

Tracking and Q^2 resolution

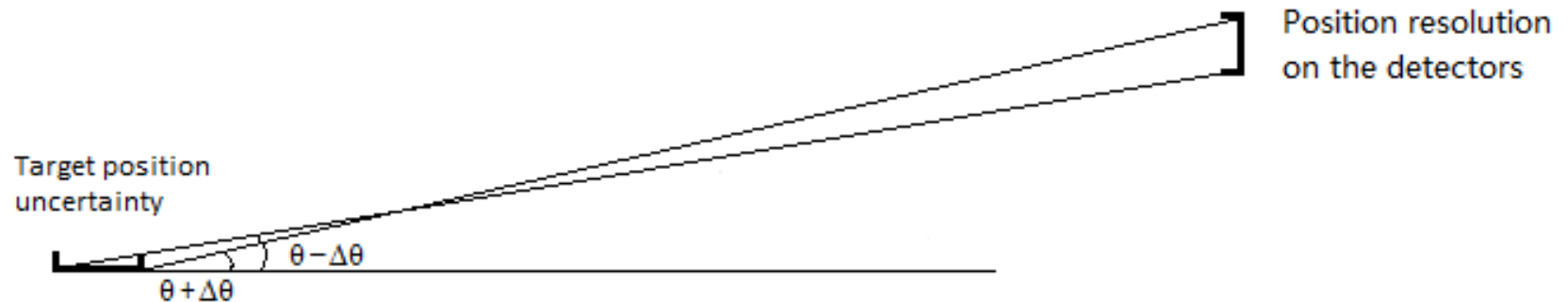
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Q² resolution

- Q² resolution is important to the experiment
 - Energy resolution, $2.6\%/\sqrt{E}$ from HyCal
 - Angular resolution, which may be improved by additional position detectors
- Angular resolution is determined by
 - Uncertainty on the target position
 - Position resolution of the detectors

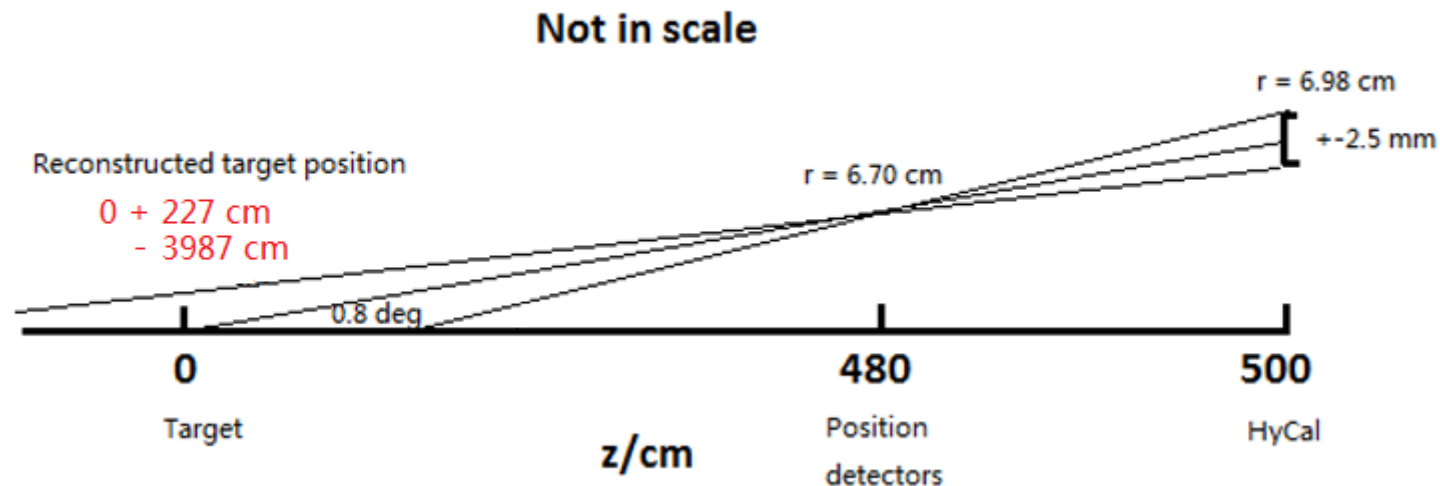


Tracking

- With only 1 position detector (HyCal), we can only estimate the target position is inside the target cell ($z = 0 \pm 2$ cm)
- Tracking requires additional position detectors, and it may provide information on determining the target position
- However, due to a leverage problem. The determination on the target positions cannot improve the angular resolution in our experiment

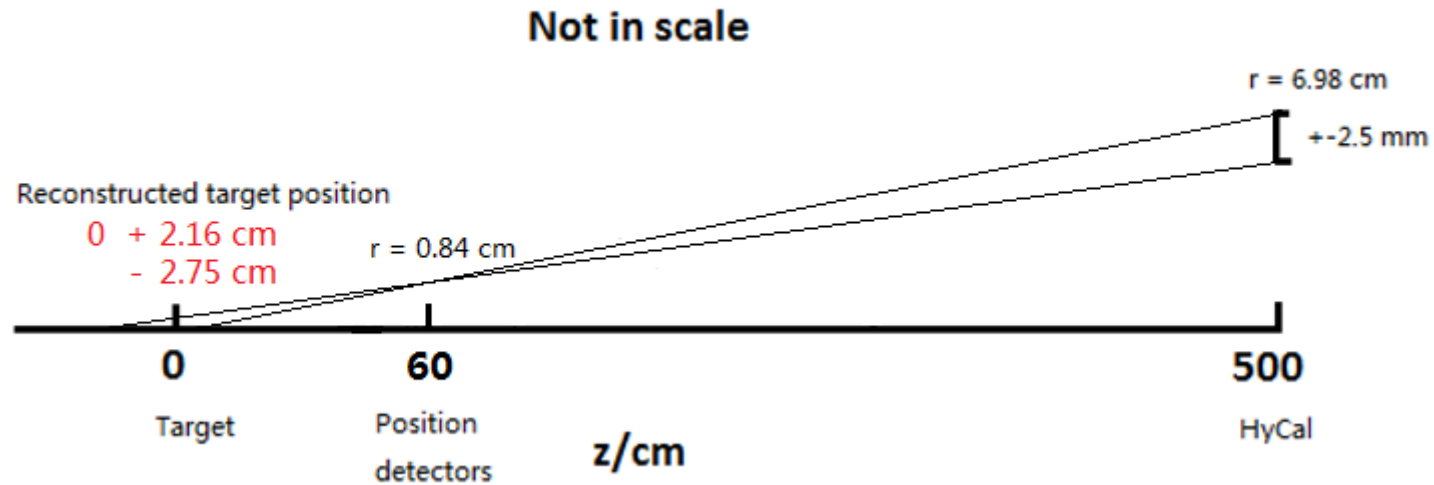
Leverage problem

- The plot shows an ideal case that a position detector with resolution = 0 is put between the target and HyCal
- As shown in the plot, it is almost impossible to get a good reconstructed target position if all the tracking devices are put behind the vacuum box



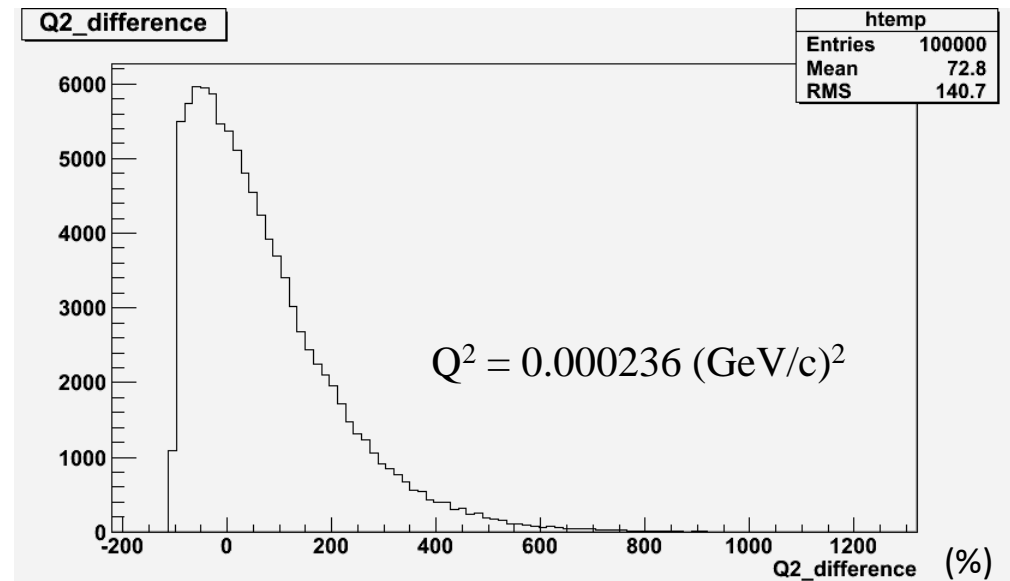
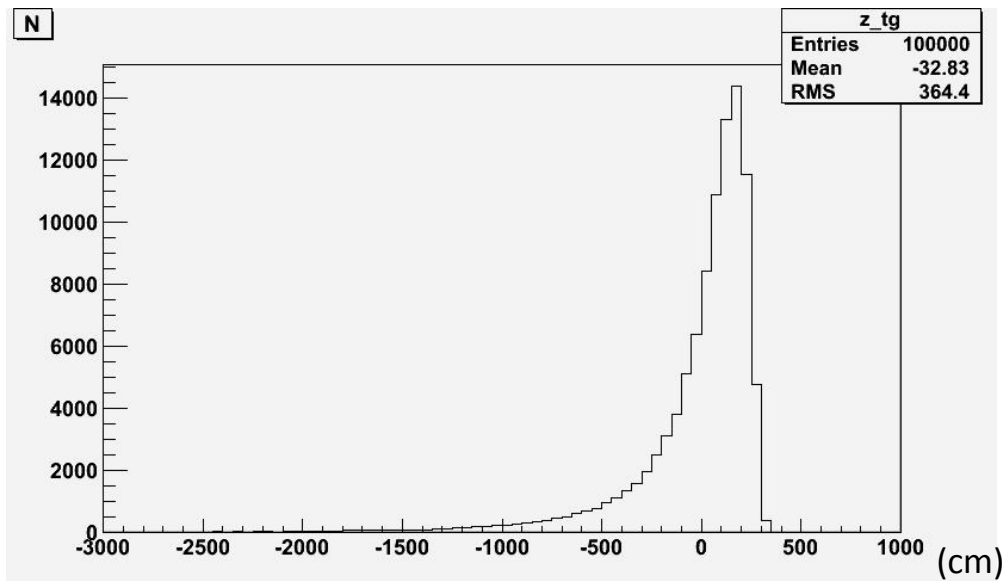
Leverage problem

- Trying to put the position detector close to the target will improve the reconstruction



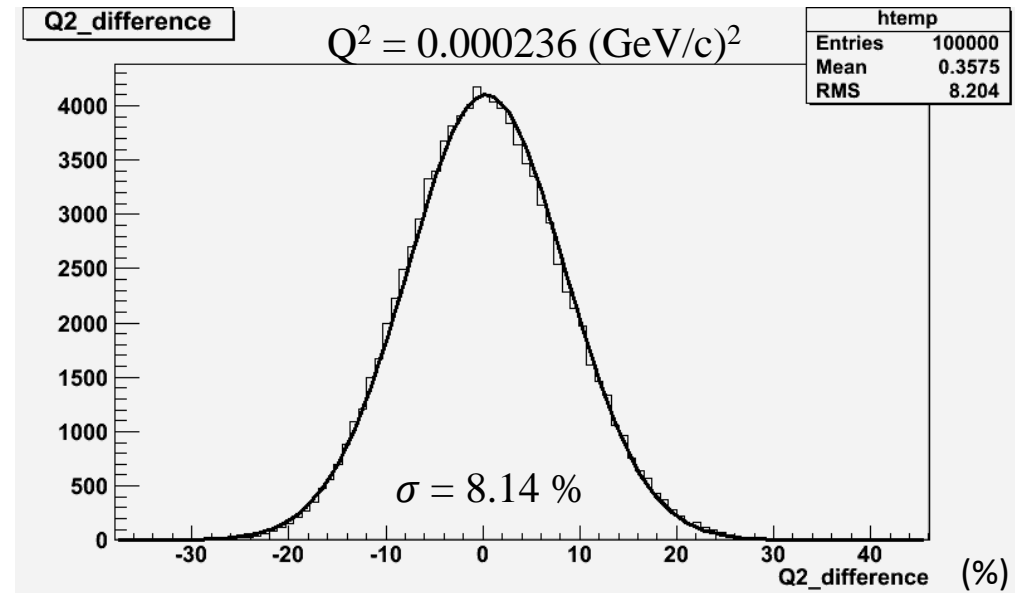
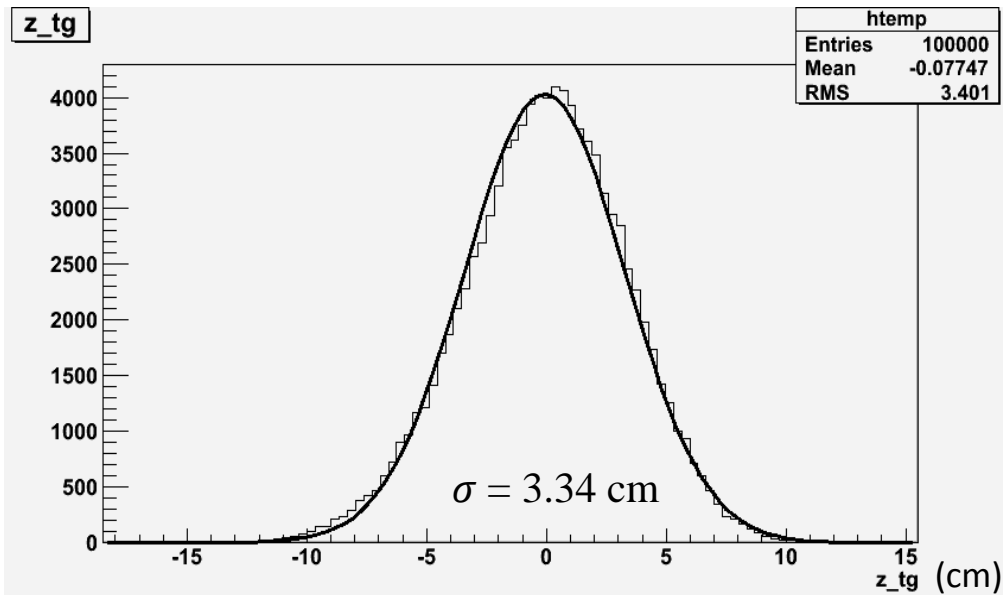
Tracking simulations

- 2 position detectors are used as tracking devices in the simulation
- Tracker (fibers for example, resolution 0.29 mm) + HyCal (resolution 2.5 mm)
- Tracker placed at $z = 470$ cm, HyCal is placed at $z = 500$ cm, true target position is set to be $z = 0$, scattered angle = 0.8 degree
- Q^2 is determined based on the reconstructed angle from tracking information.



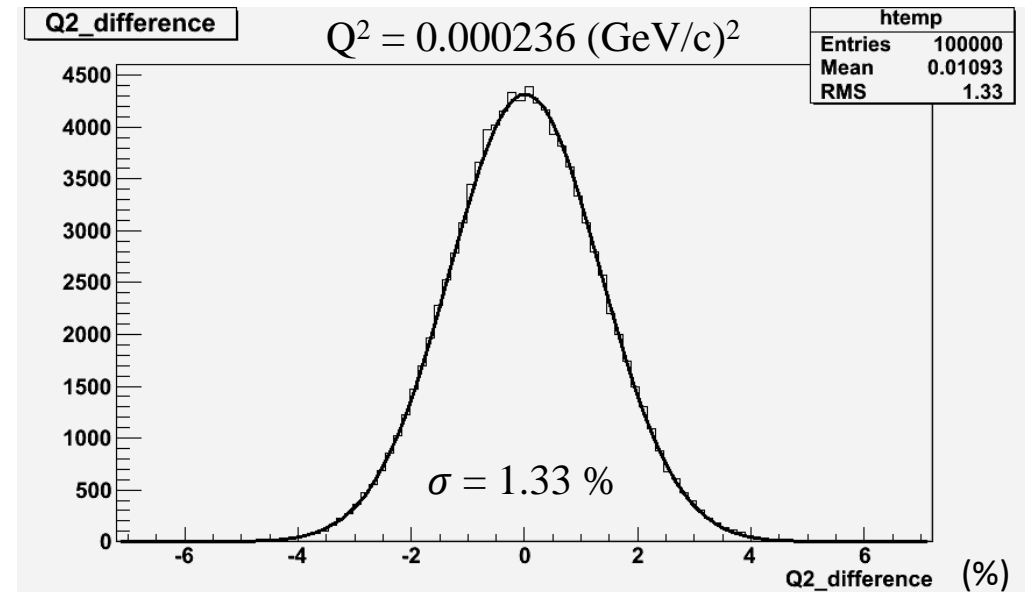
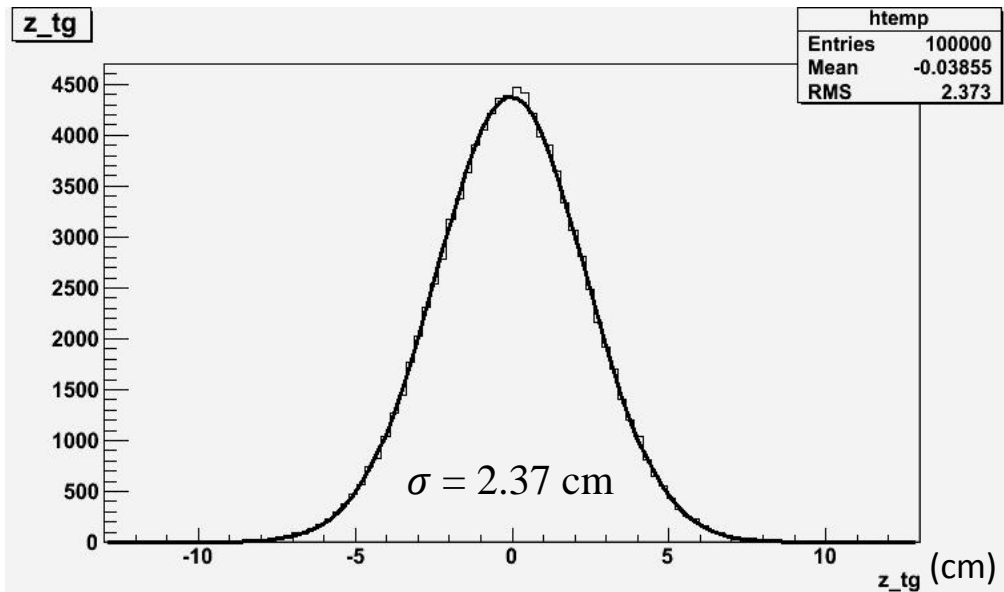
Tracking simulations

- If a tracker is moved from $z = 470$ cm to 60 cm, other conditions do not change
- It is improved significantly, but still not good enough



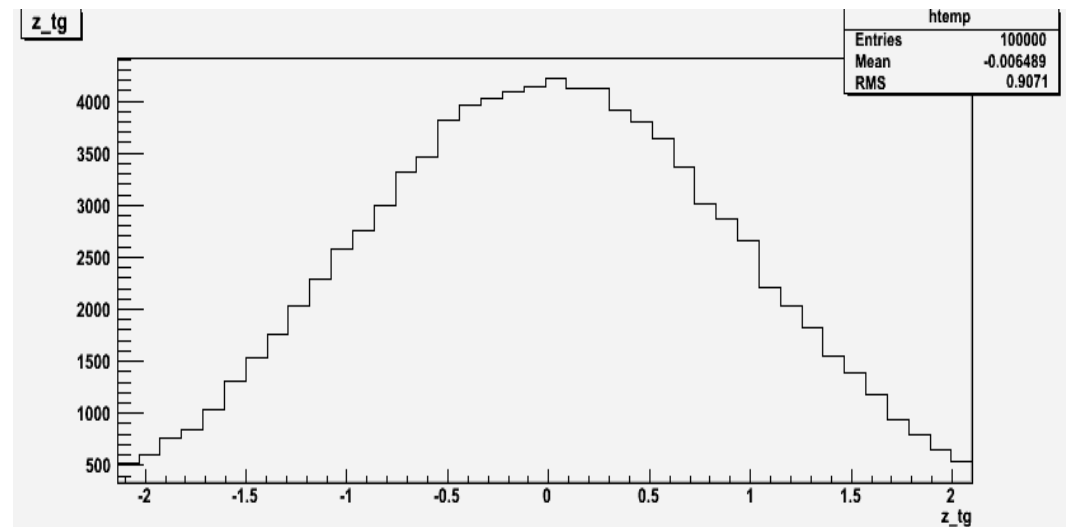
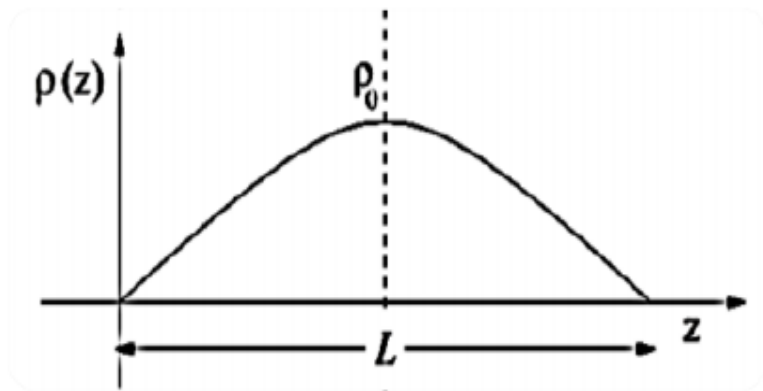
Tracking simulations

- If we use 2 trackers, one at 60 cm, the other one at 490 cm
- The reconstructed target positions are still worse than the estimation based on the target length, so it is impossible to determine the target position by tracking (Q^2 resolution is improved because of the much better position resolution at 490 cm)



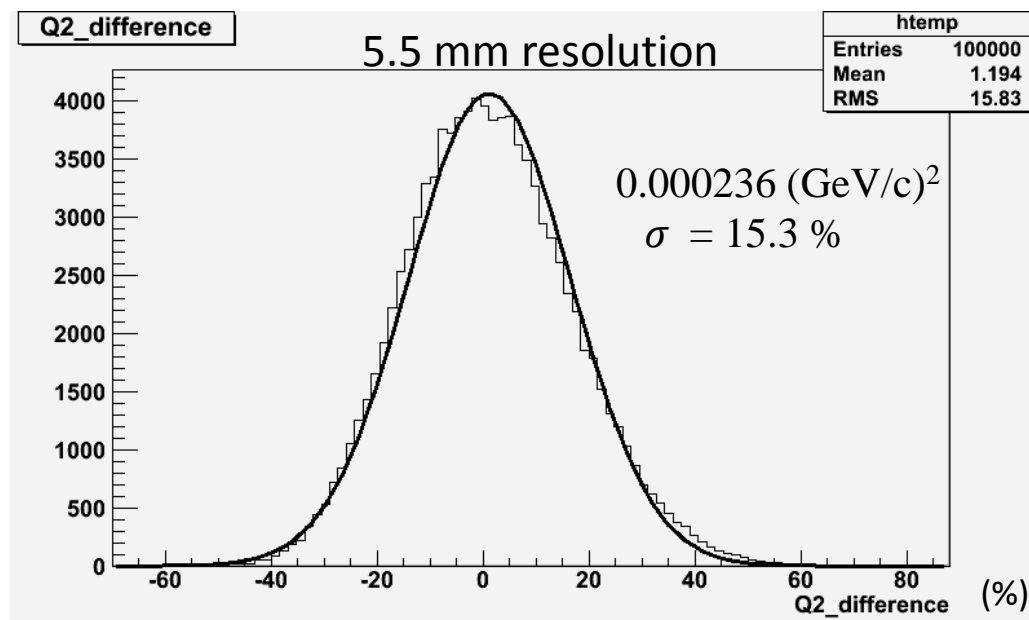
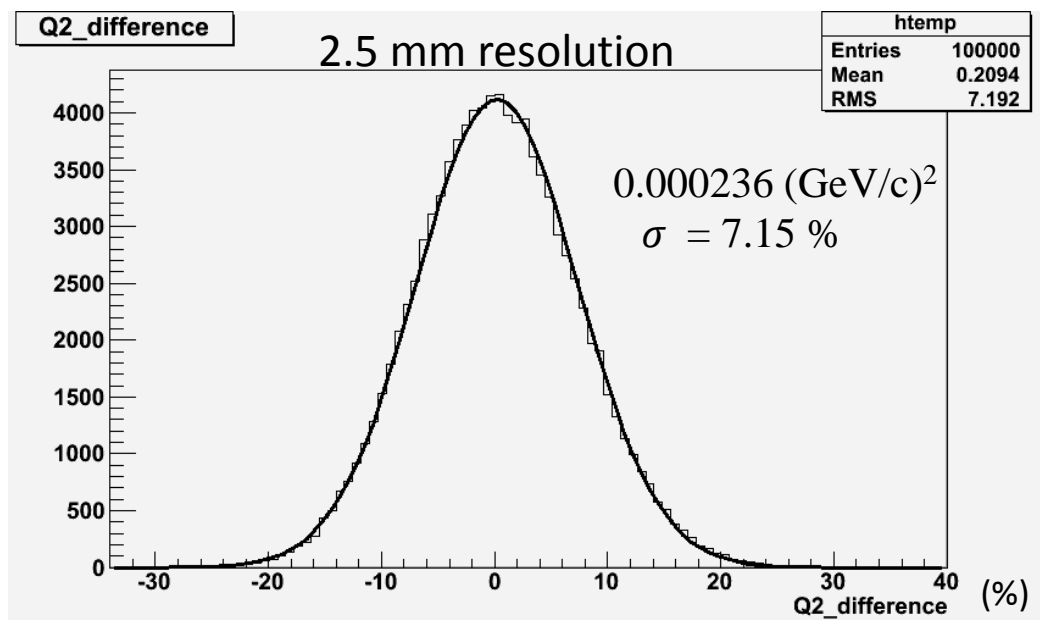
Q^2 resolution

- The determination of target position has a large uncertainty, which is much worse than a simple assumption $z = 0 \pm 2 \text{ cm}$
- Assuming the target position distribution is similar to the target density distribution: approximately a Gaussian with $\sigma = 1 \text{ cm}$



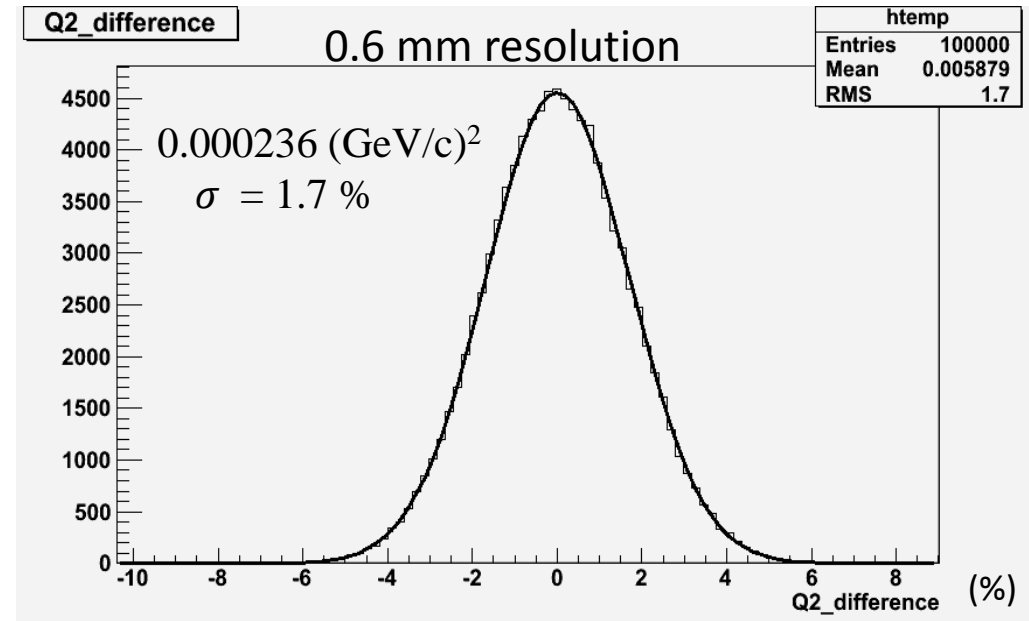
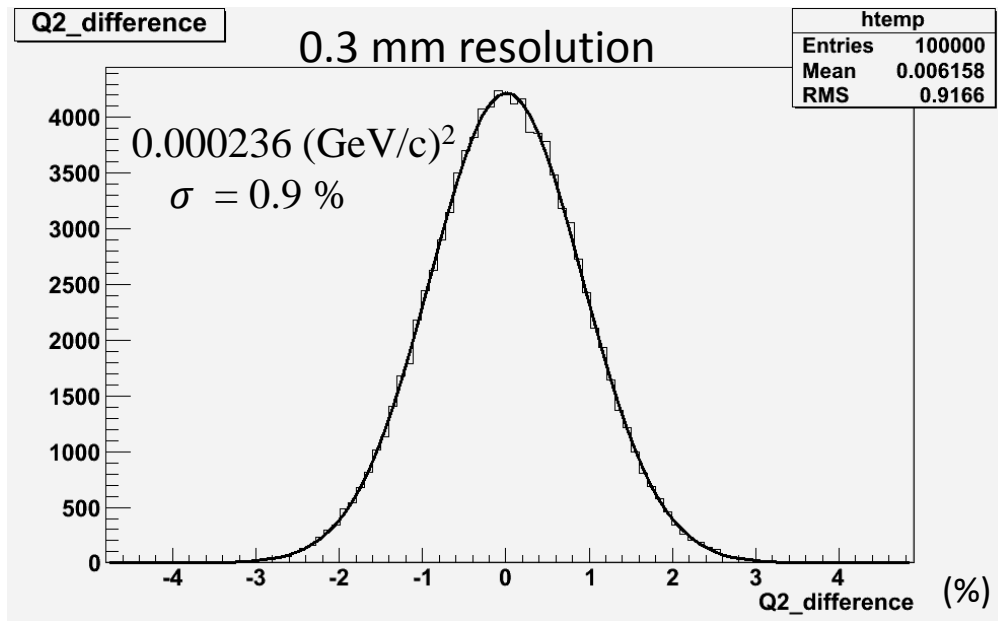
Q² resolution

- The effect of the target position uncertainty is very small, the Q² resolution is consistent with the number in the proposal
- If we assume the biased position reconstruction increases the position resolution to 5.5 mm/sqrt(E), the Q² resolution becomes much worse



Q² resolution

- If fibers are used as the position detectors, and placed very close to HyCal
- Position resolution is improved to 0.3 mm or 0.6 mm, Q² resolution is thus improved significantly



Summary

- Due to the leverage problem, determination on target positions by tracking cannot improve our Q^2 resolution
- The poor determination also shows it is impossible to cut the background from halo or residual gas by tracking
- We can improve the Q^2 by simply adding a high resolution position detector close to HyCal