NLSRT Memo No. 59

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Here are a few comments on recent memos in the technical design committee mail.

I agree with Larry's comment that the long wavelength secondary feeds are too big to be practical. From our experience at Green Bank and my feeling for the desires of the HI observers, I strongly suspect that 21-cm work will favor prime focus unless it is precluded by the secondary focus compromises. I can't emphasize enough how important 10 and 15% gains in G/T are to HI observers. I am really keen to see focal-plane array feeds developed, but it will be a long time before these match our current waveguide feed G/T's.

Also, because of feed size, I would guess that Jim Condon's multi-beam 6-cm survey receiver(s) will best be built at prime focus. Sorry to keep pushing prime focus so hard, but I would feel badly if our achievements of better G/T systems are designed out of the telescope. Remember that we are not shaping the dish, so we are not getting the efficiency gains of the VLBA design at the secondary focus either.

I see the rationale for a short F/D, but something as small as 0.30 is EXTREMELY uncomfortable for prime focus. Such a compromise would go against the fact that the pulsar and HI observers are the ones who want maximum G/T and multi-beam capability which will require efficient prime focus operation.

Sri touched on the problem when he mentioned that the hybrid mode feeds are near their cutoff size with an F/D of 0.43 and smaller F/D's will mean less efficiency. I agree with this from experience in designing the 2HE feeds.

May I recommend that you look at the article by Minnett and Thomas in Proc. IEE, Vol. 115, pp 1419-1430, 1968, reprinted in Love's book "Reflector Antennas" p 56. Figures 13 and 14 are particularly important. In this paper they calculate paraboloid focal plane fields and the theoretical maximum efficiencies obtainable with ideal hybrid mode feeds.

One conclusion to be drawn from this paper is that focal plane fields of small F/D paraboloids are fundamentally very difficult to match with waveguide feeds. In fact, for F/D's less than about 0.4 the power flow in part of the focal plane is reversed, and the area over which a given fraction of the power is spread increases with decreasing F/D. From figure 13 we can see that recovering the efficiency loss due to small F/D with bigger feeds is practically very difficult. A rough estimate from that diagram says that for the same size feed the efficiency at F/D=0.30 is about 83% of that at F/D=0.43. This is equivalent to an 8%

reduction in aperture diameter.

Figure 14 shows that the feed aperture size for a given illumination efficiency is a minimum at F/D of about 0.6. The minimum is quite broad for low efficiency feeds but rather sharp for higher efficiency prime focus feeds. This is important when considering arrays of feeds for mult-ibeaming - higher F/D and smaller feeds allow closer beam spacing up to F/D=0.6 or so.

Another consideration for multi-beam work is that the field of view for a given off-axis-feed aperture efficiency increases with increasing F/D. Mapping and source searches are an important part of long-centimeter-wave work, and increasing the number of simultaneous beams is an extremely cost effective way of increasing the efficiency of a filled aperture telescope for this work.

Roger's comment about secondary feed bandwidth is quite right. We know how to make these feeds up to 1:2 bandwidth, and we know how to make 30-40% bandwidth OMT's so we might as well do it.

In your efficiency calculations, don't forget that we have never achieved the theoretical values. Discrepancies can be quite large. For example, for our single mode feeds we calculate about 65% efficiency and get about 52%. These differences seem typical. Compare only theoretical to theoretical values or measured to measured, and be very careful about cross comparisons. An efficiency of 54% seems very optimistic with an F/D of 0.3. What does Bonn get for aperture efficiency and spillover temperature at 1 cm?

I disagree with some of the technical points of Bernie Burke's letter and much of the conservatism. The offset reflector feed is not a new development project. Our current designs will work quite nicely with slightly different detailed parameters for all but the high polarization purity case. The F/D of 0.4 is no longer magic. My guess is that it came from the prime focus feed designs of some time ago which no longer apply. Bernie mentions an f-ratio of 0.2. I guess this is the F/D of the paraboliod from which the offset reflector is cut, but that is not terribly important from the feed design point of view. The subtended angle of the actual reflector is the main criterion.

At the December meeting I expressed reservations about the mechanical problems of the offset design and proposed that we look into low-blockage symmetrical ideas. So far we have not heard much in the way of encouragement about reducing symmetrical antenna blockage by more than 30-50%, which is much less than I had hoped.

Everyone must put their own weight on various parameters in the compromises. I realize that the symmetrical design is not the last word, but it is a good focus for comments.

So far, at least, I don't see a strong improvement on the Bonn antenna emerging. The blockage is somewhat better, and the high frequency surface may be bigger, but I don't see much more, yet. The baseline problem will be just as bad on the proposed design, and that is a very severe limitation to the Bonn antenna. The millimeter wave antennas are the only ones that have made significant improvements in this area, and they have done it because of large secondary focal ratios (path length modulators).

We will be roundly criticized if we don't attack this problem in the basic design.

Interference immunity must be a strong consideration in the design. The Quiet Zone is an important element, but, if we don't improve on other telescopes in the ability to observe in the presence of satellites, the Quiet Zone advantage will be severely eroded over the lifetime of the antenna. Backends can be improved in this respect, but blockage must be aggressively reduced in this design if we are to improve on competing antennas. I've heard some valid reservations about how much scattering can be reduced, even with an offset design, but we may be forgetting that if we reduce the scattered power to about 0.5% of the feed response (about 10 dB below current designs) we can use absorber to achieve at least 10 dB additional reductions without substantial system noise penalty. Given this, a 20 dB reduction with the offset design sounds conservative.

At the risk of advocating something I don't really favor, I would make the point that, if we insist on secondary focus operation down to 50 cm, we should strongly shape the main reflector and go for maximum gain. We cannot use the potential wide field of view at secondary focus, anyway, because of size restrictions at all but the shortest wavelengths. My only point here is that we should make a big gain in AT LEAST one important parameter even if we can't say that it has a larger diameter than Bonn.