Outgoing radiation lengths for the HD target. V3

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This note can be found at: http://www.jlab.org/Hall-B/HDIce/technotes/hd_rl.pdf

The values are given for distances perpendicular to the beam line, i.e. for particles going out at scattering angle $\theta = 90^o$. For the general case of scattering at angle θ, some of the contributions should be scaled as $RL/sin\theta$.

Note: For minimizing the elastic tail at large W, *incoming* radiation length is most important. Outgoing and incoming are important for the **0.16%** width of peaks and for radiative corrections.

1 List of value for the HD target

- $\frac{1.5}{2}$ cm of solid HD (RL= 783 cm): **0.10%**
- Cooling wires. 700 Al wires, (5×10^{-3} cm diameter. taking 7 cm for length). ⇒ Total volume of wires: 0.096 cm^3. ⇒Total mass of Al is 0.268 g. The cell dimension is 1.5cm diameter with 5cm length. ⇒Cell volume is 2.8125 cm^3. ⇒Al wires density is 0.05 g/cc. For dimaeter/2=0.75 cm, Al thickness is 0.0715 g/cm^2. With Al RL=24.01 g/cm^2, this yields a RL: **0.30%**
- Target wall: 0.05cm of Kel-F (Polytrifluorochloroethylene RL=13.4cm): **0.37%**
- Inner vacuum can: 0.05cm of Kel-F: **0.37%**
- NMR coil holder: Kel-F, assume 0.1 cm: **0.75%**
- Main field solenoid: 4 layers of 2.29×10^{-2} cm diameter 1.3:1 CuSc multi-filament wires+ 2.5×10^{-3} cm insulation.
  - Cu RL: 1.436 cm; Sc (40% Nb, RL=1.158 cm, 60% Ti, RL=3.56 cm). ⇒ 1.3:1 CuSc RL=$\frac{\sqrt{1.3}*1.436+0.4*1.158+0.6*3.56}{1+\sqrt{1.3}} = 1.980$ cm.
  - ⇒RL due to 4 uninsulated wires: 4.63%

  - Adding 2.5×10^{-3} cm insulation (assume mylar, RL: 28.54 cm): 0.04%
  - Accounting for one layer of 5×10^{-4} cm of epoxy to glue the wire (RL:38.7cm): Negligible
  - To account for the wire circular cross section, we scale by the circle/square area ratio $\pi/4$. (We neglect the gas that fills in between wires).
  - $\Rightarrow$Total RL for solenoid: (4.63%+0.04%)*$\pi/4$=**3.67%**

- LHe can: 30 mil Al $\times$2: **1.71%**
- 80K shield: $\sim$ 50 mil Al: **1.425%**
- Vacuum chamber: 1/2 inch Rohacell foam (polymethacrylimide. RL˜332 cm: took the RL of polymethylmethacrylate: 34.07cm and scaled by its density (1.19 g/cc) divided the density of Rohacell (0.122 g/cc)): **0.38%**
- Epoxy and Al paint of Roacell chamber: **??%**. This is neglected for now.
- Safety coil: 3 layers of 0.1 cm diameter Al. wires with insulation (total diameter: 0.111cm): RL=2.24%$\times\pi/4$=**2.64%**
- Plate of 1/4 mm Al: RL=**0.28%**
- Start counter: EJ-200 2.15 mm thick (total thickness 0.26g/cm^2): **0.252%**
- 2m air: **0.6%**
- DC region 1: **0.16%**

Total HD target: 13.01% (with 3 layers for coil for safety magnet)

Note: Particles with $\theta \lesssim 14^o$ won't go through the main solenoid and thus see much less RL. Same for safety solenoid for larger θ.

2 Comparison with FROST

This list is for 90^o particles:

- Butanol (RL=52.23cm for 0.81 g/cc density). radius of target material holder: 0.325"=0.826cm. 60% packing fraction: **RL=0.95%**
- L^{3}He/L^{4}He (assume L^{4}He, RL=755.2cm) between the butanol beads: **RL=0.04%**
- L^{3}He/L^{4}He. External mixing chamber radius:0.450"=1.143cm: **RL=0.15%**
- Target wall PCTFE (Polychlorotrifluoroethylene, RL=13.42cm), 0.025"=0.0635 cm. **RL=0.47%**
- Magnet Holder 0.040"=0.102 cm Al. **RL=1.14%**

- Magnet (3 layers of supracon 54S43 SC wire 0.014 cm od. RL=2.0cm. One more wire layer on the sides. We don't count it). Accounting for insulation and glue, we have **RL=2.07%**
- superinsulation layer (10 layers): negligible
- Heat shield (Al., 0.05 cm): **RL=0.56%**
- superinsulation layer (10 layers): negligible
- Scattering chamber wall (Foam, density 0.122g/cc, RL=332cm), thickness: 1.105 cm. : **(RL=0.33%)**
- Start counter: EJ-200 2.15 mm thick (total thickness 0.26g/cm^2): **0.252%**
- 2m air: **0.6%**
- DC region 1: **0.16%**

Total FROST target: 6.72%

3 Comparison with EG4 (DNP amonia target)

This list is for forward angle particles

- NH3: 0.795%
- Superinsulation layers: 0.072%
- Kapton exit window: 0.08%
- Aluminized kapton window: 0.02%
- Banjo exit window: 0.281%
- 77K shield: 0.028%
- Vacuum vessel exit: 0.056%
- Vacuum window: 0.080%
- 2m air: 0.6%
- DC region 1: 0.16%

Total EG4: 2.08%