



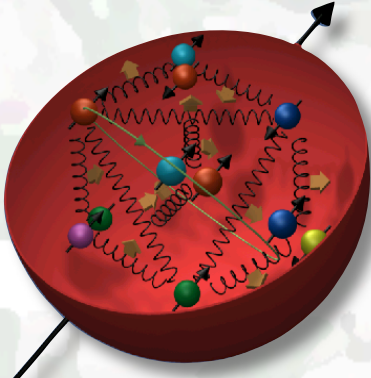
Status and Prospects of the STAR W boson spin physics program at RHIC at BNL

Bernd Surrow



Massachusetts
Institute of
Technology

(On behalf of the STAR Collaboration)



Outline

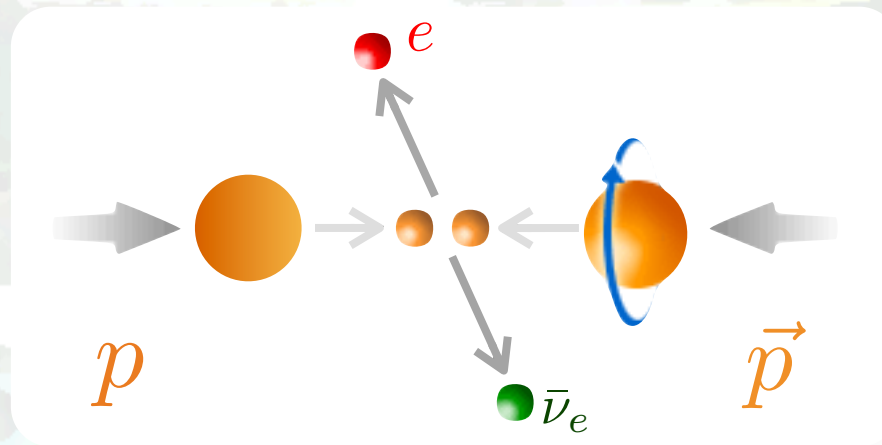
□ First observation of W production at STAR

- Run 9 - First 500GeV polarized pp collisions
- Local polarimetry
- W Cross-section and A_L

□ Future Plans - STAR W Program

- Overview of the STAR Forward GEM Tracker
- Projections of future STAR measurements

□ Theoretical foundation - STAR W Program

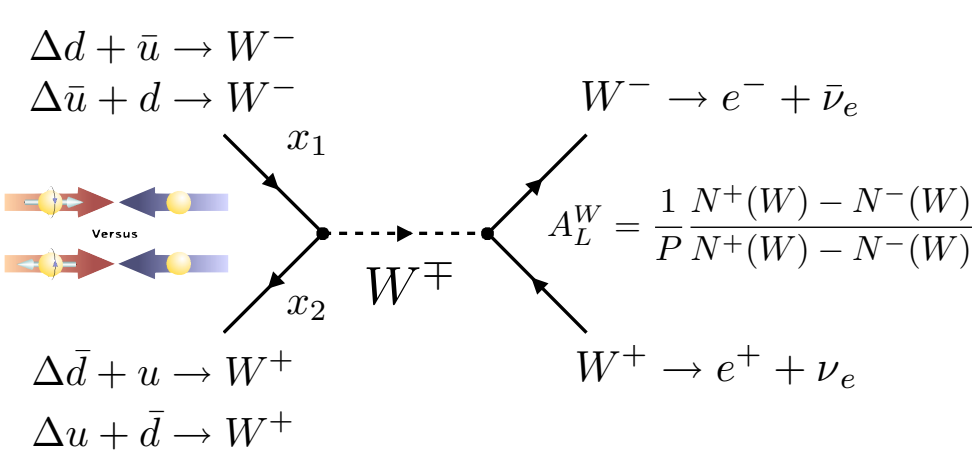


□ Summary and Outlook



Theoretical foundation - STAR W Program

- Delineate quark spin contributions by flavor to the proton spin



$$y_l = y_W + \underbrace{\frac{1}{2} \ln \frac{1 + \cos \theta^*}{1 - \cos \theta^*}}_{y_l^*}$$

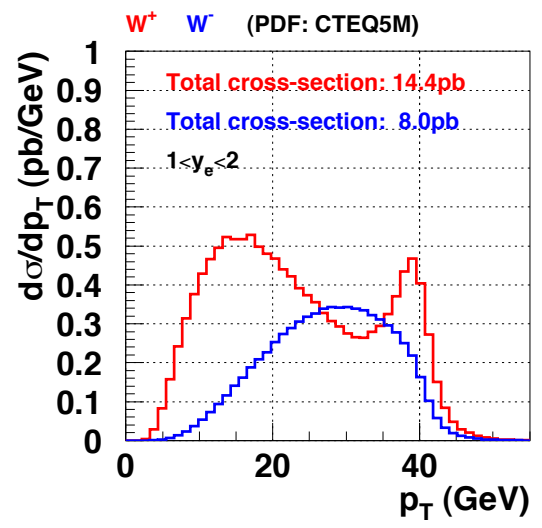
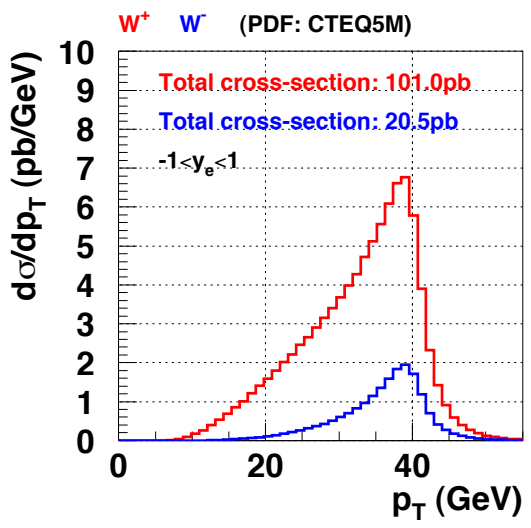
$$p_T = p_T^* = \frac{M_W}{2} \sin \theta^*$$

$$x_1 = \frac{M_W}{\sqrt{s}} e^{y_W}$$

$$x_2 = \frac{M_W}{\sqrt{s}} e^{-y_W}$$

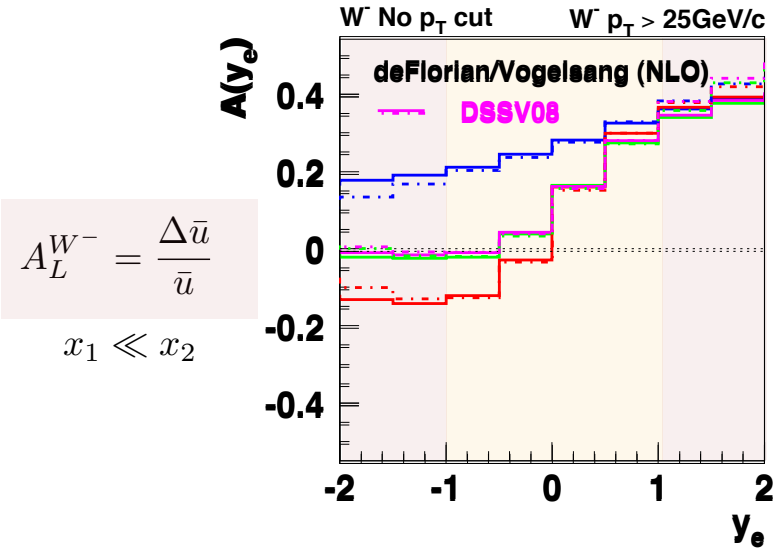
$$\frac{M_W}{\sqrt{s}} = 0.16$$

- **Key signature:** High p_T lepton (e^-/e^+ or μ^-/μ^+) (Max. $M_W/2$) - Selection of W^-/W^+ : Charge sign discrimination of high p_T lepton
- Required: Lepton/Hadron discrimination



Theoretical foundation

□ A_L : STAR mid-rapidity and forward rapidity (A_L calculations at $\sqrt{s}=500\text{GeV}$)



$$A_L^{W^-} = \frac{\Delta \bar{u}}{\bar{u}}$$

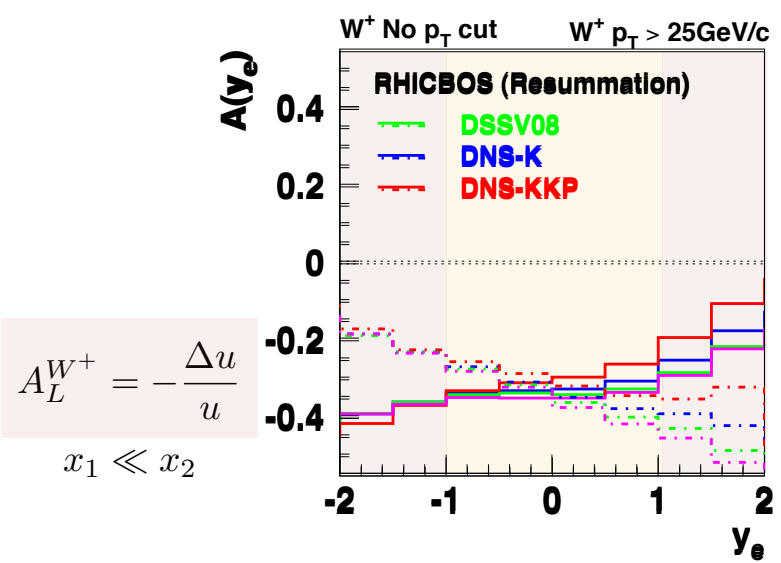
$x_1 \ll x_2$

$$A_L^{W^-} = -\frac{\Delta d}{d}$$

$x_1 \gg x_2$

$$A_L^{W^-} = \frac{1}{2} \left(\frac{\Delta \bar{u}}{\bar{u}} - \frac{\Delta d}{d} \right)$$

$x_1 = x_2$



$$A_L^{W^+} = -\frac{\Delta u}{u}$$

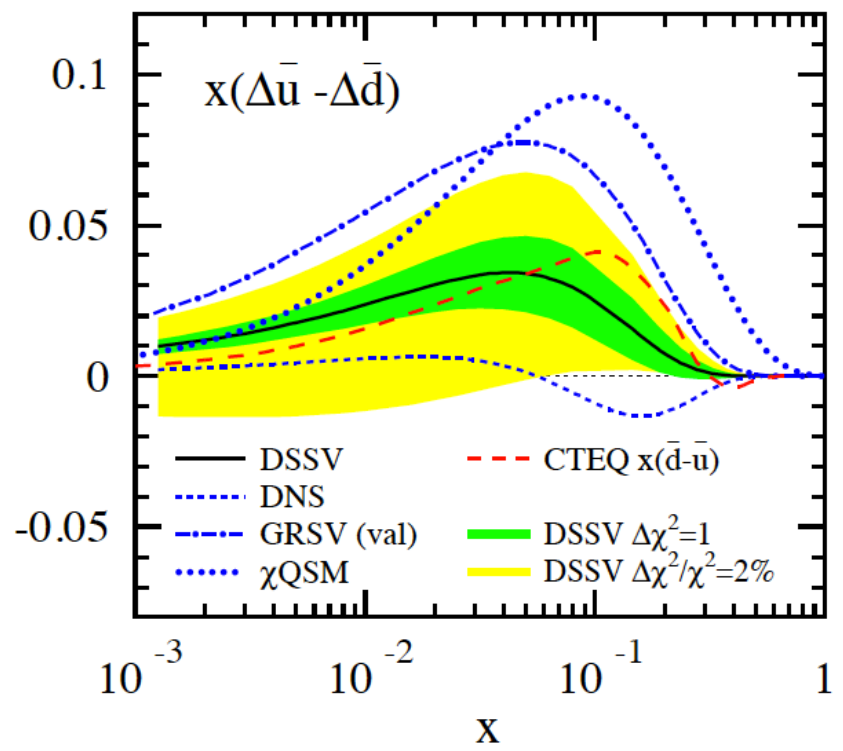
$x_1 \ll x_2$

$$A_L^{W^+} = \frac{1}{2} \left(\frac{\Delta \bar{d}}{\bar{d}} - \frac{\Delta u}{u} \right)$$

$x_1 = x_2$

$$A_L^{W^+} = \frac{\Delta \bar{d}}{\bar{d}}$$

$x_1 \gg x_2$



Calculations:

- 1) RHICBOS: P.M. Nadolsky and C.-P. Yuan, Nucl. Phys. B666 (2003) 31.
- 2) deFlorian / Vogelsang: D. deFlorian, private communications.

The STAR Experiment at RHIC

□ Overview

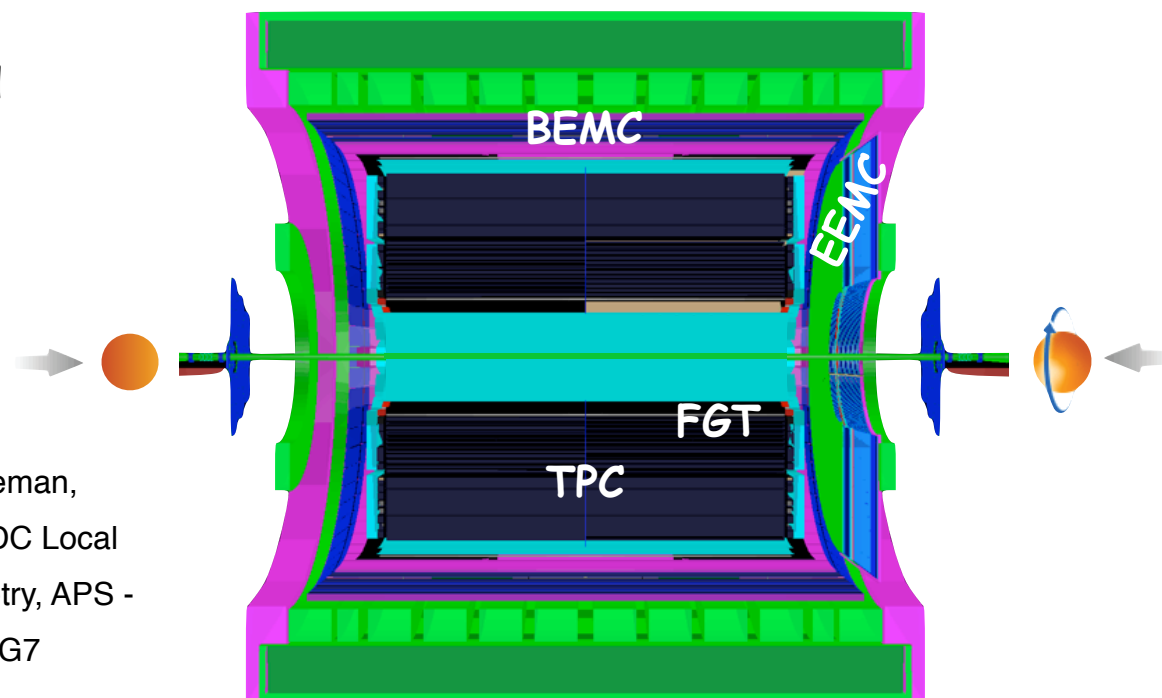
- Calorimetry system with 2π coverage: BEMC ($-1 < \eta < 1$) and EEMC ($1 < \eta < 2$)

- TPC: Tracking and particle ID

- ZDC: Relative luminosity and local polarimetry

- BBC: Relative luminosity and Minimum bias trigger

First collisions of polarized proton beams at STAR at $\sqrt{s} = 500\text{GeV}$: Run 9 ($P \sim 40\%$ / $L \sim 14\text{pb}^{-1}$)

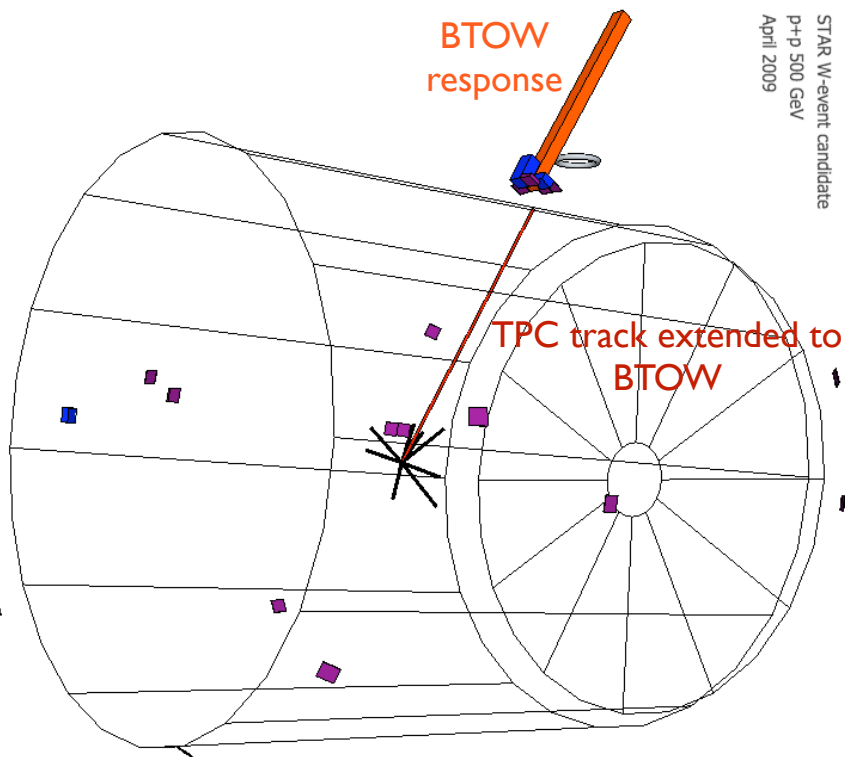


A. Bridgeman,
STAR ZDC Local
Polarimetry, APS -
Session G7

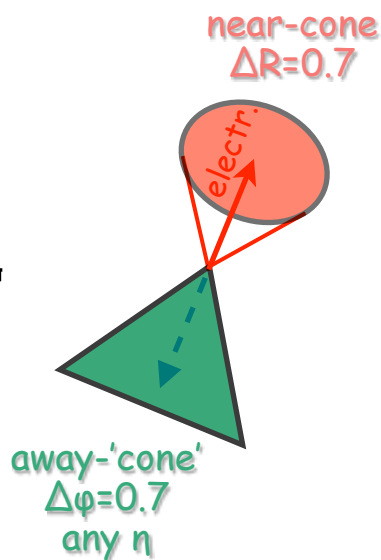
- STAR Mid-rapidity W program ($-1 < \eta < 1$): BEMC and TPC
- STAR Forward/Backward W program ($1 < \eta < 2$): EEMC and TPC / FGT (Installation in summer 2011)

First observation of W production at STAR

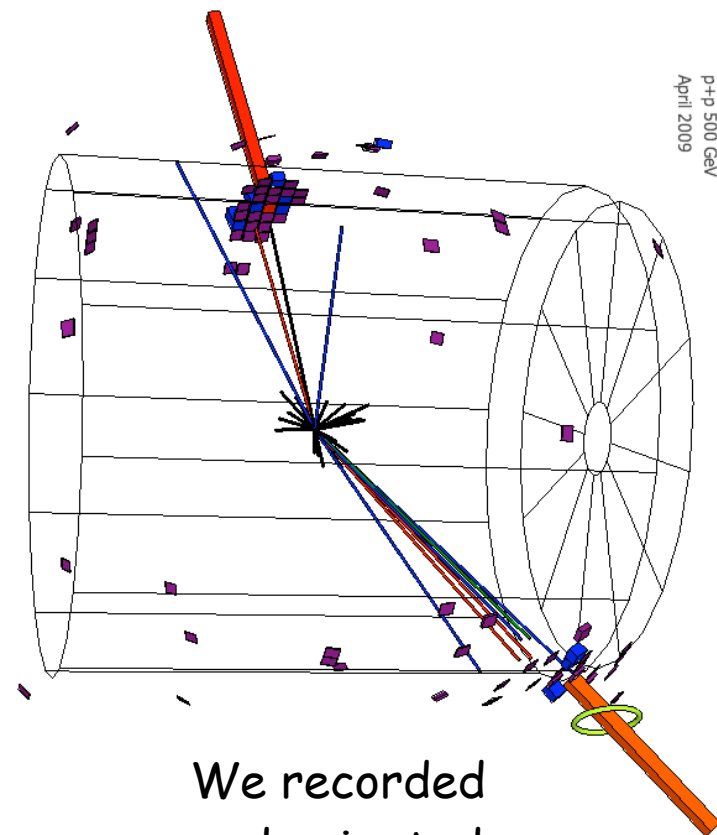
- Event display and detector signature: W candidate and QCD background event



We found
~400 W
candidate
events!



Run 9 STAR Data ($\sqrt{s}=500\text{GeV}$)



We recorded
and rejected
~1.5M QCD
background
events!



First observation of W production at STAR

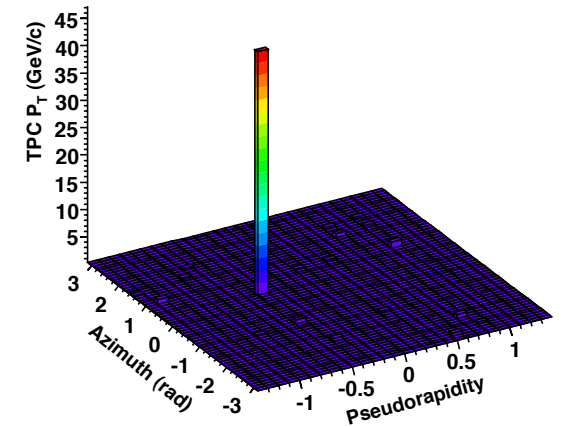
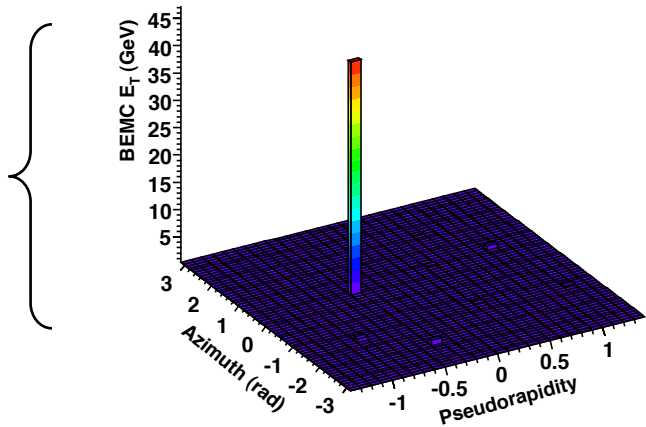
□ Lego plots - STAR BEMC/TPC

W event

BEMC E_T Distribution (GeV)

TPC p_T Distribution (GeV/c)

Run 9 STAR Data ($\sqrt{s}=500\text{GeV}$)

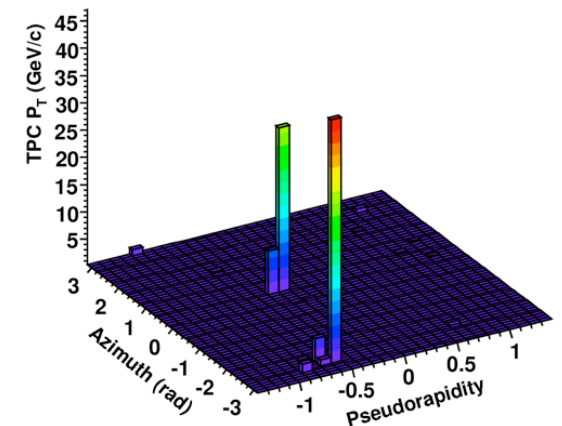
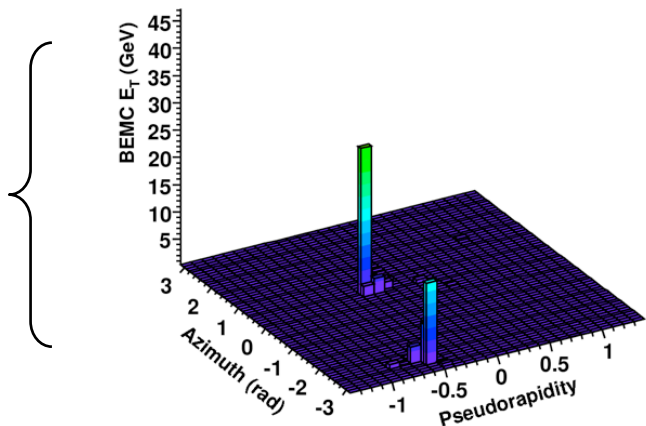


BEMC E_T Distribution (GeV)

TPC p_T Distribution (GeV/c)

Run 9 STAR Data ($\sqrt{s}=500\text{GeV}$)

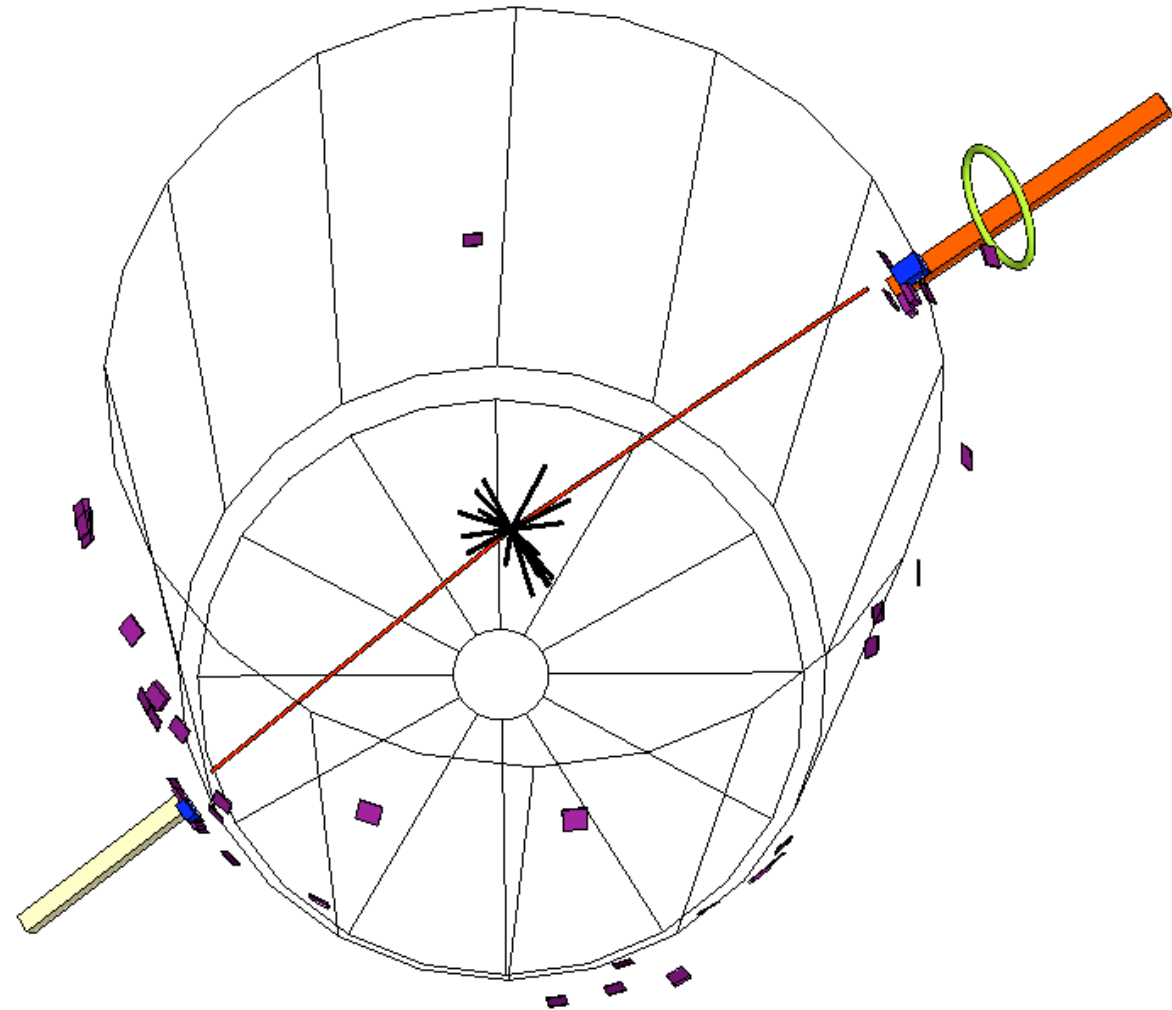
Di-Jet event



First observation of W production at STAR

- Event display and detector signature: Z^0 candidate event

Run 9 STAR Data ($\sqrt{s}=500\text{GeV}$)



We found
a handful
of Z^0
candidate
events!

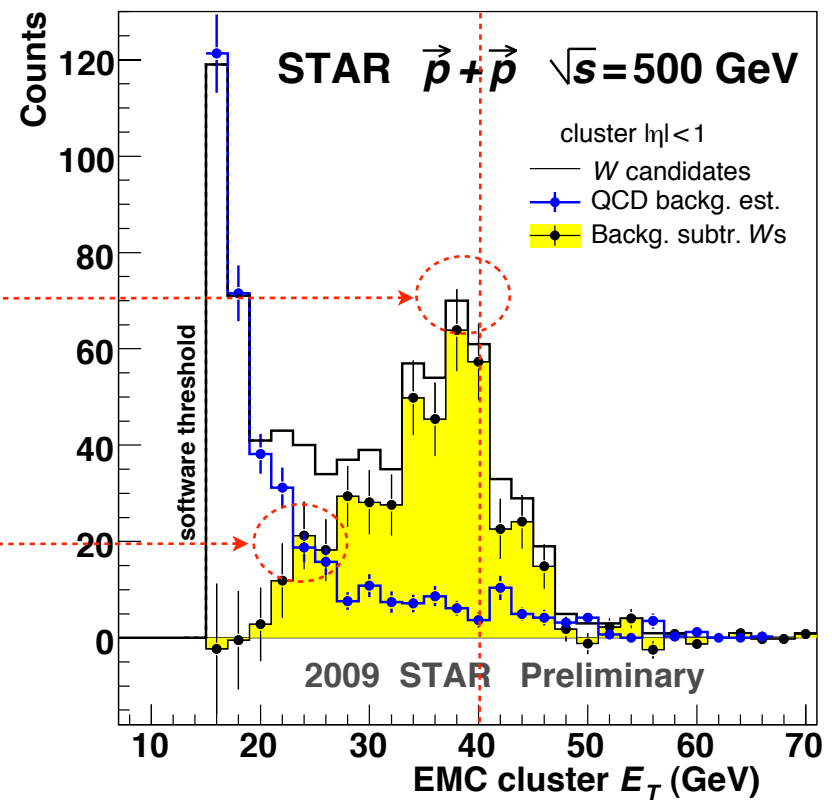
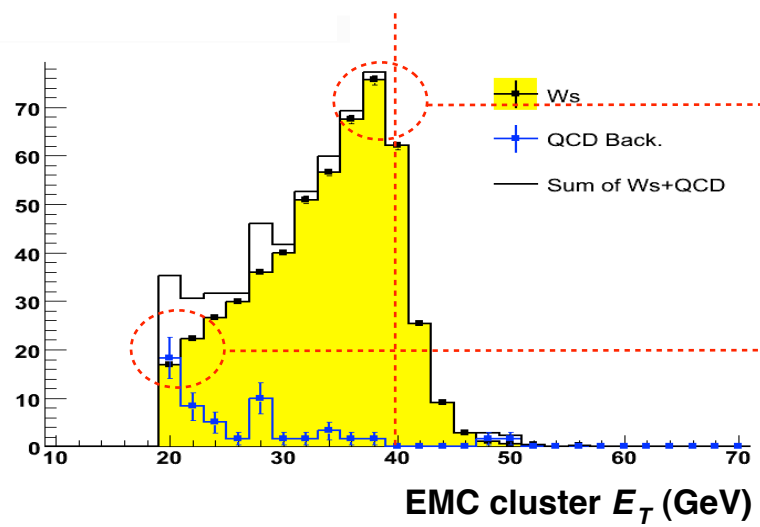


First observation of W production at STAR

Data / MC Comparison: First Observation of W boson production at STAR

J. Seele (MIT): DNP 2009

W PYTHIA MC Simulation (10pb⁻¹)



⇒ Comparable shape/yield of W

PYTHIA MC Simulation and Data Run 9

- First result: Charge sum - **Jacobian peak**
- Next: Charged separated **W⁺/W⁻ cross-section** and **A_L asymmetry**



First observation of W production at STAR

□ Preliminary results: First Observation of W production at STAR

- **Luminosity measurement** in 500GeV p-p collisions at RHIC:
Ross Corliss (MIT)

APS
Session: D7
Saturday,
February 13,
2009

- **Cross-section measurement** for W^+/W^- bosons at mid-rapidity:
Justin Stevens (Indiana University)

APS
Session: X11
Tuesday,
February 16,
2009

- **Parity violating single-spin asymmetry measurement** for W^+/W^- bosons at mid-rapidity:
Jan Balewski (MIT)

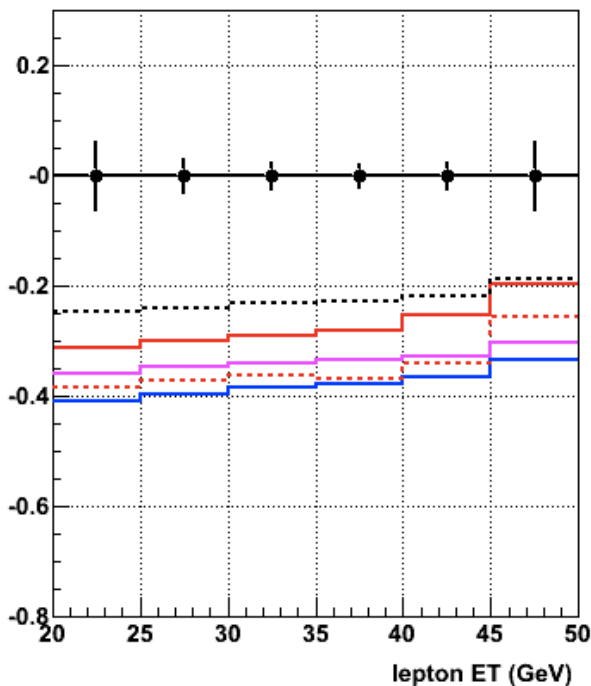
APS
Session: X11
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Future prospects: $W A_L$ projections

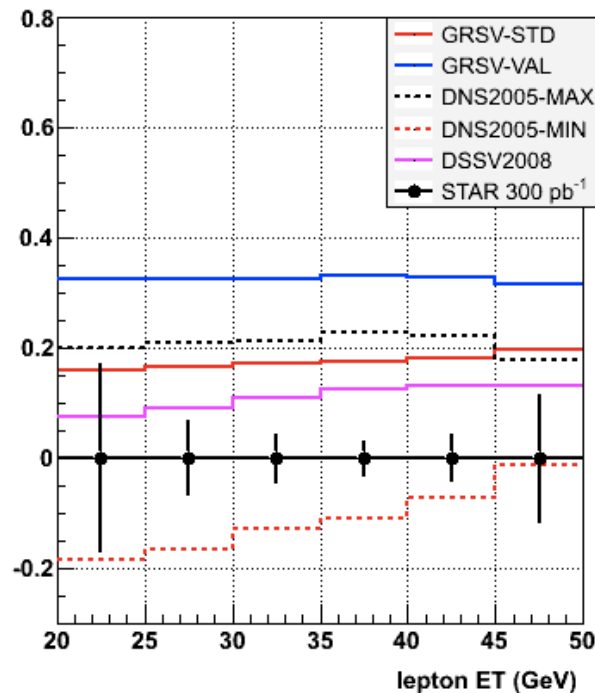
□ A_L projections: Mid-rapidity

STAR projections for $LT=300 \text{ pb}^{-1}$, $\text{Pol}=0.7$, $\text{effi}=70\%$, including QCD background, 2 beams, no vertex cut

$A_L(W^+)$ for positron $|\eta| < 1$



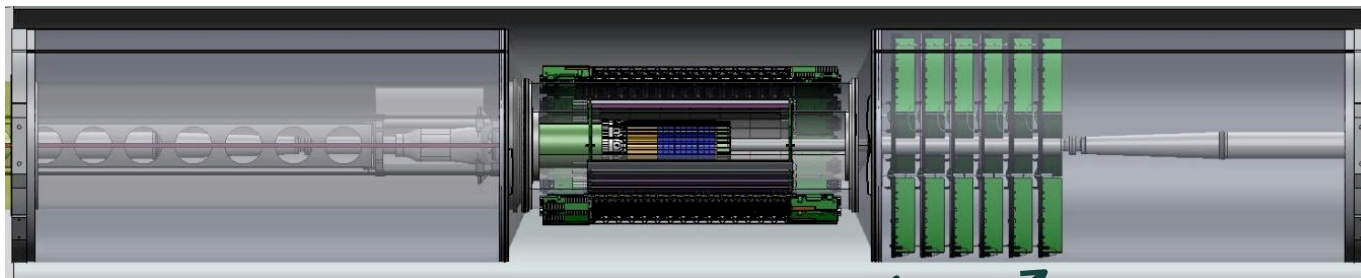
$A_L(W^-)$ for electron $|\eta| < 1$



DOE RHIC SPIN Progress
report, June 2008

- Important constraints on polarized anti-quark distributions, in particular anti-d, from precision A_L measurements for mid-rapidity W production!

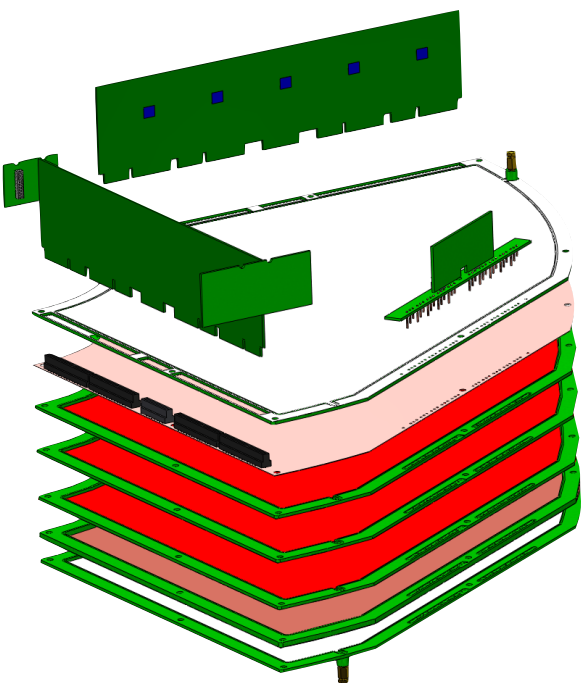
Future prospects: W production - FGT upgrade



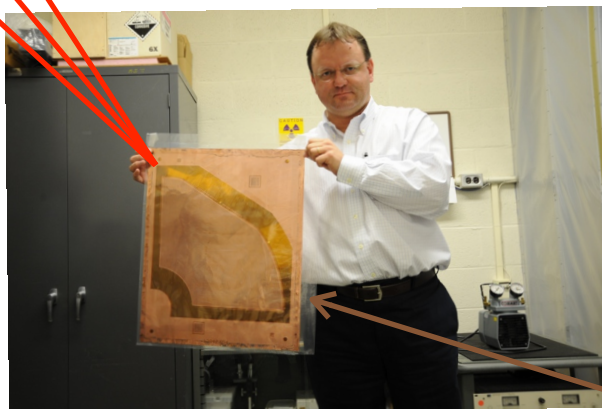
□ STAR Forward GEM Tracker (FGT)

- **Physics Motivation:** Spin Flavor Structure of the proton - Large sensitivity at forward rapidity
- FGT: **Enhance forward tracking capabilities** at STAR ($1 < \eta < 2$)
- Main purpose: **Charge-sign discrimination of high- p_T e^-/e^+** from W^\pm decays : Forward A_L

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



FGT quarter section (1/4 of full disk)



FGT GEM foil

Future prospects: $W A_L$ projections

□ A_L projections: Forward/backward rapidity

○ Large asymmetries dominated by

quark polarization - Important

consistency check to existing DIS

data with 100pb^{-1} (Phase I)

○ Strong impact constraining unknown

antiquark polarization requires

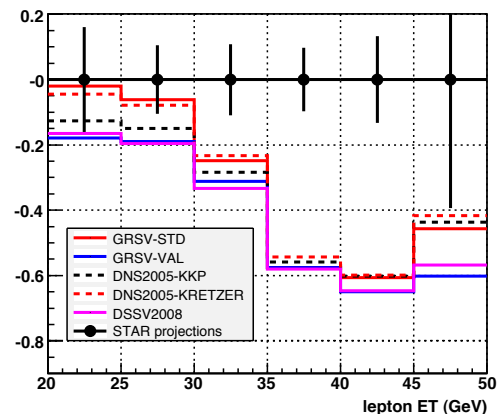
luminosity sample at the level of

300pb^{-1} for 70% beam polarization

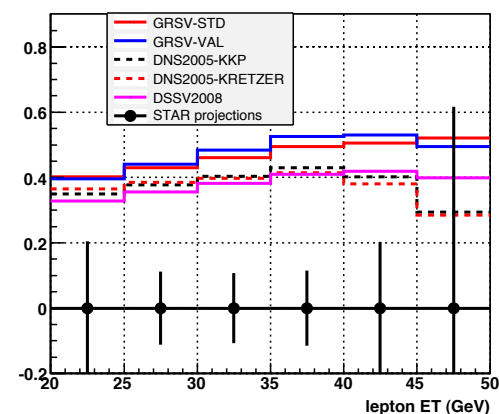
(Phase II)

STAR projections for $LT=300\text{ pb}^{-1}$, $\text{Pol}=0.7$, including QCD background and detector effects

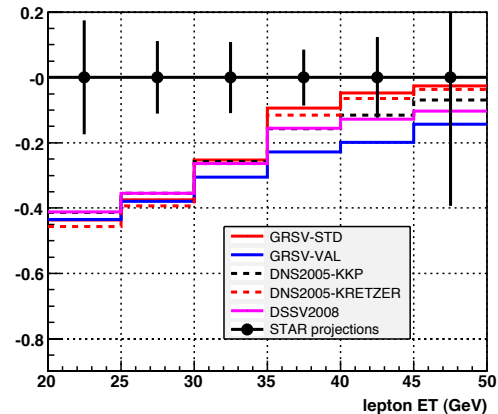
Forward $A_L(W^+)$ for positron



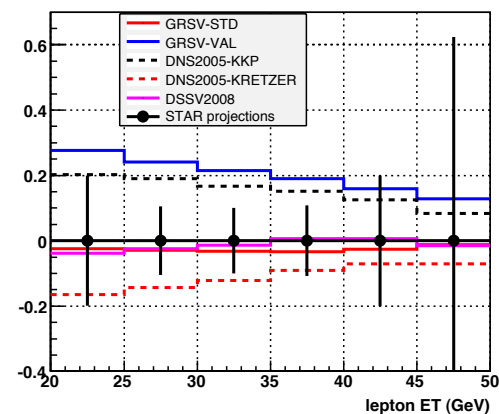
Forward $A_L(W^-)$ for electron



Backward $A_L(W^+)$ for positron



Backward $A_L(W^-)$ for electron



DOE RHIC SPIN Progress

report, June 2008



Summary and Outlook

- Run 9: First observation of W production at STAR in 500GeV polarized p-p collisions at mid-rapidity
 - Run 9: First 500GeV production of polarized p-p collisions ($P \sim 40\%$ / $L \sim 14 \text{ pb}^{-1}$)
 - W^\pm Cross-section and Parity violating single-spin asymmetry measurement
- Critical analysis aspects:
 - Charge-sign discrimination at high p_T
 - Rejection and treatment of QCD background
- STAR W program at forward/backward rapidity:
 - Installation of STAR Forward GEM Tracker ($1 < \eta < 2$) (FGT): Summer 2011