Inclusive Electron Scattering from Nuclei at x>1 and High Q^2 with a 5.75 GeV Beam

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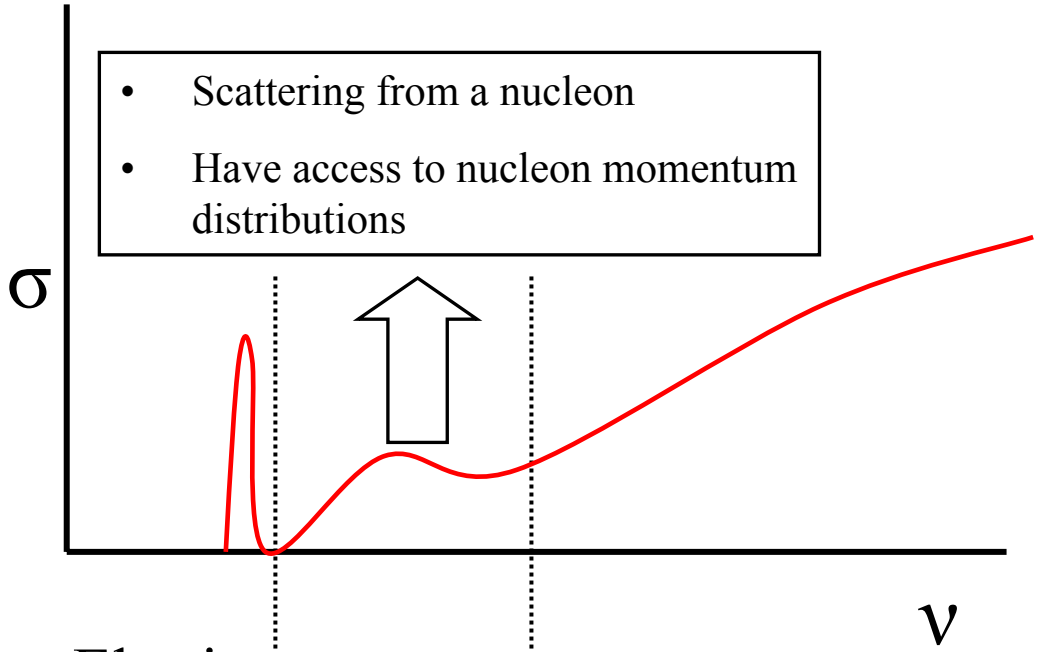
Hall C Meeting – January 18th, 2007

Overview

- Introduction
- Physics Background and Motivation
- Progress since January 2006
- Preliminary Results

Introduction to Quasi-Elastic Scattering



- Scattering from a nucleon
- Have access to nucleon momentum distributions

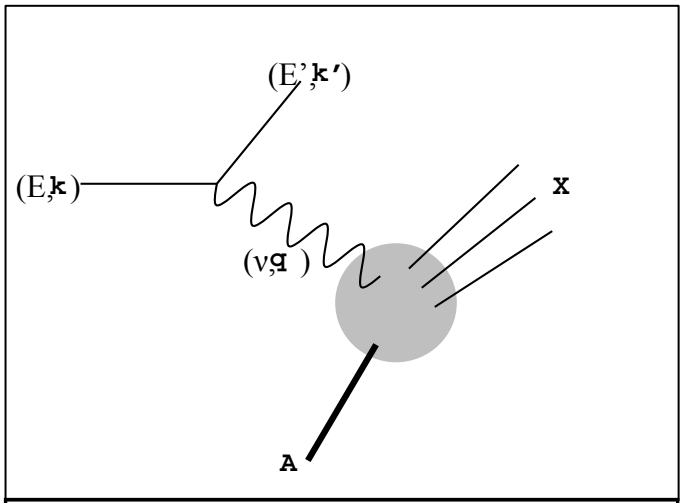
Elastic

QES

DIS

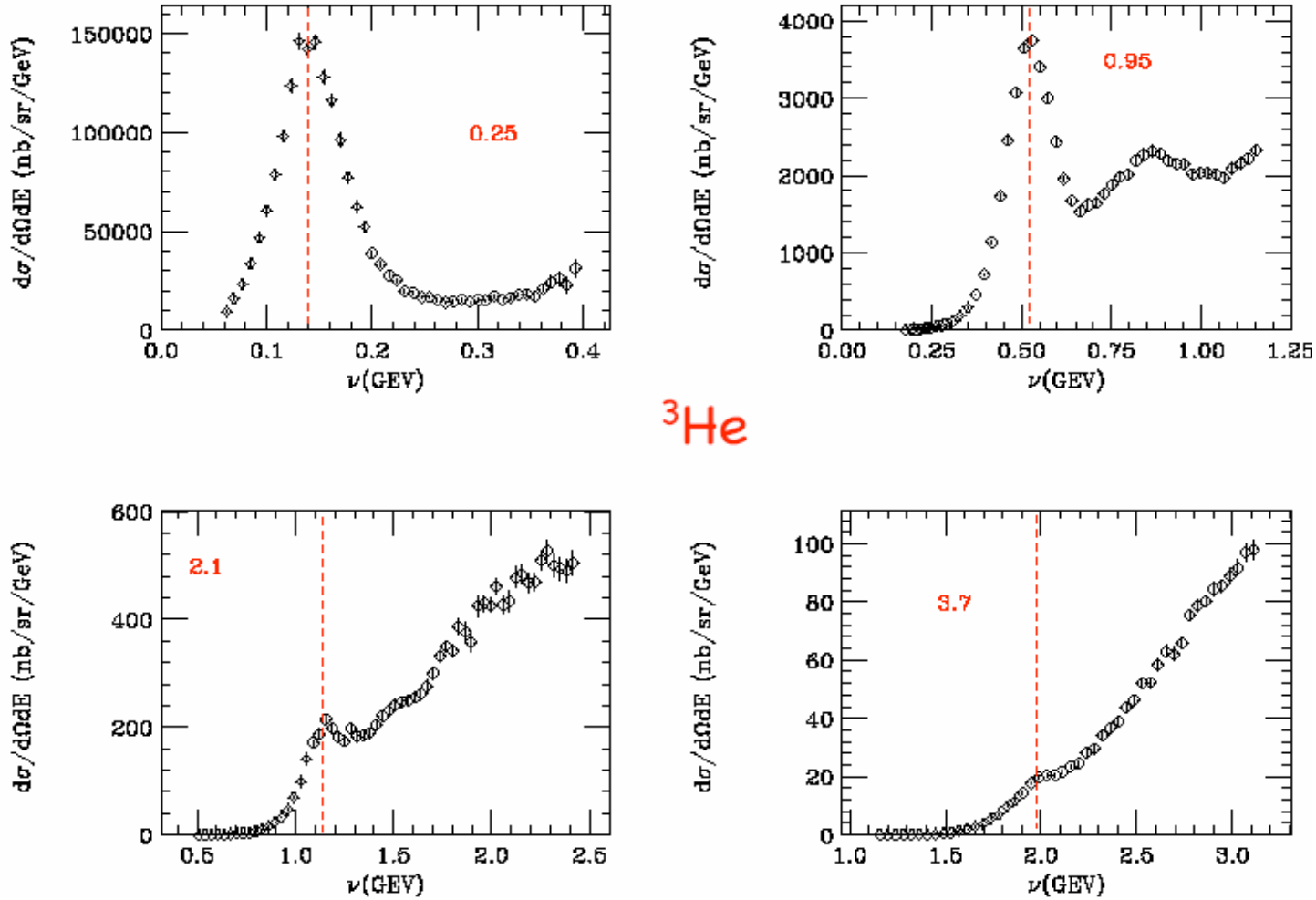
- Scattering from a nucleus

- Scattering from a single quark
- Have access to quark momentum distributions



Inclusive Reaction

Introduction to Quasi-Elastic Scattering

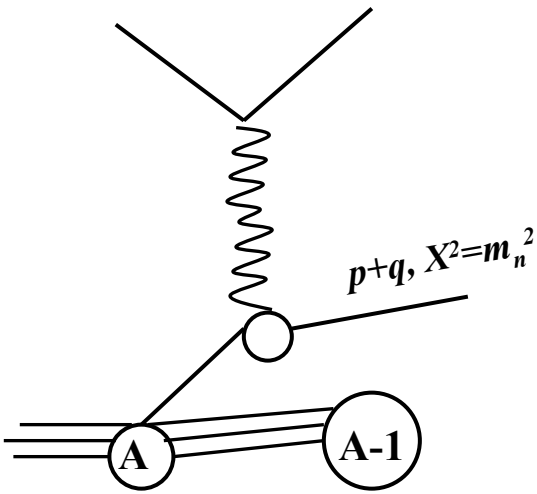


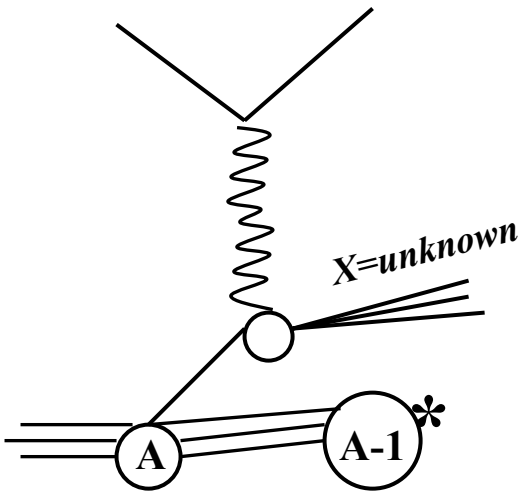
• At low ν, the cross section is dominated by the momentum distribution of the nucleons, but as the momentum transfer increases, inelastic scattering from the nucleons begins to play a larger role.

$$\left(x = \frac{Q^2}{2M_p \nu}\right) \quad > 1$$

QES	DIS
Intermediate Q^2 values	Higher Q^2 values
Scattering from a nucleon	Scattering from quarks
Y-scaling	X and ξ-scaling

Scaling -> Dependence of the cross-section on just one variable





Topics we can study at x>1

- Momentum distributions of nucleons inside nuclei
- Short range correlations (the NN force)
  - ⇨ 2-Nucleon and 3-Nucleon correlations
  - ⇨ Comparison of heavy nuclei to ^{2}H and ^{3}He
- Scaling (x,ξ, y) at large Q^2
  - ⇨ Structure Function Q^2 dependence

X,ξ-scaling

$$\nu W_2(x, Q^2) = \frac{\frac{d^2\sigma}{d\Omega\, d\upsilon}}{\sigma_{mott}} \frac{\nu}{(1+\beta)}$$

, where

$$\beta = 2\tan^2\left(\frac{\theta}{2}\right) \cdot \frac{1+\frac{\nu^2}{Q^2}}{1+R}$$

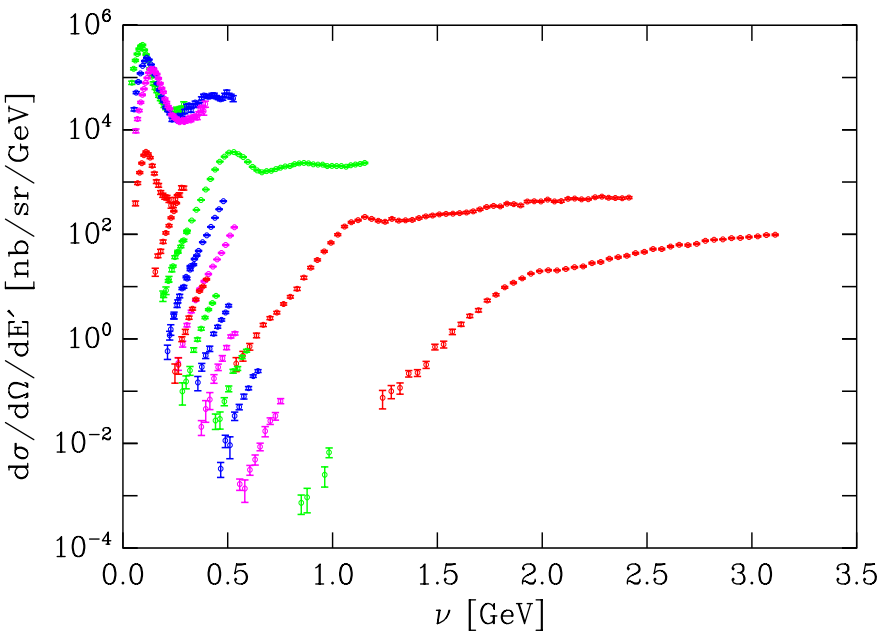
- In the limit of $\nu, Q^2 \rightarrow \infty$, x is the fraction of the nucleon momentum carried by the struck quark, and the structure function in the scaling limit represents the momentum distribution of quarks inside the nucleon.
- As $Q^2 \rightarrow \infty$, $\xi \rightarrow x$, so the scaling of structure functions should also be seen in ξ, if we look in the deep inelastic region.
- It's been observed that in electron scattering from nuclei at SLAC and JLAB, the structure function νW_2, scales at the largest measured values of Q^2 for all values of ξ, including low ξ (DIS) and high ξ (QES).

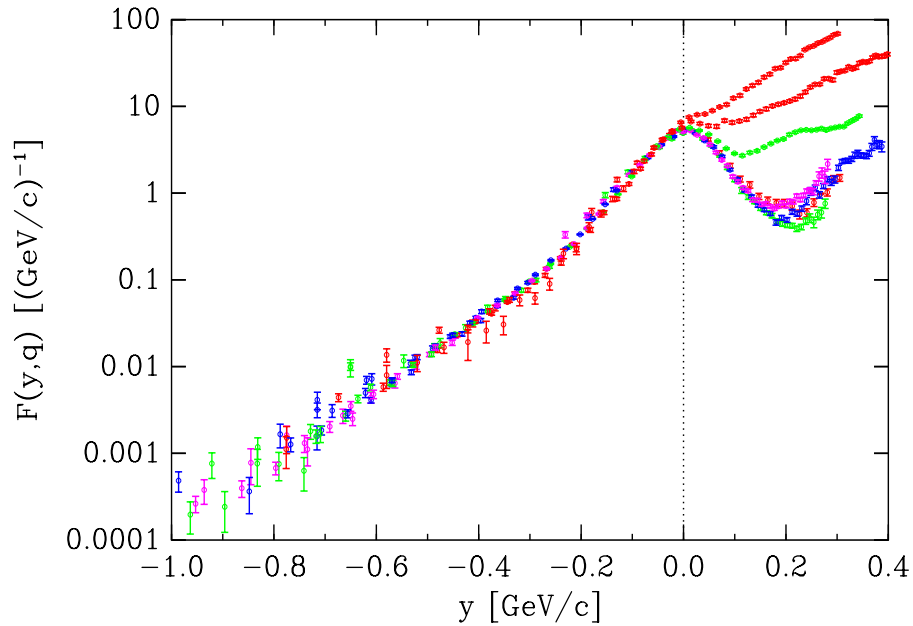
$$\xi = \frac{2x}{\left(1+\sqrt{1+\frac{4M^2x^2}{Q^2}}\right)}$$

As $Q^2 \rightarrow \infty$, $\xi \rightarrow$ $x = \frac{Q^2}{2M_p\nu}$

y-scaling: From cross sections to momentum distributions

- y is the momentum of the struck nucleon parallel to the momentum transfer
- F(y) is defined as ratio of the measured cross-section to the off-shell electron-nucleon cross-section times a kinematic factor



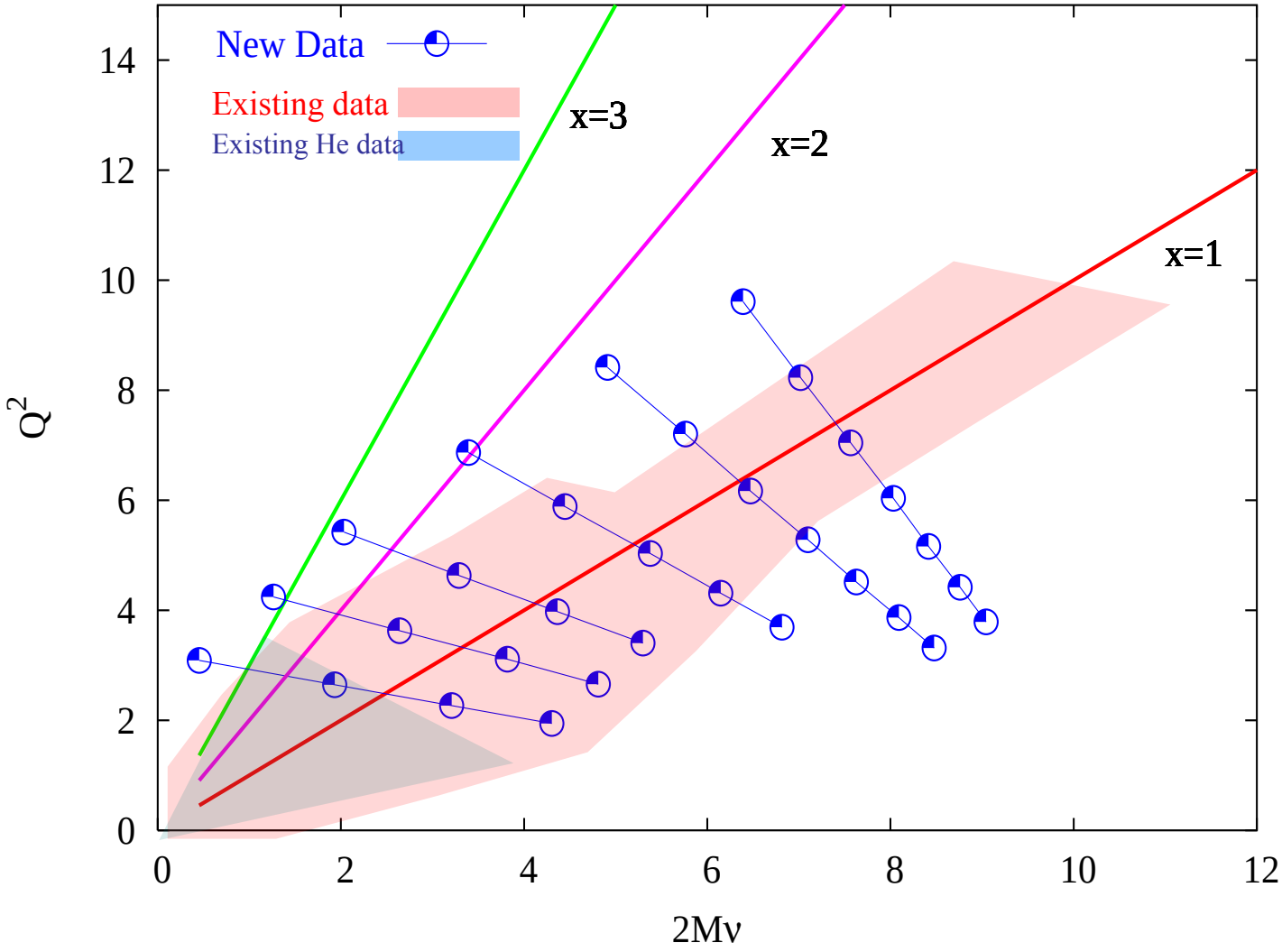


$$F(y) = \frac{d^2\sigma}{d\Omega d\upsilon} \frac{1}{(Z\sigma_p + N\sigma_n)} \frac{\mathbf{q}}{\sqrt{M^2 + (y+q)^2}} = 2\pi \int_{|y|}^{\infty} n(k) k dk$$

E02-019 Details

- E02-019 running is completed (Nov/Dec 2004)
- E02-019 is an extension of E89-008, but with higher E (5.75 GeV) and Q^2.
- Cryogenic Targets: H, ^{2}H, ^{3}He, ^{4}He
- Solid Targets: Be, C, Cu, Au.
- Spectrometers: HMS and SOS (mostly HMS)

Expanded Kinematic Coverage



Analysis Update

There are 4 graduate students (guided by J.Arrington and D.Gaskell)

- Nadia Fomin (UVA)
- Jason Seely (MIT, graduated)
- Aji Daniel (Houston)
- Roman Trojer (Basel)

Calibrations:

- Calorimeter
- Drift Chambers
- TOF
- Čerenkov

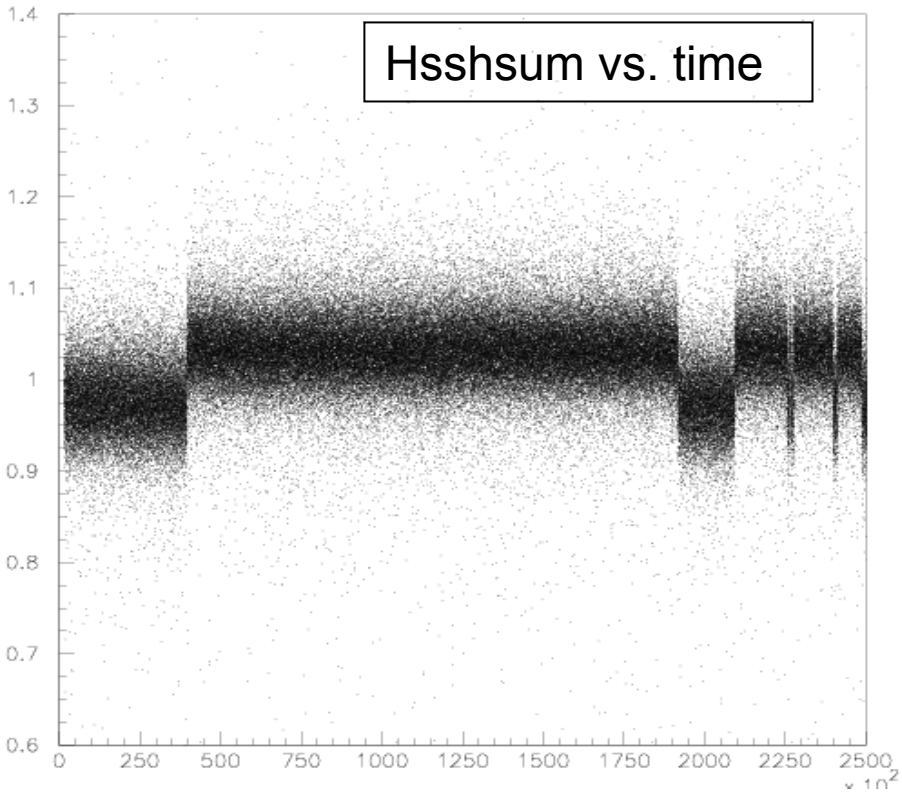
Corrections:

- Charge-symmetric background subtraction
- Acceptance Corrections
- E-loss Corrections
- Target-Boiling Corrections
- Radiative and bin-centering corrections
- Coulomb Corrections

Calorimeter **Re**Calibration

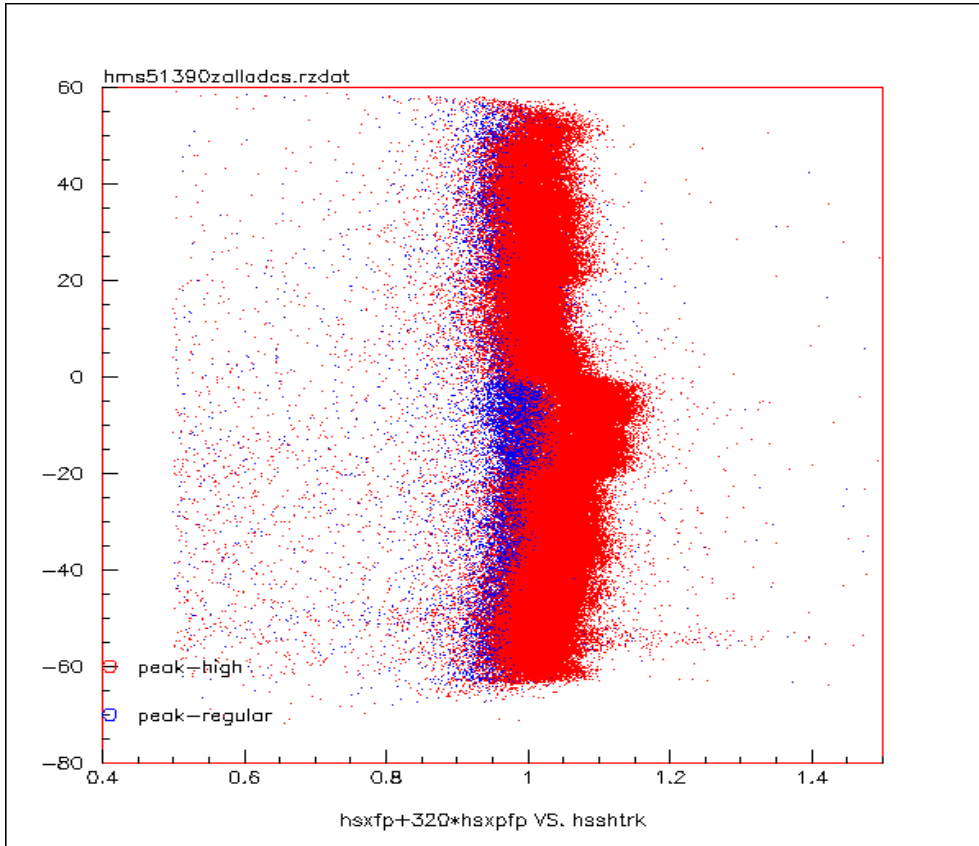
•It was noticed that while the HMS calorimeter calibration placed the peak at or very near 1, it had a position dependence.

•Also, the hope was that instead of having a different calibration for every angle, one good one could be used for the whole data set



•Redid the calibration with stand alone random walk code.

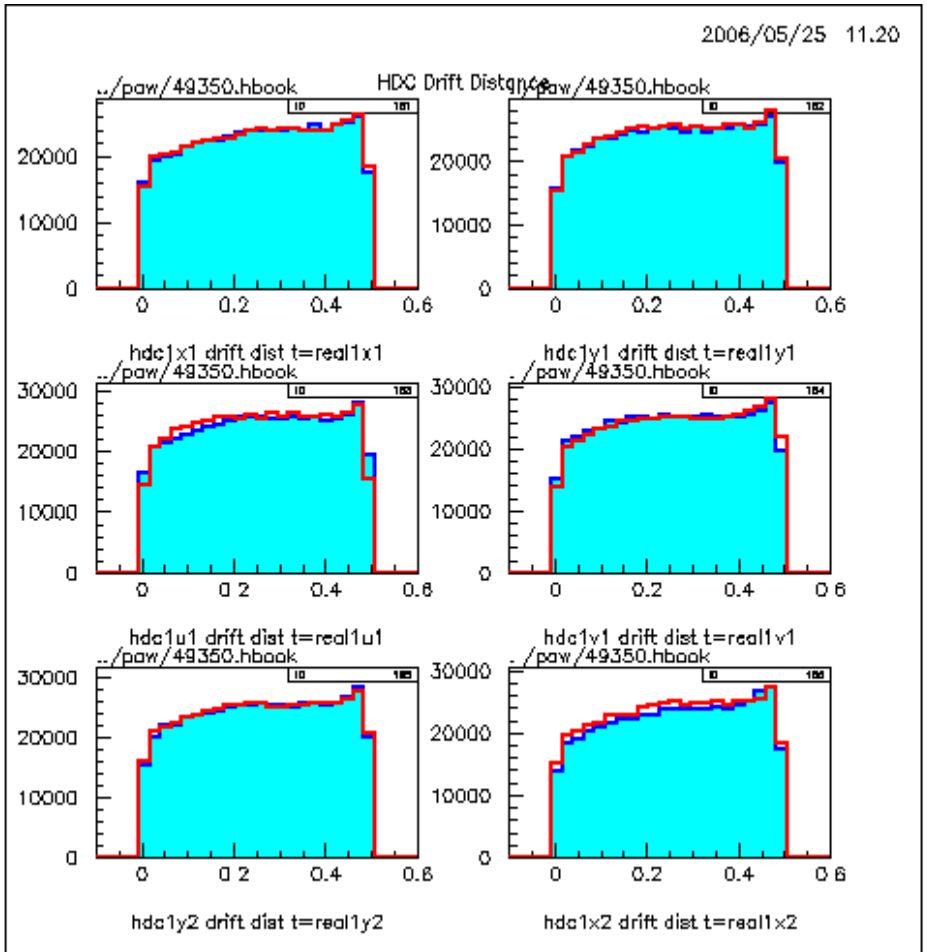
•Single calibration for all the data



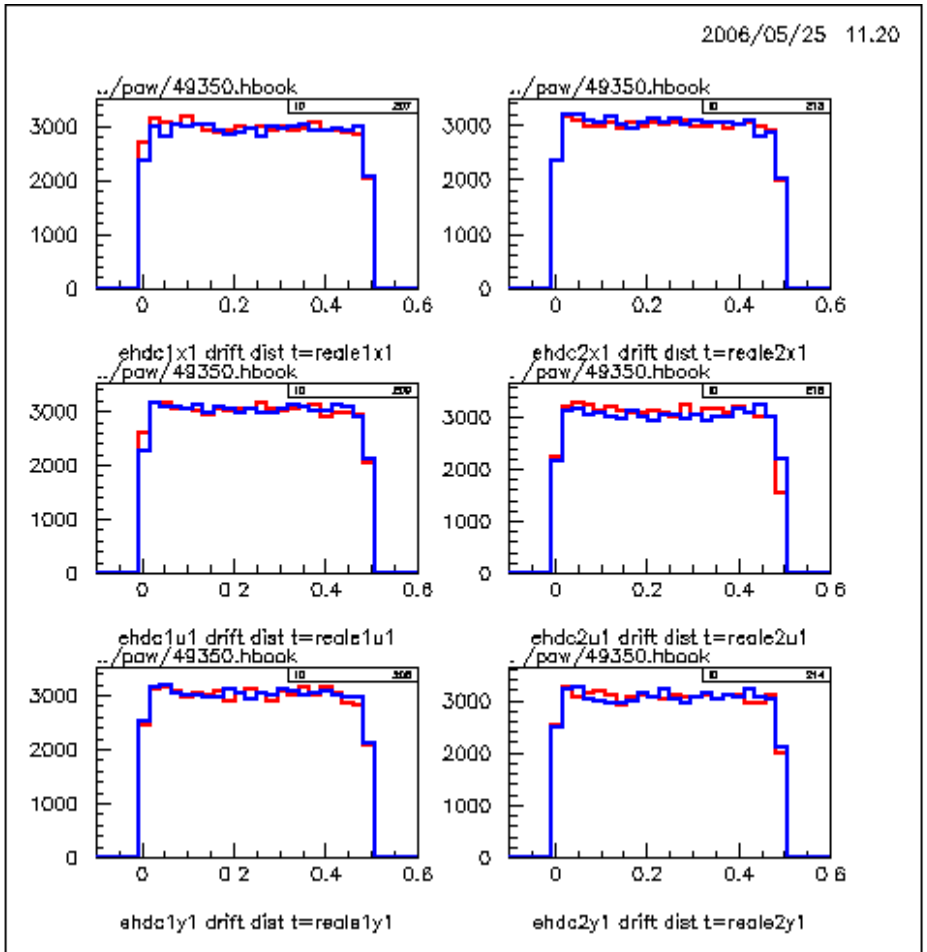
Drift Chamber **Re**Calibration

- Originally, used all events to calibrate the chamber ->redone with ***e***$^-$ events only

Original Calibration



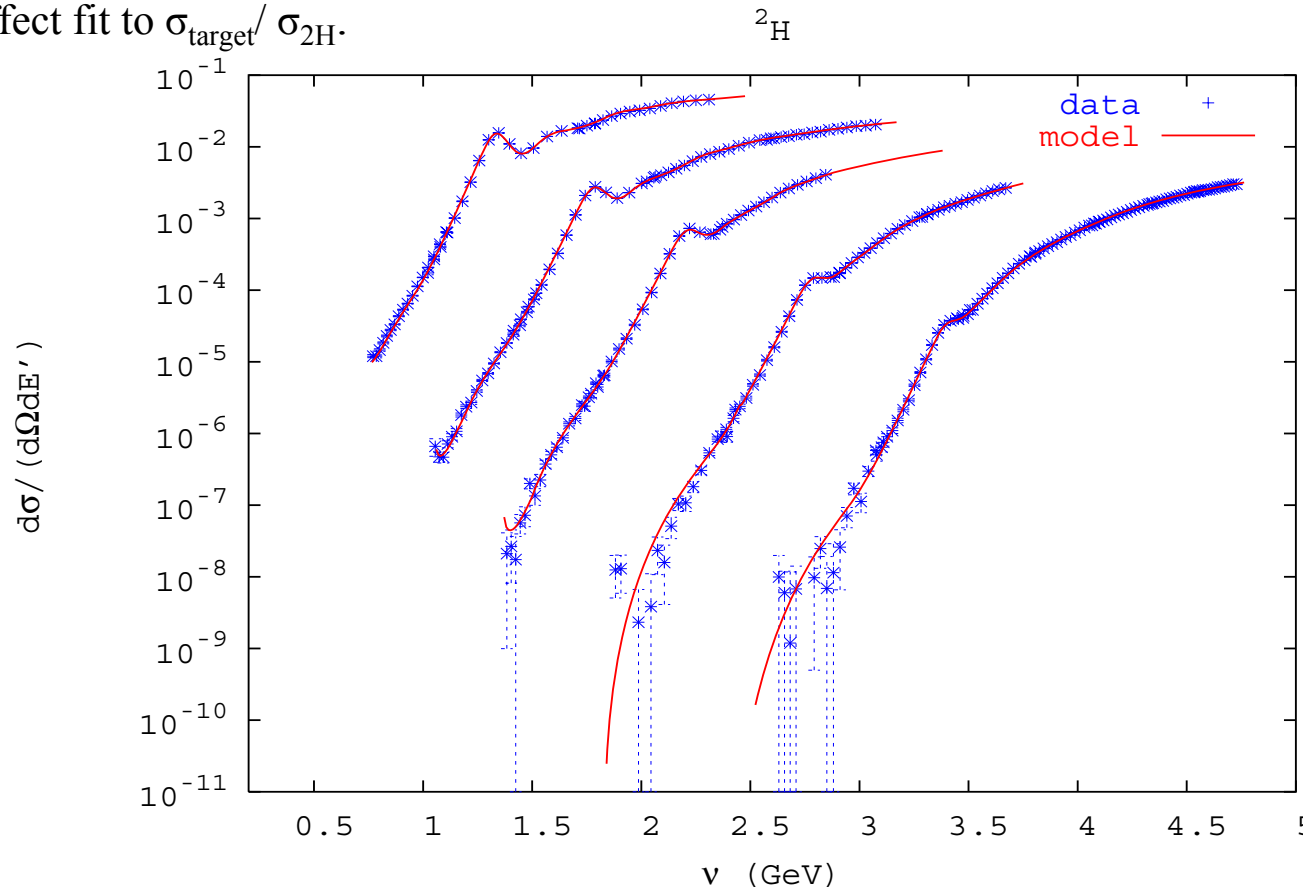
Redone with ***e***$^-$ only



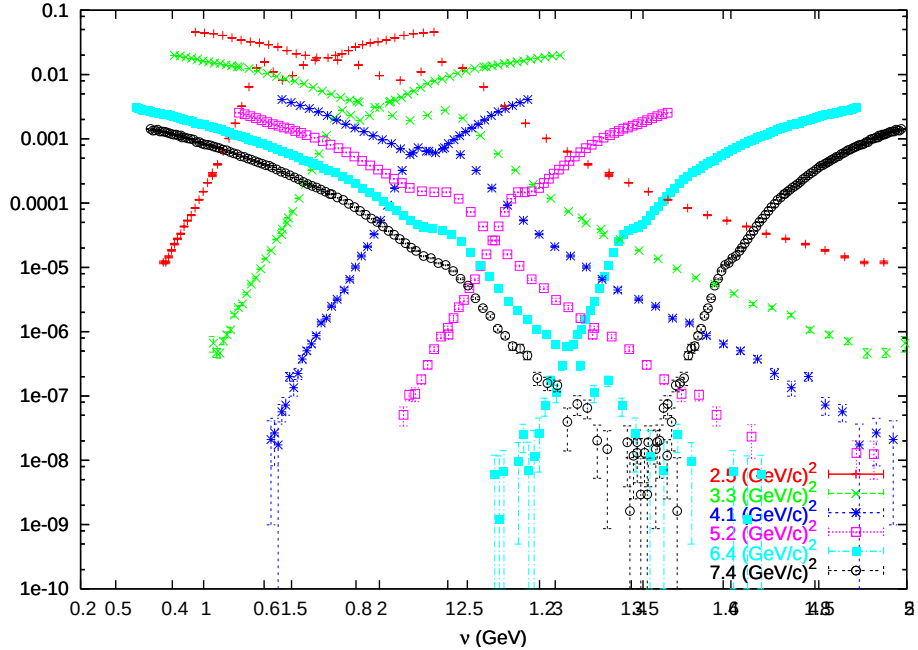
Cross Section Model

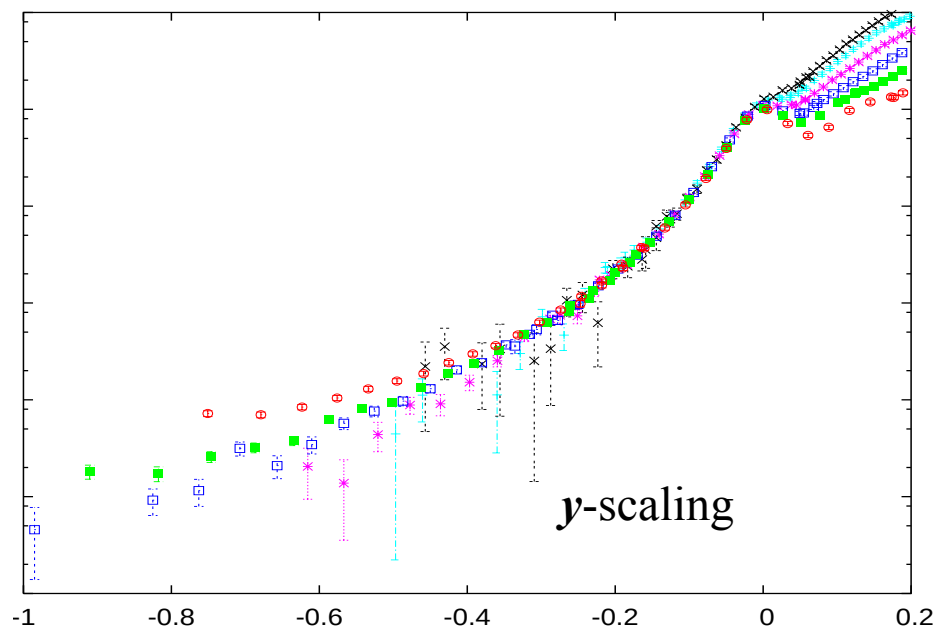
- $\sigma = \sigma_{dis} + \sigma_{qe}$
- $\sigma_{qe} = F(y)*(Z\sigma_{ep} + N\sigma_{en})*K$
  - Iteration involves taking σ_{data}, extracting F(y) and fitting it to a function form -> difficulties arise from poor knowledge of the inelastic contribution at high x_{bj}, which needs to be subtracted first.
- σ_{dis}=> Changed in December 2006
  - ^{2}H: Smearing of the f2p and f2n structure functions using the n(k) from the iteration of the F(y) scaling function.
  - Other targets: EMC-like effect fit to $\sigma_{target}/\sigma_{2H}$.

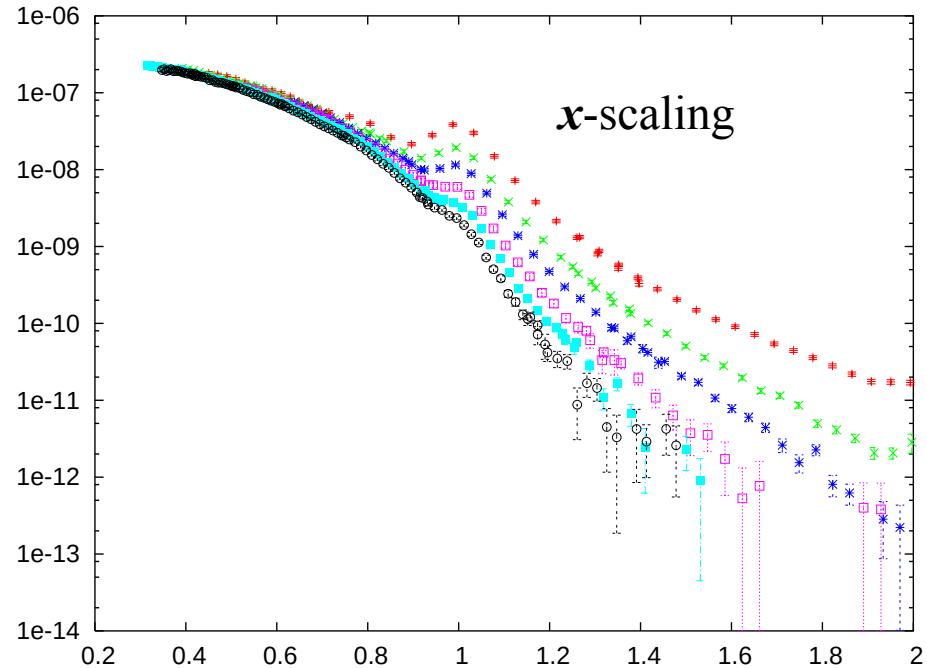
Best agreement between data and model yet

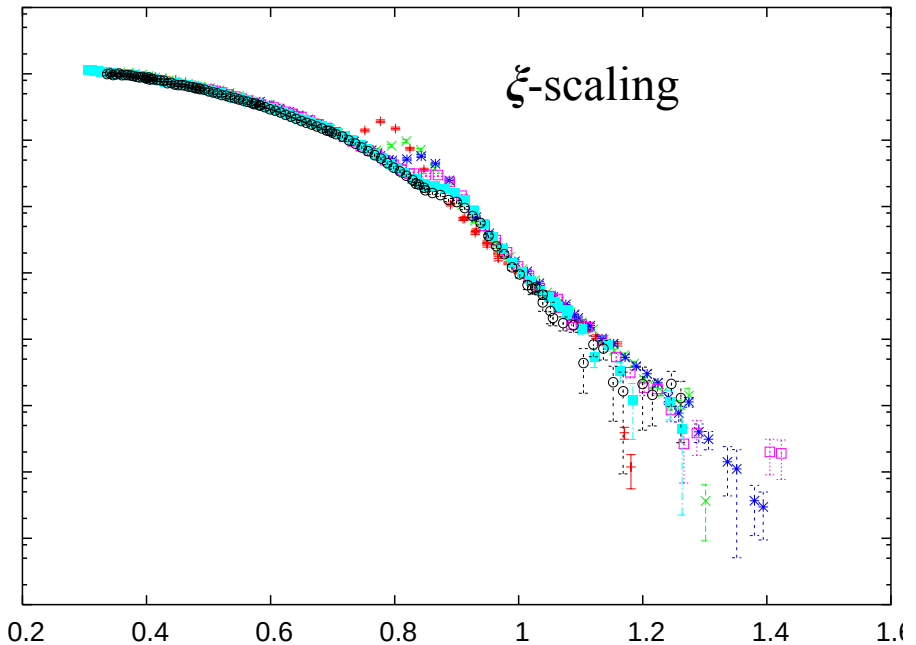


Preliminary Results: Deuterium

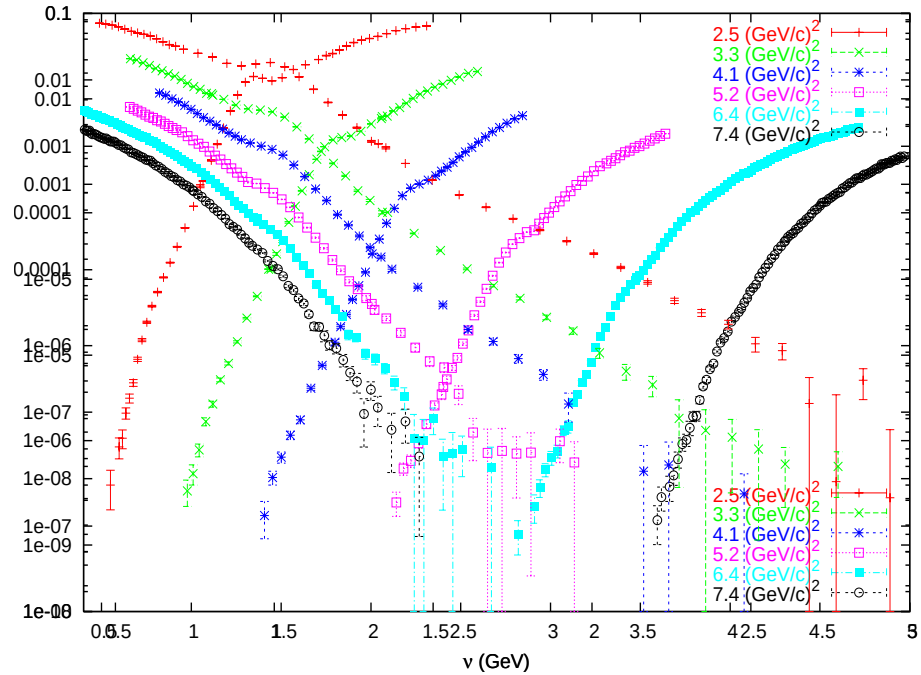


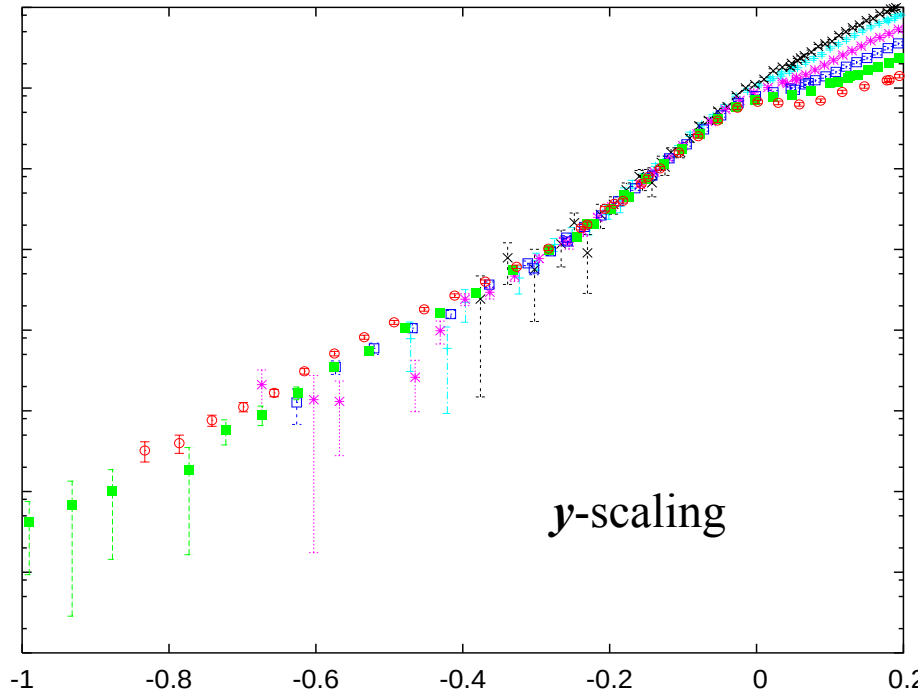


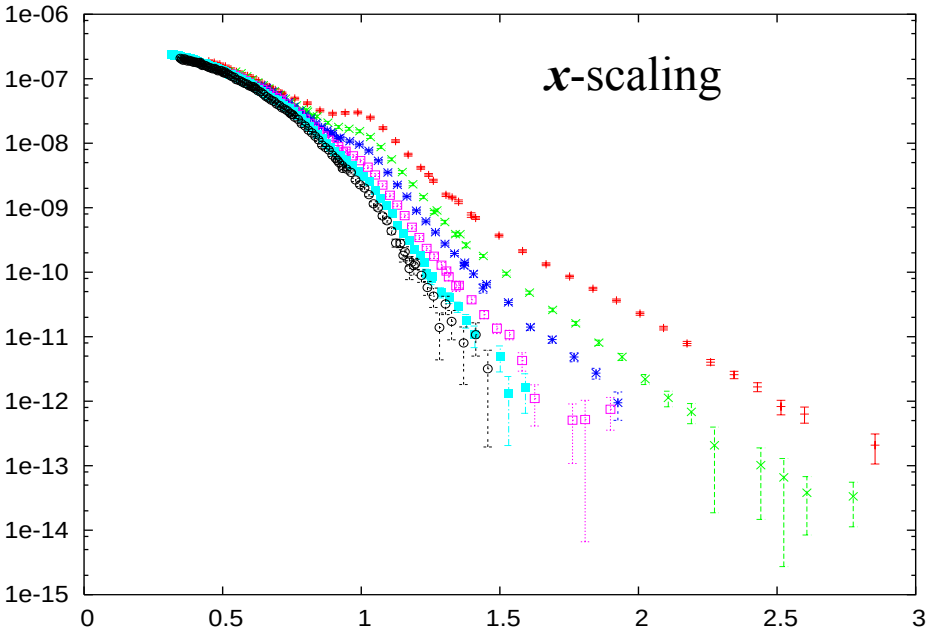


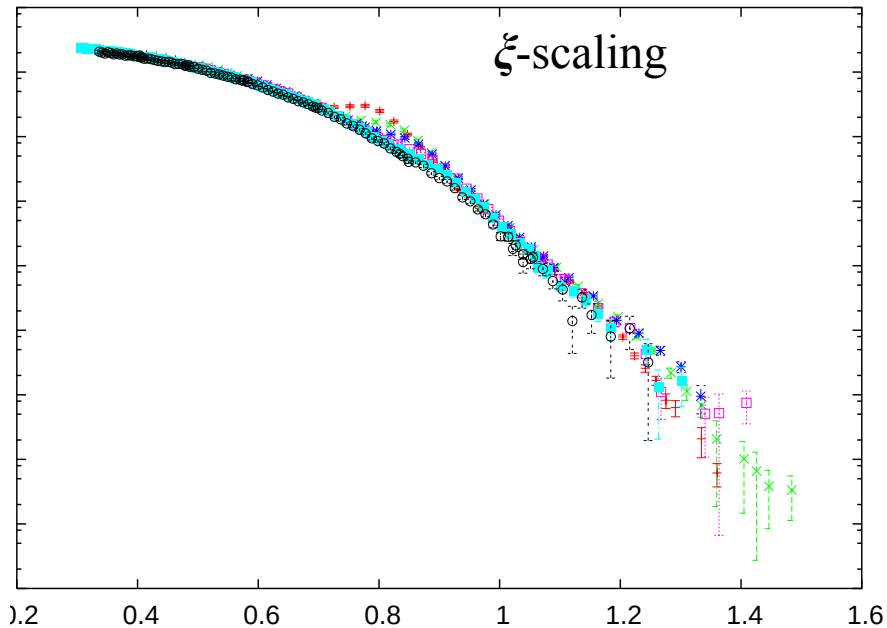


Preliminary Results: Helium 3

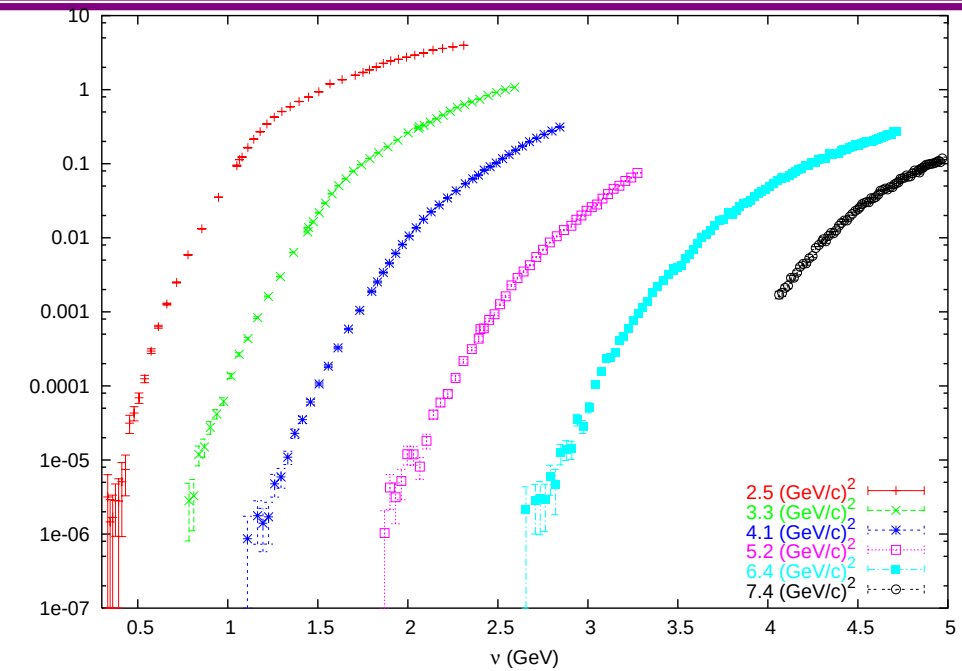


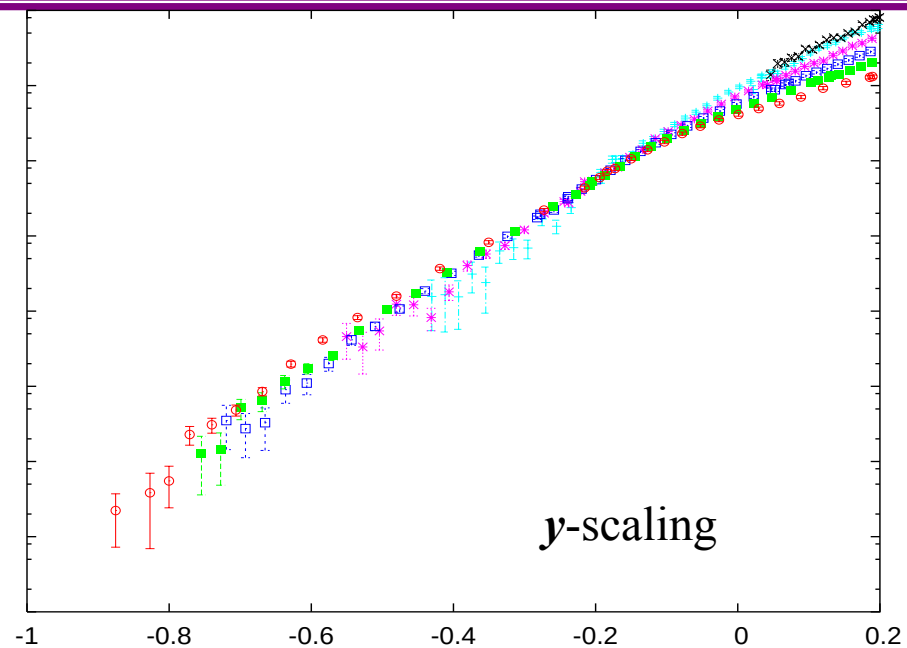


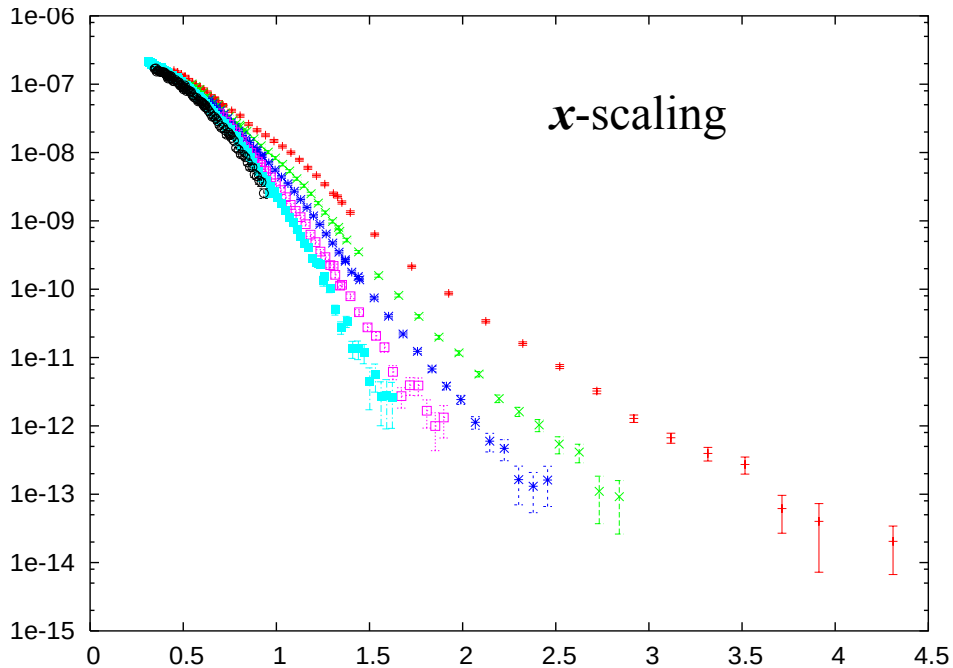


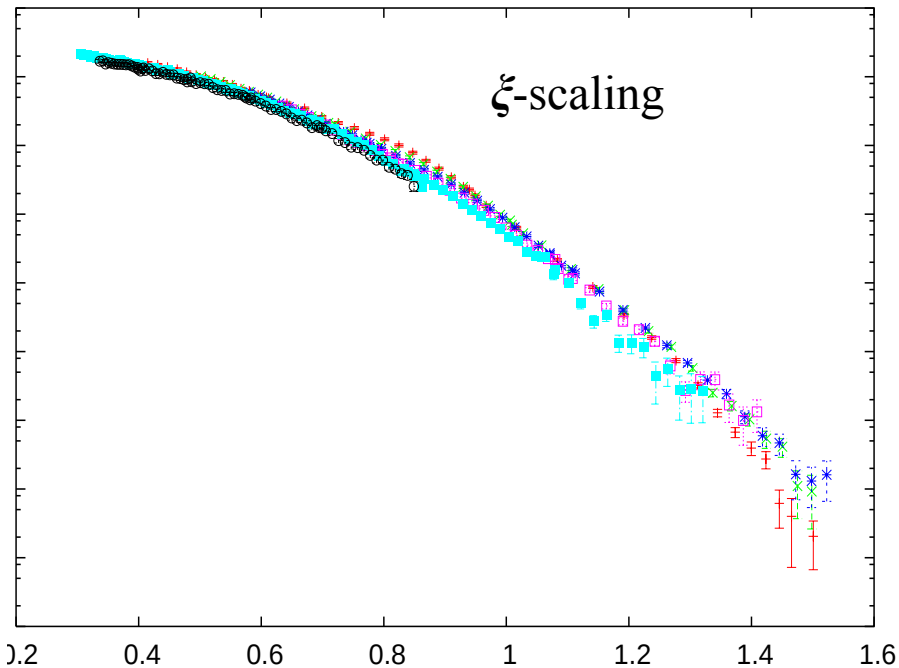


Preliminary Results: Gold

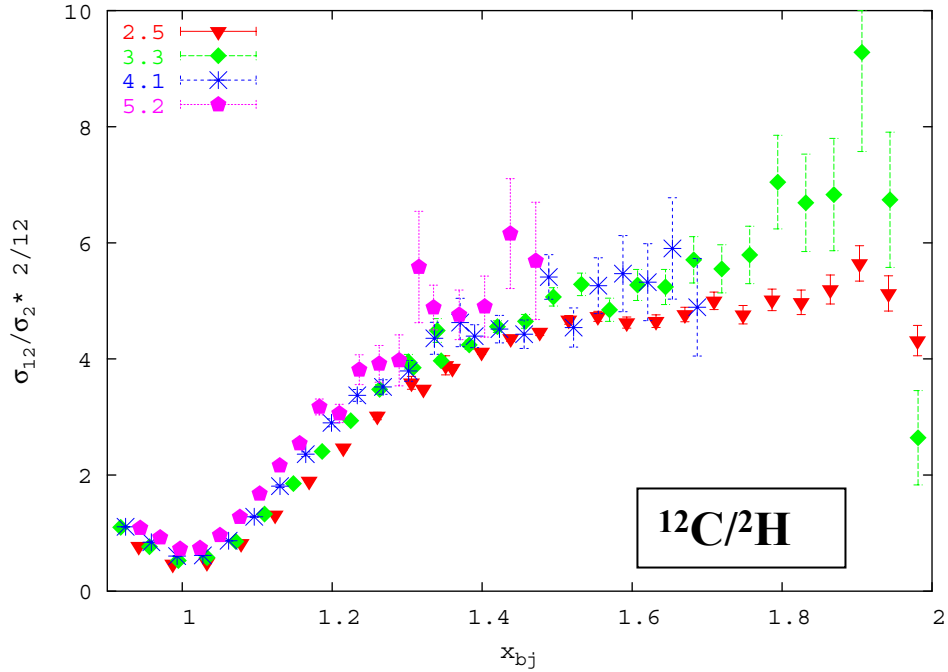








Short-Range Correlations

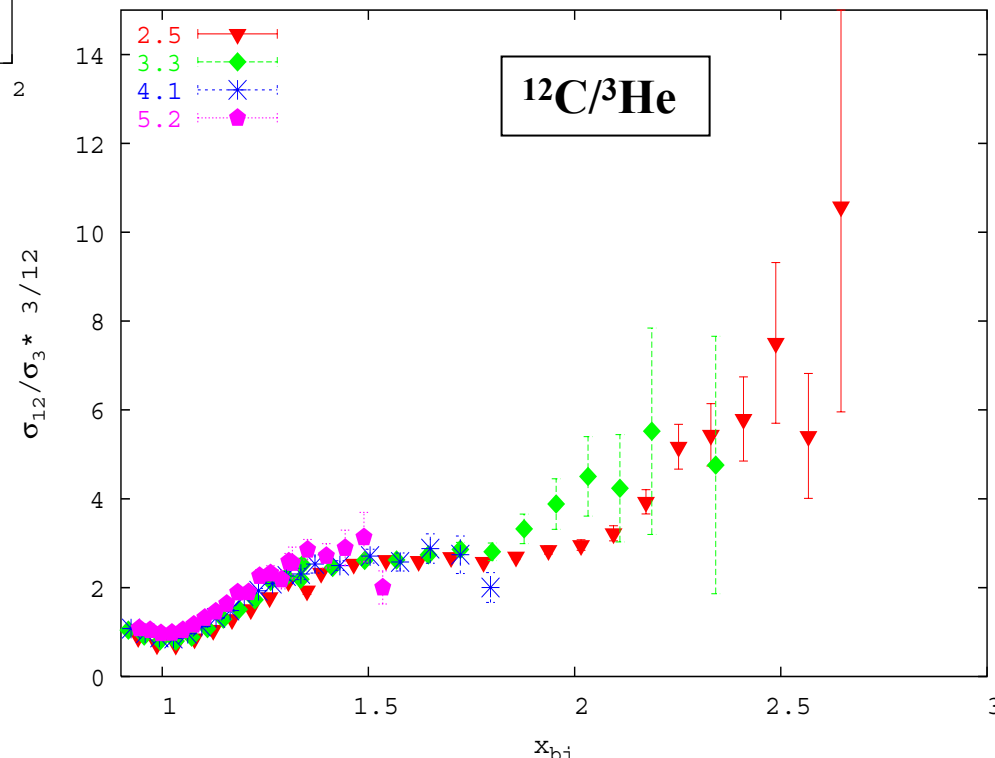


$$\frac{2}{A}\frac{\sigma_A}{\sigma_2} = a_2(A)$$

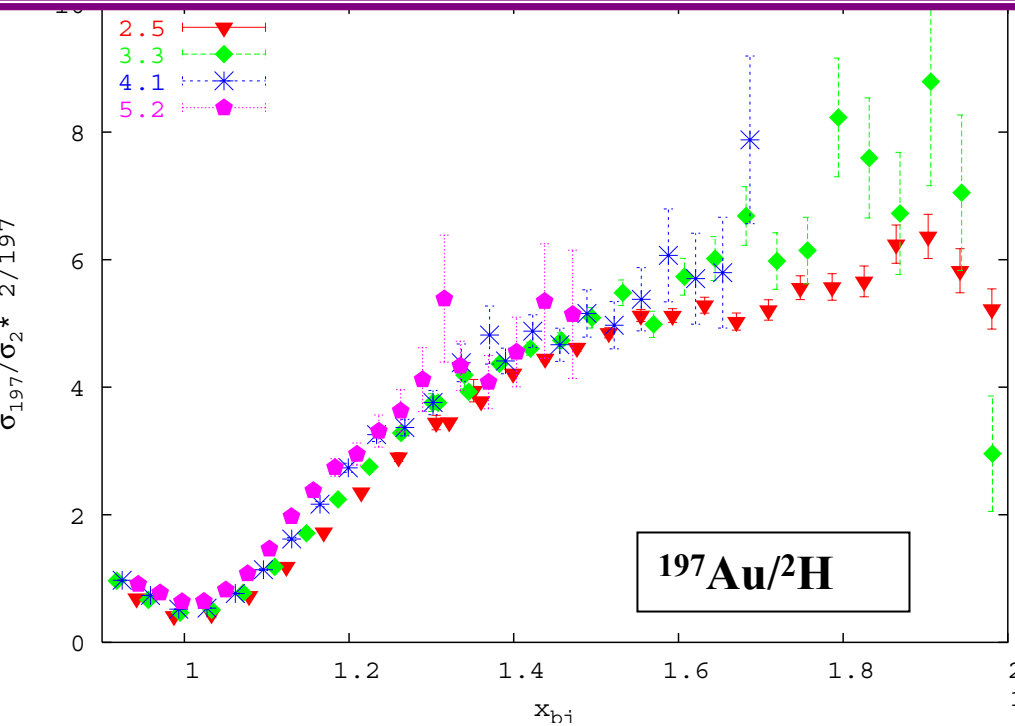
Where $a_2(A)$ is proportional to the probability of finding a j-1 nucleon correlation

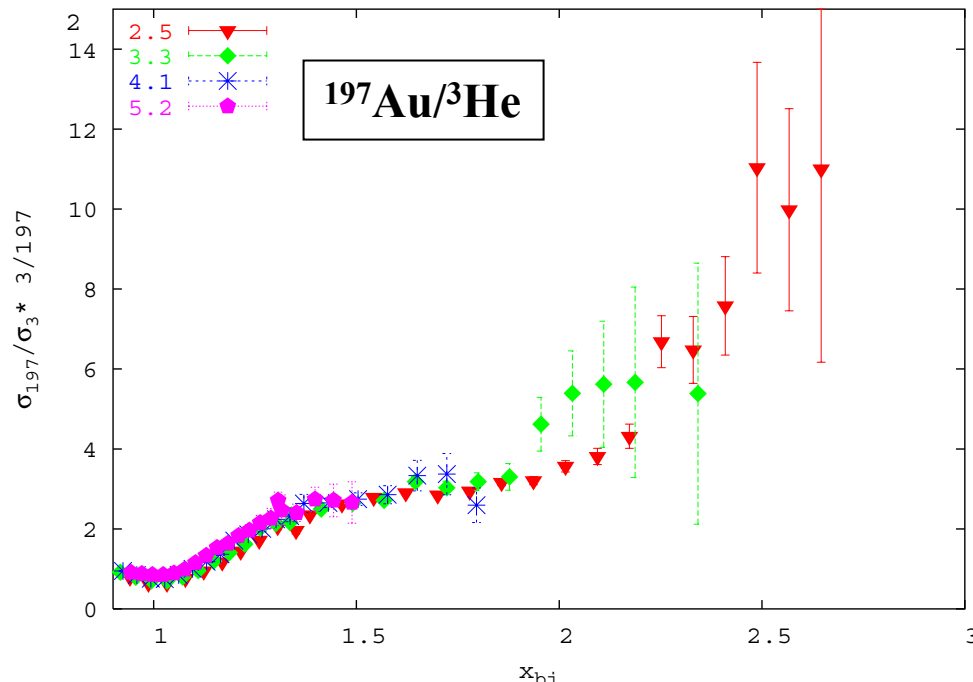
1<x<2 => 2 nucleon correlation

2<x<3 => 3 nucleon correlation



Short-Range Correlations





1<x<2 => 2 nucleon correlation

2<x<3 => 3 nucleon correlation

To do (not much):

<u>Corrections:</u>

•Refine/Iterate model used for bin-centering and radiative correction ⟶ not getting much better

•Calculate the remaining systematic errors

<u>Physics:</u>

•Careful extractions of scaling functions and n(k)

•Structure function Q^2 dependence

•Create Ratios of Heavy/Light nuclei -> Correlations

E02-019 Collaboration

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