W^+/W^- ratio analysis Run 17

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Overview

- $W \rightarrow \tau$ sample
  - In W reconstruction analysis (Sal & Oleg), $W^- \rightarrow \tau^-$ yielded no surviving events, while a ”good” number of $W^+ \rightarrow \tau^+$ events were found.
  - In l^W tagging (present) analysis, both samples yielded close-to-zero events.
  - Both of these issues have been found to originate from the embedding production stage and have been resolved since.

- First look at the systematic uncertainties
  - Currently focuses on W^+/W^- cross section ratio in η within the barrel region ($|\eta| < 1$).
  - Based on previous study (Run 11,12,13).
  - Conducted with 90-100 % of data, $W^\pm \rightarrow e\nu$, and $Z \rightarrow e^+e^-$ samples
  - And $\sim$30% of $W^\pm \rightarrow \tau\nu$ samples, privately generated.

Tau sample

- No events in lepton tagging analysis
  - This is due to “TAUOLA” package not being implemented in Pythia.

Official production

Event listing (summary)

I	particle/jet	KS	KF	orig	p_x	p_y	p_z	E	m
1	!p+!	21	2212	0	0.000	0.000	254.998	255.000	0.938
2	!p+!	21	2212	0	0.000	0.000	-254.998	255.000	0.938
3	!u!	21	2	1	-1.299	0.158	87.231	87.240	0.000
4	!dbar!	21	-1	2	0.682	0.754	-28.552	28.570	0.000
5	!u!	21	2	3	-1.110	0.135	74.545	74.554	0.000
6	!dbar!	21	-1	4	-9.722	-8.440	-19.964	23.755	0.000
7	!W+!	21	24	0	-10.832	-8.304	54.581	98.309	80.618
8	!tau+!	21	-15	7	20.012	7.259	-11.117	24.081	1.777
9	!nu_tau!	21	16	7	-30.843	-15.563	65.698	74.228	0.000
10	(W+)	11	24	7	-10.832	-8.304	54.581	98.309	80.618
11	tau+	1	-15	10	20.012	7.259	-11.117	24.081	1.777
12	nu_tau	1	16	10	-30.843	-15.563	65.698	74.228	0.000

No tau decay

Test production

Event listing (summary)

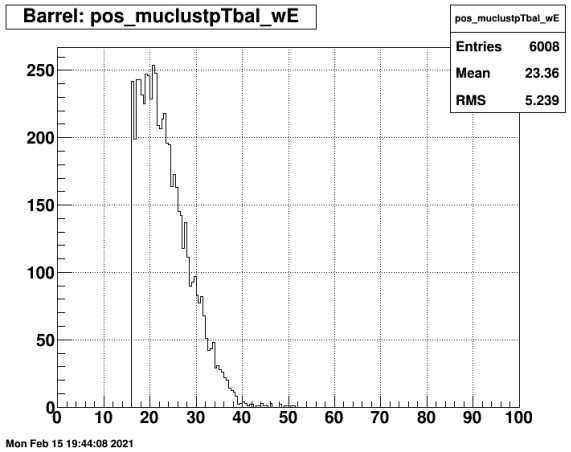
I	particle/jet	KS	KF	orig	p_x	p_y	p_z	E	m
1	!p+!	21	2212	0	0.000	0.000	254.998	255.000	0.938
2	!p+!	21	2212	0	0.000	0.000	-254.998	255.000	0.938
3	!dbar!	21	-1	1	0.926	-2.309	60.285	60.336	0.000
4	!u!	21	2	2	-0.523	-1.581	-39.219	39.254	0.000
5	!dbar!	21	-1	3	1.050	-1.345	41.438	41.473	0.000
6	!u!	21	2	4	-0.523	-1.581	-39.215	39.250	0.000
7	!W+!	21	24	5	0.528	-2.926	2.223	80.723	80.637
8	!tau+!	21	-15	7	-2.096	-16.686	38.384	41.944	1.777
9	!nu_tau!	21	16	7	2.624	13.760	-36.161	38.779	0.000
10	(W+)	11	24	7	0.528	-2.926	2.223	80.723	80.637
11	(tau+)	11	-15	10	-2.096	-16.686	38.384	41.944	1.777
12	nu_tau	1	16	10	2.624	13.760	-36.161	38.779	0.000
13	(d)	A 12	1	1	-0.628	0.706	-1.064	1.423	0.000
50	K_S0	1	310	37	0.479	0.327	1.799	1.955	0.498
51	K_L0	1	130	48	-0.148	0.389	18.052	18.063	0.498
		sum:	2.00		-0.000	0.000	-0.000	510.000	510.000

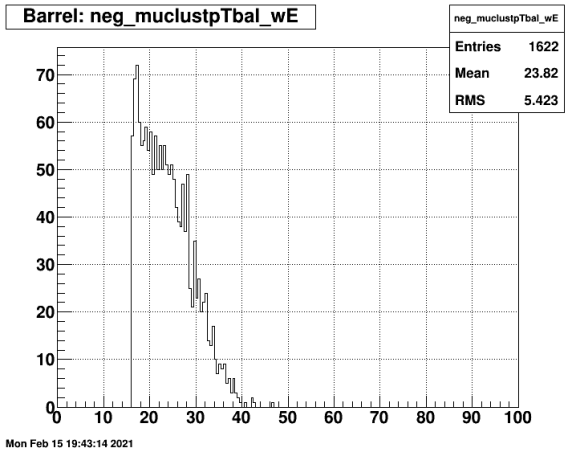
in tauola
NDEC 1
in tauola loop
second list

52 nu_taubar	1	-16	11	-0.938	-11.411	25.203	27.682	0.010
53 mu+	1	-13	11	-1.174	-4.627	11.122	12.104	0.106
54 nu_mu	1	14	11	0.016	-0.648	2.059	2.158	0.000
	sum:	2.00		0.000	0.000	-0.000	510.000	510.000

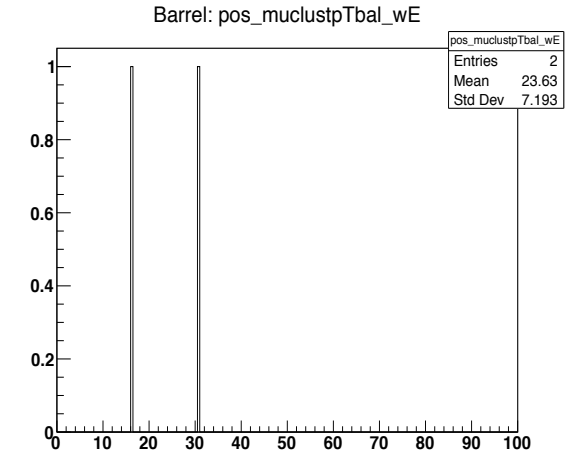
- No τ^- in W reconstruction
  - The automated script (preparexmlslr.sh) does not configure $W^- \rightarrow \tau^-$ setup properly.
  - “starsim … config=Wminus_tau …” need to be added manually

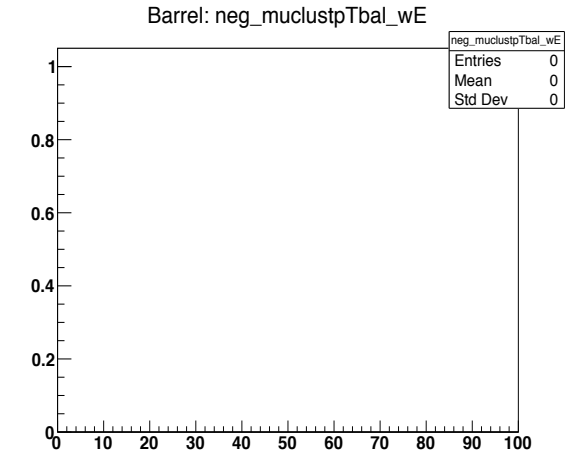
Run 13
(left: W^+ right:W^-)



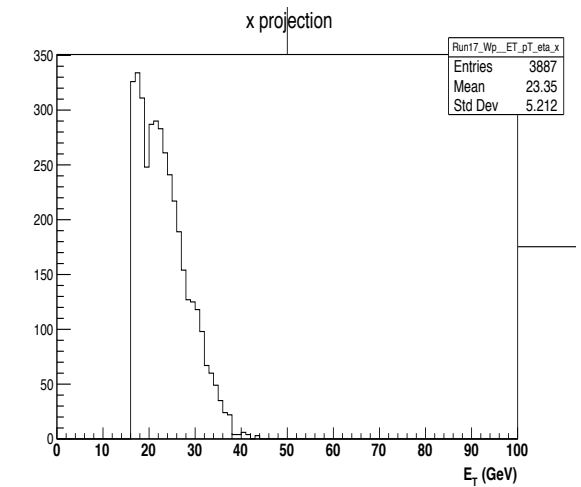


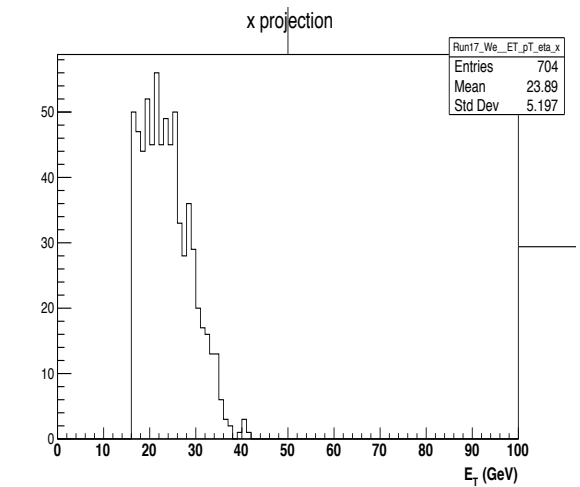
Run 17
(Official production)



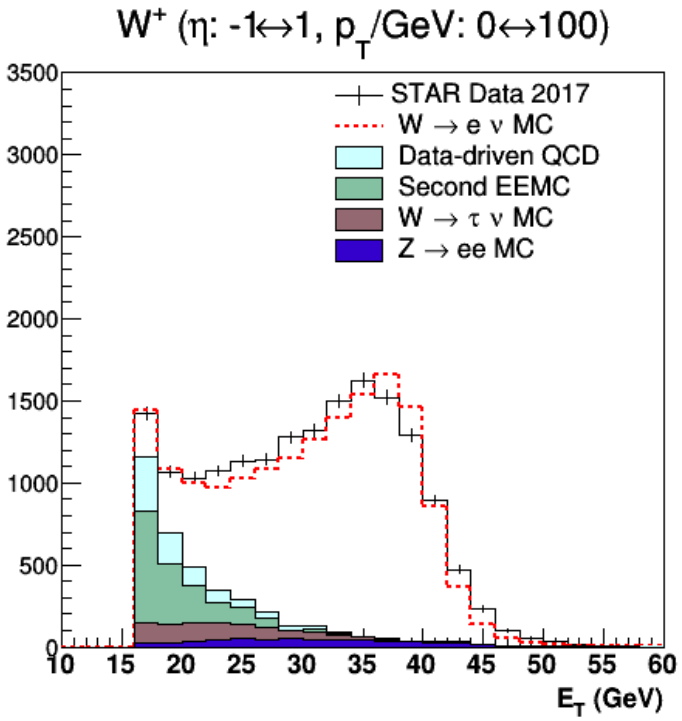


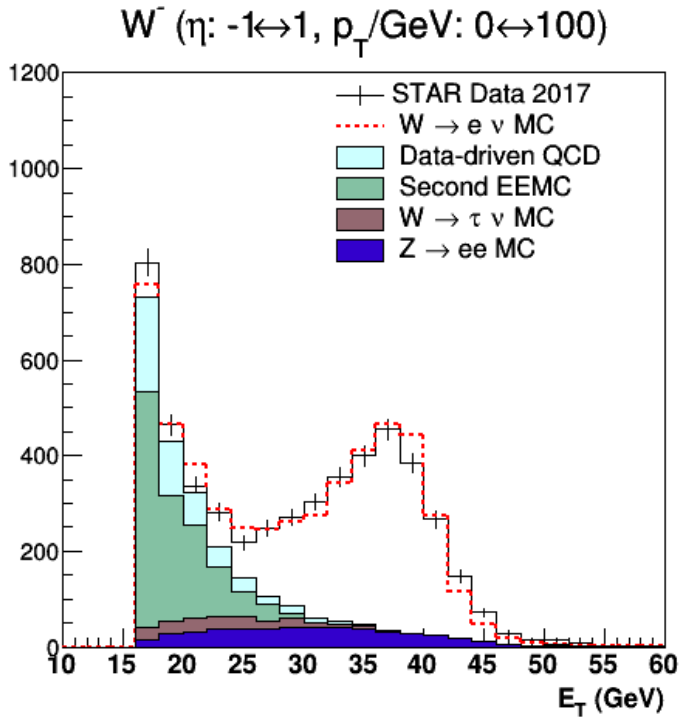
Run 17
(Test production)





New $W \rightarrow \tau\nu$ sample



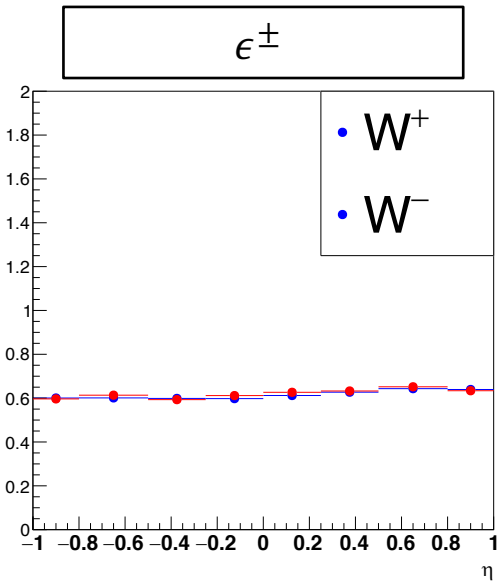


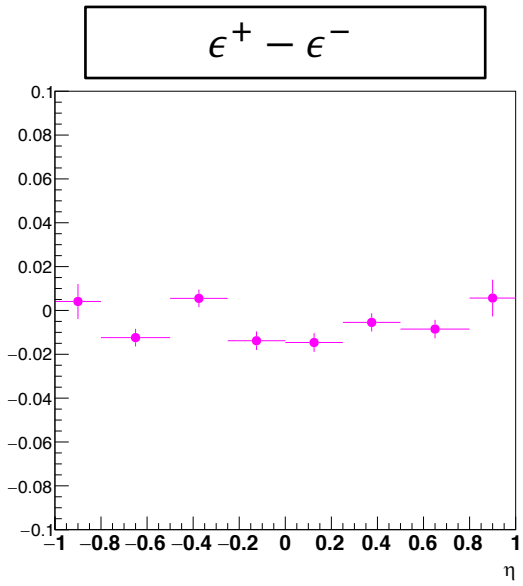
- Results with the new tau sample.
  - -4.2% BEMC gain correction applied to data based on Z mass
  - $W \rightarrow \tau$ background size consistent with Run 11,12,13 measurement
  - W^+: 2.4 ± 0.1 / 2.1 ± 0.1 W^-: 2.7 ± 0.3 / 2.1 ± 0.2 (Run 17 / Run 11-13)
  - Good description of data

Systematic uncertainties

- List of systematic uncertainties:
  - Luminosity
    - cancelled out in cross section ratio measurement
  - Tracking efficiency
    - cancelled out
  - BEMC calibration
    - The uncertainty associated with the BEMC calibration gain has been estimated to be ~ 3%.
    - The contribution from the calibration uncertainty is estimated by observing the variation in W efficiency ratio while varying the BTOW gain by 3%.
  - Charge dependence in tagging efficiency
    - Estimated by taking the difference between $W^{\pm}$ efficiencies.
  - QCD background
    - Uncertainty associated with the choice of QCD background shape and normalization.
    - Estimated by varying the choice of $p_{T,bal}^{cut}$ from $5-25$ GeV (nominal is $16\ GeV$) and the upper normalization window in E_T from $18 < E_T^{up} < 24\ GeV$ (nominal is $21\ GeV$).

Systematics (Efficiency)

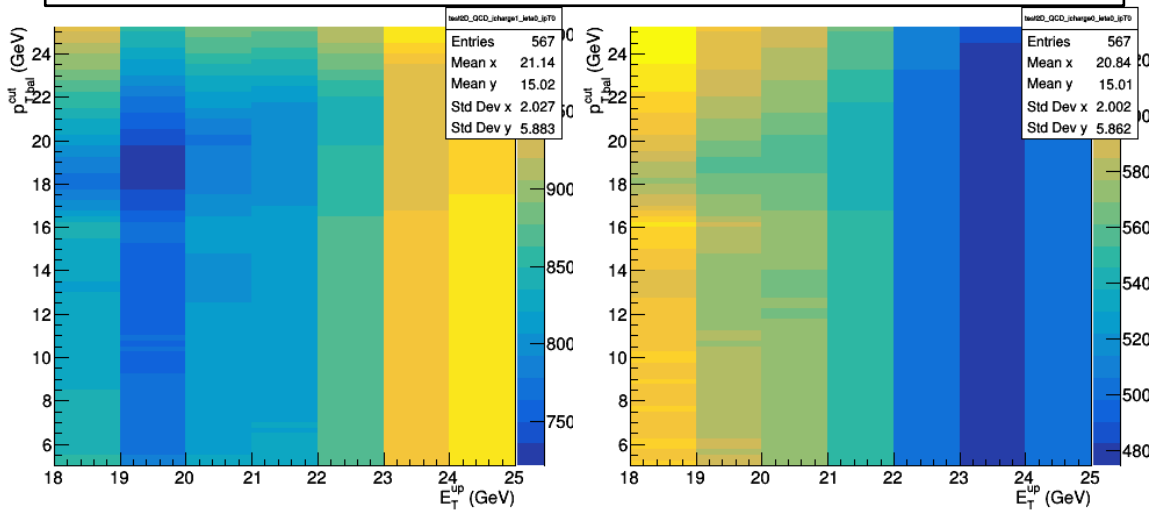




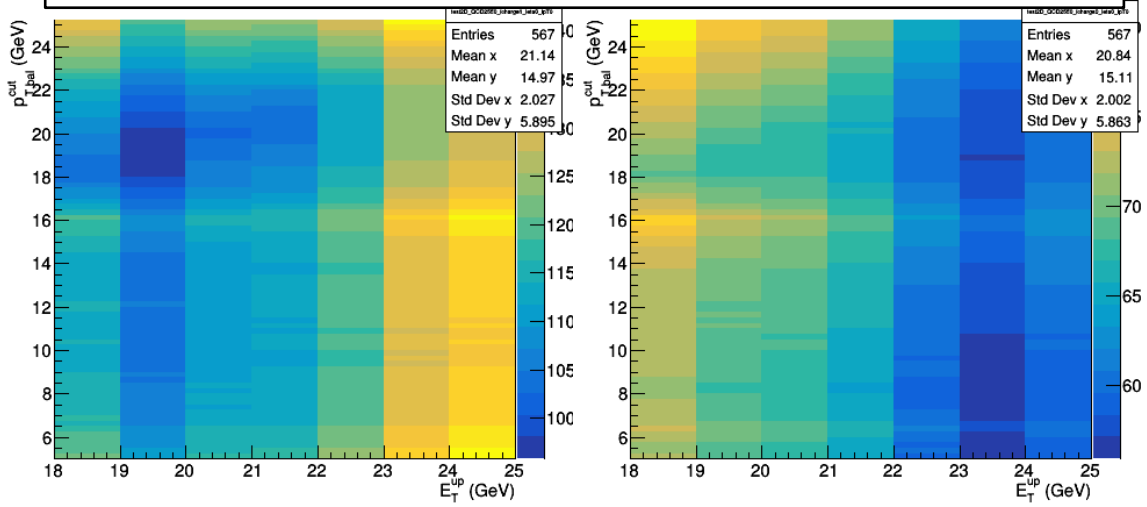
η bin	1	2	3	4	5	6	7	8
$\delta_{\Delta\epsilon}$(%)	0.3	-1.0	0.5	-1.0	-1.0	-0.4	-0.7	0.4
δ_{BEMC}^{high} (%)	0.2	0.0	0.0	0.0	-0.1	0.0	-0.4	0.3
δ_{BEMC}^{low} (%)	0.2	0.3	-0.3	-0.2	-0.2	-0.3	0.0	0.5

Systematics (QCD Background)

N^{QCD} in $p_{T,bal}^{cut}$ vs E_T^{up} (left: W^+ right:W^-)



$N_{25<E_T<50}^{QCD}$ in $p_{T,bal}^{cut}$ vs E_T^{up} (left: W^+ right:W^-)



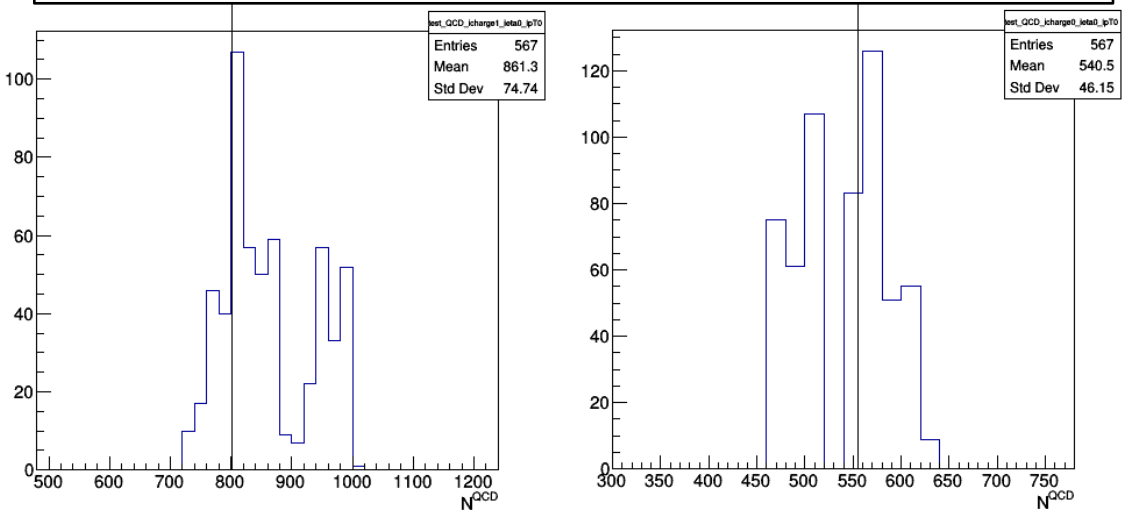
- Change in QCD background while varying:
  - Along y: $p_{T,bal}^{cut}$ from $5 - 25\ GeV$

  → Variation in shape.
  - Along x: E_T upper range of normalization ($E_T^{low} = 16GeV$).

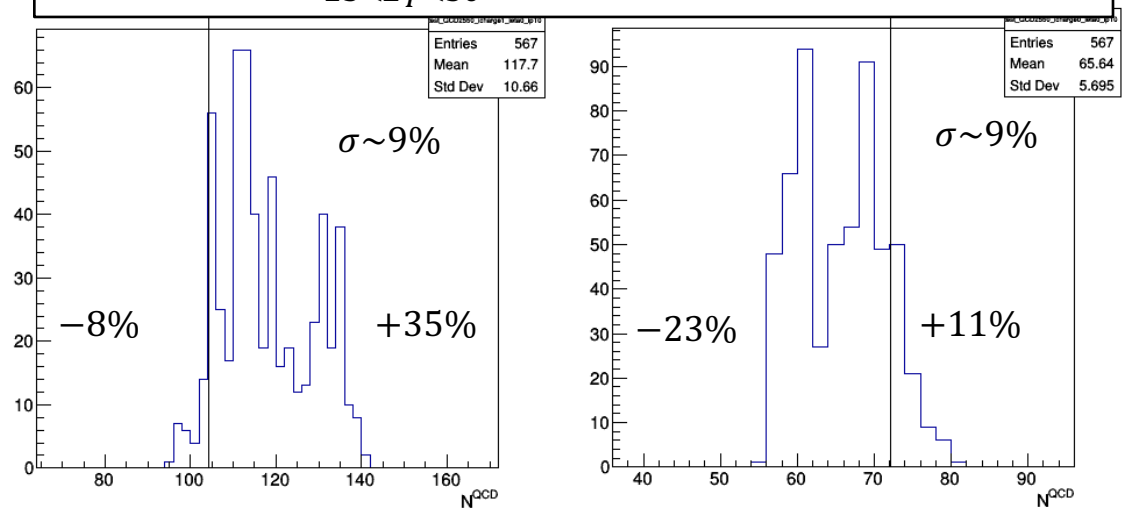
  → Variation in normalization.
- Small variation along $p_{T,bal}{}^{cut}$ confirms that our description of the shape of QCD background is stable.
- Systematic uncertainty associated with QCD background description is estimated by varying both $p_{T,bal}^{cut}$ and E_T^{up}.

Systematics (QCD Background)

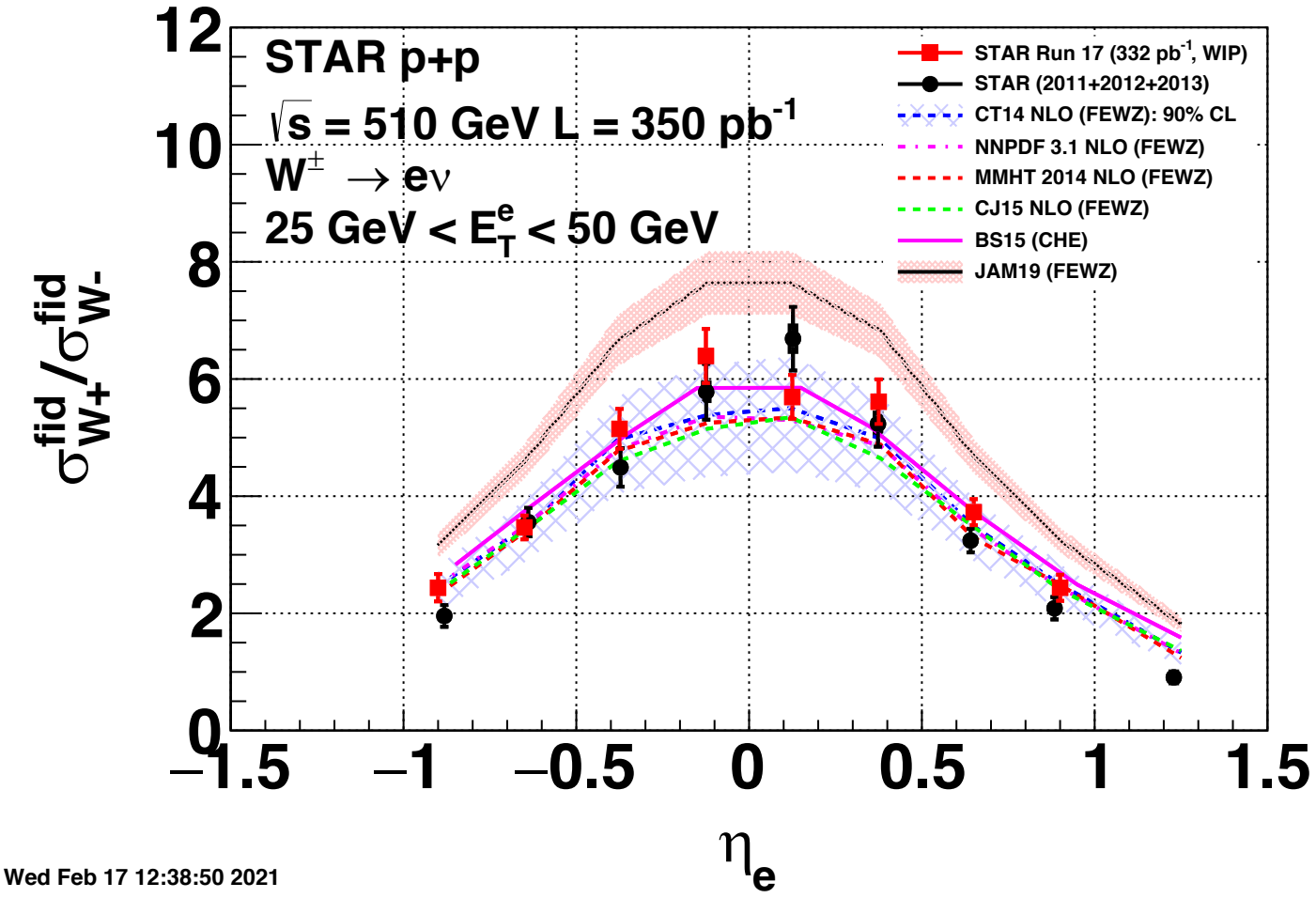
N^{QCD} (left: W^+ right:W^-)



$N^{QCD}_{25<E_T<50}$ (left: W^+ right:W^-)



Results (w/o syst)



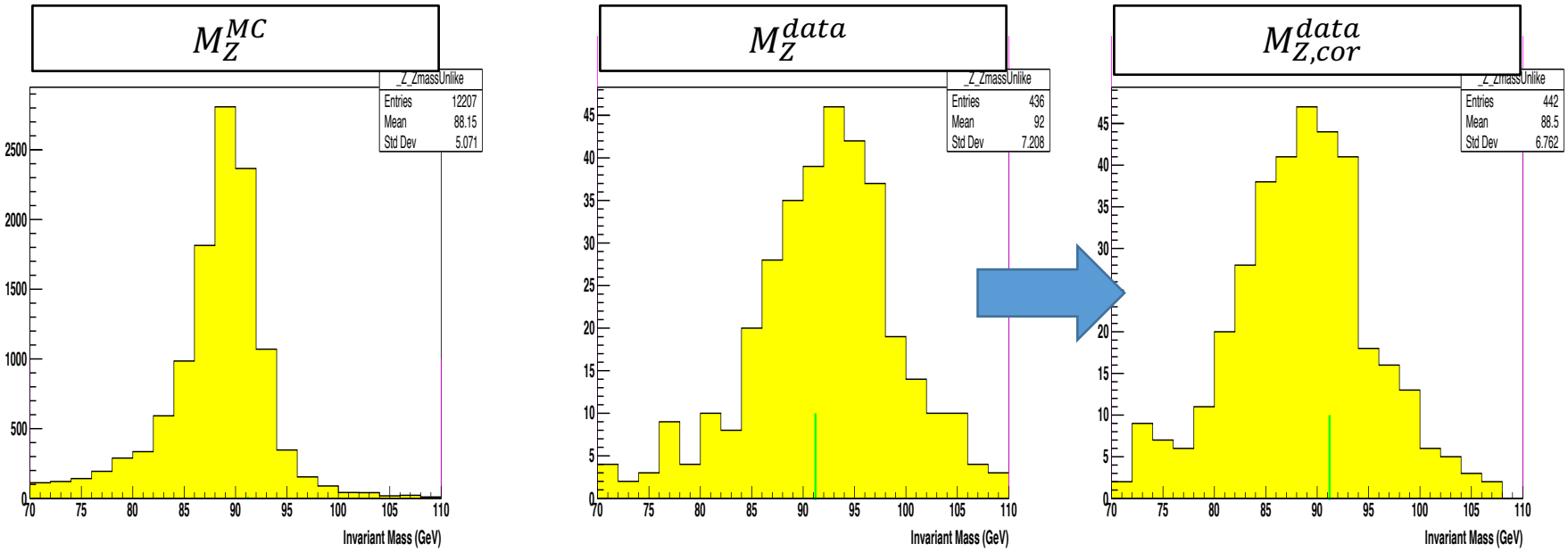
Summary

- Embedding test production
  - Currently at ~1/3 statistics of what was initially intended.
  - Results from test sample is consistent with Run 13
  - Full production will be requested.

- First look at Systematics
  - ~1% effect from charge dependence in lepton tagging efficiency.
  - Negligible effect from BEMC calibration.
  - Few percent effect from QCD background
    - Needs to be evaluated per eta bin.

- Plan forward
  - Preliminary request for W^+/W^- ratio analysis for DIS 2021.
    - Barrel-region, variation along lepton-η
    - First preliminary request during the collab. meeting (Mar 2-3).

BEMC gain correction



- EMC calibration gains are corrected at the analysis stage based on Z mass mean.
  - For Run 17, a correction of -4.2% has been applied to BEMC gain for data.