Science and Status of the Maunakea Spectroscopic Explorer

Alan McConnachie
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MSE Project Scientist

Wide Field Astronomy - Canada
10 - 12 October 2018
**MSE Key Capabilities**

<table>
<thead>
<tr>
<th>Accessible sky</th>
<th>30000 square degrees (airmass &lt; 1.55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture (M1 in m)</td>
<td>11.25m</td>
</tr>
<tr>
<td>Field of view (square degrees)</td>
<td>1.52</td>
</tr>
<tr>
<td>Etendue = FoV x π (M1 / 2)^2</td>
<td>151</td>
</tr>
<tr>
<td><strong>Modes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td></td>
</tr>
<tr>
<td>Wavelength range</td>
<td>0.36 - 1.3 μm, 1.5 - 1.8 μm</td>
</tr>
<tr>
<td>Spectral resolution, $R = \lambda / d\lambda$</td>
<td>2500 (3000)</td>
</tr>
<tr>
<td>Multiplexing</td>
<td>3249</td>
</tr>
<tr>
<td>Spectral windows</td>
<td>Full</td>
</tr>
<tr>
<td>Sensitivity ★</td>
<td>$m=24.0$ *</td>
</tr>
<tr>
<td>Velocity precision ★</td>
<td>20 km/s ▼</td>
</tr>
<tr>
<td>Spectrophotometric accuracy</td>
<td>&lt; 3 % relative</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td></td>
</tr>
<tr>
<td>Wavelength range</td>
<td>0.36 - 0.95 μm</td>
</tr>
<tr>
<td>Spectral resolution, $R = \lambda / d\lambda$</td>
<td>3000 (5000)</td>
</tr>
<tr>
<td>Multiplexing</td>
<td>3249</td>
</tr>
<tr>
<td>Spectral windows</td>
<td>=Half</td>
</tr>
<tr>
<td>Sensitivity ★</td>
<td>$m=23.5$ *</td>
</tr>
<tr>
<td>Velocity precision ★</td>
<td>9 km/s ▼</td>
</tr>
<tr>
<td>Spectrophotometric accuracy</td>
<td>&lt; 3 % relative</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td></td>
</tr>
<tr>
<td>Wavelength range</td>
<td>0.36 - 0.45 μm</td>
</tr>
<tr>
<td>Spectral resolution, $R = \lambda / d\lambda$</td>
<td>40000</td>
</tr>
<tr>
<td>Multiplexing</td>
<td>1083</td>
</tr>
<tr>
<td>Spectral windows</td>
<td>$\lambda / 30$</td>
</tr>
<tr>
<td>Sensitivity ★</td>
<td>$m=20.0$ ♦</td>
</tr>
<tr>
<td>Velocity precision ★</td>
<td>&lt; 100 m/s ★</td>
</tr>
<tr>
<td>Spectrophotometric accuracy</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Survey speed & sensitivity:**

11.25m primary

**Spectral performance & multiplexing:**

low, moderate, high resolution; opt - H band; >4300 fibres

**Dedicated & specialized operations**

consider an 11m version of SDSS on arguably the best optical astronomy site on the planet
Left: Etendue versus wavelength for all upcoming extreme MOS
Discovery Space

Left: Etendue versus wavelength for all upcoming extreme MOS

Right: Survey speed for all the >8m class upcoming extreme MOS
Facility transformation

CFHT

MSE
Maunakea Spectroscopic Explorer

Facility transformation

CFHT

MSE
Enclosure: Calotte style with vent modules for excellent airflow.

Acquisition and Guide Cameras, Prime Focus Hexapod and Instrument Rotator: Provide accurate pointing, tracking and guiding.

Telescope Structure: Altitude and azimuth rotation, prime focus configuration supported by six spiders.

Fiber Positioner System: 4332 “Sphinx” positioners providing simultaneous (LMR and HR) full field coverage.

Fiber Transmission System: 3249 fibers feeding low-moderate spectrographs, 1,083 fibers feeding high resolution spectrographs.

Wide Field Corrector and Atmospheric Dispersion Corrector: 1.5 square degree field of view.

M1 System: 11.25m aperture with 60 1.44m hexagonal segments.

Low-moderate resolution spectrographs: six located on both instrument platforms (only four shown).

High resolution spectrographs: two located in environmental stable Coude room (only one shown).

Observatory Building and Facilities: renovated spaces for observatory support.
Recent highlights

2015 — 2017: Major subsystem Conceptual Design studies conducted by partners

2017: 10 different subsystem Conceptual Design Reviews for 8 different subsystems

January 2018: System-level Conceptual Design Review held in Waimea / transition to Preliminary Design Phase begins

Conceptual Design Costs to-date USD7.7M

2018: Partners signing document to govern MSE development through Preliminary Design (~USD25M, of which >USD13M already identified)

Texas A&M and NCOA currently observers as they explore possibilities of become full partners

The “MSE Book 2018” will be released imminently, providing a comprehensive summary of the design and development to date

• System Level CoDR Panel:
  • Chair: Michael Strauss (Princeton)
  • Scott Roberts (TMT)
  • Hermine Schnetler (STFC/ATC)
  • Ken Chambers (Hawaii)
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Science Development 2018+

- MSE Book 2018 released
- Decadal planning decisions: Australia, Canada, France, US
- Detailed Science Case v2 released
- New call for Science Team membership (now 320+)
- CFHT LP completion

(AIVC) on Maunakea.

Timeline:
- 2017: Conceptual Design
- 2019: Preliminary Design
- 2020: Final Design
- 2021: UH Land Authorization
- 2022: Construction
- 2026: AIVC
Call for new Science Team members released in March 2018. More than 200 new members joined.

- Science Team now consists of 325 people from 30 countries (!)
- Canada has 35 members on the science team (joint second biggest, behind the USA) from 17 institutions
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- Will kick-off Design Reference Survey development (actually planning the specific surveys that achieve the science goals of MSE)
Schedule and Costings

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- Detailed Science Case v2 released
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- MSE managed as a cost-capped project (USD313M, 2018 economics)
- No cost constraints imposed during Conceptual Design Phase; partners asked to design MSE subsystems as required by SRD

- Current costing of MSE based on Conceptual Design studies is ~USD370M
- Rationalization of cost/scope/science in 2019

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AIVC on Maunakea.

CONCEPTUAL DESIGN

PRELIMINARY DESIGN

FINAL DESIGN

CONSTRUCTION

SCIENCE OPERATIONS
"We consider the scientific case for a large aperture (10-12m class) optical spectroscopic survey telescope with a field of view comparable to that of LSST. We find that such a facility could enable transformational progress in several broad areas of astrophysics, and may constitute an unmatched ESO capability for decades."

"The facility will also have synergistic impact, e.g. in following up ‘live’ and ‘transpired’ transients found with LSST, as well as providing targets and the local environmental conditions for follow-up studies with E-ELT and future space missions."

“…ESO should be open to considering international partnerships in all of the above.”

*ESO Future of Multi-Object Spectroscopy Working Group Report, Ellis et al. 2017*
“The National Science Foundation should support the development of a wide-field, highly multiplexed spectroscopic capability on a medium- or large-aperture telescope in the Southern Hemisphere to enable a wide variety of science…”

Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System, NAS, Elmegreen et al.
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“Develop or obtain access to a highly multiplexed, wide-field optical multi-object spectroscopic capability on an 8m-class telescope, preferably in the Southern Hemisphere… [There] is an urgent need to investigate possible development pathways now, so that the needed capabilities can be available in the LSST era. Possibilities include … joining an international effort to implement a wide-field spectroscopic survey telescope (e.g., the Maunakea Spectroscopic Explorer at CFHT or a future ESO wide-field spectroscopic facility) if the facility will deliver data well before the end of the LSST survey.”

Website: mse.cfht.hawaii.edu
MSE Book 2018: Released in October 2018