Science with Gemini

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Dennis Crabtree
Associate Director of Science Operations
Campos do Jordao, March 2010
Outline

- Science highlights
- How effective is the queue?
- How does Gemini compare?
- A look at the output of the Gemini partners
Gemini South: Cerro Pachón (2700m), Chile
Gemini North: Mauna Kea (4200m), Hawaii
Monitoring weather on Titan

Monitoring weather on Titan

April 2008 burst (IRTF spectrum)

Triggered NIRI observations

Mid latitude activity may instigate clouds at southern latitudes

Where cloud formation is unstable

Accounting for surface features such as streams, valleys

Crash on Jupiter

Jupiter • July 23, 2009
Hubble Space Telescope
Wide Field Camera 3

NASA, ESA, H. Hammel (Space Science Institute), and the Jupiter Impact Team

CrashGonGJupiter

Crash site found by amateur Wesley on July 21, 2009

Dark in visible light Impactor a few hundred meters in diameter

credit:MNASA/ESA/MH.MHammel
Crash on Jupiter

[Image: A close-up view of Jupiter with an arrow pointing to a bright impact site.]

*Imke de Pater (UC Berkeley), Heidi B. Hammel (Space Science Institute), Travis Rector (University of Alaska Anchorage), Gemini Observatory/URA*

Impact site
Direct images of planets

1RXS2J160929.17210524:2~52Myr
Normal star ~0.85Msun D=150pc
NIRI/ALTAIR images and spectra separation 330AU
M~82MJup low mass companions found at large separation
radial velocity, transits less sensitive

J H K
Three planets around HR8799

Keck H-band July 14, 2004UT
Keck K-band Sept. 18, 2008UT

HR28799: ~602Myr A2 star D=39pc First 2 images of "planetary family" M~5 to ~132 MJup orbiting at 24 to 268 AU scaled up solar system

Higher mass central star similar temperature radii NIRI/ALTAIR detection Marois et al. 2008, M.

Science M.
Marois et al. have reprocessed original Gemini/ALTAIR Kp images of HR 8799. Continuous tracking through fast rotating transit actually helps detection of the nearest planet.

N.B.: the planets can be seen in 1077302s exposures with Keck or Gemini.
NICI

NICI Campaign: Surveying ~300 nearby, young stars
NICI facility instrument – useful for other science
NICI planet-finding campaign

- Campaign requirement

![Images showing different ratios and graphs representing the campaign requirements.](image-url)
NICI imaging of Eta Car

1840's "great eruption": lobes

1890's event: [Fe II] spectrally detected earlier; first direct images here

H2, Brγ, [Fe II]
GRB 090423 at $z \approx 8.2$

Most distant object in the Universe

Swift detected GRB 090423 on April 22nd, 2009 at 3h55am EDT

NIRI: bright object J, H bands

No detection at Y or z (GMOS)

Photometric redshift: $z \approx 8.2$

Tanvir Met Mal. M 2009, M Nature

[Graph showing number of gamma-ray bursts vs. redshift and age of the Universe]
Star formation in merging galaxies
Star formation in merging galaxies

\[ \chi^2 = 3.6 \quad A_V = 5.5 \]

\[ \chi^2 = 0.4 \quad A_V = 16 \]
Massive “dead” galaxies at $z > 2$
Massive “dead” galaxies at $z > 2$
Black hole masses in galaxies

velocity \( \sigma \)

NGC 524  NGC 2549
Quasar luminosity function at $z=6$

- color selection for candidates
- followup spectroscopy with GMOS
- nod and shuffle: good background subtraction
- forthcoming red sensitive CCDs will help
Quasar luminosity function at $z=6$
No $^{6}\text{Li}$ in exoplanet host stars

- Giant planets host stars are systematically metal rich by ~0.2 dex.
- $^{6}\text{Li}/^{7}\text{Li}$ isotopic ratio is a strong test – $^{6}\text{Li}$ is destroyed more effectively than $^{7}\text{Li}$.
- Presence of $^{6}\text{Li}$ is a sign of pollution.
- GSbHROSR ~150,000 observations of 252 stars with exoplanets.
- No detectable $^{6}\text{Li}$ in any of the stars.
- $^{6}\text{Li}/^{7}\text{Li} < 0.0270.03$
- Less than 0.25 ± 0.70 Jupiter.
High-pressure outflow in M82

• • •
Cluster formation in the Antennae

- Most clusters studied here formed in the original disks.
- A few (3/16) are destined for the halo.

Galactic superwind outflow at $z=2$

- AGN and starburst contribute to IR and submillimeter emission
- Galactic scale superwind detected in broad line profiles
- Requires kinetic energy $\sim 10^{44}$ erg/s comparable to spheroid binding energy
- AGN or starburst drives outflow

Line profiles and velocity field
Scientific Effectiveness of the Queue
Advantages of the Queue

1. Excellent image quality, photometric, low water vapor.
2. Programs (NGS/LGS) have higher science ranked programs get priority.
3. Ensure that higher ranked programs obtain data in the conditions required.
4. Almost all the highest ranked programs (30% of programs) get 100% of their data.
5. Depends on TAC "getting it right".
Completion rates - all partners
As of UT 2010 jan 20

Lines mark the requirements
Queue is inherently more complicated/sophisticated than Classical. Ability to tune system to get desired programs executed in conditions required.
Proposal to Publication – Top Science

- Top Science Proposal
  - TAC
    - Classical Schedule
    - Queue
  - Data
    - Paper?
High Impact Science
2005-2008 Papers

Impact versus Science Band

Average Impact per Paper

SRB1 SRB2 SRB3 SRB4 Classical
Science Enabled by the Queue
# The Top 20 Most Cited Gemini Publications as of January 19, 2010

<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Year</th>
<th>Journal</th>
<th>Total citations</th>
<th>Refereed citations</th>
<th>Instrument</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astier, P. + 41</td>
<td>The Supernova Legacy Survey: measurement of ...</td>
<td>2006</td>
<td>A&amp;A</td>
<td>1130</td>
<td>868</td>
<td>GMOS</td>
<td>Q</td>
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<tr>
<td>Genzel, R. + 14</td>
<td>The Stellar Cusp around the Supermassive Black Hole ...</td>
<td>2003</td>
<td>ApJ</td>
<td>276</td>
<td>210</td>
<td>Hokupaa</td>
<td>DD</td>
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<tr>
<td>Fox, D. + 35</td>
<td>The afterglow of GRB 050709 and the nature ...</td>
<td>2005</td>
<td>Nature</td>
<td>212</td>
<td>164</td>
<td>GMOS</td>
<td>Q</td>
</tr>
<tr>
<td>Glazebrook, K. + 11</td>
<td>A high abundance of massive galaxies 3-6 billion years ...</td>
<td>2004</td>
<td>Nature</td>
<td>199</td>
<td>159</td>
<td>GMOS</td>
<td>Q</td>
</tr>
<tr>
<td>Juneau, S. + 13</td>
<td>Cosmic Star Formation History and Its Dependence ...</td>
<td>2005</td>
<td>ApJ</td>
<td>183</td>
<td>150</td>
<td>GMOS</td>
<td>Q</td>
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<tr>
<td>Berger, E. + 23</td>
<td>The afterglow and elliptical host galaxy of the short ...</td>
<td>2005</td>
<td>Nature</td>
<td>164</td>
<td>137</td>
<td>GMOS</td>
<td>Q</td>
</tr>
<tr>
<td>Abraham, R. + 11</td>
<td>The Gemini Deep Deep Survey. I. ...</td>
<td>2004</td>
<td>AJ</td>
<td>141</td>
<td>120</td>
<td>GMOS</td>
<td>Q</td>
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<tr>
<td>Close, L. + 3</td>
<td>Detection of Nine M8.0–L0.5 Binaries: ...</td>
<td>2003</td>
<td>ApJ</td>
<td>140</td>
<td>130</td>
<td>Hokupaa</td>
<td>C</td>
</tr>
<tr>
<td>LeFloch, E. + 13</td>
<td>Are the hosts of gamma-ray bursts sub-luminous ...</td>
<td>2003</td>
<td>A&amp;A</td>
<td>140</td>
<td>114</td>
<td>Hokupaa</td>
<td>Q</td>
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<tr>
<td>Simon, J. + 2</td>
<td>Constraints on the redshift dependence of ...</td>
<td>2005</td>
<td>PhRvD</td>
<td>139</td>
<td>108</td>
<td>GMOS</td>
<td>Q</td>
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<tr>
<td>Fynbo, J. + 30</td>
<td>No supernovae associated with two long-duration ...</td>
<td>2006</td>
<td>Nature</td>
<td>139</td>
<td>100</td>
<td>GMOS</td>
<td></td>
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<tr>
<td>Sullivan, M. + 29</td>
<td>Rates and Properties of Type Ia Supernovae as ...</td>
<td>2006</td>
<td>ApJ</td>
<td>134</td>
<td>109</td>
<td>GMOS</td>
<td>Q</td>
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<tr>
<td>Vreeswijk, P. + 31</td>
<td>The host of GRB 030323 at z=3.372 ...</td>
<td>2004</td>
<td>A&amp;A</td>
<td>119</td>
<td>98</td>
<td>ACQCAM</td>
<td>Q</td>
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<tr>
<td>Gal-Yam, A. + 25</td>
<td>A novel explosive process is required for ...</td>
<td>2006</td>
<td>Nature</td>
<td>116</td>
<td>84</td>
<td>GMOS</td>
<td>Q</td>
</tr>
</tbody>
</table>
Move to queue is similar to moving to automobile from horse and buggy. The H&B model had reached a limit in effectiveness and a new model is needed to improve productivity/effectiveness. The queue will continue to evolve, as does the automobile, as understanding of the processes and technology improve.
Gemini in Comparison
Impact

Citation counts for a paper grow with age.

Use median impact of an AJ paper as a standard measuring stick.

Impact of a paper defined as the number of citations divided by the number of citations for the median AJ paper of the same year.

The median is determined from ALL AJ papers, not just observatory papers.
Impact Distribution Function (IDF)
# IDF

<table>
<thead>
<tr>
<th>Name</th>
<th>Impact Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>0 - 1</td>
</tr>
<tr>
<td>Low</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Moderate</td>
<td>2 - 4</td>
</tr>
<tr>
<td>High</td>
<td>4 - 7</td>
</tr>
<tr>
<td>Very High</td>
<td>7 - 11</td>
</tr>
<tr>
<td>Extreme</td>
<td>&gt; 11</td>
</tr>
</tbody>
</table>

*A flatter IDF indicates better performance.*
Impact Distribution of 2005-2008 Papers

Impact:
- Very Low
- Low
- Moderate
- High
- Very High
- Extreme

Institutions:
- CFHT
- Gemini
- HST
- JCMT
- Keck
- Subaru
- UKIRT
- VLT

IDF
Partnership Productivity and Impact
More Gemini Specifics
**Breakdown by Program Type (and telescope)**

<table>
<thead>
<tr>
<th>Program Type</th>
<th># of Papers</th>
<th>Average Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB1</td>
<td>153</td>
<td>5.60</td>
</tr>
<tr>
<td>SRB2</td>
<td>89</td>
<td>3.46</td>
</tr>
<tr>
<td>SRB3</td>
<td>41</td>
<td>2.21</td>
</tr>
<tr>
<td>SRB4</td>
<td>11</td>
<td>1.39</td>
</tr>
<tr>
<td>Classical</td>
<td>41</td>
<td>3.06</td>
</tr>
<tr>
<td>Commissioning</td>
<td>5</td>
<td>0.87</td>
</tr>
<tr>
<td>Discretionary</td>
<td>55</td>
<td>1.62</td>
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<tr>
<td>Demo Science</td>
<td>5</td>
<td>0.82</td>
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<tr>
<td>Payback</td>
<td>2</td>
<td>1.42</td>
</tr>
<tr>
<td>Science Verification</td>
<td>12</td>
<td>0.93</td>
</tr>
<tr>
<td>All Papers*</td>
<td>438</td>
<td>3.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telescope</th>
<th># of Papers</th>
<th>Average Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>GN</td>
<td>200</td>
<td>4.20</td>
</tr>
<tr>
<td>GS</td>
<td>135</td>
<td>4.12</td>
</tr>
</tbody>
</table>

* This includes papers whose source of data could not be identified.

This includes only papers based on queue or classical data and does not include discretionary, payback, etc.
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- Average impact of papers the same regardless of telescope #
- Papers decreases with lower science bands expected from lower # of programs with 75% or more data in lowers science bands
- 12% of papers based on classical data consistent with % of classical programs
- Classical papers have close to the same impact as papers in science band 2
- Impact of discretionary time papers is lower than impact of science band 3 papers on average
## Breakdown by Partner

<table>
<thead>
<tr>
<th>Country</th>
<th># of Papers</th>
<th>% of Papers</th>
<th>Average Impact</th>
<th>Approximate Share of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>3</td>
<td>0%</td>
<td>1.07</td>
<td>2%</td>
</tr>
<tr>
<td>AU</td>
<td>61</td>
<td>8%</td>
<td>7.31</td>
<td>5%</td>
</tr>
<tr>
<td>BR</td>
<td>28</td>
<td>4%</td>
<td>5.58</td>
<td>2%</td>
</tr>
<tr>
<td>CA</td>
<td>128</td>
<td>18%</td>
<td>4.41</td>
<td>13%</td>
</tr>
<tr>
<td>CL</td>
<td>17</td>
<td>2%</td>
<td>3.89</td>
<td>5%</td>
</tr>
<tr>
<td>GS</td>
<td>56</td>
<td>8%</td>
<td>2.29</td>
<td>9%</td>
</tr>
<tr>
<td>UH</td>
<td>39</td>
<td>5%</td>
<td>2.47</td>
<td>5%</td>
</tr>
<tr>
<td>UK</td>
<td>130</td>
<td>18%</td>
<td>2.98</td>
<td>21%</td>
</tr>
<tr>
<td>US</td>
<td>258</td>
<td>36%</td>
<td>3.47</td>
<td>39%</td>
</tr>
</tbody>
</table>
Comments on Previous Slide

Australia, Brazil, and Canada produce a higher share of papers than expected from amount of time US, UK, Chile, and Gemini staff produce a slightly lower share of papers than expected from amount of time. Australia produces papers with higher impact than the average Gemini paper. Australia is the real standout in both paper production and average impact of Australian-supported papers. Australia also has one of the highest % of joint proposals.
Conclusions
Conclusions