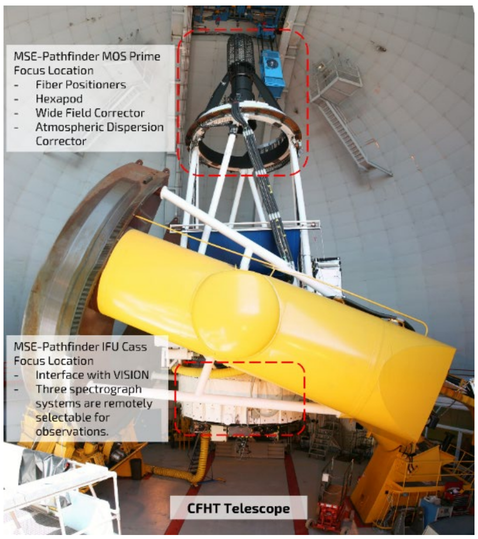
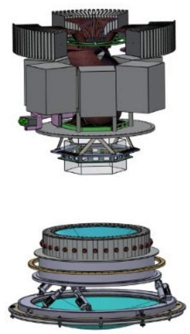
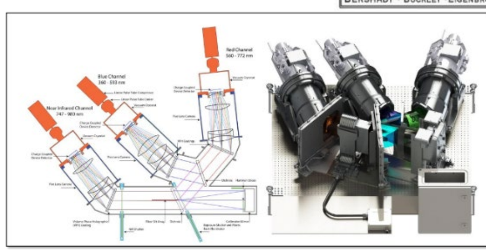
Maunakea Spectroscopic Explorer Pathfinder Instrument at the Canada-France-Hawai‘i Telescope

The Canada-France-Hawai‘i Telescope will seek collaborators for the development of a precursor instrument to the Maunakea Spectroscopic Explorer (MSE). The MSE-Pathfinder will have Integral Field Unit (IFU) and Multi-Object Spectrograph (MOS) capabilities and will be developed on an accelerated timescale at CFHT in tandem with collaborators. The envisaged operational model will allocate 80% of observing time for large survey programs and the remainder 20% for PI programs. While undertaking science campaign, MSE-Pathfinder will retire identified risks for MSE in parallel.







The baseline design for the MSE-Pathfinder calls for approximately 1000 fibers that feed DESI-type spectrographs and operate at medium spectral resolution (R ~ 3000-5000) over the optical wavelength regime (λ = 360-980 nm). The initial project schedule anticipates a 4-5 year development timeline for the IFU and an additional 1-2 years for the completion of the MOS. The MSE-Pathfinder will operate for sizeable number of nights on CFHT (100-200 nights annually, TBD) under a guaranteed time observations arrangement with its collaborators.

Currently, the design entails a large-format IFU with a 33” x 28.5” field of view and high spatial sampling situated at the Cassegrain port. The MOS will be located at prime focus with a 1.3 degree diameter FOV and employ tilting spine fiber positioners. Ultimately, the exact technical specifications of the MSE-Pathfinder will be finalized by the collaborators.

The MSE-Pathfinder IFU will interface with CFHT’s upcoming VISION system, which will provide access to single object high-resolution spectroscopy in either the optical, near-infrared (through K-band), or both simultaneously. IFU and VISION will be remotely operable and together form a powerful system for time domain spectroscopic follow-up. Combined with MegaCam, a highly efficient one-degree field optical imager (with 378 megapixels), this CFHT suite of instruments becomes both a self-contained survey machine and a versatile complement to a myriad of ground-based and space-based facilities.

Pathfinder Science

MSE-Pathfinder's MOS and IFU capabilities will enable the exploration of a wide range of science cases from cosmology to stellar astrophysics. Five potential science areas of focus are:

- Time Domain and Transients
- Galactic Science
- Cosmology
- High-Energy
- Galaxy Evolution

The MSE-Pathfinder will provide the spectroscopic data necessary to maximize the science return from a variety of space-based and ground-based facilities. MSE-Pathfinder spectroscopic observations will complement large area space missions such as Gaia, eROSITA, Roman, and JWST. In addition, MSE-Pathfinder spectroscopic follow-up will augment the data from several current and future ground-based facilities including ZTF, VRO LSST, KIDS, DES, and SKA. Finally, the IFU will perform rapid transient follow-up with a dedicated target-of-opportunity observation mode while the MOS will reserve fibers to acquire time series observations and perform long baseline monitoring. These capabilities are a direct response to the Astro2020 report citing time domain astrophysics as the highest mid-scale scientific priority for US astronomy. The table below lists potential science cases for the MSE Pathfinder:

Science Area	Facility Follow-Up/Target Population	Science Goal/Science Area	MSE Pathfinder Follow-Up Type
Time Domain	LSST Follow-Up; Time Critical	SNe + Galaxy Hosts	IFU + MOS
	LSST Follow-Up; Time Critical	TDE	IFU
	LSST Follow-Up; Time Critical	GRB	IFU
	LSST Follow-Up; Time Critical	Blazar	IFU
	LSST Follow-Up; Non Time Sensitive	Eclisping Binaries	MOS
	LSST Follow-Up; Non Time Sensitive	Brown Dwarfs	MOS
	LSST Follow-Up; Non Time Sensitive	Pulsating Stars	MOS
	LSST Follow-Up; Non Time Sensitive	Exoplanet Hosts	MOS
Galactic Archaelogy/Near Field Cosmology	Gaia; MW Halo	3D dark matter halo potential of the Milky Way and its substructure	MOS
	Gaia; MW Halo	Accretion and in situ formation history of Milky Way stellar halo	MOS
	Gaia; MW Halo	Inner/Outer Halo Distinction	MOS
	Gaia +OS; MW Bulge	Formation scenarios: accretion vs. disk instability formation of the bulge	MOS
	Gaia +OS; MW Bulge	Transition regions	MOS
	Gaia + OS; MW Disk	Dynamics of the bar and spiral arms to constrain stellar mass distribution	MOS
	Gaia + OS; MW Disk	Importance of stellar radial migration	MOS
	Gaia + OS; MW Disk	Origin of the thin and thick disks	MOS
	Gaia + OS; MW Disk	Chemical enrichment history of the disk	MOS
	Gaia Faint End Follow-Up	Chemodynamics of MW Populations	MOS
Cosmology/Galaxy Evolution	Euclid, Roman, LSST, SKA Follow-Up	Dark Energy/Dark Matter (BAO, RSD, Ly alpha Forest)	MOS
	Euclid, Roman, LSST, SKA Follow-Up	Dark Energy/Dark Matter (Lensing)	MOS+IFU
	Euclid, Roman, LSST, SKA Follow-Up	Transients (SNe Ia, SNe CC, SNe exotic)	MOS+IFU
High Energy Sky	eROSITA Follow-Up	Cosmology with X-ray Clusters to z~0.8	MOS+IFU
	eROSITA Follow-Up	X-ray AGN/galaxy evolution and cosmology to z~5	MOS+IFU
	eROSITA Follow-Up	Galactic X-ray Sources, Resolving the Galactic Edge	MOS
Galaxy Evolution	SKA PF, SKA, Roman, LSST, Euclid Follow-Up	Galaxy Evolution (Galaxies)	MOS+IFU
	SKA PF, SKA, Roman, LSST, Euclid Follow-Up	Galaxy Evolution (Clusters)	MOS+IFU