Atacama
Large
Millimeter /
submillimeter
Array

Performance of H Maser During the EOC Week – 29 July to 03 August

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Prepared by:	Organization:	Date:
Anthony Remijan (EOC Program Scientist for Extension and Optimization of Capabilities)	ALMA	03 August 2014

Atacama Large Millimeter/
Submillimeter Array
Alonso de Córdova 3107
Vitacura - Santiago Chile

MEMORANDUM

To: DSO/ADE Teams

From: Anthony Remijan, ALMA Program Scientist (EOC), APP Team

Date: 11/16/2014

Subject: Performance of H Maser during the EOC week – 29 July – 03 Aug

Background:

The installation of the H maser provides a new 5 MHz standard for ALMA and enables another large step toward VLBI capabilities with ALMA. Prior to the activities reported in this memo, the H Maser installation and testing plan has progressed well, with the following accomplishments (all performed in coordination with the APP, ADE, DSO and EOC teams):

1. The seismic rack to house the maser in the ALMA LO room at the AOS was installed on May 10, 2014, including all connection for power.
2. On May 11, 2014, the H maser was installed in the maser rack, powered on and testing began. Testing quickly revealed a faulty micro-controller board, and a new one was shipped from the manufacturer. The thermal systems on the maser were left powered on so that the maser could reach thermal equilibrium in the LO room.
3. From June 4-8, 2014, the faulty board was replaced and the maser was brought fully on line for testing. During this period, the maser was observed to meet all specifications. Figures 1 and 2 show the short term stability and phase noise of the maser observed at this time and the long-term drift with respect to GPS measured over a month. As shown in Figure 1, some adjustments were required to remove the linear drift in the maser 1pps signal, and some optimization for VLBI may yet be required.
4. Since the June 4-8 campaign, the maser has been monitored daily by the APP team at MIT Haystack and at the NRAO NTC in Charlottesville. The points/tests that have been constantly monitored include: internal and external temperatures, power draw, hydrogen usage, and phase-lock parameters of the 5/10 MHz maser outputs. Over the course of the past 6 weeks, there have been no deviations of any of these monitor points/tests from the nominal values.

Given the monitoring and apparent stability of the maser over this time, the decision was made to integrate the maser into the ALMA system during the EOC week starting 29 July. The decision to integrate at this time was to provide a long period of monitoring the stability of the maser before the start of the long baseline campaign starting in September 2014. In addition, the integration of the maser should not affect any Early Science observations over the course of this time so additional tests were performed to ensure the maser performance on ES scheduling blocks.

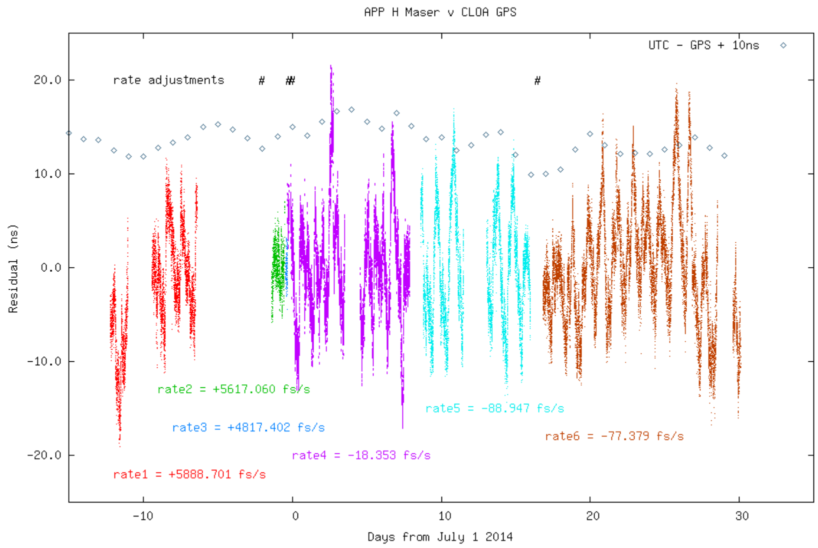


Figure 1: Long term comparison of Maser-derived 1pps and GPS 1pps. Colored values show the offset in time between Maser and GPS 1pps ticks after the drift rates shown have been removed. Diurnal variations are due to ionospheric changes that affect GPS signal propagation. Times marked by '#' characters indicate when the maser synthesizer was adjusted to remove the measured drift rate. At the current drift rate, the maser will deviate from GPS by less than 7 ns per day.

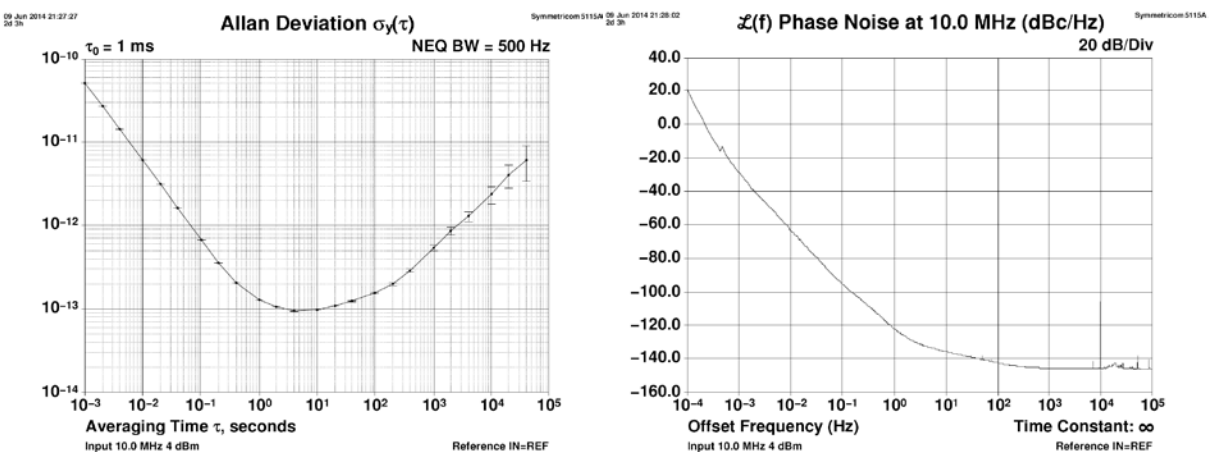


Figure 2: Short term stability and phase noise of the Maser compared to an Oscilloquartz 8607 crystal. (left) Allan Deviation plot showing adev ~ 1.3e-13 at 1 second integration time. (right) Phase noise plot showing -122 dBc/Hz at 1 Hz from the 10MHz Maser signal. Both values are within VLBI specifications. Data taken 9 July 2014.

Test Plan and Results:

On Tuesday, 29 July 2014, the APP team with support from EOC, ADE and ADC integrated the new H maser into the ALMA system. A detailed hourly test plan was reviewed and enacted by members of the APP/EOC/ADE and ADC teams[1]. As part of the maser integration test procedure, three distinct tests were done before and after the integration to test the initial performance of the maser. They are listed below:

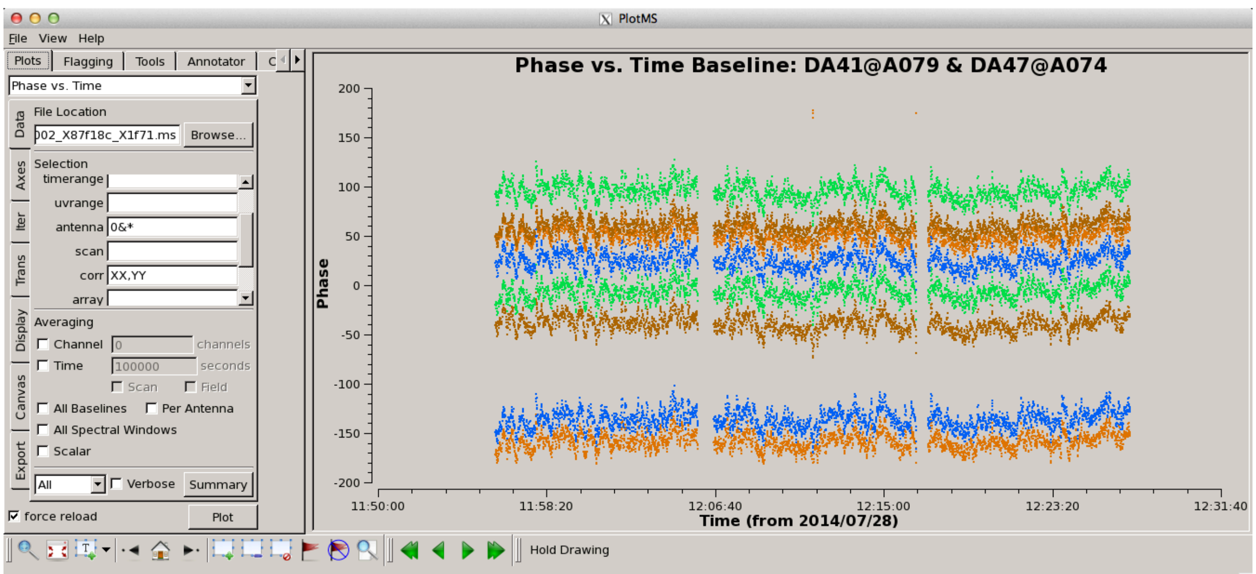
[1] Hourly integration plan can be found at: https://wikis.alma.cl/twiki/pub/AIV/EOCMemos/EOC_Memo10_Jul25_FINAL.pdf

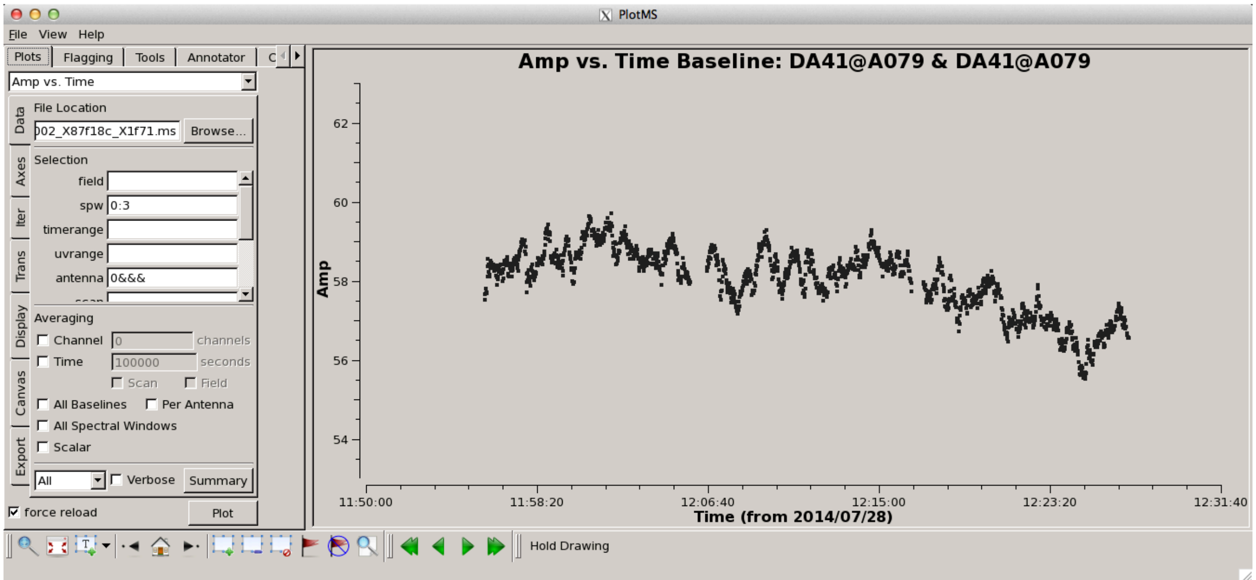
1. DelayCal.py was run in TDM mode on 3c279 (or comparable quasar with adequate flux density) over the course of ~30-45 mins to look at the overall phase stability vs. time.
2. DelayCal.py was run in a high resolution FDM mode on the v=1, J=2-1 transition of SiO towards VyCanis Majoris to determine if there is any evidence of line broadening.
3. A similar, high spectral resolution observation of an ES program was run to test the "end to end" performance of the maser. A thorough QA0/2 was performed on the dataset to ensure the data quality.

Full instructions to run both the DelayCals and the ES observation are available on the EOC weekly top priority page available at: https://wikis.alma.cl/bin/view/AIV/29July-05Aug%2c2014. Furthermore, the uids of each test are recorded in the work log of the following JIRA: http://jira.alma.cl/browse/CSV-3107. Below we summarize the results.

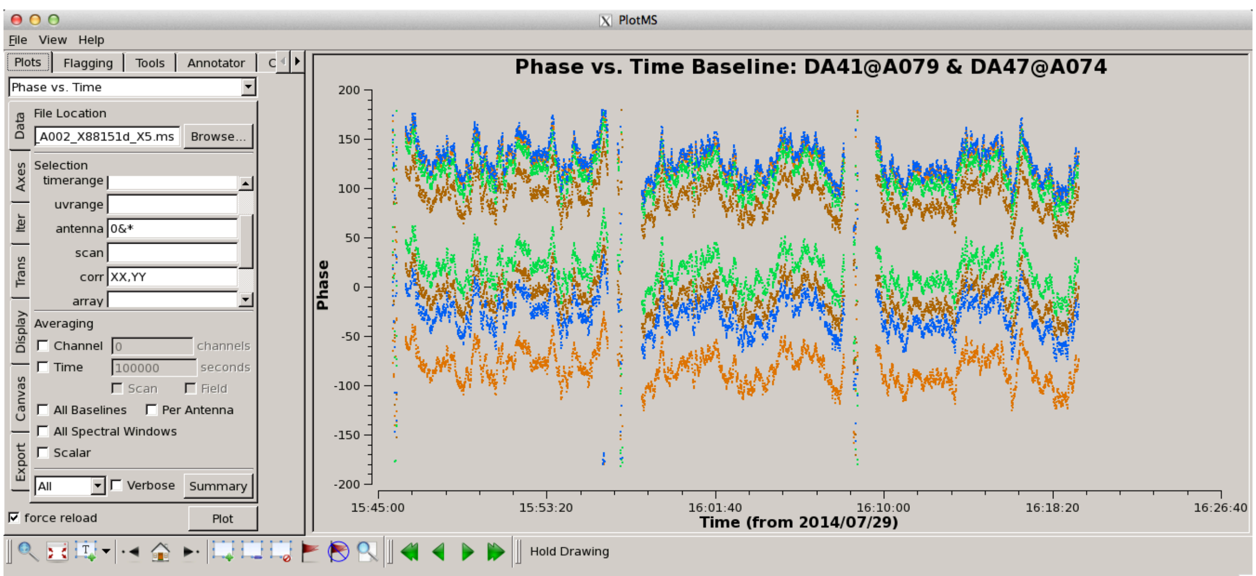
DelayCal on bright quasar:

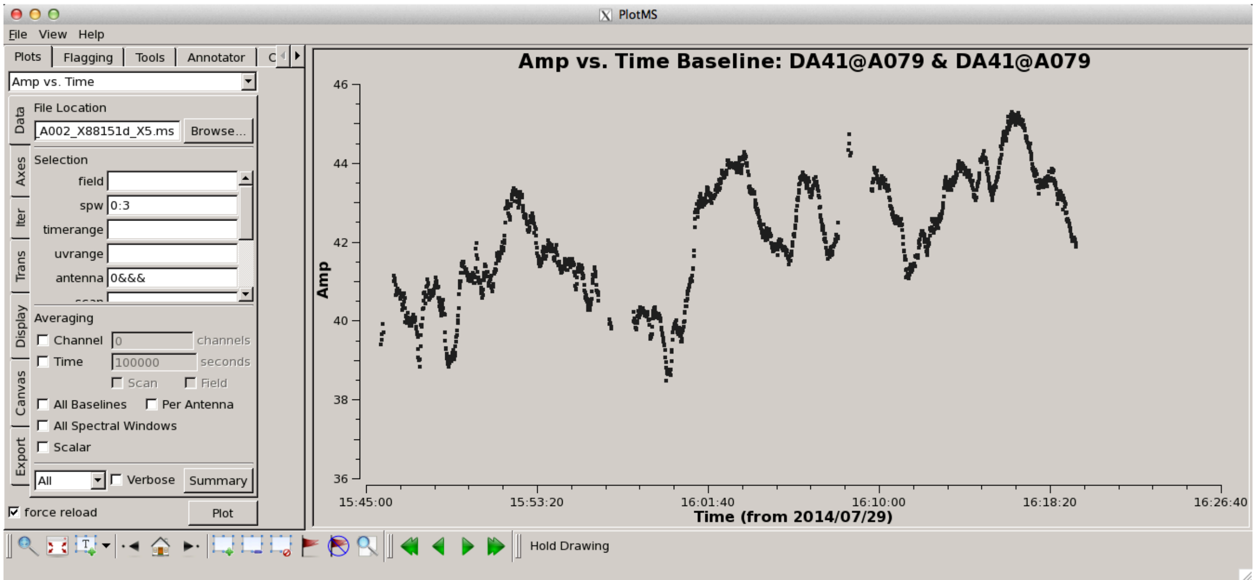
Data obtained using the Rubidium Standard:
DelayCal.py -b 6 -P 4 -d 600 -r 3 -s 3c279 --wvr --wvrSkyCoupling <-- ***NB: 3c279 not observable; replaced with J0522-364***





Data obtained using the H maser:
DelayCal.py -b 6 -P 4 -d 600 -r 3 -s J0522-364 --wvr –wvrSkyCoupling





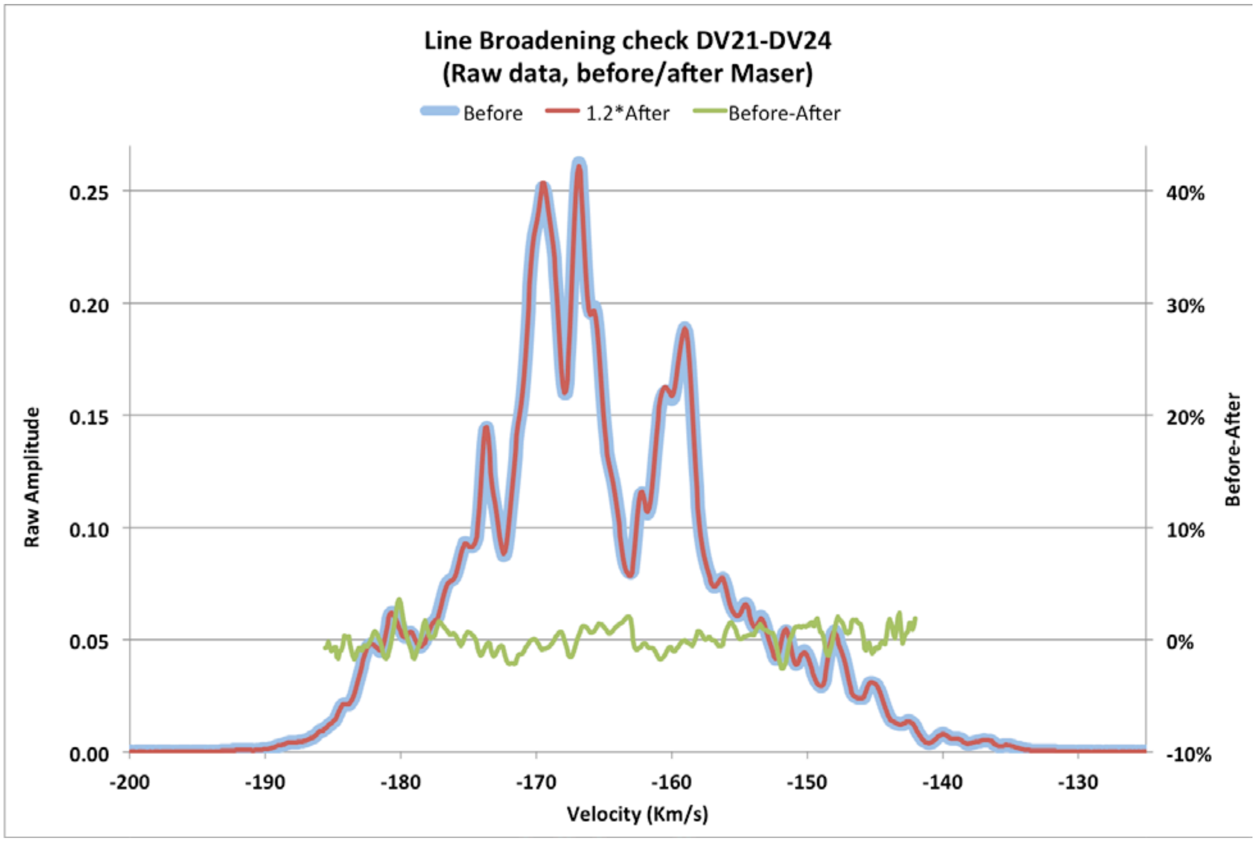
Conclusion (Paraphrased from Sawada-san comments from CSV-3107):

Above are the plots from the 0522-364 datasets uid://A002/X88151d/X5 (after) and uid://A002/X87f18c/X1f71 (before). The WVR-corrected phases of the channel-averaged visibility in the baseline DA41-DA47 (102m) are shown; colors represent SPWs (basebands), only polarizations XX and YY are shown among the four products. Obviously the phase stability is poorer in the data collected with the H maser compared with the Rubidium standard. Perhaps it is accounted for the poorer atmospheric condition, although the plots shown above are already WVR-corrected. Also shown are the WVR channel 3 amplitudes which clearly illustrate the much more unstable conditions from the data taken with the H maser. Therefore, the fluctuations in the phase vs. time are easily attributed to the more unstable atmospheric conditions and not the H maser.

DelayCal on the SiO maser transition toward VyCanis Majoris:

Data obtained using the Rubidium Standard:
DelayCal.py -r 10 -b 86.2433e9 -d 300 -n FDM -w 16 -s 'vy_cma'

Data obtained using the H maser:
DelayCal.py -r 10 -b 86.2433e9 -d 300 -n FDM -w 16 -s 'vy_cma'



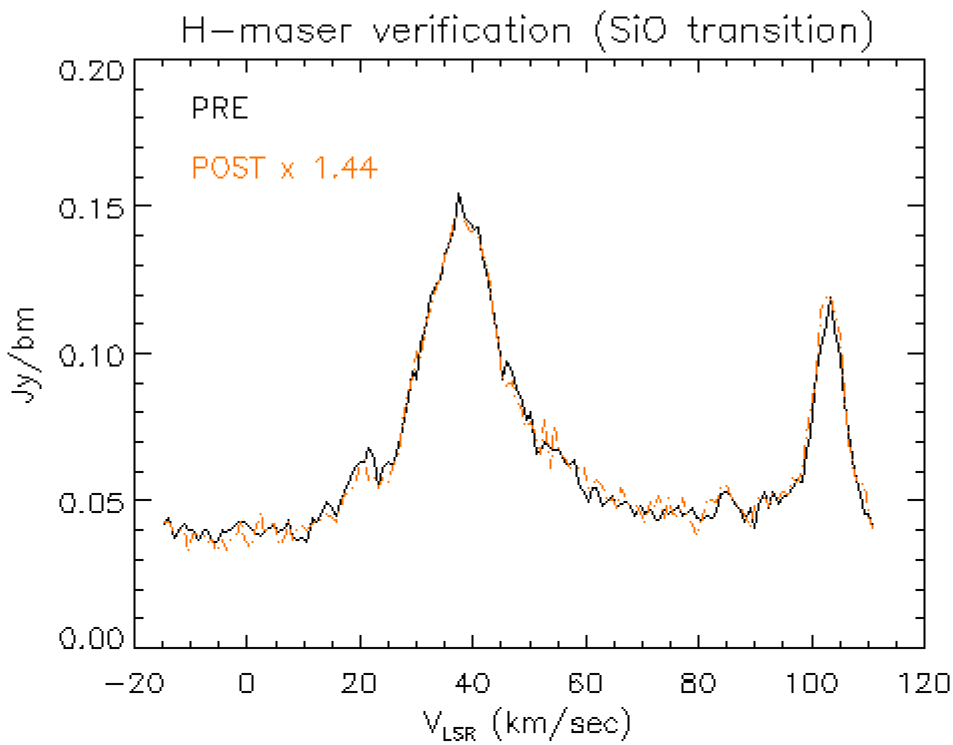
Conclusion (Paraphrased from Remo and Tim's comments from CSV-3107):
The data were analyzed before and after the installation of the H maser. The figure above shows and overplot of the SiO maser feature using the longest baseline (DV24-DV21). There is no evidence of broadening of the spectral feature before and after the integration of the maser. The SiO spectral feature complex are reproduced with the same width, albeit with a slightly lower amplitude after the install of the H maser compared to before. This is easily attributed to a difference in amplitude gains (i.e. the data were not properly amplitude corrected). After applying a constant factor of 1.2 the data with the new maser reproduces the feature almost exactly. Furthermore, the data from all the other antennas were inspected and no evidence of line broadening was found anywhere. Therefore, there is no evidence of spectral line broadening with the new H maser standard and the amplitude fluctuations between the 2 days is easily attributed to the unstable atmospheric conditions and the lack of proper amplitude calibration.

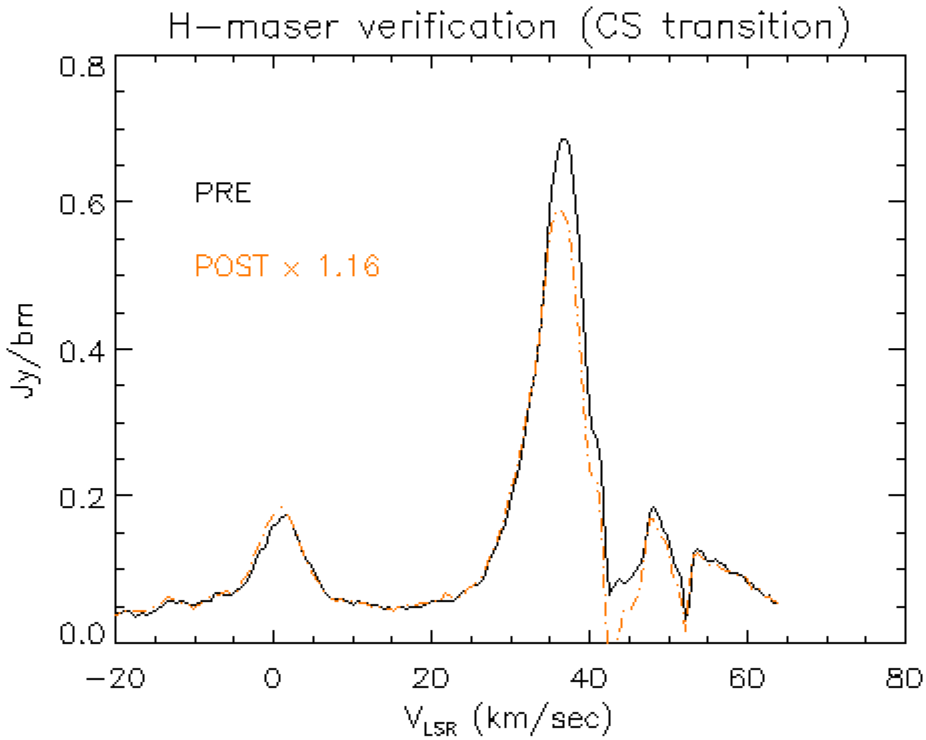
High spectral resolution observation of an ES program:

In order to test the maser performance on an ES project, in coordination with DSO, EOC observed the following SB: Name: g19.61-0_a_03_TE of Project: 2013.1.00266.S. This program was chosen specifically for its LST range and for its high spectral resolution setup. The full data reduction using the procedures for QA0/2 outlined for by hand data reduction were followed and the data reduced in the standard way.

Data obtained using the Rubidium Standard:
40 minutes
Project: 2013.1.00266.S
SB Name: g19.61-0_a_03_TE
ExecBlock uid: uid://A002/X87c075/X2cd9

Data obtained using the H maser:
40 minutes
Project Code 2013.1.00266.S
SchedBlock g19.61-0_a_03_TE
ExecBlock uid://A002/X883455/X12f





Conclusion (Paraphrased from Brian and Tony's comments from CSV-3107):
The above figures show the spectral line profiles of the SiO J=2-1, v=1 transition (86.24337 GHz) and the 2-1 transition of CS (97.98 GHz) toward the high mass star forming region G19.61-0.24A. Again, adjustments in the overall amplitude were required because:

1. the selected region to view the spectral profile were not precisely consistent between the before and after maser installation datasets
2. the image was not cleaned and the beams were not identical for the before and after maser installation datasets showing the spectral line profile.
3. the overall distribution of CS and SiO are much different which directly relates to the difference in scaling factors derived for each dataset.

However, as previously shown, no line broadening or any other issues were found in these data that can be attributed to the new H maser standard. Therefore, no issues in the ES collected in the standard way using the CYCLE2_ON control software were found using the H maser.

Conclusions:
Since the initial tests, EOC has used the H maser standard for testing during the high frequency campaign and to characterize the baseline lengths and other tests. In addition, ADC has been using the new H maser standard since Tuesday, 29 July for the subarray mission of the 2014.2 control software. During this time, the subarray mission has successfully performed tests using 4 subarrays and EOC has collected data using manual scripts to scheduling blocks ranging from bands 3 to bands 10. We have found no indication of any lack of performance or anomalies found in the data that we can attribute to the new H maser standard.

Therefore, it is the recommendation of EOC and APP teams to DSO and ADE to leave the new H maser integrated into the ALMA system as the new 5MHz standard from this point forward.