Designing, Manufacturing, Programming, and Deploying Environmental Sensing Instruments using Visible and Infrared (IR) Cameras for the Mauna Kea Observatories (MKO) All-Sky Infrared & Visible Analyzer (ASIVA)

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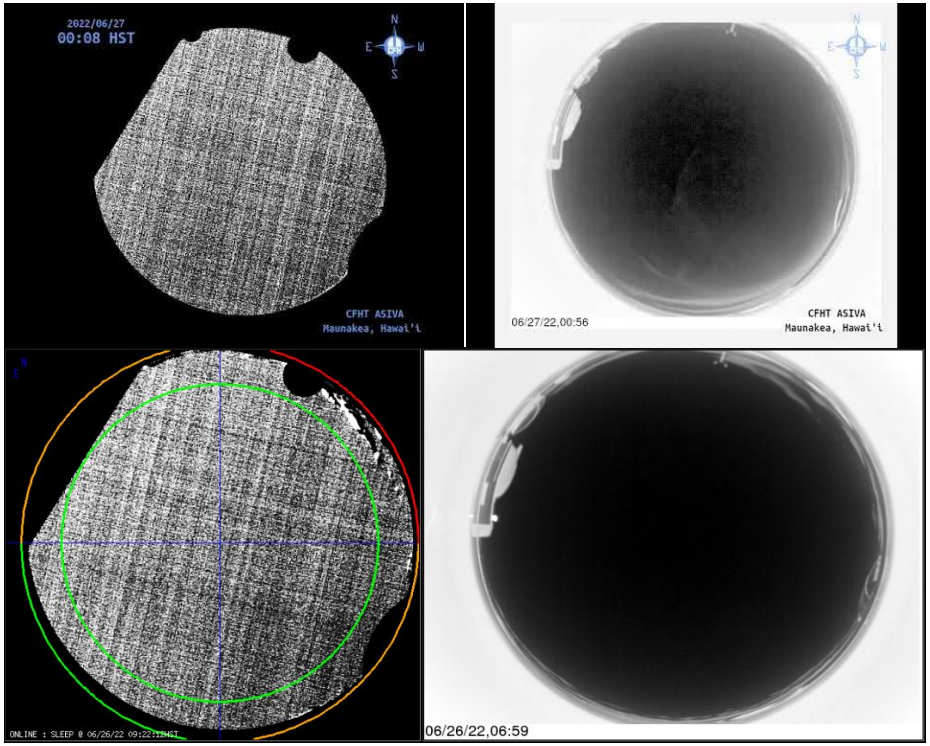
Columbia University Engineering
CFHT
Mentor: Billy Mahoney

What is ASIVA?

- All Sky Infrared and Visible Analyzer
- Dual-Camera System:
  - IR Camera
  - Vis Camera
- Machine Learning
- Vital to telescope operations



ASIVA Issues

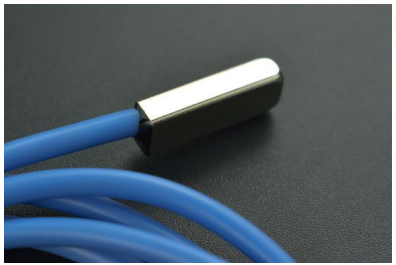
- Vis camera down
- Ambient temperature sensor down
- Technology outdated
- No backup if IR camera goes down
- Upkeep is difficult and expensive

Working group formed in February

- Representatives from all but one observatory

Project Goals

1. Install a new visible camera
2. Establish a replacement for ASIVA's IR camera in case it goes down
3. Restore temperature sensing
4. Work toward a portable ASIVA replacement (Dual-Cam)



Project Components

Vis Camera

- Testing
- Mounting
- Installation

IR Camera

- Testing
- Mounting planned
- Installation procedure laid out

Dual-Camera

- Testing
- Mounting
- Installation
- Continued work

Vis Camera

- ZWO ASI 178 mm
- Ethernet or USB type B interface
- 6.4M pixels
- 14 bit data
- 60 fps, 3096 * 2080 resolution
- Default lens: 170 degree FOV
- Possibility of colored version

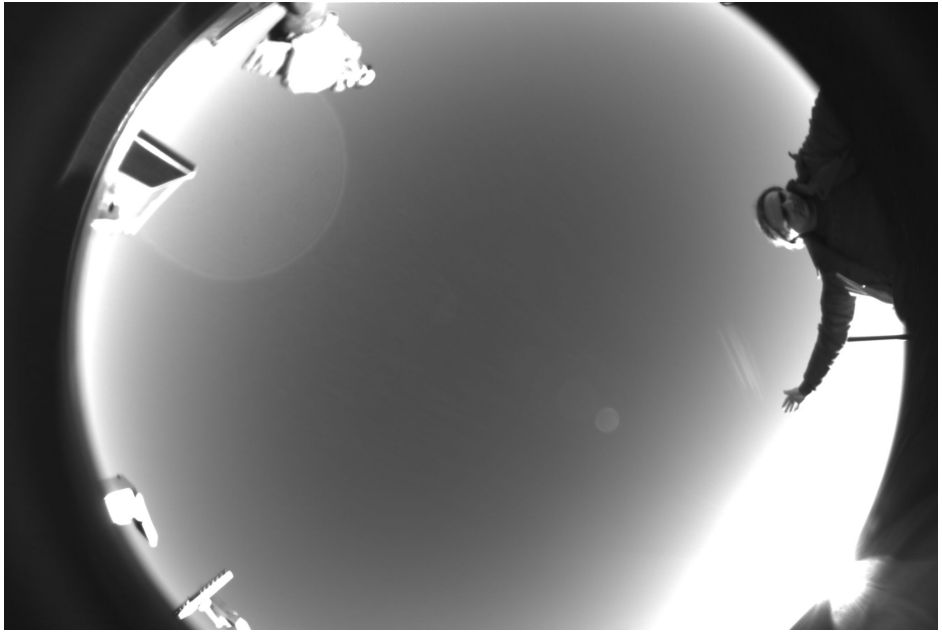
Vis Cam 1 (from ASI website)

Vis Cam 2 (from ASI website)

Vis Cam 3

Vis Sample Images

Vis CFHT



Vis ASIVA Site

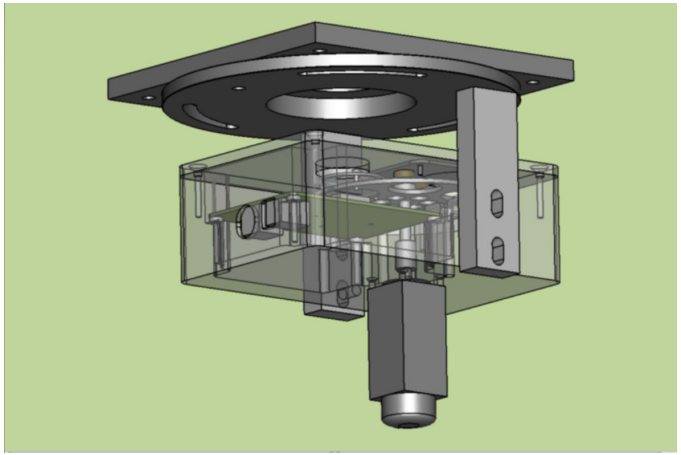
Vis Camera Installation

Mount an independent system into the ASIVA housing

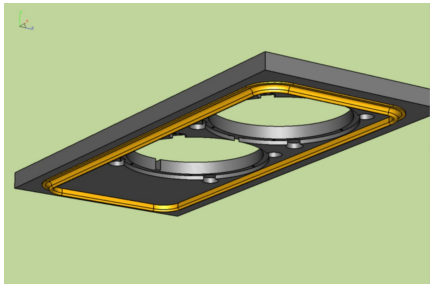
- Raspberry Pi (RPI) communicates with Vis camera using open-source C-programs
- Pulls network and power from same sources as ASIVA
- Communicates to CFHT network independently

ASIVA Housing

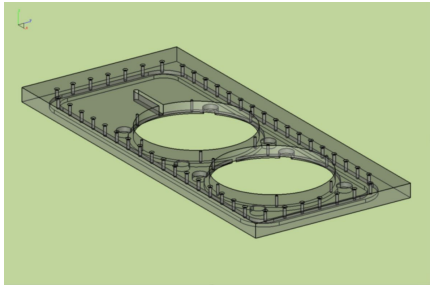
Vis Mounting: Old



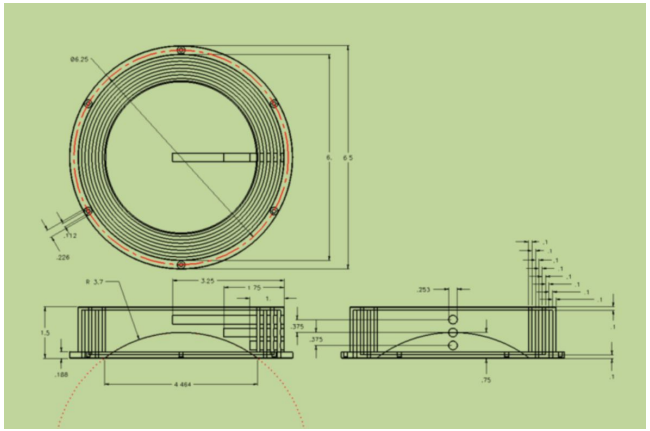
ASIVA Vis Assembly (from CFHT)



ASIVA Top Plate 1 (from CFHT)

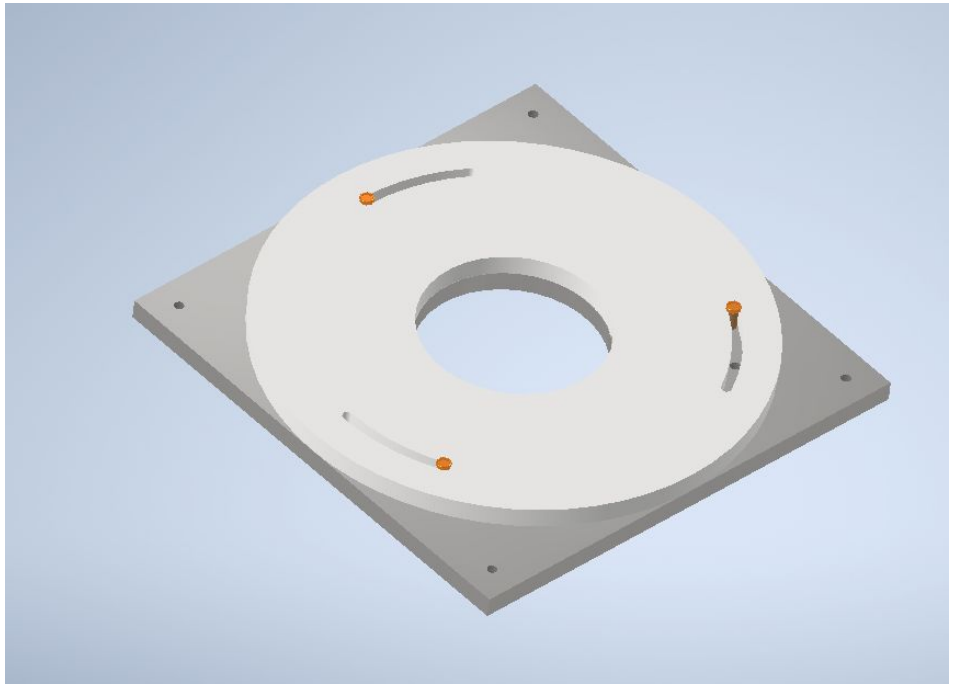


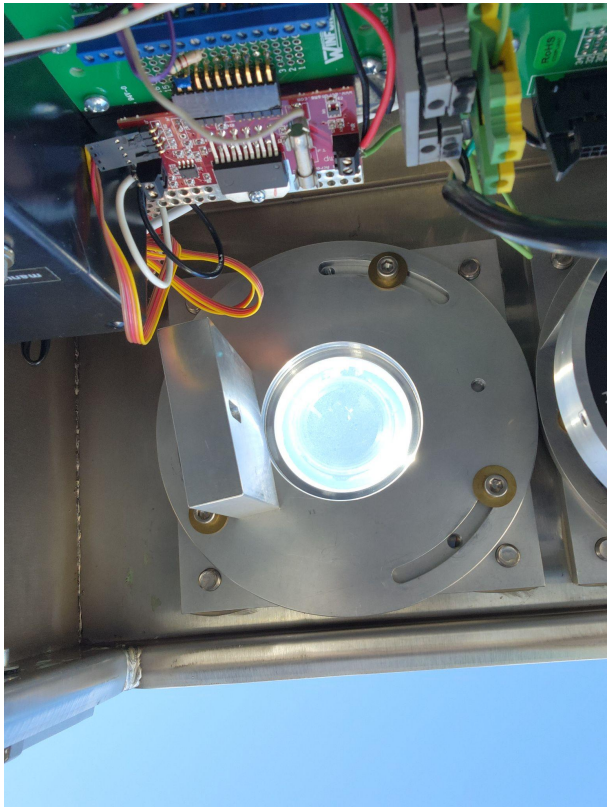
ASIVA Top Plate 2 (from CFHT)



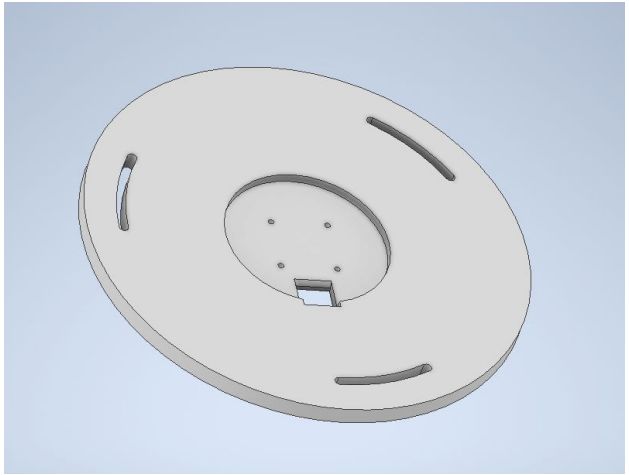
ASIVA Lens (from CFHT)

Vis Mounting: Old

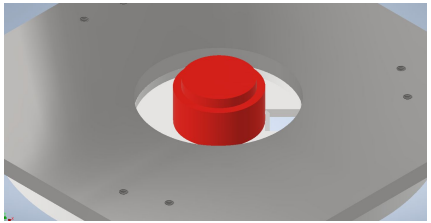




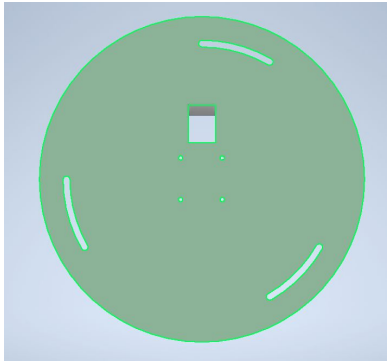
Vis Mounting: New Plate



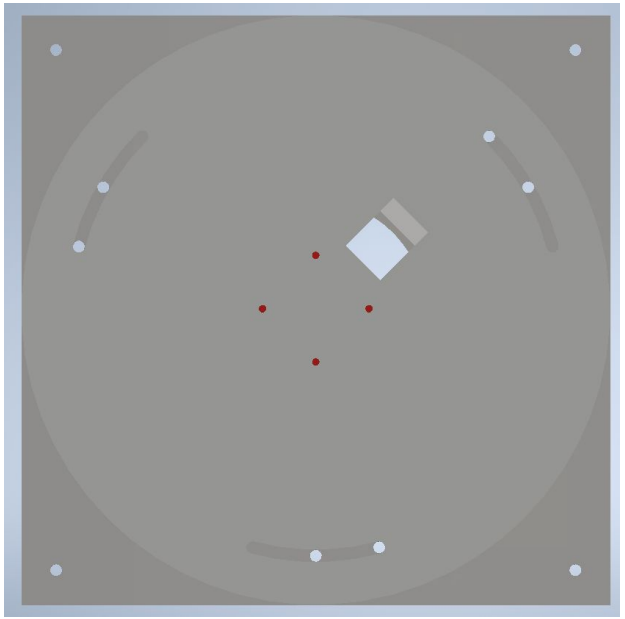
ZWO Plate 1



ZWO Plate 2



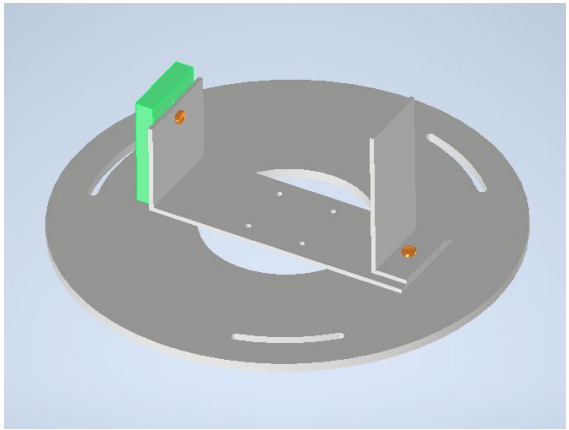
ZWO Plate 3



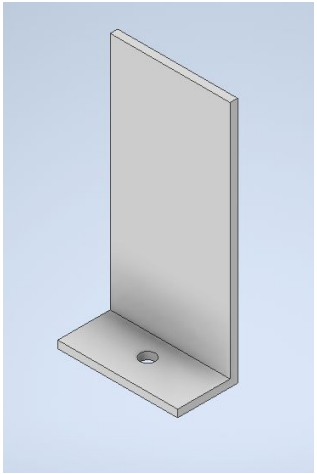
ZWO Plate 4

Vis Mounting: Reuse

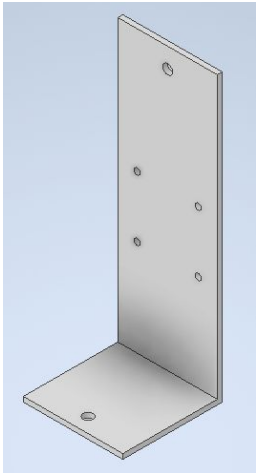
ASIVA Reuse Assembly 1



ASIVA Reuse Assembly 2



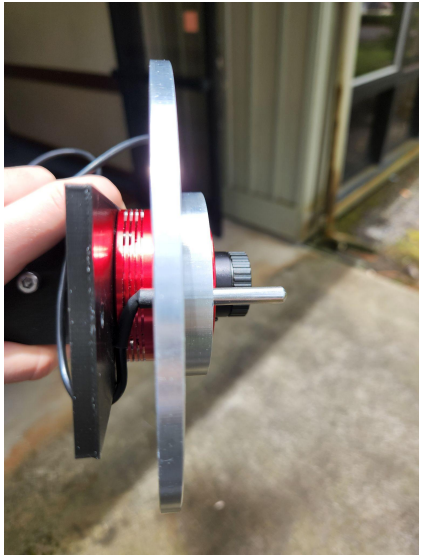
ASIVA Reuse Part 1



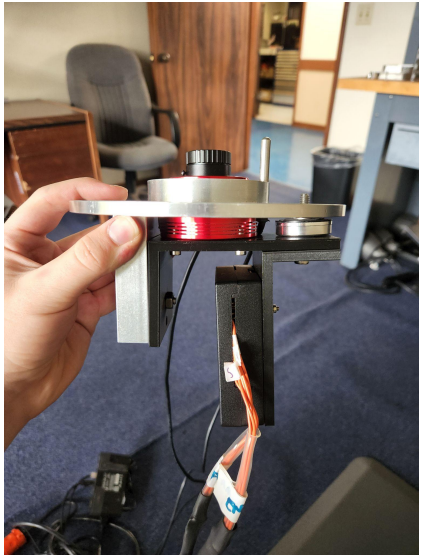
ASIVA Reuse Part 2

Vis Mounting: Assembly

ASIVA Reuse Assembly 3



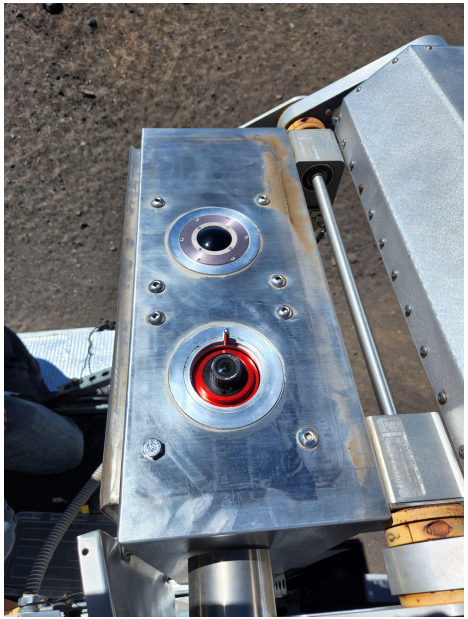
ASIVA Reuse Assembly 4

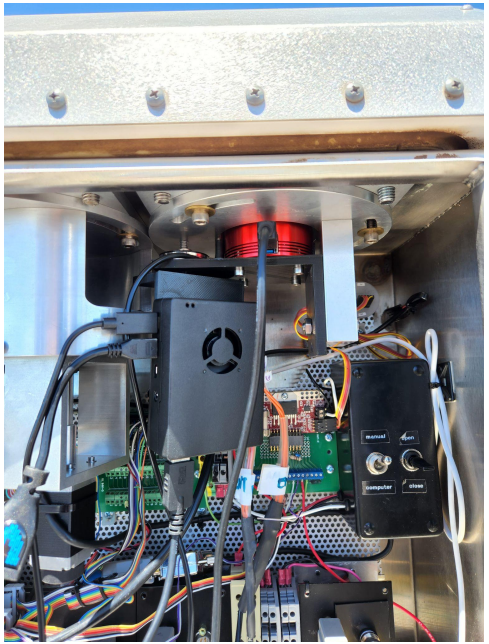


ASIVA Reuse Part 5

Installation: July 14

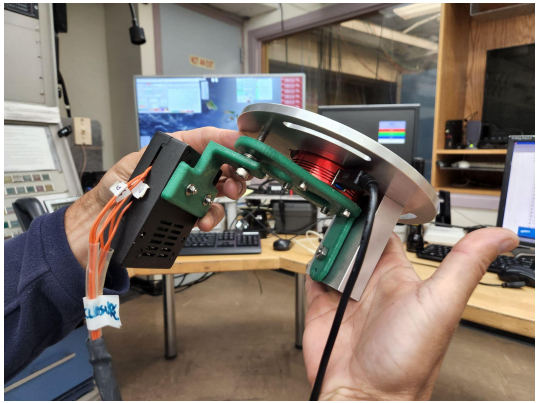
- Installed the assembly
- Weren’t able to get on network
- Broke the chain for the hatch

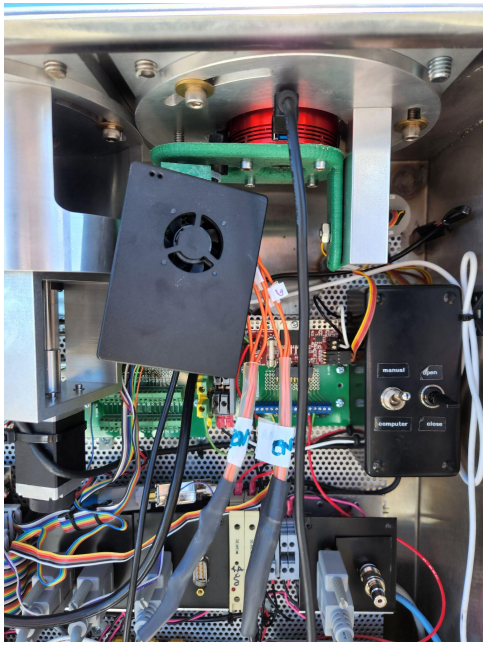




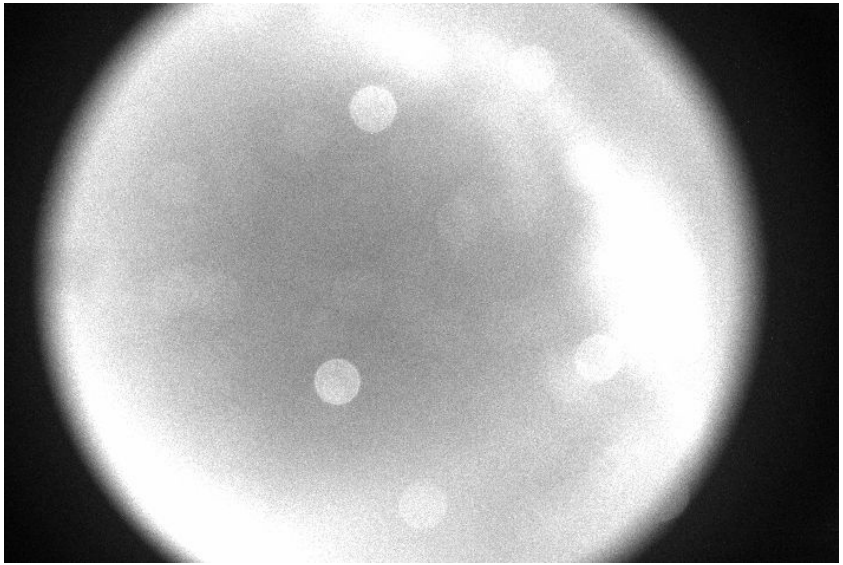
Installation: July 20

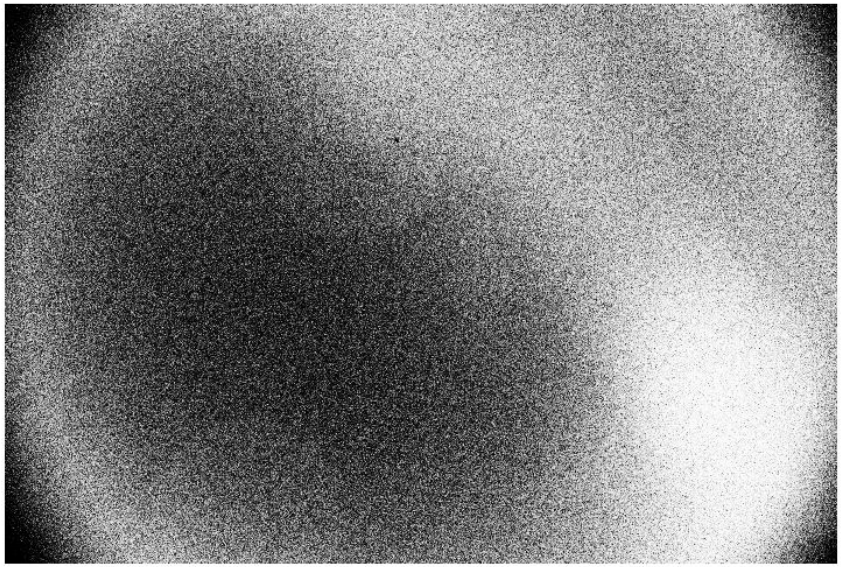
- New Print
  - Better bolt holes
  - Hole for temp sensor
- Fixed chain
- Recrimped Ethernet
- Sealed Vis cam in silicon
- Got temperature data





Visible First Light





IR Camera

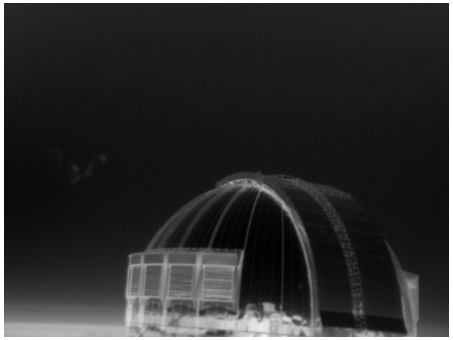
- FLIR Tau 2
- Uses a TEAX Thermalgrabber for frame-grabbing
- 640 x 512 resolution
- 17 µm pixel size
- Mini USB interface
- 19 mm lens
- Temperature data

IR Cam (from FLIR website)

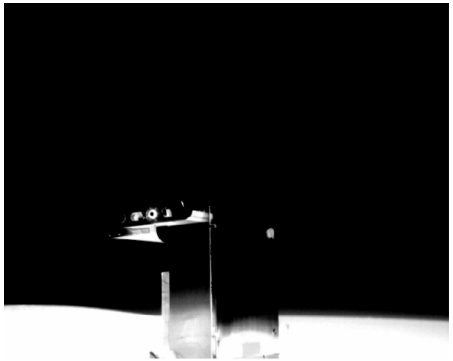
IR Sample Images

Observed sites:

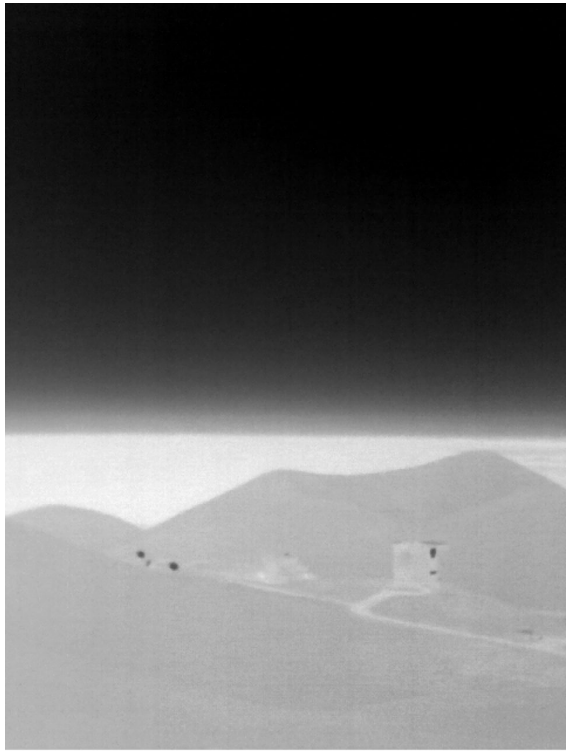
- ASIVA site
- Flashlight cameras
- Cloud cameras
- Other observatories



IR Dome View



IR ASIVA View



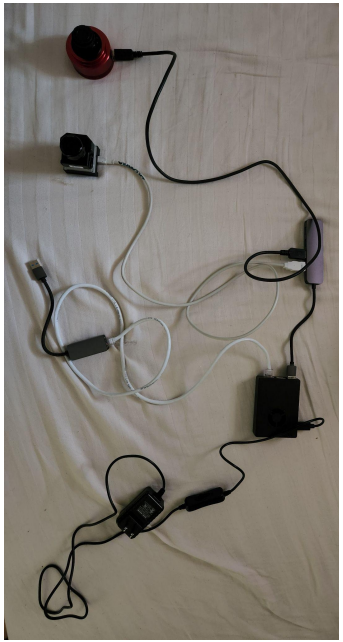
IR Cloudcam View (night)

Dual-Camera System

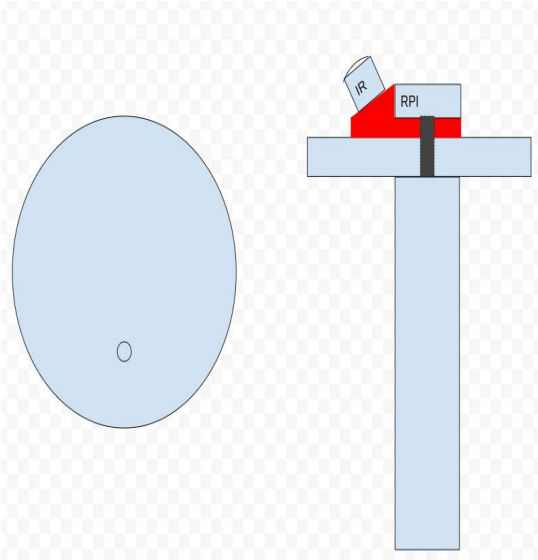
- Emulate ASIVA functionality for a fraction of size and cost
- Work toward portability
- Code written in-house and open-source

Dual-Camera Prototype

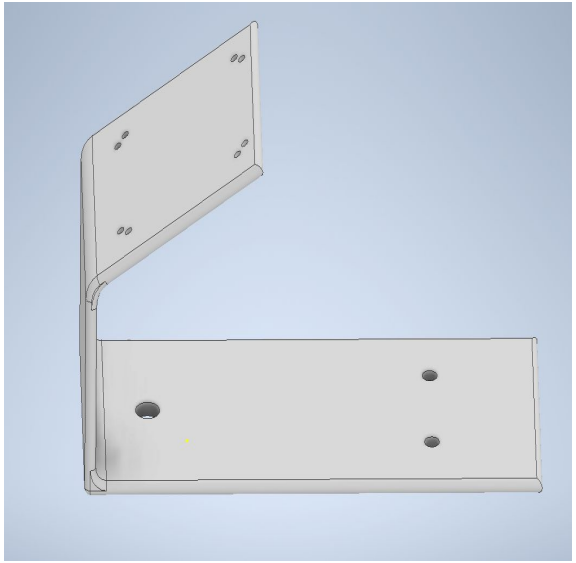
- ASI 178 mm Vis camera
- FLIR Tau 2 IR camera
- Controlled by Raspberry Pi (RPI)
- Programs written in C with provided SDK
- Decided to mount inside CFHT dome



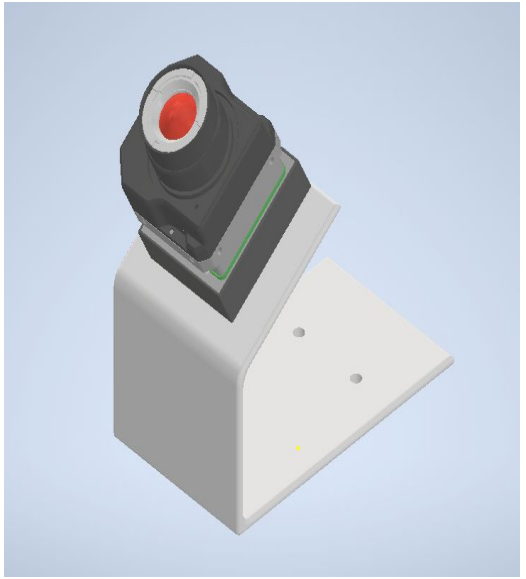
Dual-Camera Mount



Dual-Cam 1

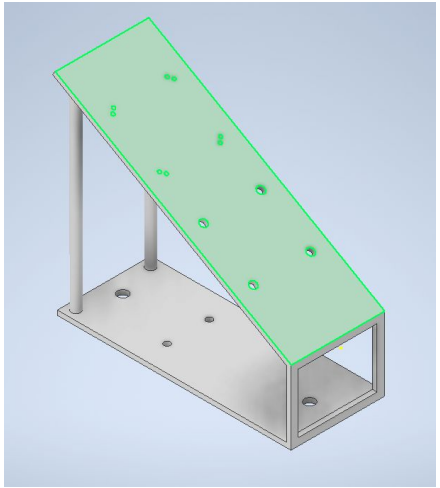


Dual-Cam 2

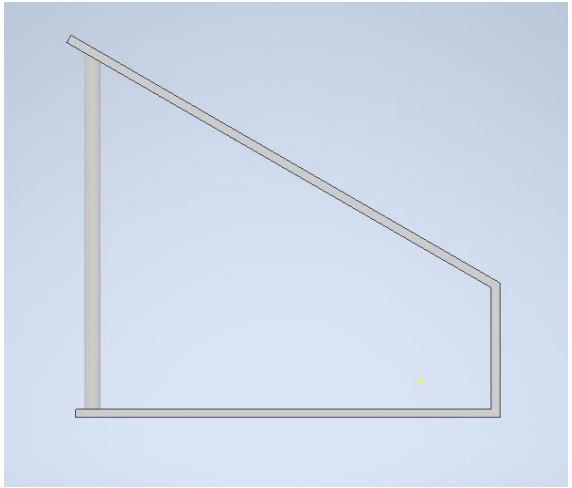


Dual-Cam 3

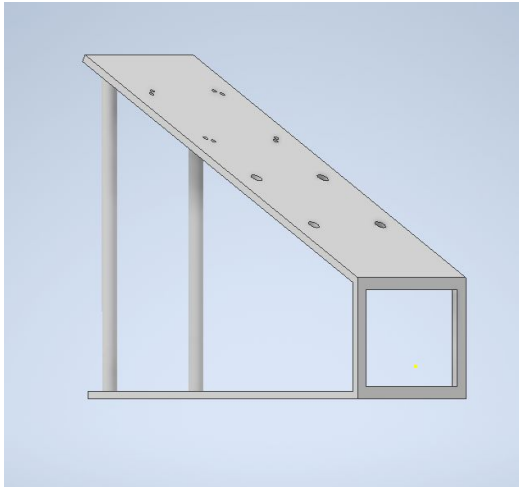
Dual-Camera Mount



Dual-Cam 4



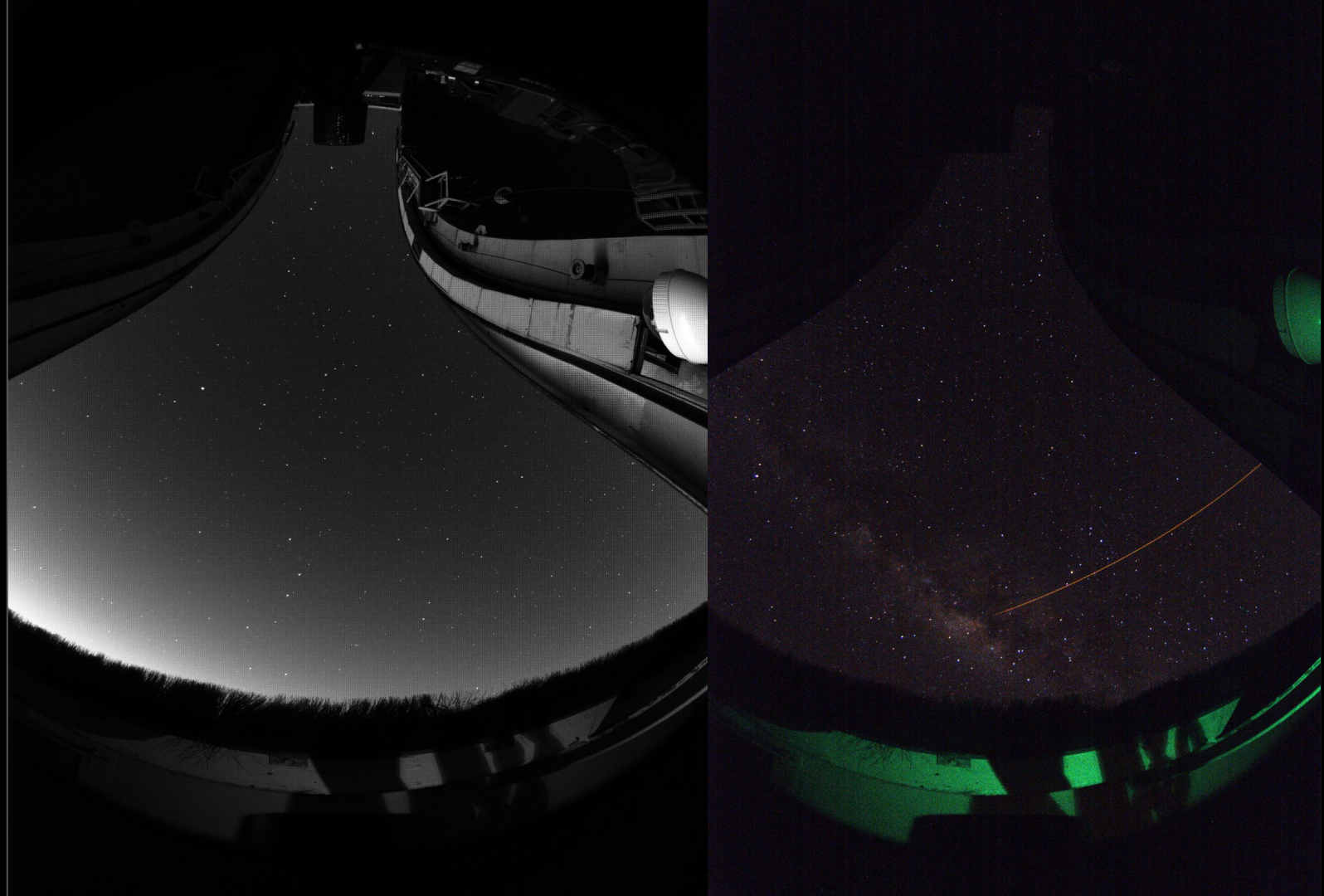
Dual-Cam 5



Dual-Cam 6

Installation: July 27

- Focused ASIVA Vis camera
- Installed Dual-cam system



Cost Analysis

ASIVA Cost	$100K

Optional

Part	Cost
Battery	$53 - $300
ASI 178 mm (Color)	$269
Stepper motor	$25

Part	Cost
ASI 178 mm	$300
FLIR Tau 2	$1500
TEAX Thermalgrabber	$1460
Raspberry Pi 4	$35
PNY 250 GB SSD	$27
UGREEN Hard Drive Enclosure	$14
USB hub	$16

Total: $3352

AKAMAI WORKFORCE INITIATIVE

Summary

- Installed a new Visible-light camera in ASIVA
- Demonstrated IR backup functionality
  - FLIR Tau 2 can be installed in the same process as the visible-light camera
- Restored temperature sensing (2 new temp sensors)
- Started development of backup ASIVA: dual-cam system
  - Continuing work, developing mount and weatherproof housing

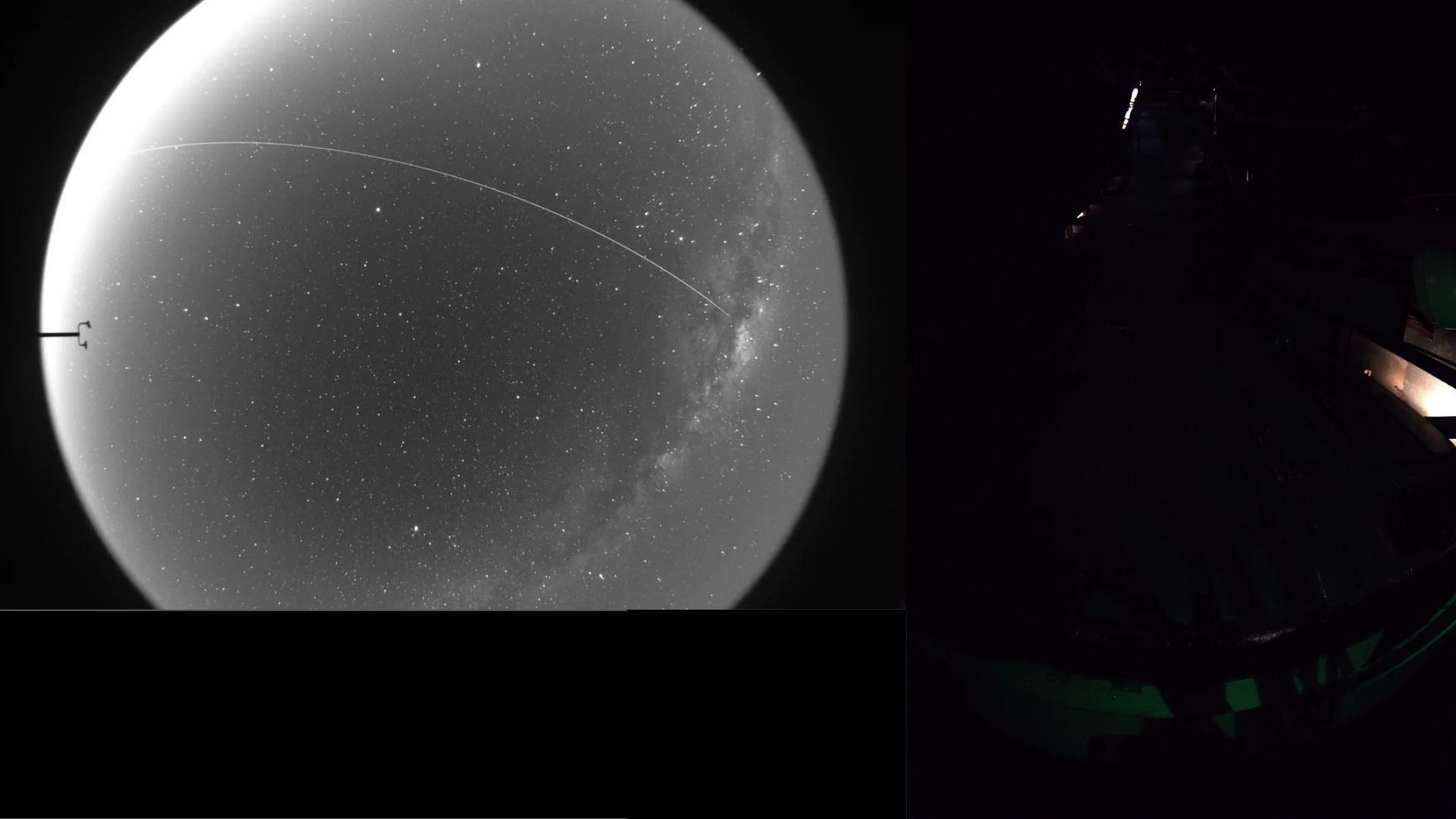
Acknowledgments

Billy Mahoney

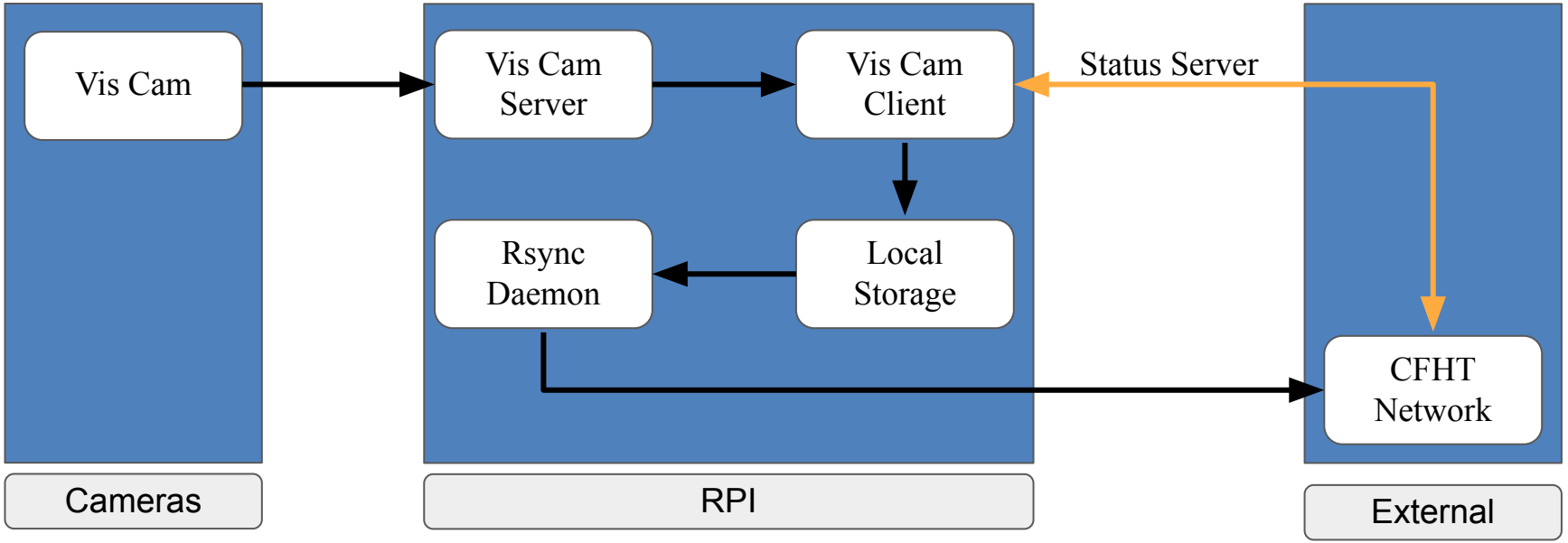
Mary Beth Laychak, Marc Baril, Kevin Ho, Grant Matsushige, Les Mizuba, Tom Vermuelen, Cam Wipper, Greg Green, Ludwig Leto

The Akamai Internship Program is managed by the Institute for Scientist & Engineer Educators at the University of California, Santa Cruz, in partnership with the University of California Observatories, the University of Hawai'i Institute for Astronomy, and the University of Hawai'i at Hilo. Full details of funders for the 2022 program are:

- Hawai'i Community Foundation Kukio Community Fund
- National Science Foundation (NSF, AST#1743117)
- Daniel K. Inouye Solar Telescope (NSF)
- Gemini Observatory / NOIRLab (NSF)
- Keck Planet Finder project (NSF AST#2034278)
- University of California Observatories
- Keck All Sky Precession AO project (NSF AST-1836015)
- KBR
- Maunakea Observatories
- Event Horizon Telescope (NSF AST#2034306)
- Canada-France-Hawai'i Telescope



Data Flow


Vis Cam
Vis Cam Server
Vis Cam Client
Status Server
Rsync Daemon
Local Storage
CFHT Network
Cameras
RPI
External

Upkeep

ASIVA

- Work required on site
- Outsourced project/closed source
  - Can’t work with code
- Equipment is old
  - Minimal documentation/support
- Parts are custom

New Unit

- Work can be done anywhere
- In-house project
  - Full control of code
- Equipment is up to date
  - Lots of documentation/support
- Parts are standard