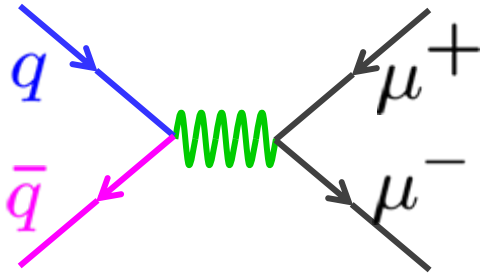
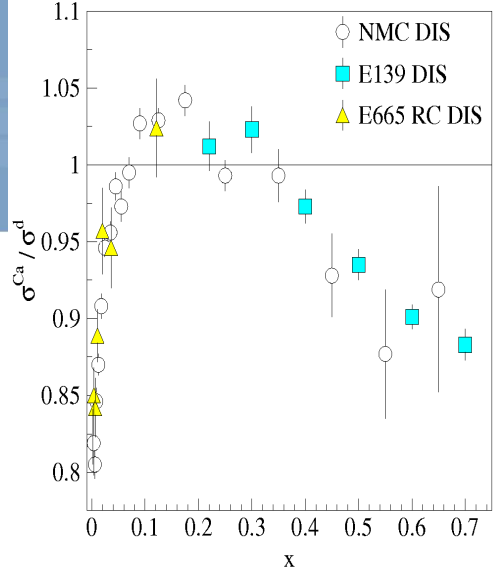
Measurement of nuclear effects in antiquark distributions





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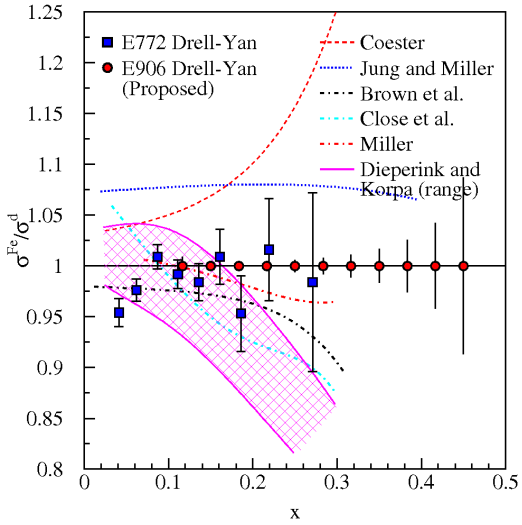
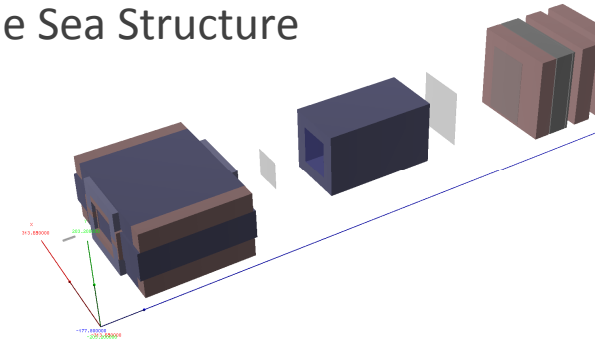
I. Partonic structure modifications in Nuclear Matter

II. Drell-Yan Measurements of the Sea Structure

III. Fermilab E-906/SeaQuest



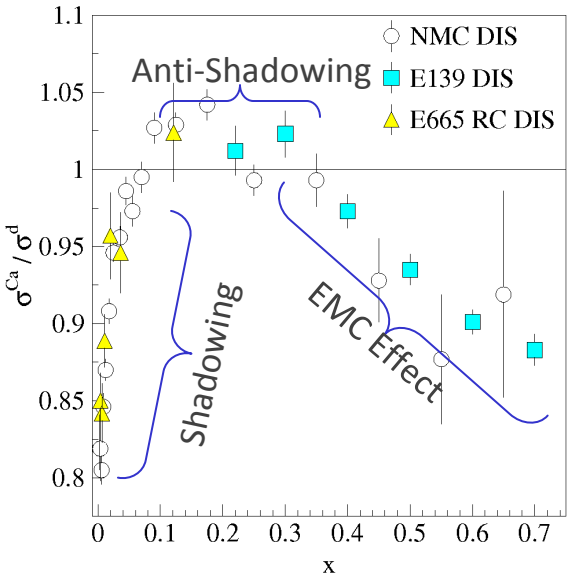


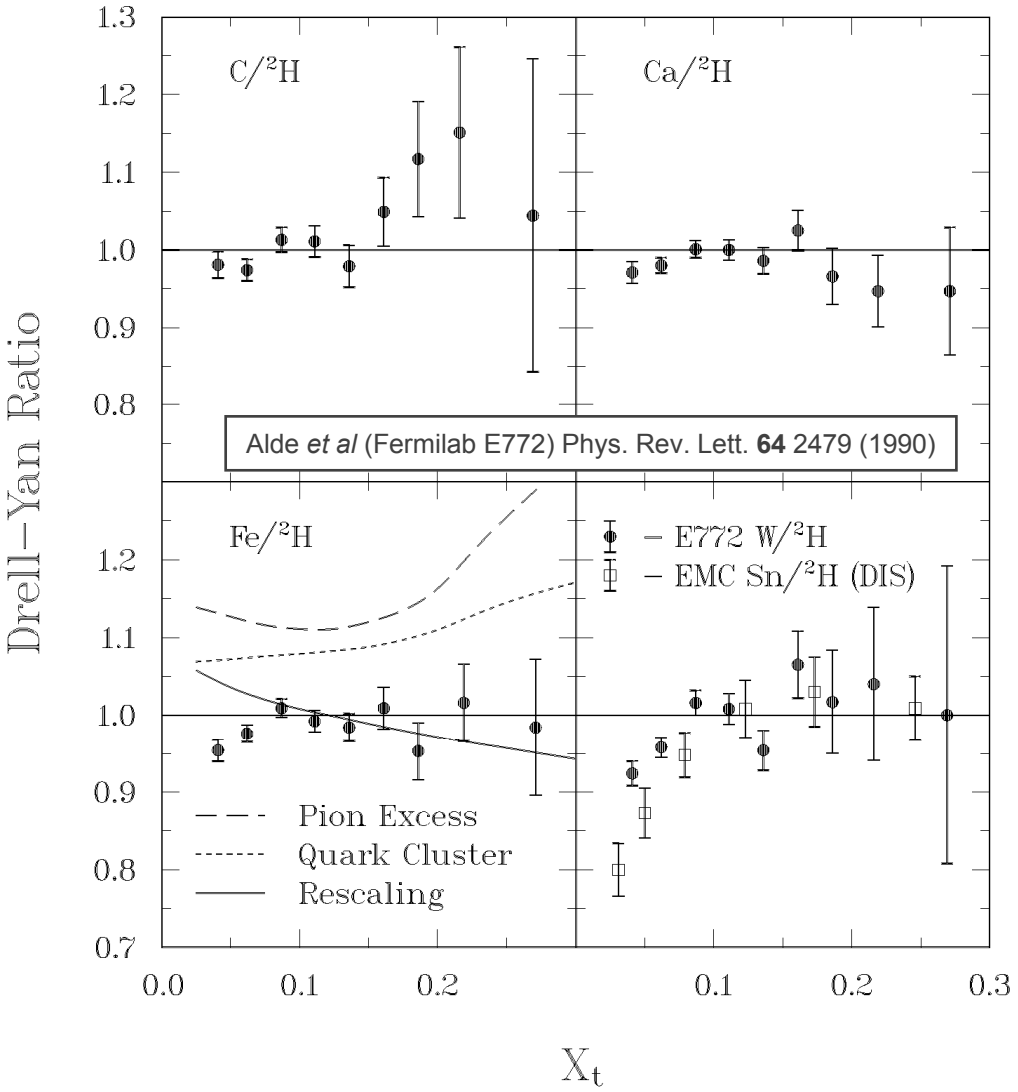
This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

Structure of nucleonic matter: How do sea quark distributions differ in a nucleus?

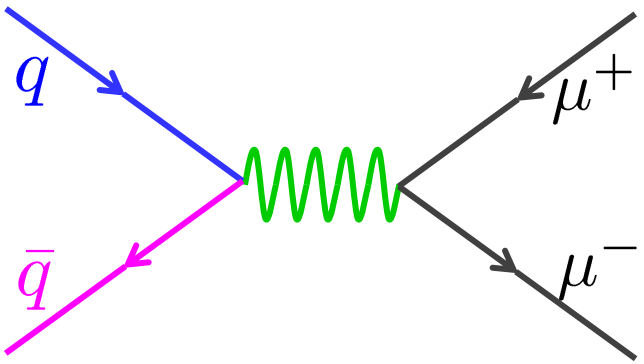
Comparison with Deep Inelastic Scattering (DIS)

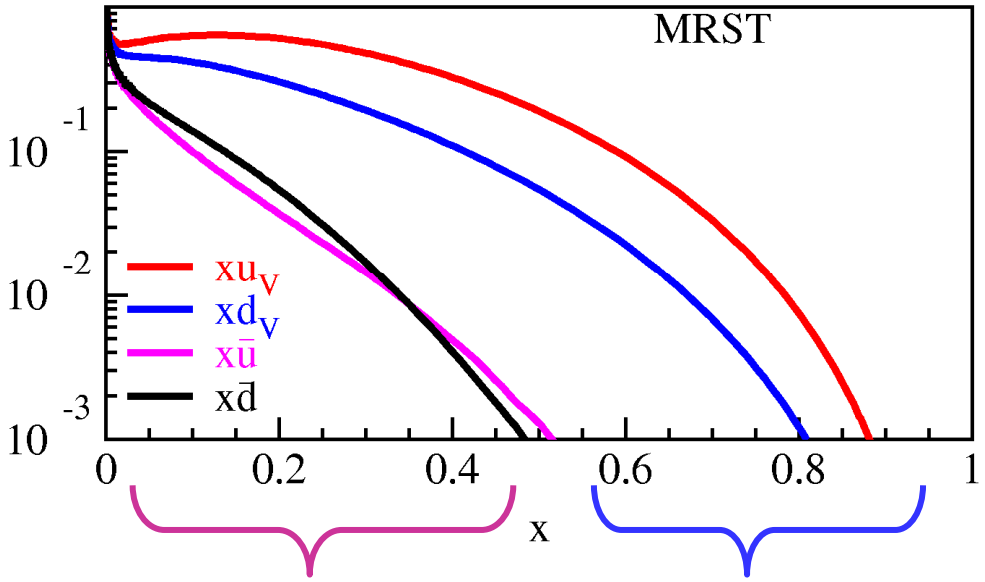
- EMC: Parton distributions of bound and free nucleons are different.
- Antishadowing not seen in Drell-Yan—Valence only effect





Drell-Yan scattering: A laboratory for sea quarks

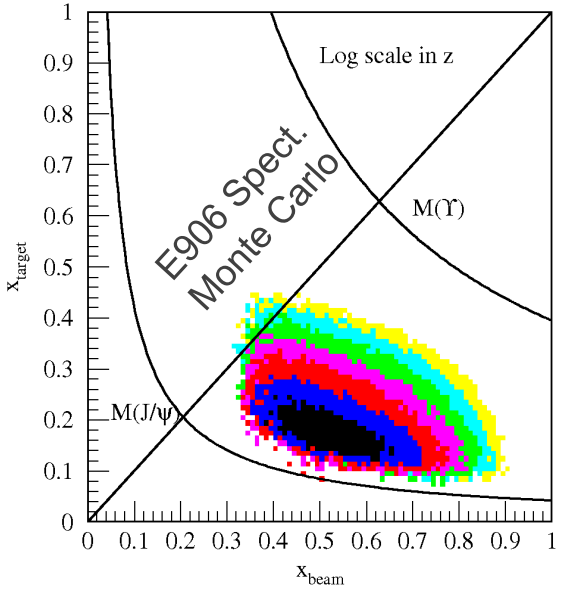




$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_1x_2}\frac{1}{s}\sum e^2\left[\bar{q}_t(x_t)q_b(x_b) + q_t(x_t)\bar{q}_b(x_b)\right]$$

Detector acceptance chooses x_{target} and x_{beam}

- Fixed target $\Rightarrow$ high $x_F = x_{beam} - x_{target}$
- Valence Beam quarks at high-x.
- Sea Target quarks at low/intermediate-x.

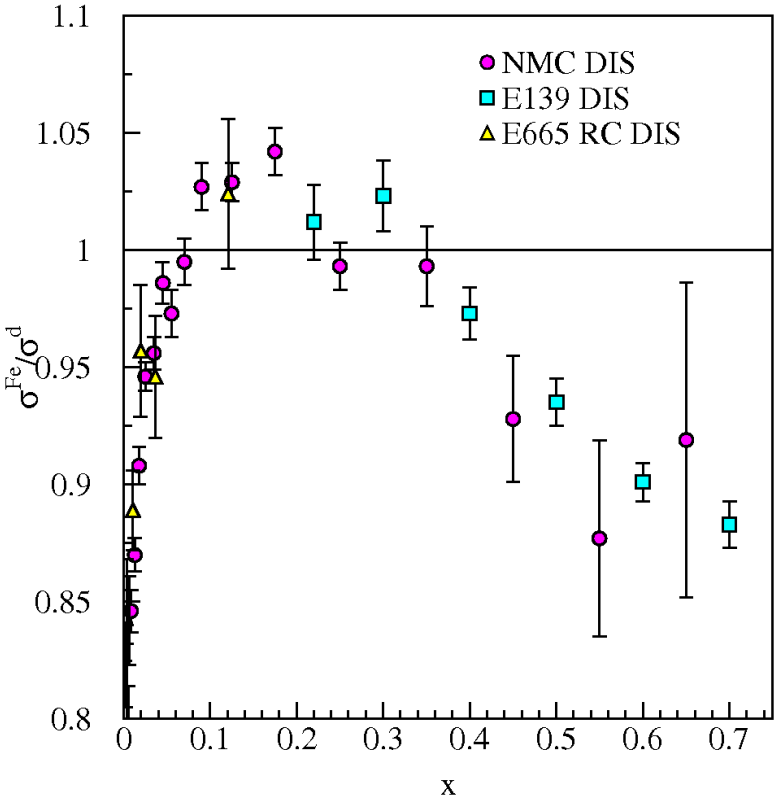


Structure of nucleonic matter: How do sea quark distributions differ in a nucleus?

Intermediate-*x* *sea* PDF's

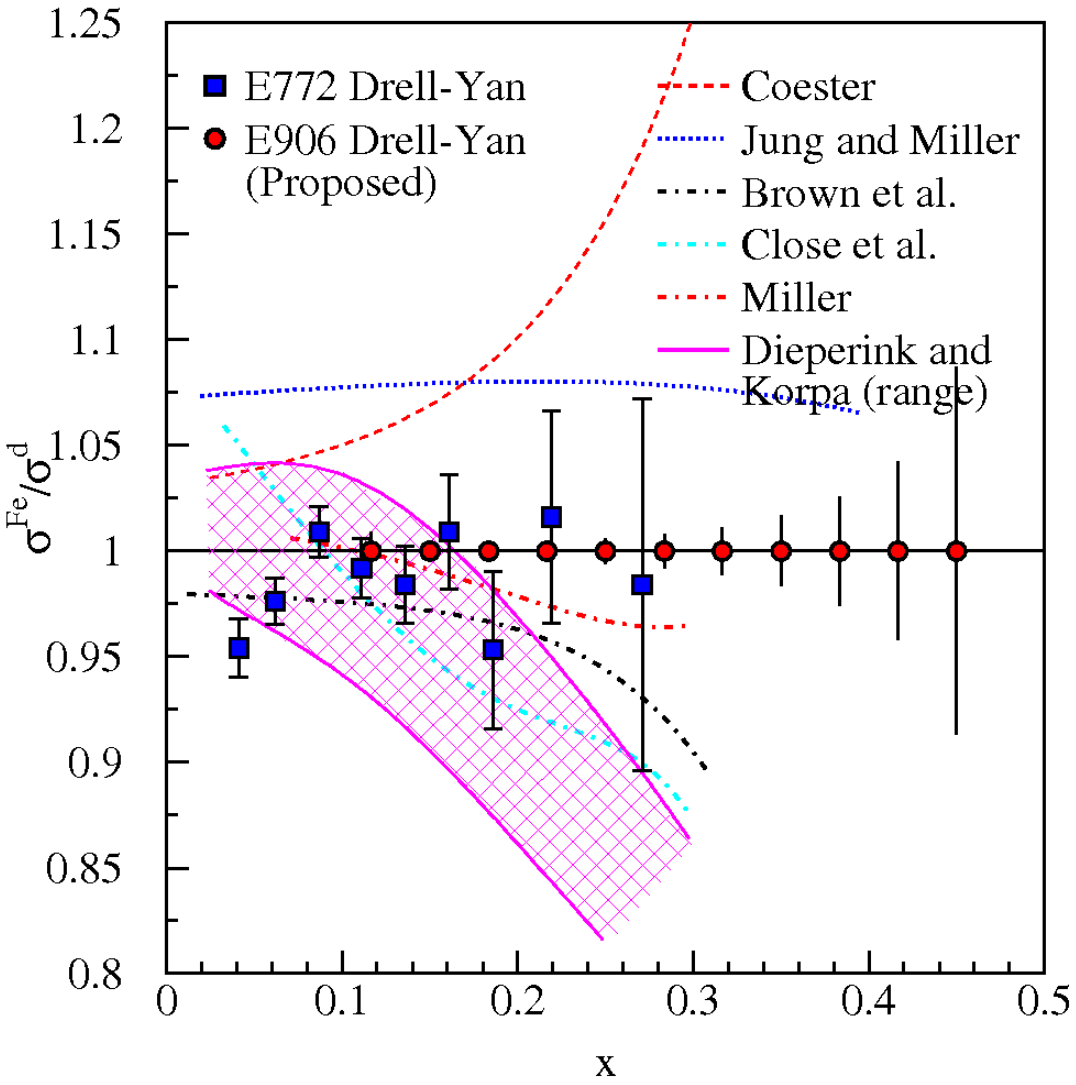
- ν-DIS on iron—Are nuclear effects with the weak interaction the same as electromagnetic?
- Are nuclear effects the same for sea and valence distributions

- What can the sea parton distributions tell us about the effects of nuclear binding?



Structure of nucleonic matter: Where are the nuclear pions?

- The binding of nucleons in a nucleus is expected to be governed by the exchange of virtual “Nuclear” mesons.
- No antiquark enhancement seen in Drell-Yan (Fermilab E772) data.
- Contemporary models predict large effects to antiquark distributions as x increases.
- Models must explain both DIS-EMC effect and Drell-Yan



Advantages of 120 GeV Main Injector

The (very successful) past:

Fermilab E-772

- Nuclear targets
- 800 GeV proton beam

The future:

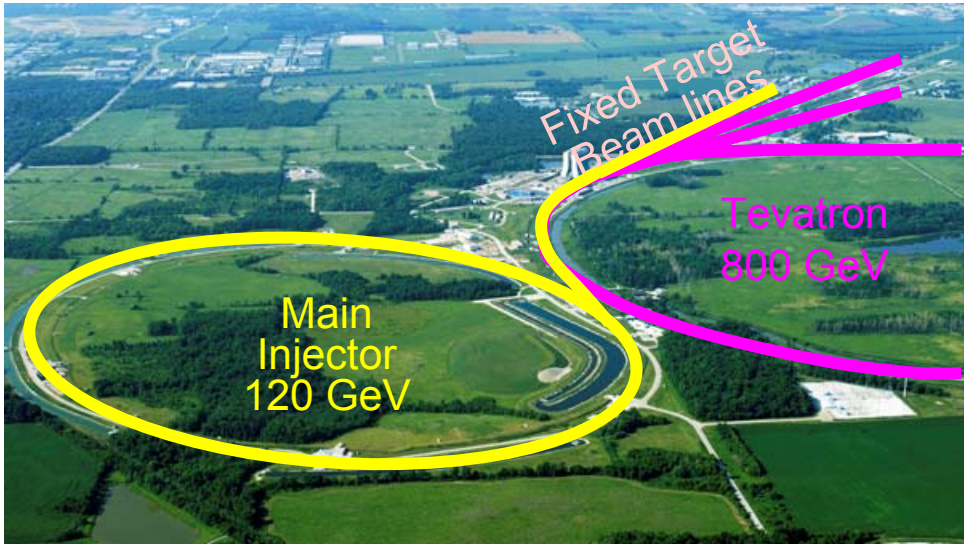
Fermilab E-906/SeaQuest

- Data in 2010-13
- ^{1}H, ^{2}H, and nuclear targets
- 120 GeV proton Beam

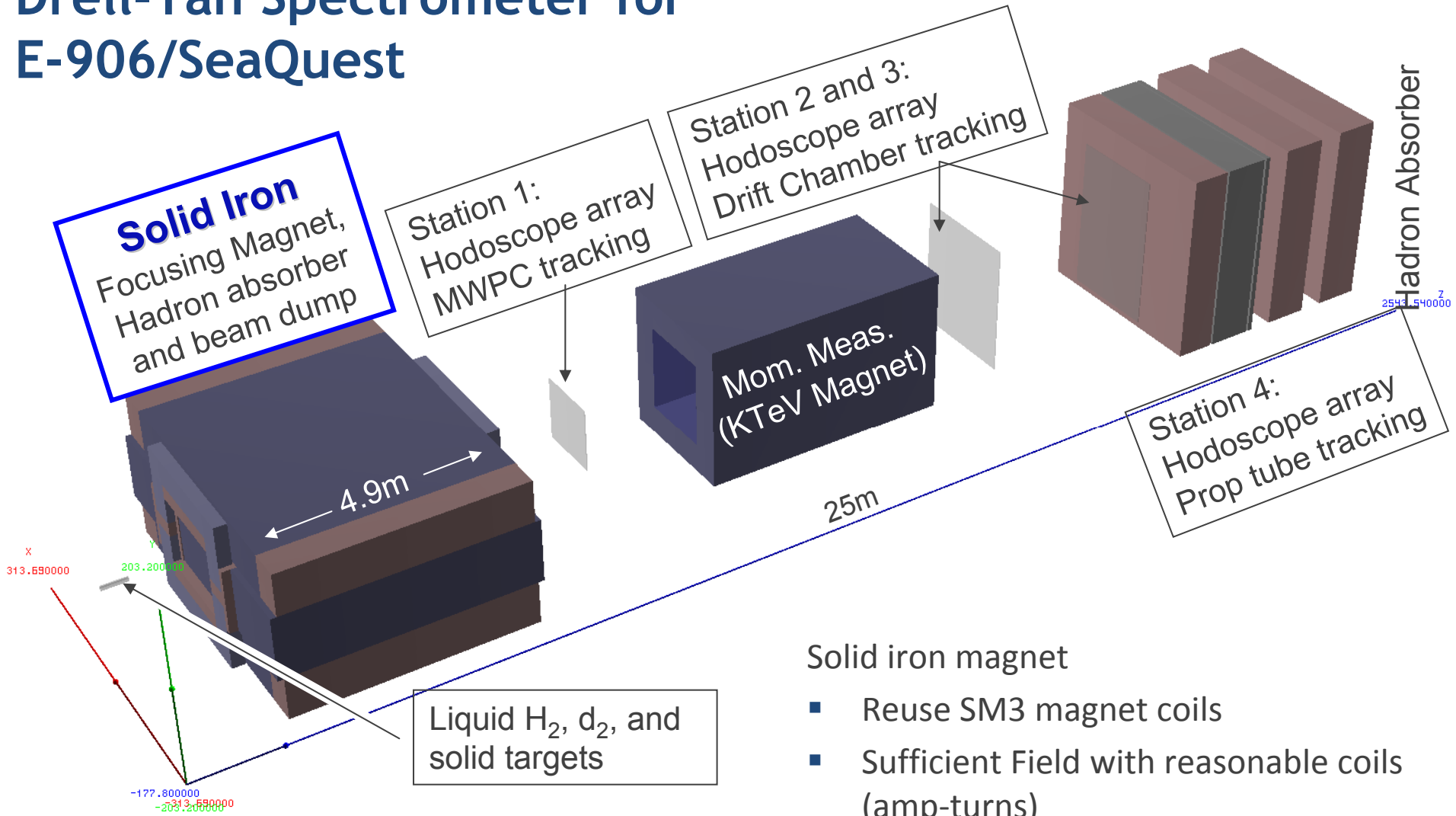
$$\frac{d^2\sigma}{dx_t dx_b} = \frac{4\pi\alpha^2}{9x_1x_2s} \times \sum_i e_i^2 \left[q_{ti}(x_t)\bar{q}_{bi}(x_b) + \bar{q}_{ti}(x_t)q_{bi}(x_b)\right]$$

- Cross section scales as 1/s
  - *7× that of 800 GeV beam*
- Backgrounds, primarily from J/ψ decays scale as s
  - *7× Luminosity for same detector rate as 800 GeV beam*

50× statistics!!



Drell-Yan Spectrometer for E-906/SeaQuest

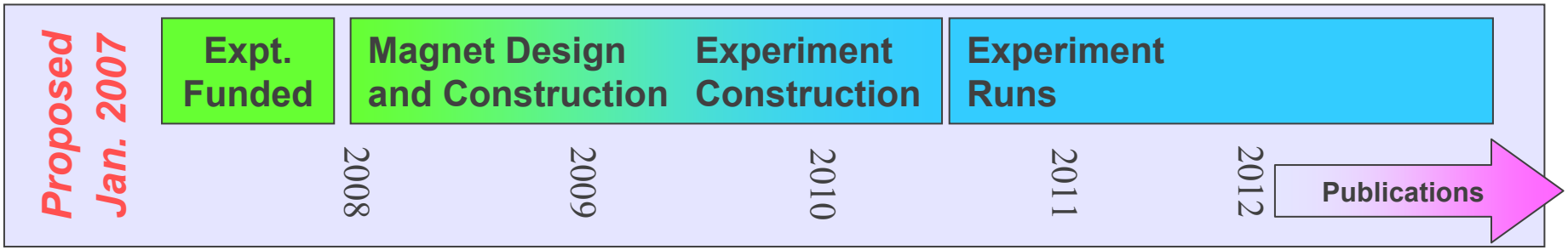


Solid iron magnet

- Reuse SM3 magnet coils
- Sufficient Field with reasonable coils (amp-turns)
- Beam dumped within magnet

E906/Drell-Yan timeline

- Fermilab PAC approved the experiment in 2001, but experiment was not scheduled due to concerns about “proton economics”
- Spectrometer upgrade funded by
  - DOE/Office of Nuclear Physics, US (Most of the money has already been received.)
  - NSF/Mathematical and Physical Sciences, US
  - JSPS, RIKEN, MEXT and G-COE, Japan
  - National Science Council , Taiwan
- Scheduled to run starting in summer, 2010 for approx. 2 years of data collection
- Does not require Tevatron to run



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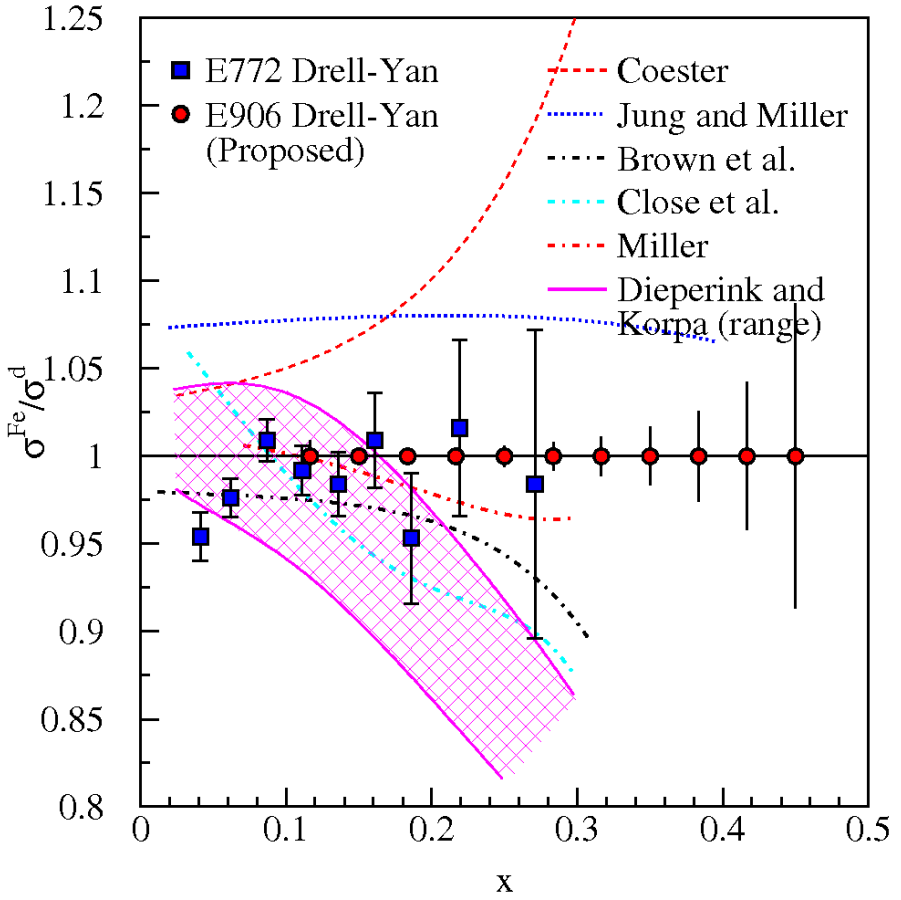
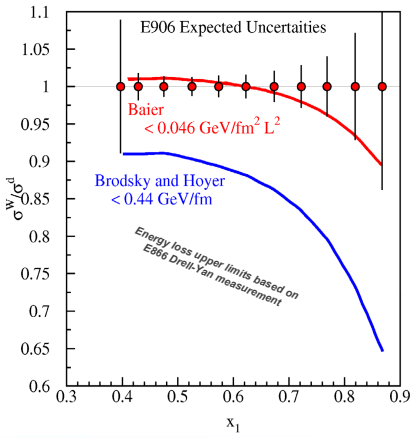
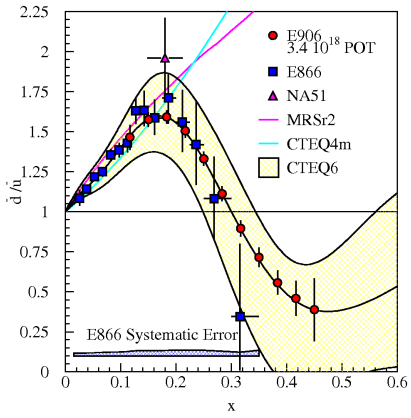
Drell-Yan at Fermilab E-906/SeaQuest

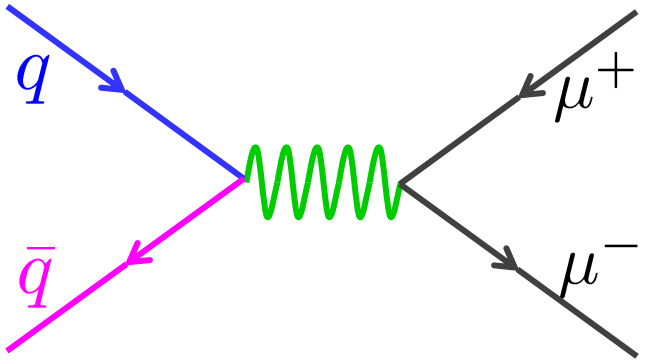
- **What is the structure of nucleonic matter?**
  - Where are the nuclear pions?
  - Is anti-shadowing a valence effect?
- **Fixed Target Drell-Yan scattering will allow for selective study of the antiquark distributions in nuclei.**
- **Data Collection in summer 2010.**
- **Part of a much broader unpolarized Drell-Yan Physics Program**
  - dbar/ubar ratio in proton
  - Partonic energy loss
  - Angular distributions—Boer Mulders effect
- **CEU posters on E-906/SeaQuest**







Event Reconstruction



- We measure
  1. Direction of particles
  2. Absolute momentum of particles
- We assume
  3. Particles are muons

momentum vector

Relativistic energy-momentum vector $\boldsymbol{p}$

$$\mathcal{P}^2 = m_\circ^2 = x_t x_b s$$

$$\frac{2p_l}{\sqrt{s}} = x_F = x_b - x_t$$

- Add 4-vectors of muons to get 4-vectors of virtual photon $\boldsymbol{p}$
  - Now we know everything