CLAS-NOTE 2004-038
CVS: docs/clas_notes/eg3_target
Original: October 8, 2004

Considerations for the eg3 hardware

E.S. Smith and S. Stepanyan

1 Introduction

We have conducted two beam tests to study the trigger rates for Experiment 04-010, "Search for Exotic Cascades with CLAS using an untagged virtual photon beam." The first test was conducted with an electron beam using the flux of virtual photons produced in the target. The second test used the standard configuration for tagged photon beams of Hall B. The trigger rates under both configurations were reported in a previous note [1]. The present note considers the dimensions and position of the target which would be used using the beam of real photons.

Table 1: Material in the target and foam scattering chamber during the eg3 photon test.

Layer	Material	Density (g/cm^3)	Thickness (mm)	Areal Density (g/cm^2)
Target	deuterium	0.179	20	0.358
ROHACELL XT-110 foam	Polymethacrylimide (PMI)	0.11	10	0.110

2 Beam size

The characteristic half-angle, θ_C, of the beam at 5.75 GeV is 8.9×10^{-5} rad, which projected to the target 22 m away is 2 mm. Therefore, an aperture of $\pm4\theta_C$ is 1.6 cm. However the collimated aperture is determined by the collimator located at -16.18 m upstream of the target. Presently available collimators have diameters of 2.6 and 8.61 mm, but additional intermediate sizes will be available soon. Using the 8.61 mm diameter collimator, we have a collimated beam diameter of 33 mm at the nominal location of the CLAS target. Thus the target diameter should be larger than this to eliminate the possibility of the tails of the photon beam from interacting with any supporting material.

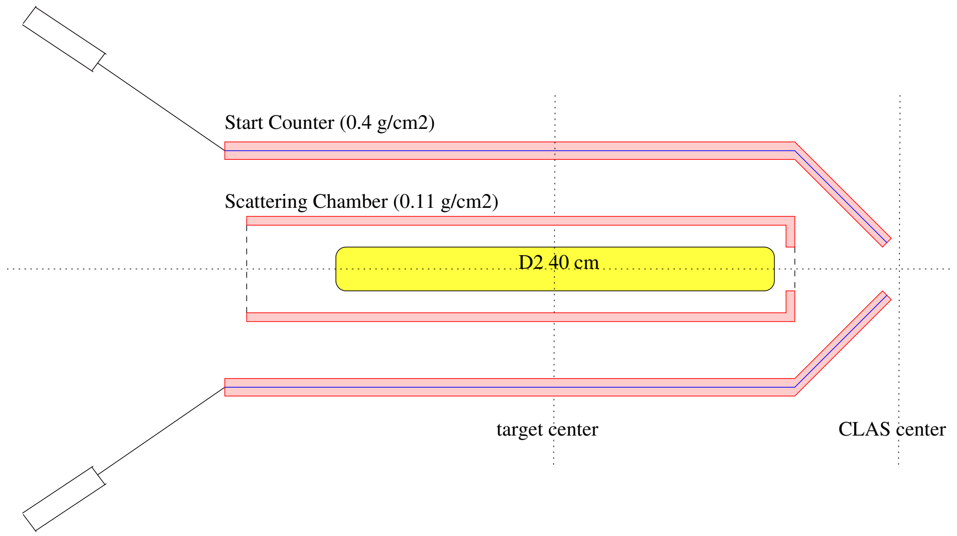

Figure 1: Schematic view of the target, foam scattering chamber, and start counter used for g11 and the eg3 photon beam test. During g11, the center of the target was 10 cm upstream of CLAS center. For the eg3 photon beam test, the target center was positioned 31.6 cm upstream, as shown.

3 Materials surrounding the target

The target configuration for g11, and also for the eg3 photon beam test, is shown in Fig. 1. The materials in the target are given in Table 1 and 2. The total thickness in the foam scattering chamber is 0.11 g/cm^2 and 0.40 g/cm^2 in the start counter, which results in a total material excluding the target of 0.511 g/cm^2. The radial thickness of the deuterium target is 2 cm (0.358 g/cm^2), and practical targets require at least 1 cm (0.2 g/cm^2). Fig. 2 shows the amount of material (measured in radiation lengths) in the path of outgoing particles as a function of angle. Also shown in the figure is the minimum momentum required for protons to penetrate the target and surrounding scattering chamber and start counter. The curves are plotted assuming the particles originate on the beamline for a 1-cm and 2-cm radius deuterium target cell. The differences between the two target diameters is quite small.

4 Target length

To determine the length of the target we need to optimize various competing requirements. On the one hand, we expect the primary background contribution may

Table 2: Materials in the Hall B start counter (wrapping #1). The total thickness is 0.41 g/cm^2. Wrapping #2 lacks two of the layers of Tedlar, resulting in a thickness of 0.40 g/cm^2.

Layer	Material	Density (g/cm^3)	Thickness (mm)	Areal Density (g/cm^2)
ROHACELL XT-110 foam	Polymethacrylimide (PMI)	0.11	5.3 6.1(cone)	0.058 0.067
Photographic tape	Cotton	1.02	0.27	0.028
Tedlar	PolyvinylFluoride (PVF)	1.15	0.05	0.006
Mirror	VM-2000	1.30	0.064	0.008
Scintillator	EJ-200	1.032	2.15	0.222
Mirror	VM-2000	1.30	0.064	0.008
Tedlar	PVF	1.15	0.10	0.011
ROHACELL XT-30 foam	PMI	0.031	9.75	0.030
Photographic tape	Cotton	1.02	0.27	0.028

come from accidental coincidences between a pion and a decay sequence which reconstructs to a Ξ^-. This background decreases with increasing target length as shown in Fig. 3. Three-fold accidentals of pions and a proton optimized for short targets, but are not expected to limit our sensitivity. The acceptance of the start counter and efficient reconstruction of tracks in the detector argue for a target length that can be accommodated within the geometry of the start counter. Fig. 4 shows the expected distribution of vertices as a function of position for 24-cm and 40-cm targets. Ninety-five percent of all decays are contained within 44 cm (55 cm) for the two targets, respectively. The acceptance of the start counter covers 55 cm, if all tracks are forward of 90°. As shown in Fig. 25 of the proposal for the experiment [2], very few tracks are emitted at angles greater than 90°, and even fewer are accepted by the trigger at the larger angles. This is due to the loss of protons at forward angles, which are kinematically correlated with large-angle pions.

A longer target also lowers the tagger rate for fixed luminosity. This keeps the instantaneous rates in the tagger counters at a minimum as well as reduces any accidental coincidences between CLAS and the tagging system. The instantaneous rate of the T-counters can be run up to 4-5 MHz, which was used for g6c, without the pmts sagging. The instantaneous rate for T1-19 during the test run at 150 nA

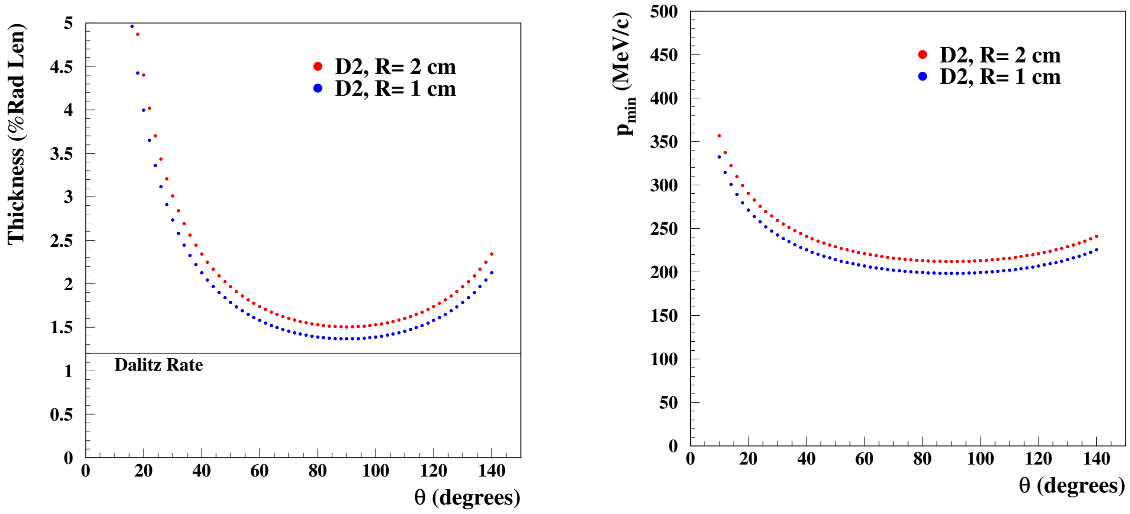

Figure 2: Left: Radiation length of material a function of angle. The increased thickness of the target at small angles is calculated for the most upstream portion of the target and is therefore exaggerated for the rest of the target. Right: Minimum momentum required for protons to penetrate the target and start counter as a function of angle.

was approximately 1 MHz. Thus the electronics allows for 5 times higher rates, but one will likely run at lower rates due to DAQ and triggering limitations, or increased accidentals.

In conclusion, the 40-cm target with the upstream end located at the beginning of the start counter is close to optimum for the cascade experiment.

5 Target center

The position of the target relative to the center of CLAS is chosen by optimizing the acceptance of the cascade pentaquark signals. Monte Carlo simulations based on phase-space production mechanism of the Ξ_5^{--} have been run and the acceptance has been computed for two target postions. GSIM was run for the modified g11 configuration with the target centered at -25 cm and -50 cm. The final state of interest here requires 3 π^- in addition to the proton.

In Fig. 5 the number of detected negative particles is shown for events with at least 2 charged tracks to simulate the trigger condition. The difference between the number of events with 3 negative tracks (almost all negative particles are pions) is only 25% between two target locations: -25cm and -50cm. In the top row of Fig. 6 we plot the distribution of positive tracks for events that have at least two charged

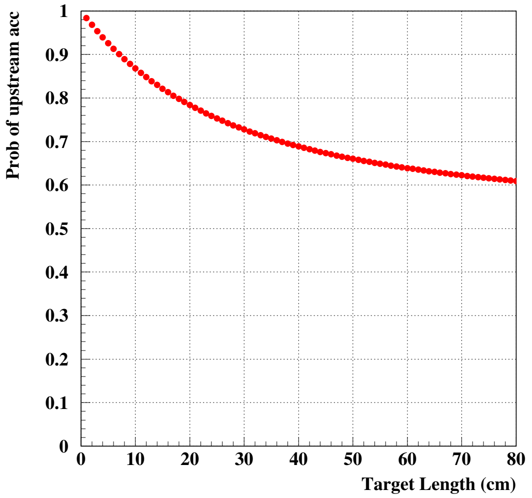

Figure 3: Probability of a single accidental pion produced in the target upstream of a decay sequence as a function of target length. The decay sequence would correspond to $\Xi^- \to \Lambda\pi^- \to p\pi^-\pi^-$, identified correctly or incorrectly.

tracks. In the lower row of the figure we plot the distributions of positives with an identified proton and 3 π^- in the final state. For these events, the acceptance for the target position at -50cm is about 70% larger than for target position at -25cm. Based on these preliminary calculations, the location at -50 cm is preferable. However, we are continuing to study the acceptance, as it is sensitive to details of the simulation and road files for track reconstruction.

6 Radiator thickness

The photon beam test, and the g11 experiment, used a 10^{-4} radiator. The photon flux needed for a luminosity which corresponds to $10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ for electron running requires 162 nA incident on that radiator. The tagger beam dump is currently rated for 800 W (140 nA at 5.75 GeV). For the experiment we would like to be able to run at higher photon fluxes, so we would require a thicker radiator. We would like to install a 5×10^{-4} radiator, which would allow us to run at the nominal luminosity for the experiment at 32 nA. This configuration would allow us to run with luminosities of up to 4.4 times the nominal before reaching the limits of the tagger beam dump. The multiple scattering contribution in the radiator results in a beam size of approximately $\sigma_x = 0.6$ mm for a 10^{-4} radiator, or 1.3 mm for a radiator of five times the thickness. This is to be compared to the natural size of the beam at 5.75 GeV which results in

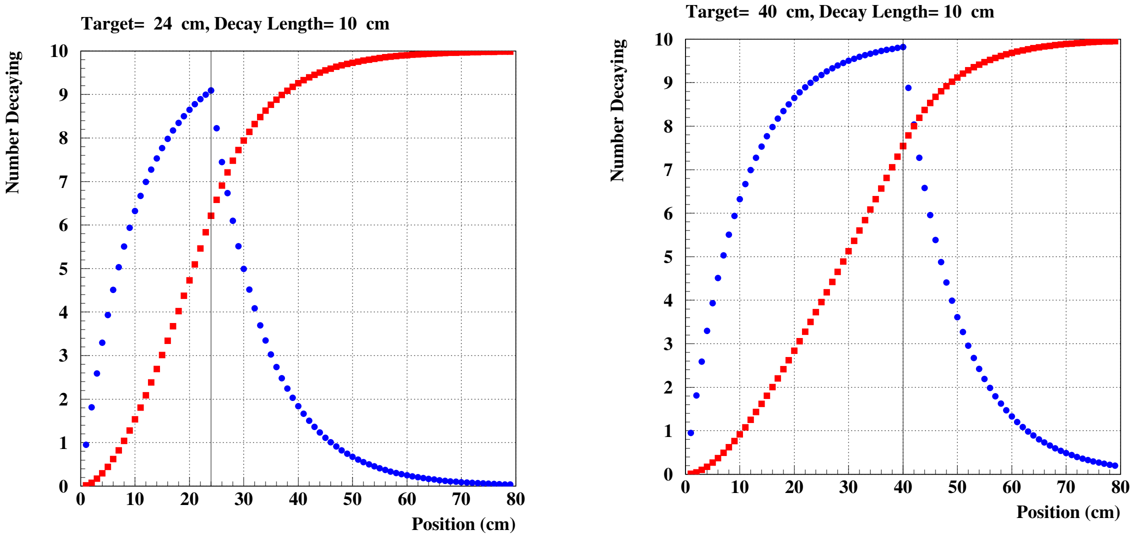

Figure 4: Left: Blue circles show the decay distribution assuming $\gamma\beta c\tau$= 10 cm, and uniform production along the 24-cm target. The red rectangles show the integrated distribution. Right: Blue circles show the decay distribution assuming $\gamma\beta c\tau$= 10 cm, and uniform production along the 40-cm target. The red rectangles show the integrated distribution.

a half size of 1.9 mm. Therefore, the size of the beam will increase by approximately 20% due to the thicker radiator. A convenient radiator would be 1.5 μm of platinum.

References

[1] E.S. Smith, S. Stepanyan, V. Batourine, "Evaluation of rates during eg3 beam tests," CLAS-NOTE 2004-031, August 26, 2004.

[2] JLab experiment E-04-010, R. Gothe, M. Holtrop, E.S. Smith, S. Stepanyan, spokespersons. See

`http://www.jlab.org/exp_prog/proposals/04/PR04-010.pdf`

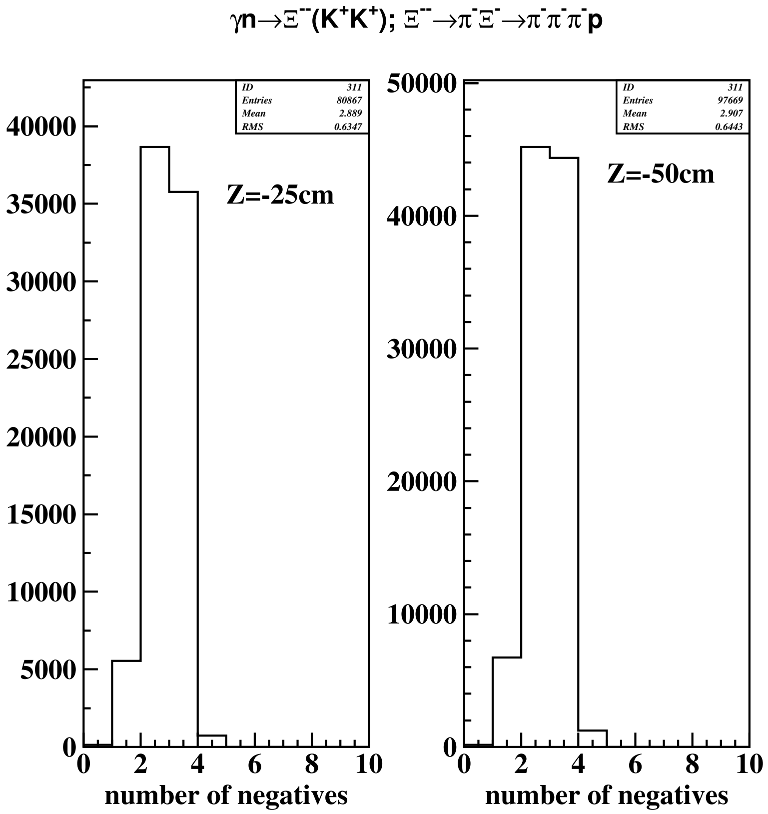

Figure 5: The number of reconstructed negative tracks for events with two tracks, which simulate the trigger condition.

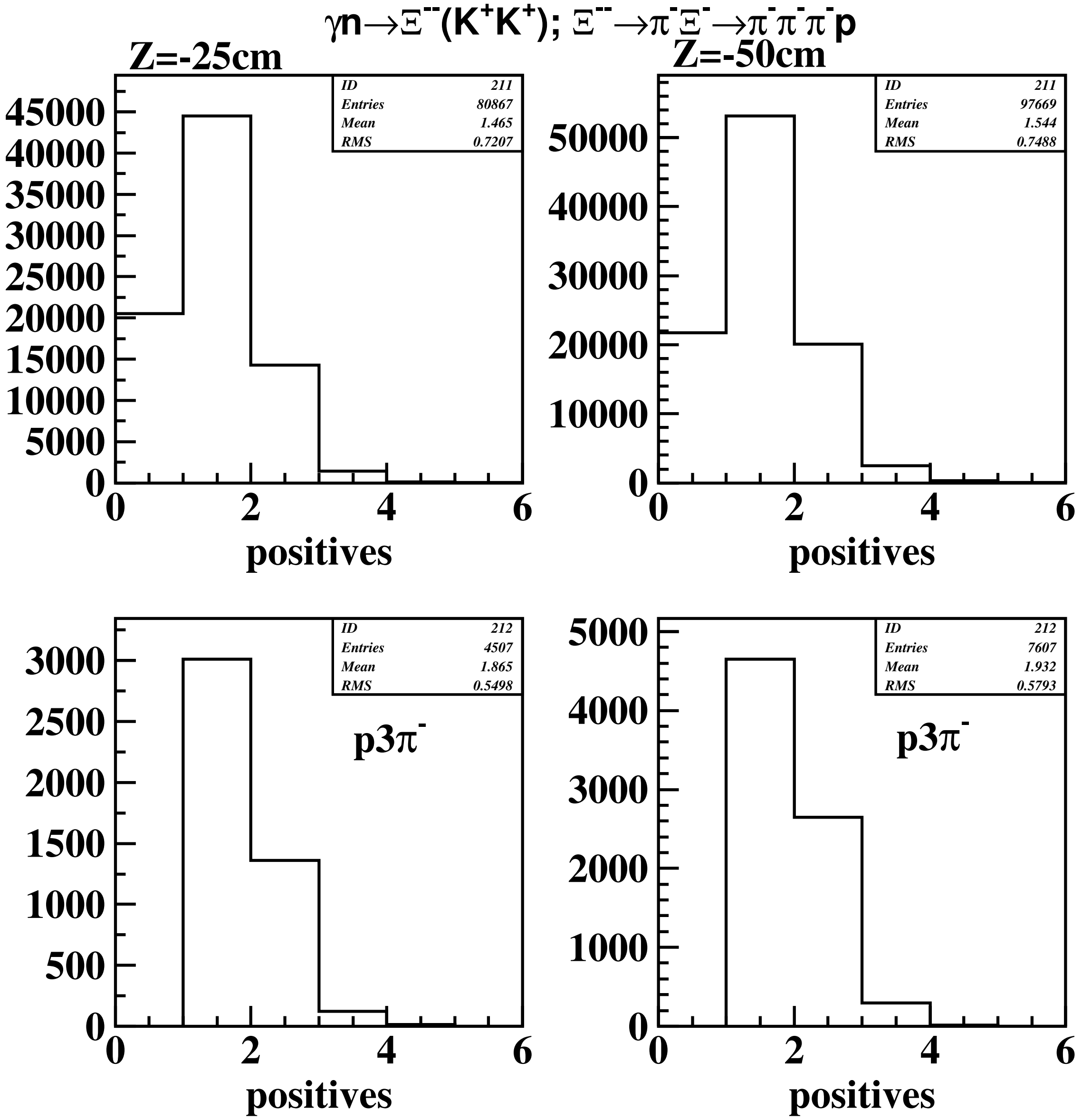

Figure 6: The number of positive particles events with two tracks (top) and for events that have 3 π^- and an identified proton (bottom).