Snowmass2021 - Letter of Interest

The Maunakea Spectroscopic Explorer

Thematic Areas: (check all that apply □/■)

□ (CF1) Dark Matter: Particle Like
□ (CF2) Dark Matter: Wavelike
■ (CF3) Dark Matter: Cosmic Probes
■ (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
□ (CF5) Dark Energy and Cosmic Acceleration: Cosmic Dawn and Before
■ (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
□ (CF7) Cosmic Probes of Fundamental Physics
□ (Other) *[Please specify frontier/topical group]*

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Collaboration: Maunakea Spectroscopic Explorer Collaboration

Abstract: The Maunakea Spectroscopic Explorer (MSE) is the first of the future generation of dedicated observational facilities that enable massively multiplexed spectroscopic study of faint astrophysical objects. MSE is designed to enable transformative science, being completely dedicated to large-scale multi-object spectroscopic surveys, each studying thousands to millions of objects. MSE will use an 11.25 meter aperture telescope to feed thousands of fibers over a 1.5 square degree field of view and has the capability to observe at optical and near-Infrared wavelengths at a range of spectral resolutions, with all spectral resolutions available at all times across the entire field. MSE will collect more than 10 million fiber-hours of spectroscopic observations every year and is designed to excel at precision studies of large samples of faint astrophysical targets. With these capabilities, MSE stands as a premier facility for next-generation experimental astrophysical studies of the nature of dark matter, dark energy, and the universe as a whole.

Introduction The past two decades have seen major advancements in our understanding of the physics that governs the universe, thanks in large part to modern imaging surveys that study large areas of the sky at optical and near-Infrared wavelengths. The most recent of these surveys have resulted in the discovery and study of some of the faintest and most distant objects in the universe, enabling for the first time large-scale studies of the observed properties of dark matter and dark energy, among many other studies. To realize their full scientific potential, however, many (if not most) of the objects discovered of these imaging surveys must be studied in further detail using spectroscopic techniques. Today a new generation of massively multiplexed spectroscopic instruments are beginning to come online in the form of DESI and soon SDSS-V, 4MOST, WEAVE, and other installations on 4-meter-class telescopes. In the near future, larger aperture telescopes will be required to access the faintest and most distant objects of interest, particularly once future deep imaging facilities such as the Rubin and Roman Observatories begin operations. Several next-generation spectroscopic facilities are currently in the planning stages and include MSE and also PFS, Megamapper, SpecTel, and FOBOS. These facilities will enable a plethora of unique, high impact, and exceptionally diverse transformational science cases, opening another new window onto the faint and distant universe.

The Maunakea Spectroscopic Explorer MSE is the most advanced of the future generation of dedicated massively multiplexed spectroscopic facilities, having completed a Conceptual Design of the facility in 2018[1]. MSE is designed to enable transformative next-generation science, being completely dedicated to large-scale multi-object spectroscopic surveys, each studying thousands to millions of astrophysical objects. Figure 1 shows an overview of the planned MSE facility.

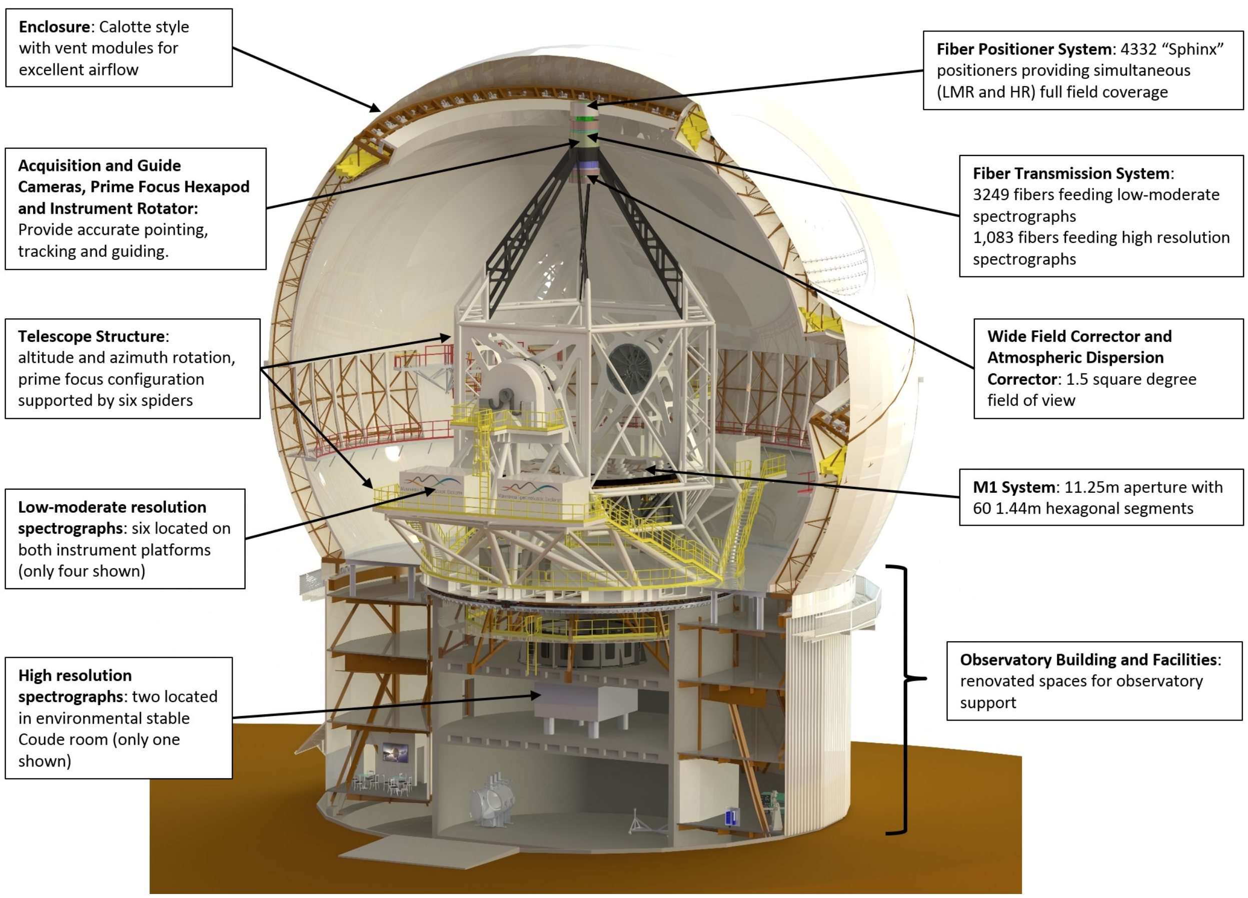

Figure 1: MSE Observatory architecture, as described by the 2018 Conceptual Design study[1].

MSE uses an 11.25 meter aperture telescope to feed more than 4,000 fibers over a wide 1.52 square degree field of view. The 2018 Conceptual Design described a fiber positioner system comprising 4,332 fibers; trade studies are currently underway to investigate significantly increasing the number of fibers in the focal plane. Each fiber carries light to one of MSE's two types of spectrographs, which have the capability to obtain spectra at optical to near-Infrared wavelengths at a range of spectral resolutions, from R$\sim$3,000 to R$\sim$40,000, with all resolutions available at all times across the entire field. MSE will have an on-target observing efficiency of more than 80%; this, coupled with the dedicated nature of the MSE facility, will maximize on-sky time and ensure a high scientific productivity, while the large 11.25 meter diameter collecting area is well-matched to followup of imaging surveys produced by 4-meter or larger telescopes. MSE will collect hundreds of millions of spectra over its lifetime, enabling the most ambitious possible studies using extremely large samples of the faintest astrophysical phenomena.

To ensure that the planned MSE facility is optimized for maximum scientific productivity, the MSE Science Team has recently produced an up-to-date Detailed Science Case[2] that describes in detail a wide array of astronomical and astrophysical science cases, most of which would be impossible to execute with current generation facilities. Of these, two of the key MSE science cases (and perhaps many more!) are of considerable interest to the astroparticle physics community; these have been submitted as LOIs to Snowmass2021: *Probing Dark Matter Physics with MSE* (Li, Kaplinghat, & the MSE Science Team) and *Cosmology with MSE* (Yèche, Percival, & the MSE Science Team).

Project status MSE completed its Conceptual Design Phase in 2018 and is currently preparing to begin a two-year Preliminary Design Phase in 2021. At that time the remaining project development schedule will be 10 years according to the technically-paced schedule, with science operations beginning in 2030. This timescale is well-suited to the renegotiation of the new Maunakea Master Lease process that is currently underway so that agreement may be made well in advance of the Lease expiring in 2033. More information about the MSE project may be found at http://mse.cfht.hawaii.edu/.

Summary MSE is a completely dedicated, massively multiplexed spectroscopic facility optimized for the design, execution, and scientific exploitation of spectroscopic surveys of the faintest and most distant astrophysical objects. It will unveil the composition and dynamics of the faint universe, and will impact nearly every field of astrophysics across all spatial scales, from individual stars to the largest scale structures in the Universe. MSE will provide critical follow-up for millions of faint sources found in deep imaging surveys and enables important synergies between not only theoretical and experimental astroparticle physics but also between optical/near-Infrared wide-field imaging surveys and facilities operating at other wavelengths and from space, as well as filtering of these immensely large survey datasets to enable more detailed studies by future 30-meter-class telescopes. The stand-alone science potential of MSE is awesome, but more importantly the strategic importance of MSE within the context of planning for the next phases of experimental astrophysical studies cannot be overstated.

Acknowledgments The Maunakea Spectroscopic Explorer Conceptual Design Phase was conducted by the MSE Project Office, which is hosted by the Canada-France-Hawaii Telescope. MSE partner organizations in Canada, France, Hawaii, Australia, China, India, and Spain all contributed to the Conceptual Design. The authors and the MSE collaboration recognize the cultural importance of the summit of Maunakea to a broad cross section of the Native Hawaiian community.

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