New Measurements of Short Range Correlations and EMC effect at JLab Hall C at 11GeV

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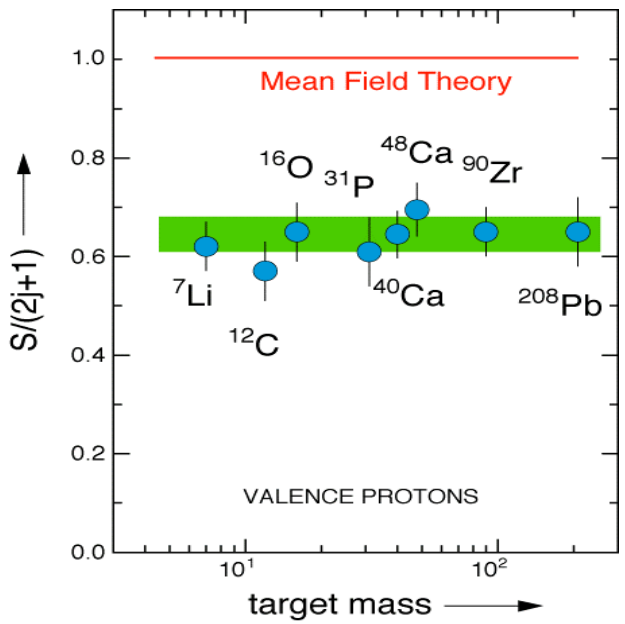
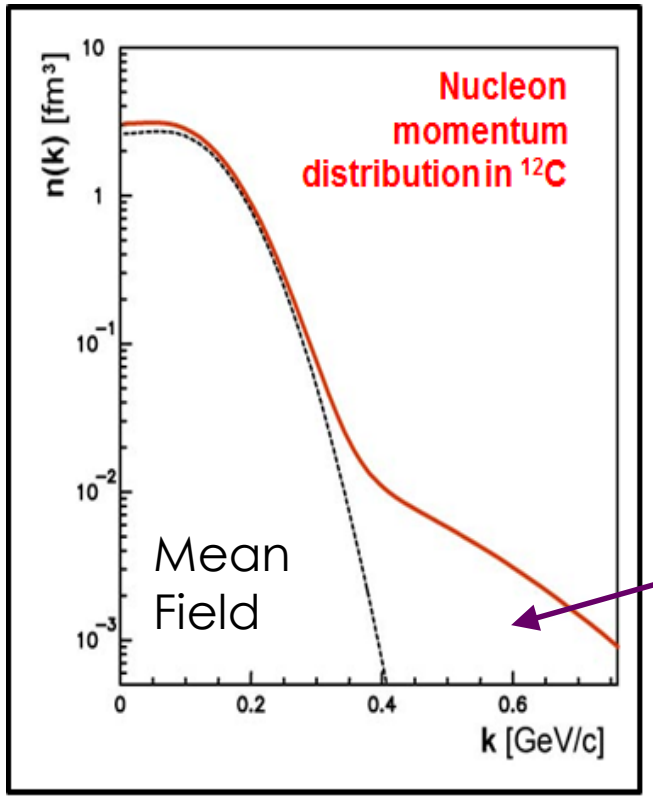
Shortcomings of IPSM

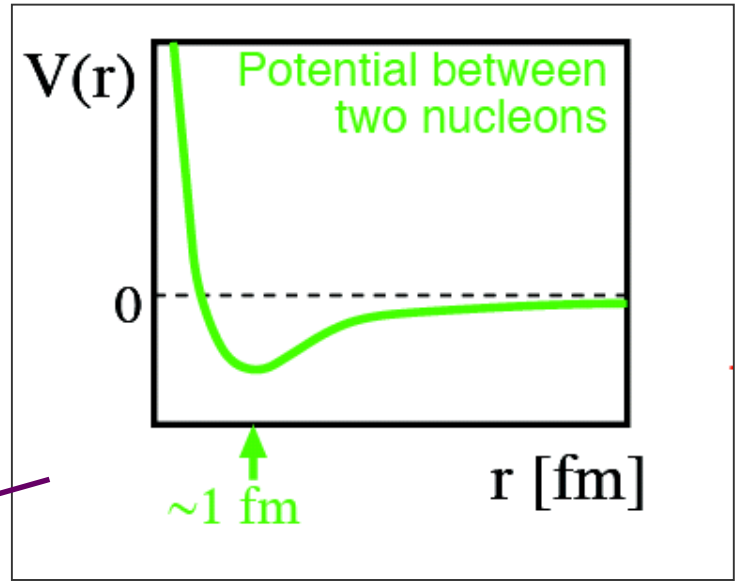
- Independent Particle Shell Model (IPSM) says S_α should be equal to 2j+1, the number of protons in given orbital
- Experimentally found to be ~2/3 this value
- Bulk of missing strength thought to come from Short Range Correlations (SRCS)
  - NN interaction generates high momenta (k>k_{fermi}) which can be seen in momentum distributions

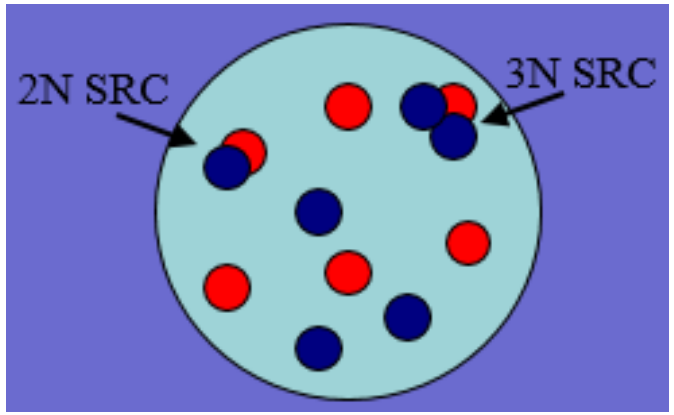
$$S_\alpha = \int S(E_m, p_m) p_m^2 dp_m \delta(E_m - E_\alpha)$$



High Momentum Nucleons

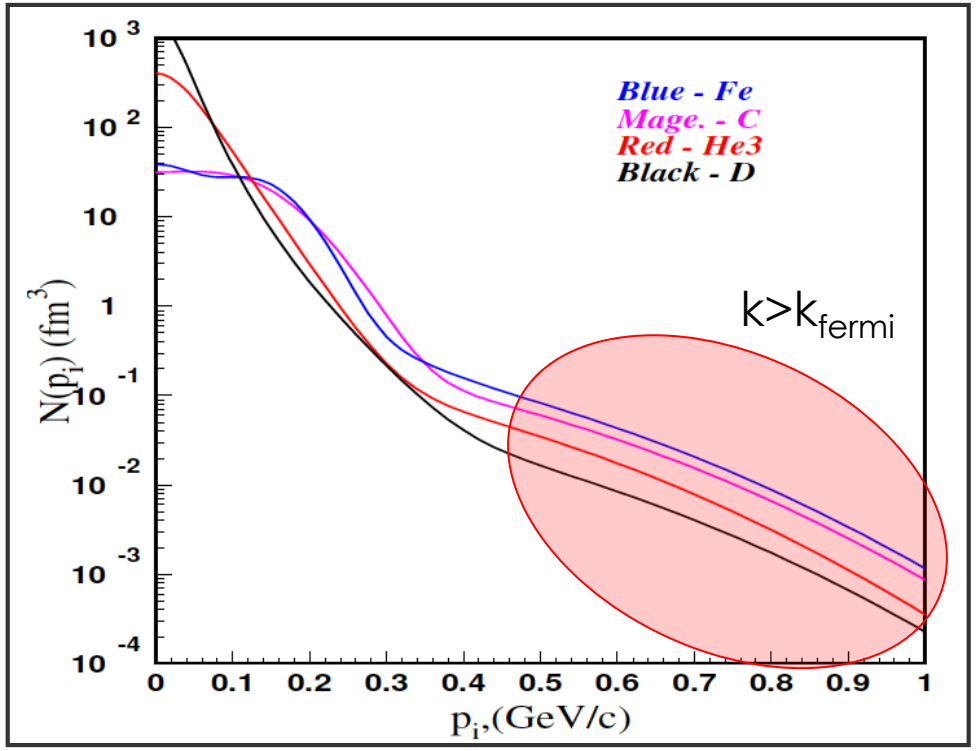






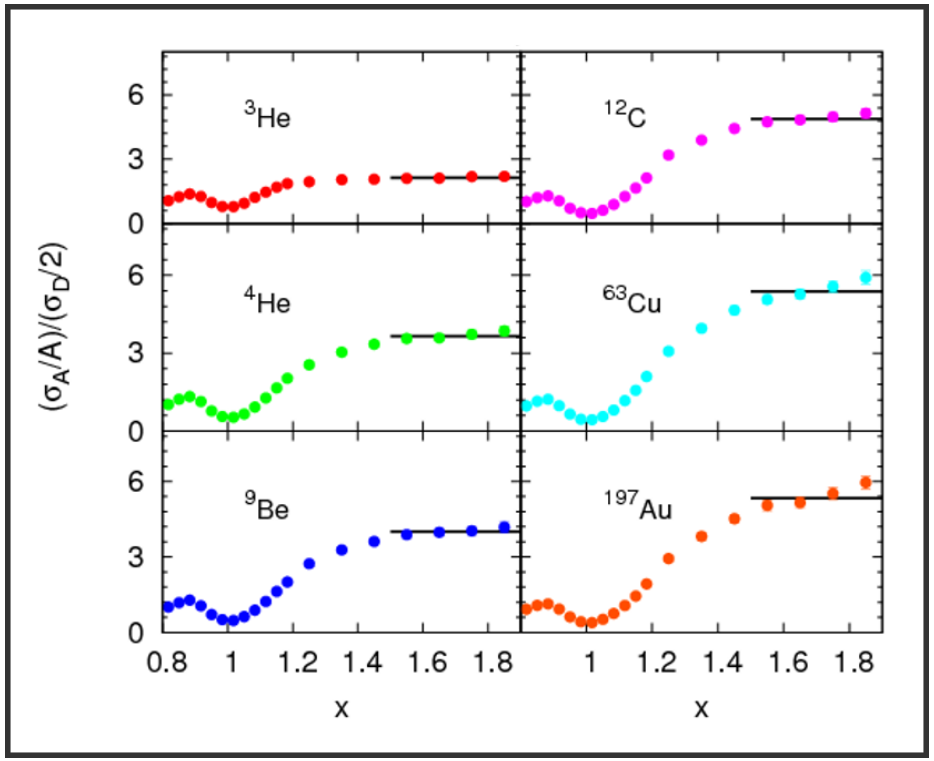
High Momentum Nucleons

- High momentum nucleons have k>k_{fermi}
- Similar shape because tail is from 2N SRCs
  - Nuclei with higher number of nucleons have higher probability to be in correlated pair and produce high momentum nucleons, have larger tail
- Calculable for nuclei up to 12C



C.Ciofi degli Att and S. Simula, 1989

Short Range Correlations (SRCs)



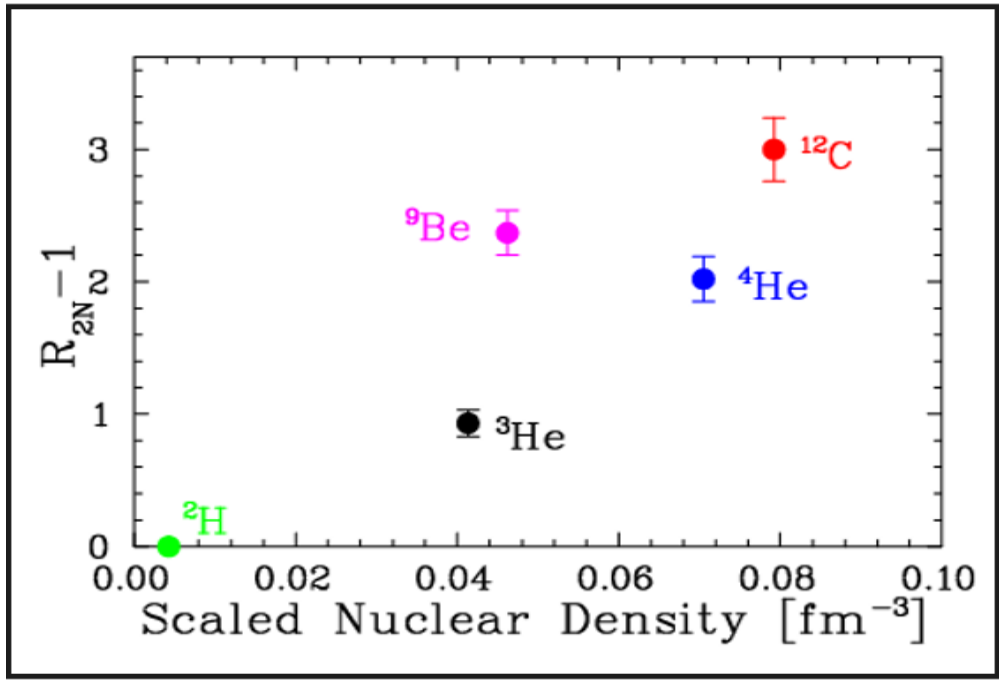
Phys.Rev.Lett. 108 (2012) 092502.
E02-109's 6GeV data at $\langle Q^2 \rangle = 2.7$ GeV^2

$$\boldsymbol{Q^2 = -q^2 = \vec{q}^2 - v^2,\ x = \frac{Q^2}{2Mv}}$$

- $\sigma(x, Q^2) = \sum_{j=1}^{A} A \frac{1}{j} a_j(A)\, \sigma_j(x, Q^2)$
- 2N corr. probability 1.4 < x < 2
  - $\frac{\sigma_A(x, Q^2)}{\sigma_D(x, Q^2)} \frac{2}{A} = a_2(A)$
- 3N corr. probability 2.4 < x < 3
  - $\frac{\sigma_A(x, Q^2)}{\sigma_{A=3}(x, Q^2)} \frac{3}{A} = a_3(A)$

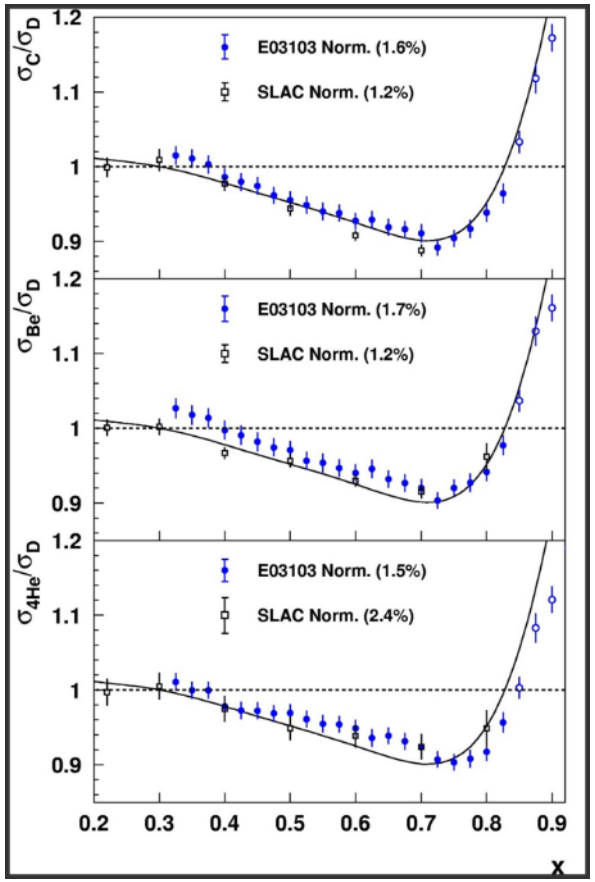
Nuclear Dependence of SRCs

SRCs



EMC Effect

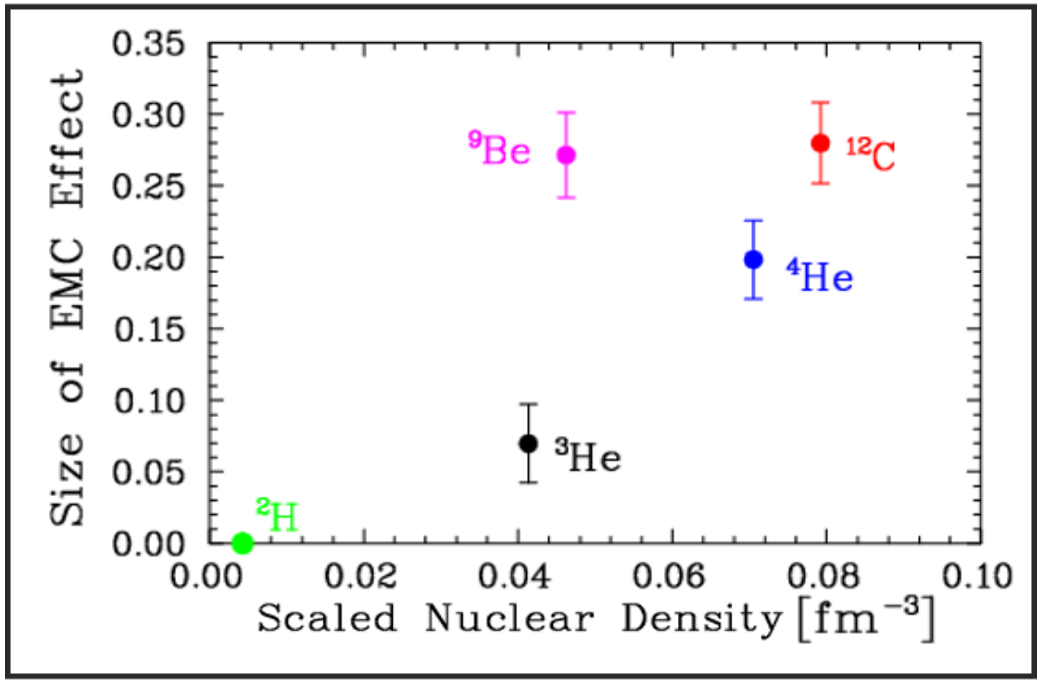
- European Muon Collaboration investigated Deep Inelastic Scattering (DIS) of muons on H, D, Fe
- Structure function:
  - Expected: $F_2^A(x) = ZF_2^p(x) + NF_2^n(x)$
  - Structure fns related to quark distributions
- Expected: $\frac{\sigma_A/A}{\sigma_D/D} \approx 1$
- Experiment concluded $\frac{\sigma_A/A}{\sigma_D/D} \not\approx 1$
- EMC is measure of medium modification of quark distributions



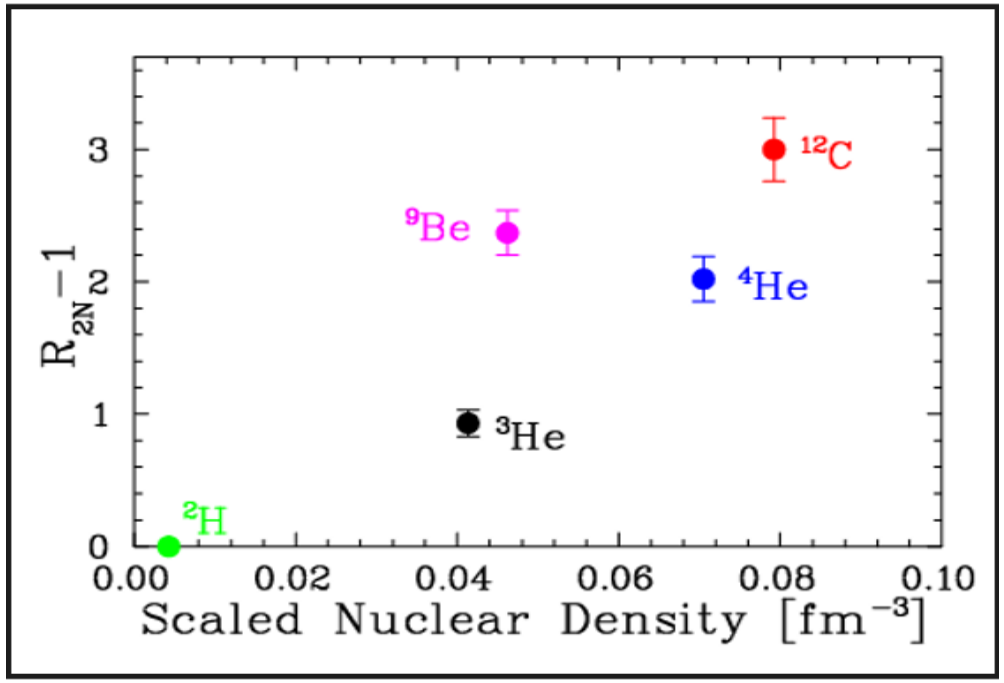
- Magnitude of EMC effect: Fit slope of ratio between 0.3 < x < 0.7
  - $\frac{dR_{emc}}{dx}$

Common Nuclear Dependence

EMC Effect

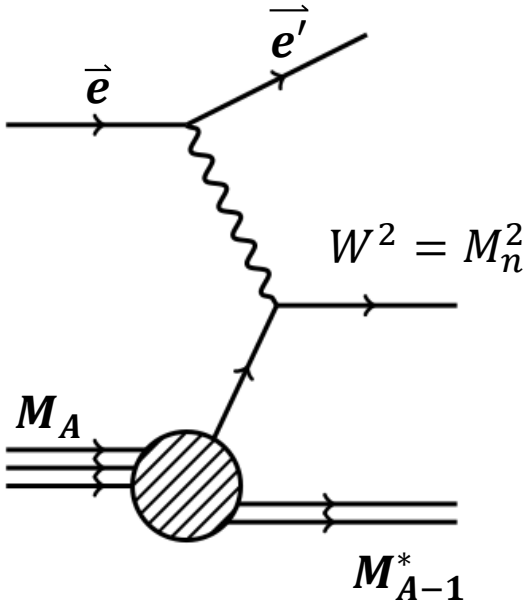


SRCs



Quasielastic vs Deep Inelastic

Quasielastic:
Scatter from **nucleons** in nucleus



Resolution: $\lambda = \frac{h}{\sqrt{Q^2}}$

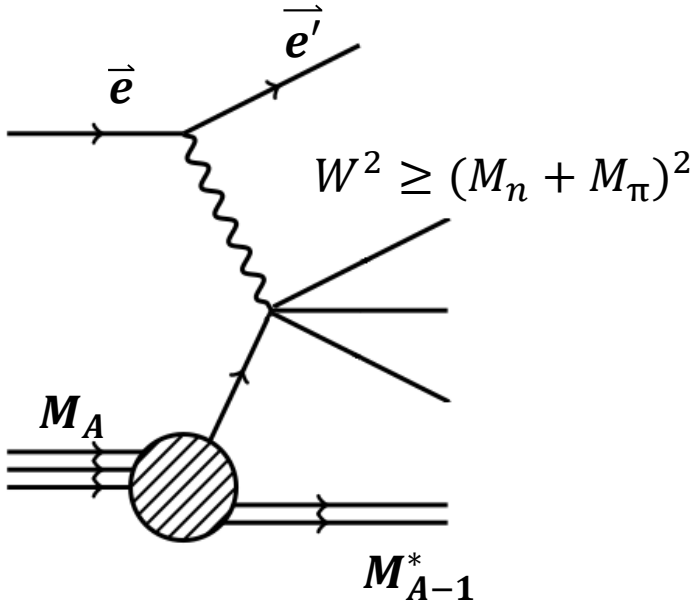
$$\nu = E - E'$$

$$Q^2 = -q^2 = \vec{q}^{\,2} - \nu^2$$

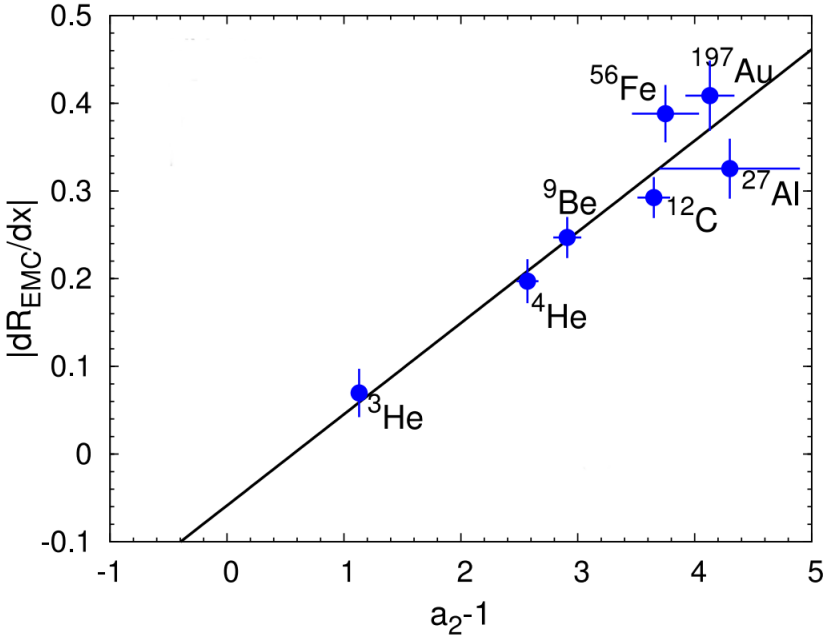
$$W^2 = 2M\nu + M^2 - Q^2$$

$$x = \frac{Q^2}{2M\nu}$$

Deep Inelastic:
Scatter from **quarks** in nucleons



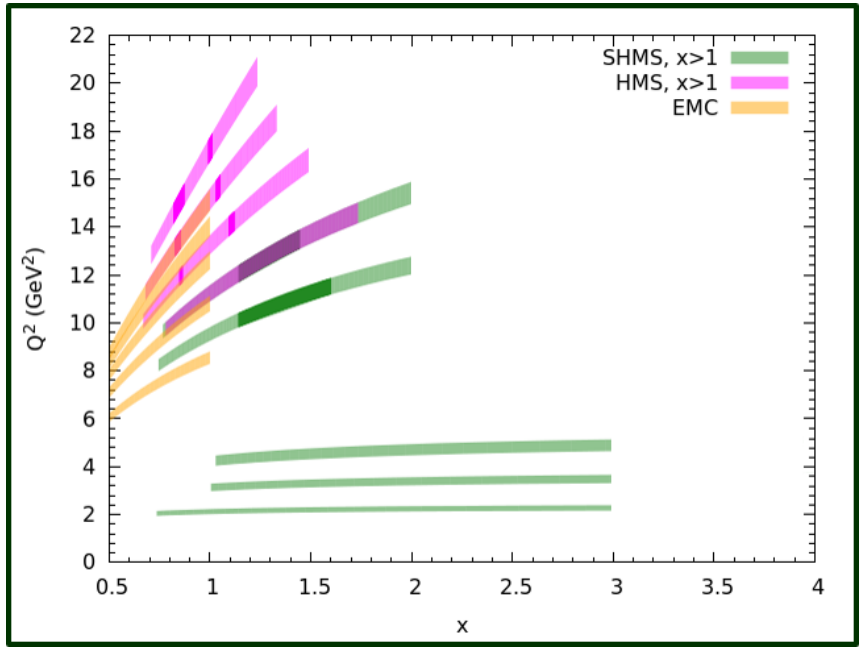
Connections



Phys.Rev. C86 (2012) 065204

- Both SRC and EMC effect have been studied for many years
- No obvious linear nuclear dependence for either, but excellent correlation between them
- This correlation could be that each have a common cause, or one could be a function of the other

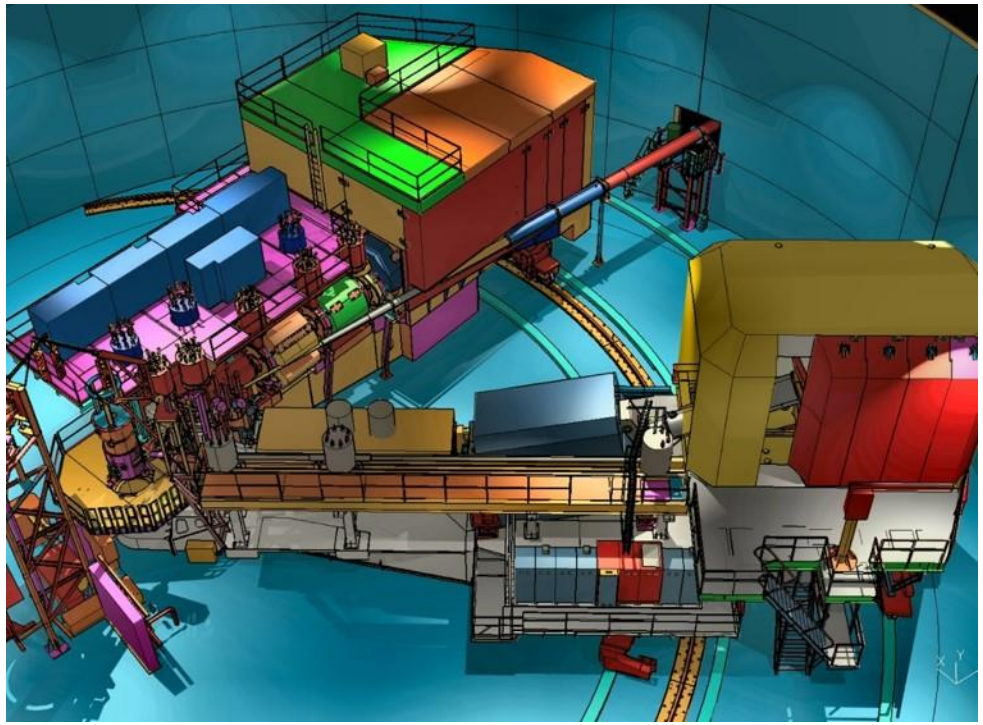
Mapping the Connection



- E12-06-105 (SRCs)
  - Inclusive Scattering from Nuclei at x>1 in the Quasielastic and Deep Inelastic regimes
  - Many targets, x>1, varied range of Q^2
- E12-10-008 (EMC effect)
  - Detailed studies of the nuclear dependence of F2 in light nuclei
  - Light to medium-heavy, 0.1<x<1, Q^2 up to 15 GeV^2

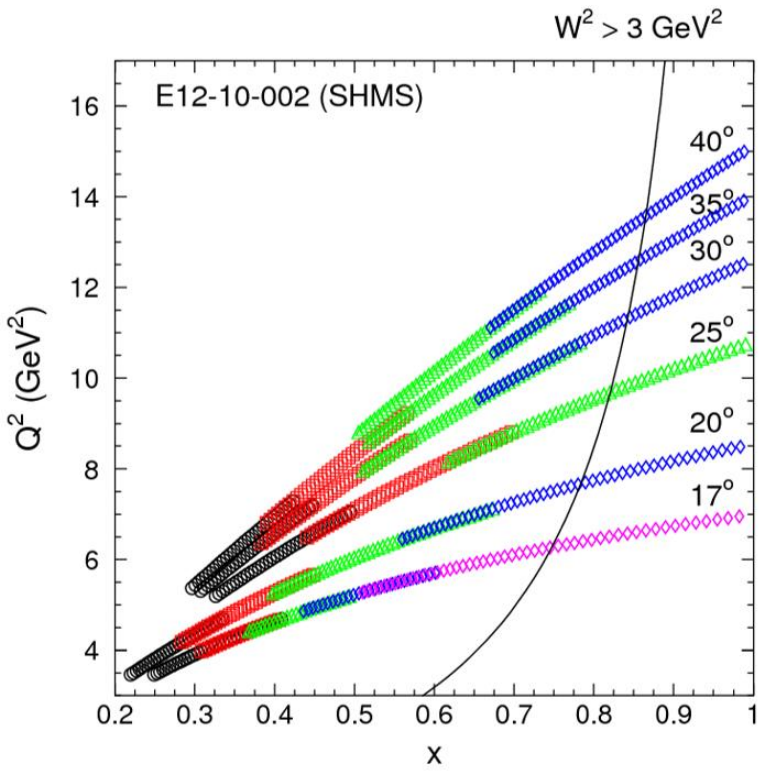
Experiment: Hall C

- Jlab 11 GeV's upgrade has allowed to explore a greater range of Q^2
- Because of energy upgrade Short Orbit Spectrometer (SOS) replaced by Super High Momentum Spectrometer (SHMS)



Commissioning Run

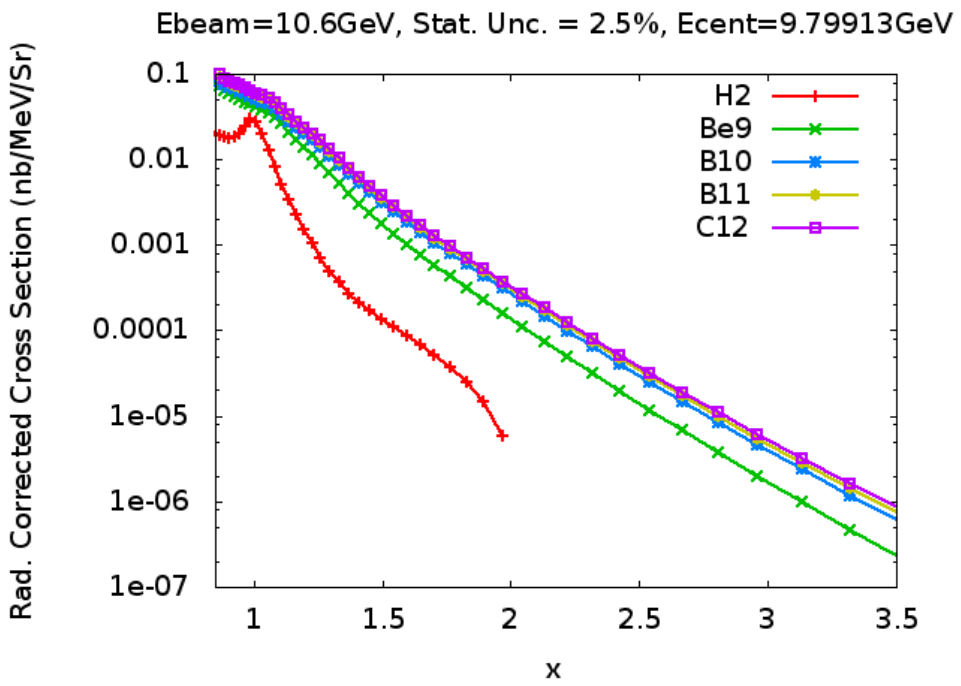
- E12-06-105 will run concurrently with E12-10-002 in early 2017
  - Both expts have combined 48 PAC hours, with 8 PAC hours set aside for E12-06-105's commissioning run
  - This initial run provides additional data of ^{12}C, ^{9}Be, ^{2}H and new measurements of ^{11}B, ^{10}B
  - Other targets will be measured in a future run



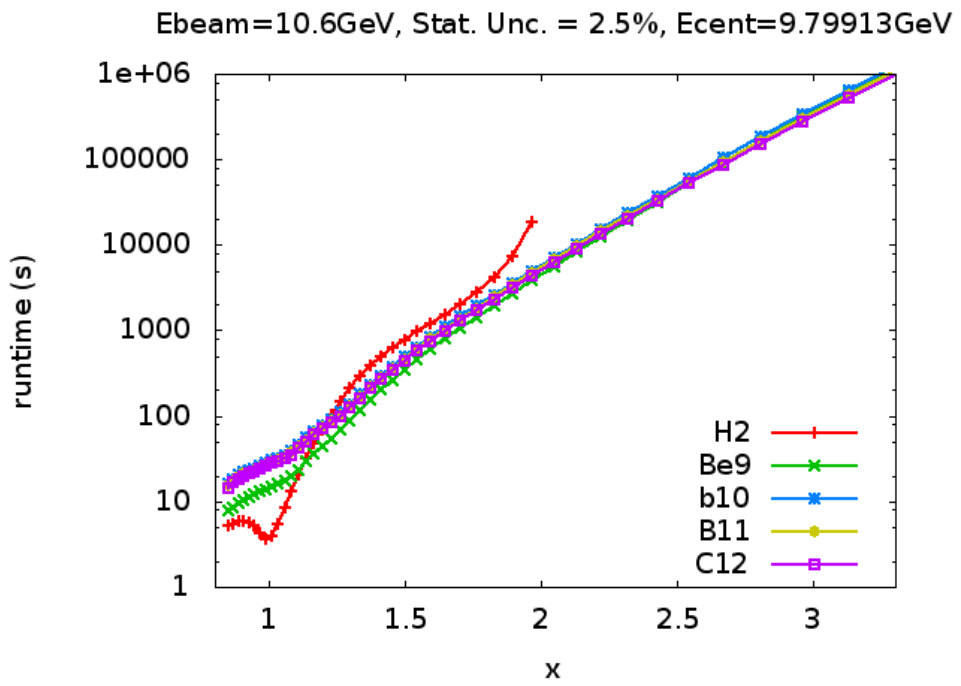
Plot by Simona Malace

x >1 Run Plan

- Cross section model used to calculate runtimes for different targets to allocate time efficiently
  - DIS part of Born CS based on Peter Bosted's F1F21N09 model
  - QE CS based on F(y) scaling fn with parameters fitted from Hall C E02-109 and Hall A E08-014
  - Radiated CS uses Peaking Approximation
    - Coulomb effect taken into account



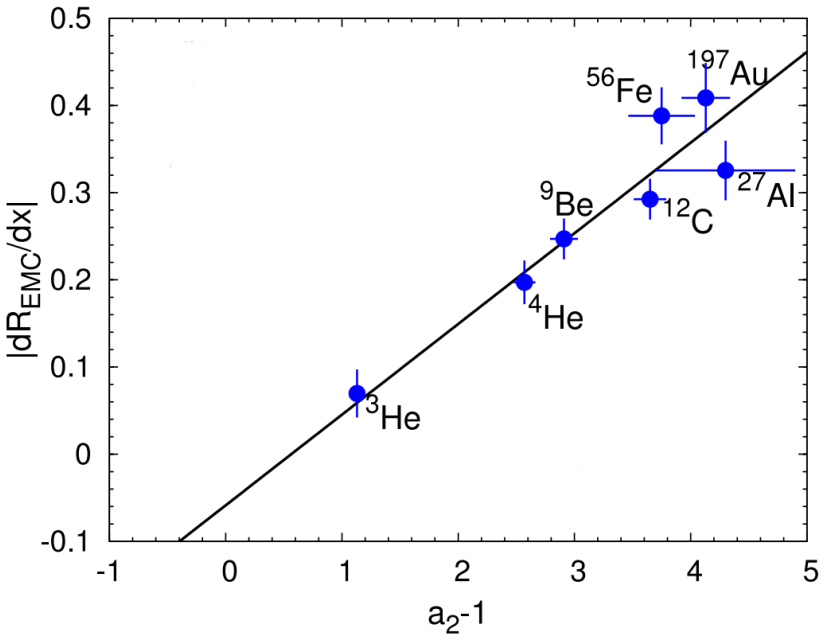
x >1 Run Plan (Preliminary)

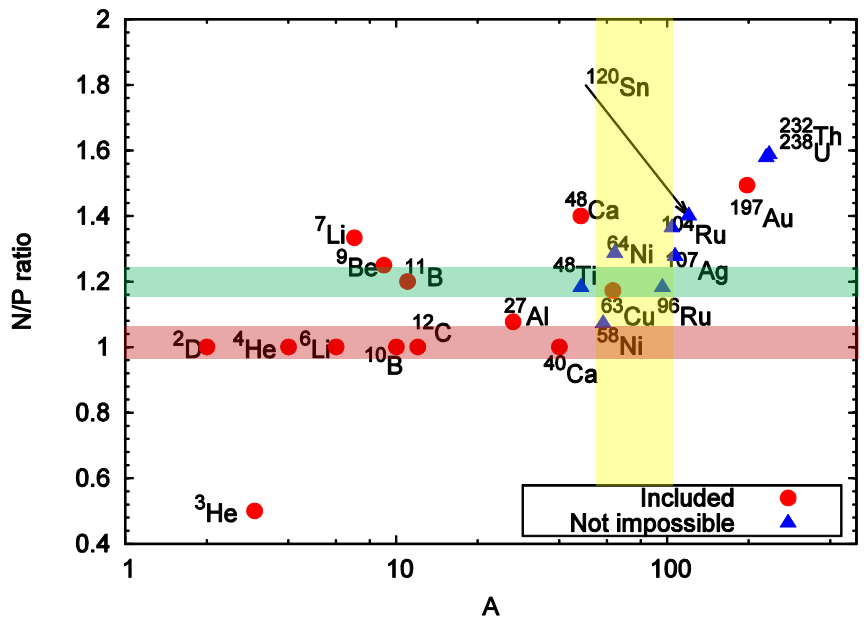


Nuclei	Thickness	Time (hr)
^{12}C	2%R.L.	1.23
^{11}B	1.2%R.L.	1.30
^{10}B	1.2%R.L.	1.38
^{9}Be	2%R.L.	1.07
^{2}H	10cm	5.06
Total		10.04

- Runtime estimation based on 2.5% stat. uncertainty in bin closest to x = 2, beam current 40 μA

Future Running





- Strategically chosen targets in order to search for source of correlation
  - 2 bands of ~constant N/P ratio
  - 1 band of ~constant A

Summary and Outlook

- JLab's 6GeV era yielded illuminating measurements of both SRCs and the EMC effect
- JLab's energy upgrade to 12GeV improves existing measurements and adds new measurements
- Run plan currently in the works for Hall C commissioning that is slated to begin early 2017
- Making a combined run plan for x>1/EMC experiments will provide optimal information on correlation between EMC and SRCs