Project: PS-TGT-14-001 Hall A Tritium Target

Tittle: Multiple scattering of the electron beam in 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 multiple scattering in Be isolation window. Given the distance of 15 cm from isolation window to target window, the effects of multiple scattering are considered on the target. Lowest expected beam energy is chosen for this calc.

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

Beam properties:

$I_{beam} := 20 \cdot \mu A$ beam current

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

$E_e := 1000 \cdot MeV$ Beam energy

$\tau := \frac{E_e - m_e \cdot c^2}{m_e \cdot c^2} = 1.956 \cdot 10^3$ 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

$X := \log(\beta \cdot \gamma) = 3.292$

$\eta := \beta \cdot \gamma = 1.957 \cdot 10^3$

Be isolation window properties

$L_x := 0.008 \cdot in$ thick of window material

$Z := 4$ Atomic number

$A := 9.012$ Atomic weight in gm/mol

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

Multiple scattering angle

$x := \rho \cdot L_x \cdot \frac{cm^2}{gm}$

$p_e := P_e \cdot \frac{c}{MeV}$

$F := 0.9$

$\chi_c := \sqrt{0.157 \cdot \left(\frac{Z \cdot (Z+1)}{A}\right) \cdot \frac{x}{p_e^2 \cdot \beta^2}}$

$\chi_a := \frac{0.0045}{p_e} \cdot Z^{\frac{1}{3}} \cdot \sqrt{1 + 3.34 \cdot \left(Z \cdot \frac{\alpha}{\beta}\right)^2} = 7.153 \cdot 10^{-6}$

$\Omega := \frac{\chi_c^2}{\chi_a^2}$

$\nu := 0.5 \cdot \frac{\Omega}{(1-F)}$

$\theta := \left(2 \cdot \frac{\chi_c^2}{1+F^2} \cdot \left(\frac{1+\nu}{\nu} \cdot \ln(1+\nu) - 1\right)\right)^{\frac{1}{2}} \cdot rad = 2.986 \cdot 10^{-4}$

Assuming the distance from the cell entrance to the Be window is 6 inch the beam spread is at 3σ given below

$$\Delta z_{ent} := 15 \cdot cm$$

$$\Delta x := \Delta z_{ent} \cdot \tan(6 \cdot \theta) = 0.027\ cm$$

At the exit of the cell we have

$$\Delta z_{exit} := 40 \cdot cm$$

$$\Delta x := \Delta z_{exit} \cdot \tan(6 \cdot \theta) = 0.072\ cm$$

Note that the expected raster size is 2 x 2 mm square. Thus, the multiple scattering is not expected to be an issue.