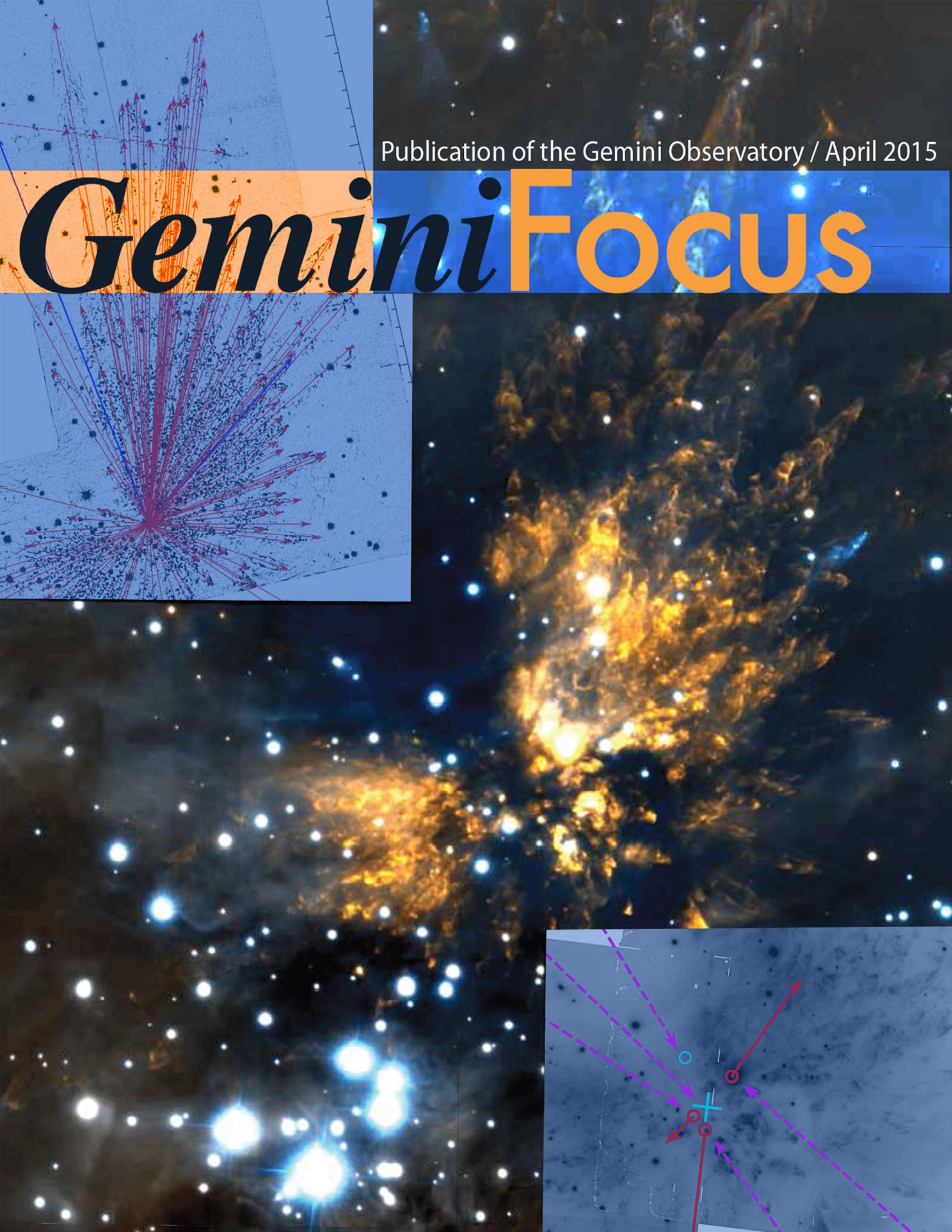
Publication of the Gemini Observatory / April 2015

GeminiFocus



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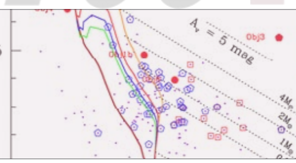
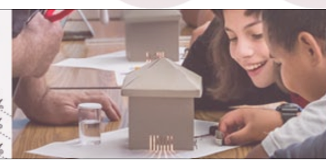


ON THE COVER: Gemini South adaptive optics image of the “Orion Fingers,” and two figures from the recent paper by John Bally et al. *For more details see the Science Highlight summarizing this work, starting on page 12.*

Gemini*Focus April 2015*

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Markus Kissler-Patig

Director's Message

Gemini starts 2015 with the successful implementation of our Fast Turnaround program — a world-wide innovation in the observatory proposal process. We also look back at a record number of Gemini publications in 2014, and ahead at new instrumentation on the horizon.

Fast Turnaround (FT) Proposals — Have You Heard About Them Yet?

The first Fast Turnaround (FT) recipients have already received their data, having proposed by the program's initial deadline at the end of January. Users who were slower to start applied for the deadline at the end of February. What? You missed the February deadline as well? No worries, the next proposal submission deadline is at the end of March, and then the end of April, and then the end of May... you get the picture.

From now on, whenever you have a great idea, or need some complementary data, you will not need to wait for months to get observing time anymore. It will always be time to submit your proposal. And the best part: You can get the corresponding data within about six weeks (assuming your object is available in the sky — which is now the only limit). No more waiting for data. Oh, and if your proposal wasn't successful? Just update it with the comments from your eight referees and resubmit it again for the next month's cycle!

We are extraordinarily excited to be the first observatory to introduce such a "fast turnaround" mode — to complement our regular, twice annual, Call for Proposals, and our yearly Call for Large and Long programs. This scheme has the potential to revolutionize observational astronomy, especially in the era of growing synergies between great observatories.

The first comments from FT users were incredibly positive. Here are a few:

"I am deeply impressed with this review system. It is smooth, easy to use, and looks like it's been well-tested in advance. Bravo! I have already praised it publicly, and will continue to do so."

— Peter Maksym, astronomer, University of Alabama

"The Fast Turnaround program is fabulous, and I enjoyed the review process — a nice way to get us all involved, learn more about what Gemini is used for, and move toward a tighter Gemini community. Thanks!"

— Steve Howell, Kepler Mission Project Scientist, NASA Ames Research Center

"If successful, then this observing mode will distinguish Gemini Observatory from the other 6- to 10-meter class observatories. And this may bring new and unique science to Gemini. I expect it to also significantly increase the publication rate of papers based on Gemini data."

Learn more about Gemini's FT program in the article starting on page 17 of this issue.

The year 2014 is worth one more look back: Last year, you, our users, published more papers than ever with the Gemini telescopes (225 total; ***see link***), and for the first time papers were almost equally split between Gemini North (131) and Gemini South (129); note that some papers used both telescopes and are not double counted in the grand total. The most noticeable fact is that 51 (nearly a quarter) of these papers used Gemini adaptive optics (AO) in one form or another — stressing how important that technology has become, and encouraging us to commission further instrument modes with AO.

Returning our focus back to 2015, the Gemini High-resolution Optical Spectrograph (GHOST) is now firmly underway, and efforts to launch the third of the fourth generation instruments (*aka* Gen4#3) are moving forward rapidly. Eight teams responded to Gemini's Call for Feasibility Studies (Gemini Instrument Feasibility Studies, GIFS) in December, and four were selected to develop science cases and to put forward concepts. These teams will present their ideas at the upcoming triennial users' meeting, "Future and Science of Gemini Observatory," to be held this year in Toronto, from June 14th to 18th. If you are not registered yet, there is still time to do so, at ***this website***. This is your best chance to directly influence Gemini's future! For more details on future instrumentation at Gemini see the *On the Horizon* article starting on page 22.

Finally, I'm pleased to mention one recent highlight of our Public Information and Outreach team: In the first week of March, the 11th edition of our annual Hawai'i flagship educational program in "Journey through the Universe" was again an incredible success (see page 25 of this issue)! Thousands of kids enjoyed visits to their classrooms by our staff educators. This year, about 5000 students were introduced to observatory STEM professions and the marvels of the universe. Over 50,000 children have now been reached during the life of this Gemini-lead program. The smiles and wonder on the children's faces are the best argument to pursue Gemini's mission: "Exploring the Universe, Sharing its Wonders."

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

Benoit Neichel

RCW 41: Dissecting a Very Young Cluster with Adaptive Optics

New high-resolution observations of a galactic star-forming region with the Gemini Multi-conjugate adaptive optics System (GeMS), in union with the Gemini South Adaptive Optics Imager (GSAOI), have shed new light on how star-forming regions, and the young stellar objects within them, evolve.

All stars are born from an original collapsing cloud of gas and dust. When the core of one of these molecular clouds becomes unstable, it collapses and forms protostars. When the protostars are massive, they achieve temperatures hot enough to ionize the surrounding gas (mostly hydrogen) causing it to glow; we call this glowing stellar nursery an emission nebula or HII (H^+) region.

Stellar Nurseries

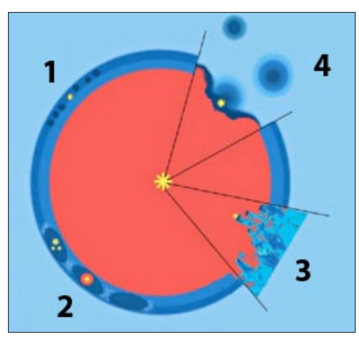

Figure 1.
The different mechanisms that may trigger the formation of a new generation of stars at the edges of an ionized (HII) region (from Deharveng et al., 2010).

Massive stars form HII regions that expand in the surrounding medium at supersonic speeds. Once a sphere of ionized gas is far from the newborn stars, the outer boundary (the ionization front) slows to subsonic speeds. Continued expansion of material ejected from the nebula builds pressure behind the front, before it breaks through as a shock. This second wave of expansion at the edges of the HII region can create a layer of cold neutral material, which accumulates between the ionized and the shock fronts. This layer may become unstable and form a new generation of stars through different physical mechanisms. Those mechanisms are summarized in Figure 1. These include small- and large-scale instabilities (denoted as

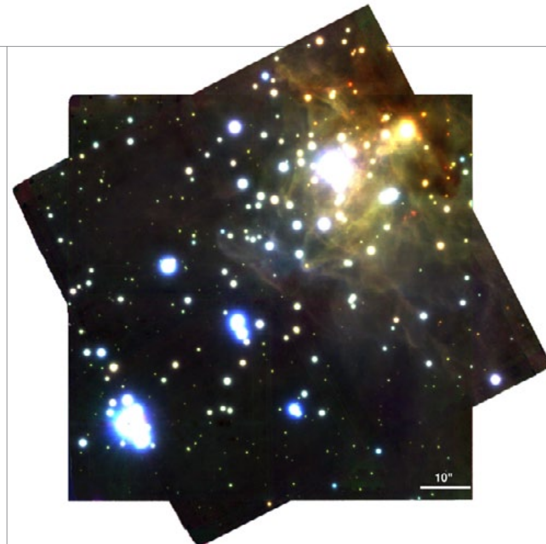

Figure 2.
JHK color-composite image of RCW 41 observed with GeMS at Gemini South.

1 and 2, respectively; also called "collect and collapse"); interaction with a pre-existing turbulent media (3; leading to the formation of pillars); and interaction with pre-existing clumps (4).

One of the key questions in this field of research is what is the causal link between the first generation massive stars (the ones associated with the large HII regions) and the young (possibly second-generation) stars observed at the edges of HII regions? Dissecting the young clusters that formed at the edges of HII regions is therefore an important step to refine our knowledge on star-formation mechanisms.

The Sharp Gemini Eye

Studies of young star clusters are still limited. Young, recently formed stars in clusters are shy, and usually hide inside a heavily obscured and dense environment. High spatial resolution in the near infrared (NIR) is needed to resolve individual members and detect the fainter ones.

The Gemini South telescope offers one of the most advanced adaptive optics (AO) suites currently available on a large telescope. Among these capabilities, the Gemini Multi-conjugate adaptive optics System (GeMS) delivers a uniform, almost diffraction-limited image quality at near-infrared wavelengths over an extended field-of-view of 2 arcminutes across.

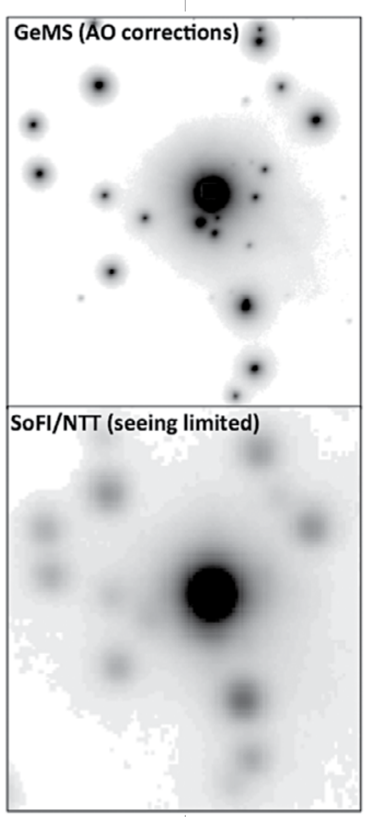

Figure 3.
GeMS/GSAOI (top) and SofI (bottom) images of the central part of the RCW 41 cluster observed in H-band.

GeMS utilizes five artificial laser guide stars, up to three natural guide stars, and multiple deformable mirrors (DMs) that are optically conjugated with the main atmospheric turbulence layers. This results in an AO corrected field that is 10 to 20 times larger than previous generations of AO systems. GeMS works in conjunction with the Gemini South Adaptive Optics Imager (GSAOI), which covers an 85″ × 85″ field-of-view with a plate scale of about 20 milliarcseconds. This combination of new instruments is perfectly suited for young cluster studies, as it provides a uniform and unprecedented spatial resolution spanning a large portion of the young cluster's angular extent.

Back in 2013, during the GeMS science verification period, we pointed this high-resolution machine toward RCW 41, a Galactic ionized region located in the Vela molecular ridge. We used three filters (J, H, and K_s), combined to produce the image shown in Figure 2. In this image, the resolution is ~ 0.1 arcsecond, and quite uniform over the field. At the cluster's distance, ~ 4200 light-years (1.3 kiloparsecs), the field covered by the image represents ~ 1.5 light years (0.5 pc), with a resolution corresponding to 130 astronomical units. This is 5 to 10 times better than previously available images, which were obtained in seeing-limited circumstances.

To highlight the gain in resolution brought by GeMS/GSAOI, Figure 3 compares the seeing-limited images obtained with the European Southern Observatory's large-field infrared spectrograph and imaging camera SofI (Son of Isaac) on the New Technology Telescope, and the new GeMS/GSAOI images in H-band. The region shown here is the cluster's center, where the stellar density is the highest. GeMS/GSAOI not only resolves many more stars, but by concentrating the light over smaller areas it also enhances the sensitivity and limiting magnitude in this crowded region. Determining the stellar content of young clusters (by resolving their individual members and gaining access to their faintest ones) is a key in understanding the process of their star formation.

Young Stellar Objects: Identification and Cluster Age Determination

Based on the photometry derived from GeMS/GSAOI, complemented by images taken by NASA's infrared Spitzer Space Telescope, we have identified a total of 80 Young Stellar Object (YSO) candidates based on their unusual red colors. Indeed, these recently-formed stars are still embedded in native material, and circumstellar emission from each star's disk and envelope dominate the spectral energy distribution.

The signature of their youth, however, reveals itself at longer wavelengths, where their spectrum significantly deviates from a pure photospheric emission. Constructing color-color diagrams, we find that YSOs tend to cluster in a specific region, making them easy to identify.

Once identified, these candidate YSOs can then be used to estimate the age of the cluster. Indeed, in the absence of proper motion studies, or spectroscopic information, the distinction of true low-mass members from the contaminating field stars projected along the line of sight is difficult. We therefore used these YSO sources, which are more likely associated with the cluster, to derive an approximate age of the region.

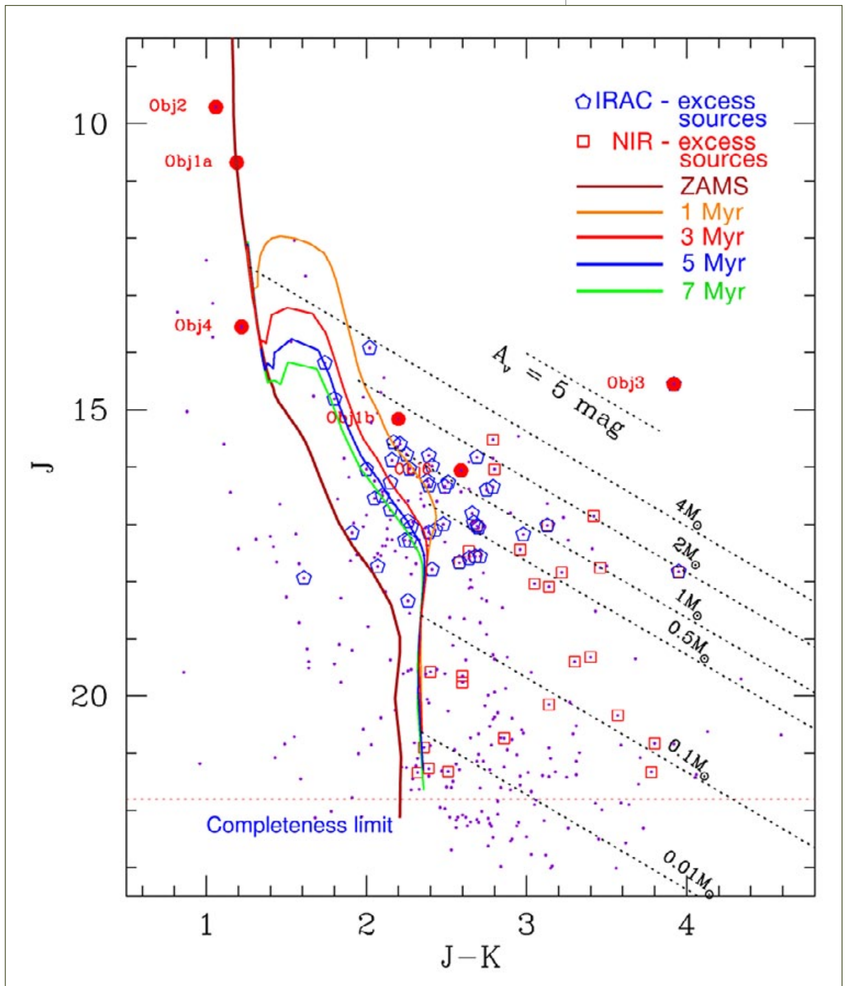

Figure 4.

Magnitude-color diagram for all stars detected in the RCW 41 cluster. Stars marked with a blue polygon or a red square are the YSOs. The pre-main sequence models used to estimate the cluster's age are shown with the solid color lines.

Age determination was done through the color-magnitude diagram shown in Figure 4. For each YSO, we track its position with respect to pre-main sequence models. The different models assume different colors for different YSO age. This allows us to basically assign an age for each object. Of course uncertainties are large. However, this exercise allowed us to find evidence for the cohabitation of two potentially distinct populations of YSOs.

More specifically, we found that two-thirds of the YSOs were young, with a mean age lower than 3 million years (Myr), while one-third had a mean age of about 5 Myr. This might be the sign of an evolutionary star formation sequence (progression) at work in this region.

Evolving Stars?

To test whether different evolutionary stages are present in the cluster, we looked at the spatial distribution of these two possible populations. From this it appears that the "red", highly embedded, and probably younger, YSOs are mainly distributed around the northwest region (top right), while the "blue", and probably older, population is preferentially located toward the southeast (bottom left) region. This distribution seems to indicate the presence of an age gradient diagonally across the image, and where the denser cluster region would be younger than the blue sub-cluster region.

We also found that one of the bluest massive stars, located in the southeast sub-cluster, is likely the ionizing source of the region. This star probably is the one that originally lit up RCW 41, and has already cleaned up its environment. On the other hand, moving toward the dense cluster region, the presence of a dense clump of molecular gas has been detected, a signpost of active ongoing high-mass star formation. This suggests that star formation progresses toward the clump and could have been triggered by the interaction of the ionized region with the clump.

Cluster Mass Distribution

To go one step further, we derived the mass and mass distribution of the dense cluster, formed at the edge of the RCW 41 HII region. The stars in this region have roughly the same age and metallicity. In addition, since the effects of stellar and dynamical evolution are minimal in young clusters, the observed present day mass function should be a fair representation of the underlying Initial Mass Function (IMF).

The IMF is a fundamental parameter to characterize cluster properties, and various theories of star formation predict different outcomes for its overall shape. However, as for the age, deriving a mass for each star is an indirect process, and many uncertainties may add up along the way.

We derived the IMF of the young cluster, which is presented in Figure 5. Among the first interesting features is that we can detect and study stars down to

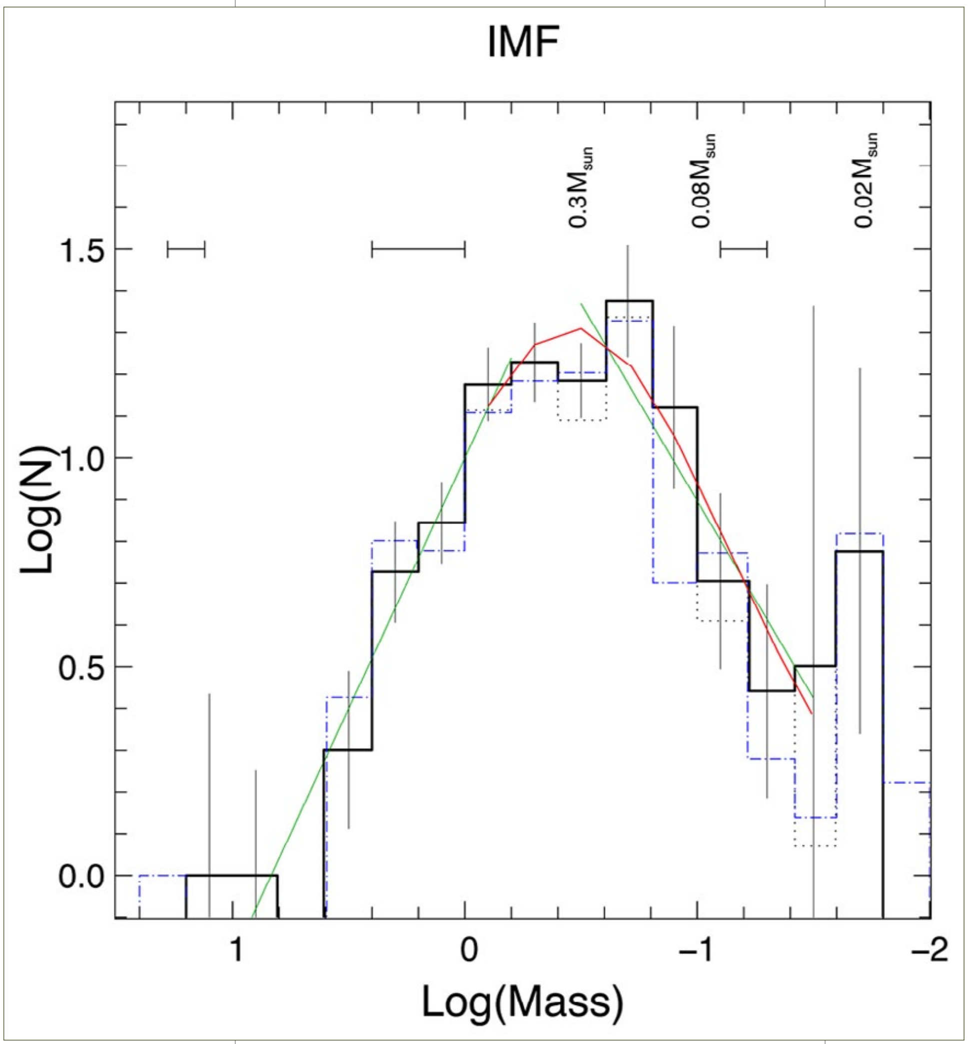

Figure 5.
Mass distribution of the young cluster forming at the edge of the RCW 41 HII region. Thanks to the gain in resolution and sensitivity brought by GeMS/GSAOI, masses down to 0.01 solar mass are probed in this cluster.

a mass limit of ~ 0.01 solar mass — only 10 times the mass of Jupiter! Only the gain in sensitivity brought by GeMS/GSAOI allows us to reach such a low mass limit in a cluster as distant as RCW 41.

Brown Dwarfs

Objects below 0.08 solar mass, *i.e.* below the hydrogen-burning limit, are known as brown dwarfs. We demonstrate here that GeMS/GSAOI opens the way for studies of brown dwarfs, and brown dwarf formation processes in distant clusters.

In particular, there have been several proposed mechanisms to explain the origin of brown dwarfs — such as through turbulent fragmentation, disk fragmentation, ejection of newly formed fragments in multiple systems, and photoevaporation. All of these scenarios may predict a different brown dwarf fraction. For instance, isolated brown dwarfs may be the remains of prestellar cores, after strong ultraviolet emission from nearby massive stars photoevaporated their accretion disks. We therefore expect a higher brown dwarf ratio for clusters hosting massive stars.

RCW 41 does host many massive stars, allowing us to compare its brown dwarf fraction with other known clusters hosting massive stars, such as the Trapezium region in the Orion Nebula. From this comparison we found that the fraction of brown dwarfs in RCW 41 was actually significantly smaller than that of the Trapezium. This is also true for another distant cluster — the one in M16, the Eagle Nebula. This might indicate that different processes are at work to shape the low-mass IMF and the brown dwarf content.

Coming Next

Accurately deriving the stellar content of young clusters is a challenge for which GeMS/GSAOI is certainly a unique facility. These capabilities offer us an opportunity to pin down each of the least massive stars present in distant clusters and push the observational limits one step further. The resolution provided by GeMS/GSAOI is also an ideal complement to the radio observations delivered by the newly commissioned Atacama Large Millimeter Array (ALMA). Combining near-infrared, with radio wavelengths — at a similar spatial resolution — opens the way for strong synergies and breakthrough discoveries.

We are also exploring the need for new data reduction tools specifically designed for this new generation of AO systems. As shown in this paper, many uncertainties in the data still exist, and error bars need to be carefully treated. Finding ways to reduce these error bars will allow us to push the limits of technology, better constrain theoretical models, and improve our understanding of those rich and complex star-forming regions.

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Other members of the team are: Manash R. Samal, A. Zavagno, and A. Bernard from Laboratoire d'Astrophysique de Marseille, France; H. Plana from Universidade Estadual de Santa Cruz, Brazil; and T. Fusco from ONERA, France.

Nancy A. Levenson

Science Highlights

Data from instruments on both Gemini North and South have boosted our understanding of the structure and kinematics of hypersonic bullets in the Orion Molecular Cloud region, led to a significant color-magnitude diagram of a cannibalized extragalactic globular cluster, and confirmed the existence of a 12 billion solar mass black hole in a quasar that formed only about 875 million years after the Big Bang.

New Clarity and Change in an Explosive Stellar Outflow

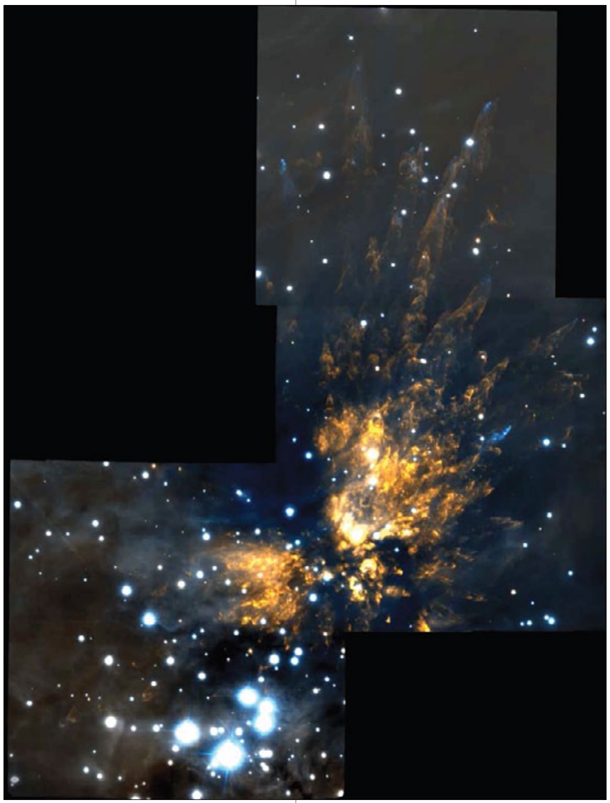

Figure 1. *The outflow of the "Orion Fingers" is evident in this high-resolution image. The leading fingertips appear in [Fe II] (cyan), and the trailing fingers are evident in molecular hydrogen emission (orange). Comparison with earlier observations shows the motion and morphological changes of the emitting knots.*

The outflow that emerges from the Orion Molecular Cloud 1 (OMC1) offers a rare opportunity to observe a catastrophic episode in a massive star-forming region. The outflow's large scale, and the common dynamical age of its many high-velocity knots (in the region known as the "Orion Fingers"), point to an explosive origin. New observations using the Gemini Multi-Conjugate Adaptive Optics System (GeMS), and the Gemini South Adaptive Optics Imager (GSAOI), provide the sharpest views ever obtained of the large region, nearly reaching the diffraction limit with a resolution of 0.08 to 0.1 arcsecond.

The new narrow-band images show [Fe II] emission at the fingertips, where the material is ionized and excited at the leading shock fronts (Figure 1). Additional shocks excite molecular hydrogen in the wakes of the trailing regions. John Bally (University of Colorado) and collaborators directly measure the motion of specific fingers in the outflow and their morphological changes. They also compare the current data with earlier observations, especially those obtained using adaptive optics (Altair/NIRI) at Gemini North. They find proper motions up to 300 kilometers per second (km/s).

Survival of these knots requires that they have densities much larger (factors of 10^3 or greater) than the ambient medium through which they propagate. Numerical simulations reproduce the overall structure and kinematics of a moving knot. The authors suggest that stellar merger events could produce such outflows, while ejecting massive stars from their birthplaces

Additional images are posted at the ***Gemini website***. A preprint is now ***available***, and full results will be published in *Astronomy and Astrophysics.*

A New Low-luminosity Cluster in the Outskirts of the Milky Way

New discoveries, and detailed measurement, of the stellar populations in the outer reaches of the Milky Way reveal the history of our Galaxy. Dongwon Kim (Australian National University) and collaborators contribute to our understanding by reporting on the discovery of a faint, low-density stellar cluster in the constellation Indus. Called Kim 2, the cluster, located in the outer Milky Way halo, is 10 times more distant than typical globular clusters and shows signs of having lost significant mass.

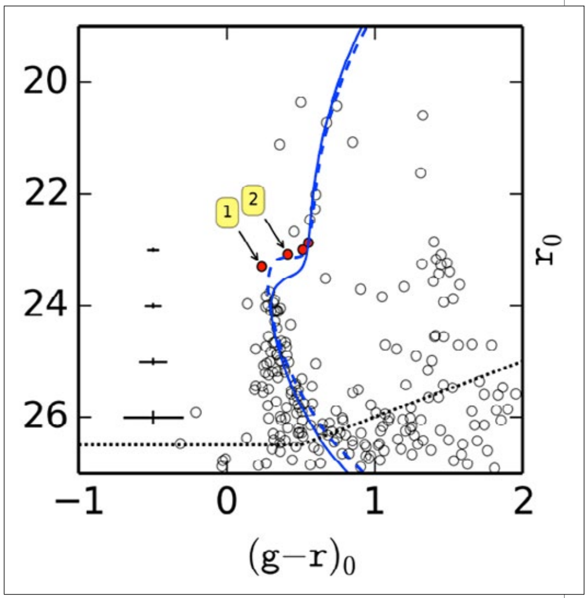

Figure 2.

Color-magnitude diagram of all stars within 1.3 arcminutes of the Kim 2 cluster center, from GMOS-S observations. The main sequence is well-defined, and the two best-fitting isochrones are overplotted (blue lines). Filled red circles mark candidate subgiant and main sequence turnoff members, and those labeled 1 and 2 are also located near the cluster center.

The lower luminosity ($M_V \sim -1.5$) and higher metallicity ([Fe/H] ~ –1.0) compared with typical Milky Way globular clusters suggest that Kim 2 was previously located in a dwarf Milky Way satellite galaxy and only recently accreted into the halo of our Galaxy. These characteristics are similar to other clusters associated with the Milky Way's dwarf satellites and tidal streams. In addition, as a low-mass cluster, the relaxation time (~1.1 billion years (Gyr)) is much shorter than its age (~11.5 Gyr), providing sufficient time for dynamical mass segregation, which is observed.

The cluster was discovered as part of the Stromlo Milky Way Satellite Survey, using the Dark Energy Camera (DECam) at the Cerro Tololo Inter-American Observatory. This work surveys large areas of the sky and uses processing algorithms to search preferentially for old and metal-poor overdensities. Director's Discretionary Time using the Gemini Multi-Object Spectrograph (GMOS) on Gemini South rapidly enabled deep follow-up observations to yield a significant color-magnitude diagram of the cluster. The main sequence is well defined to magnitude 26.5 (Figure 2), containing candidate subgiant and main sequence turnoff members, but no clear subgiant or red giant branches.

Full results are posted in a ***preprint*** and will be published in *The Astrophysical Journal*. A Gemini press release is also ***available***.

An Extremely Massive Black Hole in an Extremely Distant Quasar

Infrared observations with the Gemini North telescope have confirmed a 12 billion solar mass black hole in an exceptionally bright quasar in the very early universe. The team used Gemini, as well as telescopes from around the world, to discover and characterize this extremely massive black hole at redshift $z = 6.3$, only about 875 million years after the Big Bang.

This result requires extremely rapid growth of the black hole. While black holes of comparable mass have been observed — after they have had billions of years to gradually gain mass over cosmic history — this quasar challenges astronomers to determine how such a huge object could exist so early in the history of the universe. Mass accretion at the Eddington limit, over most of cosmic time, is required to reach the large mass at this early epoch.

Color selection in optical and infrared imaging surveys identified the target as a candidate high-redshift quasar, which the team, led by Xue-Bing Wu (Peking University, China), followed with multi-wavelength spectroscopic observations. The near-infrared observations from both the Gemini Near-Infrared Spectrograph (GNIRS) on Gemini North, and the Magellan Telescope, show the emission of ionized magnesium (Mg II), which was used to estimate the black hole mass from scaling relationships applicable to quasars. In addition to standing out for its extreme black hole mass, this quasar, SDSS J010013.02 + 280225.8, is exceptionally luminous, having a bolometric luminosity greater than 10^{48} ergs per second; it is in fact the most luminous one known at $z > 6$. This work is published in *Nature* (***Vol. 518, p 512***).

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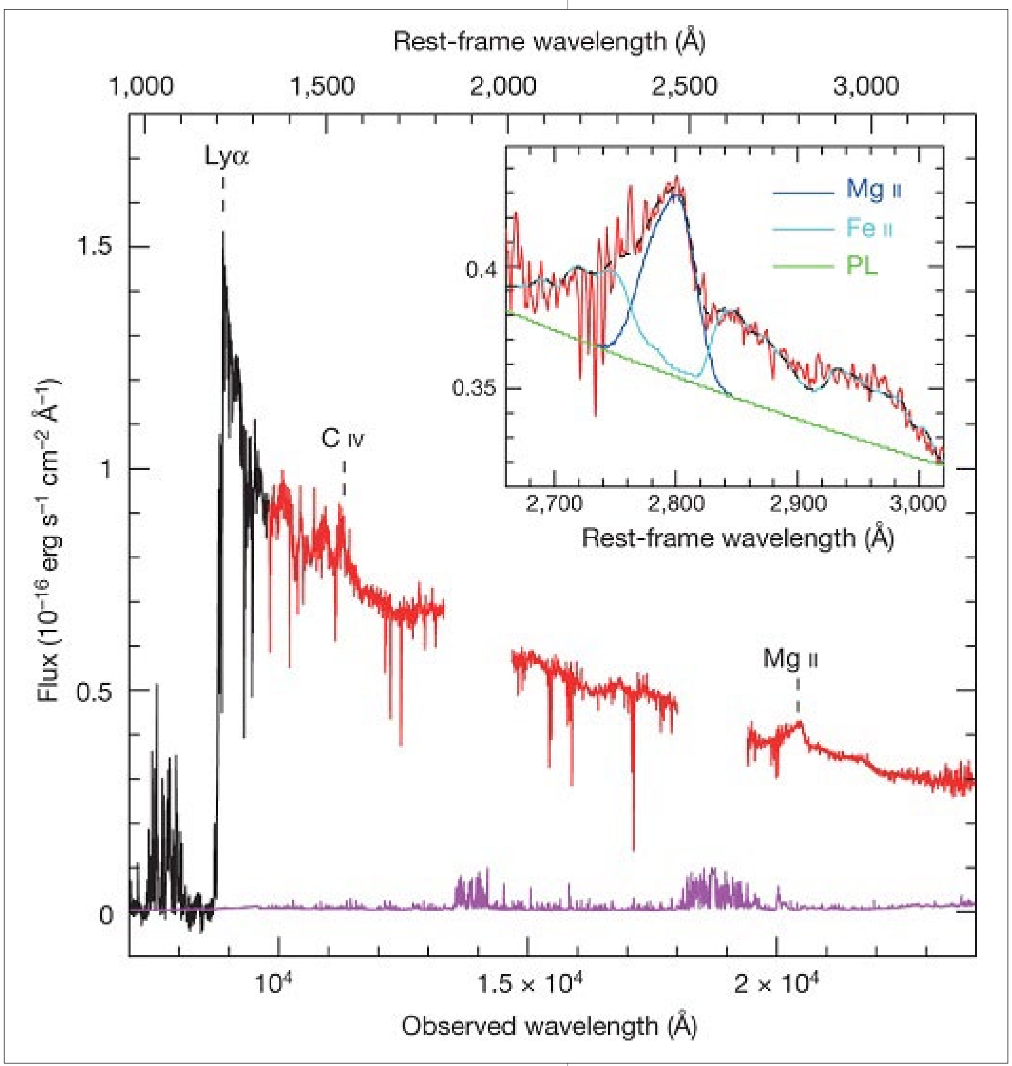


Figure 3. *The spectrum of quasar SDSSJ010013.02 + 280225.8, obtained using the Gemini Near-Infrared Spectrograph combined with observations from the Magellan Telescope, appears in red; gaps are regions of low sky transparency. The optical spectrum (from the Large Binocular Telescope; black) and noise (magenta) are also plotted. The inset shows the three components of the fit to a portion of the near-infrared emission. The ionized magnesium (Mg II; blue) emission is used to estimate the extremely large black hole mass, of 12 billion times the mass of the Sun. Figure credit:* Nature.

Gaetano Sivo, Vincent Garrel, Rodrigo Carrasco, Markus Hartung, Eduardo Marin, Vanessa Montes, and Chad Trujillo

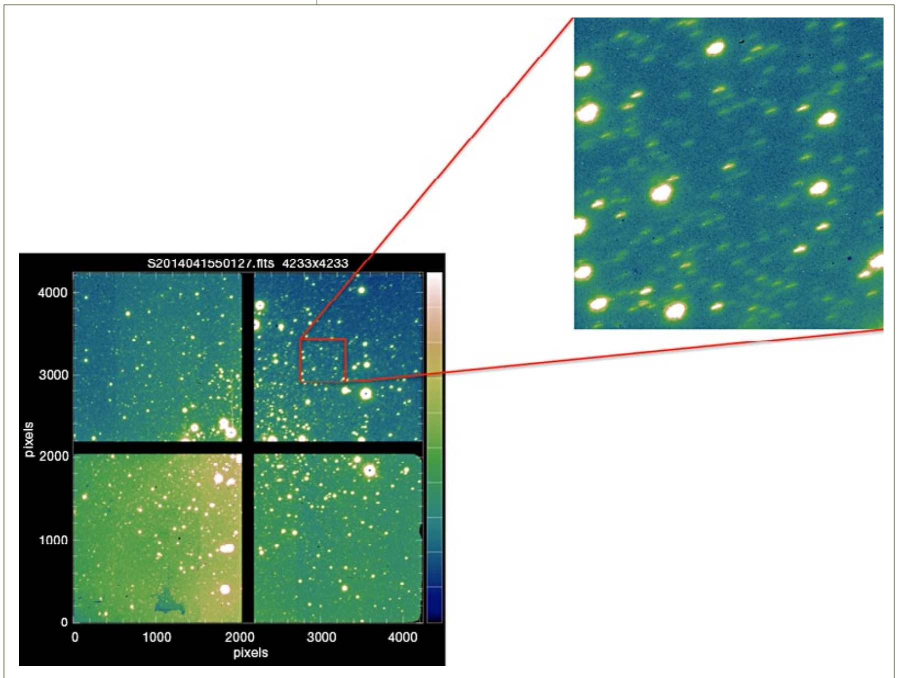
News in Adaptive Optics at Gemini South

Adaptive optics (AO) activities conducted during last year at Gemini South have not only improved image quality but also resulted in some exciting recent science (see this issue's feature article on young star clusters starting on page 3, and the Science Highlight on page 8) obtained with the Gemini Multi-conjugate adaptive optics System (GeMS) coupled with the Gemini South Adaptive Optics Imager. Future AO activities are expected to expand dramatically at Gemini South once the Natural Guide Star system for GeMS is upgraded and a more reliable laser is installed.

Adaptive optics systems rely on laser guide star wavefront sensors (LGSWFS) for high-order measurements of distortions to starlight caused by Earth's atmosphere. Of course precise alignment of the system is critical for optimal performance. During the winter (Southern Hemisphere) telescope shutdown of 2013, the AO group decided to realign the CCD and lenslets assembly of the LGSWFS; we had calculated that the system's collimator and lenslets were offset by 1.8 centimeters, which corresponds to a misconjugation of about 51 (km) on the sky.

A Puzzling Image Quality Issue with Canopus

Post shutdown, the laser beacon showed a Rayleigh pattern on the LGSWFS that appeared physically impossible. This first led the AO team to believe that a pixel was swapped inside a quadcell subaperture used to center the laser beam to a certain spot. Even if this were the case, the reconfiguration of the WFS introduced unwanted side effects, so the AO team reverted very quickly to the original configuration, which required two additional days of work on the telescope.



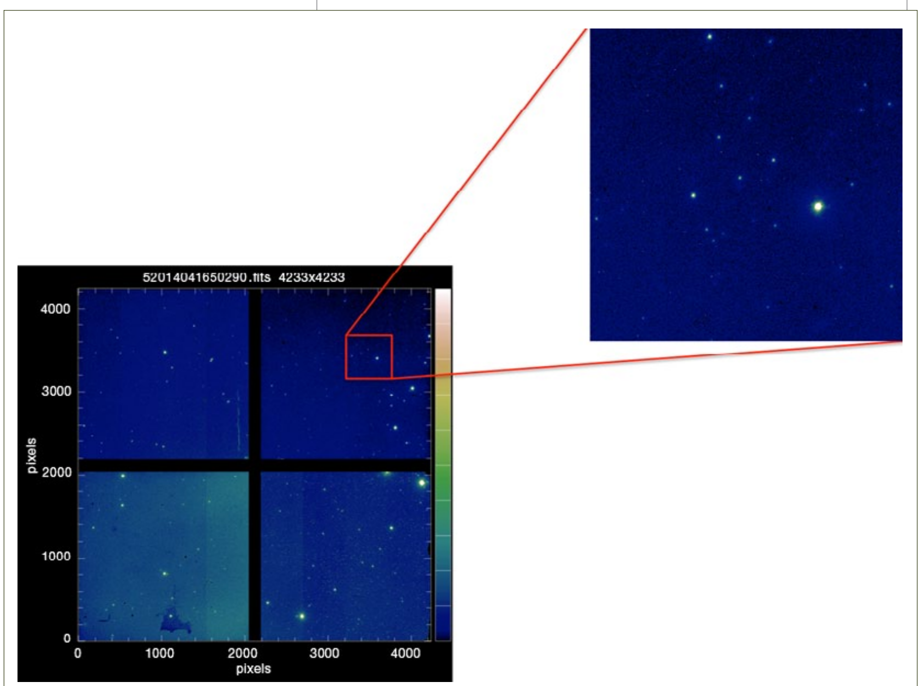


Figure 1:
Example of the elongation issue present on GeMS/GSAOI images.

Figure 2:
GeMS/GSAOI image using a ground-layer adaptive optics reconstructor.

In early 2014, during the first run of Semester 2014A, our team discovered that stars imaged with the Gemini South Adaptive Optics Imager (GSAOI) were elongated especially at the edges of the field, yielding poor performance (up to 250 milliarcseconds). One of the issues uncovered was an incorrect procedure used for saving Zernike coefficients (that control the figure of the Gemini South 8.1-meter primary mirror (M1)). Figure 1 illustrates the image elongation issue.

Once the M1 model was fixed, we still had a somewhat intermediary situation, where elongation was present, but to a lesser extent. After a few simple tests, we determined that the LGSWFS system was the problem, since running GeMS with only the Deformable Mirror (DM) conjugated to 0 km (DM0), used essentially in a ground layer adaptive optics mode, showed no signs of the elongation seen while running in a full MCAO mode with DM at an altitude of 9 km (DM9; Figure 2).

This indicated that we had something odd coming from the LGSWFS that was being offloaded to the DM when conjugated to an altitude of 9 km (DM9). During two further runs in 2014 (May and June), we acquired some science data using a software patch that removed a semi-static shape on the DM9. As several optical phenomena could cause this issue, the AO team decided to shutdown the GeMS system in concert with the general telescope shutdown and proceed with a more thorough investigation inside Canopus — the AO bench that is the heart of GeMS.

To maximize the effectiveness of this shutdown, we approached previous GeMS AO team members François Rigaut, Benoit Neichel, and Marcos van Dam, all of whom agreed to assist the current AO team in diagnosing and correcting the issue.

Finding the Source, and a Solution, for the Elongation

During August 2014, we removed Canopus from the telescope and installed it in the instrument laboratory on Cerro Pachón. After several tests, we found that its five field stops were not properly aligned with the rest of the optical train, thus vignetting the beam. The vignetting pattern was different for each of the five WFS, which explained the unusual semi-static pattern on DM9.

The field stops are extremely difficult to reach, as they are enclosed in a mechanical set positioned between two lenses, a consequence of the compact design of the Canopus optical bench. Rather than adjust the field stops, the other option we identified was to realign the CCD behind each LGSWFS and the calibration source. Doing this, we realized, would restore alignment to the calibration source, the field stops, and the CCDs.

We proceeded with this option because (1) it was the least invasive, and (2) the LGSWFS CCDs were the easiest elements to move. We then remounted Canopus on the telescope and waited for the telescope shutdown to end.

During the first post shutdown GeMS observing run (September 2014), we confirmed that the realignment of the CCDs had indeed removed the elongation issue (Figure 3). Since then, several successful science runs with the system have produced excellent results. Figure 4 illustrates the level of performance that the system can now provide.

Future Plans for GeMS

A New Natural Guide Star WFS System

The AO team at Gemini, with collaborators from the Australian National University, is currently working on upgrading the Natural Guide Star Wave Front Sensor (NGSWFS) system. This upgrade will allow the system to use natural guide stars as faint as magnitude 17.5 — a gain of about two magnitudes over the current NGSWFS. This gain will increase AO sky coverage by a huge margin, while opening up many extragalactic science opportunities; up to 50 percent of the sky around the Galactic poles would be available with at least one guide star.

A More Reliable Laser

The laser currently used in Gemini South is a 50 Watt (W) sodium laser created by non-linearly combining two infrared beams inside a crystal. Since its infancy, the laser

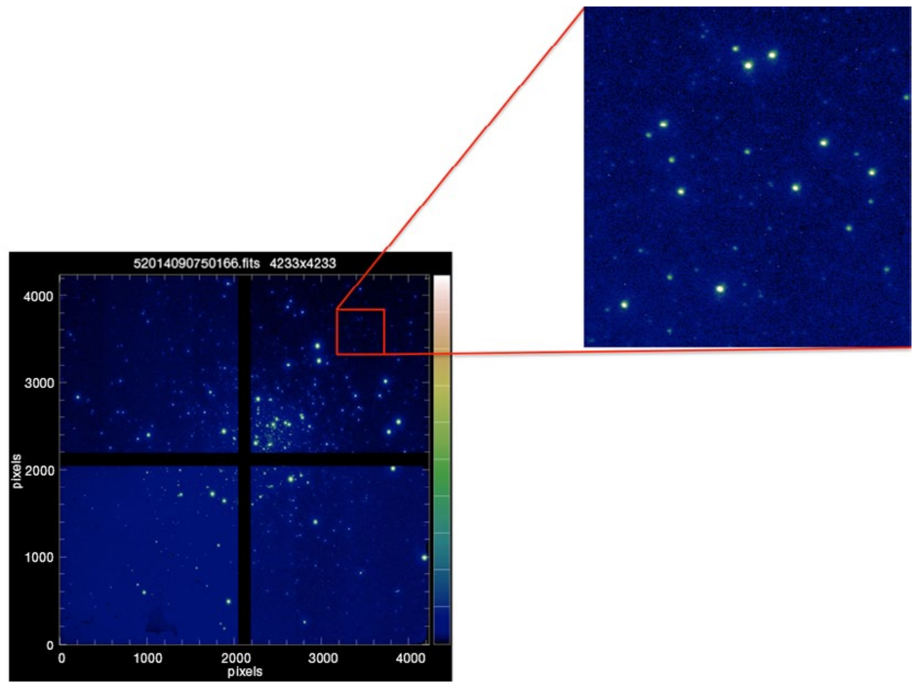


Figure 3.
Post shutdown GeMS/GSAOI image.

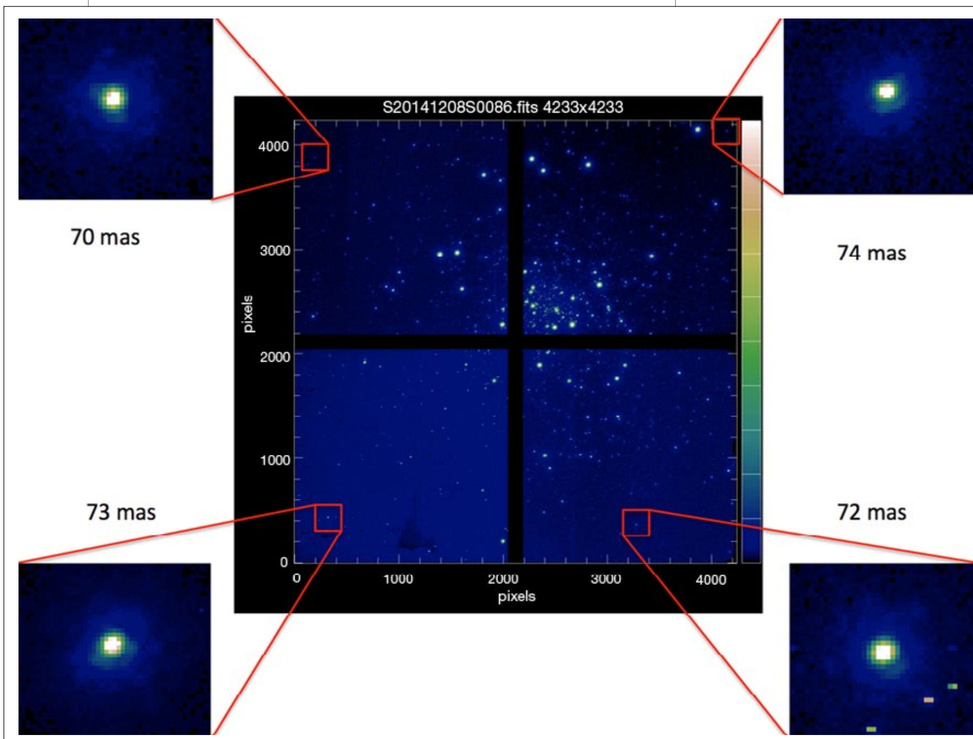


Figure 4.
Performance results achieved using GeMS/GSAOI. ~75 mas in the whole field-of-view.

has required a well-qualified technician to perform the necessary (and precise) optical alignments. After the unfortunate passing of our colleague, and friend, Vincent Fesquet — who was the laser specialist at Gemini South and the keystone of the laser's maintenance — Gemini has committed a huge effort to maintain the laser. This commitment included four external contractors, and utilized help from Gemini North staff. This has allowed sustained operations, but at a level that is somewhat disappointing. To date we have not been able to maintain a laser output higher than 35 W, even requiring the cancellation of two runs over the past year.

The goal now is for Gemini to replace the existing laser with a more sustainable upgrade. A dedicated team is overseeing a feasibility study to consider replacing the current GeMS laser with a more reliable version using the most recent technologies.

Despite the challenges presented in this article, the GeMS system has already produced some exciting science. This bodes well for the system's future potential, especially with the improvements described here. Examples of recent science is presented in this issue in the article starting on page 3 and in the Science Highlight on page 8.

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Contributions by Gemini staff

News for Users

Get your proposals ready for 2015B as well as ideas for the return of the visiting instrument DSSI (Differential Speckle Survey Instrument) late in Semester 2015B. In addition, the first observations by Korean Principal Investigators with Korea as a limited-term partner have begun, and finally, the Gemini IRAF package will make data reduction easier on several fronts.

Semester 2015B Call for Proposals Released

The Call for Proposals for 2015B is out, and we welcome proposals from our user community (*see link*). Besides the standard facility instrument offerings, this call draws attention to the following new and notable capabilities and announcements:

- GRACES, the Gemini Remote Access to the CFHT ESPaDOnS Spectrograph (via a fiber feed from Gemini North) will be offered for optical spectroscopy between 400 and 1000 nanometers, with an average resolution of R = ~67,500. This is in a visiting, block-scheduled mode.
- The non-redundant mask for the Gemini Planet Imager, is planned to be commissioned and characterized in 2015A, and offered for common use in 2015B.
- New Large and Long program proposals will be accepted for observations beginning in 2015B.
- The visiting Differential Speckle Survey Instrument (DSSI) will be available late in Semester 2015B (see details later in this article).
- The "Bring One, Get One" program will continue in 2015B. Gemini will subsidize up to US $2000 for the travel expenses of individual undergraduate or graduate students and other early-career observers, when accompanying a senior observer to Gemini North or South.

Please see the relevant instrument pages and subsections of the Call for Proposals page linked above for more details.

Speckle Imaging Available Late in Semester 2015B!

The visiting Differential Speckle Survey Instrument (DSSI) has become a fixture at Gemini in the middle of each of the previous two years. The instrument, which provides diffraction-

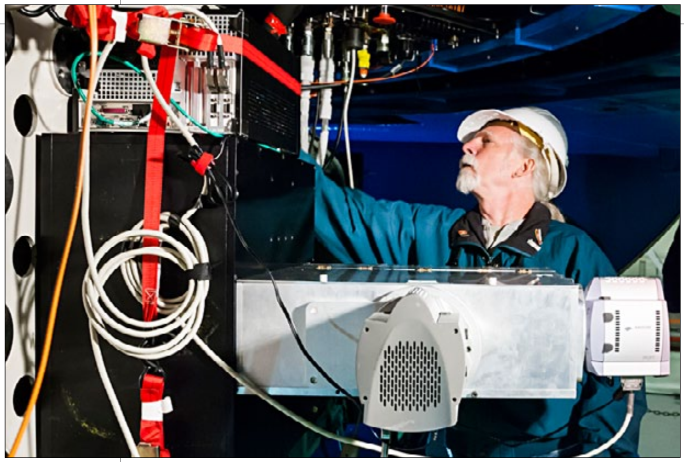


Figure 1.
Principal Investigator Steve Howell works on DSSI at Gemini North during a previous visit of the instrument.

limited visible imaging at two wavelengths simultaneously, was designed as a follow-up camera for confirming objects of interest discovered by NASA's Kepler exoplanet discovery mission (by ruling out chance coincidences of a Kepler field star with a background variable, for example). Although DSSI was usually scheduled to coincide with the observability of the Kepler field, in Cygnus, the camera has been used on a wide variety of science during runs undertaken to date. For Semester 2015B, the team (led by Steve Howell and Elliott Horch of the NASA-Ames Research Center and Southern Connecticut State University, respectively) has proposed bringing DSSI to Gemini late in the semester. This will open up new regions of the sky, and potentially some exciting new astronomy (including the follow-up of Kepler mission results). Check out the capabilities of DSSI, via this ***web page linked on the Instruments' page***.

Figure 2.
The first Korean observing team at Gemini North, shown here while making observations in March.

First Korean Time on Gemini

This semester, Gemini welcomes its first limited-term partner: Korea. The Korea Astronomy and Space Science Institute (KASI) has taken on the job of coordinating the vetting of proposals from all over Korea and producing "miniqueues," which will be executed in pre-scheduled blocks of time on both Gemini North and Gemini South.

The first block was scheduled for March at Gemini North (just before this issue went to press). The Korean community showed great interest in observing at Gemini North and a total of seven Principal Investigators or Co-Investigators, plus three KASI staff, helped with implementation of the programs during an intense week carried out in Priority Visitor observing mode (see Figure 2). The science is varied — star clusters, active galactic nuclei, galaxy clusters, high-redshift galaxies, *etc.* — but mostly of extragalactic nature. The Gemini Multi-Object Spectrographs (both North and South) dominated the proposal statistics.

Welcome, Korea, and we hope this relationship is long and fruitful.

Gemini IRAF Software Package Released

A new version of the Gemini IRAF software package (v1.13) for data reduction has been released (January 29, 2015) and is available. This full release supersedes the recent commissioning and patch releases.

Of special note, this latest release will support GMOS-S Hamamatsu data, with quantum efficiency corrections, provide new and improved tasks in support of GMOS integral field unit data reduction, and offer better handling of variance and data quality planes throughout the GMOS package.

The new package is available for download on ***this web page***.

Rachel Mason

Fast Turnaround Program Pilot Underway

The new Fast Turnaround program enjoyed a successful launch and is proving popular with our user community. Work continues behind the scenes to monitor and improve the process, including the novel peer review scheme.

In the October 2014 issue of *Gemini*Focus we reported on progress towards launching the Fast Turnaround (FT) program. The pilot scheme is now well underway, and we are pleased to report that participation and feedback have been encouraging so far.

To recap, the FT program offers monthly opportunities to submit proposals for observations that will be executed starting roughly a month after each proposal deadline. To enable this rapid response, proposals are reviewed by the Principal Investigators (PIs) or designated Co-Investigators of other proposals submitted during the same cycle. The experimental scheme has been in operation at Gemini North since January of this year, accounting for 10 percent of the available telescope time for Argentina, Brazil, Canada, the University of Hawaii (UH), and the rest of the US community.

The FT program moves quickly, and we are constantly gaining experience and receiving feedback. This article is therefore necessarily a snapshot of the first few weeks of the system. With that in mind, the following is an overview of the first 1.5 cycles.

Cycle Overview

The first Call for Proposals, with a January 31st deadline, elicited an enthusiastic (and encouraging) response. We received 17 valid proposals, requesting 60 hours of observing time. Since Gemini dedicates three nights per month to the program, and because the weather loss on Maunakea is typically in the range of 25-30 percent, the response corresponds to an oversubscription factor of about three. The science areas covered by the proposals were very diverse, as were the reasons for asking for FT time. Some of these include:

- obtaining data to complete a thesis or get the last pieces of data needed to complete a paper;
- compensating for an observing run lost to poor weather at another telescope;
- conducting pilot observations or gathering information for upcoming standard proposals;
- complementing multi-wavelength monitoring campaigns;
- and, finally, simply pursuing topics of interest to the submitting PI.

On the other hand, the proposals were generally short (all but one asking for less than about six hours). Roughly 75 percent requested the Gemini Multi-Object Spectrograph (GMOS), and most came from the mainland United States. This is not to say that the other partners were not represented; Canada, Brazil, and UH also participated in this first cycle.

The mix of proposals received for the second call, due at the end of February, was somewhat different, with more emphasis on infrared instrumentation. Slightly less time (54 hours) was requested overall from the 12 proposals submitted. We speculate that the oversubscription of the FT program will eventually self-regulate, with high values discouraging people from submitting proposals (too much work for too small a chance of success) and low values having the opposite effect ("free" telescope time!). It will also be interesting to see if the regular (semester-based) proposal deadline at the end of March has any effect on the number of FT proposals received for that cycle.

On Trial: Fast Turnaround Peer Review

The peer review process is the most novel, high-profile, and little-tested, aspect of the FT program, and we have been watching it unfold with great anticipation.

Would there be signs of bias and unfairness in the system? Would the reviewers all submit on time? Would the reviewers choose the "right" proposals?

Reviewers are assigned eight proposals each, which they must grade from 0 (poor, do not observe) to 4 (excellent, must observe). They also must provide a brief written review and assess their own knowledge of the subject area on a scale of 0 ("I know little about this field") to 2 ("I work or have recently worked in this field").

It's too early for a statistically sound analysis of the process. However, it does appear that most of the reviews — which are returned anonymously to the PIs — have been thoughtful and useful. Of the handful of PIs who have filled in their feedback surveys so far, 75 percent report that the reviews they received were "mostly helpful," with 25 percent considering them to be "variable." A small fraction of reviewers essentially restated the proposals, or gave single-sentence assessments, prompting us to update the web pages with advice about how to write a helpful review.

We have also found that reviewers tend to weigh the need for rapid response more highly than instructed. A main aim of the program is to enable good science, whether that means timely observations of an object that is swiftly fading, or simply taking data for a project that the researcher is excited about right now. Whether a program is time-critical is intended to be a secondary consideration. We are not sure why people are putting so much emphasis on this. Perhaps they feel that, to paraphrase the feedback of one early-career reviewer, "Time Allocation Committees [TACs] are better at judging proposals than we are, so only proposals that really need the FT program should go through this route." Or perhaps there's a psychological component, something like "my program really needs to be done soon, so why should it compete against something that can wait?" In any case, we have updated the instructions to emphasize that the need for a quick response is not paramount. Time will tell if this works.

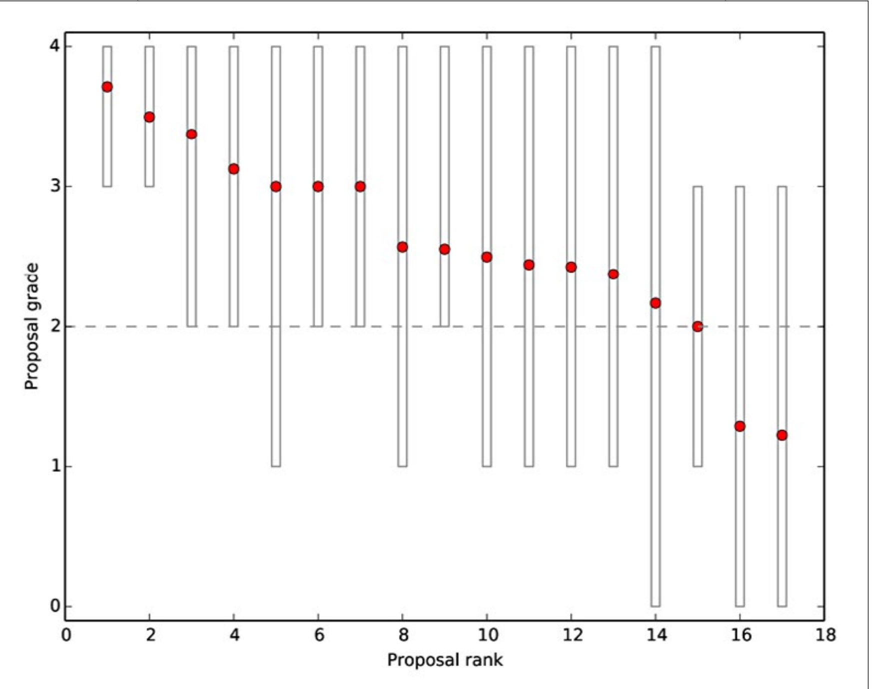


Figure 1.

Mean proposal grade vs. proposal rank for the first FT cycle. The vertical bars show the range of scores received by each proposal (on a scale of 0-4), and the dashed horizontal line indicates the cutoff score that any proposal must reach in order to be awarded telescope time.

Although we don't yet have a lot of data to work with, in true astronomer fashion we haven't been able to resist the temptation to start analyzing the numbers we do have. Figure 1, for instance, shows the mean proposal grade vs. proposal rank for the first FT cycle. Clearly, the dispersion in grades is rather large for most of the proposals. However, a couple of things stand out. The top two proposals were uniformly recognized to be very good or excellent, and the three lowest-ranked proposals were not rated as excellent by any of the reviewers. This roughly mirrors what many people say about proposal assessment mechanisms in general: the top and bottom proposals are easy to recognize, while those in the middle elicit much less agreement.

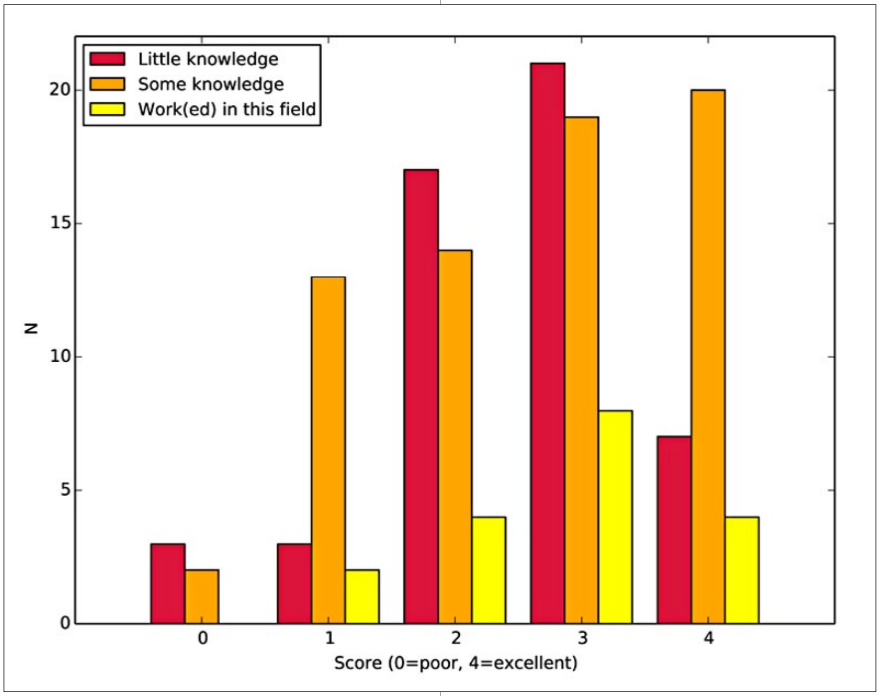
One concern that we have heard from the community is that non-expert reviewers may be too easily swayed by a proposal and unable to recognize its flaws. Figure 2, which shows the number of times each score was awarded, separated by the reviewer's self-proclaimed expertise, allows us to look for signs that this is the case.

If anything, it seems that the opposite may be happening; the lowest scores were given almost exclusively by reviewers who consider themselves not to be particularly familiar with the subject area of a proposal. While data from more FT cycles are certainly needed to show whether this trend persists, prospective PIs may wish to ensure that their proposals are accessible to a broad, non-expert audience.

Figures 1 and 2 also show that most reviewers thought most proposals were "good" or better. Some have wondered whether people will exploit the peer review system to give competing proposals unfairly low grades. We see no evidence of this so far, although we will continue to monitor carefully.

Others have questioned how the quality of FT proposals will compare to that of "regular" Gemini proposals. Will the people with the best ideas be wary of the peer review system? To gauge this, the feedback survey asks how the FT proposals compare to other proposals the reviewers may have judged in the past. Of the reviewers who have replied so far, all reported that the FT propos-

Figure 2.
Histogram of proposal scores, separated by reviewers' self-declared level of knowledge of the subject area.



als were largely similar in quality with those they have assessed elsewhere. For an independent (if subjective) measure of this, the successful proposals are also being sent to two (former) members of Gemini TACs.

Seven out of 17 proposals were accepted during the first cycle. The FT team's job was to assess the technical feasibility of the top-ranked proposals, and then figure out which ones could be accepted given all the potential conflicts between a target's right ascension, observing conditions, GMOS gratings, *etc.*, while sticking as closely as possible to the peer review rankings. We were relieved that in the end it was feasible to select the seven top-ranked proposals.

Also on Trial: Success of Accepted Programs

Once selected, we need to observe the accepted programs. As one (otherwise positive) first cycle participant commented, "The verdict is out until we see whether the queue actually collects most of the data for the approved Fast Turnaround programs."

Indeed, we have to (sadly) report that the first scheduled FT observing block (March 9-11) is being wiped out, as this is written, by a blizzard so severe that even the road-clearing crew can't reach the summit of Maunakea. FT observations remain valid for three months, but still it's unfortunate to have lost the first block to winter weather.

At this point, you might be asking why we don't simply merge the FT programs with the regular queue, instead of reserving distinct nights. There are several reasons for this.

First, unpredictable weather losses mean that observations pile up at certain right ascensions as the semester progresses. To avoid PIs writing proposals for regions of the sky that already have too many queue programs to complete, we would have to track this and make the information available for FT PIs every month. Not only do we not have appropriate tools to do that, but our data would always be out of date by the time the proposals were accepted.

Second, separating queue and FT programs means that their relative priorities are clear.

A highly-ranked FT program is not competing against an already-started Band 1 queue program, and vice versa.

Third, we value the transparency the present system provides. We can very clearly state what happened to the FT programs during their observing nights, rather than having them "disappear" into hundreds of hours of other programs. We may have to rethink this approach, as we see how things progress, but for now we'll simply monitor and evaluate.

Monitoring the FT program will be an important part of our team's work in the next few months. We'll be gathering statistics, soliciting user feedback, and also preparing a report for the oversight committees' meetings in May. Once we have sufficient data for a reliable evaluation, we (in conjunction with the oversight committees) will make a decision about the program's future — should it continue in similar or modified form? Be scaled up and expanded to Gemini South? Or be stopped entirely?

We will be sure to share our evaluation and assessment with our user communities. Meanwhile, regular updates can be found on the ***FT blog***.

Rachel Mason is an associate astronomer at Gemini North. She can be reached at:
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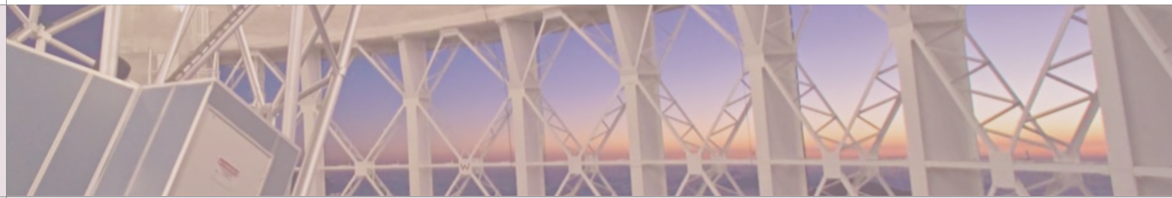

Contributions by Gemini staff

On the Horizon

New developments in Gemini's instruments of the future are carrying the Observatory closer to achieving its goals. GHOST is planning its critical design review by year's end. Base Facility Operations work packages are on schedule. Hamamatsu has completed the new CCDs for GMOS-N. And the Gemini Instrument Feasibility Study project is progressing with contract agreements pending.

Progress on GHOST

The Gemini High-resolution Optical SpecTrograph (GHOST) is moving into the project's critical design stage this month. The design team — led by the Australian Astronomical Observatory and also consisting of Canada's National Research Council-Herzberg and the Australian National University — has been implementing project-strengthening recommendations made in January by the project's preliminary design review committee. The project should be prepared for a critical design review by the end of the year.

Base Facility Science Operations Taking Shape

Gemini's Base Facility Operations (BFO) project — tasked to *design, fabricate, procure, integrate, test, and commission all systems necessary to remotely operate all observatory systems required for Science Operations from the Base Facilities with little or no human presence at either summit* — is on schedule. The majority of the 19 work packages (including systems to continuously monitor environmental and telescope conditions and to control critical telescope functions safely, among other tasks) are reaching the end of the design phase before they enter into the implementation phase; one of the largest (Telescope Systems Remote Switch) is nearly ready to start the first round of tests. In the coming months we will see some of the BFO's staff from Gemini South visit Gemini North to collaborate on the project. Most of the hardware work should take place towards the end of the second quarter of 2015.

We will deliver new features as the testing and verification milestones are completed, so that the nighttime staff can begin using them. This will provide us with the opportunity to improve or adjust the new systems, if needed, to suit nighttime operations even before BFO is fully deployed.

The Transponder-Based Aircraft Detection (TBAD) system work package, which will eliminate the need for manually spotting aircraft during laser runs, is almost finished. We expect to have our first laser run relying on TBAD in June (see Figure 1).

GMOS CCD Updates — North and South Generation Laser

Hamamatsu has completed the new CCDs for the Gemini North Multi-Object Spectrograph (GMOS-N). The first detector arrived in Hilo in February and we are testing its performance. If the tests are successful, we will be authorizing Hamamatsu to send the remaining CCDs shortly thereafter. This first set of tests is necessary to verify performance because Hamamatsu could not guarantee or test all the specifications we require to ensure a successful upgrade.

A possible solution to the saturation issue seen in the GMOS-South (GMOS-S) CCD installation is now being tested both in the lab and at Gemini South; it involves using a new version of the Astronomical Research Camera video board used in the GMOS-S installation. Once proved for GMOS-S, we will then deploy the fix for the GMOS-N installation. Because of the CCD testing and controller solution uncertainty, we don't know exactly when the GMOS-N CCDs will be installed, but if everything works as planned from here on out, we're now on track for installation during the third quarter of 2015.

GIFS Project Continues

The Gemini Instrument Feasibility Studies (GIFS) project continues to make solid progress since the last edition of GeminiFocus. Gemini received eight highly competitive proposals by the December 15, 2014, deadline.

An independent panel of six experts — including members from the Gemini Board of Directors, the Science and Technology Advisory Committee, and the Large Synoptic Telescope Survey — were asked to evaluate the proposals on behalf of Gemini Observatory, using the selection criteria contained within the request for proposals.

Figure 1.
Paul Hirst coordinates with the ground crew at Gemini base and Maunakea facilities during the TBAD (Transponder-Based Aircraft Detection) overflights of Gemini North on Saturday March 28, 2015.

An evaluation report was sent to the Gemini Director for endorsement. The quality of the proposals was so high that Gemini decided to allocate additional funds and internal resources to fund and support a fourth study; only internal resources stopped us from funding a fifth.

Strictly following clauses in the Request for Proposals, Gemini contacted the leading teams to negotiate any contract clauses. This process is still ongoing at the time of writing, with an expectation that the process would be completed during the first week in April. As soon as this process concludes, Gemini will publicly announce details of the funded studies.

Within two weeks of the contracts being signed, Gemini and each study team will hold a kickoff meeting to discuss the requirements of the study and aspects of the team's proposal.

The teams will present their works in progress for discussion among the broader community at the Toronto Future and Science of Gemini meeting, and we encourage potential users to be there to contribute and give their feedback.

To learn more about GIFS and to see how you could be involved, contact Stephen Goodsell at: *sgoodsell@gemini.edu*.


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
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Registration and information: www.gemini.edu/fsg15

Janice Harvey

Journey through the Universe

Gemini North's flagship local outreach program launches into its second decade with unflagging support from the community and Maunakea observatories.

Jeff Donahue, Gemini's senior optics technician, explores the properties of light with students at Hilo Union Elementary School as part of a Journey through the Universe *classroom presentation.*

2015 ushered in the second decade of *Journey through the Universe* on the Big Island of Hawai'i. During our 11th year of "Journey" week, over 50 astronomers, engineers and observatory staff continued to inspire and engage thousands of local Hawai'i students (over 5000 this year!)

Since its conception 11 years ago, Journey has partnered successfully with Hawai'i Department of Education's Hilo/Waiakea School Complex, to augment its science curriculum and spark an interest in astronomy and Science, Technology, Engineering and Mathematics (STEM)-related initiatives. District Superintendent Valerie Takata elaborates, "Our schools' stellar partnership with the observatories, business organizations, and community is Journey through the Universe's STEM initiative. As part of the educational system," she continues, "our complex area is overwhelmed with appreciation for the enthusiasm and energy this initiative has generated for our schools… students, teachers and administrators, and families. This concerted effort has made this grassroots program a sustaining reality as we move into our second decade. We humbly thank the community for their continued support as we all work together toward common goals and building a better future."

As Takata so eloquently explained, this stellar outreach initiative has a broad impact on our community. Following is a sampling of the events that lit up the Hilo schools and community with our STEM-inspired outreach activities.

We welcome you to become a part of our Journey team. For more information please visit [**www.gemini.edu/journey**](http://www.gemini.edu/journey).

Janice Harvey is the Community Outreach and Education Programs Leader at Gemini North. She can be reached at: jharvey@gemini.edu

Gemini astronomer, Chad Trujillo, demonstrates the scale of our Solar System to 3rd grade students at Ha'aheo Elementary School.

Honoring Janice Harvey, a Gemini "Shining Star!"

At the annual Hawai'i Island, and Japanese Chamber of Commerces' Journey celebration, attended by a record number of Journey participants and local businesses, Gemini North's Community Outreach and Education Program Leader Janice Harvey received the Department of Education's prestigious Shining Star award (inset). In the photo, Hawai'i State Department of Education Superintendent Kathryn Matayoshi (right), and District Superintendent Valerie Takata (left) present the award to Janice for her hard work and devotion to the Journey program. The award recognizes outstanding service and dedication to education in Hawai'i and as Gemini staff know, Janice's efforts are indeed stellar. We are especially proud of her seemingly infinite ability to share our work and inspire the future of students.

— Peter Michaud

For his presentation at Hilo High School, Gemini Director Markus Kissler-Patig discusses how, when looking for life in outer space, we might first look at Earth's own extreme life forms.

Gemini science operations specialist Michael Hoenig uses an infrared camera at a 5th grade class at Hilo's De Silva Elementary School to demonstrate how astronomers observe the universe in different types of light.

Gemini North's local outreach assistant Christine Copes helps an interested visitor build an origami cube featuring Gemini images at the annual Journey Family Science Day. The event, which attracted over 2300 participants, is a partnership with the 'Imiloa Astronomy Education Center.

Hawai'i State Department of Education Superintendent Kathryn Matayoshi participates with a 4th grade class at Keauakaha Elementary School in Hilo as students build and explore a 3-D constellation using wooden beads hanging from strings. The demonstration was led by Gemini's André Nicolas-Chené (not shown).

Gemini North's Public Information and Outreach Manager Peter Michaud enlightens 6th graders at Hilo Union Elementary School as they design and build simple spectroscopes to explore light.

Maunakea (snowy peak at center) and Maunaloa (rear left) taken by Gemini's Joy Pollard at the end of the TBAD test flight, March 28, 2015 (story page 22-23).

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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