Antiquark pPDFs from parity violating single spin asymmetries in W production

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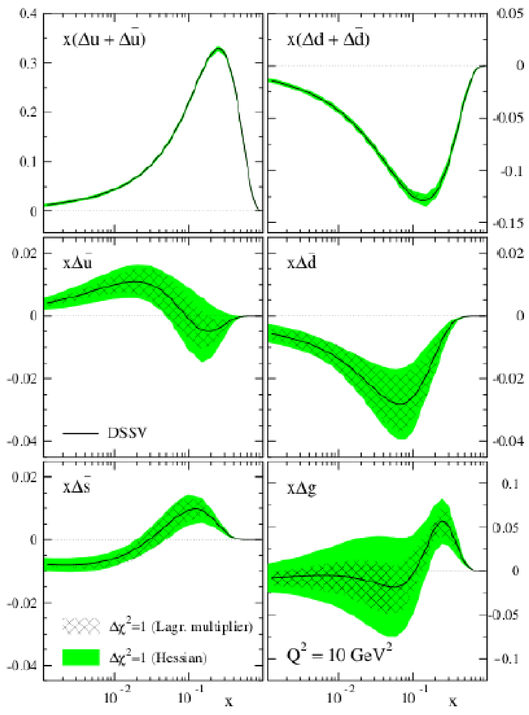
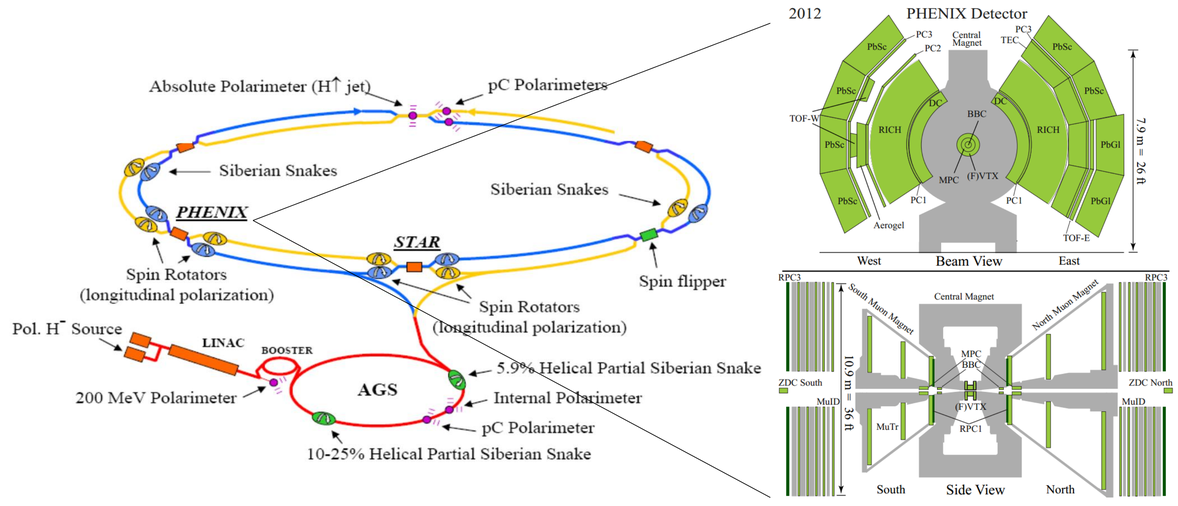
Motivation – large uncertainties on antiquark pPDFs

- (SI)DIS measurements have constrained quark polarized parton distribution functions (pPDFs) to a very good level
- Significant uncertainties remain for antiquark pPDFs
- The RHIC W program gives a clean measurement tool to improve our knowledge



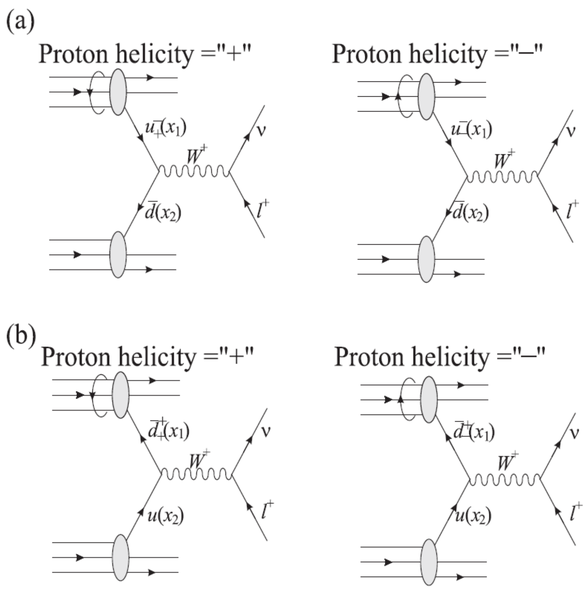
DSSV Global Analysis[3]

RHIC and PHENIX



- Highest energy polarized proton proton collider in the world
- One of the two major experiments at RHIC, PHENIX can measure W decay electron (in the central arms) and muons (in the forward, backward directions)

Using the W boson parity violating coupling

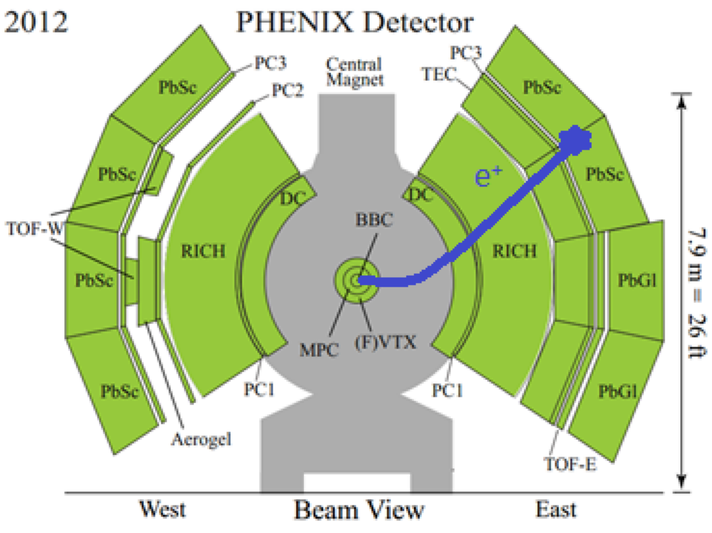


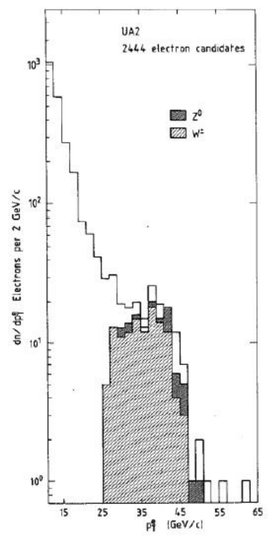
$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

$$A_L^{W^+}(y) = \frac{\Delta\bar{d}(x_1)u(x_2) - \Delta u(x_1)\bar{d}(x_2)}{\bar{d}(x_1)u(x_2) + u(x_1)\bar{d}(x_2)}$$

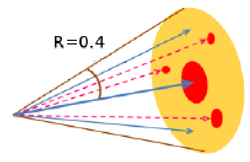
- Use W decays to access quark and antiquark polarized PDFs directly[1]
- Through the maximally parity violating nature of the W(+ above) coupling the decay lepton direction indicates the polarization direction of the antiquark

W measurements at PHENIX

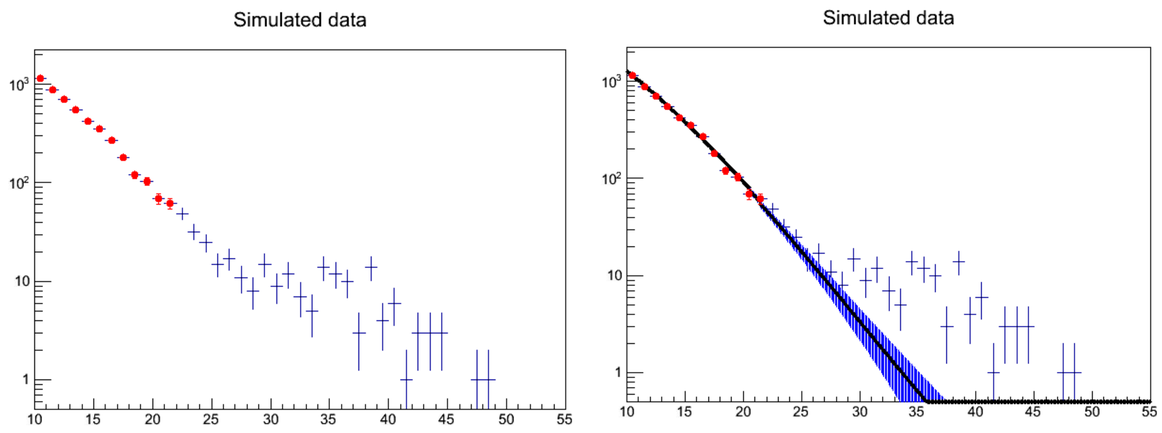




- Limited Φ coverage means the central arms can measure the decay electron only
- Main background discriminator is a relative isolation cut which excludes events that have more than 10% of the candidate energy in a R=0.4 cone



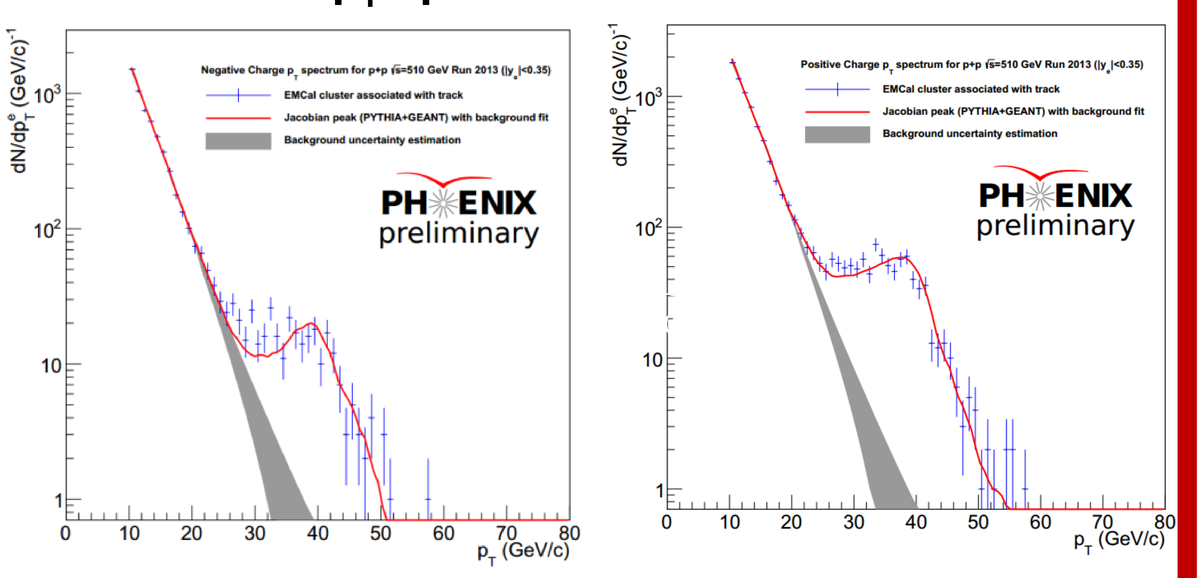
Gaussian Process Regression



$$k(x, x') = \sigma_f^2 \exp\left[\frac{-(x - x')^2}{2l^2}\right] + \sigma_n^2 \delta(x, x')$$

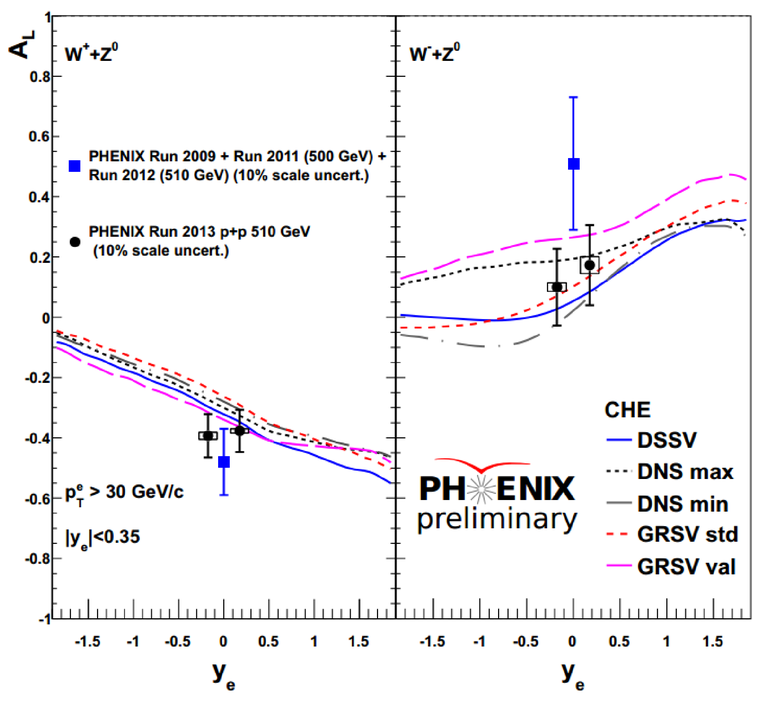
- Characterize background shape through the data points between 10 and 20 GeV
- Use correlation function to encode this relationship between the points and minimize to obtain hyperparameters [4-5]

p_T spectra for 2013 data



- The p_T spectra for both charges show a clear indication of the W signal
- The GPR determined background shape is tested together with a PYTHIA/GEANT generated signal shape against the data with very good consistency

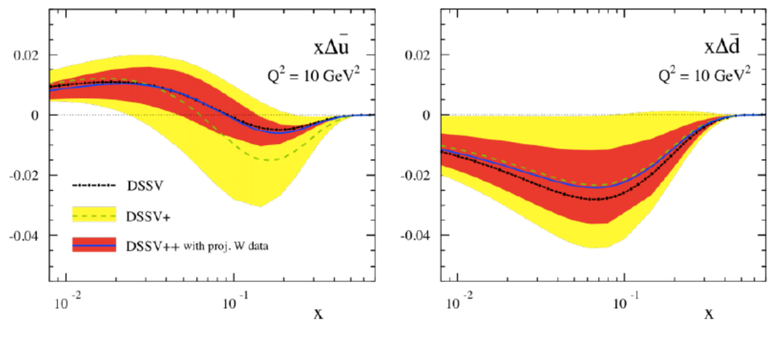
Single spin asymmetries



- The 2009, 2011 and 2012 data points are combined for better statistical accuracy
- The 2013 data can be separated into two rapidity bins to give more information on the shape of the asymmetry
- The single spin asymmetries obtained are consistent with the theoretical predictions

Conclusions

- Large parity violating W asymmetries were observed in the electron decay channel using the PHENIX central arm detector
- These asymmetries together with the PHENIX muon arm results and the ones obtained by the STAR collaboration are expected to be added into a Global Analysis with a significant impact on the uncertainties of the antiquark pPDFs expected



References:
1) J. Bunce *et. al,* Ann. Rev. Nucl. Part. Sci. **50**, 525-575 (2000).
2) E. Aschenauer *et. al*, The RHIC Spin Program: Achievements and Future Opportunities (2013).
3) D. de Florian *et. al.* Phys. Rev. D**80**, 034030 (2009).
4) David J. MacKay, Information Theory, Interference, and Learning Algorithms (2003).
5) C. E. Rasmussen and K. I. Williams, Gaussian Processes for Machine Learning (2006).