Project: PS-TGT-12-001 Hall A Tritium Target

Tittle: Beam energy loss for the Be isolation window

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Code(s) of Record:

Reference:

Leo: Techniques for Nuclear and Particle Physics

Description:

General calculations for beam energy loss in Be isolation window. Calc follows Bete-Bloch with simplified parameterization of density effect instead of full Sternheimer's. Only electron collision energy loss is considered.

Reference Drawing(s):

TGT-103-1002-0001 Be window assy

Units and constants:

$$eV := 1.602 \cdot 10^{-19} \cdot J$$

$$MeV := 10^{6} \cdot eV$$

$$r_e := 2.817 \cdot 10^{-13} \cdot cm$$ classical radius of electron

Collision energy loss of elecron beam on target material. The method is from Leo. The shell correction is neglected.

Beam properties:

$I_{beam} := 30 \cdot \mu A$ beam current

$m_e := 0.511 \cdot \frac{MeV}{c^2}$ electron rest mass

$E_e := 10000 \cdot MeV$ Beam energy

$\tau := \frac{E_e - m_e \cdot c^2}{m_e \cdot c^2} = 1.957 \cdot 10^4$ kinetic enervy of e- in units of m_e

$P_e := \frac{1}{c} \cdot \sqrt{E_e^{\,2} - \left(m_e \cdot c^2\right)^2}$ momentum of e-

$v_e := \sqrt{\frac{P_e^{\,2}}{m_e^{\,2} + \frac{P_e^{\,2}}{c^2}}}$ velocity of e-

$\beta := \frac{v_e}{c}$ beta

$\gamma := \frac{1}{\sqrt{1 - \beta^2}}$ gamma

$X := \log(\beta \cdot \gamma) = 4.292$

$\eta := \beta \cdot \gamma = 1.957 \cdot 10^4$

Energy loss in the Be isolation window

$L_x := 0.008 \cdot in$ — length of absorber material

$Z := 4$ — Atomic number

$A := 9.012 \cdot \frac{gm}{mol}$ — Atomic weight

$\rho := 1.85 \cdot \frac{gm}{cm^3}$ — density

$$I := \text{if } Z < 13 \quad \left\| (12 \cdot Z + 7) \cdot eV \right. \quad \text{else} \quad \left\| \left(9.76 \cdot Z + 58.8 \cdot Z^{-0.19}\right) \cdot eV \right.$$

Ionization potential

$hv_p := 28.816 \cdot \sqrt{\frac{\rho \cdot Z}{A}} \cdot eV \cdot \sqrt{\frac{cm^3}{mol}} = 26.112\ eV$ — plasma energy

$C_1 := -2 \cdot \left(\ln\left(\frac{I}{hv_p}\right) + 1\right)$ — constant

$$\delta := \text{if } X < 3 \quad \left\| 4.6052 \cdot X + C_1 + \frac{C_1}{27} \cdot (3 - X)^3 \right. \quad \text{else} \quad \left\| 4.6052 \cdot X + C_1 \right.$$

$$F_t := 1 - \beta^2 + \frac{\frac{\tau^2}{8} - (2 \cdot \tau + 1) \cdot \ln(2)}{(\tau + 1)^2}$$

first function of τ

$$dE := -2 \cdot \pi \cdot N_A \cdot r_e^{\,2} \cdot m_e \cdot c^2 \cdot \rho \cdot \frac{Z}{A} \cdot \frac{1}{\beta^2} \cdot \left(\ln\left(\tau^2 \cdot \frac{(\tau+2)}{2\left(\frac{I}{m_e \cdot c^2}\right)^2} \right) + F_t - \delta \right)$$

Power loss in the Be window:

$$Q_{Be} := dE \cdot L_x \cdot \frac{I_{beam}}{e_c} = -2.387\ W$$