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DESI Overview

• **MS-DESI is the Mid-Scale Dark Energy Spectroscopic Instrument (DESI for short)**

• **Pioneering Stage-IV Experiment**
  — recommended by Community DE report (Rocky-III, 2012).
  — should fill the gap between DES and LSST
  — on sky before Euclid

• **MS-DESI meets this goal**
  — scientifically ambitious enough to satisfy Stage IV criteria
  — At least $x10$ more galaxies than BOSS
  — technically advanced enough to be ready on 2018 time frame
  — will be a statistically limited
  — rich scientific program: incl. DE, inflation, neutrino mass hierarchy
MS-DESI Will Discriminate Between Dark Energy Models

Alternative Universes for constant $w$, $\Omega_m = 0.27$, and $\Omega_\Lambda = 0.73$

- SNe (binned)
- BOSS + SDSS (existing)
- MS-DESI (predicted)
MS-DESI science reach: BAO

Dark energy from Stage IV BAO

— Geometric probe with 0.3-1% precision from z=0.5 -> 3
— 35 measurements with 1% precision

MS-DESI BAO “Hubble diagram”

- MS-DESI
- WiggleZ BAO
- BOSS (in progress)
- SDSS-II + 2dF + 6dFGS BAO
- HST Key Project, 10% error
DESI Compared to Current/Future Surveys

![Graph showing Distance Scale Errors (dilation factor) for BOSS, eBOSS, DESI, and Euclid (50 mil.).]
## DESI Science reach: DE Figure of Merit

<table>
<thead>
<tr>
<th>Survey Size</th>
<th># Galaxy</th>
<th>Dark-time hours (KPNO)</th>
<th>BAO (galaxy + Ly-α) DE FOM</th>
<th>Add Power Spectrum DE FoM : MoG FoM</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSS</td>
<td>1.5M</td>
<td></td>
<td>21</td>
<td>22</td>
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<tr>
<td>MS-DESI 10K</td>
<td>17M</td>
<td>3750</td>
<td>104</td>
<td>149</td>
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<tr>
<td>MS-DESI 14K</td>
<td>24M</td>
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<td>MS-DESI 18K</td>
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<tr>
<td>MS-DESI 14K-HD</td>
<td>40M</td>
<td>8100</td>
<td>187</td>
<td>267</td>
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</table>

Table. All fits, Planck only. Broadband power for k < 0.1 h/Mpc. DE FOM is per DETF. MoG FoM = 1/(σγ * σG9). With power spectrum, DE FoM is marginalized over MoG parameters. Ref: P. McDonald
DESI - RSD Constraints on the growth of density fluctuations

From CF5 growth.pdf report
Terrestrial experiments measure $\Delta m^2$ of neutrino masses

→ **MS-DESI sensitivity is 0.017 eV, measured from power spectrum of galaxy map**

Terrestrial $\Delta m_{23} = 0.049$ eV (PDG 2011)

**Diagram:**
- $\Delta m_{12}$
- $\Delta m_{23}$
- $\Sigma m_\nu > 0.049$ eV (normal hierarchy)
- $\Sigma m_\nu > 0.098$ eV (inverted hierarchy)
- $\nu_e$, $\nu_\mu$, $\nu_\tau$
Broad Scientific Goals

Improvement over Planck + BOSS (normalized to 1.0):

- $\Delta m_{\nu} = 0.017\text{eV}$

Ref: P. McDonald (LBL)
The DOE Office of Science calls for a Mid-scale Dark Energy Spectroscopic Instrument (MS-DESI) experiment in September 2012.

The new instrument to be operated in the 2018 - 2022 time period and perform Stage IV dark energy measurements.

We have started the conceptual design phase of the project.

Completed science alternatives analysis
   — Received charge from DOE on Feb 14 to compare science reach for 4-m telescopes at Kitt Peak, Arizona and Cerro Tololo, Chile

DOE requested Mayall site from NSF as the preferred site
   — Mayall available with up to 100% of dark time, provides greater scientific potential.

Established reference concept

Conceptual design review scheduled for Jan, 2013
MS-DESI Reference Concept

- Scale up BOSS to a massively parallel fiber-fed spectrometer
- Stage-IV BAO and Power Spectrum, build upon BOSS
- Broad range of target classes: LRG’s, ELG’s, QSO’s
- Broad redshift range: $0.5 < z < 1.6$, $2.2 < z < 3.5$
- Sky area: 14,000 – 18,000 square degrees
- Number of redshifts: 20 – 35 million
- Medium resolution spectroscopy, $R \sim 3000 – 5000$
- Spectroscopy from blue to NIR
- Automated fiber system, $N_{\text{fiber}} \sim 4000 – 5000$

5000 fiber actuators

New 3° field-of-view corrector

New spectrographs

Mayall 4-m Telescope
New Corrector for the Mayall

- M. Liang (NOAO)
- f/3.6 (Mayall Primary is f/2.9)
- ~900kg glass (3.2°)
- Four fused silica lens elements
- Two elements have aspheres on one surface each (C2 and C3)
- Two ADC prisms (N-BK7)
- Foundation award to initiate corrector
DESI Instrumentation

fiber positioners in an array of precision holes in the focal plate
Actuator Development

- **Actuator competition**
  - LBNL (Swiss) brushless motor
  - IAA stepper motor
  - AAO piezo
  - USTC stepper motor

- **Initial results suggest all actuators should be able to meet XY targeting goals**
Industry RFP for first unit released June 4
Unit #1 funded by Moore Foundation
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<th>Current Institutions (and growing)</th>
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Conclusion

• MS-DESI will have a rich science program
  — scientifically ambitious enough to satisfy Stage IV criteria
  — rich scientific program: incl. DE, inflation, neutrino mass hierarchy
  — Expect to be in operation in 2018
• Mayall selected as preferred site
• Gordon and Betty Moore Foundation Award
  — Spectrograph RFP
  — Corrector glass limited-RFP in Fall
• Conceptual design review by DOE, Jan 2014.