Remote Observing at UCO/Lick Observatory (Part 2)

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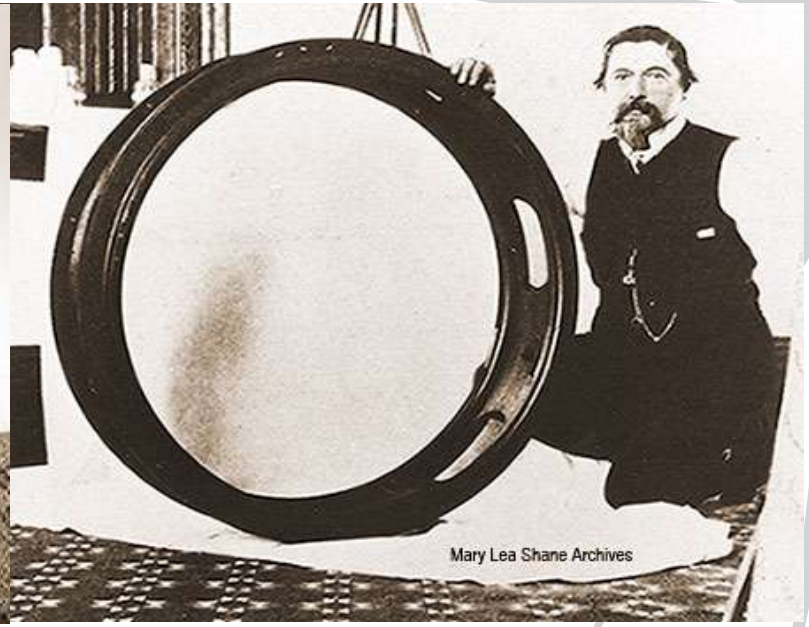
Outline of Presentation

- Background: Lick, UCO, and Keck
- Keck remote observing from Waimea
- Remote observing from home institution:
  - Motivation & goals
  - Obstacles
  - Networks and protocols
  - Operational experience & usage statistics
  - Future plans
- Conclusions

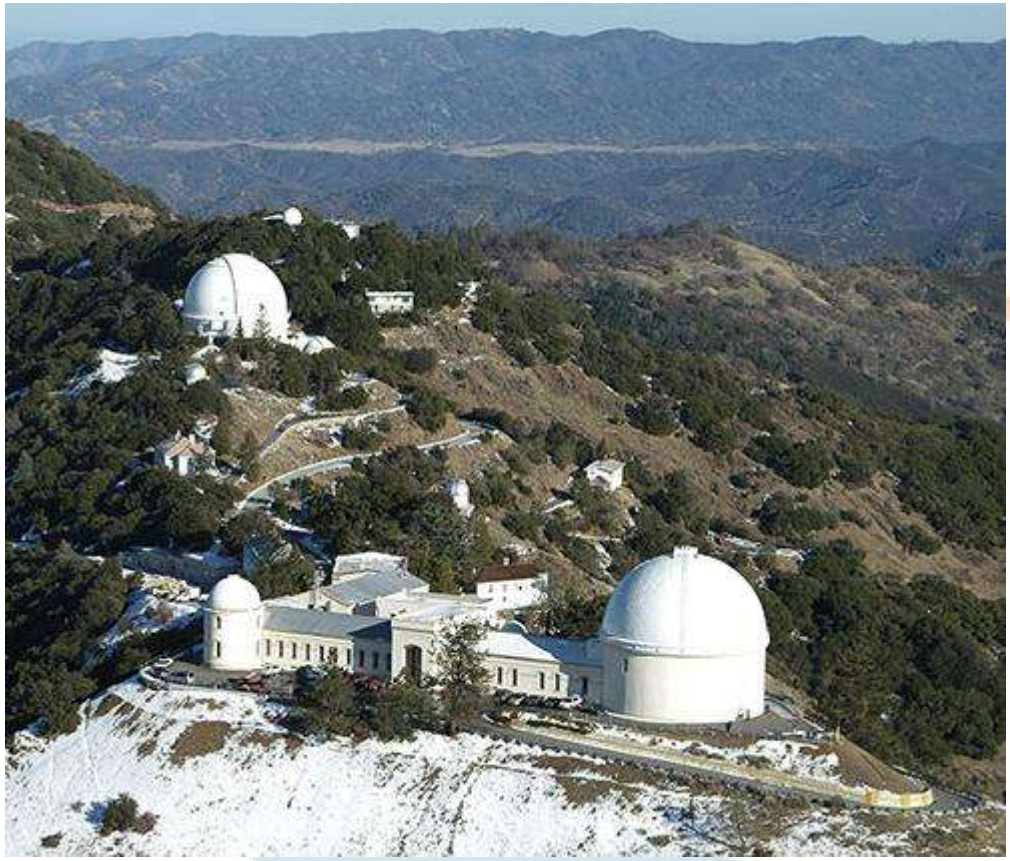
Lick Observatory, Mt. Hamilton, California (1888)

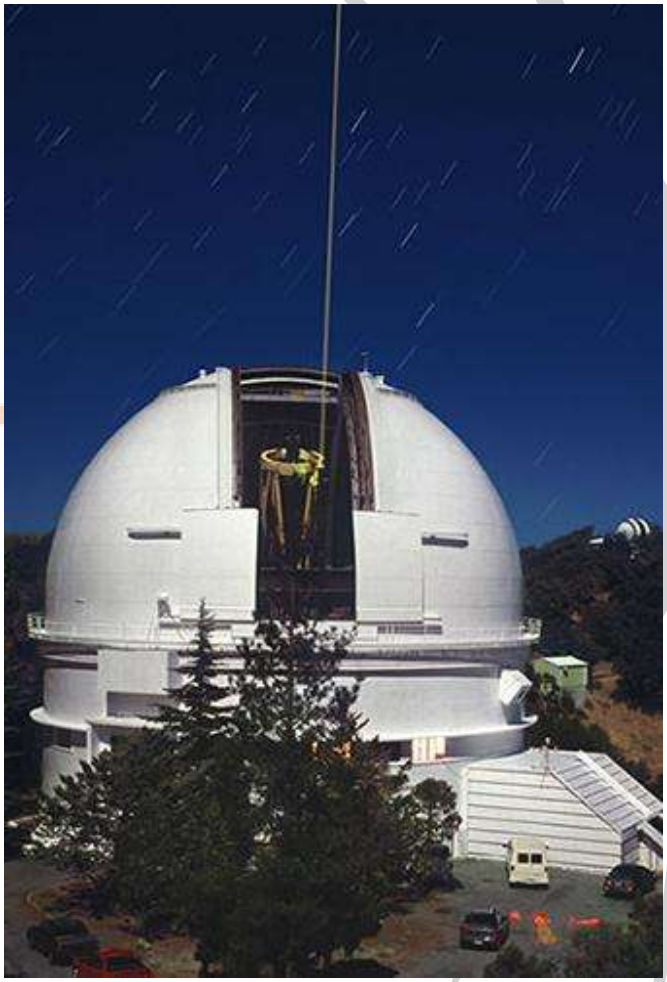
- 1st mountaintop observatory
- World's largest telescope (36-inch lens)
- UC's first scientific research facility



Lick Observatory, Mt. Hamilton, California (2008)

- 120th Anniversary



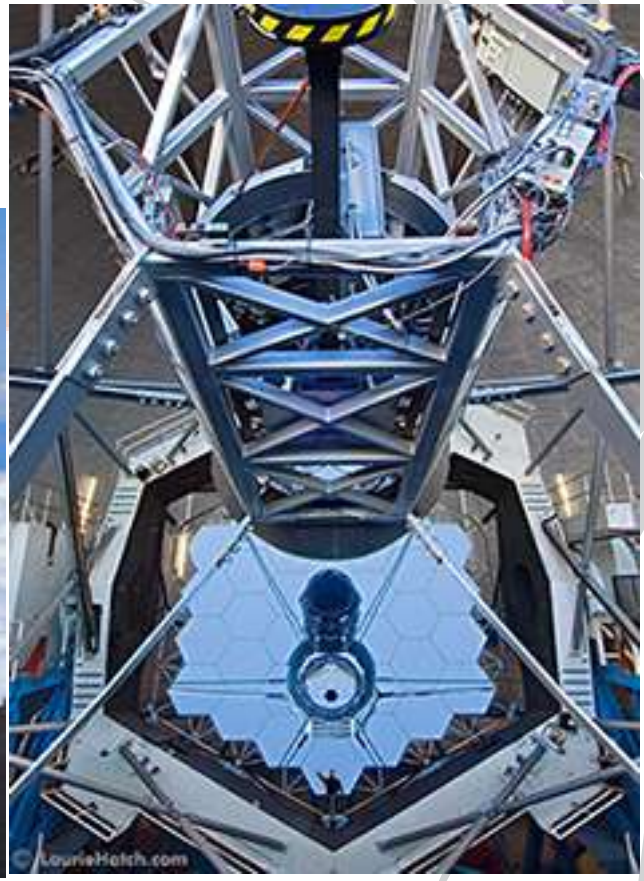


University of California Observatories (1988)

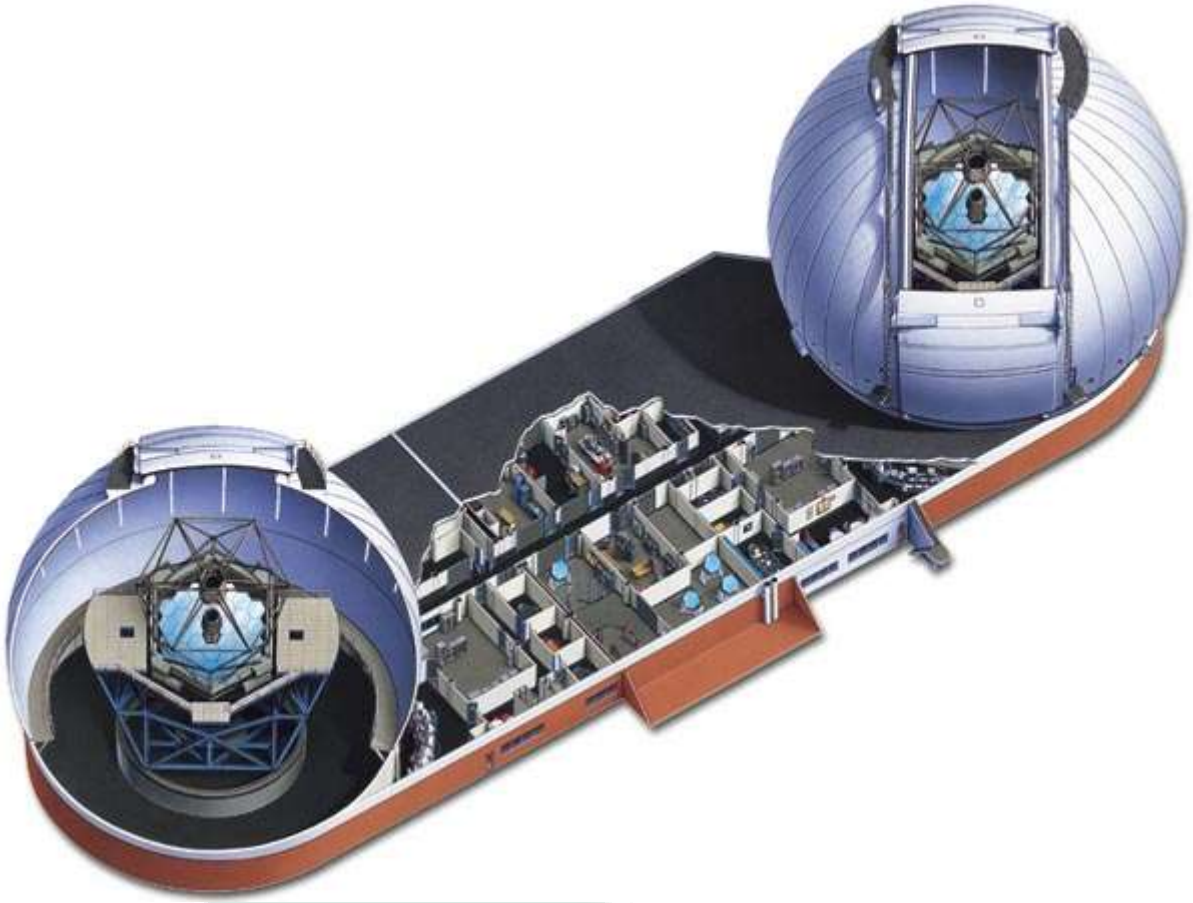
- Multi-campus research unit (MRU)
- Established in 1988
- Headquarters at U.C. Santa Cruz
- Oversees:
  - Lick Observatory, Mt. Hamilton
  - UC component of the Keck Observatory
- Designs & builds instruments for both
- Coordinates remote observing programs

W.M. Keck Observatory, Mauna Kea, HI (1993)

- World's largest telescopes
- Summit altitude is 13,796'



1993-1995: Keck observers work from Mauna Kea summit



Challenges of working at the summit

- Oxygen 60% of that at sea level
- Reduced alertness
- Observing efficiency impaired
- Altitude sickness
- Other health issues
- Extreme weather

W.M. Keck Observatory HQ, Waimea, HI

- Headquarters at lower altitude in Waimea
- Remote observing from HQ starting in 1996
- More oxygen
- More alert

Remote observing from Waimea

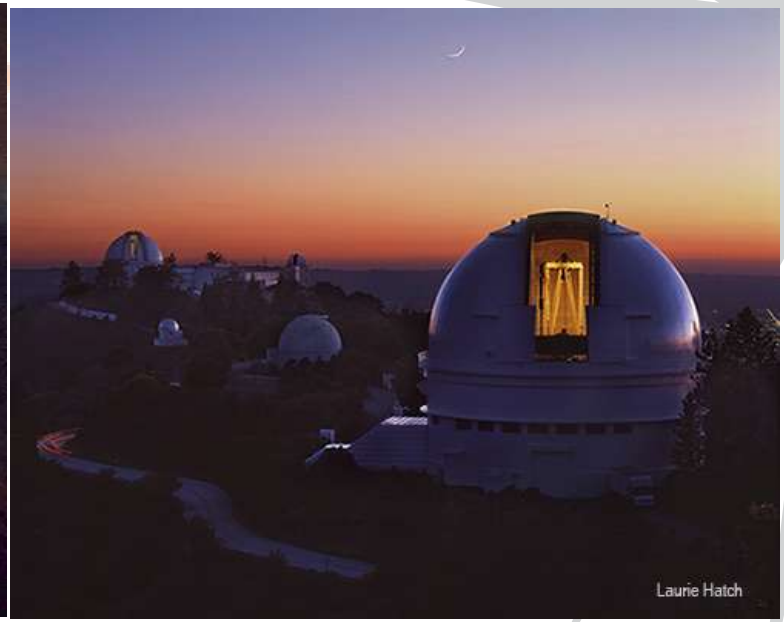
- At the summit:
  - Telescope operator runs the telescope
  - Operational software runs on summit hosts
  - Instrument data written to summit disks
- Astronomers in Waimea:
  - Access summit software applications via X
  - Access instrument data on summit via NFS
- Sites linked via H.323 video conferencing

Summit to Waimea link history

- 1995: T1 link installed (1.5 Mbps)
- 1996:
  - Keck 1 remote observing operational
  - Keck 2 observing from summit commences
- 1997: Link upgraded to DS3 (45 Mbps)
  - 50% of Keck 1 observing done from Waimea
- 2000: Waimea is default for Keck 1 & 2
- 2007: Link upgraded to GigE (1000 Mbps)

Remote observing from the observer's home institution

- Keck Telescopes, Mauna Kea
- Lick Telescopes, Mount Hamilton



Keck Observatory Observers

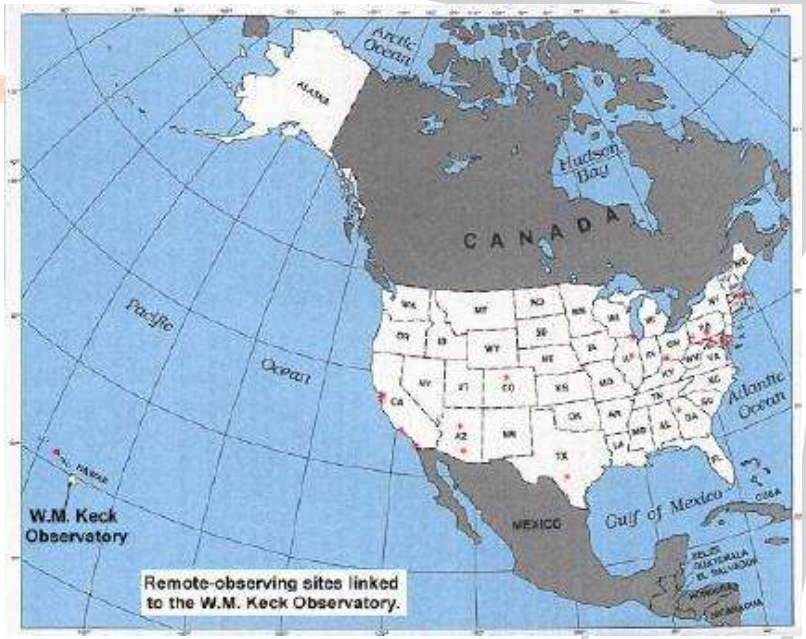
- UC, CIT, UH, and NASA all share Keck
- Most Keck observers reside on mainland
- Prior to 2001: All Keck observers fly to HI
- Collective direct travel costs > $400K / yr.

Keck remote observing from observer's home institution

- Motivation:
  - Round trip travel time to Hawaii is 2 days
  - 50% of observing runs last 1 night or less
  - Travel costs ~ $1,000 per observer
- Goals
  - Provide equivalent capabilities from California
  - Remote access to Keck support staff
  - Keep it simple

Distance from telescope to remote site

- Keck HQ in Waimea, HI: 32 km.
- Typical California site: 3200 km.



Obstacles & Solutions

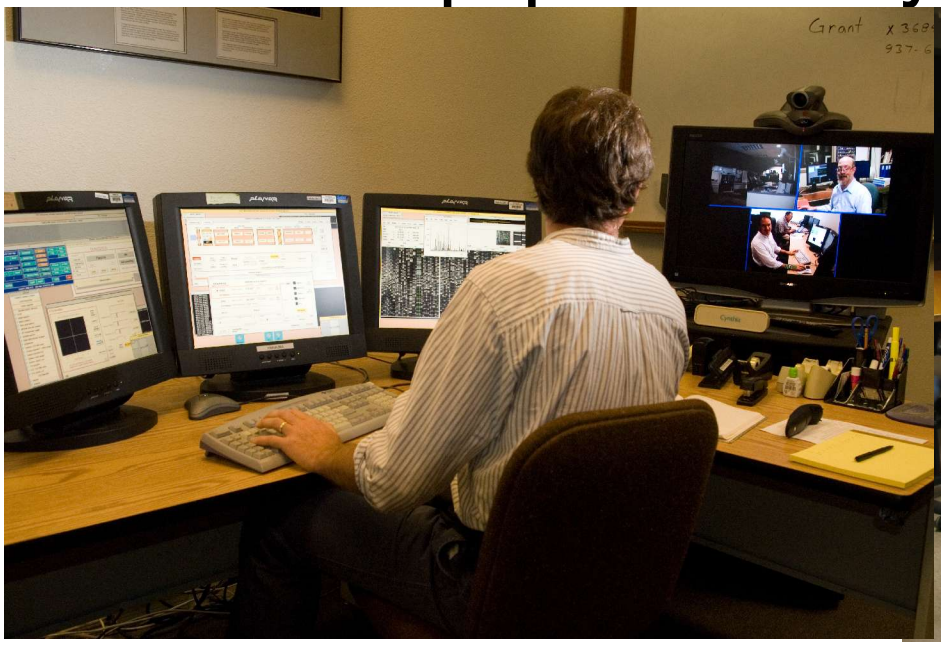
- Obstacles:
  - Bandwidth bottlenecks
  - 60 to 90 ms. round trip time (bad for X)
  - **Fear of network interruptions**
- Solutions:
  - Upgrade bandwidth of critical links
  - Use VNC rather than X protocol
  - TCP tuning
  - Provide ISDN-based fallback path

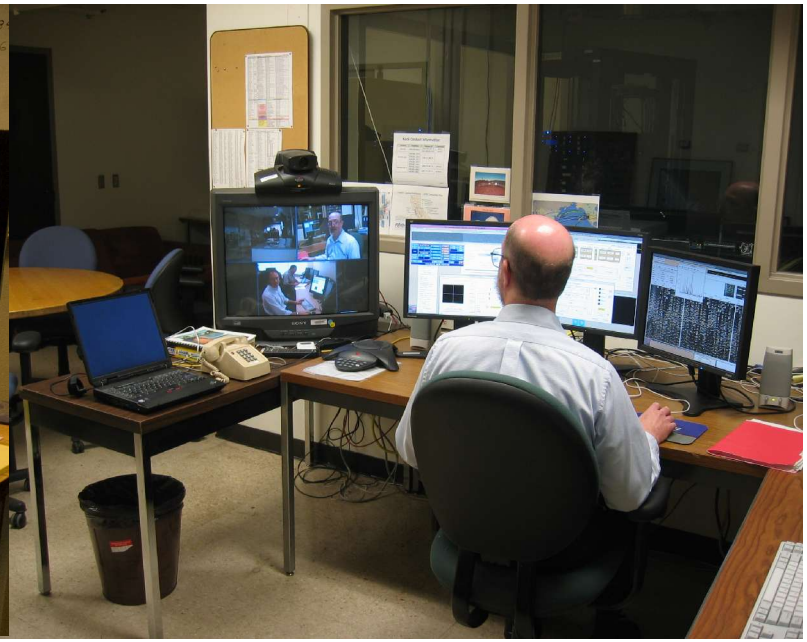
Hawaii to California link history

- 1997: 1.5 Mbps Hawaii to Oahu
- 1998: 10.0 Mbps Oahu to mainland
- 1999: 45.0 Mbps Internet-2 to Oahu
- 2000: 45.0 Mbps Mauna Kea to Oahu
- 2001: ISDN fallback path to Mauna Kea
- 2002: 155.0 Mbps Oahu to mainland
- 2007: 1000.0 Mbps Mauna Kea to mainland

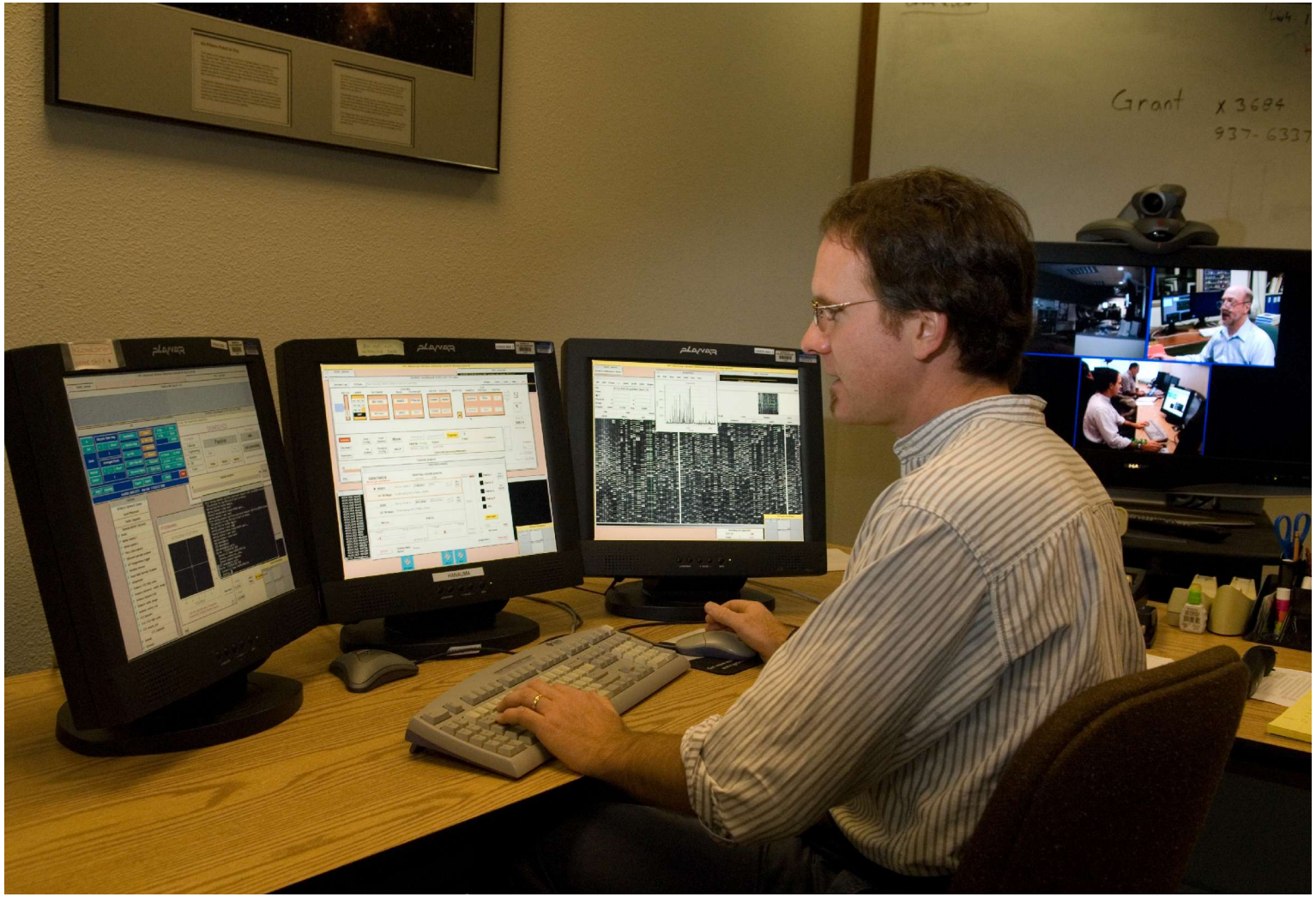
Key collaborative tools

- Video conferencing
- Multiple shared VNC desktops
- Similar equipment / layout at each site





Multiple shared desktops



Similar layout at each site

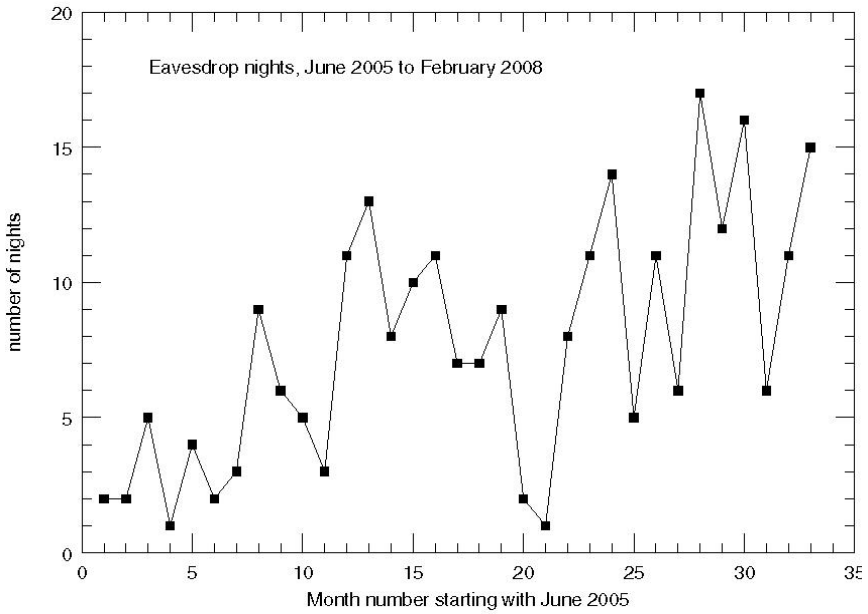
Video conferencing is key

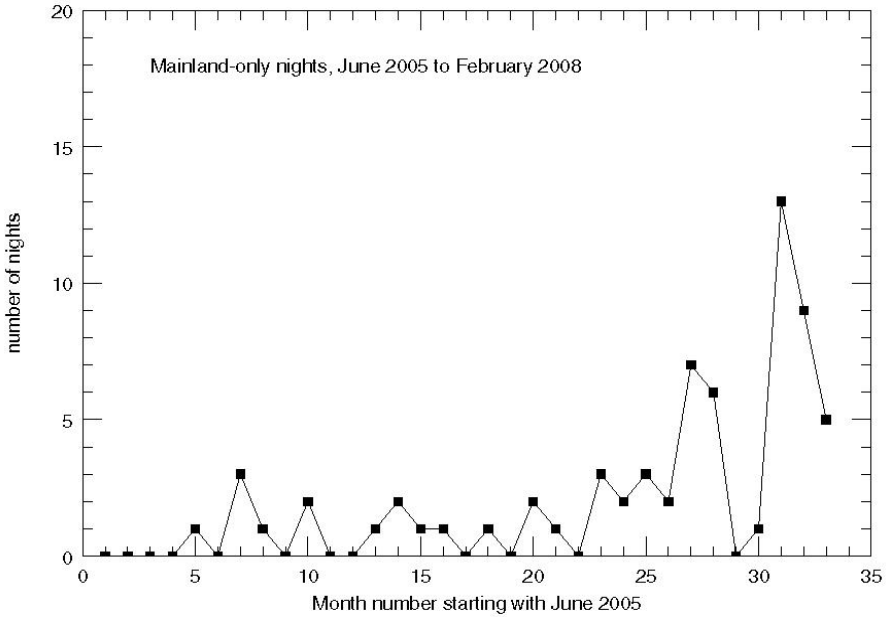
California sites providing Keck remote observing

- UC Santa Cruz (2001)
- Caltech (2002)
- UC San Diego (2003)
- LBNL (2005)
- UC Los Angeles (2006)
- UC Berkeley (2007)
- *UC Santa Barbara (2007)
- *UC Riverside (4/2008)

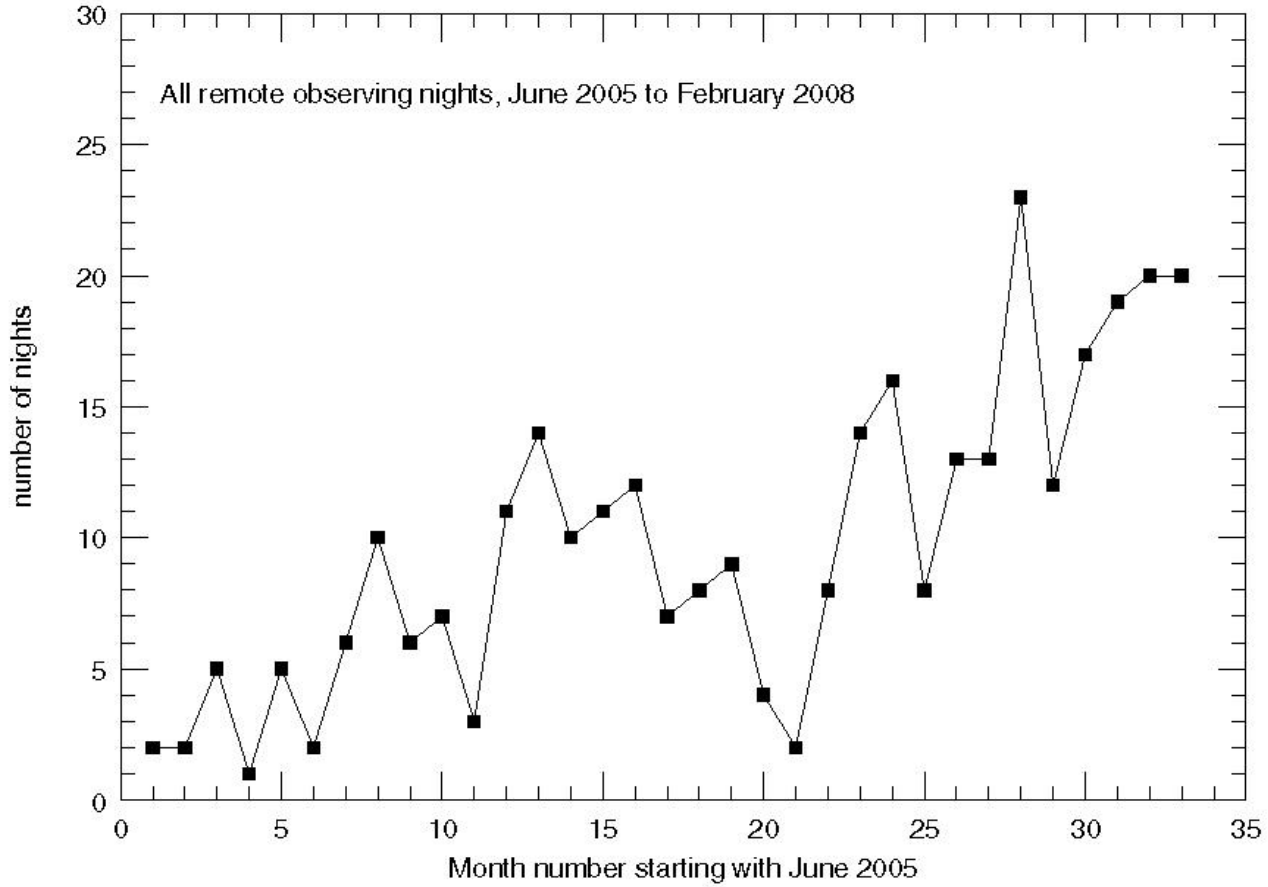
Keck remote usage statistics

- Observing from mainland is now routine
- > 50% of nights now involve mainland sites
- “Eavesdrop” vs. “mainland-only” modes





Overall usage (both modes) Nights/month – 6/05 to 2/08



Lick remote observing from observer's home institution

- Motivation:
  - Increase utilization of smaller telescopes
  - Enable greater use by undergraduates
  - Support novel observing programs
- Goals:
  - Leverage experience from Keck
  - Share existing remote observing facilities
  - Keep it simple

Obstacles & Solutions

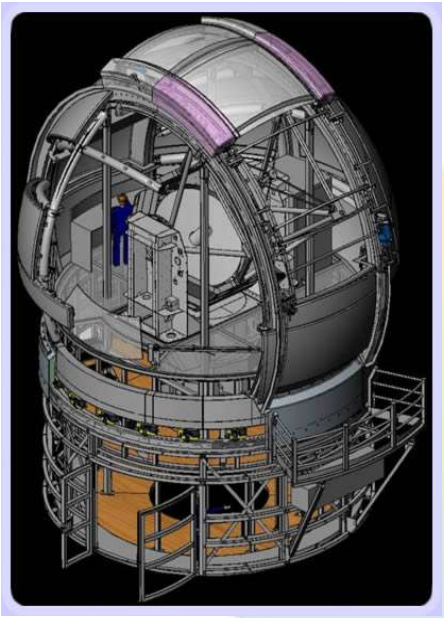
- Obstacles:
  - Limited bandwidth to Mt. Hamilton (4 Mbps)
  - 7 to 15 ms. round trip time (not good for X)
  - **Fear of network interruptions**
- Solutions:
  - Traffic shaping at link endpoints
  - Use VNC rather than X protocol
  - *Install hi-speed wireless link to Bay Area site
  - Use existing triple-T1 link as fallback path

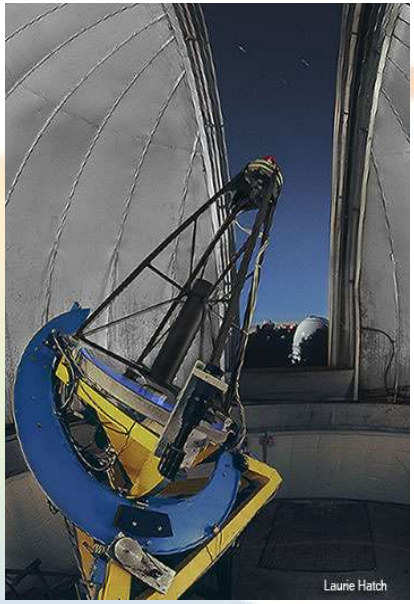
Proposed high speed wireless link from Mount Hamilton

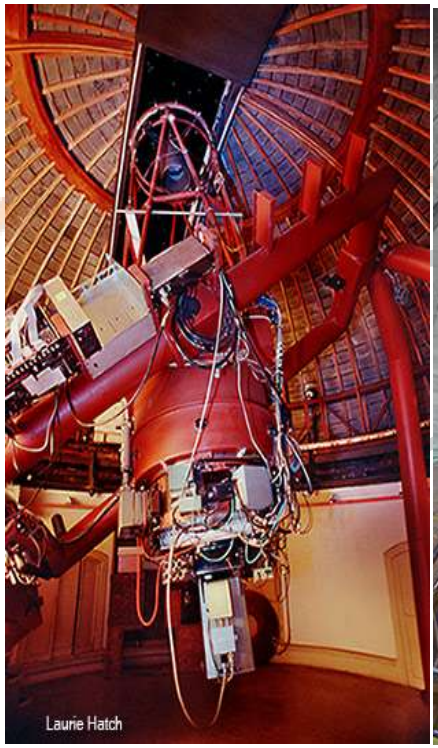
- NASA Ames
- UARC to UCSC
- All UC sites

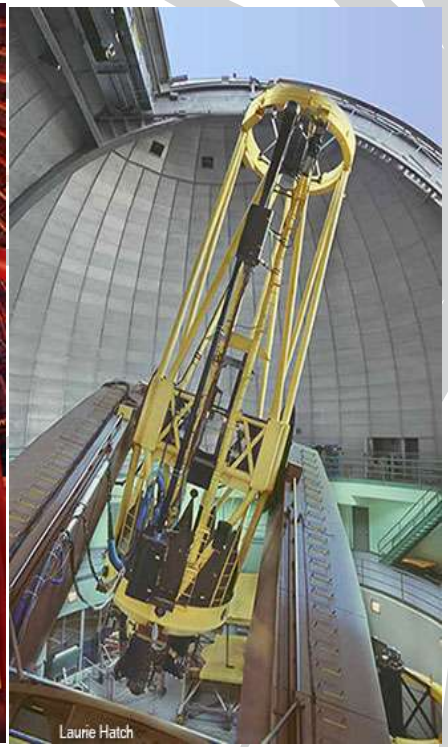
Current remote usage of Lick Telescopes

- Nickel & KAIT: heavy usage from UCB
- Shane 3-meter: trials underway from UCSD
- APF 2.4-meter



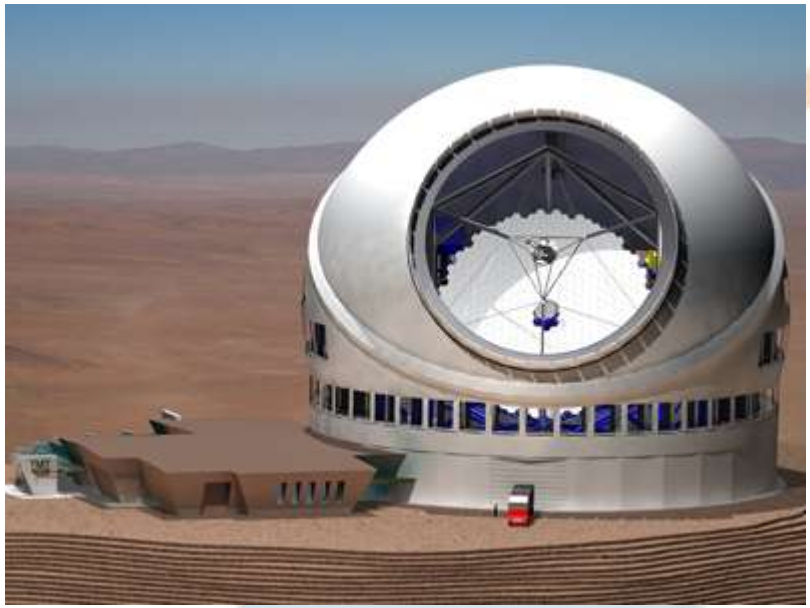


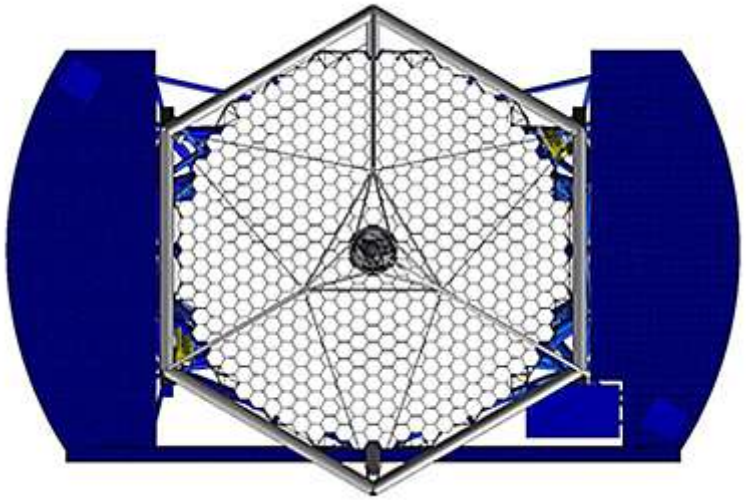




Future plans

- Thirty Meter Telescope Project
- Possible sites: Mauna Kea or Chile
- Remote observing will be essential





Conclusions

- Reliable networks enable remote observing
- Remote observing:
  - Enables new observing modes
  - Increases student participation
  - Increases usage of smaller telescopes
  - Facilitates multi-site observing teams
  - Reduces travel costs
  - Improves ability to respond to changing events

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