# Cycle 4 Imaging IF Pipeline & Cy5 Reqts:
## Summary for Italian ARC Node Workshop
## Jan 23, 2017

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# Cycle 4 Imaging IF Pipeline & Cy5 Reqts: Summary for Italian ARC Node f2f

Part I: Cycle 4 Imaging PL Products & Pitfalls

Part II: Material from July 2016 PL Review (updated)

# PART I: Cycle 4 Imaging PL Products & Pitfalls

Products

# Cycle 4 Interferometric (IF) Imaging Pipeline: Overview

- First automated imaging pipeline for radio/mm observatory
- Continuum images of phase, bp calibrators
- Image-plane based continuum identification routine
  - frequency ranges used for making continuum images and doing continuum subtraction
- Per-spw & aggregate continuum images
- Per-spw continuum subtracted cubes
  - continuum fit & subtracted in visibility domain
- Shallow clean using simple mask
  - Clean thresholds are based on theoretical noise and expected dynamic range (shallower for brighter sources)
  - Mask = fixed level of PB response

**Doc 4.13, ver. 1** | October, 2016

# ALMA Science Pipeline User's Guide for CASA 4.7.0

## Interferometric and Single-Dish Data

ALMA

www.almascience.org

ALMA, an international astronomy facility, is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

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# IF Imaging PL Products

After PL run, in /products

- pipeline-20161114T172721
- PPR_uid___A001_X885_X5b.xml
- ~~scriptForImaging.py~~
- uid___A001_X885_X5a.antennapos.csv
- uid___A001_X885_X5a.casa_commands.log
- uid___A001_X885_X5a.casa_piperestorescript.py
- uid___A001_X885_X5a.casa_pipescript.py
- uid___A001_X885_X5a.cont.dat
- uid___A001_X885_X5a.flux.csv
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- uid___A001_X885_X5a.J1037-2934_bp.spw19.mfs.I.pbcor.fits
- uid___A001_X885_X5a.J1037-2934_bp.spw21.mfs.I.pb.fits
- uid___A001_X885_X5a.J1037-2934_bp.spw21.mfs.I.pbcor.fits
- uid___A001_X885_X5a.J1037-2934_bp.spw23.mfs.I.pb.fits
- uid___A001_X885_X5a.J1037-2934_bp.spw23.mfs.I.pbcor.fits
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- uid___A001_X885_X5a.J1038-2151_ph.spw17.mfs.I.pbcor.fits
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- uid___A001_X885_X5a.pipeline_manifest.xml
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- uid___A001_X885_X5a.PKS_1045-188_sci.spw17_19_21_23.cont.I.pb.tt0.fits
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- uid___A001_X885_X5a.PKS_1045-188_sci.spw21.mfs.I.pb.fits
- uid___A001_X885_X5a.PKS_1045-188_sci.spw21.mfs.I.pbcor.fits
- uid___A001_X885_X5a.PKS_1045-188_sci.spw23.cube.I.pb.fits
- uid___A001_X885_X5a.PKS_1045-188_sci.spw23.cube.I.pbcor.fits
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- uid___A001_X885_X5a.PKS_1045-188_sci.spw23.mfs.I.pbcor.fits
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- uid___A001_X885_X5a.weblog.tgz
- uid___A002_Xba839d_X5dcc_flagtargetstemplate.txt
- uid___A002_Xba839d_X5dcc.ms.calapply.txt
- uid___A002_Xba839d_X5dcc.ms.flagversions.tgz

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Arrange | Share | Edit Tags | Action | ? | Search

- calibration
  - antennapos.csv
  - flux.csv
  - uid___A001_X2fa_X2dd.cont.dat
  - uid___A001_X2fa_X2dd.session_1.caltables.tgz
  - uid___A002_Xb5aa7c_X196a_flagtargetstemplate.txt
  - uid___A002_Xb5aa7c_X196a_flagtemplate.txt
  - uid___A002_Xb5aa7c_X196a.ms.calapply.txt
  - uid___A002_Xb5aa7c_X196a.ms.flagversions.tgz
- log
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  - casa-20161202-165428.log
  - casa-20161202-165608.log
  - casa-20161202-191634.log
  - uid___A001_X2fa_X2dd.casa_commands.log
- product
  - oussid.s3_0.NGC_2872_sci.spw25.cube.I.iter1.image.pbcor.fits
  - oussid.s3_0.NGC_2872_sci.spw25.cube.I.iter1.pb.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw19.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw19.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw21.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw21.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw23.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw23.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw25.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0854+2006_bp.spw25.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw19.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw19.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw21.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw21.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw23.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw23.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw25.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.J0931+1414_ph.spw25.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19_21_23_25.cont.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19_21_23_25.cont.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19.cube.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19.cube.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw19.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw21.cube.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw21.cube.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw21.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw21.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw23.cube.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw23.cube.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw23.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw23.mfs.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw25.cube.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw25.cube.I.pbcor.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw25.mfs.I.pb.fits
  - uid___A001_X2fa_X2dd.NGC_2872_sci.spw25.mfs.I.pbcor.fits

member_ouss_id

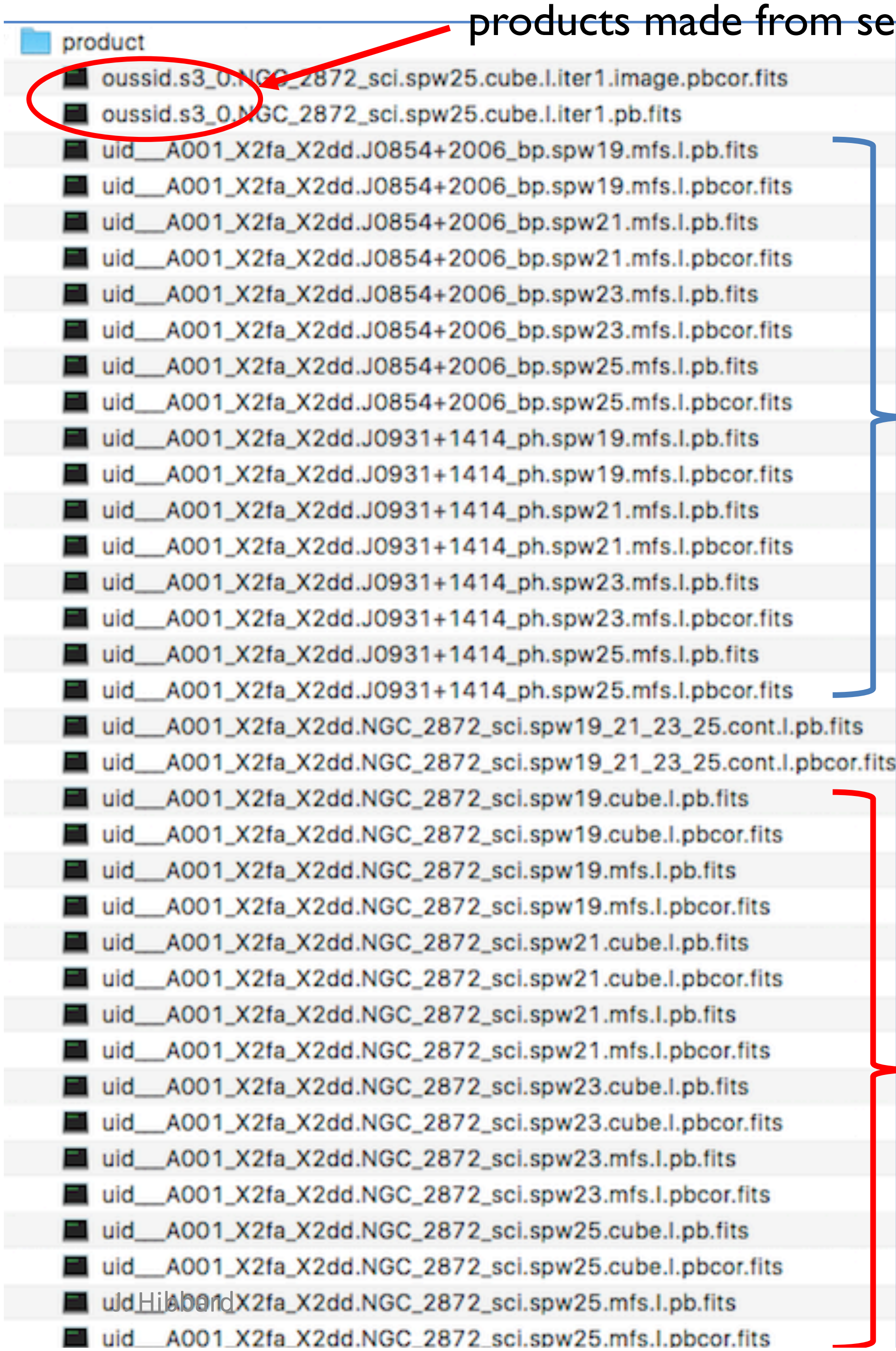
Arrange | Share | Edit Tags | Action | ?

Name

- calibration
- log
- product
- qa
  - pipeline-20161202T165751
  - pipeline-20161205T163212
  - uid___A001_X2fa_X2dd.weblog.tgz
- README.header.txt
- README.header.txt~
- script
  - casa_piperestorescript.py
  - casa_pipescript.py
  - PPR_uid___A001_X2fa_X2de.xml
  - scriptForImaging.py
  - scriptForPI.py

After PL Delivery

products made from separately running imaging PL tasks




# IF Imaging PL Products

After PL Delivery

## Calibrator images

_bp, _ph = bandpass, phase (check will be added at patch)
.spw##.mfs = multifrequency synthesis (continuum) of spw
.pb = primary beam; primary beam corrected
.pbcor = primary beam; primary beam corrected

## Science target aggregate continuum

.pb = primary beam; primary beam corrected
.pbcor = primary beam; primary beam corrected

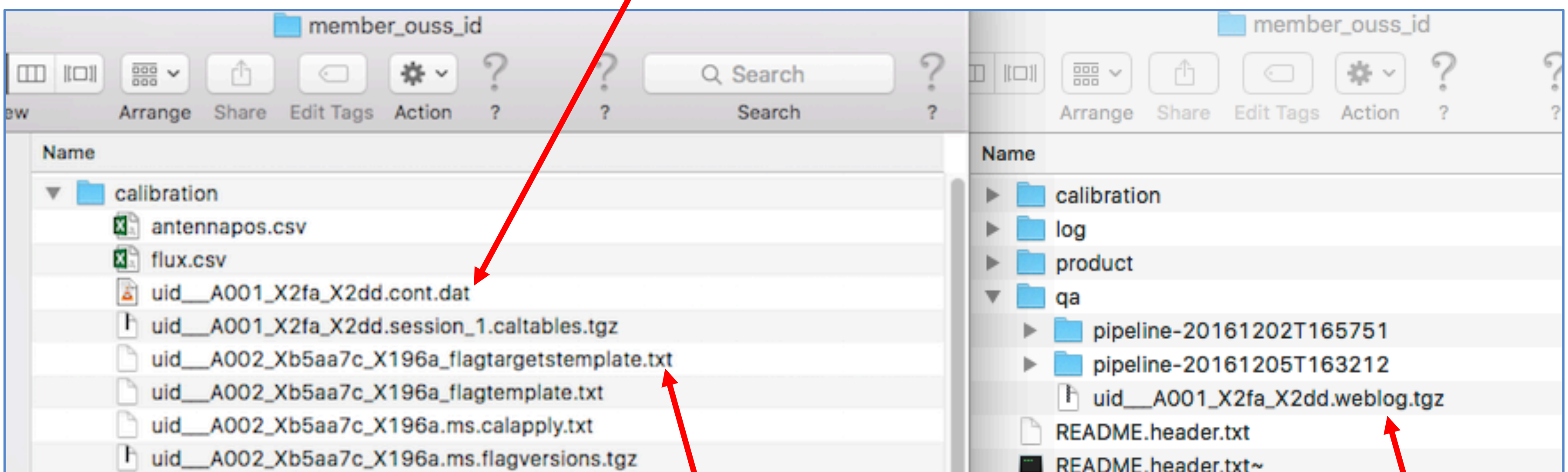
## Science target images

.spw##.mfs = multifrequency synthesis (continuum) of spw
.spw##.cube = continuum subtracted lines cube of spw
.pb = primary beam; primary beam corrected
.pbcor = primary beam; primary beam corrected

# IF Imaging PL Products: new non-imaging products

After PL Delivery

- Lists frequency ranges used for continuum identification for each source/spw.
- Can be edited to set alternative ranges & re-run PL continuum fitting/subtraction & imaging commands




- Can be used to enter source flagging commands (same syntax as uid*flagtemplate.txt)
- If present, will be applied before imaging tasks are run

Weblog also includes PL imaging stages

# QA2 Data Products Package: Log Directory – *Pipeline Calib.*

Contains CASA log files from QA2 processing

```
log
├── casapy-20141129-145932.log
├── casapy-20141129-150412.log
├── casapy-20141129-150456.log
├── casapy-20141223-170951.log
├── casapy-20141229-164757.log
└── uid___A001_X121_X2e5.casa_commands.log
```

- `casapy` log files contain pipeline logs for data import, applying calibration, flagging, and imaging
- `casa_commands` log file: provided to aid investigators in re-running different steps with their own customizations
  - Shows the equivalent CASA task that were invoked by each pipeline task
  - Does not include pipeline heuristic calculations (just their results)
  - Individual commands can be copy+pasted & run in CASA (but can't execute file as is)

# QA2 Data Products Package:
# Script Directory - *Pipeline Calib.*

Contains scripts to reproduce the QA2 calibration and imaging

```
script
├── casa_piperestorescript.py
├── casa_pipescript.py
├── PPR_uid___A001_X121_X2e6.xml
├── scriptForImaging.py
└── scriptForPI.py
```

- casa_piperestorescript.py ← Restores calibrated MS - called by scriptForPI.py
- casa_pipescript.py ← calibrates data from scratch using pipeline tasks
- PPR_uid___A001_X121_X2e6.xml ← pipeline input parameters
- scriptForImaging.py ← regenerates imaging products
- scriptForPI.py ← top-level wrapper restores calibrated MS(s)

# casa_pipescript.py

calibrates data from scratch using pipeline tasks

```
__rethrow_casa_exceptions = True
h_init()
try:
    hifa_importdata(dbservice=False,
vis=['uid___A002_X877e41_X452'], session=['session_1'])
    hifa_flagdata(pipelinemode="automatic")
    hifa_fluxcalflag(pipelinemode="automatic")
    hif_rawflagchans(pipelinemode="automatic")
    hif_refant(pipelinemode="automatic")
    hifa_tsyscal(pipelinemode="automatic")
    hifa_tsysflag(pipelinemode="automatic")
    hifa_antpos(pipelinemode="automatic")
    hifa_wvrgcalflag(pipelinemode="automatic")
    hif_lowgainflag(pipelinemode="automatic")
    hif_gainflag(pipelinemode="automatic")
    hif_setjy(pipelinemode="automatic")
    hifa_bandpass(pipelinemode="automatic")
    hifa_spwphaseup(pipelinemode="automatic")
    hifa_gfluxscale(pipelinemode="automatic")
    hifa_timegaincal(pipelinemode="automatic")
    hif_applycal(pipelinemode="automatic")
    hif_makeimlist(intent='PHASE,BANDPASS,CHECK')
    hif_makeimages(pipelinemode="automatic")
    hif_exportdata(pipelinemode="automatic")
# Start of pipeline imaging commands
    hif_mstransform(pipelinemode="automatic")
    hifa_flagtargets(pipelinemode="automatic")
    hif_makeimlist(specmode='mfs')
    hif_findcont(pipelinemode="automatic")
    hif_uvcontfit(pipelinemode="automatic")
    hif_uvcontsub(pipelinemode="automatic")
    hif_makeimages(pipelinemode="automatic")
    hif_makeimlist(specmode='cont')
    hif_makeimages(pipelinemode="automatic")
    hif_makeimlist(width='')
    hif_makeimages(pipelinemode="automatic")
    hif_exportdata(pipelinemode="automatic")
finally:
    h_save()
```

**Figure 1: Example of a Pipeline casa_pipescript.py script for a dataset that was run through the Pipeline for both calibration and imaging**

## Calibration Tasks

- No point running as is – its faster to use casa_piperestorescript.py
- Best re-use – use to add additional commands in between pipeline tasks (flux equalization), or after adding additional flags to flagtemplate.txt

## Imaging Tasks

- Expensive to rerun as is (would redo continuum identification)
- Best re-use:
  - image sources/spw that were not delivered
  - Comment out findcont, edit cont.dat and redo cont. subtraction for specific sources/spw

# CASAguide: Imaging Pipeline Reprocessing

https://casaguides.nrao.edu/index.php/ALMA_Imaging_Pipeline_Reprocessing

## ALMA Imaging Pipeline Reprocessing

**Contents** [hide]



## About This Guide

**This guide describes some examples for perfecting the interferometric imaging products from the ALMA Cycle 4 Pipeline.** If your dat

Additional documentation on the Cycle 4 pipeline can be found at the ALMA Science Portal

# IF Pipeline Weblog

- Examples posted to
  https://safe.nrao.edu/alma/PipelineTestResults/Cycle4_weblog_examples/
  - User = pipetesters
  - Pw =

PROPRIETARY TILL
MAR 27 2017
Mar 04 2017

0000.0.00331.CSV_2016_09_30T20_04_46.344/
  - 7m-array mosaic, single mosaic, Multi-EB
  - Demonstrates mosaic imaging

2015.1.00131.S_2016_09_27T13_07_13.302/
  - 12m-array single field, 9 sources TDM continuum
  - Demonstrates hif_findcont for continuum not always optimal, but probably not enough in this case to significantly alter final rms noise.
  - Includes a check source in the calibrator imaging (calibrator imaging score < 1)

2015.1.01068.S_2016_09_27T17_30_21.391/
  - 12m-array single field, 1 source FDM strong spectral lines, Mulit-EB
  - Demonstrates Imaging residuals for dynamic range limited case
  - Divergence for spw='27' and '35', though cubes are fine

# Weblog: By task view

0000.0.00331.CSV

## Task Summaries

| Task | | QA Score |
|---|---|---|
| 1. **hifa_importdata**: Register measurement sets with the pipeline | | 1.00 |
| 2. **hifa_flagdata**: ALMA deterministic flagging | 16.15% data flagged | 0.90 |
| 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 | | 1.00 |
| 8. **hifa_antpos**: Correct for antenna position offsets | | 0.90 |
| 9. **hifa_wvrgcalflag**: Calculate and flag WVR calibration | No QA | N/A |
| 10. **hif_lowgainflag**: Flag antennas with low gain | | 1.00 |
| 25. **hif_uvcontfit**: UV continuum fitting | | 1.00 |
| 26. **hif_uvcontsub**: UV continuum subtraction | | 1.00 |
| 27. **hif_makeimages**: Make target per-spw continuum images | | 1.00 |
| 28. **hif_makeimlist**: Set-up image parameters for target aggregate continuum imaging | | 1.00 |
| 29. **hif_makeimages**: Make target aggregate continuum images | | 1.00 |
| 30. **hif_makeimlist**: Set-up image parameters for target cube imaging | | 1.00 |
| 31. **hif_makeimages**: Make target cubes | | 1.00 |
| 32. **hif_exportdata**: Prepare pipeline data products for export | | 1.00 |

### CASA logs and scripts

- View, view in new tab or download casa-20160909-214113.log (26.1 MB)
- View, view in new tab or download casa_commands.log (121.1 KB)
- View, view in new tab or download casa_pipescript.py (1.5 KB)
- View, view in new tab or download casa_piperestorescript.py (204 bytes)

Each task has an overall QA score. If <1.0, should check stage for messages

QA Scores defined in User's Guide

Useful logs and scripts linked to at bottom of By Task page

Figure 7: By Task summary view. The page has been truncated so both the top and bottom can be seen. Each pipeline stage is listed, along with its QA score (colored bars to the right), and links to the CASA logs and scripts.

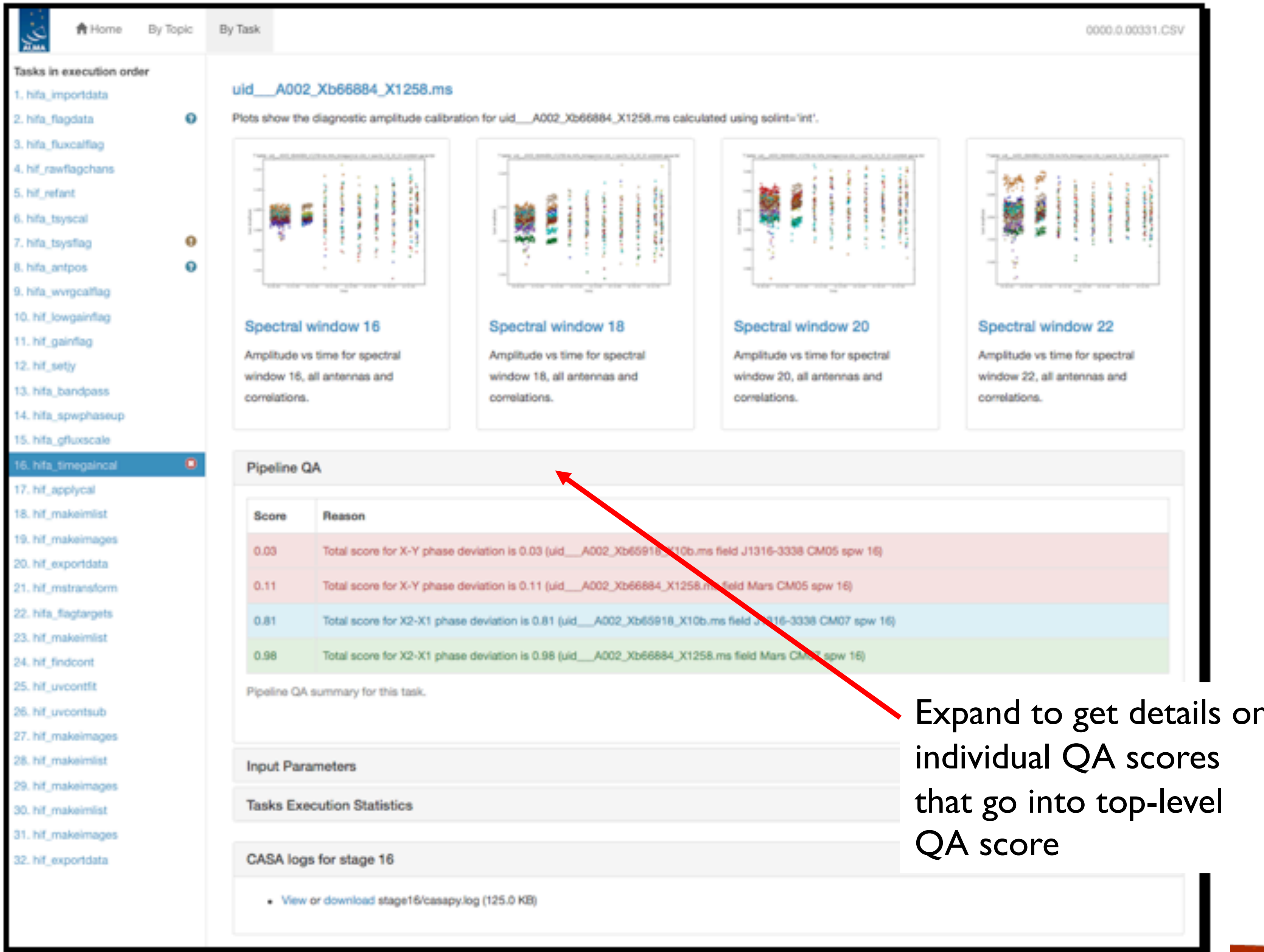



**Figure 9: Bottom of the hifa_timegaincal page, showing the expanded Pipeline QA section, as well as the expandable sections for Input Parameters, Task Execution Statistics and link to the CASA logs for this stage.**

# QA Scores defined in User's Guide

## 7.7 WebLog Quality Assessment (QA) Scoring

Pipeline tasks have scores associated with them in order to quantify the quality of the dataset and the calibration. The scores are between 0.0 and 1.0 and are colourized according to the following table:

| Score | Colour | Comment |
|---|---|---|
| 0.90-1.00 | Green | Standard/Good |
| 0.66-0.90 | Blue | Below standard |
| 0.33-0.66 | Yellow | Warning |
| 0.00-0.33 | Red | Error |

### 7.7.1 Interferometric Pipeline QA Scores

| Pipeline Task | Pipeline QA Scoring Metric | Score |
|---|---|---|
| **hifa_importdata** | Checking that the required calibrators are present | 1.0 all present |
| | | 0.1 subtracted for missing bandpass or flux calibrator |
| | | 1.0 subtracted for missing phase calibrator or Tsys calibration |
| | | 0.5 subtracted for existing processing history |

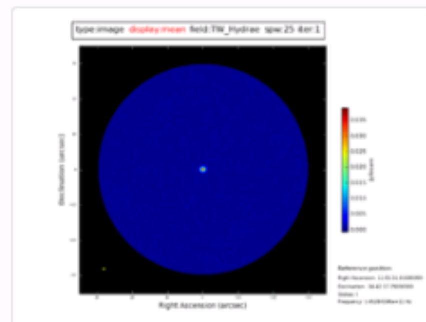
# By Task Weblog: hif_makeimages

## 27. Tclean/MakeImages

Make target per-spw continuum images

BA

### Image Details

| Field | Spw | Pol | Image details | | Image result |
|---|---|---|---|---|---|
| TW_Hydrae (TARGET) | 25 | I | center frequency of image | 146.2842GHz (LSRK) |  View other QA images... |
| | | | beam | 0.59 x 0.36 arcsec | |
| | | | beam p.a. | 88.1deg | |
| | | | final theoretical sensitivity | 3.4e-05 Jy/beam | |
| | | | cleaning threshold | 0.00097 Jy/beam<br>Dirty DR: 1.1e+03<br>DR correction: 7.2 | |
| | | | non-pbcor image rms | 0.00011 Jy/beam | |
| | | | pbcor image max / min | 0.0389 / -0.00134 Jy/beam | |
| | | | fractional bandwidth / nterms | 0.64% / 1 | |
| | | | aggregate bandwidth | 0.935 GHz (LSRK) | |
| | | | score | 1.00 | |

= 4x theoretical sensitivity
x DR correction
(clean to 4-sigma if DR low)

Related to Ratio of measured sensitivity to clean threshold / 4
If ratio=1, score=1
If ratio>5, score=0

Figure 15: Example of hif_makimages WebLog page for per-spw images. Clicking on the thumbnail will enlarge the image. Clicking on the "View other QA images" link will bring up the detailed image page (Figure 16).

# By Task Weblog: continuum hif_makeimages detail

The "View Other QA Images' links for each image show the primary beam corrected image, residual, clean mask (red area), dirty image, primary beam, psf, and clean model (Figure 16).

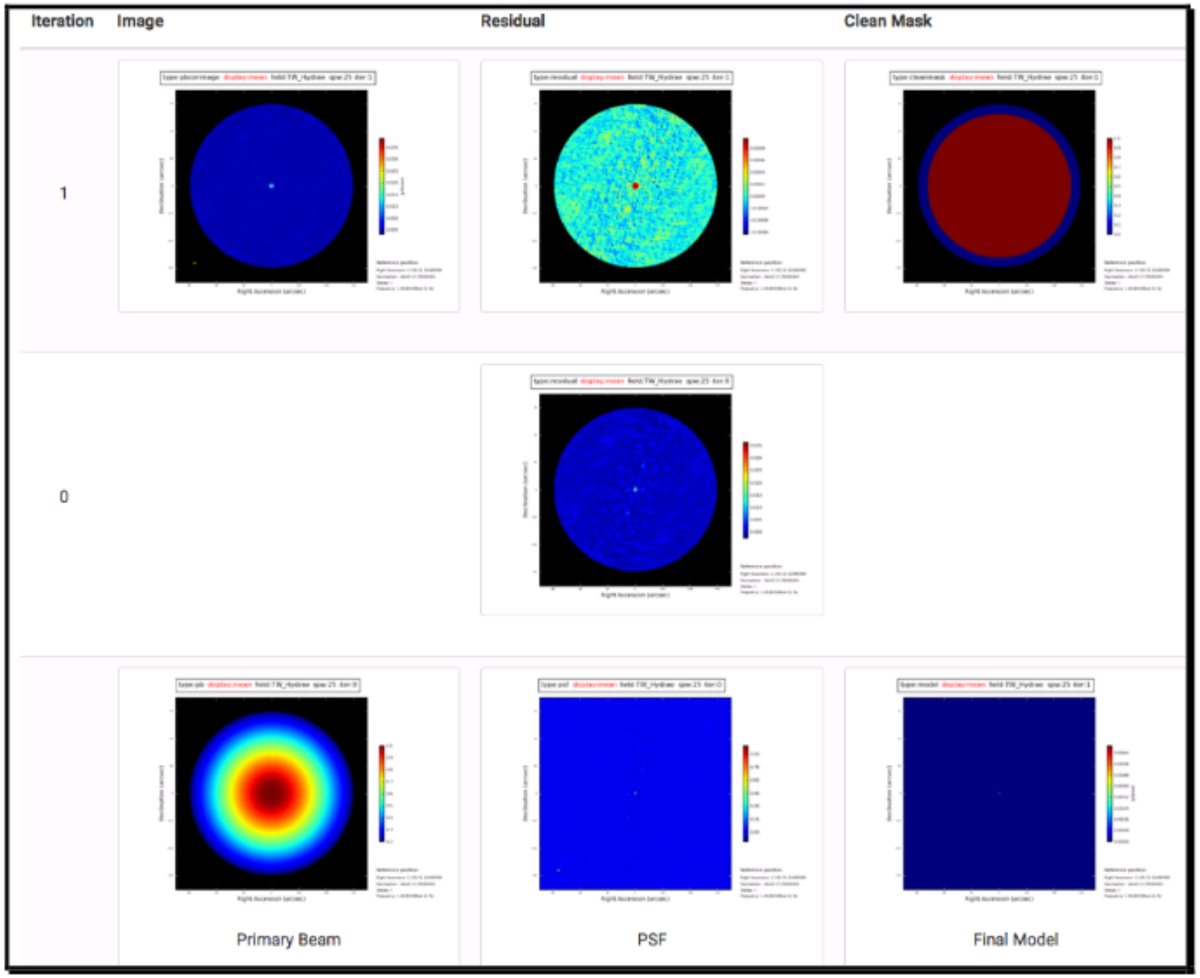
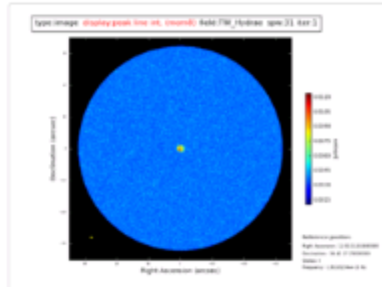



Figure 16: Details page that is displayed after clicking on the "View other QA images" link on the **hif_makimages** WebLog page.

# By Task Weblog: hif_makeimages

| | | | | |
|---|---|---|---|---|
| TW_Hydrae (TARGET) | 31 | I | center frequency of cube | 136.1815GHz (LSRK) |
| | | | beam | 0.65 x 0.38 arcsec |
| | | | beam p.a. | 89.3deg |
| | | | final theoretical sensitivity | 0.0009 Jy/beam |
| | | | cleaning threshold | 0.0036 Jy/beam<br>Dirty DR: 13<br>DR correction: 1 |
| | | | non-pbcor image rms | 0.0010 Jy/beam |
| | | | pbcor image max / min | 0.0189 / -0.0185 Jy/beam |
| | | | channels | 3838 x -0.4883MHz (LSRK) |
| | | | score | 1.00 |
| | | | image file | uid___A001_X865_X19.s31_0.TW_Hydrae_sci.spw31.cube.I.iter1.image |



View other QA images...

Figure 17: Example of `hif_makimages` WebLog page for image cubes.

Contains additional image: Mom0 calculated over channels used for continuum subtraction (should be noise-like)

# PART II: Cycle 4 Imaging PL Products & Pitfalls

Pitfalls

**Doc 4.13, ver. 1** | October, 2016

# ALMA Science Pipeline User's Guide for CASA 4.7.0

## Interferometric and Single-Dish Data

ALMA

www.almascience.org

ALMA, an international astronomy facility, is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.

## 2 What's New in Cycle 4

**New features** of the Cycle 4 pipeline include:

- The interferometric calibration pipeline has a low signal-to-noise heuristic that will calculate the temporal phase variations by combining spectral windows (stage `hifa_spwphaseup`).
- The Interferometry Pipeline now includes science target imaging, as well as including "check sources" in the calibrator imaging stage and improved calibrator quality assurance scores.
- The Single-dish Pipeline has been refactored to use Measurement Set rather than scan table format.
- There are improved defaults for the `hif_gainflag` task.
- Files previously exported as .tar.gz are now exported as .tgz.

**Known limitations** of the Cycle 4 pipeline include:

- No flux equalization between the different executions of multi-epoch observations.
- No automated science target flagging (although a flag template file is available for pipeline to apply manually identified flags).
- The frequency ranges for interferometric continuum identification and subtraction are done in an automated manner that works well over a very broad range of observing modes and source properties. In some cases (e.g. hot core line emission, noisy broadband continuum), it is expected that better results can be obtained by more careful examination of individual sources and/or spectral windows.
- The frequency ranges for single dish line identification and spectral baseline subtraction are done in an automated manner that has been optimized to detect moderate channel width (wider than 100 channels) emission lines at the center of a spectral window. It is expected that better results can be obtained by more careful examination of individual sources and/or spectral windows. The following cases are most strongly affected:
  - Narrow emission lines (less than 100 channels wide), especially in TDM mode.
  - Emission at the edge of spectral window.
  - Cubes with a "forest" of emission lines.
- Science target deconvolution is done with a generic mask and shallow dynamic-range limited clean thresholds, meaning that images with moderate to strong emission will benefit from more carefully defined masks and deeper cleaning thresholds.
- The clean may terminate early if a (conservative) divergence criteria is met (warning is given in WebLog).
- The pipeline does not include science target self-calibration. Therefore, the pipeline imaging products of bright sources may be dynamic range limited.

# Important “known limitations” for Cy4 IF PL

- No automated science target flagging (although a flag template file is available for pipeline to apply manually identified flags).
- The frequency ranges for interferometric continuum identification and subtraction are done in an automated manner that works well over a very broad range of observing modes and source properties. In some cases (e.g. hot core line emission, noisy broadband continuum), it is expected that better results can be obtained by more careful examination of individual sources and/or spectral windows.
- Science target deconvolution is done with a generic mask and shallow dynamic-range limited clean thresholds, meaning that images with moderate to strong emission will benefit from more carefully defined masks and deeper cleaning thresholds.

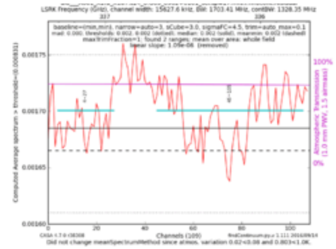
# Imaging PL Pitfalls: automated continuum ID

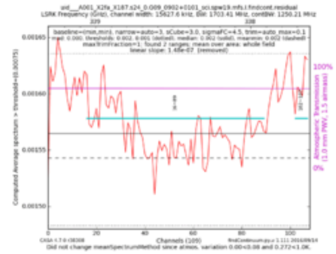
Home

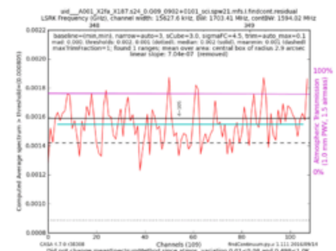
**Tasks in execution order**

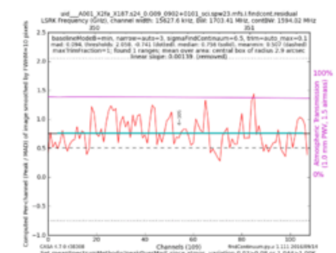
1. hifa_importdata
2. hifa_flagdata
3. hifa_fluxcalflag
4. hif_rawflagchans
5. hif_refant
6. hifa_tsyscal
7. hifa_tsysflag
8. hifa_antpos
9. hifa_wvrgcalflag
10. hif_lowgainflag
11. hif_gainflag
12. hif_setjy
13. hifa_bandpass
14. hifa_spwphaseup
15. hifa_gfluxscale
16. hifa_timegaincal
17. hif_applycal
18. hif_makeimlist
19. hif_makeimages
20. hif_exportdata
21. hif_mstransform
22. hifa_flagtargets
23. hif_makeimlist
24. hif_findcont
25. hif_uvcontfit
26. hif_uvcontsub
27. hif_makeimages
28. hif_makeimlist
29. hif_makeimages
30. hif_makeimlist
31. hif_makeimages
32. hif_exportdata

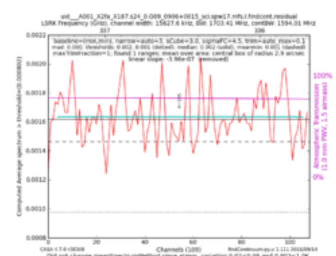
| | | | |
|---|---|---|---|
| G09_0902+0101 | 17 | 335.72068 GHz | 336.67397 GHz |
| | | 336.93964 GHz | 337.31470 GHz |
| | 19 | 337.62715 GHz | 337.72092 GHz |
| | | 337.90845 GHz | 339.06489 GHz |
| | 21 | 347.75332 GHz | 349.34734 GHz |
| | 23 | 349.75355 GHz | 351.34757 GHz |
| G09_0906+0015 | 17 | 335.72005 GHz | 337.31407 GHz |









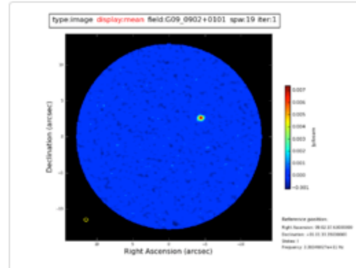
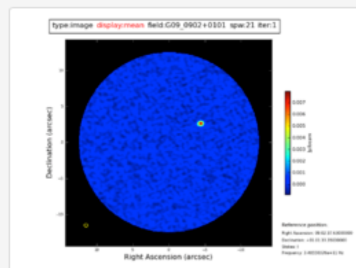


Pure continuum science case: Overall, hif_Findcont did a good job, but tends to be conservative - sometimes does not get complete BW

# Imaging PL Pitfalls: automated continuum ID

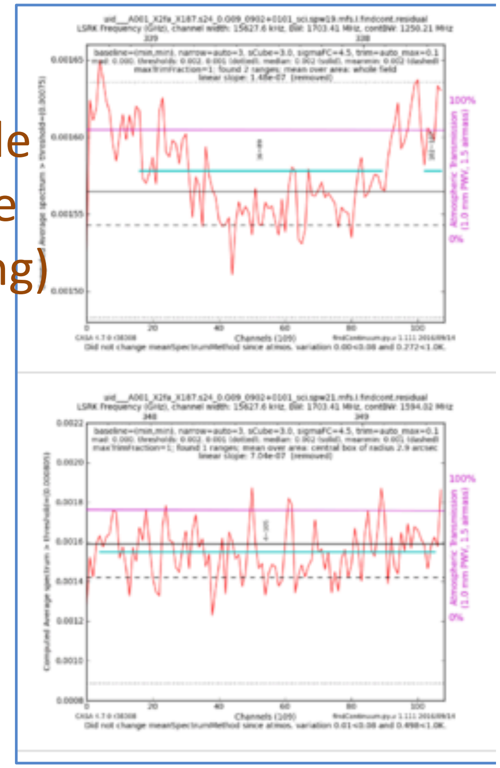
Home | By Topic | By Task 2015.1.00131

xecution order
- oortdata
- gdata
- xcalflag
- flagchans
- nt
- scal
- sflag
- tpos
- rgcalflag
- vgainflag
- inflag
- jy
- andpass
- owphaseup
- fluxscale
- negaincal
- plycal
- keimlist
- keimages
- oortdata
- transform
- agtargets
- keimlist
- dcont
- contfit
- contsub
- keimages
- keimlist
- keimages
- keimlist
- keimages
- oortdata

| | | | | | |
|---|---|---|---|---|---|
| | | | image file | uid___A001_X2fa_X187.s27_0.G09_0902+0101_sci.spw17.mfs.I.iter1.image | |
| G09_0902+0101 (TARGET) | 19 | I | center frequency of image | 338.3460GHz (LSRK) |  View other QA images... |
| | | | beam | 0.56 x 0.47 arcsec | |
| | | | beam p.a. | 86.1deg | |
| | | | final theoretical sensitivity | 0.00021 Jy/beam | |
| | | | cleaning threshold | 0.0012 Jy/beam<br>Dirty DR: 36<br>DR correction: 1.5 | |
| | | | non-pbcor image rms | 0.00024 Jy/beam | |
| | | | pbcor image max / min | 0.00918 / -0.00278 Jy/beam | |
| | | | fractional bandwidth / nterms | 0.43% / 1 | |
| | | | aggregate bandwidth | 1.25 GHz (LSRK) | |
| | | | score | 1.00 | |
| | | | image file | uid___A001_X2fa_X187.s27_0.G09_0902+0101_sci.spw19.mfs.I.iter1.image | |
| G09_0902+0101 (TARGET) | 21 | I | center frequency of image | 348.5503GHz (LSRK) |  View other QA images... |
| | | | beam | 0.54 x 0.46 arcsec | |
| | | | beam p.a. | 82.7deg | |
| | | | final theoretical sensitivity | 0.0002 Jy/beam | |
| | | | cleaning threshold | 0.0012 Jy/beam<br>Dirty DR: 40<br>DR correction: 1.5 | |
| | | | non-pbcor image rms | 0.00023 Jy/beam | |
| | | | pbcor image max / min | 0.0101 / -0.00220 Jy/beam | |
| | | | fractional bandwidth / nterms | 0.47% / 1 | |
| | | | aggregate bandwidth | 1.59 GHz (LSRK) | |
| | | | score | 1.00 | |

79% of available spw (after edge channel flagging)

Corresponding hif_findcont plots



# IF PL Workflow (SCIREQ-910, SCOPS-4091)

## Post-IF PL Imaging Interventions

- Anticipate most common modes:
  - Re-doing continuum subtraction after modifying cont.dat
  - Re-doing continuum imaging using interactive clean or with selfcal (add additional casa imaging script)
  - Re-making one source/cube/spw for subset of channels, with better cleaning different channel width (add additional casa imaging script)
- Its up to DRMs to decide if/when intervention needed
  - Probably only if MOUS would otherwise be QA2 Fail

# Cy4 IF Pipeline Pitfalls: resource intensive

- Pipeline does not use parallelized CASA – takes very long to run
- Temporary area (/working) has many cubes with associated .masks, .pb, .resid, etc. – can take up 10-100x disk space of final products
- Both have lead to problems with Cy4 PL operations at both JAO and ARC

# Imaging Intervention for Cy4 Patch

- PL reqt: must run in < 1day
- Not possible Until parallelized tclean (and even then?)
- PLWG estimates that ~70% of Cy4 long baseline observations would take > 1 week to run through IF imaging at default (all channels, all spw, all sources, full FOV)
- Defined subset-imaging “cascade” in SCIREQ-958 based on estimated max cube size (30GB) & total product size (400GB)
  - If Nchan=1920 or 3840, then make with bin=2,4
  - Still too big: If not mosaic, only image to 0.5 PB
  - Still too big: Use 3pix/beam instead of 5
  - Still too big: don’t image all sources
- Additional cascade for Cy5: consider imaging only reference spw before last test

# Cy4 IF Pipeline Pitfalls: extensive weblog

- Designed by experts, who want more and more diagnostics
- Priority on IF imaging PL meant neither PLWG nor developers had effort available to improve weblog/QA scores
- As a result, weblog can be unwieldy; not clear what level to dig down into, or whether outliers in all plots are consequential

# 2015.1.00137.S weblog: findcont (Nspw x Nsource = 52 x 4 = 208)

Home | By Topic | By Task | 2015.1.00137.S

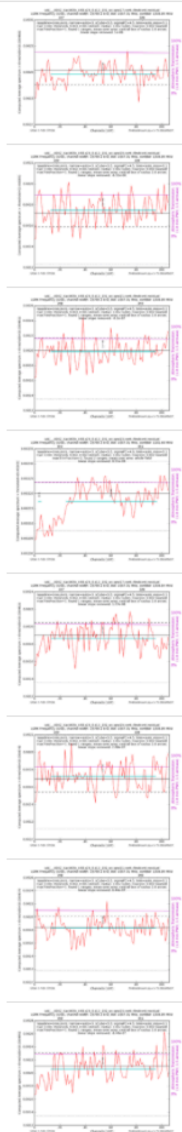
**Tasks in execution order**

1. hifa_importdata
2. hifa_flagdata
3. hifa_fluxcalflag
4. hif_rawflagchans
5. hif_refant
6. hifa_tsyscal
7. hifa_tsysflag
8. hifa_antpos
9. hifa_wvrgcalflag
10. hif_lowgainflag
11. hif_gainflag
12. hif_setjy
13. hifa_bandpass
14. hifa_spwphaseup
15. hifa_gfluxscale
16. hifa_timegaincal
17. hif_applycal
18. hif_makeimlist
19. hif_makeimages
20. hif_exportdata
21. hif_mstransform
22. hif_makeimlist
23. hif_findcont
24. hif_uvcontfit
25. hif_uvcontsub
26. hif_makeimages
27. hif_makeimlist
28. hif_makeimages
29. hif_makeimlist
30. hif_makeimages

## 23. Find Continuum

BACK

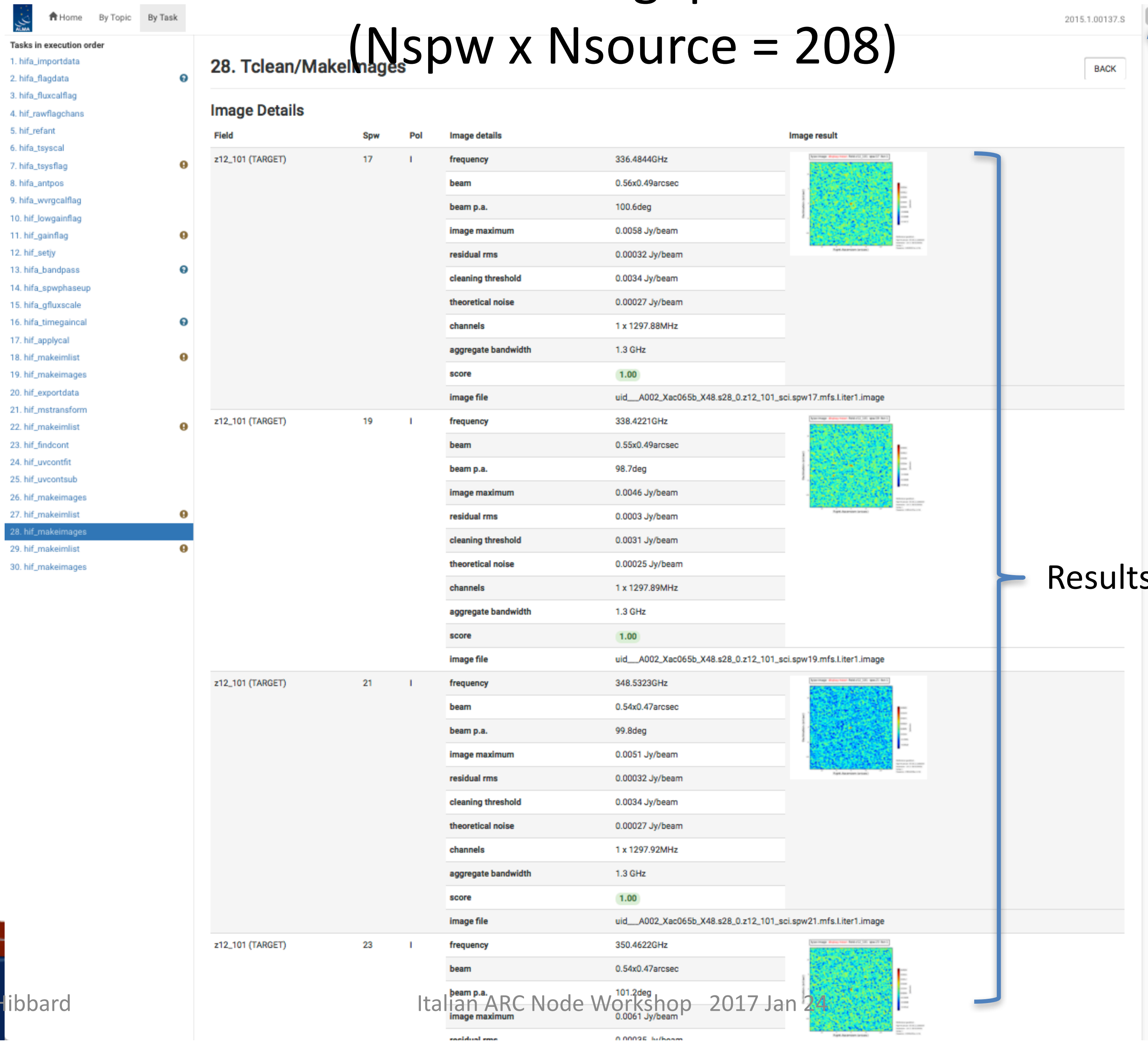
| Field | Spw | Continuum Frequency Range: Start | End | Frame | Status | Average spectrum |
|---|---|---|---|---|---|---|
| z12_101 | 17 | 335.83802 GHz | 337.13110 GHz | LSRK | NEW | |
| | 19 | 337.77569 GHz | 339.06876 GHz | | | |
| | 21 | 347.88623 GHz | 349.17931 GHz | | | |
| | 23 | 349.72871 GHz | 349.76025 GHz | | | |
| | | 350.07563 GHz | 351.19525 GHz | | | |
| z12_102 | 17 | 335.83769 GHz | 337.13076 GHz | | | |
| | 19 | 337.77535 GHz | 339.06843 GHz | | | |
| | 21 | 347.88589 GHz | 349.17896 GHz | | | |
| | 23 | 349.88606 GHz | 351.17914 GHz | | | |



Note size of scroll bar

Results for 1 source

# 2015.1.00137.S weblog: per mfs continuum (Nspw x Nsource = 208)



Home | By Topic | By Task — 2015.1.00137.S

Tasks in execution order

1. hifa_importdata
2. hifa_flagdata
3. hifa_fluxcalflag
4. hif_rawflagchans
5. hif_refant
6. hifa_tsyscal
7. hifa_tsysflag
8. hifa_antpos
9. hifa_wvrgcalflag
10. hif_lowgainflag
11. hif_gainflag
12. hif_setjy
13. hifa_bandpass
14. hifa_spwphaseup
15. hifa_gfluxscale
16. hifa_timegaincal
17. hif_applycal
18. hif_makeimlist
19. hif_makeimages
20. hif_exportdata
21. hif_mstransform
22. hif_makeimlist
23. hif_findcont
24. hif_uvcontfit
25. hif_uvcontsub
26. hif_makeimages
27. hif_makeimlist
28. hif_makeimages
29. hif_makeimlist
30. hif_makeimages

## 28. Tclean/MakeImages

BACK

### Image Details

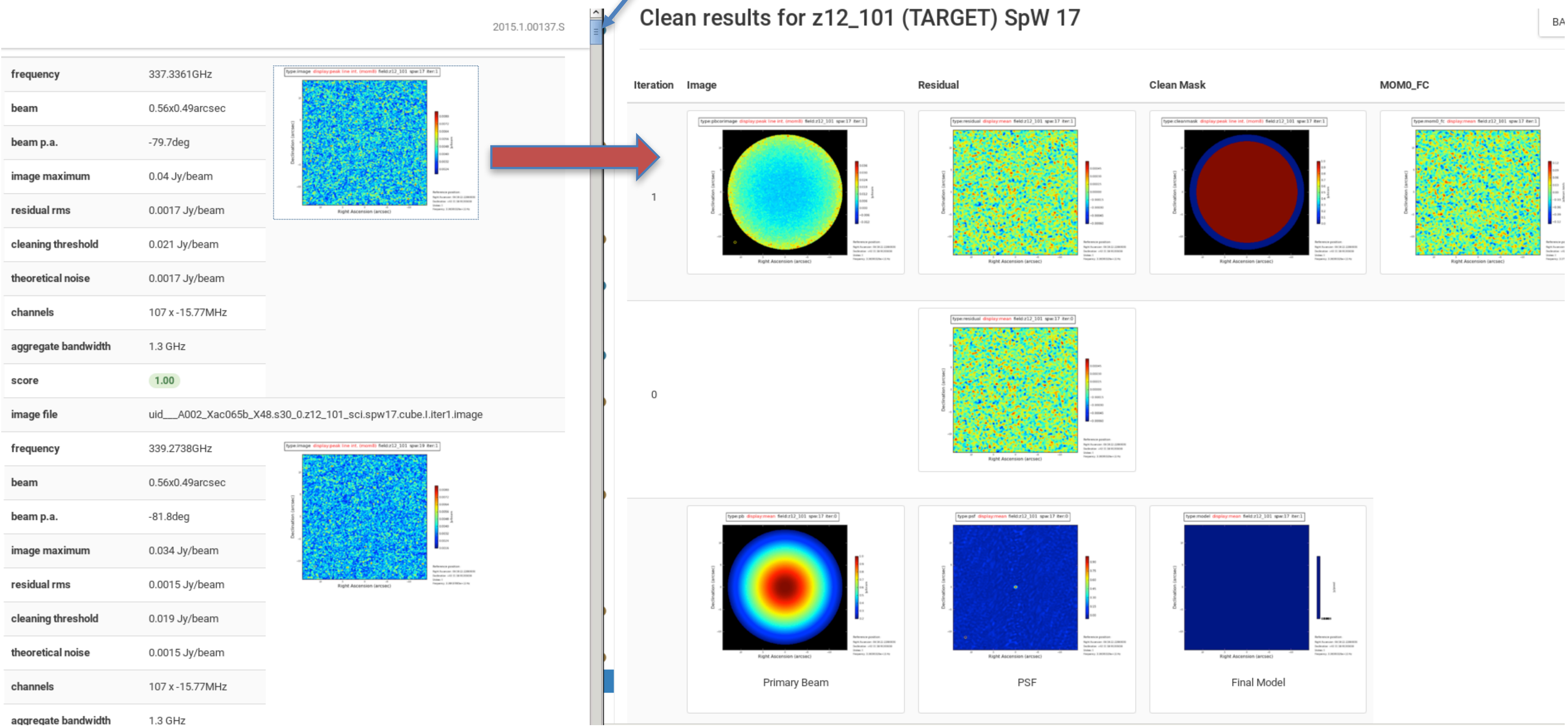
| Field | Spw | Pol | Image details | | Image result |
|---|---|---|---|---|---|
| z12_101 (TARGET) | 17 | I | frequency | 336.4844GHz | |
| | | | beam | 0.56x0.49arcsec | |
| | | | beam p.a. | 100.6deg | |
| | | | image maximum | 0.0058 Jy/beam | |
| | | | residual rms | 0.00032 Jy/beam | |
| | | | cleaning threshold | 0.0034 Jy/beam | |
| | | | theoretical noise | 0.00027 Jy/beam | |
| | | | channels | 1 x 1297.88MHz | |
| | | | aggregate bandwidth | 1.3 GHz | |
| | | | score | 1.00 | |
| | | | image file | uid___A002_Xac065b_X48.s28_0.z12_101_sci.spw17.mfs.I.iter1.image | |
| z12_101 (TARGET) | 19 | I | frequency | 338.4221GHz | |
| | | | beam | 0.55x0.49arcsec | |
| | | | beam p.a. | 98.7deg | |
| | | | image maximum | 0.0046 Jy/beam | |
| | | | residual rms | 0.0003 Jy/beam | |
| | | | cleaning threshold | 0.0031 Jy/beam | |
| | | | theoretical noise | 0.00025 Jy/beam | |
| | | | channels | 1 x 1297.89MHz | |
| | | | aggregate bandwidth | 1.3 GHz | |
| | | | score | 1.00 | |
| | | | image file | uid___A002_Xac065b_X48.s28_0.z12_101_sci.spw19.mfs.I.iter1.image | |
| z12_101 (TARGET) | 21 | I | frequency | 348.5323GHz | |
| | | | beam | 0.54x0.47arcsec | |
| | | | beam p.a. | 99.8deg | |
| | | | image maximum | 0.0051 Jy/beam | |
| | | | residual rms | 0.00032 Jy/beam | |
| | | | cleaning threshold | 0.0034 Jy/beam | |
| | | | theoretical noise | 0.00027 Jy/beam | |
| | | | channels | 1 x 1297.92MHz | |
| | | | aggregate bandwidth | 1.3 GHz | |
| | | | score | 1.00 | |
| | | | image file | uid___A002_Xac065b_X48.s28_0.z12_101_sci.spw21.mfs.I.iter1.image | |
| z12_101 (TARGET) | 23 | I | frequency | 350.4622GHz | |
| | | | beam | 0.54x0.47arcsec | |
| | | | beam p.a. | 101.2deg | |
| | | | image maximum | 0.0061 Jy/beam | |

Note size of scroll bar

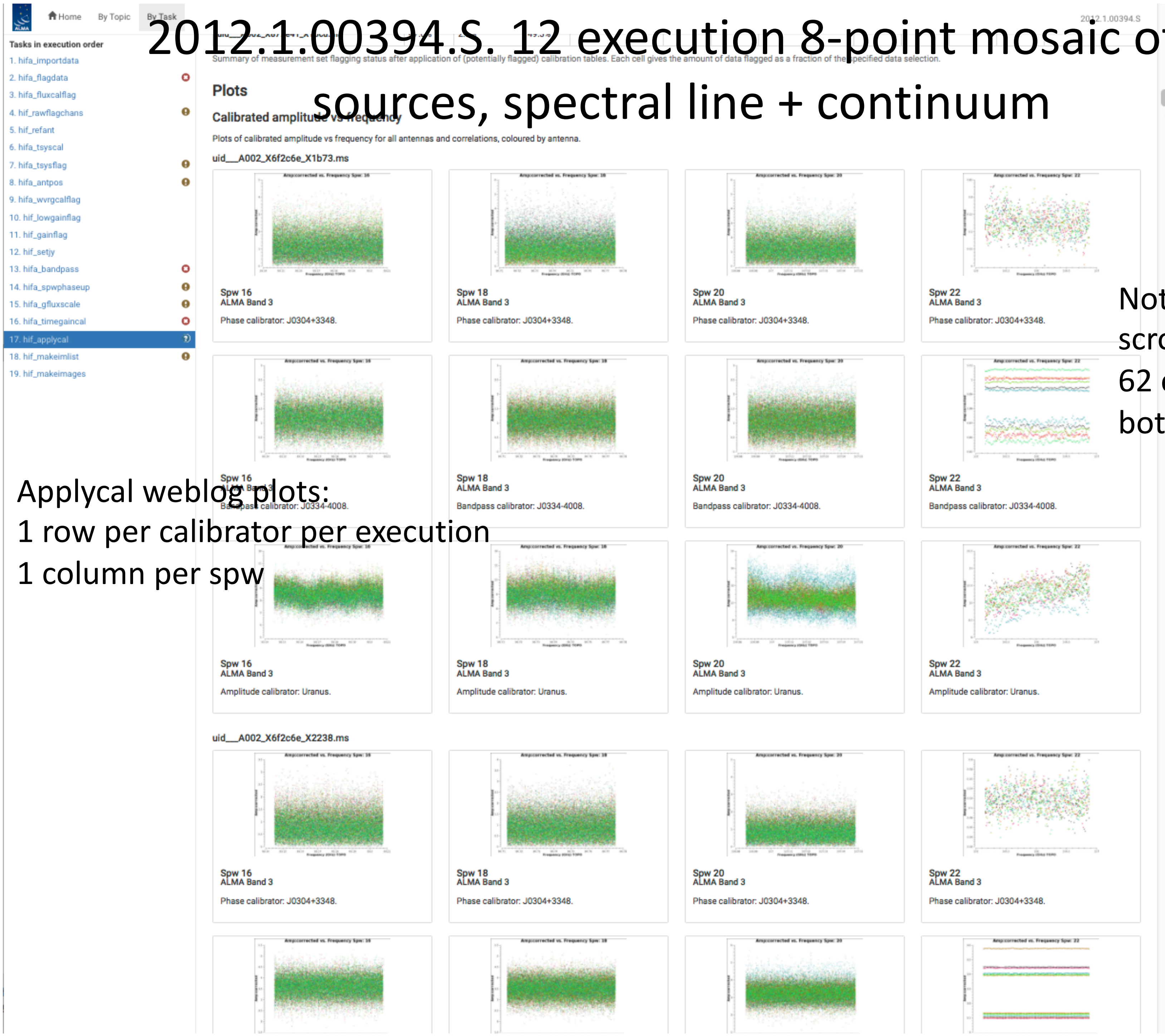
Results for 1 source

# 2015.1.00137.S weblog: details for each cube thumbnail (Nspw x Nsource x 8 detail plots = 1664 plots)

Note size of scroll bar



# 2012.1.00394.S. 12 execution 8-point mosaic of 6 sources, spectral line + continuum




Note size of scroll bar. Takes 62 clicks to get to bottom of page

Applycal weblog plots:
1 row per calibrator per execution
1 column per spw

# Part II: Material from July 2016 PL Review (updated)

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

# ALMA Pipeline Requirements: Outline

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

# 1. Current Resources

- Primary resource: PLWG (n=10)
  - NA: SsS (JHibbard) + CL (RIndebetouw) + Heuristics lead (Thunter)+ Imaging Team lead (CBrogan)
  - JAO: dSsS (EVillard) + Ops Lead/Deputy (LVidela/HFrancke)
  - EU: CL (LHumphreys)
  - EA: SD SsS (RMiura)+ CL (DEspada)
- Additional resources:
  - NA SW Support Team for imaging requirements + heuristics + testing
  - EU ARC nodes for some specific tasks (e.g. improved flagging heuristics; FITS keyword script)
- Tasks (SCIREQ-694):
  - Develop Heuristics from our own tests or inputs from others
  - Requirement definition & prioritization
  - Testing against requirements & oversee acceptance
  - Error sleuthing
  - Documentation
  - *These activities overlap*

# ALMA Pipeline Requirements: Outline

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

# 2. Input from Stakeholders

- 5 Year Plan (shared with SSG & ISOpT)
  - https://wikis.alma.cl/bin/view/DSO/5yearPlans#Pipeline
- For 1st & 2nd instance of Imaging PL: Comprehensive requirements document
  - Cy3 Im. PL Reqts produced by DMG/ISOpT (Feb 2015)
  - Cy4 Im. PL Reqts produced by NA Imaging Team & PLWG (Mar & May 2016)
  - Both circulated & added to SCIREQ for comment & modified based on inputs from others (notably, Archive)
- Obsmode (f2f meeting + document + telecons)
  - new capabilities
  - moving modes from “non-standard” (≠ Pipelineable) to standard (= Pipelineable)
- SCIREQ tickets for other subsystems interacting with PL
  - E.g. OT (#585), AQUA, Cal Survey, Archive (#110, #652), Scheduler (#586)
- CAS tickets for PL expert users (PLWG, SACMs)
- SCOPS-1338 for errors encountered during PL operations

# ALMA Pipeline Requirements: Outline

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

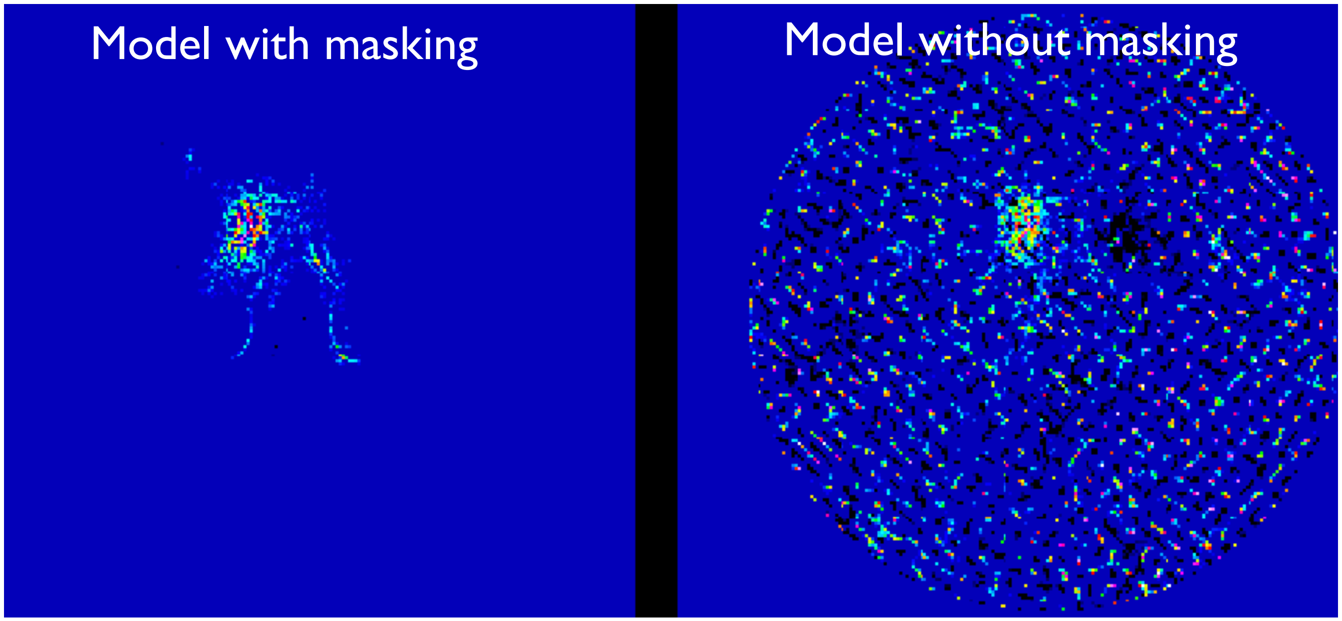
# 3. Prioritization

- Sources:
  - Cycle 5: SCIREQ-993
  - 5yr plan: https://wikis.alma.cl/bin/view/DSO/5yearPlans#Pipeline
- Cy5 Prioritization based on AMT directives (after July 2016 PL Review):
  - *“reducing the human time required to pass the processing from step to step is the first priority”*
  - *“expansion of pipeline to cover a broader scope of capabilities will be considered as second priority”*
  - *“assuming a basic level of imaging products, developing higher order products is a third priority”*
- In following, I break priorities into the following categories:
  - Improved imaging (reduces workload; better products to PIs)
  - New PL modes (increases PI science)
  - Improve calibration weblog review (reduces workload, time to PI)
  - Pipeline performance & interfaces (improves operations)
- *I list current priorities; PLWG will re-evaluate after Obsmode6*

# 3a: Improved imaging

- *Goal: reduce manual workload; provide better products to PIs*
  - Improve workflow
    - Cube of rep. source/spw at "bandwidth for sensitivity" (Cy5 high)
  - Decrease amount that need manual imaging intervention
    - "Would take too long" imaging intervention (Cy4 patch)
    - Smart-boxing/thresholding (Cy5 high)
    - Weighting/UV taper based on PI resolution (Cy5 high)
    - Science target flagging heuristics (Cy6 high)
    - Self-calibration (Cy8 low)
  - Shorten time to publication for PIs
    - Group OUS processing (Cy6,7 low); Multiscale clean

# Automasking (Cy5 PL target): CASA Testing from AKepley




- Important for accurate reconstruction of sources. Essential for self-cal!
- Key ingredients:
  - Threshold-based masking
  - Pruning regions of spurious emission
  - Adding margin to mask
  - Growing to low s/n using binary dilation

# 3b: New PL modes

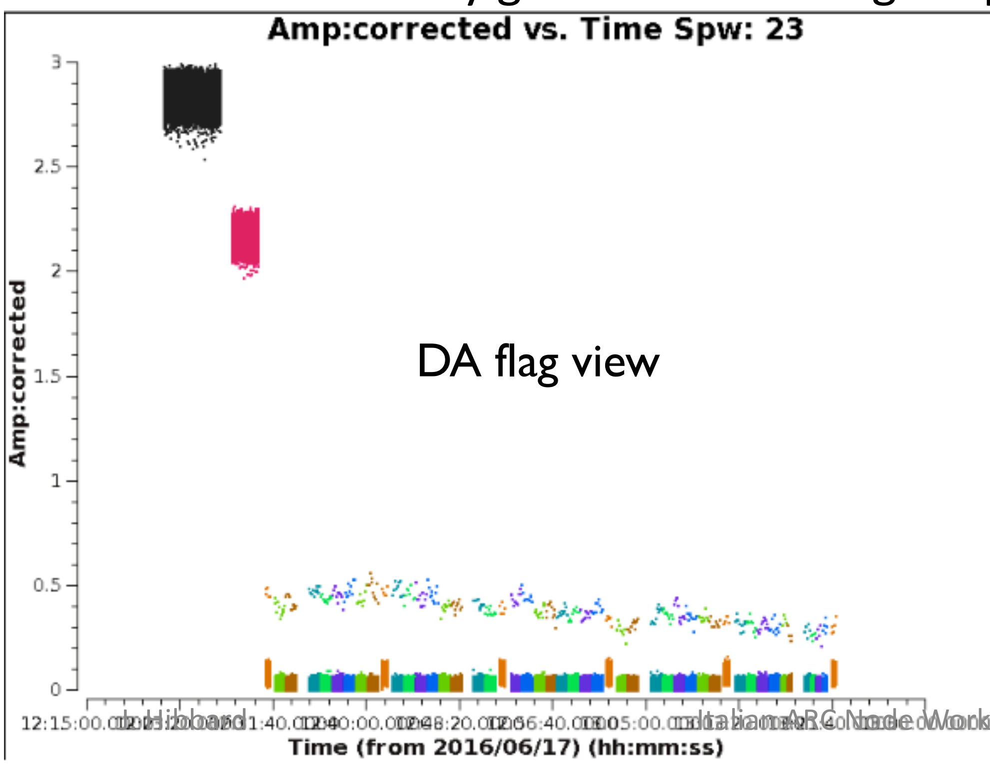
- *Goal: increase PI science (since get removed from non-standard queue)*
- Requires procedures to be rigorously & reliably demonstrated first (script generator or similar) *– rarely followed!*
- 5yr plan (will be re-evaluated after Obsmode6)
  - Sessions (Cy5 medium – PL infrastructure only)
  - Cy5 PL “no-ops”: Band 5; 90deg Walsh; multiple intents; B7 long baseline
  - Polarization (Cy6)
  - High-frequency and/or low SNR heuristics
    - Smarter SPW mapping: Cy6 low
    - DGC (BWSW, B2B): Cy6 low
  - Reduce online WVR corrected data (Cy6 low)
  - Reduce joint 12m+7m observations (Cy6 low)
  - ALMA part of VLBI (Cy8 low)

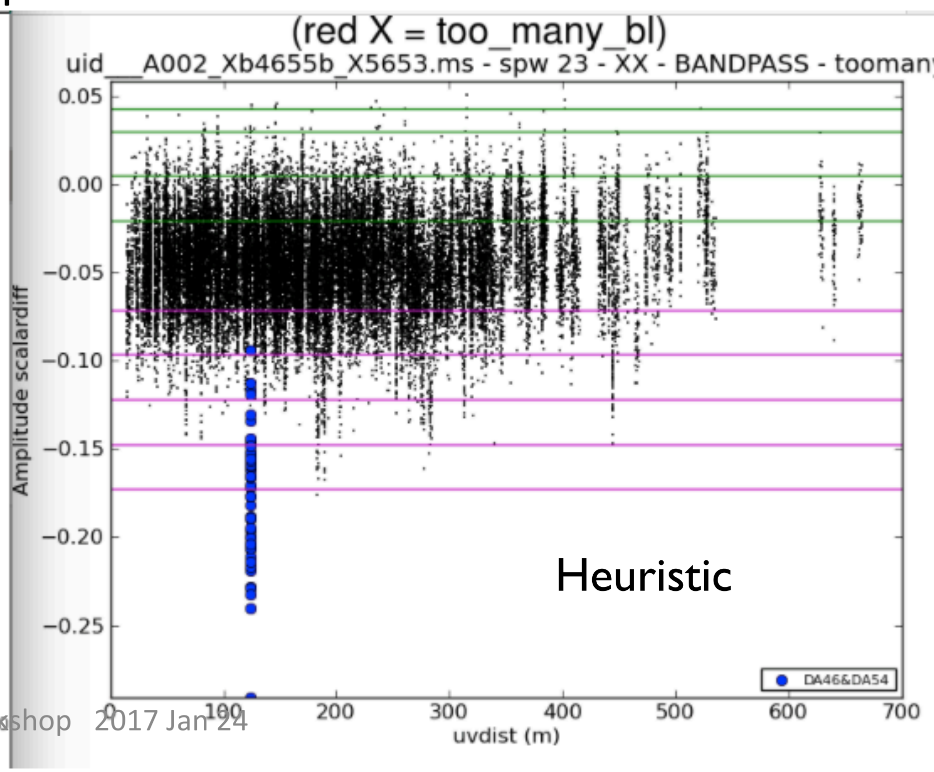
# 3c: Improve calibration weblog review

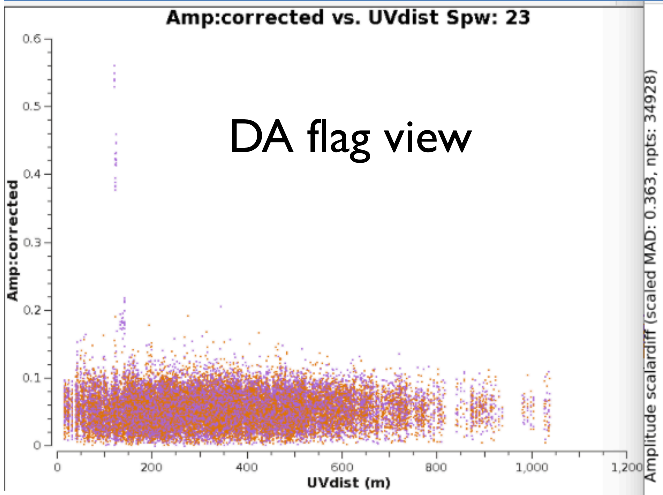
- *Goal: reduce workload, time to PI*
  - Quicker identification of outlier points
    - More per-antenna plots in applycal details page (Cy4 patch)
  - Reduce need manual calibration intervention
    - Improved flagging heuristic – Amp vs. uvdist (Cy5 high)
  - Pre-imaging Checks
    - Pre-imaging estimate of reference source/spw resolution/sensitivity (Cy5 high)
  - Improve presentation of information
    - Refine QA scores & high-level QA score (Cycle 6)
    - Develop weblog “By Topic” page (Cycle 6 low)
    - *Needs agreement of scope between AQUA & PL*

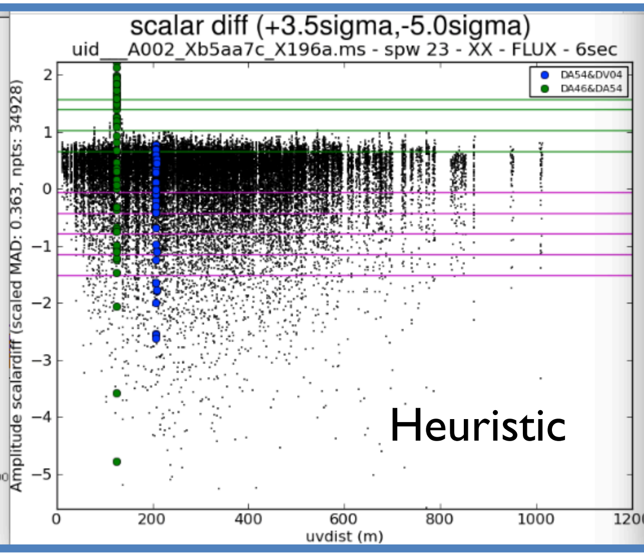
# New Cy5 Flagging Heuristic

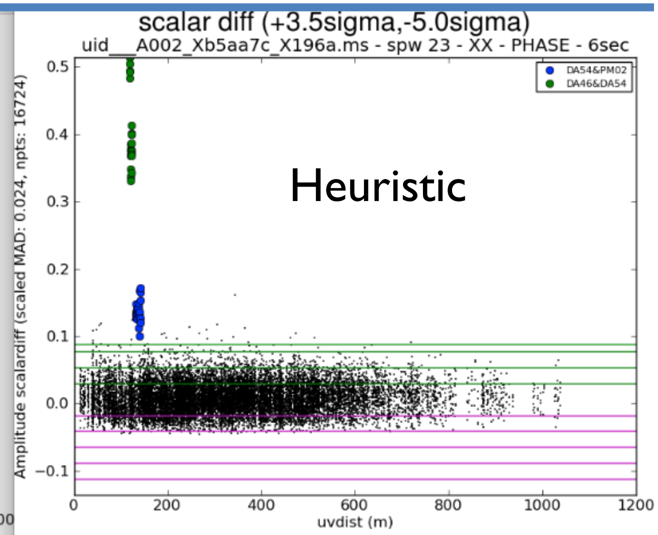
- https://safe.nrao.edu/wiki/bin/view/Main/VisibilityOutliers (THunter)
- Based on amplitude outliers in Scalar difference in Amp and model amplitude vs. UVdist plane
  - Amplitude outliers identified by Italian ARC node as "tallest pole" for manual flags – SCIREQ-720
- Available in Cy4 as stand-alone script (in directory with analysis utils) – automatically generates uid*flagtemplate.txt

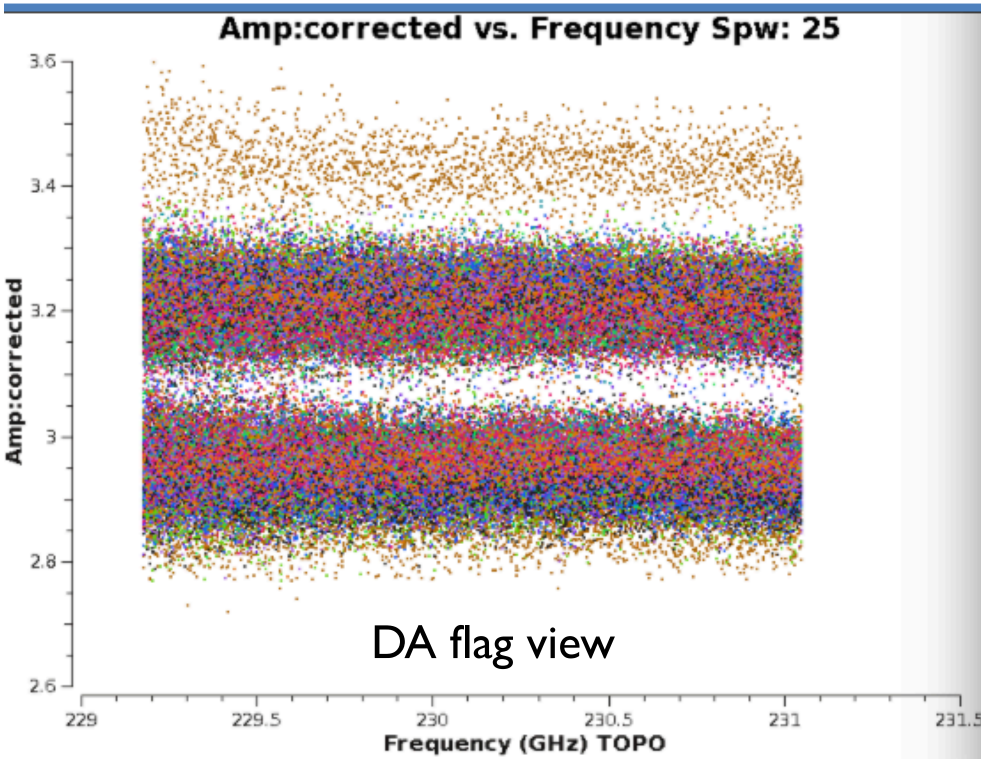


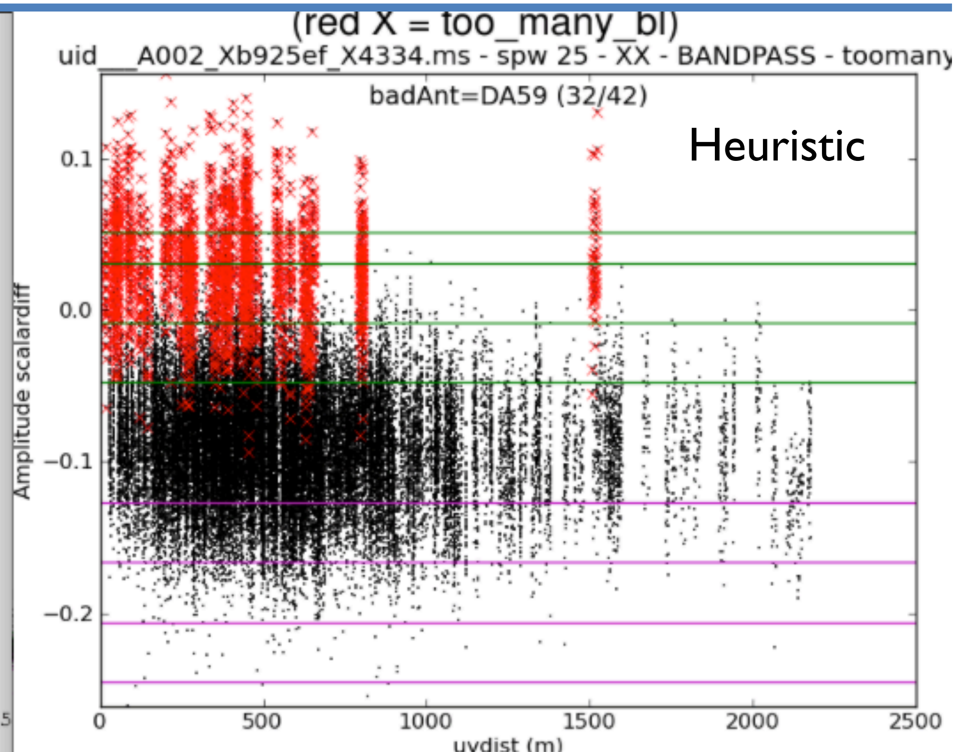




Amp:corrected vs. UVdist Spw: 23
DA flag view
Amp:corrected
UVdist (m)


scalar diff (+3.5sigma,-5.0sigma)
uid___A002_Xb5aa7c_X196a.ms - spw 23 - XX - FLUX - 6sec
Amplitude scalardiff (scaled MAD: 0.363, npts: 34928)
Heuristic
uvdist (m)


scalar diff (+3.5sigma,-5.0sigma)
uid___A002_Xb5aa7c_X196a.ms - spw 23 - XX - PHASE - 6sec
Amplitude scalardiff (scaled MAD: 0.024, npts: 16724)
Heuristic
uvdist (m)


Amp:corrected vs. Frequency Spw: 25
Amp:corrected
DA flag view
Frequency (GHz) TOPO


(red X = too_many_bl)
uid___A002_Xb925ef_X4334.ms - spw 25 - XX - BANDPASS - toomany
badAnt=DA59 (32/42)
Heuristic
Amplitude scalardiff
uvdist (m)

# 3d: Improve PL performance & interfaces

- *Goal: better operations*
  - PL parallelization (Cy5 high)
  - FITS Keywords needed by AQUA (Cy5 high)
  - Product naming standards (Cy5 medium)
  - Query ALMA telescope & SC databases at runtime (Cy 5 medium)
  - Query ALMA Jy/K database at runtime (Cy6)
  - Automatic triggering / interaction with state system (Cy 6,7 medium)

# ALMA Pipeline Requirements: Outline

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

# 4. PL Development Timescale

- PL has 1 year sw development cycle
  - May: ObsmodeN+1 & PLWG F2F with developers
  - Mar, July-Aug: testing of impending PL release
  - Oct-Nov: PLWG defines new requirements for next cycle
- New requirements given in Oct need to be based on proven techniques!!
  - Means lead-time for e.g. new algorithms, QA scores is actually > 1 yr!

# 4. Development Timescale (cont'd)

| Month of year | Cycle N | Cycle N+1 |
|---|---|---|
| Dec - Feb | | |
| Mar - Apr | CyN R1 testing; punchlist | |
| May | | Obsmode f2f; PLWG f2f: Cy N+1 "wish list" |
| June | | |
| July | CyN R2 testing | Obsmode doc review & telecons |
| Aug | CyN E2e testing | Obsmode doc review & telecons |
| Sept | Acceptance; Finalize CyN user documentation; PL public release | |
| Oct - Nov | | Cy N+1 New Reqt & heuristics definition |

Implications:

- We have to set Cycle N+1 PL requirements & priorities before we even understand behavior of Cycle N PL!
- We have to develop new heuristics for Cy N+1 when we've only had 1-2mo in-use experience with Cy N PL! (or put off to next cycle)

# ALMA Pipeline Requirements: Outline

1. Current Resources
2. Input from Stakeholders
3. Prioritization
4. Development Timescale
5. Bottlenecks

# 5. Bottle Necks

- New reduction procedures & metrics should be fully developed outside of PL; usually not general enough for PL implementations. PLWG & developers left to figure out pathologies or corner cases
- Testing overlaps with research required for meaningful requirements
- Informative metrics/plots competes against other requirements
- So far not so much effort on streamlining effort (e.g. more efficient weblog review)
  - Scientist tend to like MORE scores/plots, not less!
- Missed opportunity: manual calibration informed PL calibration QA/weblog, but no similar feedback captured for imaging
  - Science target flagging? Flux equalization? Selfcal criteria?

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# IF PL Workflow (SCIREQ-910, SCOPS-4091)

## Making & Executing the PPR

- To be automated in CalibPipeIF.py. Likely syntax:
  - CalibPipeIF.py --env=<C4R2.sh> --flags=<flagdir> --image --break
  - "image" parameter uses procedure_hfa.xml to make PPR with all imaging steps
  - "break" parameter adds breakpoint to PPR between calibration and imaging steps
- Basic process:
  - setenv C4R2.sh
  - pipelineMakeRequest <MOUSid> intents.xml procedure_hifa.xml true
  - eppr.execute(<PPR.xml>, bpaction=break, importonly=True)
  - Do fixes for flux.csv, antennapos.csv
  - eppr.execute(<PPR.xml>, bpaction=break, importonly=False)