Pulsar Astrometry with the VLBA: Second Update to BC120/BC123

We have proposed a large, multi-epoch VLBA project (BC120) that aims to measure parallaxes and proper motions of a large sample of pulsars. Since submission of this proposal, we have completed a VLA survey which constitutes the necessary ground work for this project, and data acquisition for the first epoch of pulsar observations with the VLBA is now nearly complete. As described below, there has also been progress on related observational fronts, all of which enhance our confidence in the feasibility, timeliness and scientific returns of this large project. Here we provide another brief progress report on the project, and request continued observational support from the VLBA.

Preliminary VLA Survey at 1.4 and 8.4 GHz: As discussed in our original proposal, good preliminary positions are essential for successful VLBI astrometry, and the detection of in-beam calibrators offers an exceptionally good route for high-precision astrometry. In our previous update (May 2002), we reported the completion of an A-array survey of 63 target pulsar fields. In this survey, initial positions were obtained for all 63 pulsars to better than $\sim$100 milliarcsecond. In addition, after imaging 1060 sources at 1.4 GHz and follow-up observations of 269 sources at 8.4 GHz, compact in-beam calibrator candidates were located for 55 of our potential targets. Complete results, including images of each source, are publicly available, at: `http://www.astro.cornell.edu/~shami/psrvlb/vla/`

VLBA First Epoch Observations: From our sample, 34 targets were chosen for first epoch VLBA observations. These observations (BC123A–BC123AH) are now approaching completion, with only three more targets to observe. 23 targets have already been examined: preliminary results indicate that at least 13 have good in-beam calibrators and an additional 4 are amenable to wideband ionospheric calibration. All observation key files and logs are archived at: `http://www.astro.cornell.edu/~shami/psrvlb/`

Pulsar Gating: In order to boost the observation signal to noise ratio, all pulsar observations are being processed with the pulsar gate. Timing solutions have been made available on request from Jodrell Bank, and are archived online with the observation key files and logs: we anticipate that timing data will continue to be available as needed.

VLBA Data Reduction: For most consistent astrometry, we have automated as much of the data reduction process as possible with `autoaips`. This allows every step of processing, except for data flagging and the final imaging, to be completed by scripts. Once the (human-generated) flags are recorded for each observation, consistent data reduction for all observation epochs becomes straightforward.

Supplementing the VLBA with Arecibo and the GBT: The first gated, phase-referenced pulsar observations with Arecibo and the VLBA have been successfully completed, and we obtain the benefits of a 10$\times$ sensitivity increase on Arecibo-VLBA baselines compared to VLBA-only baselines. We are currently scheduling a long-delayed project to observe three pulsars with the GBT and the VLBA, and expect to have successful results from that as well. The proven ability to add larger antennas to the VLBA in phase-referenced observations offers a huge sensitivity boost, and will allow us to observe fainter pulsars that are of scientific interest in the future.

This report summarizes our progress in key areas for this pulsar VLBI project: we have demonstrated (in the proposal and in updates) the technical feasibility of this project. We reiterate our belief that the continued commitment of VLBA observing time is justified by the anticipated science payoff, and request continuing VLBA time allocation in this trimester and beyond.

Supplementary material relating to this proposal, including results from the VLA surveys at 1.4 and 8.4 GHz, as well as current pilot projects, 5 GHz observations, `autoaips`*, and current parallaxes, are available on the web, at:* `http://www.astro.cornell.edu/~shami/psrvlb/`

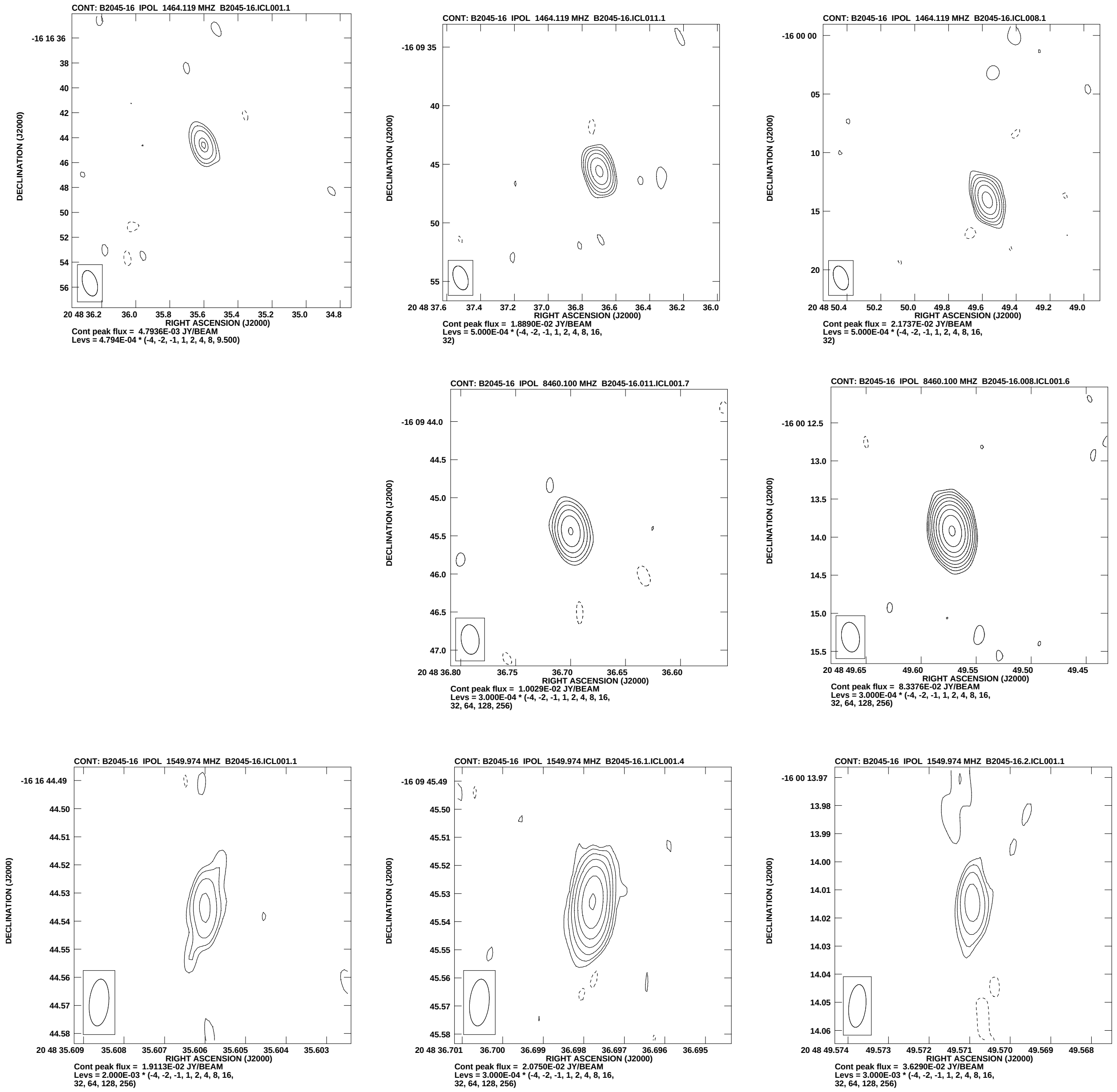

Fig. 1.— An illustration of the selection and refinement process for in-beam calibrator candidates for PSR B2045−16. Note the change in field of view for each row. Top row: Images at 1.4 GHz, VLA A-array, showing the pulsar and two compact in-beam sources. Besides the pulsar, 14 sources were detected in the field, and 6 were found to be relatively compact. Middle row: Follow-up observations at 8.4 GHz, VLA A-array. The pulsar was not observed at this high frequency, but all 6 targets were; 2 of the 6 (shown here) are observed to be compact. Bottom row: First epoch VLBA observations at 1.4 GHz. The pulsar and both in-beam calibrator candidates are detected. A sub-milliarcsecond parallax should be measurable for this pulsar.