Tests of Lead Target

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In this note we describe the tests of the Hall A lead targets in early October 2000. We tested a thin (0.05 mm) and thick (0.5 mm) lead target. The thick lead target is our "high power design" which has the diamond backing (two layers 0.15 mm each), and is cooled by liquid helium. It has a thick copper frame with a hole 17 mm horizontally and 12 mm vertically to allow the 4 mm square rastered beam to pass, see figure 1. The thin lead target is mounted on one of our standard target frames and has no other material within ± 12 mm of the beam. The purposes of the tests: 1) Measure the momentum spectrum for both targets at low current and understand it in terms of rates, resolution, and backgrounds; and 2) Ramp the beam current up on the thick target to verify it does not melt and to measure radiation levels. The setup was: E = 821 MeV, $\theta = 15^{\circ}$, $q = 1.088\,\mathrm{fm}^{-1}$.

We'll discuss results from the ramp-up test first. The MCC operators tuned the beam to the middle of the diffuser and minimized the signal on the ion chambers which monitor the radiation near and downstream of the target. The operators had a lot of trouble finding a good beam tune – it took 1.5 hours. With their best tune we were able to ramp up to 83 μA before we started tripping the ion chambers which turns off the beam. The radiation levels were recorded but I haven't received these data yet. The rate from the target climbed linearly with the beam current and remained stable for 20 minutes at the highest current, at which time we stopped this part of the test. We subsequently did some low current tests to measure backgrounds and the results were not any different from before the ramp up. Although I have not yet had a chance to visually inspect the target, I would say the target did not melt.

The goal of understanding the momentum spectrum is more interesting at present because of the large "background" we've observed in this test and previous tests. Figure 2 shows the momentum spectrum for the October 2000 tests with the thin target and the thick target. Contrary to what I have told some of you, the peak that is separated by 1.9 MeV to the first peak *was always present* for the thick lead target during these measurements. This energy shift is consistent with a ^{12}C elastic peak from the diamond backing, and the expected rate from diamond is 1.3 times the rate from Pb. In the proposed experiment's kinematics ^{12}C will be a 4.5% background.

In the thin lead target momentum spectra there is a peak at 4.5 MeV which I believe is the 4.5 MeV 6^+ state of Pb which has a maximum here and is 6% of the elastic. The 2.6 MeV state should be $\approx$ 1.2% but we don't see it. It would be very useful to compare this spectrum to some high quality existing Pb data (maybe in a next version of this report). The thick lead target spectra is shifted 1.1 MeV relative to the thin lead spectra; I computed an average dE/dx loss in the Pb + diamond of 0.8 MeV, which falls a bit short of the observed shift. One also sees a peak at 7.5 MeV in that plot which I believe is the 4.4 MeV state of ^{12}C, which has a maximum near this q and should be 14% of the elastic rate.

The absolute rates are a bit higher than what we calculated, but the ratio of rates between thick and thin targets is reasonable. For the thick target, we see 48 kHz/μA on the whole focal plane in our scintillator trigger which requires the "and" of two scintillators and should be mostly charged particles. Of this 48 kHz, 13% arrives in the elastic peak, hence 6 kHz. But we compute an expected 4.4 kHz at this kinematics (73% of what is observed). For the thin target, we have two effects on the rate that partially cancel: As ratios to the thick target, the thickness is 0.1 but the radiative loss is smaller by 0.35 so the ratio of rates to the thick target should be 0.29 which is what we observed.

During the test, I was worried we were scraping the copper frame, because of the large background in the momentum spectrum. In earlier tests with the Pb-aluminum sandwich target we also observed a second peak in the momentum, and there was no good explanation for it; for example, it could not be elastic aluminum. It is worthwhile doing some future tests to prove that the background is understood, e.g. to make the peak separate more or change in relative size by varying the kinematics. A test plan will be developed. The same test plan should satisfy us that we know how to tune the beam, see below.

I have been worried about how we know the beam position relative to the 17 (horizontal) by 12 mm (vertical) target frame hole. This hole needs to be small for cooling the Pb; we made it wider in the horizontal to accommodate a swing of the target ladder when it is drawn under vacuum. In the beginning of the test we centered the beam on the BeO target; the position was X= 2 mm and Y=0 at the BPM two meters from the target. During the tests there was a lot of confusion about how to tune the beam (should we center on diffuser ? center on BeO ?). It took 1.5 hours and accelerator optics experts were called. At some point we became "blind", as our target camera apparently burned out in the high radiation. During the six hours of this test we recorded BPM readings, and they varied at the two BPMs upstream of our target from -3 mm to +6 mm horizontally and ± 2 mm vertically. The rastered beam size was 4 mm square, measured with a fast readout, and it also looked this size on the BeO target. Therefore, it seems unlikely that the beam was scraping the copper frame. However, I would like to talk to the MCC operators and Hall A target experts about the procedure to tune the beam and know its location.

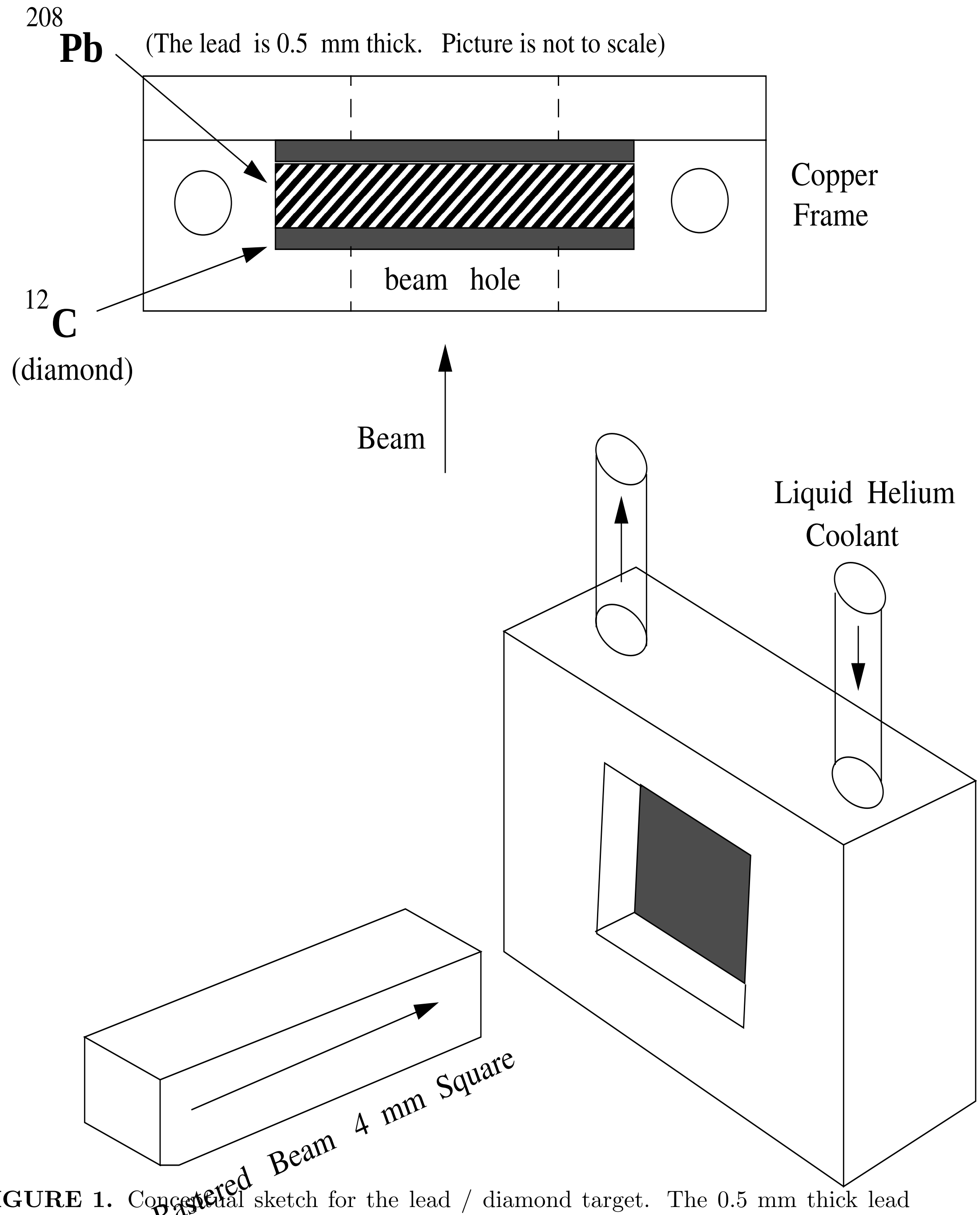

FIGURE 1. Conceptual sketch for the lead / diamond target. The 0.5 mm thick lead foil is sandwiched between two 0.15 mm thick sheets of diamond which has a very high thermal conductivity. Liquid helium flows around the boundary of the target. Although the beam hole appears square shaped in the figure, it is actually 17 mm (horizontal) by 12 mm (vertical).

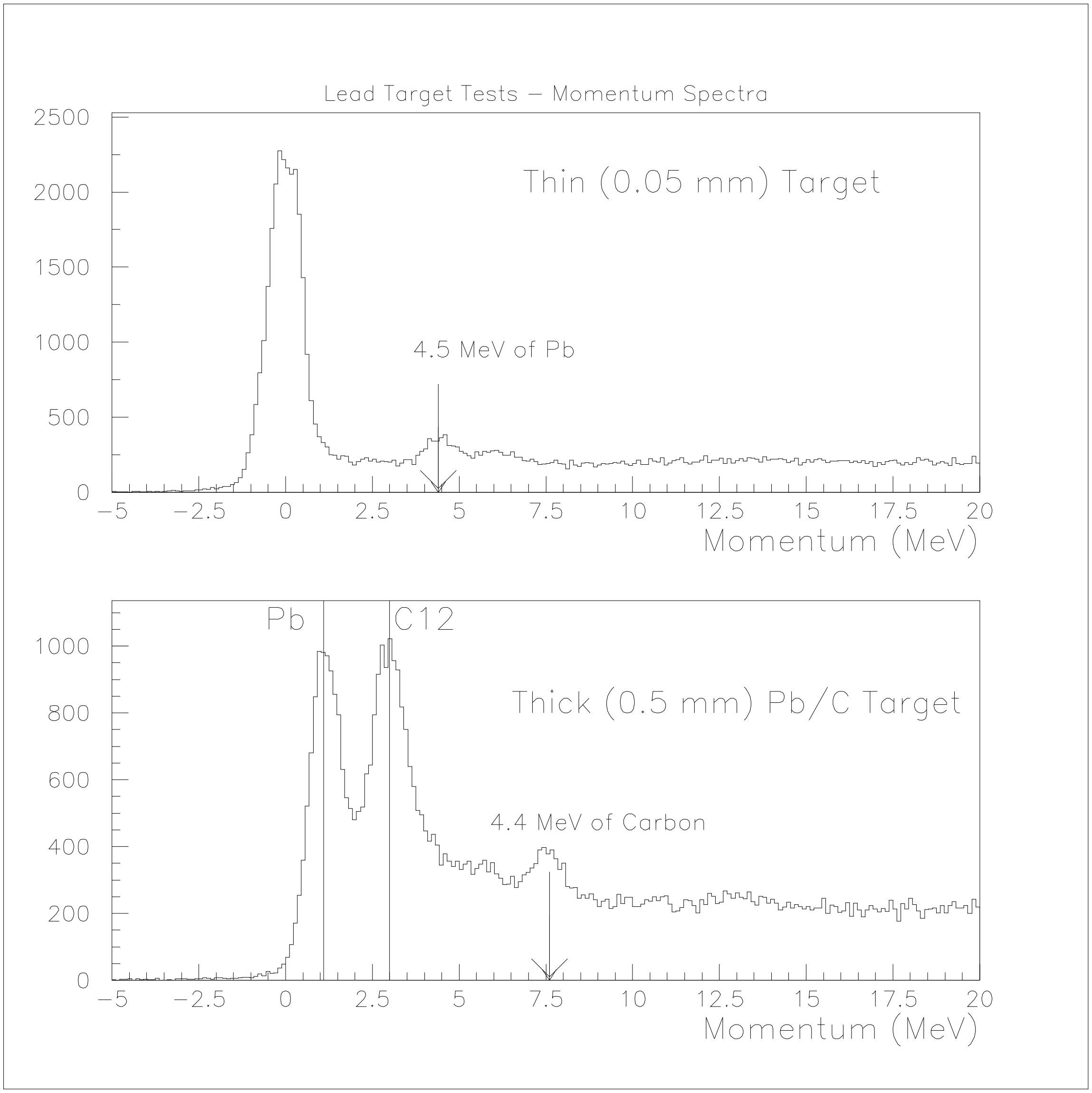

FIGURE 2. Momentum spectrum from Lead Target Tests in October 2000. The top figure is from the thin lead target which has a large clearance hole. The bottom figure is from the thick diamond-backed helium-cooled "high power" lead target.