W BOSON PRODUCTION IN POLARIZED P+P COLLISIONS

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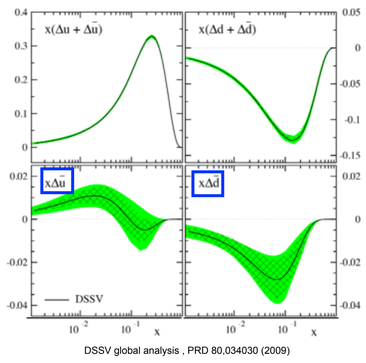
MOTIVATION

Proton Spin

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

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

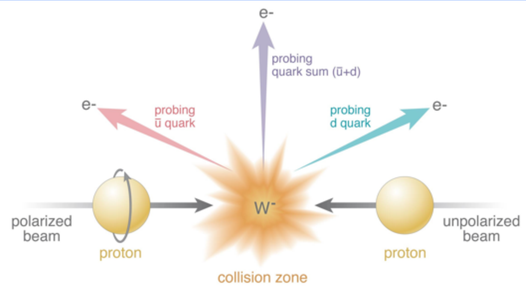


DSSV global analysis , PRD 80,034030 (2009)

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

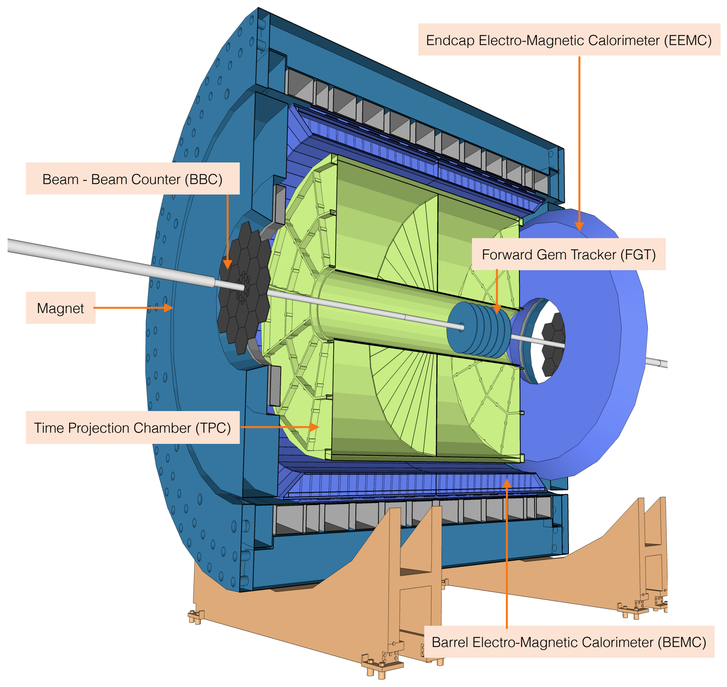
W - Boson Production

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

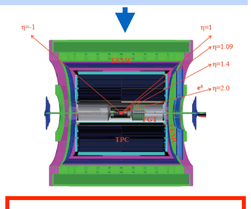


- Maximum parity violating coupling of Ws gives access to quark and antiquark pPDFs.
- Very high scale (Q^2) is defined by the W mass and No fragmentation functions are required.
- Large parity violating single spin asymmetries (A_L) can be measured by varying helicity configurations of the incoming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

THE STAR EXPERIMENT



STAR coordinates



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

STAR detector η coverage

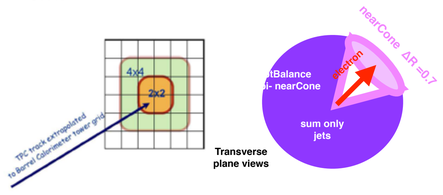
TPC	$-1.3 < \eta < +1.3$
BEMC	$-1.0 < \eta < +1.0$
EEMC	$+1.1 < \eta < +2.0$
FGT	$+1.0 < \eta < +2.0$

ANALYSIS

e⁺/e⁻ candidate event selection

Selecting high transverse momentum (p_t>10GeV) 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_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.

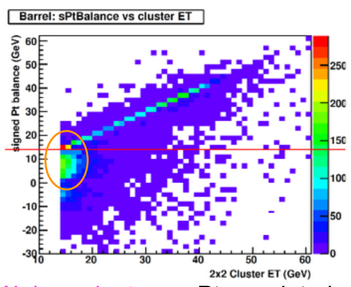
W candidate event selection

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:

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

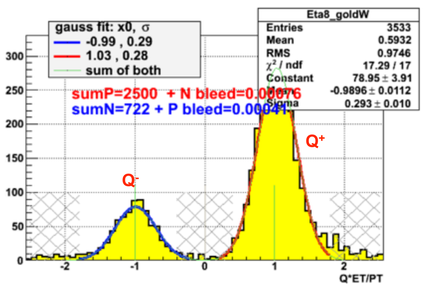
$$\text{signed } P_T\text{-balance} = \frac{\left(\vec{p_T}^{\,e} \cdot \vec{p_T}^{\,balance}\right)}{|\vec{p_T}^{\,e}|}$$



- For W-decay leptons, sPt correlated with E_t where as for jets sP_t is balanced by the opposite jet.

W charge sign separation

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

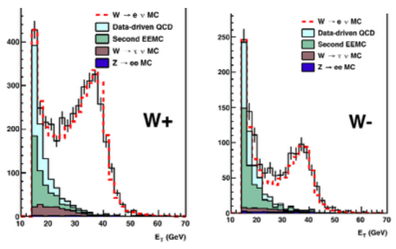


- Clear valley between opposite charge sign shows effectiveness of this discrimination of the TPC.

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	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



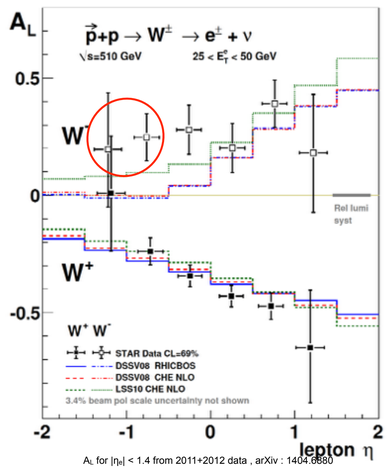
- Significant BG contribution is coming from QCD jet like events due to opposite jet escaping the detection.

RESULTS / RUN 12 + RUN 11

Leptonic Asymmetry from W-decay

$$A_L^{W^\pm} = \frac{1}{\beta^\pm}\frac{2}{P_1+P_2}\frac{R_{++}N_{++}^{W^\pm} - R_{--}N_{--}^{W^\pm}}{\Sigma_i R_i N_i^{W^\pm}} - \frac{\alpha^\pm}{\beta^\pm}$$

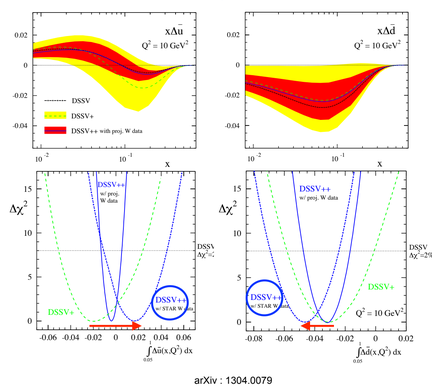
Where:, P_1,P_2 - Avg. beam polarization, N_{ii} - $W^{+/-}$ candidate yields, R_{ii} - Relative luminosities, α - polarized BG, β - unpolarized BG



A_L for $|\eta_e|$ < 1.4 from 2011+2012 data , arXiv : 1404.6880

- Larger $A_L(W^-)$ for η_e < 0 than the predictions indicate large anti u quark polarization.

Impact of STAR W result



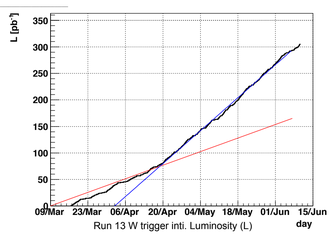
arXiv : 1304.0079

- DSSV++ which include run 12 W data shows significant constrain on Δū and Δd̄ and shift in the central value in $\Delta\chi^2$ 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.



Run 13 W trigger inti. Luminosity (L)

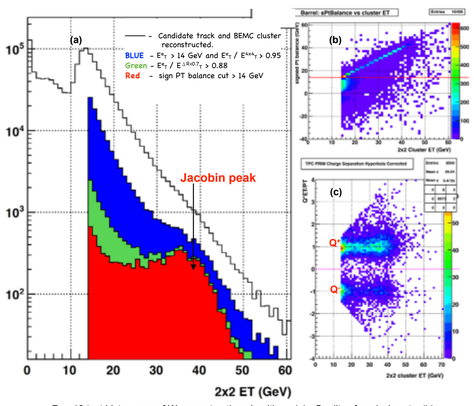
	L (pb	Polrization (P)	FOM (P
Run 9	12	0.38	1.7
Run 11	9.4	0.49	2.3
Run 12	77	0.56	24
Run 13	**~300**	**~0.53**	**~84**

Run 13 statistics compare to previous years

QA of data

Half of the data is produced and QA of both data and software algorithm is ongoing.

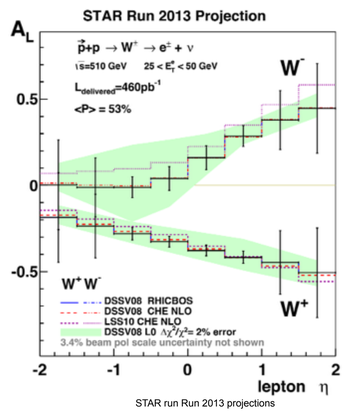
Jacobin peak : e^+ and e^- near mid-rapidity from W decay are characterized by a large E^e_T that peaks near half of the W mass (~ 40 GeV)



Run 13 test histograms of W reconstruction algorithm : (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 constrain on Δū and Δd̄.
- Recent result shows large $A_L(W^-)$ indicating large anti u quark polarization.
- Large statistics of run 13 will further constrain 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 minimize the predicted uncertainties.

REFERENCES

- SN-PRL-W2012-ver1.3 - Run 12 STAR Analysis notes
- PRL 106, 062002 (2011) - Run 2012 STAR W paper
- PRD 80,034030 (2009) - DSSV global analysis

AGS-RHIC user meeting, BNL, Upton, NY, USA, June 17-20, 2014.