Amplitude calibration load design proposal

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This hot calibration load is designed for the ALMA frequency bands 3-10. However, it is also expected to have acceptable performance for the bands 1 and 2. This design has as well has potential to fulfill requirements for the ambient load to cover bands 1-10, although some modifications to the “pocket” absorber may be needed based on the outcome of further analysis.

The main cone has an input aperture of 100 mm and a length of 230 mm, corresponding to 24 degree full opening angle. This will allow 7 reflections for the plain wave before it comes out the cone. Crude estimates have shown that 7 reflections are minimum required to obtain <-60 dB return loss requirement with some margin. Input aperture of the cone is 100 mm, corresponding to 4.5 beam radius at 85 GHz*, bottom of the band 3. This corresponds to about -45 dB of the total power falling outside the main cone at that frequency. At frequencies 100 GHz and up the input aperture is 5 beam radius, corresponding to -55 dB edge taper*.

The cone will be casted with Eccosorb, 110-114, with 1-3 mm thickness, choice of Eccosorb type and its thickness will be made based on the outcome of the development program, which will aim to optimize all parameters to fulfill requirements on the return loss and emissivity at the same time. It is also envisaged to optimize coating thickness along the cone, if necessary, to improve thermal uniformity.

At the input of the cone we envisage to have a blacked reflector. This is very similar to a “Christmas tree” idea and this design was analyzed by A. Murk, showing acceptable performance. The currently proposed design has to be analyzed as well, although I expect only improvement in performance since the input aperture of the system has been reduced by a factor of 2. To insure better thermal uniformity of the air around the absorber and also to account for some absorption in that, it is proposed to heat this reflector as well. We don’t need to have it precisely of the same temperature, but getting close to the main cone temperature would be enough.

To accommodate lower frequency bands, extra absorber “pocket” is being proposed. It has an irregular shape and thus more difficult to accommodate uniform coating by means of casting. However, since it is meant only for the bands 1 and 2, surface roughness here is not very important, so that simply painting it black with SiC filled Stycast should do. There is room for material choice here; it is very likely to have a better absorber for these frequencies. This “pocket” absorber should be heated as well. Thermal accuracy of that has to be looked into. However, this will only be of some importance for the band 1, because even +-10 K accuracy should be good enough here for the 70 GHz of band 2 because the edge taper at this frequency is -30 dB* (0.1% of total power will be absorbed in this pocket). I propose to use 1-2 mm thick Al as backing material, and introduce a separate from the main cone thermal control to heat up this as well as the reflector.

This design has a potential to be used for ambient load as well, more simulations are needed here. Especially important will be optimization of coating thickness for the lower frequencies, as Eccosorb absorption decreases substantially towards longer wavelengths. On the other side, we expect smaller

thermal gradient between the varying ambient and the metal backing, so that the trade-off will have to made based on dedicated analysis using electromagnetic and thermal models already developed by A. Murk and his colleagues at UB.

*Edge taper calculations assume Gaussian beam, these are probably too optimistic for the “real” ALMA beams, such calculations have to be redone using GRASP simulations of the ALMA optics.