The VLA Pipeline

John Tobin

Pipeline Overview

- The ‘real-time’ pipeline is automatically run on all Scheduling Blocks as soon as the raw data are ingested into the archive:
  - Flagged and calibrated visibility data are delivered to users
  - All pipeline output undergoes basic quality assurance checks by NRAO staff
  - Pipeline should run correctly on all ‘standard’ Stokes I science SBs
  - Detailed checks are made for C-band and higher continuum projects as part of Science Ready Data Products (SRDP) processing
    - Reports generated are archived as pipeline products
  - Imaging and self-calibration (if needed) are left to the end users to perform at their institution or on NRAO computing

Pipeline Overview

- Current versions available:
  - CASA integrated pipeline: compatible with ALMA pipeline infrastructure, and used as real-time pipeline since Sep 2015
    - recommended pipeline version
    - Instructions for installation and operation of the VLA CASA Calibration Pipeline are available at http://go.nrao.edu/vla-pipe
    - Uses CASA 6.1.2, similar to current real-time pipeline
    - See the VLA CASA pipeline guide at http://go.nrao.edu/vla-casa-tut
  - "scripted" pipeline: collection of python scripts that use CASA tasks wherever possible, but also uses toolkit calls. It was the original VLA pipeline and used on all science data from 2013 and until Sep 2015.
    - Final update for CASA 5.3, no further updates planned
    - Portions more easily modified relative to CASA integrated

Will the Pipeline work for you?

- The pipeline successfully completes on ~92% of all science SBs observed on the VLA; whether the output can be used for science depends on the science goal, and whether the observations were correctly set up
  - Pipeline includes Hanning smoothing, RFI flagging, and weight calculations that may not be appropriate for (some) spectral line projects.
  - No polarization calibration but can use pipeline output as a starting point.*
  - Will probably work for data taken since May 2012, may work for earlier EVLA data, likely that extra flagging and editing may be needed in these cases

*CASA 5.6.2 and later, requires that you have used the correct polarization intents when setting up the observations

Pipeline Requirements

- "Standard" Stokes I science SB means:
  - 128 MHz spws (64 MHz for L-band; default setup), but may work on other set-ups as well
    - Can work for narrower BWs, depends on the strength of the calibrators
    - Heuristics currently make some assumptions about the strength of the calibrators, in particular, the delay calibrator
      - currently requires a S/N=3 limit on initial gain calibration *per integration*
  - Contains correctly labeled and complete scan intents
    - And also that the observations have been set up correctly!

Pipeline Requirements

- Correct observation set-up
  - Independent of whether you want to run the pipeline!
  - Remember: simple observing set-ups are always easier to calibrate
  - Do not skimp on calibration to spend more time on your target – you may end up not being able to calibrate the target data at all
    - Spending 3 minutes pointing could buy you more sensitivity than doubling the time on your target.

Pipeline Requirements

- Scan intents
  - The pipeline relies entirely on correct *scan intents* to be defined in each SB
  - In order for the pipeline to run successfully on an SB it must contain, *at minimum*, scans with the following intents:
    - A flux density scale calibrator scan that observes one of the primary calibrators (3C48, 3C138, 3C147, or 3C286)* – this will also be used as the delay and bandpass calibrator if no bandpass or delay calibrator is defined
    - Complex gain calibrator scans

*Some of these calibrators are variable (especially 3C48, 3C138), use 3C286 if possible

(Real-Time) Heuristics (I)

- Assuming requirements are met, the pipeline:
  - Loads the data (SDM-BDF or MS)
    - Retrieves the observing set-up from metadata
  - Hanning smooths*
  - Applies deterministic flags (online flags, shadowed data, end channels of spectral windows, etc.)
  - Identifies primary calibrators and loads calibrator[1] models

*May want to modify inputs and/or omit entirely for spectral line reductions, unless heavily impacted by RFI or dealing with a very strong spectral line feature (i.e., masers).

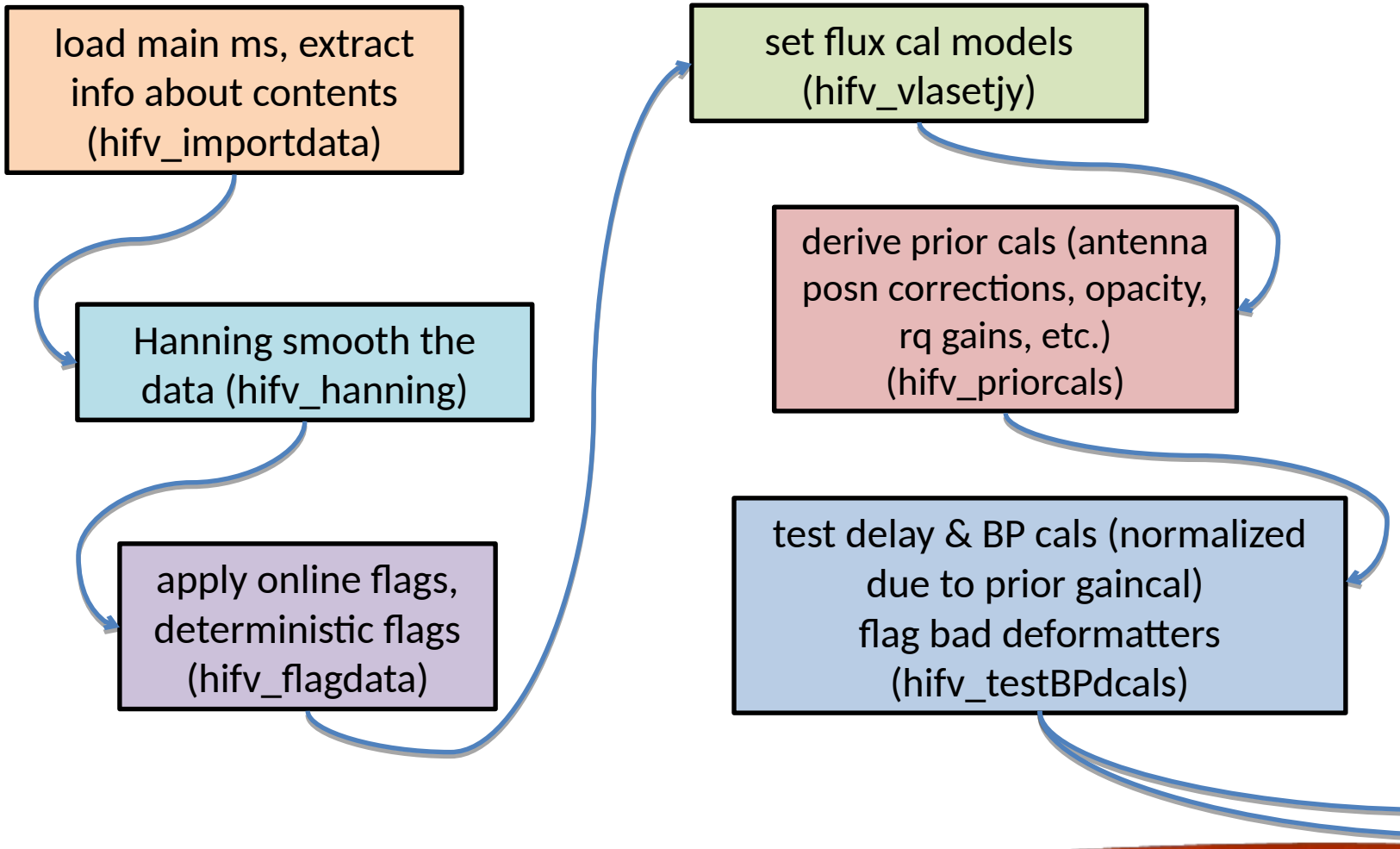
[1]Models only available for 3C48, 3C138, 3C147, and 3C286

(Real-Time) Heuristics (II)

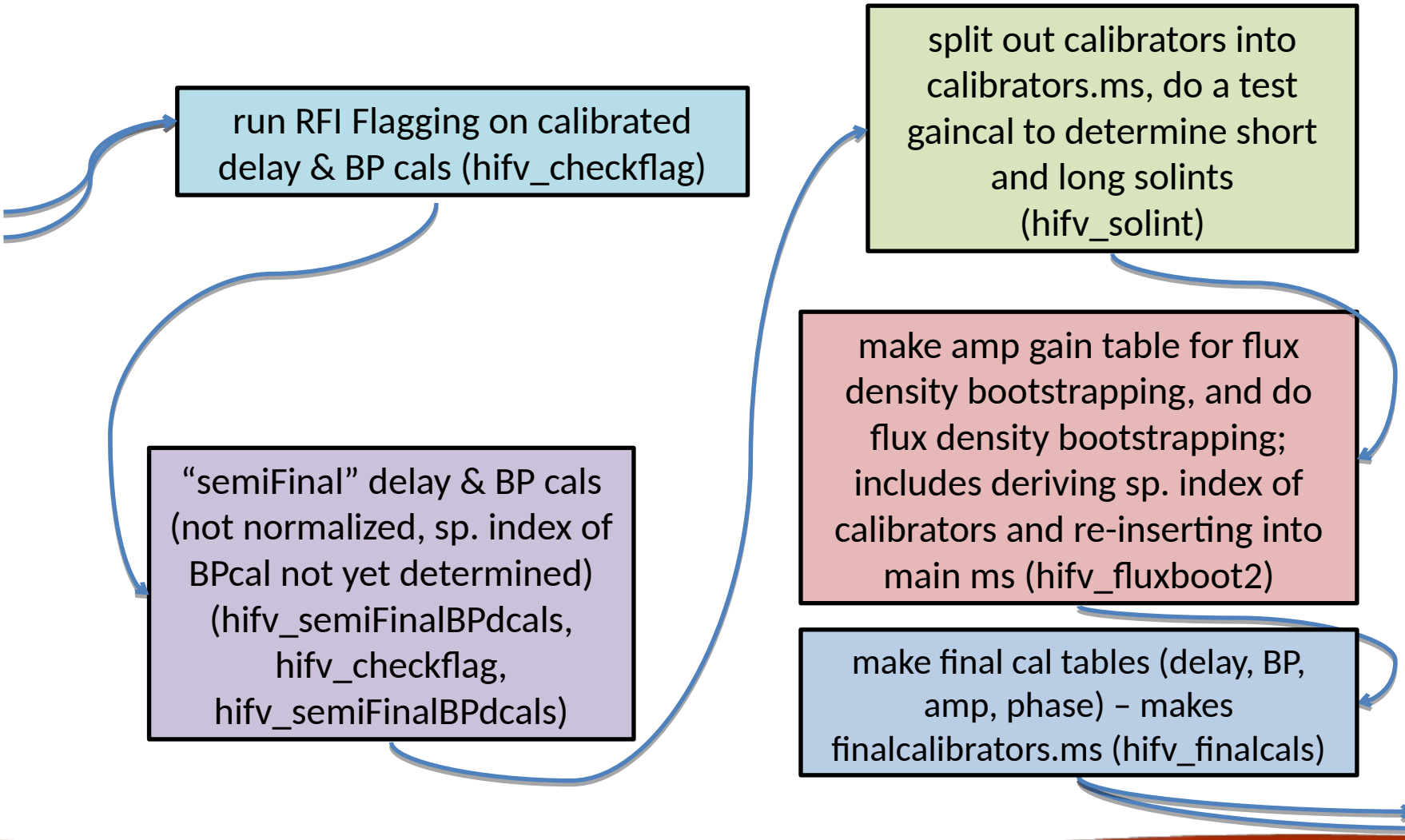
- Derives all prior calibrations (antenna position corrections, gain curves, atmospheric opacity, requantizer gains)
- Iteratively determines initial delay and bandpass solutions, including running RFLAG, and identifying system problems
- Derives initial gain solutions, does flux density bootstrapping and derives spectral index of all calibrators.
- Derives final delay, bandpass, and complex gain calibrations
- Applies all calibrations to the MS
- Runs RFLAG algorithm on all fields, including target*
- Runs statwt to derive proper relative weights per antenna/spw*

*May want to modify inputs and/or omit entirely for spectral line.

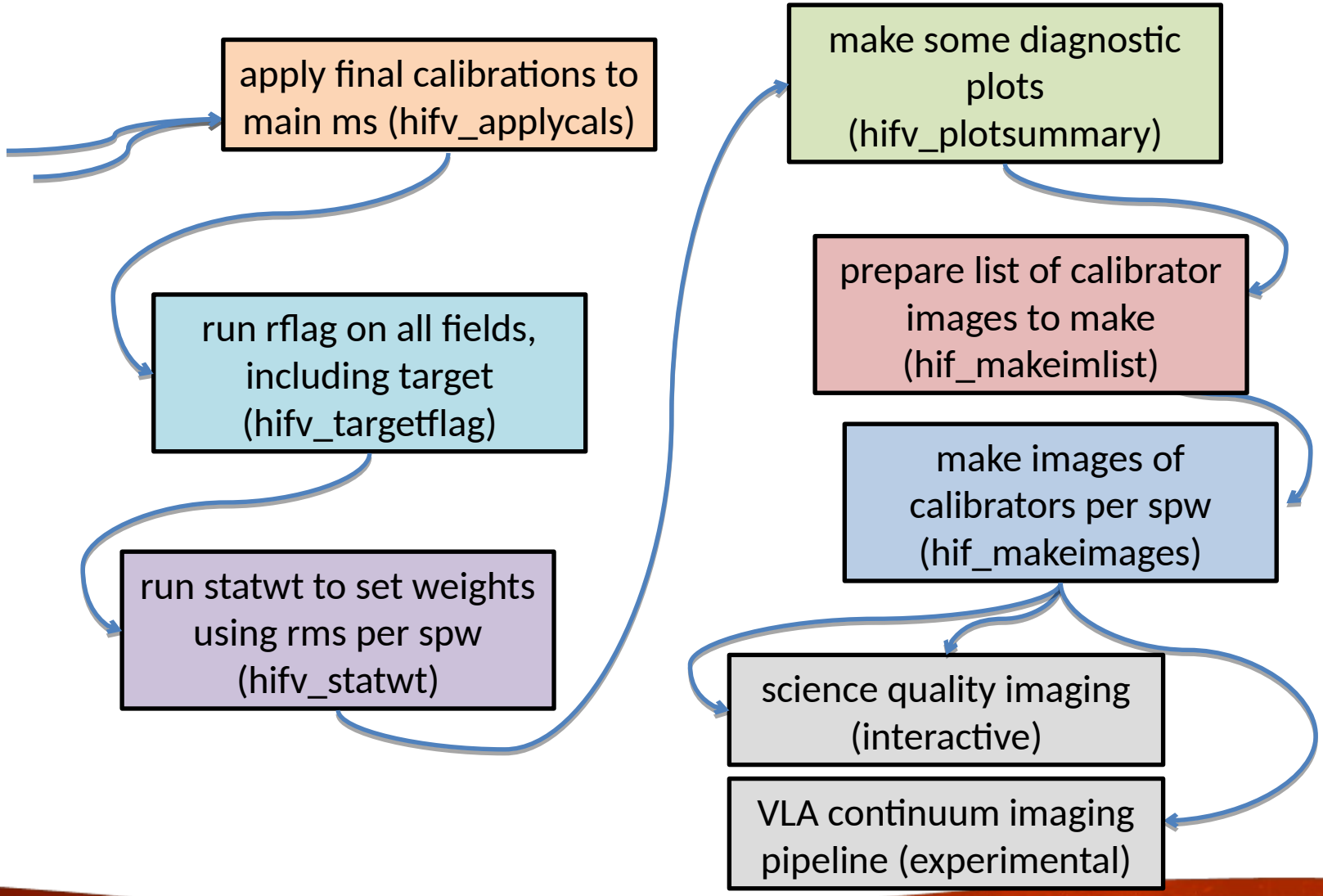
Flow chart (CASA pipeline)



Flow chart


run RFI Flagging on calibrated delay & BP cals (hifv_checkflag)
split out calibrators into calibrators.ms, do a test gaincal to determine short and long solints (hifv_solint)
make amp gain table for flux density bootstrapping, and do flux density bootstrapping; includes deriving sp. index of calibrators and re-inserting into main ms (hifv_fluxboot2)
make final cal tables (delay, BP, amp, phase) – makes finalcalibrators.ms (hifv_finalcals)
“semiFinal” delay & BP cals (not normalized, sp. index of BPcal not yet determined) (hifv_semiFinalBPdcals, hifv_checkflag, hifv_semiFinalBPdcals)

Flow chart


apply final calibrations to main ms (hifv_applycals)
run rflag on all fields, including target (hifv_targetflag)
run statwt to set weights using rms per spw (hifv_statwt)
make some diagnostic plots (hifv_plotsummary)
prepare list of calibrator images to make (hif_makeimlist)
make images of calibrators per spw (hif_makeimages)
science quality imaging (interactive)
VLA continuum imaging pipeline (experimental)

Pipeline Weblog

- Pipeline weblog is created in real-time (can check while running)
  - Sometimes browser security issues, informational page will render telling you how to fix the problem
  - located in *pipeline-YYYYMMDDTHHMMSS/html/index.html* in pipeline working directory
- Diagnostic plots and tables for most stages.
- CASA log file by task or as a whole (can be really large)
- Calibrator images per observing band.
- Example used here, and in our Pipeline CASA Guide:

https://casa.nrao.edu/Data/EVLA/Pipeline/CASA6.1.2/html/

https://casa.nrao.edu/Data/EVLA/Pipeline/CASA6.1.2/html/

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Observation Overview

Project	uid://evla/pdb/14411854
Principal Investigator	Prof. Dominik A. Riechers
Observation Start	2013-03-23 05:09:03 UTC
Observation End	2013-03-23 08:08:30 UTC

Pipeline Summary

Pipeline Version	2020.1.0.36
CASA Version	6.1.2.7 (environment)
Pipeline Start	2020-12-08 14:15:32 UTC
Execution Duration	1 day, 9:47:08

Observation Summary

Measurement Set	Receivers	Num Antennas	Time (UTC)			Baseline Length			Size
			Start	End	On Target	Min	Max	RMS	
Scheduling Block ID: uid://evla/pdbsb/17165245									
Session: default									
13A-398.sb17165245.eb19476558.56374.213876608796.ms	1cm (Ka)	27	2013-03-23 05:09:03	2013-03-23 08:08:30	2:17:48	40.0 m	1.0 km	441.9 m	146.0 GB

Pipeline Weblog

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Session: default

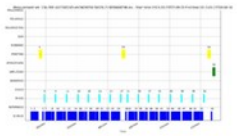
13A-398.sb17165245.eb19476558.56374.213876608

Overview of '13A-398.sb17165245.eb19476558.56374.213876608796.ms'

Observation Execution Time

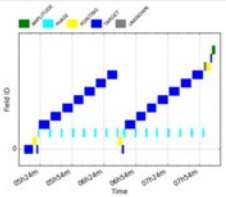
Start Time	2013-03-23 05:09:03
End Time	2013-03-23 08:08:30
Total Time on Source	2:55:04
Total Time on Science Target	2:17:48

LISTOBS OUTPUT



Intent vs Time

Track scan intent vs time



Field vs Time

Track observed field vs time

Spatial Setup

Science Targets	'CP1', 'CP2', 'CP3', 'CP4', 'CP5', 'CP6', 'CP7', 'J1041+0610' and 'J1331+3030'
Calibrators	'J1041+0610' and 'J1331+3030'

Spectral Setup

All Bands	'1cm (Ka)' and '3cm (X)'
Science Bands	'1cm (Ka)'
VLA Bands: Basebands: Freq range: [spws]	KA: A1C1: 34.975 GHz to 37.023 GHz: [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17] KA: A2C2: 36.975 GHz to 39.023 GHz: [18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33] KA: B1D1: 30.975 GHz to 33.023 GHz: [34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49] KA: B2D2: 32.975 GHz to 35.023 GHz: [50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65]

Antenna Setup

Min Baseline	40.0 m
Max Baseline	1.0 km
Number of Baselines	351
Number of Antennas	27

Sky Setup

Min Elevation	39.55 degrees
Max Elevation	82.72 degrees

Pipeline Weblog

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Session: Session_default

13A-398.sb17165245.eb19476558.56374.21

listobs.txt

BACK

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================================================================================
           MeasurementSet Name:  /lustre/aoc/sciops/emomjian/pipe-demo/13A-398.sb17165245.eb19476558.56374.213876608796.ms      MS Version 2
================================================================================
   Observer: Prof. Dominik A. Riechers     Project: uid://evla/pdb/14411854
Observation: EVLA
Data records: 72213336       Total elapsed time = 10767 seconds
   Observed from   23-Mar-2013/05:09:03.0   to   23-Mar-2013/08:08:30.0 (UTC)

   ObservationID = 0         ArrayID = 0
  Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)    ScanIntent
  23-Mar-2013/05:09:03.0 - 05:12:00.0     1      0 J1041+0610            124254  [0,1]  [1, 1] [OBSERVE_TARGET#UNSPECIFIED]
              05:12:03.0 - 05:16:57.0     2      0 J1041+0610           2201472  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
0,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65]  [3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
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              05:17:02.0 - 05:17:05.0     3      1 J1041+0610              2106  [0,1]  [1, 1] [UNSPECIFIED#UNSPECIFIED]
              05:17:06.0 - 05:20:30.0     4      1 J1041+0610            136188  [0,1]  [1, 1] [CALIBRATE_POINTING#ON_SOURCE]
              05:20:33.0 - 05:21:57.0     5      0 J1041+0610            628992  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:22:03.0 - 05:23:00.0     6      2 J1041+0610            426816  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:23:03.0 - 05:29:27.0     7      3 CP1                  2875392  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:29:30.0 - 05:32:24.0     8      3 CP1                  1302912  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:32:30.0 - 05:33:54.0     9      2 J1041+0610            628992  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:34:00.0 - 05:40:24.0    10      4 CP2                  2875392  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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Pipeline Weblog

Home | By Topic | By Task | Project Code N/A

Session: Session_default

13A-398.sb17165245.eb19476558.56374.21

listobs.txt

BACK

```
================================================================================
           MeasurementSet Name:  /lustre/aoc/sciops/emomjian/pipe-demo/13A-398.sb17165245.eb19476558.56374.213876608796.ms      MS Version 2
================================================================================
   Observer: Prof. Dominik A. Riechers     Project: uid://evla/pdb/14411854
Observation: EVLA
Data records: 72213336       Total elapsed time = 10767 seconds
   Observed from   23-Mar-2013/05:09:03.0   to   23-Mar-2013/08:08:30.0 (UTC)

   ObservationID = 0         ArrayID = 0
  Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)    ScanIntent
  23-Mar-2013/05:09:03.0 - 05:12:00.0     1      0 J1041+0610             124254  [0,1]  [1, 1] [OBSERVE_TARGET#UNSPECIFIED]
              05:12:03.0 - 05:16:57.0     2      0 J1041+0610            2201472  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3] [OBSERVE_TARGET#UNSPECIFIED]
              05:17:02.0 - 05:17:05.0     3      1 J1041+0610               2106  [0,1]  [1, 1] [UNSPECIFIED#UNSPECIFIED]
              05:17:06.0 - 05:20:30.0     4      1 J1041+0610             136188  [0,1]  [1, 1] [CALIBRATE_POINTING#ON_SOURCE]
              05:20:33.0 - 05:21:57.0     5      0 J1041+0610             628992  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:22:03.0 - 05:23:00.0     6      2 J1041+0610             426816  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:23:03.0 - 05:29:27.0     7      3 CP1                   2875392  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:29:30.0 - 05:32:24.0     8      3 CP1                   1302912  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
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              05:32:30.0 - 05:33:54.0     9      2 J1041+0610             628992  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
0,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65]  [3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3] [CALIBRATE_AMPLI#UNSPECIFIED,CALIBRATE_PHASE#UNSPECIFIED]
              05:34:00.0 - 05:40:24.0    10      4 CP2                   2875392  [2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,4
0,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65]  [3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3] [OBSERVE_TARGET#UNSPECIFIED]
```
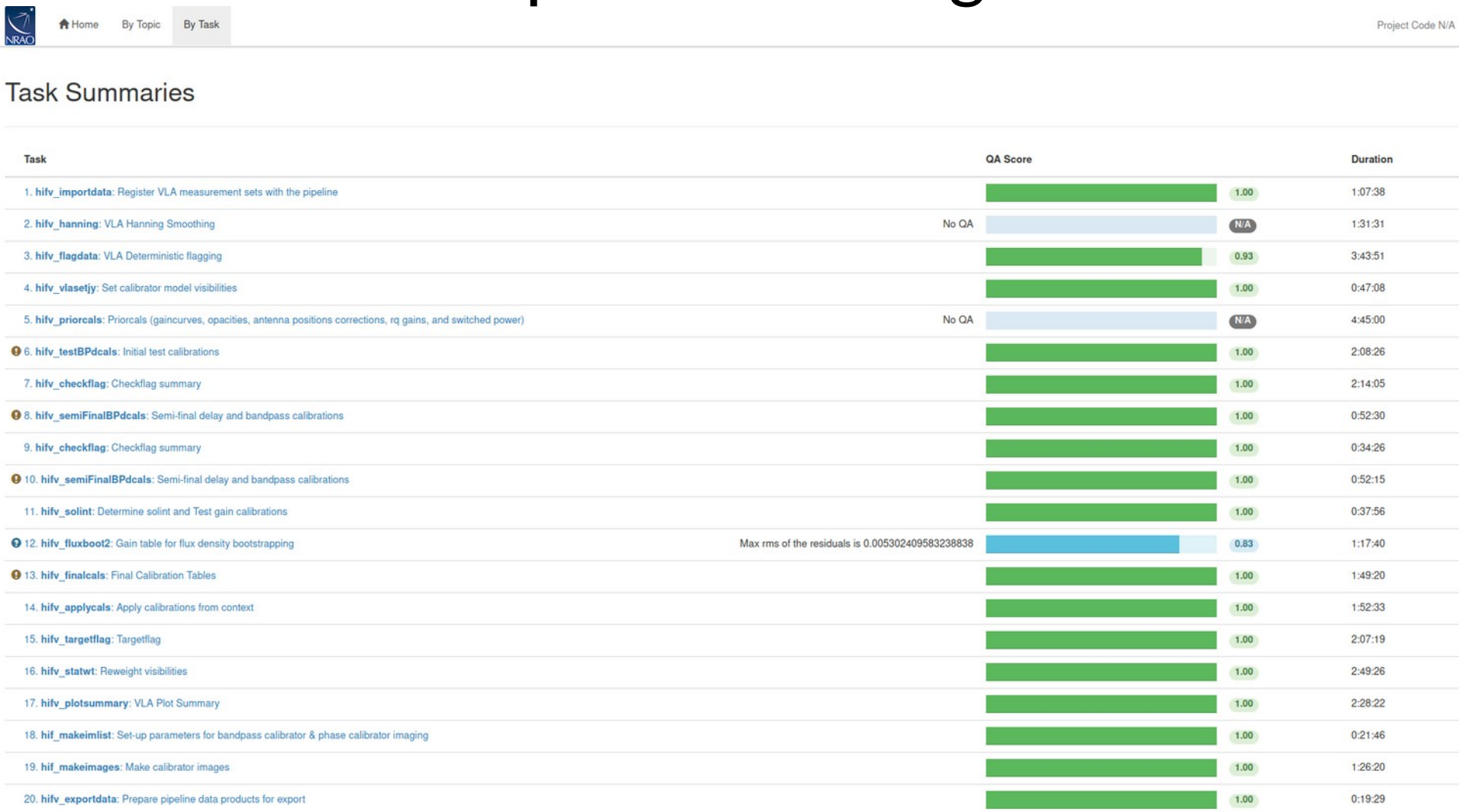

Pipeline Weblog



Pipeline Weblog

- The following pipeline steps provide key checks for calibration quality:
  - hifv_flagdata *deterministic flagged data fraction*
  - hifv_testBPdcals *hardware problems and other obs. issues*
  - hifv_solint *solution intervals for phase cals, input gain tables*
  - hifv_fluxboot2 *fitted calibrator flux densities and spectral indices*
  - hifv_finalcals *final calibration tables applied to the data*
  - hifv_plotsummary *useful diagnostic plots of calibrated data*

Deterministic Flags (hifv_flagdata)

Home | By Topic | By Task

Project Code N/A

Tasks in execution order

1. hifv_importdata
2. hifv_hanning
3. hifv_flagdata
4. hifv_vlasetjy
5. hifv_priorcals
6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

3. VLA Deterministic Flagging

BACK

Flagging agents

Measurement Set	ANOS	Shadowed Antennas	Unwanted Intents	Other Online Flags	Flagging Template	Autocorr	Edge Channels	Clipping	Quack	Baseband	Agent Commands
13A-398.sb17165245.eb19476558.56374.213876608796.ms	✔	✔	✔	✔	✖	✔	✔	✔	✔	✔	View

Flagging agent status per measurement set.

Template Files

	Other Online Flags		Flagging Template	
Measurement Set	File	Number of Statements	File	Number of Statements
13A-398.sb17165245.eb19476558.56374.213876608796.ms	13A-398.sb17165245.eb19476558.56374.213876608796.flagonline.txt	2665		

Files used for template flagging steps.

Flagged data summary

		Flagging Agent (Total Vis)			Flagging Agent (Science Vis)								Measurement Set
Data Selection (by intent)	Before Task	ANOS	Shadowed Antennas	Unwanted Intents	Other Online Flags	Flagging Template	Autocorr	Edge Channels	Clipping	Quack	Baseband	Total Science	13A-398.sb17165245.eb19476558.56374.213876608796.m
All Data	3.12%	10.20%	0.00%	0.28%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	8.84%
Science Spectral Windows	3.12%	9.76%	0.00%	0.00%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	8.84%
Bandpass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Flux	3.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.45%	0.08%	3.22%	1.36%	11.12%	11.12%
Phase	3.12%	35.09%	0.00%	0.00%	0.24%	0.00%	0.00%	6.44%	0.23%	1.26%	1.39%	9.56%	9.56%
Target	3.12%	6.05%	0.00%	0.00%	0.82%	0.00%	0.00%	6.40%	0.09%	0.00%	1.40%	8.71%	8.71%
13A-398.sb17165245.eb19476558.56374.213876608796.ms	3.12%	10.20%	0.00%	0.28%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	

Deterministic Flags (hifv_flagdata)

Home | By Topic | By Task

Project Code N/A

Tasks in execution order

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2. hifv_hanning
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6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

Data Selection (by intent)	Before Task	ANOS	Shadowed Antennas	Unwanted Intents	Other Online Flags	Flagging Template	Autocorr	Edge Channels	Clipping	Quack	Baseband	Total Science	13A-398.sb17165245.eb19476558.56374.213876608796.m
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Science Spectral Windows	3.12%	9.76%	0.00%	0.00%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	8.84%
Bandpass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Flux	3.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.45%	0.08%	3.22%	1.36%	11.12%	11.12%
Phase	3.12%	35.09%	0.00%	0.00%	0.24%	0.00%	0.00%	6.44%	0.23%	1.26%	1.39%	9.56%	9.56%
Target	3.12%	6.05%	0.00%	0.00%	0.82%	0.00%	0.00%	6.40%	0.09%	0.00%	1.40%	8.71%	8.71%
13A-398.sb17165245.eb19476558.56374.213876608796.ms	3.12%	10.20%	0.00%	0.28%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	

Summary of flagged data. Each cell states the amount of data flagged as a fraction of the specified data selection, with the *Flagging Agent* columns giving this information per flagging agent.

Flagging reason vs time

Plots of flagging reason vs time. The reasons for flagging the data are defined in the plot legend.

13A-398.sb17165245.eb19476558.56374.213876608796.ms

Pipeline QA

Input Parameters

Tasks Execution Statistics

Deterministic Flags (hifv_flagdata)

Home | By Topic | By Task

Project Code N/A

Tasks in execution order

1. hifv_importdata
2. hifv_hanning
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6. hifv_testBPdcals
7. hifv_checkflag
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12. hifv_fluxboot2
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14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

Data Selection (by intent)	Before Task	ANOS	Shadowed Antennas	Unwanted Intents	Other Online Flags	Flagging Template	Autocorr	Edge Channels	Clipping	Quack	Baseband	Total Science	13A-398.sb17165245.eb19476558.56374.213876608796.m
All Data	3.12%	10.20%	0.00%	0.28%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	8.84%
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Bandpass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Flux	3.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.45%	0.08%	3.22%	1.36%	11.12%	11.12%
Phase	3.12%	35.09%	0.00%	0.00%	0.24%	0.00%	0.00%	6.44%	0.23%	1.26%	1.39%	9.56%	9.56%
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13A-398.sb17165245.eb19476558.56374.213876608796.ms	3.12%	10.20%	0.00%	0.28%	0.75%	0.00%	0.00%	6.40%	0.11%	0.19%	1.40%	8.84%	

Summary of flagged data. Each cell states the amount of data flagged as a fraction of the specified data selection, with the *Flagging Agent* columns giving this information per flagging agent.

Flagging reason vs time

Plots of flagging reason vs time. The reasons for flagging the data are defined in the plot legend.

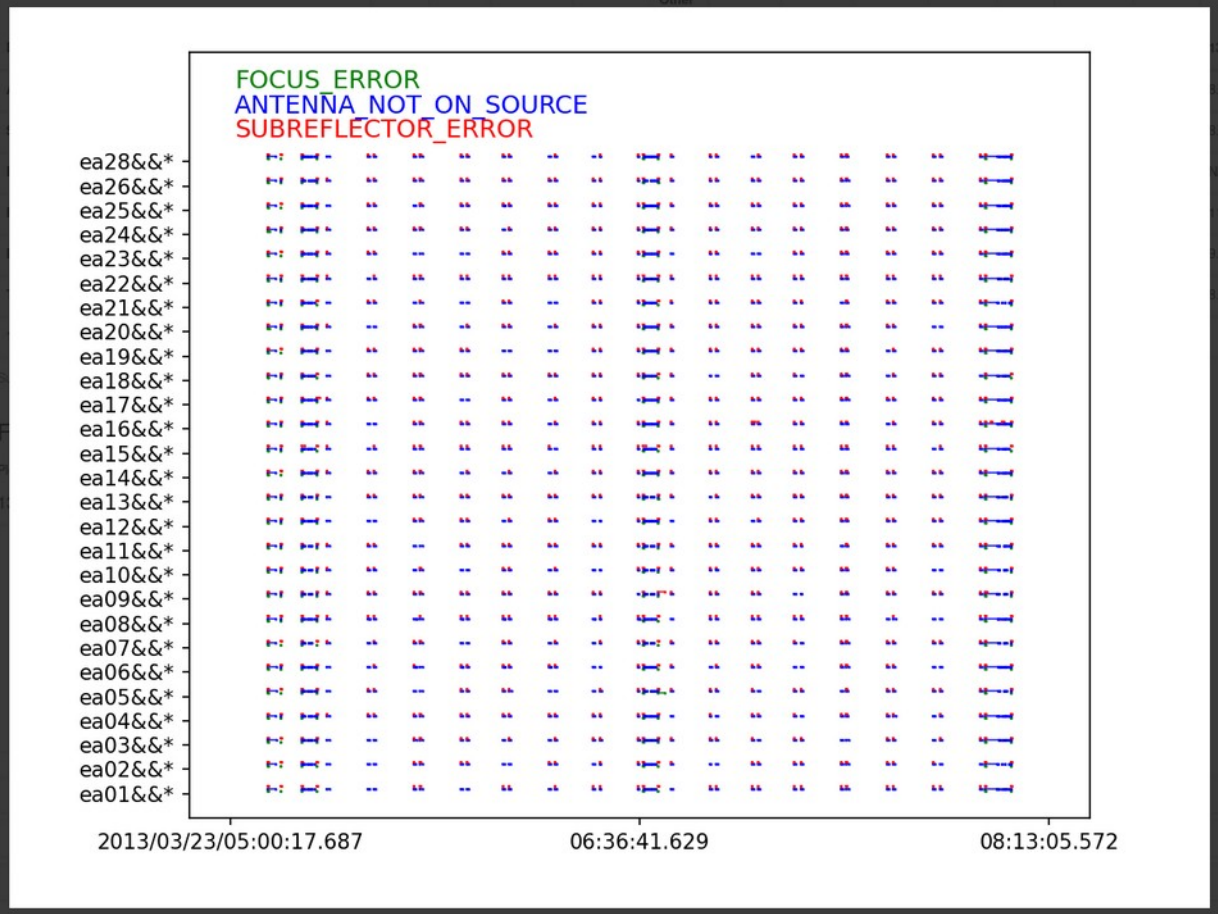
13A-398.sb17165245.eb19476558.56374.213876608796.ms

Pipeline QA

Input Parameters

Tasks Execution Statistics

Deterministic Flags (hifv_flagdata)



Hardware Issues (hifv_testBPdcals)

Tasks in execution order

1. hifv_importdata
2. hifv_hanning
3. hifv_flagdata
4. hifv_vlasetjy
5. hifv_priorcals
6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

Task notifications

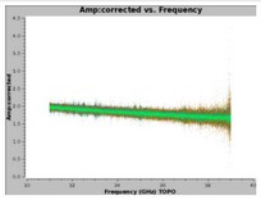
Warning! Antenna ea21, spws: 50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65 have a flagging fraction of 1.0.

Initial test calibrations using bandpass and delay calibrators

Plots: Test delay plots | Gain Amplitude | Gain Phase | BP Amp solution | BP Phase solution

testBPdcals summary plot

13A-398.sb17165245.eb19476558.56374.213876608796.ms



Initial calibrated bandpass

Flag bad deformatters

Identify and flag basebands with bad deformatters or RFI based on bandpass (BP) table amps and phases.

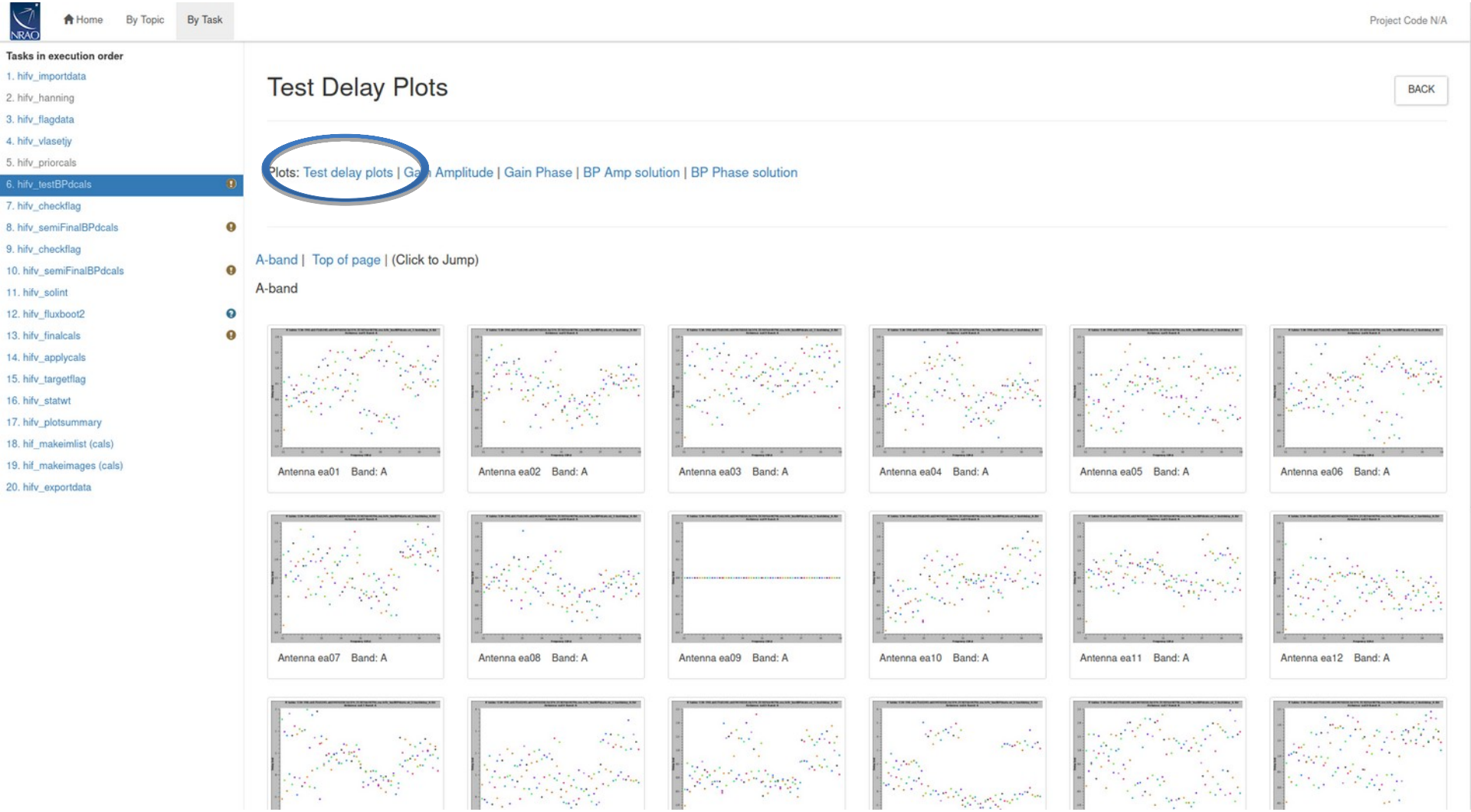
BP Table Amps

Antenna	SPWs	Band / Basebands
None	None	A

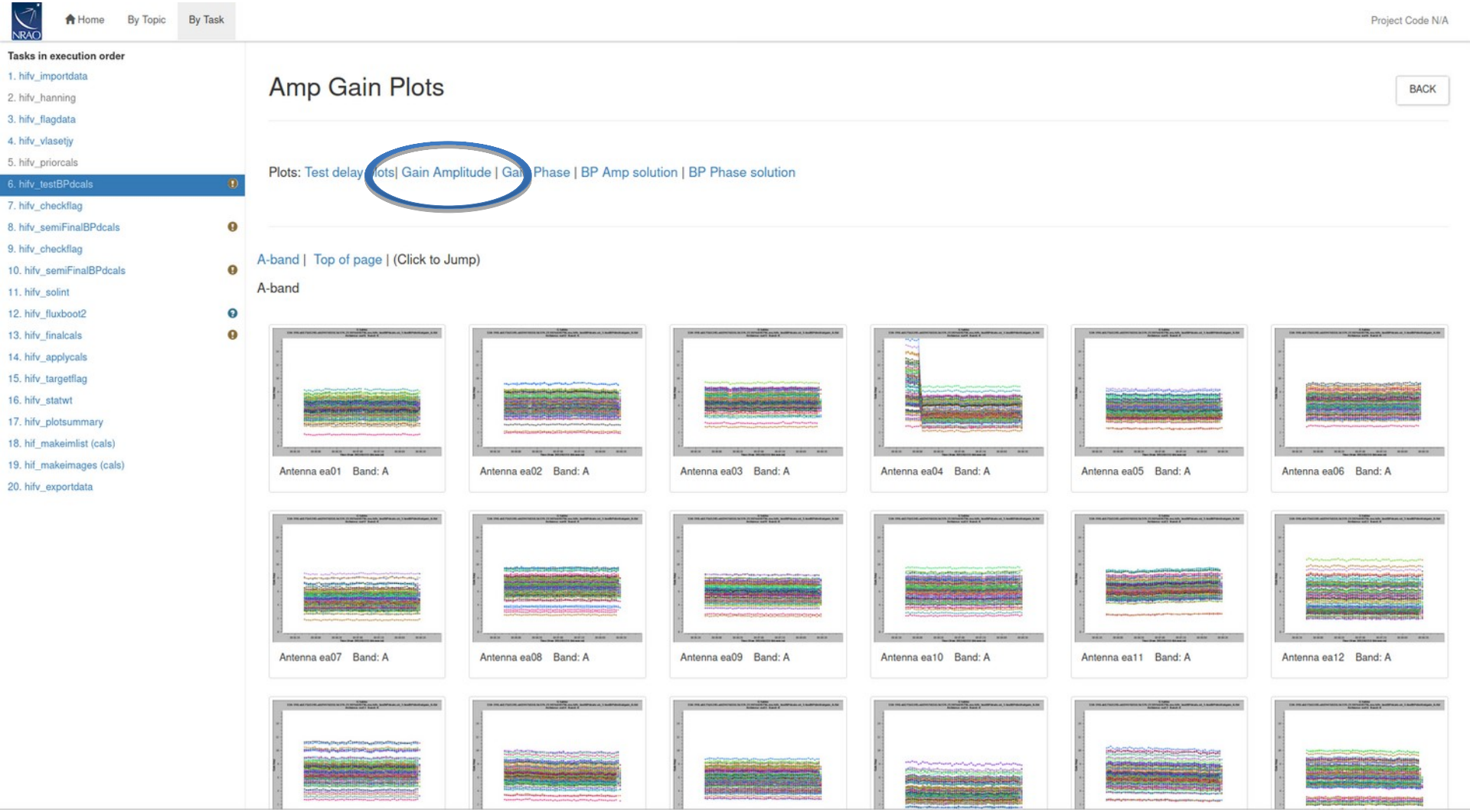
BP Table Phases

Antenna	SPWs	Band / Basebands
None	None	A

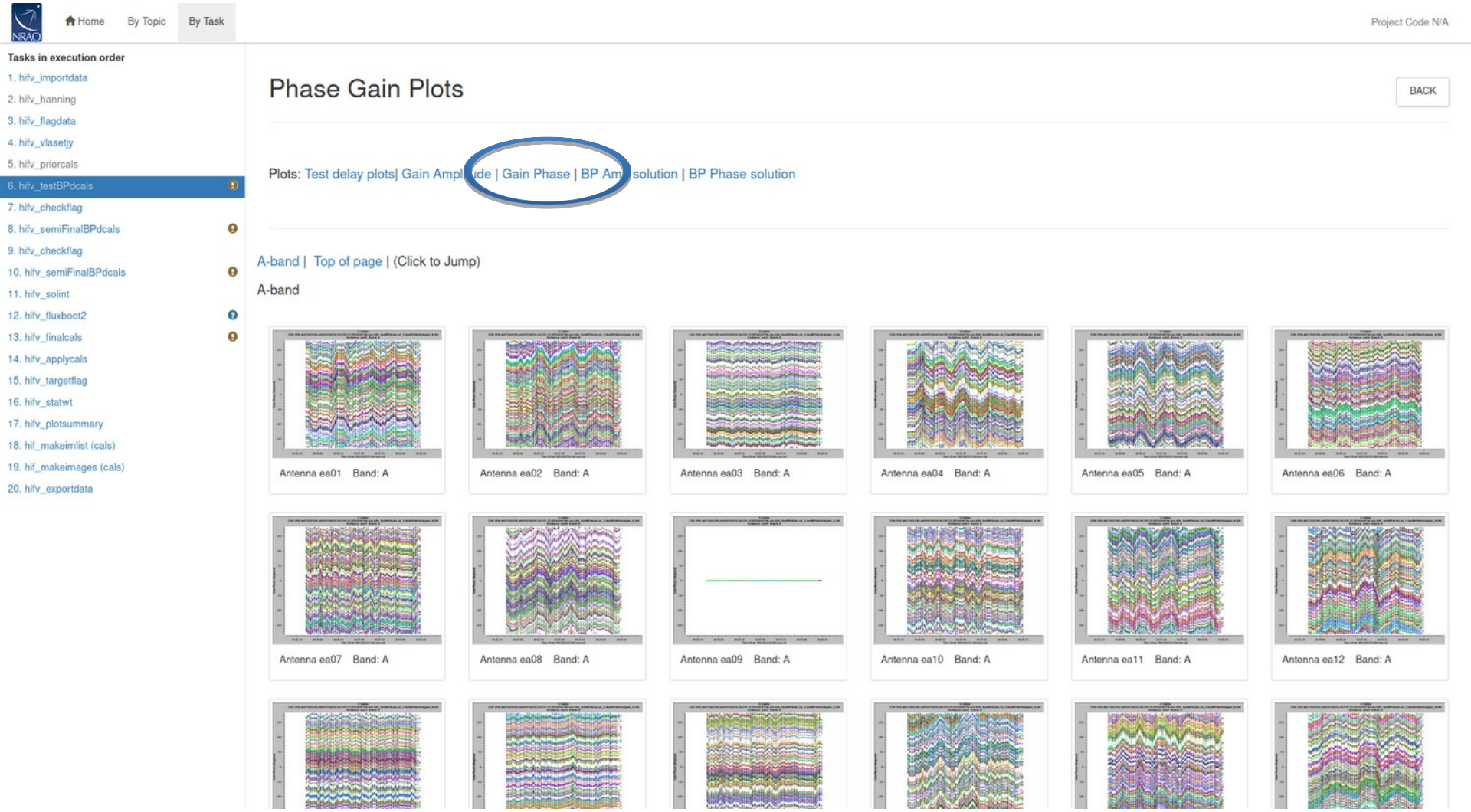
Hardware Issues (hifv_testBPdcals)



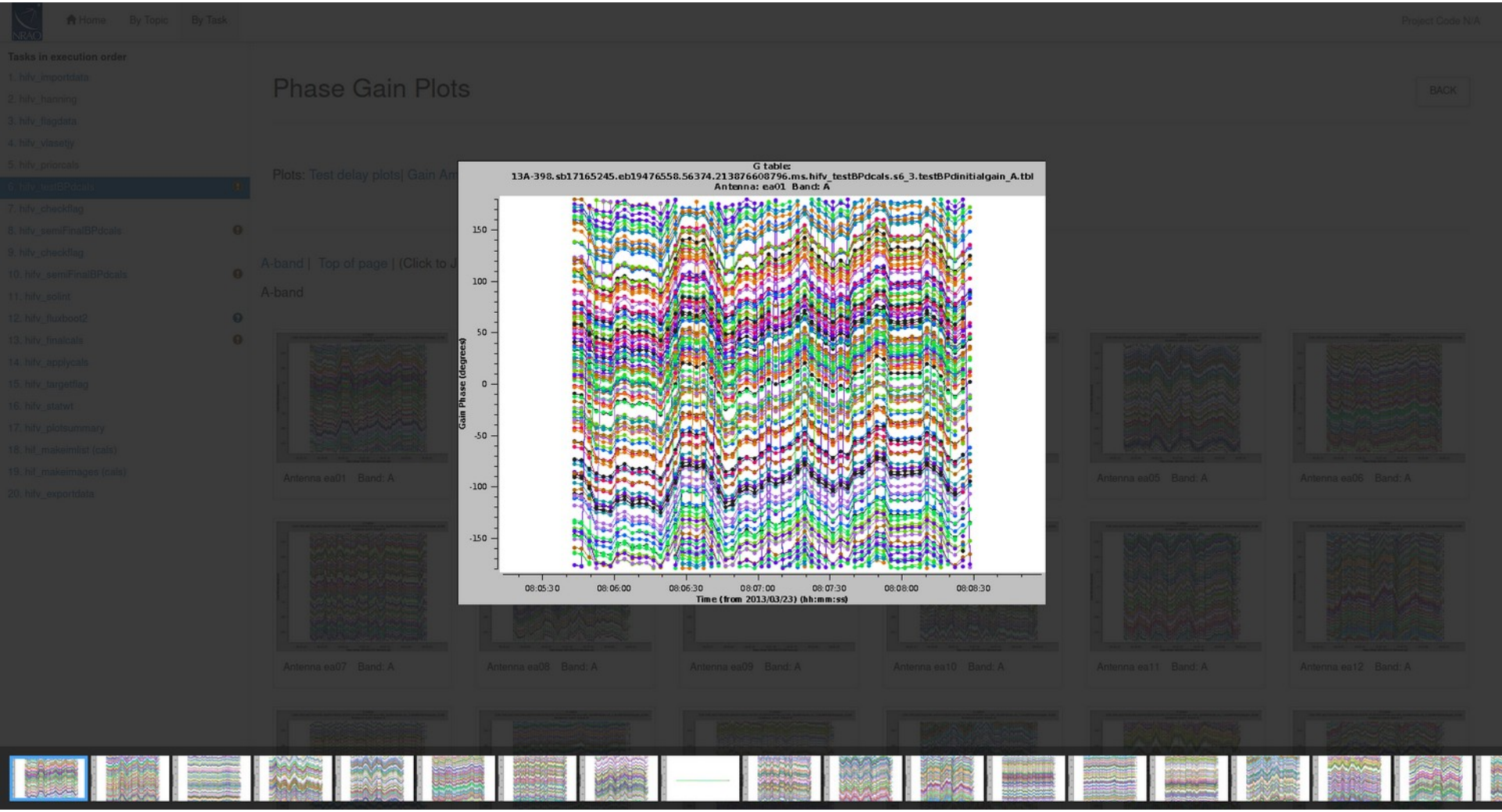
Hardware Issues (hifv_testBPdcals)



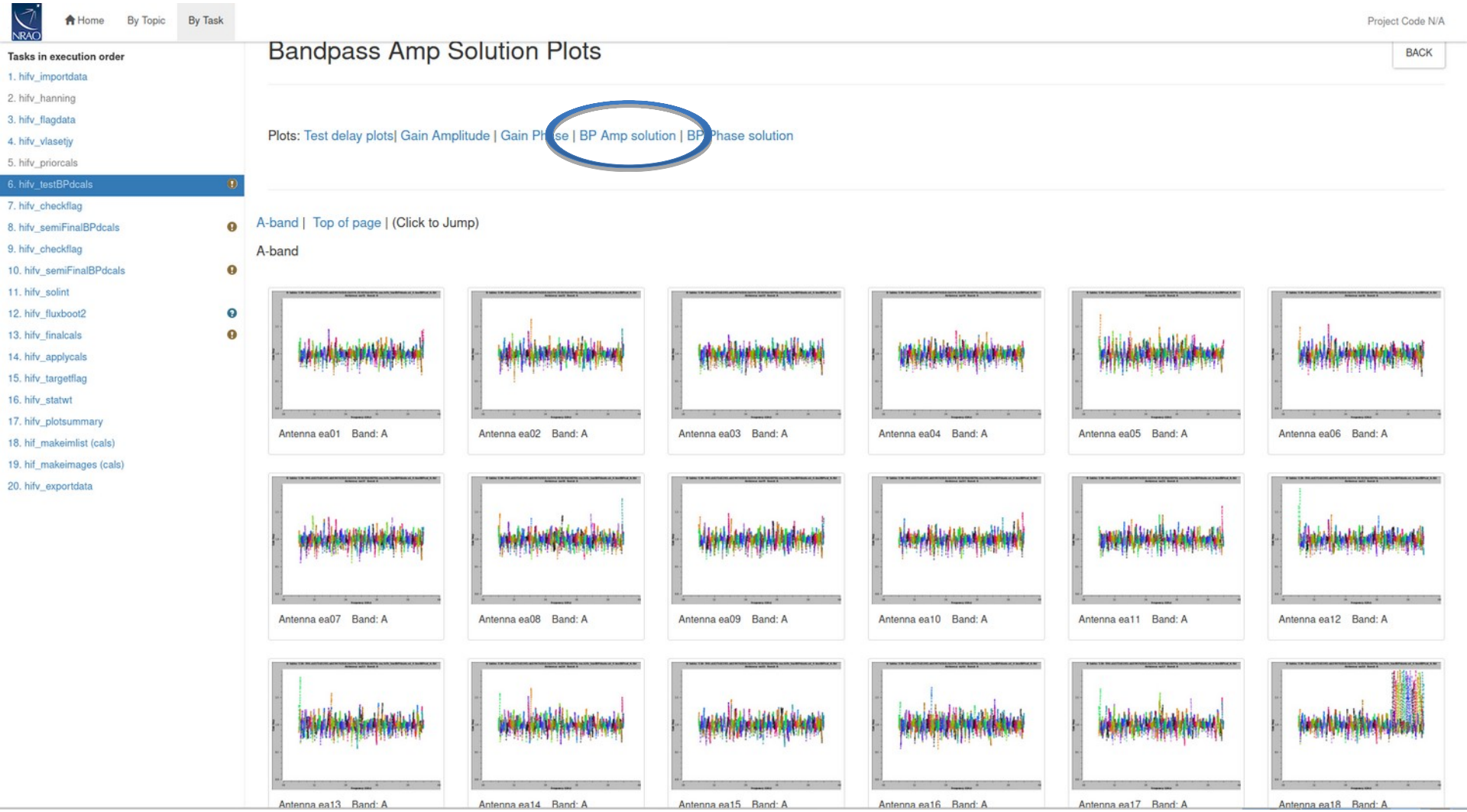
Hardware Issues (hifv_testBPdcals)



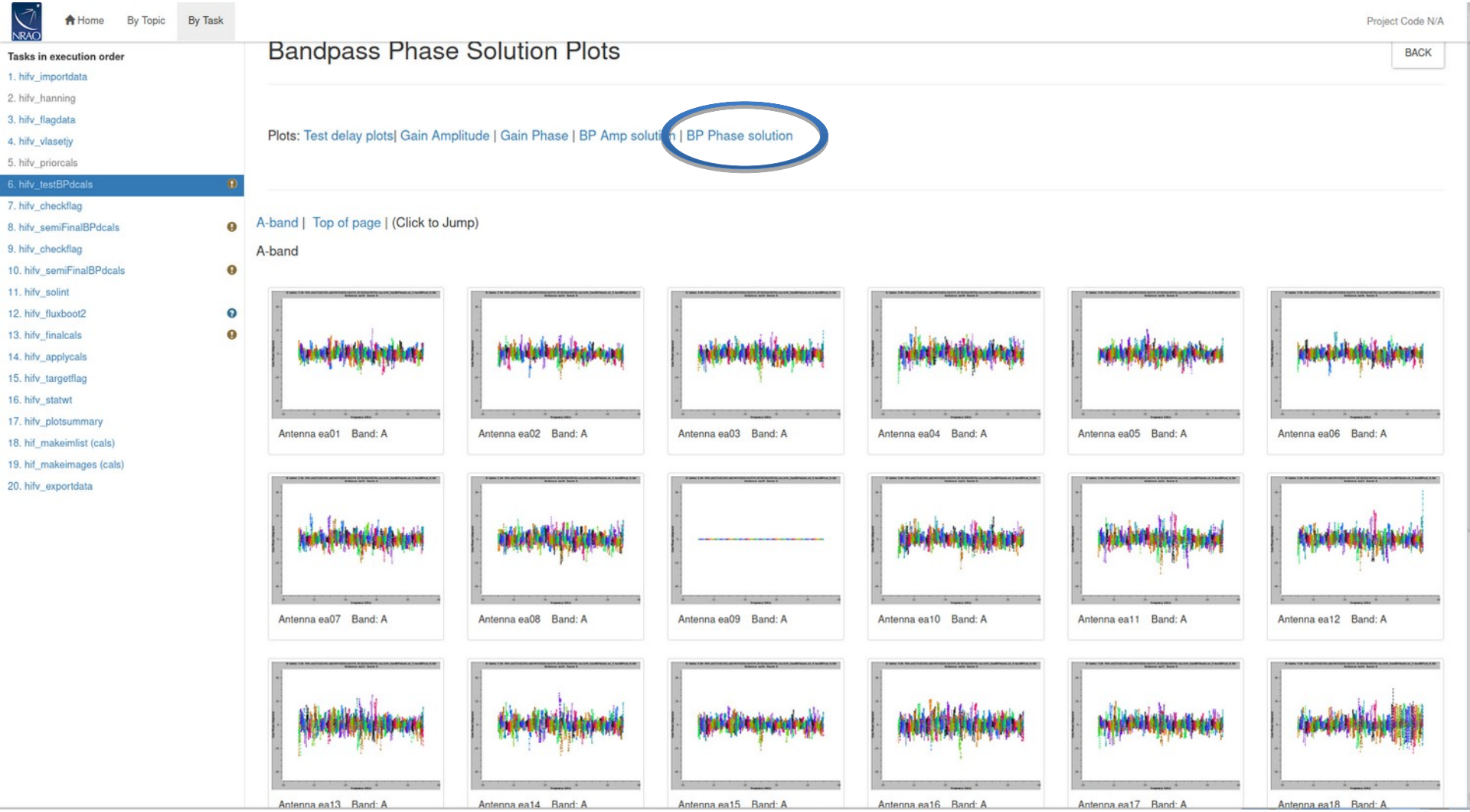
Hardware Issues (hifv_testBPdcals)



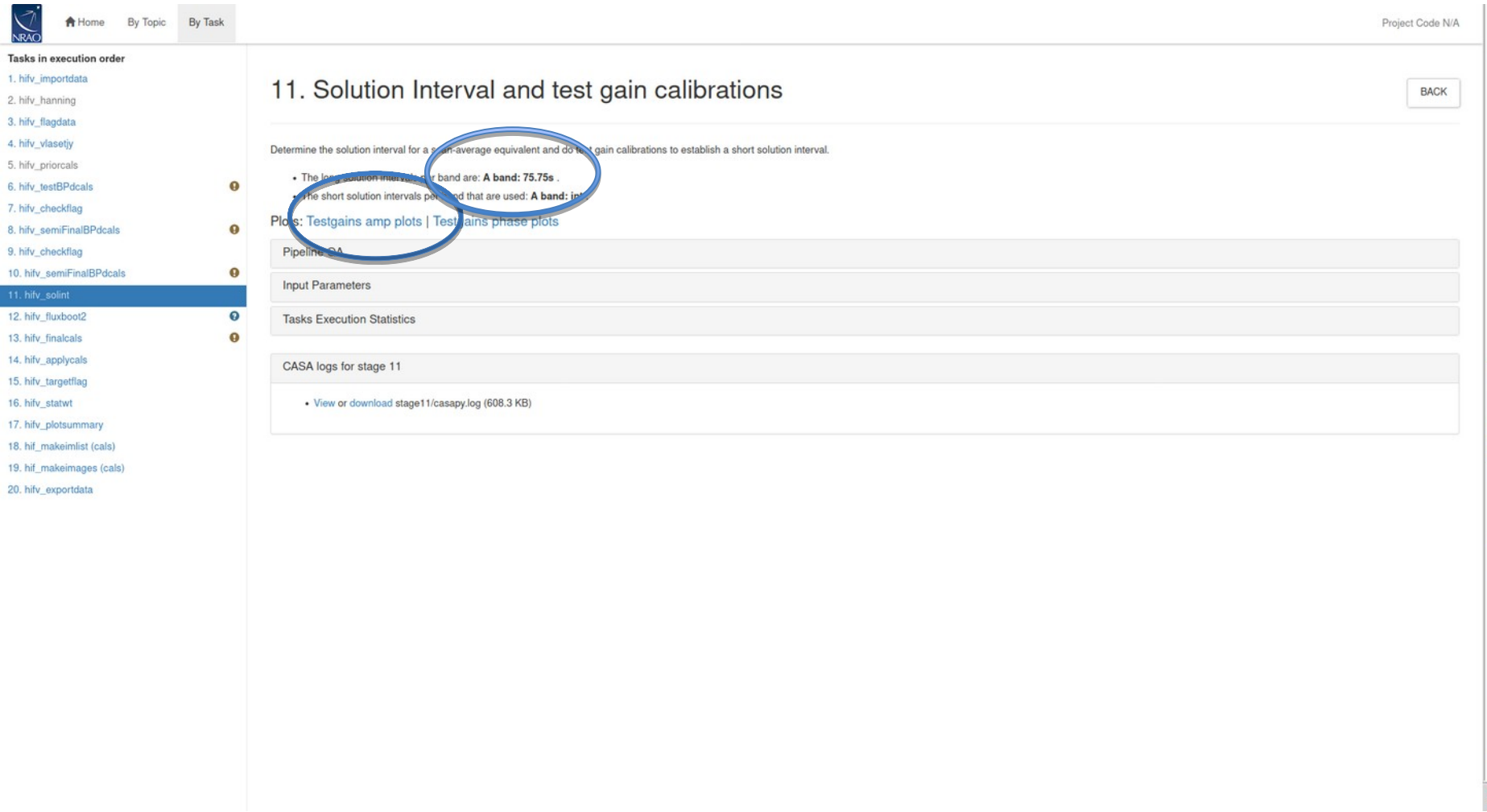
Hardware Issues (hifv_testBPdcals)



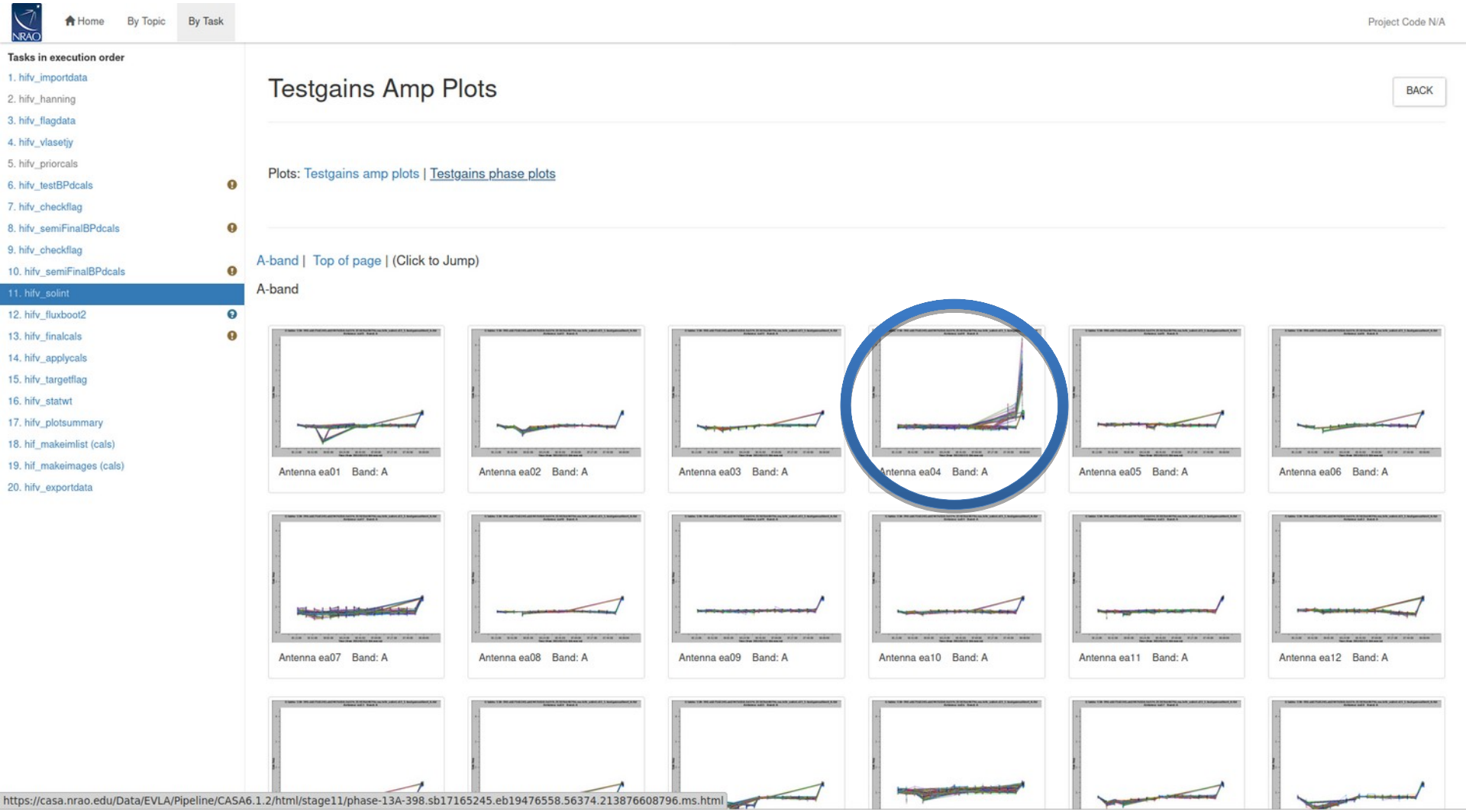
Hardware Issues (hifv_testBPdcals)



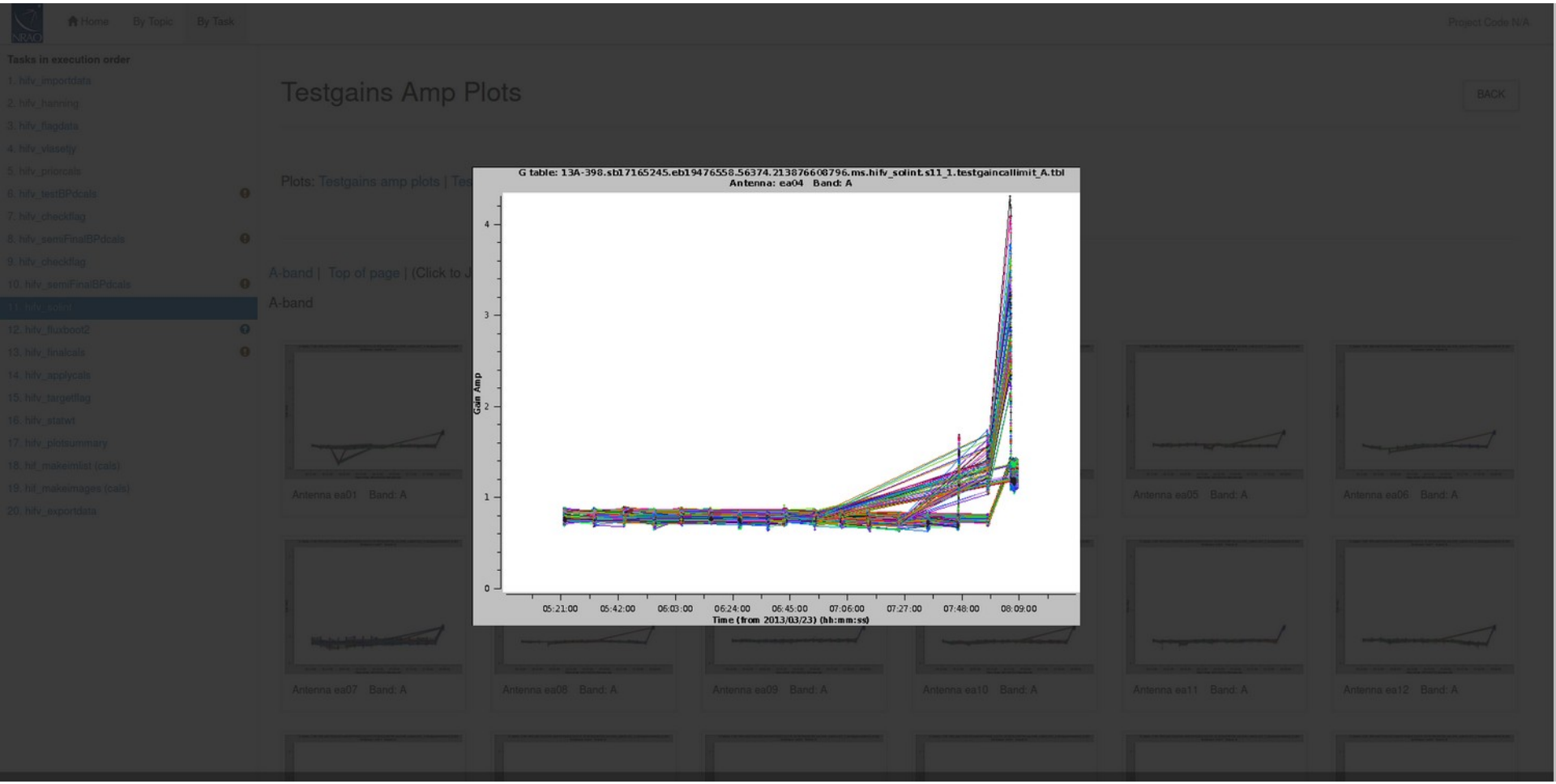
Gain Solution Intervals (hifv_solint)



Gain Solution Intervals (hifv_solint)



Gain Solution Intervals (hifv_solint)



Flux Density Bootstrapping (hifv_fluxboot2)

Home | By Topic | By Task | Project Code N/A

Tasks in execution order

1. hifv_importdata
2. hifv_hanning
3. hifv_flagdata
4. hifv_vlasetjy
5. hifv_priorcals
6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
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17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

12. Flux density bootstrapping and spectral index fitting

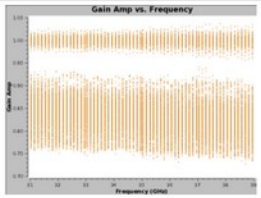
BACK

Make a gain table that includes gain and opacity corrections for final amp cal and for flux density bootstrapping.

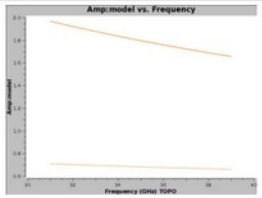
Fit the spectral index of calibrators with a power-law and put the fit in the model column.

Fluxboot summary plots

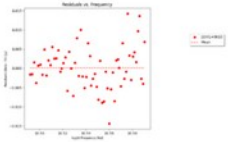
13A-398.sb17165245.eb19476558.56374.213876608796.ms



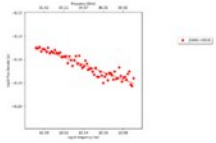
Caltable: fluxgaincal.g. Plot of amp vs. freq.



Model calibrator. Plot of amp vs. freq.



Fluxboot residuals vs. frequency



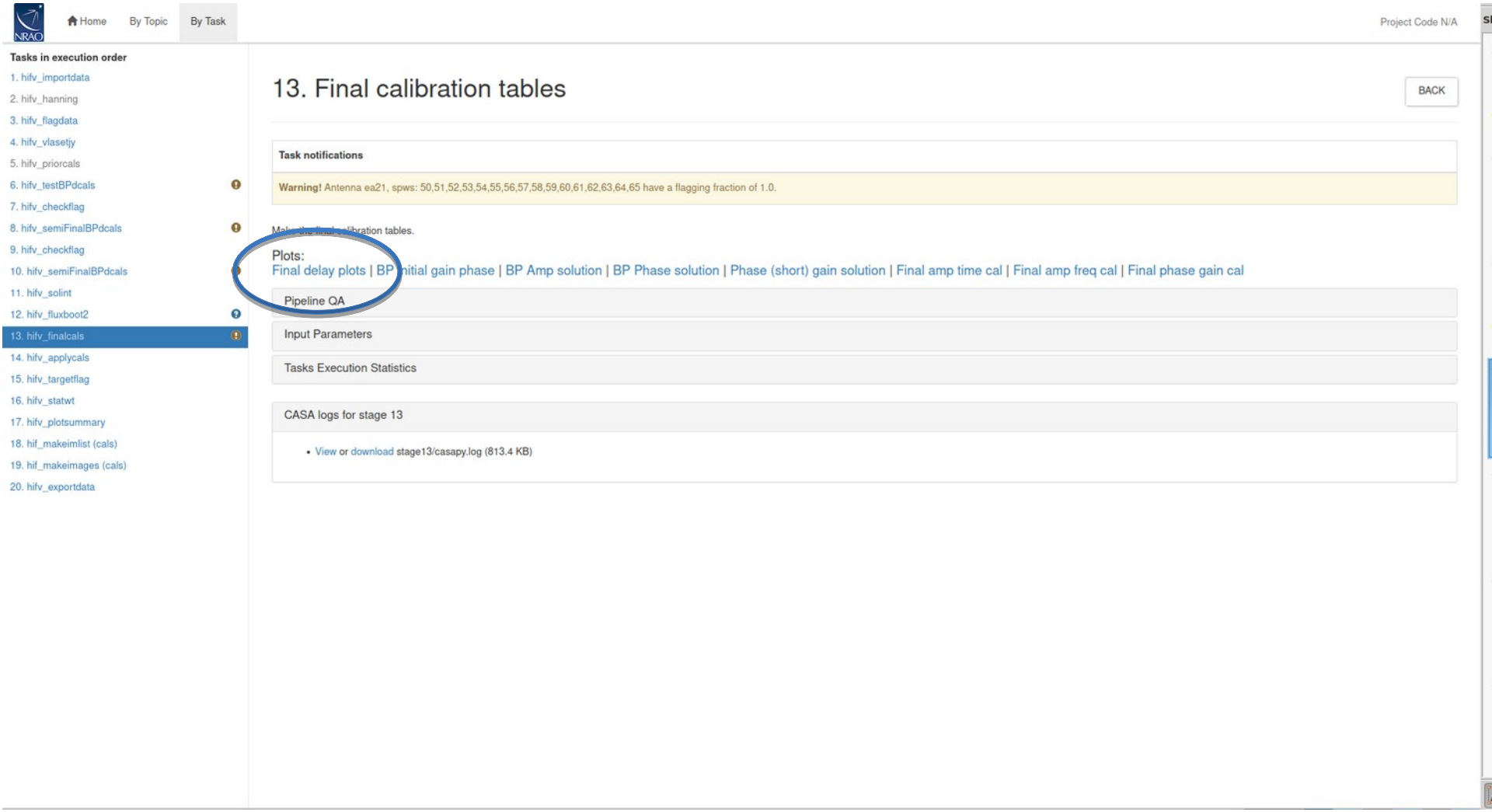
Flux vs. frequency

Source	Fit Order	Band	Band Center [GHz]	Flux density [Jy] (at Band Center)	Spectral Index	2nd order coeff	3rd order coeff	4th order coeff
J1041+0610	1	A	35.00000	0.68286 +/- 0.00064	-0.31871 +/- 0.01398	----	----	----

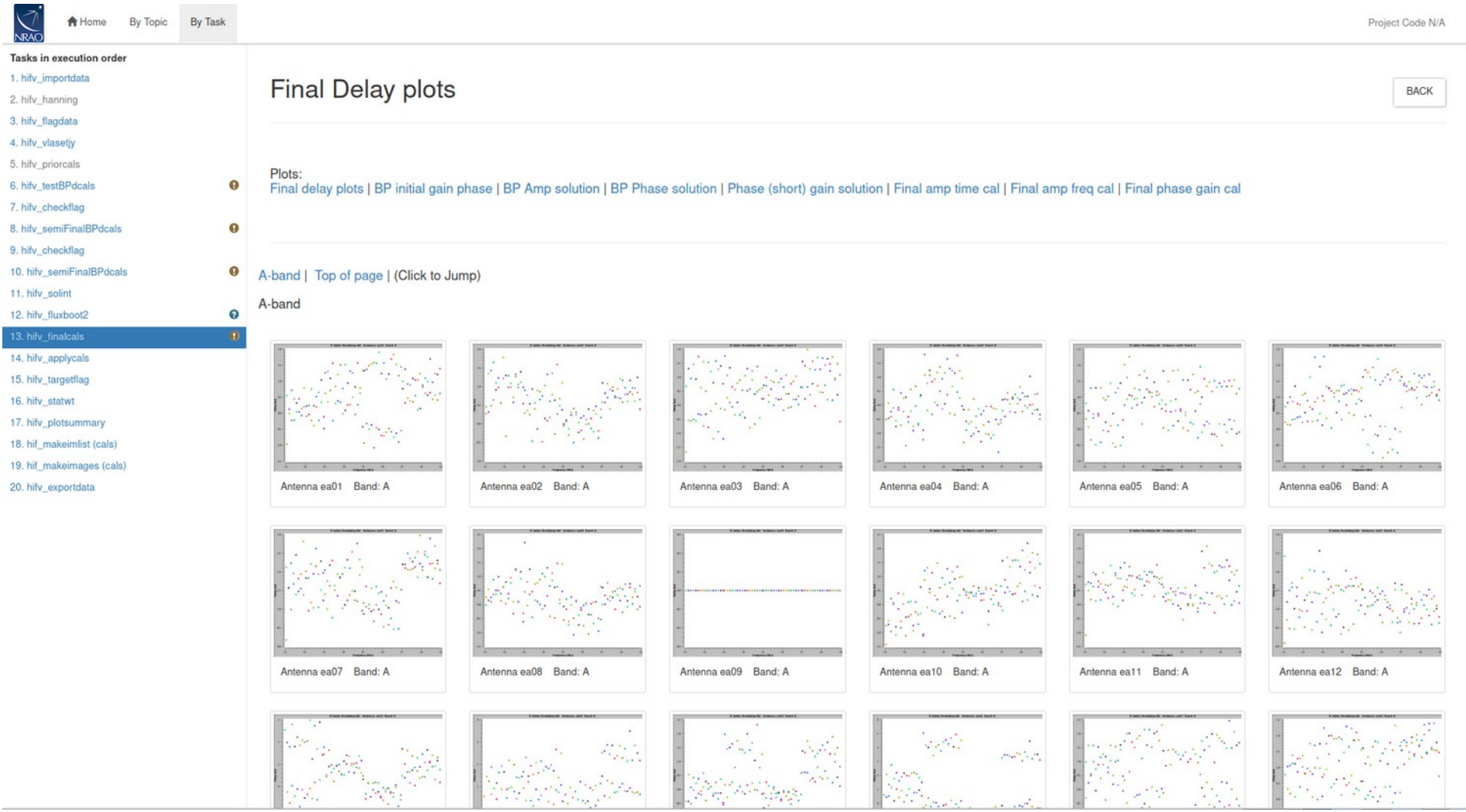
Table showing the flux density and spectral properties computed at each band center, based on the global coefficients of the fit across all bands.

Source	Frequency [GHz]	Data	Error	Fitted Data	Residual: Data-Fitted Data
J1041+0610	31.039	0.7079	0.005843	0.7095	-0.001558
	31.167	0.7074	0.006000	0.7086	-0.001493
	31.295	0.7092	0.007022	0.7077	0.001584
	31.423	0.7029	0.005594	0.7067	-0.003784
	31.551	0.7065	0.005343	0.7058	0.000720
	31.679	0.7059	0.005863	0.7049	0.000973
	31.807	0.7024	0.005819	0.7040	-0.001650
	31.935	0.7080	0.006131	0.7031	0.004930

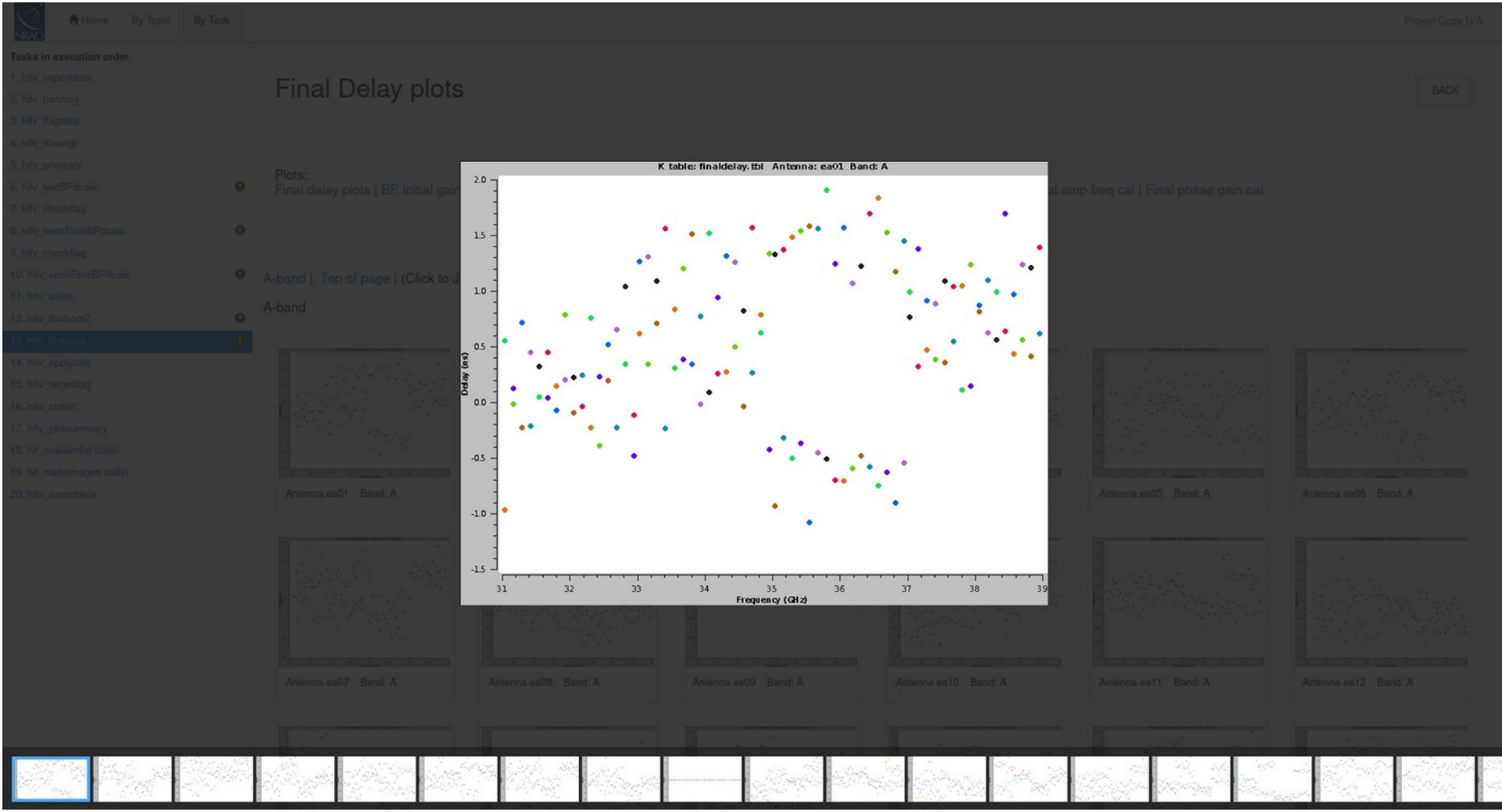
Final Calibration Tables (hifv_finalcals)



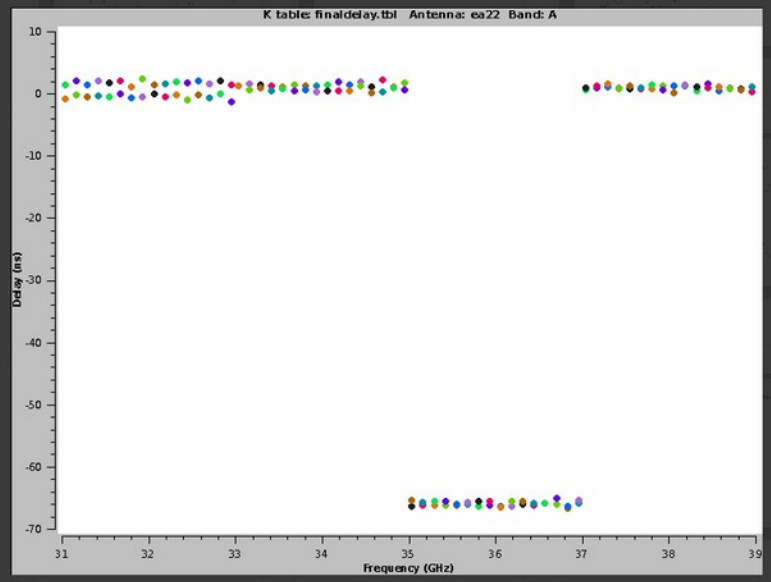
Final Calibration Tables (hifv_finalcals)



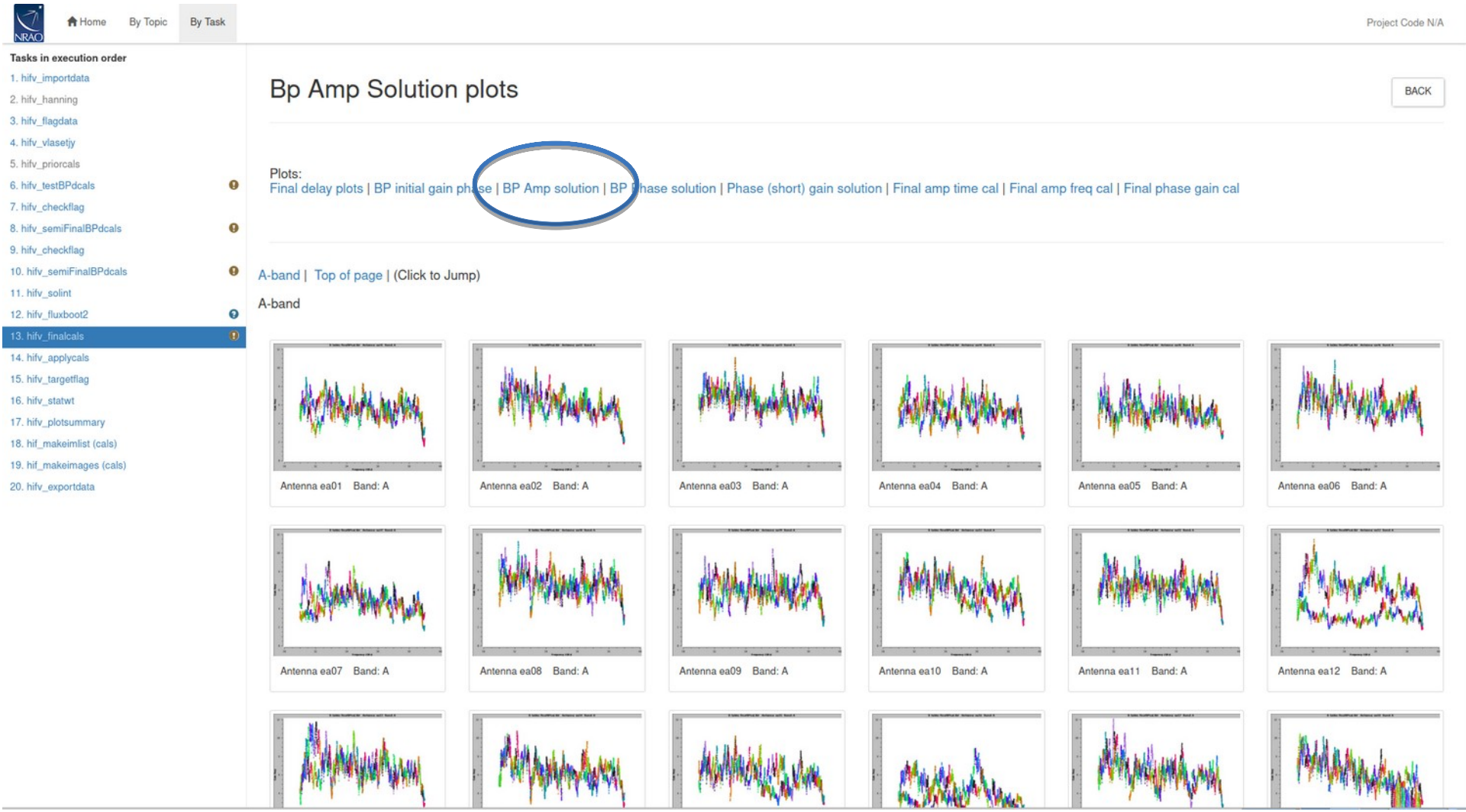
Final Calibration Tables (hifv_finalcals)



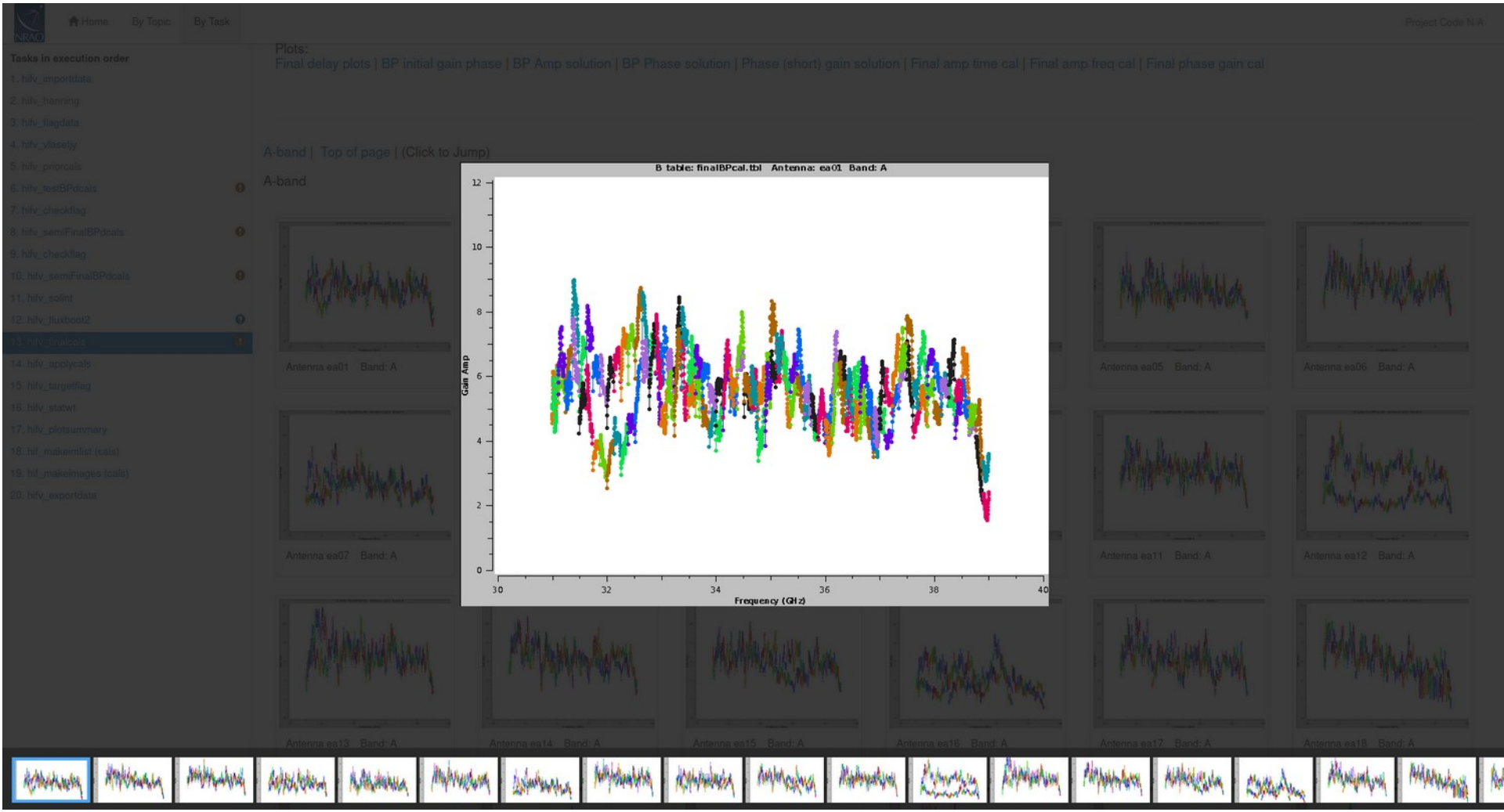
Final Calibration Tables (hifv_finalcals)



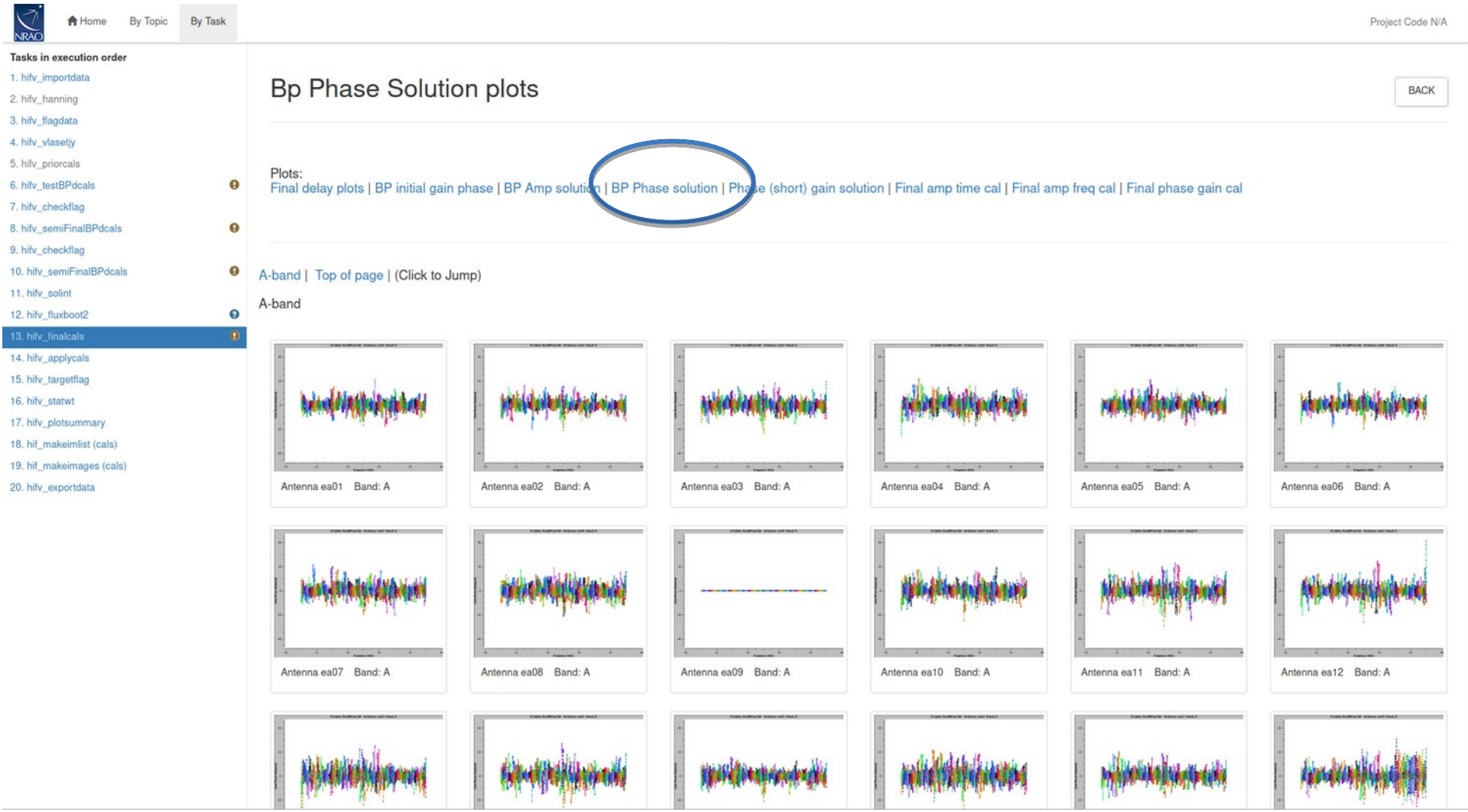
Final Cal Tables: bandpass



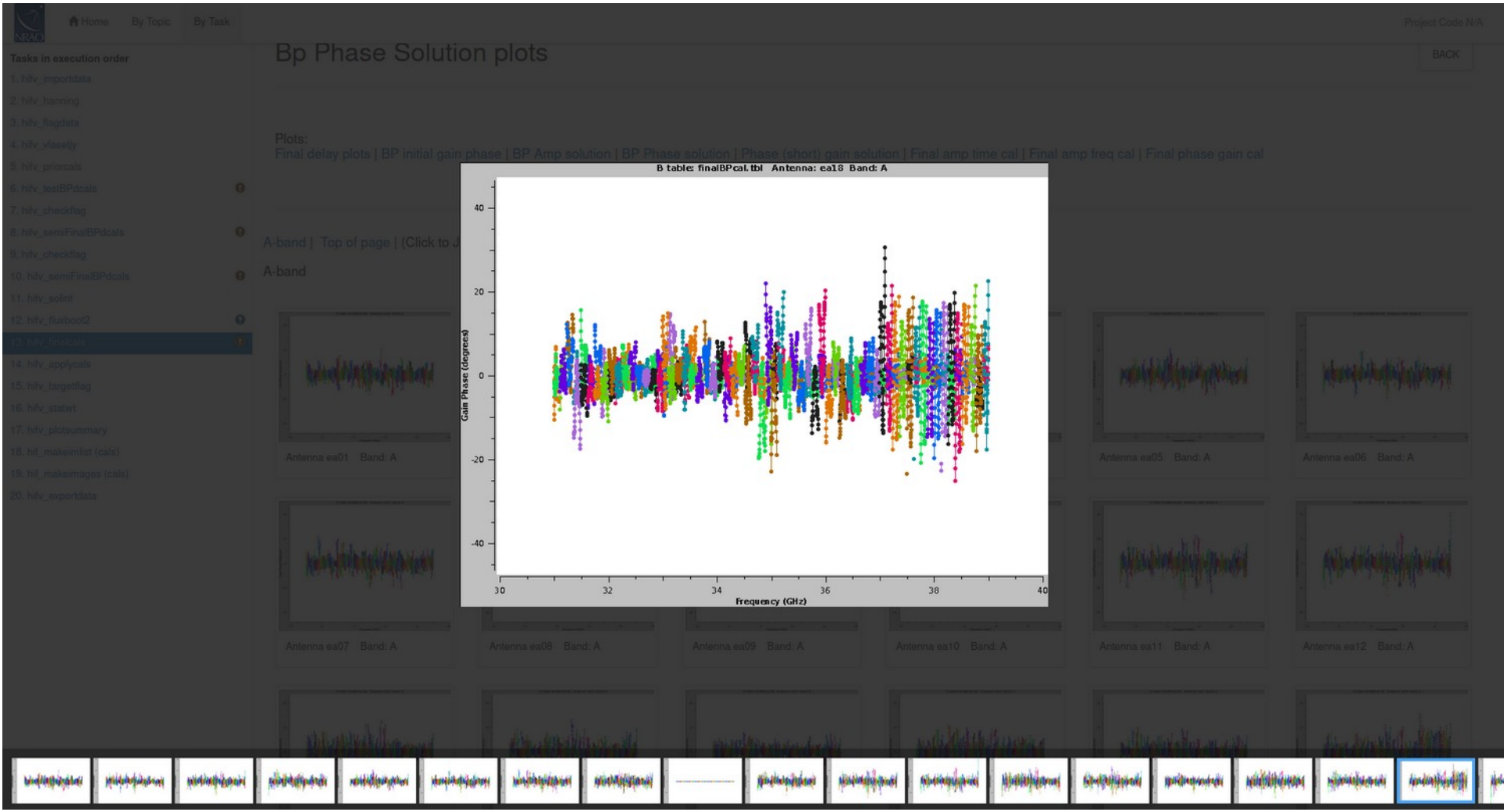
Final Cal Tables: bandpass



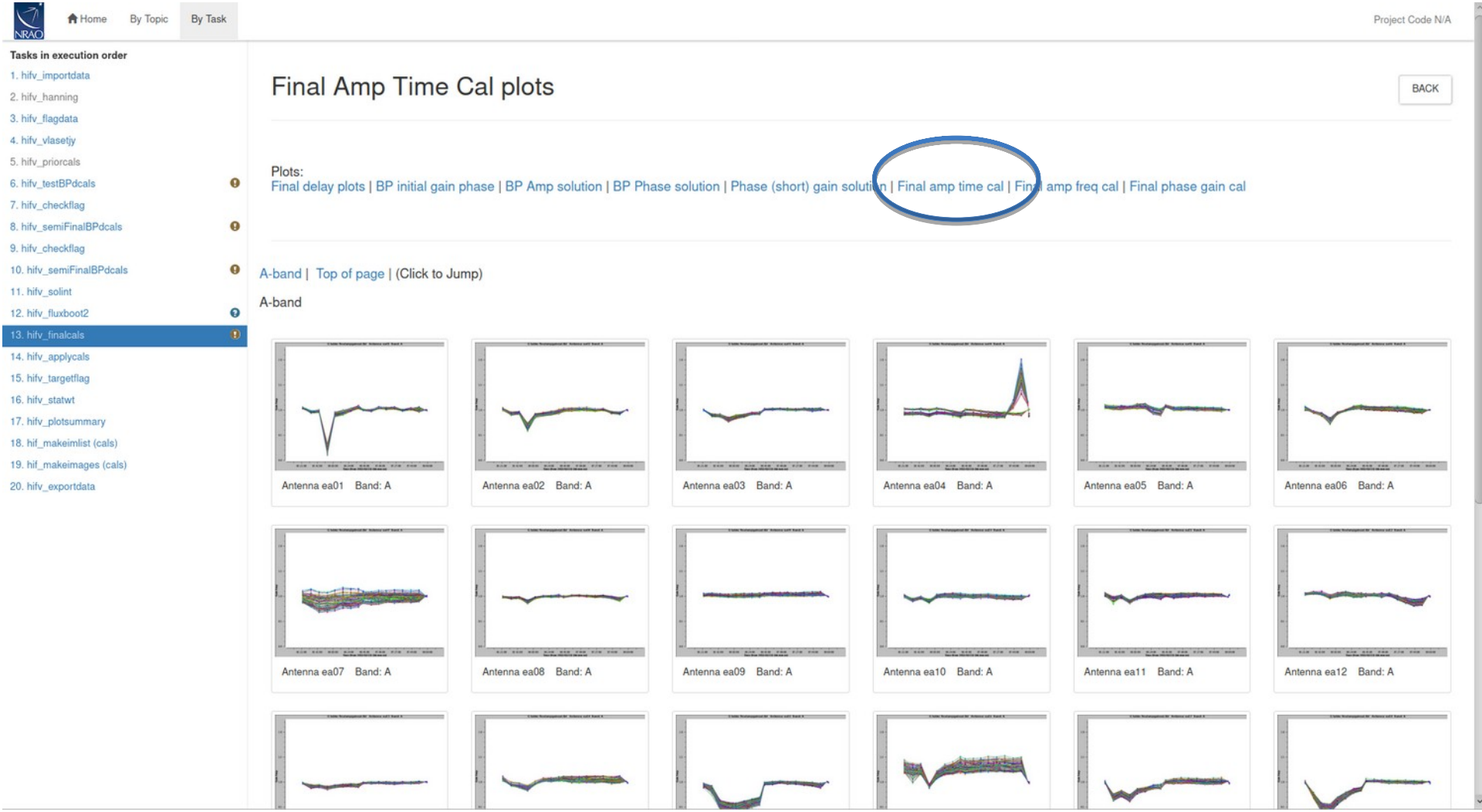
Final Cal Tables: bandpass



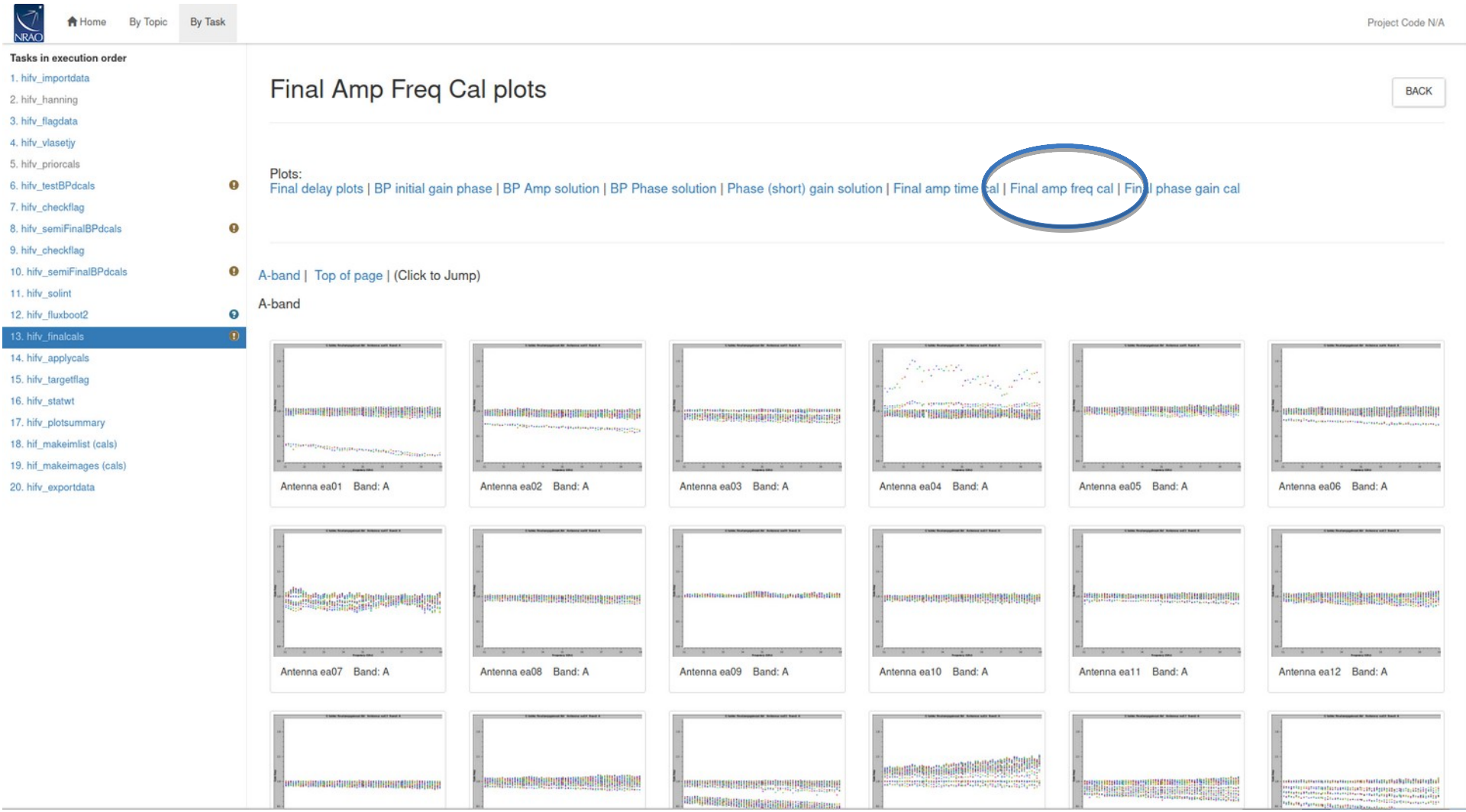
Final Cal Tables: bandpass



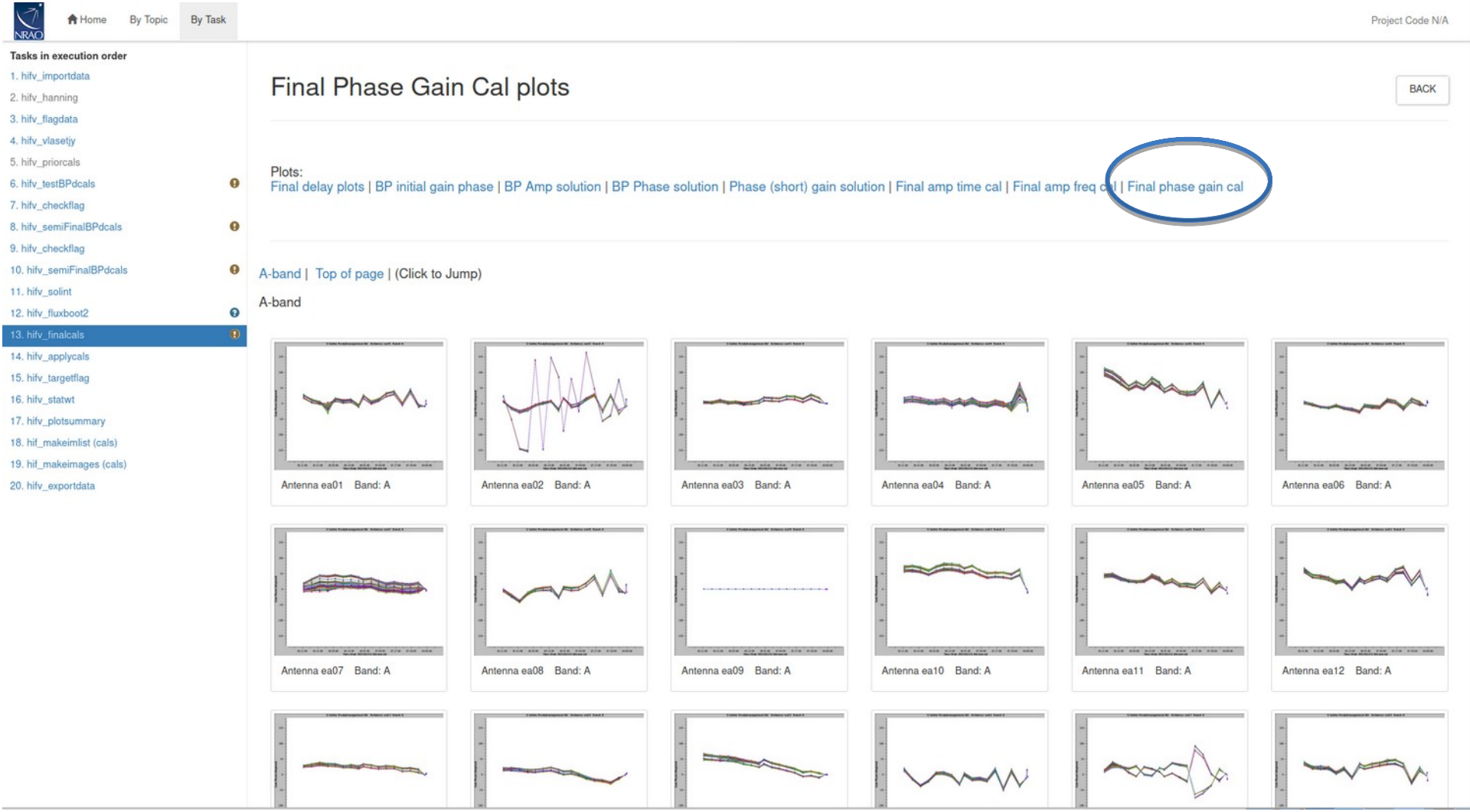
Final Cal Tables: amplitude and phase



Final Cal Tables: amplitude and phase



Final Cal Tables: amplitude and phase



Summary Plots (hifv_plotsummary)

Home | By Topic | By Task | Project Code N/A

Tasks in execution order

1. hifv_importdata
2. hifv_hanning
3. hifv_flagdata
4. hifv_vlasetjy
5. hifv_priorcals
6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata

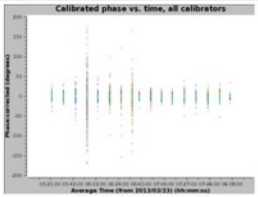
17. Plot Summary

BACK

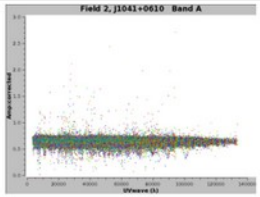
VLA Pipeline Summary Plots

Phase vs. time for all calibrators, Amp vs. UVwave for all calibrators, as well as a representative selection of fields with intent='TARGET' with Amp vs. UVwave plots.

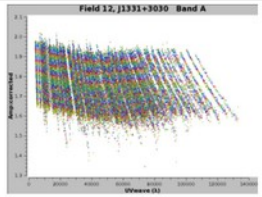
13A-398.sb17165245.eb19476558.56374.213876608796.ms



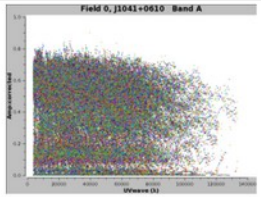
All calibrators Band: All bands



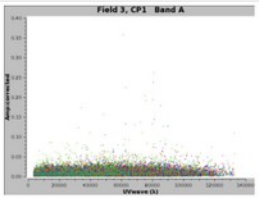
Field 2, J1041+0610 Band: A



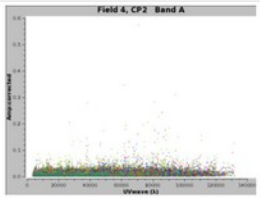
Field 12, J1331+3030 Band: A



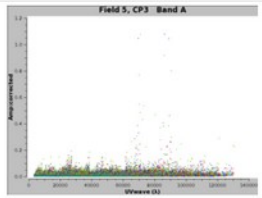
Field 0, J1041+0610 Band: A



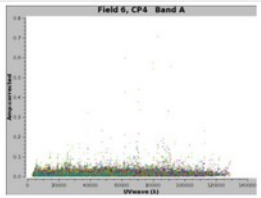
Field 3, CP1 Band: A



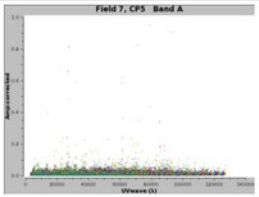
Field 4, CP2 Band: A

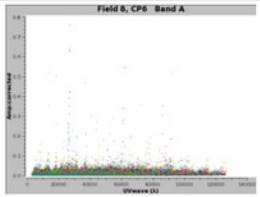


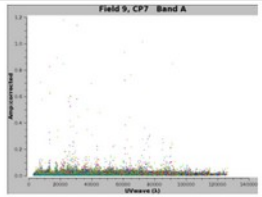
Field 5, CP3 Band: A

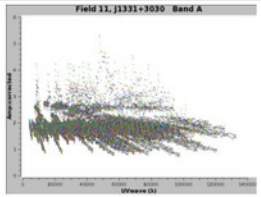


Field 6, CP4 Band: A

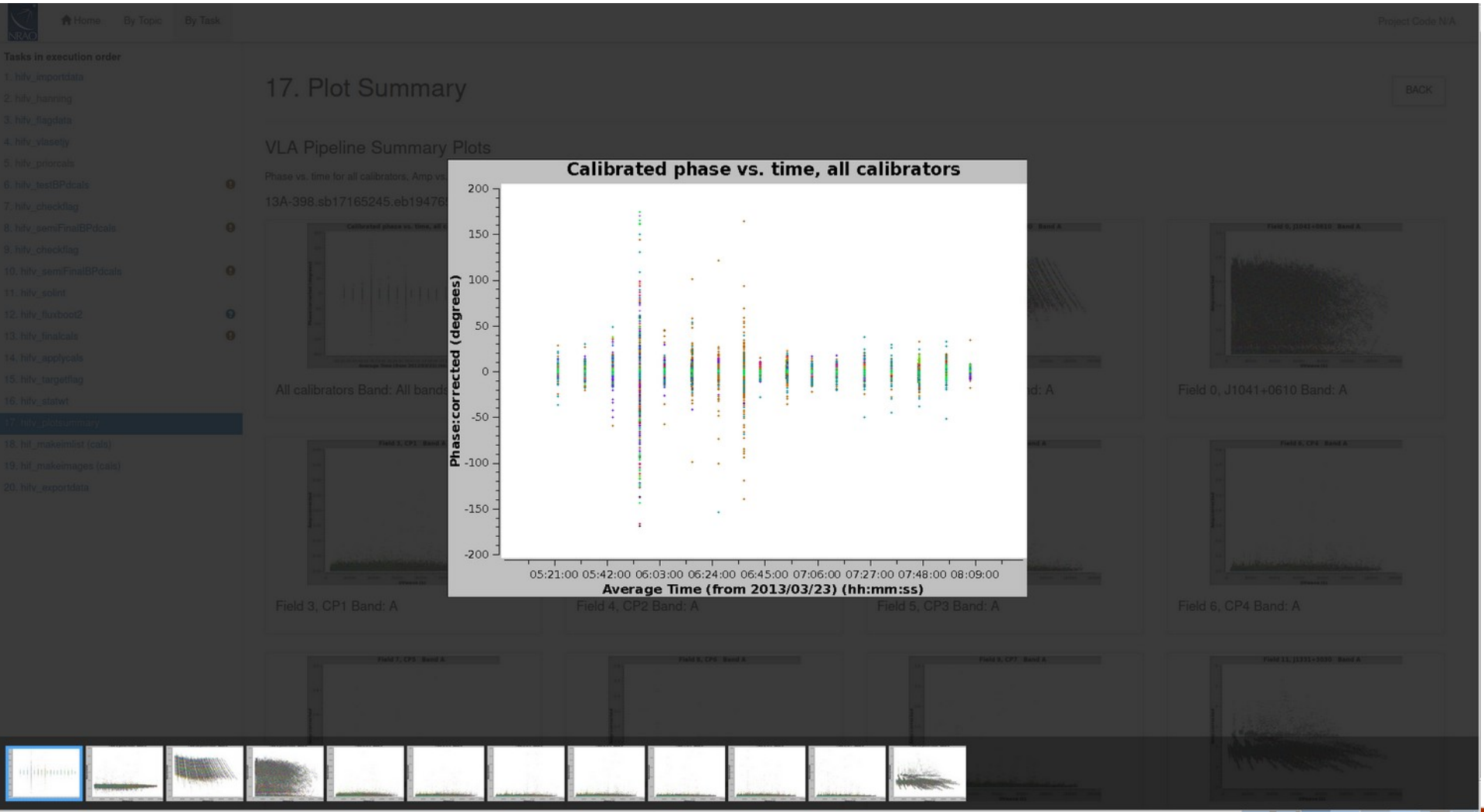




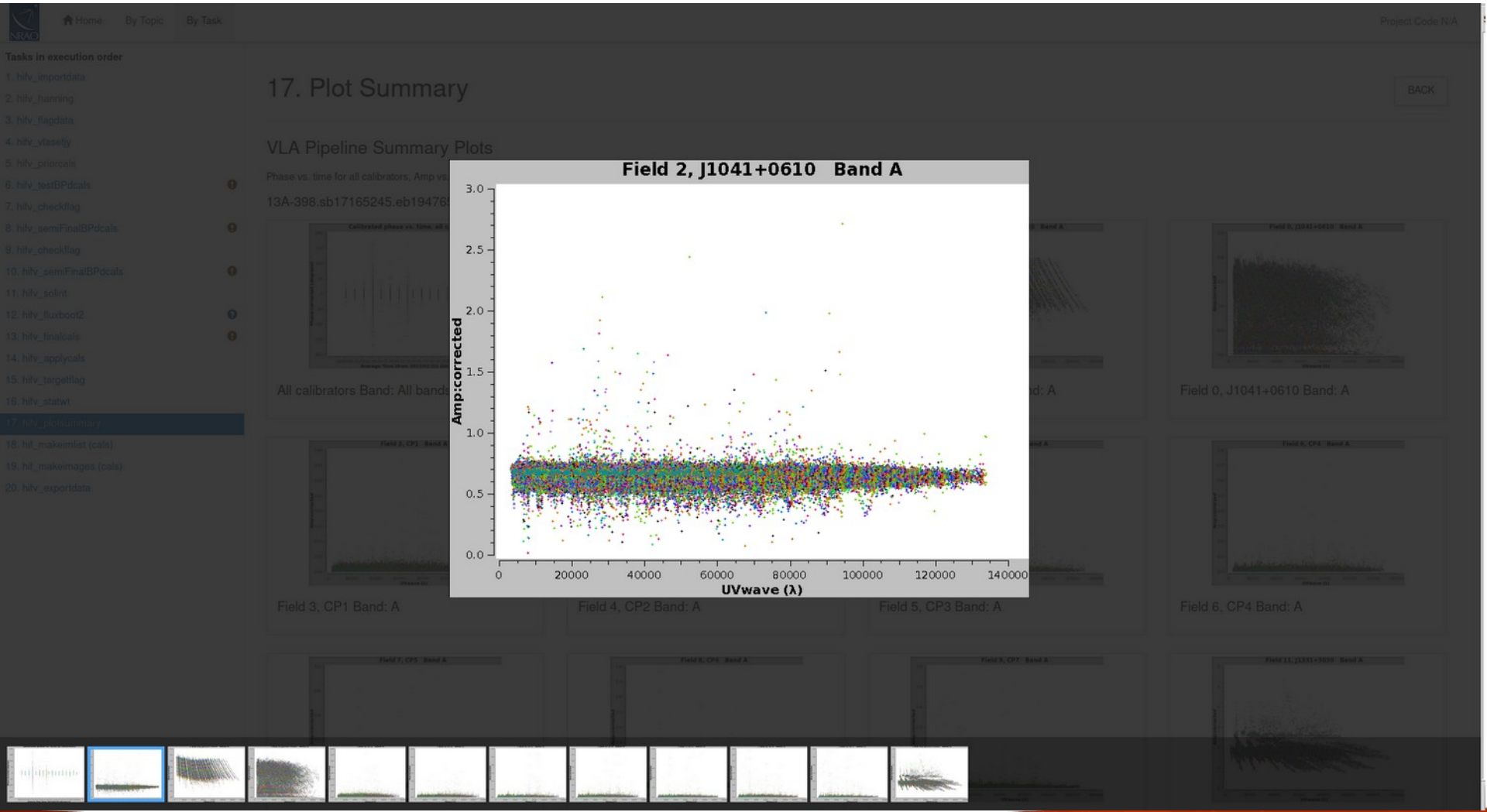




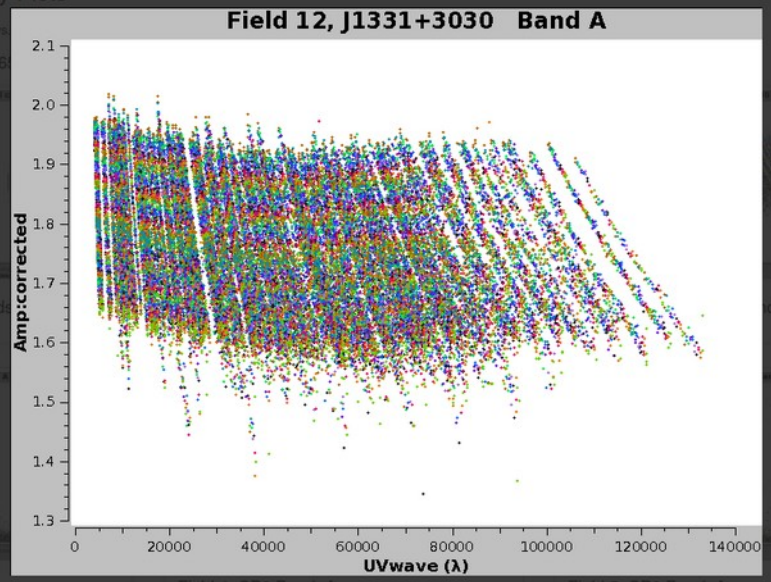
Summary Plots (hifv_plotsummary)



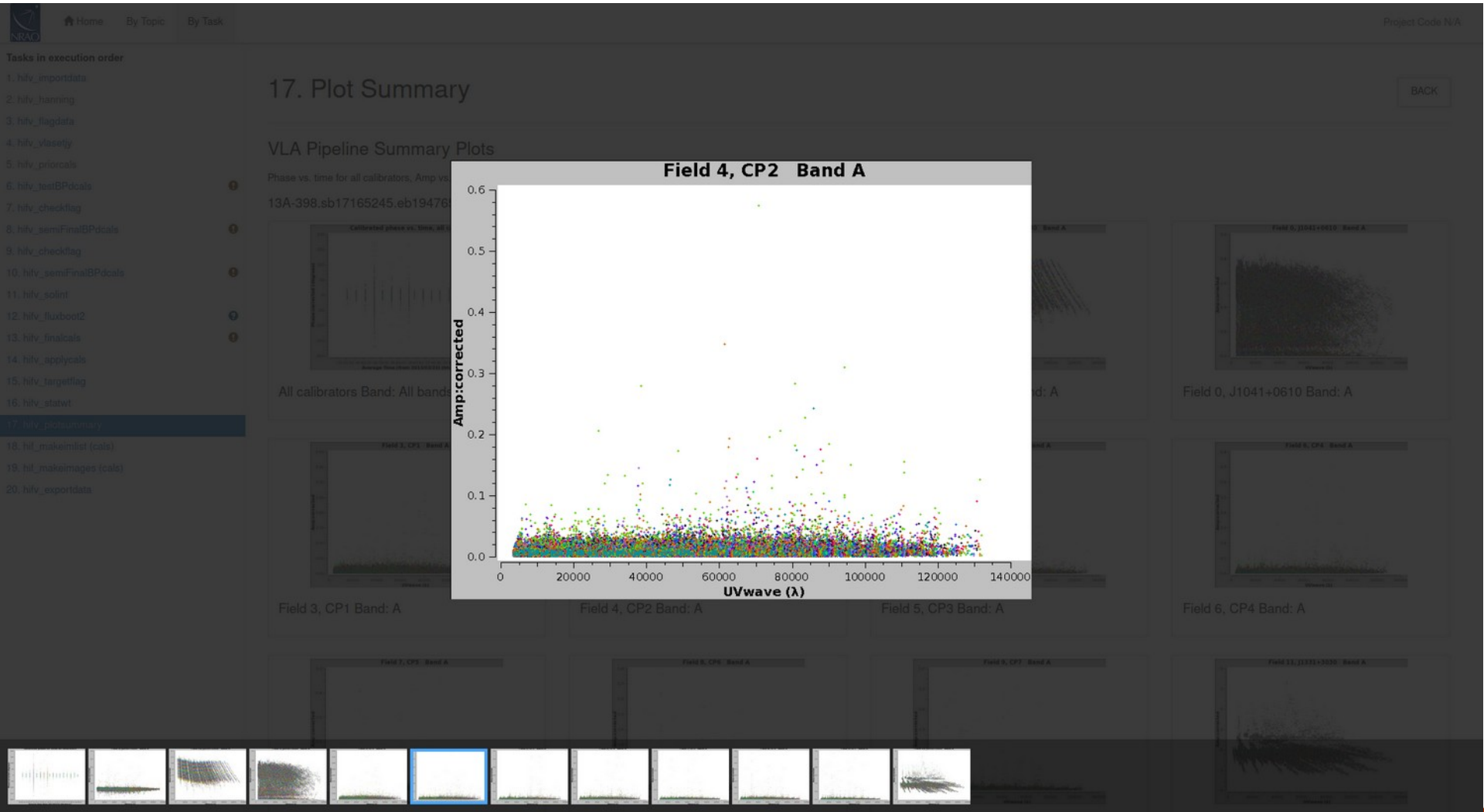
Summary Plots (hifv_plotsummary)



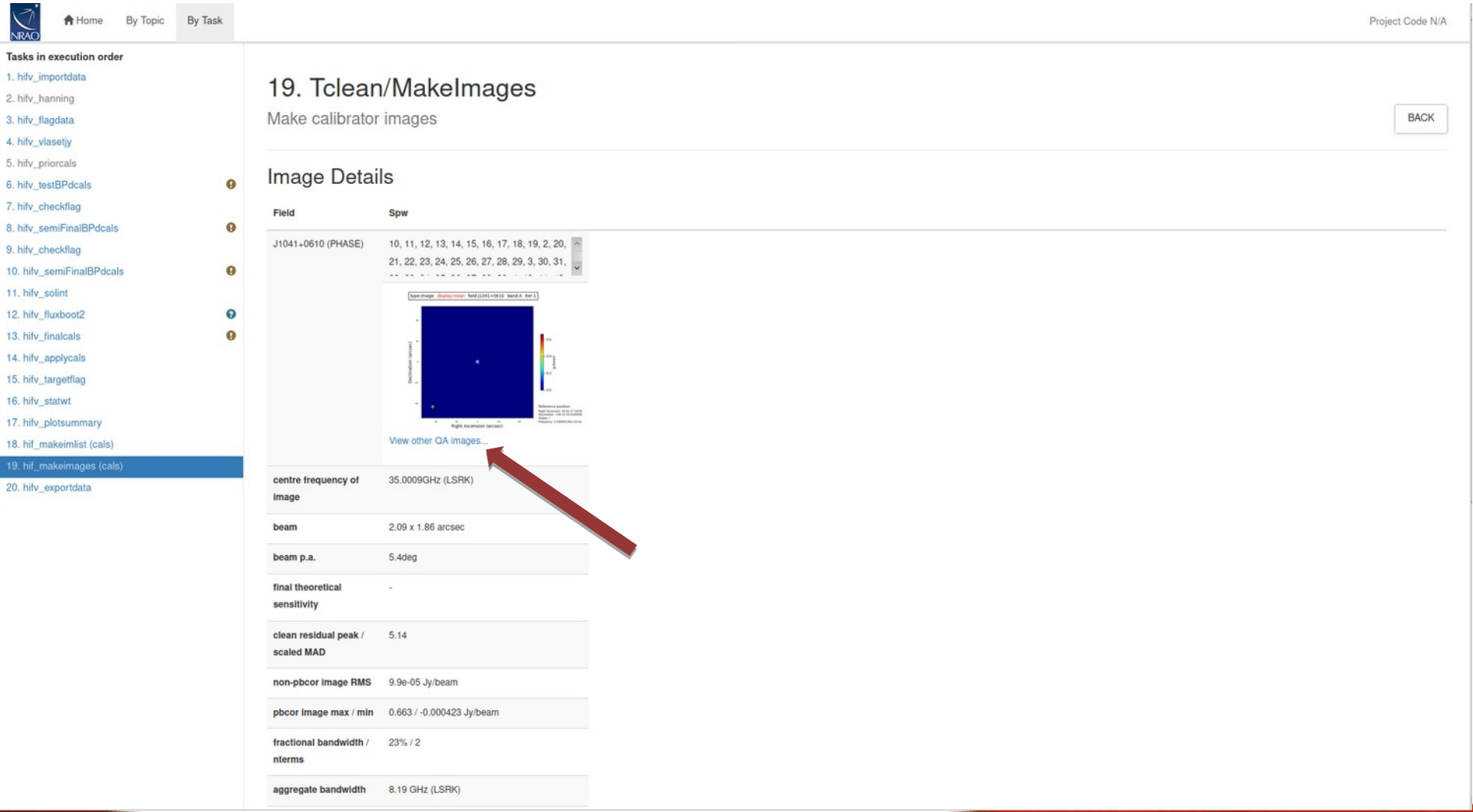
Summary Plots (hifv_plotsummary)



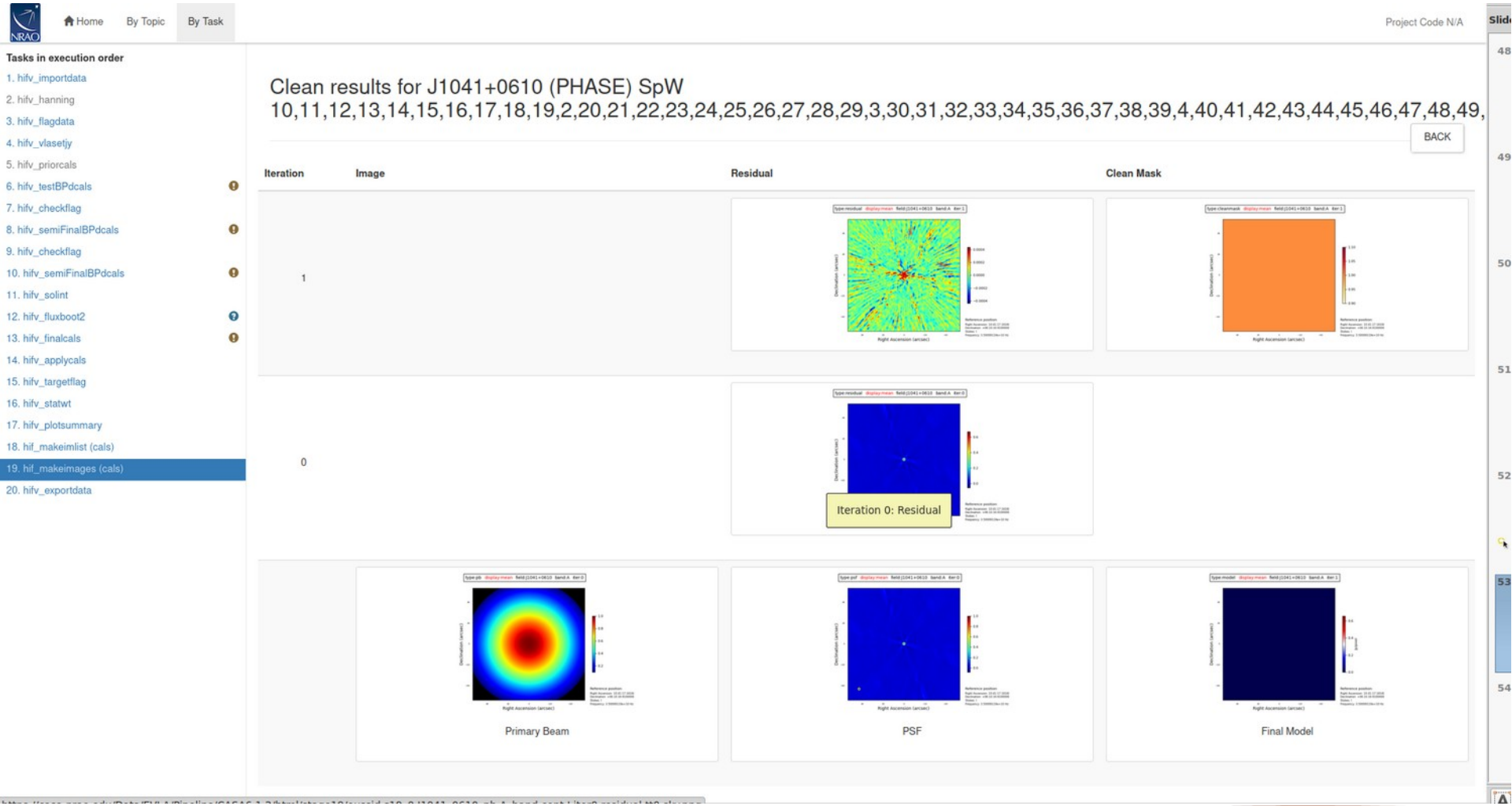
Summary Plots (hifv_plotsummary)



Calibrator Images (hif_makeimages)



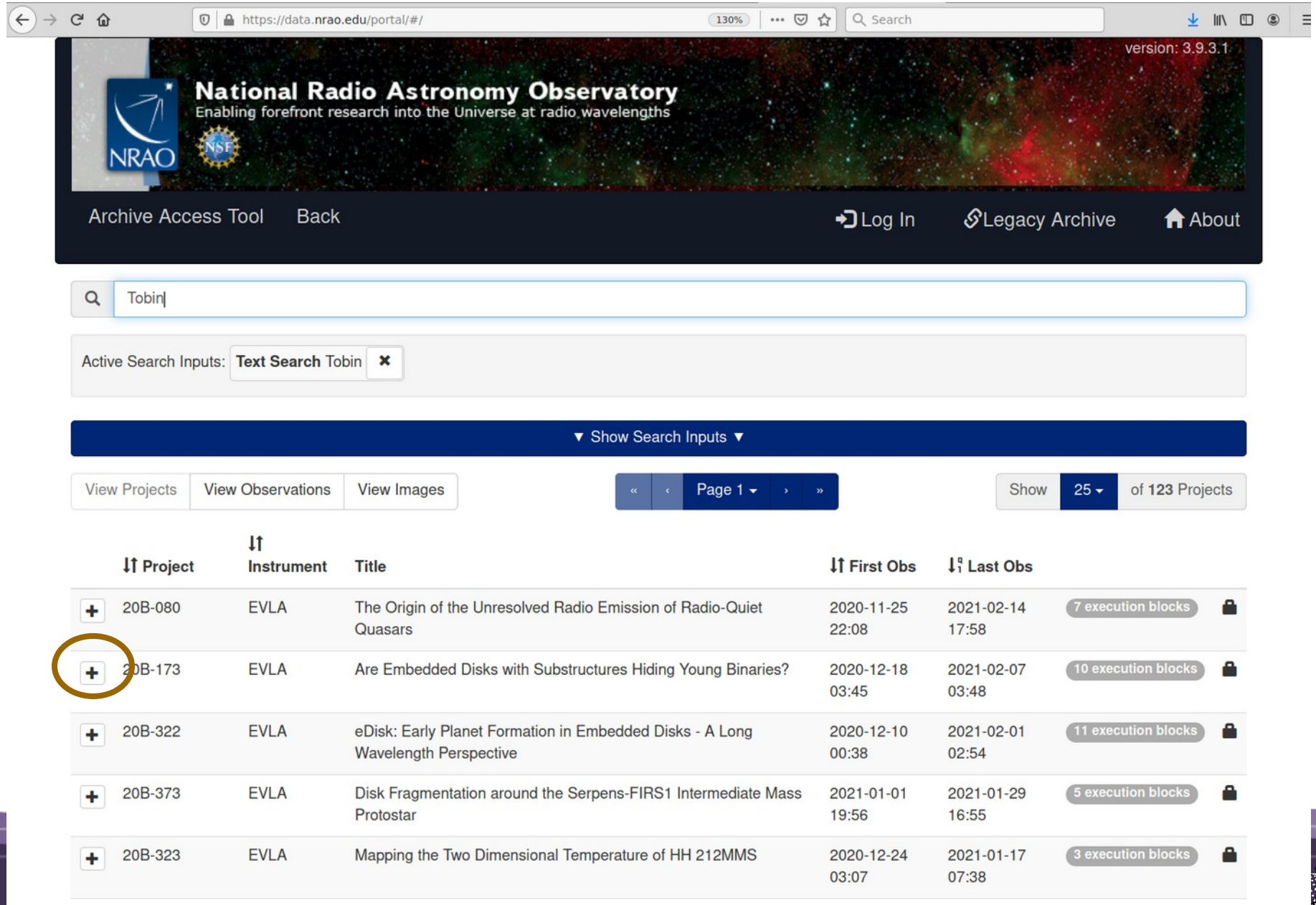
Calibrator Images (hif_makeimages)



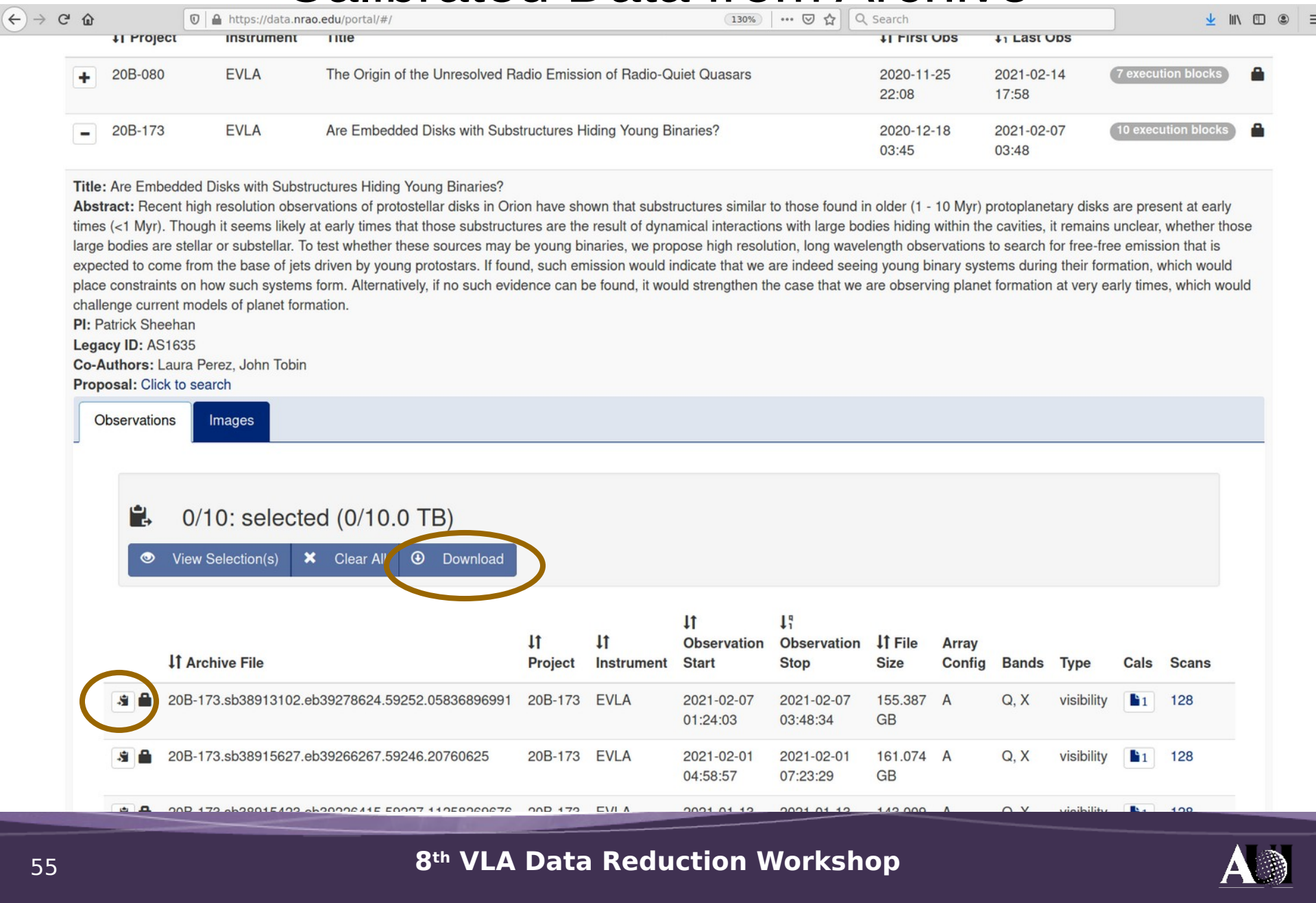
Pipeline Products and Outputs

- Flag versions and calibration tables (archived)
- Calibrated MS (available for 15 days, not archived)
- Logs, including weblog used by quality assurance (QA) staff and QA report.
- Calibrated MSes can be retrieved later from new NRAO Archive
  - https://data.nrao.edu
  - Calibrated MSes are restored on-demand using NRAO computing and staged for download
  - You can also restore on your own (next presentation)
- If you are happy with the pipeline calibration, then:
  - Do further flagging if necessary
  - Split out your target and image

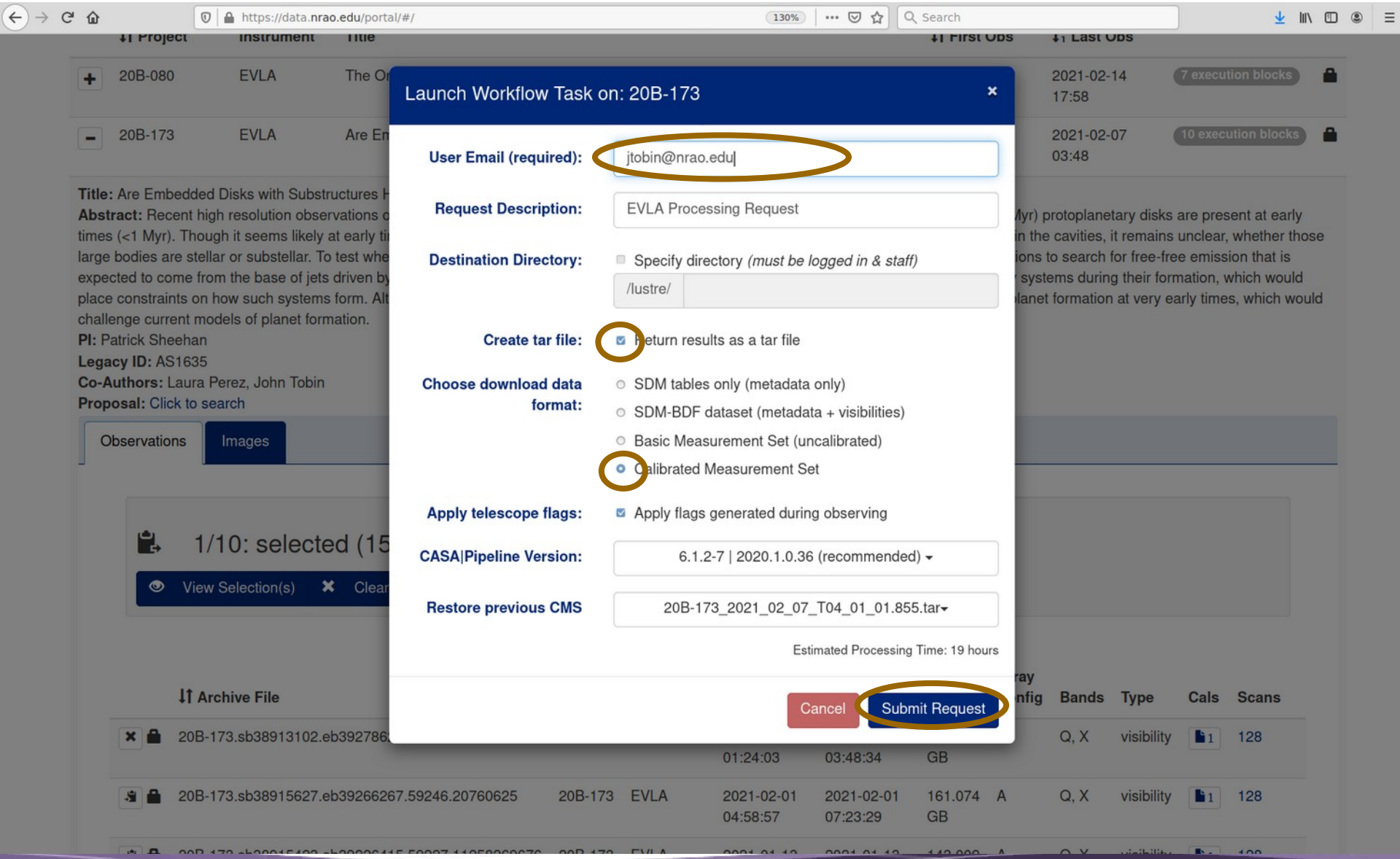
Calibrated Data from Archive



Calibrated Data from Archive



Calibrated Data from Archive



Pipeline Products and Outputs

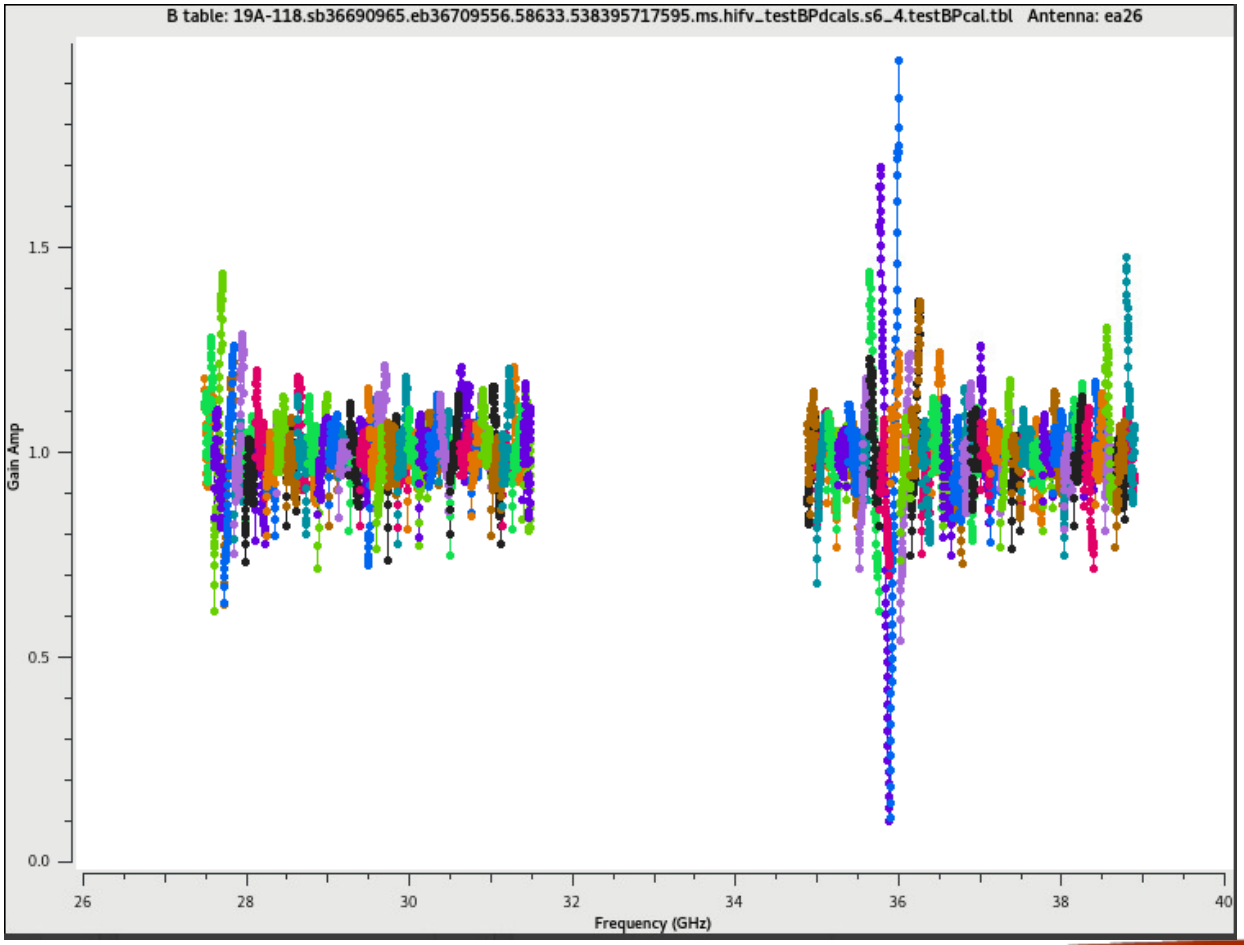
- In some cases the pipeline and/or the MS may need to be modified (and/or flagged) and rerun
  - Download the SDM from the archive plus pipeline scripts
  - Follow the directions at http://go.nrao.edu/vla-pipe
- In some cases the pipeline heuristics may not be appropriate for your data (e.g., some L-band set-ups do not work well with the pipeline yet, P-band)
  - Reduce data by hand

Known failure modes and issues

- In general the pipeline does very well, but there are possible failure modes:
  - No flux density or gain calibrator intents defined, or flux density calibrator not one for which we have models
    - *work around in scripted pipeline or reduce by hand*
  - Wrong scan intents
    - *modify Scan.xml in SDM; see https://science.nrao.edu/facilities/vla/data-processing/pipeline#section-28*
  - Does not always identify deformatter problems (but does NOT usually have false positives – L-band may be an exception)
    - *flag remaining bad spws*
  - Calibrators are too weak for given spw bandwidth
    - *reduce data by hand, bandpass smoothing, spectral window mapping*

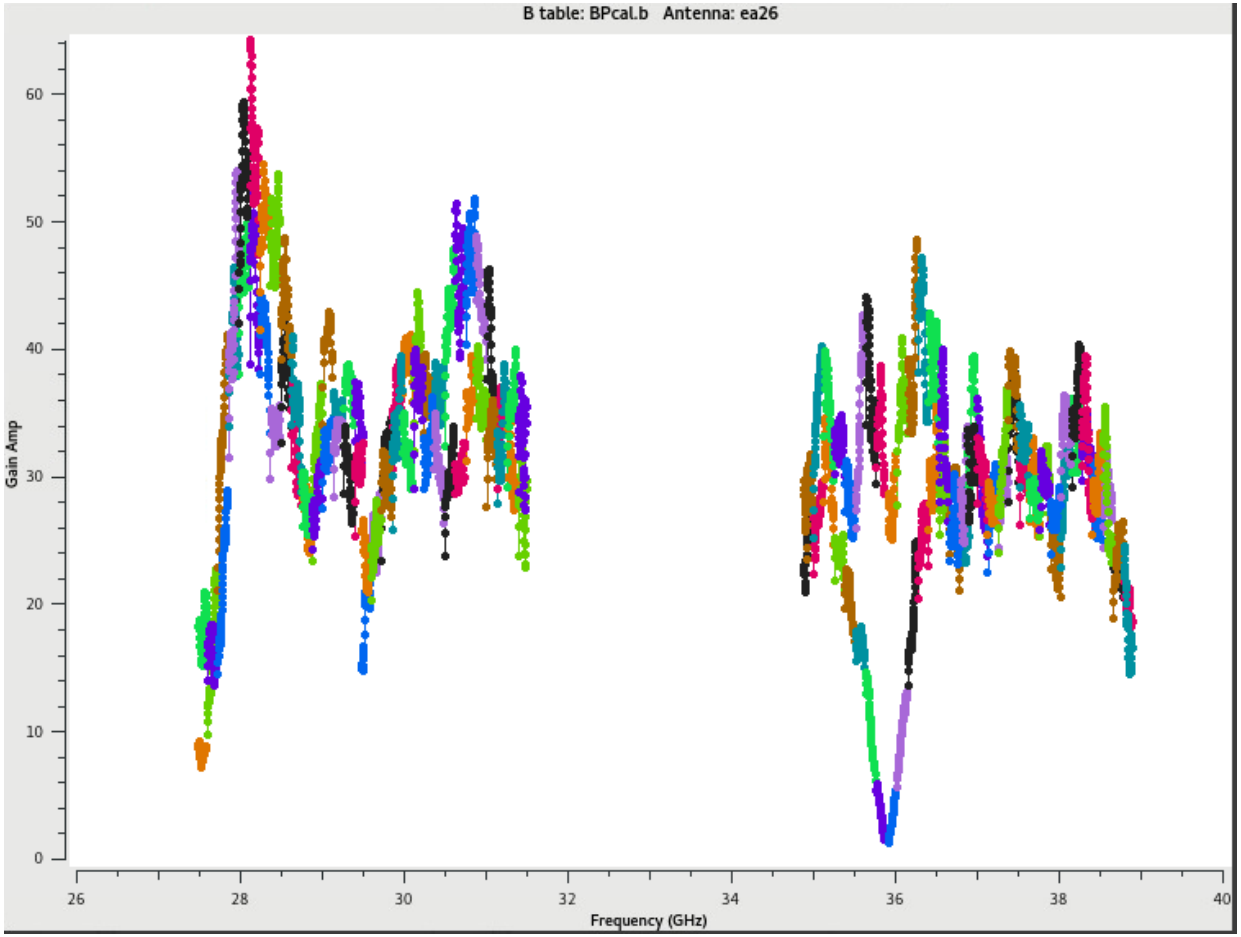
Known failure modes and issues

hifv_testBPdcals ea26 bandpass, bad data (DTS issue)



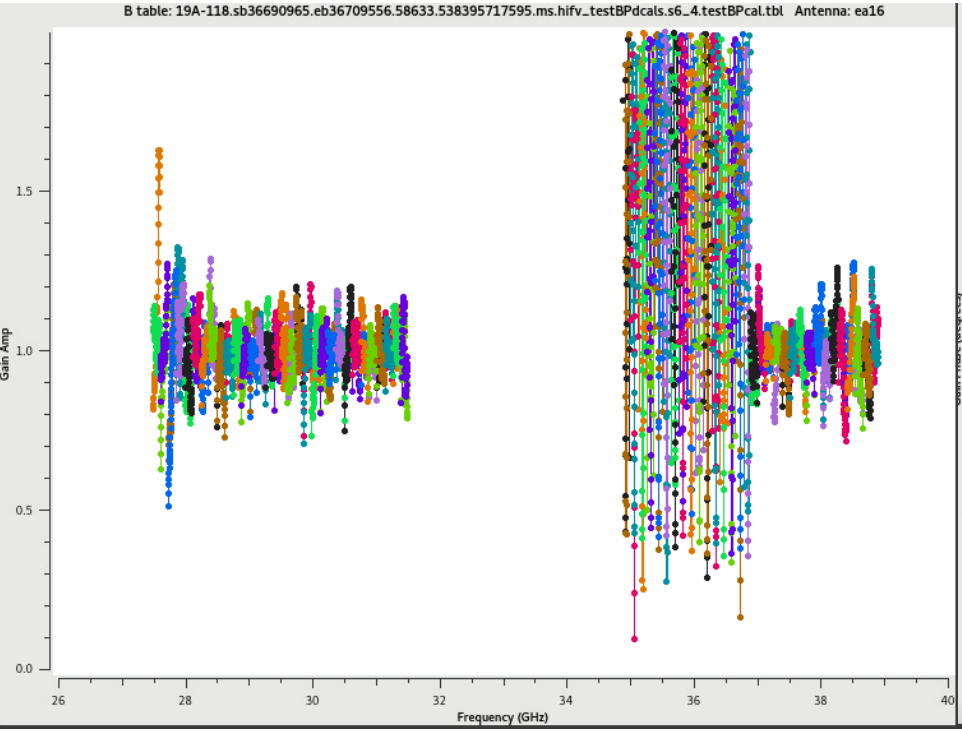
Known failure modes and issues

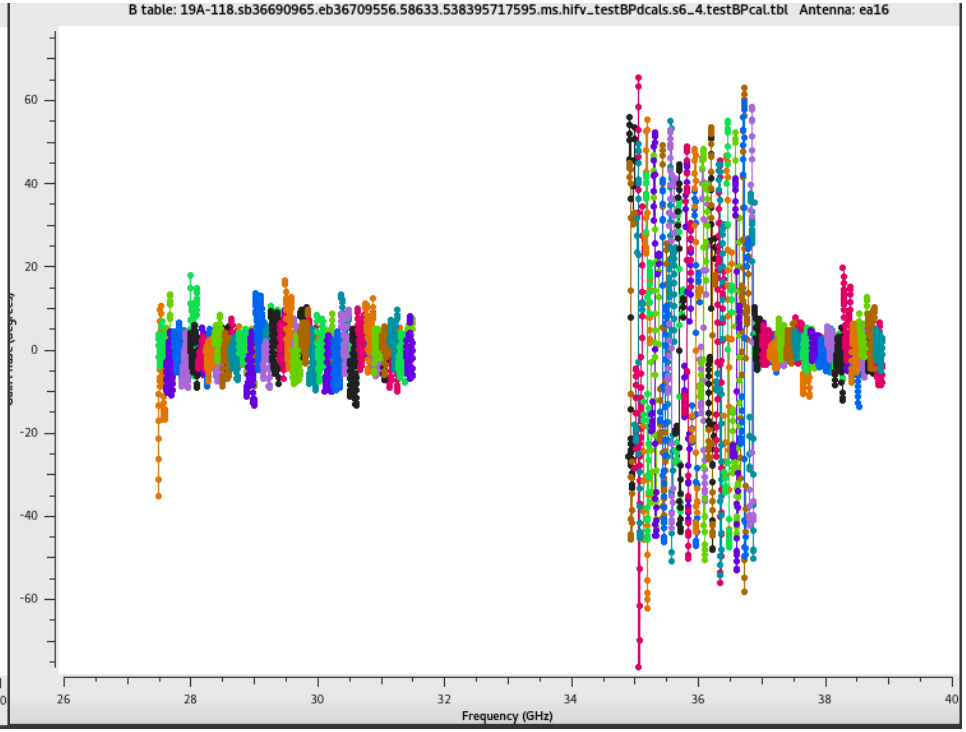
hifv_semifinalBPdcals ea26 bandpass, bad data (DTS issue)



Known failure modes and issues

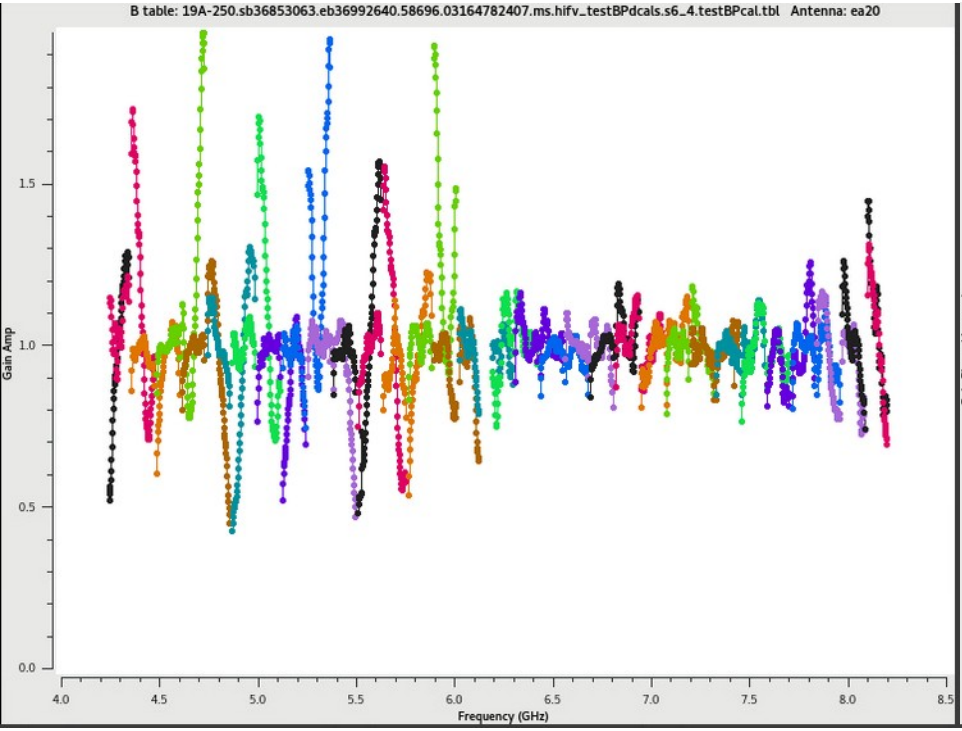
ea16 Amp **and** Phase affected (DTS issue for 35-37GHz)

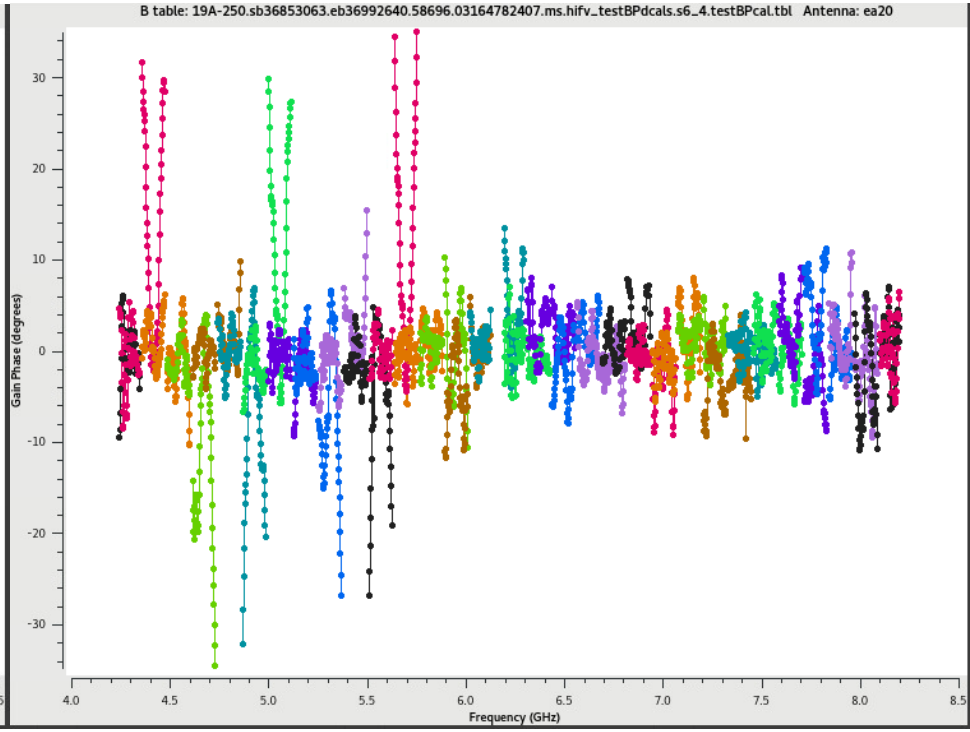




Known failure modes and issues

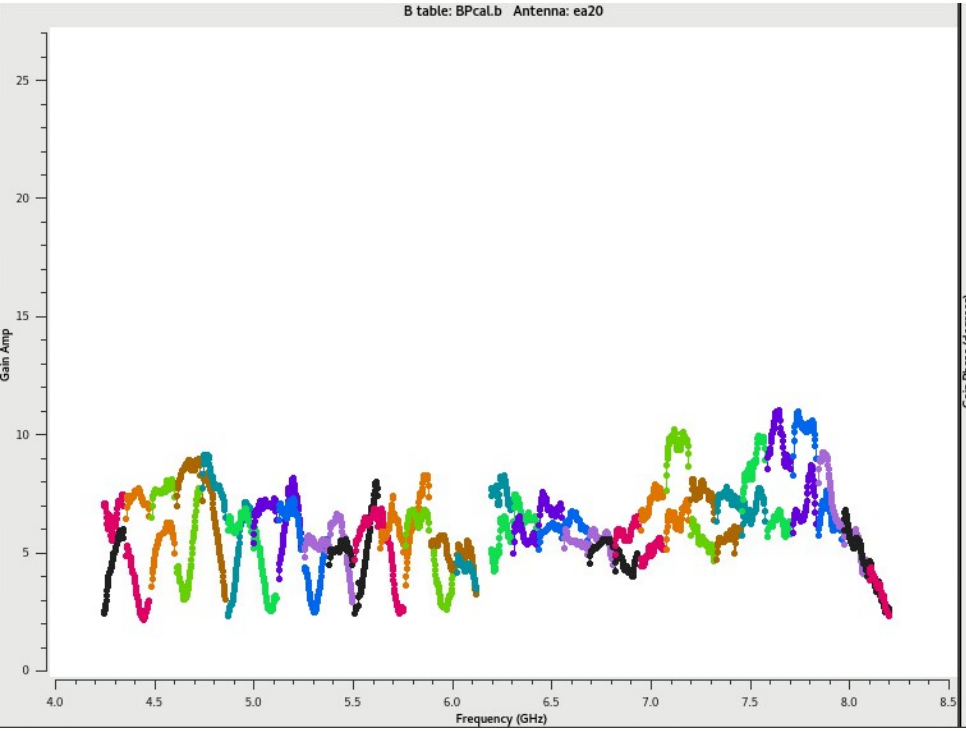
hifv_testBPdcals: ea20 bandpass, bad data (DTS issue)

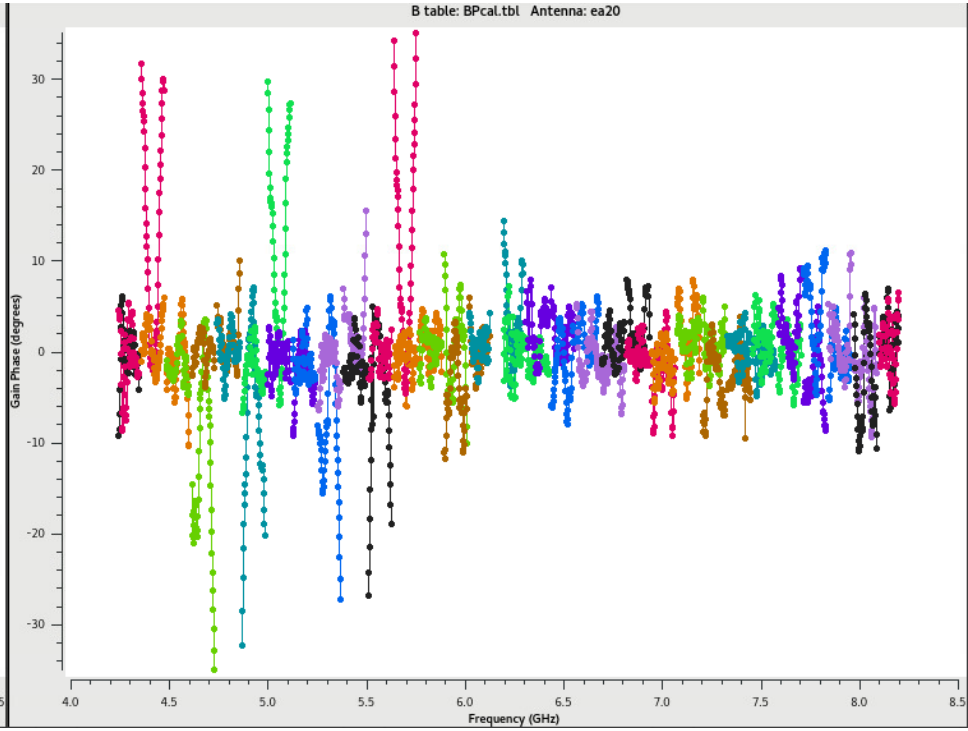




Known failure modes and issues

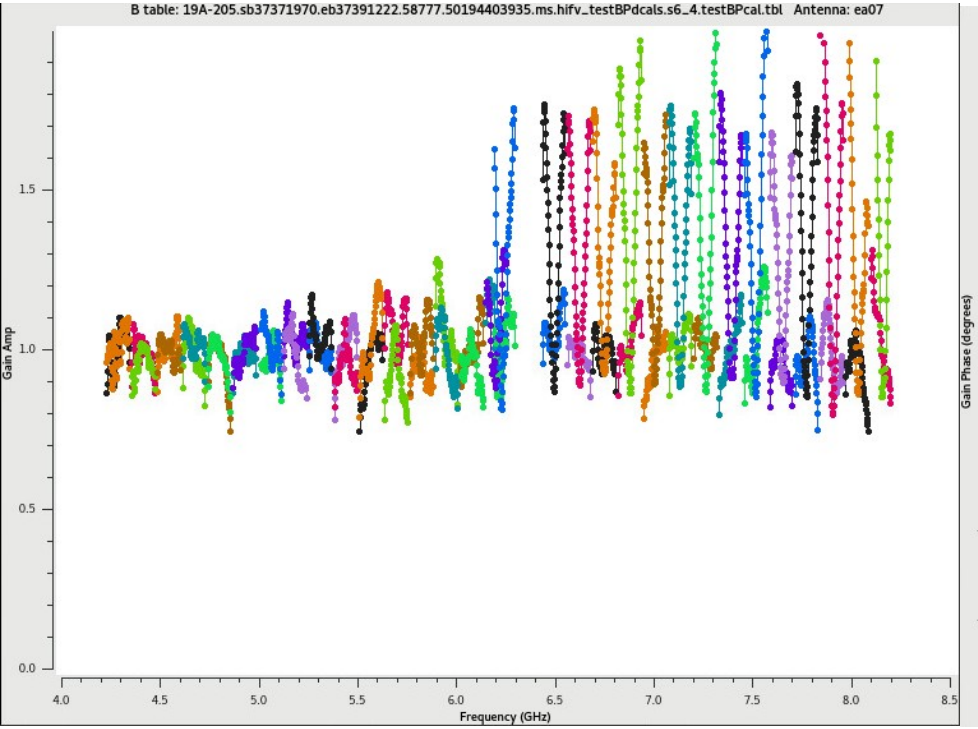
hifv_semifinalBPdcals: ea20 bandpass, bad data (DTS issue)

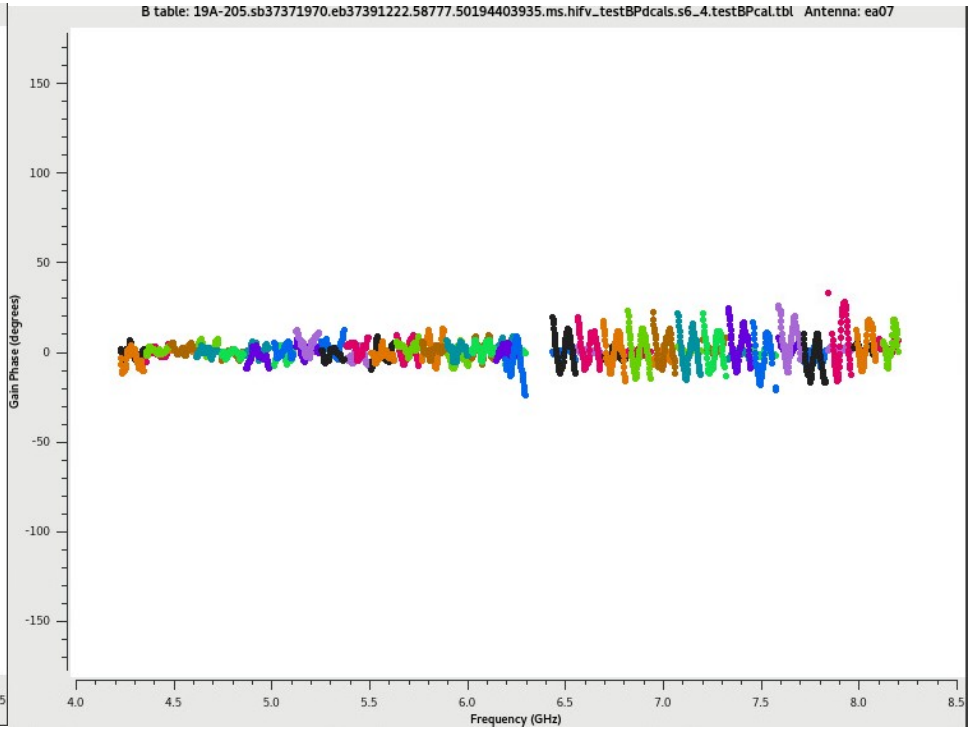




Known failure modes and issues

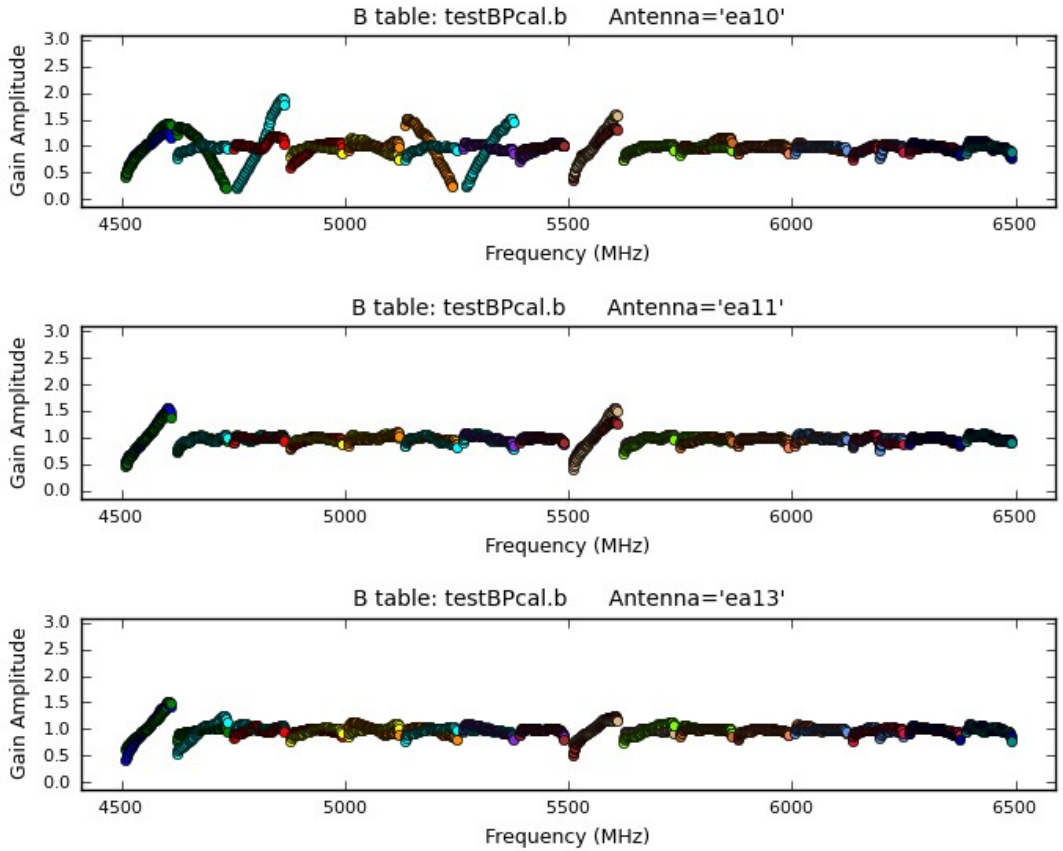
hifv_testBPdcals: ea07 bandpass, bad data (DTS issue)





Known failure modes and issues

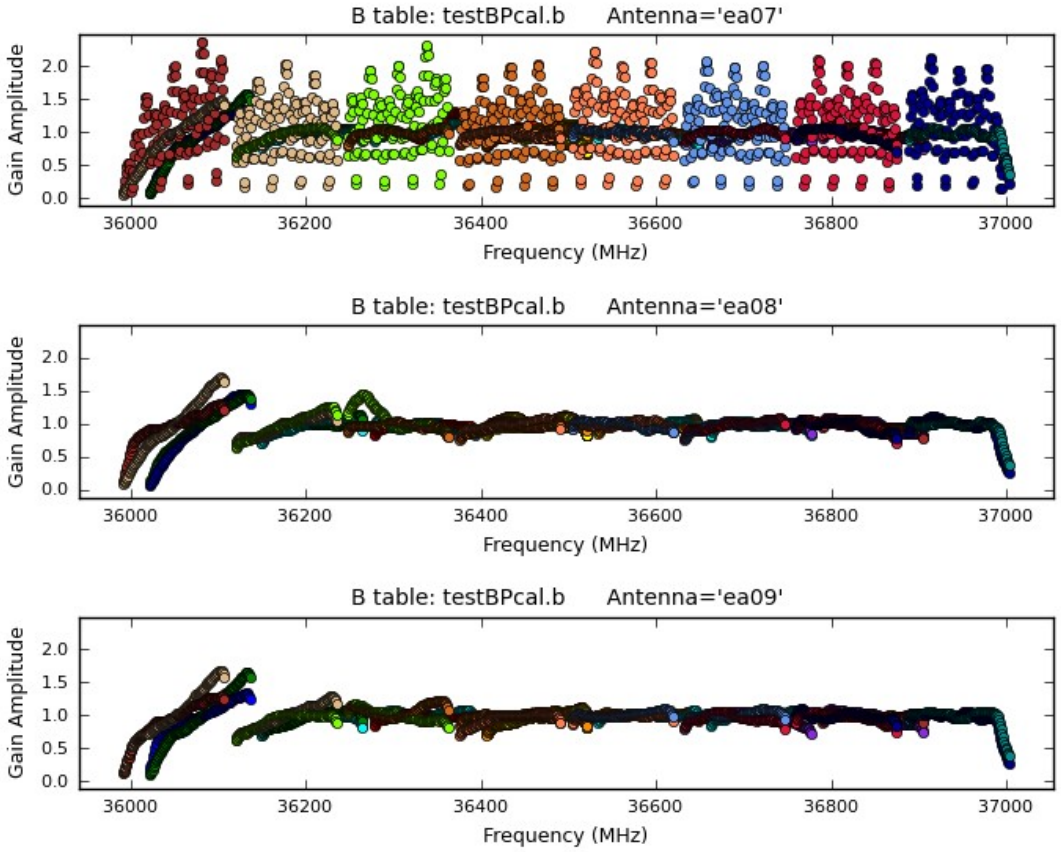
ea10 bandpass, bad data (DTS issue); ea11, ea12 OK



plot from scripted pipeline

Known failure modes and issues

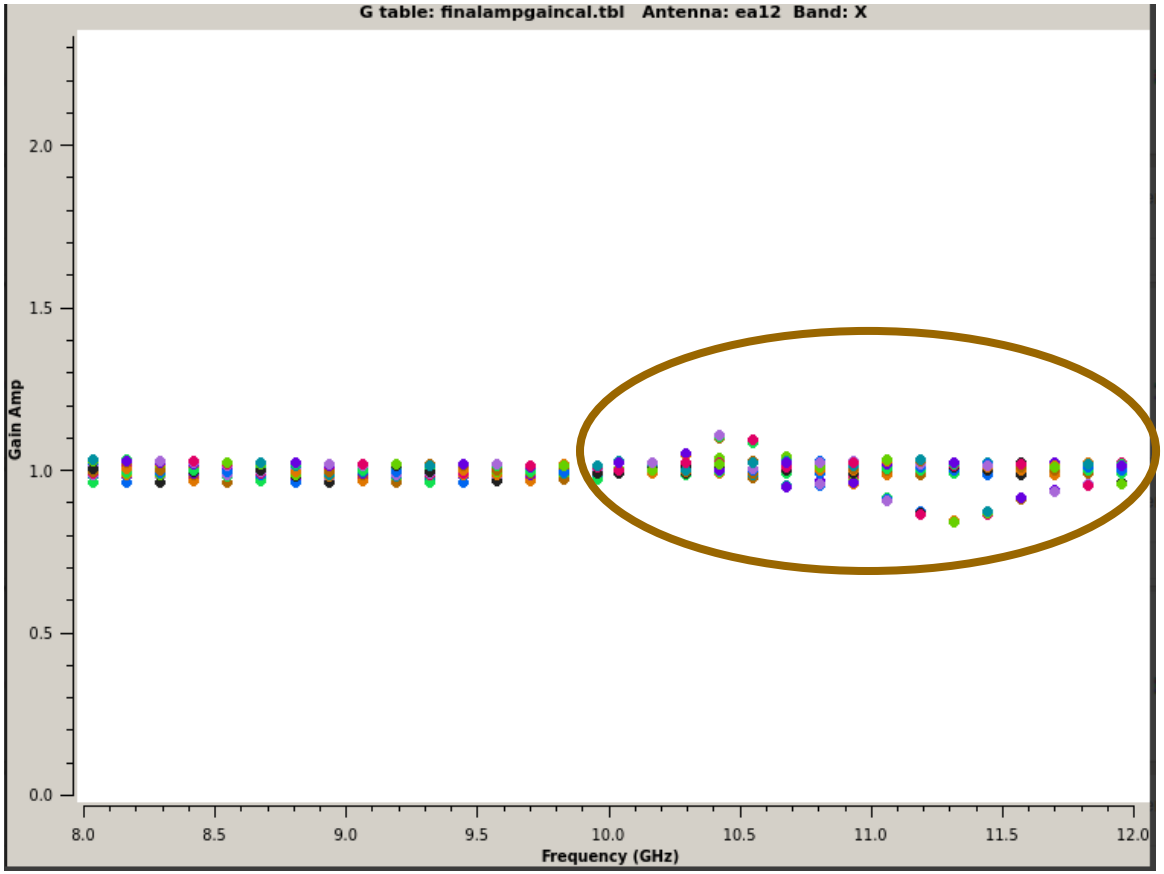
ea07 bandpass, bad data (DTS issue); ea08, ea09 OK



plot from scripted pipeline

Known failure modes and issues

ea12 amp vs. frequency, switch issue 10 -12 GHz



Spectral line data

- Several steps in the real-time pipeline may not be appropriate for spectral line data:
  - Hanning smoothing (increases effective channel width)
  - Flags 5% of ***each*** spw edge and the first and last 10 channels of each baseband
  - Last run of RFLAG on target (may eliminate your line as interference!)
  - Statwt calculates rms based on scatter of channels per spw, per visibility; may want to run manually with channel selection turned on to eliminate use of channels containing line emission in calculating the rms

  ⇒ *Specify a "cont.dat" file to avoid known lines for RFI flagging and statwt*

- With the above modifications, the pipeline will work with spectral line data as long as the calibrators are strong enough

The cont.dat file

```
Field: M82

SpectralWindow: 19
37.104~38.29GHz LSRK
38.30~39.104GHz LSRK

SpectralWindow: 37
31.360~32.123GHz LSRK
32.130~33.360GHz LSRK

Field: NGC3077

SpectralWindow: 37
31.360~32.123GHz LSRK
32.130~33.360GHz LSRK
```

- The *cont.dat* file enables you to specify the continuum regions within your spws.
  - Weights for whole spw set based on defined the continuum regions
  - RFI flagging only happens in continuum regions
- statwt and RFI flagging only carried out on spws specified in *cont.dat*
  - Other spws will not be process for RFI/statwt
  - Changes to this behavior proposed (process unspecified windows using default behavior)

Mixed correlator set-ups

- With WIDAR capabilities it is common to observe both wide and narrow spws to obtain both continuum and spectral line data simultaneously or multiple receiver bands
  - A single heuristic (e.g., gain calibration solution interval) for entire dataset may not be appropriate
- Solution:
  - Run pipeline through hifv_flagdata, including Hanning smoothing if you are going to use it
  - Split the MS by spw and/or scans
  - Run pipeline on split MSs WITHOUT Hanning smoothing (you have already applied it, if you are going to use it)
  - Warning: output flagging statistics may not be correct

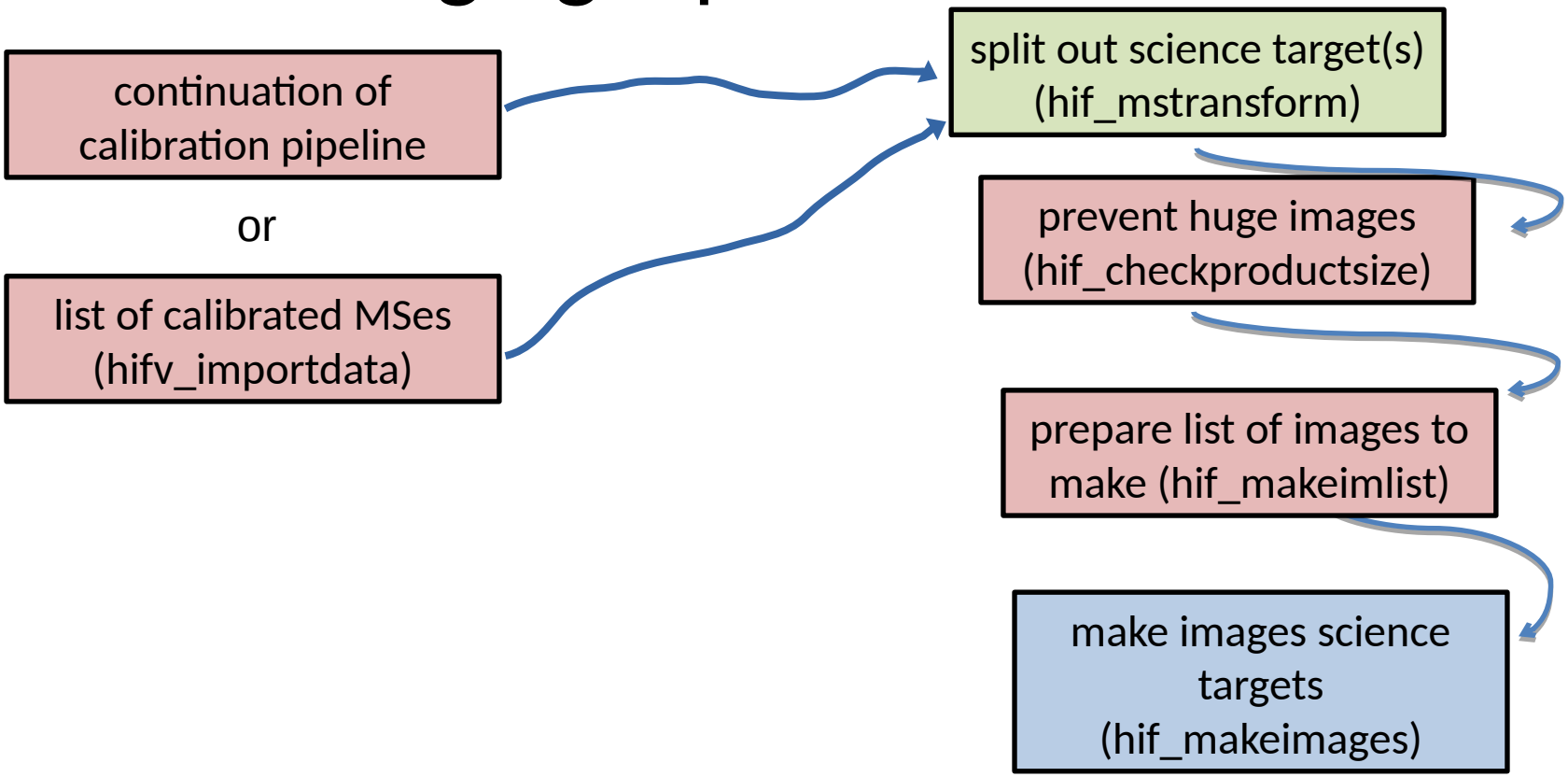
Multi-band data

- Continuum data taken in multiple bands in a single EB handled properly by pipeline in single pass
  - All bands must use same flux density and bandpass calibrators
  - If using different flux/bandpass cals per band
    - Split by spw and run each band individually

VLA Imaging Pipeline

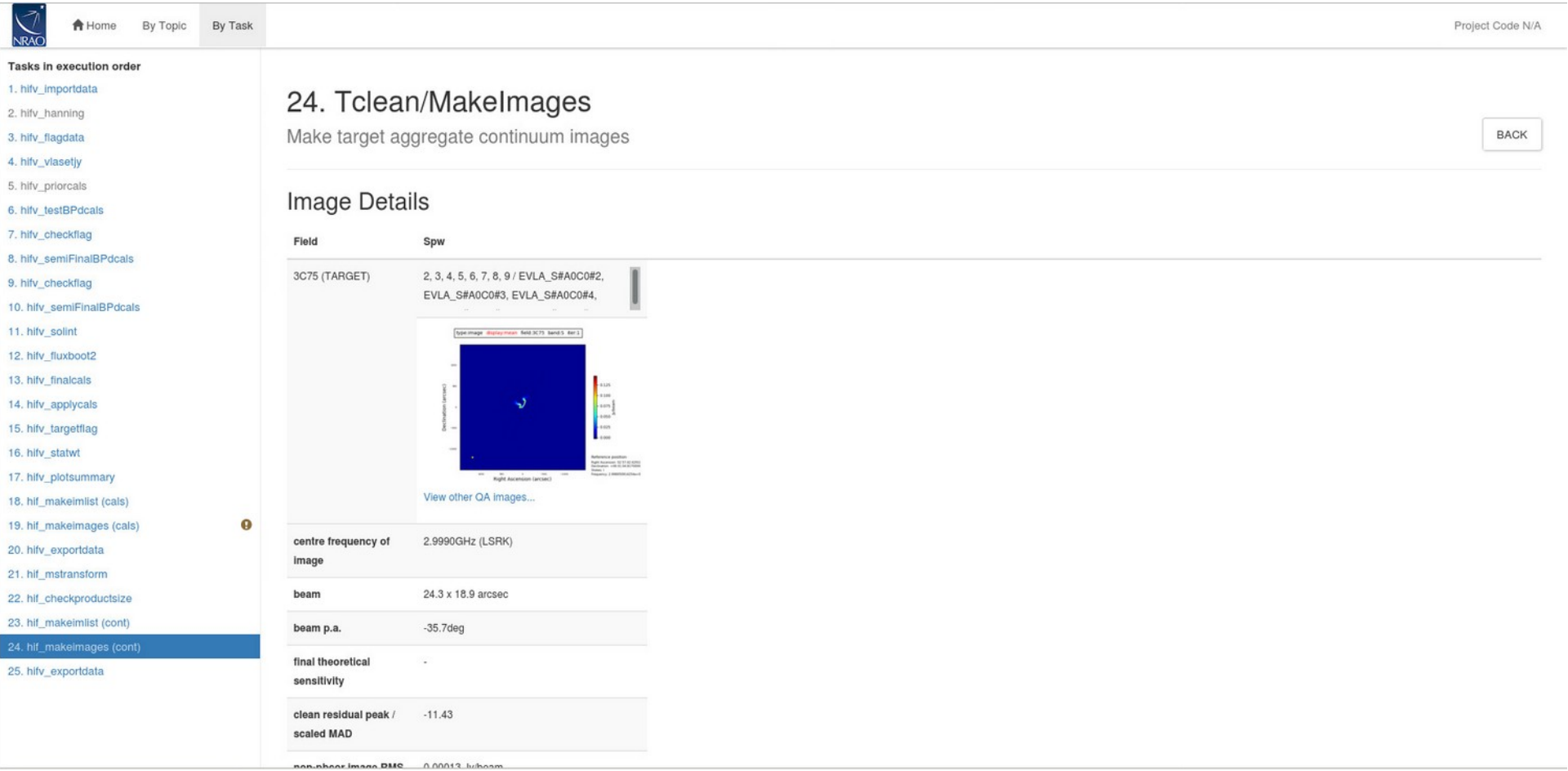
- Building on pipeline infrastructure, a VLA continuum imaging pipeline is now available
  - https://science.nrao.edu/facilities/vla/data-processing/pipeline/VIPL
  - Single image per-band, per-science target
  - Cleaning done without a mask to 5-sigma level
  - Robust=0.5 is used by default
  - Synthesized beam sampled by 5 pixels
  - Mosaicking not supported (each mosaic image is separate)
  - If possible, will create image encompassing entire primary beam
    - Images are limited to 16384
    - No w-projection
- One can certainly do better with their own tclean calls and masking
  - provides uniformly created image products to assess observed data

VLA Imaging Pipeline - Flow chart



VLA Imaging Pipeline

VLA Imaging Pipeline



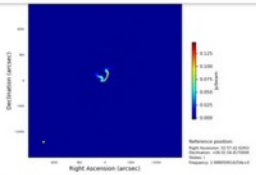
VLA Imaging Pipeline

Home | By Topic | By Task

Project Code N/A

Tasks in execution order

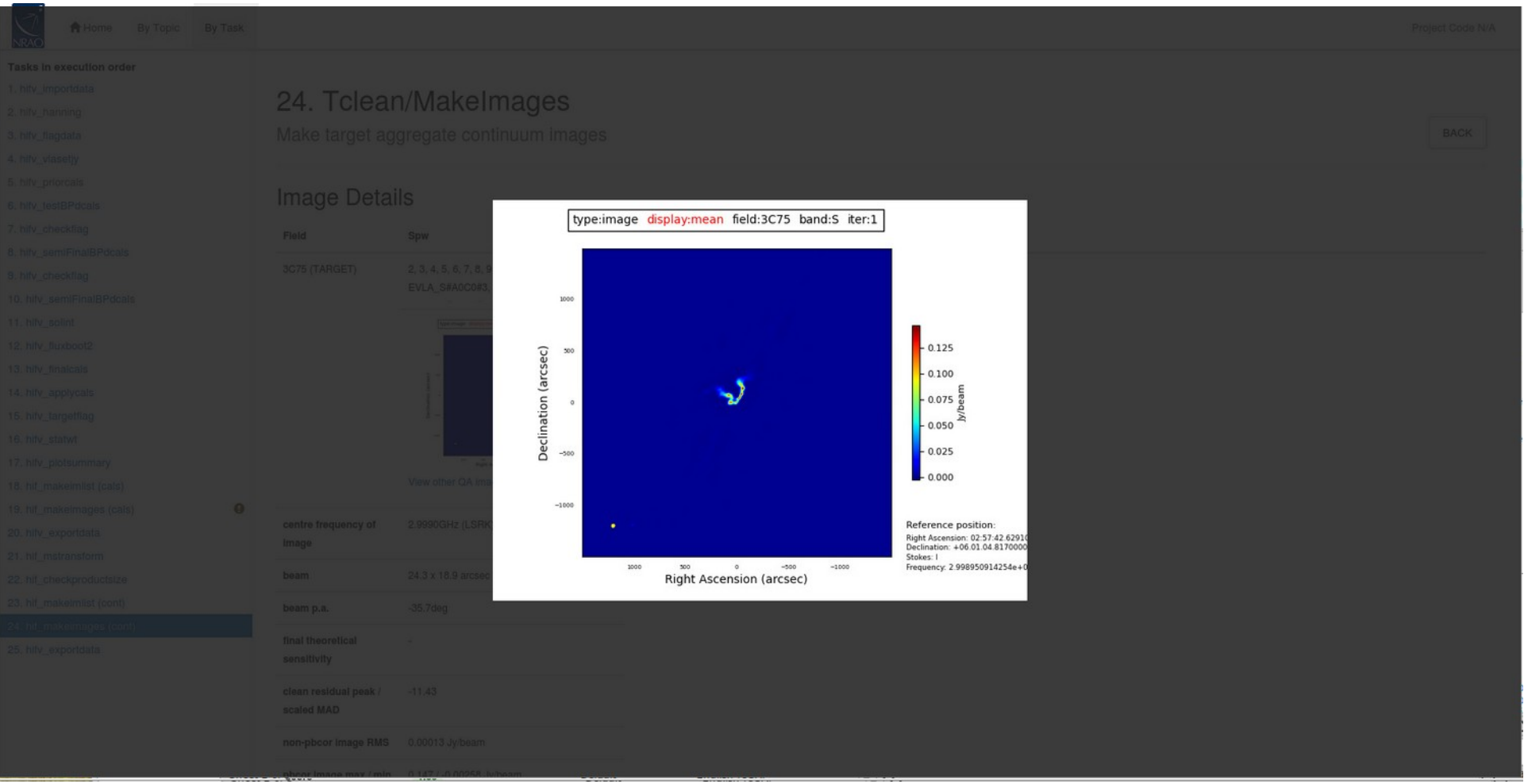
1. hifv_importdata
2. hifv_hanning
3. hifv_flagdata
4. hifv_vlasetjy
5. hifv_priorcals
6. hifv_testBPdcals
7. hifv_checkflag
8. hifv_semiFinalBPdcals
9. hifv_checkflag
10. hifv_semiFinalBPdcals
11. hifv_solint
12. hifv_fluxboot2
13. hifv_finalcals
14. hifv_applycals
15. hifv_targetflag
16. hifv_statwt
17. hifv_plotsummary
18. hif_makeimlist (cals)
19. hif_makeimages (cals)
20. hifv_exportdata
21. hif_mstransform
22. hif_checkproductsize
23. hif_makeimlist (cont)
24. hif_makeimages (cont)
25. hifv_exportdata



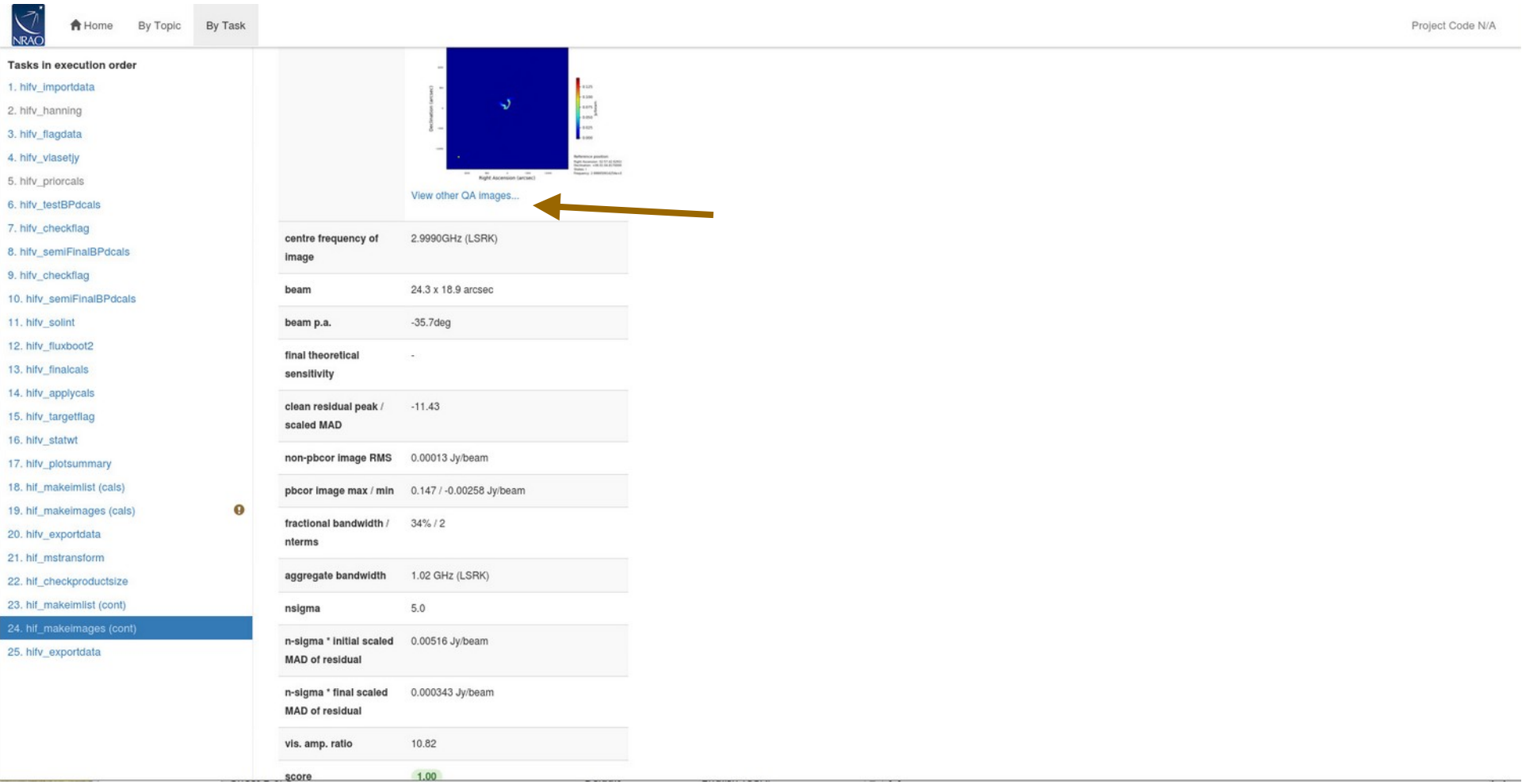
View other QA images...

centre frequency of image	2.9990GHz (LSRK)
beam	24.3 x 18.9 arcsec
beam p.a.	-35.7deg
final theoretical sensitivity	-
clean residual peak / scaled MAD	-11.43
non-pbcor image RMS	0.00013 Jy/beam
pbcor image max / min	0.147 / -0.00258 Jy/beam
fractional bandwidth / nterms	34% / 2
aggregate bandwidth	1.02 GHz (LSRK)
nsigma	5.0
n-sigma * initial scaled MAD of residual	0.00516 Jy/beam
n-sigma * final scaled MAD of residual	0.000343 Jy/beam
vis. amp. ratio	10.82
score	1.00

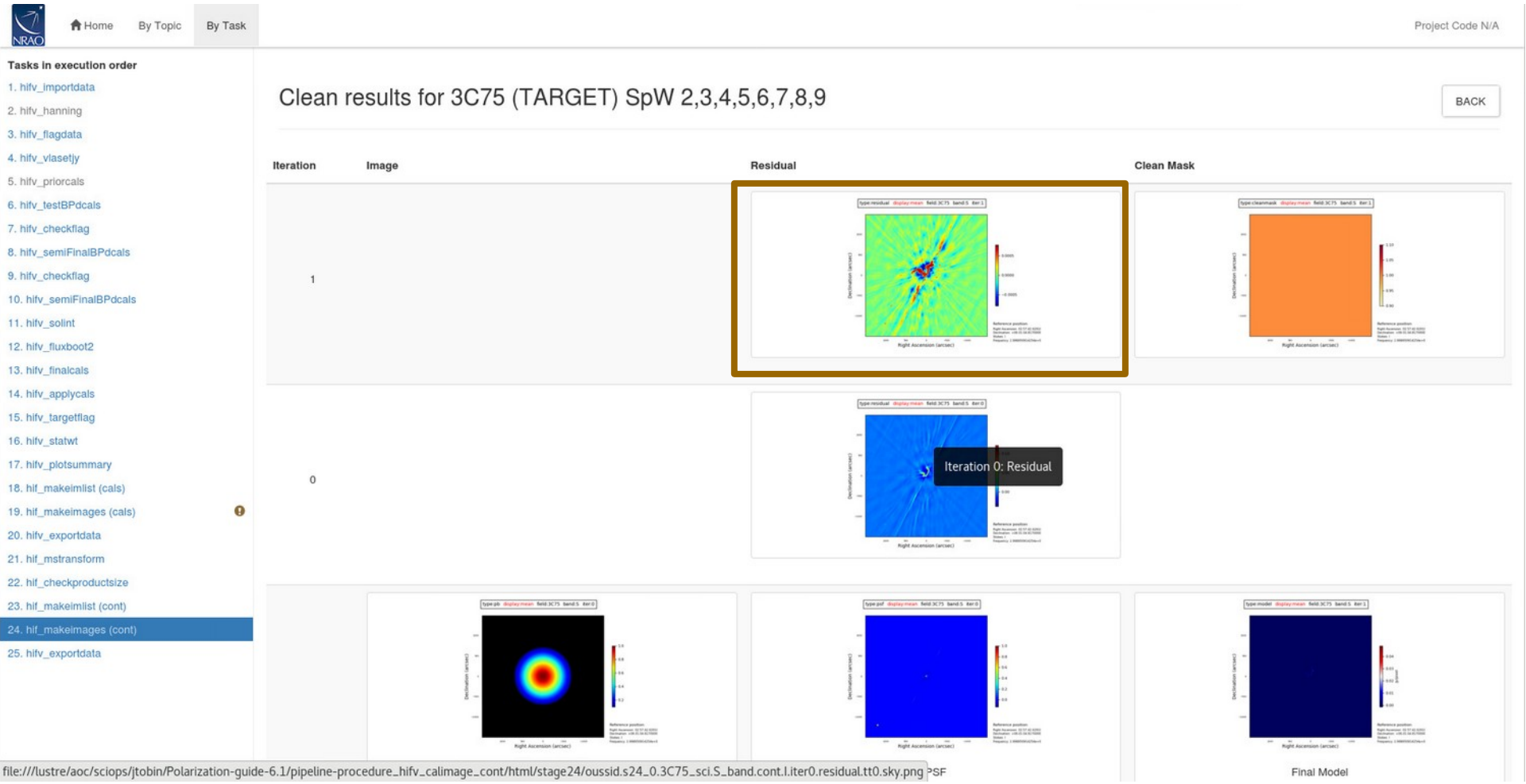
VLA Imaging Pipeline



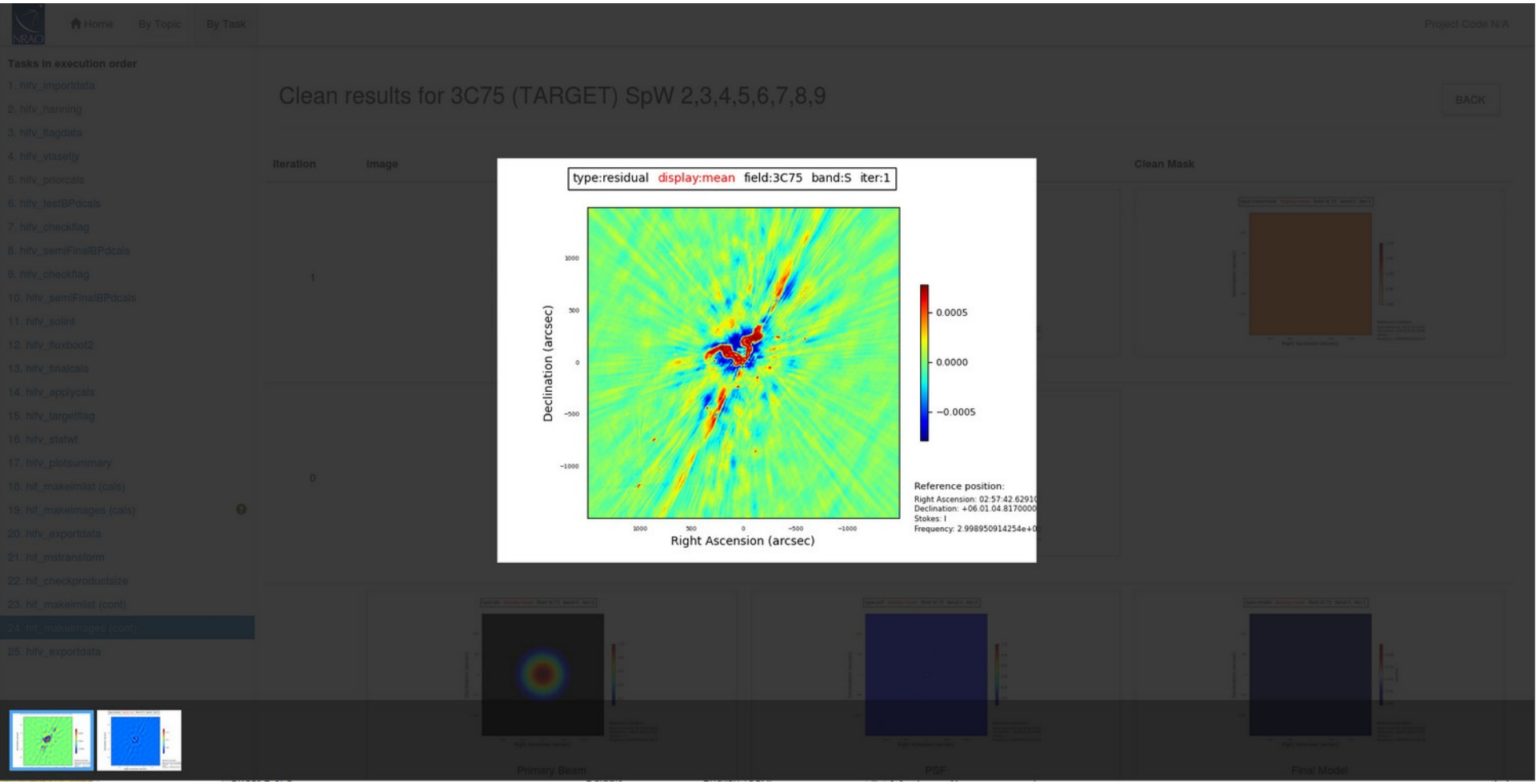
VLA Imaging Pipeline



VLA Imaging Pipeline



VLA Imaging Pipeline



Future Developments

- The NRAO Science Ready Data Products initiative is tentatively planning the following development over the next year:
  - Improved RFI flagging for calibrators and targets - VLASS derived
  - Improved detection of DTS issues and high delays
  - Gain outlier detection
  - Compression correction
  - Improved long solint calculation
  - Gain compression correction - VLASS derived
  - Imaging pipeline improvements
    - Mosaicking
    - Masking

Questions?

- VLA CASA Calibration Pipeline information at:
  http://go.nrao.edu/vla-pipe

- Have Questions?
- Need Help?
- Report a bug?

- Use the **NRAO HelpDesk**: **https://help.nrao.edu/**

- Submit your ticket under the **Pipeline Department.**

- Please include specific details when submitting HelpDesk tickets.
  (Project code, SB number, CASA/PL versions, errors, etc.)

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