The STAR W Physics Program : New Results and Future Measurements

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Collaboration

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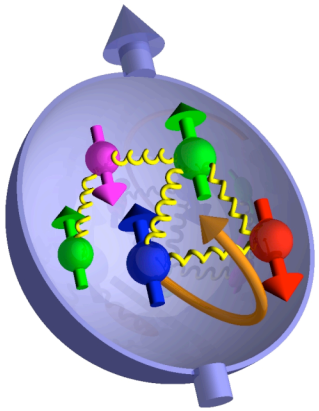
2010

The Spin Puzzle



The proton is viewed as being a "bag" of bound quarks and gluons interacting via QCD

Spins + orbital angular momentum need to give the observed spin 1/2 of proton

Being measured at RHIC

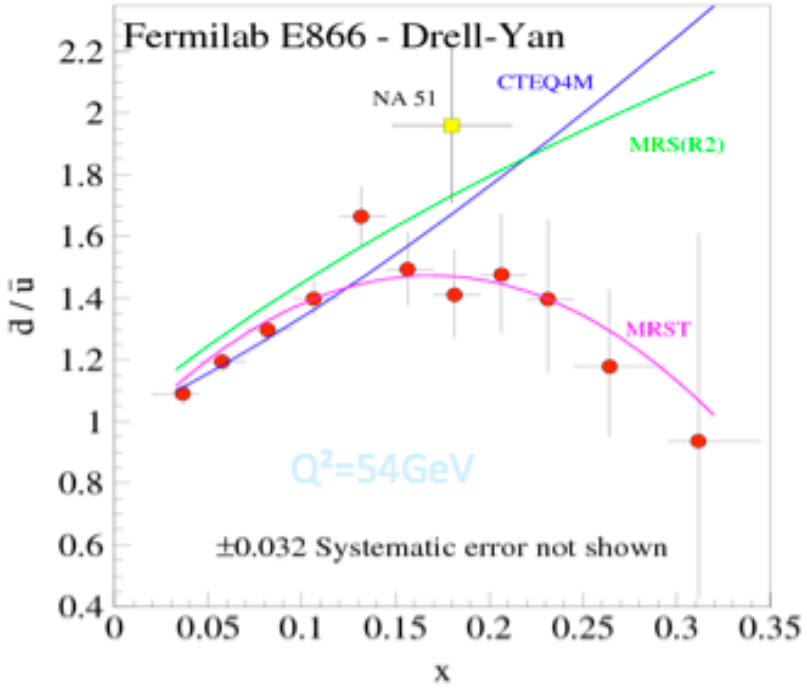
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q^z + \Delta G + L_g^z$$

Fairly well measured only ~30% of spin

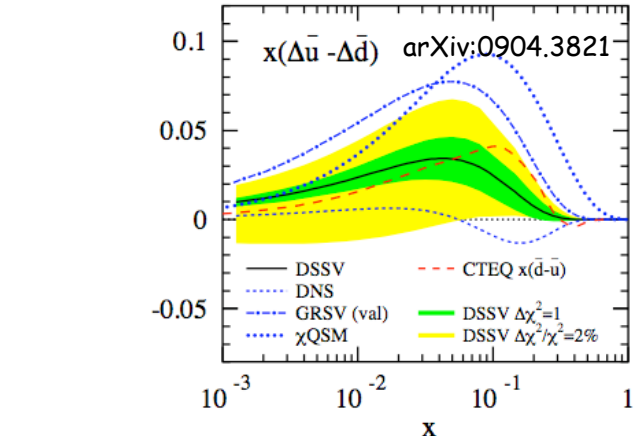
Its decomposition is not well understood, especially the sea… needs data

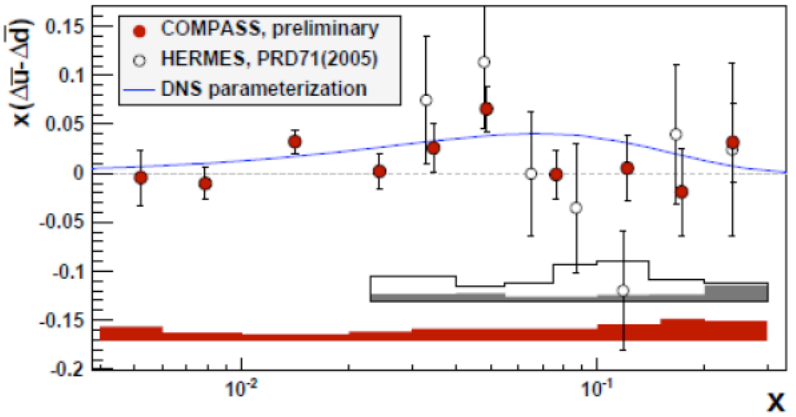
$$\Delta\Sigma = \int (\Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s} + \cdots)dx$$

Flavor Asymmetry in the Sea



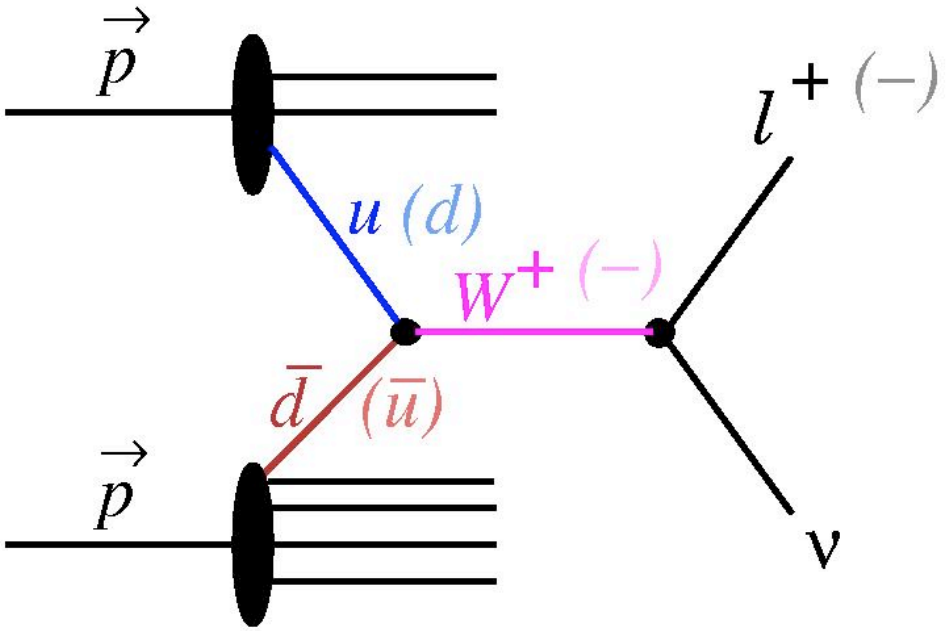
• E866 results are qualitatively consistent with pion cloud models, instanton models, chiral quark soliton models, etc.





• Pauli blocking should contribute to the observed signal, but how much is currently debated
• Non-perturbative processes may be needed in generating the sea

Probing the Sea through Ws



$$u + \bar{d} \rightarrow W^+ \rightarrow e^+ + \nu$$

$$\bar{u} + d \rightarrow W^- \rightarrow e^- + \bar{\nu}$$

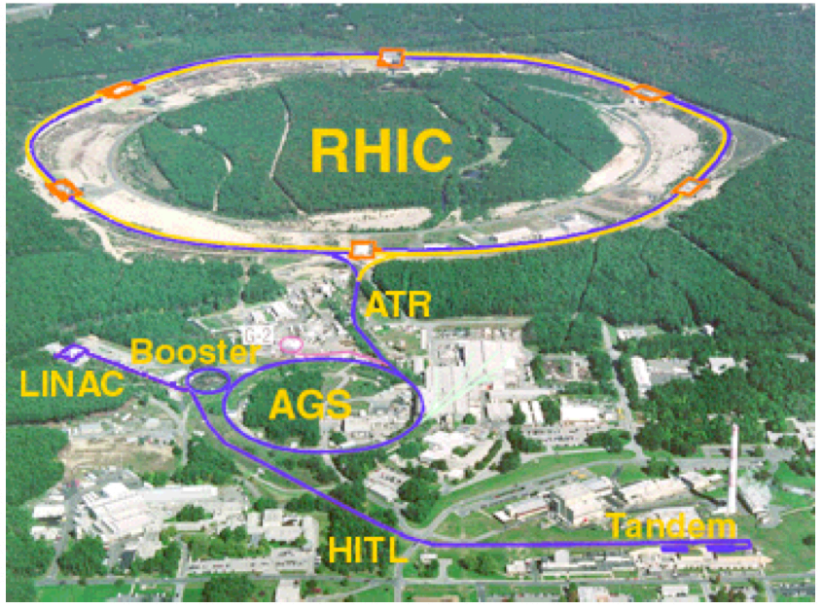
- Detect Ws through e^+ and e^- decay channels
- V-A coupling leads to perfect spin separation
- Neutrino helicity gives preferred direction in decay

Measure parity violating single helicity asymmetry A_L

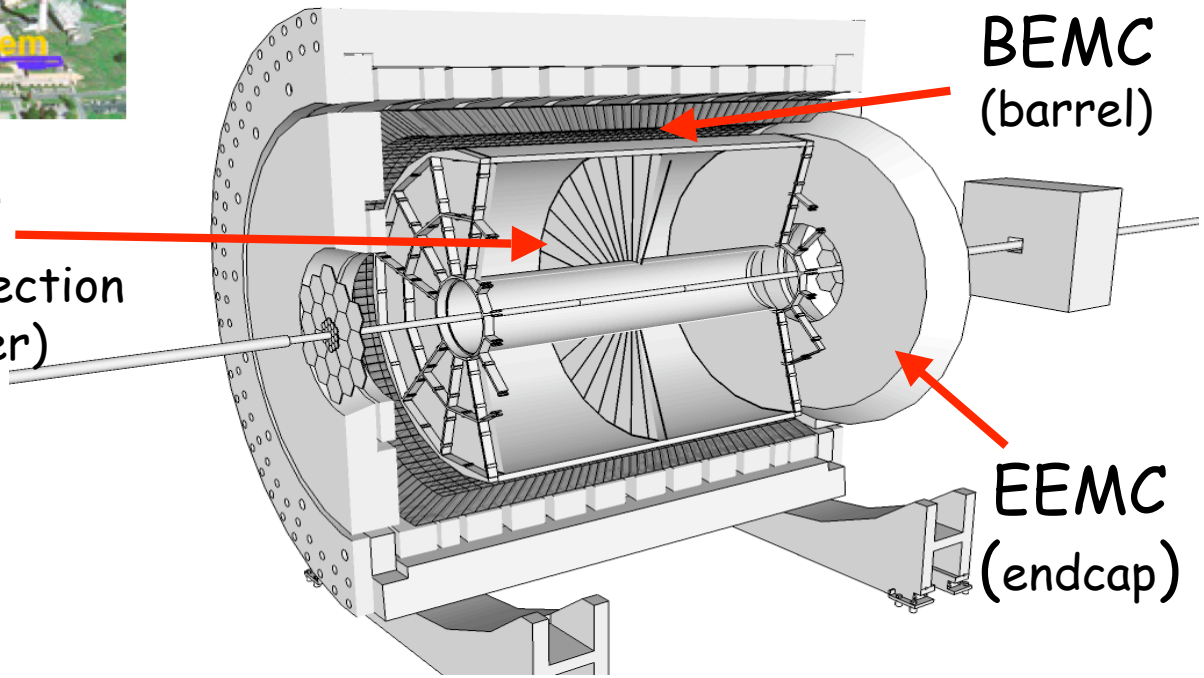
(Helicity flip in one beam while averaging over the other)

$$A_L^{W^-} \propto -\Delta d(x_1)\bar{u}(x_2) + \Delta\bar{u}(x_1)d(x_2) \qquad A_L^{W^+} \propto -\Delta u(x_1)\bar{d}(x_2) + \Delta\bar{d}(x_1)u(x_2)$$

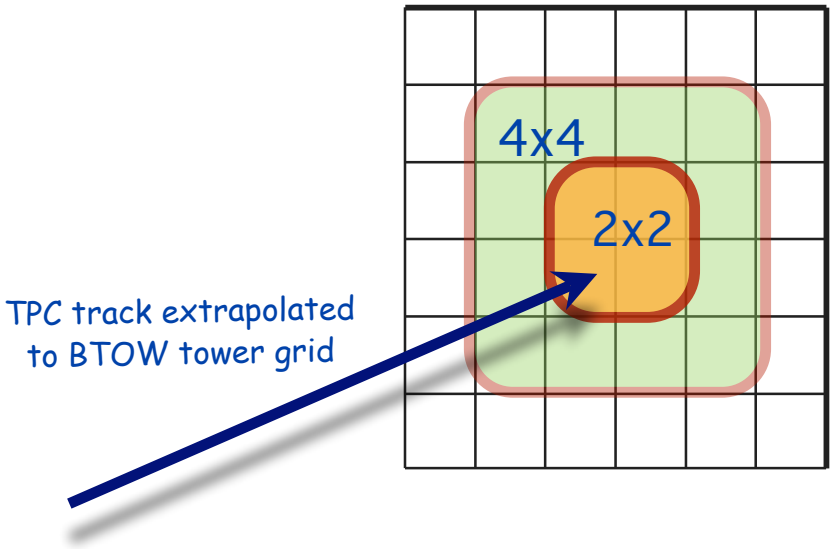
RHIC and STAR



A polarized proton-proton collider to study spin in QCD

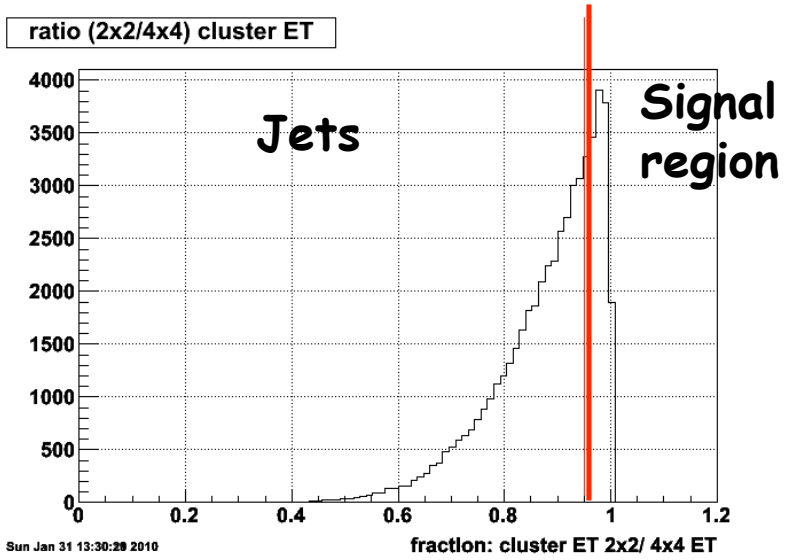


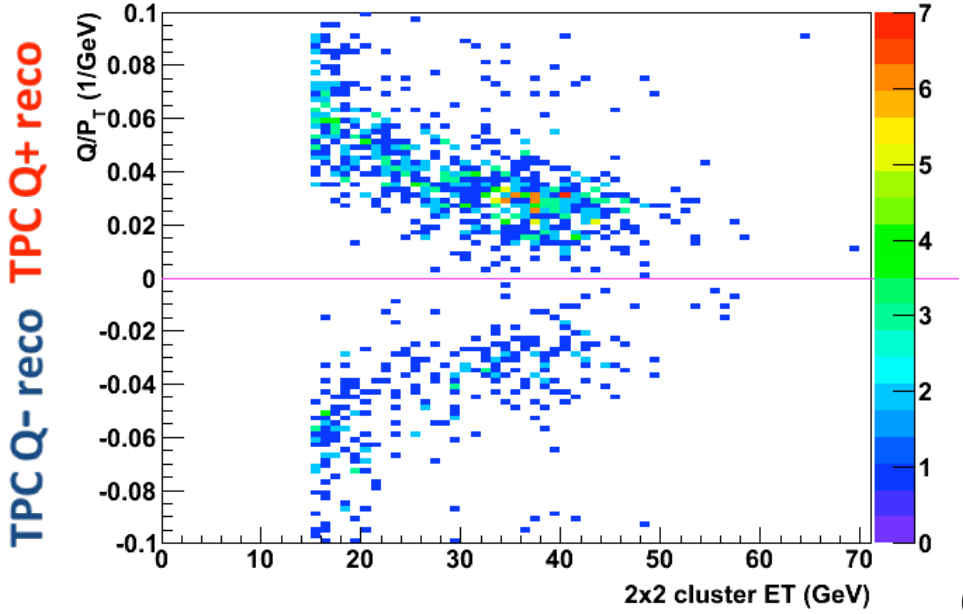
W Algo: Lepton Isolation



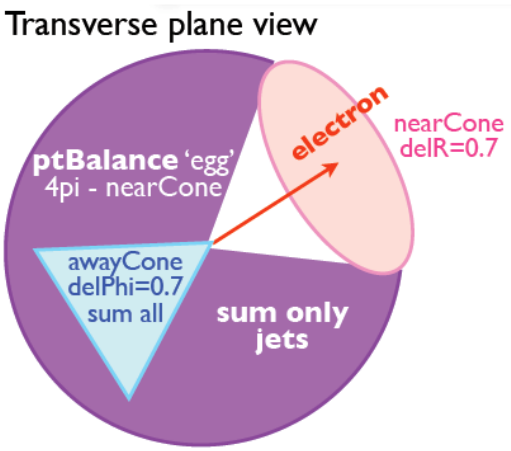
Lepton Isolation Cuts:

- 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
- Get charge sign of lepton



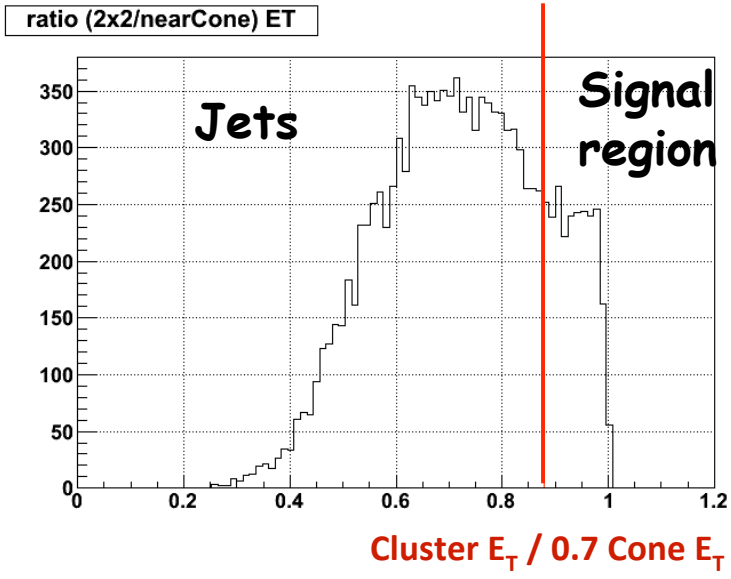


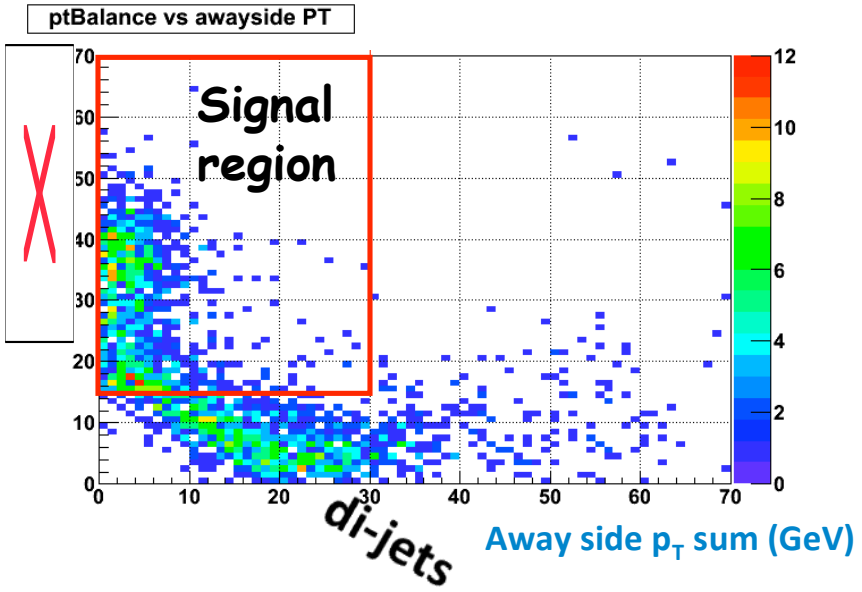
W Algo: Suppress QCD Background



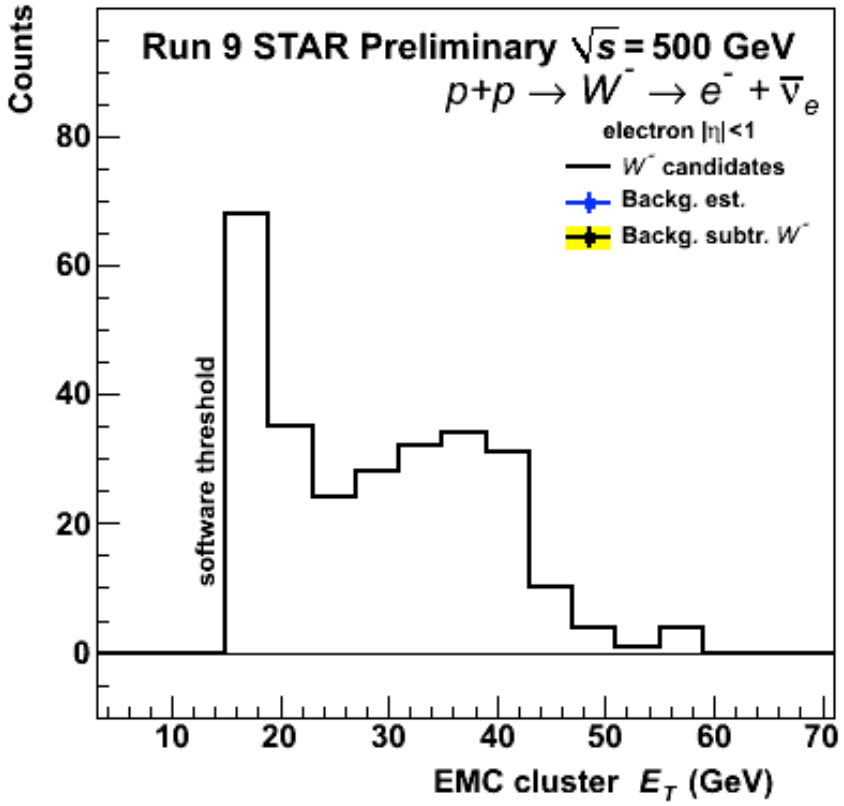
Suppress jets with leading hadron
- Near side jet-cone veto

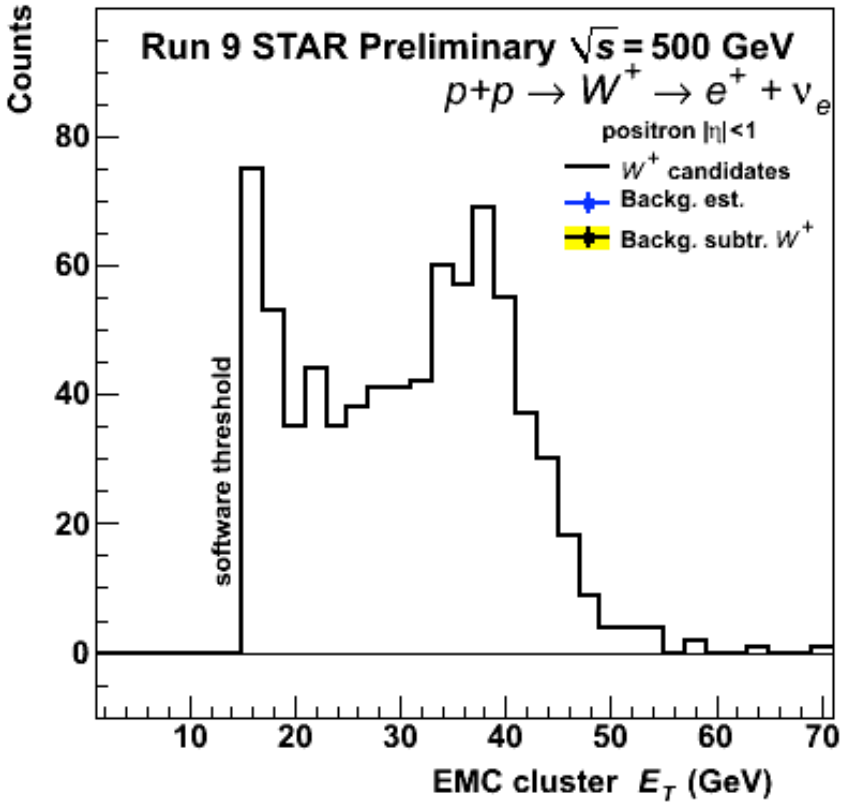
Suppress di-jets and multi-jet events
- Away side p_T sum veto
- Require an imbalance in p_T of the lepton cluster and any jets reconstructed outside the near side jet cone





The Raw Signal

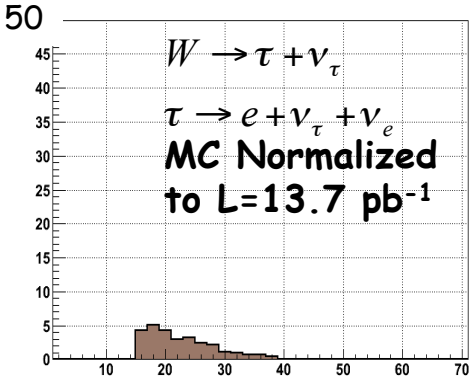




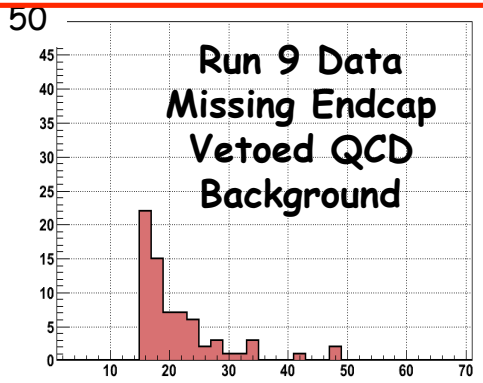
STAR recorded 13.7pb^{-1} in the run9 500 GeV running period

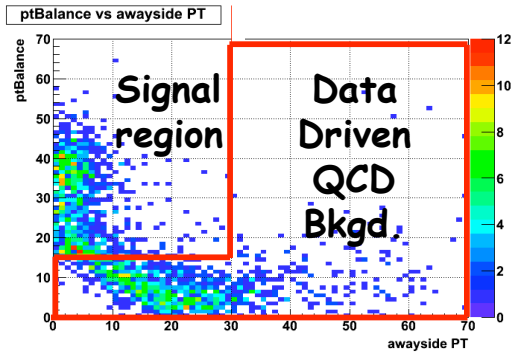
Extracting the W Signal

PYTHIA+GEANT MC →

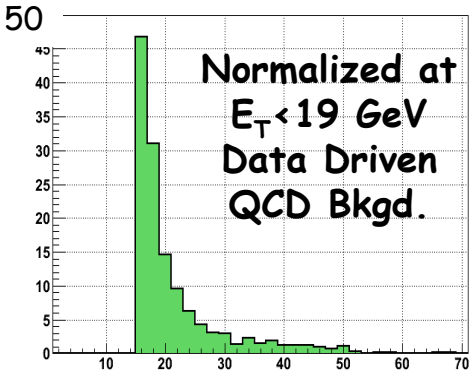


1. Run analysis with EEMC in veto cuts
2. Run analysis without EEMC in veto cuts
3. Subtract two raw signals

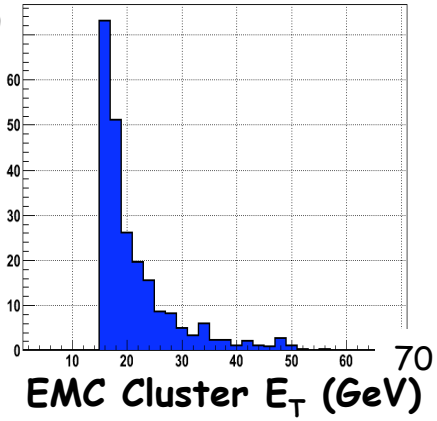




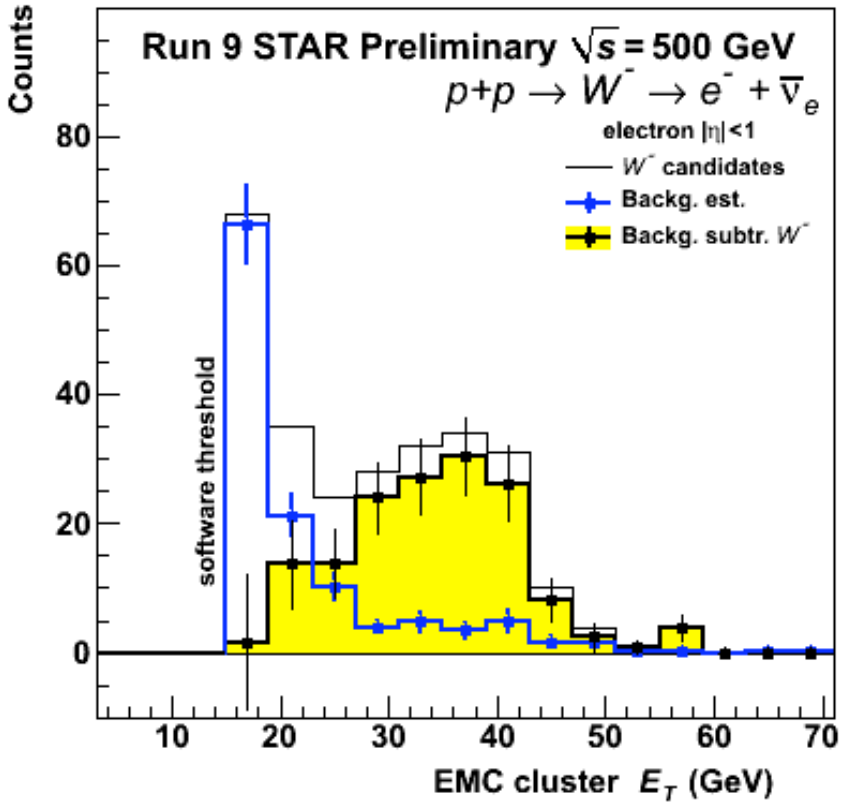
→

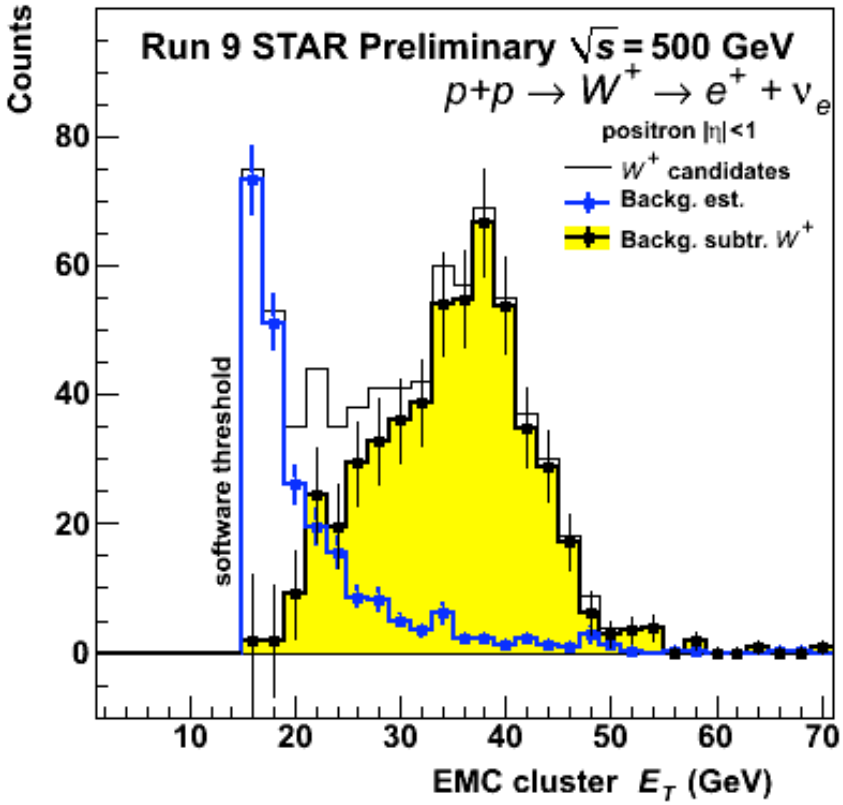


Total Background

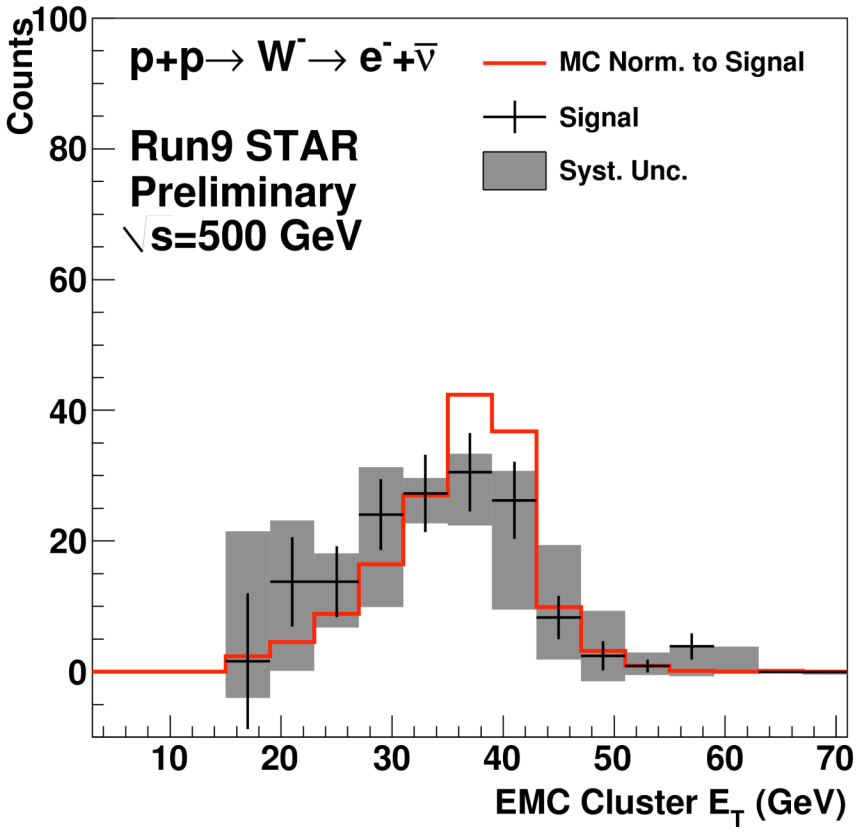


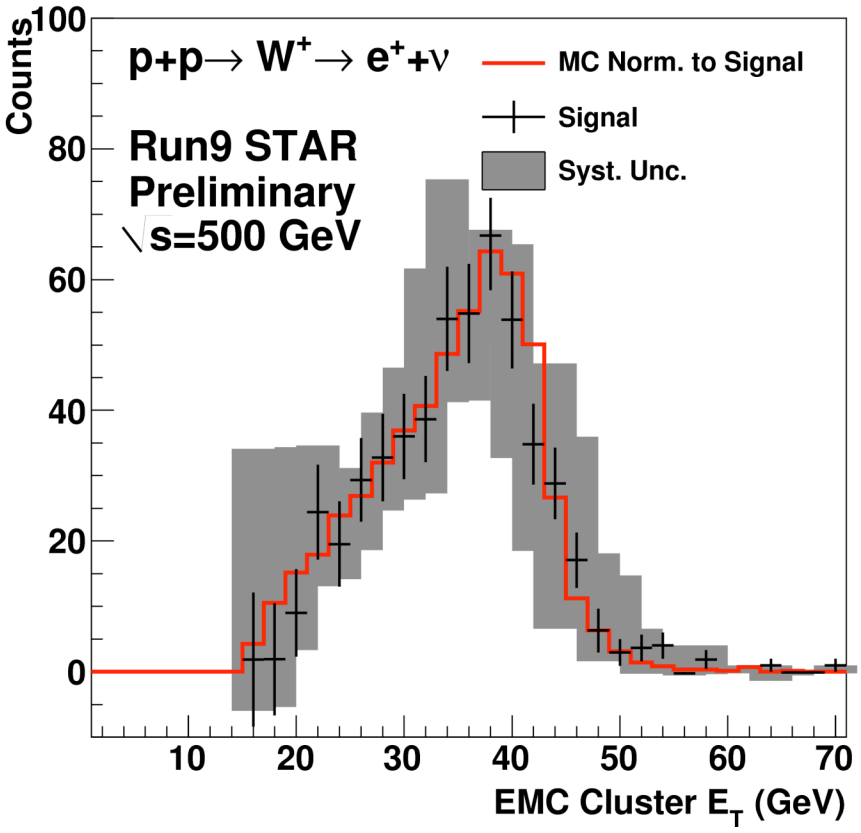
STAR W Signals





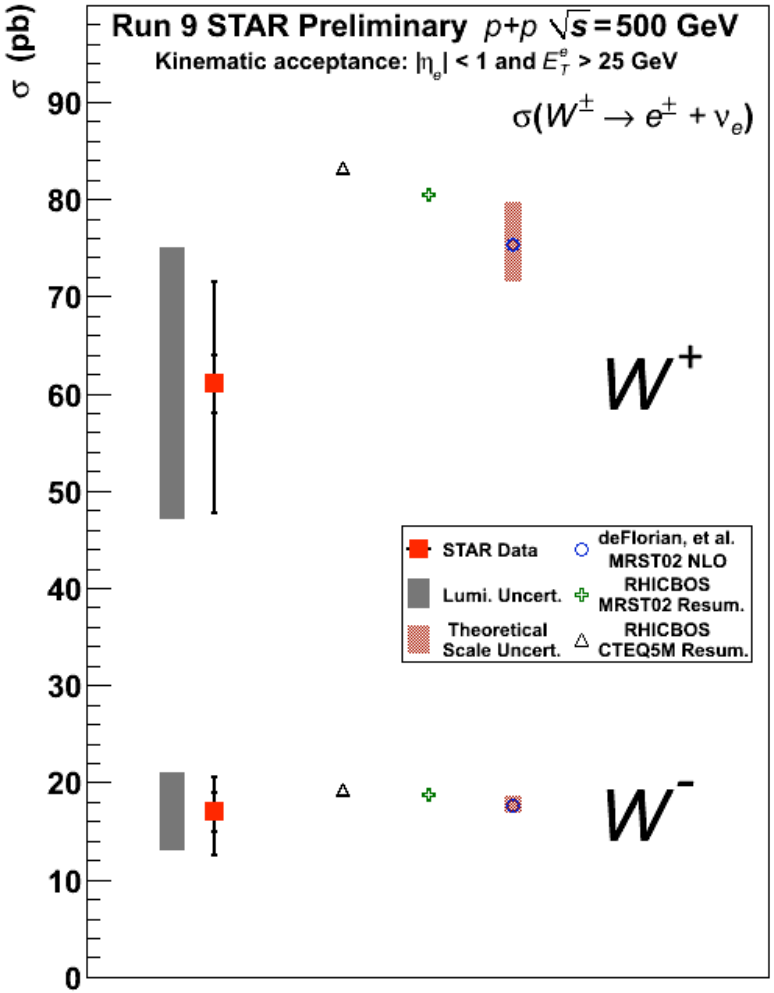
Data/MC Shape Comparison





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

First STAR W Cross Section



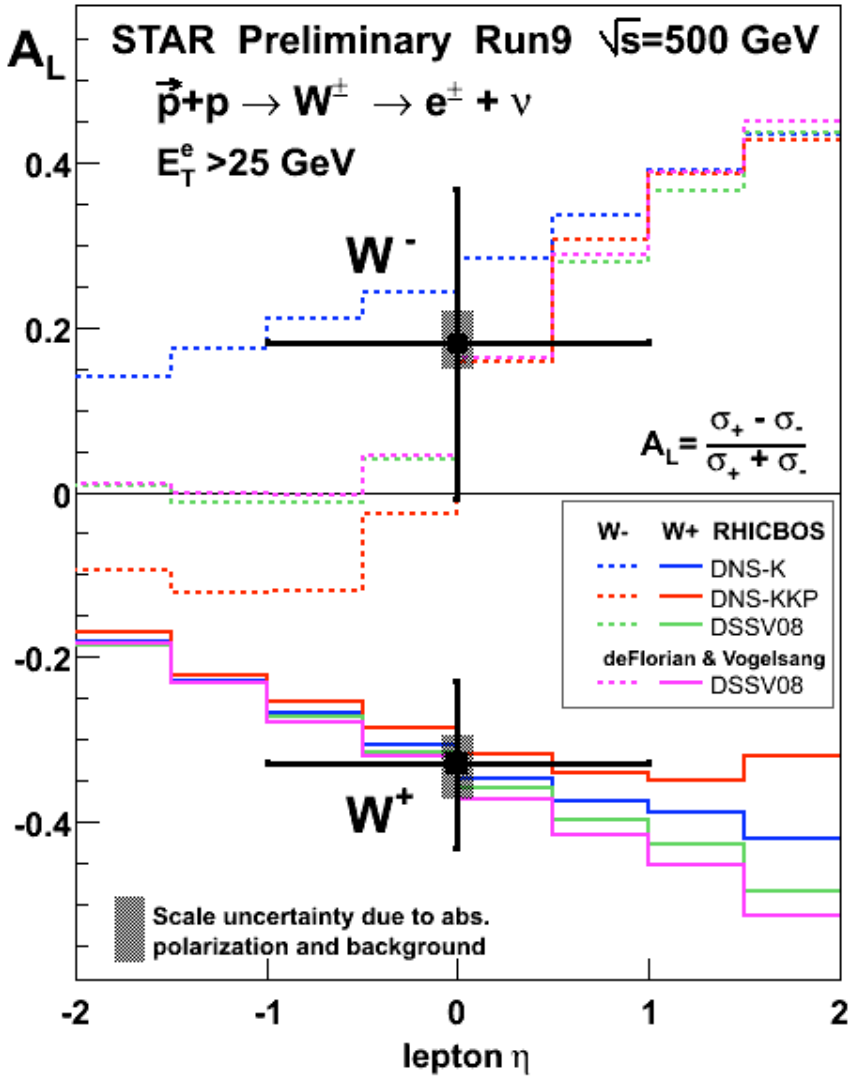
	$W^- \to e^- + \bar{\nu}_e$	$W^+ \to e^+ + \nu_e$
N_W^{obs}	156	513
N_{back}	$25\ ^{+21}_{-7}$	$46\ ^{+36}_{-11}$
ϵ_{total}	$0.56\ ^{+0.11}_{-0.09}$	$0.56\ ^{+0.12}_{-0.09}$
$\int Ldt\ (\mathrm{pb}^{-1})$	13.7 ± 3.2	13.7 ± 3.2

Run 9 STAR Preliminary (p+p 500 GeV)

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

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

First STAR W A_L



Then spin sorting, we calculate the A_L

$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

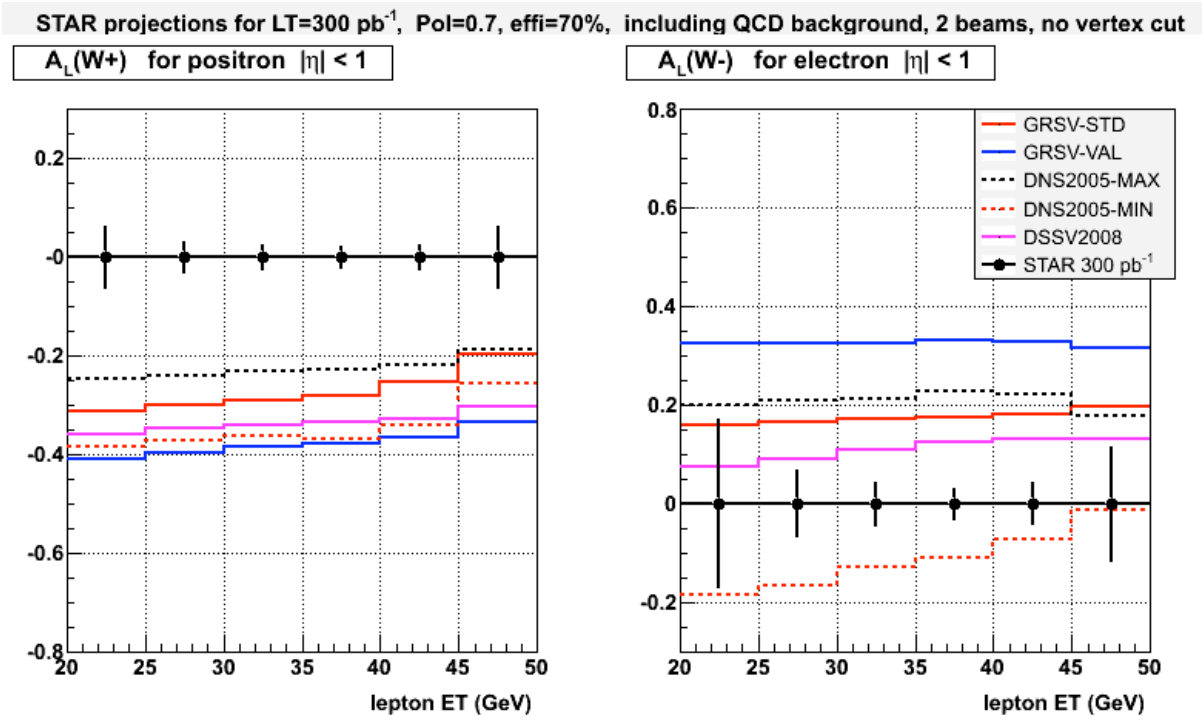
STAR Preliminary Run 9

$$A_L(W^+) = -0.33 \pm 0.10(\text{stat.}) \pm 0.04(\text{syst.})$$

$$A_L(W^-) = 0.18 \pm 0.19(\text{stat.}) \; ^{+0.04}_{-0.03}(\text{syst.})$$

Future W A_L Measurements

Future Ws at mid-rapidity



STAR has shown the capability to detect the W at mid-rapidity.

With the expected 300pb^{-1} for the 500 GeV program STAR will provide strong constraints on the polarized sea pdfs using the mid-rapidity data

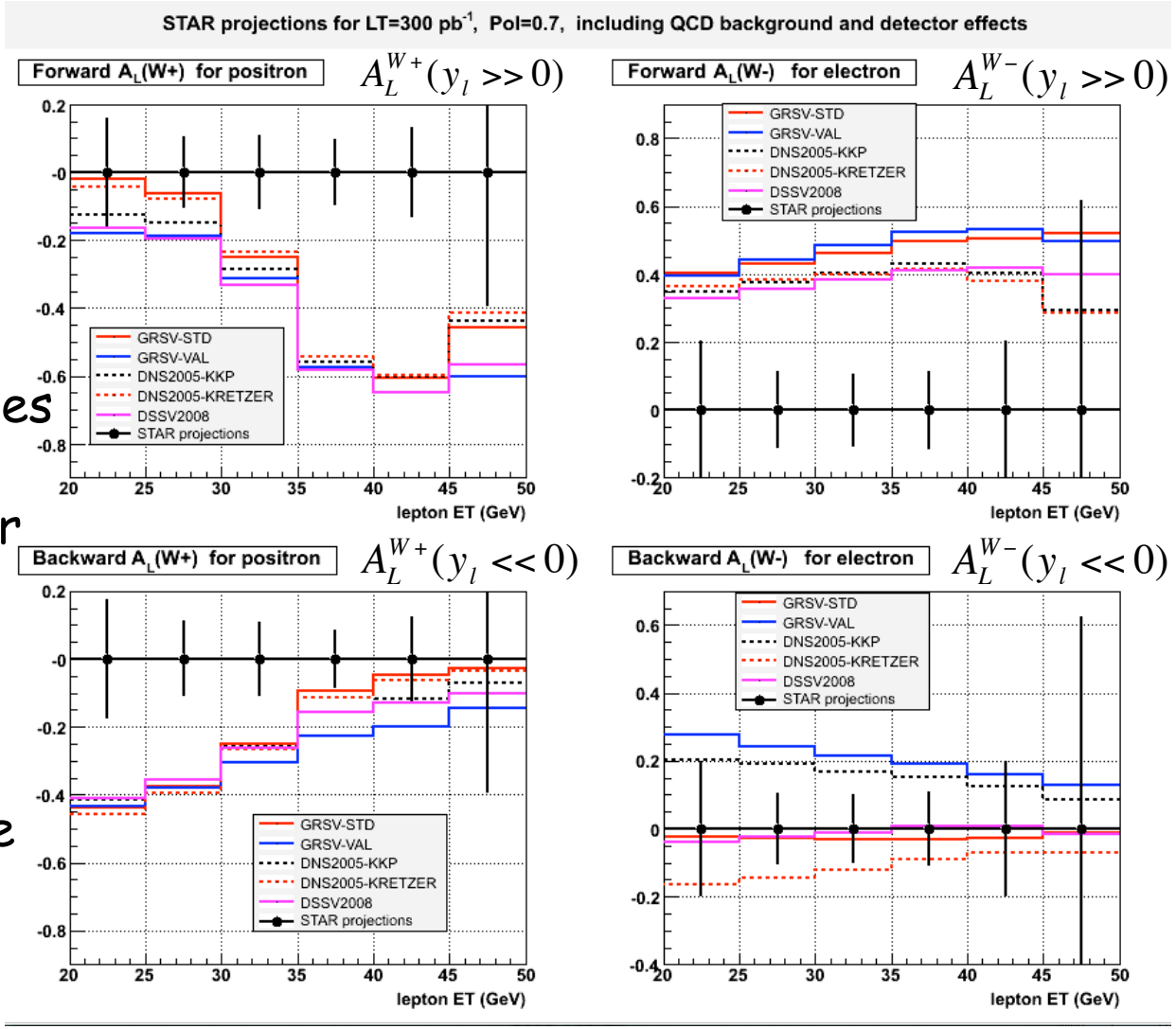
Future Ws at forward rapidity

At forward/backward rapidity the A_Ls become more sensitive to a single quark flavor

The expected uncertainties for the 500 GeV program are shown to the right for the endcap acceptance

$$1 < \eta < 2$$

Measurements rely on the planned Forward GEM Tracker upgrade



Conclusions

- Measurements of the W in polarized p+p collisions provide needed information about the polarized sea in the proton.
- STAR has shown a first extraction of the cross section and single helicity asymmetry of the W signal in polarized p+p collisions at sqrt(s)=500 GeV
- Planned STAR measurements will provide strong constraints on the polarized sea of the proton.