

ALMA Pipeline products and restoring calibrated data



Twentieth Synthesis Imaging Workshop 15 – 22 May 2024



Atacama Large Millimeter/submillimeter Array Expanded Very Large Array Robert C. Byrd Green Bank Telescope Very Long Baseline Array





Your CASA tutorial team







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Outline

- ALMA Data Reduction Overview
- ALMA archive and data products
 - Download data from Archive Query and Request Handler tools on the ALMA Science Portal
 - What's in your downloaded dataset?
- Tutorial example Review & Restore Calibration
 - ALMA Pipeline
 - The Pipeline Weblog-Calibration and Imaging Information
 - How to restore the calibrated measurement set
 - How to re-run the pipeline, if needed
 - How to re-do imaging
- Science Ready Data Products Initiative (SRDP)
 - Automated Self-Calibration



ALMA observing project hierarchy





Different data reduction paths for ALMA data

- Manually calibrated and imaged (non-standard datasets, e.g. solar observations, VLBI etc.) ~2% (NA)
- Pipeline calibrated and imaged (most standard datasets) ~98% (NA) - fast lane/slow lane
- Pipeline calibrated and manually imaged (e.g. PL cannot image because the data products are too large; Full Polarization)
- Pipeline calibrated and imaged, with additional subset imaging using PL scripts (different robust, manually identified continuum)
- Each MOUS is processed separately, different MOUSes may have different data reduction paths



Obtaining calibrated measurement sets

- Archive stores only raw data, calibration tables, scripts, products, etc.
- Calibrated visibilities for PIs:
 - NA ARC: PIs get a download link through the Helpdesk (<u>https://help.almascience.org/</u>) once their data is delivered, with 30 days to download the file
 - EU ARC: Request through the Helpdesk
 - EA ARC: PI gets a download link
- For non-proprietary data, calibrated measurement sets can be requested through the Helpdesk at any time
- For Cycle 5 and later, NRAO's SRDP initiative (later slides)
- Download archive files and restore calibrated measurement set manually (this tutorial)



Introduction to ALMA pipeline (PL)





Introduction to ALMA pipeline (PL)

- Used to calibrate ALMA interferometric (IF) and single-dish (SD) data - has different recipes for different types of observations
- Automated calibration and imaging
- Modular calibration and imaging tasks within CASA, put together based on standard prescriptions or recipes
- Produces a WebLog a collection of webpages with diagnostic messages, tables, figures and Quality Assurance (QA) scores
- User's guide and other useful documentation: <u>https://almascience.nrao.edu/processing/science-pipeline</u>



Standard interferometric calibration and imaging recipe for ALMA

rethrow casa exceptions = True context=h init()try: hifa importdata(dbservice=False, vis=['uid A002 X877e41 X452'], session=['session 1']) ## Uses flux.csv hifa flagdata() ## Uses *flagtemplate.txt hifa fluxcalflag() hif rawflagchans() hif refant() h tsyscal() hifa tsysflag() hifa antpos() ## Uses antennapos.csv hifa wvrgcalflag() hif lowgainflag() hif setmodels() Calibration tasks: hifa bandpassflag() hifa bandpass() ## indicates the use of hifa spwphaseup() hifa gfluxscaleflag() hifa gfluxscale() pipeline helper files hifa timegaincal() hifa targetflag() hif applycal() hif makeimlist(intent='PHASE,BANDPASS,AMPLITUDE') hif makeimages() hif makeimlist(per eb=True, intent='CHECK') hif makeimages() hifa imageprecheck() hif checkproductsize(maxproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0) hifa renorm() hifa exportdata() # Start of pipeline imaging commands hif mstransform() hifa flagtargets() ## Uses *flagtargetstemplate.txt hif makeimlist(specmode='mfs') ## Uses cont.dat hif findcont() ## Modifies cont.dat hif uvcontsub() Imaging tasks: hif makeimages() ## Uses cont.dat hif makeimlist(specmode='cont') ## Uses cont.dat hif makeimages() ## Uses cont.dat ## indicates the use of hif makeimlist(specmode='cube') ## Uses cont.dat hif makeimages() ## Uses cont.dat pipeline helper files hif makeimlist(specmode='refBW') ## Uses cont.dat hif makeimages() ## Uses cont.dat finally: h save()





Note about pipeline tasks

- Task name examples h_tsyscal, hif_applycal, hifa_antpos, hsd_image
- hif and hifa interferometric tasks, hifa ALMA, hifv VLA
- hsd single dish tasks
- h common to all pipelines
- h_init initializes pipeline, creates new pipeline context
- h_save saves context
- h_resume resumes specified or last context to resume pipeline run





Standard calibration recipe





Standard calibration recipe





Standard calibration recipe







Standard imaging recipe





Standard imaging recipe







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Exploring the ALMA Archive

- All projects start with the ALMA Archive proprietary or public
- New archive interface
 - http://almascience.nrao.edu/aq





Searching the Archive

- Filter columns based on target, project, or publication
- Hover over the top left search bar for expanded search fields

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Cycles 5-Present

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Cycles 5-Present: Auxiliary Tarball

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QA2 Data Products Package:

Cycles 1-4 Packages

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a la raw	2016.1.00484.L_uidA002_Xc067f7_Xa6d.asdm.sdm

Raw data tar balls.

Tar ball with imaging products, logs, calibration tables and scripts.





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	File		
			4
01_X2dfa_X138.README.txt idA001_X2dfa_X138_001_of_001.tar idA001_X2dfa_X138_auxiliary.tar idA002_Xfe83cd_X2148.asdm.sdm.tar idA002_Xfe83cd_X2fa2.asdm.sdm.tar	Choose one of the follow Download Script	The download methods: The downloads are scripted for you. You just need to execute the script from the command line, after making it executable by typing chmod u+x download*.sh	3
	Java Download Manager	ALMA's download manager had to be discontinued due to changes in java. Please use one of the other options instead.	
	File List	View a text file containing a list of URLs. This is useful for using third-party download manager's such as <i>DownThemAll</i> .	





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- ALMA Data Reduction Overview
- ALMA archive and data products
 - Download data from Archive Query and Request Handler tools on the ALMA Science Portal
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QA2 Data Products Package: Directory Structure

After un-tarring the processed data we have a directory tree: **Science**





QA2 Data Products Package: Calibration directory

Pipeline Calibration Tables

uid___A002_Xe20b32_X84e7_target.ms.auxcalapply.txt uid A002 Xe20b32 X84e7.ms.flagversions.tgz uid __A002_Xe20b32_X84e7.ms.calapply.txt member.uid A001 X146c Xa2.session 1.caltables.tgz member.uid___A001_X146c_Xa2.session_1.auxcaltables.tgz member.uid___A001_X146c_Xa2.hifa_calimage.auxproducts.tgz **Contains** All flags will be restored during calibration PL helper files flux.csv antennapos.csv cont.dat uid A002 Xe20b32 X84e7.flagtargetstemplate.txt uid____A002_Xe20b32_X84e7.flagtsystemplate.txt uid A002 Xe20b32 X84e7.flagtemplate.txt




QA2 Data Products Package:

Product directory

Products:

A001 X87a X9fe.M83 sci.spw16.cube.I.mask.fits.gz member.uid A001_X87a_X9fe.M83_sci.spw16.cube.I.pb.fits.gz A001_X87a_X9fe.M83_sci.spw16.cube.I.pbcor.fits member.uid member.uid A001 X87a X9fe.M83 sci.spw16.mfs.I.mask.fits.gz member.uid A001 X87a X9fe.M83 sci.spw16.mfs.I.pb.fits.gz A001 X87a X9fe.M83 sci.spw16.mfs.I.pbcor.fits member.uid A001 X87a X9fe.M83 sci.spw16 18 20 22.cont.I.mask.fits.gz member.uid A001_X87a_X9fe.M83_sci.spw16_18_20_22.cont.I.pb.fits.gz member.uid member.uid A001_X87a_X9fe.M83_sci.spw16_18_20_22.cont.I.pbcor.fits member.uid A001_X87a_X9fe.M83_sci.spw18.cube.I.mask.fits.gz member.uid A001_X87a_X9fe.M83_sci.spw18.cube.I.pb.fits.gz member.uid A001 X87a X9fe.M83 sci.spw18.cube.I.pbcor.fits member.uid A001 X87a X9fe.M83 sci.spw18.mfs.I.mask.fits.gz A001 X87a X9fe.M83 sci.spw18.mfs.I.pb.fits.gz member.uid A001_X87a_X9fe.M83_sci.spw18.mfs.I.pbcor.fits member.uid A001 X87a X9fe.M83 sci.spw20.cube.I.mask.fits.gz member.uid member.uid A001 X87a X9fe.M83 sci.spw20.cube.I.pb.fits.gz member.uid A001 X87a X9fe.M83 sci.spw20.cube.I.pbcor.fits member.uid A001_X87a_X9fe.M83_sci.spw20.mfs.I.mask.fits.gz member.uid A001 X87a X9fe.M83 sci.spw20.mfs.I.pb.fits.gz A001 X87a X9fe.M83 sci.spw20.mfs.I.pbcor.fits member.uid member.uid A001_X87a_X9fe.M83_sci.spw22.cube.I.mask.fits.gz member.uid A001_X87a_X9fe.M83_sci.spw22.cube.I.pb.fits.gz A001_X87a_X9fe.M83_sci.spw22.cube.I.pbcor.fits member.uid member.uid A001 X87a X9fe.M83 sci.spw22.mfs.I.mask.fits.gz member.uid A001 X87a X9fe.M83 sci.spw22.mfs.I.pb.fits.gz A001 X87a X9fe.M83 sci.spw22.mfs.I.pbcor.fits member.uid

Calibration and Target images produced from QA2

QA2 Data Products Package: Cycle 4 - now

https://help.almascience.org/kb/articles/what-calibration-and-imagingproducts-will-be-delivered-to-me /

Naming convention for pipeline products

Image products are named according to the following convention:

<*MOUS UID>.<Source Name>_<intent>.<spectral window(s)>.<dimensionality>.<calibration type>.<stokes>.<comment>. <imagetype>.fits*

MOUS UID is a string that uniquely identifies the dataset (e.g. uid___A001_X88f_X270)

<intent> is the observation intent of the source, e.g. *sci* for science target, *ph* for phase calibrator, *bp* for bandpass calibrator.

The spectral window list contains the spectral window numbers used in the product (e.g. spw17, spw17_19_21_23). The quickest way to identify which spectral window corresponds to which frequency/resolution combination is to click on the link to the measurement set on the Home page of the weblog, then to click on the "LISTOBS OUTPUT" button.

<dimensionality> is either *mfs* for multifrequency synthesis (resulting in an image with two spatial dimensions), *cont* for continuum aggregated over all spectral windows (two spatial dimensions), or *cube* for a cube with two spatial axes and a frequency/velocity axis. You may also see *ttO* and *tt1* for mfs images made using the the zeroth and first Taylor terms, respectively. The *tt0* image corresponds to the regular image, the *tt1* image is related to the spectral index image.

<calibration type> indicates if the data were self-calibrated with .selfcal. or not self-calibrated with . Only data imaged with the Cycle 10 pipeline and later will have this designation.

<stokes> indicates the Stokes parameter in the image (e.g., I).

<comment> can be explanatory text, usually added by a manual reducer.

<*imagetype* is *pbcor* for a primary beam corrected image, *pb* for the primary beam image, *mask* for the mask image, or *sd* for single dish.





Image analysis

- ADMIT (ALMA data-mining toolkit)
 - Tools for analyzing image data cubes
 - <u>http://admit.astro.umd.edu/</u>
 - CASA guide: <u>https://casaguides.nrao.edu/index.php?title=ADMIT_Produ</u> <u>cts_and_Usage</u>
- CARTA (Cube Analysis and Rendering Tool for Astronomy)
 - <u>https://cartavis.github.io/</u>





QA2 Data Products Package: Raw directory

If you also download and untar 2016.1.****.S_uid*.asdm.sdm.tar







QA2 Data Products Package: Script directory

Pipeline Calibration Scripts:

Commands to re-run the pipeline from scratch

member.uid ____A001_X87a_X9fe.calimage.product_rename.txt
member.uid ____A001_X87a_X9fe.hifa_calimage.casa_commands.log
member.uid ____A001_X87a_X9fe.hifa_calimage.casa_piperestorescript.py
member.uid ____A001_X87a_X9fe.hifa_calimage.casa_pipescript.py
member.uid ____A001_X87a_X9fe.hifa_calimage.pipeline_manifest.xml
member.uid ____A001_X87a_X9fe.hifa_calimage.pprequest.xml
member.uid ____A001_X87a_X9fe.hifa_calimage.pprequest.xml

Run scriptForPI.py to restore calibration¹





QA2 Data Products Package: QA directory

QA reports (Cycle 6 - now) and weblog







QA2 Data Products Package: The QA2 Report (previously README)

Different format before Cycle 5

-- member.uid ____A001_X1299_X39.README.txt

Cycle 0-4

Project code: 2015.1.02572.S PI name: Bob Hops Project title: A first look at Space Configuration: 0.241 km Proposed rms: Proposed beam size: 3.4-CASA version: 4.7.2 Comments from Reducer: This scheduling block was manually calibrated and imaged. Several antennas were flagged for particularly high Tsys. Continuum images were produced using scriptForImaging.py. They include the entire bandwidth. Continuum: Beam= 4.33" by 2.59" RMS = 5.0 Jy/Beam over 7.5 GHzbandwidth

Cycle 5

You can download the AQUA quality report for these observations from SnooPI using the following URL...

https://asa.alma.cl/snoopi

If you are not on the project and need the QA2 report of the public data, submit HD ticket

Cycle 6-Now

Details about the quality of the data processing are in

qa/member.uid___A001_X135e_X 8f.qa2_report.pdf (or html)

Details about the processing are in

qa/*weblog.tgz

Details about the quality of the raw data are in

qa/*qa0_report.pdf (or html)



https://help.almascience.org/kb/articles/how-are-alma-data-products-packaged



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Example dataset

- Project code: 2019.2.00028.S
- Project title: A Representative Interferometric Survey of Galaxies in the z=0 Universe with Full IFU Spectroscopic Coverage: EDGE
- PI: Alberto Bolatto
- 7m (ACA)
- Scheduling Block (SB) name: IC1528_a_06_7M
- 2 science targets
- 4 science spectral windows (spw)
- Originally processed with CASA 6.1.1.15





Exploring the dataset

- Untar the files: tar xvf *.tar (* file name)
- Creates a directory called 2019.2.00028.S
- cd into this directory, and explore:

cd 2019.2.00028.S/science_goal.uid___A001_X14c3_X593/group.uid___A001_X14c3_X5e2/member.uid___A001_X14c3_X5e3/

• Is to list contents of directory

```
raw
product
log
qa
cd qa
script
calibration
uid___A002_Xed9025_X8eb5.qa0_report.pdf
member.uid___A001_X14c3_X5e3.qa2_report.pdf
member.uid___A001_X14c3_X5e3.hifa_calimage.weblog.tgz
```



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Restoring calibrated measurement set

- Recommend using same CASA version used in processing
- Two ways:
 - Method I: Using scriptForPI.py for pipeline and manually reduced data – the recommended and fastest way
 - Method II: Using casa_piperestorescript.py to restore pipeline calibrated data only, invoked by scriptForPI.py



Restoring calibrated measurement set:

- <u>https://help.almascience.org/kb/articles/interferometric-calibration-and-imaging-regeneration</u>
- Recommend using same CASA version used in processing
- But if you do want to use a newer version, inspect the measurement set carefully to make sure flags were applied correctly.
- A few known issues are posted here:
 - <u>https://help.almascience.org/kb/articles/why-does-scriptforpi-py-crash-with-the-error-no-such-file-or-directory-rawdata-uid-a002-x12345</u>
 - <u>https://help.almascience.org/kb/articles/why-does-scriptforpi-py-</u> crash-with-nameerror-name-hif-restoredata-is-not-defined
 - For new issues post a Helpdesk ticket <u>https://help.almascience.org/</u>



cd 2019.2.00028.S/science_goal.uid___A001_X14c3_X593/group.uid___A001_X14c3_X5e2/member.uid___A001_X14c3_X5e3/ calibration/ log/ product/ qa/ raw/ script/

Restoring calibrated measurement set: scriptForPI

- cd into script directory
- Start the correct version of casa (casa --pipeline for PL tasks)
- Run scriptForPI.py (with spacesaving options, if needed) execfile('member.uid___A001_X1465_X2ed7.scriptForPI.py')

cd script

```
casa -c "SPACESAVING=N; execfile('scriptForPI.py')" --pipeline
where N is an integer from 0 to 3 with the following meaning:
```

- SPACESAVING = 0 same as not set (all intermediate MSs are kept)
 - = 1 do not keep intermediate MSs named *.ms.split
 - = 2 do not keep intermediate MSs named *.ms and *.ms.split
 - >= 3 do not keep intermediate MSs named *.ms, *.ms.split, and *.ms.split.cal (if possible)
 - = -1 do not check disk space







scriptForPI - PL calibration + imaging

Working directory:

INRAO

byspw flux.csv pipeline-20240502T124600 pipeline-20240502T124600.context pipeline-20240502T124600.timetracker.db pipeline-20240502T124600.timetracker.json pipeline-20240502T130504 pipeline-20240502T130504.context pipeline-20240502T130504.timetracker.db pipeline-20240502T130504.timetracker.json uid A002 Xed9025 X8eb5.flagonline.txt uid A002 Xed9025 X8eb5.flagtargetstemplate.txt uid___A002_Xed9025_X8eb5.flagtemplate.txt uid___A002_Xed9025_X8eb5.flagtsystemplate.txt uid____A002_Xed9025_X8eb5.ms uid A002 Xed9025 X8eb5.ms.flagversions uid___A002_Xed9025_X8eb5.ms.h_tsyscal.s6_1.tsyscal.tbl uid___A002_Xed9025_X8eb5.ms.hifa_bandpass.s13_3.spw16_18_20_22.channel.solintinf.bcal.tbl uid___A002_Xed9025_X8eb5.ms.hifa_spwphaseup.s14_3.spw16_18_20_22.solintinf.gpcal.tbl uid___A002_Xed9025_X8eb5.ms.hifa_timegaincal.s17_2.spw16_18_20_22.solintinf.gpcal.tbl uid___A002_Xed9025_X8eb5.ms.hifa_timegaincal.s17_3.spw16_18_20_22.solintint.gpcal.tbl uid___A002_Xed9025_X8eb5.ms.hifa_timegaincal.s17_7.spw16_18_20_22.solintinf.gacal.tbl uid___A002_Xed9025_X8eb5.ms.s1.3.callibrary uid___A002_Xed9025_X8eb5.ms.s1.3.calstate

Applying Renormalization corrections

- If your dataset has not been checked for renormalization (indicated in the QA2 report or weblog)
- Run in /calibrated/working directory
- Available in CASA 6.2.1.7 and pipeline version 2021.2.0.128 and above only
- Corrections applied if renormalization factor > 2%
- Creates weblog with plots and calculated renormalization factors

```
__rethrow_casa_exceptions = True
h_init()
try:
    hifa_importdata(vis=['uid___A002_Xe3da01_X18fa.ms'], session=['session_1'], ocorr_mode='ca')
    hifa_renorm(apply=True, atm_auto_exclude=True)
    hif_mstransform(pipelinemode='automatic')
finally:
    h_save()
```



https://casaguides.nrao.edu/index.php?title=ALMA_Renormalization_Correction

Applying Renormalization corrections

• If your dataset has not been corrected for renormalization (indicated in the QA2 report or weblog)

Imaging issues: None

General info:

It is recommended that the PI carefully assess the results on the hif findcont weblog page, and the "line-free moment 6" images on the cube imaging weblog page. Self-calibration was not performed.

This dataset has been checked for the so-called "renormalization issue". A detailed description about this issue, and how the renormalization process is carried out, can be found at the following link: https://help.almascience.org/kb/articles/what-are-the-amplitude-calibration issuescaused-by-alma-s-normalization-strategy

The requirement of rescaling due to any astronomical lines detected in this dataset has been evaluated and the largest peak rescaling value has been estimated to be 1.360,

as displayed in the table in the hifa_renorm task of the delivered weblog. The effect of rescaling is a channel-dependent increase of the line flux, which is largest in the brightest channels.

This is not an increase in flux-scale uncertainty, but a flux offset correction. When comparing such an offset to the nominal absolute flux accuracy,

which is 5% in Bands 3, 4 & 5 and increasing to 20% in Bands 9 & 10, it is concluded that offsets up to 2% are considered negligible.

Since the rescaling factor is above this threshold, this dataset has been corrected for the above issue





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Automated Self-Calibration



Restoring calibrated measurement sets: scriptForPI - PL calibration + Manual Imaging

calibrated directory if only calibration pipeline was run:

products -> ../calibration Measurement set rawdata uid___A002_Xdd9a29_X17e0.ms.split.cal —____ containing only science spectral windows (spw) of working all sources

Look for scriptForImaging.py in the script directory

member.uid___A001_X131c_X167.scriptForPI.py
member.uid___A001_X131c_X167.scriptForImaging.py
member.uid___A001_X131c_X167.image.product_rename.txt
member.uid___A001_X131c_X167.hifa_cal.pprequest.xml
member.uid___A001_X131c_X167.hifa_cal.casa_pipescript.py
member.uid___A001_X131c_X167.hifa_cal.casa_piperestorescript.py
member.uid___A001_X131c_X167.hifa_cal.casa_piperestorescript.py
member.uid___A001_X131c_X167.hifa_cal.casa_commands.log
member.uid___A001_X131c_X167.cal.product_rename.txt



cd 2019.1.00195.L/science_goal.uid___A001_X146c_X95/group.uid___A001_X146c_X9d/member.uid___A001_X146c_Xa2/ calibrated calibration product qa raw script

Restoring calibrated measurement sets: PL calibration + imaging + subset imaging

- Results of running scriptForPI.py same as that for PL calibration + imaging
- Subset imaging reasons: self-calibration, improved continuum selection, different robust parameter, etc.
- If subset imaging was done manually, look for scriptForImaging.py in script directory
- If additional subset PL imaging was done after the imaging pipeline was run, look for member.uid*.manual_imaging.tgz in the script directory



Restoring calibrated measurement sets: using PL script casa_piperestorescript.py

- Create rawdata/, working/, and products/ subdirectories.
- Download the raw ASDMs from the archive and put them in rawdata/. Make sure the naming of the raw ALMA data is consistent with those provided in the script (e.g. if the data ends in .asdm.sdm then move to names which do not have this suffix).
- Copy or move *manifest.xml, *caltables.tgz, *flagversions.tgz, and *calapply.txt to products/.
- Copy uid*casa_piperetorescript.py to casa_piperestorescript.py to working/.
- In working/, start casa –pipeline, and execfile("casa_piperestorescript.py").

Resulting uid*.ms in working directory For more information, refer to the user's guide: https://almascience.nrao.edu/processing/science-pipeline





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After Observations – QA2

- Calibration by pipeline or DA/staff.
- Final QA checks include
 - RMS of complex antenna-based gains
 - Absolute flux calibration scale
 - T_{sys} within acceptable range
 - Proper phase transfer cadence
 - Proper bandpass corrections
- Assessment of Imaging Products
 - RMS noise and angular resolution
 - No strong artifacts
 - Performed on the reference source/spectra
- Information about QA review is aggregated for delivery in the QA2 Report



The QA2 Report (Cycle 5 to now):

Project information



JALMA

ALMA

Name Code Pl Organization Co-Is	A Representative Interferometric Survey of Galaxies in the z=0 Universe with Full IFU Spectroscopic Coverage: EDGE 2019.2.00028.S Alberto Bolatto Department of Astronomy, Maryland, University of J. Barrera-Ballesteros, L. Blitz, Y. Cao, D. Colombo, J. Cortes, H. Dannerbauer, B. Diemer, D. Fisher, G. Galaz, R. Herrera-Camus, K. Joachimi, V. Kalari, V. Kalinova, L. Lenkic, A. Leroy, Y. Leung, R. Levy, E. Ostriker, E. Rosolowsky, M. Rubio, S. Sanchez, K. Sandstrom, P. Teuben, D. Utomo, M. Valdivia Mena, G. van de Ven, B. Vila Vilaro, V. Villanueva, S. Vogel, F. Walter, T. Wong								
ObsUnitSet information									
Name QA2 Status	Member OUS (IC1528) Pass								
Member OUS Status ID SchedBlock name SchedBlock UID Array Mode Band Repr.Freq. (sky) Spectral setup Sources Other SBs in this Group OUS (Member OUS Status ID in brackets):	uid://A001/X14c3/X5e3 IC1528_a_06_7M uid://A001/X14c3/X511 7M Standard ALMA_RB_06 227.26 [GHz] ACA IC1528, MCG-02-02-030								
execution count	1.50 OF 1 expected								

CASA version: 6.1.1.15

Final QA2 comment

Reduction mode: PL calibration and imaging;

INRAC



Open the Weblog

- We'll look at the CASA 6.5.4 PL run weblog today
- Run the command: tar -xvzf uid___A001_X1465_X2ed7.weblog.tgz
- Open pipeline-20230505T202834/html/index.html in a browser (recommend using Firefox)
- Note: If using Firefox version >= 68.0, open about:config and change "privacy.file_unique_origin" property to false or "security.fileuri.strict_origin_policy" to False if you get the following error message:



 Recommended to use h_weblog: <u>https://help.almascience.org/kb/articles/what-is-the-best-way-to-view-the-weblog</u>





QA directory: WebLog

Home By Topic

2019.2.00028.S

Observation Overview

Bv Task

Project	uid://A001/X146c/X45	Pipeline Version	2023.1.0.125 (documentation)
Principal Investigator	bolatto	CASA Version	6.5.4.9 (environment)
OUS Status Entity id	uid://A001/X14c3/X5e3	IERSeop2000 Version	0001.0179 (last date: 2024-02-08 00:00:00)
Observation Start	2021-07-05 08:00:58 UTC	IERSpredict Version	0623.1511 (last date: 2024-07-06 00:00:00)
Observation End	2021-07-05 09:26:33 UTC	Pipeline Start	2024-04-26 18:02:56 UTC
Number of Execution Blocks	1	Execution Duration	2:26:21

Pipeline Summary

Observation Summary

			Time (UTC)			Baseline Length							
Measurement Set	Receivers	Num Antennas	Start	End	On Target	Min	Max	RMS	Size				
Observing Unit Set Status: uid://A001/X14c3/X5e3 Scheduling Block ID: uid://A001/X14c3/X511 Scheduling Block Name: IC1528_a_06_7M													
Session: session_1 ACS Version: Unknown, Build Version: ONLINE-CYCLE7-B-515-2021-03-16-28-00-00													
uidA002_Xed9025_X8eb5.ms	ALMA Band 6	9	2021-07-05 08:00:58	2021-07-05 09:26:33	0:48:13	8.9 m	45.0 m	24.6 m	2.3 GiB				
uidA002_Xed9025_X8eb5_targets.ms	ALMA Band 6	9	2021-07-05 08:24:30	2021-07-05 09:25:15	0:48:13	8.9 m	45.0 m	24.6 m	1018.6 MiB				
uidA002_Xed9025_X8eb5_targets_line.ms	ALMA Band 6	9	2021-07-05 08:24:30	2021-07-05 09:25:15	0:48:13	8.9 m	45.0 m	24.6 m	1018.6 MiB				



Pipeline users guide: https://almascience.nrao.edu/processing/science-pipeline



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Re-running the pipeline using casa_pipescript.py

NKAU

```
rethrow casa exceptions = True
context=h init()
try:
 hifa importdata(dbservice=False, vis=|'uid A002 X877e41 X452'], session=|'session 1']) ## Uses flux.csv
 hifa flagdata() ## Uses *flagtemplate.txt
 hifa fluxcalflag()
 hif rawflagchans()
 hif refant()
 h tsyscal()
 hifa tsysflag()
 hifa antpos() ## Uses antennapos.csv
 hifa wvrgcalflag()
                                                                                                                  Calibration tasks;
 hif lowgainflag()
 hif setmodels()
 hifa bandpassflag()
                                                                                                                  ## indicates the use of
 hifa bandpass()
 hifa spwphaseup()
                                                                                                                  pipeline helper files
 hifa gfluxscaleflag()
 hifa gfluxscale()
 hifa timegaincal()
 hifa targetflag()
 hif applycal()
 hif makeimlist(intent='PHASE,BANDPASS,AMPLITUDE')
 hif makeimages()
 hif makeimlist(per eb=True, intent='CHECK')
 hif makeimages()
 hifa imageprecheck()
 hif checkproductsize(maxproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0)
 hifa renorm()
 hifa exportdata()
# Start of pipeline imaging commands
 hif mstransform()
 hifa flagtargets() ## Uses *flagtargetstemplate.txt
 hif makeimlist(specmode='mfs')
                               ## Uses cont.dat
                                                                                                                   Imaging tasks:
 hif findcont() ## Modifies cont.dat
 hif uvcontsub()
 hif makeimages() ## Uses cont.dat
                                                                                                                   ## indicates the use of
 hif makeimlist(specmode='cont') ## Uses cont.dat
 hif makeimages() ## Uses cont.dat
                                                                                                                   pipeline helper files
 hif makeimlist(specmode='cube') ## Uses cont.dat
 hif makeimages() ## Uses cont.dat
 hif makeimlist(specmode='refBW') ## Uses cont.dat
 hif makeimages() ## Uses cont.dat
finally:
 h save()
```

Re-running the calibration pipeline using casa_pipescript.py

- Create rawdata/, working/, and products/ subdirectories
- Copy uid*casa_pipescript.py to casa_pipescript.py in the working/ directory (edit to include PL steps you wish to repeat)
- Copy flux.csv, antennapos.csv (if present) and uid*flagtemplate.py (one flagtemplate.py per execution, modify as needed) to the working directory (found in uid*auxproducts.tgz from cycle 6-now)
- Copy raw ASDMs (rename without suffix .asdm.sdm) to rawdata/ directory
- Start CASA using casa --pipeline
- Run the script using execfile('casa_pipescript.py')





Outline

- ALMA Data Reduction Overview
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 - The Pipeline Weblog-Calibration and Imaging Information
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Manual Imaging following PL calibration

- Automasking Guide https://casaguides.nrao.edu/index.php/Automasking_Guide
- Manual imaging template available at: <u>https://casaguides.nrao.edu/index.php?title=Guide_to_the_N</u> <u>A_Imaging_Template</u>
- Combining multiple MOUS: <u>https://casaguides.nrao.edu/index.php?title=M100_Band3_C</u> <u>ombine_6.4</u>
- casa_commands.log in the script directory
 - list of equivalent CASA task commands used by the PL
 - comments indicate which Pipeline stage the tasks were called from, and why
 - Imaging commands can be modified to produce new



imaging products with more finely tuned inputs (e.g. interactive masks and deeper cleaning thresholds)

Pipeline Image Reprocessing ALMA

- To re-run imaging tasks also, copy uid*flagtargetstemplate.txt and cont.dat to the working/ directory
- Pipeline images are quality assessed but may not be science ready
 - All sources/spws may not be imaged (image mitigation to avoid long PL runs)
 - Change continuum selection
 - Change weighting, channel width, automasking, etc.
- For pipeline calibrated data, see <u>https://casaguides.nrao.edu/index.php/ALMA_Imaging_Pipeline_Reprocessing</u>





Imaging pipeline reprocessing

- <u>https://casaguides.nrao.edu/index.php?title=ALMA_Cycle_10</u>
 <u>Imaging_Pipeline_Reprocessing</u> for examples of imaging recipes
- Common re-imaging examples:
 - Make pipeline aggregate continuum image with all channels
 - Revise continuum selection before PL continuum subtraction
 - Restore PL continuum subtraction and use channel binning for subset of spws and fields for PL imaging of cubes
 - Remake images with uvtaper





Example imaging recipe

Make Pipeline Aggregate Continuum Image With All Channels

This example moves the cont.dat file to a backup name so it is not picked up by pipeline, in which case all unflagged channels are used to make an aggregate continuum image continuum bandwidth is possible than it identified (i.e. due to noise spikes etc).

```
## Edit the USER SET INPUTS section below and then execute
## this script (note it must be in the 'calibrated/working' directory.
import glob as glob
____rethrow_casa_exceptions = True
pipelinemode='automatic'
context = h_init()
## USER SET INPUTS
## Select a title for the weblog
context.project_summary.proposal_code='NEW AGGREGATE CONT'
## Delete uid*_targets.ms and flagversions if it exists
os.system('rm -rf uid*_targets.ms')
os.system('rm -rf uid*_targets.ms.flagversions')
os.system('rm -rf uid*_targets_line.ms')
os.system('rm -rf uid* targets line.ms.flagversions')
## Move cont.dat to another name if it exists
os.system('mv cont.dat original.cont.dat')
## Make a list of all uv-datasets appended with *.ms
MyVis=glob.glob('*.ms')
try:
    ## Load the *.ms files into the pipeline
    hifa_importdata(vis=MyVis,dbservice=False,pipelinemode=pipelinemode)
    ## Split off the science target data into its own ms (called
    ## *targets.ms) and apply science target specific flags
    hif_mstransform(pipelinemode=pipelinemode)
    hifa_flagtargets(pipelinemode=pipelinemode)
    ## calculate the synthesized beam and estimate the sensitivity
    ## for the aggregate bandwidth and representative bandwidth
    ## for three values of the robust parameter.
    hifa_imageprecheck(pipelinemode="automatic")
    ## check the imaging product size and adjust the relevent
    ## imaging parameters (channel binning, cell size and image size)
    ## User can comment this out if they don't want size mitigation.
    hif_checkproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0)
       Skip the continuum subtraction steps and make an aggregate
   ## continuum image with all unflagged channels (file imaging)
## cont.dat should NOT be present in director). Select different imaging
hif_makeimlist(specmode='cont', pipelinemode=pipelinemode)
hif_makeimages(pipelinemode=pipelinemode)
                                               ired. modes
       Export new images to fits format if
    hifa_expertdata(pipelinemode=pipelinemode)
finally:
    h_save()
```



Example imaging recipe

Revise the Continuum Ranges (cont.dat) Before Pipeline Continuum Subtraction and Remake Pipeline Images

This example uses the pipeline imaging tasks to remake the pipeline imaging products for one spw (17 in the example) after manually editing the cont.dat file.

Edit the cont.dat file(s) for the spw(s) you want ## to change the continuum subtraction for. In this example ## spw 17 was changed.

Edit the USER SET INPUTS section below and then execute
this script (note it must be in the 'calibrated/working' directory.

import glob as glob __rethrow_casa_exceptions = True pipelinemode='automatic' context = h_init()

Select a title for the weblog context.project_summary.proposal_code = 'NEW CONTSUB'

Delete uid*_targets.ms and flagversions if it exists
os.system('rm -rf uid*_targets.ms')
os.system('rm -rf uid*_targets.ms.flagversions')
os.system('rm -rf uid*_targets.ms.flagversions')

OS.Syster(Im -rr uid*_targets_line.ms.flagversion

Select spw(s) that have new cont.dat parameters
If all spws have changed use MySpw=''
MySpw='17'

Select different spws

Continuum

subtraction

using revised

Make a list of all uv-datasets appended with *.ms
MyVis=glob.glob('*.ms')

try:

Load the *.ms files into the pipeline hifa_importdata(vis=MyVis,dbservice=False,pipelinemode=pipelinemode)

Split off the science to science target specific flags
yters.coms; and apply science target specific flags
mil mstransform(pipelinemode=pipelinemode)
hifa_flagtargets(pipelinemode=pipelinemode)

Fit and subtract the continuum using revised cont.dat for all spws hif makeinlist(spcende='mfs', spw=MySpw) hif uvcontsub(pipelinemode=pipelinemode) hif makeimage(pipelinemode=pipelinemode)

calculate the synthesized beam and estimate the sensitivity
concide aggregate bandwidth and representative bandwidth
for three torus of the senucl accomplete.

hifa imageprecheck(pipelinemode=pipelinemode)

check the imaging product size and adjust the relevent
imaging parameters (channel binning, cell size and image size)
User can comment this out if they don't want size mitigation.
hif_checkproductsize(maxproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0)

Make new aggregate cont

hif_makeimlist(specmode='cont',pipelinemode=pipelinemode)
hif_makeimages(pipelinemode=pipelinemode)

Make new continuum subtracted cube for revised spw(s) hif_makeimlist(specmode='cube', spw=MySpw,pipelinemode=pipelinemode) hif_makeimages(pipelinemode=pipelinemode)

Export new images to fits format if desired. hifa_exportdata(pipelinemode=pipelinemode)

finally: h_save()



selection


Example imaging recipe

Revise the Continuum Ranges (cont.dat) Before Pipeline Continuum Subtraction and Remake Pipeline Images [edit]

This example uses the pipeline imaging tasks to remake the pipeline imaging products for one spw (17 in the example) after manually editing the cont.dat file.

<pre>## Edit the cont.dat file(s)</pre>	for the spw(s) you want
Home By Topic	By Task
14. hifa_spwphaseup	
15. hifa_gfluxscaleflag	
16. hifa_gfluxscale	cont.dat
17. hifa_timegaincal	
18. hifa_targetflag	
19. hif_applycal	Field: Serpens_Main_850_00
20. hif_makeimlist (cals)	
21. hif makeimages (cals)	SpectralWindow: 12
	335.6109403008~335.6158234543GHz LSRK
22. htt_makeimlist (checksrc)	335.6539120516~335.74180881466HZ LSKK
23. hif_makeimages (checksrc)	335.8111/050/3-335.8/02381016CHz SPK
24. hifa_imageprecheck	335-8638876521~335-8834202661GHz LSRK
25. hif checkproductsize	335.9195556020~335.9508077844GHz LSRK
	335.9947561659~335.9996393194GHz LSRK
26. hita_renorm	336.0230784562~336.0670268377GHz LSRK
27. hifa_exportdata	336.1070686964~336.2057083971GHz LSRK
28. hif_mstransform	336.2262176418~336.2633296084GHz LSRK
20 bits floatorasts	336.2818855917~336.3014182057GHz LSRK
29. hlia_liagtargets	336.4371698730~336.4410763958GHz LSRK
30. hif_makeimlist (mfs)	336.4723285782~336.4967443457GHz LSRK
31. hif_findcont	336.5192068518~336.5416693579GHz LSRK
32 bif uvcontfit	336.5621786026~336.6110101376GHz LSRK
	330.005/014508~330.09109385500HZ LSKK
33. hif_uvcontsub	330./028134234~330./11003099/UHZ LSKK
34. hif_makeimages (mfs)	336.8287987837~336.84833139776Hz SRK
35. hif makeimlist (cont)	336.8834901029~336.9254852230GHz LSRK
	336.9743167581~337.0163118782GHz LSRK
so. mi_makeimages (cont)	337.0641667825~337.0836993965GHz LSRK
37. hif_makeimlist (cube)	337.1549934376~337.1588999604GHz LSRK



Export new images to fits format if desired. hifa_exportdata(pipelinemode=pipelinemode)



Example imaging recipe

Restore Pipeline Continuum Subtraction for Subset of SPWs and Fields and Use Channel Binning for Pipeline Imaging of Cubes

Using Pipeline Tasks

This example uses the pipeline imaging tasks to remake the cubes for a subset of sows and fields with channel binning and a more naturally-weighted Briggs robust parameter

Edit the USER SET INPUTS section below and then execute ## this script (note it must be in the 'calibrated/working' directory.

import glob as glob ____rethrow_casa_exceptions = True pipelinemode='automatic' context = h_init()

**** ## USER SET INPUTS

Select a title for the weblog context.project_summary.proposal_code = 'SUBSET CUBE IMAGING'

Delete uid*_targets.ms and flagversions if it exists
os.system('rm -rf uid*_targets.ms')
os.system('rm -rf uid*_targets.ms.flagversions')
os.system('rm -rf uid*_targets_Line.ms) system('rm -rf uid*_targets_line.ms.flagvers system('rm -rf uid*_targets_line.ms.flagvers

Select spw(s) to image and channel binning for each spcifie ## MySpw. All spws listed in MySpw must have a corresponding M ## entry, even if it is 1 for no binning. MySpw='17,23' MyNbins='17:8,23:2'

Select subset of sources to image by field name. ## To select all fields, set MyFields=' MyFields='CoolSource1,CoolSource2'

Select Briggs Robust factor for data weighting (affects angular ## resolution of images) MvRobust=1.5

Make a li MyVis=glob.glob('*.ms')

try:
 ## Load the *.ms files into the pipeline
 ## Load the *.ms files
 hifa_importdata(vis=MyVis, dbservice=False, pipelinemode=pipelinemode)

ed with *.ms

- ## Split off the science target data into its own ms (called
- ## *targets.ms) and apply science target specific flags
 ## In this example we split off all science targets and science
- ## spws, however hif_mstransform could also contain the spw and field
- ## selections
- hif_mstransform(pipelinemode=pipelinemode)
- hifa_flagtargets(pipelinemode=pipelinemode)
- ## Fit and subtract the continuum using existing cont.dat
- ## for selected spws and fields only.
- hif_makeimlist(specmode='mfs')
 hif_uvcontsub(spw=MySpw,field=MyFields,pipelinemode=pipelinemode) hif_makeimages(pipelinemode=pipelinemode)
- ## calculate the synthesized beam and estimate the sensitivity

- ## for the aggregate bandwidth and representative bandwidth ## for three values of the robust parameter. ## Don't need to run this task if you will use a different robust value anyway.
- ## hifa_imageprecheck(pipelinemode=pipelinemode)
- ## check the imaging product size and adjust the relevent
- ## Lingth the Langeling product Size and adjust the relevent ## Lingting parameters (channel blinning, cell size and image size) ## User can comment this out if they don't want size mitigation. hi[_checkproductsize(maxproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0)
- ## Make new continuum subtracted cube for selected spw(s) and fields hif_makeimlist(specmode='cube',spw=MySpw,nbins=MyNbins,field=MyFields,robust=MyRobust, pipelinemode=pipelinemode) hif_makeimages(pipelinemode=pipelinemode)

Export new images to fits format if desired. hifa_exportdata(pipelinemode=pipelinemode)

finally: h_save()

Select channel binning for spws, subset of sources, different weighting





- <u>https://casaguides.nrao.edu/index.php?title=ALMA_Cycle_10</u> <u>Imaging_Pipeline_Reprocessing</u> – for examples of imaging recipes and instructions
- cd into calibrated/working
- Copy PL helper files cont.dat and uid*flagtargetstemplate.py from calibration/ directory to working
- Select imaging pipeline recipe, edit and save into a file, e.g. scriptForImaging.py (aggregate continuum image using all channels for a science target)
- Start casa --pipeline
- execfile('scriptForImaging.py')
- Example scriptForImaging.py available at: <u>https://bulk.cv.nrao.edu/almadata/public/SIS2024/ALMA_Pip</u> <u>eline_Tutorial/</u>





Example imaging script

Edit the USER SET INPUTS section below and then execute
this script (note it must be in the 'calibrated/working' directory.

```
import glob as glob
 rethrow casa exceptions = True
pipelinemode='automatic'
context = h init()
**********************
## USER SET INPUTS
## Select a title for the weblog
context.project summary.proposal code = 'SUBSET CUBE IMAGING'
## Delete uid* targets.ms and flagversions if it exists
os.system('rm -rf uid* targets.ms')
os.system('rm -rf uid* targets.ms.flagversions')
os.system('rm -rf uid* targets line.ms')
os.system('rm -rf uid* targets line.ms.flagversions')
## Select spw(s) to image and channel binning for each spcified
## MySpw. All spws listed in MySpw must have a corresponding MyNbins
## entry, even if it is 1 for no binning.
MySpw='16'
                                Select spw and specify
MyNbins='16:4'
                                binning
## Select subset of sources to image by field name.
## TO select all fields, set MyFields=''
MvFields='IC1528'
                               Select a subset of sources
## Select Briggs Robust factor for data weighting (affects angular
## resolution of images)
MyRobust=1.5
```





Example imaging script

```
*****
```

```
## Make a list of all uv-datasets appended with *.ms
MyVis=glob.glob('*.ms')
```

try:

```
## Load the *.ms files into the pipeline
hifa_importdata(vis=MyVis, dbservice=False, pipelinemode=pipelinemode)
## Split off the science target data into its own ms (called
## *targets.ms) and apply science target specific flags
## In this example we split off all science targets and science
```

```
## spws, however hif_mstransform could also contain the spw and field
```

selections

```
hif_mstransform(pipelinemode=pipelinemode)
hifa flagtargets(pipelinemode=pipelinemode)
```

```
## Fit and subtract the continuum using existing cont.dat
## for selected spws and fields only.
#hif_makeimlist(specmode='mfs')
hif_uvcontsub(spw=MySpw,field=MyFields,pipelinemode=pipelinemode)
#hif_makeimages(pipelinemode=pipelinemode)
```

```
## calculate the synthesized beam and estimate the sensitivity
## for the aggregate bandwidth and representative bandwidth
## for three values of the robust parameter.
## Don't need to run this task if you will use a different robust value anyway.
```

```
## hifa_imageprecheck(pipelinemode=pipelinemode)
```

```
## check the imaging product size and adjust the relevent
## imaging parameters (channel binning, cell size and image size)
```

User can comment this out if they don't want size mitigation.

```
#hif checkproductsize(maxproductsize=350.0, maxcubesize=40.0, maxcubelimit=60.0)
```

Make new continuum subtracted cube for selected spw(s) and fields

hif_makeimlist(specmode='cube',spw=MySpw,nbins=MyNbins,field=MyFields,robust=MyRobust, pipelinemode=pipelinemode) hif_makeimages(pipelinemode=pipelinemode)

Export new images to fits format if dee hifa_exportdata(pipelinemode=pipelinemode)

finally:
 h_save()

Make cont. subtracted cube for spw with specified robust and binning



- Will create:
 - new pipeline-*/html directory with weblog and casa_commands.log file
 - Images (PL imaging products are always named the same, exported to calibrated/products)
 - Calibrated MS files for each ASDM containing only science targets and spectral windows (uid*_targets.ms and uid*_targets_line.ms)
 - After hif_mstransform, the DATA column in uid*_targets.ms has calibrated continuum+line data
 - After hif_uvcontsub, the DATA column in uid*_targets_line.ms has calibrated continuumsubtracted line data



 ▲ Home
 By Topic
 By Task

 Tasks in execution order
 .

 1. hifa_importdata
 Image: Comparison of the system of the

6. hif_makeimages (cube)
 7. hifa_exportdata

0

Θ

5. Make image list

Set-up parameters for target cube imaging

QA Score: 1.00 All clean targets defined All QA Scores (2 green)

Most Severe Notification: Warning! Could not determine aggregate bandwidth frequency range for spw 18. Exception: Vis list ['uid___A002_Xed9025_X8eb5_targets_line.ms'] does not contain any MS with data for spw 18 <u>All Notifications (3)</u>

List of Clean Targets

field	intent	spw	data type	phasecenter	cell	imsize	imagename	specmode	nbin	robust
IC1528	TARGET	16	REGCAL_LINE_SCIENCE	ICRS 00:05:05.7090 -007.05.33.147	['0.97arcsec']	[144, 144]	oussid.sSTAGENUMBER.IC1528_sci.spw16.cube.regcal	cube	4	1.5

Clean Targets Summary

Input Parameters

Tasks Execution Statistics



SUBSET CUBE IMAGING

BACK

By Topic By Task Home Tasks in execution order Θ 1. hifa_importdata 6. Tclean/Makelmages 2. hif_mstransform Make target cubes 3. hifa flagtargets 4. hif_uvcontsub θ 5. hif_makeimlist (cube) 6. hif_makeimages (cube) 0 7. hifa_exportdata

QA Score: 0.96 MOM8 FC image for field IC1528 virtspw 16 has a peak SNR of 2.8052 and no significant flux histogram asymmetry. All QA Scores (2 green)

Most Severe Notification: Warning! Could not determine aggregate bandwidth frequency range for spw 18. Exception: Vis list ['uid___A002_Xed9025_X8eb5_targets_line.ms'] does not contain any MS with data for spw 18 <u>All</u> <u>Notifications (3)</u>

In this stage, images with significant emission are cleaned to a threshold of 2 x (predicted rms noise) x (dynamic range correction factor) using automasking. If a clean mask is not found automatically, then this threshold is doubled and the bulk of the whole image is used (PB>0.3). The dynamic range correction factor (abbreviated as "DR correction") accounts for the fact that sources with a high dynamic range will typically exhibit larger imaging artifacts, resulting in a noise level greater than an equivalent blank field. The artifacts are worse for poorer UV coverage, so different dynamic range (DR) correction factors are adopted for different antenna configurations (12m Array vs. 7m Array multi-EB vs. 7m Array single-EB), and for different targets (science targets vs. calibrators). See the Pipeline User's Guide for details.

The DR correction adopted is a function of the dirty dynamic range (abbreviated as "Dirty DR"), which is defined as the peak intensity divided by the theoretical rms sensitivity delivered by the visibilities.

Image Details





SUBSET CUBE IMAGING

BACK

تى



More Pipeline Imaging Resources

 Cycle compatibility and new tool: <u>https://casaguides.nrao.edu/index.php?title=ALMA_Imaging_Pipeli</u> <u>ne_Reprocessing_Tool</u>

About the Imaging Pipeline Reprocessing Tool - scriptForReprocessing.py

scriptForReprocessing.py is intended to be a convenient wrapper for many of the ALMA imaging pipeline functions (including continuum subtraction) that users may wish to use on their NA delivered value-added products. See the Pipeline Users Guide and Reference Manual 🗗 for a full description of the ALMA pipeline.

The script can be launched via CASA with any version of CASA that includes the ALMA pipeline from Cycle 9 or later. See the above link for a mapping of ALMA Cycle, CASA version, and Pipeline version. Thus it should be launched as:

\$ casa --pipeline -c scriptForReprocessing.py [options]

- I-TRAIN #1: imaging with the ALMA Pipeline:
 - <u>https://almascience.eso.org/tools/eu-arc-network/i-train</u>
 - https://www.youtube.com/watch?v=Tqql8lhvyPE





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B. Kent+NINE program

NRAO Science Ready Data Products

https://science.nrao.edu/srdp

https://data.nrao.edu/portal/#/



ALMA User-Defined Imaging (AUDI) - calibrated Measurement Set + Imaging

- Cycle 5 and beyond
- Only pipeline-calibrated data
- Users can select their own imaging parameters via a web interface
- Pipeline software will apply the calibration to the raw data, then make the image per the users' request.
- Allows the user to image the part of the cube they want, at the resolution they need.
- NEW! Automated self-calibration: <u>https://science.nrao.edu/srdp/self-calibration-preview</u>



https://data.nrao.edu/portal/#/

Launch Optimized Imaging on: 2017.1.00236.S

×

		View	View	
	↓† Project	t	↓† Instrument	Title
-	2017.1.00	236.S	ALMA	Feedi Unive

Title: Feeding and feedback in an unbiased an **Abstract:** We will map CO(2-1)in the central 3 quantify the global AGN feeding and feedback down to 10^5 Mo, derive outflow rates, gas resonaure inflow rates. With the continuum map ALMA archival observations, will provide a sam legacy value comes from combining uniform C resolution follow-up to dynamically constrain the **PI:** Matthew Malkan

Co-Authors: Francoise Combes, Miguel Pereir Masatoshi Imanishi, Matthew Malkan, Kotaro I

M	OUSes	Images		
		MOUS		lţ oi
	-	ngc_2992_a	_06_TM1	2017

User Email (required):	
Request Description:	Request Description
Destination Directory:	□ Specify directory (must be logged in & staff) 2018-11-28 1 execution blocks 11:09
CASA Version:	5.4.2-8 (recommended) → 5.4.2
SPW:	spw:19 (225.392 GHz-227.330 GHz) dnu = 124995k 2 bright AGN in 27 hours which, when added to of a similarly selected sample of LINERs. The itable bright nearby AGN for ALMA high-
Field:	ngc_2992
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Rest Frequency:	GHz
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Width:	km/s ownload Restored MS Optimized Imaging
N Channels:	8
End:	km/s
	Cancel Submit Request d Universities, Inc.





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- Currently only supports single pointing observations (non-ephemeris)
- Possible to use self-calibration with ALMA and VLA pipelines
- Used in ALMA pipeline starting Cycle 9

Example Results from Automated Self-calibration



ALMA Band 6 images of the NGC 2071 IR star forming region from ALMA project 2018.1.01038.S (<u>Cheng et al. 2022</u>). The *left* image is without self-calibration, while the *right* image is from the automated self-calibration within the pipeline.





Selfcal stage in ALMA Pipeline

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flag													
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Selfcal stage in ALMA Pipeline

Home By Topic	By Task								
13. hifa_bandpass 14. hifa_spwphaseup	0	Success / Final Solint		Yes /	inf				
15. hifa_gfluxscaleflag		Stop Reason		Estimated_SNR_too_k	ow_for_so	lint 81.92:	s		
16. hifa_gfluxscale		Initial/Final Image Compari	sons						
17. hifa_timegaincal	0	Initiarrinai iniage compan	5015						_
18. hifa_targetflag		Solint	inf_EB	inf	81.92s	30.72s	10.24s	int	t
19. hif_applycal	0		Pass	Pass					
20. hif_makeimlist (cals)		Result	QA Plots	QA Plots					
21. hif_makeimages (cals)		Internet of Flore	150 570 + 17 005 1-	107.070 - 10.001 1-					
22. hif_makeimlist (checksrc)		Integrated Flux	153.578 ± 17.995 mJy	167.076 ± 16.661 mJy					
23. nit_makeimages (checksrc)	e	Integrated Flux Change	1.063	1.012					
25. hif_checkproductsize		Dynamic Range	53.559	59.582					
26. hifa_renorm	0		1.000	1.040					
27. hifa_exportdata		DR Improvement	1.288	1.048					
28. hif_mstransform		Dynamic Range (N.F.)	53.676	59.954					
29. hifa_flagtargets		DR Improvement (N.F.)	1 287	1.050					
30. hif_makeimlist (mfs)		Dit improvement (14.1)	1.207	1.000		_			
31. hif_findcont		RMS	0.420 mJy/bm	0.388 mJy/bm					
32. hif_uvcontsub		RMS Improvement	1.176	1.016					
33. hif_makeimages (mfs)									
34. hif_makeimlist (cont)		RMS (N.F.)	0.419 mJy/bm	0.386 mJy/bm					
35. hif_makeimages (cont)		RMS Improvement (N.F.)	1.175	1.017					
36. hif_makeimlist (cube)		Room Dro							
37. hif_makeimages (cube)		Dealitie	0.341"x0.247" -85.906 deg	0.341"x0.247" -85.905 deg					
38. hif_makeimlist (cube_repBW)		Beam post							
39. hif mel surages (cube_rep. 94)		Ratio of Beam Area	1.000	0.999					
41. hif_makeimlist (mfs)		Clean Threshold	2.401 mJy/bm	1.894 mJy/bm					
42. hif_makeimages (mfs)	· · · · ·	Maggurament Cat		4002 Vd0aE88 V1b22 tar	roto mo				
43. hif_makeimlist (cont))	Measurement Set	uid	A002_A00a586_A1D32_tai	Jets.ms				
44. hif_makeimages (cont)			Automa Positions colorized by Sellical Plagging	Advana Positions colorized by Sellival Plagging					
45. hif_makeimlist (cube)			Care 100-1	-001					
<pre>wi_bif_makeimages (cube)</pre>		Flagged Frac.	1						
47. hif_makeimlist (cube_repBW)		by antenna	and and a second	and					
48. hif_makeimages (cube_repBW)									
49. hifa_exportdata			-680 513 542 542 542 542 542 542 542 542 542 542	-880 - 118 -		-			
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Selfcal stage in ALMA Pipeline

Home By Topic By Task	k				E2E6.1.00007.S
13. http://www.news.com/ 14. http://www.news.com/ 14. http://www.news.com/	9				
15. hifa ofluxscaleflag	16 Makal	magas			
16. hifa_gfluxscale	40. Maker	mayes			
17. hifa_timegaincal	Make target cu	bes			BACK
18. hifa_targetflag					
19. hif_applycal	0 04 Seare: 0.00 MON	M9 EC image for field W/114-1 virteow 17 has a peak SND of	5 9901 and no cignificant flux histogram asymmetry All OA	Secres (16 green)	
20. hif_makeimlist (cals)	QA Scole. 0.99 Midi	vio PC image for field viv 114-1 virtspix 17 has a peak Sivik of	5.6691 and no significant flux instogram asymmetry. <u>All QA</u>	<u>I Scores (To green</u>)	
21. hif_makeimages (cals)	In this stage, images with s	significant emission are cleaned to a threshold of 2 x (predicted rm	is noise) x (dynamic range correction factor) using automasking. If a	a clean mask is not found automatically, then this threshold is do	ubled and the bulk of the whole image is used (PB>0.3). The dynamic range
22. hif_makeimlist (checksrc)	correction factor (abbreviat	ted as "DR correction") accounts for the fact that sources with a hi	gh dynamic range will typically exhibit larger imaging artifacts, resul	Iting in a noise level greater than an equivalent blank field. The ar	tifacts are worse for poorer UV coverage, so different dynamic range (DR)
23. hif_makeimages (checksrc)	correction factors are adop	oted for different antenna configurations (12m Array vs. 7m Array r	nulti-EB vs. 7m Array single-EB), and for different targets (science ta	argets vs. calibrators). See the Pipeline User's Guide for details.	
24. hifa_imageprecheck	The DR correction adopted	is a function of the dirty dynamic range (abbreviated as Dirty DR), which is defined as the peak intensity divided by the theoretical m	ns sensitivity delivered by the visibilities.	
25. hif_checkproductsize	Image Detai	ils			
26. hifa_renorm	9 mage beta				
27. hifa_exportdata	Field	Spw			
28. hlf_mstransform	VV114-1 (TARGET)	17/	19 /	21 /	23 /
19. hifa_flagtargets		X2132808557#ALMA_RB_09#BB_1#SW-01	X2132808557#ALMA_RB_09#BB_1#SW-02	X2132808557#ALMA_RB_09#BB_2#SW-01	X2132808557#ALMA_RB_09#BB_2#SW-02
10. hif_makeimlist (mfs)		Anterimane destavated interve investi Seld V/2161 vrises 37 Serci	There make displayered line of (month field W1163 where 15 Fer 0	Aver-make disdoverabline of Growell Reld W1863 where 21 Rel 0	here make distributed the of (munit) \$60192163 where 27 fm3
1. hif_findcont					
12. hlf_uvcontsub		· · · · · · · · · · · · · · · · · · ·			а. Та
3. hif_makeimages (mfs)		- 445 - 445			
:4. hif_makeimlist (cont)		ε. Better and	ents A compared to the second se	- = 0 400	- 62 - 63
5. hif_makeimages (cont)		and the second se			
:6. hif_makeimlist (cube)		Pipel Accession (1972) 2000000 Internal 1 Filipit Accession (access(1)	 Appl Increase (1) of 0.00000	Ref Lances 121 of United	Iteration 1: image
7. hif_makeimages (cube)		View other QA images	View other QA images	View other QA images	View other QA images
8. hif_makeimlist (cube_repBW)					
.9. hif_makeimages (cube_repBW)	stokes	1	I.	1	I
40. htt_selfcal	centre / rest frequency of	f cube 665.8755GHz / 665.9116GHz (LSRK)	675.9581GHz / 676.0000GHz (LSRK)	663.8756GHz / 663.9116GHz (LSRK)	677.9580GHz / 678.0000GHz (LSRK)
2. hif_makeimist (mis)					
12. http://www.inages.com/	beam	0.351 x 0.258 arcsec	0.348 x 0.254 arcsec	0.358 x 0.262 arcsec	0.351 x 0.259 arcsec
Id hif makeimages (cont)	beam p.a.	-85.2deg	-84.1deg	-85.7deg	-85.5deg
15. hif_makeimlist (cube)	final theoretical sensitivit	ty 3.8 mJy/beam	4 mJy/beam	3.3 mJy/beam	3.9 mJy/beam
(Luce)	cleaning threshold	findCont=AllCont. no cleaning	findCont=AllCont. no cleaning	findCont=AllCont. no cleaning	19 m.lv/beam
7. hif_makeimlist (cube_repBW)	ereating an eeron	0 Jy/beam	0 Jy/beam	0 Jy/beam	Dirty DR: 1.5e+02
9 hif makaimagas (cuba ranPW)		Dirty DR: 9.1	Dirty DR: 5.8	Dirty DR: 6.1	DR correction: 2.5
40. III_IIIakeiIIIages (cube_repb14)					





- Stand-alone scripts available for use with older data
- Development version (mosaics, spectral scan, and long-baseline support): <u>https://github.com/psheehan/auto_selfcal</u>
- Stable version (heuristics used by current pipeline): <u>https://github.com/jjtobin/auto_selfcal/</u>
- Demo dataset from ALMA observatory filler project, we will use one EB from this project:

2018.A.00050.T	Sgr A* Coordinated observations with Spitzer, Chandra, NuSTAR	This project will observe the galactic center in the Band 6 or Band 7 continuum in coordination with Spitzer, Chandra, and NuStar. The ACA observations will be obtained on 3 days in July for approximately 7 hours each day. The description of the
		campaign is available at https://www.cfa.harvard.edu/irac/gc/.





- Stable version (heuristics used by current pipeline): <u>https://github.com/jjtobin/auto_selfcal/</u>
- Script runs on ALMA or VLA *_targets.ms file
- If cont.dat is available, performs self-cal on the continuum only
- Instructions to run from calibrated_final.ms (delivered by NA ARC) on website:

To run this code with a concatenated calibrated_final.ms that one might receive from the NA ARC, one must split out the groups of SPWs associated with the individual observations, selecting on SPW, such that one has a set of MSes with SPWs that are all the same. For example, if an MS has SPWs 0,1,2,3,10,11,12,13, and 0,1,2,3 are from the first observation and 10,11,12,13 are from the second observation, they should be split out as follows: split(vis='my_concat.ms',spw'0,1,2,3',outputvis='my_ms_0_target.ms') split(vis='my_concat.ms',spw'10,11,12,13',outputvis='my_ms_1_target.ms') We provide a script split_calibrated_final.py to do this automatically.

• We will start from uid*.ms file created after restore





 prep_data.py contains PL tasks necessary to create uid*_targets.ms from uid*.ms, creates a PL weblog

```
h_init()
hifa_importdata('uid___A002_Xdf0444_Xc22.ms')
hif_mstransform()
h_save()
```



Task Summaries

Task		QA Score		Duration
O 1. hifa_importdata: Register measurement sets with the pipeline	Flux catalog service not used. Source.xml is the origin.		0.30	0:11:55
2. hif_mstransform: Create science target MS			1.00	0:02:13
CASA logs and scripts				
View, view in new tab or download casa-20240430-154713.log (87.8 KiB)				
View, view in new tab or download casa_commands.log (1.1 KiB)				
 View, view in new tab or download casa_pipescript.py (123 bytes) 				
View, view in new tab or download (672 bytes)				





- Script performs phase self-calibration first and then amplitude self-calibration
- Amplitude self-cal turned off by setting the variable 'do_amp_selfcal'=False in auto_selfcal.py

Brief instructions:

- 1. Create an empty directory
- Copy into this directory the *_target.ms files that have identical setups (targets and spectral windows) to be self-calibrated (must contain only the targets desired for self-calibration and only TARGET observation intents)
- 3. Copy cont.dat file for all targets into directory (will be used to flag out spectral lines).
- 4. Copy all .py files in the cloned auto_selfcal repo into your working directory
- 5. Run script with mpicasa -n X casa -c auto_selfcal.py; X is the number of mpi threads to use

If serial operation is desired (without mpicasa), run with casa -c auto_selfcal.py





- Script finds uid*_targets.ms, determines all parameters necessary for self-cal and imaging of science targets
- Outputs uid*_targets.selfcal.ms
- Outputs script 'applycal_to_orig_MSes.py', which applies self-cal solutions to original MS file so line data is also self-calibrated
- Outputs script 'uvcontsub_orig_MSes.py', if cont.dat exists, to exclude same regions for continuum fitting as were flagged for continuum self-calibration
- Summaries generated in weblog/index.html for all targets





SelfCal Weblog

Date Executed:2024-04-30

Targets:

SgrAstar

Bands:

Band_7

Solints to Attempt:

Band_7: inf_EB, inf, 141.12s, 40.32s, int

SgrAstar Summary

Back to Top

Band_7

Selfcal Success?: True Stop Reason: S/N decrease; NF S/N decrease; All sub-fields failed

Final Successful solint: 141.12s







Initial vs. Final Noise Characterization



Per solint stats: Solint: inf EB inf 141.12s 40.32s int Result: Fail S/N decrease; NF S/N decrease; All sub-fields failed -Pass Pass **Pass** Integrated Flux: 4190.429 +/- 167.827 mJy 4501.707 +/- 109.553 mJy 4612.355 +/- 94.540 mJy 4683.586 +/- 88.312 mJy Integrated Flux Change: 1.025 1.034 0.999 0.998 62.972 99.582 117.118 128.670 Dynamic Range: 1.637 1.409 DR Improvement: 1.009 0.995 Dynamic Range (near-field): 62.972 99.582 117.118 128.670 DR Improvement (near-field): 1.637 1.409 1.009 0.995 RMS: 6.441e+01 mJy/bm 4.204e+01 mJy/bm 3.595e+01 mJy/bm 3.298e+01 mJy/bm RMS Improvement: 1.575e+00 1.364e+00 1.004e+00 9.881e-01 RMS (near-field): 4.204e+01 mJy/bm 3.595e+01 mJy/bm 6.441e+01 mJy/bm 3.298e+01 mJy/bm RMS Improvement (near-field): 1.575e+00 1.364e+00 1.004e+00 9.881e-01 -Ratio of Beam Area: 1.000e+00 1.000e+001.000e+001.000e+00 Clean Threshold: 5.585e+02 mJy/bm 2.834e+02 mJy/bm 1.628e+02 mJy/bm 1.225e+02 mJy/bm Plots: QA Plots QA Plots QA Plots QA Plots Flagged solutions by antenna: uid___A002_Xdf0444_Xc22_targets.selfcal.ms: Nsols 88 88 242 858 Flagged_Sols 0.000 Frac_Flagged 0.000 0.000 0.000

Per SPW stats:

	Virtual SPW ID:	0	1	2	3						
	Virtual SPW to	real SPW mapping									
	uidA002_Xdf0444_Xc22_targets.selfcal.ms:	16	18	20	22						
	Metadata	and Statistics									
	bandwidth:	2.0000 GHz	2.0000 GHz	2.0000 GHz	2.0000 GH						
	effective_bandwidth:	1.0958 GHz	1.5392 GHz	0.8790 GHz	1.7599 GH						
	SNR_orig:										
	SNR_final:										
	RMS_orig:										
l	RMS_final:										





Thank you! Questions?

