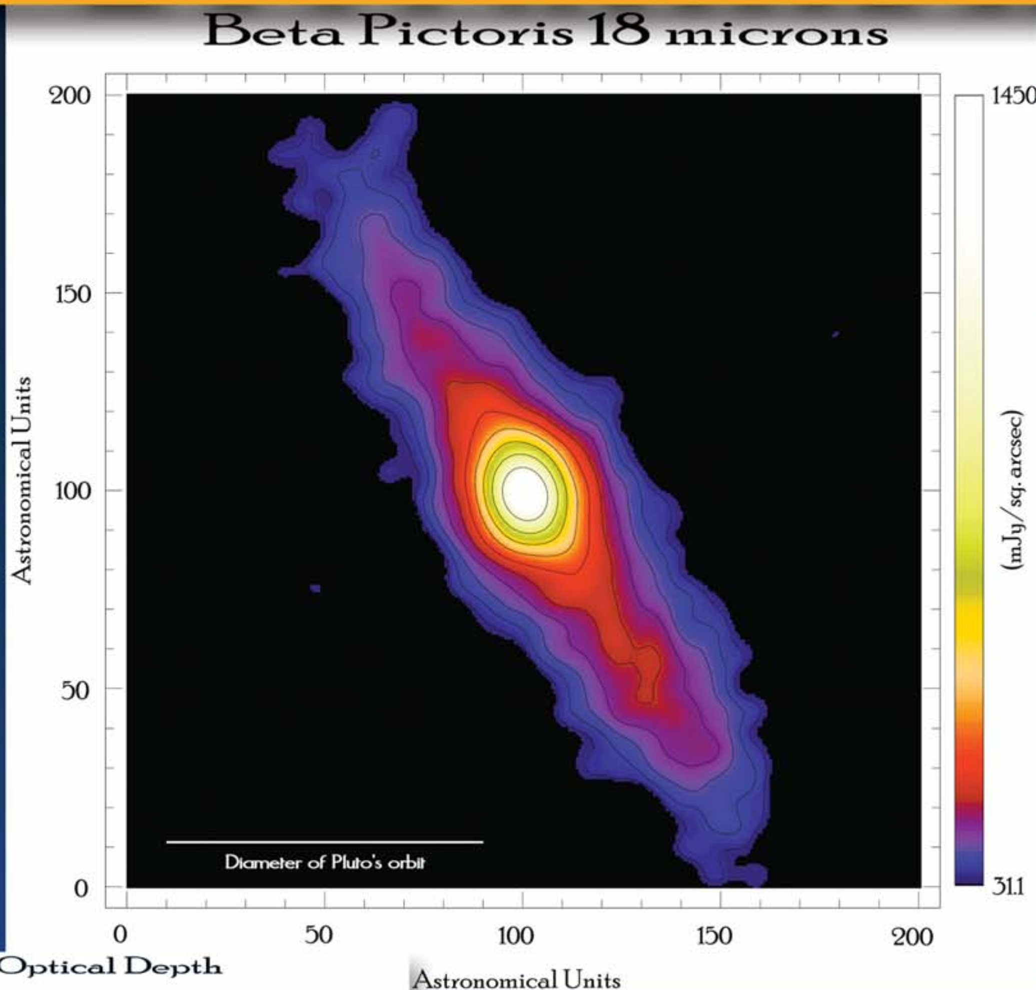
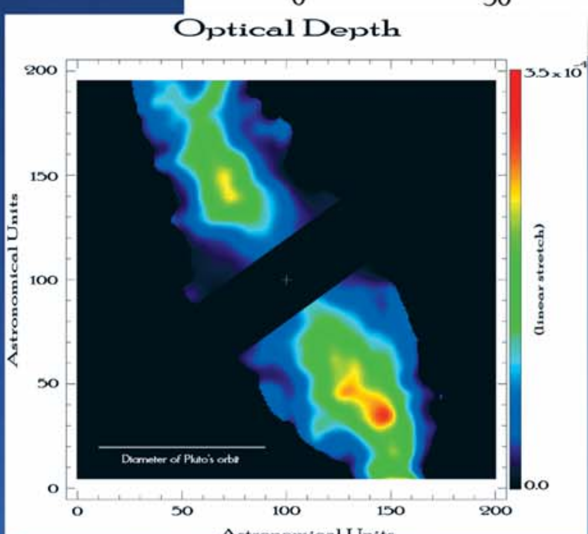
GEMINI OBSERVATORY NEWSLETTER

June 2003 Issue 26





Gemini South Explores a Young Planetary System

Inside This Issue

STARS OVER GEMINI NORTH

The star-trail image above is a "stack" of about 100 images from a new time-lapse movie of the early summer sky rising over Gemini North. A final image was added that reveals the stars offset by about 20 minutes and shows the stars of the constellation of Scorpius (among others) over the Gemini dome. Automobile tail-lights can be seen as well as a red light that was used to highlight the dome. The yellowish light on the right side of the dome is light from the setting moon, and the light on the left side of the dome is from the first glow of dawn. A Nikon D1X digital camera was used with a AFNikkor 14mm lens (at f/2.8) for each 50-second exposure. A dark frame subtraction was also used to reduce noise from the charge-coupled device (CCD) in the camera.

The smaller images shown at the top are individual frames from the sequence obtained during the course of the night. The image at left shows the first glow from the early morning sunrise and the rising Milky Way. The image at right reveals the final glow of evening twilight with the 10-day old moon (not visible) still high in the sky illuminating the Gemini enclosure. Both images have the same technical specifications as the star-trail image.

Gemini Observatory Images

GEMINI OBSERVATORY NEWSLETTER

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THROUGH A CRADLE OF DUST: GEMINI EXPLORES A YOUNG PLANETARY SYSTEM

Scott Fisher

A team from the University of Florida and Gemini Observatory obtained this data with Gemini South in December 2001. Team members include: C. M. Telesco, N. Mariñas, R. S. Fisher, J. T. Radomski, R. K. Piña and T. L. Hayward.

Until recently, Beta Pictoris was a relatively bright (m_{V} = 3.9) but unremarkable star in the southern constellation Pictor. That all changed when the Infrared Astronomy Satellite (IRAS) observed it in 1984.

What IRAS discovered was that the star emitted much more infrared radiation than was expected for a normal main-sequence type-A star. This "excess" infrared emission was detected at all the wavelengths IRAS could observe: 12, 25, 60 and 100 microns. Moreover, the excess was strong. After calibration of the data, it was found that the source is at least an order of magnitude brighter than expected at mid- and far-infrared wavelengths ($\lambda >$ 12 microns). The origin of the excess emission was attributed to emission from a disk of dust surrounding the star that was being heated by the star itself. This hypothesis was subsequently proven correct by the first images of the disk taken soon after the IRAS observations.

In part due to its proximity to Earth (19.3 parsecs), the dust disk around Beta Pictoris is one of the few that is bright

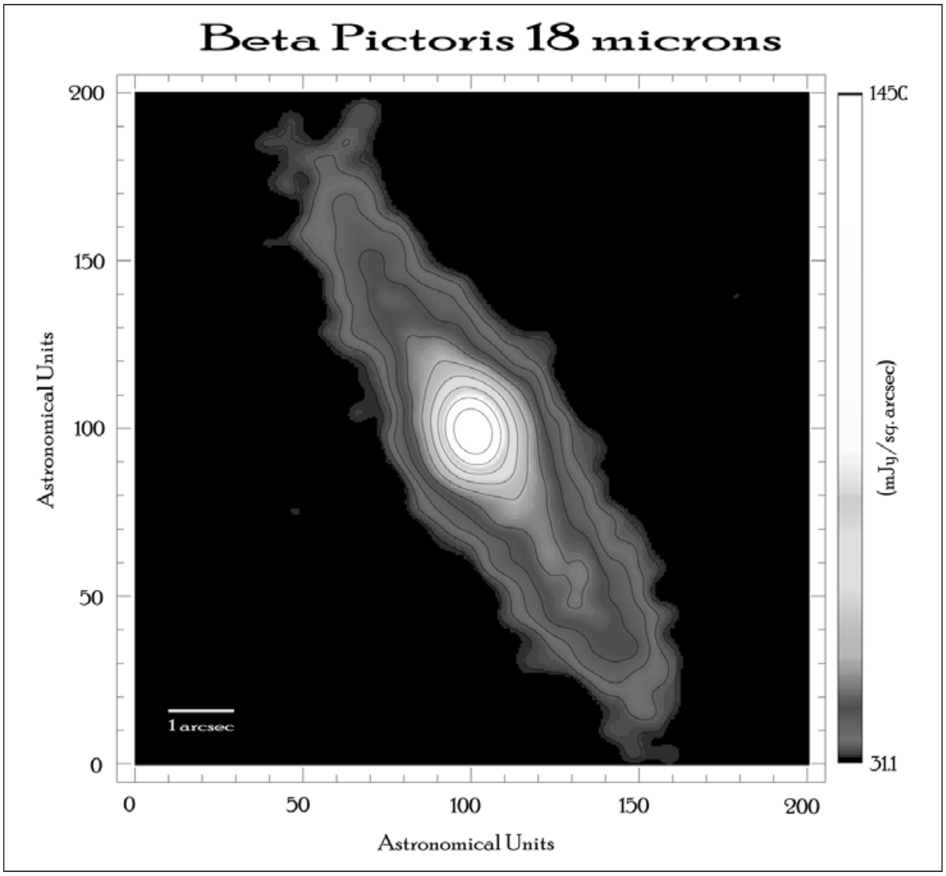

Figure 1: *Beta Pictoris at 18 microns. Here we see emission from the star as the bright source in the center of the image with the disk extending to either side. Particularly interesting (and never seen before) is the small-scale structure in the disk. The "S curve" shape seen in the lower right side of the disk is likely caused by one or more as-yet-unseen planets orbiting the central star. This kind of structure is akin to the "wake" of the planets as they shape the distribution of dust while circling deep within the disk itself. (See color image on cover.)*

enough and large enough in the sky to study in detail. Indeed, Beta Pictoris has become the archetypal proto-planetary disk source and has been studied intensely for the last 20 years at most wavelengths, from the ultraviolet to radio.

We have continued the study of this archetype by observing it at mid-infrared wavelengths (10 and 18 microns) with OSCIR on Gemini South. The data we present here are the highest resolution images of the disk ever made at these wavelengths. The southern declination (-51 degrees) of Beta Pictoris combined with the excellent image quality provided by OSCIR and Gemini South let us resolve structure in the disk to an unprecedented resolution of approximately (~) 0.5 arcseconds at 18 microns. These images of the disk are also among the deepest ever obtained in the mid-infrared. In particular, we have resolved the disk at the "short" wavelength of 10 microns to the same extent as at 18 microns. This has important consequences on how we can use our data to study the disk, which we discuss in the following paragraphs.

There is good reason to observe these disks at mid-infrared wavelengths. Not only does the dust of the disk glow brightly at these relatively long wavelengths, it is also only in this part of the spectrum that the contrast between the extremely bright central star and the relatively faint emission from the dust is low enough that the disk is not overwhelmed by its stellar host as it is in the visible, and to a certain extent, in the near-infrared. Because of this, we do not need to observe the source with a coronagraph that would block out the inner section of the disk, which is a very important consideration in this case since we are trying to study the disk as close to the central star as possible.

In ***Figure 1***, we show our 18-micron image of Beta Pictoris with contours of constant-brightness overlaid. Presented with a 0.375-arcsecond Gaussian smooth applied to the data, the lowest contour (edge of the color shading) traces three times the smoothed noise in the image (3σ = 31 mJy/square arcsecond). The contours are spaced logarithmically. Photospheric emission from the central star is seen as the bright white spot in the center of the disk, and the disk itself is seen as the elongation of the source to the northeast and southwest (north is up, and east is to the left).

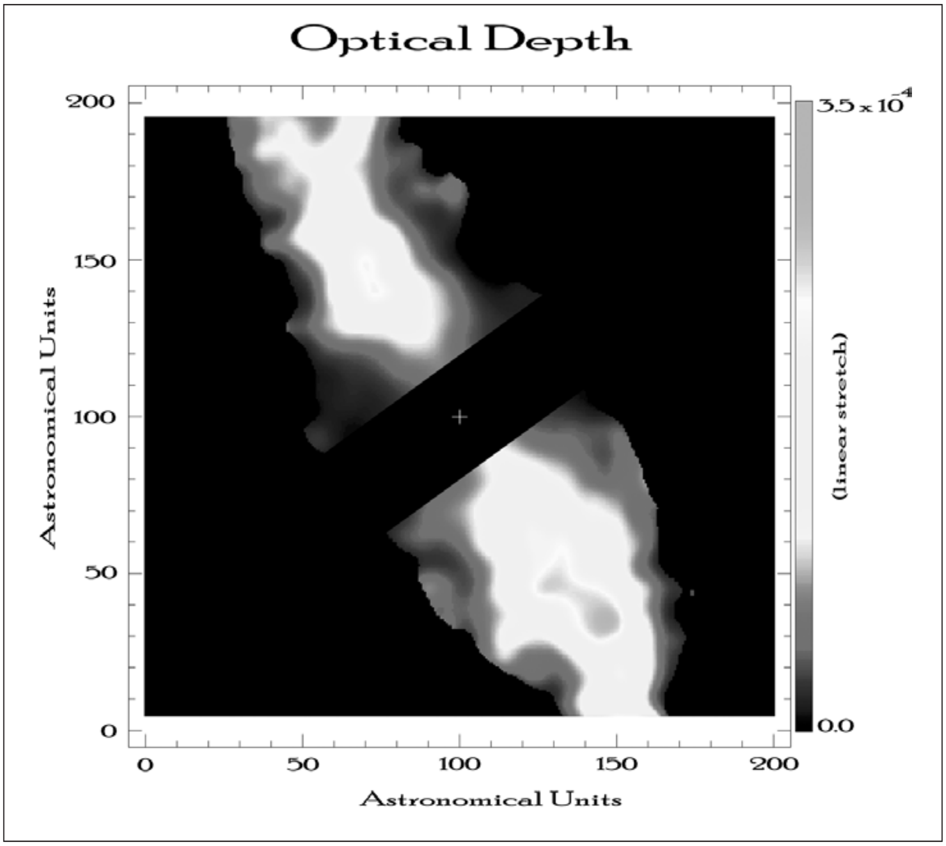

Figure 2: *Map of the optical depth of the dust in the Beta Pictoris disk. The optical depth is a measure of how dense the dust is along the line of site at a given point in the disk. The position of the central star is at the central cross. The inner 40 astronomical units of the map are blocked due to contamination from silicate emission, which skews the calculation of the optical depth. The red lobes on either side of the disk (see color image on the cover) likely represent a "ring-like" structure in the disk that is related to the "S curve" seen in* ***Figure 1****. This is additional evidence for perturbation of the dust by planetary bodies within the disk.*

This image shows that we have strongly detected the emission from the disk to a diameter of greater than 200 astronomical units. Perhaps the most striking features of ***Figure 1*** are the never before seen small-scale structures detected in the approximate mid-plane of the disk. The "S curve" shape seen in the southwest lobe (lower right) is particularly exciting since it may be direct evidence for one or more as-yet-unseen planetary companions orbiting the star. Ongoing modeling of the structure implies that this kind of structure is akin to the "wake" of the planet(s) as it travels through the disk and redistributes the dust through its gravitational influence.

Another exciting discovery in our data is the presence of what seems to be a ring-like structure within the disk. Evidenced by brighter clumps of emission seen symmetrically in both lobes of the 18-micron image, these "rings" likely trace regions of space where there is an enhanced density of the dust due to the shrouded planets sculpting the disk from within.

As we previously mentioned, a unique aspect of this data set is that we have detected emission from the disk at 10 microns to the same extent as at 18 microns. This is a significant point since observing the disk at two mid-infrared wavelengths gives us the information we need to investigate the temperature, density and even the size of the dust grains that are emitting the radiation.

In ***Figure 2***, we show a map of the optical depth of the dust in the disk. This is essentially a measure of how dense the dust is along the line of sight at a given point in the disk. Only possible due to the high-quality data we have at two mid-infrared wavelengths, this map provides us a first look at several previously unseen and exciting characteristics of the disk.

The central part of the image is masked out due to contamination of the optical depth map by emission from warm silicate grains in that region of the disk. On the broadest scale, we can see that the disk has a toroidal shape (think of a bagel turned on its side and cut in half; you can see the two lobes pointed toward us as the large green areas). The "doughnut" shape of the disk has been theorized for several years now and is not too surprising to see. However, the small-scale structures seen within the large lobes are entirely new. Analysis of these substructures has revealed that the densest part (the red areas on the cover color image) of the disk is likely related to the ring-like structure seen in the direct images. It is also interesting to note that the highest density region of the disk is spatially coincident with the "S curve"' seen in ***Figure 1***.

The line cut through the disk presented in ***Figure 3*** reveals perhaps the most exciting discovery yet. The area of low optical depth in the center of the disk represents a central cleared region that is essentially devoid of dust. Since we expect the dust to spiral into the star under the force of gravity in a relatively short period of time, the fact that this cleared region exists is the strongest evidence yet for planetary companions. Namely, we believe it is the presence of planets that are "sweeping up" the dust as it falls toward the star that keeps this region clear. Interestingly, the central cleared region is almost the exact size of our own Solar System. Given the much higher density of dust just outside this cleared region, we believe that what we are seeing in this map is the first mid-infrared detection of an exo-solar Kuiper belt.

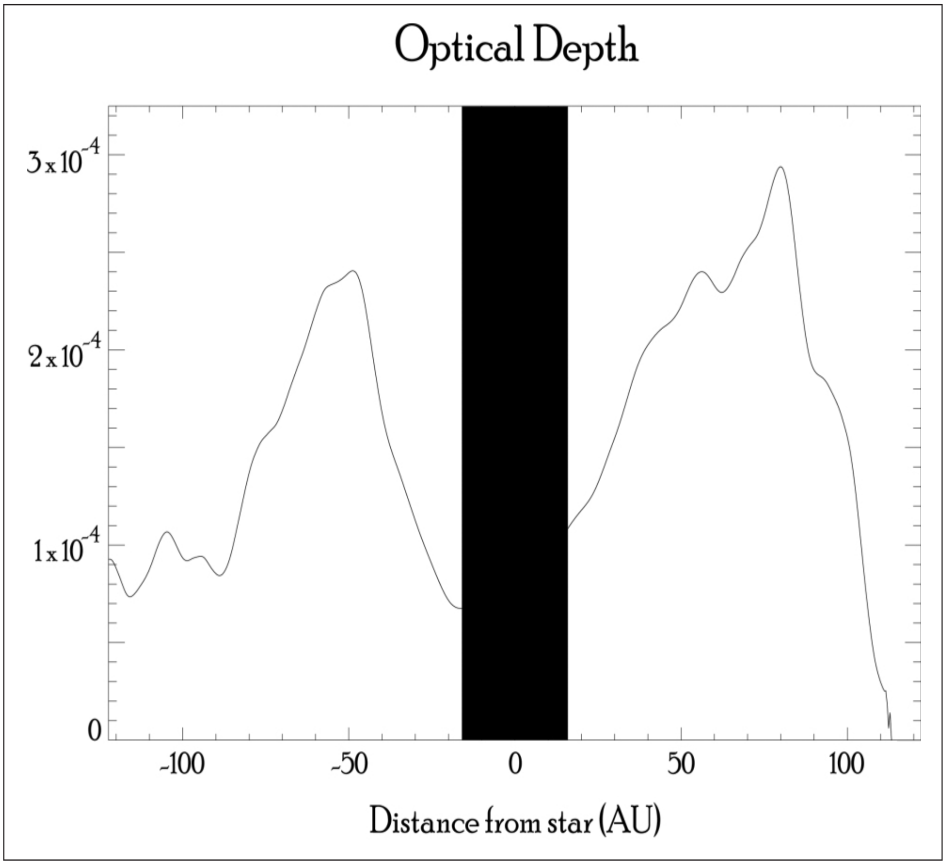

Figure 3: *Scan through the map shown in Figure 2. The scan runs through the peak in optical depth in the lower right and upper left (red spot on either side of the star). The lower values of optical depth in the center of the disk represent a central cleared region where there is little dust present. Similar in size to our Solar System, this inner hole seems to define the size of the Beta Pictoris planetary system and may be giving us our very first mid-infrared look at an exo-solar "Kuiper belt."*

Caught in the act of forming a planetary system, Beta Pictoris and its disk give us a snapshot glimpse at what we believe the Solar System looked like approximately 5 billion years ago. With an estimated age of around 20 million years, the central star and disk are very young, so young in fact we believe that the star has only recently reached the main sequence. However, it is in this early stage of evolution where the remnant material from the formation of the star itself aggregates and coalesces into bodies that will form, or have formed, into planets like those in the Solar System.

Probing the detailed structure of these disks is *exactly* the kind of project for which Gemini was intended. Designed from the ground up with infrared-optimization in mind, Gemini will be able to explore this (and other) circumstellar disks with unprecedented resolution and sensitivity. Using front-line, large-aperture telescopes like Gemini in the mid-infrared is the best way to see through the cradles of dust hiding these baby solar systems, which in turn will let us extend the understanding of the origin of our own Earth.

THE GEMINI DEEP DEEP SURVEY:

Status Report and Overview of the GMOS Nod-and-Shuffle Mode

The Gemini Deep Deep Survey Team

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Conventional spectroscopy of galaxies at redshifts of 1<z<2 suffers from technical challenges and the lack of strong spectral features at visible wavelengths. To date, near-infrared spectroscopy has yielded results for only a handful of high-star-formation-rate objects, and the multiplexing advantages of multi-aperture near-infrared spectrographs are modest at best. In principle, redshifts and diagnostic spectra can be obtained over 1<z<2 via ultradeep, poisson-limited spectroscopy on 8-meter-class telescopes, by targeting weak absorption features in the rest ultraviolet spectra of galaxies. However, unless exposure times are short (less than a few hours), Multi-Object Spectrograph (MOS) spectroscopy with 8-meter-class telescopes is generally not photon-limited. The main contributors to the noise budget are imperfect sky subtraction and fringe removal. The product of these difficulties is the so-called redshift desert, a paucity of optical redshifts at 1<z<2.

The position in redshift space of this redshift desert is a major problem for studies of galaxy evolution because it seems to span the major epoch of galaxy building. Intermediate-redshift surveys e.g., *Canada-France Redshift Survey (CFRS;* Lilly, et al., 1995) reveal that 50 to 100 percent of the stellar mass in L>L* galaxies was in place by z=1. At higher redshifts, the Lyman Break galaxies contain approximately (~) 20 percent of the present-day stellar mass (Shapley, et al., 2001). Therefore, the redshift range over which most of the mass is being built up in galaxies is exactly the range in which spectroscopic redshifts are notoriously difficult to obtain.

One way forward out of this dilemma is to use an innovative new approach to sky subtraction and multiplexing known as "nod and shuffle" (Glazebrook & Bland-Hawthorn, 2001; Cuillandre, et al., 1994). "Nod and shuffle" (N&S) is a mode of observing where parts of the charge-coupled device (CCD) are used as a "storage register" in a beam-switched image. Beam-switching is achieved by rapid alternation between object and sky positions ("nodding"), which is undertaken with no readout penalty. Instead, the sky image is shuffled to a storage region. Typically, nodding takes place every 30–60 seconds, which is a timescale faster than the variations of airglow emission lines. Because both the sky and objects are observed quasi-simultaneously through the same optical path, slits and pixels, N&S provides an order of magnitude improvement in sky subtraction opening up significant new observational capabilities for large telescopes. For example, very deep integrations (ten times longer than is practical with conventional spectroscopy) are possible with N&S at very high slit densities.

GMOS Nod and Shuffle

In the last 12 months, our team proposed, developed and commissioned a nod-and-shuffle mode for the Gemini Multi-Object Spectrograph (GMOS) in order to undertake the *Gemini Deep Deep Survey (GDDS)*, the deepest redshift survey ever undertaken. This work was performed using the Frederick C. Gillett Gemini Telescope (Gemini North) on Mauna Kea, Hawai'i. The resources for this effort were provided by a unique university-institutional partnership bringing together the Gemini Observatory, the Herzberg Institute of Astrophysics (HIA), the National Optical Astronomy Observatory (NOAO), Carnegie Observatories, Johns Hopkins University and the University of Toronto. Early results from our survey will be shown at the end of this article, and all data from the GDDS will be made publicly available soon at the project website (http://www.ociw.edu/lcirs/gdds.html).

Nod and shuffle is now a fully supported common-user mode for GMOS. The GMOS implementation of the mode represents a significant technical advance in two ways: (1) this is the first time N&S has been implemented on an 8-meter-class facility, and (2) this is the first time N&S has been used to shuffle multiple CCDs (the three GMOS EEVs, simultaneously).

Since this mode will be of interest to many readers of this newsletter who are not followers of recent developments in faint galaxy evolution, we briefly digress from our survey to describe the basic nod-and-shuffle concept and its specific implementation on GMOS before describing the early results from the GDDS in the next section. Readers interested in the details of GMOS N&S at a level beyond that which we have space for here are referred to the following web page: http://www.gemini.edu/sciops/instruments/gmos/gmosIndex.html.

It is important to emphasize that in most ways N&S observing with GMOS is the same as normal observing with the instrument. However, life is far simpler with N&S mode once the photons have been collected because sky subtraction is reduced to a trivial operation e.g., a single Image Reduction and Analysis Facility (IRAF) command that subtracts the skies as an entire frame of data in one step automatically. As will be described below, the added complexity of N&S comes at the initial mask design stage.

The observing procedure for N&S is as follows:

1) Calibration data (arcs/flats/standards/etc.) are obtained in the normal way. It is not necessary to shuffle these. In fact, it may not even be necessary to use them to first order N&S as it makes bias and flat field corrections unnecessary. For higher order corrections, it may be necessary to shuffle bias/dark frames. If biases and darks are to be taken in N&S mode, then for bias frames the number of nod and shuffle cycles (described below) should be the same as for the science observations. For dark frames, all parameters should be identical to those for the science observations.

2) The field should be acquired in the normal way by centering the reference stars in their mask apertures.

3) Guide stars should be set up on probes, and their placement should bear in mind the nod vector.

At this point several parameters must be set before N&S observations can be initiated. These are: (i) the shuffle distance, Y; (ii) the subintegration time; and (iii) the number of subintegrations. With the specification of these parameters, the N&S observation can be initiated. The observing system proceeds by activating the following nod-and-shuffle sequence:

1) An observation is taken at a first position on the sky (position A) while guiding.

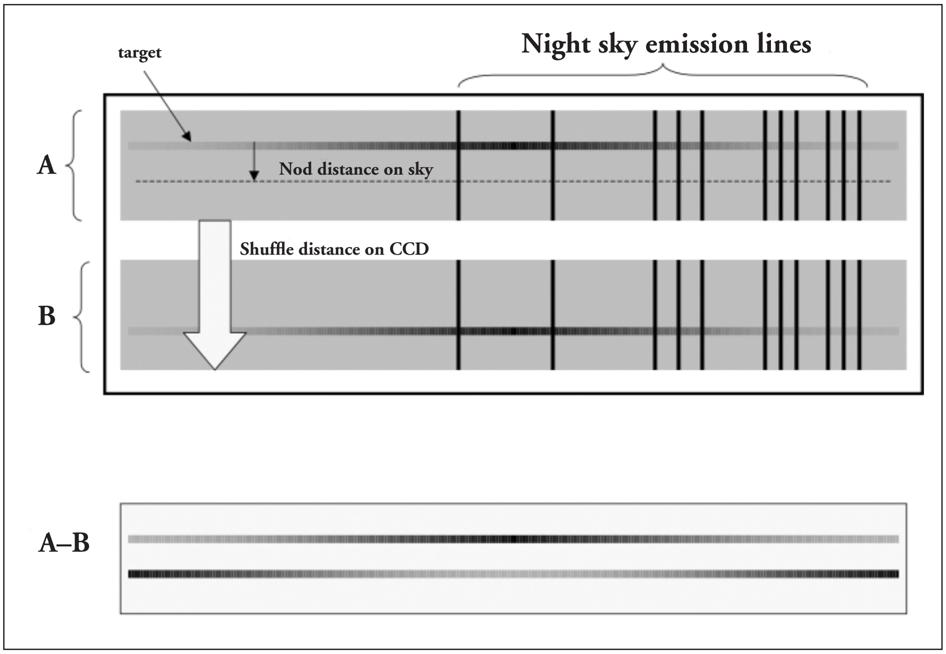


Figure 1: Schematic of nod-and-shuffle for a single slit. When the telescope is in the "object" position, CCD area "A" records a spectrum. The "sky" position records the nodded spectrum (in this case the telescope has been nodded a few arcseconds along the slit direction). The area "B" is non-illuminated by the mask and serves as a storage area for the "sky position." The image difference subtracts the sky, and leaves a positive and negative object spectrum for subsequent extraction.

2) The shutter is closed, and charge is shuffled by +Y pixels.

3) The telescope is moved to a second position (position B).

4) The shutter is opened at position B, and the observation is continued.

5) The shutter is closed, and charge is shuffled by -Y pixels.

6) The telescope is moved back to position A.

7) The procedure is iterated until the exposure is complete. The final exposure time is the product of the subintegration time and the number of subintegrations.

In addition to these steps, we have found that (because of low-level charge traps in the EEV detectors) the quality of combined N&S spectra is enhanced by dithering the GMOS detector controller translation stage and central wavelength position slightly between long exposures.

The common case of nodding along a slit is shown schematically in ***Figure 1*** for a single slit. The close coordination required between telescope motion and charge motion embodied by this sequence is fully automated. Once initiated, it is transparent to the observer at the telescope. All that is required to subtract the sky from the spectrum is to subtract the sky portion of the CCD image from the object portion of the CCD image (conveniently accomplished with the *gnssky* subtask in the Gemini IRAF software distribution). At this point, the sky-subtracted spectrum can be extracted in the usual way with the usual tools. As will be described below, some mask designs allow the object to be observed at a different position on the slit, or on a separate slit, while the telescope is at position B. In which case, a positive and negative object spectrum results, and the two must be extracted separately (and the latter needs to be multiplied by -1 before the two spectra added together can maximize the signal-to-noise ratio).

A trade-off between observing efficiency and multiplexing lies at the heart of N&S, and this can make mask design quite tricky. The optimal mask design depends sensitively on target brightness and sky density. For example, one may choose to maximize multiplexing using many

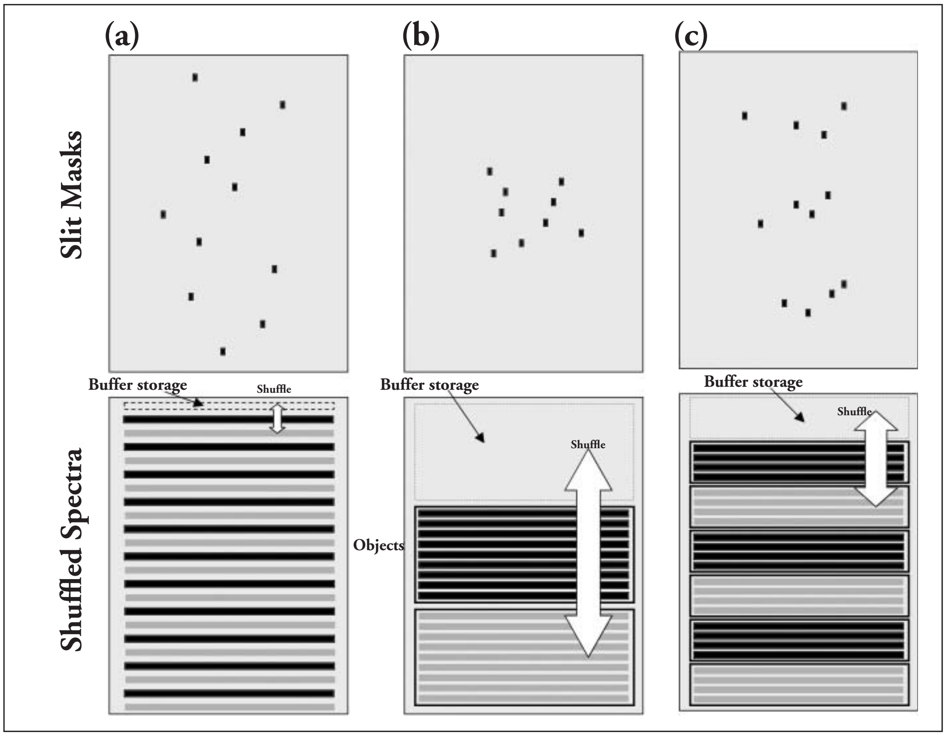


Figure 2: Illustration of masks with different shuffle distances. The top row shows the input masks, and the bottom row shows the resulting shuffled object-sky spectra. The black spectra correspond to image A in Figure 2, and the light grey spectra correspond to image B in the same figure; (a) a mask where the shuffle is only a few pixels, and the sky is stored below the object – appropriate for extended, relatively low-source-density regions. (b) a mask where the shuffle is large, appropriate for cases with compact regions of high-source density. (c) an intermediate case. This compromise has the advantage of allowing a high-density extended field to be tacked while minimizing the number of object-storage interfaces where it is necessary to leave gaps. Note that in reality the area we have shown as a single "detector" is three CCDs (in GMOS, these are arranged left to right).

small slits ("microslits"), or even holes, as an extended slit is not required for sky-subtraction. Alternatively, one may wish to maximize on-source integration time by observing the object in both the nominal "object" and "sky" positions in which case it is either necessary to have a long enough slit to accommodate the nod or to have a pair of holes. Some of the considerations and some suggestions for mask design are illustrated in ***Figure 2***. We illustrate two extreme cases as well as an intermediate case, which in many circumstances will be the best compromise:

Case 1 (***see Figure 2a***): The shuffle distance is small, and the sky image is recorded immediately below each object image. In this limit (for high densities), 50 percent of the detector is used for storage. The packing density is limited by the necessity to leave small gaps between the images to allow for the Point Spread Function (PSF) width. This case is perhaps the easiest to deal with as it requires no modification to the mask-making software. One can design effective masks by just pretending the effective slit length is bigger, and by nodding along the slit. This is a good mask design strategy if the density of the most interesting sources is sufficiently low.

Case 2 (***see Figure 2b***): The whole field is shuffled in one large shuffle. In this case, 66% of the detector must be used for storage, which is larger than ***Case 1***, but still less than standard MOS modes. This would be a good design for fields in which a compact distribution of objects is to be observed (such as a grouping of HII regions or emission-line knots in a single galaxy).

Case 3 (***see Figure 2c***): An intermediate case. In many cases, a design such as this is probably optimal in terms of packing density and minimization of storage overhead. Here the number of interfaces between object-sky regions in the mask is reduced since these have to be greater than the instrumental PSF width.

For the *GDDS*, we chose to use a ***Case 1*** mask design because our prime targets (infrared-selected candidate 1<z<2 galaxies) have a source density low enough (~50 to 100 objects/mask) that extreme multiplexing is not required.

Early Data From the Gemini Deep Deep Survey

The *GDDS* is a joint US-Canadian Band-1 Gemini redshift campaign targeting galaxies at 1<z<2. Four independent fields are being observed with GMOS for ~100,000 seconds each to a limiting magnitude of I(AB)=24.7. The

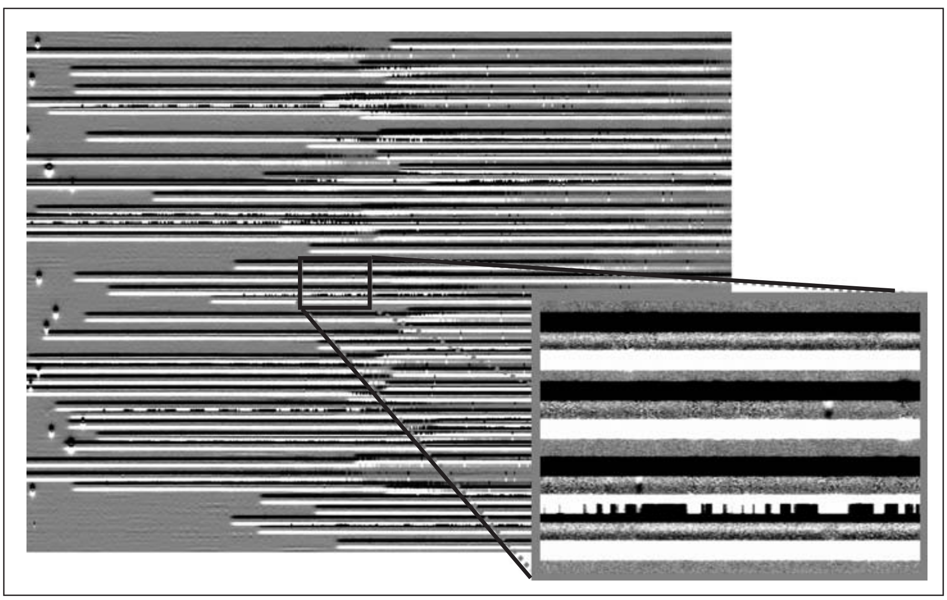


Figure 3: An image showing the "supercombined" GDDS 22h mask. Object spectra are sandwiched between positive and negative sky spectra on the mask. The inset shows a blow-up of a small region showing part of four spectra. These show positive and negative continua and emission lines.

microshuffling mode of N&S allows us to observe 65 to 85 red-selected galaxies in each 5'x5' GMOS field. Two fields have been completed to date, and the two remaining fields are being observed in semester 2003A.

Our sample is taken from the *Las Campanas Infrared Survey (LCIR)* and is K-band selected to a limit of K=20.8 that is nearly a magnitude deeper than the K20 survey (McCarthy, et al., 2001; Chen, et al., 2001; Firth, et al., 2001). Photometric redshifts from the 8-color LCIR imaging survey allow us to reject the z<1 foreground. The high-slit density afforded by N&S allows us to add additional I-band-selected and photo-z-filtered objects in regions of the field devoid of suitable K-selected objects. A sky-subtracted GMOS frame showing how this sky density is translated to spectral coverage on the CCD frame is shown in ***Figure 3***. This frame is the result of running a combined data frame through the Gemini IRAF package's *gnssky* subtask, which is used to subtract a shifted copy of the image from itself, resulting in regions of clean-sky-subtracted slits sandwiched between light and dark bands that correspond to noise where the data has been subtracted out-of-phase.

The *GDDS* is presently achieving >90 percent spectroscopic completeness and median spectroscopic redshifts of z=1.1 to 1.2 with essentially no contamination by galaxies at redshifts z<0.8 and a tail to z=2 in each field. The total *GDDS* sample will be comprised of ~300 galaxies with redshifts at 0.8<z<2.0. Approximately 150 of which are candidate early-type systems. Our focus is squarely upon the most massive systems at high redshifts. Unlike most high-redshift surveys, we are not biased in favor of selecting high-star-formation-rate systems. Around 40 percent of the redshifts in our sample are of pure absorption-line galaxies with no detectable (or at best very weak) emission features. Representative spectra from the *GDDS* are shown in ***Figure 4***. The first spectrum is of a post-starburst elliptical galaxy at z=1 that is near both

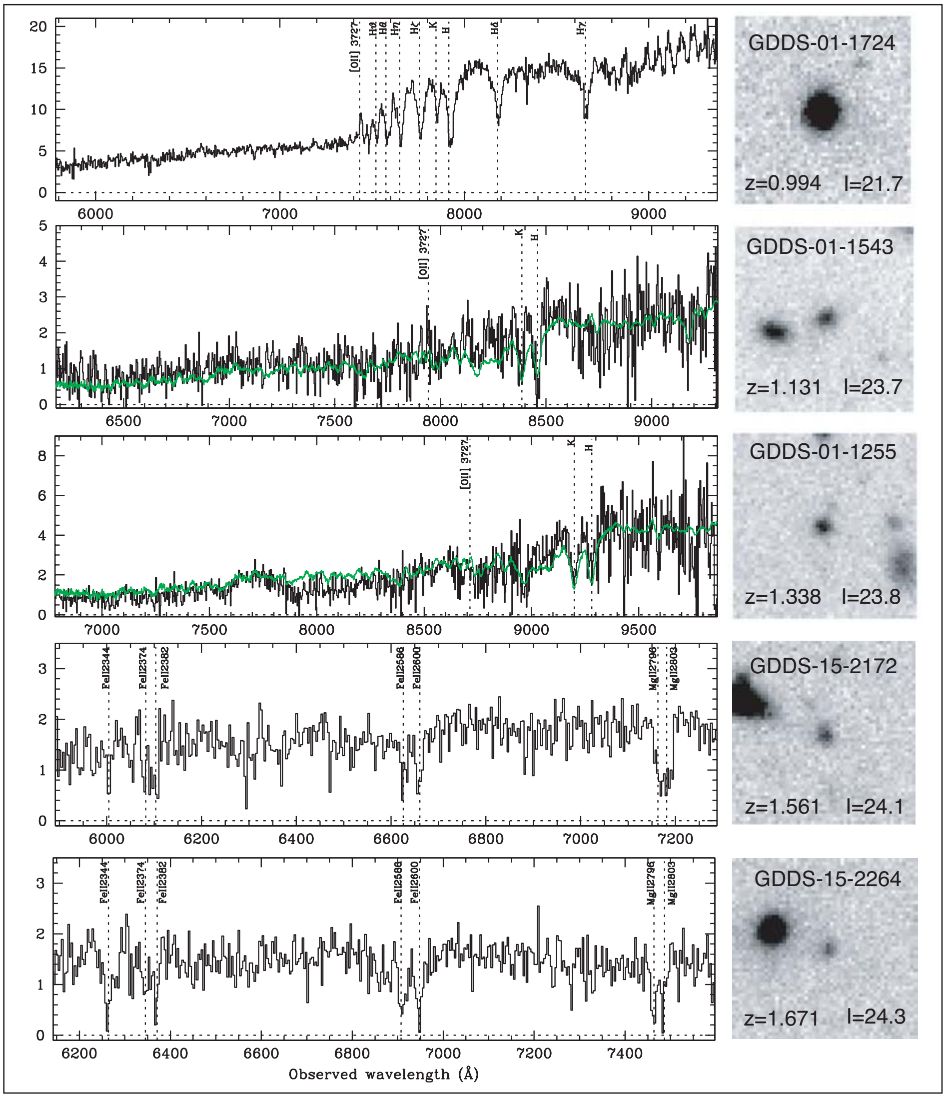


Figure 4: *Montage of 100ks Gemini GMOS nod-and-shuffled spectra from the GDDS. Ground-based I-band images (in ~0.8 arcsecond seeing) are shown at right. Objects shown span a redshift range of 0.994<z<1.671 and a magnitude range of 21.7<I<24.3 magnitude. A post-starburst system with prominent Balmer absorption features is shown at top followed by two quiescent early-type systems (with early-type spectral templates superimposed). About 40 percent of the red population shows similar spectra. The bottom two spectra show blue ultraviolet continua, consistent with recent star formation, together with narrow interstellar medium (ISM) absorption lines (MgII, FeII).*

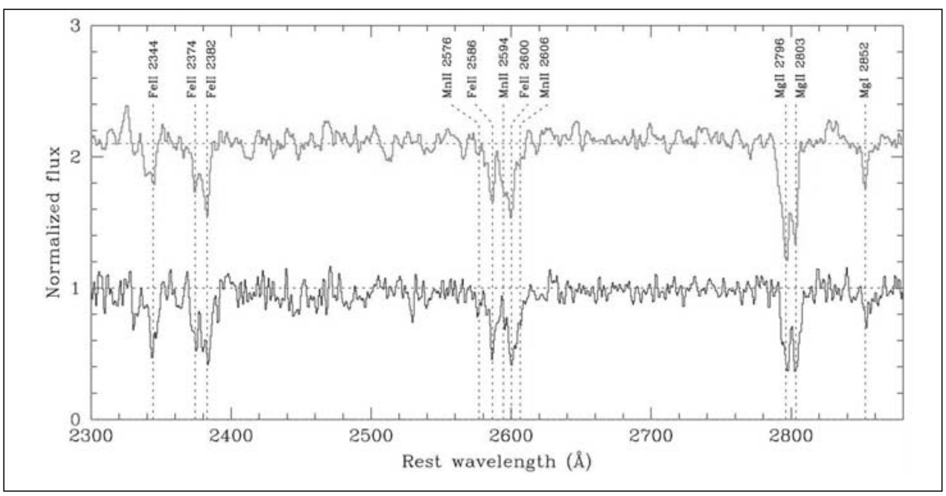


Figure 5: *Lower black curve: Composite GDDS spectrum of 13 galaxies with strong ISM absorption lines. The redshift range covered by the spectra is 1.260<z<1.895 (with a mean of z=1.53). This sample represents about 29 percent of the total number of galaxies detected by the first two masks of the GDDS in the redshift interval 1.13<z<2.00. Detected absorption features are marked by the dotted lines. As a reference, we also show the composite spectrum of 14 local starburst-dwarf galaxies observed with HST/FOS (upper gray curve). This spectrum has been magnified for comparison.*

the redshift and magnitude limit of the *CFRS*. This spectrum illustrates the spectacular signal-to-noise ratio achieved in 100ks with Gemini/GMOS for galaxies near the limits of the previous generation of surveys. Each of the four other representative spectra demonstrate our ability to determine absorption line redshifts squarely in the middle of the so-called redshift desert, and show canonical ultraviolet spectral features and the typical signal-to-noise achieved for fainter galaxies in our sample. GDDS-01-1543 (z=1.13) and GDDS-01-1255 (z=1.34) are well matched by a local early-type galaxy template (overlaid on the object spectra in the figure), while GDDS-15-2172 (z=1.56) and GDDS-15-2264 (z=1.67) show narrow metallic absorption features characteristic of local starbursts and originating in the galaxies' interstellar medium (ISM).

The K-band-selected objects in ***Figure 4*** that are red at rest visual wavelengths but which show blue rest-ultraviolet continua are particularly interesting. ***Figure 5*** shows a composite spectrum obtained by combining individual spectra for 13 such systems at 1.3<z<1.9. The resulting spectrum is quite comparable in signal-to-noise to a stack of 14 local dwarf-starburst spectra obtained with HST/FOS (kindly supplied by C. Tremonti) and also shown in the figure. The *GDDS* spectral database is of sufficiently high signal-to-noise to allow a myriad of uses aside from the basic goal of obtaining redshifts. The column density distribution implied by the narrow ISM lines in this figure will be the focus of one of the first *GDDS* papers (Savaglio, et al., 2003) prepared by our team.

A comparison between the colors and redshifts of GDDS galaxies and those of local samples and of Lyman Break galaxies from the Hubble Deep Field (HDF) is shown in ***Figure 6***. This figure illustrates the remarkable success of the *GDDS* in opening in probing the poorly understood 1<z<2-redshift range. More importantly, the figure also shows that the *GDDS* is opening up this redshift range in a manner that is unbiased with respect to star-formation rate. This is in sharp contrast to studies with strong star-formation rate-selection biases, such as infrared surveys targeting emission lines at similar redshifts to the *GDDS*, or Lyman Break selection at higher redshifts. The colors of Lyman Break galaxies in HDF are ~2 magnitudes bluer than our sample. Because of its depth and underlying infrared selection characteristics, the *GDDS* is at present the only redshift survey capable of constraining the space density of quiescent, evolved, massive early-type galaxies at the peak epoch of galaxy assembly.

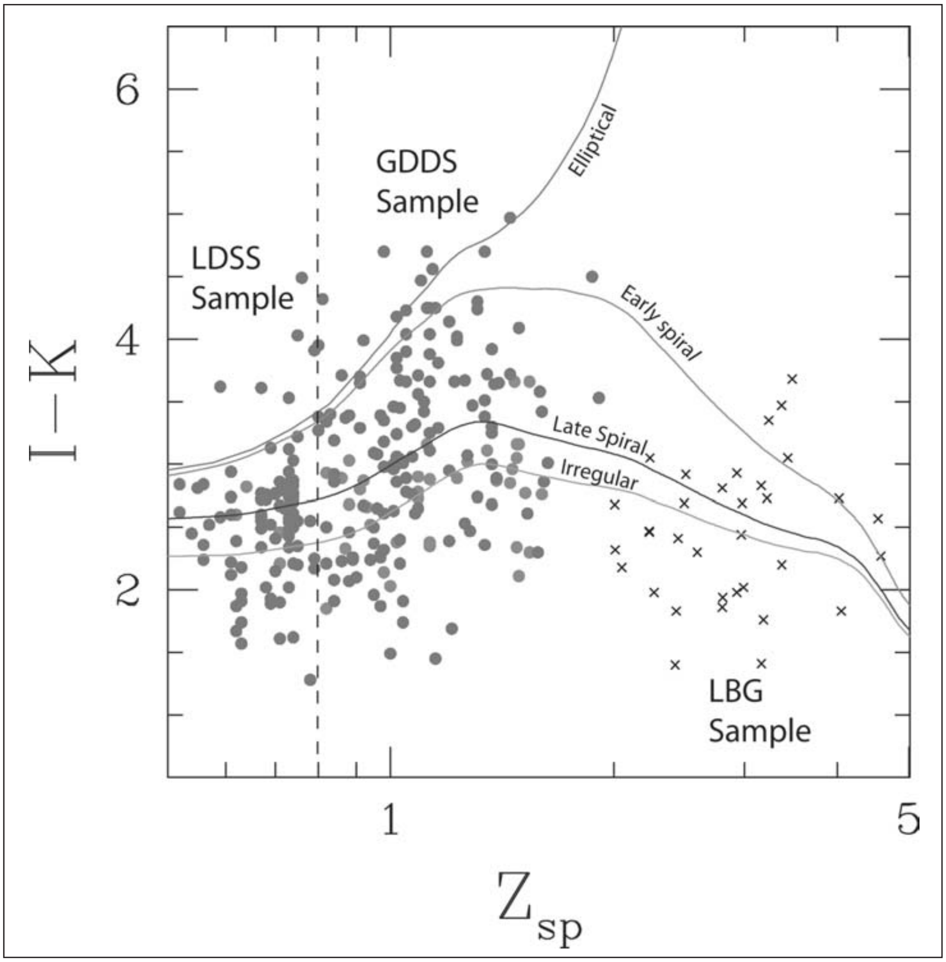


Figure 6: *I-K color as a function of redshift for the GDDS + LDSS (Low-Dispersion Survey Spectrograph) sample (solid circles) and for a sample of Lyman Break galaxies (crosses) in the HDF (courtesy of Mark Dickinson and collaborators). Note that the GDDS has few galaxies at z<0.8 (none at all in our latest mask), and the z<0.8 points shown come from LDSS spectroscopy of the GDDS fields we have undertaken with Magellan. Conversely, almost all points at z>0.8 are from the GDDS. Tracks correspond to the predictions of spectral synthesis models for a variety of star-formation histories. Note how the GDDS spans nearly the whole of the so-called redshift desert at 1<z<2, and is sensitive to the full range of possible star-formation histories, including quiescent early-type systems that may hold substantial mass yet remain undetectable in other surveys. Points shown in lighter gray are fainter than the K-band magnitude limit of the survey but were included to fill unused portions of our masks.*

REFERENCES:

Chen, H.W.; McCarthy, P. J.; & Marzke, R. O., et al., 2002, Ap.J., 570, 54.

Chen, H.W.; Marzke, R. O.; & McCarthy, P. J., et al., 2003, Ap.J., in press.

Cuillandre, J. C., et al., 1994, A&A, 281, 603.

Firth, A. E.; Somerville, R.; & McMahon, R. G, et al., 2002, MNRAS, 332, 617.

Glazebrook, K. & Bland-Hawthorn, J., 2001, PASP, 113, 197.

Lilly, S., et al., 1995, Ap.J, 455, 108.

McCarthy, P. J.; Carlberg, R. G.; Chen, H. W.; & Marzke, R. O., et al., 2001, Ap.J., 560, L131.

Shapley, A., et al., 2001, Ap.J., in press (astro-ph/01073234).

Steidel, et al., 1999, Ap.J., 519, 1.

RECENT SCIENTIFIC HIGHLIGHTS

Jean-René Roy & Phil Puxley

The year 2002 was the first year of abundance for referred papers based on data from the Gemini telescopes. Twenty-four papers (compared with two in 2001) were published in the main reference journals. The majority of them were based on data obtained with the visitor instruments OSCIR and Hokupa'a on the Frederick C. Gillett Gemini Telescope (Gemini North), and four papers were from data obtained with the Gemini Multi-Object Spectrograph on Gemini North (GMOS-N). The first paper from Gemini South based on data obtained with the high-resolution spectrograph Phoenix was published in December 2002. The first Near-Infrared Imager (NIRI) paper appeared in March 2003, a study of host galaxies of z approximately (~) 4.7 quasars.

Recently, a top highlight has been the implementation of the nod-and-shuffle technique on both GMOS North and South. An international team led by Bob Abraham (University of Toronto) and Karl Glazebrook (John Hopkins University) in close collaboration with Gemini staff has provided Gemini with a unique and very powerful technique, which counters the fluorescence of the night sky that contaminates the far-red end of the optical spectrum. The result of this work is that Gemini can obtain much deeper spectra in this spectral region than has ever been possible before. Called "nod and shuffle," this technique synchronizes a small shift in the telescope's pointing on the sky with a precise shuffling of the images on a charge-coupled device (CCD) detector. This results in a significant increase in the signal-to-noise ratio of the data. Using this technique, Gemini astronomers have discovered that the apparent "redshift desert" of galaxies, which was thought to exist at an epoch of about one-third to one-half the age of the Universe, is actually well populated with galaxies representing the various stages of evolution. More details are given in the previous article (starting on page 4) in this issue.

Companionship in Low-Mass Stars

Finding large Jupiter-like planets around nearby stars has been the goal of several programs using the University of Hawaii's Hokupa'a adaptive optics system on the Gemini North telescope. Although no Jupiter-like planets have yet been found, the exploration of several stars has revealed a relatively high number of brown-dwarf stars, which are a sort of celestial hybrid between a giant planet and a small star. Brown dwarfs have masses less than 7 percent that of the Sun and 100 times that of giant planets like Jupiter. A brown dwarf's low mass doesn't allow for nuclear fusion, but does allow for planetary characteristics such as atmospheric weather.

The study of low-mass stars by Laird Close and his collaborators at the University of Arizona has led to some surprising results. This work comes the closest yet to a large program on Gemini, as evidenced by the amount of excellent data that were obtained, analyzed and published.

Compared to their more massive cousins, low-mass stars of about one-tenth or less the mass of our Sun come in pairs more often and form much tighter orbiting systems. This unexpected finding was disclosed by Laird Close, Melanie Freed, Nick Siegler and Beth Biller of the University of Arizona using the adaptive optics system Hokupa'a on the Gemini North telescope. Their observations also showed that many low-mass star systems have brown-dwarf companions ***(Figure 1)***. This research indicates that the frequency of brown-dwarf companions

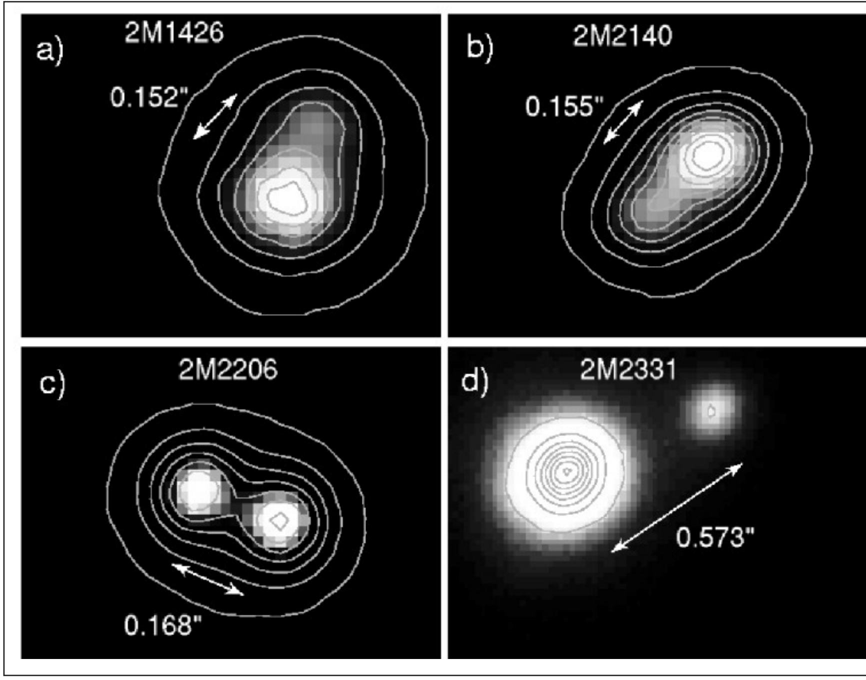


Figure 1: *Low-mass stars come more often in pairs and form tighter systems than their more massive cousins. The four images obtained with the adaptive optics system Hokupa'a on Gemini North are part of a survey done by Laird Close and his University of Arizona colleagues. The size of the arrows shows the angular distance in arcseconds between the two components, and the scale is comparable to the approximate distance between our Sun and Jupiter or Saturn. (Gemini Observatory)*

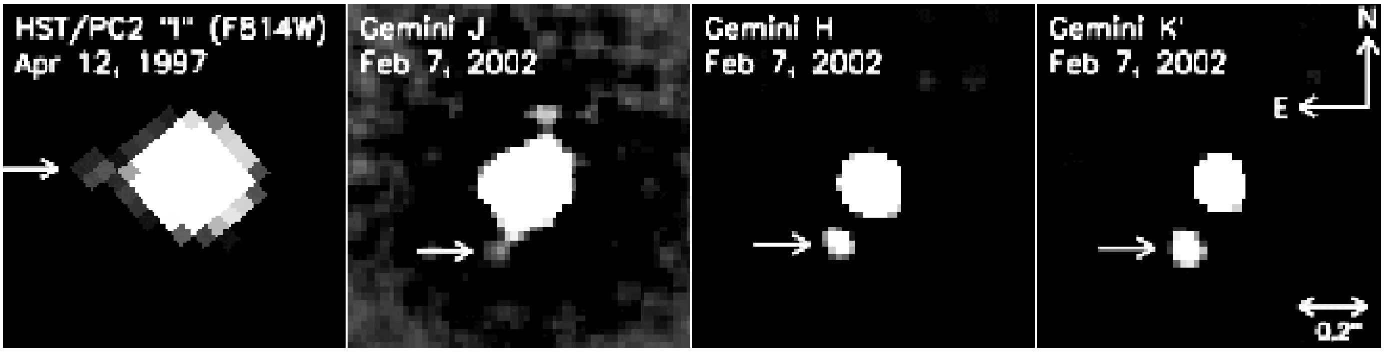


__Figure 2:__ The tightest-orbiting brown-dwarf companion ever directly imaged was discovered around low-mass star LHS 2397a. The faint companion completes its orbit around the parent star every 20 years. The first image on the left is an image at visible wavelength obtained with the Hubble Space Telescope on April 12, 1997. The brown dwarf is seen as the very faint object at 9 o'clock and is very difficult to detect in this unenhanced image. The next three images were obtained using adaptive optics in the near-infrared wavelength (J, H, K band) on Gemini North about 5 years later (February 7, 2002).

__Figure 3:__ The binary low-mass star system LHS 2397a (also shown in __Figure 2__) contains the closest brown-dwarf companion ever spotted (imaged) around a star. This system is located about 50 light-years away, and the companion orbits at a distance that is less than the distance of Jupiter from our Sun. The brown-dwarf companion is the fainter object at about the 7 o'clock position in this image. The system, found by Melanie Freed and her team at the University of Arizona, used adaptive optics on the Gemini North telescope to obtain this data. (Gemini Observatory)

to very-low-mass stars can be up to 20 times that of Sun-like stars. This comes as a surprise since there is a distinct lack of brown-dwarf companion detections at small separations from Sun-like stars. From giant planets searches, it is estimated that only about 0.5 percent of stars have brown-dwarf companions within 3 astronomical units. This paucity of brown dwarfs in normal stars has been referred to as the "brown-dwarf desert."

The very-low-mass binaries are tight and also tend to have companions that are nearly equal in mass. While there is a dearth of wide systems, the absence of a brown-dwarf desert in tight, low-mass pairs has profound implications on how we think low-mass binaries might form and evolve.

It is theorized that "gravitational kicks" eject preferentially low-mass stars through interaction with other stars in stellar clusters where stars are born. If the stars are pairs or multiple systems, this kicking process selectively unbinds wider and looser systems, while allowing tighter systems to survive. Understanding the mechanism that forms tight-orbiting low-mass stars may also throw light on why such a wide variety of planetary system configurations exists, many of which have giant planets with masses and properties approaching those of brown dwarfs.

The Arizona team also imaged the tightest-known brown-dwarf-star pair around the low-mass star LHS 2397a. Located at about 50 light-years from our Sun, this binary system represents the first clear example of a brown-dwarf orbiting within 4 astronomical units of its parent star — this is less than the orbital distance between Jupiter and the Sun ***(Figures 2 and 3)***.

Watching the Clouds and Probing the Icy Highlands of Titan

Saturn's moon Titan, the second-largest moon of the Solar System, is surrounded by a thick atmosphere of molecular nitrogen with a few percent methane. This atmosphere appears to host a variety of meteorological features that show a seasonal cycle.

Titan's apparent angular diameter from Earth (~0.8 arcsecond) can be resolved from the ground only with advanced techniques such as adaptive optics. The opacity of Titan's stratospheric haze decreases sharply with wavelengths across the visible into the infrared. There are narrow spectral windows in the near-infrared between methane bands through which it is possible to probe Titan's surface and lower atmosphere.

Henry Roe at the University of California, Berkeley and his collaborators used adaptive optics on the Gemini North and Keck II telescopes to study the tropospheric haze and the discrete clouds of Titan, and to probe its surface ***(Figure 4)***. Their observations have revealed that the southern hemisphere shows more cloud activity than the northern one ***(Figure 5)***. Since no tropospheric brightening is seen in the far northern latitudes of Titan, it is suggested that the south polar haze and clouds are of a seasonal origin. During the Titan summer (as is currently the case in it's northern hemisphere in April 2003), the haze bank is depleted of high concentration of molecules, such as C_2H_4, C_4N_2, CH_3CN and C_3H_8, and cloud activity ceases, especially near Titan's north pole ***(Figure 5)***. During Titan's long winter (~8 Earth years long), lack of sunlight drives the chemistry of the lower polar stratosphere towards an extremely different equilibrium relative to the sunlit stratosphere. This increases

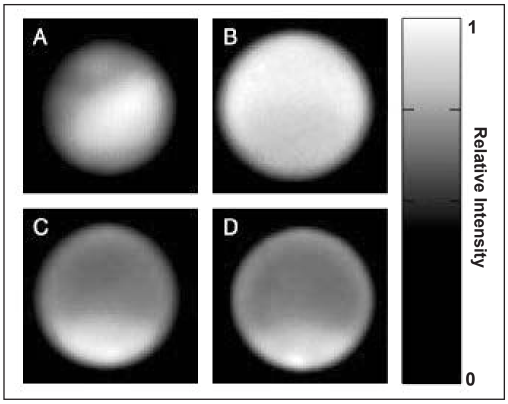


__Figure 4:__ Hokupa'a/Gemini images of Titan obtained with Gemini North using a filter probing the surface of Titan on December 7–9, 2001. Image A corresponds to the surface of the moon, and B probes its mid-stratosphere. Images C and D show the lower troposphere. The bright feature at the southern pole (C and D) is the so-called bright continent. This may be an icy highland surrounded by seas or lakes of hydrocarbons. The true nature of Titan's surface and the composition of the dark and bright areas remain unknown.

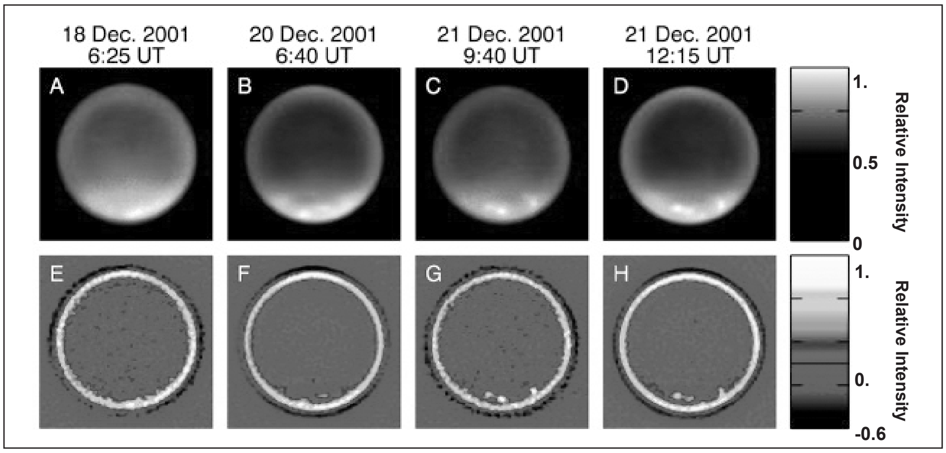


__Figure 5:__ Keck II adaptive optics images of the clouds on Titan during December 18–21, 2001. A special filter probing the troposphere was employed. Cloud activity in the south of the moon increased from December 18 (A, E) to December 21 (C, G) and (D, H). The bottom row of images is the result of a wavelet transform of the images.

the concentration of the above molecules, a process that favors condensation and cloud formation (happening now in the southern hemisphere of Titan). The cloud activity that we now see at Titan's south pole will cease when another Titan southern spring occurs in 2026.

Meanwhile, the Cassini spacecraft due to arrive at Titan next year will be able to look for these southern polar clouds. If the mission remains active for more that 4-5 years, it will monitor the start of spring cloud activity at Titan's north pole.

Speeding Massive Star Plows Through Interstellar Dust and Gas Near the Galactic Center

Located 25,000 light-years from the Sun in the direction of the constellation of Sagittarius, the nucleus of the Milky Way is host to numerous high-energy phenomena including a supermassive black hole estimated to weigh in at some 3 million times the mass of our Sun, which makes our galaxy's nucleus environment very dynamic and a source of weird phenomena. There are also several bright and compact objects whose nature, morphology and origin are unclear. Most of these objects are hidden from ultraviolet and optical observations because of the high dust content along the line of sight to the Galactic Center. However, infrared detectors and adaptive optics allow us to peak right through to the very nucleus of our Galaxy.

IRS-8, a strong emitter at infrared wavelengths, has long been one of the mystery objects in the central stellar cluster at the Galactic Center. François Rigaut, Tom Geballe and Jean-René Roy from the Gemini Observatory, and Bruce Draine of Princeton University have analyzed the exquisite Galactic Center images obtained with the University of Hawaii's adaptive optics camera Hokupa'a-QUIRC on the Gemini North telescope in order to study the source IRS-8. The object is located about 4 light-years north of the Galactic Center ***(Figures 6 and 7)***.

The adaptive optics images have revealed that the short-wavelength infrared emission from IRS-8 is largely in the form of a spectacular bow-shock surrounding a central star ***(Figure 7)***. The dust in the bow-shock is heated and radiates because it is compressed. It also absorbs ultraviolet radiation from IRS-8 itself and from the ambient Galactic Center energetic radiation field.

The interstellar bow-shock is produced by a massive star, embedded in a dense wind envelope, moving at supersonic speeds e.g., tens or hundreds of kilometers/second, into the surrounding gas/dust of the interstellar medium. The phenomenon is not unlike the bows created by ships or other crafts moving in water (except that the water does not compress). With its apex at about 0.03 light-years (or 1,000 times the Earth-Sun distance) from the central star, the IRS-8 bow-shock is about 100 times smaller than all other known bow-shocks formed by speeding stars.

The reason for this compactness is the high density of the gas and dust through which IRS-8 is moving. Independent infrared and radio observations indicate that the density of the gas/dust is 100 to 1,000 times higher than the average interstellar density in the Milky Way. IRS-8 may actually be colliding with the "Northern Arm" of our Galaxy, a region of high-density molecular gas that has been mapped by infrared and radio observations.

The second reason for the bow-shock's tightness is the high velocity of the star. If the stellar wind properties of IRS-8 are normal, the bow-shock geometry and size require a space velocity of approximately 150 kilometers/second, which is not unusual for objects within a few light-years of a supermassive black hole like IRS-8. Using the axis of the bow-shock to give the direction of motion, IRS-8 could have been in the vicinity of the nucleus about 10,000 years ago. It is possible that IRS-8 was flung out of the central cluster of stars by gravitational interactions at the time.

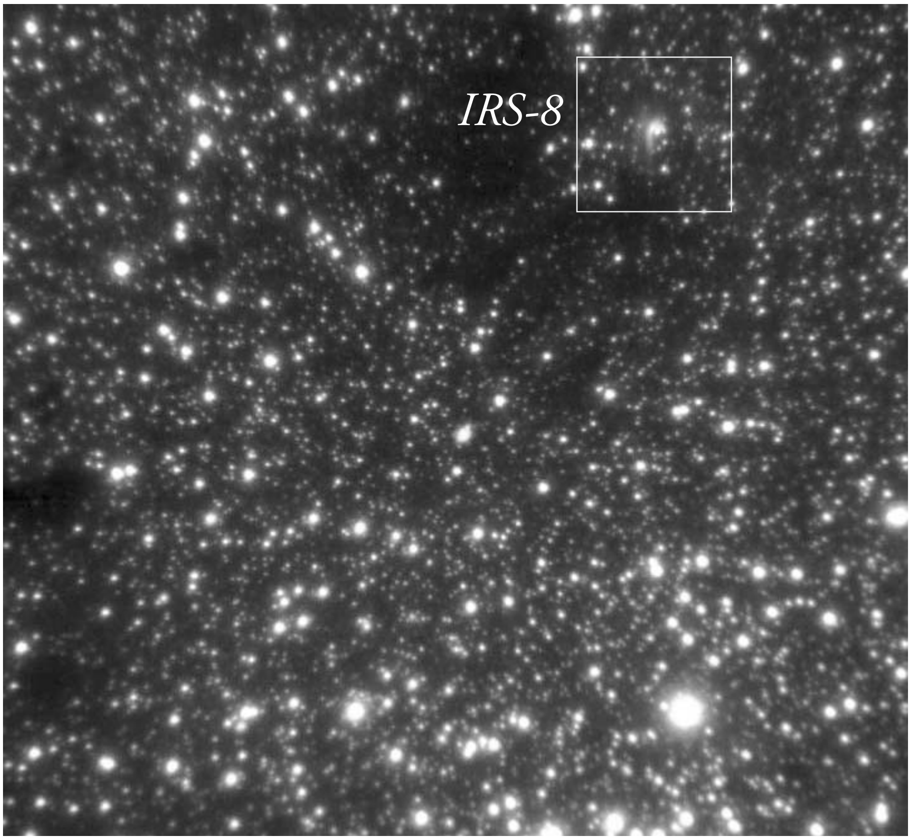


Figure 6: Gemini/Hokupa'a adaptive optics image of the Galactic Center region made of a composite of three images obtained in the infrared bands J, H and K'.

Figure 7: Smaller field J-H-K' color composite (from Figure 6 image) of IRS-8 and its bow-shock.

The very center of our Milky Way contains a number of objects with characteristics similar to IRS-8 that are also the result of shock-heating or shock-compression of dust. IRS-8 is the most conspicuous member of this class of fast-moving massive stars in the Galactic Center and emphasizes the violent nature of the Galactic Center environment associated with its massive black hole.

Rigaut, et al., Presented their results at the Galactic Center conference held in Kona, HI in November 2002, and their paper was published in the proceedings of the conference. Gemini sponsored and led this extremely successful conference.

Probing the Heated Dust in the AGN of NGC 4151 with OSCIR

James Radomski of the University of Florida and his collaborators used Gemini North/OSCIR to observe the nuclear region of NGC 4151 at 10.8 and 18.2 microns. NGC 4151 is one of the nearest (13.2 megaparsecs) and best studied active galactic nuclei (AGN). It hosts a highly variable continuum and line emission source. The mid-infrared emission of NGC 4151 has been suggested to arise from either thermal emission from the dust grains or synchrotron emission. The OSCIR observations show that the mid-infrared emission of NGC 4151 is compact but resolved. It extends ~3.5 arcseconds, or 200 parsecs across at a position angle that matches the narrow line region as observed in [OIII]5007 by the Hubble Space Telescope ***(Figure 8)***. The most likely explanation for the extended mid-infrared emission is dust in the narrow line region heated by the central engine that is likely powered by a black hole. The authors find no extended emission associated with the proposed torus and are able to place an upper limit on its mid-infrared size of < 35 parsecs.

Exploring Wolf-Rayet Stars in the Local Group Starburst Galaxy IC 10

Getting spectra of individual stars in nearby galaxies is something that has been done with 4-meter-class telescopes for some time. However, when the science goals require high spectral resolution or very high signal-to-noise ratios, the use of an 8-meter telescope becomes essential. Principal Investigators Paul Crowthers of the University College London and Laurent Drissen of Université Laval and

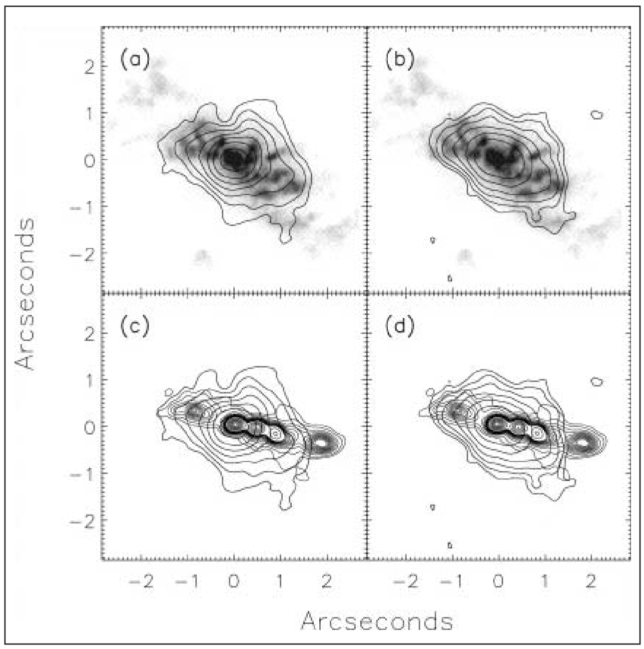


Figure 8: Contours of filter band N and IWW18 emission (after point-spread-function subtraction) overlaid on the Hubble Space Telescope [OIII]5007 ionization region in (a) and (b). Images (c) and (d) show the same N and IWW18 emission overlaid on the radio jet observed at 18 centimeters by Pedlar, et al. (1998)

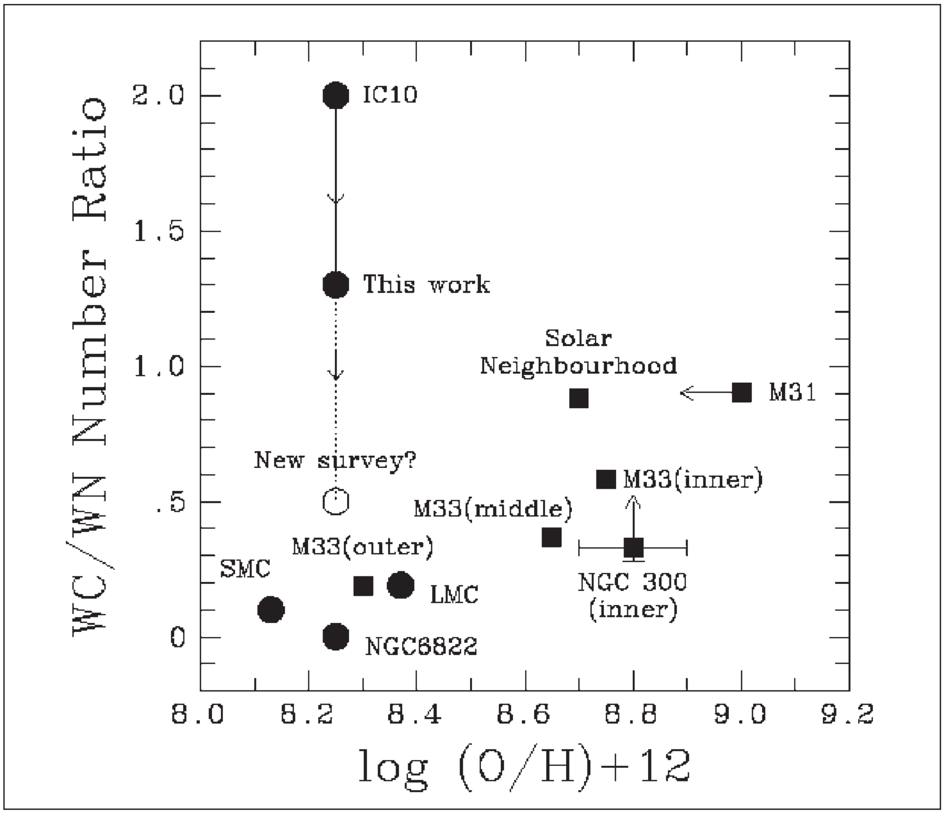


Figure 9: *Shows the trend of WC/WN ratio for Local Group and Sculptor Group spiral and irregular galaxies versus oxygen content, which is a good indicator of the overcontent in heavier elements. The new Gemini data show how the position of IC 10 on this diagram is brought down closer to the general trend.*

their collaborators employed GMOS-N to obtain high signal-to-noise spectra of 28 Wolf-Rayet candidates in the nearby galaxy IC 10 in order to ascertain the ratio of the WC/WN galaxies, which should normally be <<1 in a galaxy with a metallicity as low as one-fourth that of our Sun. The galaxy, located at about 0.7 +/- 1 megaparsecs, is remarkable for its very high star-formation rate. While all other Local Group galaxies show a clear trend of decreasing WC/WN with lower metallicity, previous works had inferred an abnormally high ratio of 2.0.

The effect of a relatively higher number of WC stars is thought to arise from the deeper depletion of the stellar upper layers when metallicity is high. Winds are more powerful and mass loss reveals deeper layers down to the carbon core of the stars. From the GMOS-N spectra (and a few spectra from the Canada-France-Hawaii Telescope), the authors deduced a ratio of WC/WN ~1.5 ***(Figure 9)***. They also provide evidence that the number of WN stars is underestimated, and show that the ratio is probably closer to 0.6. The authors re-emphasize that IC 10 hosts a substantial population of WR stars (where confirmed, WC stars outnumber WN stars). They predict that deeper studies will make IC 10 consistent with the expected metallicity trend, thereby, removing the need to call upon a skewed Initial Mass Function in IC 10.

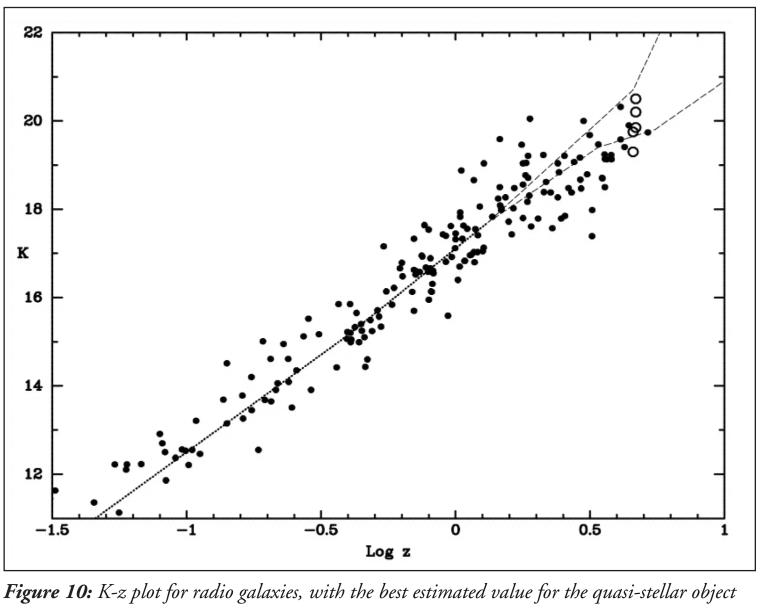


Figure 10: *K-z plot for radio galaxies, with the best estimated value for the quasi-stellar object host (open circles on the plot) from the Gemini NIRI observations. The lines sketch in passive evolution models for 1.0 and 0.1 Gyr starbursts at z = 20.*

Exploring Host Galaxies of z ~ 4.7 Quasars with NIRI

Using NIRI, John Hutchings of the Herzberg Institute of Astrophysics/ National Research Council imaged five redshift z ~ 4.7 quasar with NIRI using 2-micron broad- and narrowband imaging with Gemini North. The [OII]3727 nebular emission lines, which trace regions of high star-formation rate, are shifted into the near-infrared red that are close to 2 microns for these quasars. The [OII] emission is spatially resolved in all five quasars. Hutchings shows that the quasars tend to be located in one centrally located unresolved body within a network of knots and filaments that extend to several arcseconds. Line emission is localized in small regions within the host galaxy where star formation must be very active. He suggests that we may be seeing host galaxies that are in the early stages of assembly, and notes that luminous quasars at z ~ 4.7 are found inside the most luminous galaxies ***(Figure 10)*** with a probable evolution of the galaxy stellar populations along the K-z relationship.

GEMINI INSTRUMENTATION PROGRAM UPDATE

Doug Simons

The past few months have marked the beginning of a period of intense activity within the instrument program, as long-awaited instruments arrived at both sites, enabling significant new avenues for research on the Frederick C. Gillett Gemini Telescope (Gemini North) and Gemini South. A total of six facility-class instruments are scheduled to arrive in a one year period. It is doubtful that such a large "wave" of new instrumentation will arrive at Gemini ever again, and coordinating the arrival, integration, commissioning and release of each instrument, while maintaining regular science operations, will be a challenge. In the meantime, the Gemini Multi-Object Spectograph on Gemini North (GMOS-N) and our Near-Infrared Imager (NIRI) remain in operation at Gemini North with only minor planned upgrades in the near future, e.g., more gratings for GMOS-N and testing of new higher resolution grisms in NIRI for use in adaptive optics spectroscopy. We are also beginning to formulate plans for the next generation of instruments developed for Gemini that will no doubt help define the scientific frontiers in ground-based astronomy through approximately 2010.

Figure 1: *GMOS-S on the up-looking instrument port is shown with its commissioning team in the foreground.*

GMOS South (GMOS-S)

The first facility instrument to arrive at Gemini South was GMOS-S, the clone of its highly successful counterpart in Hawai'i. GMOS-S had its engineering first light on 18 January 2003, and like GMOS-N impressed everyone with its on-sky performance. ***Figure 1*** shows GMOS-S on the up-looking port just before engineering first light. On its first integration, GMOS-S recorded images with a full-width at half-maximum (FWHM) of 0.9 arcsecond and an alignment error with respect to the Cassegrain rotator of only 1 arcsecond.

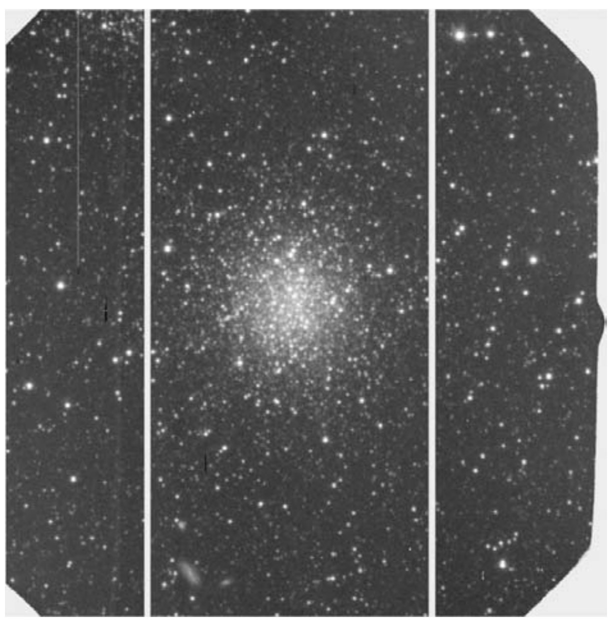


Figure 2: *This 20-second R-band integration of Hodge 11 was the second image recorded with GMOS-S during commissioning.*

Figure 2 shows the second image ever recorded with the instrument, a 20-second integration on a southern globular cluster called Hodge 11. The GMOS-S commissioning team went on that night to demonstrate fast tip/tilt guiding, closed-loop focus control and active optics corrections on the telescope using the GMOS-S on-instrument wavefront sensor.

These remarkable achievements certainly did not occur accidentally. They are the result of painstaking work on the part of the builders of GMOS-S, the commissioning team and the hard work in Hawai'i commissioning GMOS-N, so that lessons learned with the first instrument could be used to make GMOS-S as "plug-'n-play" as possible. Since engineering first light, GMOS-S has completed most of its baseline commissioning tasks (imaging and single-slit and multi-slit spectroscopy). A second integral field unit (IFU) is being fabricated for GMOS-S at the University of Durham UK, and the atmospheric dispersion compensators are being completed at the Herzberg Institute of Astrophysics (HIA) for both instruments, meaning additional modes will eventually be commissioned in the months ahead.

Michelle

About a week after GMOS-S collected its first photons in Chile, Michelle experienced first light in Hawai'i on Gemini North. This followed a successful science campaign on the United Kingdom Infrared Telescope (UKIRT) and was the starting point of a year-long deployment on Gemini North for this shared instrument. Prior to its arrival, a new science grade detector was installed in Michelle, and the instrument was reconfigured in its "Gemini mode," which includes new fore optics and a frame to mount its thermal electronics enclosures. Michelle experienced two runs in early 2003 on Gemini North, both of which were dedicated primarily to working out engineering interface issues, verifying basic instrument focus and alignment with respect to the telescope, and working on fast tip-tilt guiding while also chopping—something that is unique to Gemini among 8-to-10-meter-class telescopes. Michelle is currently back at UKIRT, and the Gemini fore-optics were sent back to Edinburgh, Scotland where engineers at the Astronomy Technology Centre are adjusting its internal optics to align them with respect to the telescope's pupil. We expect these modifications to be completed in time for more Michelle commissioning observations in June, in support of releasing Michelle for use by the Gemini community in Semester 2003B.

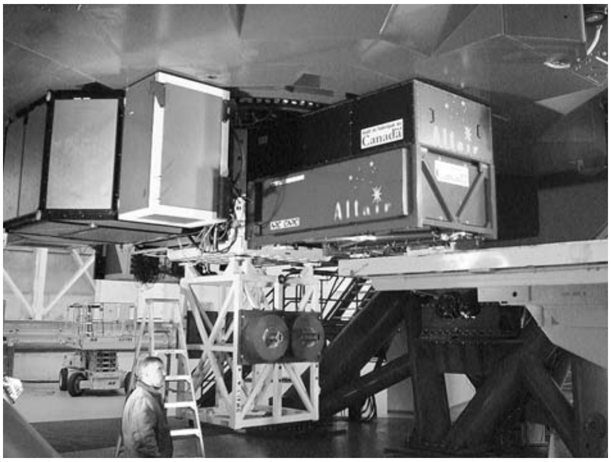


Figure 3: *Altair on Gemini North's instrument support structure side port.*

Altair

Gemini's first facility adaptive optics (AO) system, built by Herzberg Institute of Astrophysics, arrived in October 2002, and was used twice on the Gemini North telescope later that year during extensive commissioning runs. The first attempt to close the AO loop with Altair resulted in an image recorded by NIRI with a strehl of approximately (~) 25% at H, with the highest strehl achieved during the first commissioning runs of ~55% at K. As expected, integrating Altair's control system into the Gemini North control system was a major task due to the complexity of operating the AO system, telescope and instrument in a coordinated manner. These complexities include correctly opening and closing various guide loops while dither patterns on the sky are executed. Additionally, various offsets must be delivered to M1 and M2 along with methods for dealing with acquisition and residual noncommon path aberrations. Work was also conducted to measure Altair's throughput (~89 percent) during these runs. After these runs Altair was removed from the telescope, and modifications were made to its wavefront sensor, which we expect to enable more stable performance under a broad range of seeing conditions and further reduce non-common path errors. Commissioning for Altair will continue in semesters 2003A

Altair Commissioning Update

As this issue of the newsletter neared completion, the third Altair commissioning run took place from April 15 to 22. After three months of rework at HIA and Gemini, this run has been very successful. One by one, the major functionalities of the system, including the interaction features with the telescope control system and the data acquisition sequencer, were successfully debugged, tested and characterized. Altair is now able to (i) receive signals from the instrument On-Instrument WaveFront Sensor (OIWFS) and use them to compensate for slow drift of image centering and defocus due to flexures; (ii) offload at a slow rate the quasi-static shape of the deformable mirror to the telescope primary mirror; (iii) offload the centering tip-tilt and defocus errors to M2; and (iv) optimize several of the system operating parameters in real time such as modal gains and WaveFront Sensor (WFS) centroid gain.

Altair is well integrated both with the Telescope Control System (TCS) and the Telescope Control Console (TCC). The telescope operator may now start and stop adaptive optics corrections from its TCC control screens.

After dealing with system functionalities, the main thrust of the team's effort during the last nights of testing shifted toward performance evaluation and improvements. Things are taking shape on this front. Images of full width at half maximum (FWHM) were obtained from 59 to 85 milliarcseconds (mas) on the vast majority of objects observed. This is slightly short of the ultimate diffraction limit (42 milliarcseconds in H and 57 milliarcseconds in K), but the main culprits have been identified. We have specific plans for improving these areas to reach our diffraction limited goals.

The team was generally very pleased with the behavior of the system. The rework at HIA and Gemini in the past three months – including the refitting of a new lenslet array, work on the NIRI OIWFS gimbal mechanisms and several software improvement and fixes – has brought considerable improvements in the stability and overall performance of Altair. Following these successes, we are more confident than ever that the Gemini facility AO system will be fully competitive with its most serious competitors (e.g. NAOS).

During the next two commissioning runs in May and July, we expect to concentrate on the remaining problems and gray areas, including:

1. A relatively strong vibration occurs somewhere in the system, varying from 5 to 35 milliarcseconds per axis. Investigations show that this comes from within Altair and most probably from the common path. The main suspect is the tip-tilt mirror, which could vibrate due to an electrical coupling with an external source. This prevents Altair from reaching the ultimate diffraction limit. We have been routinely achieving 60-65 milliarcseconds at H and K wavelengths.

2. Although calibration of the static aberrations dependency vs. flexure was carried out successfully with the Altair internal calibration source, we measured large static aberrations on the sky. We are working on identifying the source of these aberrations. One possible cause is from spatial aliasing of high-order aberrations on the order of a few tens of nanometers rms from the telescope.

3. Regarding the isoplanatic angle, the offloading of the Altair deformable mirror static shape to M1 has done a lot to improve the performance off-axis. We are fully aware of the importance of this issue. To address this, we regularly observed stellar fields during the run. The data are being analyzed and a database has been established which will help us characterize the anisoplanatism.

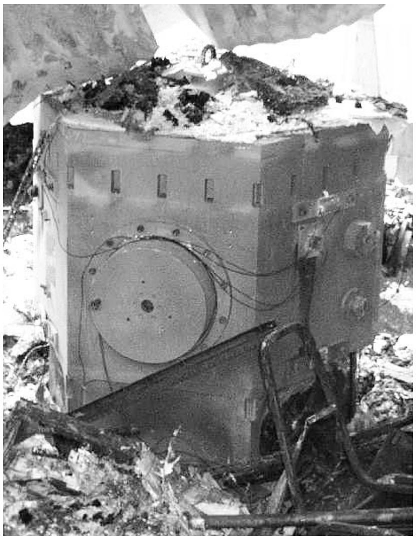


Figure 4: The badly damaged remains of NIFS are shown in this photo. The vacuum jacket was burned through and interior components gutted during the fire.

and 2003B, with the latter semester including the first science use of Altair via system-verification observations. The data from these observations will be released to the community soon after they are acquired.

NIFS

As has been widely reported, Mt. Stromlo suffered devastating bush fires in January 2003, which destroyed the Near-Infrared Integral Field Spectrograph (NIFS) being built there. This tragic fire actually happened at the exact same time that we were celebrating the outstanding engineering first-light results of GMOS-S making for a bitter-sweet moment in the brief history of Gemini's instrument program. ***Figure 4*** shows the burned hulk that remains of the instrument that was partially vaporized from the intense heat of the fire. Prior to the fire, NIFS was on track for a mid-2003 delivery to Hawai'i where it was planned to be used with Altair to provide a key new AO-based integral field spectroscopy capability at Gemini North.

Luckily, all of the NIFS design drawings and several critical components, including the HAWAII-2 science detector, were spared. Since the time of the fire, thanks to the fortitude of the NIFS team, a plan was forwarded to Gemini and was recently approved to build NIFS again. In order to prevent resource collisions with other instruments being built there (see *GSAOI* reference on page 17), the replacement NIFS is actually being contracted out to Auspace Limited, a commercial aerospace company in Canberra, Australia, which already has a close working relationship with the team at Mt. Stromlo. Under the current plan, we expect NIFS to be commissioned on Gemini North in 2005, soon after the laser mode of Altair has been commissioned. This will be key to the use of NIFS since we expect the laser-guide-star mode of Altair to enable observations of many more targets compared to relying on natural adaptive optics guide stars.

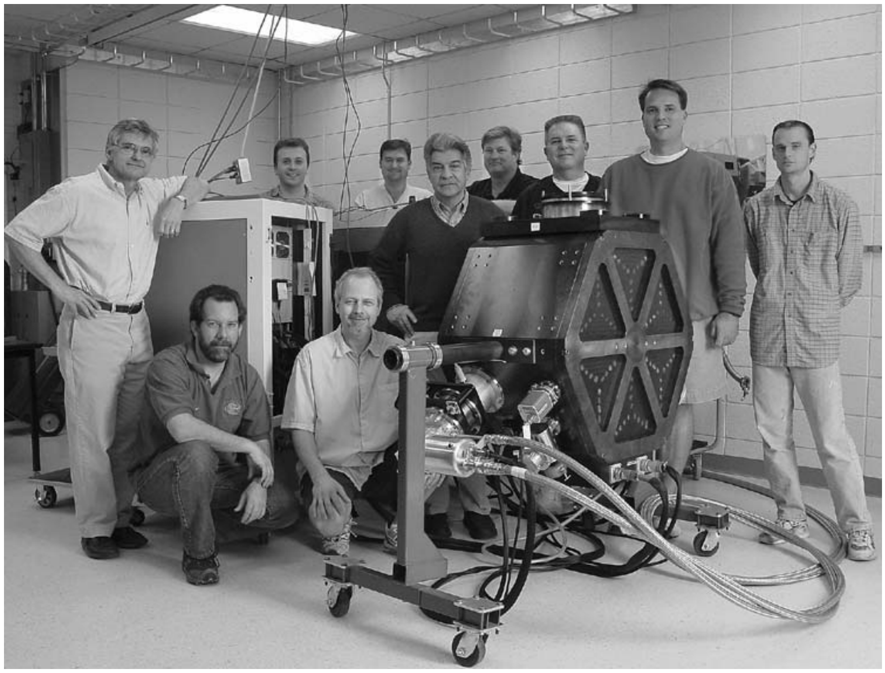


Figure 5: The University of Florida's T-ReCS team is shown surrounding the instrument just prior to its shipment to Chile.

T-ReCS

Soon after January's engineering first-light activities commenced for new northern and southern instruments, Gemini sent teams to two more instrument development sites to conduct final pre-ship acceptance testing in mid-February. One team was sent to Gainesville, FL, where Gemini's facility Thermal-Region Camera Spectograph (T-ReCS) was rigorously tested over a ~10-day period to verify that key performance and interface requirements were met. After a few weeks of rework to deal with items identified by the acceptance test team, T-ReCS was shipped to Chile where the University of Florida team will lead its reassembly and work closely with the Gemini South engineering team to fully integrate T-ReCS into the various optical, mechanical and control system environments in which it must operate. We look forward to T-ReCS experiencing first light in June. At that point, an aggressive commissioning campaign will be used to make it available during Semester 2003B for shared-risk use.

bHROS

The other acceptance team (referenced in the previous section) went to London to perform final pre-ship acceptance tests on Gemini's new fiber-fed, bench-mounted High-Resolution Spectrograph (bHROS) in mid-February. Built by the University College London, this is Gemini's only non-Cassegrain-mounted instrument. With a spectral resolution of 150,000, it represents a fairly unique facility on large telescopes. bHROS reached the summit of Cerro Pachón during the first week in April where it will be assembled and aligned in the pier lab, an area that has been substantially refurbished over the past year to accommodate the singular

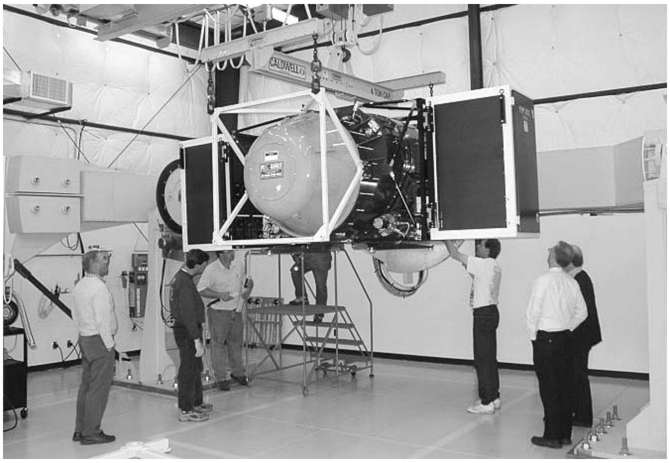


Figure 6: GNIRS is shown fully integrated in a horizontal position on the new NOAO flexure rig facility in Tucson, AZ.

needs of a high-resolution spectrograph. Though the instrument is scheduled to be integrated in the pier lab during the second quarter of 2003, its fiber-fore optics will not be fully integrated into GMOS, which will be used as its acquisition system, until sometime in 2004. This is due to the aforementioned flood of instruments that are now being delivered to Gemini South, the need to maintain at least 70 percent science time for our community starting in Semester 2004A, the sequence in which instruments are arriving and the scientific priorities assigned to facility instruments (and their various modes) by the Gemini Science Committee. While we remain excited about integrating bHROS at Gemini South in 2003, commissioning will not commence until next year.

GNIRS

The fourth in the sequence of instruments arriving in Chile this year will be the Gemini Near-Infrared Spectrograph (GNIRS) built by the National Optical Astronomy Observatory (NOAO). ***Figure 6*** shows GNIRS being rigorously tested on the flexure rig facilities at NOAO. GNIRS has gone through several cold tests in Tucson, AZ since mid-2002. We are making progress each time with resolving the usual types of problems and challenges that such a large cryogenic instrument experiences during its development phase. GNIRS is now fully assembled including all of its optics (except for the IFU being fabricated by the University of Durham, UK), science and wavefront sensor detector systems, mechanisms, electronics and control system. GNIRS commissioning is planned to begin in 2003B. Whether it is used as a single-slit spectrometer, across-dispersed spectrometer or an integral field spectrometer, we expect GNIRS to be popular within our community and to become an important research tool for viewing programs that encompass nearby star-formation regions to distant galaxies.

Ongoing Instrument Program

Gemini's instrument program has a vigorous development component that will be used to maintain a steady stream of state-of-the-art instrumentation at both telescopes beyond those previously mentioned. The newest instrument to be started up is the Gemini South Adaptive Optics Imager (GSAOI), which was recently awarded to the Research School of Astronomy and Astrophysics at the Australian National University with Peter McGregor as the Principal Investigator. This instrument is scheduled for delivery in 2005 and is intended for use as both the commissioning camera and primary 1-to-2.5-micron science imager for Gemini's southern adaptive optics system. It is unique in both its simplicity (single-plate scale) and complexity in that it will be the first Gemini instrument to use a mosaic of $2{,}048^2$ infrared detectors in its focal plane. These HAWAII-2RG detectors are being made for Gemini under a separate contract with Rockwell Scientific.

A laser guidestar (LGS) upgrade to the Altair adaptive optics system is planned for the fourth quarter of 2004. The solid state, sum frequency laser system is now under development at Coherent Technologies, Inc., in Lafayette, CO following a kickoff meeting held in Hilo in January of this year. The laser launch telescope contract at Electro-Optical Systems Technology (EOST) in Tucson, AZ, also passed its critical design review during January, and the critical design review for the internal work on the beam transfer optics system was held in March. Work on the Safe Aircraft Localization and Satellite Acquisition System (SALSA) safety systems is also progressing.

Design and development work for the Gemini South adaptive optics system and its multi-conjugate adaptive optics (MCAO) capability is now well underway (see ***Figure 7***). Work on a contract for the optical bench, natural guide -star wavefront sensors, and electronics enclosures began at EOST last November. The realtime controller subsystem is under development at the Optical Sciences Company (tOSC) in Anaheim, CA where a preliminary design review was successfully completed in February of this year. Two prototype deformable mirrors with 37 actuators and the 5 millimeter interactuator spacing

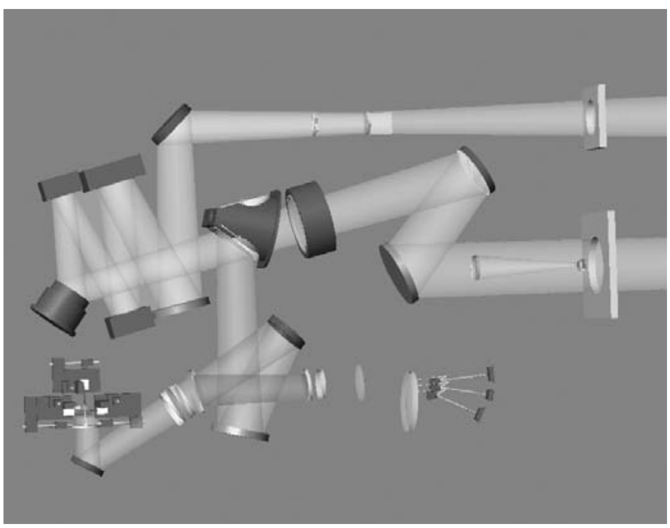


Figure 7: The optical path of the Gemini MCAO system currently under development by Gemini staff.

required for the GSAO design are in fabrication at Xinetics in Cambridge, MA with test results expected by June. Two conceptual design studies for the MCAO laser- guide-star wavefront sensor at HIA and tOSC were completed in April, and the request for proposals for the laser system is planned for later this year. The overall program schedule calls for the delivery of the major subsystems to Gemini in mid-2005 followed by system integration leading to first light and commissioning in the first half of 2006.

Other facility-class instruments under development include NICI, which is Gemini's first Near-Infrared Coronagraphic Imager, and is scheduled for deployment in Chile in early 2005. Also under development is Flamingos-2, which is being built by the University of Florida and is scheduled to arrive in Chile in the second semester of 2005. Likewise, Hokupa'a-85, which is a visitor adaptive optics system under development at the University of Hawaii, is scheduled for completion in mid-2003. It will be used at Gemini South until NICI arrives that will provide the same narrow-field adaptive optics imaging as Hokupa'a-85.

Finally, the next generation of Gemini instruments will be broadly defined in the near future through a network of national, and ultimately international, science workshops attended by Gemini's broad family of users. These workshops are intended to distill the scientific ambitions of our community into basic design guidelines that should be used to procure instrumentation out through 2010. Forecasting scientific frontiers is always a challenge. Nonetheless, having community input into the basic capabilities of Gemini's next generation of instruments is crucial as we find the common threads among the myriad of possible science missions identified through these workshops. From there, we hope to craft widely capable instruments that will carry us into the next decade.

Once again, it is truly a remarkable and exciting time in Gemini's instrument program, with an unprecedented "wave" of new facility-class instruments arriving now at both telescopes, and we are taking the first steps in defining our next-generation instruments.

PIO REPORT

Peter Michaud

The past few months have been a very productive period of growth for the Gemini Public Information and Outreach (PIO).

The new Gemini Virtual Tour-Image/Animation Gallery CD-ROM is now updated and available for distribution. We have just duplicated 10,000 copies of this CD-ROM for use in Gemini outreach programming, and the disc is available upon request for educational use (to obtain additional copies, contact pmichaud@gemini.edu). Most copies of this issue of the *Gemini Newsletter* were shipped with the new Virtual Tour as well. Please take a look at the copy provided (it runs on either Macintosh or Windows platforms). The tour is still late in the development stage, and we appreciate any comments or suggestions for improvement or content enhancement.

We are also developing several additional enhancements including partner-country language translations, professional narrations with a music background, several new "science modules" that highlight specific Gemini science findings, increased content from Gemini South and more staff profiles. The CD-ROM also contains a wide selection of the latest images and animations, including the very popular adaptive optics animation, which is located at the end of both the Gemini North and South telescope animations.

Regarding animations, a contract has been signed with Akira Design to produce a 60 to 90-second animation showing the operation of the planned Gemini Laser Guidestar System (LGS). This is the same company that produced the much- acclaimed Gemini Telescopes and adaptive optics animations (on the new CD-ROM), and we anticipate a great product. Preliminary draft cuts look extremely promising, and we anticipate this animation to be ready for distribution by late 2003. Watch for details about the LGS animation on the Gemini website and in the next issue of this newsletter.

Many readers have probably already noticed that the Gemini website has become more dynamic over the past 6 months. We are now changing the homepage headline every 2 weeks to keep content fresh and timely. This is a coordinated effort between the Gemini Science Team and the PIO staff, and we think it has been extremely successful. However, one can never rest on laurels. The website's horizons are still expanding. As this newsletter goes to press, the

Gemini web redesign team headed up by the PIO staff, along with the Science and Networking staff, have developed a beta version of the new Gemini homepage, a sample of which is shown in ***Figure 1***. We expect this new look to go public early in the second half of 2003, so keep your browser pointed at http://www.gemini.edu.

One of the most visible and exciting PIO projects of the past 6 months has been the hugely successful StarTeachers Exchange program. StarTeachers is a teacher exchange program that allows three teachers from each Gemini community (Hilo and La Serena) to travel to the other's community for a period of 2 weeks. During the exchange, the teachers teach in the host classroom while using Gemini's networking technologies to concomitantly teach their classes "back home."

In late March and early April, the three StarTeachers from Hawai'i traveled to Chile. As Hawai'i teacher Alicia Hui said, "Out of 100 points, this experience was a 200!" During the exchange, teachers used Gemini's internet technologies to send back images, live and recorded video, and even used a digital white board so their students at both Gemini base facilities could interact in this exciting global classroom created by Gemini. In the end, everyone learned a great deal about cultural, technological and scientific exchanges. Preparations are now underway for the Chilean teachers to visit Hawai'i in October 2003. For more program information and images see http://www.gemini.edu/project/announcements/press/2003-1.html.

Figure 1: *A design concept for the new Gemini homepage.*

The StarLab portable planetarium continues to fuel the growth of other ongoing outreach programs. StarLab is proving to be a valuable educational tool and a real hit with educators in both Hawai'i and Chile. A new initiative in Hawai'i began with the training of about 25 local teachers who can now borrow the StarLab equipment for lessons and multiple-day programming in their schools. This has been the primary mode of operation in Chile with the joint StarLab program between Gemini, CTIO and RedLaser. Recently, the company that makes the StarLab equipment, Learning Technologies in Cambridge, MA, offered to donate a second complete StarLab to the Gemini Outreach office in La Serena for expanded programming to local schools. This exciting development will allow Gemini to provide a new level of programming to local schools and will complement the existing partnership with CTIO and RedLaser.

"Adventures Along the Spectrum," a dynamic and interactive science program for students, is another new initiative that is proving to be extremely successful. It was a development of local outreach programming in schools to augment another new educational program about observatory careers. Both of these programs have been made possible by interns provided by the NASA-funded program "New Opportunities Through Minority Initiatives in Space Science" (NOMISS) at the University of Hawaii at Hilo. See http://hubble.uhh.hawaii.edu/NOMISS/background.htm for more information.

A key milestone has also been reached in the Gemini PIO effort with the hiring of full-time Press Officer/Writer Jennifer Anderson Akingkubedaggs. Jennifer's office is located at the Gemini offices in Hilo, and she will serve as the primary contact for local and international media as well as become the main conduit for the Gemini PIO Liaison Network. Hiring the

Figure 2: *Students from StarTeacher Kristen Luning's class at Keaau High School interact live with students in Chile using a digital whiteboard during a videoconference lesson from the Gemini base facilities in Hawai'i and Chile.*

Figure 3: *The three Hawai'i StarTeachers are joined by their counterparts and Gemini outreach staff in Chile during a visit to Cerro Pachón and Cerro Tololo in late March. From left to right: Antonieta Garcia (Gemini Staff), Viviana Calderón Tolmo (Chilean StarTeacher), Kristen Luning (Hawai'i StarTeacher), Jenny Opazo González (Chilean StarTeacher), Alicia Hui (Hawai'i StarTeacher), Janice Harvey (Gemini Staff), Carmen Luz Briones Castillo (Chilean StarTeacher), Chrisine Copes (Hawai'i StarTeacher).*

Press Officer completes the staffing portion of the 5-year PIO expansion effort. Now PIO will concentrate its efforts for the next 2.5 years on expanding, developing and evaluating PIO programming.

Visitors to the Gemini base facility in Hilo will notice a new exhibit in the main lobby (see ***Figure 4***). It incorporates twin LCD display screens that dissolve dozens of images from Gemini with short captions in any language. The images are updated nightly from a webserver so each day the images can reflect the latest information and findings from the Gemini telescopes. We anticipate that the National Science Foundation will be installing this system at their headquarters in Arlington, VA in the next few months. A similar system will be installed in the lobby of the Gemini Southern Operations Center during the second half of this year. Any partner who would like to install a similar system at their facilities may do so by contacting the PIO Office to obtain a copy of the software and specs on recommended hardware.

Finally, the Gemini PIO Office will be hosting two meetings this summer. Following the International Astronomical Union (IAU) meeting in Australia (where we will also present a teacher workshop on Gemini educational programs at the Powerhouse Museum on July 26th), the second annual Gemini PIO Liaison Meeting will be held in Hilo on July 30–August 1. We are anticipating at least one representative from each Gemini partner, and expect to resolve many issues related to the interactions between our Press Office in Hilo and the Gemini partnership. Immediately after that, on August 4–6th, we will host the 3rd annual State-of-the-Art Telescope Education Consortium (STARTEC) meeting. STARTEC consists of representatives from most major state-of-the-art telescopes, and each of these meetings will include tours of Gemini and several of the telescopes on Mauna Kea. Learn more about STARTEC at http://www.startec-intl.org/

Figure 4: *Gemini's new Press Officer, Jennifer Anderson Akingkubedaggs, with the new digital display in the lobby of the Gemini Southern Operations Center.*

Gemini Collaborates with the Virtual Museum of Canada

In our ongoing effort to leverage the education and outreach resources developed by Gemini, we have been working with the Canadian Heritage Information Network (CHIN) to provide content, visuals, animations and interactive elements from the Gemini Virtual Tour for a new virtual exhibit on astronomy at the Virtual Museum of Canada (VMC).

By participating in this project we join other participants in Canada, Australia and Hawai'i to share a wide variety of high-quality online materials that range from the latest scientific discoveries and techniques to the rich cultural and historical connections between people around the globe and the sky. Since its inauguration in 2001, the VMC has served more than 5 million visitors with over 20 million pages viewed. It is expected that this new virtual exhibit will continue to broaden both the VMC and Gemini audiences while expanding the public's access and understanding of astronomy and the part that observatories like Gemini play in our exploration of the cosmos.

Another benefit that this collaboration has already delivered to Gemini was a one-month Young Canada Works International internship that brought a young Canadian Graphic Artist, Sonja Wermann, from the Manitoba Museum to the Gemini Offices in Hilo. While Sonja was here in February of 2003, she did extensive photography of Gemini and other observatories on Mauna Kea, including the production of several new QuickTimeVR® movies that will be incorporated into the Gemini Virtual Tour materials.

For more information on the Virtual Museum of Canada, please visit: www.virtualmuseum.ca

Other VMC Astronomy Virtual Exhibit Participants Include:

Australian Museums & Galleries Online, Australia
Centre of the Universe, Canada
Glenbow Museum, Canada
Manitoba Museum, Canada
Mauna Kea Astronomy Education Center, Hawai'i
National Research Council of Canada
Planétarium de Montréal, Canada

MVC MUSÉE VIRTUEL CANADA

VMC VIRTUAL MUSEUM CANADA

PROFILE: PETER McEVOY

Jennifer Anderson Akingkubedaggs

While hitchhiking from Madrid to Alicante, Pete McEvoy listened to his sister chat fluently in Spanish with the driver of the beer truck in which they were riding. Pete and his sister had negotiated a deal for traveling together on holiday in Spain - she would show him Spain, where she was at university, and he would show her how to hitchhike. During that fateful trip, unable to converse, Pete decided to learn Spanish.

Upon his return to London, Pete began purchasing copies of "El País," the Spanish newspaper, from a local newsstand. Each week, he sat down at a local Spanish café, armed with just a Spanish-English dictionary and a simple book of Spanish grammar and learned the basics of the language by translating "El País" articles about sports, art and news. It was a word-by-word advance. As an interesting level 2 course, Pete translated the lyrics of songs by Julio Iglesias and Los Panchos. These budding Spanish language skills and his formal university studies formed the bridge between Pete's past and his future.

Born near Leeds in Northern England, Pete grew up with a brother and two younger sisters. At the tender age of 13, Pete's life was changed forever when his mother died. While his father worked to support their family, he accepted responsibility early and became almost a second "Dad" as well as a brother. He played soccer and rugby in his youth, captained his university's rugby team and remains a devoted sports enthusiast. After graduating with honors from Brunel University, Pete continued his studies there culminating in a Master's degree in Industrial Relations and Labor Law.

Living in London gave way to exciting career opportunities, overseas travel and adventure sports. He spent the first half of his career working as a manager in human resources strategy for a multinational telecommunications company. Pete's career prior to joining Gemini required him to travel extensively. Among his favorite destinations are Chile - his chosen home - South Africa, northeast Brazil and Colombia. Not one to fear a challenge, Pete has gone parachuting, bungee jumping, microlyte flying and whitewater rafting. He described one whitewater-rafting trip near Victoria Falls, Africa, during which he nearly drowned. "One portion of the river," he explains, "looked like a toilet bowl flushing." He fell from the raft and despite a life preserver and helmet, he found himself trapped at the bottom of the Zambezi River, and slipped into unconsciousness. His body surfaced 100 yards downstream. After regaining consciousness, he became violently ill. Then, astonishingly, he grabbed an oar and immediately started rowing again. "Every day is an absolute privilege," he says while reflecting on the impact of the experience.

Pete and his wife, Heleny Zafiropulos Themistocleus, who is Chilean of Greek parentage, have created a family life that has taught Pete about love and helped to mend wounds caused by his mother's passing early in his life. Pete and Heleny's son, Thomas Dimitri ("Tom"), is 4, and their daughter, Pauline Zoiche ("Lula"), is 2. Both have recently learned to swim, and the family enjoys spending time together at the beach in La Serena and at the AURA's recinto pool. Pete refers to his favorite book, "The Art of Loving," by Eric Fromm as inspirational and a contribution to his family life.

When asked about ongoing participation in adventure sports, Pete's wife has firmly ruled, "anything dangerous is now banned." Pete has not given up hope, however, and even persuaded Heleny to allow him to take Tom, as a 2-year-old, for a trip under the massive Foz de Iguazu falls, where the borders of Brazil, Paraguay and Argentina meet. Pete says that he was pleased that, although drenched and confused by it all, Tom seemed to really enjoy the experience.

Peter McEvoy stands in front of the new Gemini South Base Facility.

After a transfer with a previous employer sent Pete to Santiago, Chile, from his base in the UK, he joked with friends that at least a doubling of his salary would be required to convince him to leave. "With so many clear morning skies over Santiago, it is possible to really enjoy the spectacle of the sun 'rising' over the steep mountains. You realize that you have another day to play with," he says. Now that he lives in La Serena with his family, Pete is unsure if even a doubling of his salary would convince him to return to Santiago, despite La Serena's frequent foggy mornings. The people, the surroundings and the wonderful environment for his family have a tremendous value for him.

Pete confesses to a certain sense of awe at the amount of talent around him at Gemini South, adding that just experiencing the commitment to always improve the operation is a great motivating factor and one of the reasons he loves being there. He looks forward to the opportunity to introduce practical improvements in the quality of administrative services at Gemini South. Getting home to his family in the evening rather than spending it at his computer is also a very high priority. He summarizes his vision in simple terms, "Gemini South Administration must come to be recognized as a center of professionalism with a clear focus on making a valuable contribution to the achievement of goals in all work groups. We must function like clockwork."

UNITED STATES

Taft Armandroff

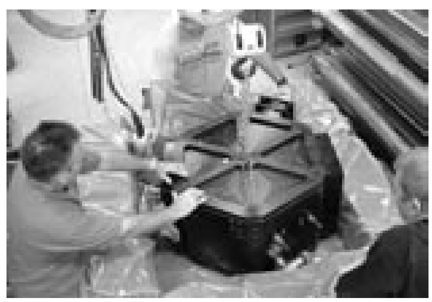
Gemini support in the United States (U.S.) has been the responsibility of the U.S. Gemini Program (USGP). The National Optical Astronomy Observatory (NOAO) is the home of the U.S. National Gemini Office. NOAO has reorganized USGP into the NOAO Gemini Science Center (NGSC). Our change in name from the construction-era designation of USGP to the NGSC is intended to clearly express our science emphasis and our association with NOAO.

NGSC saw an enthusiastic response from the U.S. community to the Gemini Call for Proposals for 2003B. On Gemini North for 2003B, 60 proposals were received: 28 for the Gemini Multi-Object Spectrograph - North (GMOS-N), 21 for the Near-Infrared Imager (NIRI) and 13 for Michelle. Fifty-two U.S. proposals were received for Gemini South: 18 for T-ReCS, 17 for GMOS South, 15 for Phoenix and 2 for the Acquisition Camera. In total, 107 U.S. Gemini proposals sought 215 nights on the two Gemini telescopes.

NGSC organized a booth for the January American Astronomical Society meeting held in Seattle, WA. The NGSC booth featured displays on how to propose for Gemini observing opportunities, brochures on available Gemini instruments and tutorials on preparing Phase II programs. Numerous community members visited the NGSC booth.

T-ReCS

T-ReCS, the Thermal-Region Camera Spectrograph, is a mid-infrared imager and spectrograph, for the Gemini South telescope that was developed at the University of Florida by Charlie Telesco and his team. In late November, T-ReCS passed the first portion of its preshipment acceptance testing. Gemini and NGSC personnel traveled to Gainesville, FL and ran tests to determine whether T-ReCS could meet its optical performance requirements. The image quality achieved in T-ReCS was found to be outstanding and passed all such performance requirements. Gemini, NGSC and Florida personnel carried out the remaining electronic, mechanical and software acceptance tests in February. After a few additional adjustments and fixes, T-ReCS was judged to have achieved all of the preshipment performance requirements by late March. Then, T-ReCS was packed for shipment to Gemini South. As of this writing in early April, T-ReCS has been shipped to Cerro Pachón and will soon begin integration with the Gemini control systems and then undergo final acceptance testing.



T-ReCS being lowered into shipping crate in Florida for shipment to Gemini South.

GNIRS

The Gemini Near-Infrared Spectrograph (GNIRS) is an infrared spectrograph for the Gemini South telescope that will operate from 1 to 5 microns and will offer several features: two plate scales; a range of dispersions; and long-slit, cross-dispersed and integral-field modes. The project is being carried out at NOAO in Tucson under the leadership of Neil Gaughan (Project Manager), Jay Elias (Project Scientist) and Dick Joyce (Co-Project Scientist).

In December, the GNIRS team carried out its second cycle of GNIRS cold testing. The cold cycle was performed with an engineering-grade array installed in GNIRS. During the cold test, the instrument reached the desired operating temperature. All motors and mechanisms performed within specification including the on-instrument wavefront sensor provided by the University of Hawaii Institute for Astronomy. Spectra were obtained with the detector and the instrument was controlled by the complete GNIRS software suite. Based on the results of this testing, a series of adjustments were made to the instrument, and the science-grade detector was installed. The instrument was also tested for weight and center of gravity and achieved these requirements.

In March, another cycle of GNIRS cold testing was carried out. With the science-grade infrared array installed, detailed tests of the spectroscopic performance in various modes were performed. The results of these tests are encouraging. In addition, flexure testing was performed using the NOAO Flexure Test Facility, and these results are also encouraging.

As of early April, GNIRS is being warmed up for some additional adjustments. Once these are complete, the GNIRS team will begin another cold cycle that is designed to test compliance with all instrument-performance requirements.

GNIRS is shown fully integrated on the new NOAO flexure rig facility in Tucson.

Then, once Gemini agrees that all of the GNIRS preshipment performance tests have been successfully completed, GNIRS will be shipped to Gemini South. The project schedule indicates that 99 percent of the work toward GNIRS preshipment acceptance has been completed.

NICI

The Near-Infrared Coronagraphic Imager (NICI) will provide a 1–5 micron dual-beam coronagraphic imaging capability on the Gemini South telescope. Mauna Kea Infrared (MKIR) in Hilo is building NICI under the leadership of Doug Toomey. The NICI cryostat components are undergoing fabrication as are the NICI optical elements. In addition, development of the array controller for the two NICI ALADDIN arrays is progressing well. Overall, 50 percent of the work to NICI final acceptance by Gemini, which is planned for December 2004, has been completed. (See also the Instrument Update article in this issue.)

Other Activities

U.S. involvement continues in the Gemini next-generation instrumentation planning process. NGSC will hold a community workshop on "Future Instrumentation for the Gemini 8-Meter Telescopes: U.S. Perspective in 2003" in the Phoenix, AZ vicinity on May 30-31 in order to discuss future Gemini science and instrumentation opportunities. A subset of the participants in this meeting will represent the U.S. at the international Gemini instrumentation-planning meeting in Aspen, CO in late June.

NGSC hosted a meeting of the Gemini Operations Working Group in Tucson, AZ on February 10, 2003. The working group had a productive meeting, with the added feature of a tour of GNIRS and the NOAO Flexure Test Facility.

U.S. Gemini Fellowships provide South American students and educators from Argentina, Brazil and Chile with opportunities to study, conduct independent research, work and teach in the U.S. at universities and similar research institutions of their choice. The recipient of the U.S. Gemini Fellowship for the 2003-2004 cycle is Katia Cunha, PHD, currently at the Observatorio Nacional in Rio de Janeiro, Brazil. Dr. Cunha will take her U.S. Gemini Fellowship to the University of Texas at El Paso. Her research plan addresses the chemical evolution of Local Group galaxies via high-resolution infrared spectroscopy. Cunha plans to use the Gemini South telescope and NOAO's high-resolution infrared spectrograph Phoenix in her research. The U.S. Gemini Fellowship is carried out as a partnership between AURA and NGSC, with funding from the National Science Foundation, and provides research support for up to 2 years.

UNITED KINGDOM

Isobel Hook

Very significant progress has been made over the last 6 months on all the major U.K. instruments. Since the last newsletter, two of these (GMOS South and Michelle) have had engineering first light on the Gemini telescopes. A third instrument (bHROS) has been delivered to Gemini South. Two others (GMOS North and CIRPASS) are in regular science use in Semester 2003A.

GMOS-S (built jointly by the UK Astronomy Technology Centre [UKATC] in Edinburgh, U.K., and the Herzberg Institute of Astrophysics in Victoria, Canada) was the first facility instrument to be installed on Gemini South and had engineering first light in January. Since then, commissioning has progressed at great speed. The one faulty charge-coupled device was replaced in April, giving a fully operational array of three EEV detectors. GMOS-S system verification has now begun, and the instrument will be offered for community use in Semester 2003B. The integral field unit for GMOS-S is under construction at the University of Durham and is due to be shipped to Gemini South later this summer.

Meanwhile on Gemini North, Michelle (built at UKATC) also had first light on Gemini in January. Initial tests uncovered a telescope problem with guiding while chopping, but this and other telescope interface issues that will also affect T-ReCS are now being addressed as high-priority engineering tasks. The sensitivity of Michelle is as expected, image quality is good (0.4 arcseconds, full-width at half-maximum at 11.6 microns) and the instrument is on track for community use as an imager late in Semester 2003A.

The fiber-fed high-resolution bench spectrograph (bHROS), was shipped from University College London to Gemini South in late March. Over the next couple of months, bHROS will be assembled in the pier lab at Gemini South where it will ultimately be fed light through a fiber feed from the GMOS-S mask plane. The fibers themselves are currently being worked on at La Palma Observatory and will be shipped to the U.K. where the bHROS relay optics will be attached and tested before shipment to Chile. The mechanical support for the fiber mechanism has been designed and is being manufactured in the U.K. for shipment to Chile in mid-May. Integration of bHROS in Chile is due to be completed in mid-June, but telescope time for on-sky commissioning has yet to be scheduled.

As the number of facility instruments and the available science time on the telescopes increase, the U.K. Gemini support group is also expanding. Dimitra Rigopoulou joined the group in February and is responsible for U.K. user support of T-ReCS as well as taking over from Alistair Glasse for user support of Michelle. Prior to joining Gemini, Dimitra was a Junior Science Staff member at the Max Planck Institute for Extraterrestrial Physics (MPE) in Munich. Before that, she worked as a postdoctoral research assistant at MPE and as a European Union Fellow at Imperial College in London. Her research interests include studies of ultraluminous infrared galaxies, in particular, investigating their nature (the starburst-active galactic nuclei connection) and evolution (ellipticals in formation). She is also studying the nature of the sources responsible for the cosmic infrared-submillimeter background, and she is a co-investigator on the Space Infrared Telescope Facility deep field surveys that include the *Hubble Deep Field South* and the *Chandra Deep Field South*.

Semester 2003A was the first semester that the national offices were responsible for receiving and checking Phase II files from successful applicants and forwarding the files to Gemini for inclusion in the queue. This process went reasonably well, although it is clear that the community is still coming to grips with the Observing Tool software!

In April, we held a tutorial on the use of the Gemini Observing Tool for Phase II preparation. This took place during the National Astronomy Meeting in Dublin.

The number of U.K. proposals received for 2003B remained high: 38 proposals for Gemini North and 22 for Gemini South. This compares to 42 and 16 respectively in 2003A. However, the number of hours requested per proposal has increased particularly for Gemini South. The oversubscription rates appear to have remained approximately constant despite a more than 50-percent increase in available time on Gemini South.

Finally, preparations continue for the Aspen 2003 workshop in Colorado. In January, a meeting was held to begin discussing the U.K.'s requirements, and there have been further discussions organized along the scientific themes of the Aspen meeting. Ten U.K. representatives will attend the Aspen workshop in June.

CANADA

Dennis Crabtree

Canadian astronomers are busy preparing for the Gemini Instrumentation Workshop that will be held in Aspen, CO at the end of June. Canada has established a parallel process to the Gemini international one. Science teams in each of four "themes" are investigating the most interesting Gemini science from a Canadian perspective for the period 2007–2012. We will have a workshop in Montréal on May 4th and 5th where the work of the teams will be presented, discussed, and science cases drafted. The timing of the meeting allows for further work and finalization of the science cases before the Aspen workshop.

Canada received a total of 35 proposals for Semester 2003B on Gemini. The distribution of the proposals is shown in the following two tables. The first table shows the number of proposals, and the second shows the distribution of time requested.

Telescope	Instrument Acquisition Camera	GMOS	Michelle	NIRI	Phoenix	T-ReCS	Total
Gemini North		15	2	5			22
Gemini South	2	6			3	2	13
Total	**2**	**21**	**2**	**5**	**3**	**2**	**35**

Telescope	Instrument Acquisition Camera	GMOS	Michelle	NIRI	Phoenix	T-ReCS	Total	Subscription Rate
Gemini North		251.5	18.3	69.7			339.5	2.63
Gemini South	14.5	68.6			33.7	10.9	127.7	1.06
Total	**14.5**	**320.1**	**18.3**	**69.7**	**33.7**	**10.9**	**467.2**	**1.87**

Canadian proposal totals for Gemini Semester 2003B. The top table indicates number of proposals. The bottom table shows distribution of time requested.

The number of proposals is encouraging, but with the average proposal request at just over 13 hours, the oversubscription rate is somewhat low. As expected, the largest number of proposals is for Gemini Multi-Object Spectrograph, with 70 percent of these requests for Gemini North.

The contract for the development of the Gemini Science Archive is now signed, and work is proceeding. National Research Council-Herzberg Institute of Astrophysics and Gemini staff held a very successful "kickoff" meeting in late March in Hilo. The development phase is expected to take about 1 year. Negotiations are now underway on an operations contract. The plan is to begin operating a very simple archive this summer and to incrementally add functionality as the development process moves forward.

AUSTRALIA

Warrick Couch

Writing this issue's contribution is made easy with the abundance of news, but is made difficult in having to report the terrible events that have affected the Australian astronomy community, and more broadly, Gemini in the last 6 months.

On what has become known as "Black Saturday" (January 18, 2003), a massive bush fire swept up the slopes of Mt. Stromlo, and destroyed much of the observatory at its summit. All of the telescopes were damaged beyond repair, including the 74–inch and 50–inch telescopes, the latter receiving worldwide recognition for its role in the MACHO (Massive Compact Halo Objects) experiment and about to commence an all-southern-sky digital survey. Many other buildings were lost, including the heritage-listed administration building (which housed the design office and library), the mechanical and electronic workshops, and astronomers'/students' houses. The bad news for Gemini was that its Near-Infrared Integral Field Spectrograph (NIFS), which was within 6 months of being completed and delivered to Gemini North, was undergoing its third cool-down within the workshops, and was totally destroyed by the extreme heat and building collapse. While the damage to property was immense, we can be thankful that no observatory personnel were injured or lost their lives.

In the face of this calamity, the Research School of Astronomy and Astrophysics (RSAA) staff and the Australian National University (ANU) have responded magnificently, with plans for rebuilding the observatory, and thus, maintaining its importance within Australia as a research center and national icon well underway. Central to these plans is getting its Gemini instrument construction program back on track, not just in recovering from the loss of NIFS, but also ensuring that the building of the Gemini South Adaptive Optics Imager (GSAOI) — the contract that was awarded to the RSAA at the end of 2002 — is delivered to Gemini in a timely manner.

Within a month of the fire, Peter McGregor and his team had a recovery plan for NIFS in place, which involved building a clone by the end of 2004, and making it available to the Gemini community by mid-2005. While clearly an ambitious plan, the recovery process is aided enormously by the fact that key NIFS components — such as the designs and drawings, the HAWAII-2 science detector, the pupil and field mirror arrays, and most of the lenses — all survived the fire. Another key aspect is that all the fabrication will be out-sourced, through a subcontract to the Canberra-based aerospace company Auspace Limited (which has worked closely with the RSAA for many years and has already been involved in the NIFS project). Importantly, this will allow the RSAA team to concentrate on GSAOI.

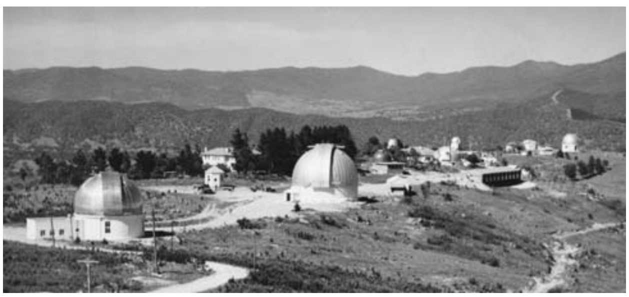


Image of Mt. Stromlo Observatory circa 1955

Fortunately, NIFS was covered by ANU insurance, although by a policy that will pay the RSAA only to build a replacement. Hence, the rebuild will allow Gemini to recover its investment in NIFS and, provided it is done in a 2-year timeframe, will provide an instrument that is still very competitive scientifically.

As such, the RSAA has now received approval from Gemini's director to proceed with this plan. Meanwhile, the design and construction of GSAOI continues almost uninterrupted, thanks to temporary office and workshop facilities being made available on the ANU campus and at the nearby Australian Defence Force Academy.

Rear view of the administration building and remnants of the 50 inch telescope on Mt. Stromlo after the January fire.
Photo courtesy of Matthew Colless, RSAA, ANU.

Despite these events, Australia has continued to actively prepare for the second Gemini Future Instrumentation Workshop, in Aspen, CO. This has been organized and structured around the same four science theme areas that are the focus for Aspen. For each of these areas a local "Group Chair" has been appointed, whose brief has been to canvas the members of our Gemini community as to what their scientific needs and visions are in the post-2006 era and, accordingly, develop science cases (with associated instrument requirements) that they will take to and present at Aspen. Our Group Chairs are: Tim Bedding, Stuart

Ryder, Brad Gibson and Brian Boyle. To carry out this consultation process, they have organized a series of mini-workshops and meetings across all the astronomical institutions within Australia. The input from these meetings is now being collated and merged into a "science driver" document for each group. In early May, we will hold our second community-wide "Pre-Aspen" workshop, where the science cases for each group will be presented, discussed, and final input received before they are taken to Aspen.

The Semester 2003B proposal deadline has just passed. Pleasingly, the number of proposals received (20) represented a factor of 2 increase on the number received for 2003A returning us to the levels experienced in the 2002 semesters. There was also much stronger demand for Gemini South time, a result of GMOS South being offered for the first time. The overall subscription factor for Gemini North was 2.1 with six proposals requesting time on GMOS North, two on NIRI and two on Michelle. For Gemini South, the overall subscription factor was 2.4 with eight proposals requesting time on GMOS-S, one on Phoenix and one on T-ReCS. Of note was the number of "hedged" proposals involving the use of either GMOS-N and/or GMOS-S as well as Michelle and/or T-ReCS for their programs.

Finally, Gemini will have a strong presence at the upcoming International Astronomical Union (IAU) General Assembly in Sydney, Australia in July with both the Gemini Observatory and the Australian National Gemini Office having exhibits alongside each other. This will provide a good opportunity to publicize both national and international Gemini activities to the large number of astronomers who will attend the IAU as well as to the Sydney public. We hope that there will be good turnout at the IAU from astronomers throughout the Gemini partnership, and we look forward to seeing you in Sydney in July!

BRAZIL

Max Faúndez-Abans

We have successfully provided the Brazilian Gemini community our first National Gemini Office (NGO) instrument support. It has been a good opportunity to tighten the contact with other Gemini scientists and technicians, and we have gained experience. Our service has had a good reception by the users, which assures us that we have done a good job.

As for the proposals for Semester 2003B, a total of 38.87 hours at Gemini North have been requested representing a pressure factor of 1.77. For Gemini South, 88.39 hours have been requested with a pressure factor of 4.42. There has been a clear rise in the number of proposals submitted by the Brazilian community in comparison to the last semesters e.g., 21 proposals in 2003B compared with 18 in Semester 2002B.

The Brazilian NGO is working together with Gemini to develop the staff training program that supports the instruments in the Phase II process. We expect to have our first experiences with the instruments at the telescopes during the second semester of 2003.

We are glad to announce that Kátia Cunha, Ph.D. from Ministério da Ciência e Tecnologia/Observatório Nacional has been granted the U.S. Gemini Fellowship at the University of Texas at El Paso for the 2003–2004 cycle. The Brazilian NGO wishes to thank all the members of the Gemini Fellowship Committee and the members of the National Science Foundation, Association of Universities for Research in Astronomy, Inc. and the National Optical Astronomy Observatory involved in the process for the kind assistance during the selection, and for this great career opportunity for Dr. Cunha.

The Brazilian NGO, Laboratório Nacional de Astrofísica (LNA), intends to intensify the PIO activities in Brazil through press releases based on Brazilian investigators and Gemini results as well as through increasing the number of Gemini highlights presented at talks and public visitations.

Half of the senior citizens group (65—87 years old) visiting the OPD/LNA to learn about observatories in general and about Gemini.

The LNA operates the Pico dos Dias Observatory (OPD) where a public visitation program for schools is carried out by the NGO staff astronomers. About 1,400 students per year visit the OPD and learn about the observatory, astronomy, instrumentation, Gemini and SOAR (SOuthern Astrophysical Research Telescope).

Senior citizens are also one of our target groups for our outreach effort. They are willing to learn about modern technology and the latest achievements of science and, as such, they are amazed by the Gemini Observatory and the kind of science that is done with the twin telescopes.

We have used Gemini as an example of international cooperation, national effort and state-of-the-art technology. The LNA has worked closely with ECONTI, a senior citizens center based in Itajubá, Minas Gerais (see picture).

CHILE

Luis Campusano & Sebastián López

CONICYT, as a national host to Gemini, continued to receive proposals for the use of its Gemini South telescope time through the partnership. This reflects the new modality of Chile participation in the partnership, which better serves the Chilean astronomical community and the Gemini Observatory. A fund to invest in the development of astronomy and closely related sciences within Chile is under consideration. The current access to 8-meter-class telescopes that Chilean astronomers have is indeed very large in comparison to the other partner astronomical communities. Thus, Gemini South with its instrumentation has to compete with the Very Large Telescope and Magellan telescopes to get the attention and interest of our privileged astronomers. Fortunately, both the formation of human resources departments and the increase of researchers in Chilean institutes are now in an expansive period.

Only three proposals (two for CIRPASS, and one for Phoenix) were received for Semester 2003A. The number of requested hours was 83, yielding a formal subscription factor of 1.3, which is still rather small.

We have continued to use the Phase I Tool (PIT) with no complaints reported and submissions via e-mail. No major problems were identified during the feasibility reviews of the proposals, which is an indication that a sufficient amount of information is being provided in the Gemini web pages. We expect far more proposals in 2003B now that GMOS is being offered. The review committee should have more work and discussion this time. The deadline for receipt of 2003B proposals was again set to mid-April (14th), about 2 weeks later than deadlines of other observatories in Chile. The latest news for 2003B is that ten proposals were received (seven for GMOS and three for T-ReCS) asking for 205 hours in total, which corresponds to a more healthy subscription factor of 2.4 .

Semester 2003A was the first semester where National Offices played an active role in supporting Phase II. Several issues were identified in this first trial, which will help us to prepare Chilean-specific guidelines for the upcoming Phase II. For example, it will allow us to optimize the NGO-PI (National Gemini Office-Principal Investigator) interaction and identify the different levels of queries we may receive.

The PPARC Gemini studentship 2003, available for Chilean students and administered in Chile by the Fundación Andes, had a strong competition this year. It was awarded to Antonio Hales, a B.Sc. graduate in Astronomy from the University of Chile, who was accepted at the University College London (UCL) to study for a Ph.D. in Astronomy. We wish Antonio a very successful research experience at UCL and a happy return to Chile in a few years' time.

THE GEMINI SOUTHERN OPERATIONS CENTER

Peter McEvoy

Gemini Observatory passed a major milestone in its development during the first weekend of March, when months of construction and logistical work terminated in the successful move of all staff and equipment at Gemini South from temporary working quarters to the new Southern Operations Center, located at the AURA Recinto in La Serena, Chile.

The initial clearing of the site for the building took nearly 17 months. The bulk of the construction work began in January 2002. Gemini contracted with three companies – Oda-McCarty Architects, who designed the Hilo facility, the Andes Group, a prestigious Chilean architectural firm, and Rencoret Limited, a major local builder – to work together on the project with a small Gemini construction taskforce led by Paul Gillett and Paul Collins. Their work provided Gemini South staff with very comfortable office and laboratory space. The remarkable dedication of all involved to safe working standards resulted in no days lost due to accidents during the approximately 100,000 construction hours required to build the facility. This record compares very favorably against both Chilean and U.S. standards.

Detailed plans for the move were developed to cover more than 70 distinct work packages, and have ensured that issues such as safety, network, power, telephony, air conditioning, office furniture and equipment, and videoconferencing facilities were appropriately considered. All were in place extremely quickly with minimal disruption after the physical move.

A skeleton team of Gemini South staff plus several very welcome volunteers were directly involved in the removal of furniture, office equipment and related materials from the "Casa Verde" and their subsequent placing in the new building during long days over the weekend of March 1–2, 2003.

The front entrance of the Gemini South Base Facility showing the locally quarried stone facade and Chilean copper roof. See additional images of this new facility on the opposite page.

Costing US$2.3 million, the two-story building's 17,668 square feet (1,642 m^2) provides office and conference room space for 60 staff and visitors. Shared with its neighbors CTIO and SOAR, the 42-seat lecture theater and major instrument laboratory are important additions to the AURA infrastructure in La Serena. The Operations Room is designed, in a similar fashion to Gemini North, to facilitate base-level visitor and staff interaction to the telescope during observing runs.

In March 2003, the new building hosted the Gemini Oversight Committee, and Gemini Board members experienced the building for themselves when they met in La Serena in May.

Dominating the landscape at the AURA Recinto, the impressive building has many Chilean touches in its design, including facades of beautiful local stone with a copper roof (Chile is the world's number one producer of copper). Regrettably, while many office windows overlook the city of La Serena and the Pacific Ocean, few staff members have the time to appreciate their view across the facility's landscaped gardens. There are no complaints, however. After the years spent in temporary office space loaned from CTIO and in the old Casa Verde, all are enjoying the spaciousness, quiet and working comforts available in the new Southern Operations Center.

The move itself was a tremendous example of planning and team coordination at a very detailed level, and the building stands as a symbol of Gemini's progress. As one staff member commented during the first week of the building's occupancy, "It is now very much up to us at Gemini South to make sure we perform top-class work here to justify the wonderful infrastructure, which has been put in place for us, not to just work with, but to enjoy."

WELCOME TO THE NEW GEMINI SOUTHERN OPERATIONS CENTER

GEMINI OBSERVATORY NEWSLETTER

THE GEMINI OBSERVATORY
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Interior of the Frederick C. Gillett Gemini Telescope (Gemini North) by moonlight. This 50-second exposure was obtained on February 9th, 2003 using the same equipment as the images on the inside front cover.