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Memo to: Paul VandenBout
From : B.E. Turner
Subject: What New Telescope for GreenBank?

WHAT SPECTRAL REGIONS BETWEEN 0 AND 115 GHZ ARE SCIENTIFICALLY IMPORTANT?

The spectral region between 0 and 115 GHz breaks up fairly conveniently into 5 regions so far as science is concerned. I briefly describe that science, then rank the importance of each region on a scale of 1 to 10, using ALL of the scale. "1" is most important, "10" least. I largely omit continuum work; others will hopefully address it.

1) 0 to 1.8 GHz:
Pulsars and 21 cm work. Hardly needs elaboration. (OH is included by going to 1.8 GHz). Requires the largest aperture possible, which is compromised by going to higher frequency. Rank = 1.

2) 1.8 to 5 GHz
Contains CH (3.3 GHz) and H_2CO (4.8 GHz). 100-meter aperture would be nice. Anything smaller means Bonn does it better. Rank = 5. Higher rank if continuum has strong need.

3) 5 to 25 GHz
primarily important for NH_3 (23.8 GHz and lower) and H_2O (22.2 GHz), but C_3H_2 (18.2 and 21.5 GHz) and a few other molecules are of interest also, which cannot be studied with the VLA. The VLA is (and will be) incapable of studying NH_3 in its low-brightness, extended-emission form which characterizes its most useful diagnostic capabilities in dark clouds. NH_3 is one of the 5 most important diagnostic molecules. Rank = 4.

4) 25 to 50 GHz
The only spectroscopic item of significant interest is the SiO masers in circumstellar envelopes (43 GHz). As a single dish item, SiO masers can always be done as well or better at 86 GHz, so the question really involves the VLBI of these objects. Little VLBI has been done at 43 GHz, and the prospects are for even less because of the rapidly improving prospects of VLBI at 3 mm. Rank = 10.

5) 70 to 115 GHz
CO studies of all kinds; molecular spectroscopy of all kinds, at unprecedented single dish resolutions and sensitivities to low surface brightness. A 70 meter class instrument would fill the void in the 3 mm window left by the demises of the NRAO 25-meter and Algonquin 46-meter resurfacing projects. CO studies of all kinds would be superbly addressed. Most of them do not require the 230 GHz lines, the primary need being high resolution and high sensitivity to low brightness; thus the comparison to make involves the 9 arcsec resolution of a 70 m dish at 115 GHz vs. the 11 arcsec resolution of the IRAM 30 m at 230 GHz. Of course, the two would complement each other. Rank = 2.

I conclude that a 70-meter telescope designed to work optimally in the to 43 GHz region is highly mismatched to scientific needs. Scientific needs are best addressed by either a very large low-frequency dish (hopefully working to 6 cm), or a dish aimed at the 3 mm window. The latter may be politically difficult, and may also be poorly matched to the GreenBank site, but still would be scientifically very important at a good site.

WHAT SHOULD WE DO?

A 70-meter telescope would have to service the following catagories:
1) Space VLBI (to which it is well matched)
2) SETI (fairly well matched, but not if the water-hole is considered of major importance).
3) Pulsars and 21 cm: poorly matched. Arguably a backward step.
4) Spectroscopy: poorly matched, and much worse if it doesn't reach 115 GHz.
5) Continuum

I assumes that each of these areas would get only a modest (~20%) fraction of the time. At present, spectroscopy receives ~ 70% of 140 ft time, plus a small amount of 300 ft time (OH and CH). Pulsars and 21 cm areas received ~ 50% of 300 ft time. Continuum receives ~ 40% of 300 ft time. Thus pulsars and 21 cm would be reduced a factor 2.5 in time and have a smaller dish (70 m vs. 91 m). Continuum would be reduced a factor of 2 and likewise have a smaller aperture (more confusion for surveys). Spectroscopy would be reduced a factor 3.5 in time, but would have a telescope superior to the 140 ft; it is difficult to estimate the overall effect on the science by these conflicting parameters, but few 140 ft users use the MPI 100-meter to complement their 140 ft work.

Obviously the space VLBI is the thrust behind the 70-meter concept, and would benefit over the 140 ft at K-band by roughly a factor of 3 in sensitivity. Most other science currently done at GreenBank stands to suffer, however.

The question of the fate of the 140 ft must be considered carefully. Descriptions of the 140 ft as being "obsolete", "expensive to maintain", "of inadequate surface accuracy and pointing to service high frequencies", need to be examined. In terms of parts and power, the 140 ft costs only about $100K more per year than the 300 ft (~ $550K vs. ~$400K, the major expense in both cases being personnel). So the question is whether a new telescope would require significantly fewer people to operate it than does the 140 ft. As to surface accuracy and pointing, the 140 ft performs entirely adequately up to 25 GHz, and probably up to 30 GHz; it is considerably superior to the Haystack antenna. Above these frequencies the science is unimportant until one reaches the 3 mm window. It is therefore entirely unclear that more science would be produced by a new 70-meter antenna which offered a factor of 3.5 less time than does the 140 ft for programs for which the latter is most used. It IS clear that user frustration in these areas would increase.

Therefore, there seem to be two possibilities for best serving the science:
1) If space VLBI is to be a driving force, we should retain the 140 ft under NSF operation, and attempt NASA funding for a new 70-meter telescope which would have space VLBI (and SETI) as its highest priorities, endeavours in which NASA has a keen interest. This plan leaves the pulsar/21 cm science at a disadvantage.
2) Alternatively, we should build a low-frequency, very large aperture instrument that replaces the 300 ft, only better, and serves the pulsar/21 cm science. If it operates to 6 cm, it also serves spectroscopy to some degree, and space VLBI perhaps to a lesser degree.

In either case, I strongly advocate retaining the 140 ft in its present operation.