NEW SPW PHASE DIAGNOSTIC PLOTS IN THE ALMA PIPELINE WEBLOG

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V1 - 8aug2017
V2 - 23oct2017 – clarify diagnostic criteria
V3 – *8nov17 –clarify diagnostic reporting actions; add description of QA scores.*

This is a short description of the new SPW phase stability diagnostic plots in the ALMA pipeline weblog. The purpose of these plots is to identify instances where the *instrumental phases between spectral windows are not stable, as some of our observing and calibration techniques assume they are*. At present (Cycle 4 & 5) and given current procedures, such instrumental instabilities would mainly affect a) low-SNR data (i.e. data where the phase calibrator is below an SNR of 25); b) band to band or bandwidth switching observations. The specifications for the plots are originally given on CAS-10072. *Note also that the new phase offset plots are only diagnostically significant if some form of SPW-mapping or SPW-combine has been performed.* In practice this means, they matter if the QA score for stage 13 (hifa_spwphaseup) is anything **except** GREEN (1.0).

It will also be useful to briefly state the updated SNR heuristics, which are:

- If SNR on the phase-cal is > 25 for each and every SPW, do a standard (per SPW) phase solution. This results in a GREEN (good/1.0) QA score for stage 13 (hifa_spwphaseup).
- If SNR on the phase-cal is < 25 for ALL SPWs, use combine=SPW. This results in a YELLOW (warning/0.66) QA score for stage 13 (hifa_spwphaseup).
- If there is a mix of high (>25) and low SNR SPWs, use a SPWMAP such that the low SNR SPWs use the solution from the highest SNR SPW, instead of their own solutions. If the SPW-map crosses sideband boundaries, the QA score for stage 13 will be YELLOW; otherwise it will be BLUE (notice).

Qualitatively the idea behind the plot is to do a per-SPW phase INF (ie scan-length) solution *with the actually applied phase solutions pre-applied*. In cases where combine=SPW or a SPW-map is used, this will allow the SPW-to-SPW phase stability with time to be diagnosed: the calibration method is assuming that any instrumental phases do not change with time. (see PRTSPR-24865 for some examples of the particular pathology that motivated these plots)

The new plots appear in the hifa_timegaincal() stage (#15). See the screen shot below, with the link to the new plots at the top of the weblog page in question circled in red:

16. Gain Calibration

This task creates gain solutions for each measurement set.

- Plots
  - Phase vs time
  - Phase structure
  - Amplitude vs time
- Diagnostic plots
  - Phase vs time
  - Phase offsets vs time
  - Amplitude vs time

There are three general cases that will occur:

1) High-SNR data – neither combine=SPW nor SPW-mapping was required.
2) Moderate SNR data that required SPW-mapping for some SPWs.
3) Low SNR data that required combine='SPW' be used with all SPWs.

The weblog will clearly indicate in bold text which is the case.

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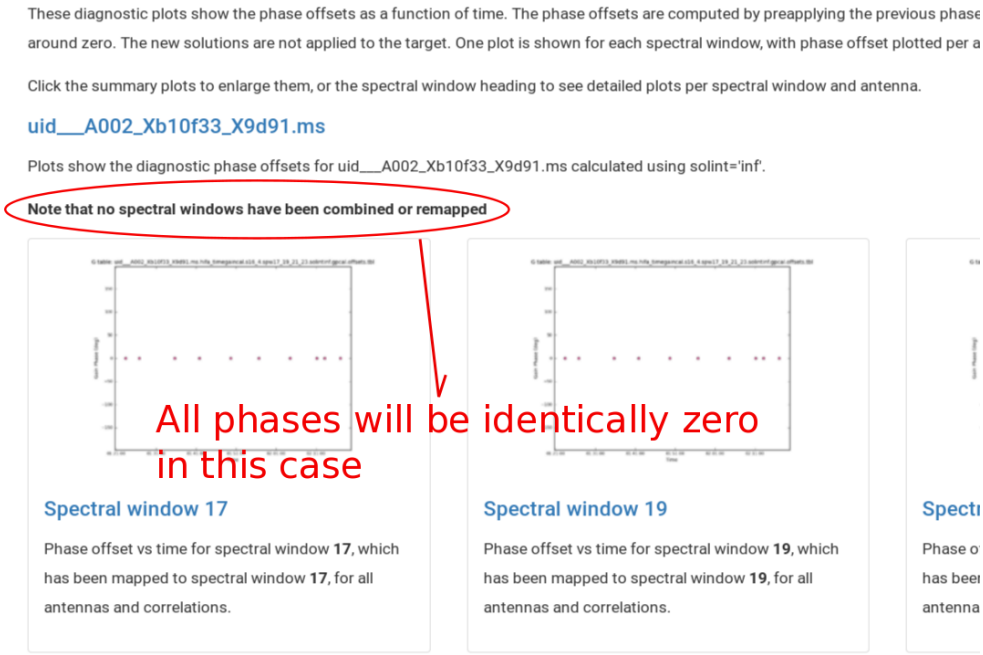
In case 1 (high SNR), the plots are of little use and can be skipped: they should all be identically zero (and I can't think of how they wouldn't be). This will be indicated by the following text in the weblog: "**Note that no spectral windows have been combined or remapped.**" See screen shot below:



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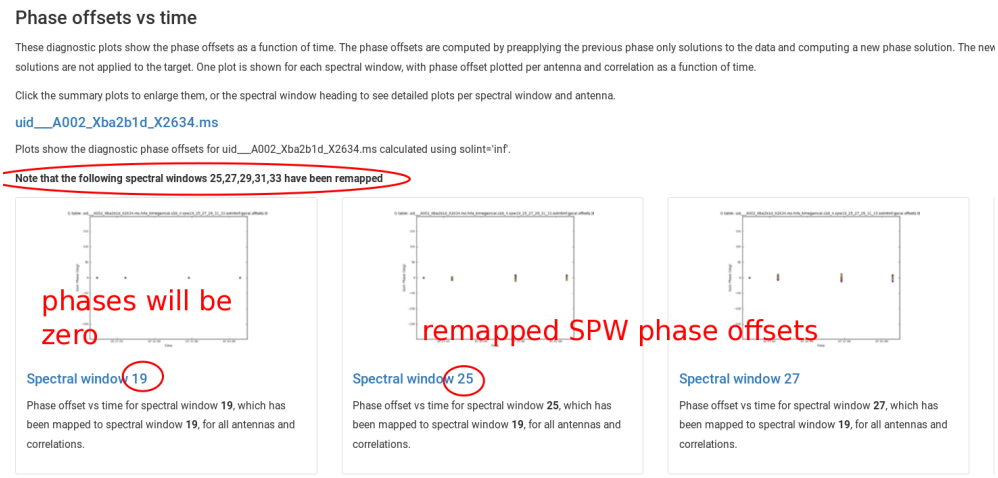
In case 2 (at least one high SNR SPW, some low SNR windows which get mapped to use the highest SNR SPW phase solution) the weblog will say "**Note that the following spectral windows X,Y,Z have been remapped**". Here X, Y and Z will be the SPW numbers of the low-SNR SPWs which are using the phase solutions from the highest SNR window. The high SNR (not remapped) windows will have phases that are zero. You want to look at the remapped SPW phase plots for problems (see comments at end of document for what "problems" look like).

See screen shot below – in this case SPW 19 is the only not-remapped SPW (you know this b/c it isn't called out in the list of X,Y,Z values), so its phases are zero. The others are meaningful diagnostics.



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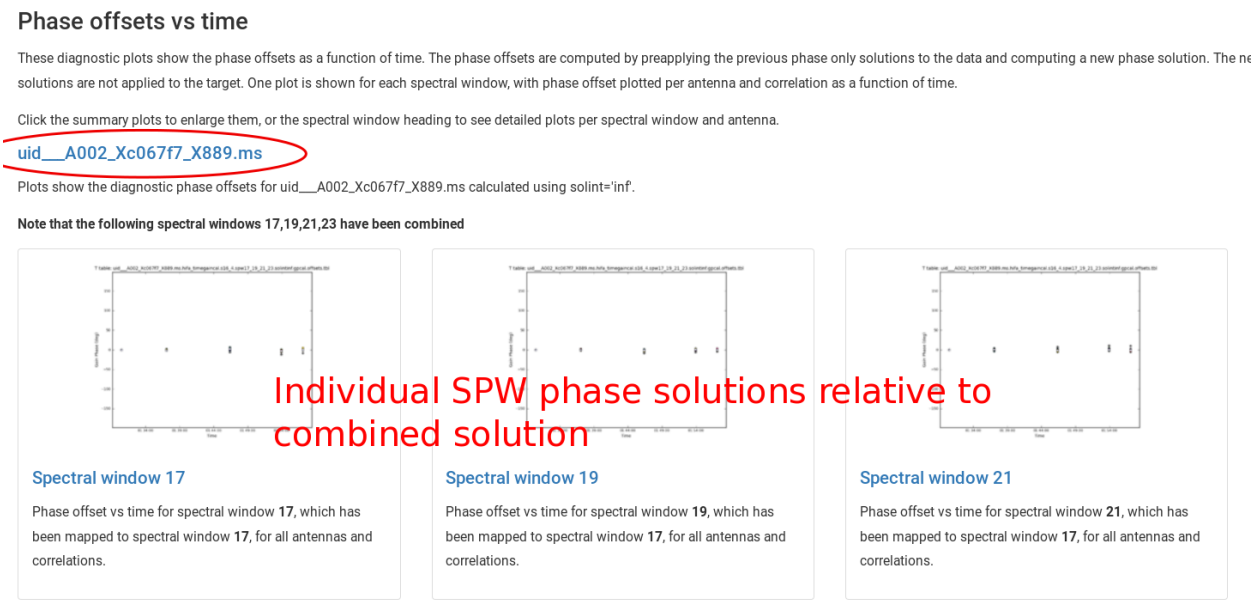
Case 3 is the case where combine='SPW' was invoked. In this case all the diagnostic plots are useful to look at. It will be identified by the text "**Note that the following spectral windows X,Y,Z have been combined**" – this will for cycle 5 always be the full list of science SPWs. See screen shot below:



What to look for in the phase plots

For diagnostically significant plots (not identically zero), the phases will still scatter around zero with some noise. The noise in a phase solution in radians is 1/SNR, so even for quite low SNR the noise shouldn't be too extreme – for example, SNR=10 gives a phase noise of about 6 degrees RMS.

You are looking for systematic trends in the residual phases at a significant level – say > +/- 50 degrees away from zero. In data we've looked at in detail this has usually been due to antenna-based SPW phase instabilities (sometimes more than one SPW). You can click on the plots as usual to look at individual antenna phase (residual) solutions.

Actions to take if an antenna shows phase residuals greater than the threshold (systematically +/- 50 degrees):

1. Report the offending SPW & Antenna appropriately within the project so that potential hardware defects can be identified, tracked, and fixed. Also report MOUS, project, SB name, EB UID, any comment(s) describing the issue; and if feasible give a pointer to a weblog & a screenshot representative of the problem.
2. If SPW-combine was invoked, flag the offending SPW/Antenna combination.
3. If SPW-mapping was invoked, flag the offending SPW/Antenna *if the offending SPW is one of the mapped SPWs.*

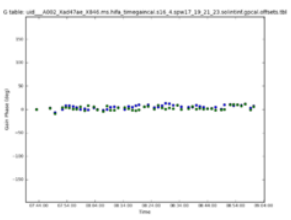
Bad antenna positions can also cause non-zero phases in these plots, particularly if the SPWs that are combined or referenced are at significantly different frequencies. Again this information should be passed on as appropriate.

The report attached to PRTSPR-24865 has many examples of bad data. *See also the plots on the next page.*

Phase offset vs time for u

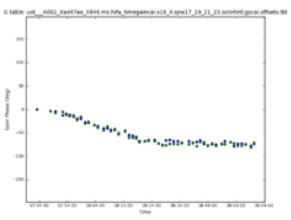
Antenna filter

Show all antennas



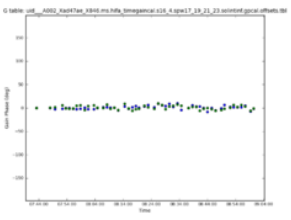
DA42 GOOD

Spw 23



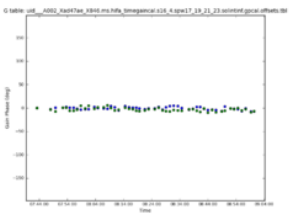
DA44 BAD!

Spw 23



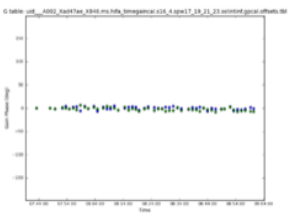
DA51 GOOD

Spw 23



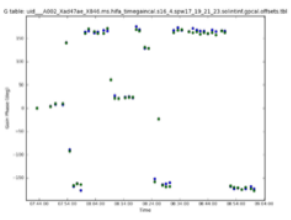
DA52 GOOD

Spw 23



DA63 GOOD

Spw 23



DV03 BAD!!!

Spw 23

Expanded “Phase Offset vs Time” plot showing examples of GOOD and BAD phase stability for individual antennas. (pipeline test dataset 2015.1.00005.S, MOUS A002/Xad2d3f/X17)