Neutron Extraction: A First Approach

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Outline

Overview

In order to extract neutron information from ^{3}He:

- Use polarizations of neutron and proton
- Correct for off-shell nucleon spin structure functions
- Use several models to compute g_1^p and $g_2^{p,WW}$
- Models used:
  - DSSV - Phys.Rev.Lett.101:072001,2008
  - BB - hep-ph/0203155
  - DNS2005 - D.de Florian, G.A. Navarro, and R. Sassot, Phys. Rev. D71 (2005) 094018.
  - GS - T. Gehrmann and W.J. Stirling, Phys.Rev. D53 (1996) 6100.
- **NOTE:**
  - $g_2^p = g_2^{p,WW}$
  - Neutron corrections valid for DIS region only ($x \lessapprox 0.5 - 0.6$)

^{3}He Correction

Calculate g_1^n and g_2^n from equations 1 and 2

$$g_1^{^3He} = (P_n + 0.056)\, g_1^n + (2P_p - 0.014)\, g_1^p \quad (1)$$

$$g_2^{^3He} = (P_n + 0.056)\, g_2^n + (2P_p - 0.014)\, g_2^{p,WW} \quad (2)$$

where:

- $g_1^{^3He}$ and $g_2^{^3He}$ are E06-014 data
- g_1^p and $g_2^{p,WW}$ are calculated from 4 models
- P_n = 0.86 $\pm$ 0.02 (neutron polarization)
- P_p = -0.028 $\pm$ 0.004 (proton polarization)
- 0.056 and -0.014 come from off-shell nucleon corrections (See Xiaochao Zheng thesis)

Polarized Structure Functions: g_1

4.74 GeV

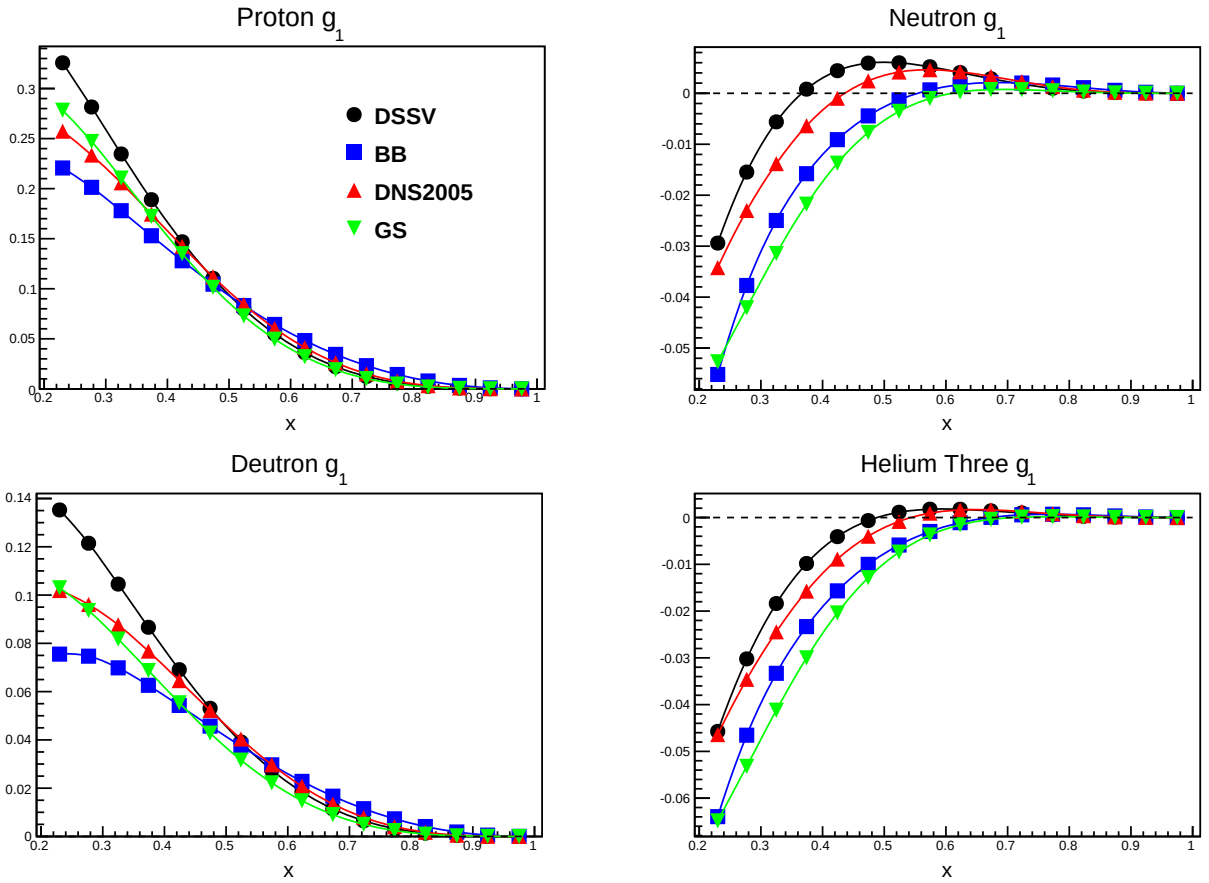


Figure: Each of the four models results for the proton, neutron, deuteron and helium three g_1 polarized structure function at beam energy of 4.74 GeV and E06-014 x and Q^2 values.

Polarized Structure Functions: g_2^{WW}

4.74 GeV

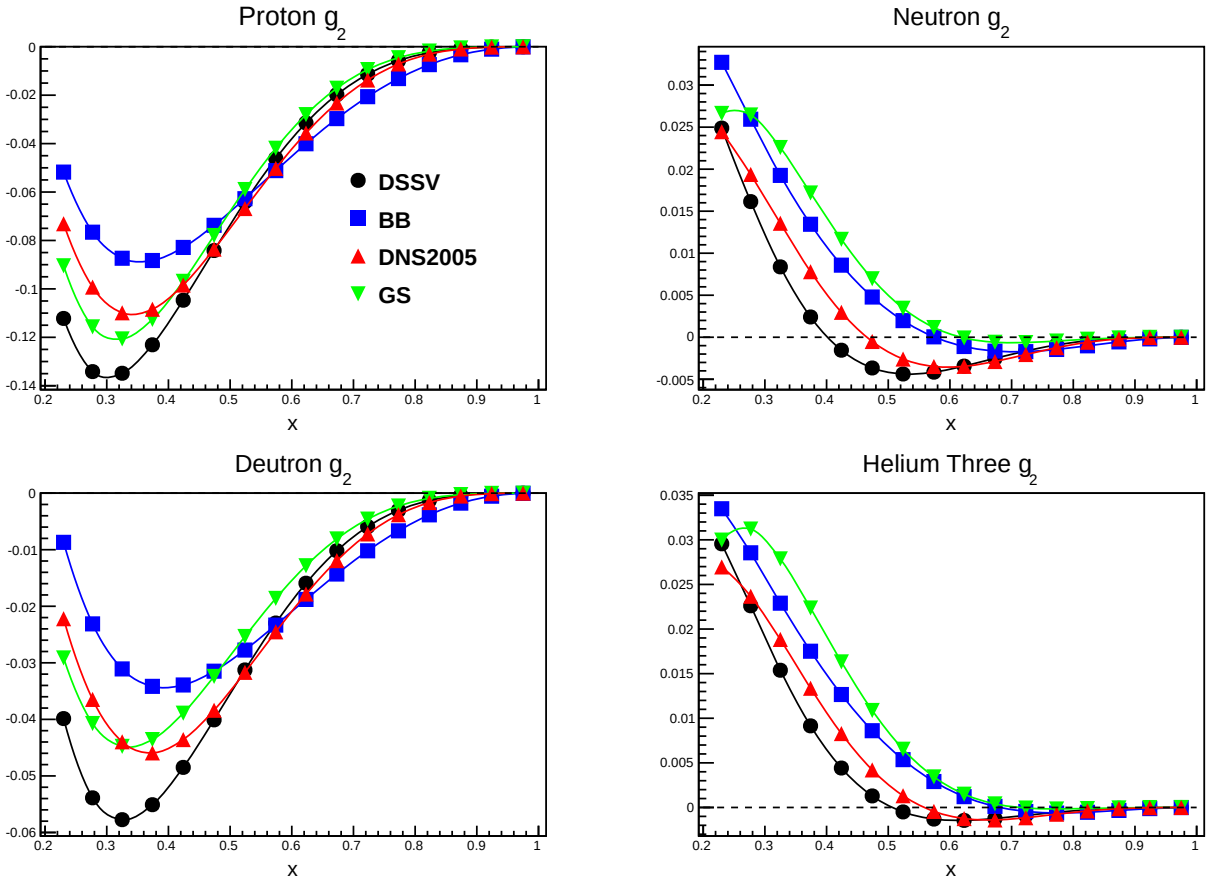


Figure: Each of the four models results for the proton, neutron, deuteron and helium three g_2^{WW} polarized structure function at beam energy of 4.74 GeV and E06-014 x and Q^2 values.

Polarized Structure Functions: g_1

5.89 GeV

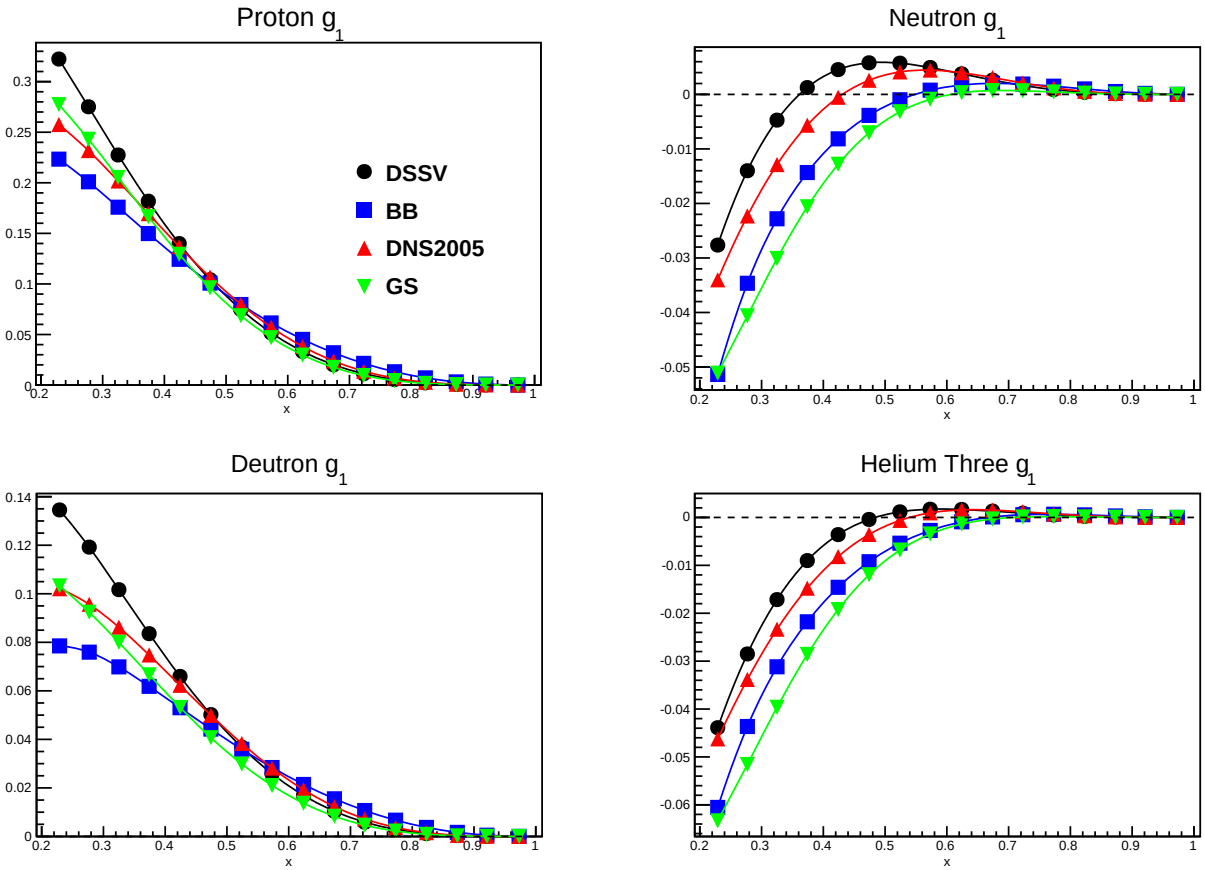
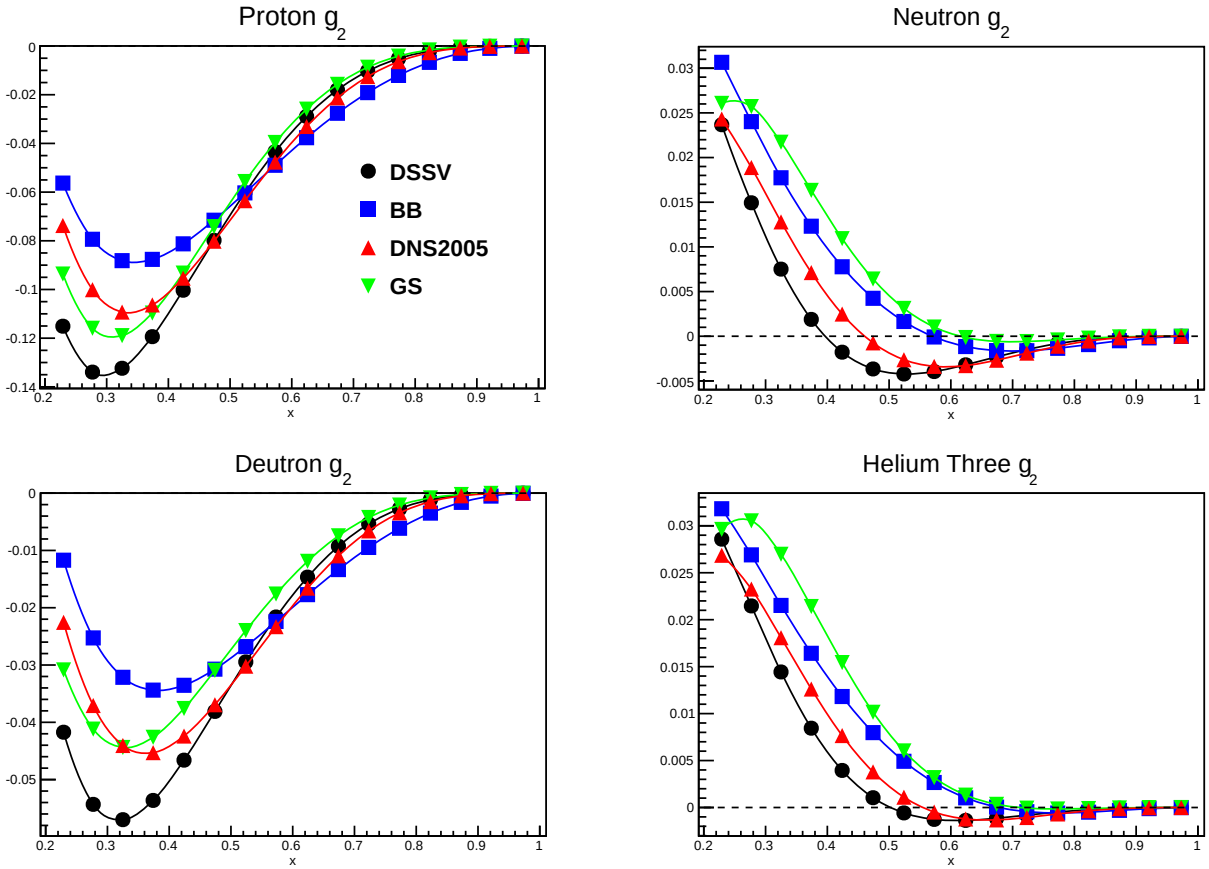


Figure: Each of the four models results for the proton, neutron, deuteron and helium three g_1 polarized structure function at beam energy of 5.89 GeV and E06-014 x and Q^2 values.

Polarized Structure Functions: g_2^{WW}

5.89 GeV



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Nuclear Correction Size

4.74 GeV

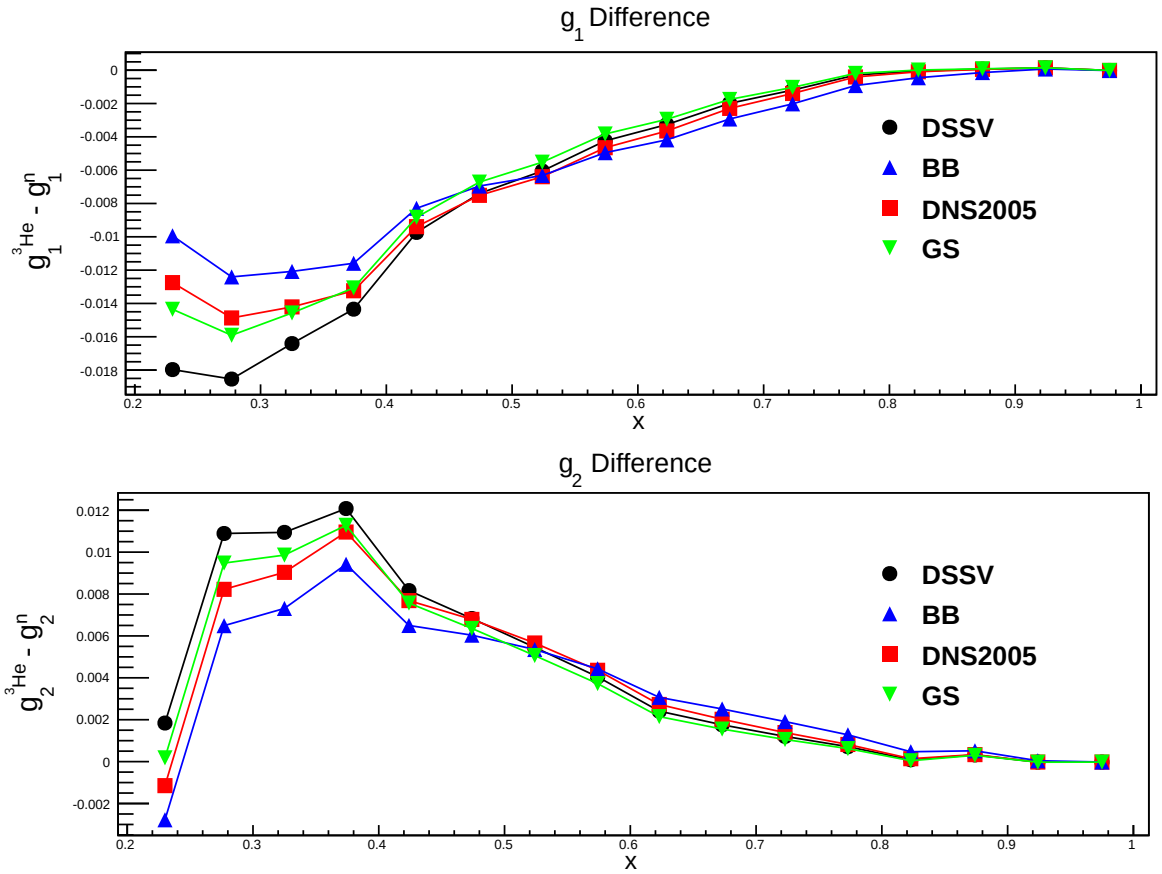


Figure: The difference between the ^{3}He and extracted neutron structure functions are shown as a function of x at a beam energy of 4.74 GeV.

Nuclear Correction

4.74 GeV

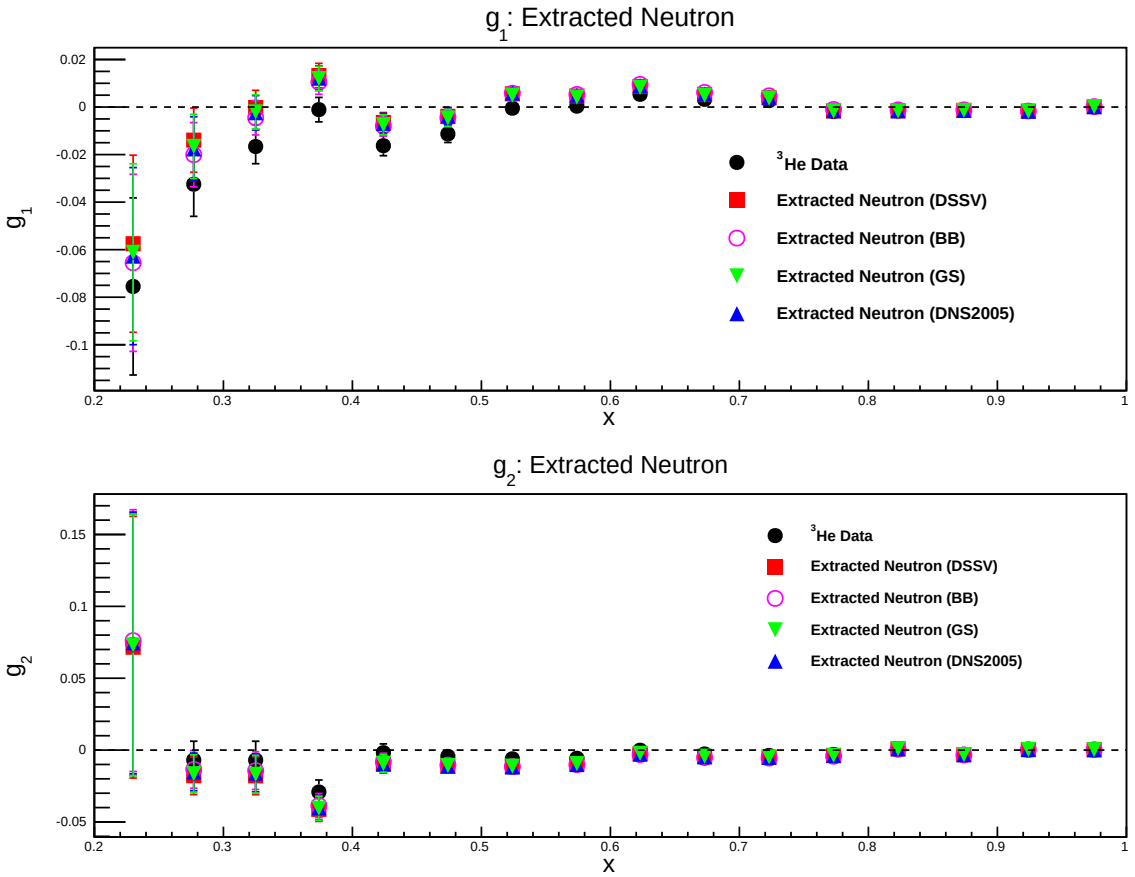
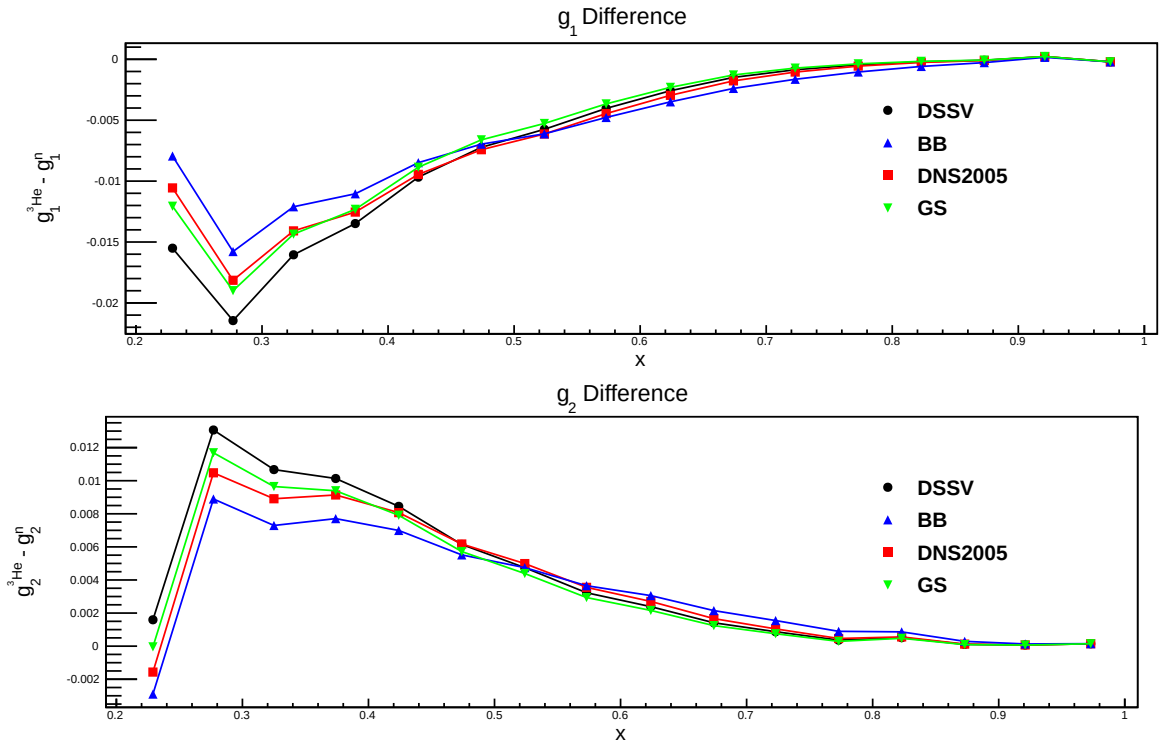


Figure: Plotted are the polarized structure function results to the neutron extraction using the defined method compared to the ^{3}He polarized structure functions at E = 4.74 GeV. All uncertainties are from ^{3}He statistical uncertainties.

Nuclear Correction Size

5.89 GeV



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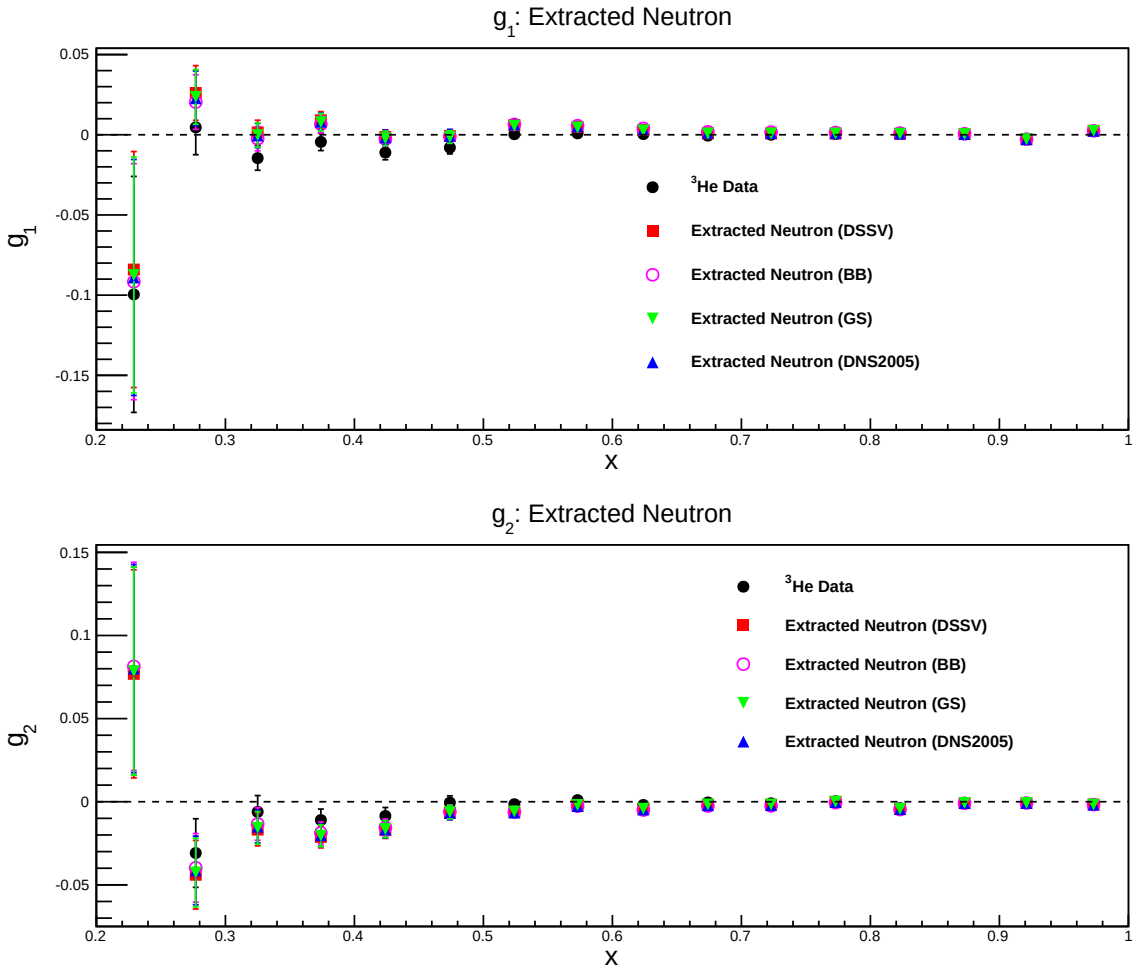
Nuclear Correction

5.89 GeV



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Systematic Uncertainty Contributions

The following uncertainties contribute to the total uncertainty:

- Neutron and proton polarizations
- Dependence from all models
- Dependence on a single model

The first two contributions are considered here

Polarization Uncertainties

The uncertainty from the neutron and proton polarization are given by:

$$(\delta g_1^n)^2_{P_p} = \left(\frac{2g_1^p}{P_n + 0.056}\delta P_p\right)^2 \quad (3)$$

$$(\delta g_1^n)^2_{P_n} = \left(\frac{g_1^{^3He} - (P_p - 0.014)\, g_1^p}{(P_n + 0.056)^2}\delta P_n\right)^2 = \left(\frac{g_1^n}{P_n + 0.056}\delta P_n\right)^2 \quad (4)$$

$$(\delta g_1^n)_{Pol} = \sqrt{(\delta g_1^n)^2_{P_p} + (\delta g_1^n)^2_{P_n}} \quad (5)$$

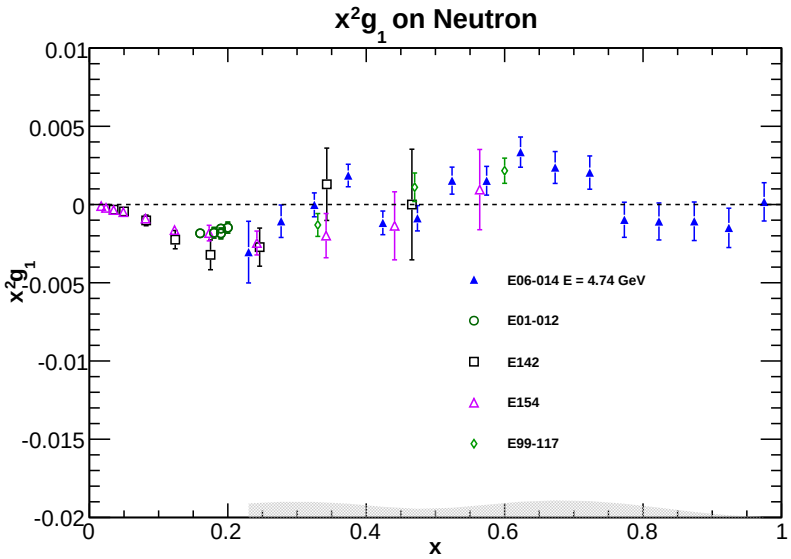
- Similar for g_2^n, with $g_1^n \to g_2^n$, $g_1^p \to g_2^{p,WW}$ and $g_1^{^3He} \to g_2^{^3He}$
- Each model gave similar uncertainties, so they were averaged together for each x bin.

Model Difference Uncertainty

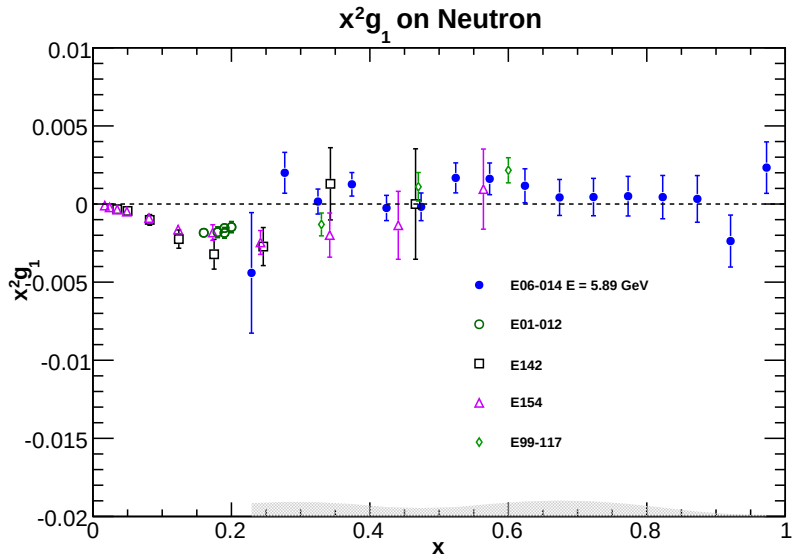
Assign an uncertainty based on difference between the 4 models

- Computed the difference of g_1^n and g_2^n from each of the models (i.e. $|g_1^n{}_{DSSV} - g_1^n{}_{GS}|$)
- The differences varied in size between the models, so largest difference was taken as the uncertainty for each x-bin
- Total systematic uncertainty is quadrature sum of the model difference and polarization uncertainties
- Total systematic uncertainty approximately order of magnitude smaller than statistical error.

g_1^n



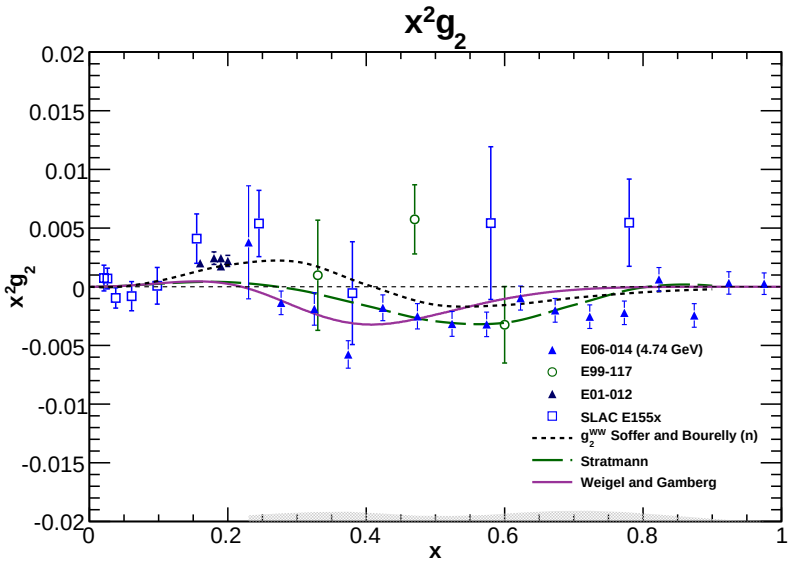
(a) 4.74 GeV



(b) 5.89 GeV

Figure: Preliminary g_1^n results for 4 and 5 pass data. The gray band represents the systematic uncertainty currently assigned to the neutron extraction. Note that these results are only valid up to x = 0.5 in the 4.74 GeV data and x = 0.6 in the 5.89 GeV data.

g_2^n



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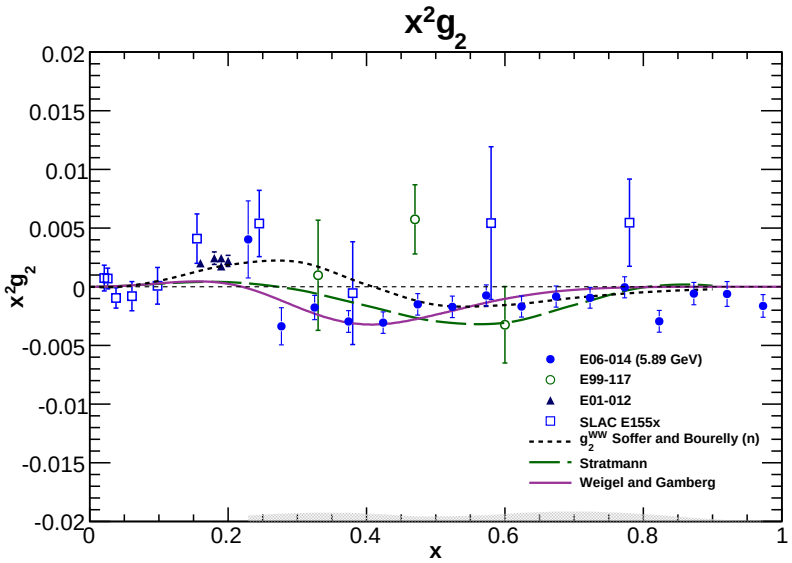

(b) 5.89 GeV

Figure: Preliminary g_2^n results for 4 and 5 pass data. The gray band represents the systematic uncertainty currently assigned to the neutron extraction. Note that these results are only valid up to x = 0.5 in the 4.74 GeV data and x = 0.6 in the 5.89 GeV data.

Summary

- All 4 models lead to similar polarized neutron structure functions
- Good agreement with world data
- For second approach:
  - Integrate Wally's neutron extractions
  - Correct resonance region corrections
  - Apply single model dependence (?)

To Do

- Form and fit LHRS,BB,CLAS and E142 e+/e- ratios to use for pair-production dilution factor
- Closer look at implementing bad preshower block in GEANT4
- Study distributions of $\pi^{+/-}$ and $e^{+/-}$ in BigBite
- Apply Wally's neutron corrections