Brems by Target Atmoc Electrons

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Let

$$
\begin{aligned}
m_e &= \text{electron mass} && (1)\\
M &= \text{incident charge particle mass } > m_e && (2)\\
E &= \text{incident energy} && (3)\\
\gamma &= E/M = \frac{1}{\sqrt{1-\beta^2}} && (4)\\
t &= \text{emitted brems gamma energy} && (5)\\
w_m &= \text{max possible knock-on electron kinetic energy} && (6)\\
&= \frac{2m_e(\gamma\beta)^2}{1+2\gamma m_e/M+(m_e/M)^2} && (7)\\
&\to 2m_e\beta^2 \quad (m_e/M \ll 1, \gamma \to 1) && (8)\\
&\to \frac{2}{3}E \quad (m_e/M \ll 1, \gamma \sim M/m_e) && (9)\\
&\to E \quad (1/m \ll 1, \gamma \gg M/m_e) && (10)\\
u &= w_m/m_e && (11)\\
& && (12)
\end{aligned}
$$

For a mass m particle, the target brems is considered when $E\sqrt{\frac{m_\mu}{m}} > 5(\text{GeV}/m_e)$, i.e, if $m \sim 16$ GeV/m_e, $E >\sim 60$ GeV/m_e, where $\sim 0.4\%$ effect is expected. At 1.2 TeV/m_e, the effect will be $\sim 2\%$.

Let express brems photon energy by t and the distribution be $f(t)dt$

Then, with $u = w/m_e$,

$$I(0 \sim w) = \int_0^w tf(t)dt = 0.00116(\log(2\gamma) - \log(2u)/3)\log^2(2u) \qquad (13)$$

$(0.00116 = \alpha/2\pi)$

Full $= I(0 \sim w_m)$

Cutted $= I(0 \sim w_0)$

Restricted $=I(w_0 \sim w_m) = Full - Cutted = I(0 \sim w_m) - I(0 \sim w_0)$

Then, $(a = 0.0016)$

$$\frac{dI(0 \sim w)}{dw} = wf(w) = \frac{du}{dw}\frac{d}{du}\left[a(\log(2\gamma) - \frac{\log(2u)}{3})\log^2(2u)\right] \tag{14}$$

$$wf(w) = \frac{1}{m_e}\frac{a}{u}\log(2u)[2\log(2\gamma) - \log(2u)] \tag{15}$$

$$f(w) = \frac{a}{(m_e u)^2}\log(2u)[2\log(2\gamma) - \log(2u)] \tag{16}$$