The STAR W Physics Program at RHIC

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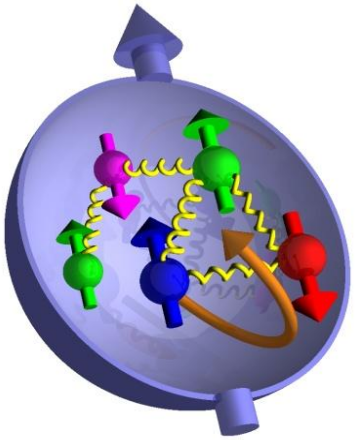
for the STAR Collaboration

DNP Meeting

November 4, 2010

Proton Spin Puzzle



The observed spin of the proton can be decomposed into contributions from the intrinsic quark and gluon spin and orbital angular momentum

$$\left\langle S_p \right\rangle = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

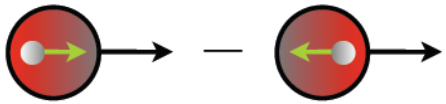
Being measured at RHIC (Jets, hadrons, etc.)

Integral of quark polarization is well measured in DIS to be only ~30%, but decomposition (especially sea) is not well understood

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

Polarized PDFs

$$\Delta f(x) =$$



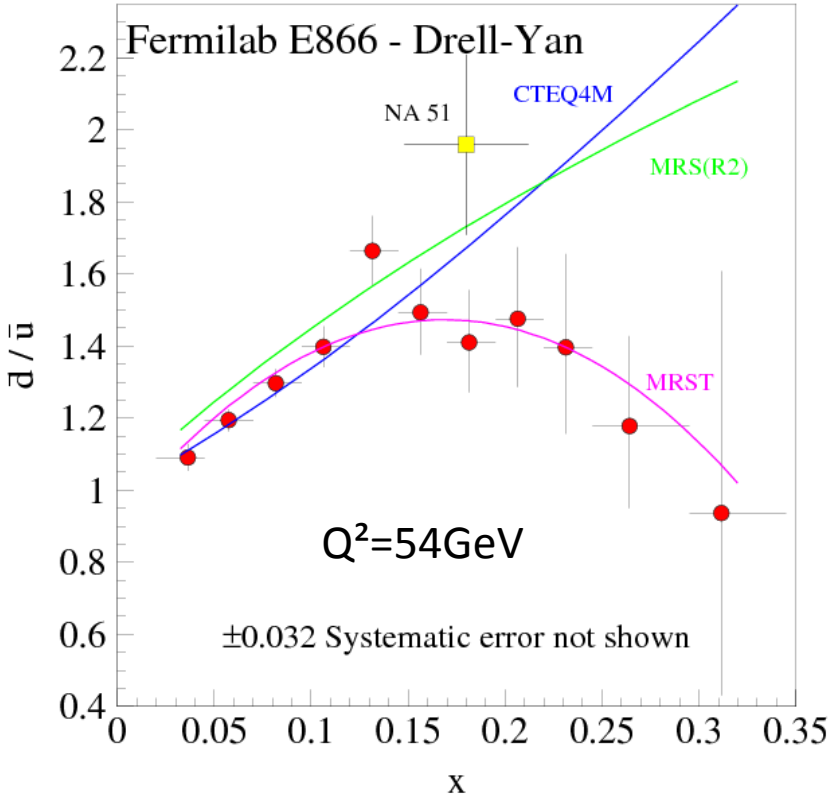
$$f^+(x) - f^-(x)$$

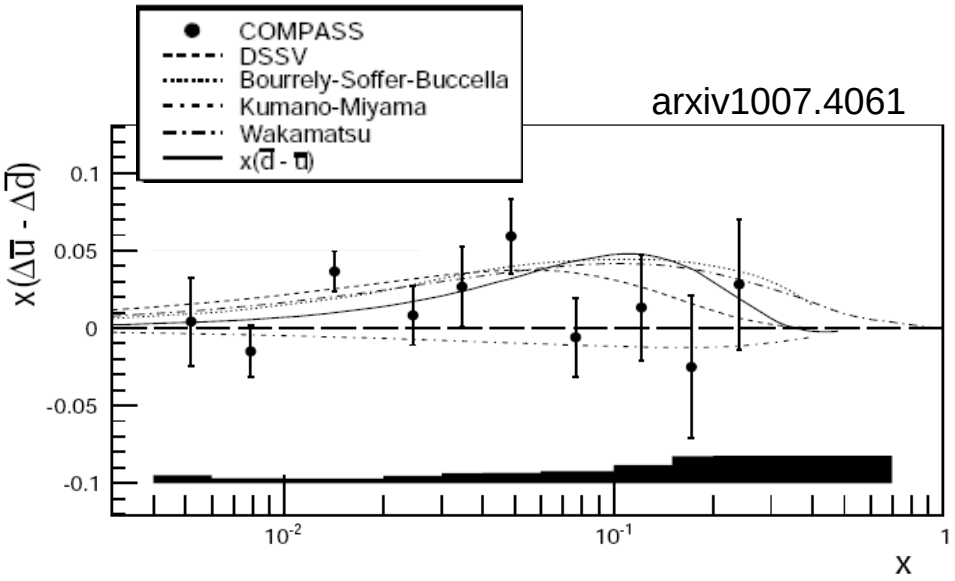
Flavor Asymmetry of the Sea

PRL **80,** 3715 (1998)

Upolarized Flavor asymmetry:

- Quantitative calculation of Pauli blocking does not explain $\bar{d}/\bar{u}$ ratio
- Non-perturbative processes may be needed in generating the sea
- E866 results are qualitatively consistent with pion cloud models, chiral quark soliton models, instanton models, etc.

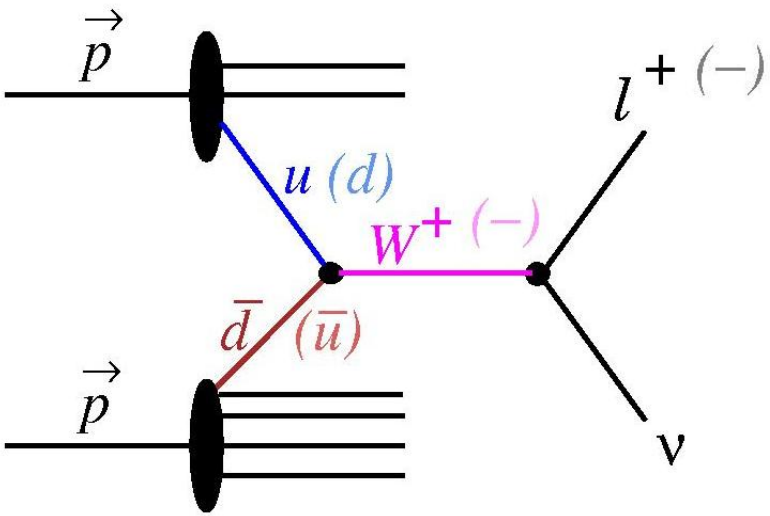




Polarized flavor asymmetry:

- Recent COMPASS data
- Polarized flavor asymmetry $x(\Delta\bar{u}-\Delta\bar{d})$ could help differentiate models

Probing the Sea Through W Production



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

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

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

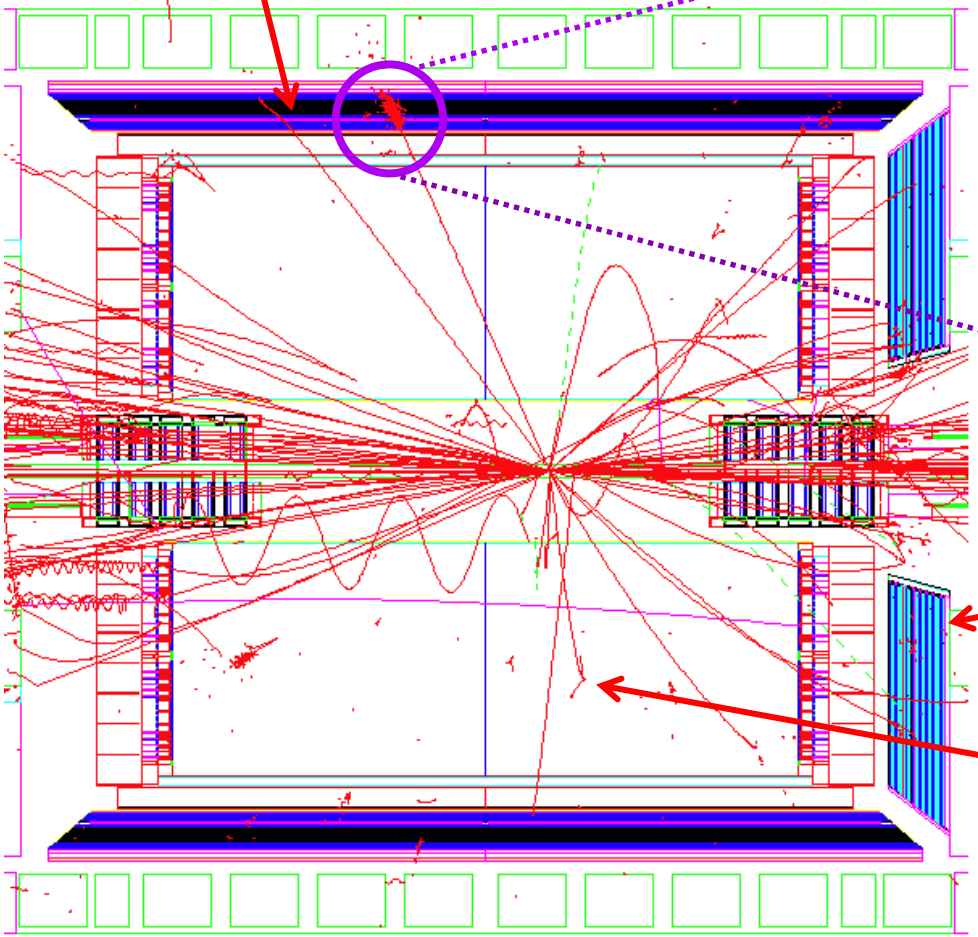
Measure parity-violating single-spin asymmetry: $A_L = \dfrac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$

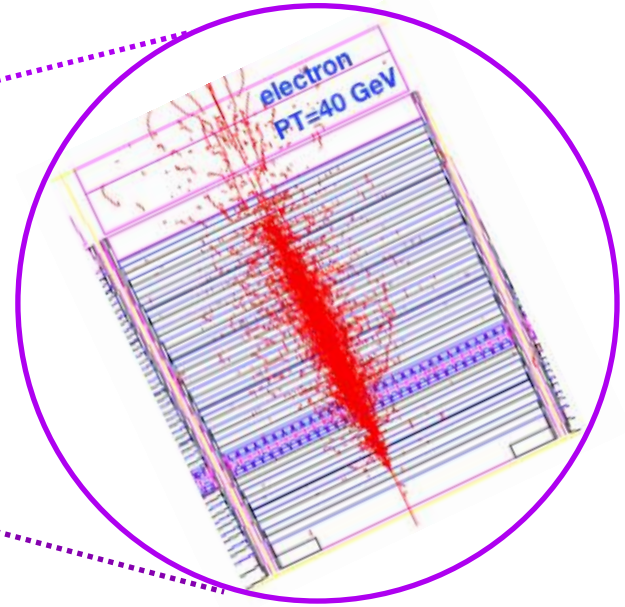
(Helicity flip in one beam while averaging over the other)

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

STAR Detector

Barrel EM Calorimeter:
Lepton Energy
Veto jets

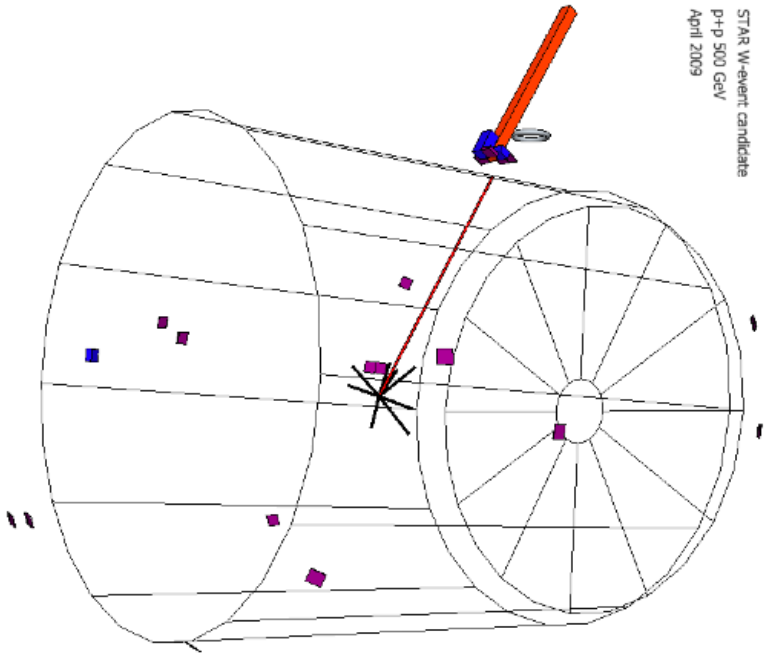




Endcap EM Calorimeter:
Veto jets

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

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

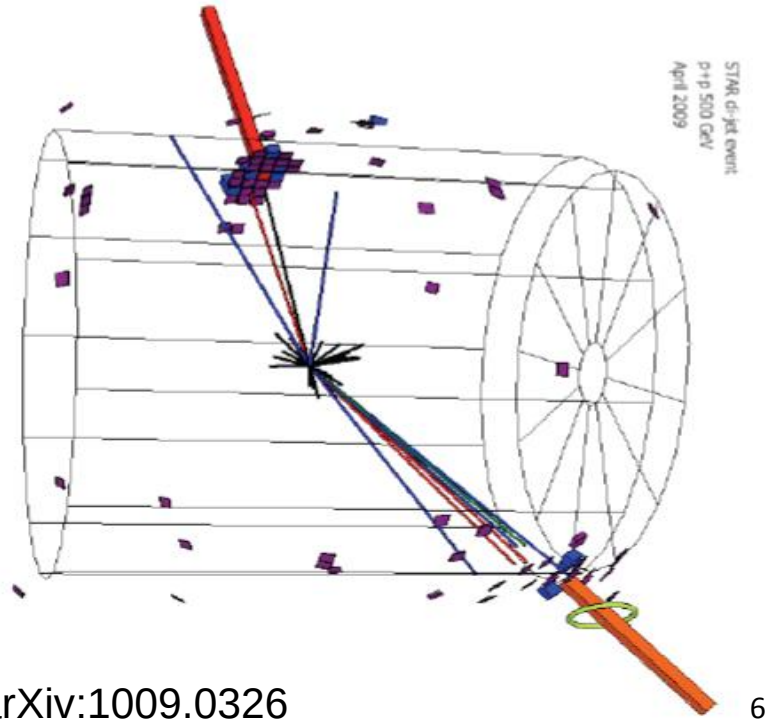


W -> e + ν Candidate Event

- Isolated track pointing to isolated EM deposit in calorimeter
- Large “missing energy” opposite electron candidate

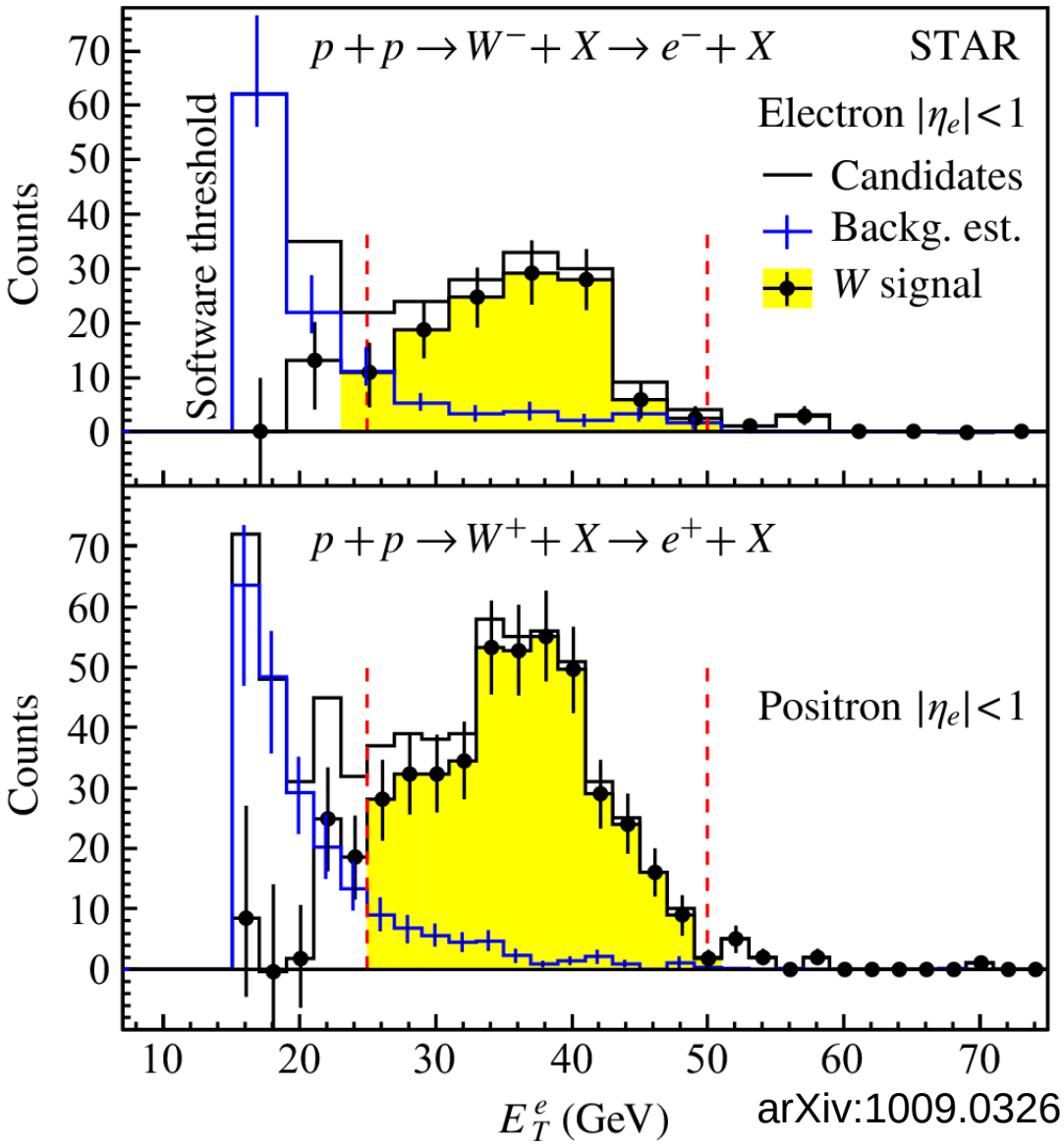
Di-jet Background Event

- Several tracks pointing to EM deposit in calorimeter spread over a few towers
- Vector pt sum is balanced by opposite jet, “missing energy” is small



More reconstruction details at arXiv:1009.0326

STAR Ws from Run 9



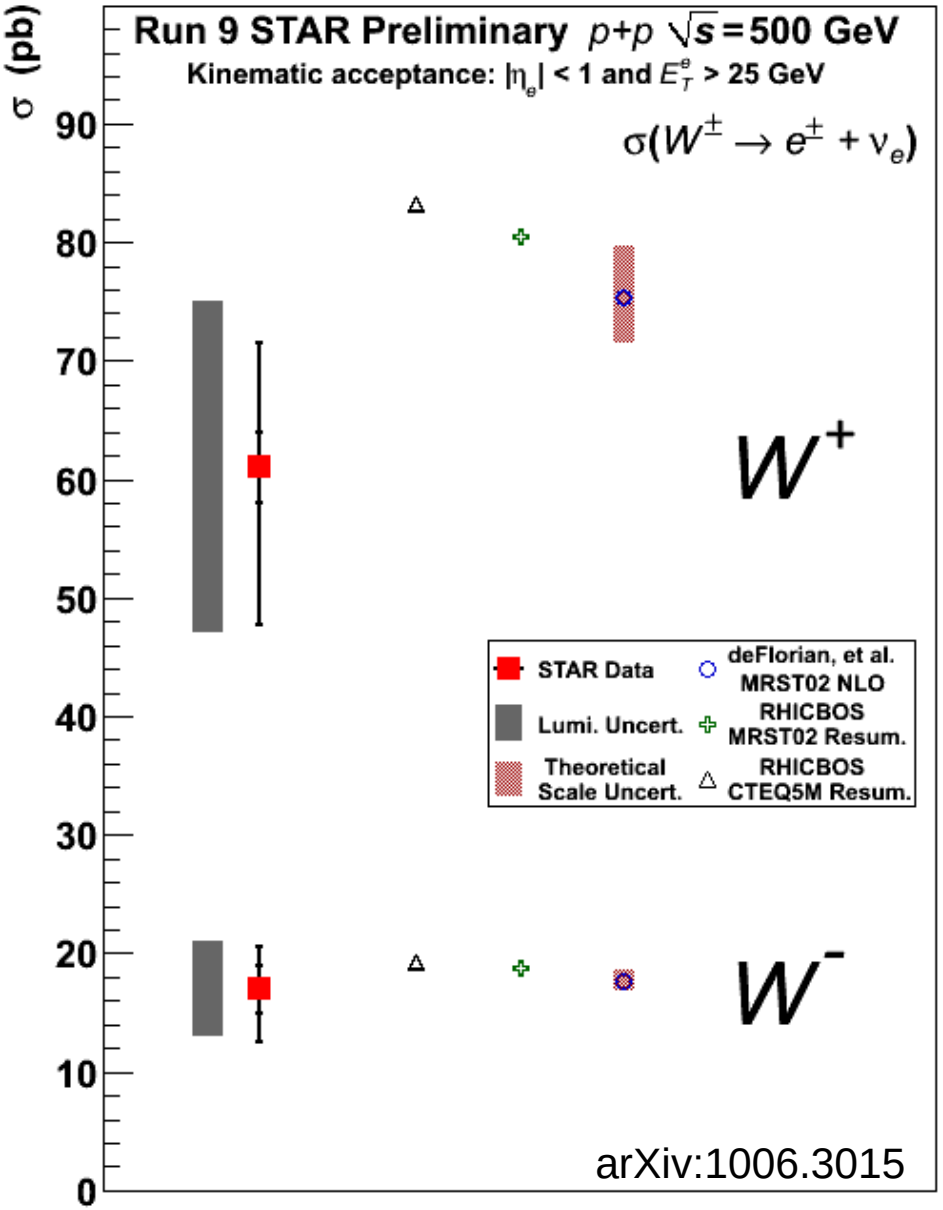
W Signal

- "Jacobian Peak"

Background Estimation

- Electroweak:
  - Z -> e e
  - W -> τ ν
- QCD :
  - Data-driven

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}	$0.56\ ^{+0.11}_{-0.09}$	$0.56\ ^{+0.12}_{-0.09}$
$\int Ldt$ (pb^{-1})	13.7 ± 3.2	13.7 ± 3.2

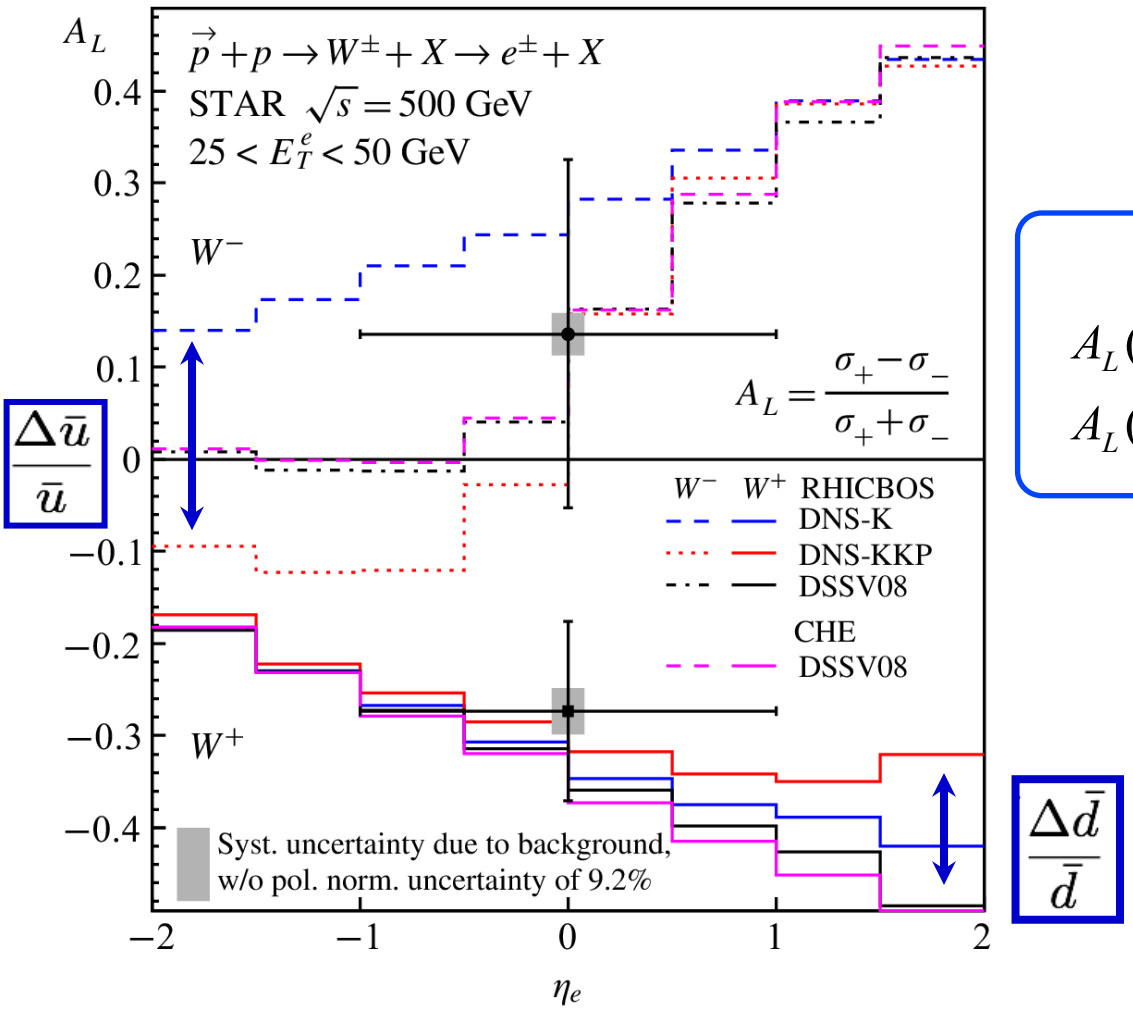
Run 9 STAR Preliminary (p+p 500 GeV)

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

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

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

First STAR W A_L



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

STAR Run 9 Result

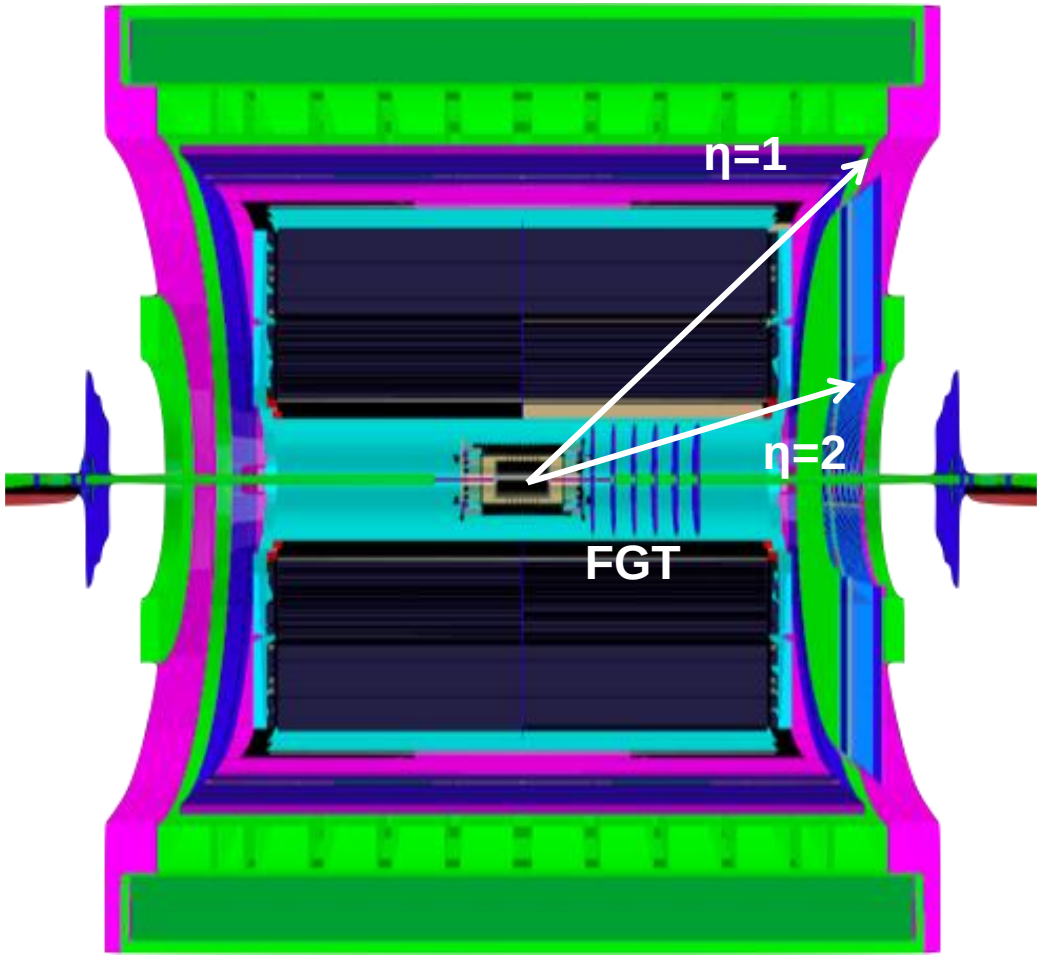
$$A_L(W^+) = -0.27 \pm 0.10(stat) \pm 0.02(syst)$$

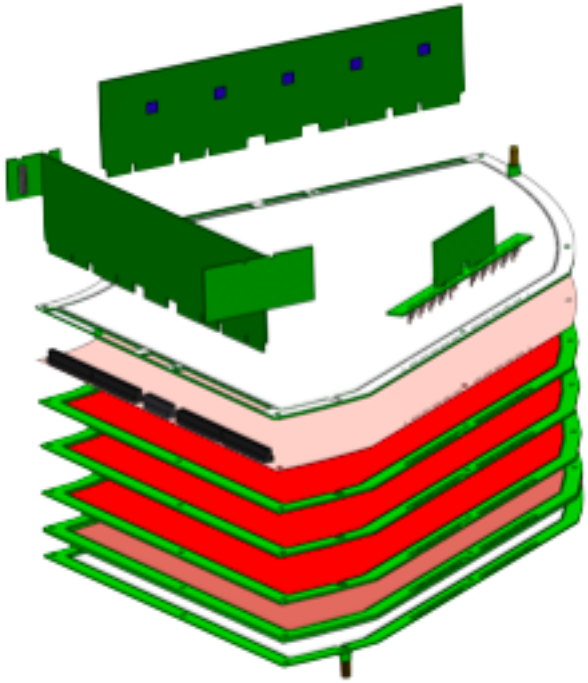
$$A_L(W^-) = 0.14 \pm 0.19(stat) \pm 0.02(syst)$$

arXiv:1009.0326

At forward/backward rapidity there is increased sensitivity to single quark flavor

Forward Tracking: FGT Upgrade

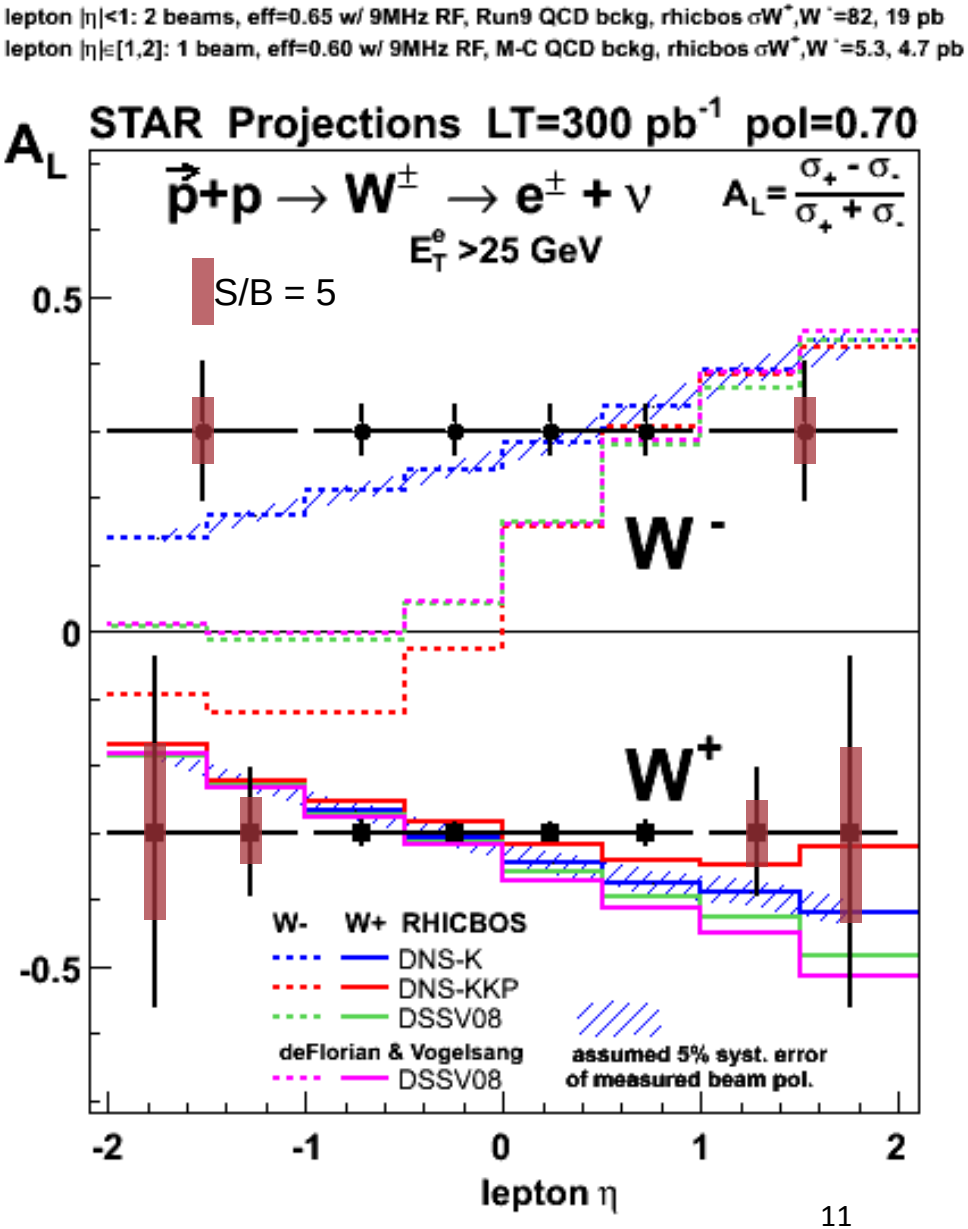




- FGT: 6 light-weight triple-GEM disks using industrially produced GEM foils (Tech-Etch Inc.)
- Expected installation: Summer 2011

Future STAR W A_L

- Near term (Run 11)
  - L ≈ 100 pb^{-1}
  - P ≈ 35-50%
- Multi-year program
  - L ≈ 300 pb^{-1}
  - P ≈ 70%
  - FGT extends rapidity coverage (available in Run 12)



Conclusions

- W boson production in polarized p+p collisions provides a new means of studying the spin-flavor asymmetries of the proton sea quark distributions
- The cross sections for W^+ and W^- measured at STAR are consistent with theoretical expectations
- The parity-violating asymmetries, A_L, were observed and agree with theoretical predictions
- Future planned STAR measurements at mid-rapidity and forward rapidity with increased luminosity and beam polarization will provide significant constraints on the polarized sea