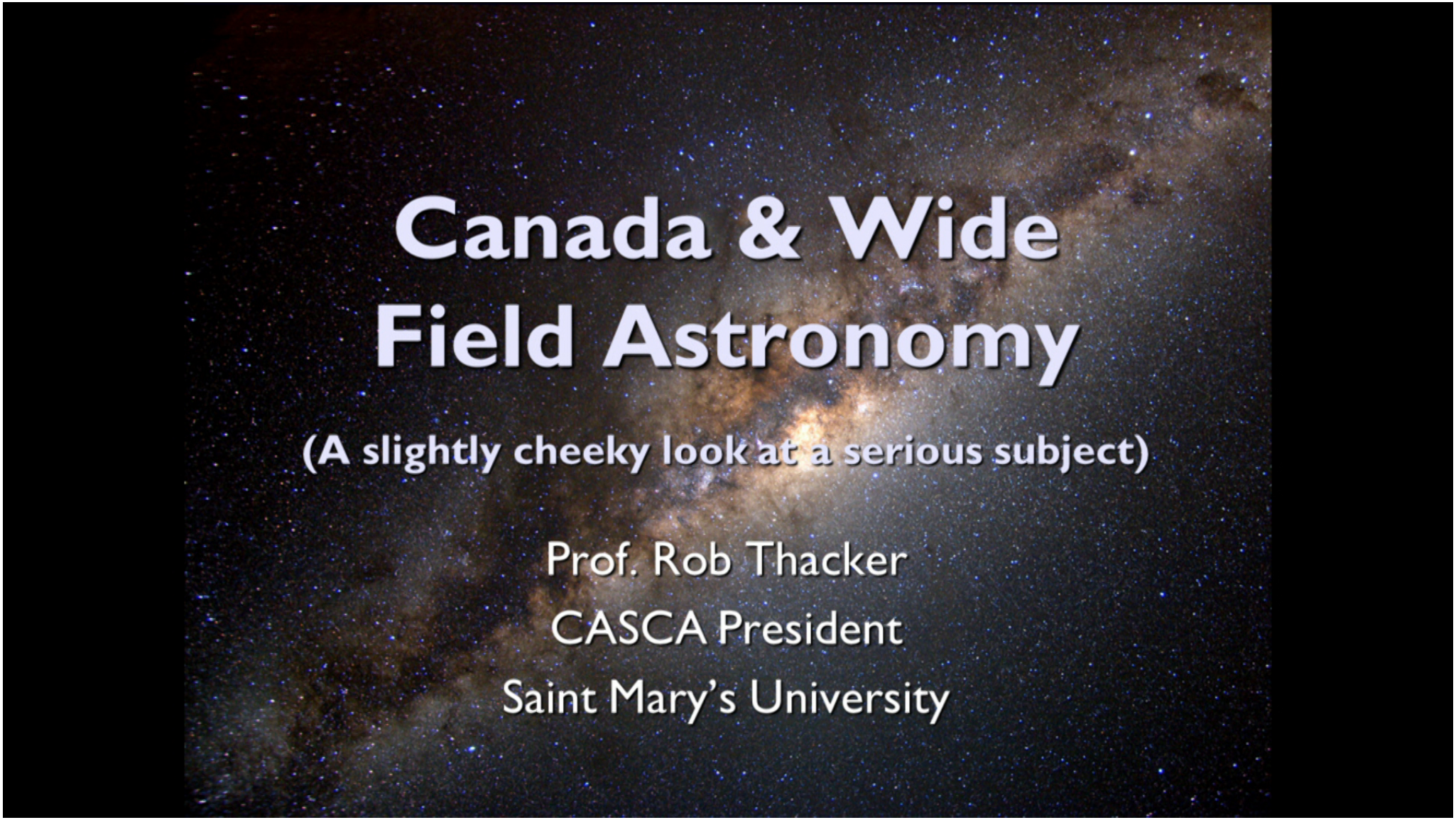
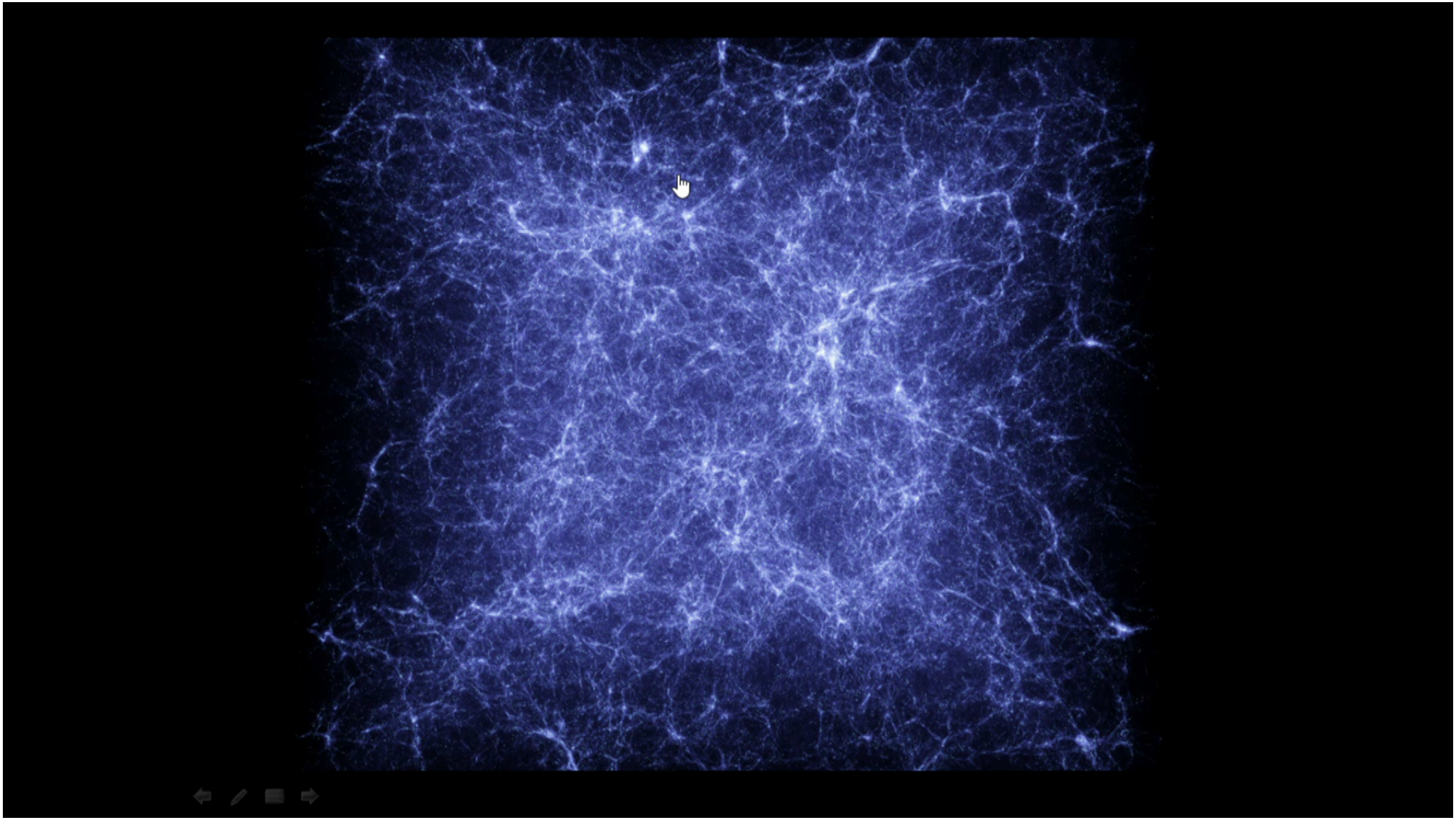
Title: Canada and Wide Field Astronomy

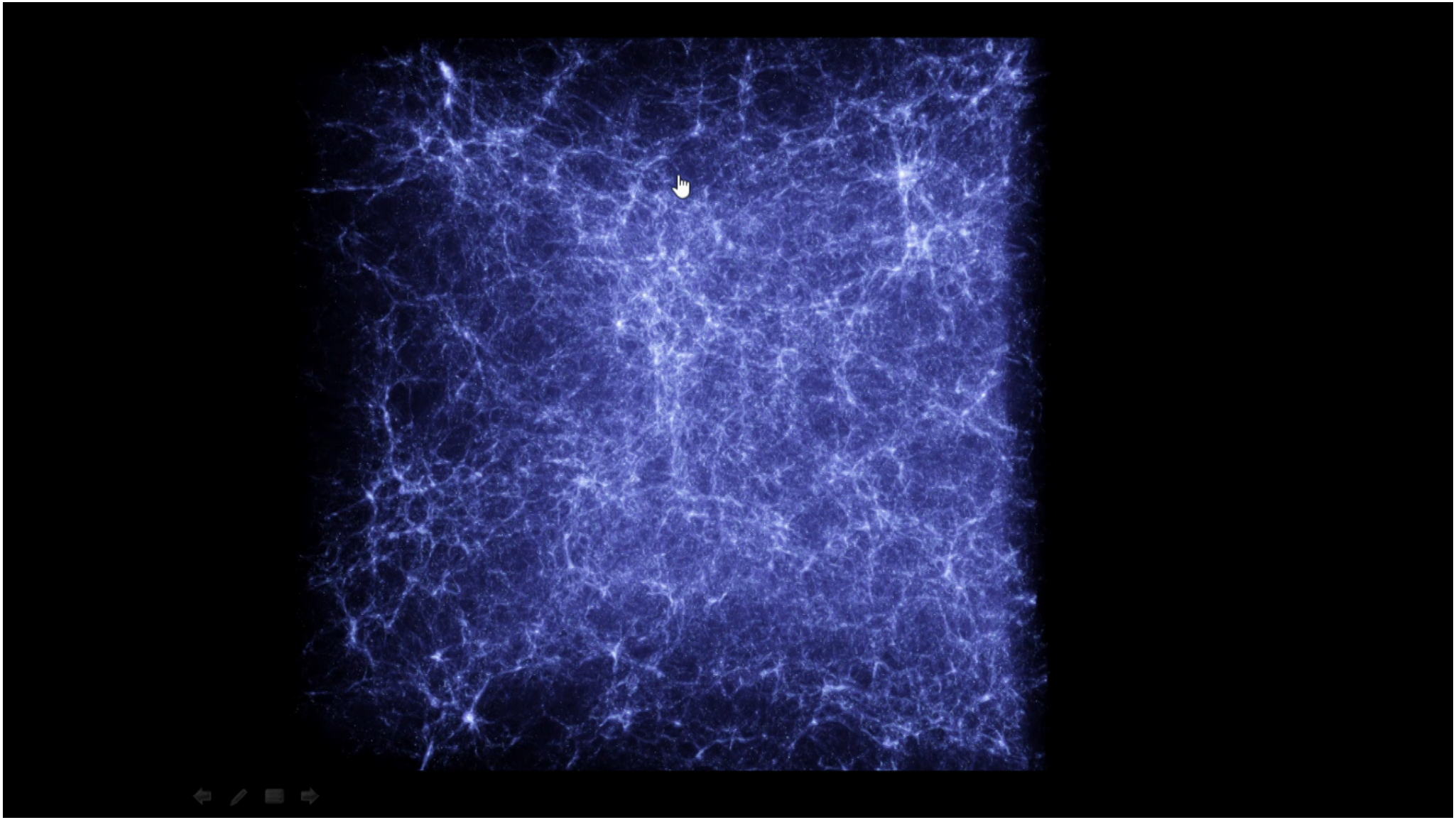
Date: Oct 10, 2018 02:00 PM

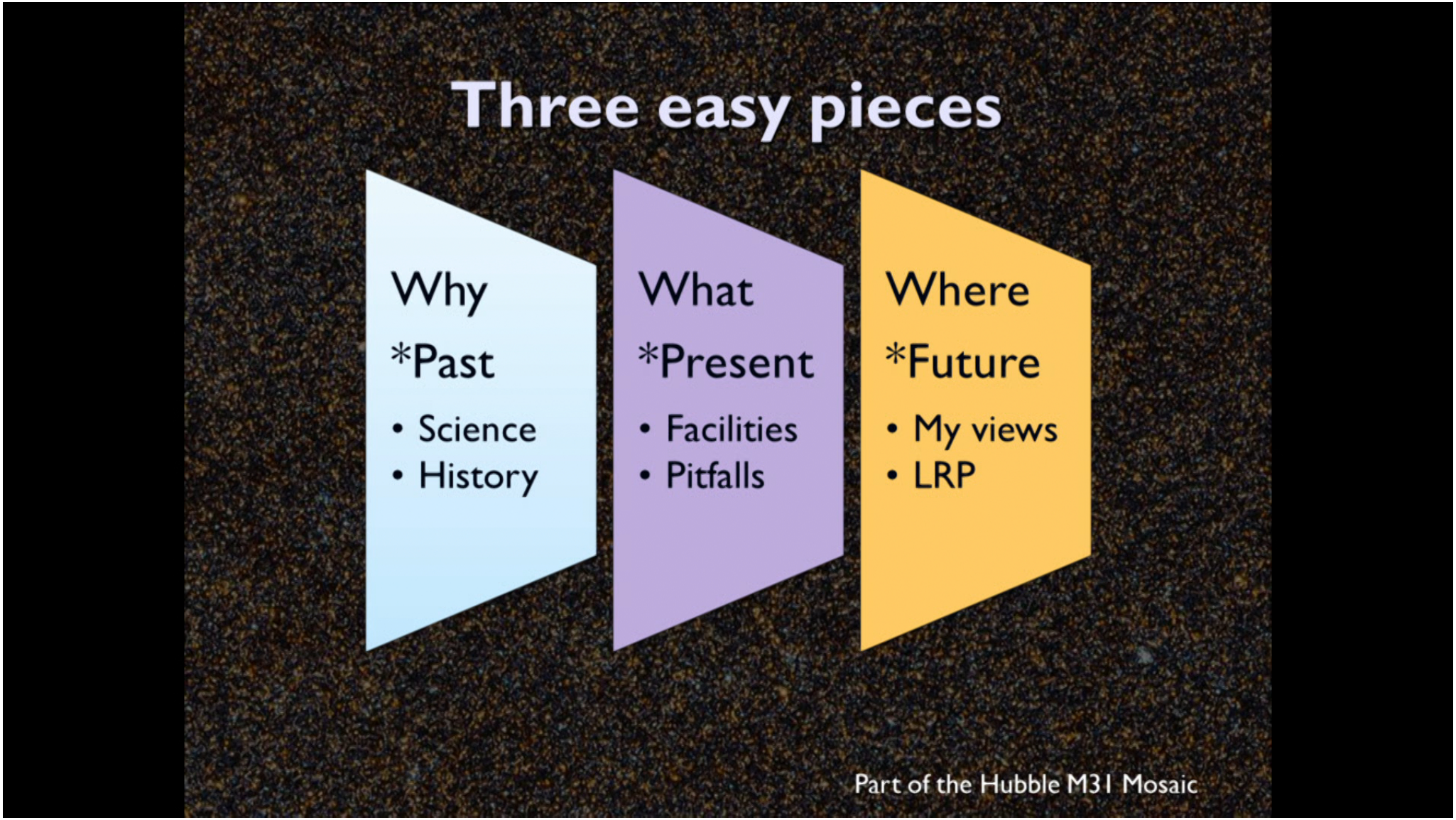
URL: http://pirsa.org/18100063

Abstract: While the term â€œwide-field telescopeâ€• might sound like an oxymoron, a strong argument can be made that wide-field instruments lie behind much of the success of Canadian astronomy. Furthermore, despite the large size of the optical-IR community in Canada, this success has been made possible by considering multiple wavelength windows, from gamma to radio, and access to a suite of facilities. Over the past two decades, through a pair of 10-year Long Range Plans, Canadian astronomy has carefully structured its facility access, to ensure, as best as can be reasonably hoped, that the community maintains access to world-leading facilities. Iâ€™ll summarize the progression of the community vision on wide-field astronomy, highlighting successes and some missteps. As we head towards the creation of the 3rd Canadian Long Range Plan for astronomy, Iâ€™ll also present some personal views on what scientific leadership means and the challenges that it presents for a smaller country (at least in the G7 sense!) like Canada.


Canada & Wide
Field Astronomy
(A slightly cheeky look at a serious subject)
Prof. Rob Thacker
CASCA President
Saint Mary's University





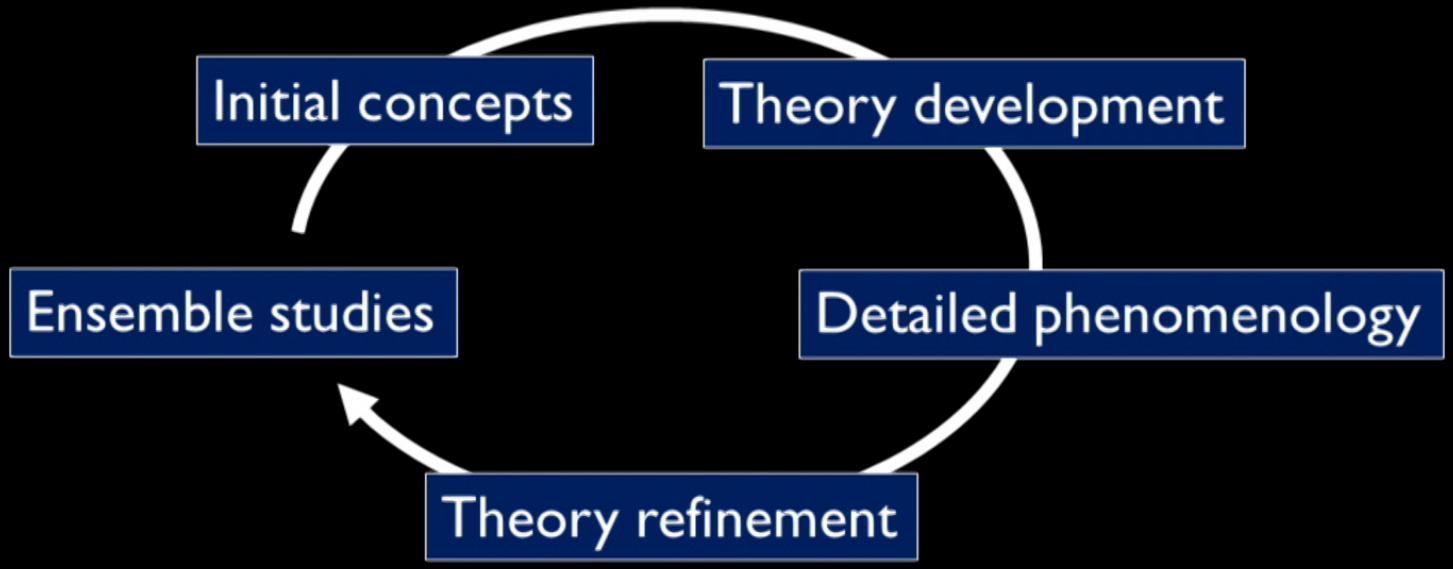

Three easy pieces
Why
*Past
• Science
• History
What
*Present
• Facilities
• Pitfalls
Where
*Future
• My views
• LRP
Part of the Hubble M31 Mosaic

Discovery-based vs hypothesis-based science

Discovery-based vs hypothesis-based science

Don’t sweat it – they actually inform one another

Ensemble studies vs object phenomenology



A Few Science Drivers 2020-30

Exoplanet hunting & characterization

NEOs

Star & planet formation (+astrochemistry)

Solar system

Galaxy & black hole mass assembly across cosmic time

Galactic dynamics & archaeology

Fundamental physics (DE, GW,
inflation constraints)

Transient & time domain astronomy

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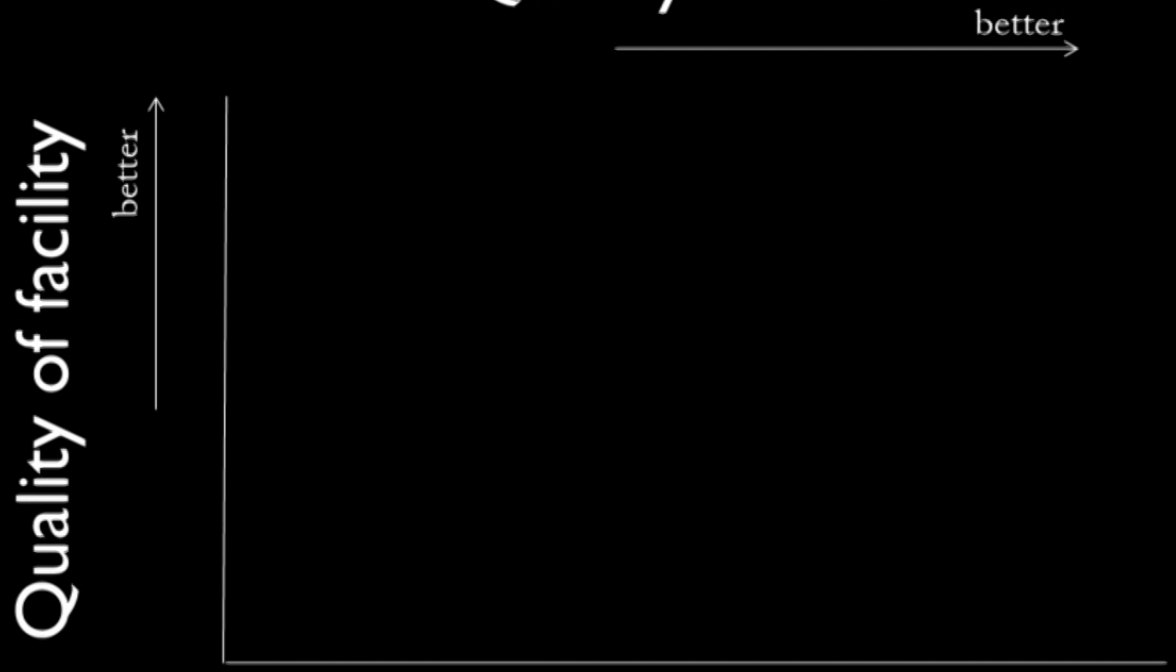
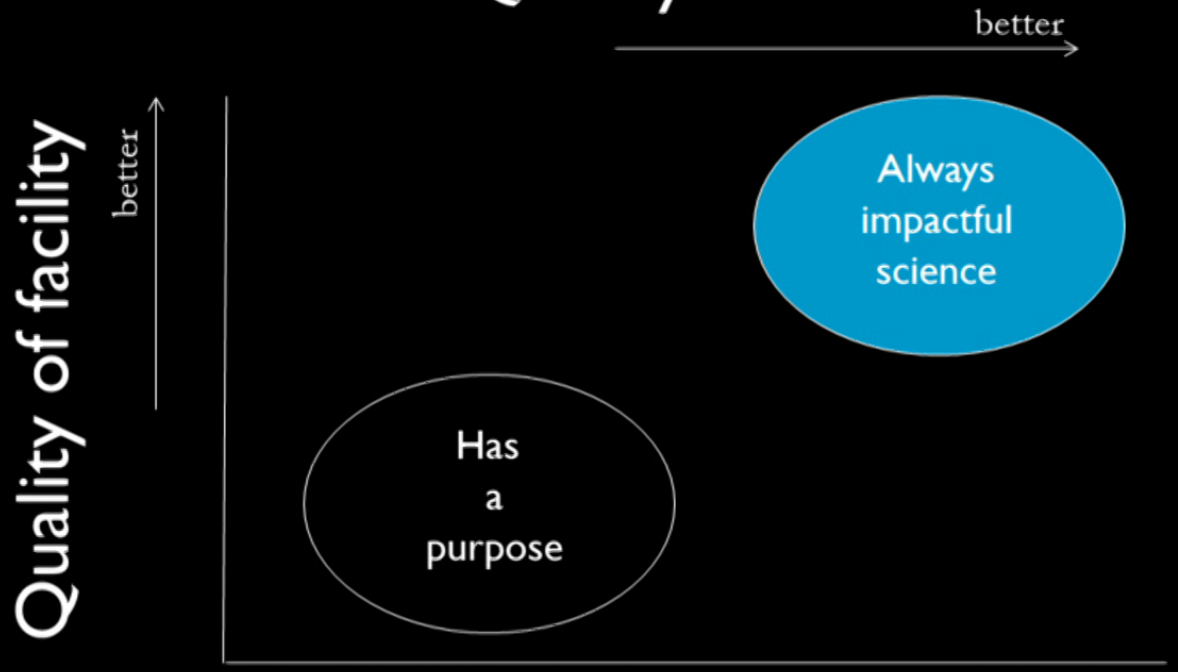
Common viewpoint

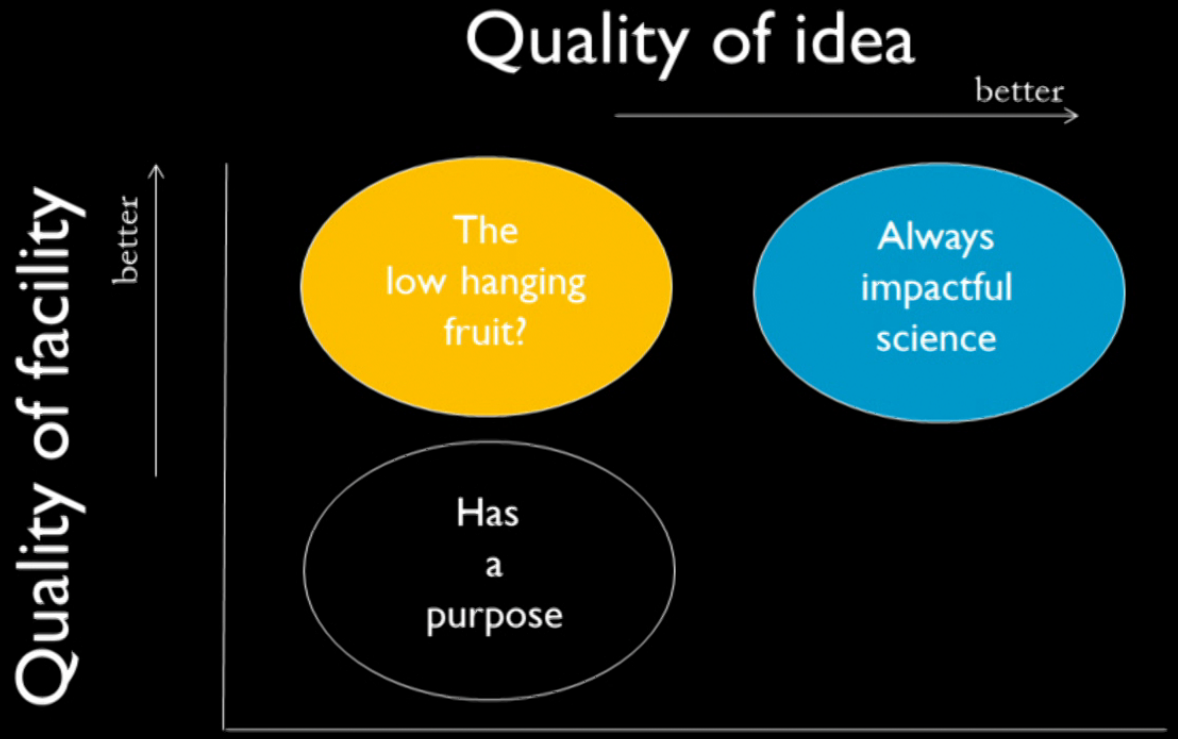


Common viewpoint

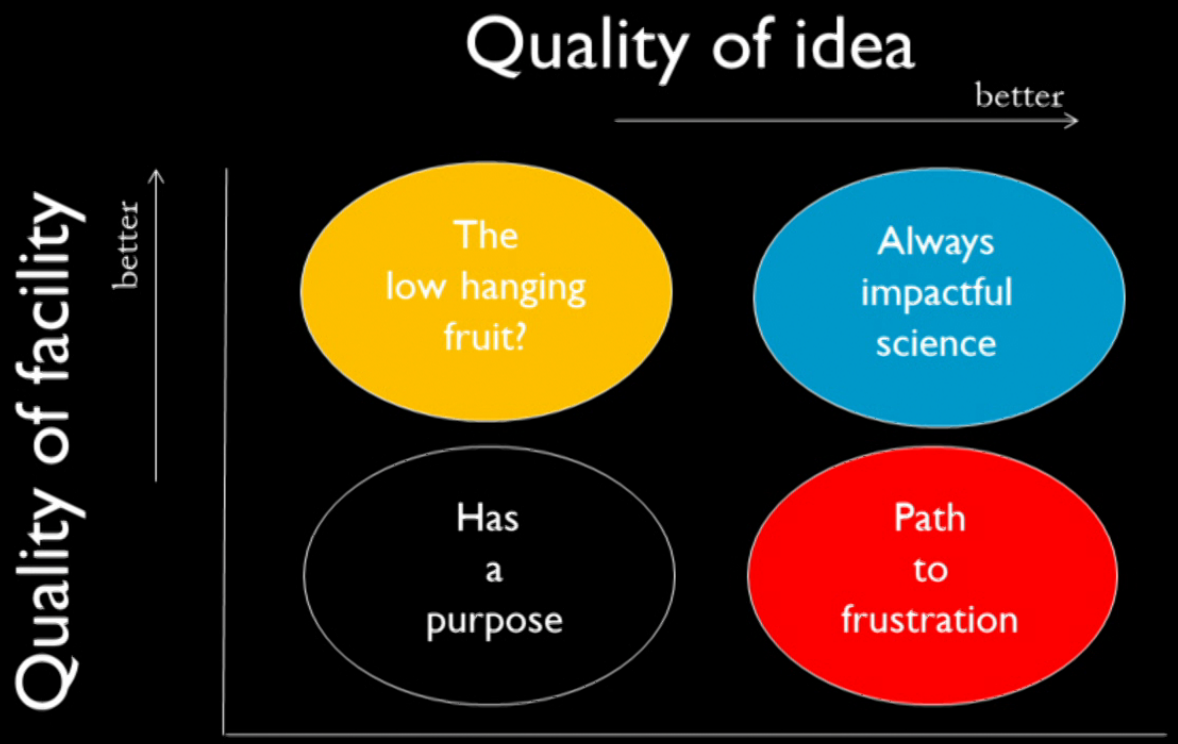
Common viewpoint



Common viewpoint



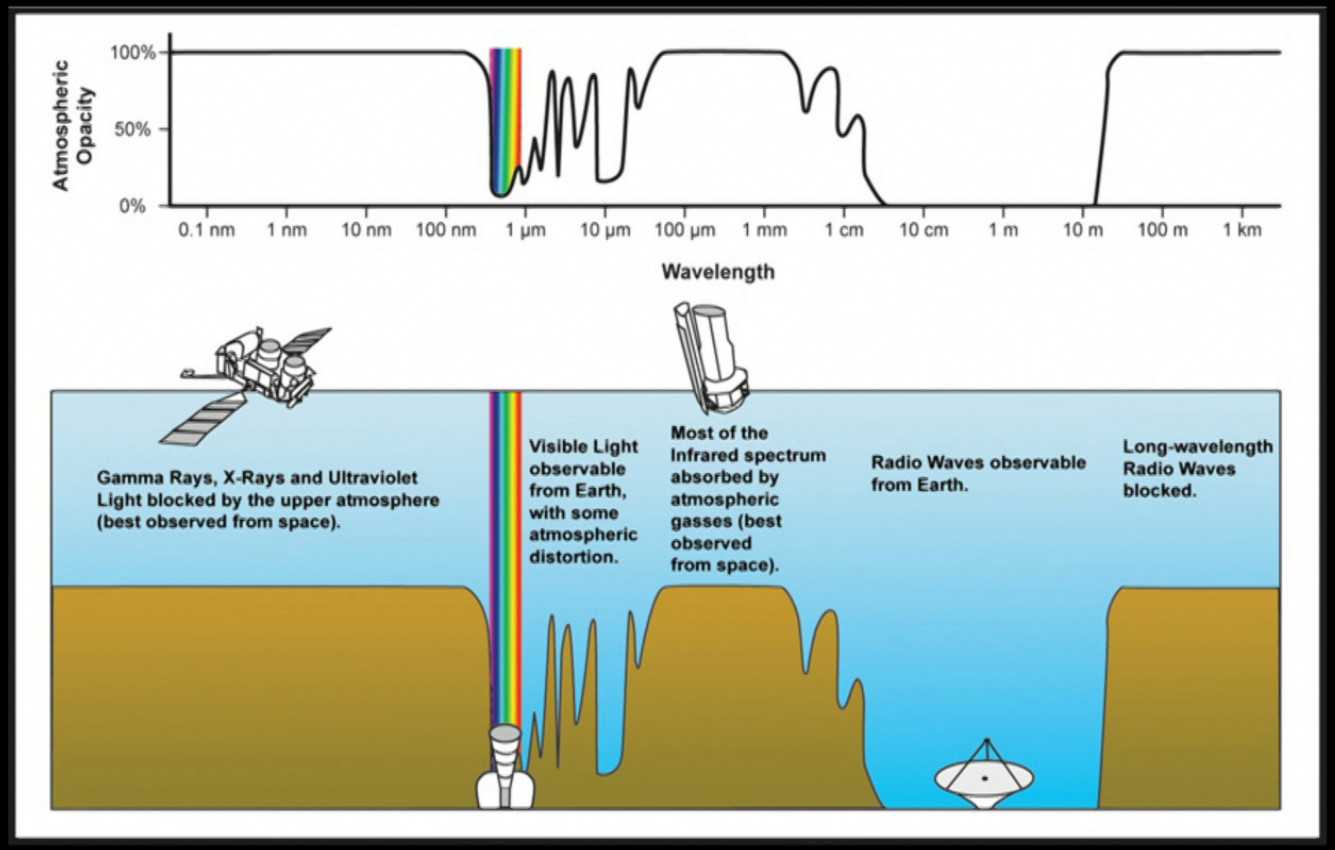
Common viewpoint



Something for PI to consider

Is a deluge of data
going to make astronomy
'theory poor'?

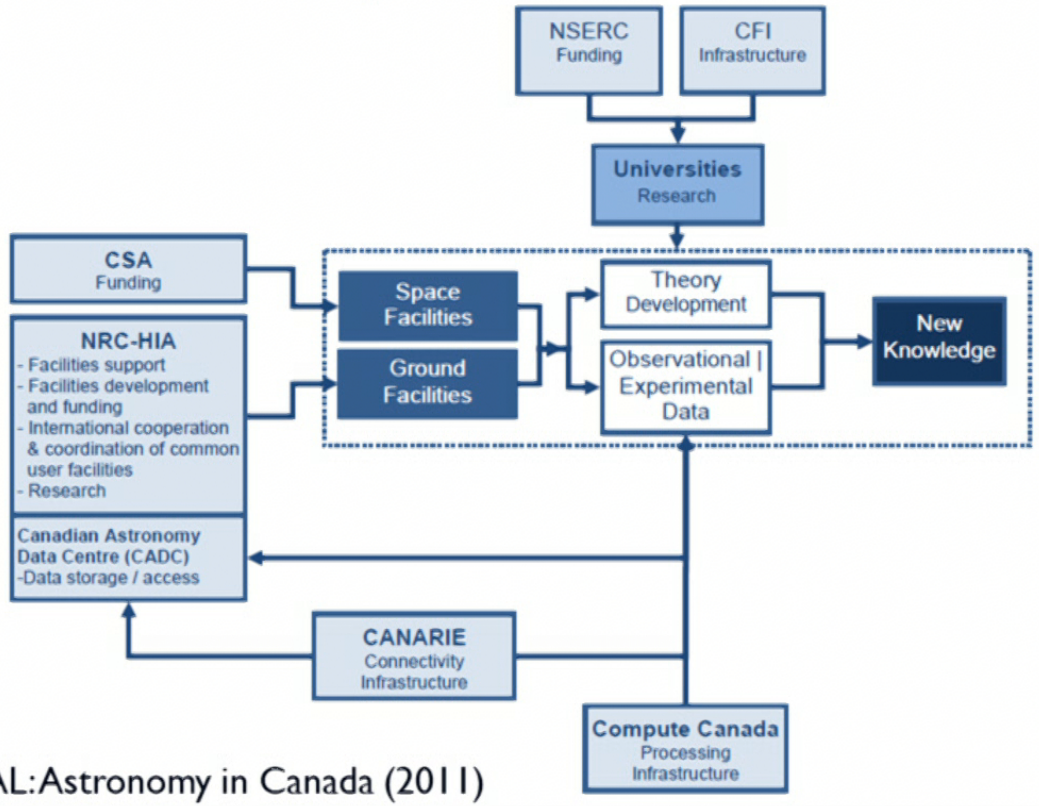
Space vs ground I



Space vs ground II WF – adaptive optics won't save you

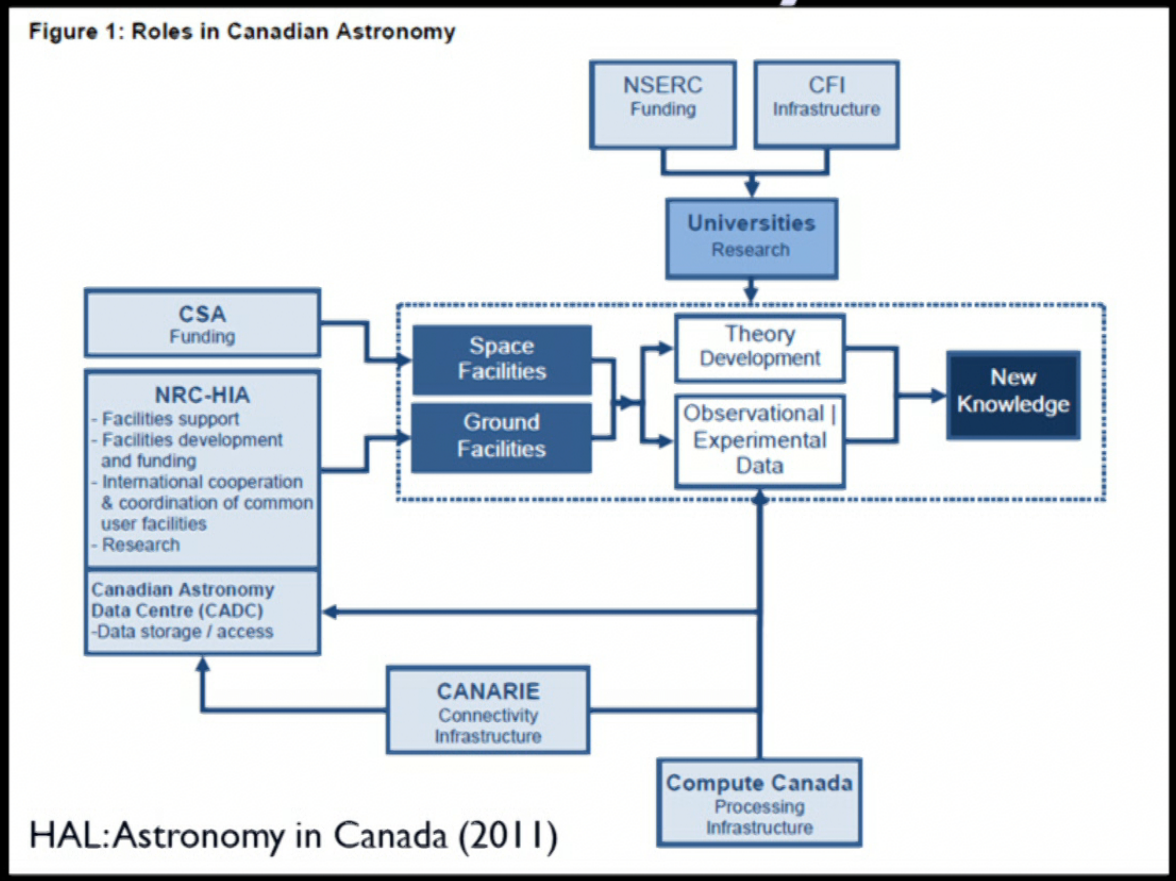
Organization of Canadian astronomy

Figure 1: Roles in Canadian Astronomy

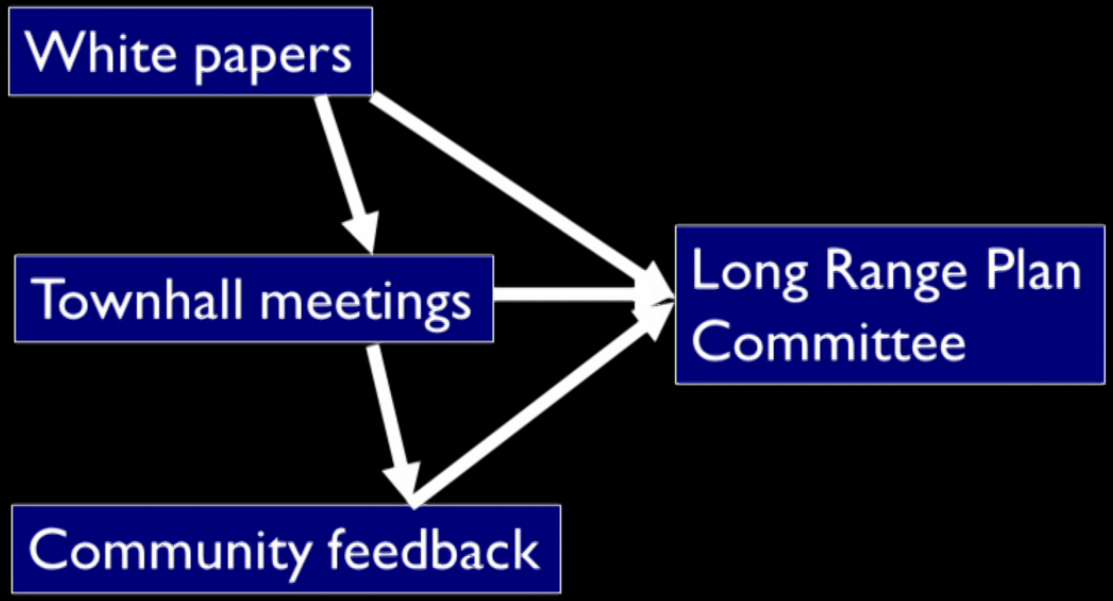


HAL:Astronomy in Canada (2011)

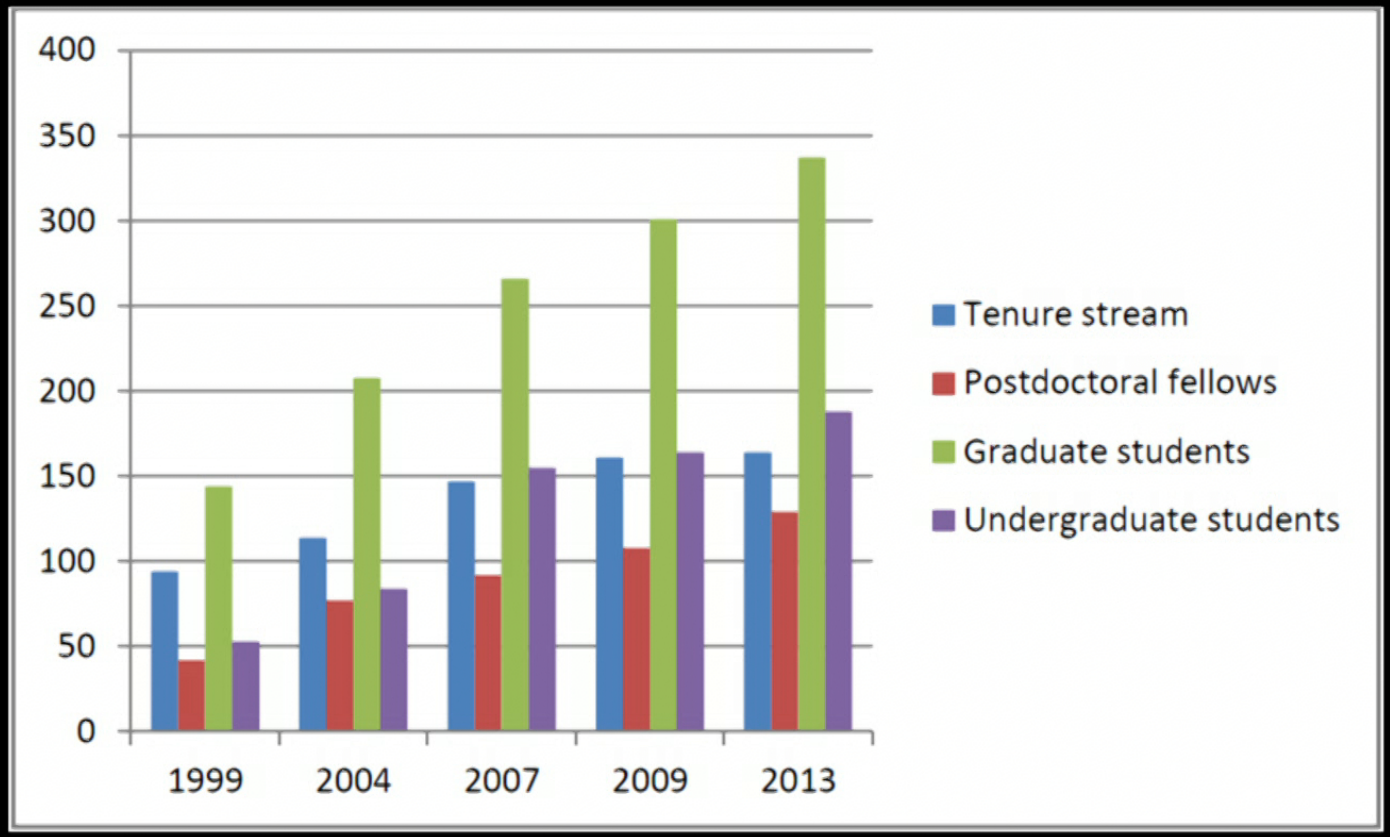
Organization of Canadian astronomy



Building a research plan



Community background



MTR2015 & ACURA

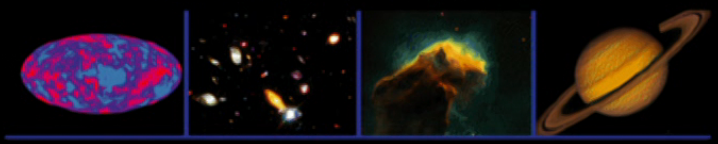
Cost of astronomy (per year)

Country	Ground-based [$CAD M]	Space-based [$CAD M]	Total [$CAD M]	GDP [$CAD M]	Spending/GDP As %	Relative to Canada
UK	170	165	335	2222000	0.015	2.7
ITALY	255	55	310	2121000	0.015	2.6
FRANCE	248	84	332	2688000	0.012	2.2
GERMANY	327	69	396	3332000	0.012	2.1
USA	550	1103	1653	14799000	0.011	2.0
AUSTRALIA	79	13	92	1192000	0.008	1.4
CANADA	51	36	87	1556000	0.006	1.0

LRP2010


ASTROPHYSICS (US)
Decadal Survey Missions
1972
Decadal Survey
Hubble
1982
Decadal Survey
Chandra
1991
Decadal Survey
Spitzer, SOFIA
2001
Decadal Survey
Webb
2010
Decada
Survey
WFIRST

LRP2000



CANADIAN ASTRONOMY AND ASTROPHYSICS IN THE 21ST CENTURY

Dr Simon Morris
(then NRC)

Dr Ernie Seaquist
(U.Toronto)

Dr Gilles Joncas
(U. Laval)

The Origins of Structure in the Universe

Dr Andrea Dupree
(Harvard U.)

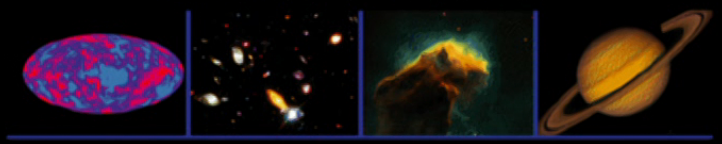
Dr Jack Wlech
(UC Berkeley

Report of the NRC-NSERC Long Range Planning Panel

Dr Ralph Pudritz
(Mcmaster U.)

Dr Bill Harris
(McMaster U.)

LRP2000



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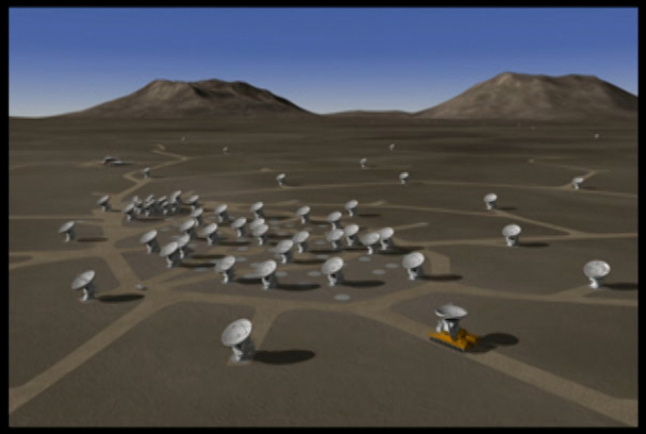
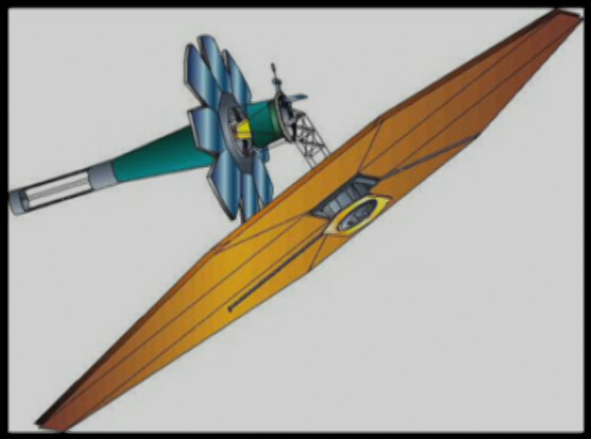
Outcomes





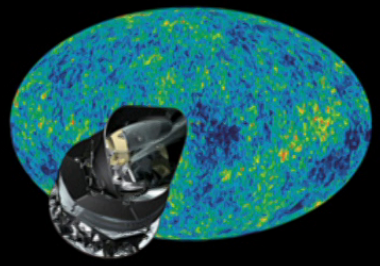
ALMA
(JCMT withdrawal as well)

NGST (JWST)

+ develop very large optical telescope concept

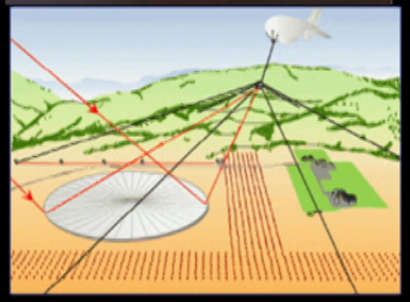
WF Recommendations

"join and participate in the Planck satellite mission"



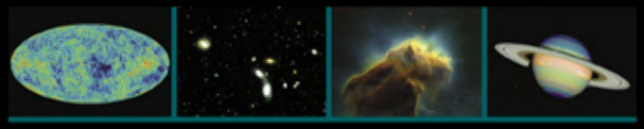
"In order to keep our community competitive in the era of 8 metre optical and infrared telescope science, a new, wide field of view, 8 metre telescope should be constructed"

the Canadian Large Adaptive Reflector (LAR) concept be carried forward into prototypes for key component (phase B) SKA studies.



+ WIDAR for JVLA

MTR2005



CANADIAN ASTRONOMY AND ASTROPHYSICS IN THE 21ST CENTURY

Mid-Term Review

A Report to the Canadian Astronomical Society

The Origins of Structure in the Universe

Dr George Mitchell
(Saint Mary's U.)

Dr Harvey Richer
(UBC)

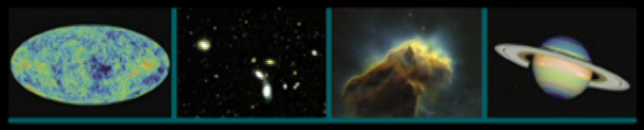
Dr Gretchen Harris
(U.Waterloo)

Dr Hugh Couchman
(McMaster U.)

Dr Vicky Kaspi
(McGill U.)

Dr Ernie Seaquist
(U.Toronto)

MTR2005



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Dr Vicky Kaspi
(McGill U.)

Outcomes

ALMA, JWST, SKA all reaffirmed as key projects

Thirty Meter Telescope elevated to high priority

WF Implications

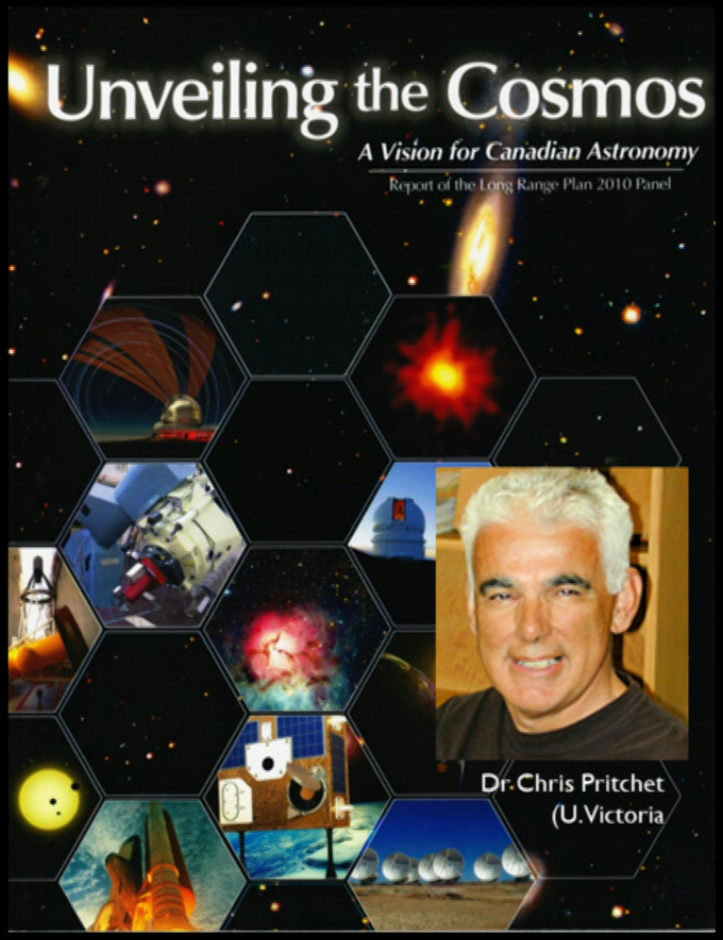
8m wide-field concept dropped in favour of pursuing TMT

LRP2010

Dr Vicky Kaspi
(McGill U.)

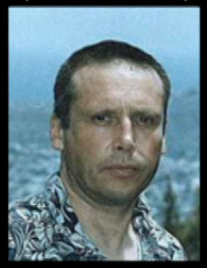
Dr Ernie Seaquist
(U. Toronto)

Dr Rob Thacker
(Saint Mary's U.)



Dr Bob Abraham
(U. Toronto)

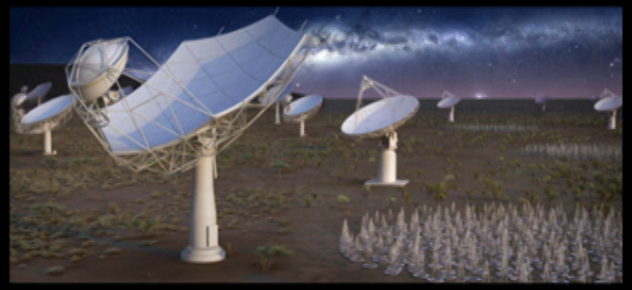
Dr Rene Doyon
(U. de Montreal)



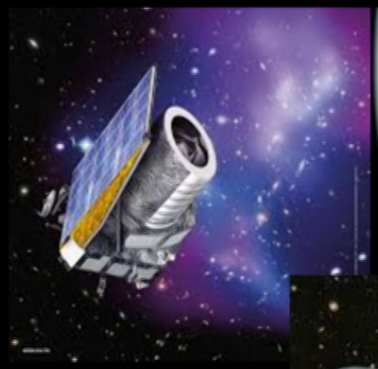
Dr Nick Kaiser
(U. of Hawaii)

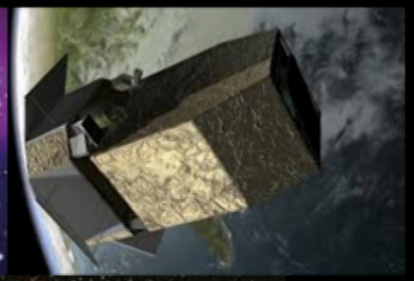
Outcomes

TMT & SKA
affirmed as
1 & 2 priorities



Dark energy
mission becomes
top space
priority
(CST, Euclid, WFIRST)

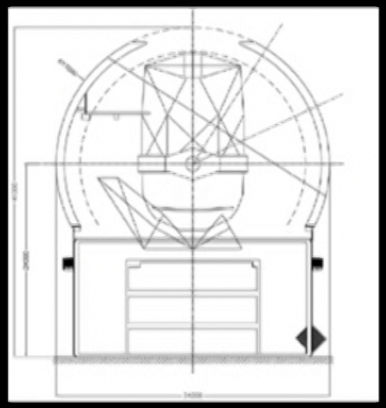




WF Implications

CHIME stands out as great radio wide-field facility

ngCFHT concept strongly supported for further study



MTR2015

Unveiling the Cosmos

Canadian Astronomy 2016–2020

Report of the Mid-Term Review 2015 Panel

Dr Chrs Wilson
(McMaster U.)

Dr Michael Balogh
(U.Waterloo)

Dr David Crampton
(NRC)

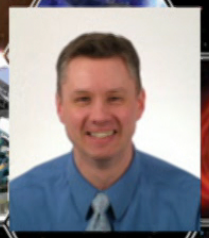
Dr Matt Dobbs
(McGill U.)

Dr Kristine Spekkens
(RMC)

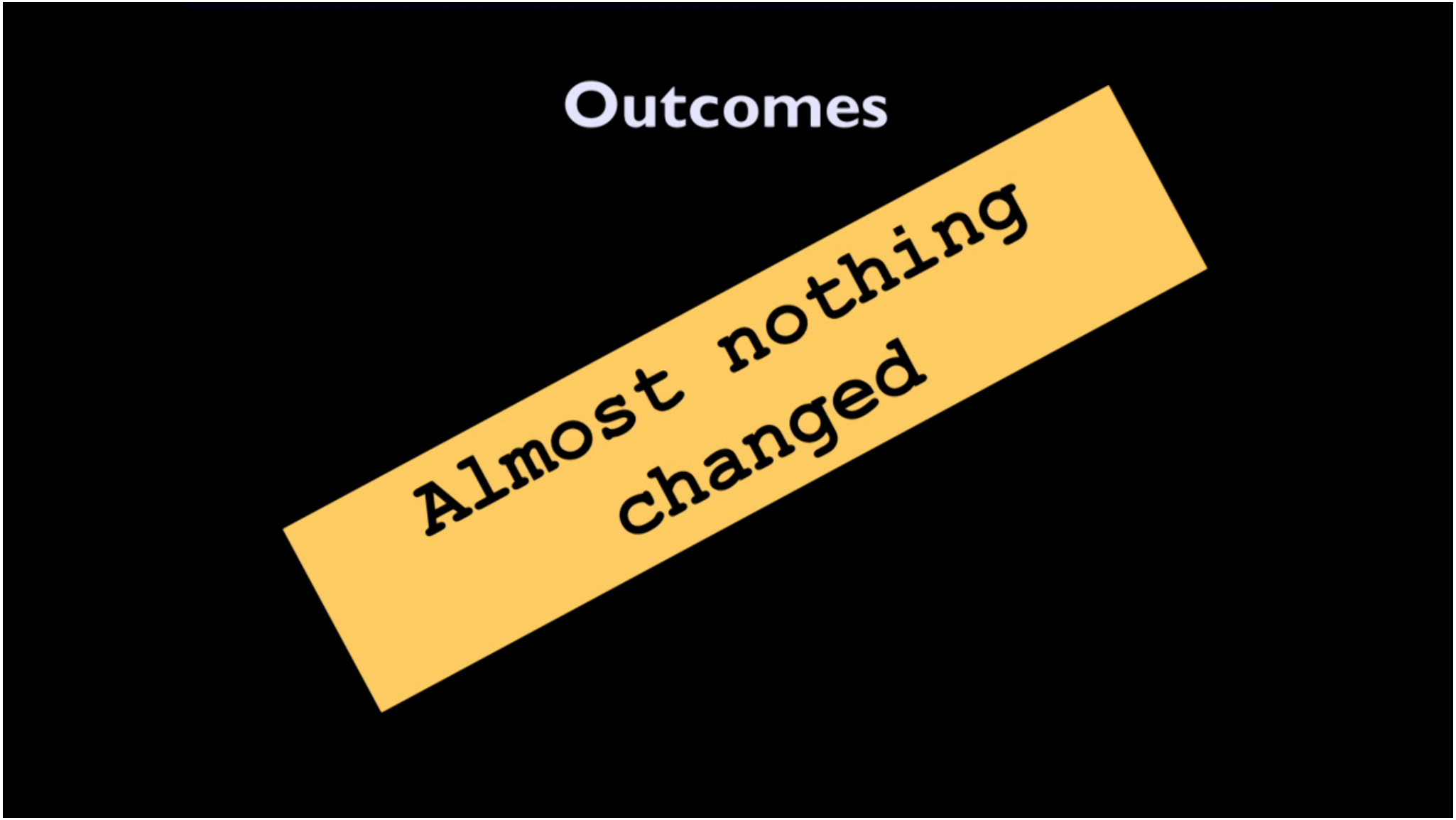
Dr Kim Venn
(U.Vic.)

Dr Michael Strauss
(Princeton U.)

Dr Marten van Kerkwijk
(U.Toronto)



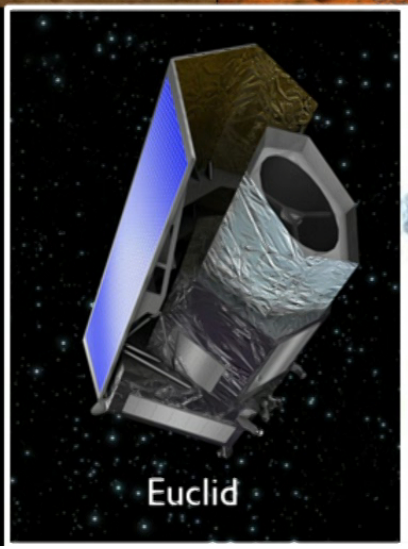
Dr Rob Thacker
(Saint Mary's U.)


Outcomes
Almost nothing changed

Canada-wide WF facility access 2018

WF "experiment" access 2018 + future

+more at individual level access

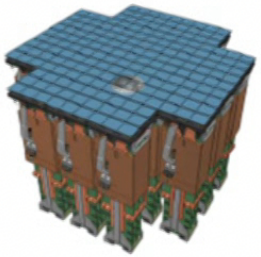


International context - key facilities

Credit: Paul O'Co

Comparisons with contemporary mosaic FPAs

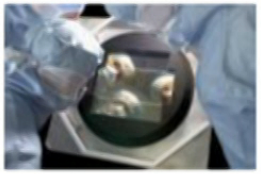
- Pixel/chip count
  - LSST: 3.1Gpix (189 CCDs)
  - PanSTARRS GPC1: 1.4Gpix (60 CCDs)
  - HyperSuprimeCam: 940Mpix (112 CCDs)
  - DECam: 500Mpix (62 CCDs)
  - CFHT MegaCam: 340Mpix (36 CCDs)
- Focal ratio
  - LSST: f/1.23
  - SuprimeCam: f/1.87
  - DECam: f/2.7
  - PanSTARRS: f/4
  - CFHT MegaCam: f/4.2
- Readout time
  - LSST: 2s
  - PanSTARRS GPC1: 6s
  - DECam: 17s
  - CFHT MegaCam: 40s
  - Suprime-Cam: 18s
- Data rate
  - LSST: 1.0TB/hr
  - PanSTARRS GPC1: 0.22
  - HSC 0.03



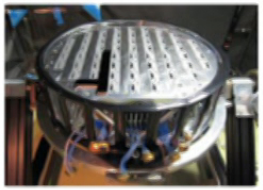
LSST

Only large mosa
with ASIC read

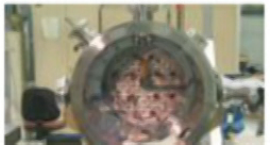
GPC1



MegaCam



HSC



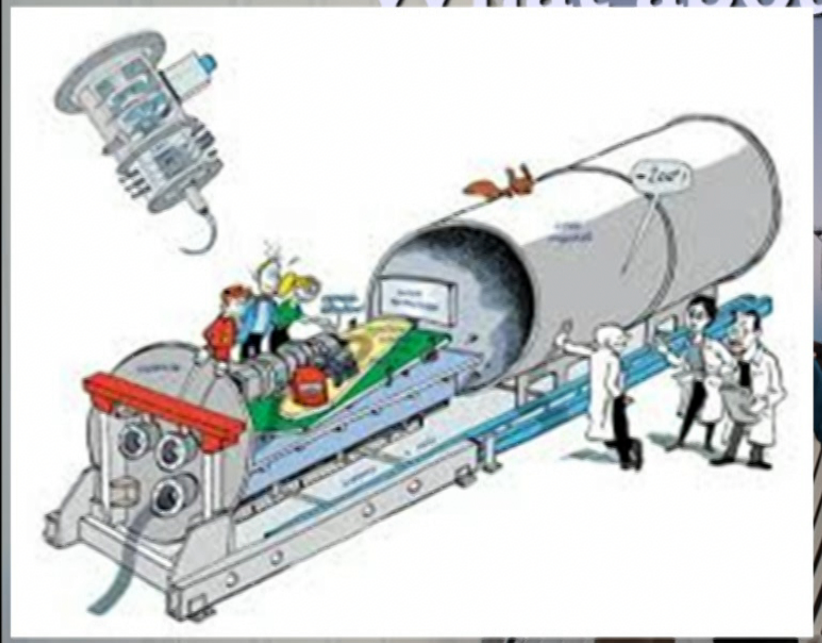
DECam

LRP2010 'feature' – no LSST vision

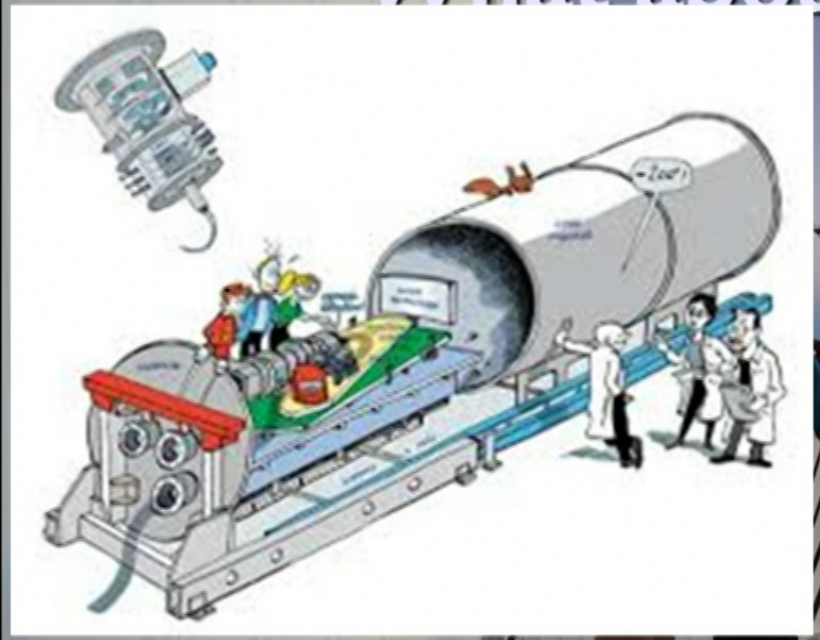
Incorrect assumptions on data access plus other things to think about…


What about CFHT?

What about CFHT?



What about CFHT?



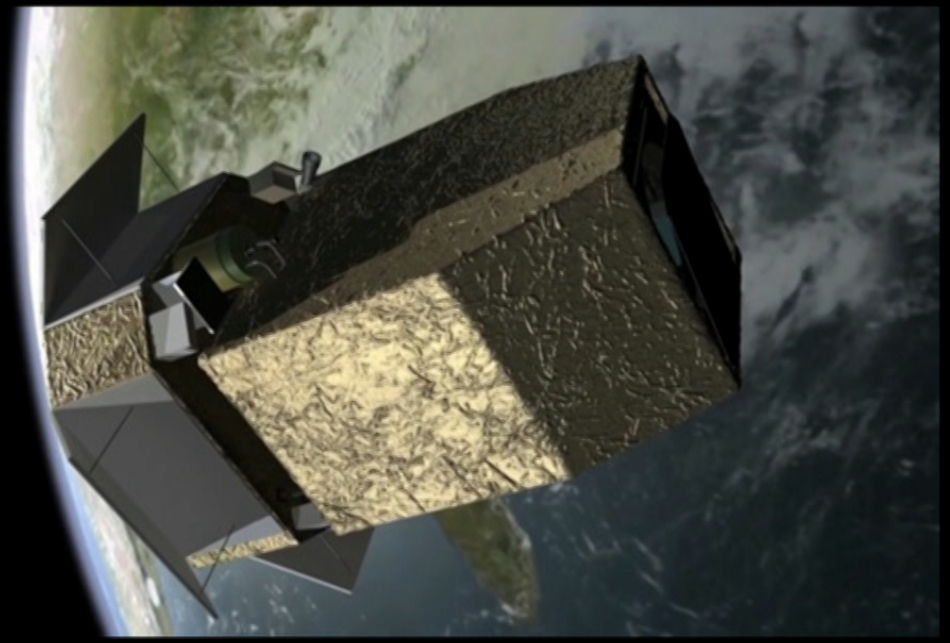
Still competitive in u-band

Leveraging this capability
e.g. Canada France Imaging Survey
CLAUDS

Next generation space-based imaging

CASTOR

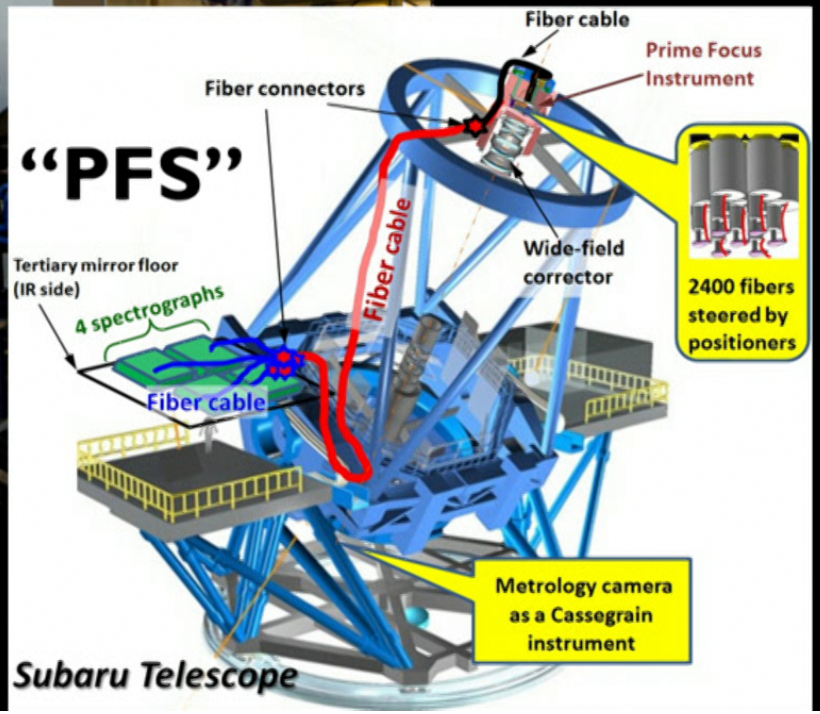
The Cosmological Advanced Survey Telescope
for Optical and UV Research



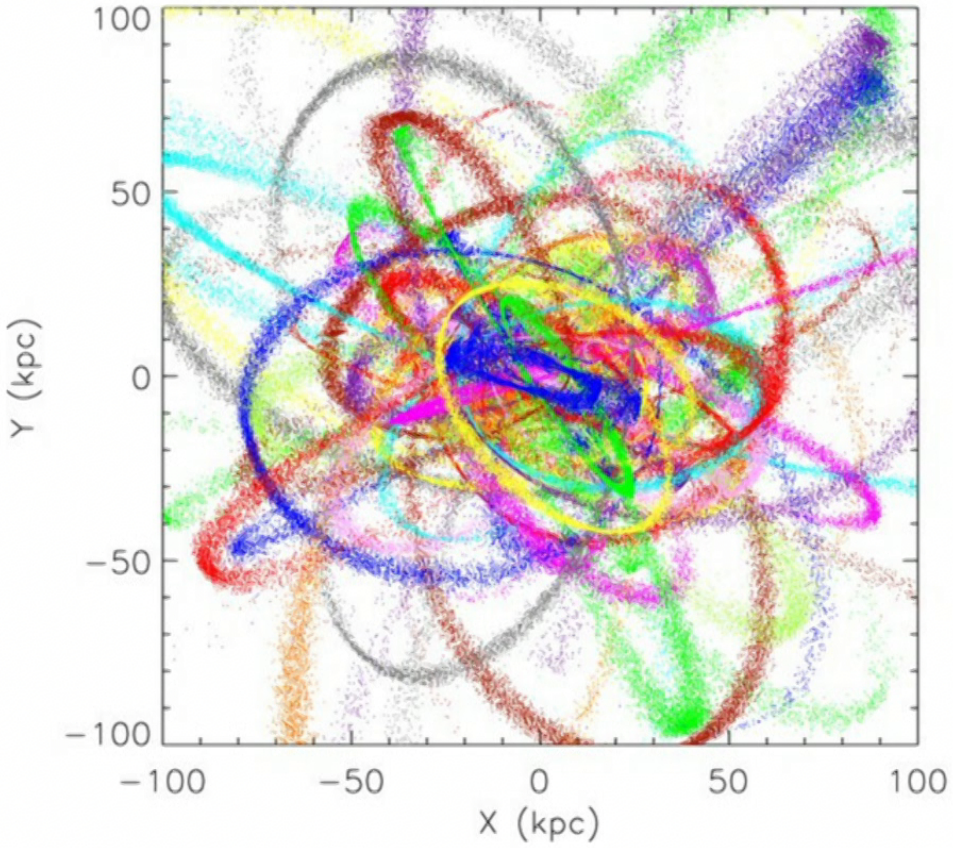
International context - wide field spectroscopy

VLT "MOONS"

8m class



Theoretical Predictions



Starkenberg et al 2009

Galaxy formation/evolution = giant blender!

Credit: Blendtec

Galaxy formation/evolution = giant blender!

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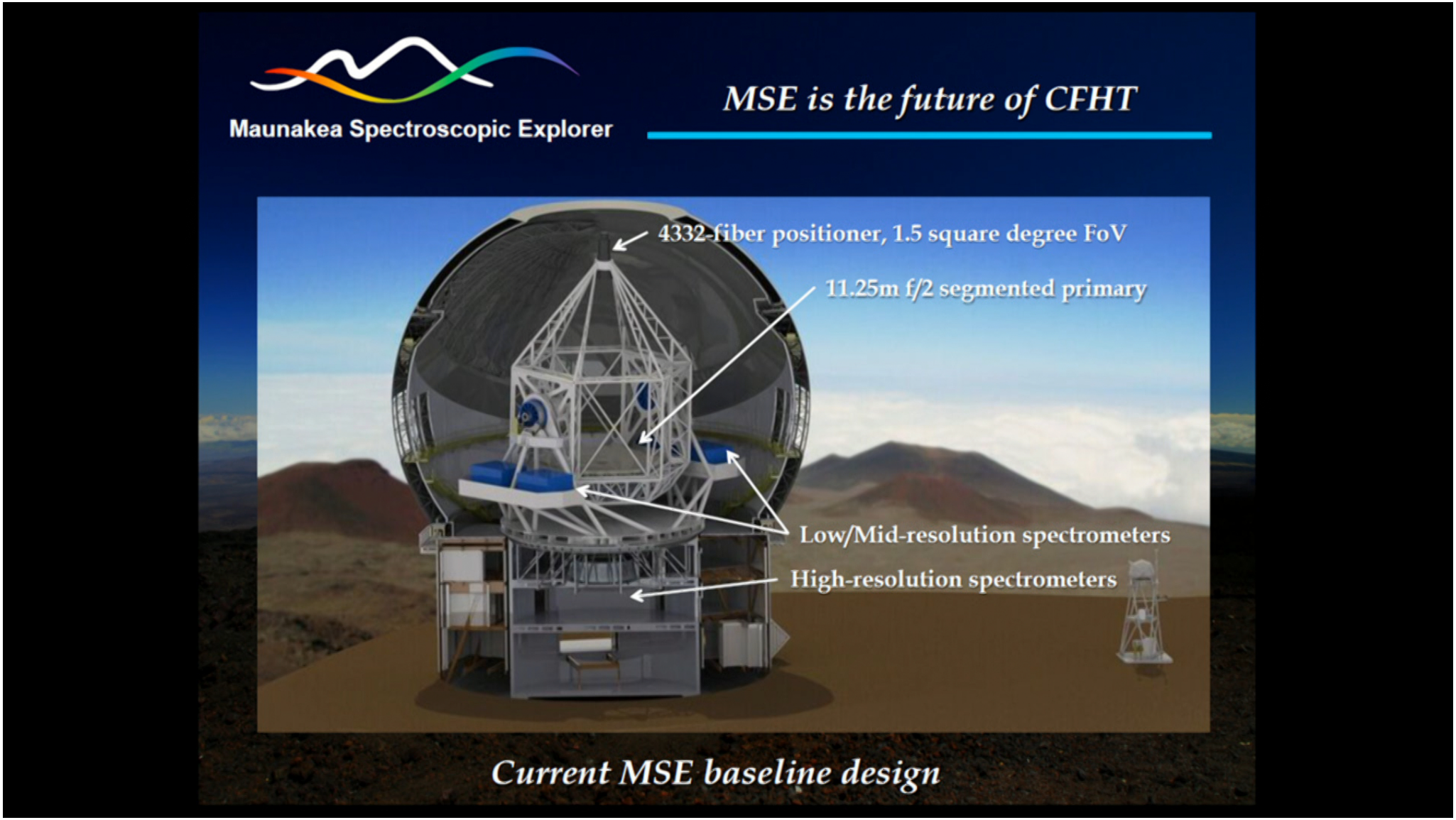
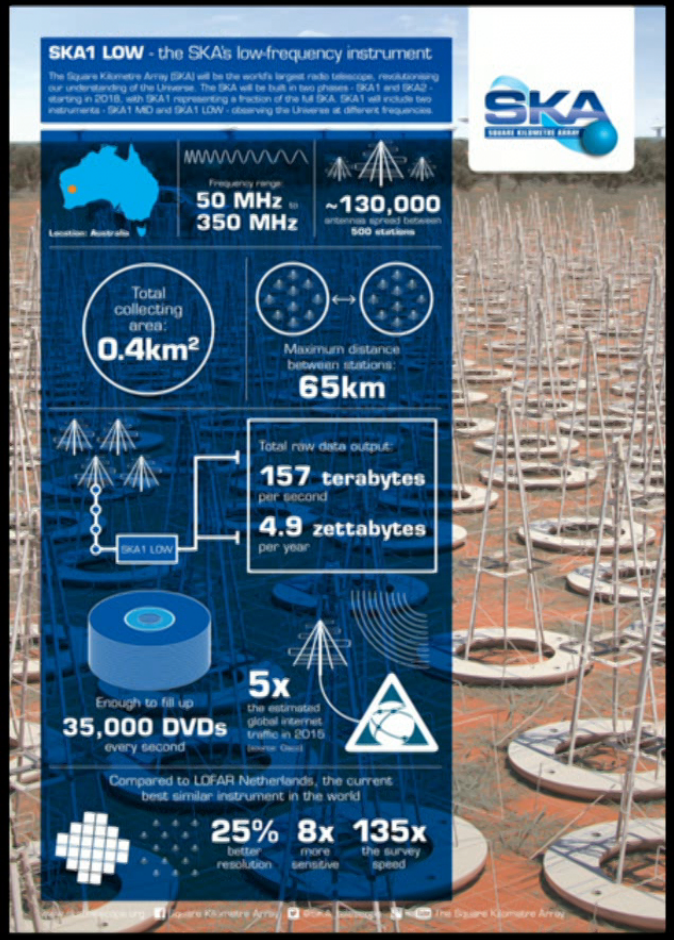
Credit: Blendtec

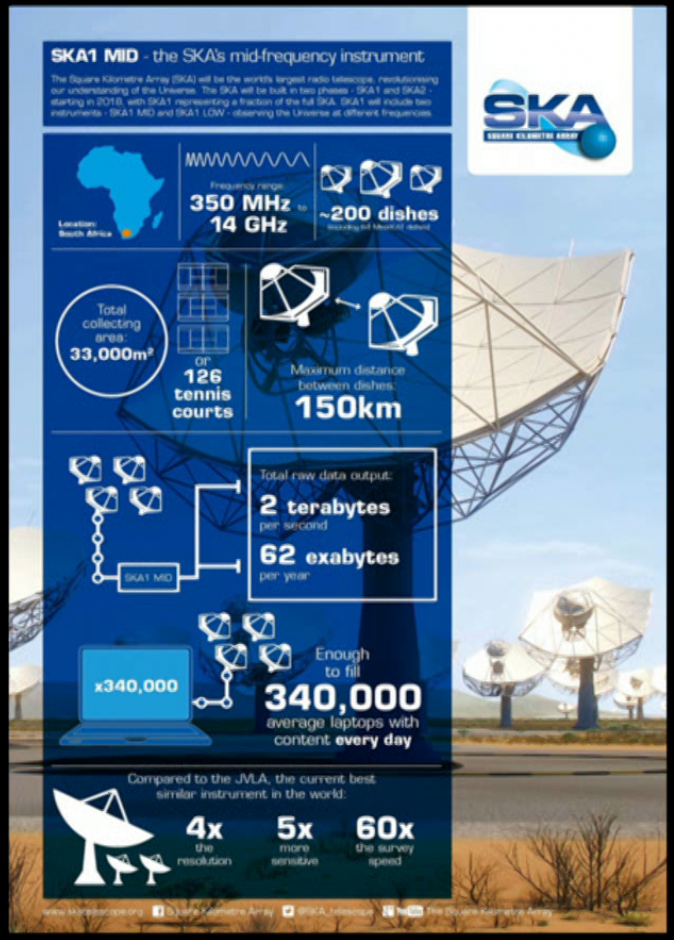

Maunakea Spectroscopic Explorer
MSE is the future of CFHT
4332-fiber positioner, 1.5 square degree FoV
11.25m f/2 segmented primary
Low/Mid-resolution spectrometers
High-resolution spectrometers
Current MSE baseline design

Total time required for all Kavli/NOAO/LSST surveys (sorted by telescope aperture; in dark-years). Leader for each column shown in red.

Instrument / Telescope	Total (no halo survey, dark-years)	Total (8000 sq. deg. halo survey, dark-years)	Total (20k sq. deg. halo survey, dark-years)
4MOST	22.1	34.7	53.6
Mayall 4m / DESI	15.8	22.5	32.5
WHT / WEAVE	22.2	35.5	55.4
Magellan LASSI	5.6	15.1	29.3
Subaru/PFS	3.7	11.9	24.1
VLT/MOONS	8.3	75.4	175.9
Keck/Deimos	26.1	499.2	1208.8
MSE	1.9	5.1	9.8
FOBOS	4.9	66.2	158.1
GMT/MANIFEST + GMACS	1.0	17.9	43.2
GMT/MANIFEST + GMACS	1.5	18.4	43.7
TMT / WFOS	4.4	78.8	190.5
Fiber WFOS-pessimistic	1.3	39.3	96.2
Fiber WFOS-optimistic	0.5	15.3	37.6
E-ELT / MOSAIC optical	2.3	64.6	158.1
E-ELT / MOSAIC NIR	3.2	65.5	159.0

Credit: Jeff Newman, U. Pittsburgh


SKA1 LOW - the SKA's low-frequency instrument
The Square Kilometre Array (SKA) will be the world's largest radio telescope, revolutionising our understanding of the Universe. The SKA will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - SKA1 MID and SKA1 LOW - observing the Universe at different frequencies.
SKA
Location: Australia
Frequency range:
50 MHz to 350 MHz
~130,000
antennas spread between 500 stations
Total collecting area:
0.4km²
Maximum distance between stations:
65km
Total raw data output:
157 terabytes
per second
4.9 zettabytes
per year
SKA1 LOW
Enough to fill up
35,000 DVDs
every second
5x
the estimated global internet traffic in 2015
Compared to LOFAR Netherlands, the current best similar instrument in the world
25% better resolution
8x more sensitive
135x the survey speed


SKA1 MID - the SKA's mid-frequency instrument
The Square Kilometre Array (SKA) will be the world's largest radio telescope, revolutionising our understanding of the Universe. The SKA will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - SKA1 MID and SKA1 LOW - observing the Universe at different frequencies.
SKA
Location: South Africa
Frequency range:
350 MHz to 14 GHz
~200 dishes
Total collecting area:
33,000m²
or
126 tennis courts
Maximum distance between dishes:
150km
Total raw data output:
2 terabytes
per second
62 exabytes
per year
SKA1 MID
x340,000
Enough to fill
340,000
average laptops with content every day
Compared to the JVLA, the current best similar instrument in the world:
4x the resolution
5x more sensitive
60x the survey speed

My thoughts for planning

Small community

My thoughts for planning

Small community

Opportunity cost of not getting things right is large

My thoughts for planning

Small community

Focus on the key
"platforms" to allow
flexibility

My thoughts for planning

Small community

If national coordination is necessary it must be genuine

Selling a Long Range Plan

As scientists we naturally focus on statistical arguments and dismiss anecdotes

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Cliched advice: policy makers wants stats, MPs want human stories

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As scientists we naturally focus on statistical arguments and dismiss anecdotes

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You need both to craft an effective pitch

- People matter!

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- People matter!

Personal stories that connect to economic & social benefits are especially powerful


NRC·CNRC
NSERC
CRSNG
SAINT MARY'S UNIVERSITY
Huge thanks to Perimeter &
let's have a great few days!
NSRIT
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Canada Research Chairs
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Canada Foundation for Innovation
Fondation canadienne pour l'innovation