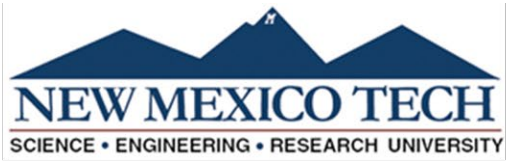
Interferometer, Instrument Control and Data Acquisition Software: Next Steps in MROI's Fringes Era

Ian Schofield

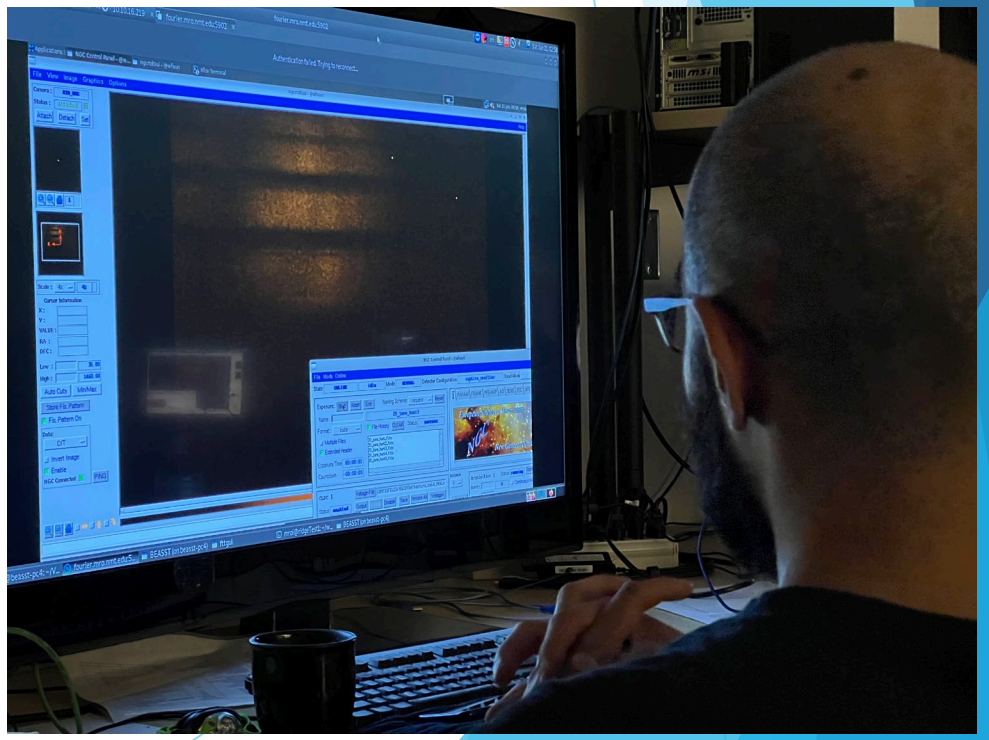
MROI Software Team

CHARA-MROI Science Meeting, March 16, 2026

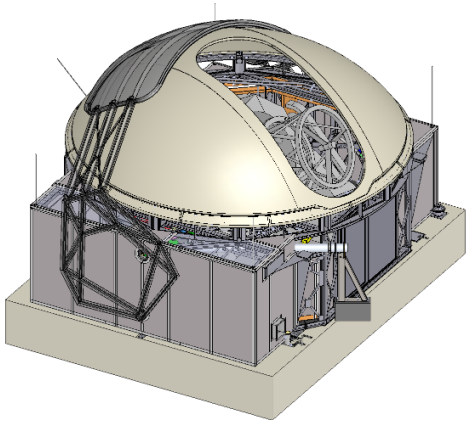


MROI Software

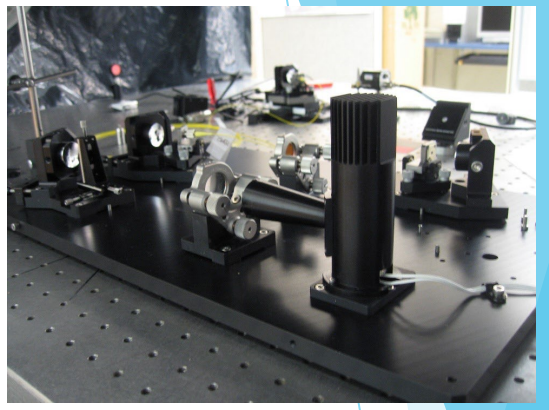
- MROI software systems tie together all the constituent hardware systems to enable operation of the interferometer
- Produce organized, decipherable science & engineering data
- Flexible: adapt to different array configurations



Unit Telescope

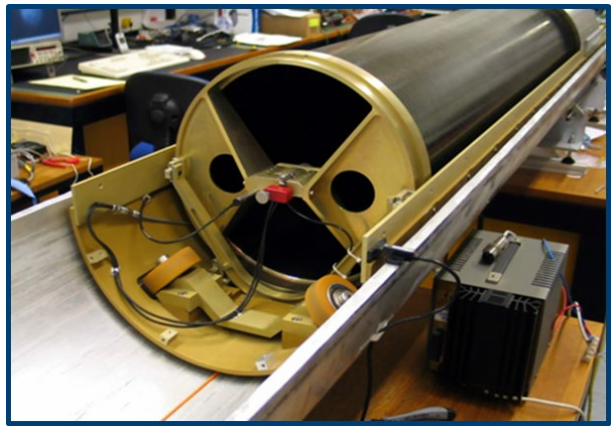


Enclosure

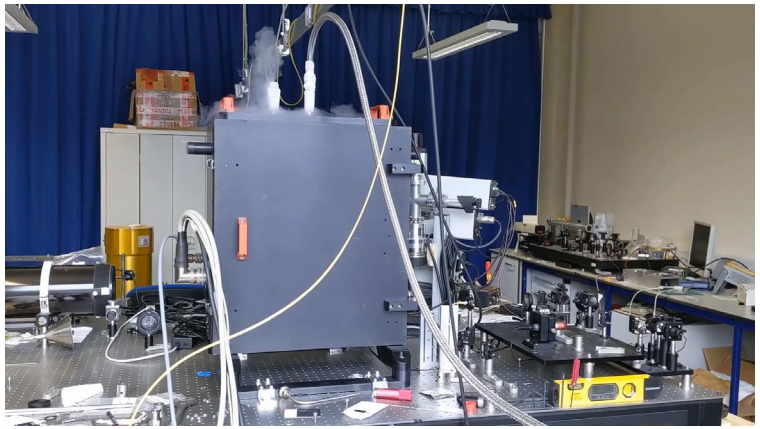


Fast Tip-Tilt (active optics)

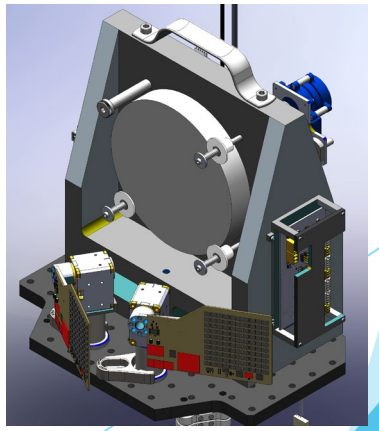
Interferometer Supervisory System (ISS)



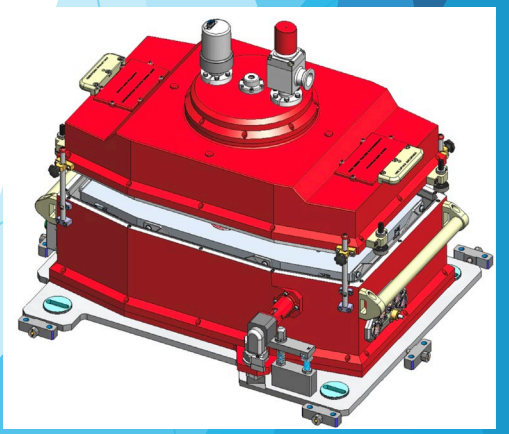
Delay Line



Fourier (science instrument)



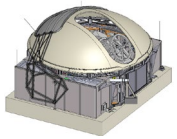
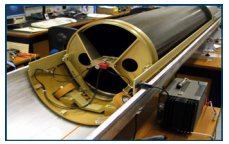
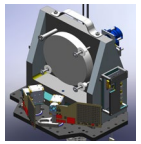
Beam Relay System



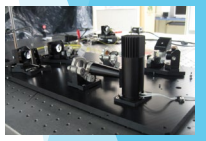
ICoNN (fringe tracker)

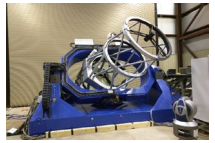
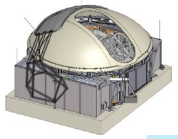
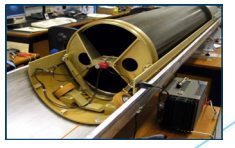
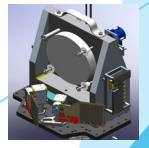
Magdalena Ridge Observatory

Interferometer Supervisory System (ISS)

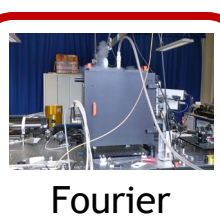





Beamline 1



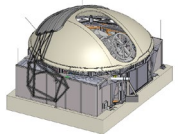
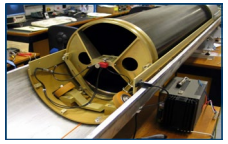
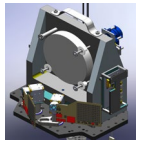





Beamline 2

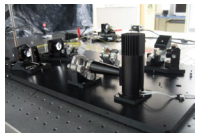


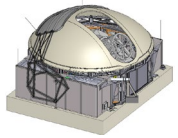
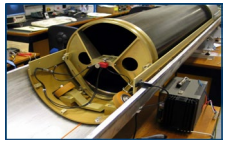
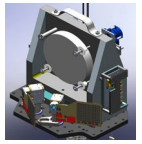
ICoNN

Fourier

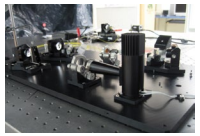





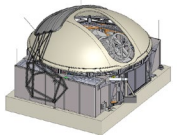
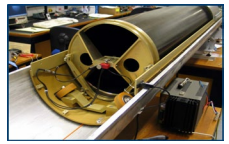
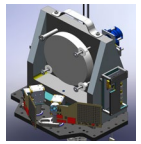
Beamline 3



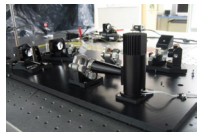





Beamline 4

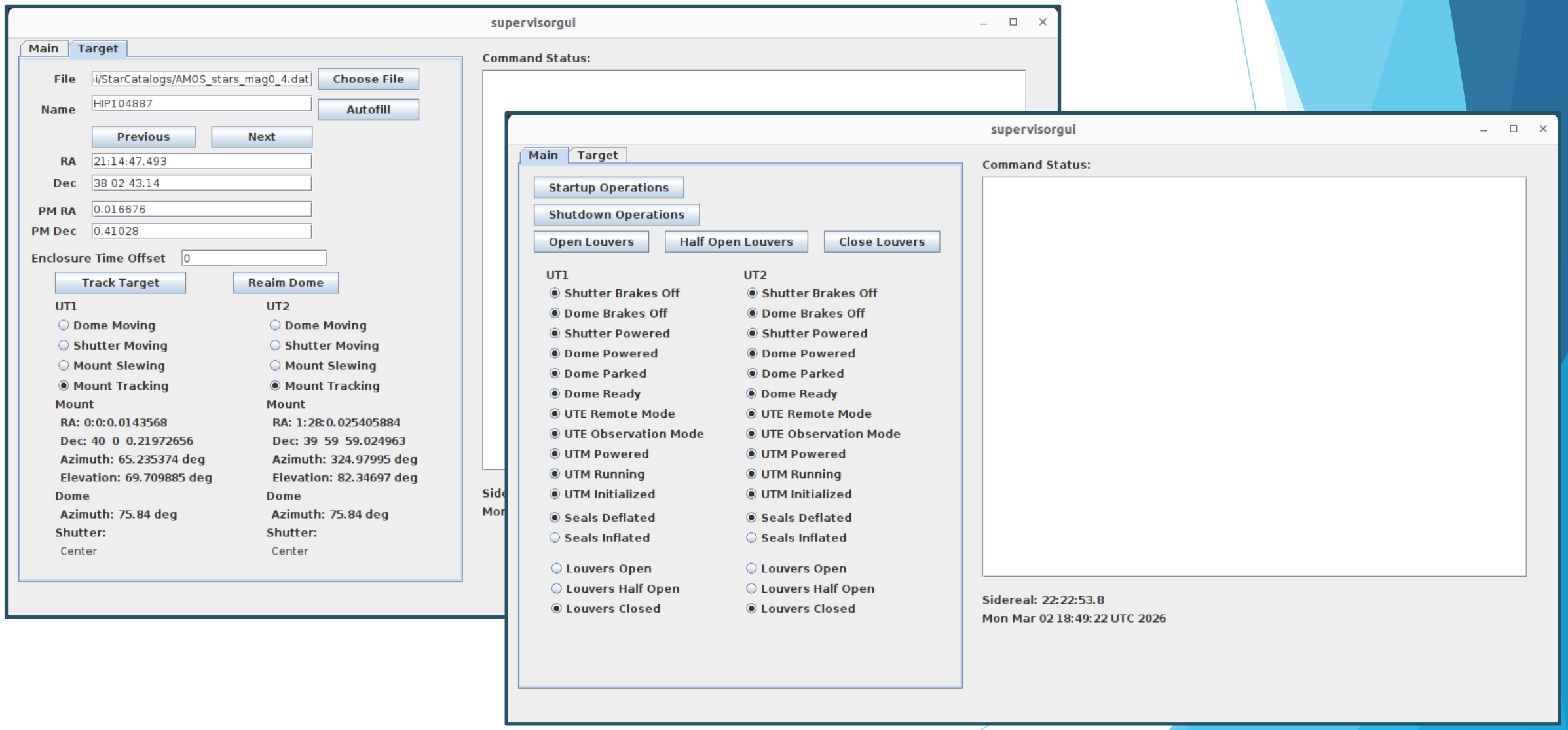


Beamline 5



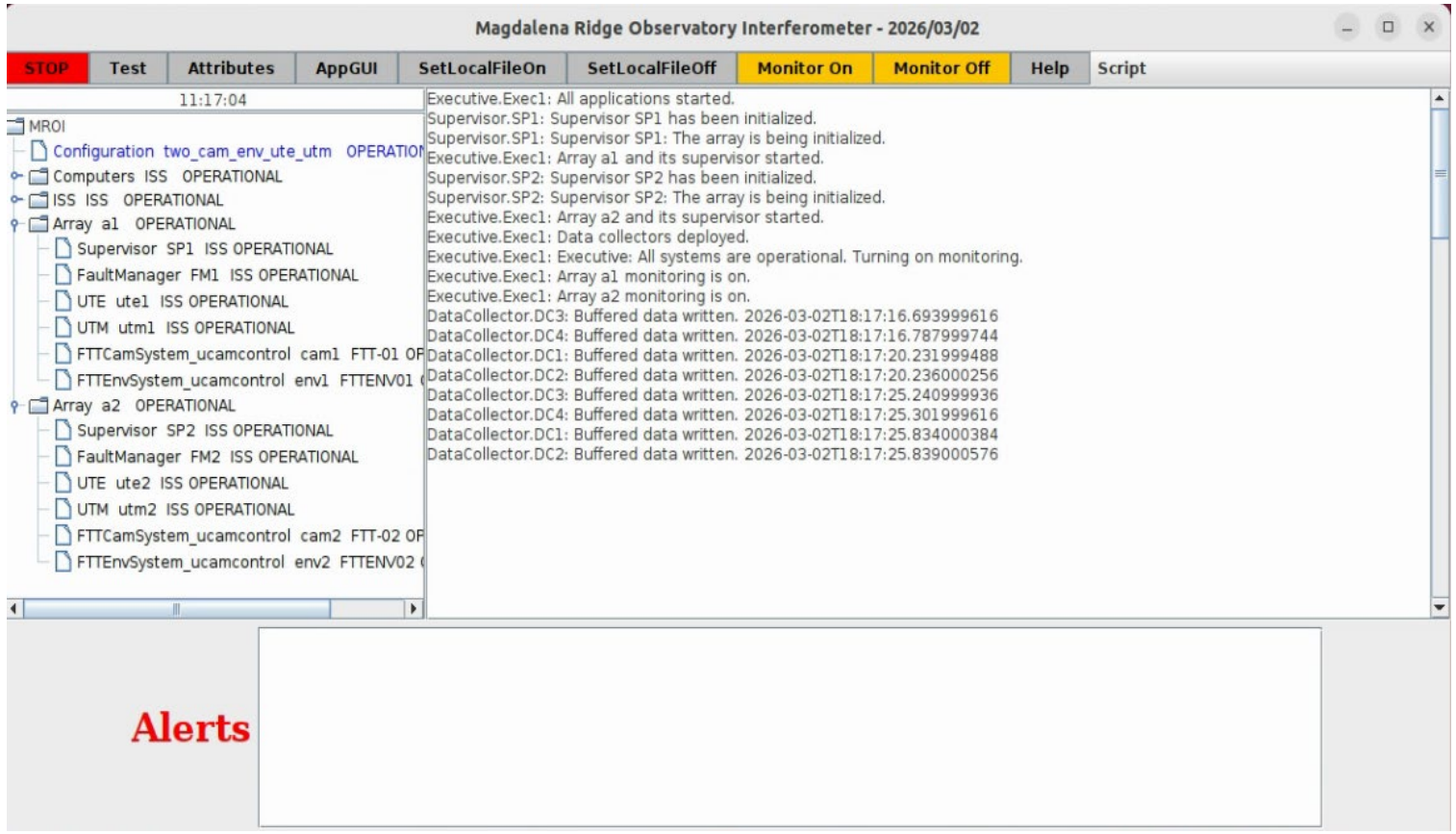
Supervisor GUI



Observing Teams
manual operation of software systems

- MROIs 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

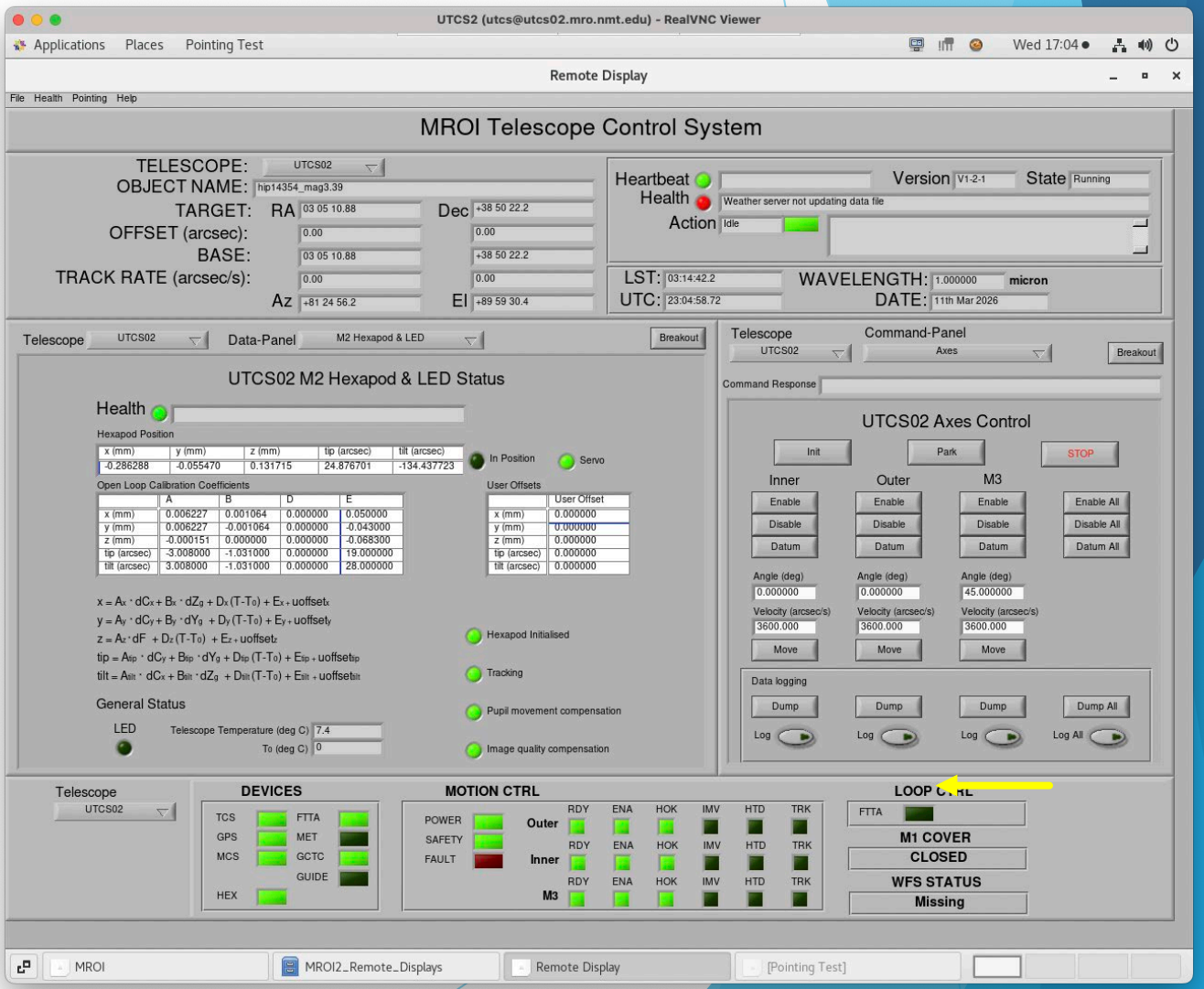
Subscriber /publisher methodology (design pattern).

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

Data recording: system apps

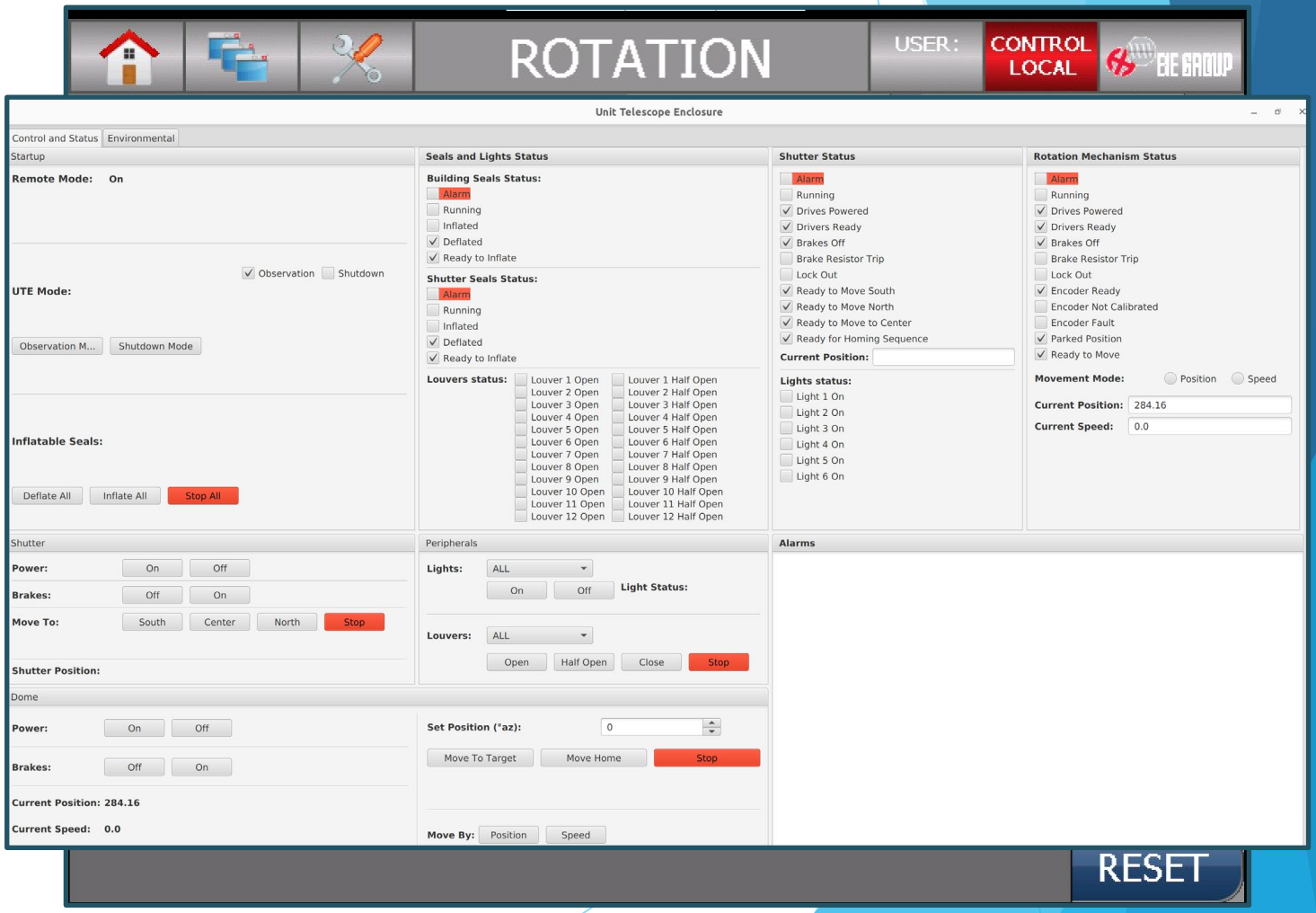
Unit Telescope Control system (UTCS)

- 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 FTT
  - Primary control interface
- Future: ISS operator GUI



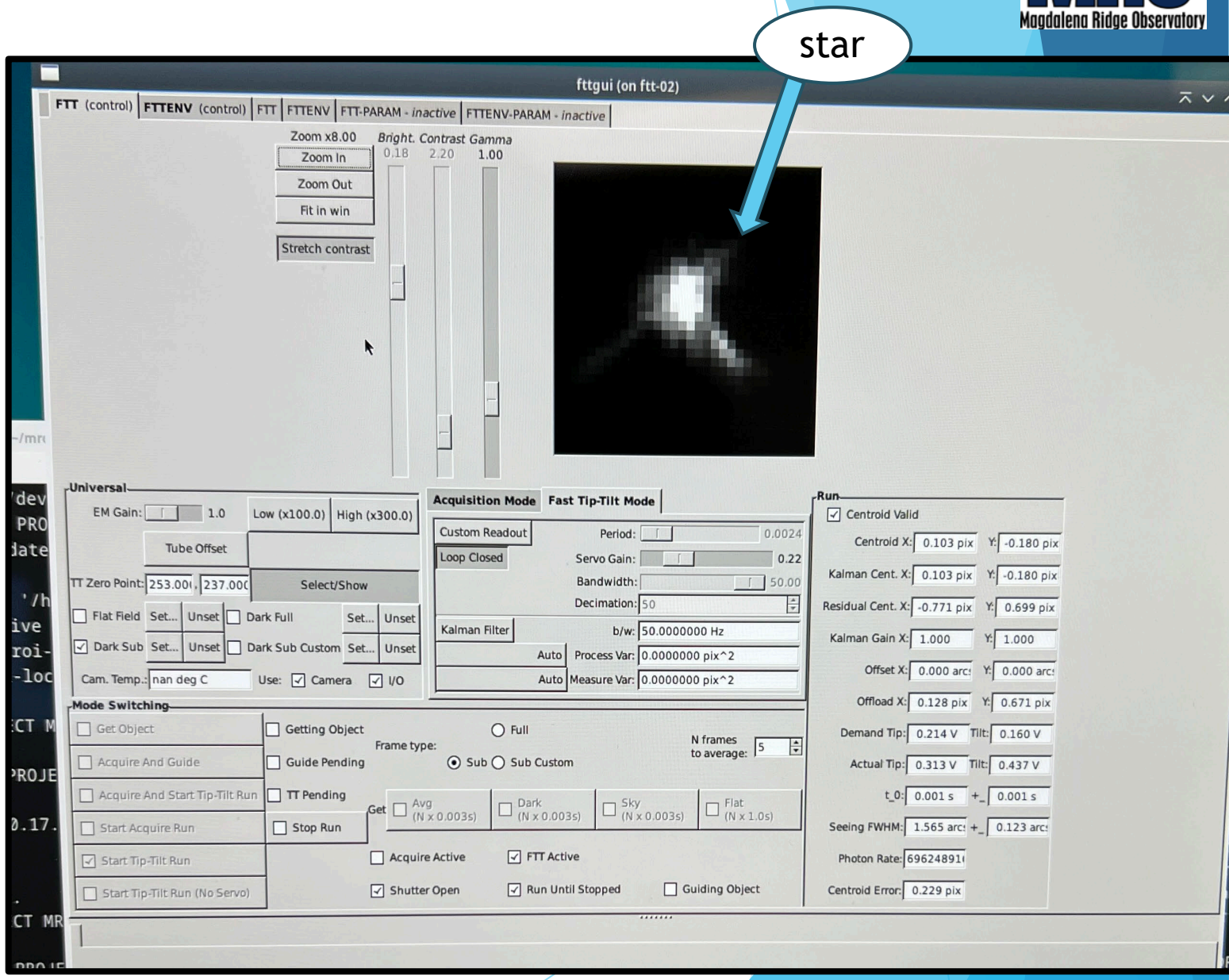
Unit Telescope Enclosure (UTE)

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



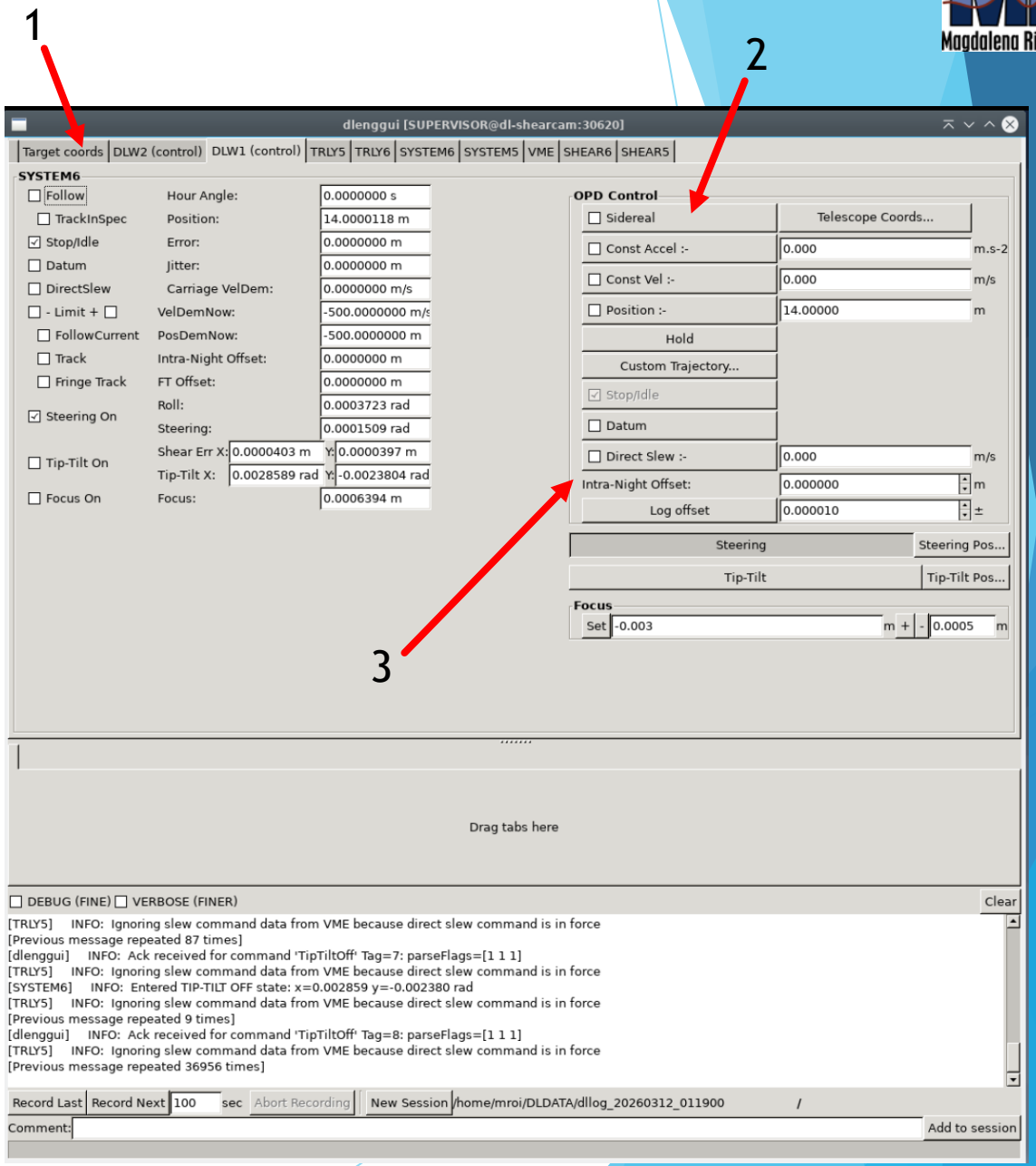
Fast Tip Tilt (FTT)

- FTTGUI user interface
- Image stabilization:
  - manual tune FTT Servo loop to minimize centoid
- 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



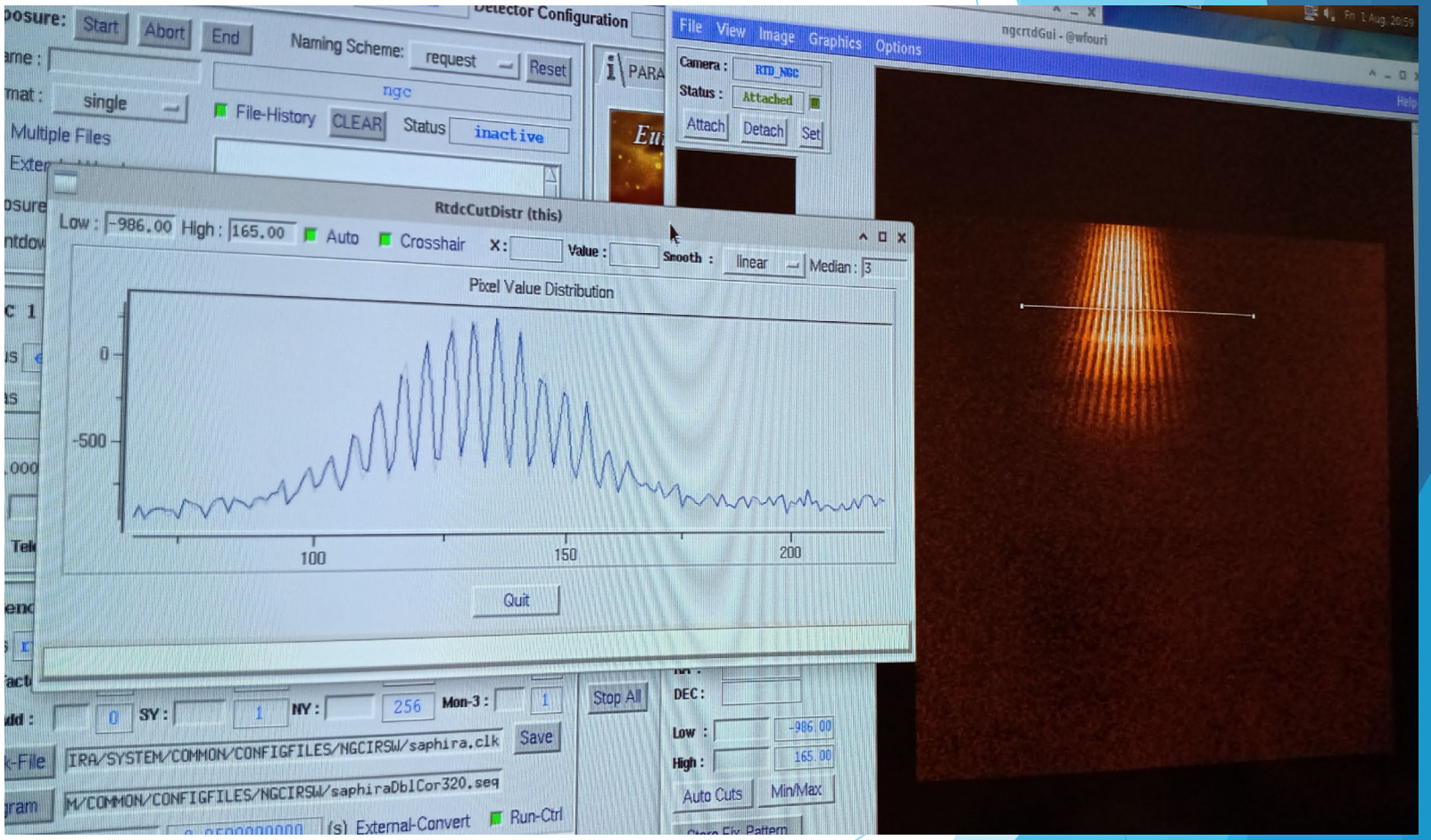
Delay Line

- 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 ←→ FOURIER)

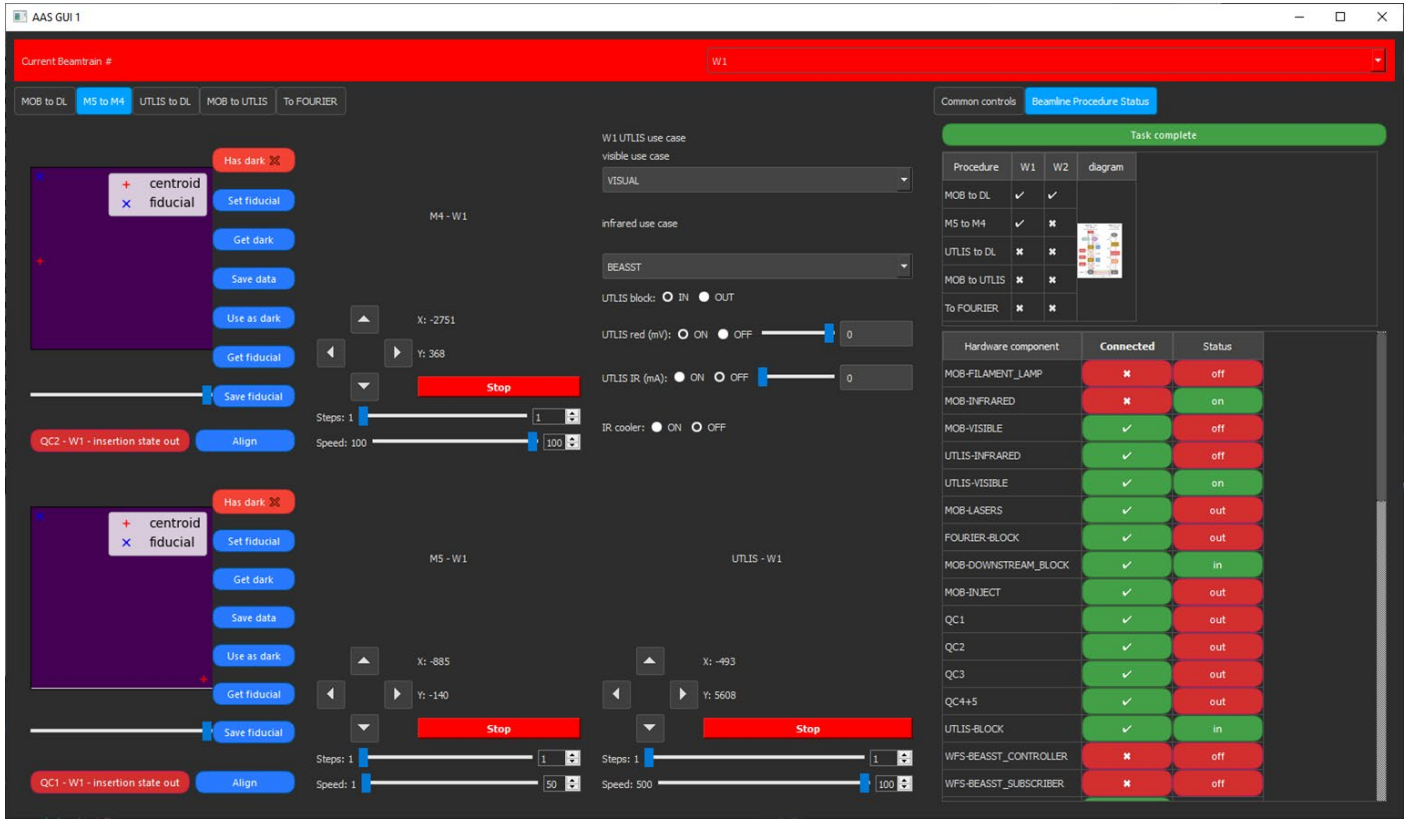


Fourier

- 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)



- 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

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