Opto-Mechanics and Cryostat
Instrument Overview

- Estimated weight: 751 lbs
- Estimated Hold time at zenith: 2.2 days

<table>
<thead>
<tr>
<th>Item</th>
<th>Mass (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Bench</td>
<td>193</td>
</tr>
<tr>
<td>Image Rotator Mechanism</td>
<td>4.7</td>
</tr>
<tr>
<td>Cross Disperser Mechanism</td>
<td>19.4</td>
</tr>
<tr>
<td>Radiation Shield</td>
<td>8.2</td>
</tr>
<tr>
<td>Slit Mechanism</td>
<td>5.2</td>
</tr>
<tr>
<td>Order Sorting Mechanism</td>
<td>5.2</td>
</tr>
<tr>
<td>Immersion Grating Mechanism</td>
<td>5.2</td>
</tr>
<tr>
<td>Filter Wheel Mechanism</td>
<td>5.6</td>
</tr>
<tr>
<td>Detector, H2RG</td>
<td>6.6</td>
</tr>
<tr>
<td>Detector, Alladin</td>
<td>1.2</td>
</tr>
<tr>
<td>LN Can w/12L LN</td>
<td>40</td>
</tr>
<tr>
<td>Optics + Mounts</td>
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</tr>
<tr>
<td><strong>Total Est</strong></td>
<td><strong>751.2</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>Cryostat</td>
<td>230</td>
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<tr>
<td>Trusses</td>
<td>8.9</td>
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<tr>
<td>Cryo Cooler</td>
<td>30</td>
</tr>
<tr>
<td>He Lines</td>
<td>20</td>
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<tr>
<td>Copper Flanges</td>
<td>5</td>
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<td>Aladdin Controller</td>
<td>13.6</td>
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<tr>
<td>H2RG Controller</td>
<td>21.4</td>
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<td><strong>Telescope Interface</strong></td>
<td>108</td>
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<tr>
<td><strong>Total Est</strong></td>
<td>751.2</td>
</tr>
</tbody>
</table>
Instrument Layout – Fore Optics
Fore Optics
Instrument Layout – Spectrograph
Spectrograph Optics
Cooling Approach

- LN Dewar
  - Cools the bench
  - 12 L Capacity at zenith
  - 2.2 Days hold time

- Cryo Cooler
  - First stage cools the radiation shield
  - Second stage cools two imagers
Cryostat – *Meyer Tool & Manufacturing*

- Meyer Tool & Manufacturing – *experienced in large cryostat fabrication*
  - South Pole Telescope Cryostat
  - Pocketed Walls
  - Aluminum Welded Construction

- NEWFIRM Dewar
  - Aluminum Welded Construction
  - Powder Coated
Cryostat – *Meyer Tool & Manufacturing*

- AURA One Degree Instrument (ODI)
- Vacuum rated welds
- O-ring grooves with dovetail
- Large Capacity Milling Machines
- Vacuum testing capability
Telescope Interface

- Three point interface to the Multiple Instrument Mount (MIM Cart) to facilitate final alignment to the telescope
- Gussets provide open access to the calibration optics and cryostat window
Trusses

- Three truss configuration (Titanium)
- Truss cross section optimized for maximum strength and thermal resistance
- Approximately 5W combined thermal load conducting through the trusses
Requirement: Co-alignment of the cold stop and telescope exit pupil to within 1% of their diameters...

*This is equivalent to 2.4mm image displacement at the secondary*

- Worst case gravity vectors used (60° from zenith)
- The resulting angular deflection of the optical axis is expressed as image displacement at the secondary
- Total contribution is 0.45 mm at the most - 20% of the allowable displacement

Includes Contributions From:
- Telescope Mount
- Cryostat
- Trusses
- Optical Bench
Optical Bench

- Two sided bench
- Milled from a single billet
- Pocketed for weight reduction
Optic Mounts - *Doublets*

**Spectrograph Side**
- Immersion Grating
- Order Sorter Wheel
- OAP
- Cross Disperser
- H2RG Mount

**Fore Optics Side**
- Filter Wheel
- Aladdin Mount
- Slit Wheel
- Image Rotator
- LN Can
SpeX Lens Barrel Design

Used on SpeX with good results
Doublet Lens Barrel Concept

Proven design approach
Used on SpeX instrument

Three Axial Support Pads
- Cone geometry provides tangent-line contact with convex lenses
- Spring preloaded

Two Radial Support Pads
- Same diameter for all lenses and spacers
- Cylindrical geometry
- Spring preloaded
Doublet Lens Barrel Concept

*Lens and Spacer Stack*

**Axial Preload Spacer**
- Protects lens from rubbing contact with spring clips
- Same pad geometry as lens spacers

**Lens Spacer**
- Three pad contact on front and back
- Cone geometry on pads for tangential-line contact
- Flat geometry when contacting bevels
- Small gaps allow evacuation
Doublet Lens Barrel Concept

Radial Spring Preload

Radial Spring
- Ladder Rung Design
- 6Al4V Titanium (grade 5)
- One rung per lens/spacer

Externally Installed
- Captured in the “spring well”
- Preload generated by the spring cap
- Avoids chipping lens edges

Spring Cap
- Light Tight
- Preload bosses determine the amount of spring deflection

Flush External Surface
Doublet Lens Barrel Concept

*Interface to Optical Bench*

- Mount Pads (3x)
- Located with pins (2x)
- Pin holes are chamfered to allow for mushroom effect around the pin base
- Can be shimmed if necessary
- Same approach used in SpeX
Optic Mounts – *Slit Wheel Optics Group*

**Spectrograph Side**
- Immersion Grating
- Order Sorter Wheel
- OAP
- Cross Disperser
- H2RG Mount

**Fore Optics Side**
- Filter Wheel
- Slit Wheel
- Image Rotator
- LN Can
- Aladdin Mount
Slit Viewer Optics

- Group of optics above the slit wheel
- Need access to the Slit Wheel
- Need access to the Dekker Mechanism
- Need to be able to remove and install the optics group without requiring realignment
Slit Viewer Optics - Subplate

- Four optic mounts
  - Two mirrors
  - Two doublets
    - Individually shimmable
- The optics group can be removed as an assembly
- Realignment not required
- Spherolinder Kinematic Mounts (3x)

3/29/13
Slit Viewer Optics - *Spherolinders*

- Sphere on top, Cylinder on bottom
- 25mm sphere capable of 2 tons per spherolinder
- Hardened 440C Steel
- COTS assembly with mating cone block, V block, and preloading connector.
OAP Mirrors

- Two OAP mirrors
- Mirrors and Mount to be fabricated by the optics vendor
- Mirrors will be aligned to the mount at the vendor’s facility
OAP Mount Concept

- Mirror/Mount interface uses three pads and two pins
- Mount/Bench interface uses three pads and two pins
- Wide footprint for stability and shimming resolution
• ISHELL has three large lenses in the Spectrograph Camera Lens
  • $\Omega \sim 100\text{mm}$ each
  • $V \sim 96\text{ mm}^3$ each
  • $m \sim 250\text{ g}$ each

Previous designs used lenses no larger than 80mm
Spectrograph Camera Lens

**Barrel Mount Concept**

- 3 axial and 2 radial mount pads per lens
- External coil springs hold the lens in place.
  - One per axial pad (3x)
  - One for radial loading
  - Precise holding force (10 G’s or 2.5 kg)
  - Easier assembly
- Two piece lens barrel used for manufacturability
  - Precision locating features at the split
  - All lens reference surfaces are cut on a single lathe setup
LiF Lens – Thermal Stress Analysis

LiF Lens is the most susceptible to fracture – selected for analysis

- FEA transient thermal analysis
- FEA internal stress analysis
- NIRCam analysis used for reference

NIRCam same sized LiF element (94 mm)
LiF Lens – *Thermal Analysis*

- Symmetry used to simplify the analysis
- Contact resistance modeled at mount points (400 W/m²·K)
- Lens cell cooled at a rate of 0.5 °K/min from 298 °K down to 73 °K.
- Includes radiative and conductive effects

- Max temp gradient ~ 3.6 °K across the lens.
- Dominated by conductive heat transfer
- Total cooling time of 500 min (8.3 hrs).
  - Similar to SpeX
LiF Lens – Stress Analysis

- Stress analysis based on output from thermal analysis
- NIRCam used a criteria of “maximum resolved shear stress” < 2.0 MPa.

- Largest stresses occur at 7.5 hrs
- Calculated shear stresses are ~1.25 MPa
- Mount pads need to be sized to reduce the additional contribution from contact stress.
- Risk Reduction: Plan to use a LiF blank for verification