A simple study of the angular and Q^2 resolutions

Alexander Gramolin

Budker Institute of Nuclear Physics, Novosibirsk, Russia

PRad Weekly Meeting, 01/31/2014

Why do we need a tracking system?

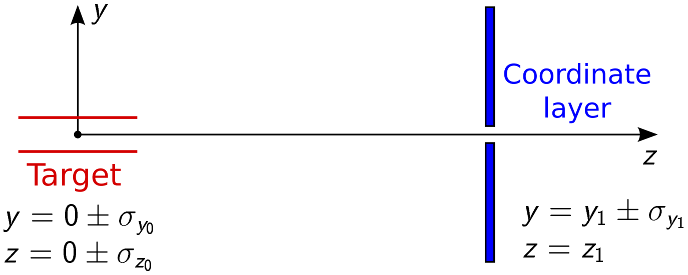
- ✓ To determine Q^2 values for *ep* scattering events
- ✓ To recognize Møller scattering events
- However, it will not help us to recognize *ep* scattering events
- Probably, to reconstruct event vertices, which can help to reject background events. However, in this case we need to have at least two coordinate layers.

Can we use a GEM-based detector?

- ✓ Very good coordinate resolution (0.07–0.1 mm)
- ✓ Relatively small radiation thickness (about 0.3% X_0)
- ✓ It is easy to make a small central hole for the passage of the beam
- ✓ Hall A is developing large-area (40x50 cm^2) GEMs for Super Bigbite
- However, they can not work in vacuum without additional protection

Angular resolution with a single coordinate layer

With a single coordinate layer, we can not determine the vertex position. So, we need to estimate it using the beam position (x and y coordinates of the vertex) and the length of the target cell (z coordinate of the vertex).



We can estimate $\sigma_{y_0} = 0.2$ mm (CEBAF beam) and $\sigma_{z_0} = 10$ mm (target cell). Two-dimensional analisys should be accurate enough, since $\sigma_{x_0}, \sigma_{y_0} \ll \sigma_{z_0}$.

$$\theta = \arctan \frac{y_1}{z_1}, \qquad \sigma_\theta = \frac{1}{y_1^2 + z_1^2} \sqrt{z_1^2 \sigma_{y_1}^2 + z_1^2 \sigma_{y_0}^2 + y_1^2 \sigma_{z_0}^2}$$

How to determine Q^2 for the process $ep \to ep$

NB: $\sigma_E/E = 10^{-4}$ (beam energy), $\sigma_{E'}/E' = 0.026/\sqrt{E'} \approx 2 \cdot 10^{-2}$ (HyCal)

1. Using the beam energy and the energy of scattered electron:

$$Q^2 = 2M(E - E')$$

$$\sigma_{Q^2} = 2M\sqrt{\sigma_E^2 + \sigma_{E'}^2} \approx 2M\sigma_{E'} \approx 5 \cdot 10^{-2}\sqrt{E'}\ \mathrm{GeV}^2 \Rightarrow \text{It is useless for us}$$

2. Using the beam energy and the electron scattering angle:

$$Q^2 = \frac{2ME^2(1-\cos\theta)}{M + E(1-\cos\theta)}, \qquad \sigma_{Q^2} = \sqrt{\left(\frac{\partial Q^2}{\partial E}\right)^2 \sigma_E^2 + \left(\frac{\partial Q^2}{\partial \theta}\right)^2 \sigma_\theta^2}$$

$$\frac{\partial Q^2}{\partial E} = Q^2\left[\frac{2}{E} - \frac{Q^2}{2ME^2}\right] \approx \frac{2Q^2}{E}, \quad \frac{\partial Q^2}{\partial \theta} = Q^2 \frac{\sin\theta}{1-\cos\theta}\left[1 - \frac{Q^2}{2ME}\right] \approx Q^2 \frac{\sin\theta}{1-\cos\theta}$$

3. Or using a combined formula: $Q^2 = 4EE'\sin^2\frac{\theta}{2}$

Clearly, the second formula (with E and θ) is the best for us.
The Q^2 resolution is limited by the angular resolution in our case.

The angular and Q^2 resolutions

$z_1 = 580$ cm, $\sigma_{y_1} = 0$, $\sigma_{y_1} = 0.1$ mm, $\sigma_{y_1} = 0.3$ mm, $\sigma_{y_1} = 0.6$ mm