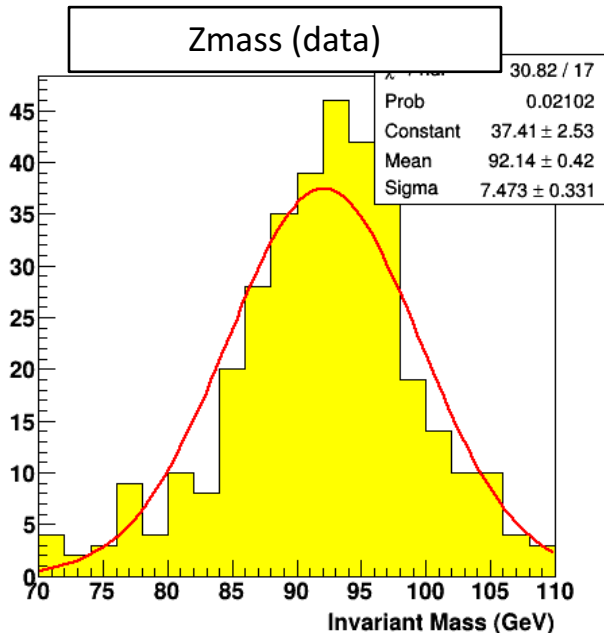
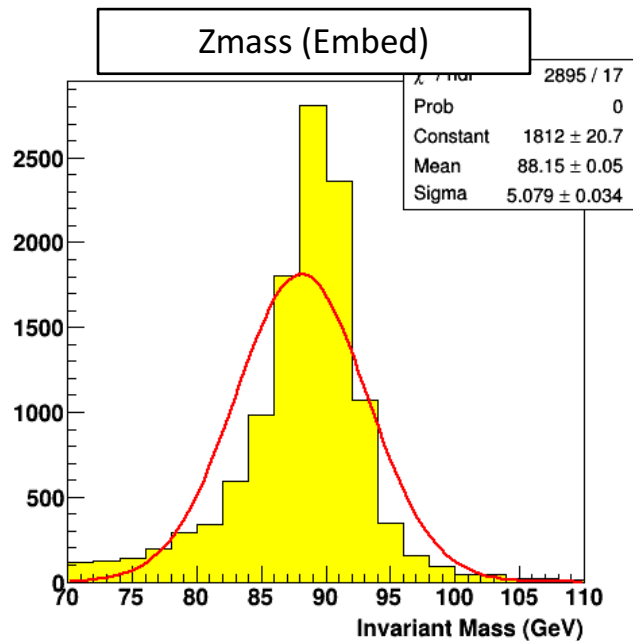


Progress Report

Jae D. Nam
Temple Univ.
20221116



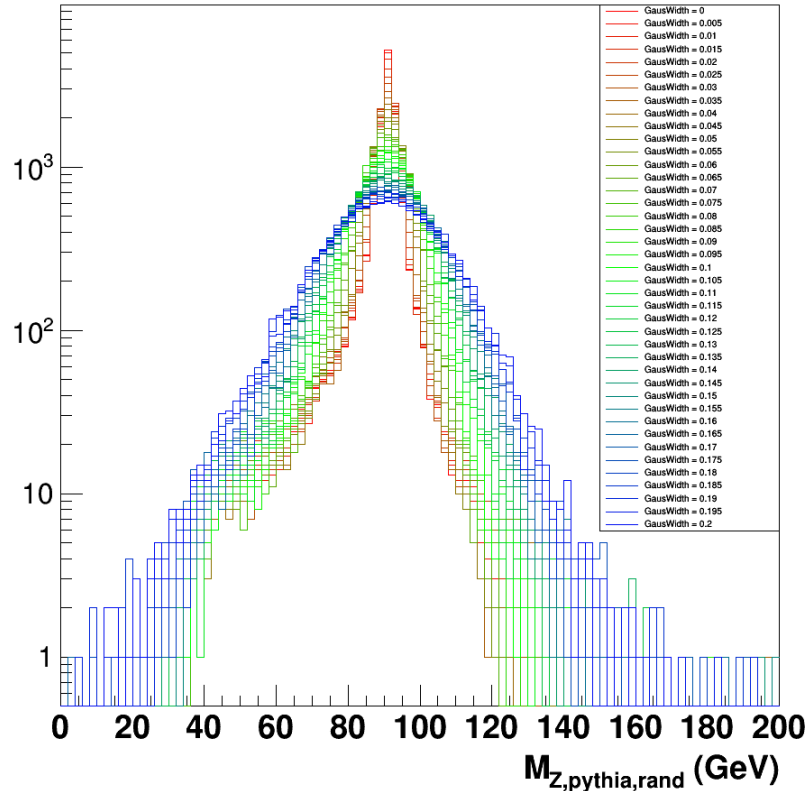
Z mass shift



- Z mass study in relation to data-embed mismatch continues.
- Validity of BEMC calibration and data description by embedding tested.
 - Long-awaited M_Z width study with MC Pythia.
 - Additional dependence of M_Z originating from BEMC calibration.

BEMC Gain Uncertainty with Pythia

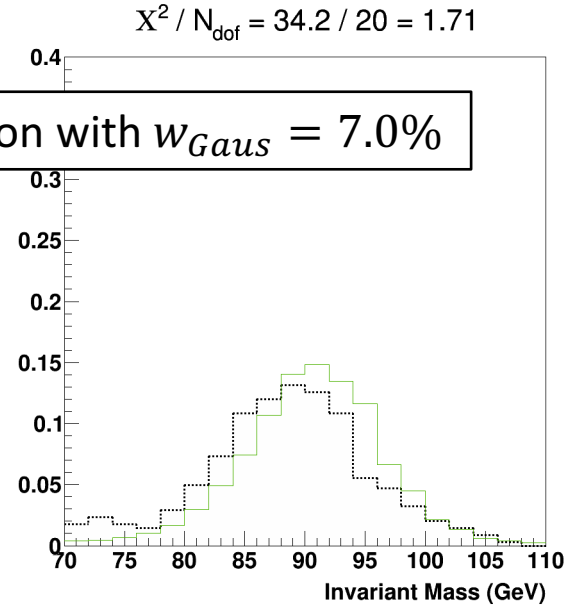
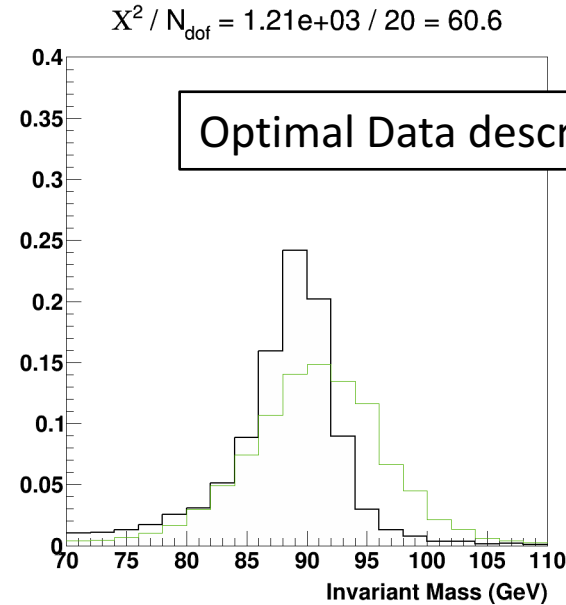
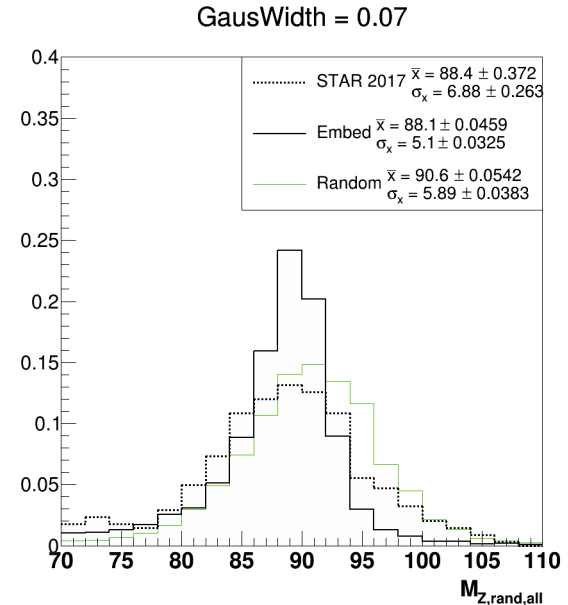
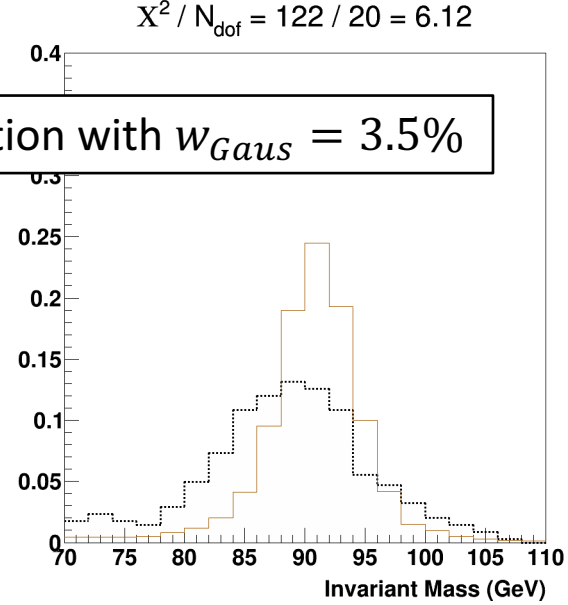
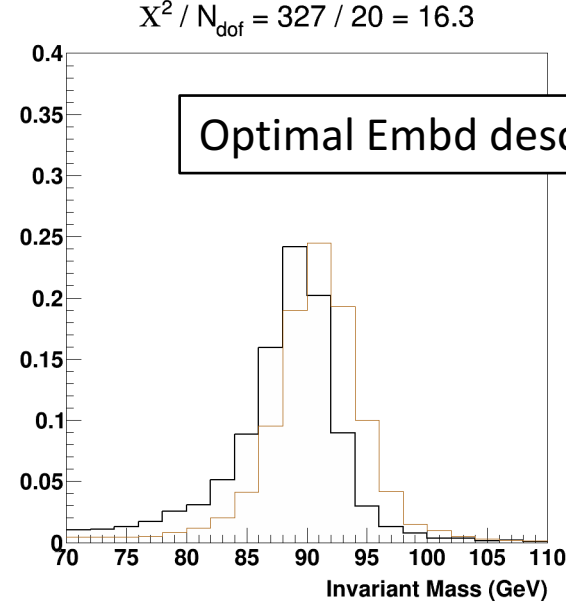
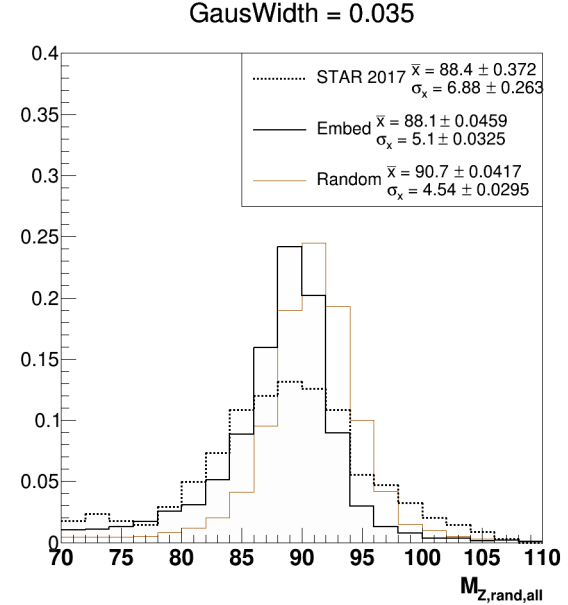
- A BEMC gain uncertainty due to detector resolution effect inserted in to Pythia electrons.



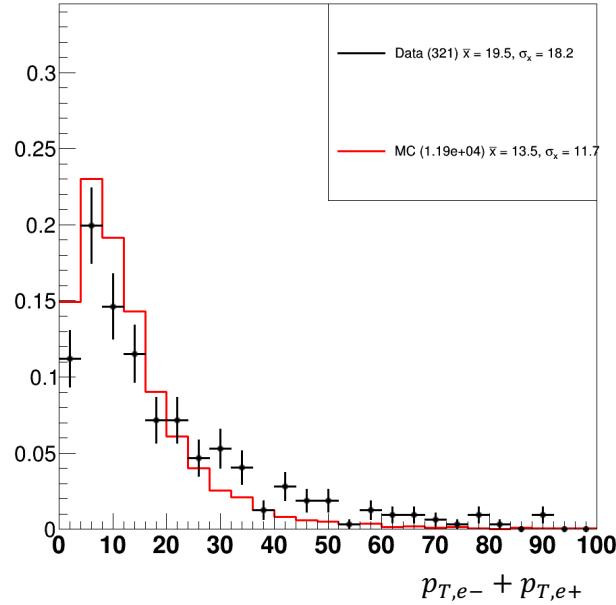
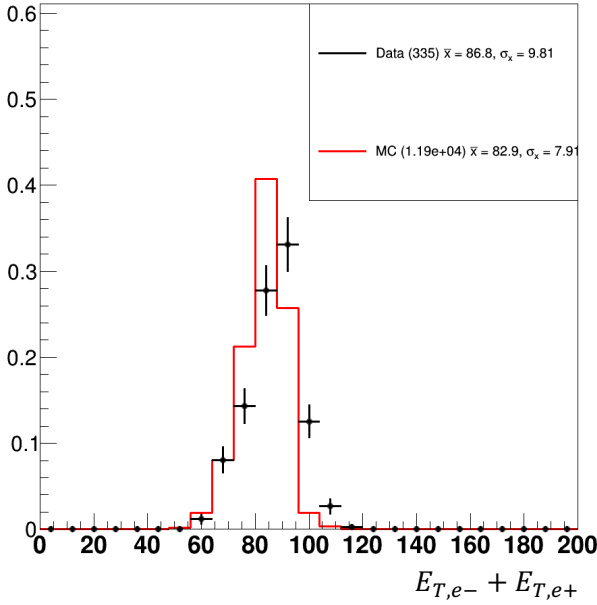
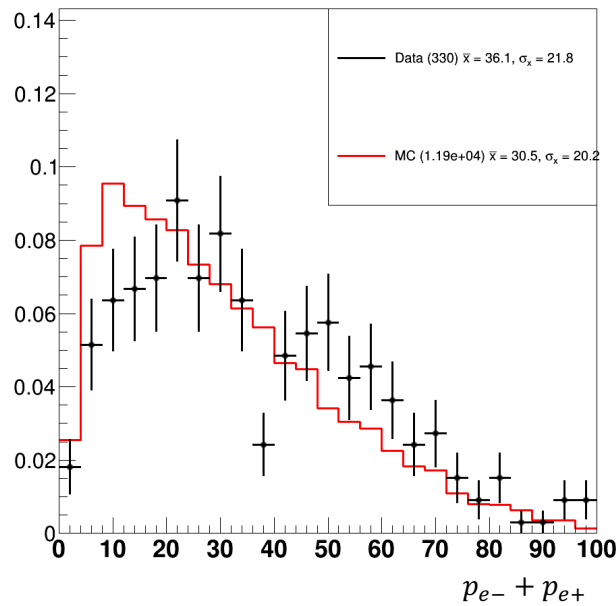
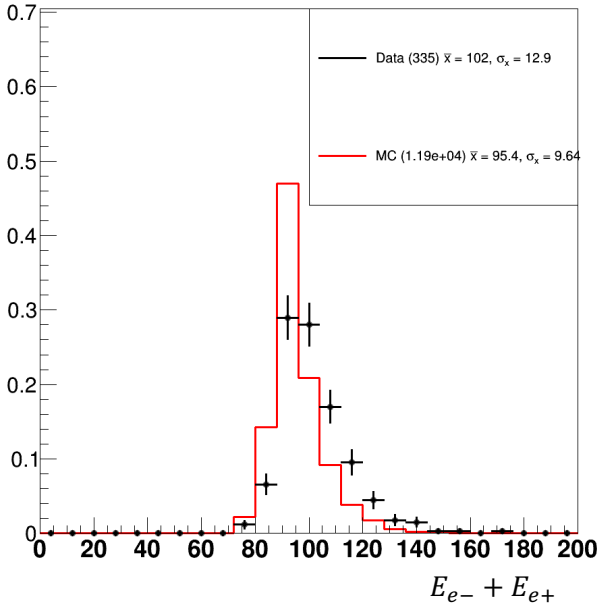
- Pythia electrons treated as a real track with momentum = particle momentum originating from pythia event vertex.
- These tracks projected to BEMC surface via THelix.
- Energy varied by a certain fraction based on Gaus distribution.
 - 0-20% across 40 samples
 - i = initial seed $\{0, \dots, 40\}$
 - j = BEMC cell ID $\{0, \dots, 4799\}$
 - k = final seed = $10000 \times i + j$
 - w = Gaussian width = $0.005 * i$
- The randomized Pythia Z mass is compared to data and embedding.
 - $\sim 4\%$ correction to data applied.
 - ~ 2 GeV shift in Z mass peak compared to embed & corrected data.
 - Since each bin in the histogram = 2 GeV, comparison was performed with bin m in data and MC to $m + 1$ in Pythia.

Results

- Constant 2 GeV shift between data/embed vs Pythia
- $\rightarrow \chi^2$ calculated with the adjacent bin (bin width 2GeV).



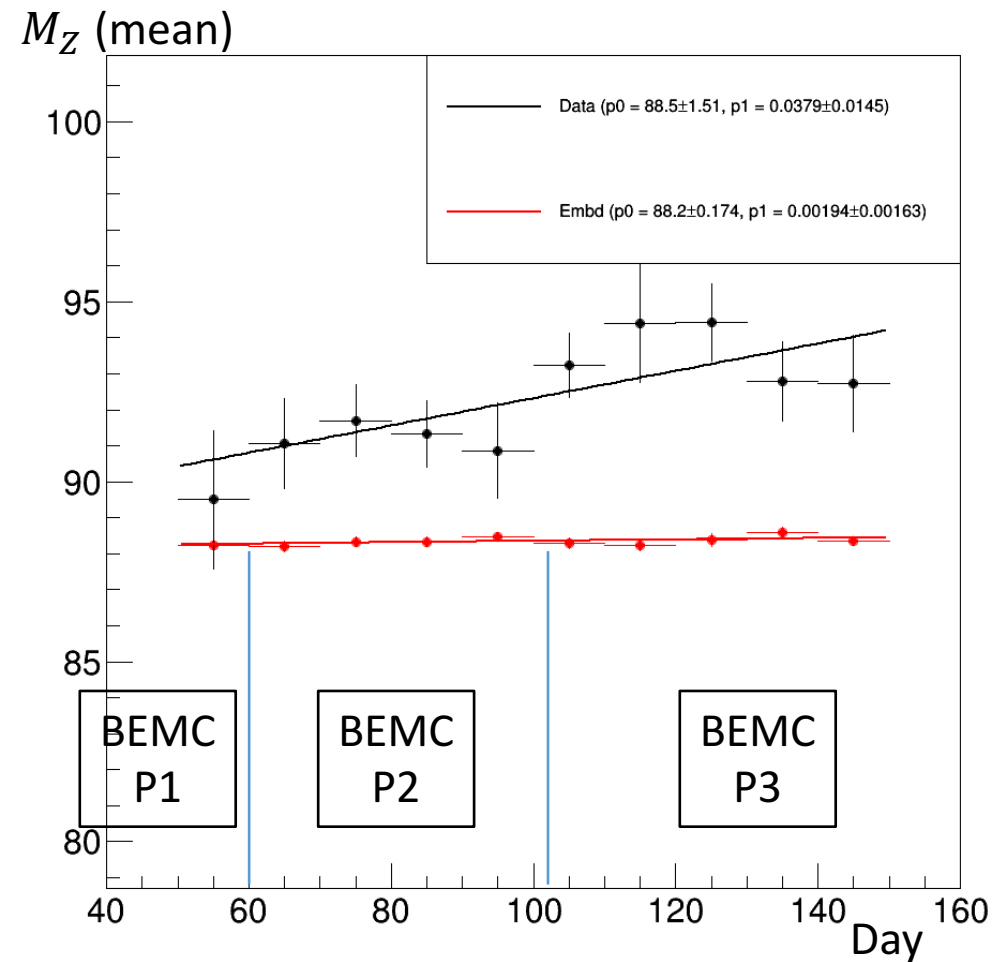
Data-Embd Comparison



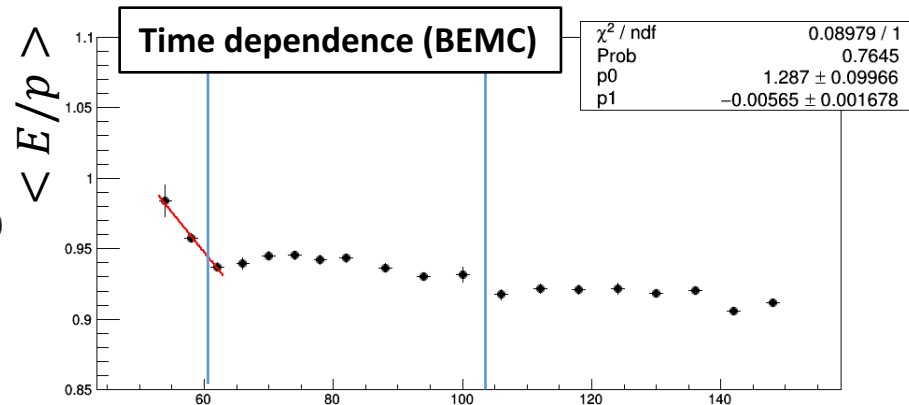
- 4% correction no longer applied for data-embd comparison.
- M_Z separated into E_Z and p_Z .
 - $p_Z = p_{e-} + p_{e+}$
 $= E_{e-} \cdot \hat{p}_{e-} + E_{e+} \cdot \hat{p}_{e+}$
- A larger shift ($\sim 4\% \rightarrow \sim 7\%$) observed in E_Z comparison.
- Part of it is cancelled out by mismatch in p_Z .



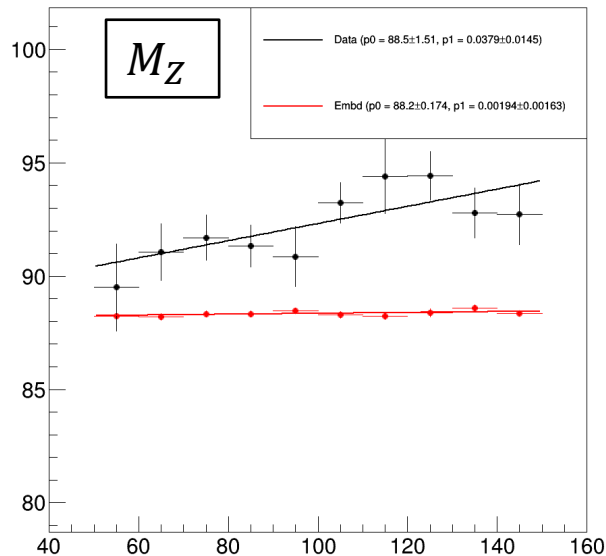
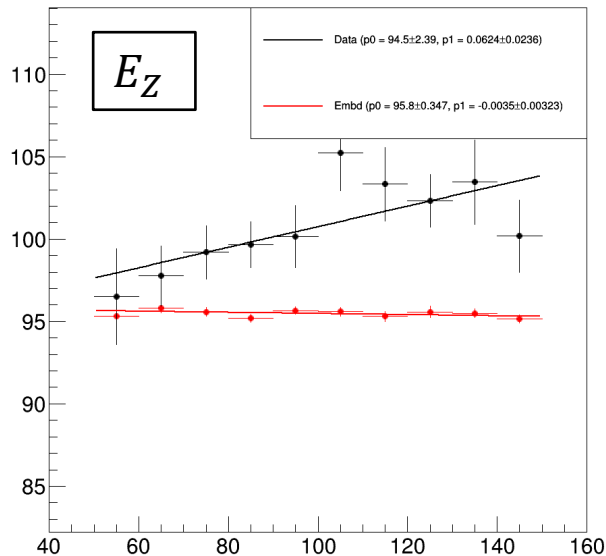
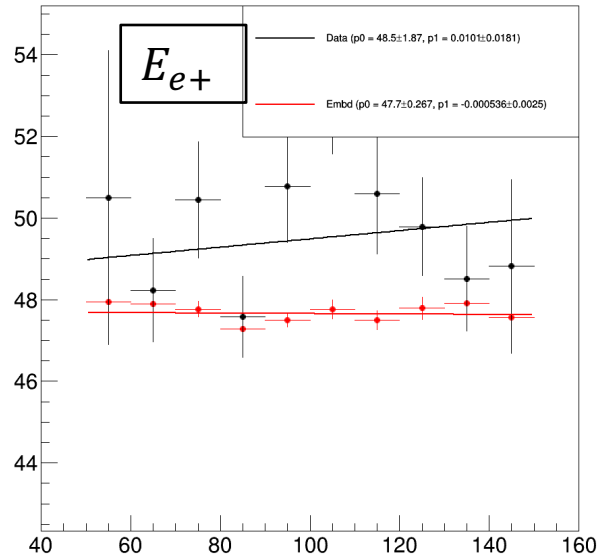
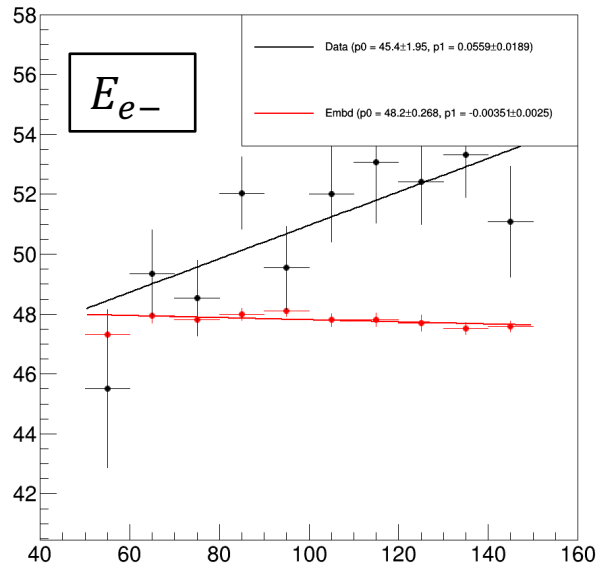
Time Dependence



- Each data point represents statistics over 10-day period.
- Breakdown of Run 2017 in BEMC calibration:
 - P1 = Day 53 – 59 (~Bin 1, Day 50 – 59)
 - P2 = Day 60 – 103 (~Bin 2-5, Day 60 – 99)
 - P3 = Day 104 – 149 (~Bin 6 – 10, Day 100 – 150)
- $> 2\sigma$ time dependence in data.
- BEMC calibration (period separation scheme) may have overcorrected the time dependence.

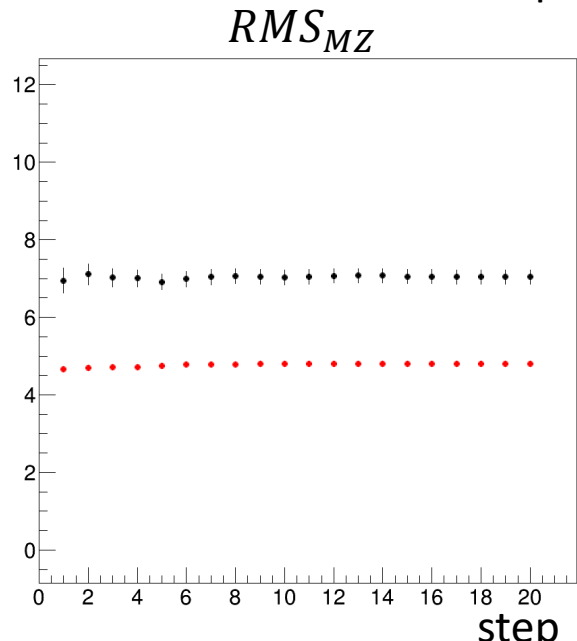
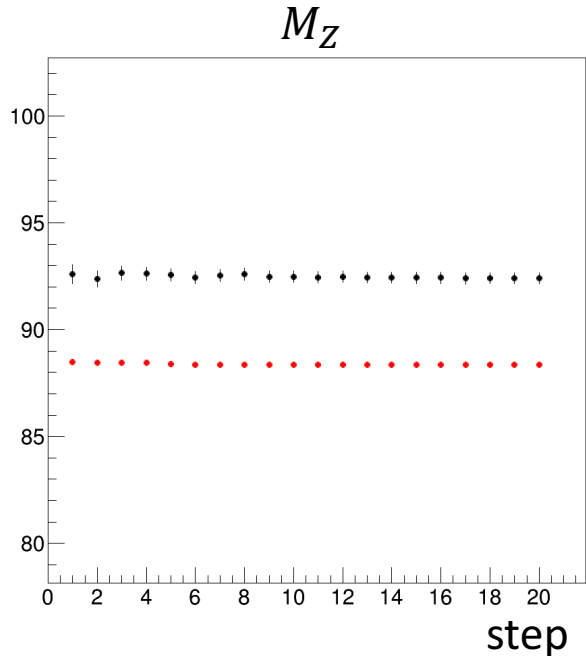
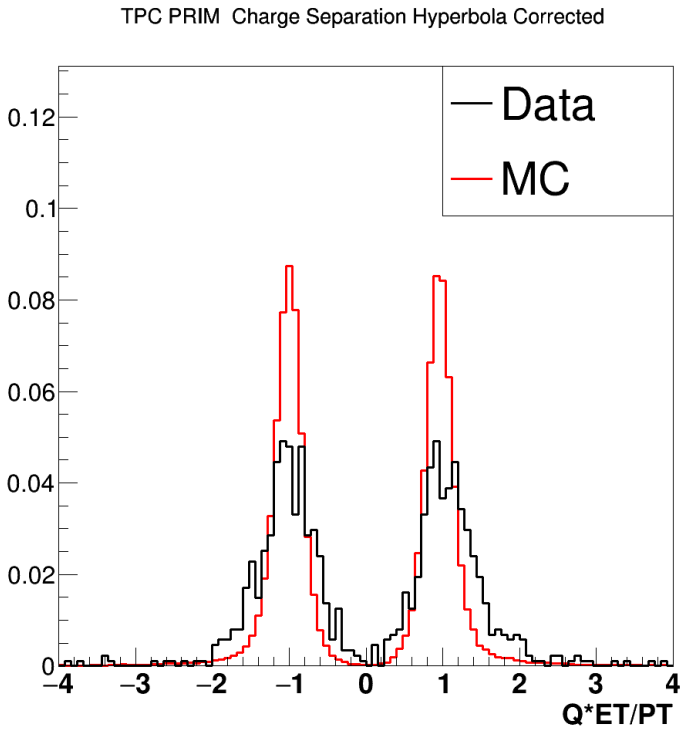


Time Dependence (cont'd)



- Detailed look at the time-dependence.
- E_Z and M_Z shows similar ($> 2\sigma$) time dependence.
- Run 17 spans over ~ 100 days, corresponding to $\sim 4\%$ shift in M_Z and $\sim 6.5\%$ shift in E_Z .
- BEMC relative uncertainty study may need to be revisited.

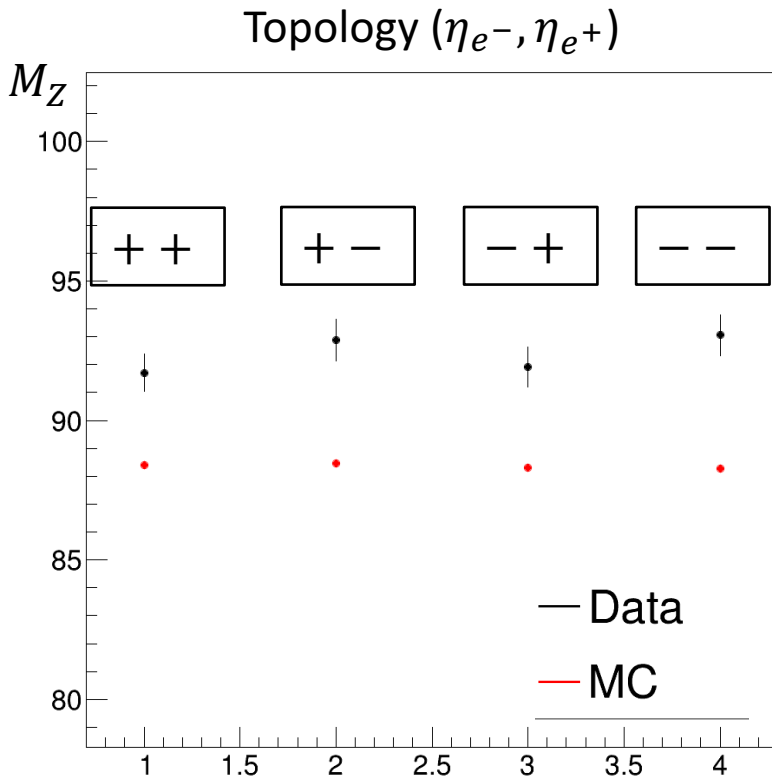
Charge Selection Dependence



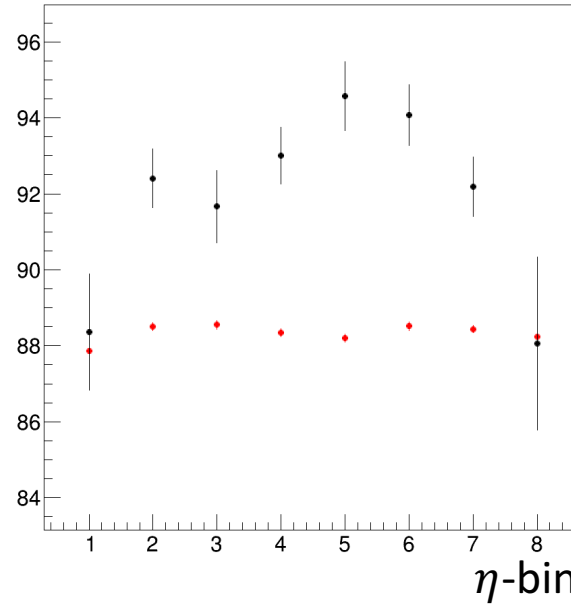
- $|Q \times E_T / p_T|$ window varied in 20 steps.
 - Lower limit: 0.95 \rightarrow 0.00
 - Upper limit: 1.15 \rightarrow 4.00
- No significant charge dependence found.



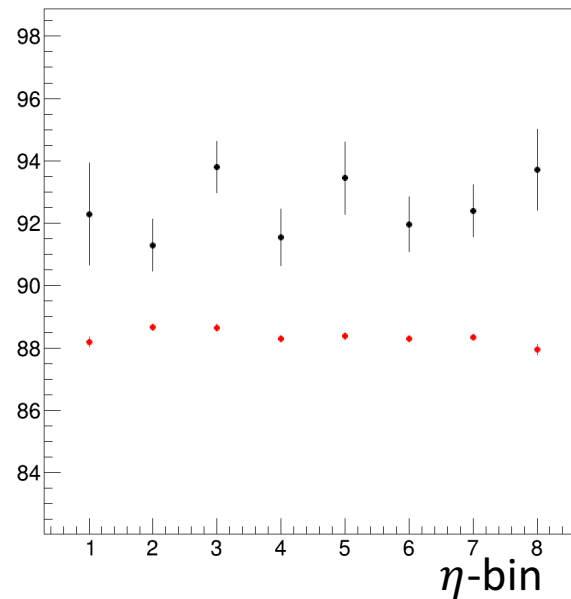
Topology & η



M_Z vs η_{e^-}



M_Z vs η_{e^+}



- No strong topology dependence.
- η -binning follows the one used for W measurement.
- [-1, -0.8, -0.5, -0.25, 0, 0.25, 0.5, 0.8, 1]
- No strong η_e dependence.



Summary & Outlook

- Summary

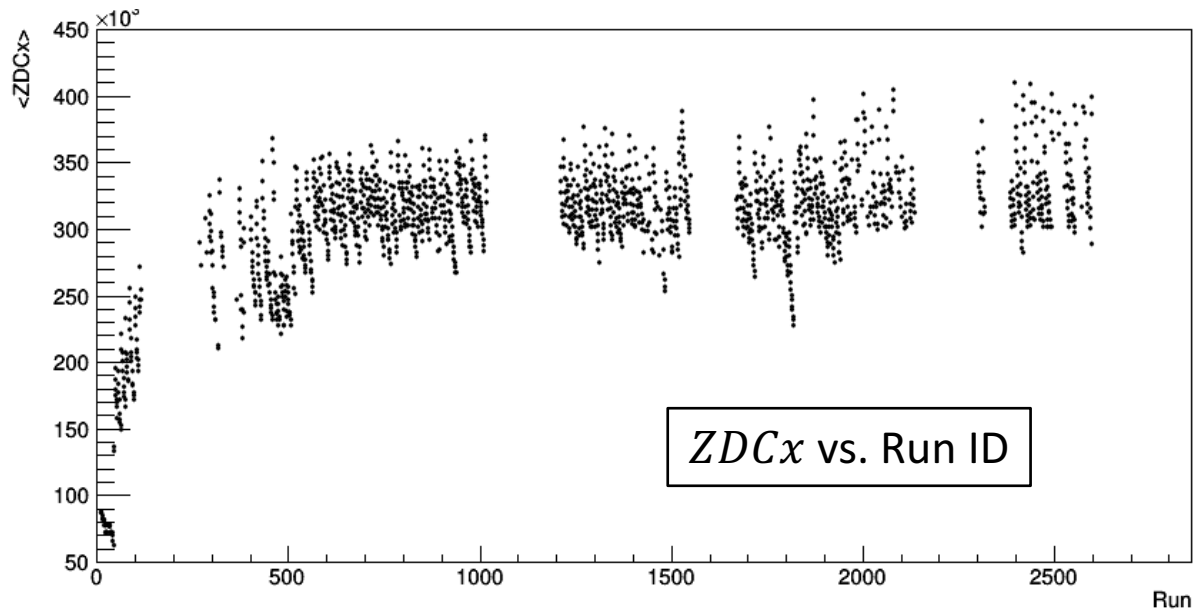
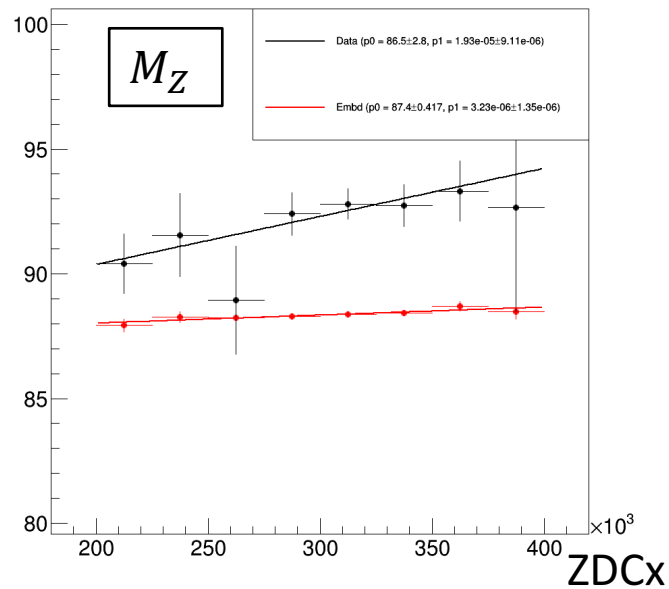
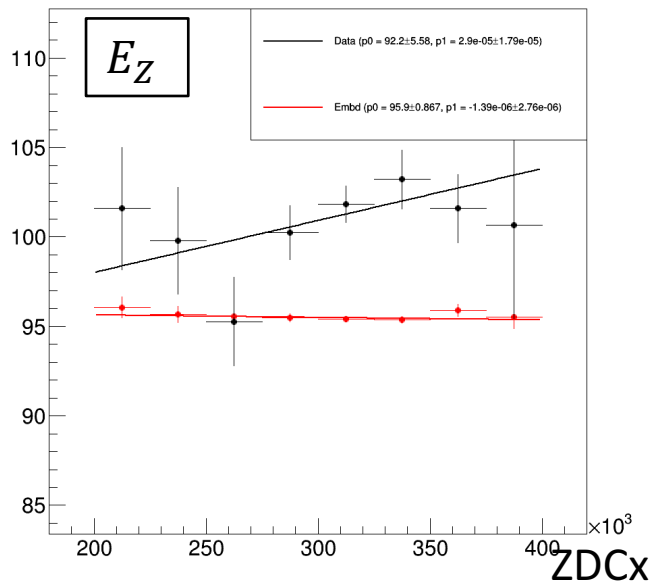
- The relative gain uncertainty in BEMC calibration has been tested with the help of Pythia electrons.
 - $\delta_{BEMC,rel} \sim 7\%$, although time-dependent evaluation may reduce the magnitude.
- The $E_Z (= E_{e+} + E_{e-})$ suggests that the mismatch between data and embed may be as large as 7%.
- $> 2\sigma$ time-dependence in both E_Z and M_Z found.
 - Possible overcorrection from BEMC calibration.
 - But, why appear at high momentum? Or is it also seen in low momentum?

- Outlook

- Time-dependent BEMC gain correction for W Jacobian peak
→ Time-dependent systematics (BEMC uncertainty) evaluation.

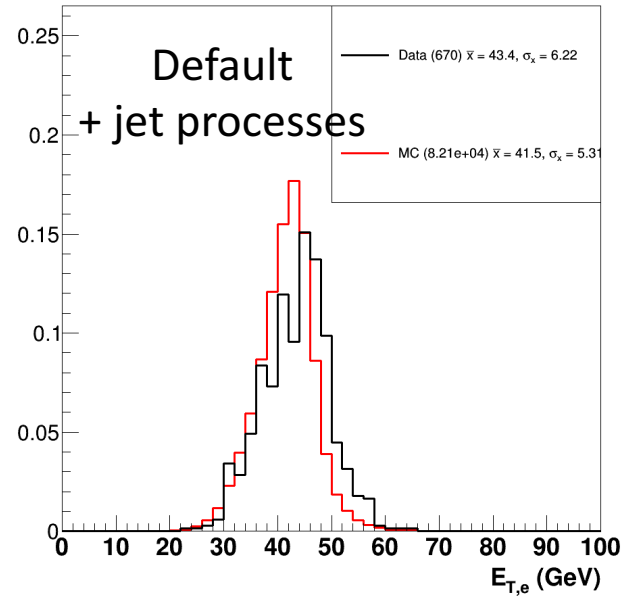
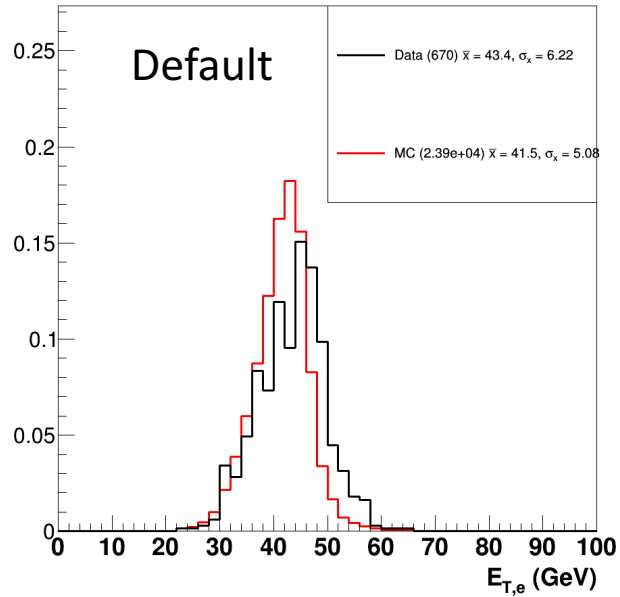


ZDCx

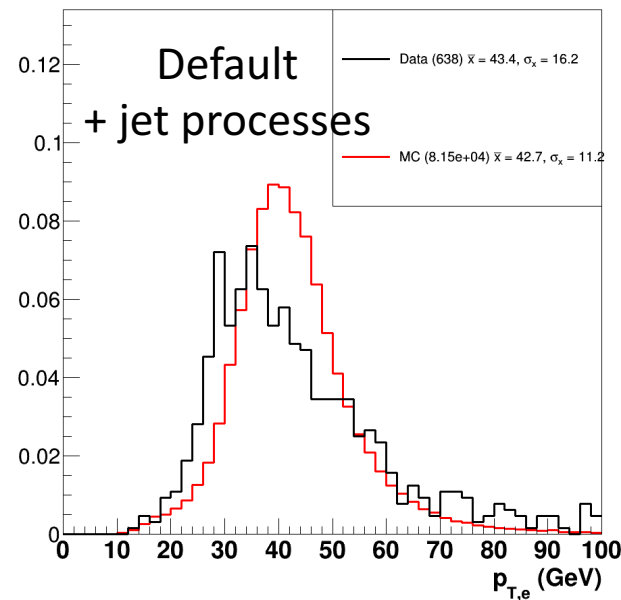
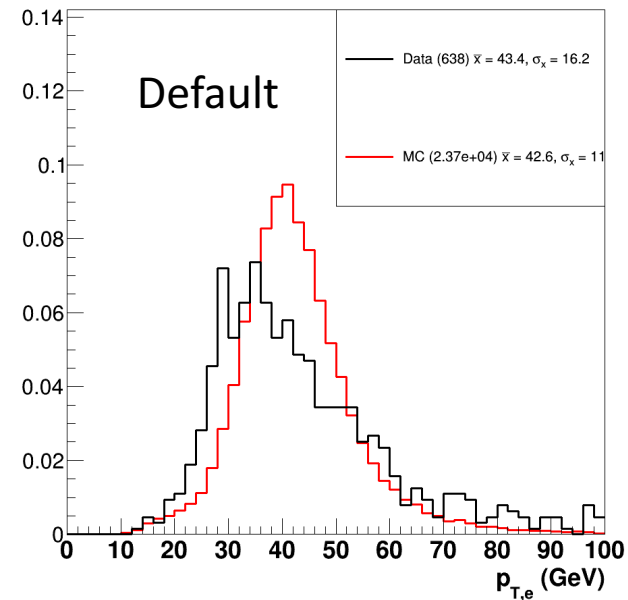


- Some ($\sim 2\sigma$) ZDCx dependence is seen.
- ZDC rate highly time correlated in Run ID < 600.
- ZDC dependence in the time independent (ID > 600) period will be tested.

Jet producing subprocesses



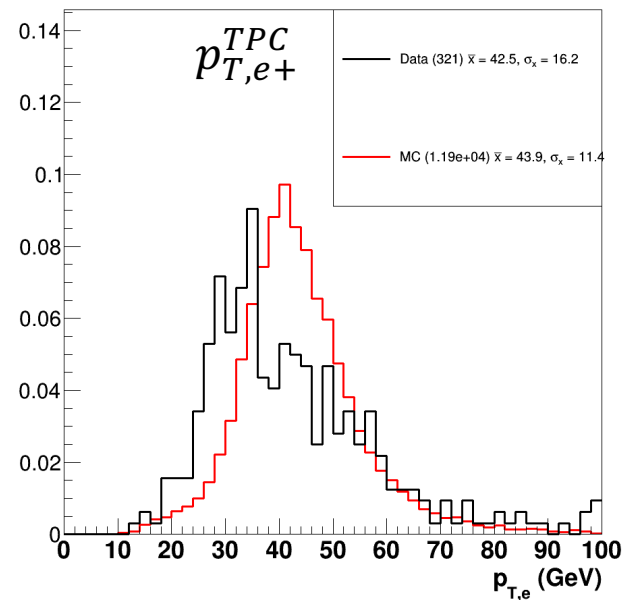
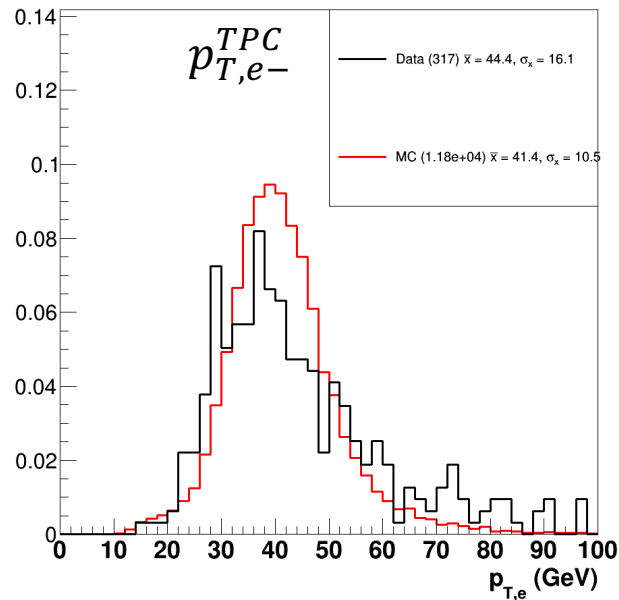
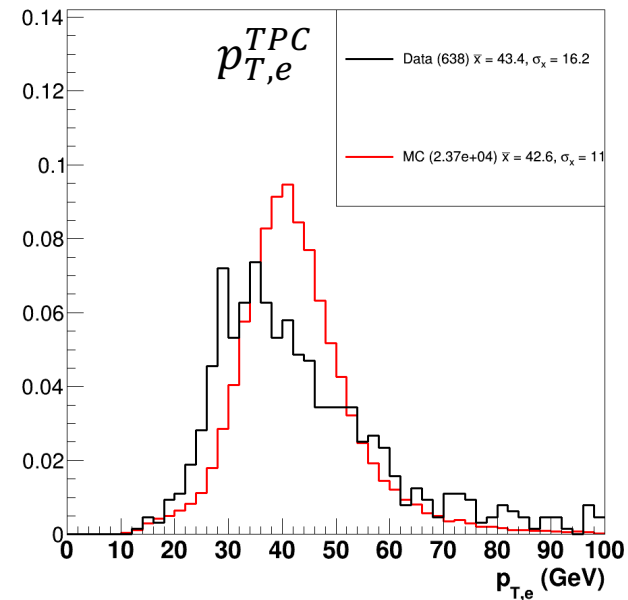
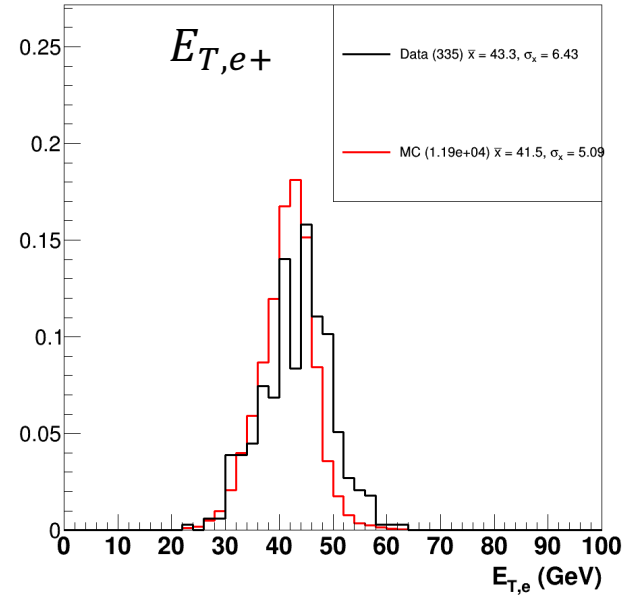
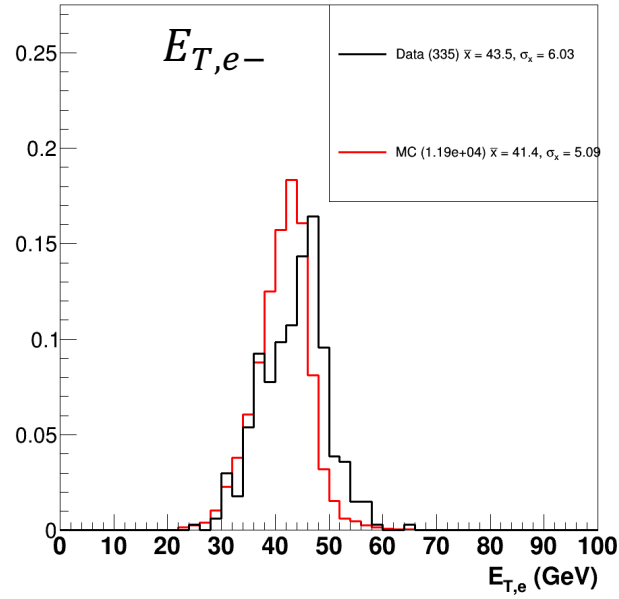
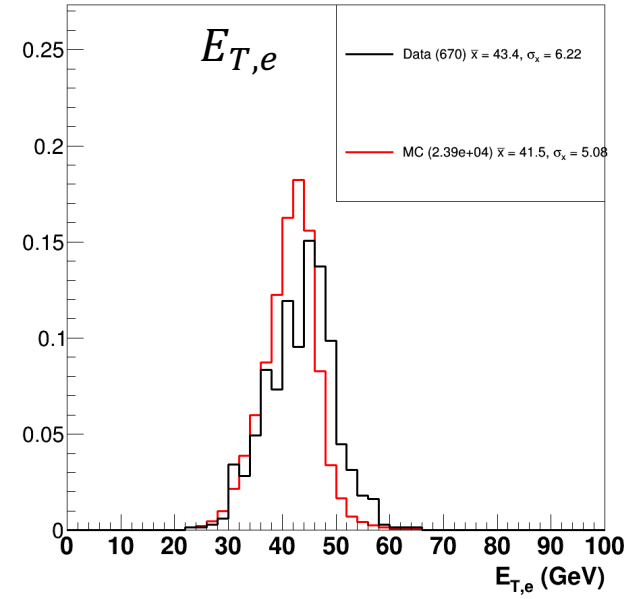
- Jet producing subprocesses (right) has little to no effect.
- $ff \rightarrow \gamma^*/Z^0$ (default, left+right)
- $ff \rightarrow g(\gamma^*/Z^0)$ (right)
- $fg \rightarrow f(\gamma^*/Z^0)$ (right)



Electrons

~4% correction not applied in data

Charge cut $|Q \times E_T / p_T| < 3$



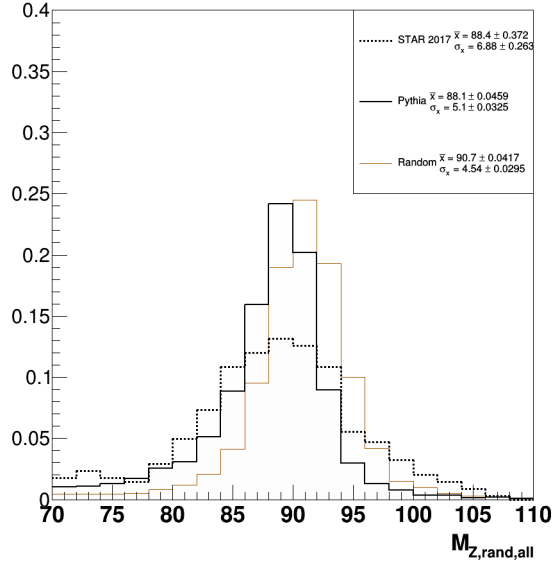




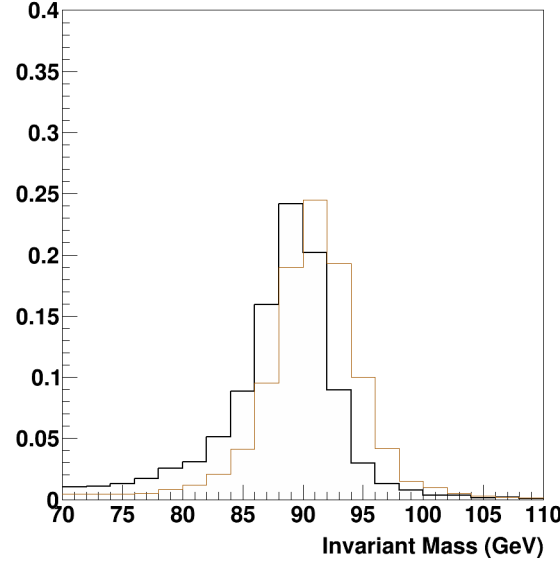
Z Mass

- $M_Z = \sqrt{E_Z^2 - p_Z^2}$, where p_Z takes direction from TPC but magnitude from EMC.
- $M_Z = \sqrt{(E_{e^-} + E_{e^+})^2 - (E_{e^-} \cdot \hat{p}_{e^-} + E_{e^+} \cdot \hat{p}_{e^+})^2}$

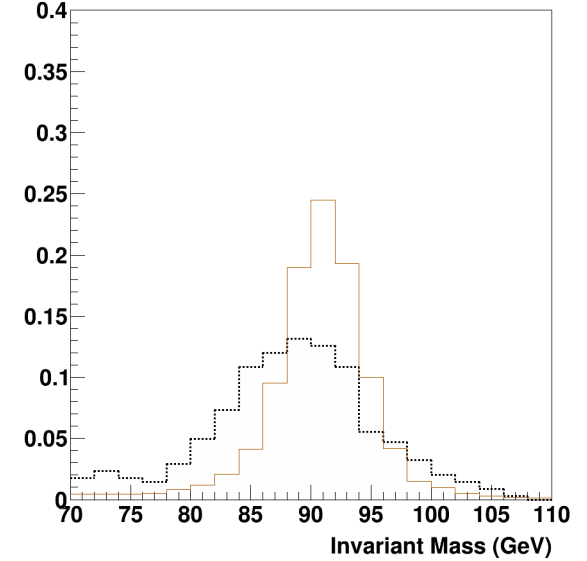
GausWidth = 0.035



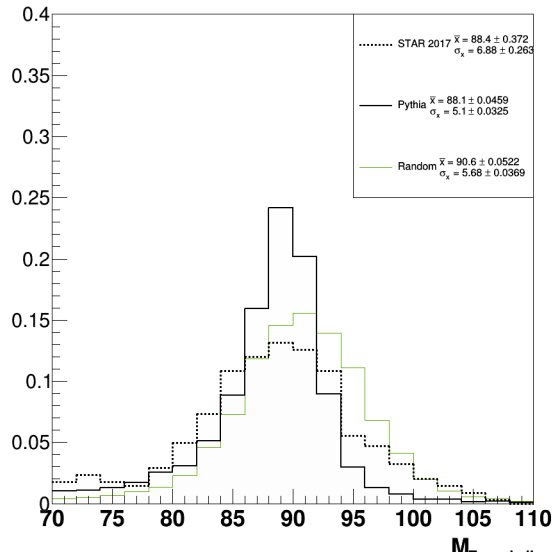
$\chi^2 / N_{\text{dof}} = 327 / 20 = 16.4$



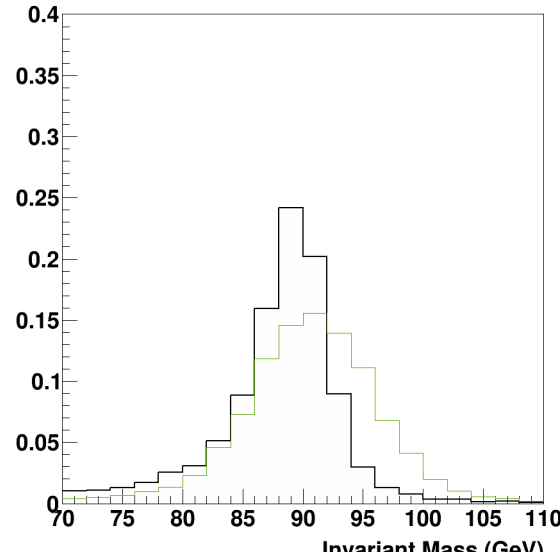
$\chi^2 / N_{\text{dof}} = 122 / 20 = 6.12$



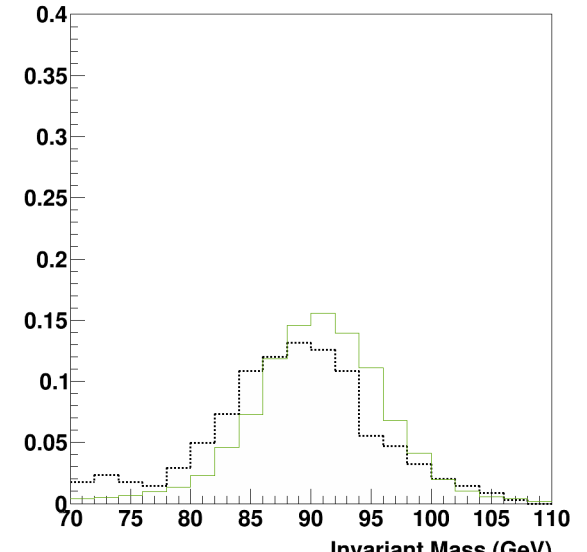
GausWidth = 0.065



$\chi^2 / N_{\text{dof}} = 1.06\text{e}+03 / 20 = 53$



$\chi^2 / N_{\text{dof}} = 29.6 / 20 = 1.48$



DIS 2023

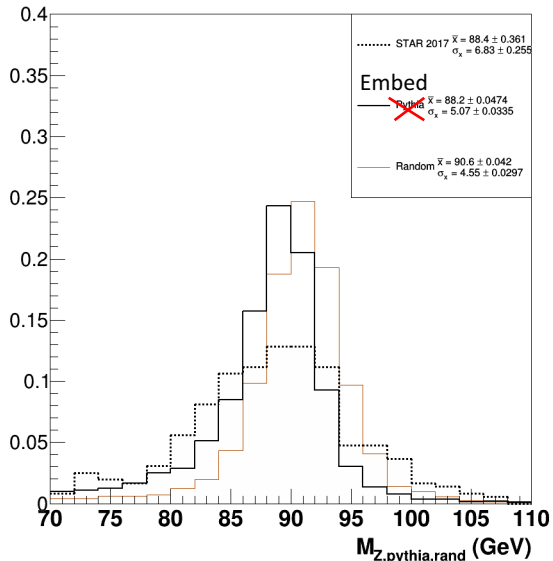
- Next step for STAR W measurement is publication.
- Publishing the analysis by March 2023 while there still is an on-going investigation seems difficult.
- ZEUS analysis, especially preliminary release of q_T and $\pi - \Delta\phi$ measurements seems much more plausible.



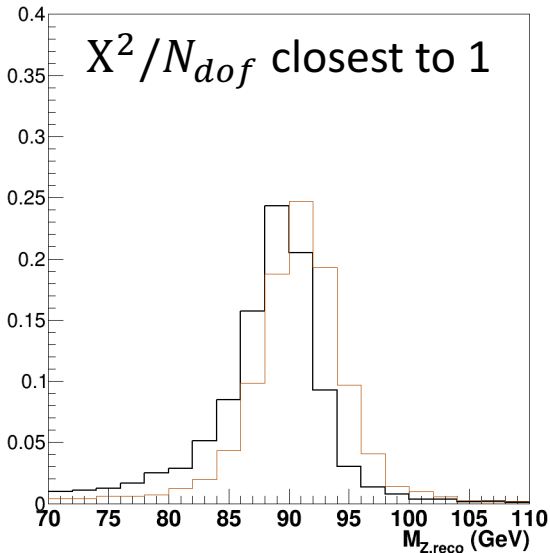
Results

$$\begin{aligned} \bar{x}_{data} &= 88.4 \pm 0.361, & \sigma_{x,data} &= 6.83 \pm 0.255 \\ \bar{x}_{embed} &= 88.2 \pm 0.0474, & \sigma_{x,embed} &= 5.07 \pm 0.0335 \\ \bar{x}_{i=6} &= 90.6 \pm 0.042, & \sigma_{x,i=6} &= 4.55 \pm 0.0297 \\ \bar{x}_{i=14} &= 90.7 \pm 0.0593, & \sigma_{x,i=14} &= 6.41 \pm 0.0419 \end{aligned}$$

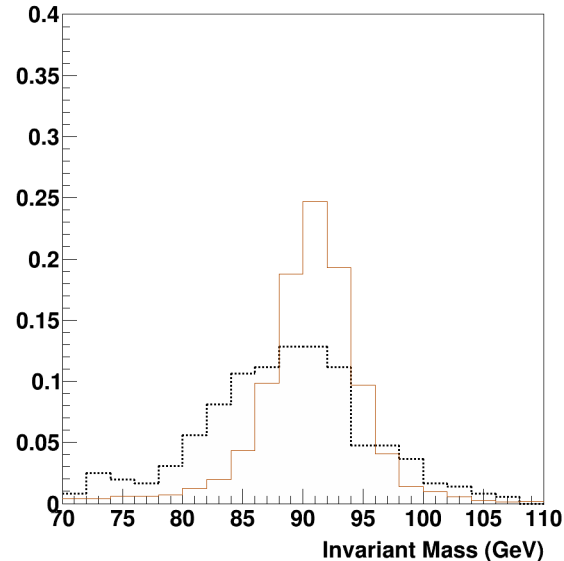
GausWidth = 0.03



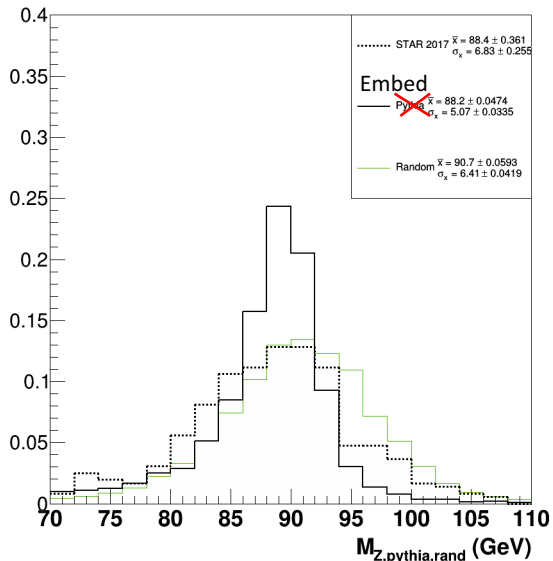
$\chi^2 / N_{dof} = 263 / 20 = 13.1$



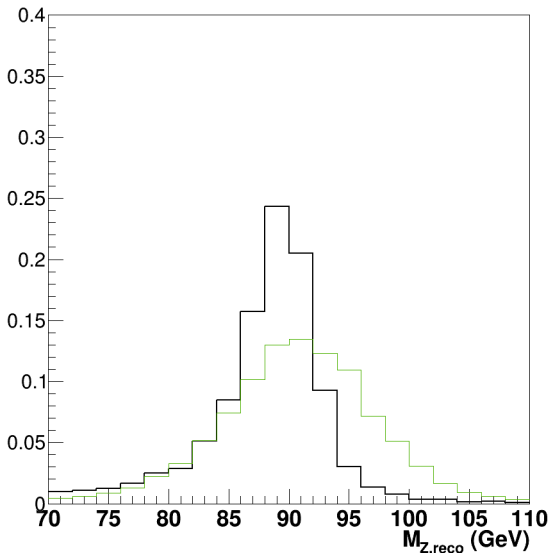
$\chi^2 / N_{dof} = 135 / 20 = 6.73$



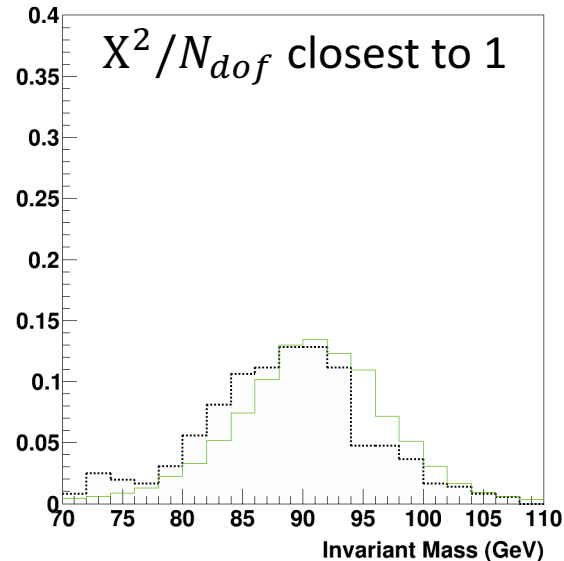
GausWidth = 0.07



$\chi^2 / N_{dof} = 1.6e+03 / 20 = 80$



$\chi^2 / N_{dof} = 40.7 / 20 = 2.04$

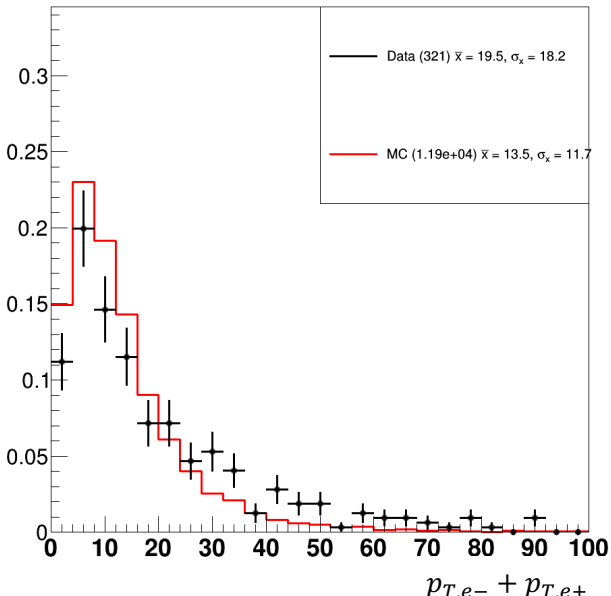
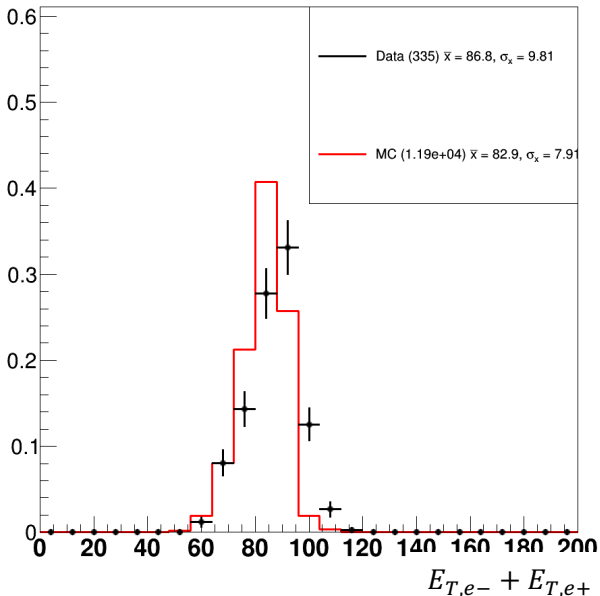
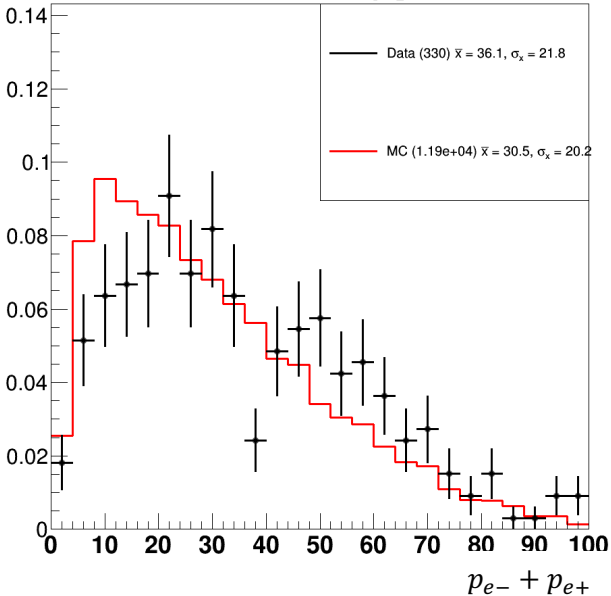
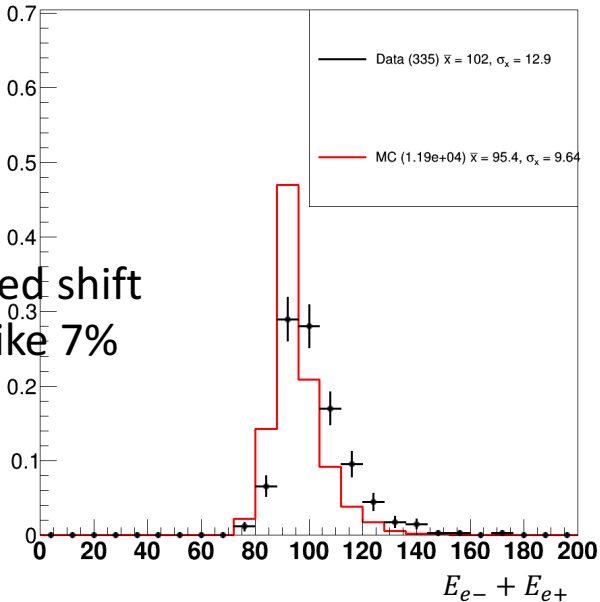


Results

~4% correction not applied in data

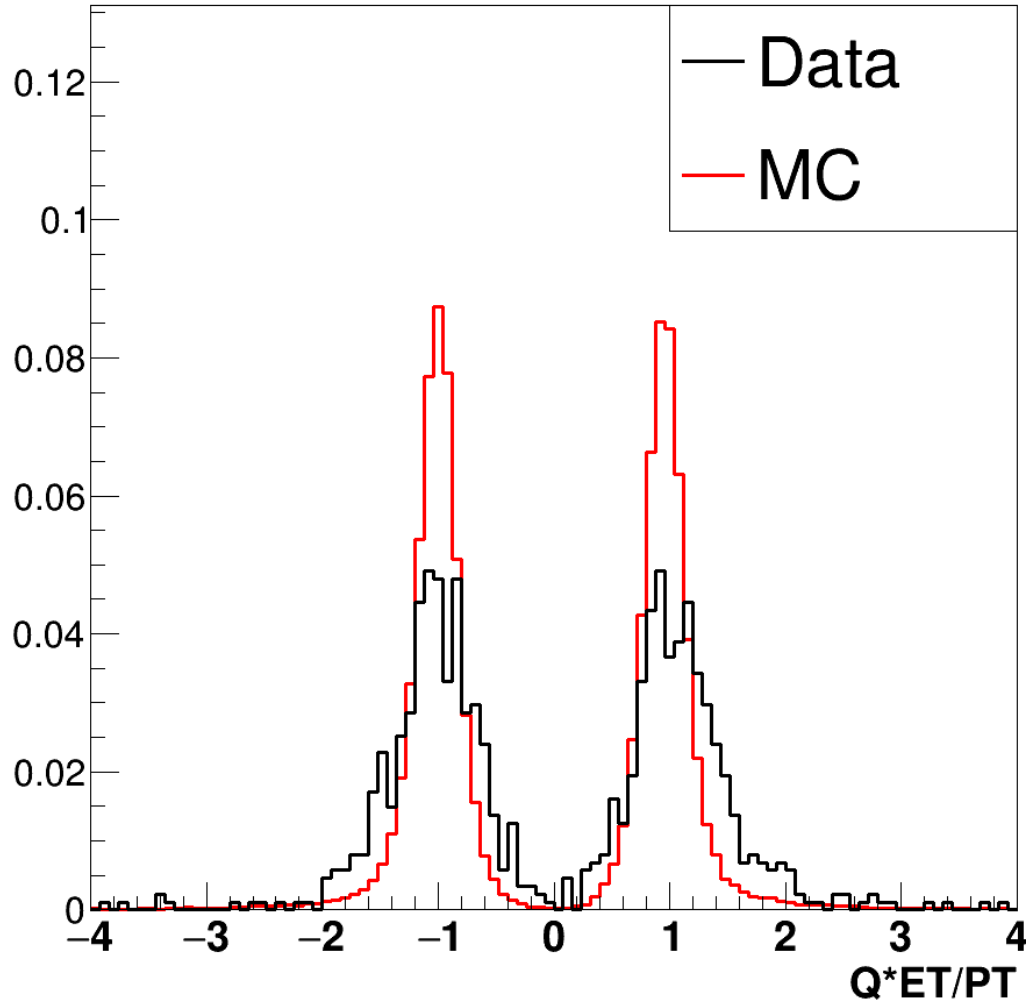
Charge cut $|Q \times E_T / p_T| < 3$

Data-embed shift
is more like 7%



Charge distribution

TPC PRIM Charge Separation Hyperbola Corrected



- Charge ($|Q \times E_T / p_T|$) dependence of Z mass will be investigated.



