ABSOLUTE CALIBRATION OF A 200 MeV PROTON POLARIMETER FOR USE WITH THE BROOKHAVEN LINAC

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Construction of the polarimeter for use with the Brookhaven National Laboratory 200 MeV LINAC polarized beam has been completed. The instrument was tested and calibrated during December 1982 at the Indiana University Cyclotron Facility.

The polarimeter was calibrated with unpolarized and polarized beams of 200-MeV protons at the Indiana University Cyclotron Facility. A 0.010" × 0.020" carbon filament target scattered the protons to scintillator telescopes at 12 and 16 degrees in the horizontal plane and 16 degrees in the vertical plane. The target design (see Fig. 1b) allows three different carbon targets to be placed on instrument center to an accuracy of 0.001 inch or to be removed from the beam. The targets are machined graphite ribbons of variable horizontal width W, vertical height H, and variable thickness T along the beam direction. The design is such that H >> height of beam spot, W << width of beam spot, and T can be chosen to obtain suitable count rates. By choosing W, the destruction of the beam (H^- stripped to H+) can be kept to a few percent. The analyzing power of the carbon target was determined at 12 and 16 degrees, and as a function of ranging materials in an attempt to maximize the efficiency.

Initially, with unpolarized beam, all photomultiplier tubes were individually monitored for counting rate as a function of the voltage across that tube. A scintillator telescope, maintained at fixed bias, was used to normalize the scattering rates over beam flux variations. The final voltage of each of the RCA 8575 tubes was set 150 V above the onset voltage of the counting-rate plateau to ensure efficient counting. The instrumental asymmetry was then measured as a function of target position, where the asymmetry is defined as:

$$(N_L-N_R)/(N_L+N_R),$$

(see Fig. 2). The instrumental asymmetries are 0.017 for the 12 degree angle and 0.006 for the 16 degree angle with the target at the optically-surveyed position of the polarimeter axis. These small instrumental asymmetries can be accounted for due to small errors in fabrications of the small plastic scintillators and small errors in the 12 degree settings.

Using a 75% polarized beam, the analyzing power of carbon scattering for the polarized beam was measured to be 0.620±.004 at 12 degrees and 0.511±.004 at 16 degrees. In addition, the analyzing power was studied as a function of copper absorber thickness placed just before the second detector in each telescope. The analyzing power was enhanced by ranging out the inelastically-scattered particles, (see Fig. 3). Of course, as the amount of copper absorber was increased to enhance the analyzing power A, the counting rates decreased, (see Fig. 4). Counting rates were measured for symmetrically positioned telescopes. In Fig. 4,

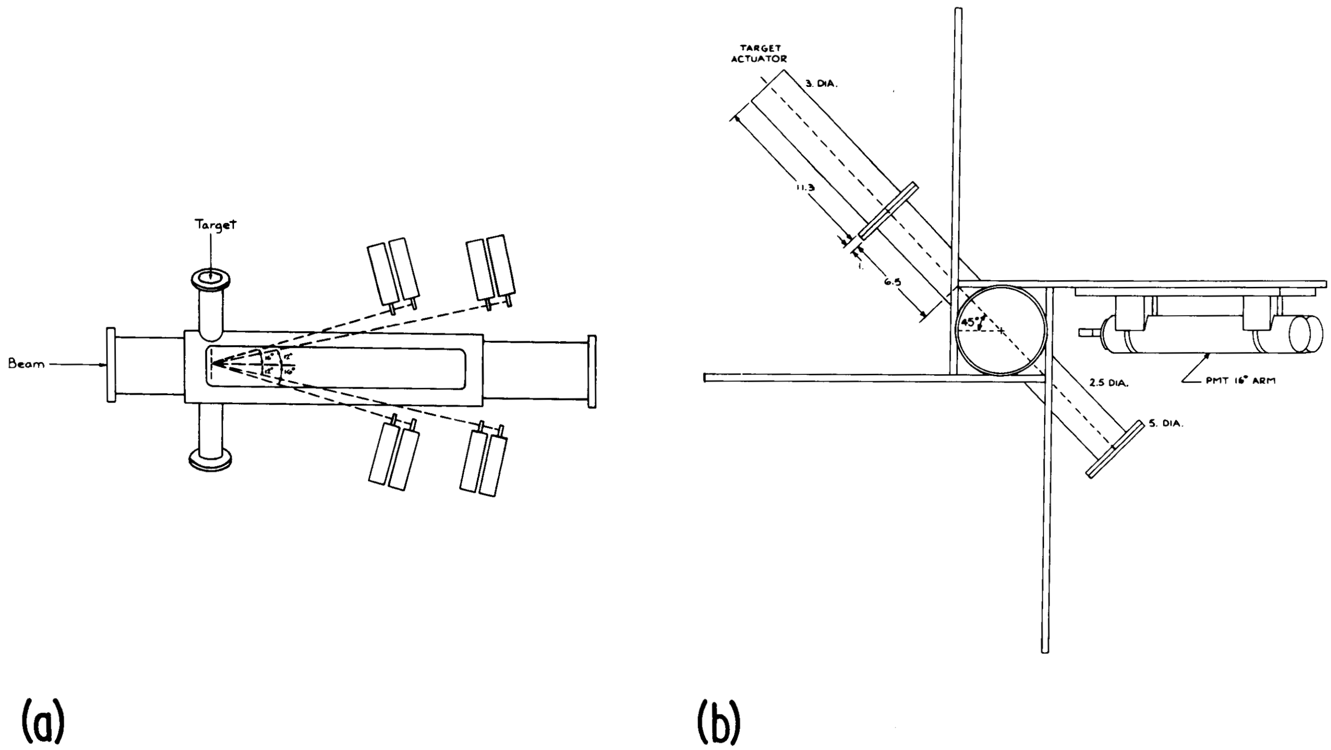

Figure 1. Schematic diagram of the 200 MeV proton polarimeter for use with the Brookhaven LINAC. Figure 1a is a plan view. Figure 1b view from the upstream direction of beam travel.

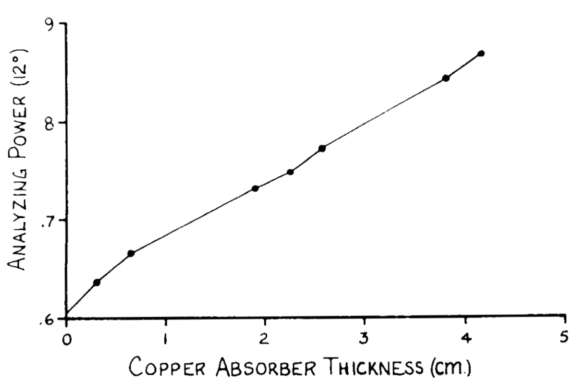

Figure 2. Instrumental asymmetry as a function of target position for detectors at ±12° and 16°.

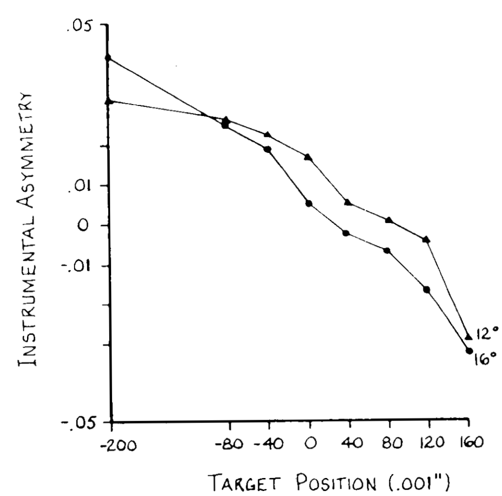

Figure 3. Analyzing power versus thickness of copper absorber placed between the polarimeter target and the ±12° detectors. As more energetic protons are stopped in the side counter the average analyzing power increases.

the 12 degree horizontal telescopes counts, with added absorber, are denoted as N_L and N_R (for left and right) and are compared to the 12 degree up and down telescopes with no absorber. To optimize the polarimeter's measurement efficiency, a quality factor was defined. Since the error in the measured polarization, P is:

$$E_p = \frac{1}{2}\left(\frac{1 - P^2A^2}{N_L + N_R}\right)^{1/2}$$

the quality factor to be maximized is then $A^2 d\sigma/d\Omega$ (see Fig. 5). A maximum quality factor of 127 mb/sr is obtained for 0.650 cm of copper absorber placed immediately upstream of the 12 degree telescopes' downstream scintillators; however, the variation versus absorber is small. At the conclusion of these tests the hardware was taken to Brookhaven National Laboratory and left there for later installation and integration into the AGS computer system.

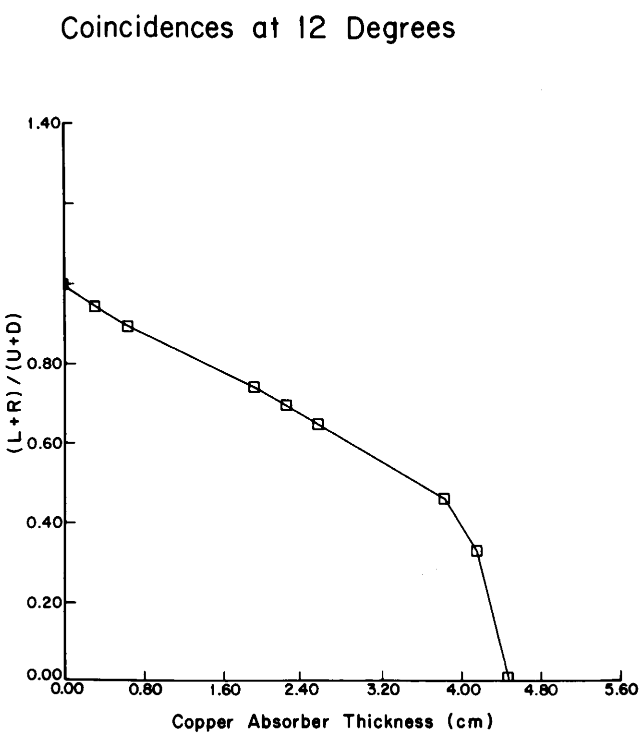

Figure 4. Ratio of summed counts in the ±12° counter to summed counts in the ±16° up-down counters a function of copper absorper thickness front of the side counters only. Count rates in the side counter fall with increasing thickness.

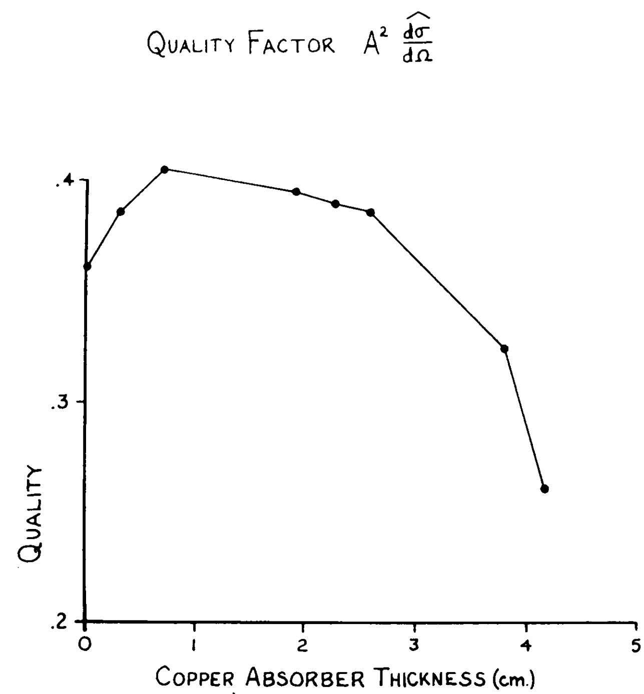

Figure 5. Plot of polarimeter quality factor versus copper absorber thickness.