NLSRT Memo No. 6

Sept. 9, 1988

To: K. I. Kellermann

From: F. J. Lockman

Subject: What a BFD would give us that we don't now have.

This memo gives a rough, incomplete, estimate of the extra "observing power" that NRAO could offer to users if we had a Big Floppy Dish. I assume that the instrument under discussion is that proposed in NLSRT memos 3 and 4: with a diameter of 100m, horizon to horizon tracking, a minimum declination of $-46°$, and a fully offset or low-blockage design.

First let us look at the competition. At frequencies $\lesssim$5 GHz NRAO can now offer users the 300-foot, the 140-foot and the VLA. NAIC can offer the Arecibo telescope. I will assume that the VLA is not a serious competitor with the BFD even though for certain projects, like some pulsar observations at selected frequencies, it is about as sensitive as the BFD will be. The reason I neglect the VLA is that it is certainly a waste of the VLA's power to operate it like a single dish very often, even if it is phased up occasionally. Also, there are many observations that can not be done suitably on the VLA regardless of its configuration.

I will also not consider "foreign" telescopes as competition, for they have never been available to US astronomers on a regular basis, and are rarely operated for outside users.

The instruments which the BFD will improve on will be the NRAO 300-foot and 140-foot telescopes, and most particularly the 300-foot. While nothing can match Arecibo in its declination range, it can reach no more than one-third of the sky, and that particular third is relatively uninteresting to galactic astronomers. Further, it is a semi-transit instrument and thus cumbersome to use. As powerful as Arecibo is, its limited sky coverage and tracking make it insufficient for many uses. This will become apparent in some of the comparisons given below.

1. Sky Coverage. With the exception of the VLA, there is no US instrument which can put an effective area > 1000 square meters in the direction of the galactic center. The BFD will have an effective area of order 5 times this value, and it will cover fully 86% of the **entire** sky. In contrast, the 300-foot can point at only 66% of the sky, and Arecibo only gets 33%. The effect of the increased sky coverage is more striking than one might imagine, for the low declinations accessible to the BFD but not to Arecibo or the 300-foot contain an exceptional concentration of interesting galactic objects including the galactic center. This is partly illustrated in the following table:

Sky Coverage

	Arecibo	300-foot	BFD
Total Sky:	33%	66%	86%
Galactic Plane:	26%	62%	80%
Pulsars:	30%	62%	77%
HII Regions:	16%	52%	70%
Globular Clusters:	18%	34%	86%

The BFD will give a major improvement in sky coverage in every category, especially for galactic objects and those concentrated toward the galactic center.

2. Sensitivity. Over the part of the sky now reached by the 300-foot telescope the BFD will increase our sensitivity mainly because it will track. At L-band the increase will be a factor of 200 in time per day, giving a possible increase in S/N of an order of magnitude. The unblocked design will give another factor of 1.5 increase in L-band sensitivity because of its higher efficiency and smaller spillover.

At declinations south of $-19°$, which are inaccessible to the 300-foot and must be covered by the 140-foot, the BFD will increase our sensitivity by a factor of 6 over its wavelength range.

The BFD will have more collecting area than the entire VLBA, and baselines that use it will have greater sensitivity by a factor of 4.

3. Freedom from Interference. This is harder to estimate, but the unblocked design should reduce sidelobes by about a factor of 20 averaged over the entire sky. In directions where there are now sidelobes caused by diffraction from the feed support legs, the improvement may be even greater. Because virtually all interference comes in through the sidelobes, its strength should be reduced accordingly. In combination with the National Radio Quiet Zone, this will make the BFD uniquely powerful, worldwide, for cm-wave radio astronomy.

4. Additional Capabilities. VLBI: Our biggest telescopes, Arecibo and the 300-foot, are both semi-transit and thus not often used for VLBI. A BFD will add major new capabilities in this area.

Galactic HI: Because of its low sidelobe levels, the BFD will be the only telescope anywhere that can provide good resolution, high dynamic-range capabilities for galactic HI. It will have no competition.

Pulsar Timing: With its extensive sky coverage, frequency range, and tracking ability, the BFD will greatly increase our capability to measure pulsar periods and their change. This is becoming an increasingly important area of research.

Tracking: Many faint spectral lines need to observed for several hours to get a detection on even the most sensitive telescope. Getting this much time on the 300-foot has been impractical (12 hours of integration time at L-band takes nearly 200 days to acquire), but will be easy for a BFD. This new capability will be important for redshifted HI studies and observation of molecular lines.