Shadowing Effects in Nuclear Parton Distributions

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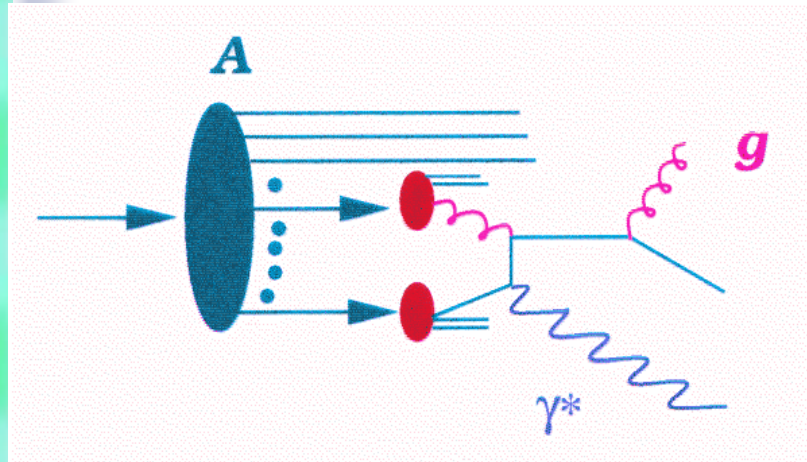
Introduction

- **Experiment**
  - **Overwhelming number of low and high energy reactions do not know anything about the size of the nucleon**
  - **Nuclear shadowing might be most suitable laboratory for studying the role of nucleon topology for PDF**
- **Theory**
  - **Momentum space considerations and light-cone approach are equally successful in describing the shadowing effects within experimental errors.**
  - **Which technique is most adequate when experimental precision increases?**

Parton fusion process



- **Geometrical parameters that might be involved in the overlap of partons in a nucleus:**
  - R_A **– nuclear radius**
  - R_i **– internucleon spacing**
  - R_N **– nucleon radius**

Experimental status

Q^2 INDEPENDENCE of NUCLEAR

SHADOWING : Hermes, E665, NMC

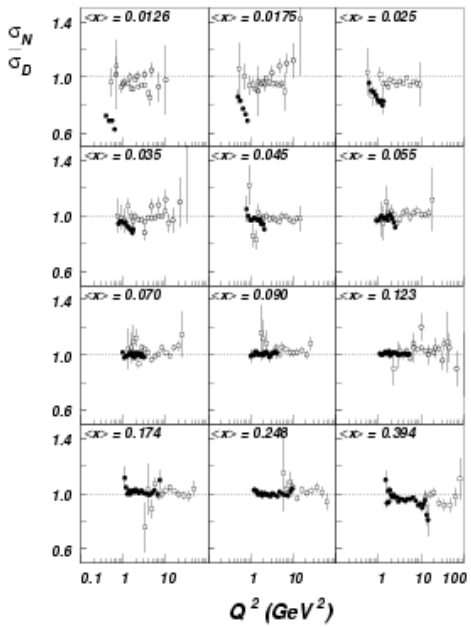


Figure 2: HERMES: Cross section ratios ^{3}He/D versus Q^2.

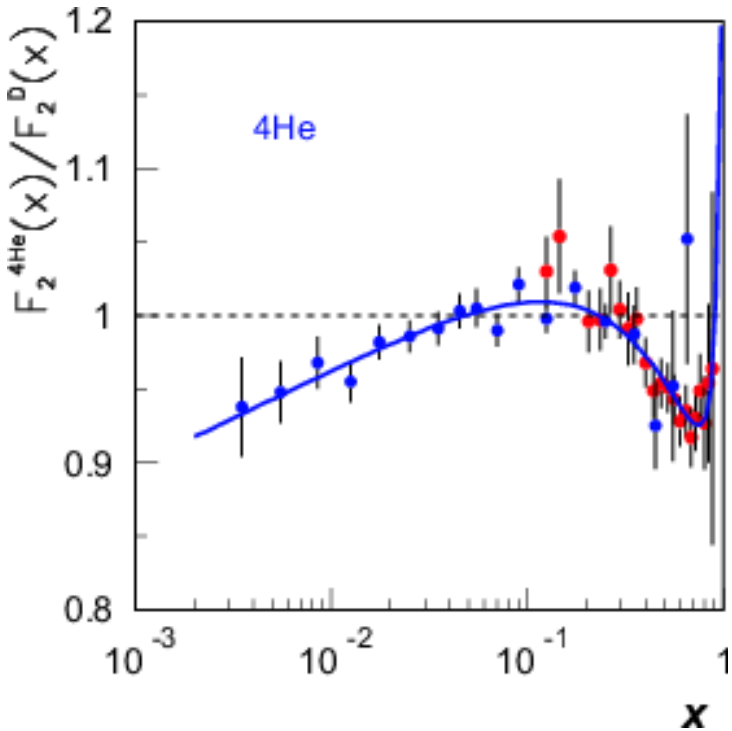
- **Including into the analysis high statistics data from SLAC and BCDMS one obtains that the independence of nuclear effects on Q^2 is well justified in the range**

$1 < Q^2 < 200$ GeV^2

Both statistical and systematic errors are high if $x < 0.05$

Bjorken x Dependence (experiment)

- **Best data on the shadowing in ^{4}He : NMC (and SLAC)**
- **Poor statistics around x ≈ 0.1**
- **No data below x = 3•10^{-2}**



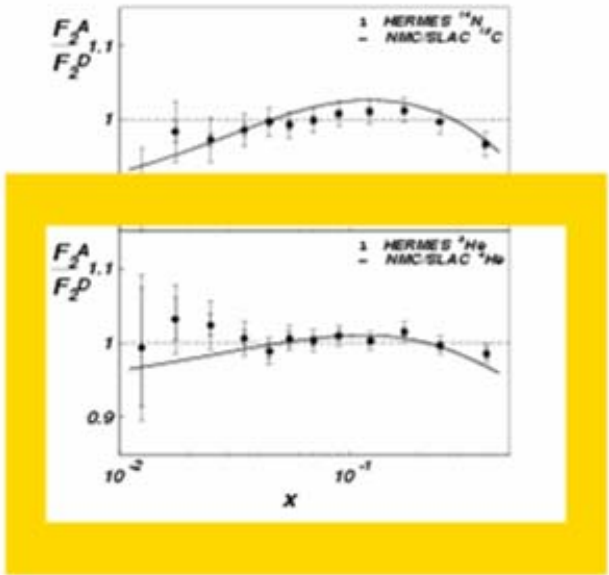
Shadowing in ^{3}He

SHADOWING in the LIGHTEST NUCLEI

Best to study the onset because:

1) R_A is about the same ~ 2 fm

2) R_i decreases fast: D : 3H : 4He ~ 4 : 2 : 1



^{3}He – Not conclusive yet

To be reckoned:

D is not a free nucleon target as many assume

Onset of the shadowing

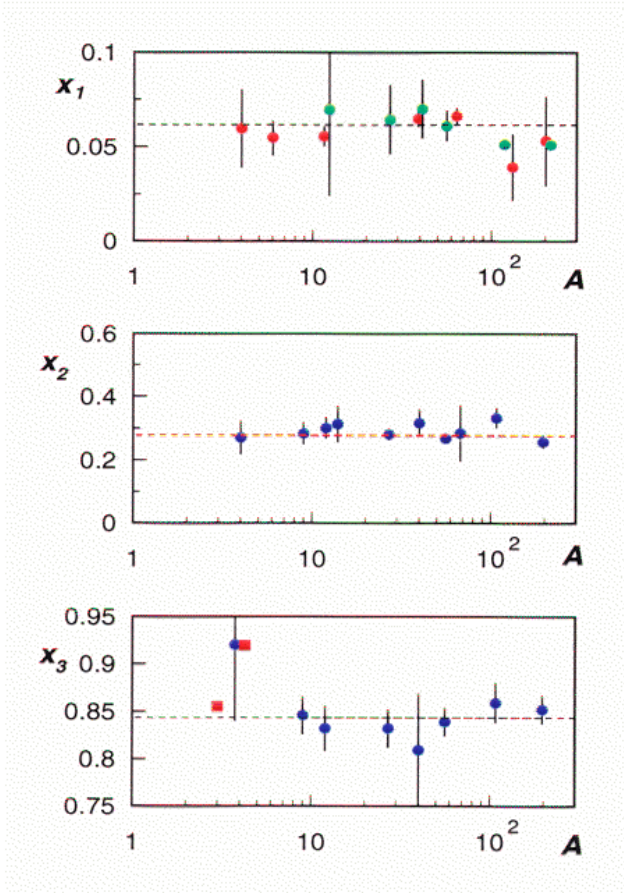
- **Nucleon size is not considered to be a world constant – still there is something universal in the shadowing onset:**

$x_1 = 0.0615 \pm 0.0024$

independent of Q^2 and A if $A > 4$

The onset is determined by the number n of overlapping nucleons:

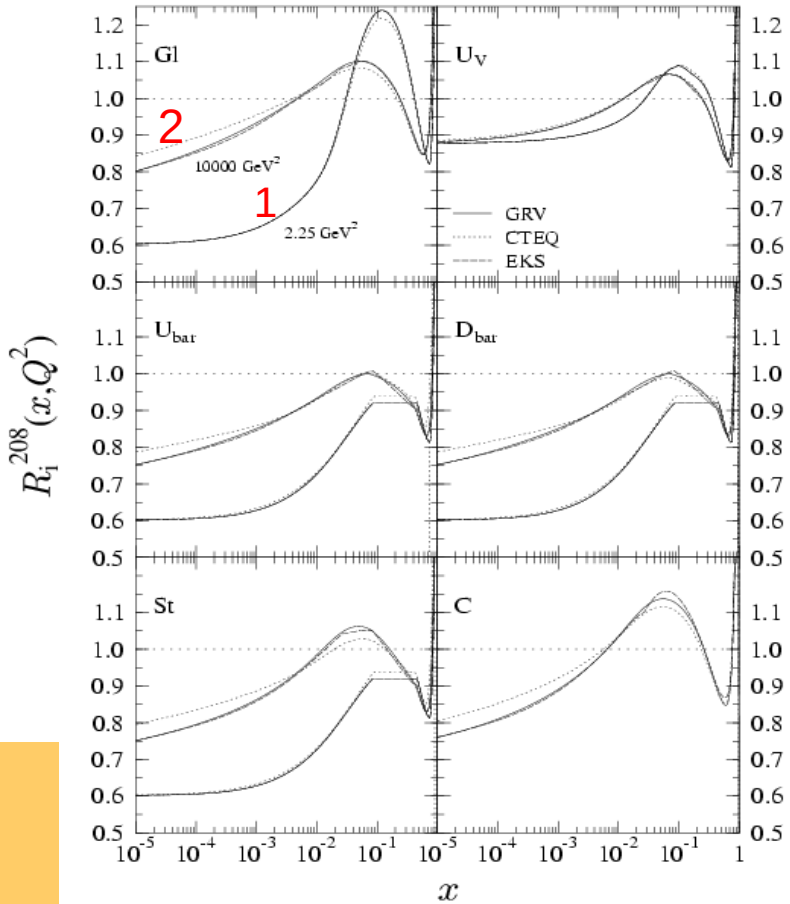
$n = 2.98 \pm 0.08$



Theoretical status

Q^2 Dependence (QCD model)

- **Valence Quarks:**
  - **Virtually no Q^2 dependence for x > 0.001 (mainly from data)**
  - **Weak Q^2 dependence for x < 0.001 (QCD extrapolation)**
- **Gluons:**
  - **Strong Q^2 dependence (QCD)**



EKS – Eskola et al.

1 – $Q^2 = 2.25$ GeV^2
2 – $Q^2 = 10^4$ GeV^2

Open problems

- **No data for the shadowing in the lightest nuclei from the same experiment ($A \leq 4$).**
- **Is it topology of nuclear forces or rather QCD dynamics, which is responsible for the build up of the shadowing ?**
- **Onset of the shadowing**
  - **Why $n = 3$ for medium and heavy nuclei ?**
  - **No data on A dependence of the onset in the range of $A \leq 3$, poor statistics for $A = 4$.**
- **Too poor statistics for medium-weight nuclei to constrain QCD evolution in the range of $x < 0.05$.**

Summary

- **Partons know about nucleon and nuclear size a lot more than we do**
- **Shadowing is not necessary the effect of nuclear environment**
- **New experiments on the lightest nuclei are indispensable for the understanding of relations between nucleon topology and QCD dynamics.**