

Status of Pipeline Flagging Heuristics

*Todd Hunter, Crystal Brogan, John Hibbard,
Remy Indebetouw (NAASC)*

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Introduction: Types of ALMA data flags

- Online flags (generated during data acquisition)
 - “BDF”: correlator-generated flags
 - “XML”: control system generated flags (e.g. antenna off source, ACD incorrect position, etc.)
 - “QA0”: flags generated by examining TelCal results just before ASDM is finalized (they get appended to Flag.xml)
- Offline flags (generated during data reduction)
 - Due to the original design of the pipeline, most flags are generated by examining caltables, and then applying them to caltables (these are almost all antenna-based).

Types of flags applied by pipeline (C4R2.1) -I

- BDF flags (hif_importdata: importasdm) [CAS-8491](#)
- Deterministic flags (hif_flagdata)
 - Unwanted intent (pointing, focus, ATMcal)
 - QA0 (data capture):
 - Only pointing-related flags take effect, Trx/Tsys flags have no effect because the SYSCAL table is not regenerated, also the pipeline Tsys flagging is already significantly better
 - All the other online XML (hardware-generated) flags
 - Autocorrelations
 - Flagtemplate (manually-identified flags)
 - Shadow
 - Edge channels of TDM spws

Types of flags applied by pipeline (C4R2.1) -II

- Heuristics-based flags (none on science target!!):
 - Frequency dependent issues on BP cal (hifa_rawflagchan):
e.g. bad quadrant, bad baselines, birdies (32% of OUS)
 - Tsys flags (hifa_tsysflag): Six heuristics: median, derivative, edge, shape, birdies, and “too many”
 - Spectral lines in SSOs (hifa_fluxcalflag)
 - Venus, Mars, Titan, Neptune ([CAS-4975](#))
 - Antenna-based low/high bpcal gains, $\pm 30\%$ (hif_lowgainflag)
 - 28% of all OUS
 - Antenna-based deviant bpcal gains (hif_gainflag):
 - 65% of all OUS
 - **73% have one of hif_gainflag or hif_lowgainflag**

NOTE: hif_lowgainflag and hif_gainflag statistics were derived for C3/C4 NA projects that have required manual flagging (details in following slide). Global statistics should be assessed, but probably not much different.

Analysis of all C3/C4 NA pipeline executions that used C4 pipeline (2016Oct01–2017Feb27)

- Motivation: the (now) correct BDF flagging resolves some of the earlier issues seen frequently in C3 testing
- Of all OUS processed (~250), 79 required flagging (129 EBs).
- We have a spreadsheet listing these 79 OUS, the required manual flag commands, and the weblog plots that led the DAs to find the problem. Issues later evaluated and categorized by me.
- Of the ones that contain amplitude outliers (majority), I have run the new heuristics to help tune the parameters.
- I have compiled most of the results onto a wiki page: <https://safe.nrao.edu/wiki/bin/view/Main/VisibilityOutliers>

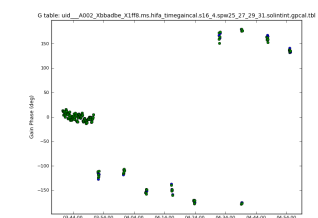
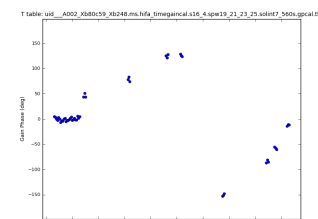
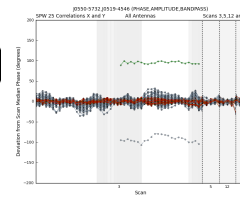
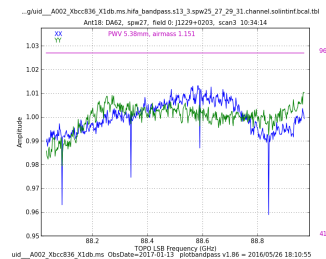
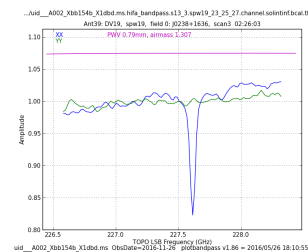
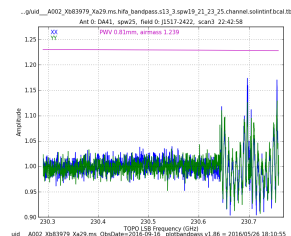
Major categories that led to manual flagging

Percentages of the 79 OUS requiring manual flags

- 56% Amplitude outliers (antenna, baseline, or time-based)
- 9% Refant selection failure (fix underway for C5: [CAS-8439](#))

=> At least 37% have only the 2 issues above

- 30% Various frequency dependent issues:
 - 9% Bandpass unstable or slope after calibration, Tsys shape changes
 - 4% Digitizer ringing beyond edge channels
 - 4% One or two bad FDM subbands
 - 4% Bandpass birdies (one antenna, one pol)
 - 3% Tsys birdies (not caught by pipeline heuristics)
 - 3% “Vampire teeth” (lack of synchronization, [BCMIN-117](#))
- 14% Phase drift after calibration (e.g. antpos error)
- 10% Phase offset after WVR (needs investigation)
- 6% Phase issues not visible in amplitude
- <10% Unnecessary flags (based on misleading weblog plots, see line 12 of [wiki](#); decorrelation, noisy edges of baseband...)



New flagging heuristic: C5R1

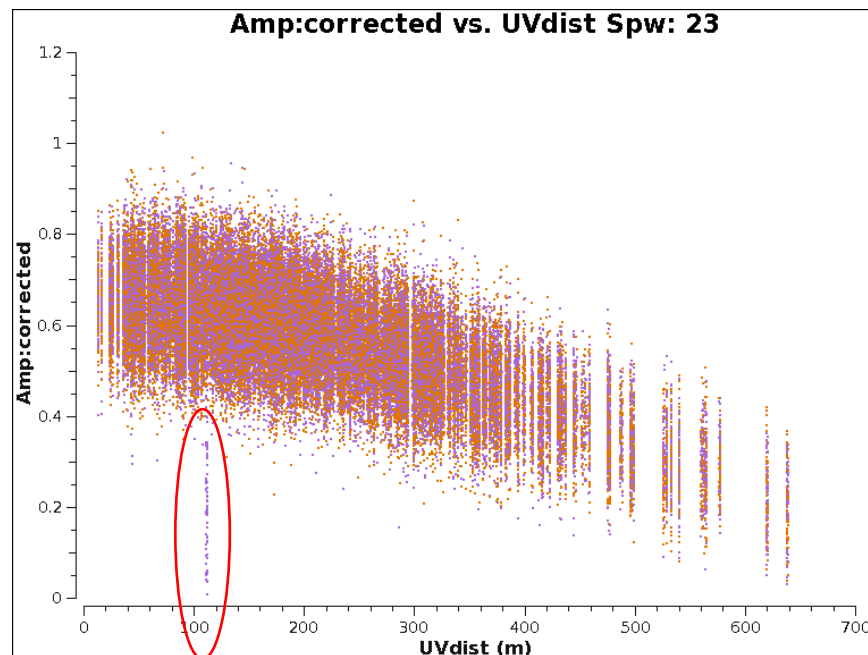
- For each calibration intent, do initial calibration, apply caltable, find amplitude outliers with respect to the model, flag outlier data, and generate final caltable for that intent. Flags are propagated to science target if seen on both the FLUX and PHASE calibrators.
- This will provide a more sensitive version of hif_gainflag, and will only flag bad data that cannot be recovered through calibration.
- First implementation in aU: visibilityOutliers.makeFlagTemplate('MOUS')
 - Compute scalar difference of chan. avg of full-res spws: (corrected – model)
 - This is not what you get if you use plotms(ydatacolumn='corrected-model')
 - Look for outliers from the median ($> N \times \text{MAD}$) $N=+3$ & -3.7 ; $+5.8$ & -8
 - If enough data are outliers, flag that baseline
 - If enough baselines are outliers, flag that antenna
 - If remaining outliers come from a few timestamps, flag those timestamps
 - Double the thresholds if large outliers are present: decorrelation
 - Full algorithm described in [CAS-9437](#)
 - Implementation into C5 pipeline is now being done by Vincent ([CAS-9438](#)): hif_bandpassflag (and hopefully hifa_gfluxscaleflag later this year)

Example 1: Bad Baseline

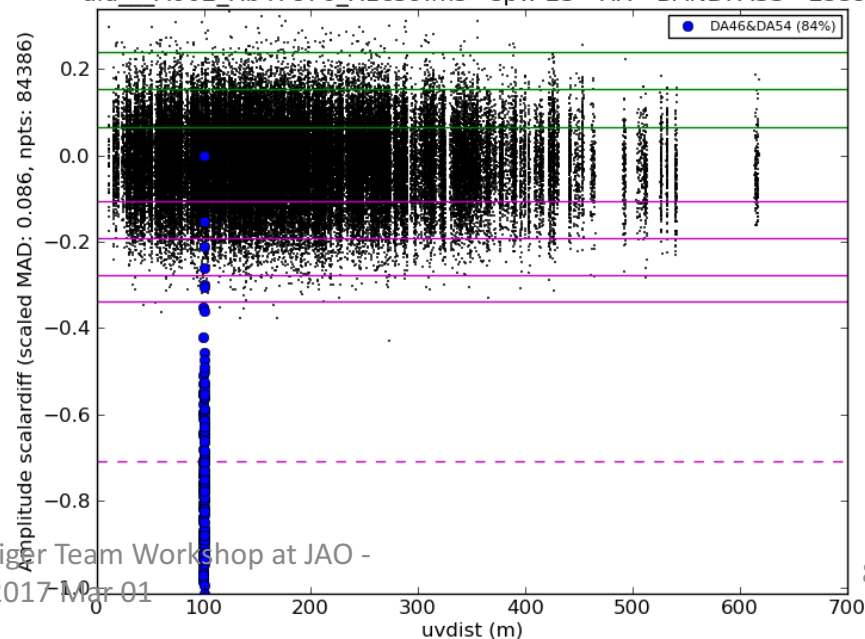
hif_applycal view
(note: SS object)

Heuristic “view”

84% of integrations
exceed threshold of -3.7
sigma. (Only 18% is
required to trigger.)

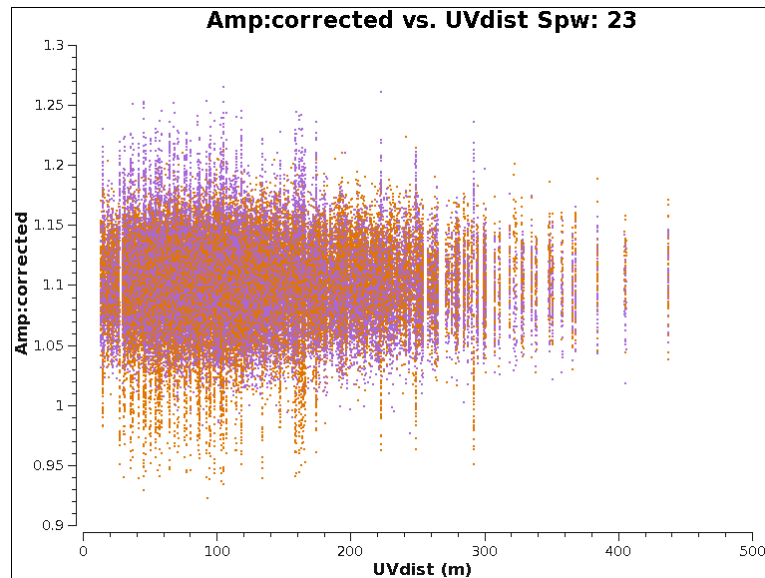


scalar diff (+3.0sigma,-3.7sigma) model=1.159Jy
uid_A002_Xb47876_X1c39.ms - spw 23 - XX - BANDPASS - 2sec

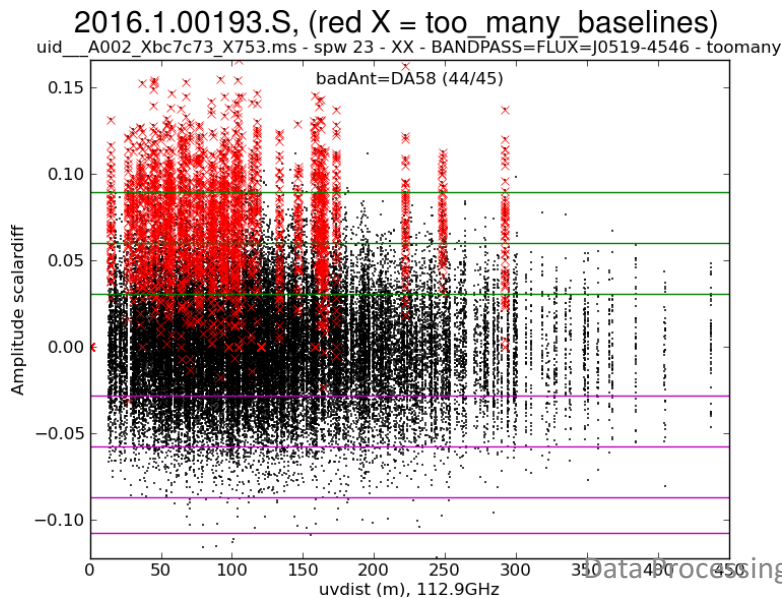


Example 2: Bad Antenna

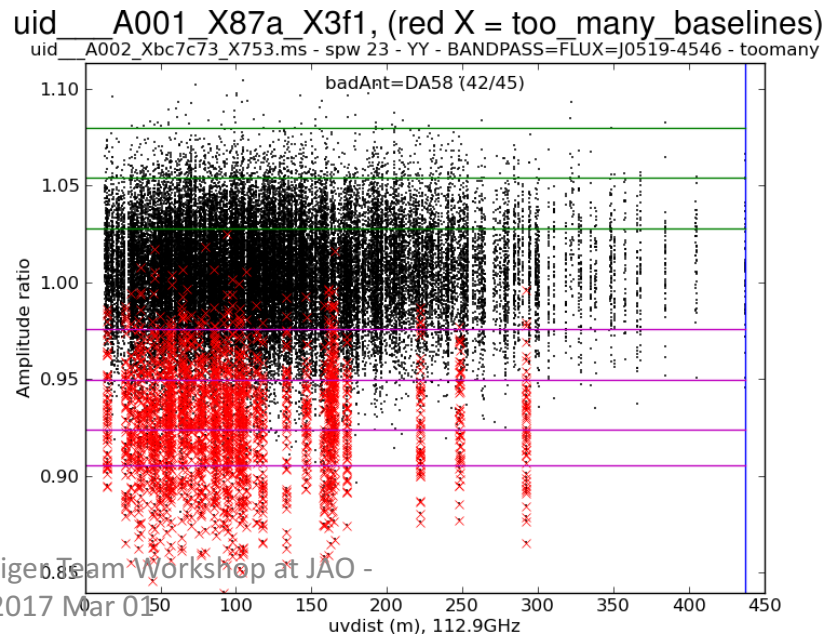
hif_applycal view:



Positive outlier (Xpol)



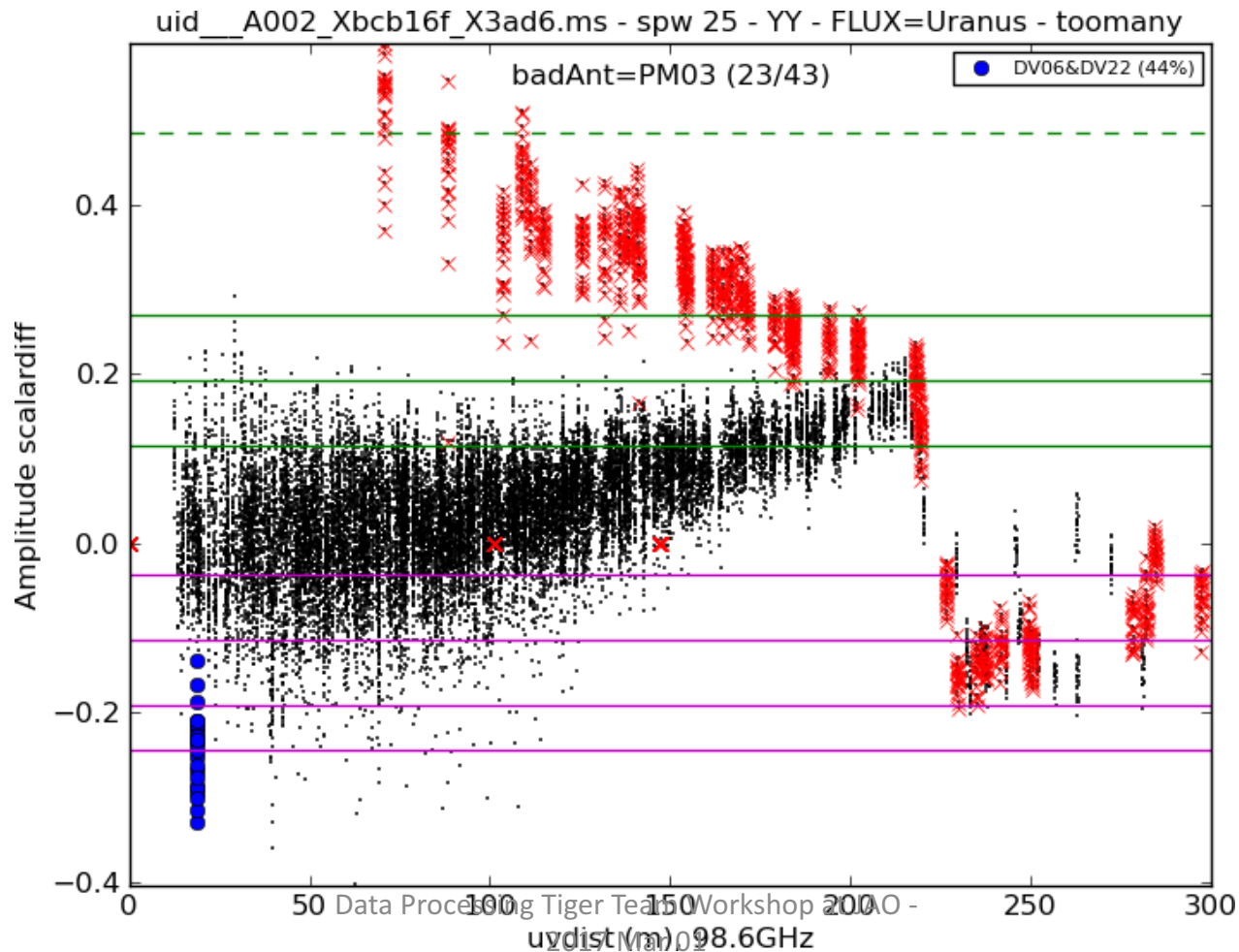
Negative outlier (Ypol)



Example 3:

Bad Antenna on a more resolved SSO

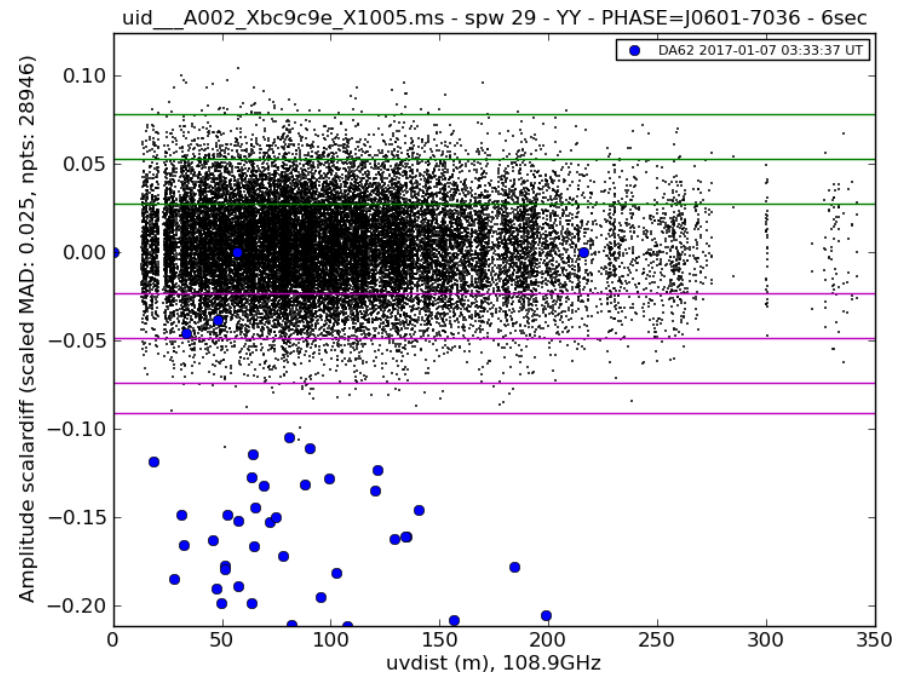
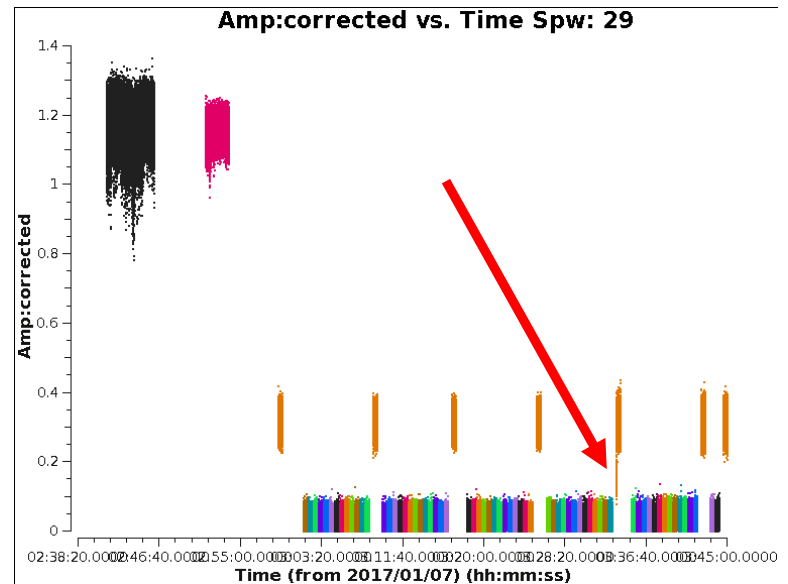
(Uranus in Band 3 out to 300m, through null)



Example 4:
Bad Timestamp on
one or more antennas
("quack")

hif_applycal view:

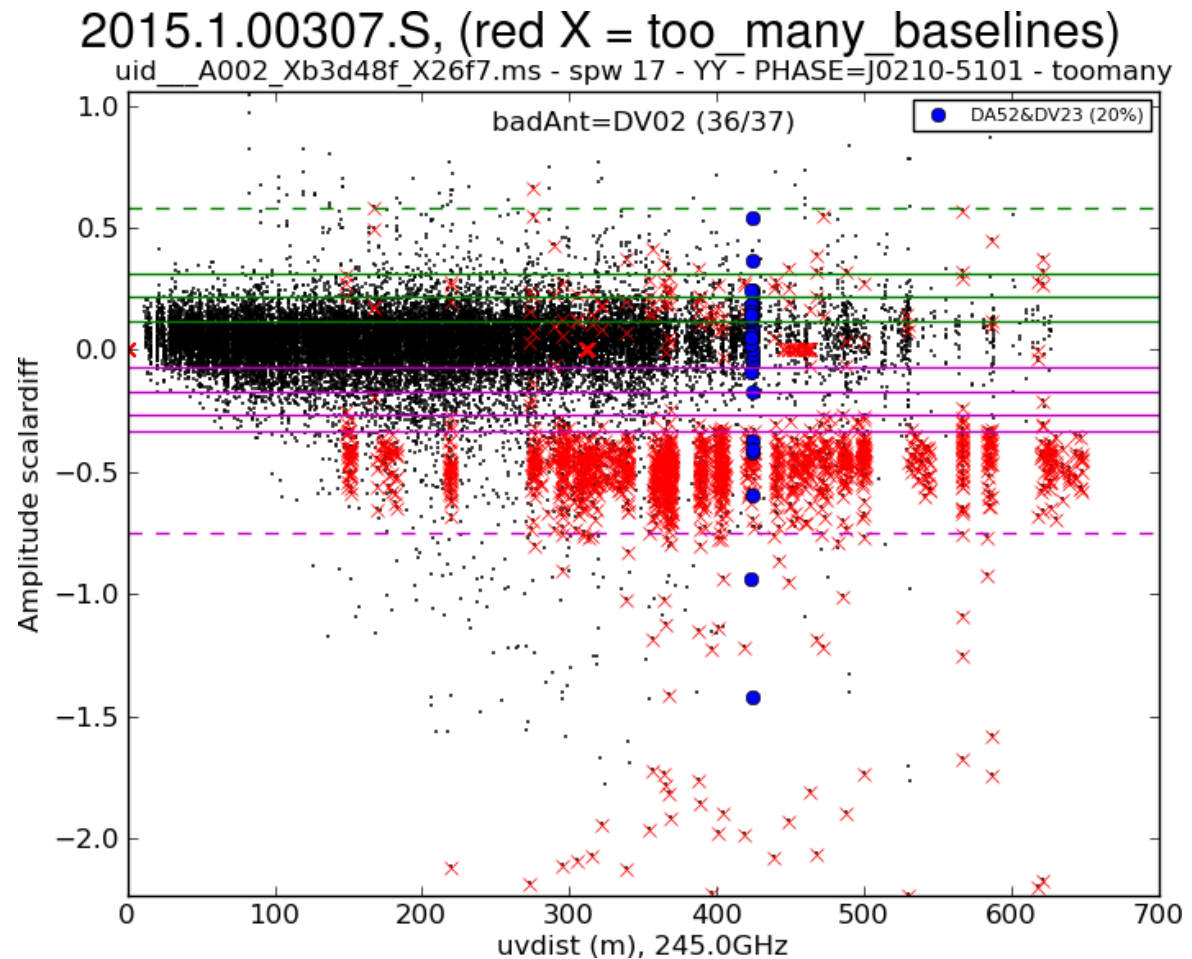
Heuristic "view":



Example 5:

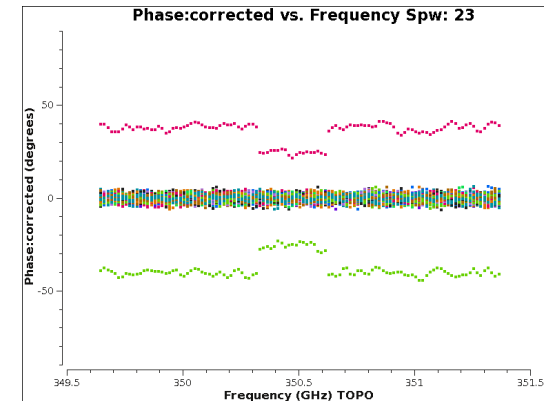
Avoids flagging
general decorrelation
but still catches low
antennas (red points)

But in order to be this
sensitive, it will catch
the occasional baseline
that do not need
flagging (blue points)

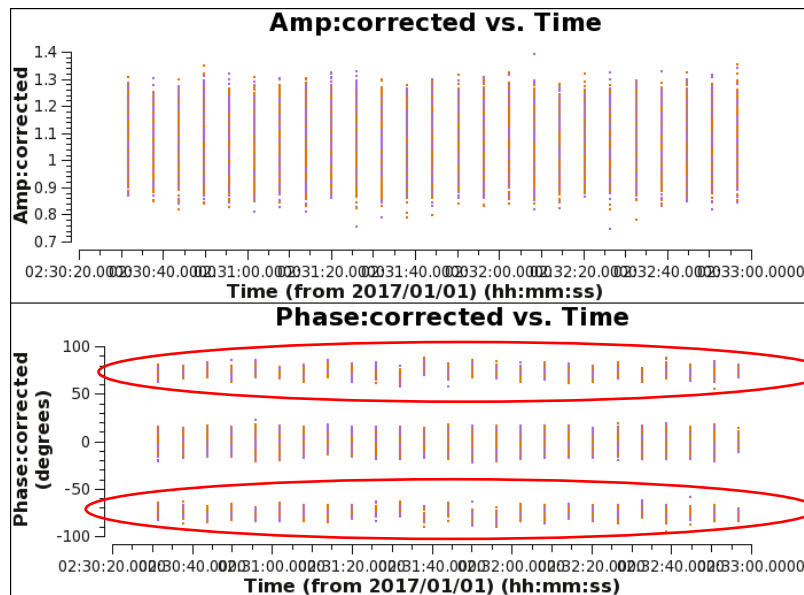


Some issues affect phase but not amplitude!

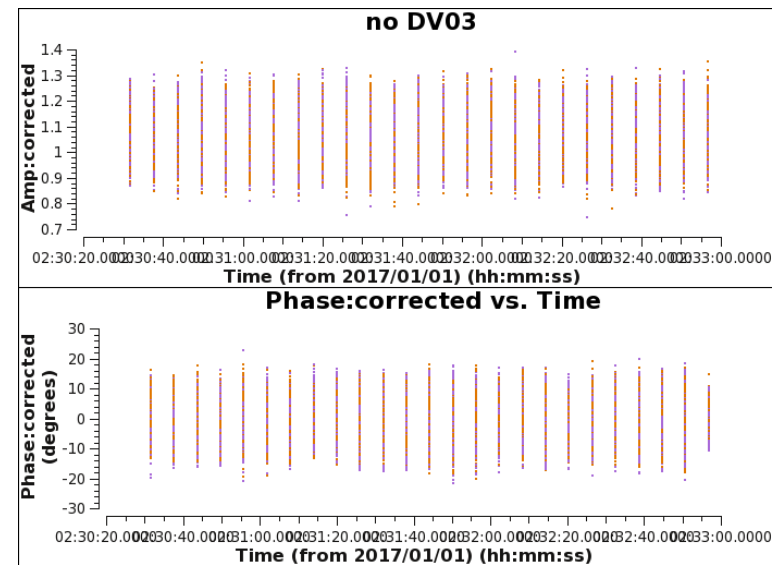
- These things will not be caught by this new heuristic
- Example below: Antenna DV03 calibrates fine on the 3 TDM spws but shows an offset on the FDM spw



All data



Excluding DV03



Status of hif_findcont

- There is a ticket for reporting failures or non-optimal results in NA from findContinuum: [CAS-9269](#). It has only 5 cases since October (~1 per month), with only 1 still open. There must be more cases, given the 7% that Mark quoted yesterday, but I have not seen them.
- findContinuum issues are also reported on [SCOPS-1338](#) pipeline triage ticket, but there are only 2 cases relevant to the heuristics: with 1 still open (comb pattern in the noise)
- One clear improvement could be gained if the task could be passed an indicator that it is a “single-continuum” project in the OT. If this item will be available to pipeline in C5 (?), then I will write a ticket for findContinuum to behave differently.

Conclusions

- Assuming the pipeline developers can implement the corrected amplitude heuristic (and PLWG can do enough testing prior to release), the Cycle 5 pipeline should be far more resilient to amplitude outliers than C4R2.1.
- Largest additional gains would come from QA0 flags which can catch:
 - frequency-dependent issues, e.g. FDM subband issues & vampire teeth (BCMIN-117)
 - phase drift with time (incl. antenna position error)
 - issues that manifest in phase statistics but not in amplitude.
- Improvements to findContinuum may be possible (at expense of other pipeline heuristics), but the current algorithm needs to be documented first.