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

Nadia Fomin

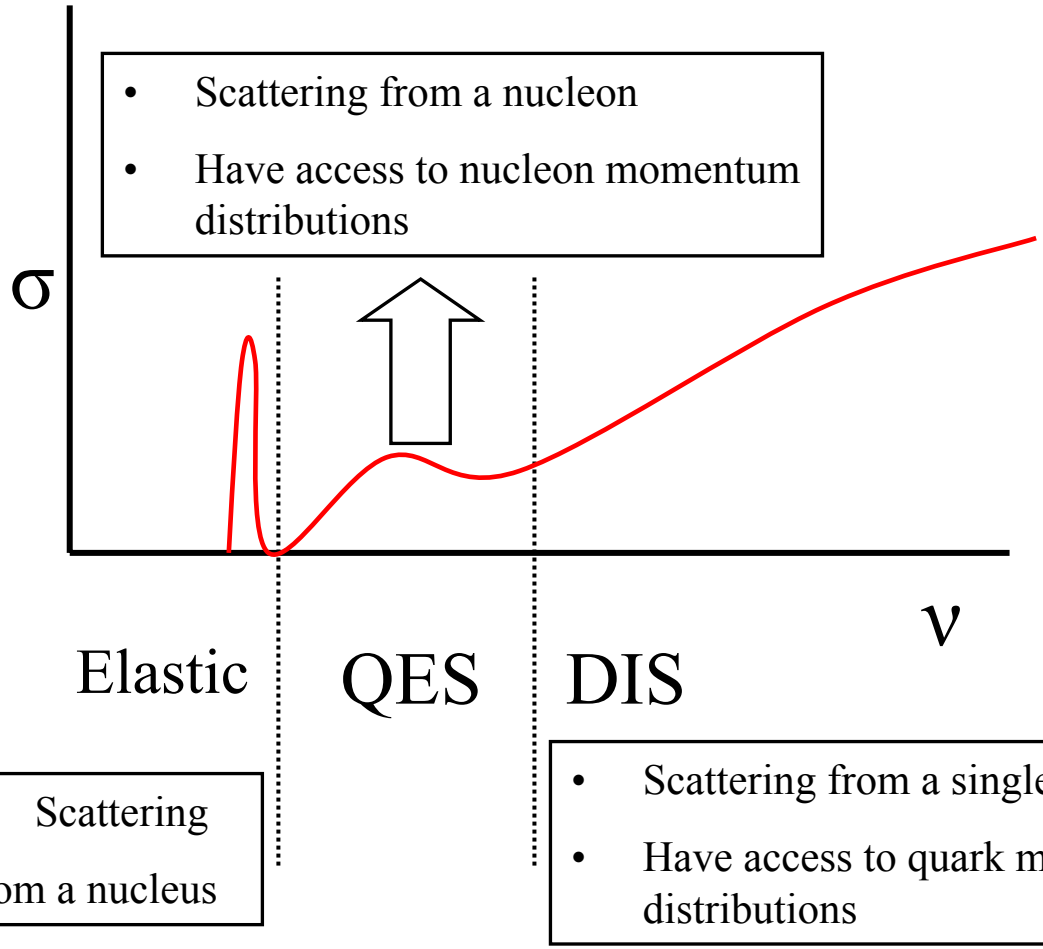
University of Virginia

User Group Meeting, June 2006

Overview

- Introduction
- Physics Background and Motivation
- Analysis Status
- Preliminary Results

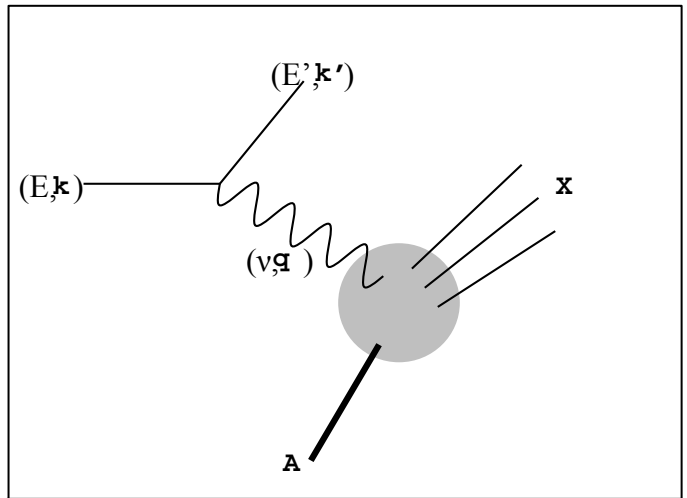
Introduction to Quasi-Elastic Scattering



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

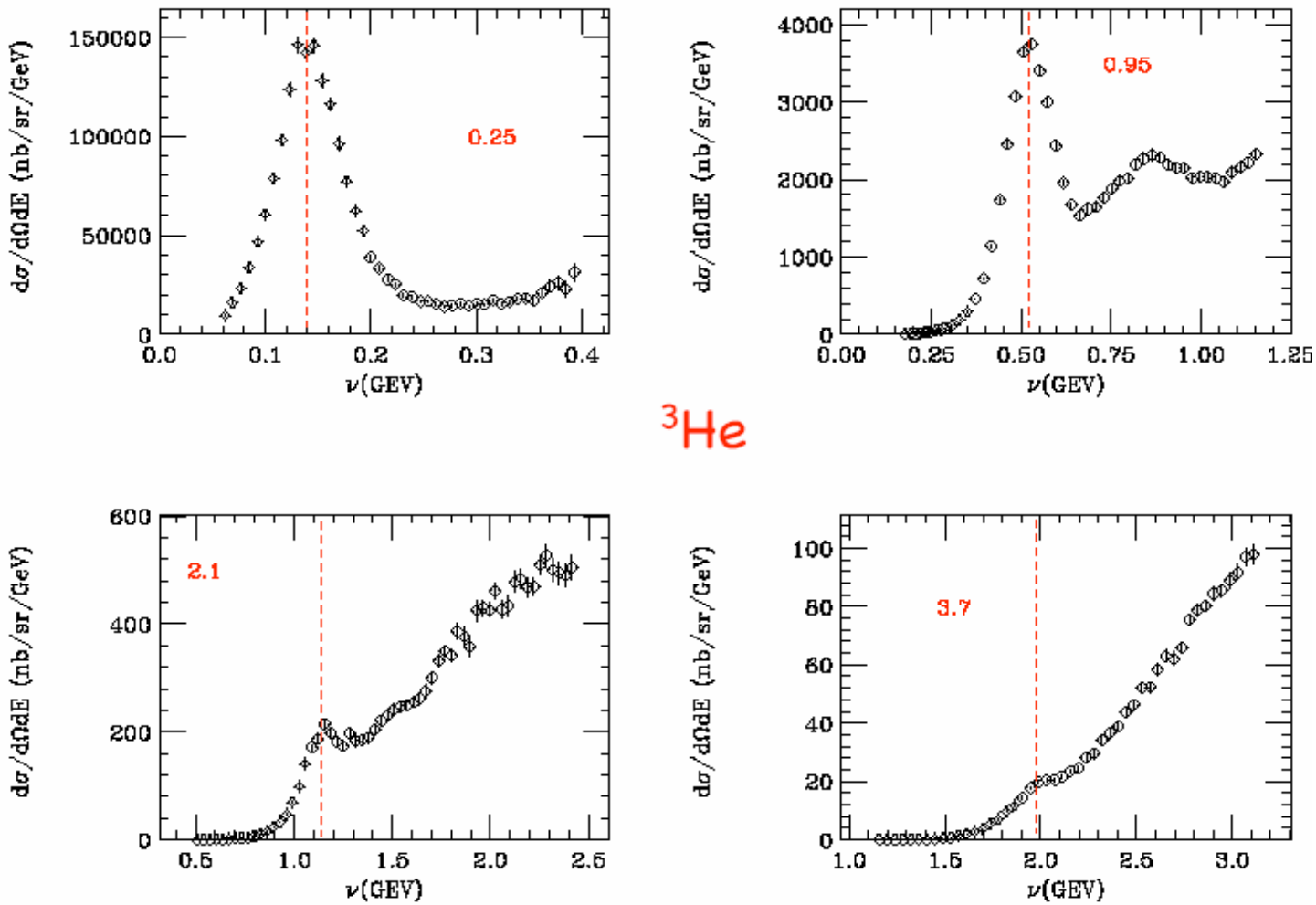
- Scattering from a nucleus

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



Inclusive Reaction

Introduction to Quasi-Elastic Scattering

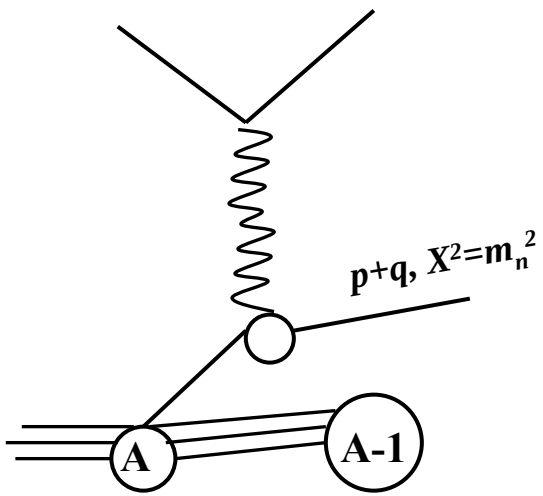


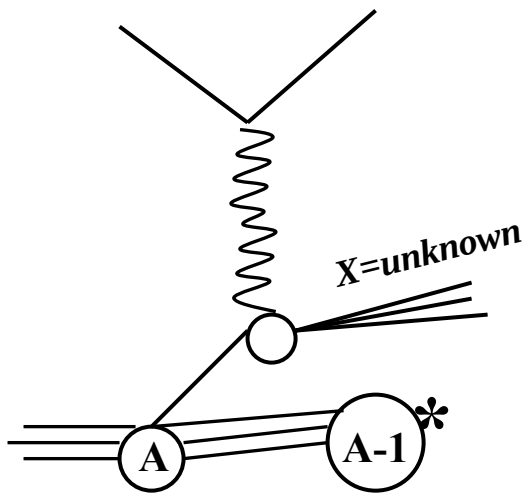
• At low ν, the cross section is dominated by the momentum distribution of the nucleons, but as the momentum transfer increases, inelastic scattering from the nucleons begins to play a larger role.

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

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*

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

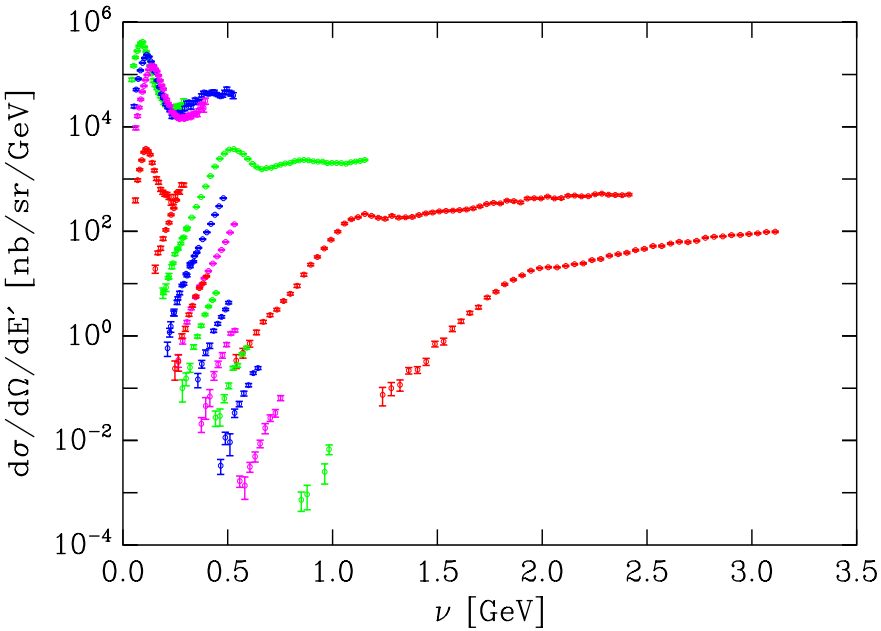
- In the limit of $\nu, Q^2 \rightarrow \infty$, x is the fraction of the nucleon momentum carried by the struck quark, and the structure function in the scaling limit represents the momentum distribution of quarks inside the nucleon.
- As $Q^2 \rightarrow \infty$, $\xi \rightarrow x$, so the scaling 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).

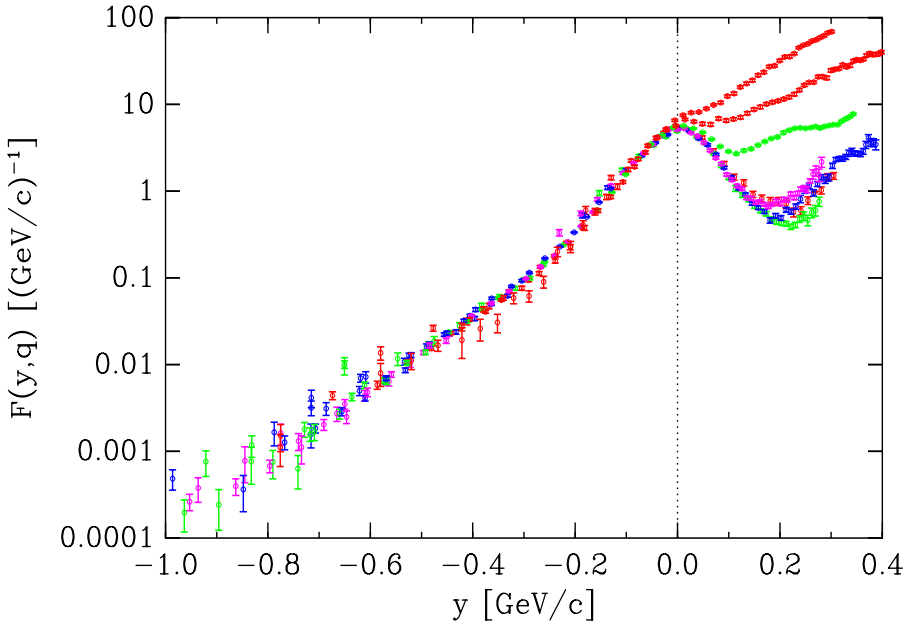
$$\xi = \frac{2x}{\left(1+\sqrt{1+\frac{4M^2x^2}{Q^2}}\right)}$$

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



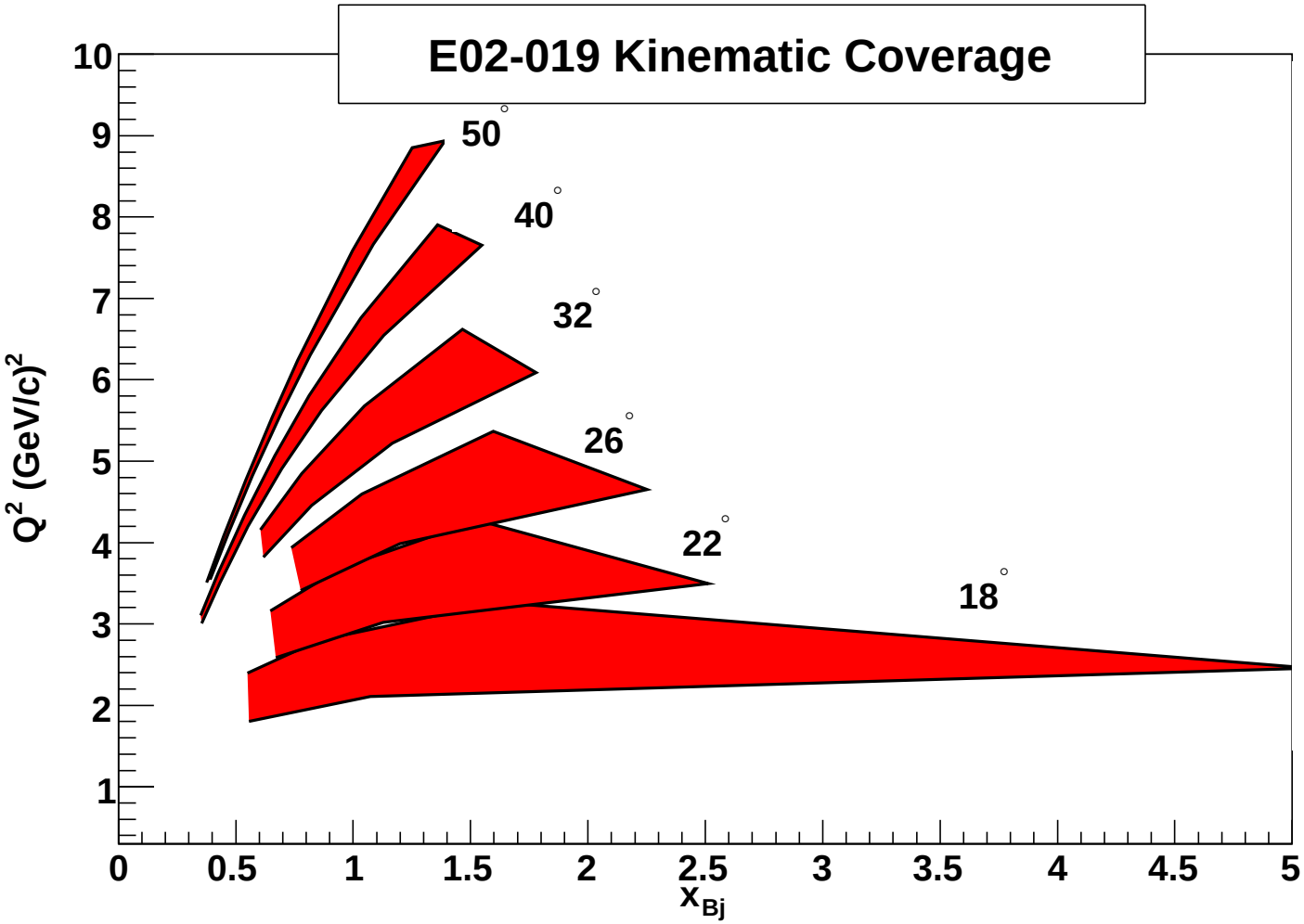


$$F(y) = \frac{d^2\sigma}{d\Omega d\upsilon} \frac{1}{(Z\sigma_p + N\sigma_n)} \frac{\mathbf{q}}{\sqrt{M^2 + (y+q)^2}} = 2\pi \int_{|y|}^{\infty} n(k) k dk$$

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)

Corrections:

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

Nadia Fomin (UVA)

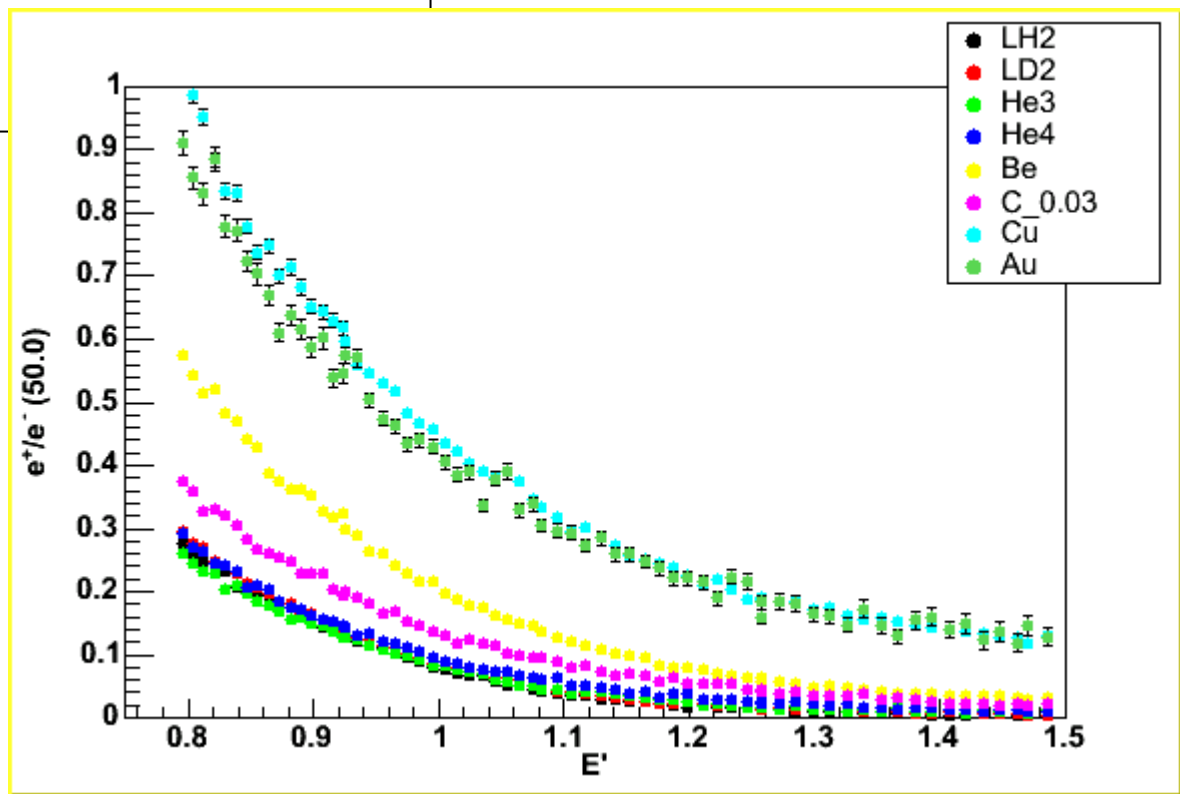
Jason Ceely (MIT)

Aji Daniel (Houston)

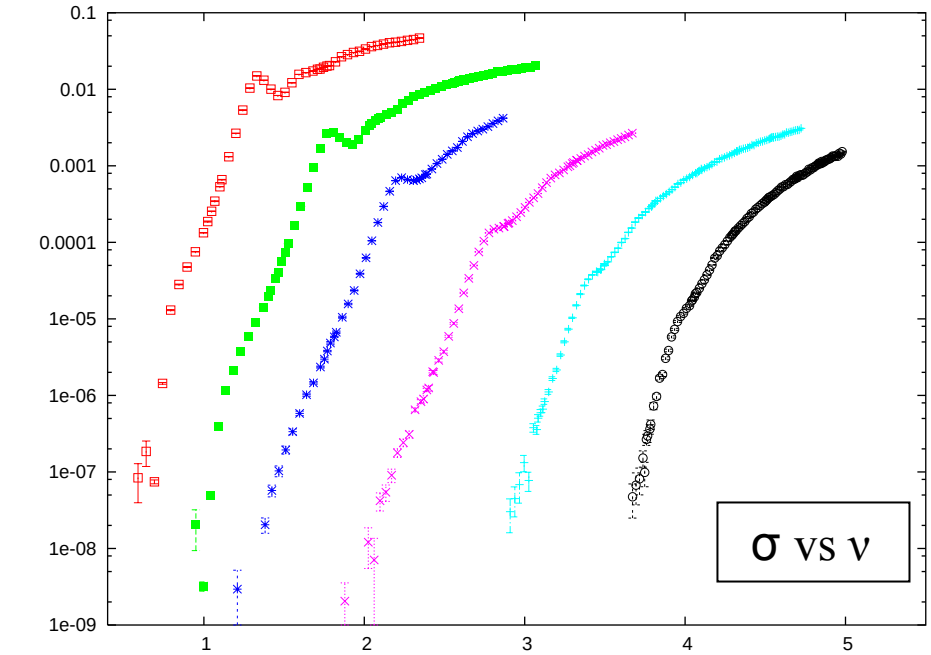
Roman Trojer (Basel)

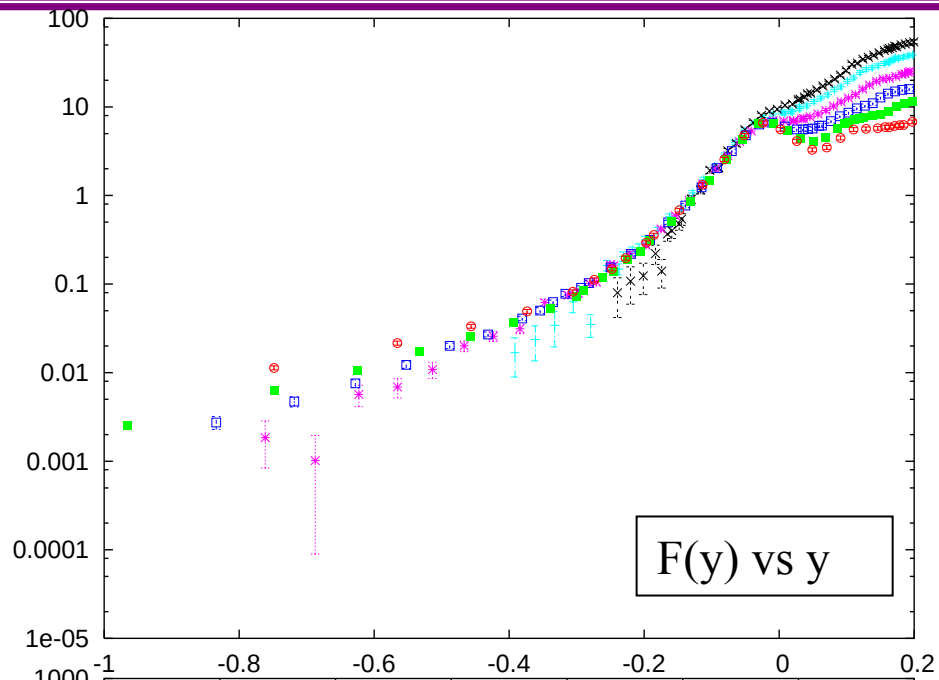
Calibrations:

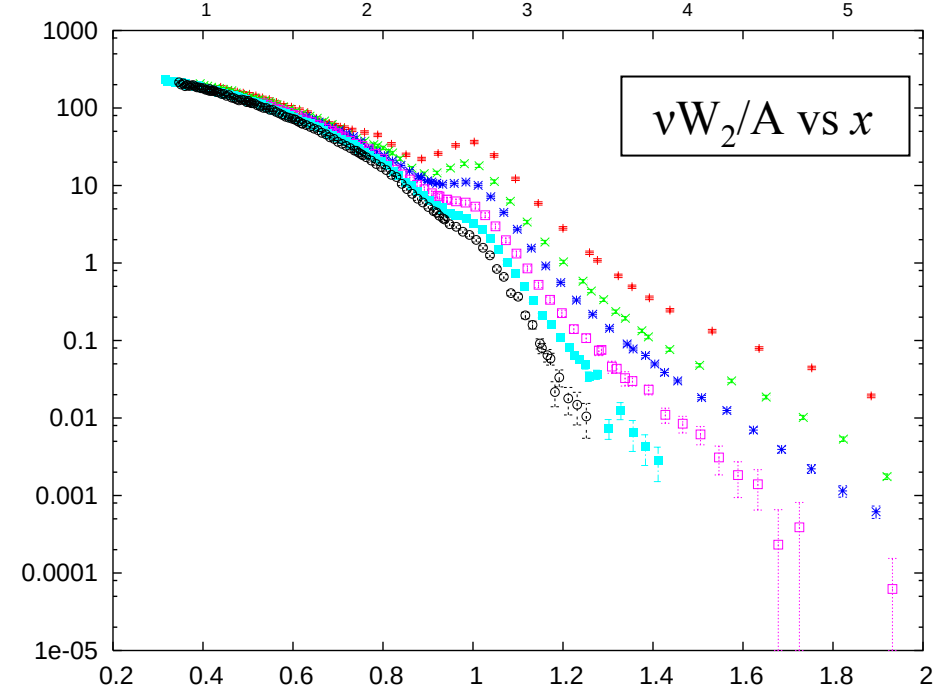
- Calorimeter
- Drift Chambers
- TOF
- Čerenkov

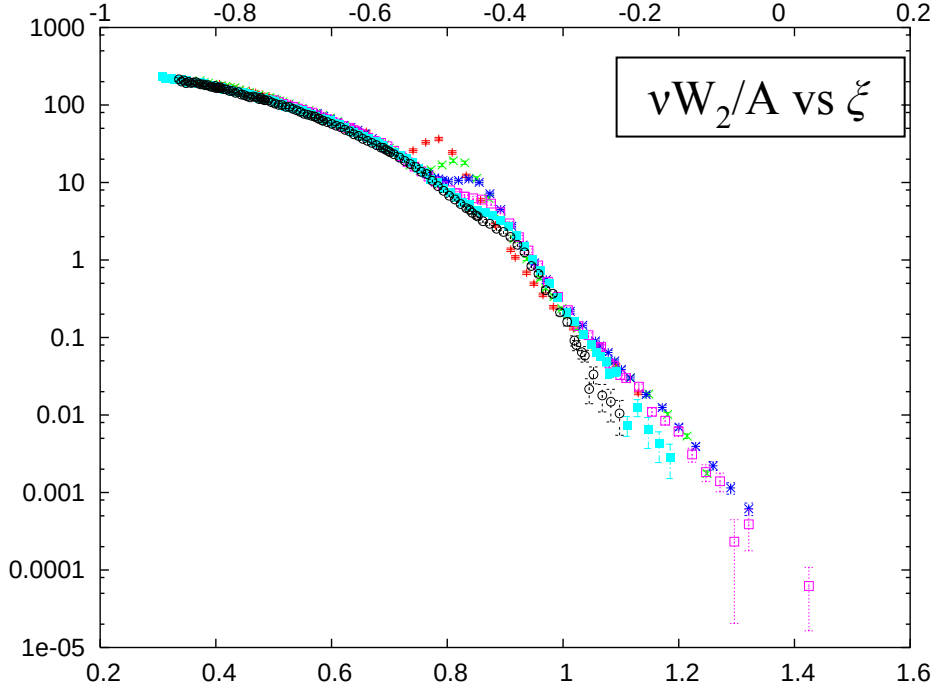


Preliminary Results: Deuterium

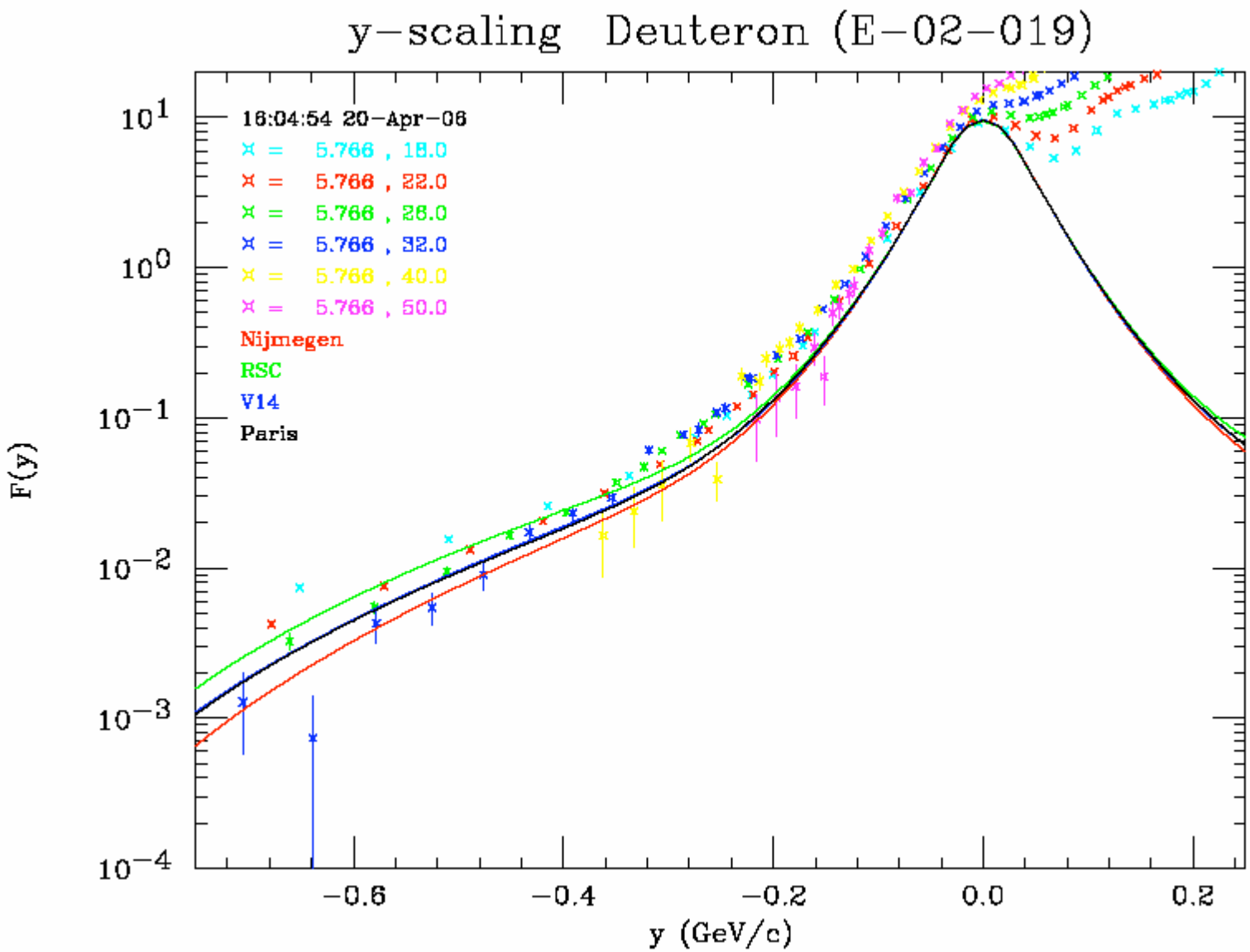




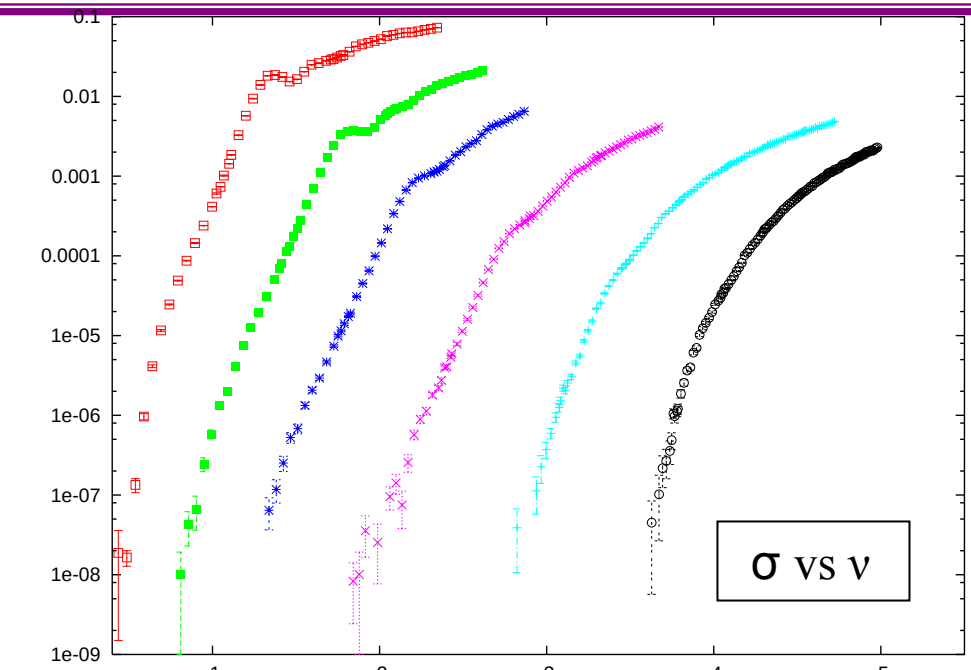


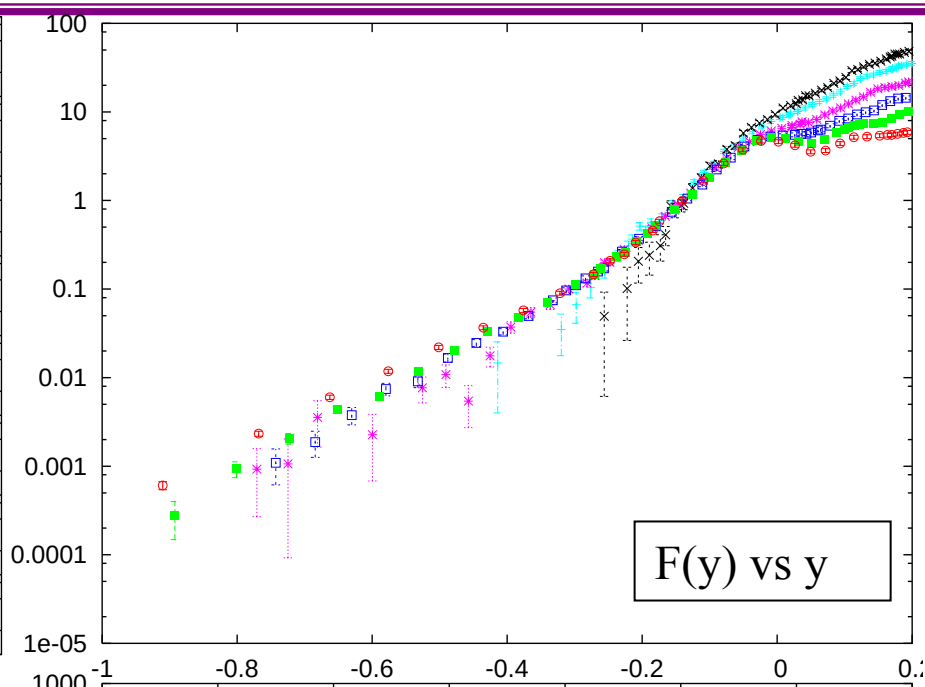


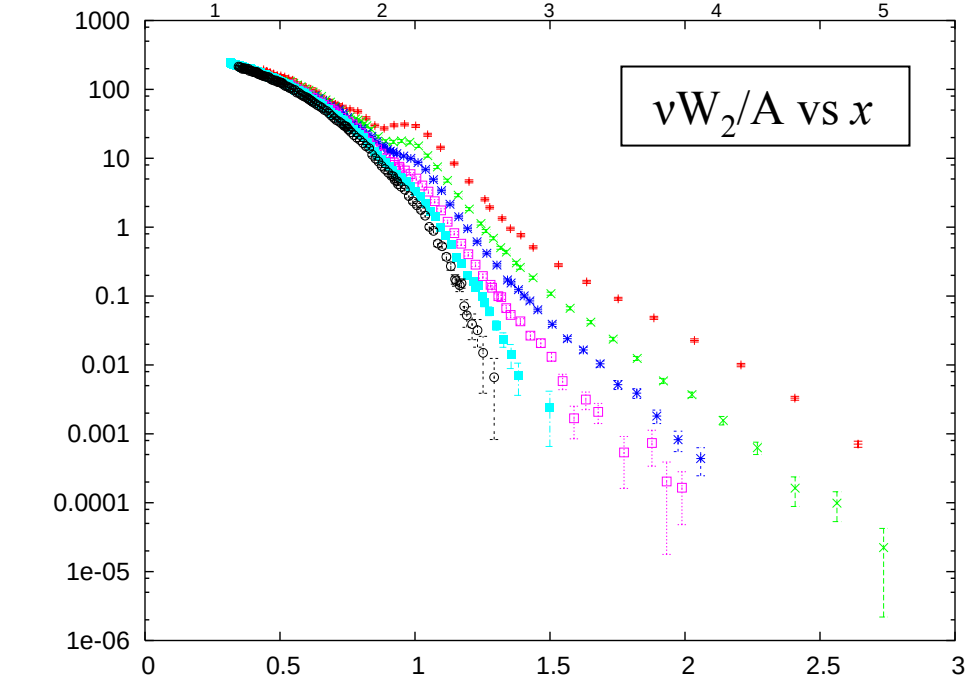
Deuterium Y-scaling: Comparison to Theory

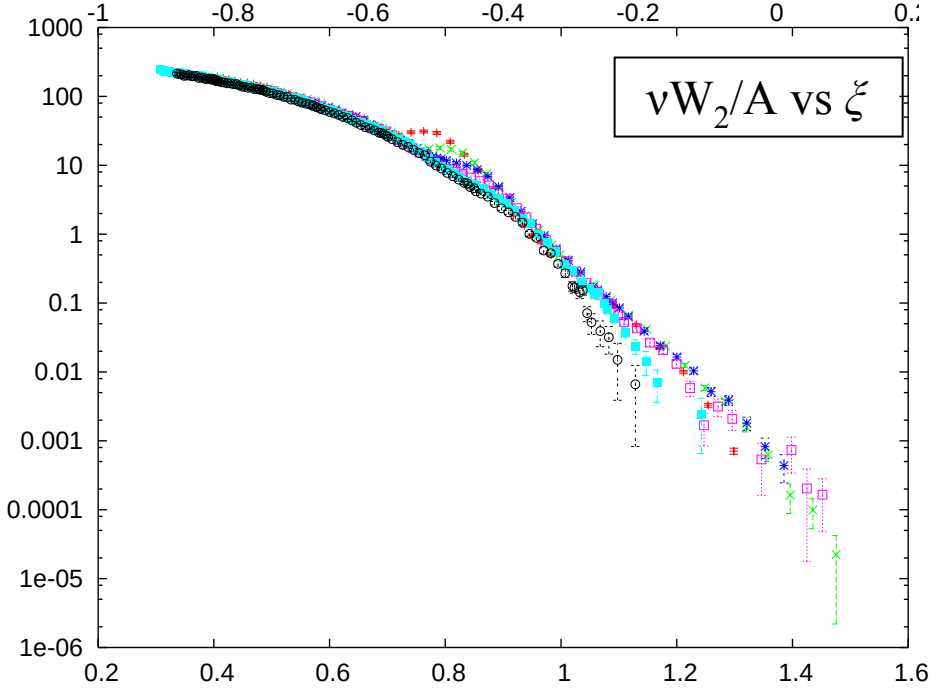


Preliminary Results: Helium 3

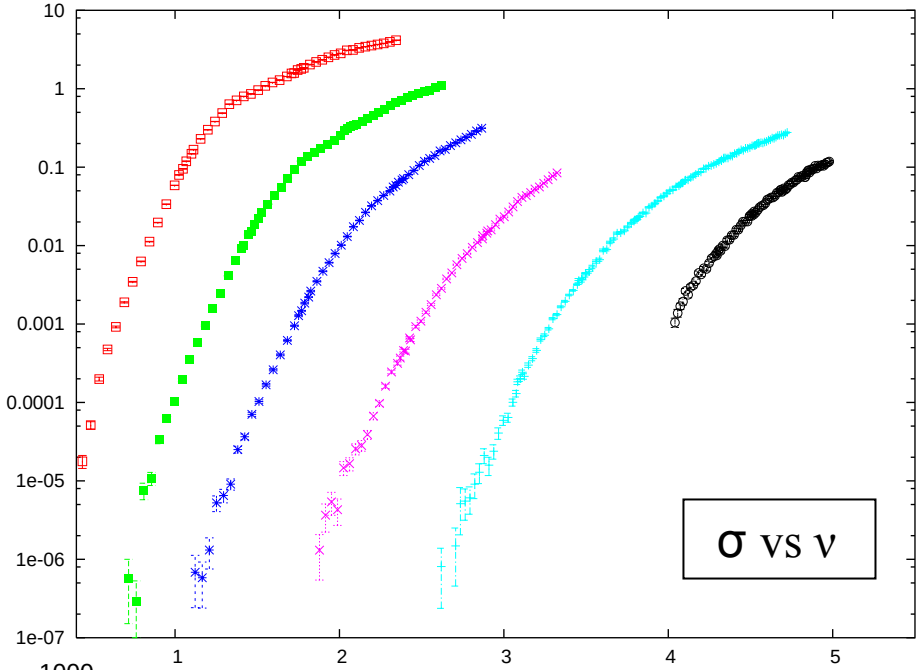


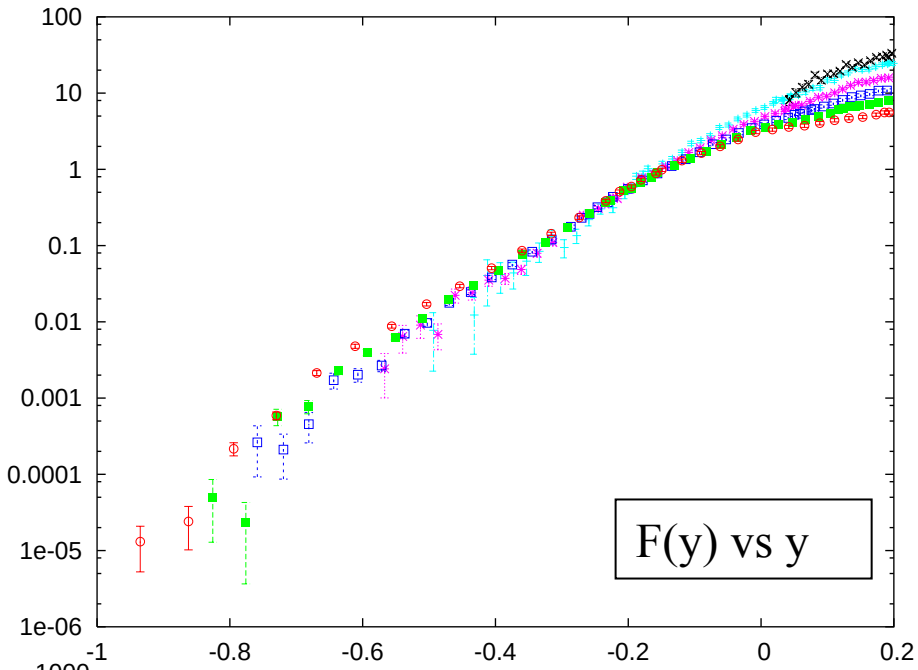


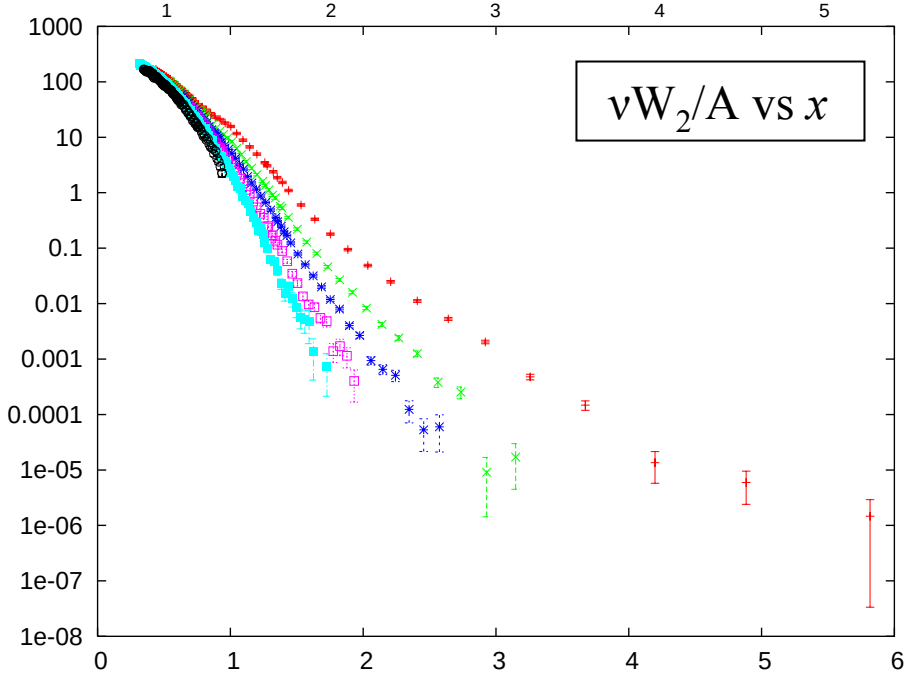


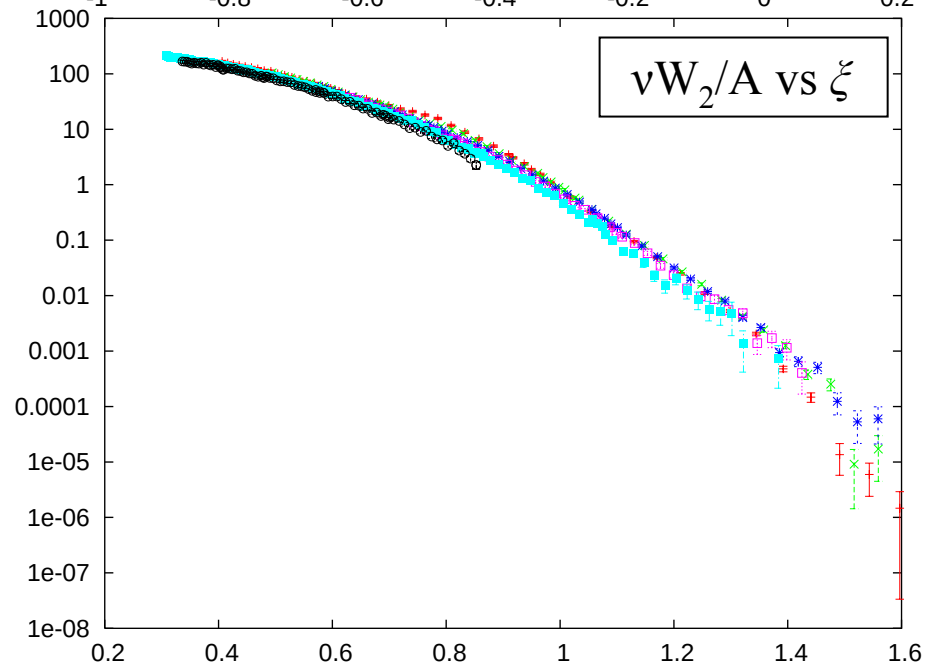


Preliminary Results: Gold

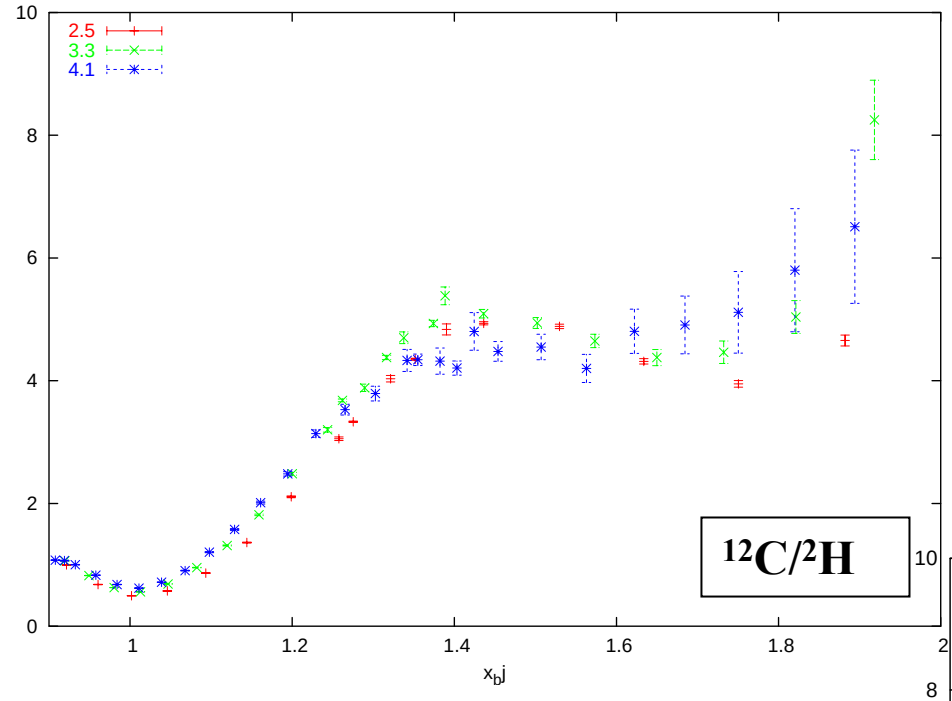






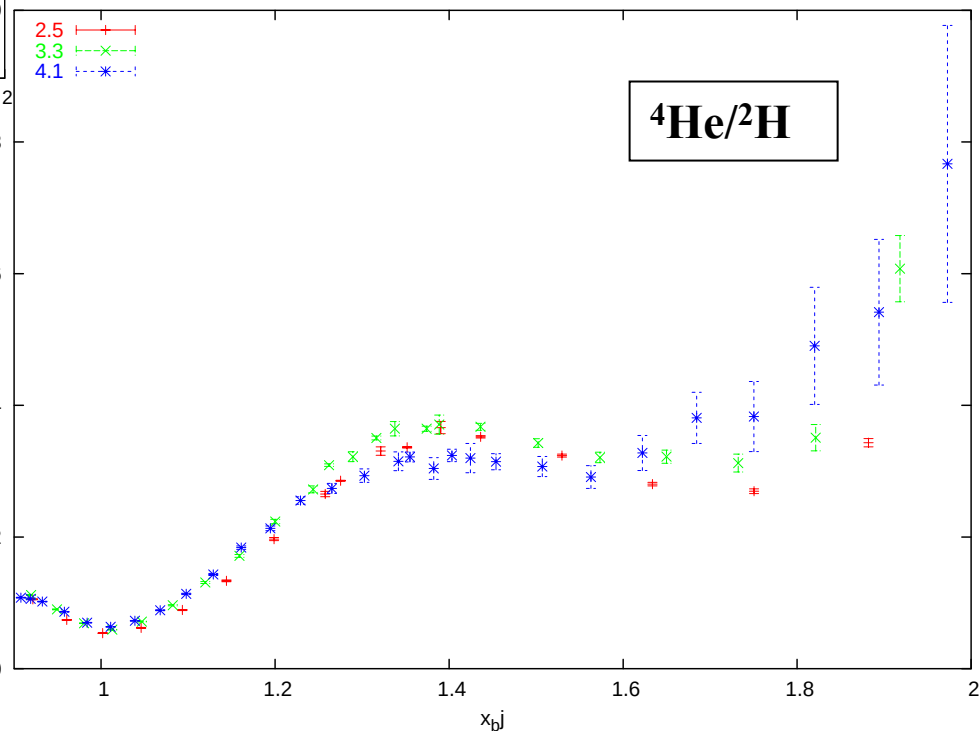


Short-Range Correlations



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

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

To do:

Corrections:

- Refine/Iterate model used for bin-centering and radiative corrections

Physics:

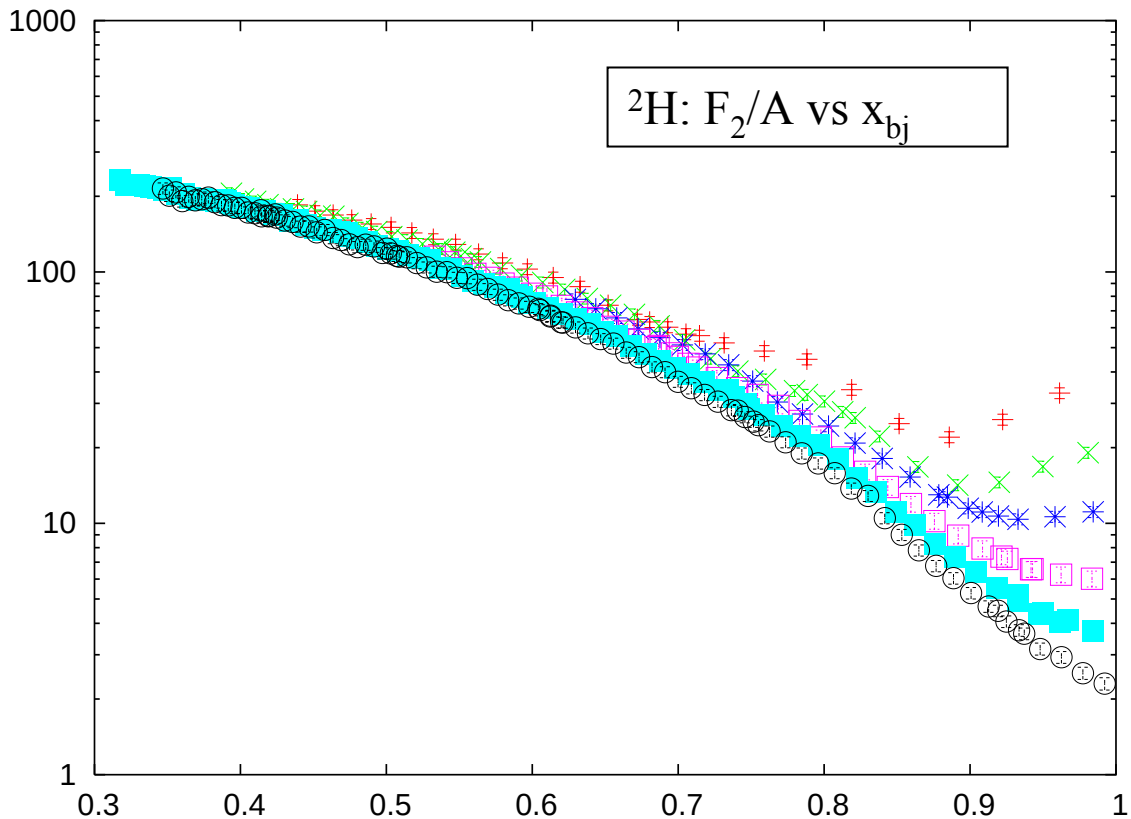
- Careful extractions of scaling functions and n(k)
- Structure function Q^2 dependence
- Create Ratios of Heavy/Light nuclei -> Correlations

Other possible uses for the data

- Extracting Moments of the F_2 structure function
- Bloom-Gilman Duality
- Medium Modifications
- Structure Function Q^2 dependence and Higher Twists
- Scaling in other variables, superscaling

Same data coverage for:

- H
- ^{3}He
- ^{4}He
- Be
- ^{12}C
- Cu
- Au



E02-019 Collaboration

J. Arrington (spokesperson), L. El Fassi, K. Hafidi, R. Holt, D.H. Potterveld, P.E. Reimer, E. Schulte, X. Zheng

Argonne National Laboratory, Argonne, IL

B. Boillat, J. Jourdan, M. Kotulla, T. Mertens, D. Rohe, G. Testa, R. Trojer

Basel University, Basel, Switzerland

B. Filippone (spokesperson)

California Institute of Technology, Pasadena, CA

C. Perdrisat

College of William and Mary, Williamsburg, VA

D. Dutta, H. Gao, X. Qian

Duke University, Durham, NC

W. Boeglin

Florida International University, Miami, FL

M.E. Christy, C.E. Keppel, S. Malace, E. Segbefia, L. Tang,

V. Tvaskis, L. Yuan

Hampton University, Hampton, VA

G. Niculescu, I. Niculescu

James Madison University, Harrisonburg, VA

P. Bosted, A. Bruell, V. Dharmawardane, R. Ent, H. Fenker, D. Gaskell, M.K. Jones, A.F. Lung (spokesperson), D.G. Meekins, J. Roche, G. Smith, W.F. Vulcan, S.A. Wood

Jefferson Laboratory, Newport News, VA

B. Clasie, J. Seely

Massachusetts Institute of Technology, Cambridge, MA

J. Dunne

Mississippi State University, Jackson, MS

V. Punjabi

Norfolk State University, Norfolk, VA

A.K. Opper

Ohio University, Athens, OH

F. Benmokhtar

Rutgers University, Piscataway, NJ

H. Nomura

Tohoku University, Sendai, Japan

M. Bukhari, A. Daniel, N. Kalantarians, Y. Okayasu, V. Rodriguez

University of Houston, Houston, TX

T. Horn, Fatiha Benmokhtar

University of Maryland, College Park, MD

D. Day (spokesperson), **N. Fomin**, C. Hill, R. Lindgren, P. McKee, O. Rondon, K. Slifer, S. Tajima, F. Wesselmann, J. Wright

University of Virginia, Charlottesville, VA

R. Asaturyan, H. Mkrtchyan, T. Navasardyan, V. Tadevosyan

Yerevan Physics Institute, Armenia

S. Connell, M. Dalton, C. Gray

University of the Witwatersrand, Johannesburg, South Africa