

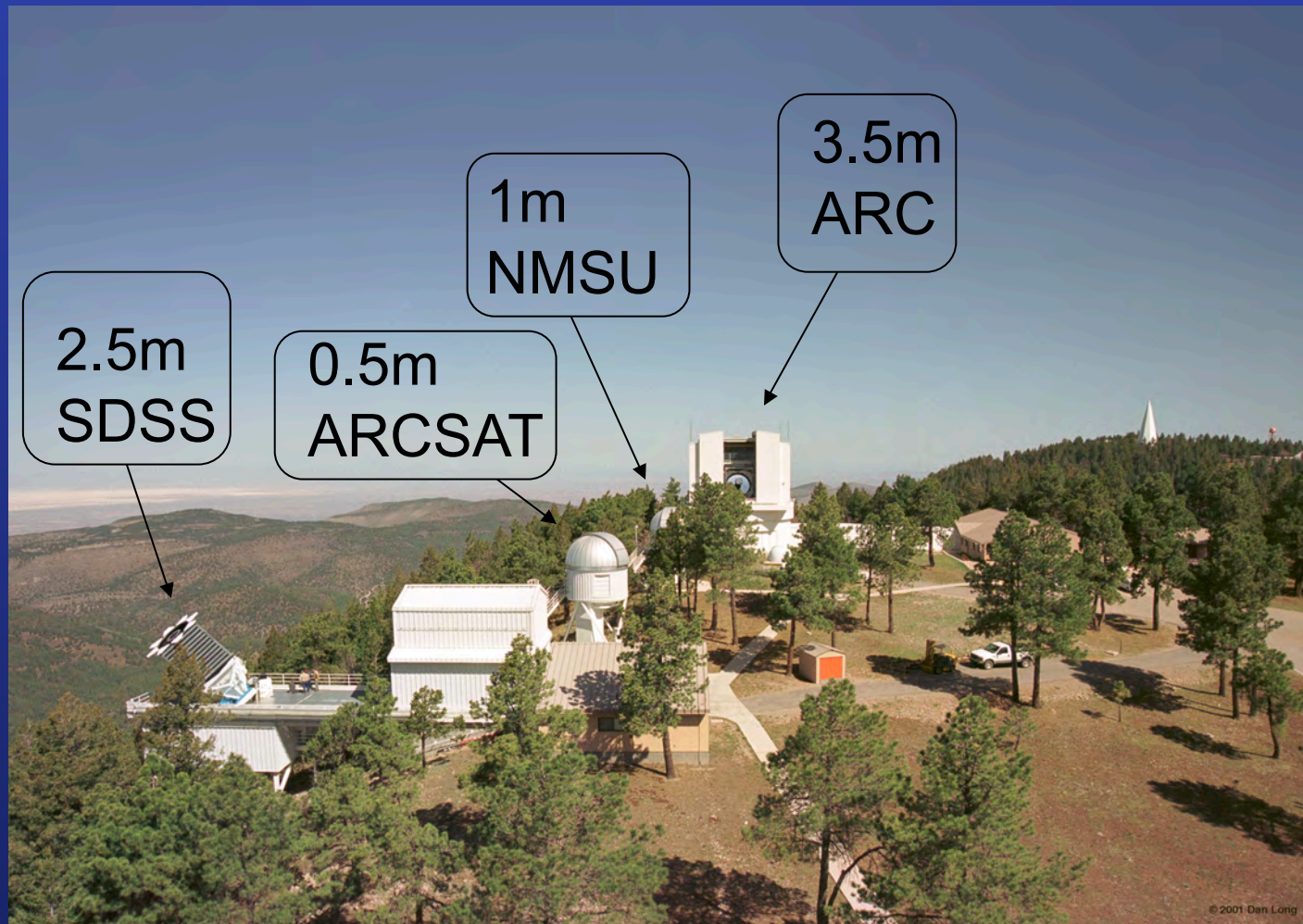
# ARC 3.5m Telescope Apache Point Observatory

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For more information: <http://www.apo.nmsu.edu>

# Apache Point Observatory



# Astrophysical Research Consortium (ARC) Partner Institutions (2012)

- 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%)



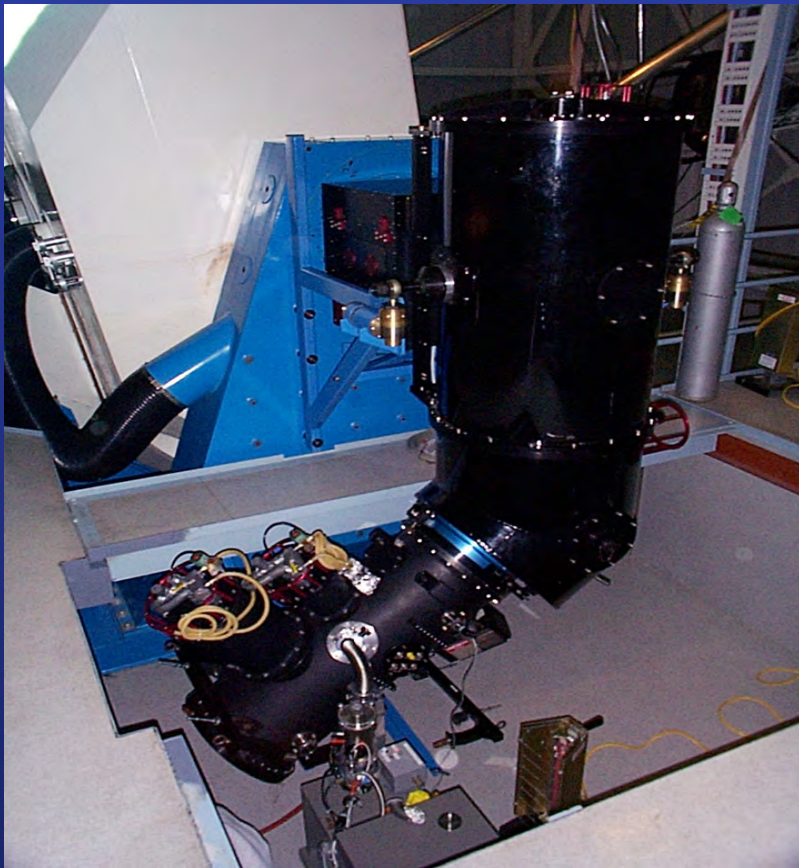


# ARC 3.5m Telescope

- 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, 90% of observing is remote by University partners using TUI (Telescope User Interface) software

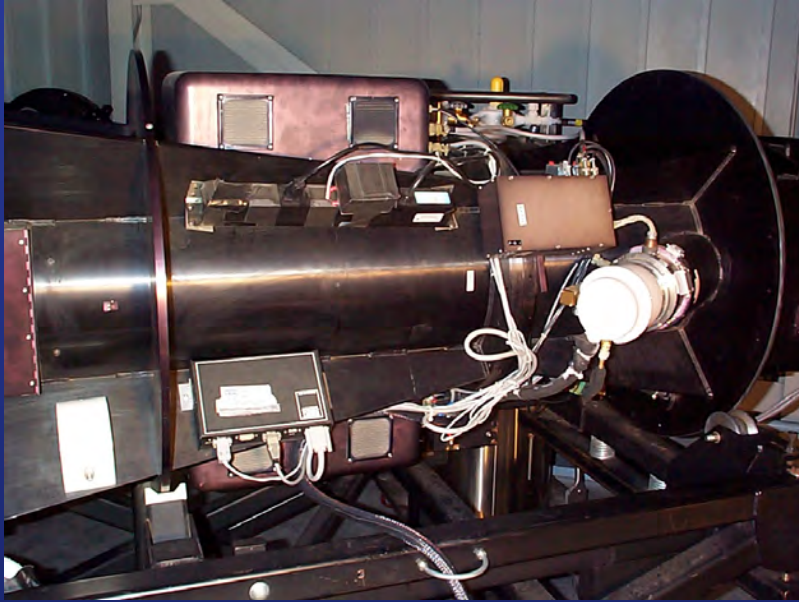


# Echelle Spectrograph



- $R = 30,000$
- Full wavelength coverage from 3900-9800Å
- $V \sim 15$  in one hour (S/N=10)
- Single object

# 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 ( $S/N=10$ )
- Long slit (6') and some multi-slit capability

# Optical Imaging Camera (SPIcam)



- 2048x2048 CCD,  
4.7'x4.7' FOV
- UBVRI, ugriz, many  
narrow band filters
- $V \sim 22$  in 5 min  
(S/N = 10)



# Near Infrared Camera (NIC-FPS)



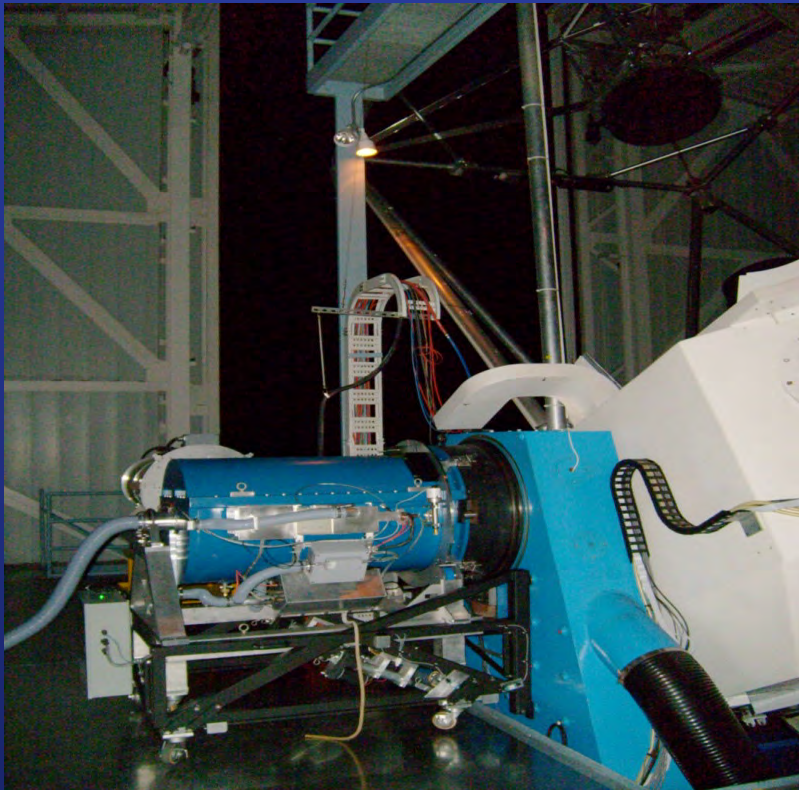
- 1024x1024 HAWAII-1RG detector, 4.5'x4.5' FOV
- ZJHK + many narrow band filters
- J~20 in 5 min (S/N=10)

# High Speed Photometric Camera (Agile)



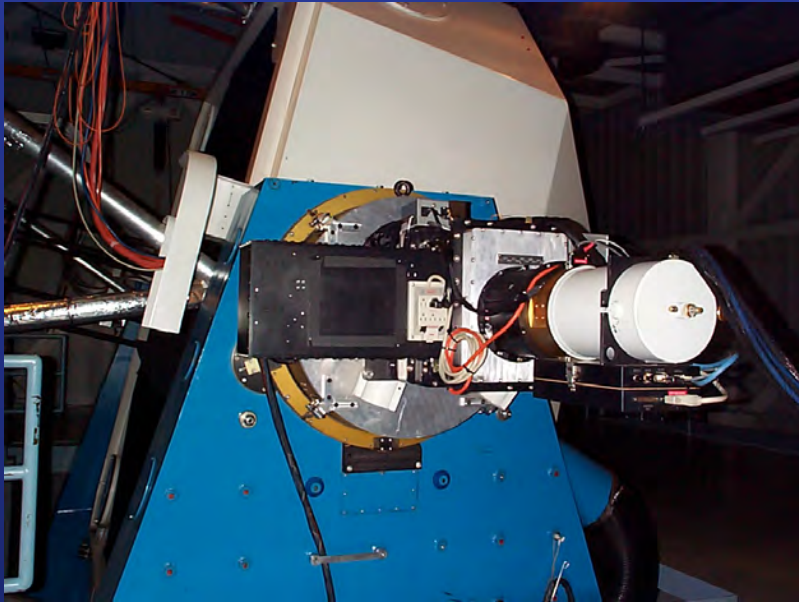
- Dedicated port, always available (planetary transits)
- Blue sensitive frame transfer camera, 0.5 sec time resolution, 2.5' FOV
- Can use same filters as SPIcam
- $r \sim 19$  in 15 sec (S/N=10)

# Near Infrared Spectrograph (Triplespec)



- 2048x1024 HAWAII-II detector
- Integral K-band slitviewer
- $R=3500$ , cross-dispersed, obtain JHK spectra simultaneously
- $J \sim 15$  in 30 min (S/N=10)

# Goddard Fabry-Perot Spectrograph



- High resolution narrow band imaging
- Permanent Visitor instrument
- Usage in collaboration with Bruce Woodgate (NASA)



# 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

# Telescope User Interface (TUI) remote observing software

The screenshot displays the Telescope User Interface (TUI) software with several panels open:

- Message:** A chat window showing a conversation between users. The text includes: "07:24:27 PU04:strauss: When you refocused, did you still conclude that seeing was about 1.1"?", "07:25:32 APO:Russet: When did I say 1.1? I got 0.86 arcsec at alt 60, 0.73 at alt 80, 1.15 at alt 40.", "07:25:52 APO:Russet: So the 0.86 should hopefully be representative.", "07:26:13 PU04:strauss: OK, I guess I mis-heard you. That's great!", "07:26:52 APO:Russet: Oh, you're still using NFS=1. Might not be significant for this integration time, though.", "07:27:52 APO:Russet: The only bright star in your current field is soft-saturating, so I can't really measure seeing but I can keep an eye on focus.", "07:31:32 APO:Russet: Clouds.", "07:32:29 PU04:strauss: I thought I had changed it to zero. Maybe I didn't hit the 'apply' button.", "07:32:39 PU04:strauss: Clouds, eh?", "07:33:53 PU04:strauss: I wonder if I can ask your help with something. This is a brand-new mac I'm using, and I don't have ds9 up and running yet. I wonder if you can take a look at the first few images, and tell me if we're having any trouble with over-exposing the sky. Definitely a concern if the clouds are problematic.", "07:34:30 APO:Russet: As I recall, the dynamic range on my focus star was 20K for the first few images. But let me
- Status:** A panel showing telescope parameters for object SA95\_74. It includes RA (3:55:31.00 hms), Dec (-0:09:13.00 arc), CSys (FK5 J2000.0), and other data like HA, LMST, UTC, Az, and Alt.
- Sky:** A star chart showing the current field of view with a red dot indicating the target position. The coordinates are SA95\_74 3:55:31.00, -0:09:13.00.
- Focal Plane:** A diagram of the focal plane showing the NICFPS camera position and orientation.
- Offset:** A panel for setting offsets in RA and Dec. It shows RA offset at -60 arc and Dec offset at 60 arc.
- Slew:** A panel for setting slew parameters, including Name (SA95\_74), RA, Dec, CSys, Rot, Az, and Alt.
- NA2 Guider:** A panel for the guider, showing a live image of the star field with a pink crosshair. It includes a "Hold" button and a "Choose..." button.
- NICFPS Expose:** A panel for the camera's exposure settings, including Seq Status, Exp Status, User, Comment, Prefs, Type, Time, #Exp, File Name, and Comment.
- NICFPS:** A panel for the camera's configuration, including Filter (MK-J), Slit (Out), Etalon (Unknown), Detector, Window, Image Size, and Environment (OK).

# APO Facilities

- Dormitories, kitchen, observing room, instrument lab, machine shop, operations building, staff offices
- SDSS (2.5m), NMSU (1m), ARC SAT (0.5m) telescopes
- ~20 staff (engineering, software, observing support, administrative)
- Located ~ 1 mile from National Solar Observatory site at Sacramento Peak

# Scientific Productivity

- ~ 500 papers in refereed journals
- ~ 30 PhD theses
- ~ 200 graduate and undergraduate students trained to observe
- Major followup resource for SDSS
- Many ground-based campaigns simultaneous with satellite observations (e.g. HST, Chandra)
- Numerous ToO and time domain programs



# Summary of APO 3.5m Attributes

- Efficient, low-risk, low-cost, fully functional telescope with large suite of instruments and very low downtime (<1% per year for past 4 years). Our primary goal is that users get good data, every night!
- Flexible scheduling - half nights, rapid followup, target of opportunity, long term monitoring programs, surveys
- Fast instrument changes - all instruments kept cold and available every night
- Remote observing - reduces costs, improves efficiency, easy to use, good documentation
- Graduate student training and access
- Opportunities for university instrumentation groups, innovative programs (e.g. APOLLO laser ranging)