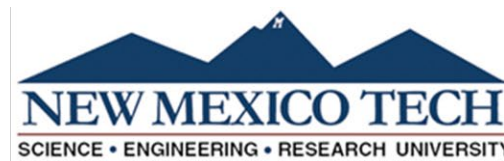


Interferometer, Instrument Control and Data Acquisition Software: Next Steps in MROI's Fringes Era

Ian Schofield

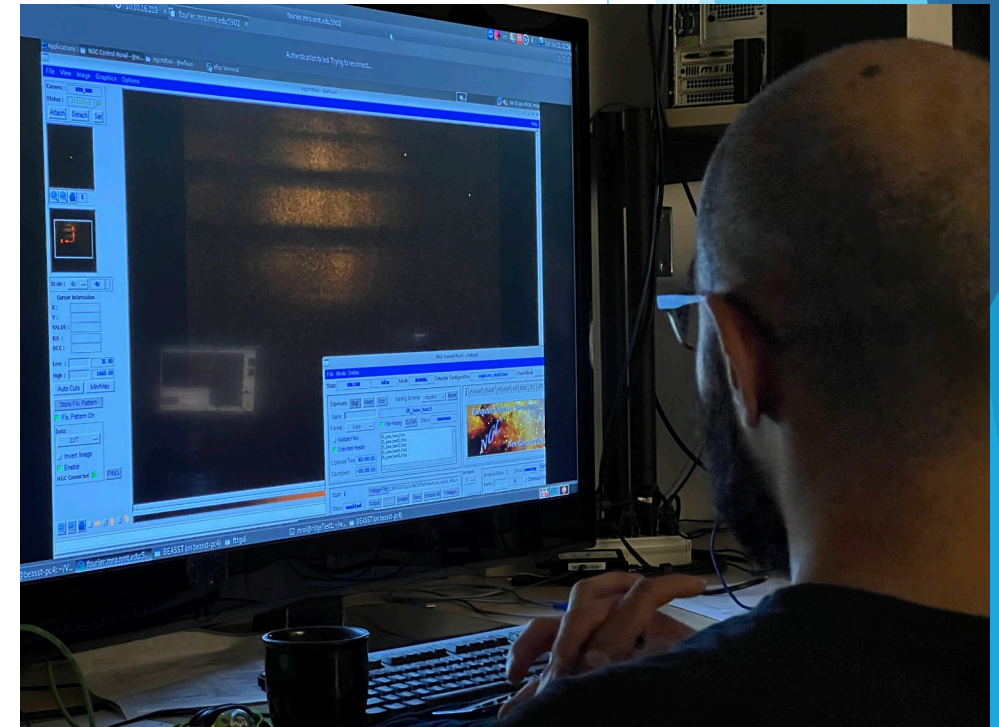
MROI Software Team

CHARA-MROI Science Meeting, March 16, 2026



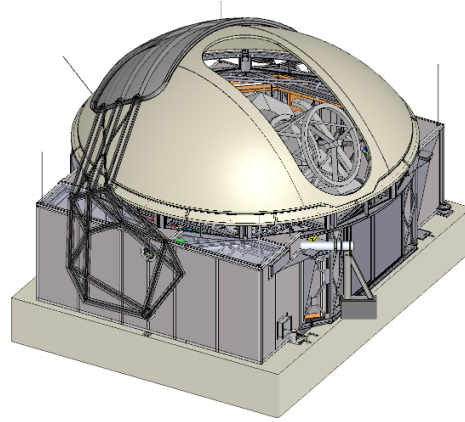
MROI Software

- ▶ MROI software systems tie together all the constituent hardware systems to enable operation of the interferometer
- ▶ Produce organized, decipherable science & engineering data
- ▶ Flexible: adapt to different array configurations

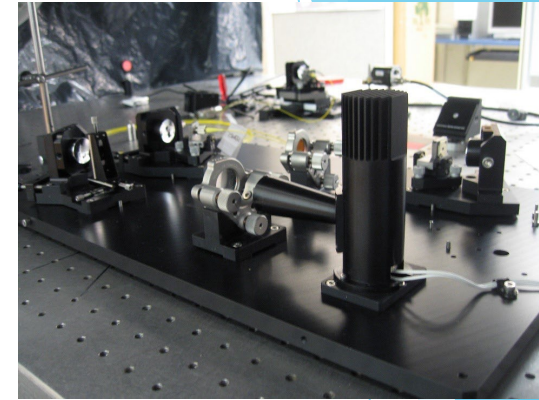




Unit Telescope

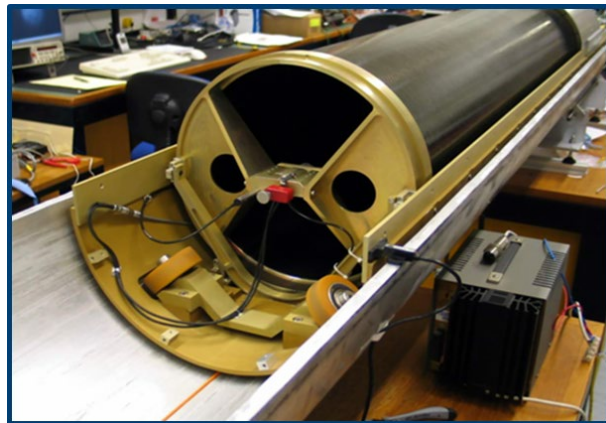


Enclosure

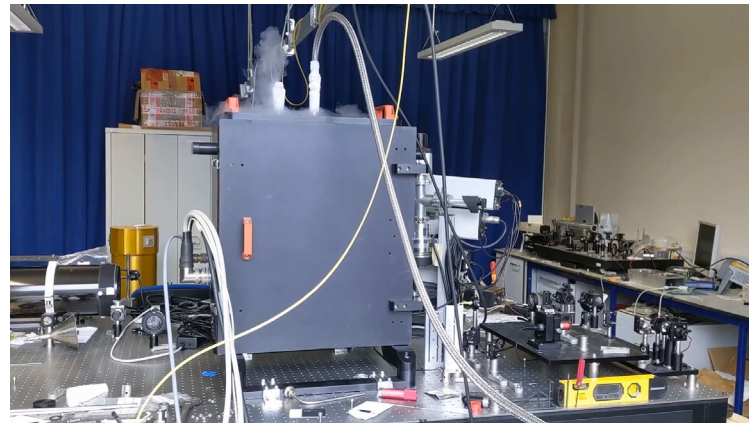


Fast Tip-Tilt (active optics)

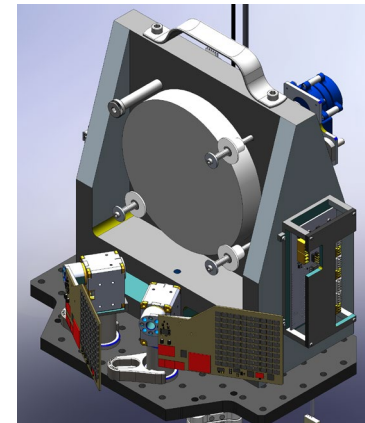
Interferometer Supervisory System (ISS)



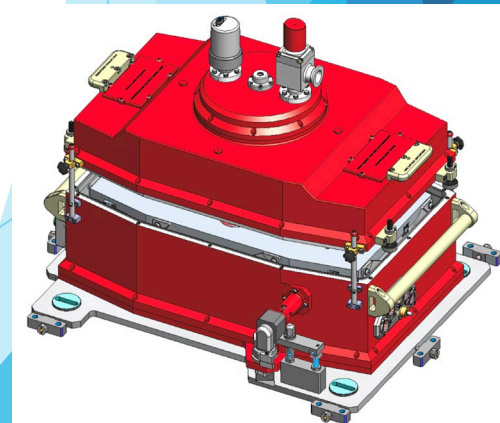
Delay Line



Fourier (science instrument)



Beam Relay System



ICoNN (fringe tracker)

Interferometer
Supervisory
System (ISS)



Beamline 1

Beamline 2

Fourier

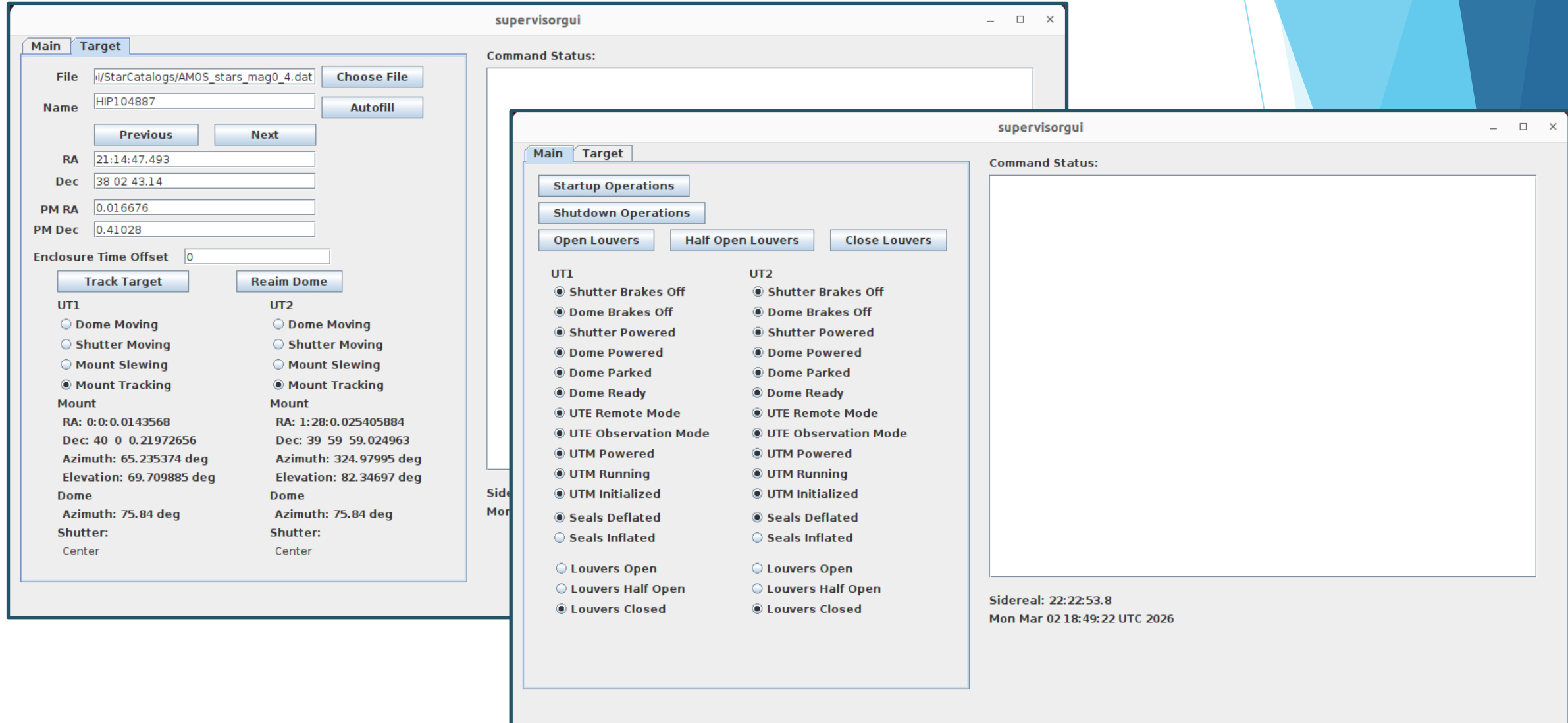
ICoNN

Beamline 3

Beamline 4

Beamline 5

Supervisor GUI



The image displays two overlapping windows of the 'supervisorgui' application. The background window shows the 'Main' tab with file selection and target coordinate input fields. The foreground window shows the 'Target' tab with operational controls and status indicators for two units, UT1 and UT2.

Background Window (Main Tab):

- File:
- Name:
- Buttons:
- RA:
- Dec:
- PM RA:
- PM Dec:
- Enclosure Time Offset:
- Buttons:

Foreground Window (Target Tab):

Buttons:

Buttons:

UT1	UT2
<input checked="" type="radio"/> Shutter Brakes Off	<input checked="" type="radio"/> Shutter Brakes Off
<input checked="" type="radio"/> Dome Brakes Off	<input checked="" type="radio"/> Dome Brakes Off
<input checked="" type="radio"/> Shutter Powered	<input checked="" type="radio"/> Shutter Powered
<input checked="" type="radio"/> Dome Powered	<input checked="" type="radio"/> Dome Powered
<input checked="" type="radio"/> Dome Parked	<input checked="" type="radio"/> Dome Parked
<input checked="" type="radio"/> Dome Ready	<input checked="" type="radio"/> Dome Ready
<input checked="" type="radio"/> UTE Remote Mode	<input checked="" type="radio"/> UTE Remote Mode
<input checked="" type="radio"/> UTE Observation Mode	<input checked="" type="radio"/> UTE Observation Mode
<input checked="" type="radio"/> UTM Powered	<input checked="" type="radio"/> UTM Powered
<input checked="" type="radio"/> UTM Running	<input checked="" type="radio"/> UTM Running
<input checked="" type="radio"/> UTM Initialized	<input checked="" type="radio"/> UTM Initialized
<input checked="" type="radio"/> Seals Deflated	<input checked="" type="radio"/> Seals Deflated
<input type="radio"/> Seals Inflated	<input type="radio"/> Seals Inflated
<input type="radio"/> Louvers Open	<input type="radio"/> Louvers Open
<input type="radio"/> Louvers Half Open	<input type="radio"/> Louvers Half Open
<input checked="" type="radio"/> Louvers Closed	<input checked="" type="radio"/> Louvers Closed

Command Status: [Empty]

Sidereal: 22:22:53.8
Mon Mar 02 18:49:22 UTC 2026

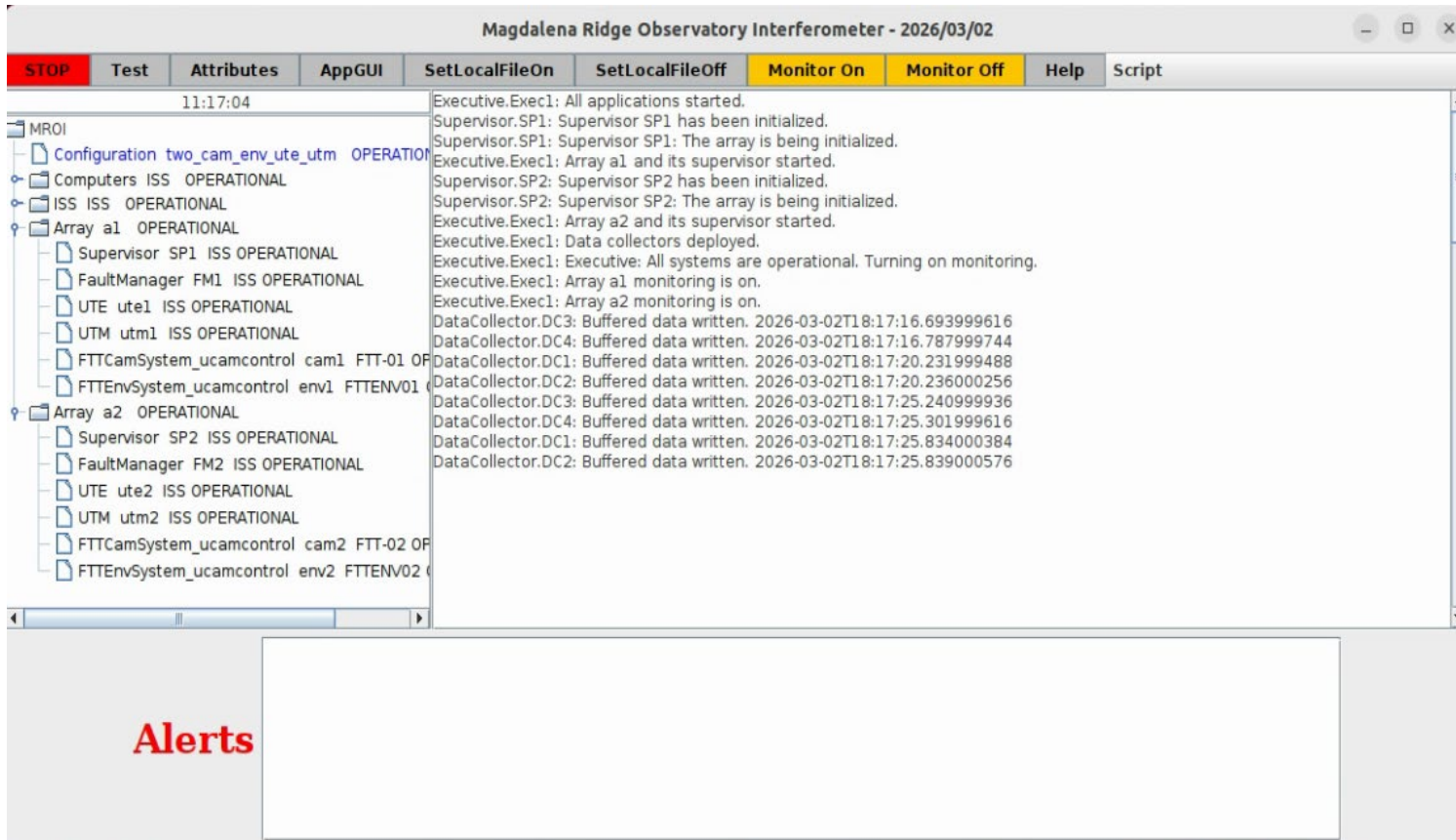
Observing Teams

manual operation of software systems

- ▶ MROs observational systems are still loosely coupled
- ▶ Unit Telescope (UT)
- ▶ Fast Tip Tilt (FTT)
- ▶ Delay Lines
- ▶ Fourier: fringe imager
- ▶ Calibration
 - ▶ Wavefront Sensor
 - ▶ Automated Alignment System
 - ▶ Beamline alignment using
 - ▶ Vacuum Can Hubs (VCH)



Interferometer Supervisory System (ISS)



Top level controller of interferometer

Allow connected systems to communicate with each other

Message passing mechanism

Subscriber /publisher methodology (design pattern).

Save data: engineering, select science data, runtime configurations → PostgreSQL RDBS

Data recording: system apps

Unit Telescope Control system (UTCS)

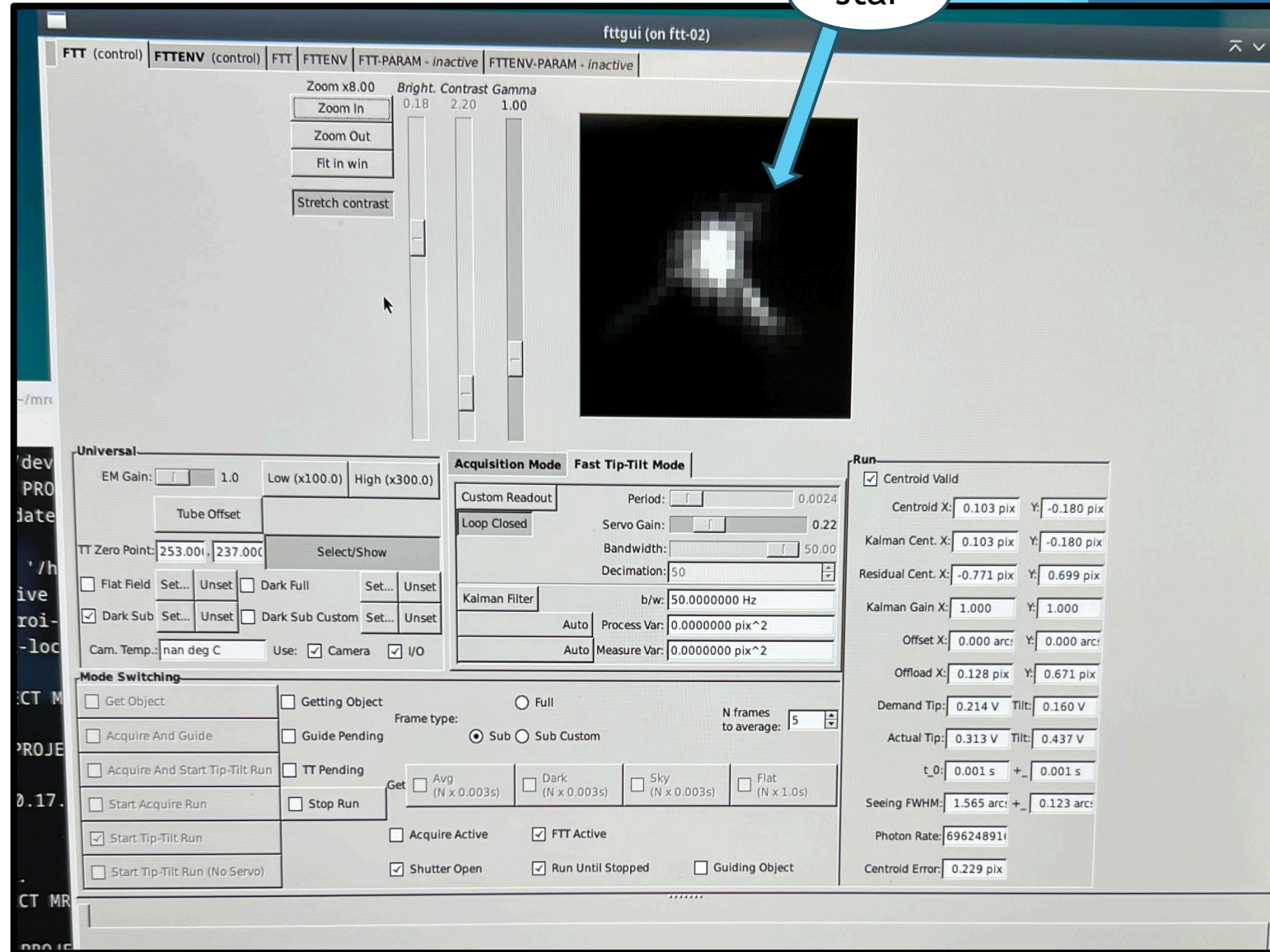
- ▶ Vendor-supplied telescope control system (Observatory Sciences Ltd)
 - ▶ Controls AMOS 1.4 m telescope.
- ▶ Networked client/server application programming interface (API)
 - ▶ Integrated with ISS
- ▶ Engineering GUI
 - ▶ Configure UT
 - ▶ Acquire targets
 - ▶ Show offloads (coordinates) from FFT
 - ▶ Primary control interface
- ▶ Future: ISS operator GUI

Unit Telescope Enclosure (UTE)

- ▶ Dome command & monitoring
- ▶ Vendor-supplied unit telescope enclosure engineering GUI.
- ▶ Future:
 - ▶ ISS-based UTE operator GUI
 - ▶ To be automated

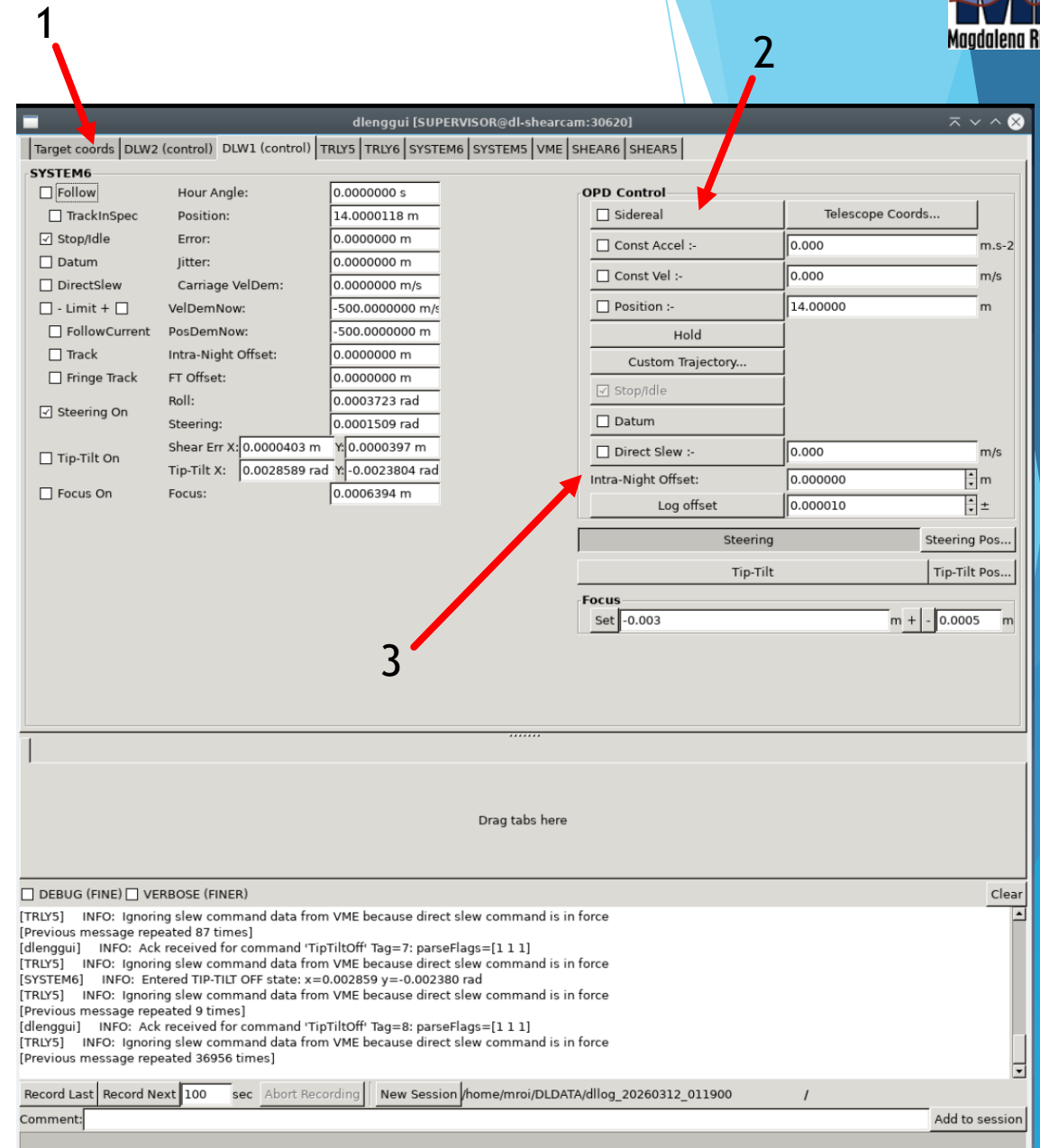
Fast Tip Tilt (FTT)

- ▶ FTTGUI user interface
- ▶ Image stabilization:
 - ▶ manual tune FTT Servo loop to minimize centroid
- ▶ Tip/Tilt actuators controlled via RT operating system: Xenomai 3.x
- ▶ Tip/Tilt offloads
 - ▶ Starts offloads (alt/az adjustments) to unit telescope - locks position of object
- ▶ Integrated with ISS



Delay Line

- ▶ FTTENGGUI: control panels for each delay line
 - ▶ Operator uses DL GUI with Fourier GUI to perform fringes search
 - ▶ Manual operation
 - ▶ Define our coordinates (1)
 - ▶ Start tracking sidereally (2)
 - ▶ Apply offsets until fringes found (3)
- ▶ Fringe tracking software automates this procedure (DL \leftrightarrow FOURIER)



The screenshot shows the 'dlenggui' interface for 'SYSTEM6'. It features several control panels and a log window at the bottom.

1 points to the 'Target coords' tab at the top left.

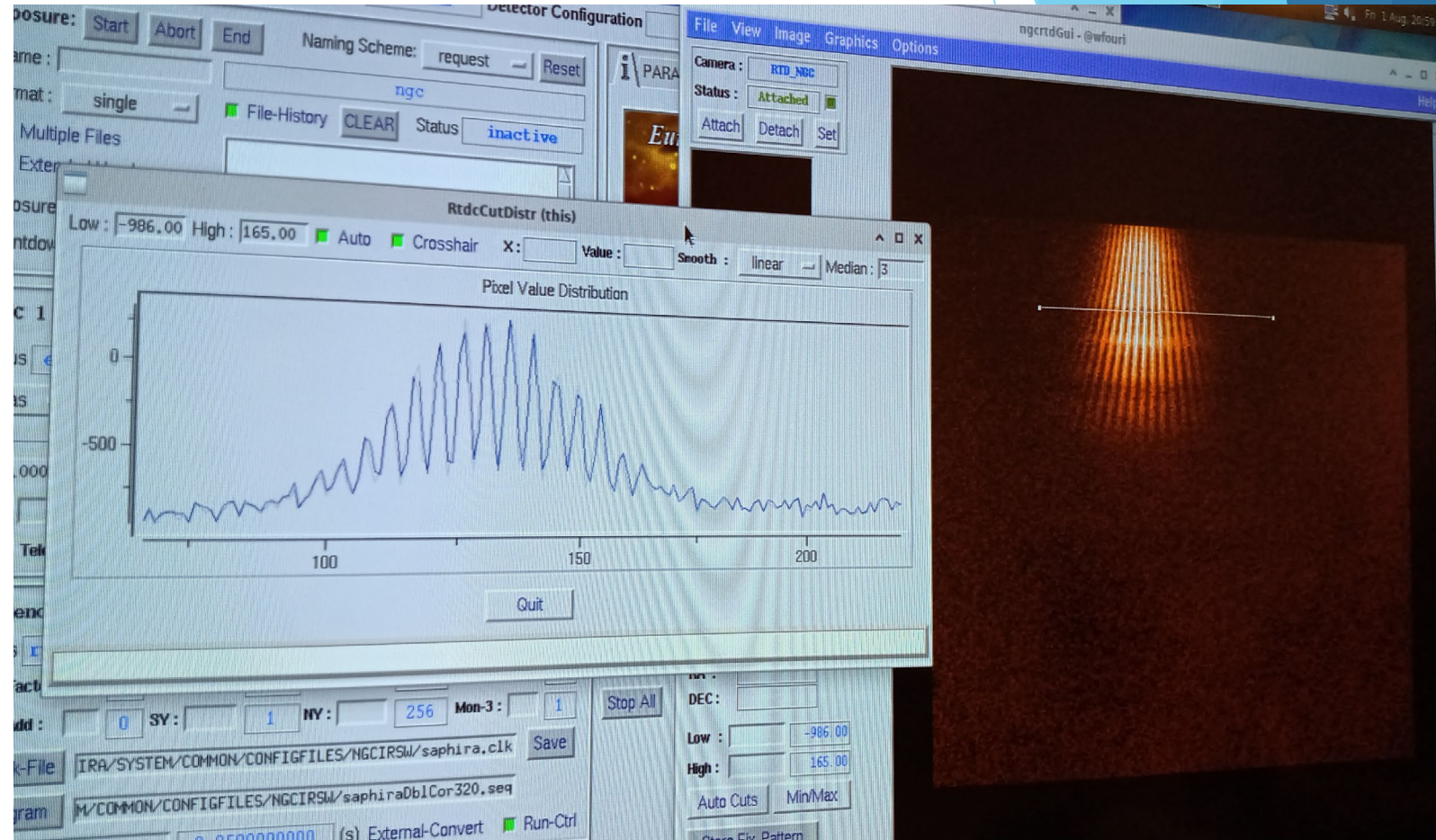
2 points to the 'OPD Control' panel on the right, specifically the 'Sidereal' checkbox.

3 points to the 'Intra-Night Offset' field in the 'OPD Control' panel.

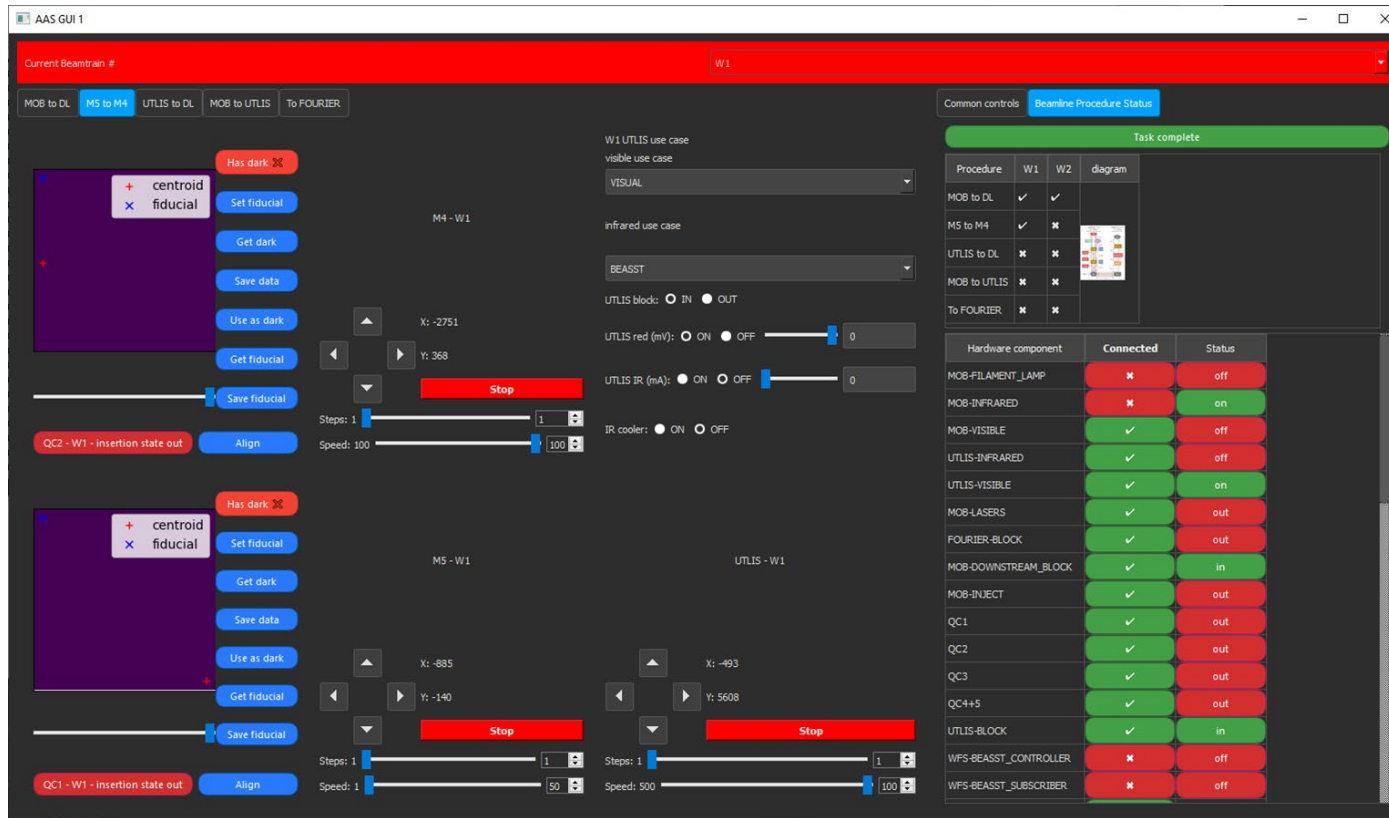
The interface includes a 'SYSTEM6' control panel with various checkboxes and numerical input fields for parameters like 'Hour Angle', 'Position', 'Error', 'Jitter', 'Carriage VelDem', 'VelDemNow', 'PosDemNow', 'Intra-Night Offset', 'FT Offset', 'Roll', 'Steering', 'Shear Err X/Y', 'Tip-Tilt X/Y', and 'Focus'. The 'OPD Control' panel has checkboxes for 'Sidereal', 'Const Accel', 'Const Vel', 'Position', 'Direct Slew', and 'Intra-Night Offset', along with numerical input fields and buttons like 'Hold', 'Custom Trajectory...', 'Steering', and 'Tip-Tilt'. The log window at the bottom shows system messages and status updates.

Fourier

- ▶ Infrared science instrument for fringe imaging
- ▶ ESO designed and built
 - ▶ Custom hardware/software
 - ▶ ESO New General detector Controller (NGCGUI)
- ▶ Fringe imager
 - ▶ Fringe searching
 - ▶ Records images
- ▶ Future: fringe tracking
 - ▶ Link image output with ICoNN fringe tracker



Automated Alignment System (AAS)



The screenshot displays the AAS GUI 1 interface, which is used for beamline alignment. The interface is divided into several sections:

- Current Beamtrain #:** W1
- Navigation:** MOB to DL, M5 to M4, UTILIS to DL, MOB to UTILIS, To FOURIER
- Beamline Diagrams:** Three diagrams are shown for M4 - W1, M5 - W1, and UTILIS - W1. Each diagram includes a 'Has dark' button, a 'centroid fiducial' selection, and various control buttons like 'Set fiducial', 'Get dark', 'Save data', 'Use as dark', 'Get fiducial', and 'Save fiducial'. Below each diagram are 'Steps' and 'Speed' sliders and a 'Stop' button.
- Common controls:** Includes a 'Beamline Procedure Status' section with a 'Task complete' indicator and a table of procedure status.
- Hardware Component Status Table:** A table listing hardware components, their connection status, and their current status.

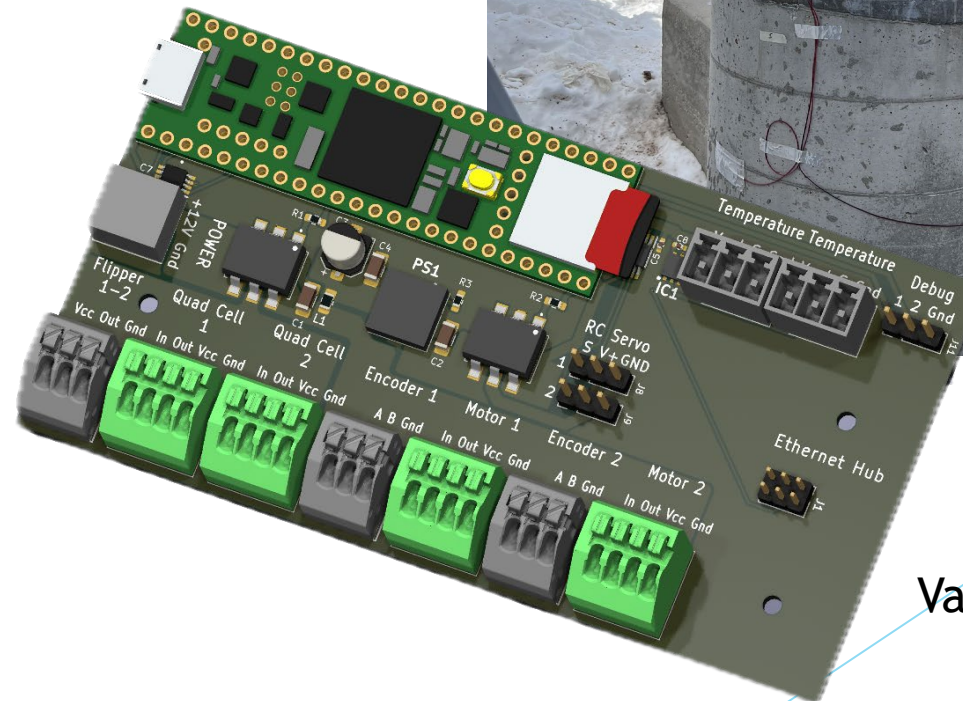
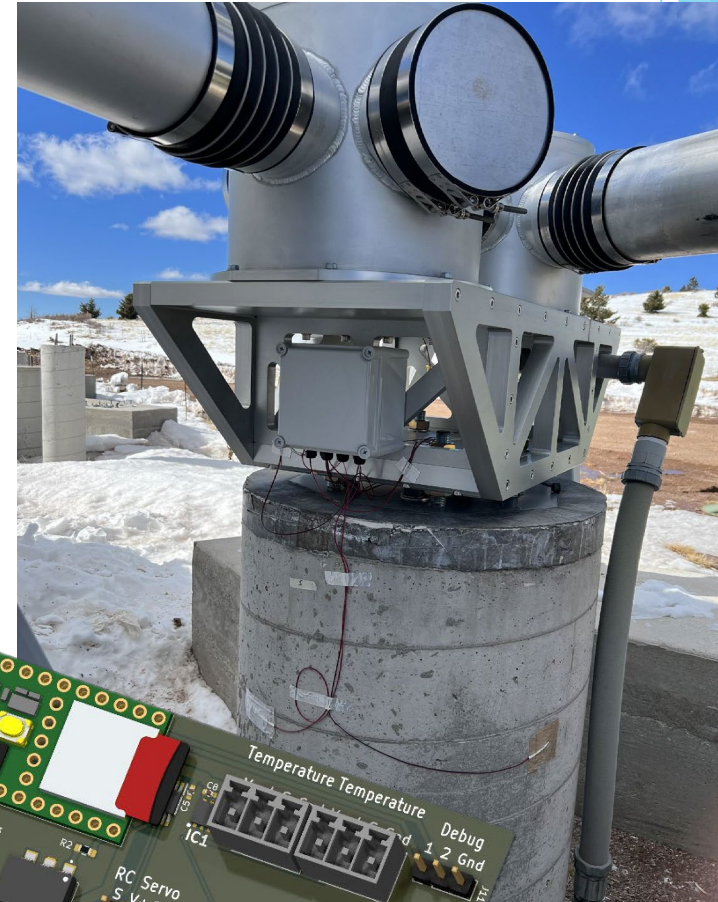
Procedure	W1	W2	diagram
MOB to DL	✓	✓	
M5 to M4	✓	✗	
UTILIS to DL	✗	✗	
MOB to UTILIS	✗	✗	
To FOURIER	✗	✗	

Hardware component	Connected	Status
MOB-FILAMENT_LAMP	✗	off
MOB-INFRARED	✗	on
MOB-VISIBLE	✓	off
UTILIS-INFRARED	✓	off
UTILIS-VISIBLE	✓	on
MOB-LASERS	✓	out
FOURIER-BLOCK	✓	out
MOB-DOWNSTREAM_BLOCK	✓	in
MOB-INJECT	✓	out
QC1	✓	out
QC2	✓	out
QC3	✓	out
QC4+5	✓	out
UTILIS-BLOCK	✓	in
WFS-BEAST_CONTROLLER	✗	off
WFS-BEAST_SUBSCRIBER	✗	off

- ▶ Beamline alignment tool
- ▶ Controls
 - ▶ Mirrors
 - ▶ Alignment light sources
 - ▶ Beamline detectors (QC,WFS, BEAAST)
 - ▶ Temperature sensors
- ▶ Often connects with VCH stations

Vacuum Can Hub (VCH)

- ▶ Custom designed HW controller board
 - ▶ Arduino MCU (Teensy 4.1: ARM Cortex M7 600 MHz)
 - ▶ Underclocked to 24 MHz (low heat)
- ▶ Networked
 - ▶ ModbusTCP
- ▶ Multiple serial channels
- ▶ Network interface:
 - ▶ Actuators
 - ▶ Temp sensors
 - ▶ Beamline detectors (QC)
 - ▶ Alignment light sources
- ▶ Applications
 - ▶ Beamline alignment
 - ▶ Vacuum cans, optical tables



Vacuum Can Hub (v1.0 pictured)

Current Efforts

- ▶ Increase software systems' stability
 - ▶ Integration and testing stage
 - ▶ Discover and correct hard-to-find bugs (FTT, ISS)
- ▶ Migrate from manual to semi-automatic operation
 - ▶ More applications unified with ISS, fewer GUIs
- ▶ Data archiving
 - ▶ Logs, engineering and science data into one location
 - ▶ Flat files, human readable, metadata descriptions
 - ▶ Search and quick-look

Challenges & Future Efforts

- ▶ Instruments & systems age out
 - ▶ Legacy parts scarcity
 - ▶ Migrating to newer standards (PCIe)
 - ▶ Update applications to current versions (Xenomai 2 → 4)
- ▶ Add more unit telescopes
 - ▶ Need to scale software to handle ≥ 3 UTs
- ▶ New instruments
 - ▶ ICoNN Fringe Tracker
 - ▶ VCH 2.0

Acknowledgements

At NMT/MROI: J. Altamirano, W. Cook, M. J. Creech-Eakman, C. Eakman, A. Farris, E. Floyd, D. Frothingham, J. Giron, M. Giron, C. Greiner, A. Haque, J. Hernandez, A. Jorgensen, J. Luis, J. C. Mason, R. Norris, A. Olivares, S. Orizaga, G. Owens, S. Rochelle, V. D. Romero, C. Salcido, R. Santoro, I. Schofield

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