Measurement of the Cross Section for W Boson Production at $\sqrt{s}$ = 500 GeV at STAR

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for the STAR Collaboration

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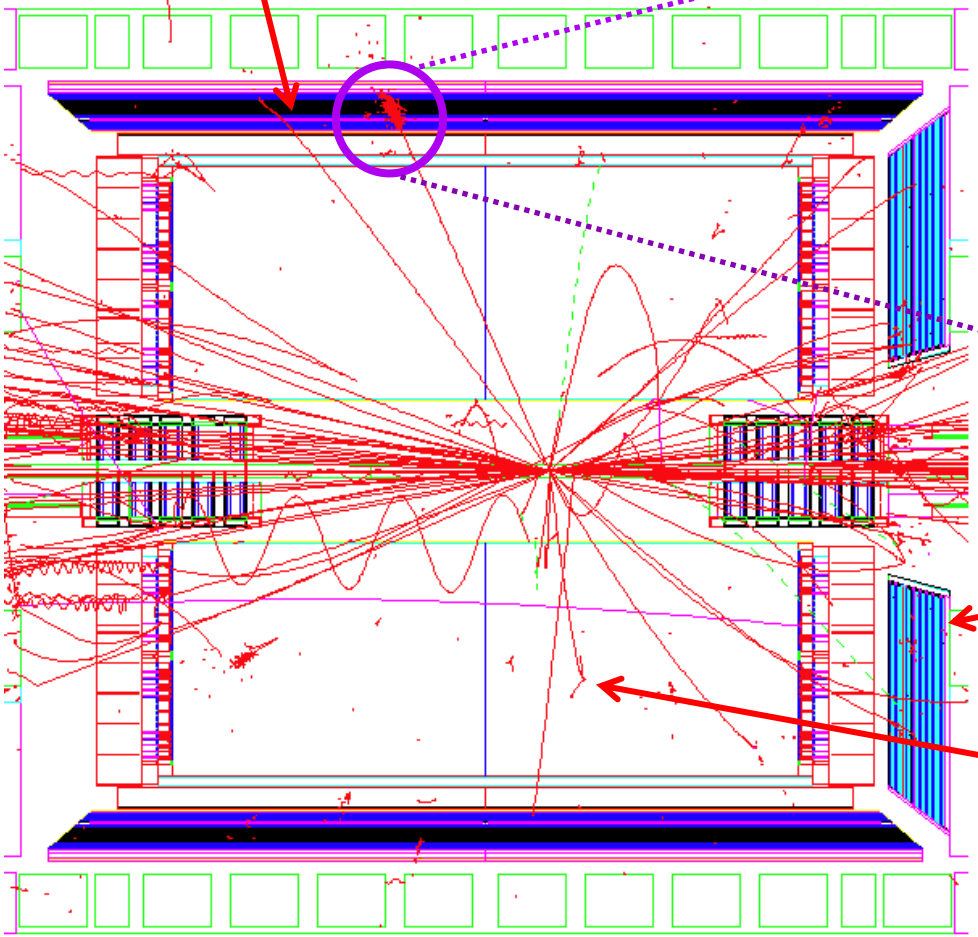
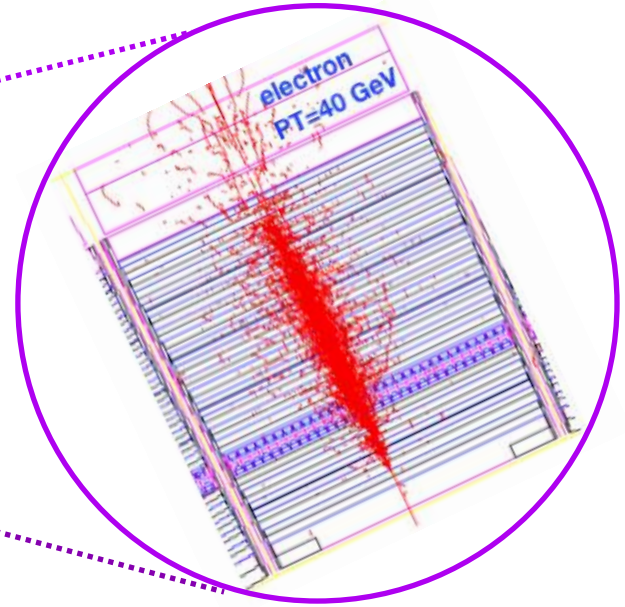
STAR Detector

Barrel EM Calorimeter:
Lepton Energy
Veto jets





Endcap EM Calorimeter:
Veto jets

Time Projection Chamber (TPC):
Vertex
Charge Separation
Veto jets

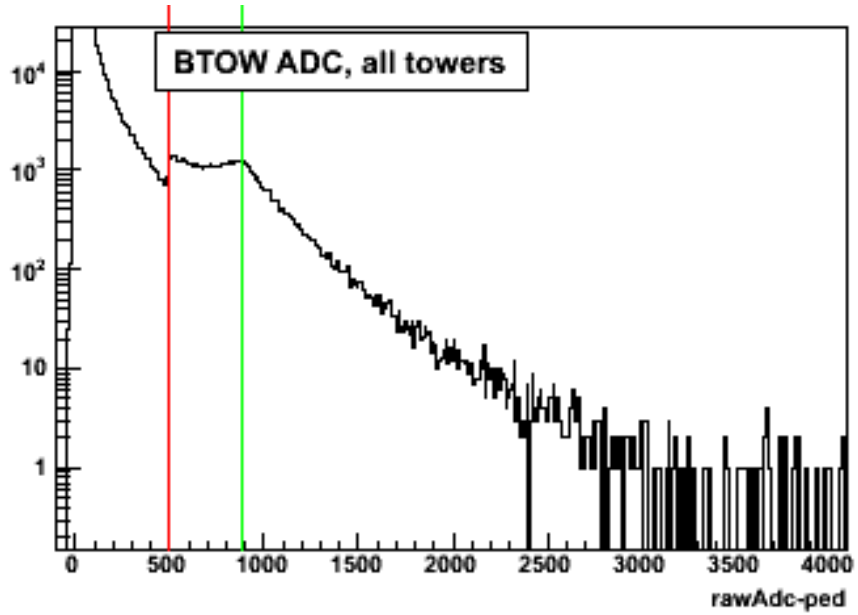
Pythia+Geant p+p→W→e+ν event @ 500 GeV

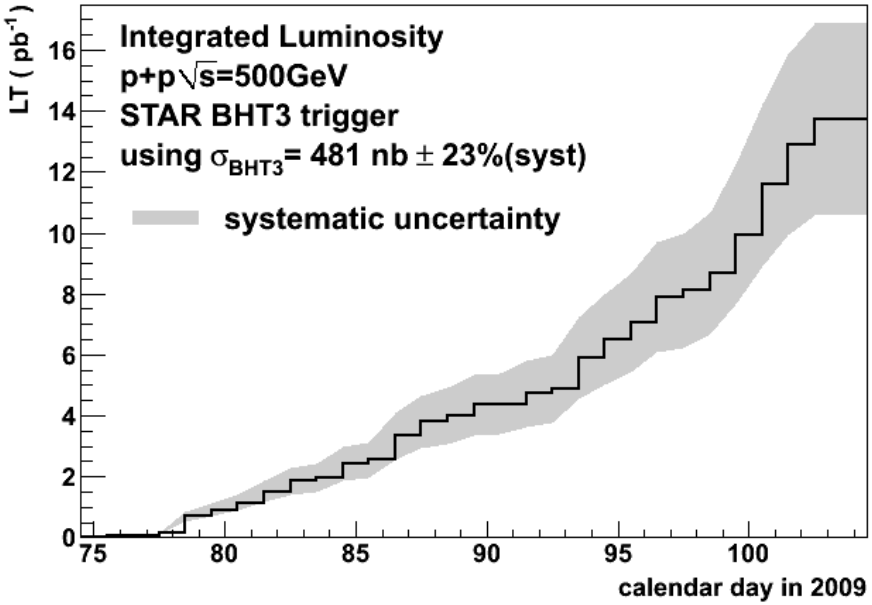
500 GeV Data Set from Run 9

W Trigger:

High Tower Hardware L0 Trigger (E_T > 7.3 GeV)

High E_T 2x2 Cluster Software L2 (E_T > 13 GeV)





Integrated Luminosity @ 500 GeV:

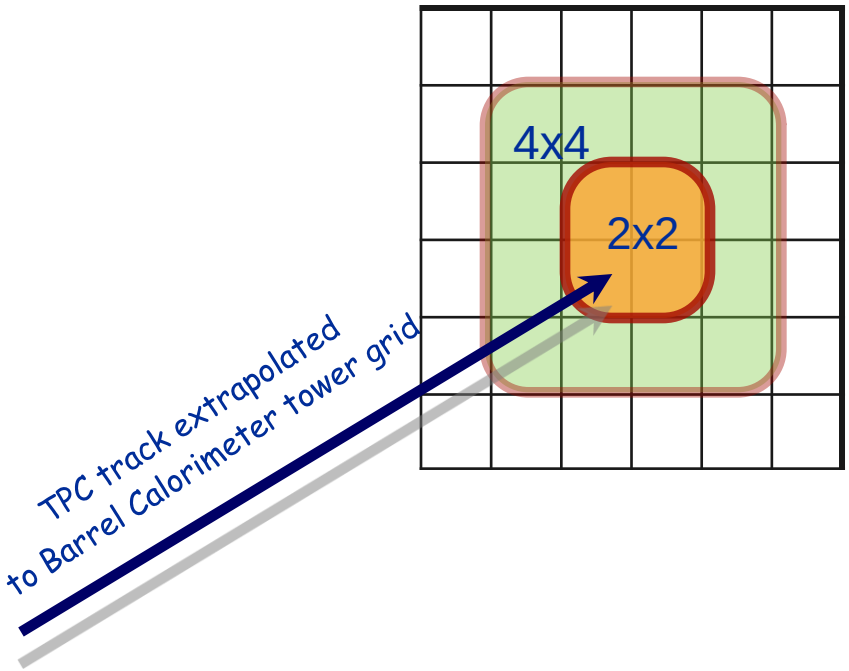
•**Vernier Scan** technique used to measure cross section for high tower trigger

$$\sigma_{BHT3} = 481\,\text{nb} \pm 10\,(\text{stat.}) \pm 110\,(\text{syst.})$$

•Scaling the number of background-subtracted high tower triggers by $1/\sigma_{BHT3}$ yields the integrated luminosity of **L=13.7 pb^{-1}**

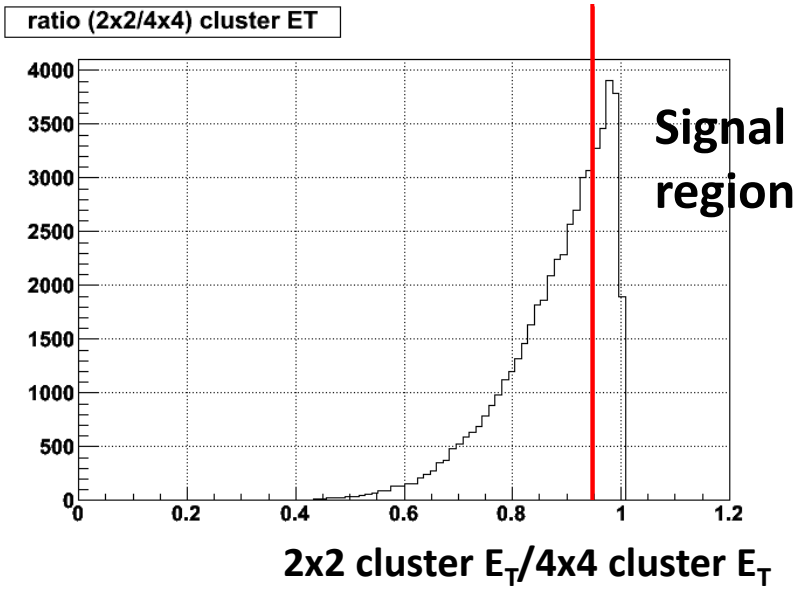
(See talk by Ross Corliss: Session D7)

W Algorithm: Lepton Isolation

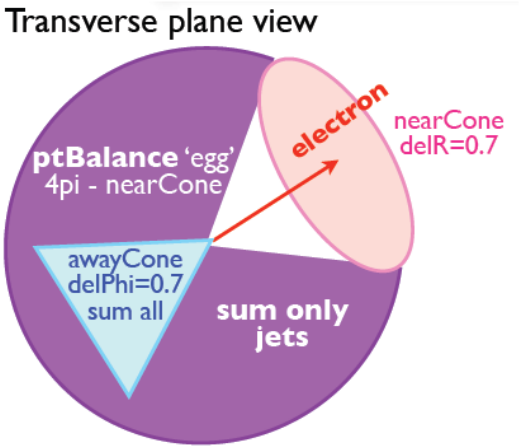


Lepton Isolation Cuts:

- Require TPC track with p_T > 10 GeV
- Extrapolate track to Barrel Calorimeter
- Require highest 2x2 cluster around pointed tower sum E_T > 15 GeV
- Require excess E_T in 4x4 cluster < 5%
- Match track to 2x2 cluster position



W Algorithm: Suppress QCD Background

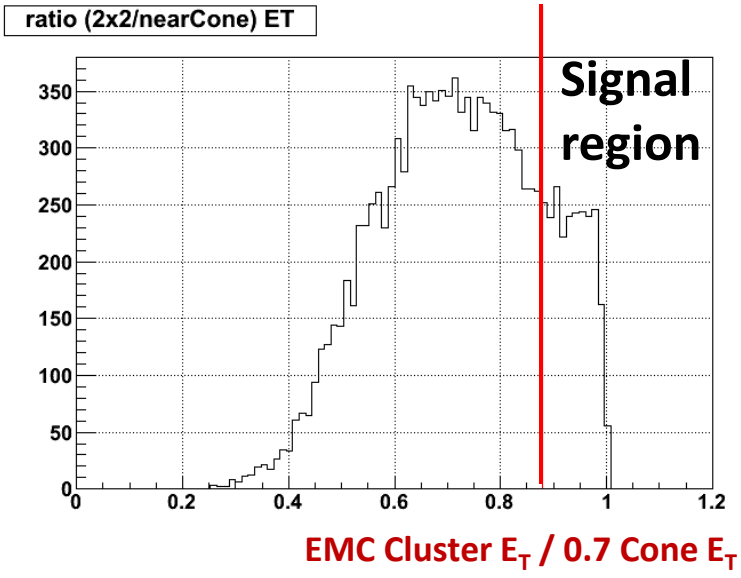


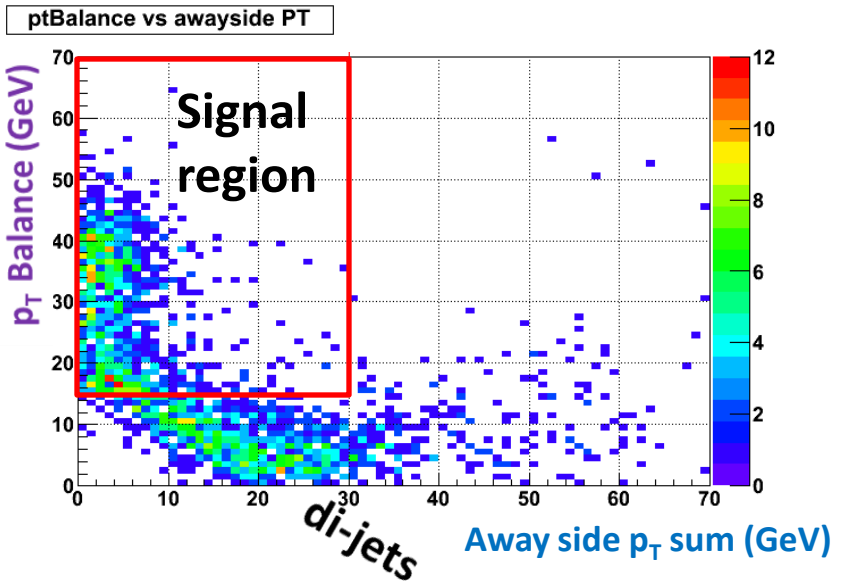
Suppress jets with leading hadron

- Near side jet-cone veto

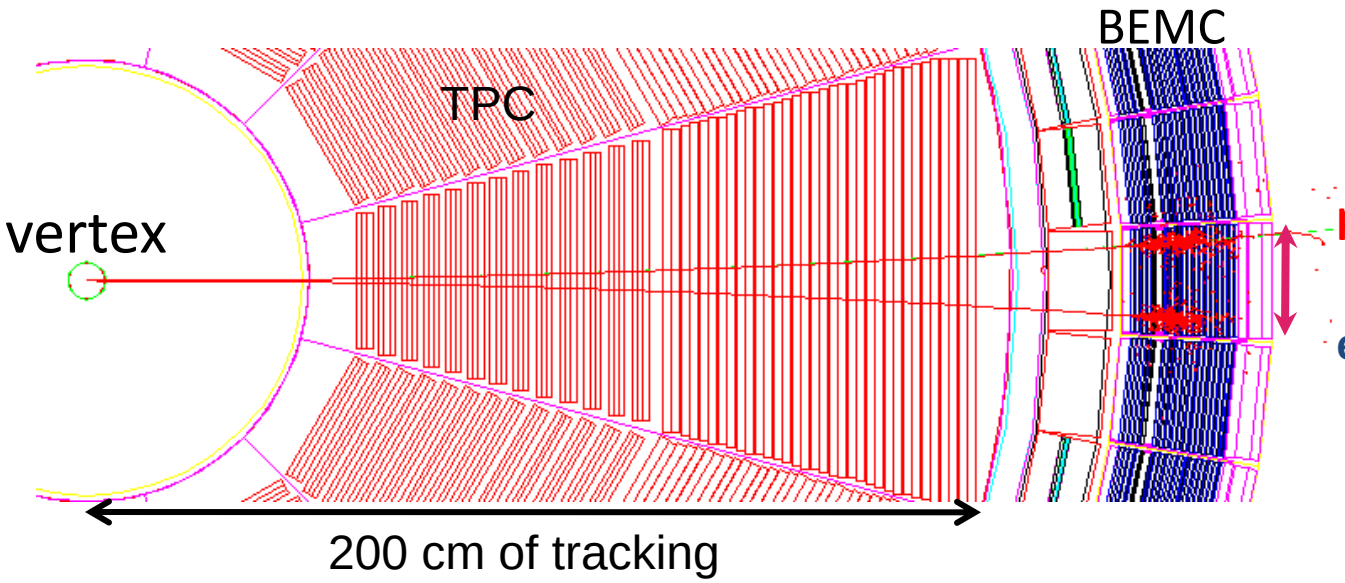
Suppress di-jets and multi-jet events

- Away side p_T sum veto
- Require an imbalance in p_T of the lepton cluster and any jets reconstructed outside the near side jet cone





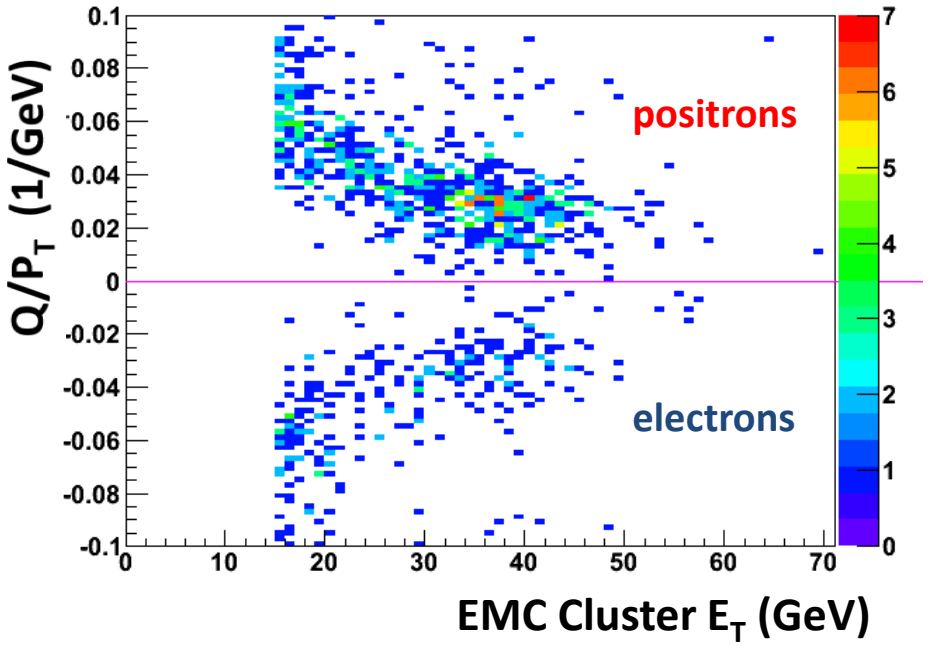
e^+/e^- Charge Separation at High P_T



+/- distance D ~ $1/P_T$

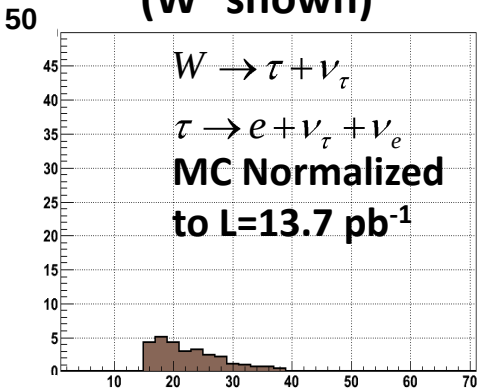
P_T=5 GeV : D~15 cm

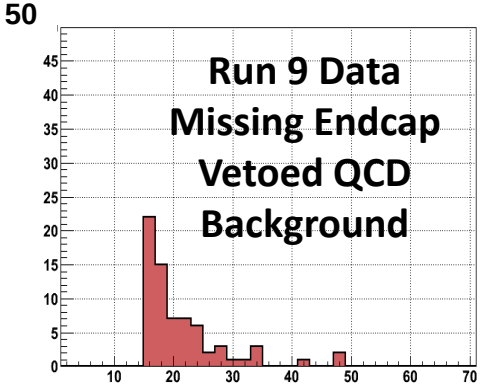
P_T=40 GeV : D ~2 cm

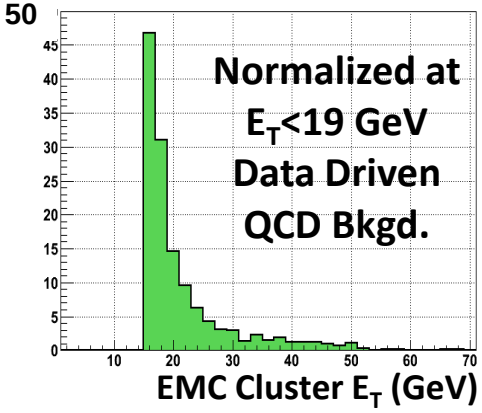


Background Subtraction

(W⁺ shown)

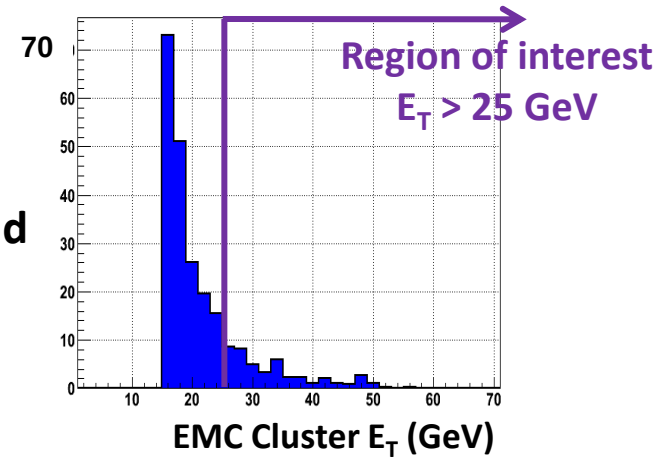


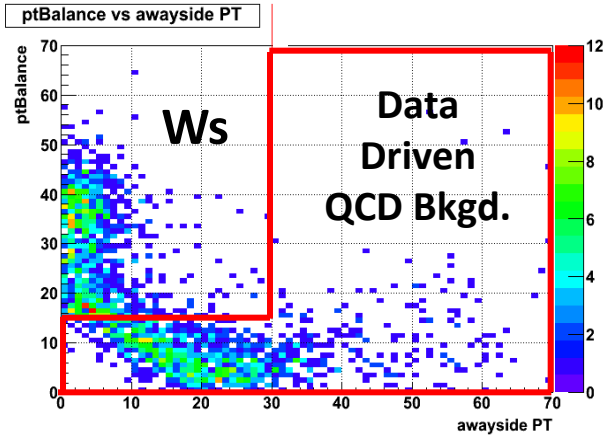




Background Events ($E_T > 25$ GeV)	$W^- \rightarrow e^- + \bar{\nu}_e$	$W^+ \rightarrow e^+ + \nu_e$
$W \rightarrow \tau + \nu_\tau$	2.7 ± 0.7	8.4 ± 2.2
Missing Endcap	14 ± 4	13 ± 4
Normalized QCD	$8.0\ ^{+20}_{-4}$	$25\ ^{+36}_{-9}$
Total	$25\ ^{+21}_{-7}$	$46\ ^{+36}_{-11}$

Total Background

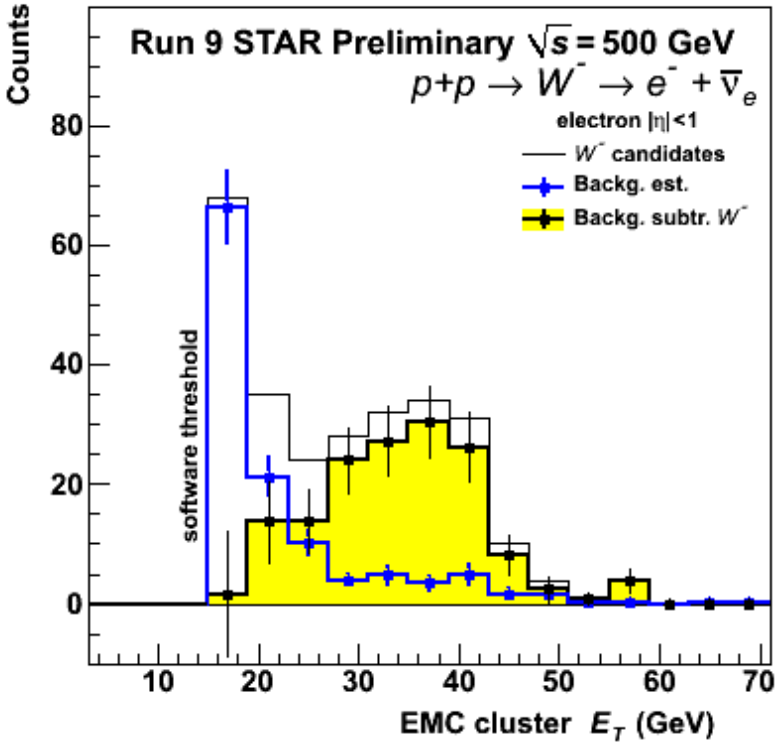


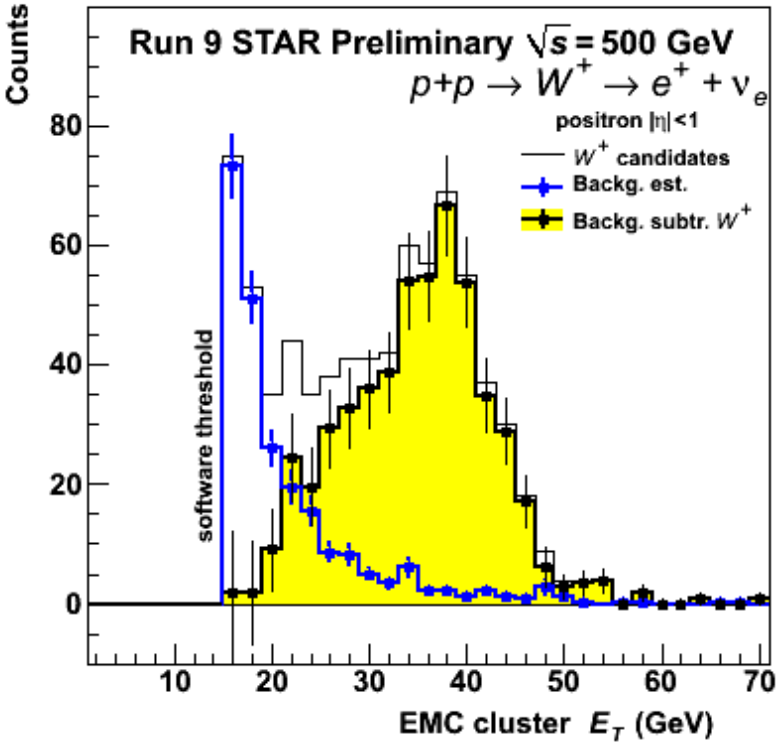


Background Systematic

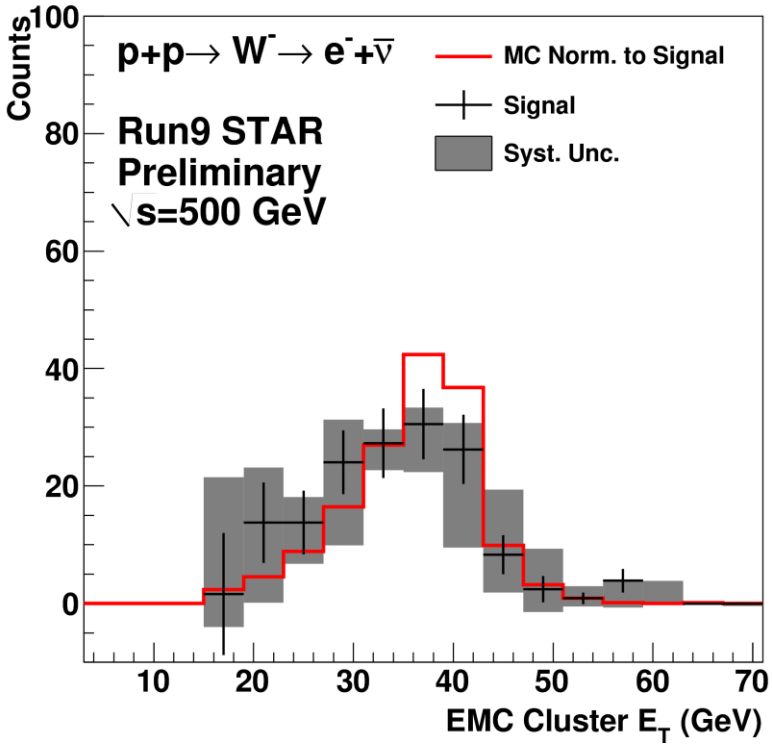
- Calculate different data driven QCD background shapes by varying p_T Balance and away side p_T cuts
- Vary normalization region (E_T < 17 and E_T < 21 GeV)
- The largest deviation in each bin gives an estimate of the systematic uncertainty

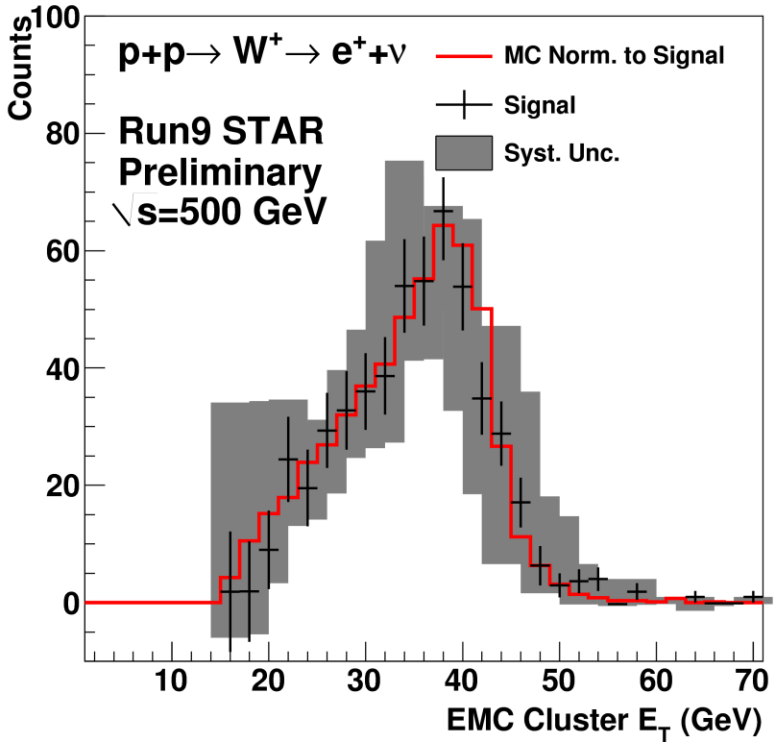
STAR Ws from Run 9





Data/MC Shape Comparison





Monte-Carlo is full PYTHIA+GEANT simulation of W→e+v events at 500 GeV

Cross Section

$$\sigma_W = \int dE_T^e \int d\eta^e \frac{d^2\sigma_{W\to ev}}{d\eta^e dE_T^e} = \frac{1}{L}\frac{1}{\varepsilon_{trig}}\frac{1}{\varepsilon_{vertex}}\frac{1}{\varepsilon_{reco}}\left(N_W^{obs} - N_{back}\right)$$

Kinematic acceptance : $|\eta_e| < 1$ and $E_T^e > 25\,\text{GeV}$

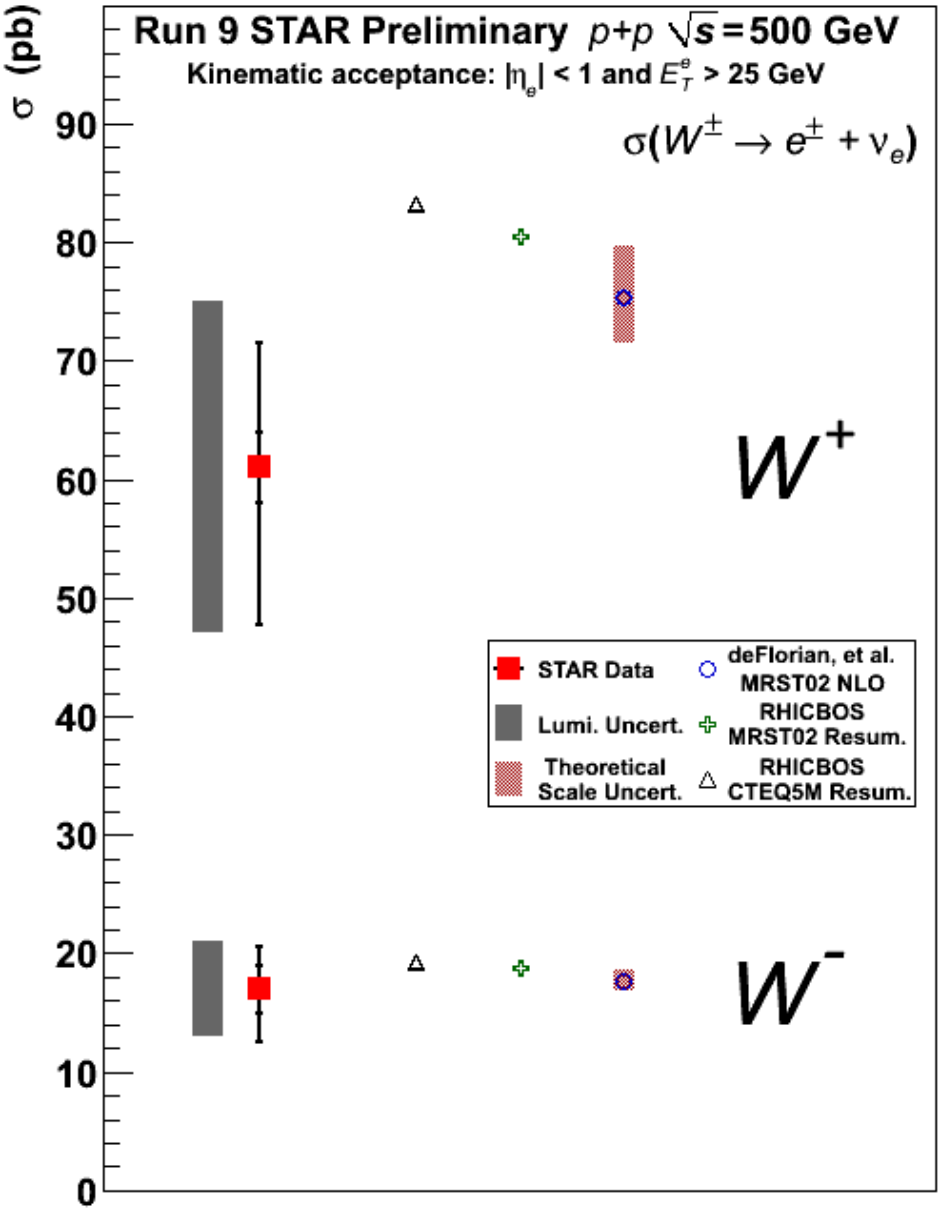
Efficiencies Calculated from full PYTHIA + GEANT simulations

Efficiency Component	$W^- \to e^- + \bar{\nu}_e$	$W^+ \to e^+ + \nu_e$
Trigger: ϵ_{trig}	0.86 ± 0.04	0.88 ± 0.04
Vertex: ϵ_{vertex}	0.91 ± 0.03	0.91 ± 0.03
Reconstruction: ϵ_{reco}	$0.72\ ^{+0.13}_{-0.11}$	$0.71\ ^{+0.14}_{-0.11}$
Total: ϵ_{total}	$0.56\ ^{+0.11}_{-0.09}$	$0.56\ ^{+0.12}_{-0.09}$

Cross Section Uncertainties

- W Reconstruction Systematic
  - Track Reconstruction: 15-20%
  - Vertex Reconstruction: 4%
  - Energy Scale: < 1%
- Normalization/Luminosity Systematic
  - Vernier scan absolute cross section: 23%
- Background Systematic
  - Vary data driven QCD background shape and normalization region

W Production Cross Section at STAR



	$W^- \to e^- + \bar{\nu}_e$	$W^+ \to e^+ + \nu_e$
N_W^{obs}	156	513
N_{back}	$25\ ^{+21}_{-7}$	$46\ ^{+36}_{-11}$
ϵ_{total}	$0.56\ ^{+0.11}_{-0.09}$	$0.56\ ^{+0.12}_{-0.09}$
$\int Ldt\ (\mathrm{pb}^{-1})$	13.7 ± 3.2	13.7 ± 3.2

Run 9 STAR Preliminary (p+p 500 GeV)

$$\sigma_{W^+ \to e^+ + \nu} = 61 \pm 3\,(\mathrm{stat.})\ ^{+10}_{-13}\,(\mathrm{syst.}) \pm 14\,(\mathrm{lumi.})\ \ \mathrm{pb}$$

$$\sigma_{W^- \to e^- + \bar{\nu}} = 17 \pm 2\,(\mathrm{stat.})\ ^{+3}_{-4}\,(\mathrm{syst.}) \pm 4\,(\mathrm{lumi.})\ \ \mathrm{pb}$$

There is reasonable agreement between the measured and expected cross sections.

Conclusions

- STAR has measured the production cross section for $W \rightarrow e+\nu$ in p+p collisions at $\sqrt{s}$ = 500 GeV
- Charge separation provided by the TPC demonstrated for lepton E_T up to 50 GeV
- Large QCD background reduced to 9% and 16% of the W^+ and W^- signal, respectively at $E_T^e > 25$ GeV
- The theoretically expected and experimentally measured cross sections are in agreement to within uncertainties