JCMT Receiver-A Upgrade

Ming-Tang Chen, ASIAA
Background

• Lowest frequency band to utilize telescope time in bad weather
• Wet dewar receiver, require LHe and manpower. Need renovation
• Single pixel, with relatively small bandwidth (almost 2 GHz)
• HIA receiver, 20+ year old
  – Tuning ranger 211-272 GHz (gap around 252 GHz)
  – Trx 50-150 K
  – Auto tuning Double sideband (1 IF) - no SSB
• ASIAA/SMA front-end
  – 185 – 250 GHz, work up to 270 GHz with degraded performances
  – Single pixel, DSB
  – Frontend can output 8 GHz IF, but limited by IF and backend
  – Possible upgrade to SMA 240 GHz mixer to cover 272 GHz
Objective

Within limited time frame (2 years?) and within collaborations among EAO regions

- Upgrade Rx-A with up-to-date technology
- With closed-cycle dewar
- Wider bandwidth 12 GHz
- Dual linear polarizations
- Sideband separation mixer
- More than one pixel
- More than one frequency channels
Logistics

• Where is Rx-A
• How to install Rx-A
• What does Rx-A look like
RxA is located inside the receiver cabin, which rotate with the primary dish (cryostat tipping issue)
RxA Upgrade Options

- Utilize existing space - Overhaul entire configuration; dewar, optics, LO, monitor/control, calibration.
- Utilize existing space - Replacing “blue” cryostat with a custom-made, closed-cycle 4K dewar.
- Dual linear pols receiver; circular polarization?
- Bandwidth goal: 4 – 18 GHz?
- Single- or double-sideband mixer?
- Two-pixel or dual channel frontend?
- LO injection: Existing setup with new components, or W/G injection using YIG setup.
- Keep calibration setup?
- Reuse as much existing control and monitor interface?
RxA Upgrade – Front End

• Two DSB feeds/mixers with cold wire grid: (optical LO)
  – Identical feeds for dual pol observation (2 IF)
  – Existing mixer requires optical LO injection. LO source need to be rotated (?)
  – Different feeds for dual-channel, single sideband observation.

• Single feed with OMT: (optical injection still possible)
  – 2 DSB mixers, 2 IF outputs
  – 2 SSB mixers, with one sideband output (2 IF)
  – 2 SSB mixers, with both sideband outputs (4 IF)

• Two feed each w/ OMT: (No optical LO)
  – 2 set of 2 DSB mixers, 4 IF outputs
  – Feeds pointing at different sky; two-pixel, dual-pol (4 IF)
  – Feeds operating at different f; dual-channel, dual pol (4 IF)
  – 2 set of 2 SSB mixers, 4 (8) IF outputs, each with 8 (12) GHz bandwidth.
RxA Upgrade – IF/LO Spectrometer

- Gunn Oscillator is outdated - YIG or VCO based oscillator
- LO injection scheme – optical or cold injection
- IF signal process and transmission network
- IF signal conditioning and digitization
- LO tuning, possible switching, power condition and processing
- CASPER or other technology, eg, GPU.
- 5 GS, 8-bit sampler; 10 GS, 4-bit
- CASPER ROACH2 and upcoming ROACH3
- Scalable for future array receiver?
Proposed New SMA Rx Front end

With existing and underdevelopment elements

• Smooth wall feed horn
• Planar OMT
• W/G LO coupler
• Wideband SIS
• Wideband isolator
• Low noise amplifier
• YIG based LO

Edward Tong @ CfA
## Example 1: Cost Estimate

<table>
<thead>
<tr>
<th>Category</th>
<th>Unit (US$)k</th>
<th>Q't</th>
<th>Cost (US$)k</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryostat</td>
<td>150</td>
<td>1</td>
<td>150</td>
<td>Custom-made, 4K cold head, compressor</td>
</tr>
<tr>
<td>Front-end</td>
<td>60</td>
<td>1</td>
<td>50</td>
<td><strong>Single-feed, dual-pol, 2 DSB mixers, OMT</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>YIG, power amplifier, multiplier, WG, tuner, phase lock module</td>
</tr>
<tr>
<td>LO Source</td>
<td>60</td>
<td>1</td>
<td>60</td>
<td>Interface and revision of the existing board and software</td>
</tr>
<tr>
<td>Eleco &amp; control</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>Possible down conversion, amplification, gain controller,</td>
</tr>
<tr>
<td>IF Processing</td>
<td>50</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Signal transport</td>
<td>30</td>
<td>1</td>
<td>30</td>
<td>Fiber transmission with WDM heads</td>
</tr>
<tr>
<td>ADC 10 Gs</td>
<td>6</td>
<td>6</td>
<td>36</td>
<td>4-16 GHz, three Nyquist zone samplers, dual pol</td>
</tr>
<tr>
<td>ROACH 2</td>
<td>15</td>
<td>6</td>
<td>90</td>
<td>Assume one R2 handles 4 GHz BW, (64Gb of data)</td>
</tr>
<tr>
<td>Contigen 20%</td>
<td></td>
<td>95.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>571.2</strong></td>
<td><strong>Component cost. Lab and labor not included.</strong></td>
</tr>
</tbody>
</table>
## Example 2: Cost Estimate

<table>
<thead>
<tr>
<th>Category</th>
<th>Unit (US$)k</th>
<th>Q't</th>
<th>Cost (US$)k</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryostat</td>
<td>150</td>
<td>1</td>
<td>150</td>
<td>Custom-made, 4K cold head, compressor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Single-feed, dual-pol, 2 SSB mixers, OMT, 1 IF from each mixer</strong></td>
</tr>
<tr>
<td>Front-end</td>
<td>60</td>
<td>1</td>
<td>100</td>
<td>YIG, power amplifier, multiplier, WG, tuner, phase lock module</td>
</tr>
<tr>
<td>LO Source</td>
<td>60</td>
<td>1</td>
<td>60</td>
<td>Interface and revision of the existing board and software</td>
</tr>
<tr>
<td>Elec &amp; control</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>Possible down conversion, amplification, gain controller,</td>
</tr>
<tr>
<td>IF Processing</td>
<td>50</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Signal trans</td>
<td>30</td>
<td>1</td>
<td>30</td>
<td>Fiber transmission with WDM heads</td>
</tr>
<tr>
<td>ADC 10 Gs</td>
<td>6</td>
<td>6</td>
<td>36</td>
<td>4-16 GHz, three Nyquist zone samplers, dual pol</td>
</tr>
<tr>
<td>ROACH 2</td>
<td>15</td>
<td>6</td>
<td>90</td>
<td>Assume one R2 handles 4 GHz BW, (64Gb of data)</td>
</tr>
<tr>
<td>Contigen 20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Subtotal</strong> 631.2 <strong>Component cost. Lab and labor not included.</strong></td>
</tr>
</tbody>
</table>

*Con@gen 20%*
Timeline: 24-month Scenario

- **Month 0 – 6:**
  - System design
  - Frontend development, LO injection, LO source
  - Develop spectrometer, 10Gs ADC.
- **Month 7-12:**
  - Acquiring cryostat
  - Prototyping frontend, LO, IF.
  - Build up spectrometer
- **Month 13 – 18:**
  - Receiving and testing cryostat
  - Testing frontend integration
- **Month 19- 24:**
  - System integration; test.
  - Final test and deployment