W^+/W^- cross-section ratio with STAR Run 2017

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Recap

3. Predictions

FEWZ predictions

- Thanks for screenshots of input cards for FEWZ...
- We are ≈ able to reproduce your theoretical predictions.
- Total:

Note ≈ 35% reduction from 0 jet cut.

Channel	Data	FEWZ total (0jet cut)	FEWZ total (no 0jet cut)
Z	$3.0 \pm 0.2^{\text{stat}} \pm 0.0^{\text{sys}} \pm 0.3^{\text{eff}}$	2.64 ± 0.01	3.57 ± 0.01
W^+	$64.3 \pm 0.7^{\text{stat}} \pm 0.9^{\text{sys}} \pm 3.4^{\text{eff}}$	67.1 ± 0.1	92.4 ± 0.1
W^-	$17.3 \pm 0.5^{\text{sys}} \pm 0.4^{\text{stat}} \pm 0.9^{\text{eff}}$	19.8 ± 0.1	27.0 ± 0.1

- ~30% shift in W^+/W^- cross section
  → mis-estimation of **spTbal** cut efficiency with **mock-W** sample (Z data)
- The origin of Z mismatch (FEWZ vs Data) needs to be understood
  - Discussion with Werner and Daniel postponed
- **Strategy**
  - Independent extraction of Z cross section
    to identify potential sources of FEWZ-data mismatch
  - Using Run 17 data with (pseudo) Run 13 cuts
  - Results will be reproduced with Run 17 cuts

Selection cuts

Criteria	This study	Run 17
Trigger	L2BW || L2EW	L2BW || L2EW
Vertex N_{vtx}	≥ 3 (data), ≥ 1 (MC)	
Vertex $\lvert Z_{vtx}\rvert$	$< 100\ cm$	$< 100\ cm$
Vertex Rank	> 0	> 0
Track $N_{hit,fit}$	> 15	
Track $N_{hit,fit}/N_{hit,poss}$	> 0.51	
Track $R_{TPC,in}$	$< 90\ cm$	
Track $R_{TPC,out}$	$> 160\ cm$	
Track p_T (presel)	$> 10\ GeV$	
Cluster E_T	$\mathbf{> 15\ GeV}$	$\mathbf{> 25\ GeV}$
Cluster $E_T/E_T^{4\times4}$	> 0.95	
Cluster E_T/E_T^{near}	$\mathbf{> 0.88}$	$\mathbf{> 0.90}$
Cluster ΔR	$< 7\ cm$	
Candidate $\Delta\phi^{e+e-}$	$> \pi/2$	> 0 (Not Applied)
Candidate $q \times E_T/p_T$	$\mathbf{\lvert X\rvert < 3}$	$\mathbf{0.4 < \lvert X\rvert < 1.8}$

Truth-Level Kinematic Range

This study	Run 17
$p_{T,e} > 15\ GeV$	$p_{T,e} > 25\ GeV$
$\lvert\eta_e\rvert < 1$	$\lvert\eta_e\rvert < 1$
$70 < M_{inv} < 110\ GeV$	$73 < M_{inv} < 114\ GeV$

- Differences: This study (Run 13 pub) vs Run 17 pub
  - Minor differences in cluster isolation
  - Charge mis-identification needs to be understood
  - Differences in the $p_{T,e}$ range → any big impact?

Strategy

11 + 10 = What we see
11 + 01 = What we want

- Like-sign pairs are subtracted from data
  - $M^{data} = M^{sig} - M^{bgr}$
- MC events distributed into the following groups:
  - **Group 11** = Event reconstructed + **passes** all detector-level selection, and falls **inside** the (truth-level) kinematic range of the measurement
  - **Group 10** = Event reconstructed + **passes** all detector-level selection, but falls **outside** the truth-level range (migration BGR)
  - **Group 01** = Event is not reconstructed/**does not pass** the selection, but falls **inside** the truth-level range (inefficiency)
  - **Group 00** = Event correctly **rejected**

= Efficiency cor. × Unfolding × Migration BG cor.

- Truth-level yield from data extracted by

$$N^{data} = N_{11}^{data} + N_{01}^{data} = \frac{N_{11}^{MC} + N_{01}^{MC}}{N_{11}^{MC}} \times A^{-1} \left[\frac{M_{11}^{MC}}{M_{11}^{MC} + M_{10}^{MC}} \times M^{data} \right]$$

$$\rightarrow \frac{d\sigma}{dX} = \frac{1}{L} \times \frac{N_i^{data}}{\Delta X_i}$$

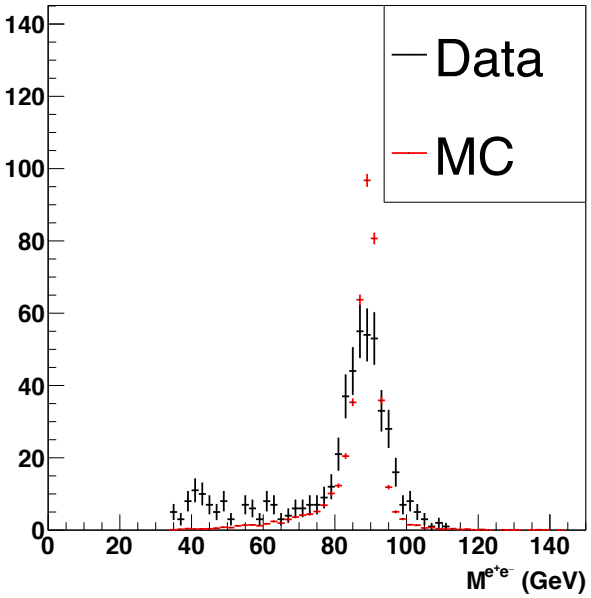
- Simple binwise unfolding performed to convert $M \rightarrow N$

$$A^{-1} \rightarrow N_{11}^{MC} / M_{11}^{MC}$$

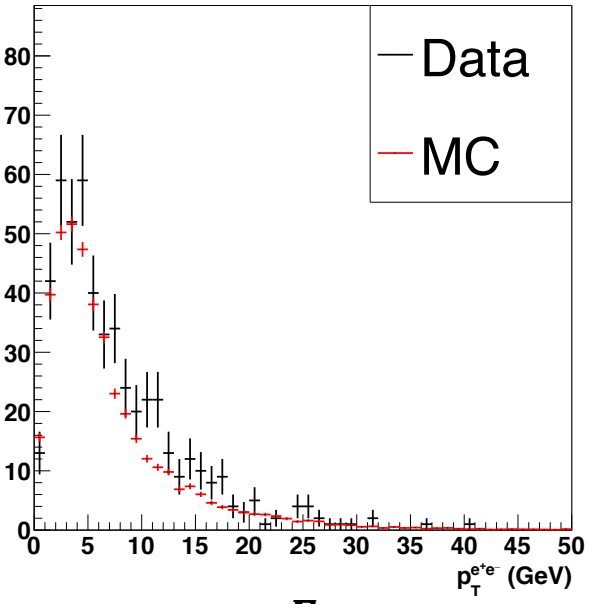
Reconstructed Signal

(No mass window cut for all plots)

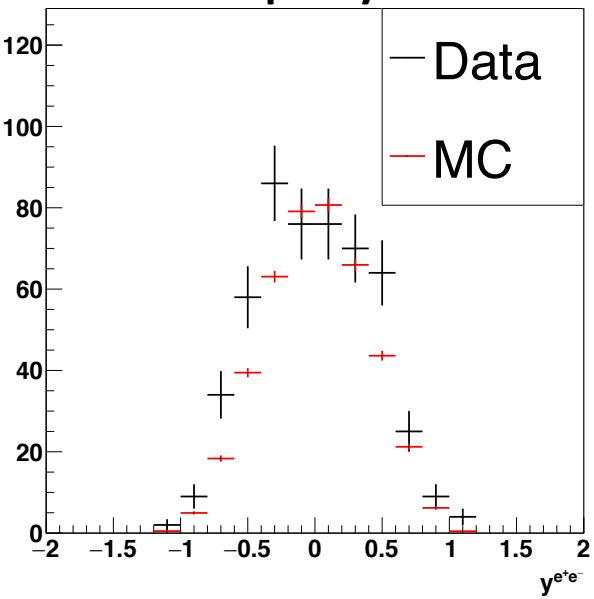
Z mass



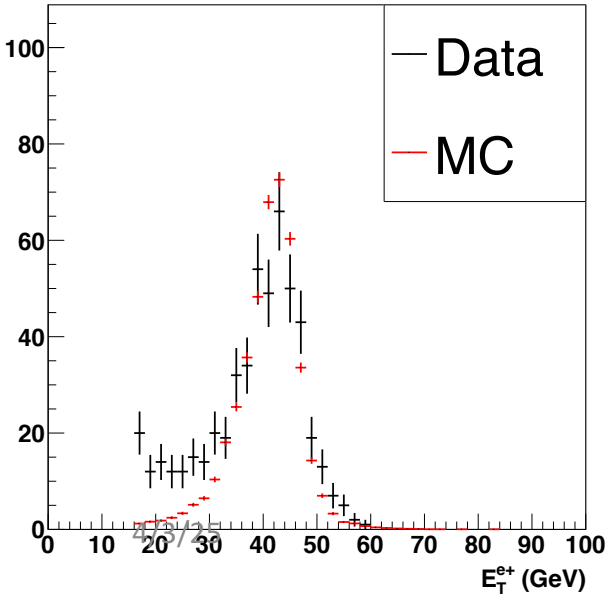
pT



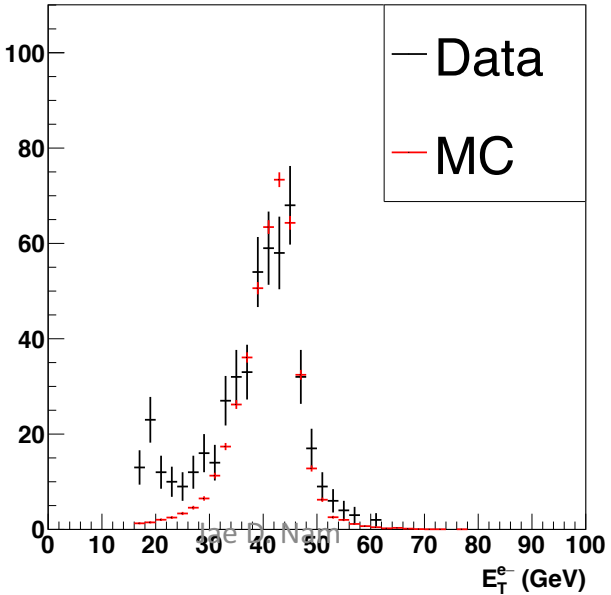
rapidity



$E_{T,e+}$



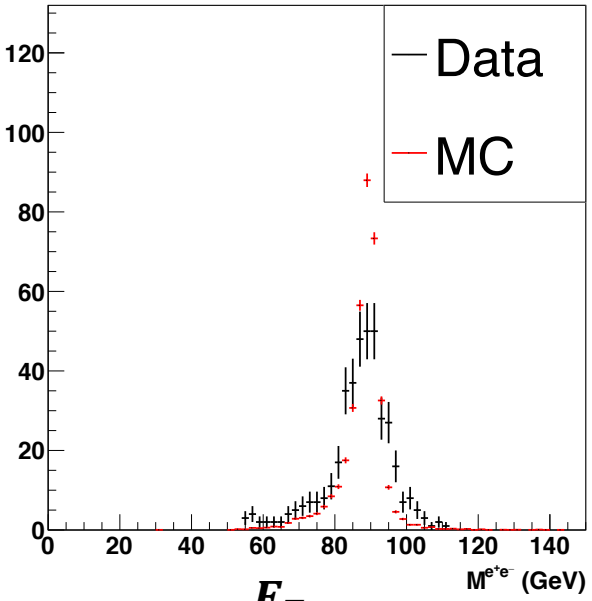
$E_{T,e-}$



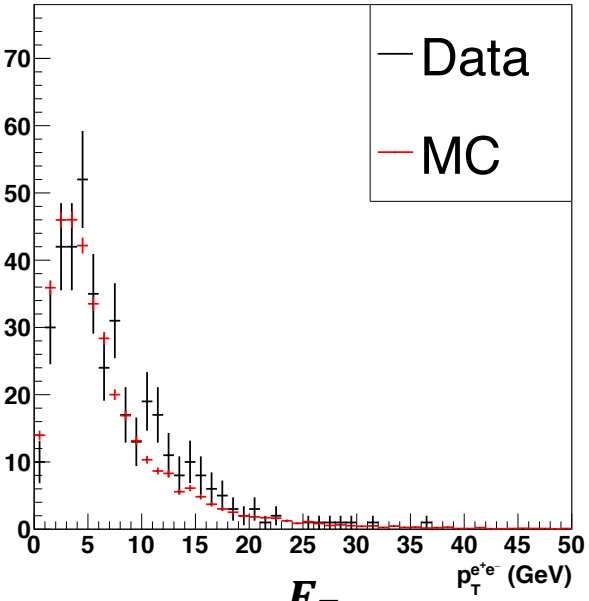
- Wider mass peak in data due to BEMC calibration not reproduced well in MC
- Low mass background
  → Estimated in Run 17 publication with Like-sign distribution
- $E_{T,e}$ cut from 25 to 15 GeV
  → ~14% of data, ~ 3% MC
  → mass correlation needs to be understood

Reconstructed Signal (Run 17 cuts)

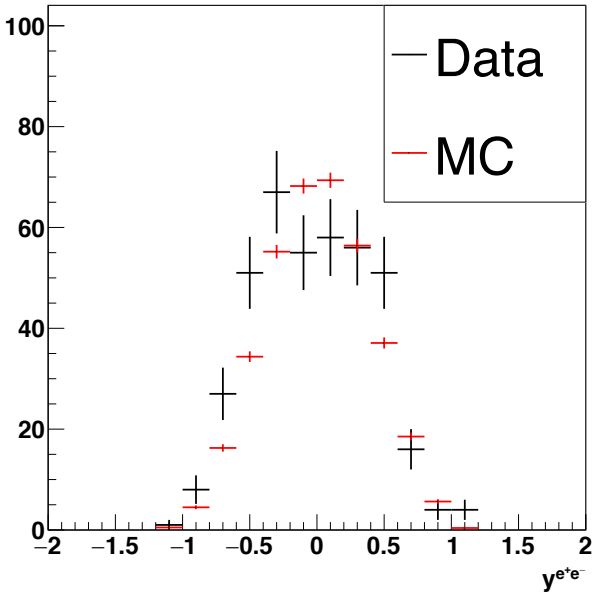
Z mass



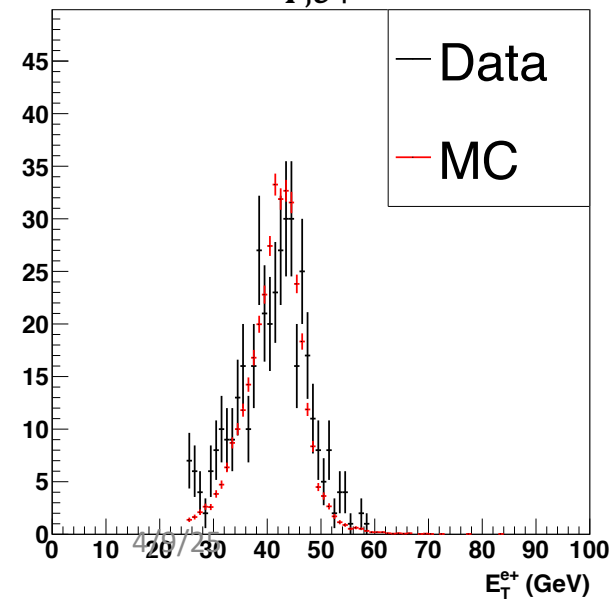
pT



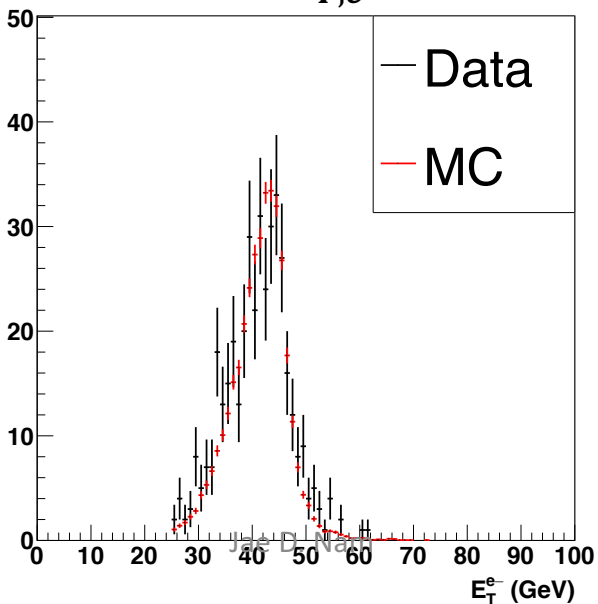
rapidity



$E_{T,e+}$

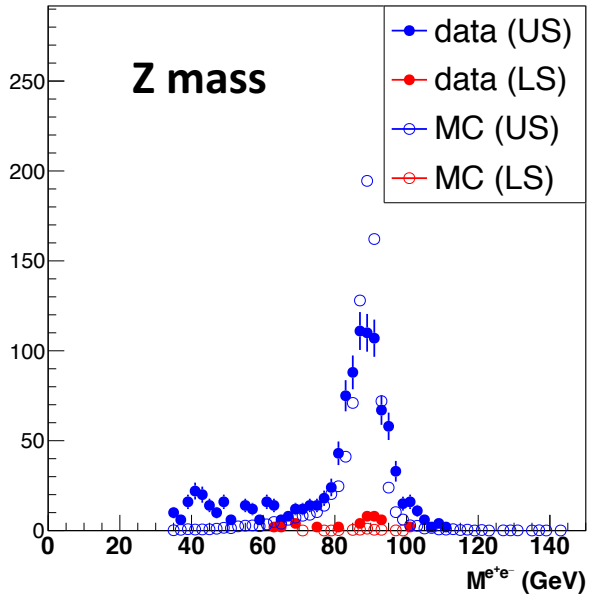


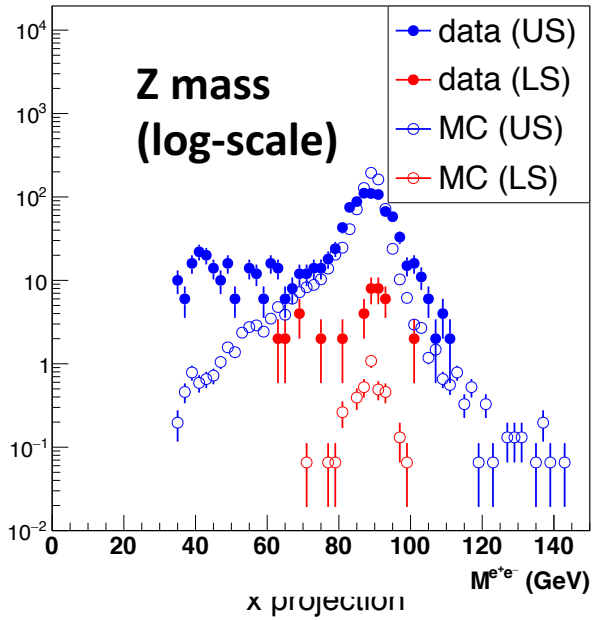
$E_{T,e-}$

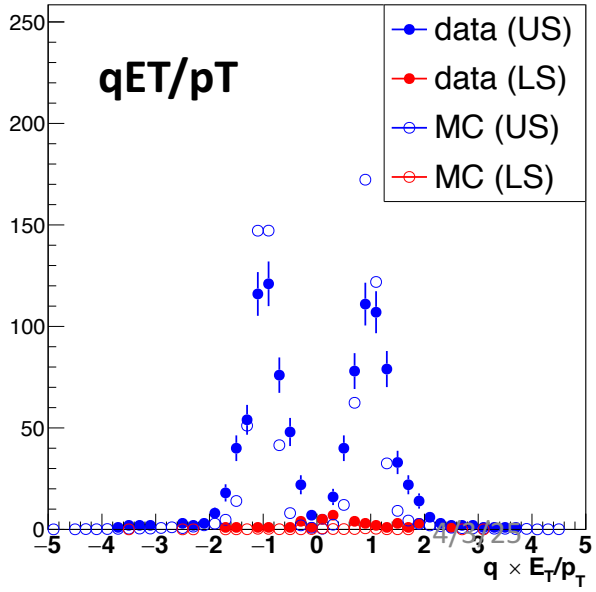


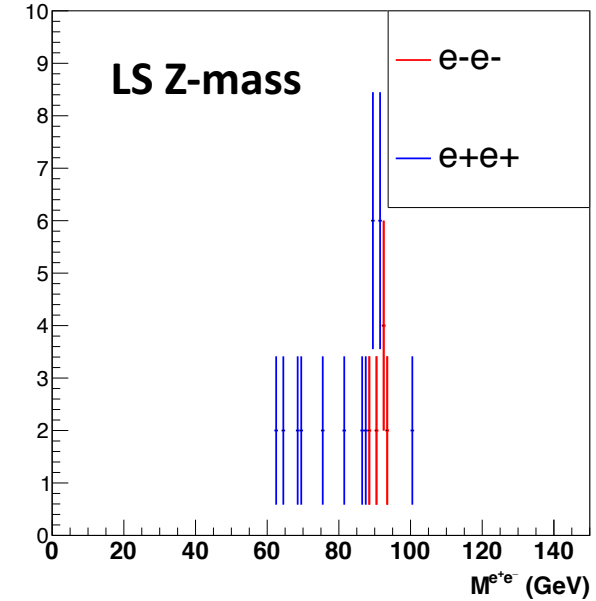
- Wider mass peak in data due to BEMC calibration not reproduced well in MC
- Low mass background disappears with Run 17 cuts

Charge mis-identification



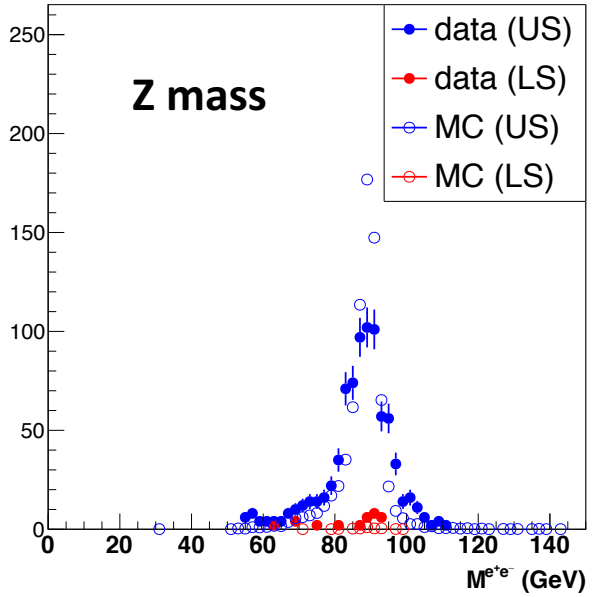


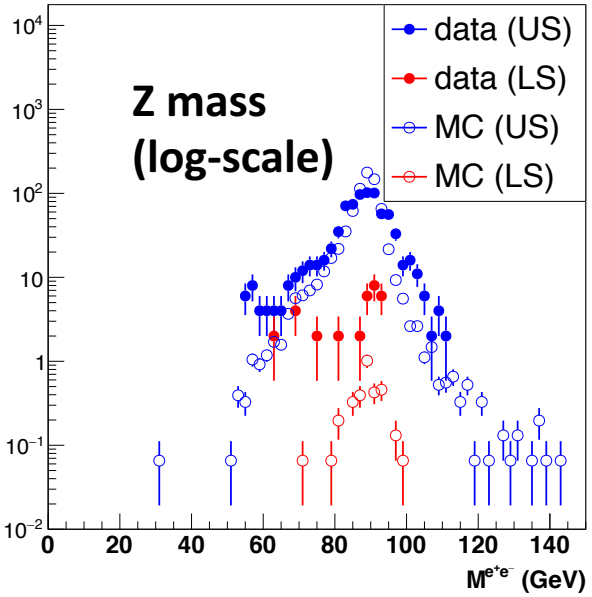




- qE_T/p_T cut at $\pm 3 \rightarrow$ 0.4-1.8 cuts out about 16% in data and 4% in MC
- LS background ~20 events (4%) mostly occupying $\sim M_Z$ region, indicating they are likely true Z events with incorrect charge assignment

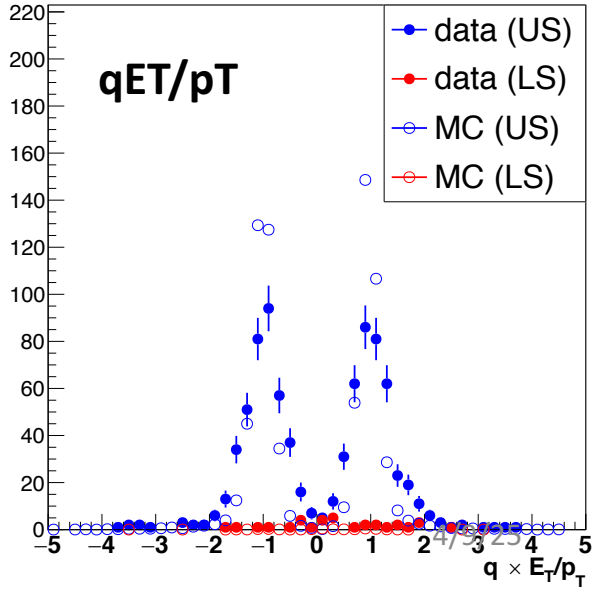
Charge mis-identification (Run 17 cuts)

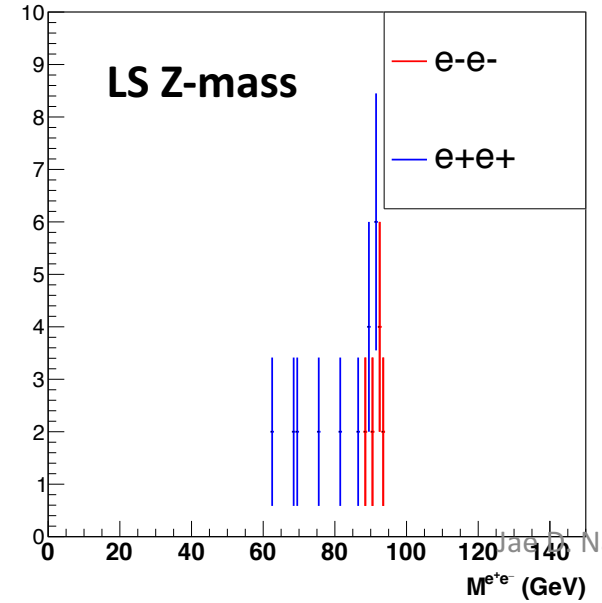




x projection

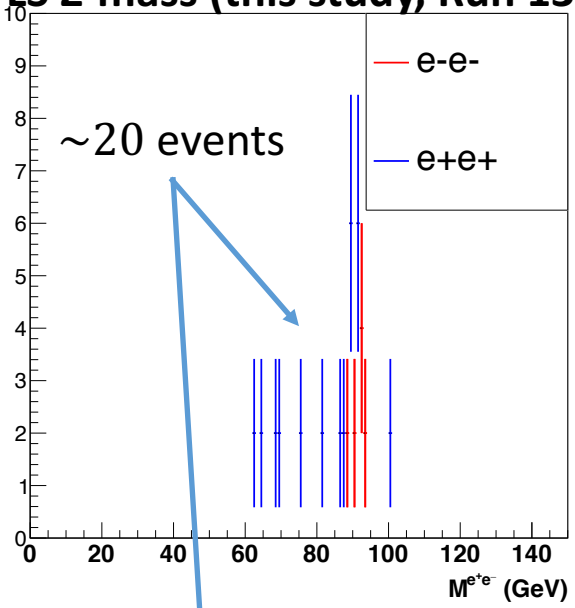
- Similar behavior with Run 17 cuts
- LS background really a background?
- qET/pT cut at [0.4, 1.8] justified?



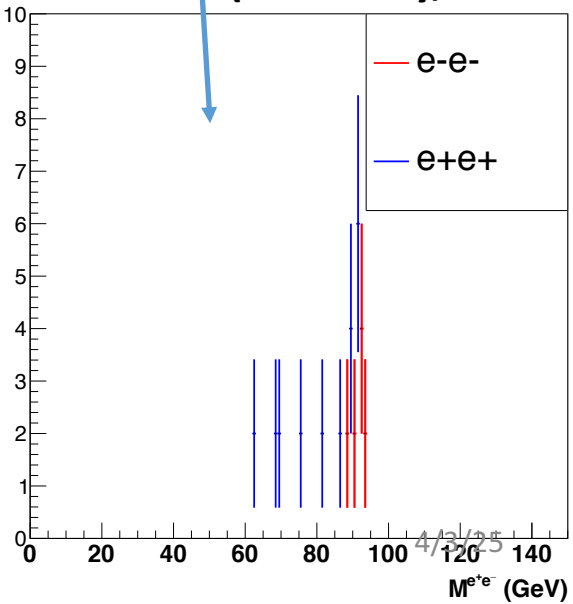


Charge mis-identification

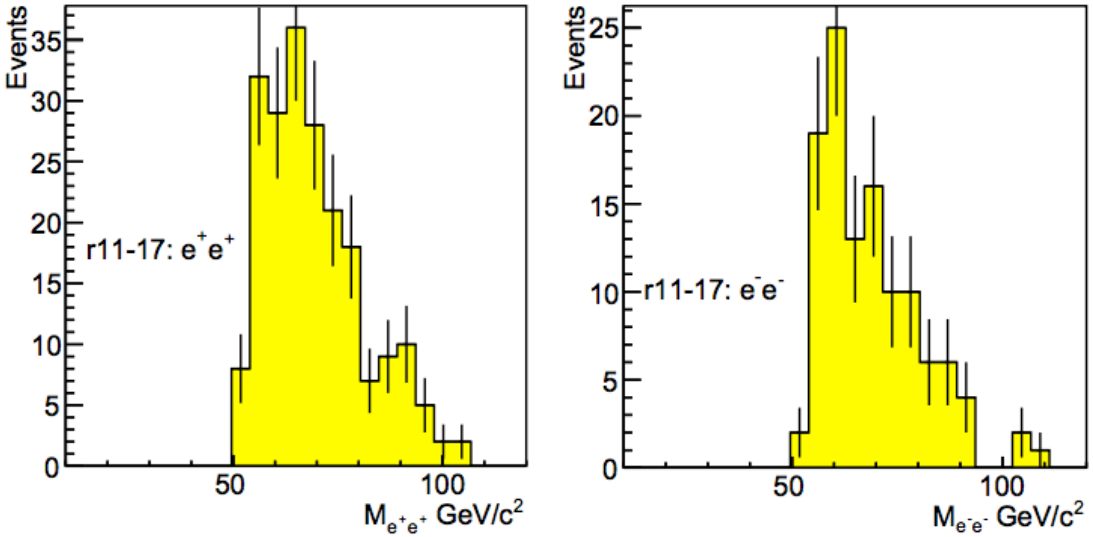
LS Z-mass (this study, Run 13 cuts)



LS Z-mass (this study, Run 17 cuts)



Run 17 Z publication (analysis note)



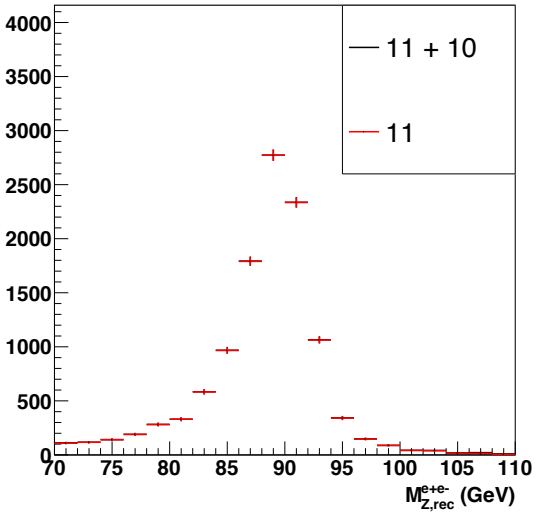
Run 13 W/Z publication (analysis note)

Run	Unlike Charges	Like Charges	Like Charges/Total (%)
11	33	1	3.0
12	80	2	2.5
13	298	13	4.4

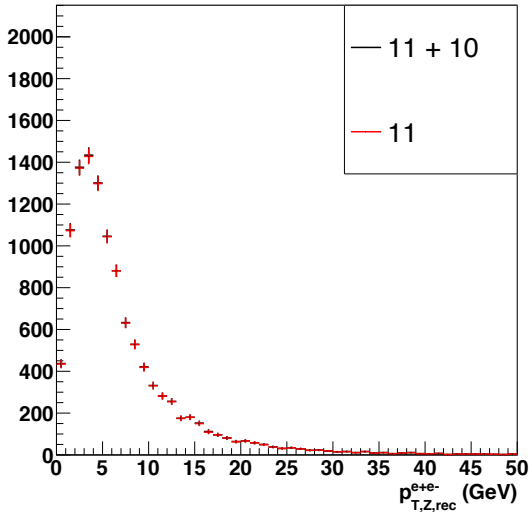
- Mismatch in LS BGR between Run 17 pub and this study currently being investigated

Migration Background (MC)

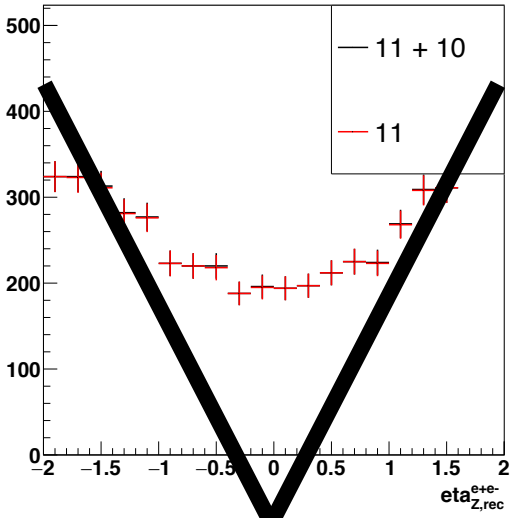
Raw yield (MZ)



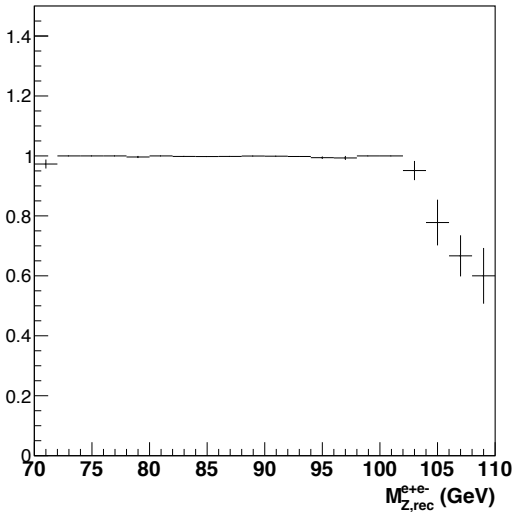
Raw yield ($p_{T,Z}$)



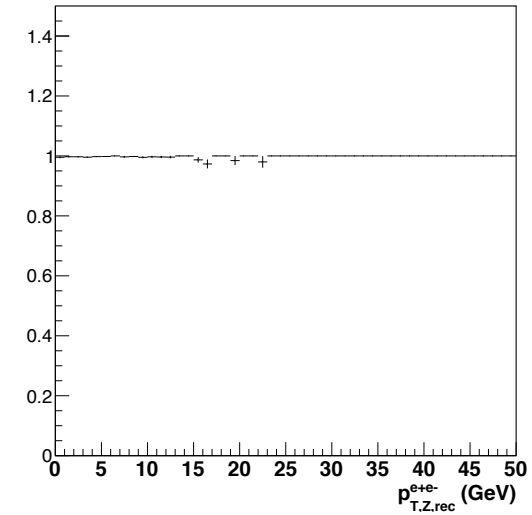
Raw yield (y_Z)



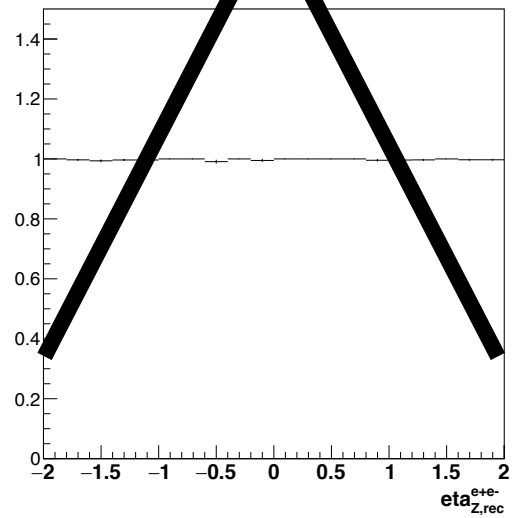
Correction (MZ)



Correction ($p_{T,Z}$)



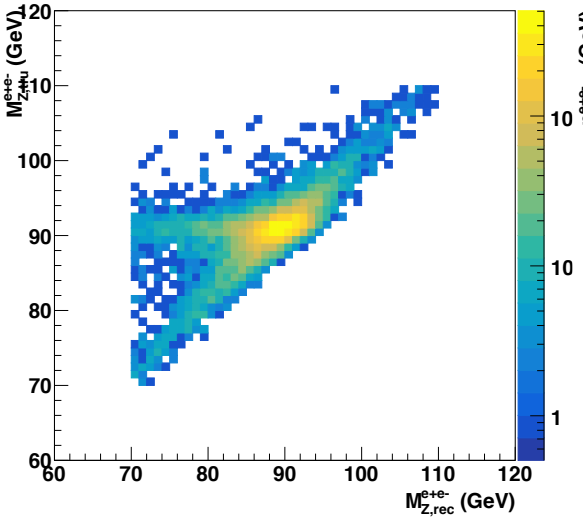
Correction (y_Z)



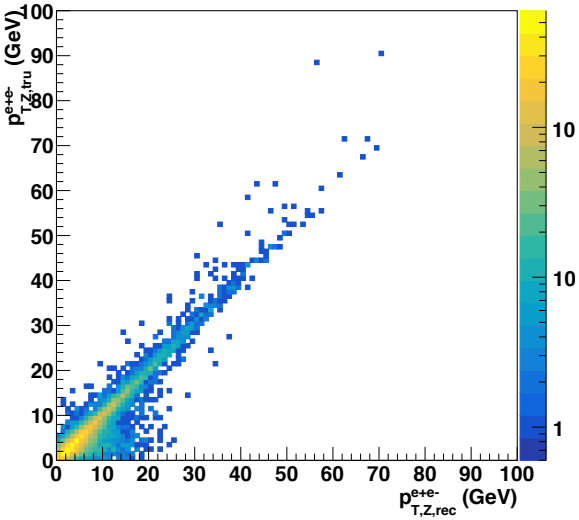
- No results with Run 17 cuts available from this point and on

Unfolding (MC)

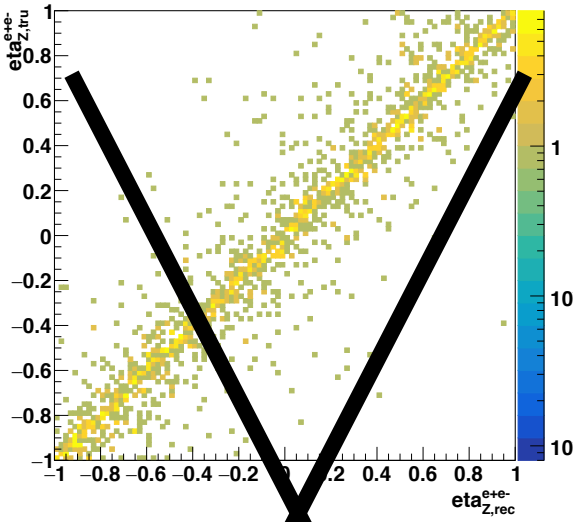
Migration Matrix (M_Z)



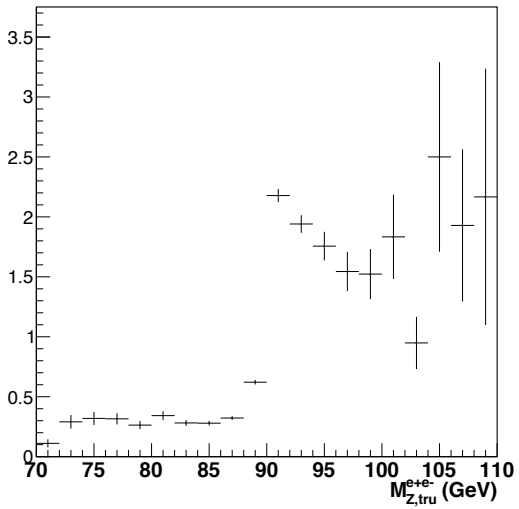
Migration Matrix ($p_{T,Z}$)



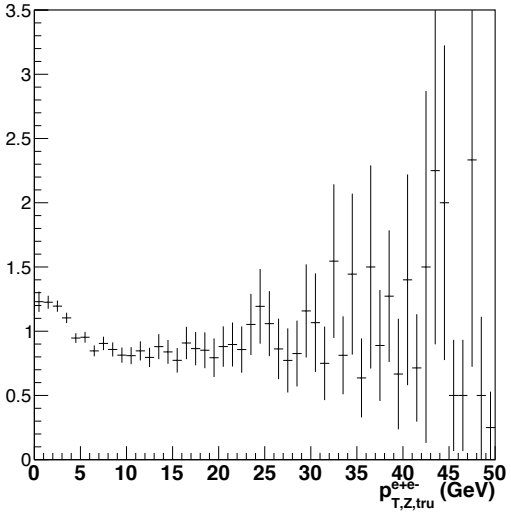
Migration Matrix (y_Z)



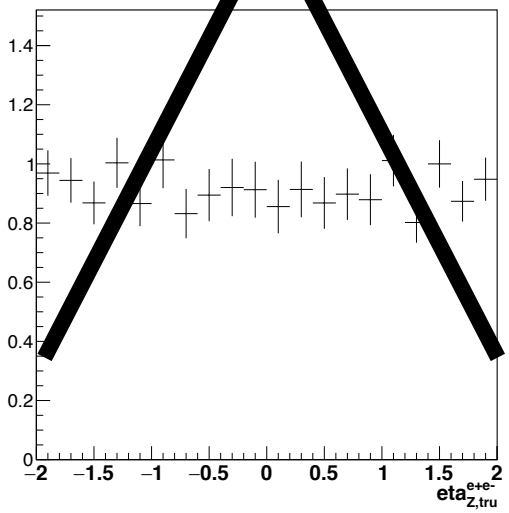
Binwise correction (M_Z)



Binwise correction ($p_{T,Z}$)

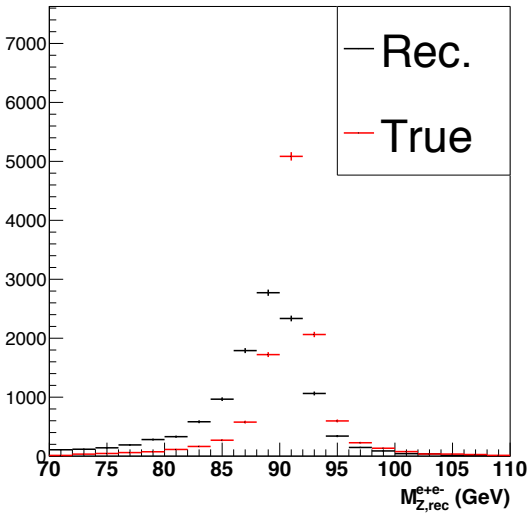


Binwise correction (y_Z)

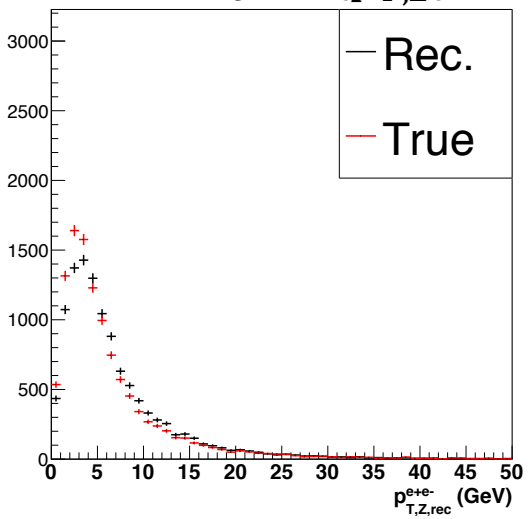


Unfolding (MC)

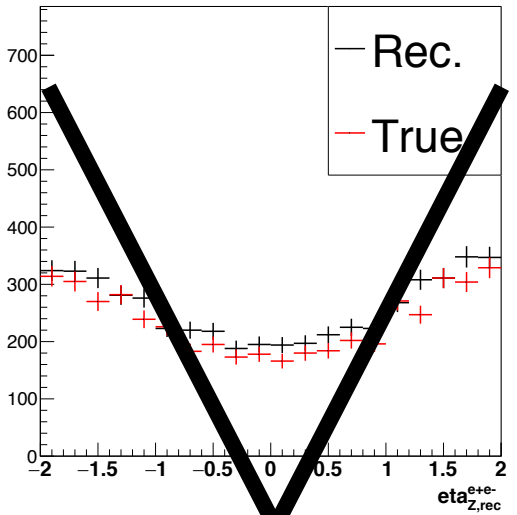
Raw yield (MZ)



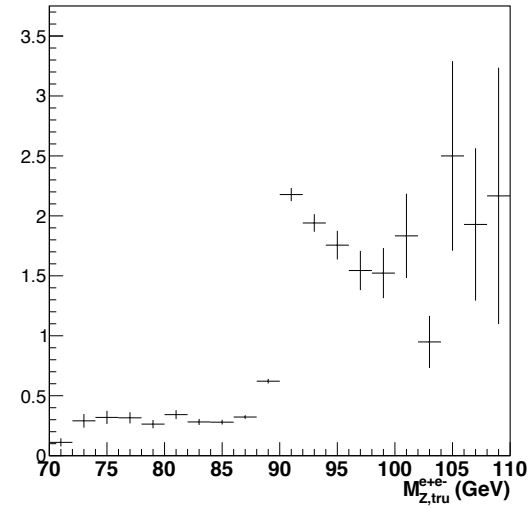
Raw yield ($p_{T,Z}$)



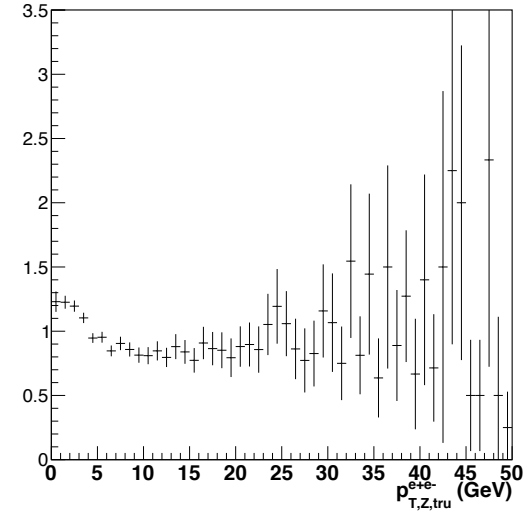
Raw yield (y_Z)



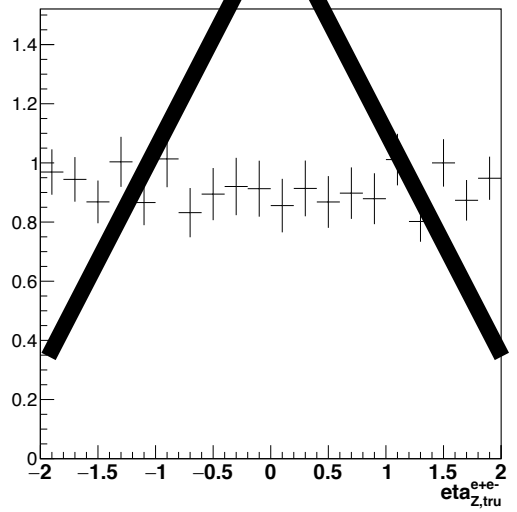
Binwise correction (M_Z)



Binwise correction ($p_{T,Z}$)

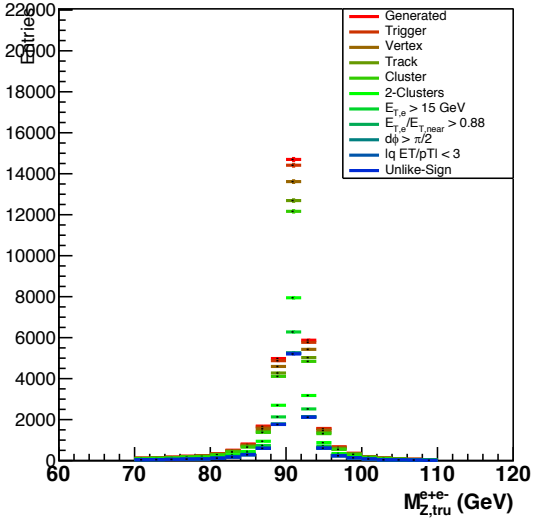


Binwise correction (y_Z)

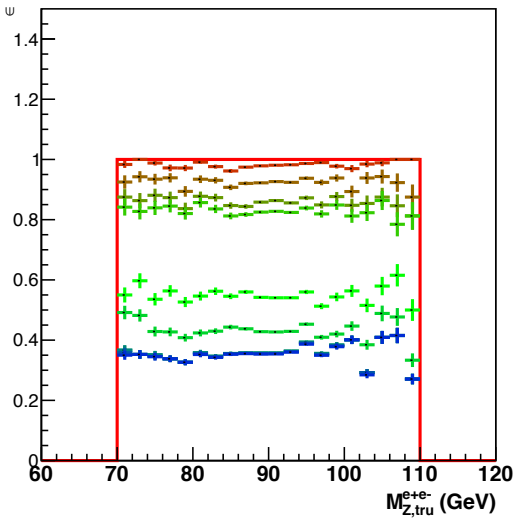


Efficiency

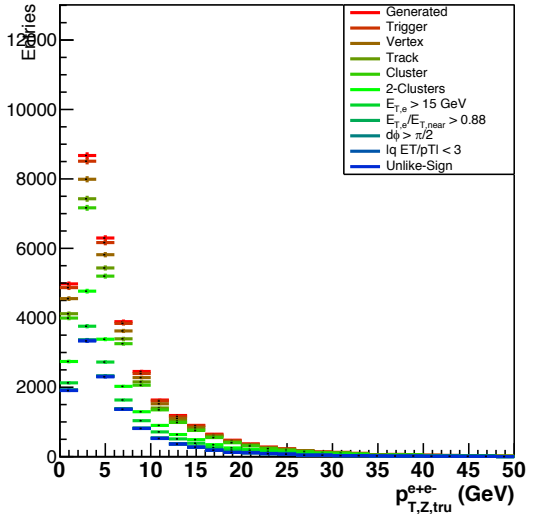
Raw yield (M_Z)



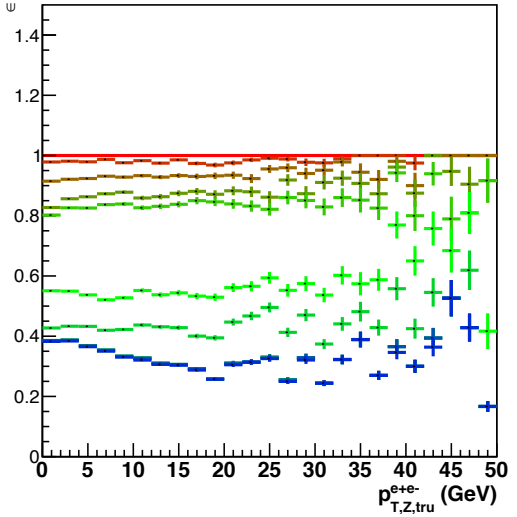
Correction (M_Z)



Raw yield ($p_{T,Z}$)



Correction ($p_{T,Z}$)

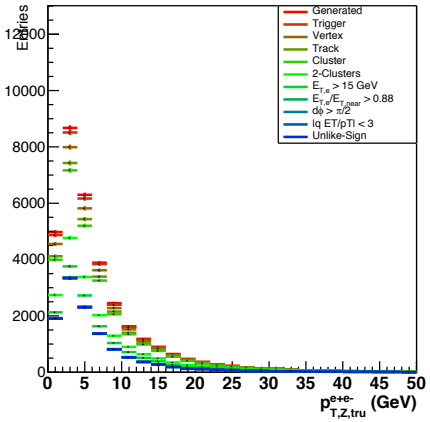


- No significant M_Z bias
- ETnear cut disfavors high pTZ events
  → How well does MC capture high-pT suppression?
  (Integrated pT study suggest < 4% impact)

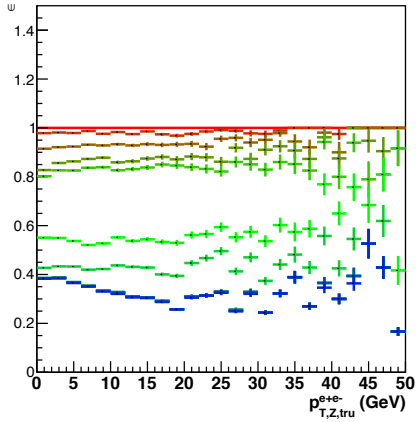
p_T efficiency

This study

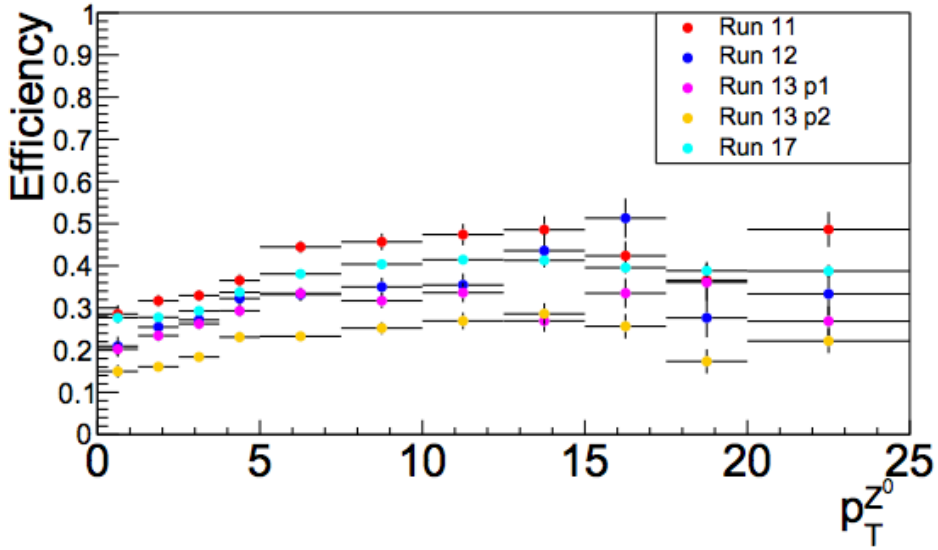
Raw yield (p_T)



Efficiency (p_T)



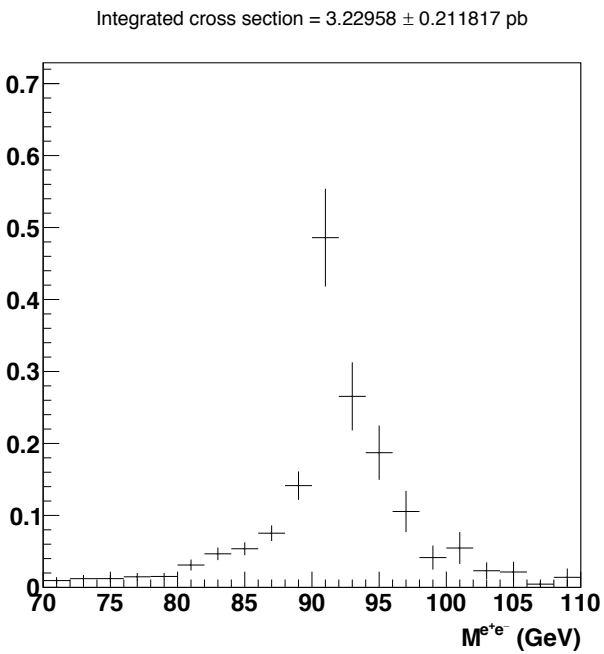
pTZ Efficiency (Run 17 pub)

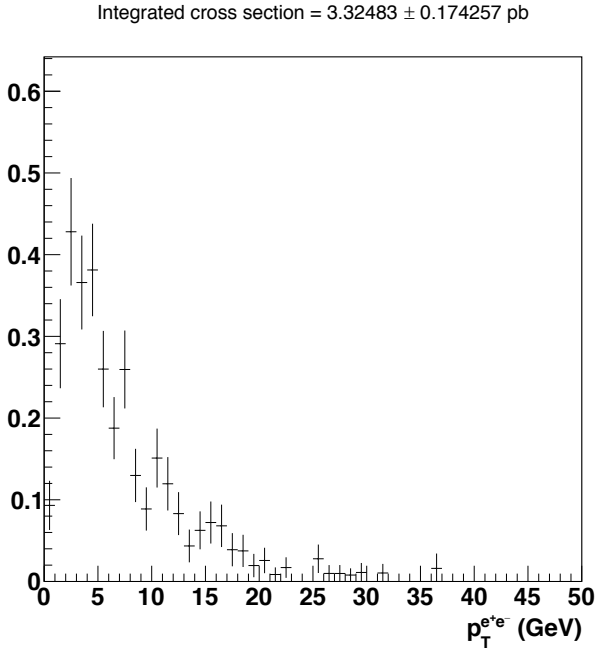


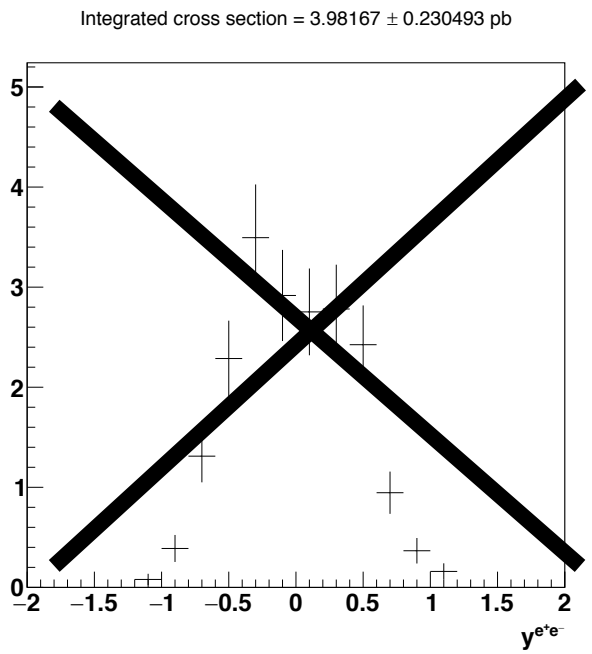
- Run 17 pub vs this study
  - Similar magnitude, opposite trend
  - Perhaps, in previous publications, detector-pT?
  - Mechanism behind low pTZ suppression?
  - Currently under investigation (can have an impact on the final result)

Results

3% difference
Multi-dimensional unfolding more suitable?







- Cross section measured in
  - $p_{T,e} > 15\ GeV, |\eta_e| < 1,$
  - $70 < M_Z < 110\ GeV$
- The resulting $\sigma^{fid} = 3.2(3.3) \pm 0.2\ pb$
- Run 13 publication: $\sigma^{fid}_{11-13} = 3.0 \pm 0.2\ pb$
- Run 17 publication: $\sigma^{fid}_{11-13,17} = 2.7 \pm 0.1\ pb$

3. Predictions

FEWZ predictions

- Thanks for screenshots of input cards for FEWZ...
- We are ≈ able to reproduce your theoretical predictions.
- Total:

Note ≈ 35% reduction from 0 jet cut.

Channel	Data	FEWZ total (0jet cut)	FEWZ total (no 0jet cut)
Z	$3.0 \pm 0.2^{\text{stat}} \pm 0.0^{\text{sys}} \pm 0.3^{\text{eff}}$	2.64 ± 0.01	3.57 ± 0.01
W^+	$64.3 \pm 0.7^{\text{stat}} \pm 0.9^{\text{sys}} \pm 3.4^{\text{eff}}$	67.1 ± 0.1	92.4 ± 0.1
W^-	$17.3 \pm 0.5^{\text{sys}} \pm 0.4^{\text{stat}} \pm 0.9^{\text{eff}}$	19.8 ± 0.1	27.0 ± 0.1

Summary

- Z cross section extracted with Run 17 data + Run 13 cuts
  - Run 17 data with Run 17 cuts on the way
- To be understood better
  - Tighter $q \times E_T / p_T$ cut justified? (~10% effect, not simulated well in MC)
  - Nature of Like Sign background?
  - Efficiency calculation (as a function of pTZtrue or pTZrec)?
- The result within $< 2\sigma$ from FEWZ NLO
  - Perhaps, mismatch between data vs pQCD NLO for Zs not as significant?
- Plans
  - ResBos2 (NLL included) calculation on the way
    (currently for Ws, do we want for Zs?)
  - W cross section / ratio paper preview request soon with spTbal cor.
    with Run 11-13 pub summed before this (refer to it as LO cross section)