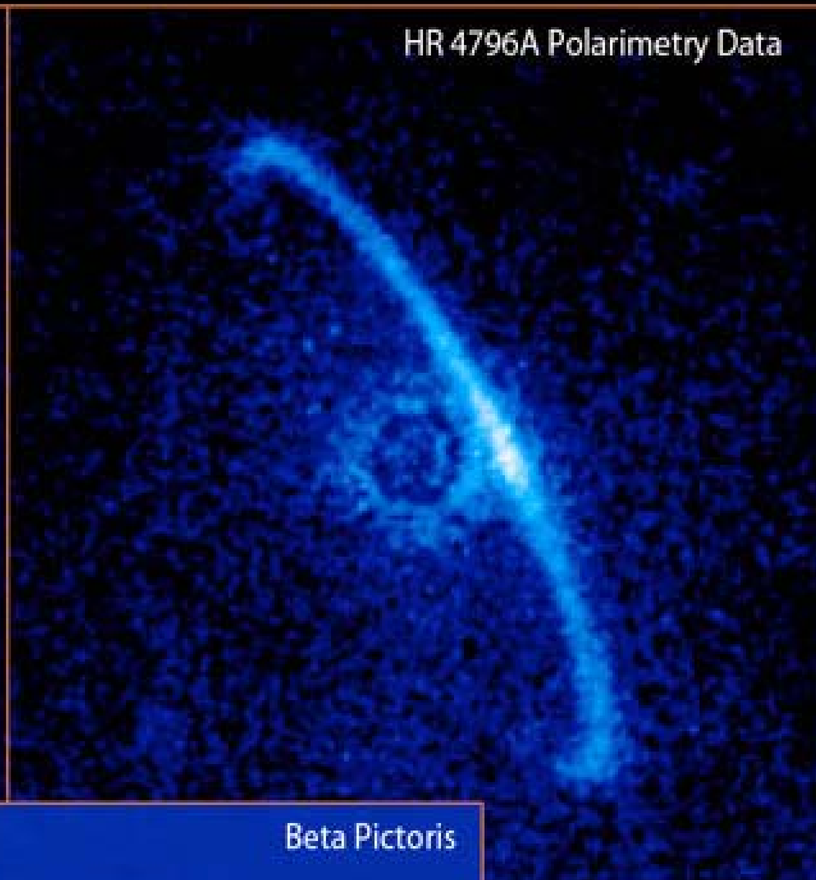
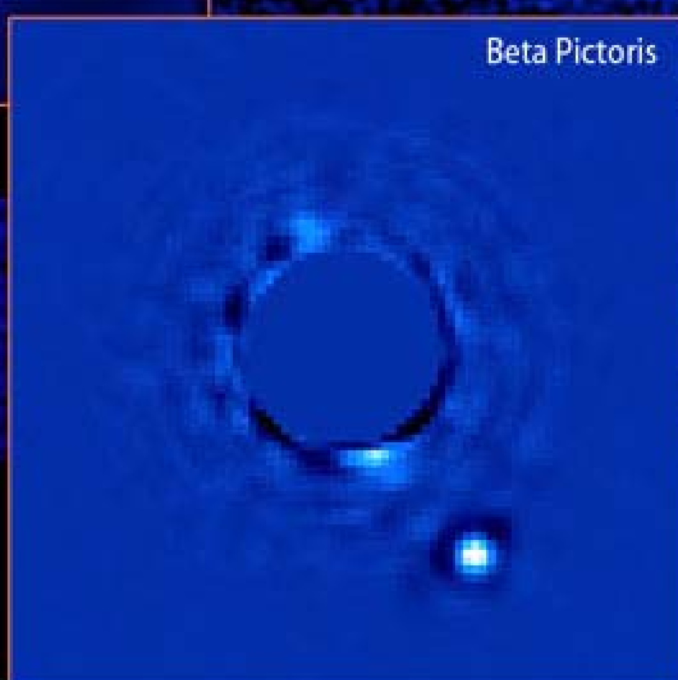
Gemini Focus

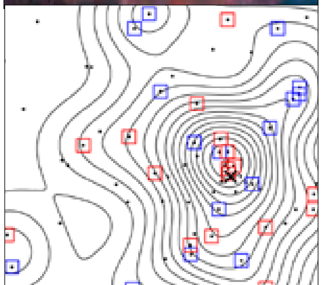
Publication of the Gemini Observatory | January 2014

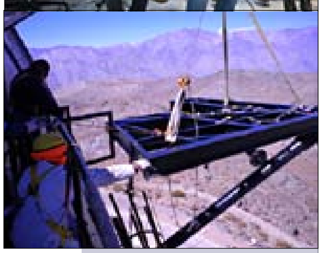

HR 4796A Circumstellar Disk


HR 4796A Polarimetry Data

GPI First Light!


Beta Pictoris



*Gemini*Focus

ON THE COVER:

The cover of this issue features first light images from the Gemini Planet Imager that were released at the January 2014 meeting of the American Astronomical Society held in Washington, D.C. See the press release that accompanied the images starting on page 8 of this issue.

Gemini*Focus January 2014*

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Markus Kissler-Patig

Director's Message

2013: A Successful Year for Gemini!

As 2013 comes to an end, we can look back at 12 very successful months for Gemini despite strong budget constraints. Indeed, 2013 was the first stage of our three-year transition to a reduced operations budget, and it was marked by a roughly 20 percent cut in contributions from Gemini's partner countries. Nevertheless, our staff excelled at working on the many initiatives that will allow us to operate Gemini in a sustainable way, while providing most of the services that our users appreciate.

We also managed to deliver to the Gemini community three new exciting instruments at Gemini South, as well as host two visiting instruments at Gemini North. In addition, we launched the new Large and Long Programs, complementing the standard semester-based method of administering telescope time.

Gains at Gemini South

With four facility-class instruments and an adaptive optics system, Gemini South is now configured as it will operate for the next few years. First, the Gemini Multi-conjugate adaptive optics System (GeMS) with the Gemini South Adaptive Optics Imager (GSAOI) was introduced early in the year with first science. The system moved into regular operations soon thereafter. This complex system will still require a few more semesters of operations until it runs as smoothly as some of the old workhorse instruments, but the first papers based on its data have appeared, and the instrument is heavily subscribed.

Second, FLAMINGOS-2 was commissioned in imaging- and long-slit modes during the first half of the year. It jumped immediately to the next-most demanded instrument behind the two Gemini Multi-Object Spectrographs. We anticipate that the remaining image-quality problems can be solved in 2014, after which we will add the much anticipated near-infrared Multi-Object Spectrograph mode.

Finally, the Gemini Planet Imager made a flamboyant entry with its integration of first light in November (see article on page 8 of this issue)!

Gemini North News

At Gemini North, we took routine operations to a high level — dedicating close to 95 percent of 2013 to science observations. Also, we were able and happy to host two visiting instruments: the Differential Speckle Survey Instrument (Steven Howell, Principal Investigator (PI)) and the Texas Echelon Cross Echelle Spectrograph (John Lacy, PI). Both instruments have unique capabilities that enhance Gemini's complement of facility-class instruments. Beyond being used for the PI's dedicated programs, both visiting instruments were offered to the user community while being operated by the PI's teams. In the coming years, we are looking forward to more groups bringing their instruments or experiments to our state-of-the-art telescopes!

Operations Decisions

Driven by budget cuts, we reviewed the core Observatory operations. We reflected on how our users' science could direct the way in which we operate, rather than having our operations constrain the users' science. This concept generated many ideas. In particular, it led us to consider adding two future proposal modes: 1) Large and Long programs that enable multi-year, high-impact ambitious projects; and 2) a Fast Turnaround proposal scheme, allowing users to obtain data only a few weeks after submitting their proposals.

Large and Long programs have received the go-ahead from the Gemini Board, and the first call went out in December. This scheme also led us to introduce "Priority Visiting Observing" — a way to observe classically while mitigating the risk of weather loss. Check it out at: *http://www.gemini.edu/node/11101?q=node/12096*. The Fast Turnaround scheme has been reviewed by our advisory committees and is now being prototyped. We hope to introduce it by the end of 2014.

We also recognized that more "post-observing" support would be very beneficial to the user community. While in-house efforts are being spent, we also wanted to engage our users in supporting each other. As a result, we are launching a new Data Reduction User Forum at: *http://drforum.gemini.edu*. Please add to the discussion — the best contributions will be rewarded with Director Discretionary Time!

Overall, during 2013 we saw many advances in our support of the community, with original ideas that contribute to Gemini's uniqueness. Our outlook for 2014 promises to be no less exciting. We are looking forward to many new discoveries by our community in the new year.

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

Stephen Justham and Jifeng Liu

Weighing the Black Hole in M101 ULX-1

Astronomers have measured the mass of an ultra-luminous X-ray source, producing a puzzle over how to explain the observed X-ray properties and leaving a hole in the quest for intermediate-mass black holes.

Figure 1.
Artist's impression of M101 ULX-1. In the foreground is the black hole, surrounded by an accretion disk; matter falling into the black hole via the disk produces the X-ray luminosity of the system. That matter originates from the wind of a Wolf-Rayet star, shown in the distance. In the far background is one of the spiral arms of M101.

Gemini illustration by Lynette Cook.

M101 ULX-1 is a transient ultra-luminous X-ray source with characteristics expected of an accreting, intermediate-mass black hole (IMBH). A series of Gemini spectra have detected a Wolf-Rayet star in the system and revealed its orbital motion. This constrains the mass of the black hole in M101 ULX-1; the object is too massive to be a neutron star but very unlikely to be an intermediate-mass black hole. The data also show that the black hole accretes from the wind of the star, not the overflow of the donor star's Roche lobe, as illustrated in Figure 1.

"Ultra-luminous X-ray sources" (ULXs) sit at the intersection of two fundamental problems in astrophysics, since this class of systems contains objects which appear to be more luminous than the Eddington limit allows for stellar-mass black holes. That definition is somewhat imprecise because we don't know the definitive upper mass limit for "stellar-mass" black holes. Nonetheless, the questions raised by the existence of these systems are clear: Is the Eddington limit somehow exceeded in ULXs? Or do ULXs contain black holes with higher-than-expected masses, perhaps even intermediate-mass IMBHs?

Such IMBHs have long been the topic of speculation and searches. Two classes of black holes are observationally well-established: the stellar-mass black holes discovered in Galactic X-ray binaries, and the supermassive ones in the centers of galaxies, with a large mass gap separating the two classes. The best IMBH candidate so far is in ESO 243-49 HLX-1, for which the recently-inferred black hole mass does enter the upper end of the IMBH range (Webb *et al.*, 2012), depending on the definition adopted.

The remaining wide gap between stellar-mass and supermassive black holes is frustrating for those hunting them, since many theorists assume that today's supermassive black holes formed via "seed" IMBHs. If no IMBHs exist in the present-day universe, it would throw doubt on that scenario. Whilst not detecting IMBHs is not the same as proving they are not present — black holes are, after all, not intrinsically bright objects — a direct detection would be very welcome. There have been indirect inferences of the presence of IMBHs in globular clusters, but the arguments are not universally accepted.

Circumventing the Eddington Limit

One way around the apparent Eddington limit would be if the emitted radiation was non-spherical, *i.e.,* if the luminosity of ULXs was preferentially directed towards us. This option cannot be excluded in all cases; how would Galactic microquasars such as SS 433 or GRS 1915+105 appear if we were looking directly down their jets? However, measurements of the energy which is deposited into nebulae around ULXs suggest that the power output of typical ULXs is unlikely to be significantly smaller than the value which is derived using the assumption that the emission is spherically-symmetric (see, *e.g.*, Pakull and Mirioni, 2003).

Another easy-looking option would be to discard the Eddington limit (which assumes spherical symmetry) on the plausible-seeming grounds that accretion through a disk is not spherically-symmetric. The simple version of this argument fails, however, because, at luminosities approaching the Eddington luminosity, the inner parts of the accretion disk are expected to become radiation-pressure dominated. Without some additional unknown mechanism, the inner disk would consequently thicken and the accretion geometry would become quasi-spherical.

More complicated ways of circumventing the Eddington limit have been proposed. These have tended to invoke a mechanism for transferring energy from the inner accretion disk to a corona surrounding the black hole. The concept connects naturally with the fact that the spectra of many ULXs are dominated by a power-law component (see, *e.g.,* Gladstone, Roberts, and Done, 2009). That power law is normally identified with a "Comptonising" corona, in which photons gain energy by "inverse Compton scattering" from high-energy electrons. More energy is emitted by that component than by the component found in the spectra, which is identified with the accretion disk.

The Nature of ULXs

Since the ULX class was identified, astronomers have shown great interest in their nature. Successfully measuring the mass of the accreting object in a ULX is guaranteed to produce an interesting result for the following reasons: 1) If a particular ULX contains an IMBH, then the system affects our understanding of the cosmological population of black holes; and 2) If no IMBH is present, then we are forced to conclude that the apparent Eddington limit can be circumvented. Deducing the mechanism by which the latter is possible should teach us about the still-poor-

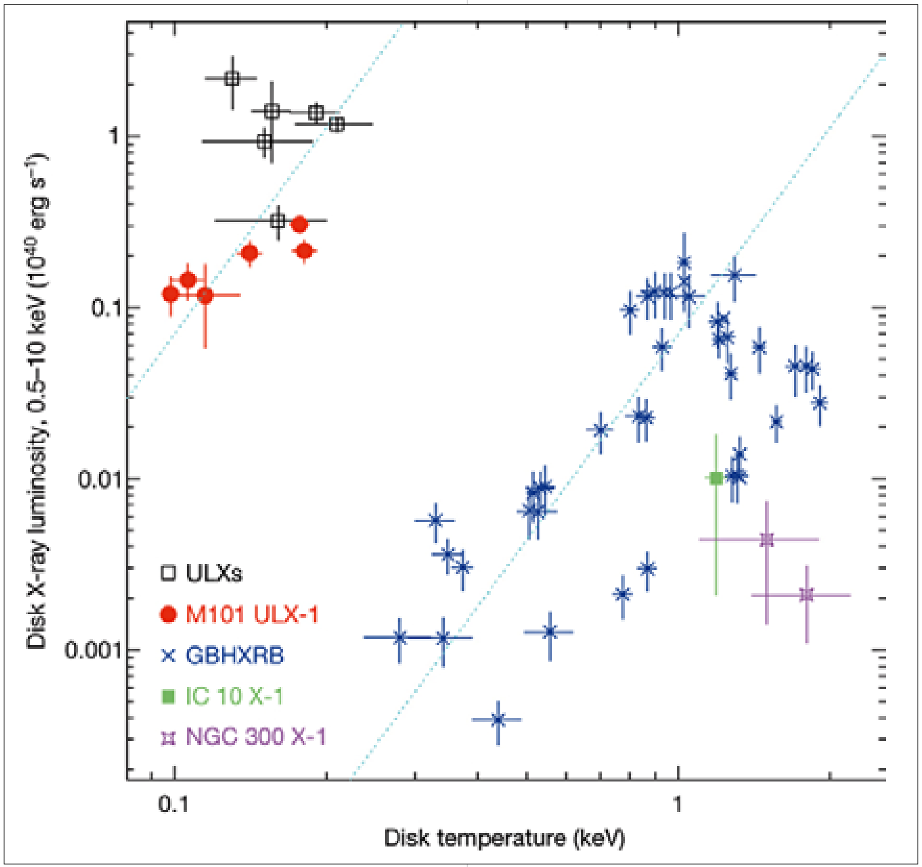

Figure 2.

Quantities derived from fits to the X-ray spectra of a variety of X-ray sources indicate that the accretion disk properties divide naturally into two groups. M101 ULX-1 (shown in red) is a member of the class which apparently maintains very cool inner disk temperatures whilst attaining a high luminosity, as would be expected for IMBHs. Galactic black-hole X-ray binaries (labelled as GBHXRB) and two other known Wolf-Rayet black-hole X-ray binaries lie in a distinctly different region of the parameter space. The dotted lines describe the expected variation in disk luminosity with a fixed inner disk radius (which, naively, would be correlated with black hole mass). For further details, please see Liu et al., *(2013).*

ly-understood process of accretion, and the conditions which prevail in the strong gravity close to a black hole.

Measuring the masses of the components in ULXs is hard, partly because the great luminosity of the accretion disk overwhelms the light from the star. However, rare systems are transient, sometimes entering a state in which they are sufficiently luminous to qualify as ULXs, sometimes returning to a quiescent state in which it might be possible to directly detect the motion of the star.

M101 ULX-1 is one such system. It was detected as the brightest X-ray source in the galaxy M101 but since then has regularly been observed in lower-luminosity states. Moreover, M101 ULX-1 is one of the ULXs from which the X-ray spectral energy distribution contains no hint of a Comptonising corona, which reduces the chance that the presently-proposed super-Eddington accretion mechanisms are helping to explain the high luminosity. Furthermore, the X-ray spectrum is easily fitted by a standard thermal accretion disk with a super-soft temperature of only 100 or 200 electron volts, which implies that the inner disk temperature is exceptionally cool (see Figure 2). This combination of spectral characteristics, combined with the high outburst luminosity, is exactly the set of properties which one would expect an IMBH to display.

Gemini Observations of a Black Hole Donor Star

Based on these arguments, a Gemini proposal was approved to try to detect the motion of the donor star in M101 ULX-1. This resulted in 10 spectra with exposures ranging between 3200 and 9600 seconds, and a combined integration time of 15.6 hours.

The first discovery from these observations was the nature of the companion star. Clear helium emission lines indicate that it is a Wolf-Rayet star (an evolved and helium rich

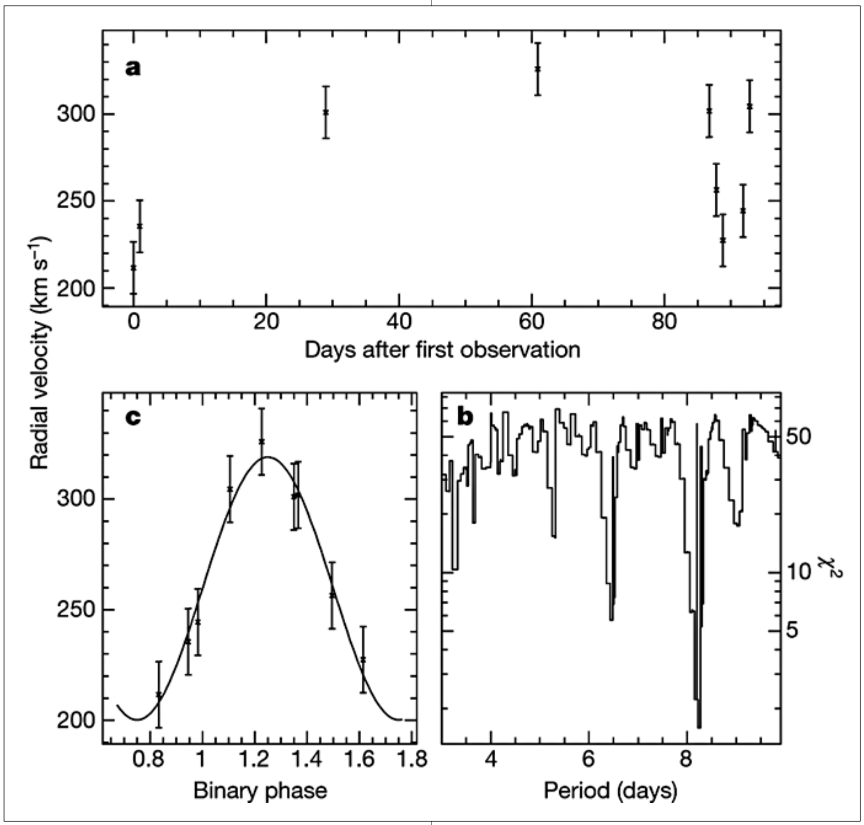

Figure 3.
Panel (a) presents the radial velocities measured from the 4686 Angstrom helium emission line in the Gemini spectra of M101 ULX-1. Panel (b) illustrates the chi-squared value obtained when fitting circular orbits of different periods to the data, demonstrating that the best-fitting orbital period is 8.2 days. Panel (c) again shows the measured radial velocities, now folded over the inferred orbital period. For further details, please see Liu et al.*, 2013.*

massive star that burns brightly, fiercely, and erractically). More detailed analysis indicated a star with spectral type WN8, with a mass somewhere between 17.5 and 19 solar masses. For details, see the journal paper (Liu *et al.,* 2013).

The motion of those emission lines showed clear radial velocity variations, indicating that the observations had successfully detected the orbital motion of the donor star about the black hole (see Figure 3). Assuming a circular orbit, the best-fitting orbital period was 8.2 days (which achieved a chi-squared value of 1.6). Clearly substantial uncertainties remain, given moderately large error bars for each of the radial-velocity measurements and imperfect phase coverage (remember that this is in a galaxy about 20 million light-years away!)

In reality, the orbit might also have non-zero eccentricity (as often observed in the wind-accreting Galactic high-mass X-ray binaries), although the good fit to the data using a pure sine curve suggests that any eccentricity in this case would be small. The best-fit model radial velocity curve indicates a minimum mass for the compact object in M101 ULX-1 of five solar masses, which confirms that it is a black hole.

Despite those uncertainties in the precise properties of the binary, two conclusions are very hard to escape: the black hole in M101 ULX-1 is not an IMBH, and it accretes from the wind of the Wolf-Rayet star.

For any binary system whose inclination is unknown, radial velocity measurements can only ever lead to a lower limit on the component masses — since the binary could, in principle, be arbitrarily close to face-on to the line of sight. However, the chance of detecting such a system is small. For M101 ULX-1, the combination of our best-fitting orbital period and Wolf-Rayet mass would require an orbital inclination within 5 degrees of face-on to contain a black hole of 300 solar masses or greater. This means we'd have a 0.3 percent probability of discovering such a system by chance. If ULXs are systems in which the X-ray emission is strongly beamed, however, and if the beaming axis is perpendicular to the orbital plane, then that would increase the ULX's chance of being observed in such an apparently unlikely orientation.

Even so, it would be bold to invoke observationally-disfavored beaming to argue that a system has a reasonable probability of containing an IMBH, given that beaming was first applied in this context to avoid the need for IMBHs. Taken at face value, then, the system is unlikely to be sufficiently face-on to contain an IMBH. Much of the ULX community will not be surprised by that broad conclusion; the idea that most ULXs contain stellar-mass black holes has gradually become the dominant position. Nonetheless, the Gemini data are the most direct observations supporting that conclusion.

More unexpected is our finding that the black hole in M101 ULX-1 can sustain such a high luminosity from wind accretion. Capture of material from a stellar wind is typically associated with fairly low-luminosity accretion, but M101 ULX-1 demonstrates that sometimes wind capture can be extremely efficient. This unlooked-for result might be as important as the mass measurement itself.

Whatever the final scientific impact that these results produce on our understanding of black holes and their accretion, we marvel that it is possible to measure the motion of a star orbiting a black hole in M101 — some 20 million light-years away — and thereby to constrain the mass of that black hole.

Acknowledgements:

J.-F.L. and S.J. thank the other authors of the associated journal article: Joel Bregman, Yu Bai, and Paul Crowther. We also thank the Chinese Academy of Sciences and National Science Foundation of China for support during this work.

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Bruce Macintosh and Peter Michaud

World's Most Powerful Planet Finder Turns its Eye to the Sky: First Light with the Gemini Planet Imager

The following article is an adaptation of the news featured in a press conference at the January 2014 meeting of the American Astronomical Society.

After nearly a decade of development, construction, and testing, the world's most advanced instrument for directly imaging and analyzing planets around other stars is pointing skyward and collecting light from distant worlds.

The instrument, called the Gemini Planet Imager (GPI), was designed, built, and optimized for imaging faint planets next to bright stars and probing their atmospheres. It will also be a powerful tool for studying dusty, planet-forming disks around young stars. It is the most advanced such instrument to be deployed on one of the world's biggest telescopes — the 8-meter Gemini South telescope in Chile.

"Even these early first light images are almost a factor of 10 better than the previous generation of instruments. In one minute, we are seeing planets that used to take us an hour to detect," says Bruce Macintosh of the Lawrence Livermore National Laboratory who led the team that built the instrument.

GPI detects infrared (heat) radiation from young Jupiter-like planets in wide orbits around other stars, those equivalent to the giant planets in our own Solar System not long after their formation. Every planet GPI sees can be studied in detail.

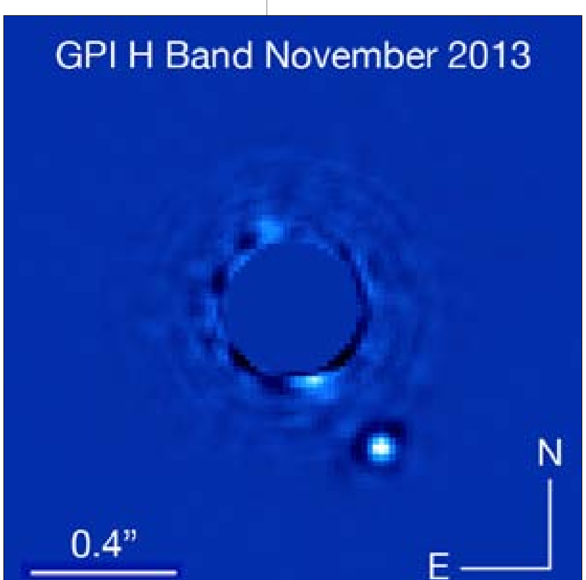


Figure 1.
Gemini Planet Imager's first light image of Beta Pictoris b, a planet orbiting the star Beta Pictoris. The star, Beta Pictoris, is blocked in this image by a mask so its light doesn't interfere with the light of the planet. In addition to the image, GPI obtains a spectrum from every pixel element in the field-of-view to allow scientists to study the planet in great detail.

Beta Pictoris b is a giant planet — several times larger than Jupiter — and is approximately 10 million years old. These near-infrared images (1.5-1.8 microns) show the planet glowing in infrared light from the heat released in its formation.

Processing by Christian Marois, NRC Canada.

"Most planets that we know about to date are only known because of indirect methods that tell us a planet is there, a bit about its orbit and mass, but not much else," says Macintosh. "With GPI we directly image planets around stars — it's a bit like being able to dissect the system and really dive into the planet's atmospheric makeup and characteristics."

GPI carried out its first observations last November — during an extremely trouble-free debut for an extraordinarily complex astronomical instrument the size of a small car. "This was one of the smoothest first light runs Gemini has ever seen," says Stephen Goodsell, who manages the project for the observatory.

For GPI's first observations, the team targeted previously known planetary systems, including the well-known Beta Pictoris system; in it GPI obtained the first-ever spectrum of the very young planet Beta Pictoris b. The first light team also used the instrument's polarization mode — which can detect starlight scattered by tiny particles — to study a faint ring of dust orbiting the very young star HR 4796A. With previous instruments, only sections of this dust ring, (which may be the debris remaining from planet formation), could be seen, but with GPI astronomers can follow the entire circumference of the ring.

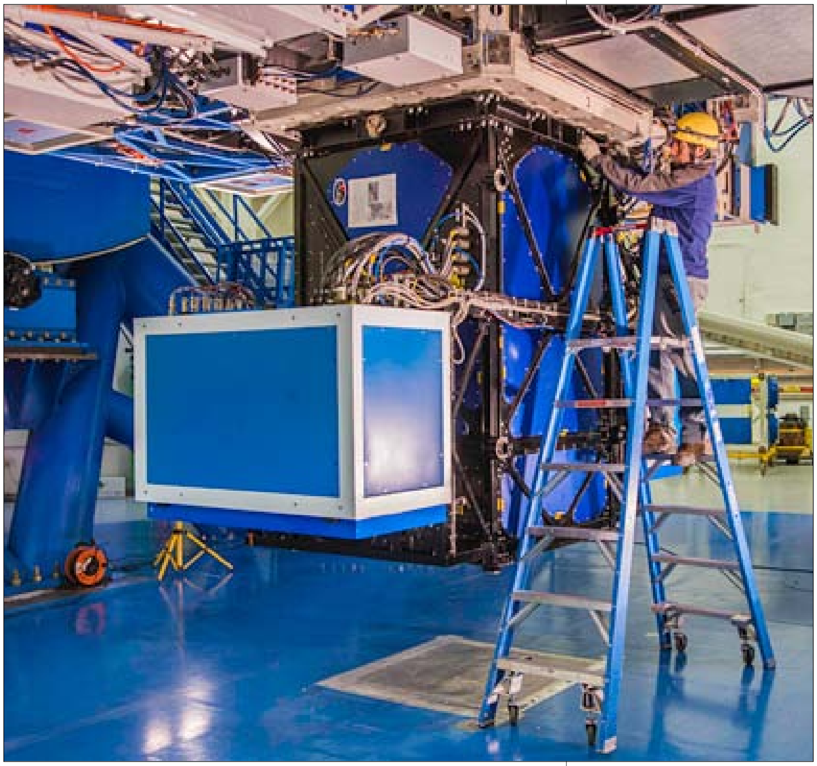
Although GPI was designed to look at distant planets, it can also observe objects in our Solar System. The accompanying test images of Jupiter's moon Europa, for example, can allow scientists to map changes in the satellite's surface composition. The images were released at the 223rd meeting of the American Astronomical Society.

"Seeing a planet close to a star after just one minute was a thrill, and we saw this on only the first week after the instrument was put on the telescope!" says Fredrik Rantakyro, a Gemini staff scientist working on the instrument. "Imagine what it will be able to do once we tweak and completely tune its performance."

"Exoplanets are extraordinarily faint and difficult to see next to a bright star," notes GPI chief scientist Professor James R. Graham of the University of California who has worked with Macintosh on the project since its inception. GPI can see planets a million times fainter than their parent stars. Often described, 'like trying to see a firefly circling a streetlight thousands of kilometers away,' instruments used to image exoplanets must be designed and built to "excruciating tolerances," points out Leslie Saddlemyer of NRC Herzberg (part of the National Research Council of Canada), who served as GPI's systems engineer. "Each individual mirror inside GPI has to be smooth to within a few times the size of an atom," Saddlemyer adds.

"GPI represents an amazing technical achievement for the international team of scientists who conceived, designed, and constructed the instrument, as well as a hallmark of the capabilities of the Gemini telescopes. It is a highly-anticipated and well-deserved step into the limelight for the Observatory", says Gary Schmidt, program officer at the National Science Foundation (NSF), which funded the

Figure 2.
GPI is mounted on the Gemini South telescope prior to first light observations in late 2013.



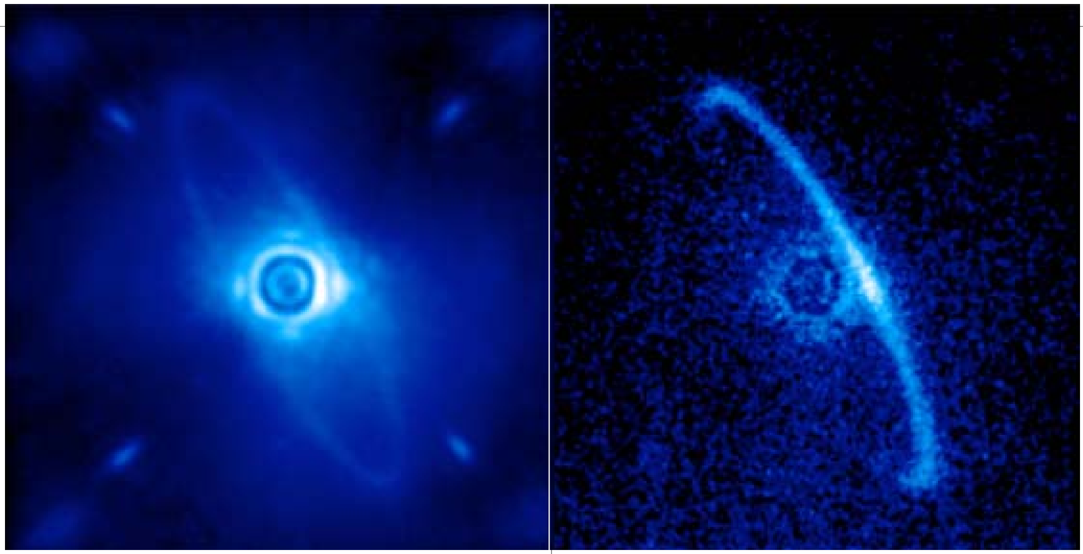


Figure 3.
Gemini Planet Imager's first light image of the light scattered by a disk of dust orbiting the young star HR 4796A. This narrow ring is thought to be dust from asteroids or comets left behind by planet formation; some scientists have theorized that the sharp edge of the ring is defined by an unseen planet. The left image (1.9-2.1 microns) shows normal light, including both the dust ring and the residual light from the central star scattered by turbulence in the Earth's atmosphere. The right image shows only polarized light. Leftover starlight is unpolarized and hence removed from this image. The light from the back edge of the disk is strongly polarized as it scatters towards us.

project along with the other countries of the Gemini Observatory partnership.

"After years of development and simulations and testing, it's incredibly exciting now to be seeing real images and spectra of exoplanets observed with GPI. It's just gorgeous data," says Marshall Perrin of the Space Telescope Science Institute.

"The entire exoplanet community is excited for GPI to usher in a whole new era of planet finding," says physicist and exoplanet expert Sara Seager of the Massachusetts Institute of Technology. Seager, who is not affiliated with the project adds, "Each exoplanet detection technique has its heyday. First it was the radial velocity technique (ground-based planet searches that started the whole field). Second it was the transit technique (namely Kepler). Now, she says, "it is the 'direct imaging' planet-finding technique's turn to make waves."

In 2014, the GPI team will begin a large-scale survey, looking at 600 young stars to see what giant planets orbit them. GPI will also be available to the whole Gemini community for other projects, ranging from studies of planet-forming disks to outflows of dust from massive, dying stars.

Looking through Earth's turbulent atmosphere, even with advanced adaptive optics, GPI will only be able to see Jupiter-sized planets. But similar technology is being proposed for future space telescopes.

"Some day, there will be an instrument that will look a lot like GPI, on a telescope in space," Macintosh projects. "And the images and spectra that will come out of that instrument will show a little blue dot that is another Earth."

GPI is an international project led by the Lawrence Livermore National Laboratory (LLNL) under Gemini's supervision, with Macintosh as Principal Investigator and LLNL engineer David Palmer as project manager. LLNL also produced the advanced adaptive optics system

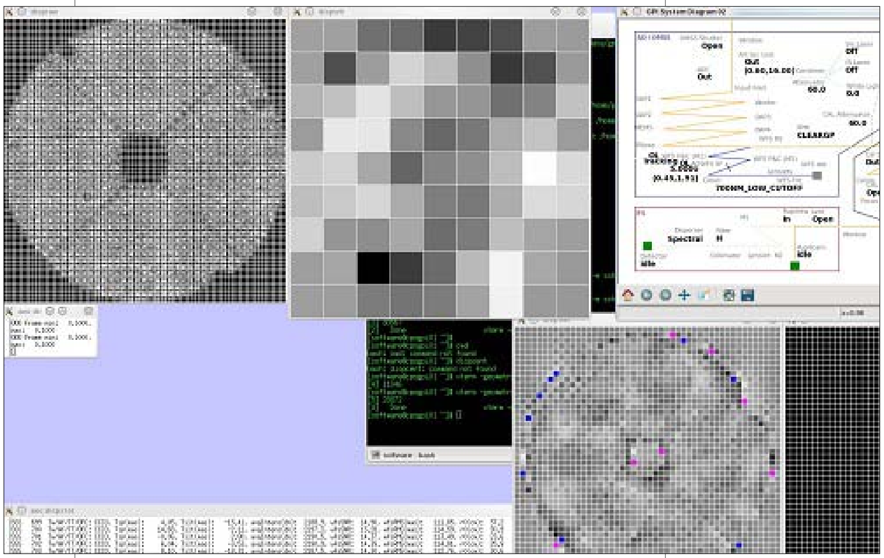


Figure 4.
Status display showing wavefront sensor (upper-left), upper-middle grid represents values being sent to lower order deformable mirror (woofer), upper-right is the GPI light-path, lower-right grid represents values sent to the higher order deformable mirror (tweeter).

that measures and corrects for atmospheric turbulence a thousand times per second. Early studies for the GPI project were spearheaded by the University of California's Center for Adaptive Optics, with funding from the National Science Foundation. Donald Gavel, at Lick Observatory UC Santa Cruz, led laboratory research efforts that proved the micromirror and coronagraph technologies. Scientists at the American Museum of Natural History, led by Ben Oppenheimer (who also led a project demonstrating some of the same technologies used in GPI on the 5-meter Palomar project) designed special masks that are part of the instrument's coronagraph which blocks the bright starlight that can obscure faint planets. Engineer Kent Wallace and a team from NASA's Jet Propulsion Laboratory constructed an ultra-precise infrared wavefront sensor to measure small distortions in starlight that might mask a planet. A team at the University of California Los Angeles' Infrared Laboratory, under the supervision of Professor James Larkin, together with Rene Doyon at the University of Montreal, assembled the infrared spectrograph that dissects the light from planets. Data analysis software written at University of Montreal and the Space Telescope Science Institute assembles the raw spectrograph data into three-dimensional cubes. NRC Herzberg in British Columbia Canada, built the mechanical structure and software that knits all the pieces together. James R. Graham, as project scientist, led the definition of the instrument's capabilities. The instrument underwent extensive testing in a laboratory at the University of California Santa Cruz before shipping to Chile in August. Franck Marchis at the SETI institute in California manages GPI's data and communications.

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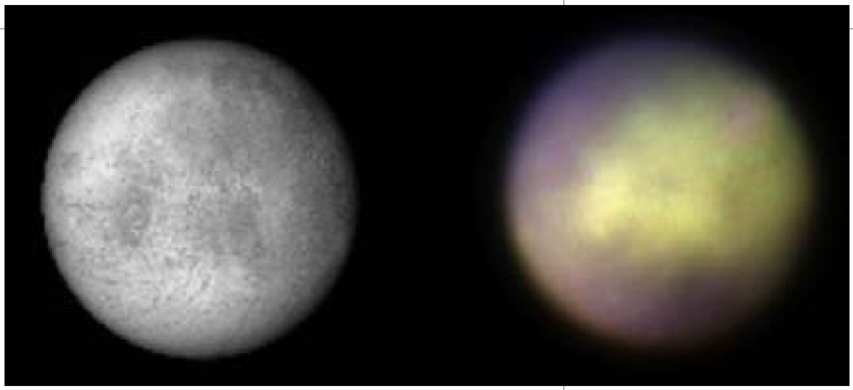


Figure 5.
Comparison of Europa observed with Gemini Planet Imager in K1 band on the right and visible albedo visualization based on a composite map made from Galileo SSI and Voyager 1 and 2 data (from USGS) on the left. While GPI is not designed for "extended" objects like this, its observations could help in following surface alterations on icy satellites of Jupiter or atmospheric phenomena (e.g., clouds, haze) on Saturn's moon Titan. The GPI near-infrared color image is a combination of three wavelength channels.

Image credit: Processing by Marshall Perrin, Space Telescope Science Institute and the Franck Marchis SETI Institute.

Figure 6.
The GPI first light imaging team celebrates the success of the instrument on the sky at Gemini South.

Nancy A. Levenson

Science Highlights

Recent reports on the most powerful flare ever observed on an L dwarf, spiral patterns in a protoplanetary disk, and the properties of galaxies in intermediate-mass clusters.

The Most Powerful Flare ever Observed on an L Dwarf

Astronomers used the Gemini Multi-Object Spectrograph on Gemini North to capture the most powerful flare ever observed on an L dwarf. At its peak, the brightness of the Jupiter-sized source increased by a factor of three, with a total flare energy output of 1.6 x 10^{32} ergs. The team suggests that similar flares may be common in this class of substellar objects, occurring once or twice per month. The Gemini data also provided the L1 spectral type of the brown dwarf, named WISE J190648.47+401106.8 for its discovery using NASA's WISE satellite, or W1906+40 for short.

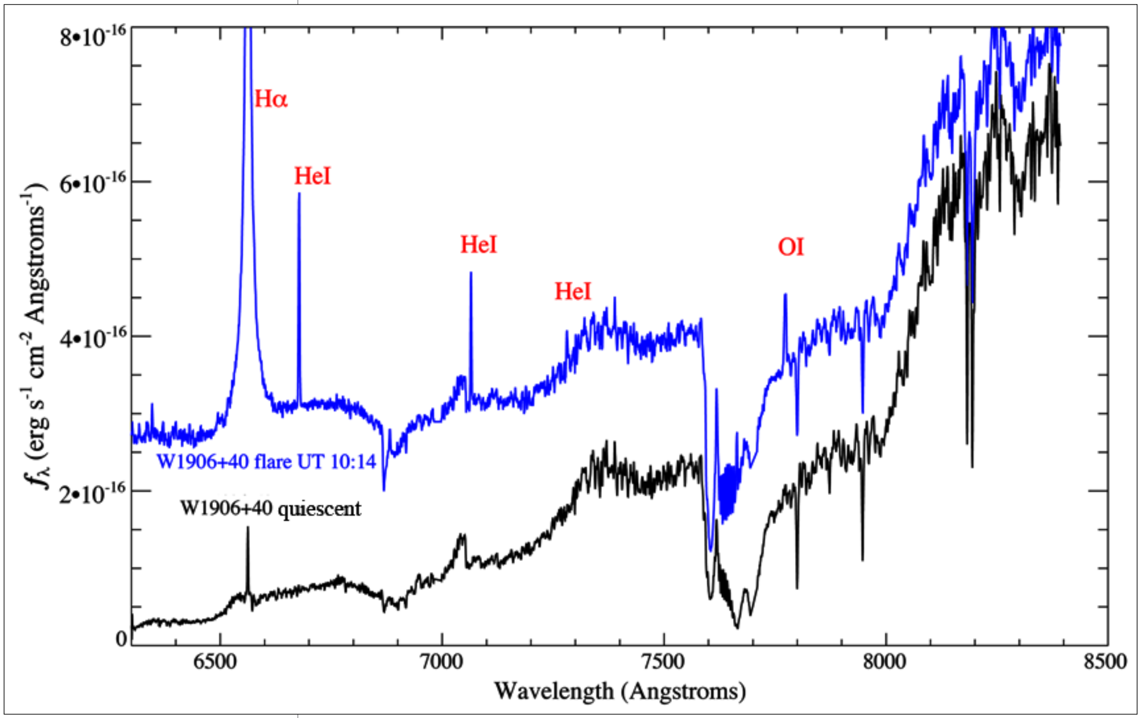
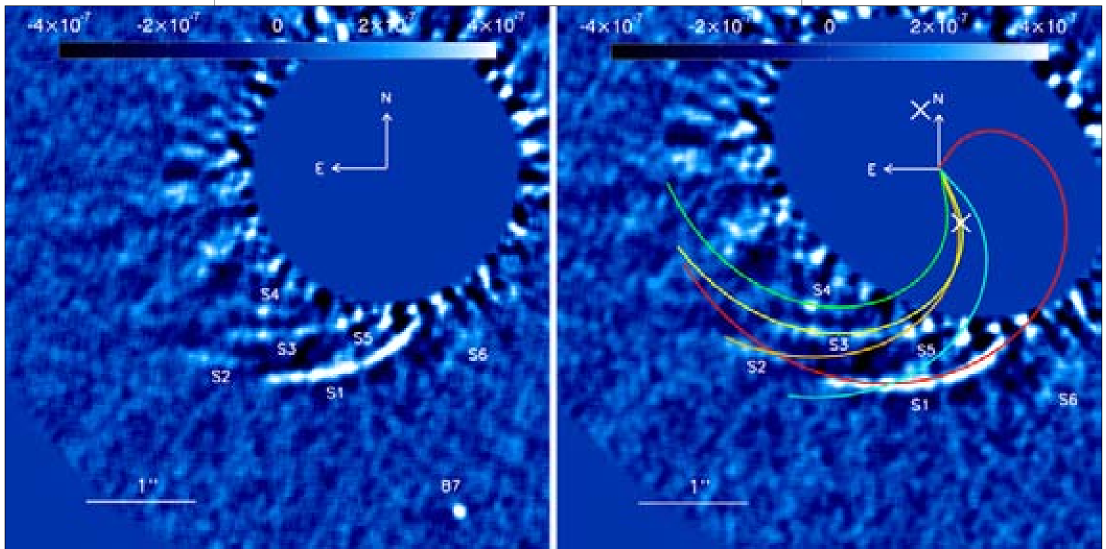


Figure 1. *Gemini spectrum of W1906+40, in its quiescent state (black) and during a strong flare (blue). In addition to the overall increase in luminosity, the Hα emission appears broad and the overall spectral shape corresponds to higher temperatures during the flare. (The spectra are not corrected for the effects of Earth's atmosphere.)*

John Gizis (University of Delaware) and collaborators have been observing W1906+40 using the Kepler satellite and a variety of ground-based facilities. The long-term (15-month) monitoring with Kepler shows a regular brightness variation at the 1 percent level with a period of 8.9 hours. The team models this variability as the presence of a single "spot" of lower-thanaverage luminosity that moves in and out of view as the dwarf rotates. They suggest that a magnetic starspot could provide such cooler material, although they also consider the possibility of clouds in the atmosphere (similar to Jupiter's Great Red Spot), which could also produce the same effect.



Given their spectral characteristics, which include broadening of emission lines and a bluer or hotter continuum, the strong flares observed with Gemini (Figure 1) also have a magnetic origin. In contrast to the quiescent characteristic temperature of 2300 K, the flare corresponds to a temperature of 8000 K. These results show a continuity of flare properties from the higher-mass M dwarfs to the L class. They also confirm W1906+40 as a magnetically active brown dwarf, despite the attribution of variability observed in some L dwarfs due to atmospheric variations, such as changing cloud distributions.

Complete results are in press in *The Astrophysical Journal*; a preprint is available at **arXiv** 1310.5940.

Spiral Patterns in a Protoplanetary Disk

Spiral patterns measured in a protoplanetary disk offer an exemplary study aimed at accounting for the full process of planet formation. Planets are expected to form in the remains surrounding the formation of a star, called a protoplanetary disk. The star HD 100546 is an excellent candidate for such a detailed investigation, being young (age 5-10 million years), and showing excess infrared emission, which is characteristic of a dusty — potentially planet-forming — disk.

The disk, which extends from the central star to distances of 80 times that between the Earth and Sun, has previously been resolved and some of its spiral patterns identified. In new work using archival observations obtained with the Near-Infrared Coronographic Imager on the Gemini South telescope, Anthony Boccaletti (Observatoire de Paris, France) and collaborators show additional detail of the spiral patterns in HD 100546 and uncover hints of a planet that may be responsible for producing them.

Special data processing techniques of angular differential imaging reveal the subtle details of the spirals in the near-infrared, resolving the southern feature into multiple arms, and provide contrast at the level of 10^{-5} to 10^{-6} at distances of 1 and 2 arcseconds from the star, respectively (Figure 2). The team models these arms and concludes that gravitational perturbations by inner bodies most likely cause the spirals. Concentrating on the star's immediate vicinity shows a

Figure 2.
NICI observation of HD 100546 in the K_s band, processed to reveal multiple southern spiral arms (left), which are modeled (colored lines overlaid, right).

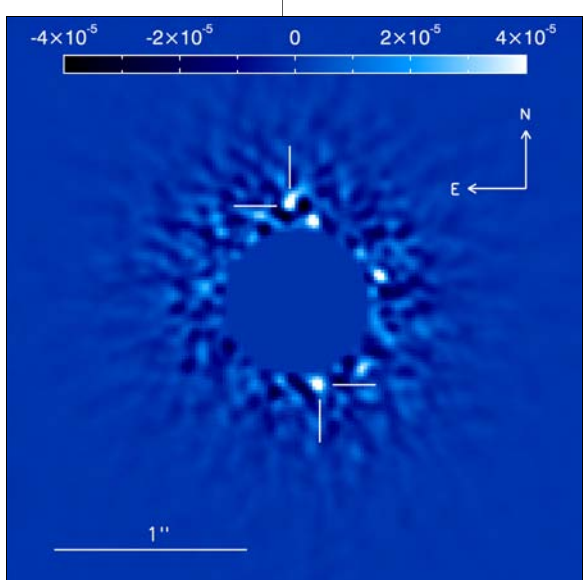


Figure 3.
Zooming in to the central star's 3 arcseconds shows a candidate planet to the south, which may be responsible for producing the spiral arms. (The spot marked to the north of the star is an artifact of processing).

candidate source responsible (Figure 3). The source emerges just at the detection limit, so confirmation requires more contrast at closer separations from the bright star — capabilities that the Gemini Planet Imager can provide.

Full results will appear in *Astronomy and Astrophysics*; a preprint is available now (**arXiv**:1310.7092).

Observations of Galaxies in Intermediate-mass Clusters

Do galaxies evolve in intermediate-mass clusters the same way they do in high-mass clusters? The environment is a function of cluster mass, and therefore influences evolutionary processes that reflect "nurture" as opposed to intrinsic "nature" of galaxies. José Luis Nilo Castellón (IATE-CONICET, Argentina, and Universidad de La Serena, Chile) and colleagues present first results from a sample of seven galaxy clusters and find that the general trends of these intermediate-mass clusters match those observed in high-mass clusters, in agreement with previous related work.

The sample was selected based on low X-ray luminosity, and multi-band imaging observations using both Gemini Multi-Object Spectrograph instruments allows classification of the galaxies. In color-magnitude plots, the low-redshift examples tend to show a red cluster sequence of early-type galaxies that is well-defined over several orders of magnitude with little scatter and which contains most of the cluster members. These clusters tend to be centrally concentrated, and nearly 70 percent of the red galaxies are located in the cluster cores. Similar to the case for richer clusters, the fraction of blue galaxies increases with redshift. In the higher-redshift group here, red and blue peaks are evident in the overall distribution of galaxy colors. In addition, the higher-redshift examples of the cluster density maps show multiple concentrations and a mix of red and blue galaxies in the cores (Figure 4).

This work is in press in *Monthly Notices of the Royal Astronomical Society*; a preprint is available at **arXiv**:1311.0788.

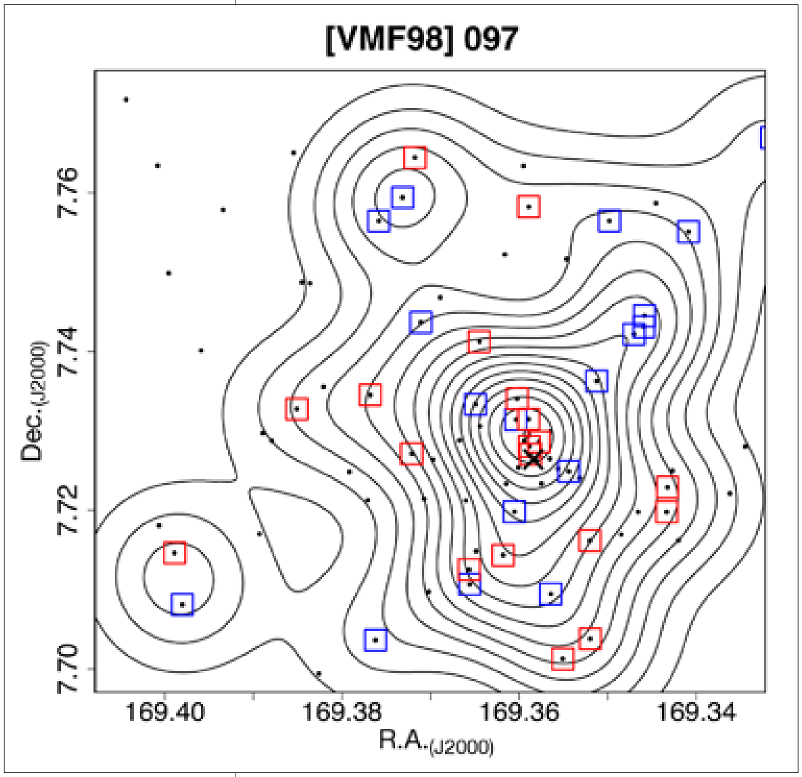


Figure 4. *Contours show the galaxy density distribution in the redshift 0.48 cluster [VMF98] 097, with red and blue galaxy cluster members plotted in color. A cross marks the location of the X-ray emission peak. This cluster is not relaxed, and shows several significant concentrations as well as a mix of red and blue galaxies in the central region.*

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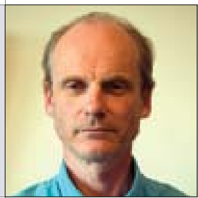


Andy Adamson

with contributions by Sandy Leggett, Chris Yamasaki, Inger Jørgensen, Bernadette Rodgers, Rodrigo Carrasco, and Benoit Neichel

Operations Corner

From visiting instruments, to changes in data checking and software development, 2013 ushered in the reshaping of Gemini's operations. With powerful new instruments like the GeMS multi-conjugate adaptive optics System, FLAMINGOS-2, and the Gemini Planet Imager — all either progressing through integration, or approaching operational status — our users can look forward to even more of the most powerful discovery tools in astronomy today.

An Exceptionally Busy Year at Gemini South

2013 was one of the most event-filled years for operations at Gemini South in recent memory. Most of the activity followed a planned maintenance shutdown early in Semester 2013B (see details in section below). During that time the Gemini Planet Imager (GPI) was not only delivered, integrated, and comissioned, but saw first light (see cover article in this issue). GeMS/GSAOI (the multi-conjugate adaptive optics system and infrared imager) was also accepted into scientific operations, and FLAMINGOS-2 began doing regular science; the latter attracted many 2013B proposals (see update in the 2013 instrument development article in this issue).

The flurry of new instrumentation at Gemini South meant that something had to give, and with T-ReCS already removed from the complement, that something was the Near-infrared Camera and Imager (NICI). Despite some hardware and computer problems in its last few weeks of operation, 70 percent of the 2013A NICI programs received more than 75 percent of their requested data.

Gemini South Shutdown

The Gemini South winter shutdown was completed successfully, with a wide variety of assignments carried out. One of the biggest jobs was a complete reworking of the summit data center, which included replacing old obsolete racks with new ones. To achieve this, we had to install the computer systems themselves in temporary racks while the old ones were swapped out. We also did maintenance and improvement work on the telescope infrastructure, including the Acquisition & Guiding (A&G) unit and the Cassegrain Rotator. Significant work was also done on GMOS-South to improve reliability of the mask exchange unit.

Finally, we replaced the large chiller, which is used for the toughest cooling tasks in the building (including the air handling units in the dome itself). This was a major undertaking. It required a choreographed exchange between the existing chillers and the new unit, which enabled the new one to run in a test mode so that stability could be achieved before we permanently switched the units. The new unit appears to work very well, and, because it is much more efficient, we expect to realize significant savings on electricity — a critical (and our largest) single expense.

Gemini North Operations in 2013

In 2013, the most significant change in operations that users noticed at Gemini North was the change in Semester 2013A in the amount of data checking performed. This was driven by the reduction of Gemini's budget and the need for staff astronomers and Science Operation Specialists to use their efforts where it has the most impact. Most significantly, at night, the observer takes responsibility for setting quality assurance flags to the best of his or her ability, using a variety of tools, including data checking programs and the environmental sensors.

Figure 1.
The Gemini North 8-meter primary mirror is inspected inside of the coating chamber.

During the day all band 1 data are checked as usual, as well as any programs where a check is deemed to be necessary by the Queue Coordinator (up to a limit of 30 percent of the night's data in total). Other programs, including band 4 and classical programs, are not checked, and may be left with their quality assessment state set to "UNDEFINED", if the nighttime observer was unable to review them in real-time

This change represented a considerable cultural shift for Gemini staff; our dedication to our product is strong. However, the change is unquestionably necessary and has already produced effort savings in the north and will soon be applied to Gemini South operations as well.

Gemini North Shutdown

An extensive planned shutdown at Gemini North in Semester 2013B, primarily to recoat the 8-meter primary mirror, started on September12th. The operation was completed successfully (see Figure 1). The mirror now has unprecedented reflectivity (blue: 470 nanometers = 93.0%; green: 530 nm = 95.0%; red: 650 nm = 95.2%; near-infrared 880 nm = 96.4%; thermal infrared 3300 nm = 99.0%). Also 100% adhesion was achieved. Senior Optical Technician Clayton Ah Hee says Gemini should get at least as long a life out of this coating as the last one, which lasted almost six years!

During this shutdown, the team also accomplished many other tasks, including repairing the mirror cover and A&G unit, and performing upgrades and repairs to the instruments.

Gemini North and South Safety Platforms

In 2013, major safety milestones were achieved at Gemini North and South with the installation of new, exterior Shutter Service Platforms (see Figures 2-7). These structures are designed to provide a safe means to perform critical periodic maintenance on the enclosure shutter drive motors, encoders, gear-boxes, and chains.

Figure 3 shows the 150-foot telescoping crane used later in the year at Gemini North, which was required to pick up and place the platforms into position. For the crane to safely perform the lift, Gemini had to excavate and grade a level foundation pad and limit the operation to wind speeds less than 20 miles per hour; both items impacted the time and cost of the installation work.

Visiting Instruments

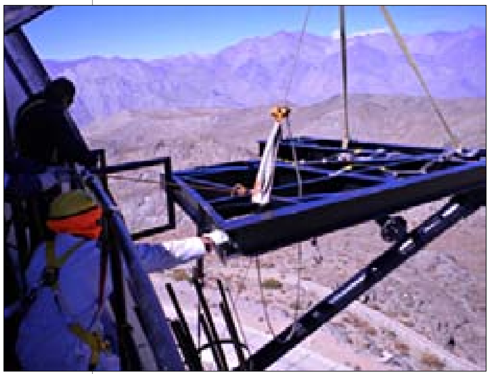
Gemini's new visiting-instrument policy, developed jointly by the Observatory and the Science and Technology Advisory Committee (STAC), allows a quick process for bringing a visiting instrument to the telescope on a "once-off" basis. It also allows for the possibility of attracting a wider base of users within the Gemini partnership, who may be interested in the performance potential of these instruments (without going the whole way to facility class, which is a much larger, and likely prohibitive, undertaking).

The policy (see *http://www.gemini.edu/sciops/instruments/visiting-instrument-policy*), was put into action with the Differential Spectral Survey Instrument (DSSI); a speckle camera, which Gemini offered in the 2013B Call for Proposals. The instrument was used for eight nights on the telescope in July. Five science programs were observed, including the DSSI team's own.

This plan worked out quite well, with three of the five programs either completed or nearly completed, and two programs more than half completed; the shortfall was due to target position and filter availability, as well as observing conditions, includ-

Figure 2.
View from the newly installed Shutter Service Platform at Gemini North, installed to facilitate safety and accessibility during shutter motor servicing.

Figure 3.
A 150-foot telescoping crane was needed to install the Shutter Service Platform.



Figures 4-7 (below):
Clockwise, from top left (all at Gemini South):

- *Installing the base plate of the first platform.*
- *Fleshing out the first platform.*
- *Working on the completed platform.*
- *The installed platforms, looking like they belong there even ahead of painting.*

ing the loss of a complete night to the passage of Tropical Storm Flossie.

The science included measuring the diameters of nearby stars, Kepler exoplanet confirmations, and observations of Pluto and Charon — a wide range of exciting science observations for a niche capability. It is expected that the instrument will be offered again for 2014B; its capabilities and performance are summarized here: *http://www.gemini.edu/sciops/instruments/dssi-speckle-camera-north*.

In November, DSSI was succeeded onto Gemini North by TEXES, a mid-IR high-resolution spectrometer making its third visit to the telescope (the last having been before 2010). The winter weather was not very helpful, but the TEXES team still obtained useful observations on a mini-queue of programs granted by the Time Allocation Committee, with a total of 90 hours.

DSSI and TEXES were oversubscribed by factors of two and three, respectively.

User Software Improvements

The UREKA Unified Release

In june, we released a new a new mechanism for installing and running the Gemini reduction package and all of its supporting software. The idea of Ureka (also known as the "unified release") is to bundle all the required pieces and release them together in one easily-installed package. Ureka has the added bonus of not interfering with any existing installations.

A quote from the Ureka page sums up what it's about: "Ureka is a collection of useful astronomy software that is generally centered around Python and IRAF. The software provides everything you need to run the data reduction packages provided by the Space Telescope Science Institute and Gemini." Since its Beta release to the community, Ureka has been downloaded by hundreds of users, and feedback is being used to bring it to production release status.

Observatory Control Software Improvements

Work has been going on "under the hood" of the other operations software to enable significant future improvements, and to make the software more maintainable. Overall, the OCS (Observatory Control Software) has been reduced in size by about 1/3, due to the removal of internal communications layer. Users will not see much change, though the changes also required the implementation of "Sync" to replace the old "Fetch/Store" mechanism, which should be simpler for PIs to use, and prevent data loss. This change was included in the December 2013 software release.

Users' Data Reduction Forum Added

We are pleased to announce the release of the Gemini Data Reduction User Forum, located at: *http://drforum.gemini.edu/*. This is intended as a user-supported site for the trading of ideas, scripts, and best practices, and for taking part in user-driven public discussions on data reduction processes and strategies. If you have written a script, procedure, tip, or description of your own process that you think other Gemini users may find helpful in reducing their data sets, please consider posting it here.

The Forum's "start here" page (*http://drforum.gemini.edu/start-here/*) gives a brief introduction and some points to note when posting or taking part in discussions. Both the Observatory and the Users' Committee for Gemini are keen to see this Forum well utilized and become helpful to a broad segment of our user community. To encourage your involvement, Gemini Director Markus Kissler-Patig has agreed to award Director's Discretionary observing time to two individuals who will be selected based on the usefulness of their posts.

New: Large and Long Programs at Gemini

Gemini offered a new proposal mode, for Large and Long Programs (LPs), with first observations in Semester 2014B.

The participating partners — United States, Canada, Australia, and Argentina — contributed up to 20 percent of their time to a common pool for these programs. As a guideline, LPs either require significantly more time than a partner typically approves for a single program, or are extend over two to six semesters, or both.

Large programs are expected to promote collaborations across the partnership's communities, have significant scientific impact, and, normally, provide a homogeneous data set potentially for more general use. PIs must be based in an institution of one of the participating partner countries, though there is no restriction on Co-investigator affiliation.

With the LPs, Gemini will also introduce a new observing mode, "priority visiting observing." In this mode, the PI or team member comes to Gemini prepared to observe either their own program, if the conditions are sufficiently good, or execute approved queue programs, if the conditions are too poor for the LP.

The LP will be charged only for time devoted to the program, and additional observations may be made by Gemini staff during the semester. With this mode and that of traditional "classical" observing, we encourage the benefits of being directly involved with the program team in observing, and their interaction with Gemini staff who also support the program.

LPs will be reviewed through a dedicated LP Time Allocation Committee, and the process will bring additional application and reporting requirements. Specifically, Letters of Intent will be required in advance, the proposal will include a management plan component in addition to the usual scientific justification, and approved programs will be reviewed annually.

There may be additional partner-specific procedures or requirements, as well. Complete details will be available with the Announcement of Opportunity, which Gemini expects to release in early December 2013. Proposals will be due around the usual 2014B deadline at the end of March 2014. Instruments and observing modes that are fully commissioned at the time of the announcement of opportunity will be open for LPs; a specific list will be provided at that time.

Development of the Fast Turnaround Mode

The foundation for a new mode of proposing at Gemini is being laid with an initiative called Fast Turnaround Program. This new concept underwent considerable development in 2013 and is poised for implementation later in 2014. This mode of proposing is intended to provide a means for submitting proposals that have time constraints due to their dynamic or time-dependent nature. As 2013 closes, both the STAC and Gemini Board have approved the concept, and work is well-along to develop internal procedures to assure a successful launch.

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Contributing authors from Gemini's staff: Rodrigo Carrasco, Inger Jørgensen, Sandy Leggett, Bryan Miller, Benoit Neichel, Bernadette Rodgers, and Chris Yamasaki

Scot Kleinman

with contributions by Bernadette Rodgers, Benoit Neichel, Rodrigo Carrasco, Andre-Nicolas Chene, Chad Trujillo, Percy Gomez, Stephen Goodsell, Fredrik Rantakyro, Eric Tollestrup, Maxime Boccas, and Peter Michaud

Instrument Development: 2013 Review

2013 was an exceptional year for instrumentation at Gemini, with a suite of new instruments and events at Gemini South, including the highly successful Gemini South Multi-conjugate adaptive optics System (GeMS) combined with the Gemini South Adaptive Optics Imager (GSAOI), and the arrival, integration, first light, and start of commissioning of the Gemini Planet Imager (GPI). In parallel, we continue to look to the future in order to develop the capabilities of both Gemini telescopes and support the diverse needs of our user community.

Rapid progress in a host of new instrumentation initiatives at Gemini occurred throughout 2013. Most of these reached fruition at Gemini South, with the most tangible being queue science with GeMS/GSAOI, FLAMINGOS-2, and first light for GPI.

At Gemini North, the fiber-fed, shared use of CFHT's ESPaDOnS instrument through the GRACES project points to a good collaborative effort that is trailblazing the astronomical use of long fibers and furthering Gemini's North's exciting future on Mauna Kea.

The following brief summaries provide a taste of what the present and future holds for Gemini instrumentation. Watch for further details in future issues of *Gemini*Focus and on the Gemini website at: http://www.gemini.edu/sciops/future-instrumentation

FLAMINGOS-2: On Sky, Doing Science

"Gemini Observatory's latest tool for astronomers, a second-generation infrared instrument called FLAMINGOS-2 (F2), has 'traveled a long road' to begin science observations for the Gemini scientific community." So begins the August 2013 press release (www.gemini. edu/node/12047), showcasing several spectacular F2 on-sky commissioning images and presenting an update on progress (FIgure 1). Since then, science observations have begun!

After finishing optical rework in April 2013 (Figure 2), F2 stepped closer to its final round of commissioning observations when it was moved from the Gemini South summit instrument lab onto port 5 of the Instrument Support Structure on June 11, 2013. The first preliminary science queue data were obtained July 19th, and regular queue observations began in late September.

F2 began obtaining data in "shared-risk" mode in August 2013 and between then and mid-December has executed 15 queue programs. Despite this exciting milestone, challenges remained. One problem involved the instrument's On-Instrument Wavefront Sensor (OIWFS) used to optimize the delivered image quality to the camera. During on-sky checks on the night of August 24th, an alignment problem with the OIWFS became apparent. An inspection quickly followed, and the mechanism was realigned as precisely as possible with minimum intrusion (*i.e.*, without moving other optical components).

PIs with programs in the 2013B queue were informed of the possibility of reverting to the use of PWFS2, and observations were prepared for either option, allowing queue observations to continue. An additional problem was discovered with repeatability of the Lyot wheel mechanism, but a solution was identified and the problem resolved in December. However, delivered image quality is a significant remaining issue, and is still under active investigation.

Figure 1.
FLAMINGOS-2 near-infrared commissioning image details part of the magnificent Swan Nebula (M17), where ultraviolet radiation streaming from young hot stars sculpts a dense region of dust and gas into myriad fanciful forms. M17 lies some 5,200 light-years distant in the constellation Sagittarius and is one of the most massive and luminous star-forming regions in our Galaxy. Field-of-view: 5.5 x 4.0 arcminutes.

Credit: Gemini Observatory/AURA.

These 2013B programs requested a total of 180 hours or 17 percent of the total available time on Gemini South, despite the fact that only imaging and the long-slit spectroscopy modes were offered in this first semester. Work is ongoing to offer the multi-object spectroscopy (MOS) mode later, after we gain more experience and time with the instrument.

In parallel to the start of "shared-risk" science operations, and before the end of the 2013B semester, Gemini held an internal Operations Handover Review for F2. The review took a close look at the performance and operability of F2 in its present state with respect to the ultimate goal of successfully operating, maintaining, and supporting F2 as a facility-class Gemini instrument, and delivering the expected scientific return to the Gemini community. The committee also assessed the remaining work going forward, including improving the

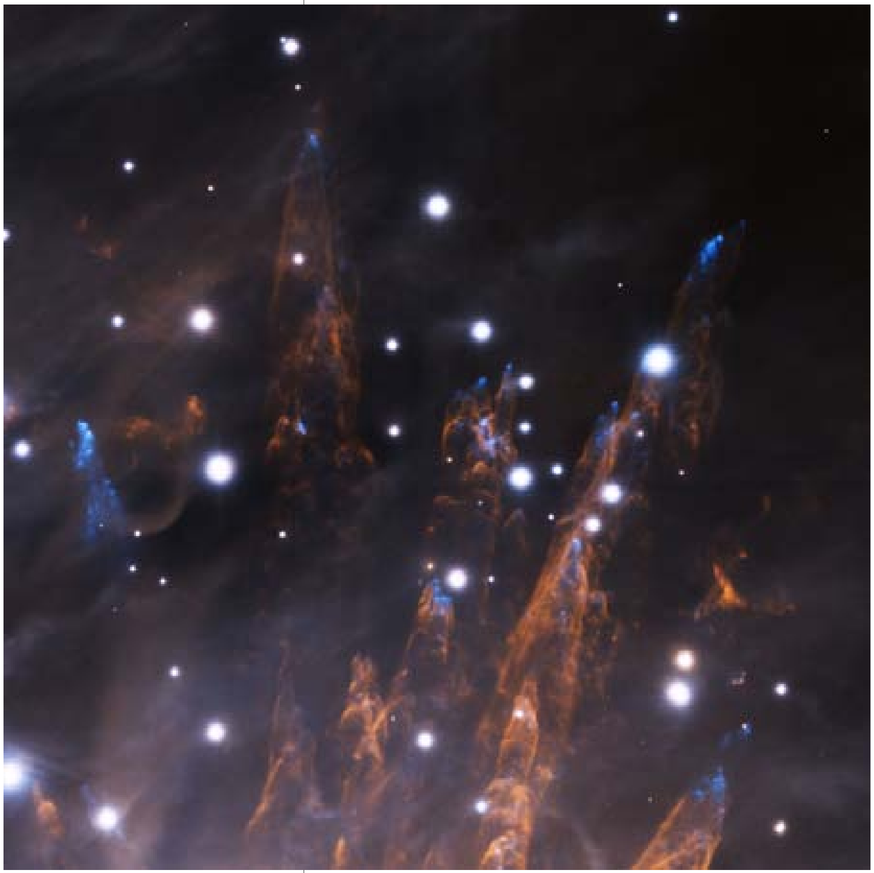
Figure 2.
Optical Engineer Constanza Araujo works on FLAMINGOS-2's optical alignment and image quality testing prior to cool-down.

delivered image quality and commissioning the powerful multi-object spectroscopy (MOS) mode.

GeMS/GSAOI Moving Toward More Robust Operations

Figure 3.
Image of the Orion Bullets obtained during the late commissioning phase of the GeMS adaptive optics system, with the Gemini South AO Imager (GSAOI). The large adaptive optics field-of-view (85 arcseconds across) demonstrates the system's extreme resolution and uniform correction across the entire field.

Image Credit: Gemini Observatory/AURA.



The Gemini Multi-conjugate adpative optics System (GeMS), along with its dedicated imager, the Gemini South Adaptive Optics Imager (GSAOI), has, in 2013, completed the transition from a development project into System Verification (SV) observations. In Semester 2013B, the instrument neared normal science queue operations.

During these transitions, GeMS/GSAOI produced a variety of very impressive results, including a stunning new first light image of the Orion Nebula "Bullets" region among several other targets (see: http://www.gemini.edu/node/11925, and Figure 3). Data obtained during the SV period also resulted in the first refereed journal article based on GeMS data ("Haffner 16: A Young Moving Group in the Making," Davidge *et al.*). This paper appeared in *The Publications of the Astronomical Society of the Pacific* and is now part of a rapidly growing collection of cutting-edge science papers made possible with GeMS.

During a telescope shutdown in June and July, many improvements were made to GeMS. These included: 1) Routine cold head maintenance of the Gemini South Adaptive Optics Imager (GSAOI, the science camera behind GeMS); 2) Repair of filter wheel #2 and the utility wheel, along with cleaning of optical elements; 3) Maintenance (including diode replacement) to improve the power output of the laser used to produce the artificial guide stars and provide better adaptive optics corrections; 4) Installation of new higher reflectivity mirrors in the transfer optics that launch the Laser, and 5) Movement of the laser wavefront sensor in Canopus (the adaptive optics instrument itself) to improve performance and investigation of some minor optical alignment issues related to the natural guide star (NGS) part of the system, and make improvements in the operational software. Overall, these improvements were designed to increase the operability and performance of the system as it entered normal queue operations mode.

From September 12-16, the system was scheduled to be on-sky in order to return GeMS to a state of readiness for queue operations after the shutdown work. This was only partially accomplished, in part due to poor weather during the run (cirrus clouds prevented use of the laser, and poor seeing prevailed), and because a number of technical issues were uncovered. Despite these problems, some useful progress was made, including: 1) successful testing of a number of operational software improvements; 2) calibration of beam transfer optics for the laser; 3) calibration of Canopus probes that acquire the natural guide stars; and 4) on-sky use of the GeMS laser. The October and December runs culminated in the return of GeMS to queue readiness, including the first Classical time observations made with GeMS in late December.

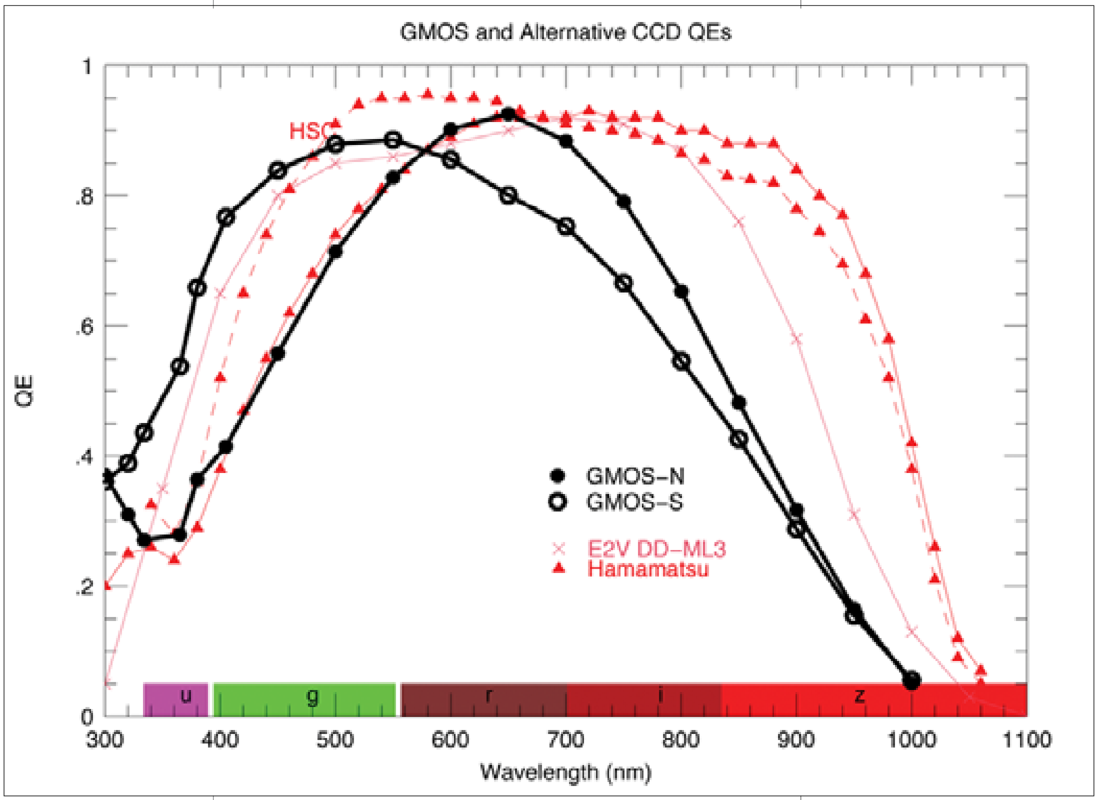


Figure 4.

Quantum Efficiency (QE) comparison for the legacy GMOS-N CCDs, the current GMOS-N e2v-DD devices, the current GMOS-S, and the Hamamatsu detectors planned for the pending upgrade. This plot considers only the detector, not the instrument camera, telescope, or atmospheric transmission.

The GeMS team also completed the instrument's first operational Acceptance Review (AR) in November, with the final review scheduled for January 2014. The AR clearly defined the extra support personnel and tasks needed prior to each GeMS run to ensure that the instrument is ready for science. This effort includes members of many groups across Gemini — Science Operations, Optical Systems, Electronics and Instrumentation, Systems Engineering, Software, Information Systems, and, of course, the Adaptive Optics group — and demands that they work together in a coordinated manner.

In addition, the AR stressed that every successful night of GeMS operation requires careful communication between the telescope operator, observer, laser technician, adaptive optics group support, and laser spotters. The key to a successful transition to routine queue operations of GeMS is communication between all of these highly technical and savvy individuals.

Finally, the GeMS AR also documented key performance metrics and identified areas where improvements can be made in 2014 and beyond. During queue operations the roles and communications defined in the AR will allow Gemini to navigate a clear path to our goal of state-of-the-art adaptive optics success.

GHOS

Since the loss of one of the proposed subcontractors for the Gemini High-resolution Optical Spectrograph (GHOS), we have been working closely with the instrument team and our governing and advisory committees to develop the best path forward. As these plans finalize, we will make announcements on the Gemini website.

GMOS

New Hamamatsu CCDs for the Gemini Multi-object Spectrograph (GMOS) are now successfully integrated in the Hilo lab with an in-dewar electrostatic discharge protection board. The system has been fully characterized at Gemini North and will be shipped to Gemini South in early 2014, pending required approvals from the U.S. government for some of the International Traffic in Arms Regulations (ITAR) controlled components. We expect to install the CCDs into GMOS at Gemini South in May 2014, with the revitalized instrument returning to science use in July.

We are currently ordering additional detectors for GMOS-N and expect installation into the instrument during 2015. Compared to the relatively recently installed e2v Deep Depletion CCDs in GMOS-N, we expect to get improved sensitivity in the red, specifically ~30 percent improvement at 900 nm and ~2x greater sensitivity longward of 950 nm (according to the reported QE values). (See Figure 4.)

The Gemini Planet Imager

The Gemini Planet Imager (GPI) project — a revolutionary instrument in the field of exoplanet research — saw final testing, shipment to Gemini South, integration, the start of commissioning, and official first light all in 2013 (see the story starting on page 8 featuring the GPI first light press release).

Early in 2013, GPI was turned almost upside down and frozen down below 0° Centigrade. First, GPI was mounted on the flexure rig, then tilted and hung vertically, to simulate the effects of gravity on the instrument, which changes when the telescope points to different parts of the sky (figure 5). Next, GPI went into a cold room and was exposed to the large range of temperatures that will occur at Gemini South.

Figure 5.
The Gemini Planet Imager being tested on the flexure rig at the University of California Santa Cruz.

While being tilted at varying angles and subjected to freezing temperatures, the team took GPI through a large set of tests and demonstrated to micrometer precision that it was able to maintain its extremely high contrast performance. As expected, GPI passed these rigorous exams, resulting in successful pre-ship acceptance tests and the OK to ship to Gemini South.

GPI was transported to Chile in August, and unpacked on August 26th at Cerro Pachón. It then went through another subset of these rigorous tests to assure that shipping the instrument several thousand kilometers didn't cause any ill effects. Next, GPI was mounted onto the telescope at the beginning of the fourth quarter of 2013. The instrument's much awaited first light for engineering and testing followed on the night of November 11-12, which revealed the instrument's amazing capabilities (see article on GPI first light also in this issue). On-sky observations are currently ongoing for technical integration with the Gemini South telescope. Commissioning and System Verification activities occupied GPI for the rest of the year.

GRACES

Work on the Gemini Remote Access to the Canada-France-Hawaii ESPaDOnS Spectrograph (GRACES) project is proceeding substantially on course. GRACES is tentatively scheduled for commissioning in 2014. A call for SV proposals will be made once commissioning on Gemini is completed.

The primary accomplishment of 2013 was the successful production of a complete 200-meter-long test fiber that met all the project requirements. The fiber is GRACES's most critical component. As the article goes to press, the vendor (FiberTech) has completed one of the two needed full-length science fibers with initial testing that appears promising. The final 270-meter-long optical fiber cable, with its two individual shielded fibers, is expected to be completed and sent to NRC-Herzberg (formerly the Herzberg Institute for Astrophysics) in January, 2014. In order to compete with other similar 8- to 10-meter class instruments, the fiber must achieve its specified high performance in term of its focal-ratio degradation (FRD), internal transmission, and spectral range coverage.

The successful 200-meter test fiber was a milestone event toward achieving the required FRD within the 270-meter-long science cable of ~10 percent (required) to ~20 percent (goal); the test cable was fabricated, polished, shielded, and had connectors attached before it was tested and delivered in July. All of the optics (*e.g.*, lenses and slicer) and commercial hardware (*e.g.*, translation stages, adjusters, and mounts) have been received, and the custom hardware parts have been fabricated, many of them in the machine shop at NRC-Herzberg.

The injector unit uses a Gemini North Multi-Object Spectrograph (GMOS-N) filter cassette, which allows GMOS-N to act as an acquisition camera for GRACES. Permanently installed in ESPaDOnS, the slicer (see Figure 6) includes a deployable fold mirror that allows ESPaDOnS to be used with the CFHT or GRACES by simply moving the fold mirror in and out of the optical path of ESPaDOnS. Critically, this swap can be done without affecting the alignment or performance of either instrument.

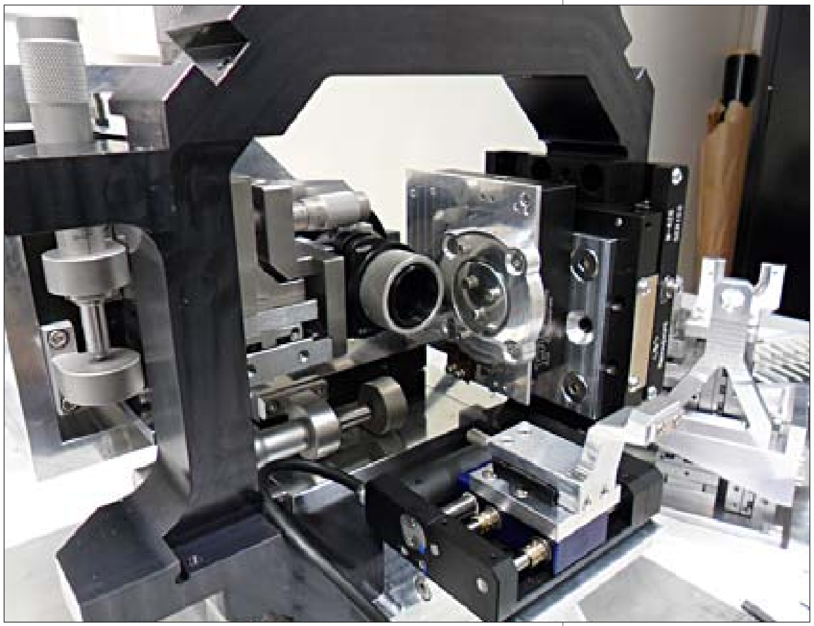


Figure 6.
The slicer bench, which will be installed inside ESPaDOnS, will receive light from the fiber and send it to the image slicer (not yet installed on the bench). The sliced image is then directed to the ESPaDOnS spectrograph.

Looking Ahead to 2014

Our plans for 2014 are to see a completely revitalized instrument suite at Gemini South with GeMS/GSAOI, GPI, and FLAMINGOS-2 in regular operations and new state-of-the-art-detectors in GMOS-S. We expect to complete the preliminary design stage of GHOS and launch a request for proposals for the next-generation, new Gemini instrument in 2014.

We plan to be testing GRACES during the second quarter of 2014 and, if successful, will work to offer high-resolution optical spectroscopy to our community with this instrument. In the lab, we will start assembly of a new focal plane array for GMOS-N, to be installed in early 2015.

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This image showing the propagation of the Gemini South laser guide star system is dedicated to the memory of Vincent Fesquet. Vincent worked tirelessly to make the Gemini South laser guide star system work efficiently and reliably. This image shows the laser propagating for the first time since Vincent's passing. Leave your memories of Vincent at: www.gemini.edu/staff/vfesquet

Special thanks to the W.M. Keck Observatory and Pete Tucker for the extra assistance necessary to make this laser propagation possible in early December 2013.

Image by Manuel Paredes. Gemini Observatory/AURA.

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