Laser Guide Star Operations at W. M. Keck Observatory

Bob Goodrich, Observing Support Manager
Randy Campbell, AO Operations Lead
Introduction

• Background and history
• Organization
• Safety challenges
• Looking to the future
Laser Guide Stars

• Create an artificial “star” in the thin layer of sodium atoms 90 km above the Earth’s surface

• Allows AO in 95% of the sky, rather than the 2% near a bright star.

• Converts IR astronomy to an active experiment; implies changes to operations.
Center of Our Galaxy
Science Productivity

![Graph showing the number of papers published each year from 1995 to 2012 for different observatories.]

- Robo-AO
- Subaru
- Palomar
- VLT
- Gemini-N
- Lick
- Keck II
- Calar Alto
- Starfire

Number of Papers (219 total)

Year of Publication

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Keck AO Time Line

- 1998: Laser Delivery Keck Headquarters
- 1999: NGSAO Science Operations
- 2001: NIRC2
- 2003: First Closed Loop Tests On Sky
- 2004: LGSAO Science Operations
- 2005: OSIRIS
- 2005: Transition Team
- 2007: Wavefront Controller Upgrade
- 2007: AO Ops Team
- 2010: Keck I Laser First Propagation on sky
- 2010: Free Space Transport
- 2012: OSIRIS Science On Keck I
- 2013: TBAD Approval

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LGS-AO Transition Team

- Elements of operations and development groups
- Clear expectations for handover
- Clear training expectations
- Development team “service” after commissioning
- Operated strongly for one year, plus some cleanup in the second year
AO Operations Team

• Took over where the Transition Team ended
• Led by Randy Campbell, our most senior Support Astronomer
• Includes AO Support Astronomers, AO Specialists, and engineers
• AO development team mostly on-site
• Continual upgrades based on operational experience
Science

**Efficiency**
- Automation
- Scripts
- Flexibility

**Observers**
- Feedback on observing experience
- Advice on improvements
- Help characterizing the system

**Reliability**
- Closed-loop dye system
- New lasers

**Performance**
- Nightly system checkout
- Advanced training

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Coordination with External Agencies

- Other Mauna Kea observatories
- Civilian aircraft
- Military aircraft
- Satellites
Other Observatories

- Our laser beam can contaminate visible-light observations of other telescopes.
- LTCS (Laser Traffic Control System): calculates the geometry of participating telescopes to look for and predict “collisions.”
- We are moving from “laser always gives way” to “first on target.”
Civilian and Military Aircraft

• Coordinate with the U.S. FAA (Federal Aviation Administration)
  – Human aircraft spotters
  – Last month, we received “permission” to replace humans spotters with a transponder-based system. (see next slides)
  – Note: *no* all-sky camera

• Coordination with military flights
  – Local military training base sometimes hosts night-time flight operations
  – We provide details about our operational cone
TBAD: Transponder-Based Aircraft Detection

- Passive antennae (wide-field + narrow-field) listen for aircraft transponders
- The ratio of signal strength tells whether the aircraft is in the narrow beam.
- Advantages: never gets sleepy, always pointed the same as the laser, a sophisticated fail-safe configuration.

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TBAD PI: Tom Murphy, UCSD
Satellites

• Laser can damage visible-light detectors on downward-looking satellites.

• Coordination with U. S. Strategic Command
  – We send them our list of targets, they tell us when during the night we are not allowed to lase at each target position (typically 10–30 seconds).
  – Excellent working relationship; processing highly automated on our end.

• Disadvantages
  – hard to add a target at the last minute
  – requires better tactical planning during the night
  – “blanket closures” prevent all LGS observing.
Time Domain Astronomy

• Currently only during scheduled LGS-AO nights
  – Scheduling human spotters
  – Coordination with U. S. Strategic Command
  – K2 laser warm-up and checkout, but...

• Enabling technologies for more flexibility
  – TBAD
  – New lasers
  – A deployable tertiary mirror on Keck I
Conclusions

• Complex, costly systems that benefit greatly from interaction between operations and development groups
• Transition and operations teams to optimize operational aspects
  – Tools developed specifically from operational experience
• Cooperation with external agencies is crucial