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Instrument Development Update

The development team at Gemini and its partner institutions are nearing completion on a variety of ongoing instrument projects. This report presents updates on most of the projects currently underway or in planning.

Since our last report in the June 2012 issue of *Gemini*Focus, the development team at Gemini, and our large family of partner institutions throughout the Gemini community, have worked hard on a variety of ongoing instrument projects. Many of these are nearing completion, and a few are just getting started. Here we provide a brief status report on our largest projects.

GeMS Progress

Since May 2012, the Gemini Multi-Conjugate Adaptive Optics System (GeMS) has been in engineering shutdown. As in 2011, we decided to exploit the Chilean winter (during which time conditions are less favorable for AO observations) to work on several upgrades for GeMS. We had three main objectives: 1) to optimize and improve the sensitivity of the Natural Guide Star Wave-Front Sensor (NGSWFS); 2) to add remote control and automation in the Laser and Beam Transfer Optics; and 3) prepare the instrument's software for the transition of GeMS into operations.

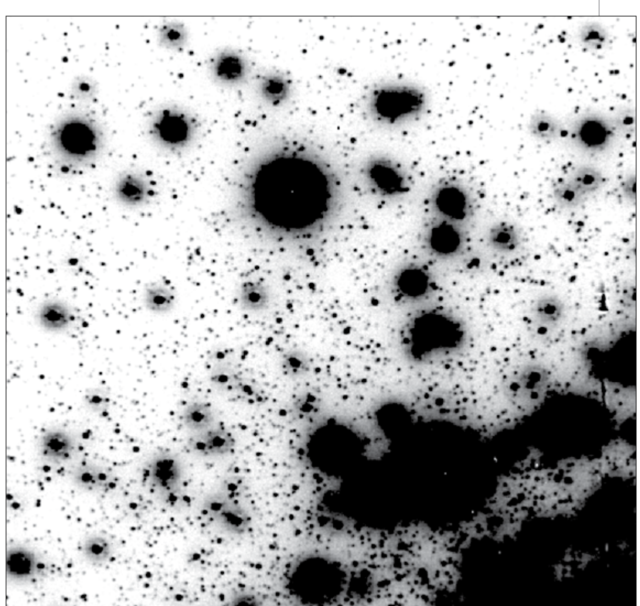

Figure 1.
Star cluster NGC 1851 acquired in H-band. The full-width at half-maximum of the stars are around 120 milliarcseconds and uniform across the 85 x 85 arcsecond field-of-view of GSAOI.

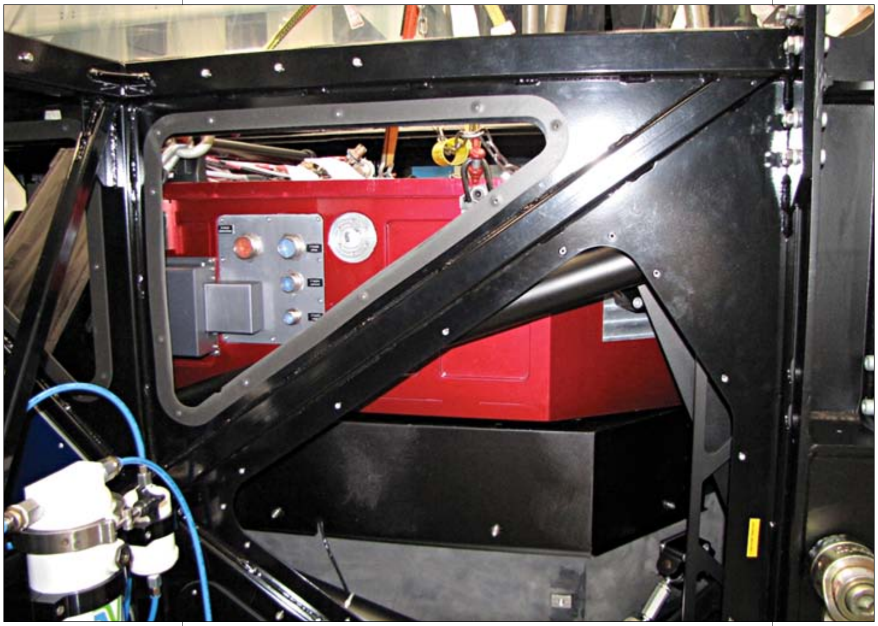

Figure 2.
GPI with the UCLA Integral Field Spectrograph installed.

Good progress has been made on these fronts, even though the NGSWFS is still lacking more optimizations to improve the current limiting magnitude. We are now considering an alternative design using a low-noise detector that would improve both performance and efficiency on-sky.

The winter shutdown has also allowed us to advertise the first GeMS results. In particular, our team has presented as many as five talks on GeMS at the 2012 SPIE (the international society for optics and photonics) conference in Amsterdam. The first on-sky GeMS results were definitely one of the main highlights of the meeting.

At the end of August 2012, we made a call for System Verification (SV), offering around 60 hours of GeMS + GSAOI (the Gemini South Adaptive Optics Imager, a Near-Infrared camera working with GeMS) to our users. We received about three times as many proposals as we required; the final selection can be seen at: *http://www.gemini.edu/sciops/instruments/gsaoi/system-verification?q=node/11895.* We also offered GeMS/GSAOI for 2013A in a shared-risk mode for a total of around 100 hours. We received a very good response from the community to that as well, with, once again, an over-subscription ratio of three.

By October 19th, GeMS went back on-sky with a three-night run to work out all the Laser and Laser Guide Star Facility systems. A second commissioning run took place at the beginning of November, aiming at optimizing and stabilizing performance, as well as smoothing operations. Unfortunately, a combination of low laser power, low sodium content, and bad weather/seeing prevented us from accomplishing all the tasks planned. Low sodium return is currently one of the main performance limitations of GeMS. However, with a little more work, we should improve the laser's power and performance in the current and upcoming semesters.

To illustrate how GeMS performed in the November run, the image in Figure 1 shows a portion of the star cluster NGC 1851 acquired in H-band. The full-width at half-maximum of the stars are around 120 milliarcseconds and uniform across the 85 x 85 arcsecond field-of-view of GSAOI. Although not at the level of the diffraction limit, the image still offers a significant improvement compared to uncorrected images. A third commissioning was run in December, and SV will start in January. This New Year's Eve will be a laser night, wishing the best for GeMS in 2013.

Gemini Planet Imager Nears Acceptance Testing

The Gemini Planet Imager (GPI) continues its march toward becoming the next-generation extrasolar planet imager and spectrograph at the Gemini Observatory (Figure 2). The GPI team is now preparing for the instrument's Acceptance Test Stage (planned in the first quarter of 2013), where the completed instrument will be subjected to several tests to verify its performance and usability. If all goes well, acceptance testing

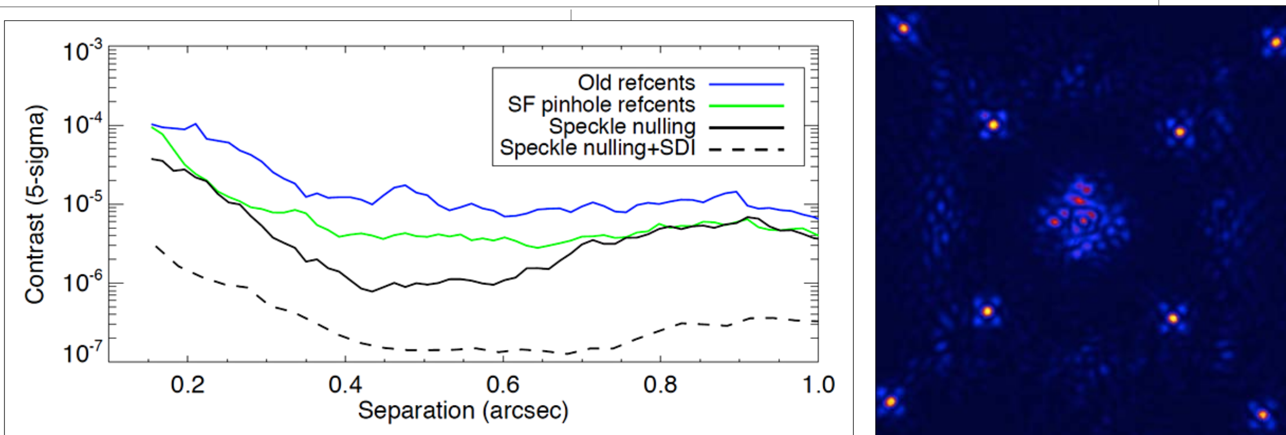

Figure 3.
Left: Contrast vs. radius in closed-loop GPI testing, with no external aberrations. The light source represents a bright (H~3 magnitude) star. Top blue curve shows contrast with WFS reference centroids generated using an optical fiber during final alignment. The green curve shows contrast with WFS reference centroids generated immediately before the experiment using the spatial filter pinhole mode. The solid grey curve shows the contrast after speckle nulling. The dashed curve shows the same data set with a simple multi-wavelength spectral differencing algorithm applied to the IFS channels.
Right: IFS image, 2.8 arcseconds on a side. The two sets of four reference spots generated by the apodizer grid can be seen in the diagonals.

is scheduled to reach completion in April, 2013. Next, the instrument will be shipped to Gemini South for on-site acceptance testing in May-June, 2013. Verification and commissioning is scheduled to start in August 2013, with the science campaign beginning in late 2013B.

The GPI's Integral Field Spectrograph has now been successfully integrated with the rest of the instruments, and the resulting remediation task list has been completed. We are also starting to see very good contrast ratios in the lab, as shown in Figure 3.

In late May, 2012, the primary deformable mirror (DM) in GPI developed a sticky actuator which limited its motion. Luckily, the new bad actuator is quite near a spider vane in the Lyot masks, so we have now made and installed new masks with a new extension off one vane to block the offending actuator. Simulations show we will still be able to achieve the desired science specifications even with this bad actuator.

High-resolution Optical Spectroscopy at Gemini: GHOS and Graces

GHOS

As of this writing, we are starting the contract approval process for the post-Conceptual Design Stage for GHOS, the future Gemini High-resolution Optical Spectrograph. This contract will see us through the Preliminary and Critical Design stages as well as the Build and Integration and Testing work. Once approved by both key institutions (Gemini and the build team), the contract needs to go to the Association of Universities for Research in Astronomy Board for approval, then on to the National Science Foundation and the team's funding agencies for the final sign-off. It is difficult to predict how long this approval process will take, but we certainly expect to be able to have more concrete details about GHOS and the design/build team to share with you in the next issue of *Gemini*Focus, with a public announcement well before that.

GRACES

Since the previous *Gemini*Focus article, several fibers of different lengths and types have been tested at HIA for throughput and focal ratio degradation. Unfortunately, the results were not consistent and we were unable to make any conclusive statements about the suitability of the fibers we are exploring for the inter-telescope connection between Gemini North and the Canada-France Hawaii Telescope. As a result, the fiber has been outsourced to a vendor who will completely prepare the fiber ends and properly protect and sheathe the cable before delivery. The result should be the final fiber optic cable we can install and use with GRACES. The vendor is expected to deliver the fiber by the end of the 2012, so we should have additional information soon. Given this switch to procuring the full fiber cable commercially, the project has been delayed by a few months, but we should still see on-telescope testing beginning in early 2013 at Gemini North.

Gemini Multi-Object Spectrograph CCD Upgrade:

In the June 2012 issue of *Gemini*Focus, we highlighted our plan to install the new Hamamatsu CCDs into the Gemini Multi-Object Spectrograph (GMOS) at Gemini North in January 2013, and subsequent installation into GMOS at Gemini South in semester 2013B. Given the successful installation of the deep depletion e2v CCDs into GMOS-N in 2011, scientific priorities expressed by Gemini's Science and Technology Advisory Committee and other community members, and resource conflicts with other projects at Gemini, we have instead decided to install the CCDs into GMOS-S first.

Given the current activity at Gemini South with FLAMINGOS-2, GeMS, and GSAOI, as well as the expected delivery of GPI in the southern autumn, the earliest window for installation into GMOS-S is now around June 2013. Installing within this window, however, necessitates there being other instruments capable of filling the queue with GMOS off the telescope. GeMS, GSAOI, FLAMINGOS-2, and GPI should all be available, but if two or more of these projects suffer additional delays, we may have to delay the GMOS-S CCD installation until these other instruments become available. Our baseline plan, though, is to install the CCDs in GMOS-S in the southern winter, then into GMOS-N in early 2014.

Meanwhile, we believe the hardware signal filtering mentioned in our last *Gemini*Focus article, and implemented by Gemini's Detector Engineer, Kevin Hanna, has satisfactorily reduced the read noise. We have also replaced one previously damaged science CCD. The new CCD comes with an enhanced coating from Hamamatsu which maintains the red sensitivity of the other two CCDs and adds blue sensitivity quite similar to the current GMOS-S CCDs. This new CCD, therefore, will be placed in the blue-most spectral position in the array to make maximum use of its enhanced sensitivity in that part of the spectrum. Figure 4 shows the setup used at the Hilo Base Facility to precisely align the three new CCD chips.

Kevin has also developed an internal electrostatic discharge (ESD) protection circuit that will fit inside the GMOS dewar and seat between the CCDs and the outside world. ESD consultants have reviewed and approved this circuit that will help make the new CCDs safe for what we hope is a long life inside the GMOS instruments. Unlike the e2v CCDs currently in GMOS, these new Hamamatsu detectors do not have built-in ESD protection, and thus, these very sensitive devices are quite vulnerable to damage. Once installed, this circuit should provide the missing required protection.

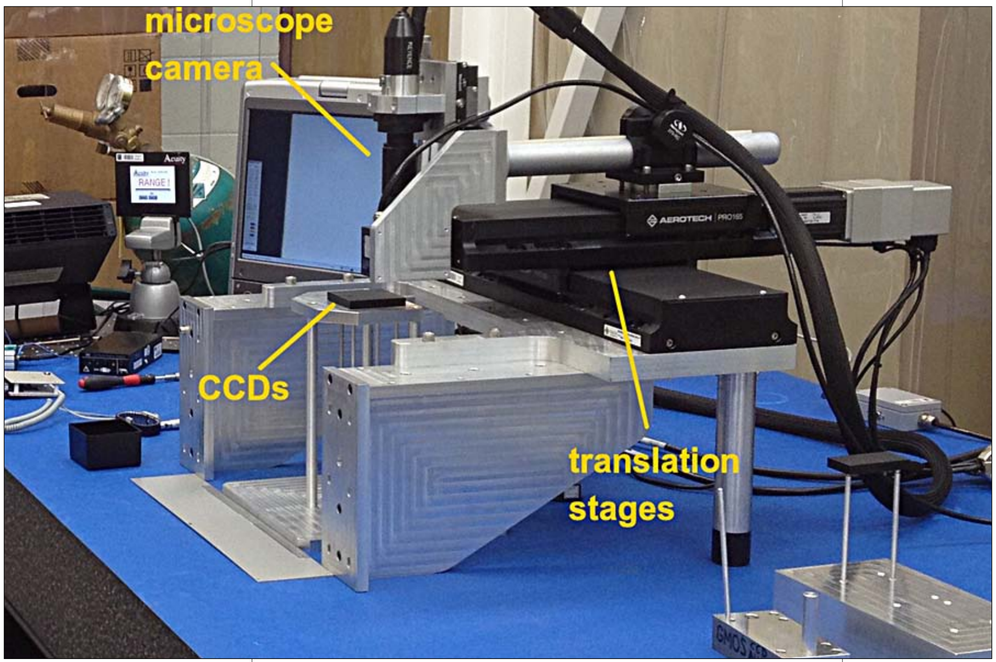

Figure 4. *GMOS-CCD metrology setup at the Hilo Base Facility lab. This is used to precisely align the three new detector chips.*

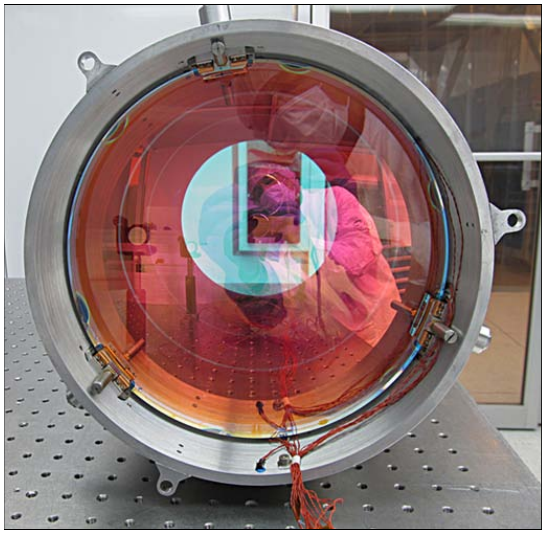

Figure 5.
New collimator (L1) lens for FLAMINGOS - 2 mounted in redesigned cell. The cell and glass are equipped with temperature sensors to monitor thermal cycles.

FLAMINGOS-2:

A very active and dedicated team, lead by Patricio Gonzalez, Percy Gomez, and Gabriel Perez are working hard to resolve problems with FLAMINGOS-2 and getting it ready for scientific use in early 2013. The broken lens mentioned in the last issue of *Gemini*Focus has been replaced and the lens mount redesigned to eliminate the mechanical stresses that the original mounts produced in the lenses (Figure 5).

There is still some concern over the thermal stresses since the lens that broke is in the Multi-Object Spectrograph dewar, which experiences regular thermal cycling in order to change masks. While we have made some thermal improvements, a more complete solution would require significantly more time to implement. Given the community demand for this instrument, we have decided to concentrate on getting the instrument on-sky as soon as possible. Once the instrument is back on the telescope, we will mitigate the thermal risk by reducing the number, and increasing the lengths, of the thermal cycles.

We currently estimate restarting FLAMINGOS-2 commissioning in May 2013. If we cannot get the multi-object spectroscopic mode (and its associated thermal cycling lens work) performing in time, we leave open the option to begin only with imaging and long-slit modes. We feel it is important to get FLAMINGOS-2 on the telescope and collecting some real data while we obtain additional experience with the instrument and plan the next stage of improvements.

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