Pulsar Astrometry with the VLBA: Third 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. As outlined in the previous quarterly report, we have completed a VLA survey which constitutes the necessary ground work for this project. Currently, we are in the process of acquiring astrometric data: each of our targets has been observed for two to three epochs with the VLBA, and the progress so far reinforces 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.

VLBA Observations: In first epoch VLBA observations, 34 targets were observed. Since then, as requested by the scheduling committee, we have reduced our target list to 26 objects. Of these, 25 have been observed for three epochs, and fourth epoch observations are in progress. In order to boost the 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 we anticipate that this will continue. The current project status is updated daily, at:
`http://www.astro.cornell.edu/~shami/psrvlb/observe/`

Data Reduction: For the 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.

Preliminary Results: Based on the first three epochs of processed data, we have preliminary proper motion measurements for a number of pulsars, including B0136+57 ($\mu_\alpha = -21.5 \pm 1.5$ mas/yr, $\mu_\delta = -15.7 \pm 1.2$ mas/yr), B0818−13 ($\mu_\alpha = 23.6 \pm 1.2$ mas/yr, $\mu_\delta = -38.1 \pm 1.5$ mas/yr), B1508+55 ($\mu_\alpha = -72 \pm 2$ mas/yr, $\mu_\delta = -67 \pm 3$ mas/yr) and B2045−16 ($\mu_\alpha = 113.5 \pm 0.4$ mas/yr, $\mu_\delta = 15.4 \pm 1.1$ mas/yr). Figure 1 illustrates two of these proper motions.

In addition, preliminary parallax values are measurable for B0818−13 ($\pi = 0.9 \pm 0.5$ mas; see Figure 2) and B2045−16 ($\pi = 2.1 \pm 0.5$ mas), although these values are not very significant, since there are 6 data values and 5 free parameters in the fits. The position uncertainties at each epoch include statistical errors, which depend on the S/N ratio attained (affected by pulsar scintillation), as well as systematic errors which are poorly quantified as yet. While the preliminary indications are favorable, 8 epochs over two years will be important for accurate error estimates and robust parallax measurements.

Supplementing the VLBA Sensitivity: Second epoch gated, phase-referenced pulsar observations with Arecibo and the VLBA have been successfully completed, and we obtain the benefits of a 10× sensitivity increase on Arecibo–VLBA baselines compared to VLBA-only baselines. Two epochs of observations have also been obtained with the GBT and the VLBA. 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.

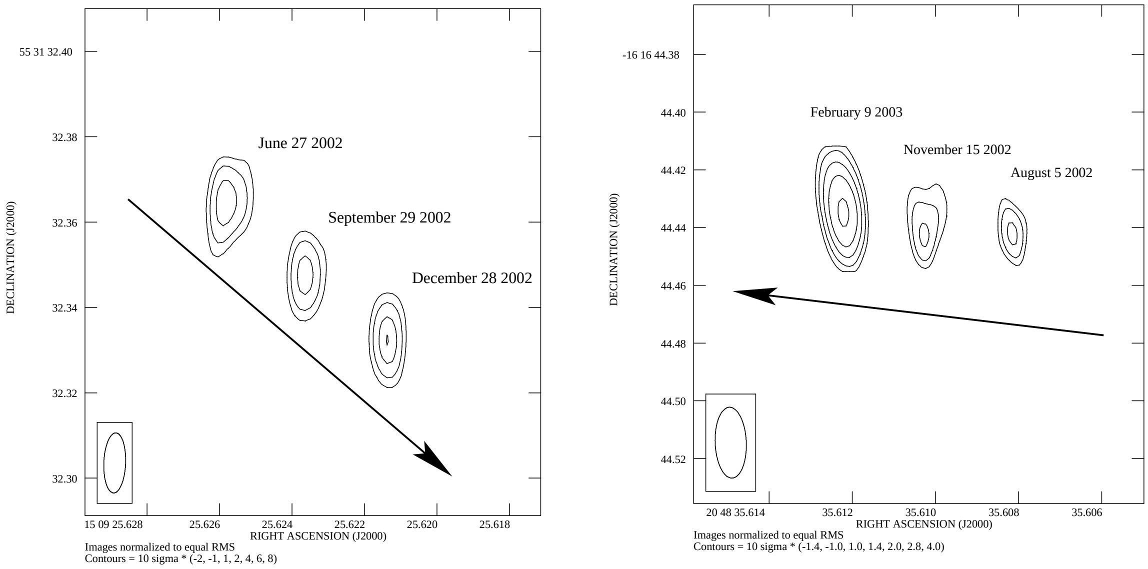

Fig. 1.— Three-epoch proper motions for B1508+55 (left) and B2045−16 (right). Images are normalized to equal RMS before co-adding, and reflect the epoch-dependent signal to noise ratio attained. The arrow represents the annual proper motion vector.

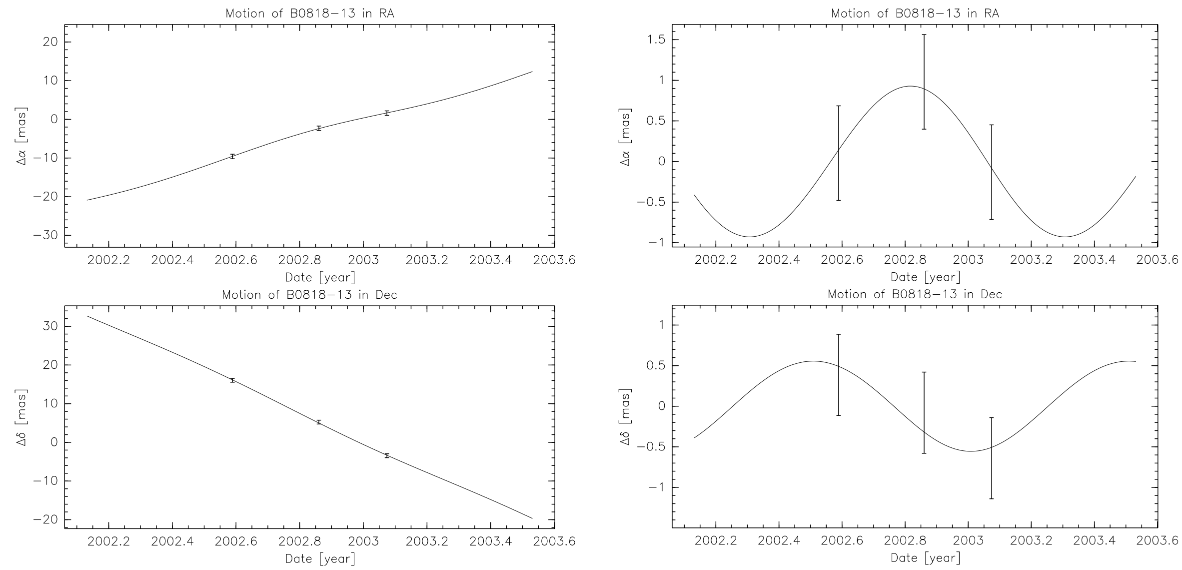

Fig. 2.— Preliminary fits for proper motion and parallax of B0818−13 ($\mu_\alpha = 23.6 \pm 1.2$ mas/yr, $\mu_\delta = -38.1 \pm 1.5$ mas/yr, $\pi = 0.9 \pm 0.5$ mas). We show position offsets (left) and parallax residuals after subtracting the best fit proper motion (right). These fits are preliminary, since equal errors have been assigned to each epoch, and there is only one degree of freedom.

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/`