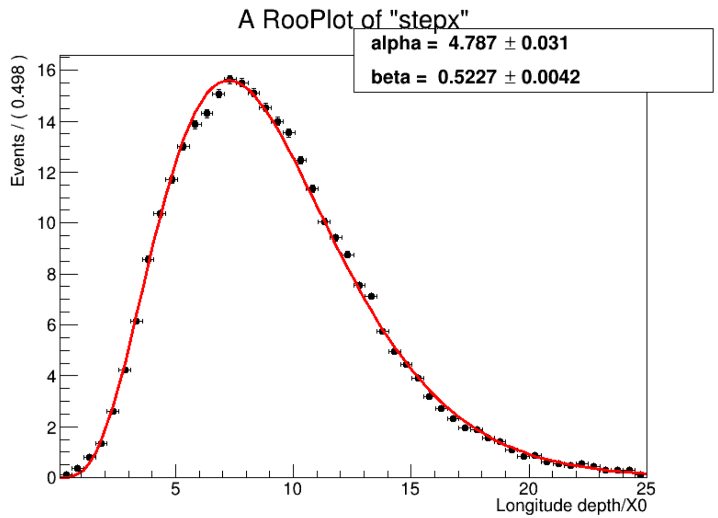
EM shower profile

Longitudinal profile

Fit longitudinal profile for 30GeV photon

- Perform fit for truth G4step.
- $\left\langle \frac{1}{E}\frac{dE(t)}{dt} \right\rangle = f(t) = \frac{(\beta t)^{\alpha-1}\beta\,\exp(-\beta t)}{\Gamma(\alpha)},\ \langle t \rangle = \frac{\alpha}{\beta},\ T = \frac{\alpha-1}{\beta}$
- For each event, iterate to get the shower maximum depth T
- Fit the profile for 100 single photon.



Radial profile

RADIAL PROFILE

Average radial energy profiles,

$$f(r) = \frac{1}{dE(t)} \frac{dE(t,r)}{dr}, \tag{22}$$

at different shower depths in pure uranium are presented in Fig.9. These profiles show a distinct maximum in the core of the shower which vanishes with increasing shower depth. In the tail ($r \gtrsim 1 R_M$) the distribution looks nearly flat at the beginning ($1-2X_0$), becomes steeper at moderate depths ($5-6X_0$, $13-14X_0$), and becomes flat again ($22-23X_0$). A variety of different functions can be found in the literature to describe radial profiles [14, 15, 16, 17, 18, 5]. We use the following two component Ansatz, an extension of [5]:

$$\begin{aligned} f(r) &= p f_C(r) + (1-p) f_T(r) \\ &= p \frac{2 r R_C^2}{(r^2+R_C^2)^2} + (1-p) \frac{2 r R_T^2}{(r^2+R_T^2)^2} \end{aligned} \tag{23}$$

with

$$0 \le p \le 1.$$

Here R_C (R_T) is the median of the core (tail) component and p is a probability giving the relative weight of the core component. For the shower depth $1-2X_0$ the distributions $f(r)$, $pf_C(r)$, and $(1-p)f_T(r)$ are also indicated in Fig.9.

The following formulae are used to parameterize the radial energy density distribution for a given energy and material:

$$\tau = t/T$$

$$R_{C,hom}(\tau) = z_1 + z_2 \tau \tag{24}$$

$$R_{T,hom}(\tau) = k_1 \{\exp(k_3(\tau - k_2)) + \exp(k_4(\tau - k_2))\} \tag{25}$$

$$p_{hom}(\tau) = p_1 \exp\left\{\frac{p_2 - \tau}{p_3} - \exp\left(\frac{p_2 - \tau}{p_3}\right)\right\} \tag{26}$$

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with

$$\begin{aligned} z_1 &= 0.0251 + 0.00319 \ln E \\ z_2 &= 0.1162 + -0.000381 Z \\ k_1 &= 0.659 + -0.00309 Z \\ k_2 &= 0.645 \\ k_3 &= -2.59 \\ k_4 &= 0.3585 + 0.0421 \ln E \\ p_1 &= 2.632 + -0.00094 Z \\ p_2 &= 0.401 + 0.00187 Z \\ p_3 &= 1.313 + -0.0686 \ln E \end{aligned}$$

Radial profile

Divide steps by longitudinal depth(X0)

Perform a unbinned simultaneous fit in $t \in [5, 9]$.

$$
\begin{aligned}
z_1 &= 0.0251 + 0.00319 \ln E \\
z_2 &= 0.1162 + -0.000381 Z \\
k_1 &= 0.659 + -0.00309 Z \\
k_2 &= 0.645 \\
k_3 &= -2.59 \\
k_4 &= 0.3585 + 0.0421 \ln E \\
p_1 &= 2.632 + -0.00094 Z \\
p_2 &= 0.401 + 0.00187 Z \\
p_3 &= 1.313 + -0.0686 \ln E
\end{aligned}
$$