To indicates that the time dependence ferers to the post-sampling bandwidth (not the pre-sampling one) $1/\sqrt{Hz}$ is usualy replaced by $\sqrt{s}$ in the units.

With efficiency for best observing mode for each architecture, including the bandwidth factor:

$\eta_{ob} := \sqrt{\frac{2}{0.8}}$ $\eta_{ob} = 1.6$ $\eta_{ob}^2 = 2.5$ $\eta_{oh} := \sqrt{\frac{2}{0.45}}$ $\eta_{oh} = 2.1$ $\eta_{oh}^2 = 4.4$

bare pixel, FWHM beam

$$bNET_{Tb} := \frac{\eta_{ob}}{\sqrt{2}} \cdot pNET_{Tb1}$$

$$bNEFD_{Tb} := \frac{\eta_{ob}}{\sqrt{2}} \cdot pNEFD_{Tb1}$$

heterodyne full beam

$$bNET_{Th} := \frac{\eta_{oh}}{\sqrt{2}} \cdot pNET_{Th}$$

$$bNEFD_{Th} := \frac{\eta_{oh}}{\sqrt{2}} \cdot pNEFD_{Th}$$

$$bNET_{Tb} = \begin{pmatrix} 0.37 & 0.46 \\ 0.40 & 0.75 \\ 0.37 & 1.17 \\ 1.35 & 16.70 \end{pmatrix} mK\cdot\sqrt{s}$$

$$bNEFD_{Tb} = \begin{pmatrix} 2.1 & 2.6 \\ 2.6 & 4.8 \\ 3.5 & 10.7 \\ 23.1 & 284.5 \end{pmatrix} mJy\cdot\sqrt{s}$$

Column 1 (2) = results for 1 (7) mm of water vapor.

Lines correspond to:

$$\lambda = \begin{pmatrix} 3.2 \\ 2.1 \\ 1.3 \\ 0.9 \end{pmatrix} mm$$

$$bNET_{Th} = \begin{pmatrix} 0.56 & 0.73 \\ 0.61 & 1.25 \\ 0.55 & 2.02 \\ 2.14 & 29.50 \end{pmatrix} mK\cdot\sqrt{s}$$

$$bNEFD_{Th} = \begin{pmatrix} 2.7 & 3.5 \\ 3.3 & 6.7 \\ 4.3 & 15.3 \\ 32.3 & 440.8 \end{pmatrix} mJy\cdot\sqrt{s}$$

Remark: I use a prefix letter in front of NET and NEFD to stress the existence of these different definitions, and to stress that authors in litterature are not always clear about the one they use !

MAMBO 2

MAMBO 2 pixels have a measured noise of ~40 mJy on data chopped with 0.52 sec and 0.22 sec integration time per phase [Zylka, private communication]. Both MAMBOs rms after 10 minutes of integration with skynoise removal is 1.5 mJy [S.Leon on the 30m Telescope Summary IRAM page]. Mean rms sensitivity measured is ~32 mJy*s$^{1/2}$ [S.Leon on the iram.es Main Wiki noise Stat page]. Pixels tables of sensitivity give NEFD of 20 to 35 (units not specified !) [F.Bertoldi MAMBO pages on MPiFR uni-bonn.de web site].
All these incomplete references seem to indicate that MAMBO bNEFD is about 30 mJy*s$^{1/2}$ (pixel same size as beam). Indeed:

Zylka observing factors: $\frac{0.22}{0.52} = 0.42$ thus bNEFD (assuming 1σ measured noise) $40\cdot\sqrt{\frac{0.42\cdot 2}{2}} = 26$ mJy*s$^{1/2}$

Assuming S.Leon integrated rms is 1σ, it gives a NEFD: $1.5\cdot\sqrt{600} = 37$ mJy*s$^{1/2}$

==> the measured sensitivities are not clearly defined, and fluctuate between 20 and 40 mJy*s$^{1/2}$.
==> there's a factor 10 difference with the theoretical calculations above, but I can't find any document about the theoretical expected sensitivity for MAMBO.

Quick calculations using rough rectangle fit to spectral response from MPiFR web page, assuming good weather conditions (1mm wv), and optical chain transmissions similar to λ_2:

$\lambda_M := 1.2mm$ $\nu_M := \frac{c}{\lambda_M}$ $\nu_M = 250\,GHz$ $\Delta\nu_M := 80GHz$ $\eta_M := 0.8$ $\lambda_2 = 1.25\,mm$

$$P_{TM} := \eta_M \cdot \upsilon_h \cdot \lambda_M^{\ 2} \cdot \Delta\nu_M \cdot \left(\begin{array}{l} eta(\nu_M, 0, 2, F_{efTh}, nfh) \cdot B(T_{atm}, \nu_M) \ ... \\ + ett(\nu_M, na, 2, F_{efTh}, nfh) \cdot B(T_{tel}, \nu_M) \ ... \\ + et77(\nu_M, na, 2, na, na) \cdot B(77K, \nu_M) \end{array} \right)$$

Background power: $\boxed{P_{TM} = 75\,pW}$

Poissonian shot noise: $NEP_{Mp} := \sqrt{2h \cdot \nu_M \cdot P_{TM}}$

Bunching noise (max theoretical value: i.e. assuming Δ=1, maybe much less in reality, see III.3.): $NEP_{Mb} := \dfrac{P_{TM}}{\sqrt{\Delta\nu_M}}$

$NEP_{Mp} = 16 \dfrac{10^{-17} W}{\sqrt{Hz}}$ $NEP_{Mb} = 27 \dfrac{10^{-17} W}{\sqrt{Hz}}$ $NEP_{TM} := \sqrt{NEP_{Mp}^{\ 2} + NEP_{Mb}^{\ 2}}$

Total transmission efficiency from sky to pixel: $\eta t := \eta_h(u_h, \nu_M) \cdot \left(ta(\nu_M, 0) \cdot tt \cdot to \cdot tf^{\ nfh+1} \cdot \eta_d \right)$

=> Theoretical OnOff sensitivity: $NEFD_{TM} := \sqrt{\dfrac{1}{0.42}} \cdot \dfrac{NEP_{TM}}{A \cdot \eta t \cdot \Delta\nu_M}$ $\boxed{NEFD_{TM} = 3.8\,mJy \cdot \sqrt{s}}$

==> Why is there a **factor ~7 between the theoretical optimal NEFD and the best measures**, whereas MAMBO is said to be nearly background limited ?

- If this excess NEFD was **only** due to the **pixel intrinsic noise**, then **NEP_{pix}~7*NEP_{TM}** ! Which looks surprisingly far from the expected specifications !
- If the pixel is background limited (**NEP_{pix}<<NEP_{TM}**). The only two other possible hypothesis explaining the difference between the theoretical optimal noise and the measured noise are: (1) sky noise, (2) a **supplementary attenuating componant in the optical chain**. Sky noise must be correlacted to the independant real time measures of the atmosphere opacity; this is the case in the observed data down to the ~30 $mJy \cdot \sqrt{s}$ floor. Only remains the 2nd hypothesis. The atmosphere and telescope dominates the background.

-- **If** the supplementary attenuating componant is a pure grey body (**e_{sup}+t_{sup}=1**) with **T_{sup}~T_{atm}~T_{tel}**, then the total background power is roughly unchanged (P_{sup}+P_{TMnew}~=P_{TMold}), thus the NEP, then from the formula above $NEFD_{measured}$=GM*$NEFD_{TM}$:

$GM := 7$ $t_{sup} := \dfrac{1}{GM}$ $t_{sup} = 14\,\%$

-- **If** the supplementary componant is such that P_{sup}<<P_{TMnew}, so **P_{TMnew}~=t_{sup}*P_{TMold}**, which and be reach if the supplementary componant is partially reflective and/or has a low temperature, then t_{sup} can be calculated from the formula above and $NEFD_{measured}$=GM*$NEFD_{TM}$:

$$t_{sup} := \frac{2 \cdot h \cdot \nu_M \cdot P_{TM}}{\left(\sqrt{0.42} \cdot A \cdot \eta t \cdot \Delta\nu_M \cdot GM \cdot NEFD_{TM}\right)^2 - \dfrac{P_{TM}^{\ 2}}{\Delta\nu_M}} \qquad t_{sup} = 0.54\,\%$$

Every other possible optical caracteristics of the supplementary component stands between these two extremes, and both are too bad to explain the measured excess noise ! So what's wrong with MAMBO 2 ? Is there really something wrong with the instrument ? Or something really wrong in the optical chain ? Or something wrong in the theoretical calculations I did ? Or a combination of several of these options ?