Gemini Focus

Publication of the Gemini Observatory | April 2016

GeminiFocus

1 Director's Message
Markus Kissler-Patig

3 Dusting the Universe with Supernovae
Jennifer Andrews

7 Science Highlights
Nancy A. Levenson

10 A Transition Coming to an End
Inger Jørgensen

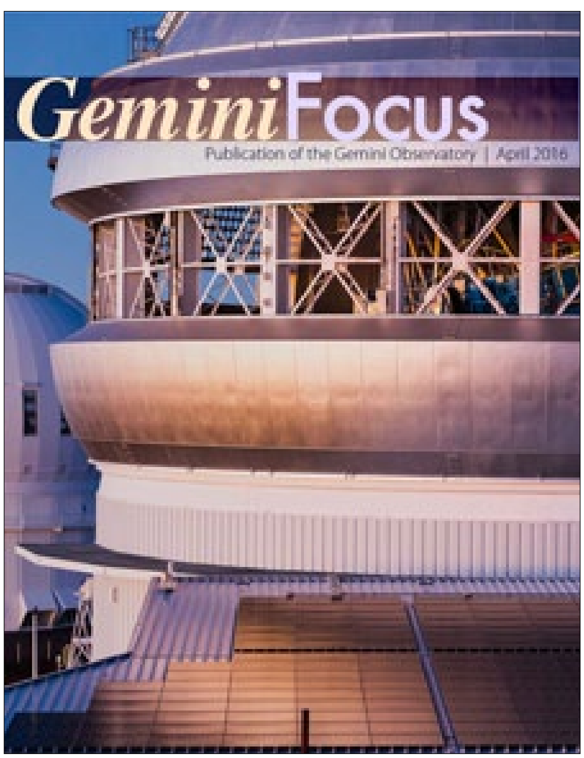
14 News for Users
Gemini staff contributions

21 On the Horizon
Gemini staff contributions

23 Journey Through the Universe: Twelve Years, and Counting!
Alexis-Ann Acohido

ON THE COVER:
Energy saving projects are a core component of Gemini's Transition Program. Here we see recently installed photovoltaic panels on the Gemini North telescope facility on Maunakea as part of that effort.

Photo credit: Joy Pollard



Gemini*Focus* April 2016

GeminiFocus is a quarterly publication of the 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

Markus Kissler-Patig

Director's Message

Gemini Observatory starts 2016 by looking into the future.

During the last three years, Gemini Observatory underwent a massive transition with an approximately 25% reduction in budget. The transition was successful, and the Observatory transformed. See the article starting on page 10 in this issue for a summary of this milestone. Now it is time to focus on the future, specifically on what Gemini will look like beyond the year 2020.

As mentioned in the last edition of *Gemini*Focus, the Gemini Board has set up a Strategic Vision Committee, whose charge can be found on Gemini's website (***view here***). In essence, the Strategic Vision identifies the Observatory's purpose, direction, and fundamental principles. It directly addresses the role the Observatory will play beyond 2021 and considers a variety of funding and partnership scenarios.

By the end of this year, the Strategic Vision will be in place. Along the way, we will seek input from the user community on how they see the way forward and what opportunities we should pursue. If you have ideas, please feel free to share them in the form of White Papers, or just e-mail them to me (*mkissler@gemini.edu*). In June we will host a formal community consultation.

Once the Gemini Board approves the Strategic Vision, the Observatory will develop a Strategic Plan. This detailed roadmap for reaching a preferred future will be aligned with, and derived from, the Strategic Vision; it must encourage new opportunities, consider budget shifts, and examine the changing landscape of astronomical facilities. Once the Board approves the Plan, the Observatory will own it.

The Observatory will have until mid-2018 to prepare this Strategic Plan. The timeline conforms to the Assessment Point (within calendar year 2018) executed by the Gemini Board, in accordance to the International Agreement governing the Gemini Observatory. At the Assessment Point, our international partners will confer about the future of the Observatory and state their intentions to remain in the Partnership.

We at Gemini already have many ideas on how the Observatory could optimally interplay with existing and future ground-based facilities in Chile and in Hawai'i, as well as support expected space missions, such as the James Webb Space Telescope. Lots of exciting opportunities lie ahead. In particular, we are looking into how Gemini North and South can optimize operations with the suite of international telescopes on Maunakea in Hawai'i and the AURA-managed facilities in Chile. We very much look forward to incorporating these ideas into our Strategic Plan.

We also received some excellent related news in February. The National Science Foundation (NSF) has selected the Association of Universities for Research in Astronomy (AURA), Inc., to continue managing and operating the Gemini Observatory. This new six-year, $208 million cooperative agreement will provide the necessary stability for the Observatory to develop a promising plan for the next decade.

So, please join us this year in defining our future by sending us your best ideas for Gemini in 2020 and beyond!

Now, Back to the Present

Meanwhile, we will continue striving to be the best observatory in the world for the execution of flexible, innovative, and efficient science programs. In 2016A, we are offering three Visitor Instruments in addition to our suite of facility instruments.

One of these, the Differential Speckle Survey Instrument (DSSI), provides simultaneous diffraction-limited optical images as faint as V ~ 16-17 in two channels over an ~ 2.8 - 5.6 arcsecond field-of-view. This is the first time for DSSI at Gemini South, and we are grateful to the DSSI team for regularly returning to Gemini and offering this fabulous instrument to the community. DSSI is being offered during the second half of June 2016.

Gemini also welcomes a "newcomer," PHOENIX, a high spectral resolution (R ~ 50,000 - 80,000) near-infrared (1-5 micron) echelle spectrometer. PHOENIX rose from its ashes; as veteran Gemini users will remember, the instrument was offered years ago, including in 2003, when it sampled multiple stellar atmospheres and revealed clues about the origin of fluorine; it is now back as a Visitor Instrument at Gemini South and is scheduled for mid-May 2016.

We are also extremely thankful to the Canada-France-Hawai'i Telescope for once again kindly offering Gemini remote access to its ESPaDOnS Spectrograph (GRACES). This fiber feed to the high-resolution spectrograph was in very high demand last semester at Gemini North. We will continue to offer it to the community (as a Visitor Instrument) at least until the Gemini High-resolution Optical SpecTrograph (GHOST) arrives. GHOST, our next facility instrument, concluded the second half of its Critical Design Review in March. It is now marching forward and is expected to arrive at Gemini South in late 2017 or early 2018.

Finally, in early March, Hawaii's Governor David Ige proclaimed "Journey Week" to celebrate the 12th year of Gemini North's flagship public outreach program: Journey Through the Universe. An immense success, this year's program was extended to more schools then ever before, and the program reached well over 7,000 Hawai'i students during the week-long event. See the article and pictorial starting on page 23 of this issue.

We are very proud that Gemini continues to create new knowledge and share it with the world. Join us as we continue "Exploring the Universe, Sharing its wonders"!

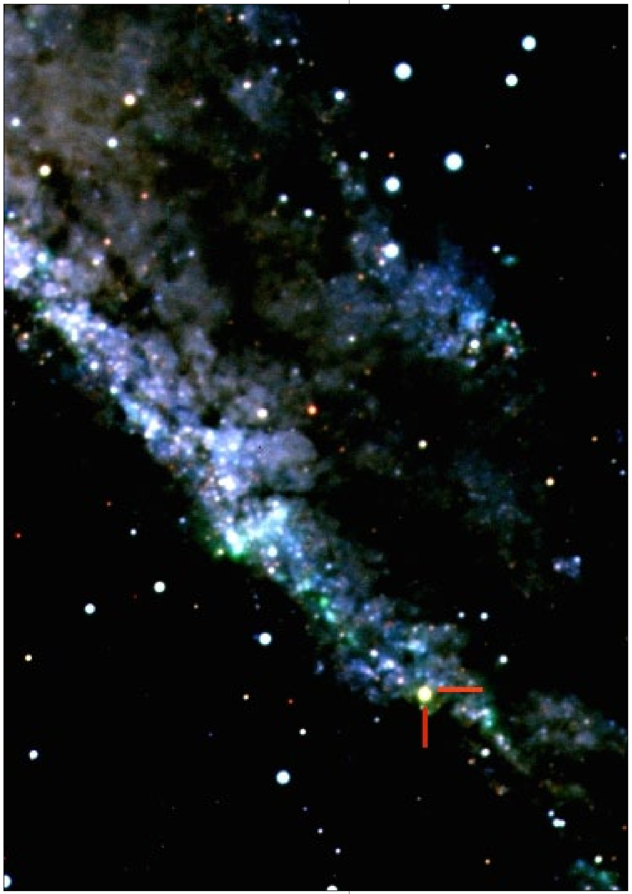
Markus Kissler-Patig is Gemini's Director. He can be reached at: mkissler@gemini.edu

Jennifer Andrews

Dusting the Universe with Supernovae

Long-term observations made with the Gemini Multi-Object Spectrograph at Gemini South, combined with Spitzer space telescope data, reveal how core collapse supernovae can make an important, yet largely unrecognized, contribution to the overall dust budget of the Universe.

Figure 1.
GMOS-S g′, r′, and i′ color composite image of SN 2011ja from April 2012 (day 112). In the original image, the supernova looks red due to a combination of bright hydrogen (Hα) emission, strong extinction around the object, and new dust formation.



Stars more than eight times the mass of our Sun end their lives in fantastic explosions we call core collapse supernovae (CCSNe). Most common are Type II-Plateau (Type II-P) events, which show broad hydrogen emission lines in their spectra along with a near constant plateau of optical luminosity throughout the first ~100 days.

It has long been known that heavy elements and dust grains can be formed in the leftover material ejected in a CCSN explosion. However, only recently have we recognized the importance of this contribution to the overall dust budget in the Universe.

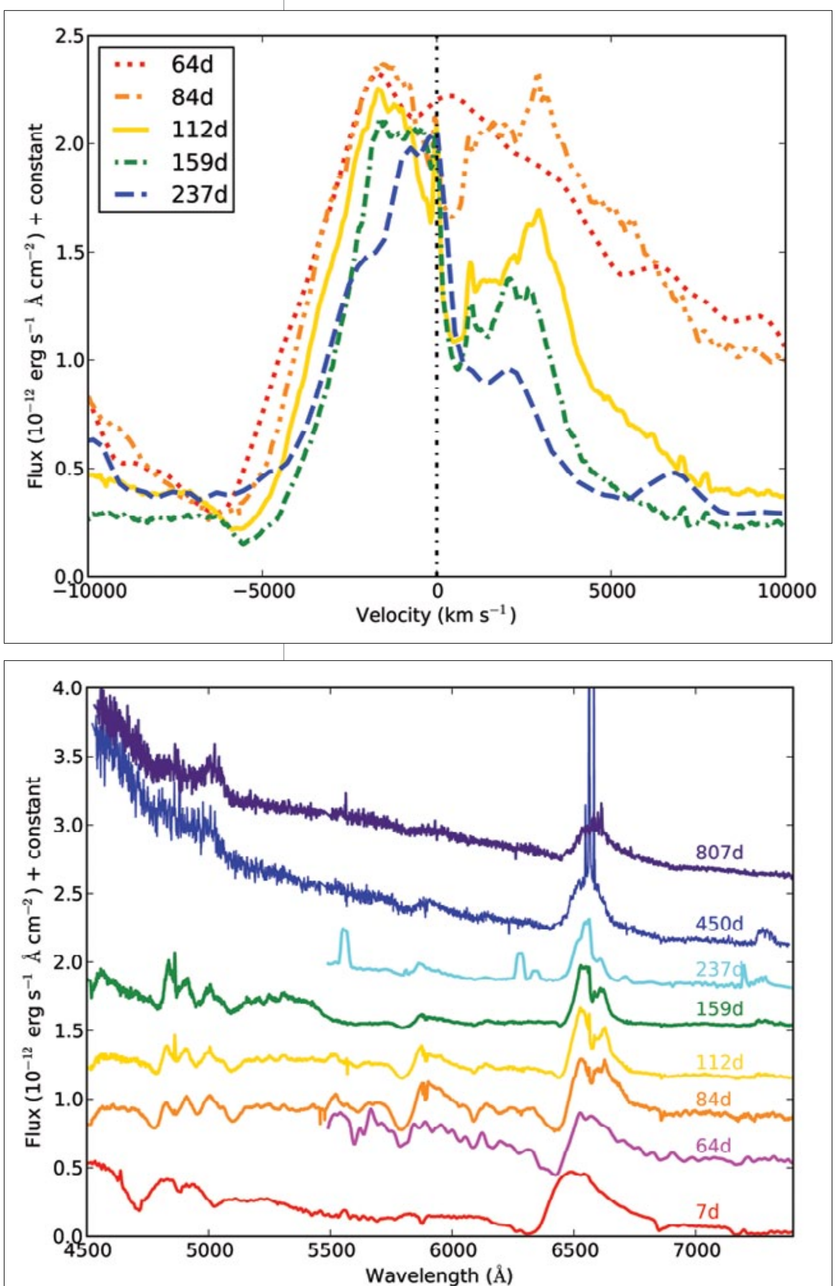
Generally we thought that asymptotic giant branch stars were the main contributors of dust in galaxies; these low- to intermediate-mass stars form dust grains in their stellar winds over millennia and deposit them into the interstellar medium (ISM). But this does not explain how high-redshift galaxies ($z > 6$) can have more dust than their young ages should allow. Thus we began to revisit the role that CCSNe play in dust production, especially their ability to quickly return gas and dust to the ISM.

Extending the Search with GMOS

Over the past decade, our team has been using ground- and space-based optical and IR imaging and spectroscopy to look for signatures of dust formation in young CCSNe. In particular the size and sensitivity of GMOS has allowed us to follow a collection of objects for years after explosion in a search for the three telltale signs of grain condensation.

Figure 2.

(Top): Ha evolution of SN 2011ja during the first 8 months. The degredation of the red peak at ~2,500 km/s is a sign of dust formation. (Bottom): Full spectroscopic evolution of SN 2011ja over the first two years.



First, as dust forms, the optical luminosity will decrease while almost simultaneously the near-infrared (NIR) will increase, as the dust grains absorb the shorter wavelength light and re-emit it in the IR. Grain formation will also alter the optical spectrum, creating asymmetric and blue-shifted lines as the dust grains attenuate the red (receding) side of the ejecta preferentially.

And while we initially believed that the dust grains could only condense 300-600 days after explosion (when the ejecta had expanded and cooled) there have been more and more confirmed cases of dust forming much earlier, within 100 days of explosion.

An early onset of dust formation can occur when shocks interact with nearby circumstellar material (CSM), creating an area known as the cool dense shell (CDS) with temperatures and densities appropriate for grain growth. This not only allows a separate channel for dust formation in CCSNe, but can also reveal important properties of SN evolution and progenitor mass loss.

In February 2012, we also began using GMOS in an extensive observing campaign on SN 2011ja in NGC 4945 (Figure 1). This "normal" Type II-P SN, located ~ 11 million light years away, has an absolute I-band magnitude of ~ -18.3. Our goal was to follow SN 2011ja from near peak to well past 600 days. This allowed us to look for both channels of dust formation, and to quantify the mass and composition of any forming dust.

The Evolution of SN 2011ja

Using the new B600 grating and 0.75 arcsecond slit, we obtained GMOS-South medium-resolution spectra of SN 2011ja — 84, 112, 159, 450, and 807 days after explosion (Figure 2). We also obtained g′, r′, and i′ imaging at the same time (Figure 1). Both datasets are supplemented by European Southern Observatory optical and NIR photometry (Figure 3), as well as optical spectra.

We immediately noticed the strange multi-peaked shape of the hydrogen lines (Figure 2, top) that appeared as the SN was transitioning out of the plateau phase. Most interestingly, the strength of the blue peak of Hα increases relative to the red, and the line peaks themselves begin to flatten over time.

Multipeaked emission lines are mostly attributed to a toroidal or disk geometry of surrounding CSM material, while the flattening is caused by the ejecta interacting with the CSM. From the optical spectra alone, we can therefore infer that the SN is running into asymmetric mass-loss from the SN progenitor. Chandra X-ray observations provide further support as the SN's early X-ray emission only increased over the first 100 days.

The degrading of the red peak with time was our first clue that dust was forming early on, as the grains were obscuring the receding side of the ejecta more than the approaching side. While this in itself may have been enough to determine dust was forming within a few months of explosion in SN 2011ja, the IR and optical light curves also added credence: there is a 0.4 magnitude brightening in the K-band between day 121 and 243, and a simultaneous drop of ~0.5 magnitude in the optical brightness as can be seen in Figure 3.

All observational signs pointed to dust formation occurring sometime around day 100. Together with the spectral signatures of CSM interaction, this would seem to indicate that the dust is in the CDS, formed between the forward and reverse shocks created as the ejecta plows into the pre-exisitng gas and dust lost by the progenitor before the end of its life.

Modeling the Dust

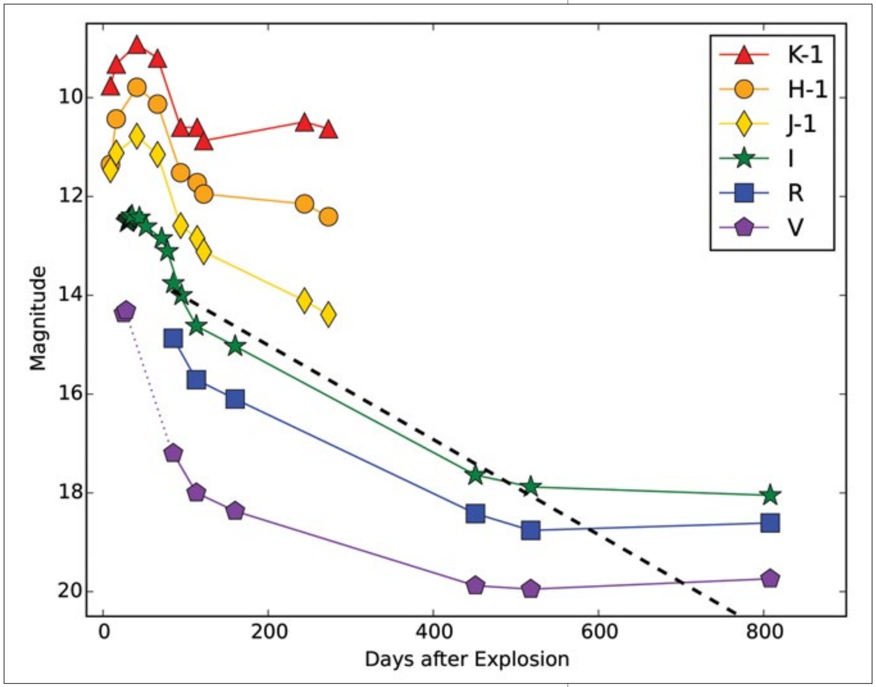
Now that we had observational evidence of dust grains forming in SN 2011ja, we could turn our attention to modeling the dust: how much, what kind, and where was it located.

Using our 3D Monte Carlo radiative transfer code MOCASSIN and our optical and IR observations, we modeled various geometries and compositions of dust, including a spherical shell of smooth and clumped dust, as well as a smooth distribution of dust in a torus of increasing inclinations around the system. We limited our dust composition to carbon grains only, since 10.8 micron Very Large Telescope observations did not detect strong silicon emission.

The modeling of four GMOS and Spitzer Infrared Array Camera epochs revealed about 1×10^{-5} solar masses of pre-existing dust located about 3,500 AU away from the center of the SN, and up to 6×10^{-4} solar masses of newly formed dust in a torus inclined roughly 45° from edge on and closely surrounding the SN.

This dust mass is still much less than that observed from SN 1987A and other SN remnants. By continuing to follow SN 2011ja as it expands and cools, we will likely see more and more dust being formed, albeit at a much lower temperature.

Figure 3.
Optical and NIR light curves of SN 2011ja. The NIR curves have been shifted down a magnitude for clarity, and the dashed line indicates ^{56}Co decay.



Signs of a Massive Progenitor

While we had found evidence for early dust formation within the first 100 days, we needed to continue observing the object as long as possible to search for additional grain formation in the ejecta. After 400 days or so, we noticed little change in its optical luminosity (Figure 3). Normally we would expect to see a fading of about 1 magnitude every 100 days due to the radioactive decay of ^{56}Co which powers the late-time lightcurves of SNe.

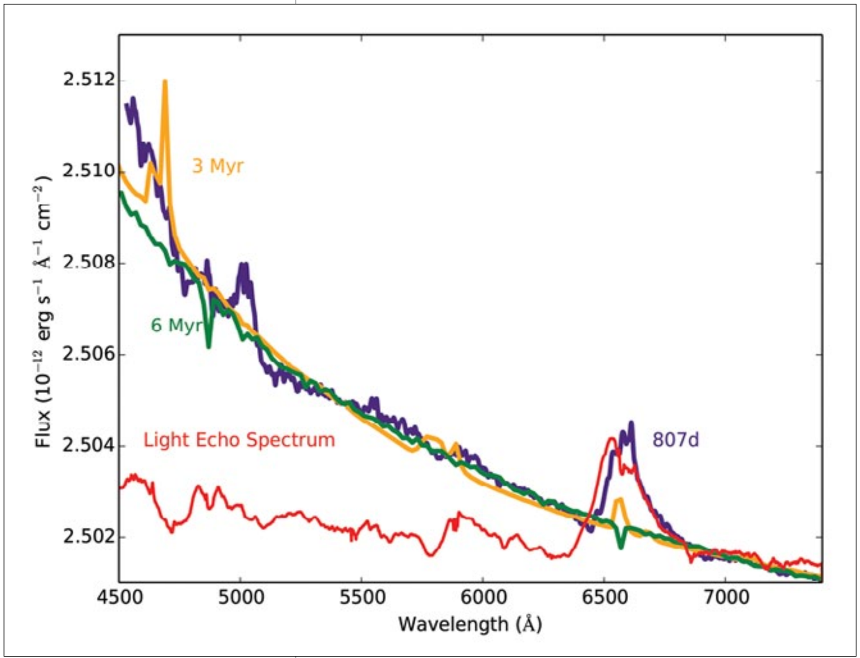
Light echoes scattering off dust clouds between us and the SN, or radiative shocks plowing into nearby CSM, may have caused this late-time brightness. But most likely in this case the SN continuum had faded below the brightness of the parent star cluster from which the massive progenitor star was born. This scenario would allow both the strong broad Hα emission line, and a bright blue continuum.

Comparing the day 807 spectra with Starburst99 stellar synthesis models of young massive star clusters (Figure 4) indicates that the late-time luminosity most likely has a large component of the parental stellar cluster, which is between 3-6 million years (Myr) young, corresponding to a SN progenitor mass of 20-30 Suns.

The absolute magnitude at maximum (I = ~ -18.3) in tandem with the short plateau duration and the steep drop into the radioactive decay phase of the optical light curve, all point to a CCSN with a small hydrogen envelope.

Combined with the estimated age of the parent cluster, this would suggest SN 2011ja likely went through a strong mass-loss phase not long before eruption.

Figure 4. *Day 807 spectrum (purple) of SN 2011ja showing enhanced blue emission. Comparison with the light echo spectrum created from an integrated fluency of the first 84 days (red) indicates that a light echo cannot be responsible for the flux bluewards of 6,000 Å. The orange and yellow spectra are synthesized stellar populations created with Starburst99 for 3 and 6 Myr. It is possible that the late-time luminosity has a large component of the parental stellar cluster.*



The Future

Our group is continuing to study CCSNe at late times to look for increased dust formation. Specifically we are monitoring the dust as the ejecta cools and expands, to determine how the progenitor mass of the SN correlates with dust mass. We currently have a project underway using GMOS to look at SNe with ages between 4-60 years in order to model their Hα emission.

Tests done on SN 1987A have shown that the shape and strength of the broad Hα line can be correlated to dust mass. This will be amazingly useful, especially in the era before James Webb Space Telescope, since data suggest the peak dust production may occur in the cooler dust regimes only accessible by long-wavelength instruments.

Jennifer Andrews is a postdoctoral researcher at the University of Arizona. She can be reached at: jandrews@as.arizona.edu

Nancy A. Levenson

Science Highlights

The following summaries highlight several recent papers based on Gemini data. Included is the detection of a possible (proto)planet around a nearby star, a new limit on the binary nature of cool Y dwarfs, the downsizing of a once extreme black hole, and the detection of an ultraviolet wind expelled by a quasar at nearly 20% the speed of light.

Traces of Planet Formation in a Stellar Disk

Planets form in the disks around young stars, and the relatively nearby TW Hydrae is an excellent candidate in which to observe this process. In polarimetric observations with the Gemini Planet Imager (GPI) on the Gemini South telescope, Valerie Rapson (Rochester Institute of Technology, New York) and collaborators probe the disk of TW Hya — from about 80 astronomical units (AU) to within 10 AU of the central star — at a resolution of about 1.5 AU and detect structure. The observations show a gap located around 23 AU that is about 5 AU wide, suggesting the presence of a forming planet (Figure 1).

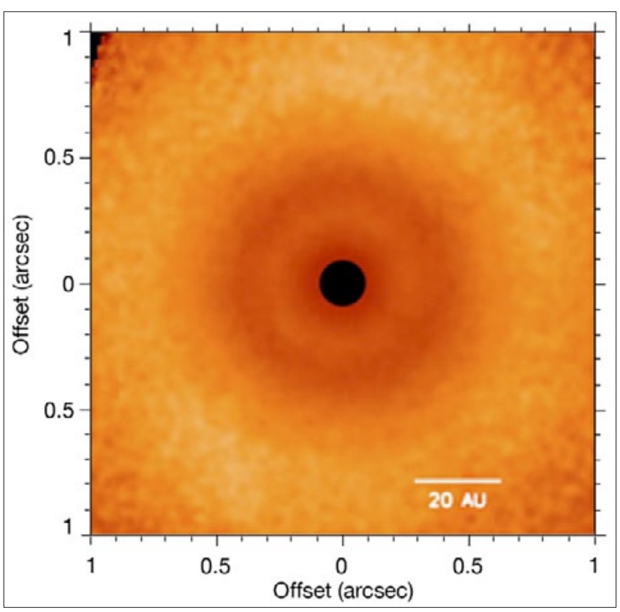


Figure 1.
Radially scaled polarized intensity in the J-band shows the variation of dust density distribution in the disk of TW Hydrae. The coronagraph blocks light in the central region. Comparison with simulations suggests that the gap around 23 AU could be cleared by a planet of mass about 0.2 $M_{Jupiter}$.

The researchers deduce the properties of the possible (proto)planet comparing with simulations. They find good agreement with a planet of mass 0.16 $M_{Jupiter}$ located at 21 AU from the star, about the distance of Uranus from the Sun. Details of the differences between the model and observations suggest that more complex distributions of dust in the disk (radially and vertically) may be relevant. The authors acknowledge other processes that can create gaps and rings, such as grain fragmentation and ice condensation fronts. A definitive test would be to observe the planet directly. It would need to be actively accreting material to be bright enough to detect easily in future GPI observations. The Gemini **website** has some more information, and complete results are published in *The Astrophysical Journal Letters*.

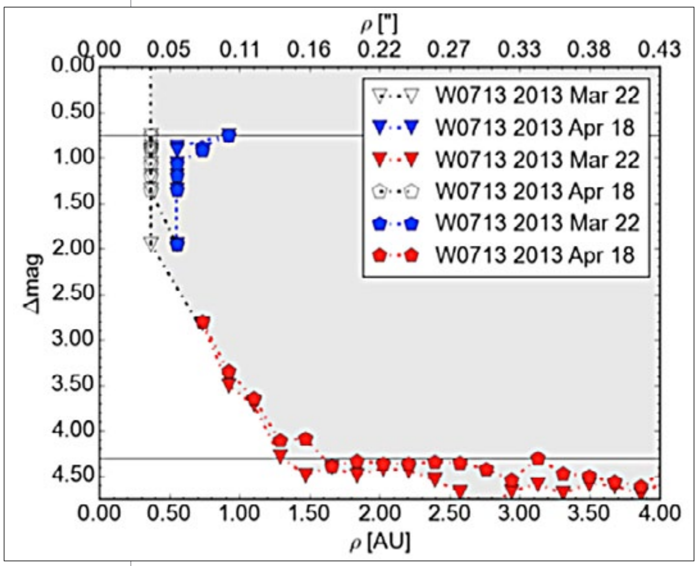


Figure 2.
Limits on separation and magnitude for a binary companion to one of the Y dwarfs Opitz and colleagues observed using GeMS/GSAOI. An equal-brightness companion is ruled out to within about 0.5 AU (0.04 arcsecond), and fainter companions are ruled out at somewhat larger radii.

Seeking Companions of the Coolest Brown Dwarfs

Examples of the coolest and least massive brown dwarfs, Y dwarfs, were first identified in 2011. Having temperatures just above those of the gas giant planets (around 250 K), they help bridge the gap from stellar objects to planets. The binary nature of any of these objects is linked to their formation process. Previous observations indicate that the frequency of multiplicity declines from around 65% (for solar-type stars) to 10–30% (for the slightly warmer and more massive L and T dwarfs). Does this trend continue to the Y dwarfs, or does it indicate only our observational limits? Also, some Y dwarfs show a spread of luminosity or otherwise seem overluminous. Are undetected companions the explanation?

Daniela Opitz (University of New South Wales, Australia) and colleagues used the fine spatial resolution of the Gemini Multi-conjugate adaptive optics System (GeMS) and the Gemini South Adaptive Optics Imager (GSAOI) to begin to answer these questions, examining a small sample of five Y dwarfs. The delivered Full-Width at Half-Maximum was ~0.1arcsecond and the limiting angular separation was around 0.04 arcsecond. Although the observations were sufficiently sensitive to detect companions of roughly equal mass at separations of 0.5–1.9 astronomical units (AU), they did not find any evidence for binaries. Figure 2 shows the limits on separation and brightness for a binary companion to one of the Y dwarfs studied.

At least one of the sources had previously been identified as "overluminous." The presence of clouds in the atmosphere, rather than a companion, may account for the excess luminosity. The few cases observed here are a good start, not a definitive determination of the general trends. They do point to the extreme scenarios (separations less than 1 AU and extremely faint sources) that may arise in cases of Y dwarf binaries. This work is featured on the Gemini **website**, and complete results appear in *The Astrophysical Journal*.

A Supermassive Black Hole That Wasn't So Massive

One sign of an extreme supermassive black hole at a galaxy's core is a light deficit — the consequence of stars ejected from the central region. The brightest cluster galaxy of Abell 85 had been identified as such an example, claimed to host one of the most massive black holes ever detected in the Universe at around 10^{11} M_{Sun}.

Juan Madrid, then a Science Fellow at Gemini South, along with Carlos Donzelli (Observatorio Astronómico de Córdoba, Argentina), used images obtained with the Gemini Multi-Object Spectrograph (GMOS) on Gemini South (Figure 3) to probe the galaxy's center and demonstrate that the black hole's mass is not so extreme. Rather than a deficit, data from their Director's Discretionary Time program show the strong nuclear emission in the cen-

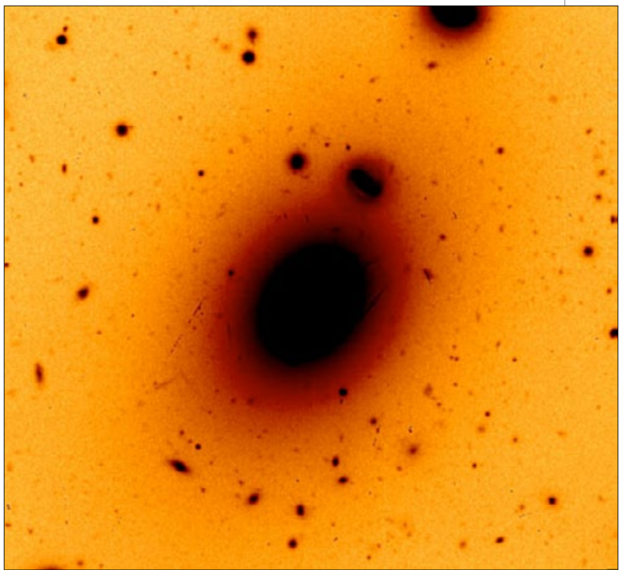


Figure 3.
GMOS-South image of the center of the Abell 85 galaxy cluster, which shows that the brightest cluster galaxy at the center does not contain the most massive known black hole in the Universe, contrary to previous estimates.

tral kiloparsec as a light excess that may be due to a nuclear stellar disk. The observations were very short, only seven minutes. The key to the measurement was the spatial resolution to probe the innermost arcsecond. More information about this work is posted at the Gemini ***website***, and full results are published in *The Astrophysical Journal*.

The Fastest Quasar Ultraviolet Wind

Quasar winds may be fundamental to the growth of black holes and the evolution of galaxies, being an intimate part of the feedback mechanism that regulates black holes and stellar growth over cosmic time. Jesse Rogerson (York University, Canada) and collaborators have discovered an extreme example, the fastest ultraviolet wind, whose velocity approaches 20% of the speed of light.

The researchers originally used the Sloan Digital Sky Survey to find quasars that show new broad absorption line troughs. Further observations using the Gemini Multi-Object Spectrograph (GMOS) at both Gemini North and Gemini South show spectral changes over time in this case. At a redshift of $z = 2.47$, the galaxy's rest frame ultraviolet emission appears at optical wavelengths, and broad CIV absorption is the key feature the team traced.

This exceptional example, called SDSS J023011.28 + 005913.6 or J0230 for short, is also interesting in showing a second strong component, with an outflow velocity around 40,000 kilometers per second. The multiple observations of the quasar at various times show variability (on timescales as short as 10 days in the quasar rest frame; Figure 4) and enable the team to rule out some simple models of bulk motion. Instead, they show that some more complex geometric configurations are consistent with the observations — namely a "crossing disk" model (of a circular cloud that crosses a circular emitting region) and "flow tube" (where a spatially extended absorbing region passes in front of the emitting region) for the faster and slower outflows, respectively.

Continued study of the larger sample of about 100 candidates may reveal more systematic characteristics of the broad absorption features and their origin. This work is featured on the Gemini ***website***, and full results are published in *Monthly Notices of the Royal Astronomical Society* (***viewable here***).

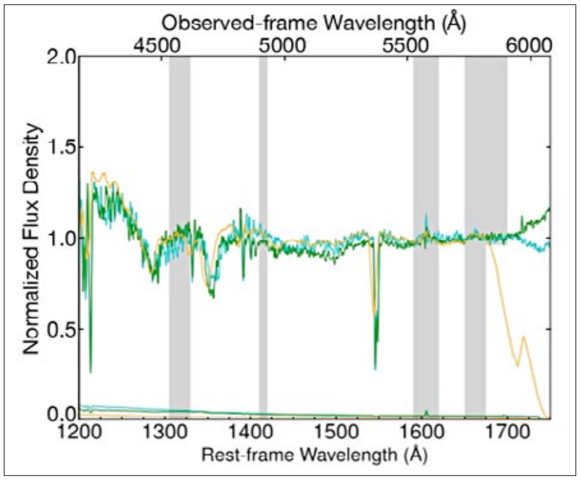
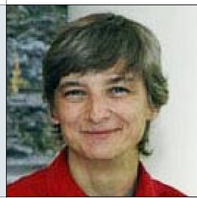


Figure 4.
Three GMOS (North and South) spectra obtained at different times of the z = 2.47 quasar J0230 show the variability of the absorption features, especially the CIV near rest-frame wavelength 1550 Å. The spectra have been normalized based on measurements in the shaded regions.

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



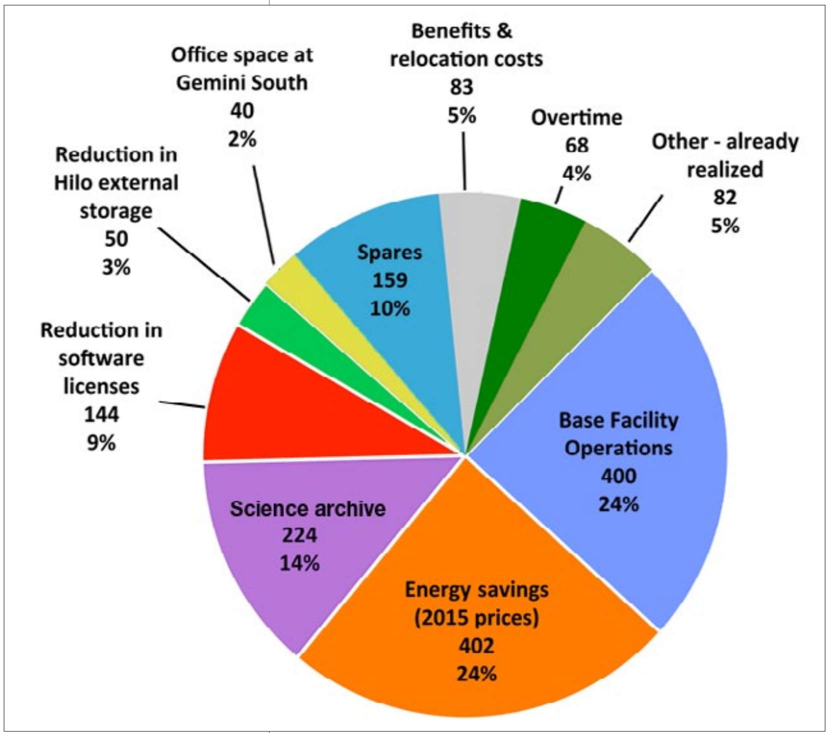
Inger Jørgensen

A Transition Coming to an End

Gemini's Transition Program 2011-2015.

In 2010 the United Kingdom announced its intention to leave the Gemini Partnership. This prompted the Observatory to plan for a roughly 25% reduction in its annual operations budget, which translates to about $6.5 million in 2012 dollars. To handle this situation, we developed a plan that touched all areas of the Observatory, including nighttime science operations, energy consumption, maintenance schedules for printers, and just about everything in between. Thanks to the Observatory's available cash reserves, we could stretch the implementation through 2015.

Figure 1.
Savings from the Transition Program projects. Amounts are in thousands of dollars.



The plan, called the Transition Program, consisted of three general areas of focus: staff reductions, general reductions, and the implementation of specific projects. Staff reductions contributed about $3.5 million to the required savings. General reductions in non-labor expenses — enabled by tight tracking of budgets, reduction in travel expenses, lower computer prices, *etc.* — saved about $1.5 million. And the implementation of about 25 projects (aimed at reducing non-labor costs or enabling operations with a smaller staff) also secured about $1.5 million, of which about $400,000 are still to be realized in 2016. Figure 1 gives an overview of these savings.

Some of the changes resulting from the Transition Program are visible to our users while many are only visible internally. As of this writing, the Observatory has implemented the majority of the Transition Program. Ongoing developments continue in 2016 on projects that enable additional energy savings, reduce expenses (such as restructuring lab space at Gemini South for use as office space), and support for the transition to Base Facility Operations at Gemini South.

Changes that Affect Our Users

Users are most directly affected by changes within Science Operations. Table 1 summarizes these changes as well as those within Engineering Operations, which indirectly impact our users.

Table 1. *Changes affecting our users.*

Change	Description
Reduced (and changed) data quality assessment	*In early 2013 we changed the quality assessment on queue data to be done primarily at night by the observer. Only Band 1 data receive additional checks during the day. In addition, we have implemented an automatic data quality assessment pipeline, which covers all imaging and acquisition observations. Users are encouraged to review their data promptly and contact us in case of issues. The fraction of observations that have to be repeated has not increased due to these changes.*
Non-research queue observers	*We have gradually phased in non-research staff members as queue observers. The goal is for non-research staff to perform 75% of the queue observing. This has been the case at Gemini North for several semesters and we expect that Gemini South will reach a similar level within 1-2 semesters, as training is completed.*
Base Facility Operations	*We have moved nighttime operations to the Gemini North Base Facility. The same will take place at Gemini South in 2016. Visiting observers are (positively) affected by this change, which also saves a total of about $400,000 annually in lodging, meals, and transportation costs.*
Archive	*We have implemented an archive that serves all science (and engineering) data from the Amazon Web Services. The archive went through extensive reviews by the Users Committee, staff from the National Gemini Offices, and repeat users of Gemini. Full implementation was in place by December 2015, and the move saves us more than $200,000 annually. The archive is available here: https://archive.gemini.edu*
Priority Visitors	*Principal Investigators of Large and Long programs and selected Band 1 programs can now visit Gemini as Priority Visitors. They can take their own data (if conditions allow) or execute queue observations. This arrangement improves our contact with users, while saving a small amount of staff effort.*
Four facility instruments + adaptive optics at each site	*The two Gemini telescopes will each operate with a maximum of four facility instruments and a facility adaptive optics system. This ensures that we (with the reduced staff) have sufficient effort to support these instruments.*
Reductions in engineering staff	*A reduction in engineering staff, coupled with the above-mentioned limitation on facility instruments, means that we will not be able to support future major instrument rework or instrument building (such as on FLAMINGOS-2 and Canopus). Thus, any instruments procured in the future will have to meet requirements prior to arriving at Gemini. The reduced engineering staff may also mean that major technical faults have a longer response time.*

Behind the Scenes

Our users will not see many of the essential Transition Program changes required for realizing savings on the non-labor budget, as well as those enabling us to operate with a reduced staff. Table 2 presents a brief overview of the most important of these changes. Figure 1 shows the non-labor savings from some of them.

Table 2. *Changes "behind the scenes."*

Change	Description
Software supporting queue operations	*We have developed software that decreases the effort needed to operate the queue. The software covers queue filling during the Time Allocation Committee process, queue planning through visualization tools, and handling of the military's requirement for clearances during laser operations.*
Software leading to lower maintenance effort	*The Observatory Control System software has been upgraded and improved, primarily to lower the maintenance effort. However, improvements in both the Phase I Tool and the Observing Tool have greatly benefited our users.*
Energy	*Energy saving projects are a core component of the Transition Program. We have installed photovoltaic panels at the telescope on Maunakea (Figure 2); in 2016 we plan to do the same at the Base Facility in Hilo and on Cerro Pachón. We are also applying the recommendations from an energy audit of the Gemini North facilities, which include replacing the chillers at the summit, refurbishing the air conditioners at the base, and replacing all lighting with LEDs. All computer rooms have been separated into hot/cold zones. The total annual savings on our electricity costs are $400,000, while we reduce by about 30% our reliance on utility-provided power (most of which is produced using fossil fuels).*
Base Facility space usage	*We have reduced the need for external storage at Gemini North, while at Gemini South lab space will be converted to office space; these changes will remove the need for renting additional buildings for offices.*
Spares	*After reviewing our spares inventory and purchases and making better risk assessments, we have significantly reduced the funds used annually to restock spares.*
Overtime	*We reduced overtime payments to hourly paid staff, primarily by eliminating weekend checks at Gemini South and limiting overtime usage during telescope shutdowns.*
Software licenses	*Sizable savings were realized by switching either to software with lower license costs or to free software.*
Administrative services	*Purchasing, contracts, and human resources administration are centrally handled by AURA, either in Tucson or by personnel in La Serena.*
Transportation	*We have eliminated several vehicles at both sites, and restructured the use of common transportation at Gemini South.*

The End Result

With the Gemini Transition Program changes largely executed, the Observatory is now in a healthy state to move forward in a more streamlined, efficient, cost-effective, and energy-conscious way. The Observatory is thankful for the universal cooperation it received during this difficult period. Gemini is now better positioned to focus on the needs of its global Partnership, the future of its scientific programming, and the suite of leading-edge instruments that will take us to the forefront of research while remaining fiscally responsible.

Inger Jørgensen is Gemini's Deputy Associate Director of Operations. She can be reached at: inger@gemini.edu

Figure 2.
Recently installed photovoltaic panels on the Gemini North telescope facility on Maunakea are some of the energy saving initiatives that are part of the Transition Program. Since installation, the panels have provided approximately 10% of the energy needed at the Gemini North telescope.
Photo credit: Joy Pollard

Contributions by Gemini staff

News for Users

With the start of Semester 2016A, we are recovering from a difficult 2015B at Gemini South. We put that bad semester in context here by describing the way the queue responds to difficult weather and instrumentation circumstances. Also in the south, reductions in GPI's vibrational signature have resulted in a much better raw wavefront and a better vibrational environment for the other instruments. We have also begun the process of replacing the GeMS laser. Elsewhere, the new Gemini Observatory Archive is off to a good start, and we give some early usage statistics. Finally, we look back at Australia's key contributions during its Partnership with Gemini, which ended in December 2015.

How the Queue Responds to Adversity

All observatories attempt to complete science programs against a variety of competing factors: weather, equipment failures, earthquakes, *etc.* Queue scheduling attempts to preferentially complete programs blessed with the highest science ranking by the Time Allocation Committees (TACs), whatever the competing factors put in the way.

Weather losses, commissionings, earthquakes, and other events in recent years have given us quite a roller-coaster ride, and it's interesting to see how queue scheduling (recently the largest part of the Gemini science program) has responded to these challenges. Here we look at an exceptional semester (one with good conditions and more science time than originally planned) and a bad semester (affected by weather and technical problems) and summarize the results.

Recent Challenges

Figure 1 shows the average program completion rate of Bands 1-3 over the past five years. Many factors are at play in these plots, but we can single out examples of exceptionally good and exceptionally bad semesters.

For instance, Semester 2012A at Gemini South was particularly good, because more science time became available when the Observatory cancelled planned commissioning work. The most recent semesters at Gemini South have been challenging, especially 2015B, which we discuss later). Semester 2014A at Gemini North was unusually poor, as bad weather and dome shutter failures hit us hard; but we recovered and are now back at roughly average performance compared to the last five years.

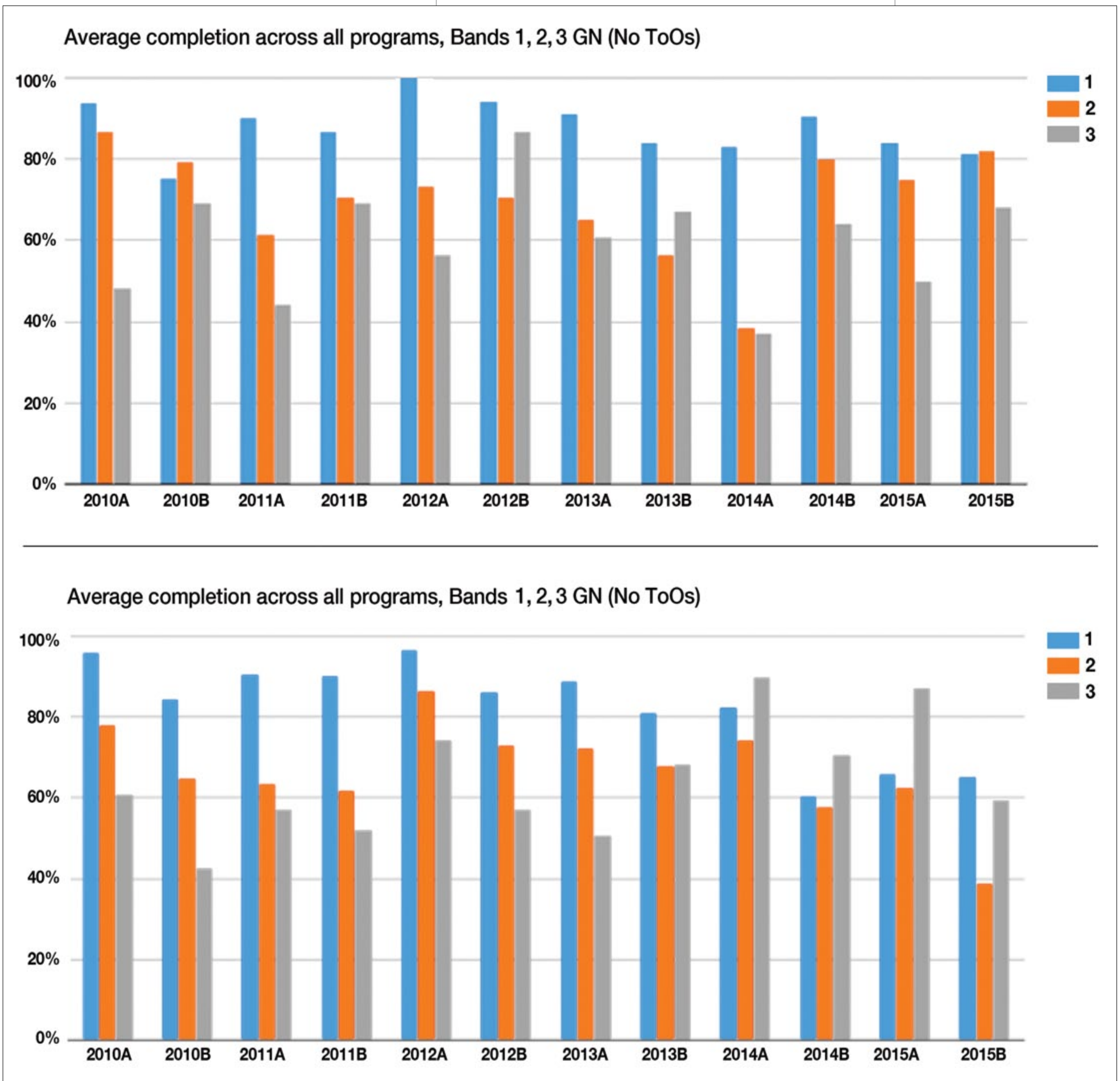


Figure 1. *Average program completion across Bands 1, 2, and 3 (blue, orange, and grey, respectively), for all semesters since 2010A. Top: Gemini North. Bottom: Gemini South.*

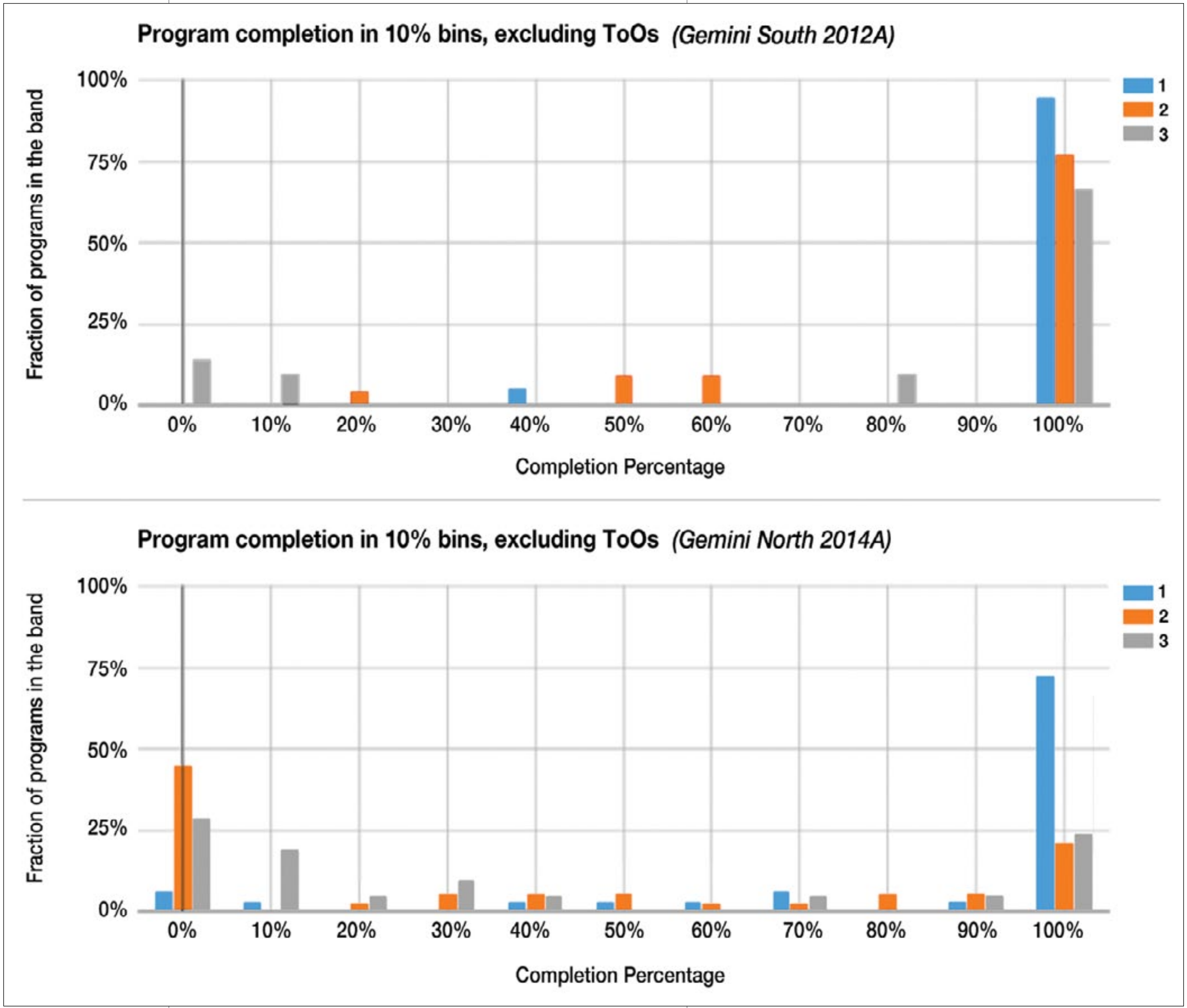


Figure 2.
In 10% bins, the fraction of programs ending the semester at a given completeness level. Top: an unusually good semester (Gemini South 2012A). Bottom: an unusually bad semester (Gemini North 2014A).

The two charts in Figure 2 show histograms of queue program completion at Gemini South 2012A and Gemini North 2014A.

The very sparse tail of programs below the 100%-complete bin in the "exceptional" semester compares with large numbers of programs ending at 90% and below in the "bad" semester. Numerous programs were not started at all in 2014A at Gemini North.

Note that the queue preferentially protects Band 1 observations in a "bad" semester, as it should. In the "exceptional" semester at Gemini South the Band 1 completion exceeded that of Band 2, which in turn exceeded that of Band 3. In a "normal" semester (neither exceptional nor terrible) results lie somewhere between these extremes, with Band 1 completion higher than that in the other two bands.

While Band 2 completion usually exceeds that in Band 3 during a "normal" semester, it is a signature of bad weather that in some semesters Band 3, in which programs can typically take poorer conditions, does better. As you can see in Figure 1, in recent semesters, Band 3 has done well relative to the others at Gemini South; again, this is a symptom of weather adversity.

Addressing Weather Loss at Gemini South

Weather conditions at Gemini South repeat themselves fairly regularly across each semester. In the past we didn't make any allowance for that. Recently, we've made a change to the way we fill the queue for Gemini South. Figure 3 shows a repetitive five-year pattern of weather losses at Gemini South; because we filled the queue each month as if the weather loss was uniform (and it wasn't), we forced ourselves to battle the elements at the worst times of the year. In the 2016A TAC process, we adjusted the way we fill the queue: we no longer overload May-September, and allow more programs into the southern summer months. We'll see how it goes now that we're into the semester itself.

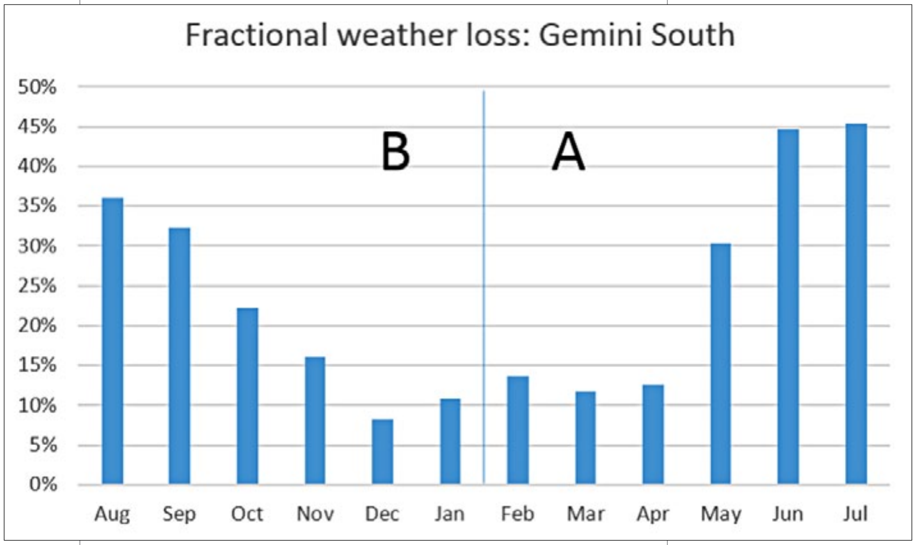


Figure 3.
Percentage of time lost to weather at Gemini South. This pattern is quite reproducible from year to year. We now take better account of it in the time allocation process; we no longer overload the mid-year months (May-September), and allow more programs into the southern summer time.

2015B: Major Challenges at Gemini South

As mentioned, Gemini South has had some challenging semesters of late. Semester 2015B, for instance, had plenty of adversity to go around: the Gemini Multi-conjugate adaptive optics System (GeMS) out of action due to a major earthquake that struck in September 2015; the Gemini Planet Imager (GPI) still ramping up; and many programs either lost completely to weather, or executed under marginal conditions. Based on the discussion above, we would therefore expect a significant hit on programs in all Bands, with Band 3 (able to take the worst conditions, and therefore not containing any GPI or GeMS programs) performing reasonably well. That's borne out by the results shown in Figure 4: a significant number of GPI programs were not attempted at all, hardly any GeMS programs started, and many programs ended up in the "tail" of completions below 100%.

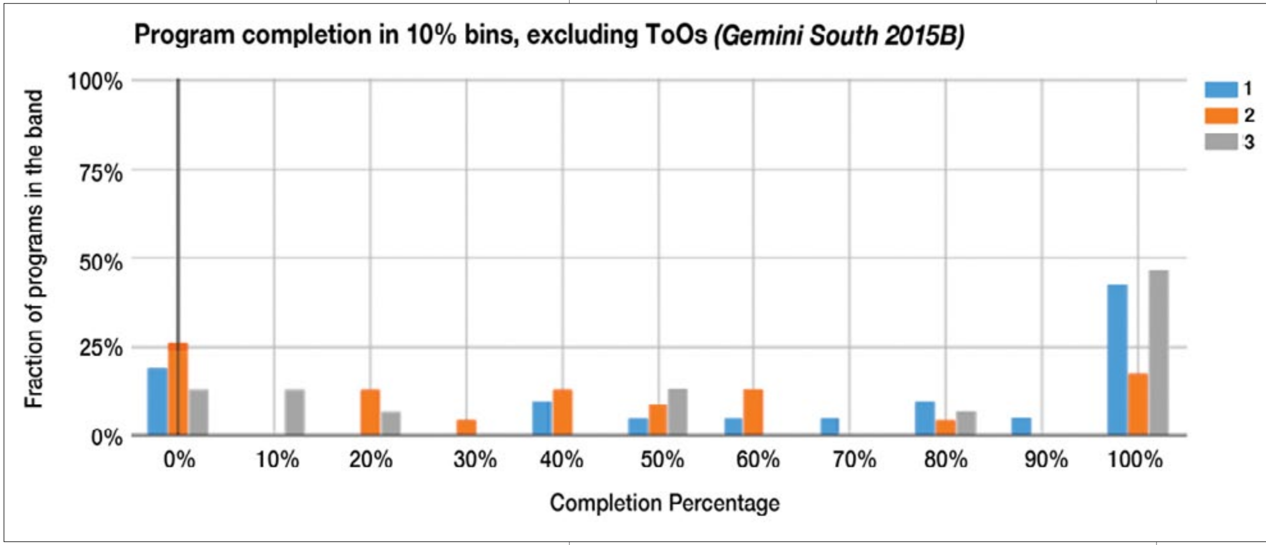
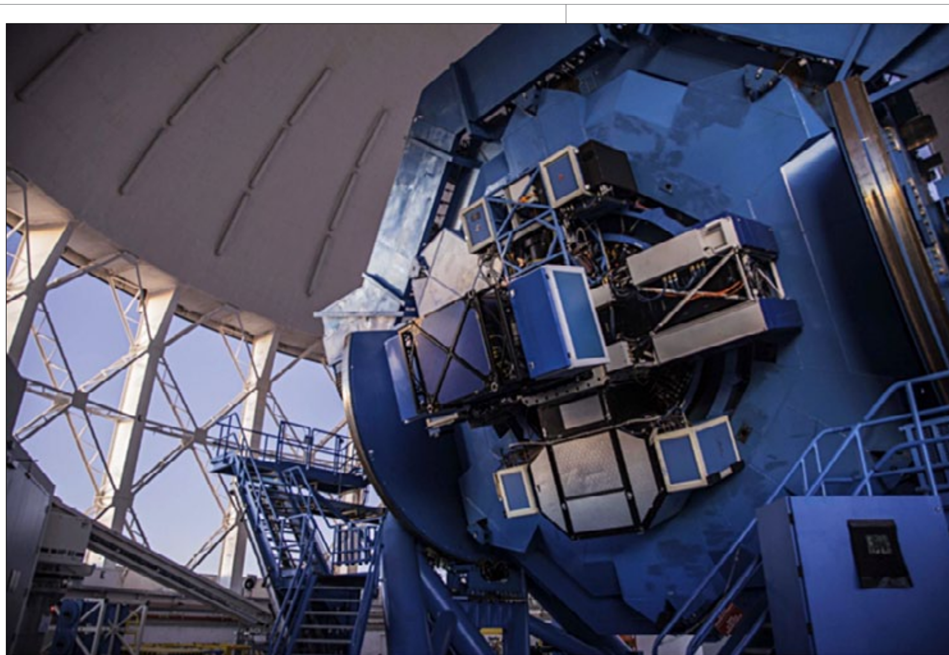


Figure 4.
Program completion in 2015B at Gemini South. Note the significant numbers of unstarted programs (driven by instrument unavailability), and the excess of Band 3 programs in the 100%-complete bin (a signature of bad weather).

Figure 5.
GPI (center) installed on the up-looking port of Gemini South. FLAMINGOS-2 is at top, and GMOS-S is at bottom.

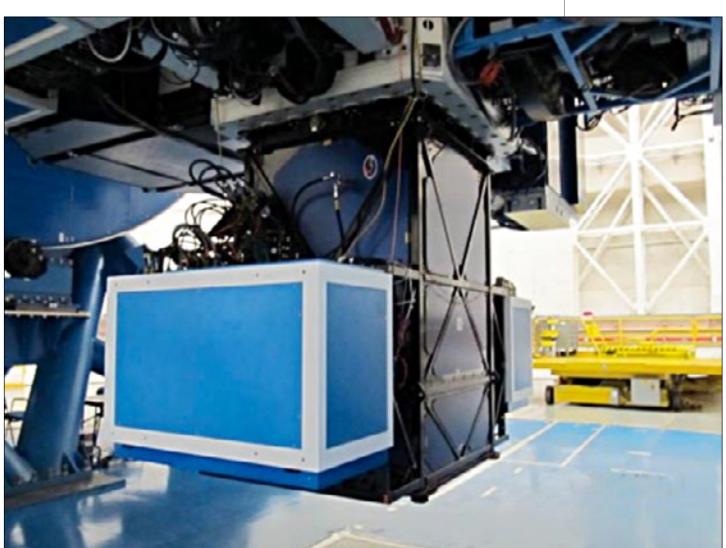


GPI and Telescope Vibration

In late 2013, early commissioning tests of the Gemini Planet Imager (GPI) on the Gemini South telescope (Figure 5) revealed a strong oscillation in the corrected wavefront, similar to defocus. The 60 Hz oscillation frequency pointed to the GPI Stirling cycle cryocoolers (which run at 60 Hz) as the cause. But we did not understand the mechanism that disturbed the optical wavefront. After fitting the telescope optics with accelerometers, a team of Gemini scientists and engineers detected the oscillations in the primary mirror (M1). The center of M1 was vibrating relative to the outer edge with a peak-to-peak amplitude of 840 nanometers (nm) — sufficient to cause a focus-like shift of about 1 millimeter at the GPI focus. The vibration completely disappeared when we turned off the GPI cryocoolers.

To improve the delivered wavefront, the GPI team first developed a software filter to measure the 60 Hz focus oscillations. They then applied a correction signal to GPI's adaptive optics. The filter improved GPI's performance to a satisfactory level, but the 60 Hz vibrations remained in M1, potentially affecting other science instruments. Therefore, in mid-2015, Gemini upgraded the GPI cryocooler controller to a new model — one with an active damping system that measures the cryocooler's acceleration and applies a counteracting one to dampen the vibrations at their source (Figure 6). Measurements with GPI indicate that the new system reduces the 60 Hz defocus residual wavefront errors from about 50 nm root-mean-square (rms) to as low as 1 nm rms — a factor of 50 reduction!

Figure 6.
Close-up of GPI attached to the instrument support cube (white, at top). Vibrations from the instrument's cold heads coupled very efficiently into the cube and then into the mirror cell.



Work on vibrations in GPI is part of a long-term program to characterize and reduce vibration effects on both Gemini telescopes. Over the next two years, we plan to install a common accelerometer system on both telescopes to permit continuous monitoring of vibration levels.

Early Use of the Gemini Observatory Archive

Early use of the new Cloud-based Gemini Observatory Archive has been healthy. Here are some initial statistics as of April 2, 2016.

- We have 303 registered users, and the number is increasing all the time.
- Since we went live, users have made a total of 45,000 archive searches and downloaded 550 GB in 117,000 files. We're currently seeing about 1,750 archive searches and about 30 GB (compressed) downloads per week.
- Currently, we have 3.3 million files in the archive, a total of 8.6 TB (compressed), and 29 TB (uncompressed) FITS data.

Finally, don't forget that in order to access proprietary data from your program you will need to register your program ID with your archive user account. See ***this paragraph on the help page*** for further instructions.

Australia's Partnership in Gemini: A Retrospective

December 31, 2015, marked the end of Australia's time as a full member in the international Gemini Partnership. Stuart Ryder, Head of the Australian Gemini Office (AusGO), reflects on Australia's participation as a Partner over almost two decades.

Australia joined Gemini in 1998, with the first time allocations made in Semester 2001A. Over the next 30 semesters, the Australian Time Allocation Committee received a total of 739 Gemini proposals. Of these, 440 were allocated queue time, and a further 25 were allocated classical nights on Gemini (or Subaru via the time exchange program). The average oversubscription factor was 2.0. Thanks to the flexibility offered by Gemini's queue mode, almost two-thirds of these programs got 80% or more of the data they requested under the required conditions.

Following are some notable Australian contributions to Gemini:

- Development of the Near-infrared Integral Field Spectrograph (NIFS) and the Gemini South Adaptive Optics Imager (GSAOI), two of the more productive and reliable instruments on the Gemini telescopes.
- The Australian Gemini Undergraduate Summer Studentship (AGUSS) program. Since 2006, the program has sponsored 23 Australian undergraduate students, who spent a summer at Gemini South carrying out research projects with Gemini staff and becoming excellent ambassadors for Gemini within the Australian community.
- The Australian Gemini School and Amateur Astronomy Contests. Since 2009, these contests have inspired school students (and more recently amateur astronomers) to suggest targets to image with GMOS-S, resulting in some awe-inspiring color pictures of galaxies and nebulae.
- A Joint Proposals Database. Established and operated by the Australian Gemini Office (AusGO, now hosted by Gemini), this database enables the sharing of one technical assessment for joint proposals, thereby improving collaboration and efficiency across the Partnership.
- With the participation of Gemini staff, the AusGO ran two very successful Observational Techniques workshops (in 2011 and 2014), with a legacy of online talks and tutorials.

Figure 7.
Gemini South image of NGC 3310 obtained as a result of the Australian Gemini Cosmic Poll in 2015. NGC 3310 is a grand design galaxy about 50 million light years distant that likely collided with a smaller galaxy about 100 million years ago — warping its disk and inciting bursts of star formation (the pink regions in the galaxy's arms).

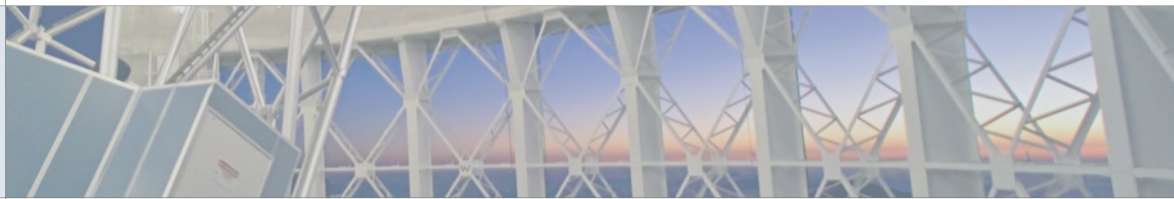
Of the almost 1,800 Gemini papers in refereed journals, about 15% have at least one Australian-affiliated author, reflecting the collaborative nature of many of the programs' allocated time. This works out at one Gemini paper with Australian involvement for every eight hours of Gemini time used. Gemini data from Australia has contributed to the PhD theses of 45 students at Australian institutions.

Australian Gemini Cosmic Poll

Throughout Australia's membership in the Gemini Partnership, AusGO ran an annual competition in which school students and amateur astronomers competed to define an observation to be done in queue time.

New AusGO staff member Elaina Hyde took the 2015 Australian Gemini Image Contest in a new direction by transforming it into the "Australian Gemini Cosmic Poll." Rather than requiring high school students or amateur astronomers to propose suitable targets as in earlier contests, the entire Australian public were invited to vote on one of four categories of objects to be observed: an individual galaxy, a galaxy pair, a planetary nebula, or another type of nebula.

In a spirit of friendly competition, each AusGO staff member pitched their favorite class of object in a short video. The science and media ***technology platform*** hosted the poll, and it received more than 100 votes in the space of two weeks; in the end, the "individual galaxy" category came out on top, and the selected target was NGC 3310. While the observations were made active in the Gemini queue, Elaina coordinated a "Live from Gemini" video event with Peter Michaud and André-Nicolas Chené, and posted regular updates to the AAO's ***Facebook page*** and Twitter (***@AAOastro, #ITSOaao***) accounts. AusGO released the final stunning image of NGC 3310 (Figure 7) just before Christmas — a fitting way to mark the end of Australian usage of Gemini's queue mode.



Contributions by Gemini staff

On the Horizon

The GHOST team completes its Critical Design Review and moves toward its Build Phase. The National Science Foundation and AURA have selected Toptica Photonics AG to produce the new GeMS laser. Scheduling for Gemini's next facility instrument, Gen 4#3, is being driven so that commissioning occurs in concert with the Large Synoptic Survey Telescope's science operations; look for a Request for Proposals later this year.

GHOST Update

We continue to make good progress on the Gemini High-resolution Optical SpecTrograph (GHOST) project. In early March 2016, we held the second half of a two-part project milestone: the Critical Design Review at Canada's National Resource Council-Herzberg in Victoria, British Columbia. The review committee was generally quite pleased with the progress made, impressed with the quality of the GHOST team's design, and satisfied with the improvements made in team coordination and integration, expressing confidence in the team's ability to successfully complete the instrument.

This review primarily focused on the spectrograph's opto-mechanical and thermal enclosure designs. It also provided several recommendations for design and process improvements that we are currently implementing. We expect to begin the project's Build Phase near the end of April, once we complete these tasks and finalize the manufacturing drawings.

Another bit of positive news is the arrival of the red and blue CCD detectors, both engineering and science grade. For both science grade CCDs, the vendor test results show excellent quantum efficiency performance and a higher grade quality than expected.

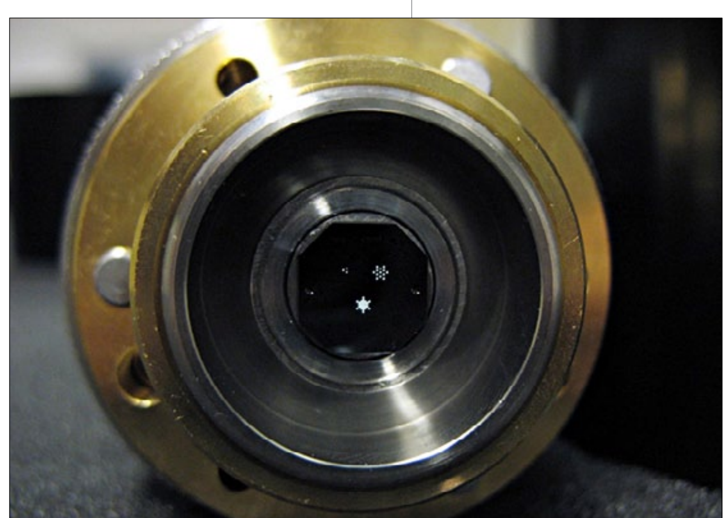
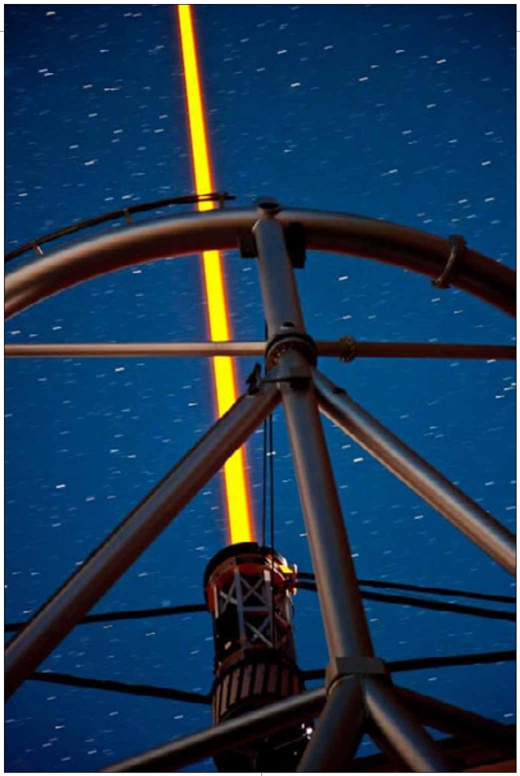


Figure 1.
The assembled GHOST optical fiber array now assembled in the input pattern. Seen here are the illuminated fiber arrays for the low-resolution object and sky Integral Field Units (IFUs) on top, and the high-resolution object IFU on bottom.

Figure 2.
The Gemini South laser propagating prior to the September 2015 earthquake.



GeMS Laser Progress

Users of the Gemini Multi-conjugate adaptive optics System (GeMS) will know that the GeMS laser has caused significant issues over the past year, particularly since the earthquake of September 2015. Major efforts finally got us back to a working system (delivering 30 of its 50 watts, which is sufficient in good conditions) by the time of the February 2016 GeMS run. However, as the current laser (Figure 2) is not robust enough for regular operations, the process of finding a replacement system is now well under way.

The National Science Foundation, in partnership with AURA/Gemini, has selected Toptica Photonics AG to produce a new laser for GeMS. The new laser will still produce the constellation of five artificial guide stars on which GeMS relies to provide excellent and stable image quality over the Gemini South Adaptive Optics Imager's full field-of-view. We expect the new laser will be significantly more robust and reliable than the old one, removing what has been an achilles heel of GeMS in operation.

Gen 4#3

The Gen 4#3 team has made steady progress in the past three months on crafting the Request for Proposals (RfP) for this next facility instrument. In their November 2015 meeting, the Gemini Board requested the Science and Technology Advisory Committee (STAC) review the outcomes of the Gemini Instrument Feasibility Studies and work with Gemini to identify core capabilities. The Board also placed a high priority on schedule and cost control. The STAC met in December and identified some expanded core capabilities for the Gen 4#3 instrument (***viewable here***). They also highlighted the importance of instrument throughput and operational efficiency. They agreed that schedule is a primary driver for Gen 4#3, and emphasized that Gemini should be fully prepared to use Gen 4#3 to take advantage of early Large Synoptic Survey Telescope (LSST) science. We are therefore driving the Gen 4#3 schedule to help ensure the instrument is commissioned by the planned start of LSST science operations.

We still anticipate the release of the Gen 4#3 RfP in 2016Q2.

GMOS CCD Issues

While the Hamamatsu CCDs installed in GMOS-South continue to perform well, the internal GMOS team encountered a few technical issues in preparing a similar system for GMOS-North. Specifically, various controller and other electronic components have changed from the versions used in GMOS-S. As these changes are apparently causing some performance degradation, we have cancelled the planned 2016Q3 GMOS-N CCD installation. We will update our web pages as we develop a new timeline for installation, likely some time in early 2017.

Additional information can be found on ***this webpage***.

Alexis-Ann Acohido

Journey Through the Universe: Twelve Years, and Counting!

Each year, for the past 12 years, Journey Through the Universe, Gemini North's premiere local educational outreach program, has impacted thousands of Hawai'i Island students. The program is designed to increase their interest in Science, Technology, Engineering, and Math, while inspiring them to participate in the exploration of the Universe.

Early in March 2016, over 80 observatory staff professionals — ranging from astronomers to information technology specialists — shared their passion for exploration with over 7,000 local Hawai'i students. The excitement and energy can be seen here in the selection of images from the 12th annual *Journey Through the Universe* program on the Big Island of Hawai'i, a week-long event that began on March 4th.

The program is a collaboration with the Department of Education Hilo-Waiākea Complex, Hawai'i Island business community, Maunakea observatories, and NASA. More images and details can be found on the ***program's webpage***.

Figure 1.
Gemini Safety Manager John Vierra engages students with safety equipment that observatory technicians must wear to work on large telescopes.

Figure 2.
Hilo High students observe various light sources through gratings that create a spectrum and separate the light into a rainbow of colors.

Figure 3 (center, left).
Evan Sinukoff (University of Hawai'i Institute for Astronomy) and Virginia Aragon-Barnes (Thirty Meter Telescope; both at left) direct students on how to "pace" the Universe, using their steps as measurements.

Figure 4 (center, right).
Subaru Astronomer Julien Lozi (left) and Gemini Public Information and Outreach staff person Alyssa Grace (second from left), make scaled-down comets for students at Waiākeawaena Elementary School using dry ice, gravel, colored sand, and corn syrup.

Figure 5.
NASA Solar System Exploration Research Virtual Institute director Yvonne Pendleton uses coin faces to help students visualize how the Moon rotates as it orbits the Earth and keeps the same side facing the Earth.

Figure 6.
Gemini Science Fellow Jenny Shih (standing) helps students at Waiākea Intermediate School classify galaxies.

Figure 7.
Robert Sparks of the National Optical Astronomy Observatory has students at Waiākea High School use filters to observe how light is polarized.

Figure 8.
Gemini Software Engineer Angelic Ebbers inspires students at Waiākea Elementary to show off their engineering skills in a "Zip Line Challenge."

Figure 9.
Gemini Astronomer Rachel Mason works with students from Hilo's Connections school to model the relative distances to the planets with toilet paper.

Figure 10.
Information Systems Engineer Jerry Brower features a simple representation of the Saturn Gemini Legacy Image, where the pixels are enlarged to illustrate how pictures are stored in computers for students at Waiākea Intermediate.

Figure 11.
Hawai'i Governor David Ige and Hawai'i Lieutenant Governor Shan S. Tsutsui proclaimed March 4-11, 2016, as Journey Through the Universe Week.

STATE OF HAWAII
1959

Proclamation

Presented to

Mauna Kea Observatories

WHEREAS, Journey Through the Universe promotes sustained education in the critical areas of science, technology, engineering and mathematics (STEM), and is a celebration of exploration and the joys of learning science and astronomy; and

WHEREAS, Journey Through the Universe brings together scientists, educators, community leaders and Hawai'i Island students for an unparalleled exploration of astronomy in the classroom; and

WHEREAS, Journey Through the Universe demonstrates the power of cross-sector support for astronomy throughout the community and the limitless possibilities for Hawai'i; and

WHEREAS, meeting and learning from a diverse array of Mauna Kea Observatory scientists and NASA specialist showcase the inspiring types of career opportunities our youth can aspire to, sparked by a love of STEM and the presence of the Mauna Kea Observatories here in Hawai'i; and

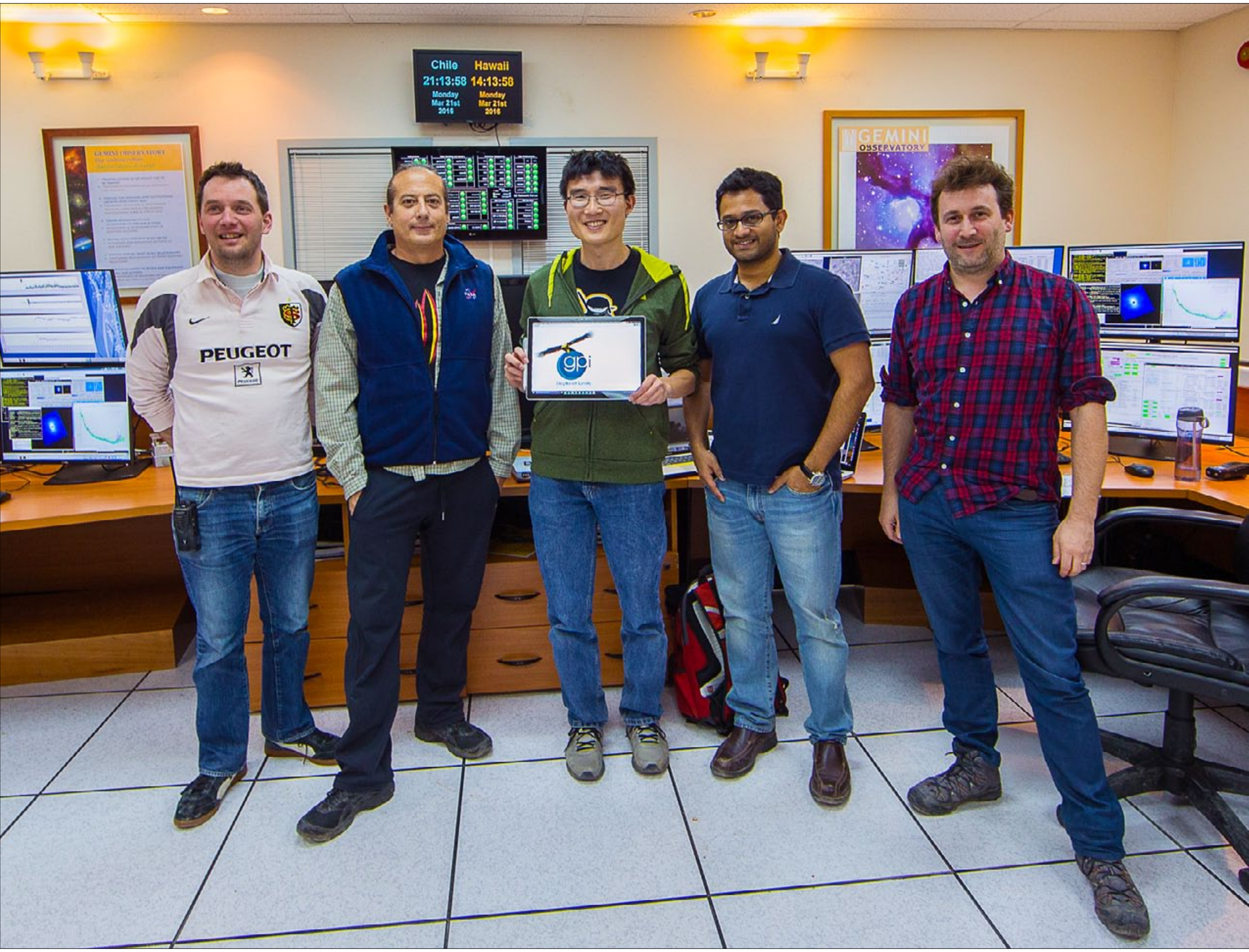
NOW, THEREFORE, I, DAVID Y. IGE, Governor, and **I, SHAN S. TSUTSUI, Lieutenant Governor** of the **State of Hawai'i,** do hereby proclaim March 4 – 11, 2016 as

"JOURNEY THROUGH THE UNIVERSE WEEK"

DONE at the State Capitol, in the Executive Chambers, Honolulu, State of Hawai'i, on this first day of March 2016.

DAVID Y. IGE
Governor, State of Hawai'i

SHAN S. TSUTSUI
Lt. Governor, State of Hawai'i



The visiting GPI observing team at Gemini South take a quick break from observing to pose for a group shot.
From left to right: Laurent Pueyo, Paul Kalas, Jason Wang, Abhi Rajan, and Ben Burningham.
Photo credit: Manuel Parades

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.

United States | Canada | Brazil | Argentina | Chile

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