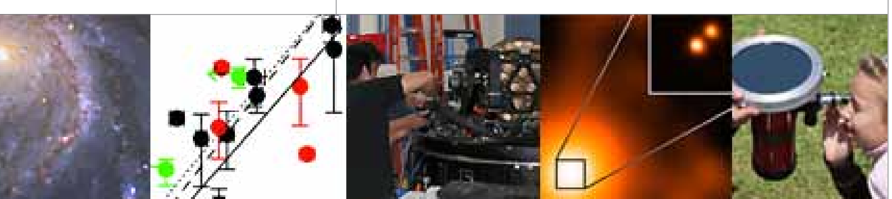
# *Gemini*Focus

Publication of the Gemini Observatory / April 2013

*Gemini*Focus April 2013





*On the Cover: See page 24*


*Gemini*Focus *April 2013*

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Markus Kissler-Patig

# Director's Message

## *Transforming Gemini — Changes Ahead*

As we enter the year 2013, major changes take effect within Gemini. For one, as of December 31, 2012, the United Kingdom is no longer a partner of the Gemini Observatory. Although we knew this a few years in advance, the UK, a founding partner of Gemini, leaves behind a gap that is hard to fill. On behalf of Gemini, I would like to express our gratitude to the UK community for their important contributions to this great Observatory.

As an immediate consequence of the UK's withdrawal, Gemini sees its budget cut by about 20 percent. The Observatory will need to adjust to this constraint over the next three years, during which time it will use accumulated carry-forward funds to smooth the transition. A vigorous plan is in place to adapt the operations costs, but, needless to say, some of the services that users are accustomed to will be reconsidered.

These losses will be compensated by new initiatives, both in instrumentation and operations. As described in the last issue of the *Gemini*Focus, new facility instruments are underway, and we will be welcoming more visiting instruments in the future. In 2013, I am happy to welcome back both the Differential Speckle Survey Instrument, responsible for the sharpest images ever obtained by Gemini at visible wavelengths, and the Texas Echelon Cross Echelle Spectrograph, which will offer powerful mid-infrared capabilities to our user community.

## *The Operations Front*

On the operations front, a yearly call for large programs is being set up in addition to the regular semesterly call for proposals. Studies are also underway to establish a process for the fast turnaround of proposals. In the future, Gemini users will have multiple avenues to apply for observing time optimally suited for all types of science projects.

I am particularly pleased, that the time exchange program with the Subaru telescope is now based on a firm agreement. The minimum time exchanged between Gemini and Subaru in 2013B was increased again resulting in at least five nights on Subaru available to the Gemini community.

As we carefully prepare for remote observing from the Base Facilities (and later from other points as well), eavesdropping has become almost routine. Remote observing and eavesdropping will enhance classical and queue observing, respectively. A fair number of users have already been contacted during their queue observations and experienced the advantages of eavesdropping by supporting our night crew.

Also noteworthy is that in 2012 Gemini's on-sky science time (averaged over both semesters at both telescopes) averaged 87.25 percent, exceeding the Board-set goal of 86 percent.

## *Instrument Development*

Gemini South is slowly rolling out its (long-awaited) powerful new instrumentation. The Gemini Multi-conjugate Adpative Optics System completed 12 out of the 13 proposed System Verification programs with some spectacular results (see the January Press Release and the cover page of this issue). Gemini is now turning GeMS into a science machine and is proud to offer this world-class unique capability to its users for regular science programs in 2013.

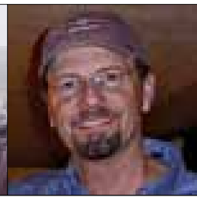
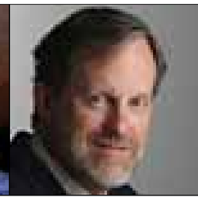
At the same time, FLAMINGOS-2, the near-infrared spectrograph, has largely recovered from its catastrophic failure in early 2012 and is being offered in imaging and long-slit mode in 2013B, with the multi-object mode soon to follow.

Finally, the Gemini Planet Imager (GPI) has successfully started a series of acceptance tests at the University of California Santa Cruz. First results demonstrate that GPI will indeed be a world-leading facility instrument! We expect to ship it to Gemini South in June and see first light in the 3rd quarter of this year.

Last but not least, Gemini continues not only to explore the universe, but also to share its wonders. Gemini led two fantastic outreach programs in the last months: the Astro-Day Chile and week-long Journey through the Universe in Hawai'i.

Read about all this and more in this issue. While we can expect challenging years ahead, they will also provide us with a chance to shape Gemini into a nimble and even more powerful observatory.

*Markus Kissler-Patig is Gemini's Director. He can be reached at: mkissler@gemini.edu*

Eric Hsiao, Howie Marion, and Mark Phillips

# The Earliest Near-infrared Spectroscopy of a Type Ia Supernova

*Gemini Near-infrared Spectrograph (GNIRS) observations have lead to surprising results on the nature of Type Ia supernovae (SNe Ia). Time-series, near-infrared spectra of SN 2011fe reveal that more SNe Ia harbor unprocessed carbon than previously believed, and what we thought was the main driver of the luminosity-decline rate relation may not be correct.*


**Figure 1.**
*Color image of SN 2011fe in M101. (Credit: B. J. Fulton/ LCOGT/PTF)*

Type Ia supernovae (SNe Ia) provide the most direct measure of the expansion history of the universe and have led to the discovery of the accelerated expansion, which was awarded the 2011 Nobel Prize in Physics. The unknown cause of the accelerated expansion is commonly referred to as "dark energy."

SNe Ia are not perfectly homogenous, showing significant variation in the shapes and peak brightnesses of their light curves. Rather, their utility as cosmological distance indicators at optical wavelengths rests on the discovery of an empirical correlation between the SNe Ia's peak absolute magnitude and the rate at which the brightness declines (luminosity-decline rate relation; Phillips 1993). Most astronomers agree that these explosions result from the total thermonuclear disruption of a carbon-oxygen white dwarf in a close binary system; however, the details of the explosion mechanism and the mass-donating companion star are still unclear.

## A Near-infrared Shift

Although SNe Ia remain the most proven technique for studying dark energy, we do not understand the nature of these explosions, and that ultimately limits their accuracy. Fortunately, shifting the observations to the near-infrared offers a way forward. In the near-infrared, SN Ia luminosities are less affected by dust and show much smaller intrinsic scatter than in the optical. A recent study, also using Gemini data, demonstrated an amazing distance accuracy of 6 percent using SN Ia peak luminosity in the near-infrared (Barone-Nugent *et al.,* 2012).

A key ingredient to realizing the full potential of near-infrared SN Ia cosmology is near-infrared spectroscopy, which allows us to convert the peak luminosities to the rest frame. With the limited size of the world's current sample, the time evolution and the diversity of the near-infrared spectral features are poorly understood. These uncertainties directly affect the determination of the peak luminosity.

To improve our knowledge of this relatively unexplored wavelength region, the Carnegie Supernova Project and the CfA Supernova Group have embarked on a joint program to obtain a statistically significant sample of near-infrared spectroscopic observations.

On August 24, 2011, SN 2011fe was detected within hours of its explosion in M101 (Figure 1; Nugent *et al.,* 2011). Its proximity and early detection provided a unique opportunity to make exquisitely detailed observations of a supernova. SN 2011fe appears to have been a typical SN Ia in all respects and serves as an ideal baseline to compare to other objects.

Ten near-infrared spectra of SN 2011fe were obtained in the span of a month, including one SpeX spectrum and nine GNIRS spectra. We present two of the more intriguing findings from our recently published paper on these near-infrared spectra (Hsiao *et al.*, 2013).

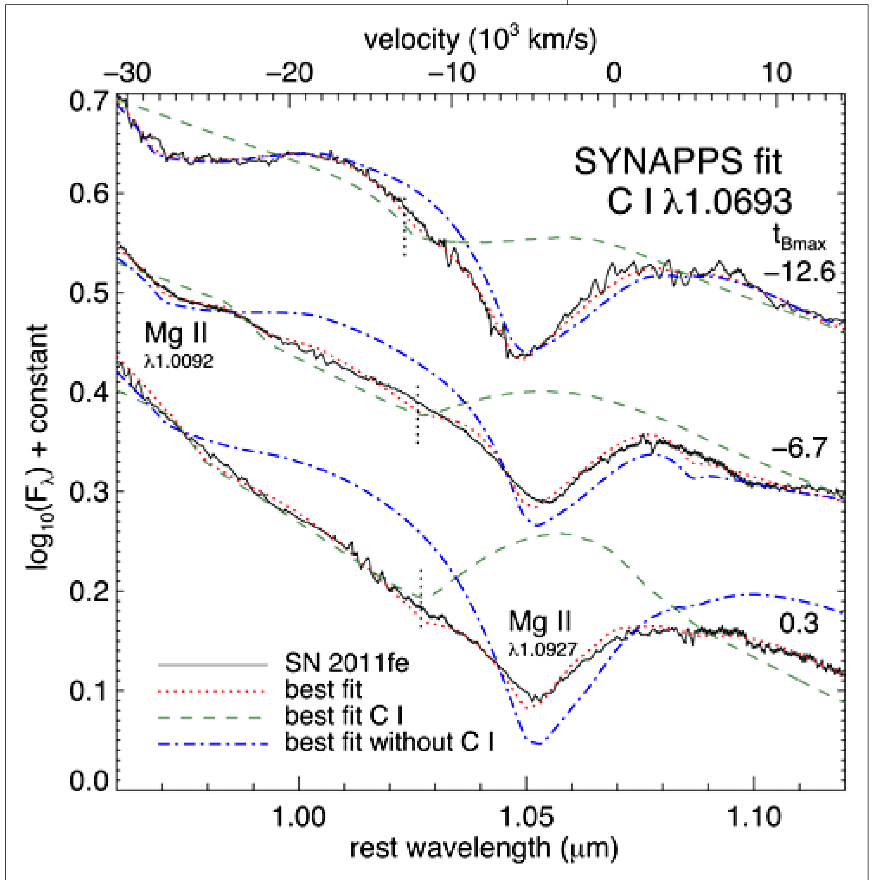



**Figure 2.**
*SYNAPPS (Thomas* et al. *2011) model spectrum fit to the GNIRS spectra of SN 2011fe around the near-infrared carbon line. The observed spectra are plotted as solid black curves. The best-fit model spectra are plotted as follows: with all ions, with carbon only, and with all ions except carbon. These are plotted as red dotted, green dashed, and blue dash-dotted curves, respectively. The vertical dotted lines mark the locations of the best-fit carbon velocity. The phases relative to maximum light are noted.*

## Primordial Carbon in Type Ia Supernovae

During a SN Ia explosion, the thermonuclear burning front rips through the carbon-oxygen white dwarf, converting carbon and oxygen into heavier elements. Since oxygen is also converted from carbon in this process, carbon provides the most direct probe of the primordial material from the progenitor carbon-oxygen white dwarf. Because conditions in the explosion models, such as the speed of the burning front, sensitively control the amount of carbon that remains, the detection of carbon in observed spectra serves as one of the most important discriminators between explosion models.

The first convincing detection of carbon in a SN Ia was presented not long ago by Thomas *et al.,* (2007). Since then, several studies using large and independent sets of optical spectra have reached the same conclusion that

20-30 percent of SNe Ia harbor unprocessed carbon. Meanwhile, there had been no detection of carbon in the near-infrared spectra of a normal SN Ia. The issue appeared settled. It was up to the theorists to find the right combination white dwarf binary systems and explosion mechanism to reproduce the observed rate of carbon detection.

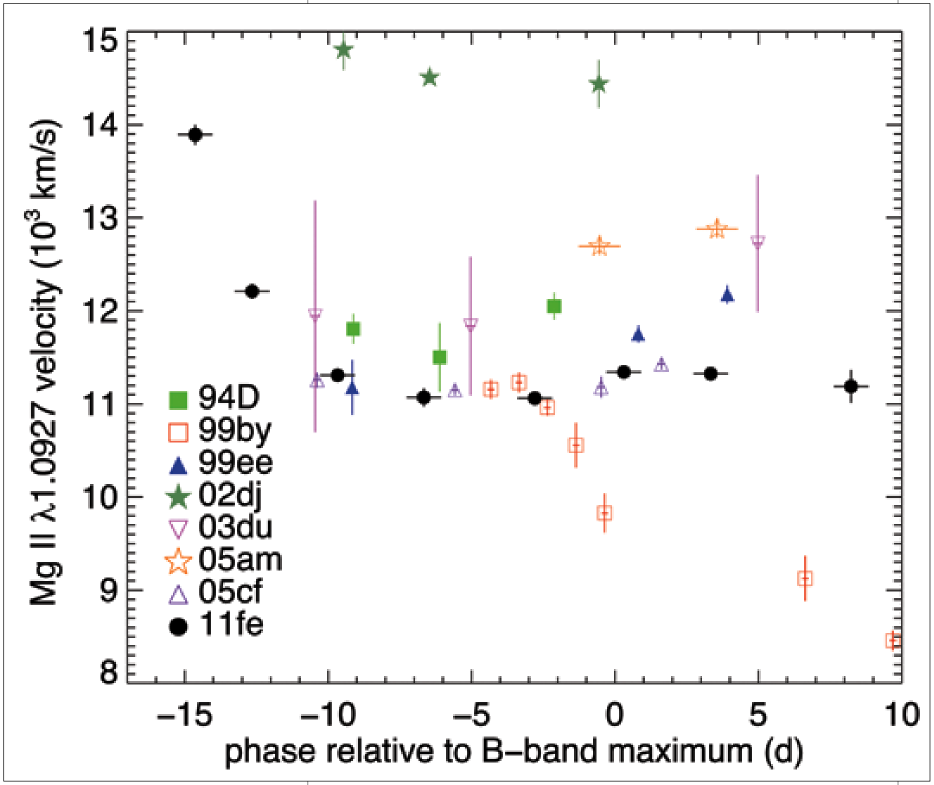
The situation changed, however, in 2011. Using the high quality GNIRS spectra and a more sophisticated spectrum modeling technique, we were able to detect carbon in SN 2011fe, a first in the near-infrared wavelengths for a normal SN Ia. In Figure 2, we show the comparison between observed and model spectra. The near-infrared carbon line we studied is relatively isolated and ideally located between two magnesium lines. Our model spectra show that the presence of carbon is required to produce the observed "flattened" profile near 1.03 microns.

Furthermore, the time-series GNIRS observations indicate that the influence of carbon increases with time (Figure 2). The carbon line in the optical, on the other hand, usually disappears very early, requiring that the supernova be discovered at a very young age. We propose that the delay in the onset of the near-infrared carbon feature can be explained simply by the change in the ionization condition.

As the supernova ejecta expands, the temperature decreases. The optical carbon line in its first ionized state then gradually recombines into neutral carbon which forms the ever stronger neutral carbon feature in the near-infrared. Due to this fortuitous delay in its appearance, the near-infrared neutral carbon feature is potentially a superior probe of unprocessed material to the more commonly used optical feature.

The "flattened" profile caused by the presence of carbon in SN 2011fe appears to be common in normal SNe Ia. This suggests that many SNe Ia harbor unprocessed carbon. Again, the low rate of detection in the optical may be caused by the difficulty of obtaining spectra within a few days of the explosion. Since the conclusion of ubiquitous unprocessed carbon would have profound implications for our understanding of SN Ia explosions, we are currently conducting a careful survey of the near-infrared carbon feature in our growing sample of near-infrared spectra.

**Figure 3.**
*Time evolution of SN Ia near-infrared magnesium velocity. The magnesium velocity of the GNIRS SN 2011fe spectra underwent a rapid decline and an extended period of constant velocity. Note that SN 1999by is a spectroscopically peculiar SN Ia, much like SN 1991bg. The magnesium velocity of normal SNe Ia all show similar constant behavior as that of SN 2011fe.*




## *The Main Driver of the Luminosity-Decline Rate Relation*

A landmark paper by Wheeler *et al.* (1998) identified the strong and relatively isolated absorption feature near 1.05 microns as magnesium. They predicted that the velocity of this feature would decrease rapidly and then settle to a constant velocity. The prediction is finally confirmed 15 years later, as our SpeX and GNIRS spectra caught the rapid decline for the first time and unambiguously showed the subsequent constant velocity (Figure 3).

Magnesium is a product of thermonuclear carbon burning and not oxygen burning. At the phase of constant velocity, the magnesium line therefore locates the boundary between carbon and oxygen burning. This boundary is thought to be where the transition from a subsonic to a supersonic burning front occurs, and its location is sensitively controlled by the density under which the transition occurs. If the transition density is the origin of the observed spread in the peak luminosities, it might also drive the luminosity-decline rate relation (Hoeflich *et al.* 1995).

The time-series GNIRS spectra of SN 2011fe shows an extended period of constant velocity for the magnesium feature, beginning at 10 days before maximum light and lasting until the feature disappears at 10 days past maximum light. Therefore, a single spectrum obtained at any phase within this range is sufficient to determine the transition density of a SN Ia. Armed with this insight, we surveyed the near-infrared spectra in the literature and measured their near-infrared magnesium velocity in a consistent manner (Figure 3).

Surprisingly, when we plot up the magnesium velocities, as a proxy for the transition densities, against the decline rate of the supernova light curves, there is no correlation. The transition density does not seem to have a strong influence on the peak luminosities. We need to go back to the drawing board and rethink the origin of the observed variation in the peak luminosities. It is likely that the transition density affects the luminosity on a secondary level, which offers the possibility of improving further the standardization of SN Ia luminosities. We are currently investigating the cosmological utility of these velocity measurements.

**References:**


Barone-Nugent, R. L., *et al.*, "Near-infrared observations of Type Ia supernovae: the best known standard candle for cosmology," *Monthly Notices of the Royal Astronomical Society*, Vol. **425:** pp.1007–1012, 2012.

Hoeflich, P., *et al.*, "Delayed detonation models for normal and subluminous Type Ia supernovae: absolute brightness, light curves, and molecule formation," *The Astrophysical Journal,* Vol. **444:** pp. 831–847, 1995.

Hsiao, E. Y., *et al.*, "The earliest near-infrared time-series spectroscopy of a Type Ia supernova." Accepted for publication in *The Astrophysical Journal,* **arXiv:**1301.6287, 2013

Nugent, P. E., *et al.*, "Supernova SN 2011fe from an exploding carbon-oxygen white dwarf star," *Nature*, Vol. **480:**, pp. 344–347, 2011.

Phillips, M. M., "The absolute magnitudes of Type Ia supernovae," *The Astrophysical Journal*, Vol. **413:** pp. L105–L108, 1993.

Thomas, R. C., *et al.*, "Nearby Supernova Factory observations of SN 2006D: on sporadic carbon signatures in early Type Ia supernova spectra," *The Astrophysical Journal*, Vol. **654:** pp. L53–L56, 2007.

Thomas, R. C., *et al.*, "SYNAPPS: data-driven analysis for supernova spectroscopy," *Publications of the Astronomical Society of the Pacific*, Vol. **123:** pp. 237–248, 2011.

Wheeler, J. C., *et al.*, "Explosion diagnostics of Type Ia supernovae from early infrared spectra," *The Astrophysical Journal*, Vol. **496:** pp. 908–914, 1998.



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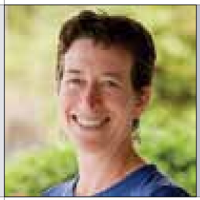


Nancy A. Levenson

# Science Highlights

*Recent results from Gemini cover a wide gamut of subjects — from the spectroscopic confirmation of a very nearby brown dwarf pair to the use of a single near-infrared spectrum to determine a black hole's mass within an active galactic nucleus.*

## *Closest Solar Neighbor Discovered in Past Century*

Large proper motion suggested that an object recently detected with NASA's Wide-field Infrared Survey Explorer satellite (WISE), WISE J104915.57-531906, is nearby, with parallax measurements confirming a distance of only 6.5 light-years (2 parsecs). This makes the new object the closest found in a century, and the third closest overall.

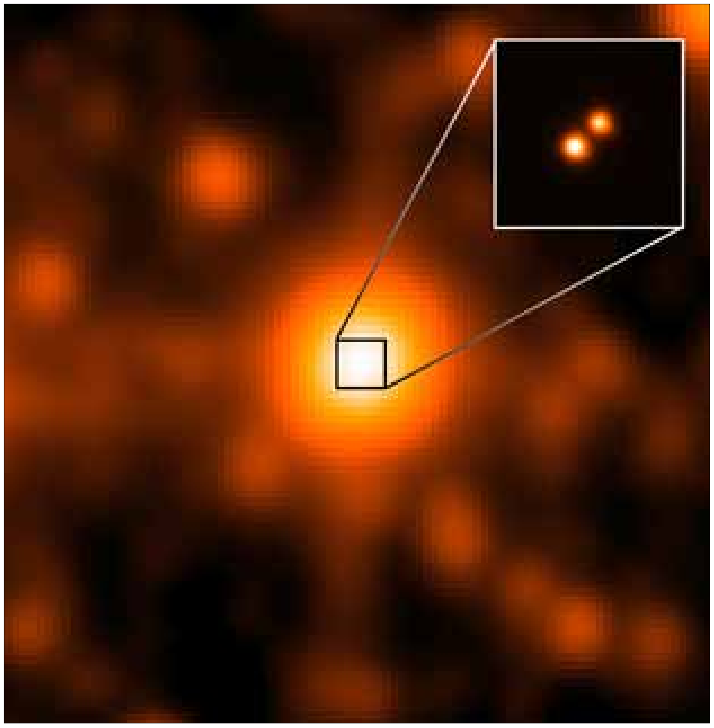


**Figure 1.**
*WISE J104915.57-531906 lies at the center of the larger image. It appears as a single object in this image from WISE. Higher resolution observations using GMOS-South revealed its binary nature (inset) and enabled classification of the brown dwarf pair.*

The combination of WISE and other near-infrared surveys has provided multi-epoch data for such proper-motion searches, enabling detection of nearby cool (and optically faint) objects. WISE alone, having exceeded its original planned lifetime, provides the multiple observations required.

Kevin Luhman (Penn State University) discovered the large proper motion of WISE J104915.57-531906 in the WISE data. He then recovered the object in other earlier surveys to obtain a more accurate distance measurement.

The outstanding question remained: "What is this object?" Director's Discretionary Time enabled spectroscopy with the Gemini Multi-Object Spectrograph (GMOS) on Gemini South to provide an answer, and more. Luhman classified the object as an L8 dwarf, showing good agreement with a template spectrum. For ages less than 10 billion years, the temperature is well below that of the hydrogen burning limit. Also, considering the strong lithium absorption, Luhman concludes that the object is a brown dwarf.

As an unexpected bonus, the acquisition image resolved the source into two components (Figure1). The pair, separated by 1.5 arcseconds, corresponds to 3 astronomical units at the object's determined distance. Examination of earlier, archival images does not show either source at their present location, arguing that they form a common binary system.

The secondary is only about half a magnitude fainter than the primary, which suggests that it is also a brown dwarf and near the L/T spectral class transition. Brown dwarf models are sensitive to age, so a binary system offers robust tests of models and potentially strong constraints on mass, assuming the objects formed at the same time.

The GMOS observations were obtained on February 23, 2013, and the full paper will appear in *The Astrophysical Journal Letters*. A preprint is available at:
http://arxiv.org/abs/1303.2401,
as is more information from
http://www.gemini.edu/node/11966.

## Light Echoes Show the Asymmetric Explosion of SN1987A

Observations of light echoes — reflections of a transient event in the surrounding material — allow astronomers to change perspective. Rather than being effectively fixed

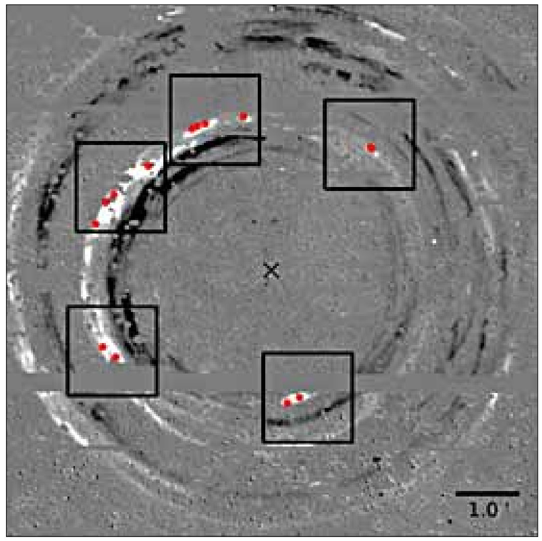


**Figure 2.**
*Difference image shows SN1987A light echoes as positive and negative (bright and dark) circular rings. They appear uniformly circular because the echo is reflected off sheet-like dust structures. Black boxes mark the GMOS fields, and red points show the spectral locations.*

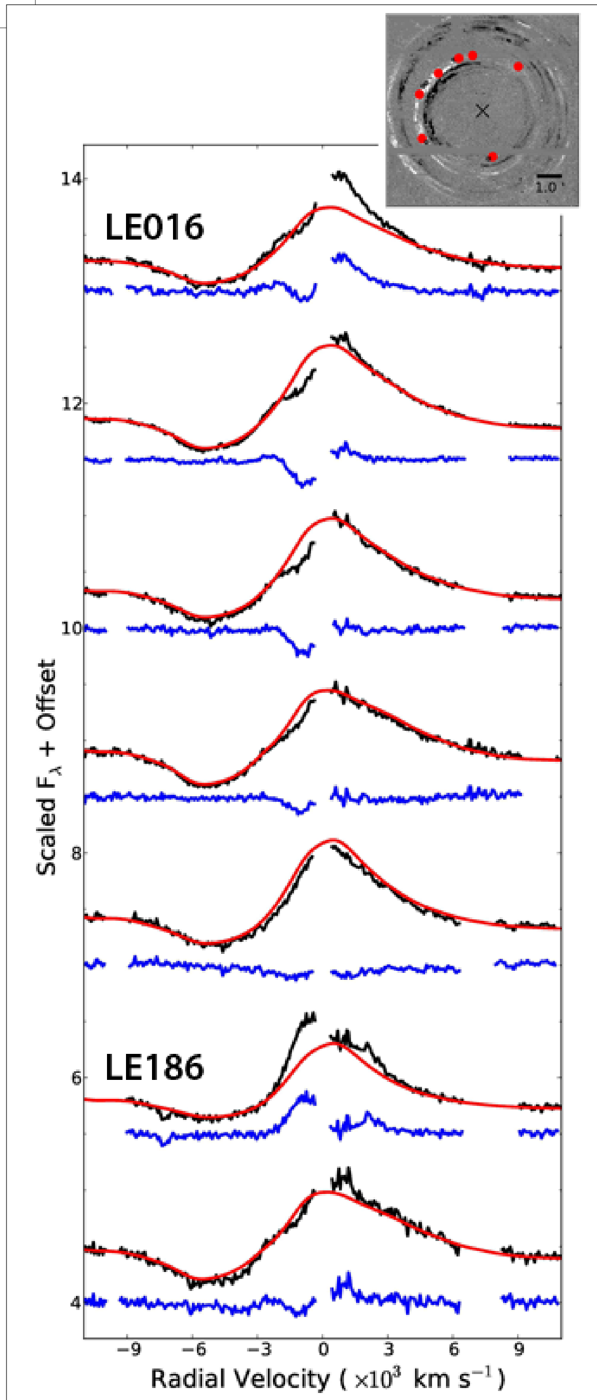
to a viewpoint on Earth, light echoes reveal the source object from a variety of viewing angles. Brendan Sinnott (McMaster University) and colleagues used light echoes from supernova 1987A (SN1987A) to conclude that this Type II event was asymmetric, with an elongated $^{56}Ni$ structure. The strongest asymmetry they measure is in the H$\alpha$ line, and this asymmetry aligns well with the observed axis of ejecta.

The five fields the team observed with GMOS on Gemini South probe the supernova emission over its first 300 days. Figure 2 shows the prominent light echos, which appear as nearly circular rings, along with the slit positions on the GMOS fields.

Variations in spectra obtained at different locations alone do not imply asymmetry in the supernova emission. The source spectrum itself changes, so the reflected light depends not only on the dust properties and its distribution but also on the exact region observed. The echo spectra must be compared to an appropriate isotropic source model, which is based on the original SN1987A outburst observations. The well-known source spectrum (SN1987A) is advantageous, then, because it provides an excellent reference for isotropic emission scenarios.

The H$\alpha$ line shows some of the strongest deviations from the isotropic assumption (Fig-

**Figure 3.**
*Hα profiles observed (black) and modeled (red; assuming an isotropic source). Residual error is plotted in blue, and spectra are offset for clarity. Regions of poor sky subtraction are not plotted.*




ure 3). Two particularly interesting examples come from opposite sides of the echo circle, identified as LE016 and LE186. LE016 shows excess redshifted emission and a "knee" at around -2000 kilometers per second (km/s). LE186 shows excess blueshifted emission and a knee around 2200 km/s.

The research team argues for a one-sided asymmetry in the original supernova based on the bulk asymmetry of these line profiles. Specifically, they suggest overabundance of $^{56}$Ni in the southern hemisphere as the cause. The decay of $^{56}$Ni produces much of the supernova's light and determines the shape of the light curve.

In addition, the small-scale features (the knees) require some asymmetric emission, which may be related to the "Bochum event" — a transient spectral feature that lasted for only a few weeks, some three months after the supernova event. This would suggest the presence of high-velocity $^{56}$Ni in the northern region of the supernova.

Most theoretical models of supernovae require some asymmetry to explode successfully, and observations such as these obtained with Gemini South of SN1987A can better constrain the simulations. The complete results will be published in *The Astrophysical Journal*, Volume 767. Link is also now available:
http://iopscience.iop.org/0004-637X/767/1/45

## *Black Hole Masses from Near-infrared Observations of AGN*

Black holes are intimately tied to the growth and evolution of galaxies, and active galaxies offer some of the best examples in which to measure the mass of the central black hole, the quantitatively significant property. In a new work, Hermine Landt (Durham University and University of Melbourne) and collaborators expanded the sample of well-measured galaxies to allow determination of black hole masses from single near-infrared (NIR) spectra of active galaxies.

The underlying physical relationship is between the velocity of emitting material and its distance from the central black hole. The observational proxies for these properties are the spectral width of the broad emission lines and the active galactic nucleus (AGN) continuum luminosity, where the distance is expected to go as the square root of luminosity (assuming the line is produced at a lo-

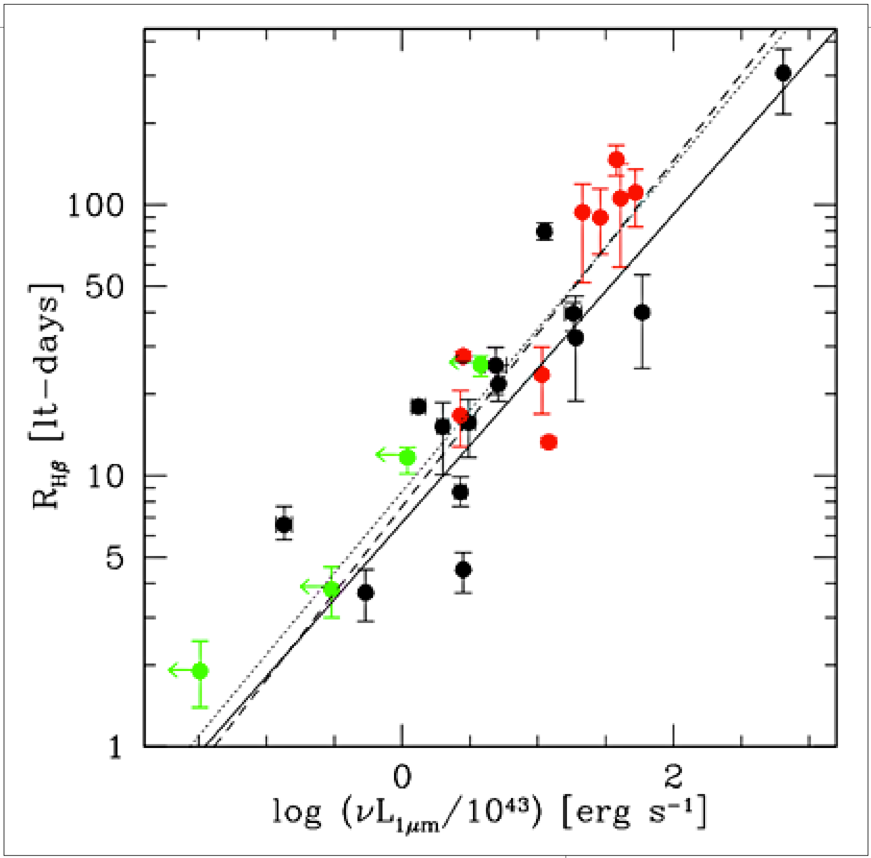



**Figure 4.**

*The location of broad Hβ emission (measured in light-days, from reverberation mapping) versus 1-micron continuum luminosity. Previous observations are plotted in black, new results are shown in red, and upper limits result when the host galaxy dominates the emission (green). The different lines show fits obtained using various techniques, all of which are consistent with a slope of 0.6±0.1.*

cation of fixed ionizing flux). Reverberation mapping at optical wavelengths establishes this relationship, where the continuum variability is observed after a delay in the broad line emission. This technique has the disadvantage of being observationally time-consuming, and fewer than 50 AGN have been measured. Once the radius-luminosity relationship is established, however, further measurements are observationally easier.

This new work provides the observational correlations in the NIR, using observations with the Gemini Near-infrared Spectrograph (GNIRS). This wavelength regime offers advantages over the optical and ultraviolet, including being less contaminated by host galaxy stellar emission, having lines that are less confused by blending, and being less affected by dust obscuration. The sample is restricted to galaxies that have reverberation mapping results, and the new data especially help to fill out the high-luminosity range.

Figure 4 shows the resulting radius-luminosity relationship, where the radius, *R*, is based on previous measurements, and the NIR provides the luminosity, *L*. The observed scatter and lack of change with the enlarged sample here suggest that some of the scatter is intrinsic to the relationship, not measurement uncertainty. With a direct measurement of the velocity spread from the width of Paschen α or β lines, the black hole mass can be calculated.

Alternatively, the combination of NIR luminosity and line width together can be related to the previously measured black hole mass. The complete paper, to be published in *Monthly Notices of the Royal Astronomical Society*, provides the resulting quantitative relationships, including consideration of different techniques for determining the velocity spread. A preprint is available at: http://arxiv.org/abs/1303.1923

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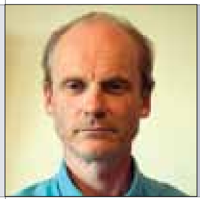

Andy Adamson *(with multiple contributing authors, see page 16 for list)*

# Operations Corner

*After an extremely eventful year for Gemini Operations in 2012, including the end of the NICI exoplanet campaign and a large number of Target of Opportunity programs, the Operations team plans to continue improving overall service to our users in 2013.*

For most observatories the twice-annual Calls for Proposals are a highlight of the operational year. It is no different here at Gemini. With many new capabilities coming online, the Semester 2013B Call is particularly exciting for us. In addition to significant progress with facility instruments at Gemini South, two visitor instruments (one new; one previously-established) are offered at Gemini North, with access dependent on demand.

More guide modes are now available with the Gemini Multi-conjugate Adaptive Optics System (GeMS)/Gemini South Adaptive Optics Imager (GSAOI) system, and this is accompanied by a significant relaxation in condition constraints. These more relaxed constraints come as a result of experience gained during the course of System Verification and execution of the 2013A queue programs. Significantly more time is also available with this system when compared to Semester 2013A. The long-awaited FLAMINGOS-2 near-infrared imager is also offered, both in imaging and long-slit modes, on shared-risk basis.

The Call for Proposals at Gemini North included two visiting instruments: the Differential Speckle Survey Instrument (DSSI) and the Texas Echelon Cross Echelle Spectrograph (TEXES). DSSI is a dual-channel speckle camera offering diffraction-limited reconstructed imaging in the visible; it became available after a highly successful test run last summer. TEXES is a high-resolution mid-infrared spectrometer, last seen at Gemini a few years ago. Further details on the availability of these two instruments is given below.

We're pleased to include a guaranteed minimum number of Subaru nights (five) under the recently formalized exchange program.

The table that follows shows instruments offered at Gemini North and South in 2013B.

**North**

- All instruments available in queue or classical mode, except the visitor instruments and the Laser Guide Star Adaptive Optics System, which are queue mode only.
- Gemini Multi-Object Spectrograph (GMOS): workhorse visible-wavelength imager / spectrometer / MOS /Integral Field Unit (IFU), available all semester.
- Gemini Near-infrared Spectrograph (GNIRS): popular 1-5 micron long-slit and cross-dispersed spectrometer with a limited imaging mode, available from mid-August.
- Near-infrared Integral Field Spectrometer (NIFS): available all semester.
- Near-infrared Imager (NIRI): 1-5 micron imager, available all semester.
- DSSI/Speckle: visiting diffraction-limited visible-wavelength imager, available for up to 110 hours during July and August bright time.
- TEXES: visiting extremely high-resolution mid-IR spectrometer, available for up to 110 hours in October bright time.

**South**

- All instruments available in queue mode only, except for GMOS-South, which can be queue or classical.
- FLAMINGOS-2: 1-2.5 micron imager, long-slit spectrometer, and MOS, available all semester in imaging and long-slit modes only on shared-risk basis.
- GMOS-South: workhorse visible-wavelength imager / spectrometer / MOS / IFU, may not be available in October and November for an upgrade to the CCDs and other maintenance work.
- GeMS+GSAOI: multi-conjugate AO system + 1-2 micron imager with 1.5 arcminute field-of-view, up to 150 hours available between September and January.

## *The Gemini North Shutdown*

The delivery of science results to the Gemini community relies heavily on two components of the telescope: the primary mirror, and the acquisition and guidance (A&G) unit (Figure1). The A&G unit has improved in reliability over the years due to work done by engineering staff and because of this the frequency of "A&G unit shutdowns" is now reduced to once-annually.

The shutdown scheduled for January 2013 included both normal maintenance on the A&G unit and a recoating of the primary mirror. However, a spell of extremely cold weather caused the cancellation of the coating activity (when the massive coating plant incurred freezing damage); the primary will now be coated in 2013B (schedule pending).

The rest of the maintenance was carried out as planned. Some major safety improvements were made in both the A&G unit and GMOS-N, reacting to mechanical problems encountered in recent semesters. Key elements performed included:

- Maintenance on the primary mirror cover mechanism.
- Installation of a skew sensor on the science fold linear drive (to avoid a recurrence of the fault that cost significant time-loss at Gemini South in 2011)
- Installation of a new gear box on the science fold mirror drive.
- Installation of vibration-monitoring accelerometers on both the science and AO fold mirrors.

**Figure 1.**
*Layers of the A&G unit being worked on in the lab. Foreground: module 2 (PWFS, AO fold); background: science fold (the mirror is pointing away from you). Working on the science fold module, left to right: Neal Masuda, Cy Bagano, Eduardo Tapia, and Harlan Uehara.*

- Installation of a sensor on the GMOS mask exchange mechanism –– to avoid recurrence of a failure mode in which an incompletely retracted MOS mask could cause damage when the exchange mechanism moves to a different slot.
- Cleaning of GMOS and GCAL optics with $CO_2$.
- Installation of a water separator in the Hydraulic Bearing System.

## GeMS/GSAOI

Over the past few months at Gemini South we have seen the transition of GeMS/GSAOI (the multi-conjugate AO system and IR imager) from a Development project into its Commissioning and System Verification (SV) stages. During this transition, some 2013A queue observations have been carried out as well.

In pure statistical terms, the SV phase was very productive with 28 proposals received, requesting 138 hours. Of these, 13 were slotted into the 55 available hours, spanning both bands 1 and 2 and covering image quality bins from the 20$^{th}$ to the 85$^{th}$ percentile. At the time of writing, fully 89 percent of the SV observations have been completed.

Only one project proved impossible to execute, due to inaccessibly faint natural guide stars. Throughout this exciting period, the system's usability has continuously improved, and the number of staff required to run the system has decreased. Still, a lot of work remains to bring the system into truly "normal" operations in the regular Gemini queue.

## 2012 Science Operations

2012 was an eventful year for Gemini Operations, with new activities keeping things interesting for all concerned. A considerable effort to improve overall service to our users included: (1) a new protocol of sending of "Program Completed" emails on completion of queue projects; and (2) the first tests of a new eavesdropping capability to allow Principal Investigators (PIs) to get a better view of (and participate in) the observing process.

The latter test took place late in the year, and we are using the results to develop a more economical process in 2013 and beyond.

Facility instrumentation produced a number of problem-solving opportunities during the past year. This is exemplified by the second stage of GNIRS refurbishment which was carried out between June and October. This work resulted in significantly more robust mechanical performance and a much reduced rate of alpha particle detections due to the replacement of the thorium-coated lenses in the short blue camera.

At Gemini South, T-ReCS presented staff with many difficult mechanical challenges, keeping it off the telescope for two months. GMOS-S suffered the indignity of being turned on its head in a successful effort to replenish the oil layer between lenses in the camera optics. Later in the year, GMOS-S also suffered a major fault when the mask exchange mechanism moved while the cassette was not fully retracted.

As previously mentioned, the Gemini North shutdown was used to establish a failsafe mechanism to prevent this from happening again, and the same fix was fitted to GMOS-S shortly thereafter. While GMOS-S was off-sky, a number of science programs were transferred to GMOS-N, demonstrating the flexibility that comes with two telescopes running identical software and queues.

Visiting instruments began to impact Gemini operations with a visit of the DSSI speckle camera (PI: Steve Howell) showing that (reconstructed) image quality at the diffraction limit can be achieved on Gemini in visible light.

A new policy for visiting instruments was developed in consultation with the Gemini Science and Technology Advisory Committee (STAC) and Board, and is now posted on the web site for potential instrument PIs' information. DSSI, having demonstrated excellent performance on Gemini in mid-2012, has been invited back subject to TAC approvals; it is now offered to the community in the Call for Proposals for 2013B, as is TEXES (PI: John Lacy).

The NICI exoplanet Campaign ended in 2012. This major milestone was accompanied by another: the release of the first tranche of campaign data to the worldwide community.

Gemini continues to service large numbers of Target of Opportunity (ToO) programs.

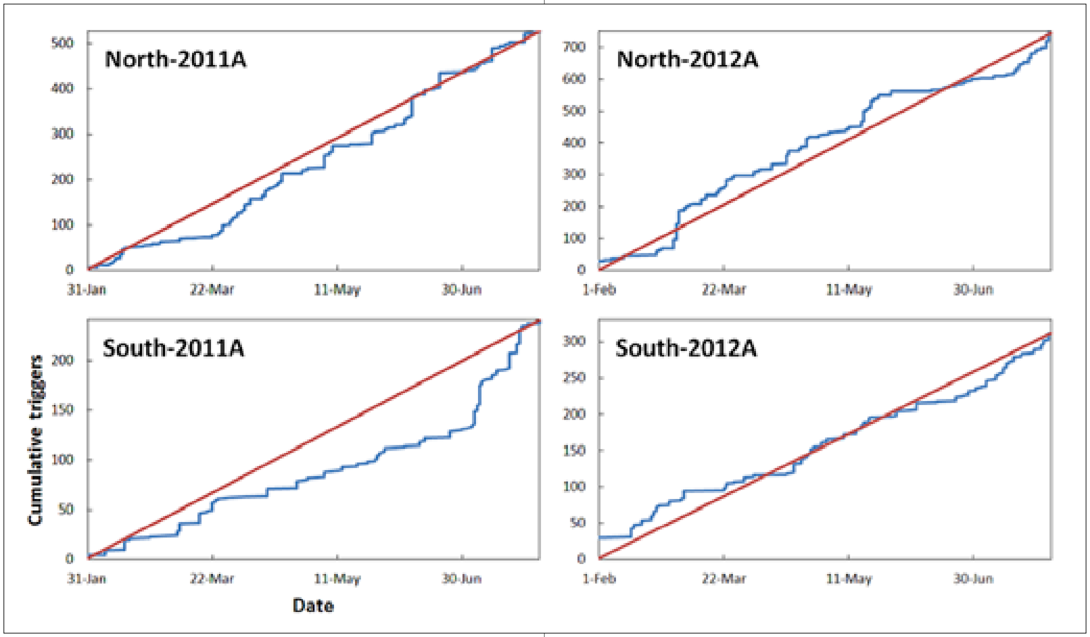


**Figure 2.**
*Target of Opportunity triggers compared between 2011A and 2012A. For 2011A (on the left), note – particularly in the south – a tendency to delay triggering until late in the semester (the red line is a uniform distribution of triggers through the semester). A significant number of the late triggers simply could not be observed. At both telescopes, the situation was much improved in 2012A (right).*

For example, in 2012A Gemini North alone serviced 743 ToO triggers! It was good to see that the triggers through the semester, on both telescopes, became more evenly distributed through the semesters, rather than large numbers being triggered near the end (when we have little chance of executing them all). We're grateful to PIs for keeping on top of their ToO programs in this way.

Every semester, the Gemini Board places two limits on the amount of science time to be delivered: (1) the minimum requirement; and (2) a goal to be met if possible (science time is everything that is left after removing engineering and commissioning time). In 2012, both telescopes exceeded the requested minimum science time.

Gemini North delivered science time close to or in excess of the Board's goals in both semesters, and in 2012B Gemini South comfortably exceeded it, albeit with the unwelcome assistance of cancelled instrument commissioning time being returned to the queue. Weather losses on Cerro Pachón were significantly lower for the year than on Mauna Kea.

The year 2012 was eventful for Gemini Operations. With the new facility instrumentation operational at Gemini South (and GPI delivering to the telescope in mid-year), visiting instruments at Gemini North, and the bedding in of eavesdropping and the ramp-up of work on base-facility operations, both the Observatory and its users have a lot to look forward to in 2013.

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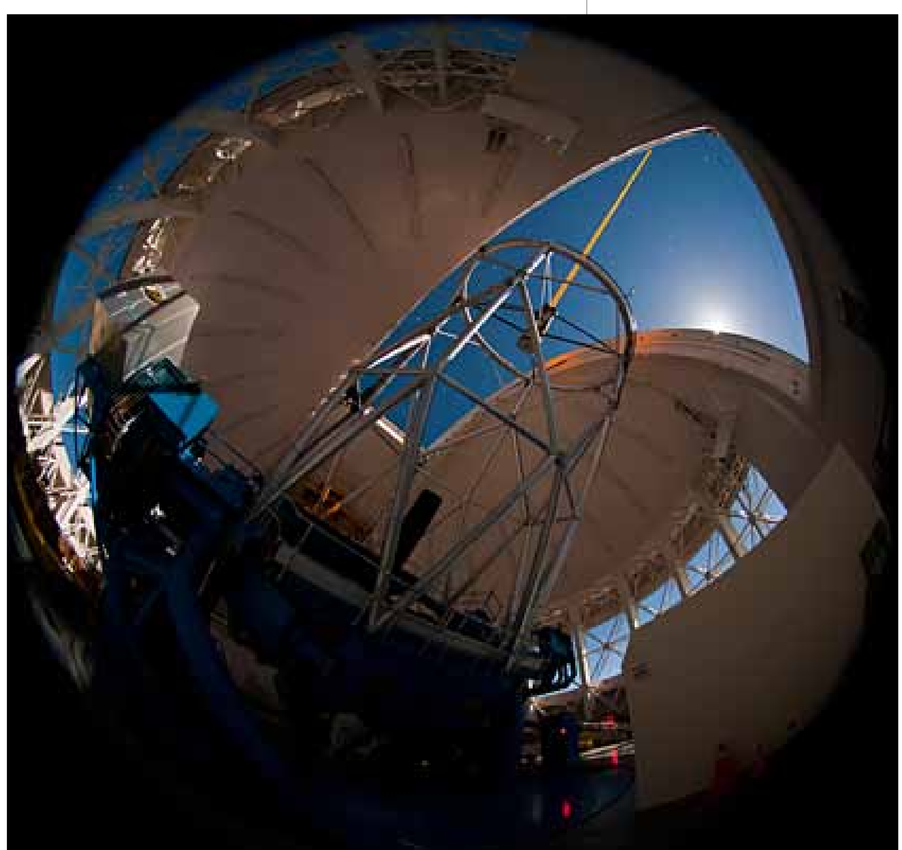
Scot Kleinman, Maxime Boccas, and Peter Michaud

# Instruments Update

*With the highly visible success of the Gemini South Multi-conjugate Adaptive Optics System combined with the Gemini South Adaptive Optics Imager, to several new initiatives at Gemini North, both Gemini telescopes are poised to enter a new era of cutting-edge capabilities to support the needs of our user community.*

**Figure 1.**
*The Moon illuminates the Gemini South telescope during a recent laser propagation of the Multi-conjugate Adaptive Optics System.*



Rapid progress in myriad new instrumentation initiatives at Gemini occurred during the first quarter of 2013. Those reaching fruition at Gemini South on Cerro Pachón, however, are currently the most tangible (see the cover image of the Orion Bullets from GeMS); before the year is out, GeMS will be in regular science operations, the Gemini Planet Imager (GPI) should be well into on-sky commissioning, and FLAMINGOS-2 will be on its way to establishing itself as Gemini South's near-infrared imager and spectrograph.

Meanwhile, progress on longer-term development at Gemini North is none-the-less significant. For instance, several initiatives from the shared use of GRACES with CFHT to negotiations on the Gemini High-resolution Optical Spectrograph will point to Gemini's North's exciting future on Mauna Kea.

All of these activities are strategically positioning both Gemini telescopes for user opportunities in the future as we look ahead to Gemini's place in the rapidly approaching age of the next generation of telescopes.

It's an extremely exciting time for Gemini users watching (and anticipating) the Observatory's development. The following brief summaries provide a taste of what the future holds for Gemini instrumentation; watch for further details on the Gemini website: [www.gemini.edu](www.gemini.edu),
Facebook [facebook.com/geminiobservatory](facebook.com/geminiobservatory), and in this (now quarterly) electronic newsletter [www.gemini.edu/geminifocus](www.gemini.edu/geminifocus).

## GeMS

The Gemini Multi-conjugate Adaptive Optics System (GeMS), along with its dedicated imager, the Gemini South Adaptive Optics Imager (GSAOI), has completed the transition from a development project into Science Verification (SV) observations. During this transition, GeMS/GSAOI produced a variety of very nice results, including a stunning new image of the Orion Nebula "Bullets" region featured on the cover of this issue.

**Figure 2.**
*The Gemini Planet Imager being tested on the flexure rig at the University of California Santa Cruz.*

Semester 2013A queue observations are currently on-going, as noted in the operations report starting on page 12 of this issue. As of the start of SV, the GeMS laser has also been restored to full power (~ 50W), which provides better corrections (Figure1).

## GPI

The Gemini Planet Imager (GPI) has started acceptance testing at the University of California Santa Cruz and, so far, tests have been going very much as expected. Currently, the instrument is undergoing a range of flexure tests (Figure 2), after which it will be moved to a cold chamber for environmental testing. The deformable mirror has remained stable since the last update and the replacement actuator has been successfully masked. The team is still on track to deliver the instrument to Gemini South as planned in June 2013.

## GRACES

The fiber procurement for GRACES (a feed that carries Gemini's light to the Canada-France-Hawaii Telescope's instrument called ESPaDOnS) has always been the key element of this project's success. The vendor has experienced trouble obtaining consistent performance from its fiber-end treatment (polishing and connectors) but recent results show significant improvements, so we expect a fiber delivery in the second quarter of 2013.

The hardware needed to interface the fiber into GMOS, at the Gemini end, and ESPaDOnS, at the CFHT end, is well underway, having recently passed a thorough design review with no major issues. Effort is now

**Figure 3.**
*Optical Engineer Constanza Araujo works on FLAMINGOS-2's optical alignment and image quality testing prior to cool-down.*

being transferred from design and mockup generation to producing the final hardware components needed.

## GMOS

The Gemini Multi-object Spectrograph (GMOS) CCDs have been successfully integrated in the Hilo lab with an in-dewar electrostatic discharge protection board. We expect to characterize the science CCDs in April 2013, with installation into GMOS at Gemini South in October 2013. Installation into GMOS at Gemini North will occur sometime in 2014.

## FLAMINGOS-2

FLAMINGOS-2 has finished its last bit of optical rework. It is now aligned and beginning its last round of testing on the flexure rig (Figure 3) before being put back onto the telescope for on-sky testing and commissioning in April 2013. In Semester 2013B, FLAMINGOS-2 will be offered for both imaging and long-slit spectroscopy; MOS-mode will come sometime later, pending successful on-sky observations in the current modes.

## GHOS

The Gemini High-resolution Optical Spectrograph continues to inch ever closer to a signed contract. As this issue goes to press, an update is still pending. Watch for announcements on the Gemini webpage, Facebook, and the next issue of *Gemini*Focus in early July 2013.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Peter Michaud, Maria Antonieta García, & Janice Harvey

# Giving Back...

Gemini's guiding principle: "Exploring the Universe, Sharing its Wonders" has rarely been more apparent than in the first few months of 2013.

During this period, two of Gemini's flagship annual outreach programs — AstroDay Chile (held in January), and Hawai'i's Journey through the Universe (held in March) — inspired thousands of students and residents in our host communities of La Serena and Hilo, respectively. For staff and others who participated, these programs offered excellent opportunities for them to share their passion for the stars with the public who support us. They also got to inspire local students who may become our next generation of scientific explorers.

The images that follow strive to capture the essence of exploration that drives both of these programs.

## *AstroDay Chile*

An estimated 2700 visitors descended upon the Outreach Center at the University of La Serena on Saturday, January 12, 2013, for Gemini's annual celebration of AstroDay Chile. Because Gemini South hosted it this year during the peak summer season, both visitors and local residents experienced the thrill of exploring the universe from a Chilean point-of-view.

*Dignitaries cut a ceremonial ribbon to officially open AstroDay Chile 2013. This year 17 institutions participated in the program, including Association of Universities for Research in Astronomy (AURA) facilities, Cerro Tololo Inter-American Observatory, and the Southern Astrophysical Research Telescope. Other participants came from as far away as Santiago, as well as a number of public observatories in the La Serena/Coquimbo area (Region 4).*

The Head of the university, Nibaldo Avilés, stated the importance of astronomy to the university. "Responding to a community request and obvious need, the University of La Serena is offering the Bachelor in Astronomy degree for the first time. We hope to continue creating stronger ties in the area of scientific research but also contributing to tourism."


*Gemini scientist Rodrigo Carrasco explains distances in the universe. Gemini and AURA Observatories' staff played an integral role in making the program a success, while all of the participating organizations made this year's activities especially dynamic and engaging.*


*La Serena's Mayor Roberto Jacob (left) visits the Gemini display at the University of La Serena's Outreach Center; he is joined by Gemini's Deputy Director Nancy Levenson, astronomer Peter Pessev and engineer Pedro Gigoux (left to right). Jacob remarked that La Serena and Hilo, Hawai'i, have been sister cities united under the stars since 2000. "It is an honor to host such great research centers in our city," he said, "and we look forward to find out what projects each one of you are developing these days."*


*Ariel López explains the positions of celestial objects while Viviana Bianchi, a volunteer from Argentina, shares educational booklets with young (and future) scientists.*

*For the almost 3000 people who joined in AstroDay Chile 2013, a wide assortment of displays and activities captured both the attention and imagination of participants.*

## *Journey through the Universe Hawai'i*

Journey through the Universe (JttU) 2013 was the ninth and biggest year yet for the program. Over 50 scientists and engineers went out to local Hawai'i Island schools and reached almost 8000 students. "This program is alive and well in Hawai'i," said Jeff Goldstein, who started the U.S. national JttU program. "Thanks to Gemini, the Big Island community, and all of the Mauna Kea observatories, the spirit of TttU continues to grow in many new and exciting ways — ways that even I couldn't have even imagined when we started the program back in 1991."

Gemini's Janice Harvey, who directs the program, sees this year's success as only a glimmer of what to expect next year, noting specifically that 2014 will be our 10th anniversary. "We are going to pull all the stops to make it even better and more inspiring than it was this year," she said.

JttU 2013, though, will be a tough act to follow, as illustrated by the images shown here.

HAWAI'I

*Students at Waiakea Intermediate School experiment with light using a "Light House," which demonstrates reflection, refraction, and how telescopes collect light to study the universe.*

*Gemini PIO Manager Peter Michaud explains condensation, clouds, and sublimation with a block of dry ice later used to make a comet for second grade students at Hilo's E.B. DeSilva School.*

*Subaru Observatory's Olivier Guyon shows students at Ha'aheo Elementary School the surface of the Sun using a safe solar filter.*

*Gemini Astronomer Richard McDermid uses an exercise ball to engage students in understanding the scale of our solar system at E.B. DeSilva Elementary School.*

*Robotic insect critters are used to challenge Waiakea Intermediate School students as they solve problems and understand the mechanics of mobile mechanical devices.*

*Orion Nebula Bullets region image, then… and now.*


## *On the Cover:*

*Regular (and attentive) readers of* GeminiFocus *might notice that the subject of this issue's cover, the Orion Nebula Bullets region, already appeared on the cover of the June 2007 issue. This is not a glaring oversight, but is intentional. The April 2013 cover shows a new image of the region, obtained with the GeMS/GSAOI multi-conjugate adaptive optics system on Gemini South; it illustrates the next-generation of adaptive optics technology. Having just completed a dozen System Verification science observations, GeMS/GSAOI is already setting new standards for wide-field observing with, and uniform corrections in, adaptive optics systems.*

*For more details on this milestone image, see: www.gemini.edu/node/11925*


AURA

The Gemini Observatory is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the National Science Foundation on behalf of the Gemini Partnership.

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