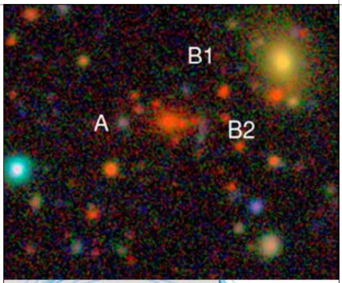
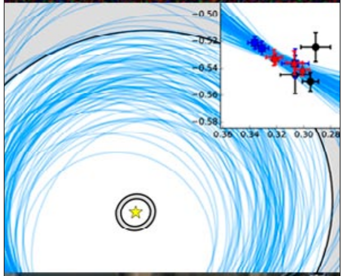
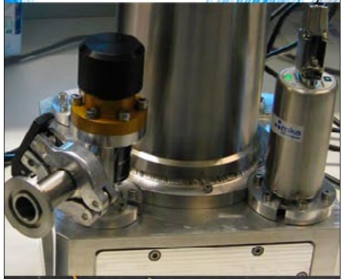
GeminiFocus

Publication of the Gemini Observatory / July 2016







ON THE COVER:
Gemini South GeMS adaptive optics image of the young active star-forming region N159W in the Large Magellanic Cloud. Learn more about this image in Science Highlights starting on page 9 of this issue. Gemini Observatory/ AURA image

Gemini*Focus July 2016*

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Director's Message

How would you prefer Gemini to look in the future?

Gemini is preparing for the next decade. As mentioned in the April 2016 issue of *Gemini*Focus, the Gemini Board of Directors has set up a Strategic Vision Committee to provide guidance for the years 2022 and beyond. Does the thought of planning that far into the future make you dizzy? It should not; if we want the Observatory to perform optimally in the next decade, we need to set the course in the next few years. And in order to get your input, we have launched a user poll (***accessible here***) and would be delighted to hear from you until the end of July 2016.

Various ideas have already been suggested. For instance, the Gemini Board of Directors and its Science and Technology Advisory Committee have proposed some high-level principles (see the poll's first six questions); please let us know if you agree with these. Furthermore, the Strategic Vision Committee has shared some (partial or full) specialization scenarios for Gemini North and South (13 short descriptions are listed in the poll); would you subscribe to any of these for the decade 2022-2032? Take the poll and let us know what you think!

Visiting Instruments on the Rise

We continue to have many requests for visitor instruments to be used on the Gemini 8-meter telescopes. As per our policy, we offer these instruments to our users when they prove to operate well in the Gemini environment. For instance, after several successful visits to Gemini North, the Differential Speckle Survey Instrument is now offered at Gemini South. Also, PHOENIX (a previous Gemini instrument) had its first run in mid-May as a visiting instrument at Gemini South. In the North, GRACES continues to be immensely popular and makes great use of the Canada-France-Hawai'i spectrograph ESPaDOnS. And in 2018, look for two new visiting instruments: POLISH2 (a highly specialized polarimeter for inclination studies of "hot Jupiters") that Sloane Wiktorowicz of the University of California Santa Cruz will bring to Gemini; and IGRINS (an immersion grating infrared spectrometer) whose University of Texas team will use in a Large and Long Program (***more information here***).

All of these instruments are vastly broadening the observational parameter space that Gemini can offer to its users. We encourage all Gemini users to continue to seize these opportunities and approach us with any new ideas or instruments you may have, or experiments you may want to conduct at Gemini.

What Else Is New?

On the time exchange front, we have expanded our agreement with the Subaru telescope: as of May, the Japanese community can apply for Fast Turnaround time and one Large and Long Program at a given time. In exchange, the Gemini community can propose for a Subaru "Intensive Program" in the future. (***More information viewable here***.)

If you have not yet tried the Fast Turnaround mode, do so; in this scheme, any month is a good month to submit a proposal. To motivate you, here is a user's quote from the last round: "The Gemini's Fast Turnaround is a great program for astronomers to perform experiments in a quicker and easier way! Thanks to all the FT's staff/scientists for the effort! You are doing a great job here!"

Finally, this issue of *Gemini*Focus contains some great science from recent observations with Gemini, often combined with other facilities. For example, the lead science article from Brian Nord and Elizabeth Buckley-Geer describes how they used Gemini to confirm the first galaxy- and galaxy-cluster scale gravitational lensed systems found in the Dark Energy Survey data. But see also Science Highlights for news of the 17-billion-solar-mass black hole in a large galaxy (measured by Jens Thomas *et al.* at Gemini North), the tracing of a young planet's orbit in the disk of the HD 95086 planetary system (Julien Rameau *et al.*), the story behind our cover image of the young star-forming region N159W in the Large Magellanic Cloud (observed with GeMS-GSAOI by Anaïs Bernard *et al.*), and the observations of a "hot Jupiter" with with GRACES by Jean-François Donati *et al*.

We are proud to see so many exciting results being enabled by Gemini — truly living our statement of purpose, "Exploring the Universe, Sharing its Wonders."

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

Brian Nord and Elizabeth Buckley-Geer

A Case of Warped Space: Confirming Strong Gravitational Lenses Found in the Dark Energy Survey

Spectroscopic observations with the Gemini Multi-Object Spectrograph at Gemini South provide precise redshifts that confirm strong gravitational lensing systems discovered in early Dark Energy Survey (DES) data. These confirmations are the first at galaxy- and galaxy-cluster scales in the multi-year effort of lens follow-up enabled by a Large and Long Program.

Massive astronomical objects sufficiently warp space-time to change the path of light on its way from distant galaxies to an observer. Consequently, strong gravitational lensing systems are revealed to us by the distorted images of these galaxies.

Most of the strong lensing systems discovered during the last decade were found by searching through existing data or through new observational campaigns. These investigations across many wavebands — from the optical to the millimeter — have resulted in ~ 1,000 candidates or confirmed lensing systems of varying masses, with distorted galaxy images in arcs of varying sizes around them.

The ***Dark Energy Survey*** (DES; @TheDESurvey)— an ongoing international, collaborative effort to produce the largest and deepest contiguous map of the southern sky to date in optical wavelengths — has the potential to add to the roster twice as many strong lenses in the optical as have ever been discovered across all wavelengths.

Finding and confirming candidates are the first steps in measuring cosmic structure and dark energy with strong lenses. The results will help us to understand why the Universe is accelerating and not being slowed by the mass it contains.

When Space Gets Warped

One maxim of Einstein's Theory of General Relativity is that space-time — the concept that space and time are one — tells energy how to move, and energy tells space-time how to curve. Gravitational lensing demonstrates both of these concepts: the path of light traveling from a distant object (like a galaxy) is deflected by a depression in the fabric of space-time caused by a massive object nearer to us. The more massive this intervening lensing object, the larger the crater, and the more distorted the observed image of the distant *source* galaxy.

Gravitational lenses act like terrestrial lenses made of plastic or glass, bending light in ways we can model well with geometric optics; the equations have multiple simultaneous solutions, which describe the different paths light can take from a single source, as well as the amount of magnification in the lensed image. A single source galaxy can appear highly magnified and have multiple images — both telltale signatures of a strong lensing system.

What Can Strong Lenses Tell Us about the Universe?

With strong gravitational lensing we can examine in detail galaxies normally too faint to observe. The observations also provide an avenue for studying galaxy evolution at epochs earlier in the Universe than would be available otherwise. The total lensing mass and its spatial distribution dictate the morphologies of lensed images. By measuring the amount and type of distortion of the source image, we can learn more about the mass distribution (including that due to dark matter) in the lensing galaxies or clusters.

Moreover, particular configurations of lenses can help constrain dark energy models. In systems with two or more source galaxies

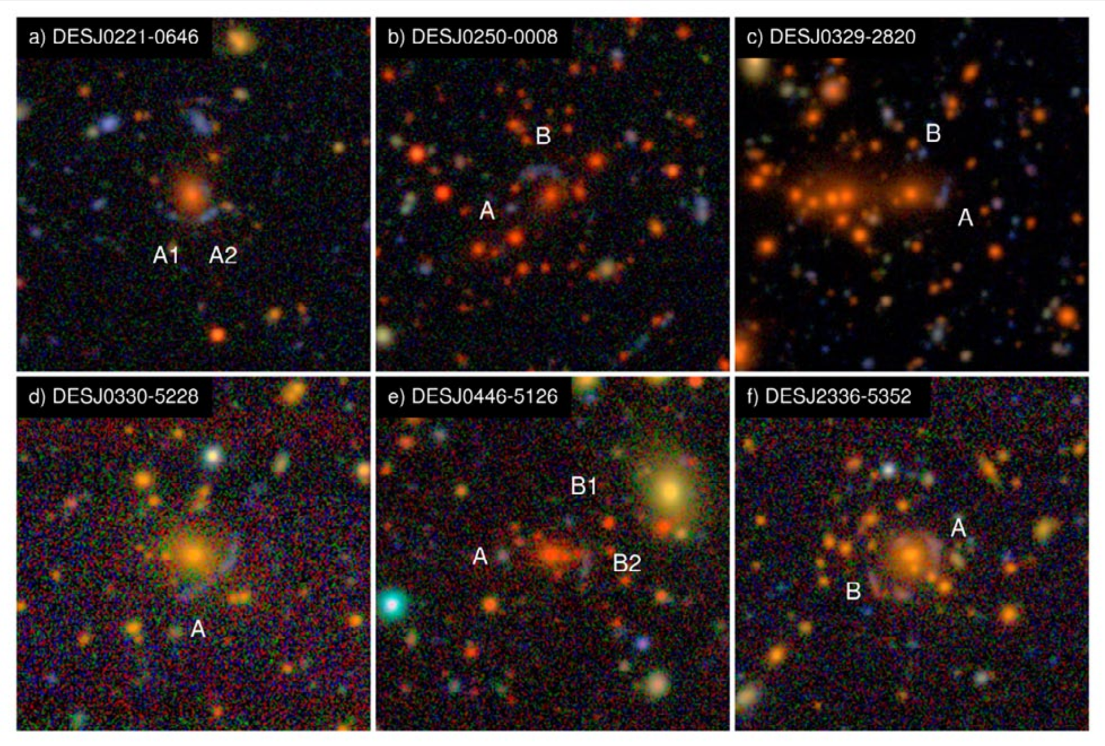


Figure 1. *Color images of six strong lenses confirmed with Gemini South spectroscopic follow-up: a) DES J0221-0646, b) DES J0250-0008, c) DES J0329-2820, d) DES J0330-5228, e) DES J0446-5126, f) DES J2336-5352. Each of these systems is a galaxy group or richer cluster, but just one or a few galaxies near the center of the cluster cause most of the lensing. (All figures reproduced from Nord et al., 2016.)*

along the line of sight behind the lens (*e.g.*, SDSSJ0946+1006, which shows multiple concentric rings) the relationship between the distances and the lens mass contains information about the dark energy density. However, these are rare: only 10 are expected in the entire DES footprint (Gavazzi *et al.*, 2008). Also, time-delay measurements of variable-luminosity objects, like lensed quasars, can allow for measurements of the Hubble constant (Refsdal *et al.*, 1964).

We see a variety of morphologies in the first galaxy- and galaxy cluster-scale lenses discovered in early DES data sets, shown in Figure 1; the lensed sources range in redshift, $0.80 < z < 3.2$. The STRong-lensing Insights into Dark Energy Survey (STRIDES; Treu *et al.,* 2015) program aims to discover and follow up new time-delay lenses in DES data. Under these auspices, we have also discovered and confirmed two lensed quasars at $z \sim 1.6$ and ~ 2.4 (Agnello *et al.*, 2015). Although these discoveries were made using Magellan/Baade, our Gemini Large and Long Program (GLLP) is providing the capability for future confirmations.

Detective Work

DES is a deep-sky survey that covers 5,000 square degrees (sq. deg.) of the southern Galactic Cap in five optical filter bands (g, r, i, z, and Y). The main instrument for DES is the Dark Energy Camera (DECam), a wide-field (3 sq. deg.) camera mounted on the Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory in the Chilean Andes (Flaugher *et al.*, 2015). The survey has finished three out of the planned five years. The Science Verification (SV) season took place after commissioning in late 2012 before the official science survey began. The SV data cover 250 sq. deg. (< 5% of the full area) and provide the imaging data for this work.

Searching through this area of sky is the first challenge in finding lenses. A team of ~ 20 DES scientists visually scanned the SV sky area, looking primarily for morphological features — multiple images, arcs, and full (Einstein) rings. We first performed a non-targeted search of the entire SV area, without focusing on any particular fields or objects. We then undertook a targeted search in the fields of galaxy clusters in the DES footprint. The redMaPPer cluster-finder (Rykoff *et al.,* 2014) provided optically selected clusters. Overlapping fields of South Pole Telescope (SPT) data provided clusters selected with the Sunyaev-Zel'dovich effect (Bleem *et al.*, 2015).

The resulting list of candidates was then refined by a group of three expert scanners, who reduced the total number of highly ranked candidates to 53.

We also predicted the number of lenses we could find in DES by comparing our list to a different sample of highly ranked candidates/confirmed lenses found in the Canada-France-Hawai'i Telescope Legacy Survey (CFHTLS) Strong Lensing Legacy Survey (S2LS; More *et al.*, 2012) — including source galaxies that survived a cut on the DES magnitude limit (24.5 magnitude in g-band). There may be over 2,000 similar lenses in the full DES area, and about 100 in the SV region. While we accounted for the relative sky areas and depths of the two surveys, we had no mechanism to affirm the efficiency of human visual inspection.

Confirming Lenses with Spectroscopic Follow-up

The next puzzle piece we needed was confirmation that a source galaxy lies beyond the putative lensing galaxy. This requires a sufficiently precise spectroscopic measurement of the source galaxy's redshift. Photometric redshifts provide a measure of distance, but they are relatively imprecise and much less reliable for the more remote galaxies likely to be lensed.

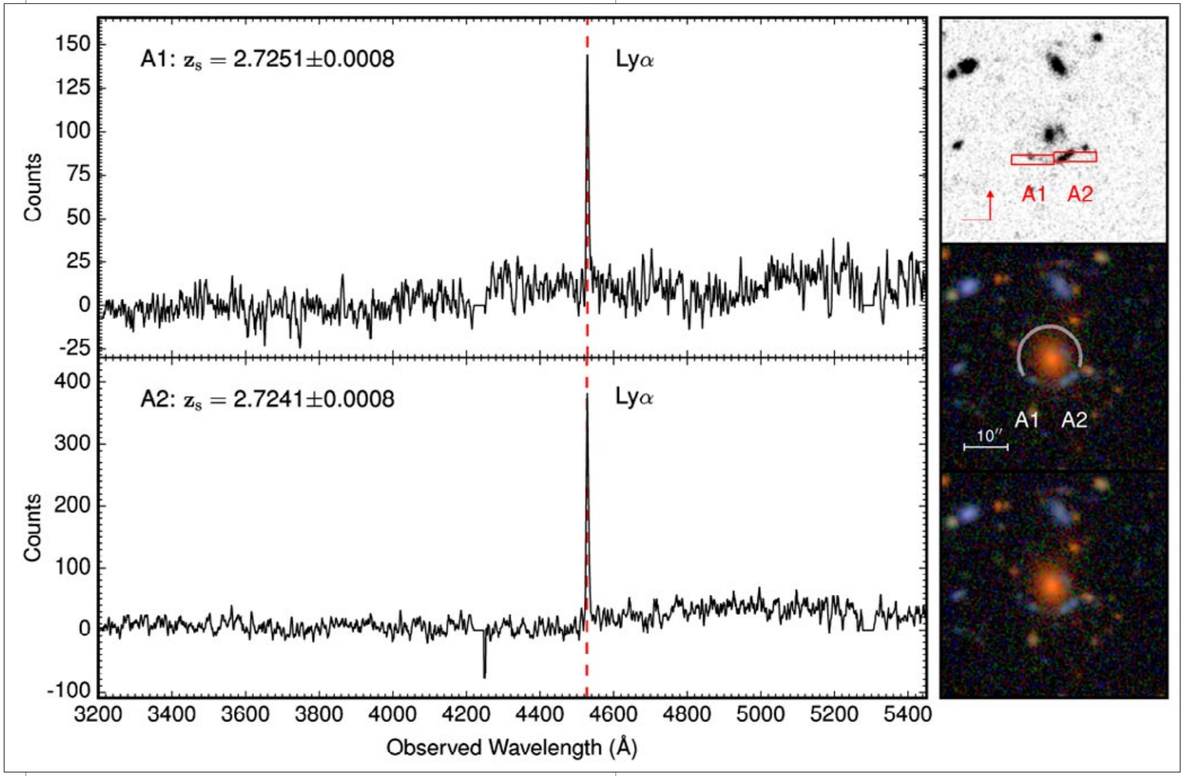
To measure redshifts, we look for specific features, like emission or absorption lines, in the spectra of source galaxies: the higher the redshift, the further these features shift from their rest wavelength. We use the R150 grating in conjunction with the GG455 filter to obtain spectra with a wavelength coverage of 4500-10000 angstroms (Å). For the sources that we expect to be late-type emission line galaxies, this would allow us, in many cases, to detect [OII]3727 to $z \sim 1.7$, H-beta to $z \sim 1.0$, and Lyman-alpha in the range $2.7 < z < 7.2$. We use the B600 grating to obtain spectral coverage of 3250-6250 Å, which would allow us to detect sources with $z > 2.0$ that emit Lyman-alpha.

We acquired spectroscopic data for 21 of the 53 systems: 17 were observed at Gemini South (taken through the Gemini Large and Long Program), and five were observed with the Inamori Magellan Areal Camera and Spectrograph at the Magellan/Baade telescope (with an overlap of one system). We confirmed six strong lensing candidates with Gemini South, rejected two, and the status of 13 remain inconclusive. For the rejected systems, we found that the putative source galaxies were actually foreground galaxies. The inconclusive systems may have spectral features at higher wavelengths, which would require the use of other instruments or telescopes.

Let's look in detail at some of the confirmed systems. Figure 2 shows spectra of the source galaxy images A1 and A2, along with images of the lensing system DES J0221-0646. Taking into account the absence of other spectral features, we assign the features at 4535 Å to be Lyman-alpha, which gives a redshift of ~ 2.752, placing it behind the redshift 0.672 lensing galaxy.

The middle color image of Figure 2 shows an Einstein radius estimated by manually fitting a circle that passes through the spectroscopically confirmed source images, where the center is chosen to be the arcs' center of curvature. With these radii, we estimated the mass enclosed within that circle. This system, like the others from this confirmed sample, are challenging to model in detail for a pre-

Figure 2.
DES J0221-0646. The spectra for source images A1 and A2 are shown on the left. The gray-scale DES g-band image in the upper right shows where we placed the GMOS slits as needed to optimize flux from the source images. In the color co-add image in the middle right panel, the Einstein radius is marked by a white arc.



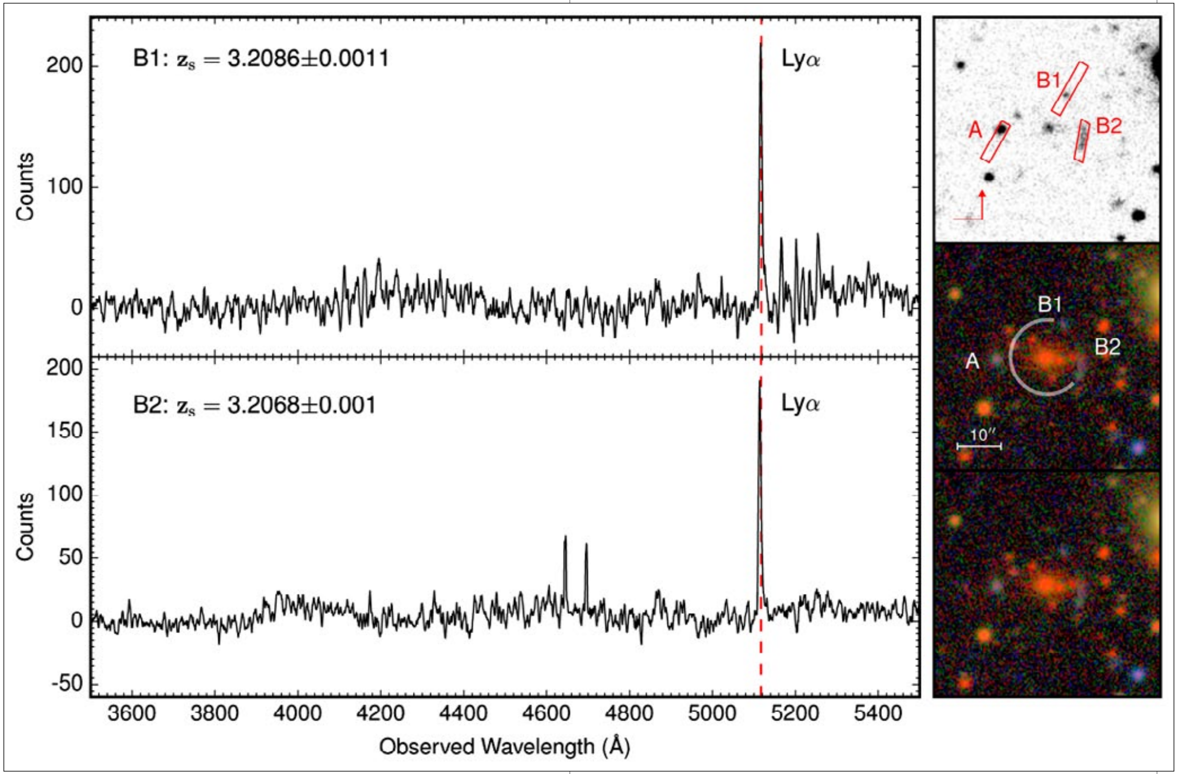


Figure 3.
DES J0446-5126. The spectra for source images B1 and B2 are shown on the left. The spectrum for A is not shown, but has an emission line consistent with an interpretation as a foreground object.

cise mass measurement: while there are multiple images of the lensed galaxy, they both occur on one side of the lensing galaxy. We would need well-resolved *counter-images* for a more precise measurement. The limited resolution of DES images obscures some lensing features, especially for systems with smaller (< 3″) Einstein radii.

In Figure 3, we see another confirmed lensing system, DES J0446-5126. Prominent Lyman-alpha emission lines in both arcs B1 and B2 occur at the same observed wavelength of 5117 Å, originating in a single source at redshift 3.2. The object labeled A also has emission lines (not shown), which we interpret as [OII]3727 and [OIII]5007: this must then be a foreground object at redshift 0.17.

A Warped Future

The spectroscopic observations taken through the GLLP made it possible to confirm six new gravitational lensing systems in DES data. We are currently reducing spectroscopic data from the 2nd season of GLLP observations on GMOS South. We are also developing and exploiting automated lens-finding methods, such as ring-finders, arc-finders, and machine-learning algorithms. With these tools we will continue to search for the lenses that can reveal the most about dark energy and the cosmic expansion rate. Large cosmological surveys, like DES and the Large Synoptic Survey Telescope (LSST), will have a plethora of data on strong lensing systems. Our main challenges will be not only to obtain complete and pure samples of lenses, but also to find those precious few systems that enable dark energy science.

Brian Nord is a cosmologist and postdoctoral researcher at Fermi National Accelerator Laboratory in Batavia, Illinois. He can be reached at nord@fnal.gov or on Twitter @briandnord.

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Nancy A. Levenson

Science Highlights

In these summaries from recent papers based on Gemini data, we explore an unexpected 17-billion-solar-mass black hole in an unlikely galaxy, track a young planet's orbit in the disk of the HD 95086 planetary system, reveal the story behind our cover image of the young star-forming region N159W in the Large Magellanic Cloud, and investigate a "hot Jupiter" with GRACES.

A 17-Billion-Solar-Mass Black Hole Surprise

Astronomers using the Gemini Multi-Object Spectrograph (GMOS) integral field unit on the Gemini North telescope have measured a 17-billion-solar-mass black hole dominating the core of NGC 1600, a large galaxy in the low-density environment of a galaxy group. This is a surprise, given that we expect to find monster black holes in very massive galaxies at the centers of large galaxy clusters. Astronomers have also observed luminous quasars hosting very massive black holes in the distant Universe, and this result sheds light on large black holes in the more local Universe, suggesting they are likely relics, the descendants of luminous quasars at higher redshift.

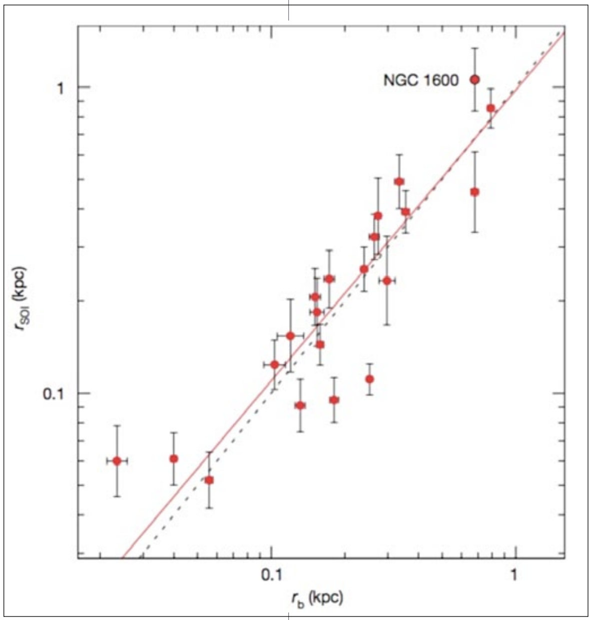


Figure 1. *The relationship between core radius (r_b) and the black hole sphere of influence (r_{SOI}) is tighter than other relationships with the black hole mass, such as stellar velocity dispersion.*

In the high-mass regime, Jens Thomas (Max Planck Institute for Extraterrestrial Physics, Germany) and collaborators find that a host galaxy's core radius is a robust proxy for the mass of the central supermassive black hole; it correlates more tightly than stellar velocity dispersion, σ. NGC 1600 is, in fact, something of an outlier on the more common "M-σ" plot. Figure 1 shows the relationship between this core radius (r_b) and the black hole sphere of influence (r_{SOI}). A Gemini ***press release*** features the work, and complete results are published in ***Nature***.

Constraining the Architecture of the HD 95086 Planetary System

New observations obtained using the Gemini Planet Imager (GPI) on the Gemini South telescope, combined with earlier data, provide more quantitative information about the confirmed exoplanet that the star HD 95086 hosts and suggest the presence of multiple planets. Julien Rameau (Université de Montréal, Canada) and colleagues directly observed the planet, called HD 95086 b, and determined its orbital parameters. They find the orbital semi-major axis around 62 astronomical units and low eccentricity ($\varepsilon < 0.21$).

The star's debris disk, where such young planets form, produces additional infrared emission. Considering multiple pieces of evidence, the architecture of this system — including the disk, its gaps, and the confirmed exoplanet — likely requires another planet or more in addition to HD 95086 b to explain the observations. See more about this work at the ***Gemini webpage***. The work has been published in ***The Astrophysical Journal Letters***.

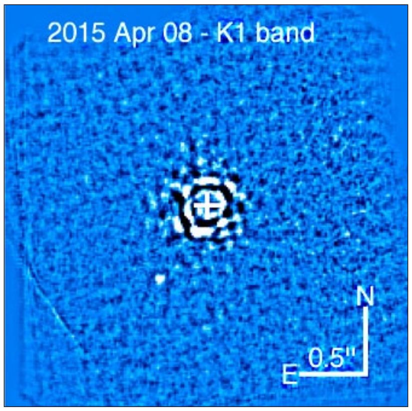


Figure 2.
A deep K1-band image of HD 95086 from GPI clearly shows a planet, located at about the 7-o'clock position and within 0.5" of the central star.

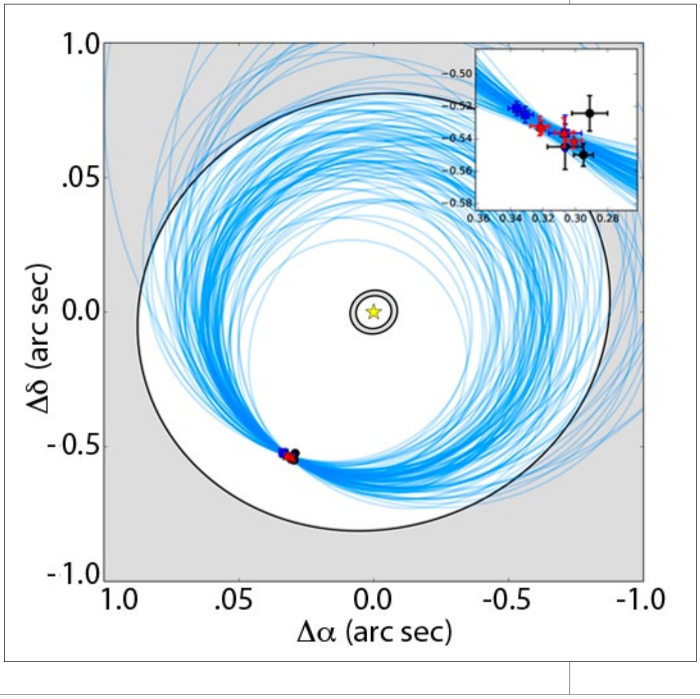


Figure 3.
This schematic diagram shows observed locations of the planet HD 95086 b (black and red points, with error bars) and numerical simulations of possible orbits (blue lines). Gray shaded regions mark the locations of inner and outer dust rings.

N159W: Dissecting Triggered Star Formation with MCAO

Massive stars (greater than eight solar masses) shape their surroundings by ionizing the local interstellar medium to create expanding HII regions, which may compress nearby gas and enhance local star formation. Observing this starbirth *in situ* presents a challenge because dust hides the strong ultraviolet and optical emission of the newborn stars, and all the activity occurs on very small spatial scales. PhD student Anaïs Bernard (Laboratoire d'Astrophysique de Marseille, France) and collaborators have used the Gemini Multi-conjugate adaptive optics System (GeMS) with the Gemini South Adaptive Optics Imager (GSAOI) to overcome these difficulties.

Figure 4 shows the result. The image reveals fine details (on scales of ~ 0.09 arcsecond) in the near-infrared light that penetrates the obscuring dust of N159W, a young star-forming region located ~ 150,000 light years distant in the Large Magellanic Cloud. The 100 young stellar object (YSO) candidates associated with N159W lie mostly at the border of the ionized (HII) bubble — where cold, neutral material accumulates in clumps and subclusters — and displays signs of recent active star formation. In contrast, the estimated age of the two (blue) massive stars and the associated cluster at the bubble's center is about two

Figure 4. *Gemini South GeMS/GSAOI near-infrared image of the N159W field in the Large Magellanic Cloud. The image spans 1.5 arcminutes across, resolves stars to about 0.09 arcsecond, and is a composite of three filters (J, H, and K_s in blue, green, and red, respectively). Integration time for each filter was 25 minutes. Color composite image by Travis Rector, University of Alaska Anchorage.*

million years. Thus, the authors suggest that the first generation of massive stars at the bubble's core triggered the recent birth of the YSOs around the periphery. A [***Gemini image release***] features this work, and full results will be published in *Astronomy and Astrophysics*. A [***preprint***] is now available.

Innovative Gemini/CFHT Partnership Explores a "Hot Jupiter"

The exploration of other worlds has shown that gas-giant planets lie very close to their host stars. As they could not have formed in their present locations (radiation would have dissolved them) questions remain: do these giants move close-in when the system is young, after interacting with the protoplanetary disk, or do they only move later, following interaction with multiple planets? The discovery of a 0.77 $M_{Jupiter}$ exoplanet located within 0.06 astronomical units of V830 Tauri — a young (< 2 million years) T-Tauri star — confirms both rapid planet formation and early migration. Such early forming "hot Jupiters" likely play a key role in shaping planetary systems overall.

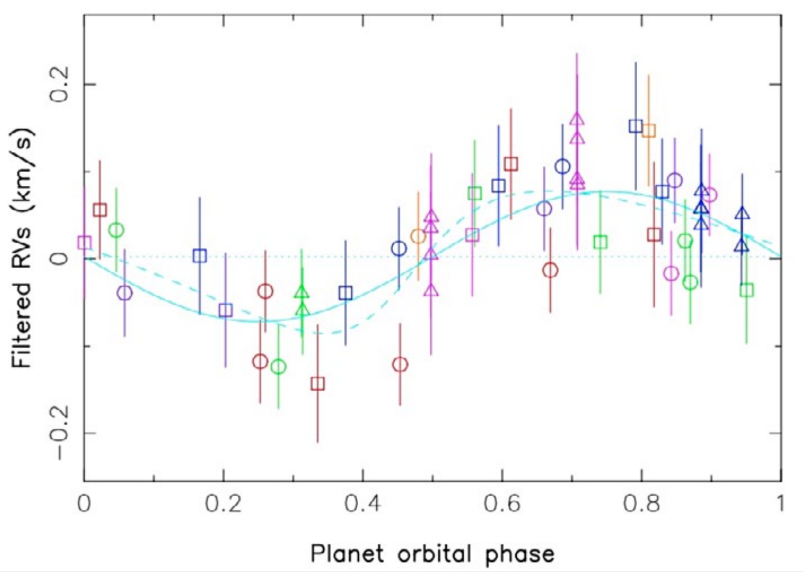


Figure 5. *Radial velocity (RV) measurements of V830 Tauri, after filtering out stellar activity, reveal the presence of a "hot Jupiter." Data from ESPaDOnS/Gemini, ESPaDOnS/CFHT, and NARVAL/TBL are plotted as triangles, circles, and squares, respectively, with colors that code rotation cycles. Lines show fits to circular (solid) and eccentric (dashed) orbits.*

High-resolution spectroscopy over a 1.5-month campaign revealed the presence of the exoplanet in a telltale spectral "wobble," leading the discovery team to isolate the signal of the planet, find its orbit, and determine its mass. Jean-François Donati (Observatoire Midi-Pyrénées, France) led the work, which took advantage of the novel collaboration between the Gemini Observatory and the Canada-France-Hawai'i Telescope (CFHT) in GRACES (Gemini Remote Access to CFHT ESPaDOnS Spectrograph). GRACES uses an innovative 270-meter fiber cable to transport light from Gemini North's 8-meter mirror to the ESPaDOnS Spectrograph at CFHT. For this work, the researchers also used ESPaDOnS on CFHT and the spectropolarimeter NARVAL on the 2-meter Telescope Bernard Lyot. Full results appear in [***Nature***] and are featured on the [***Gemini web page***].

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

Contributions by Gemini staff

News for Users

The current semester at Gemini South has had its ups and downs: poor weather conditions have prevented almost all scheduled observations in May; but on the bright side, preventative maintenance on FLAMINGOS-2 is complete. In Hawai'i, repairs to the Gemini North wind blind will start in early July. We've made several major changes to the new 2016B Observing Tool, and we invite you to contribute to the Gemini community by registering for the Gemini Data Reduction User Forum.

A Month to Forget

May 2016 may have been the worst month ever for weather at Gemini South on Cerro Pachón in Chile. In an average year, May is the first of five "bad" months, with weather loss usually on the order of 30% (see the chart in News for Users in the April 2016 *Gemini*Focus). By contrast, in May 2016, we had 16 nights during which we observed nothing at all, and a further seven during which we observed for less than three hours; in fact, weather interrupted observations every night to some degree during this period.

An extended and unusually poor weather period started in April and lasted well into June, with mainly high clouds as seen in Figure 1 (but resulting in surprisingly little precipitation). This could be an effect of the strong *El Niño* event that is gradually ending. Given that, on average, weather losses on Cerro Pachón peak in June and July, we can only hope that 2016 isn't "average," and that we will have better observing conditions in the following months. Obviously, the impact on observations has been significant. Bad weather wiped out most of the Phoenix visiting instrument run and greatly hin-

Figure 1.
Gemini South's shutters remained closed for most of May 2016, due to persistent poor weather.
Photo credit: Sandra Romero, Gemini

dered our progress on the many programs scheduled for this semester.

The good news is that, as reported in the April 2016 issue of *Gemini*Focus, we have begun adjusting the queue filling to account for the typical pattern of bad weather at Gemini South. So, fortunately, the queue was not overloaded in May as it had been in the past.

FLAMINGOS-2 Stand-down Completed

In May, we removed FLAMINGOS-2 from the Gemini South telescope for a preventative maintenance stand-down. Moving to dedicated instrument stand-downs ensures that key resources and the laboratory environment are available without competing against other important tasks. This has been an issue during other single annual telescope shutdowns.

A large team of engineers, technicians, and science staff completed a variety of tasks. First they replaced the instrument's three coldheads (one is shown in Figure 2), which were approaching the end of their lifetime; indeed, the coldheads should keep the detector at a selectable temperature, but we have seen the temperatures gradually increasing. Replacing coldheads might sound easy, but accessing and replacing them requires dismantling the instrument.

Another outstanding issue was addressed by fixing the On-Instrument WaveFront Sensor used to measure distortions at the instrument imaging plane. Careful testing and analysis revealed an electronics problem, which we resolved. We also thoroughly tested all mechanisms, which raised some additional suspicions during the movement of the Multi-Object Spectroscopy (MOS) wheel (Figure 3). Further inspection indicated significant wear in some of the ball bearings, so all were replaced. The team then reassembled and successfully tested the entire mechanism.

Finally, the instrument was cooled down, first with liquid nitrogen in the lab, before we connected it to the helium compressors on the telescope. We returned FLAMINGOS-2 to the telescope, tested it during the night, and cleared it for scientific operation. With this success, a large period of intensive work came to an end. The instrument should benefit from reliable operations for the coming semesters, and we can now begin working on the commissioning of the MOS observing mode. Weather permitting, we expect to be commissioning MOS mode in July and August of this year.

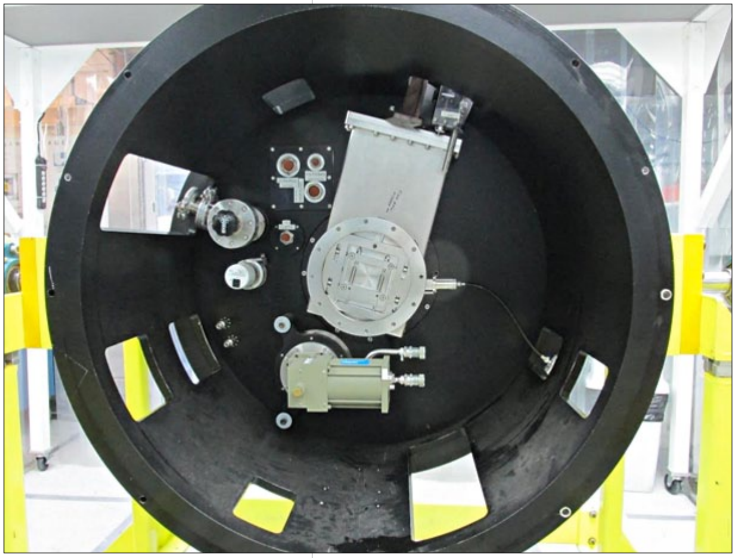


Figure 2 (left). *The new camera cold head (green mechanism, at bottom). Above it is the gate valve baffle, which is employed during MOS mask swaps due to previous thermal background issues. Photo Credit: Gabriel Perez/ Gemini/AURA*

Figure 3 (right). *The MOS wheel (larger segmented black wheel, in front, showing slots for MOS masks) and Dekker wheel (smaller black wheel, behind). Photo Credit: Gabriel Perez/ Gemini/AURA*

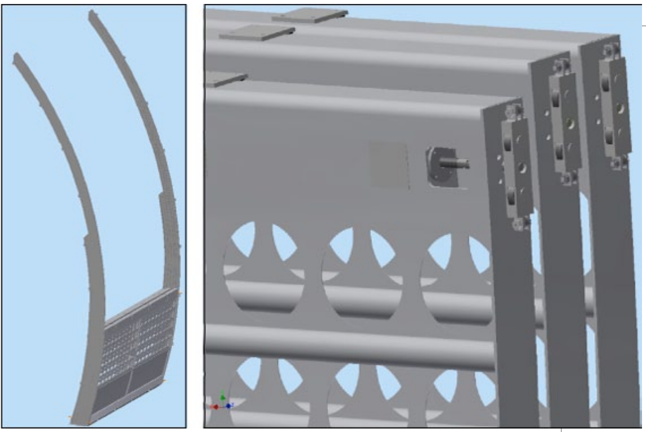


Figure 4.

The Gemini wind blind design drawings. Left: blind segments all stowed, with the guide tracks above them following the shape of the dome arch. Right: detail of the segments; the largest is 5.5 meters (18 feet) high.

Repairing the Gemini North Wind Blind

Both Gemini domes are equipped with a three-segment wind blind, which is deployed by moving the lower shutter to shield the telescope structure from wind coming from the direction of the open slit (Figure 4). Gemini North's wind blind has caused concern since early 2015, when we found excess wear on the track and roller system during regular maintenance. Considered a serious problem, we disconnected it in the second half of 2015 (when historically winds are lowest) to decrease run time and wear.

We reconnected the wind blind in November, to provide shielding during this more windy period, but decreased its maximum travel from 60 to 55 degrees. With Base Facility Operations in the North now implemented, we are able to focus on this problem and plans are now in place to work on it over the Northern Hemisphere summer. The project involves replacing all tracks guiding the wind blind and all guide roller assemblies, and performing repairs on any other damage found.

This is a major job, requiring three different pieces of heavy equipment, including a 120-ton mobile crane. We have requested and received approval to hire and use that equipment on Maunakea. Work will start immediately after the July 4th holiday, and will continue for two weeks. Observers cannot use the wind blind at night throughout this period. We'll report on the outcome in a future edition of *Gemini*Focus. The equivalent system at Gemini South has been inspected and shows no signs of similar problems, however, the process is being documented by staff to assist on future possible work.

DR User Forum

The ***Gemini Data Reduction (DR) User Forum*** is a platform created for trading ideas, scripts, and best practices. Anyone is invited to ask questions or trigger discussions about data reduction, processes, and strategies. The DR Forum permits immediate diffusion to a broad audience. It allows users to have the attention of many experts that would otherwise be difficult to contact. The Forum also offers a different, more direct, channel to contact Gemini staff, instrument builders, and experienced researchers.

Please visit, search, read, and contribute to the Gemini DR Forum. If you would like a new topic to be covered, simply ***register*** (if you have not already) and add it to the discussions. Each new post will receive attention promptly.

For additional questions or comments, please contact us at: *sus_inquiries@gemini.edu*

Is the DR Forum for you? The answer is probably yes, but especially if:

- *You are performing optical or infrared data reduction for the first time:*
    - *— Because you are working on your thesis*
    - *— Because you are expanding your work to include wavelength bands or instruments with which you are not particularly familiar.*
- *You are adept with optical and infrared reduction but would like to share best practices with your colleagues so they can utilize good habits, which will lead to clearer and more accurate descriptions of their data reduction methods.*
- *You are simply facing a specific issue with your current data reduction, and you want to share your questions or solutions with a broad community of astronomers.*

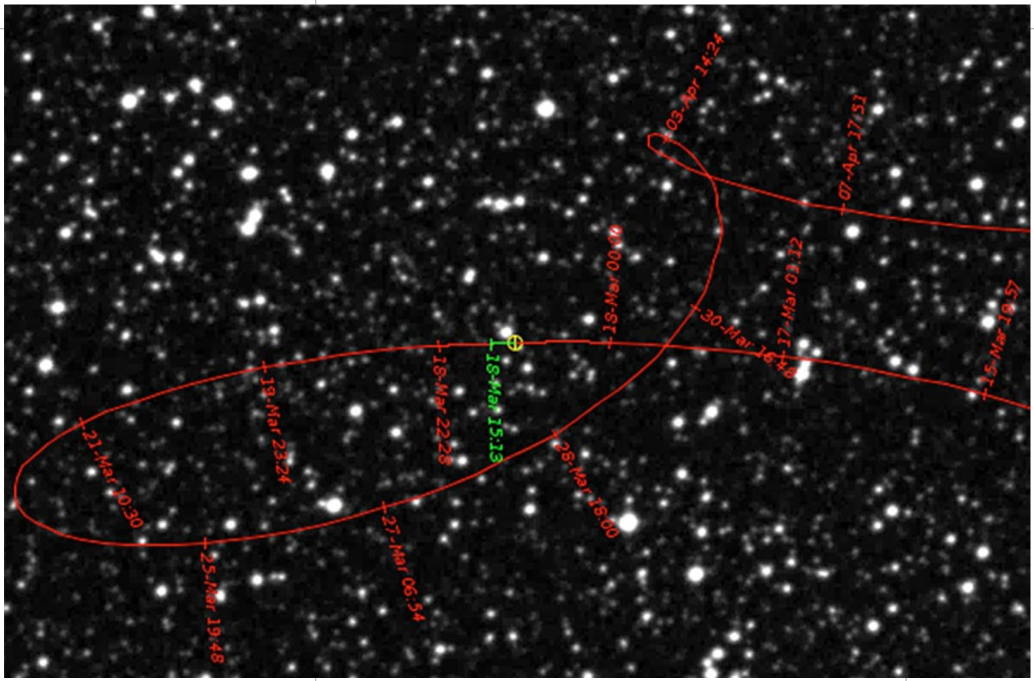


Figure 5. *Position Editor showing the position of Saturn's moon Titan (green line) with the start of the observation indicated by the yellow circle.*

2016B Observing Tool

The 2016B Gemini Observing Tool (OT) was released on June 3, 2016. Installers for Mac, Linux, and Windows may be downloaded from the ***OT webpage***. This version of the OT has several significant improvements to make preparing Gemini observations easier.

The first big change is the removal of the button to trigger the Automatic Guide Star (AGS) search. Guide star queries are now performed automatically in the background whenever users create or modify observations. This new feature works with all instruments and will update the guide star whenever an observation, or observing conditions, is/are updated. It will also automatically select the best guide star when the nighttime observer updates the time of non-sidereal or parallactic angle observations. If you don't like the automatically chosen guide star you may use the Catalog Query Tool (new in 2016A) to manually select your preferred one. Manually selected guide stars (and guide stars from previous semesters) are displayed in a "Manual" target group, and the auto-guide star system will not modify them.

The second big change is an overhaul of non-sidereal target support, which is fundamentally different in the 2016B OT. The 2016A OT handled non-sidereal targets using a mix of data — Minor Planet Center and Jet Propulsion Laboratory (JPL) minor planet orbital elements, a selectable list of the eight major planets, and manually generated ephemerides — which can be confusing and cause errors when preparing observations.

The 2016B OT supports all non-sidereal targets using automatically generated and updated ephemerides from JPL HORIZONS. When a user creates an observation the OT will download a low (~6-hour sampling) resolution ephemeris covering the entire semester for planning purposes. For accurate visualization in the Position Editor and optimal guide star selection, this is augmented by ~5-minute resolution data for the scheduled night observation. The Observing Database independently keeps track of active non-sidereal observations and downloads high (1-minute sampling) resolution ephemerides the day before an observation might be scheduled.

New plotting capabilities in the Position Editor accompany these infrastructure changes, displaying the path of non-sidereal targets throughout the semester. The red line in Figure 5 shows the orbit of Titan as seen from Maunakea in March-April 2016. The yellow circle in the center marks the start of an observation, and the green line segment shows the position of Titan during the scheduled observation.

There were many smaller improvements and bug-fixes too numerous to mention. Please see the ***OT Release Notes*** for more details, and for more news on upcoming software changes please follow the ***Gemini Science Software Blog***.

Contributions by Gemini staff

On the Horizon

Despite some technical issues, installation of the GMOS-N new detector system is progressing. Other updates include progress on the new Toptica Photonics GeMS laser, the release of the Gen 4#3 Request for Proposals for worldwide solicitation, and the start of the GHOST project's build phase.

GMOS CCD Update

The GMOS-N CCD upgrade project encountered some technical delays and is now back on track for installation later this year. The reason is because the latest Astronomical Research Camera (ARC) controllers (which are different from those in GMOS-S) created unexpected technical issues, such as high read-out noise (RON).

Tim Hardy from Canada's National Research Council Herzberg (NRC-H) helped debug the GMOS-N detector system, getting its performance closer to that of the already-installed GMOS-S system. We have been able to lower the RON from 5.6 electrons-root mean square (e_{rms}) down to 3.9e_{rms} (current GMOS-S performances). We also replaced the two original cable sets that were found to be erratic, and repaired two new boards designed to mitigate electrostatic dam-

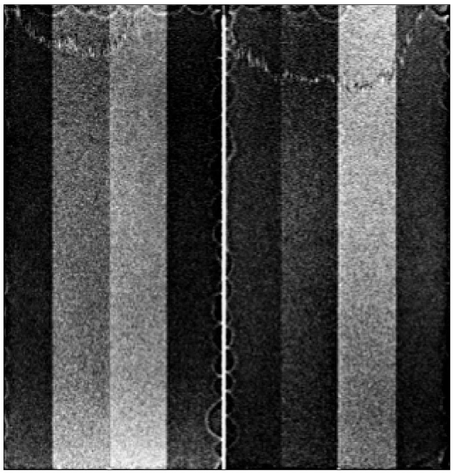


Figure 1 (left). *Bias image with the new GMOS-N focal plane array while adjusting the vertical clock voltages to optimize the full well.*

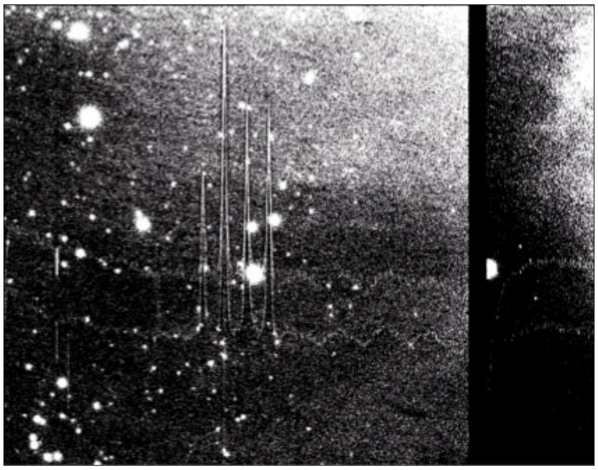


Figure 2 (right). *Sum of 10 acquisitions from GMOS-S to reveal the very low level pattern.*

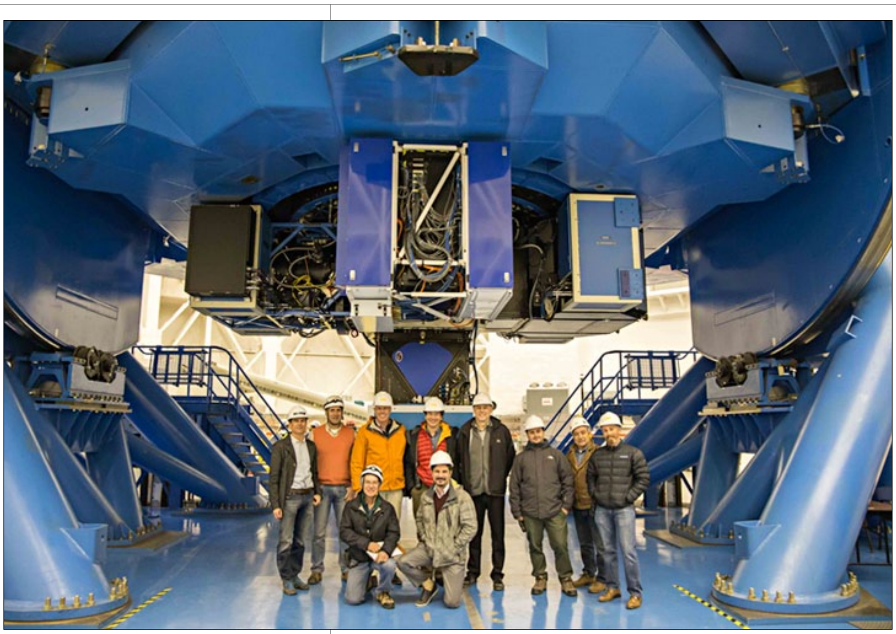


Figure 3.
Participants of the LGSF kick-off meeting visit the Gemini South telescope facility in Chile.

age to the charge-coupled devices (CCD). By reproducing one of the "unwanted features" of the current GMOS-S focal plane array (very low level pattern removable by dithering) we have learned how to work around this issue in the future.

We conducted some of these tests using a custom printed circuit board that simulated the CCD's electrical interface, allowing direct and safe measurement of the signals at the CCD pins. This also provided faster testing as we could avoid the thermal cycle overheads. This "dummy CCD board" will become a new diagnostic tool for operation at both Gemini North and South.

Once the ARC controller is validated (July 2016), we will mount and align the science CCDs in the Gemini North Instrumentation Lab for their acceptance test.

All this work has been done thanks to strong support from Detector Engineer Luc Boucher, instrumentation specialists John White and Eduardo Tapia, who all invested a lot of time and effort to make sure this progress happened.

We expect to have the complete system ready for installation in 2016B with actual installation into GMOS-N in early 2017A.

LGSF Update

Gemini South is procuring a new laser from the German corporation Toptica Photonics AG for the Gemini South Multi-conjugate adaptive optics System. On April 28th three representatives of Toptica's Laser Guide Star Facility (LGSF) upgrade project, and stakeholders from science and engineering operations, attended the kick-off meeting for Toptica's SodiumStar 20/2, the company's new laser guide star system.

Participants visited Cerro Pachón where they clarified several technical issues to ensure smooth installation of the new laser at the Gemini South telescope (Figure 3). Meeting participants also discussed the delivery schedule and required infrastructure to receive the new laser. The Toptica Laser is scheduled to arrive at Cerro Pachón by mid-November 2016 after passing Factory Acceptance Testing, scheduled to take place by September.

Work packages for the LGSF upgrade project are progressing and we expect to have received, tested, installed, and commissioned the new laser by May 2017.

For efficient operations we will install the Toptica Laser Control Electronics Cabinet

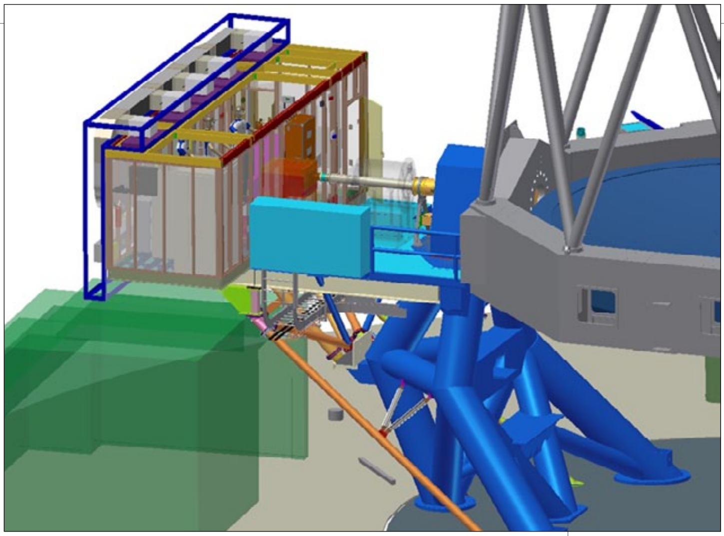


Figure 4 (left).
Illustration showing the area on the altitude platform where the EC and LH will be located on the Gemini South telescope.

Figure 5 (right).
Laser Head (left) and Electronics Cabinet (right).

(EC) and the Laser Head (LH) on the elevation platform of the telescope, near the Lockheed Martin Coherent Technologies laser enclosure. This will allow easier injection of the Toptica laser beam into the telescope Beam Transfer Optics. Figures 4 and 5 show the EC and LH as well as their planned location on the telescope structure.

Gen 4#3 Request for Proposals

We are pleased to announce the release of the Generation 4, instrument number 3 (Gen 4#3) Request for Proposals (RfP) for worldwide solicitation. The result of the RfP process is to receive proposals from those interested in helping us to design, fabricate, assemble, test, deliver, and commission our next facility-class instrument. Gen 4#3 will be a wide-band medium-resolution spectrograph designed to take advantage of observations by the Large Synoptic Survey Telescope (LSST) currently under construction in Chile. Gemini has a maximum available budget of $15 million (USD). The instrument must be commissioned by December 31, 2022, to coincide with the planned start of LSST operations. For further information, please see the ***Gen 4#3 RfP webpage*** and download the Gen 4#3 RfP documentation set.

Interested parties from 13 institutions attended our successful Gen 4#3 Proposers Conference, held on June 8, 2016, in Tuscon, Arizona. The aim of the conference was to provide a forum to review the RfP material and encourage potential proposers to ask questions regarding the RfP documentation set. A list of attendees, presentations, and conference recordings is hosted on the Gen 4#3 Proposers Conference webpage, found through the link previously mentioned.

Gemini strongly encourages collaborations in this RfP, and we have provided an online forum for those seeking additional partners to complete a team for this work. Groups interested in Gen 4#3 should submit a notice of intent and use our forum to find addition-

Figure 6.
Gen 4#3 Proposers Conference held on June 8, 2016, in Tuscon, Arizona.

al partners. Details on teams looking for collaborators can be found at the Gen 4#3 webpage linked above. If you would like to add your information here, please send an ***email***.

Notices of intent to submit proposals are due August 1, 2016, and proposals are due on August 29, 2016. Any questions regarding the Gen 4#3 RfP can be directed to Karen Godzyk via ***email here***.

GHOST on the Move

The Gemini High-resolution Optical SpecTrograph (GHOST) team has started the project's build phase. This means that the two organizations building the hardware — the Australian Astronomical Observatory (AAO) and the National Research Council Herzberg (NRC-H) — are busy procuring and fabricating components; meanwhile, the Australian National University (ANU) software team continues to move forward on their work. As components arrive, assemblies will be built and tested. Several of these assemblies are highlighted here.

The NRC-H has built a prototype cryostat for the charge-coupled device (CCD) detector system, shown in Figure 7. The tall cylinder contains the cryocooler, with the vacuum valve and vacuum sensor in front of the cooler. NRC-H has used this prototype for various tests to check the system design and is now fabricating the final cryostats for the instrument. The team will run them through a series of tests before they are ready for installation of the CCD detectors, the most costly components in the instrument.

The AAO continues to make progress on the optical cable assembly mentioned in the April 2016 issue of *Gemini*Focus, page 21. The work to test the performance of the optical fibers after the ends were fixed and polished is complete, yielding excellent results. The next step is to attach the microlens arrays to the fiber ends. The team will do this after these arrays receive their optical coating.

The ANU keeps steadily working on both the instrument control system software and the data reduction pipeline.

Figure 7.
Prototype cryostat for GHOST at the NRC-H.

Alexis Ann Acohido

Gemini Harnesses the Sun from Both Hemispheres

Figures 1-2. *Photovoltaic panel installations at the Gemini South Cerro Pachón facility in Chile (top and bottom).*

In 2015 the Observatory installed photovoltaic (PV) panels on the Gemini North Maunakea facility. Now we have done the same on the Gemini South Cerro Pachón facility and the Gemini North Hilo Base Facility. The effort is part of our commitment to positive stewardship of our planet and eco-efficient operations.

Installation of an impressive 680 panels at the Gemini South Cerro Pachón facility was completed in late June, 2016, and the cabling phase to connect them to Gemini's electrical system should be completed by the release of this issue of *Gemini*Focus. The panels are on the rooftop adjacent to the telescope dome, as well as mounted on the ground (Figures 1 and 2), and are estimated to provide ~20% of the annual power consumption at the telescope.

Almost simultaneously, panel installation on the roof of HBF (Figures 3 and 4) started in late May 2016 and ended in mid-June 2016. Cabling of the system was completed on June 15, 2016, and the panels are now online.

Alexis Ann Acohido is a Media Relations and Local Outreach Assistant at Gemini North. She can be reached at: aacohido@gemini.edu

Figures 3-4

Installation of photovoltaic panels on rooftop of Gemini's Hilo Base Facility in Hawai'i (top and bottom).

Peter Michaud

Gemini Connections

Authors of three recent books on astronomy share direct ties with Gemini. The books cover topics spanning the history of modern astronomy on Maunakea, how astronomers create stunning astronomical images, and the story of George Herbig's pioneering work in early stellar evolution. Brief reviews of these works follow.

A Sky Wonderful with Stars: 50 Years of Modern Astronomy on Maunakea

This absolutely stunning book by Michael J. West is clearly a labor of love fueled by a passion for astronomy. Some will recall that Michael served as Gemini's Head of Science Operations at Gemini South from 2006-2007, as well as a professor of astronomy and physics at the University of Hawai'i Hilo, and his influence remains strong especially on Maunakea. Michael is currently the Deputy Director of Science at the Lowell Observatory in Arizona.

Michael's love for astronomy and Maunakea is evident on every page of this book. Thanks to the vision of the University of Hawai'i Press this book was made possible in 2015 to coincide with the 50th anniversary of the first telescopic observations of the Universe from Hawaii's highest peak.

Figure 1.
Image from the Michael West book "A Sky Wonderful with Stars: 50 Years of Modern Astronomy on Maunakea."

With each page readers experience a profound view, and written perspective, of the mountain and the Universe. Michael tells the story of modern astronomy on Maunakea with an elegance that borders on poetry; his words transcend the printed page and succeed in conveying the poetry of the mountain and modern astronomy. This large-format book belongs on the coffee table of everyone who loves the unparalleled beauty of both Maunakea and astronomy.

Coloring the Universe: An Insider's Look at Making Spectacular Images of Space

Anyone familiar with Gemini's Legacy Images will recognize Travis Rector's name as the creative genius who massages selected Gemini data into aesthetically pleasing pictures. While his work isn't limited to Gemini data (he has worked for years with Cerro Tololo Inter-American Observatory, Kitt Peak National Observatory, and other observatories) his experience makes him uniquely qualified to serve as an "insider" as the book's subtitle states. Joining Travis in this ambitious work are NASA's Kimberly Arcand and Megan Watzke, who collectively have produced and promoted astronomical imaging to a level of artistry that is evident with even a quick flip-through of this 250-page large-format book.

Figure 2.
Excerpt from the book "Coloring the Universe" that features dozens of Gemini images.

The authors use accessible language and striking astronomical images to describe and show the telescopes and instruments used to take these colorful images, the techniques of astronomical data processing, and what astronomy we can learn from the results. The chapters are merged seamlessly into a cohesive story in this book published by the University of Alaska Press, Fairbanks (where Rector teaches astronomy and physics).

George Herbig and Early Stellar Evolution

A new Gemini Board member, Bo Reipurth, from the University of Hawaii's Institute for Astronomy, is author of a recently published book that chronicles the life and work of astronomer George Herbig. All astronomers (and most Astronomy 101 students) know something about George and his work on the early evolution of stars. However, did you know that although his mother encouraged him to become a chemist (it paid well), his passion for astronomy and amateur telescope making kept him firmly entrenched on his ultimate career path (which is fortunate for astronomy).

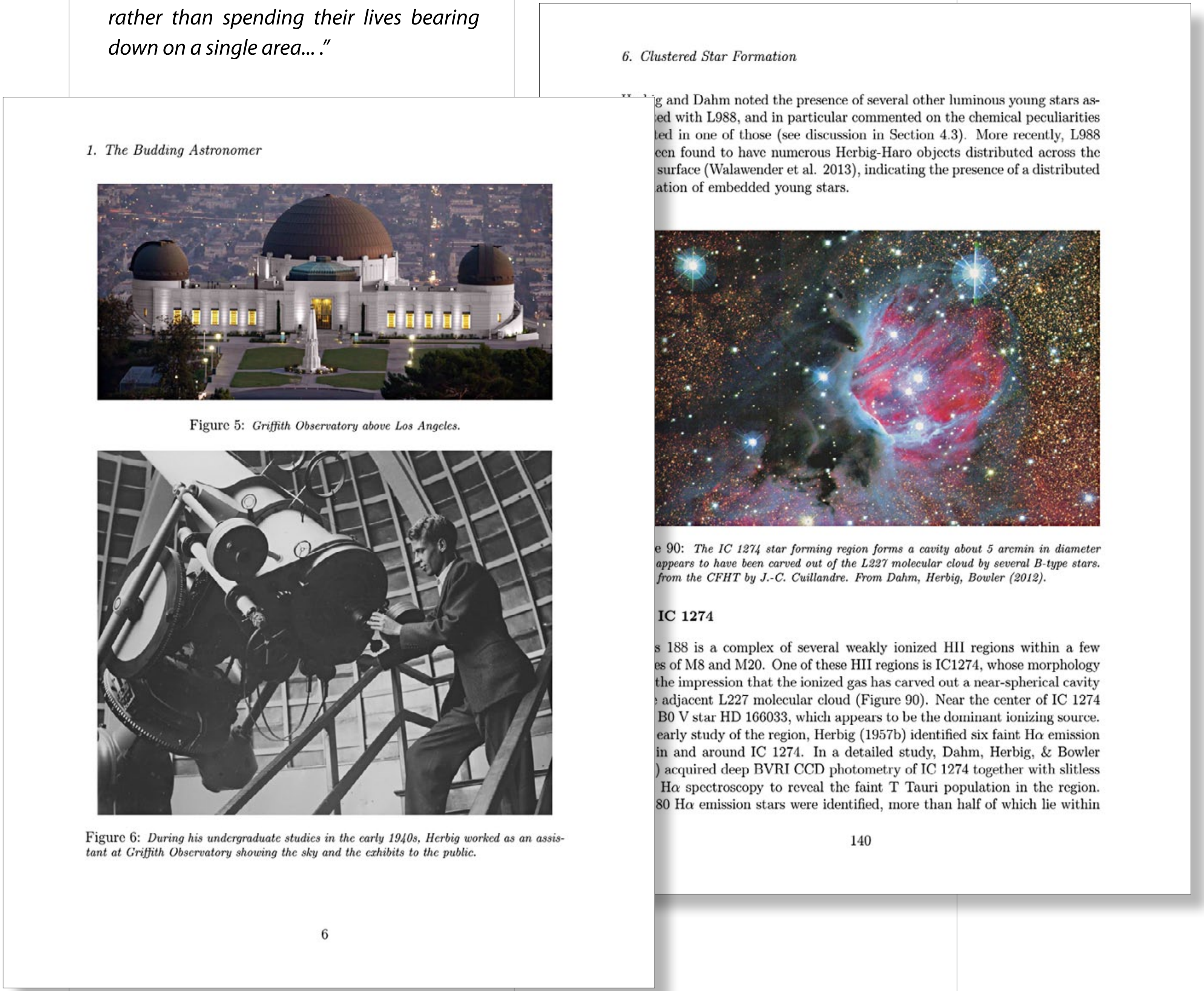
Bo is in a unique position to write this biography, since George — prior to his death at age 93 and while still in his mid-70's — entrusted to Bo volumes of his detailed notes, comments, and autobiographical sketches. In the book's foreword, Bo includes this quote from George, as he documented his life as a scientist:

"For reasons not entirely clear, I have thought it worthwhile to try to put down a kind of inventory or outline of the various astronomical activities that I have pursued, and how my involvement in each of them came about — to the extent that I can remember or reconstruct reasons and motives at this late date (January 1993). The scornful phrase 'jack of all trades, master of none' has more than once come to my mind, for I recall old-timers speaking with contempt of colleagues who frittered away their energies on a host of activities rather than spending their lives bearing down on a single area... ."

Astronomy owes a huge debt to George's "frittering," as does Bo for telling the engaging story of this remarkable man. Bo has generously made this self-published e-book freely available for download ***here***.

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

Figure 3-4.
Extracted pages from Bo Reipurth's book on George Herbig.



1. The Budding Astronomer

Figure 5: *Griffith Observatory above Los Angeles.*

Figure 6: *During his undergraduate studies in the early 1940s, Herbig worked as an assistant at Griffith Observatory showing the sky and the exhibits to the public.*

6

6. Clustered Star Formation

g and Dahm noted the presence of several other luminous young stars as-
ted with L988, and in particular commented on the chemical peculiarities
ted in one of those (see discussion in Section 4.3). More recently, L988
een found to have numerous Herbig-Haro objects distributed across the
surface (Walawender et al. 2013), indicating the presence of a distributed
ation of embedded young stars.

e 90: *The IC 1274 star forming region forms a cavity about 5 arcmin in diameter*
appears to have been carved out of the L227 molecular cloud by several B-type stars.
from the CFHT by J.-C. Cuillandre. From Dahm, Herbig, Bowler (2012).

IC 1274

s 188 is a complex of several weakly ionized HII regions within a few
es of M8 and M20. One of these HII regions is IC1274, whose morphology
the impression that the ionized gas has carved out a near-spherical cavity
adjacent L227 molecular cloud (Figure 90). Near the center of IC 1274
B0 V star HD 166033, which appears to be the dominant ionizing source.
early study of the region, Herbig (1957b) identified six faint Hα emission
in and around IC 1274. In a detailed study, Dahm, Herbig, & Bowler
) acquired deep BVRI CCD photometry of IC 1274 together with slitless
Hα spectroscopy to reveal the faint T Tauri population in the region.
80 Hα emission stars were identified, more than half of which lie within

140

Gemini Legacy Image Releases

A New Look for Gemini's Legacy Images

A beautiful new set of 16 Gemini Legacy images are now available in redesigned 8.5 x 11-inch prints (or as electronic files). Shown here are several examples of the new sheets (including background information which is provided on the flip-side of each sheet).

All of these, plus prior Legacy images not included in this update, are available as full-resolution downloads on the ***Gemini Image Gallery***. Gemini's participating country offices (and the public) may request printed copies via ***email***.

We hope you enjoy these images, and watch for spectacular new ones as Gemini continues to explore the Universe!

Light from Dark

Image Credit: Gemini Observatory/AURA

Gemini Observatory Legacy Image

GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

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Gemini Observatory Facts

PRIMARY MIRRORS:
Diameter: 8.1 meters; 26.57 feet; 319 inches
Mass: 22.22 metric tonnes; 24.5 U.S. tons
Composition: Corning Ultra-Low Expansion (ULE) Glass
Surface Accuracy: 15.6 nm RMS (between 1/1000 - 1/10,000 thickness of human hair)

TELESCOPE STRUCTURES:
Height: 21.7 meters; 71.2 feet; 7 stories (from "Observing Floor")
Weight: 380 metric tonnes; 419 U.S. tons
Optomechanical Design: Cassegrain ; Alt-azimuth

DOMES:
Height: 46 meters; 151 feet; 15 stories (from ground)
Weight: 780 metric tonnes; 860 U.S. tons (moving mass)
Rotation: 360 degrees in 2 minutes
Thermal Vents: 10 meters; 32.8 feet (width – fully open)

GEOGRAPHICAL DATA:
Elevation: Gemini North: 4,214 meters; 13,824 feet
Gemini South: 2,737 meters; 8,980 feet
Location: Gemini North: 19°49.4'N; 155°28.1'W
Gemini South: 30°14.5'S; 70°44.8'W

To see this, and many other images, please visit: http://www.gemini.edu/legacyph

GEMINI OBSERVATORY
Exploring the Universe, Sharing its Wonders

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Laser Vision

This exterior shot of the Gemini South telescope shows the result of the Gemini Multi-conjugate adaptive optics System (GeMS) with the Gemini South Adaptive Optics Imager (GSAOI) propagating a laser guide star skyward. The laser's light is split into five separate beams that are necessary for the Gemini South adaptive optics system.

The GeMS/GSAOI system is a revolutionary approach to adaptive optics in astronomy. The technique samples the turbulence structure in the atmosphere at several levels and then uses a technique similar to medical tomography to reconstruct a 3D snapshot of how the atmosphere is distorting starlight. This is then used to shape a series of deformable mirrors to cancel out this distortion. All of this happens about 1,000 times a second.

In the sky to the upper left of the dome, floating like detached fragments of the Milky Way, lie the Large and Small Magellanic Clouds. These glowing orbs are actually irregular dwarf galaxy companions to the Milky Way some 200,000 light years distant.

Gemini dedicates this image to the memory of Vincent Fesquet, who worked tirelessly to make the Gemini South Laser Guide Star System work efficiently and reliably.

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To see this, and many other images, please visit: http://www.gemini.edu/legacyph

Laser Vision

Gemini Observatory Legacy Image

Image Credit: Gemini Observatory/AURA/Manuel Paredes

Image montage from the Michael West book "A Sky Wonderful with Stars: 50 Years of Modern Astronomy on Maunakea."
See the summary of this book on pages 21-22 of this issue.

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