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

Nadia Fomin

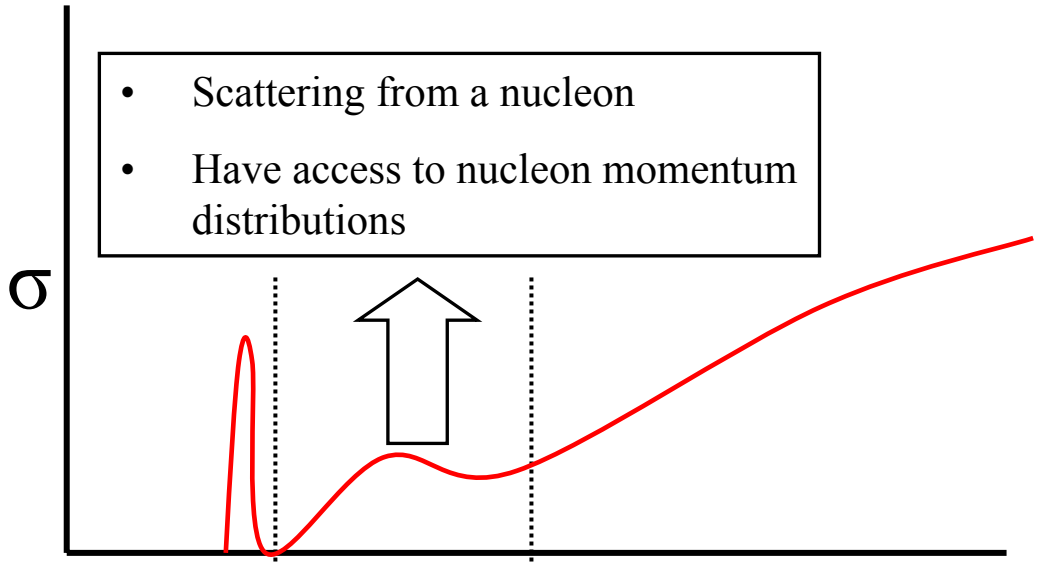
University of Virginia

Hall C Meeting, January 2006

Overview

- Introduction
- Physics Background and Motivation
- Progress since January 2005
- Preliminary Results

Introduction to Quasi-Elastic Scattering



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

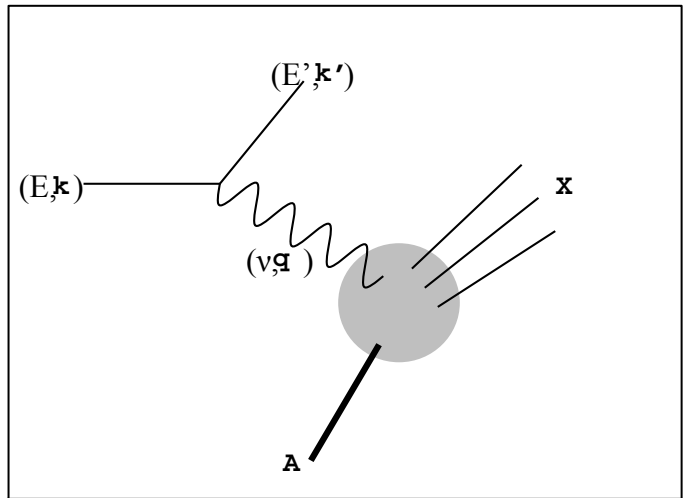
Elastic

QES

DIS

- Scattering from a nucleus

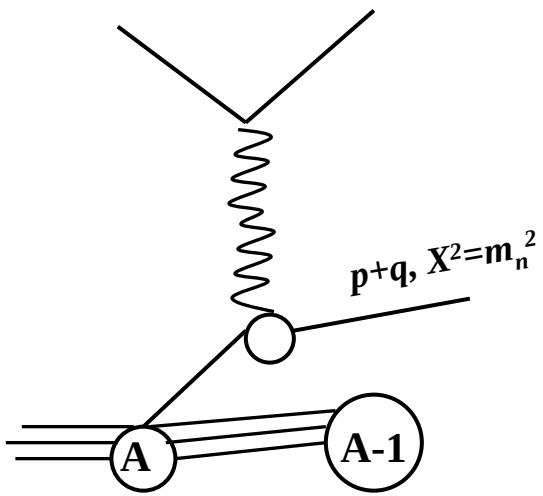
- Scattering from a single quark
- Have access to quark momentum distributions

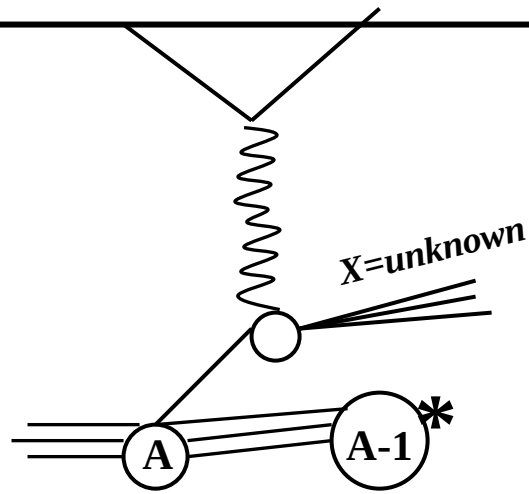


Inclusive Reaction

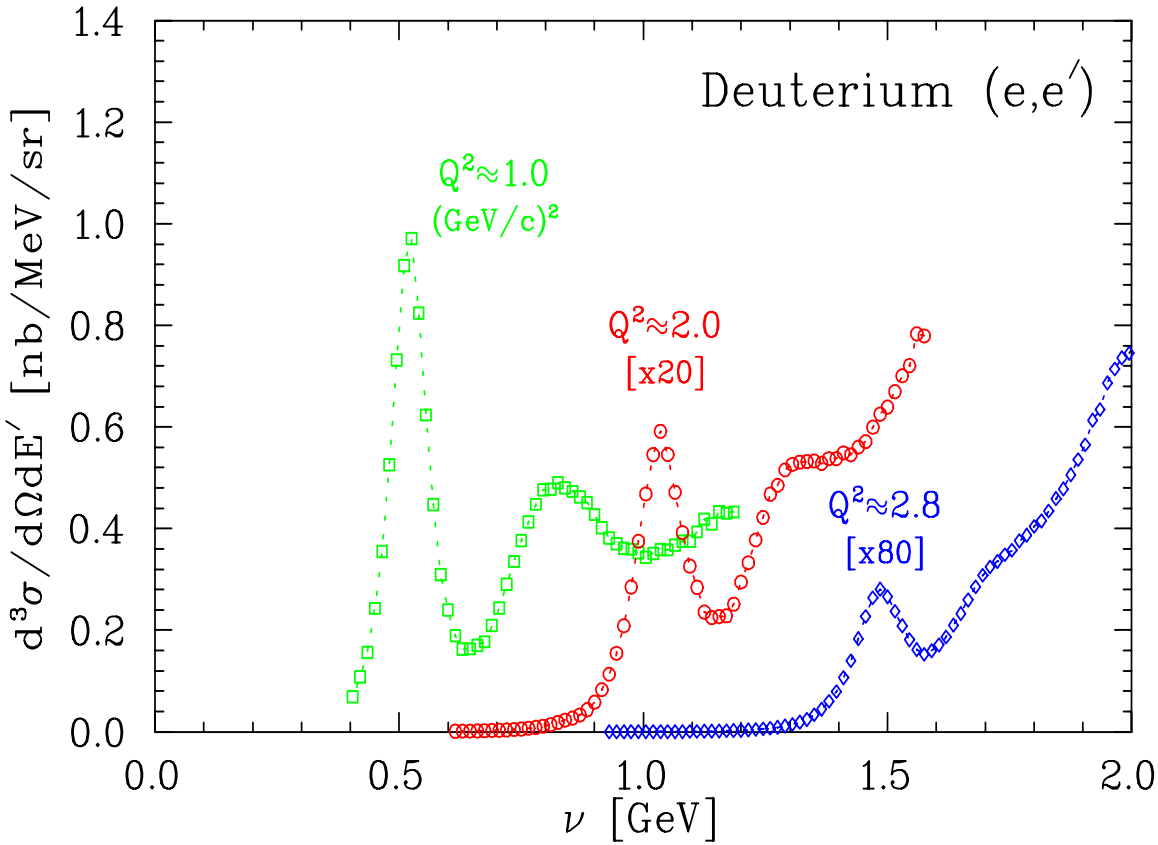
$$(x = \frac{Q^2}{2M_p \nu}) > 1$$

QES	DIS
Intermediate Q^2 values	Higher Q^2 values
Scattering from a nucleon	Scattering from quarks
Y-scaling $F(y) = \frac{d^2\sigma}{d\Omega d\upsilon} \frac{1}{(Z\sigma_p + N\sigma_n)} \frac{\mathbf{q}}{\sqrt{M^2 + (y+q)^2}} = 2\pi \int_{\lvert y \rvert}^{\infty} n(k) k dk$	X and ξ-scaling $\xi = \frac{2x}{(1 + \sqrt{1 + \frac{4M^2x^2}{Q^2}})}$





Quasielastic scattering: an example (Deuterium)

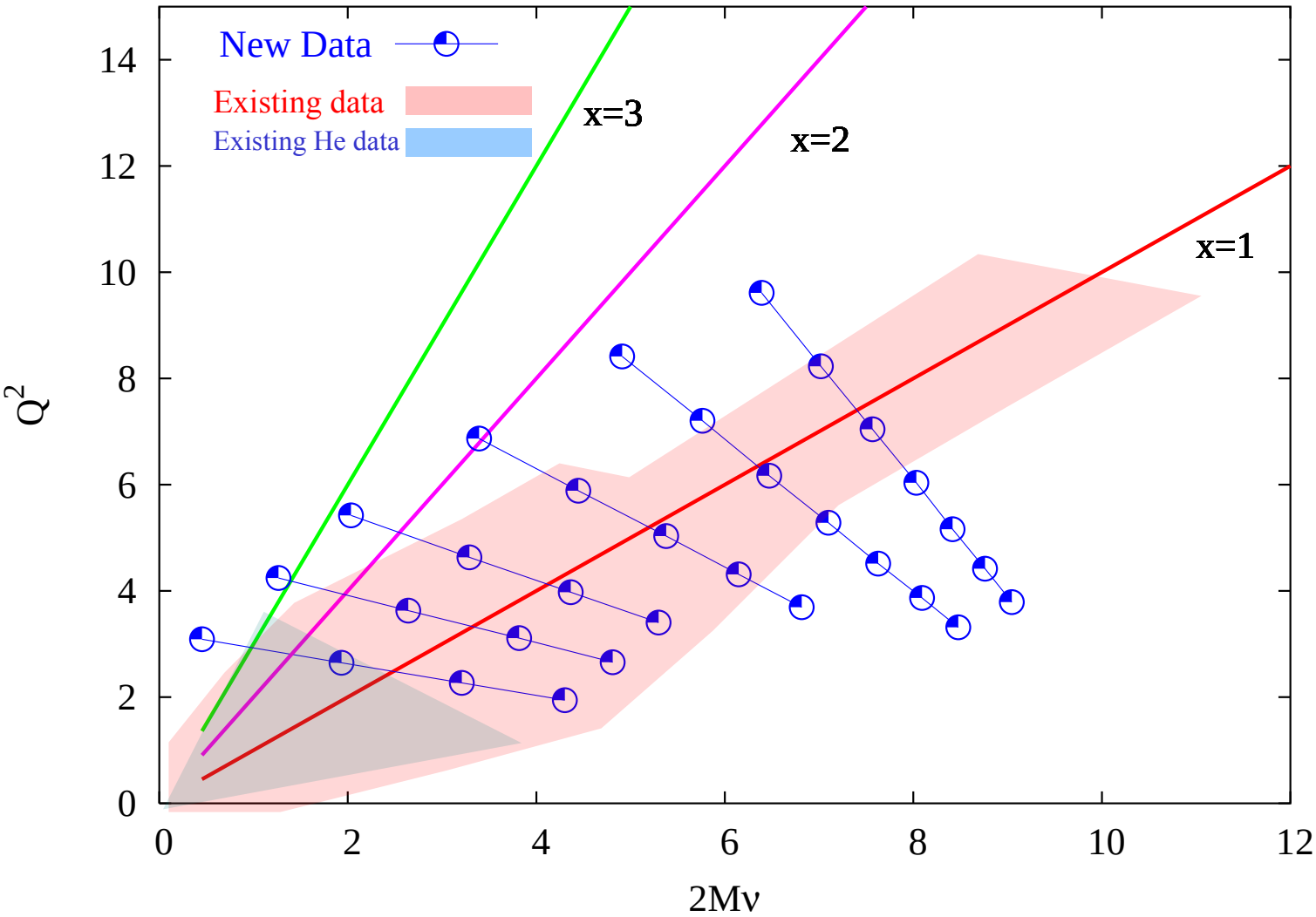


- At low ν (energy transfer), the cross-section is dominated by quasi-elastic scattering
- As the energy transfer increases, the inelastic contribution begins to dominate

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, y) at large Q^2
  - ⇨ Structure Function Q^2 dependence
- Constraints on the high momentum tail of the nuclear wave function

New Frontiers

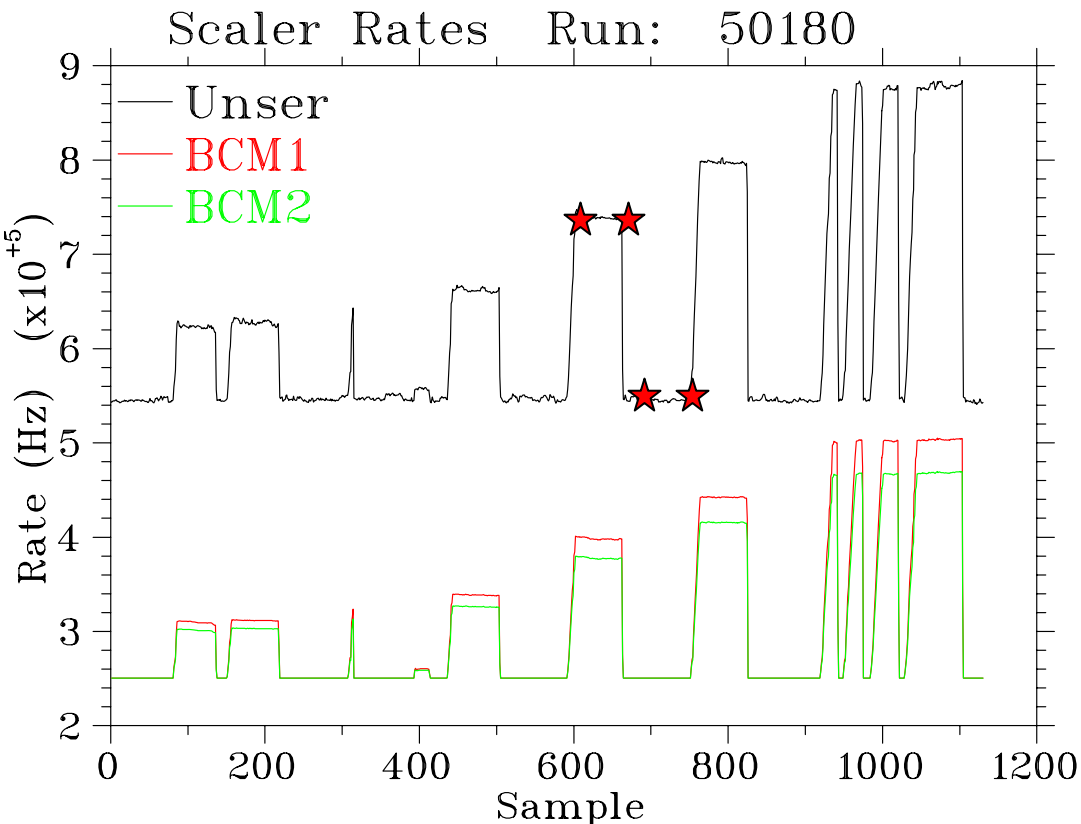


E02-019 Details

- E02-019 running is completed (Sep-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)

January 2005: Recap

- BCM Calibrations
  - ⇨Unser Drift observed
  - ⇨Calibrations redone using “local” zeroes
  - ⇨No noticeable change (0.01%)



January 2005: Plans for the immediate future

- Calibratons
  - ⇨Calorimeter ✓Done
  - ⇨Drift Chambers ✓Done
  - ⇨TOF ✓Done
- First replay of all the data ✓Done

- Second Replay of all the data ✓Done

Analysis Progress

There are 4 graduate students

- Nadia Fomin (fortran)
- Jason Seely (C++)
- Aji Daniel (fortran)
- Roman Trojer (fortran/C++)

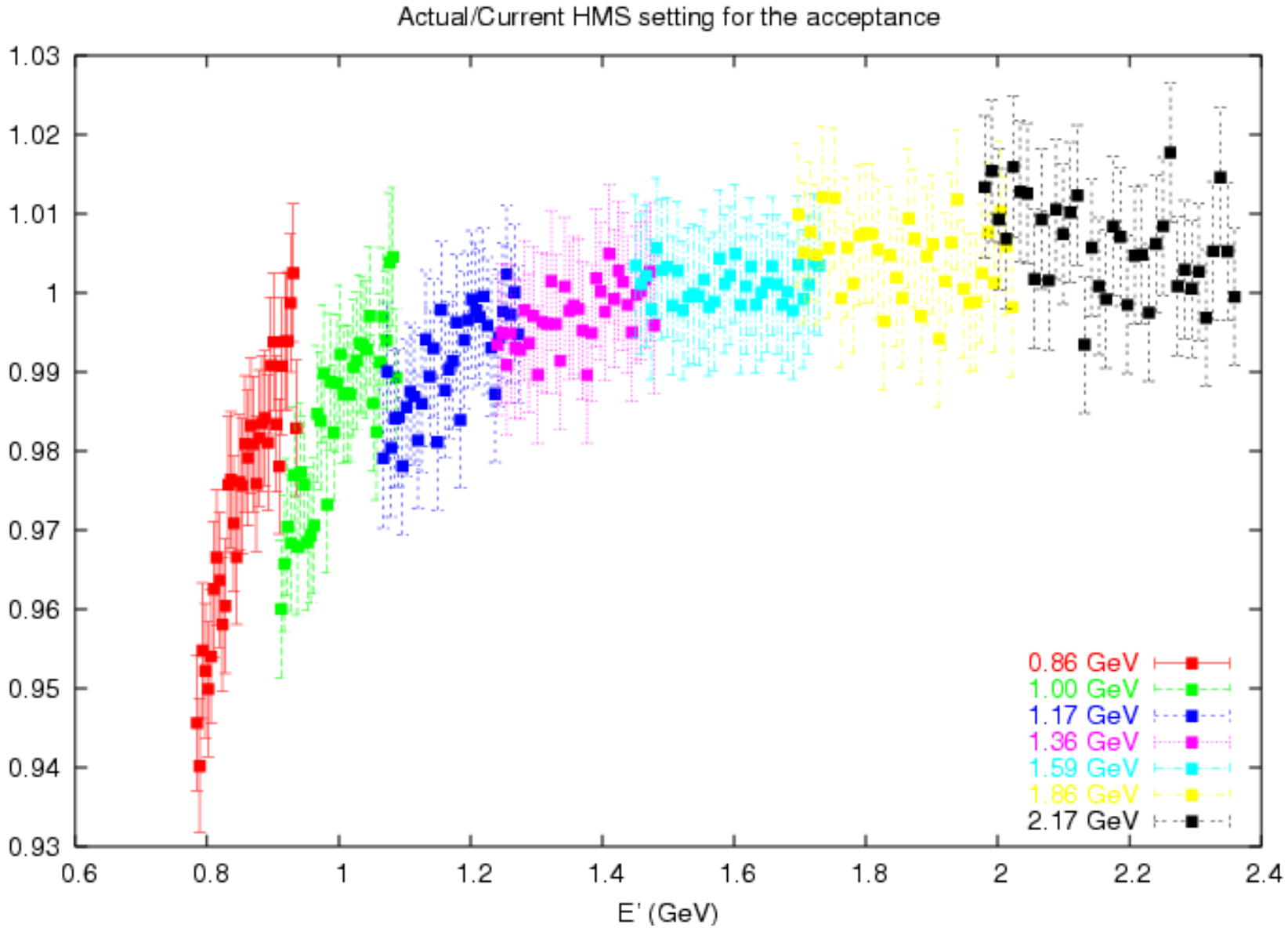
Every student is responsible for his/her own analysis code, which gives us 4 cross-sections to compare and help eliminate mistakes.

- Comparisons are performed often, yields agree at the 0.01% level
- Cross-sections are extracted using 2 different methods

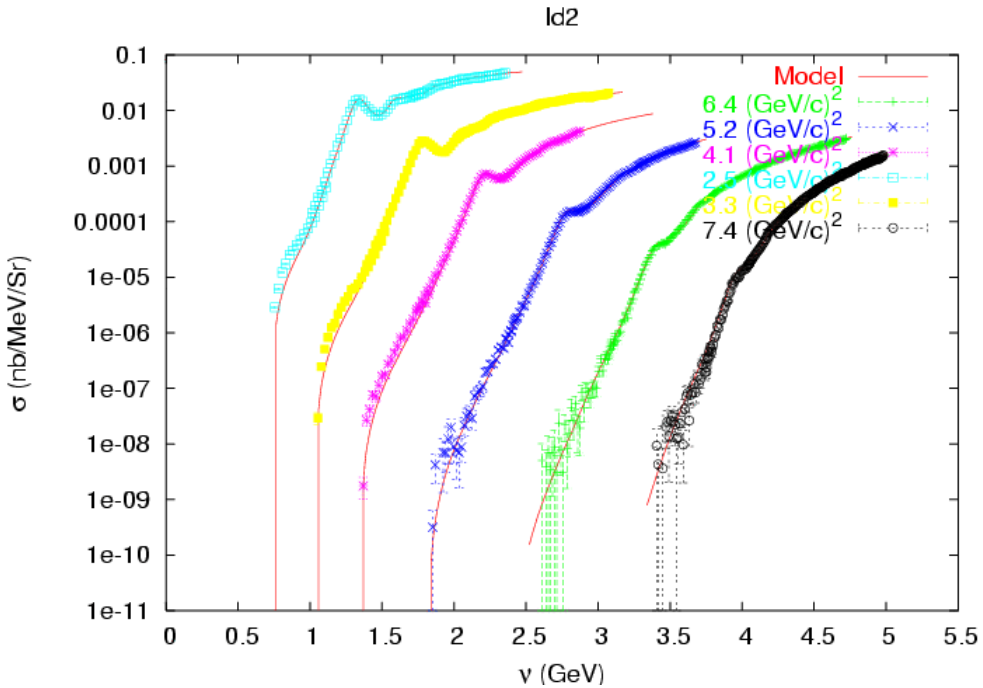
Analysis Progress

- Bin-centering Corrections
- Charge-symmetric background subtraction
- Radiative Corrections
- Acceptance Corrections (including Vladas' extra correction)
  - ↳Some trouble with reconstruction at low $\boldsymbol{p}$ in MC
- E-loss corrections (not all the analyses)
- Coulomb Corrections (in progress)
- Target Boiling Corrections ("done")

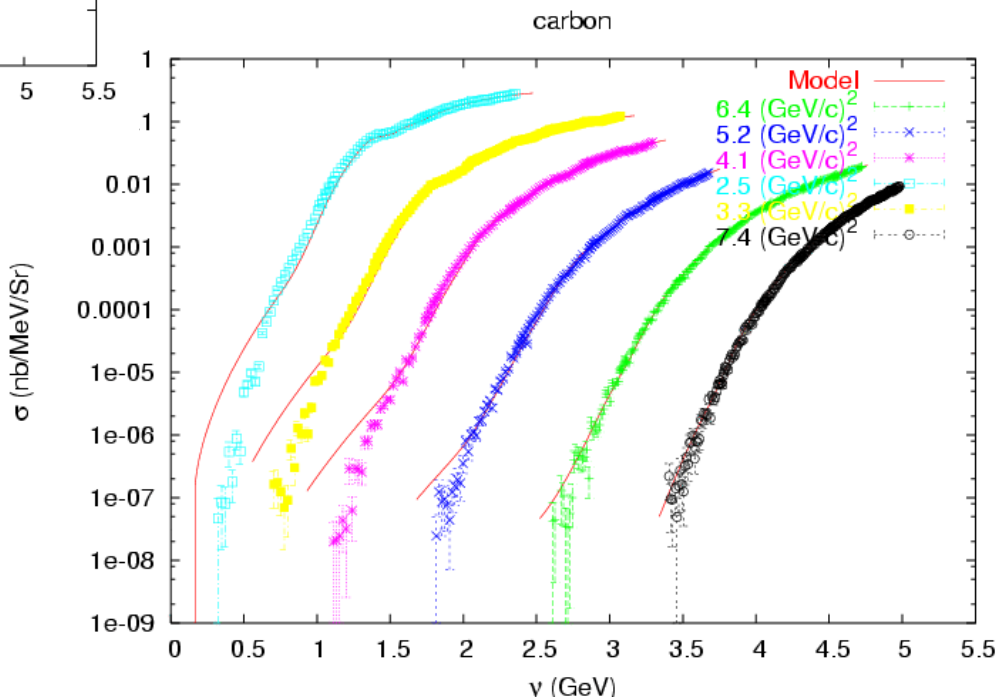
Analysis Progress: Acceptance Function



Data Range and Quality

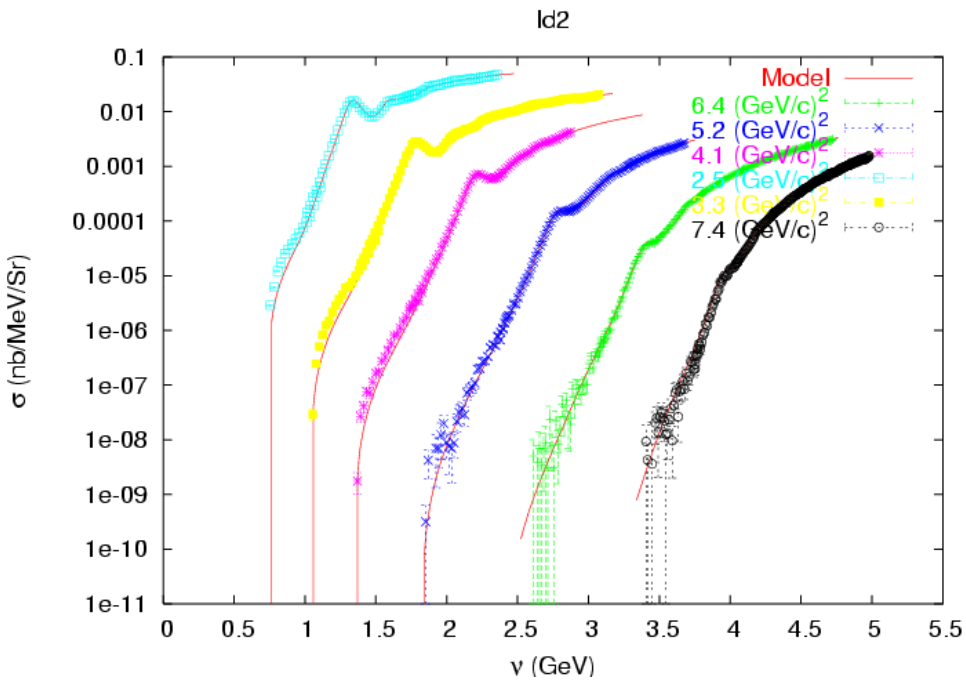


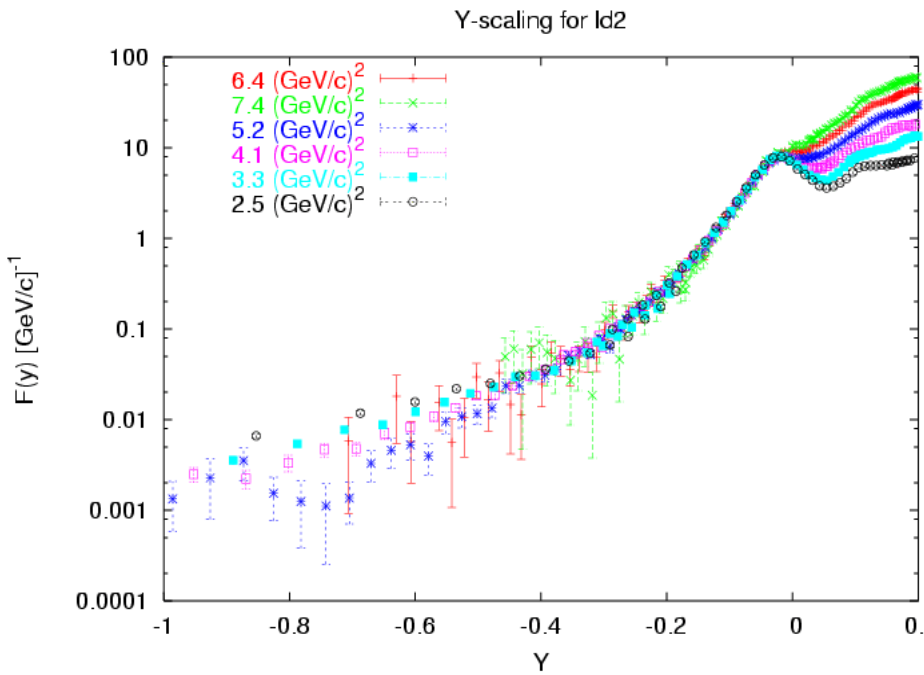
- Data has had radiative, and bin-centering corrections applied and the charge-symmetric background has been subtracted
- Coulomb corrections remain to be done



- The quasi-elastic peak is easily seen at the lowest Q^2, but gets suppressed by DIS contributions as Q^2 is increased

Y-Scaling (Example: Deuterium)

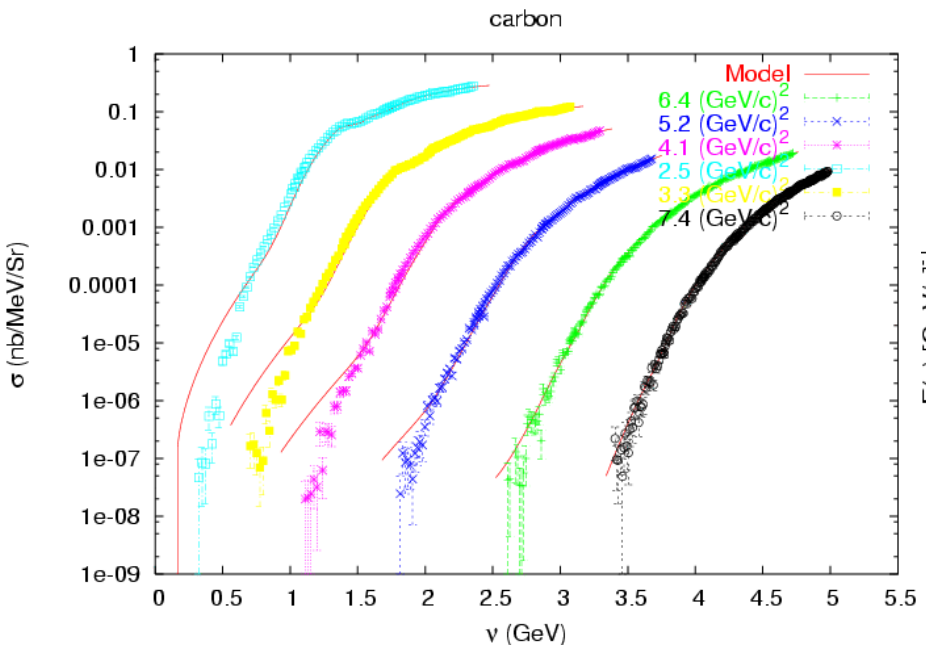


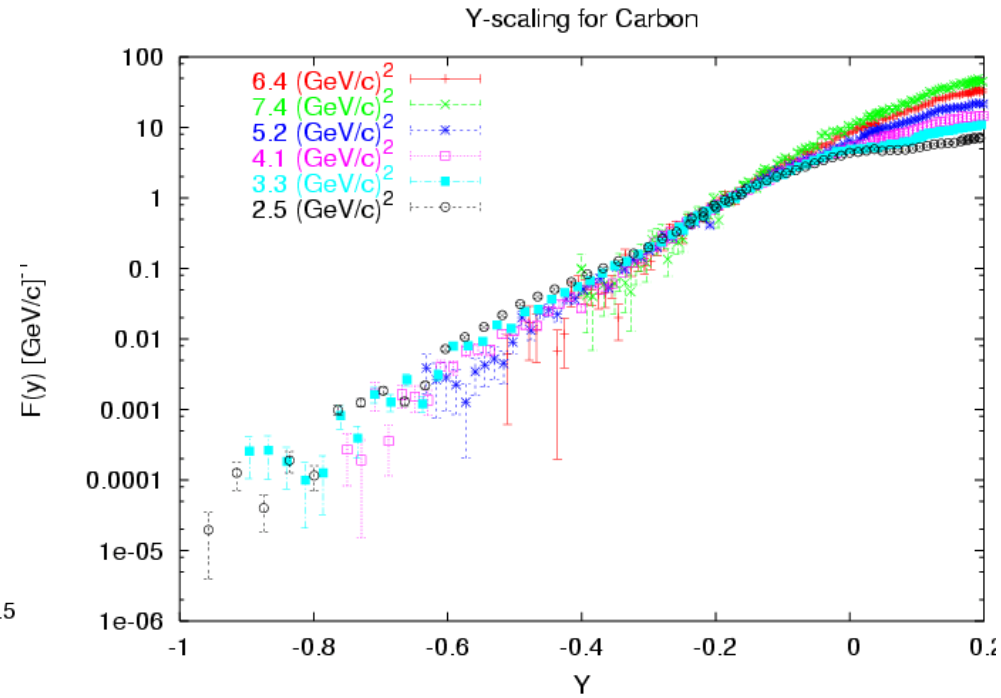


$$F(y) = \frac{d^2\sigma}{d\Omega d\upsilon} \frac{1}{(Z\sigma_p + N\sigma_n)} \frac{\mathbf{q}}{\sqrt{M^2 + (y+q)^2}}$$

$2.5 < Q^2 < 7.4\ (\mathrm{GeV}^2)$

Y-Scaling (Example: Carbon)

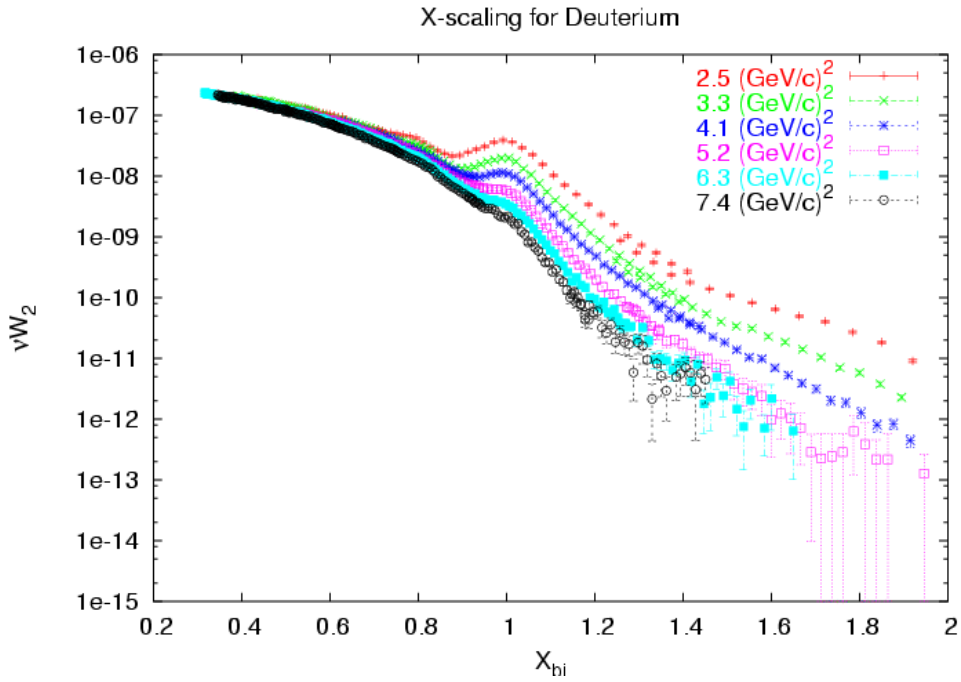


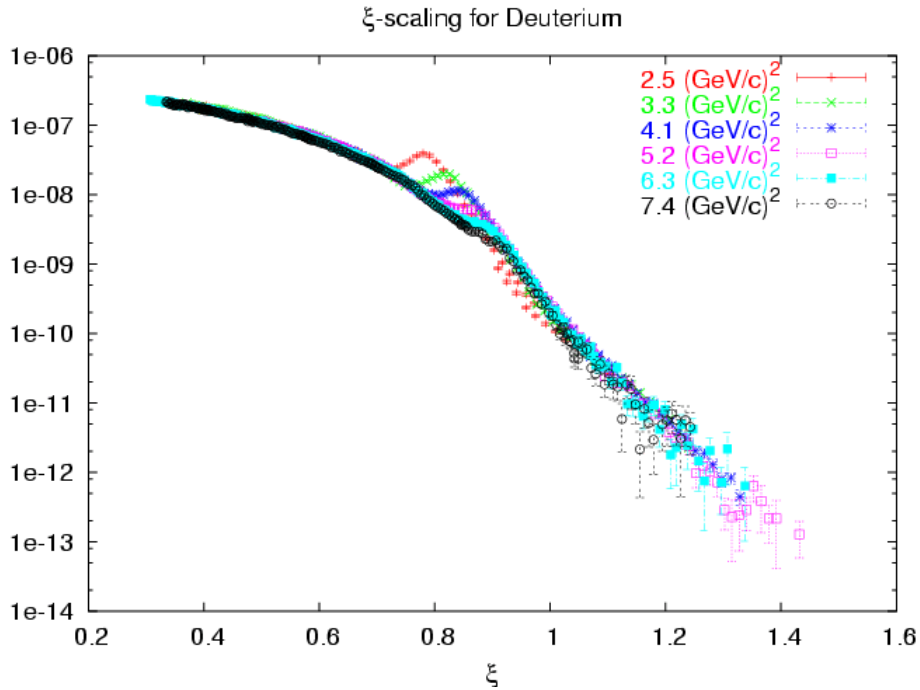


$$F(y) = \frac{d^2\sigma}{d\Omega d\upsilon} \frac{1}{(Z\sigma_p + N\sigma_n)} \frac{\mathbf{q}}{\sqrt{M^2 + (y+q)^2}}$$

$2.5 < Q^2 < 7.4$ (GeV^2)

x,ξ-scaling

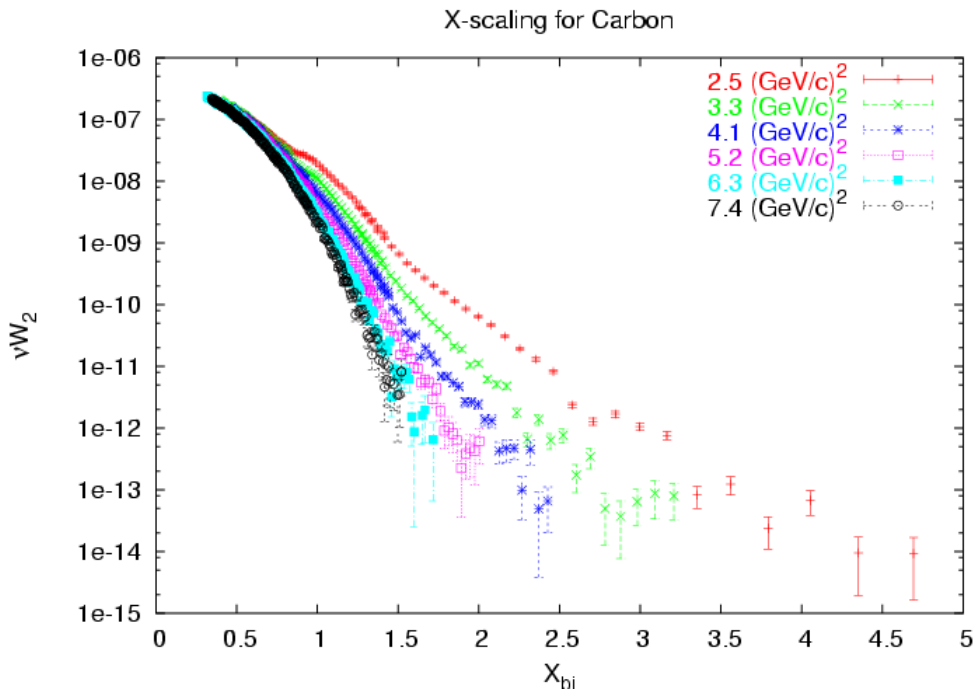


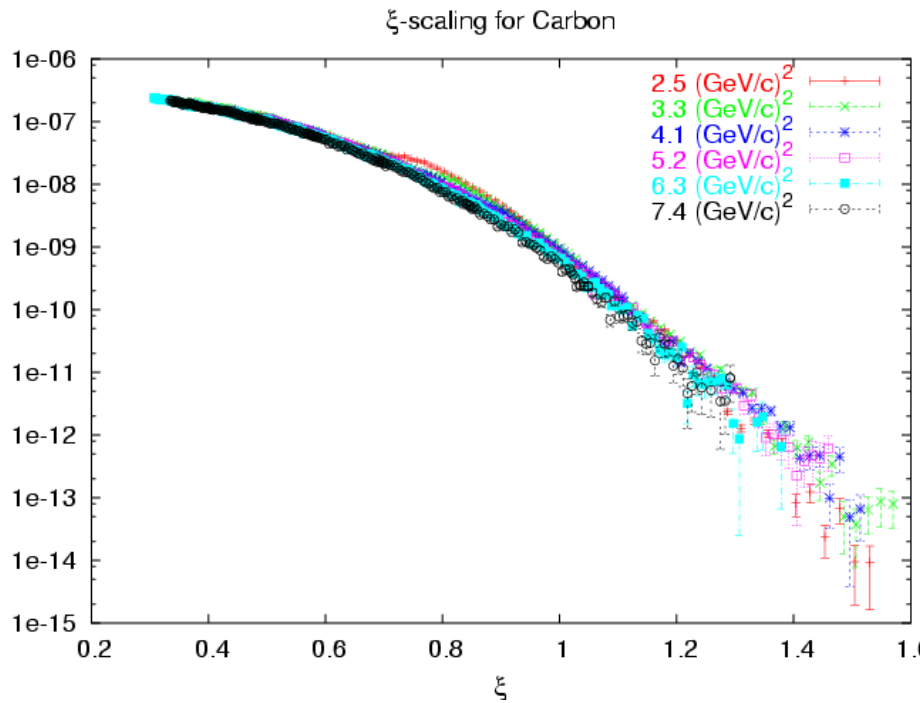


Scaling is observed only at low values of x

The structure function appears to approach a universal curve

x,ξ-scaling (continued)





- Can better scaling be explained by the role of momentum distributions?

- Scaling is observed in two kinds of variables: one that assumes scattering from a quark and the other, scattering from a nucleon. Is this accidental or evidence of duality?

To Do:

- Finalize model used in Radiative and Bin-centering Corrections
- Implement Coulomb Corrections (for those of us who haven't)
- Extract Scaling functions (much of the mechanism is in place)
- A long list of "little things"

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

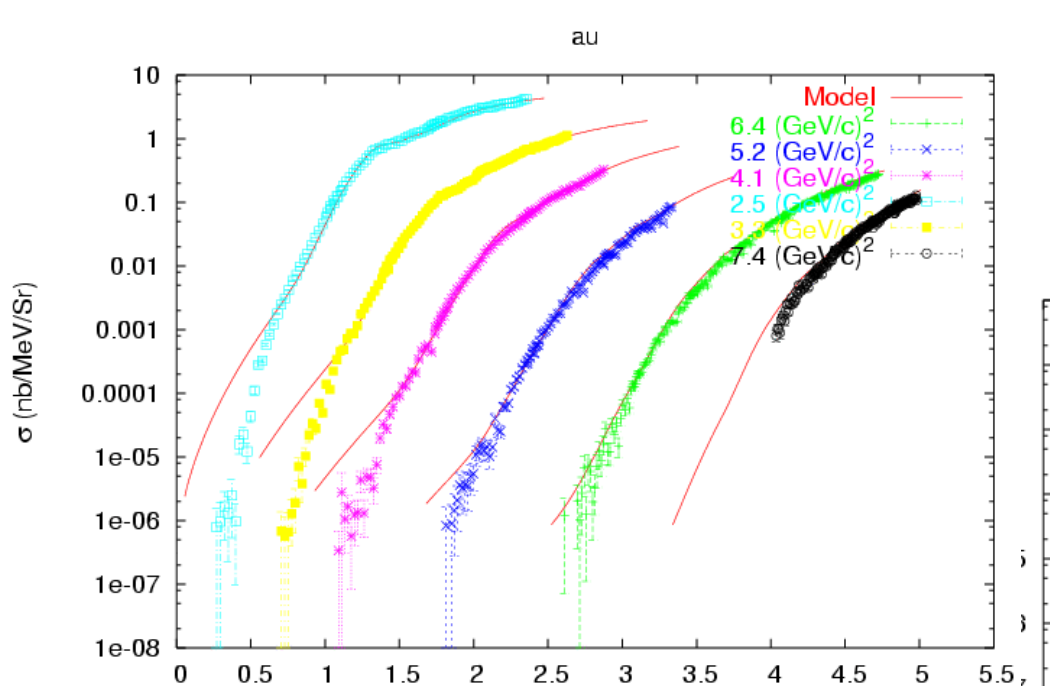
University of Virginia, Charlottesville, VA

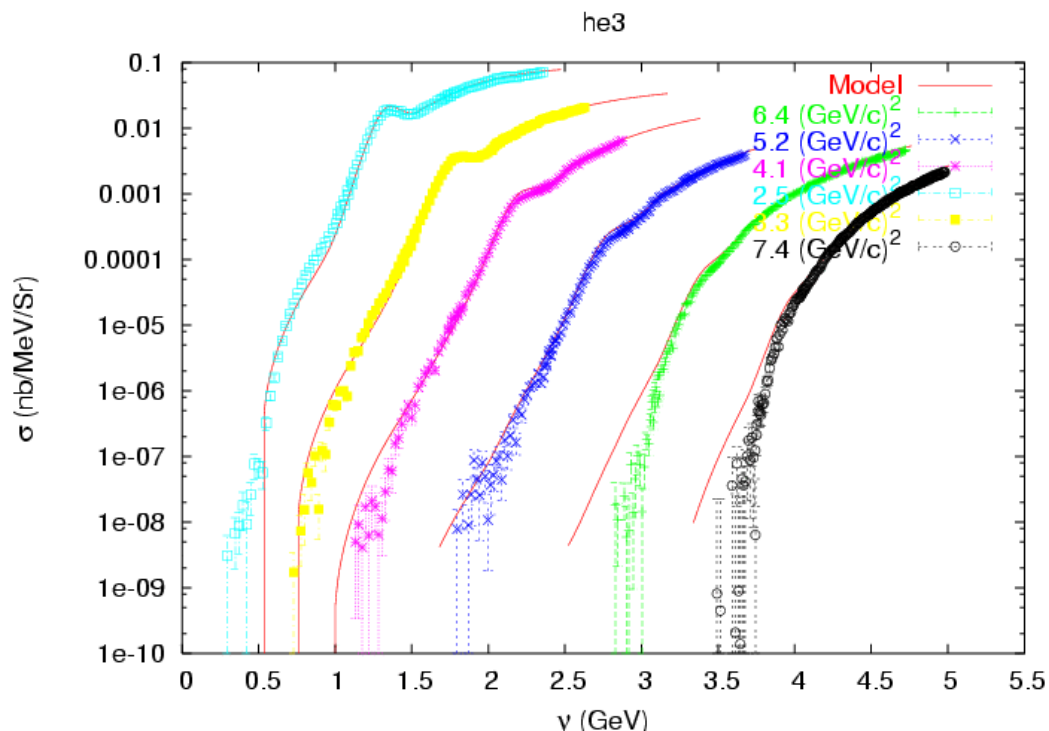
R. Asaturyan, H. Mkrtchyan, T. Navasardyan, V. Tadevosyan

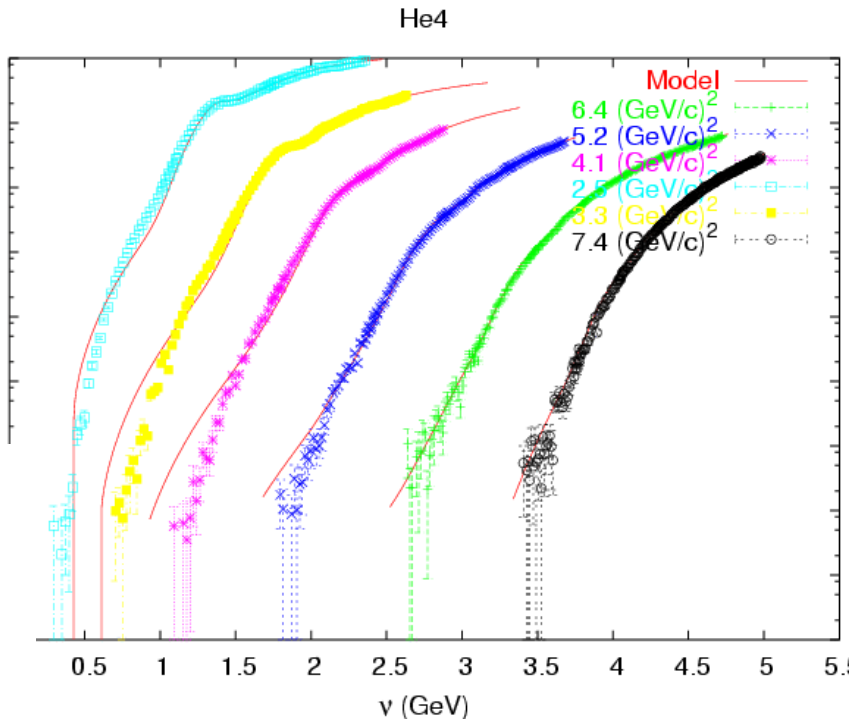
Yerevan Physics Institute, Armenia

S. Connell, M. Dalton, C. Gray

University of the Witwatersrand, Johannesburg, South Africa


au
Model
6.4 (GeV/c)2
5.2 (GeV/c)2
4.1 (GeV/c)2
2.5 (GeV/c)2
3.3 (GeV/c)2
7.4 (GeV/c)2
σ (nb/MeV/Sr)


he3
Model
6.4 (GeV/c)2
5.2 (GeV/c)2
4.1 (GeV/c)2
2.5 (GeV/c)2
3.3 (GeV/c)2
7.4 (GeV/c)2
σ (nb/MeV/Sr)
ν (GeV)


He4
Model
6.4 (GeV/c)2
5.2 (GeV/c)2
4.1 (GeV/c)2
2.5 (GeV/c)2
3.3 (GeV/c)2
7.4 (GeV/c)2
ν (GeV)