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Memo from G.A.Ediss
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Optics for a 86 to 116 GHz test receiver in JT1

I have made preliminary calculations of the optics which would be required for a 86-116 GHz receiver and which could fit in the present JT1 dewar. Assuming ALMA telescope optics to be F# 8 and a secondary edge taper of 14 dB, the telescope waist (w = 8.7dB radius) varies from 22.6 mm at 86 GHz to 16.7 mm at 116 GHz. The minimum size for any optical element (i.e. window at the waist, 5*w) is then 113 mm (~4.5 inches), and for matching to a feed horn with a 10 to 12 degree 8.7 dB half beam width a minimum focal length of 98.8 mm is needed. This is much to large to fit in the dewar.

A second possibility is the use of a Gaussian telescope with two optical elements, this can match the two waists with a third intermediate one, but still has a minimum size of 113 mm on the telescope side, and requires greater path lengths. The first element could be a lens however, which would produce a small enough waist at the dewar window. This could then be transformed to the ALMA waist at a later stage, if required, by a large external mirror. In order to pass through the dewar window with no diffraction the waist should be at the position of the window and be smaller than 14.8 mm (6*w for a window diameter of 3.5 inches). In order to fit the present dewar I would recommend a f = 45 mm lens which will produce a 9.8 mm waist at the window. This has an 8.7 dB half angle of 6.5 degrees at 86 GHz. The lens should have a diameter of > 2.2 inches and would have a thickness of approx. 15 mm (giving a loss of 0.03 dB at 90 GHz for HDPE).

At a distance of 150 mm (the minimum possible for the center of the chopper wheel) the beam will have expanded to a diameter of 100 mm (5*w) which easily passes though the hole in the chopper wheel (150 mm). The center of the chopper can be moved to a maximum distance of 275 mm from the dewar before diffraction becomes a problem.

A further consideration is the size of the cold load used in the chopper measurements (12*12 inches). This can be at over 600 mm from the dewar window before there is a spillover of 1%.