Pulsar Astrometry with the VLBA: An Update to BC120

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. As described below, there has also been progress on related observational fronts, all of which enhance our confidence in the feasibility, timeliness and potential scientific returns of this large project. Here we provide a brief progress report on our preliminary work.

VLA 1.4 GHz Survey: As discussed in the 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. An A-array survey of all 63 target pulsars (Proposal Tables 2,3) has now been completed. All pulsars were detected, and initial positions have been determined to better than $\sim$100 milliarcsecond. All other sources in the fields have also been imaged, out to the edges of the primary beam. 1060 sources brighter than 1 mJy were detected, of which 269 were identified as compact in-beam source candidates (within $25'$ and stronger than 3 mJy). Complete results, including images of each source, are publicly available, at: `http://www.astro.cornell.edu/~shami/psrvlb/vla/`

VLA 8.4 GHz Survey: All 269 in-beam candidates were followed up at 8.4 GHz with the VLA A-array, in order to verify compactness and estimate the spectral index. 97 sources survive this screening, an average of 1.5 sources per target pulsar, with 55 of 63 targets having at least one suitable in-beam calibrator candidate. Complete results are available online, at: `http://www.astro.cornell.edu/~shami/psrvlb/vla-x/`

VLBA First Epoch Observations: Observations are now being scheduled with the VLBA, which will provide first-epoch positions and confirm in-beam candidates. We recognize that the VLA and VLBA survey observations might be of interest as a random extragalactic source sample over $\sim$35 square degrees, and will publish the results after we process the first epoch of VLBA observations. We will also continue to make all results available online immediately.

Wide-band Ionospheric Calibration: Pulsar parallaxes obtained using this technique as Brisken's Ph.D. thesis work have now been published (Brisken et al. 2002). Further refinements in the technique continue to push it towards lower minimum flux requirements.

High Frequency Observations: Pulsar observations at 5 GHz are very successful. With pulsar gating (using timing solutions from Jodrell Bank), we have now detected 5 pulsars (of 6 observed at this frequency) at high S/N ratio. Figure 1 illustrates the high-quality astrometry that can be achieved.

Supplementing the VLBA: In a recent observation (April 2002) we have obtained fringes between Arecibo and the VLBA for a phase-referenced pulsar observation (Figure 1). This offers a huge sensitivity boost and will allow us to observe, in future, fainter pulsars that are of scientific interest.

This progress report demonstrates that the VLA survey data have been processed completely, and are being exploited to the full extent possible. We reiterate our belief that a large commitment of VLBA observing time is justified by the potential science payoff, and that we have demonstrated (in the proposal and in this update) the technical feasibility of this project.

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, GPS ionospheric corrections and new parallaxes, are available on the web, at: `http://www.astro.cornell.edu/~shami/psrvlb/`

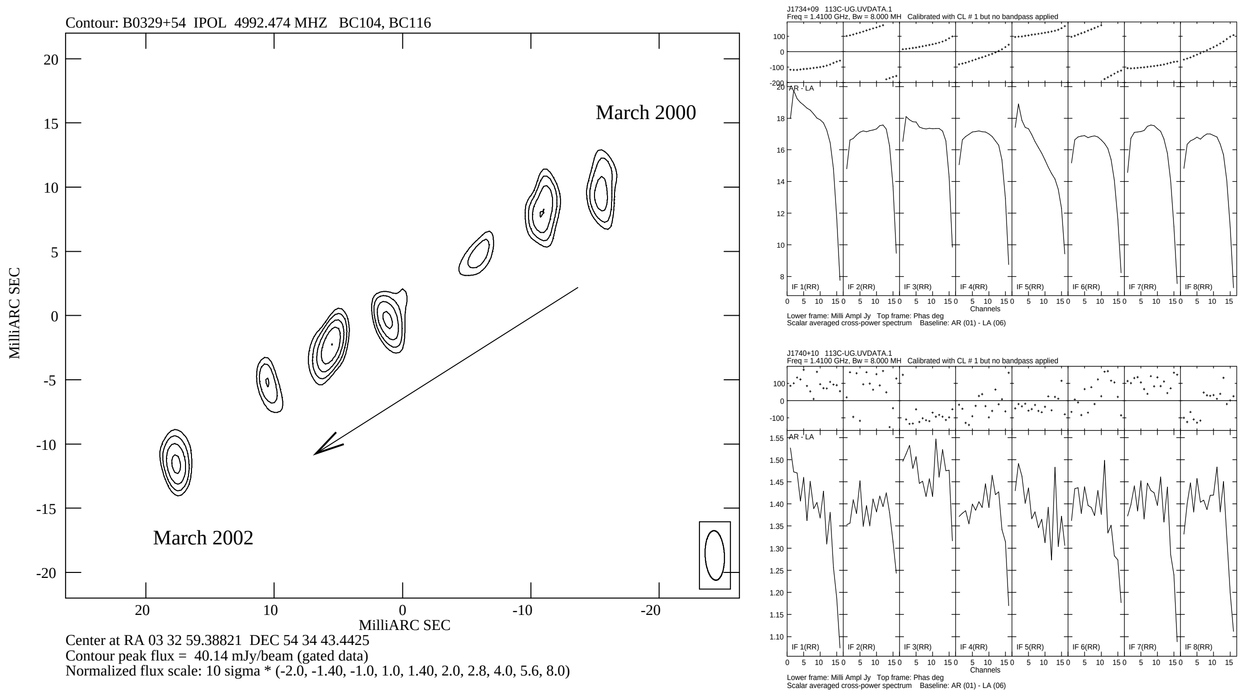

Fig. 1.— Further technique development with the VLBA. Left: 5 GHz observations of B0329+54, spaced every 4 months from 2000 to 2002, demonstrating high frequency VLBA pulsar observations. Right: Very recent (April 2002) data, showing fringes between Los Alamos (VLBA antenna) and Arecibo before any calibration was applied, (top) for the nodding calibrator and (bottom) for the weak target pulsar.

REFERENCES

Brisken, W. F., Benson, J. M., Goss, W. M., & Thorsett, S. E. 2002, ApJ, in press (astro-ph/0204105)

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