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

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Recap

- Issue present
  - Pythia describes STAR data well after all of the selection/reconstruction + corrections to data rely on Pythia ($\sigma_{data} \sim \sigma_{MC}$)
  - Pythia prediction ~30% lower than NLO calculations

  → Mismatch between STAR data and NLO
- Potential origins?
  - Detector effects (EMC, TPC, etc.) or coding error that are not accounted for

  → No significant effects so far
  - Event selection/reconstruction artificially driving Pythia-Data match

  → ETaway? ETnear? pTbal? that are sensitive to soft effects
- Proposed ways forward
  - NLO+PS frameworks (as was done in LHC)
  - K-factor correction
- Suggestions
  - Looking at Z's
  - Discussions with Werner + Daniel

Studies with Z (in progress)

- Strategy
  - Estimate the impact ETaway/pTbal cuts with Z data:
    - Create mock-W data with Z (select 1 electron, blind the other)
    - Obtain $\epsilon_{ETaway}^{Z,data}$ in comparison to $\epsilon_{ETaway}^{W,MC}$ and also pTbalance
    - WIP

- Concerns
  - Does ETaway (and perhaps pTbalance) encapsulate all of NLO?
  - Does the Z sample retain NLO info?

Z's with Run 11-13 vs Run 17

- $\sigma^{tot}_{Z,data} = \sigma^{fid}_{Z,data}/A$, where A = acceptance correction
- $A = \sigma^{fid}_{Z,FEWZ}/\sigma^{tot}_{Z,FEWZ}$
- Based on the corresponding analysis notes,
  - $\sigma^{tot}_{Z,11-13}(8.7\ pb) \approx \sigma^{tot}_{Z,17}\ (8.7\ pb)$
  - $A_{11-13} = 0.35$, and $\sigma^{fid}_{Z,FEWZ}$ computed with 0-jet requirement
  - $A_{17} = 0.32$, also with the 0-jet requirement
  - $\sigma^{tot}_{Z,data} \sim \sigma^{tot}_{Z,FEWZ,NLO}$
- $\sigma^{fid}_{Z,data} \approx \sigma^{fid}_{Z,FEWZ,NLO+0j}\ (\approx \sigma^{fid}_{Z,FEWZ,LO})$

$$A = \frac{\sigma^{fid}_{NLO+0j}}{\sigma^{tot}_{NLO}} = \frac{\sigma^{fid}_{NLO}}{\sigma^{tot}_{NLO}} \times \frac{\sigma^{fid}_{NLO+0j}}{\sigma^{fid}_{NLO}}$$

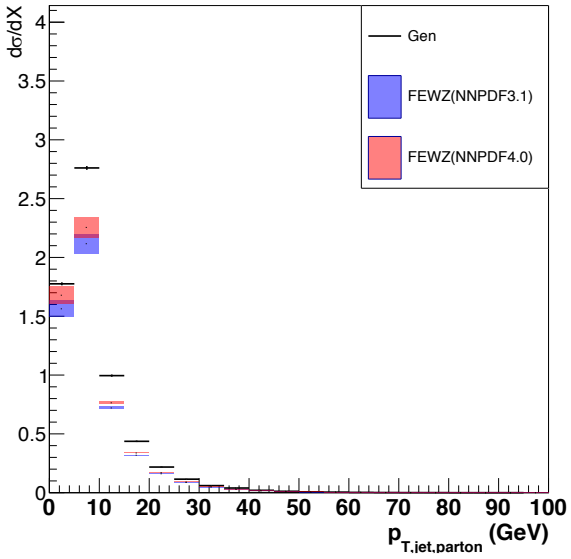
Effectively, k-factor correction

→ Same issue as with W!

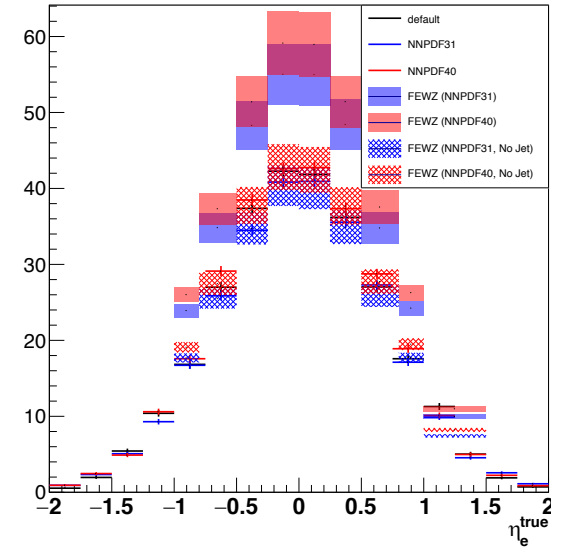
- Z with Run 17 suffers from the same issue
- Perhaps, ETaway, pTbalance aren't the culprits? Or isolation cut mimics ETaway cut?

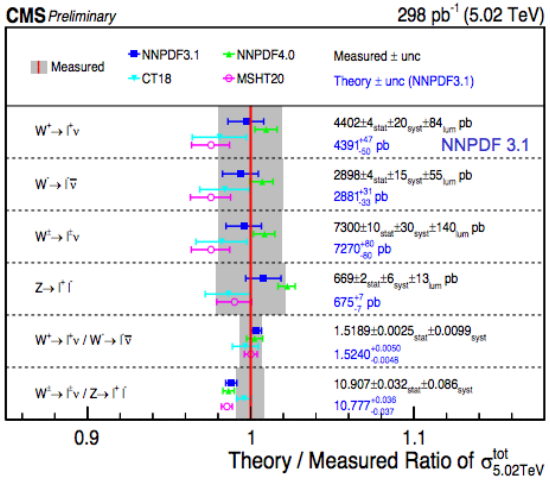
→ Will wait for mock-W study with Z

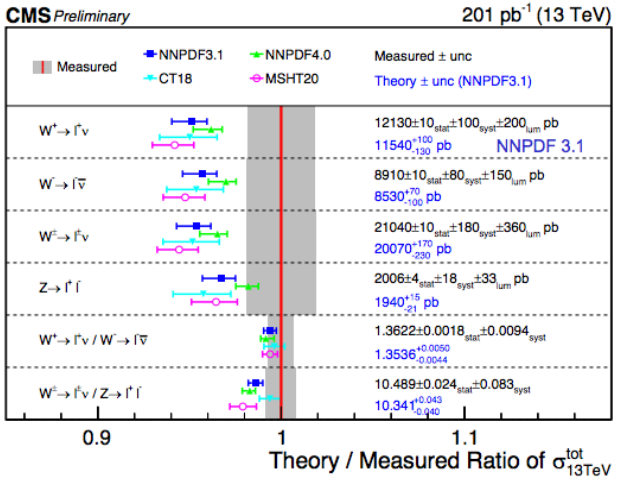
Discussions with Werner and Daniel



- Questions to Werner and Daniel
  - Performance of pQCD describing DY with very soft jets, $p_T > 3.5\ GeV$?
  - Performance of pQCD in this scale? (describes LHC within 5%)
  - What is the nature of $\sigma^{Pythia} \sim \sigma^{pQCD,LO}$?
- Suggestions?
- Slides uploaded on agenda



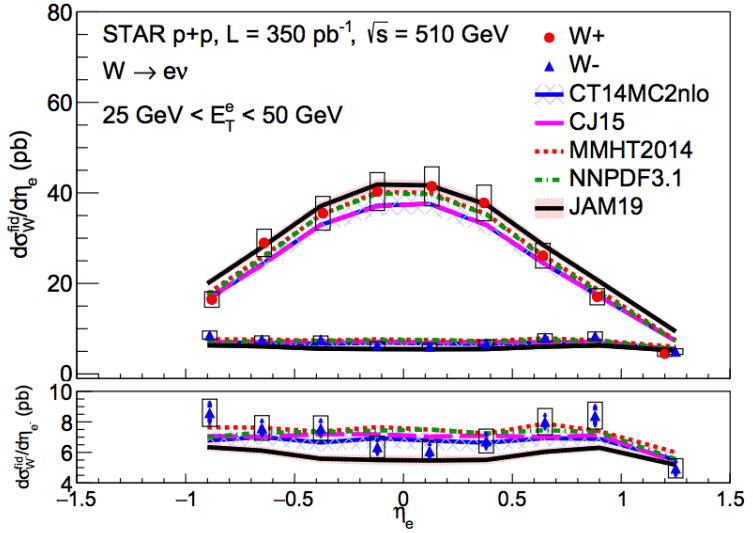


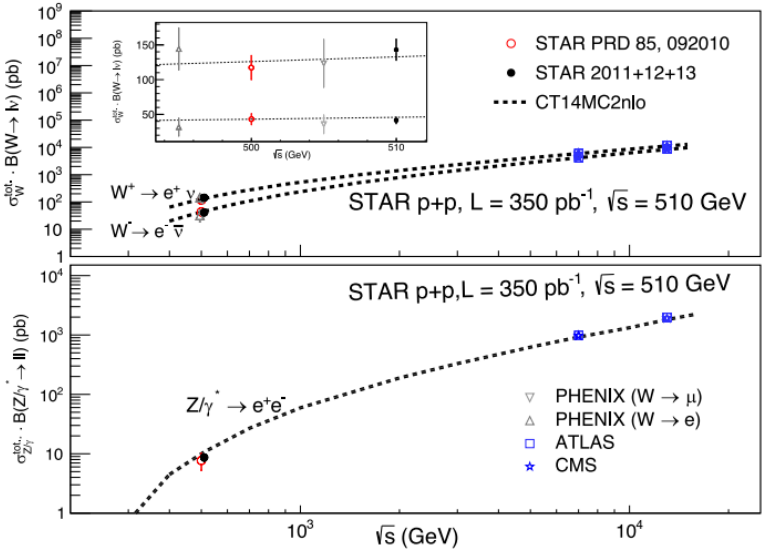


Summary

- $\sigma^{W}_{data} \sim \sigma^{W}_{MC} \sim \sigma^{W}_{FEWZ,NLO+0j} \sim \sigma^{W}_{FEWZ,LO}$
- This is observed throughout Run 11-13,17 and both W and Z
- Previous publications → Effective k-factor correction
- WIP: Z-study w/ and w/o isolation (ETnear) selection
- Input from Werner and Daniel (slides uploaded on agenda)
- Proposal
  - Kosher approach = Move away from Pythia to a better event model and re-evaluate W/Z event selection/reconstruction scheme
    → Unrealistic time scale (Geant4, Root6, jet tuning, etc.)
    → Run 22
  - Discuss in the paper the limitations of the current approach and present fiducial + total cross section + acceptance + k factor (or some combinations of them)

Backup: Previous results (Run 11-13)





$< \eta_{e^+} >$	$d\sigma_{W^+}^{fid}/d\eta_{e^+}$ (pb)
−0.88	16.5
−0.64	29.0
−0.37	35.5
−0.12	40.3
0.13	41.4
0.37	37.8
0.64	26.1
0.89	17.1
1.20	4.5
$< \eta_{e^-} >$	$d\sigma_{W^-}^{fid}/d\eta_{e^-}$ (pb)
−0.89	8.6
−0.65	7.6
−0.38	7.6
−0.12	6.4
0.12	6.1
0.38	6.7
0.65	8.0
0.88	8.4
1.25	5.0

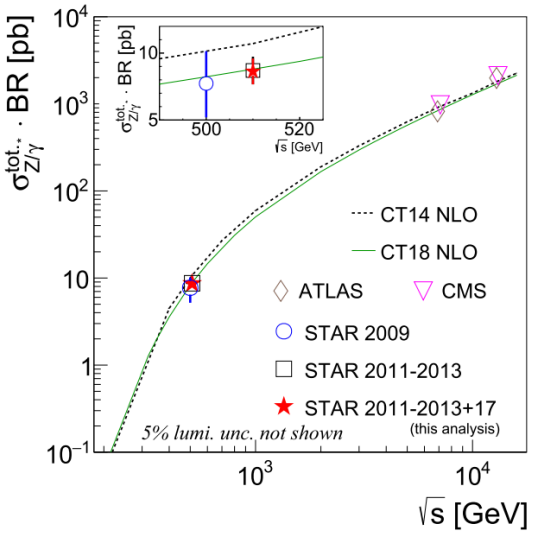
$< y_Z >$	$d\sigma_Z^{fid}/dy_Z$ (pb)
−0.74	0.5
−0.41	1.4
0.02	2.7
0.37	2.3
0.71	0.6

A_{W+}	A_{W-}	A_Z
0.45 ± 0.01	0.42 ± 0.01	0.35 ± 0.01

	Value(pb)
σ_{W+}^{fid}	64.3
σ_{W-}^{fid}	17.3
σ_Z^{fid}	3.0

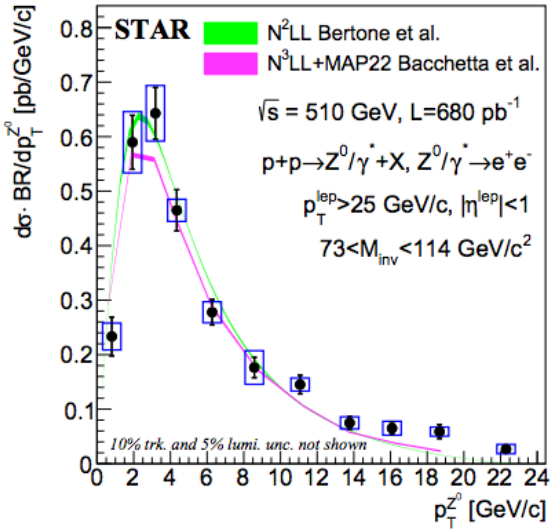
	Cross Section (pb)
$\sigma_{W^+}^{tot} \cdot B(W^+ \to e^+\nu)$	143.0
$\sigma_{W^-}^{tot} \cdot B(W^- \to e^-\bar{\nu})$	41.2
$\sigma_Z^{tot} \cdot B(Z \to e^+e^-)$	8.7

Backup: Previous results (Run 17 Z)



Year	ref	A_{Z^0}	$\sigma^{tot.}_{Z/\gamma^*} \pm stat_{err} \pm sys_{err}$ [pb]
2009	PRD 85,092010	0.378 ± 0.012	$7.7 \pm 2.1\ ^{+0.5}_{-0.9} \pm 1.0(Lumi)$
2011-13	PRD 103,012001	0.35 ± 0.01	$8.7 \pm 0.5 \pm 0.1 \pm 0.9(Eff)$
2011-13+17	this analysis	0.32 ± 0.014	$8.85 \pm 0.39 \pm 0.27 \pm 0.89(Eff) \pm 0.44(Lumi)$
2017	this analysis	0.32 ± 0.014	$8.72 \pm 0.31 \pm 0.31 \pm 0.87(Eff) \pm 0.44(Lumi)$

pb^{-1}. Results can be found in Fig. 28. The fiducial cross section integrated with all the p_T bins is $2.72 \pm$ (stat) $0.09 \pm$ (sys) 0.10. The systematic uncertainty will be explained in the next Section

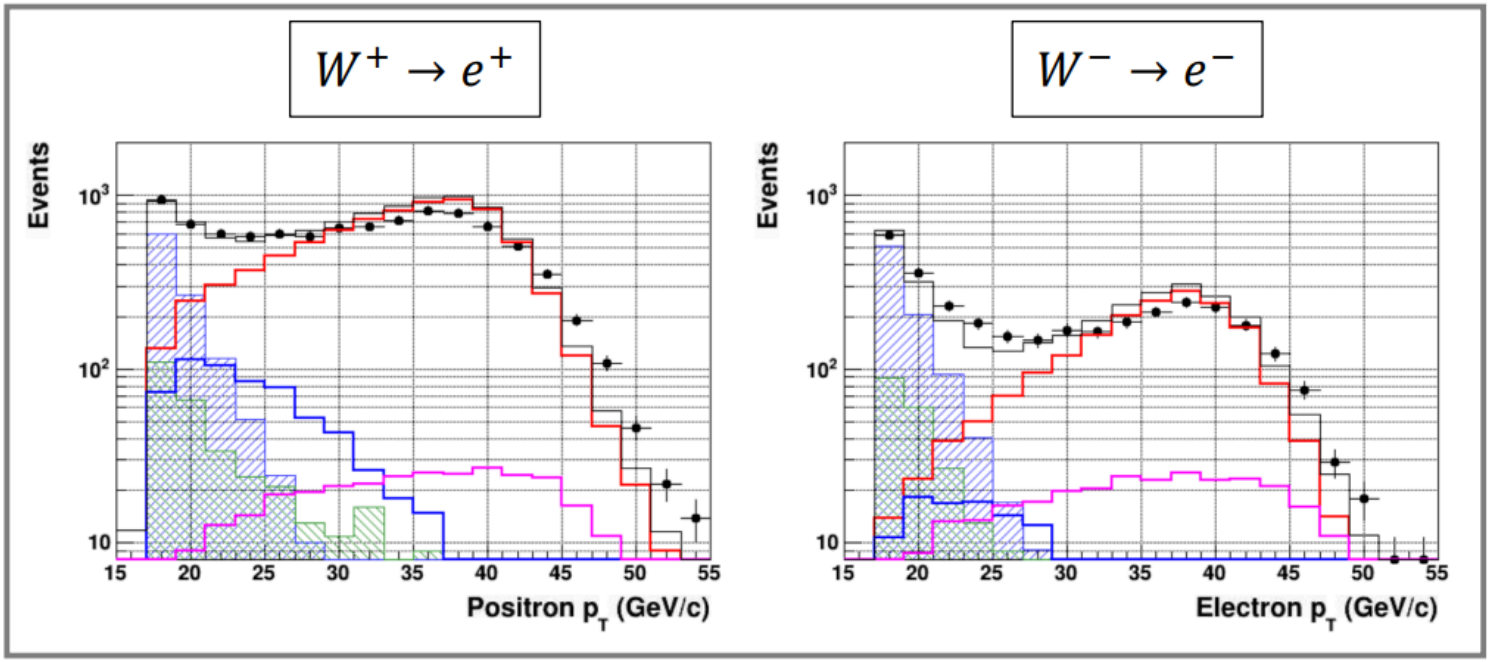


p_T = 0, 1.25, 2.5, 3.75, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25 in GeV/c,

Table 3: Z^0 p_T spectrum in each p_T bin.

$\langle p_T \rangle$[GeV/c]	$\frac{d\sigma}{dp_T}$ [pb/GeV/c]	Statistical error [pb/GeV/c]	Systematic error [pb/GeV/c]
0.81	0.23	0.04	0.03
1.93	0.58	0.05	0.07
3.18	0.63	0.05	0.05
4.35	0.46	0.04	0.02
6.28	0.27	0.02	0.02
8.58	0.17	0.02	0.02
11.07	0.14	0.02	0.01
13.77	0.07	0.01	0.01
16.08	0.06	0.01	0.01
18.67	0.06	0.01	0.01
22.30	0.03	0.01	0.01

Backup: Previous results (Run 17 W)



TPC hits (≥15) and fit fraction (>51%)

EMC $E_{2\times2}/E_{4\times4} > 0.96$

$E_{2\times2}/E_{R=0.7} > 0.88$

$p_{T,bal} > 0.8\, p_T$

$E_{T,away} < 10$ GeV