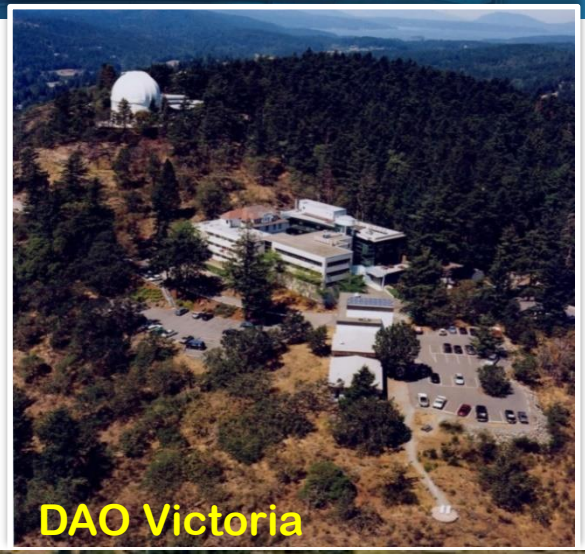
Canada and Subaru

Luc Simard
Director General
Herzberg Astronomy and Astrophysics Research Centre
Subaru Users Meeting, 28-30 January 2019

NRC Herzberg: Canada's National Centre for Astronomy and Astrophysics

Operate from two historical sites

- Dominion Astrophysical Observatory (DAO)
- Dominion Radio Astrophysical Observatory (DRAO)
  - Operating telescopes on both sites
  - Main role: **national laboratory for the support and development of Canadian ground-based astronomy**
  - Facilities include 4 offshore telescopes operated in international partnerships


DAO Victoria

Research Centre staff :

- 65 engineers/scientists in research, development and scientific support roles
- 12 technicians
- 14 computational specialists
- 14 administrative/management


DRAO Penticton

NRC Herzberg: Canada's National Centre for Astronomy and Astrophysics

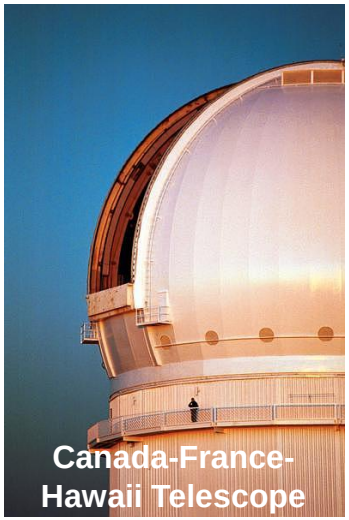
- **Unique within Canada:**
  - Mandated by the NRC Act
  - Contributions support the development, construction, operations and decommissioning of offshore telescopes operated in partnerships that include NRC
- Observatory instrumentation is developed with agencies/organizations that form our partnerships
- More than two dozen countries are involved in our partnerships: our stage is global
- Work with Canadian University labs
- Work closely with Canadian Industry

NRC Act:
"operate and administer any astronomical observatories established or maintained by the Government of Canada"

"A key characteristic of contemporary astronomy … is the importance of **international collaboration,** both on the facility side, where collaboration is now the norm for supporting new instruments, and on the research side."

Astronomy in Canada
HAL 2011

Canada's International Observatories

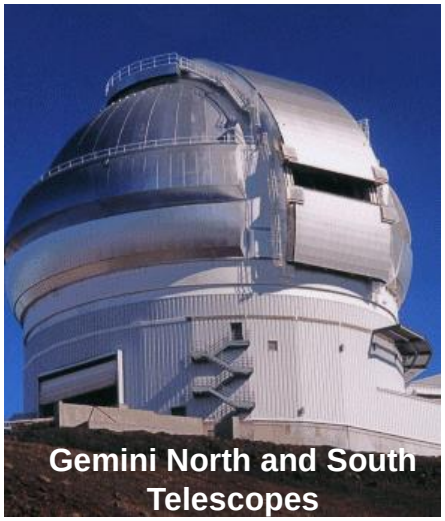


Canada-France-Hawaii Telescope

Agreement: 1974

Canada	42.5%
France	42.5%
Hawaii	15.0%

Locale: Hawaii
Optical–InfraRed
3.6m primary



Gemini North and South Telescopes

1993

U.S.A.	67.24% (2018)
Canada	18.15%
Argentina	3.10%
Brazil	6.51%
Korea	5.00%

Hawaii + Chile
Optical–InfraRed
2 × 8m primary

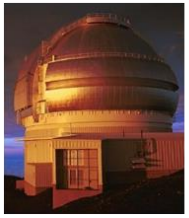
Atacama Large Millimetre Array

2003

N. America	37.5%
(Canada	2.8%)
Europe (ESO)	37.5%
Japan/Taiwan	25.0%

Chile
Sub-millimetre array
66 antennae

International Telescopes: Deliverables



Near Term

- Canadian astronomers have access to leading-edge facilities and technology.
- Qualified students have access to advance their training.
- New technologies are developed for new telescopes and instruments.
- Timely publication is facilitated by efficient management of telescope time and by timely availability of telescope data.
- Telescope data is effectively managed to help create and disseminate new knowledge.

Intermediate

- Canada plays a prominent role in international science
- Scientific benefit to Canada is maximized through science conducted with leading-edge instrumentation.
- Canadian industry has increased opportunities to participate in advanced scientific projects and increased opportunities to benefit from contracts and technology development.
- New technology is transferred to industry.

Long Term

- Important knowledge is acquired about the universe.
- Canada's position is enhanced among the world's leaders in astronomy.
- Canadian industry is afforded the opportunity to become more globally competitive through the development of technologies related to international observatories.

These deliverables are very important for Canada's portfolio of observing facilities

WIDE FIELD ASTRONOMY IN CANADA

Conference Date: Wednesday, October 10, 2018 (All day) to Friday, October 12, 2018 (All day)
Scientific Areas: Astronomy
Astrophysics
Cosmology

Canada has great ambitions in the area of wide-field astronomical surveys, and a strong heritage. On the eve of the Canadian Long Range Plan 2020, this workshop brings together the Canadian wide field astronomy community to discuss our strategy, including possible areas of scientific and technical coordination. We will review existing and near-term surveys, on facilities including CFHT, MWA, CHIME, Dragonfly, Gaia, SDSS-V, DESI, Euclid, and LSST, as well as future projects like MSE and SKA1 on the ground and WFIRST and CASTOR in space. Invited talks will highlight areas of rapid expansion, including time domain astrophysics and radio surveys, as well as data archives and computing platforms like CADC, Canfar, and CIRADA that enable the exploitation of wide field and time-domain data by the community. Our activities aim to ensure that wide field and time-domain science emerge with strong support in LRP2020 and are able to attract significant funding.

Registration for this event is now closed.

This workshop is being held in partnership with the Dunlap Institute.

PERIMETER INSTITUTE | UNIVERSITY OF TORONTO | DUNLAP INSTITUTE for ASTRONOMY & ASTROPHYSICS

Canadian Interests in Subaru

- Wide-field imaging for cosmology, stellar population and Solar System studies
  - Building upon 20-year legacy in mosaic imaging
  - Significant expertise in processing and analysis including algorithms and infrastructure (CADC / CANFAR)
  - Experience with large teams

- Wide-field, highly multiplexed spectroscopy
  - Essential complement to imaging (as shown by SDSS)
  - No current Canadian involvement in 2020-2025 surveys

    ➡ Need to prepare our community for MSE

- High spatial resolution, wide-field observations

A Story of Wide-Field and Pixels: MegaPrime

FOCAM (2K x 2K; 1994)

➡ MOCAM (2x2 x 2k x 2k; 1996)

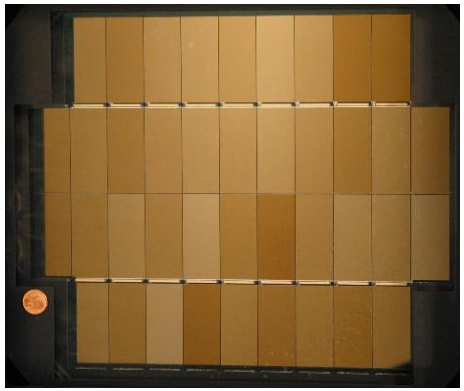
➡ CFH12k (6x2 x 2K x 4k; 2000)

➡ MegaPrime = Prime Focus Upper End (INSU) + Wide-field Corrector (NRC) +

Image Stabilizing Unit (Obs. de Paris) +

Focus Stage Assembly and Guider (NRC) +

Megacam (CEA; 4x9 x 2k x 4k; 2003)



A Story of Wide-Field and Pixels: Unveiling the Outer Solar System

The Astronomical Journal, 142:131 (24pp), 2011 October doi:10.1088/0004-625

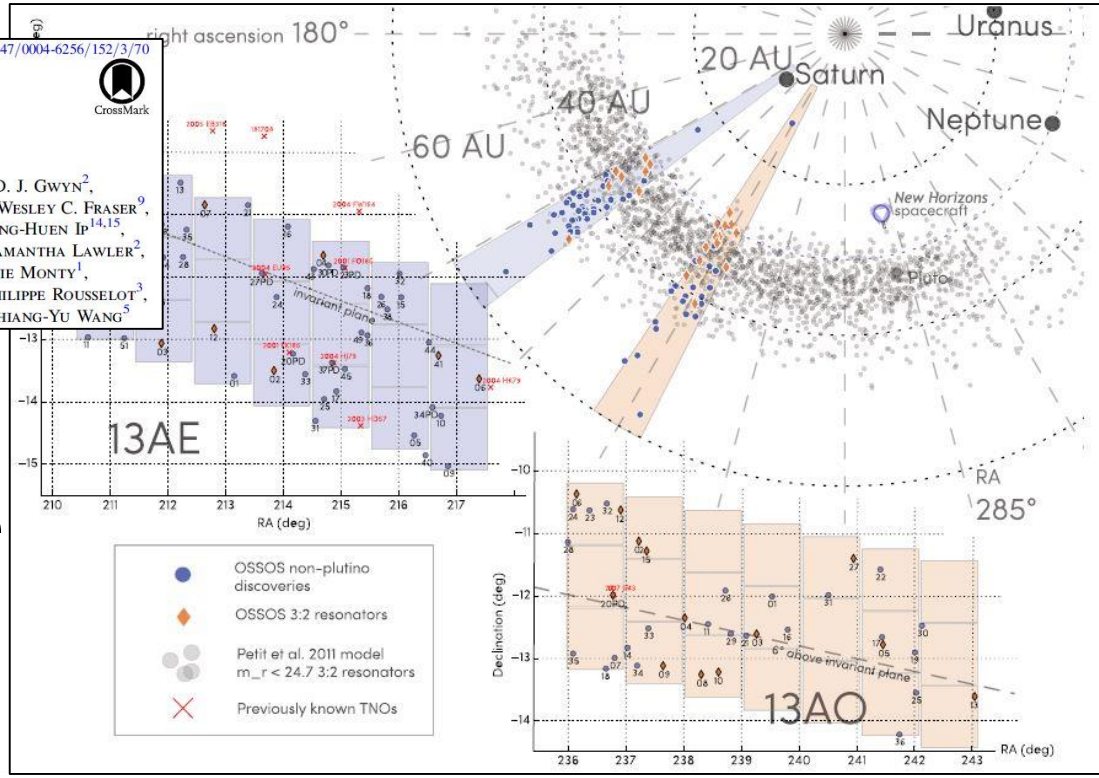
THE CANADA–FRANCE ECLIPTIC PLANE SURVEY—FULL DATA RELEASE: THE ORBITAL STRUCTURE OF THE KUIPER BELT*

J.-M. Petit[1,2], J. J. Kavelaars[3], B. J. Gladman[2], R. L. Jones[2,3], J. Wm. Parker[4], C. Van Laerhoven[2,5], P. Nicholson[6], G. Mars[7], P. Rousselot[1], O. Mousis[1], B. Marsden[8,11], A. Bieryla[4], M. Taylor[9], M. L. N. Ashby[8], P. Benavidez[10], A. Campo Bagatin[10], and G. Bernabeu[9]

The Astronomical Journal, 152:70 (25pp), 2016 September doi:10.3847/0004-6256/152/3/70

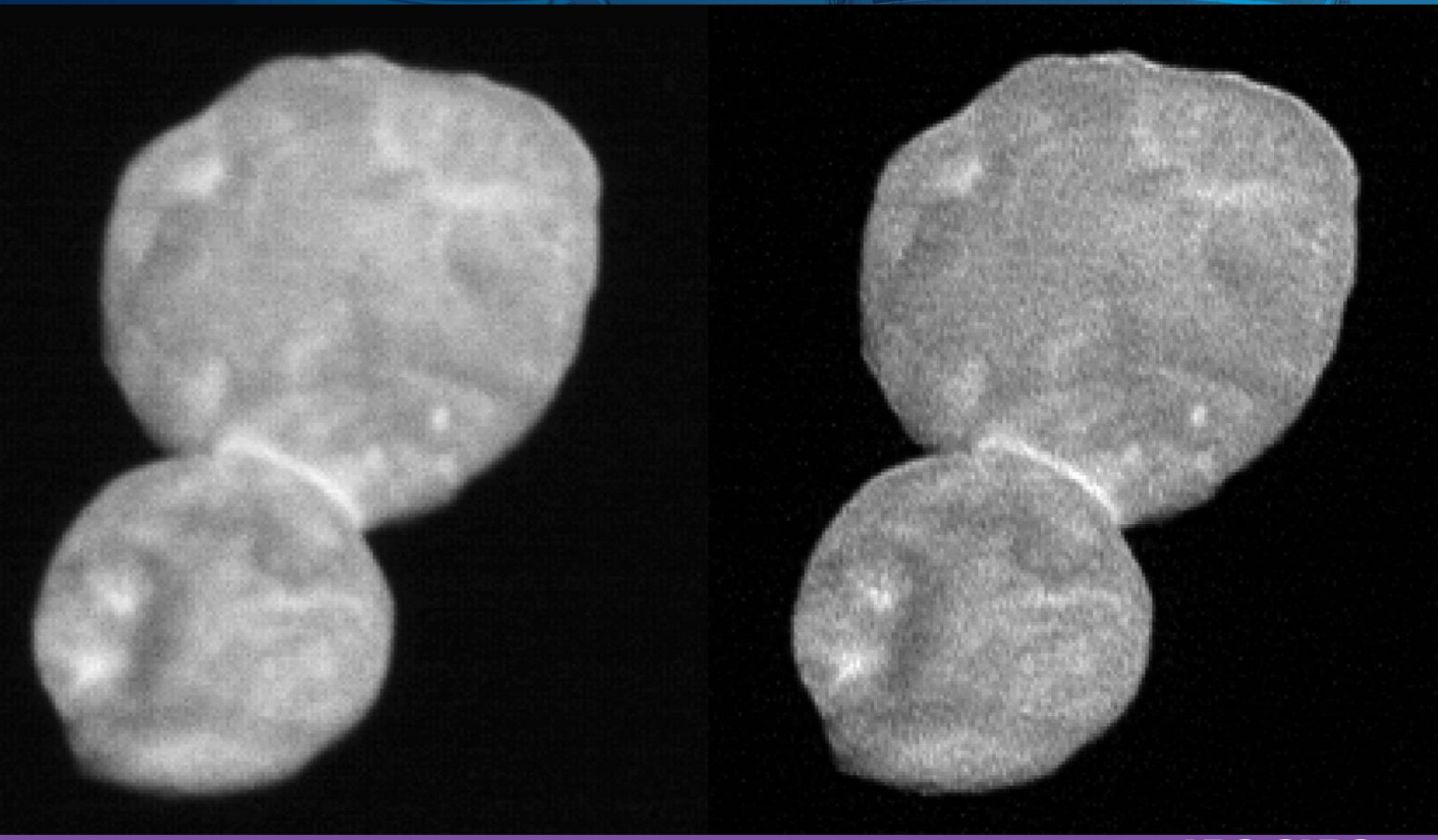
THE OUTER SOLAR SYSTEM ORIGINS SURVEY. I. DESIGN AND FIRST-QUARTER DISCOVERIES

Michele T. Bannister[1,2], J. J. Kavelaars[1,2], Jean-Marc Petit[3], Brett J. Gladman[4], Stephen D. J. Gwyn[2], Ying-Tung Chen[5], Kathryn Volk[6], Mike Alexandersen[4,5], Susan D. Benecchi[7], Audrey Delsanti[8], Wesley C. Fraser[9], Mikael Granvik[10,11], Will M. Grundy[12], Aurélie Guilbert-Lepoutre[3], Daniel Hestroffer[13], Wing-Huen Ip[14,15], Marian Jakubik[16], R. Lynne Jones[17], Nathan Kaib[18], Catherine F. Kavelaars[1], Pedro Lacerda[9], Samantha Lawler[2], Matthew J. Lehner[5,19,21], Hsing Wen Lin[14], Tim Lister[21], Patryk Sofia Lykawka[22], Stephanie Monty[1], Michael Marsset[8,23], Ruth Murray-Clay[24], Keith S. Noll[25], Alex Parker[26], Rosemary E. Pike[1], Philippe Rousselot[3], David Rusk[1], Megan E. Schwamb[5], Cory Shankman[1], Bruno Sicardy[27], Pierre Vernazza[8], and Shiang-Yu Wang[5]



From unveiling the structure of the Kuiper Belt to space navigation near Pluto!

ULTIMA THULE (2014MU69) - January 2019



The latest survey with a “C” in its name …

The Canada-France Imaging Survey (CFIS)

- 135 collaborators, mostly in Canada, France and Hawaii
  - 39 Canadians at 15 institutes
- 3 papers accepted to date
- Largest LP since the CFHT Legacy Survey

A. McConnachie @ WFA 2018

- Large Program started in 2017A, that grew out of previous LP Luau (Legacy for the u-band all-sky universe; 2015-16)
- u and r-band imaging:
  - u band: 24.4 @ SNR=5, 10,000 sq. degs
  - r band: 24.85 @ SNR=5, 4,800 sq. degs
- 321 night request
  - Allocated 271 nights in 2016LP call
  - Additional 50 nights requested in 2018LP call
  - Top ranked proposal, but SAC decided not to allocate any time
  - Instead, the 50 nights are going to be used for a “Completion Policy” for the current LPs

Large Spectroscopic Surveys in 2020-2025

Spectroscopic Survey Facilities around the Year 2020								
Survey (facility)	N_{target}	R_{spec}	N_{res}	$\bar{\lambda}[\mu m]$	Ω_{sky}	N_{epoch}	Timeframe	$m_{primary}$
SDSS-V	7×10^6	22,000 2,000	500	1.51-1.7 0.37-1	4π	$4-60$	2020-2024	$m_H \leq 12$ $m_G \leq 18$
Gaia (RVS)	2×10^6	8000	270	0.85-0.87	4π	~ 60	2013-2020	$m_G \leq 12$
Gaia-ESO	0.1×10^6	17,000	140	0.55& 0.85	0.02π	~ 1	2013-2018	$m_G \leq 17$
GALAH	0.8×10^6	28,000	400	0.40- 0.85	π $\|b\| \geq 10$	~ 1	2015-2020	$m_G \leq 13$
WEAVE	0.8×10^6	5,000 & 20,000	1000	0.37-0.9	$\sim \pi$	$\sim 1-2$	2018-2023	$m_G \leq 19$
DESI	8×10^6	3,000	5000	0.36-0.98	$\sim \pi$ $\|b\| \geq 25$	$\sim 1-2$	2019-2024	$m_G \leq 19$
LAMOST	8×10^6	1,800	4000	0.4-0.9	0.5π	~ 1	2010-2020	$m_G \leq 16$
4MOST	10×10^6	5,000 & 20,000	1600 & 800	0.4-0.9	1.5π	$1-2$	2023-2028	$m_g \leq 21$ $m_V \leq 16$
APOGEE-1& -2	5×10^5	22,000	300	1.51-1.7	0.5π	~ 4	2011-2019	$m_H \leq 12$
PFS	1×10^6	3,000	2400	0.4-1.6	0.05π	1	2018-2021	$m_g \leq 22$
MOONS	2×10^6	5,000 & 20,000	1000	0.6-1.8	0.05π	1	2020-2025	$m_g \leq 22$ $m_H \leq 17$

Table from Juna Kollmeier

Canadian Technical Interest in ULTIMATE: Science Instrument

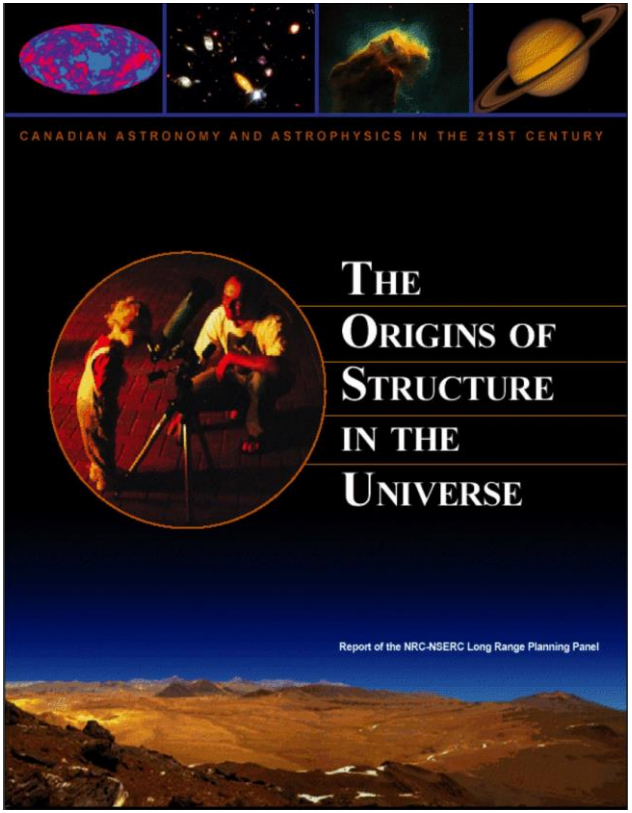
1. Wide-field imager (Pazder 2013) based on:
   - Adaptive Secondary Mirror + Concentric corrector providing a universal 22′.8 diameter field of view with residual aberrations less than 66 mas
   - 4-barrel imaging system feed :
     - Each barrel has 4K×4K H4RG detector covering 6′.8×6′.8 FoV w/ 0′′.1/pixel
   - Total imager FoV of 185 square arcminutes

2. Higher resolution (R~30,000), fiber-fed, multi-object spectrograph
   - Could leverage GHOST and SPIRou/NIRPS designs
   - GLAO IQ would positively impact spectrograph design

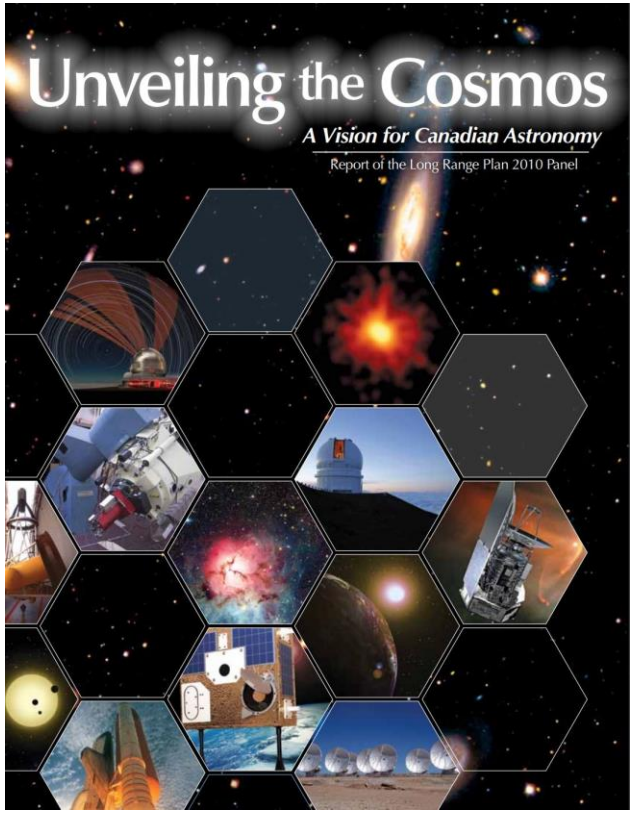
3. AO-assisted, deployable multi-IFU spectrograph
   - Could leverage GIRMOS design work
   - GLAO would provide AO “woofer” + MOAO “tweeter”

Canadian Long Range Plans for Astronomy

2000-2010



2010-2020



2020-2030

?

Long Range Plan Process

- Preparatory Workshops (e.g., Wide-Field Astronomy in October 2018)
- White papers
  (e.g., https://www.casca.ca/lrp2010/Docs/LRPReports/WhitePaperList.html)
- Townhalls to discuss white paper submissions
- Panel Report
- Mid-Term Review (MTR)
- LRP Implementation Committee (LRPIC)

More information on Canadian Astronomical Society website:
https://casca.ca/?page_id=75

LRP recommendations drive funding priorities for all three Canadian agencies with funding for astronomy: Natural Sciences and Engineering Research Council (NSERC), National Research Council Canada (NRC) and Canadian Foundation for Innovation (CFI)

LRP2010 Priorities

Category	*Project*	*§*	*$*	*Note*
Very Large (above $100M)	A significant share of a VLOT: highest priority is TMT if it can be built in a timely manner; otherwise E-ELT	4.1.1	$5M/yr preconstruction $300M construction	1, 3
Large	SKA R&D	4.1.2	$3.5M/yr preconstruction $56M construction (Phase 1)	1, 4
Medium ($5M-30M)	1. CHIME	4.2.1	$15M	2, 5
	2. CFHT new instrumentation	3.1.1	$5M	2, 6
	3. CCAT	4.2.2	$0.9M pre-construction $14M construction	2, 7
Small (below $5M)	1. Arctic site testing and telescope	4.2.3	$0.2M/yr site testing $3-5M telescope (if feasible) $0.5-1M/yr operations (if feasible)	2, 8
	2. ngCFHT R&D	4.2.4	$2M over decade	2, 9

Note: $ amounts are for Canada's contribution only.

Ground-based

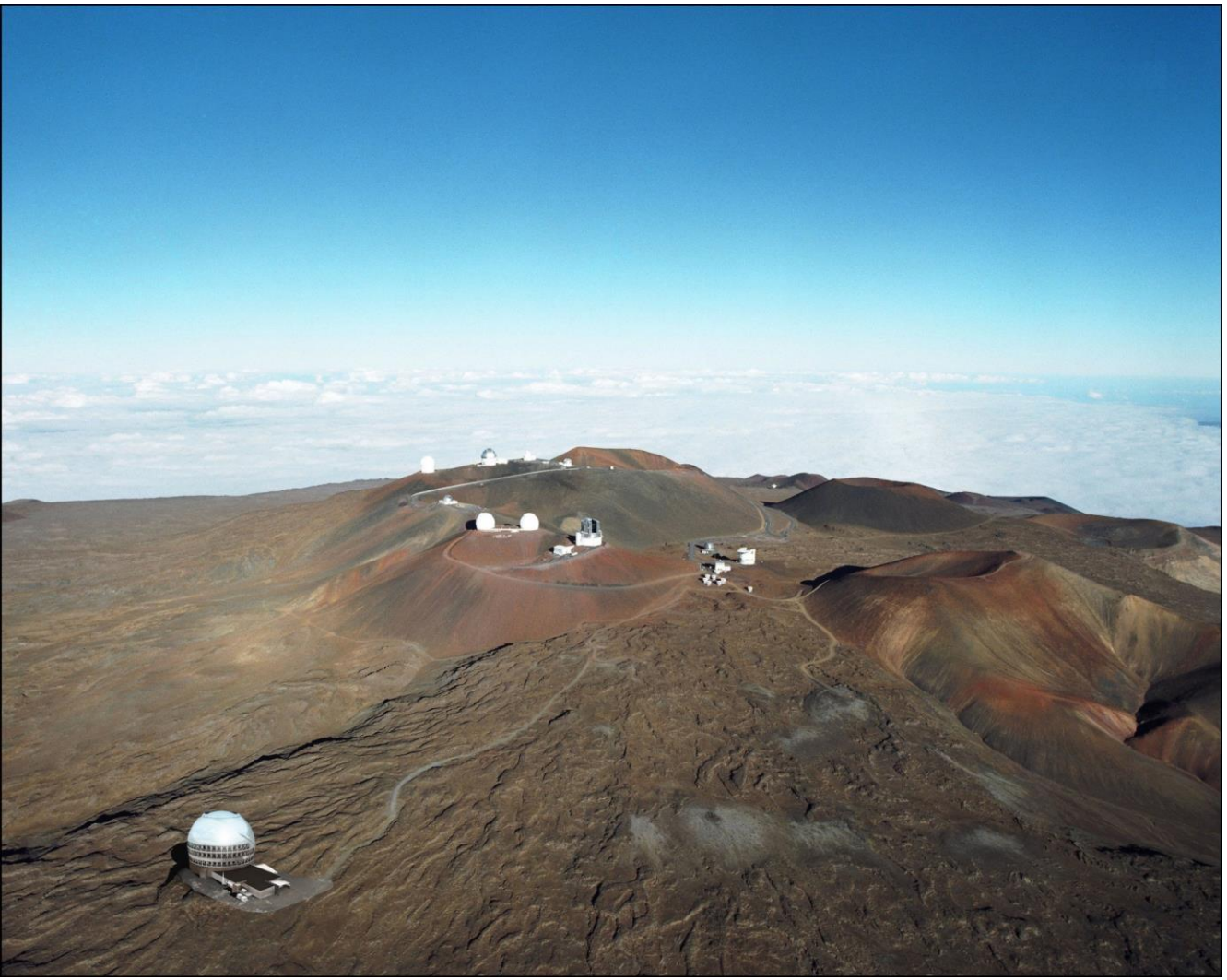
Category	*Project*	*§*	*$*
Large	Dark Energy Satellite (e.g. Euclid or WFIRST or CST)	5.1	$100M
Medium	1. IXO R&D	5.2	$15M
	2. SPICA	5.3	$10M
Small	1. Astro-H	5.2	$5M:
	2. Stratospheric Balloon Programme	5.5	$5M:
	3. Nanosat/Microsat Programme	5.4	$5M:

Space-based

LRP2020

- Co-chairs announced in January 2019:
  - Dr. Pauline Barmby (Western University)
  - Dr. Bryan Gaensler (Dunlap Institute, University of Toronto)
- Terms of Reference published in January 2019
- Panel members being appointed
  - Selected from university, government and industry
- Call for white papers followed by townhall meetings
- Panel report expected in 2020 – will be timed to be a few months after US Decadal Survey report release

The ‘Ohana of Maunakea Observatories

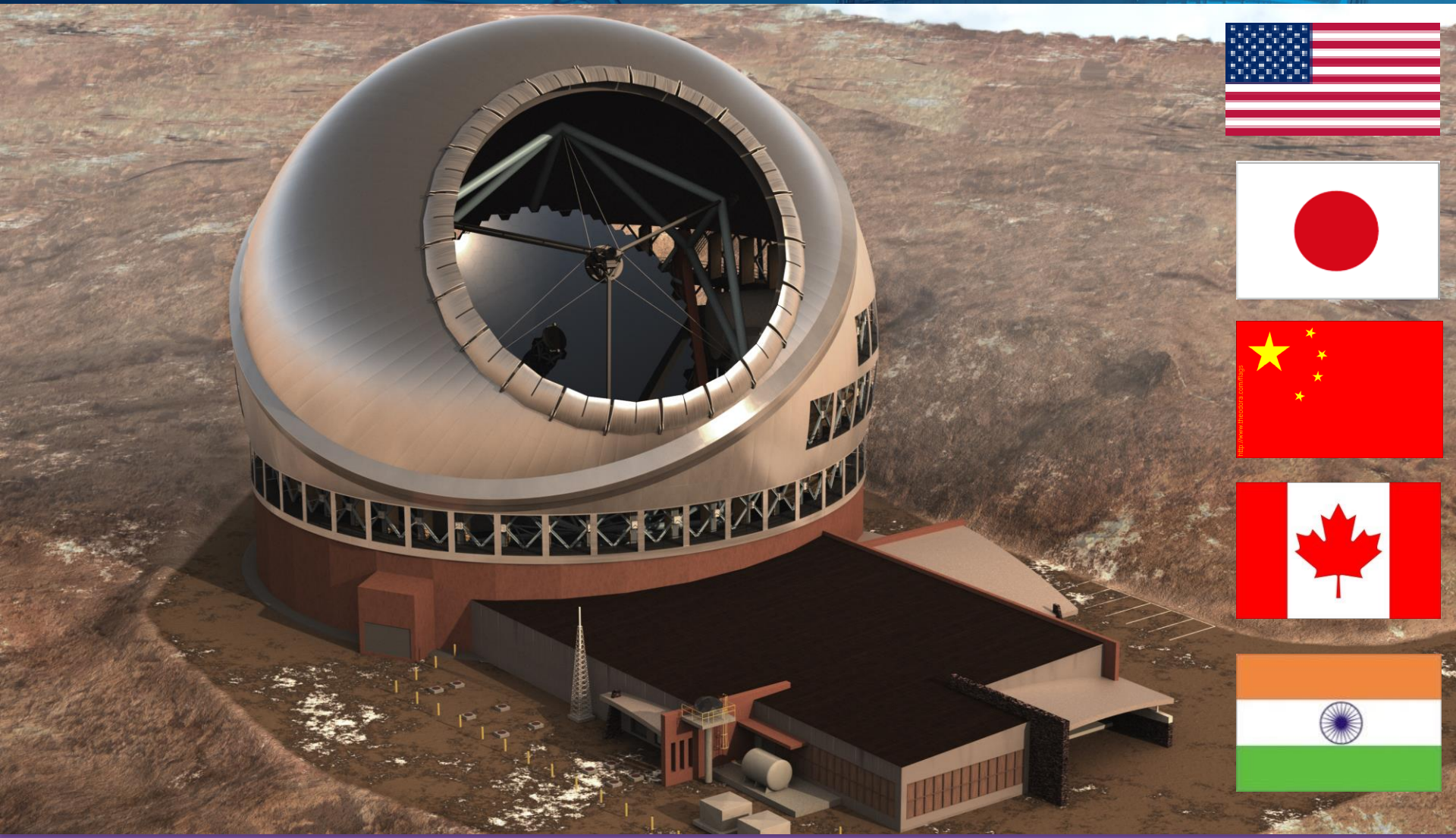


Joint scientific programs, operations and development efforts will become critical elements of the future especially in the TMT era

Investing in a system of telescopes and not in individual telescopes

A powerful argument for funding agencies

Thirty Meter Telescope (TMT)



Thank you!

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