The STAR W Physics Program: New Results and Future Measurements

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2009 APS DNP/JPS Meeting
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.

\[
\frac{1}{2} = \frac{1}{2} \Delta \Sigma + L^z_q + \Delta G + L^z_g
\]

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

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

Fairly well measured only ~30% of spin.
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

- 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)

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

A polarized proton collider to study spin in QCD
STAR

TPC (time projection chamber)

BEMC (barrel)

EEMC (endcap)
2009 500 GeV Data Set

Required a high tower trigger ($E_T > 7.3$ GeV) and a high $E_T$ 2x2 clusters ($E_T > 13$ GeV)

STAR recorded $\sim 10\text{pb}^{-1}$ in the 500 GeV

leptons from Ws should appear here
**W Algorithm**

**W → lepton + neutrino**

*Expect a large QCD background* (data shown after some cuts are applied)

J. Seele - 2009 DNP
Full PYTHIA + GEANT simulations were done to assess the performance of the algorithm.

Spectra are scaled to $10\text{pb}^{-1}$

Disclaimer: PYTHIA has been known to not accurately predict the number of high-$z$ fragmenting jets.
First STAR W Results

Using the algorithm a clear Jacobian peak can be seen in the data

Estimate QCD background in a fully data-driven manner

Background from “missing” endcap

The normalized background is subtracted from the $E_T$ spectrum to obtain a $W$ signal.
Example Lego Plots

**W event**

**Dijet event**
Future W Measurements
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.
At forward/backward rapidity the $A_L$s 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 (see B. Surrow's talk on Sat.)
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 a Jacobian peak of a W signal in p+p collisions at sqrt(s)=500 GeV confirming our expectations.
• Planned STAR measurements will provide strong constraints on the polarized sea of the proton.
Backup Slides