ALMA weblog tutorial

ALMA pipeline reduction and imaging inspection

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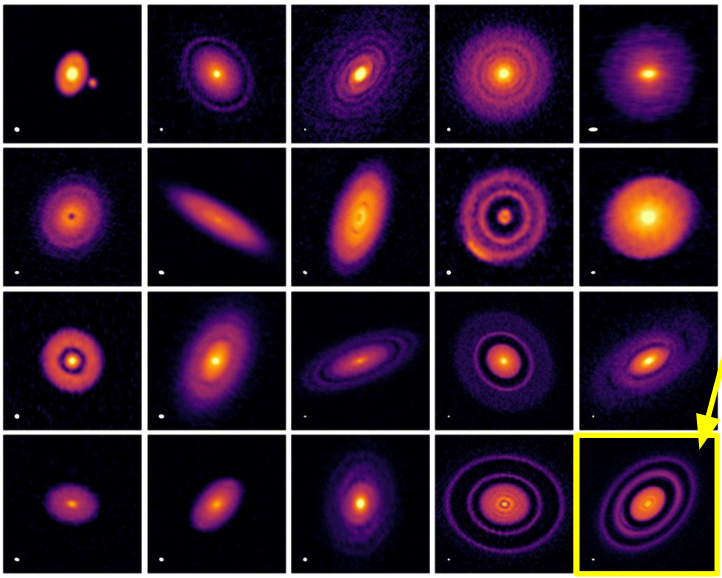
EUROPEAN ARC
ALMA Regional Centre || Allegro

UNIVERSITY OF LEEDS

Based on / including slides from:
H. Nagai + A. Mignano + M.C. Toribio + L.T. Maud + ALMA EU nodes tutorials + ALMA Science Portal and Technical Handbook + CASA Guides +....



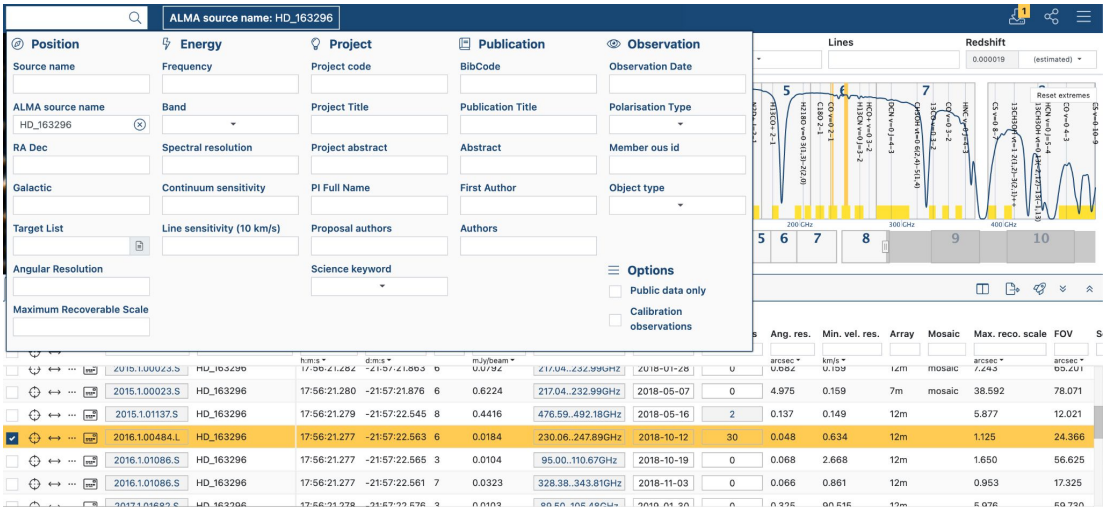
Disk Substructures at High Angular Resolution Project (DSHARP)

Target: HD 163296
Project: 2016.1.00484.L

Publications: e.g.
Andrews et al. 2018, ApJL, 869, L41
Rab et al. 2020, A&A, 642, A165

https://almascience.eso.org/alma data/lp/DSHARP/

ALMA archive: https://almascience.eso.org/aq/

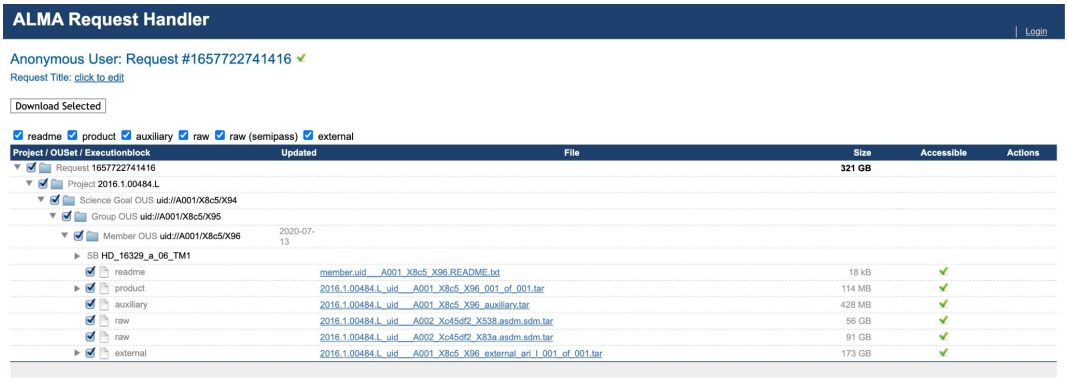


Documentation: almascience.eso.org/alma-data/archive/archive-documentation

- Hover mouse on Search box to open the ‘search by parameter’ window
- To download data, click on the upper-right download icon

OLD

ALMA archive: https://almascience.eso.org/aq/



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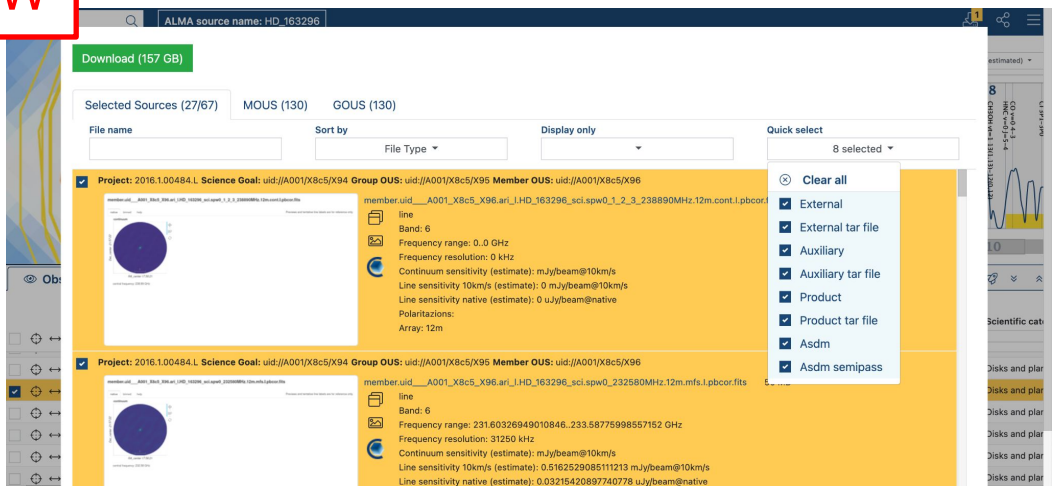
Could try to download at least the auxiliary tar file. It takes ~2min to download and untar

NEW

ALMA archive: https://almascience.eso.org/aq/



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Use the “quick select” box to choose the type of files you want to download (check sizes!)

Tutorial data

Target: HD 163296
Project: 2016.1.00484.L
MOUS: uid://A001/X8c5/X96

Weblogs:

- HD163296_weblog.tgz:
  - Original: pipeline-20170914T223247
  - ARI-L: pipeline-20210529T073751

Datasets for imaging:

- HD163296_data_new.tgz

Data packaging

Example of data structure after unpacking:

2016.1.00484.L/science_goal.uid___A001_X8c5_X94/group.uid___A001_X8c5_X95/member.uid___A001_X8c5_X96

With subdirectories/files:

README calibration log product qa raw script

Directory structure

project_id/
    sg_ouss_id/
        group_ouss_id/
            member_ouss_id/

README	READ THIS FIRST (text file)
calibration/	calibration tables
log/	calibration and imaging log files
product/	the FITS cubes of all images
qa/	diagnostic summary and plots
raw/	created when ASDMs are unpacked
script/	calibration and imaging scripts

- MOUS (Member Observing Unit Set, one per Execution/Scheduling Block) are found inside the GOUS (Group Observing Unit Set) folder. Each GOUS folder can contain several MOUS which will usually be combined during reduction and imaging (e.g. different antenna configs.). The different GOUS folders (often for different sources or spectral setups) are all within a science goal (SG) folder. There can be multiple science goals per project.
- ASDM = ALMA Science Data Model
- README: contains CASA pipe version, QA2 summary, contents of each dir, various kinds of instructions (e.g. how to restore calibrated data)

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Scripts

scriptForPI.py

- Performs all necessary steps to obtain a **calibrated** Measurement Set
- Run within CASA — check version in the README file or in WEBLOG

Directory structure

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group_ouss_id/
member_ouss_id/

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raw/	created when ASDMs are unpacked
calibrated/	**created when scriptForPI.py is run**

Final calibrated MS will be here

Directory structure

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This is where the tarred weblog file is stored. It needs to be untarred and the html/index.html opened in a web browser.

Weblog inspection

UNDERSTAND YOUR OBSERVATIONS!

- ✓ Check observation summary
- ✓ Check flagging summaries
- ✓ Check calibrated data
  - – If any suspicion, check relevant calibrations
- ✓ Check flux consistency
  - – Search calibrator fluxes in the ALMA Source Catalogue

The weblog is checked by the ALMA staff in charge of QA before data delivery, but various parts of it are also useful for the user to review

Weblog inspection

Please navigate to your folder

cd pipeline-20170914T223247/html/

LINUX: firefox index.html &

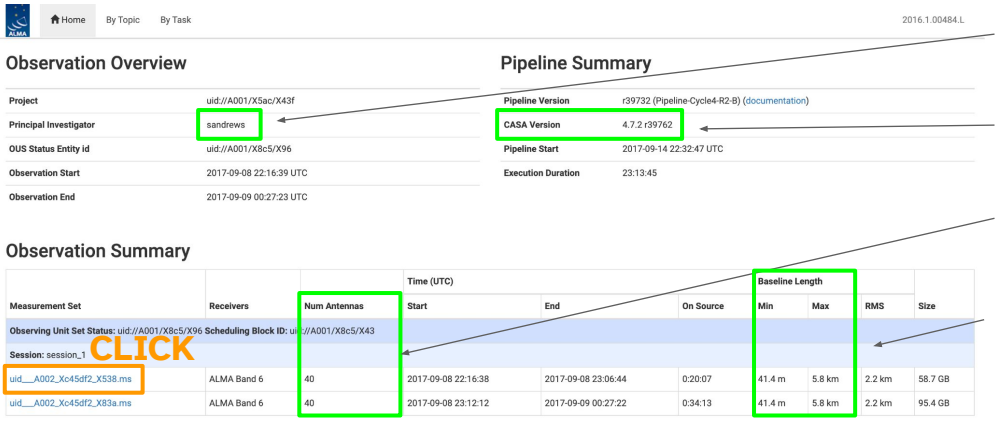
OSX: open -a Firefox index.html &

If there are problems:
https://help.almascience.org/kb/articles/what-is-the-best-way-to-view-the-weblog

Display error? In a terminal, in the html/ folder, type:

```
python3 -m http.server 8080 --bind 127.0.0.1
```

Weblog inspection



Who is the PI of the project?

Which CASA version was used for the pipeline run?

How many antennas observed?

Minimum and maximum baseline length?

- Home weblog page: overview of the observations
- The pipeline is run for each of the observing sessions (EBs) separately. The data for one EB is surrounded by orange box above.

2016.1.00484.L

Overview of 'uid___A002_Xc45df2_X538.ms'

CLICK

Observation Execution Time

Start Time	2017-09-08 22:16:38
End Time	2017-09-08 23:06:44
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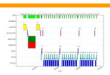
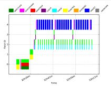


Intent vs Time

Track scan intent vs time



Field vs Time

Track observed field vs time

Spatial Setup

Science Targets	'HD_163296'
Calibrators	'J1742-1517', 'J1743-1658', 'J1751-1950' and 'J1924-2914'

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All Bands	'ALMA Band 6' and 'WVR'
Science Bands	'ALMA Band 6'

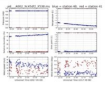
Antenna Setup

Min Baseline	41.4 m
Max Baseline	5.8 km
Number of Baselines	780
Number of Antennas	40

Sky Setup

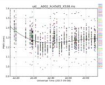
Min Elevation	57.12 degrees
Max Elevation	87.65 degrees

Weather



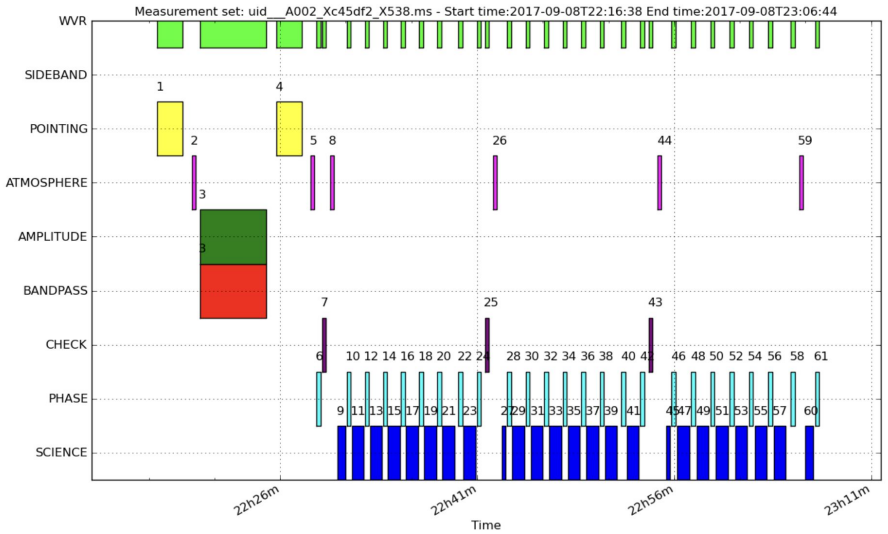
Weather plot

PWV



PWV plot

Scans



Type of source

Check when each calibrator was observed

2016.1.00484.L

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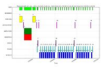

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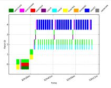

Field vs Time

Track observed field vs time

Spatial Setup

CLICK

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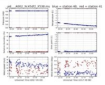
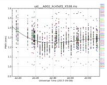


Weather plot

PWV



PWV plot

Scans

Spatial Setup Details

BACK

Sources

ID	Source Name	Source Position			Proper Motion		# Pointings	Intent
		RA	Dec	Ref. Frame	X	Y		
0	J1924-2914	19:24:51.056	-029.14.30.121	ICRS			1	AMPLITUDE, ATMOSPHERE, BANDPASS, POINTING, WVR
1	J1742-1517	17:42:11.663	-015.17.29.159	ICRS			1	POINTING, WVR
2	J1751-1950	17:51:41.344	-019.50.47.504	ICRS			1	ATMOSPHERE, PHASE, WVR
3	J1743-1658	17:43:06.218	-016.58.16.967	ICRS			1	CHECK, WVR
4	HD_163296	17:56:21.278	-021.57.22.564	ICRS	-1.226e-15 rad/s	-6.024e-15 rad/s	1	ATMOSPHERE, TARGET

Sources in uid___A002_Xc45df2_X538.ms

Which source is the target?

Which source is the amplitude calibrator?

Which source is the bandpass calibrator?

Which source is the phase calibrator?

2016.1.00484.L

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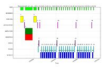

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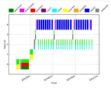
Track scan intent vs time



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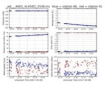

Weather plot

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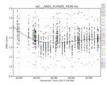

PWV plot

Scans

Spectral Setup Details

BACK

Science Windows | All Windows

Science Windows

	Frequency (TOPO)				Channels (TOPO)				
ID	Start	Centre	End	Bandwidth (TOPO)	Number	Frequency Width	Velocity Width	Correlator Axis	Band
19	231.583 GHz	232.583 GHz	233.583 GHz	2.000 GHz	128	15.625 MHz	20.140 km/s	XX, YY	ALMA Band 6
21	243.971 GHz	244.971 GHz	245.971 GHz	2.000 GHz	128	15.625 MHz	19.122 km/s	XX, YY	ALMA Band 6
23	245.888 GHz	246.888 GHz	247.888 GHz	2.000 GHz	128	15.625 MHz	18.973 km/s	XX, YY	ALMA Band 6
25	230.052 GHz	230.521 GHz	230.990 GHz	937.500 MHz	3840	244.141 kHz	317.505 m/s	XX, YY	ALMA Band 6

Spectral Windows with Science Intent in uid___A002_Xc45df2_X538.ms

Which spectral window contains the ^{12}CO line?

How do you recognize continuum spectral windows?

Broad bandwidth

Small number of channels / low frequency resolution

2016.1.00484.L

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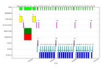

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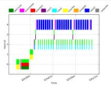

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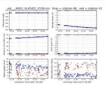
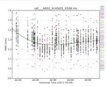


Weather plot

PWV



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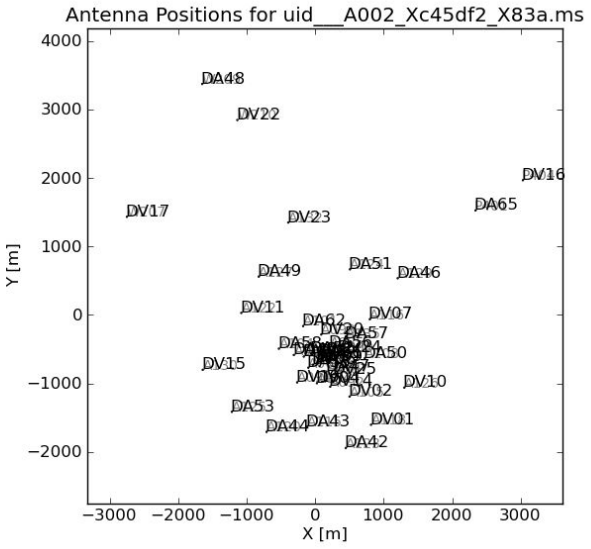
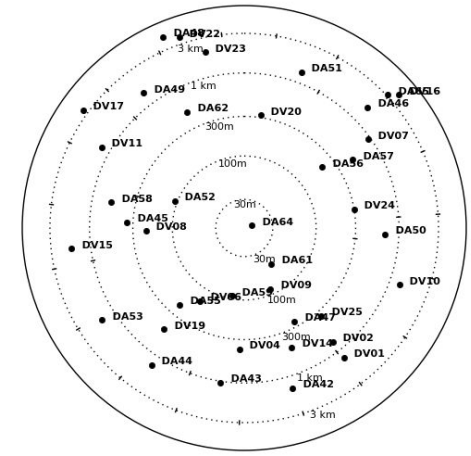


DA42: 1.4 km, 163°
DA43: 1.0 km, -171°
DA44: 1.3 km, -146°
DA45: 0.4 km, -87°
DA46: 1.6 km, 46°
DA47: 0.3 km, 152°
DA48: 4.3 km, -23°
DA49: 1.4 km, -37°
DA50: 0.7 km, 93°
DA51: 1.4 km, 20°
DA52: 0.1 km, -69°
DA53: 1.5 km, -123°
DA55: 0.2 km, -140°
DA56: 0.2 km, 52°
DA57: 0.5 km, 58°
DA58: 0.6 km, -79°
DA59: 0.1 km, -170°
DA61: 0.0 km, 143°
DA62: 0.5 km, -26°
DA64: 0.0 km, 73°
DA65: 3.1 km, 47°
DV01: 1.3 km, 142°
DV02: 0.7 km, 142°
DV04: 0.4 km, -178°
DV06: 0.1 km, -149°
DV07: 0.9 km, 54°
DV08: 0.2 km, -91°
DV09: 0.1 km, 157°
DV10: 1.3 km, 110°
DV11: 1.3 km, -61°
DV14: 0.5 km, 158°
DV15: 1.7 km, -97°
DV16: 3.9 km, 49°
DV17: 3.5 km, -54°
DV19: 0.5 km, -141°
DV20: 0.3 km, 8°
DV22: 3.6 km, -19°
DV23: 2.0 km, -13°
DV24: 0.3 km, 80°
DV25: 0.3 km, 139°



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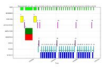
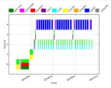


Intent vs Time

Track scan intent vs time



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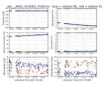
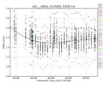


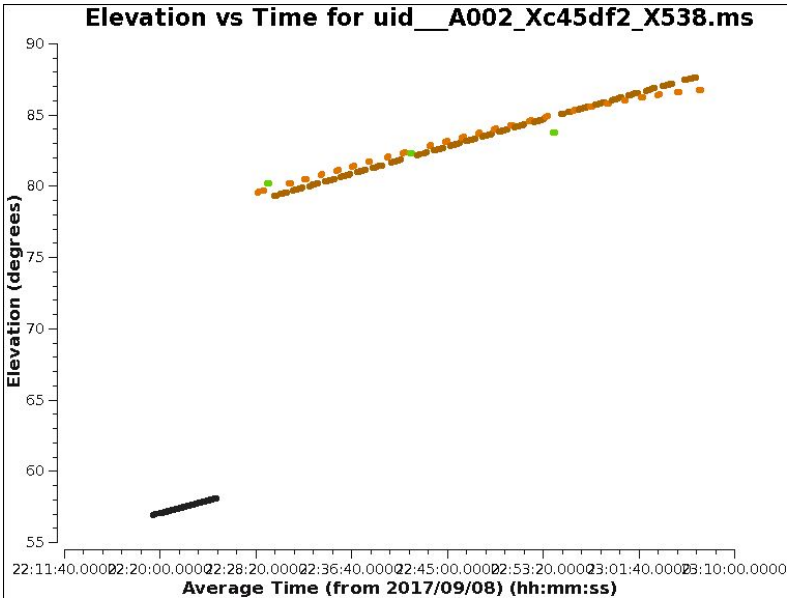
Weather plot

PWV



PWV plot

Scans



Check elevation of target

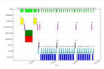
Low elevation can have influence on signal-to-noise ratio

Overview of 'uid___A002_Xc45df2_X538.ms'

Observation Execution Time

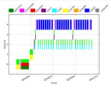
Start Time	2017-09-08 22:16:38
End Time	2017-09-08 23:06:44
Total Time on Source	0:39:20
Total Time on Science Target	0:20:07

LISTOBS OUTPUT



Intent vs Time

Track scan intent vs time



Field vs Time

Track observed field vs time

Spatial Setup

Science Targets	'HD_163296'
Calibrators	'J1742-1517', 'J1743-1658', 'J1751-1950' and 'J1924-2914'

Spectral Setup

All Bands	'ALMA Band 6' and 'WVR'
Science Bands	'ALMA Band 6'

Antenna Setup

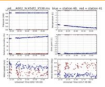
Min Baseline	41.4 m
Max Baseline	5.8 km
Number of Baselines	780
Number of Antennas	40

Sky Setup

Min Elevation	57.12 degrees
Max Elevation	87.65 degrees

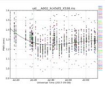
CLICK

Weather



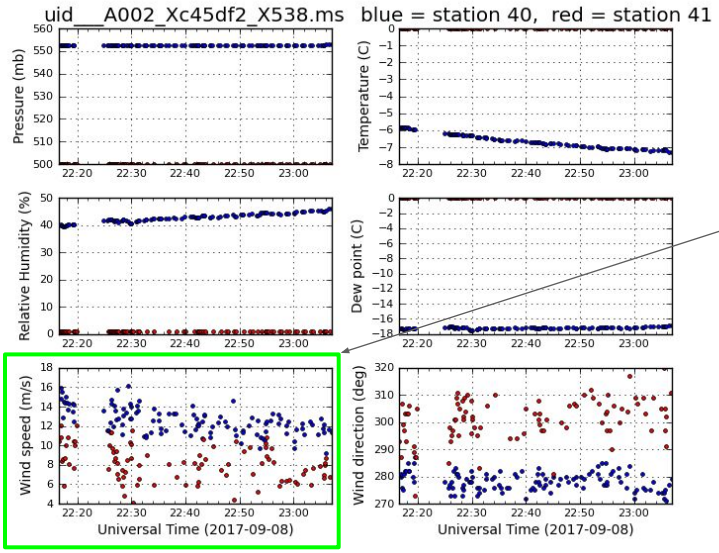
Weather plot

PWV



PWV plot

Scans



Check weather conditions during observations

High wind speeds can have influence on signal-to-noise ratio

2016.1.00484.L

Overview of 'uid___A002_Xc45df2_X538.ms'

Observation Execution Time

Start Time	2017-09-08 22:16:38
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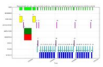
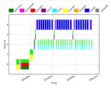
LISTOBS OUTPUT



Intent vs Time

Track scan intent vs time



Field vs Time

Track observed field vs time

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Calibrators	'J1742-1517', 'J1743-1658', 'J1751-1950' and 'J1924-2914'

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Sky Setup

Min Elevation	57.12 degrees
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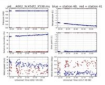
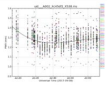
Weather



Weather plot

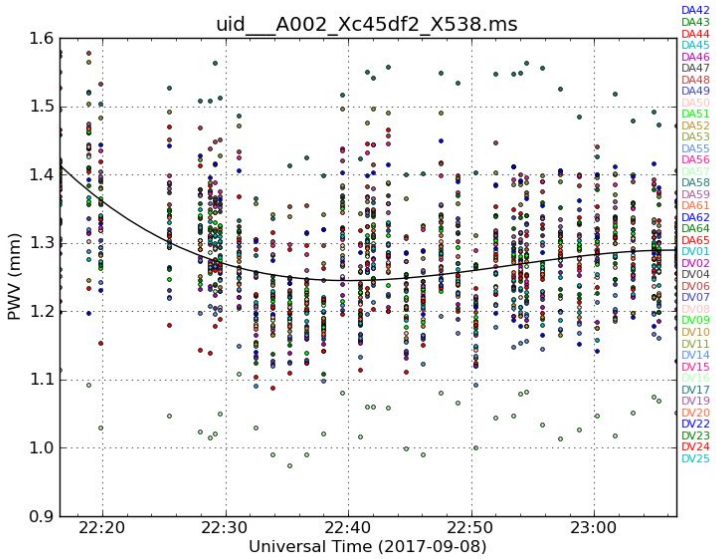
PWV

CLICK



PWV plot

Scans



Check precipitable water vapour conditions during observations

High PWV and/or rapidly changing PWV can have influence on signal-to-noise ratio (depending on observing frequency)

CLICK

Home | By Topic | By Task

2016.1.00484.L

Observation Overview

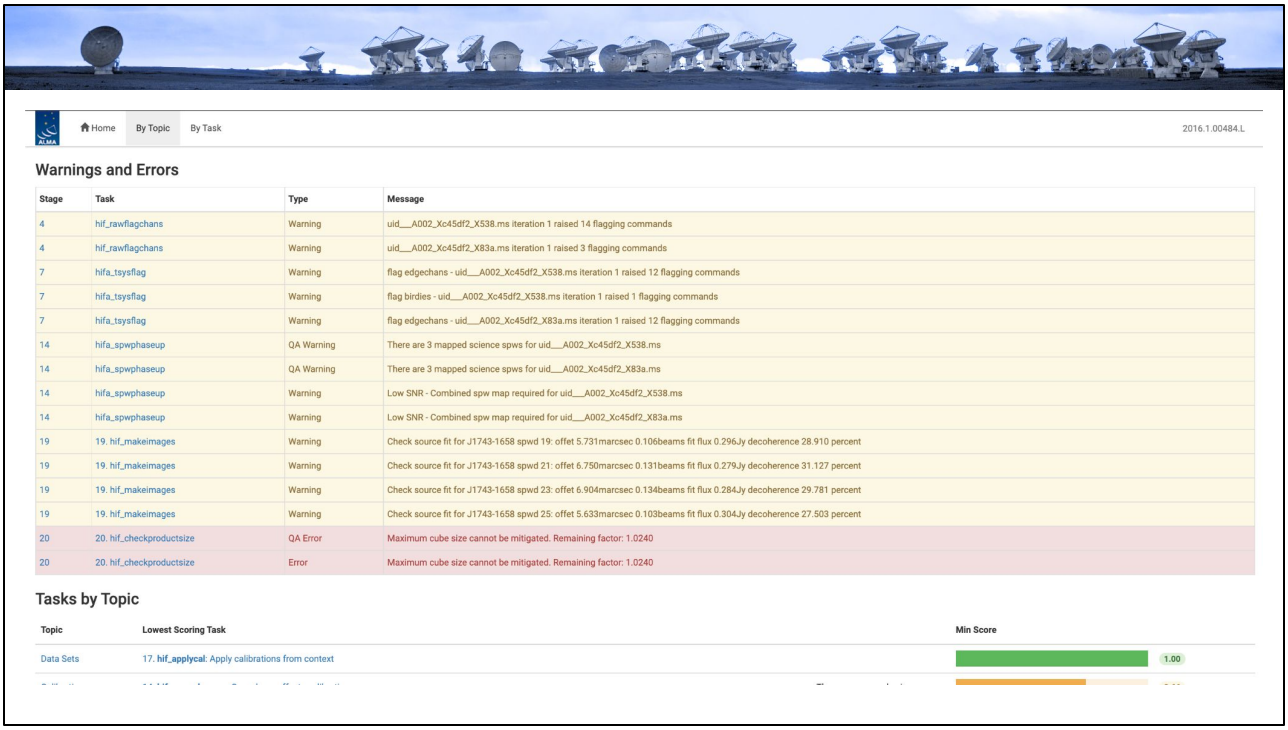
Project	uid://A001/X5ac/X43f
Principal Investigator	sandrews
OUS Status Entity id	uid://A001/X8c5/X96
Observation Start	2017-09-08 22:16:39 UTC
Observation End	2017-09-09 00:27:23 UTC

Pipeline Summary

Pipeline Version	r39732 (Pipeline-Cycle4-R2-B) (documentation)
CASA Version	4.7.2 r39762
Pipeline Start	2017-09-14 22:32:47 UTC
Execution Duration	23:13:45

Observation Summary

			Time (UTC)			Baseline Length			
Measurement Set	**Receivers**	**Num Antennas**	**Start**	**End**	**On Source**	**Min**	**Max**	**RMS**	**Size**
Observing Unit Set Status: uid://A001/X8c5/X96 **Scheduling Block ID:** uid://A001/X8c5/X43									
Session: session_1									
uid___A002_Xc45df2_X538.ms	ALMA Band 6	40	2017-09-08 22:16:38	2017-09-08 23:06:44	0:20:07	41.4 m	5.8 km	2.2 km	58.7 GB
uid___A002_Xc45df2_X83a.ms	ALMA Band 6	40	2017-09-08 23:12:12	2017-09-09 00:27:22	0:34:13	41.4 m	5.8 km	2.2 km	95.4 GB



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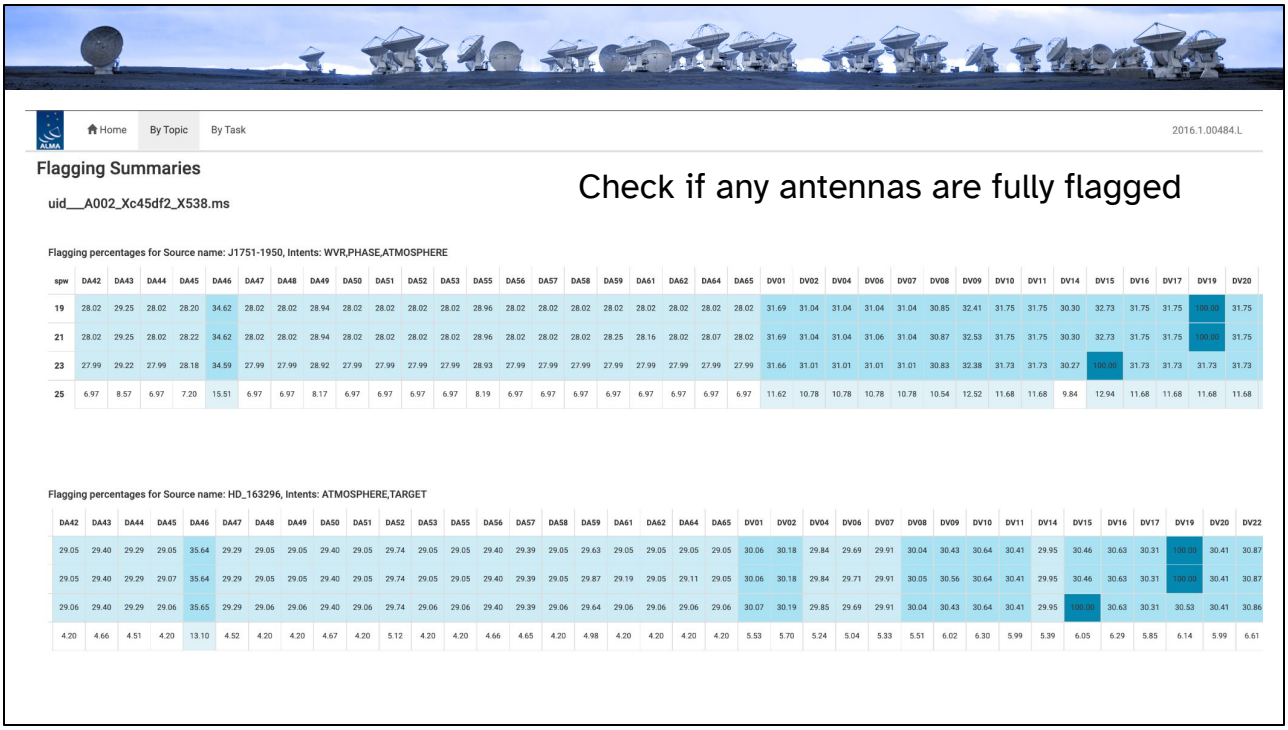
Warnings and Errors

Stage	Task	Type	Message
4	hif_rawflagchans	Warning	uid___A002_Xc45df2_X538.ms iteration 1 raised 14 flagging commands
4	hif_rawflagchans	Warning	uid___A002_Xc45df2_X83a.ms iteration 1 raised 3 flagging commands
7	hifa_tsysflag	Warning	flag edgechans - uid___A002_Xc45df2_X538.ms iteration 1 raised 12 flagging commands
7	hifa_tsysflag	Warning	flag birdies - uid___A002_Xc45df2_X538.ms iteration 1 raised 1 flagging commands
7	hifa_tsysflag	Warning	flag edgechans - uid___A002_Xc45df2_X83a.ms iteration 1 raised 12 flagging commands
14	hifa_spwphaseup	QA Warning	There are 3 mapped science spws for uid___A002_Xc45df2_X538.ms
14	hifa_spwphaseup	QA Warning	There are 3 mapped science spws for uid___A002_Xc45df2_X83a.ms
14	hifa_spwphaseup	Warning	Low SNR - Combined spw map required for uid___A002_Xc45df2_X538.ms
14	hifa_spwphaseup	Warning	Low SNR - Combined spw map required for uid___A002_Xc45df2_X83a.ms
19	19. hif_makeimages	Warning	Check source fit for J1743-1658 spwd 19: offet 5.731marcsec 0.106beams fit flux 0.296Jy decoherence 28.910 percent
19	19. hif_makeimages	Warning	Check source fit for J1743-1658 spwd 21: offet 6.750marcsec 0.131beams fit flux 0.279Jy decoherence 31.127 percent
19	19. hif_makeimages	Warning	Check source fit for J1743-1658 spwd 23: offet 6.904marcsec 0.134beams fit flux 0.284Jy decoherence 29.781 percent
19	19. hif_makeimages	Warning	Check source fit for J1743-1658 spwd 25: offet 5.633marcsec 0.103beams fit flux 0.304Jy decoherence 27.503 percent
20	20. hif_checkproductsize	QA Error	Maximum cube size cannot be mitigated. Remaining factor: 1.0240
20	20. hif_checkproductsize	Error	Maximum cube size cannot be mitigated. Remaining factor: 1.0240

Tasks by Topic

Topic	Lowest Scoring Task	Min Score
Data Sets	17. **hif_applycal**: Apply calibrations from context	1.00

- Errors and warnings triggered during pipeline runs



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Flagging Summaries

uid___A002_Xc45df2_X538.ms

Check if any antennas are fully flagged

Flagging percentages for Source name: J1751-1950, Intents: WVR,PHASE,ATMOSPHERE

spw	DA42	DA43	DA44	DA45	DA46	DA47	DA48	DA49	DA50	DA51	DA52	DA53	DA55	DA56	DA57	DA58	DA59	DA61	DA62	DA64	DA65	DV01	DV02	DV04	DV06	DV07	DV08	DV09	DV10	DV11	DV14	DV15	DV16	DV17	DV19	DV20
19	28.02	29.25	28.02	28.20	34.62	28.02	28.02	28.94	28.02	28.02	28.02	28.02	28.96	28.02	28.02	28.02	28.02	28.02	28.02	28.02	28.02	31.69	31.04	31.04	31.04	31.04	30.85	32.41	31.75	31.75	30.30	32.73	31.75	31.75	100.00	31.75
21	28.02	29.25	28.02	28.22	34.62	28.02	28.02	28.94	28.02	28.02	28.02	28.02	28.96	28.02	28.02	28.02	28.25	28.16	28.02	28.07	28.02	31.69	31.04	31.04	31.06	31.04	30.87	32.53	31.75	31.75	30.30	32.73	31.75	31.75	100.00	31.75
23	27.99	29.22	27.99	28.18	34.59	27.99	27.99	28.92	27.99	27.99	27.99	27.99	28.93	27.99	27.99	27.99	27.99	27.99	27.99	27.99	27.99	31.66	31.01	31.01	31.01	31.01	30.83	32.38	31.73	31.73	30.27	100.00	31.73	31.73	31.73	31.73
25	6.97	8.57	6.97	7.20	15.51	6.97	6.97	8.17	6.97	6.97	6.97	6.97	8.19	6.97	6.97	6.97	6.97	6.97	6.97	6.97	6.97	11.62	10.78	10.78	10.78	10.78	10.54	12.52	11.68	11.68	9.84	12.94	11.68	11.68	11.68	11.68

Flagging percentages for Source name: HD_163296, Intents: ATMOSPHERE,TARGET

DA42	DA43	DA44	DA45	DA46	DA47	DA48	DA49	DA50	DA51	DA52	DA53	DA55	DA56	DA57	DA58	DA59	DA61	DA62	DA64	DA65	DV01	DV02	DV04	DV06	DV07	DV08	DV09	DV10	DV11	DV14	DV15	DV16	DV17	DV19	DV20	DV22
29.05	29.40	29.29	29.05	35.64	29.29	29.05	29.05	29.40	29.05	29.74	29.05	29.05	29.40	29.39	29.05	29.63	29.05	29.05	29.05	29.05	30.06	30.18	29.84	29.69	29.91	30.04	30.43	30.64	30.41	29.95	30.46	30.63	30.31	100.00	30.41	30.87
29.05	29.40	29.29	29.07	35.64	29.29	29.05	29.05	29.40	29.05	29.74	29.05	29.05	29.40	29.39	29.05	29.87	29.19	29.05	29.11	29.05	30.06	30.18	29.84	29.71	29.91	30.05	30.56	30.64	30.41	29.95	30.46	30.63	30.31	100.00	30.41	30.87
29.06	29.40	29.29	29.06	35.65	29.29	29.06	29.06	29.40	29.06	29.74	29.06	29.06	29.40	29.39	29.06	29.64	29.06	29.06	29.06	29.06	30.07	30.19	29.85	29.69	29.91	30.04	30.43	30.64	30.41	29.95	100.00	30.63	30.31	30.53	30.41	30.86
4.20	4.66	4.51	4.20	13.10	4.52	4.20	4.20	4.67	4.20	5.12	4.20	4.20	4.66	4.65	4.20	4.98	4.20	4.20	4.20	4.20	5.53	5.70	5.24	5.04	5.33	5.51	6.02	6.30	5.99	5.39	6.05	6.29	5.85	6.14	5.99	6.61

Flagging summaries. Check for completely flagged antennas, and perhaps also those with >~30% flagged data

CLICK

Home | By Topic | By Task

2016.1.00484.L

Observation Overview

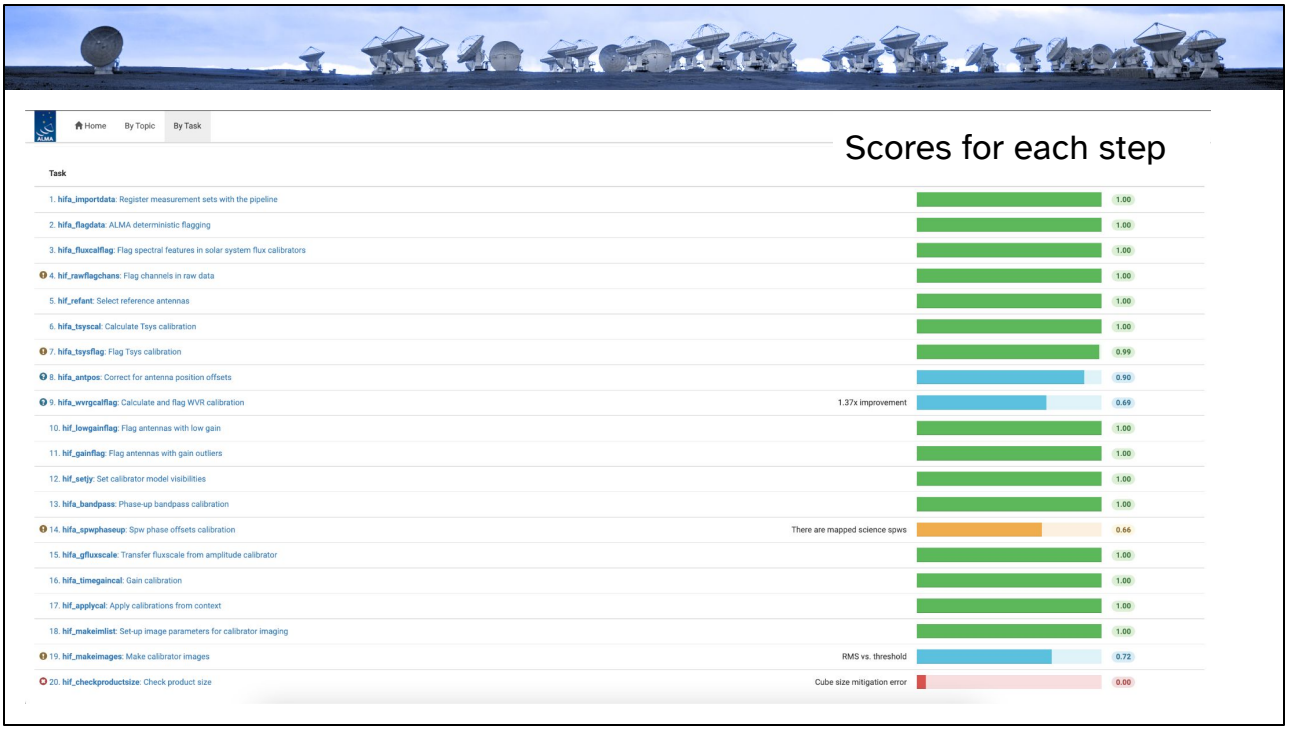
Project	uid://A001/X5ac/X43f
Principal Investigator	sandrews
OUS Status Entity id	uid://A001/X8c5/X96
Observation Start	2017-09-08 22:16:39 UTC
Observation End	2017-09-09 00:27:23 UTC

Pipeline Summary

Pipeline Version	r39732 (Pipeline-Cycle4-R2-B) (documentation)
CASA Version	4.7.2 r39762
Pipeline Start	2017-09-14 22:32:47 UTC
Execution Duration	23:13:45

Observation Summary

			Time (UTC)			Baseline Length			
Measurement Set	**Receivers**	**Num Antennas**	**Start**	**End**	**On Source**	**Min**	**Max**	**RMS**	**Size**
Observing Unit Set Status: uid://A001/X8c5/X96 **Scheduling Block ID:** uid://A001/X8c5/X43									
Session: session_1									
uid___A002_Xc45df2_X538.ms	ALMA Band 6	40	2017-09-08 22:16:38	2017-09-08 23:06:44	0:20:07	41.4 m	5.8 km	2.2 km	58.7 GB
uid___A002_Xc45df2_X83a.ms	ALMA Band 6	40	2017-09-08 23:12:12	2017-09-09 00:27:22	0:34:13	41.4 m	5.8 km	2.2 km	95.4 GB



- “By task” summary is not displayed per measurement set as the Pipeline performs each step on every measurement set sequentially before proceeding to the next step
- The pipeline has its automatic algorithms to set the score at each step/task. These are refined each cycle. Colour-coded according to “goodness” of the score (all four colours displayed here)
- The little warning signs in yellow indicate there are warning/flag messages in that step

Home | By Topic | By Task | 2016.1.00484.L

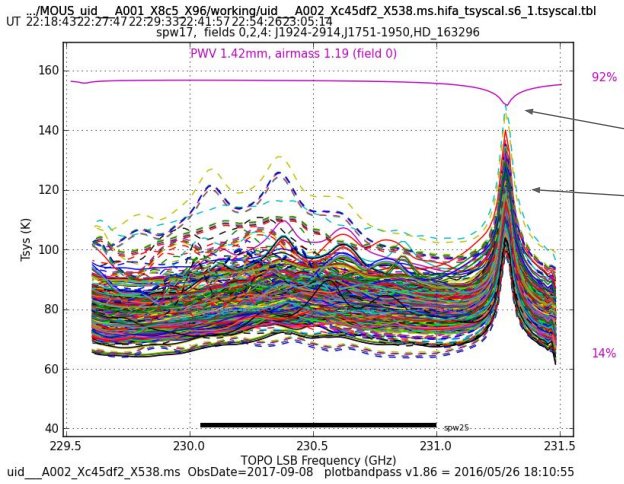
Task	QA Score	
1. **hifa_importdata**: Register measurement sets with the pipeline		1.00
2. **hifa_flagdata**: ALMA deterministic flagging		1.00
3. **hifa_fluxcalflag**: Flag spectral features in solar system flux calibrators		1.00
4. **hif_rawflagchans**: Flag channels in raw data		1.00
5. **hif_refant**: Select reference antennas		1.00
6. **hifa_tsyscal**: Calculate Tsys calibration		1.00
7. **hifa_tsysflag**: Flag Tsys calibration		0.99
8. **hifa_antpos**: Correct for antenna position offsets		0.90
9. **hifa_wvrgcalflag**: Calculate and flag WVR calibration	1.37x improvement	0.69
10. **hif_lowgainflag**: Flag antennas with low gain		1.00
11. **hif_gainflag**: Flag antennas with gain outliers		1.00
12. **hif_setjy**: Set calibrator model visibilities		1.00
13. **hifa_bandpass**: Phase-up bandpass calibration		1.00
14. **hifa_spwphaseup**: Spw phase offsets calibration	There are mapped science spws	0.66
15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator		1.00
16. **hifa_timegaincal**: Gain calibration		1.00
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

CLICK

6. **hifa_tsyscal**: Calculate Tsys calibration

7. **hifa_tsysflag**: Flag Tsys calibration

Check Tsys calibration!



Tsys → sensitivity of each antenna with time (atmosphere & receivers)

Atmospheric features can lead to increased Tsys values.

If Tsys peak without atmospheric feature → Problem!

tsysflag: Several kinds of flags, each with its own algorithm. The most common are ‘edge flags’, and ‘birdies’ (spikes)

Home | By Topic | By Task | 2016.1.00484.L

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5. **hif_refant**: Select reference antennas		1.00
6. **hifa_tsyscal**: Calculate Tsys calibration		1.00
7. **hifa_tsysflag**: Flag Tsys calibration		0.99
8. **hifa_antpos**: Correct for antenna position offsets		0.90
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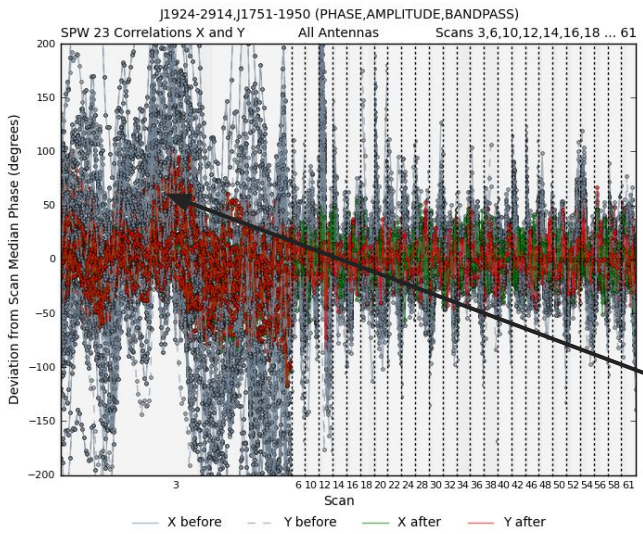
16. **hifa_timegaincal**: Gain calibration		1.00
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

CLICK

9. **hifa_wvrgcalflag**: Calculate and flag WVR calibration

Check WVR correction!



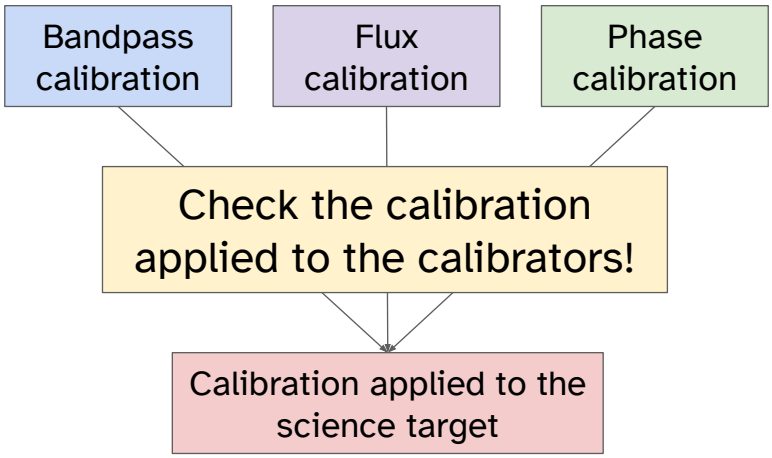
Variations in the amount of water vapour lead to atmospheric phase fluctuations (very short timescales < 1 min)

(see also www.alma-allegro.nl/wvr-and-phase-metrics/wvr-scaling/)

Phase noise should decrease
—> If not, pipeline will not apply the correction

- Typically the decision on whether to apply the correction is based on the BP scan improvement level.
- In our case, the second MS has a smaller improvement (1.37), hence the blue colour on task summary page. Correction applied in both cases.

Calibration basics

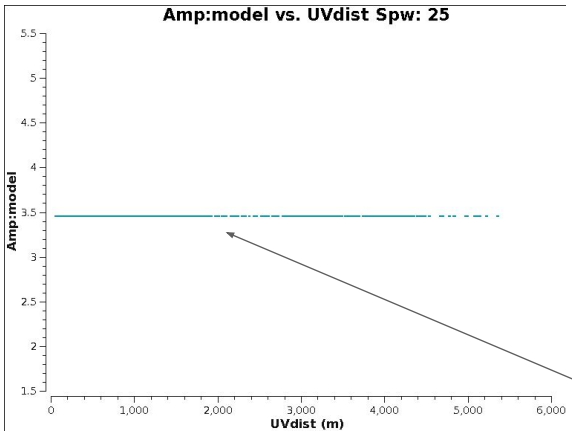


To be calibrated per antenna, spw, scan and polarisation (except for bootstrapped phase/amp cal when flux cal is polarised)

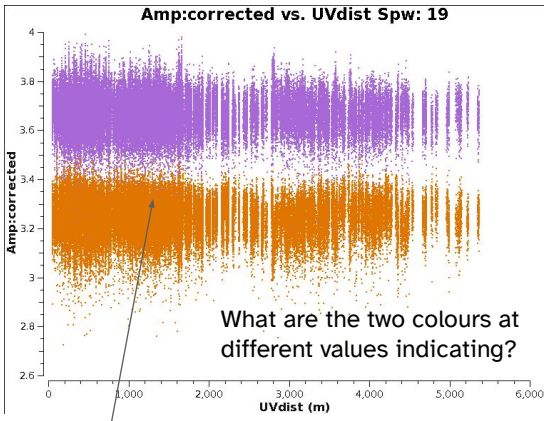
Weblog shows weird behaviour of model in spw 21 (for both MSs). Needs to be investigated.

Flux calibrator model

12. **hif_setjy**: Set calibrator model visibilities



Input model



Output calibrated amplitudes

Calibrator is polarised but averaged amplitudes are used for flux calibration

Home | By Topic | By Task | 2016.1.00484.L

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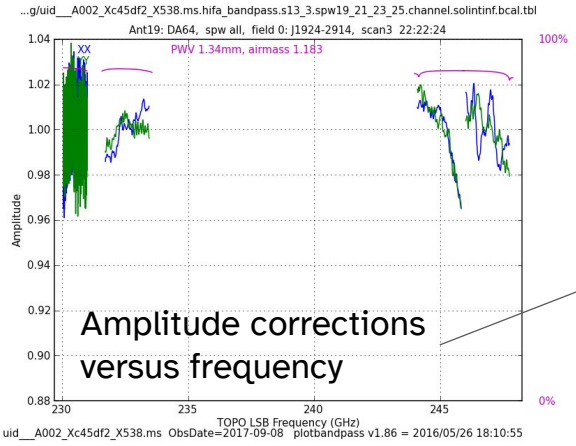
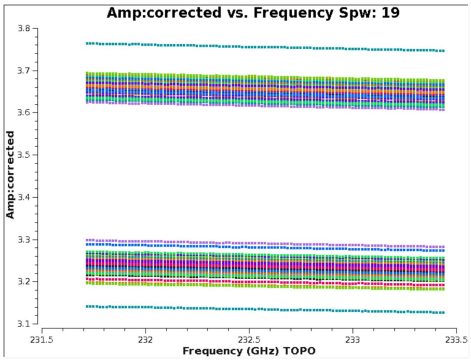
9. **hifa_wvrgcalflag**: Calculate and flag WVR calibration	1.37x improvement	0.69
10. **hif_lowgainflag**: Flag antennas with low gain		1.00
11. **hif_gainflag**: Flag antennas with gain outliers		1.00
12. **hif_setjy**: Set calibrator model visibilities		1.00
13. **hifa_bandpass**: Phase-up bandpass calibration		1.00
14. **hifa_spwphaseup**: Spw phase offsets calibration	There are mapped science spws	0.66
15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator		1.00
16. **hifa_timegaincal**: Gain calibration		1.00
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

CLICK

Bandpass calibration

13. **hifa_bandpass**: Phase-up bandpass calibration



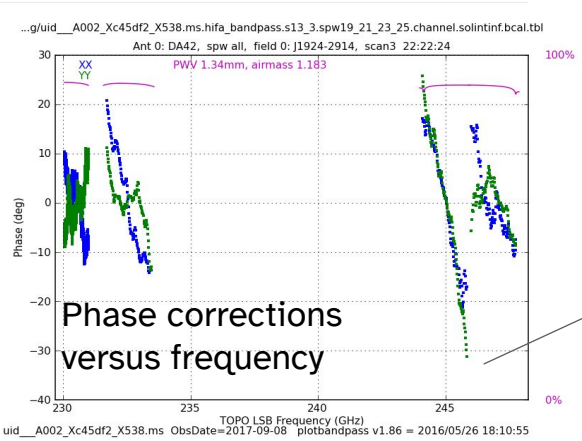


Corrected amplitudes (note polarised source)

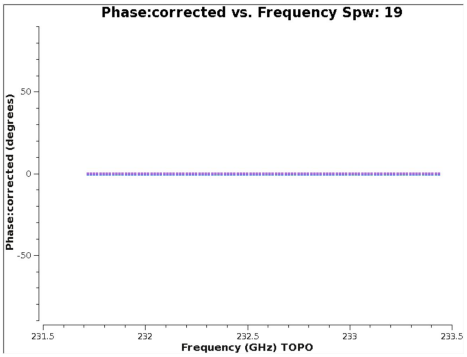
The plot on the left shows corrections to be applied to the other calibrators & target source. The plot on the right shows the corrected amplitudes for the bandpass calibrator (shown in a later task, not here).

Bandpass calibration

13. **hifa_bandpass**: Phase-up bandpass calibration



Phase corrections versus frequency



Corrected phases: flat, close to zero!

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Task	QA Score	
1. **hifa_importdata**: Register measurement sets with the pipeline		1.00
2. **hifa_flagdata**: ALMA deterministic flagging		1.00
3. **hifa_fluxcalflag**: Flag spectral features in solar system flux calibrators		1.00
4. **hif_rawflagchans**: Flag channels in raw data		1.00
5. **hif_refant**: Select reference antennas		1.00
6. **hifa_tsyscal**: Calculate Tsys calibration		1.00
7. **hifa_tsysflag**: Flag Tsys calibration		0.99
8. **hifa_antpos**: Correct for antenna position offsets		0.90
9. **hifa_wvrgcalflag**: Calculate and flag WVR calibration	1.37x improvement	0.69
10. **hif_lowgainflag**: Flag antennas with low gain		1.00
11. **hif_gainflag**: Flag antennas with gain outliers		1.00
12. **hif_setjy**: Set calibrator model visibilities		1.00
13. **hifa_bandpass**: Phase-up bandpass calibration		1.00
14. **hifa_spwphaseup**: Spw phase offsets calibration	There are mapped science spws	0.66
15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator		1.00
16. **hifa_timegaincal**: Gain calibration		1.00
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

CLICK

Flux consistency

15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator

Derived flux density

J1751-1950 (#2) PHASE	19	232.583 GHz 2.000 GHz	55.946 mJy ± 810.164 µJy (1.4%)	0.000 Jy	0.000 Jy	0.000 Jy	1.163
			48.100 mJy	0.000 Jy	0.000 Jy	0.000 Jy	
	21	244.971 GHz 2.000 GHz	54.629 mJy ± 1.057 mJy (1.9%)	0.000 Jy	0.000 Jy	0.000 Jy	1.177
			46.400 mJy	0.000 Jy	0.000 Jy	0.000 Jy	
	23	246.888 GHz 2.000 GHz	54.796 mJy ± 906.133 µJy (1.7%)	0.000 Jy	0.000 Jy	0.000 Jy	1.186
			46.200 mJy	0.000 Jy	0.000 Jy	0.000 Jy	
	25	230.521 GHz 937.500 MHz	58.307 mJy ± 1.064 mJy (1.8%)	0.000 Jy	0.000 Jy	0.000 Jy	1.205
			48.400 mJy	0.000 Jy	0.000 Jy	0.000 Jy	

Catalog flux density

Compare with https://almascience.eso.org/sc/

Absolute flux density error: ~10-15%

In new weblogs there is a plot comparing fluxes with online catalog

Home | By Topic | By Task | 2016.1.00484.L

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13. **hifa_bandpass**: Phase-up bandpass calibration		1.00
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15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator		1.00
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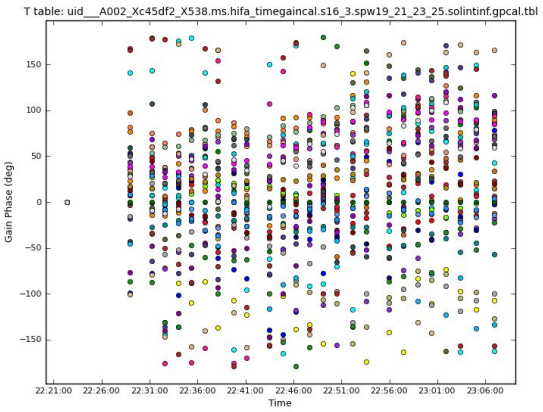
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

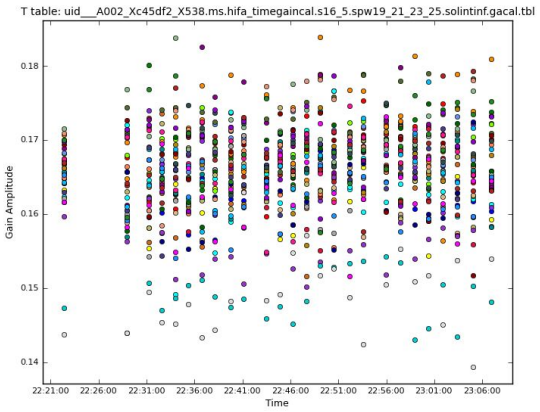
CLICK

Phase calibration

16. **hifa_timegaincal**: Gain calibration

Phase and amplitude corrections to be applied to the target





Left: phase; right: amplitude

Apply all calibration

Calibration "Table" \ Calibrator	BP CAL	FLUX CAL	PHASE CAL	TARGET
FLUX SCALING	FLUX CAL (Scaled in fluxscale)	FLUX CAL (Model in setJy)	FLUX CAL (Scaled in fluxscale)	
BANDPASS	BP CAL	BP CAL	BP CAL	BP CAL
PHASE	BP CAL (short interval time solutions)	FLUX CAL (short time interval solutions)	PHASE CAL (long time interval solutions	PHASE CAL (long time interval solutions
AMPLITUDE	BP CAL (short interval time solutions)	FLUX CAL (short time interval solutions)	PHASE CAL (long time interval solutions	PHASE CAL (long time interval solutions

For target (rightmost column), you apply the bandpass calibration from the bandpass calibrator and phase and amplitude calibration (bootstrapped from the flux calibrator) from the phase calibrator. The other columns show what source is used to carry out each part of the calibration (flux scaling, bandpass, phase and amplitude calibration) for each calibrator. The calibration shown for the first three columns/sources is not strictly required for calibrating the data, but applying the calibrations back onto the calibrator sources serves as a check of how well the calibration has gone, as we know what these should look like once calibrated.

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Task	QA Score	
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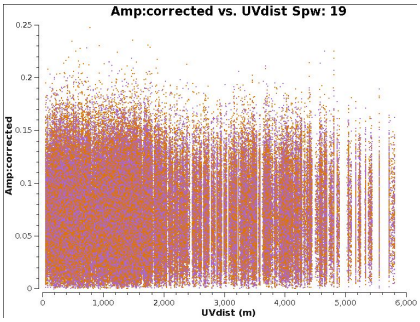
12. **hif_setjy**: Set calibrator model visibilities		1.00
13. **hifa_bandpass**: Phase-up bandpass calibration		1.00
14. **hifa_spwphaseup**: Spw phase offsets calibration	There are mapped science spws	0.66
15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator		1.00
16. **hifa_timegaincal**: Gain calibration		1.00
17. **hif_applycal**: Apply calibrations from context		1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator imaging		1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold	0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error	0.00

CLICK

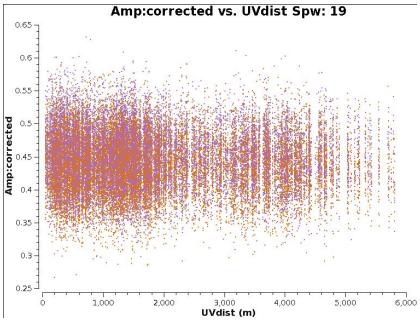
Apply all calibration

17. **hif_applycal**: Apply calibrations from context

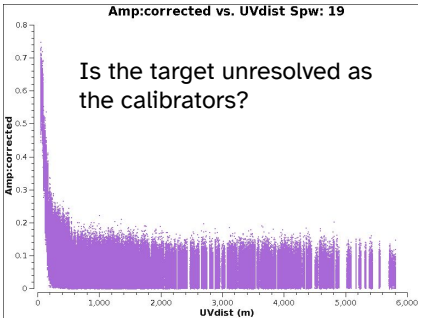
Phase calibrator



Check source



Target

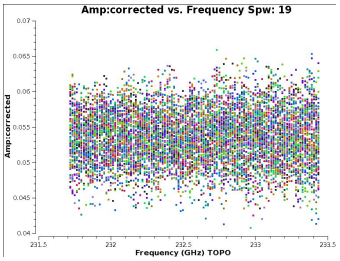


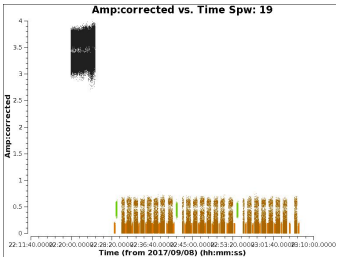
- The target is resolved as the amplitude is not constant with uv distance
- A check source used for resol<0.25” and/or freq>400 GHz - it should be bright and point-like. All of the same calibrations applied to the target are applied to the check source. It is used to evaluate the quality of the phase calibration and therefore the image quality expected on the target.

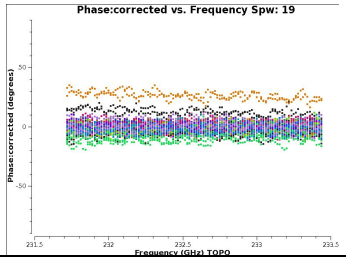
Apply all calibration

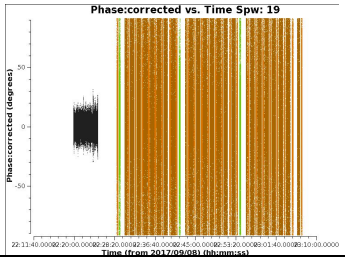
17. **hif_applycal**: Apply calibrations from context

Phase calibrator







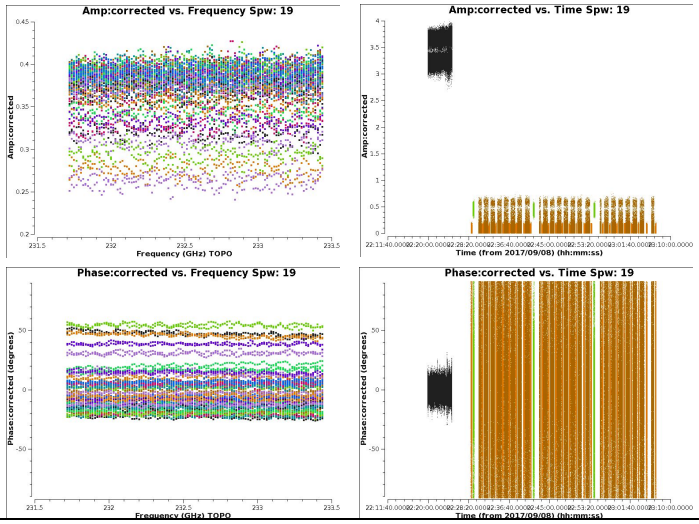


Phases should be around zero and amplitudes constant in time for phase calibrator and check source.

Apply all calibration

17. **hif_applycal**: Apply calibrations from context

Check source

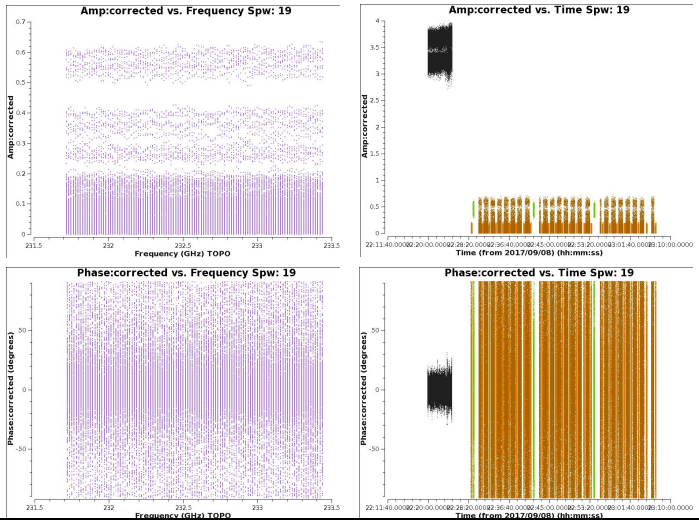


Phases should be around zero and amplitudes constant in time for phase calibrator and check source.

Apply all calibration

17. **hif_applycal**: Apply calibrations from context

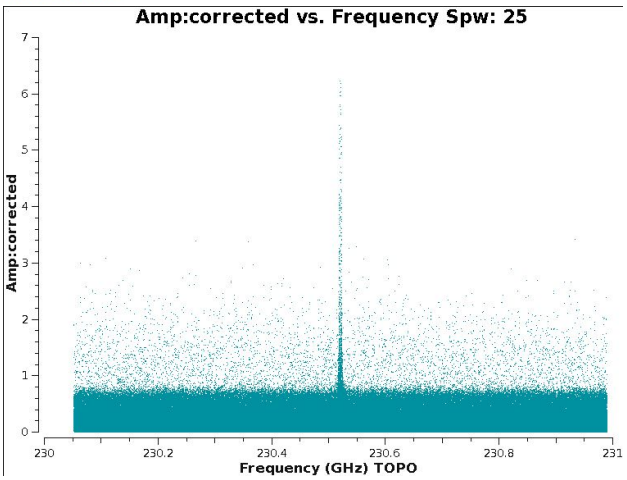
Target



Corrected data for target may be more complex, however you can see above that source is centred at phase centre as data is clustered around phase=0 deg.

^{12}CO line

17. **hif_applycal**: Apply calibrations from context



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6. **hifa_tsyscal**: Calculate Tsys calibration	1.00
7. **hifa_tsysflag**: Flag Tsys calibration	0.99
8. **hifa_antpos**: Correct for antenna position offsets	0.90
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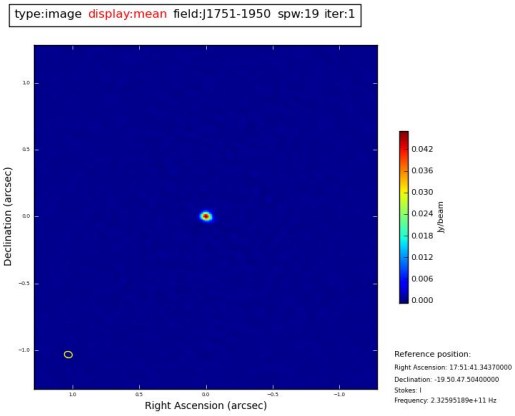
10. **hif_lowgainflag**: Flag antennas with low gain	1.00
11. **hif_gainflag**: Flag antennas with gain outliers	1.00
12. **hif_setjy**: Set calibrator model visibilities	1.00
13. **hifa_bandpass**: Phase-up bandpass calibration	1.00
14. **hifa_spwphaseup**: Spw phase offsets calibration	There are mapped science spws 0.66
15. **hifa_gfluxscale**: Transfer fluxscale from amplitude calibrator	1.00
16. **hifa_timegaincal**: Gain calibration	1.00
17. **hif_applycal**: Apply calibrations from context	1.00
18. **hif_makeimlist**: Set-up image parameters for calibrator images	1.00
19. **hif_makeimages**: Make calibrator images	RMS vs. threshold 0.72
20. **hif_checkproductsize**: Check product size	Cube size mitigation error 0.00

CLICK

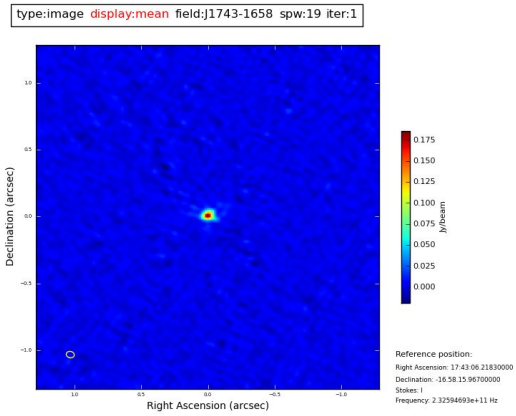
Calibrator images

19. **hif_makeimages**: Make calibrator images

Phase calibrator



Check source



Once data are calibrated we can start making images, starting with the calibrators

ARI-L

https://almascience.eso.org/alma-data/aril

The Additional Representative Images for Legacy (ARI-L) in the ALMA Science Archive (ASA) is a Development project for ALMA. The project aims to increase the legacy value of the ALMA Science Archive by bringing the reduction level of ALMA data from Cycles 2-4 close to that of what is processed with the ALMA Imaging Pipeline in more recent Cycles.

Please navigate to your folder

cd pipeline-20210529T073751/html/

LINUX: firefox index.html &

OSX: open -a Firefox index.html &

Display error? In a terminal, below the html/ folder, type:

```
python3 -m http.server 8081 --bind 127.0.0.1
```

ARI-L project: re-imaging pre-Cycle 5 data in pipeline mode to add functionality that is now part of the standard pipeline weblog since Cycle 5.

ARI-L Weblog

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

Observation Overview

Project	uid://A001/X5ac/X43f
Principal Investigator	sandrews
Observation Start	2017-09-08 22:19:17 UTC
Observation End	2017-09-09 00:27:41 UTC

Pipeline Summary

Pipeline Version	42866 (Pipeline-CASA56-P1-B) (documentation)
CASA Version	5.6.1-8 (environment)
Pipeline Start	2021-05-29 07:37:51 UTC
Execution Duration	6 days, 3:16:00

Observation Summary

			Time (UTC)			Baseline Length			
Measurement Set	**Receivers**	**Num Antennas**	**Start**	**End**	**On Source**	**Min**	**Max**	**RMS**	**Size**
Observing Unit Set Status: unknown **Scheduling Block ID:** uid://A001/X8c5/X43									
Session: session_1									
uid___A002_Xc45df2_X538.ms.split.cal	ALMA Band 6	40	2017-09-08 22:19:17	2017-09-08 23:07:03	0:19:58	41.4 m	5.8 km	2.2 km	105.6 GB
uid___A002_Xc45df2_X538.ms.split_target.ms	ALMA Band 6	40	2017-09-08 22:30:22	2017-09-08 23:06:34	0:19:58	41.4 m	5.8 km	2.2 km	31.8 GB
uid___A002_Xc45df2_X83a.ms.split.cal	ALMA Band 6	40	2017-09-08 23:14:51	2017-09-09 00:27:41	0:33:52	41.4 m	5.8 km	2.2 km	173.2 GB
uid___A002_Xc45df2_X83a.ms.split_target.ms	ALMA Band 6	40	2017-09-08 23:29:15	2017-09-09 00:27:07	0:33:52	41.4 m	5.8 km	2.2 km	53.9 GB

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Task Summaries

Task		QA Score	Duration
1. **hifa_importdata**: Register measurement sets with the pipeline	1/1 have HISTORY	0.50	0:11:33
2. **hif_mstransform**: Create science target MS		1.00	0:17:06
3. **hifa_flagtargets**: ALMA Target flagging		1.00	0:03:29
4. **hifa_imageprecheck**: ImagePreCheck		1.00	1:49:08
5. **hif_checkproductsize**: Check product size	Size was mitigated	0.50	0:08:04
6. **hif_makeimlist**: Set-up parameters for target per-spw continuum imaging		1.00	0:02:26
7. **hif_findcont**: Detect continuum frequency ranges		1.00	6:01:22
8. **hif_uvcontfit**: UV continuum fitting		1.00	2:20:32
9. **hif_uvcontsub**: UV continuum subtraction		1.00	0:15:41
10. **hif_makeimages**: Make target per-spw continuum images		1.00	8:42:13
11. **hif_makeimlist**: Set-up parameters for target aggregate continuum imaging		1.00	0:02:31
12. **hif_makeimages**: Make target aggregate continuum images		1.00	6:31:18
13. **hif_makeimlist**: Set-up parameters for target cube imaging		1.00	0:02:26
14. **hif_makeimages**: Make target cubes		1.00	5 days, 0:47:54
15. **hif_makeimlist**: Set-up parameters for representative bandwidth target cube imaging	No clean targets expected	N/A	0:00:09
16. **hif_makeimages**: Make representative bandwidth target cube	Nothing to image	N/A	0:00:06

CASA logs and scripts

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

Task Summaries

Task		QA Score	Duration
1. **hifa_importdata**: Register measurement sets with the pipeline	1/1 have HISTORY	0.50	0:11:33
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3. **hifa_flagtargets**: ALMA Target flagging		1.00	0:03:29
4. **hifa_imageprecheck**: ImagePreCheck		1.00	1:49:08
5. **hif_checkproductsize**: Check product size	Size was mitigated	0.50	0:08:04
6. **hif_makeimlist**: Set-up parameters for target per-spw continuum imaging		1.00	0:02:26
7. **hif_findcont**: Detect continuum frequency ranges		1.00	6:01:22
8. **hif_uvcontfit**: UV continuum fitting		1.00	2:20:32
9. **hif_uvcontsub**: UV continuum subtraction		1.00	0:15:41
10. **hif_makeimages**: Make target per-spw continuum images		1.00	8:42:13
11. **hif_makeimlist**: Set-up parameters for target aggregate continuum imaging		1.00	0:02:31
12. **hif_makeimages**: Make target aggregate continuum images		1.00	6:31:18
13. **hif_makeimlist**: Set-up parameters for target cube imaging		1.00	0:02:26
14. **hif_makeimages**: Make target cubes		1.00	5 days, 0:47:54
15. **hif_makeimlist**: Set-up parameters for representative bandwidth target cube imaging	No clean targets expected	N/A	0:00:09
16. **hif_makeimages**: Make representative bandwidth target cube	Nothing to image	N/A	0:00:06

CASA logs and scripts

CLICK

Image Precheck

4. **hifa_imageprecheck**: ImagePreCheck

Assumed Values (Goal information not available):

Representative Target: HD_163296 (First science target)
Representative Frequency: 232.5748 GHz (SPW 0) (Center of first science spw)
Bandwidth for Sensitivity: 15.62 MHz (repBW=15.62 MHz, channel width of first science spw)
Min / Max Acceptable Resolution: Not available
Maximum expected beam axial ratio (from OT): Not available
Goal PI sensitivity: Not available
Single Continuum: Not available

robust	uvtaper	Synthesized Beam	Cell	Beam Ratio	Bandwidth	BW Mode	Effective Sensitivity
0.0	[]	0.0503 x 0.0379 arcsec @ 73.5 deg	0.0076 x 0.0076 arcsec	1.33	15.62 MHz	repBW	0.00019 Jy/beam
0.0	[]	0.0486 x 0.0377 arcsec @ 74.0 deg	0.0075 x 0.0075 arcsec	1.33	6854 MHz	aggBW	1.69e-05 Jy/beam
0.5	[]	0.0618 x 0.0463 arcsec @ 74.4 deg	0.0093 x 0.0093 arcsec	1.33	15.62 MHz	repBW	0.000151 Jy/beam
0.5	[]	0.0602 x 0.0466 arcsec @ 76.7 deg	0.0093 x 0.0093 arcsec	1.33	6854 MHz	aggBW	1.34e-05 Jy/beam
1.0	[]	0.0725 x 0.0626 arcsec @ 84.7 deg	0.013 x 0.013 arcsec	1.16	15.62 MHz	repBW	0.000137 Jy/beam
1.0	[]	0.0716 x 0.0600 arcsec @ 88.0 deg	0.012 x 0.012 arcsec	1.16	6854 MHz	aggBW	1.21e-05 Jy/beam
2.0	[]	0.0800 x 0.0684 arcsec @ 85.2 deg	0.014 x 0.014 arcsec	1.17	15.62 MHz	repBW	0.000135 Jy/beam
2.0	[]	0.0778 x 0.0659 arcsec @ 84.8 deg	0.013 x 0.013 arcsec	1.17	6854 MHz	aggBW	1.19e-05 Jy/beam

- Usually the P.I. requests are given in the “Assumed Values” section (not available here)
- The task tries different robust weighting schemes for imaging and decides on the one that best matches the P.I.’s requests for imaging

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Task Summaries

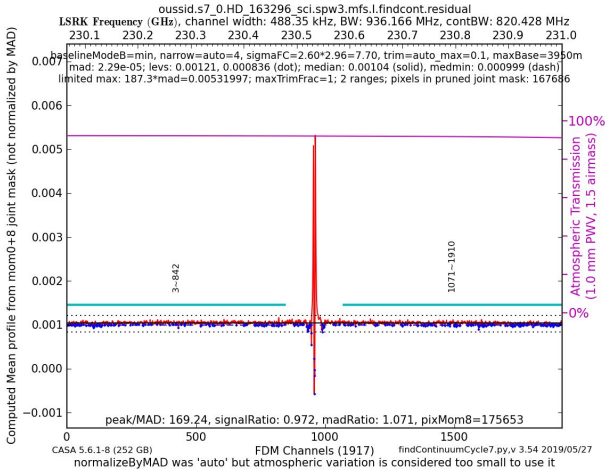
Task		QA Score	Duration
1. **hifa_importdata**: Register measurement sets with the pipeline	1/1 have HISTORY	0.50	0:11:33
2. **hif_mstransform**: Create science target MS		1.00	0:17:06
3. **hifa_flagtargets**: ALMA Target flagging		1.00	0:03:29
4. **hifa_imageprecheck**: ImagePreCheck		1.00	1:49:08
5. **hif_checkproductsize**: Check product size	Size was mitigated	0.50	0:08:04
6. **hif_makeimlist**: Set-up parameters for target per-spw continuum imaging		1.00	0:02:26
7. **hif_findcont**: Detect continuum frequency ranges		1.00	6:01:22
8. **hif_uvcontfit**: UV continuum fitting		1.00	2:20:32
9. **hif_uvcontsub**: UV continuum subtraction		1.00	0:15:41
10. **hif_makeimages**: Make target per-spw continuum images		1.00	8:42:13
11. **hif_makeimlist**: Set-up parameters for target aggregate continuum imaging		1.00	0:02:31
12. **hif_makeimages**: Make target aggregate continuum images		1.00	6:31:18
13. **hif_makeimlist**: Set-up parameters for target cube imaging		1.00	0:02:26
14. **hif_makeimages**: Make target cubes		1.00	5 days, 0:47:54
15. **hif_makeimlist**: Set-up parameters for representative bandwidth target cube imaging	No clean targets expected	N/A	0:00:09
16. **hif_makeimages**: Make representative bandwidth target cube	Nothing to image	N/A	0:00:06

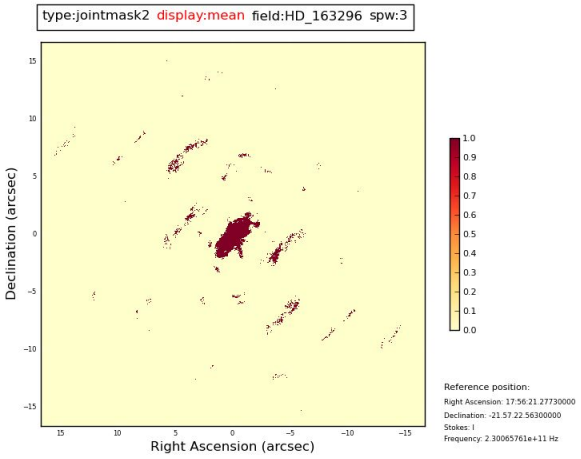
CASA logs and scripts

CLICK

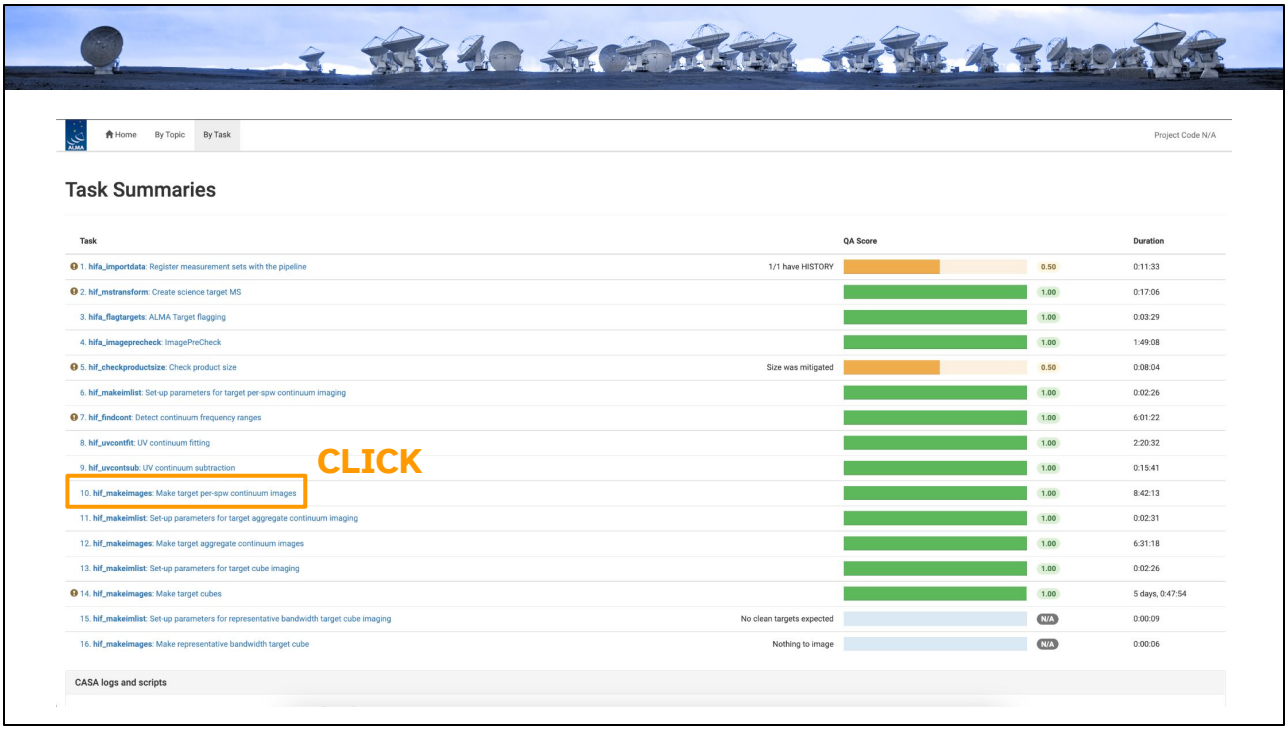
Continuum subtraction

7. **hif_findcont**: Detect continuum frequency ranges





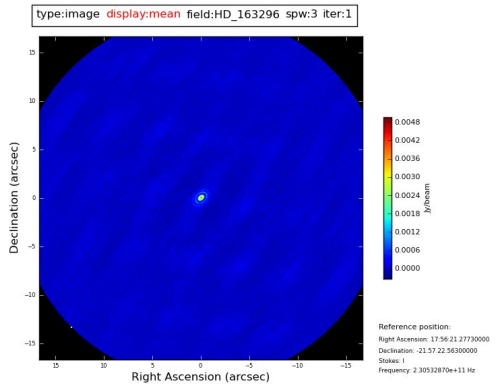
Spectrum shown is cube integrated over the masked pixels (red) on the right image, which are areas where emission was detected. The pipeline fits a slope (parameters can be tweaked by user) to the line-free channels in the next task.

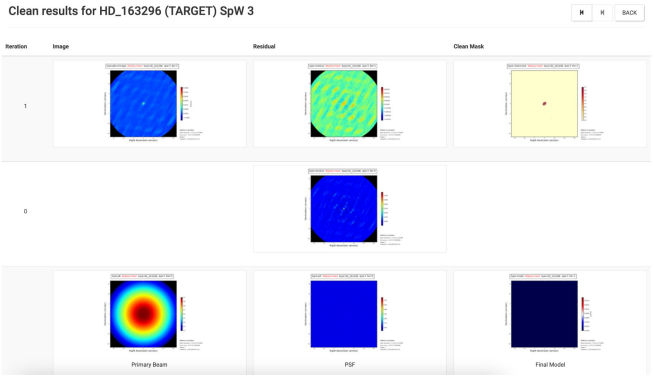


Actual tclean task (imaging) in pipeline is run according to previously defined parameters

Continuum image - ^{12}CO spw

10. **hif_makeimages**: Make target per-spw continuum images





Extra plots displayed for the representative spw (continuum)

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Task Summaries

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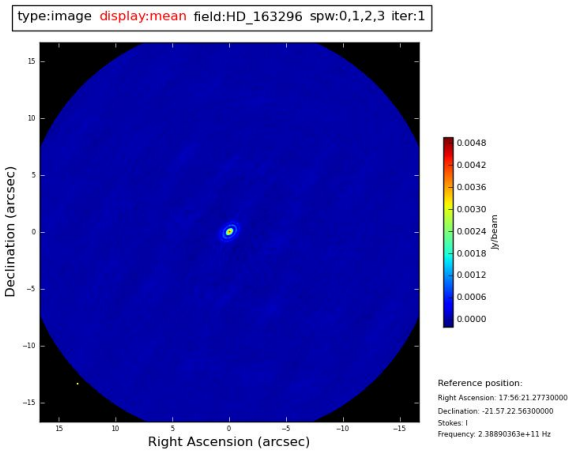
5. **hif_checkproductsize**: Check product size	Size was mitigated	0.50	0:08:04
6. **hif_makeimlist**: Set-up parameters for target per-spw continuum imaging		1.00	0:02:26
7. **hif_findcont**: Detect continuum frequency ranges		1.00	6:01:22
8. **hif_uvcontfit**: UV continuum fitting		1.00	2:20:32
9. **hif_uvcontsub**: UV continuum subtraction		1.00	0:15:41
10. **hif_makeimages**: Make target per-spw continuum images		1.00	8:42:13
11. **hif_makeimlist**: Set-up parameters for target aggregate continuum ...		1.00	0:02:31
12. **hif_makeimages**: Make target aggregate continuum images		1.00	6:31:18
13. **hif_makeimlist**: Set-up parameters for target cube imaging		1.00	0:02:26
14. **hif_makeimages**: Make target cubes		1.00	5 days, 0:47:54
15. **hif_makeimlist**: Set-up parameters for representative bandwidth target cube imaging	No clean targets expected	N/A	0:00:09
16. **hif_makeimages**: Make representative bandwidth target cube	Nothing to image	N/A	0:00:06

CASA logs and scripts

CLICK

Continuum image - combined

12. **hif_makeimages**: Make target aggregate continuum images



Aggregate continuum image (4 spws combined)

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Task Summaries

Task		QA Score	Duration
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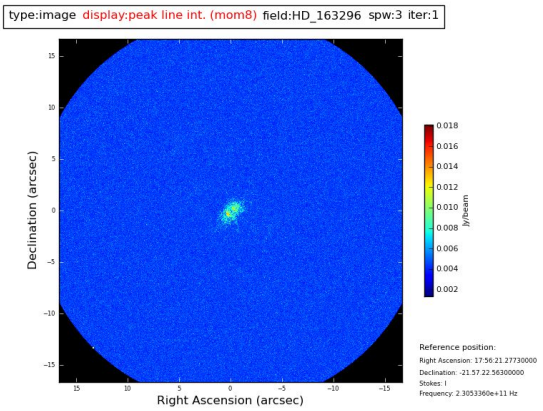
4. **hifa_imageprecheck**: ImagePreCheck		1.00	1:49:08
5. **hif_checkproductsize**: Check product size	Size was mitigated	0.50	0:08:04
6. **hif_makeimlist**: Set-up parameters for target per-spw continuum imaging		1.00	0:02:26
7. **hif_findcont**: Detect continuum frequency ranges		1.00	6:01:22
8. **hif_uvcontfit**: UV continuum fitting		1.00	2:20:32
9. **hif_uvcontsub**: UV continuum subtraction		1.00	0:15:41
10. **hif_makeimages**: Make target per-spw continuum images		1.00	8:42:13
11. **hif_makeimlist**: Set-up parameters for target aggregate continuum imaging		1.00	0:02:31
12. **hif_makeimages**: Make target aggregate continuum images		1.00	6:31:18
13. **hif_makeimlist**: Set-up parameters for target [illegible]		1.00	0:02:26
14. **hif_makeimages**: Make target cubes		1.00	5 days, 0:47:54
15. **hif_makeimlist**: Set-up parameters for representative bandwidth target cube imaging	No clean targets expected	N/A	0:00:09
16. **hif_makeimages**: Make representative bandwidth target cube	Nothing to image	N/A	0:00:06

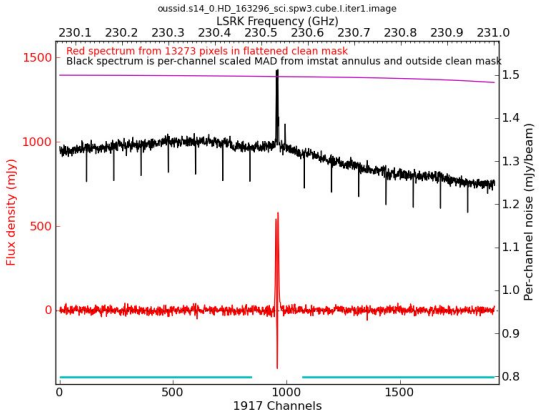
CLICK

CASA logs and scripts

^{12}CO image

14. **hif_makeimages**: Make target cubes





Cube provided for the representative frequency spw
MAD = Median Absolute Deviation

What's next?

If you decide to make your own images:

run the **scripts/scriptForPI.py** within CASA and you can work on the **calibrated** MS.

Problems? - Tweak the pipeline!

e.g, Extra flagging needed or flux rescale:

- add extra flagging in calibration/*flagtemplate.txt and rerun casa_pipescript.py.
- Modify flux.csv and rerun the pipeline
- Alternatively, add flagging commands before imaging.

More details at:
“Tweaking the pipeline script” by R. Miura (NAOJ)
https://www2.nao.ac.jp/~eaarc/DATARED/reference/TweakPipeline.pptx.pdf

The European ARC network

For support on ALMA proposal preparation and data reduction you can contact your local ALMA ARC node or the ALMA helpdesk!

https://www.eso.org/sci/facilities/alma/arc.html

References

Allegro CASA Training 2018:
www.alma-allegro.nl/casatraining2018/#presentations

Data inspection tutorial (H. Nagai):
alma-intweb.mtk.nao.ac.jp/~nagai/tutorial/tutorial.pdf

ERIS School 2019 and 2017:
https://www.chalmers.se/en/researchinfrastructure/oso/events/ERIS2019/Pages/Software-packages-and-datasets.aspx
www.astron.nl/eris2017/lectures.php

Interferometric Data Processing Workshop for eMerlin & ALMA:
www.alma.ac.uk/index.php/meetings/uk-arc-node-meetings/256-alma-interferometric-data-processing-workshop-dublin-10-12-sept-20178

9th IRAM Interferometry School:
http://www.iram-institute.org/EN/content-page-342-7-67-331-342-0.html

References

ALMA Documentation:
almascience.eso.org/documents-and-tools

ALMA Technical Handbook:
almascience.eso.org/documents-and-tools/cycle9/alma-technical-handbook

ALMA Archive and QA2 Data Products:
almascience.eso.org/documents-and-tools#section-3

ALMA Science Pipeline:
almascience.eso.org/processing/science-pipeline

i-TRAIN tutorials
https://almascience.eso.org/tools/eu-arc-network/i-train