iSHELL status

Progress since the Sep. MOWG meeting.

• Project manager from Oceanit hired (Dan Kokubun); started work Nov. 2012.
• Tolerance analysis completed.
• Preliminary alignment plan completed.
• Optical specifications completed. Selection of vendors nearly complete.
• Cryostat concept completed.
• Preliminary Design Review set for April 1 & 2. Optics will be at Critical Design Review stage (and ordering will proceed starting in May).
SPECTROGRAPH

- Camera Lens
- H2RG Array
- XD Grating
- Spectrum Mirror
- IG Selection Mirror
- SLIT Area
- OAP1
- OAP2
- IG
- XD Grating
- H2RG Array
- Camera Lens
- Order Sorter
- Dekker
- SLIT
- OAP
Remaining optical design tasks to CDR

- Immersion grating specs ✔
- Refractive camera versus TMA/FMA ✔
- Final optical element specs ✔ and drawings ✗
- Opto-mechanical tolerancing ✗ (80%)
- Optical element mount designs ✗
- Negotiate irregularity specs with vendors ✔
- Final ghost image analysis ✔
- Integrate baffling into cryostat layout ✗ (50%)
- Final XD grating specs ✔
- Final order sorting filter specs ✔
- Final calibration system design and layout ✔
- Optical alignment plan ✗ (50%)
- Documentation ✗ (50%)
Remaining optical design tasks to CDR

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- Final optical element specs ✔ and drawings ✗
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- Optical alignment plan ✔
- Documentation ✔

3/13/13
Diamond-machined aluminum off-axis parabolas (OAPs)

Three options for OAP fabrication

1. Corning NetOptix about $200 K using LEC technique to minimize diamond turning ‘grooves’
2. Use standard diamond-turning procedure on RSP aluminum material to minimize grooves. **Risky?**
3. Use standard diamond-turning procedure on standard material and since grooves have minimal effect on scattered light (e.g. Durham Precision Optics about $30 K)
Diamond-machined Al OAPs

- Typical PSD from diamond-machined mirror from Corning standard and LEC process
- Amount of scatter is proportional to area under curve
- Scatter due to periodicity is therefore small
LM grating successfully fabricated

- Fabricated by contact lithography process at UT
- Meets spec., surface 0.061 waves RMS at 2.1 μm
- Grating will serve as backup since UT ‘can do better’
Immersion grating update

Schedule has slipped in an effort to better understand the sources of the dominant errors:

• Using new light meter to improve UV beam uniformity (contact lithography)
• Purchased own Zygo
• Plasma etch specialist now employed (Cindy Brooks)
• Plan to pattern $LM$ grating (contact lithography) and $JHK$ grating (e-beam lithography) in March 2013
Next step: cut substrate to shape
Immersion grating: stray light
Immersion grating: stray light
Summary of high-level thermal design requirements

1. Optical enclosure temperature < 78 K, stability < 1 K
2. Detector array cooling/warming rate < 0.5 K/min
3. Lens element cooling/warming rate < 0.5 K/min (rate measured for the SpeX optical mounts)
4. Spectrograph array temperature 38 K, stability < 0.1 K
5. Guider array temperature 30 K, stability < 0.1 K
6. Immersion grating temperature 80 K, stability < 0.1 K
7. If used, liquid nitrogen hold-time must be longer than about two days
8. Cooling/warming times must be no longer than three days with a goal of two days
iSHELL opto-mechanical progress

- Lens mount design is based on SpeX and NSFCAM designs (up to 80 mm diameter)
- Since some iSHELL lenses are bigger (100 mm diameter and twice the mass) we are conducting a thermal analysis to assess the risk of breaking the lenses on cooling
- iSHELL design includes one sensitive LiF$_2$ lens
- FEA modeling of transient thermal analysis
- FEA modeling of internal stress distributions
- We are confirming results with a similar analysis of the existing SpeX LiF$_2$ lens
- Models are showing that stresses are high but within limits.
  Contact resistance of the mounting points is significant
iSHELL opto-mechanical progress

- Transient cooling at 0.5 K/min down to 80 K
- Individual lenses held with 5 hard points and 4 springs
- Analysis includes conduction and radiation
- Contact resistance is modeled

- Maximum temperature gradient is 3.6 K
iSHELL opto-mechanical progress

- Coupled transient thermal analysis to stress analysis
- Thermal gradients cause internal stresses
- Effects most pronounced at the mounting points

- Maximum principle stresses are at a level of 2.5 MPa
- Maximum shear stress tolerated is at a level of 1.25 Mpa
- JWST NIRCAM criteria “resolved stress” < 2.0 Mpa for a similar LiF lens
Dekker piezo-stage testing (Bonnet)

- Refurbished an old instrument into a test dewar.
- Test plan includes cryo & vacuum test, position hold test, re-initialization test, hard-stop test and lifecycles.
- First test unsuccessful. No movement at 77K. Stage was sent back to vendor. Second test on the way. Alternative design is being considered.
iSHELL Dekker Piezo-Stage: Alternative Concept

- Flexure Stage designed using Flex-Pivots.
- Powered using a Stepper + Worm Gear + Eccentric Cam.
Cross-disperser tilt control

Choice of position sensor:
1. Hall effect sensor (F.W. Bell FH-301-040)

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
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<tbody>
<tr>
<td>- Price</td>
<td>- Unknown Accuracy</td>
</tr>
<tr>
<td>- Already implemented in SpeX</td>
<td>- Too much effort needed to quantify at the level of accuracy required.</td>
</tr>
<tr>
<td>- Passive Sensing. Can be used</td>
<td>- Range is limited. “Physical range reduction trick” (*) isn’t applicable.</td>
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<tr>
<td>simultaneously with Detector</td>
<td>- No package or mount included.</td>
</tr>
<tr>
<td>Readout.</td>
<td>- Potential irregular magnetization</td>
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2. Eddy current sensor (Kaman DIT-5200L / 20N)

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<td>- Known accuracy.</td>
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<td>- Extremely Linear.</td>
<td>- Active sensor: can perturb detector readout.</td>
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<td>- Range can be tuned using a “Physical range reduction trick”. (*)</td>
<td>- Needs 10/15 minutes to warm up and give reliable data after turning it on =&gt; RF switch needed.</td>
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<td>- Easier to implement</td>
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Cross-disperser tilt control
Mechanical Layout (Kokubun)

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

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<td>Detector, H2RG</td>
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<td>Detector, Alladin</td>
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<td>Optics + Mounts</td>
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<td><strong>Total Est</strong></td>
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3/13/13
Telescope interface

• Three point interface to the Multiple Instrument Mount (MIM cart) to facilitate initial alignment
• Gussets provide open access to the calibration optics and cryostat window
Optical Bench

- Two sided bench
- Milled from a single billet
- Pocketed for weight reduction

Spectrometer Side

- Immersion Grating
- Order Sorter Wheel
- Cross Disperser
- H2RG Mount
- OAP

Fore Optics Side

- Filter Wheel
- Slit Wheel
- Aladdin Mount
- Image Rotator
- LN Can
Trusses

- Three truss configuration (Titanium)
- Truss cross section optimized for maximum strength and thermal resistance
- Approximately 5W combined thermal load conducting through the trusses
Flexure Study

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 flexure

Includes Contributions From:
- Telescope Mount
- Cryostat
- Trusses
- Optical Bench
In order to meet this aggressive schedule, we have two mechanical engineers at the IFA and in addition we will:

• Employ a junior ME to work closely with Kokubun to generate designs for the lens barrels, mirror mounts, cryostat subassemblies, and calibration optics.

• Employ two experienced drafters, who will convert CAD models into shop drawings.

• Work closely with the IFA machine shop head to send out work to outside machine shops as necessary to maintain schedule.
Break