.

Receiver Considerations for 7 mm λ[1]

January, 1994

Suggested Receiver Plan

S. Srikanth, Roger Norrod and I met in late December at Ivy Road to discuss some aspects of the design of the long millimeter-wave receivers for the Green Bank Telescope (GBT). Here, I will try to summarize some of the points of that discussion.

For many scientific reasons, many of them covered in my Dec, 1991 memo (GBT memo 109), observations of the high frequency sky can be most economically accomplished with a multibeam system. The GBT beam at 50 GHz (θ=15") allows many beams across a typical cloud core, even if the closest practicable spacing of the beams is two to three beam diameters, the best that now seems possible.

Bringing the output of the multiple beams down from the telescope requires multiplexing. For the currently planned 8 GHz IF, eight interconnections between optical receivers and converter modules are available (GBT IF System draft dated 19 Nov 1993). Thus, eight beams may be supported by the currently planned IF system.

Some targets are spatially compact, and/or emit very weak signals, and will not require multiple beam observations. For maximum sensitivity on these targets, at least one of the beams should allow dual polarization observations. Optimal placement of the dual polarization beam would be along the optical axis. Presumably, if there are significant variations in detector performance, the best detectors would be located on these beams.

An optimal placement of the six remaining single polarization beams seems at present to be in a hexagon arranged about the central dual polarization beam. For beam separations of Θ=45" or 30" the maximum extent of the eight feed pattern would be 105" to 75", comparable to the sizes of beams of most telescopes operating at 3mm, and to the sizes of the cores of nearby molecular clouds. Nine distinct pointings would provide a completely sampled cross shaped 63 pixel image of 105" extent, with best sensitivity in the inner nine pixels, for the three beamwidth separation of the feeds. For a two beam separation, four pointings provide 28 pixels extending over 90". Larger areas might be covered most effectively using 'on-the-fly' mapping and appropriate

[1] Al Wootten, NRAO, Charlottesville

data binning. At the moment the utility of having the independent beams at independent frequencies escapes me, unless several beams happened to fall on distant galaxies at differing redshifts. It would, of course, be useful to be able to place the beams independently spatially, as can be done with multiple input spectrometers on optical telescopes such as OCTOPUS. One approach to this proposed by John Bally was discussed at the Fall 1991 future instrumentation workshop.

To track parallactic angle on the sky, provision should be made to rotate the feed structure through at least $\pm 95^o$

Ideally, the frequency range of the system would cover the range spanned by the SiO resonance emission at 43 GHz at the lower end, and by the C_3H_2 resonance emission at 52 GHz.

S. Srikanth has discussed some design criteria for the tertiary reflector in GBT Memo #82 and in a document dated 11 Nov 1993. As noted in GBT Memo 109, there is potential for the GBT to be able to detect thermal dust emission from protoplanetary systems in nearby clouds of the mass of the minimum mass solar nebula in seconds. Many millimeter continuum systems do not integrate noise down well after ten minutes or so; even if the continuum limit of the GBT is set by a ten minute integration at 7mm it should be capable of detecting dust emission from luminous galaxies at z=2-3, such as that from IRAS10214, at the tens of μJy level. To maximize sensitivity at 7mm, provision should be made to rotate the tertiary so that atmospheric emission at constant air mass may be subtracted with highest accuracy. The tertiary should be place in as cold an environment as possible also, to minimize pickup of thermal radiation. The tertiary should chop over a 4 arcminute throw at 10Hz, and there may be some utility to having a throw as large as 8 arcminutes, but frequencies below 3 Hz will compromise the efficiency of atmospheric subtraction.

As the GBT could provide the most sensitive measurements of the thermal dust emission from protoplanetary systems in the world, it would be extremely useful to know the spectral index of that emission. These measurements are extremely difficult, even on the IRAM 30m at 3mm. At higher frequencies, dust opacity in the infall envelope may be substantial, and measured fluxes reflect conditions in the envelope more than those in the disk. For this reason, it would be useful to divide the broadband measurements (10 GHz bandwidth was assumed for the cases mentioned above) into smaller bands[2]. Ideally, half a dozen or so separate frequencies would cover the 7mm band for the dual polarization central beam receivers. Across a 20% bandwidth, the flux of a typical source would increase by a factor of two or so from 40 to 50 GHz. A multiband continuum system could provide both accurate flux and spectral index measurements after tens of minutes or less integration.

[2] Lee Mundy, private suggestion