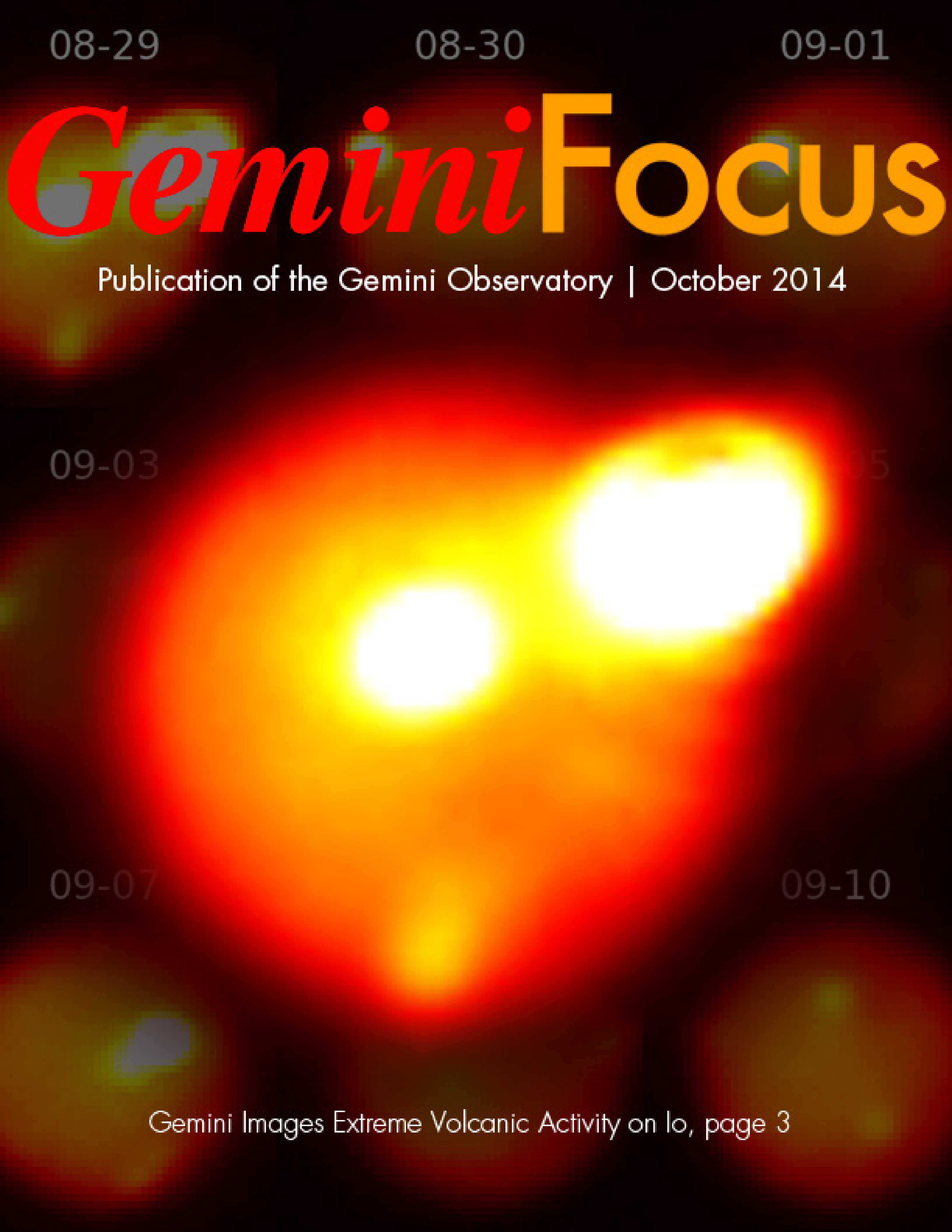
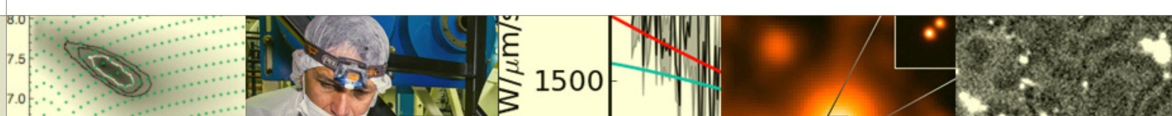
Gemini Focus

Publication of the Gemini Observatory | October 2014



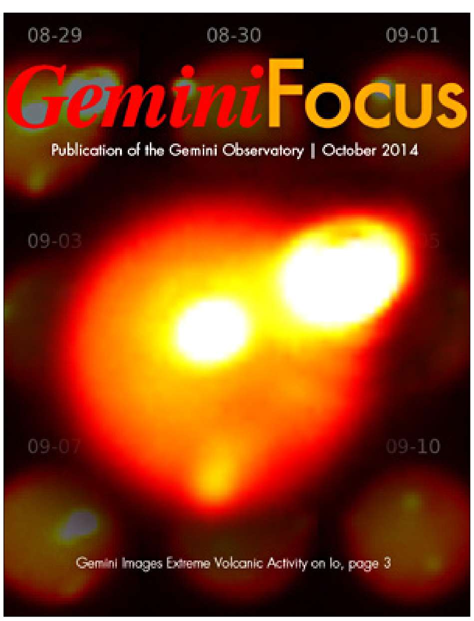
Gemini Images Extreme Volcanic Activity on Io, page 3

GeminiFocus



On the Cover:

Images from this issue's feature science article by Katherine de Kleer on extreme volcanism on Jupiter's moon Io (see page 3).



Gemini*Focus October 2014*

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Markus Kissler-Patig

Director's Message

Large and Long Programs are here (and so much more).

With the start of Semester 2014B, Gemini's new Large and Long programs have begun. The Gemini Board selected seven, which can be viewed *here*. The scheme was largely oversubscribed, by a factor of five to six, compared to the standard programs that typically oversubscribe by about half that amount.

The start of the Large and Long programs also initiated our Priority Visitor (PV) observing mode (*view PV here*). PV runs essentially mitigate the weather, as classical observers can stay longer than their allocated number of nights; during that period, they chose when to observe their program. The rest of the time, the visitors, assisted by Gemini staff, have to observe the programs of their peers. The first PV runs have been extremely successful, and we anticipate an increased number of users taking advantage of this mode, especially when we offer it in 2015B to all programs.

Interestingly, the first PV observers also took advantage of Gemini's "Bring One, Get One" offer to subsidize students and young career astronomers when they accompany senior classical observers (*view here*). Thus, we had a lively populated control room for the nine nights of the first Large and Long program, as well as this July's visiting instrument run with the Differential Speckle Survey Instrument (see the report in this issue, starting on page 24).

As the Large and Long programs rolled out, we continued to prepare the deployment of our third new mode for requesting time on the Gemini telescopes: namely, the Fast Turnaround program. This mode allows users to obtain data only a few weeks after submitting their proposals. The scheme's final design review was passed in April, and the Gemini Board gave its go-ahead in May. The Canadian National Gemini Office kindly ran the peer-review component experimentally in parallel with the most recent time-allocation process. We included the lessons learned as final touches to the process. The first call for Fast Turnaround proposals is slated for release in January 2015, and monthly thereafter; initially this mode will only be offered at Gemini North. I am especially excited about this mode, since Gemini users will now be able to regularly obtain data four to eight weeks after they have submitted a proposal!

Gemini Fellowships

To all young researchers who would like to join the Gemini team in these exciting times, I am happy to announce the new Gemini Fellowships. From this year forward, Gemini will, late each year, offer two, three-year fellowships — one in Hawai'i, and another in Chile. The fellowships are aimed at young researchers who would like to experience working at an observatory while pursuing an active research program.

Through access to Director's Discretionary Time, and a very generous research budget, our goal is to ensure that Gemini Fellows will be optimally prepared to apply for permanent positions at observatories and in academia after their three years at Gemini. The advertisement appears on the American Astronomical Society job register site, so please check it out (*view here*). The deadline for this year's applications is November 30th.

A New Partnership

On the Gemini partnership front, we are extremely pleased that the Korean Astronomy and Space Science Institute (KASI) is engaging in a limited-term partnership with Gemini in 2015. We look forward to hosting our Korean colleagues at the Observatory, opening our telescopes to a new community, and sharing its capabilities.

Starting this year, the Gemini Board has enabled limited-term alliances with countries and institutions from outside the partnership. Whether the terms are negotiated for contributions in cash or in-kind, Gemini is eager to enlarge its family of partners.

Finally, do not miss our lead science article in this issue: Katherine de Kleer (University of California Berkeley) and collaborators used Gemini to catch an act of extreme volcanism on Jupiter's moon Io! It is one of the largest volcanic eruptions ever observed in the Solar System.

With all the upcoming changes, we are looking ahead to even more great science with Gemini.

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

Katherine de Kleer

Gemini Captures Extreme Eruption on Io

A brief exposure of Jupiter's volcanically active moon Io taken at the W.M. Keck Observatory spurred on a team of researchers to use Gemini North to capture a volcanic blast on Io so powerful that it rates as one of the largest volcanic events ever recorded in the Solar System. A series of follow-up observations with both Gemini North and NASA's Infrared Telescope Facility allowed the team to monitor the event's evolution for nearly two weeks. The results provide us with a critical new perspective on the frequency and magnitude of these fantastic outburst events. (See the Gemini press release on this result here.)

The Gemini Near-Infrared Imager (NIRI) captured one of the brightest and most powerful volcanic eruptions ever detected on Io, the most volcanically active body in the Solar System. The temperature and scale of these events give us a glimpse into volcanism in Earth's early history, while this occurrence — within weeks of two other powerful eruptions on Io — suggests that we may have underestimated the frequency of extreme volcanic events on this active Jovian moon.

Volcanism in the Early Solar System

In the Solar System's early history, the planets had hotter interiors than they do today due to the heat produced by accretion and differentiation of matter during planetary formation, as well as radioactive decay of short-lived naturally occurring elements.

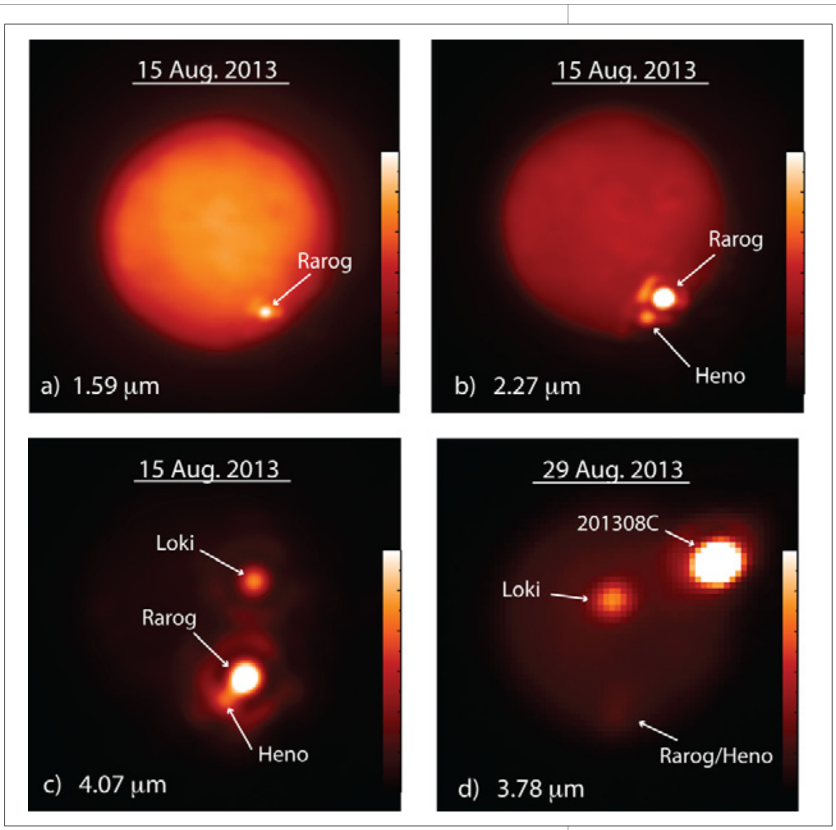

Figure 1.
Detection of the three outbursts. Panels a-c are observations at the W.M. Keck Observatory; the image in panel d was captured at Gemini N. Figure adapted from de Pater et al., *2014, and de Kleer* et al., *2014.*

During this time, volcanic activity was both widespread and vigorous on all the terrestrial planets and many smaller bodies; ancient volcanic features on their surfaces preserve records of this activity. As the Solar System aged and cooled, active volcanism died out on most of these bodies, while on planets such as Earth, where it still takes place today, the activity has vastly diminished in intensity.

An exception to this trend is Jupiter's moon Io, which hosts hundreds of active volcanoes over a surface area smaller than the continent of Asia. The most energetic eruptions on Io dwarf anything we see on Earth today — in temperature, power, and spatial extent. Io's blasts can produce sulfurous plumes that reach hundreds of miles above the moon's surface.

The moon's extreme volcanism is powered by tidal heating: Io is locked in an orbital resonance with the neighboring moons Europa and Ganymede, meaning that it encounters these moons at the same position in each orbit. This leads to a coherent gravitational pull that forces Io into an eccentric path around Jupiter. The changing distance from Jupiter over the course of each orbit — a mere 1.77 days — causes the moon's surface to bulge by varying amounts, which generates the intense internal friction that heats Io's interior and powers its volcanic activity.

Although Io is the only of Jupiter's moons to display active surface volcanism, the gravitational interaction that heats its interior also acts on Europa and Ganymede, keeping their interiors warm enough to host subsurface oceans of liquid water. Though the heating processes in these moons are hidden from view by their icy surfaces, the insight we gain into heat dissipation in Io's interior is directly applicable to Europa and Ganymede, and can help us understand the formation and history of their hidden oceans.

Observing Volcanoes from a Volcano

On the night of August 15, 2013, Imke de Pater (University of California Berkeley), a member of our team, used the W.M. Keck

Observatory atop Hawaii's Mauna Kea (long dormant) volcano to target the atmosphere of Uranus. When she finished, de Pater decided to take brief images of Io in anticipation of our team beginning a program to monitor Io in the near-infrared at the Gemini North telescope and NASA's Infrared Telescope Facility (IRTF), also located on Mauna Kea.

The Keck images revealed a pair of incredibly bright eruptions near Io's south pole. These events fall into the rare "outburst" class of Ionian volcanoes. They represent the hottest and most energetic volcanic activity on the moon but are typically seen only once every year or two. Both the Gemini N and IRTF telescopes scheduled follow-up observations through Director's Discretionary Time in the subsequent days to watch the events evolve.

The first follow-up observations, made simultaneously at the IRTF and Gemini North telescopes, revealed something unexpected and even more incredible: a third eruption, far from the site of the previous ones. This new event was both brighter and more powerful than the initial pair combined. Figure 1 shows images at multiple wavelengths from the Keck detection of the first two eruptions on August 15th alongside the Gemini detection on August 29th of the third.

Over the following two weeks, Gemini scheduled near-nightly imaging of Io to follow the course of the third eruption (Figure 2); the first three of which were conducted simultaneously with the IRTF. These near-daily observations, utilizing a combination of Gemini's adaptive optics and the spectral information from the IRTF data, gave us unprecedented coverage of this rare event.

Looking into Earth's Distant Past

Volcanism is one of the few processes linking the hidden interior of a planet with the observable exterior. It is therefore one of the few ways of learning about what's happening inside planets. The question of Io's dominant magma composition is still unanswered, but is important for understanding how Io's interior translates tidal forcing into volcanic eruptions.

Does Io erupt basaltic lavas similar to those we see on Earth (at Hawaii's Kilauea volcano, for example), or is the magma composition different? By determining the peak temperatures reached by volcanic eruptions, we can constrain which minerals might exist in melt form. Basaltic magmas erupt at a temperature near 1475 Kelvin (K). Higher temperatures could indicate runnier magnesium-rich magmas of an ultramafic composition that require a higher internal heat to melt, such as Earth had when it first formed.

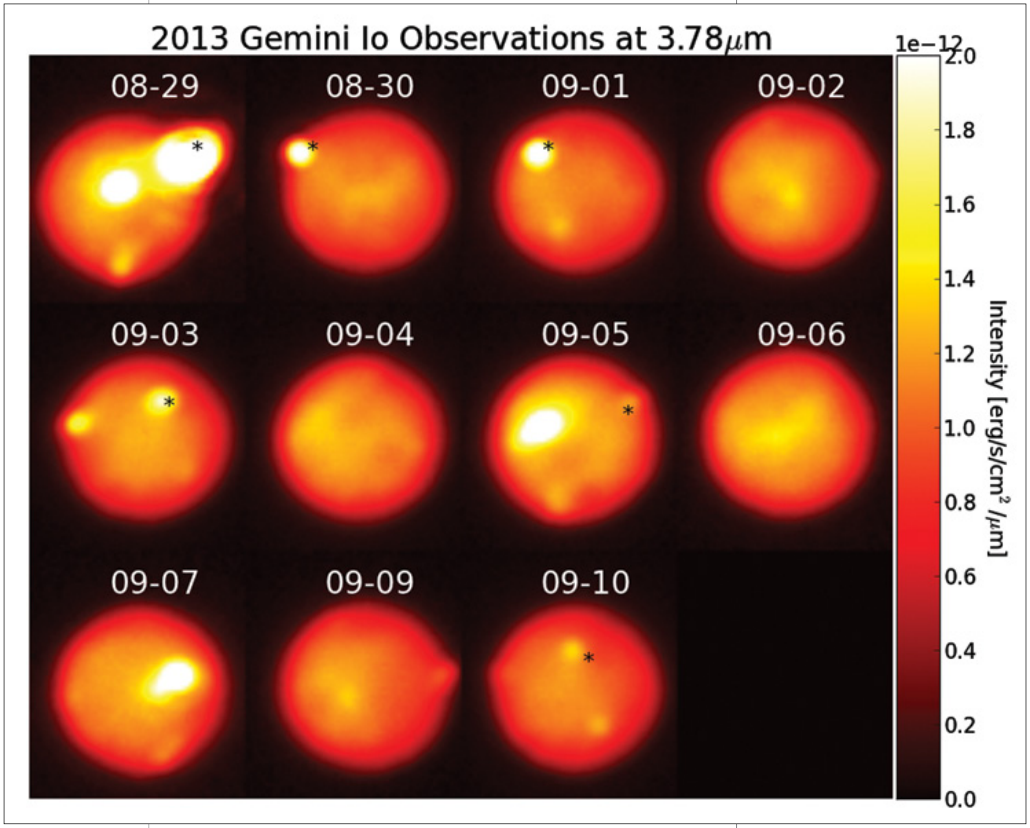

Figure 2.
Observations of the August 29th volcanic outburst on Io over a two-week period. The star indicates the outburst site; other smaller-scale events are also visible. Figure adapted from de Kleer et al., *2014.*

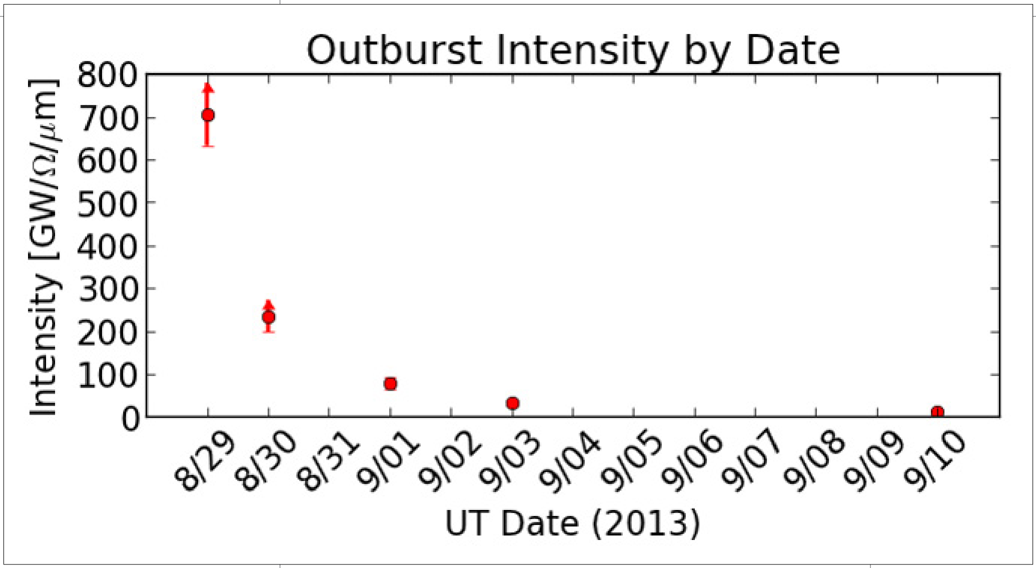

Figure 3.
The decline in the 3.8-micron intensity of the August 29th outburst, derived from Gemini observations. Figure adapted from de Kleer et al., 2014.

Geological features on Earth tell us that this latter type of volcanism was widespread 1-2 billion years ago, during the era when life was evolving. While we can only infer what this activity looked like on Earth by surface features created in the distant past, we see such eruptions continuing on Io today, allowing us, in a sense, to look back in time.

Eruption temperatures can be derived from near-infrared (2-5 micron) spectra, where we see the peak in thermal emission from objects with temperatures in the 600-1450 K range. Combining data from the IRTF and Gemini N we extracted the eruption's spectrum and modeled the event as a multi-component system, including small high-temperature eruption zones and larger, cooler regions of spreading lava. We fit the models to the spectrum to determine the temperatures and emitting areas of the various components. Figure 4 shows the outburst spectrum with model spectra for lava temperatures of 1475 K and 1900 K, corresponding to basaltic and ultramafic lava compositions, respectively.

Our modeling placed a lower bound on the eruption temperature of 1200-1300 K with best-fit temperatures above 1500 K. These upper values indicate ultramafic magma composition, but the difficulty of observing Io at the short wavelengths required to constrain these temperatures means that the upper bounds are highly uncertain. For now, the question of Io's dominant magma composition remains an intriguing mystery for future observations to settle.

Fountains of Lava

The high eruption temperatures we measured suggest freshly-exposed lava continuously gushing from an area of tens of square kilometers. Ashley Davies, a member of our team and a volcanologist at the Jet Propulsion Laboratory who specializes in Io, says that the eruption most likely occurred in the form of fire fountains erupting from long fissures along Io's surface.

Volcanic events on Io range from bright bursts that last only a few hours to hot spots that persist for months or years. The near-daily observations at Gemini North in the two weeks following the August 29th detection allowed us to watch the eruption's rapid decay in brightness as it transitioned from vigorous lava fountaining to the resultant fluid flows that spread rapidly over thousands of square kilometers of Io's surface while slowly cooling. Figure 3 plots the change in the eruption's 3.8-micron brightness in the days following detection.

We measured a peak power of 15-25 terawatts (TW), making this one of the most powerful eruptions observed in the Solar System to date. The highest-power eruption ever observed on Io was at the Surt volcano in 2001; it emitted around 78 TW, a factor of a few above this event (Marchis *et al.*, 2002). Both of these numbers completely overwhelm lava fountains we see on Earth today; for comparison, the lava fountains associated with the 2010 eruption of Eyjafjallajökull emitted a peak of only 1 gigawatt (Davies *et al.*, 2013).

Outlook

While these enormously powerful eruptions are exciting and important for advancing our knowledge of Io, a global understanding requires studying the whole range of volcanic processes on this moon over time. With this goal in mind, we have been monitoring Io with Gemini North and the IRTF regularly since the fall of 2013; we will continue our Gemini observations into 2015. This program allows us to watch the week-to-week variability in Io's overall volcanic activity and the evolution of specific active regions. The study is key to understanding how the volcanic dissipation of Io's tidally-generated heat is distributed spatially and temporally.

In addition, frequent observations increase our chances of capturing major eruptions as they occur. Our detection of three such energetic Ionian events in the same month (or even the same year!) is extremely unusual. Perhaps these events were physically linked by an unknown mechanism, and clusters of eruptions are more common than we think. Or perhaps we fortuitously caught Io at a unique point when three unrelated eruptions happened to coincide. Then again, previous analyses may have simply underestimated the frequency of outburst eruptions in general.

At this point in time, too few such events have been detected to distinguish between these possibilities. Future observations, including our ongoing program at Gemini North, will help answer this question.

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Davies, A.G., *et al.*, "Observing Iceland's Eyjafjallajökull 2010 eruptions with the autonomous NASA volcano sensor web," *Journal of Geophysical Research*: Solid Earth, **118:** 1–21, 2013

de Kleer, K., *et al.*, "Near-infrared monitoring of Io and detection of a violent outburst on 29 August 2013," *Icarus*, in press, 2014

de Pater, I., *et al.*, "Two new, rare, high-effusion outburst eruptions at Rarog and Heno Paterae on Io," *Icarus*, in press, 2014

Marchis, F., *et al.*, "High-resolution Keck adaptive optics imaging of violent activity on Io," *Icarus*, **160:** 124–131, 2002

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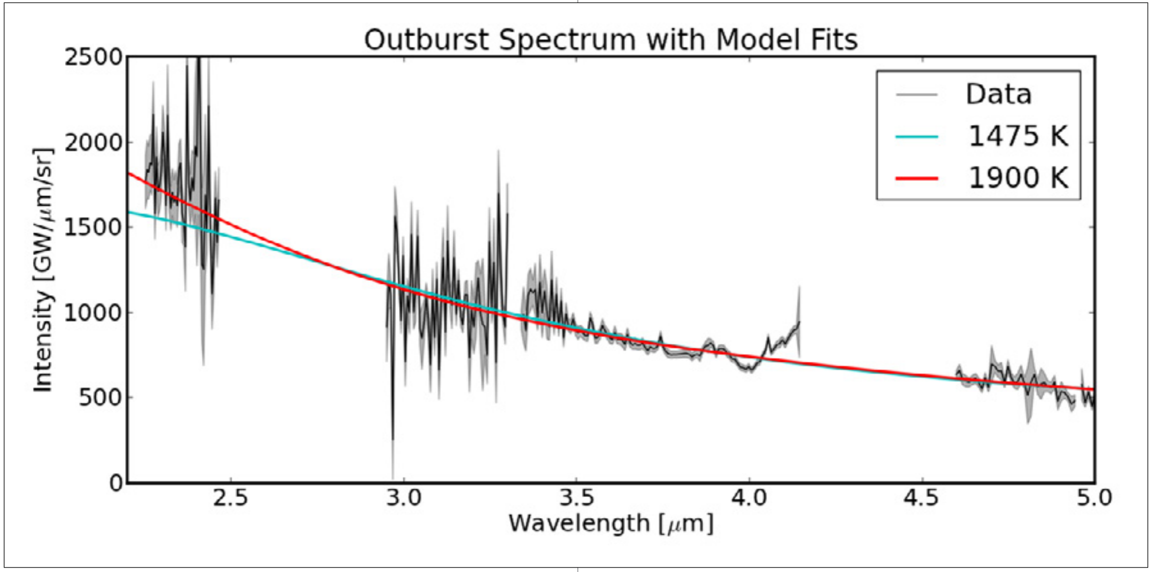

Figure 4.
IRTF SpeX spectrum of the August 29th outburst with model fits. The 1475 K model assumes basaltic magmas, while the 1900 K model assumes an ultramafic magma composition. Figure adapted from de Kleer et al.*, 2014.*

Nancy A. Levenson

Science Highlights

This issue's Science Highlights focuses on black holes of various sizes starting with an ultracompact dwarf galaxy hosting an unexpectedly large supermassive black hole, followed by a stellar tidal disruption event caused by a moderate-mass black hole, and finally tests of black hole mass measurements in an active galaxy.

The Origin of an Ultracompact Dwarf Galaxy and Its Black Hole

Peering into the center of an ultracompact dwarf (UCD) galaxy, Anil Seth (University of Utah) and collaborators found an unexpectedly large supermassive black hole. Using the Near-infrared Integral Field Spectrometer (NIFS) and the laser guide star adaptive optics system on Gemini North, the team obtained high spatial resolution kinematic data to measure the black hole's mass, of 21 million solar masses. This accounts for 15 percent of the total mass of the galaxy and makes this object, called M60-UCD1, the lowest mass galaxy known to host a supermassive black hole.

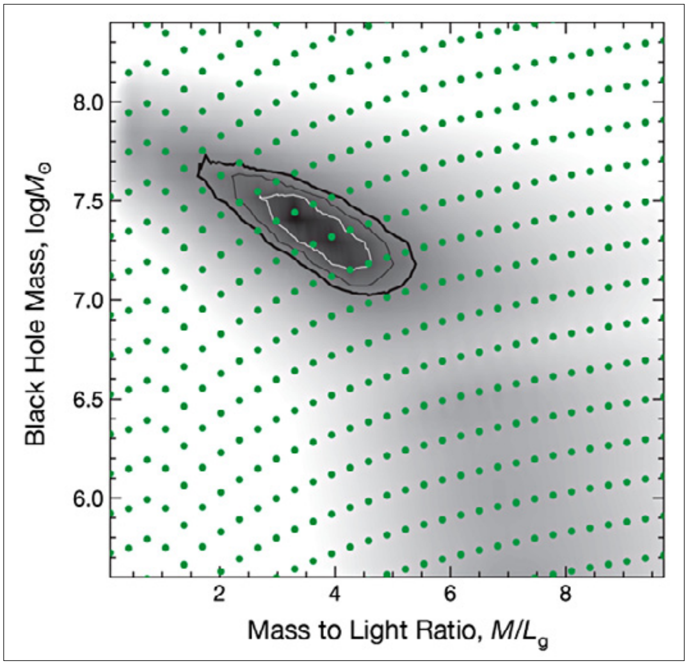

Figure 1.
The black hole mass is derived from dynamical modeling, where the stellar CO bandhead provides the kinematic information. This figure shows the goodness-of-fit measurement considering variations in black hole mass and stellar mass-to-light ratio, calculated at the discrete green points. Contours mark the 1, 2, and 3σ confidence levels.

UCDs are extremely dense, showing some similarities to globular clusters, which raises the question of their origin. Are they massive versions of ordinary globular clusters, or did they come from galaxies that have lost their extended components? The extremely large black hole mass fraction and relatively normal stellar mass-to-light ratio of M60-UCD1 suggest the latter — that it is the remains of a tidally-stripped galaxy. This galaxy would have lost many of its stars in encounters in the dense environment around the massive elliptical galaxy M60.

The research team suggests the UCD black holes are indeed common, doubling the number of known supermassive black holes in galaxy clusters and therefore greatly increasing the number density of black holes overall in the local universe.

Complete results are published in the journal *Nature* ([view here]()), and more highlights and images are available on the Gemini web page ([view here]()).

A Tidal Disruption Event Due to a Low-mass Black Hole

Archival data from the Chandra X-ray Observatory show an X-ray flare near the galaxy cluster Abell 1795, first detected in observations from 1999. A number of different processes could plausibly explain such X-ray variability, including a flare of an active galactic nucleus in the field or the tidal disruption of a star in a nearby galaxy. Peter Maksym (University of Alabama) and collaborators used the Gemini-Multi-Object Spectrograph on Gemini North to obtain a deep observation of the field and identify the flare's host as an inactive dwarf galaxy that is a member of the Abell cluster. They conclude that a tidal disruption event triggered the flare, occurring as a star approached too close to the black hole at the center of the dwarf galaxy to survive.

The Gemini observations show that the host is located at a redshift of $z = 0.065$, confirming it as a member of Abell 1795. Determining the distance also confirms the stellar luminosity and therefore low stellar mass, around 3×10^8 solar masses. Applying standard relationships between bulge luminosity and central black hole mass sets an upper limit for the black hole, $M_{BH} < 7 \times 10^5 M_{Sun}$. Associating an earlier bright flare with the same host galaxy sets a lower limit, $M_{BH} > 2 \times 10^5 M_{Sun}$, assuming that this event did not exceed the Eddington luminosity. Thus, the central black hole is relatively low mass, and analysis of this source type can help bridge

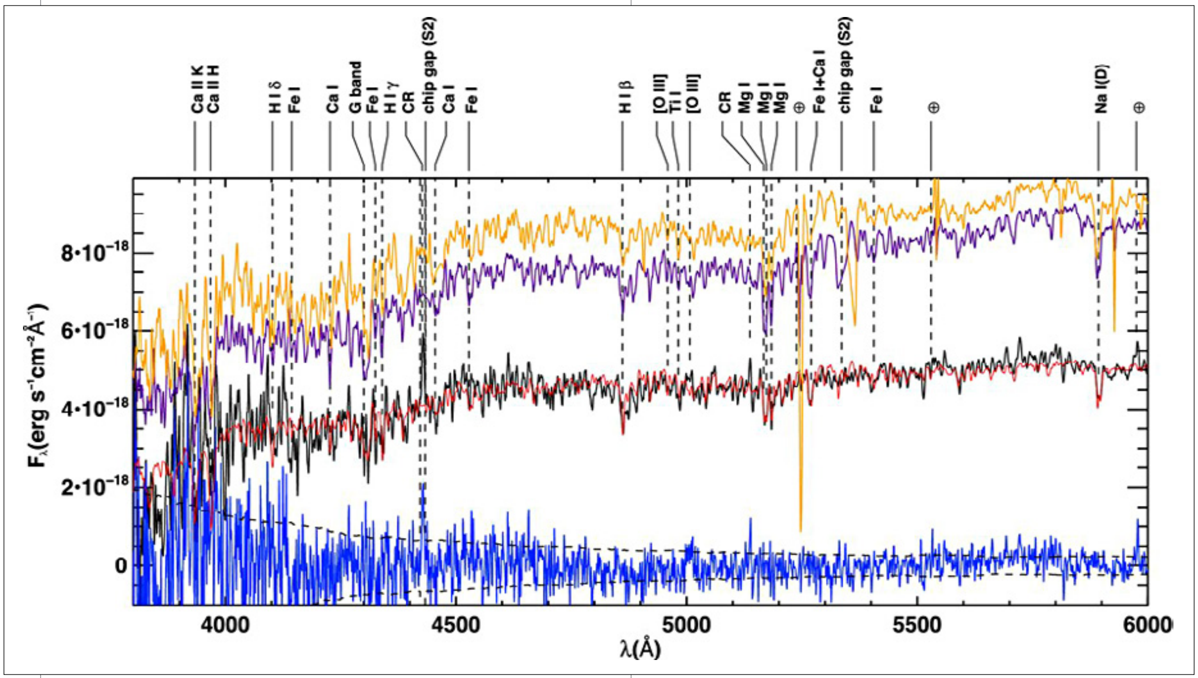

Figure 2.

The Gemini spectrum of the tidal flare source (black), with best-fitting model (red) and residuals (blue), demonstrates that the host is a low-mass quiescent member of Abell 1795. Spectra of nearby early-type galaxies are also plotted (orange and purple at the top).

the gap between the more well-studied stellar-mass and supermassive varieties.

Full results appear in *Monthly Notices of the Royal Astronomical Society*, (viewable here).

Testing Black Hole Mass Measurements in an Active Galaxy

Supermassive black holes characterize galaxy nuclei, and their masses scale with stellar properties in their hosts. This shows that black holes are fundamental to galaxy formation and evolution. With quiescent galaxies, astronomers usually employ dynamical techniques to measure the black holes. Active galactic nuclei (AGN) — which are "active" in the sense of accreting material — offer distinct techniques for the measurement of their central black holes. Specifically, reverberation mapping can reveal the size and motion of nuclear gas, and therefore the black hole mass.

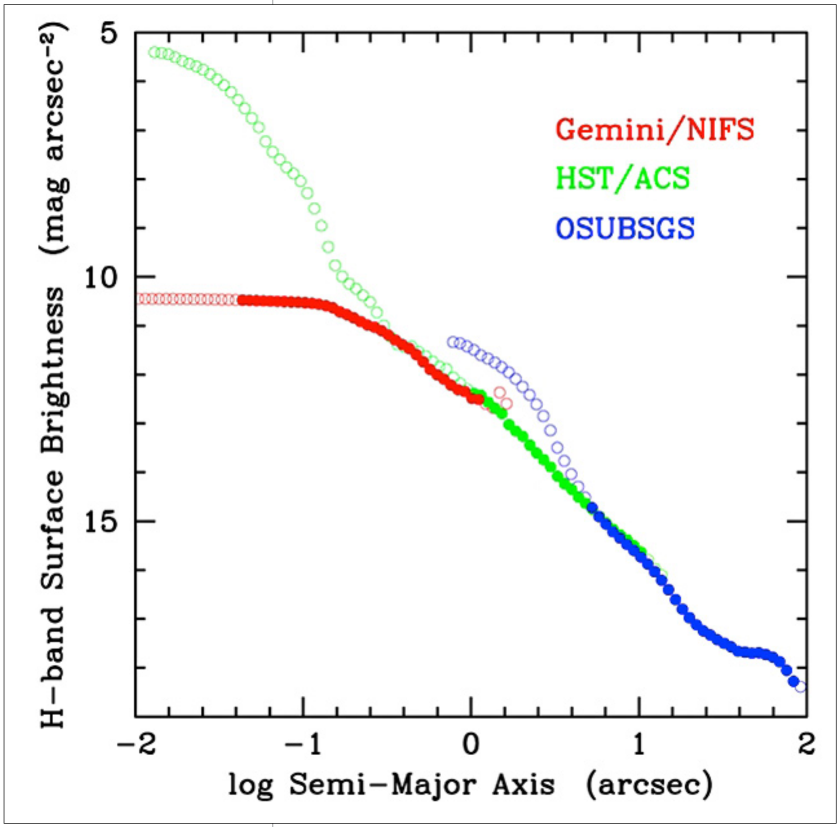

Figure 3. *Radial surface brightness profiles of NGC 4151. The Gemini/NIFS data (red) measure stellar features only (which is most relevant to the determination of black hole mass), so they do not show the increase of central surface brightness due to the AGN, which is evident in the Hubble Space Telescope (green) and Ohio State University Bright Spiral Galaxy Survey (blue) images.*

Each of these approaches is independently successful, but very few galaxies allow the results to be compared directly. NGC 4151 is an exception, being close enough for reliable dynamical measurements and also having an AGN subject of reverberation mapping campaigns. It also raised questions, as an apparent outlier from usual relationships between stellar properties and black hole mass.

Christopher Onken (Australian National University) and colleagues provide new dynamical measurements that take advantage of improved spatial resolution from the Near-infrared Integral Field Spectrometer and adaptive optics in observations from Gemini North. They find a black hole mass of 3.8×10^7 M_{Sun}, which is lower than previous measurements (obtained using lower resolution observations) and is consistent with reverberation mapping results.

Isolating measurements on small spatial scales emphasizes the region that is within the black hole's sphere of influence and avoids complications from a bar that is dynamically evident on larger scales. The resulting velocity dispersion, σ, is somewhat larger than previous measurements, with the net result of putting NGC 4151 closer to the general relationship between M_{BH} and σ, though still on the side of lower velocity dispersion. In addition, the researchers demonstrate the complication of galaxy bars in such measurements of black hole masses, predicting a discrepancy in the results obtained depending on the presence of a bar.

Complete results appear in *The Astrophysical Journal* (view here).

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Contributions by Gemini staff

News for Users

Many significant events impacting users are reported here, including a major planned shutdown at Gemini South (a shutdown at Gemini North in September will be reported in the next issue). Multiple new instrumentation milestones are also summarized, including new detectors for GMOS-South, GPI, GeMS, and FLAMINGOS-2.

Gemini South Operations Shutdown

The annual telescope shutdown at Gemini South was completed in the first half of August 2014. Work focused on three main activities: validating a set of spare electronics boards for the secondary mirror, replacing the helium supply lines in the Cassegrain cable wrap systems, and performing preventative maintenance on the Acquisition and Guidance (A&G) unit, which is within the instrument support structure.

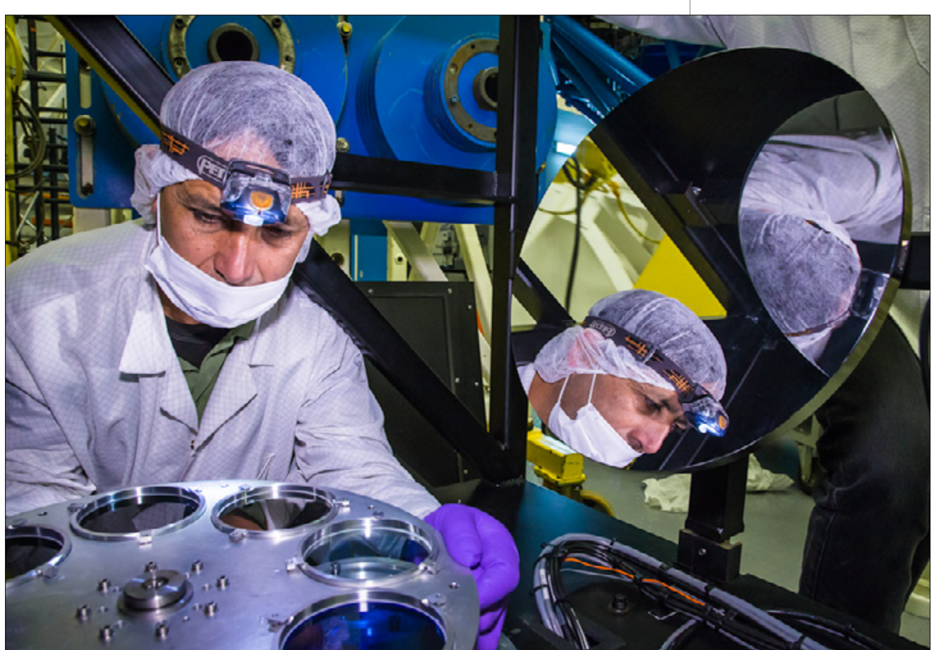


Figure 1.
Optical Technician Claudio Araya works on maintenance tasks inside the Gemini Facility Calibration Unit (GCAL), during the operations shutdown of Gemini South.

After two days of testing, the electronics boards were validated on the telescope, and the secondary mirror worked as required. A complete set of spare electronics boards now exist for both Gemini secondary mirrors.

Routine inspections of the helium supply lines of the Cassegrain cable wrap revealed some wear and bending, requiring all to be replaced. The lines were then twisted into a large braid to reduce movement and friction, which cause the lines to wear.

Regular preventative maintenance tasks on the A & G unit were completed successfully, and several outstanding faults were resolved. Mainly a long-standing one on the adaptive optics fold mirror, which prevented it from responding correctly, was fixed. The mirror is now working fine. The science-fold mirror was also tuned for correct movement between all the different focal stations, and measurements were taken to consider the feasibility of purchasing a spare.

Gemini Planet Imager Commissioning Run

The fourth and final planned commissioning run for the Gemini Planet Imager (GPI) was successfully completed during the first half of September. Extensive testing in the lab and on the flexure rig — to fully stress test the instrument — preceded the commissioning run, as there has been extensive work in both software and hardware. The hardware changes address heating issues in the electronics cabinet and also that with vibrations from both the telescope structure and the robust electronics within the imager itself. Software updates focused on improving instrument performance and allowing a smooth transition from commissioning into science operations.

The latest commissioning run had several major goals: to stress test the instrument's science operation integration; to dampen vibrations by modifying the adaptive optics control loops; to ameliorate the effects of vibration on the science images; to estimate the contrast on various targets under the offered conditions in the queue; and to evaluate the effect of the improvements since the last commissioning run. GPI is now being offered in 2014B.

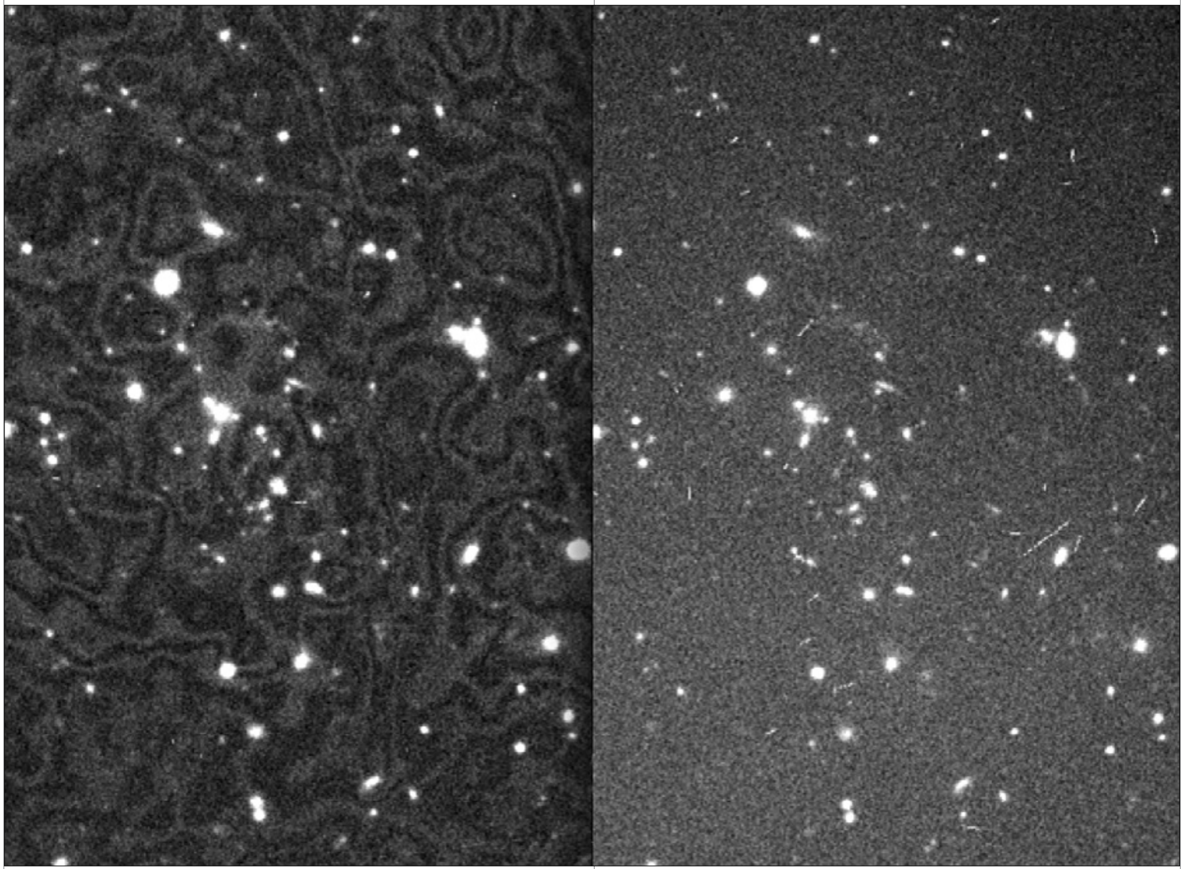


Figure 2.
Images from GMOS, showing a direct comparison between i'-band imaging of the same field (E2V on the left, Hamamatsu on the right). These are raw, unprocessed images, which show how the Hamamatsu CCDs greatly reduce fringing.

GMOS Back for Science

The Gemini Multi-Object Spectrograph (GMOS) is back at work for imaging, taking science data with the new Hamamatsu CCDs. As expected, the Hamamatsu CCDs are significantly more sensitive in the red, and appear to perform as advertised from the delivered QE curves pending final spectral throughput analysis. The new CCDs have also greatly reduced fringing, being now about 2 to 3 percent at 900 nanometers (compared to ~ 65 percent for the previous detectors).

As you might recall, a decision was made in late 2012 to upgrade the GMOS-South detectors with the newly developed highly-sensitive CCDs manufactured by Hamamatsu Photonics. After an extensive period of testing in Hilo, the new detector array was shipped to Chile last April and installed in late May. The array then underwent commissioning during the following two months — including solving some electronics issues on the controllers.

As of the start of Semester 2014B, the new CCDs are operating at full capacity. The screenshot (Figure 2) shows a direct comparison between i'-band imaging of the same field (previous E2V detector on the left, Hamamatsu on the right). These raw, unprocessed images, should help you to appreciate the new CCDs' great reduction in fringing.

FLAMINGOS-2 Observations Start

Observations for 2014B programs with FLAMINGOS-2 (F-2) have started, with a healthy distribution of 12 programs (Bands 1-3) across the partnership. The requested observing modes cover all the offered configurations: YJHKs imaging, and spectroscopy in five different spectral ranges. F-2 offers an average spectral resolution of 900 namometers for the spectral ranges JH and HK, and 2500 for J, H, and Ks.

In July 2014, F-2 was back on-sky after two weeks of shutdown for repairing its decker wheel mechanism. Queue observations were resumed, guided with the telescope's peripheral wavefront sensor. After the shutdown, the K-band internal background was found to be higher than normal in the HK spectroscopy mode, because the gate valve baffle was not positioning properly. Until a new instrument shutdown is programmed, the HK range spectroscopy observations of targets fainter than Ks ~ 16 have been put on hold.

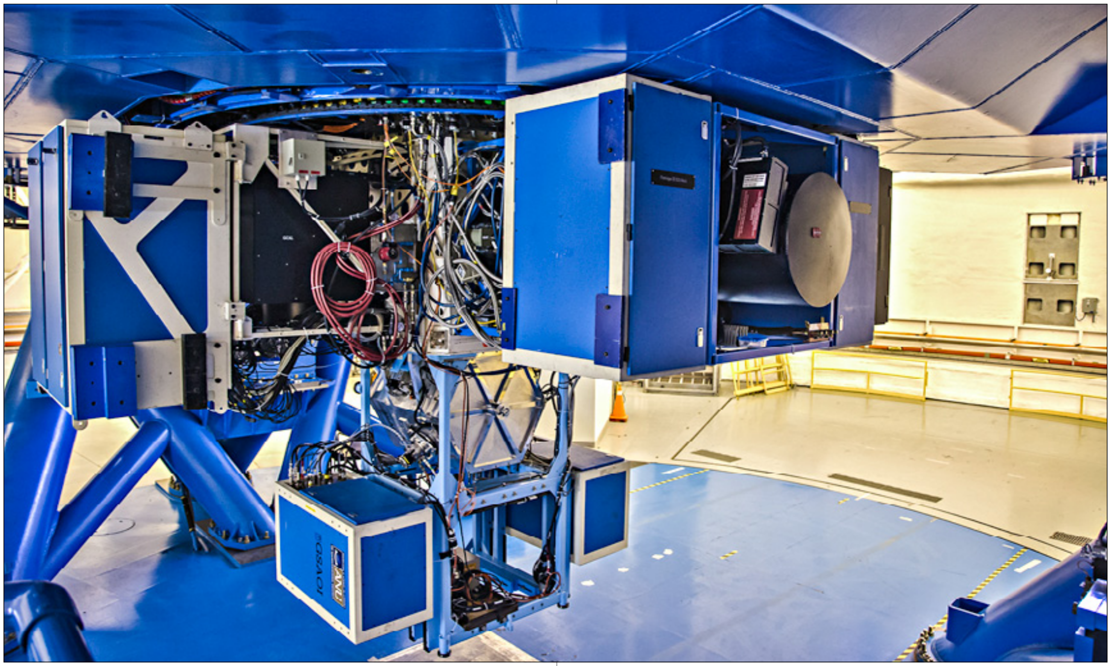


Figure 3.
After having its decker wheel mechanism repaired, FLAMINGOS-2 is operational and working on several observing programs in the current semester.

Figure 4.
Despite bad weather, astronomers using the Gemini Multi-Conjugate Adaptive Optics System (GeMs) got one clear night during its most recent run, which was enough to provide nice images for the Gemini Frontier Fields.

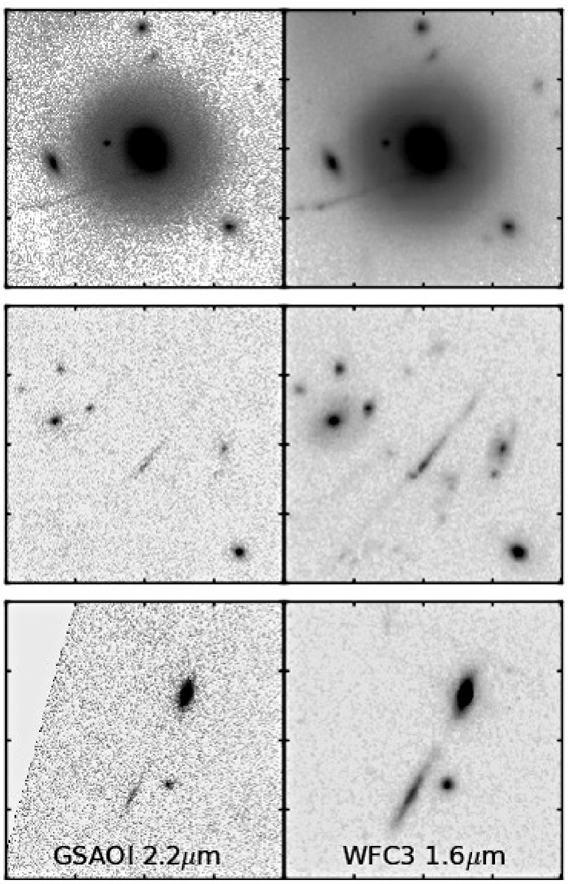


Figure 5.
Comparison of Ks-band images (2.2 micron) taken with GSAOI (left column) and H-band (1.6 micron) images (right) taken with HST/WFC3 (right column). While not as deep as HST data, the new GeMS/GSAOI dataset offers twice the resolution on the distant universe.

Good image quality is regularly achieved under good seeing conditions, with a best performance of 0.4 arcsecond Full Width at Half Maximum at the J band, across the 6 arc-minute field-of-view.

GeMS Completes Successful Run: Frontier Fields Images Released!

The Gemini Multi-Conjugate Adaptive Optics System (GeMS) completed a successful observing run during September. Poor weather conditions meant that only one of eight nights was used to observe science programs. Nevertheless, the GeMS team achieved several goals, including eliminating the elongation of images, providing a stable laser at 30 watts, and producing nice images of the giant galaxy cluster Abell 2744, for the Gemini Frontier Fields program. View here for more details and to access the public and reduced data from this program.

Contributions by Gemini staff

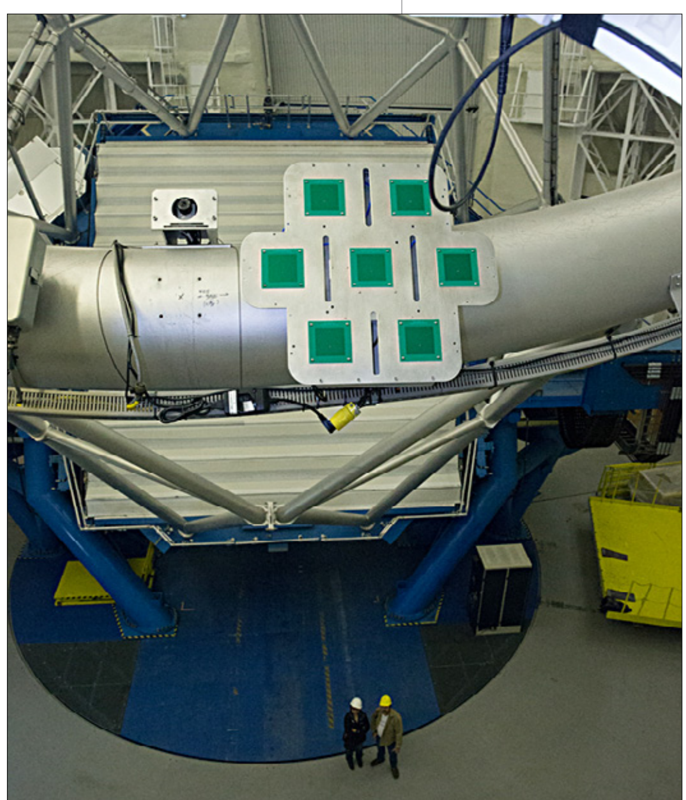
On the Horizon

Several new instruments are on the horizon at Gemini, with a new aircraft tracking system for laser guide star operations, and an upgrade to the Natural Guide Star capabilities with the GeMS adaptive optics system.

GHOST

We're making good progress in the preliminary design stage of the Gemini High-resolution Optical SpecTrograph (GHOST). Teams from the Australian Astronomical Observatory, National Research Council-Herzberg, Australian National University, and Gemini have worked cohesively over the past four months, and we anticipate completing the preliminary design in another four to five months.

Figure 1.
The TBAD receiver unit mounted on the top ring of the Gemini North truss.



The most significant milestone to date has been the completion of the optical design tradeoff study. This process involved defining the overall configuration of the spectrograph. The optical analysis, coupled with other design factors (detectors, mechanical, and science considerations) revealed that a two-arm spectrograph provides equivalent to better performance than the project's initial four-arm design. With that decision made, our next mid-stage milestone will be choosing the location within the observatory for this fiber-fed spectrograph.

Aircraft Detection for Laser Guide Star Operations

Integration of the Transponder-Based Aircraft Detector (TBAD) system at both Gemini North and South (simultaneously) is progressing rapidly and expected to significantly enhance aircraft tracking during laser runs in the near future. TBAD is designed to protect aircraft from accidental illumination by lasers and enables passive monitoring of Aircraft Transponders.

The Base Facility Operations team has successfully installed TBAD hardware and electronics at both Gemini sites; these are now being integrated into the Laser Guide Star systems for aircraft detection. The TBAD antenna is located on the top ring of the telescope and bore-sighted with the laser (Figure 1). In this position, TBAD tracks with the telescope and laser throughout the night. In addition, an external device, TSIM (Transponder Simulator), has been mounted inside of the dome for TBAD operational tests and verification.

Gemini is a partner with the W.M. Keck and Subaru observatories in the development and acceptance of the TBAD system. TBAD is a result of a study conducted by W.M. Keck Observatory. In that study, Keck successfully installed, tested, and incorporated the TBAD system on the Keck 2 telescope. They also received a letter of "No Objection" from the Federal Aviation Administration (FAA) to allow the use of TBAD as their primary aircraft detection system. Keck has since purchased TBAD for Keck 1. At the same time, Gemini and Subaru were invited to participate in the purchase, building, and installation of TBAD systems for their telescopes.

GIFS RfP Now Released!

Gemini Observatory is pleased to announce the release of the Gemini Instrument Feasibility Studies (GIFS) Request for Proposals (RfP). The project is part of a program that will present to the Observatory several study reports and presentations on community-created, science-driven instrument designs that conform to desired principles identified by Gemini's Science and Technology Advisory Committee.

A total of U.S. $300,000 has been budgeted for this project. Gemini intends to award three or more fixed-price GIFS contracts, with the maximum budget for each study limited to U.S. $100,000. Gemini is currently looking for science-driven, feasibility studies based on a facility instrument that will cost between U.S. $8,000,000 and U.S. $12,000,000 to design, build, test, and commission in six years or less. The RfP was issued on September 19th and is open worldwide, and not restricted to the Gemini community. The study

Figure 2.
Tom Murphy (center, behind computer screen), who designed the TBAD system, provides on-site training and characterization of TBAD in Hilo for Gemini and other Mauna Kea observatories.

may be awarded to profit or nonprofit institutions or companies outside of the nations that fund the Gemini Observatory's instrument program.

Gemini encourages collaborations and will provide a mechanism for groups to find additional partners to form a complete team for this work. Thus, groups with some interest in GIFS, but lacking the complete expertise needed to complete the work, should still submit a letter of intent and use our system to find additional partners for the work.

The following timeline applies: A Bidders Conference will be held on October 31st; notice of intent to submit a proposal is due November 17th; and the deadline to submit proposals will be on December 15th at 23:00 Pacific Standard Time.

The GIFS Project Team looks forward to hearing from you. For full details, please visit our website *here*.

NGS Upgrade

AURA/Gemini and the Australian National University (ANU) have entered into an agreement to significantly upgrade the Gemini Multi-Conjugate Adaptive Optics System (GeMS) at Gemini South. The advanced technology of GeMS requires the use of up to three Natural Guide Stars (NGS). These are measured by an NGS subsystem, which helps stabilize the images by removing jitter seen by the science camera.

ANU will design and build a new NGS subsystem, called the Natural Guide Star New Generation Sensor 2 (NGS2). NGS2 will be 10 times more sensitive than the current NGS subsystem and will operate with no moving parts.

This is possible due to recent advancements in imaging detector technology, which can image most of the GeMS field-of-view several hundred times per second with very little additional noise. The current system had mechanisms which moved small probes where each of the three guide stars were located in the image. This led to reliability problems with the mechanisms and throughput issues related to the probe design.

The new ANU-designed system will be able to image the entire field, allowing the control software to measure the jitter of stars in the field without any moving parts. The NGS2 subsystem will be delivered by 2016. It is expected to remarkably increase the amount of sky available for GeMS observations, improve image quality, and increase the robustness of the GeMS system.

Rachel Mason

Gemini's Fast Turnaround Program: It's About Time

Gemini's Fast Turnaround program is intended to greatly decrease the time from having an idea to acquiring the supporting data. The program combines frequent proposal submission opportunities, rapid review, and fast preparation and execution of observations. A pilot program is now gearing up to launch at Gemini North in January 2015.

As any observational astronomer knows, the path from having that outstanding idea to publishing the breakthrough paper is not necessarily smooth, or quick. Ideas can languish for months as you await the next proposal deadline, then it takes time to transform the initial spark into a sober yet attention-grabbing proposal. Weeks pass as the Time Allocation Committee (TAC) evaluates your work — positively, of course. You then have to wait for the observatory to turn the TAC's ranked list of proposals into a set of accepted programs that fits into the available time and other constraints. Next comes the process of defining your observations and waiting for them to be executed (or waiting for your turn at the telescope to arrive)… and even then the journey hasn't ended.

Having the data in hand is just the beginning of the long process of reduction, analysis, and paper writing, which always seems to involve a lot more head-scratching and tooth-gnashing than you ever foresaw at the start.

This is the way things work, and on the whole it serves the community well enough. Sometimes, though, the length of time between idea and data just doesn't suit our needs. For instance, what if an unexpected astronomical event has occurred, or a discovery has been made that sorely needs follow-up? Or, you have a great but risky idea for an observing program, and you'd like to try out the technique before putting the proposal before the TAC? Or maybe you'd just really like to finish your thesis, and getting that last bit of data right now is what you need.

Director's Discretionary Time can fulfill some of these needs, as exemplified in Figure 1, but other opportunities for good science cannot be easily met under the present system. That's why, beginning in January 2015, Gemini will be running a pilot scheme, called the Fast Turnaround program, to allow our user community to submit proposals on a monthly basis, with observations following close behind.

The Fast Turnaround Concept

Rather than relying on a standing TAC reviewing proposals every month, astronomers submitting to the Fast Turnaround program will have two weeks to review roughly 10 proposals submitted by other Principal Investigators (PIs) during the same round ("distributed peer review"; more on this follows). This scheme generates a ranked list of proposals, and a small team of Gemini staff astronomers then checks the top-ranked proposals for technical feasibility and identifies those that can be accepted in the time available.

PIs are notified of the outcome within three weeks of submitting their proposals, and successful PIs will work directly with the Gemini support team to prepare their observations by the end of the month. The Fast Turnaround observations will go into a "mini-queue," which is executed on three dedicated nights each month. The programs remain valid for three months.

Following a committee review of the program's design, the Board of Directors has granted approval for an open-ended trial of this scheme.

The first Call for Proposals will be announced in early January 2015 (initially for Gemini North only) and account for ~ 10 percent of the telescope time.

The scheme will operate alongside the standard ways of applying for Gemini time: the regular semester-based Call for Proposals, the new Large and Long proposals mode, *etc.* PIs from all but two Gemini partners will be able to submit Fast Turnaround proposals; Australia prefers to use their last year in the partnership to complete regular proposals, and Chile doesn't have access to Gemini North so will not participate.

To the best of our knowledge, this is the first time in astronomy that monthly proposal submission opportunities have been combined with PIs reviewing each other's proposals. Those two system components have, however, been used separately by other institutions. For example, the popular United Kingdom Infrared Telescope Service Observing Program encouraged submissions of short proposals (< 4 hrs), which a group of referees reviewed at the start of every month (see Howat and Davies, 1996; also this link).

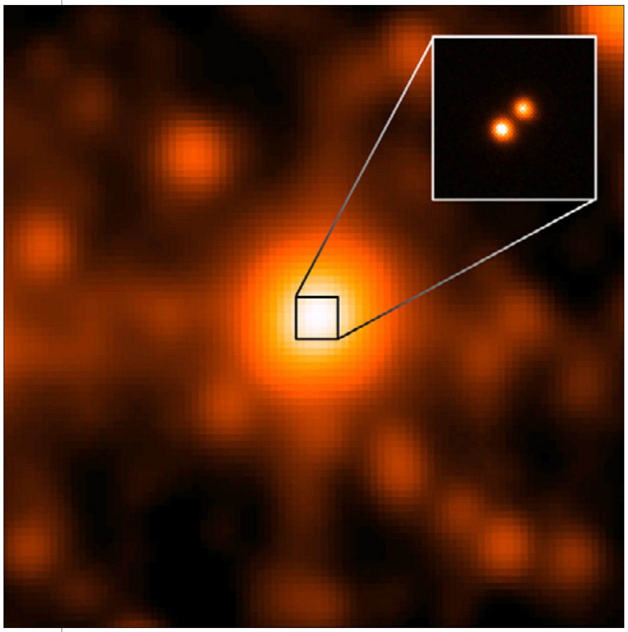


Figure 1.
These GMOS-N observations used Director's Discretionary Time to investigate a high-proper-motion object detected by by NASA's Wide- field Infrared Survey Explorer satellite. The images unexpectedly revealed the closest star system to the Sun discovered in almost a century. This kind of observation, using a fairly small amount of time to follow up results from another facility, could be a good candidate for the Fast Turnaround program. The results were published by K. Luhman in The Astrophysical Journal Letters *(2014).*

Outside of astronomy, the U.S. National Science Foundation's Sensors and Sensing Systems program used the distributed peer review system to handle its most recent round of grant applications. Applicants were informed in advance that they would each review seven competing proposals; despite the extra workload for PIs, the agency received around 40 percent more applications than usual (see Mervis, 2014).

Thought Experiments

Distributed peer review can be scaled to handle large numbers of proposals, which will be a big asset if the Fast Turnaround program proves popular. On the other hand, distributed peer review is new and different and clearly requires some careful consideration. Deciding how best to implement such a system for Gemini has been a fascinating experience.

The obvious starting point was a 2009 paper by Michael Merrifield and Donald Saari, which advanced the rather apocalyptic viewpoint that not only is the standard TAC process "horribly onerous on those unfortunate astronomers who serve on the committees," but it is also "in danger of complete collapse." In their proposed alternative, submitting a proposal commits the PI to reviewing other proposals submitted during the same round.

The twist is that, rather than giving their own opinion of the science, they aim to predict what the other reviewers will think. Those whose rankings deviate from the overall consensus can be penalized by having their own proposal downgraded, in an attempt to discourage dishonest behavior.

That paper provoked a lively discussion among the Astronomers group on Facebook in 2012, and that diversity of opinions is reflected in our informal conversations with Gemini users at universities, national astronomy meetings, and the like. How do you calibrate a system of penalties and incentives? Is such a system desirable, or would it unfairly penalize inexperienced reviewers or genuine differences of opinion? If people try to predict what others will like, will we end up rewarding mediocrity and "safe bets"?

How likely are people to cheat, anyway, in the sense of giving unfairly poor assessments of proposals that they view as competing with their own? The work of social scientists like Dan Ariely, a behavioral economist at Duke University, is illuminating, as presented in Ariely's TED talk which provides an entertaining overview of his work *(view here).*

This kind of work suggests that there are some simple psychological principles that should be taken into account as we finalize the web pages and forms that participants see in the Fast Turnaround program. Of course we will also require that reviewers declare conflicts of interest and agree to the conditions of the program (keeping the proposals confidential and using them only to provide a review).

In the end, we have decided in favor of starting with as straightforward a system as possible, beginning with the assumption that people will behave ethically. The program is an experiment that we have designed as thoughtfully as we can. However, the key will be to monitor it closely and continuously, and adjust it as necessary as we gain experience with how it works.

A Trial Run

To gain a head start, earlier this year we carried out a trial of the peer review process using PIs of Canadian Gemini proposals as the test subjects. The trial (coordinated by Stephanie Côté at the Canadian National Gemini Office) and results are described in more detail in our SPIE proceedings about the Fast Turnaround program (*click here*).

Briefly, PIs were approached after the 2014B proposal deadline and asked if they would review each other's proposals. About one-third agreed, went through the review process using the software developed for the purpose, and submitted feedback about their experience. Perhaps surprisingly, given that only ~ 30 percent of the proposals were included in the trial, the peer review results correlated quite well with those of the TAC.

The reviewers' feedback was very positive, particularly regarding how informative and educational they found the act of reviewing: "very useful... more so than a journal club" was one such comment. This is almost certainly a biased sample; the trial presumably attracted people who were already enthusiastic about the Fast Turnaround program. Given that the program will be part of a suite of proposal modes designed to cater to Gemini's large and diverse community, however, this is not necessarily a problem.

Between now and the launch of the pilot in January, we expect to be busy with several tasks, including: creating the nuts-and-bolts web pages that describe the rules and details of the program; readying the supporting software; defining the statistics, measurements, and feedback that will be gathered; and performing end-to-end system tests to find as many gaps and weak points as we can.

We're excited about the Fast Turnaround program, and just a little bit nervous. To reach its full potential, the scheme will need strong support and participation from the community, with a steady stream of high-quality proposals. We hope you'll take advantage of this new opportunity and help us make the Fast Turnaround program a standard means of applying for time on the Gemini telescopes.

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The Future and Science of Gemini Observatory

A Scientific Meeting of Gemini's Users and Stakeholders in mid-2015

Every three years, Gemini Observatory organizes a meeting of our users and stakeholders in order to sample highlights from the observatory's recent scientific output, and look ahead to the future of our facility and partnership. In 2015, the meeting, called "The Future and Science of Gemini," will convene on the waterfront in Toronto, Canada, from June 14th-18th.

The four-day meeting is shaping up to present a diverse agenda for the anticipated 100+ attendees. A critical objective of the meeting is to facilitate detailed discussions that will consolidate plans to result in the desired observatory of the 2020s. Areas of discussion will include operational and observing modes and instrument development, as well as instrument procurement models, which will offer more flexible approaches to provide the capabilities users require. Gemini Partners will each have an opportunity to present their community perspectives and interests.

Other agenda topics include exoplanet imaging and spectroscopy, time-domain astronomy, cosmic explosions, the nearby universe, and distant galaxies. We will hear perspectives from other observatories, especially from those that may be complementary to Gemini (*e.g.*, the Atacama Large Millimeter/submillimeter Array and the Large Synoptic Survey Telescope), and updates on current and future instrumentation, including work in progress on new Gemini Instrumentation Feasibility Studies (see article starting on page 15). There will also be a workshop session organized by members of the Users' Committee for Gemini focused on employing current instrumentation productively. Contributed talks and posters in all areas are encouraged.

For more details, including a list of the Local and Scientific organizing committee members, and to sign up for email updates, see the meeting's *website*.


Focusing on scientific results made possible from Gemini's latest capabilities, including new observing and proposal modes, this gathering of Gemini's users and stakeholders will also consolidate plans to assure that our scientific legacy is sustained well into the future. Contributions from participants and partner communities will serve as a focal point for next-generation instruments, observing modes and synergies with other facilities as the Observatory looks ahead to 2020 and beyond.
June 14-18, 2015
Toronto, Ontario, Canada
Toronto
2015
FUTURE & SCIENCE OF
GEMINI OBSERVATORY
Registration and information: www.gemini.edu/fsg15

Peter Michaud

Bring One, Get One: Engaging Gemini's Users and Their Students

Thanks to several new and innovative observing modes, Gemini is transforming the way our users engage with the Observatory. Among the most significant is the "Bring One, Get One" program which encourages young astronomers to experience the process of observing, acquiring data, and working directly with observatory staff.

A "typical night" at Gemini is an oxymoron. With Gemini's ever-broadening spectrum of observing modes, visiting instruments, and unique capabilities, nights at Gemini go far beyond the commonplace. These new capabilities not only bring excitement and challenges to the workplace, but also opportunities for young astronomers to gain valuable observing experience at Gemini, which is the foundation for a career in astronomy.

Exemplifying this is the "Bring One, Get One" program, which allows young astronomy professionals to accompany Principal Investigators (PIs) visiting Gemini on observing runs. The program is designed to not only help future users experience the challenges, rewards, and excitement of real-life observing but also train them in the techniques and subtleties of observing at a state-of-the-art observatory. The initiative provides funding and general support for the students; more specifics available [here.]

The DSSI team poses for a photo at Gemini North. Johanna Teske (left), PI Steve Howell (front), Elliot Horch (holding computer), David Ciardi (on computer screen), and Mark Everett (right).

Two First-hand Experiences

Two recent participants in the program — Rosemary Pike, a Ph.D. student from the University of Victoria, British Columbia, and Johanna Teske, a Carnegie Origins Postdoctoral Fellow from the Carnegie Department of Terrestrial Magnetism/Carnegie Observatories

— shared their energy and enthusiasm at the Gemini North telescope during the past semester. As described below, Johanna and Rosemary's experiences perfectly capture the spirit and essence of the program. Their impressions, as well as those of the PIs who supported them, reveal the broad impact of their experiences on our staff.

Steve Howell, Project Scientist for NASA's Kepler and K2 MIssions, and PI for the Differential Speckle Survey Instrument (DSSI), tapped into Gemini's new Bring One, Get One program to support Johanna in a visit to Gemini North during the recent DSSI visiting instrument run in July 2014. That run proved to be extremely successful; the data acquired with the instrument helped to show that at least half of all exoplanet host stars are binary. Johanna was there to participate in the process and share in the excitement first-hand.

Howell points out that the Bring One, Get One program "comes at a time when many young astronomers have little to no experience actually using a telescope." Lamenting the closure of several national observatories, Howell adds that this situation leaves students with few opportunities to go to real telescopes and experience the collecting, reducing, and analysis of data. Which, he comments, "is a fundamental learning experience for a scientist."

Johanna found that her visit not only provided her with an opportunity to experience real-life observing but to also interact and network with the DSSI team more deeply, especially during periods of bad weather.

"It was frustrating that we lost some time due to bad weather," she says, "but during those times, I got to know the other DSSI team members pretty well. They are full of good advice and interesting ideas about science and science careers."

Following shortly on the heels of Johanna's visit, Rosemary Pike, who previously worked as

Rosemary Pike (center, foreground), with part of the COLOSSOS team, including the Large and Long program PI Wes Fraser (left) and Michelle Bannister (right) during their observing run at Gemini North.

a Science Operations Specialist at Gemini, returned as a Bring One, Get One visiting student with the COLOSSOS (COLours for the Outer Solar System Object Survey) program team, one of the many ongoing observations in Gemini's new Large and Long programs mode.

"This was another successful observing run," says head of Gemini North's science operations Sandy Leggett. "It was very gratifying to get an email after the run from the PI with the subject line: Your Staff are Awesome!"

Rosemary, who spent a total of seven nights either at the telescope or operating remotely from the Hilo Base Facility, said that her previous experiences at Gemini North were especially helpful in "easing the transition into observing my own programs." Nevertheless, she adds, "it was still very challenging to run the Queue and the team's Large and Long program for seven nights."

Gemini encourages all visiting PIs to consider the Bring One, Get One opportunity for their students. "This is a commitment we are making to the future of our science," says Leggett.

To other young, budding astronomers, Johanna advises, "Take this opportunity while you can. The benefit is orders of magnitude greater than the effort it takes to apply."

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Peter Michaud

gAstronomy and Exoplanets

Gemini's Principal Investigators have many passions that go far beyond astronomical research. Here we learn how Principal Investigator Steve Howell is working with culinary master Bill Yosses to connect gastronomy to the study of exoplanets — and how they whipped up an exotic blend of tasty science and alien treats for Gemini North's local host community.

The Gemini user community is a diverse and creative lot. This becomes even more evident when you start to uncover their interests and hobbies.

Last July, for instance, Steve Howell, one of Gemini's most creative and imaginative Principal Investigators (PIs), brought the Differential Speckle Survey Instrument (DSSI) to Gemini North for the second time as a visiting instrument. Before arriving, Howell, who also serves as Project Scientist for NASA's Kepler Planet Finding Mission, mentioned that he and Bill Yosses (an esteemed former White House Executive Pastry Chief) are working together to find ways to connect gastronomy to the environments suspected on exoplanets. Howell explained, "The same science principles astronomers use to understand alien worlds are also used to create marvels of culinary delight."

DSSI's Principal Investigator Steve Howell shows a nine year old how to create exoplanet slime.

Janice Harvey, who leads Gemini's local outreach programming in Hawai'i, thought the idea was not only an extremely intriguing marriage of topics but also an appetizing concept for a new outreach program for Gemini's local community in Hawai'i. With that in mind, Harvey immediately cooked up a partnership with the 'Imiloa Astronomy Education Center in Hilo, and hatched an exotic community outreach program.

The program, held at the ʻImiloa Planetarium in mid-July, featured Howell and Yosses who each shared their expertise on exoplanets and culinary techniques, respectively. Together they combined modern molecular gastronomy methods and basic physics to teach a little of both while creating exotic taste treats. The audience got to taste samples of numerous exoplanet-inspired culinary delights, including mango spheres, exotic foam drinks, and even polymers that turned oils into powders; all of these and more titillated the audience's taste buds throughout the evening program. See a sample recipe at *this location*.

"The excitement of discovering thousands of exoplanets can be brought right into your kitchen," Howell said.

Yosses agreed. "We believe the enthusiasm we have for cooking and science is contagious," he said, "and this event at the ʻImiloa Planetarium proves that new discoveries in one field can generate waves of new ideas in others. We want to thank the Gemini and ʻImiloa teams, the volunteers, and the Hilo community for their support."

As for other PIs out there with interests that span the cosmos, please let us know if you plan a visit to Gemini; we want to share your passions with our communities (and beyond).

Peter Michaud leads Gemini's Public Information and Outreach Office and can be reached at: pmichaud@gemini.edu

Top: *Bill Yosses (left) and Steve Howell create an exotic foam column, while demonstrating the use of foam in the kitchen.*

Bottom: *Steve watches as Bill creates alien fruit spheres, among other tasty treats for the audience.*

Shot during the COLOSSOS run, which is a Large and Long program that included a Bring One, Get One student visitor (see page 24), this predawn image captures light from the rising Moon, as well as the pale pillar of zodiacal light in the eastern sky.
Photo by Gemini's Joy Pollard.

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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