Data Reduction Overview: MIRC-X/MYSTIC pipeline, OIFITS data format

Narsireddy Anugu

MIRCX+MYSTIC collaboration

Outline

- Introduction to MIRC-X and MYSTIC
- How observations are executed?
- Data reduction
- Overview of OIFITS

Useful information

Data reduction manual

https://www.chara.gsu.edu/tutorials/mirc-data-reduction

Pipeline (Python 2.7)

https://gitlab.chara.gsu.edu/lebouquj/mircx_pipeline.git

Papers

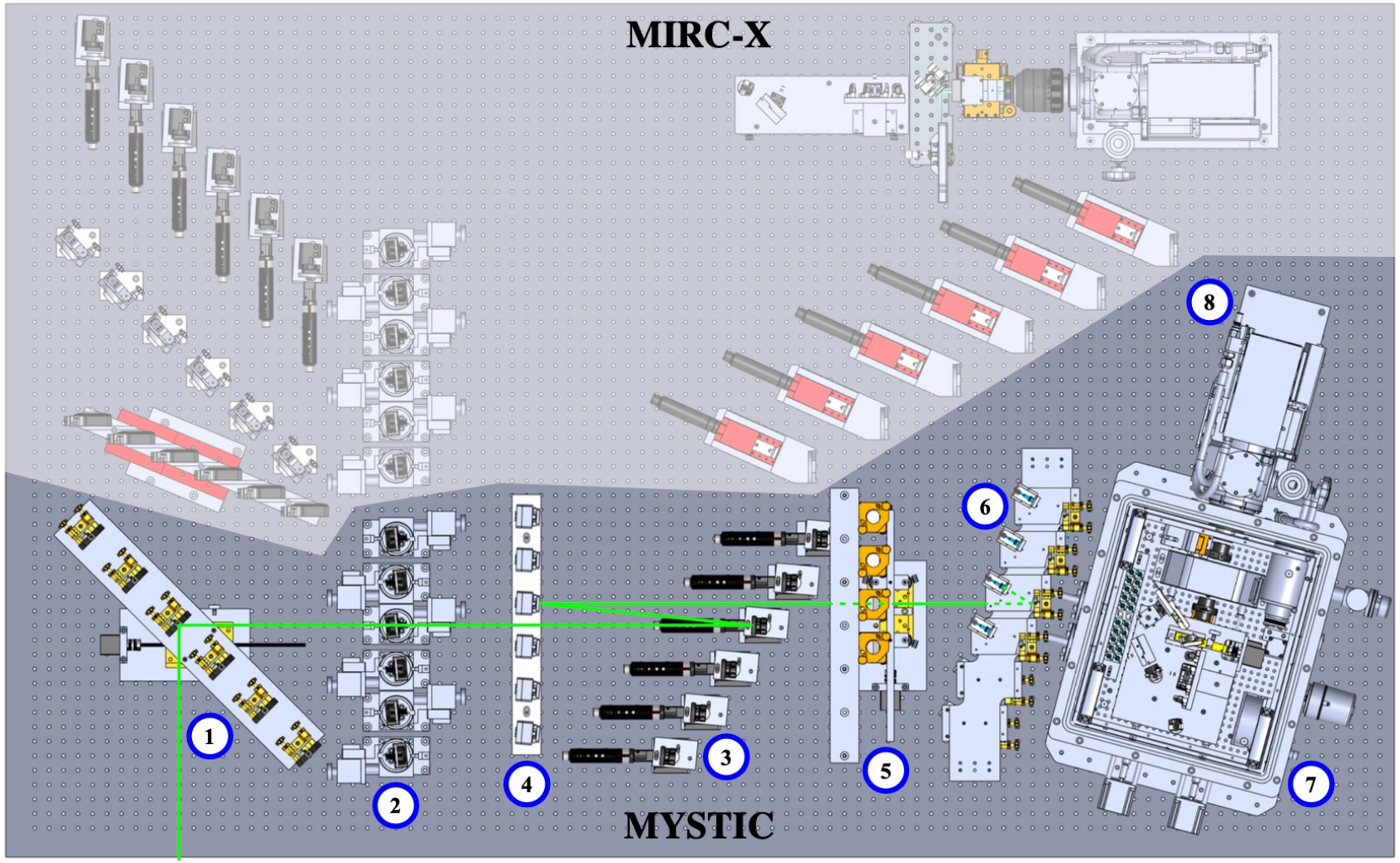
Anugu et al. 2020, Monnier et al. 2018, Setterholm et al. (submitted)

Important

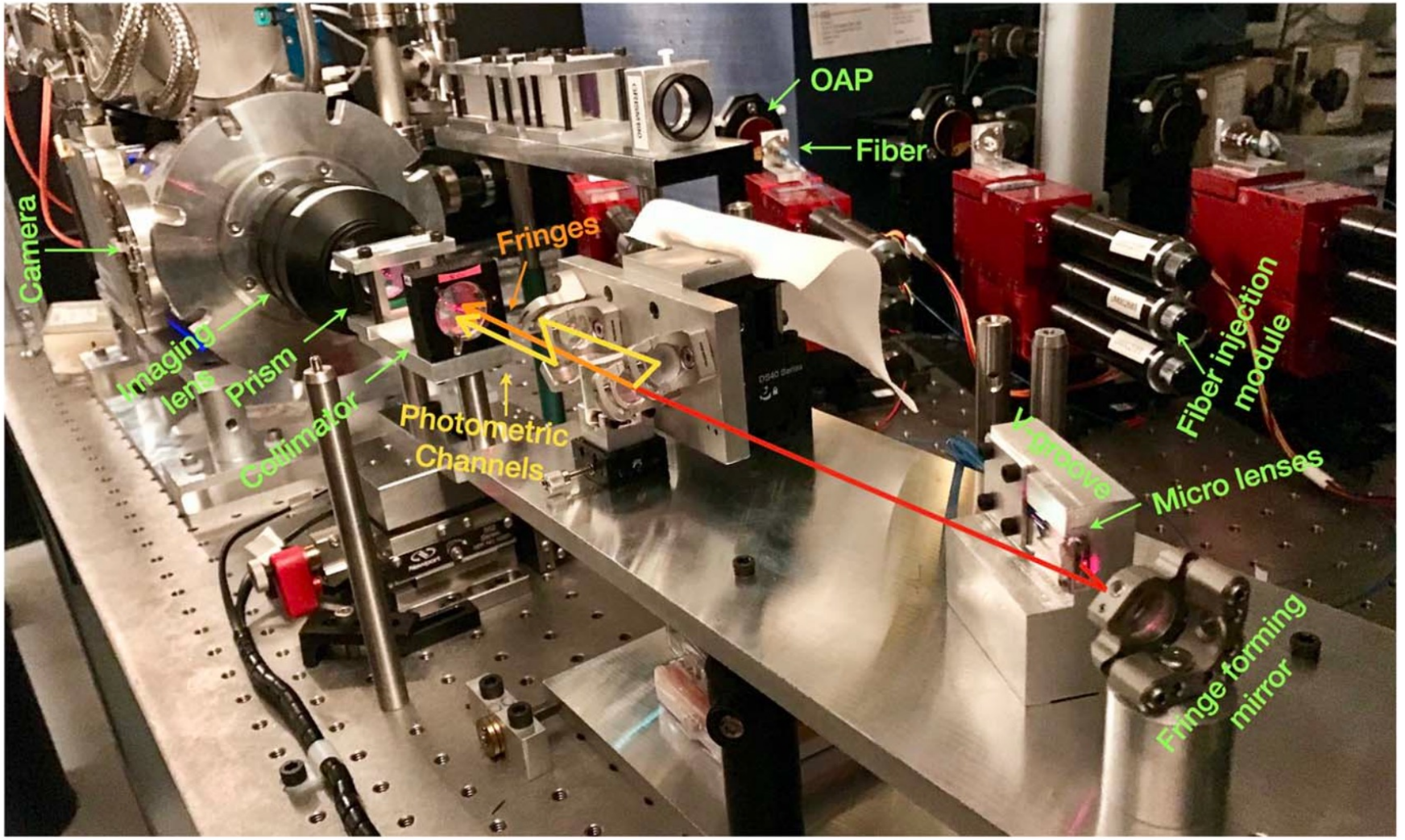
Join slack (mircx.slack.com, ask John)

Introduction to MIRC-X and MYSTIC

MIRC-X and MYSTIC

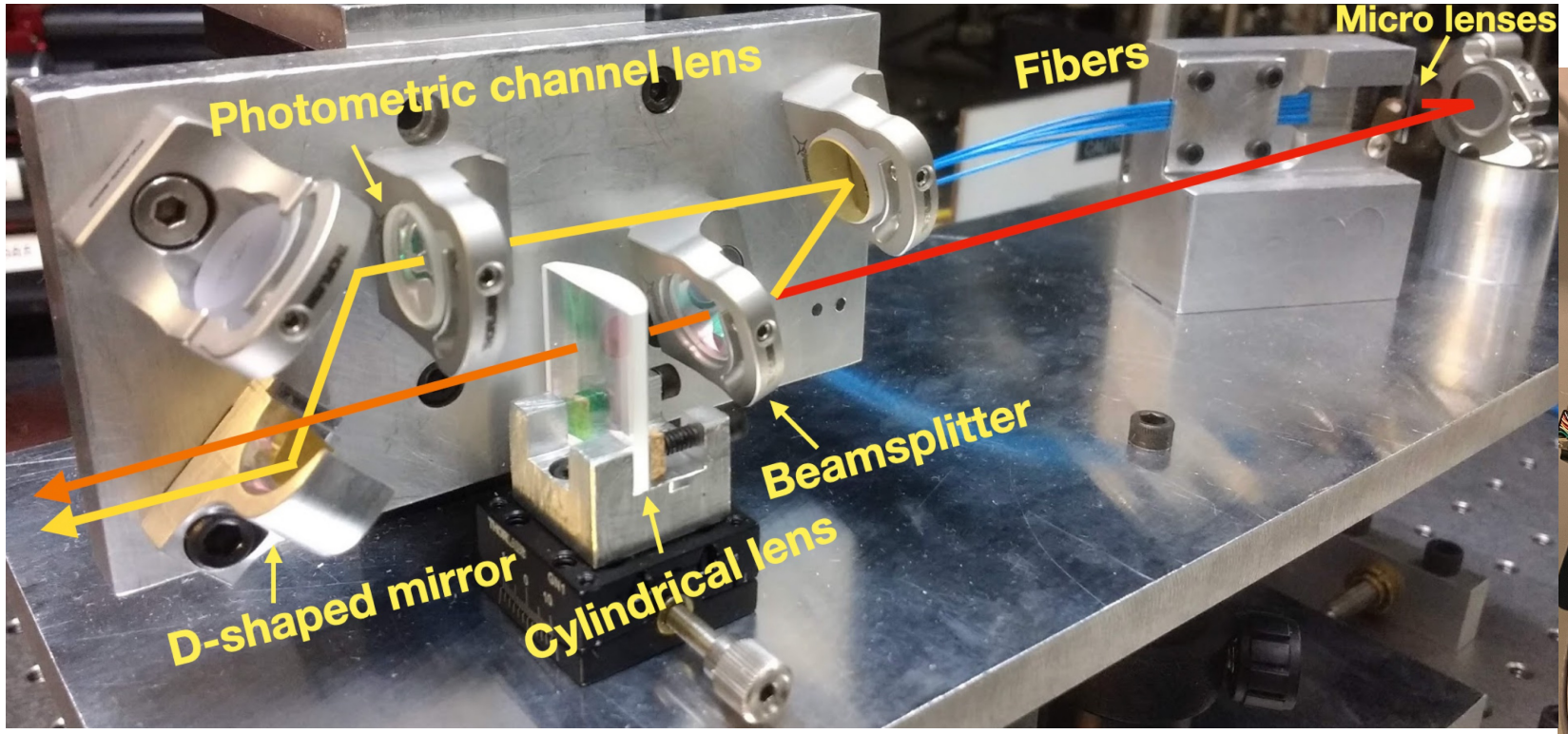


MIRC-X



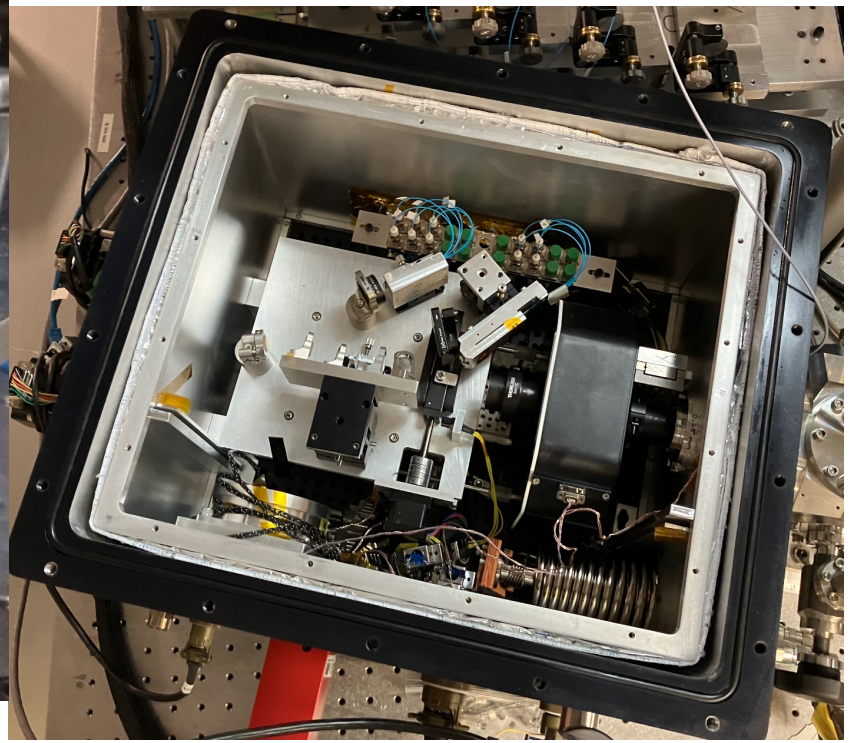
Anugu et al. 2020

Beam combiner optics



MIRC-X

Anugu et al. 2020



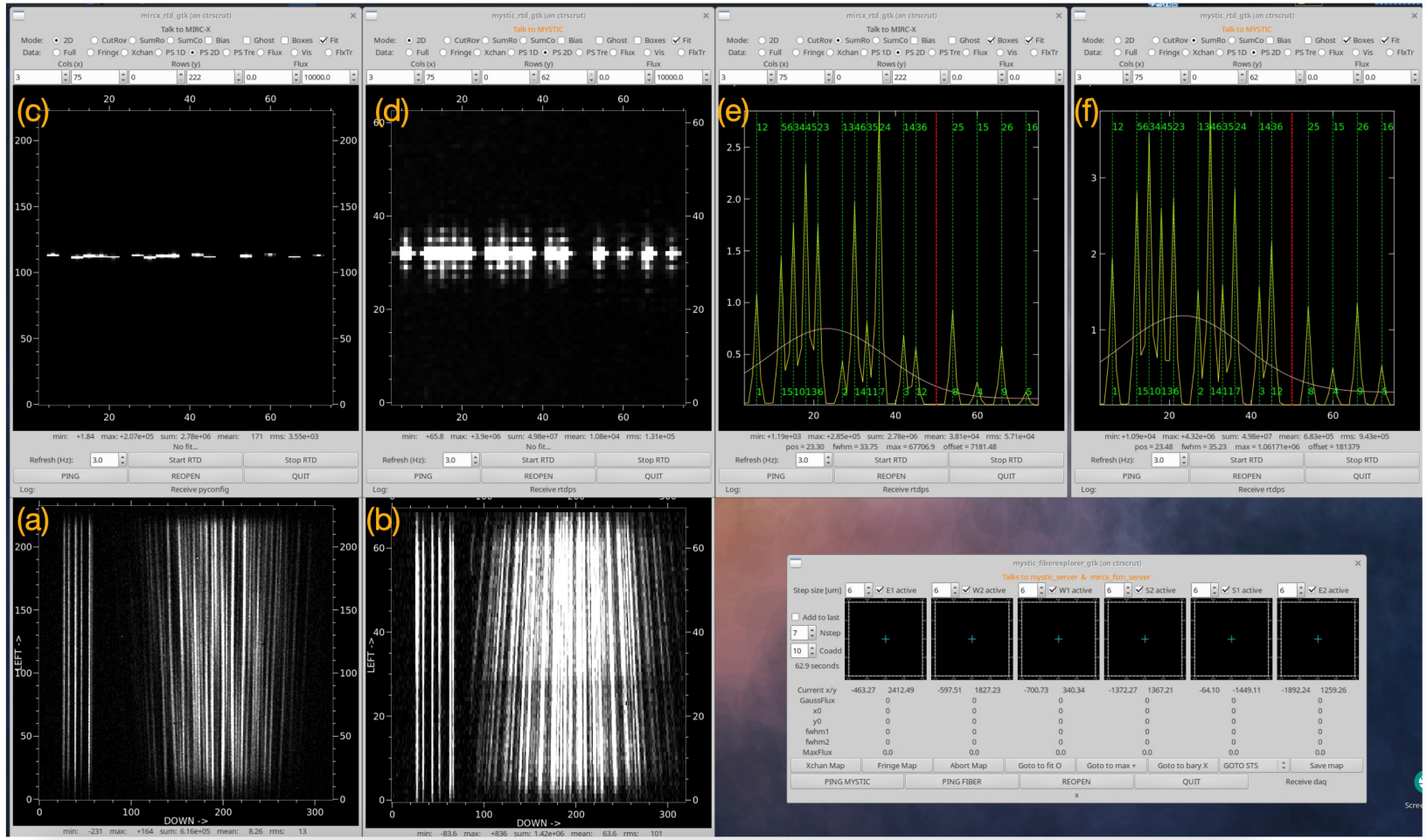
MYSTIC

Setterholm submitted

Monnier et al. 2018

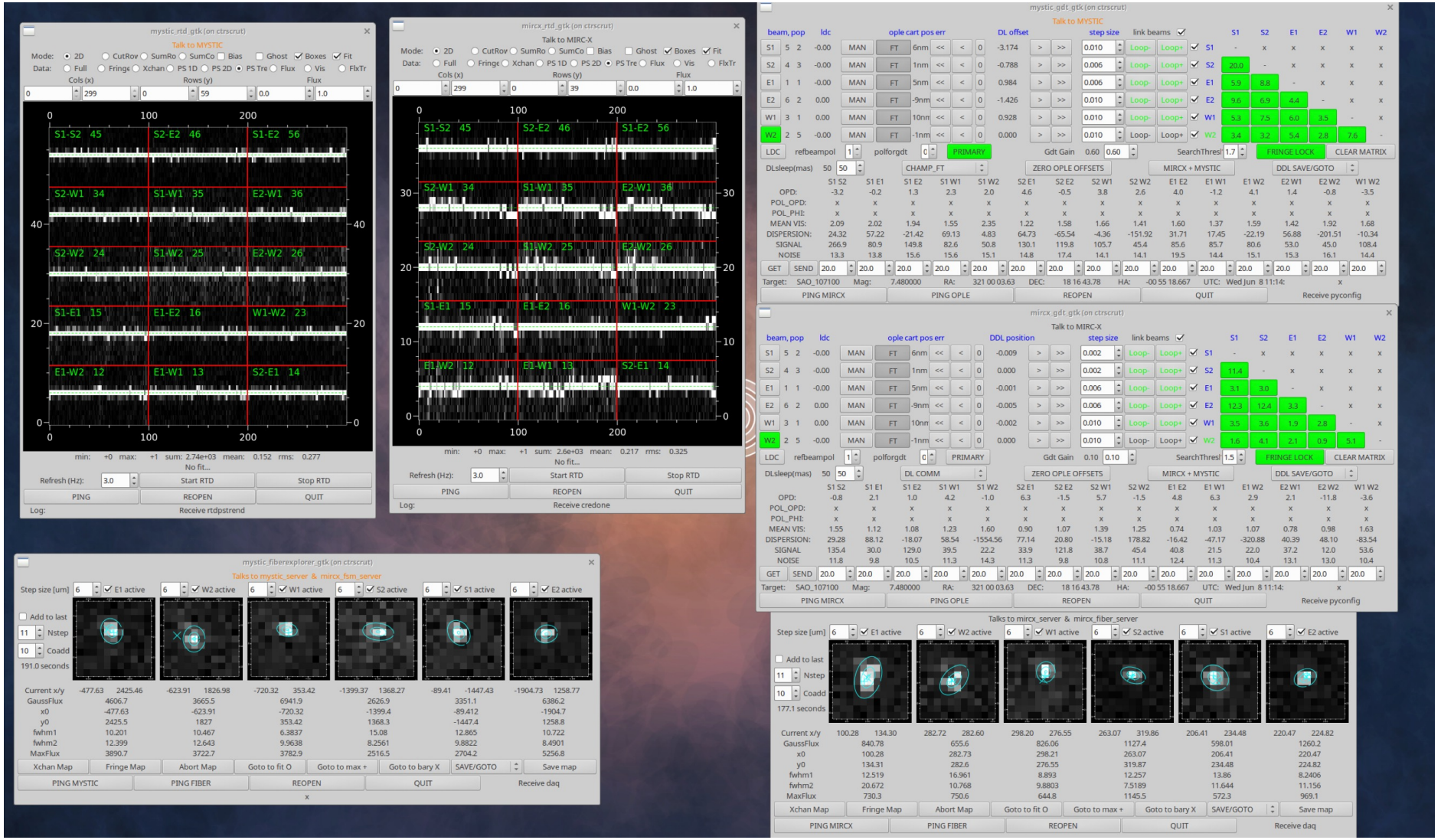
Observations

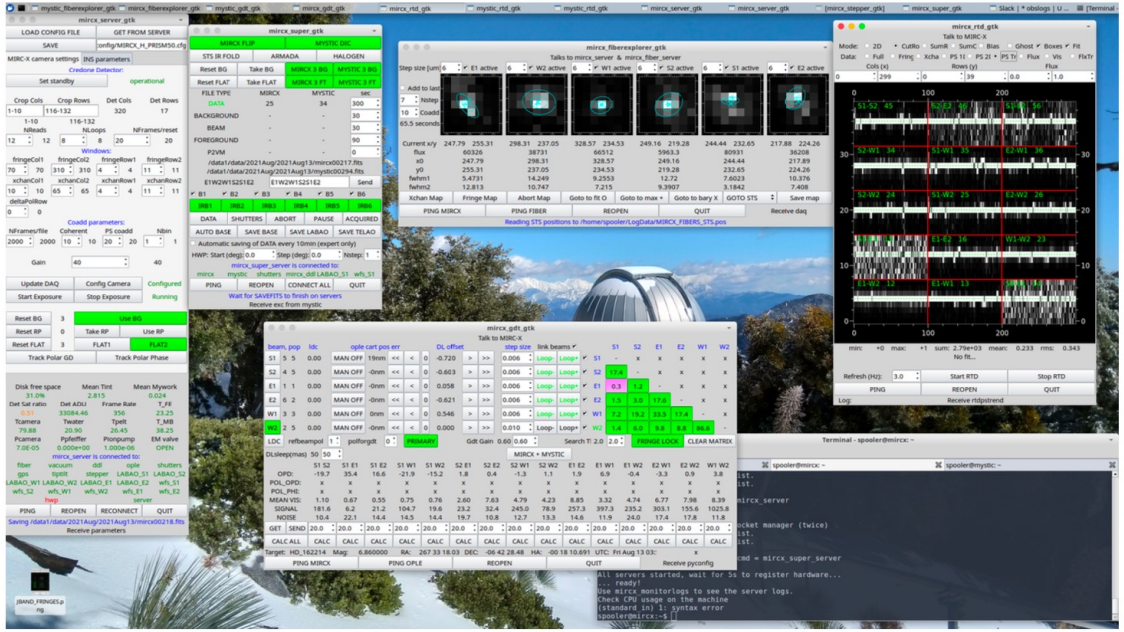
Offered observing modes

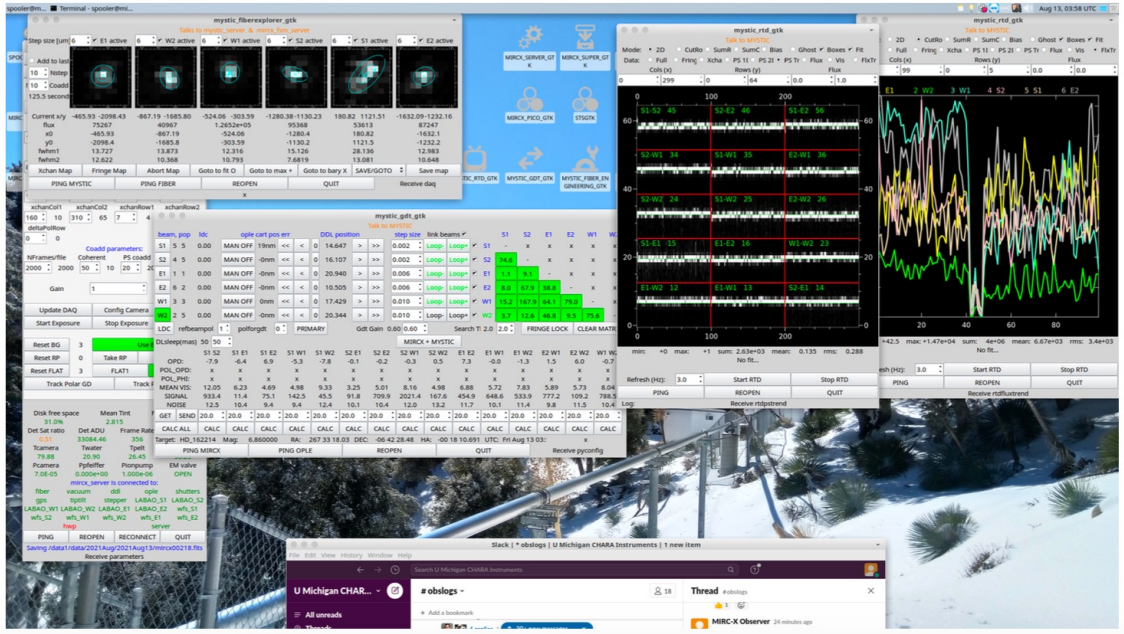


MIRC-X (R)	MYSTIC (R)
20	20
50	49
102	100
198	278
1170	981
-	1724

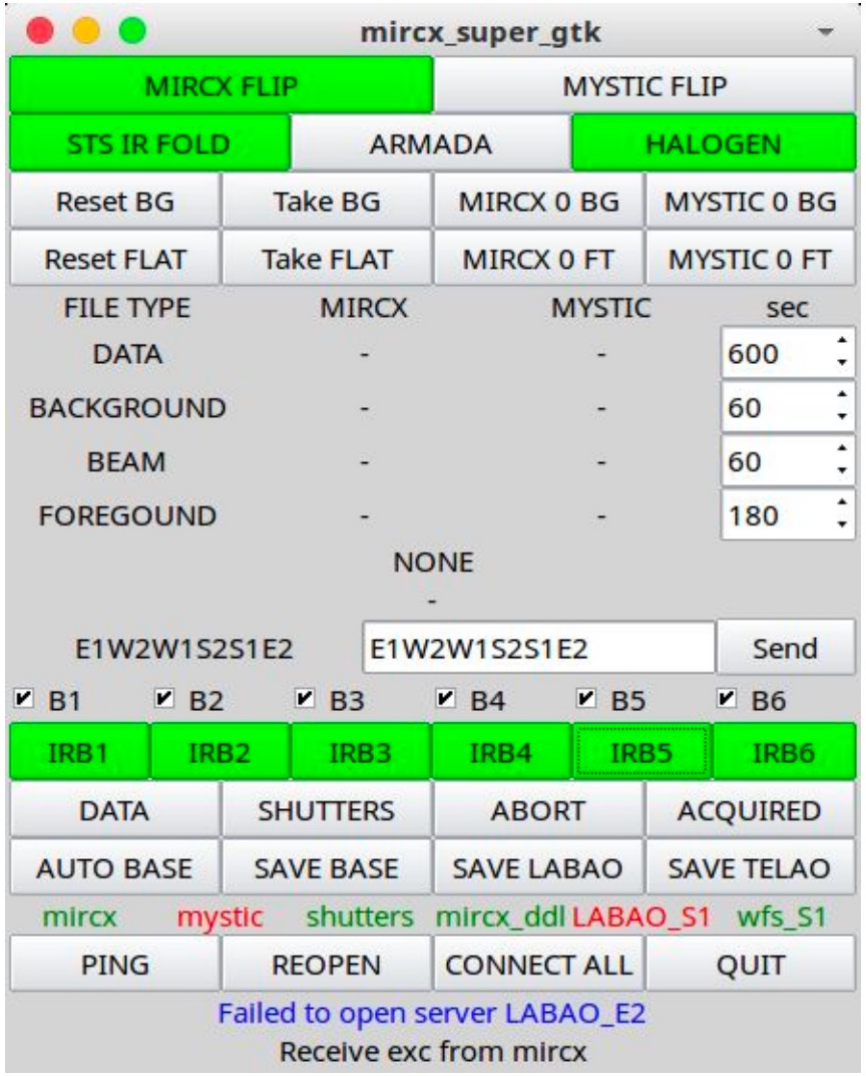
Observations: K=7.2 and H=7.5



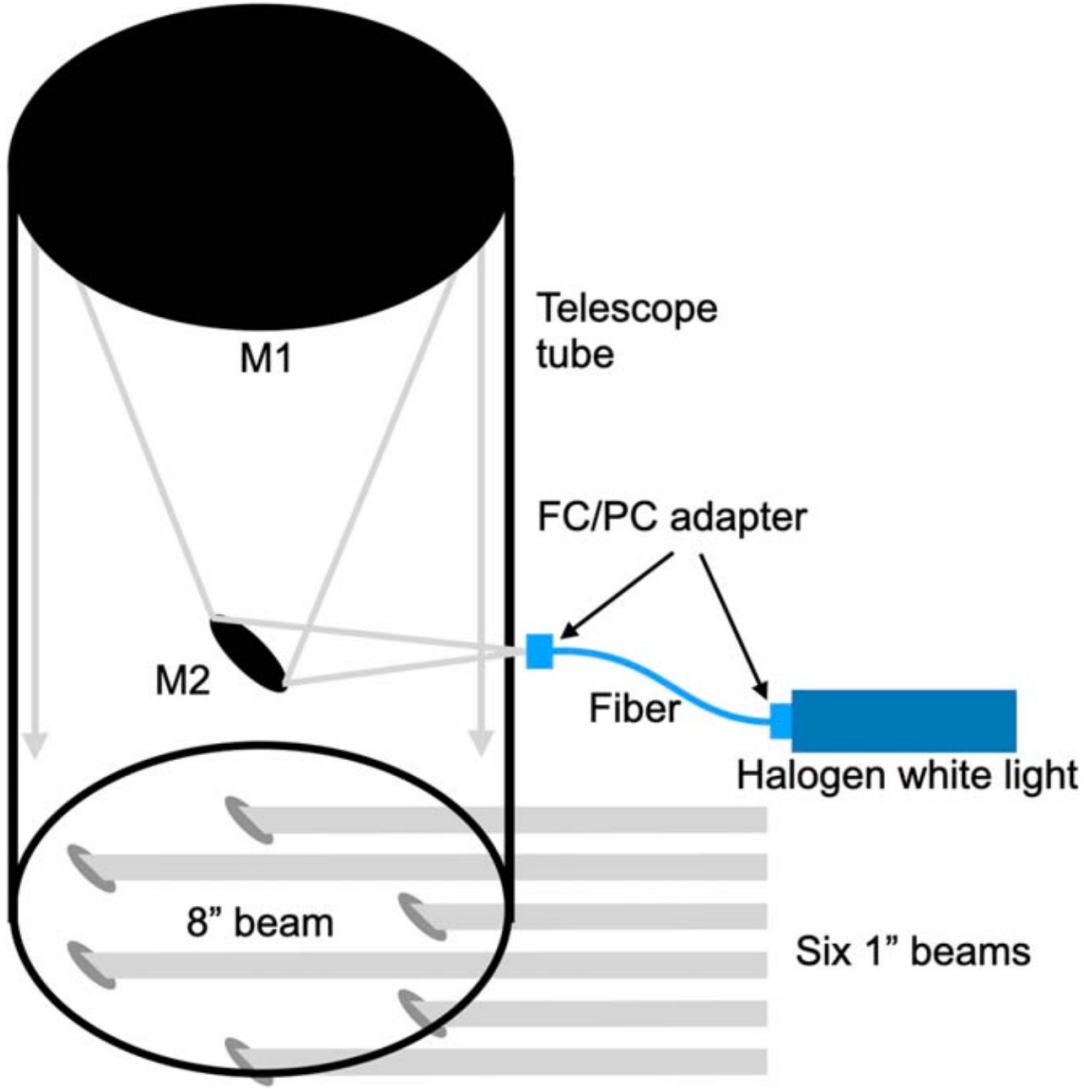




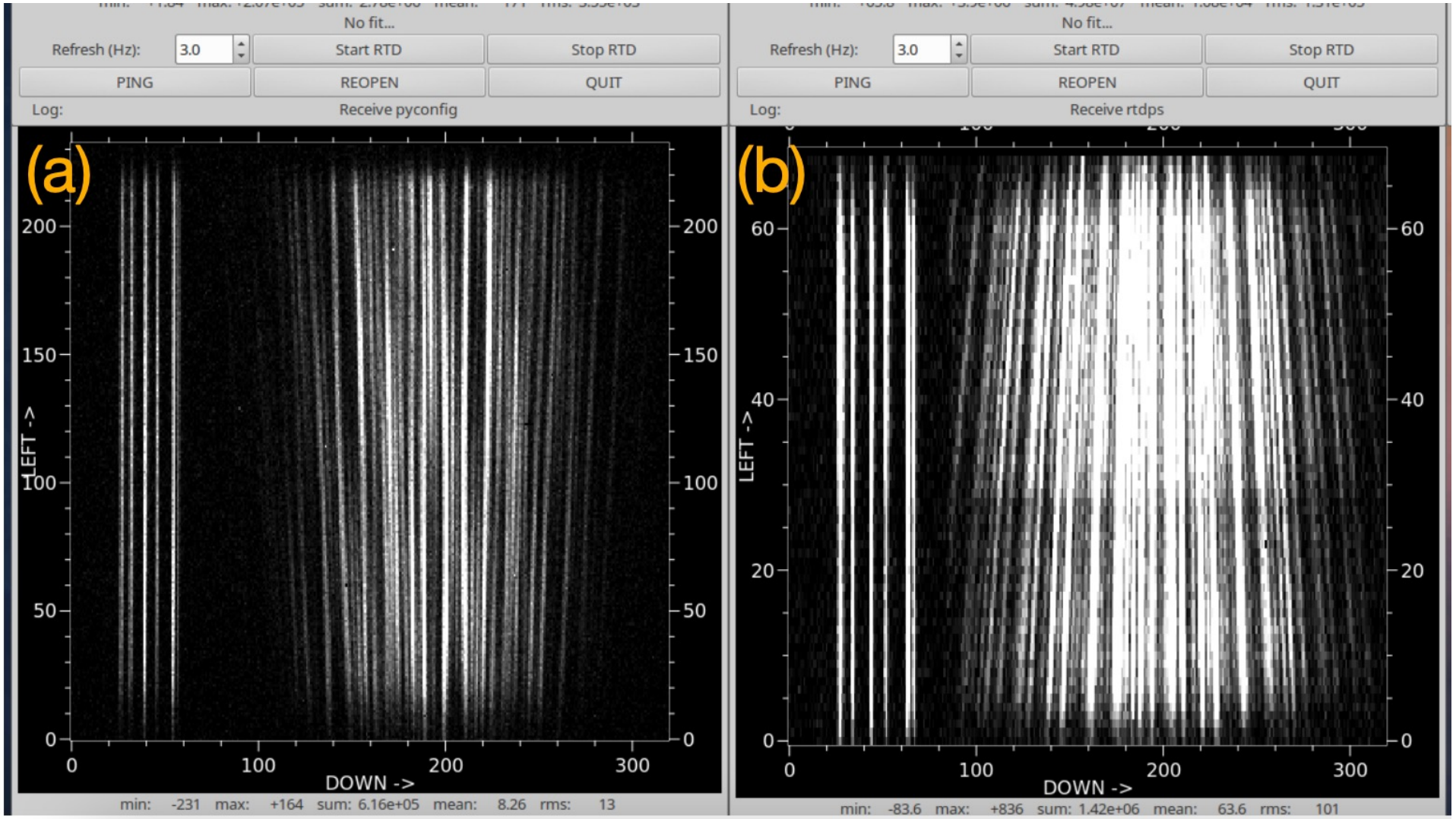
What DATA we take?



Six Telescope Simulator (STS)



What the data fits contain



Data reduction

Squared visibilities for the baseline ij

$$V_{ij}^2(\lambda) = \frac{|\langle\ I_{ij}(\lambda,\ t)\ \times\ I_{ij}(\lambda,\ t\ -\ 1)^*\ -\ \beta(\lambda)\ \rangle|}{2\langle P_i(\lambda,\ t)\ \times\ P_j(\lambda,\ t)\rangle}$$

ij – tels

Bispectrum of closing triangle ijk

$$C_{ijk}(\lambda) = \langle I_{ij}(\lambda, t) \times I_{jk}(\lambda, t) \times I_{ik}^{*}(\lambda, t) - \beta_{ijk}(\lambda) \rangle$$

How to run the pipeline

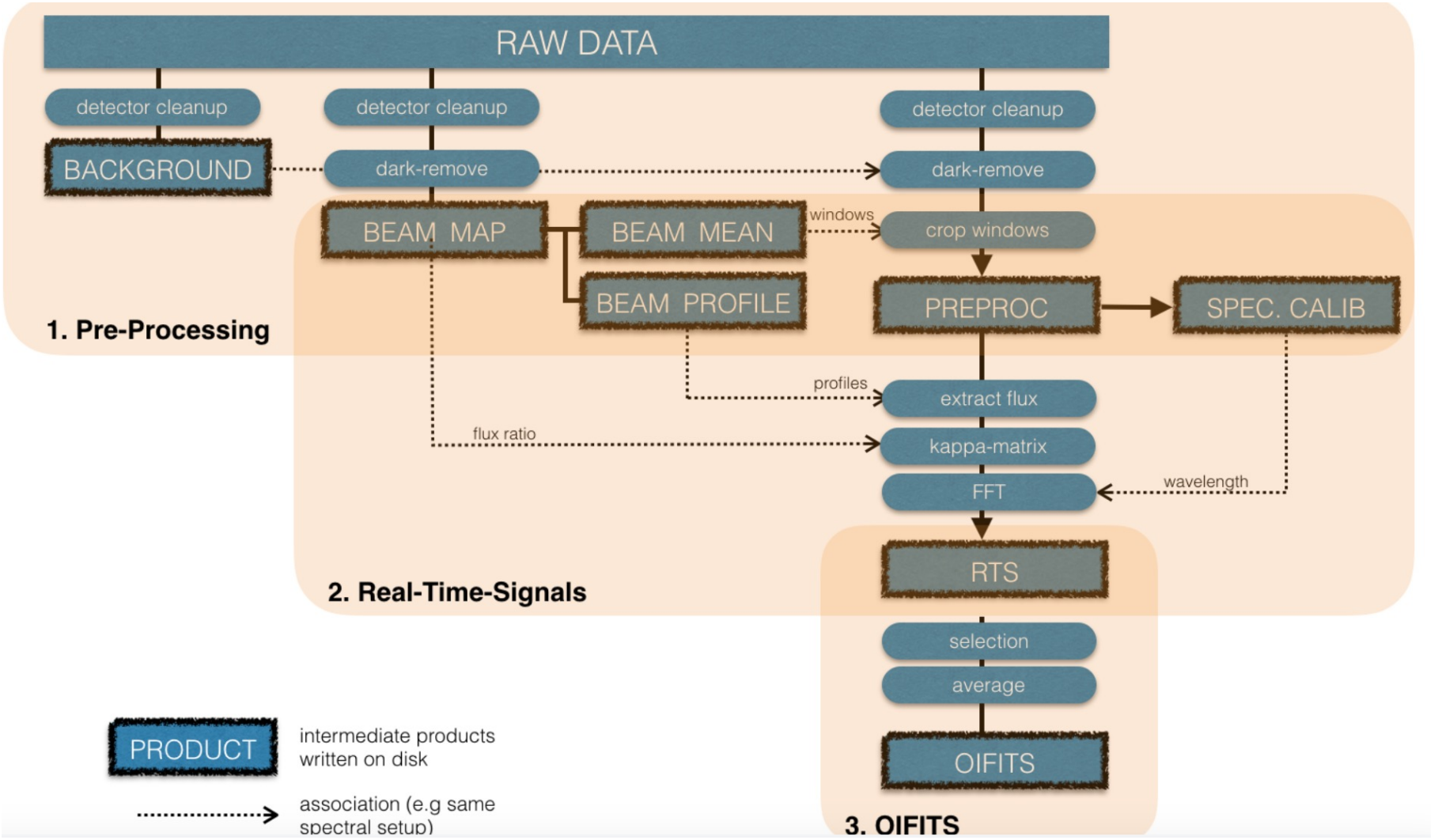
cd your_data/
mircx_reduce.py

Creates directories **preproc, rts, oifits**

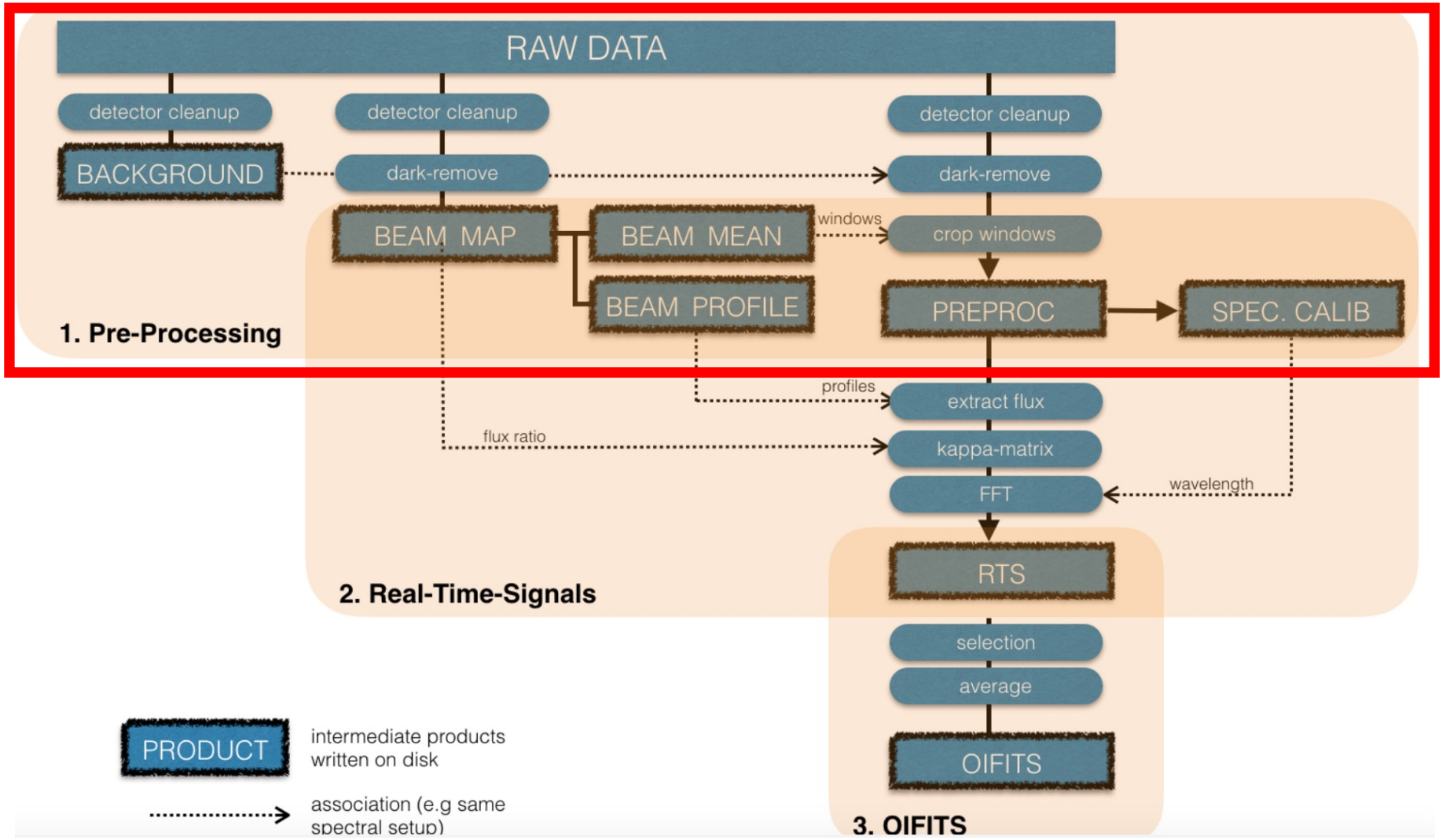
Pipeline divided into 3 steps:

- Pre-processed files (PREPROC)
- Real Time Signal (RTS)
- Raw and calibrated OIFITS

Schematic diagram of the data reduction



Preprocessing (preproc)

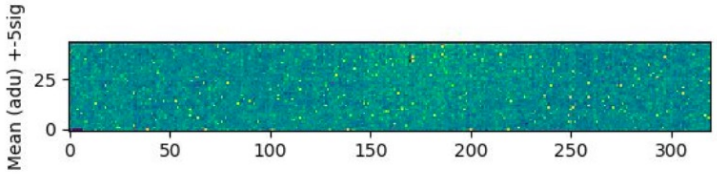


1) Pre-Processing Step

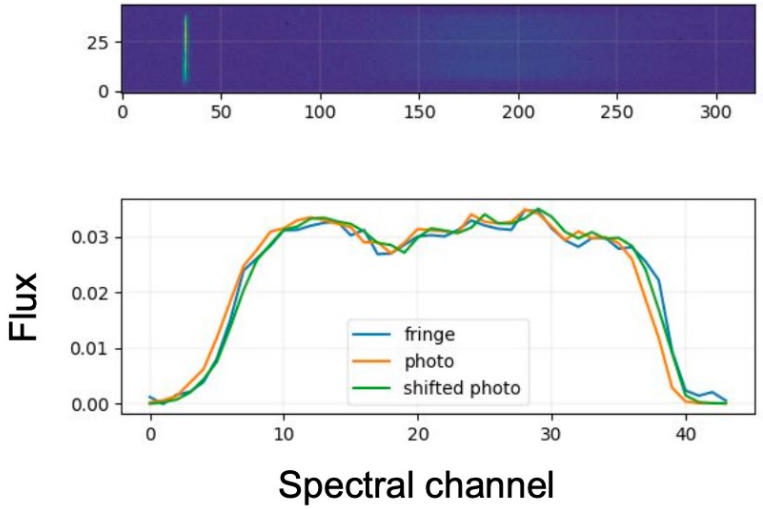
- Associate detector setups; targets / shutters
- Detector cleanup, bad pixel removal
- Creates PREPROC data files, beam maps, spectral calibration

Background Files: Either SHUTTER or SKY

G40-L6-R8 59004.4673 HD_199766

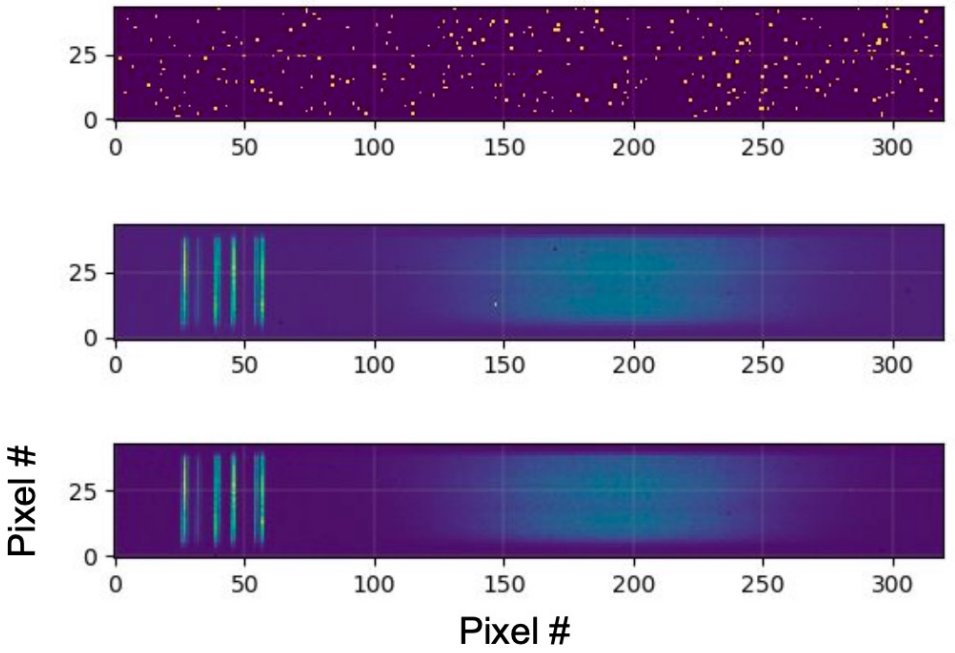


Create Beam Maps:



Create "Cleaned" Data preproc files:

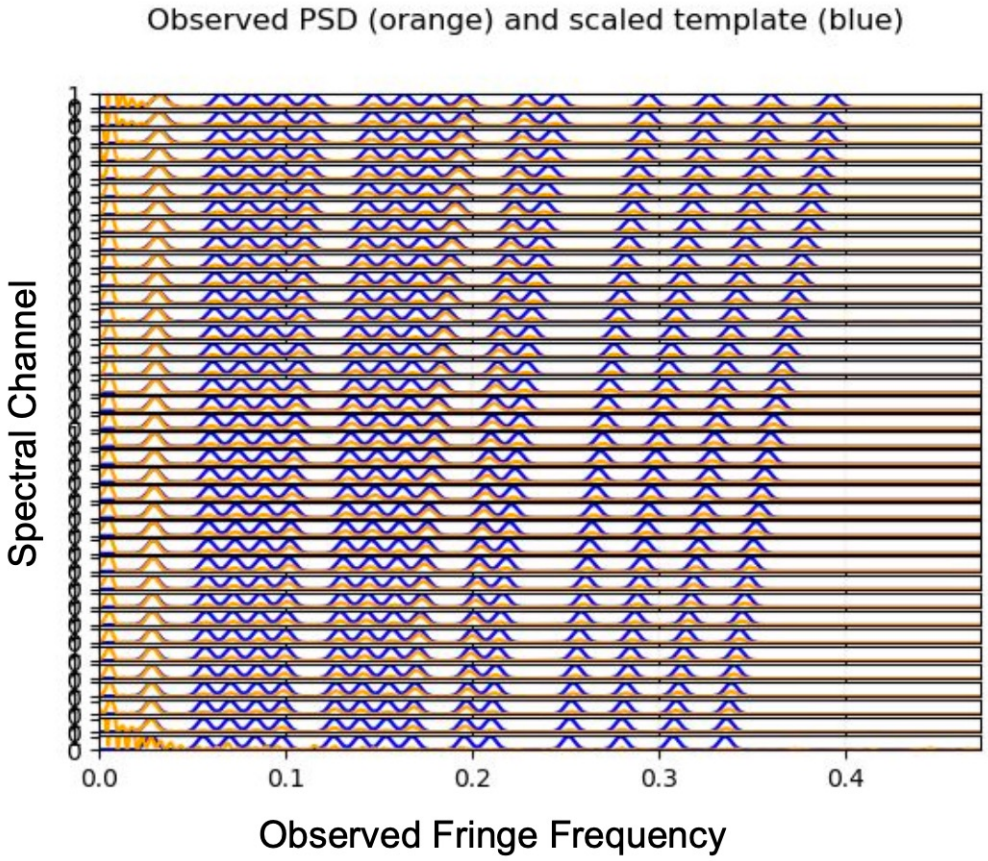
G40-L6-R8 59004.4606 HD_199766

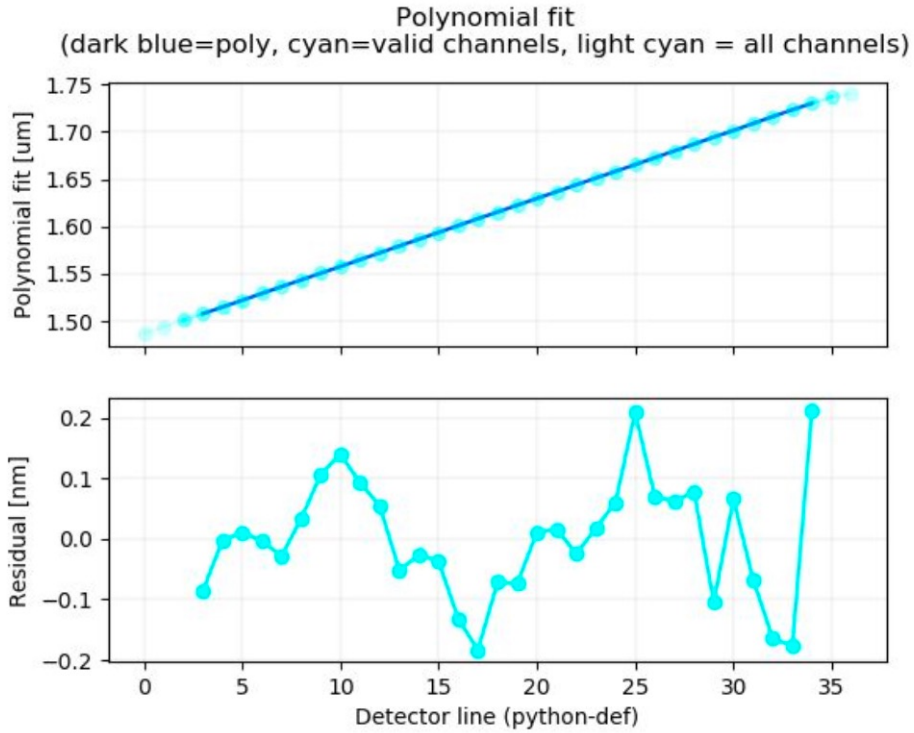


1) Pre-Processing Step

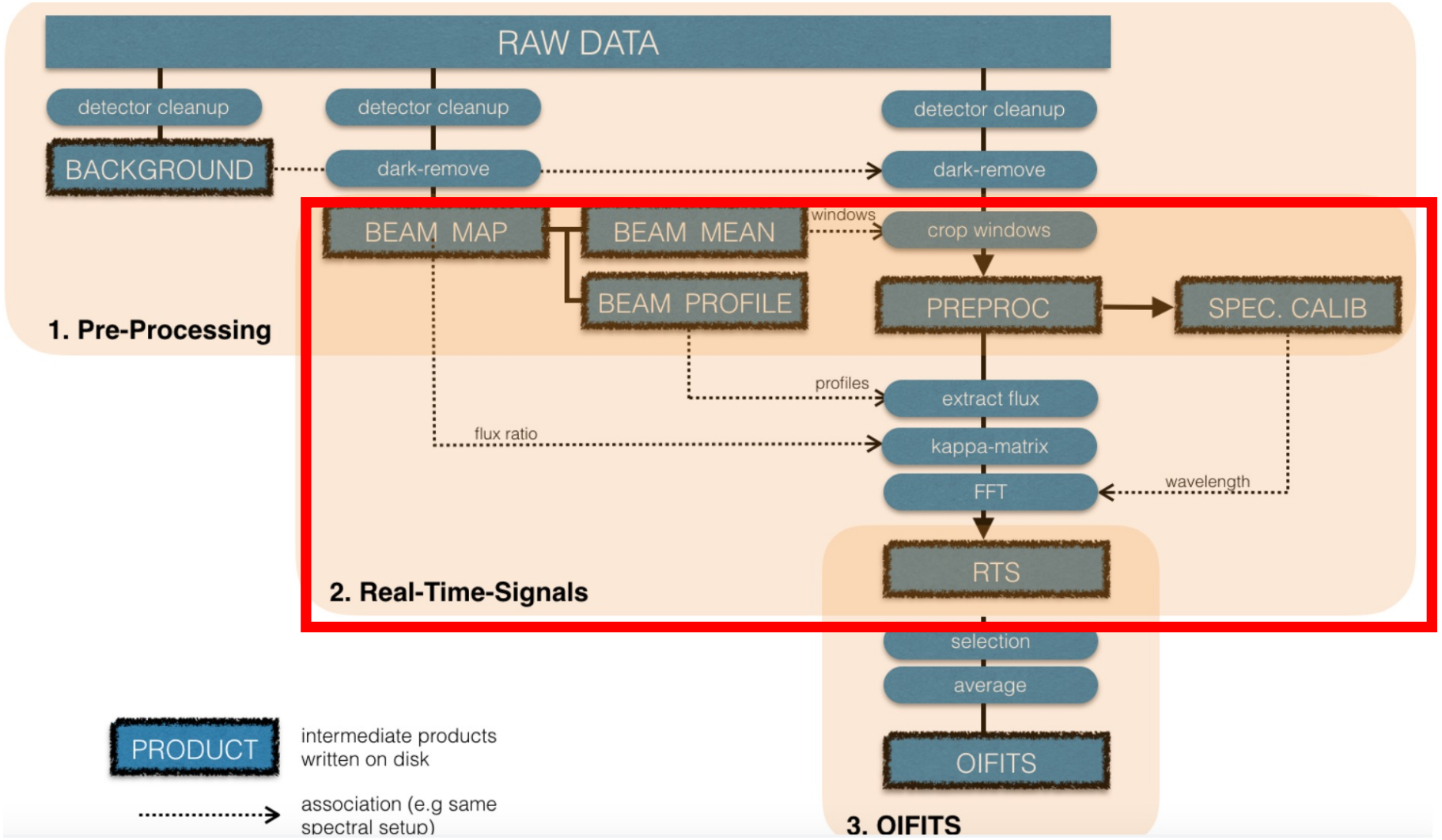
- Associate detector setups; targets / shutters
- Detector cleanup, bad pixel removal
- Creates PREPROC data files, beam maps, spectral calibration

All Fringe Files of Given Setup →
Spectral Calibration





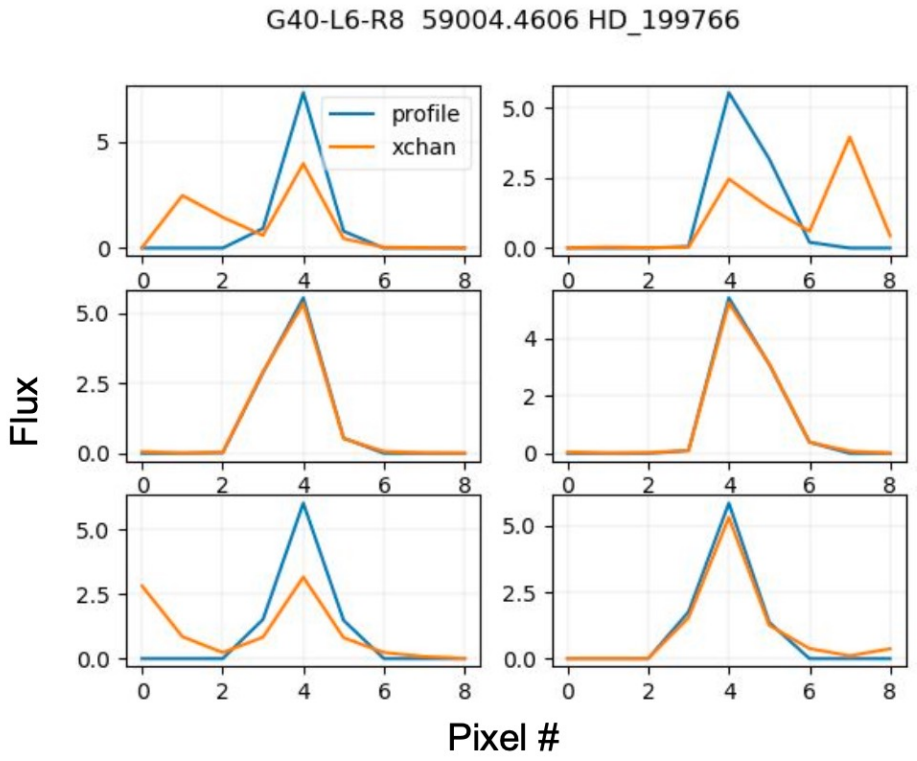
Real-Time-Signals (RTS)



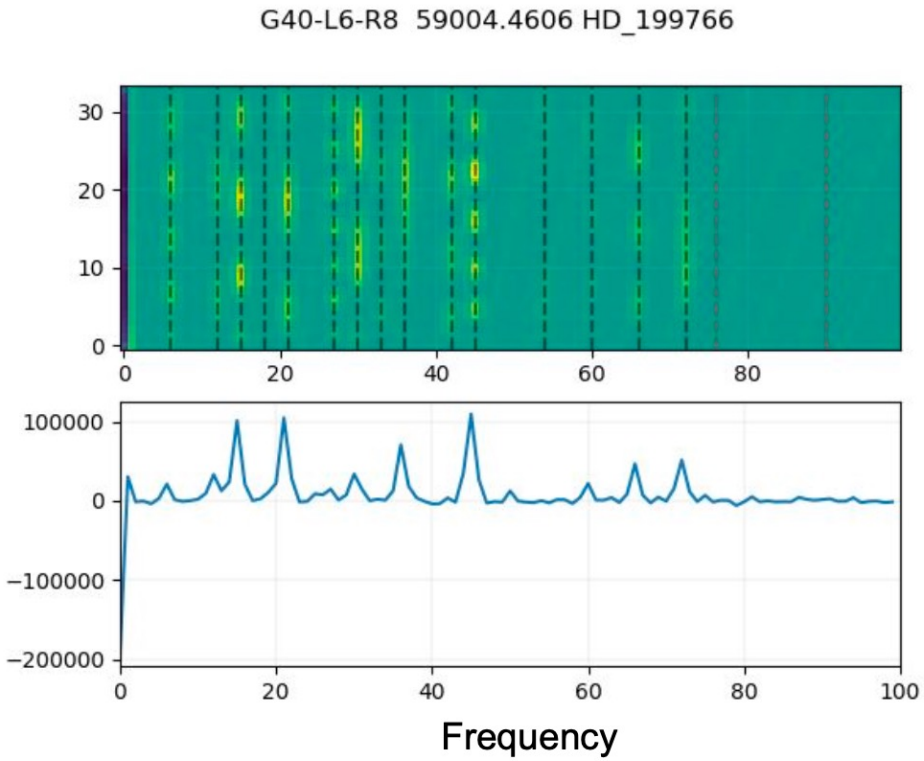
2) RTS Step

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

Beam Profiles, Photometry:

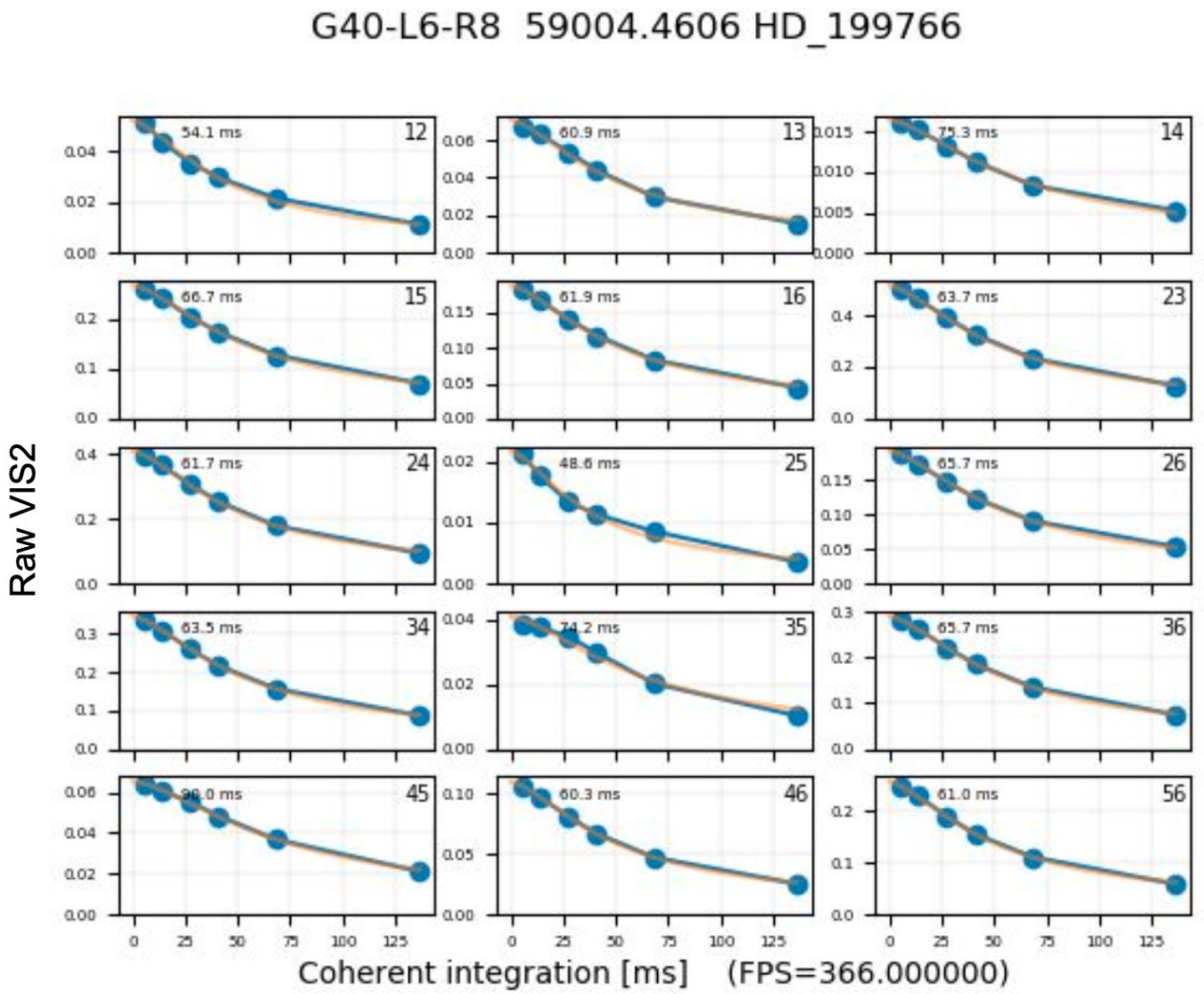


Fringes:



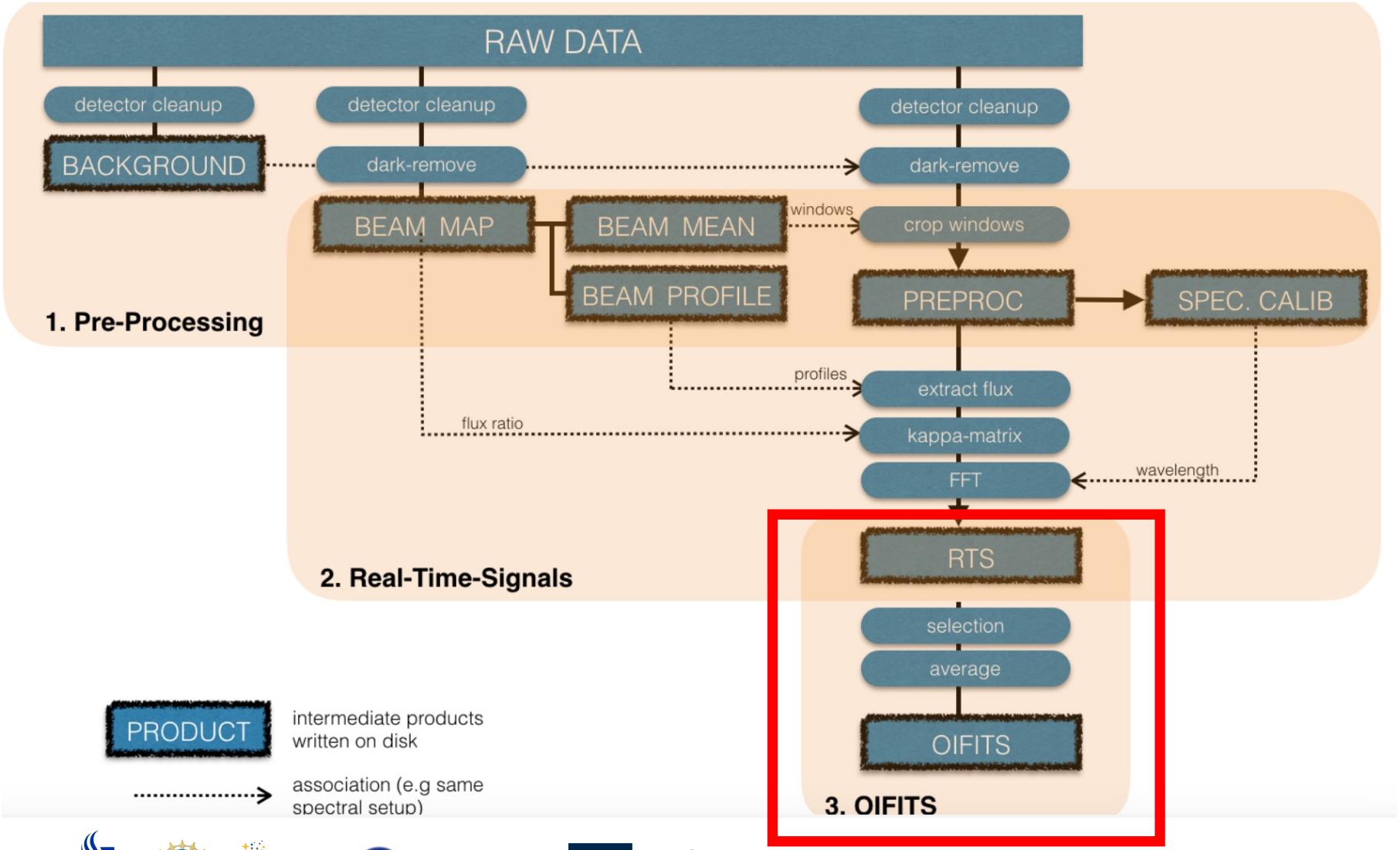
2) RTS Step

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



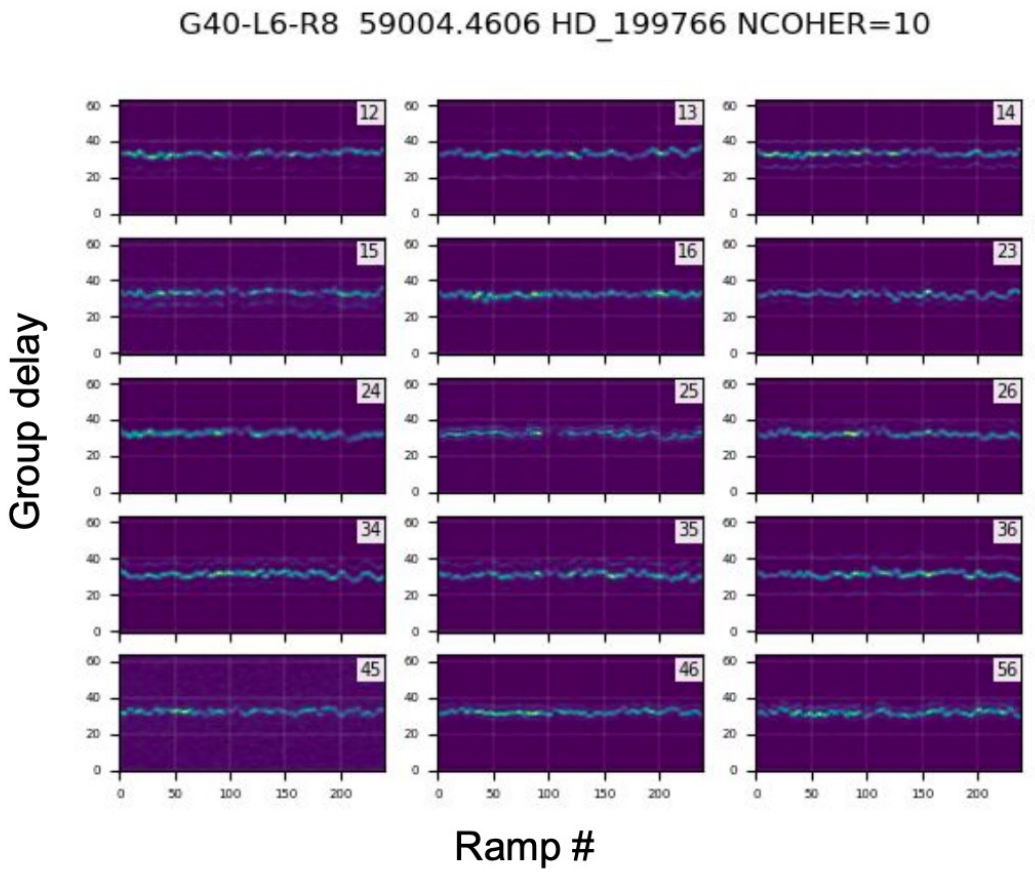
Gives an idea of how many frames to coherently average for OIFITS step

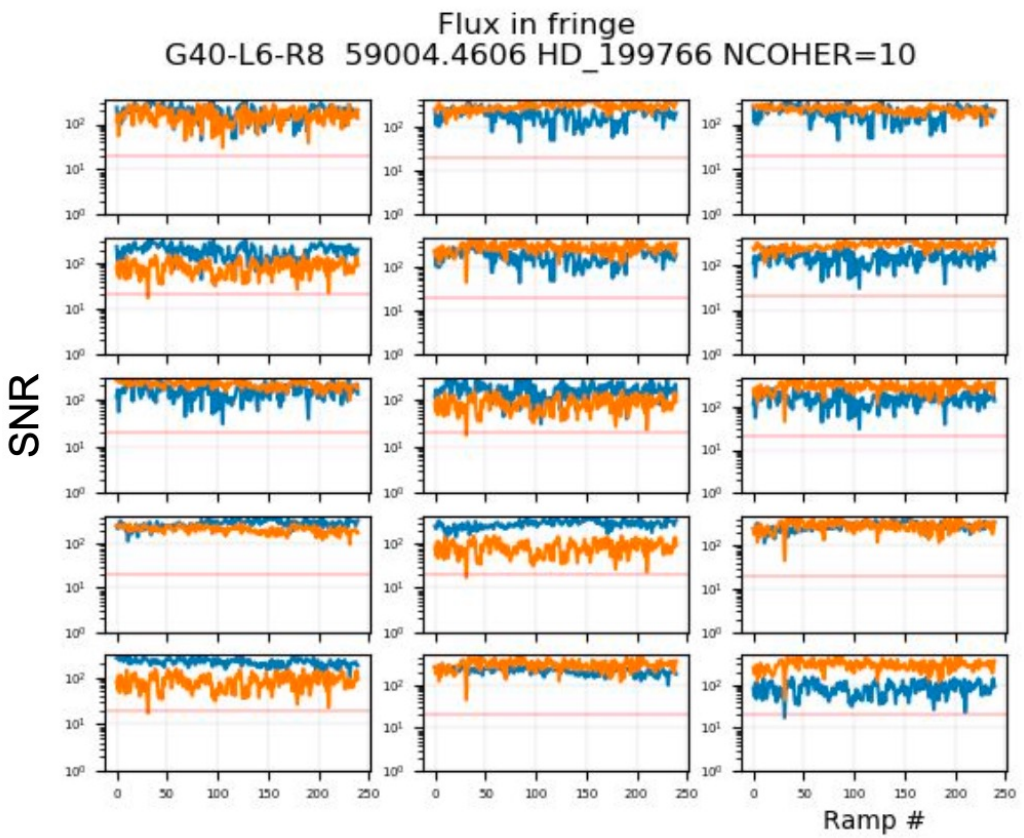
Uncalibrated OIFITS (OIFITS)



3) OIFITS Step

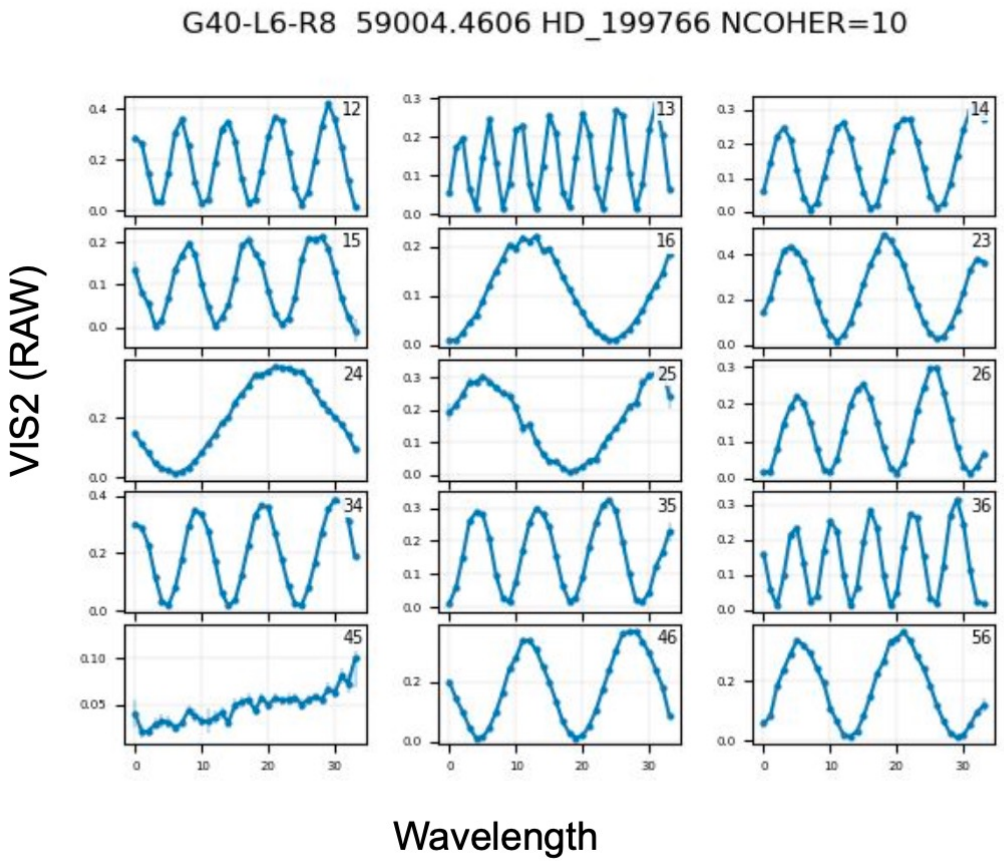
- Further selection criteria for cleaning
- Computation of raw visibilities, differential phase, closure phase

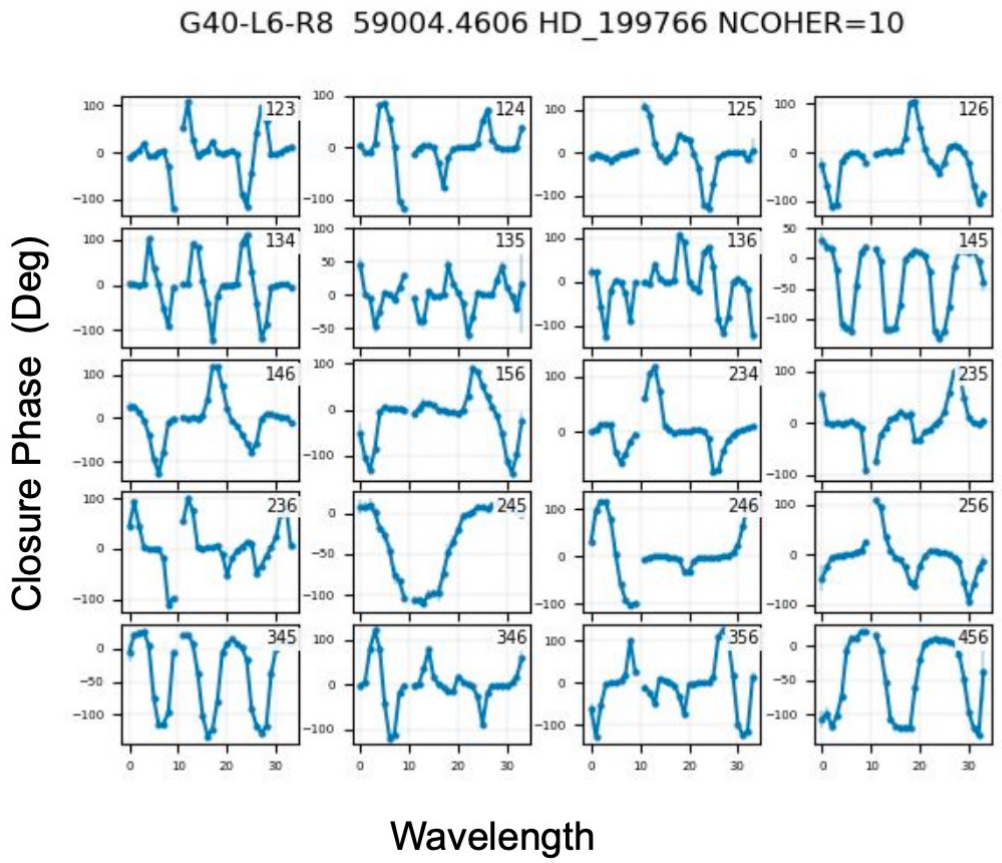




3) OIFITS Step

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



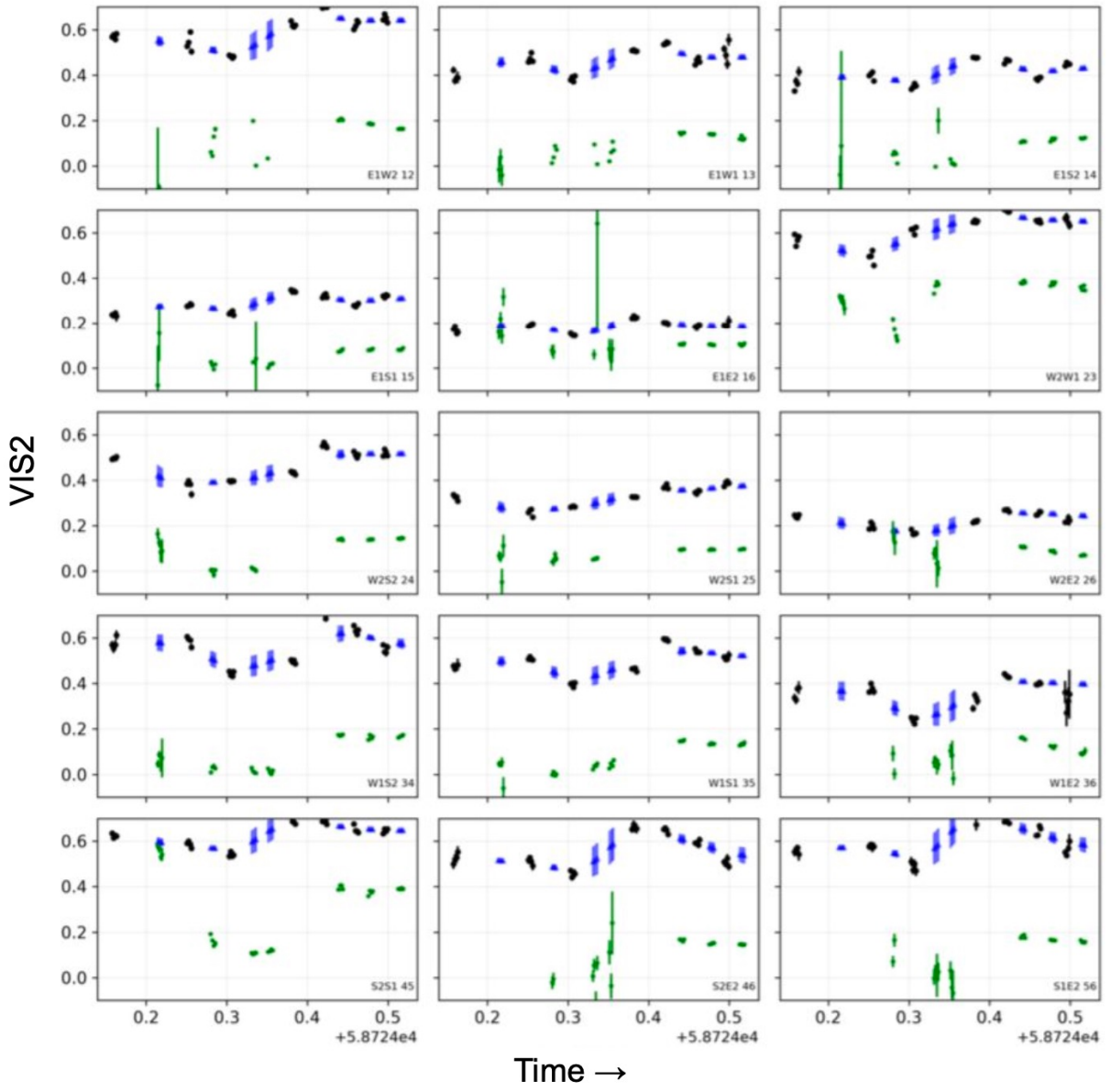


Calibration

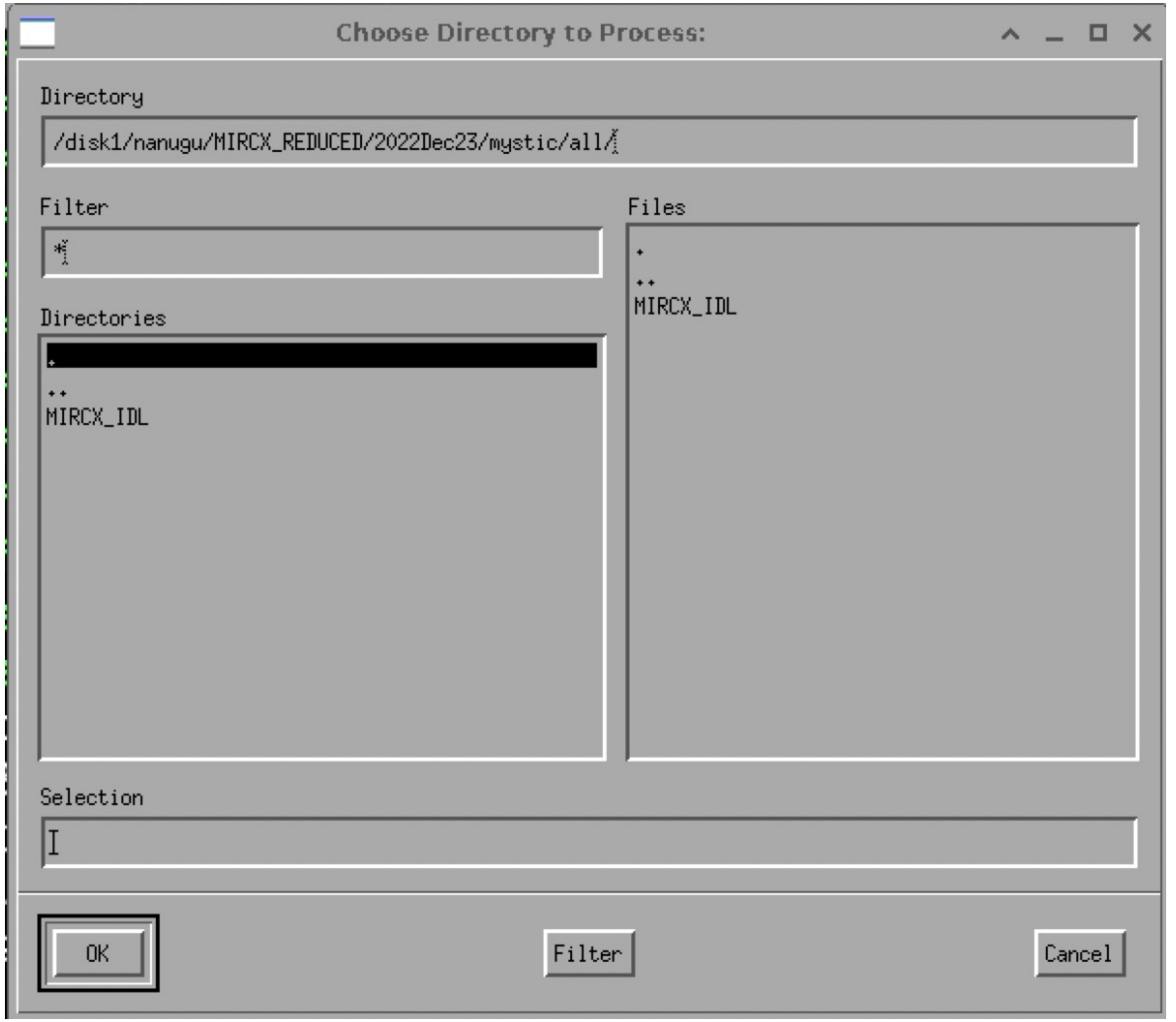
1. mircx_calibrate.py (python)
2. mircx_cal.script (IDL)

4) Calibration

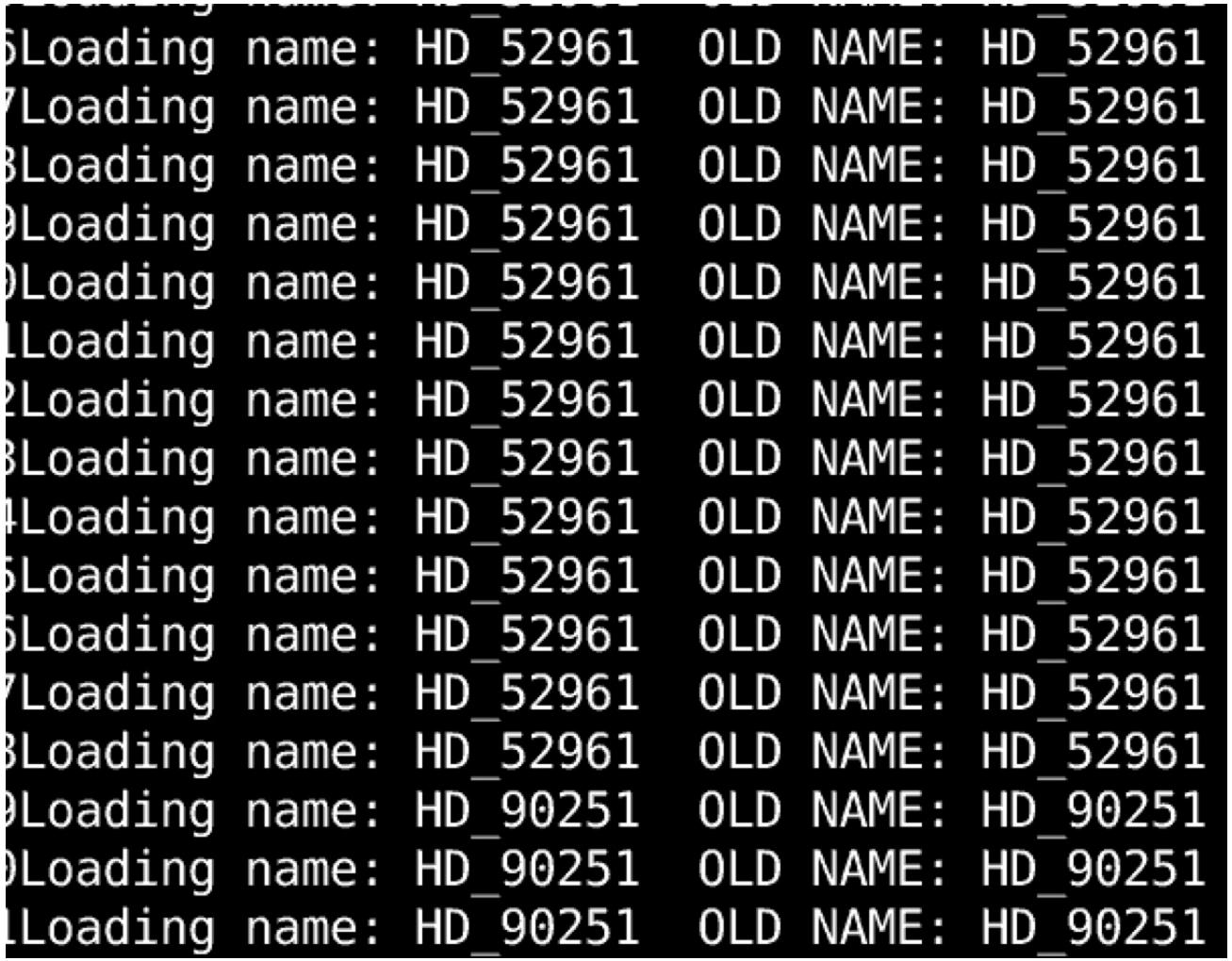
- True source visibility is corrupted by system losses
- Compute ‘transfer function’ with calibrator stars to account for this
- Use calibrators to calibrate visibilities / phases of science targets



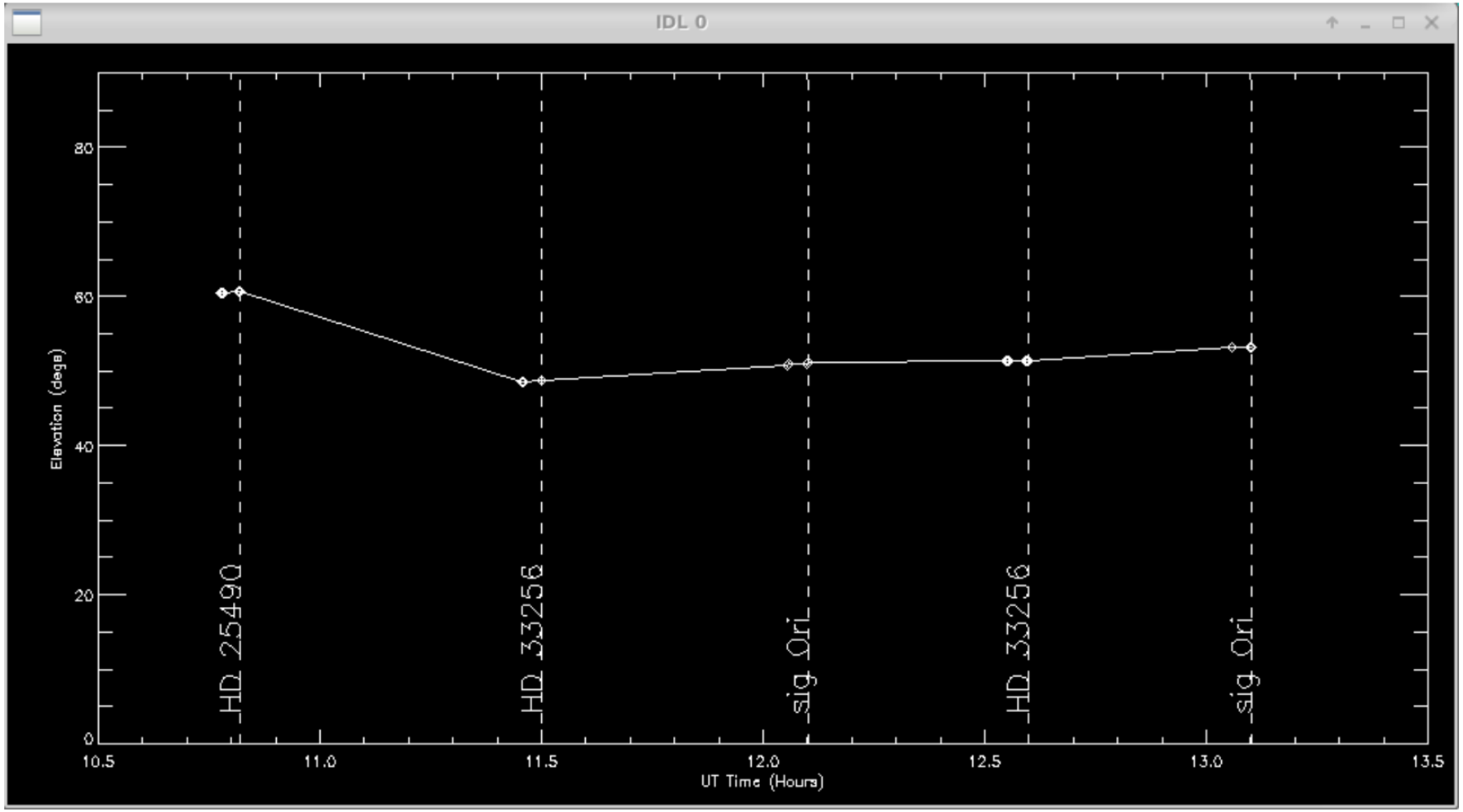
IDL mircx_cal.script



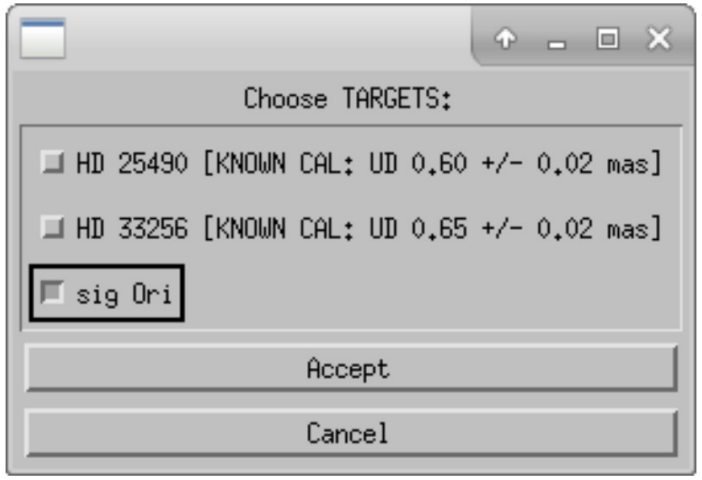
mircx_cal.script

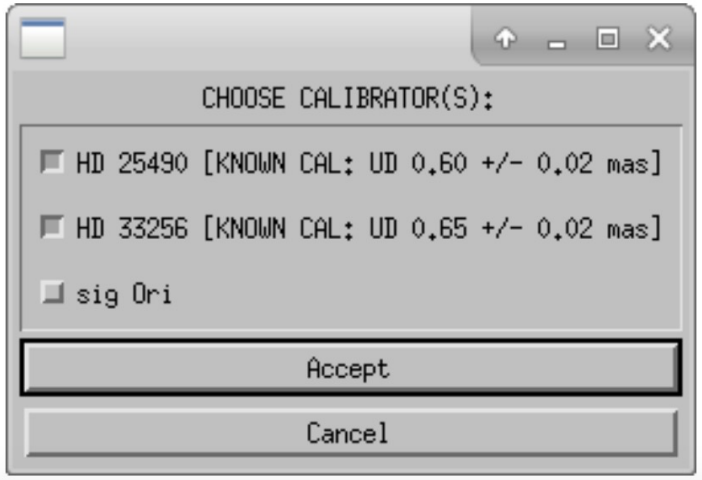


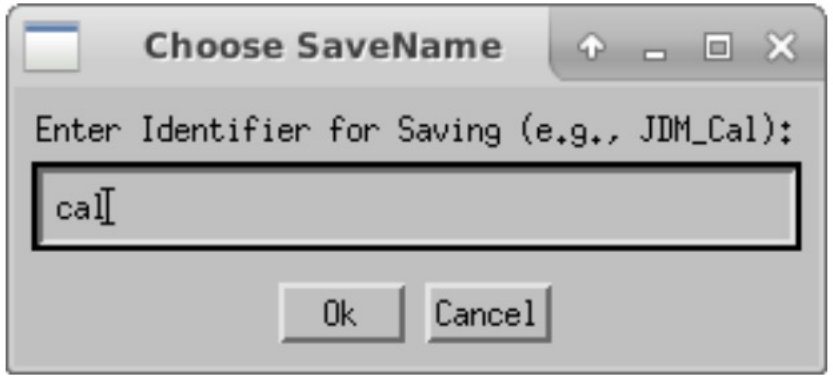
Lists the targets Elevatin vs time



Choose your targets and calibrators



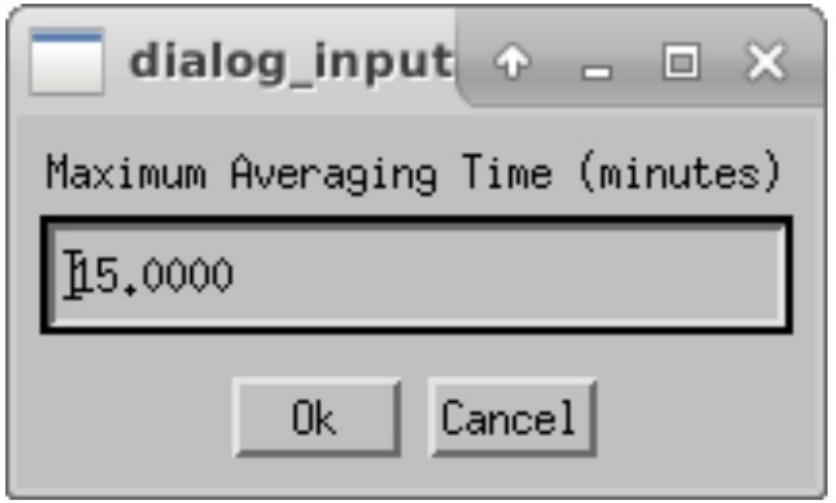




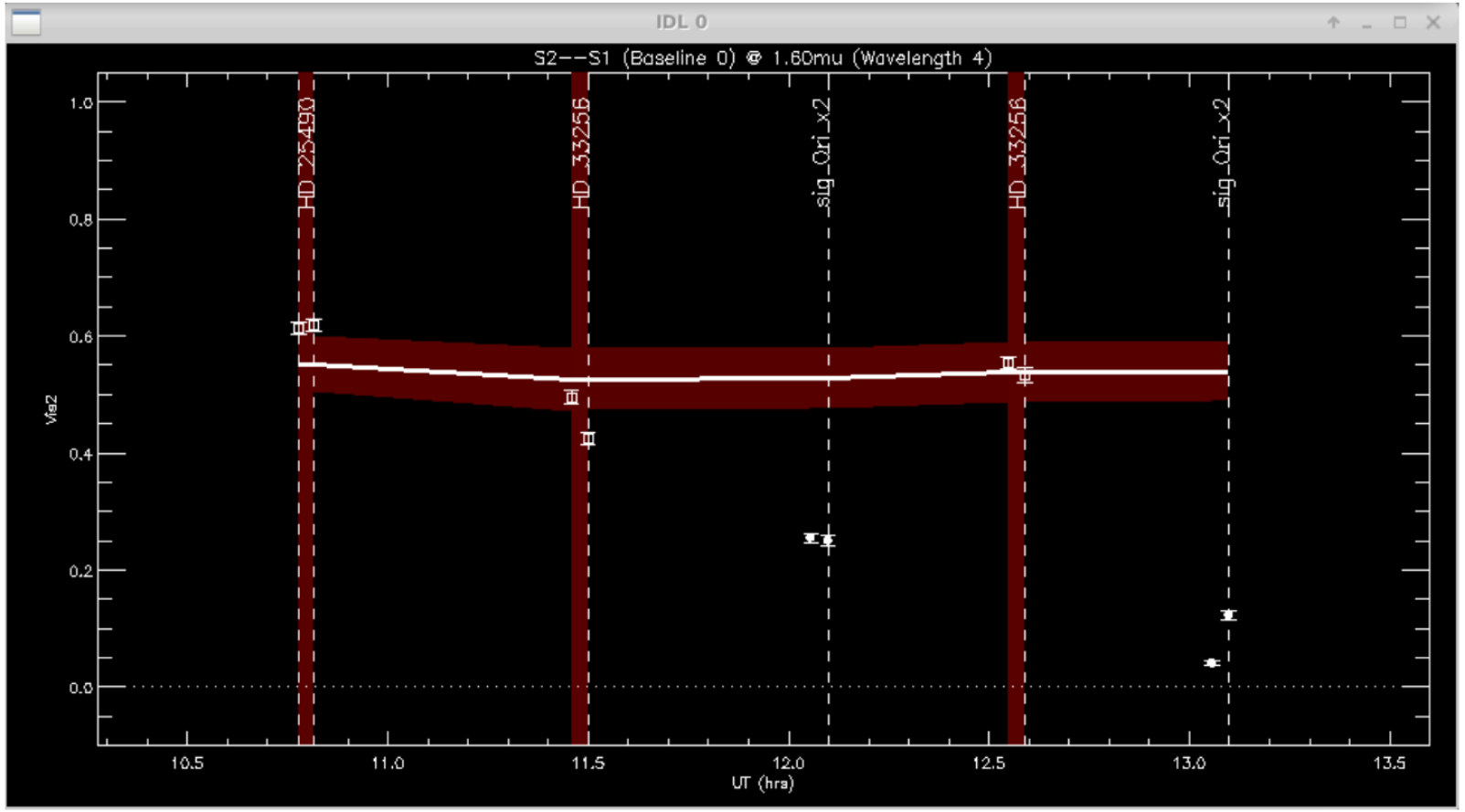
It automatically picks Calibrator UD sizes from catalogs

But you can insert if you have better calibrator sizes

Averaging of data



We can filter the data

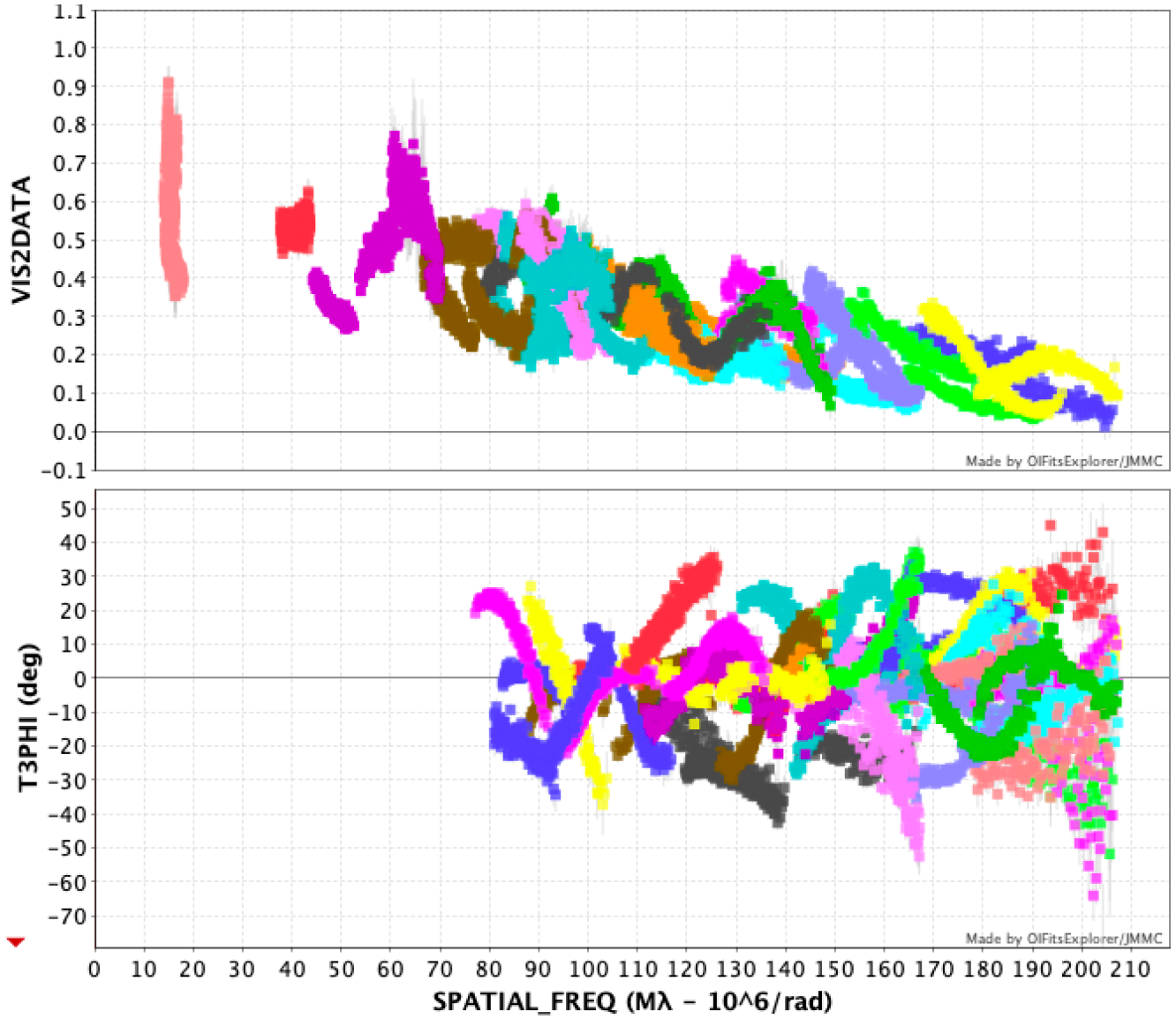


Pros:

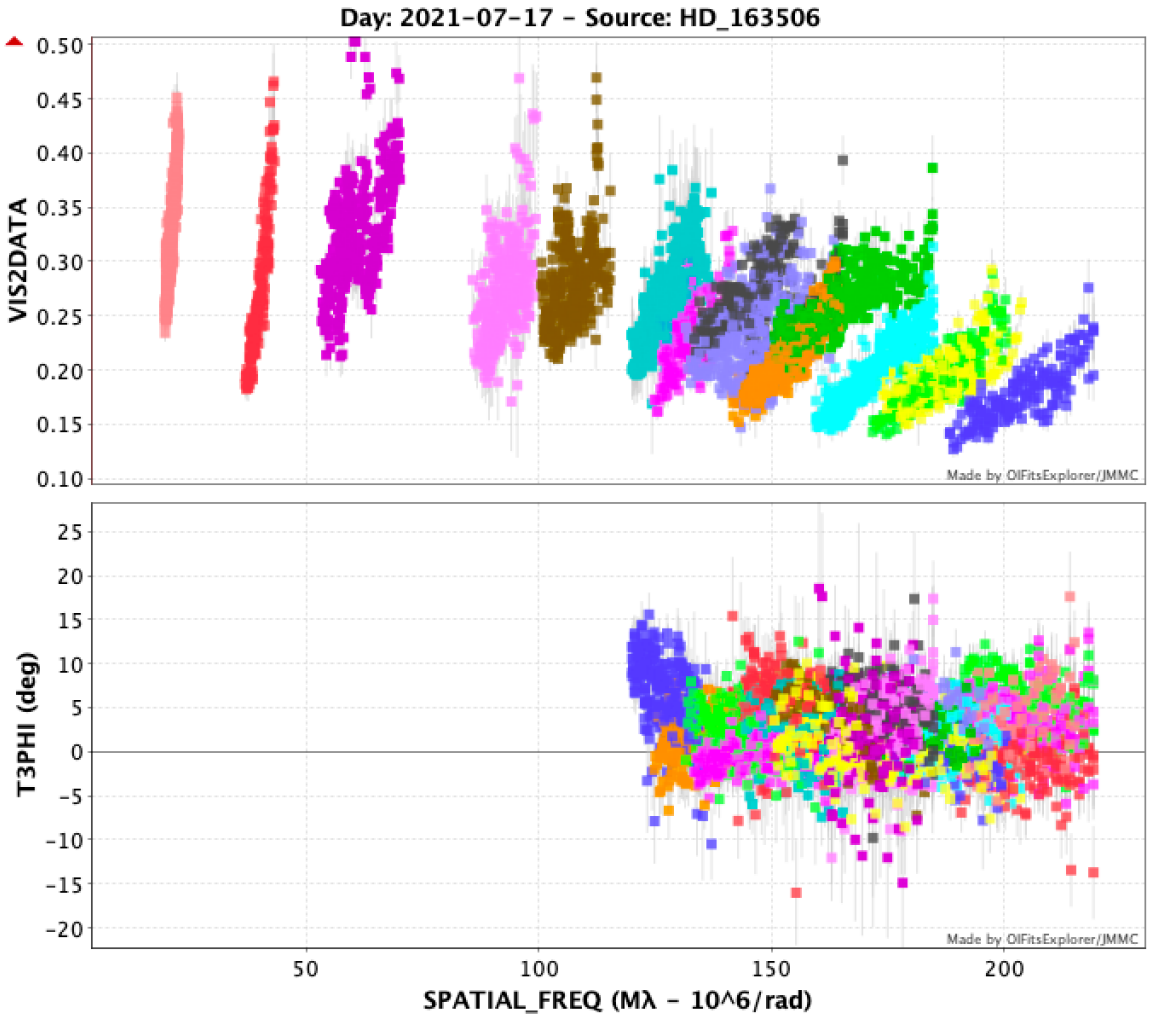
Powerful to filter the data

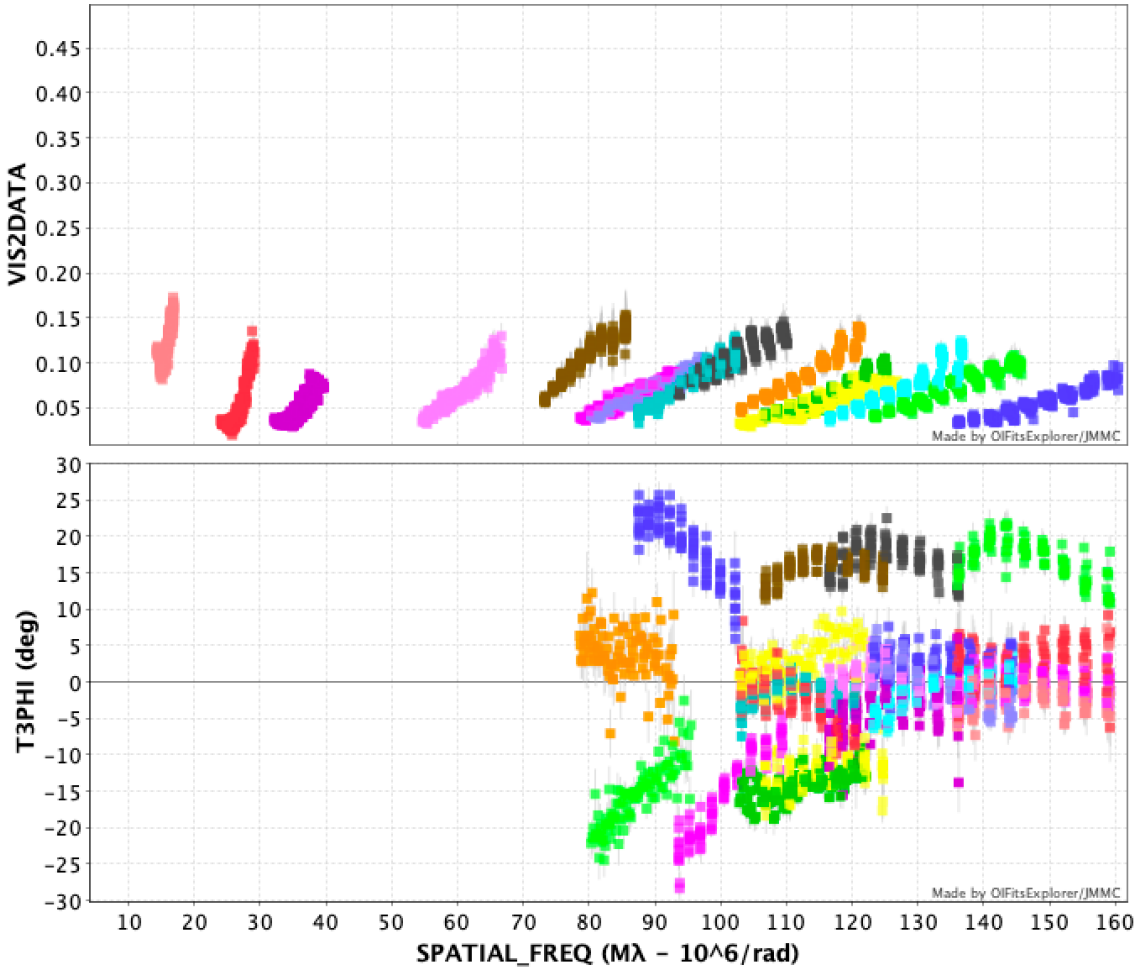
Cons:
Not repetitive as you cannot describe your filtering in the paper

Calibrated OIFITS



Calibrated OIFITS





OIFITS format


Select FITS file extension - mircx03577_oifits_viscal.fits
Extension
Header
Type
Size
#1
#2
#3
#4
#5
PRIMARY ... IMAGE 1 x 1 load
1 OI_WAVELENGTH ... BINARY TABLE 2 x 34 EFF_WAVE EFF_BAND
2 OI_TARGET ... BINARY TABLE 17 x 1 TARGET_ID TARGET RAEP0 DECEP0 EQUINOX
3 OI_ARRAY ... BINARY TABLE 7 x 6 TEL_NAME STA_NAME STA_INDEX DIAMETER STAXYZ
4 OI_FLUX ... BINARY TABLE 8 x 6 TARGET_ID TIME MJD INT_TIME FLUXDATA
5 OI_VIS2 ... BINARY TABLE 10 x 15 TARGET_ID TIME MJD INT_TIME VIS2DATA
6 OI_VIS ... BINARY TABLE 12 x 15 TARGET_ID TIME MJD INT_TIME VISPHI
7 OI_T3 ... BINARY TABLE 14 x 20 TARGET_ID TIME MJD INT_TIME T3PHI
Exit
Read All