

STAR 2013 W A_L Paper PWGC Preview

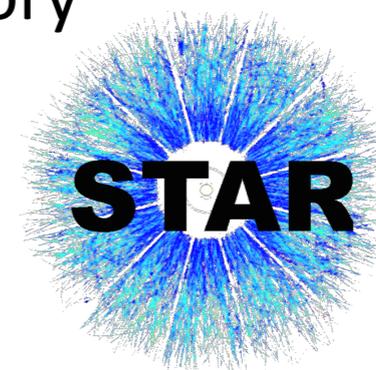
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- Introduction
- Proposed Abstract
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Introduction I

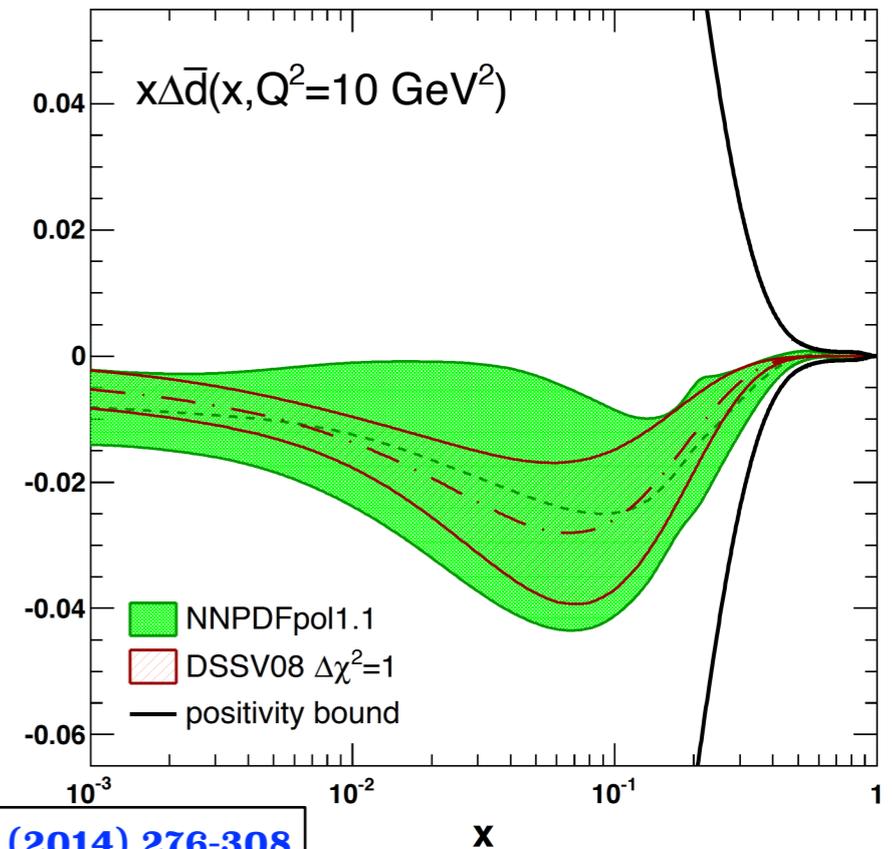
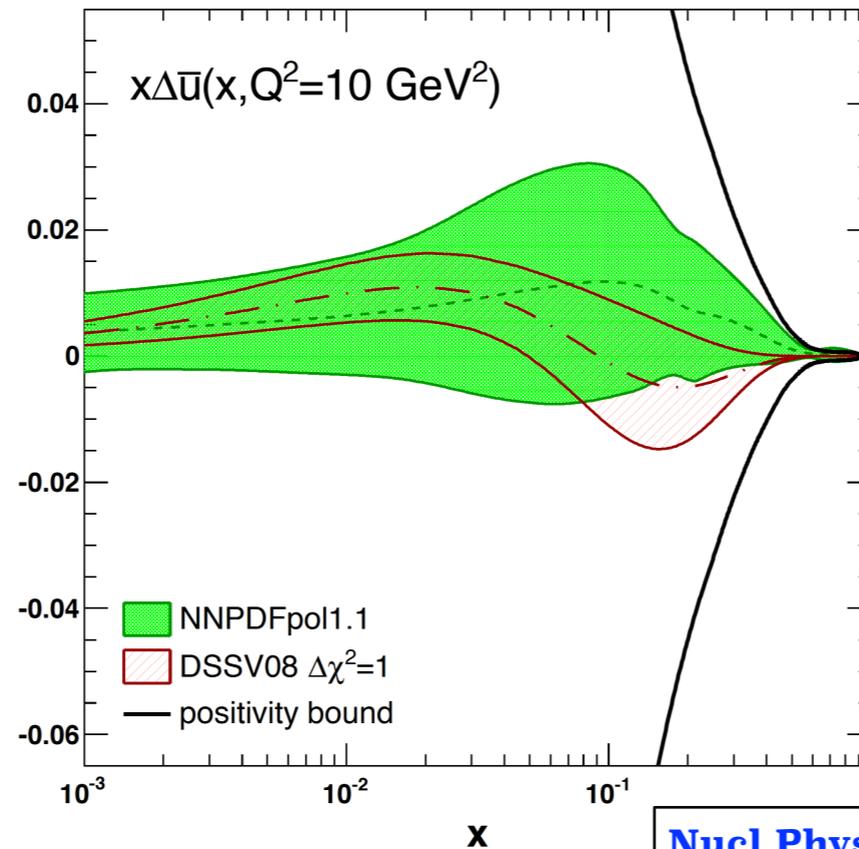
- **STAR PWG** : Spin
- **Title** : Measurement of the longitudinal single-spin asymmetry for W^+ and W^- boson production in polarized proton-proton collisions at RHIC
- **PAs** : Devika Gunarathne, Amani Kraishan, Ernst Sichtermann, Bernd Surrow, Qinghua Xu, and Jinlong Zhang
- **Target Journal** : Physical Review D Rapid Communications

Introduction II - Support Materials

- Paper Proposal Page : <https://drupal.star.bnl.gov/STAR/pwg/spinanalysisstatushtml/w-2013-analysis-meeting/run-2013-w-al-paper-proposal-webpage>
- Analysis Note : https://drupal.star.bnl.gov/STAR/system/files/analysisnote_6.pdf
- Preliminary Results Release:
 - INPC 2016, SPIN 2016, DIS 2017
- Presentations:
 - https://drupal.star.bnl.gov/STAR/system/files/CollaborationMeeting_run13WAL.pdf
 - https://drupal.star.bnl.gov/STAR/system/files/09-06-16-pwg-Update-BS.v2_0.pdf
 - https://drupal.star.bnl.gov/STAR/system/files/spin_mar13_v3.pdf

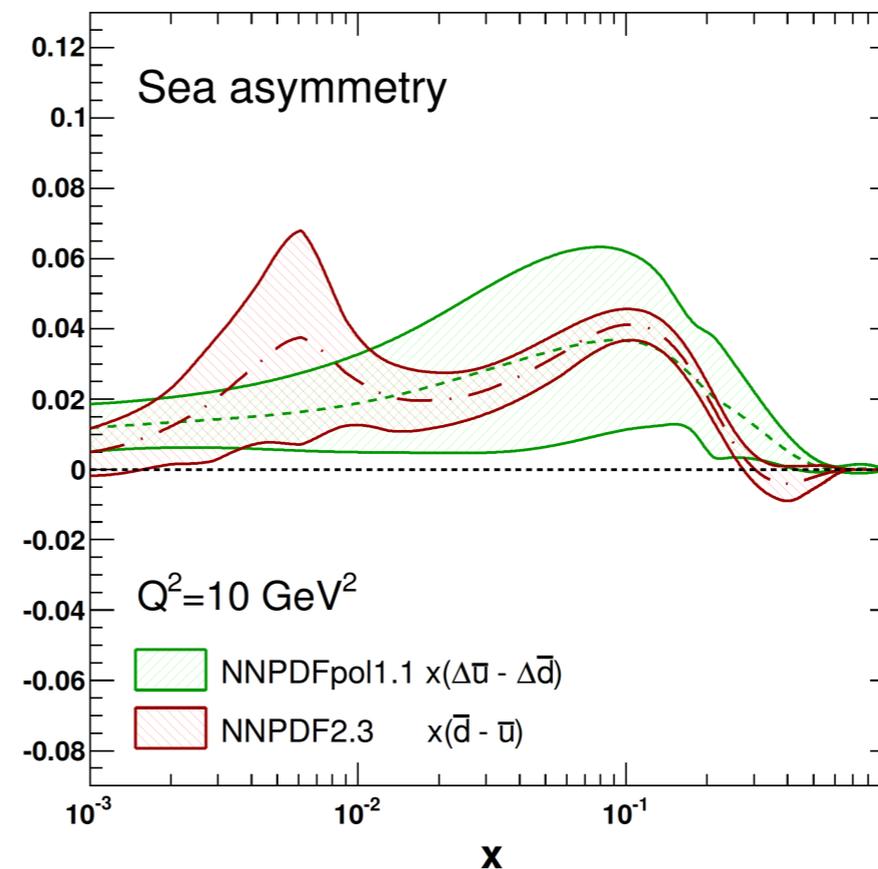
Introduction III - Physics Goal

- To further constrain the current understanding of light anti-quarks helicity PDFs.



Nucl.Phys. B887 (2014) 276-308

- To further constrain the current understanding of the polarized light quark sea asymmetry.



Proposed Abstract

Measurement of the longitudinal single-spin asymmetry for W^+ and W^- boson production in polarized proton-proton collisions at RHIC

STAR author list

(Dated: October 5, 2017, version 1.0)

We report new measurements of single- and double-spin asymmetries for W^+ and W^- boson production in polarized proton+proton collisions at $\sqrt{s} = 510$ GeV as a function of the decay lepton pseudorapidity. These new measurements based on 256 pb^{-1} of data are combined with previous results based on 86 pb^{-1} . The combined results are compared to theoretical predictions constrained by polarized deep-inelastic scattering measurements and prior results in polarized p+p collisions suggesting an asymmetry in the helicity distributions of anti-u and anti-d quarks for $0.05 < x < 0.2$.

Proposed Figure - 1

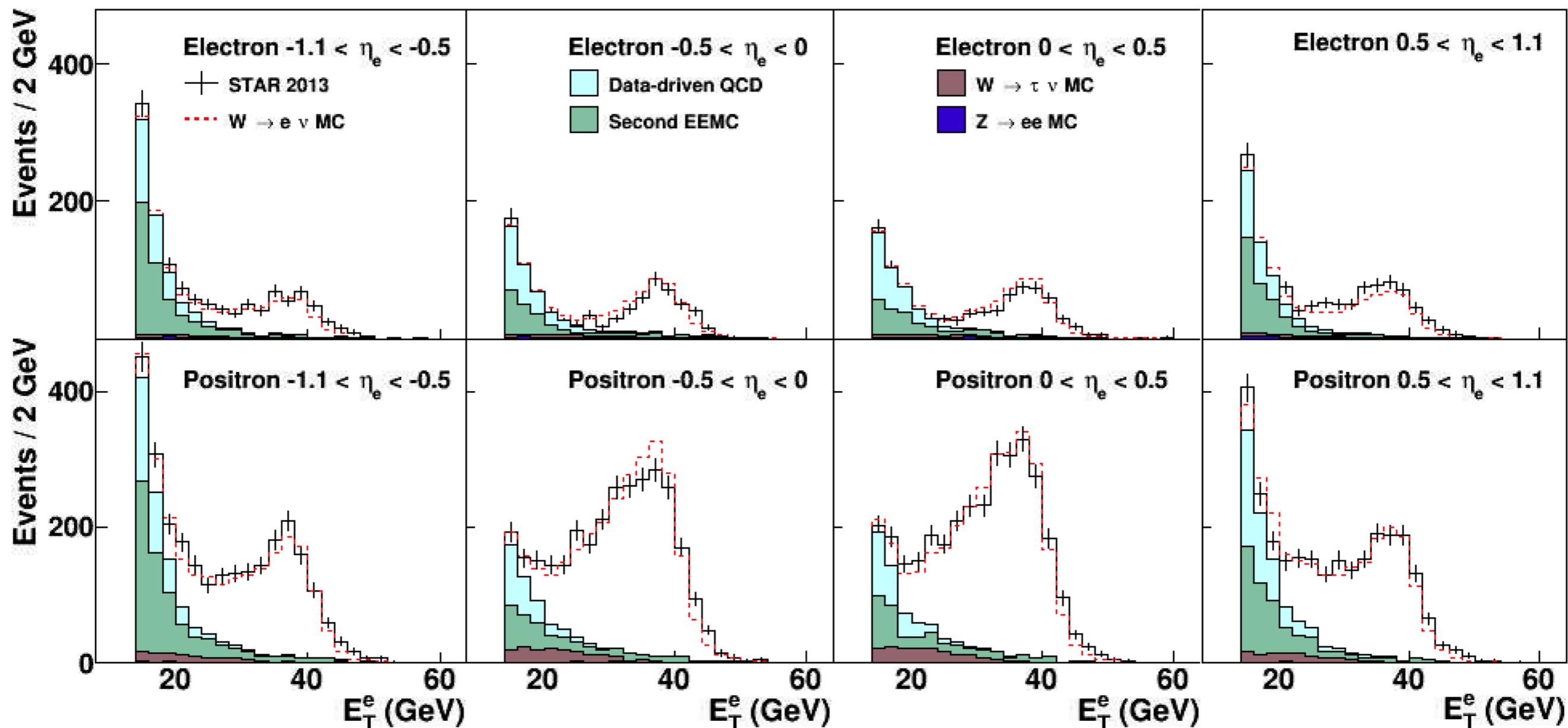


Figure 1. E_T^e distributions of W^- (top) and W^+ (bottom) candidate events (black), background contributions, and sum of backgrounds and $W \rightarrow e \nu$ MC signal (red-dashed) in the BEMC region.

Proposed Figure - 2

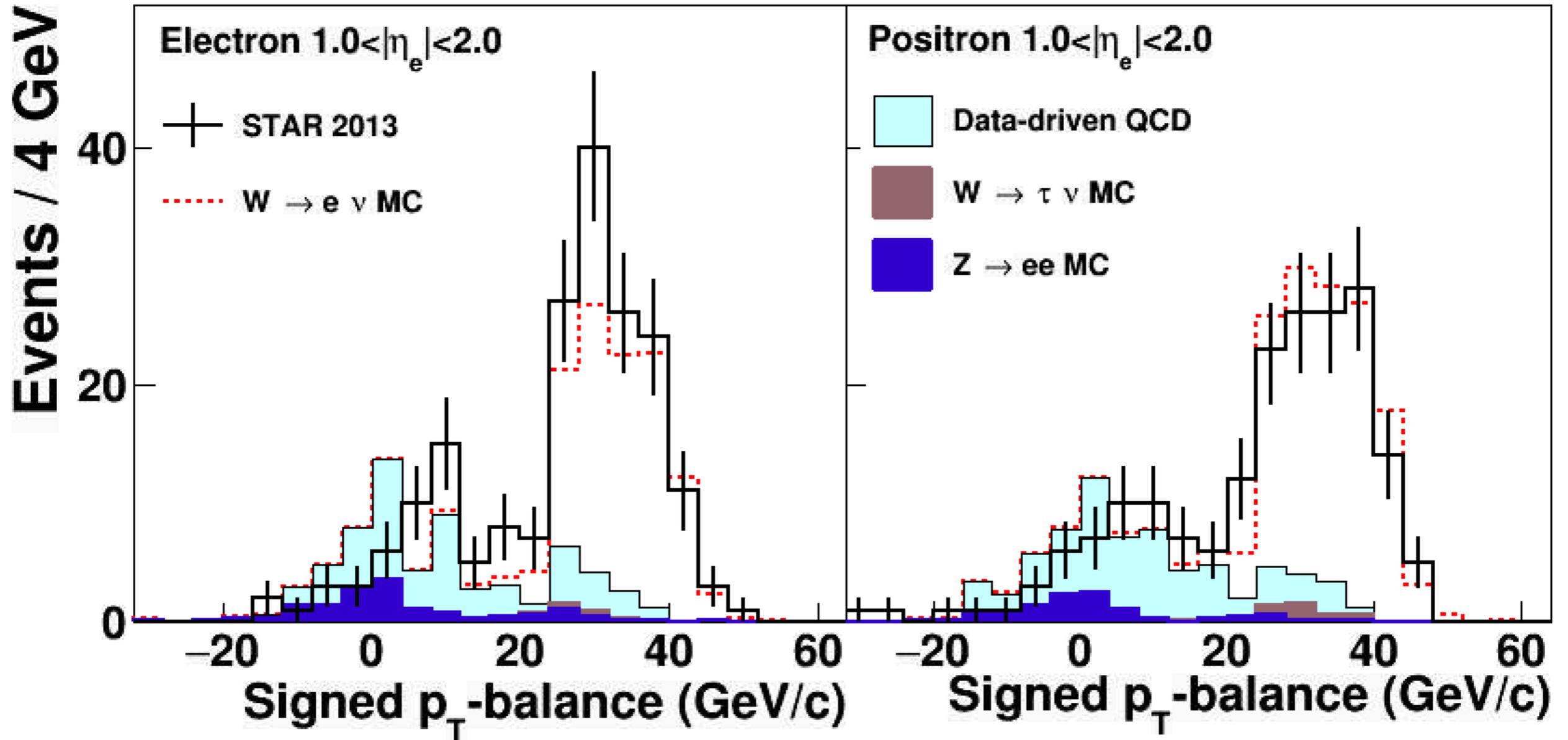


Figure 2. Signed p_T -balance distributions for W^+ (right) and W^- (left) candidate events (black), background contributions, and sum of backgrounds and $W \rightarrow e \nu$ MC signal (red-dashed) in the EMC region.

Proposed Figure - 3

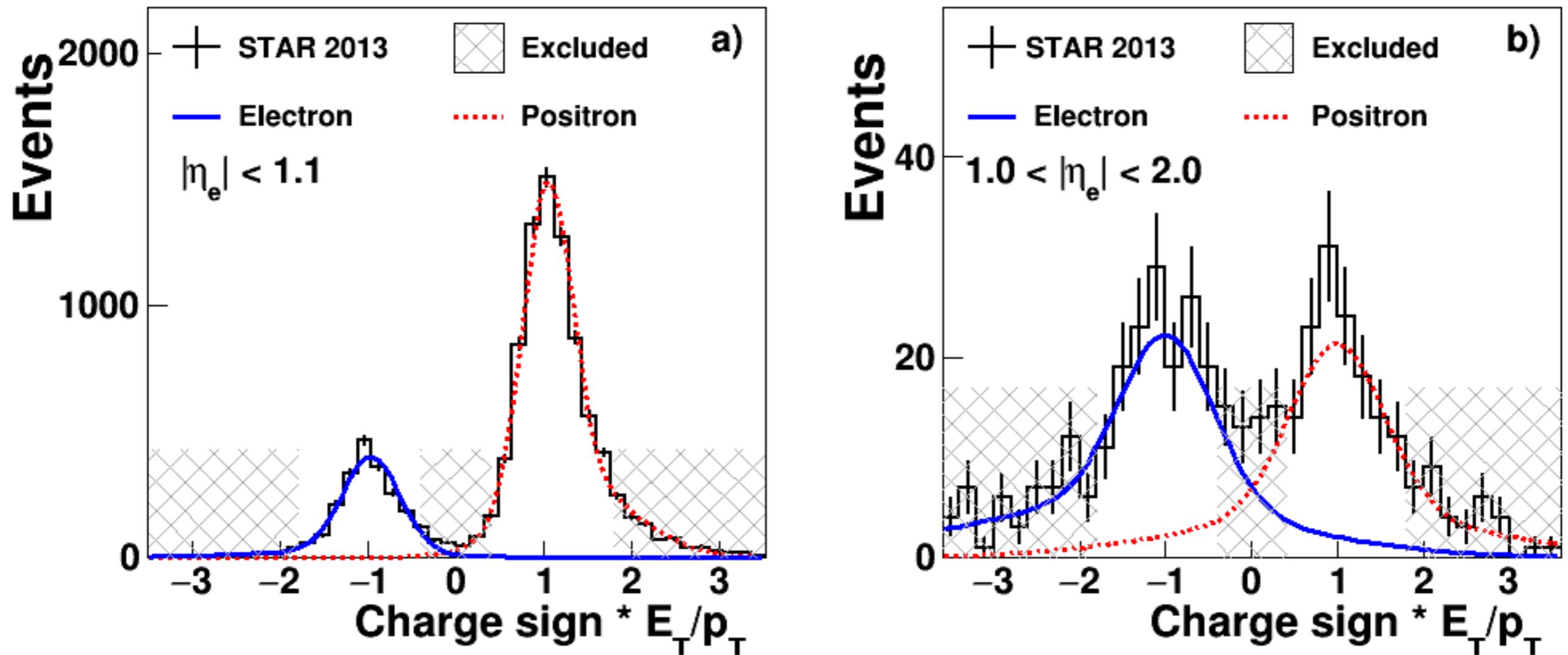


Figure 3. Distributions of the product of the TPC-reconstructed charge sign and E_T/p_T in the BEMC region (left) and the EEMC region (right). The electron (blue) and positron (red) candidate events have been fitted with double-Gaussian distributions. The excluded regions are marked by hatched shades.

Proposed Figure - 4

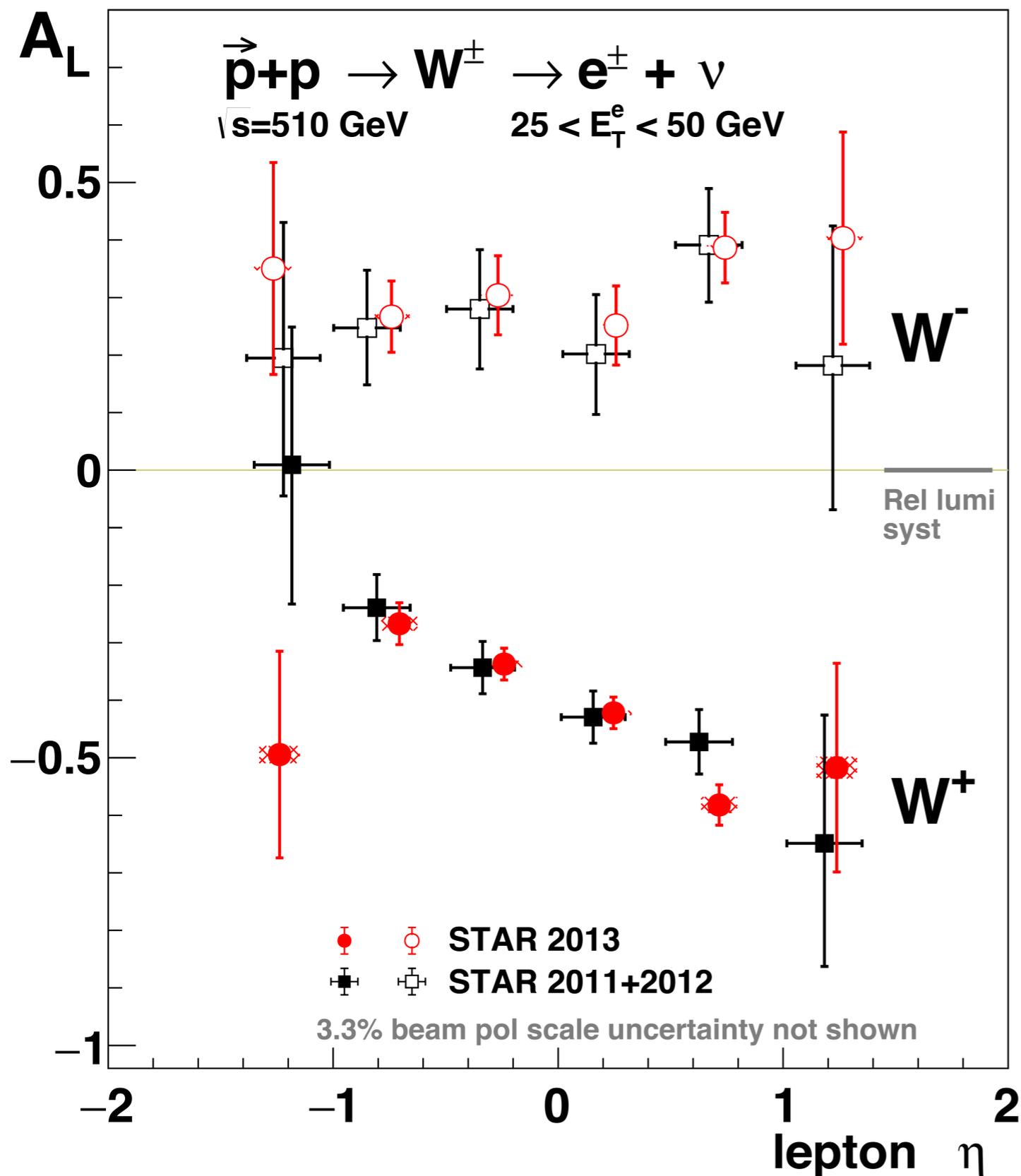


Figure 4. Longitudinal single-spin asymmetry, A_L , for W^\pm production as a function of the lepton pseudorapidity, η_e , separately for the 2011+2012 (black squares) and 2013 (red circles) STAR data samples for $25 < E_T^e < 50 \text{ GeV}$

Proposed Figure - 5

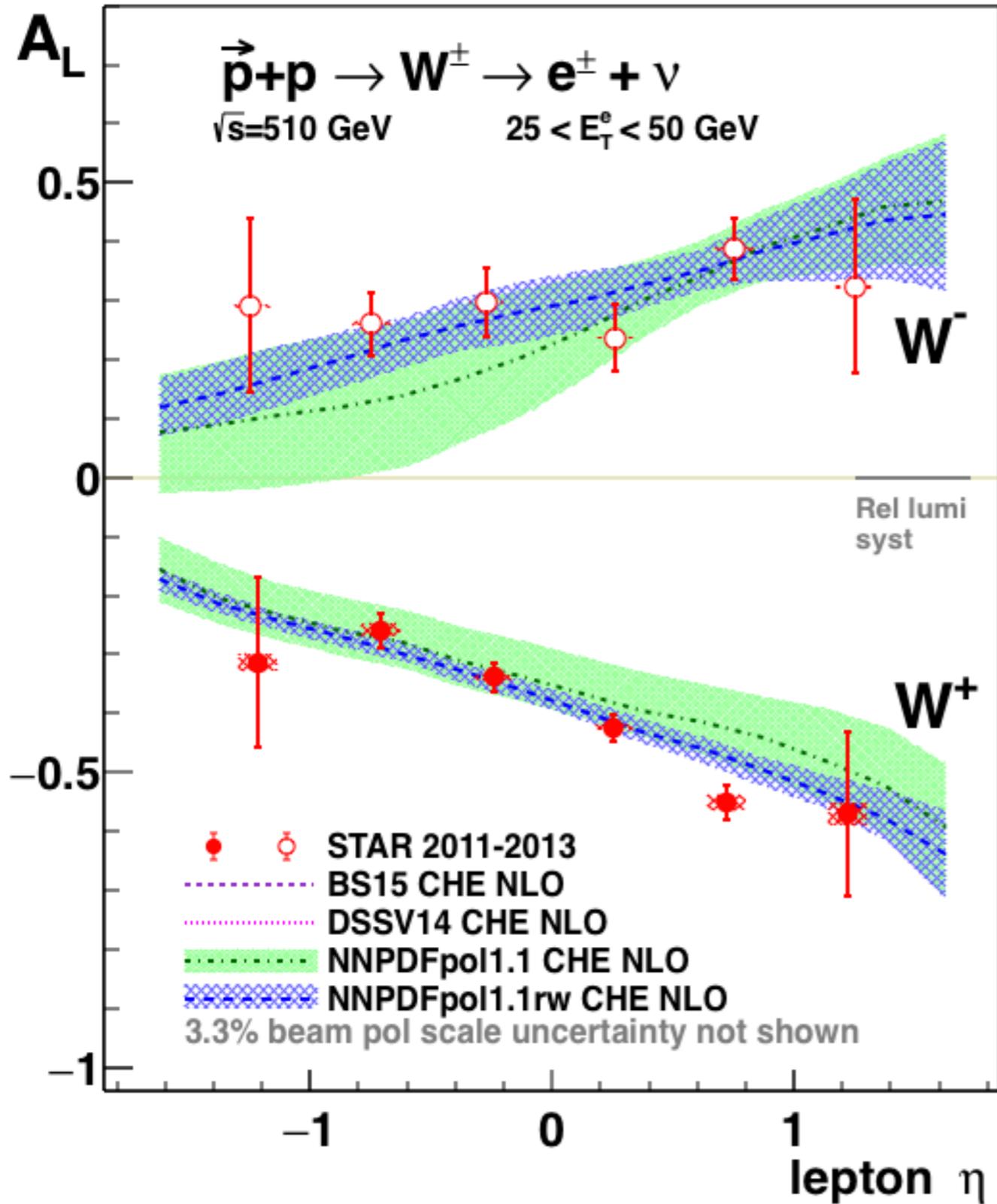


Figure 5. Longitudinal single-spin asymmetry, A_L , for W^\pm production as a function of the lepton pseudorapidity, η_e , for the combined 2011+2012 and 2013 (red circles) STAR data samples for $25 < E_T^e < 50 \text{ GeV}$ in comparison to theory predictions (See text for details)

Proposed Table

	$\langle \eta_e \rangle$	$A_L (\pm stat \pm syst)$		$A_{LL} (\pm stat \pm syst)$	
		2013	2011-2013	2013	2011-2013
W^+	-1.24	$-0.494 \pm 0.180 \pm 0.015$	$-0.314 \pm 0.144 \pm 0.015$		
	-0.71	$-0.267 \pm 0.036 \pm 0.012$	$-0.259 \pm 0.030 \pm 0.012$	–	–
	-0.24	$-0.337 \pm 0.028 \pm 0.006$	$-0.339 \pm 0.024 \pm 0.006$		
	0.25	$-0.422 \pm 0.027 \pm 0.004$	$-0.424 \pm 0.023 \pm 0.004$	$0.032 \pm 0.050 \pm 0.025$	$0.010 \pm 0.043 \pm 0.025$
	0.72	$-0.582 \pm 0.035 \pm 0.014$	$-0.551 \pm 0.030 \pm 0.014$	$0.063 \pm 0.065 \pm 0.025$	$0.083 \pm 0.055 \pm 0.025$
	1.24	$-0.517 \pm 0.181 \pm 0.019$	$-0.571 \pm 0.139 \pm 0.019$	$-0.053 \pm 0.328 \pm 0.060$	$-0.001 \pm 0.260 \pm 0.060$
W^-	-1.27	$0.350 \pm 0.184 \pm 0.003$	$0.292 \pm 0.146 \pm 0.003$		
	-0.74	$0.267 \pm 0.062 \pm 0.004$	$0.261 \pm 0.053 \pm 0.004$	–	–
	-0.27	$0.304 \pm 0.069 \pm 0.001$	$0.297 \pm 0.057 \pm 0.001$		
	0.26	$0.251 \pm 0.069 \pm 0.002$	$0.236 \pm 0.057 \pm 0.002$	$0.086 \pm 0.124 \pm 0.014$	$-0.003 \pm 0.104 \pm 0.014$
	0.74	$0.387 \pm 0.061 \pm 0.004$	$0.388 \pm 0.052 \pm 0.004$	$-0.126 \pm 0.111 \pm 0.014$	$-0.046 \pm 0.095 \pm 0.014$
	1.27	$0.403 \pm 0.184 \pm 0.003$	$0.324 \pm 0.148 \pm 0.003$	$-0.132 \pm 0.331 \pm 0.044$	$-0.146 \pm 0.260 \pm 0.044$

TABLE I. Longitudinal single- and double-spin asymmetries, A_L and A_{LL} for W^\pm production obtained from STAR 2013 data sample, as well as the combination with 2011+2012 results. The longitudinal single-spin asymmetry is measured over six pseudorapidity bins. The longitudinal double-spin asymmetry is measured over the same bins combining bins belonging to the same absolute value.

- Z boson A_L is also calculated. We plan to include the value either in the table or in the text, or in both.

Proposed Summary

In summary, we report a new STAR measurement of the longitudinal single-spin asymmetries, A_L , for W^+ and W^- , boson production in polarized proton+proton collisions at $\sqrt{s} = 510$ GeV. The production of W bosons in these collisions and their subsequent leptonic decay is a unique process to delineate the quark and anti-quark polarizations in the polarized proton by flavor. The data, combined with previously published STAR results, show a significant preference for an up anti-quark helicity distribution that is larger than the down antiquark helicity distribution in the fractional momentum range $0.05 < x < 0.2$ at a scale $Q^2 = 10 \text{ GeV}^2$, opposite to the spin-averaged quark-sea distributions.

BackUp

Data and Simulation

Data

	Run 13 Barrel Period 1	Run 13 Barrel Period 2	Run 13 Endcap Period 1	Run 13 Endcap Period 2	Run 12 (Barrel + Endcap)	Run 11 (Barrel + Endcap)
Production	P16ig	P16ig	P16ig	P16ig	P13ib	P11id
Int. Luminosity (QA'd)	124.16 pb ⁻¹	121.28 pb ⁻¹	109 pb ⁻¹	100 pb ⁻¹	77.4 pb ⁻¹	9.4 pb ⁻¹
Number of Runs	925	712	878	596	638	143
Beam Polarization	B = Y = 0.56	B = 0.55 Y = 0.57	B = Y = 0.49			

MC Simulation / Embedding

PYTHIA	Tune	STAR library	Tau Decay
6.4.28	Perugia 0 (320)	P16ig_embed	Tauola 2.7

Event Channel	PYTHIA Cross section	2013 Period 1	2013 Period 2	Run 12	Run 11
$W^+ \rightarrow e^+ \nu$	98.5 pb	135.6 K	147.4 K	109.1 K	11.9 K
$W^+ \rightarrow e^- \nu$	31.3 pb	43.5 K	47.4 K	34.9 K	3.8 K
$W^+ \rightarrow \tau^+ \nu$	98.5 pb	135.6 K	147.4 K	109.1 K	11.9 K
$W^+ \rightarrow \tau^- \nu$	31.3 pb	43.5 K	47.4 K	34.9 K	3.8 K
$Z/\gamma \rightarrow e^+ e^-$	23.9 pb	31.2 K	34.2 K	25.1 K	2.7 K

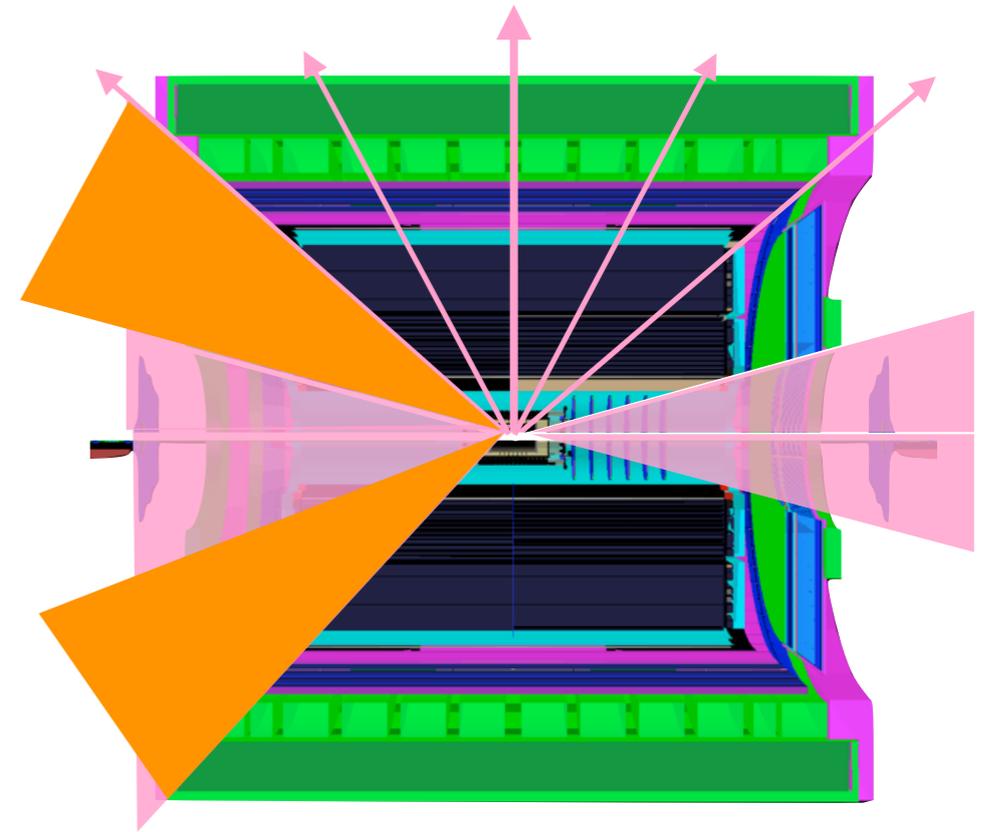
Analysis

W Selection Algorithm / Cuts

Trigger Level	Event Level	High Pt / high Et candidate e ⁺ level			W / Z candidate level
		High Pt track selection	High Et EMC 2x2 cluster Matching	EMC cluster Isolation	
<ul style="list-style-type: none"> Level 0 EMC tower ET > 7.3 GeV 	<ul style="list-style-type: none"> Primary Vertex : PPV "rank" > 0 	<ul style="list-style-type: none"> # of TPC hits > 15 nHitFrac > 51 % 	<ul style="list-style-type: none"> 2x2 ET > 14 GeV 	<ul style="list-style-type: none"> 2x2 / 4x4 > 95 % 	<ul style="list-style-type: none"> sign - Pt > 14 GeV
<ul style="list-style-type: none"> Level 2 EMC 2x2 cluster ET > 12 GeV 	<ul style="list-style-type: none"> Z_{vertex} < 100 cm 	<ul style="list-style-type: none"> Nearest TPC point radius < 90 cm Furthest TPC point radius > 160 cm Pt > 10 GeV 	<ul style="list-style-type: none"> Δr < 7 cm 	<ul style="list-style-type: none"> 2x2 / near Cone > 88% 	<ul style="list-style-type: none"> away side ET < 11 GeV

Background Estimation

Electro Weak BG	QCD BG
W → τ ^{±±} ν estimated using simulation	" Second Endcap " using EEMC
Z → e ⁺⁺ e ⁻ estimated using simulation	" Data- Driven QCD " using data-driven method of scaling QCD BG shape to data



Z invariant mass and A_L^{Z/γ^*}

