

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

Title: 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 electron 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 energy of e- in units of m_e

$$P_e := \frac{1}{c} \cdot \sqrt{E_e^2 - (m_e \cdot c^2)^2}$$

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

$L_x := 0.008 \cdot \text{in}$ length of absorber material

$Z := 4$ Atomic number

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

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

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

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

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

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

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

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