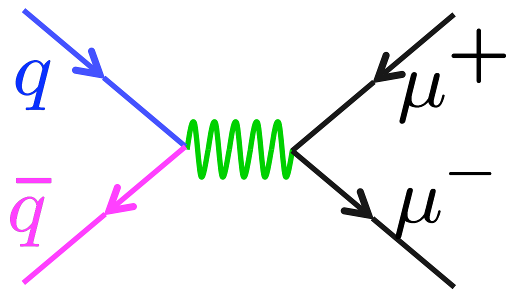
Drell-Yan Measurements of Light Antiquarks in the Nucleon and in Nuclei

E.R. Kinney, University of Colorado
on behalf of the Fermilab E906 Collaboration

- Introduction and Results from Previous Experiments
- Fermilab Experiment E906
- Physics Projections
  - ➡ Light antiquark sea of the nucleon
  - ➡ High *x* valence distributions of the nucleon
  - ➡ Nuclear modification of the sea
  - ➡ Partonic energy loss in cold nuclear matter
- Outlook and Timeline



Exploring the Sea

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  ➡ Limited knowledge of sea at intermediate and high x

  ➡ Direct measurements of the sea quark distributions are required!

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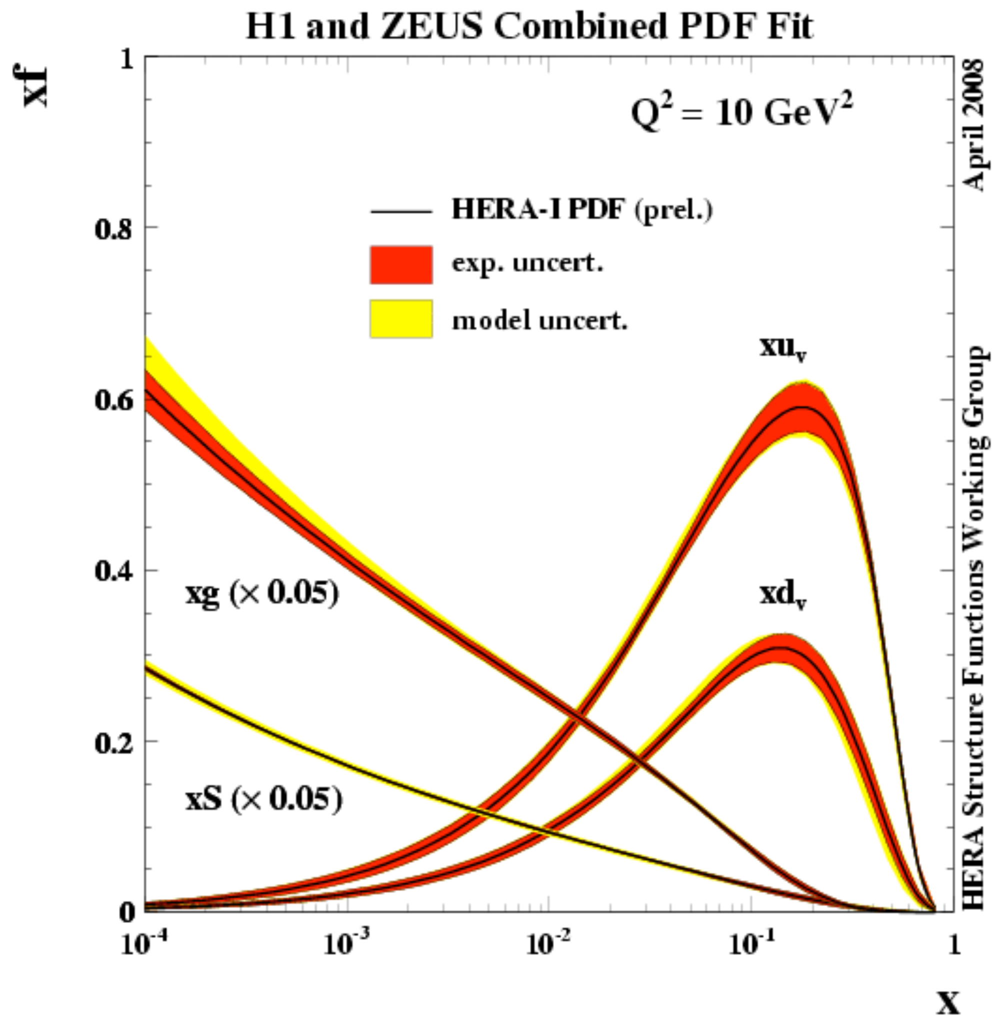

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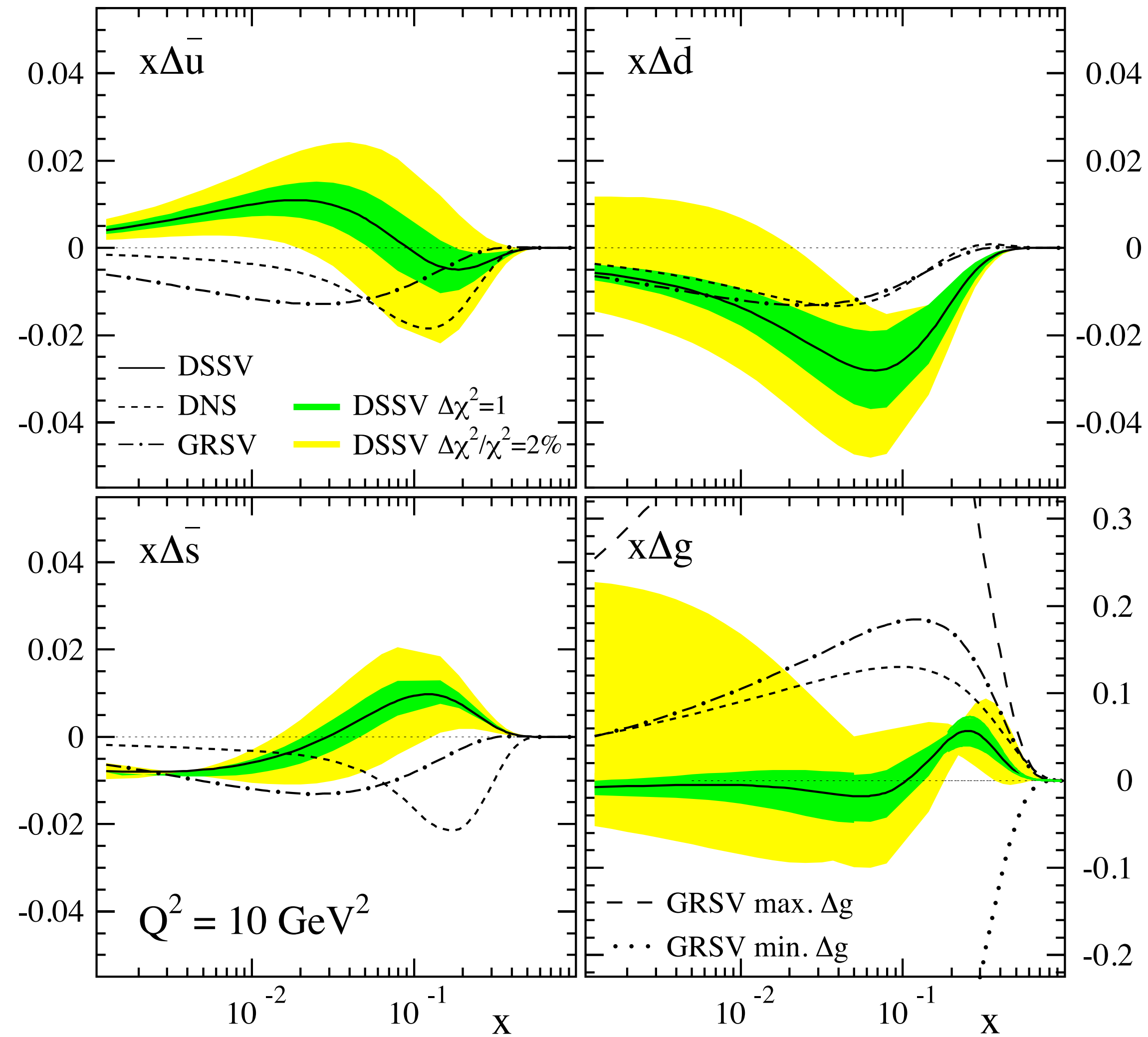

DeFlorian, Sassot, Stratmann, Vogelsang, PRL101 (2008) 072001

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  - ➡ Most recent fits to world data prefer a node in the polarized strange quark and gluon distributions at intermediate x
- Models which generate (non-perturbative) light sea link its properties to spin structure providing an important test

Where does the sea come from?

- Gluon splitting $g \longrightarrow q + \bar{q}$

  ➡ Flavor symmetric? $\bar{u}(x) = \bar{d}(x)$

- Pion cloud (Sullivan process): $p \longrightarrow n + \pi^+$
- Chiral mechanism: $u \longrightarrow d + \pi^+$
- Instantons
- Unknown other mechanisms?

  ➡ Flavor asymmetric? $\bar{u}(x) \neq \bar{d}(x)$

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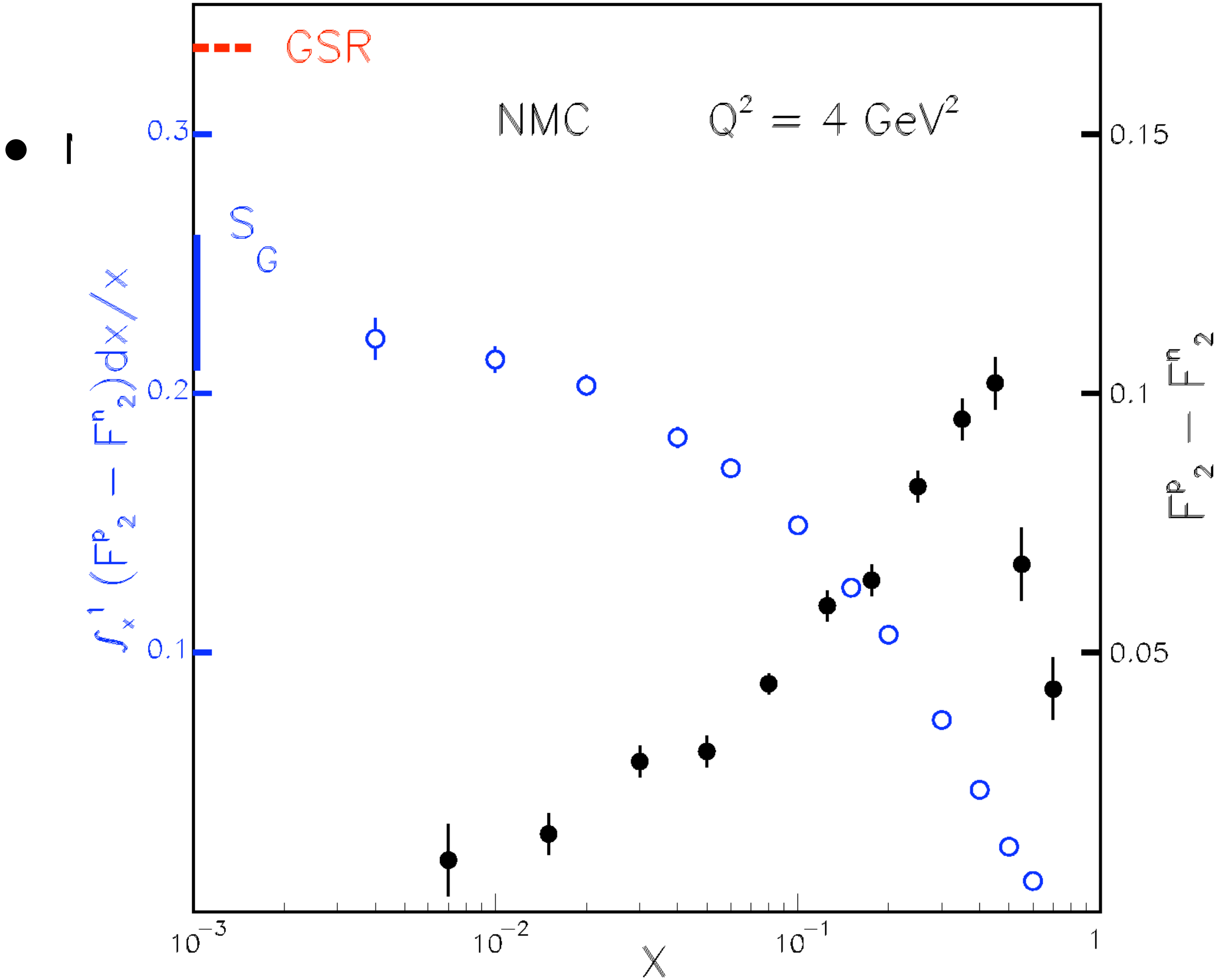

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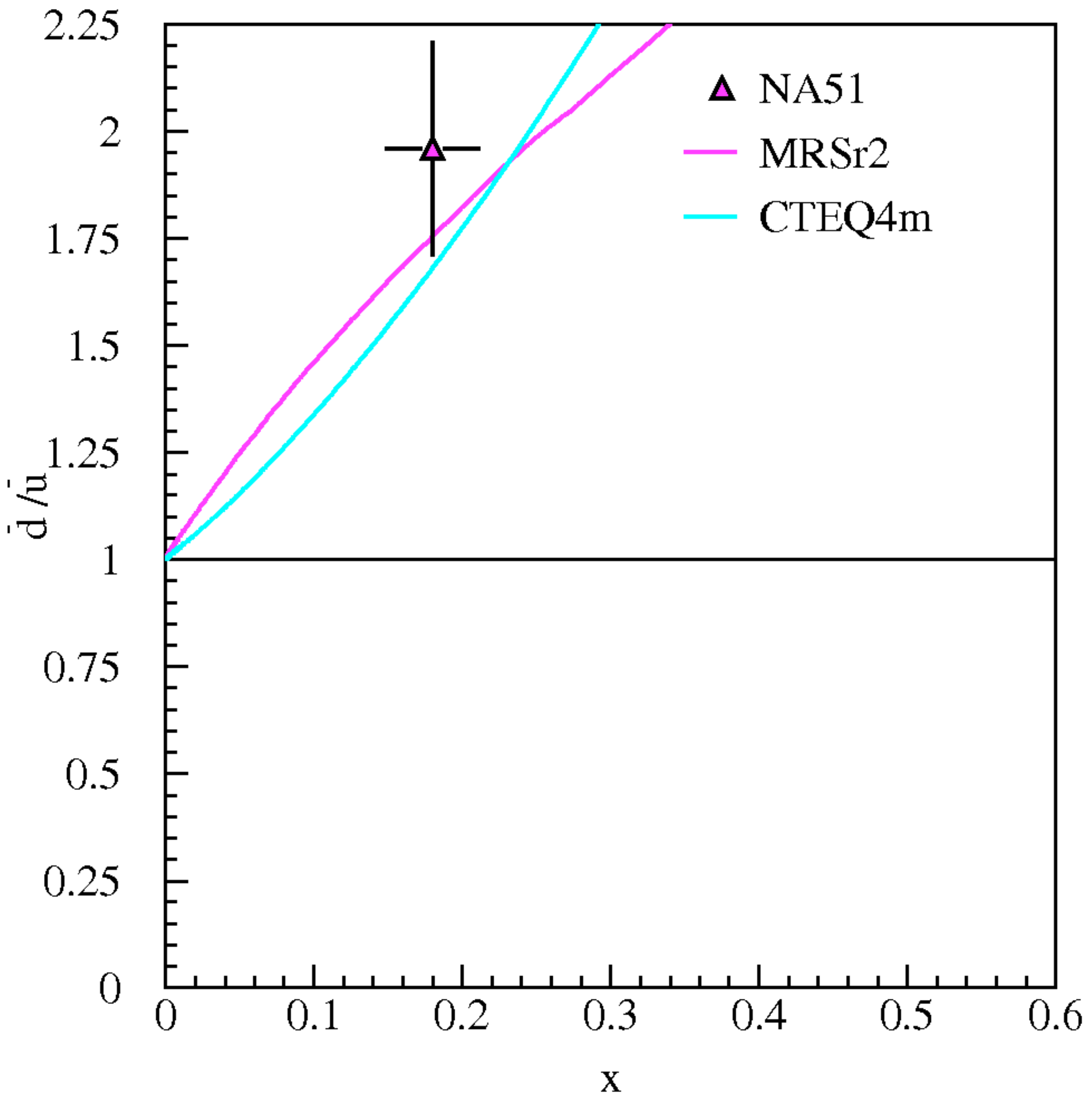

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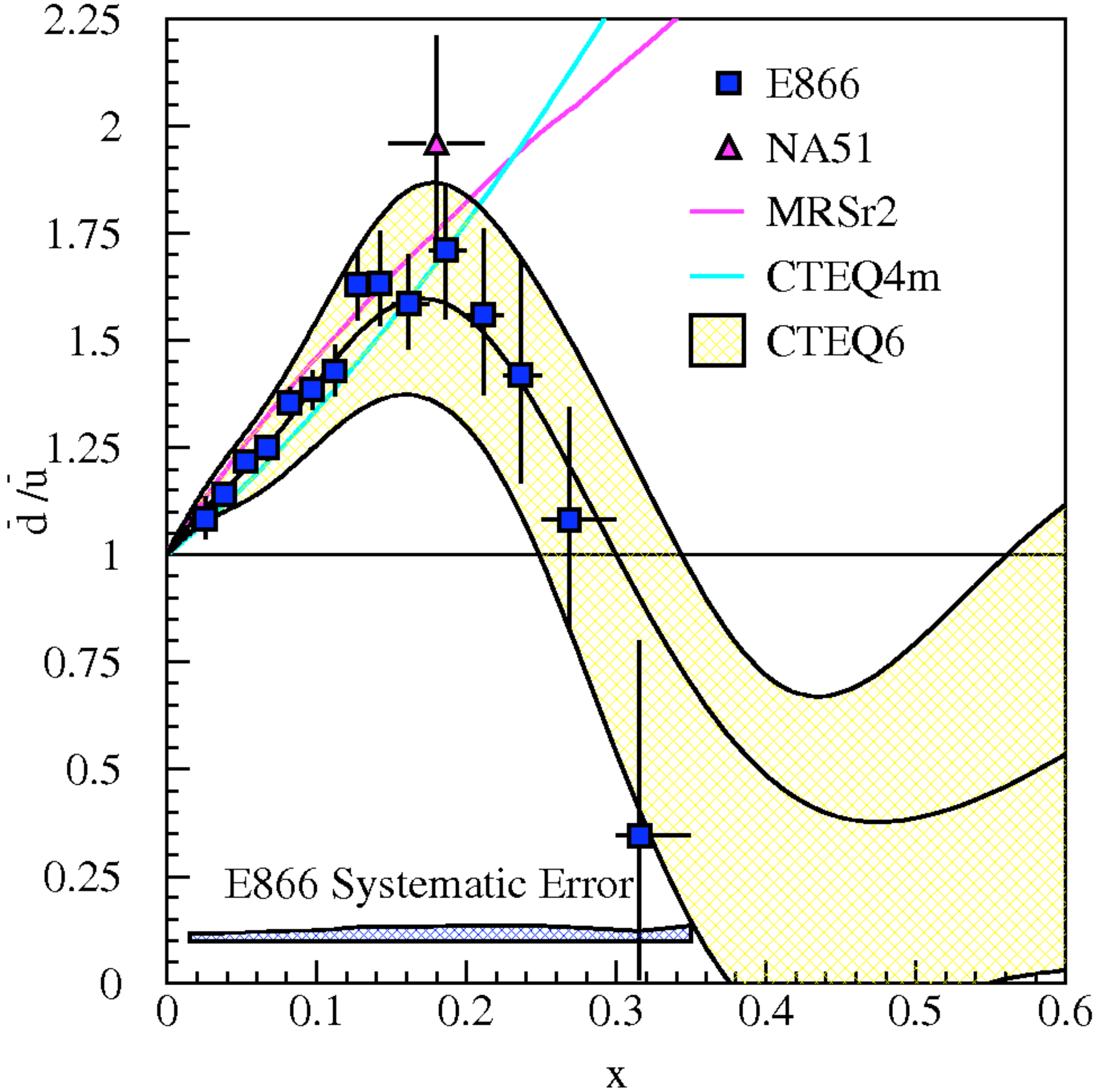

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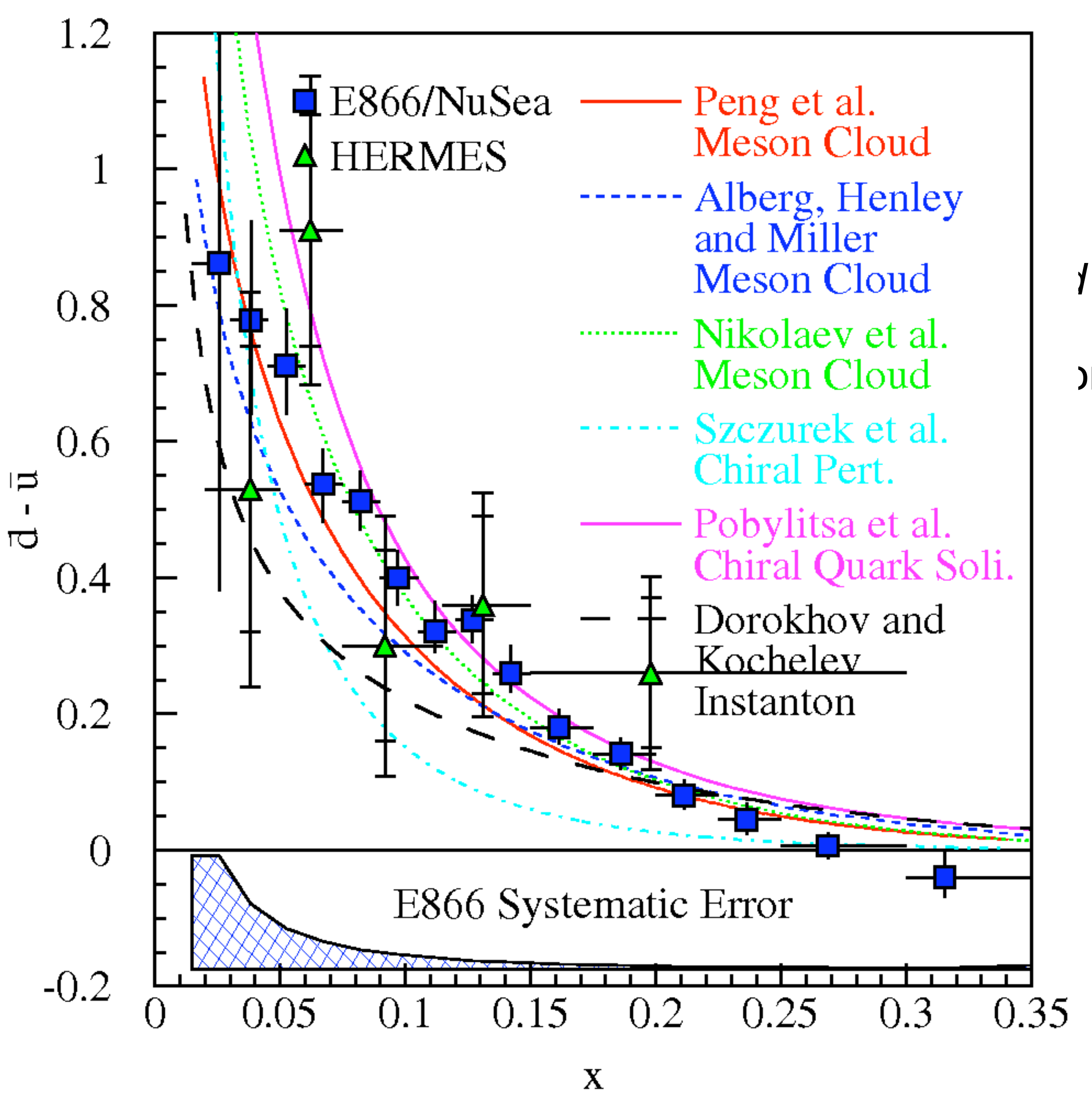

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- Comparison with models
  - ➡ High *x* behavior is not explained/predicted
  - ➡ Measuring ratio is powerful

Fermilab Experiment E906

- E906 proposes to extend Drell-Yan measurements of E866 (with 800 GeV protons) using upgraded spectrometer and 120 GeV proton beam from main injector
- Lower beam energy gives factor 50 improvement “per proton” !
  - ➡ Drell-Yan cross section for given x increases as $1/s$
  - ➡ Production of J/Ψ and similar resonances decreases as s
- Use many components from E866 to save money/time, in KTeV Hall
- Hydrogen, Deuterium and Nuclear Targets

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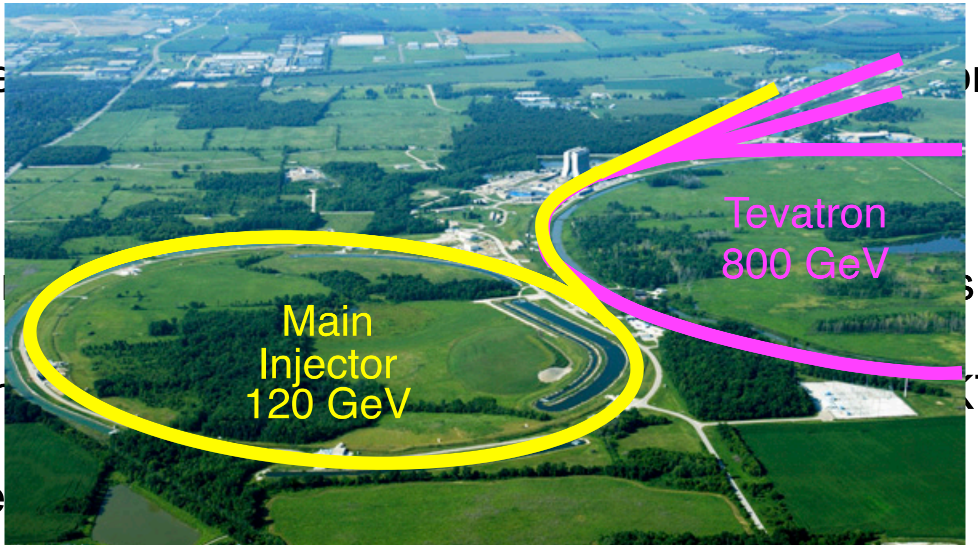

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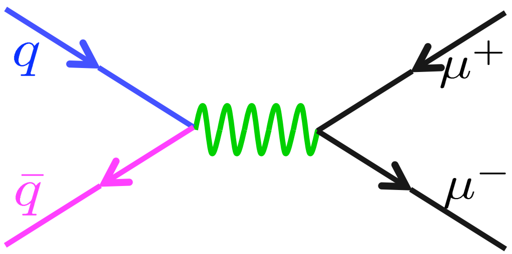

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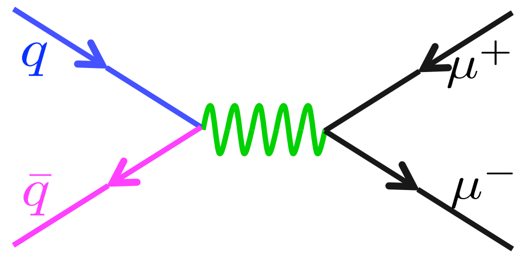

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  ➡ Determine mass and momentum of virtual photon

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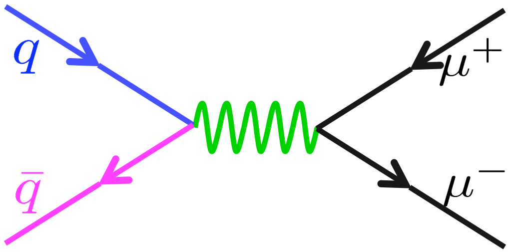

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  - ➡ $$\frac{d^2\sigma}{dx_1 dx_2} = \frac{4\pi\alpha^2}{9x_1 x_2}\frac{1}{s}\sum e^2\left[\bar{q}_t(x_t)q_b(x_b) + q_t(x_t)\bar{q}_b(x_b)\right]$$

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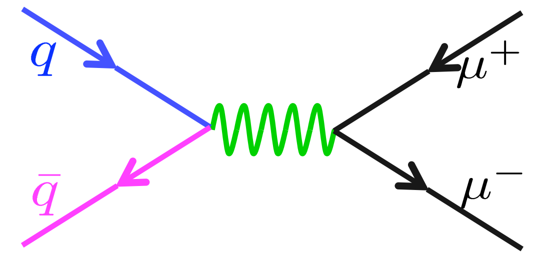

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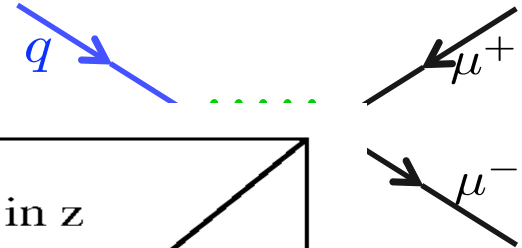

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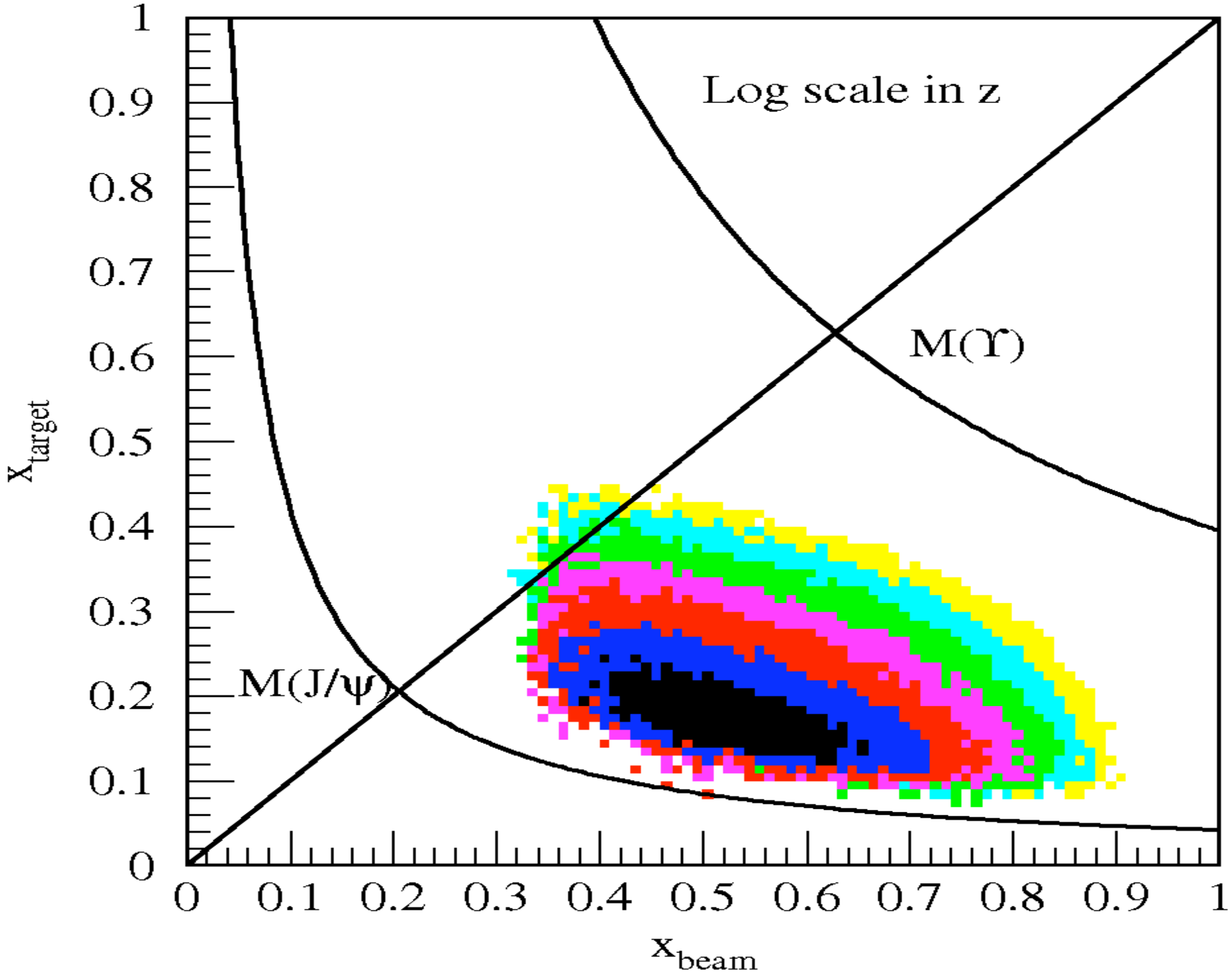

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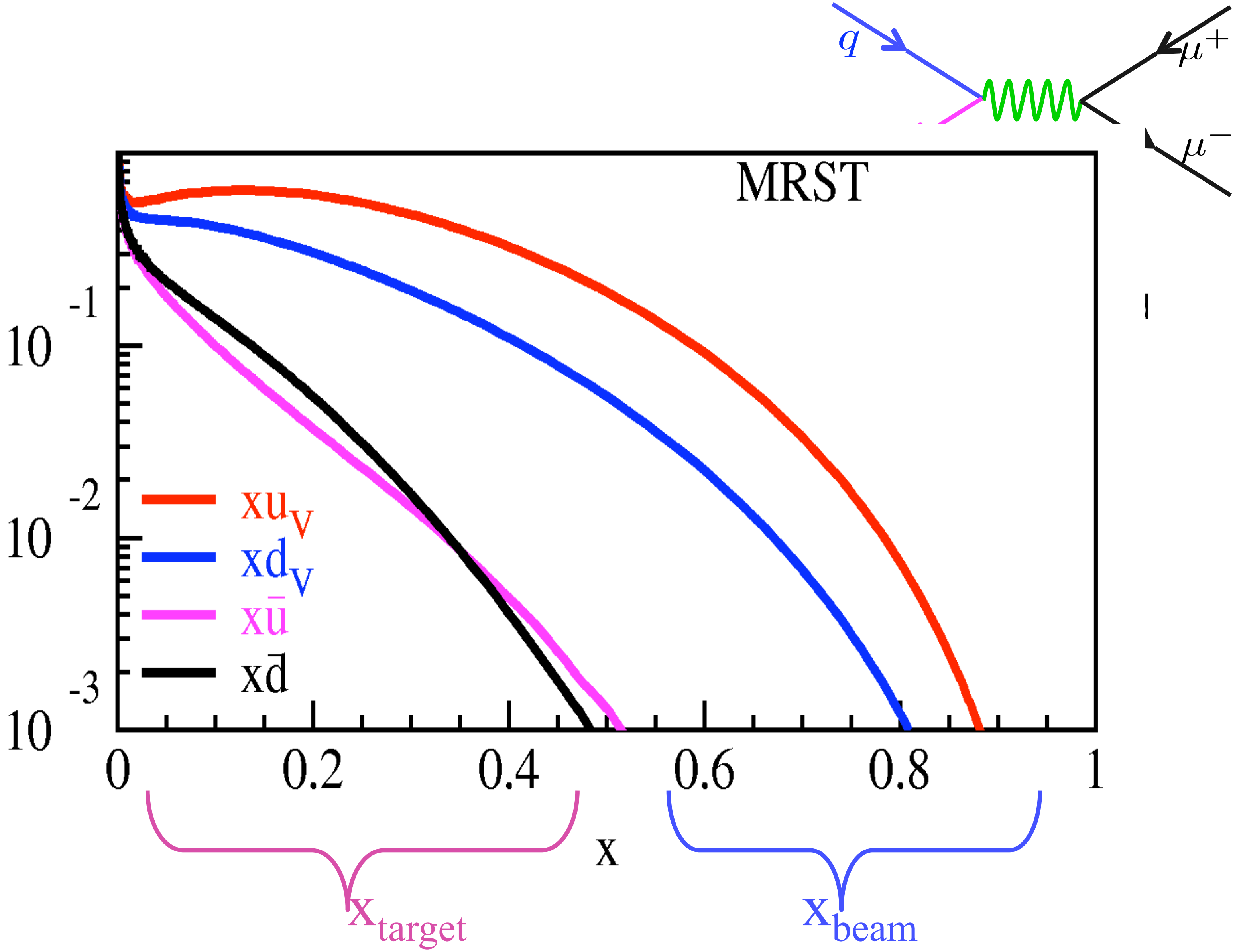

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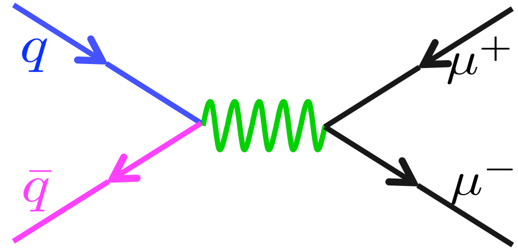

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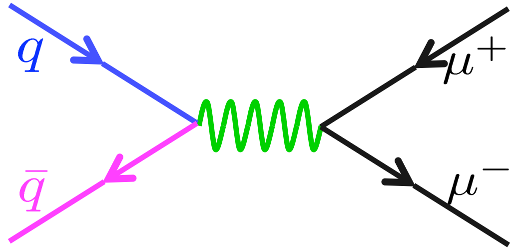

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$$\left.\frac{\sigma^{pd}}{2\sigma^{pp}}\right|_{x_b \gg x_t} \approx \frac{1}{2}\left[1 + \frac{\bar{d}(x_t)}{\bar{u}(x_t)}\right]$$

Fermilab E906/Drell-Yan Collaboration

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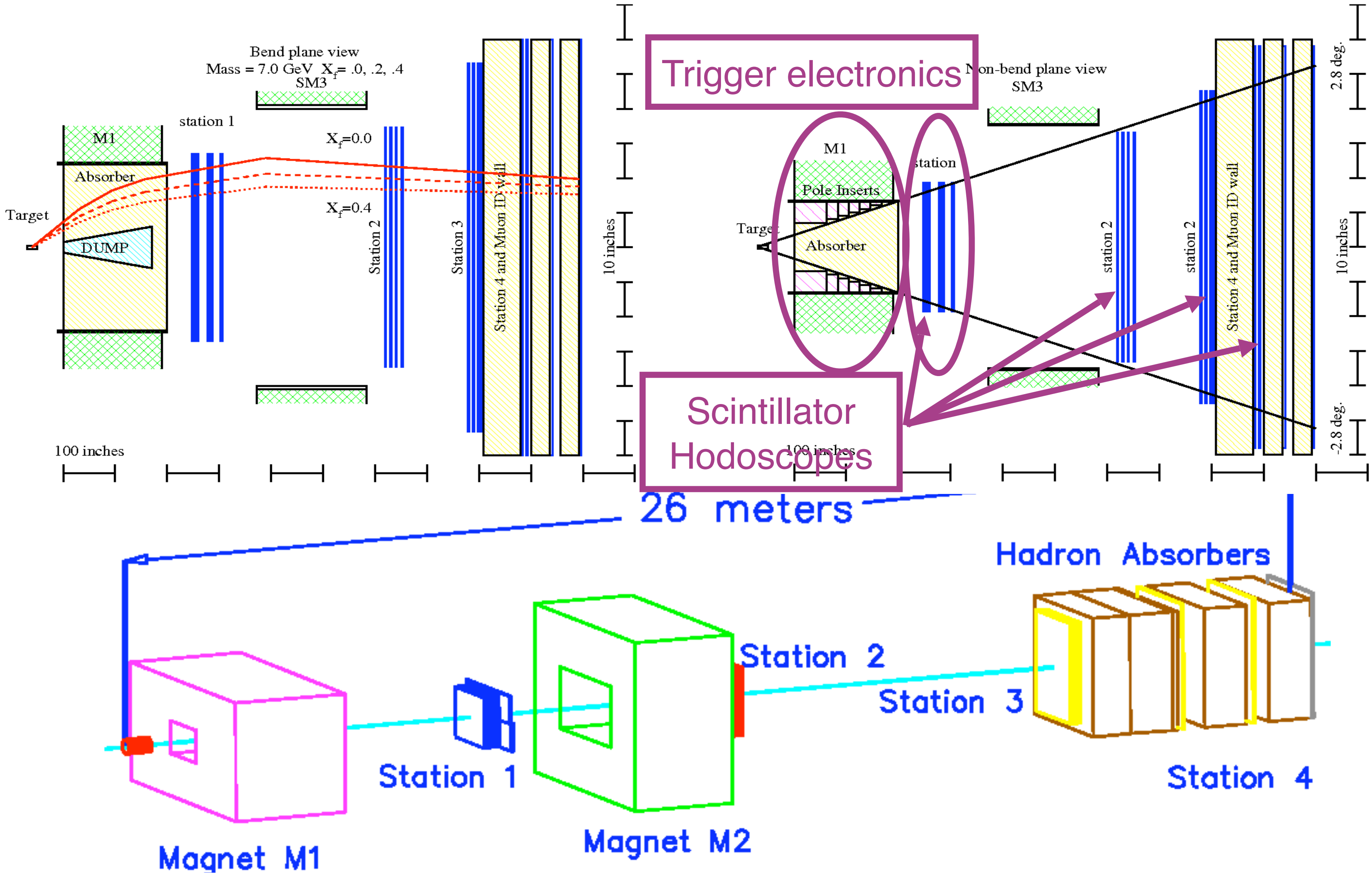
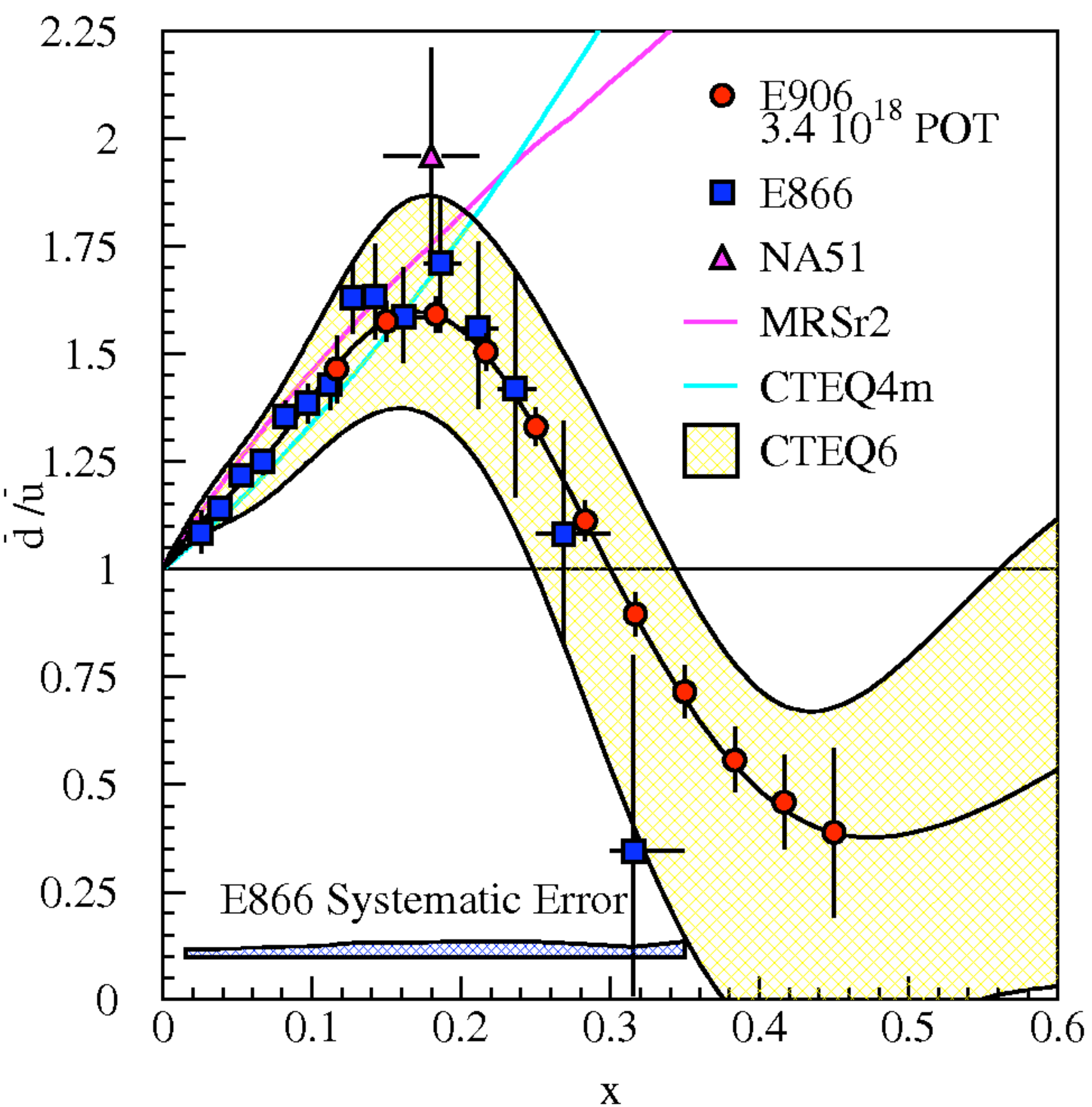
Dave Gaskell

E906 Detector



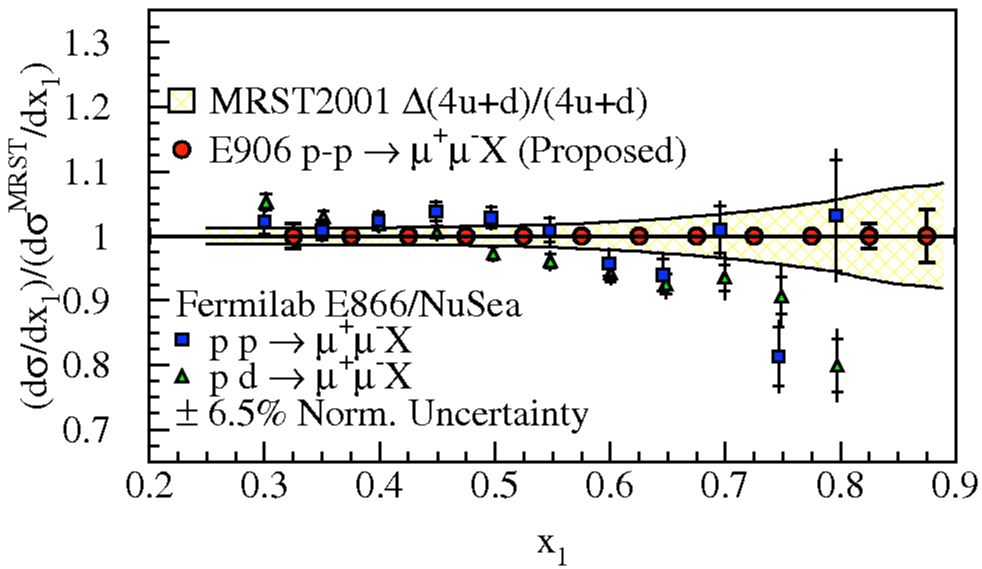
E906 Projections for Light Sea Ratio

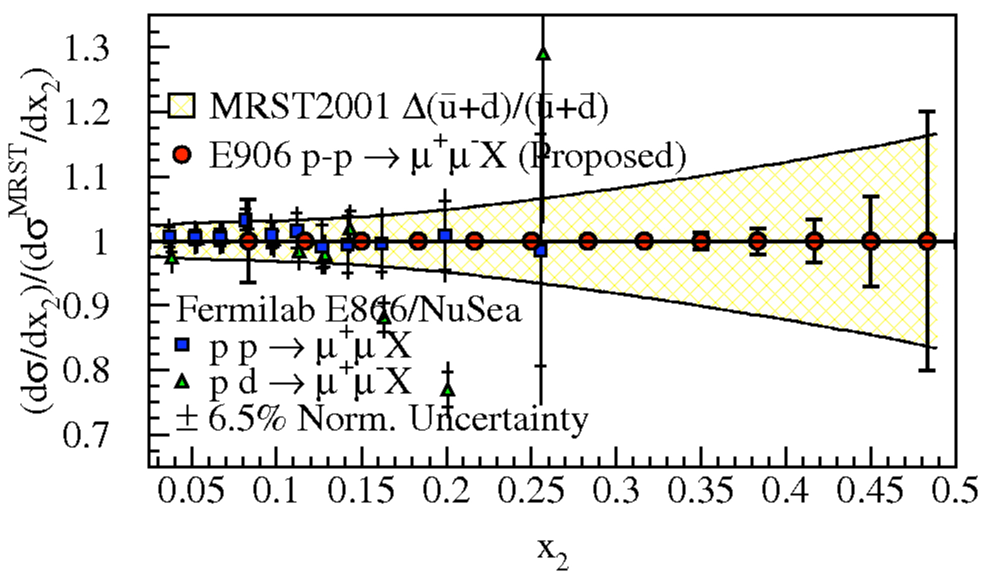
- E906 will extend these measurements and reduce statistical uncertainty.
- E906 expects systematic uncertainty to remain at approx. 1% in cross section ratio.



Drell-Yan Absolute Cross Sections

- Reach high x through beam proton
  - ➡ Large x_F gives large x_b
- High x distributions poorly understood
  - ➡ Nuclear corrections large, even for deuterium
  - ➡ Lack of proton data
- In pp cross section, no nuclear corrections
  - ➡ Direct measure of $4u+d$





Sea quark distributions in Nuclei

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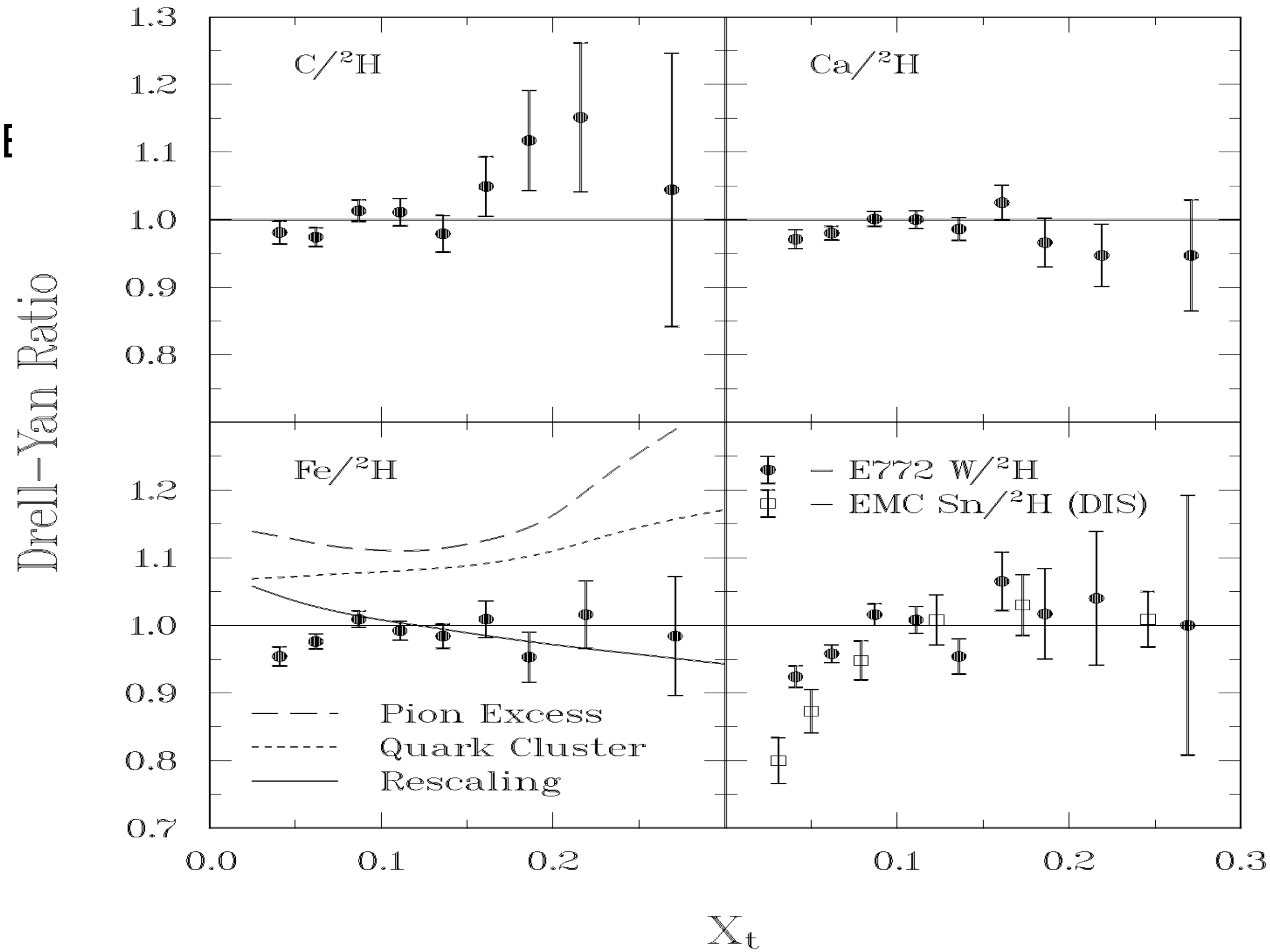
- E



Alde *et al* (Fermilab E772) Phys. Rev. Lett. **64** 2479 (1990)

Sea quark distributions in Nuclei

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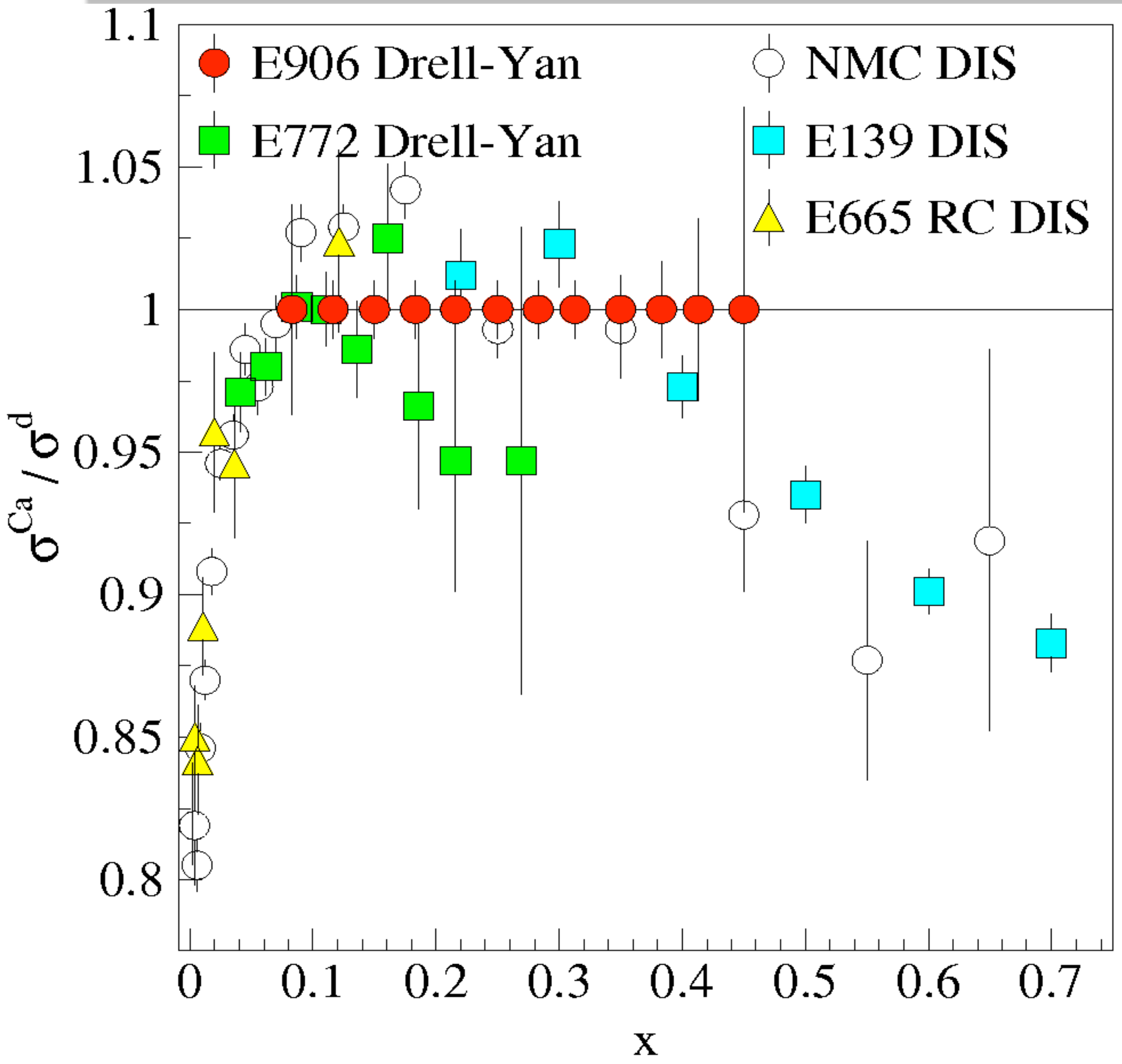
- E906 can extend statistics and *x* range

Sea quark distributions in Nuclei

- EM

- E9



Where are the exchanged pions in the nucleus?

- The binding of nucleons in a nucleus is expected to be governed by the exchange of virtual “Nuclear” mesons.
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- Contemporary models predict large effects to antiquark distributions as x increases.
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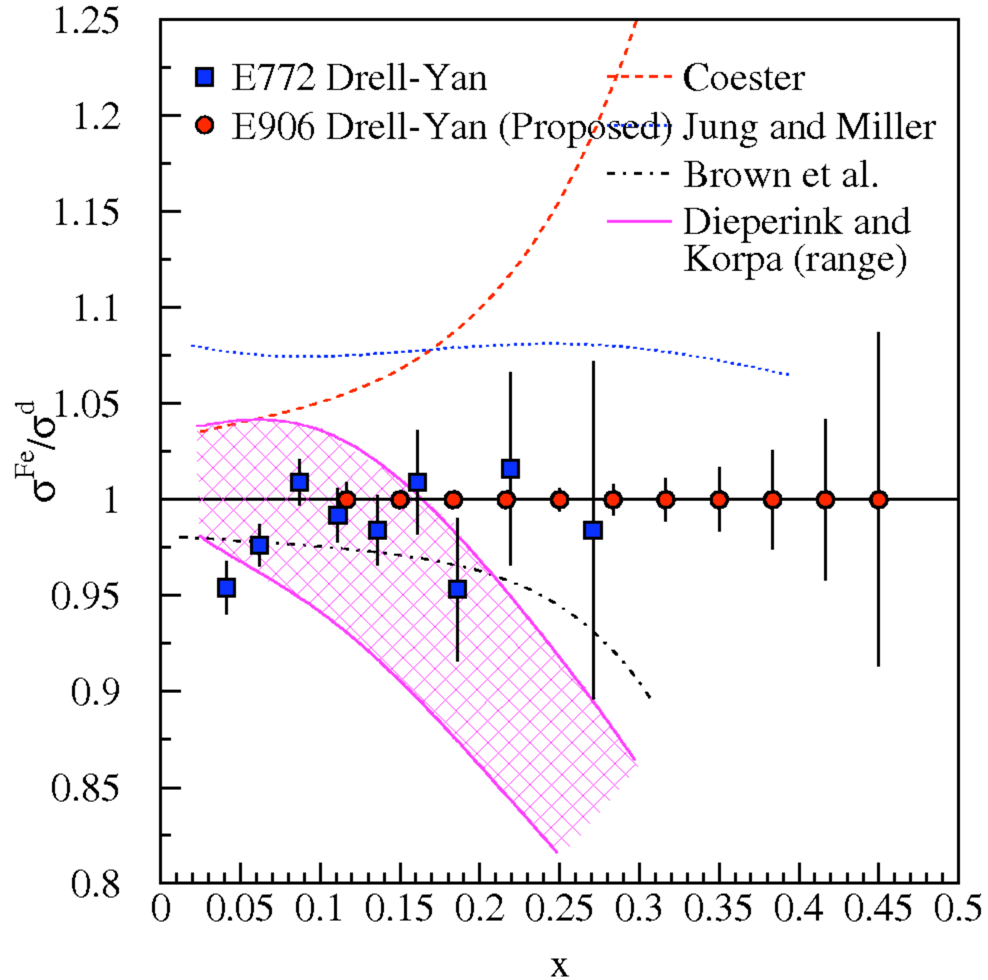
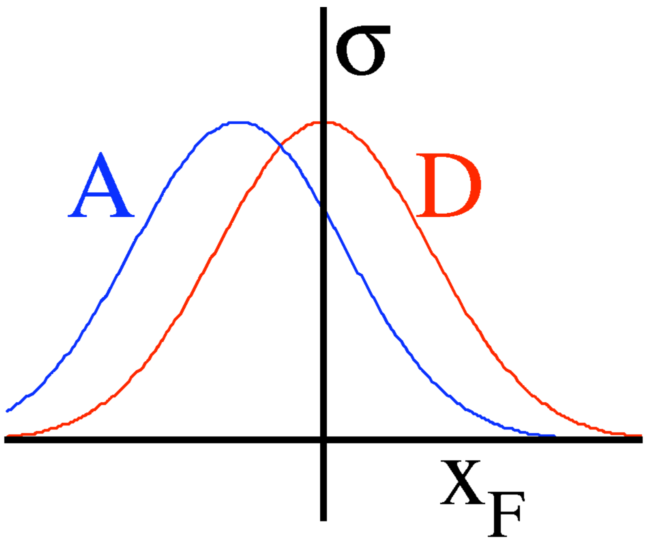
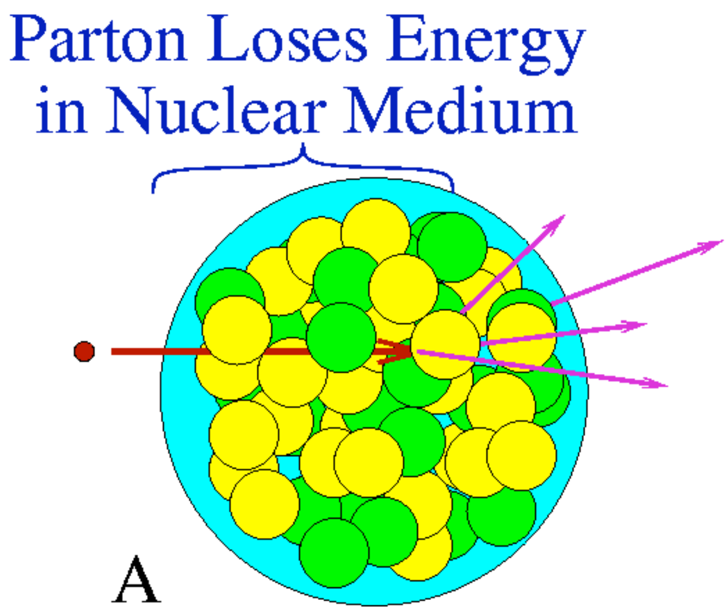


Partonic Energy Loss in Cold Nuclear Matter

- An understanding of partonic energy loss in both cold and hot nuclear matter is important to elucidating RHIC data.
- Pre-interaction parton from beam proton moves through cold nuclear matter and looses energy.
- Apparent (reconstructed) kinematic values (x_1 or x_F) is shifted
- Fit shift in x_1 relative to deuterium





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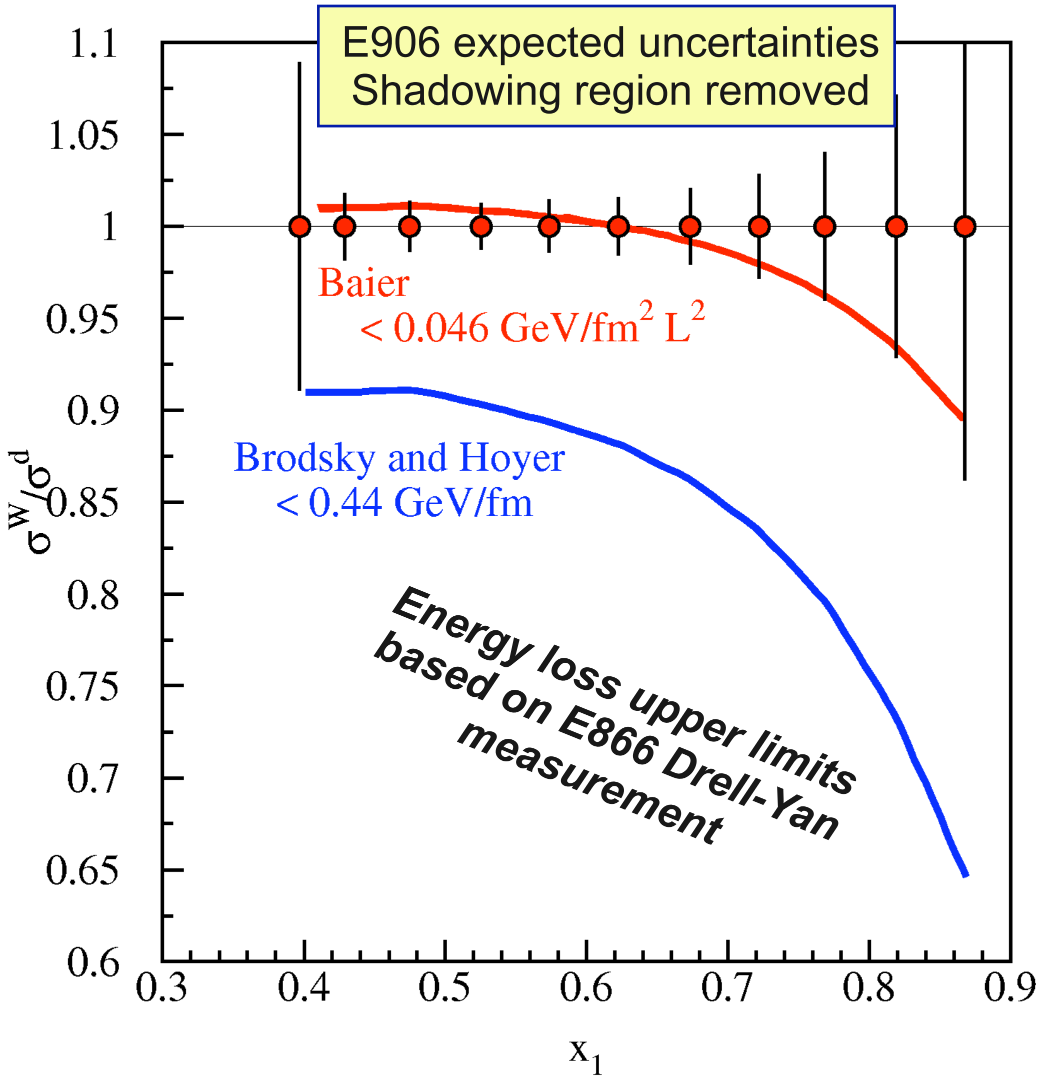

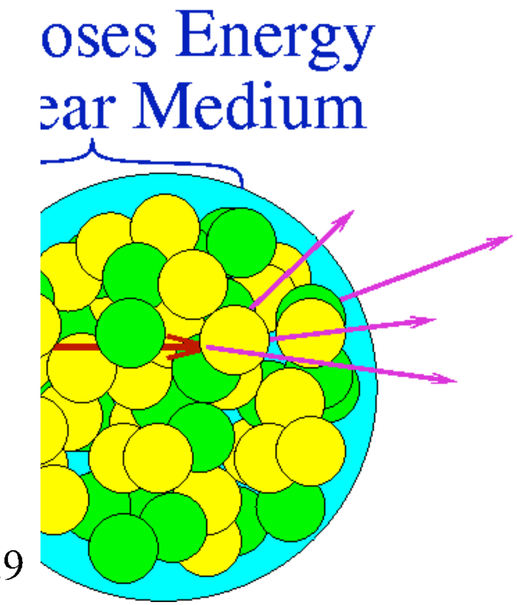

Outlook and Timeline

- E906 Approved by Fermilab PAC and funded by DOE Nuclear Physics
- MOU between Fermilab and E906 Collaboration finalized
- Fermilab Director agrees to go forward with E906 (Nov 10, 2008!)
- Spectrometer construction and installation in 2009
- First beam use in early 2010!
- Post Fermilab run, spectrometer may be moved to JPARC for further measurements