CBM TRD radiator simulation in CbmRoot*

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The transition radiation photon yield of a periodic radiator with N_f layers of thickness l_1 and spacing l_2 can be effectively described by

$$\frac{dN}{d\omega} = \frac{4\alpha}{\omega(\kappa+1)} \frac{(1-\exp(-N\sigma))}{(1-\exp(-\sigma))} \sum_n \Theta_n \left(\frac{1}{\varrho_1 + \Theta_n} - \frac{1}{\varrho_2 + \Theta_n} \right)^2 [1 - \cos(\varrho_1 + \Theta_n)] \quad (1)$$

according to [1] with σ being the total photon absorption cross section σ ($\sigma = \mu_1 \cdot l_1 + \mu_2 \cdot l_2$) for one foil and gas layer. This equation includes coherent and incoherent effects as well as the self-absorption of gap and foil material. Therefore it was used to calculate the total transition radiation (TR) yield per keV in CbmRoot. The variables are defined as

$$\varrho_i = \frac{\omega l_1}{2c} \left(\gamma^{-2} + \left(\frac{\omega_{P,i}}{\omega} \right)^2 \right), \quad (2)$$

and

$$\kappa = \frac{l_2}{l_1} \quad (3)$$

$$\Theta_n = \frac{2\pi n - (\varrho_1 + \kappa\varrho_2)}{1+\kappa} > 0. \quad (4)$$

The resulting TR photon yield spectrum is folded with the detector absorption spectrum (presented in Figure 1) to obtain the effective energy deposition spectrum in the active gas volume of the detector. Systematic deviations between measurements and theoretical predictions arising from the material budget between radiator and MWPC and radiator material and irregularity can be compensated by adding an attenuation factor a [0,1], with:

$$\left(\frac{dN}{d\omega} \right)_{measurement} = a \cdot \left(\frac{dN}{d\omega} \right)_{simulation} . \quad (5)$$

The parameters N_f, l_1 and l_2 have been measured for regular radiator or approximated for irregular radiators for each radiator prototype. The attenuation factors a have been evaluated by comparing in beam measurements and simulation as presented in Figure 2. For most radiators simulations and measurements are found to be in agreement within errors. Radiators B++, K++ and H have been implemented in CbmRoot. B++ is a classical foil Radiator made from POKALON (N_f=350, l_1=24 μm, l_2=700 μm and a=0.65), K++ is a micro-structured self-supporting foil radiator with the same parameters like B++. The best irregular radiator prototype is H made from 125×2 mm thick Polyethylene foam foils with an average bubble diameter of 900 μm, an average l_1 of 12 μm and a=0.78.

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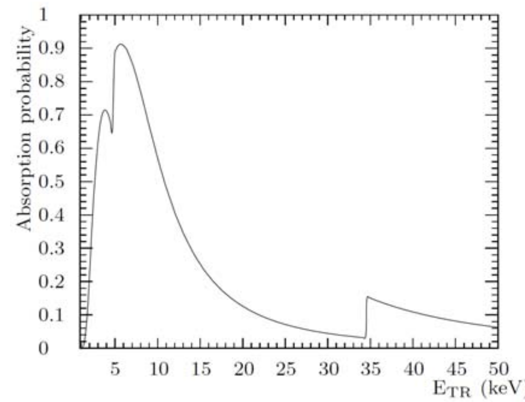

Figure 1: Approximate photon absorption probability of the 2012 MS prototypes using $XeCO_2$ (80/20).

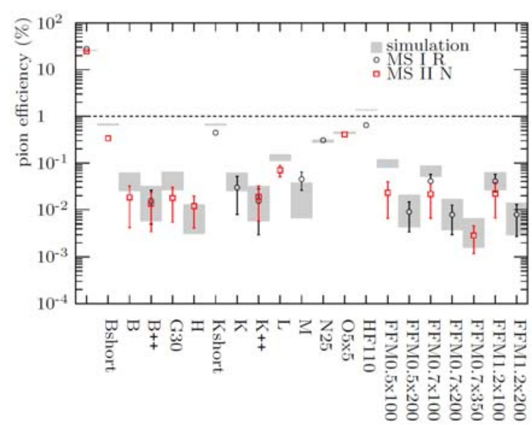

Figure 2: Comparison of different radiators showing the pion efficiency at 90% electron efficiency with 10 detector hits. The design goal for CBM TRD consisting of 10 detecor layers is indicated by the dashed line.

References

[1] M. N. Mazziotta, "A Monte Carlo code for full simulation of a transition radiation detector", `arXiv:physics/9912042 [physics.comp-ph]`, 2000