Recent results on nuclear structure functions for light nuclei

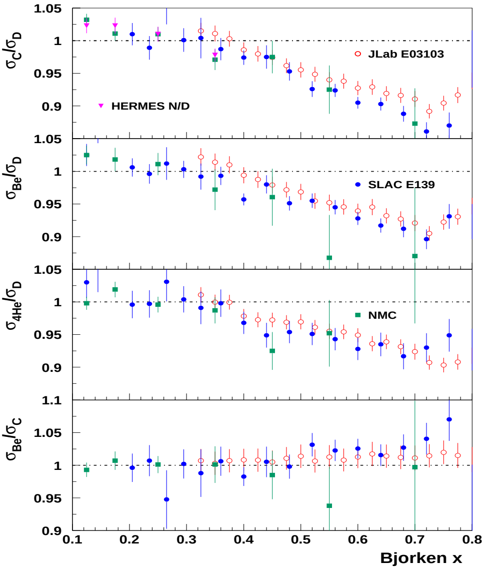
Roberto Petti[1]
Sergey Kulagin[2]

[1]U. of South Caroline, Columbia

[2]Institute for Nuclear Research, Moscow

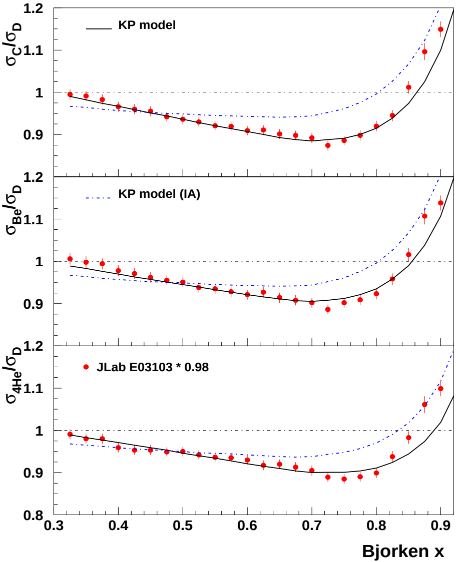
HiX Workshop at JLab
October 14, 2010

Consistency of different experiments



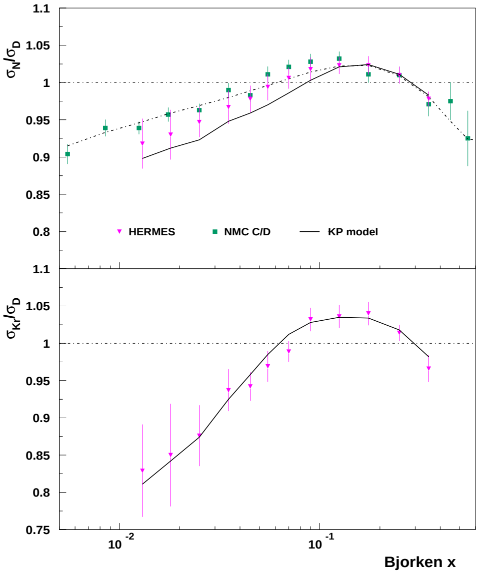
- Shapes of all nuclear cross-section ratios are consistent
- Evaluate χ^2 for each pair of experiments in coarse x-bins within the overlap region of the data sets
- Consistent overall normalization for SLAC E139, NMC and HERMES data sets
- The new JLab E03-103 data is systematically above previous measurements resulting in a $\chi^2/d.o.f. = 42.7/12$ with respect to SLAC E139 data on the same targets
- An overall normalization factor 0.98 for all JLab E03-103 points improves the statistical consistency with SLAC E139 data to $\chi^2/d.o.f. = 8.8/12$

Predictions for E03-103



- Apply overall normalization factor 0.98 to JLab data on ^{4}He/D, ^{9}Be/D and ^{12}C/D
- Very good agreement of our predictions with JLab E03-103 for all nuclear targets: $\chi^2/d.o.f. = 26.3/60$ for $W^2 > 2$ GeV^2 (for more details see SK and RP, arXiv:1004.3062 [hep-ph])
- Note that this is not a fit. Nuclear corrections at large x is driven by nuclear spectral function, the off-shell function $\delta f(x)$ was fixed from previous studies.
- A comparison with the Impulse Approximation demonstrates that the off-shell correction is crucial to describe the data leading to both modification of the slope and position of the minimum of the EMC ratios.

Predictions for HERMES



- A good agreement of our predictions with HERMES data for ^{14}N/D and ^{84}Kr/D with $\chi^2/d.o.f. = 14.7/24$
- A comparison with NMC data for ^{12}C/D shows a significant Q^2 dependence at small x in the shadowing region related to the cross-section for scattering of hadronic states off the bound nucleons nucleons.

  The model correctly describes the observed x and Q^2 dependence.

The ^{3}He/D and D/p data and F_2^n/F_2^p

- The ^{3}He/D data allows extraction of F_2^n/F_2^p. Comparison of F_2^n/F_2^p extracted from D/p and ^{3}He/D data provides a consistency test.

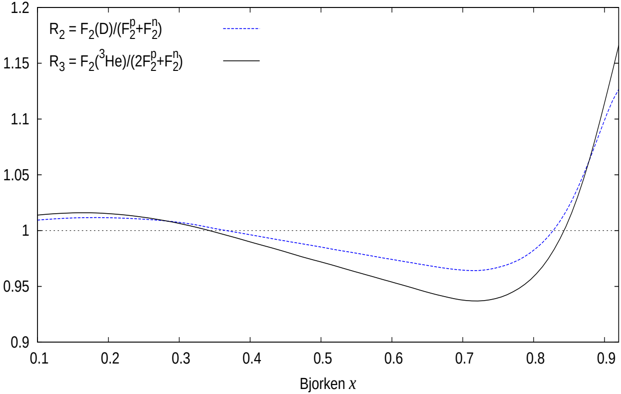
- $\mathcal{R}$(D/p) ratio. If we know $R_2 = F_2^D/(F_2^p + F_2^n)$ then

$$F_2^n/F_2^p = 2\mathcal{R}(\mathrm{D/p})/R_2 - 1$$

- $\mathcal{R}(^3\mathrm{He/D})$ ratio. If we know R_2 and $R_3 = F_2^{3\mathrm{He}}/(2F_2^p + F_2^n)$ then

$$F_2^n/F_2^p = (2-z)/(z-1), \text{ with } z = \tfrac{3}{2}\mathcal{R}(^3\mathrm{He/D})R_2/R_3$$

How about R_2 and R_3?

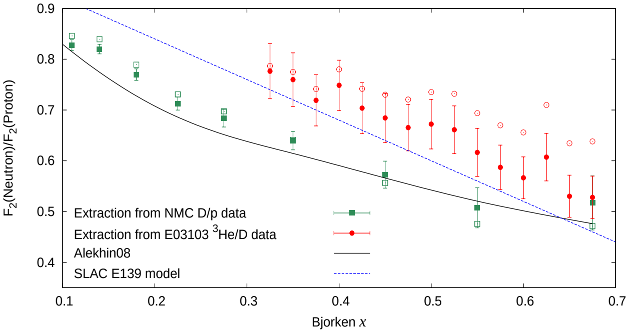


R_2 and R_3 were calculated at the values of x and Q^2 of E03-103 kinematics for $x > 0.3$ and at fixed $Q^2 = 3\,\text{GeV}^2$ for $x < 0.3$.

The Paris wave function was used for D, while the Hannover spectral function was used for ^{3}He.

- R_2 and R_3 are similar. A dip at $x \sim 0.7$ is somewhat bigger for R_3 because of stronger binding in ^{3}He.
- Nuclear effects cancel at $x \approx 0.35$, which is consistent with the measurement of EMC effect in other nuclei.

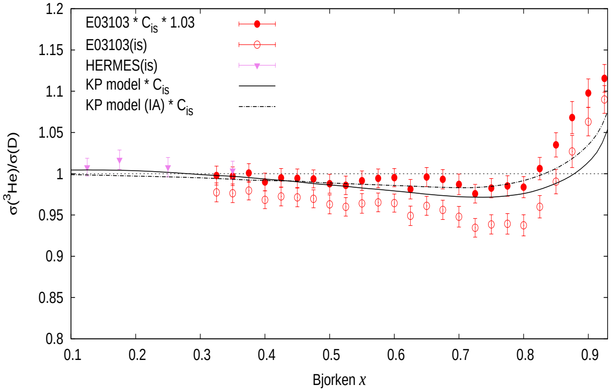
Extraction of F_2^n/F_2^p



Extraction of F_2^n/F_2^p with the full treatment of nuclear effect (full symbols) and also with no nuclear effects ($R_2 = R_3 = 1$, open symbols).

- Significant mismatch in F_2^n/F_2^p extracted from different experiments. At $x \sim 0.35$, where nuclear corrections are negligible, the F_2^n/F_2^p from E03-103 is 15% higher than that from NMC.
- Normalization of F_2^n/F_2^p is directly related to normalization of ^{3}He/D. Requiring F_2^n/F_2^p from E03-103 match NMC, we obtain a renormalization factor of $1.03^{+0.006}_{-0.008}$ for ^{3}He/D data.

^{3}He/D from HERMES and E03-103



To correct for proton excess, HERMES applies the factor

$$C_{is} = \frac{AF_2^N}{ZF_2^p + NF_2^n}$$

with F_2^n/F_2^p from NMC. E03-103 experiment does it differently, however correction factors are known.

- An unbiased way would be to compare uncorrected data, or corrected in a similar way. However, HERMES exact correction factors are lost. We uncorrect E03-103 data and then apply C_{is} together with the factor 1.03.
- After renormalization, E03-103 and HERMES data agree at the overlap ($x = 0.35$). Our calculation agree with both data (except the region $x > 0.8$).

Summary

- From a χ^2 analysis, we found a good agreement between NMC, SLAC E139 and HERMES data in the overlap region $0.1 < x < 0.7$.
- JLab E03-103 data appear systematically shifted above SLAC E139 data by an overall normalization factor $0.98^{+0.005}_{-0.003}$ common to all studied nuclei with $A \geq 4$.
- At small $x < 0.05$, the shadowing effect is more pronounced in the HERMES ^{14}N data compared to the NMC ^{12}C data. This difference can be attributed to the Q^2 dependence, since the average Q^2 of the HERMES experiment is significantly lower than the corresponding one of the NMC experiment. This effect is also confirmed by calculations in a model.
- To verify the consistency of ^{3}He/D data, we study the relation of that to F_2^n/F_2^p ratio. We extract F_2^n/F_2^p from both, the E03-103 data on the ^{3}He/D ratio and the NMC data on the D/p ratio. We found that at $x = 0.35$ and $Q^2 \approx 3\,\mathrm{GeV}^2$ the ratio F_2^n/F_2^p from JLab E03-103 data is about 15% larger than that from the NMC data. Both extractions of F_2^n/F_2^p become consistent if a normalization factor of $1.03^{+0.006}_{-0.008}$ is applied to the ^{3}He/D data of E03-103 experiment. After such renormalization the E03-103 and HERMES data on the ^{3}He/D ratio also become consistent, and our predictions are in a good agreement with both data sets in the region $x < 0.85$.