Flexible Multi-Instrument Multi-Object Spectroscopy
Gregorian Fiber Positioner

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Moderate-multiplex $R>1000$ optical spectroscopy on large aperture telescopes is a critical enabling technology for many frontier scientific programs.

Spectroscopic follow-up of targets from medium- to large-scale imaging surveys to obtain
- Redshifts
- AGN identification
- Supernova type and monitoring

Large-scale sample measurement
- Abundances of galactic and local-group halo stars
- Stellar pops, abundances, & masses in galaxies
- Black hole mass estimates in AGN
- Galaxy cluster membership determination
- Cosmic structure studies.

Identified as a key “workhorse” capability for 8-10m class telescopes for all areas of astrophysics by the recent NSF Portfolio Review.
Case Study: A Multi-Fiber Augmented MODS

Current MODS configuration:
  5 arcminute diameter primary field-of-view
  R=2000 Grating, R=200 Prism
  Grating-mode multiplex: ~20-30 targets
  Prism-mode Multiplex: ~50-60 targets

Full Direct-Gregorian Field:
  ~0.2-degree diameter unvignetted FoV
  Excellent seeing-limited image quality

R=2000 on 8.4m telescope
  Extragalactic: ~3000 targets/deg$^2$/mag at $i=21$
  In full DG field, ~400 targets per field at $i=21$

Even full DG presents us with a very “target-rich” environment.
Replace MODS by a revolver mechanism carrying up to 6 pre-plugged full fiber plates.

Feed fibers to MODS or another spectrograph.

Also proposed considering a robotic fiber positioner.
Wide-Field Moderate-Multiplex Spectroscopy

Two Performance Metrics defined by DESI (ex-BigBOSS) project:

Spectrographic Efficiency:

\[ \varepsilon = (\text{Aperture})^2 \times N_{obj} \times \eta \]

Sky Mapping Efficiency:

\[ \mu = (\text{Aperture})^2 \times \text{FoV} \times \eta \]

Normalized to SDSS/BOSS having \( \varepsilon = \mu = 1 \)

<table>
<thead>
<tr>
<th></th>
<th>( \varepsilon )</th>
<th>( \mu )</th>
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<tbody>
<tr>
<td>DESI</td>
<td>14.6</td>
<td>2.9</td>
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<tr>
<td>Current MODS</td>
<td>0.4</td>
<td>0.03</td>
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<tr>
<td>W-F Fiber MODS</td>
<td>6.4</td>
<td>0.48</td>
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AAO Star Bug Fiber Positioner

Gilbert et al. SPIE 2012, 8450

Mini, self-propelled piezo-electric robots.

Crawl on protected side of a glass field plate with LBT DG 1055mm radius of curvature.

But units could be single fibers, object/sky pairs, or multi-fiber IFU bundles.

1-3 minute configuration.
Enabling Technology: Fiber Gang Connector

Developed for APOGEE for SDSS

Allows simultaneous plug/unplug of fibers, even during a night.

Could serve multiple instruments and science modes with the same fiber positioner facility on the telescope.
A pathway to creating a moderate-multiplex fiber spectroscopic capability for the LBT

Fiber feed technologies?
  Choice of Fiber Positioner Technology
  Focal Coupling Schemes
  Connectorization from Direct Gregorian to Spectrograph
  Type of Fiber (low-OH “dry” FuSi, Fluorite for IR)?

Spectrograph to Use?
  Suitability of MODS (UV to Near-IR R=100 to 2000/ 8000)
  APOGEE Clone (0.8-2.5µm Near-IR R=10,000?)

Operational Issues:
  Fiber Positioning Configuration Efficiency?
  Instrument Setup and Night-Time Utilization?
Technology Development Roadmap

Phase 1: Lab Prototyping and Positioner Evaluation
   2014 – 2015:
   Cost: $45K (Hardware, Travel)
   OSU contributes prototype design and fabrication
   Outcome: NSF proposal in 2015

Phase 2: Demonstrator Project
   few $100K NSF ATI proposal, 2-3 years
   ~20-fiber telescope demonstrator: DG to MODS on floor

Phase 3: Full Binocular Fiber Facility (and Instrument?)
   few $M NSF MSIP proposal
   4-5 year development to deploy
   New feed instrument: APOGEE clone? Other?