by Joseph Jensen & Scot Kleinman

GNIRS Update

The accident that befell the Gemini Near-infrared Spectrometer (GNIRS) in April 2007 has resulted in the absence of this exquisite instrument for the past year. (See page 43 in the December 2007 issue of *GeminiFocus* for more background information). Once restored, GNIRS will be recommissioned for use on Gemini-North. The decision to move the instrument from Chile to Hawai'i was partly a response to logistical considerations—primarily the arrival of new instruments at Gemini South. It was also made because of the considerable benefits to the Gemini Community of having a world-class 1- to 5-micron spectrograph on Mauna Kea, with its cold and dry conditions. These, together with the better image quality on Mauna Kea and the low emissivity of Gemini North, should make GNIRS the most powerful spectrometer of its type, especially in the 3- to 5-micron region.

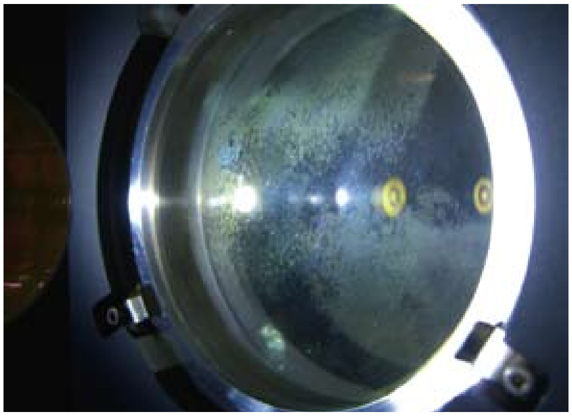
The GNIRS instrument is already in Hawai'i. Before it arrived in October 2007, considerable discussion took place and decisions were made about how the repair should proceed. The most important issues were:

- the kind of replacement detector array to be installed;
- whether repairs should be made to all observing modes; and
- were other simple but significant improvements possible.

A working group consisting of Joe Jensen, Scot Kleinman, Bernadette Rodgers, Henry Lee, Tom Geballe (from Gemini), and Jay Elias and Dick Joyce (of National Optical Astronomy Observatory (NOAO)) who had built the instrument, undertook an investigation to determine if there were good scientific reasons to replace the damaged Aladdin-3 array with the newer HAWAII-2RG 5-micron detector. The HAWAII array has pixels that are two-thirds the dimension of the Aladdin array, and there are four times as many of them (twice as many along a spectral row). The committee concluded that the need to redesign and then construct some items in the optical train (for example, the slit wheel) and the detector mount and electronics would lead to both significantly longer

Figure 1. *Top image: the contaminated entrance window from inside the dewar. The screw heads and inner baffle also show signs of the discoloring contamination seen more clearly in the bottom image of the GNIRS interior. Small areas of the contamination have been cleaned off for illustration.*

Figure 2.
One of the many lenses on GNIRS shows surface contamination and coating damage.



down time and higher expense. Although the HAWAII-2RG would produce somewhat better science than an Aladdin-3 (primarily by providing better spatial and spectral sampling and increased wavelength coverage in some scientific modes) it would not enable new science, or significantly reduce exposure times, or produce higher spectral resolution. Furthermore, the existing optics in GNIRS would not allow us to take advantage of the finer spatial sampling nor most of the possible wavelength coverage gains of the HAWAII-2RG detector without a significant redesign. Thus, the working group concluded that the Aladdin-3 was the better choice for GNIRS.

GNIRS has now been disassembled in the instrument lab in Hilo. The primary damage to GNIRS was to the G10 fiberglass supports, the optics, the Delrin™ plastic spacers, and the infrared detectors. The metal pieces, motors, and wiring are all intact and mostly undamaged.

Supports and Detectors

We are now working to fix or replace the damaged parts. The G10 fiberglass supports have already been replaced. The resin in the original supports broke down, and a yellowish deposit is now coating parts of the vacuum jacket (the coldest part of the instrument during the overheating event). The fiberglass was structurally compromised, and the replacements had to be installed before GNIRS could be shipped to Hilo for further repairs.

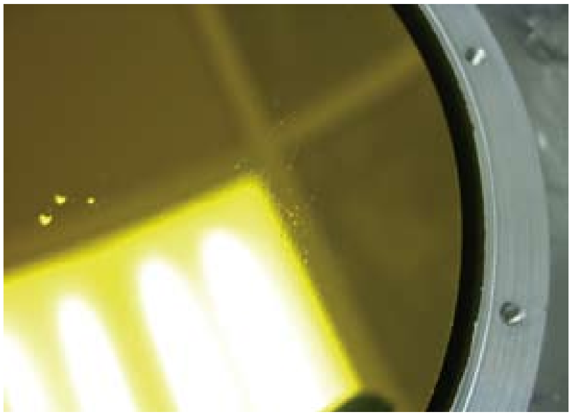
The Aladdin 3 InSb science detector was destroyed when its indium layer melted. Similarly, the HAWAII-1 array in the on-instrument wavefront sensor (OIWFS) is presumed dead. We have ordered the replacement Aladdin 3 array from Raytheon Vision Systems and expect delivery and expect delivery soon. The array will be further tested and characterized at NOAO prior to installation in GNIRS. In the meantime, a multiplexer and engineering-grade array are available for testing the repaired GNIRS before installing the new science-grade detector.

The HAWAII-1 HgCdTe detector in the OIWFS must also be replaced. The University of Hawai'i (UH) Institute for Astronomy is providing a new array and repairing the OIWFS. UH built the three wavefront sensors for NIRI, GNIRS, and NIFS. The HAWAII-1 array need not be science-grade, since only a small subset of pixels in one quadrant are used to track image motion. UH will test existing engineering-grade arrays they have on hand and choose an appropriate one to repair the GNIRS OIWFS.

Optics

Most of the optical elements have been removed and examined. A subset of the lenses and mirrors were sent to NOAO for further expert assessment. What we found was discouraging. Many of the optics, even those that

Figure 3.
Coating damage visible as pits and wrinkles on a GNIRS mirror.



were protected from direct contamination, were damaged. Some of the lenses had chips. The damage is outside the clear aperture, but the chips will have to be stoned out, and the surfaces repolished and coated. Many of the lens coatings were thermally damaged, and they appear hazy and discolored. Contamination on some lenses is especially sticky, even with fairly aggressive cleaning with solvents. It is likely that most of the lenses will require re-polishing and recoating by the original vendors.

The mirrors weren't spared either. One of the fused silica mirrors shattered, and the gold coatings on the diamond-turned collimator mirrors were damaged. The replicated epoxy diffraction gratings were destroyed, and new gratings will have to be produced. Some mirror

Figure 4. *The restored filter wheel and a sample damaged filter from GNIRS.*

samples were sent to Optical Data Associates in Tucson, Arizona, for further testing. Their report showed that the contamination on the mirrors did not have significant absorption features in the near-infrared, meaning that any optics with intact coatings may be usable.

After examining all the optics, we decided that the best approach was to send everything back to the original vendors for further testing and repair. This will take some time and money, but should get us the optics we need to repair GNIRS in a timely fashion. The flat mirrors will be replaced, and the diamond turned mirrors recut or replaced as necessary. We are also investigating some rework on the collimator to remove some original defects. This should result in better image quality, especially when used with the Altair adaptive optics system. Also, while the other optics are being repaired, we will send away the cross-dispersion prisms for repolishing. We expect that improving the prisms will result in improved spatial resolution when using GNIRS with Altair.

Like the other optics, the thermal damage to the optical coatings in the integral field unit (IFU) was significant. Because of the way it is constructed, it is probably not feasible to disassemble or repair. The IFU would most likely have to be rebuilt from scratch, and that would significantly exceed our repair budget. Although the GNIRS IFU is most likely a complete loss, we may attempt to fix it at a later time.

Although the GNIRS IFU is a complete loss, we have not lost the majority of its capabilities. Gemini has recently commissioned the Near-infrared Integral Field Spectrograph (NIFS), an IFU instrument with similar capabilities. NIFS has excellent spatial sampling and is designed to be used with the Altair Adaptive Optics system. The field of view is almost identical to the defunct GNIRS IFU, with better sampling. NIFS has spectral resolution of ~5000, similar to the resolution delivered by the GNIRS IFU. The one area where NIFS falls short in comparison to GNIRS is in the 2.5- to 5-micron regime. NIFS uses a HAWAII-2RG detector that cuts off at 2.5 microns, while GNIRS is sensitive to 5 microns. The longer-wavelength mode of the GNIRS IFU was not commonly used, however, so we expect that this loss of capability will have minimal impact on the science delivered by GNIRS.

The installed science filters were damaged beyond repair, but will be replaced with existing spares and new procurements as necessary.

After the optics are cleaned, re-polished and recoated, they will be installed and aligned. While the optics and detectors have taken most of our attention, a number of other tasks require significant effort to get GNIRS back in working order. The motors have all apparently survived, but some of the cables will need to be fixed. The solder on some connectors melted. A great deal of cleaning is needed to remove the yellow resin residue from the inside of the dewar and to take away the melted plastic from many parts. New Delrin™ lens and filter spacers are needed as well. Once all the pieces are cleaned and the optics reinstalled, we will align the optics using a warm multiplexer, test the vacuum and cooling systems, and eventually test the entire system with an engineering or science grade detector.

We expect that GNIRS will be ready for re-commissioning on the Gemini North telescope starting in semester 2009A.

The GNIRS repair effort is being lead by Gemini Senior Instrument Engineer, John White. The authors thank John for his contributions both to this article and to getting GNIRS back into service.

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