



# Science Steering Committee Meeting

## Staff Astronomer and Adaptive Optics Presentations

Virtual Meeting via Zoom

November 11, 2020

The background of the slide is a deep space image featuring several bright, colorful galaxies and nebulae. The colors range from vibrant purples and pinks to bright yellows and oranges, set against a dark, almost black background. The galaxies are scattered across the frame, with some appearing as distinct, bright spots and others as larger, more diffuse clouds of light. The overall effect is one of vast cosmic scale and energy.

# Instrument Reports



The background of the slide is a deep space image showing a large, irregularly shaped galaxy cluster or group. The galaxies are primarily purple and magenta, with some yellow and white highlights, set against a dark, almost black background. The text is centered in the upper half of the image.

Group 4  
AO, PyWFS, KPIC

# AO Operations

Jim Lyke & Juan Carlos Guerra

The screenshot displays a VNC viewer window titled "klobsao's k1ao-k1obsao-control desktop (kaalualu:3) - VNC Vie". The interface is a dense collection of control panels and data windows:

- STRAP Status:** Shows parameters like STRAP ID (TSS1), DMFS, Range (0.5), and Op (570.3).
- WFS Intensity - Keck I:** Displays a circular WFS intensity pattern.
- LEW S Img Acq v1.0:** A control panel with buttons for "Menu", "AO Control", "Tel", "WFS", "WFC", "Track", "DAR", and "Exit". It includes a "TARGET" section with R MAG (18.000) and B-V MAG (0.500), and a "WAVEFRONT SENSOR" section with Frame rate (438) and Intensity (3159). There are also "ABORT" and "Image Acquisition" buttons.
- Low-Bandwidth Manager v1.0:** Shows a graph of "Error" vs "Image" and "Image Processing (level) (off)".
- OA Permissive:** A large panel with "Permissives" for KECK I (Current, Latched) and a "Final Permissive" section with a "RESET" button. It lists various system components like OA, LICS, and BTAD.
- KL EST Sequencer:** Shows "Sequence State: PROPAGATING" with a sequence diagram and buttons for "SHUTTER", "IDLE", and "HALT ALL".
- UIT Gev unit:** A control panel with "Zero UIT" and "Laser Tip-Off" buttons.
- Revised Error (SRSec):** A graph showing error over time.
- Bottom Status Bar:** Displays system metrics: "Counts: 379.5K", "Fr Rate: 438", "Raw WF: 191ms", "Defocus: 0.22um", "BIM2 tracking: On", "TEL OFFLOAD: OK", "T BAD: GRANT", "Focuss: -5.8um", "dMUT: 05:02:27", "UTC: 05:02:16.21".

# Instrument Risk Definitions

Likelihood of Occurrence	Very Likely >70% within year					
	Probable >35% within year		Mode confusion	Upgrade or maintenance mistake	Laser failure	
	Possible >5% within year		LBWFS sensitivity	Glycol leak		
	Unlikely <5% within year		TRICK Detector degradation Non-tracking AO stage failures AO server failure	WFC crash LGS uplink	Tracking AO stage failure STRAP failure TT mirror failure	DM electronics failure
	Very unlikely <1% within year					
		Negligible: Little to no impact on Observation	Minor: Observation Compromised	Moderate: Observation Interrupted	Serious: Instrument Down one Night	Major: Instrument Down Indefinitely
Risk Severity, Impact						

# 2019 AO Ops Issues Review

## **K1**

- WFS pickup noise

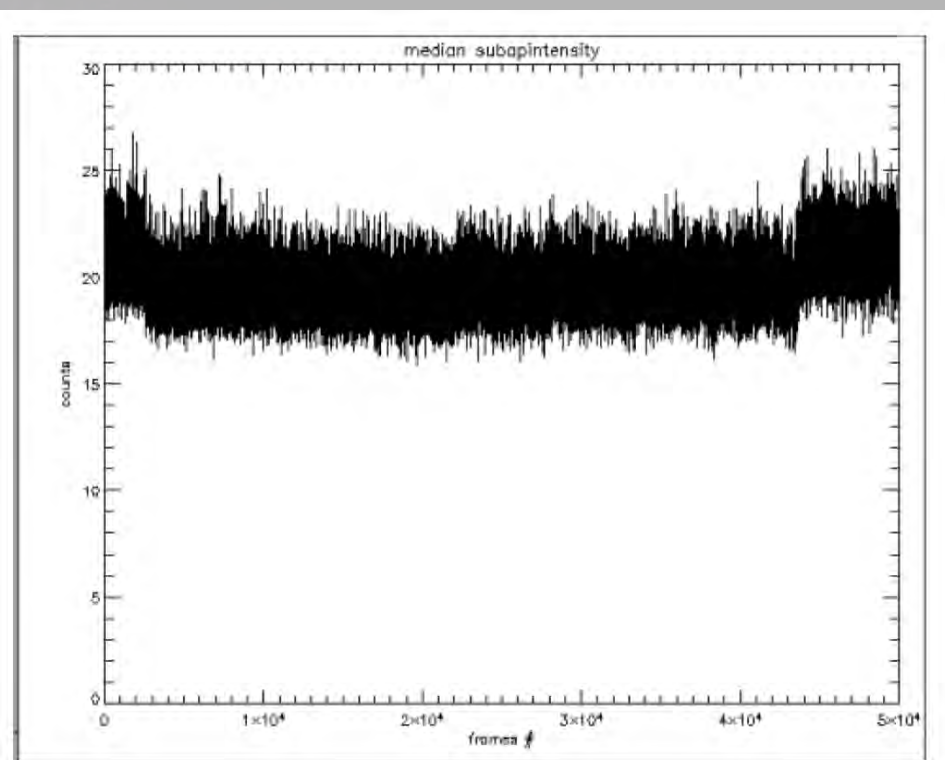
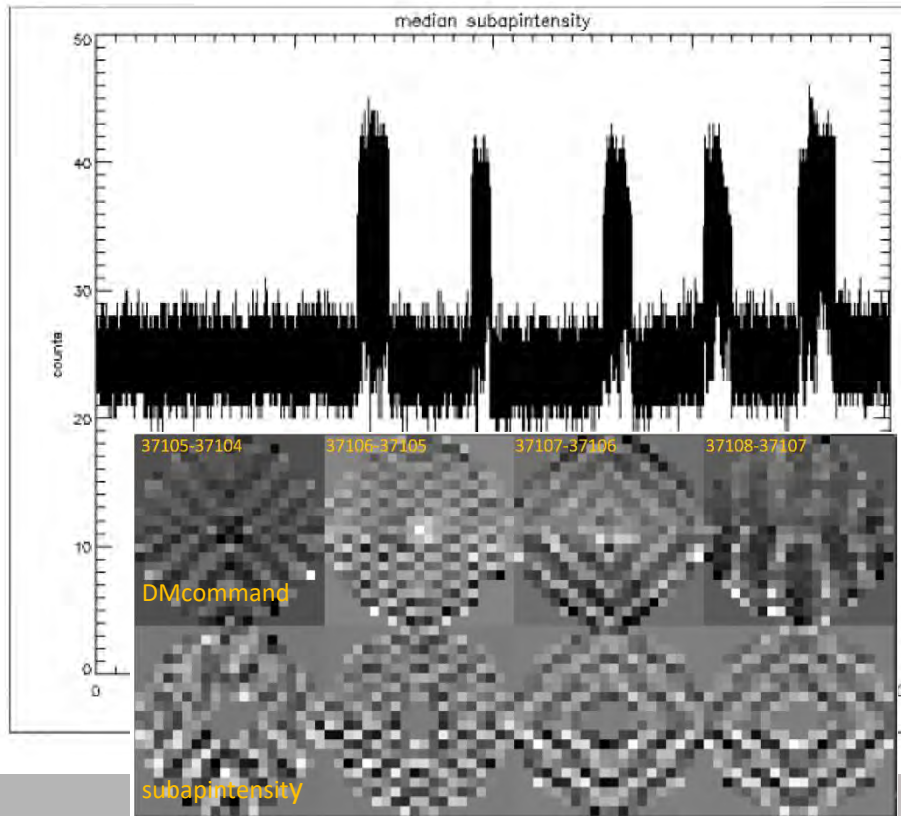
## **K2**

- DM electronics overheating



# WFS pickup noise improved

WFS intensity jumps correlate to FCS stage moves After capacitive filter on FCS stage motor

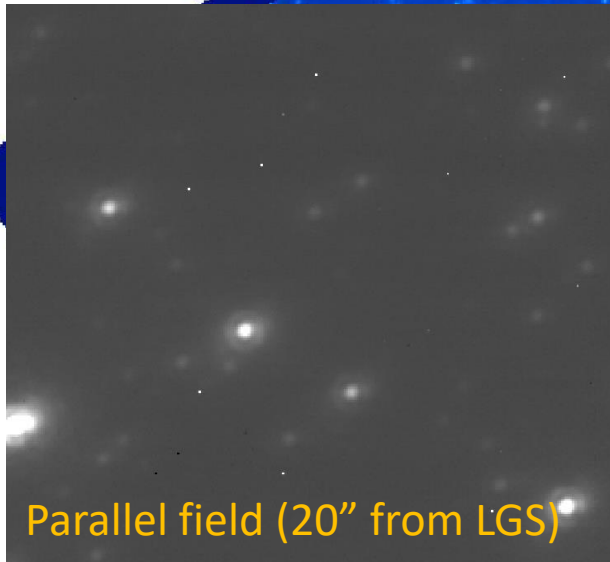


# DM electronics overheating

- At or near cooling capacity
- Added remote DM power supplies
- Moved computers from AO
- HVAC team looking at more options



## Ops w/ TRICK



- Improved Reliability
  - Fiber boards
  - Handles laser shutters
- Excellent image quality
- Requires visible TT star
- Limited to brighter than H/K ~14
- Will TRICK meet demands of KAPA?

TRICK GC

# AO Ops Efforts

## K1

- 76 scheduled nights
- TRICK reliable operations

## K2

- 163 scheduled nights
  - 16 PyWFS
- PyWFS operations
  - More calibrations

## Infrastructure

- Room cooling
- Linux keyword service builds
- Stage repairs/maintenance
- OBS power supplies
- TRS
- Ops SW cleanup

# AO Ops Look Ahead

- Continued infrastructure work
  - Want system ready and operational
  - Cooling, stage refresh, PMs (new eng hires)
- LBWFS characterization
  - MAGIQ cameras are ~1 mag less sensitive
- Deploy new aoserver computers
- Upgrade Projects
  - Stability vs. New



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# Keck Adaptive Optics Development

# Topics

- Current/recent AO development
  - KAPA, RTC, PyWFS
  - High contrast
- AO proposal development
  - Keck AO Future Study Group
  - High order DM, ORCAS, ASM, post-dawn AO

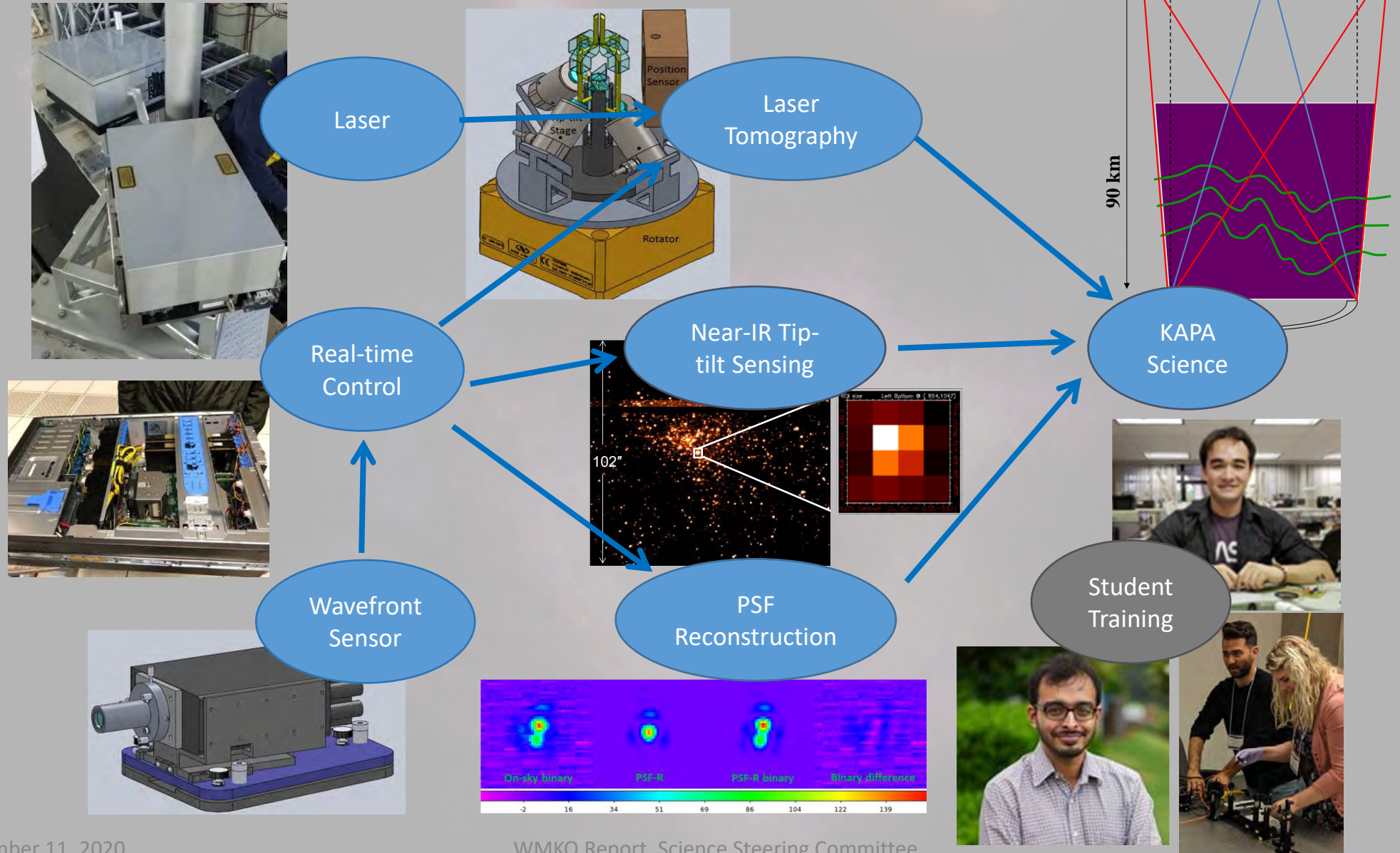
# Projects

Project	Source	Total \$k	\$k at WMKO (8/31/20)			FY						
			Acct	Funding	Unspent	18	19	20	21	22	23	24
RTC	MRI	2565	84218	2565	778	x	x	x	x	x		
KAPA Project	MSIP	7048	83018	7048	3671		x	x	x	x	x	
Science	GBMF	4300						x	x	x	x	x
Astrotech	HSF	677					x	x	x	x	x	
Turbulence Simulator	Private	50	83821	50	50				x			
FIU Coronagraph	HSF-CIT		82917	272	206			x	x	x		
Predictive WFC	HSF-UCSC		83319	90	58		x	x	x			
PyWFS Facility	WMKO	250	83219	250	86		x	x	x			
AO Refurbishment	WMKO	49	83420	49	35			x	x			
Pinhole Calib. Mask Unit	UCO	40						x	x			
ORCAS: Pre-study	Goddard		83620	6	0			x				
Mission study	NASA	141		13	13				x			
High Contrast Imaging	HSF-UCSC	995	83720	200	200				x	x	x	
Advanced WFS&C	ATI-UH			196	196				x	x	x	
	<b>Total =</b>			10739	5293							



# Keck All Sky Precision Adaptive Optics

<https://keckao.github.io/kapa/about/>



# KAPA Reviews

Date	Completed Reviews
9/26/18	WMKO Real-time Controller (RTC) PDR
12/13/18	Microgate RTC PDR
1/31/19	Laser Infrastructure Design I
5/2/19	Laser Infrastructure Design II
7/24/19	Microgate RTC DDR
9/12/19	Laser Tomography (LT) SDR
9/12/19	WFS Reducer Optics DDR
2/13/20	WMKO RTC DDR
5/7/20	Laser Operations (Ops) Handover
6/3/20	OMP Asterism Generator (AG) PDR
6/17/20	WMKO AG PDR

Date	Planned Reviews
11/19/20	LT PDR
11/20/20	WFS Pupil Relay DDR
11/20/20	Asterism Simulator (AS) DDR
12/3/20	OMP AG DDR
1/10/21	RTC Factory Acceptance
1/18/21	WMKO AG DDR
1/31/21	Keck I RTC + OCAM Pre-install
2/15/21	AS Pre-install
3/30/21	WFS Pupil Relay Pre-install
6/3/21	LT DDR
6/15/21	Keck II RTC + OCAM Pre-install
9/28/21	AG Acceptance
9/30/21	Keck I RTC + OCAM Ops Handover
10/12/21	AG Pre-install
12/30/21	Keck II RTC + OCAM Ops Handover
1/30/23	Laser Tomography Ops Handover

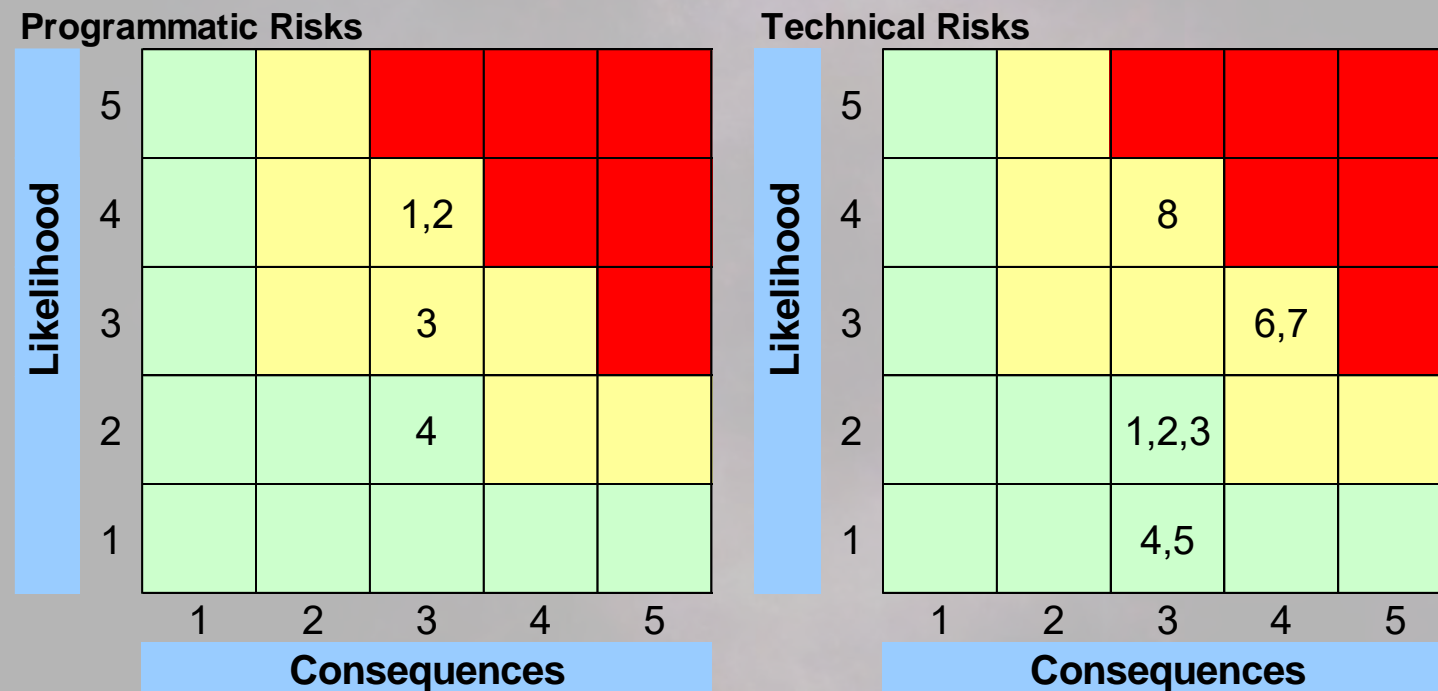
# FY21 KAPA/RTC Priorities

1. Laser handover lien completion
  - Laser performance, documentation completion
  - LMCT laser removal (lower priority than 2 to 5)
2. RTC implementation and commissioning
  - FAT (Jan. 2021); I&T; operations handover
3. Keck II RTC implementation & commissioning
4. Daytime laser tomography implementation & testing
  - Pupil relay; asterism simulator; LT algorithm; system testing
5. Asterism generator fabrication and development
  - Vendor DDR & FAT; WMKO DDR & FSD; install (Oct. 2021 start)
6. Remaining design & implementation
  - Nighttime laser tomography; TRICK; PSF-R

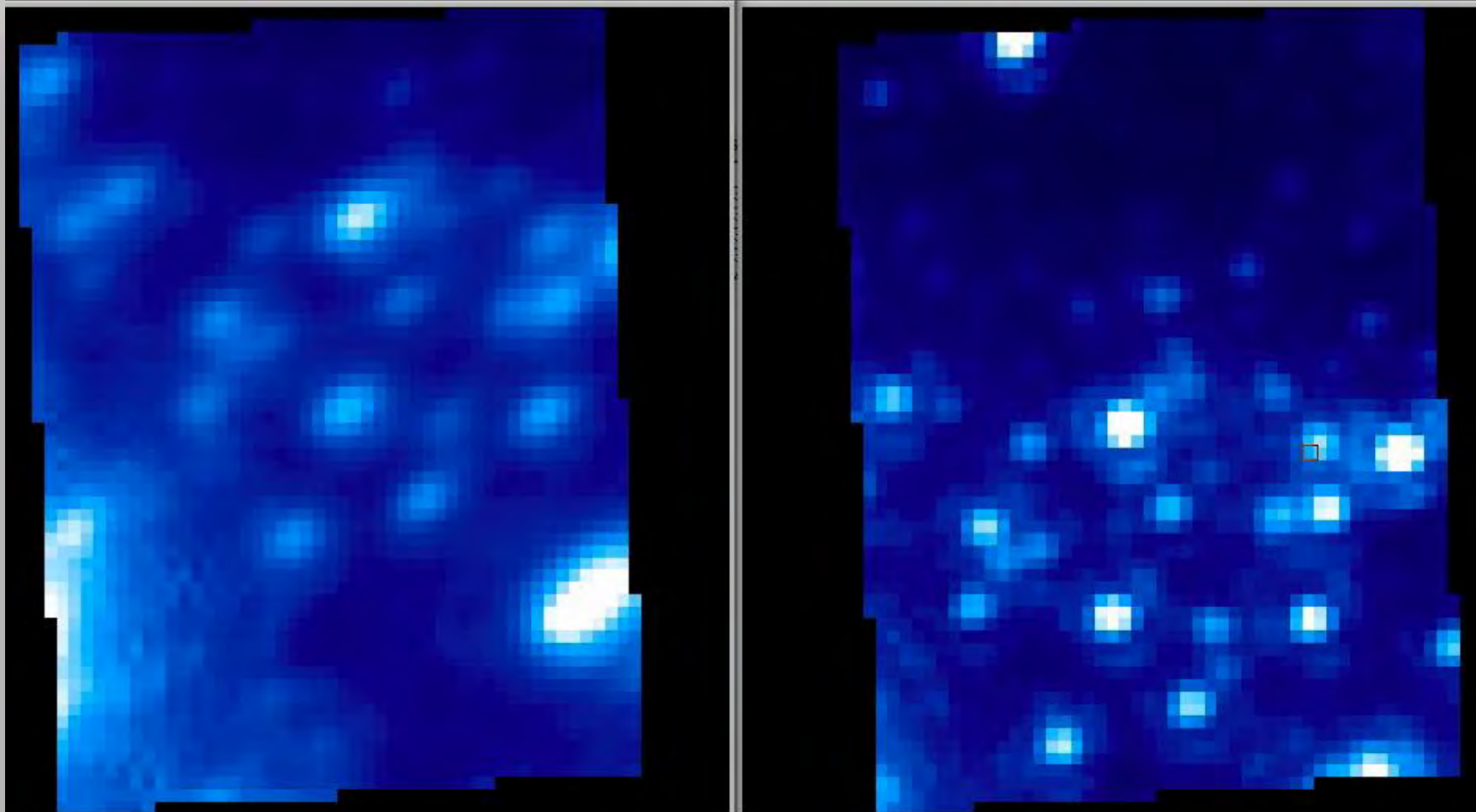


# KAPA Risks

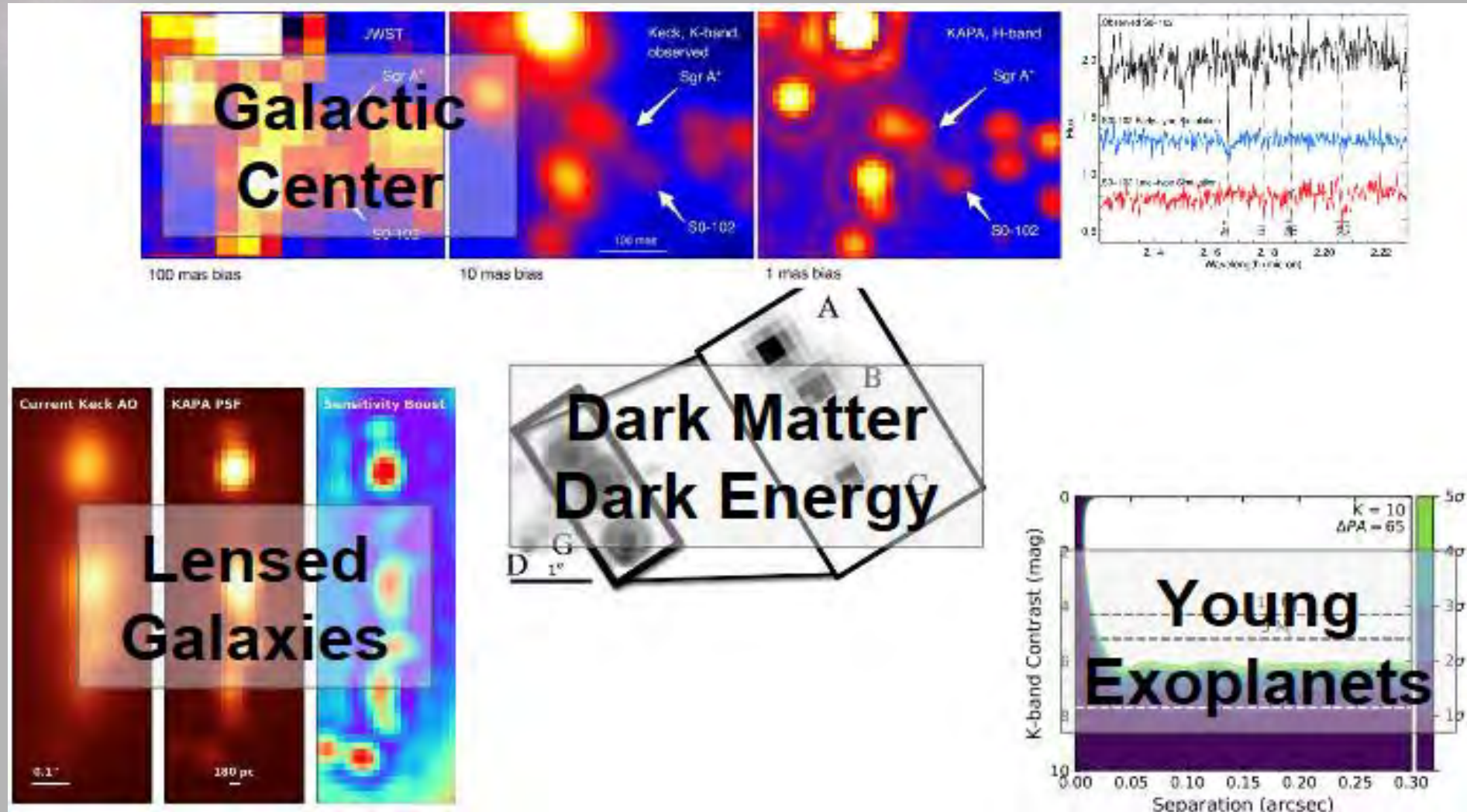
- Programmatic: 1) Inadequate contingency. 2) External contract slips. 3) Slips due to limited AO access.
- Technical: 6) TRICK unreliable. 7) PSF-R underperformers. 8) LBWFS limits performance












# OSIRIS IFU with STRAP & TRICK

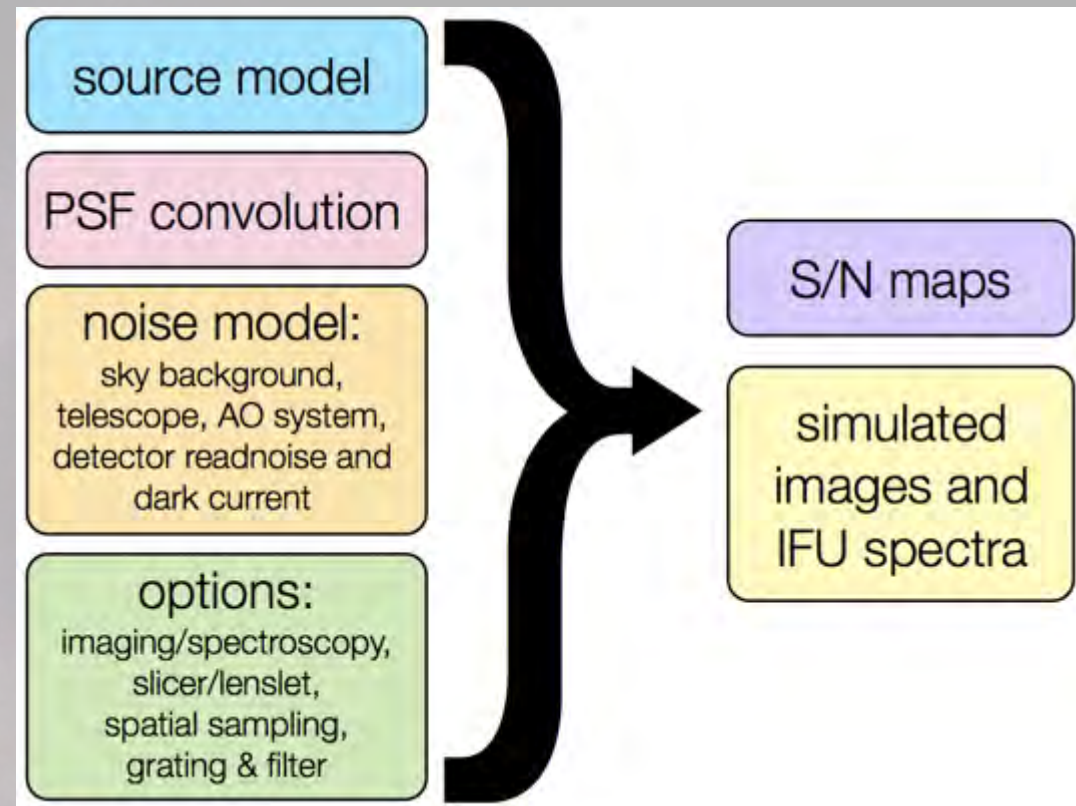
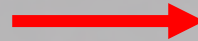


# KAPA Science



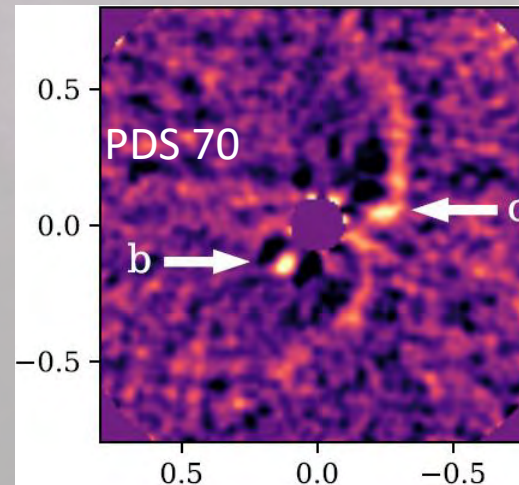
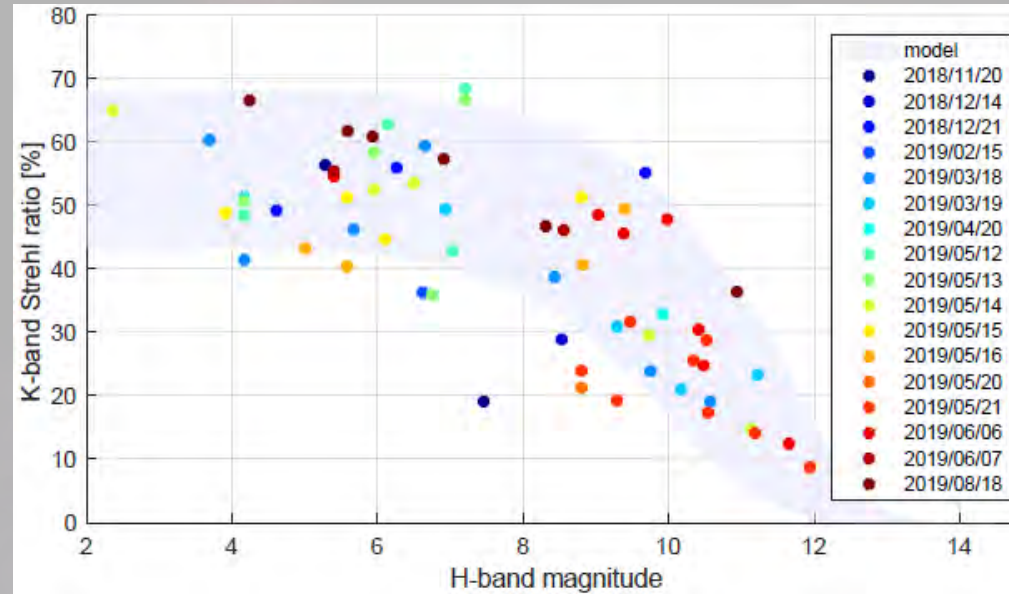
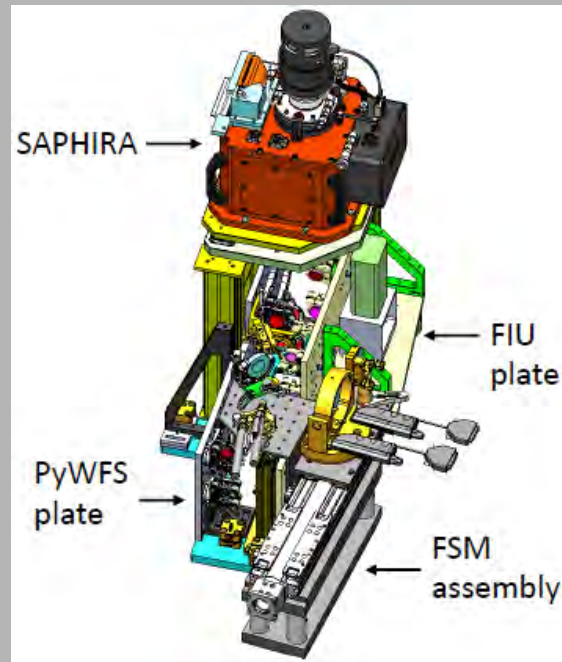
# KAPA Science Tool Development

- >  OSIRIS ETC
- >  OSIRIS Spec DRP
- >  OSIRIS Simulator
- >  OSIRIS Imag DRP
-  Improve OSIRIS Spec Extraction
- >  Simulated PSFs
- >  System Health Monitoring
-  PSF-R
- >  Performance Analysis





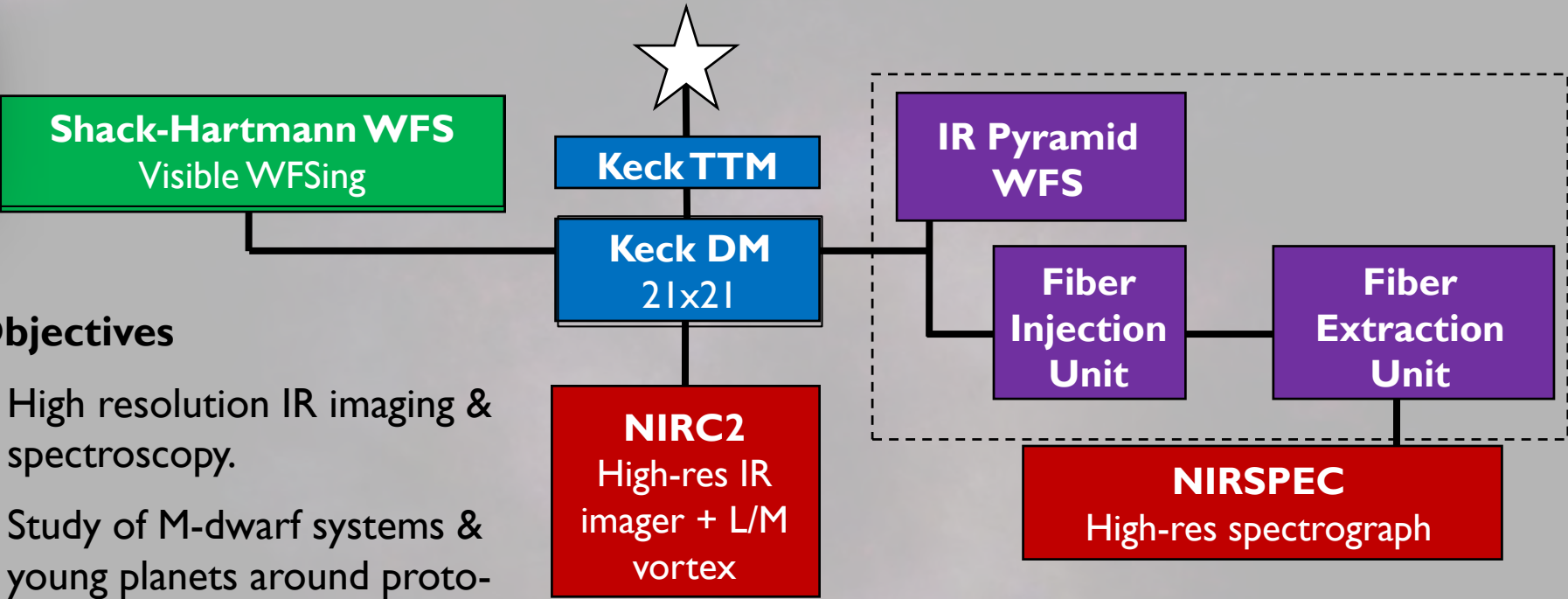
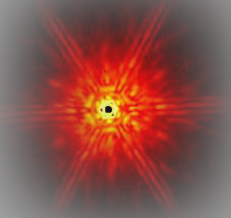
# Near-IR Pyramid WFS





# Keck Planet Imager & Characterizer

- Phase I producing science



### Objectives

- High resolution IR imaging & spectroscopy.
- Study of M-dwarf systems & young planets around proto-planetary discs.

- Phase II planned for fall 2021

# High Contrast Demos

- Predictive Wavefront Control
- Speckle Nulling
- Fast and Furious Algorithm
- Electric Field Conjugation
- Telescope Segment Phasing

# Keck AO Future Study Group

## FY20 Charter:

- Prioritize improvements
  - AO refurbishment goal
- Establish science linkages

## Recommended:

- Higher order DM
- Post-dawn AO

## FY21 Recharge topics:

- ASM
- ORCAS
- Post-dawn AO

## Membership:

- M. Chun (UH)
- C. Fassnacht (UCD)
- M. Fitzgerald (UCLA; co-chair)
- R. Jensen-Clem (UCSC)
- K. de Kleer (CIT)
- M. Liu (UH)
- J. Lu (UCB)
- J. Lyke (WMKO)
- D. Mawet (CIT)
- P. Wizinowich (WMKO; co-chair)
- S. Wright (UCSD)



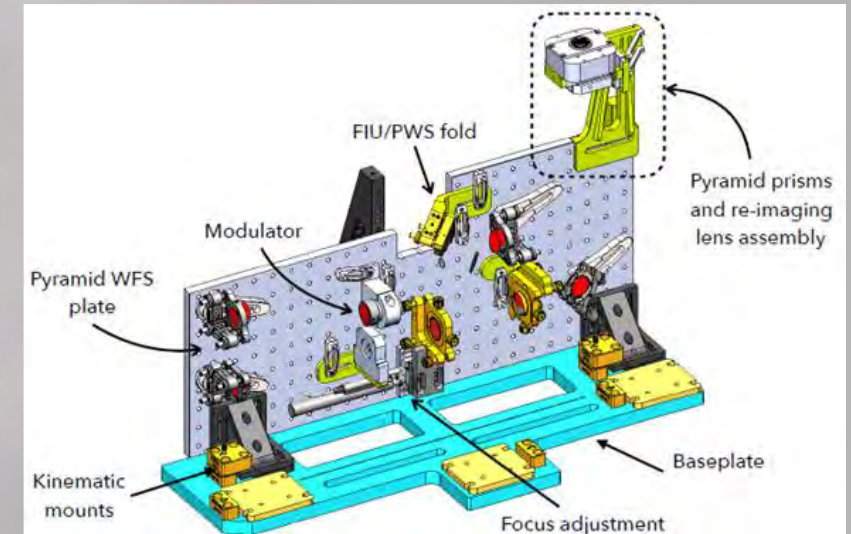
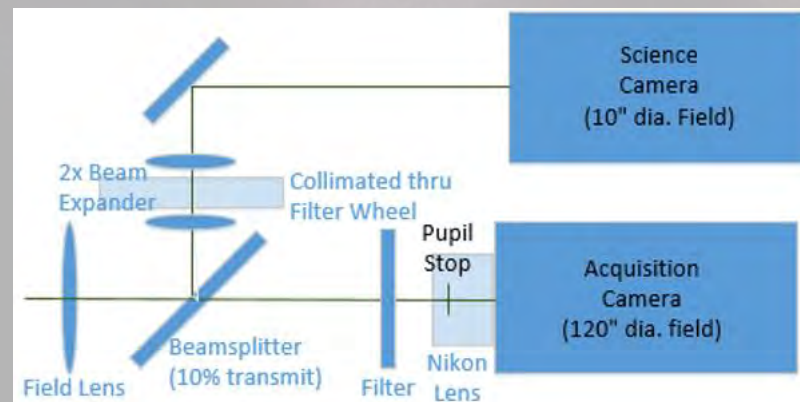
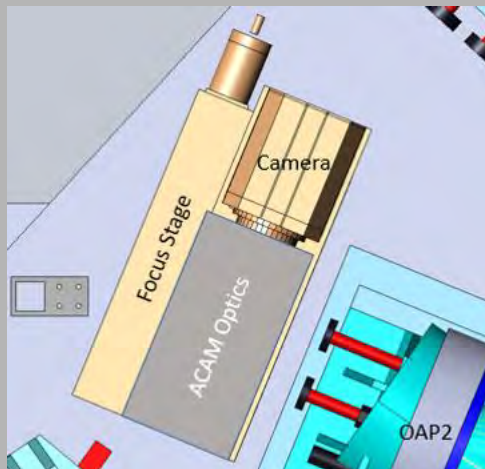
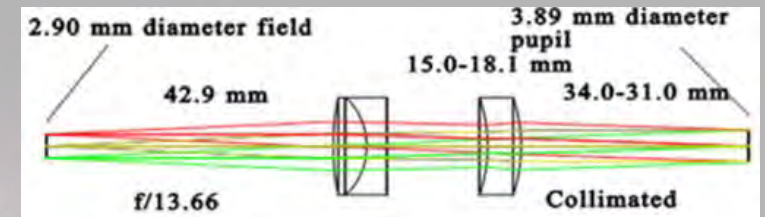
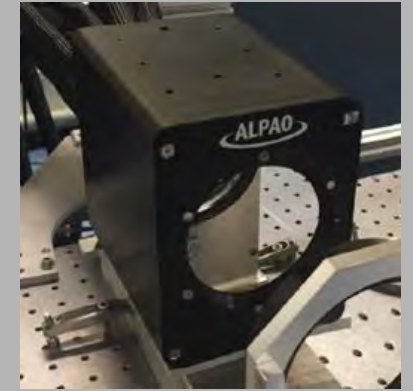
# FSG FY21 Calendar

Month	Day	Event	Milestones				
			HODM MRI	ORCAS	ASM	Post-dawn Observing	Efficiency & Stability
Sept.	16-17	KAPA Science Meeting					
	23	FSG Zoom	Draft science reqs	Review AO reqs	Draft CfAO Qs		Draft CfAO Qs
	24-25	Keck Science Meeting					
Oct.	21	FSG Zoom	Draft science cases Vis camera decision	Draft science pgms & ops models, & top-level req.		Test ideas	
	26-30	CfAO Virtual Retreat			Answer FSG Qs		Answer FSG Qs
Nov.	11-12	SSC Meeting					
	18	FSG Zoom	Remaining questions	Define opt instrum reqs	CfAO report & AIs		CfAO report & AIs
Dec.	13-18	SPIE					
	23	FSG Zoom		Define IR instrum reqs	Update on prior work		
Jan.	19	MRI Proposal due	Submit				
	20	FSG Zoom		Finalize science pgms & ops models	Update on prior work		
Feb.	17	FSG Zoom		Draft recommendations	Operational imple- mentation & impact	Ops progress update	
Mar.	10-11	SSC Meeting - FSG Update		Recommendations			
	17	FSG Zoom			Landscape that is enabled	Ops impact assessment	Motion control update
Apr.	21	FSG Zoom			Landscape that is enabled	Science cases	
May	19	FSG Zoom			White paper decision	White paper decision	White paper decision
	21	SSC Meeting					
June		FSG Zoom			Draft recommendations		
		SSC white papers due			Submit?	Submit?	Submit?
July	6-7	SSC Meeting - FSG Update			Report to SSC		
		FSG Zoom					
Aug.		ORCAS Proposal due		Submit			
Sept.		KAPA Science Meeting					
		Keck Science Meeting					

# High Order Deformable Mirror

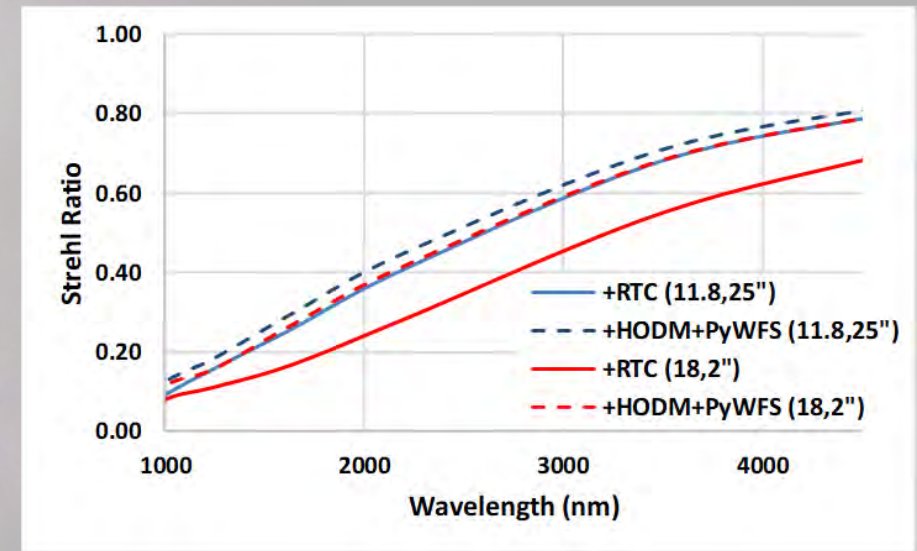
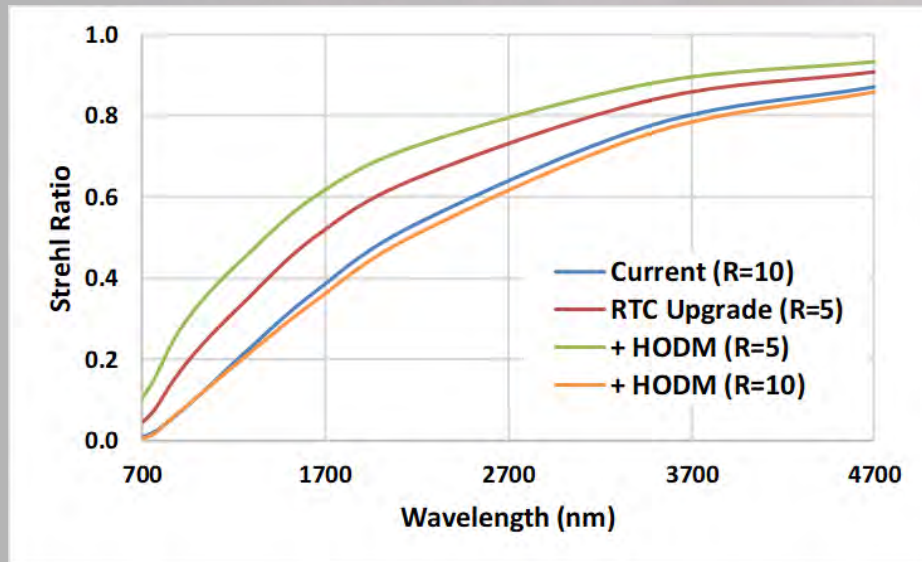
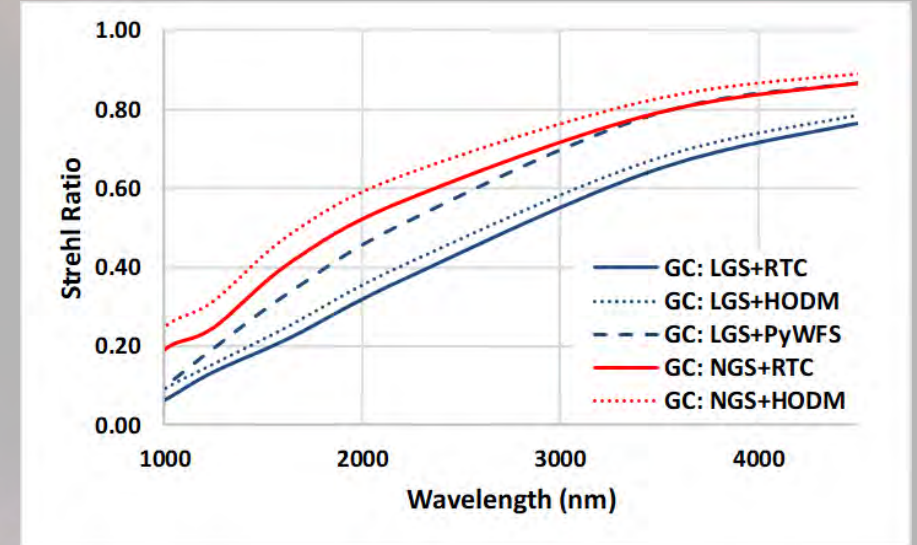
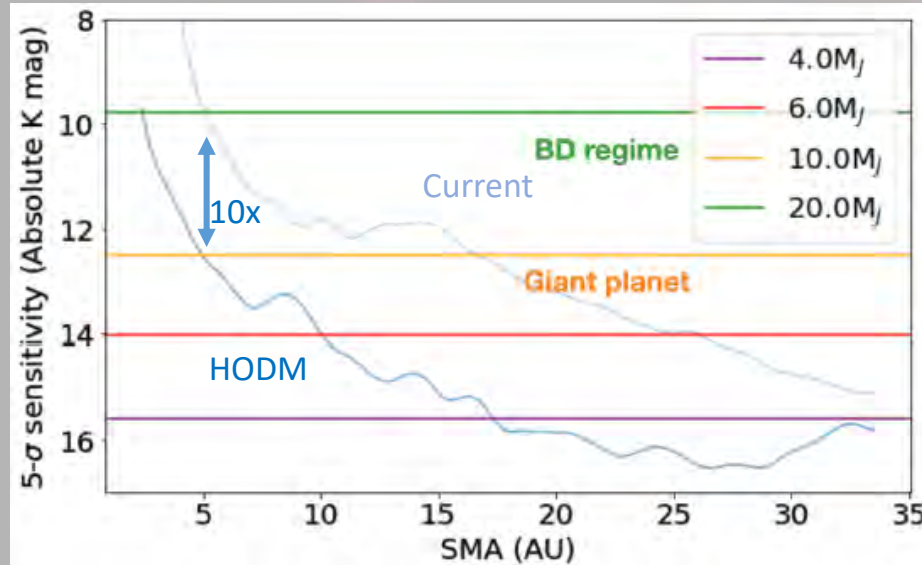
## Proposal Technical Elements:

- 58x58 actuator ALPAO DM
- High order Shack-Hartmann WFS
- High order Pyramid WFS
- Low order Pyramid WFS
- Demo Visible Science Camera



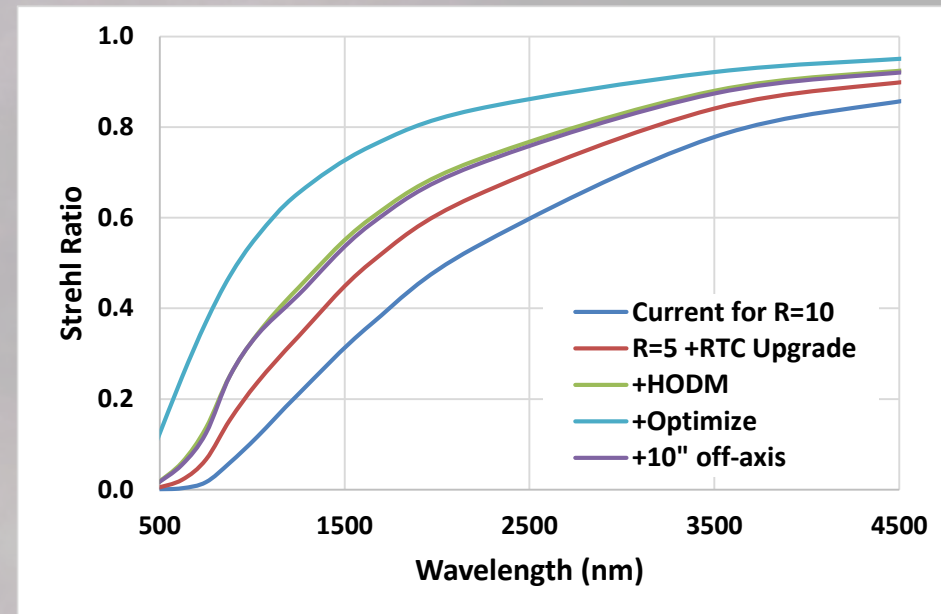
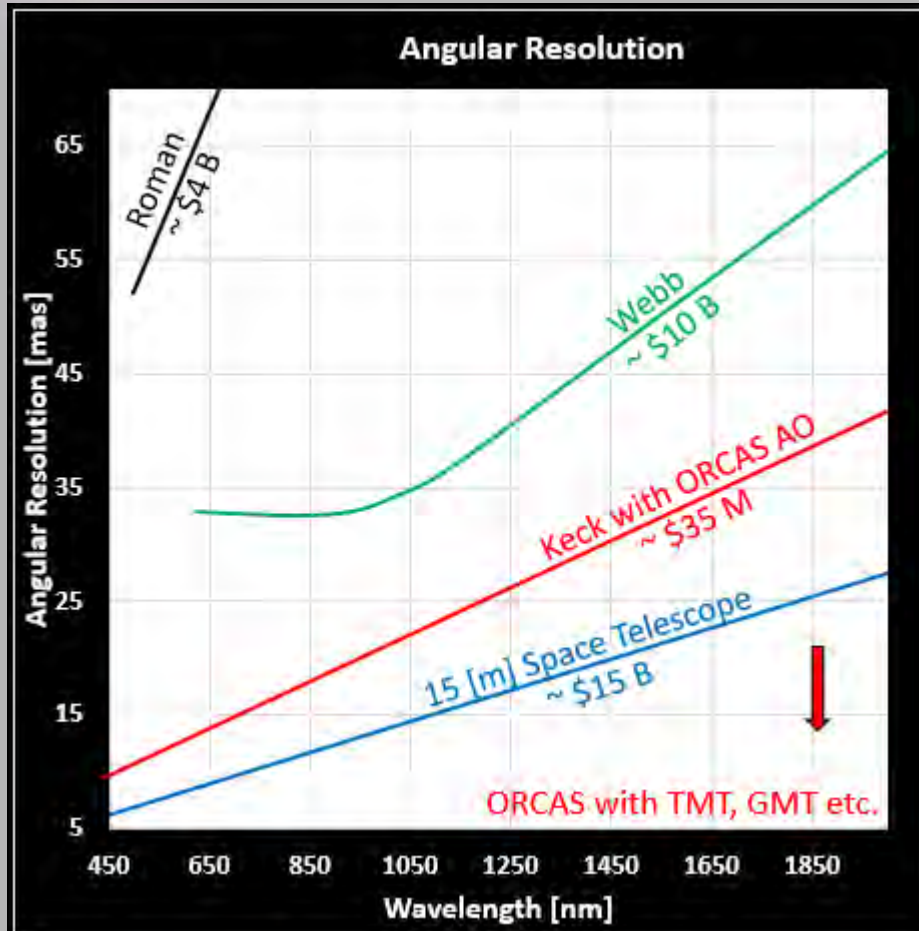
# High Order DM

NIRC2 K-band Vortex + PyWFS  
 H = 5, 30 Myr star at 30 pc





# Orbiting Configurable Artificial Star (ORCAS)





# ORCAS AO

## KAON 1352. ORCAS & Keck AO:

1. Introduction
2. Keck AO
3. Science Instruments
4. Ground Requirements & Interface
5. Potential AO Upgrades
6. Performance Predictions
7. The Competitive Landscape
8. Mauna Kea Laser Operations
9. AO Operations
10. Proposed ORCAS Ground System
11. Risk Analysis & Mitigation
12. Project Management

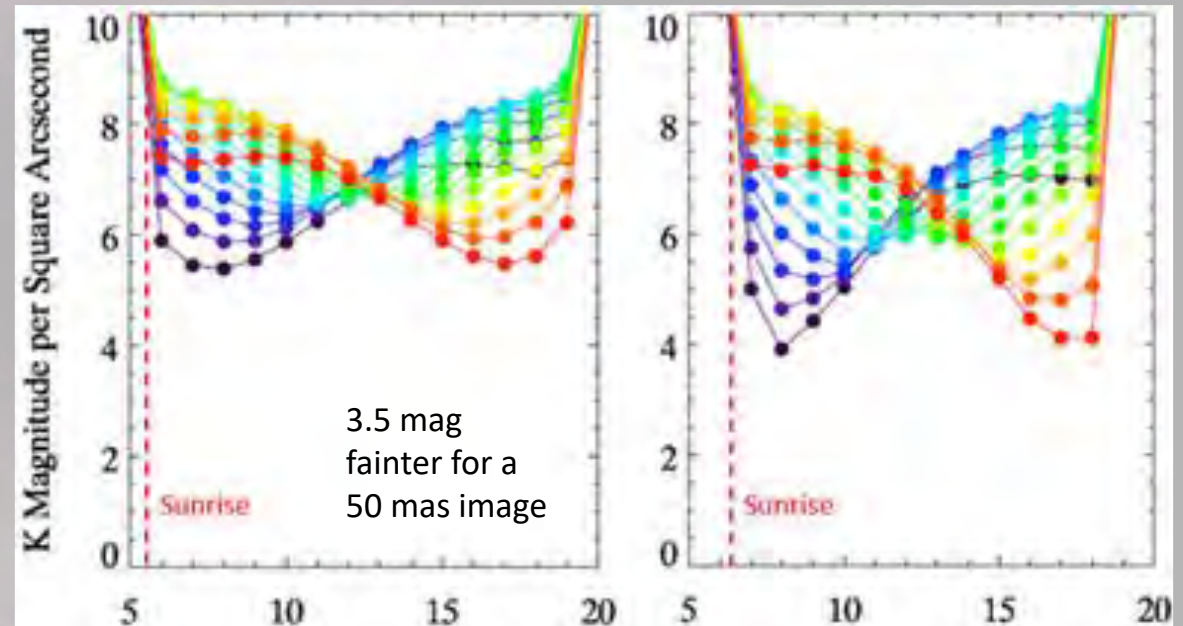
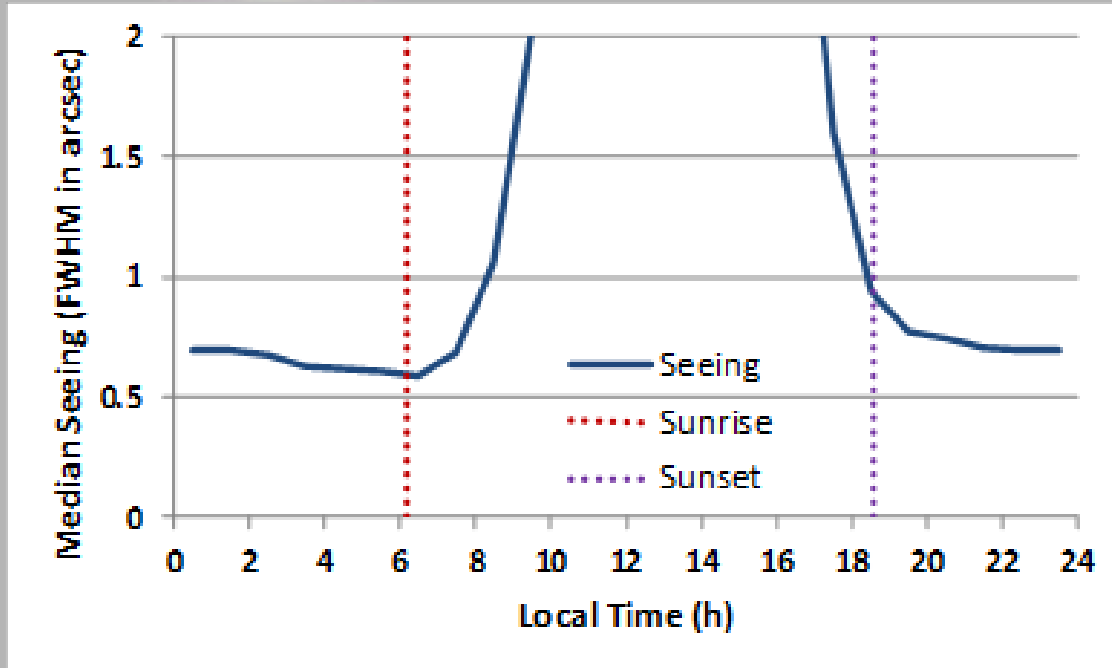
## Major Milestones:

- **Science Meeting**
  - Aug. 13-14
- **Mission Concept Reviews**
  - Nov. 2020 & Jan. 2021
- **Blue/Red Team Reviews**
  - June & Aug. 2021
- **Proposal submittal**
  - Feb. 2022
  
- **If funded: 3 year mission launched in 2025**

# Adaptive Secondary Mirror

- “Conceptual development of a new technology ASM for Keck” white paper by P. Hinz
  - High efficiency, TNO hybrid variable reluctance actuator technology being demoed at UH 2.2m
- Builds on “Ground layer adaptive optics for the W. M. Keck Observatory: feasibility study” by Lu, Chun et al. (SPIE, 2018)
- Multiple meetings since July SSC

# Post-dawn AO



# Questions?