Progress Report

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Comments from Global Fit

3. Predictions

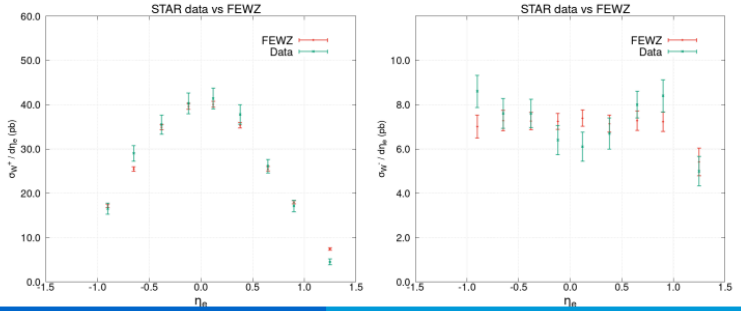
FEWZ predictions

- 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

- Applying 0 jet cut makes large difference, is it rigorous/justified?
- Differential:



Can't show for Z as don't know binning? Only bin averages given.

Thomas Cridge | STAR | 19th August 2022 | 5 / 7

- In the STAR publication, STAR data compared to FEWZ framework with 0-jet suppression on.
- Removing this creates ~35% shift in absolute cross section for W/Z in FEWZ.
- MSHT, CJ, CT, JAM are aware of this and see the same ~35% shift.
- Is the 0-jet suppression justified?

FEWZ Input

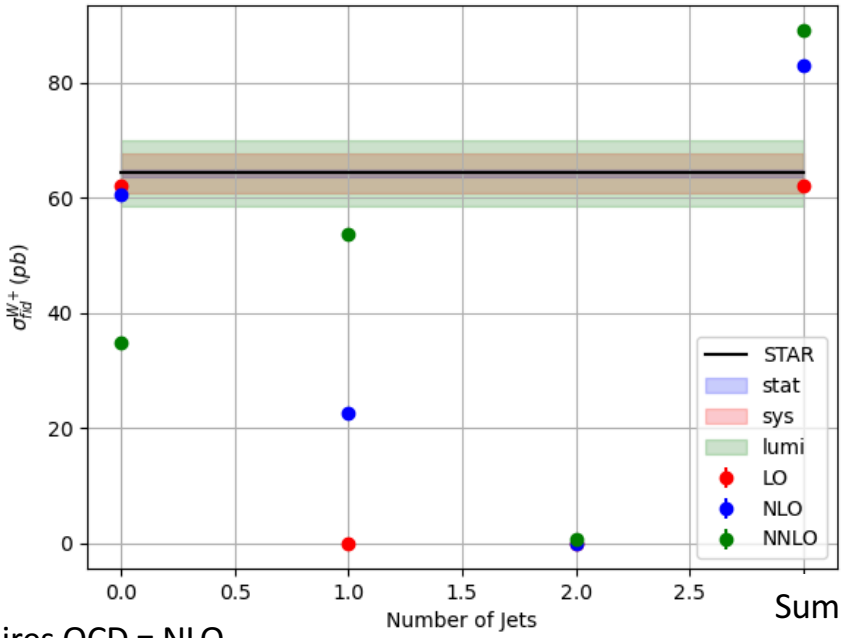
Two settings related to higher order QCD effects

- QCD Perturb. Order
- Number of Jets

```
Random number seed for vegas          =   111
================================================
'QCD Perturb. Order (0=LO, 1=NLO, 2=NNLO) = ' 2
'W pole focus (1=Yes, 0=No)     = ' 1
================================================
```

```
JET DEFINITION-------------------------------
Jet Algorithm & Cone Size ('ktal'=kT algorithm,
'ktal, aktal or cone                = ' aktal
'Jet algorithm cone size (deltaR)   = ' 0.6d0
'DeltaR separation for cone algo    = ' 1.3
'Minimum pT for observable jets     = ' 3.5d0
'Maximum eta for observable jets    = ' 4.5d0
JET CUTS-------------------------------------
'Minimum Number of Jets             = ' 0
'Maximum Number of Jets             = ' 1
'Min. leading jet pT                = ' 0d0
ISOLATION CUTS-------------------------------
'Lep-missing deltaPhi min           = ' 0.0d0
'Lep-missing deltaPhi max           = ' 4.0d0
'Lep-Jet deltaR minimum             = ' 0.0d0
================================================
```

1 Jet requires QCD = NLO
2 Jet requires QCD = NNLO



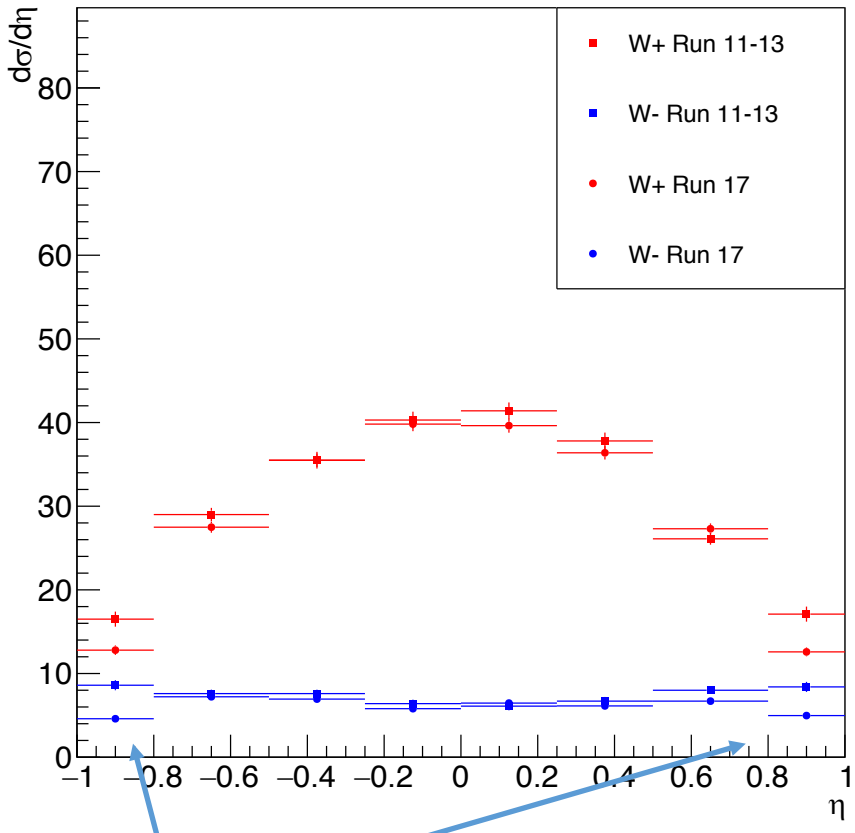
Sum

Discussion with Daniel and Werner

- Private discussion with Daniel de Florian & Werner Vogelsang
  - Both agree that higher order correction may provide ~30% correction to the LO cross section at STAR kinematics.
  - Werner's calculation for W+ cross section
    - ~67 pb at LO
    - ~85 pb at NLO
  - Consistent with the observations by MSHT.

Run 17 simulation

Run 17 W cross section



End bins for 17 not reliable (efficiency calculation)

No charge correction for Run 17

Pythia log (nominal, $2 \rightarrow 1$)

```
 ========================================================================
 I                                I                          I           I
 I           Subprocess           I      Number of points    I    Sigma  I
 I                                I                          I           I
 I--------------------------------I--------------------------I    (mb)   I
 I                                I                          I           I
 I N:o Type                       I   Generated        Tried I           I
 I                                I                          I           I
 ========================================================================
 I                                I                          I           I
 I   0 All included subprocesses  I         253        743 I  9.940D-08 I
 I   2 f + fbar' -> W+/-          I         253        743 I  9.940D-08 I
 I                                I                          I           I
 ========================================================================
```

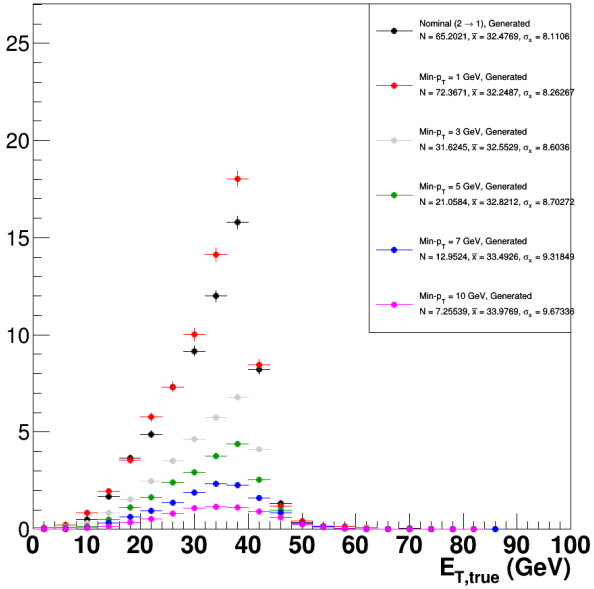
Pythia log (test, $2 \rightarrow 2$)

```
 ========================================================================
 I                                I                          I           I
 I   0 All included subprocesses  I         253       3630 I  1.181D-07 I
 I  16 f + fbar' -> g + W+/-      I         221       3368 I  1.043D-07 I
 I  31 f + g -> f' + W+/-         I          32        262 I  1.386D-08 I
 I                                I                          I           I
 ========================================================================
```

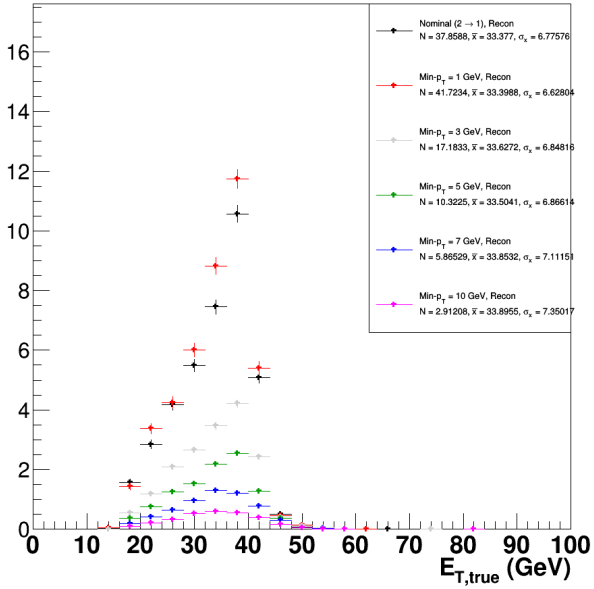
- It seems that the embedding sample for the preliminary results w/ Run 17 only simulate $2 \rightarrow 1$ process.
- $2 \rightarrow 2$ simulations take min-parton pT as input.

Subprocesses (yield)

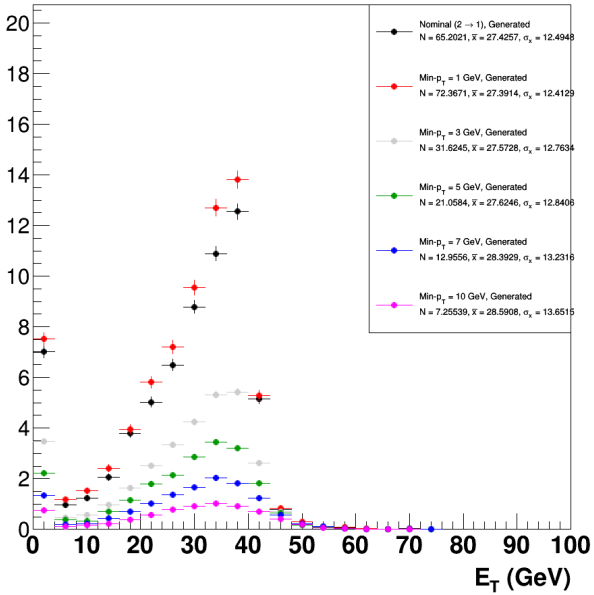
True E_T at Generation



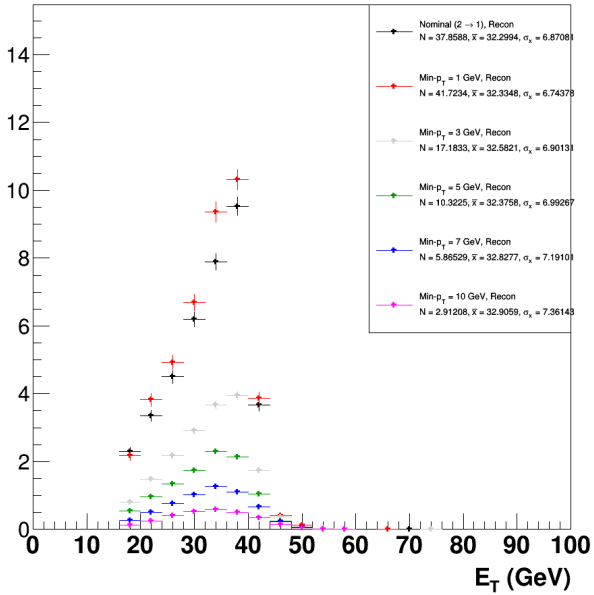
True E_T at Selection



Rec E_T at Generation



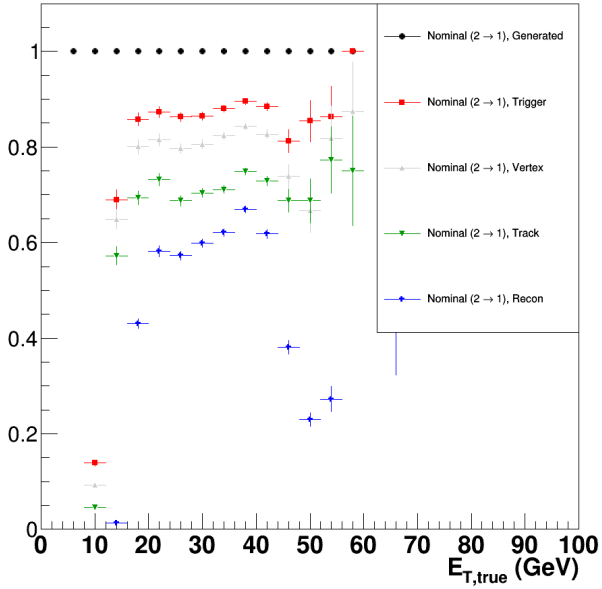
Rec E_T at Selection



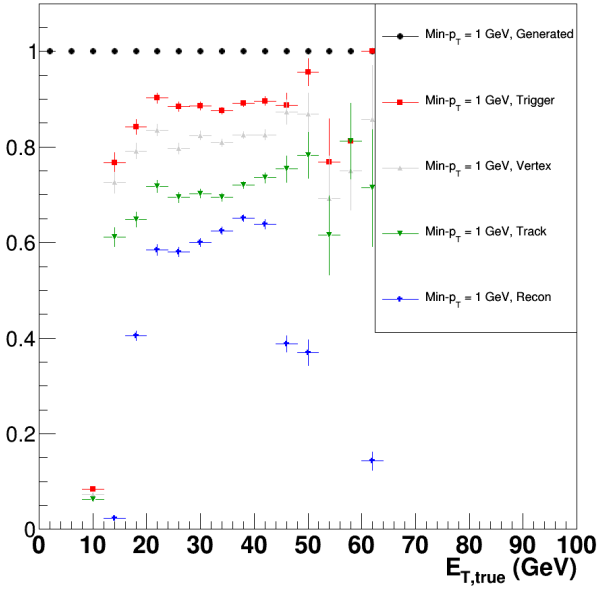
- Comparing Nominal $(2 \rightarrow 1)$ with $(2 \rightarrow 2)$ with parton min-$p_T = 1$ to 10 GeV.
- Cross section varies from 1.12 (minpT = 1 GeV) to 0.11 (minpT = 10 GeV), mostly arising from $ff' \rightarrow gW$.
- All histogram luminosity-scaled.
  - Scaled by 1/Lumi
  - Yield (N) effectively = cross section within $-1 < \eta_e < 1$.
- About $\sim 10\%$ shift in yield without much change in shape (both True and Rec ET at both generation and selection) between nominal and min-pT=1GeV sample.

Subprocesses (Efficiency)

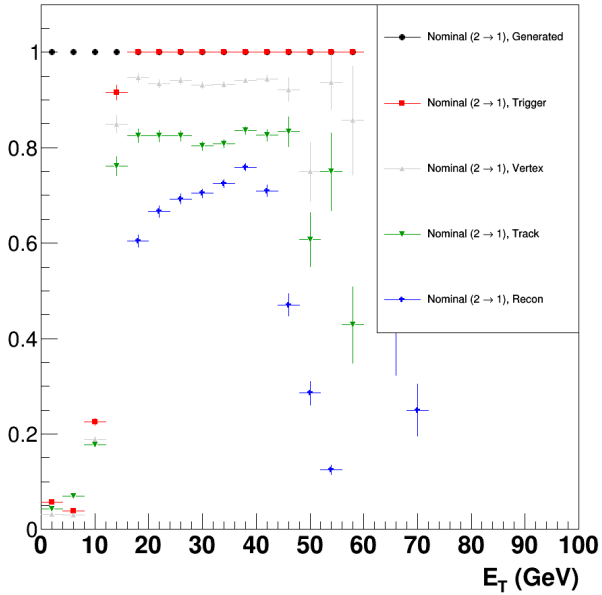
True E_T with Nominal



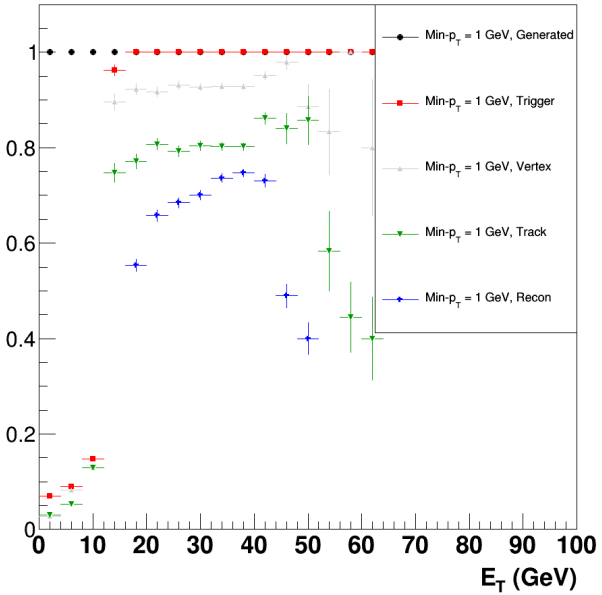
True E_T with min-pT = 1GeV



Rec E_T with Nominal



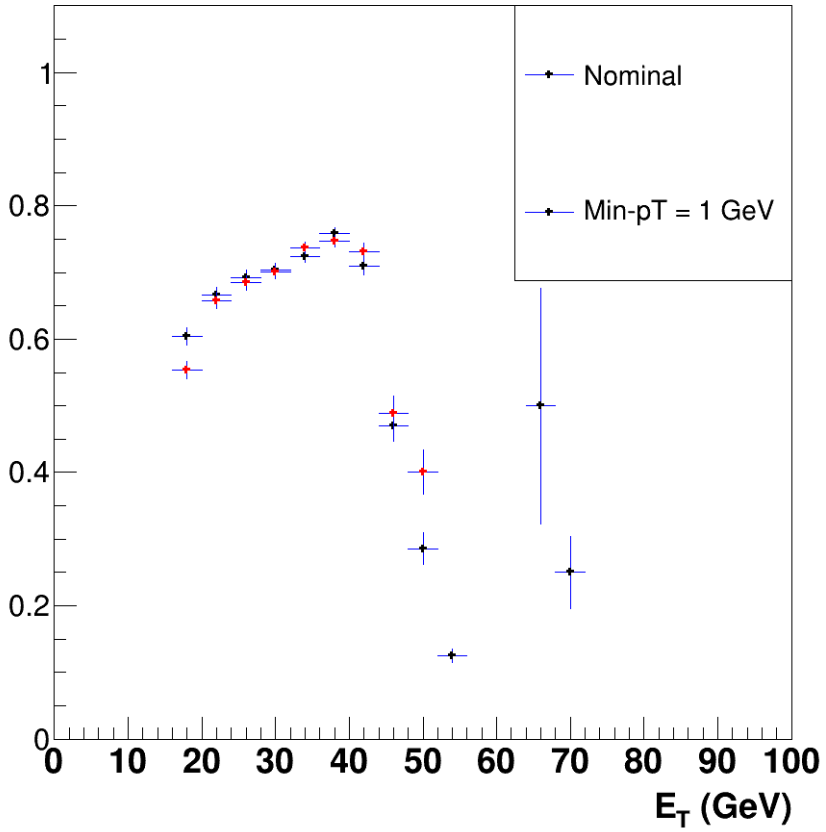
Rec E_T with min-pT = 1GeV



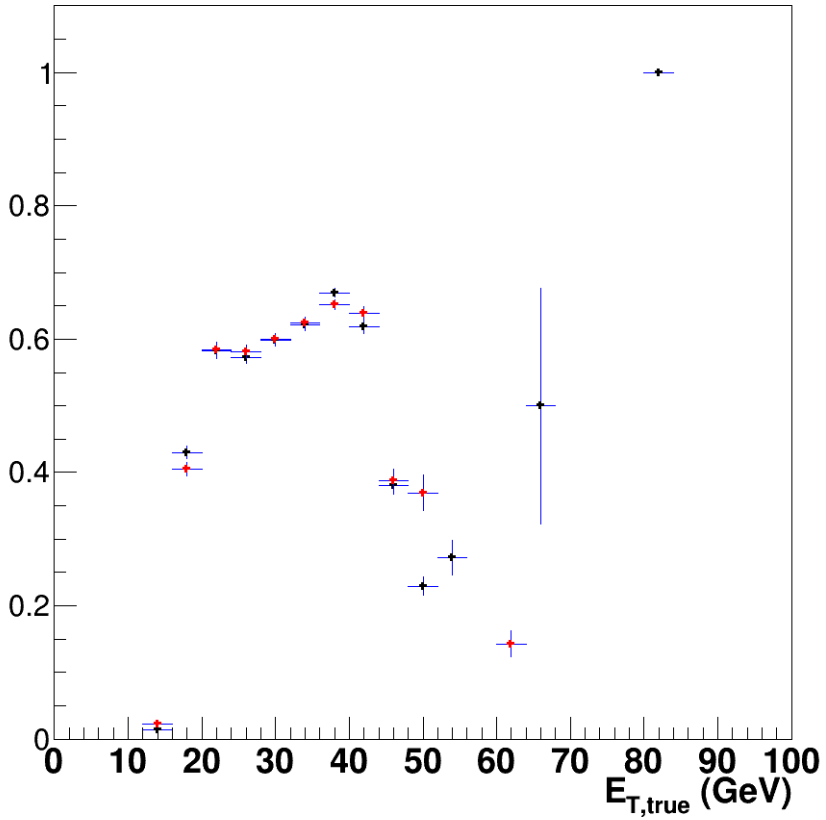
- Comparing Nominal $(2 \rightarrow 1)$ with $(2 \rightarrow 2)$ with parton min-$p_T = 1$ GeV.
- No significant change in efficiency (in terms of both size and shape) between the nominal and min-pT=1GeV sample (for both True-/Rec-ET).

Subprocesses (Efficiency)

Efficiency (Rec E_T)



Efficiency (True E_T)



→ Simulating (mostly) initial gluon radiation does not change the shape of E_T distribution both at the generation & selection, only shifts yield by ~10% (with parton-minpT = 1GeV).

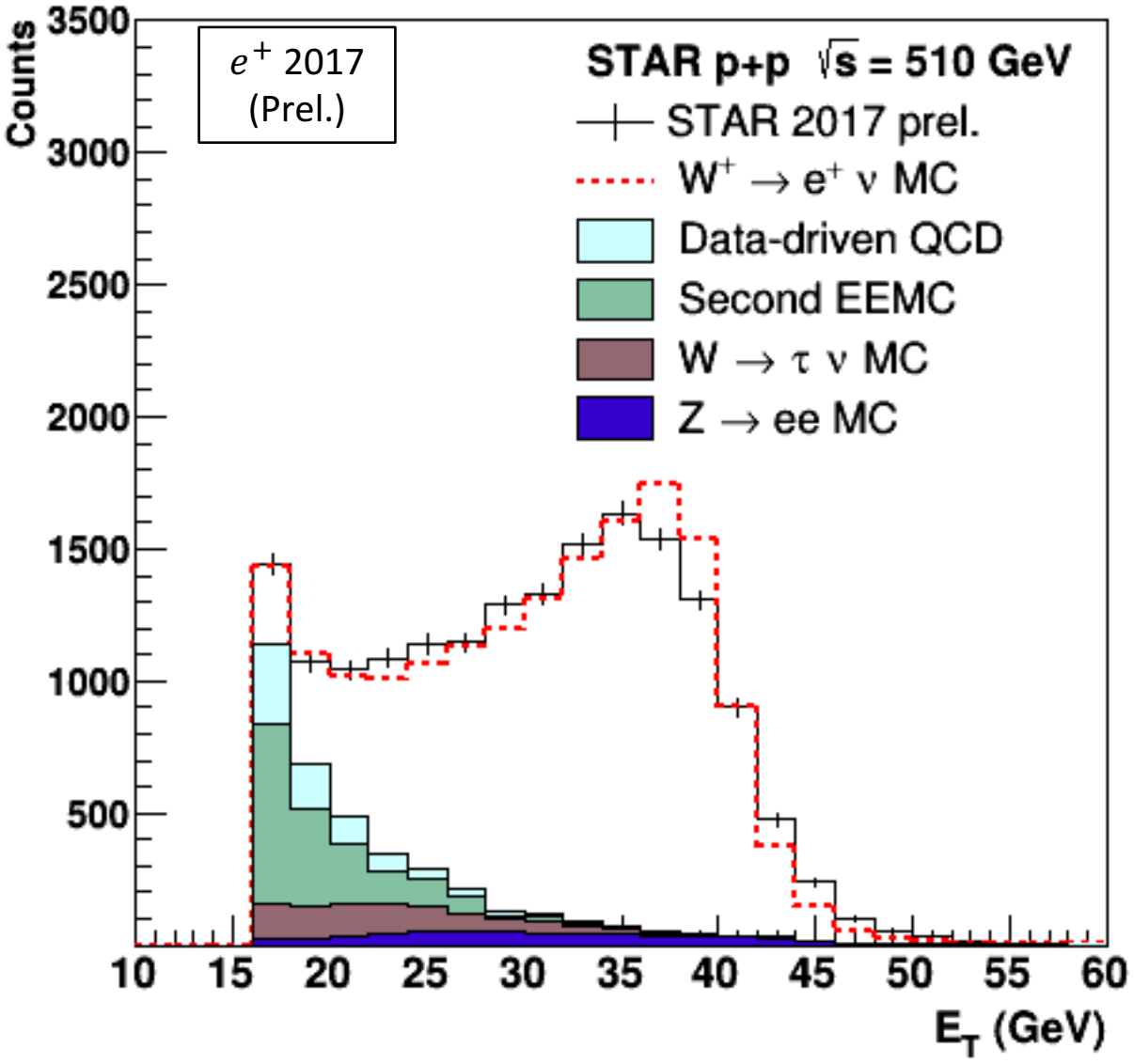
→ Will test samples with lower minpT settings.

Conclusion

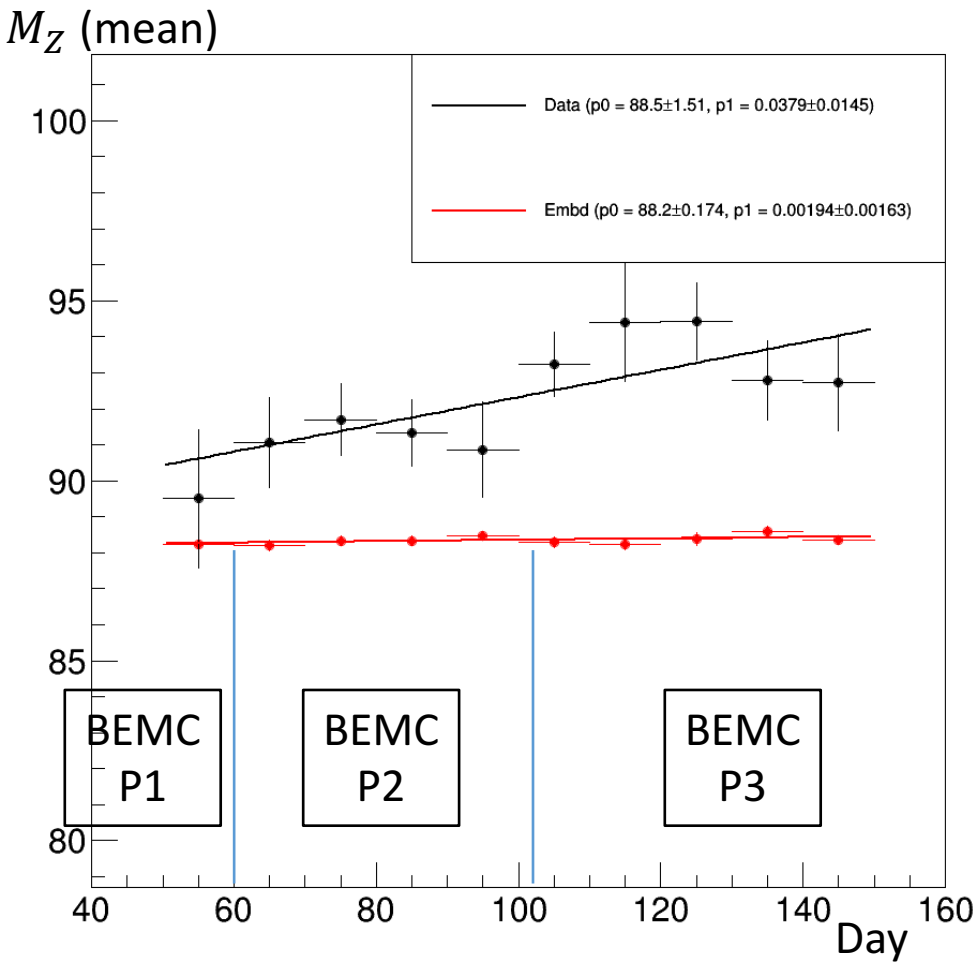
- FEWZ calculation with 0-jet suppression effectively calculates LO cross section.
- Higher order correction produces ~35% increase in cross section.
- Run 17 analysis (most likely Run11-13 as well) embedding samples only simulate LO + no parton shower $2 \rightarrow 1$ process.
- Simulating $2 \rightarrow 2$ process with parton min-pT at 1 GeV increase the cross section by ~10%.
  - Possibly higher with lower min-pT.
- This will also increase the signal yield in MC (not so much the shape) by ~10%

  $\rightarrow$ Possible mismatch between data and embedding at selection.

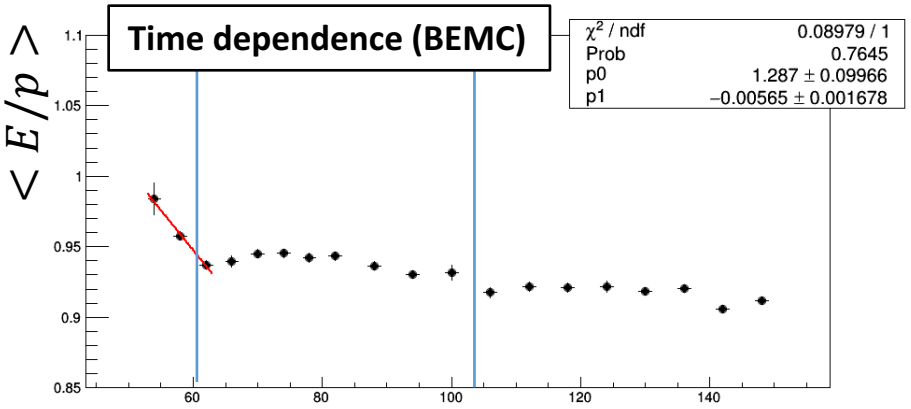
- Plans
  - Parton-pT/jet spectrum
  - Additional sample with access to lower parton pT


e^+ 2017
(Prel.)
STAR p+p $\sqrt{s}$ = 510 GeV
STAR 2017 prel.
$W^+ \rightarrow e^+ \nu$ MC
Data-driven QCD
Second EEMC
$W \rightarrow \tau \nu$ MC
$Z \rightarrow ee$ MC
Counts
3500
3000
2500
2000
1500
1000
500
10
15
20
25
30
35
40
45
50
55
60
E_T (GeV)

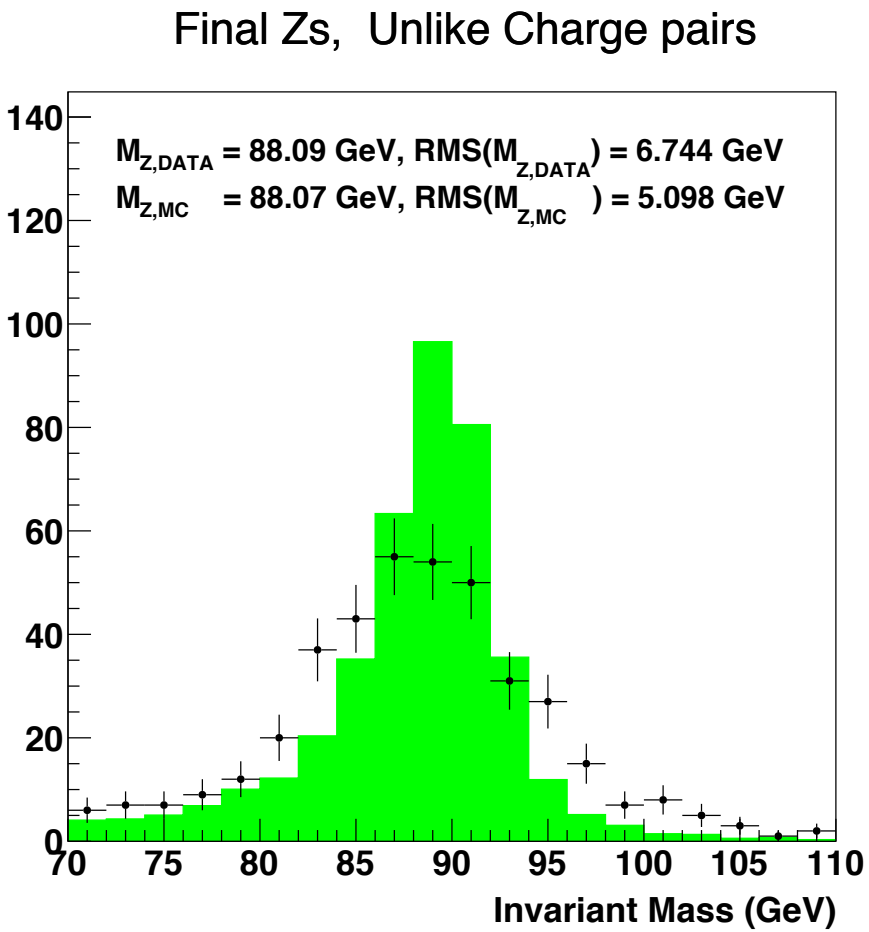
Overview (Time Dependence in M_Z)



- Each data point (left) 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 overcompensated for the time dependence.



Time-dependent BEMC gain correction



- BEMC gain reverse-corrected for time dependence.
  - CorFactor (P1) = 1.67%
  - CorFactor (P2) = 3.12%
  - CorFactor (P3) = 6.23%
- Good matching mean-M_Z
- Wider M_Z distribution in data due to:
  - Imperfect description of detector
  - Imperfect estimation of the uncertainty associated with the **relative** gain calibration.
  - k_T effects
  - DY contribution