MOS beyond 2030

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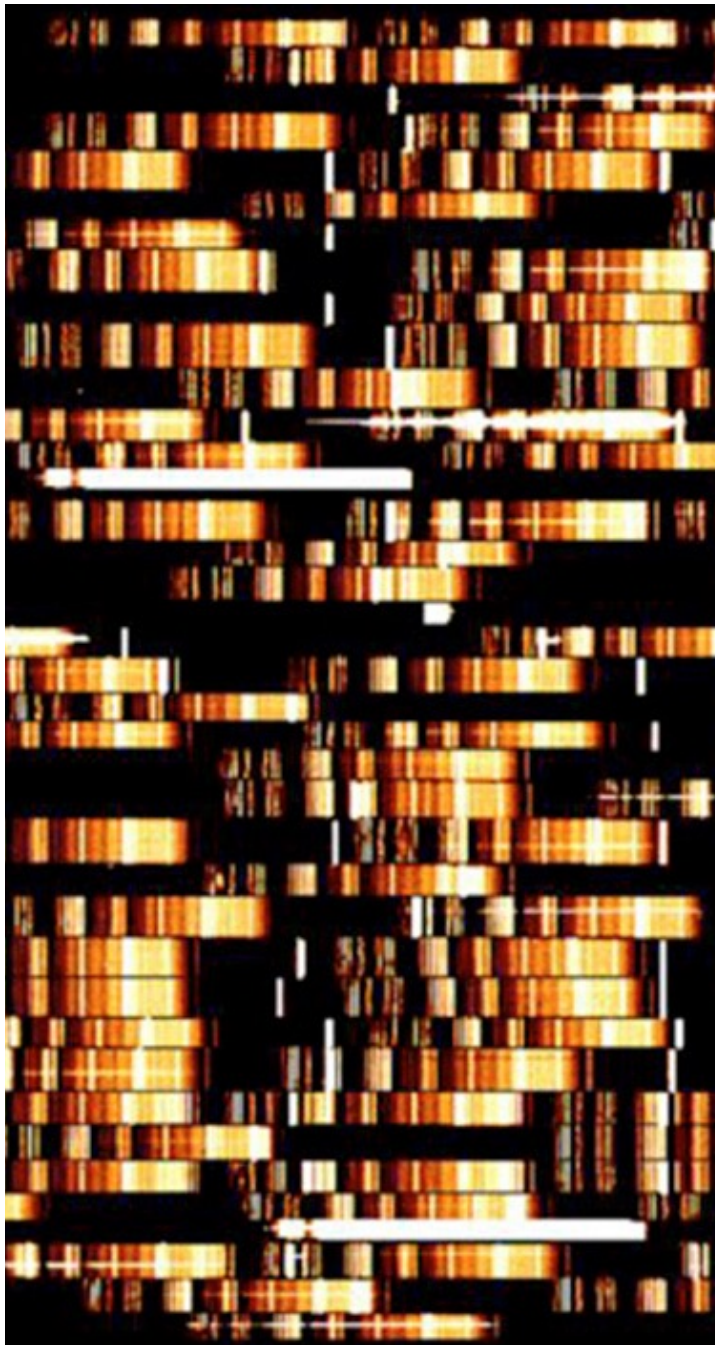


Maunakea Spectroscopic Explorer

WST

The future is bright with deep wide field imaging

Multi-bands surveys ⟶ photometric redshifts

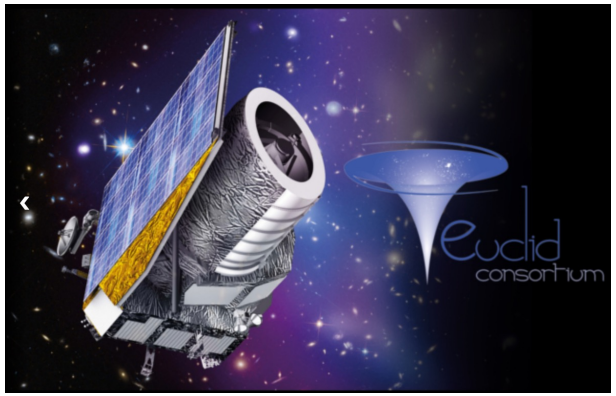
2017-2024

The Ultraviolet Near Infrared Optical Northern Survey (North)

CFHT + Pan-STARSS + Subaru

ugriz 24 mag 5000 deg^2

2023-2030



Euclid Space Telescope

1.2m, 0.7 deg ⌀

riz+YJH

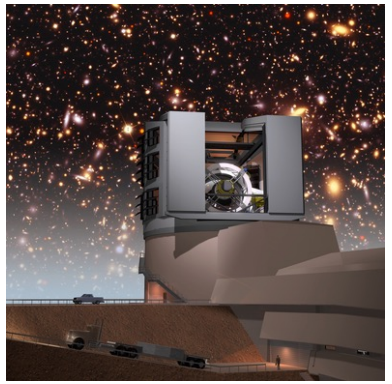
0.9-2.0 R~250 **slitless**

Dedicated facility

Wide >24 mag 17300 deg^2

Deep >26 mag 53 deg^2

2022-2032



Legacy Survey of Space and Time LSST (South)

6.4m, 3.5 deg ⌀

ugrizy

Wide 25-27 mag 18000 deg^2

Deep 27-29 mag 38 deg^2

2026-2032

Nancy Grace Roman Space Telescope

2.4m, 2.5 deg ⌀

YJH

1.35-1.95 R~460 **slitless**

Dedicated facility

Wide <27 mag 2000 deg^2

Deep fields

What about wide field spectroscopy?
→ precise redshifts

Status

- zphot or low-resolution spectroscopy with modest SNR, often one emission line - DESI, Euclid
- needs for spectroscopic redshift training sets across the imaging surveyed area and galaxy populations
- most cosmology: need for massive surveys with wide-field facilities and large telescope time allocation (dedicated facilities)

After Euclid/Rubin/Roman results on cosmological parameters
(power spectrum, BAO, growth factor, SNe, WL, neutrino masses, etc.)
what will be the key issues beyond 2030?

Deviation from the LCDM, or modification of General Relativity at large scales detected? Or not?

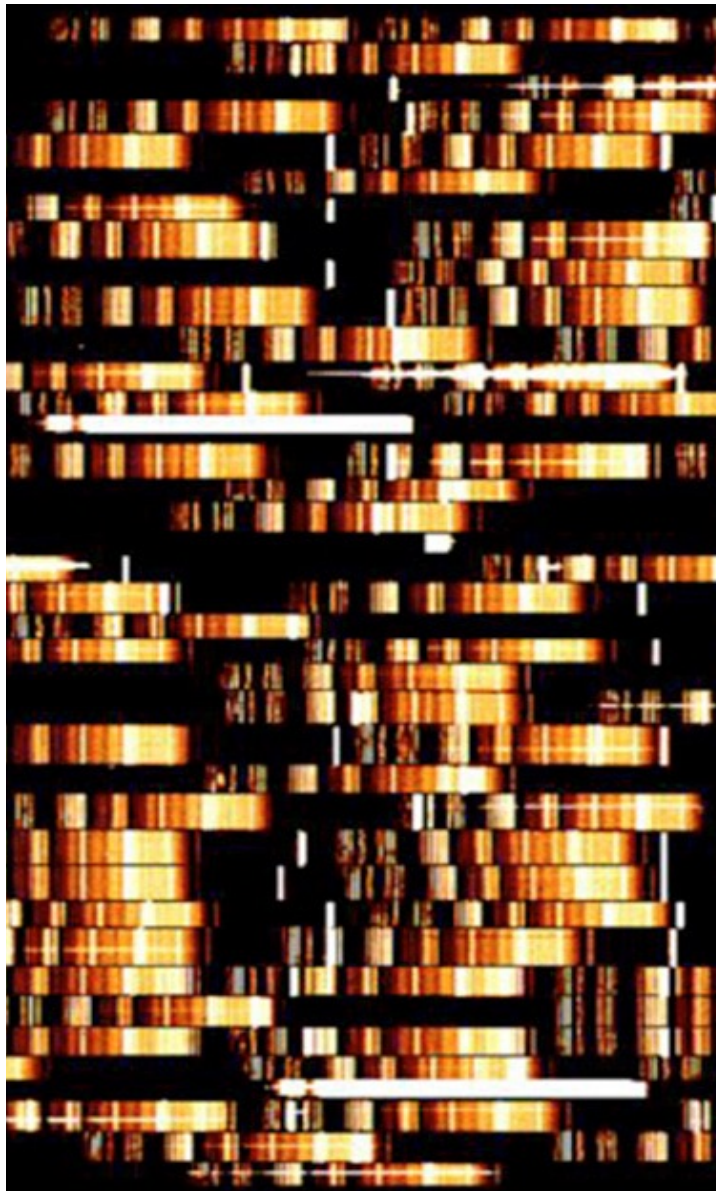
Next

- the need for precise redshifts will presumably be required over large sky area for cosmology
- keep in mind that Euclid is a compromise between the SPACE (spectro) proposal and DUNE (imaging) one
- mapping the LSS up to z = 4 to accurately reconstruct the time evolution of the DE equation of state, w(z)

Two projects proposed, 10m-class telescopes

Maunakea Spectroscopic Explorer

North
Hawaii/USA



South
Chile

WST

Wide field Spectroscopic Telescope

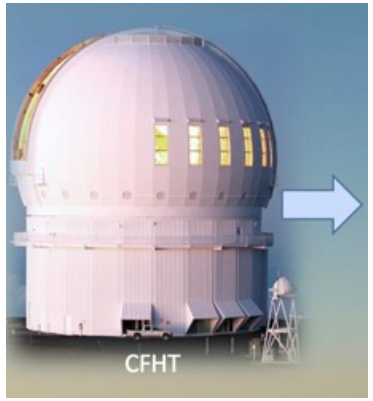
MOS beyond 2030

Maunakea Spectroscopic Explorer – MSE

A powerful, efficient and reliable survey machine

Maunakea Spectroscopic Explorer

https://mse.cfht.hawaii.edu

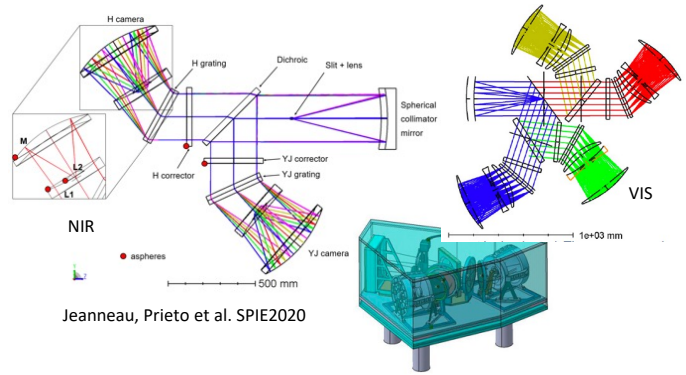


MSE in a nutshell

- Large aperture: 11.25m
- Wide field of view: 1.5 degrees
- Thousands of spectra collected simultaneously: >4000
- UV to NIR wavelengths
- Low-moderate (R=3000-5000) and high res. (R=40000)
- Dedicated and specialized operations

- Low Moderate Res. Spectro LAM (VIS) + CRAL (NIR)
- PESA LAM

Mid-term review 6-7 october 2021

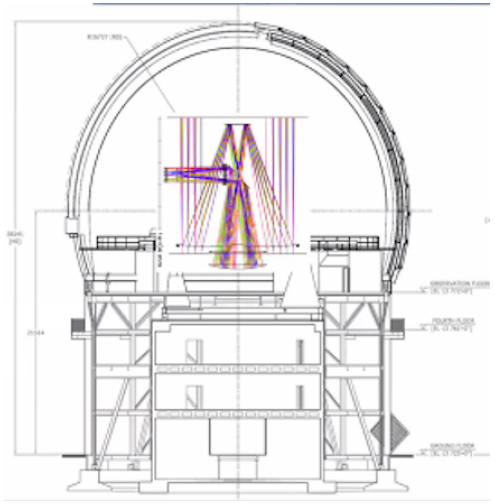


Jeanneau, Prieto et al. SPIE2020

Science Working Groups

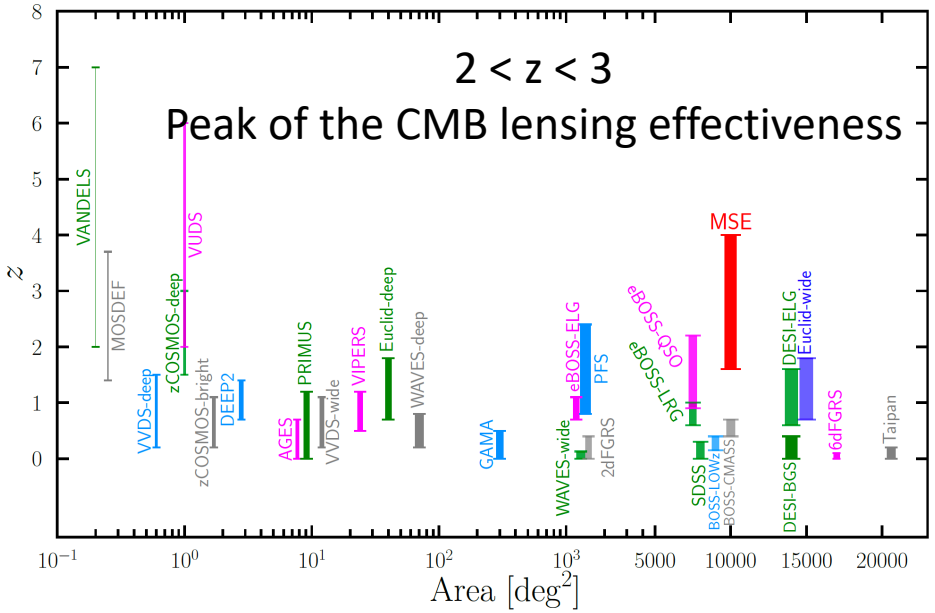
- Solar system science
- Exoplanets & stellar astrophysics
- Chemical nucleosynthesis
- Milky Way & resolved stellar population
- Galaxy formation and evolution
- Active Galactic Nuclei & supermassive black holes
- Astrophysical tests of dark matter
- **Cosmology**
- Time domain astronomy and the transient Universe

Latest news



- New Designs for the telescope : Quad-mirror
  - Multiplex increased 4000 → 15000
  - Continuous from short-blue to K-band
  - Potential for new instruments
- New director / organization
- Fundings after 2030, ideas for a pathfinder on CFHT

MSE cosmology science cases



Percival et al. 2019 arXiv:1903.03158

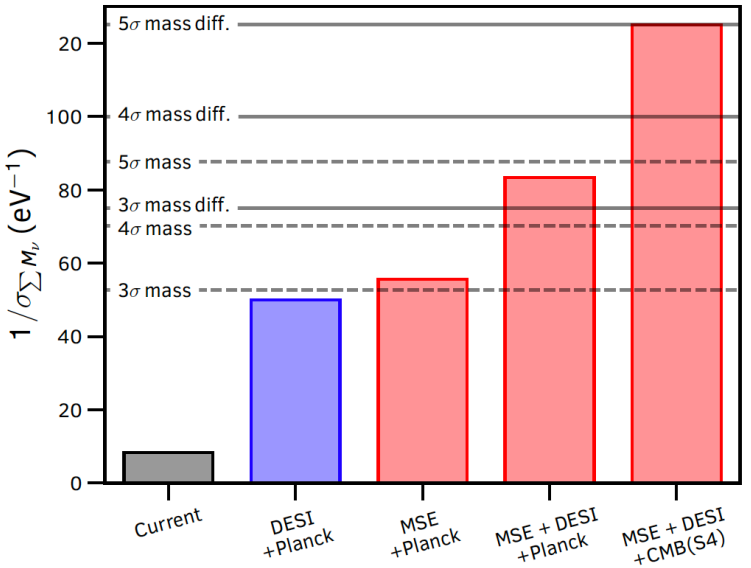
Maunakea Spectroscopic Explorer

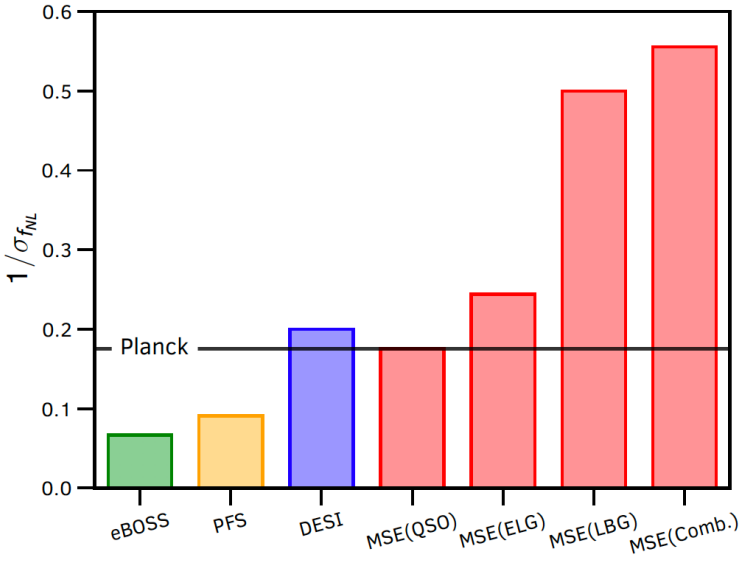
Forecasts for BAO & Growth factor

Sample	z	$\bar{n}$ $[10^{-4}h^3/Mpc^3]$	V $[Gpc^3/h^3]$	σ_{D_A}/D_A [%]	σ_H/H [%]	σ_{D_V}/D_V [%]	$\sigma_{f\sigma_8}/f\sigma_8$ [%] $k_{max} = 0.1[h/Mpc]$
ELGs	1.6 – 2.0	1.8	15.56	0.81	1.43	0.56	1.86
	2.0 – 2.4	1.8	16.20	0.74	1.30	0.51	2.05
LBGs	2.4 – 2.8	1.1	16.27	0.96	1.59	0.64	2.68
	2.8 – 3.2	1.1	16.00	0.94	1.54	0.63	2.94
	3.2 – 3.6	1.1	15.54	0.93	1.52	0.62	3.23
	3.6 – 4.0	1.1	14.99	0.94	1.52	0.62	3.59

Table 9: Forecast constraints on BAO distance precision and growth of structure precision by MSE.

Forecasts for Neutrino mass & Primordial non-Gaussianity





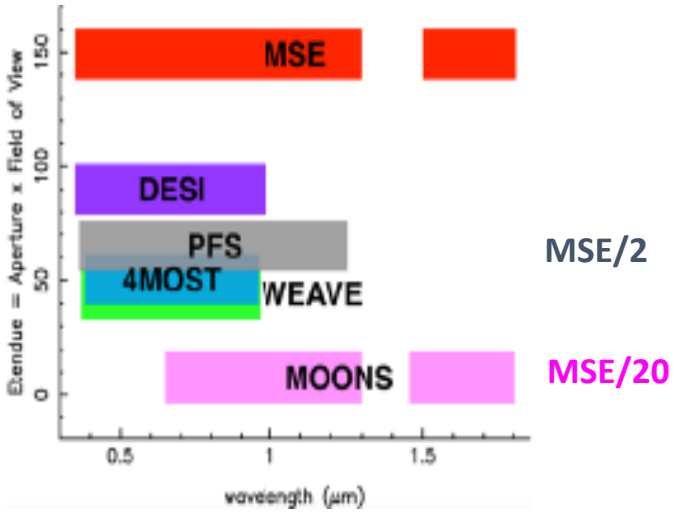
The Detailed Science Case for the Maunakea Spectroscopic Explorer, 2019 edition, April 2019 arXiv:1904.0490

MSE and other anticipated wide-field MOS facilities

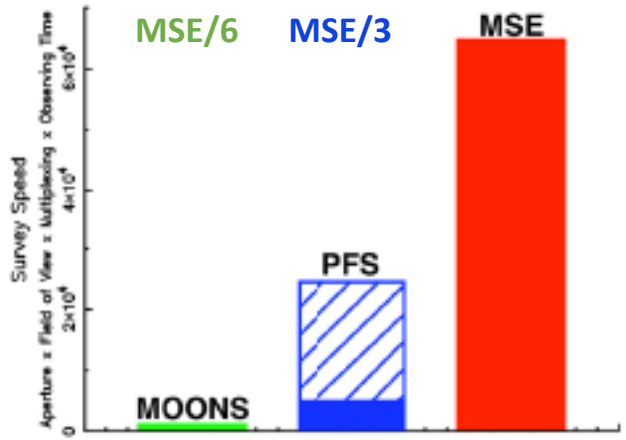
MSE is the largest of these facilities and the only dedicated facility on a large aperture telescope that could be operational in 2035++, combined with data from as Roman/LSST, Euclid, and Rubin.

To be multiplied by a factor ~3-4 with the new design

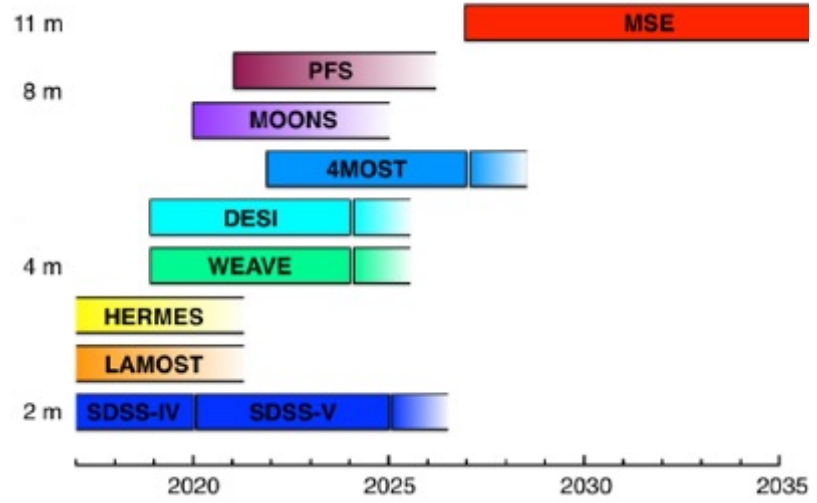
Etendue
FOV x π (M1/2)^2



Survey speed
Etendue x Multiplexing x Observing time



Wide-field MOS timelines

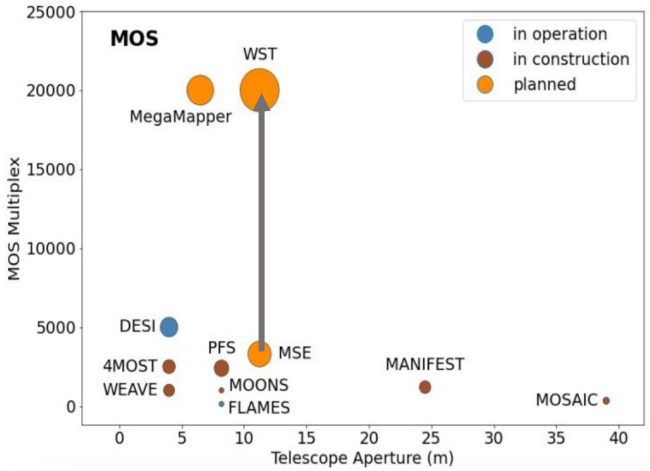


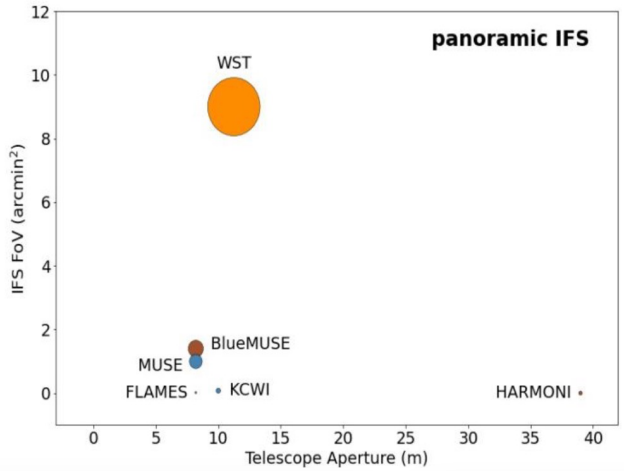
MSE is designed to enable efficient massive spectroscopic surveys in the 30's and to remain productive for several decades

MOS beyond 2030

ESO Wide field Spectroscopic Telescope – WST

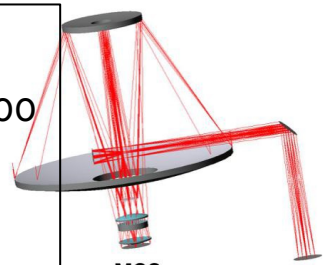
Simultaneous operation of a large FOV multiplex and MOS a giant panoramic central IFS

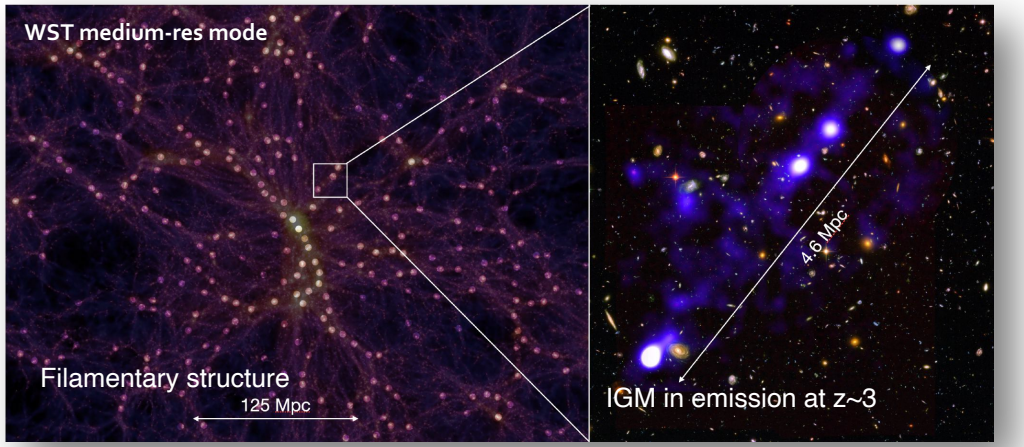


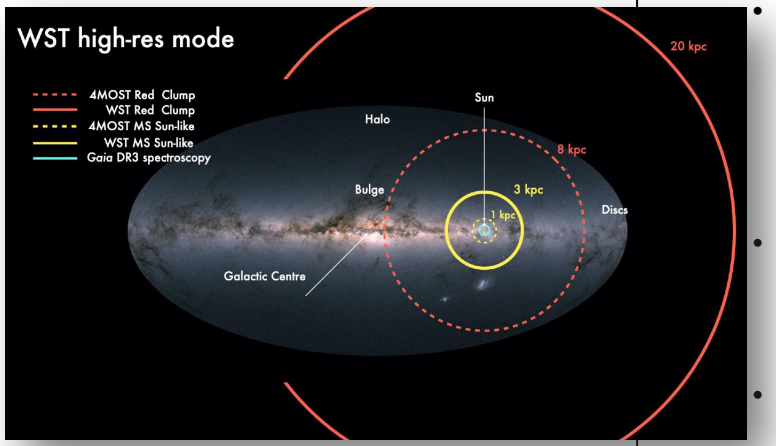


Telescope size 10-12m class aperture
FOV > 5 deg²
- ❑ MOS Med. Res. R=2000-7000, Hi. Res. R=40000
- ❑ Multiplex MR>20000, HR>2000
- ❑ IFS FOV > 3x3 arcmin²
- ❑ IFS R=3000-5000

Optical facility 360-1000 (NIR tbd)







5 years of operation, WST will provide:

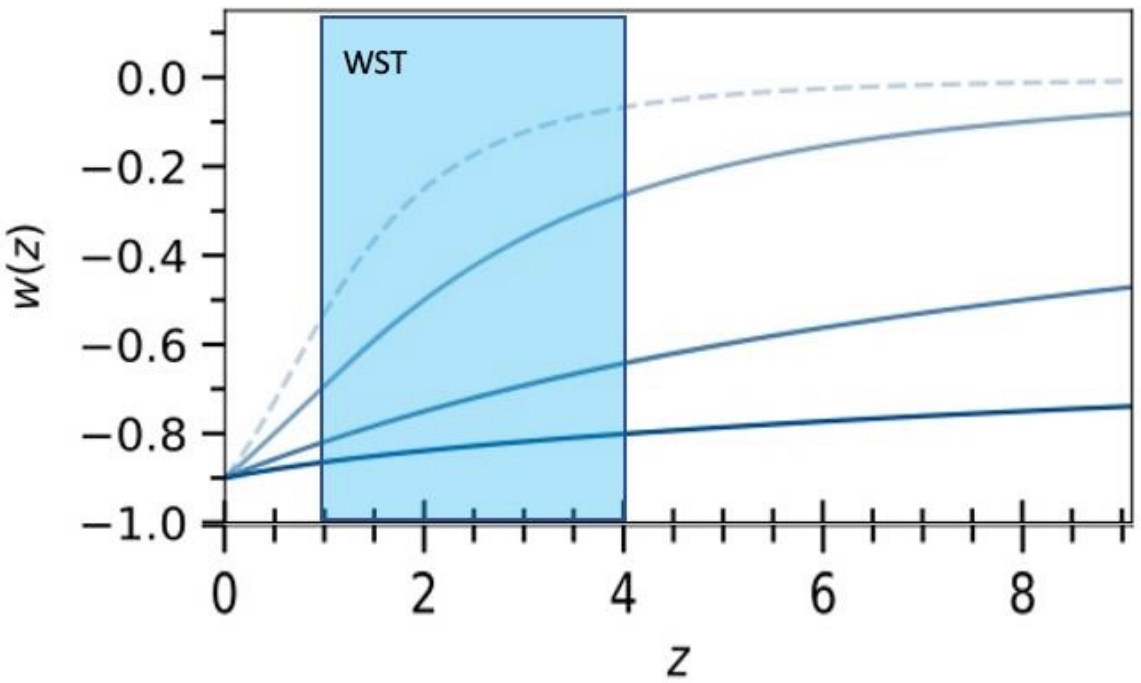
- **MOS MR**: **250 million galaxies** (to mag 24.5) over 14,000 deg² (the entire accessible sky from north Chile, excluding the Galaxy) and **25 million stars** (to mag 23.0) over the entire Galaxy and the Local Group visible from north Chile. Spectral measurements of redshifts, stellar metallicities, etc.
- **MOS HR**: **2 million stars** (to mag 17.0) over the entire Galaxy and the Local Group visible from north Chile. Spectral measurements of chemical abundances, kinematics, etc.
- **IFS**: **4 billion spectra** in 7000 fields over diverse environments (low-density fields, galaxy and star clusters, Galactic fields…). Spectral measurements of redshifts, IGM/CGM properties, etc.

- EU Horizon Infrastructure proposal (3 yr study) - PI R. Bacon (CRAL, FR) 9 international partners, 18 labs
  April 2022– well rated but not selected → resubmission in 2024
- Web site and joining the team will be open in dec 2022
- Request for a Workshop at ESO in 2023

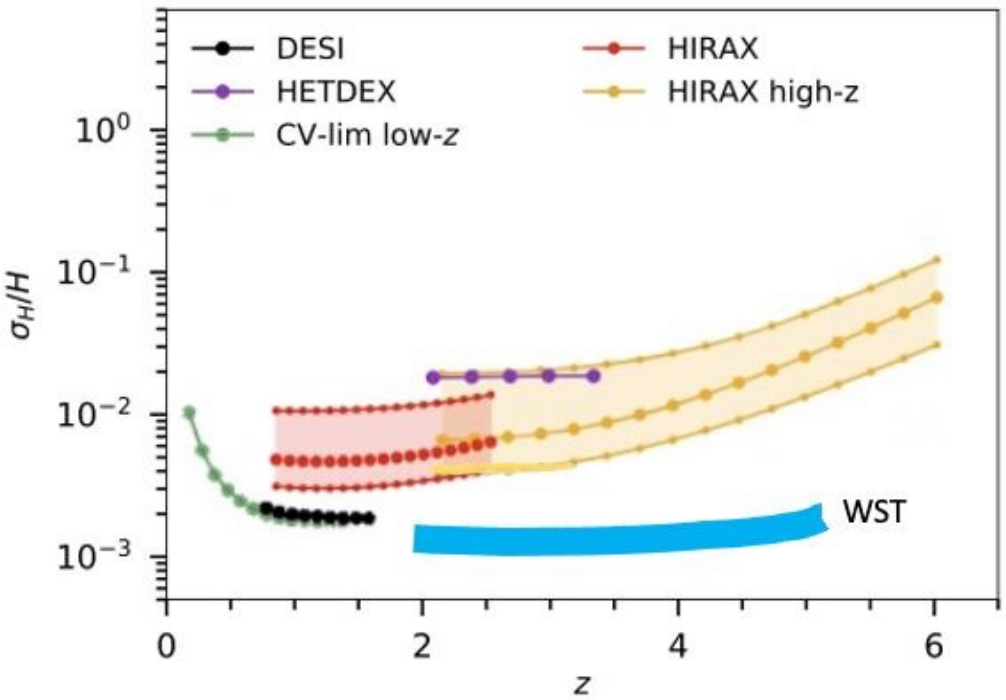
WST cosmolology science cases – preliminary

next month invitation to join to build the science case

DE equation of state with different DE models



Exemple for a WST dedicated survey to the final 10yrs LSST
Constraint on H(z)



WST proposal – Figure adapted from Bull et al. (2021)
Constraints at least an order of magnitude more precise

To sum up – on the cosmology side

Dedicated MOS wide-field 10m-class telescopes
to efficiently acquire massive large-scale deep spectroscopic surveys

and will surpass their original rationales as proved with most astronomical facilities

Large-scale imaging surveys are now on track

The need for large-scale spectroscopic surveys has been claimed since more than a decade
Recently, ESO report (SpecTel Ellis et al. 2016), 2016-2025 Australian decadal plan, Canadian plan 2020-2030, US 2020 decadal survey, ESO Users (Messenger 184, 2021)…

More complex and costly development
VLT & ELT / ESO are not dedicated to cosmology surveys
Too small FOV and multiplex capabilities, not dedicated facilities

Two complementary MOS North & South 10m-class telescope? VIS+NIR/MOS+IFU?
Foreseen timescales : first lights in 2035?