



MAUNAKEA OBSERVATORIES

Gerard Kuiper & Governor Burns
Maunakea 1964



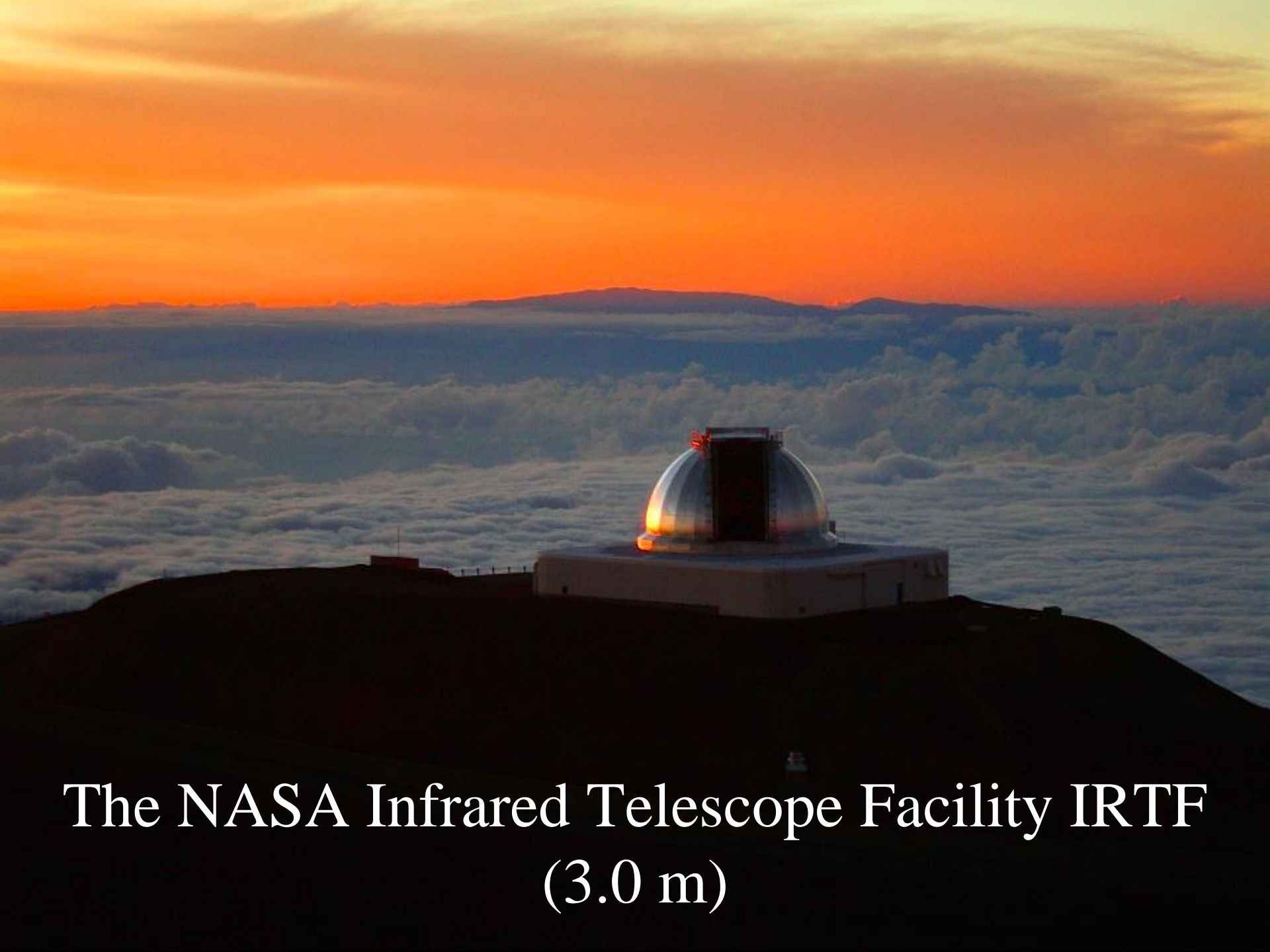




The Canada-France-Hawaii Telescope CFHT
(3.6m)



United Kingdom Infrared Telescope UKIRT
(3.8 m)



The NASA Infrared Telescope Facility IRTF
(3.0 m)

Maunakea 1979



1983 Complex Development Plan

- Mauna Kea Science Reserve – leased to UH 1968 - 2033
- Anticipated 13 Telescopes (11 major + 2 minor) by year 2000
- 1983 existing (6): 2x24" UH 2.2m CFHT UKIRT IRTF
- Foreseen (3): CSO JCMT (UKNL) Keck 1 (TMT)
- Predicted (4): 3 O/IR (Keck 2, Subaru, Gemini) + 1 Radio (SMA)
- 1989: VLBA Antenna added (not at summit)
- 1994: One 24" removed for Gemini

Subsequent UH Plans

2000 Mauna Kea Science Reserve Master Plan

- Created Office of Maunakea Management (OMKM +MKMB)
- Defined Astronomy Precinct (525 acres)
- Keck Outriggers & Pan-STARRS4 (did not happen)
- Thirty Meter Telescope (TMT) at 13 North site
- Any other future development to be at existing sites (e.g MSE)

2010 Comprehensive Management Plan (CMP)

- Management of public access, natural and cultural resources
- Incorporated 2000 Master Plan for future development
- Hokukea (UH Hilo) replaces remaining 24"
- Added a decommissioning plan
- CSO to be decommissioned by 2018
- By 2033, decommission UKIRT, VLBA, JCMT or SMA

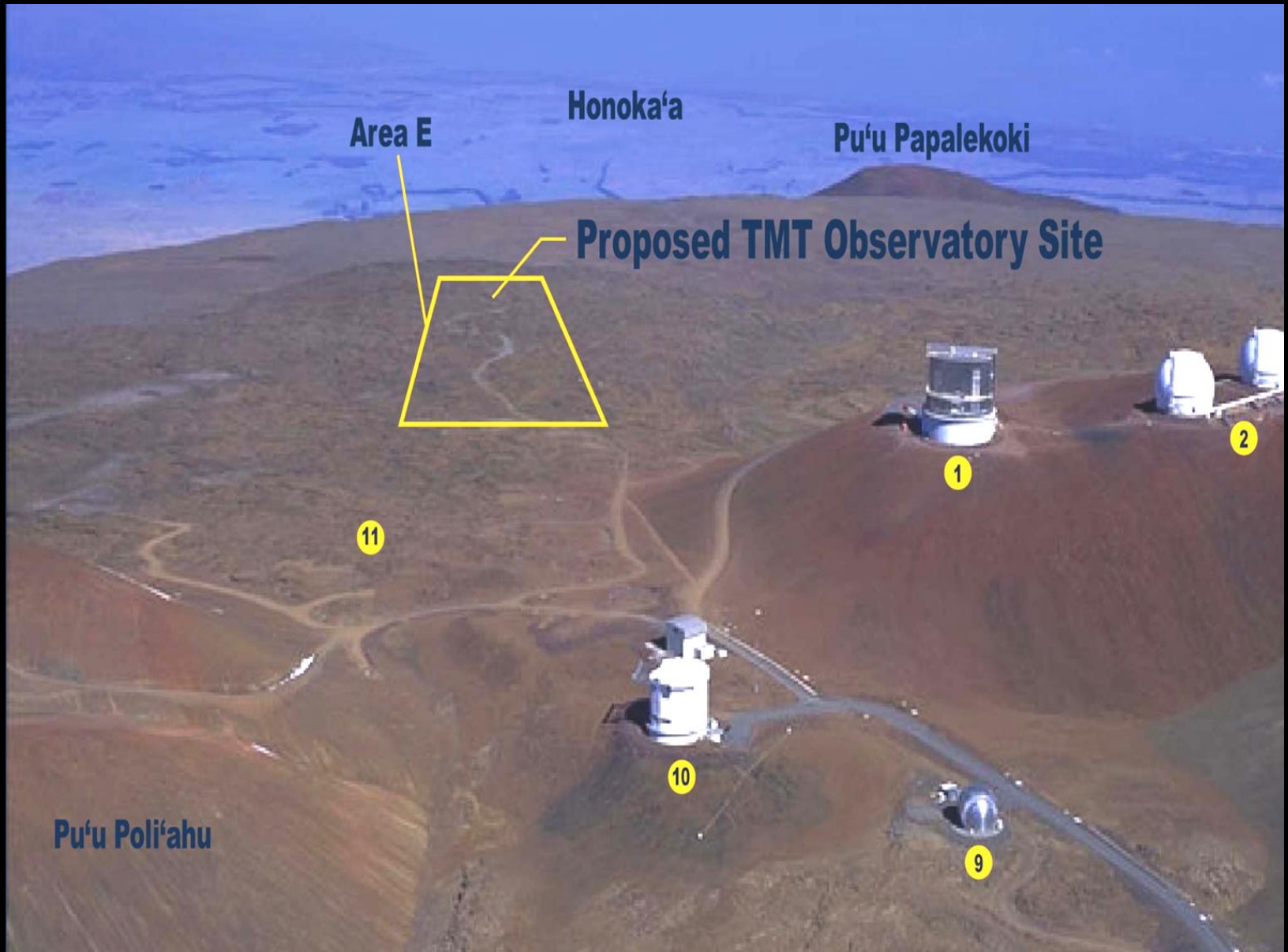
Governor Ige's 10-Point Plan 2015

- May 2015 response to TMT protests
- TMT to be last new site (already in CMP)
- Decommission 3 telescopes & their sites by time of TMT operations
- UH names 3 for decommissioning: CSO, Hokukea, UKIRT
- Return 10,000 acres of Science Reserve to State
- Restart EIS for new Science Reserve Lease
- Reduce term of new lease request (<65 years)

Maunakea Science Reserve Lease

- Currently 11,288 acres and runs through 2033
- Astronomy Precinct is 525 acres at summit
- Remainder is buffer zone
- New lease would replace existing 65-year lease
- Current subleases would be valid through 2033
- First step is Environmental Impact Statement (EIS)
- Had started EIS in Jan. 2014
- Governor's Plan requests reduced area and term
- Restart once requirement details confirmed
- **EnVision Maunakea**





Area E

Honoka'a

Pu'u Papalekoki

Proposed TMT Observatory Site

11

1

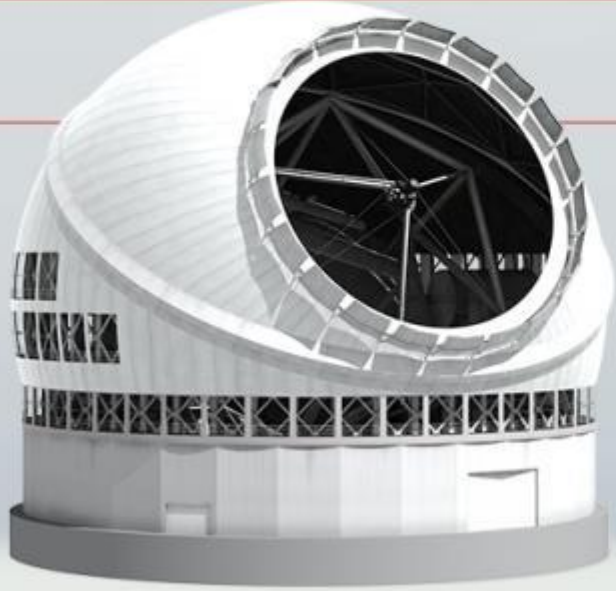
2

10

9

Pu'u Poli'ahu

TMT Relative to Subaru



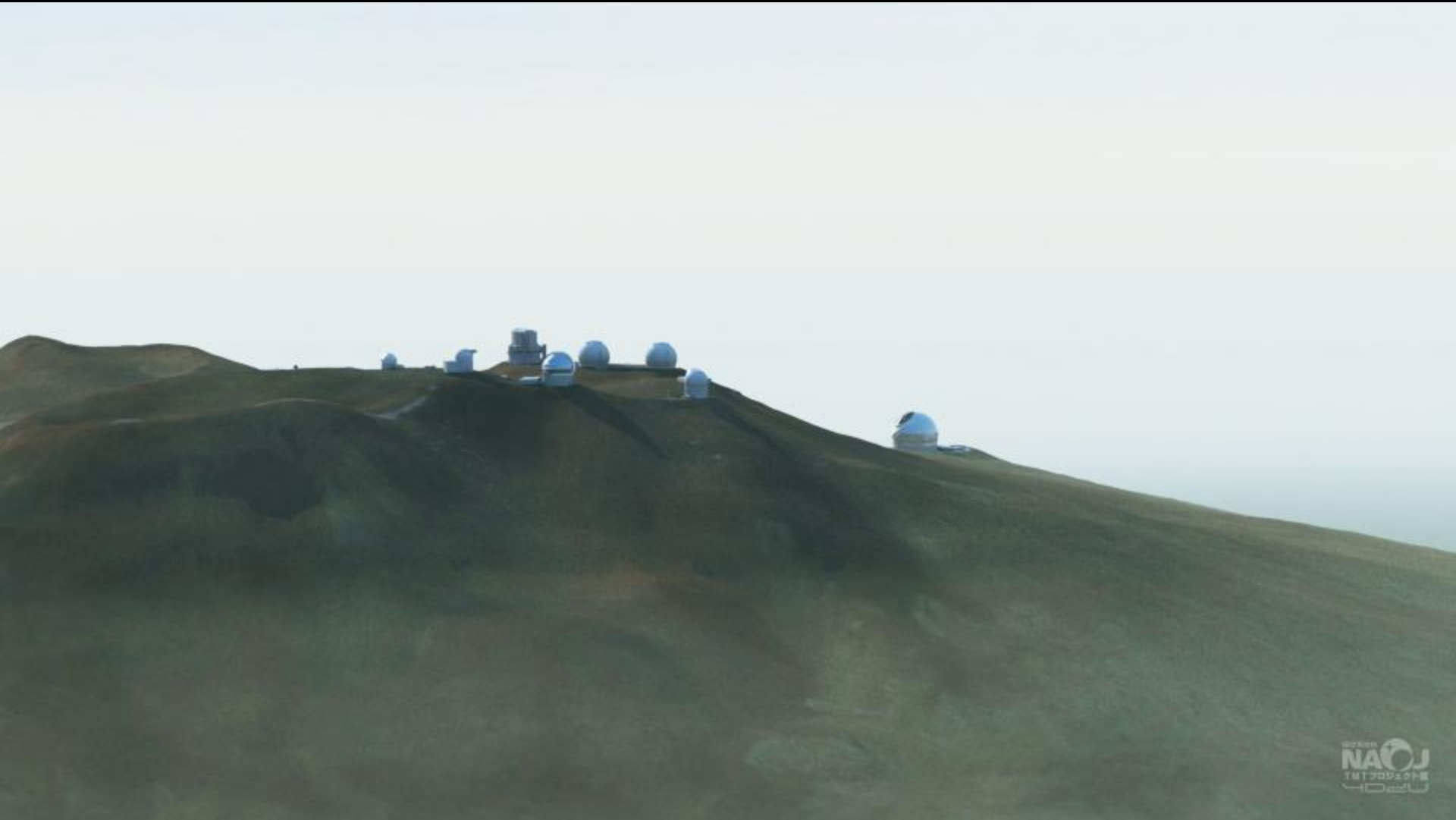
TMT 56m

すばる望遠鏡 43m

TMTはすばる望遠鏡に比べて口径が4倍近く大きいですが、ドームはひと回り大きいサイズにとどまっている。



TMT on Maunakea



TMT Situation

- Groundbreaking disrupted by protestors (October 2014)
- Protestor roadblocks prevent site work (March/April & June 2015)
- Site work was set to resume November 2015
- Hawaii Supreme Court voids permit on procedural grounds
- Court orders new contested case on permit
- Land Board selects hearing officer for contested case (3/16)
- Contested Case proceedings expected 3rd quarter 2016
- New permit needed by early 2017
- Site work needs to start by early 2018

University of Hawaii 2.2 Meter Telescope



Refurbishment of the UH 2.2m (I)

Building Renovation

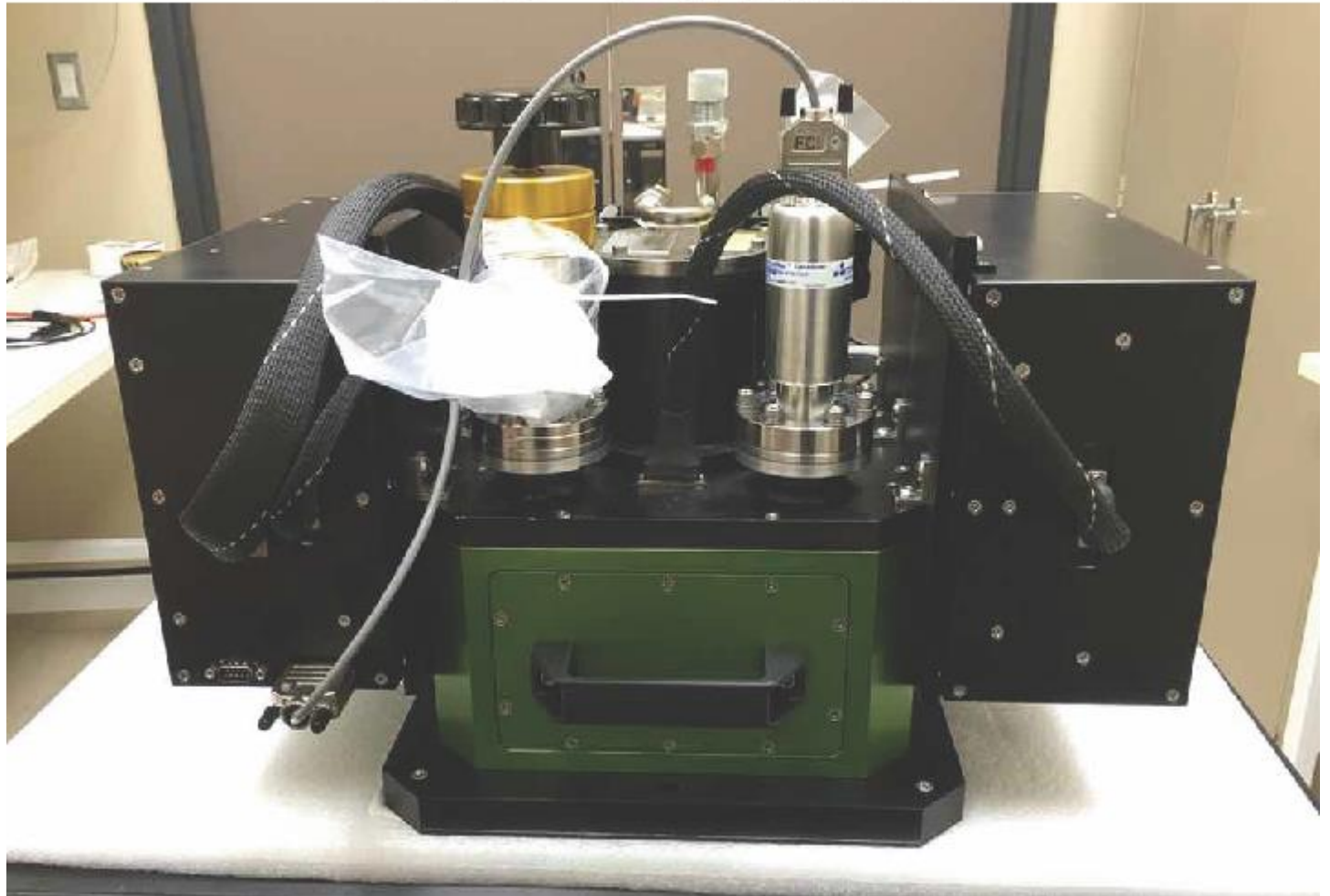
- Paint dome exterior & replace damaged siding
- New coude roof & install guardrails
- Improved lightning protection & grounding
- Safety upgrades & hazardous material abatement
- \$5M contract awarded; work to be done summer 2017

Refurbishment of the UH 2.2m (II)

Controls & Instrumentation

- New Observatory Control System (local contractor)
 - Capable of remote and robotic operation
- STA 1600 10K x10K CCD Camera
 - 9 μm pixels, 95 mm square
- Robo-AO robotic AO imaging facility
 - uses UV Raleigh laser guide star
- `Imaka Ground Layer AO Demonstrator

UH 88" 10K Camera





'Robo-AO-2' for the UH 2.2-m

State/UH: \$5M in telescope
refurbishment/robotic upgrades.

Hundreds of obs./night + ToOs.

Full visible/NIR diffraction limited imaging to
 $m_v=17$ (MV).

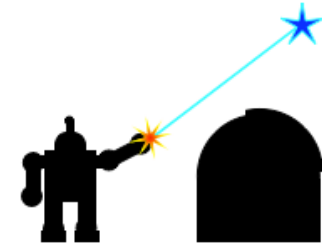
IFS for $R\sim 100$ NIR spec.

Operating early 2018.

Mapping dark matter within $z=0.1$.



–Observation trigger

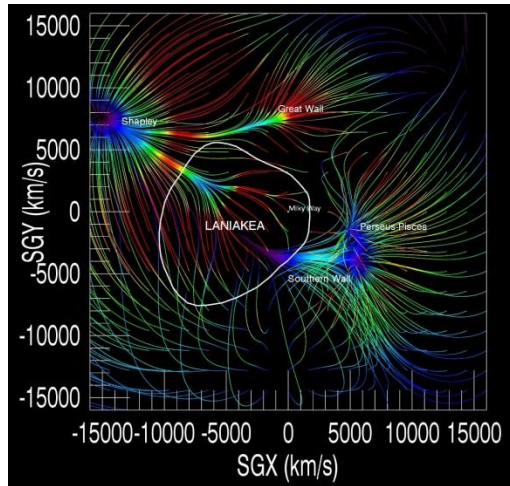
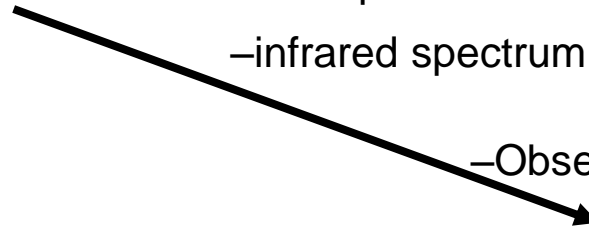


–Robo-AO-2 IR IFS

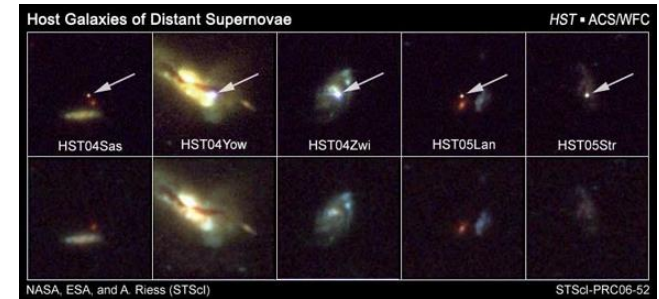
- Identify 1,000s of supernovae per year.
- Obtain peak and slope of light curves.

- Near peak luminosity, obtain a wide low-R infrared spectrum to determine extinction.

–Observations



- Combine with known galactic redshifts.



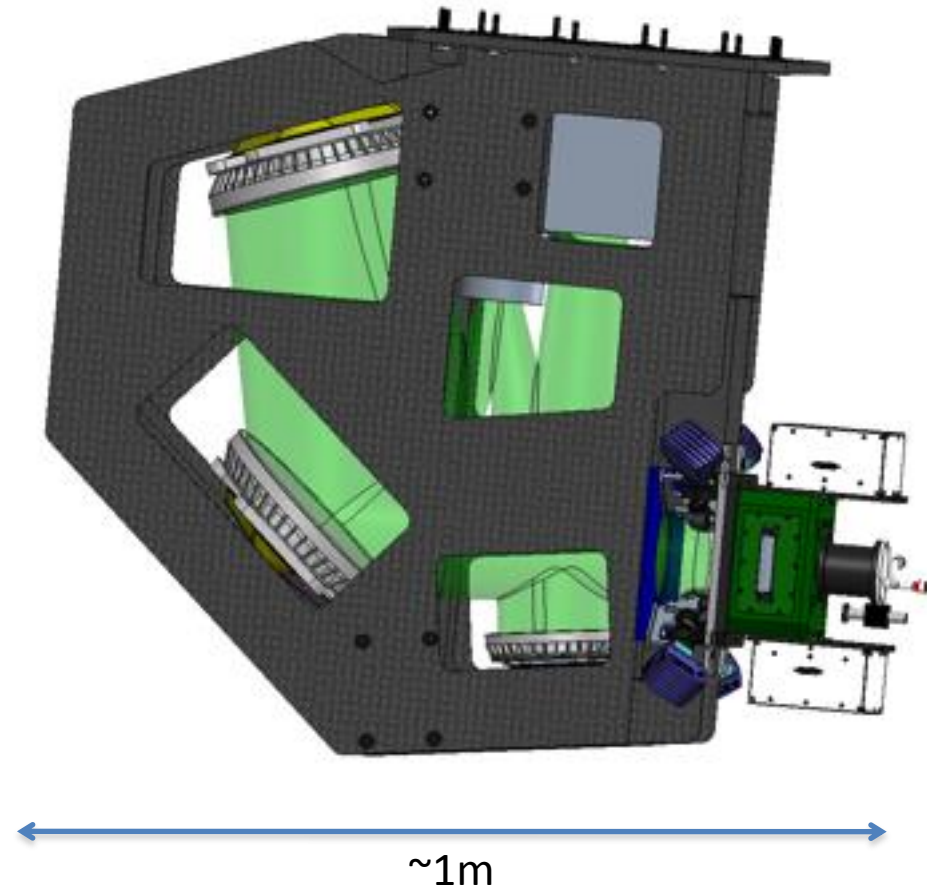
- Confirm Type Ia supernovae (SNIa).
- Derive absolute brightness of SNIa.
- Determine distance to host galaxy from apparent brightness.

- Reconstruct 3-D dark matter map to 30x volume of Laniakea!
- (a la Tully et al.)



Wide field of view AO for Maunakea

- The optical turbulence above Maunakea show a weak free-atmosphere, a thin ground layer, and dome seeing.
 - 2/3rds of the turbulence is within 100m of the ground
- GLAO corrects for just the aberrations that arise in this volume so correction applies over wide fields (1/3 deg) and achieves the free-atm seeing ($\sim 1/3''$ in visible, $0.25''$ in NIR)
- `Imaka is the demonstrator on UH 2.2m for GLAO on Maunakea – integrating now. On-sky fall.



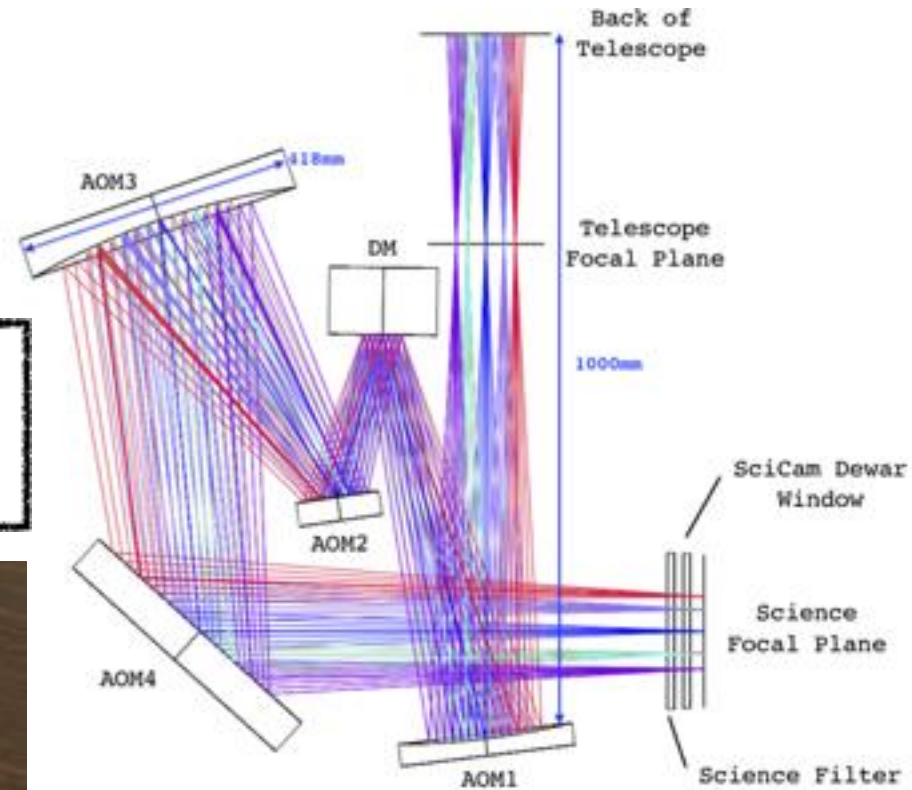


Mixture of old and new

Repurpose the
Wavefront Sensors from
CFHT mWFS Experiment



Repurpose the
Deformable Mirror from
Subaru AO36

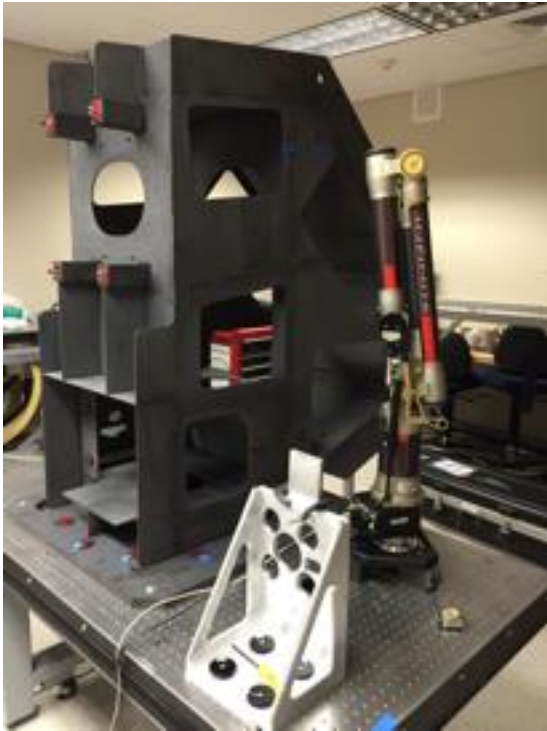


A broken Offner optical
design (Baranec)

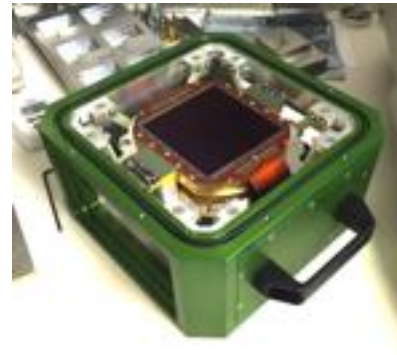


Mixture of old and new

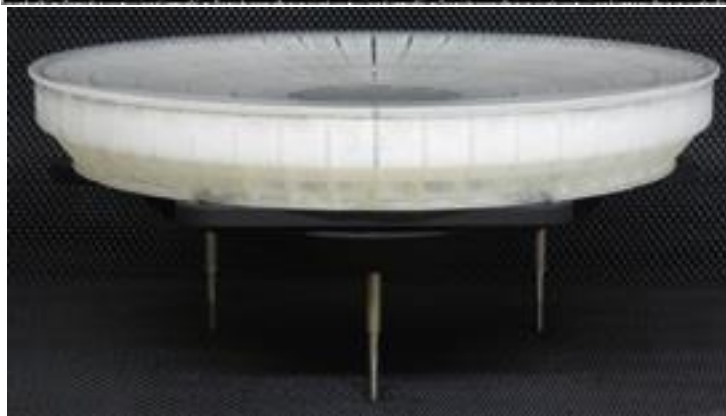
Carbon-fiber Structure - weight and CTE issues v. hygroscopic and machine tolerance issues



STA1600 – 10k x 10k CCD camera for UH88 (11'x11')

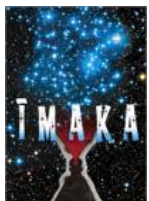


16" diameter light-weighted mirror and carbon-fiber whiffle tree



D. Hall H4RG camera (7'x7')

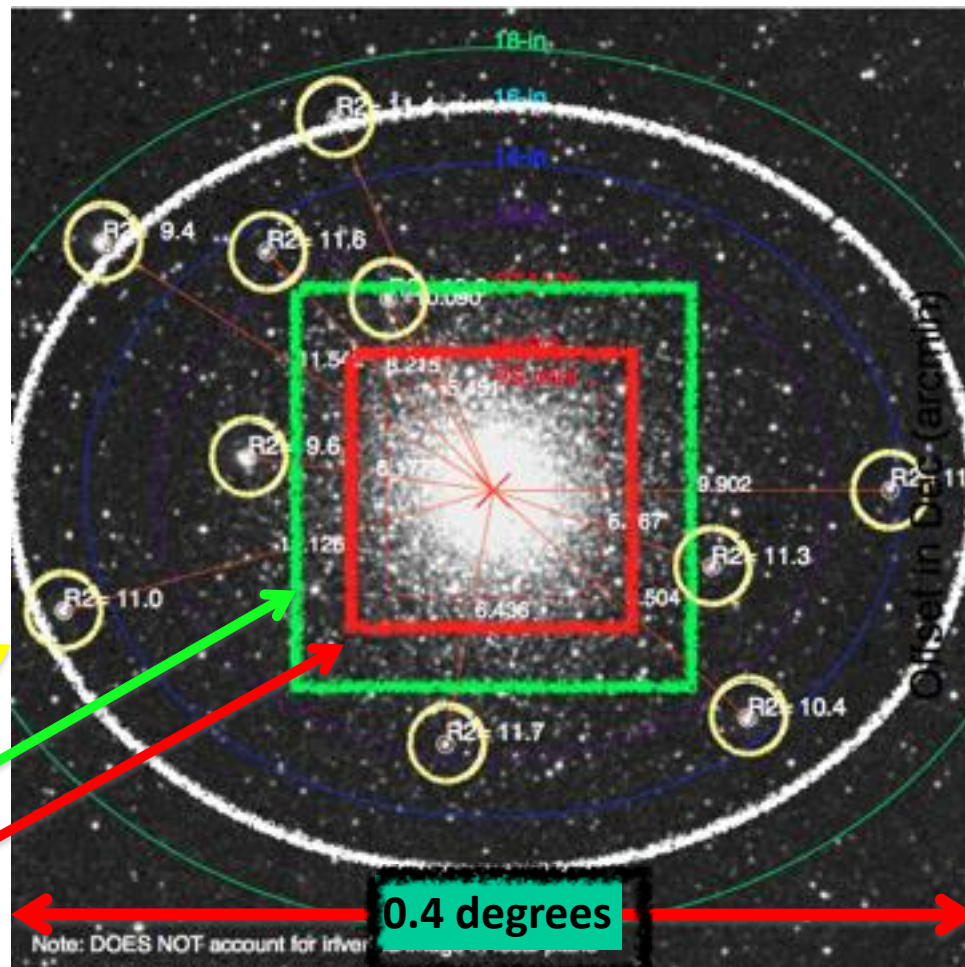




Demonstrating GLAO science cases

Imaka on M92

- Deep confusion limited fields
- Astrometry (gain in resolution, number of astrometric ref, NIR)
- Well matched to star clusters in MW, satellite galaxies to MW, deep extra-galactic MOS studies



Guide Stars

STA1600 camera FOV 11'x11'

H4RG camera FOV 7'x7'

0.4 degrees

Note: DOES NOT account for Inver...



IRTF



iSHELL for
IRTF
almost
ready to
ship

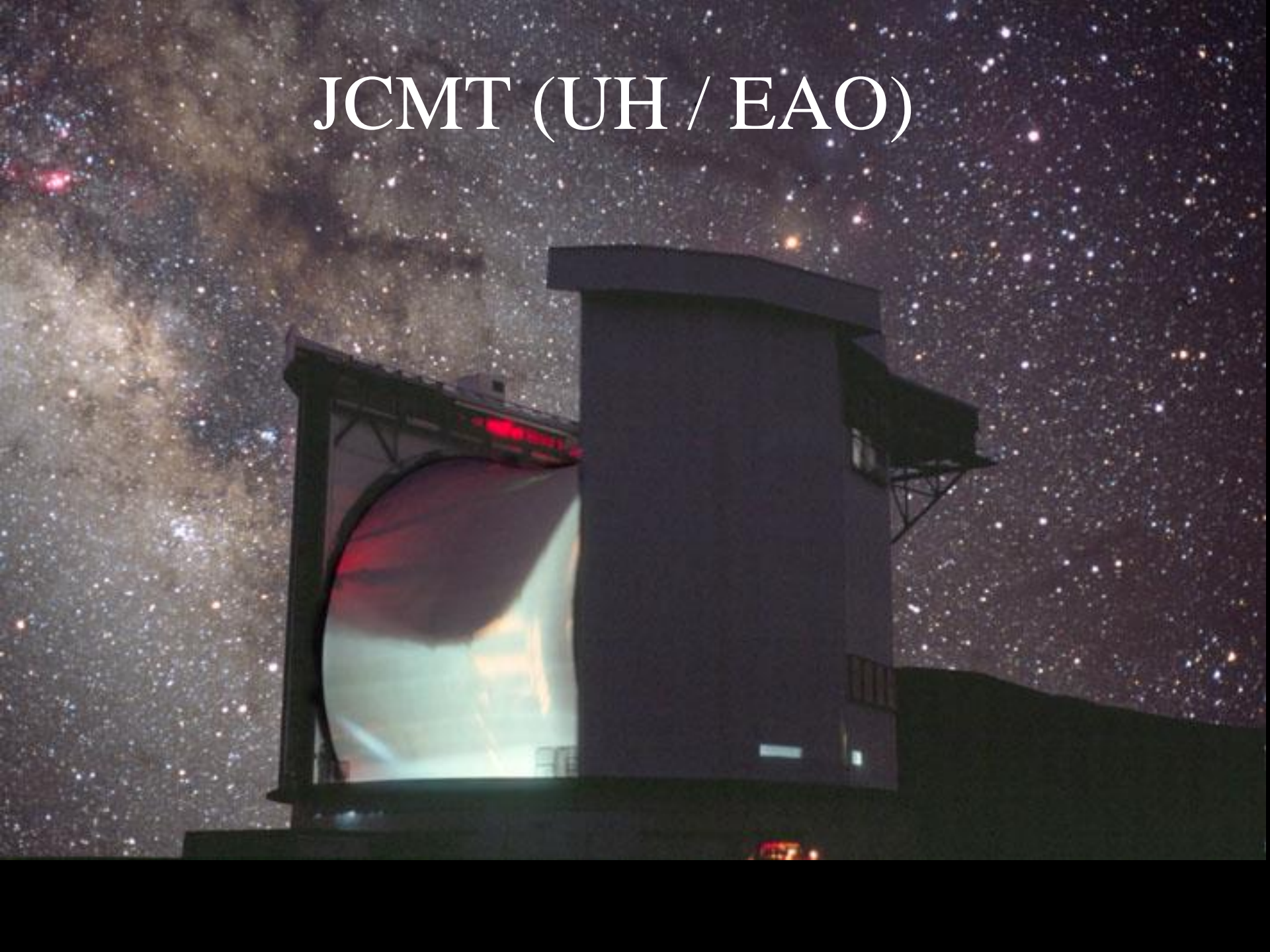
UKIRT (UH / Arizona + Lockheed Martin)



UKIRT

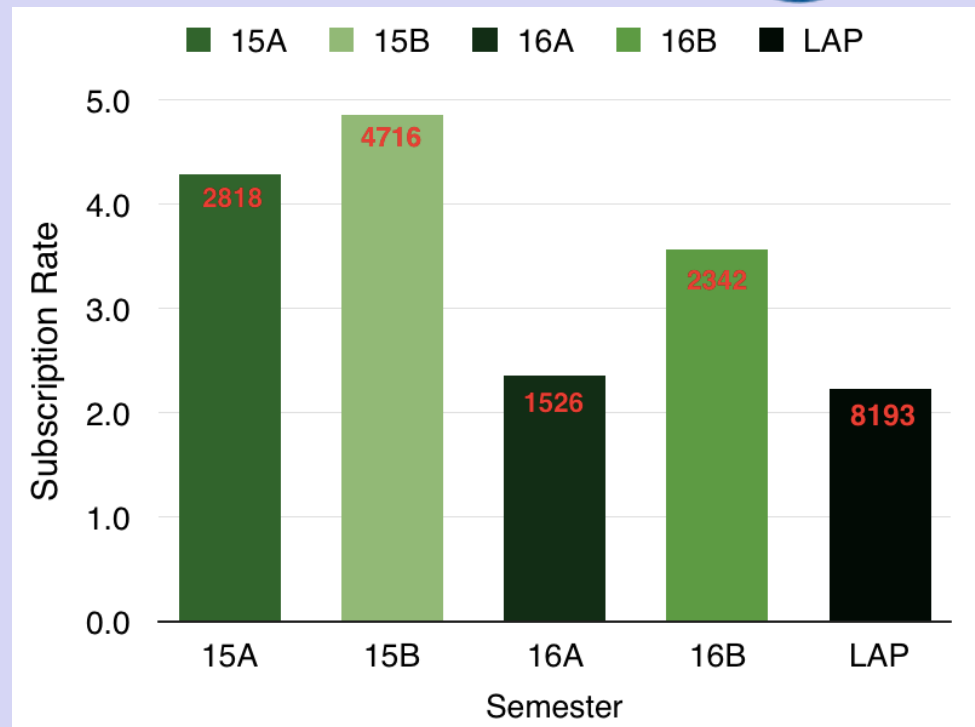
- UKIRT is the legacy 3.8-m IR-optimized telescope on Maunakea.
- UKIRT is currently being funded by NASA and operated under a Scientific Cooperation Agreement among Lockheed Martin Advanced Technology Center, the University of Hawaii, and the University of Arizona. Agreement runs through 2022.
- We have now completed more than two years of operations since termination of UK ops funding.
- NASA provides most of the current support to UA via LM through the Orbital Debris Program Office at Johnson Space Flight Center.
- NASA space debris support moving from 100% to 50% for the long run, so we anticipate adding short-term operations partners, including other space debris projects.
- UKIRT would welcome the opportunity to host SPIRou for the exclusive use of the CFHT community.

JCMT (UH / EAO)

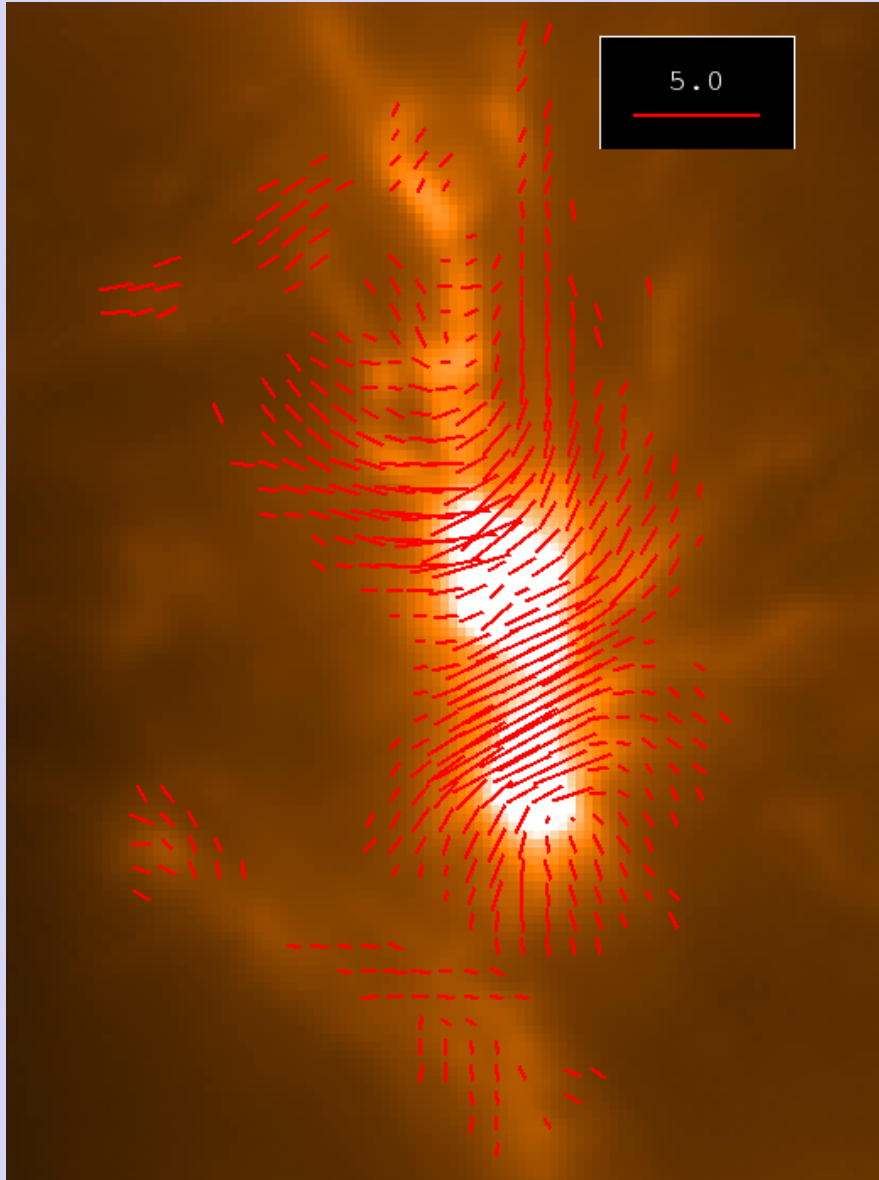


JCMT and EAO

- One year of operations by East Asian Observatory (NAOC, NAOJ, KASI, ASIAA) and UK and Canadian partnership
- Five Calls for proposals in one year!
- 20,000 hours of time requested
- 800 investigators received data in 2015/2016
- JCMT operates with summit observing and partial remote (1/3 shifts and early mornings in Hilo) returns over 10 hours of science data each night and a fault rate of less than 2.5%
- JCMT Large Programs underway - 7 programs using 1600 hours over 3 years, over 560 co-investigators involved from six regions
- El Nino - driest winter on record - two Large Programs already 60% complete



JCMT future



- POL-2: polarimeter on SCUBA-2, commissioned last month - key new science in the sub millimeter to be achieved
- VLBI capabilities improved as a participant in the Event Horizon Telescope
- New 230GHz receiver (ALMA cartridge and dewar design) by mid-2017
- SCUBA-2 upgraded filters and new arrays - sensitivity improvement of x10
- Super-heterodyne array at 345GHz - 100 pixel receiver - mapping speed increase of x10

Fully populated GPC2 Focal Plane



DKIST Enclosure Completed



Mahalo





MAUNAKEA OBSERVATORIES