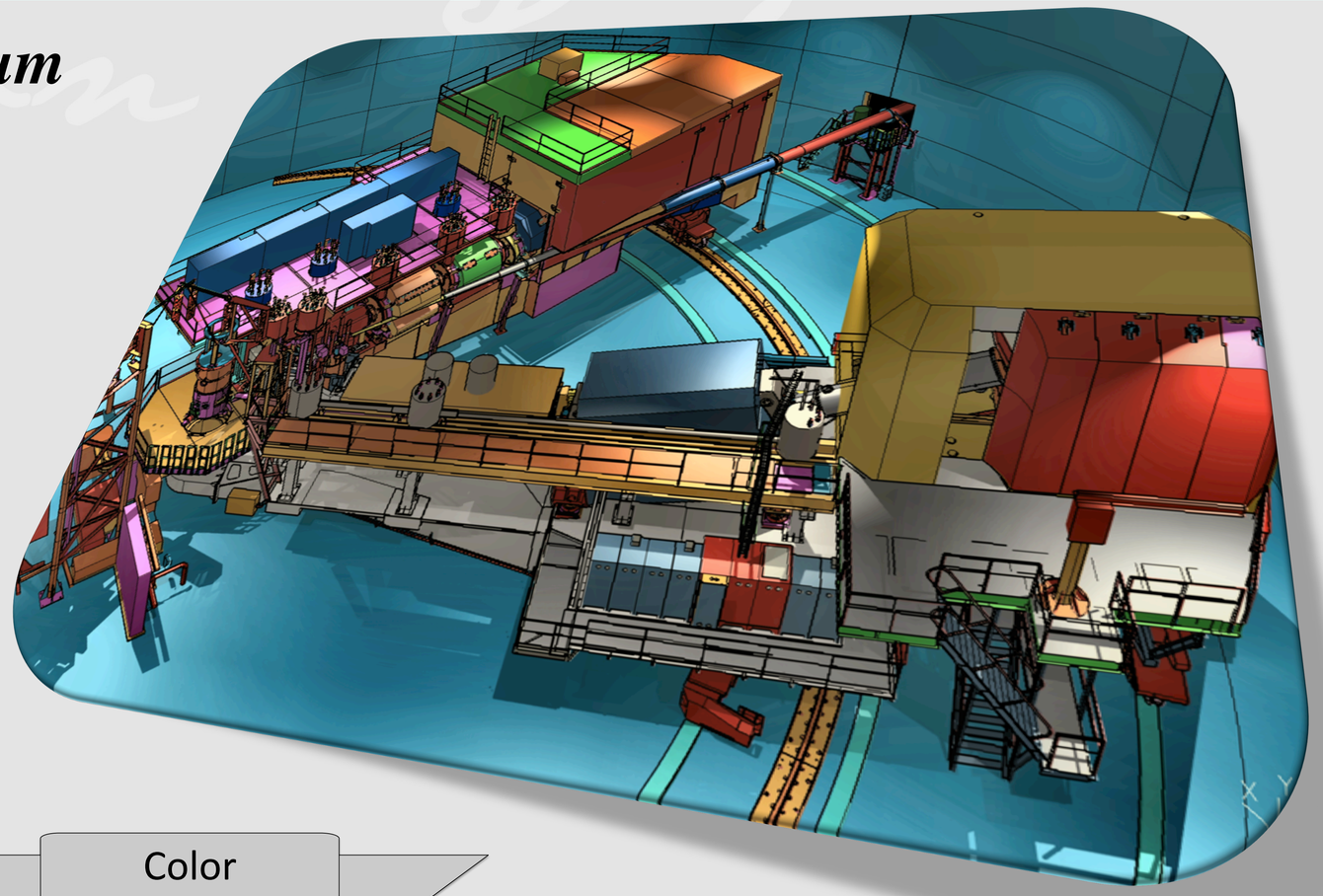
EXPERIMENTAL HALL C

Addition of a Super-High Momentum Spectrometer

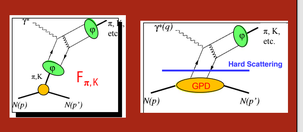


Pion and Kaon FF

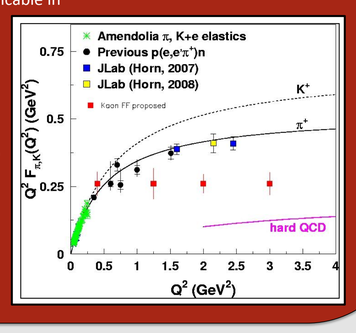
Form factors and GPDs are essential to understand the structure of nucleons.

The Q^2 dependence of F_π is also consistent with hard-soft factorization prediction (Q^{-2}) at values Q^2>1 GeV^2

BUT the observed magnitude of F_π is larger than the hard QCD prediction
– Could be due to QCD factorization not being applicable in this regime
– Or insufficient knowledge about additional soft contributions from the meson wave function of the onset of factorization



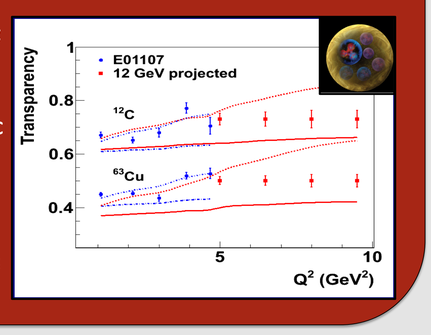
Comparing the observed Q^2 dependence of $\sigma_{L,T}$ and FF magnitude with kaon production would allow for better understanding of the onset of factorization



Color Transparency

Hadron propagation through the nuclear medium is a key element of the nuclear many body problem. At high energies, the main process is the reduction of hadron flux. This reduction is called nuclear transparency.

CT is the result of "Squeezing and Freezing":
At sufficiently high momentum transfers, scattering takes place via selection of amplitudes characterized by small transverse size (PLC) - "squeezing". The compact size is maintained while traversing the nuclear medium - "freezing". The PLC is 'color screened' - it passes undisturbed through the nuclear medium.



CT is important for understanding nuclei in terms of quarks and gluons

A1n

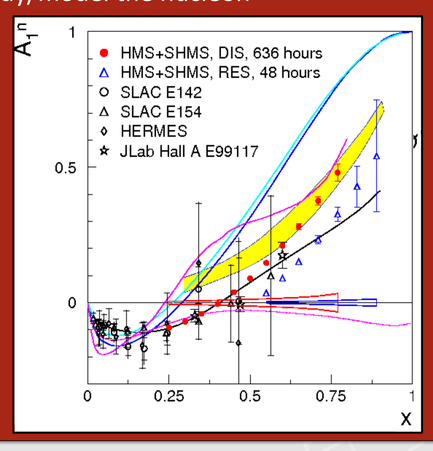
For most cases, QCD cannot predict the value of structure functions because of their non-perturbative nature.

However, the large x region provides a handful of exceptions:
- F2p/F2n and d/u
- A1p, A1n , or Δu/u and Δd/d

$$|p\uparrow\rangle = \frac{1}{\sqrt{2}}|u\uparrow(ud)_{00}\rangle + \frac{1}{\sqrt{18}}|u\uparrow(ud)_{10}\rangle - \frac{1}{3}|u\downarrow(ud)_{11}\rangle - \frac{1}{3}|d\uparrow(uu)_{10}\rangle - \frac{\sqrt{2}}{3}|d\downarrow(uu)_{11}\rangle$$

Model	F_2^n/F_2^p	d/u	Δu/u	Δd/d	A_1^n	A_1^p
SU(6) = SU3 flavor + SU2 spin	2/3	1/2	2/3	-1/3	0	5/9
Valence Quark + Hyperfine	1/4	0	1	-1/3	1	1
pQCD + HHC	3/7	1/5	1	1	1	1

At large x, valence quarks dominate, a relatively clean/easy region to study/model the nucleon

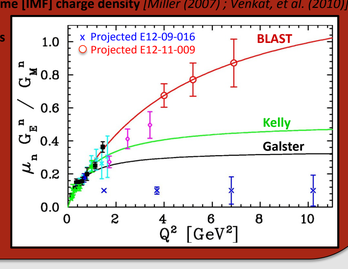


Neutron FF

Measurements of G_E^n in high Q^2 range provide important insight:
– Complete set of form factors in region with small pion cloud contributions
– Extract scalar, vector form factors, allows separation of up, down quark contributions (neglecting strangeness)
– Directly sensitive to up and down quark distributions in quark core
– Model-independent extraction of neutron infinite-momentum frame [IMF] charge density *[Miller (2007) ; Venkat, et al. (2010)]*
– Lattice QCD:
  * isovector form factor (GEp-GEn) cancels disconnected diagrams
  * Region of interest for Dyson-Schwinger Equation calculations

E12-09-016 will extend this to 10 GeV^2 using polarized ^{3}He target in Hall A.

In Hall C, E12-11-009 Recoil polarization measurement from ^{2}H, can provide additional data with very different systematics.

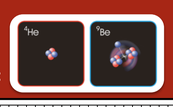


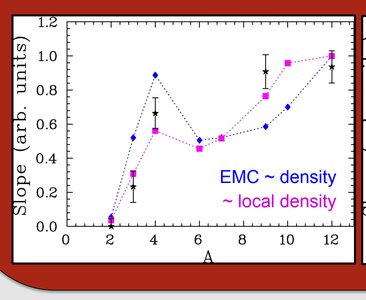
EMC effect

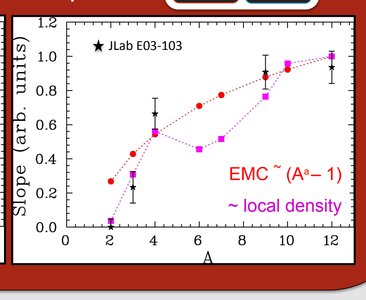
E12-10-008 will map out in greater details the A-dependence of the EMC effect for A ≤2

From E03-103 (^{3}He, ^{4}He, ^{9}Be and ^{12}C):
- Very hard to explain large ^{3}He – ^{9}Be difference in r-dependent fit
- Hard to explain large ^{3}He – ^{4}He difference in mass-dependent fit
- "Local density" works well, provides different predictions

➔ Indication of cluster dependence:



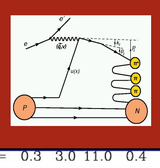


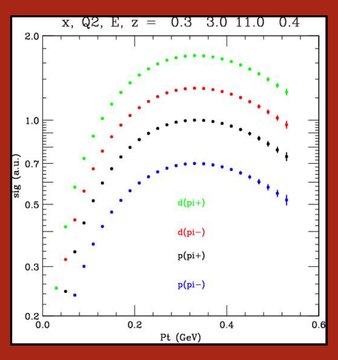


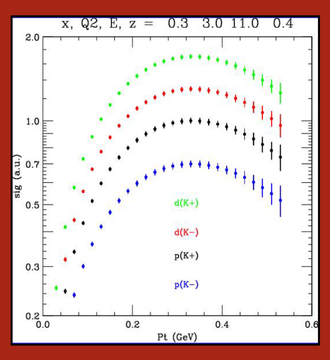
SIDIS

Transverse Momentum Dependence of Semi-Inclusive Pion and Kaon Production

- Not much is known about the orbital motion of partons
- Significant net orbital angular momentum of valence quarks implies significant transverse momentum of quarks





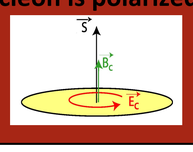


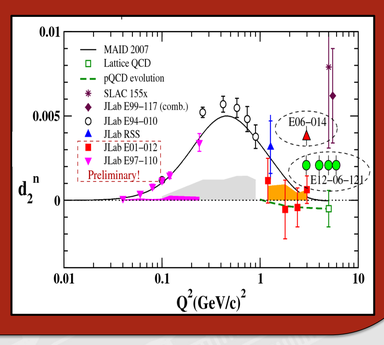
Goal: Map the p_T dependence (p_T ~ Λ < 0.5 GeV) of π^+ and π^- production off proton and deuteron targets to study the k_T dependence of (unpolarized) up and down.

d2n

How does the gluon field respond when a nucleon is polarized ?

- d_2 is a clean probe of quark-gluon correlations / higher twist effects
- Connected to the color Lorentz force acting on the struck quark (Burkardt): same underlying physics as in SIDIS $k_\perp$ studies
- Investigate the present discrepancy between data and for d_2^n at theories.





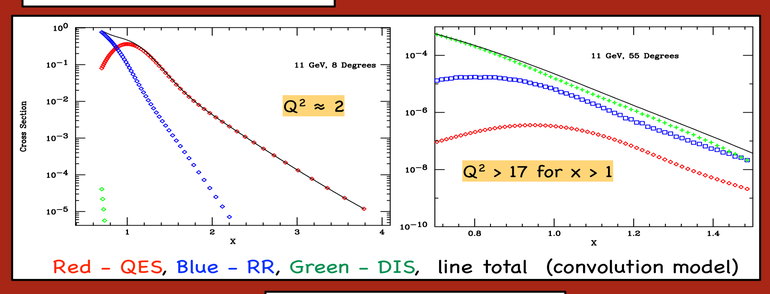
Superfast quarks

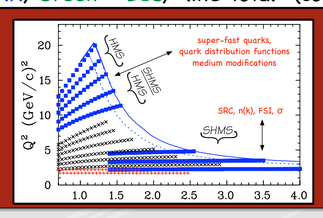
Moderate Q^2 and large x
- Two and multi-nucleon correlations
- A-dependence of strength, density-dependence, non-isoscalarity
- Provide tests of 'exact' calculations [S(k,E)] through σ, expose role of FSI
- Extrapolation to nuclear matter

$$\frac{d^2\sigma}{dQd\nu}\ \alpha \int d\vec{p} \int dE\,\sigma_{ei}\,\underbrace{S_i(p,E)}_{\text{Spectral function}}\,\delta() \quad \text{QES}$$

Very high Q^2 and 1 < x < 1.5
- Extraction of SF and underlying quark distributions at x > 1
- Provide insight into origin of EMC effect, extreme sensitivity to non-hadronic components

$$\frac{d^2\sigma}{dQd\nu}\ \alpha \int d\vec{k} \int dE\ W_{1,2}^{(p,n)}\ \underbrace{S_i(k,E)}_{\text{Spectral function}} \quad \text{DIS}$$





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