W. M. Keck Observatory 2022

Subaru Users' Meeting

Hilton Lewis, Director
January 10, 2022

Science Highlights

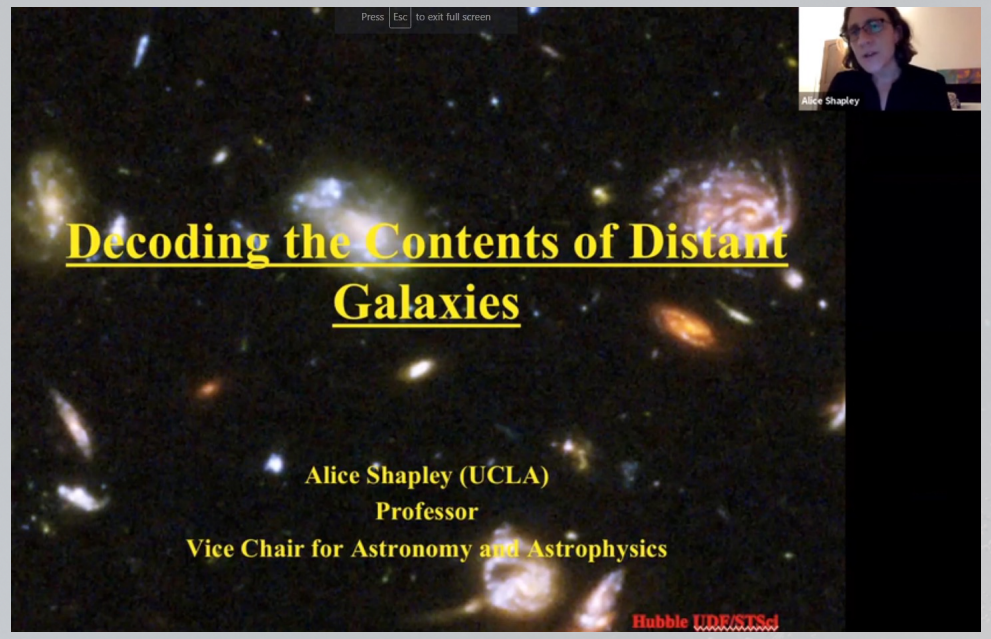
Science Highlight #1: Electron Capture Supernova

- Candidate for a new class of supernova: an electron capture supernova
- Predicted by Ken’ichi Nomoto, University of Tokyo in 1980
- Keck LRIS & DEIMOS spectra taken years after the explosion in 2018
- Provides evidence that the supernova responsible for the Crab nebula is of this type

Science Highlight #2: SN 2020 tlf: Observing a red giant in its last 130 days of existence

- Team conducting the Young Supernova Experiment (YSE) transient survey observed the red supergiant during its last 130 days of its existence.
- Pan-STARRS detected the excess radiation in summer 2020 of 2020tlf. Supernova detected in fall of 2020.
- Keck obtained first spectrum of SN 2020tlf, using LRIS. Follow-up observations conducted with DEIMOS and NIRES determined SN 2020tlf's 10 solar mass progenitor red supergiant, located in NGC 5731, about 120 million light-years away.
- Provides direct evidence of circumstellar material surrounding the star at the time of explosion.

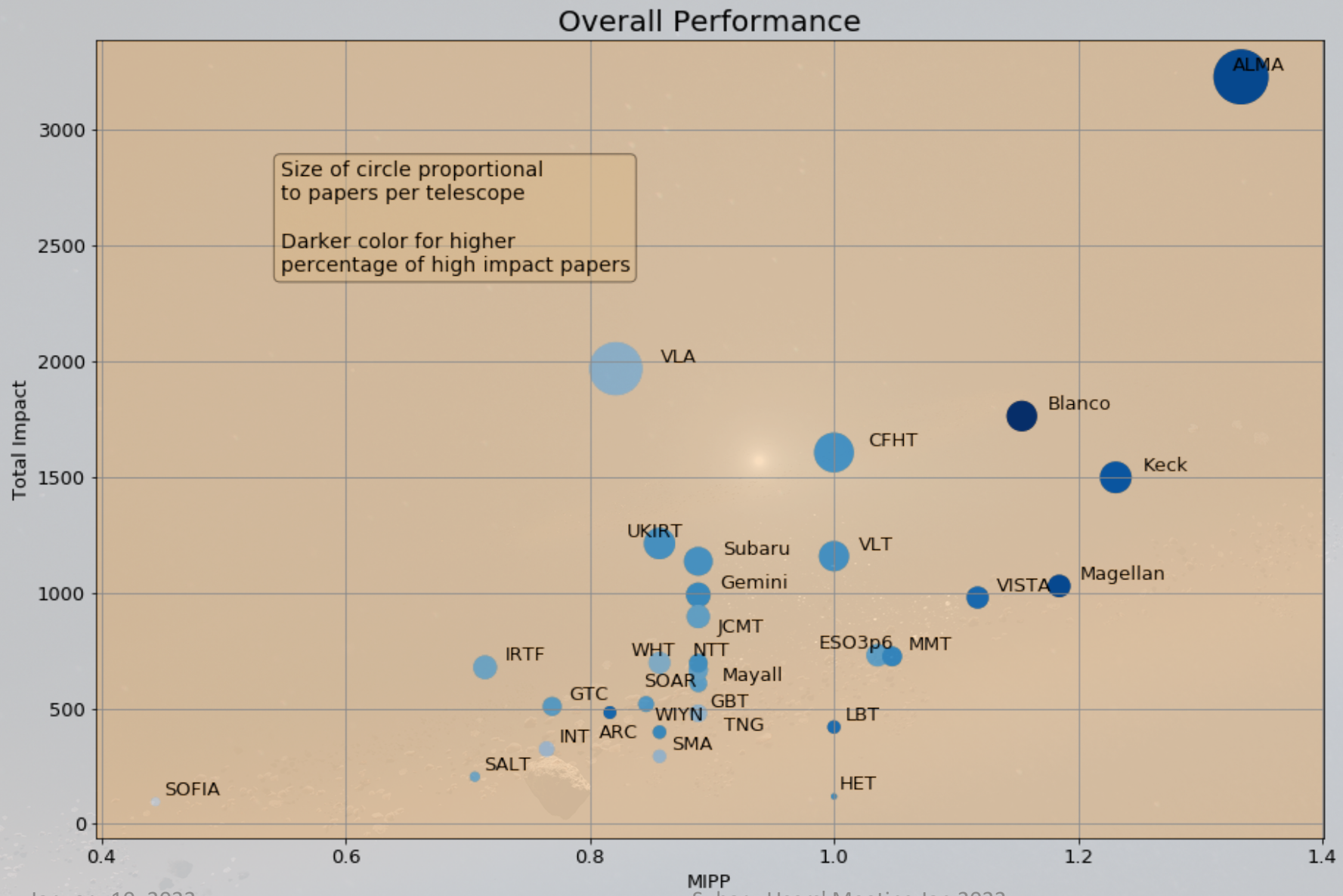
Public Talks: Year to date



- **Marla Geha**, “Dwarf Galaxies, Dark Matter, and the Milky Way”, January 14, 2021
- **John O’Meara**, “A night in the life of Keck Observatory”, February 11, 2021
- **David Ciardi**, “Kepler, TESS, and Keck: Driving our Understanding of Exoplanetary Systems, March 4, 2021
- **Alice Shapley**, “Decoding the Contents of Distant Galaxies”, June 17, 2021
- **Mansi Kasliwal**, “Cosmic Fireworks”, July 20, 2021
- **Lauren Corlies**, “Exploring Galaxies and Beyond”, August 19, 2021
- **Steven Finkelstein**, “Lifting the Fog on the Early Universe”, September 21, 2021
- **Christine Moran**, “Where I explore, where we explore: from the South Pole to Mars to exoplanets”, October 19, 2021
- **Mike Brown**, “Planet 9 from Outer Space”, November 3, 2021

Performance Metrics

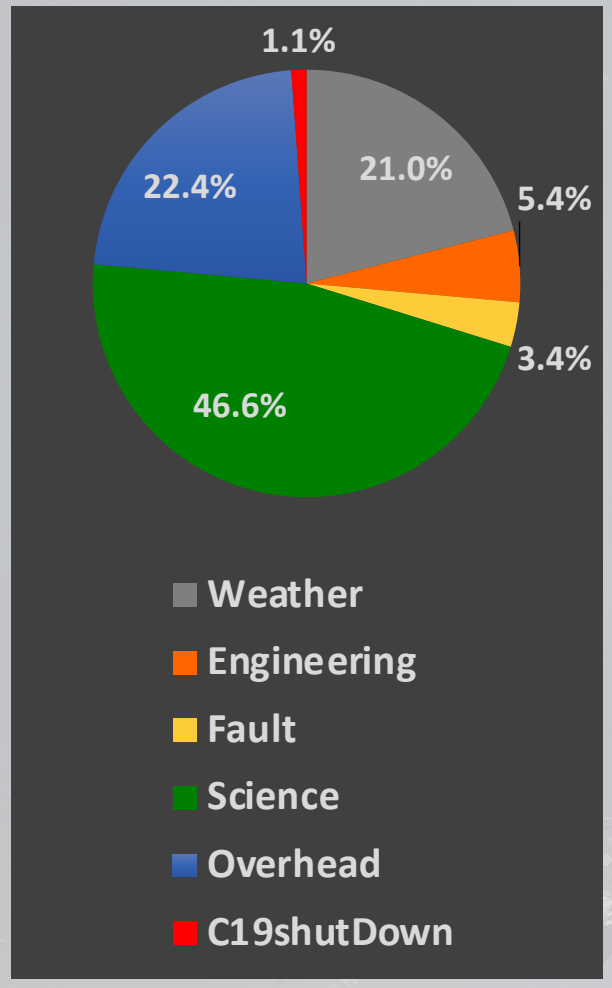
Scientific Performance 2015-2019, updated 2021

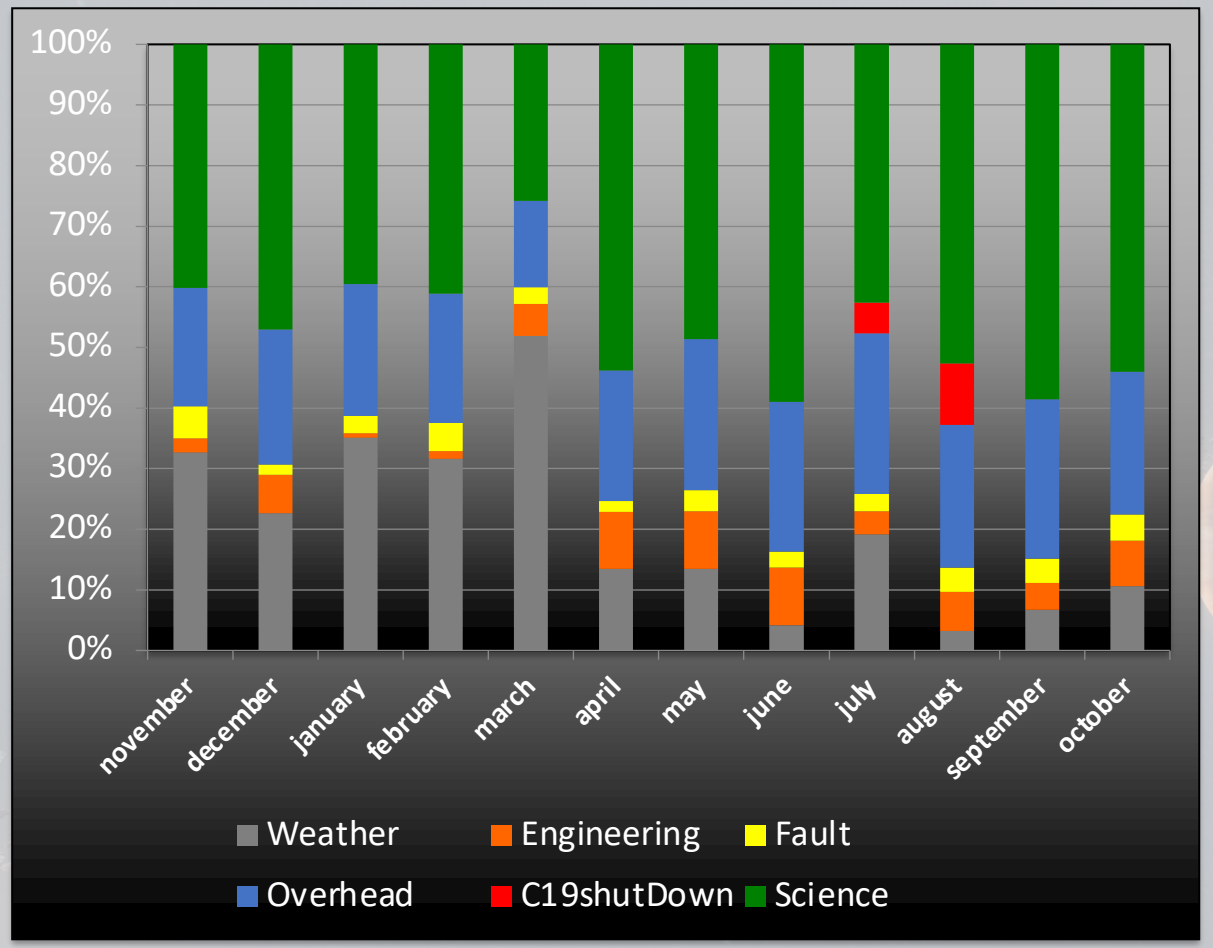


The size of the circle gives the total papers per telescope in 2015-2019

Darker color of the circles represents the fraction of papers in the top 10% of cited papers in the sample

12 Month Metrics





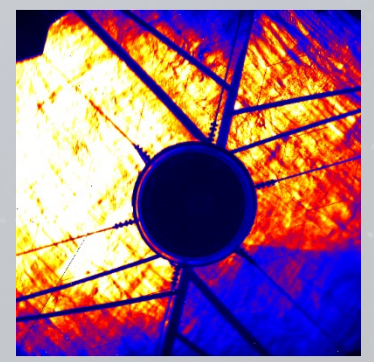
Infrastructure

K1 Pier Repair

- Concern: Excessive deflections on K1 azimuth pier related to oil penetration
- Work performed to date
  - K1: Remove drywall; Extracted concrete core test samples; Determined level of concrete damage.
  - K2: 3 locations of deflection found, one repairable but lower priority than K1 (others are stable, not a performance issue)
  - Redesigned oil return tray concept generated
- Outside expertise: CTL (Construction Technology Laboratories) & JPL
  - Although oil saturated, the concrete has adequate strength.
  - Deflections believed to be result of failing bond lines – journal to grout and grout to concrete – the "fracking" failure mode mostly occurs here.
  - A grout focused repair should be possible (echoes JPL approach on 70m Deep Space Network antennae)
  - Switch from a cementitious grout to an epoxy grout (oil resistant)
- Degradation expected to continue in a predictable fashion
  - No sudden changes => low risk to Operation

Tertiary Mirror Repair

- Support design similar to segments → similar damage at bonds
- Repaired Keck I tertiary mirror using procedures adapted from segment repair but with tighter tolerances because tertiary mirrors have no active adjustments
- Installed Keck I tertiary mirror in Keck II
  - Earthquake as mirror was being lifted from telescope
- Keck II tertiary mirror to be repaired as spare
- for Keck 1 (have a deployable tertiary on K1)



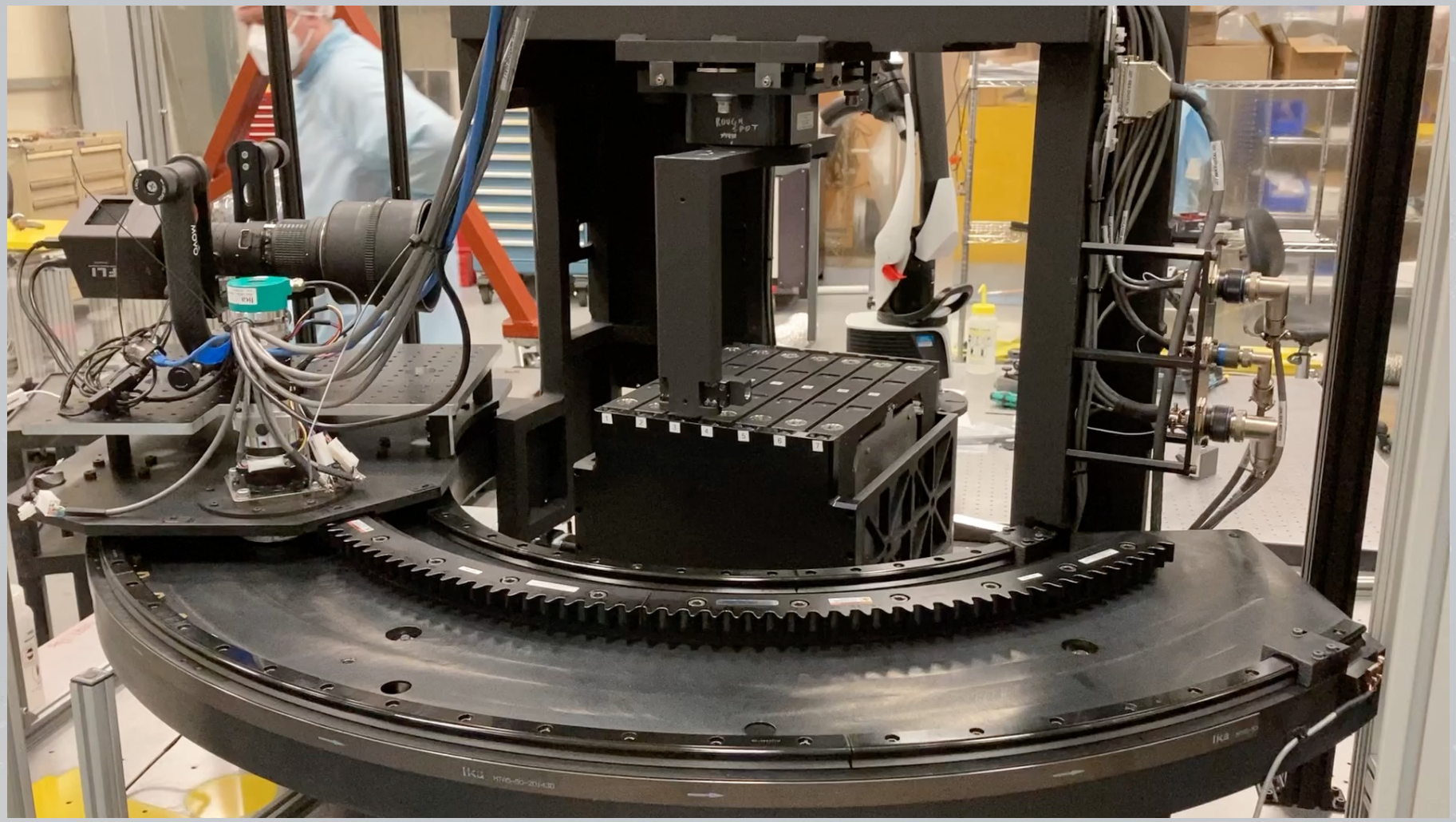
Remote Observing

- Remote sites at campuses and HQ use has plummeted (not unexpected during COVID)
- Laptop-centered ‘Pajama mode’ is the way of (much of) the future. Mixed blessing:
  - Decouples us from our observers
  - Allows more to participate in observing
- Important issue: How do we maintain our highly-valued and close connection with our community while recognizing the march of technology towards virtual interaction?

Major New Instrumentation

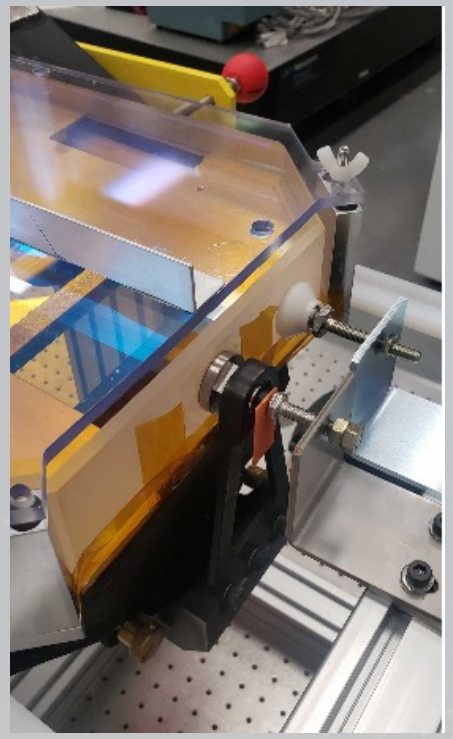
KCRM: Undergoing Lab integration

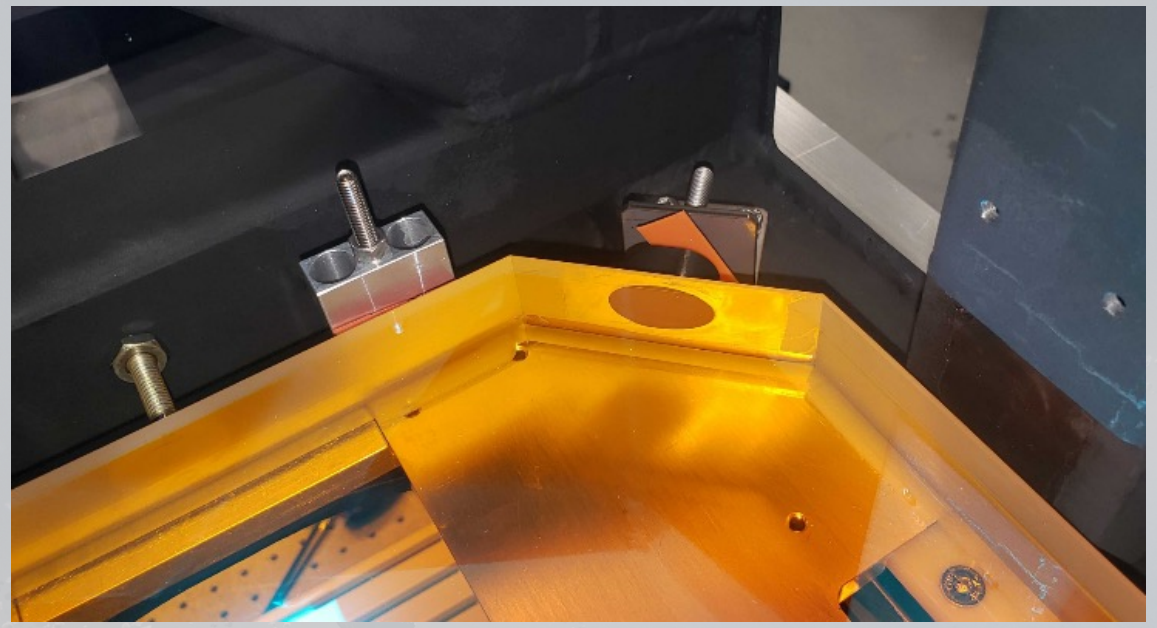
- Red channel to be integrated into KCWI: 530nm-1050nm
- Complements blue channel (350nm – 560nm)
- Delivery planned for Summer 2022

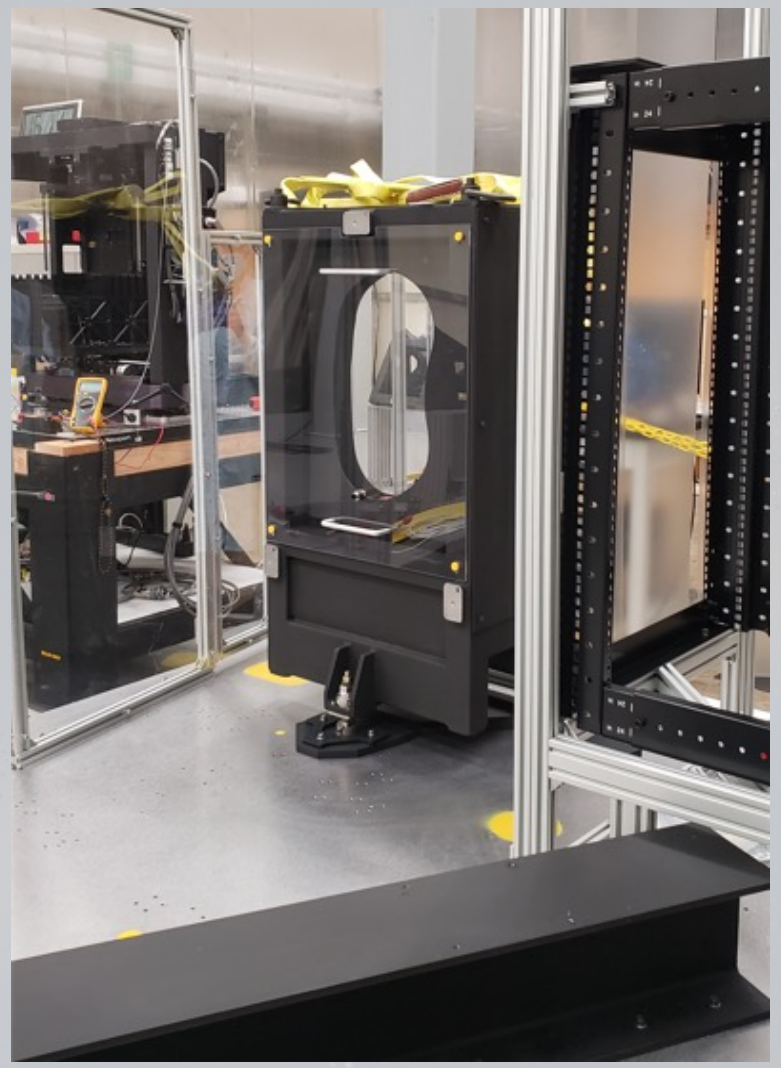


KCRM: Dichroic & FM2

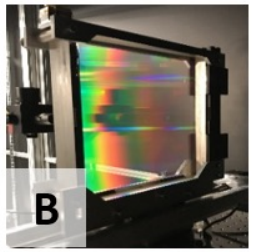
- World’s largest dichroic bonded in the lab.

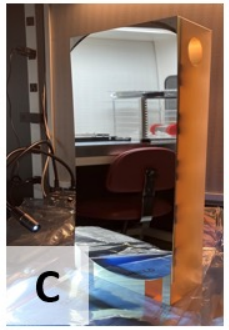


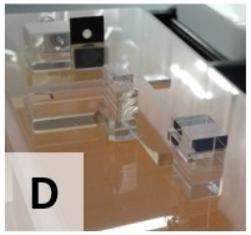


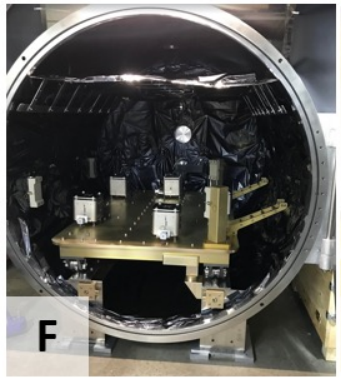


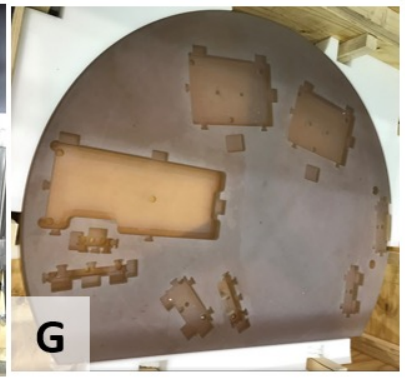
KPF: Final lab Integration in progress











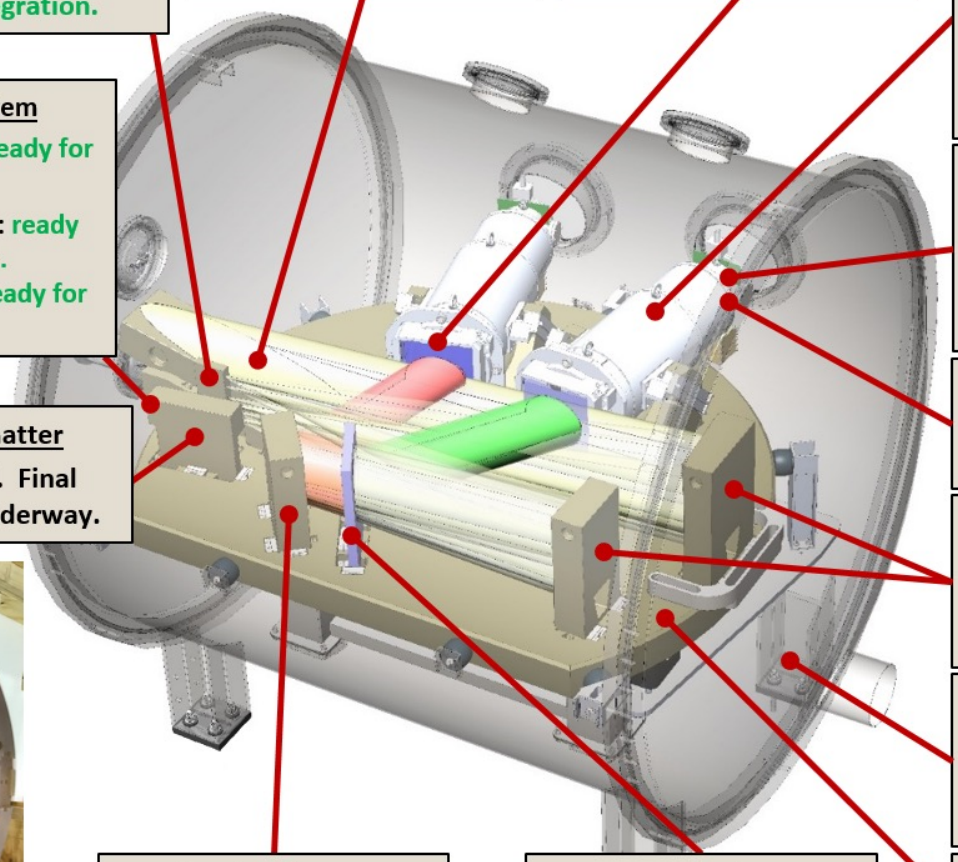
Fold Mirror
Ready for integration.

Fiber System
Fiber Cables: ready for integration.
Fiber Agitator : ready for integration.
Scramblers : ready for integration.

D) Reformatter
Optics coated. Final fabrication underway.

A) Echelle Grating
Ready for integration.

B) VPH Grisms
Ready for integration.



E) Red Fold Mirror
Ready for integration.

Dichroic
Ready for integration.

Cameras
Green: ready for integration.
Red: Optics being coated. Mechanical assembly underway.

CCD Cryostats
Green: undergoing final characterization tests.
Red: Final mechanical assembly underway.

Detectors
Both CCDs installed within the KPF cryostats.

C) Collimators
Primary: Coating underway. Secondary: ready for integration.

F) Vacuum Chamber
Chamber, bench supports passed vacuum tests.
Ready for integration.

G) Zerodur Bench
Ready for integration.

Other KPF subsystems

Fiber Injection Unit
Optics in-hand. Mechanical parts being fabricated.

Laser Frequency Comb
Delivery expected Dec. 2021.

Ca H&K Spectrometer
Optics in-hand, opto-mech assembly underway.

Facility and Enclosure
Fiber route finalized. Basement modifications well underway.

Exposure Meter
Assembled and tested, final detector expected Dec. 2021.

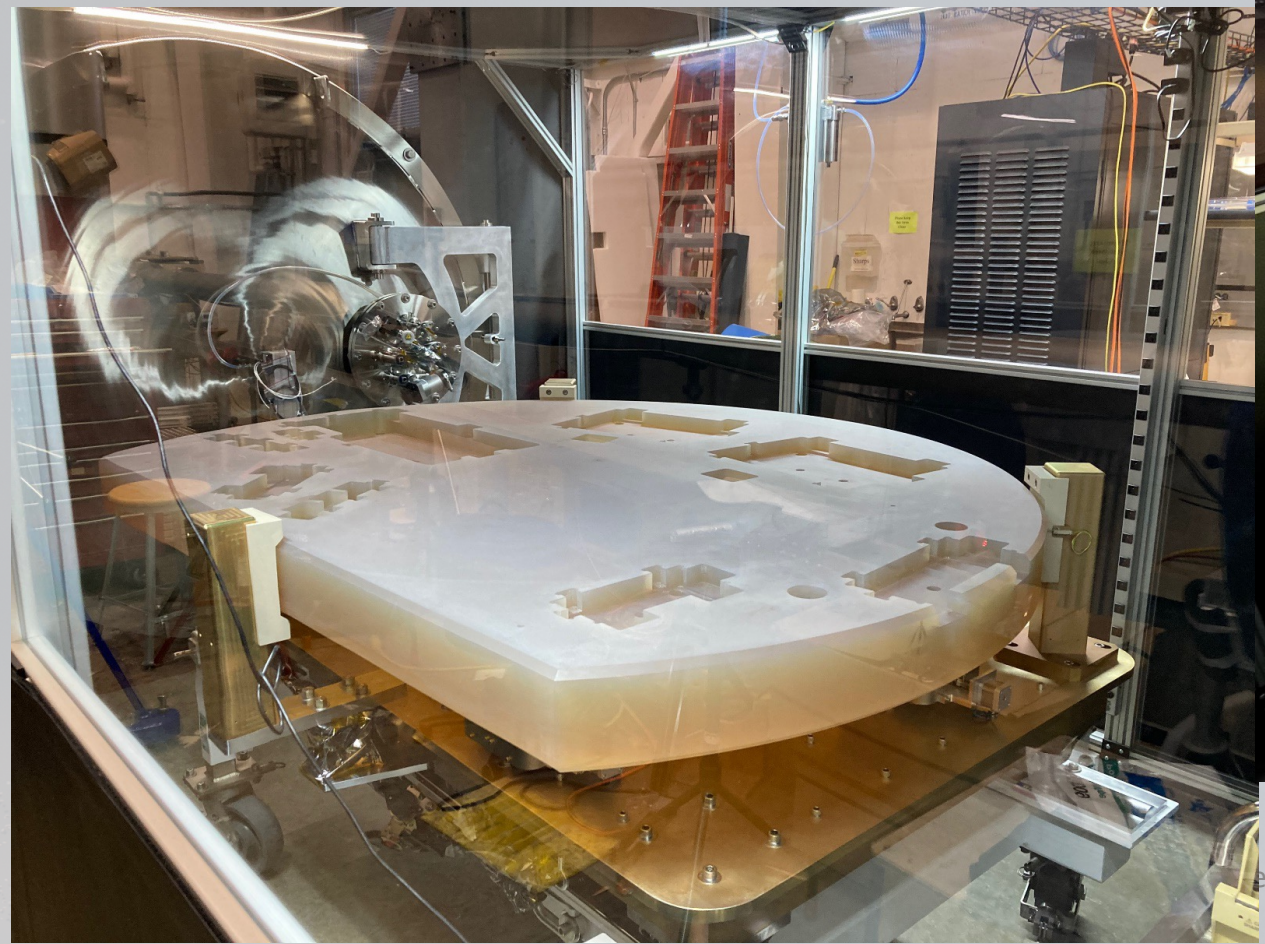
Stabilized Etalon
Fabrication underway.

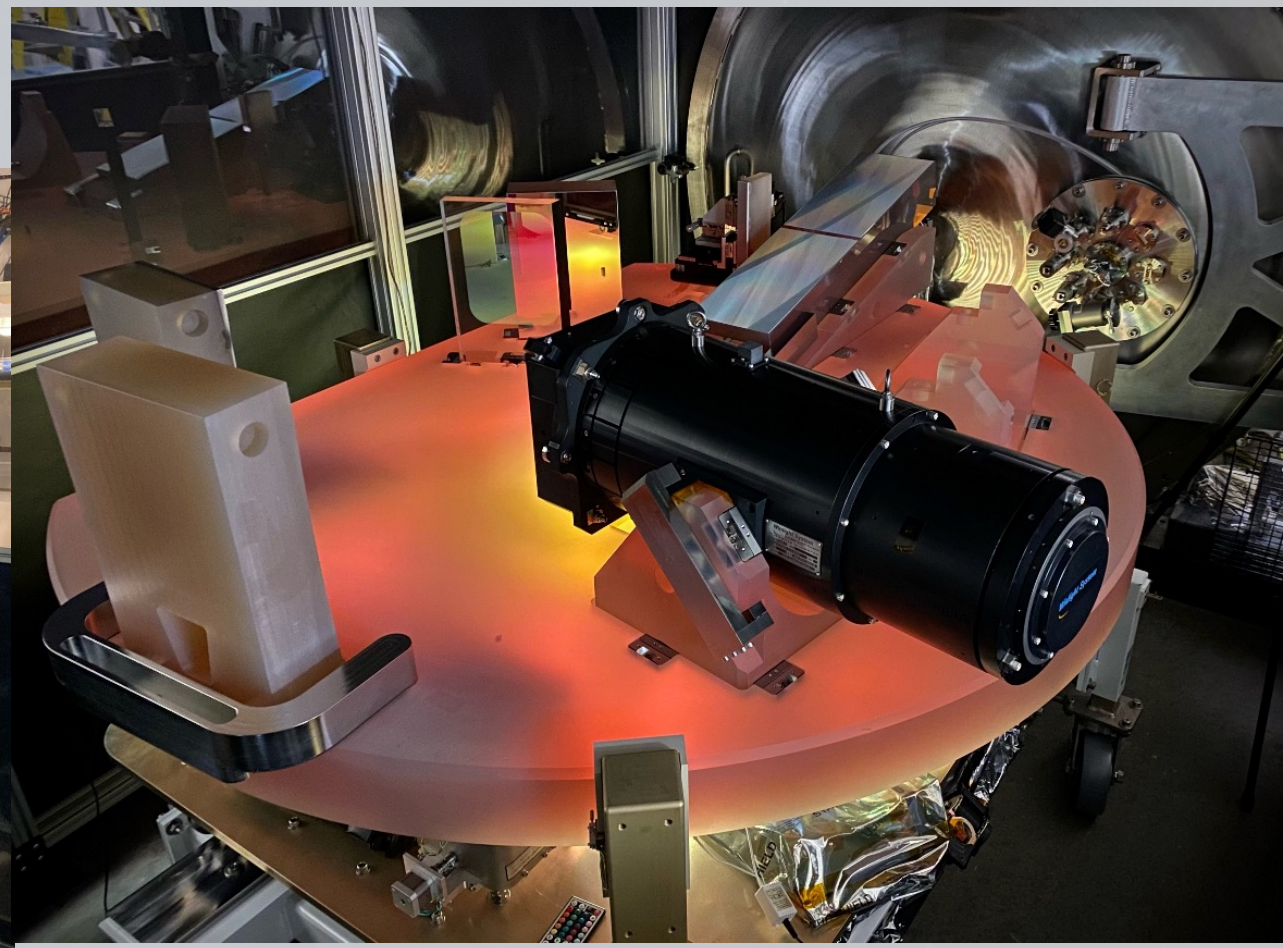
Solar Calibrator
System testing underway.

Data Reduction Pipeline
All modules in place, testing underway.

KPF: Bench touchdown

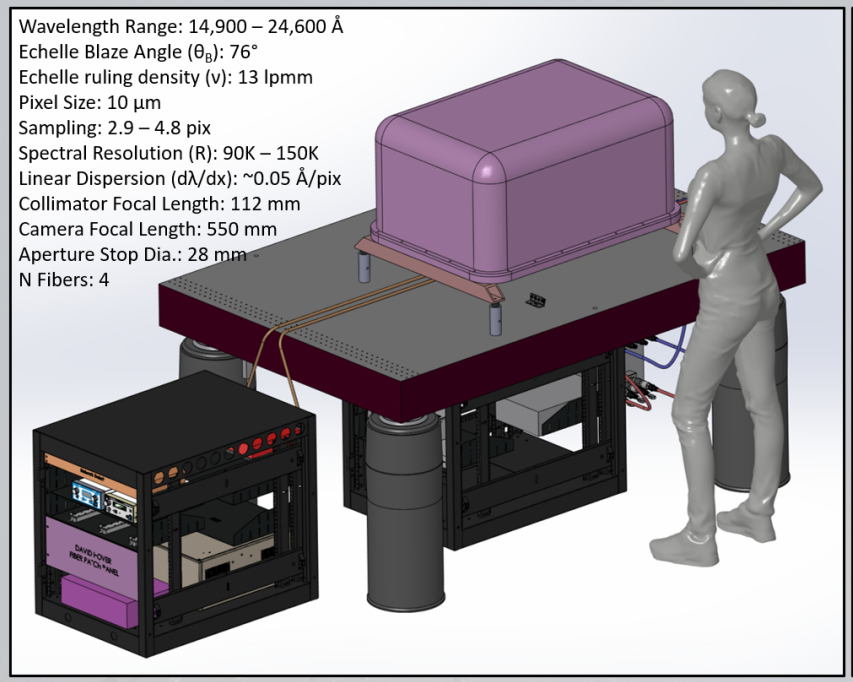
- Delivery planned in the spring
- Shared risk observing starts in semester 2022B

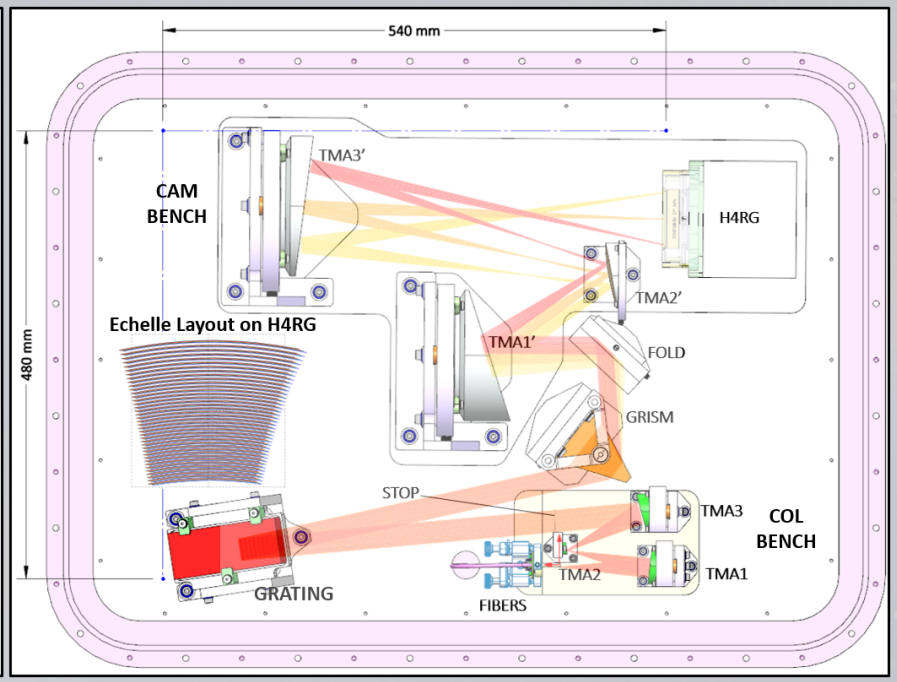




HISPEC: High-resolution Infrared Spectrograph For Exoplanet Characterization

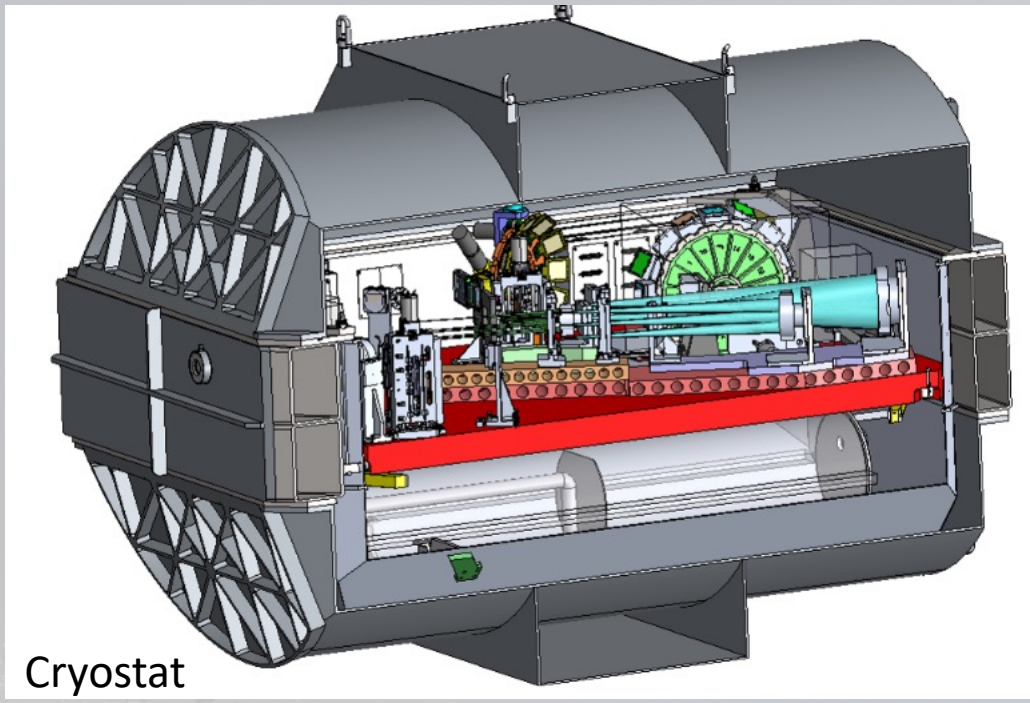
- To detect and characterize exoplanets
- AO fed, high contrast, 1-2.5μ, $R > 100{,}000$
- Used with laser frequency comb
- In preliminary design
- Most funding secured
- Delivery in 4-5 years



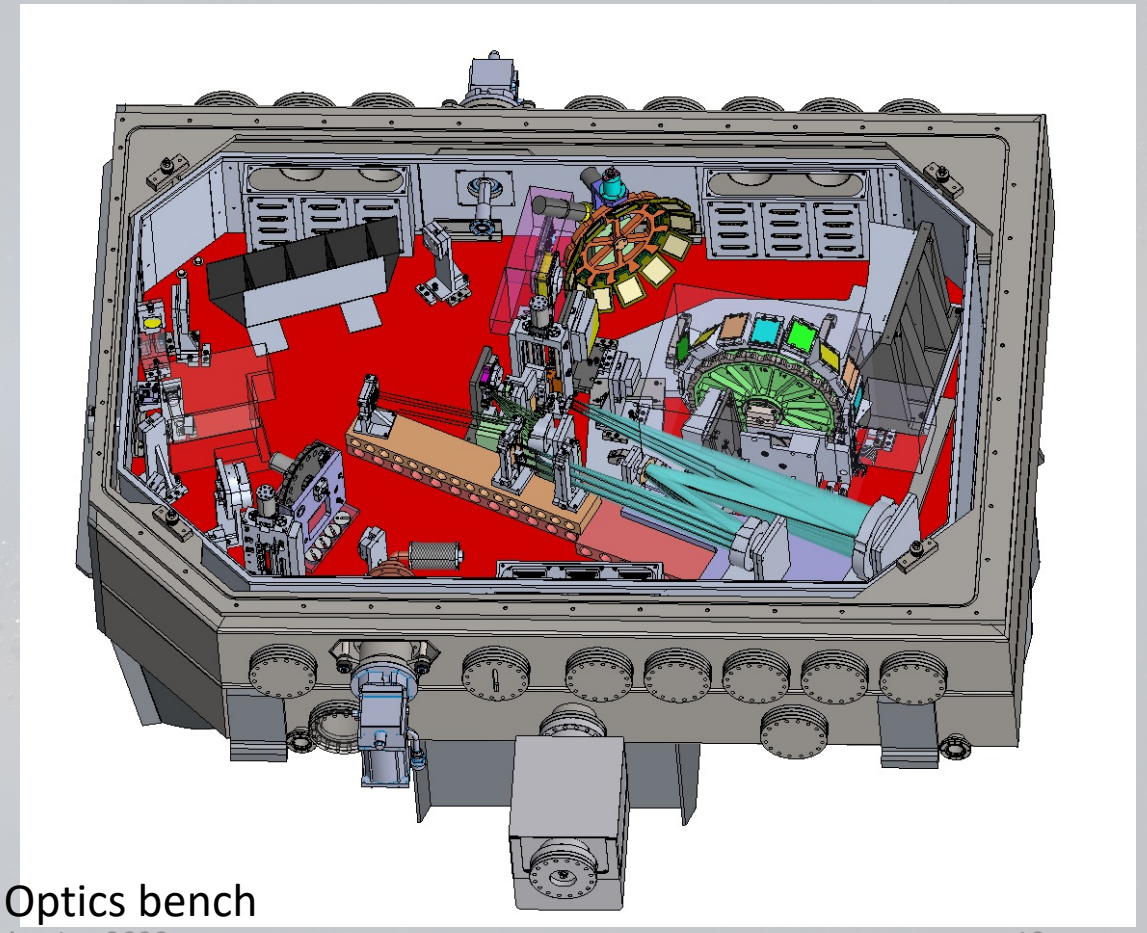


SCALES: Opto-mechanical designs

- To detect and characterize directly imaged exoplanets
- 2-5μ AO fed integral field spectrograph, 2.2 arcsec field, R ~ 50-300 and an image slicer R ~ 5,000, 3.6 arcsec field
- Preliminary design underway



Cryostat



Optics bench

Laser Frequency Comb

Frequency reference for precision radial velocity measurements initially for NIRSPEC (existing) and HISPEC (delivered in 4-5 years)

Technical Progress

- 70% of the equipment is purchased or in the queue with parts arriving in the lab at Caltech
- Basement location being prepared, hardware is being procured and utilities are being installed

Schedule:

- Expect to deliver in Spring 2022, with installation in the summer

Other Instrumentation Programs in Progress

KAPA – AO laser tomography system

- Includes new real-time controllers
- Initial science usage is also funded

KPIC – Keck Planet Imager and Characterizer

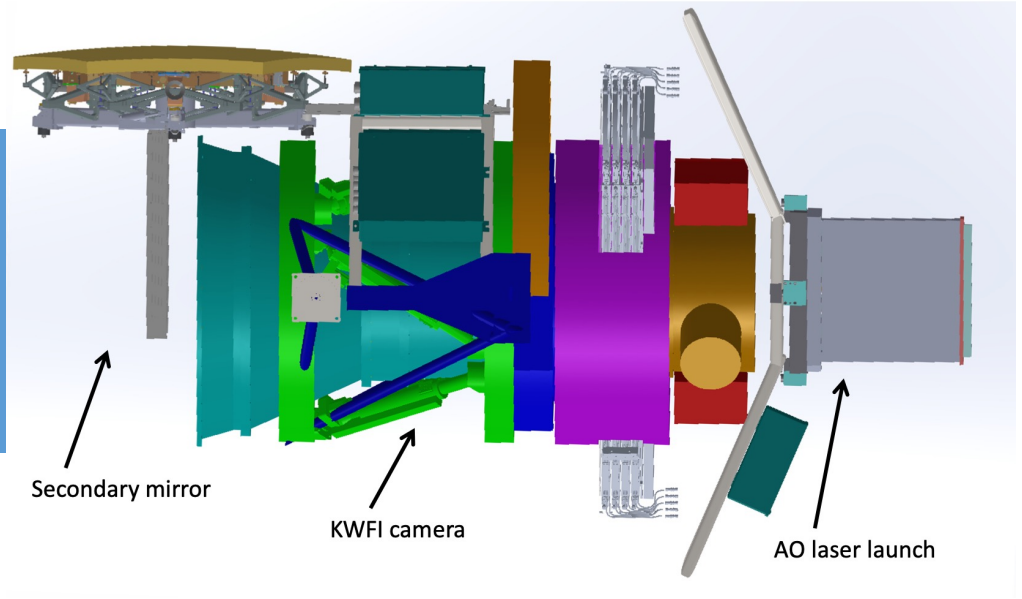
- New vortex coronagraphic masks, infrared pyramid sensor and fiber injection unit for NIRSPEC

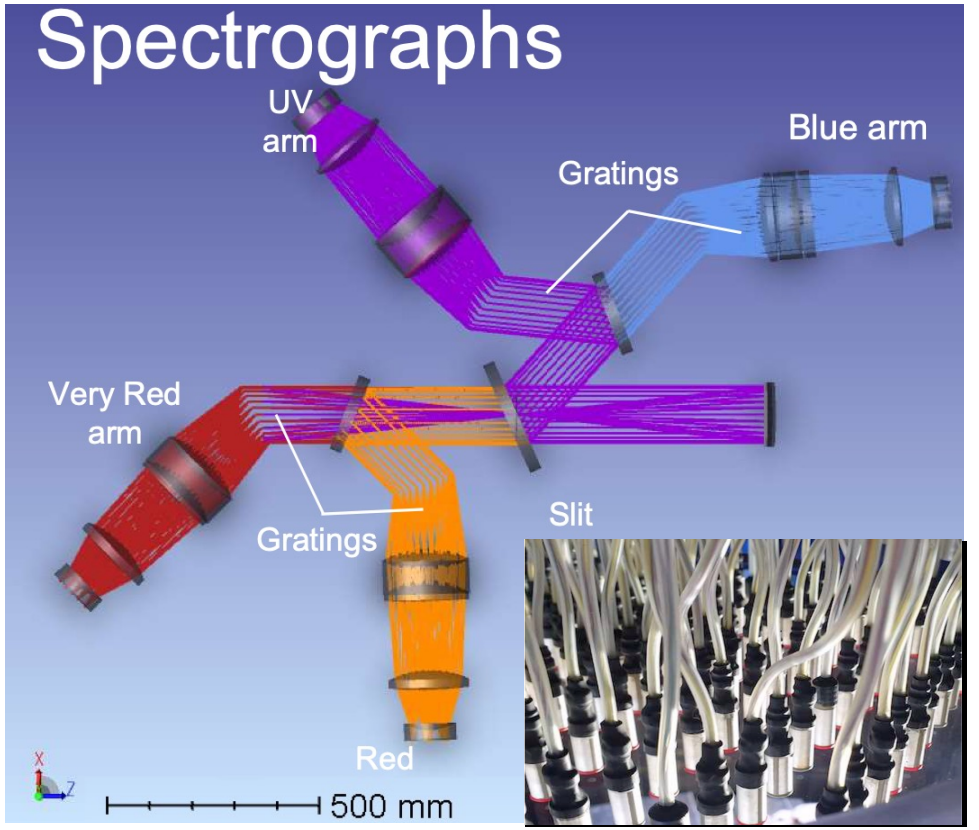
Data Services Initiative

- Provide data which is useful, usable, and quick

Instrumentation Ecosystems

- When complete, KPF, HISPEC, SCALES and the laser frequency comb will complete our planned suite of exoplanet instrumentation
- Discovery Engine: Optical wide field imaging and spectroscopy down to atmospheric UV cutoff
  - Wide field imager 1° diameter FoV, 300-1,000μ deployed at primary behind a deployable secondary
  - FOBOS: moderate resolution optical spectrograph, 1800 fiber , 45 fiber bundles over 20 arcmin FOV, 0.31-1μ, at R=3500





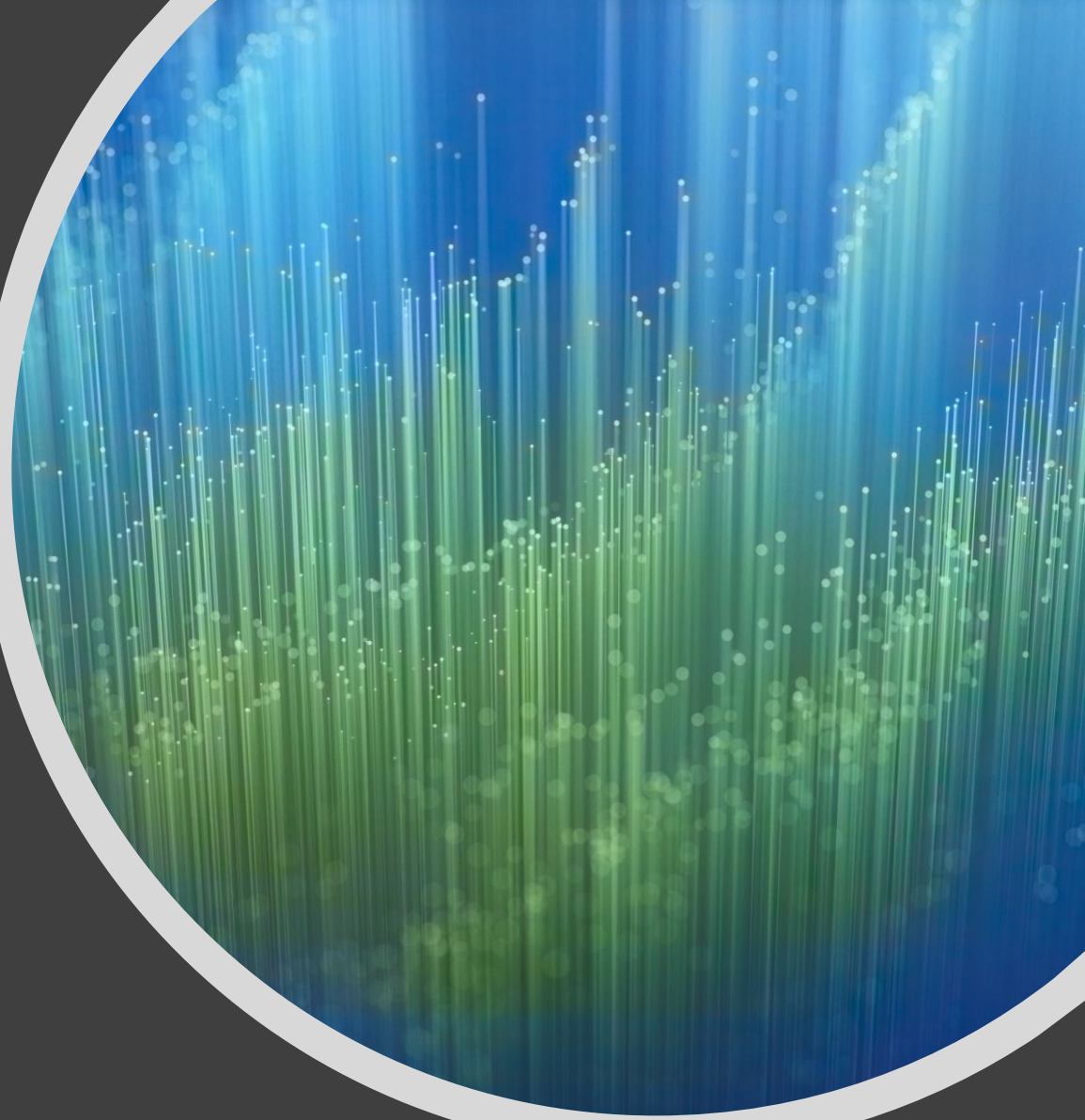
Looking forward to the ELT era

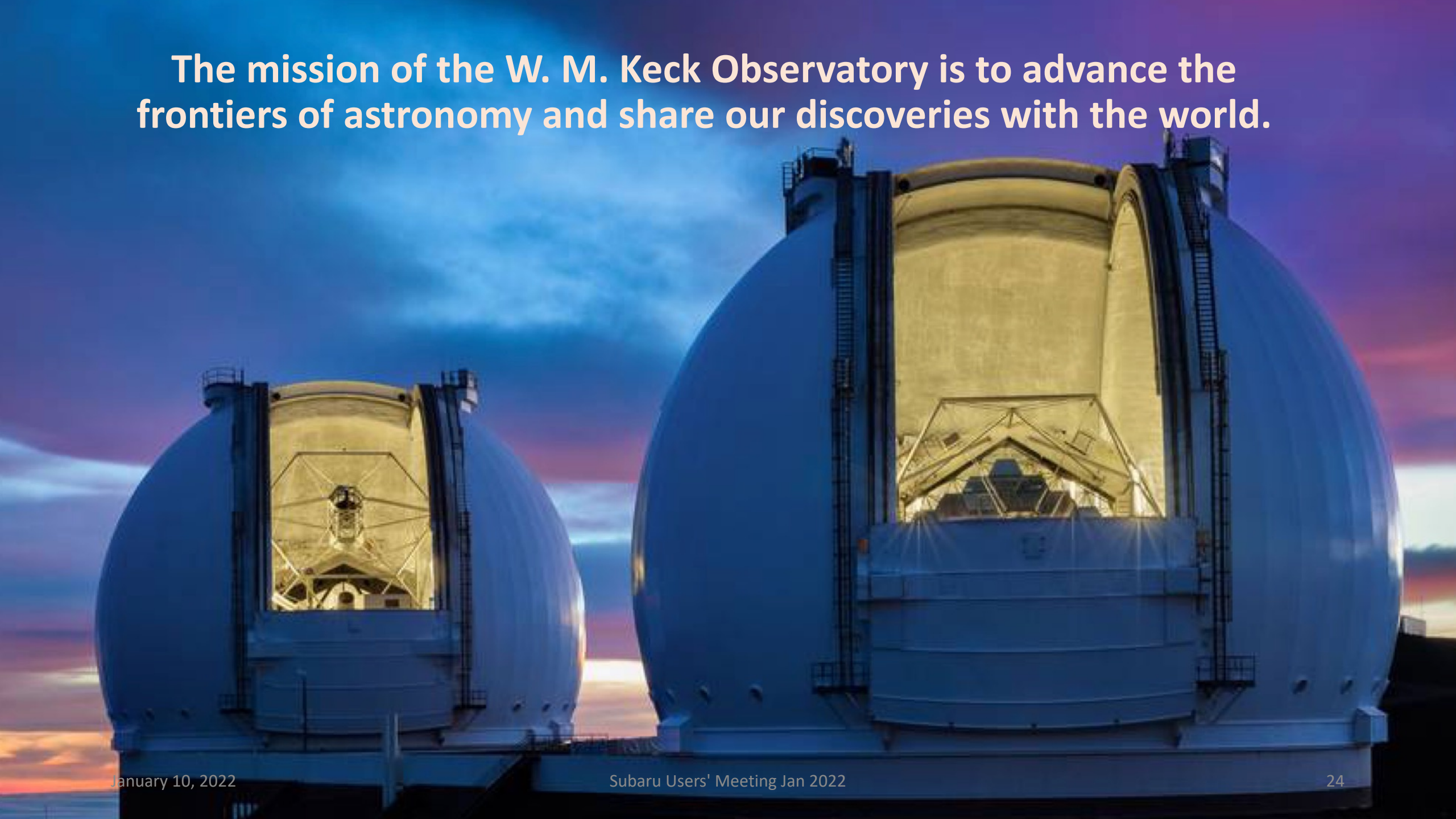
LIGER

- Preliminary design funded; draws on IRIS design heritage
- Not funded for construction yet
- Leading to IRIS/TMT

HISPEC

- Preliminary design will complete this year
- Funding path identified
- Leading to MODUS/TMT




The mission of the W. M. Keck Observatory is to advance the frontiers of astronomy and share our discoveries with the world.


Astro2020

Astro2020 offers significant opportunities for Keck

- Selection of an exoplanet/robust astrophysics flagship enables both precursor science programs at Keck and opportunities for technology development
- Augmentation of midscale programs provides opportunity to apply for instrument funding at the appropriate scale. A good example is FOBOS given its overlap with the strategic areas in the report.
- Highlights on data pipelines and archives for ground-based facilities provide opportunity for DSI funding growth
- The science pillars are Keck science strengths
- Calls for improved relations with indigenous populations mirror the approach being taken at keck