Gemini Observatory
An Introduction

Ricardo Schiavon
Gemini
SAGDW
Oct 27, 2011

With thanks to Jean-René Roy and Nancy Levenson
Contents

• A brief introduction
• Instruments
• Science highlights
• Status of commissioning instruments
• Future instruments
Gemini Observatory

Gemini North, atop Mauna Kea volcano, Hawaii, USA, alt. 4200m.
Gemini Observatory

Gemini South, atop Cerro Pachón, Chile, alt. 2700m.
Gemini in numbers

- 2 8m telescopes
- 7 member countries
- Building cost: US$ 184 mi
- Operation cost: ~1 US$/s
- 8 active instruments
- 2 commissioning instruments
- ~200 employees from 15 countries
- $10^2$ computers per site
- ~95% queue mode
Instruments

• Gemini North
  – GMOS: Optical, imaging, spectroscopy, longslit, MOS, IFU
  – NIRI: NIR/MIR, imaging, AO
  – NIFS: NIR, IFU spectroscopy, AO
  – GNIRS: NIR, longslit and cross-dispersed spectroscopy, AO
  – Michelle: MIR, imaging, spectroscopy
  – ALTAIR: AO unit

• Gemini Sul
  – GMOS: Optical, imaging, spectroscopy, longslit, MOS, IFU
  – NICI: NIR, imaging coronographer, AO
  – T-ReCS: MIR, imaging, spectrographer
  – FLAMINGOS-2: Imaging, spectroscopy, longslit, MOS, AO
  – GEMS/GSAOI: NIR, imaging, MCAO
Cassegrain focus at GS
NIRI
Near InfraRed Imager and Spectrometer
NIRI Features

- Gemini North
- Instrument scientist: Andy Stephens
- Imaging w/out AO
- Long-slit spectroscopy deactivated
- Detector Aladdin 1024 x 1024 InSb 27 μm
### NIRI - Imaging

<table>
<thead>
<tr>
<th>Camera</th>
<th>Pixel dimension (arc sec)</th>
<th>Field of View (arc sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>f/6</td>
<td>0.1171</td>
<td>119.9 x 119.9</td>
</tr>
<tr>
<td>f/14</td>
<td>0.0499</td>
<td>51.1 x 51.1</td>
</tr>
<tr>
<td>f/32</td>
<td>0.0219</td>
<td>22.4 x 22.4</td>
</tr>
</tbody>
</table>
## NIRI - Filters

<table>
<thead>
<tr>
<th>Filter Name</th>
<th>Central Wavelength (microns)</th>
<th>Coverage (microns or d/l)</th>
<th>Gemini ID</th>
<th>Transmission Curve (click for graph)</th>
<th>Numerical Transmission Data</th>
<th>Currently In Dewar?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>1.02</td>
<td>0.97-1.07</td>
<td>G0241</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>J</td>
<td>1.25</td>
<td>1.15-1.33</td>
<td>G0202</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>H</td>
<td>1.65</td>
<td>1.49-1.78</td>
<td>G0203</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>H-K notch</td>
<td>-</td>
<td>1.45-1.76;1.93-2.29</td>
<td>G0236</td>
<td>yes</td>
<td>warm</td>
<td>no</td>
</tr>
<tr>
<td>K</td>
<td>2.20</td>
<td>2.03-2.36</td>
<td>G0204</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>K(short)</td>
<td>2.15</td>
<td>1.99-2.30</td>
<td>G0205</td>
<td>yes</td>
<td>warm</td>
<td>no</td>
</tr>
<tr>
<td>K(prime)</td>
<td>2.12</td>
<td>1.95-2.30</td>
<td>G0206</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>L(prime)</td>
<td>3.78</td>
<td>3.43-4.13</td>
<td>G0207</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
<tr>
<td>M(prime)</td>
<td>4.68</td>
<td>4.55-4.79</td>
<td>G0208</td>
<td>yes</td>
<td>warm</td>
<td>yes</td>
</tr>
</tbody>
</table>

**Broad-band filters**

- Y, J, H, K, L, M.
GNIRS
Gemini Near Infrared Spectrograph
GNIRS Features

- Gemini North (Previously Gemini South)
- Instrument scientist: Rachel Mason
- Spectroscopy (long slit and cross dispersed)
- Aladdin III InSb, 1024x1024 pix

- Coverage:
  - 1 a 5.5 $\mu$m long slit, R ~ 1700, 5900 e 18000
  - 0.9 a 2.5 $\mu$m cross dispersed, com R ~ 1700

Adaptive optics.
# GNIRS - Gratings

<table>
<thead>
<tr>
<th>Grating</th>
<th>Short camera</th>
<th>Long camera</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Resolving power</td>
<td>Wavelength coverage</td>
</tr>
<tr>
<td>10.44 l/mm</td>
<td>(a)</td>
<td>(a)</td>
</tr>
<tr>
<td>31.7 l/mm</td>
<td>1700</td>
<td>0.3 * lambda ((b))</td>
</tr>
<tr>
<td>110.5 l/mm</td>
<td>5900</td>
<td>0.09 * lambda</td>
</tr>
</tbody>
</table>
## GNIRS - Slits

<table>
<thead>
<tr>
<th>Slit name</th>
<th>Slit width (pixels) [nominal values]</th>
<th>Slit width (measured, arcsec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>short camera</td>
<td>long camera</td>
</tr>
<tr>
<td>0.10 arcsec</td>
<td>n/a</td>
<td>2</td>
</tr>
<tr>
<td>0.15 arcsec</td>
<td>n/a</td>
<td>3</td>
</tr>
<tr>
<td>0.20 arcsec</td>
<td>n/a</td>
<td>4</td>
</tr>
<tr>
<td>0.30 arcsec</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>0.45 arcsec</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>0.675 arcsec</td>
<td>4.5</td>
<td>12</td>
</tr>
<tr>
<td>1.0 arcsec</td>
<td>6.7</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Slit length</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>short camera</td>
<td>long camera</td>
<td></td>
</tr>
<tr>
<td>Long-slit</td>
<td>99 arcsec</td>
<td>49 arcsec</td>
<td></td>
</tr>
<tr>
<td>Cross-dispersion</td>
<td>6.1 arcsec</td>
<td>3.1 arcsec</td>
<td></td>
</tr>
</tbody>
</table>
NIFS
Near Infrared Integral Field Spectrometer
NIFS Features

- Gemini North
- Instrument scientist: Richard McDermid
- IFU spectroscopy
- ZJHK bands (0.9 – 2.2 μm)
- Detector Rockwell Hawaii HrCdTe, 2048 x 2048
- Adaptive optics
## NIFS - Features

### Spatial Properties

<table>
<thead>
<tr>
<th>Field of View</th>
<th>3&quot; × 3&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel Scale</td>
<td>0.103&quot; across slices 0.04&quot; along slices</td>
</tr>
<tr>
<td>Spatial Resolution (FWHM)</td>
<td>0.1&quot; full AO correction (NGS/LGS) Seeing limited without AO</td>
</tr>
</tbody>
</table>

### Spectral Properties

<table>
<thead>
<tr>
<th>Grating</th>
<th>Z</th>
<th>J</th>
<th>H</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Wavelength Range (µm)</td>
<td>0.94 - 1.15</td>
<td>1.15 - 1.33</td>
<td>1.49 - 1.80</td>
<td>1.99 - 2.40</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>4990</td>
<td>6040</td>
<td>5290</td>
<td>5290</td>
</tr>
</tbody>
</table>
Michelle
Mid Infrared Echelle Spectrometer
Michelle Features

- Gemini North (originally UKIRT)
- Instrument scientist: Marie Lemoine-Busserolle
- Detector Si:As IBC 320x240 pix
- Plate scale: 0.1”/pixel (imaging) or 0.18 (spectroscopy)
- No adaptive optics (diffraction limit reached in MIR without AO).
# Michelle - Filters

<table>
<thead>
<tr>
<th>Filter Name</th>
<th>Name in Headers a</th>
<th>Central Wavelength (microns)</th>
<th>Bandwidth (microns)</th>
<th>Approximate 50% power points (microns)</th>
<th>Transmission Data (text)</th>
<th>Transmission Curves (jpeg)</th>
<th>Currently Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>N'</td>
<td>I112B21</td>
<td>11.2</td>
<td>2.4</td>
<td>10.1 - 12.5</td>
<td>✓</td>
<td>✓</td>
<td>Yes</td>
</tr>
<tr>
<td>Qa</td>
<td>I185B9</td>
<td>18.1</td>
<td>1.9</td>
<td>17.13 - 19.06</td>
<td>✓</td>
<td>✓</td>
<td>Yes</td>
</tr>
<tr>
<td>Q'</td>
<td>I198B27</td>
<td>19.8</td>
<td>5.4</td>
<td>17.1 - 22.5</td>
<td>-</td>
<td>-</td>
<td>Yes b</td>
</tr>
<tr>
<td>N</td>
<td>I105B53</td>
<td>10.5</td>
<td>5.3</td>
<td>7.7 - 13.0</td>
<td>✓</td>
<td>✓</td>
<td>Yes b</td>
</tr>
<tr>
<td>Q</td>
<td>I209B42</td>
<td>20.9</td>
<td>8.8</td>
<td>16.5 - 25.3</td>
<td>✓</td>
<td>✓</td>
<td>Yes b</td>
</tr>
</tbody>
</table>

**Mediumband and Broadband Filters**

**Silicate Filters**

| Si-1        | I79B10            | 7.7                         | 0.7                 | 7.39 - 8.08                            | ✓                        | ✓                         | Yes c              |
| Si-2        | I88B10            | 8.8                         | 0.9                 | 8.35 - 9.25                            | ✓                        | ✓                         | Yes                |
| Si-3 d      | I97B10            | 9.7                         | 1.0                 | 9.2 - 10.2                             | ✓                        | ✓                         | Yes                |
| Si-4 d      | I103B10           | 10.3                        | 1.0                 | 9.8 - 10.8                             | ✓                        | ✓                         | Yes                |
| Si-5        | I116B9            | 11.6                        | 1.1                 | 11.15 - 12.25                          | ✓                        | ✓                         | Yes                |
| Si-6        | I125B9            | 12.5                        | 1.2                 | 11.9 - 13.1                            | ✓                        | ✓                         | Yes                |

**Longpass Filters for 10um and 20um Spectroscopy**

| LP-7        | Nblock            | -                           | -                   | 6.8 - >14                              | -                        | -                         | Yes                |
| LP-16       | Qblock            | -                           | -                   | 16.1 - >25                             | -                        | -                         | Yes                |
## Michelle - Gratings

<table>
<thead>
<tr>
<th>Name</th>
<th>Usable wavelengths</th>
<th>Dispersion (microns/pixel)</th>
<th>Resolving power 10um, 2pw slit</th>
<th>Resolving power 20um, 3pw slit</th>
<th>Wavelength coverage for single grating setting (microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LowN</td>
<td>7-14um</td>
<td>0.024</td>
<td>200</td>
<td>-</td>
<td>7.7</td>
</tr>
<tr>
<td>LowQ</td>
<td>16-26um</td>
<td>0.031</td>
<td>-</td>
<td>110</td>
<td>9.9</td>
</tr>
<tr>
<td>Medium (R~1000)</td>
<td>7-26um</td>
<td>0.0047</td>
<td>1000</td>
<td>1300</td>
<td>1.5</td>
</tr>
<tr>
<td>High (R~3000)</td>
<td>7-26um</td>
<td>0.0016</td>
<td>3000</td>
<td>4000</td>
<td>0.50</td>
</tr>
<tr>
<td>Echelle</td>
<td>7-22.5um *</td>
<td>~</td>
<td>20,000-40,000</td>
<td>~</td>
<td>1500 km/sec at blaze wavelength</td>
</tr>
<tr>
<td>Name</td>
<td>Width (pixels)</td>
<td>Width (arcsec)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>-</td>
<td>-</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.201</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.402</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.603</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>0.804</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>1.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pinhole mask</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Phoenix
Near Infrared Echelle Spectrometer
Phoenix - Características

- Gemini Sul (originalmente Kitt Peak)
- Instrument scientist: Germán Gimeno
- Espectrógrafo de alta R: 25000 - 80000
- IV próximo: 1 - 5 µm (mas cobertura espectral limitada)
- Detetor InSb Alladin II, 512x1024 pix
- Largura de fenda: 0.17 - 0.34 arcsec
- Comprimento: 14 arcsec
T-ReCS
Thermal Region Camera Spectrograph
T-ReCS - Features

- Gemini South
- Instrument scientist: James Radomski
- Low-resolution spectroscopy and imaging in the MIR
- Detector Raytheon SRBC, 320x240 pix
T-ReCS - Imaging

<table>
<thead>
<tr>
<th>Mode</th>
<th>Window</th>
<th>Slit</th>
<th>Filter</th>
<th>Grating</th>
<th>Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 µm Imaging</td>
<td>ZnSe</td>
<td>Open or Occulting Bar</td>
<td>N, Si1-Si6, narrow-band</td>
<td>Imaging flat</td>
<td>High-background</td>
</tr>
<tr>
<td>20 µm Imaging</td>
<td>KRS-5</td>
<td>Open or Occultingbar</td>
<td>Qa or Qb</td>
<td>Imaging flat</td>
<td>High-background</td>
</tr>
</tbody>
</table>

- Plate scale 0.09 arcsec/pix
- Field of view 29 x 22 arcsec
**T-ReCS - Spectroscopy**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Window</th>
<th>Slit Width</th>
<th>Filter</th>
<th>Grating</th>
<th>Detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 μm Lo-Res Spectroscopy</td>
<td>ZnSe</td>
<td>10 μm I/D or 2I/D</td>
<td>N</td>
<td>10 μm Lo-Res</td>
<td>Low-background</td>
</tr>
<tr>
<td>20 μm Lo-Res Spectroscopy</td>
<td>KRS-5</td>
<td>20 μm I/D or 2I/D</td>
<td>Qbroad</td>
<td>20 μm Lo-Res</td>
<td>Low-background</td>
</tr>
<tr>
<td>10 μm Hi-Res Spectroscopy</td>
<td>ZnSe</td>
<td>10 μm I/D or 2I/D</td>
<td>N</td>
<td>10 μm Hi-Res</td>
<td>Low-background</td>
</tr>
</tbody>
</table>

- Resolution: 100 - 1000
- Slit width: 0.21 - 1.32 arcsec
- Slit length: 22 arcsec
NICI
Near Infrared Chronographic Imager
NICI - Características

- Gemini South
- Instrument scientist: Tom Hayward
- Coronographic imaging with AO
- NIR
- Optimized for detection of Jovian planets
- Two stages observe continuum and core of methane band (though other configurations possible)
- Field of view: 18x18 arcsec
- Plate scale: 18 miliarcsec / pixel
Gemini Multiconjugate Adaptive Optics System

- laser guide star facility, first light Jan 22, 2011
  typical 55W, max 65W
GeMS technical commissioning

- Canopus AO bench
- All primary loops and offloads commissioned and optimized
GSAOI

- Gemini South Adaptive Optics Imager
- 0.9 – 2.4 μm
- 85” field of view
- Plate scale 0.02”/pix
- Instrument scientist: Rodrigo Carrasco
GeMS technical commissioning

- Nearly uniform image quality over 85” field of view
- Strehl up to 20%
- FWHM 0.075”
• Ongoing 5-month shutdown
• Science commissioning starting in November
• Possible GeMS/GSAOI call for SV proposals in early 2012
FLAMINGOS-2

- 0.9-2.4\(\mu\)m imaging, longslit, and multi-object for GS
- work done to
  - improve thermal stability
  - improve mechanisms and mechanical reliability
  - install R=3000 grism
  - install new science detector

MOS wheel with new drive
grism
• to Cerro Pachón in October
• on sky in December
• expect SV call for proposals in 2012, likely January
  for early 2012 observations
Gemini Planet Imager (GPI)

- extremely high contrast imaging
- integral field spectrograph and polarimeter
- comprehensive survey of giant planets
- astrophysics of brightest ones
- science beyond planets

contrast depends on guide star magnitude
Gemini and the 2011 Nobel Prize in Physics

Based on data from HST and Keck, Riess et al. and Perlmutter et al. discovered the accelerated expansion of the universe.
Data collected from 8-10m class telescopes, including Gemini (ToO programs using mostly GMOS), were needed to confirm those results, by extension of SN observations to higher redshift, as well as a better understanding of the systematics.

Conley et al. 2011
z = 7.085 quasar

GMOS slow ToO from UKIDSS: suggested broad Lyα
GNIRS days later: obvious quasar spectrum; first z>7
no Lyα emission z>6 except within locally-ionized region
→ neutral density of IGM at z=7 much higher than at z=6

Mortlock et al. 2014
z~9.4 GRB 090429B

- Swift detection, GMOS + NIRI images. Spectroscopy prevented by bad weather.

- “normal” GRB likely not due to first generation of stars significant star formation in first few 100Myr.

Cucchiara et al. 2011
2009 Jupiter impact

Michelle images + T-ReCS spectra
impact results: heating, ammonia dredge-up, and aerosols
silicate signature in spectra → rocky impactor
(asteroid, not comet)

Orton et al. 2011
Fletcher et al. 2011
M87 black hole mass

NIFS/LGS observations + modeling

\[ M_{BH} = 6.6 \pm 0.4 \times 10^9 \, M_{\odot} \]

insensitive to dark halo contribution on this scale

M87 is useful to measure high-mass end of M-\(\sigma\) relation

Gebhardt et al. 2011
Andromeda XXIX – a newly discovered M31 satellite

- Fewer dwarf galaxies exist than predicted by cold-dark matter theory (by an order of magnitude)
- Not known whether due to incompleteness in the samples or a flaw in $\Lambda$-CDM
- Surveys of the Local Group in search of these extremely faint satellites of the Milky Way and Andromeda are important to better constrain the observational side of the problem
- Eric Bell and team identified a candidate dwarf galaxy from an enhancement in stellar density in SDSS images

Andromeda XXIX – a newly discovered M31 satellite

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- Not known whether due to incompleteness in the samples or a flaw in $\Lambda$-CDM
- Surveys of the Local Group in search of these extremely faint satellites of the Milky Way and Andromeda are important to better constrain the observational side of the problem
- Eric Bell and team identified a candidate dwarf galaxy from an enhancement in stellar density in SDSS images
- Deep follow up imaging with GMOS (only a few hours) revealed a clear giant branch, indicative of the presence of a metal-poor stellar system
- New dwarf galaxy located 200 kpc of the center of M31, where properties of satellites are poorly understood

Obrigado
Gracias
• Gemini North ALTAIR NIRI discovery of 8 M_{Jup} “companion” to K7-type solar mass star (d ~ 150 pc)
  – In ~5 Myr-old Upper Scorpio association
  – At r = 2.22” or 330 AU orbit?
• Spectroscopy of Jovian planet
  – L4-type with T\(_\text{eff}\) ~ 1800 K
• “Wide” planetary companion poses a challenge to theories
• Needs proper motion measurements over next 2-3 yrs to establish whether planet is bound to star of chance superposition.

After 10 years of trials, first imaging of a self-luminous Jovian planet ‘around’ a normal star, i.e. lowest mass companion imaged around normal star so far.

Proto-planetary Disk Kinematics with TEXES

- Kinematics of warm gas in proto-planetary disk with TEXES
  - $R = 100,000$
- H$_2$O rotational emission line resolved
  - 90 km/s FWHM
    - From $r \sim 0.3$ to 1 AU
    - “Double-horn shape profile consistent with ring of gas emission
- Could be planetary “gap” in planet forming disk or cleared out inner disk by massive proto-planets

Hypersonic gas in $\varepsilon$ Car

- Massive $\varepsilon$ Car is a Luminous Blue Variable with violent eruptions
  - Precursor to supernova
- GNIRS finds 3,500-6000 km/s gas from 1843 eruption blast wave
  - This fast material doubles kinetic energy of 19th century event
  - Explosion rivalled that of a supernova --> hence more evidence for the class of “supernova impostors”

N. Smith 2008, Nature
Supernova forensic with GN LGS AO imaging

- SN 2008cs is first SN discovered with GN NIRI ALTAIR LGS AO
  - Located 1.5 kpc from nucleus of LIRG IRAS 17138-1017
- By its radio detection by VLA, SN 2008cs is confirmed as core-collapse event
- JHK colors indicate extinction of ~17 mag in V band!

High extinction events can have impact for SN statistics and implications for high z dusty galaxy SFR


VLA-C 22.4 GHz Contours on 19 May 2008
A Rotating Nuclear Stellar Cluster

- ALTAIR/NIFS LGS AO spectroscopy of flattened nuclear star cluster in edge-on spiral NGC 4244
  - Multiple components
  - Strong rotation +/-30 km/s within the central 10 pc
    - Both young disk and spheroidal components rotate
    - Rotation is in same direction as normal disk
    - $1.7 \times 10^6$ solar mass located < 8 pc from core

Primary formation of NSC through episodic accretion of material from the disk, gas or young star clusters.

Weighing A Super-massive Black Hole with NIFS LGS

- ALTAIR NIFS LGS velocity mapping of heart of PG 1436+015 quasar
- Stellar velocity dispersion from near IR Si and Mg lines and CO bandheads
  - $M_{\text{BH}}$ lies significantly above $M_{\text{BH}} - \sigma^*$ relation
  - $\sigma^* = 217 \pm 15$ km/s from 0.1” to 1.0” (0.16 to 1.6 kpc)
- Matching K5III template indicates surprising young population

Another ALTAIR/NIFS LGS study indicates also much higher mass for central supermassive black hole than derived from RM

• Goal: produce a definitive sample of distant SN Ia for cosmology for distinguishing DE theories
• 400 spectroscopically confirmed SN from GN&GS, VLT, Keck and Magellan
  – 230 objects from Gemini (~500 hours of observing time)
• 15 refereed publications; team of ~40 from 7 countries

“Gemini’s key role was to provide spectroscopic redshifts and classification of the SN types for the most distant (hence faintest) supernovae candidates. The N&S mode on GMOS made this possible by greatly reducing systematic effects associated with sky subtraction.”

Isobel Hook

SNLS team, 2008
GRB 080319b: A naked-eye event!

- Gemini rapid ToO programs at GN&GS
  - GRBs are tracked/monitored by a battery of space and ground-based telescopes
- GRB 080319b at $z = 0.97$
  - $J \sim 4.5$ with PAIRTEL
  - Afterglow imagery with GMOS North & South
    - Deepest late-time observations
    - Evidence for an optical jet break and luminous supernova
- For 30 min (rest frame), GRB 080319b was brightest than the most luminous QSOs
  - If it had occurred in the Milky Way, would have had $M_{\text{GRB}} \sim -28.5$, several times Sun’s brightness

A freaky cosmic dwarf pair

• X-ray binary msec pulsar SAX J1808.4-3658 (d~3.5 kpc)
  – Strange pair: 1.4 \( M_{\text{Sun}} \) neutron star with 0.05 \( M_{\text{Sun}} \) brown dwarf on a 630,000 km orbit
  – BD dumps matter onto NS accretion disk
• GMOS-South orbit determination from light curve \( P \sim 2.01 \) hour
  – *Modulated light comes from irradiated companion (locked phase)*
  – *Persistent light comes from accretion disk*
• Companion will be ablated by pulsar wind \( \rightarrow \) “black widow” system

Betelgeuse and VY CMa as future supernovae

- PHOENIX spectroscopy of red supergiant circumstellar envelopes: geometry and kinematics
- Betelgeuse: from CO emission to 1000 AU
  - Velocity structures up to 35 km/s
  - Clumpy spherical shell shaped by steady stellar wind with $2 \times 10^{-6}$ Msun/yr for last 300 years
  - **Will be luminous SN II with blast wave ~15,000 km/s**
- VY Cma: CO emission coincident with KI shell
  - Clumpy asymmetric shell shaped by prodigious mass loss (100 x of Betelgeuse and multiple ejections since 1000 years
  - **Will be moderately luminous, long lasting, SN II with blast wave of a few 1,000 km/s**

Equilíbrio na “produtividade” dos países-membro. Exeções são o Brasil (altamente produtivo), Argentina (baixa produtividade)
Growth of refereed papers for GN and GS. “Gap” started to close in 2007 - but seems to continue in 2008… +/- Impact of GNIRS at GS?
At Gemini’s age (~7) observatories typically produce ~70-80 papers per telescope
Papers growth of MK single 8-10 m telescopes
Publications by Selected Instruments

- GMOS
- PHOENIX
- NIRI/NIRI-ALTAIR
- MICHELLE
- TRECS

Number of Publications

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Publications by Observing Mode

INST = instrument, COM = commissioning, SV = system verification, C = classical, DD = Director's time, Q = regular Queue program, PAY = visitor instrument payback