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GEMINI NOW AND BEYOND 2014

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ABSTRACT

After more than a decade of operations, Gemini is now well-established as Canada's forefront optical/near-infrared facility. In this paper we review the use of Gemini by the Canadian community, and describe the vital role that Gemini will continue to play into the future. We highlight how – despite the challenges brought about by recent budget cuts – Gemini has evolved into a renewed Observatory offering new competitive instruments and an improved responsiveness and connection to its users. We also discuss the future plans of the observatory and how these mesh with the needs of the Canadian astronomical community into the 2020s.

Keywords:

1. INTRODUCTION

The twin 8m Gemini North and South Telescopes, situated on Mauna Kea, HI, and Cerro Pachon, Chile, have been part of the Canadian astronomical landscape for 15 years. Although the Gemini telescopes are now two of many 8-10m class facilities, they offer distinct benefits when compared with their brethren:

- The telescopes were designed to deliver good image quality (IQ), and are at sites that enjoy good natural seeing conditions.
- By virtue of having two sites, Gemini is the only major ground-based Observatory capable of offering full sky coverage.
- Gemini's observing model allows for flexible scheduling. This is beneficial for studies of transient events and targets of opportunity, and also enables programs that require special observing conditions, such as those that require good seeing or zenith transits for exoplanet searches.
- Gemini's thermal infrared sensitivity is unmatched on the ground, thanks to the use of silver coatings and a highly optimized telescope design.

The Canadian community has been well-served by the Gemini Telescopes. The quality and impact of Canadian research that uses Gemini is discussed in Section 2. Section 3 provides information on the present state of the partnership and the telescopes, while Section 4 discusses future observatory plans into the era of 30 metre facilities.

2. CANADIAN CONTRIBUTIONS

Despite Canada's somewhat modest share in Gemini, publication statistics indicate it has served the Canadian community extremely well. Canadians produced 22% of all Gemini papers from 2000 to 2012, even though during that period our effective observing time share was between 11 to 13% (see below). If all Gemini partners produced papers with the same efficiency as Canada then Gemini would be the telescope with the most papers per year, with the exception of the HST. Even more impressive is that Canadian Gemini papers are cited more frequently than Gemini papers from other partners – the median impact of Canadian Gemini papers for the years 2008 to 2012 is 2.8, whereas the overall Gemini average is 2.0, and is comparable to the median impact of Keck papers at 2.8 (Crabtree 2014; see Figure 1). Figure 2 shows average publication impact with time. Canadian Gemini papers have had consistently higher impact on average than all Gemini papers, with an average over 2008 to 2012 of 5.0 versus the Gemini average of 3.3.

It is thus not surprising that Canadians are also responsible for 21% of all Gemini press releases, and that some of the Canadian press releases are amongst those that produced the highest impact. These conclusions hold for a broad swath of the Canadian community. The ten top-cited Gemini papers with Canadian lead authors deal with topics as diverse as exoplanets, pulsars, galaxy evolution at intermediate redshifts, and high redshift QSOs.

Gemini has a broad Canadian user base, and has far more Canadian users than any other major facility: over a 2-year period from semesters 2011A to 2012B, there were 133 individual Canadian PIs or Co-Is (and 65 unique PIs). It is then perhaps not surprising that demand by Canadians for Gemini time has been – and remains – healthy, with average oversubscription rates of 2.4 for the last two semesters, and 2.3 for the last few years from 2012A to 2015A. The traditional North versus South imbalance in demand has been shifting, with oversubscriptions growing for Gemini-South in the last years due to the commissioning of new instruments such as GPI, GeMs and Flamingos-2. Subscription rates during the past semesters are shown in Figure 3. The divison of time requested for different instruments during the last two semesters (2014B & 2015A) is shown in Figure 4.

Canadians have access to more time through Large and Long Programs. Starting in 2014B the first Call for Large Programs was made. Canada donated 20% of its time to the large program pool (roughly 80 hours), and the demand from Canada was exceptional, with 1321 hours requested from four Canadian-led programs. Two of these programs were successful, and over half of all

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the time available to Large Programs was allocated to these Canadian programs: "COLOSSOS: Colours for the Outer Solar System Object Survey", PI=Fraser; "The GOGREEN Survey of dense galaxy environments at $1< z < 5$", PI=Balogh. Canadians have also been succesful in gaining access to even more Gemini time through the time allocated to the GPI Campaign. Many Canadians are part of the team that was awarded a total of 890 hours, which will survey 600 nearby stars over 3 years to survey their Jovian planet population from 5 to 50 AU.

While much has been said about the oversubscription rates on Gemini, it should be kept in mind that Canadians have the highest number of telescope hours per astronomer of all paying partners. Although the US has access to more than 3 times the number of hours when compared with Canada, the US community that accesses Gemini is about nine times larger. This means that Canadian astronomers have roughly a factor of three advantage in terms of getting Gemini time. This is an important advantage for research programs that compete with those carried out by private US facilities that have access to large amounts of telescope time.

The comparatively large share of Canadian time also facilitates potential access to 8m time for dissertation and thesis programs. During its 15 year lifetime Gemini has enabled more theses than any other major facility to which Canadian astronomers have access. Recent semesters have seen roughly 40% of the proposals having an Msc or PhD student as a PI or co-I. Canadian supervisors and their students can start ambitious programs on Gemini with a reasonable expectation that time might be allocated and at least some data obtained. A related consideration is that queue-observing operations puts emphasis on the completion of programs, and this again will help the completion of observations required for student theses. It is thus not surprising that Gemini has proven to be a potent thesis-producing powerhouse for Canada: there are now more than 46 MSc and PhD that have been produced (or are ongoing) in a dozen Canadian universities! This number is incomplete and will grow as the CGO continues to receive updates from recent graduates. There are now on average about 5 new Canadian theses per year using Gemini data.

Canada has also benefited from a strong involvement in Gemini instrumentation development. Canada has been a major player in developing a large number of new instruments and facilities for Gemini over the years, and these include the GMOS spectrographs, the ALTAIR AO facility, the Flamingos-2 OIWFS, the Gemini Planet Imager GPI, the Gemini Remote access to CFHT/Espadons GRACES, and the high-resolution optical spectrograph GHOST (currently in development). Some of the most succesful Gemini instruments have had a Canadian stamp. Beyond the shear dollar value of development contracts, this work has brought with it intellectual enrichment to Canadian engineers and astronomers, and this has been re-directed to the development of facilities for the next generation of telescopes (e.g. NFIRAOS for the TMT), as well as pathfinder capabilities for existing telescopes (e.g. RAVEN). Finally, the detailed technical knowledge of these instruments that comes with their development allows Canadian astronomers to use them more efficiently, and sometimes even gain an advantage in obtaining large amount of observing time (e.g. the GPI team who won the Campaign time of 890 hours for their program).

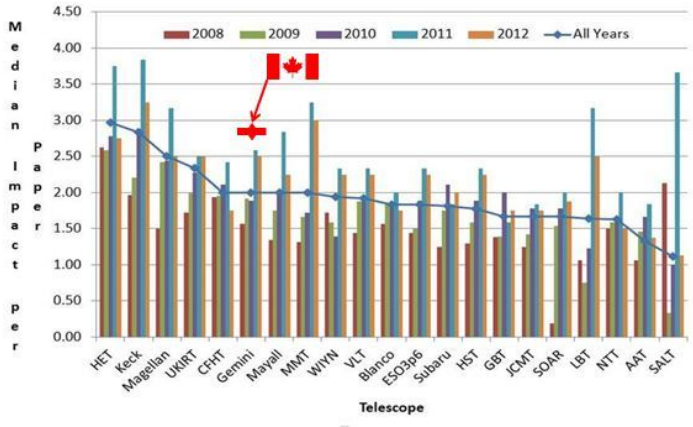

Figure 1. The median impact of Canadian Gemini papers is higher than that of the Gemini papers median, and comparable to Keck's (from Crabtree CASCA poster 2014).

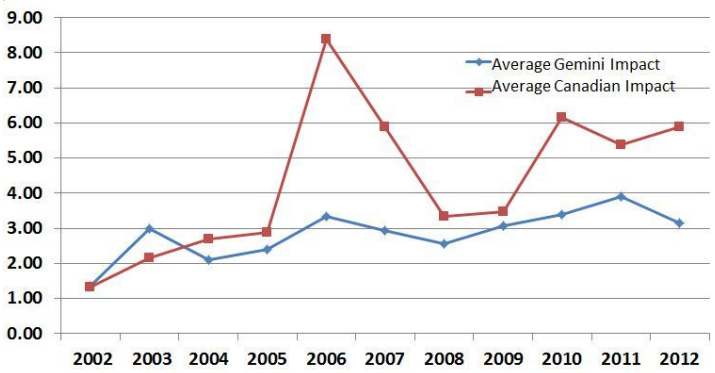

Figure 2. Average Impact of Gemini papers and Canadian Gemini papers

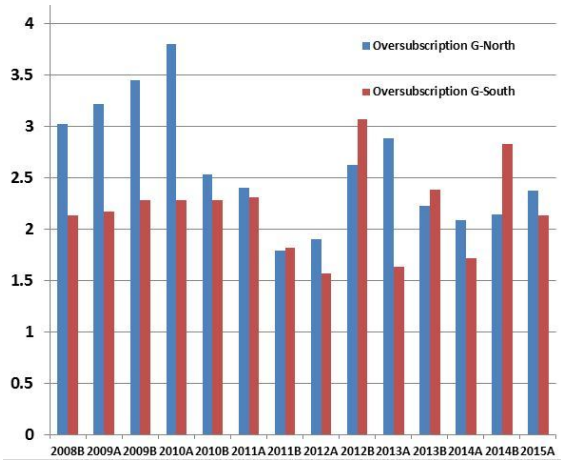

Figure 3. Oversubscription rates on Gemini-North and Gemini-South.

3. GEMINI: THE PRESENT DAY AND NEAR FUTURE

3.1. *The Current Agreement*

The current partnership agreement runs from January 2013 to December 2015, and dealt with the departure of the UK from the partnership. At present, Canada

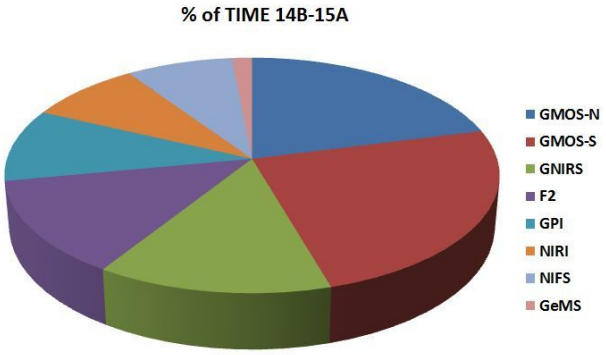

Figure 4. Percentage of total time requested from each instrument, averaged for the last two semesters.

has a 18.65% share of time. Other partners are the USA (65.5%), Brazil (6.53%), Australia (6.21%), and Argentina (3.11%). The real share of observing time to which Canadians have access is smaller than the shares given above, because there are time obligations that come 'off the top'. As site 'hosts', the University of Hawaii and Chile each receive 10% of the observing time at their respective site, while some 5% of time is allocated to Directors Discetionary time. After accounting for these overheads, Canada's observing share has been slightly below 16%, or roughly 230 hours on Gemini-North and 200 hours on Gemini-South per semester.

A new partnership agreement is being developed that will cover 2016 to end of 2021. At the last Gemini Assessment Point in 2012, Canada confirmed its renewed partnership at the same share level for this period, following a strong recommendation from the GAC. Brazil has indicated it will also remain, despite its impending ESO entry. In fact, Brazil's oversubscription rates on Gemini have been increasing despite its early access to ESO facilities, as its astronomy community continues to expand at a rapid pace. Australia has indicated that it will withdraw from Gemini at the end of the current agreement, although it will seek to continue a limited term partnership in the years to come at a small share level. The decision to actively search for new partners has quickly bore fruit, with Korea entering a limited time partnership (starting in 2015A with access to about 20 nights). The ultimate goal is for Korea to become a full partner in 2016, taking over the Australian share of time.

3.2. *The "New Gemini"*

Following the withdrawal of the UK from the Gemini partnership at the end of 2012, the Board enforced budget reductions of 23.8% on the Observatory, to be implemented over the period 2013–2015. Despite the obvious difficulties stemming from such a transition to a leaner budget, Gemini remains a vibrant Observatory, with re-newed instrumentation. The current instrumentation suite offers cutting-edge competitive instruments. Of particular note are:

- GeMS (Gemini Multi-Conjugate AO System). This is a unique capability that delivers uniform near-diffraction limited images over an 85″ diameter field. This is done using information gleaned from 3 Natural Guide Stars (NGSs) and 5 Laser Guide Stars. For comparison, the traditional single-beacon AO systems that were first implemented $\sim$ 20 years ago would deliver moderately stable images over fields that are almost an order of magnitude smaller. Sky coverage is an obvious consideration for any AO system, and the GeMS NGS wave front sensors will soon be upgraded to allow the use of fainter NGSs, which will extend the sky coverage to 87% of the sky.

- GPI (Gemini Planet Imager). This is an extreme AO imager and spectrometer, and is the most powerful planet finder in operation. GPI is designed to detect sources 10 million times fainter than their parent stars at separations as small as 0.2″. This has proven to be a popular capability with many members of the Canadian community.

GeMS and GPI continue the legacy of AO leadership established by Gemini. In fact, Gemini is now producing more AO-based papers than any other telescope.

- GRACES (Gemini Remote Access to CFHT Espadons Spectrograph). This links Gemini to the Espadons Spectrograph at CFHT via 270 meter long fibers. Despite obvious technical challenges, GRACES delivered extremely promising throughput results during initial engineering tests, surpassing the overall throughput of HIRES on Keck at red wavelengths. GRACES will likely become available to Gemini users in late 2015, providing a highly competitive high-resolution spectroscopic capability redwards of 500 nm, at higher throughput than other high resolution spectrographs on other 8-10 meters telescopes. In addition to offering scientifically useful capabilities, GRACES is also a pathfinder capability for demonstrating how telescopes on Mauna Kea can work together to capitalize on the strengths of the various facilities.

- GHOST (Gemini High resolution Optical SpecTrograph). This is an instrument that is being developed by Australia and Canada. It will deliver spectra of 2-objects with resolution R=50000 over a full wavelength coverage from the ultraviolet to the silicon cutoff. There is also a single-object mode with resolution R=75000. It will be a workhorse spectrograph that will be ideally suited for stellar chemical abundances studies, precision radial velocities, and quick follow-up of Target-of-Opportunity transient objects. An over-arching science requirement is that GHOST must have very high throughput, exceeding those of similar instruments on other telescopes. Its science niche will thus be the ability to study faint sources that might be on the borderline of feasibility with spectrographs on other 8 metre class facilities. This is of particular importance as a similar instrument will likely not be available on a 30 meter-class facility until well into the end of the 2020s - GHOST will thus be a forefront instrument for some time to come. Plans are to have GHOST deployed in 2017. There is growing interest in the Canadian community for high-resolution spectroscopy (see Venn 2013 poll of Gemini Users) and therefore GHOST is expected to serve well the community.

The new Director – Markus Kissler-Patig – has implemented new ideas on how the telescopes can be effectively exploited by the partners, with the goal of improving responsiveness and connection to its users. Specifically, Gemini has developed two new proposal modes to improve efficiency and flexibility, and these are:

- Large and Long Programs (LLPs). Access to larger blocks of time that may span multiple semesters has long been requested by many Canadian users. Historically, it has been difficult for a multi-partner team to obtain large amounts of time for a common program, due in part to multiple jeopardy through the national TACs and the modest amount of observing time that is available to most Gemini partners. In an effort to address these problems, Gemini has implemented an LLP system. Each participating partner allocates 20% of its time for a common LLP pool, and proposals are reviewed by a single international TAC. A call for LLP proposals was issued in 2014A, and this first call was very popular in Canada (see above). There will be annual calls for LLPs.

- Fast Turn Around Program (FTP). A problem with the conventional semester-driven time allocation process is that there can be a substantial delay between having a good idea for an observing program and getting the observations executed on the telescope. The FTP is designed to reduce the time between the birth of an idea and acquiring the data. Starting in January 2015 there will be monthly calls for programs, and those that pass peer review will be scheduled immediately on the telescope. About 10% of the available telescope time will be allocated for FTPs. An obvious logistical problem is having a TAC that is willing to review proposals on a timely basis on a month-by-month schedule. A novel aspect of the FTP is that the proposals will be peer-reviewed by those that apply for this time on any given month. The CGO has been leading this effort by developing the necessary scipts, and a trial run was conducted in April 2014 with Canadian PIs/Cos refereeing each others proposals. The ranking of the proposals obtained through this process correlated well with the rankings from the regular CanTAC. This first trial received extremely favorable feedback from the Canadian users. The FTP will enable Canadian PIs to access targets of interest before the competition, such as exoplanets candidates that require follow-up.

Gemini has made great strides in becoming more responsive to its users and connecting with its user community. Some points that are of particular interest include:

- The User's Committee. This committee was set up to provide feedback to Gemini on all areas of its operations that affect current users. The first meetings have already been succesful with the creation of – for example – the "Bring One, Get One" program. This program subsidize the travel expenses of a student (up to $2000) when accompanying an advisor or senior astronomer who is familiar with Gemini observing.

- Priority Visiting Observing (PVO). Under this program, visiting observers are scheduled for a block of time that exceeds their program allocation. The PIs are free to observe their program or to skip it if the observing conditions do not meet their requirements. After the run, the unexcecuted time remaining in the program is placed back in the regular queue. PVO is the default observing mode for Large Programs, and will soon be offered for standard queue programs. It is expected that PVO – especially when coupled with the "Bring One, Get One" program – will be of great value for training the next generation of Canadian astronomers.

- Eavesdropping. The ability to eavesdrop is now offered to Canadian PIs with programs in Bands 1 and 2 who can connect (via Skype) to the control room at Gemini to assist in observing their program. On a related note, progress is also being made to move summit operations to the Gemini headquarters facilities in Hilo and La Serena. Eventually it will be possible to remotely observe from any other location.

4. INTO THE FUTURE: 2021 AND BEYOND

Gemini is primed to continue to be Canada's forefront optical/infrared ground-based facility into the foreseeable future, and will only be eclipsed once all the first TMT instruments are commissioned in the mid 2020s and later. While a challenge is that the NSF is no longer able to contribute to the Instrument Development Fund at past levels, all partners are committed to continue the procurement of cutting-edge instruments. In the past, the scientific priorities of the US, the dominant partner, have always played a major role in shaping the future of the facilities. While there tends to be good agreement between the scientific priorities of the Canadian and US communities, this may not always be the case. The new instrument procurement process will be a more collaborative process between partners, and in-kind instrumentation contributions will also be accepted. A new instrument definition process has been implemented with the GIFS (Gemini Instrument Feasibility Studies) call for proposals this Fall. GIFS is a science-driven process that will define the capabilities of the next new Gemini instrument, and identify teams for the instrument's development. Responses to the GIFS RfP are due on 15 December. After evaluation, at least three and perhaps more contracts for instrument feasibility studies will be issued. The outcome of the studies will then define the call for more detailed design work on this next instrument.

In an effort to expand capabilities, Gemini is now allowing visitor instruments to be used. These can bring sought-after capabilities that are abscent from the facility instrument suite. In addition to offering scientific capabilities that are recognized by the STAC as being of interest to the Gemini community, these instruments must have a proven operational track record that demonstrates that they will require little or no support from Gemini staff. Recent semesters have seen Texes – a mid-infrared high resolution spectrograph – and DSSI – a speckle imaging camera – offered on Gemini-North. While these particular instruments have not proven pop-

ular with the Canadian community, there is the likelihood that future visitor instruments may appeal to a wider user base. As Subaru decommissions the majority of its instruments to concentrate on HSC and PFS, some of them could be recycled to Gemini if there is interest. A Canadian-built instrument (developed with CFI money, for example) may offer new and interesting capabilities that could give it visitor instrument status with approval of the Gemini STAC.

A key issue for the Canadian community, especially in the context of the Long Range Plan, is the future of Gemini beyond 2025. This will be an era in which the TMT will become operational with its initial instrument complement. However, even in the TMT era Canadian access to Gemini will remain crucial for several reasons.

- Gemini-South will offer the only access to the South for the Canadian community. This will prove important for maximizing the scientific impact of ALMA and SKA, both of which are located in the southern hemisphere.

- Canadian time on the TMT and other facilities (e.g. the JWST) may be modest. If our share in TMT is – say – 10% or less, then the need for both Gemini North and South will remain strong to accomodate community needs. If the share of time on any facility is too small then there is the danger that it will only cater to a small group of astronomers. It is likely that Gemini will continue to enable a large number of Canadian graduate student theses. As for the JWST its lifetime will be limited to 5.5 years up to 10 years top (which means it will disappear before 2028).

- Gemini will offer capabilities that are complementarity to the TMT. Despite Gemini's modest field of view, which narrows the range of options for identifying a role in the 30 meter era, there are many possibilities for Gemini's future role: for example high resolution spectroscopy at spectral resolution > 8000 in the optical and > 4000 in the near-infrared will not be available on the TMT until the late 2020s or beyond, nor on the JWST. Building on the excellent IQ capabilities and AO strength, GLAO or MOAO on Gemini North might also prove to be of interest, as Subaru appears to be evolving towards a reduced operational model with only HSC and PFS. Gemini could provide a high angular resolution capability to the "Mauna Kea Observatory", an integrated system of all the Mauna Kea Telescopes, in exchange for PFS access, say. Finally an improved GPI or GPI-2 could bring even more powerful planet finding capabilities to Gemini that would surpass what TMT will be capable of in its first decade – this is a field of studies that is in rapid expansion in the canadian community.

In summary Gemini promises to continue as a forefront facility serving the Canadian community in the coming decade and beyond. The community is invited to discuss these ideas at the upcoming "The Future and Science of Gemini Observatory" meeting to be held in Toronto on 14-18th June 2015.

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