Subaru and CFHT, now and in the future

Alan McConnachie
NRC Herzberg, Canada

Subaru International Workshop, NAOJ,
March 22 - 24 2017


Japan and friends
Canada and friends
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  - wide field imaging in the northern hemisphere
    - for stand alone science
    - for target pre-selection for upcoming wide field spectroscopic science

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- **Canada and Japan and the Asia-Pacific nations in this room should collaborate in addressing these issues**
  - the Asia-Pacific nations are natural collaborators and we should seek to cooperate to further our joint ambitions

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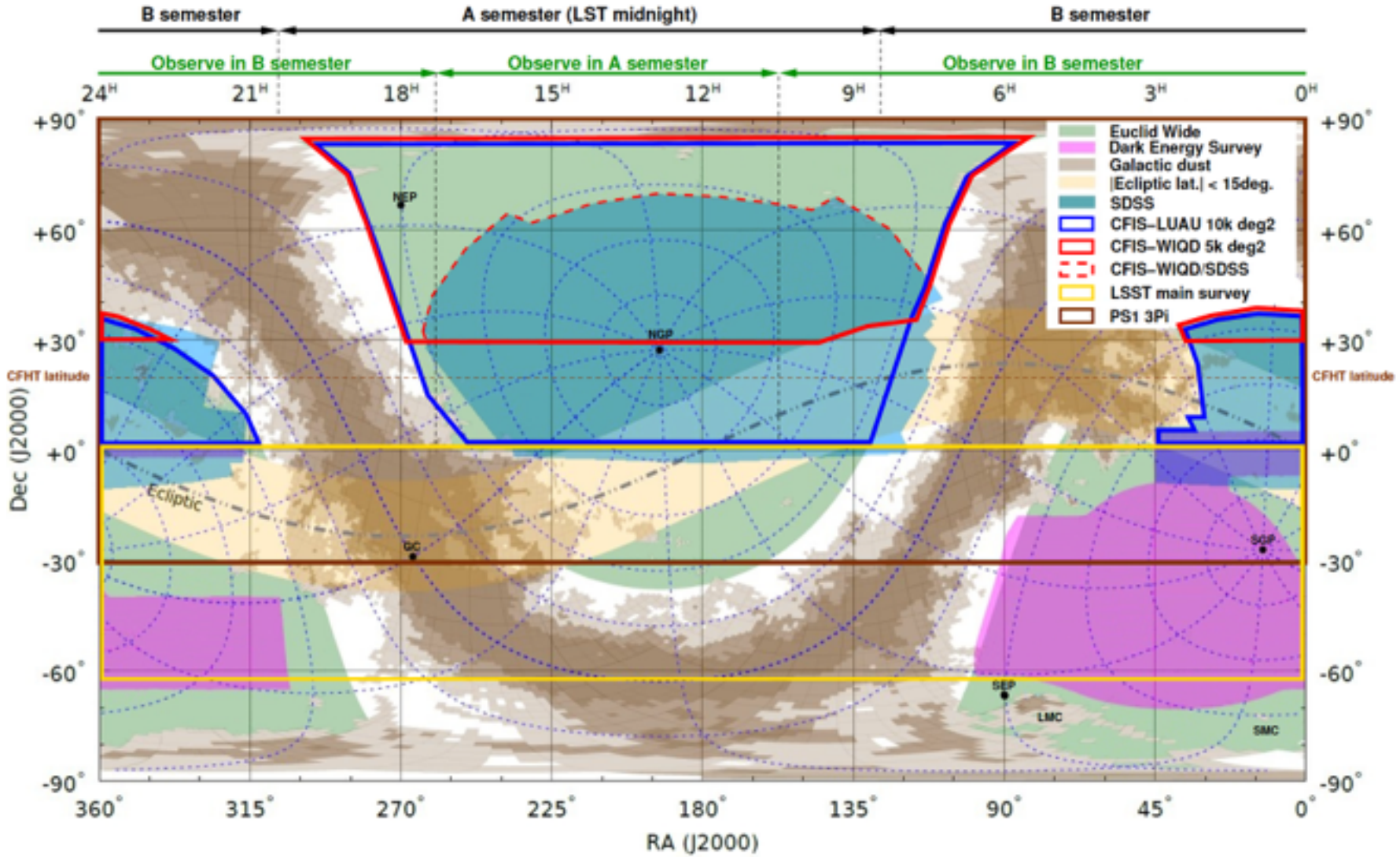
- CFIS-u: 10000 square degrees, u band, 24.5mags (point source, SNR=5) [Science Lead - Ibata]
- CFIS-r: 5000 square degrees, r band, 24.9 mags (point source, SNR=5) [Science Lead - Hudson]



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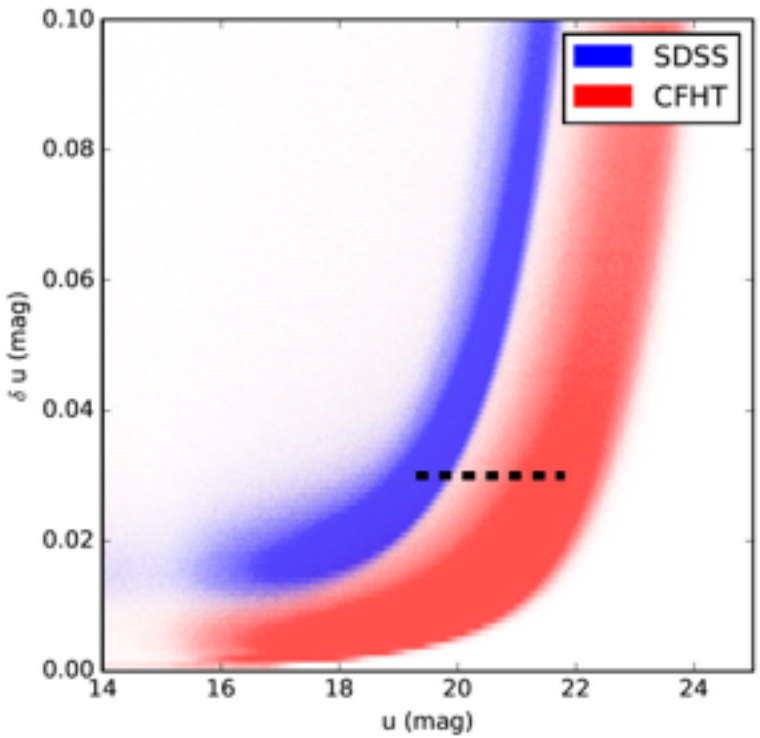
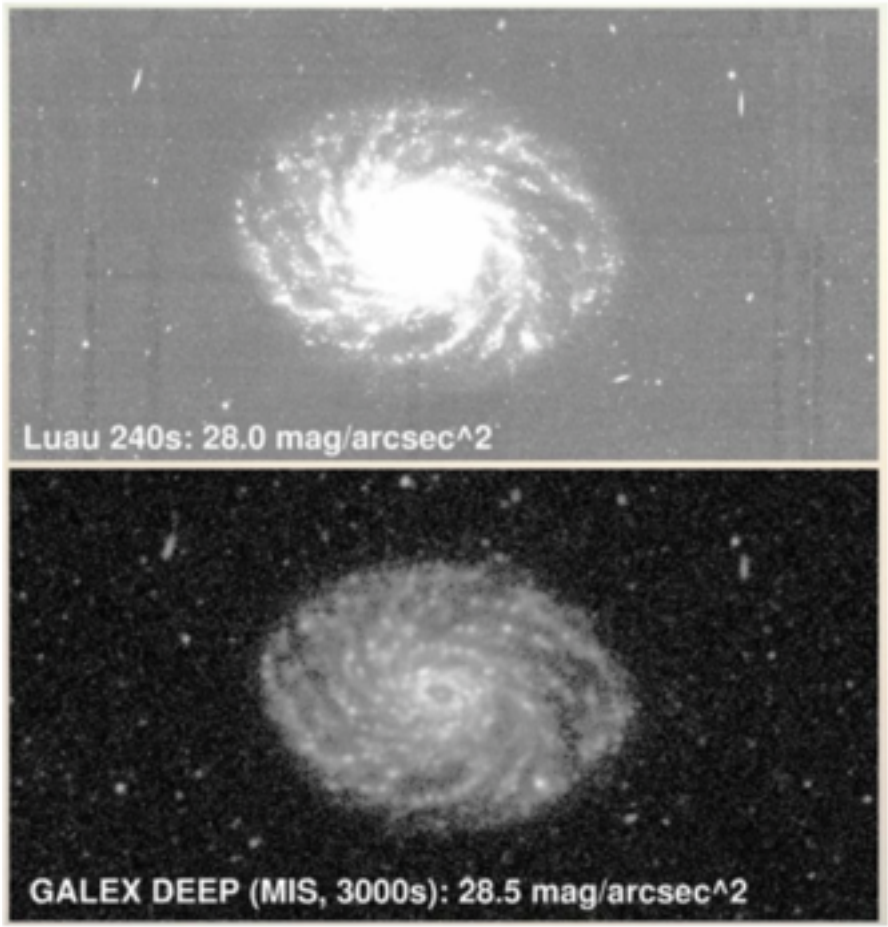
Principal science (***See Pat Cote's talk tomorrow***):
- tomographic mapping of the Galaxy and its three dimensional metallicity structure (CFIS-u+grizY)
- mapping of dark matter on the scale of galaxies and galaxy groups (CFIS-r + SDSS spectroscopy)
- Planet 9 and the outer Solar System
- Euclid photometric redshifts
- **Target selection for wide field MOS**
- First results in Ibata et al. 2017, submitted





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- g band: PanSTARRS
- i band: CEFCA (Spain)

Only z band remains to obtain full, optical, deep, mapping of the extragalactic northern hemisphere. Sufficiently deep for most spectroscopic follow-up undertaken by 8 - 12m telescopes.
- For z, HSC is the optimal instrument.

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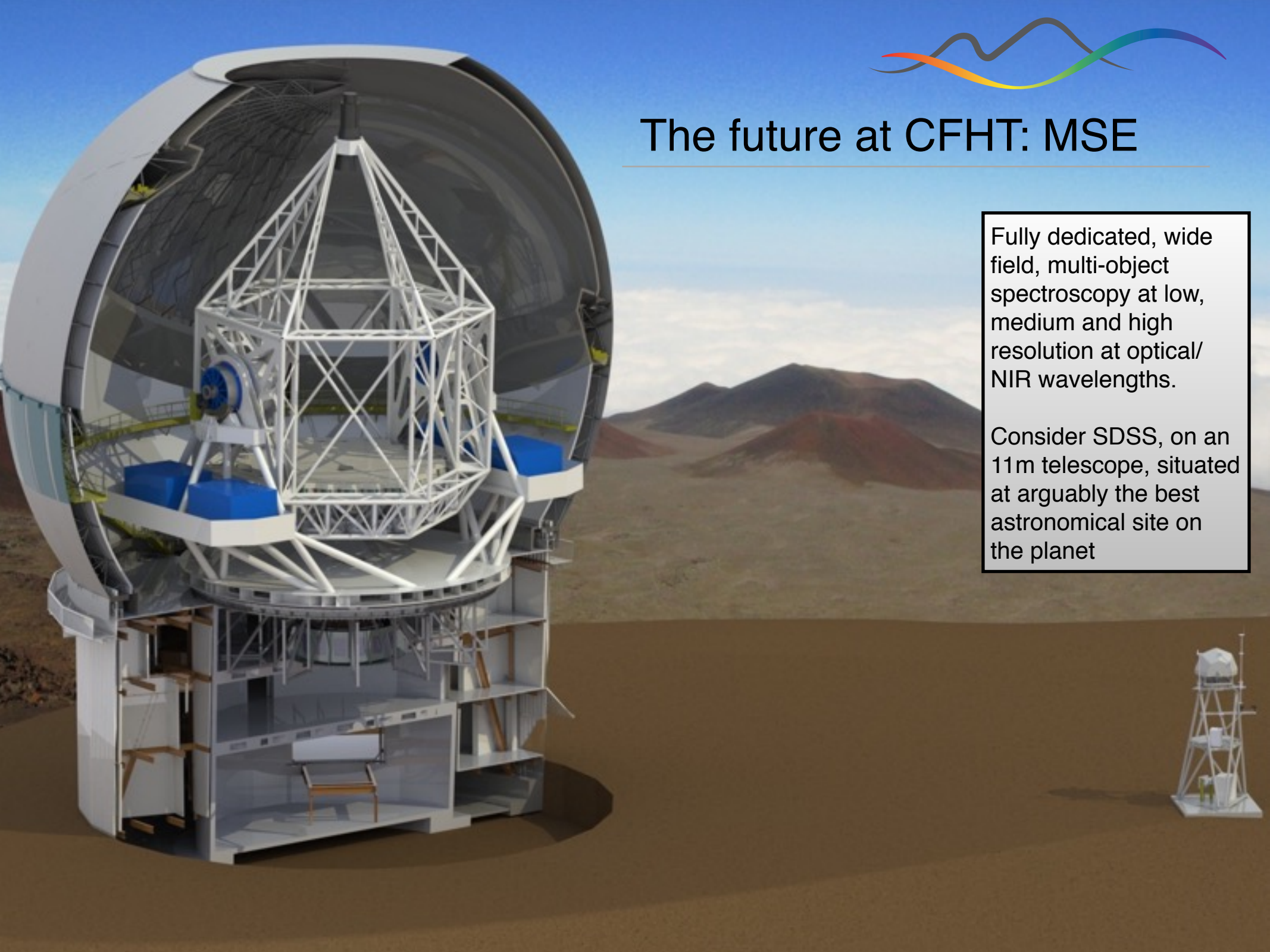
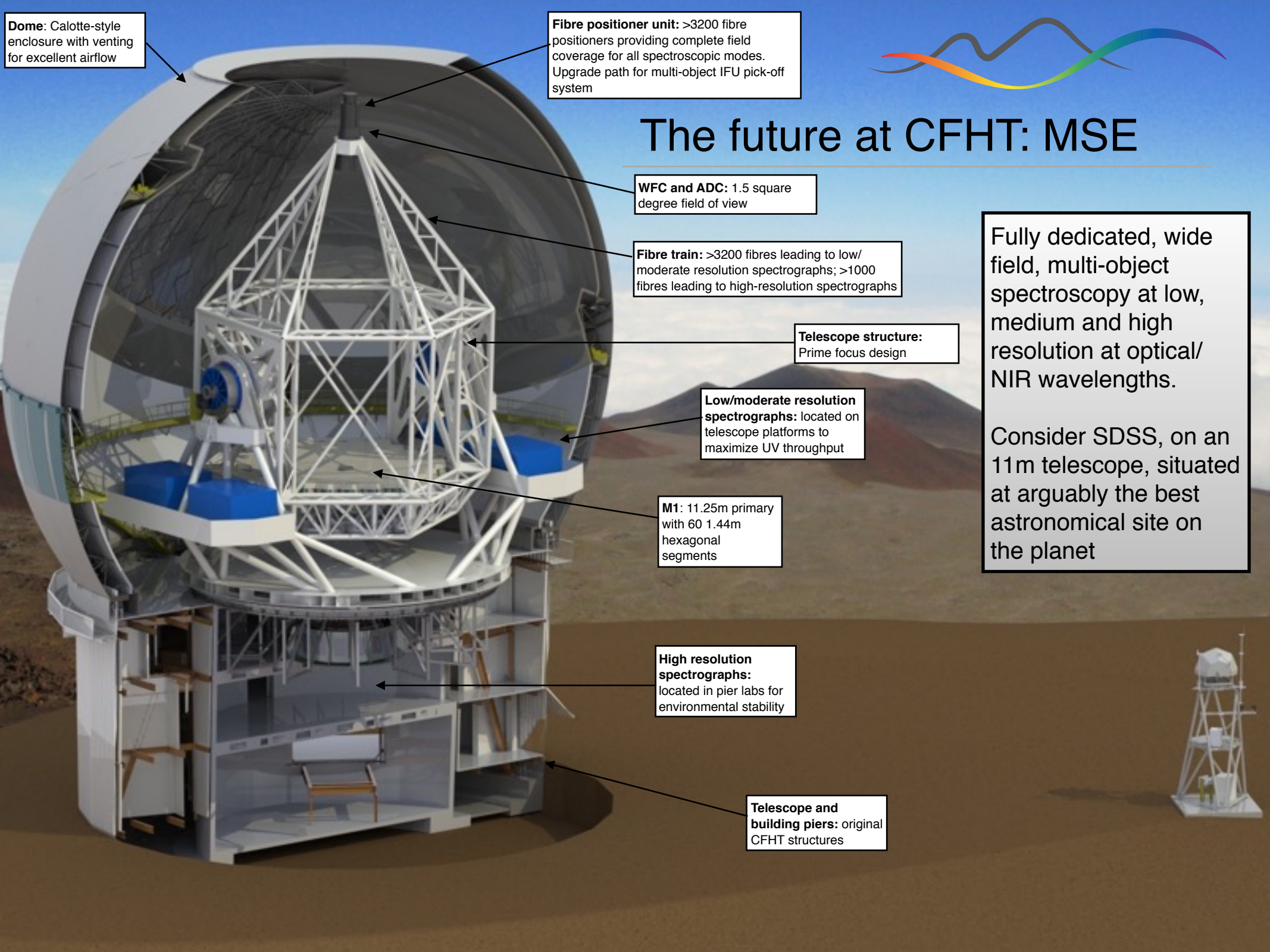
CFIS is eager to support/develop such an initiative by the Japanese community, and is happy to discuss forming a joint HSC-CFIS collaboration to enable this fantastic opportunity



The future at CFHT: MSE

Fully dedicated, wide field, multi-object spectroscopy at low, medium and high resolution at optical/ NIR wavelengths.

Consider SDSS, on an 11m telescope, situated at arguably the best astronomical site on the planet



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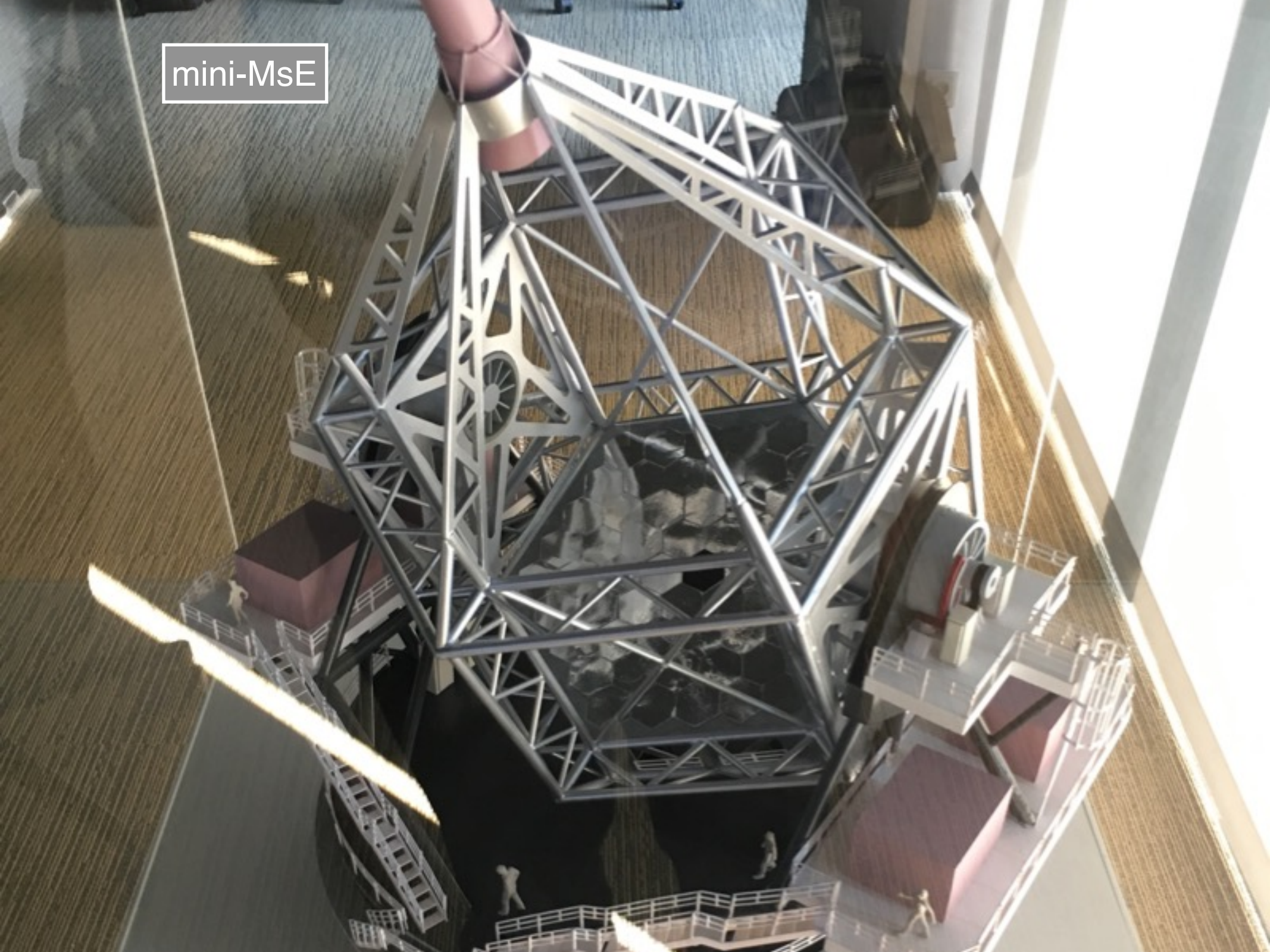
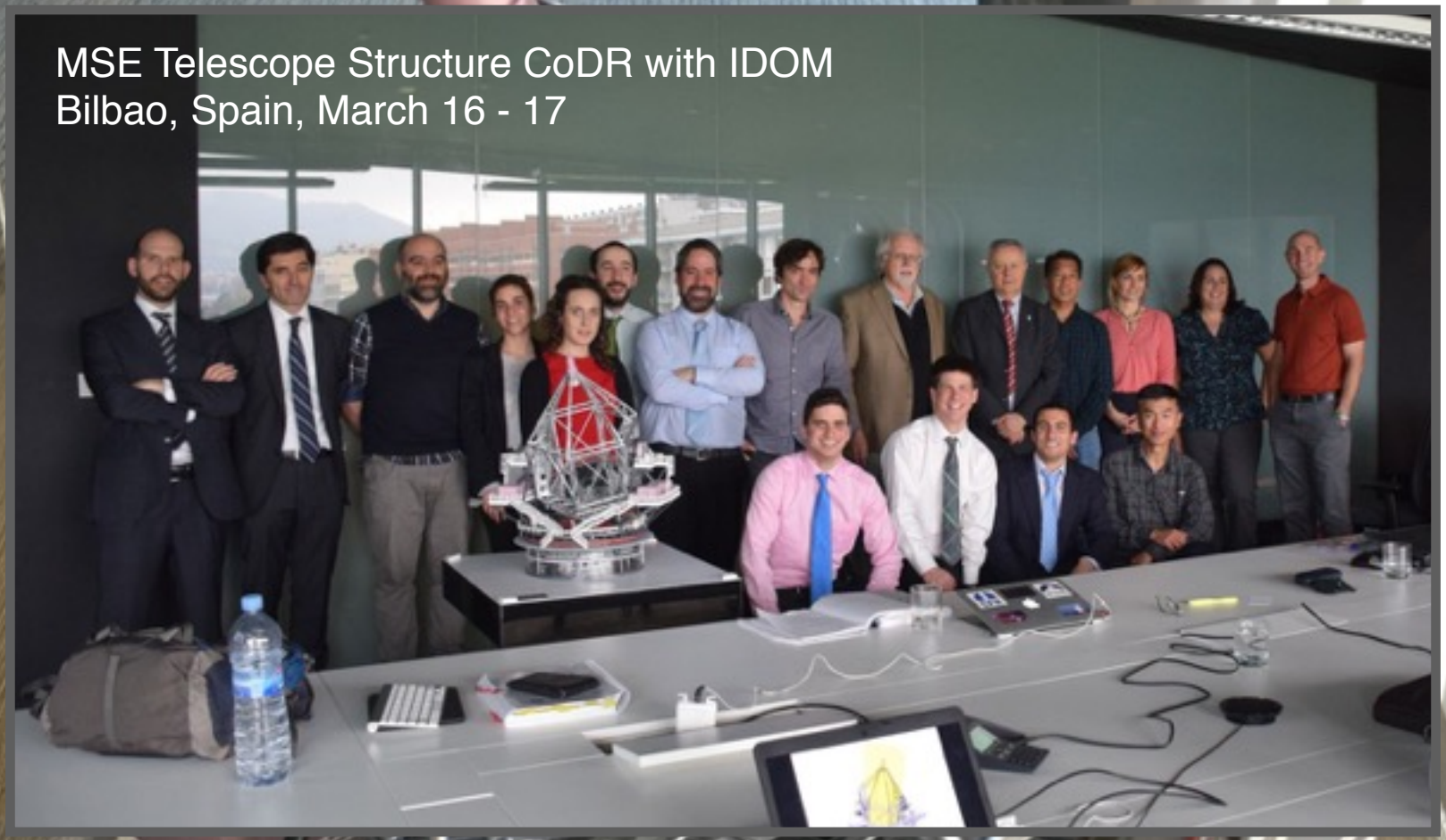

mini-MsE


MSE Telescope Structure CoDR with IDOM
Bilbao, Spain, March 16 - 17



Current CoDR Schedule has following additional reviews between now and June:

- Building, Enclosure (CFHT)
- M1 (DT INSU, France)
- Fibre positioning system x 2 (NIAOT, China / AAO, Australia)
- Low resolution spectrograph (CRAL, France)
- High resolution spectrograph (NIAOT, China)
- Fibre transport system (FibreTech, Canada)

Followed by System CoDR and Cost Review, transitioning to PDR at end of year

MSE Science Development

MSE Science Team Meeting, July 2015, Waikoloa.

Science Team (107 members): **Australia - 15; Canada - 15; China - 8**; France - 22; India - 10; Spain - 8; Other - 19

Previous strong involvement from Rep. of Korea, Taiwan - excellent opportunity to re-establish science and technical links

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- The Detailed Science Case for the MSE, 210 pages + appendices, available on astroph
- A Concise Overview of the MSE, 10 pages, also available on astroph
- Focus on science that is *uniquely possible* with MSE

Maunakea Spectroscopic Explorer

The Detailed Science Case for the Maunakea Spectroscopic Explorer:

The Composition and Dynamics of the Faint Universe

Maunakea Spectroscopic Explorer

A concise overview of the Maunakea Spectroscopic Explorer

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Accessible sky	30000 square degrees (airmass<1.55)						
Aperture (M1 in m)	11.25m						
Field of view (square degrees)	1.5						
Etendue = FoV x π (M1 / 2)^2	149						
Modes	**Low**		**Moderate**	**High**			**IFU**
Wavelength range	0.36 - 1.8 µm		0.36 - 0.95 µm	0.36 - 0.95 µm ♯			IFU capable; anticipated second generation capability
	0.36 - 0.95 µm	J, H bands		0.36 - 0.45 µm	0.45 - 0.60 µm	0.60 - 0.95 µm	
Spectral resolutions	2500 *(3000)*	3000 *(5000)*	6000	40000	40000	20000	
Multiplexing	>3200		>3200	>1000			
Spectral windows	Full		≈Half	$\lambda_c/30$	$\lambda_c/30$	$\lambda_c/15$	
Sensitivity	m=24 *		m=23.5 *	m=20.0 ♮			
Velocity precision	20 km/s ♪		9 km/s ♪	< 100 m/s ★			
Spectrophotometic accuracy	< 3 % relative		< 3 % relative	N/A			

♯ Dichroic positions are approximate

* SNR/resolution element = 2

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MSE Science Capabilities:
Chemical tagging in the post-Gaia era

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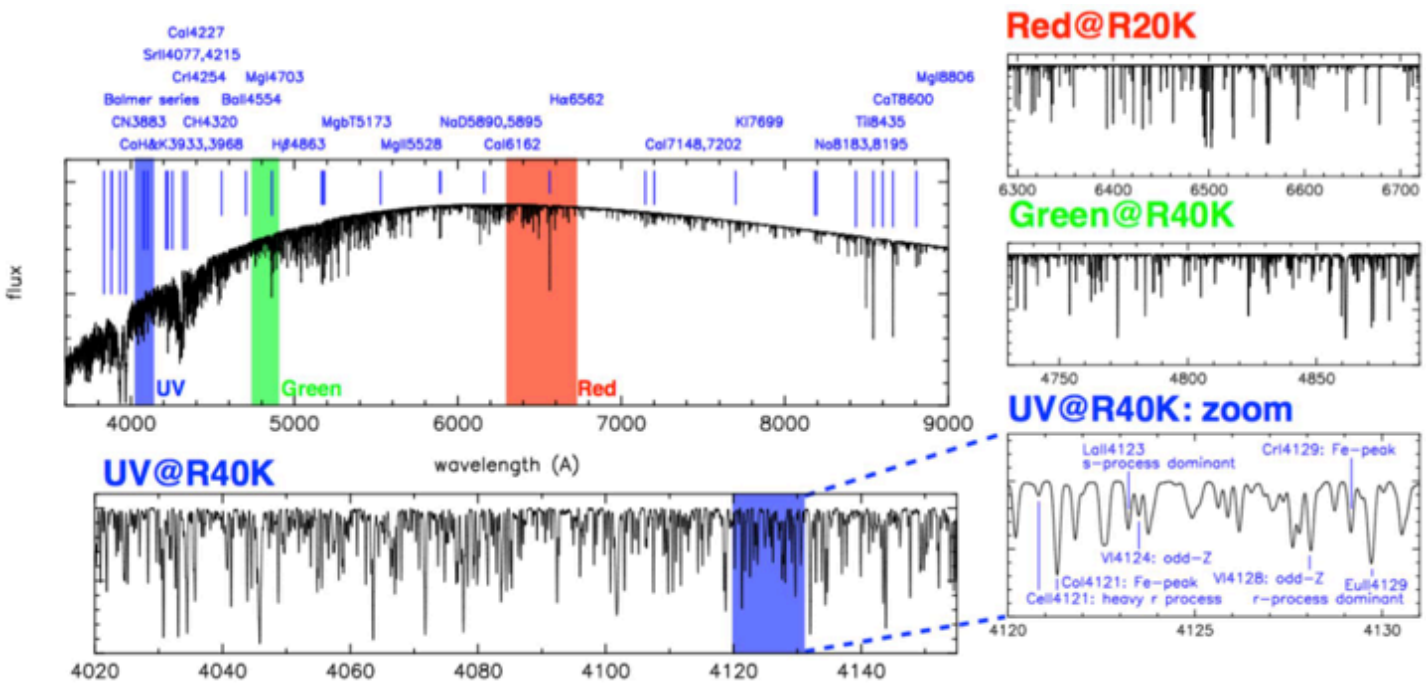

- The ultimate Gaia follow-up, chemical tagging in the outer Galaxy.
- Building on 4m class surveys such as AAT/HERMES
- Obtain abundance information for ~20+ chemical species by concentrating on bluer wavelengths at high spectral resolution
- Use in conjunction with intermediate resolution (broader wavelength coverage) for stronger lines

MSE Science Capabilities:
Galaxy evolution at cosmic noon

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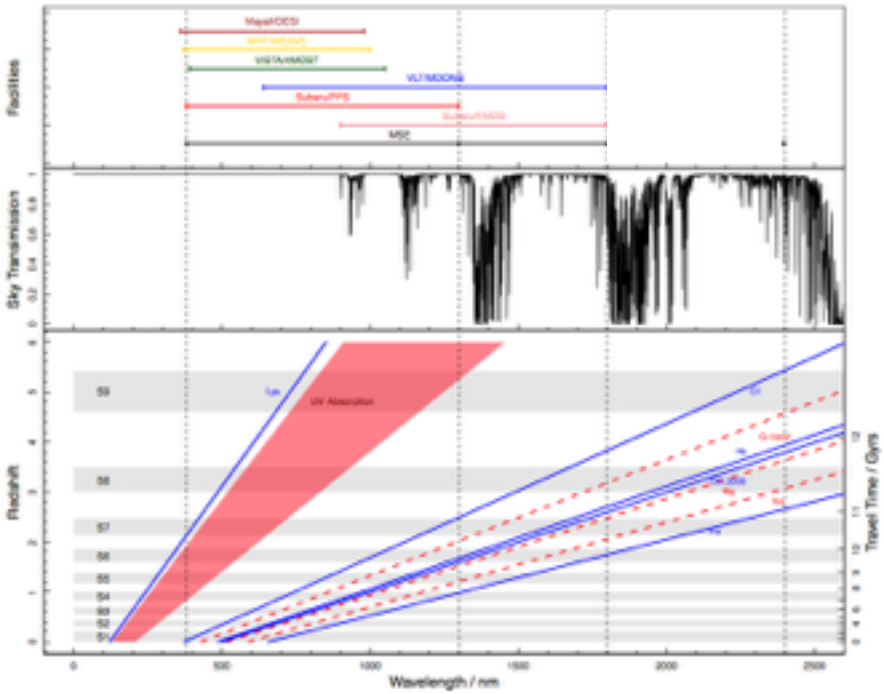

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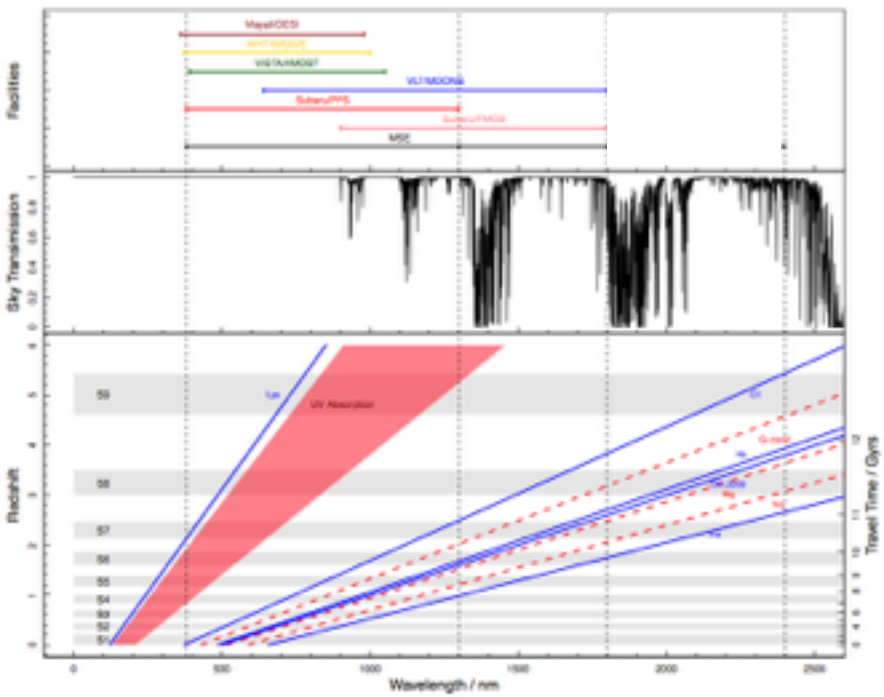

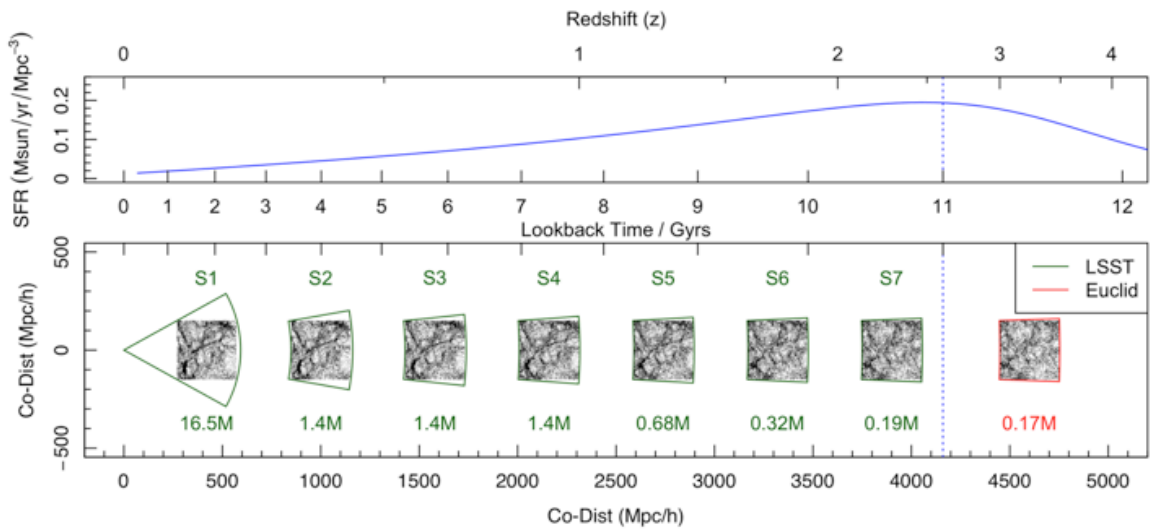

- 8 photo-z selected survey cubes to probe the build-up of large scale structure, stellar mass, halo occupation and star formation out to a redshift of z~3. 100% completeness per cube (1 dex below M* for first 4 cubes, beyond this limited by photo-z accuracies)
- An SDSS at the peak of the SFH of the Universe

MSE Science Capabilities:
AGN in the time domain

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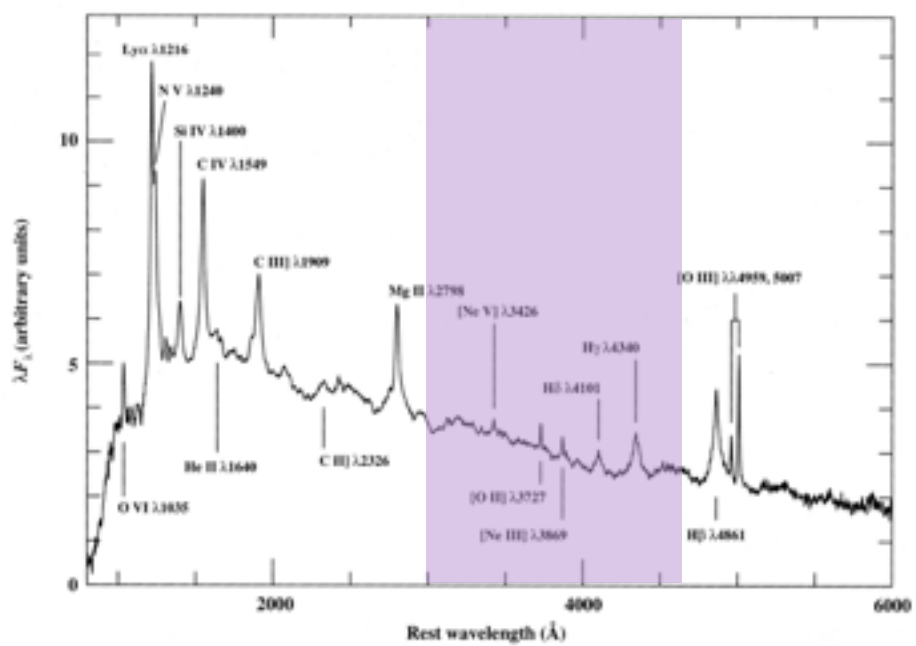

- ~100 (rest frame optical/UV) observations of 5000 quasars spread over years to map the structure and kinematics of the inner parsec of supermassive black holes actively accreting during the peak quasar era
- Compare with ~50 nearby, AGN that currently have high quality measurements
- Measure black holes masses for ~2500 quasars up to z~3.
- Spectrophotometric accuracy essential!

A common origin..

Gemini/Subaru WFMOS

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Gemini/Subaru WFMOS

DE-SCOPE

UP-SCOPE

Subaru / PFS		*Dedicated facility*	MSE		
No		*Dedicated facility*	Yes		
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1.25		*Field of View (sq. deg)*	1.5		
66		*Etendue*	149		
2400		*Multiplexing*	3468		
158400 *(= 0.31)*		*Etendue x Multiplexing*	517100 *(=1.00)*		
0.2 (first 5 years) 0.2 - 0.5 afterwards ?		*Observing fraction*	1		
2000	5000	*Spectral resolution (approx)*	3000	6500	40000
0.38 - 1.26	0.71 - 0.89	*Wavelength coverage (um)*	0.36 - 1.8	0.36 - 0.95 50% coverage	windows
No		*IFU*	Second generation		

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- e.g., precision calibration of spectrographs fed by ~ 4000 fibres is a fundamentally difficult problem
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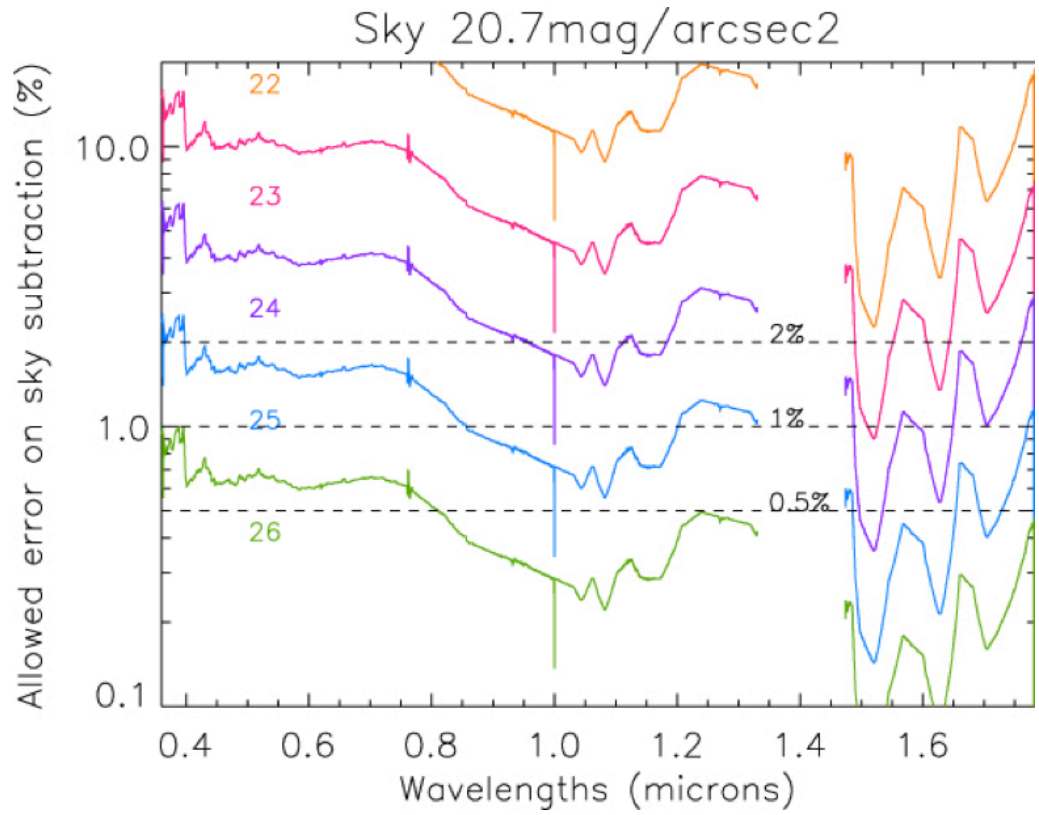
  - operational issues



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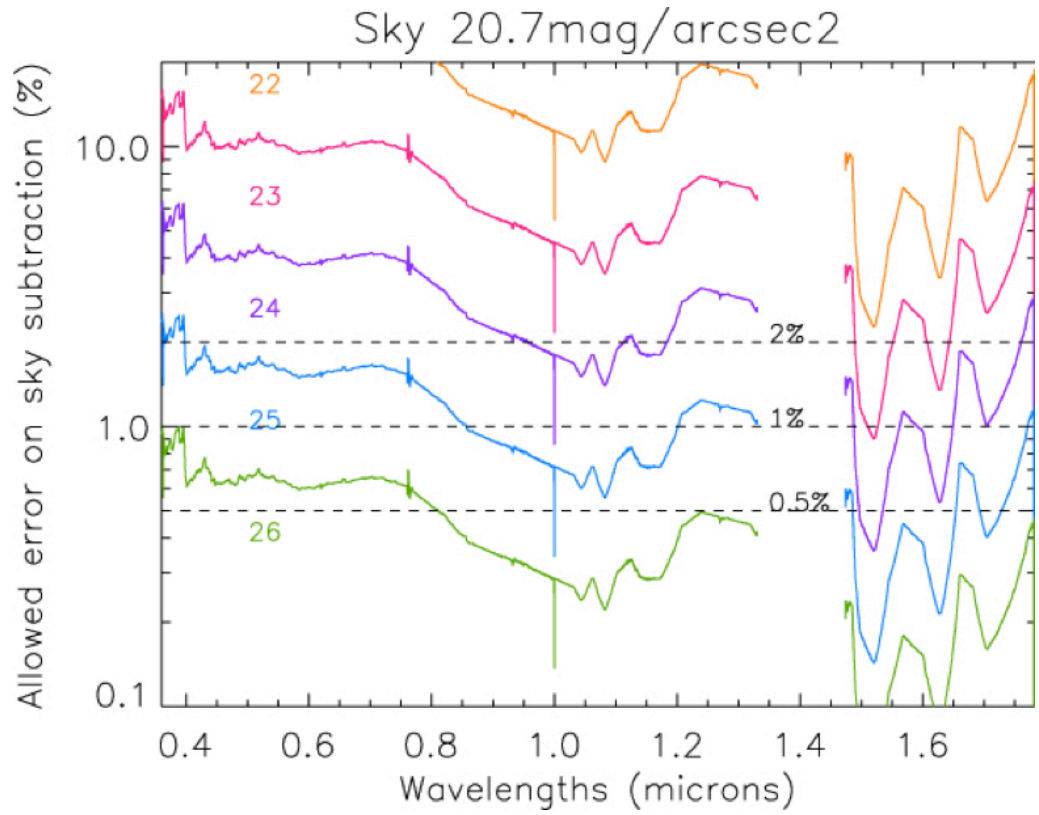
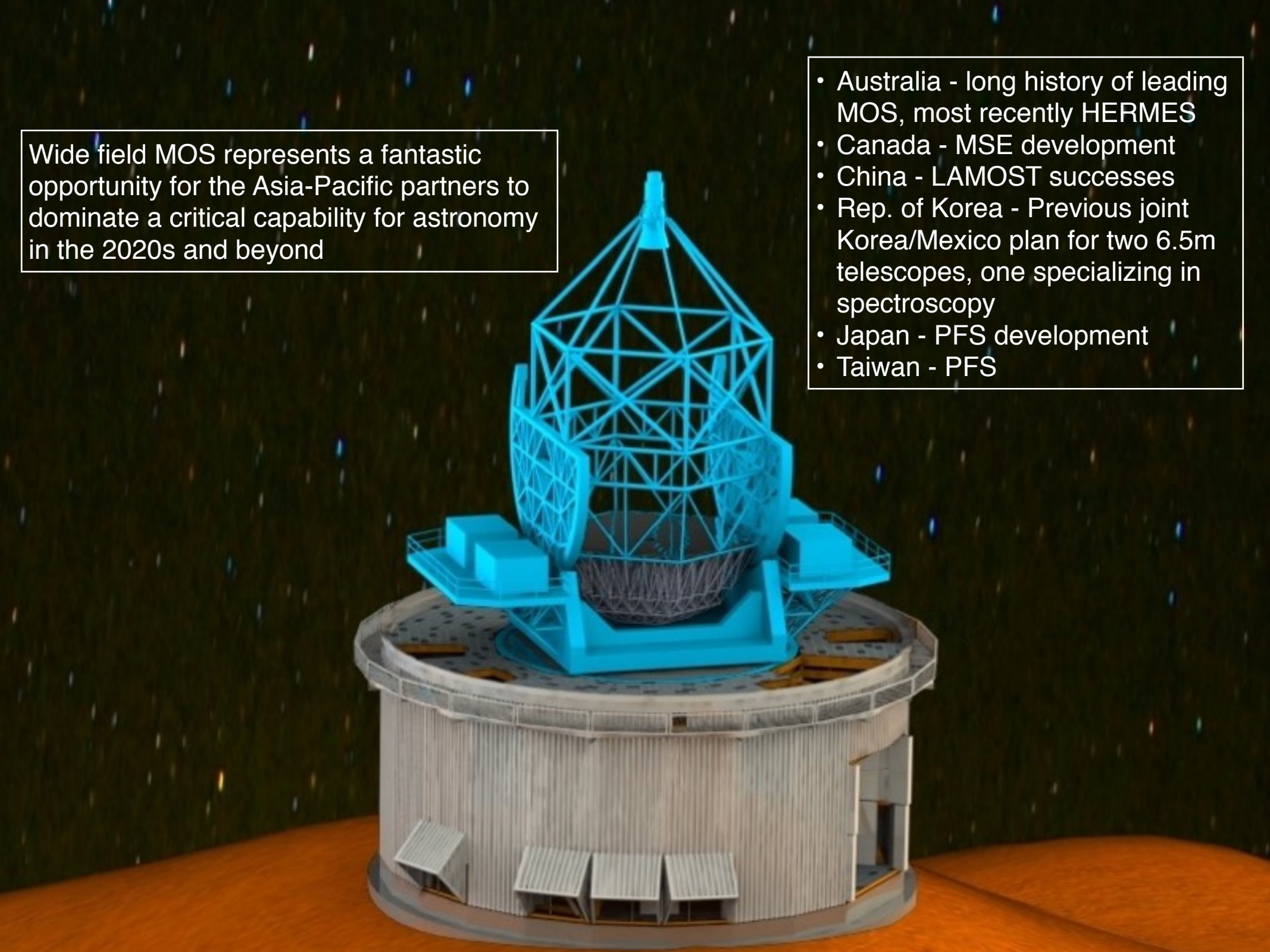
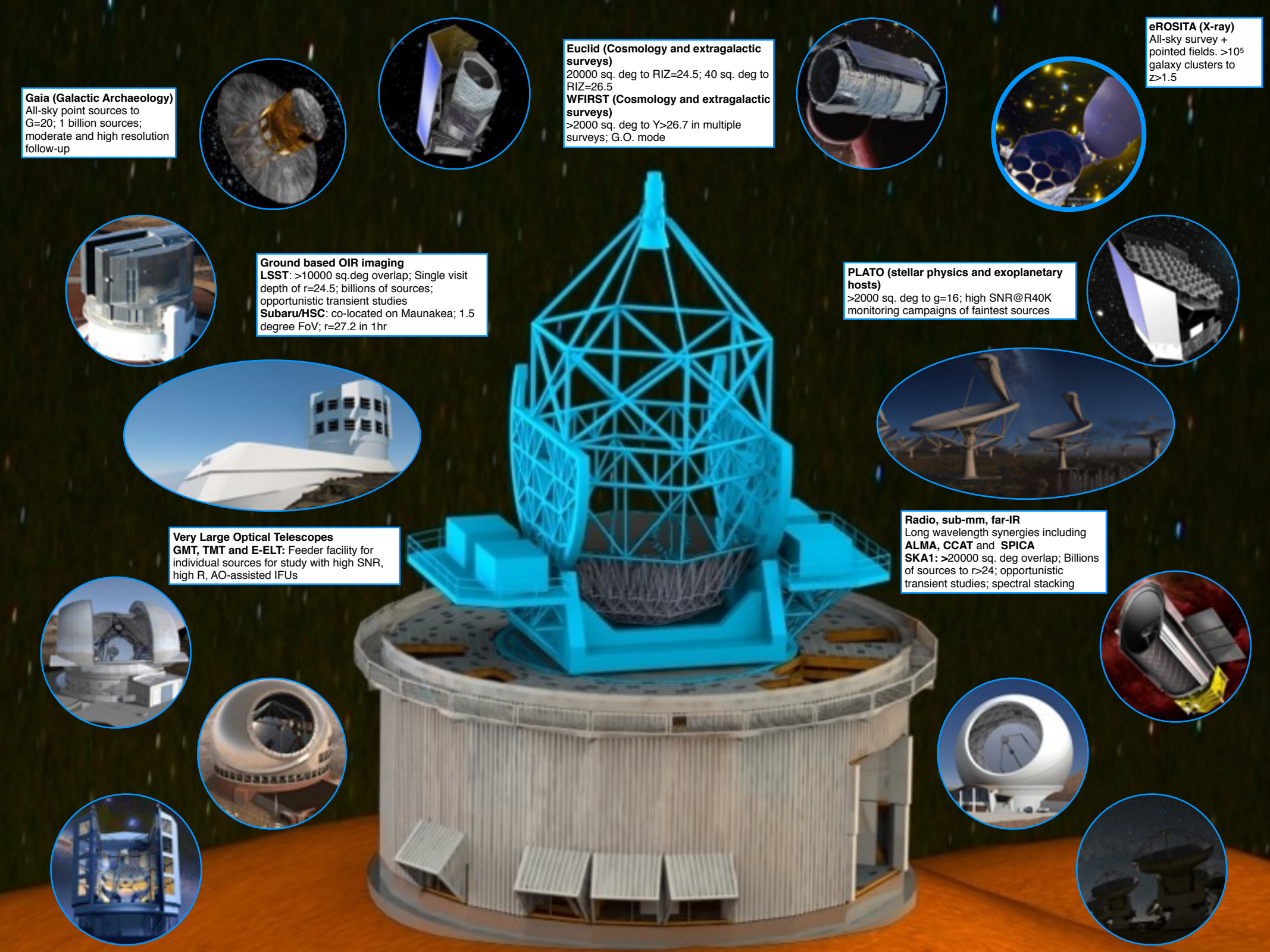


- And high resolution MOS on a ~12m telescope with multiplexing of 1000 brings its own unique problems
  - limited wavelength coverage likely
  - so what are the optimal wavelength windows?
  - a difficult problem with no analogue in PFS

Wide field MOS represents a fantastic opportunity for the Asia-Pacific partners to dominate a critical capability for astronomy in the 2020s and beyond



- Australia - long history of leading MOS, most recently HERMES
- Canada - MSE development
- China - LAMOST successes
- Rep. of Korea - Previous joint Korea/Mexico plan for two 6.5m telescopes, one specializing in spectroscopy
- Japan - PFS development
- Taiwan - PFS


Gaia (Galactic Archaeology)
All-sky point sources to G=20; 1 billion sources; moderate and high resolution follow-up
Euclid (Cosmology and extragalactic surveys)
20000 sq. deg to RIZ=24.5; 40 sq. deg to RIZ=26.5
WFIRST (Cosmology and extragalactic surveys)
>2000 sq. deg to Y>26.7 in multiple surveys; G.O. mode
eROSITA (X-ray)
All-sky survey + pointed fields. >10^5 galaxy clusters to z>1.5
Ground based OIR imaging
LSST: >10000 sq.deg overlap; Single visit depth of r=24.5; billions of sources; opportunistic transient studies
Subaru/HSC: co-located on Maunakea; 1.5 degree FoV; r=27.2 in 1hr
PLATO (stellar physics and exoplanetary hosts)
>2000 sq. deg to g=16; high SNR@R40K monitoring campaigns of faintest sources
Very Large Optical Telescopes
GMT, TMT and E-ELT: Feeder facility for individual sources for study with high SNR, high R, AO-assisted IFUs
Radio, sub-mm, far-IR
Long wavelength synergies including **ALMA, CCAT** and **SPICA**
SKA1: >20000 sq. deg overlap; Billions of sources to r>24; opportunistic transient studies; spectral stacking

Summary

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- Several difficult problems to address independent of the specific project we are talking about
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- **Canada and Japan and the Asia-Pacific nations in this room should collaborate in addressing these issues**
  - **the Asia-Pacific nations are natural collaborators and we should seek to cooperate to further our joint ambitions**
  - **we should ensure that we dominate the field of next generation wide field MOS**

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