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Target Requirements for E160

P. Bosted, K. Griffioen

Abstract

The physics requirements for the E160 targets are discussed. The most important ones are that the targets be in vacuum; be at least 1.5 cm square; be remotely changed by computer control; that the position be known to the computer to about 0.3 mm; and that the target foil thicknesses be known to 1%. The location is 15 cm up-beam entrance of the E158-D3 dipole magnet, where there will be a strong (10 kG) magnetic field. Recently added is a 4 cm long LiD target, and "hole" target for checking photon beam centering and halo.

1 Target Materials

In the E160 proposal, the suggested targets are 0.05 r.l. Be, 0.14 r.l. Al, 0.20 r.l. Cu, and 0.20 r.l. Pb.

We propose to change the maximum thickness to 0.12 r.l. This will reduce (thickness)^2 effects by a factor of three, and reduce the number of beam photons lost to pair production by almost a factor of two. The value of 0.12 r.l. is the thickest target used in the E139 "EMC effect" experiment at SLAC.

Pb was chosen for the high-Z target to match what was used in other experiments. We need to evaluate the thickness stability of lead when placed in the photon beam (will it melt or sag?). For a maximum photon power that we are likely to use of 600 W, the power deposited in 0.12 r.l. of lead is about 6 mW. We may want to use gold instead. It was a slightly lower A, but will not melt or sag. We plan to have both Pb and Au targets available in the holder.

There is a rather large gap in A between Cu and Pb. We should add a tin target with 0.12 r.l. thickness as an additional check on the A-dependence at one beam energy.

In order to test our calculations of the loss of photon flux in thick targets, and for possible (thickness)^2 effects, we should have two Al targets, with thickness 0.06, and 0.12 r.l.

To increase the range of A even further, it would be a good idea to have a LiD target, about 4 cm long in the beam direction. This can be cut from one of the six 10 cm long LiD rods at U.Va. The diameter is 1 cm.

Table 1: *List of targets for E160.*

element	Z	A	ρ (g/cm^3)	g/cm^2	cm	rad. lengths	int. lengths	b^{-1}
No Targ	-	-	-	-	-	-	-	-
LiD	2	4	0.82	3.28	4.0	0.036	0.04	1.97
Be	4	9.012	1.848	3.26	1.764	0.050	0.043	1.96
Al	13	26.980	2.700	1.52	0.533	0.060	0.013	0.92
Al	13	26.980	2.700	3.05	1.067	0.120	0.027	1.84
Al w/hole	13	26.980	2.700	3.05	1.067	0.120	0.027	1.84
Cu	29	63.546	8.960	1.54	0.172	0.120	0.011	0.93
Sn	50	118.710	7.310	1.05	0.144	0.120	0.009	0.63
Au	79	196.966	19.38	0.78	0.040	0.120	0.004	0.47
Pb	82	207.200	11.350	0.76	0.067	0.120	0.004	0.46

The targets do not need to be isotopicly pure, but the composition should be known well enough that the average A be known to 1%.

There must be a "no target" position for measurements of backgrounds. We would also like a "hole target", identical to the 0.12 r.l. aluminum target, but with a 5 mm radius hole in it, centered on beam line. This will be used to measure beam halo. This is crucial since the aperture inside D3 is only slightly bigger, at 7 mm.

The tentative list of targets is given in Table 1

2 Foil size, procurement and thickness measurements

The foils need to be uniform to $\pm 1\%$ over a scale of a few mm, so that the rates do not vary more than that amount due to changes in beam size, beam position, or foil position relative to the beam. The area of the photon beam is estimated to be 2 mm tall by 5 mm wide (FWHM). For complete safety against halo, the foils should be at least 1.5 cm wide and tall. The thickness of the targets should be measured with better than 1% absolute accuracy over a grid of about 25 points, both to check the uniformity, and to ensure that the average thickness is known to an accuracy matching the statistics of the J/ψmeasurements. This could be done with the x-ray facility at U. Mass. It is not easy to obtain uniform Sn, Au, and Pb foils, and to measure them to 1%. The other targets will be easy in comparison.

Note: the gold and two aluminum targets are the same as used in E139: they may still be available.

The LiD comes in a 1 cm diameter rod, smaller than the desired 1.5 cm diameter. To roughly provide an equal thickness (in gm/cm^2) for photons that are outside the 1 cm diameter, the LiD should be placed inside a piece of beryllium or carbon with a thickness of 3.28 gm/cm^2, with a 1 cm diameter hole in it for the LiD rod to be held.

3 Mounting, Assembly, Readout

The targets should be mounted on some kind of linear rail for insertion into the beam path. The foils should be mounted on the rail with a few mm clearance between each foil. Window frame mounts can be used for the thinner targets, while the thicker ones can be bolted directly to the rail. The use of iron should be avoided because the targets will be in a 10 kG magnetic field: screws should be brass or stainless steel. The rail can be made of aluminum or stainless steel. The rail should be located approximately 15 cm up-beam from the up-beam end of the iron yoke of the E158 D3 magnet. There should be a direct connection to the new vacuum pipe that will go through D3, with no windows either up-beam or down-beam of the target assembly.

The targets rail should be movable by an actuator so that any of the target positions can be selected with an accuracy of about 0.3 mm. The actuator should be computer controlled, and should be capable of switching between any of the targets in less than 20 seconds.

A readout of the target position should be available to the controlling computer. It is crucial that the target positions (especially the "hole" target) be aligned with respect to the C37 collimator and the D3 collimator to within 0.3 mm. The mounting should be sufficiently secure so that the target holder does not move more than 0.3 mm when pumped down to vacuum.