2.5T PF and Dilution Study

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7/19/17
Calculating Packing Fraction (reminder)

Method:

\[ N_p = \frac{AN_0}{e} \left( \rho_A L_{tg} \frac{pf}{M_A} (\sigma_N + 3\sigma_H) + \frac{\rho_{He}(L_{tg}(1-pf) + L_{out})}{M_{He}} \sigma_{He} + \frac{\rho_{Al} L_{Al}}{M_{Al}} \sigma_{Al} \right) \]

Production runs

\[ N_d = \frac{AN_0}{e} \left( \rho_{He} L_{tg} \frac{L_{out}}{M_{He}} \sigma_{He} + \frac{\rho_{Al} L_{Al}}{M_{Al}} \sigma_{Al} \right) \]

Dilution runs

\[ N_b = \frac{AN_0}{e} \left( \rho_{He} L_{tg} \frac{L_{out}}{M_{He}} \sigma_{He} \right) \]

\[ N_c = \frac{AN_0}{e} \left( \rho_c L_c \frac{\sigma_c}{M_c} + \rho_{He} \frac{L_{tg} + L_{out} - L_c}{M_{He}} \sigma_{He} \right) \]

Where

- \( A, N_0, e \) = constants
- \( M = \) molar mass
- \( \rho = \) material density
- \( \sigma = \) cross section
- \( L = \) material length

\[ pf = \frac{N_p - (C_1 - 1)N_E - N_d}{\left( \frac{M_c \rho_A L_{tg}}{M_A \rho_c L_c} \right) \left( \frac{L_{tg} + L_{out} - L_c}{L_{tg} + L_{out}} + N_E \right) \left( C_2 + 3 \frac{\sigma_H}{\sigma_c} - C_1 \right) + \frac{L_{tg}}{L_{tg} + L_{out}} N_E} \]

\( C_1 = \) He4 radiative length scaling factor
\( C_2 = N14/C12 \) mass ratio multiplied by N14 radiative length scaling factor.
• Incorrectly scaling radiative effects (elastic tail)?
• Effect is folded into systematic at ST transverse settings (ratio is constant).
• Problem seen at all 2.5T settings.
1.710GeV 2.5T Transverse

Using pf = 0.7 to match dilution from model (Bosted)
Calculating Dilution (reminder)

\[ df = 1 - \frac{Y_{bg}}{Y_{total}} \]

\[ Y_{bg} = Y_N + Y_{He} + Y_f \]

\[ Y_{He} = \frac{L_{total} - pf \cdot L_{tg}}{L_{total}} \alpha Y_{Empty} \]

\[ Y_f = Y_{Dummy} - Y_{Empty} \]

\[ Y_N = \frac{m_C \rho_N \cdot pf L_{tg} \beta}{m_N \rho_C L_C} \left( Y_{Carbon} - \frac{L_{total} - L_C}{L_{total}} \gamma Y_{Empty} \right) \]

- \( Y_{total} = \) normalized production yield
- \( Y_{N He f} = \) Nitrogen/ Helium/ foil background contributions
- \( Y_{Empty Dummy} = \) Respective dilution runs
- \( pf = \) packing fraction
- \( L_{total/ tg} = \) total nose length/ target cell length
- \( m_{CIN} = \) Carbon/ Nitrogen molar mass
- \( \rho_{CIN} = \) Carbon/ Nitrogen density
- \( L_C = \) carbon disk thickness

- \( \alpha = \) radiative/scattering scaling factor for Helium dilution to Helium (during production)
- \( \beta = \) radiative/scattering/nucleon scaling factor for Carbon dilution to Nitrogen (during production)
- \( \gamma = \) radiative/scattering scaling factor for Helium dilution to Helium (during carbon dilution)
1.157GeV 2.5T Transverse

Dilution

Yield

\( v \) [MeV]

- Carbon
- Dummy
- Empty
- Production (Material 11)
- Production (Material 12)
• Radiative scaling at the 2.5T settings needs to be approached more carefully (effect is small at 5T transverse settings).

• Possibly a different etal scattering angle depending on the target material so the effect is not cancelling in the ratios?

• Materials without good coverage (1.7 GeV material 7) I instead use a dilution model to find the packing fraction.