BR145: Observational Issues and Data Policy Information

1. Introduction

Now that our proposal has been accepted, pending working out observational and data release issues, we have started detailed planning. Here we present our thoughts on how to proceed with the observations and data releases. Of course, we are open to suggestions that would improve the program, both for us and for others who might benefit from the data.

Should questions remain, we could schedule a teleconference, or, if it would be useful, I could travel to Socorro for a face-to-face meeting.

2. Pre-parallax Observing Surveys

While we could have submitted a target list with the proposal, we can do far better science if we do the steps outlined below in order to decide on the best sources. We will select sources with the best chances of getting good astrometric data and that maximize intermediate (yearly) results by addressing specific scientific questions (eg, locations of spiral arms, pitch angles, cross-arm motions, effects of the Galactic bar, etc.) This should make publication of intermediate results (roughly yearly) more coherent and have greater impact than a less-informed selection.

Briefly, we need to find the best parallax targets and then background calibrators that are close in angle to the targets before starting parallax observing:

2.1. Target Survey (VLA: 16 hours; any configuration):

We will select target maser sources by surveying the ≈ 400 star forming region H_2O masers in the catalog of Valdettaro (and measuring the positions of up to 30 methanol masers not yet done in previous work). This survey will yield sub-arcsec accurate positions and current spectral characteristics of the target masers. It is necessary to select targets before finding background calibrators (close in angle to the targets). Most of the observations would be of H_2O masers. These would be 0.5 min snapshots, repeated twice to get better uv-coverage and to improve positional accuracy.

In Figure 1, we plot the Right Ascension (RA) distribution of the H_2O maser sources in the Valdettaro catalog. For future interest, we also plot the distribution of 6.7 GHz methanol masers from the Pestalozzi catalog. (When the 6.7 GHz receivers are deployed on the VLBA, we will need to do a second "Target Survey" of these masers to select the best ones and prepare for parallax observations.

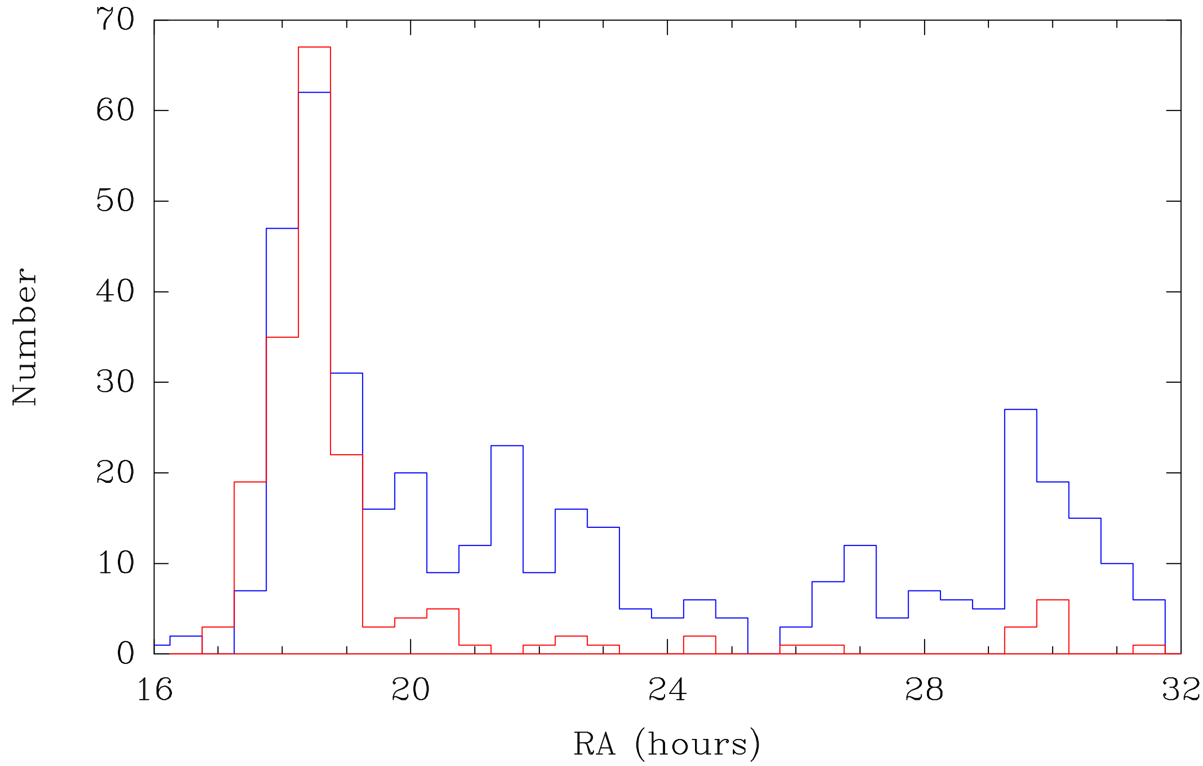

Fig. 1.— Distribution in Right Ascension of potential target 22 GHz H_2O masers (*blue*) and 6.7 GHz methanol masers (*red*).

2.2. Calibrator Survey (VLBA-GBT: 40 hours/year, 256 Mb/s recording; or VLBA-only: 120 hours/year, 512 Mb/s recording):

For each target maser, we need to find compact extragalactic background sources within $\approx 1.5^\circ$ of the target. We will select NVSS (L-band) or CORNISH (C-band) catalog point sources stronger than 20 mJy. Typically there are about 25 such candidates within about 1.5 degrees on the sky of any Galactic target position. Most of these are Galactic HII regions and not useful for our purposes. Basically we would seek a simple (self-calibrated) VLBA detection and make a plot of the real component of the visibility versus uv-distance to determine compactness.

We propose to observe at X-band with the VLBA alone (120 hours/year) or with the GBT-VLBA (40 hours/year). We need to obtain 2 mJy rms noise per baseline to reliably detect the visibility amplitude of a 20 mJy (or weaker for a falling spectral index) source. We would simply plot the visibility amplitude versus baseline length in order to assess quality (compactness, strength) as a calibrator, as is done, for example, in the VLBA Calibrator Search Tool. With the VLBA-alone mode we would observe for 3 minutes each with 512 Mb/s recording in order to achieve the required 2 mJy noise for each baseline. With the GBT we could cut the on-source time to 0.5 minutes per source and greatly speed up the survey.

Note that the calibrator survey, while time consuming, will be of long-lasting value for future VLBA, EVLA, and ALMA observations, since currently the VLA calibrator list is quite sparse in the Galactic plane. We should be adding ~ 500 good candidate calibrators in the plane.

3. Parallax Observations

Once these two surveys are completed, we will select maser target sources to be observed based on strength and complexity (more features are better) and the availability and quality (compactness, strength) of background sources. Also, the orientation of the background source on the sky from the target is important; east-west offsets are better than north-south offsets, as this minimizes differences in the source and calibrator zenith angles and improves relative astrometry. Since we proposed to share observing tracks with 3 target masers, a final target list will need to group sources that are near each other in Right Ascension, so that slew times are minimized and, most importantly, the Earth's orbit will be maximally extended for all three at the nearly same date. We will submit yearly target lists to NRAO for scheduling.

The time sequences of observing epochs reproduced from the proposal for a methanol and H_2O observation are shown in Fig. 2. One year's observing is the natural period for parallax observations, and when observing maser spots that have limited lifetimes it is prudent to make measurements in the shortest timespan.

Given the distribution of masers in the Galaxy (see Fig. 1) and the times when the Earth's orbit is maximally extended as viewed by the masers, observations will clump in the months March/April and September/October as described in the proposal. In order to quantitatively asses the impact of this clumping on the scheduling of the VLBA, we have generated trial schedules (based on the distribution of sources in the Valdettaro and Pestalozzi catalogs) that seek to distribute observations as uniformly as possible in time. This simulation assumes 21 12-GHz methanol masers, each requiring 4 epochs, and 57 22-GHz water masers, each requiring 6 epochs, yearly. We plot the results of two such trials (for year 1 and year 2) in Fig. 3.

Based on these trials, we will need between about 9 and 18 7-hour observing tracks per month. In the peak months of March/April and September/October we expect to need about 18 7-hour observing tracks. Since there are potentially 3 such tracks per day and 30 days/month, we will need 20% of the possible tracks in the 4 peak months and about 10% in the 8 off-peak months.

4. Data Products

Regarding proprietary periods, our primary scientific interest is the parallax and proper motion of the star forming regions. Therefore, we would like a reasonable proprietary period for the data

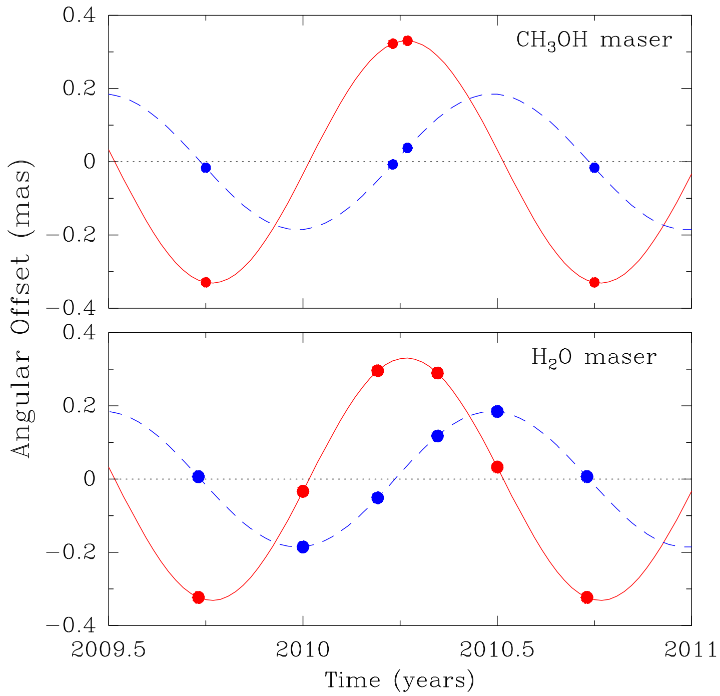

Fig. 2.— Example time sampling for near optimum parallax and proper motion measurements of a source at Galactic longitude 45° and a distance of 3 kpc. Solid red lines are for the Eastward parallax signature and dashed blue lines are for the Northward signature. *Top Panel:* Proposed methanol maser sampling. Because methanol masers have lifetimes typically >> 1 year, one can maximize the parallax accuracy for a minimum of observations by sampling at the peaks of the (often dominant) Right Ascension parallax signature. This sampling results in near-zero correlation coefficients among the parallax and proper motion parameters. *Bottom Panel:* Proposed H_2O maser sampling. Because individual H_2O maser spots have lifetimes that can be less than 1 year, one needs to observe more frequently (than for the methanol case) in order to separate the parallax and proper motion effects for maser spots that might live only about 6 months.

that can be used for that purpose. Since we plan to complete *and publish* observations of essentially all sources within 1 year of the final epoch for any source, raw data can be made public 1 year after the final epoch (i.e., not 1 year after the end of our 5 year program). For our previous large project, BR100, we submitted for publication (and placed the papers on Astroph at submission time) 6 papers well within these time-lines.

For data that cannot be used for parallax and proper motion determinations, we propose no proprietary period. This includes all of our surveys and all first-epoch parallax data. Additionally, we propose to make reduced data products from those observations available as soon as possible (within 60 days from correlation).

We summarize the proprietary periods and data products and releases in Tables 1, 2 and 3:

Table 1. Maser Survey

Data Type	Proprietary/Release Period	Product
Raw Data	None	
Processed Data	60 days	Absolute positions, spectra, image cubes

Table 2. Calibrator Survey

Data Type	Proprietary/Release Period	Product
Raw Data	None	
Processed Data	60 days post correlation	Absolute positions, visibility plots

Table 3. Parallax Observations

Data Type	Proprietary/Release Period	Product
Raw 1st epoch	none	
other epochs	1 year	
Processed 1st epoch	60 days	Absolute positions, maser spot maps/tables
other epochs	1 year	parallaxes and proper motions

Note. — “1 year” refers to the end of observations of each source separately, not after the end of the 5 year program.

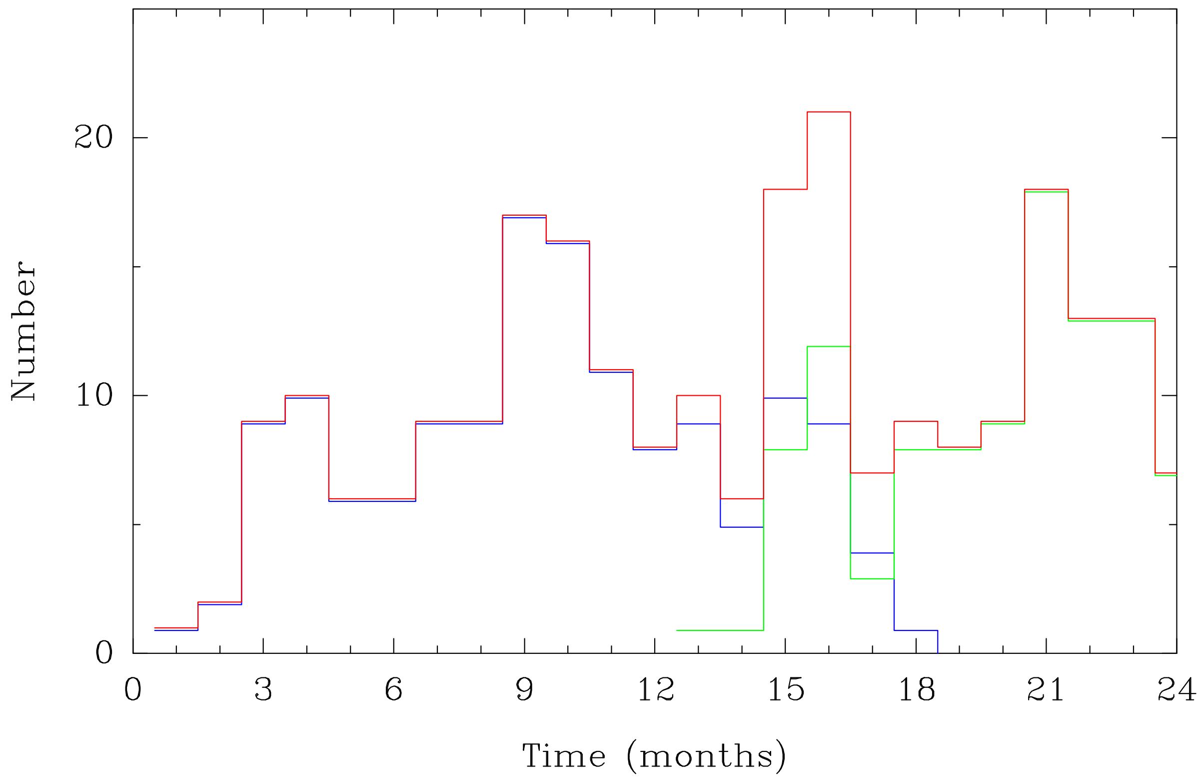

Fig. 3.— Distribution of the number of 7-hour tracks needed by month of the year for trial schedules for the first 2 years of the program. On the abscissa, Time=1 corresponds to January of the first year. The blue histogram is for the first year's sources and the green histogram is for the second year's sources. The red histogram is the sum of the two and indicates the required number of observing tracks by month.

5. Management

I will take responsibility and manage the data analysis and dissemination tasks. This group has worked together before and our rapid publication record should demonstrate that this should work. In the proposal we conservatively estimated the project would need 2 person-years per year (or 25% time of 8 people) for 5 years to analyze data. Eleven of the co-investigators have committed to this level of effort, and some would like to do 50% effort. So we will need to "ration" the data analysis, rather than seek extra manpower. Also, I intend to be available to analyze data if needed or to assist if there are unusual problems. Assignment of who will analyze which sources will be made when we actually schedule each year's observations.

The initial surveys discussed above will be handled by me and Xu Ye. I will coordinate data releases, after I receive the products from the person analyzing the data. Details of how to release data products (eg, should it be through a NRAO web site or the project web site) can be NRAO's decision.

Our plan is that each co-I who is analyzing data will publish a paper on ≈ 10 parallaxes that relate to a common theme (eg, location of a spiral arm segment, pitch angles, cross-arm motions, effects of the Galactic bar, etc.) yearly.

As this project will address a wide range of scientific problems, I am considering proposing for an NSF grant (with a Harvard University PI as NSF will not take a proposal from a Federal employee) to support 2 postdoctoral fellows. One of these fellows could be a computational theorist to help with the interpretation of the data. However, the program can certainly go ahead without the NSF grant. I assume that graduate students at U.S. universities (eg, Harvard) who wish to work on a PhD thesis associated with this project could be partially funded by the NRAO Student Support Program. Graduate students at the University of Bonn and Nanjing University could be funded by these Universities.

6. Coordination with VERA

We would like to work with VERA and indeed asked some VERA staff to be Co-I's on this proposal. However, they felt that their first responsibility was to analyze VERA data and that they would not have enough time left to analyze VLBA data. We plan to coordinate target lists with VERA in order not to duplicate parallax sources. Previous observations have demonstrated that VERA and the VLBA arrive at consistent results, so there is little value in sample overlap. However, it would be quite interesting to compare the motions of different maser species associated with the same source as well as different sources within the same giant molecular cloud. In conjunction with VERA, we would like to do this for a small number of objects. I will coordinate with Mareki Honma at VERA to achieve these goals.

7. GPS Receivers

Currently there are 6 VLBA sites with GPS receivers. It would be extremely valuable if the remaining 4 sites could have GPS receivers deployed. If this occurs, we could get continuous atmospheric (and ultimately ionospheric) delay corrections, which would improve astrometric accuracy. This would be particularly important when we go to 6.7 GHz in a couple of years, as the ionospheric delay can vary more rapidly than the global TEC models can capture.

8. C-band Receivers

If the MRI proposal for new C-band receivers is funded, we will of course like to consult on specifications as they relate to 6.7 GHz performance. However, we assume that the receivers would closely follow the EVLA design, which should work well at 6.7 GHz.

Should the proposal not be funded, we would explore other cost-sharing options. One possibility would be to seek more than the 30% contribution in the NSF proposal from the MPG. Armed with the unique and substantial allotment of telescope time to our project, we are optimistic that this could be arranged.

9. Outreach

In the proposal we discussed making a 3-dimensional model of the Milky Way and to use this model as the basis for a computer generated “movie” that would allow one to tour the Milky Way from the vantage point of 1) an extragalactic space traveler who could navigate the Milky Way and 2) a time traveler who could stand back and watch the Milky Way rotate. There is interest both in the Smithsonian and at the Purple Mountain Observatory (Nanjing) to contribute to this movie. Regarding consulting with John Stoke (NRAO EPO chief) on ”The Movie of Milky Way,” which will happen toward the end of project, we will be happy to do this.