Notes on GBT 3mm Receiver CoDR Al Wootten

A correlation receiver operating within the 3mm band was discussed. The receiver could cover any of several ranges within that band but at least two are needed to cover the whole band. There was some discussion as to what range should be covered by the first receiver–one of those two, or one centered on the most transparent portion of the window. The MAP correlation receiver upon which the design is to be based had a design bandwidth of 1.26; 1.3 might be more appropriate to cover the whole range of interest from the atmospheric cutoff at about 68 GHz up to the 1-0 line of N_2H^+ at 93.17 GHz. Within the ALMA project, this band is known as Band 2, with Band 3 going from 90 - 116 GHz. For that project the pressures of available funds have resulted in a high priority for Band 3, the prime band for pointing, focus and phase calibration, and postponement of deployment of Band 2. As a result, receiver engineers have been asked to extend the coverage of Band 3 to 84 Ghz. Note that the only other NRAO instrument operating in this range, the VLBA, covers 80 - 95 Ghz. Hence construction of the GBT receiver in the range of ALMA Band 2 results in good overlap with both ALMA and the VLBA and takes advantage of the expected better performance of the GBT at the lower end of the 3mm band. But the primary advantage offered by this receiver is the unique science capabilities it offers.

First, it offers excellent coverage of various redshifts over which CO in distant galaxies might be searched. Table 1 shows these redshift ranges.

Freq/Transition	**1-0**	**2-1**	**3-2**	**4-3**
116 GHz	-0.01	0.99	1.98	2.97
93.2 GHz	0.24	1.47	2.71	3.94
90 GHz	0.28	1.56	2.84	4.12
84 GHz	0.37	1.75	3.12	4.49
68 GHz	0.80	2.39	4.09	5.78

From the Table, one can see that except for small gaps, most z are covered; for parts of the range two CO lines may be observed at opposite ends of the band at once, providing secure redshift identification. In Figure 1, a composite spectrum of M82 scaled to a luminosity of 3 x 10^{12} L_{sun} prepared by Cox and Beelen is shown, with ALMA bands superposed. The red dashed line shows the sensitivity of ALMA in a transit observation; the GBT sensitivity should be similar. The continuum levels of redshifted galaxies will be between 5 and 50 microjanskys for z>1. In this region of the spectrum, the CO lines should outshine the continuum, suggesting that it is most appropriate for the GBT to concentrate on line emission (though the line to continuum ratio could be a rough indicator of redshift, and continuum measurements are not beyond reach as we might expect to reach 17 microJy in an hour). Note that optical and UV observations suggest that strong evolution in star formation within galaxies occurred between redshifts near 0.5, well covered by the 70-90 Ghz receiver but poorly addressed at the upper end of the band; the GBT is well suited to obtaining CO and continuum observations in this important redshift range.

A further area of scientific interest in the 68-93 band is astrochemistry. The band is

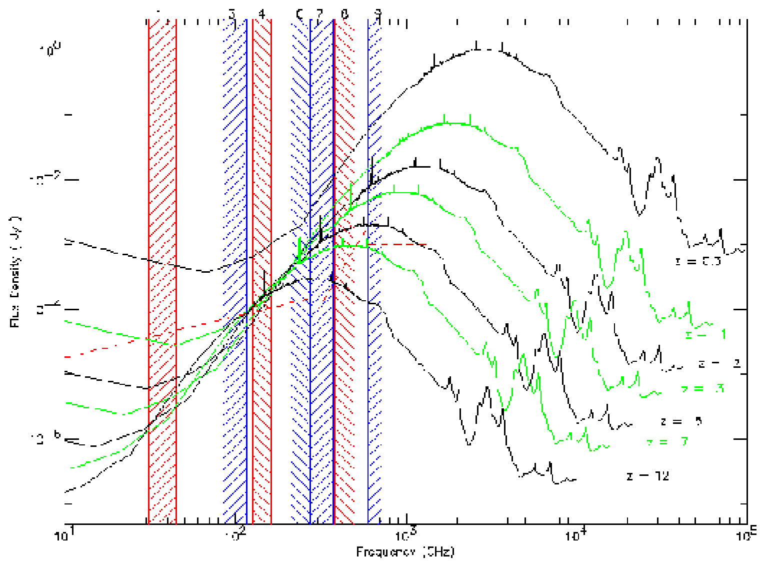

Figure 1 Redshifted composite spectra of an enhanced luminosity M82 at various redshifts. ALMA bands are superposed, along with ALMA sensitivities along the dotted red line. 70-90 GHz is ALMA Band 2, just to the left of the hatched Band 3 region. Figure by P. Cox.

currently unaddressed by any major telescope beside the NRO 45m. The fundamental lines of the most important deuterium isotopomers all lie within this band, as do the fundamental transitions of the primary isotopomers. At facilities such as the NRAO-12m which did address the 68-93 band, observations of deuterated molecules formed a hefty portion of the science requested for the band, reaching a third of all proposals during some semesters; a similar pressure has been found by the CSO for observations of other deuterium isotopomers with submillimeter transitions. Deuterium abundance offers a useful probe of cloud temperature, ionization level and astration. While the fundamental lines would be encompassed in a receiver covering 84-116 Ghz, the abundant and important formaldehyde molecule's ground state transition at 72 GHz would not. Toward a typical star-forming cloud, roughly half the column density of these molecules lies in cold gas most effectively probed by these fundamental transitions. The window has been a prime target for astronomical line searches and many additional lines including astrobiologically important molecules will fall within the window.