Apache Point Observatory
Sunspot, New Mexico

Suzanne L. Hawley
University of Washington
Director, ARC 3.5m Telescope
Apache Point Observatory

- 2.5m SDSS
- 0.5m NMSU
- 1m PT
- 3.5m ARC
Astrophysical Research Corporation (ARC) Partner Institutions

- University of Washington (25.0%)
- University of Chicago (17.0%)
- Princeton University (15.6%)
- New Mexico State University (15.6%)
- University of Colorado (12.5%)
- Johns Hopkins University (8.0%)
- University of Virginia (6.3%)
ARC 3.5m Telescope

• 3.5m borosilicate primary mirror from Arizona Steward Observatory Mirror Lab
• Alt-az telescope mount, used mostly at f/10 Nasmyth ports, NA1 and NA2
• NA1 has permanently mounted echelle spectrograph
• NA2 has instrument rotator, several instruments (optical and near IR)
• Quick change capability (15 min)
• Scheduled in half nights, most observing is remote by University partners using TUI (Telescope User Interface) software
Echelle Spectrograph

- R = 30,000
- Full wavelength coverage from 3500-9800A
- V~15 in one hour (S/N=10)
- Remote operation with TUI
Dual Imaging Spectrograph (DIS)

- Blue and red channels split by dichroic at 6000Å, observe both simultaneously
- High (R=5000) and low (R=1000) resolution
- $V \sim 20$ in one hour ($S/N=10$)
- Remote operation with TUI
Optical Imaging Camera (SPIcam)

- 2048x2048 CCD, 7.5’x7.5’ FOV
- UBVRI, ugriz, many narrow band filters
- V~22 in 5 min (S/N = 10)
- Operated remotely with linux interface
Near Infrared Camera (NIC-FPS)

- Newest instrument, (December, 2004) built by U. Colorado
- 1024x1024 HAWAII-1RG detector gives 4.5’x4.5’ FOV
- ZJHK + narrow band filters
- J~20 in 5 min (S/N=10)
- Remote operation with TUI
Goddard Fabry-Perot Spectrograph

- High resolution narrow band imaging
- Permanent Visitor instrument, Bruce Woodgate (NASA)
- Possible to operate remotely
Near Infrared Spectrograph (TripleSpec)

Being built by Univ. Virginia (with Cornell, Caltech)

Planned to Arrive at APO Spring 2007

R=3000, JHK spectral regions simultaneously
3.5m - New instruments

- High speed photometric camera - copy of successful Texas instrument (U. Washington)
- High resolution near-IR spectrograph (U. Florida)

Both relying on individual PI-led NSF grants
Telescope User Interface (TUI)
APOLLO Lunar Laser Ranging

- Fire laser at the moon through the 3.5m
- Send $10^{17}$ photons in short bursts, receive 10 back (reflected off retro-reflectors left by APOLLO astronauts)
- Calculate distance to the moon from timing information
- Improve accuracy from 2cm to 1mm
- Tests of General Relativity, Equivalence Principle
APO 3.5m Attributes

- Flexible scheduling - half nights, rapid followup, target of opportunity, long term monitoring programs, survey followup (SN)
- Fast instrument changes - all instruments available every night
- Remote observing - reduces costs, improves efficiency, allows ToO access
- Graduate student training and access
- Opportunities for university instrumentation groups, innovative programs
APO 2.5m - SDSS

• 5 color (ugriz) imaging
• 2 spectrographs with 320 fibers each
• Survey North Galactic Cap (10,000 sq deg)
• SDSS-I complete, DR5 now public
• SDSS-II underway (finish main survey, SEGUE, Supernovae)

Excellent example of private-public partnership, access to US telescope system
**ADS High-Impact Papers 2006**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Number of Citations</th>
<th>Fraction of the Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDSS</td>
<td>1843</td>
<td>17.4%</td>
</tr>
<tr>
<td>ESO</td>
<td>1365</td>
<td>12.9%</td>
</tr>
<tr>
<td>HST</td>
<td>1124</td>
<td>10.6%</td>
</tr>
<tr>
<td>WMAP</td>
<td>1121</td>
<td>10.6%</td>
</tr>
<tr>
<td>Keck</td>
<td>642</td>
<td>6.0%</td>
</tr>
<tr>
<td>Kamiokande</td>
<td>372</td>
<td>3.5%</td>
</tr>
<tr>
<td>Chandra</td>
<td>365</td>
<td>3.4%</td>
</tr>
<tr>
<td>ACBAR</td>
<td>207</td>
<td>2.0%</td>
</tr>
<tr>
<td>NOAO (KPNO/CTIO)</td>
<td>202</td>
<td>1.9%</td>
</tr>
<tr>
<td>Las Campanas</td>
<td>176</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

(Bob Williams, statistics compiled for HST)
Take home message:

• Surveys are an important part of the telescope system, provide wide access for all parts of the community

• Medium-sized telescopes important for rapid and flexible access, survey followup, training, etc.

• Instrumentation is on the ragged edge, not well addressed by TSIP or PREST for 2 - 5m telescopes
Followup of SDSS Discovery

SDSS discovery image shows luminous red galaxy (z=0.38) and blue arc

APO 3.5m imaging reveals 4 lensed images of background Lyman break galaxy at z=2.73. Brightest LBG known by > 1 mag.

Sahar Allam (FNAL) press release Nov 06, astro-ph/0611138
Same half night - obtained APO 3.5m spectra of lensed images to find redshift, confirm LBG
## ADS High-Impact Papers 2005

<table>
<thead>
<tr>
<th>Facility</th>
<th>Number of Citations</th>
<th>Fraction of the Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMAP</td>
<td>1892</td>
<td>24.9%</td>
</tr>
<tr>
<td>SDSS</td>
<td>848</td>
<td>11.2%</td>
</tr>
<tr>
<td>Keck</td>
<td>562</td>
<td>7.4%</td>
</tr>
<tr>
<td>ESO</td>
<td>549</td>
<td>7.2%</td>
</tr>
<tr>
<td>HST</td>
<td>466</td>
<td>6.1%</td>
</tr>
<tr>
<td>Chandra</td>
<td>380</td>
<td>5.0%</td>
</tr>
<tr>
<td>Kamiokande</td>
<td>324</td>
<td>4.3%</td>
</tr>
<tr>
<td>2MASS</td>
<td>250</td>
<td>3.3%</td>
</tr>
<tr>
<td>XMM-Newton</td>
<td>185</td>
<td>2.4%</td>
</tr>
<tr>
<td>CBI</td>
<td>149</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
The NMSU 1m Telescope

- Owned by New Mexico State University
- Robotic Operation
- 2048x2048 (15’ x15’ FOV) CCD imaging camera
- High speed photometer under construction
- Used mostly for variability studies
The 0.5m SDSS Photometric Telescope (PT)

- Automatic operation
- CCD imaging camera
- Observes standard star fields for SDSS calibration
- Used on all photometric nights