GeminiFocus

2014 Year in Review

Publication of the Gemini Observatory | January 2015

GeminiFocus

GeminiFocus January 2015

GeminiFocus is a quarterly publication of Gemini Observatory

670 N. A'ohoku Place, Hilo, Hawai'i 96720 USA
Phone: (808) 974-2500   Fax: (808) 974-2589

Online viewing address:
www.gemini.edu/geminifocus

Managing Editor: Peter Michaud

Science Editor: Nancy A. Levenson

Associate Editor: Stephen James O'Meara

Designer: Eve Furchgott / [Blue Heron Multimedia]()

The cover of this issue features a striking new image from Gemini that peers into the heart of a galaxy group known as VV 166. The image brings clarity and definition to the different morphological types in VV 166 despite its great distance of about 300 million light-years. One of its most fascinating features is a perfect alignment of three disparate galaxies in a precise equilateral triangle, including the giant blue spiral NGC 70 at top. Despite the apparent diversity of galaxy types in VV 166, the relative proportions of morphologies that we see in it may represent the distribution of galactic types throughout the universe. Also shown are covers of the three previous issues of GeminiFocus, 2014.

1 **Director's Message**
Markus Kissler-Patig

3 **Why Do Galaxies Stop Forming Stars in Massive Clusters?**
Adam Muzzin

8 **Gemini Captures Extreme Eruption on Io**
Katherine de Kleer

13 **GU Psc b: An Unexpected Planetary-mass Companion Discovered with GMOS**
Marie-Eve Naud and Étienne Artigau

18 **Gemini Helps Confirm First Earth-sized Planet in the Habitable Zone of a Star**
Elisa Quintana, Steve Howell, Tom Barclay, and Jason F. Rowe

23 **Science Highlights**
Nancy Levenson

34 **News for Users**
Gemini staff contributions

44 **On the Horizon**
Gemini staff contributions

54 **Fast Turnaround Program: It's About Time**
Rachel Mason

58 **Gemini Future and Science Meeting 2015**

60 **Bring One, Get One: Engaging Gemini's Users and Their Students**
Peter Michaud

62 **gAstronomy and Exoplanets**
Peter Michaud

64 **Viaje al Universo**
Peter Michaud and Maria-Antonieta García

67 **Fostering Career Opportunities within Our Local Community**
Peter Michaud

70 **Creating the Cosmos**
Lynette Cook

75 **Gemini's Journey through the Universe Reaches a Giant Milestone**

Markus Kissler-Patig

Director's Message

2014: A Successful Year — 2015: Exciting Prospects

As the end of 2014 nears we can proudly look back at a very productive and successful year for Gemini. In 2014, we brought our users several innovative programs, including a highly oversubscribed first round of Large and Long programs and the associated Priority Visitor mode (***viewable here***). The latter is working well and has now expanded into all of Gemini's regular programs. Gemini North cruised through the year with its four instruments and one adaptive optics system (almost making us forget about the unfortunate dome shutter failure events). Meanwhile, Gemini South caught up to its twin's full suite of four instruments by adding the Gemini Planet Imager to regular operations. This completes the telescope's four-instrument suite, in addition to the GeMS Multi-Conjugate Adaptive Optics System.

Gemini also introduced some subtle changes during 2014. For instance, for the U.S. user community, Phase II of the proposal preparation process is now supported by Gemini staff, rather than the National Optical Astronomy Observatory staff. We also started subsidizing students accompanying senior observers in the "Bring One, Get One" scheme (***viewable here***). Additionally, Gemini users can now exchange code, tips, and tricks through our new Data Reduction User Forum (***view here***).

In 2014, we also welcomed our first limited-term partner: the Republic of Korea, through the Korea Astronomy and Space Science Institute. Australia, which is not able to remain a full partner beyond 2015, also signed a limited-term partnership agreement (via Australia Astronomy Limited) to remain with Gemini as a limited-term partner through 2016.

Overall, we realized a welcome net gain in our user community in 2014.

But Wait…
See What 2015 Will Bring!

Starting in January, the long-awaited, and unique to Gemini, Fast Turnaround program begins (***view here***). For the first six months, we will test this mode with 10 percent of Gemini North's time. Once the program is well established, the plan is to expand the mode by offering it at both telescopes. Fast Turnaround programs will allow our users to submit proposals every month and receive data as early as six weeks after proposal submission. We very much look forward to the impact that this innovative mode will have on our users around the world!

In 2015, you, our users, will also have the opportunity to contribute directly to the future of Gemini. We encourage you to attend the "Future & Science of Gemini Observatory" meeting in Toronto (Ontario, Canada), from June 14th-18th. In addition to science presen-ta-tions, we are planning multiple discussions about Gemini's future and will present the results of the feasibility studies for our next facility-class instrument. Don't miss this op-portunity to be heard.

Invitations for the second round of Large and Long programs will also be solicited in 2015. Letters of Intent are due in early February, so watch the Gemini homepage for an announcement, or be sure to get the latest news by subscribing to Gemini's monthly e-newscast for users ***here***. Both priority visitor observing, as well as the "Bring One, Get One" scheme, will continue to be offered in 2015 — for Large and Long programs, as well as for regular ones.

We also look forward to expanding our range of instruments. In particular, we are delighted to offer high-resolution spectroscopy again in 2015B. Tests with GRACES (Gemini Remote Access to CFHT ESPaDOnS Spectrograph, our demonstrator link to the Canada-France-Hawaii Telescope's high-resolution spectrograph) were successful, and, in the Mauna Kea collaborative spirit, we came to an agreement with CFHT to access ESPaDOnS via our 300-meter fiber. (***See details here***.)

This being said, progress on our new high-resolution spectrograph, GHOST, is moving rapidly forward; with its preliminary design study concluded in the week of December 15th, it is expected to arrive at Gemini by the end of 2016. Furthermore, the Principal Investigators of our two visiting instruments in 2014 — the Differential Speckle Survey Instrument, and the Texas Echelon Cross Echelle Spectrograph — announced interest in returning; their in-struments will significantly enhance the capabilities we can offer to our users.

Finally, Gemini is not only "Exploring the Universe" but also "Sharing its Wonders." Our flagship annual local outreach program in Chile, Viaje al Universo, concluded a very successful week of activities in October, with thousands of residents, teachers, and students in attendance. Preparations for the long-running Hawai'i version, Journey through the Universe, are now ramping up for its 11th year. If you are in Hilo during the week of March 2nd, please contact Janice Harvey (***jharvey@gemini.edu***) and find out how you can participate.

Not only are we looking back at a productive year 2014, but we are very excited about all the remarkable things to come in 2015!

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

Adam Muzzin

Why Do Galaxies Stop Forming Stars in Massive Clusters?

Why galaxies in massive clusters stop forming stars has remained an unsolved problem for decades. Now, results from the Gemini CLuster Astrophysics Spectroscopic Survey (GCLASS) is providing a clearer picture of the events leading up to the quenching process.

It's not a complete mystery that several processes can occur to "quench" star formation in cluster galaxies. We know that galaxy clusters are filled with very hot, dense, X-ray emitting gas, and that as galaxies orbit the cluster, they pass through this medium. We also know that the pressure created can strip out the galaxies' own gas, which is needed to fuel their star formation; hence, if it is stripped, star formation ceases. We can even directly observe this process in action in some nearby cluster galaxies. But the details of exactly how this happens are sketchy at best.

Galaxies themselves are filled with hot diffuse gas throughout their dark matter halos. This gas is continually cooling to ultimately provide the cold molecular gas that ends up in their spiral disks to form stars. How this gas is stripped in galaxy clusters largely remains a mystery, however. The process may be strong enough to remove only the loosely bound gas in a galaxy's hot diffuse halo. If so, it will very slowly truncate the galaxy's gas supply; most disks contain enough cold gas to continue forming stars for an additional ~ 1 - 2 billion years (Gyr), if not replenished at all. Then again, the gas stripping process could be more violent and able to re-move both the diffuse halo as well as the disk's dense cold gas, and truncate star formation nearly instantaneously. At some level both are likely to happen, but it has been very challenging to prove convincingly that one process is more common than the other.

Figure 1.
Left panel: The velocity of galaxies within the 10 GCLASS clusters relative to the velocity dispersion of each cluster versus the position of each galaxy relative to the virial radius. Quiescent galaxies are plotted as red triangles, star-forming galaxies as inverted blue triangles, and post-starburst galaxies as encircled green stars. Strikingly, the post-starburst galaxies form a "ring" structure at high velocities and intermediate radius. Right panel: Galaxies in a simulated set of clusters (black points). Green stars show galaxies that are "quenched" in the simulation on a timescale of 0.1 — 0.5 Gyr after they first cross about half the virial radius. The distribution of the simulated quenched galaxies is statistically consistent with the observed post-starburst population suggesting this is where and when cluster galaxies are first quenched.

The GCLASS Survey at z ~ 1

One additional challenge in observing this quenching process in action is that until very recently we've only been able to collect data on fairly nearby clusters. Locally, the average star-forming galaxy is only converting a few solar masses of gas into stars per year. That's a pretty low level of activity. Therefore, the difference between a recently quenched local galaxy and one that has normal star-formation activity is fairly marginal. One nice solution would be to look at galaxies at higher redshifts. The average star-forming galaxy at $z \sim 1$ is 10 times more active than locally, so if the quenching process is violent, it would be much easier to identify one that has recently been stripped of its gas.

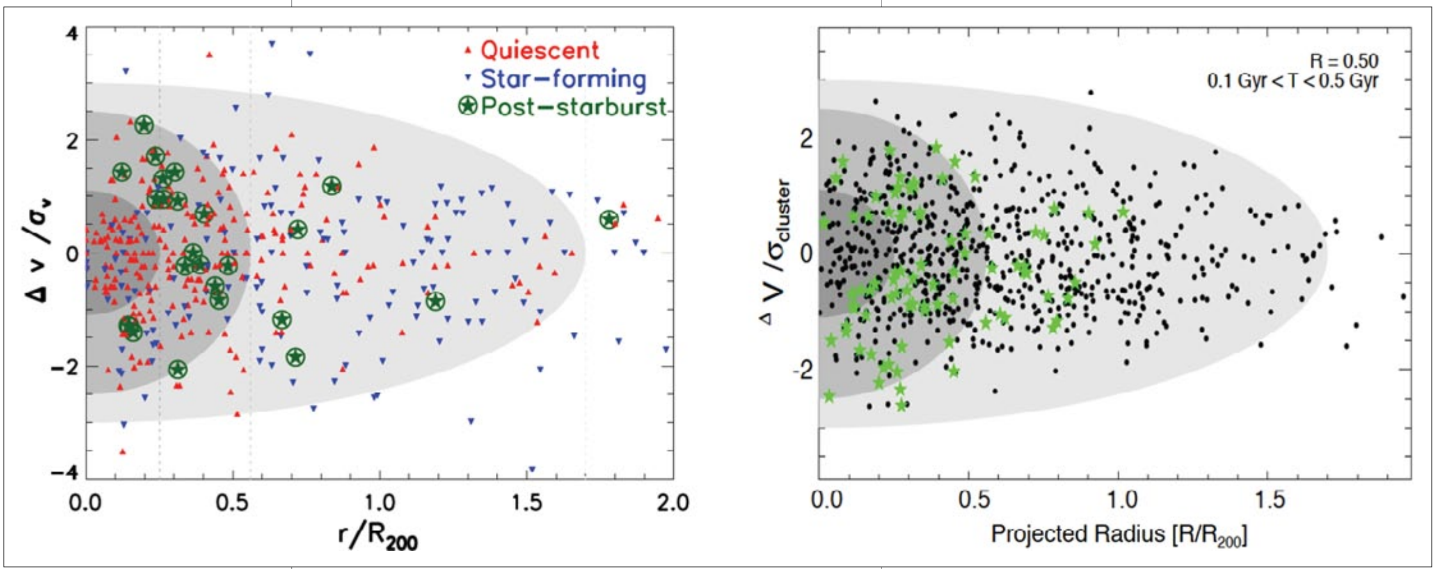
From 2009 - 2011 we carried out a large spectroscopic survey with the Gemini Multi-Object Spectrograph of 10 massive clusters at $z \sim 1$. This program, the Gemini CLuster Astrophysics Spectroscopic Survey (GCLASS) — one of the largest surveys ever carried out on the Gemini North and South telescopes — required about 220 hours of observations, but has provided spectra for ~ 500 cluster galaxies at $z \sim 1$. GCLASS marked about a 10-fold increase in the number of spectra for cluster galaxies compared to any previous cluster survey at this redshift.

GCLASS had numerous scientific goals. One was to measure how the central galaxies in clusters grow over cosmic time (Lidman *et al.*, 2012 and 2013), as well as how the stars are distributed in high-redshift clusters — both on the galaxy scale (van der Burg *et al.,* 2013) and in the global cluster scale (van der Burg *et al.,* 2014). In addition, it also looked critically at the stellar populations of cluster galaxies at $z \sim 1$ in Muzzin *et al.* (2012).

New Insights

More recently we've attacked the problem of linking cluster galaxy dynamics to the quenching process. This has led to some interesting new insights about the quenching process (*e.g.*, Noble *et al.*, 2013; Muzzin *et al.*, 2014).

One of the most striking revelations from the GCLASS data is that there appears to be a correlation between the stellar populations of the galaxies and their dynamical state within the cluster. The left panel of Figure 1 plots the GCLASS cluster galaxies relative to "typical" velocities of all galaxies (the velocity dispersion) against their distance from the cluster's center (which has been normalized to the virial radius of each cluster). Galaxies have been color-coded based on their stel-



lar populations: quenched galaxies are plotted as red triangles, and star-forming galaxies appear as inverted blue triangles. These two populations are distinctly different, with quenched galaxies tending to be found near the cluster's center and moving at slower velocities. Star-forming galaxies are found throughout the cluster and tend to be moving at higher velocities.

This had been seen before in lower-redshift clusters (*e.g.*, Biviano *et al.*, 2002; Poggianti *et al.*, 2004). It can be explained naturally by the quenched galaxies having been accreted into the cluster earlier (presumably when they were still star-forming galaxies). Most likely they experienced dynamical friction and lost kinetic energy, gradually slipping into orbits well within the clusters' gravitational potential wells. Star-forming galaxies are likely to be more recently accreted and hence have higher velocities, as they are on their first passage through the clusters.

Our team also looked at galaxies that had spectral signatures indicating recent quenching. These "post-starburst" galaxies are shown as the encircled green stars in the left panel of Figure 1. These high-velocity objects had quite a striking distribution in this Figure, as they tend to lie roughly in a "ring" structure at intermediate radius. In particular, they very clearly avoid both the cluster core region, which is dominated by quenched galaxies, and the large radius region dominated by star-forming galaxies.

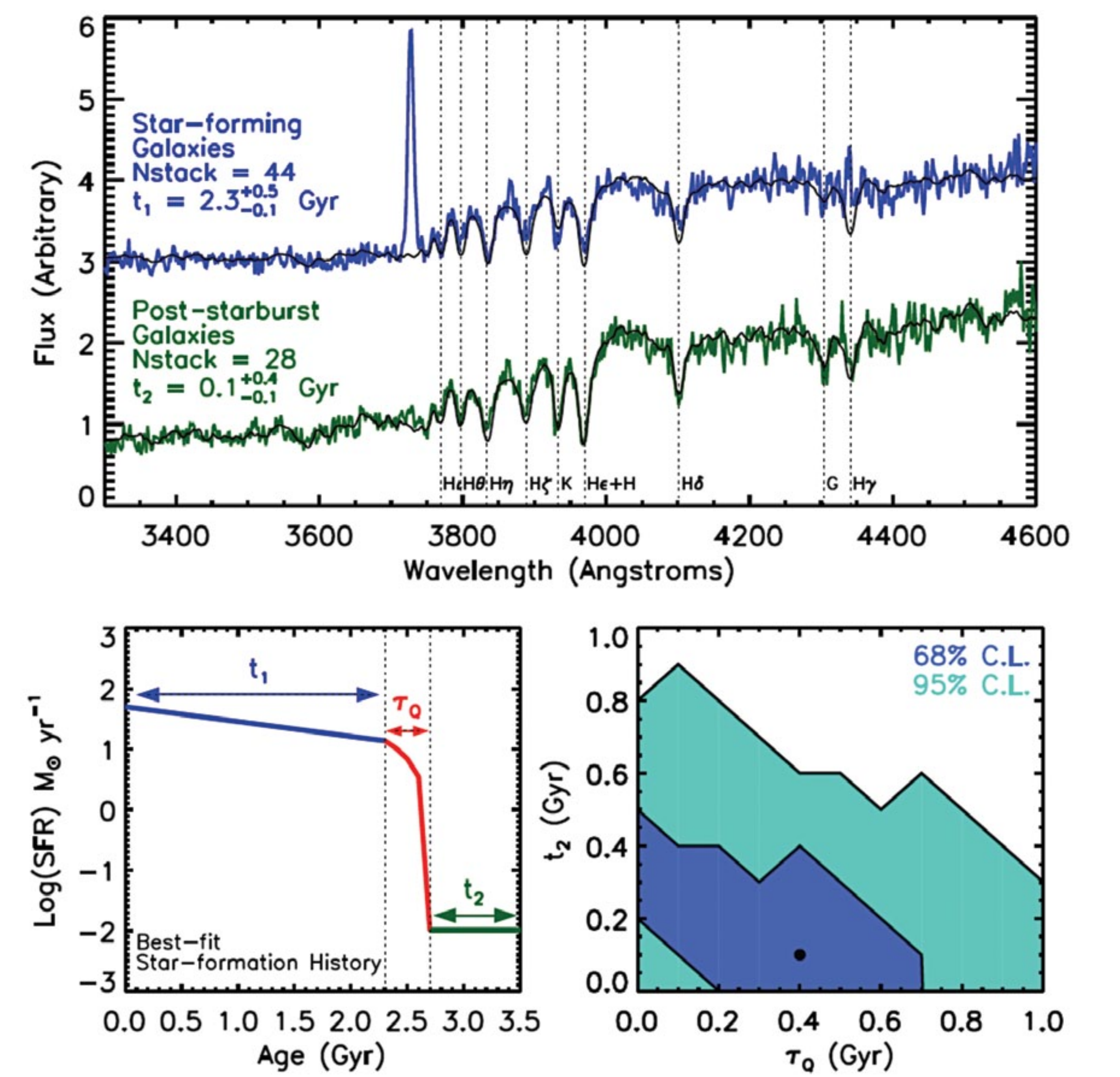
This signature has never been seen before, so modeling it seemed an obvious way to try to understand more about the quenching process. We were most interested in getting some quantitative measurements of both how long it takes for galaxies to quench (once the process begins) and where in the cluster it starts to happen. In particular, the latter measurement is unprecedented. We employed some high-resolution dark-matter-only simulations of clusters to see if we could input these numbers and reproduce the observed distribution of the post-starbursts in the right panel of Figure 1.

In the simulations, we followed galaxies as they first fell into the cluster. We then simulated quenching at different locations and with different timescales. These models easily ruled out many locations and specific timescales; the details of this can be found in Muzzin *et al.* (2014). What worked best in reproducing the distribution of the post-starbursts was if we quenched galaxies after they first passed roughly half the virial radius ($R \sim 0.5R_{200}$) on a timescale of ~ 0.1 - 0.5 Gyr. The resulting distribution of post-starburst galaxies is shown as the right panel of Figure 1, and is statistically a good match to the observation.

This was the first time that simultaneous constraints had been set on both the duration of the quenching process and where it happens. We were concerned that our findings depended heavily on a simulation, so we also used the stellar populations of the galaxies to test the model. Figure 2 shows the average spectra of both the typical star-forming galaxy in the cluster (top blue) and the average spectra of the post-starburst galaxies (bottom green). These spectra were fit to a range of models, with the best-fit star-formation history shown in the bottom left panel.

Basically, this test showed that star-forming galaxies continue forming stars for several Gyr within the cluster before they quench — and that process needs to be rapid in order to create the stellar populations seen in the post-starburst galaxies. Not only is this consistent with what we derived from our dynamical modeling, but also remarkable because these two constraints (the spectra, as well as the dynamical modeling) are completely independent indictors of what is happening.

Figure 2.
Top Panel: The average spectra of star-forming (blue) and post-starburst galaxies (green) in the GCLASS clusters. The black lines are the best-fit spectra for both types based on the star-formation history in the lower-left panel. Lower-left panel: The best-fit star-formation history of the post-starburst galaxies under the assumption that the star-forming galaxies are their progenitors. This suggests that the average post-starburst spends ~ 2.3 Gyr forming stars before it is quenched on a timescale of ~ 0.1 ± 0.4 Gyr. This is fully consistent with the quenching model derived from dynamics of the galaxy populations in Figure 1.



Towards a Physical Model of Satellite Quenching

The overall picture that emerges from this analysis is that when star-forming galaxies fall into clusters they continue forming stars for 0.5 - 1.5 Gyr — about the time it takes to fall far enough into the cluster to cross about half of the virial radius. Once this happens, the quenching process begins, and it is quite rapid, perhaps even violent. Despite having concrete numbers to work with, there are still challenges in understanding exactly what is happening.

For instance, because the quenching process appears to be so rapid, it's tempting to believe that all gas — both hot and cold — is being removed from the galaxy. But that may not be the full story. Galaxies at $z \sim 1$ are forming stars at a much higher rate than those at $z \sim 0$. If only the hot gas was removed, the higher-redshift galaxies would consume most of their cold gas quite quickly, on a timescale of ~ 0.5 Gyr, which is the upper limit of what the models permit.

So, there is clearly still work to do. Since we know that the cold gas consumption time-scales move to longer values at lower redshift, measuring any evolution in the quenching timescale with redshift is crucial for breaking this degeneracy. Some studies have been done at lower-redshift, and they tend to indicate slightly longer timescales than we measured at $z \sim 1$ (*e.g.*, Wetzel *et al.*, 2013; Haines *et al.*, 2013). This would implicate hot gas stripping, but the analysis was done in a quite different way, so the jury is still out.

The Next Steps: Hubble and the GOGREEN Survey

Our team is taking steps to better understand the quenching process in distant clusters. We have recently been awarded time to take H-alpha images of the GCLASS clusters with the Hubble Space Telescope (HST). With HST's resolution we should be able to not only resolve the star-forming disks in cluster galaxies, but also see if they really have been stripped by the intracluster gas.

Even more exciting is the recent start of the GOGREEN (Gemini Observations of Galaxies in Rich Early ENvironments) survey. This 440 hour program is one of the new Gemini Large and Long programs and will obtain spectra for ~1000 cluster and group galaxies at $1.0 < z < 1.5$ using the recently-upgraded Hamamatsu chips on both GMOS South and soon on GMOS North. GOGREEN will go much deeper than GCLASS and allow us to access higher-redshift clusters, as well as much lower-mass galaxies. This should allow us to better understand how galaxies of different masses are affected by their environments, as well as whether the whole process changes over cosmic time. GOGREEN observations are slated for completion in 2017, and we look forward to summarizing those results in a future GeminiFocus article.

References

Biviano, A.; Katgert, P.; Thomas, T.; Adami, C., "The ESO nearby Abell cluster survey", *Astronomy & Astrophysics*, **387:** 8, 2002

Haines, C., *et al.*, "LoCuSS: The steady decline and slow quenching of star formation in cluster galaxies over the last four billion years", *The Astrophysical Journal*, **775:** 126, 2013

Lidman, C., *et al.*, "Evidence for significant growth in the stellar mass of brightest cluster galaxies over the past 10 billion years", *Monthly Notices of the Royal Astronomical Society*, **427:** 550, 2012

Lidman, C., *et al.*, "The importance of major mergers in the build up of stellar mass in brightest cluster galaxies at z = 1", *Monthly Notices of the Royal Astronomical Society*, **433:** 825, 2013

Muzzin, A., *et al.*, "The phase space and stellar populations of cluster galaxies at $z \sim 1$: simultaneous constraints on the location and timescale of satellite quenching", *The Astrophysical Journal*, **796:** 65, 2014

Muzzin, A., *et al.*, "The Gemini CLuster Astrophysics Spectroscopic Survey (GCLASS): the role of environment and self-regulation in galaxy evolution at $z \sim 1$", *The Astrophysical Journal*, **746:** 188, 2012

Noble, A., Webb, T., Muzzin, A., Wilson, G., Yee, H., van der Burg, R., "A kinematic approach to assessing environmental effects: star-forming galaxies in a $z \sim 0.9$ SpARCS cluster using Spitzer 24 μm observations", *The Astrophysical Journal*, **768:** 118, 2013

Poggianti, B., *et al.*, "A comparison of the galaxy populations in the Coma and distant clusters: the evolution of k+a galaxies and the role of the intracluster medium", *The Astrophysical Journal*, **601:** 197, 2004

van der Burg, R., "The environmental dependence of the stellar mass function at $z \sim 1$ comparing cluster and field between the GCLASS and UltraVISTA surveys", *et al.*, *Astronomy & Astrophysics*, **557:** A15, 2013

van der Burg, R., "A census of stellar mass in ten massive haloes at z ~ 1 from the GCLASS Survey", et al., *Astronomy & Astrophysics*, **561:** A79, 2014

Wetzel, A., Tinker, J., Conroy, C., van den Bosch, F., "Galaxy evolution in groups and clusters: satellite star formation histories and quenching time-scales in a hierarchical Universe", *Monthly Notices of the Royal Astronomical Society*, **432:** 336, 2013

Adam Muzzin is a Kavli Fellow at the Institute of Astronomy, University of Cambridge. He can be reached at muzzin@strw.leidenuniv.nl.

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.

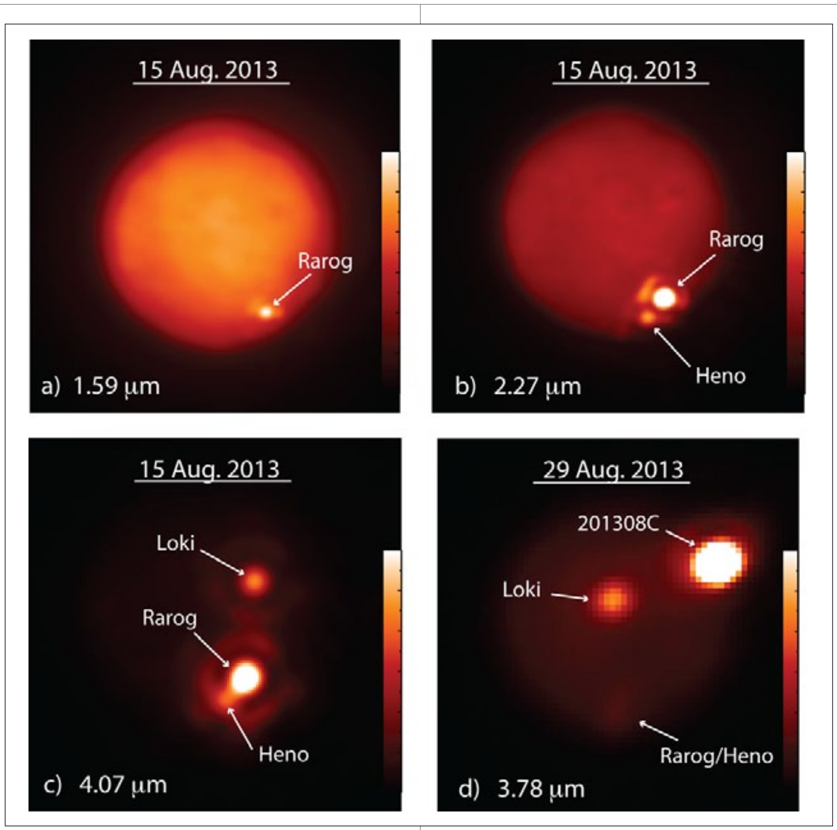


Figure 1.
Detection of the three outbursts. Panels a-c are observations at the W.M. Keck Observatory; the image in panel d was captured at Gemini N. Figure adapted from de Pater et al., *2014, and de Kleer* et al., *2014.*

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 North 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.

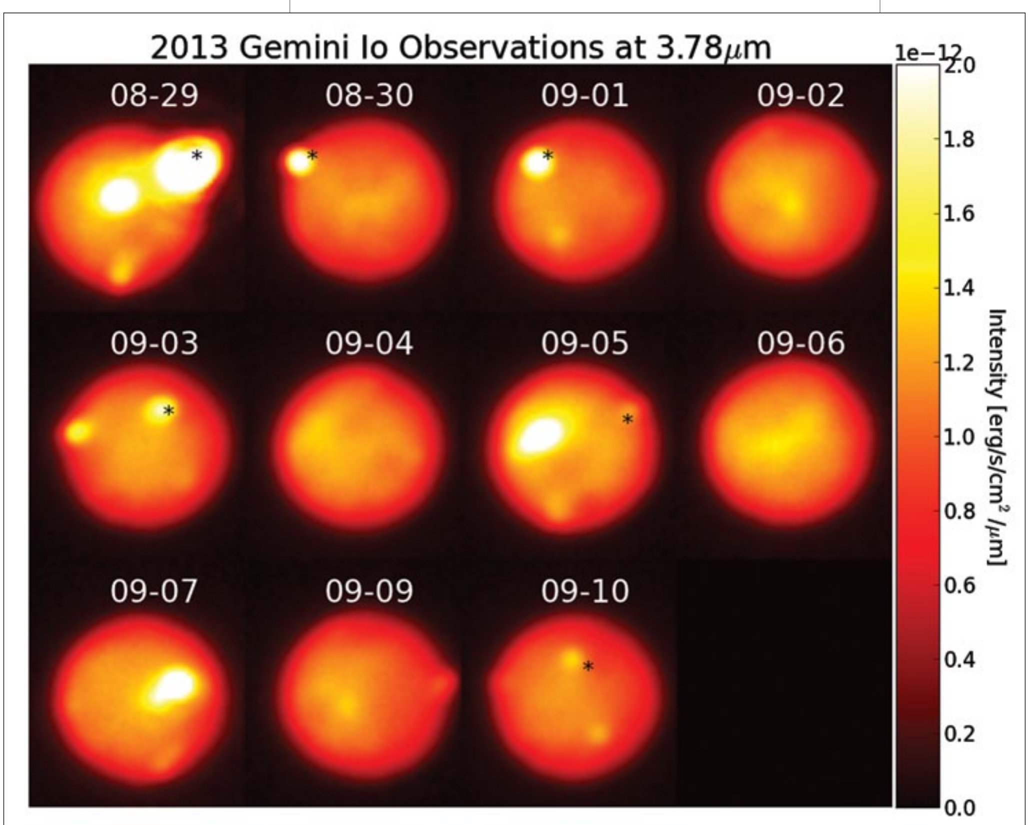


Figure 2.
Observations of the August 29th volcanic outburst on Io over a two-week period. The star indicates the outburst site; other smaller-scale events are also visible. Figure adapted from de Kleer et al., 2014.

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.

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.

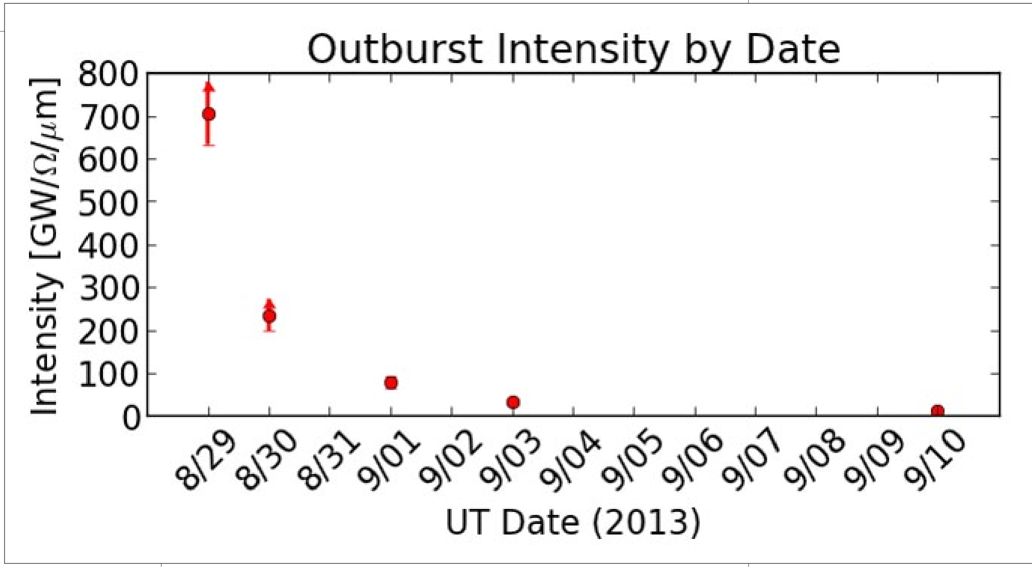


Figure 3.

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.*

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.

References:

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

Katherine de Kleer is a Ph.D. student at UC Berkeley and can be reached at: kdekleer@berkeley.edu

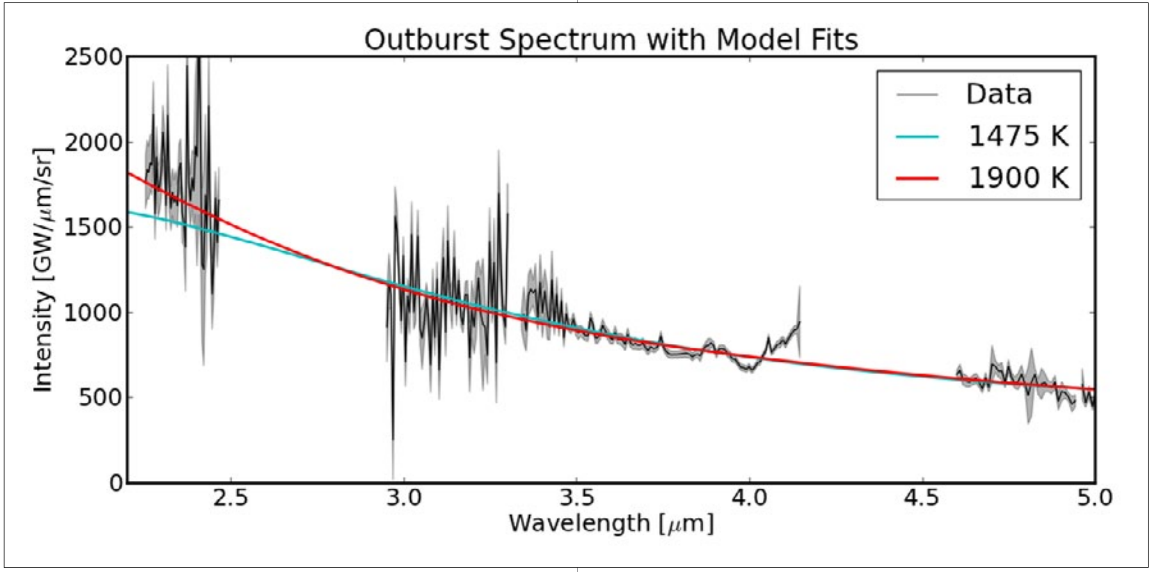


Figure 4. *IRTF SpeX spectrum of the August 29th outburst with model fits. The 1475 K model assumes basaltic magmas, while the 1900 K model assumes an ultramafic magma composition. Figure adapted from de Kleer* et al.*, 2014.*


Marie-Eve Naud and Étienne Artigau

GU Psc b: An Unexpected Planetary-mass Companion Discovered with GMOS

Capturing the faint light of an exoplanet near the blinding glow of its host star is a daunting task. It usually requires adaptive optics observations with specifically designed instruments and an arsenal of high-contrast imaging strategies. Our discovery of a giant exoplanet with the Gemini Multi-Object Spectrograph (GMOS) at Gemini South, however, shows that some planets might be much easier to find through "standard" imaging techniques.

In 2008, the direct detection (by Gemini) of a planet around 1RXS 1609-2105 and four alien planets around the distant star HR 8799 (by Gemini and the W.M. Keck observatories) paved the road to a new era of direct imaging exoplanet discoveries. Since then, a few other planets have joined the still short list of new worlds imaged, including β Pictoris b, GJ 504 b, and HD 95086 b.

There is high hope that the Gemini Planet Imager (GPI) and other new dedicated high-contrast imaging instruments will add many more objects to that list in the coming years. The amazing sophistication of these instruments, however, is testament to how difficult it remains to detect even the most massive exoplanets through direct imaging.

A Planet Where There Shouldn't Be

Our team, which includes researchers from Université de Montréal and international collaborators, just announced the discovery of a new exoplanet, GU Psc b. This planet, with

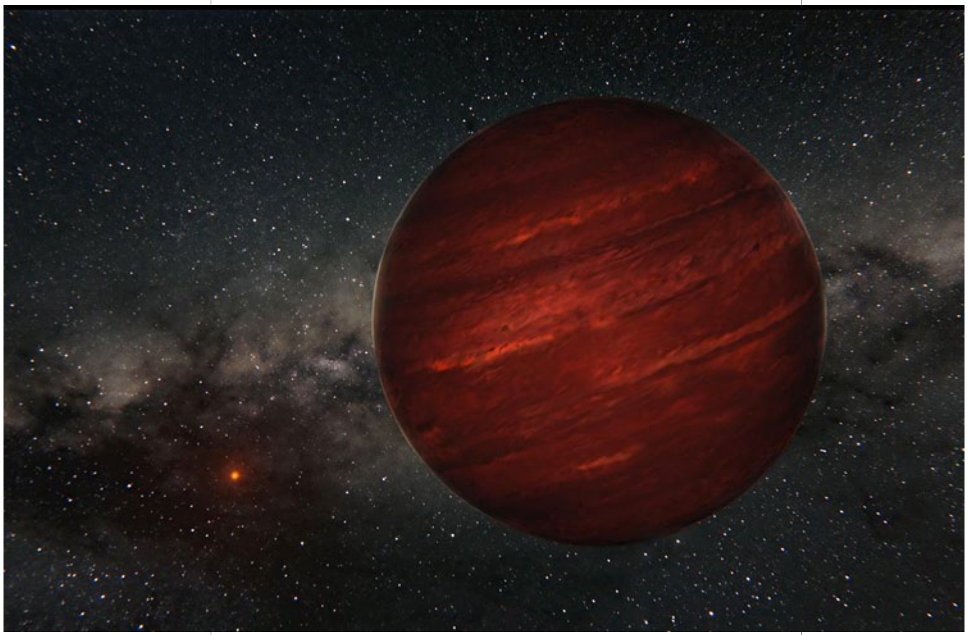


Figure 1.
Artist's concept of GU Psc b (foreground) and its distant host star. Illustration by Lucas Granito

As a complement to a survey we were carrying out with Gemini's Near-Infrared Coronographic Imager (NICI) to find planetary-mass companions to young, low-mass stars, we stepped outside the box. We decided to use GMOS to verify if really massive planets — much more massive than Jupiter — exist in the most distant realms of stellar systems.

Our survey, sensitive to objects with masses ranging from 5-7 Jupiter masses, was based on a very simple fact: that the Spectral Energy Distribution (SED) of very cool, planetary-mass objects displays a notable brightening from the red to the infrared. Therefore, we decided to take two images of the target star: one with an i filter, and the other with a z filter; cool objects could then be identified via their distinctively red i - z color.

a mass ~11 times that of Jupiter, was found through a survey carried out at Gemini South with the Gemini Multi-Object Spectrograph (GMOS) — without adaptive optics (AO) observations, nor with any sophisticated high-contrast instrument or special image analysis method.

Location, Location, Location

How then could we detect GU Psc b? Location. The key is that the planet is located very far from its host — 42 arcseconds, to be more precise, which translates to 2000 astronomical units (AU; the average distance of the Earth from the Sun), at its distance of about 48 parsecs (pc) or 157 light-years.

One reason we haven't found this world before is simply because we were not searching for planets orbiting that far from stars; probably because an anthropocentric bias motivates us to search for exoplanets where we find giant planets in our own Solar System. Also, from a theoretical point of view, current mainstream formation theories for exoplanets (core accretion, disk instability) simply do not predict giant worlds to be that far from their hosts. We discovered just the opposite.

A Newly Identified Young Star

The star sample made with NICI and GMOS at Gemini was one key to the survey's success, because the environments around young stars are ideal places to find planets through direct imaging. These worlds are still contracting and appear brighter at infrared wavelengths.

During her Ph.D. work at Université de Montréal, our colleague Lison Malo (now resident astronomer at Canada-France-Hawaii Telescope (CFHT)) developed, with René Doyon and David Lafrenière, a novel Bayesian analysis that also proved beneficial to our survey. It identifies new members of young associations based on the kinematic and photometric characteristics of the plausible candidates.

The Bayesian analysis revealed GU Psc A, an M3 star, to have a high probability of belonging to the 70-130 million-year-old AB Doradus Moving Group (ABDMG). The radial velocity estimated by the analysis agrees with the value we measured on our optical and near-infrared (NIR) spectra, which further confirm the membership. These radial-velocity data were obtained with the Phoenix spectrometer at Gemini South, CRIRES at the VLT, and ESPaDOnS at CFHT.

The star's X-ray luminosity is also consistent with that of ABDMG members. Furthermore, the many youth indicators we studied all agreed with GU Psc A being part of the ABDMG. A parallax measurement, ongoing through the Cerro Tololo Inter-American Observatory Parallax Investigation project, will allow reinforcing this membership even further. Meanwhile, as mentioned, we have adopted a distance of 48 ± 5 pc, for the star, as estimated by the Bayesian analysis.

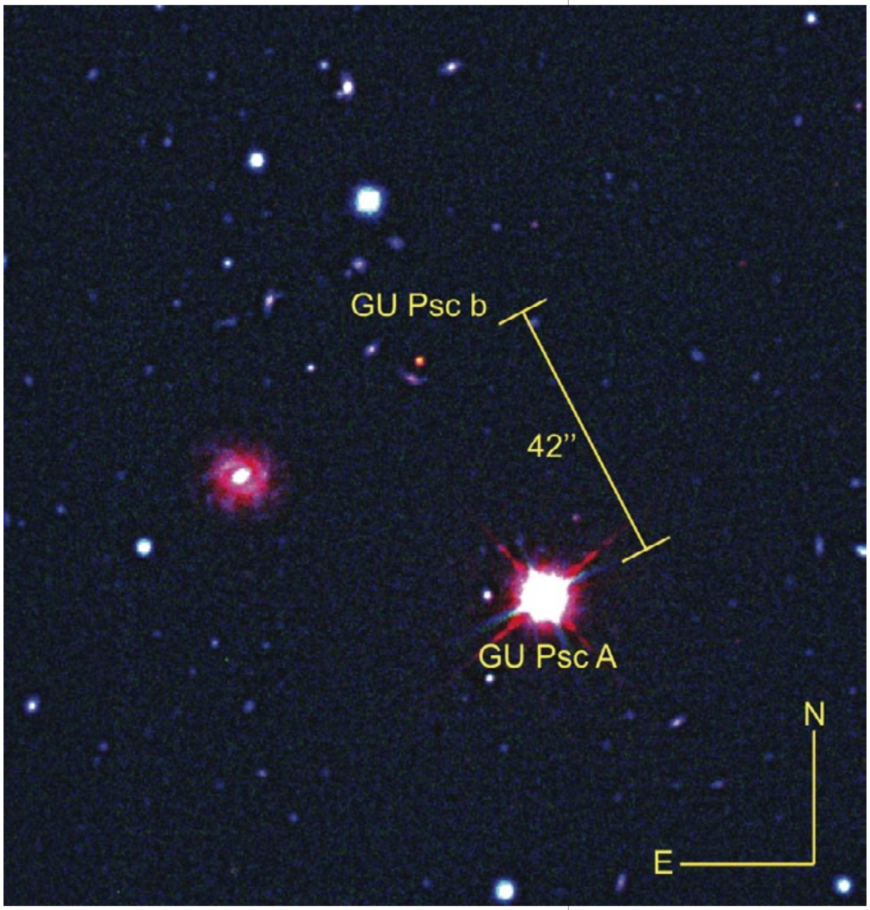


Figure 2.
Composite image of GU Psc b and its host star. The i (blue) and z (green) discovery observations from GMOS on Gemini South are shown with the follow-up J-band (red) image taken at CFHT.

GU Psc b: A Peculiar System?

As expected for a cool, planetary-mass object, GU Psc b was detected in the GMOS z observations. It is so faint in the optical, however, that the planet remained undetected in i band in a deep follow-up observation with GMOS. These results suggest a very red, i - z > 3.5, a color that is typical to a young planetary-mass object (and also ultracool field brown dwarfs and high-redshift quasars). GU Psc b was the only such object detected among the 90 stars surveyed with GMOS.

Follow-up observations were obtained with NIR cameras at Observatoire du Mont-Mégantic (CPAPIR) and at CFHT (WIRCam). Two sets of WIRCam J-band observations, spaced one year apart, allowed us to measure the proper motion of GU Psc b and to show that the suspected planet was indeed co-moving with GU Psc A. The Wide-field Infrared Survey Explorer (WISE) also observed GU Psc's field in the mid-infrared. All these photometric observations confirmed we had a planetary-mass companion; they were also of great use to calibrate the NIR spectrum, subsequently obtained at Gemini North using the Gemini Near-Infrared Spectrograph (GNIRS).

A comparison of the GNIRS spectrum both with standard objects and two models — a "Low-temperature cloud" atmosphere model provided by Caroline Morley and Didier Saumon (University of California Santa Cruz and Los Alamos National Laboratory), and a "BT-Settl" model by France Allard and Derek Homeier (Centre de Recherche Astrophysique de Lyon) — yielded precious information, including the spectral type (T3.5 ± 1) and a temperature between 1000-1100 K. In addition, the comparison showed indicators of low surface gravity (mainly the very strong K band), which is, compatible with the star's young age.

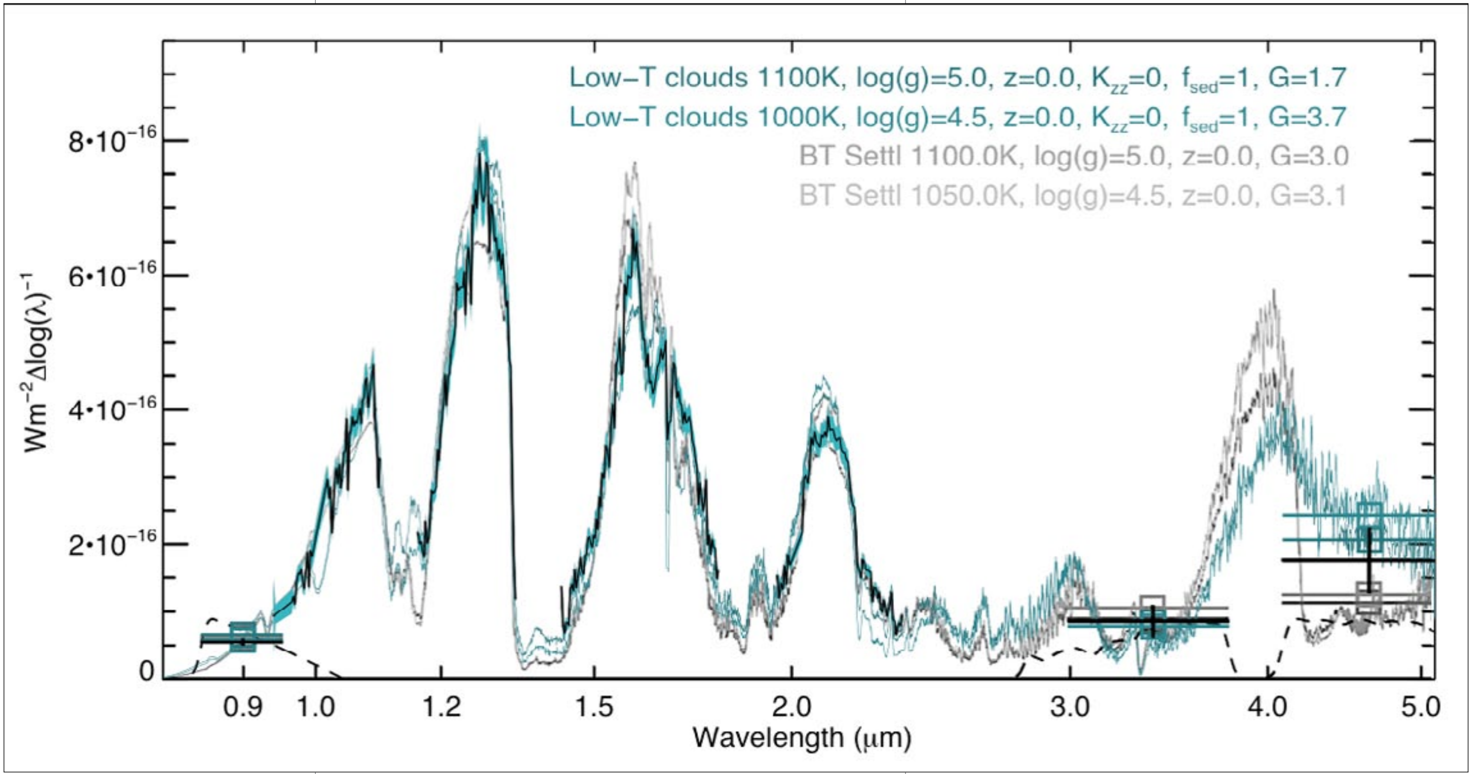


Figure 3. *The spectrum of GU Psc b, obtained at Gemini North with GNIRS, along with the GMOS z (~ 0.9 μm) and WISE W1 (~ 3.4 μm) and W2 (4.6 μm) photometric points. Also shown are the best-fitting, low-temperature cloud models of Morley* et al.*, 2012, and the BT-Settl models of Allard* et al.*, 2012.*

The spectrum also revealed a few clues hinting that the companion itself might indeed be a binary object. First, it is quite similar to the spectrum of J1021-0304, a known brown dwarf binary (T1/T5). Second, the spectrum shows an over-luminosity around 1.6 microns in the H band — a region usually already over-luminous, as modelers like Saumon and others have previously noticed.

These tentative indications encouraged us to obtain, through collaborators Christopher Gelino and Charles Beichman (both Caltech NExScI), high-resolution H and K observations with the Laser Guide Star Adaptive Optics system and the near-infrared camera NIRC2 at Keck II. These reveal only one point source, which constrains strongly the eventual binarity of GU Psc b; namely, we can exclude the presence of a companion brighter than a typical T7-T8 down to about 2 AU.

To evaluate GU Psc b's physical properties, we used two evolutionary models: one by I. Baraffe *et. al.,* 2003; and the other by Saumon and M. Marley, 2008. We determined its luminosity using observed SED and atmospheric models. The results suggest a mass between 9 and 13 Jupiters at the age of AB-DMG (70-130 million years; Myr).

Many Questions, Many Answers, Some Mysteries

The very large distance between this planetary-mass companion and its host star raises many questions. For instance, how could such a massive companion end up so far from GU Psc A after ~100 Myr? It certainly seems unlikely that GU Psc b formed "as a planet," — *i.e.* in the protoplanetary disk surrounding the star, through either core accretion or disk instability.

Could this world be in the process of being ejected? Maybe, but we know of other supposedly gravitationally bounded systems that have similar binding energies (ratio of the masses of star and companion over the distance between the two).

Most likely, GU Psc A and its companion formed in the fragmentation of a collapsing molecular cloud, similar to the way a binary star system forms. In that case, even if GU Psc b is in all likelihood below 13 Jupiter masses, and thus of "planetary mass," we can wonder if it should be called a "planet."

At this point, it's hard to exclude other exotic scenarios, such as the capture by the current host star of a free-floating planet, formed on its own, or ejected from another star system. The host star and its companion could also have been ejected from the system of a more massive star. On various fronts, this object raises many questions.

A Key to Understanding

The large distance between GU Psc b and its host star is an important attribute and a major advantage when it comes to acquiring a detailed characterization of the companion object. This planetary-mass companion can be studied like few other exoplanets, because the task requires no AO systems or sophisticated high-contrast imaging methods.

We can expect this object to help by constraining models of cool brown dwarfs and exoplanets in this age range. It can also constitute a reference in the understanding of other closer-in planets we should find with instruments like GPI.

The discovery of GU Psc b makes it clear that massive planets very distant from their host stars do exist, even around low-mass stars. Although they are probably rare, they can be discovered quite easily using "standard" direct imaging techniques.

Indeed, Frédérique Baron, a Ph.D. student at Université de Montréal under the direction of David Lafrenière and Étienne Artigau, will expand the present survey with deep z- and J-band imaging at Gemini and CFHT, targeting a sample of 300 stars. This survey will be sensitive to objects down to 1-2 times the mass of Jupiter at separations ranging from 200 to 5000 AU.

We expect to find more of these peculiar planets in the future. Their unique characteristics will allow us to not only study them in great detail but also improve our knowledge of giant exoplanets and other exotic planetary systems.

Marie-Eve Naud is a Ph.D. student at Université de Montréal. She can be reached at:
naud@astro.umontreal.ca

Étienne Artigau is a research scientist at Université de Montréal. He can be reached at:
artigau@astro.umontreal.ca

April 2014

Elisa Quintana, Steve Howell, Tom Barclay, and Jason F. Rowe

Gemini Helps Confirm First Earth-sized Planet in the Habitable Zone of a Star

Gemini North observations using the visiting Digital Speckle Survey Instrument (DSSI) contribute to a monumental discovery — the first Earth-sized planet orbiting a star in a region that could support life.

The possibility that stars other than our Sun could have habitable worlds has long captured the imagination of humanity. Now, Gemini Observatory, along with observations with the W.M. Keck Observatory has helped to take that possibility one step closer to reality.

Figure 1.
This artist's concept depicts Kepler-186f, the first validated Earth-size planet orbiting a distant star in the habitable zone — a range of distances from a star where liquid water might pool on the surface of an orbiting planet. Kepler-186f resides in the Kepler-186 system about 500 light-years from Earth in the constellation Cygnus. The discovery of Kepler-186f confirms that Earth-size planets exist in the habitable zone of other stars and signals a significant step closer to finding a world similar to Earth.
Credit: NASA/Ames/JPL-Caltech/T. Pyle

NASA's Kepler space telescope — a mission designed to search for planets in other solar systems — has discovered the first known Earth-sized planet orbiting a star in the "habitable zone" — a region where liquid water could exist on the planet's surface and possibly support life. Named Kepler-186f, this new world is one of five — all less than 50 percent larger than Earth — detected by Kepler that orbit this host star that is cooler and smaller than our Sun. Only Kepler-186f, though, lies in the star's habitable zone.

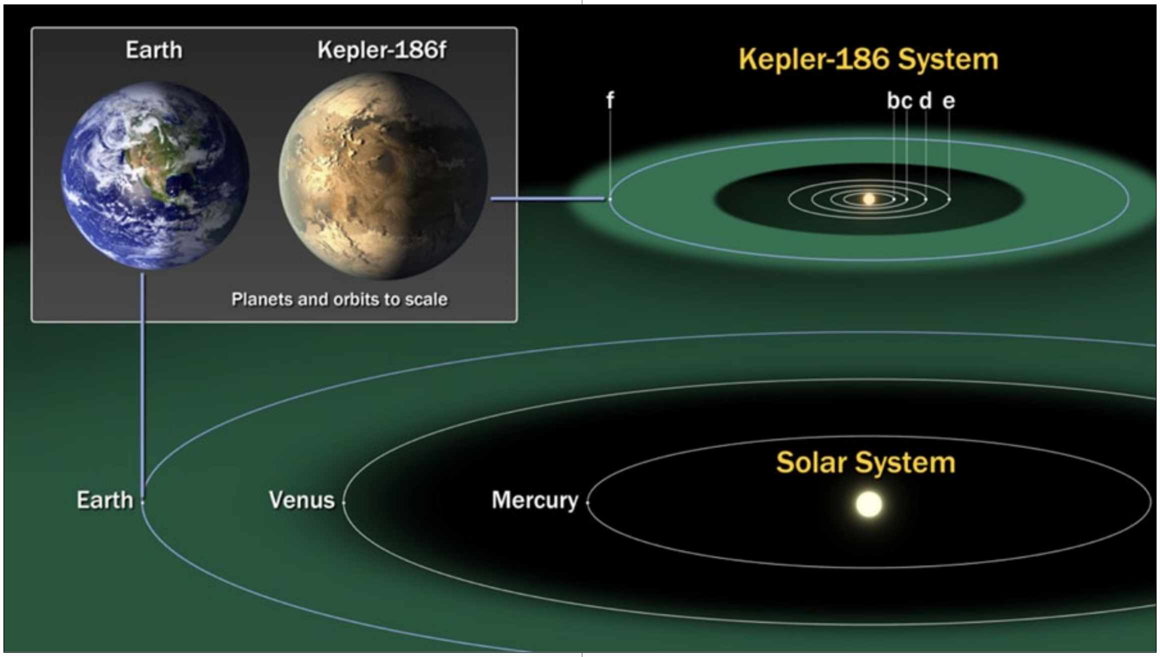


Figure 2.
Kepler-186f is within 10 percent the size of Earth, but its mass and composition are not known. Kepler-186f orbits its star once every 130-days and receives one-third the heat energy that Earth does from the Sun, placing it on the outer edge of the habitable zone (shaded region in green). The system is also home to four inner planets, all measuring less than 1.5 times the size of Earth, and orbiting a cooler and less massive star than our Sun. Because Kepler-186 is cooler and dimmer, the habitable zone is located closer in. All five planets in this system have orbital distances to their star less than Mercury's distance from the Sun. Credit: NASA/Ames/JPL-Caltech/T. Pyle

Follow-up observations with the 8-meter Gemini North and 10-meter Keck II telescopes provided high-quality observations that backed up the spacecraft's discovery, making Kepler-186f the first Earth-sized exoplanet with the potential to support life.

In Transit

The Kepler spacecraft discovered Kepler-186f by observing transits (where a planet passes in front of its host star) on several occasions. During a transit, the total amount of light we see from the star is diminished due to the

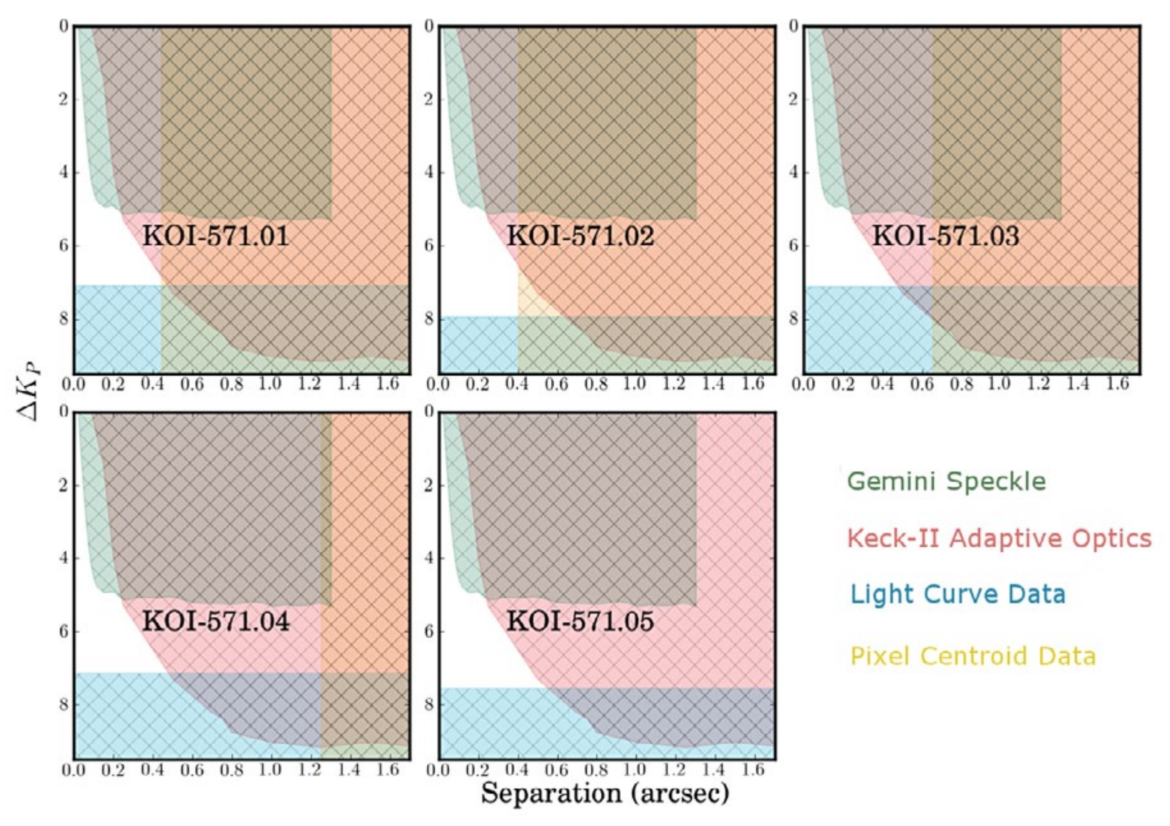
Kepler-186f: A Planet with Oceans?

The host star, Kepler-186, is an M-type star, an M dwarf, or a red dwarf. It lies in the direction of the constellation Cygnus, about 500 light-years away. The star is relatively dim with a luminosity of just about 5 percent that emitted by our Sun.

The habitable zone (HZ) around this lower-luminosity star is located much closer in compared to the habitable zone of a star like our Sun. The intensity and spectrum of the star's radiation determines the boundaries of the HZ. Kepler-186f receives about a third of the insolation (intensity of stellar radiation) as that received by Earth from the Sun and, with an orbital period of 130 days, it resides in the HZ throughout its orbit.

Since Kepler can only measure a planet's size, we don't know the mass of Kepler-186f and therefore we cannot say anything about its composition. Theoretical models have shown that planets as small as Kepler-186f are highly unlikely to be dominated by a gas envelope like Neptune, and more likely is composed of some combination of rock, iron and perhaps water or ice, material that also composes the Earth (and that we refer to as "rocky"). However, if Kepler-186f is rocky like the Earth, and has an Earth-like atmosphere, then any H_2O at its surface is likely to be in liquid form and compatible with life as we know it.

Figure 3.
Exclusion zones for each of the planet candidates in the Kepler-186 system. Prior to validation, the star was known as KOI (Kepler Object of Interest) 571, and Kepler-186f (KOI-571.05) is shown in the lower middle panel. The shaded regions indicate the parameter space that can be ruled out for having an astrophysical source (like a binary star system) that is inducing light variations that could mimic a planet signal. The region shaded in green is excluded by Gemini speckle imaging, the pink is from the Keck-II adaptive optics observations, the blue is based on modeling the transit light curve, and the yellow is based on pixel centroids data (measures of the movement of the pixels which can indicate if the primary source is a binary star system, not shown in the Kepler-186f panel). Observational constraints rule out all regions of the figure except for the white areas, which then go through additional statistical analysis. The additional shaded region provided by Gemini — looking for sources very close to the star — was crucial in our validation of Kepler-186f.
Credit: Thomas Barclay



planet's blocking of some light from the star. Kepler measurements of the brightness decrease, and the frequency of transit, as well as knowledge of the star's size, are used to determine the size of the planet and the planet's distance from its star.

The Kepler mission has contributed more than 950 exoplanet discoveries to the current count of about 1700, in addition to the 38000 potential planets that await confirmation. Several key milestones have been reached by Kepler towards the goal of finding potentially habitable planets. A small number of Earth-sized planets, such as Kepler-20e, have been found, however they all orbit close to their star, making them extremely hot and therefore inhospitable to life. About a dozen planets have been found to orbit in their star's habitable zone, however they are all larger than Earth and most have a thick atmosphere of gas like Jupiter. Kepler-186f is the first "Goldilocks planet," it has the right size, and orbits at the right distance, to allow the existence of water, thought to be a key ingredient for supporting life.

Gemini's Role

One way to verify claims of exoplanet detection is to look for a signature "wobble" in the host star, as gravity from orbiting planets tug on it. However, Earth-sized planets, like Kepler-186f, are too small to create a detectable wobble with existing technology. Confirmation had to come in a new way.

To prove that the signals in the star's light are due to planets and not other nearby astrophysical sources, high-contrast images were obtained from both Gemini North and Keck II telescopes. Some common sources of apparent variability, which can trigger a false planetary detection, include a binary star system in the background or foreground that introduces small variations in the total measured light. Alternatively, if we are truly looking at a binary star system, but a third star is so close that it dilutes the signal, or if the binary stars barely eclipse each other, then these are other scenarios that could cause a small dip in the light curve and be misinterpreted as a planetary eclipse.

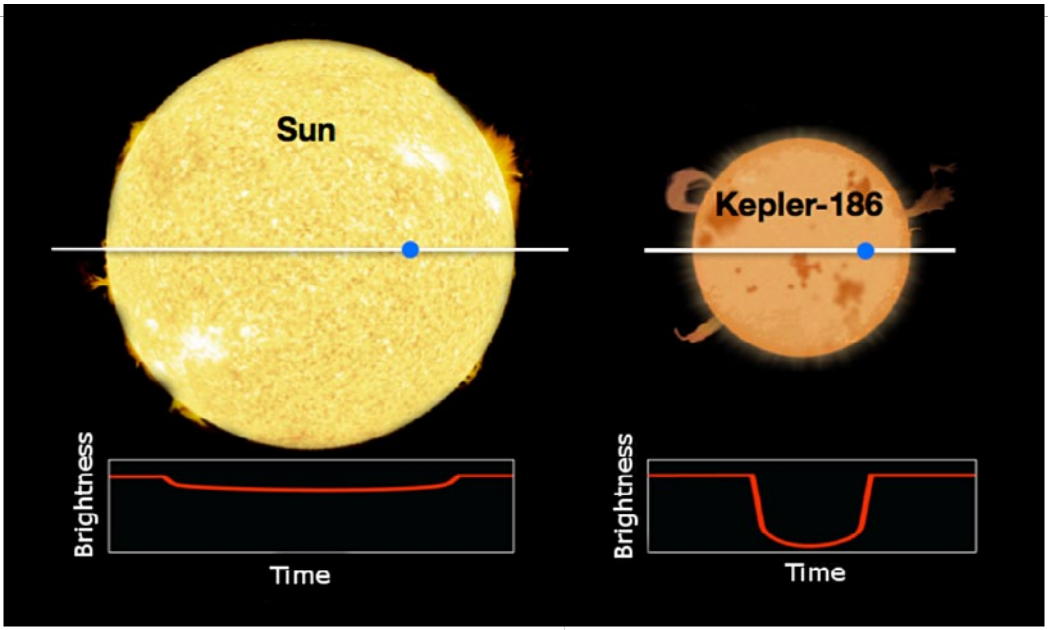


Figure 4.

An Earth-sized planet crossing in front of a Sun-like star (left) and an M dwarf like Kepler-186 (right). The amount of starlight blocked by an Earth-sized planet in the habitable zone is proportionately greater for an M dwarf than a Sun-like star, creating a larger dip in the transit light curve (bottom) and therefore making them easier to detect.

Credit: Wendy Stenzel

Kepler-186 was observed using the Differential Speckle Survey Instrument (DSSI) on Gemini North and using the NIRC2 camera on the Keck-II telescope. Gemini and Keck each imaged Kepler-186 to different degrees of proximity (to address how close to Kepler-186 another source could be resolved) and magnitude (to determine the faintest a nearby source could be detected). The exceptional data from DSSI allowed us to be sensitive to

M Dwarfs: Prime Targets in the Search for Habitable Worlds

M dwarfs (stars with 0.1-0.5 times the mass of the Sun) are excellent targets in the search for habitable worlds. Planets in the habitable zones of M stars are easier to detect than planets in the habitable zones of Sun-like stars due to their shorter orbital periods and frequency of transits detected. The proportion of starlight that they block is also greater (see Figure 4) so the transit depths are deeper. M-dwarfs are also very abundant, comprising about three quarters of all main sequence stars in our galaxy. They also evolve very slowly in luminosity, thus their habitable zones remain stable for billions of years. Furthermore, planets around M dwarf hosts may (ultimately) be imaged more easily due to higher contrast between the planet and the star.

M Dwarfs have long been thought to be unsuitable hosts for habitable planets due to the proximity of planets in the habitable zone and their vulnerability to the stellar environment. M stars are known to be highly active early in their life, often producing giant and frequent flares which could scorch planets nearby. They also gravitationally interact with the planets, causing tides that heat the planet and cause their rotations to be "tidally locked," which means one side always faces the star and the other side faces the cold open space, much like our Moon is tidally locked with the Earth. Fortunately, Kepler-186f orbits a star that is on the larger end of the M dwarf mass range and is at a large enough distance where it could very well have escaped all of these complications to habitability. Regardless, there have been many recent studies that have shown ways around each of these challenges, and there isn't any one factor that precludes M dwarf planets from being habitable.

stars just 4 AU from Kepler-186 (about the distance between Jupiter and the Sun in our own solar system). The Keck data helped us rule out sources at fainter magnitudes. No nearby sources were seen which we built into our false positive model to conclude that the probability that Kepler-186f orbits the M-dwarf star is 99.98 percent.

Kepler-186f, at a distance of about 500 light-years from Earth, is too far away for any near-future ground or space-based observations that could indicate the presence of an atmosphere or oceans. This confirmation does, however, show that Earth-sized planets in the habitable zone of stars other than our Sun do exist. Given the fact that M dwarfs comprise more than 70 percent of all main-sequence stars in our galaxy, and that the majority of nearby stars — which are better suited for follow-up observations — are M dwarfs, planets like Kepler-186f may be common, and Gemini will no doubt play a large role in confirming them.

Elisa Quintana is a scientist at the SETI Institute and a NPP Senior Fellow on the Kepler Team at NASA's Ames Research Center. She can be reached at: elisa.quintana@nasa.gov

Steve B. Howell is the Project Scientist for the NASA Kepler Mission, at NASA Ames Research Center, near San Francisco, CA. He can be reached at: steve.b.howell@nasa.gov

Tom Barclay is an SO Support Scientist on the Kepler Team at NASA's Ames Research Center. He can be at: barclay.astro@gmail.com

Jason F. Rowe is a scientist for Kepler at the NASA Ames Research Center who helped analyze the Gemini data for this work. He can be reached at: jason.f.rowe@nasa.gov

Nancy A. Levenson

Science Highlights

A diverse collection of scientific results was published with Gemini data in 2014. These highlights provide a sample of the types of cutting-edge science our users are doing.

January 2015

Discrepant Measurements of Stellar Motions in Spiral Galaxies

The bulge stars and central supermassive black holes of galaxies are fundamentally related to each other, and, empirically, measurements of their masses are correlated. Determination of stellar velocity dispersion (σ) conveniently provides the value for stars, allowing derivation of the black hole mass, which is otherwise difficult to measure directly. Observing nearby spiral galaxies, however, an international team reports that the values of σ they measure in the near-infrared are systematically different from shorter wavelength measurements.

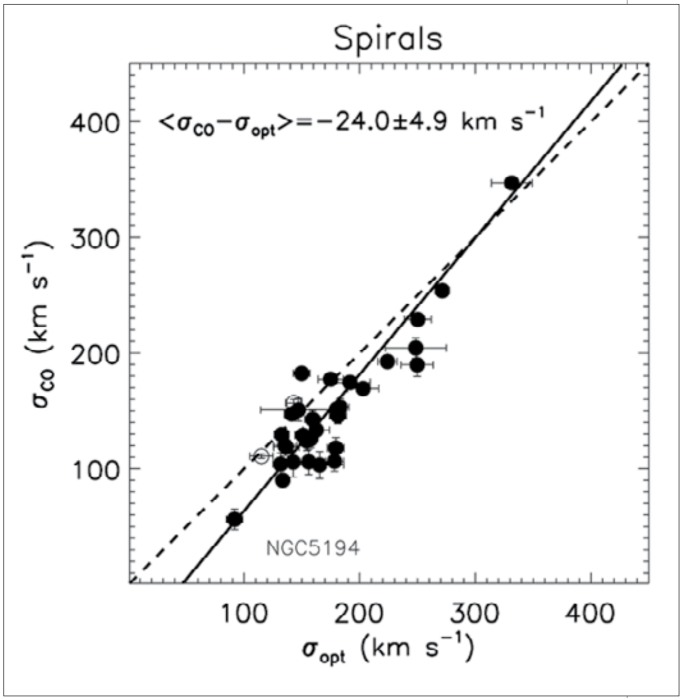


Figure 1.
The stellar velocity dispersions measured using CO and the calcium triplet are significantly different in spiral galaxies. The solid line is a fit to the data; the dashed line shows the one-to-one relationship.

The team, led by Rogemar A. Riffel (Universidade Federal de Santa Maria, Brazil), used the Gemini Near-Infrared Spectrograph (GNIRS) on Gemini North, comparing the stellar absorption lines of the CO band heads around 2.3 microns and the 0.85 micron calcium triplet. In elliptical galaxies, sigma values derived from the two sets of lines agree well. However, in ultraluminous infrared galaxies (ULIRGs) and merger remnant galaxies, σ_{CO} tends

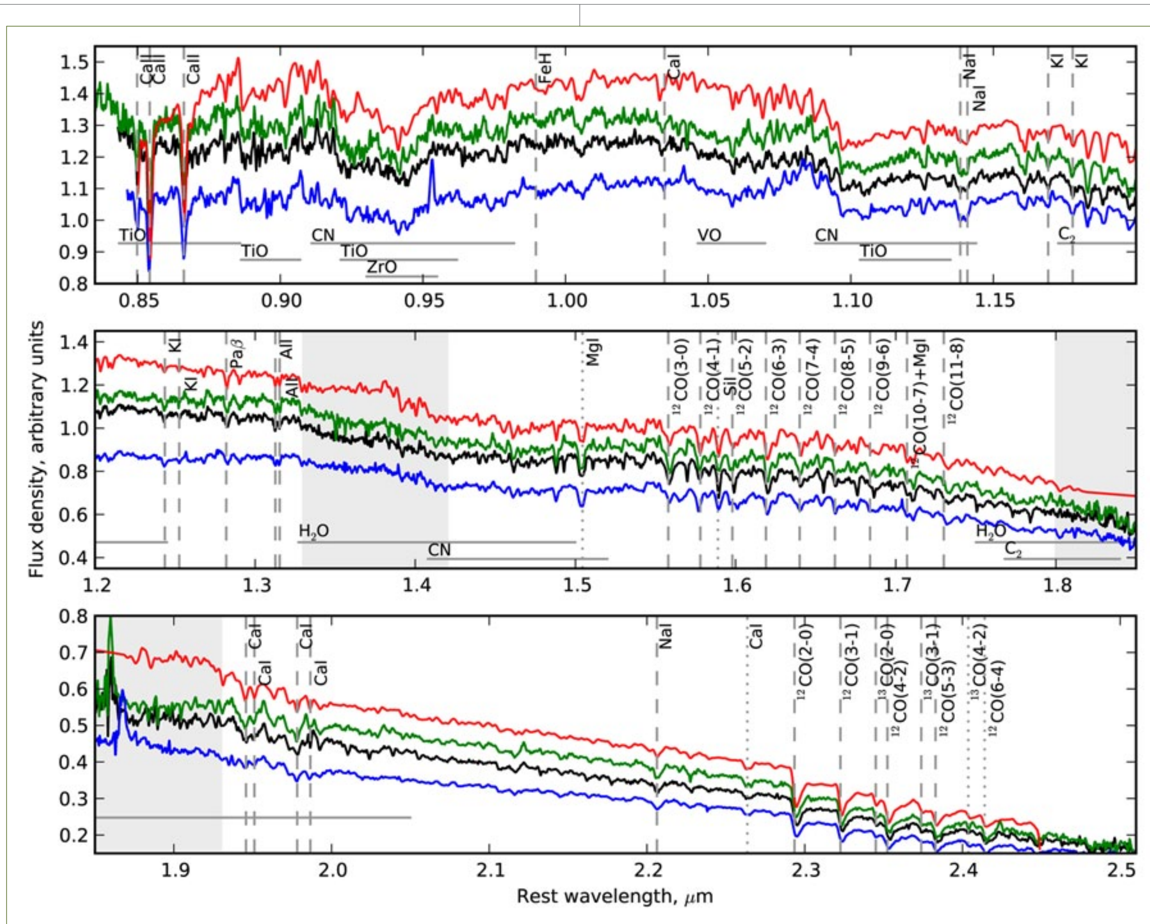


Figure 2.
Three of the GNIRS galaxy spectra from the Mason et al. *paper, showing the wavelengths of the calcium triplet, CO band heads, and numerous other atomic and molecular features. The blue, black, and green lines are observed spectra while the red line is a combination of empirical stellar spectra. The close resemblance between the stellar and galaxy data shows that most of the structure in the galaxy spectra is composed of real, weak absorption lines.*

to be smaller than σ_{CaT}. The so-called "sigma-discrepancy" has implications for our understanding of galaxy evolution; masses derived from σ_{CaT} imply that ULIRGS could evolve into giant elliptical galaxies, whereas σ_{CO} would imply them to be the ancestors of much smaller galaxies.

Members of the team wondered whether the sigma-discrepancy would also be observed in the cores of spiral galaxies. Their measurements show that although a statistically significant discrepancy is present, it is much smaller than that observed in the ULIRGS and merger remnants (Figure 1). The lower σ_{CO} indicates that a dynamically cold stellar population is present in the spiral galaxies. Based on the fact that small velocity dispersions and young stellar populations have been observed to be spatially related in Integral Field Unit spectra of a handful of galaxies, Riffel *et al.* speculate that the sigma-discrepancy is evidence of recent nuclear star formation in these spiral galaxies.

This work used a set of 50 new GNIRS cross-dispersed spectra of nearby galaxy centers (Figure 2). With wide wavelength coverage and generally good signal-to-noise ratio, the spectra are also being used to investigate several topics related to weakly active galaxies and their stellar populations. A sizable international collaboration is now further examining the data to model the stellar features and emission lines and exploring the properties of the active galactic nuclei, as well as other areas of study.

Full results from the current work are in press in *Monthly Notices of the Royal Astronomical Society* ***(view here)*** and a preprint is available ***here***. The paper presenting the data and giving access to the reduced spectra, led by Rachel Mason (Gemini Observatory), has been submitted to *The Astrophysical Journal Supplement Series.*

Evolution of the Ionized Universe

The epoch of reionization in the early universe and the subsequent evolution of ionized material is fundamentally related to cosmological evolution. New work measures the mean free path of ionizing photons at redshifts $z > 4.4$ and shows strong evolution in the ionized structures.

Gábor Worseck (Max-Planck-Institut für Astronomie and University of California Santa Cruz) and collaborators base these results on a multi-semester, multi-partner study that obtained observations of quasars using both Gemini Multi-Object Spectrographs (Figure 3). Quasars serve as bright background continuum sources and are therefore sensitive to absorption by neutral hydrogen along the line of sight. Specifically, they measured the mean free path of photons at the Lyman limit (λ_{mfp}^{912}).

In this first large set of such high-redshift quasars (numbering 163 targets), the team divided the sample into redshift bins and measured the evolution of λ_{mfp}^{912} over time. They found $\lambda_{mfp}^{912} \propto (1 + z)^{-5.4}$, which is significantly steeper than that due to cosmic expansion alone [$\propto (1 + z)^{-3}$]. The team interprets these results as due to large-scale structures of the universe. The density and neutral fraction of these filaments decreases with time, accounting for the short distances Lyman continuum photons could pass freely before absorption in the early universe.

The smooth evolution observed supports the expected result that the universe was substantially ionized by $z = 5.2$, which is the highest redshift examined in this study. Thus, this work does not probe the epoch of reionization directly. Approaching this period, however, it does set an important constraint on models of reionization, and this work rules out several models of absorbing systems in the early universe.

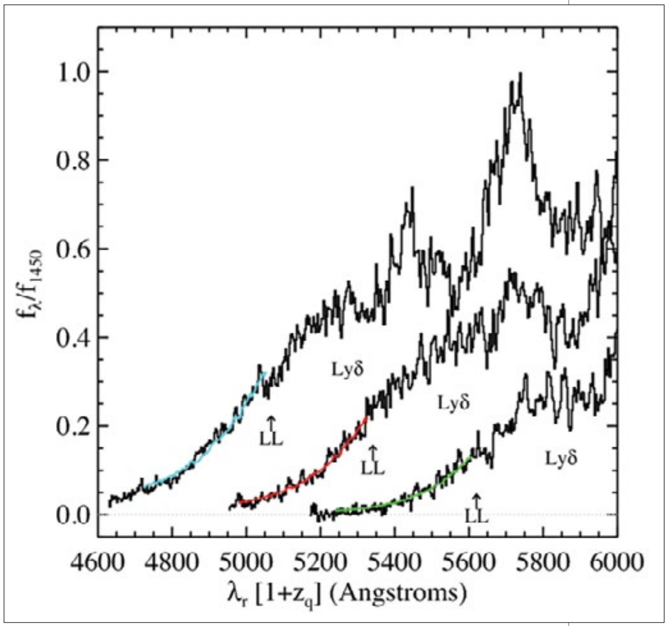


Figure 3. *Quasar spectra averaged over the redshift intervals [4.4, 4.7], [4.7, 5.0], and [5.0, 5.5] (top to bottom). The onset of the Lyman limit is marked in each case (LL). The model intrinsic quasar emission is overplotted in color.*

The paper is published in *Monthly Notices of the Royal Astronomical Society* ***(viewable here)*** and reduced quasar spectra are available ***here***.

The Origins of Massive Field Stars in the Galactic Center

The existence of massive field stars in the extreme environment of the Galactic center raises fundamental questions about their origin. The challenge is to form these short-lived stars that are not presently located in sites of obvious recent stellar birth, such as molecular clouds (which would offer the raw materials) or clusters (which would show the effects of concentrated star formation).

New work by Hui Dong (National Optical Astronomy Observatory) and collaborators provides accurate kinematic measurements of massive stars and their nearby gas regions. This work suggests some scenarios for the origin of these massive stars, finding evidence for both ejection from clusters and *in situ* formation in different examples.

The sample of eight stars was selected on the basis of Paschen α emission, characteristic of massive stars. Observations using the Gemini Near-Infrared Spectrograph (GNIRS) and Near-infrared Integral Field Spectrom-

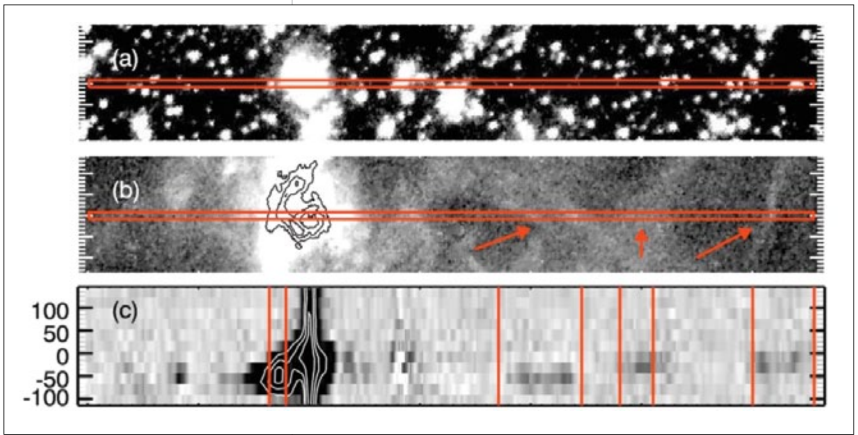


Figure 4.
Upper panels show near-infrared continuum and Paschen a images of target P35 and its associated HII region. The position-velocity plot (c) around the wavelength of Brackett γ is extracted from the GNIRS longslit spectrum (whose location is marked with horizontal lines in the upper panels). Low surface brightness features marked with arrows in (b) are evident in the position-velocity plot.

eter (NIFS), both on the Gemini North telescope, provide spectroscopy with a resolution of around 50 kilometers per second. Sample stars located near the Arches cluster are similar to the cluster population (in terms of age, mass, and spectral characteristics), suggesting that they were originally cluster members. The massive field stars could have been dynamically ejected from the cluster, especially through three-body interactions.

Two examples show velocities that are similar to those of nearby molecular and ionized gas clouds, which implies a physical association with these neighboring star-forming regions. The researchers suggest that one of these in particular, dubbed P35 (Figure 4), may have formed at this site. In contrast, other stars show differences in motion compared with nearby gaseous regions, which suggests that the stars are only passing by and were not formed originally at these locations.

In addition, the new spectroscopy confirms main sequence masses exceeding 50 M_{Sun} in all cases and enables additional spectral classification; Dong *et al.* also report the identification of a new O If+ star. Complete results appear in *Monthly Notices of the Royal Astronomical Society* ***(view here)*** and a preprint is available ***here***.

October 2014

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 (Figure 5). 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.

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

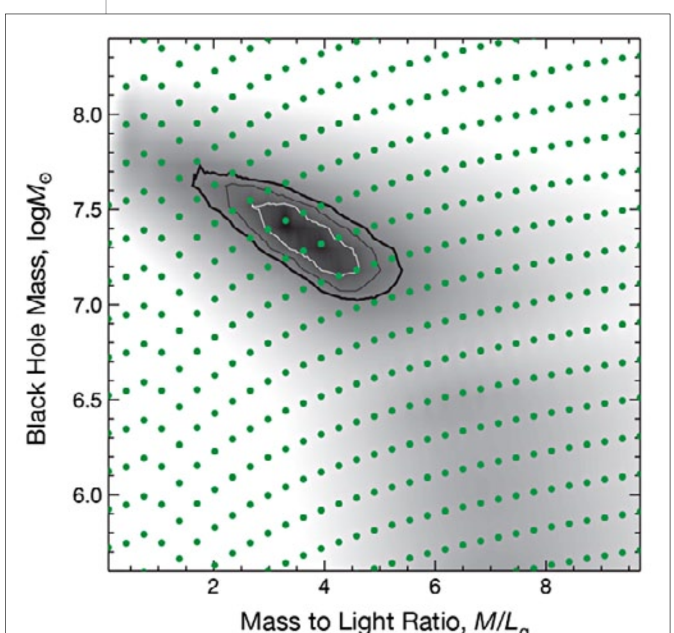


Figure 5.
The black hole mass is derived from dynamical modeling, where the stellar CO bandhead provides the kinematic information. This figure shows the goodness-of-fit measurement considering variations in black hole mass and stellar mass-to-light ratio, calculated at the discrete green points. Contours mark the 1, 2, and 3σ confidence levels.

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 (Figure 6) 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 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)***.

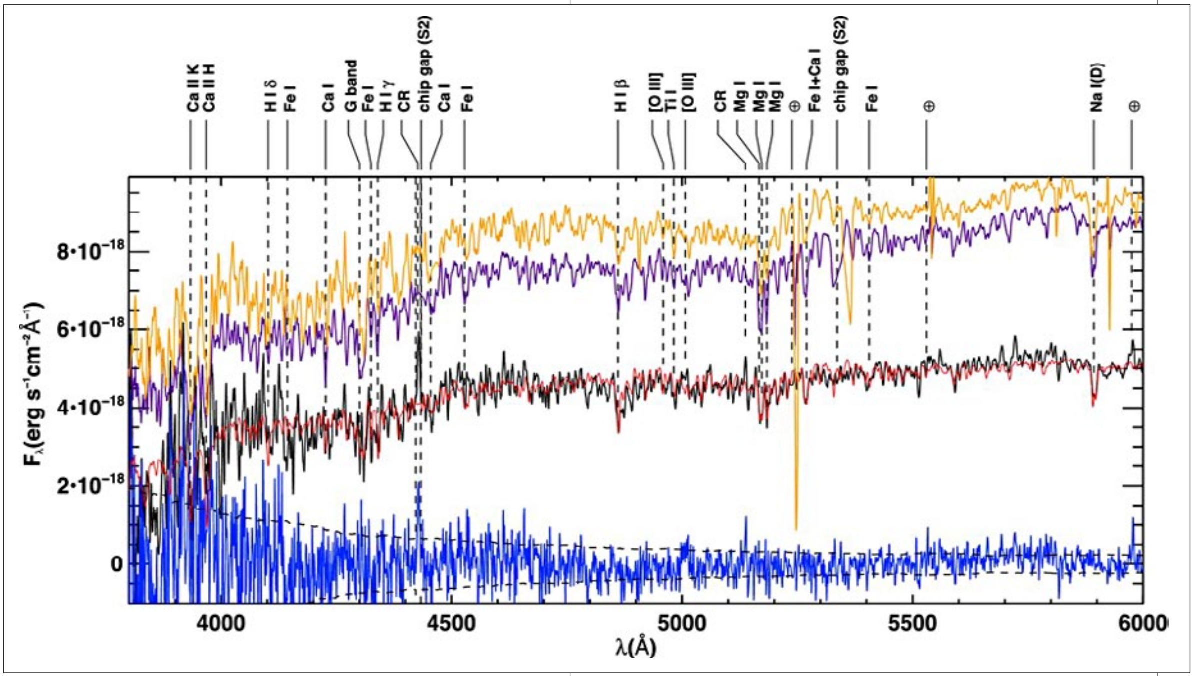


Figure 6.

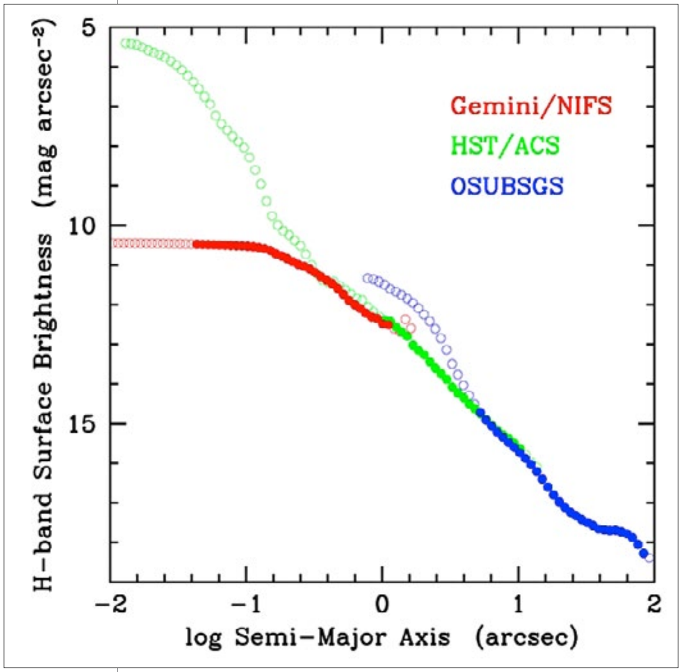
The Gemini spectrum of the tidal flare source (black), with best-fitting model (red) and residuals (blue), demonstrates that the host is a low-mass quiescent member of Abell 1795. Spectra of nearby early-type galaxies are also plotted (orange and purple at the top).

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.

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.

Figure 7.
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.



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 (Figure 7). They find a black hole mass of $3.8 \times 10^7 M_{Sun}$, 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**).

June 2014

The Origin of Lenticular Galaxies

Lenticular (S0) galaxies are more common now than they were in the past, implying that they represent the late stages or end-points of galactic evolution. Their precursors are likely spiral galaxies that have lost their disks. New work led by Evelyn Johnston (University of Nottingham) specifically traces the properties of their component stellar populations to provide evidence for this transformation.

The research team found that, unlike spiral galaxies (such as the Milky Way), lenticular galaxies have bulges that are younger and more metal-rich than their disks. The team describes an evolutionary process whereby enriched gas in the spiral disk moves to the bulge, providing the material for the last episode of star formation in the new lenticular galaxy.

The researchers concentrate on a sample of 21 S0 galaxies located in the Virgo Cluster. They employ a novel analysis technique, which uses the spatial light profile to decompose the separate bulge and disk spectra for each galaxy. This simple spatial model consists of only the bulge and disk components, so complicated morphologies, such as dust lanes and rings, are problematic.

In all cases, the team needs high signal-to-noise ratios to extract the distinct spectra, which is possible in the relatively nearby Virgo Cluster and using the Gemini Multi-Object Spectrographs (GMOS) at both Gemini North and South. Absorption lines yield age and metallicity values, with stellar indices measured directly and stellar models used to derive physical properties. While different models would provide different absolute values, the sense of the relationships remains robust, with younger and more metal-rich stellar populations in the disks (Figure 8) — the result of recent episodes of star formation in enriched material.

The cluster environment, too, is likely important in the evolutionary process, which requires a traumatic event to strip the disk gas (quenching star formation there) and funnel it toward the galaxy's center. The rich environments of clusters do provide such opportunities for the progenitor spiral galaxies to interact with other galaxies and the diffuse cluster medium. This work, however, is not sensitive to the possible effects of environmental variations.

Full results are published in *Monthly Notices of the Royal Astronomical Society*, **441:** 333, 2014, and a preprint is ***available***.

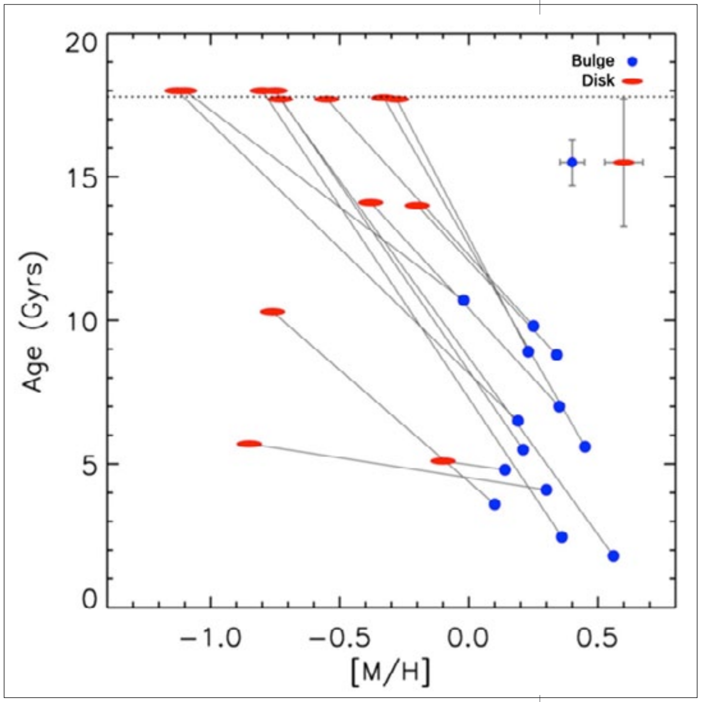


Figure 8.
Estimates of the relative ages and metallicities of the bulges (blue circles) and disks (red ellipses) of the S0 galaxies in the Virgo Cluster. Solid lines link bulge and disk stellar populations from the same galaxy. The general trend shows younger, more metal-rich bulges relative to their corresponding disks.

Galaxy-wide Outflows Common Among Quasars

New work shows that galaxy-wide outflows are common among galaxies that host luminous quasars. The underlying energetic source of these outflows is unclear, being related either to the accretion onto the central supermassive black hole or star formation. Some process to inject mass and energy into the surroundings does, however, appear to be an essential aspect of cosmic evolution.

In addition to depositing chemically-enriched material in the halo and larger intergalactic environment, outflows may be a key link that provides feedback between the growth of central black holes and star formation, which accounts for the present-day distribution of galaxy properties.

Chris Harrison (Durham University) led the study, based on observations of 16 luminous quasars at redshifts $z < 0.2$. These are all type 2 (*i.e.*, obscured) radio-quiet quasars exhibiting ordinary rates of star formation. Selected from a parent sample of 24,000 galaxies, these observations yield general conclusions

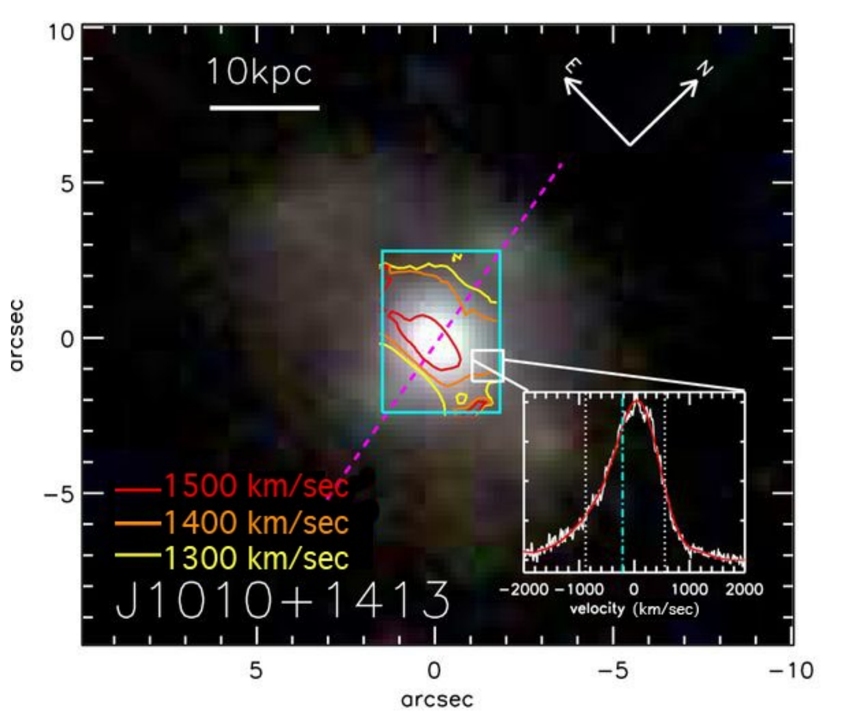


Figure 9.
An example object from the GMOS observations. The background image is from the Sloan Digital Sky Survey. The cyan rectangle shows the GMOS IFU field-of-view. The red/yellow contours show the distribution of high-velocity ionized gas. The inset shows an example oxygen emission-line profile ([O III] 5007) that was used to trace the gas velocity.

about the frequency, properties, and impact of galaxy-wide energetic outflows.

The targets are relatively high luminosity, with active galactic nucleus (AGN) contributions $L_{AGN} \sim 10^{45}$ erg/sec. They also exhibit spectrally broad [O III] emission, but this is not unusual, being characteristic of nearly half the parent sample, even without correcting for the difficulty of measuring weak broad components.

The team obtained data using the GMOS-South Integral Field Unit (IFU), which enables spatially resolved kinematic measurements based on emission of Hβ and [O III]. Bulk outflow velocities are typically in the range of 500 to 1000 km/sec, and the emission-line profiles of the two species are generally similar.

The researchers find that the ionized oxygen emission extends over sizes of 10-20 kiloparsecs, or even beyond the observed field-of-view (Figure 9). Mass and energy are flowing, with mass outflow rates typically 10 times the star-formation rate, though it is not certain whether this material will permanently escape to the galaxy halo.

Disentangling the source of the outflow as either star formation or the AGN is difficult. There are no obvious morphological differences between the two. Energy-scaling arguments alone are insufficient, since the underlying power — luminosity from star formation, AGN, and related radio sources — is generally correlated. A mix of all sources may be important. Nonetheless, these results are broadly consistent with theoretical models of AGN-driven outflows that contribute to galactic feedback.

The complete results, including detailed analysis of the individual galaxies observed, are published in *Monthly Notices of the Royal Astronomical Society*, **441:** 3306, 2014, and a preprint is [*available*].

Studying High-redshift Star Formation Nearby

Star-forming clumps are characteristic of high-redshift galaxies, especially around the peak epoch of star formation at $z \sim 2$. However, the endpoint of these massive clumps of dense gas is uncertain; they could evolve to provide the galaxy's thick disk and bulge, or they could be disrupted in place.

More sensitive observations and detailed analysis are possible in the examination of nearby galaxies; the challenge is to identify appropriate analogs in the nearby universe where these phenomena are uncommon.

Robert Bassett (Swinburne University of Technology) and colleagues present two examples of these rare, more local, analogs, ultimately favoring the first scenario and predicting that the clumps will supply the hosts' thick disks, rather than dissipate. The studied $z \sim 0.1$ galaxies were selected from among a larger sample identified by large Hα luminosity, which then further showed smooth rotation of their disks. These cases are additionally similar to the high-*z* examples in stellar mass and in high luminosity of the detected gas clumps (Figure 10).

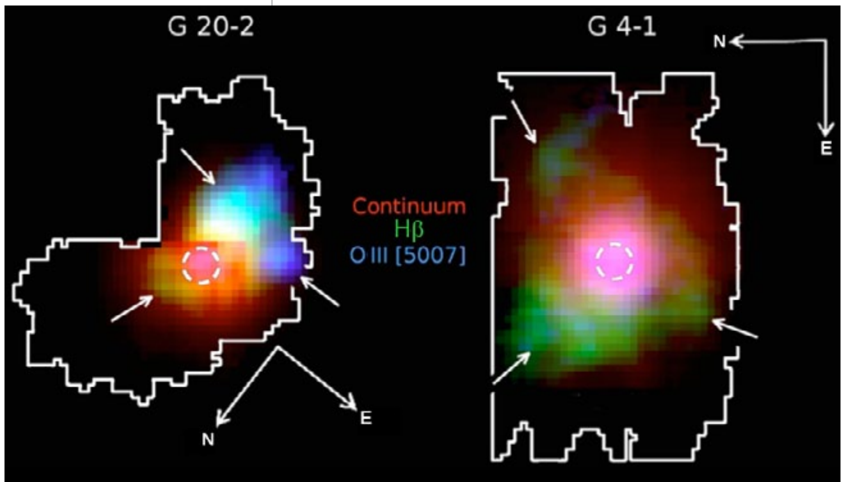


Figure 10.
False-color images of the galaxies constructed from the Gemini IFU data, with continuum, Hβ, and [O III] in red, green, and blue, respectively. The circles show the continuum peaks, which are coincident with the kinematic center in each case. The arrows mark locations of clumps, which are evident as local emission-line peaks.

The observations were made using the Gemini Mulit-Object Spectrograph Integral Field Units on both Gemini telescopes. Stellar absorption lines and ionized gas emission lines provide kinematic measurements of the stellar and gas components of the galaxies. Both the gas and the stars show smooth rotation and large velocity dispersion.

The kinematic similarity of these components suggests a common external origin for turbulence that results in the large velocity dispersion, as opposed to a feedback mechanism whereby stellar processes (including winds and supernovae) act on the gas alone.

A preprint is now ***available*** and publication is forthcoming in *Monthly Notices of the Royal Astronomical Society*.

April 2014

Discovery of the First B[e] Supergiants in M31

Michaela Kraus (Akademie ved Ceske republiky, Czech Republic) and collaborators from Argentina and Brazil have used the Gemini Near-Infrared Spectrograph (GNIRS) on Gemini North to identify the first B[e] supergiants in the nearby galaxy M31. These stars represent a short-lived phase of evolution of massive stars, after their time on the main sequence.

These stars are broadly relevant first in the context of stellar evolution and second as sources of metal enhancements in galaxies. B[e] supergiants deposit enriched material in the interstellar medium through mass loss (during post-main-sequence phases) and ultimately as supernovae. The mass loss can result in disks and rings, and the progenitor of Supernova 1987A in the Large Magellanic Cloud may, in fact, be a B[e] supergiant. Besides increasing the known population of these rare objects, M31 offers an interesting host environment, having higher metallicity (about twice solar) compared with previous examples.

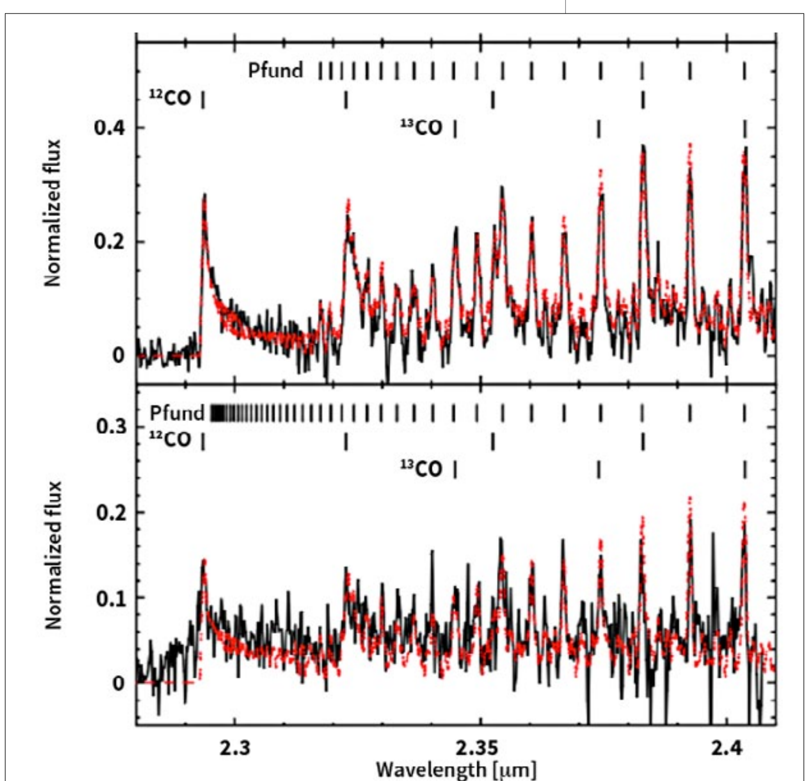
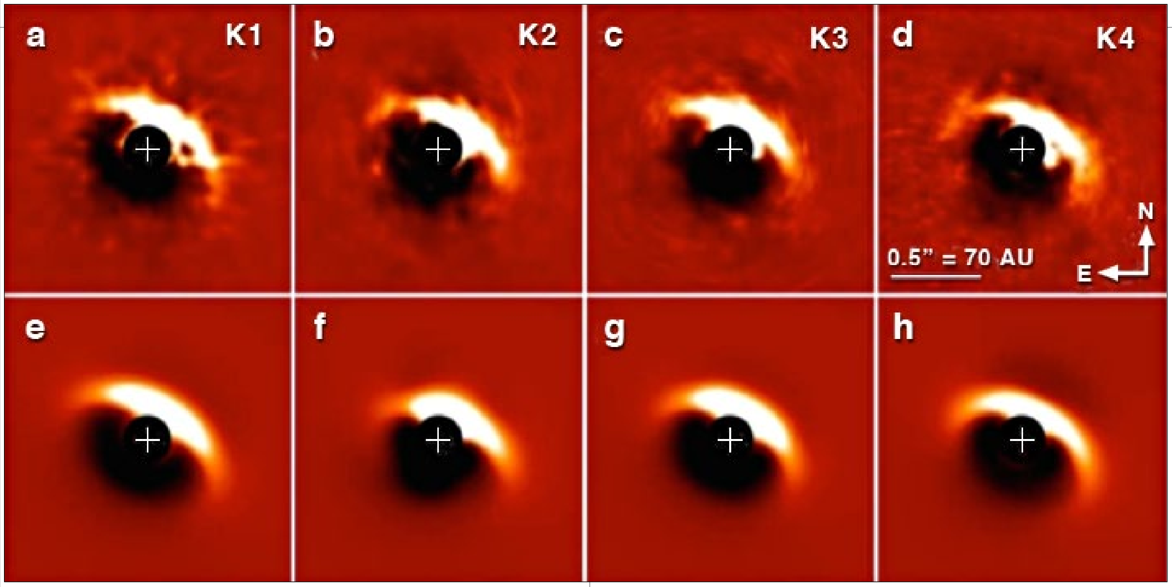


Figure 11.
GNIRS continuum-subtracted spectra of two newly identified B[e] supergiants in M31 (black), exhibiting the hydrogen Pfund series and both ^{12}CO and ^{13}CO. The red lines represent model fits to the observations.

Figure 12. *NIRI/Altair observations of LkCa 15 in the K_s band at four epochs (labeled K1 through K4), reduced using angular differential imaging techniques (top row, a–d). Corresponding model observations of the disk emission appear in the bottom row (e–h).*



One challenge in identifying B[e] supergiants is to distinguish them from luminous blue variable (LBV) stars — another short-lived phase in the post-main sequence evolution of massive stars. This study's original targets were selected from stars previously identified as "LBV candidates." These newly discovered examples lie in a typical region of the near-infrared color-color diagram, one distinct from the location of luminous blue variables.

More important, B[e] supergiants have two identifying characteristics in the infrared: hydrogen Pfund series emission lines and carbon monoxide (CO) bands (Figure 11). Both ^{12}CO and ^{13}CO are detected, and their relative strength indicates the isotope ratio of $^{12}C/^{13}C$ at the stellar surface (7 ± 2). The relative enrichment of ^{13}C here is greater than that observed in lower-metallicity environments of the Milky Way and Magellanic Clouds.

This paper can be found in *The Astrophysical Journal Letters*, **780:**10, 2014

Detailed Observations and Modeling of a Young Star's Disk

Planets form in the dusty disks left over from star formation. Planet development can shape these disks, especially by carving holes in the dense medium. LkCa 15, a nearby young star somewhat similar to the Sun, has one of these residual disks. It is an excellent target for detailed studies, because previous evidence shows a Solar-System-sized gap (~50 astronomical units) around the star. Now, in a new work, Christian Thalmann (ETH Zurich and University of Amsterdam) and collaborators use four epochs of observations to provide a detailed model of this star's disk.

One important new result is that they distinguish the disk's geometry, identifying bright emission as the near side (where light is forward scattered toward the viewer) as opposed to direct illumination of the far side. The team finds evidence for disk asymmetry, namely, an offset between the star and disk center, which could be due to an unseen planet. In addition, the disk's inner wall has a rounded or irregular shape, rather than being flat. This characteristic, too, could be related to the presence of a companion.

The disk is directly evident in observations obtained with the Near-Infrared Imager (NIRI) and the Altair adaptive optics facility on Gemini North; the researchers used data reduction techniques to enhance the contrast of the faint disk near the bright central star. While such angular differential imaging increases contrast, the resulting images cannot be used for quantitative analysis. Therefore, the researchers model a variety of disk configurations, then simulate the resulting observations, including scattered light from the central host star (Figure 12). The best-fitting models yield the bright emission results noted above, indicate an inclination of 50 degrees, and confirm the inner gap's size.

This *Astronomy and Astrophysics* paper is available in electronic form ***here***.

Identifying Low-mass Stars in Young Groups

Obtaining a complete census of low-mass stars is an important step in determining the intrinsic distribution of stellar masses (the initial mass function), and these low-mass examples also offer some of the best opportunities to image planets, because the host stars are not overwhelmingly bright. In recent work, Lison Malo (Université de Montréal) and collaborators concentrate on the case of young nearby groups of stars, providing additional evidence to identify 130 more low-mass stars as members of these young moving groups.

The original target sample included 920 low-mass stars that exhibited some evidence for youth. Bayesian statistical techniques provided distance estimates and reduced the sample of interest. The new work concentrates on the most likely candidates and adds high spectral resolution observations, obtained primarily using Phoenix on Gemini South. These data enable measurement of the radial velocity, which provides kinematic evidence for group membership, and projected rotational velocity, which indicates age.

The age is an important characteristic to confirm group membership. One further result from this work is to identify X-ray luminosity as an additional useful age discriminant for the M dwarfs of interest (Figure 13), which is shown to be even more effective than the ratio of X-ray to bolometric luminosity that has previously been been applied. The X-ray luminosity technique also offers the advantage of extending to a broader (older) age range than some other common methods, such as measurements of lithium line strength.

Absolute confirmation of the individual stars as members of these nearby (distance less than 100 parsecs) and young (age less than 100 million years) moving groups still requires measurement of parallax, although the work so far provides a high likelihood that they would be confirmed. The results will be published in *The Astrophysical Journal*, and a preprint is now available at ***arXiv:1402.6053***.

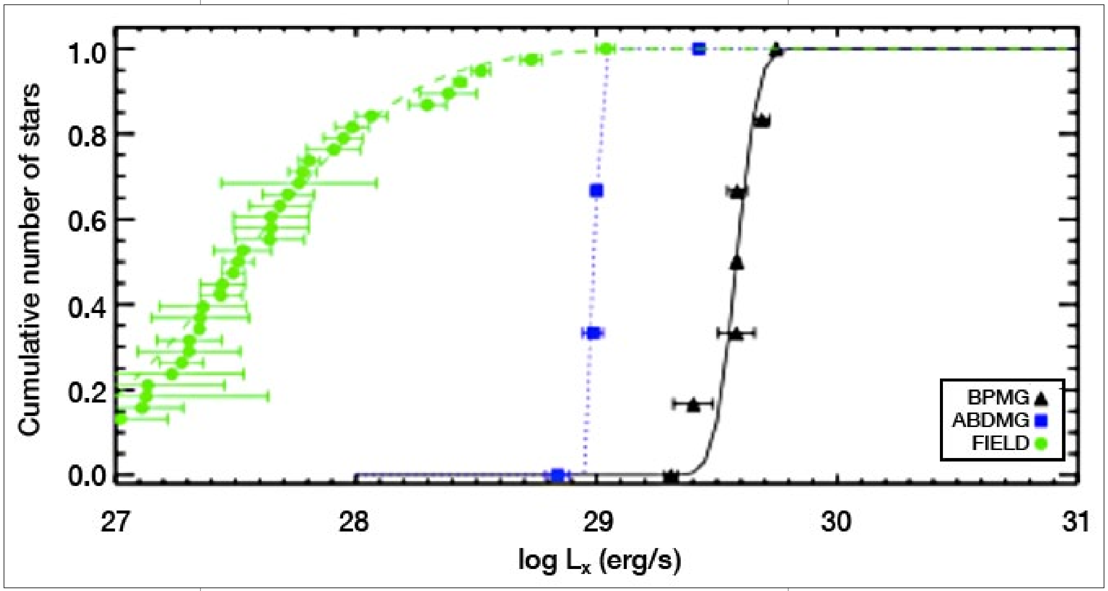


Figure 13.
Cumulative distribution of the X-ray luminosity demonstrates the utility of this measurement as an age indicator, showing field stars (green circles), confirmed members of the Beta Pictoris moving group (black triangles), and confirmed members of the AB Doradus moving group (blue squares).

Nancy A. Levenson is Deputy Director and Head of Science at Gemini Observatory and can be reached at: nlevenson@gemini.edu

Contributions by Gemini staff

News for Users

The following compilation includes "New for Users" updates from all 2014 issues of GeminiFocus. Stories are presented here in reverse chronological order, with the most recent issue first. (Some of the stories were updated in a subsequent issues; this is indicated at the end of each story.)

January 2015

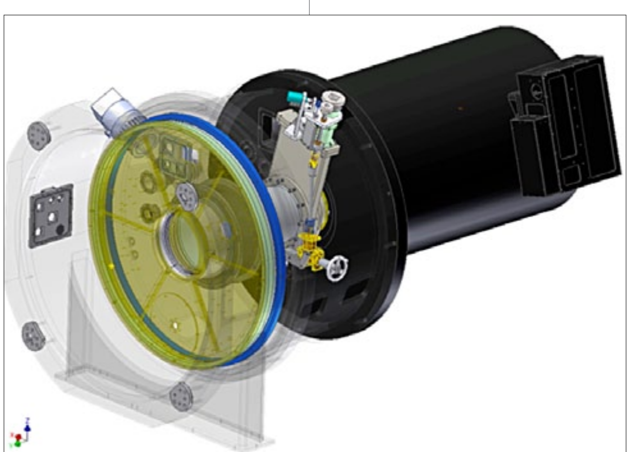
Science User Support Department

Formed in mid-2014, the Science User Support Department (SUSD) is intended to provide sustained attention to post-observing support. The new department is largely a reorganization and will consolidate effort that has been distributed around Gemini, including data reduction software development, National Gemini Office interactions, helpdesk, data-reduction-forum stewardship, and archive coordination.

Joanna Thomas-Osip manages the new department, having transitioned from a Science Operations Specialist to the post on September 15th. Joanna has a Ph.D. in astronomy from the University of Florida, as well as postdoctoral research and project management experience at both MIT and Las Campanas Observatory/Giant Magellan Telescope. Joanna's vision for SUSD is to create a collaborative community of users and staff by "encouraging interactions that induce constructive interference in our feedback cycle." In other words, feedback and solutions should flow back-and-forth between users in a cycle that fosters constant improvements.

For issues relating to user support, please feel free to contact Joanna at *jthomas@gemini.edu*, or look for her at the January Gemini Users Meeting in Toronto (Ontario, Canada).

Figure 1.
The FLAMINGOS-2 gate valve mechanism, situated in the tunnel between the two halves of the cryostat. The front, temperature-cyclable part houses the MOS wheel, and the rear includes the camera optics and detector.



Update on FLAMINGOS-2

As reported in the October 2014 issue of *Gemini*Focus, FLAMINGOS-2 is back on sky with image quality now good over the entire

6-arcminute field-of-view. The instrument remains in imaging- and long-slit modes only, pending commissioning of the Multiple Object Spectrograph mode, which may become possible in 2015. Spectroscopic resolution is quite close to the original specifications, but optical modeling has been done to see whether it can be improved. Considering this, we now believe that FLAMINGOS-2 spectroscopy has reached its full potential. The problem with high background reported in October will be addressed during a short shutdown in February 2015, see Figures 1 and 2.

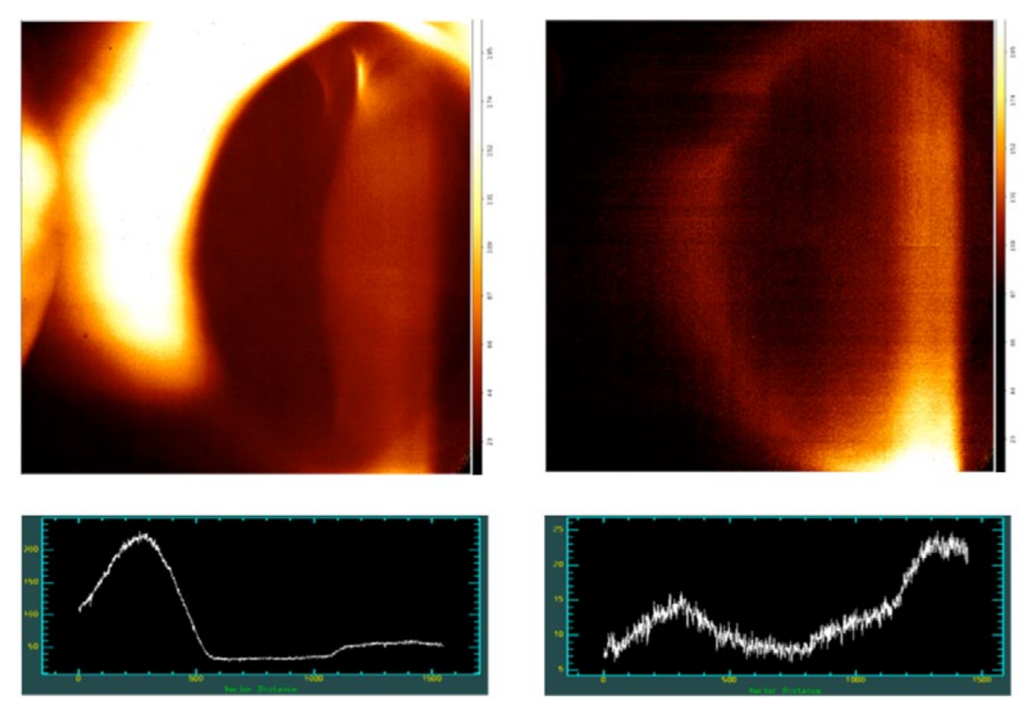


Figure 2.
The effect of the gate valve baffle not going into place properly. Radiation from the warm gate valve mechanism is "seen" in the rear cryostat. The figure shows the HK spectral range, the setup most affected by the fault. We will address this in an engineering period for FLAMINGOS-2 in February.

GPI Campaign Commencement

With the Gemini Planet Imager (GPI) now entering regular operations, the GPI Exoplanet Campaign has officially kicked off. With a total allocation of about 890 hours, the campaign is expected to take at least three years to complete. The Campaign is using GPI to produce the first-ever census of giant planet populations between 5 and 50 astronomical units from their host stars, allowing us to better understand the formation of Jovian planets, and how they migrate to-and-fro within their parent solar systems. It will also help unmask how they interact with disks and belts of debris. Finally, the results of the Campaign should bridge the gap between Jupiter and the brown dwarfs with the first examples of cool low-gravity planetary atmospheres.

The first night of Campaign observations occurred on November 8, 2014, with the first of a five-night block undertaken by the instrument team and Gemini staff. The first night was inauspicious, plagued by poor seeing varying and high winds, but the Campaign has some observations which can stand poorer conditions, and several Campaign targets were observed even on that first night. By the end of the block a good haul of Campaign targets had been observed.

GPI Queue

GPI has been in the queue since the start of Semester 14B, in scheduled blocks. Unfortunately, the weather has not been cooperating; out of six scheduled nights, we have only completed three hours of observations. Principal Investigators that have been affected have been contacted to add new targets for those that have set.

Priority Visitor Runs Begin!

Principal Investigators of Large and Long programs are becoming familiar with the "Priority Visiting" mode, in which the observing program's staff are placed at the summit for an extended visit. A PI with an allocation of 40 hours might, for example, come for a total stay of six nights, within which they can choose when to execute their observations (possibly even choosing to observe in better conditions than they formally requested).

During 2014B we have had a number of these runs, both North and South. The first was undertaken by Wes Fraser (Herzberg Institute of Astrophysics, National Research Council of Canada) and collaborators (including one taking advantage of "Bring One, Get One") in August 2014, covering between them a nine-night summit block (see article in the October issue of *Gemini*Focus). The run went very well and featured a night on which three of the big Mauna Kea telescopes were trained on the same object at the same time!

We're keeping notes on what works and what doesn't during the course of these runs, because in the longer term, as the teams become more experienced, we expect to reduce the level of astronomer support at the summit. Priority Visitor (PV) mode was announced as a general possibility in the 2015A Call for Proposals, and we are currently scheduling more such PV runs for 2015A.

Fast Turnaround Program Launched!

Early in the new year (January 2, 2015) we were pleased to announce the release of the first call for Fast Turnaround proposals. This pilot program, running at Gemini North, gives users the opportunity to apply for telescope time every month. Proposals are reviewed by the PI (or a co-Investigator) of other proposals submitted during the same round, and successful programs can be observed starting one month after the proposal deadline. See the [Fast Turnaround web pages] for full details about this innovative program.

October 2014

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.

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

Figure 3.
Optical Technician Claudio Araya works on maintenance tasks inside the Gemini Facility Calibration Unit (GCAL), during the operations shutdown of Gemini South.

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.

GMOS Back for Science at Gemini South

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).

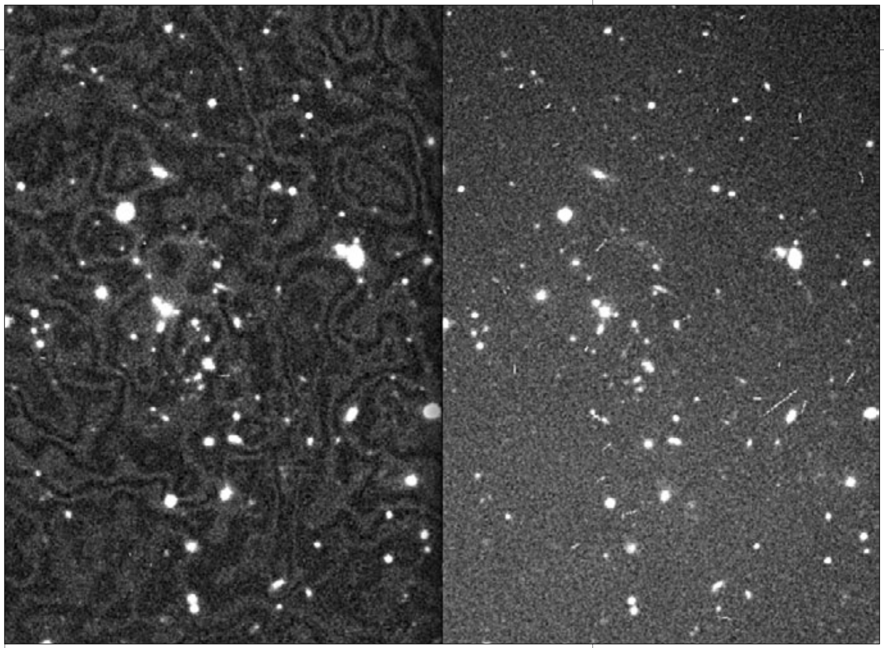


Figure 4.
Images from GMOS, showing a direct comparison between i'-band imaging of the same field (E2V on the left, Hamamatsu on the right). These are raw, unprocessed images, which show how the Hamamatsu CCDs greatly reduce fringing.

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 4) 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)

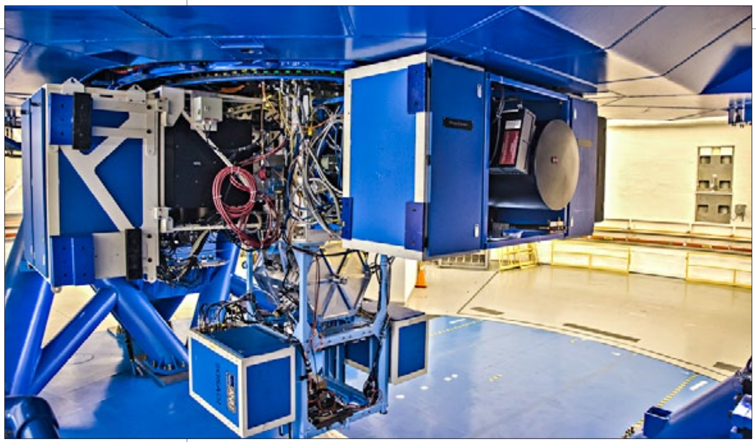


Figure 5.
After having its decker wheel mechanism repaired, FLAMINGOS-2 is operational and working on several observing programs in the current semester.

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 K_s.

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 $K_s \sim 16$ have been put on hold. 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 arcminute field-of-view.

Figure 6.
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.

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.

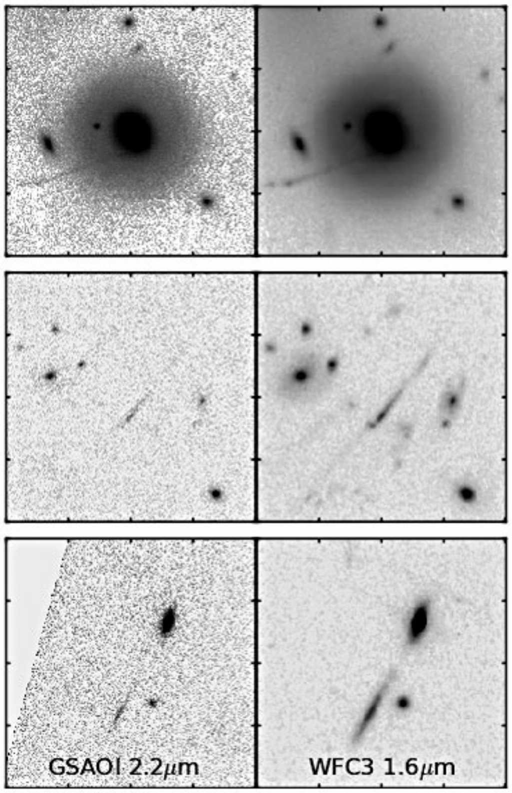


Figure 7.
Comparison of K_s-band images (2.2 micron) taken with GSAOI (left column) and H-band (1.6 micron) images (right) taken with HST/WFC3 (right column). While not as deep as HST data, the new GeMS/GSAOI dataset offers twice the resolution on the distant universe.

July 2014

FLAMINGOS-2 Developments

Although FLAMINGOS-2 (F-2) was successfully recommissioned in late 2013, the optical system had significant problems. An intensive series of consultations, modeling, and investigations determined that the problem was an inverted lens in the camera barrel. This required removal from the telescope and remedial work in April 2014. The problem was rectified in this work, and the instrument has returned to the telescope. The image quality is now excellent across the entire field-of-view (Figure 8).

Spectroscopic performance has benefited somewhat from the change, but spectral resolution away from the center remains well outside of specification. Further modeling is required to determine how to return the instrument to optimum performance — as demonstrated earlier during commissioning tests.

See updates in October 2014 (p. 37) and January 2015 (p. 34).

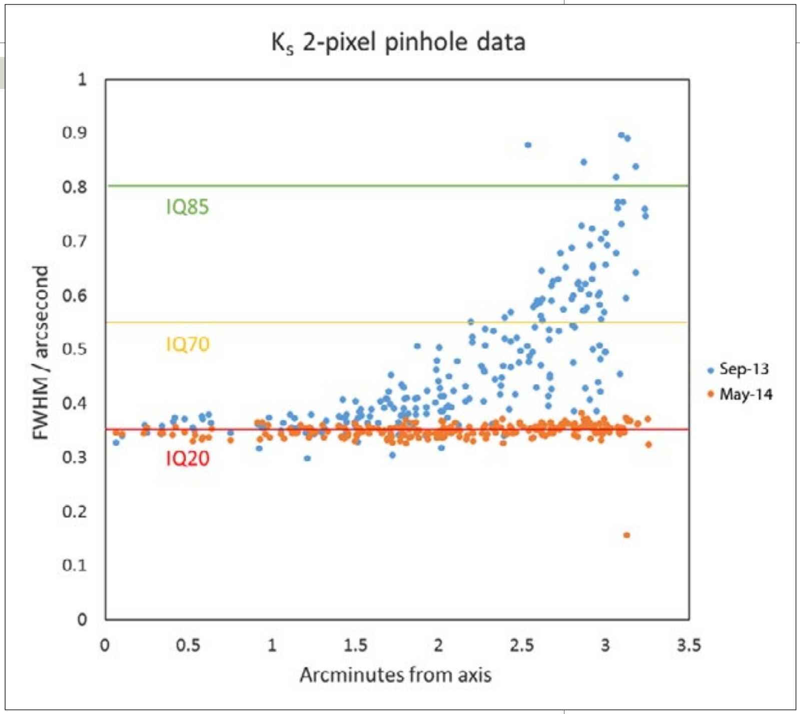


Figure 8.
Point-spread-function plot of F-2 imaging as measured relative to the center of the optical axis before (blue) and after (orange) reversal of lens mentioned in text.

GMOS CCDs

The new focal plane for the Gemini Multi-Object Spectrograph at Gemini South (GMOS-S) — equipped with three red-sensitive Hamamatsu CCDs — was shipped to Chile early in 2014. The instrument team then carried out intensive "burn-in" testing in the lab before installing it into GMOS-S. GMOS returned to the telescope two weeks ahead of schedule, and on-sky tests are currently underway as illustrated in Figure 10. Images and spectra taken with these new detectors may appear by the time the next issue of *Gemini*Focus goes to press.

GeMS Laser

The GeMS laser, specified for 50 Watts (W), has experienced significant issues and in early 2014 its power output deteriorated to 20 - 30W. Nevertheless, GeMS operations proceeded with scheduled runs in April, May, and June (Figure 9). Serendipity played a role in these runs; the return of a seasonally strong sodium layer enabled us to obtain some good data for Principal Investigator programs. With winter now in full swing in the Southern Hemisphere GeMS will return to the lab, and work will continue on returning the laser to a higher power level, which will surely be needed for consistent science returns in the next southern summer when sodium returns are lower.

Figure 9.
Gemini South laser propagates into the sky over Cerro Pachón. Despite lower power, many programs were successfully fulfilled due to the seasonal variations in the atmospheric sodium layer which provided stronger guide star returns.

Figure 10.
Gemini Staff scientists Kathy Roth (left) and Kristin Chiboucas (right) assist in observations at Gemini South (led by German Gimeno) using GMOS with its new, extended-sensitivity Hamamatsu CCDs from the Gemini North Base Facility. Gemini South observing staff in La Serena, Chile, and at the summit of Cerro Pachón, are visible on the screen at top.

Evolving User Support by Gemini and the NGOs

Starting in 2014B, Principal Investigators (PIs) will notice some changes in the way their programs are supported. The changes should provide more efficient support for PIs in the way they prepare their observations. They will also free up much-needed time for Gemini personnel to better support the later stages of the science program lifecycle — through to publication. For various reasons, these changes will come in stages and will differ from partner to partner.

The biggest single development in 2014B is that PIs in the United States will be supported in the Phase II preparation by Gemini staff astronomers, who will see U.S. programs through the entire process — from Phase II to execution on the telescope. A U.S. National Gemini Office (NGO) member will act as consultant to the Gemini staff astronomer; this NGO person will in most cases be the same one who carried out the technical assessment of the proposal. The U.S. NGO staff are also ready to support programs themselves should this prove necessary. This arrangement is a prelude to the U.S. NGO staff taking up other work, such as the writing of data-reduction cookbooks, *etc*.

For 2014B, the Phase II process for non-U.S. partners will also change in the following manner: Support for a given PI's program will be provided by a specialist in their selected observing mode, in some cases not located in the PI's home NGO. Support by a "second pair of eyes" will be provided both within the Observatory and by an NGO member at the PI's home NGO.

Gemini Planet Imager

The commissioning of GPI continues with the most recent success being a six-night run in May. Immediately following the run, the summit crew dismounted the instrument from the Instrument Support Structure (ISS) and relocated it to the Instrumentation Test Room for a final round of software improvements. GPI goes back on the ISS after the August Gemini South shutdown and preparations will proceed for the final commissioning run currently scheduled from August 30th until September 4th. The GPI Campaign is expected to begin in November.

Operationally, the 2014B programs are now in Phase II and the latest version of the Observ-

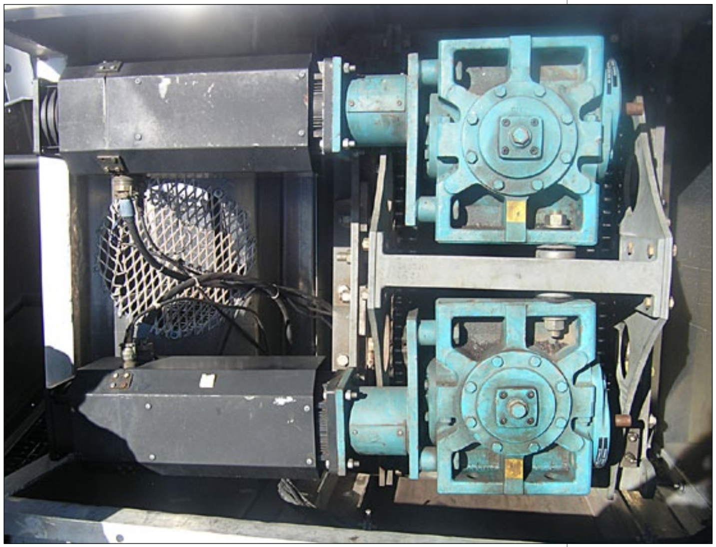


Figure 11:
Dome shutter drive unit, in which a critical bearing had sheared, causing its alignment to skew (lower aqua-colored box) and render the unit inoperable. The entire mechanism weighs about 4 tons and had to be removed from the dome for servicing.

ing Tool has GPI skeletons implemented. These skeletons allow a one-click approach to have fully-defined observations. A total of 12 GPI science programs now exist; requiring 72 hours of telescope time.

For many involved in the Gemini Planet Imager (GPI), recent efforts have concentrated on preparation for the SPIE 2014 conference in Montréal in which GPI had a huge presence. The extended GPI team delivered almost 20 presentations on various aspects of the instrument. See all Gemini-related SPIE abstracts ***here***.

See updates in October 2014 (p. 37) and January 2015 (p. 35).

Gemini North Dome Repairs

In late May, the discovery that the second dome shutter drive unit had failed at Gemini North prompted an unscheduled shutdown in order to make necessary repairs (Figure 11). Because this is the second of these drive units to fail at Gemini North, the repairs went relatively quickly and downtime was kept to a minimum (in the earlier instance the weather was also an issue; see article in the previous issue of *Gemini*Focus for details on repairs to the identical unit on the opposite side of the dome top shutter). Work is ongoing to better understand why these units both failed at Gemini North and to minimize the possibility that they will do so unexpectedly at Gemini South.

For more details on this work, see the blog that features highlights from the shutdown (including a video illustrating the difficulties of accessing the drive unit) ***available here***.

April 2014

Shutter Work Completed at Gemini North

In late December 2013, Gemini North joined the significant group of telescopes that have suffered major failures in their dome systems. A top shutter drive unit had a critical failure with one of its spherical bearings. These drive boxes are designed to last 50 years under normal operating conditions, so clearly it was a faulty mechanism and had to be replaced.

Because this failure rendered the dome unusable, repairing the unit became a high-priority project — one that needed to be completed before science operations could recommence at Gemini North. Removing this system proved extremely challenging. The Gemini North engineering team (Figure 12) worked with external consultants to develop an entirely new set of procedures to pin the shutters in place and extract the broken drive box (which weighs more than two tons and is not amenable to *in-situ* repair). Bad weather hampered an already difficult situation — winds well over 100 miles per hour were encountered in January, and there was significant snowfall during the period. The team finally extracted the unit from the dome at the end of January. Work then progressed very quickly as the unit was inspected, potential

Figure 12.
The dome repair team, just before lifting the repaired gearbox back into position.

causes of the failure identified, repairs made, and the drive box rebuilt and reinstalled. By February 15th, Gemini North was once again ready for observations.

Read a complete summary here.

Large and Long Proposal Mode Piques Interest

Interest from our user community in the new Large and Long programs (hereafter "Large Programs" or LPs) mode is excellent. These Principal Investigator-defined and -driven programs generally either require significantly more time than a partner typically approves for a single program or extend over two to six semesters, or both.

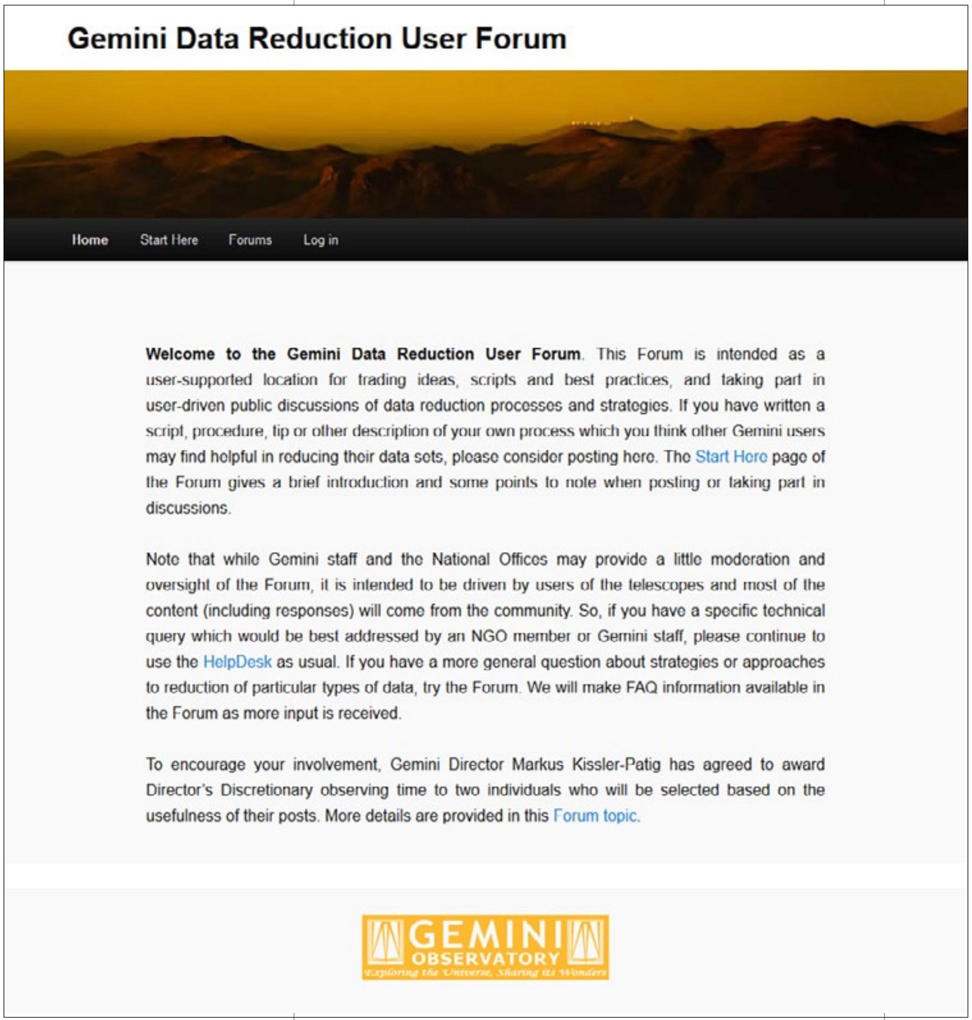
We are happy to report that our users have submitted over 40 letters of intent by the February 3rd deadline. The proposal teams include over 500 astronomers from all Gemini partner countries and beyond. Principal Investigators from all four participating countries (United States, Canada, Australia, and Argentina) intend to lead programs.

The proposals are scheduled for review by a specific Large Program Time Allocation Committee at the end of April. This committee will also make science-based recommendations to the Gemini Director. Approved programs will be merged into the semester plan at the International TAC meeting. We look forward to this first exercise that will be a regular annual opportunity.

In the longer term, Gemini will post an annual announcement of opportunity for these programs in December, with letters of intent due in early February, and final proposals closing at the end of March each year. The TAC meetings will generally precede the NTAC meetings. Program approvals will be announced along with the usual semester schedule.

More information on the program and how it will workcan be seen *here.*

Figure 13. *A screen-capture showing the Data Reduction Forum homepage.*



New Data Reduction User Forum

With the encouragement of the Users' Committee and STAC, a forum for users engaged in reduction of Gemini data is now live and very active. It's located *here.*

The forum is intended to be an online discussion site "for Gemini users, by Gemini users," where people can drop useful scripts, discuss issues relating to data reduction as applied to Gemini data sets, and more. The usefulness of a forum like this depends on the number of people getting involved and staying involved. To help promote that goal, the Gemini Director put up some discretionary observing time (as a prize) to go to the best two contributions received in the first few months!

The forum has a simple interface (Figure 13), using tags to keep track of topics by type, and is intended to provide a user-supported, and more open, complement to the Helpdesk — which will remain operated as always, by the National Gemini Offices and Gemini staff.

The forum is young, but already there have been quite a few postings by users, and some useful scripts (*e.g.* for Integral Field Unit data analysis, Gemini Near-Infrared Spectrograph, cross-dispersed spectroscopy, general imaging reduction, *etc.*) by both users and Gemini staff alike. If you're a graduate student involved in Gemini data, or a seasoned veteran with your own package to contribute, take a look at this forum and don't be shy with your contributions!

At the time of writing, the form hosts about 20 individual topic threads with a few dozen postings and replies or followups. It also has half a dozen scripts and packages, links to reduction cookbooks (some by Gemini staff, some by users), and some general threads directed at answering specific queries.

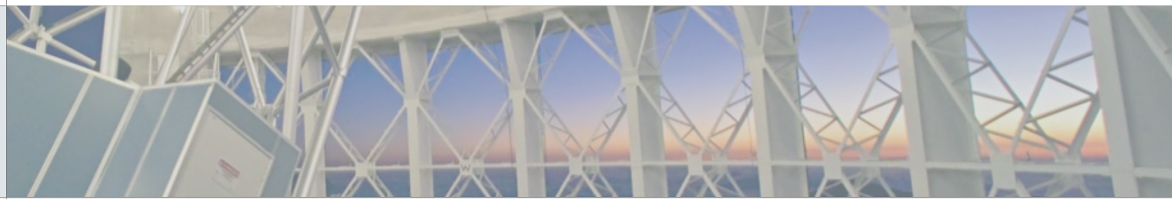
The Users' Committee for Gemini will be looking at all the postings and selecting the winners of the Discretionary Time competition.

Operations Working Group Meets in Hilo

In February, the Operations Working Group held its 26th meeting in Hilo, just before issuing the 2014B Call for Proposals. From this meeting emerged a number of resolutions and actions, including an agreement that, for users requiring good seeing, we relax the full-width at half-maximum values corresponding to Image Quality 20 (IQ20), to better reflect the actual frequency of occurrence. This will have the effect of reducing the number of IQ20 programs that have aborted sequences and is intended to increase the completion rate of such programs.

With an increased focus on visiting instruments (particularly at Gemini North, while several new instruments come online in the south; Figure 14) the Working Group discussed how to best ensure that we increase awareness and promote opportunities within partner communities to solicit visitor instruments for Gemini. To this end, the National Gemini Offices will be looking for such opportunities within their partner countries.

Figure 14.
The Gemini North visiting instrument DSSI (Differential Speckle Survey Instrument) being mounted on the Instrument Support Structure of the Gemini North telescope during an observing run in 2013.



Contributions by Gemini staff

On the Horizon

The following compilation includes "On the Horizon" updates from all 2014 issues of GeminiFocus*. Stories are presented here in reverse chronological order, with the most recent issue first. (Some of the stories were updated in a subsequent issues; this is indicated at the end of each story.)*

January 2015

GRACES: Gemini User Access to High-resolution Optical Spectroscopy Nears

After successful testing, Gemini and CFHT have now agreed on a way to offer GRACES (Gemini Remote Access to CFHT ESPaDOnS Spectrograph) to Gemini users in regularly scheduled blocks of time starting as early as 2015B. Meanwhile, some additional work will further improve GRACES' performance and make it operate more efficiently. The expected sensitivity is already impressive, as illustrated in Figure 1. Since its 270-meter fiber, which connects Gemini to the CFHT ESPaDOnS spectrograph, has a high transmission between 500 and 900 nanometers, GRACES' performance will rival that of other high-resolution spectrographs on other 8-10 meter telescopes. GRACES will operate in two modes: One offering an average resolution power of R=40,000, and another delivering R=68,000.

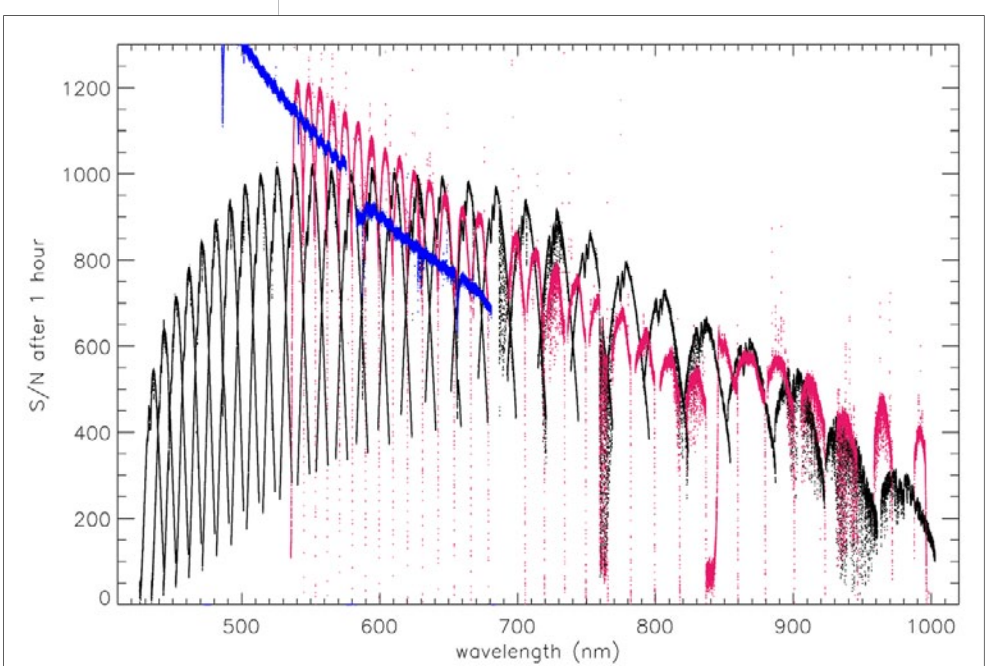


Figure 1.
Comparison of a one-hour exposure on the star Feige 66 observed with GRACES (black), Keck's High Resolution Echelle Spectrometer (HIRES; red), and ESO's Ultraviolet and Visual Echelle Spectrograph (UVES; blue). All the spectra are binned into their resolution element for fair comparisons.
Figure credits: André-Nicolas Chené, Scott Dahm (Keck), and Isabelle Percheron (ESO).

Figure 2.
The GHOST team (consisting of members from AAO, NRC-H, ANU, and Gemini) successfully passed their Preliminary Design Stage Review at Gemini North Hilo headquarters on Wednesday. A team of dedicated experts, external and internal to Gemini, supported the review and made some very good suggestions to help keep the project on track. The entire team was happy and relieved on completion of this major project milestone.

Additional information can be found on the GRACES webpage ***here*** .

GIFS Moves Ahead

The Gemini Instrument Feasibility Study (GIFS) proposal deadline passed on December 15th with eight proposals received. GIFS will provide science cases and instrument ideas that could be used for the next facility instrument (Gen4#3). Gemini will now evaluate the proposals for selection in January, 2015. There's still time, however, to provide input for Gen4#3 at the Gemini Future and Science meeting in June (see page 58). The latest information on GIFS can be viewed ***here***.

GHOST Materializing

During the third week of December 2014, the Gemini High-resolution Optical SpecTrograph (GHOST) project held its Preliminary Design Review (PDR) in Hilo, Hawai'i (Figure 2). Attending were the Review Committee and several members from the partnership: Gemini Observatory, Australian Astronomical Observatory, Australian National University, and Canada's National Research Council–Herzberg.

The PDR Committee was pleased to see the progress achieved, acknowledging the extraordinary effort of the GHOST team in achieving the PDR's passage and has recommended that the project proceed into the Critical Design Stage. The Committee also made numerous recommendations to help the team ensure success. Watch for future updates as the Critical Design Review approaches by the end of 2015; we still plan on bringing GHOST to one of the Gemini telescopes in 2017, though which one has yet to be determined.

Laser Guide Star Facility (LGSF) Upgrade: Next Generation Laser Guide Star for Gemini South

Given reliability issues experienced with the existing laser guide star system at Gemini South, Gemini is investigating procuring a new laser. The current generation of laser systems are much more reliable than our existing laser, which is difficult to maintain at full power, making its use operationally both costly and technically challenging.

In early 2015, we will explore the feasibility of integrating a current generation laser with the rest of our laser guide star system. If this integration is feasible and the new solution meets our power, reliability, delivery time, and cost requirements, we will strongly consider moving forward with procurement.

GMOS: CCD Update at Gemini North

With new red-sensitive Hamamatsu detectors installed and commissioned in the Gemini Multi-Object Spectrograph (GMOS) at Gemini South, and with the CCDs providing good science data, it's now Gemini North's turn to have its GMOS upgraded. The new Hamamatsu detectors should arrive at Gemini North in early 2015. After assembling and testing the new CCDs in the lab, we'll be ready to install them in July 2015, pending operational resources being available. Details and updates are available ***here***.

October 2014

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.

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.

See update in January 2015 section (p. 45).

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 3). 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 Feasi-

bility 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 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 was held on October 31st; notice of intent to submit a proposal was due on November 17th; and the deadline to submit proposals was on December 15th at 23:00 Pacific Standard Time.

For full details, please visit our website ***here***.

See update in January 2015 section (p. 45).

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

Figure 3.
The TBAD receiver unit mounted on the top ring of the Gemini North truss.

Figure 4.
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.

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.

See update in January 2015 section (p. 45).

July 2014

Base-facility Operations

By 2016, Gemini intends to operate both telescopes from their prospective base facilities — Gemini South from La Serena, Chile, and Gemini North from Hilo, Hawai'i. The plan is to achieve this goal in stages.

The first significant milestone is to remotely open the dome at Gemini South in order to permit it to equilibrate ahead of the night observing staff's arrival (Figure 1). According to Gemini's Associate Director of Operations Andy Adamson, this "quick win" provides much insight into the ultimate requirements for base operation.

The remote system includes comprehensive coverage of the dome and telescope with operable video cameras. This will enable staff to perform a thorough safety check of the dome and telescope before committing to opening the shutter. Weather conditions will be continually logged and the system will not allow the dome to be opened unless a series of preset criteria are met.

Fast Turnaround

Over the next few months, Gemini staff will be preparing to launch the new Fast Turnaround proposal mode. This program will offer monthly proposal deadlines and a rapid review of proposals. Accepted programs will be ready for scheduling within a month of the proposals being received. The Fast Turnaround scheme will offer Gemini users new opportunities to follow up unexpected astronomical events or discoveries, carry out pilot studies, or quickly obtain the data needed to finish a Ph.D. thesis, among others.

One novel aspect of the program is that Principal Investigators (PIs) will review each other's proposals. Thus, submitting a proposal also commits the PI (or a co-investigator) to providing grades and brief written assessments of up to 10 proposals submitted during that round by other astronomers. Gemini staff will then use this combined assessment of scientific merit to create a "mini-queue" of programs that will be executed on three nights per month reserved for Fast Turnaround observations.

The program's design — including the peer review system — has been assessed by a committee of internal and external experts, and, in May 2014, the Gemini Board of Directors gave approval to launch a trial using 10 percent of the telescope time at Gemini North. (The remainder of the telescope time will continue to be available for regular proposals, Large and Long programs, *etc*. for the foreseeable future.)

During the rest of this year, we will be establishing the software and procedures necessary to run and monitor the program, in time for the first proposal deadline at the end of January 2015. More information will be made available as the program's web pages are developed; readers may also be interested in the recent SPIE proceedings describing the design of the plan ([available here]()).

See update (page 36).

GHOST

In April 2014, the Association of Universities for Research in Astronomy delivered to the Sydney-based Australian Astronomical Observatory (AAO) a signed contract for the design, building, testing, and commissioning of the Gemini High-resolution Optical SpecTrograph (GHOST, previously referred to as GHOS) — for use on the twin 8-meter telescopes. AAO will have two partners on the project: the National Research Council Herzberg in Victoria, Canada, which will be designing and building the spectrograph portion of GHOST; and the Australian National University Research School of Astronomy and Astrophysics in Canberra, which will be developing the instrument's software.

Rounding out the project team roster are Gemini Operations and Development team members from both the north and south sites. They will work closely with their Australian and Canadian counterparts to ensure a smooth transition of this new instrument into Gemini operations.

Work on the project's Preliminary Design stage has been proceeding for the past couple of months. Last May, instrument technicians, engineers, and scientists gathered in Sydney, Australia, where they spent three days making significant progress. With an end of year 2014 goal to have the preliminary design ready for review, and a 3rd-quarter 2017 goal to be commissioning this new fiber-fed, bench-mounted spectrograph, the GHOST project team is on its way to providing this long-awaited capability to the Gemini community.

See updates (pages 45 and 46).

Figure 5.
Science operations specialist Erich Wenderoth (left), and systems engineer Andrew Serio (right), open the dome of the Gemini South telescope remotely from the La Serena Base Facility, without the assistance of an operator at Cerro Pachón. This milestone is part of the Base Facility Operations (BFO) project targeted to allow full remote operations, by the first half of 2016.

Gemini Generation-4 Instrument #3 Project

With development of the Gemini Planet Imager (GPI) ramping down as the instrument's commissioning nears completion, work on Gemini's next new instrument (called Gen4#3 for the third, 4th-generation instrument) is advancing.

The plan is to approach this new instrument as two distinctly different projects. First, we will solicit an open call for feasibility studies, which we expect to launch early in the fourth quarter of 2014. The goal of these funded, science-driven studies is to provide feasible concepts for an instrument consistent with the guidelines set by our Science and Technology Advisory Committee (STAC).

Once we have reviewed these studies with our community, the creation of two or more sets of specific instrument requirements will commence, allowing us to pursue the second project. Subsequently, we will issue a request for proposals for teams to bid and agree to contracts for the remainder of the work. We expect to then choose two teams, one for each instrument concept, with whom we will negotiate a contract for the remainder of the work.

We intend for this contract to include both the remaining design stages as well as the full construction, delivery, and commissioning stages. In this way, we avoid having to issue one contract for the Conceptual Design Stage and another for the remainder of the work as we have traditionally done. Depending on available funding and the success of each team review, we intend to allow one or both teams to continue to design, build, and deliver their instrument(s).

Aside from the new contracting approach, we can now work with instrument teams in additional ways by providing telescope time as partial compensation for work performed and accepting and partnering in possible in-kind contributions from our teams. By working together, we envision a continuation of necessary updates and improvements to Gemini's instrument suite using a variety of tools and contributions from the global Gemini community. Full details will be forthcoming and included in the Call for Proposals.

See update (page 45).

April 2014

GRACES: A Gemini and CFHT Partnership in Spectroscopy Leaps Forward

Gemini Observatory, the Canada-France-Hawaii Telescope (CFHT), and the National Research Council (NRC) Herzberg in Canada have formed an innovative partnership on a project that is progressing rapidly. Called GRACES (Gemini Remote Access to CFHT ESPaDOnS Spectrograph), this exciting initiative hopes to prove our ability to provide a powerful new tool for high-resolution optical spectroscopy at Gemini.

The project combines Gemini North's large collecting area with the high resolving power and efficiency of ESPaDOnS (Echelle SpectroPolarimetric Device for the Observation of Stars) at CFHT. Using a long fiber running from Gemini to our neighbor on Mauna Kea, CFHT, the system is poised to deliver high-

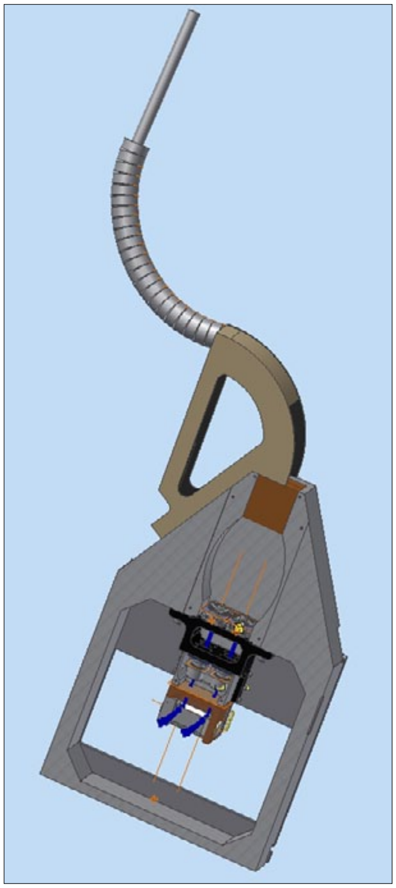


Figure 6 (left). *View of the cassette to inject light into the optical fibers. This special cassette will be inserted inside GMOS.*

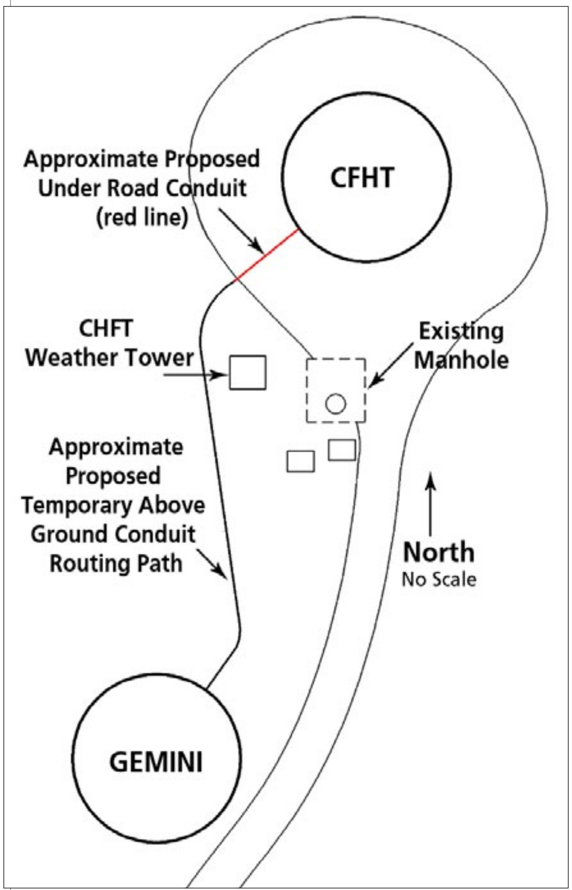


Figure 7 (right). *Approximate routing of the fibers between the two telescopes on Mauna Kea.*

resolution spectroscopy (predicted maximum resolution of R~55,000) across the optical region for predicted transmission).

GRACES consists of three primary components: 1) an injection module (replacing the GMOS Integral Field Unit) for sending the light from the Gemini telescope into the GRACES fibers (Figure 6), 2) two 280-meter-long fibers (the longest ever made for astronomy) that run through a conduit between Gemini and CFHT (Figure 7), and 3) a receiver unit that is responsible for injecting the light from the fibers into the ESPaDOnS spectrograph at CFHT (Figure 8).

As of early April 2014, all the primary GRACES components have successfully passed acceptance tests in the NRC Herzberg labs and will be shipped to Hawai'i for installation later in April. Most significant, the two 280-meter-long fibers each have a higher transmission than expected. Moreover, each fiber introduces a focal ratio degradation (FRD) of order 10 percent, amazingly below the requirement of 20 percent.

The project is still in its initial phase, which was envisioned simply as a proof of concept: is it possible to transmit light from one telescope to a spectrograph at another, 280m away? If the integrated and tested GRACES works as well as acceptance tests indicate it will, we will then work with the Gemini and CFHT communities to find ways of entering the next phase: to make this instrument a fully functioning capability at Gemini in the near future. With GRACES high-resolution optical spectroscopy at Gemini North, research into the study of stellar populations, metal-poor stars, binaries, asteroseismology, and more are potentially on the horizon for its users.

Back on the Sky — With GPI!

At the January 2014 American Astronomical Society (AAS) meeting in Washington, D.C., we released several breathtaking first-light images from the Gemini Planet Imager (GPI). While the world marveled at the images, a team of dedicated GPI scientists and engineers (led by Leslie Saddlemyer from Canada's National Research Council; NRC), kept very busy making improvements to the instrument. They meticulously executed a carefully devised remediation plan to resolve some known problems identified prior to delivery. They also strived to improve the baseline performance of the instrument. With the successful completion of this work, on-sky verification and commissioning has recommenced, and the GPI team now anticipates an early science run in April with GPI offered for general community use in 2014B.

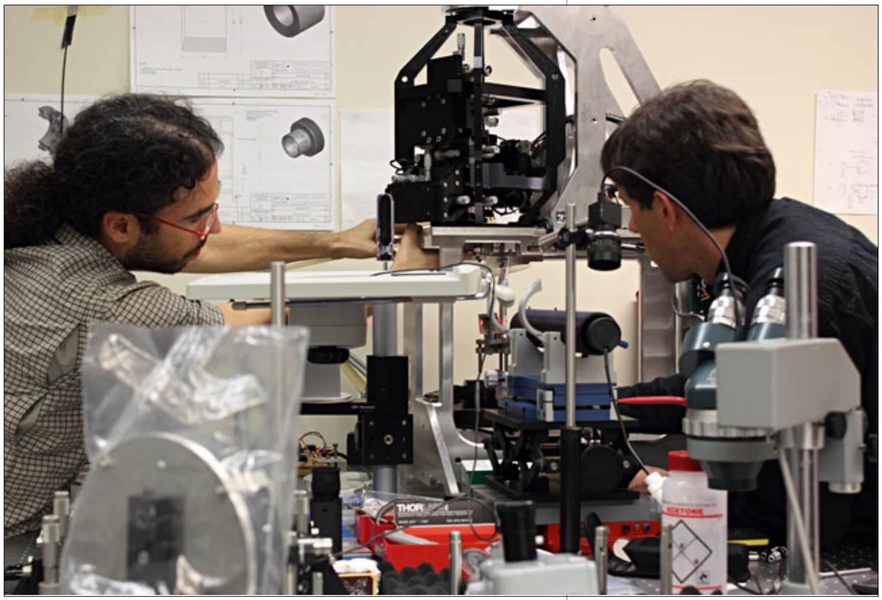


Figure 8.
A.N. Chené (Gemini) and G. Barrick (CFHT) testing the alignment procedure of the slicer bench during the acceptance tests in Canada.

Following last November's first-light and December's first verification and commissioning runs, Gemini staff removed GPI from the Instrument Support Structure and transported it to the Gemini South instrumentation lab. There it received several upgrades to address remediation needs such as malfunctioning mechanisms. To facilitate this work (and lead other post-delivery activities), Saddlemyer relocated to Gemini South for a 6-month period, starting in October 2013.

The major opto-mechanical work packages involved in this most recent work included the instrument's Integral Field Spectrograph

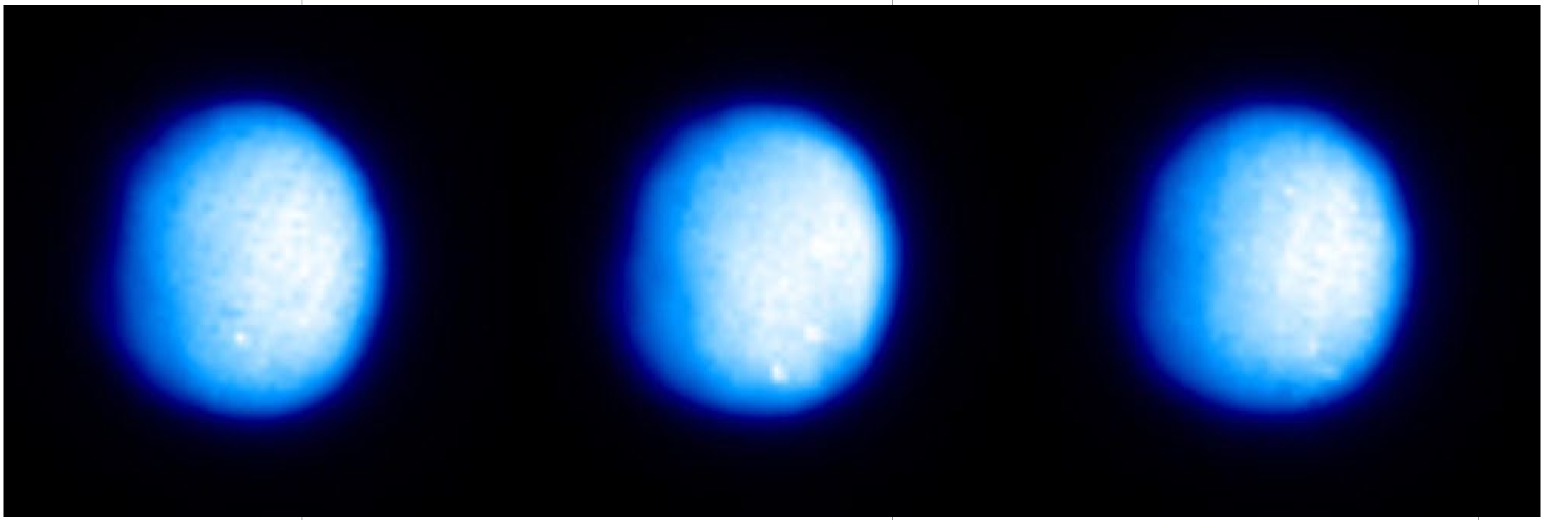


Figure 9.
Observations of 2 Pallas with GPI recorded with the J, H, and K1 gratings on March 22nd during VC2 at high airmass (>1.5). The asteroid with an angular diameter of 0.7" is well-resolved and displays a potato shape typical for a 500-km asteroid. The surface remains mostly featureless but detailed analysis may confirm a small difference in composition between the northern and southern hemispheres of the asteroid. No moons with a diameter larger than 0.5 km and at less than 1.2" were seen. Pallas was observed with the same geometry, ~7.8h later with the SOFIA telescope and its mid-IR spectrograph called FORCAST. The combination of these two set of observations could reveal the composition of this asteroid.

(IFS). Specifically, the IFS work led by James Larkin (University California Los Angeles), included the following: 1) fixing both the IFS pupil and prism slide mechanisms, to ensure robust performance; 2) installing a baffle, to eliminate a ghost image seen while calibrating the IFS; 3) installing a synchronized controller to the dual Closed Cycle Refrigerators (CCR), to reduce the vibration transmitted to the IFS; and 4) modifying the controller software, to reduce the IFS frame readout time from 7 to 3 seconds.

Other work packages included: 1) an upgrade to the control hardware for the microelectro-mechanical deformable mirror (to improve its protection); 2) a replacement to the internal communications network (to improve robustness); and 3) a number of software improvements to several subsystems, including changes to improve adaptive optics performance.

On the lab's telescope flexure rig, in late February, we tested how GPI's performance changes under various gravitational vectors, prior to mounting the instrument back on the telescope's upward looking port. One significant measured change was the reduction in the 60 hertz vibration that the CCRs were propagating to the rest of the instrument. Synchronizing the controllers reduced the intensity of the vibration and completely eliminated the beating effect caused as the controllers drifted in and out of phase.

Following lab characterization, GPI was given the green light to recommence on-sky verification and commissioning, beginning March 20, 2014. Gemini prepared "Verification and Commissioning" contracts with Stanford University, Lawrence Livermore National Laboratories, "Search for Extraterrestrial Intelligence" Institute, University California Berkeley, University California Los Angeles, the National Research Council of Canada, and the Space Telescope Science Institute to help support the verification and commissioning stage.

The first on-sky run was in December 2013, and the second occurred in March (see Figure 9, Pallas). The third and final runs are scheduled for May and September 2014. The overall plan includes a set of on-telescope and on-sky tests needed to fully characterize, optimize, and commission the instrument. Tests range from evaluating image motion to plate scale validation and stability. In total, 29 tests are detailed in this Verification and Commissioning plan, which Dave Palmer (Lawrence Livermore) is contracted to manage and execute on behalf of Gemini.

The well-attended press conference mentioned at the start of this article, resulted in over 70 articles in the international media. Shortly afterwards Gemini released a set of GPI public data ***(viewable here)*** from the 2013 runs. Further public release data will be available following future Verification and Commissioning runs.

In February, Gemini announced a GPI early call for science proposals. A number of proposals were received before the month's end. Sixteen of these proposals were selected and awarded time ***(view here)***. A variety of exciting programs will use three different instrument observing modes: direct, coronagraphic, and polarimetric observing. Observations will have begun on April 20th. The proprietary period for Early Science data is two months.

GPI has been offered for general use in 2014B. At the same time, the GPI Exoplanet Survey (GPIES) will commence. GPIES is an 890-hour exoplanet survey campaign to observe ~600 stars spanning a range of spectral types from A-M. The team will use published young association catalogs and a proprietary list that adds several hundred newly discovered young (<100 million years (Myr) old, <245 light-years (ly) distant) and adolescent (<300 Myr, <115 ly) stars. The latter, older but closer than the known young associations, allow our survey to probe within the 5 astronomical units ice line, where it is cold enough for hydrogen compounds such as water, ammonia, and methane to condense into solid ice grains. Simulations predict this survey will discover approximately 50 exoplanets, increasing the number of exoplanet images by an order of magnitude, enough for statistical investigations. (More information can be found ***here.***)

There is still much work to be completed both at Gemini South and among the groups working on the Verification and Commissioning tasks. This work is due to ramp down towards the end of 2014 and GPI will become an operational instrument. Given the early science programs, the GPIES, and the general 2014B observations, it shouldn't be too long before GPI discovers its first exoplanet!

For the latest information stay connected to the ***Gemini Facebook page***.

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 teeth-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.

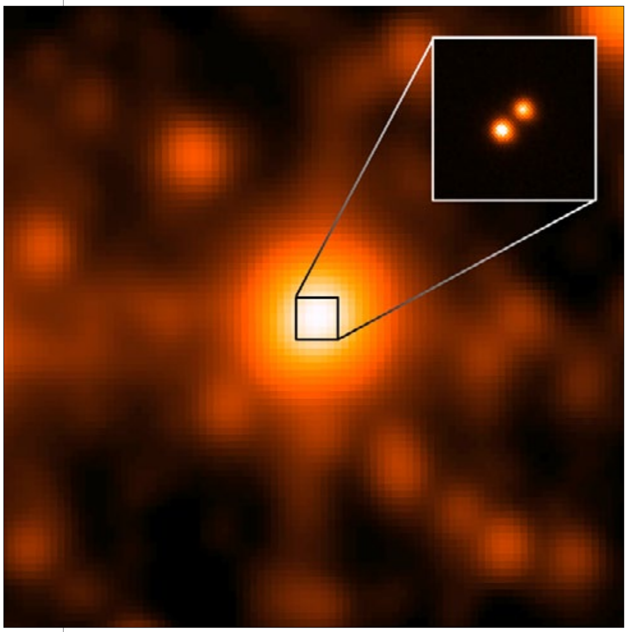


Figure 1.
These GMOS-N observations used Director's Discretionary Time to investigate a high-proper-motion object detected by by NASA's Wide- field Infrared Survey Explorer satellite. The images unexpectedly revealed the closest star system to the Sun discovered in almost a century. This kind of observation, 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).*

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***).

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.

References:

Howat, S.K.R., Davies, J.K., "UKIRTSERVICE — a decade of flexible scheduling," *Astronomical Society of the Pacific Conference Series*, **87:** 125, 1996

"An introduction to ukirtserv," **www.jach.hawaii.edu/UKIRT/service/intro.html?printable=1**

Mervis, Jeffry, "A radical change in peer review," *Science*, **345:** 248, 2014

Merrifield, Michael R., Saari, Donald G., "Telescope time without tears: a distributed approach to peer review," *Astronomy & Geophysics*, **50:** 16, 2009

Dan Ariely's TED talk: **www.ted.com/talks/dan_ariely_on_our_buggy_moral_code?language=en**

Mason, R. E., Côté, S., *et al.*, "The Gemini Observatory Fast Turnaround Program," **http://adsabs.harvard.edu/abs/2014arXiv1408.5916M**

Rachel Mason is an Associate Astronomer at Gemini North. She can be reached at:
rmason@gemini.edu

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 (Ontario, 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 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.

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.

"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."

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

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 'Imiloa 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 'Imiloa Planetarium proves that new discoveries in one field can generate waves of new ideas in others. We want to thank the Gemini and 'Imiloa 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.*


Peter Michaud and Maria-Antonieta García

Viaje al Universo

Sharing the universe with the public in Chile, and art with staff

Each year, Gemini's Viaje al Universo program engages thousands of local Chilean students, teachers, and families in a week full of education and fun. In 2014, the event carried on this tradition, growing for the fifth consecutive year as we added several new partners from the local community, including the University of La Serena, City Hall of La Serena and Coquimbo, and Chile's National Tourism Service (SERNATUR). Many Gemini staff also gave generously of their time and shared their passion for the exploration of the universe. This year we recognized 10 teachers and their school's principals for their continued support and participation in Gemini's outreach programs. The images that follow convey the essence of the week's diverse events.

The University of La Serena, overlooking the city of La Serena, was the setting for the opening ceremony of this year's Viaje al Universo. Over 100 people attended, including the Mayor of La Serena Roberto Jacob Jure, and Gemini South's Deputy Director Nancy Levenson. Also participating were local representatives from Chile's National Tourism Service, City Hall of La Serena and Coquimbo, and University of La Serena. Science staff from the Association of Universities for Research in Astronomy and Las Campanas Observatory also joined in the fun.

Gemini South volunteer Viviana Bianchi (from Argentina) uses chocolate cookies to teach girls from Colegio Germán Riesco in La Serena about Moon phases.

Over 100 children from Leonardo da Vinci school in Vicuña, Colegio Español Coquimbo, and a local language school, gather at the Alfa Aldea planetarium in Vicuña to listen to science talks provided by the University of La Serena and Gemini.

Staff from both Gemini and the Cerro Tololo Inter-American Observatory presented concurrent portable planetarium programs. Here, 3^{rd} graders prepare to enter one of the domes.

At the public library in the Mall Plaza La Serena, teachers had the opportunity to assemble and use a "Galileoscope." Here, educator Jorge Muñoz and a few of the participating teachers turn their recently assembled telescopes on the sky.

Gemini's career brochure was distributed to more than 3,000 students during their Viaje al Universo week. Here a girl and her classmates read about the variety of career opportunities available at astronomical observatories.

Gemini South science staff's Juan Madrid leads an interactive session at Colegio San Joaquín on "A Journey into Stellar Clusters" for 7^{th} and 8^{th} grade students and teachers.

Oh, and There Was Art Too!

As Viaje al Universo wrapped up, Gemini South's Artist in Residency Colleen McLaughlin Barlow arrived from Vancouver (British Columbia, Canada) to share her creativity. For the entire month of November (and a few days of October and December) Colleen immersed herself with Gemini's staff to gain inspiration for her photos, paintings, and Japanese prints with graphite, india ink, and pastels; it was a magical marriage of art and science.

This was Colleen's second observatory Artist in Residency experience, as she previously held that distinction at the Canada-France-Hawaii Telescope; the Canadian government funded her time at Gemini South. Colleen's interactions left a positive impression with staff who participated in activities like cyanotype printing, where one lays various objects on paper saturated in photosensitive chemicals before exposing it to direct sunlight.

Colleen also shared with the staff the techniques of sumi-e — a Zen-like ink-wash painting method — and Sho-do calligraphy. Mistakes do not exist, but rather become part of the art. Of the experience, Gemini's Constanza Araujo said, "In a blink of an eye I was refreshed in some special way, I felt inspired and re-energized for the rest of the workday."

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

Antonieta García is Gemini South's Outreach and Media Specialist. She can be reached at: agarcia@gemini.edu

Gemini South laser spotter Jorge Muñoz tries his hand at copying the Japanese technique called Sho-do.

Optical engineer Constanza Araujo receives instructions from Artist in Residence Colleen McLaughlin Barlow as she prepares to work on a cyanotype piece of art.

Peter Michaud

Fostering Career Opportunities Within our Local Communities

In addition to his duties as Senior Optical Technician, Clayton Ah Hee (below, and inset) assists with other work on the mountain, like the recent repairs of the Gemini North Shutter Drive Unit.

One way to ensure Gemini's healthy future is to reach out and enable career opportunities from within Gemini's local host communities in both Chile and Hawai'i. Take, for instance, the case of life-long Hilo resident Clayton Ah Hee. As a young man, Clayton would look up at the domes atop Mauna Kea and wonder what it would be like to work at an observatory. About 26 years ago, Clayton's dream came true and since then he has worked his way up to his current position as Gemini North's Senior Optical Technician. Clayton recalls that while growing up he always had a fascination with shiny things, like chrome-plated and polished components. "Funny that my primary role at the Observatory is to prep and apply the multilayer silver coatings on the all the major optics at Gemini!" he says.

Today, Clayton is a critical element of the Gemini North summit team, which is responsible for keeping everything in top form for Gemini's nighttime operations. His success story, like many similar ones at both Gemini telescopes, is now featured in new multimedia materials that share with future career candidates the opportunities available at Gemini and other astronomical observatories.

Gemini's former HR Manager Christina Terminello reviews the career brochure.

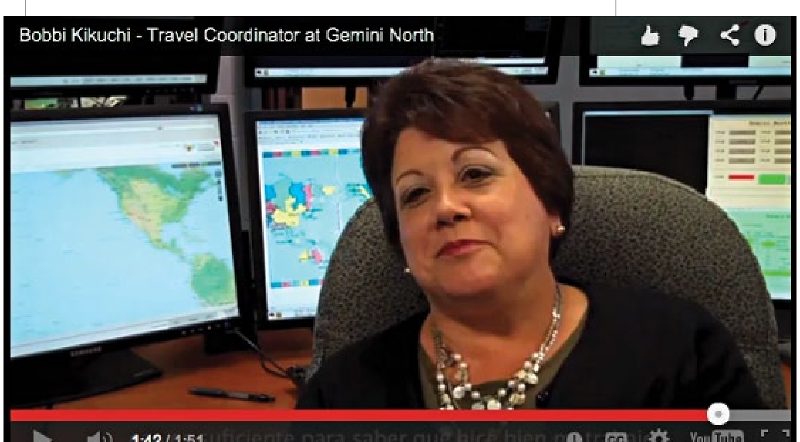
"Inspiring our youth with opportunities for the future is at the core of our work," says Gemini's Human Resource Manager Christina Terminello. "Materials like this, and follow-on opportunities — such as internships through our partnerships with local Hawai'i and Chilean schools and universities — give students a glimpse of what it's like to work at an observatory and often generate a spark that can last a lifetime!"

Building Careers

To this end, the Gemini Public Information and Outreach (PIO) Office recently debuted a new careers brochure aimed at inspiring students, residents, and others in Gemini's local host communities to consider a future at Gemini or other observatories. Available in English and Spanish, the brochure, and its companion video-interview website ***(viewable here)*** present real-life stories, like Clayton's.

"The careers brochure and videos provide a glimpse into the work-lives of a cross-section of our staff and what inspires and motivates them," says Joy Pollard of Gemini's Hilo PIO office, who helped produce the brochure and videos along with her counterpart Manuel Paredes in Chile.

The brochure is accessible in hardcopy, while both it and the videos are electronically available ***here***.



Scenes from staff video interviews found on the brochure's companion website. Above: Gustavo Arriagata (Gemini South); below, Bobbi Kikuchi (Gemini North).

The PIO staff looks forward to creating future editions of the material that will feature more Gemini employees who will share their contagious passion for what they do. The ultimate long-term goal: to feature a local student whose career was sparked by these materials and who has followed in Clayton's footsteps (or one of the 18 staff featured in the brochure!)

Peter Michaud is the Public Information Outreach Manager of Gemini Observatory. He can be reached at: pmichaud@gemini.edu

Covers and excerpts from the Gemini career brochure. The brochure is available both in print and online, in Spanish and English.

Lynette Cook

Creating the Cosmos

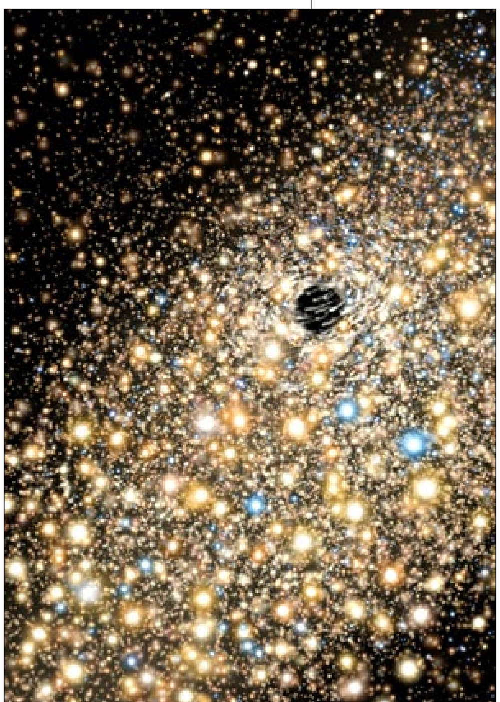


Figure 1.
This supermassive black hole has nearly 10 billion times the mass of the Sun. It is located in NGC 4889, the brightest member of the Coma galaxy cluster.
Credit: Gemini Observatory/AURA; artwork by Lynette Cook.
View online here.

The following article originally appeared in The Astronomical Society of the Pacific's *column "Astro Beat" and is reproduced here with permission of ASP and the author.*

My parents loved the outdoors, and I give them credit for my own wonder of the natural world. Favorite memories include hunting for giant puffballs and spring flowers in the Southern Illinois woods. On camping trips my mother would point out the constellations, which seemed especially close and bright on a summer vacation to Canyonlands National Park in Utah. I felt as though I could reach out, grab the stars, and pull the sparkling gems down to Earth.

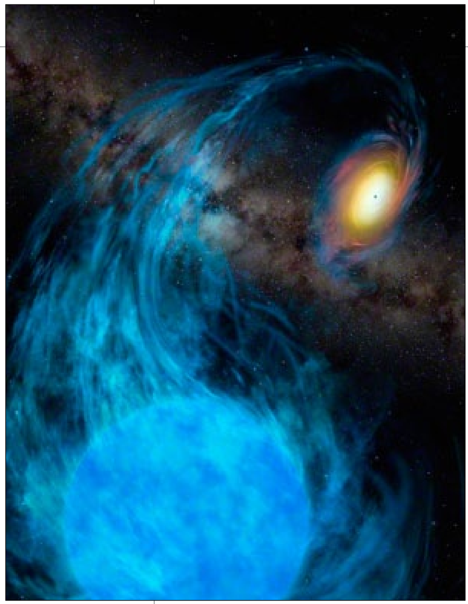
Given my aptitude and appreciation for art, it seemed fitting to become a scientific illustrator. A staff position of Artist/Photographer for the Morrison Planetarium, which I held from 1984-2000, was instrumental in connecting my art skills with astronomy. Through freelance work and subsequent self-employment, I have been privileged to work with research astronomers, science editors, and art directors, portraying the marvels of the universe visually: extrasolar planets, distant galaxies, black holes, possible life in the universe, and much more have been some of the wonderful places this work has allowed me to "visit."

Much of my artwork is commissioned for press releases about cutting edge astronomical research. How exciting it is to know the news before it makes news, and to play a role in getting the word "out there!" This process is a mystery to many, and I often am asked the question, "How do you know what to paint?" To shed light on this process, I turn to my work with the Gemini Observatory, for which I've created numerous illustrations used in press releases identifying new discoveries.

From Discussion to Form

My most recent Gemini art was for the November 26, 2013 announcement titled "Fast, Furious, Refined: Smaller Black Holes Can Eat Plenty" [***view here***]. It describes the environment around M101 ULX-1, and features a stellar-mass black hole with accretion disk and a Wolf-Rayet star that feeds the voracious appetite of the black hole.

As with many new ventures, artwork begins with brainstorming. Often the starting point is a conference call with Peter Michaud, the Public Information Outreach Manager at the Gemini Observatory, along with the Principal Investigators on the discovery team. In the case of M101 ULX-1 we resorted to e-mail communications since Stephen Justham and Ji-Feng Liu, the science contacts weighing in on the art, are with the Chinese Academy of Sciences in Beijing, China, and time zone differences were at play.



Figures 2 and 3.

Rough mockups explore options for composition and color.

Peter and Stephen began the conversation by describing the M101 ULX-1 environment, specifying which objects needed to be shown in the art. We talked about the color, which often has little or no meaning in astronomical renderings, and size of the star, accretion disk, and gas stream. Also important was the overall "look" of the disk: whether it should appear thick and dense or thinner and less structured.

With key points in mind, I created several color mockups for the committee (*i.e.* everyone weighing in on the art) to review and discuss. Years ago I would have developed these "roughs" with graphite pencil on tracing paper or colored pencil on black mat board; today they are done digitally: low in resolution and unfinished in terms of detail, yet many steps closer to finished art than the simple mockups of yesteryear. The purpose is to show different compositions, orientations, and sizes of the main objects.

The committee then weighs in with comments and suggestions for changes. In this case, a key decision was to put the black hole and disk in the foreground and the star in back. We discussed in greater depth how much material the black hole should be pulling away from the star, the likely trajectory, and appropriate colors. I then modified the roughs and invited another round of comments. This process repeated until we had one image that satisfied all the primary criteria.

With approval of the first step, I moved on to the high-resolution file, fine tuning the details so the image would pass inspection when examined closely. This step takes the most time, as I zoom in and out and scroll around to tweak the "little stuff." Regardless of how I create the various smaller components in an image, which can vary, I use Photoshop to composite all the main elements. This results in a file with many layers that becomes very large in size.

When I am satisfied, the process repeats: the committee weighs in again, more adjustments are made, and eventually all parties declare the image a "go." At that time I send Peter a final high-resolution file and my part is done.

Figure 4.

Several revisions into the process, the locations of the star and disk are switched and the structure and color of the disk are fleshed out further.

Elsewhere, work continues behind the scenes. Peter pairs the illustration with the press release text, writes a caption, and iterates with the astronomers on any remaining details. When finished, the release goes out to the media with an embargo date, which means they have a "heads up" and may prepare

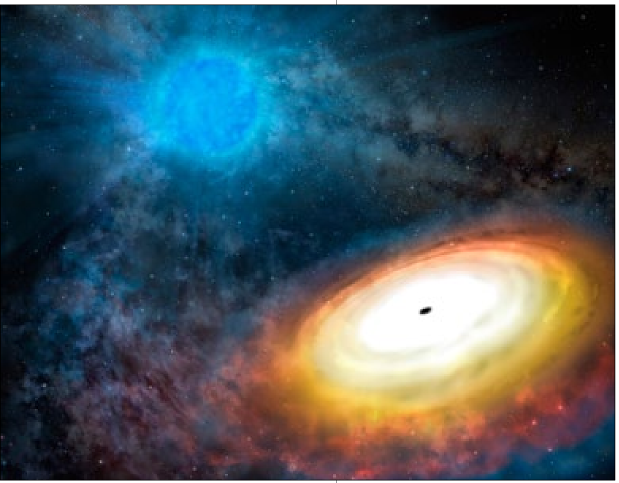


Figure 5.
The finished M101 ULX-1 artwork, showing a horizontal format. The black hole was reduced in size and the inner disk was brightened. Further adjustments were made to the density of the stream's gas, the material blowing away from the star, and the coloration of the disk.
Credit: Gemini Observatory/AURA; artwork by Lynette Cook
View artwork online here.

their news stories but may not make it public until the embargo time and date arrive. Gemini's web site is prepared and ready to go live at the exact moment the embargo lifts.

When the magic moment arrives the article and accompanying images can appear anywhere: on the web, in magazines, on the evening news, and in the next morning's newspaper. The extent of the release's reach is dependent upon how exciting the news is deemed to be and how much other breaking news gets top billing. A politician's indiscretions or movie star's arrest might bump the science off the front page, or off the evening news entirely.

It's All in the Timing

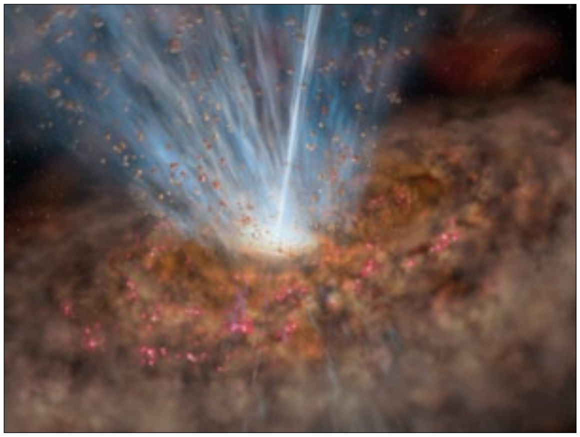


Figure 6.
The supermassive black hole at the center of Mrk 231 has a broad outflow, shown here as the fan-shaped wedge at the top of the accretion disk. A similar outflow is probably present under the disk as well and is hinted at in this illustration. A more localized, narrower jet is included as well.
Credit: Gemini Observatory/AURA; artwork by Lynette Cook.
View artwork online here.

Though I sometimes regret that the illustration world (both scientific and commercial) is largely computer-generated today, there is no question that digital art allows for faster turnaround, quicker changes, and more revisions than traditional media. And when it comes to illustrations for press releases, timing is everything. I have created art in as little as 48 hours or, when the pace was more relaxed, taken three weeks or more. The norm is about a week and a half. Figures 6 and 7 show two complex pieces that would have been nearly impossible to produce with traditional methods within the time frame available, while also allowing for communications among committee members and several changes at both rough and high-resolution stages.

It is a romantic notion to suppose that such projects are lined up in my studio at all times and that I whip them out in quick succession. In fact, they tend to come "out of the blue." One week I might be spending a little time on Earth, so to speak, painting the Golden Gate Bridge for a San Francisco Bay Area art exhibit, and then an e-mail with an exclamation mark pops into my in-box with an extra loud "Ping!" Next thing I know, I am Velcroing myself to the computer to create an exoplanet or gamma-ray burst, the embargo date looming large ahead of me.

Although each illustration is unique, some stand out as extra special. A case in point is the November 15, 2007, release about hot dust surrounding a 100-million-year-old star in the Pleiades star cluster. The star is very much like our Sun, though it is 45 times younger and is orbited by hundreds of thousands of times more dust, suggesting

Figure 7.
This rendering of W 33A showing the accretion disk (yellow/orange), torus (dark ring around disk) and bipolar outflow jets (blue) within the dense clouds of its stellar nursery.
Credit: Gemini Observatory/AURA; artwork by Lynette Cook. ***View artwork online here.***

catastrophic collisions in an evolving young planetary system. While working on this art I felt I was aboard a time machine, transporting myself into the past to witness two planets crashing into each other, spewing chucks of rock.

Topping that, an "Outer Limits" mystery: the case of the TYC 8241 2652 system. Several years ago it had all the characteristics of solar system formation. Today, however, the warm dust thought to originate from collisions of rocky planets is nearly all gone. What happened to it? For this news article I developed two images that show the "before" and "after" views. These were provided via the Observatory's website as stills and also as an animation (***viewable here***).

Communication is Key

It is said that "too many cooks spoil the broth." This usually means that the more people in the mix when it comes to input and decision-making, the more complicated the process becomes (also the more diluted and tasteless the results). To my delight, however, those with whom I've worked on press release artwork have been stellar (no pun intended). Able to narrow in on the most important elements of the science and what needs to be shown — and also able to communicate the finer details of size, color, texture, object relationships, and more — I've felt that these collaborations have gone exceedingly well, without the huge bumps in the road and frustrating impasses that can occur when individuals gather to move toward a common goal.

While good communication is necessary with Peter and the astronomers, as far as the rest of the world is concerned, this process moves in secrecy. One mustn't spill the beans about a release before its time. When someone outside our group asks what I am working on, I bite my tongue and reply with an answer that ranges from "Oh, nothing much" to "Just a 'star thing.'"

Figure 8.
Two Earth-sized bodies collide near HD 23514. Credit: Gemini Observatory/AURA; artwork by Lynette Cook. ***View artwork online here.***

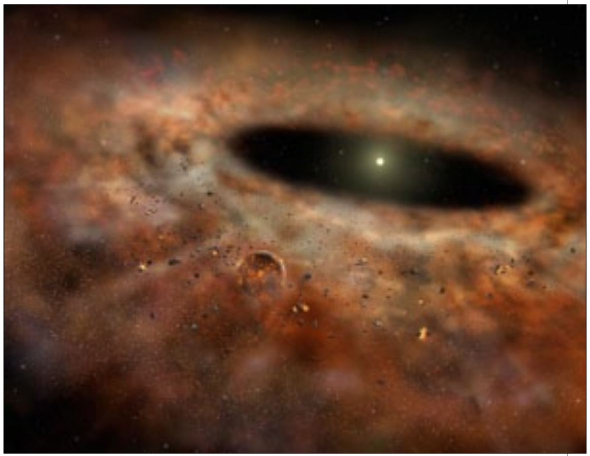


Figure 9.
The dusty TYC 8241 2652 system as it might have appeared several years ago when it was emitting large amounts of excess infrared radiation. Credit: Gemini Observatory/AURA artwork by Lynette Cook.

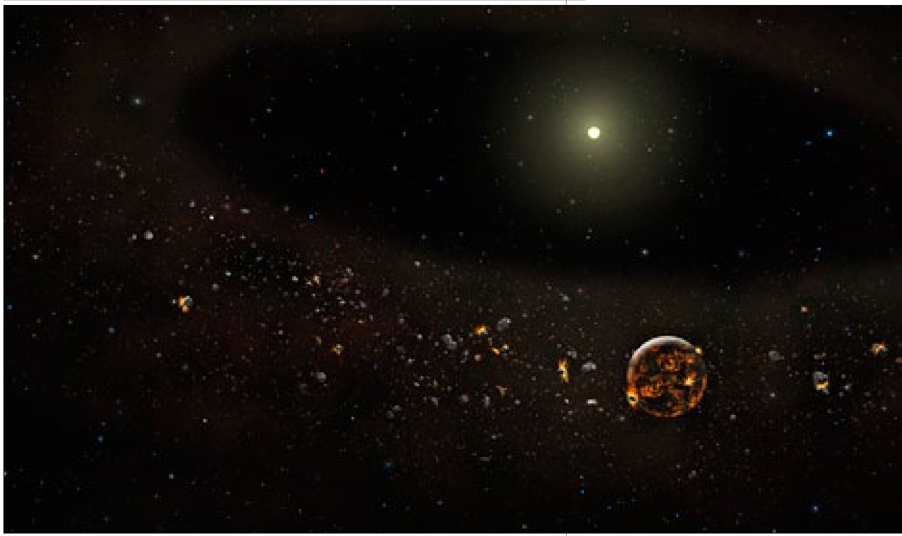


Figure 10.
Most of the surrounding dust has disappeared — based on observations by the Gemini Observatory and other ground- and space-based observatories. Credit: Gemini Observatory/AURA; artwork by Lynette Cook.

Recipe for Success

One process that can help reach the goal of creating successful art is to treasure hunt for existing photos and other imagery that might have a bearing on the new art. A prime example is using Voyager photos of Jupiter as a resource to depict exoplanets of several Jupiter masses. This said, no photo or existing art will be ideal, and this is exactly the point: I am illustrating something that has neither been seen nor illustrated before.

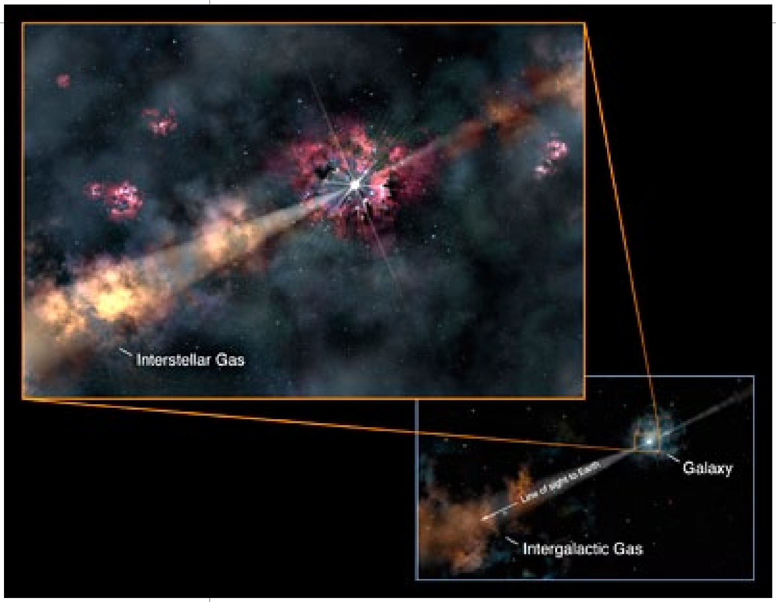


Figure 11. *Visualizing objects and distances of great proportions was necessary for this artwork. It shows light from a gamma-ray burst passing through interstellar gas in its host galaxy (close-up view, left), and also through intergalactic gas positioned between the distant galaxy and Earth (wide view, right). Photographs of nebulae and star-forming regions were useful as references. Credit: Gemini Observatory/AURA; artwork by Lynette Cook.* ***View artwork online here.***

And such fun it is to be a cosmic creator of this sort!

In my darkest hours, when my computer behaves badly or I have a question that only another artist can help with (say, how to get correct lighting on a planet's rings), there is a way to get input even when zipping my lip. The International Association of Astronomical Artists, of which I am a Fellow, is a group of talented and experienced individuals who love to paint space, both digitally and traditionally. With members in several countries, usually someone is at the computer even in the wee hours of the night and can be queried for help. (***View here*** for more information.)

I have not yet mentioned the groundbreaking "magic formula" that I use to create my astronomical art. Why? Because there isn't one. Nor have I provided a lengthy "nuts and bolts" discourse about the media, computers, software, and RAM that I use because, in the end, it doesn't matter. There are multiple paths to the same goal, including paint on paper, an old version of Photoshop, and a high end 3D software package. Creating a successful image takes basic (yet extensive) knowledge of composition, lighting, and color, plus masterful use of the tools chosen, regardless of whether these tools are digital or traditional.

As I conclude, my mind flashes on a key point drilled into me as a science illustration student: that this career path is about artist/scientist collaborations in which each person on the team lends his/her expertise to create a new visual that informs and educates. This summarizes what the Gemini Observatory and I do together: we translate the scientific data into realistic visuals that enable others to experience the wonder of the universe for themselves. What could be more magical than this?

Lynette Cook has illustrated the cosmos since the 1980s. An award-winning illustrator and painter, Lynette's art has appeared worldwide in books, periodicals, documentaries, and online articles. She also is a consultant for the NOVAS program (NASA Opportunities in Visualization, Art, and Science), which provides art/science workshops to teens in the San Francisco Bay Area. To see more of Lynette's artwork, go ***here***.

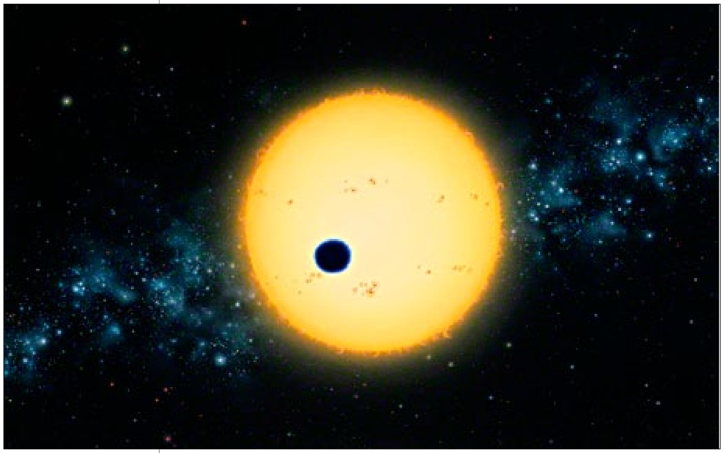
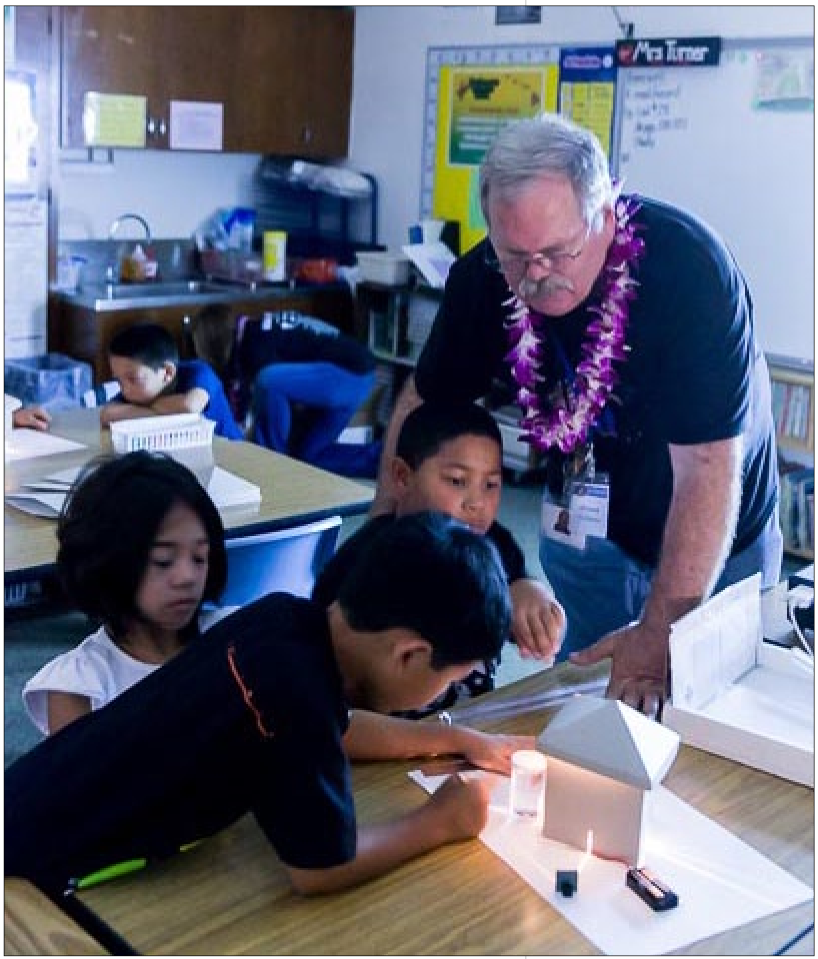


Figure 12. *The Transit of HD 209458, used in association with Geoff Marcy's press release in 1999, was created with acrylic, colored pencil, and gouache on illustration board. It generated an e-mail from a distant viewer asking what amazing image processing software I had used to get such a clear photo. Credit: © Lynette Cook, all rights reserved.*

Gemini's Journey through the Universe Reaches a Giant Milestone

Gemini's senior optics technician, Jeff Donahue, demonstrates the use of optics with a 3rd grade class at Waiakea Intermediate in Hilo.



Ten years ago Gemini North embarked on an ambitious local outreach program that grew from a successful U.S. national science education initiative called "Journey through the Universe." Since then, "Journey's" presence on the Big Island of Hawai'i has blossomed into an annual event that has far exceeded anyone's wildest expectations. Over the past decade, Gemini has brought Journey to more than 50,000 students in over 3,000 classrooms. This year's event, celebrated from March 7th-14th, added thousands more to that tally with a record number of classroom visits.

Each year through Journey, dozens of local science, technology, engineering, and mathematics (STEM) professionals from Gemini and beyond immerse themselves in local Hawai'i classrooms in Gemini North's Big Island community. Together they share the excitement of astronomical exploration with students, teachers, and the public. To sample the excitement of this year's event, please enjoy the pictorial that follows and learn more (including the final report of the 2014 program) by ***viewing here***.

University of Hawaii's Astronomy and Physics professor Marianne Takamiya helps students make a spectroscope during her classroom activities as part of Journey through the Universe.

Below: Michael Hoenig, data analysis specialist at Gemini, has participated in multiple Journey programs. Here he is using interactive techniques to show middle school students how infrared light makes seemingly hidden objects become visible.

Gemini's head of instrumentation Scot Kleinman is blindfolded and instructed how to move by students at Hilo Union Elementary School in a highly engaging demonstration of remote sensing and control.

Above: Janice Harvey, Journey through the Universe team leader, receives a special recognition plaque and commendation letter from Hawai'i Governor Neil Abercrombie. Both awards congratulate Harvey for her tremendous achievement in fostering the Hawai'i Journey program and encouraging students to envision their own futures in science and technology.

Above : Ambassador Perry Armor captures a 4th grader's delight as he wears a space suit provided by Rob Kelso, former NASA Space Shuttle Flight Director.

Left : Gemini interns, Aaron Bannister (foreground, left) and Bozi Yordanov (background, left), inspire students to "reach for the stars" at this year's Journey through the Universe Family Science Day held at 'Imiloa Astronomy Education Center in Hilo.

Hawai'i State Department of Education Superintendent Kathryn Matayoshi shares a very special thanks and praise to the Journey community for inspiring our youth and providing STEM education to over 7,000 students during Journey's 10th anniversary week.

Sharing the Wonder at AstroDay Chile!

In March, Gemini South's premier local outreach event, AstroDay Chile, also delivered the wonders of our universe to local students, educators, and the public. The 2014 program was held for the first time at La Serena's Plaza de Armas and the University of La Serena's Outreach Center. Over 20 organizations participated, ranging from local observatories to formal education institutions from several Chilean cities in and around the Coquimbo region. As this photo gallery shows, the event offered lots to explore for the nearly 3000 participants who, along with Gemini's enthusiastic staff (and others), made this the most successful AstroDay Chile ever!

Top: Tuerca Loca, a physics teacher from Santiago, Chile, entertains students from San Joaquin school by impersonating Albert Einstein and performing experiments in light diffraction and physics.

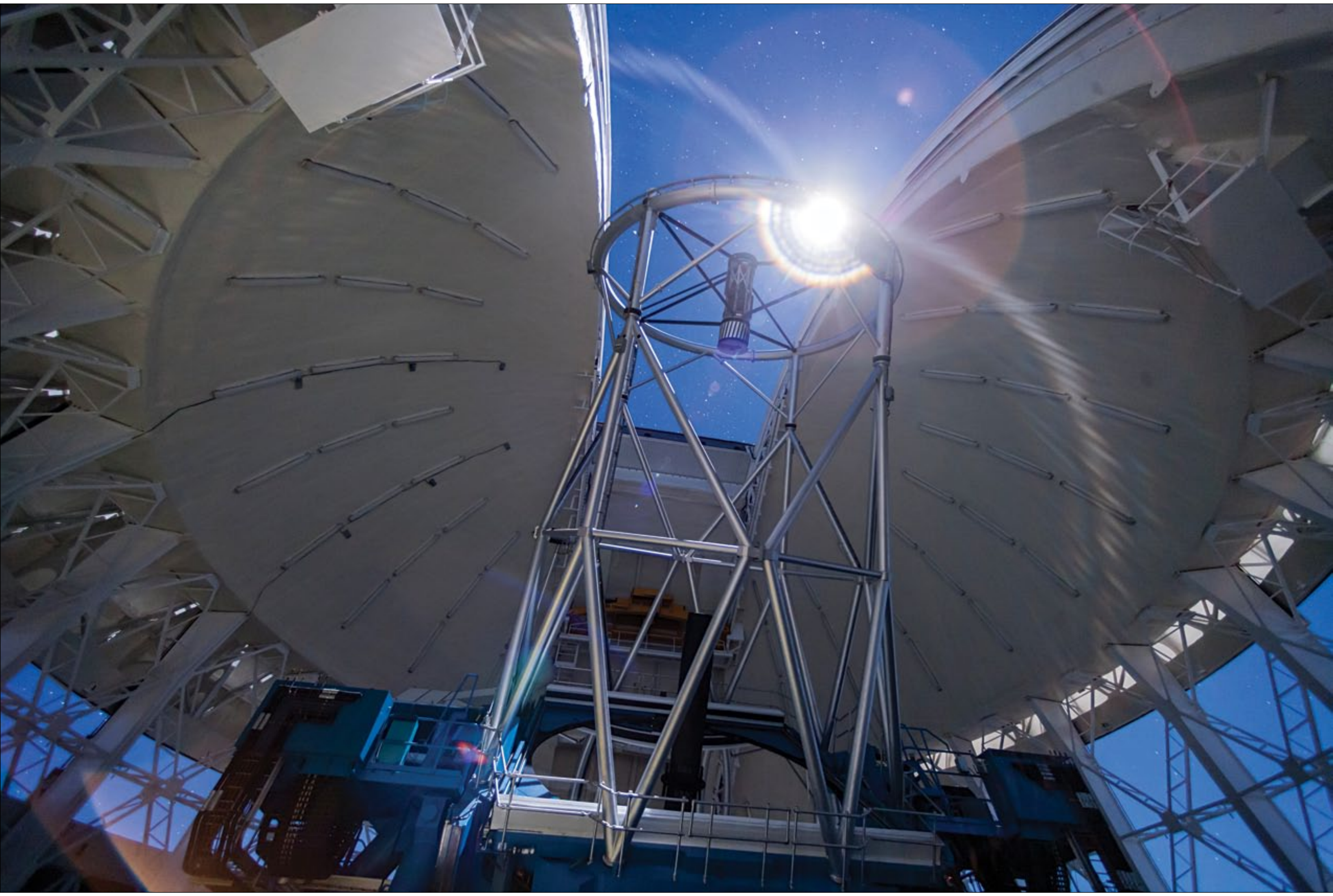
Center: Last March, local dignitaries and Gemini partners attended the ribbon cutting ceremony for the 8th-annual AstroDay Chile, held for the first time in the University of La Serena's Plaza de Armas and Outreach Center in downtown, La Serena.

Bottom: Throughout AstroDay Chile, long lines formed to look through telescopes at either the Sun and its spots during the day, or craters on the Moon at night. Stargazing continued until the event closed at midnight.

Students from Colegio José Manuel Balmaceda in la Serena cheer over their "thermal protection system" creation during a workshop led by David Yenerall, astronomer and ambassador for NASA's Van Allen Probes mission.

Gemini South's Pedro Gigoux interacts with some of the nearly 3000 visitors that attended AstroDay Chile. The event featured staffed kiosks, informative talks, portable planetarium shows, and a great photographic gallery of the Astronomy of Chile's native people.

From 5 p.m. to midnight, the city of La Serena opened its Plaza de Armas and the University of La Serena's Outreach Center to the community, offering innovative astronomy experiences. Here, girl scouts enjoy their visit to the kiosks before a popular talk titled "The Simpsons and Astronomy."



Gemini North telescope (with Moon flare) imaged by Joy Pollard on December 8, 2014.

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.

NSF
United States

NRC·CNRC
Canada

Australian Government
Australian Research Council
Australia

Argentina

Ministry of Science, Technology and Innovation
BRASIL
Brazil

Chile

Gemini Observatory
670 N. A'ohoku Place
Hilo, HI 96720 USA