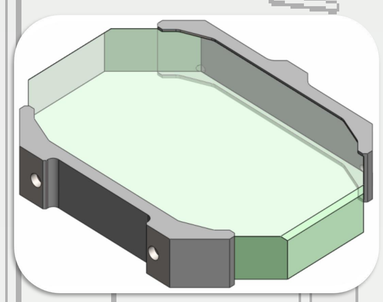
Warm-NESSI Opto-Mechanical Components: The major role of the NESSI re-imaging unit is to re-image the telescope focal plan on the multi-object mask inside the spectrograph.

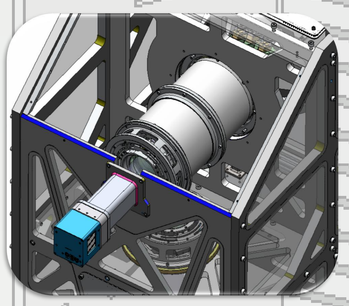
The K-Mirror is the only rotating part of the warm-NESSI opto-mechanics. It is a 3-mirror optical assembly that will follow the alt-azimuth motion of the telescope.
K-Mirror Light-weighting Detail (left): Pockets are machined on the rear surface of the Zerodur mirrors for light-weighting (top: KM-1 and KM-3; bottom: KM-2).
Field Lens and De-rotator Assembly, exploded view (right): The K-Mirror support assembly is mounted cantilever to the rotation stage and is made of aluminum tubing. The assembly is driven by a Newport RV series precision rotation stage.



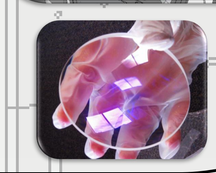
Auto-guider: An auto-guider is used for closed-loop guiding with the telescope mount. It can also be used as an acquisition camera to facilitate telescope pointing. In addition to opto-mechanical mounts for the auto-guider imaging lenses, there is a motorized focusing adjustment. Shown (left, top) is the model for the auto-guider structure and (left, bottom) the fabricated lenses.







Dichroic Beamsplitter: The infrared-visible dichroic made of fused silica separates the IR light for science and the visible light for guiding. The 2 long sides of the dichroic are glued to Invar reinforcement bars to minimize distortions.



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