

Observing and Data Reduction with MIRC-X

Tyler Gardner - University of Michigan
Arturo Martinez - Georgia State University



MIRC-X Overview

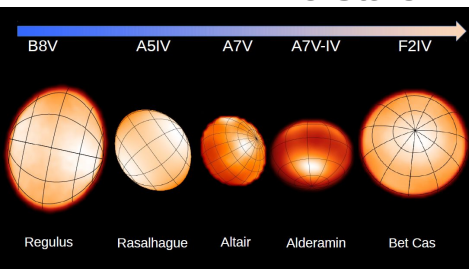


MIRC-X Overview

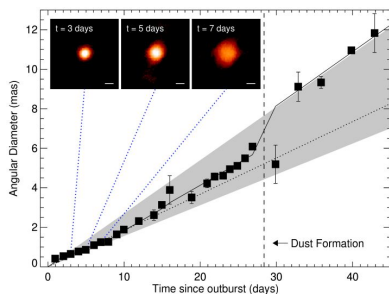
- Combines light from 6 telescopes of CHARA in J/H bands
 - 15 baselines simultaneously, up to 330m
 - Resolution: ~ 0.5 milli-arcseconds
 - Limitations: Can only observe objects with $H < 7.5$
- An upgrade of Michigan InfraRed Combiner (MIRC)
 - Monnier et al (2006; 2010)
 - Goals of upgrade: 1) Maximize sensitivity, 2) Extend wavelength coverage to J-band, 3) Enable polarization interferometry
- Observing modes currently offered:
 - H-band PRISM (R \sim 22, 50, or 102)
 - H-band GRISM (R \sim 190)
 - J-band, polarization modes to come
- MIRC-X is explained in detail in upcoming paper by Anugu et al (submitted)

MIRC-X Science Programs

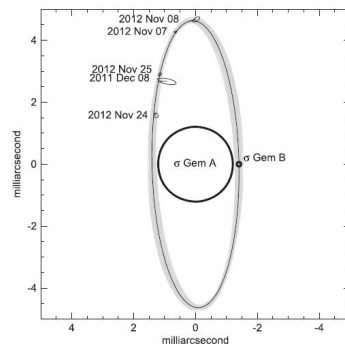
- A wide variety of science interests currently underway with MIRC-X:
 - Stellar diameters
 - Imaging!
 - Rapid rotators, RS CVn, RSG, YSOs, novae
 - Binary stars → orbits, multiplicity surveys, planet searches with precision astrometry
 - Be Stars



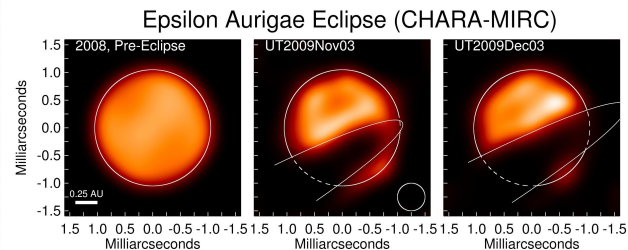
Monnier+2007, Zhao+2009, Che+2011



Schaefer+2016



Roettenbacher+15

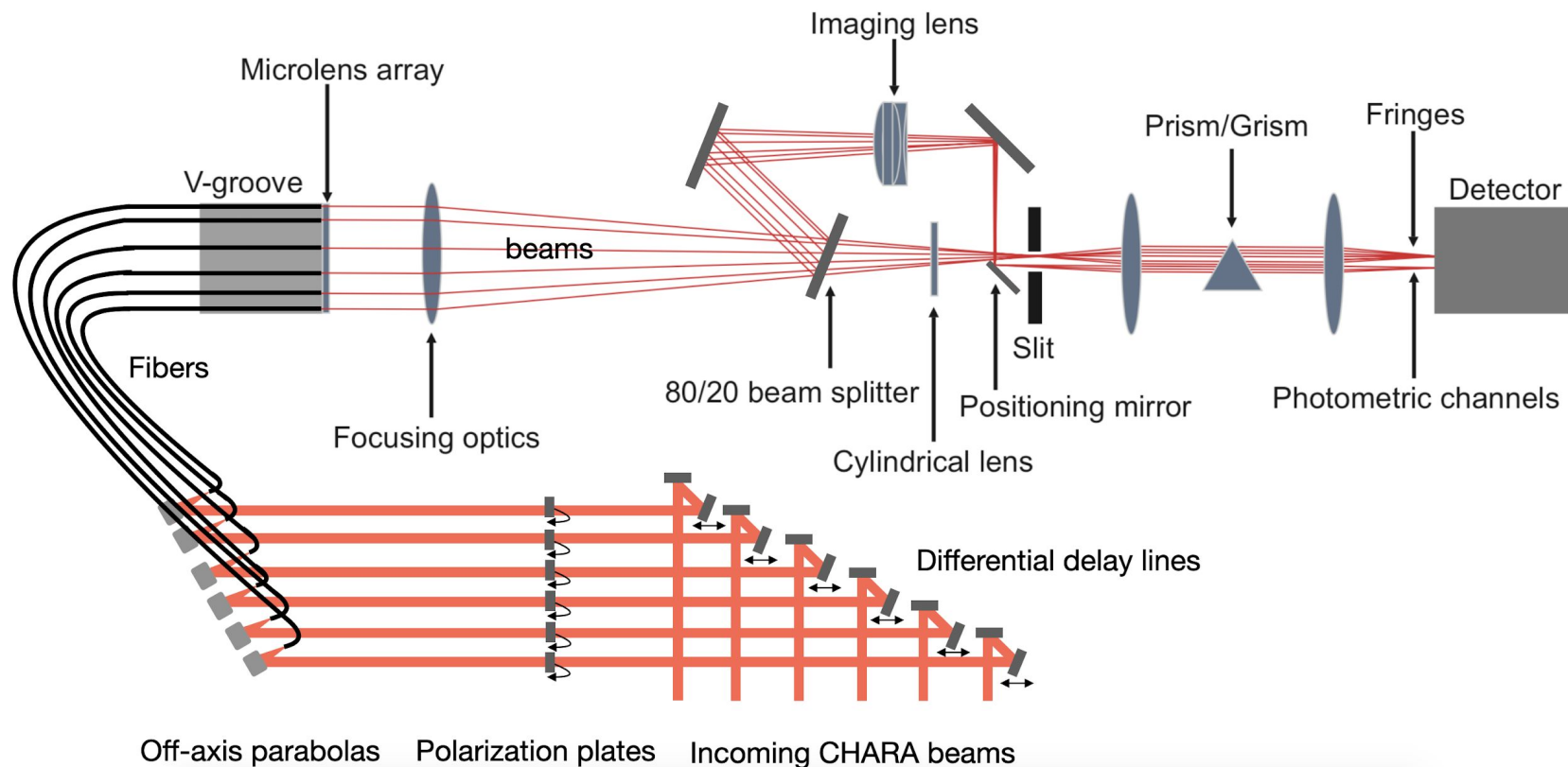


Kloppenborg+2010

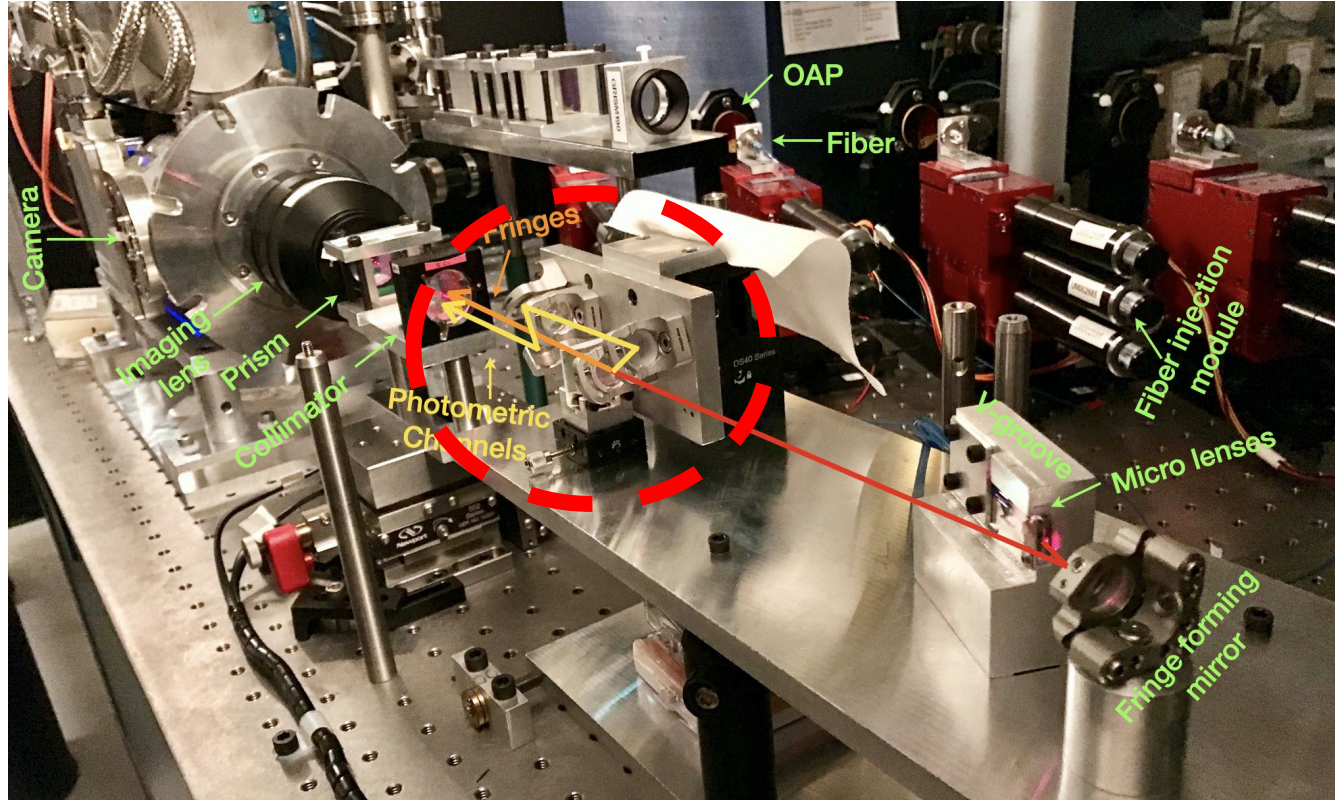
MIRC-X Instrument



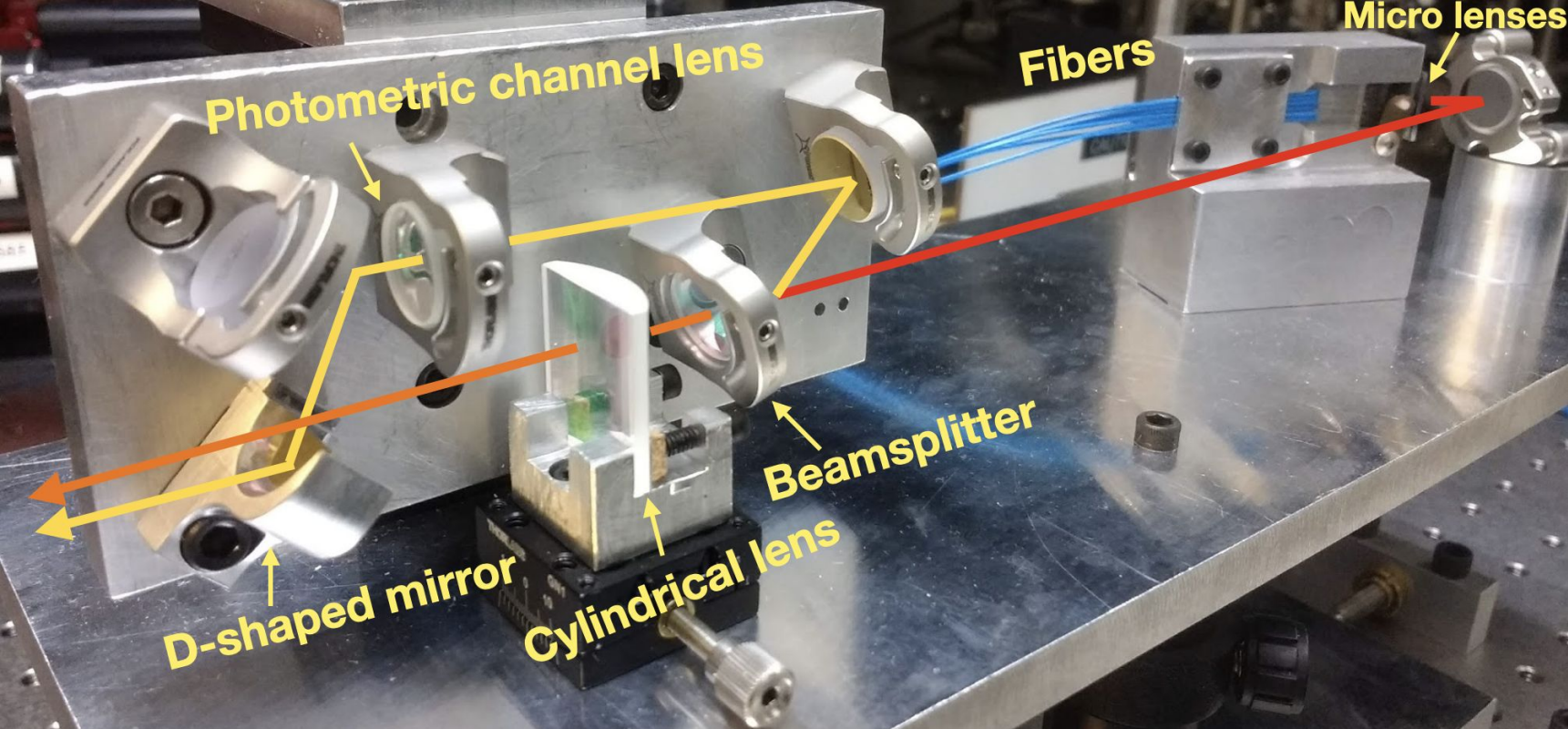
MIRC-X Instrument



MIRC-X Instrument



MIRC-X Instrument



Planning Observations

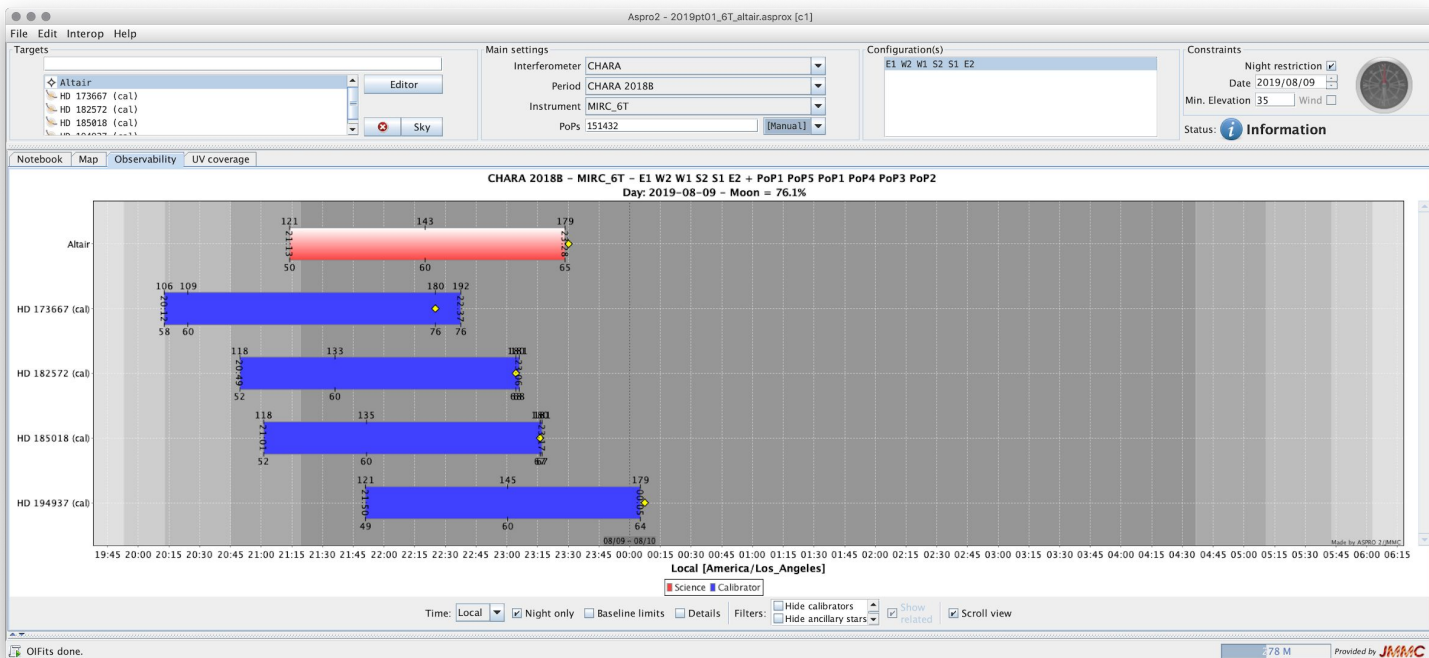


Planning Observations

- MIRC-X is a slow cadence beam combiner
 - Observations on a single object take 20 minutes at the bare minimum for recording data
- Calibrator selection
 - Make sure your calibrators are ~30 min to an hour before your target is in delay
 - Within the same mag range as your object (exception: very bright targets)
- Typical Observing sequence
 - Cal1-Obj-Cal2
- MIRC-X designated beam order (as of 2018)
 - E1-W2-W1-S2-S1-E2

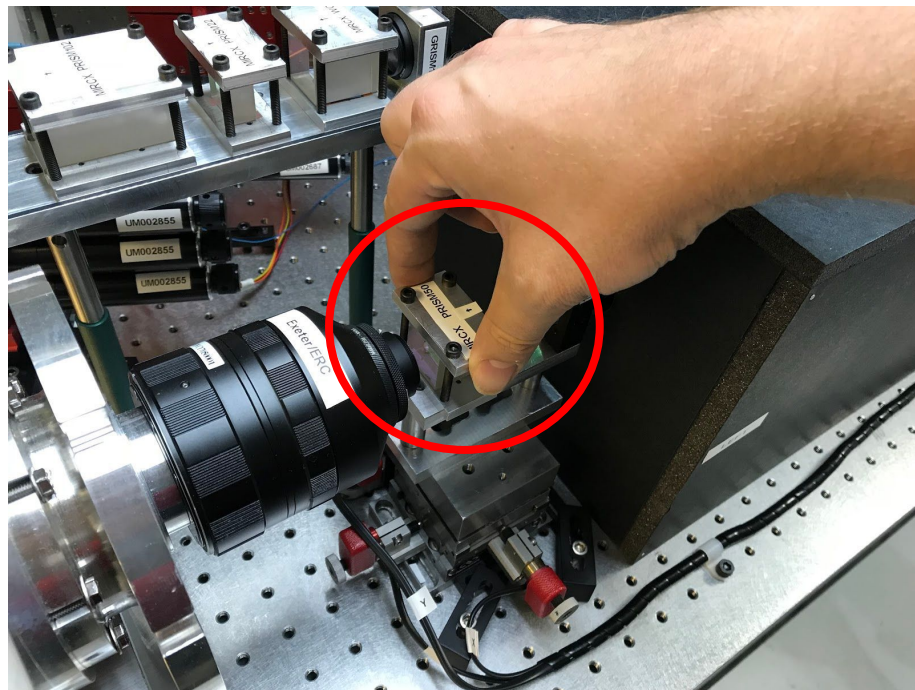
Planning Observations

- Aspro2 & searchcal



Planning Observations

- Various modes for MIRC-X
 - PRISM 50 (default mode)
 - GRISM 190
- Polarization coming soon...
- J-band mode coming soon...
- Future plans with MYSTIC (K-band)



Observing with MIRC-X

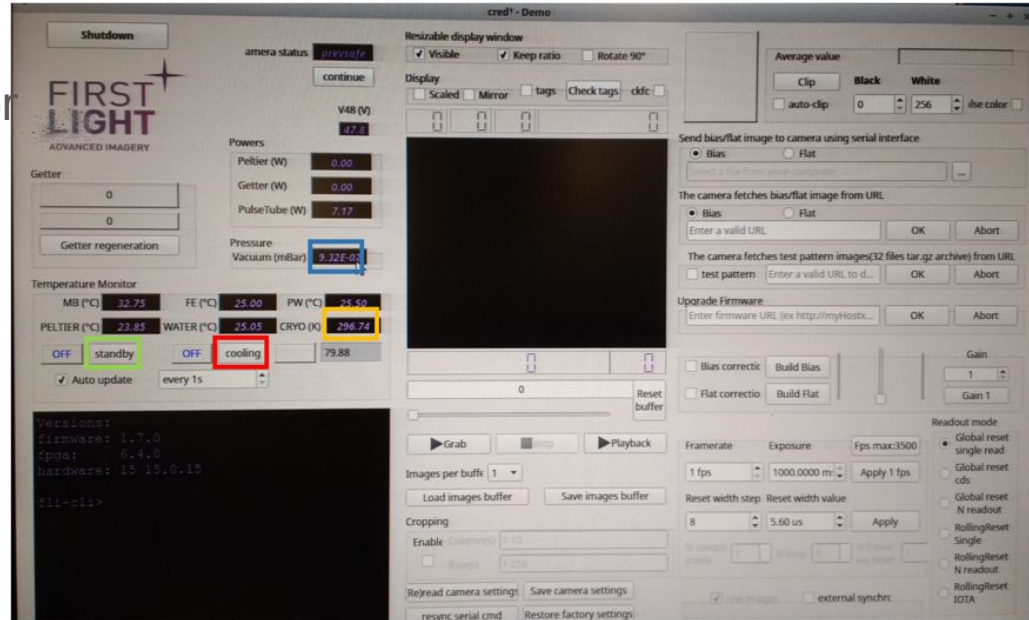


Standard Observing Sequence

1. Acquire star at the telescopes
2. Perform a fiber explorer map to align light into the fibers
3. 10 minutes of DATA, with all shutters open and fringes tracked
4. 1 minute of BACKGROUND with all shutters closed
5. 1 minute of each beam where the shutter of only one of the six beams is open sequentially
6. 3 minutes of FOREGROUND frames where all shutters are open but the optical path is set to a large value to ensure that no fringes are present in the data set

Startup & C-RED-ONE GUI

- User manual for MIRC-X observing on CHARA wiki
- Always start servers before opening any GUIs
- C-RED-ONE GUI used to monitor camera but not used throughout the night



MIRC-X server GUI

- Load in parameters for mode and send
- Now you can start operations and send your parameters to the camera
- Monitor this GUI throughout the night to make sure settings are fine!

The screenshot shows the MIRC-X server GUI with several sections:

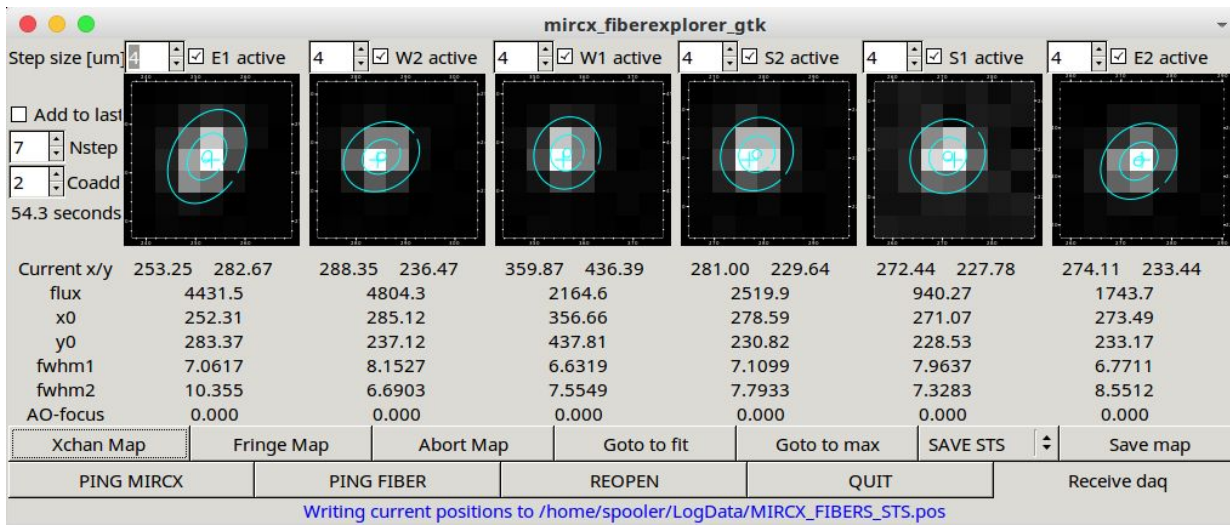
- Buttons:** LOAD CONFIG FILE, GET FROM SERVER, SAVE, /home/observe/MIRCX_H
- Ircam parameters:** Set standby (operational), Crop Cols (1-10), Crop Rows (59-102), Det Cols (320), Det Rows (44), NReads (8), NLoops (6), NFrames/reset (20)
- Windows:** fringeCol1 (70), fringeCol2 (310), fringeRow1 (4), fringeRow2 (39), xchanCol1 (10), xchanCol2 (65), xchanRow1 (4), xchanRow2 (39), deltaPolRow (0)
- Coadd parameters:** NFrames/file (2000), Coherent (10), PS coadd (20), Nbin (1), Gain (1)
- Buttons:** Update DAQ, Config Camera (Configured), Start Exposure, Stop Exposure (Running), Reset BG, Take BG (0), Use BG, Reset FLAT, Take FLAT (0), FLAT1, FLAT2, Track Polar GD, Track Polar Phase
- Status Monitors:** Disk free space (33.6%), Mean Tint (2.735), Mean Mywork (0.070), Det Sat ratio (0.31), Det ADU (20182.43), Frame Rate (364), T_FE (24.25), Tcamera (79.88), Twater (22.03), Tpel (27.73), T_MB (39.75), Pcamera (2.0E-05), Ppfeiffer (2.330e-01), Pionpump (2.300e-08), EM valve (CLOSE), Servers status: fiber, vacuum, ddl, ople, shutters, gps, tip tilt, stepper LABAO_S1, wfs_S1
- Buttons:** PING, REOPEN, RECONNECT, QUIT, fiber mapping finished, Receive parameters

The screenshot shows the MIRC-X server GUI with a detailed parameter list:

| Parameter | Current values | Value(s) |
|------------------------|--------------------|--------------------|
| lambda | 1.614000 | 1.614 |
| bandwidth | -0.256000 | -0.256 |
| Combiner | ALL-IN-ONE | ALL-IN-ONE |
| Cpeak | 6 27 42 60 72 21 3 | 6 27 42 60 72 21 3 |
| Cpeak0 | 6 27 42 59 71 21 3 | 6 27 42 59 71 21 3 |
| Cpeak1 | 6 27 42 61 73 21 3 | 6 27 42 61 73 21 3 |
| BGNoiseCol | 50 | 50 |
| Filter1 | H_band | H_band |
| Filter2 | OPEN | OPEN |
| ConfigName | H_GRISM190 | H_GRISM190 |
| Xchan pos | 48 44 36 30 22 17 | 48 44 36 30 22 17 |
| Observer | Slimfringe | |
| Comment 1 | | |
| SEND | | |
| Disk free space | 33.6% | 2.734 |
| Mean Tint | 2.734 | 0.066 |
| Mean Mywork | 0.066 | |
| Det Sat ratio | 0.31 | 20032.00 |
| Det ADU | 20032.00 | 370 |
| Frame Rate | 370 | 24.00 |
| T_FE | 24.00 | |
| Tcamera | 79.88 | 22.02 |
| Twater | 22.02 | 27.72 |
| Tpel | 27.72 | 39.25 |
| T_MB | 39.25 | |
| Pcamera | 2.0E-05 | 2.330e-01 |
| Ppfeiffer | 2.330e-01 | 2.400e-08 |
| Pionpump | 2.400e-08 | CLOSE |
| EM valve | CLOSE | |
| Servers status: | | |
| fiber | vacuum | ddl |
| ople | shutters | |
| gps | tip tilt | stepper LABAO_S1 |
| wfs_S1 | | |
| PING | REOPEN | RECONNECT |
| QUIT | | |
| fiber mapping finished | | |
| Receive parameters | | |

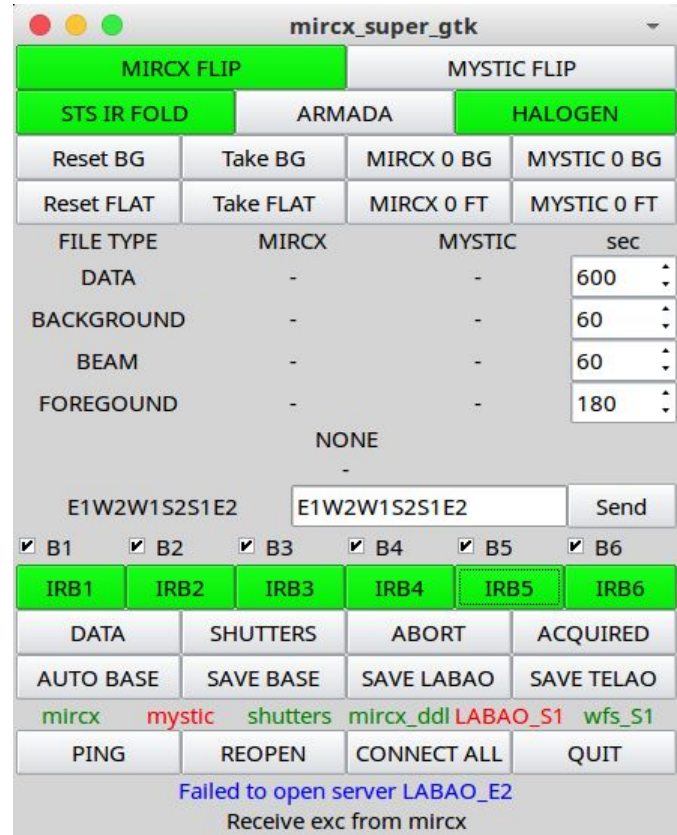
MIRC-X fiber explorer GUI

- Use this to make sure that you are getting light in the fibers
 - Can adjust Step size, Nstep, and Coadd throughout the night
- Good seeing: Beams are compact & produces nice 2D gaussian profiles
- Bad seeing: Light from beams are spread out



MIRC-X super gtk GUI

- Can reset/take backgrounds
- Can reset/take flats (for bright objects to avoid issues with cross-talk)
- Use this to record data



MIRC-X GDT GUI

- This GUI lets you control offsets between carts
- When the fringe is found, fringe lights up “yellow”;
- locking on a fringe will turn the fringes “green”
- You have the option to “track” on a fringe
- You can lock on cross-fringes but ultimately want to lock with ref cart



mirrx_gdt_gtk

| beam, pops | cart pos error | DDL position | step size | link beams | S1 | S2 | E1 | E2 | W1 | W2 |
|------------------|----------------|--------------------|---------------------|------------|-------|-------|-------|-------|-------|----|
| S1 5 0 MAN. OFF. | x | << < 0 12.198 > >> | 0.002 Loop- Loop+ ✓ | S1 | - | x | x | x | x | x |
| S2 4 0 MAN. OFF. | x | << < 0 12.910 > >> | 0.002 Loop- Loop+ ✓ | S2 | 901.4 | - | x | x | x | x |
| E1 1 0 MAN. OFF. | x | << < 0 16.280 > >> | 0.006 Loop- Loop+ ✓ | E1 | 1041. | 2424. | - | x | x | x |
| E2 6 0 MAN. OFF. | x | << < 0 8.048 > >> | 0.006 Loop- Loop+ ✓ | E2 | 991.6 | 1601. | 1501. | - | x | x |
| W1 3 0 MAN. OFF. | x | << < 0 14.414 > >> | 0.010 Loop- Loop+ ✓ | W1 | 647.2 | 1252. | 1831. | 759.6 | - | x |
| W2 2 0 MAN. OFF. | x | << < 0 16.101 > >> | 0.010 Loop- Loop+ ✓ | W2 | 754.4 | 1577. | 3028. | 1313. | 1153. | - |

refbeampol 1 polforgdt 0 MASTER Gdt Gain 0.60 0.60 Search Thresh. 2.0 2.0 FRINGE LOCK CLEAR MATRIX

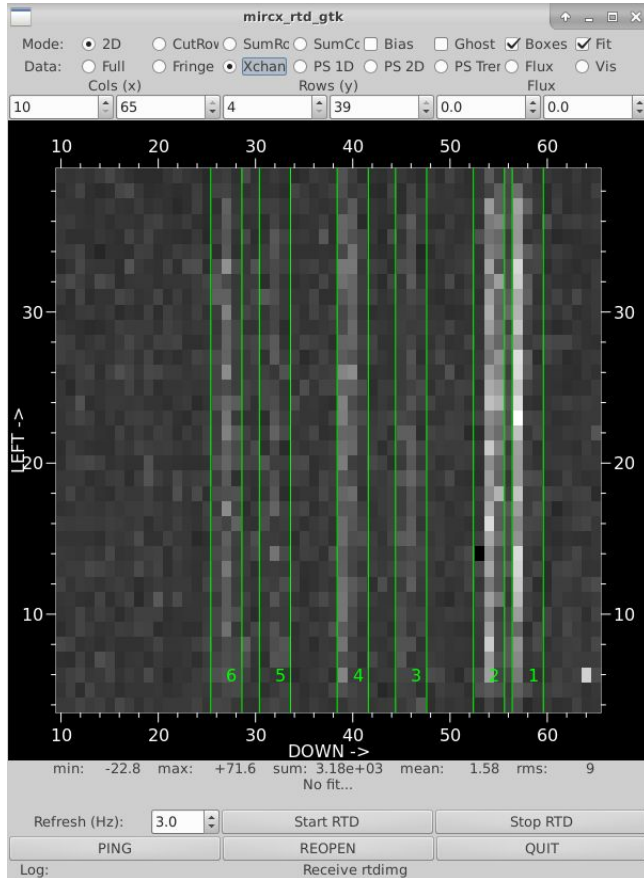
| | S1 S2 | S1 E1 | S1 E2 | S1 W1 | S1 W2 | S2 E1 | S2 E2 | S2 W1 | S2 W2 | E1 E2 | E1 W1 | E1 W2 | E2 W1 | E2 W2 | W1 W2 |
|-----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------|---------|---------|-----------|-----------|-------|-------|-------|
| OPD: | 0.7 0.5 | -0.2 0.1 | -0.2 0.1 | -0.2 -0.1 | -0.2 -0.1 | 0.5 0.5 | -0.7 -0.8 | -0.8 -0.4 | 0.4 0.5 | 0.8 0.8 | -0.2 -0.5 | -0.2 -0.2 | | | |
| POL_OPD: | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x |
| POL_PHI: | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x | x x |
| MEAN VIS: | 0.96 0.72 | 1.00 0.88 | 0.85 0.74 | 0.86 0.91 | 0.80 0.55 | 0.89 0.97 | 0.71 0.66 | 0.90 | | | | | | | |
| SIGNAL | 18028.5 20830.0 | 19832.0 12944.9 | 15087.9 48488.2 | 32032.6 25057.5 | 31542.7 30029.6 | 36638.3 60566.6 | 15192.9 26259.7 | 23073.0 | | | | | | | |
| NOISE | 20.0 20.0 | 20.0 20.0 | 20.0 20.0 | 20.0 20.0 | 20.0 20.0 | 20.0 20.0 | 20.0 20.0 | 20.0 | | | | | | | |

| GET | SEND | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| CALC ALL | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC | CALC |

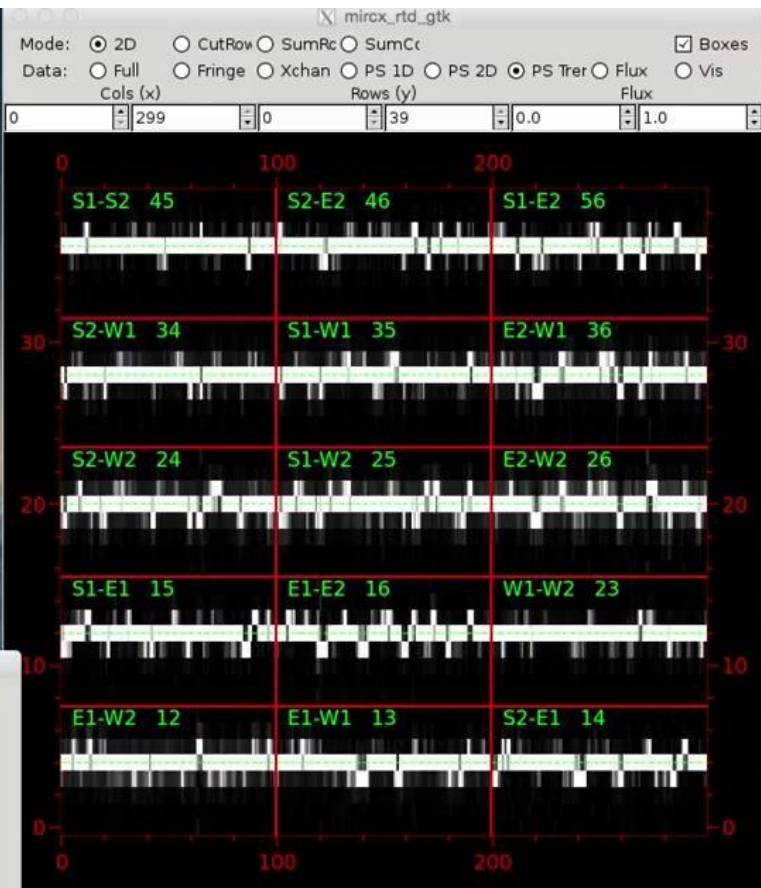
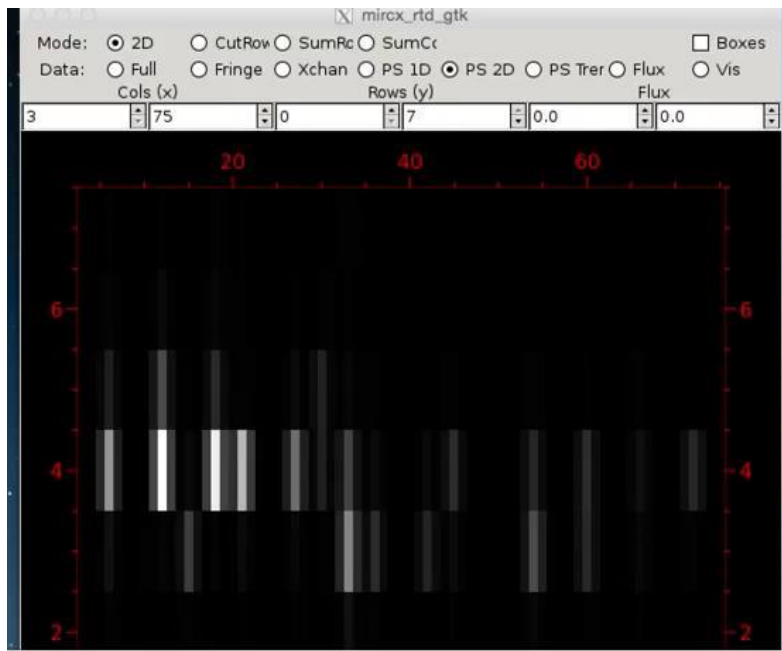
Target: x Mag: x RA: x DEC: x HA: x UTC: x r0 = 0.00

PING MIRRX PING OPLE REOPEN QUIT Receive gdtloop

Fiber Mapping → Make sure flux injected into MIRCX



Add a on-sky map here
(maybe move up this slide in
presentation?)



mirrx_gdt_gtk --> mirrx_server

step size link beams

| | | | S1 | S2 | E1 | E2 | W1 | W2 | | | |
|---|----|-------|-------------|-------------------------------------|----|------|------|------|------|------|---|
| > | >> | 0.002 | Loop- Loop+ | <input checked="" type="checkbox"/> | S1 | - | x | x | x | x | x |
| > | >> | 0.002 | Loop- Loop+ | <input checked="" type="checkbox"/> | S2 | 49.0 | - | x | x | x | x |
| > | >> | 0.006 | Loop- Loop+ | <input checked="" type="checkbox"/> | E1 | 19.5 | 10.2 | - | x | x | x |
| > | >> | 0.006 | Loop- Loop+ | <input checked="" type="checkbox"/> | E2 | 24.2 | 8.2 | 9.3 | - | x | x |
| > | >> | 0.010 | Loop- Loop+ | <input checked="" type="checkbox"/> | W1 | 16.4 | 12.3 | 15.2 | 13.7 | - | x |
| > | >> | 0.010 | Loop- Loop+ | <input checked="" type="checkbox"/> | W2 | 13.6 | 9.8 | 18.0 | 8.5 | 27.5 | - |

Search Threshold 2.0 3.0

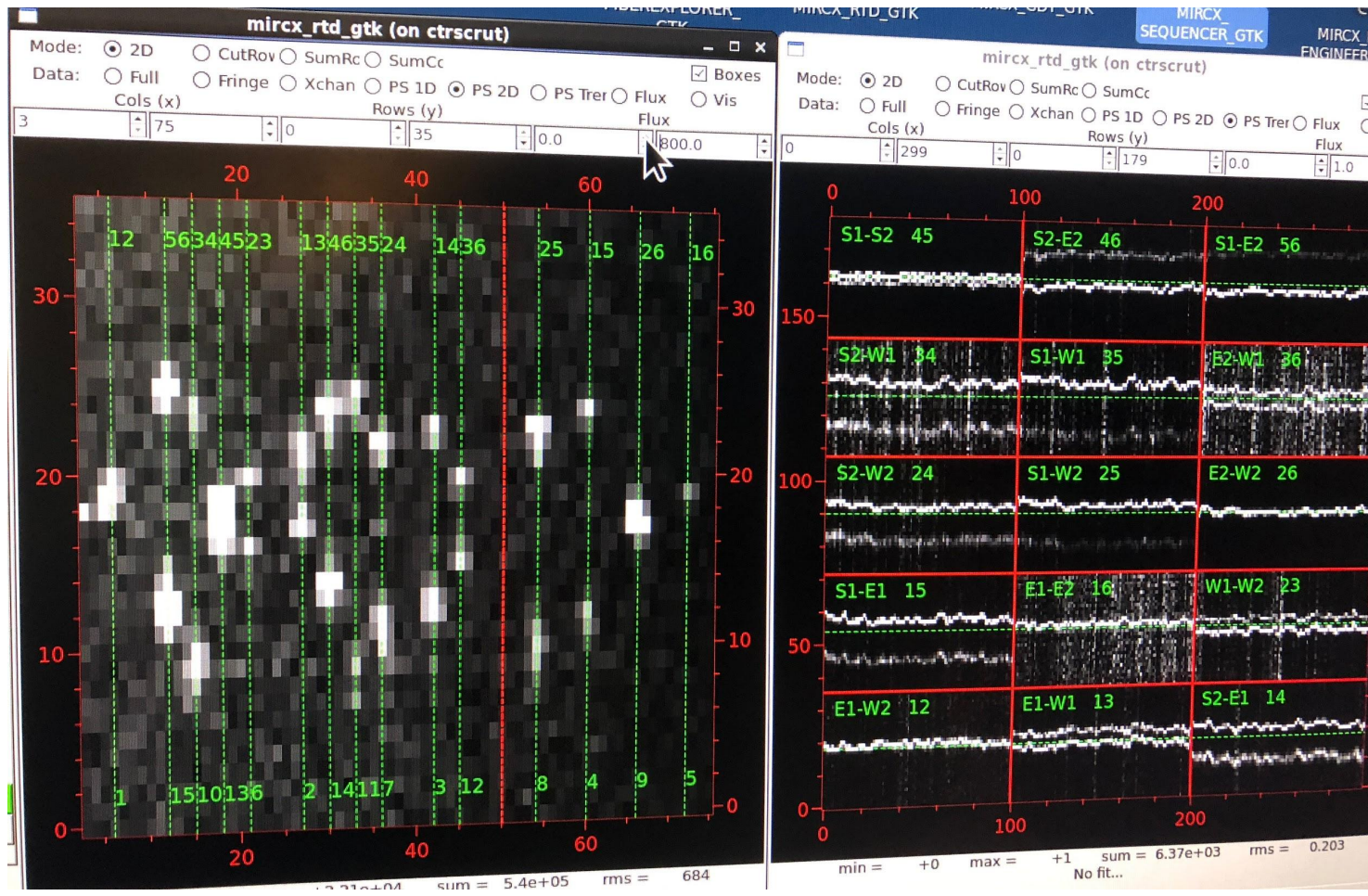
FRINGE LOCK CLEAR MATRIX

| S2 E1 | S2 E2 | S2 W1 | S2 W2 | E1 E2 | E1 W1 | E1 W2 | E2 W1 | E2 W2 | W1 W2 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| -4.2 | 1.9 | -3.1 | -2.0 | -0.4 | -0.5 | -1.2 | 0.1 | 1.3 | 0.6 |
| 0.06 | 0.06 | 0.07 | 0.06 | 0.04 | 0.09 | 0.09 | 0.06 | 0.04 | 0.11 |

Refresh (Hz): 3.0 Start RTD Stop RTD

PING REOPEN QUIT

A binary star in GRISM mode:



Six Telescope Simulator (STS)

- Internal light source for checking MIRCX performance, switching modes, testing
- Used each night before observations
- Installed in May 2019

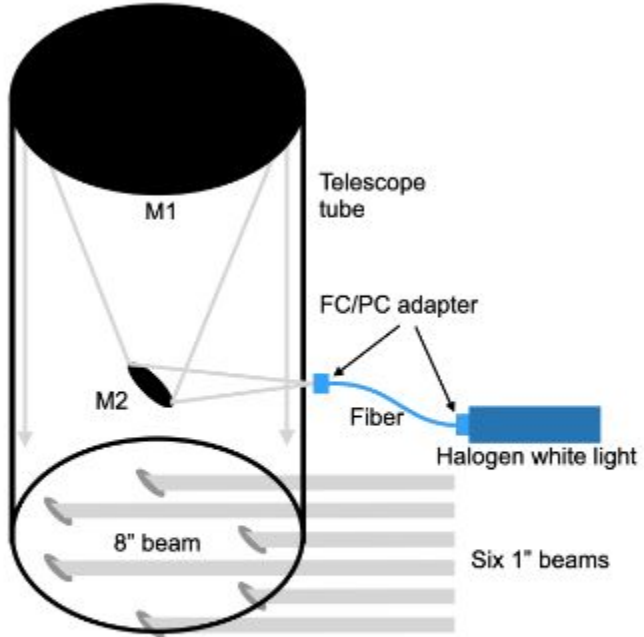
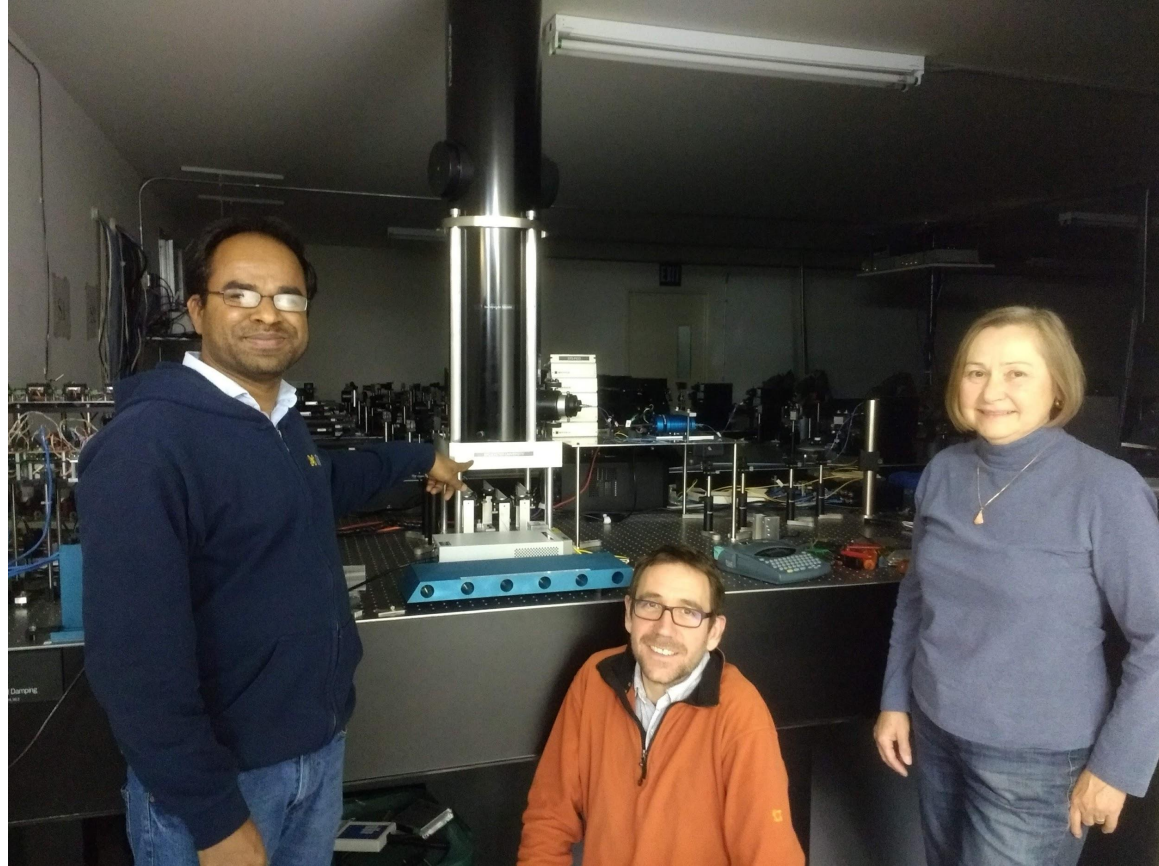


Figure 9. Layout of the six telescope simulator (STS, not to scale). Six coherent beams are extracted from an 8-inch collimated beam created by a Classical Dobsonian telescope acting in reverse. The telescope eyepiece is fed by a single-mode fiber, which is injected light from a halogen lamp.



Six Telescope Simulator (STS)

The screenshot displays the Six Telescope Simulator (STS) software interface, which is used for simulating a six-telescope system. The interface is divided into several key sections:

- Control Panel (mirrx_sequencer_gtk):** Located at the top, it features six telescope status indicators (S1-S6) with checkboxes for 'active' and 'step size' (set to 4 μm). Below these are buttons for 'Add to last', 'Nstep' (5), 'Coadd' (2), and a timer showing '25.5 seconds'.
- Data Table (mirrx_fiberexplorer_gtk):** A table displaying current coordinates and flux for each telescope.

| Current x/y | 278.15 | 291.35 | 293.03 | 247.14 | 300.37 | 301.91 | 285.40 | 221.25 | 293.78 | 244.56 | 318.54 | 228.58 |
|-------------|--------|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| flux | 51077 | 1.1177e+05 | 43030 | 61180 | 39226 | 40103 | | | | | | |
| x0 | 278.15 | 293.04 | 300.37 | 285.4 | 293.78 | 318.54 | | | | | | |
| y0 | 291.35 | 247.14 | 301.91 | 221.25 | 244.56 | 228.58 | | | | | | |
| fwfm1 | 7.1048 | 6.3415 | 7.0865 | 6.5659 | 6.4941 | 7.0049 | | | | | | |
| fwfm2 | 8.5783 | 6.6024 | 6.4663 | 8.9418 | 7.2123 | 7.606 | | | | | | |
- Flux Plot:** A plot showing flux versus position (x-axis from 0 to 80, y-axis from 0.5 to 2.5). It displays several peaks, with the highest peak at approximately x=12, y=2.5. The plot is labeled with '12 56344523 13463524 1436 25 15 26 16'.
- Beam Position Plot:** A plot showing beam positions versus position (x-axis from 100 to 300, y-axis from 10 to 30). It displays several vertical lines representing beam positions, with the highest peak at approximately x=100, y=30. The plot is labeled with '100 150 200 250 300'.
- Terminal Window (mirrx_gdt_gtk):** A terminal window showing system messages and status information. It includes a table of beam positions and a table of system parameters.

| beam, pops | cart pos error | DDL position | step size | link beams | S1 | S2 | E1 | E2 | W1 | W2 | | |
|------------|----------------|--------------|-----------|------------|-------|------|------|----|-------|-------|-------|-------|
| S1 1 0 | MAN. OFF. | x << < 0 | 11.500 | >> | 0.050 | Loop | Loop | S1 | x | x | x | x |
| S2 2 0 | MAN. OFF. | x << < 0 | 12.992 | >> | 0.050 | Loop | Loop | S2 | 145.7 | - | x | x |
| E1 3 0 | MAN. OFF. | x << < 0 | 15.774 | >> | 0.005 | Loop | Loop | E1 | 114.4 | 195.7 | - | x |
| E2 4 0 | MAN. OFF. | x << < 0 | 13.608 | >> | 0.050 | Loop | Loop | E2 | 237.2 | 216.1 | 246.7 | - |
| W1 5 0 | MAN. OFF. | x << < 0 | 12.833 | >> | 0.050 | Loop | Loop | W1 | 161.6 | 208.9 | 230.3 | 264.5 |
| W2 6 0 | MAN. OFF. | x << < 0 | 13.184 | >> | 0.020 | Loop | Loop | W2 | 112.6 | 151.4 | 127.2 | 265.2 |

Remote Observing

- VNC connection through machine in Atlanta
- Most MIRC-X runs are done remotely now

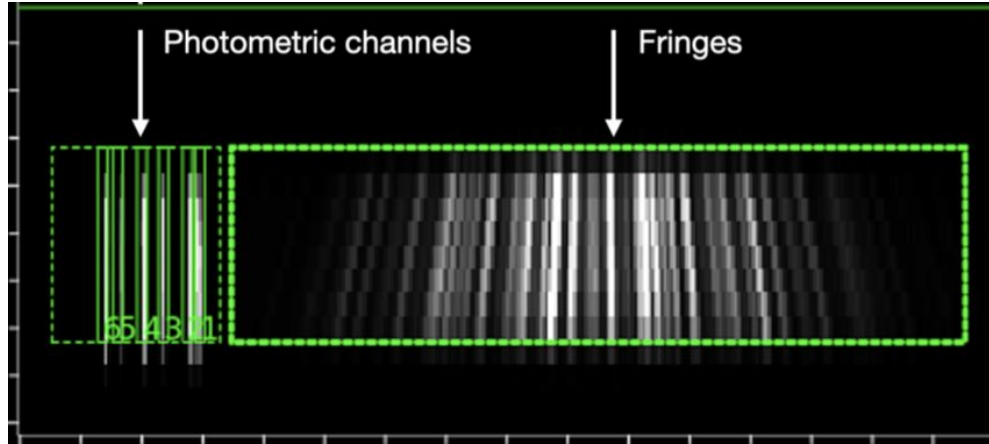
The screenshot displays a complex control interface for a synchrotron beamline, likely MIRC-X. The interface is organized into several functional areas:

- Left Sidebar:** Contains system status indicators and control buttons for various components like 'MIRC-X', 'VEGA Control', and 'MIRC-X SUPER'. It also includes a 'Credone Detector' section with operational status and a 'Set standby' button.
- Central Plot:** A large data visualization showing detector data. The plot has a grid with red and green annotations. Labels include 'S1-E2 56', 'S1-W1 35', 'E2-W1 36', 'S1-W2 25', 'E2-W2 26', 'S1-E1 15', 'E1-E2 16', 'W1-W2 23', 'E1-W2 12', and 'E1-W1 13'. The plot shows a series of horizontal lines representing data points across different detector channels.
- Top-Right Panel (mircx_gdt_gtk):** A control table with columns for 'beam, pops', 'ldc offs', 'oplc car pos err', and 'DL offset'. It includes a 'step size' column and a 'link beams' section with checkboxes for S1, S2, E1, E2, W1, W2. Below this is a 'Search' section with 'E1 E2' and 'E2 W1' options.
- Bottom-Right Panel (mircx_fiberexplorer_gtk):** A data table with columns for 'Step size [um]', 'Current x/y flux', 'x0', 'y0', 'fwhm1', and 'fwhm2'. It includes a 'PING MIRCX' section with 'PING FIBER', 'Abort Map', and 'Goto to fit' buttons. Below this is a 'PING MIRCX' section with 'REOPEN' and 'QUIT' buttons.
- Bottom Panel (mircx_super_gtk):** A status and control table with columns for 'MIRC-X FLIP', 'MISTIC FLIP', 'ST5 IR FOLD', 'ARMADA', and 'HALOGEN'. It includes a 'Reset BG' section with 'Take BG' and 'MIRC-X 3 36' buttons. Below this is a 'FILE TYPE' section with 'MIRC-X' and 'MISTIC' options. At the bottom, there is a 'Wait for SAVERTS to finish on servers' section with 'REOPEN', 'CONNECT ALL', and 'QUIT' buttons.

MIRC-X Data Reduction

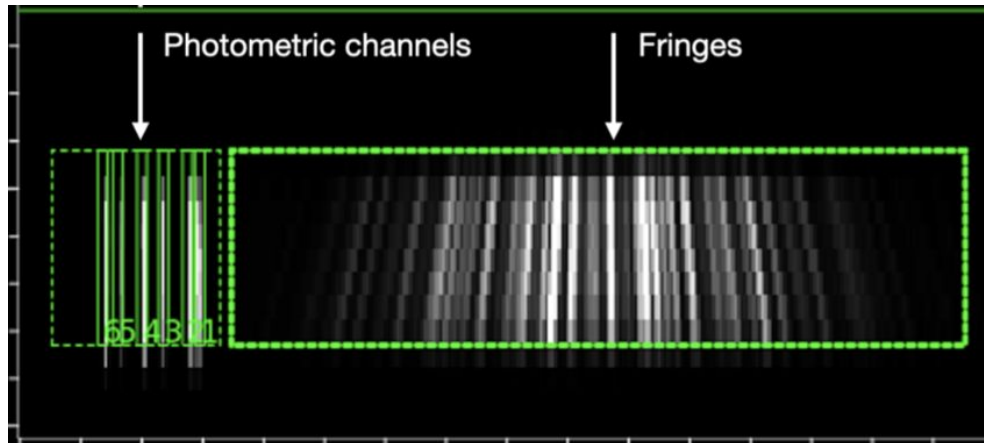


What we measure at the detector:



(stored in FITS files)

What we measure at the detector:



(stored in FITS files)

Data Pipeline

Interferometric Observables for Imaging / Modeling:

15 baselines

Squared Visibilities

“Differential” Phase

20 triangles

Closure Phase

(OIFITS files)

MIRC-X Data Reduction Pipeline - Overview

- Raw FITS files of night → Calibrated OIFITS files for imaging/modeling
- Written by Jean-Baptiste Le Bouquin
 - Python 3.7
 - Maintained on git repository: https://gitlab.chara.gsu.edu/lebouquj/mircx_pipeline
- Pipeline divided into 3 steps:
 - Pre-processed files (PREPROC)
 - Real Time Signal (RTS)
 - Raw and calibrated OIFITS

- *MIRC-X and its data reduction pipeline are detailed in an upcoming paper*
 - *Anugu et al, 2020 (submitted)*

How to Run the MIRC-X Pipeline

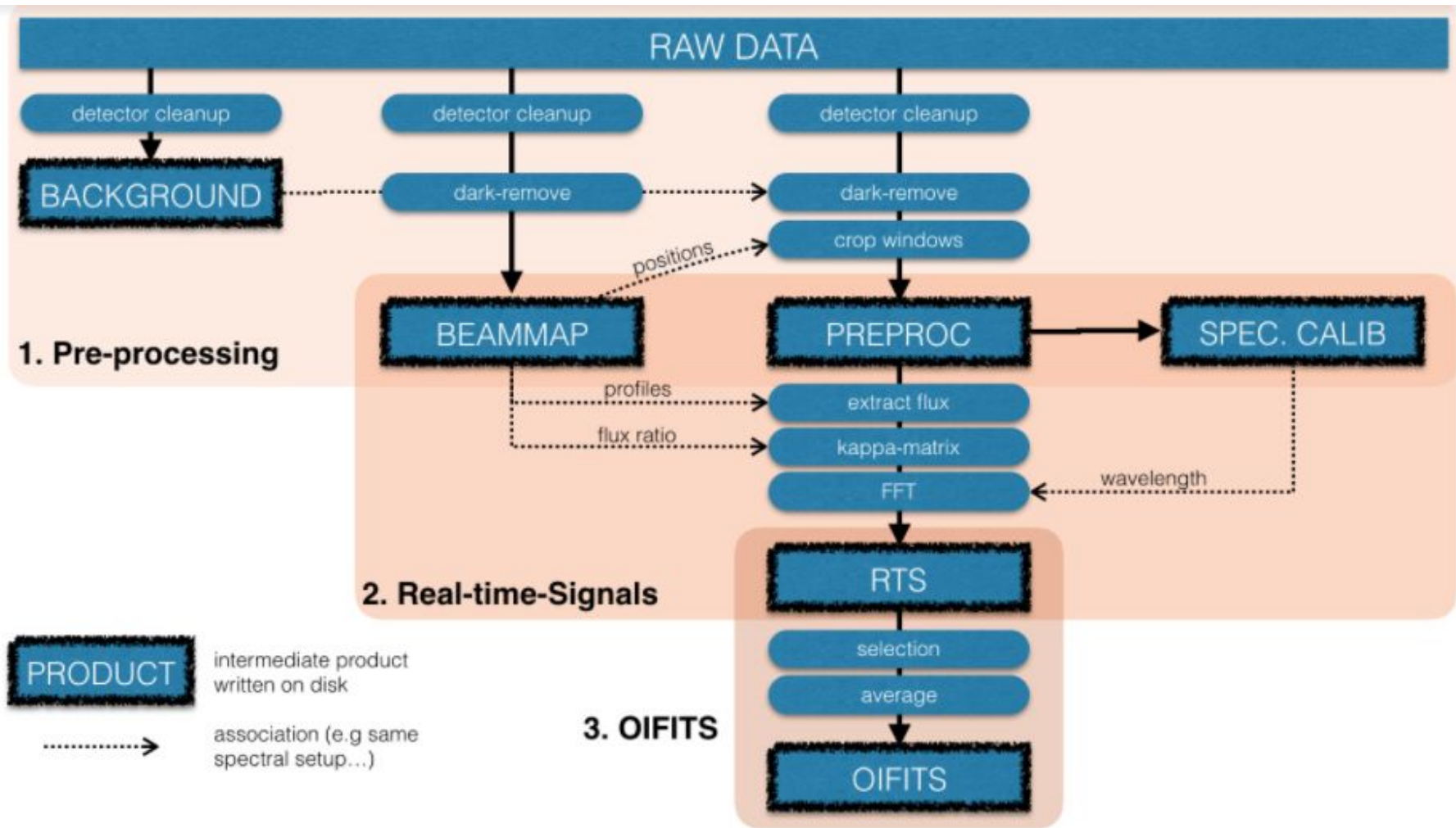
- Run via command line in terminal, designed to be automated
- Many different user input options / modes

```

tgardne — ssh monnier-mini.astro.lsa.umich.edu — 137x23
(python3) monnier-mini:~ tgardne$
(python3) monnier-mini:~ tgardne$ cd /Volumes/monnier-mini-raid48/PUBLIC/reduced/2020Jun04/
(python3) monnier-mini:2020Jun04 tgardne$
(python3) monnier-mini:2020Jun04 tgardne$ nohup mircx_reduce.py --ncoherent=10 --max-integration-time-oifits=30 --vis-reference=spec-diff
--oifits-dir=oifits_ncoh10_30sec --raw-dir=/nfs/Monnier2/MIRCX_DATA/MIRCX_2020Jun/2020Jun04/ &
[1] 45093
(python3) monnier-mini:2020Jun04 tgardne$ appending output to nohup.out

(python3) monnier-mini:2020Jun04 tgardne$
(python3) monnier-mini:2020Jun04 tgardne$ tail -f nohup.out
Git branch: um-develop + uncommitted changes:
  oifits.py preproc.py vis.py
Matplotlib backend: MacOSX
Total memory: 68.7G
-----
[INFO ] 2020-06-25T12:01:31.701 [ 5.46G]: End compute_vis in 14.32s
[INFO ] 2020-07-07T10:54:30.612 [ 0.14G]: Start mircx_reduce
[INFO ] 2020-07-07T10:54:30.613 [ 0.14G]: bbias is TRUE so force save-all-freqs=TRUE
[INFO ] 2020-07-07T10:54:30.613 [ 0.14G]: Start loaddir
[INFO ] 2020-07-07T10:54:30.776 [ 0.14G]: Load directory: /nfs/Monnier2/MIRCX_DATA/MIRCX_2020Jun/2020Jun04/
[INFO ] 2020-07-07T10:54:34.373 [ 0.14G]: Load header log /nfs/Monnier2/MIRCX_DATA/MIRCX_2020Jun/2020Jun04//mircx_hdrs.txt

```



RAW DATA

detector cleanup

BACKGROUND

1. Pre-processing

detector cleanup

dark-remove

BEAMMAP

2. Real-time-Signals

detector cleanup

dark-remove

crop windows

PREPROC

extract flux

kappa-matrix

FFT

RTS

selection

average

OIFITS

3. OIFITS

SPEC. CALIB

positions

profiles

flux ratio

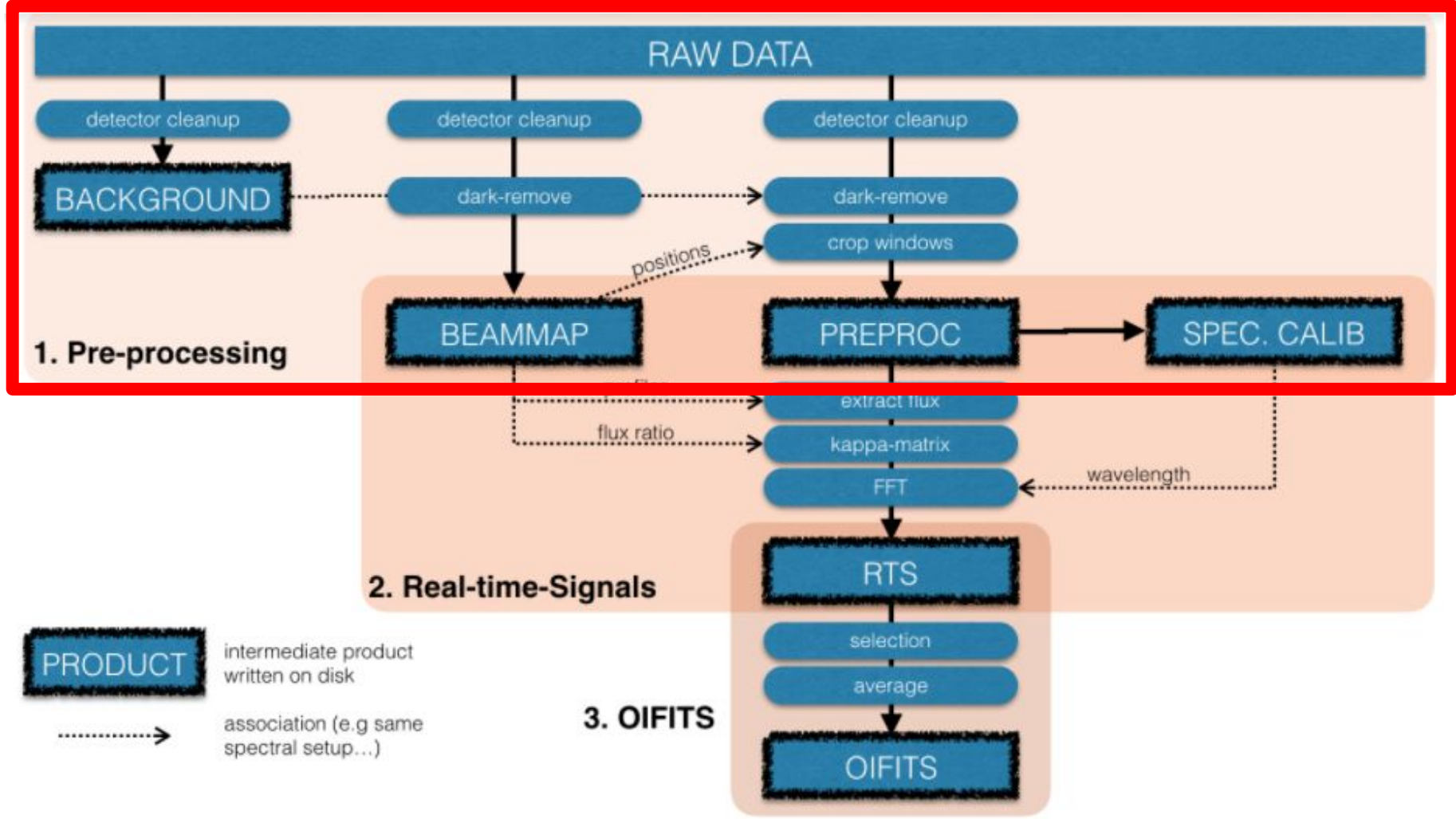
wavelength

PRODUCT

intermediate product written on disk

.....>

association (e.g same spectral setup...)

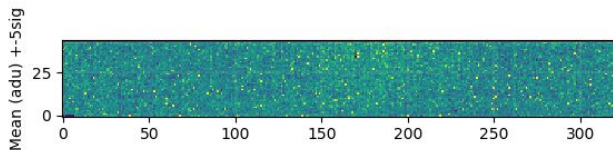


1) Pre-Processing Step

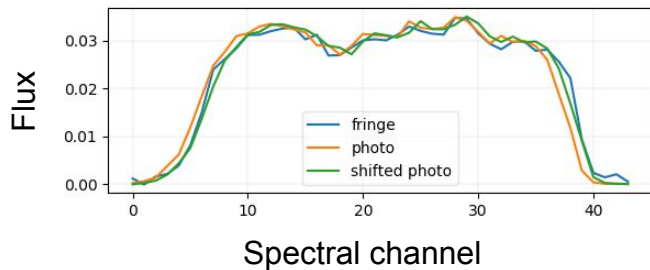
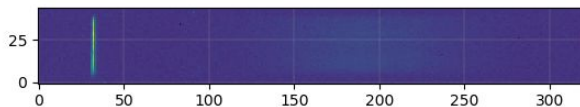
- Associate detector setups; targets / shutters
- Detector cleanup, bad pixel removal
- Creates PREPROC data files, beam maps, spectral calibration

Background Files:

G40-L6-R8 59004.4673 HD_199766

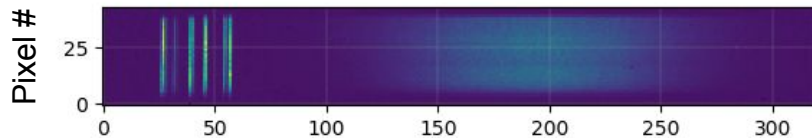
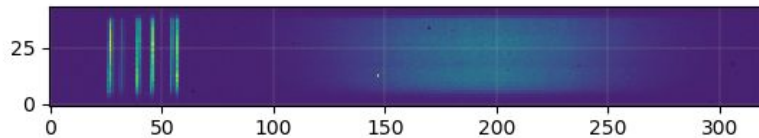
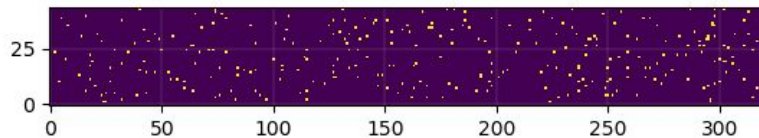


Create Beam Maps:



Create "Cleaned" Data preproc files:

G40-L6-R8 59004.4606 HD_199766

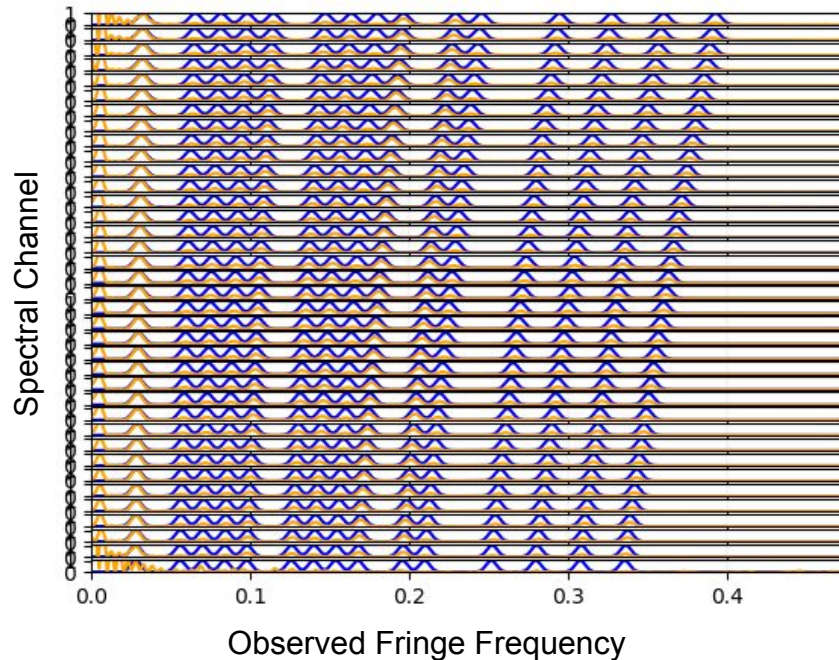


1) Pre-Processing Step

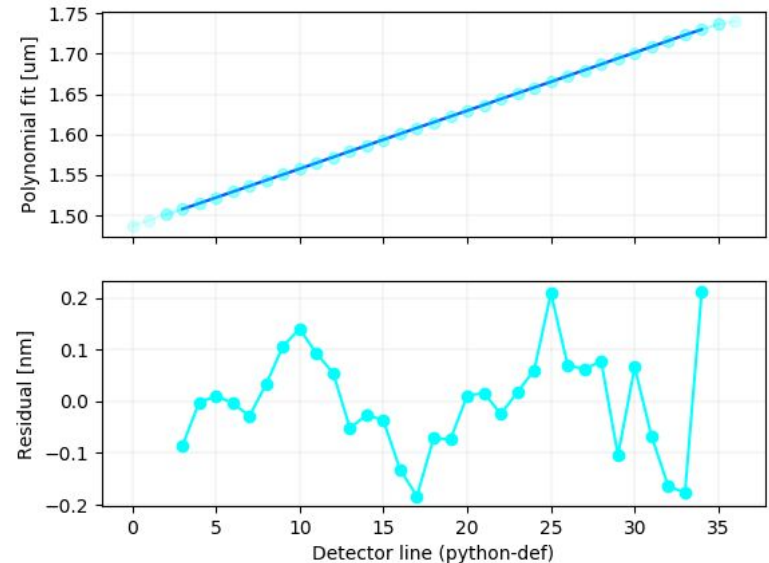
All Fringe Files of Given Setup →
Spectral Calibration

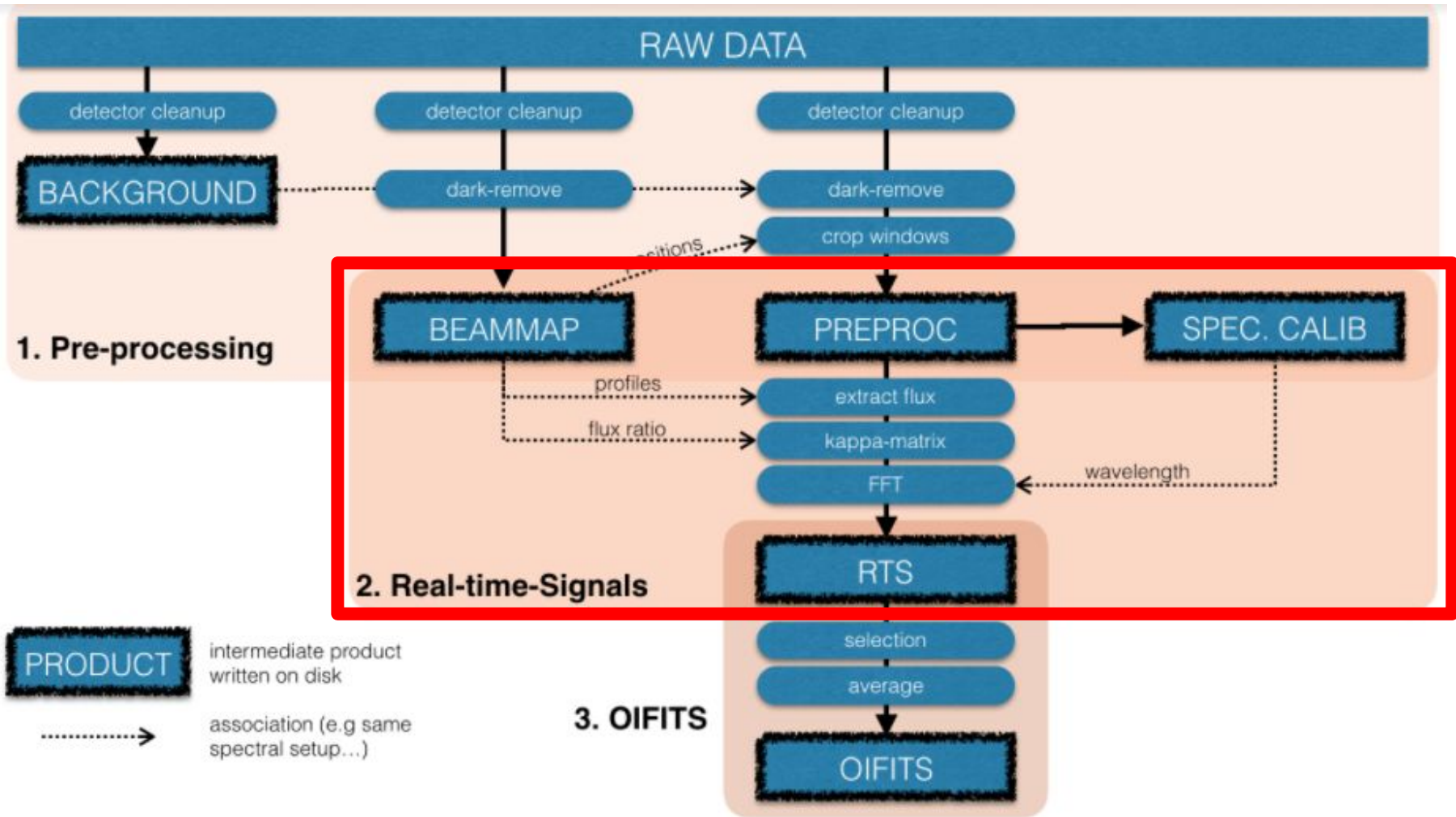
- Associate detector setups; targets / shutters
- Detector cleanup, bad pixel removal
- Creates PREPROC data files, beam maps, spectral calibration

Observed PSD (orange) and scaled template (blue)



Polynomial fit
(dark blue=poly, cyan=valid channels, light cyan = all channels)



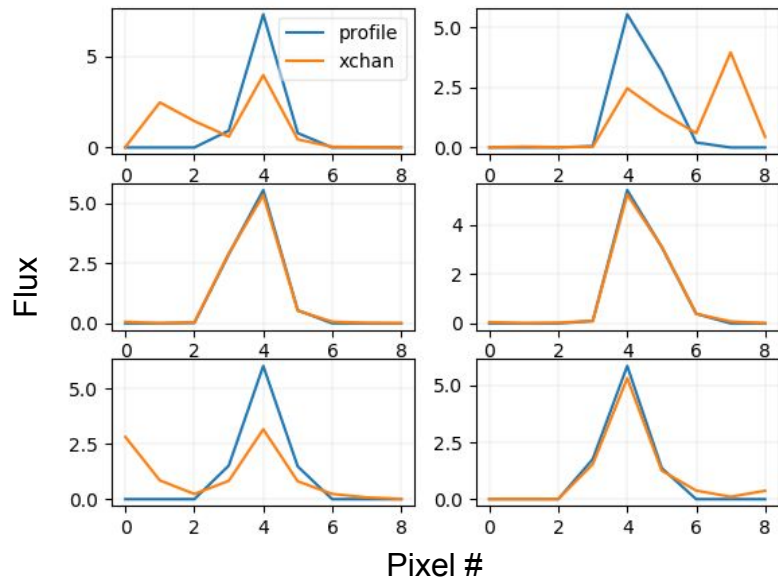


2) RTS Step

- Compute real-time photometry
- Fringe power
- Compute bispectrum bias
- Crude vis2

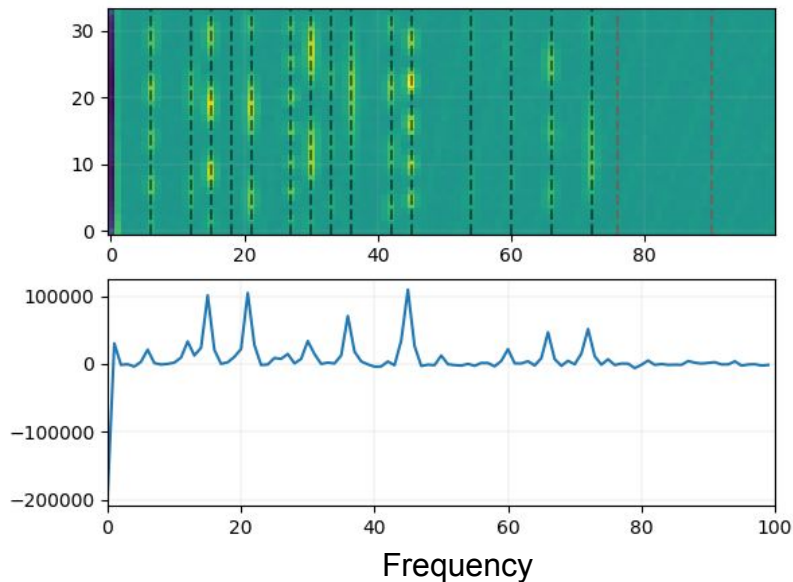
Beam Profiles, Photometry:

G40-L6-R8 59004.4606 HD_199766



Fringes:

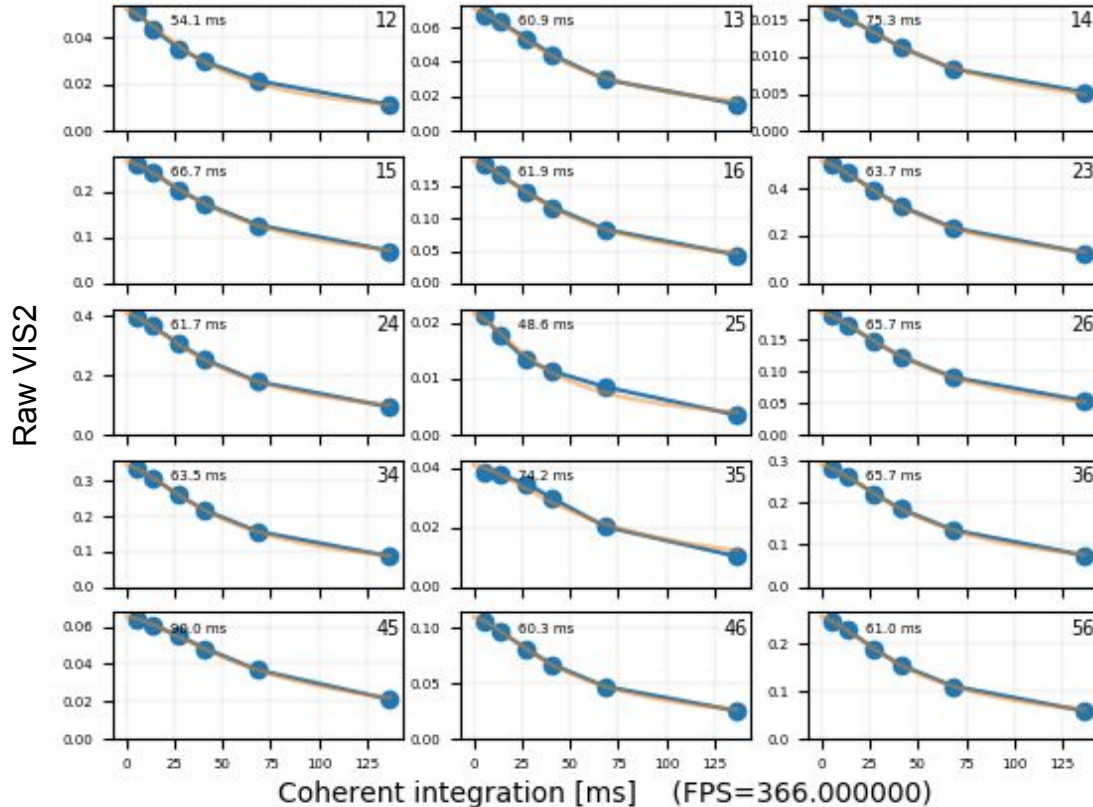
G40-L6-R8 59004.4606 HD_199766



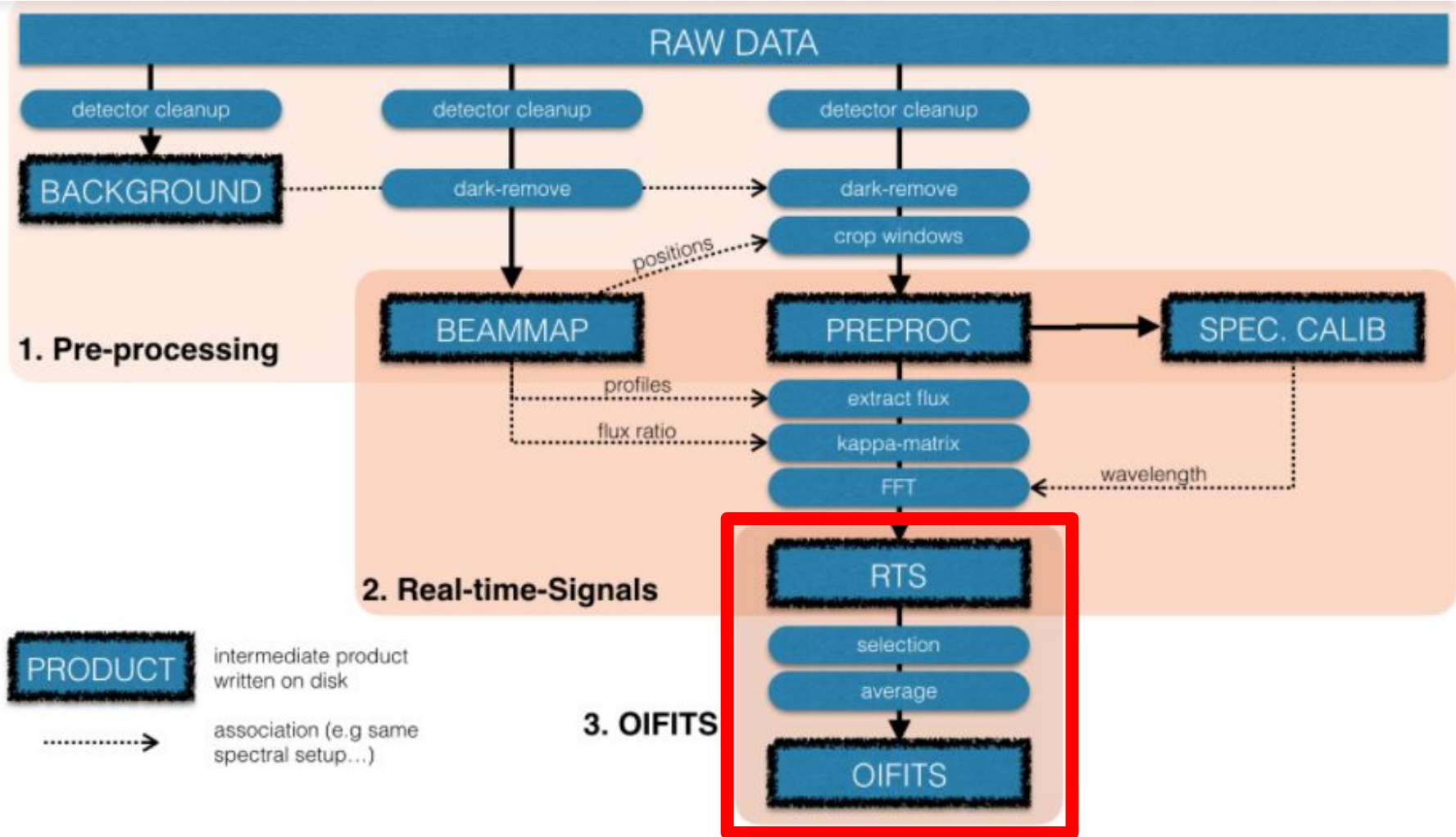
2) RTS Step

G40-L6-R8 59004.4606 HD_199766

- Compute real-time photometry
- Fringe power
- Compute bispectrum bias
- Crude vis2



→ Gives an idea of how many frames to coherently average for OIFITS step



RAW DATA

detector cleanup

BACKGROUND

detector cleanup

dark-remove

BEAMMAP

detector cleanup

dark-remove

crop windows

PREPROC

extract flux

kappa-matrix

FFT

SPEC. CALIB

RTS

selection

average

OIFITS

PRODUCT

intermediate product written on disk

.....> association (e.g same spectral setup...)

positions

profiles

flux ratio

wavelength

1. Pre-processing

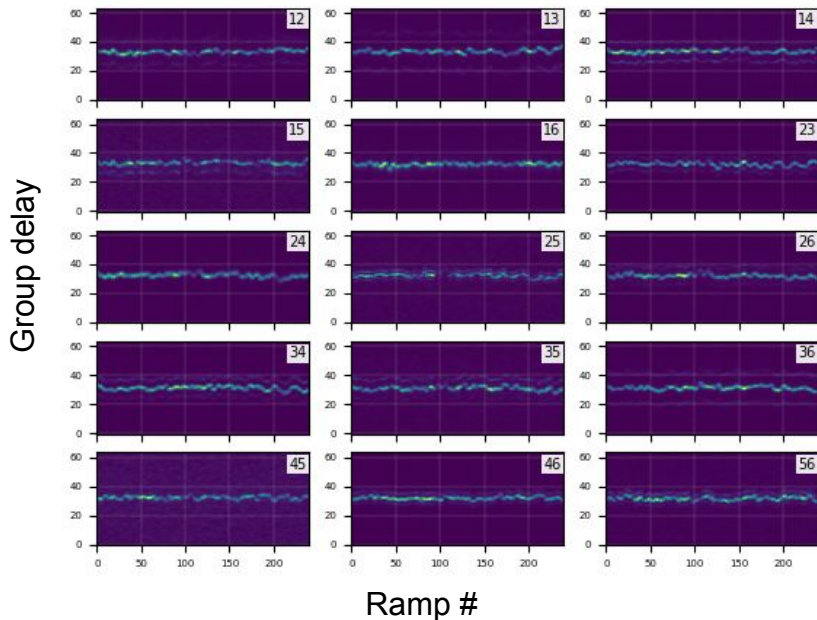
2. Real-time-Signals

3. OIFITS

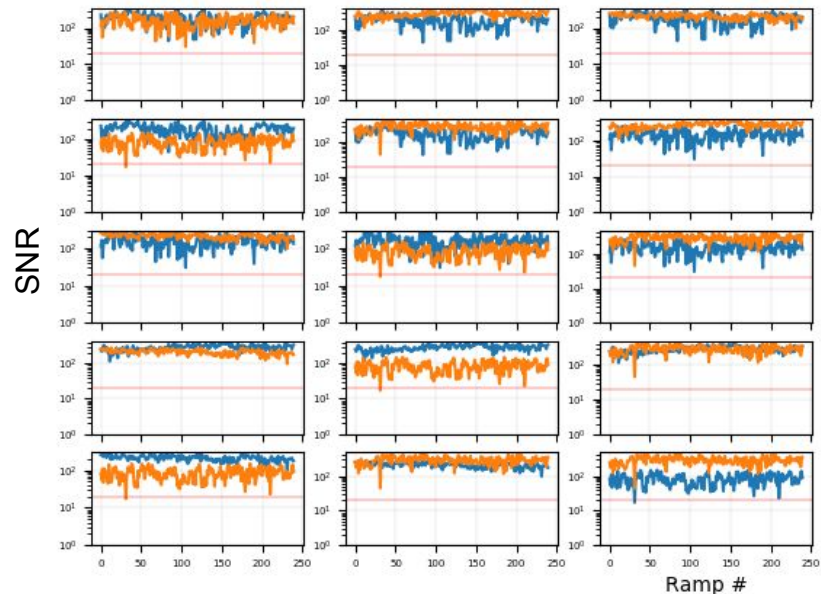
3) OIFITS Step

- Further selection criteria for cleaning
- Computation of raw visibilities, differential phase, closure phase

G40-L6-R8 59004.4606 HD_199766 NCOHER=10



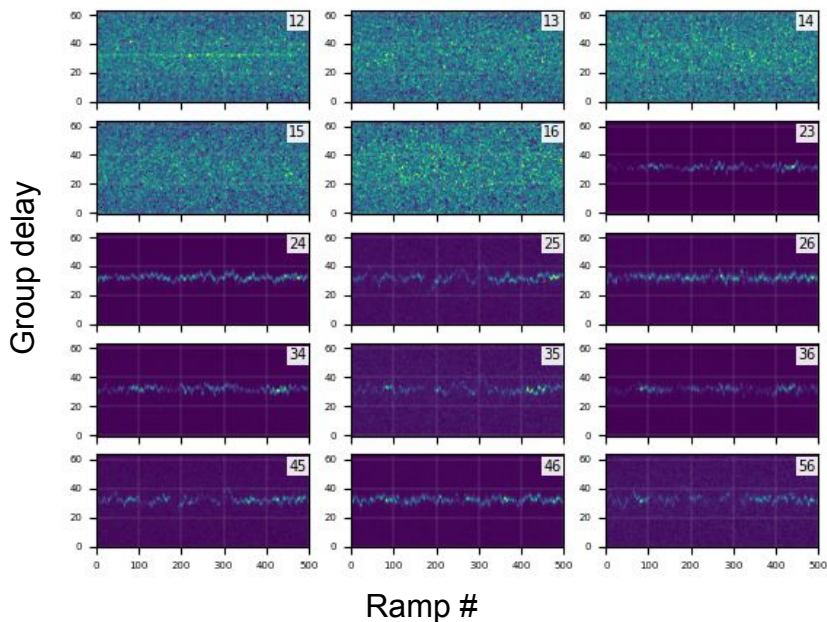
Flux in fringe
G40-L6-R8 59004.4606 HD_199766 NCOHER=10



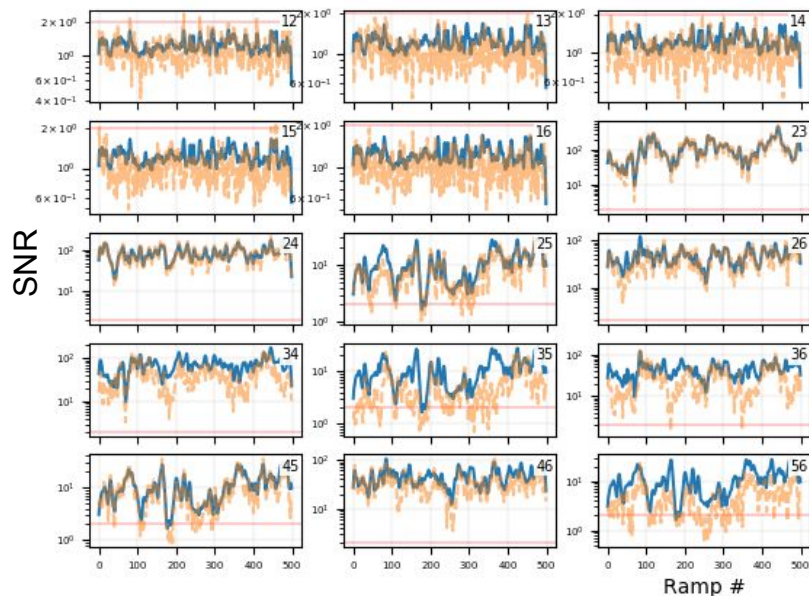
3) OIFITS Step

- Further selection criteria for cleaning
- Computation of raw visibilities, differential phase, closure phase

G40-L6-R8 58701.1829 HD_156034 NCOHER=10



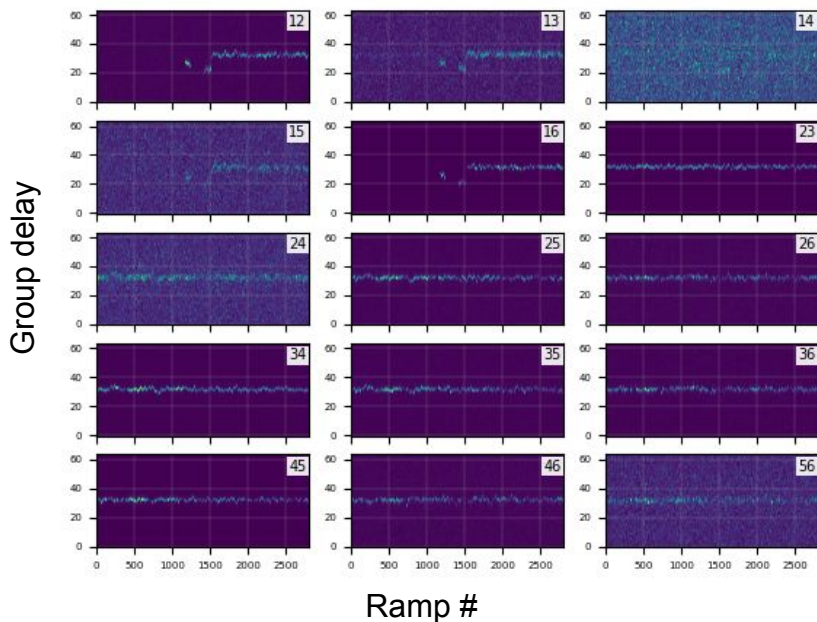
SNR versus ramp
G40-L6-R8 58701.1829 HD_156034 NCOHER=10



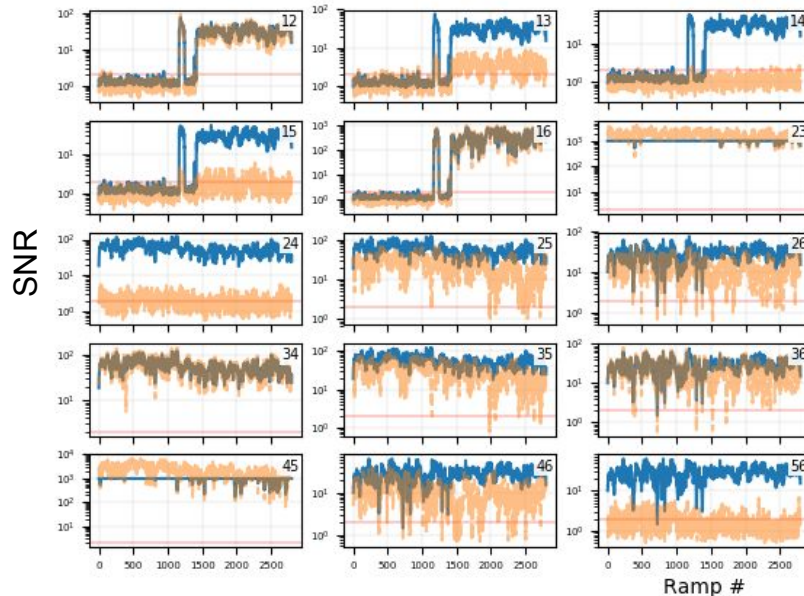
3) OIFITS Step

- Further selection criteria for cleaning
- Computation of raw visibilities, differential phase, closure phase

G40-L6-R8 58701.3971 HD_4502 NCOHER=10



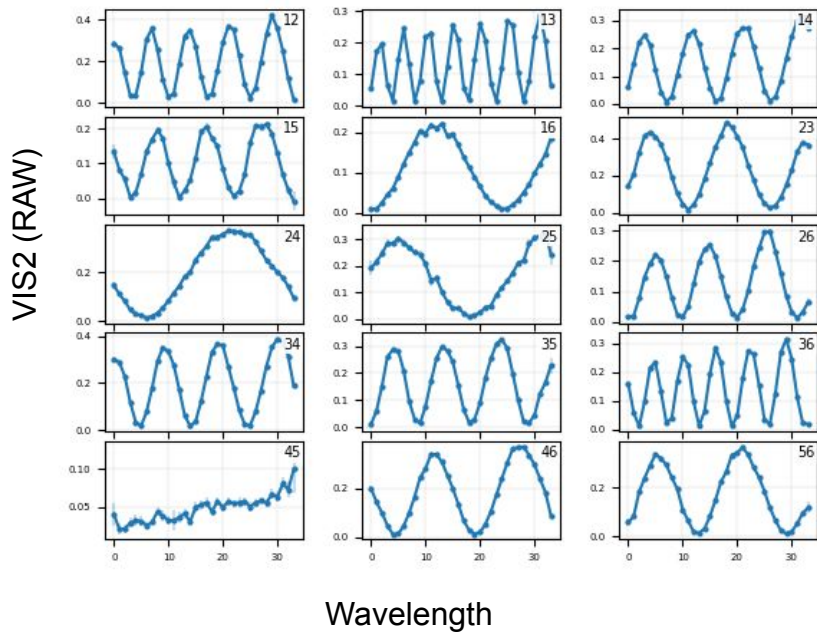
SNR versus ramp
G40-L6-R8 58701.3971 HD_4502 NCOHER=10



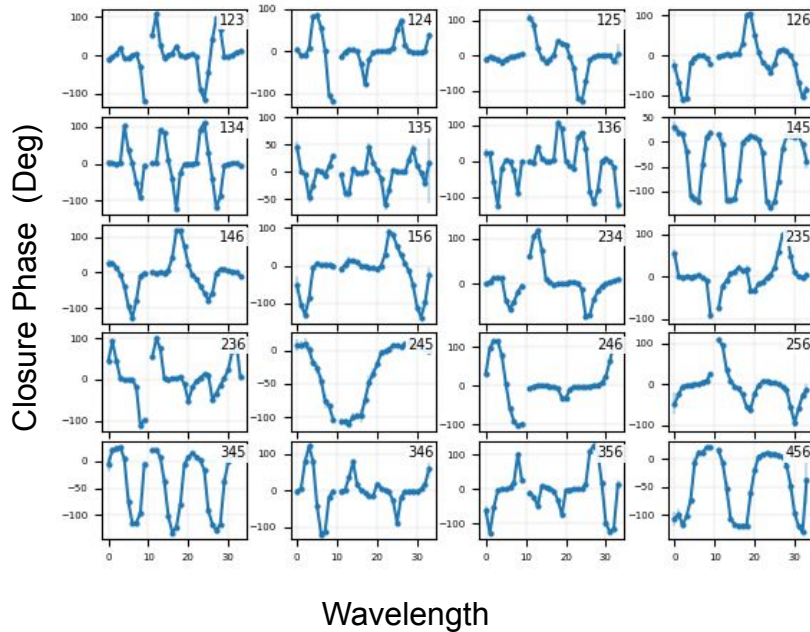
3) OIFITS Step

- Further selection criteria for cleaning
- Computation of raw visibilities, differential phase, closure phase

G40-L6-R8 59004.4606 HD_199766 NCOHER=10

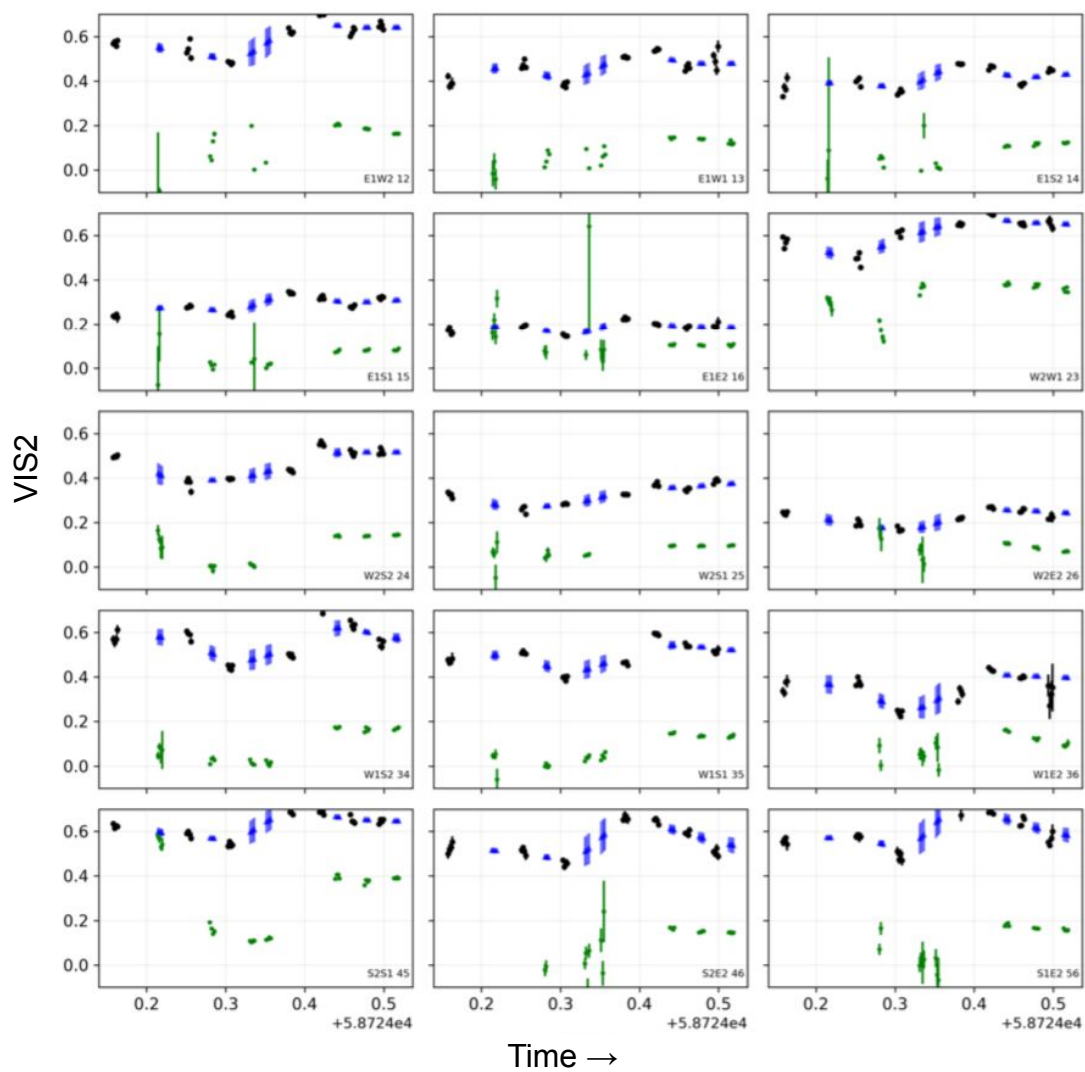


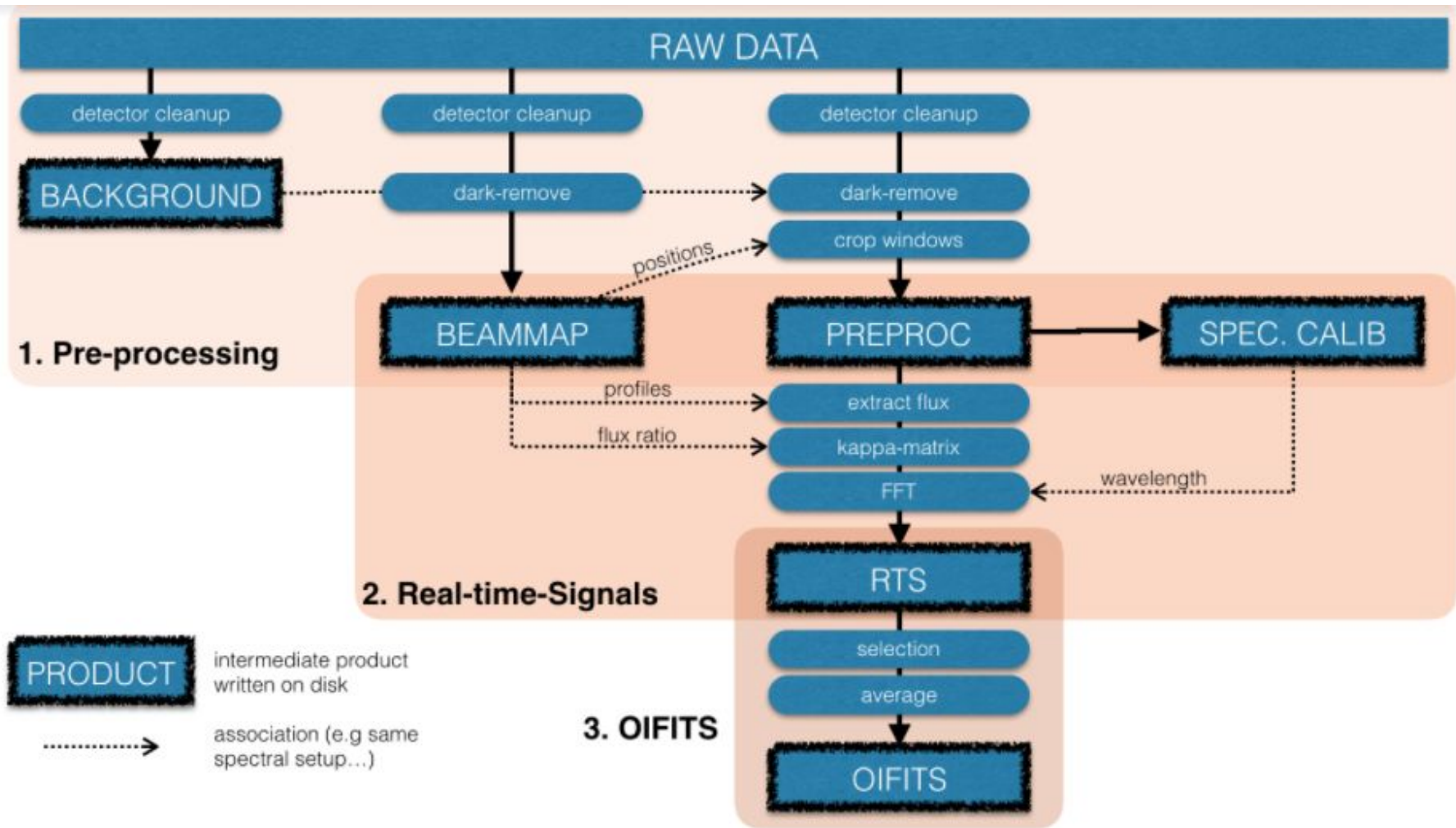
G40-L6-R8 59004.4606 HD_199766 NCOHER=10



4) Calibration

- True source visibility is corrupted by system losses
- Compute 'transfer function' with calibrator stars to account for this
- Use calibrators to calibrate visibilities / phases of science targets





RAW DATA

detector cleanup

BACKGROUND

1. Pre-processing

detector cleanup

dark-remove

BEAMMAP

2. Real-time-Signals

detector cleanup

dark-remove

crop windows

PREPROC

SPEC. CALIB

profiles

flux ratio

extract flux

kappa-matrix

FFT

RTS

wavelength

selection

average

OIFITS

PRODUCT

intermediate product written on disk

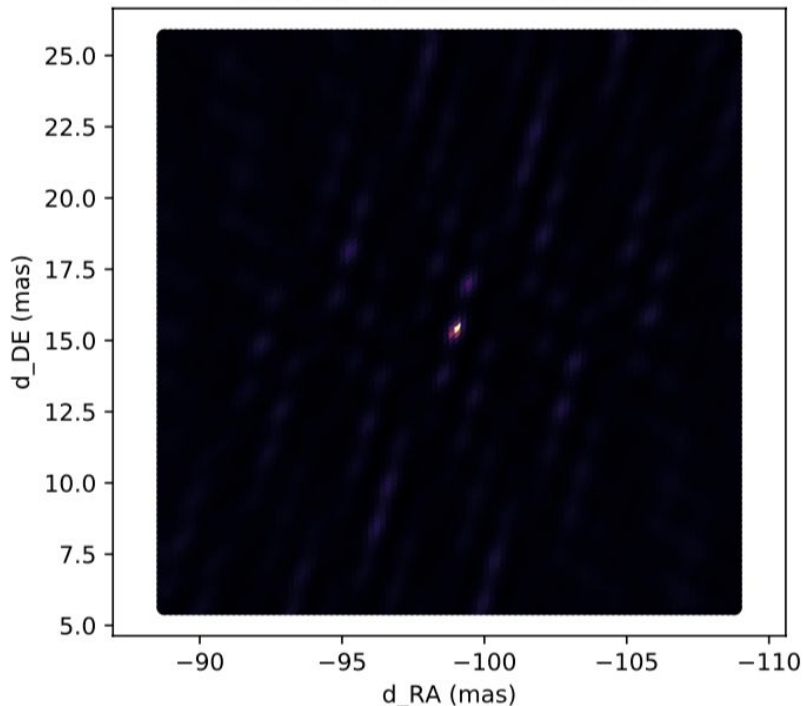
association (e.g same spectral setup...)

3. OIFITS

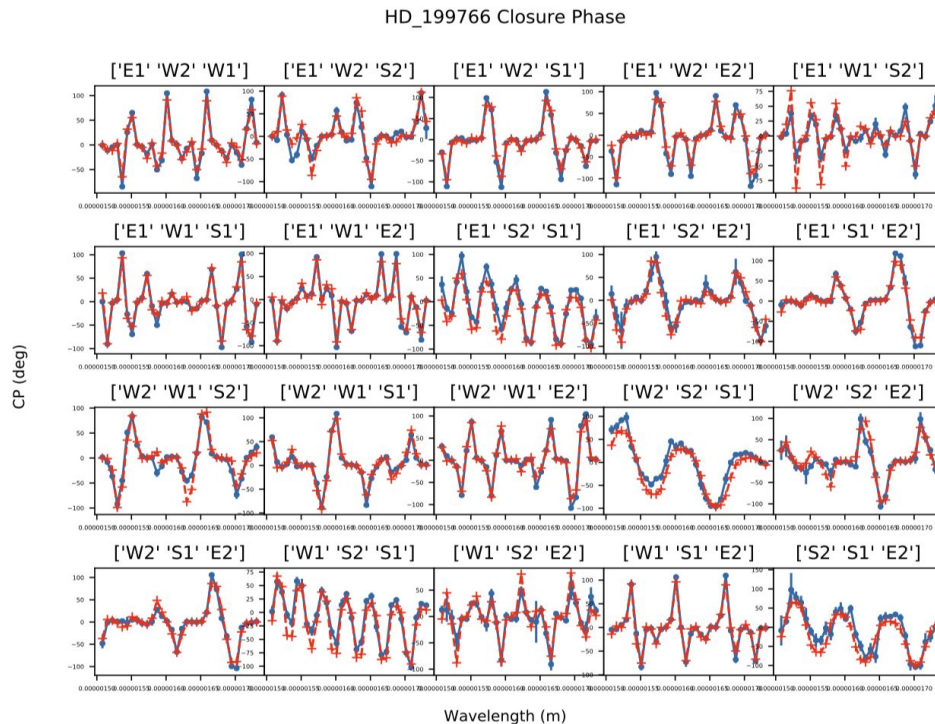
Imaging, model fitting, etc!

Example → position of a binary companion:

Best Fit - [-98.8698 15.5424]



- Calibrated OIFITS files compatible with many publicly available softwares
- e.g. CANDID, squeeze, macim, MiRA, bsmem, LITpro,



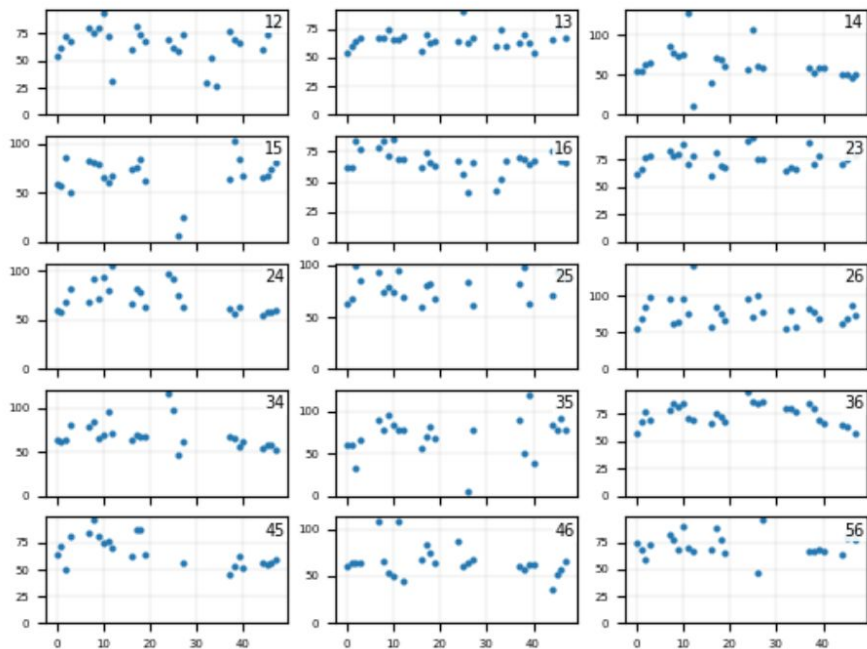
End of Night → Archiving data and MIRC-X Pipeline Wrapper

- Archive script saves 2 copies of compressed FITS data files of night
- Pipeline wrapper written by Claire Davies as a first 'quicklook' at data quality
 - Runs preproc, rts, oifits steps
 - Identifies calibrators
 - Fits binary models to check for bad calibrator stars
 - Shows fiber maps for night → beam quality

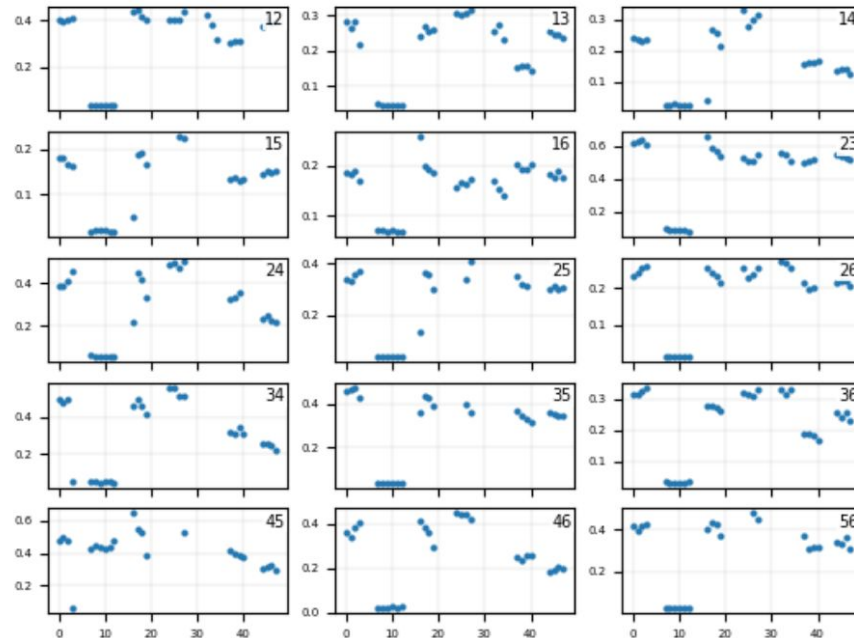
- Group receives emailed summary reports → Useful for multi-night runs!

Summary reports - Seeing / VIS2 of night

Decoherence Half Time [ms]



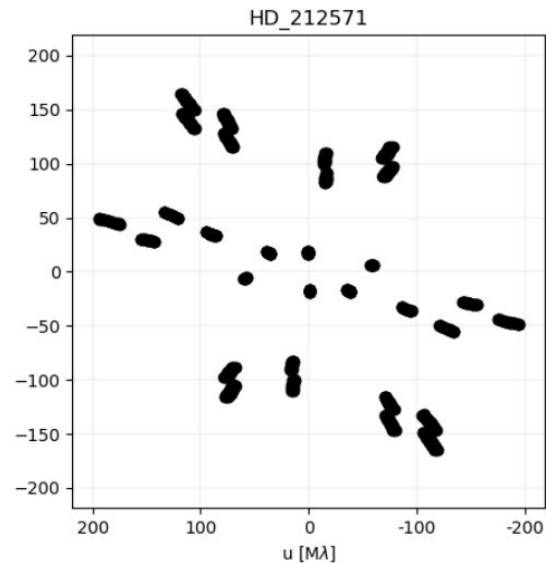
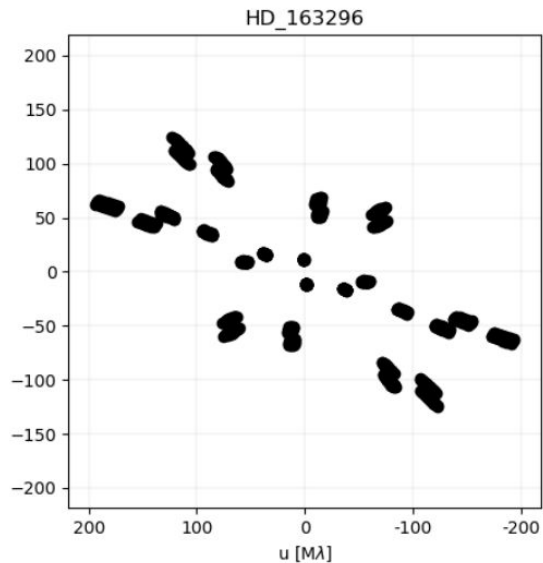
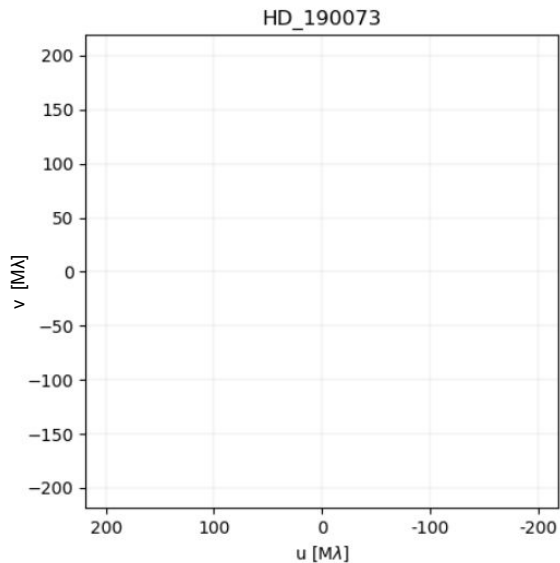
Vis2



Time →

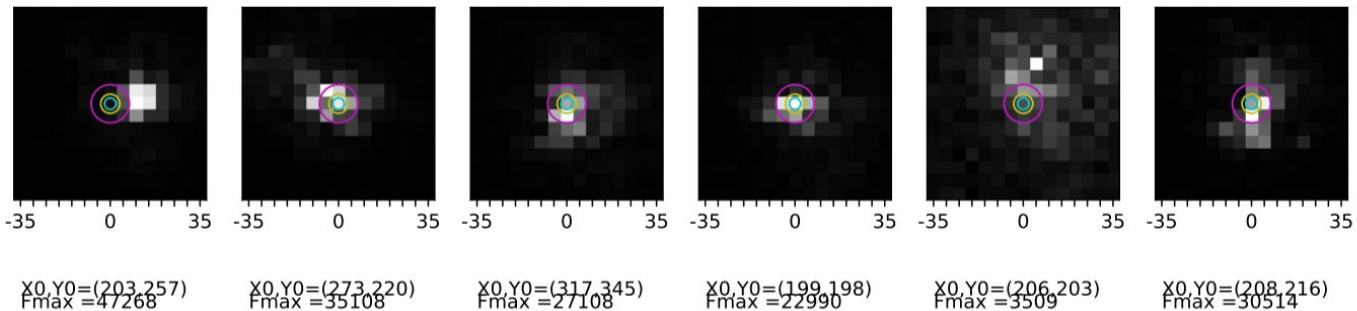
Summary reports - Identify targets / cal

Full night uv -coverage for SCI target(s)

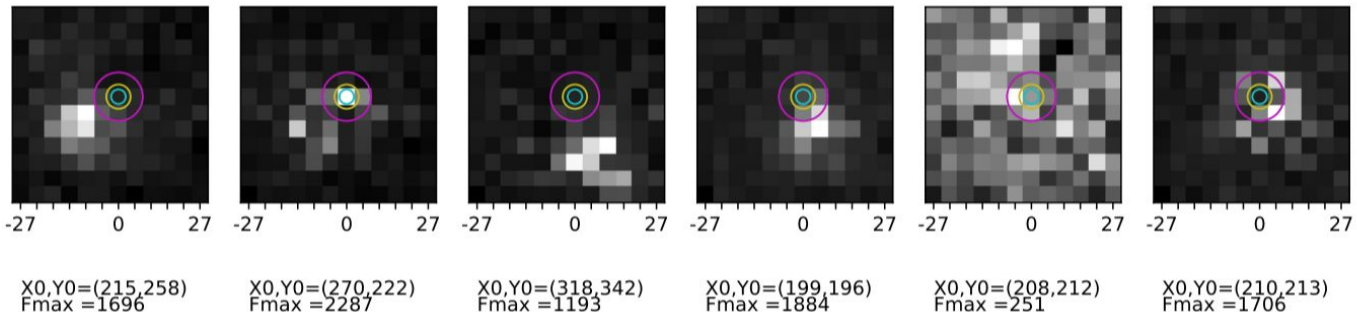


Summary reports - Fiber maps of night












04:05:29 HD_166191



04:19:17 HD_162998



MIRC-X: a highly-sensitive six telescope interferometric imager at the CHARA Array

NARSIREDDY ANUGU ^{1,2,3,*} JEAN-BAPTISTE LE BOUQUIN ^{3,4} JOHN D. MONNIER ³ STEFAN KRAUS ¹ BENJAMIN R. SETTERHOLM ³
AARON LABDON ¹ CLAIRE L DAVIES ¹ CYPRIEN LANTHERMANN ^{5,4} TYLER GARDNER ³ JACOB ENNIS ³ KEITH J. C. JOHNSON ³
THEO TEN BRUMMELAAR ⁶ GAIL SCHAEFER ⁶ AND JUDIT STURMANN⁶

Credone detector upgrade - 2017 June



Optics upgrade - 2018 Sep

