Beam energy measurement with $ep \rightarrow ep$ elastic scattering on CLAS

(For the E1d 4.8+ GeV energy run, 02/02 - 03/02 2000)

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We use elastic scattering events in the reaction $ep \rightarrow ep$ to determine beam energy using only measured angles of scattered electron and a proton. Beam energy relates to these two angle according to the following formula:

$$E_0 = \frac{m_N}{1-\cos\theta_1}\left(\cos\theta_1 + \cos\theta_p\frac{\sin\theta_1}{\sin\theta_p} - 1\right) \quad (1)$$

where m_N is the nucleon mass, θ_1 and θ_p are the polar angles of scattered electron and the proton, respectively. Comparison of obtained values of E_0 for different CLAS sectors and electron azimuthal angle, ϕ_1, will show how well tracking defines scattering angle, and how well sectors are aligned.

About 658K $ep \rightarrow ep$ events are selected for this studies from $ep \rightarrow epX$ sample using cuts:

$$178^\circ < \phi_1 - \phi_p < 182^\circ \quad (2)$$

and

$$W = \sqrt{m_N^2 + 2m_N(E_n - E_1) - 4E_nE_1(1-cos(\theta_1))} < 1GeV \quad (3)$$

where $E_n = 4.817GeV$ is a nominal beam energy, given by accelerator (from CLAS data base), and E_1 is a scattered electron energy (see Figure 1).

In Figure 2 distribution of the beam energy, calculated according to Eq.(1), is presented as a function of ϕ_1. Besides the fact that calculated energy has sector and ϕ_1 dependence, it is also $\sim 13MeV$ lower than data base value.

The ϕ dependence of E_0 shows DC geometry problem, that indicates ϕ dependence of the reconstruction of a polar angle. (Magnetic field uncertainties play little role in the polar angle reconstruction). This effect is a subject of a separate study, and perhaps corrections are needed to the reconstructed polar angle of a particle as function of azimuthal angle.

Reconstructed low average energy of the beam, $E_0 = 4.803\ GeV$, see Figure 3, can indicate ether systematic shifts in the reconstruction of angles, or wrong initial

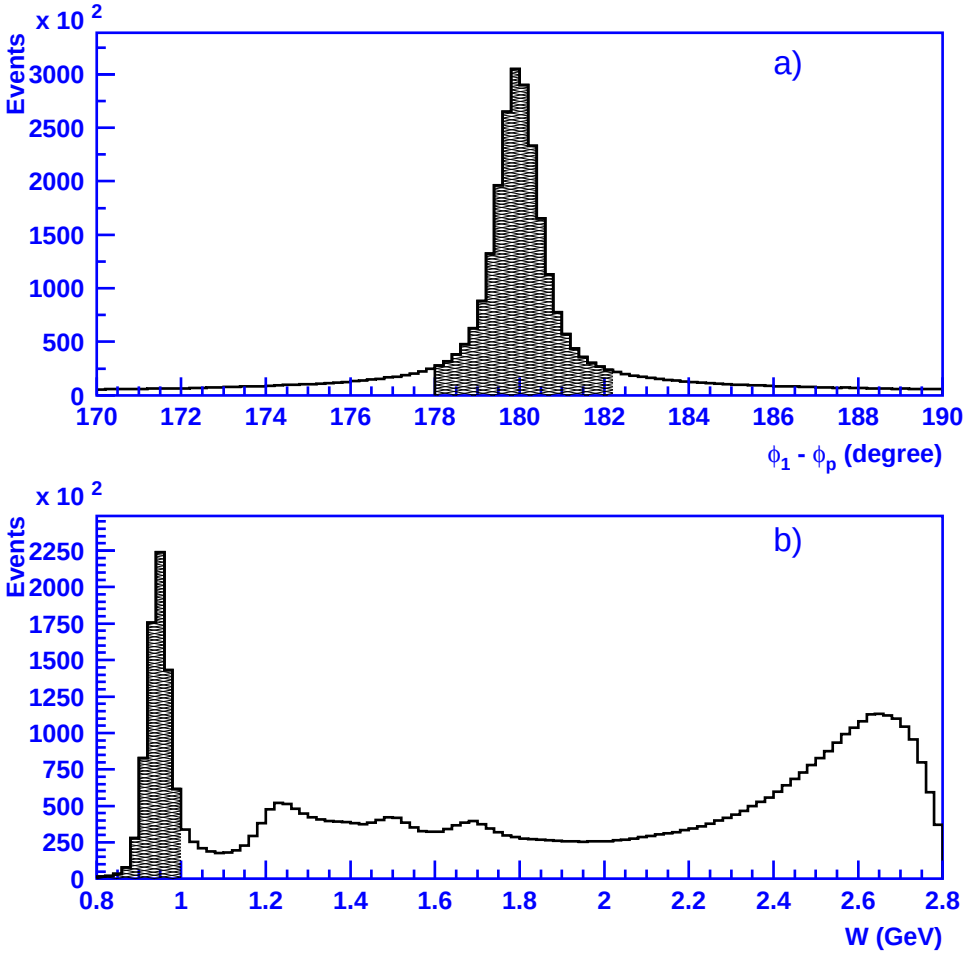

Figure 1: a) cut on the difference of azimuthal angles of the scattered electron and the proton. b) cut on the total hadronic mass, W, calculated according to Eq.(2)

value that is in the run database. This, high energy part of the e1d run was parallel to the Hall A's E89-044 experiment that had the same 5 pass beam as e1d. There have been beam energy measurements by Hall A during the period, from 02/02/00 to 02/26/00. First results are in [1], Figure 4, and show beam energy as 4.802 GeV. The second, the arc beam energy measurements, 4.8027 GeV, and the (ep) measurements, 4.8052 GeV, are documented in [2]. All these measurements indicate, that the average energy of the 5 pass beam, delivered to the Hall A, was 4.803 GeV, which is the same as the average beam energy calculated from measured angles of electron and a proton in the elastic scattering reaction $ep \rightarrow ep$.

Therefore, it is recommended in the analysis of e1d 4.8 Gev data use $E_0 = 4.803\, GeV$ as a correct value of the beam energy.

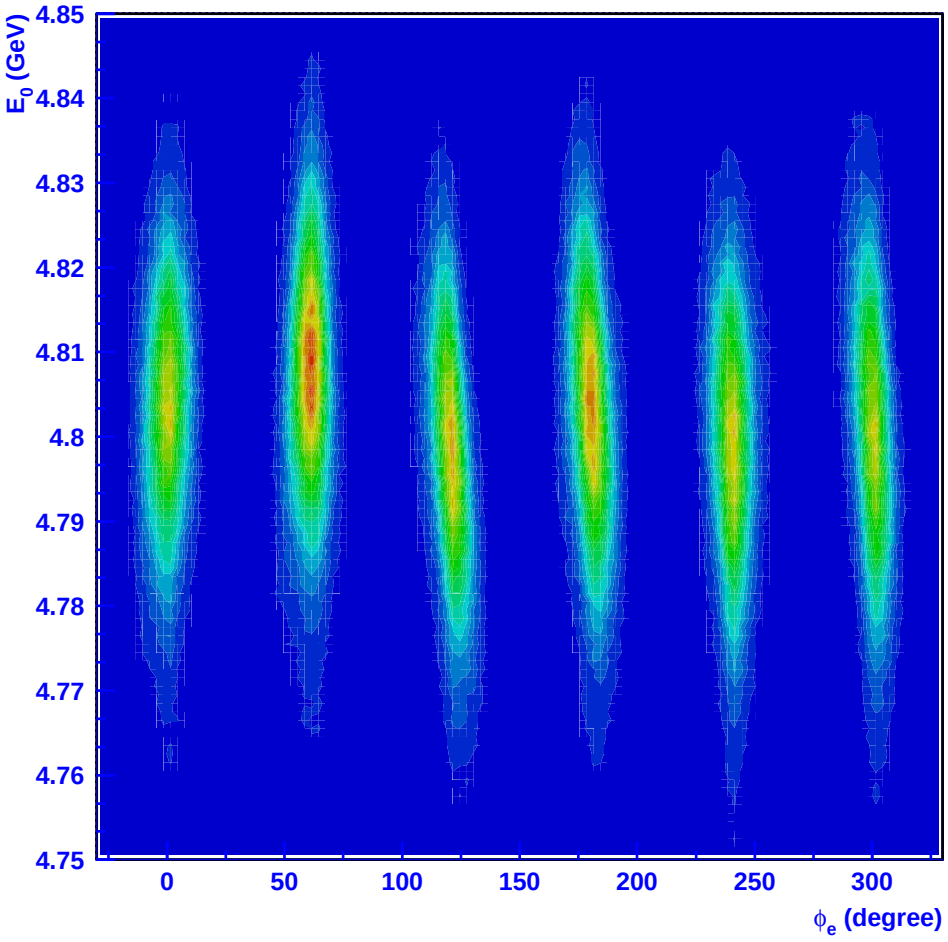

Figure 2: Beam energy calculated according to Eq.(1) using elastic scattering events in the reaction $ep \rightarrow ep$ as a function of scattered electron azimuthal angle, ϕ_1. Solid line corresponds to the energy 4.817 GeV, from run data base.

References

[1] Hall A Log Entry 34075, February 16 (2000).

[2] Hall A Log Entry 34475, February 20 (2000).

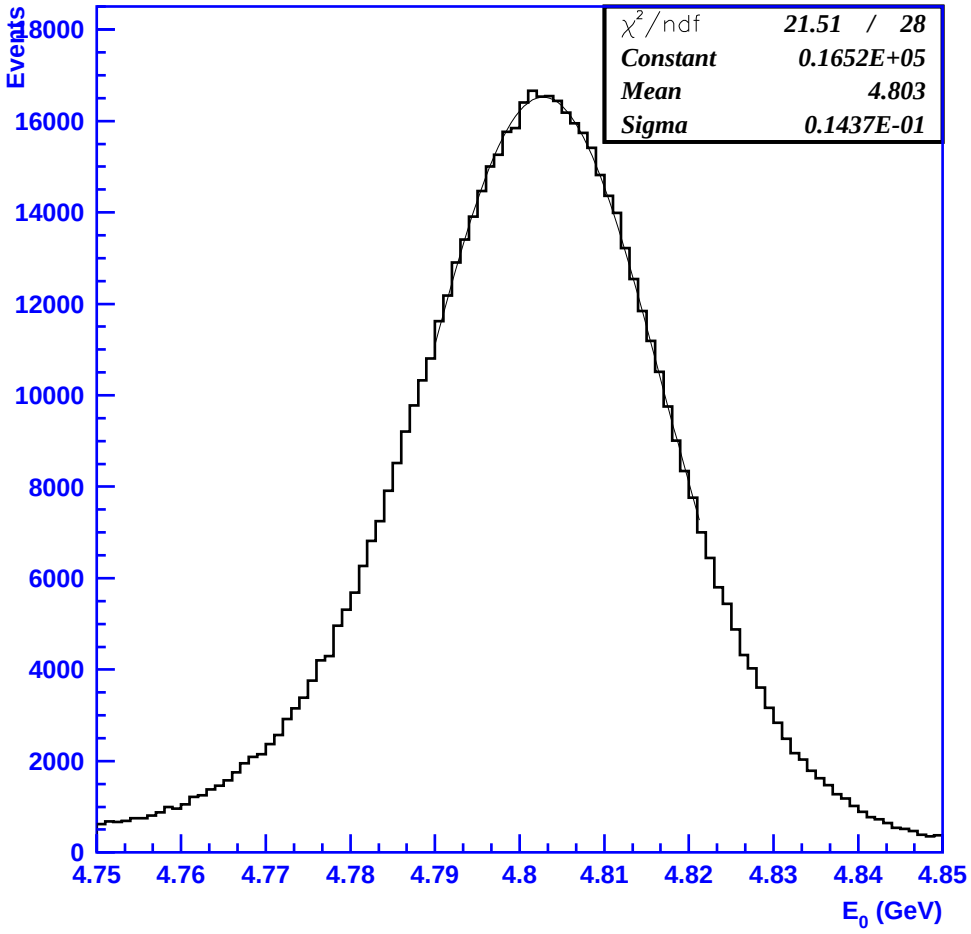

Figure 3: Beam energy calculated according to Eq.(1) and averaged over all sectors (ϕ's).

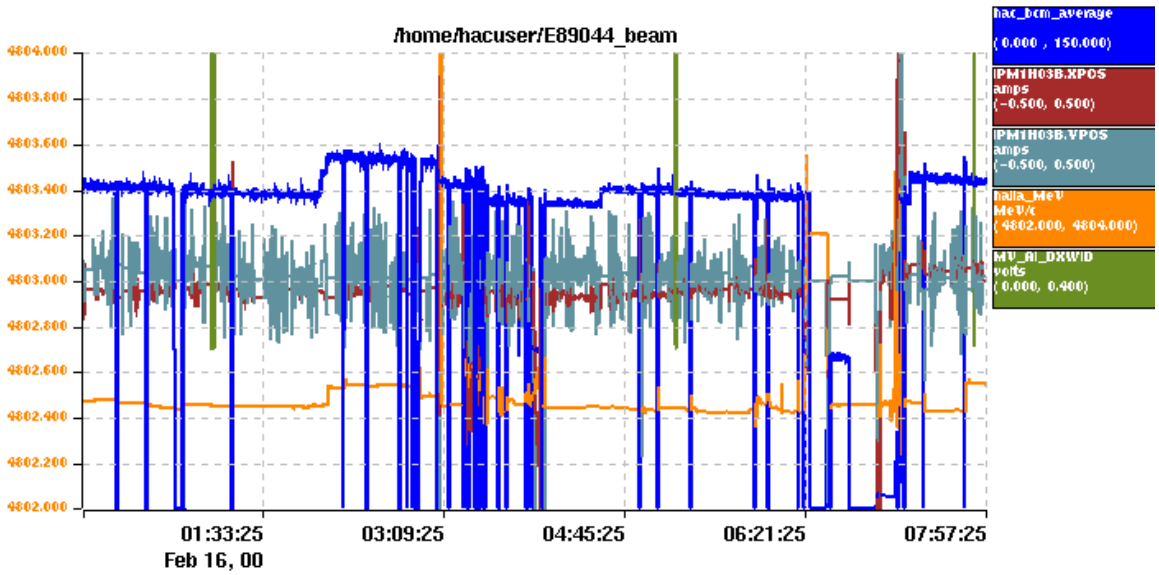

Figure 4: Beam energy measured in Hall A from [1].