W BOSON PRODUCTION IN POLARIZED P+P COLLISIONS

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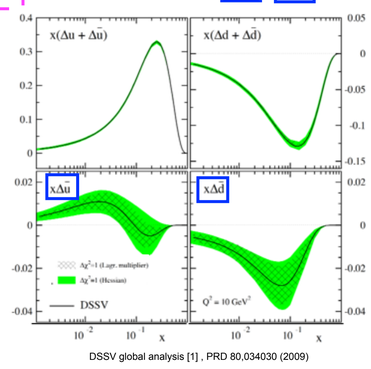
MOTIVATION

Proton Spin

One of the main contribution to the proton spin is coming from quark and antiquark polarization inside the proton.

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

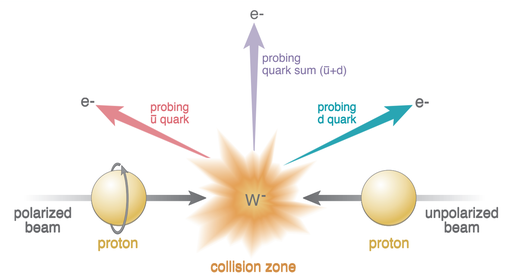


DSSV global analysis [1] , PRD 80,034030 (2009)

- Inclusive DIS experiment constrained integral of quark polarization ΔΣ to be ~30% but significant uncertainties remain for anti-quark polarization.

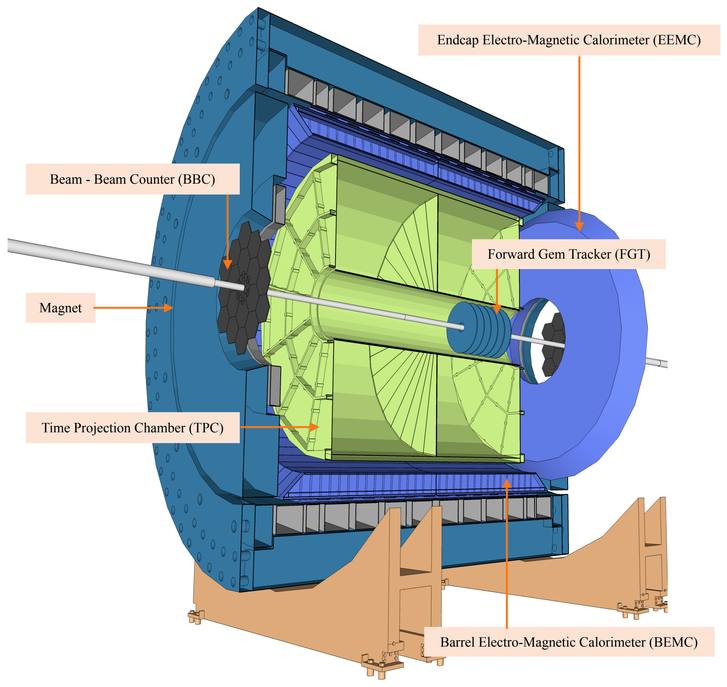
W - Boson Production

In polarized p+p collisions, W boson production is a unique tool to measure light quark and antiquark polarization of the proton

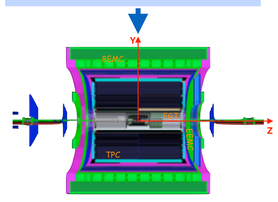


- Maximum parity violating coupling of Ws gives access to quark and antiquark helicity distribution functions.
- Very high scale (Q^2) is defined by the W mass and No fragmentation functions are required.
- Large parity violating single spin asymmetries (A_L) can be measured by varying helicity configurations of the incoming protons.

THE STAR EXPERIMENT



STAR coordinates



$$\eta = -\ln(\tan(\theta/2))$$

STAR detector η coverage

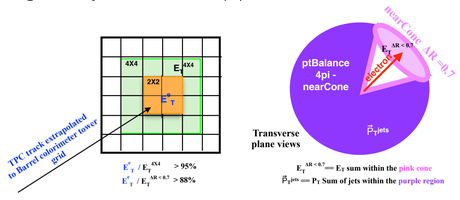
TPC	: -1.3 < η < +1.3
BEMC	: -1.0 < η < +1.0
EEMC	: +1.1 < η < +2.0
FGT	: +1.0 < η < +2.0

ANALYSIS

e^+/e^- candidate event selection

Selecting high transverse momentum (P_T >10 GeV) TPC tracks pointing to high transverse energy (E_T > 14 GeV) deposition in EMC

- Select reconstructed TPC tracks based on high energy trigger requirement and associate with primary vertex with |z|<100 cm.



- Extend high Pt TPC tracks, to match with 2x2 cluster energy (E^e_T) in EMC and require 90% energy deposition within the cluster.
- Use low energy sum requirement of w decay lepton outside the near-side cone around the candidate lepton tracks to isolate further.

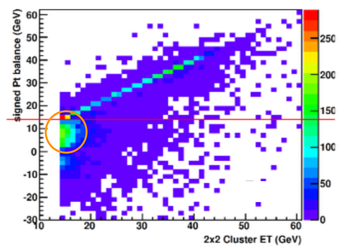
W candidate event selection

Use of imbalance in the vector P_T sum result by the large missing E_T due to undetected neutrino in a W⋯→e+ν event to differentiate from jet like event

signed pt balance (sP_T) vector:

$$\vec{p}_T^{\,balance} = \vec{p}_T^{\,e} + \sum_{\Delta R>0.7} \vec{p}_T^{\,jets}$$

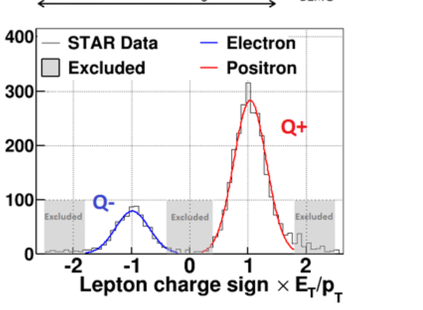
$$signed\ P_T - balance = \frac{(\vec{p}_T^{\,e} \cdot \vec{p}_T^{\,balance})}{|\vec{p}^{\,e}|}$$



- For W-decay leptons, sP_T correlated with E_T where as for jets sP_T is balanced by the opposite jet. (select events with sP_T >14 GeV as W candidate events)

W charge sign separation

Use of sign of the curvature (bending right or left in the magnetic field) of TPC tracks to discriminate W^+ from W^-.

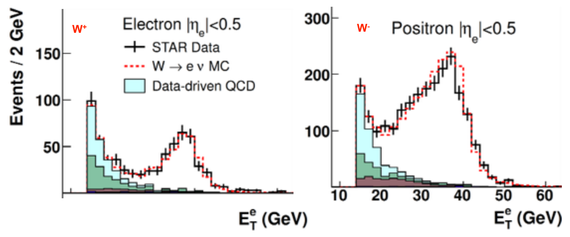


- Clear valley between opposite charge sign shows effectiveness of this discrimination of the TPC at relevant energies.

Background estimation

Reconstructed W candidate sample consist with well understood electroweak backgrounds and QCD background

BG channel	Estimating tool
W-> τ+ν	use PYTHIA+GEANT embedded simulation sample
Z->e^++e^-	use PYTHIA+GEANT embedded simulation sample
Second EEMC (because STAR is not hermetic detector)	calculate and approximate to real EEMC background.
QCD	use a data-driven BG shape

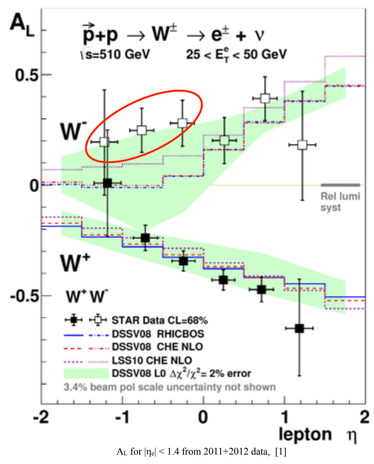


- Significant BG contribution is coming from QCD jet like events due to opposite jet escaping the detection.

RESULTS / RUN 12 + RUN 11

Leptonic Asymmetry from $W^{+/-}$ decay

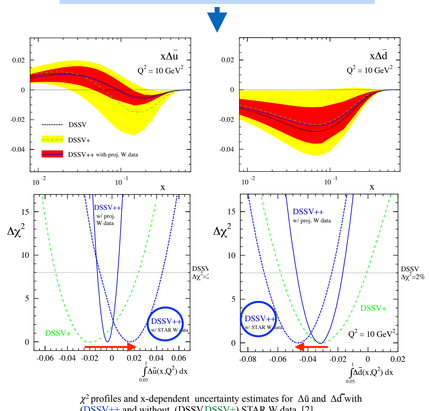
$$A_L = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} = \frac{1}{P}\frac{N_+/L_+ - N_-/L_-}{N_+/L_+ + N_-/L_-}$$



A_L for $|\eta_e|$ < 1.4 from 2011+2012 data, [1]

- Measured larger $A_L(W^-)$ for $\eta_e < 0$, than the theoretical predictions indicate large anti u quark polarization.

Impact of STAR W result



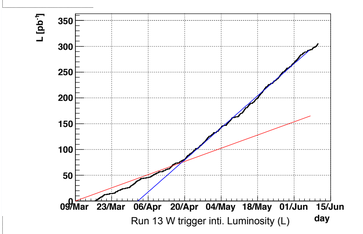
χ^2 profiles and x-dependent uncertainty estimates for $\Delta\bar{u}$ and $\Delta\bar{d}$ with (DSSV++ and without (DSSV,DSSV+) STAR W data, [2]

- DSSV++ which include preliminary run 12 W data shows significantly improved constraints on $\Delta\bar{u}$, $\Delta\bar{d}$ and shifts in the central value of $\Delta\chi^2$ minimum.

ANALYSIS STATUS / RUN 13

Data sample

In run 2013 STAR collected total luminosity of 300 pb^{-1}, which is more than three times of run 2012 data.



	L (pb^{-1})	Polarization (P)	FOM (P^2L)
Run 9	12	0.38	1.7
Run 11	9.4	0.49	2.3
Run 12	77	0.56	24
Run 13	**~300**	**~0.53**	**~84**

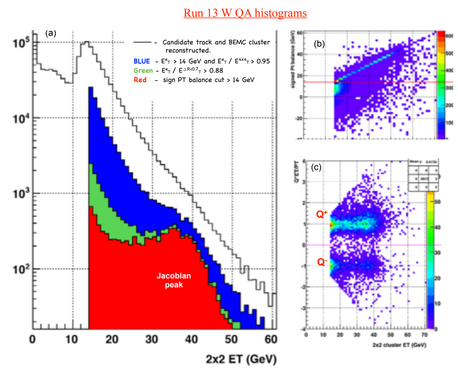
Run 13 statistics compare to previous years

QA of data

Half of the data is produced and QA of data analysis and detector calibrations is ongoing.

Jacobian peak : e^+ and e^- near mid-rapidity from W decay are characterized by a large E^e_T that peaks near half of the W mass (~ 40 GeV)

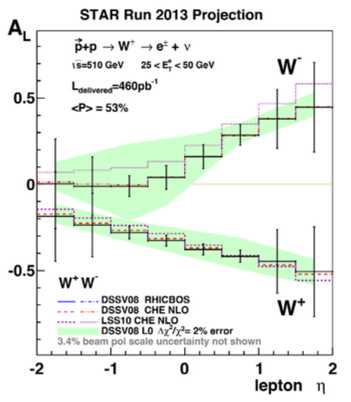
Run 13 W QA histograms



(a) : Quality of analysis cuts, (b) : Signed Pt balance variations, (c) : W charge sign separation.

Expectation / A_L

Higher precision A_L result is expected from run 2013 STAR W data using the STAR Forward Gem Tracker (FGT) in the forward η region.



STAR run Run 2013 projections

CONCLUSION

- Measured parity violating A_L for W boson production as a function of decay lepton pseudo rapidity η_e at STAR experiment provides significant constraints on $\Delta\bar{u}$ and $\Delta\bar{d}$.
- Recent results indicate significantly larger anti u quark polarization.
- Large statistics of run 13 will further constraints the light quark sea polarization.
- Ongoing analysis on extending A_L measurement from W boson production towards forward and backward regions of η_e using Forward Gem Tracker (FGT) will enhances sensitivity to $\Delta\bar{u}$ and $\Delta\bar{d}$.

REFERENCES

- [1] L. Adamczyk et al.(STAR Collaboration), Measurement of longitudinal spin asymmetries for weak boson production in polarized proton-proton collisions at RHIC, arXiv:1404.6880
- [2] The RHIC Spin program: Achievements and Future opportunities, arXiv: 1304.0079
- [3] D. de Florian, R. Sassot, M. Stratmann, and W. Vogelsang, Extraction of spin-Dependent parton Densities and Their Uncertainties, Phys. ReV. **D80**, 034030 (2009), arXiv:0904.3821