Robert Mutel
Sept - Dec 2012

# RSRO SUMMARY REPORT

I was a resident RSRO astronomer at the DSOC from 20 Sep - 15 Dec 2012, except for a brief period (1-15 Oct) during which I was on travel [meeting in Boulder and personal holiday]. My original project was to assist with integration of the phased VLA into the VLBA. However, during my tenure this project was still in a early engineering state, with only a few brief observing tests, primarily resulting in fixes to FPGA firmware, to which I could not contribute. I did attend all VLBA weekly meetings and offered a user perspective during general discussions, but found little opportunity to contribute significantly to the engineering effort. Most recently, however, I did contribute to the VLA-VLBA project, albeit tangentially: I offered to edit the VLBA call for proposals draft. This is described in section 3 below.

After realizing that the original RSRO goals for the phased VLA-VLBA project were premature, I endeavored to contribute to other EVLA developments that could benefit from a user perspective. I worked on two other projects: sub-arraying testing and pipeline testing. I will summarize these contributions below.

Finally, I would like to express my appreciation to the NRAO staff, but especially Mike Rupen, Vivek Dhawan, Claire Chandler, Jon Romney, and Juergen Ott for patience and assistance with RSRO tasks and my pursuing my own research program. It's been a productive and enjoyable experience.

## 1. *Sub-array testing*

I submitted four test SB observations to test sub-array performance, one in October, and three in November. The observations consisted of one-hour observations using two sub-arrays, at S and C band, with 13 antennas each. Since the OPT does not yet support sub-array observations, the current scheme is to make two SB's with identical observing schemes, changing only the request frequencies. The SB's were entered into the EVLA observing system manually [usually by Michael or Vivek] during daytime test time.

Two of the observations failed, but two were at least partially successful. The failures appear to have been caused by incorrect mapping of the correlator boards by the CM (configuration mapper) software. The resulting datasets were empty (only header information). Interestingly, in both cases, only one sub-array failed and the other was normal. Sonya (at DAO) has been working on fixes to the CM program and it now appears to be working, although this has not been tested (my me) yet. I have submitted another pair of SB's to be run on the morning of Dec 14 [my last day, but I hope to finish preliminary analysis in the afternoon].

An urgent problem appears to be Sonya's availability after January 1, 2013. My understanding is that she is on contract and may not be available after that date, but that she is in the best position to fix CM-software problems which continue to affect sub-array observations.

The successful sub-array observations worked well in the sub-array using C-band, with RMS noise levels about as predicted from the ELVA exposure calculator (cf. Fig. 1), and no corrupted data that wasn't attributable to RFI. At S-band, the sub-array data was not as good, (higher RMS

noise) but I strongly suspect that the problem is incomplete flagging of RFI-contaminated data rather than a problem with sub-arrays. I will continue to analyze both S-band datasets after returning home and will communicate with Michael Rupin on results.
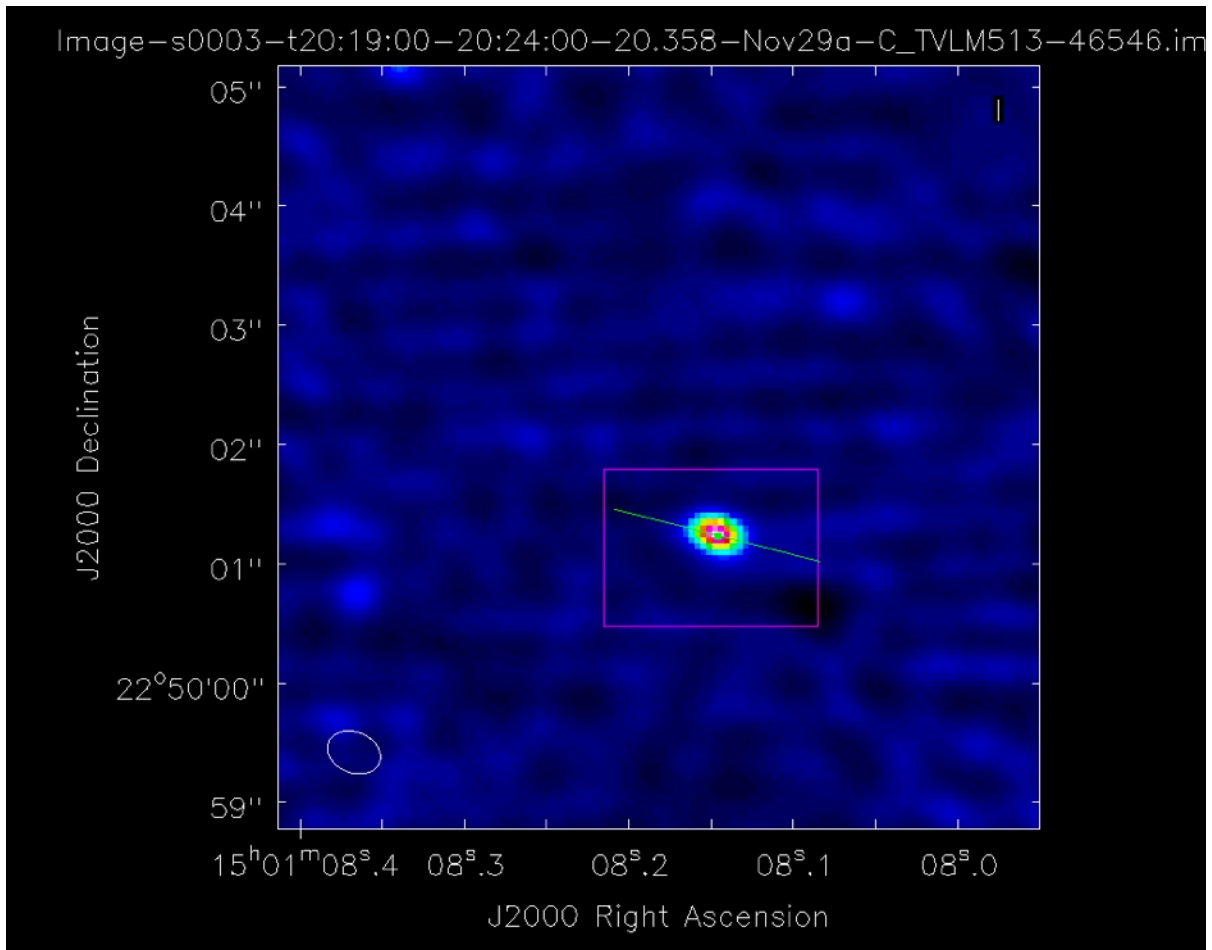


Fig .1. C band snapshot image of ultra-cool dwarf TVLM513-46546 at 4.5 GHz using a 13-antenna sub-array. The RMS noise level in a region distant from the star is 63 µJy, close to the expected value of 52 µJy expected for a 5 minute exposure at an effective bandwidth of 512 MHz (average of 4 × 128 MHz SPW's).

*Summary and recommendations:*

*a) Teach OPT to schedule sub-array observations*

*b) Continue exercising the sub-array observing mode by creating SB's with different characteristics (e.g., 3+ sub-arrays, different observing bands, spectral line observations…)*

*c) Find a solution to keeping an experienced software engineer on staff who can address CM software issues.*

## 2. **EVLA Pipeline testing**

I began testing Claire's pipeline scripts in early November, and attended several group pipeline meetings, reporting on my experiences. I tested the pipeline by first downloading the scripts to my iMac computer, providing a completely independent test with a non-standard O/S (Mac OS 10.7)

and different directory structures. This is important since it resembles the normal situation for non-NRAO users.

The datasets consisted of recent 1-3 hours EVLA observations of ultra-cool dwarf (UCD) stars (project 12B-363) at S and C band, using standard 16 × 128 MHz SPW, 64- channel per SPW mode. I user the same observing scheme at several epochs, allowing a comparison of pipeline results with datasets with the same observing parameters but different epochs.

After several iterations with Claire to fix minor software bugs, I have successfully calibrated several EVLA datasets using version 4.0 of the pipeline. I checked the quality of calibrated data in several ways. First, after running the pipeline, I quickly examined the logs for errors and looked at the calibration plots that the pipeline produces,. Next, I examined the calibrated data using CASA task *plotms*. The most useful diagnostic (IMO) is a plot of the real and imaginary visibilities of the parallel hands of the primary phase calibrator. This plot, which ideally is a tightly clustered disk centered on the flux of the calibrator, can be used to quickly isolate bad antennas, baselines, and/or correlators using the data selection tools in *plotms*. Generally, I found that the pipeline flagged almost all bad data, but there were almost always some residual bad points that I flagged manually.

After a small amount of manual flagging (perhaps 5-10 mins), I split the data using spectral window and scan slices, and imaged each split time-frequency slice. I found that the images had noise floors as expected (within 10%-15%) from the EVLA exposure calculator. I then
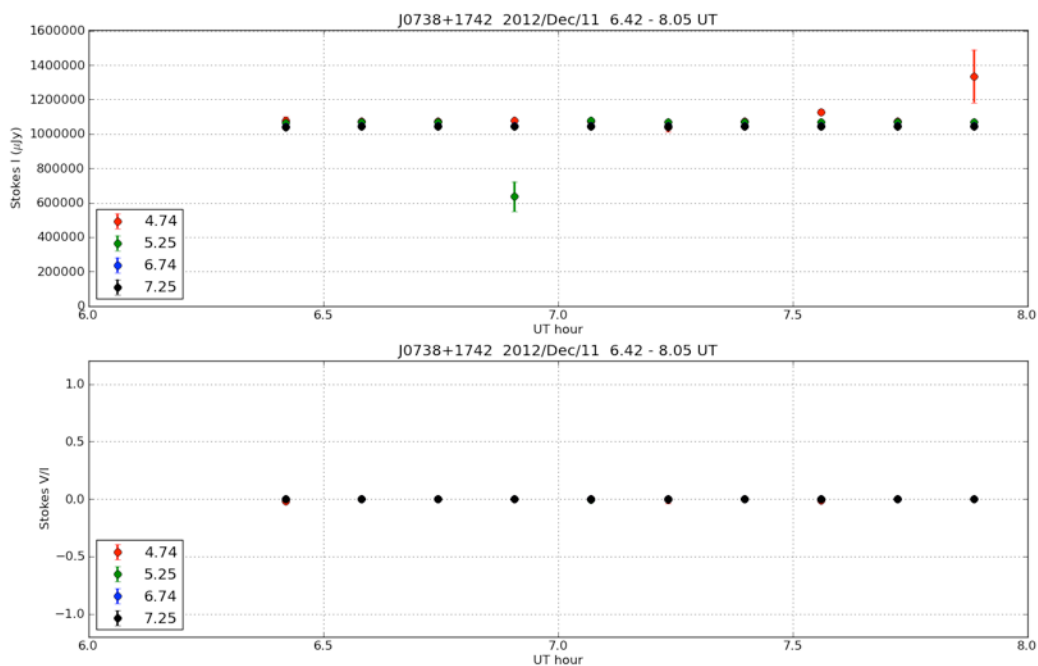


Fig 2. Stokes I (top) and V (bottom) flux density and as function of time and frequency of J0738+1742, a flat-spectrum compact source that was used as the primary phase calibrator in project 12B-363. The raw visibilities were calibrated using the EVLA pipeline v4.0 on Dec 12, 2012, with no additional flagging or other calibration.

ran *imstat* on a box centered on the primary phase calibrator location on every scan's image and each averaged-SPW. (This scheme is the same as I use to analyze time and frequency-variable pulses in UCDs). A sample diagnostic plot is shown below.

*Summary and recommendations:, pipeline testing:*

*1. Version 4.0 of the pipeline works well for the datasets used (C-band continuum),, but not S-band. This may be relate to much stronger RFI at S band.*

*2. Collecting diagnostics on easy-to-digest web pages is a very significant improvement over unsorted collections of log files and plots in the user's data directory.*

    *a. Of course, this is still a work in progress, and needs completion (especially QA summary and plot resizing) before being made public.*

*3. The pipeline needs to be tested with a larger variety of datasets.*

*4. Capture warning messages instead of displaying on screen- these are often benign or irrelevant (e.g. "SEVERE" error if pipeline doesn't find all antennas - esp. true of subarrays1).*

*5. It would help the user if three convenience functions were added:*

    *a. Option to turn off plotting, including calls to plotms (this task is buggy on the Macs in any case). One timing test I made on a 1-hour dataset reduced the pipeline compute time from 20 min to 12 mins when I commented out all plot commands. FWIW: CASA needs to be restarted after running the pipeline because it leaves plotms in horribly broken state.*

    *b. Option to turn on Hanning smoothing - this may help S-band especially.*

    *c. Report projected execution time, perhaps by scaling from a dummy exercise at the beginning.*

3. **VLBA Call for Proposals editing**.

I edited the draft CfP after consulting with Jon Romney and Michael Rupin. My goal was to rewrite the document to be more understandable to the typical VLBA user, avoiding acronyms and technical jargon and reorganizing the structure so the new VLBA capabilities and options were more clearly delineated. I gave an edited copy of the CfP to Jon Romney on Dec 13.