GAC Report
May 4, 2021

CFHT

CFHT continues to operate under COVID-19 restrictions which means night observations are executed from HQ in Waimea. Doug Simons left his position as CFHT Executive Director to become Director of the IfA in Hawaii. CFHT is grateful for his long service to the observatory. The CFHT board is already in the process of preparing the search for a new director. Significant discussions continue at the board and directorate level about options for how CFHT can further support MSE development. The details of those discussions are not yet public.

MSE

MSE continues in the Conceptual Design Phase (CoDR) and is in the process of evaluating its progress towards in the Preliminary Design Phase (PDP) via a "Preliminary Design Phase Readiness Review" which is targeted for 2022. Requirement updates have been made for the LMR and HR spectrographs.

The Table below (from Zhang et al. 2020) shows the evolution of requirements for the HR spectrograph over the CoDR phase.

Table 3. Change of design requirement in the past three years

Year	Multiplexing (fibers)	Spectral Arms	Resolution	Window Bandpass	Instrument Sensitivity (1hr)
2017	1084 fibers (Φ0.7"-0.8")	B: 360 nm - 450 nm G: 450 nm - 610 nm R: 610 nm - 900 nm	R_B=40K R_G=40K R_R=20K	B: 1/30 G: 1/30 R: 1/15	mag = 20 SNR=5@<400nm SNR=10@>400nm
2018		B: 360 nm - 430 nm G: 430 nm - 510 nm R: 510 nm - 900 nm			
2019	500 - 1084 fibers (Φ0.75"-0.8")	B: 360 nm - 500 nm G: 500 nm - 600 nm R: 600 nm - 700 nm	R_B=40K R_G=30K R_R=20K	B: 1/30 G: 1/22 R: 1/15	mag = 19 - 19.5 SNR=5@<400nm SNR=10@>400nm
2020		B: 360 nm - 420 nm G: 420 nm - 580 nm R: 580 nm - 820 nm	R_B=30K-40K R_G=20K-30K R_R=30K-40K	TBD	

The Table below (from Jenneau et al. 2020) shows the evolution of requirements for the LHR spectrograph.

Requirement	Conceptual (2017)		Revised (2019)	
	VIS	NIR	VIS	NIR
Spectral coverage	$0.36 - 1.3$ µm **OR** $0.36 - 0.95$ µm and $1.5 - 1.8$ µm		$0.36 - 1.0$ µm	$1.0 - 1.3$ µm **AND** $1.45 - 1.8$ µm
Spectral resolution (low)	$2500 < R_{avg} < 3000$	$R_{min} > 3000$	$3000 < R_{avg} < 3500$	$R_{min} > 3000$
Spectral resolution (moderate)	$\mathbf{5000 < R_{avg} < 7000}$ $\mathbf{R_{min} > 4500}$		$\mathbf{5000 < R_{avg} < 6000}$ $\mathbf{R_{min} > 5000}$	$\mathbf{6000 < R_{avg} < 7000}$ $\mathbf{R_{min} > 5500}$
Multiplexing	**3249**		**2166** (TBD)	**1083**
Sensitivity	$\text{mag}_{AB} > 24$		$\text{mag}_{AB} > 24$ (> 23 in H band)	
Cross-talk	$< 2\%$ (goal: 1%)			
On-sky fiber diameter	1.0 arcsec			
Fiber output F-number	$F/2.08$			

Plans are underway to hold a three-day workshop in August of 2021 to discuss Australian and Chinese participation in the MSE project. The goal of the workshop is to promote scientific links between Australian and China, as well as promoting technological links between the two countries in developing infrastructure components to ensure successful delivery of MSE. Jennifer Sobeck has joined the MSE project office full-time as the System Scientist. As the project manager leading the Sloan Digital Sky Survey IV (SDSS-IV) Apache Point Galactic Evolution Experiment 2 and the operations manager leading SDAA-IV operations at the Las Campanas Observatory, Dr. Sobeck brings a full complement of scientific, technical and managerial experience. She will lead the detailed planning and execution of the Design Reference Survey (DRS), and take responsibilities to maintain MSE's science performance through its development phases. Ting Li (U. Toronto) has replaced Sarah Gallagher (Western U.) as one of the two Canadian members on the Science Advisory Group. MSE presented 11 papers at the bi-annual SPIE Astronomical Telescopes + Instrumentation virtual conference on December 14-18, 2020.

ngVLA

From LRP 2020, "The Next Generation Very Large Array (ngVLA) is a transformational radio observatory being designed by the US National Radio Astronomy Observatory (NRAO). The ngVLA will consist of a central cluster of 19 (6-metre) dishes in New Mexico, a further 214 larger (18-metre) dishes distributed throughout the US Southwest, plus another 30 (18-metre) dishes spread across North America (including the DRAO site near Penticton, BC), Hawai'i and the Caribbean out to baselines of nearly 9,000 km."
The ngVLA is one of the LRP2020 recommendations for Large Ground-Based Future projects, sharing that unranked position with MSE. In particular, 2020 recommends "that

Canada pursue technical contributions to and scientific leadership in the proposed Next Generation Very Large Array (ngVLA)."

The most critical update is that ngVLA is awaiting the results of the Astro2020 Decadal report in the United States. Its future as a Canadian project is intimately tied to its future in the primary host country of the US. Current expectations suggest that we may hear about the results of the Astro2020 process in June.

In the meantime, the ngVLA Science Advisory Committee has discussed the potential of hosting a joint ngVLA-SKA meeting here in Canada as we could be members of both projects and it would be a good way to promote their synergies. Additionally, the successful summer ngVLA short talk series that ran last year is likely to resume in May/June.

Canada is well positioned to support instrumentation needs for ngVLA given DRAO's extensive history in radio astronomy; however, the scope of technical contributions that Canada can and/or would supply needs to be identified once the Astro2020 decisions are reported.

Subaru Telescope

Note: this is the first GAC report that includes Subaru Telescope updates

Subaru's Hyper-Suprime Cam, currently most-used instrument on Subaru, has been in operation since 2014. Although most of the time with the camera is spent on the Subaru Strategic Program (HSC-SSP), HSC is also used for 'open-use' programs from the world-wide community (including Canadian, through Subaru-Gemini time exchange program). Raw data from these programs, publicly available 1.5 years after the data are acquired, have not been fully exploited so far. To improve the situation, Subaru Telescope has launched the Hyper Suprime-Cam Legacy Archive (HSCLA), where processed, science-ready HSC data originally taken as part of open-use programs are made available to the community. The first data release occurred on January 13, 2021.

Subaru's next generation instrument- Prime Focus Spectrograph (PFS) - is to start scientific operation in 2023. The PFS will be capable of simultaneously collecting spectra from ~2400 objects within the field of view of 1.3 deg in diameter. It will operate in the wavelength range of 0.38-1.26 micron. In February 2021, the PSF team installed PFS's first fiber cable unit to the telescope and the telescope dome. In addition, a smaller telescope - Subaru Night-Sky Spectrograph (SuNSS) with a 4 cm aperture - was also attached to the telescope. The installation of the fiber unit and the SuNSS enabled PFS spectrometer to capture the first spectrum of the night-sky. The data PFS will acquire via SuNSS will be used for software development and to prepare for engineering runs using the main telescope aperture.

Subaru Users Meeting FY2020 was held online on March 3-5 2021. JJ Kavelaars (NRC-Herzberg) was the only presenting Canadian astronomer, discussing the collaboration between NASA New Horizons mission and Subaru Telescope to identify and characterize faint KBO objects.

The Subaru Telescope has started a new outreach camera project in collaboration with the Asahi-Shimbun, one of the most popular newspapers in Japan. This camera is used for live streaming of the night-sky from the telescope. The camera runs 24/7 via the YouTube Channel of Asahi Space Club (Uchu-Bu).

Gemini and Dragonfly

The updates on Gemini Telescopes will be provided after the Gemini STAC and Board meetings, scheduled for mid-May.

The update on the Dragonfly telescope will be provided at the same time.

ALMA

ALMA restarted science operations with the main array on 17 March 2021, roughly one year after being shutdown due to COVID-19. Operations resumed with a reduced number of antenna in the C43-4/C43-5 configuration (typically greater than 37 antennas). The planned move to more extended array configurations was delayed, however, due to rising COVID-19 cases.

Cycle 8: The ALMA Cycle 8 call for proposals was announced on 17 March 2021 with a deadline of 21 April 2021. This was the first ALMA call to use dual anonymous proposals and to have a distributed peer review process. A number of new observing modes were announced as well, including: (1) solar observations in Band 5; (2) Bands 9 and 10 observations with the ACA; (3) spectral scans with the ACA; (4) mosaics for continuum linear polarization in Bands 3 to 7 with the 12-m array (up to 150 pointings); (5) single-pointing polarization with the ACA in Bands 3 to 7 (limit of 75 total hours offered); (6) VLBI observations of faint targets; (7) pulsar observations where the main array mimics a large single-dish telescope.

ALMA continues to be a highly oversubscribed telescope with over 1600 proposal submitted for Cycle 8. This is consistent with prior cycles and indicates that ALMA is still in very high demand.

Development proposals: There was also a call by the NRAO for proposals to upgrade ALMA in January 2021. The North American Development Projects Proposals had been delayed by 6 months due to COVID-19. The notice of intent was due 1 March 2021, and the proposals were due 9 April 2021. Canadian teams are participating in this round of development programs, but the proposals are currently under review.

JCMT

The JCMT has maintained on sky observing with remote observations. For the 2021A observing semester, five Canadian proposals (including several proposals that were lead by students) were awarded a total of 30 hours in Bands 2-3 weather and 88 hours in Band 5 weather.

The 2021B call for proposals closed on 16 March 2021 with 6 proposals from Canada. These proposals are currently under review.

New camera: The new heterodyne camera, Namakanui, is undergoing commissioning. Namakanui will have three frequency receivers at 86 GHz, 230 GHz, and 345 GHz when completed. Its 230 GHzr receiver, `Ū`ū, started commissioning in October 2020 with the aim to be fully commissioned for 2022A. `Ū`ū was offered for shared risk observing for the 2021B proposal call and preliminary data with `Ū`ū shows it is performing very well, and that it has much higher sensitivity than the previous 1 mm receiver, RxA3. The 345 GHz receiver, `Āweoweo, has begun on-sky commissioning.

Large Programs: The Large Program BISTRO-2 completed its observations, making it the first large program from the 2017B call for proposals to be completed. With the commissioning of the `Ū`ū receiver, the 2016A large program, JINGLE, can be completed (this is the only large program from the 2016A semester that has not be completed).

EHT: The JCMT was involved with the Event Horizon Telescope and helped produce the image of the M87 black hole in polarized light: https://www.eaobservatory.org/jcmt/2021/03/powehi-magnetic-fields/
Additional observations for the EHT project were done in April 2021.

FYST (formerly CCAT-p)

FYST is fully funded. This funding includes a CFI grant led by the University of Waterloo. There are also additional funds to cover budget increases due to delays caused by COVID-19.

The FYST team had a virtual Collaboration Meeting April 20-23and they are also preparing a forecast paper to outline thecapabilities and survey science for Prime-Cam, the multi-band, wide-field receiver. Prime-Cam has two imaging spectrometers at 210 to 420 GHz and five broadband continuum polarimeters at 220 GHz, 280 GHz, 350 GHz, 410 GHz, and 860

GHz. FYST will be entirely a survey instrument. The Prime-Cam forecast paper outlines a number of science goals related to the CMB polarization and scattering, the epoch of reionization, Galactic foreground modeling, magnetic fields in Galactic star formation, Galactic and extragalactic dust grain properties, transients and time domain astrophysics, and galaxy and cluster evolution.

The telescope acceptance tests have been delayed at least six months from the end of 2022 until after April 2023 due to COVID-19. If telescope commissioning, instrument installation, and instrument commissioning goes smoothly, the first science observations could begin at the end of 2023. First light science will have limited receiver pixels and frequency bands.

The FYST collaboration is looking for further funding for efficiency enhancements to get the full instrument module suite on the telescope faster and reduce operating costs (e.g., enhance observing efficiencies; trenching for power and data lines down the mountain to generate power at lower altitudes).

Vera C. Rubin Observatory

For the first ten years of operation, Vera C. Rubin Observatory will perform the Rubin Observatory Legacy Survey of Space and Time (LSST). As with many telescopes, COVID-19 was a source for delay in the Rubin Observatory Construction. In a message to the LSST community (https://community.lsst.org/t/construction-schedule-impact-of-covid/4873), Rubin Observatory Director Steve Kahn and Rubin Operations Director Bob Blum described the impact of the delays, and announced that regular survey operations for Rubin will not commence before October 2023. The Rubin Observatory timeline is kept updated online at: https://www.lsst.org/about/timeline

The Canadian In-kind contributions document (submitted in September 2020) was positively reviewed by the Contribution Evaluations Committee (CEC). The contributions included a Public Archive of the LSST data releases hosted by the CADC, to be called the Canadian LSST Advanced Science Platform (CLASP, which was proposed to the 2020 CFI funding cycle), and personnel support provided to a range of Rubin Science Collaborations. These personnel (to be hired over the coming years) would be software engineers/postdocs doing 50% science pipeline support directed by the relevant science collaborations. These contributions were weighted to calculate the number of Canadian PI slots that would be available. More information on this weighting can be found in the draft Rubin In-kind Contributions Handbook (https://docushare.lsst.org/docushare/dsweb/Get/RDO-031).

The CLASP proposal was unfortunately not funded in the CFI 2020 round, however the funds from the Dunlap Institute and the University of Waterloo originally earmarked to support CLASP were thankfully retained. The Canadian in-kind contribution was revised to reflect this and to

incorporate other feedback on the proposal to Rubin, with a note that we will continue to seek funding for the international data center that was proposed in CLASP. This revised in-kind contributions proposal has been submitted to the Rubin CEC. In its current form, the proposal would yield 32 Canadian PI positions (with four associated junior co-I positions per PI) provided that the full in-kind contributions can be made by Canada, including the international data center. The CEC will work with the US agencies to review the proposals, and begin the ramp up to purchasing and hiring of personnel. This represents a big step forward for Canadian access to the Rubin Observatory. The coming months will include the formalizing of a Canadian Consortium and a structure to determine Canadian Rubin PI data access.

Meanwhile the efforts within Rubin to prepare for data continue to develop, with the Rubin Observatory recently putting out a call for scientists requesting to be one of 300 Delegates to obtain access to Data Preview 0 (see https://community.lsst.org/t/data-preview-0-an-early-opportunity-to-prepare-for-science-with-rubin-observatory/4618), with a closing date for applications as April 30, 2021. Additional calls will go out for future Data Preview Releases. Canadian scientists with interests in using Rubin/LSST data should strongly consider applying to these calls.

SDSS-V

The Sloan Digital Sky Survey began it's 5th phase (SDSS-V) in October 2020 and is currently on sky and taking data. With well-defined policies for membership at different levels (individual, associate and full institutional memberships) and data access and advanced tools for the distribution of that data, SDSS-V represents an affordable and modular way to join a large and distinguished international consortium of researchers at premier institutions across the globe. Canadian involvement presently involves York University and the University of Toronto. SDSS-V has three primary scientific components: the Black Hole Mapper, the Milky Way Mapper and the Local Volume Mapper.

The Black Hole Mapper will be probing over a half million black holes on timescales of days to decades. Key opportunities involve pinning down black hole masses via reverberation mapping, investigation of temporal changes in circumquasar structure using the time-dependent spectra, and understanding the spectral counterparts, probed by the SDSS optical spectrographs, to the X-ray sky as probed by the recently launched eROSITA mission.

The Milky Way Mapper will be probing stellar astrophysics across the Galaxy and the HR diagram. With key synergy with GAIA and TESS, the Milky Way Mapper will primarily use high-resolution infrared spectroscopy to probe millions of stars in the Milky Way. The Milky Way Mapper will probe stars at all masses and phases of evolution to understand the growth of the Milky Way, substructure within the milky way, multiplicity across the HR diagram, gravitational wave progenitors, and the birth and end states of stellar evolution.

Finally, the Local Volume Mapper will be making the largest IFU map of the sky focusing on the interstellar. medium of the Milky Way and nearby galaxies using a brand new facility at Las

Campanas Observatory. The scientific focus is to probe the ISM at sufficiently high spatial and spectral resolution to unravel energy injection, star formation and feedback in the ISM. The LVM is currently under construction in the Southern Hemisphere and first light is anticipated at the beginning of 2022.

TMT

The next major milestone for TMT will be the release of the US Astro2020 report, anticipated to be released in early June. The recommendations are likely to have an impact on Canada's own Long Range Planning regarding VLOT access and for the siting of astronomical facilities. Should TMT be strongly supported in this report, and if the NSF accepts the initial planning proposal for the US Extremely Large Telescope Program (USELTP), the NSF will formally launch a comprehensive Preliminary Design Review of the Project. This will also trigger the process for a federal Environmental Impact Statement (EIS) regarding the planned site on Maunakea.

DRAO

COVID-19 summary: we are now able to have limited staff on site, which allowed us to resume Galt Telescope operations in February. The Synthesis Telescope has, however, been down since December owing to a failure that was ultimately traced to the delay system. This has been repaired and observing should resume before the end of April. The Solar radio flux monitors, being automated, continue to operate normally. Upgrades to all 3 telescopes are progressing well.

Galt Telescope: the Galt Telescope is a 26-m single-antenna telescope with interchangeable receivers. At present it is equipped with a 400-800MHz receiver to support the CHIME project, which processes the signals using their own back-end.

Other than CHIME operations, the telescope is currently in an upgrade cycle, aimed at equipping it with a cryogenic wideband receiver (900-1800MHz) and modern spectro-polarimeter for Zeeman studies. Commissioning activities using the CHIME receiver and the new spectro-polarimeter should commence soon.

Solar Telescopes: the Solar Flux Monitor program (SFM) at DRAO records and distributes the F10.7 solar activity index used worldwide. The primary instrument employs redundant 2-m antennas (FM1 and FM2) to measure the solar radio emission at 2.8GHz (10.7cm wavelength), with carefully calibrated measurements made thrice daily and distributed to the data service. This system is undergoing upgrades to modernize the telescope control and data acquisition systems. FM2 is performing well on the updated linux/software-defined-radio system. Roll out of the same upgrades to FM1 has been delayed, but should be done in the coming months, removing the last of the antiquated software and hardware in this system.

The Next-Generation Solar Flux Monitor (NGSFM aka FM3) is a single 4-m antenna with a wideband feed and receiver system that records data at 1.4, 1.6, 2.8, 3.3, 4.9, and 8.3 GHz. Preliminary horn calibrations have commenced with good results being obtained, although final calibrations cannot be done until closer to the solstice, to minimize tropospheric and ground radiation effects. Once calibrated, the data will be suitable for distribution.

Plans to archive and distribute Solar data via the CADC are well advanced, with the intention being to transition from the current DRAO-centric "push" distribution model used for FM1/2 to one in which users will "pull" data for all the Solar telescopes from CADC.

Synthesis Telescope: the Synthesis Telescope (ST) uses seven 9-m antennas in an interferometric array operating at 408 and 1420MHz, with a 256-channel spectrometer measuring the HI line.

The NRC Small Teams project to upgrade the ST and explore new technologies - known as the Advanced Radio Telescope Test Array, 4-Antenna, or ARTTA-4 - is progressing well. Technologies being tested will include wide-band feeds (simultaneous dual-band 400-800MHz and 900-1800MHz), novel incoherent clocking, and TALON correlator technology developed for the SKA. It has been a year since the kick-off, with design work progressing on schedule, ranging from focus-box mechanical design to digital systems. Changes to the telescope are not expected for ~12 months, so operations are continuing normally for now.

CHIME/FRB:

The CHIME Fast Radio Burst (FRB) project continues to operate nominally, detecting many hundreds of FRBs in real time. The team has recently submitted its first FRB catalog, comprising 535 events, as well as several in-depth analyses of these data. These are presently under journal review. Once published, all catalog data will be available to the public and is being hosted by CADC. The CHIME/FRB team is also preparing for community real-time VOEvent alerts to facilitate rapid multi-wavelength follow-up. The alert system is currently under beta test. Additionally, the CHIME/FRB team is planning to construct. Outrigger telescopes, to enable quasi-real-time sub-arcsecond sky localizations for all CHIME/FRB events via VLBI. Ground has been broken at the first Outrigger site at Allenby, BC, and construction will begin there soon. A second CHIME/FRB Outrigger site will be located in Green Bank, WV. The site of the 3rd CHIME/FRB Outrigger is still under discussion.

CHORD

CHORD was funded by CFI, announced in 2021. Funding will begin to flow late in 2021 or early 2022. The team is currently prototyping two 6m precision dishes, feeds, mounts, and amplifiers for on-sky validation and testing. Survey and environmental studies have commenced. The project organization is structured around instrument and science working groups, all of which have kicked off and begun regular design and planning meetings. The CHORD collaboration will be hosting small community workshops to better understand the trade-offs of design choices on science, and optimize the instrument for new developments on the science frontier.