5 Detector response corrections: correction

5.2 Energy resolution and threshold cut-off

We illustrate this effect by considering the case of two PMTs run in coincidence, each with the same threshold. If the two PMTs are balanced so that an event produces the same mean number of photoelectrons in each, then, for an event producing n photoelectrons in total, the best estimates of the probabilities that $m(\leq n)$ arrive at one PMT and $n-m$ at the other are:

$$p_n(m) = e^{-n} n^m / m!$$

$$p_n(n-m) = e^{-n} n^{n-m} / (n-m)!$$

with, therefore, overall probability

$$p_{n,2}(m) = \frac{K}{m!(n-m)!}$$

where K is a normalization factor such that $\sum_{m=0}^{n} p_{n,2}(m) \equiv 1$; *i.e.* $K = n!/2^n$.

Then, for coincidence counting with a threshold of $\geq n_t$ photoelectrons in each PMT, only those events for which $n_t \leq m \leq n - n_t$ (in each PMT) are accepted. Hence the counting efficiency is

$$\eta(n, n_t) = \frac{\sum_{m=n_t}^{n-n_t} n!/m!(n-m)!}{\sum_{m=0}^{n} n!/m!(n-m)!} \tag{5.6}$$

where the $n!$ numerators are retained to avoid computational problems. An approximate analytic fit to this is:

$$\eta(n, n_t) \approx 1 - \exp\left[\frac{-2(n - 1.88 n_t + 0.66)^{1.5}}{n}\right] \tag{5.7}$$