Forward-Backward Asymmetry Study in Z/$\gamma \to \mu^+\mu^-$ at 91.1876 GeV

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Motivation

- Due to V/A nature, leptons produced in $e^+ e^- \rightarrow Z/\gamma \rightarrow \mu^+ \mu^-$ present a forward-backward asymmetry $\frac{d\sigma}{dcos\theta} = \frac{\pi\alpha^2}{2s}\left[1 + \cos^2\theta + \frac{8}{3}A_{FB}\cos\theta\right]$, then $A_{FB} = \frac{\int_0^1 \frac{d\sigma}{dcos\theta} - \int_{-1}^0 \frac{d\sigma}{dcos\theta}}{\int_0^1 \frac{d\sigma}{dcos\theta} + \int_{-1}^0 \frac{d\sigma}{dcos\theta}} = \frac{F-B}{F+B}$.

- World average : $\mathrm{Sin}^2\theta_W^{eff} = 0.23153 \pm 0.00016$
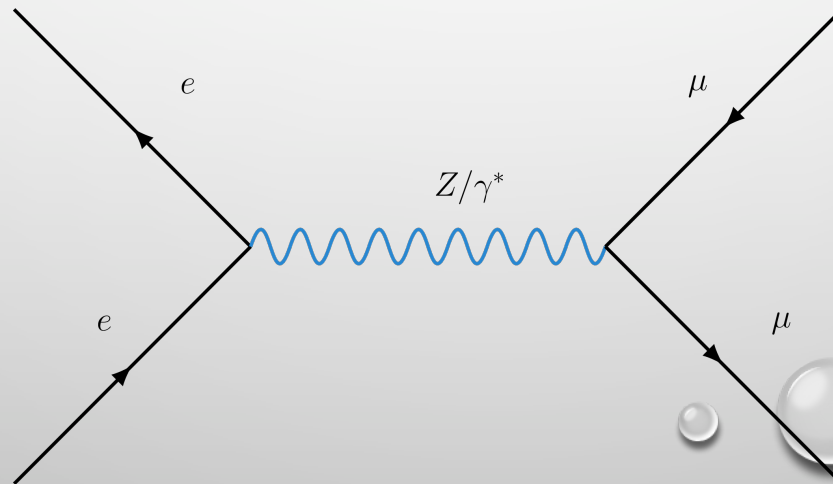
Monte Carlo Sample

- The data used for this analysis was done by the latest version of CEPC simulation software (By early 2017) and reconstructed by Arbor version 3.3.

- Beam Energies were chosen around Z Boson mass

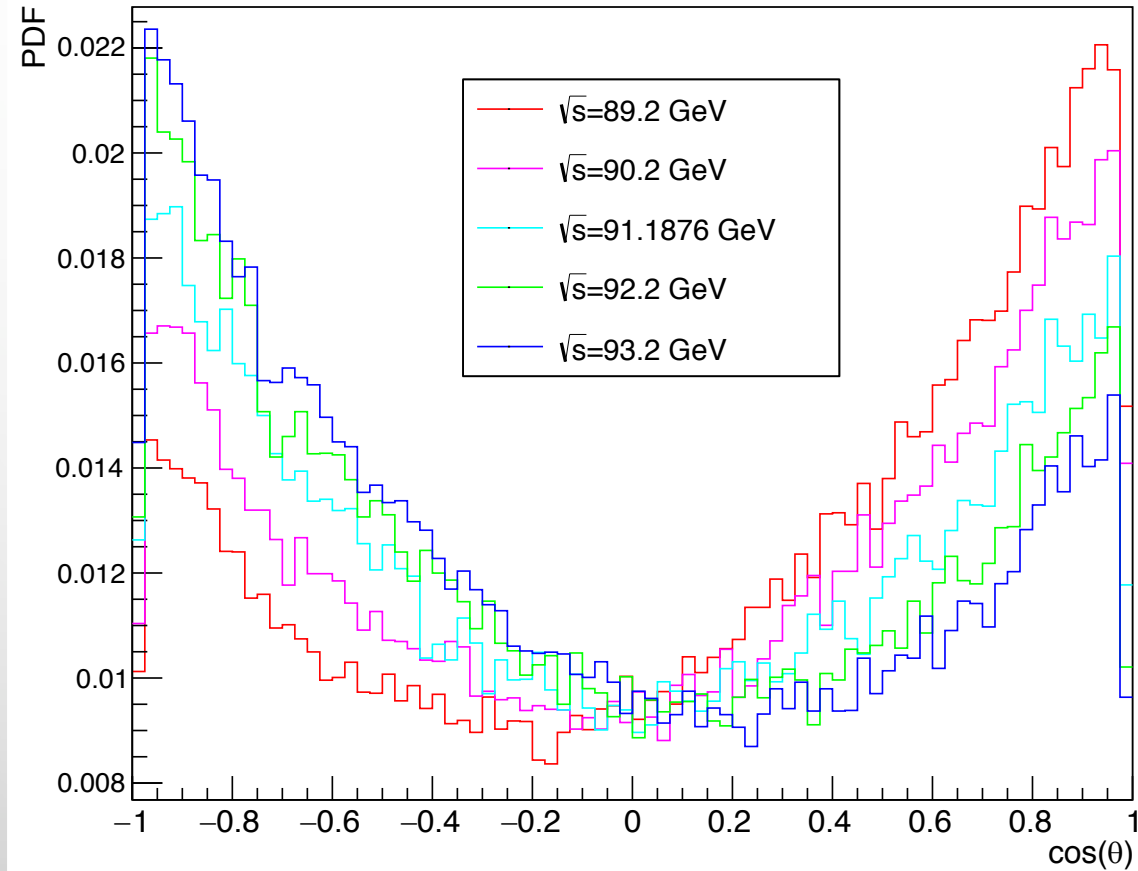| Beam Energy(GeV)	89.2	90.2	91.1876	92.2	93.2	Total
Events Reconstructed	95638	86642	73465	96297	86447	438489

Invariant Mass Reconstruction
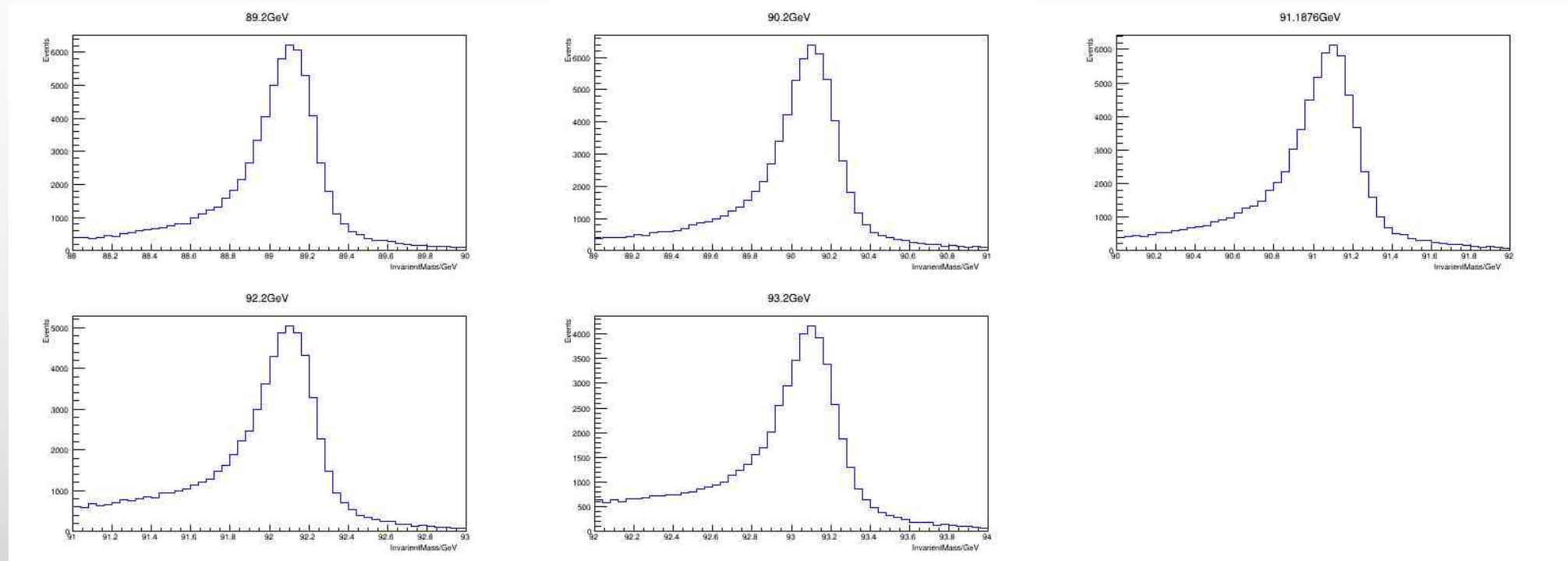
Invariant Mass at Different Energy. Resolution of invariant mass is 0.3 GeV.
At on-shell energy (92.2 GeV and 93.2 GeV), the distributions have bigger tails at low energy side.

PDF in Polar Angle (cosθ)

For high energy (92.2 GeV and 93.2 GeV), Forward (cosθ > 0) events are fewer than backward (cosθ < 0) events. For lower energy (89.2 GeV and 90.2 GeV), forward events are more than backward events.

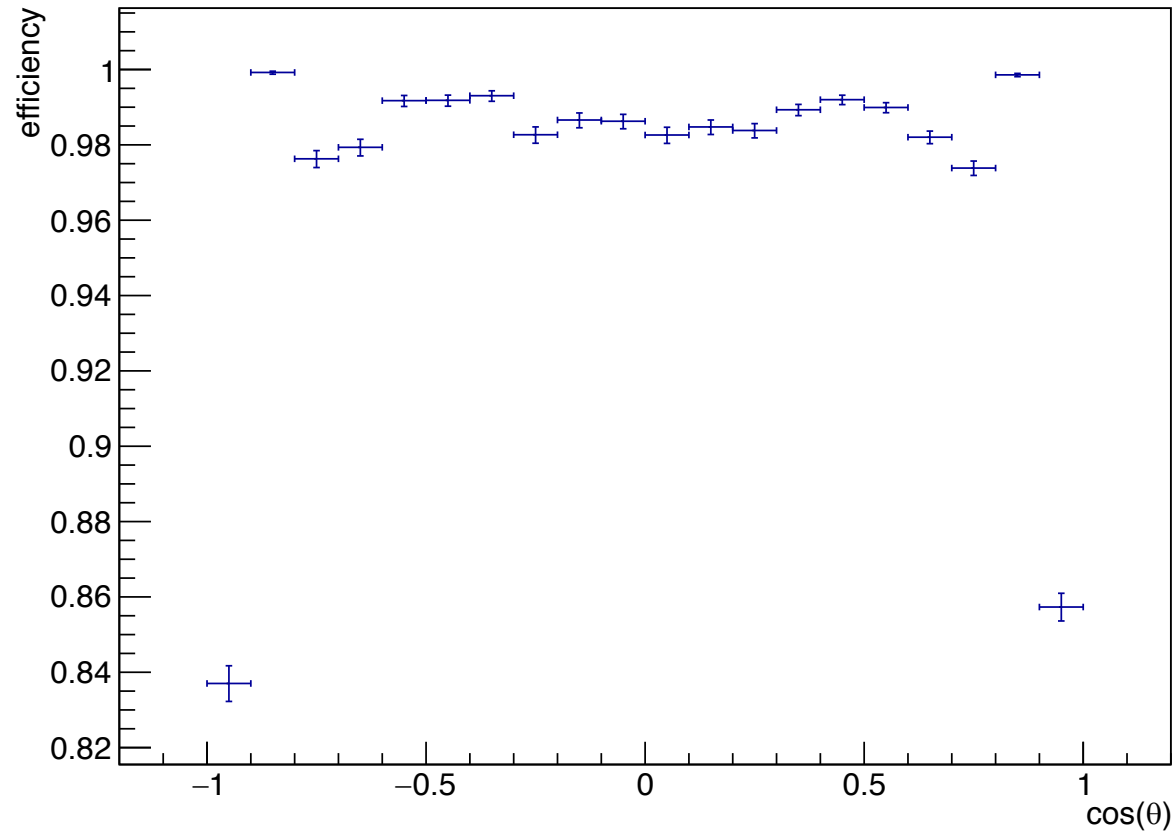# A_{FB} in Beam Energy
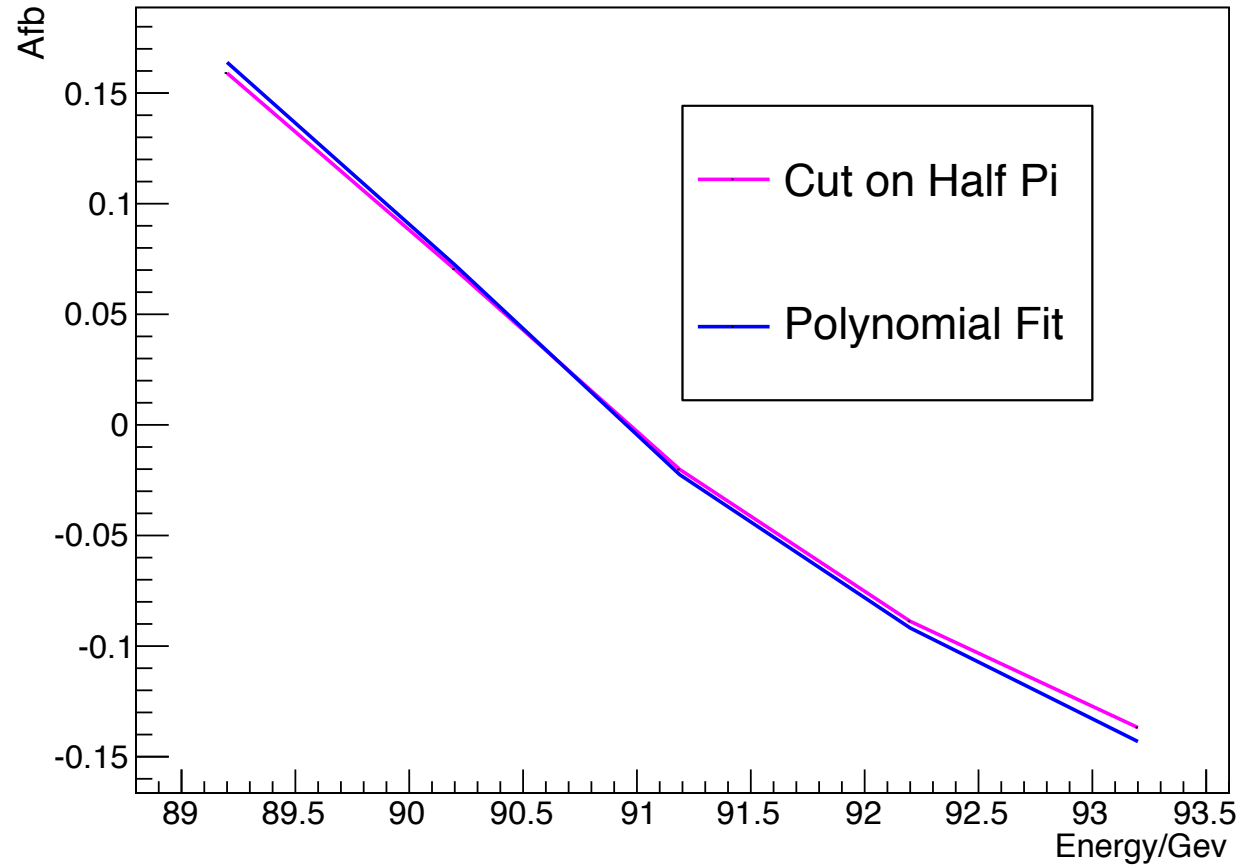
Two Approaches to obtain A_{FB}:
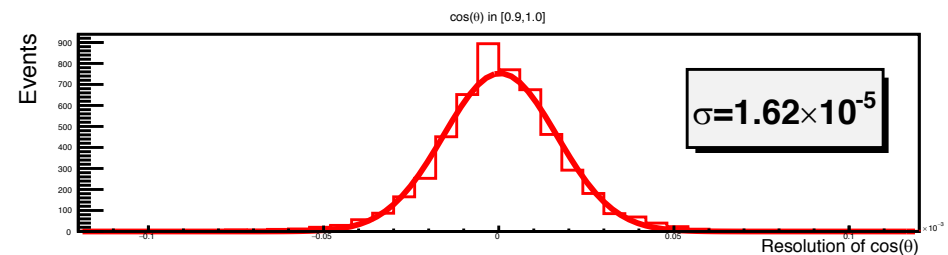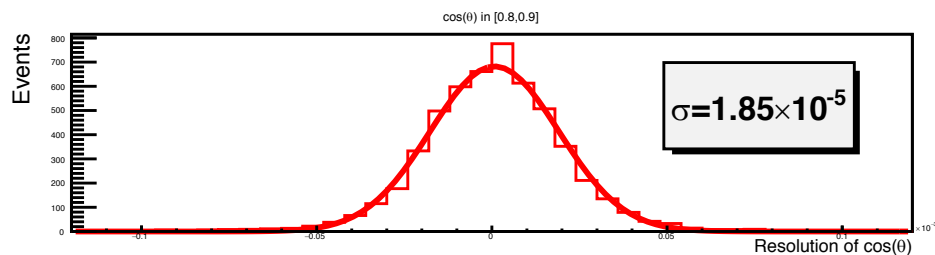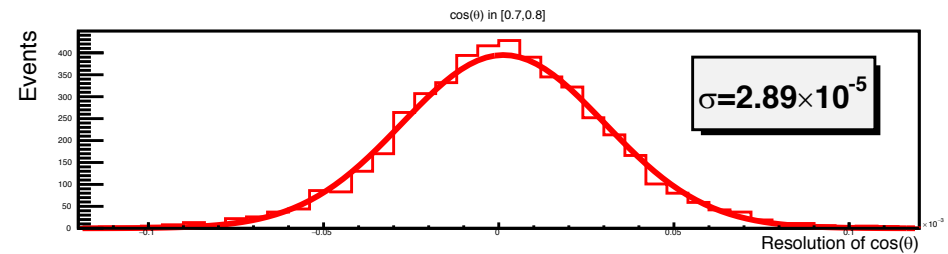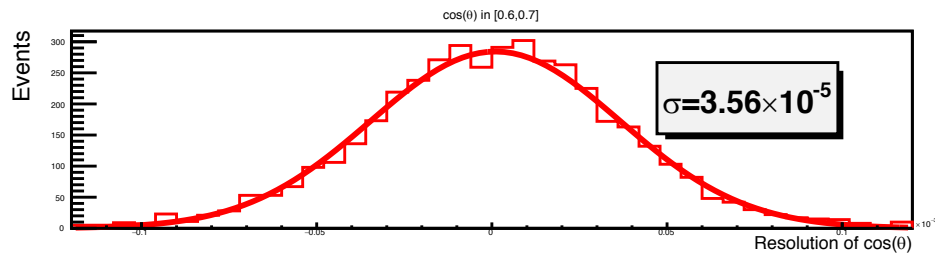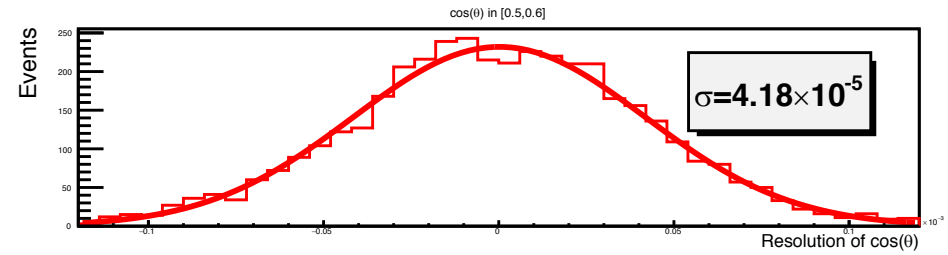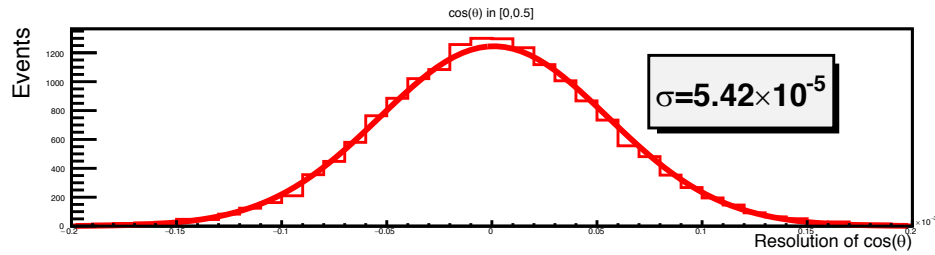
1. Cut on Half Pi: $A_{FB} = \frac{F-B}{F+B}$.

2. Polynomial Fit: Fit curves to
   $$\frac{d\sigma}{dcos\theta} = a[1 + \cos^2\theta + A_{FB}\cos\theta]$$

Efficiency in cosθ

Efficiency at the middle flat is about 98%, and there are two concave at cosθ = ±0.75, which are due to geometry of CEPC calorimeter detector. And on double sides of polar angle, η reduces to ~0.84 because of coverage.

Resolution of cosθ

Resolution of cosθ varies from 1.6×10^5 to 5.41×10^5, which is better when polar angle gets smaller.

(1) $dcos\theta \sim \dfrac{1}{r}$.

(2) Tracks with smaller polar angles go through more meterial.

Summary

- Simulation study on Forward-backward asymmetry in $e^+e^- \rightarrow Z/\gamma \rightarrow \mu^+\mu^-$.

- Resolution of invariant mass of di-muon is ~0.3GeV

- Calculate coefficient A_{FB} at different beam energies.

- Calculate reconstruction efficiency, which is around 98% at most of the coverage and decreases at two ends of calorimeter.

- Resolution of cosθ varies from 1.6×10^5 to 5.41×10^5, which is better when polar angle gets smaller.