MARATHON Update

TYLER HAGUE

KENT STATE UNIVERSITY

The JLab MARATHON Tritium Collaboration

D. Abrams, H. Albataineh, **S. Alsalmi**, D. Androic, K. Aniol, W. Armstrong, J. Arrington, H. Atac, T. Averett, C. Ayerbe Gayoso, X. Bai, **J. Bane***, **S. Barcus**, A. Beck, V. Bellini, H. Bhatt, D. Bhetuwal, D. Biswas, D. Blyth, W. Boeglin, D. Bulumulla, A. Camsonne, **M. Carmignotto**, **J. Castellanos**, J-P. Chen, C. Ciofi degli Atti, E. O. Cohen, S. Covrig, K. Craycraft, **R. Cruz-Torres**, B. Dongwi, M. Duer, B. Duran, D. Dutta, N. Fomin, E. Fuchey, C. Gal, T. N. Gautam, S. Gilad, K. Gnanvo, T. Gogami, J. Gomez, C. Gu, A. Habarakada, **T. Hague***, O. Hansen, M. Hattawy, **F. Hauenstein**, O. Hen, D. W. Higinbotham, R. Holt, E. Hughes, C. Hyde, H. Ibrahim, S. Jian, S. Joosten, A. Karki, B. Karki, A. T. Katramatou, C. Keppel, M. Khachatryan, V. Khachatryan, A. Khanal, D. King, P. King, I. Korover, S. A. Kulagin, **T. Kutz***, N. Lashley-Colthirst, G. Laskaris, **S. Li**, W. Li, **H. Liu***, S. Liuti, N. Liyanage, D. Lonardoni, R. Machleidt, L.E. Marcucci, P. Markowitz, **E. McClellan**, D. Meekins, W. Melnitchouk, S. Mey-Tal Beck, Z-E. Meziani, R. Michaels, M. Mihovilovič, V. Nelyubin, **D. Nguyen**, N. Nuruzzaman, **M. Nycz***, R. Obrecht, M. Olson, L. Ou, V. Owen, E. Pace, **B. Pandey**, V. Pandey, A. Papadopoulou, M. Paolone, S. Park, M. Patsyuk, S. Paul, G. G. Petratos, R. Petti, E. Piasetzky, R. Pomatsalyuk, S. Premathilake, A. J. R. Puckett, V. Punjabi, R. Ransome, M. N. H. Rashad, P. E. Reimer, S. Riordan, J. Roche, F. Sammarruca, G. Salmè, **N. Santiesteban**, B. Sawatzky, J. Segal, E. P. Segarra, B. Schmookler, A. Schmidt, S. Scopetta, A. Shahinyan, S. Širca, N. Sparveris, **T. Su***, R. Suleiman, H. Szumila-Vance, A. S. Tadepalli, L. Tang, W. Tireman, F. Tortorici, G. Urciuoli, M. Viviani, L. B. Weinstein, B. Wojtsekhowski, S. Wood, **Z. H. Ye**, Z. Y. Ye, and J. Zhang.

More than 140 Collaborators

Red-Boldfaced Names: Tritium Program grad students; **starred**: MARATHON Ph.D. students

Blue-Boldfaced Names: Tritium Program postdoctoral associates

The JLab MARATHON Tritium Collaboration

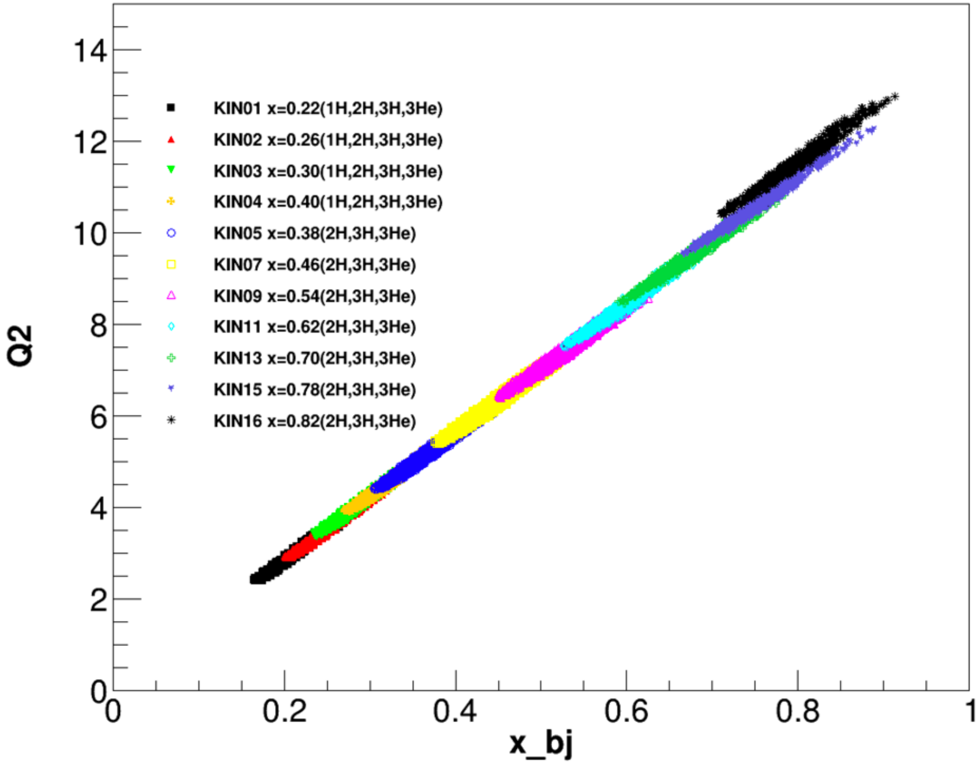
Forty Five Institutions (in no particular order): University of Virginia; Texas A & M University; Kent State University; University of Zagreb; California State University, Los Angeles; Argonne National Laboratory; Temple University; The College of William and Mary; University of Tennessee; Massachusetts Institute of Technology; INFN Sezione di Catania; INFN Sezione di Roma, INFN Sezione di Pisa; Mississippi State University; Hampton University; Florida International University; Old Dominion University; Jefferson Lab; University of Perugia; Tel Aviv University; University of Connecticut; Tohoku University; Columbia University; Cairo University; Ohio University; Stony Brook, State University of New York; Syracuse University; Nuclear Research Center-Negev, Beer-Sheva; Institute for Nuclear Research of the Russian Academy of Sciences; University of New Hampshire; University of Regina; Columbia University; Facility for Rare Isotope Beams, Michigan State University; Los Alamos National Laboratory; University of Idaho; University of Pisa; Jožef Stefan Institute, University of Ljubljana; Johannes Gutenberg-Universität Mainz; Saint Norbert College; Center for Neutrino Physics, Virginia Tech; University of South Carolina; Kharkov Institute of Physics and Technology; Norfolk State University; Rutgers University; Artem Alikhanian National Laboratory; Tel Aviv University; Northern Michigan University; University of Illinois, Chicago.

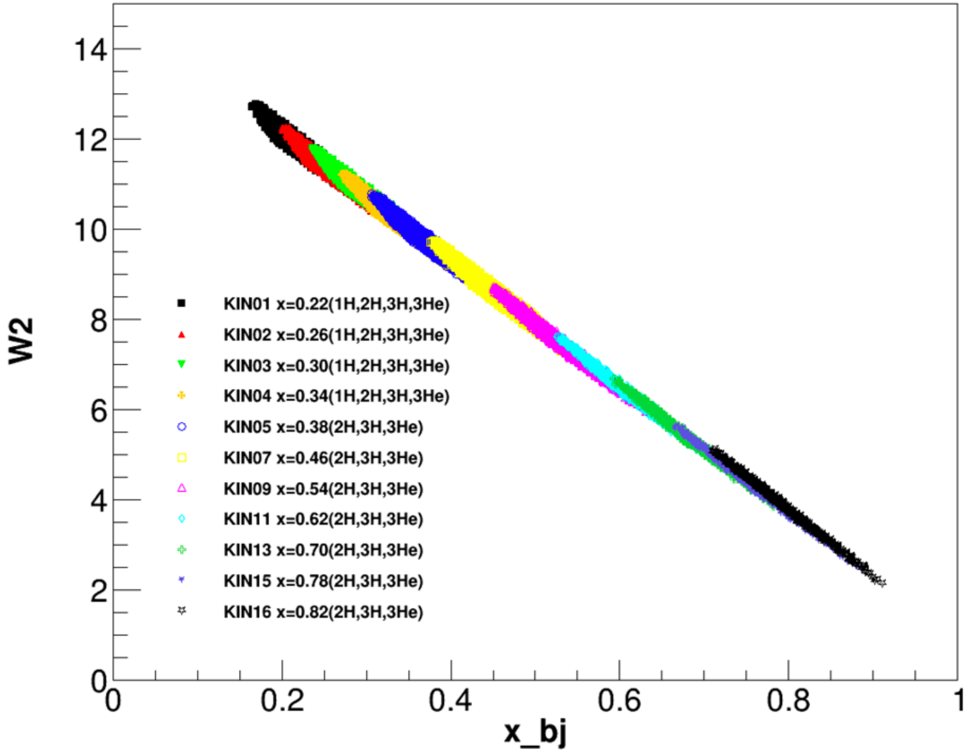
Twelve Countries: Armenia, Canada, Croatia, Egypt, Germany, Israel, Italy, Japan, Russia, Slovenia, Ukraine, United States.

Goals of MARATHON

- Extract F_2^n/F_2^p from $^3H/^3He$, exploiting mirror symmetry
- The first measurement of the ^3H EMC effect
- The first measurement of the ^3He EMC effect using only DIS data
  - The F_2^n/F_2^p extraction from $^3H/^3He$ will be used for the isoscalar corrections to the EMC ratios
- Extract the ratio of down to up quark distributions in the nucleon *d/u* (WORK IN PROGRESS)

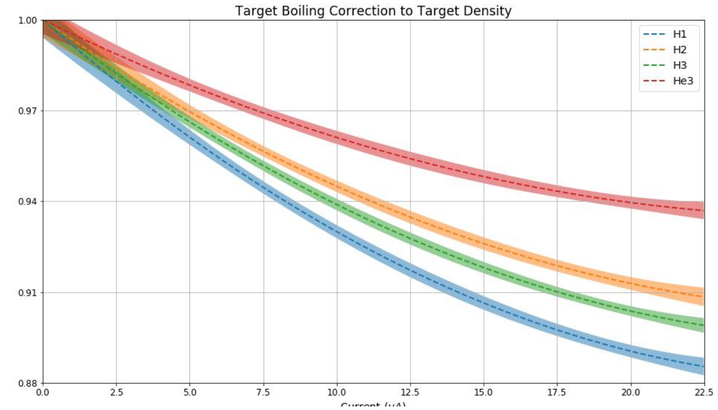
Kinematic Coverage

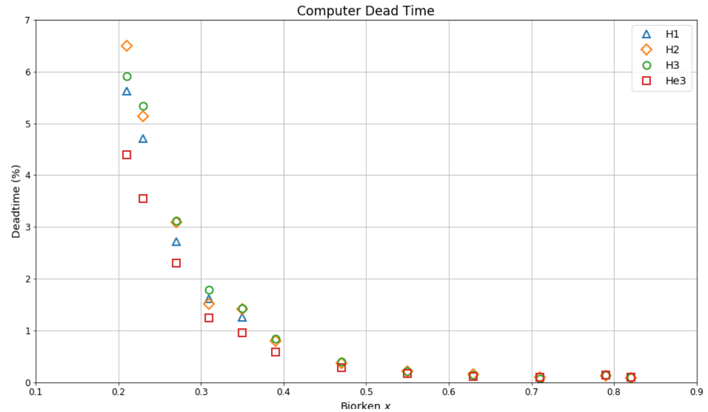


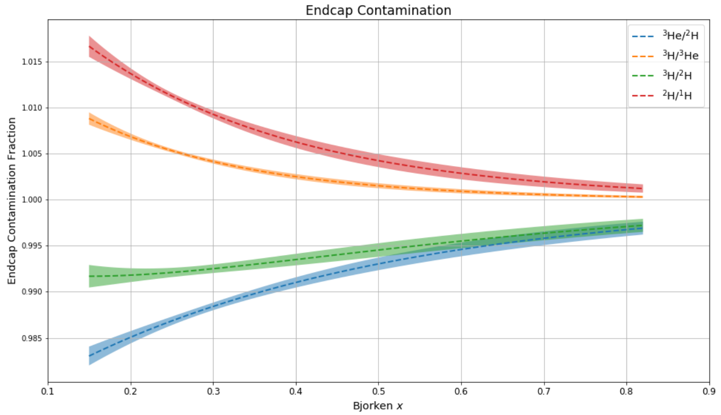


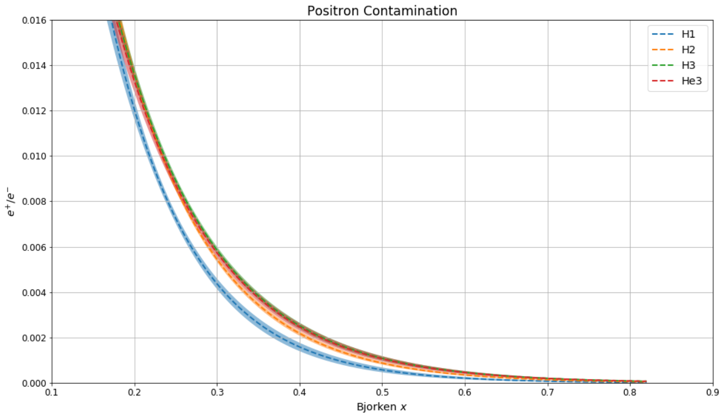
Plots courtesy of Tong Su

Corrections









F_2^n/F_2^p Extraction

- Form the "SuperRatio" of EMC-type ratios for A=3 mirror nuclei:

$$R(^3He) = \frac{F_2^{^3He}}{2F_2^p + F_2^n} \qquad R(^3H) = \frac{F_2^{^3H}}{F_2^p + 2F_2^n} \qquad R^* = \frac{R(^3He)}{R(^3H)}$$

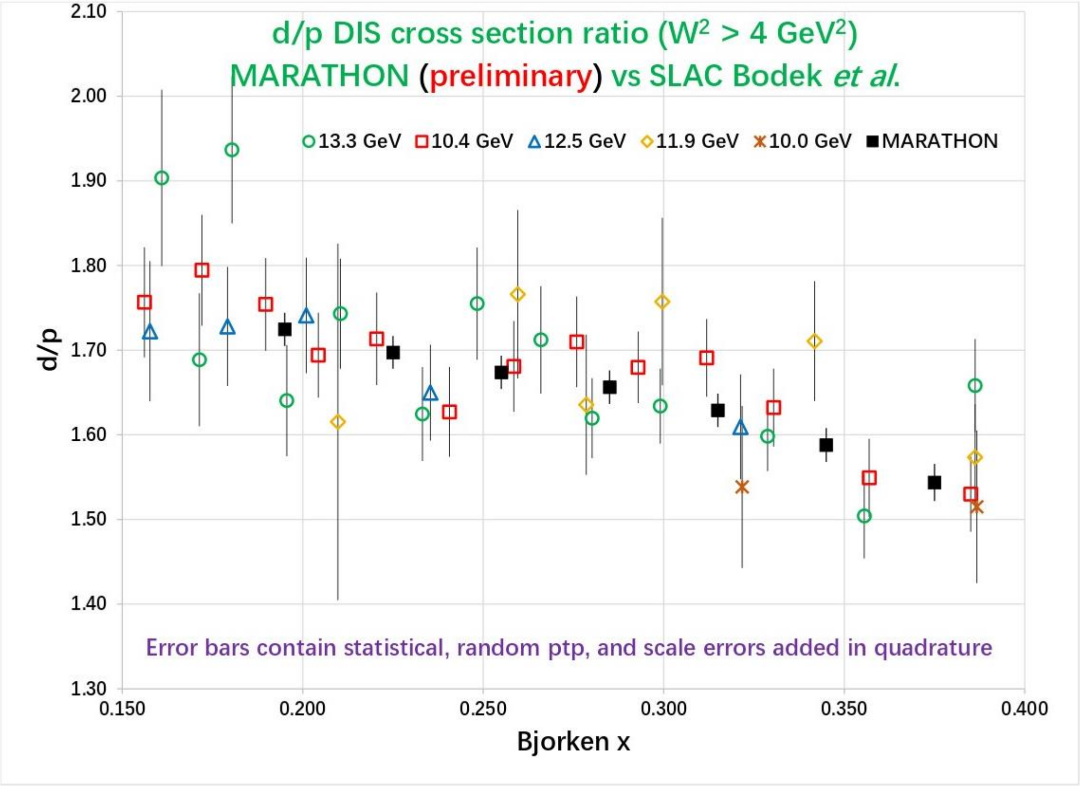
- Solve above equations for the A=3 structure function ratio:

$$\frac{\sigma^{^3He}}{\sigma^{^3H}} = \frac{F_2^{^3He}}{F_2^{^3H}} = R^* \frac{2F_2^p + F_2^n}{F_2^p + 2F_2^n}$$

- Solve for the nucleon F2 ratio and calculate it, using R* from a reliable theoretical model (value of R* is very close to unity with small uncertainty), and the measured A=3 DIS cross section ratio:

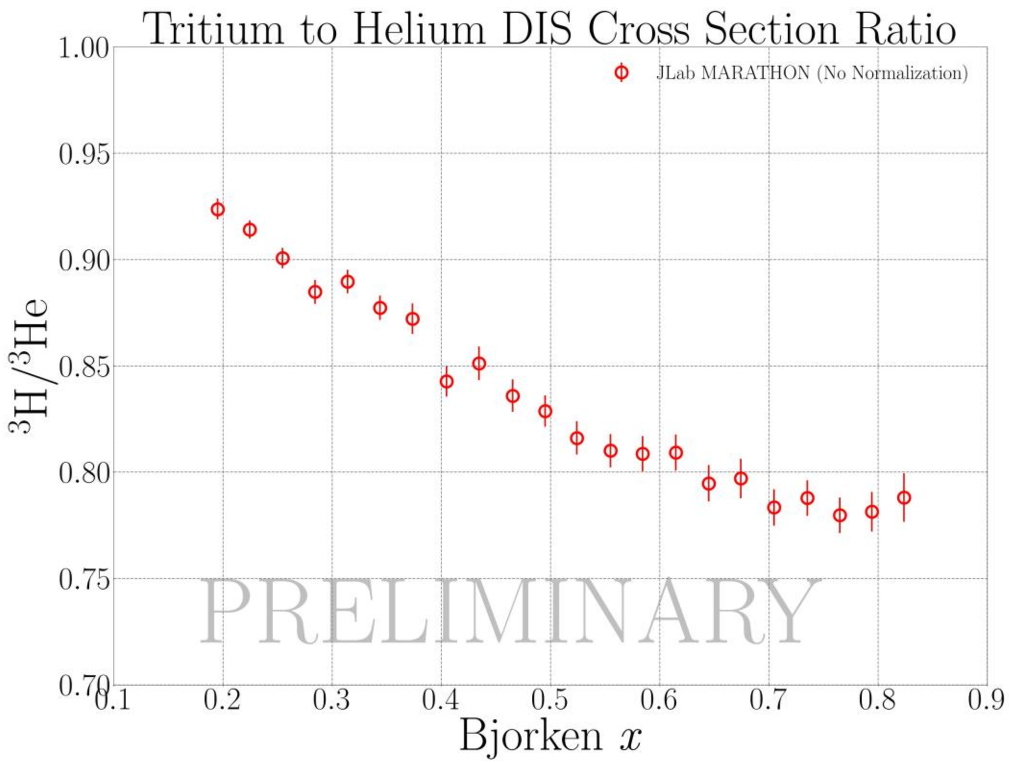
$$\frac{F_2^n}{F_2^p} = \frac{2R^* - \sigma^{^3He}/\sigma^{^3H}}{2\sigma^{^3He}/\sigma^{^3H} - R^*}$$

F_2^n/F_2^p Extracted from $^2H/^1H$



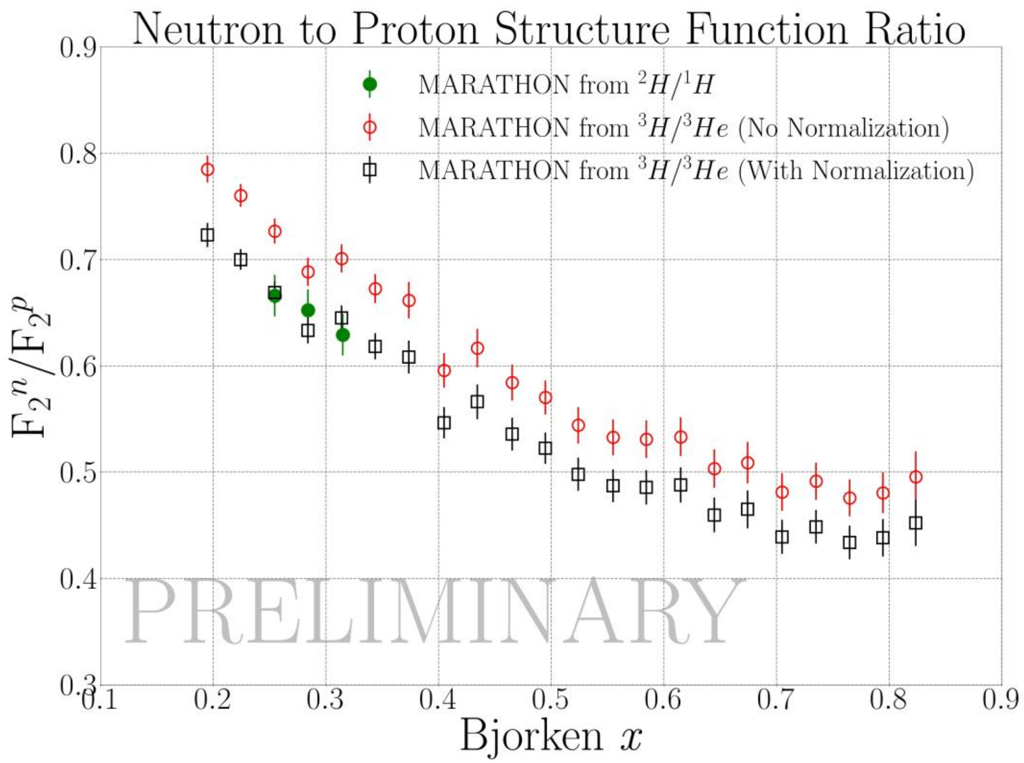
Plots courtesy of Tong Su

Raw $^3H/^3He$ Ratio



Plot courtesy of Tong Su

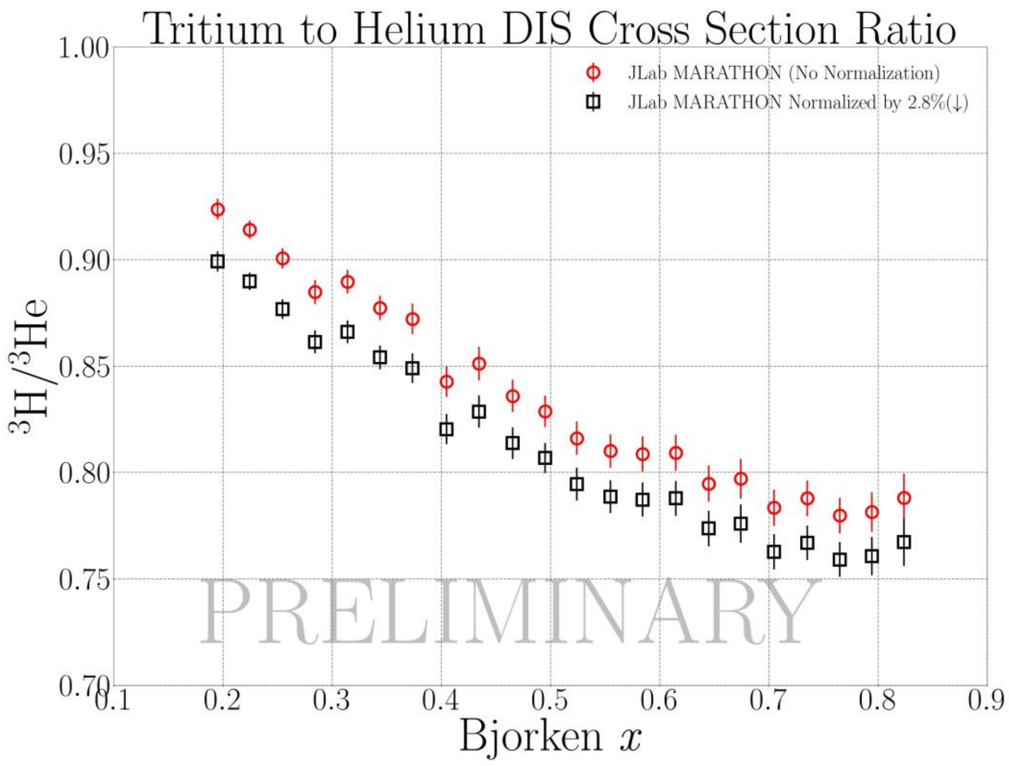
F_2^n/F_2^p Extracted from $^3H/^3He$



Plot courtesy of Tong Su

A -2.8% normalization on $^3H/^3He$ is necessary for the F_2^n/F_2^p extraction to agree with the $^2H/^1H$ extraction.

$^3H/^3He$ Ratio



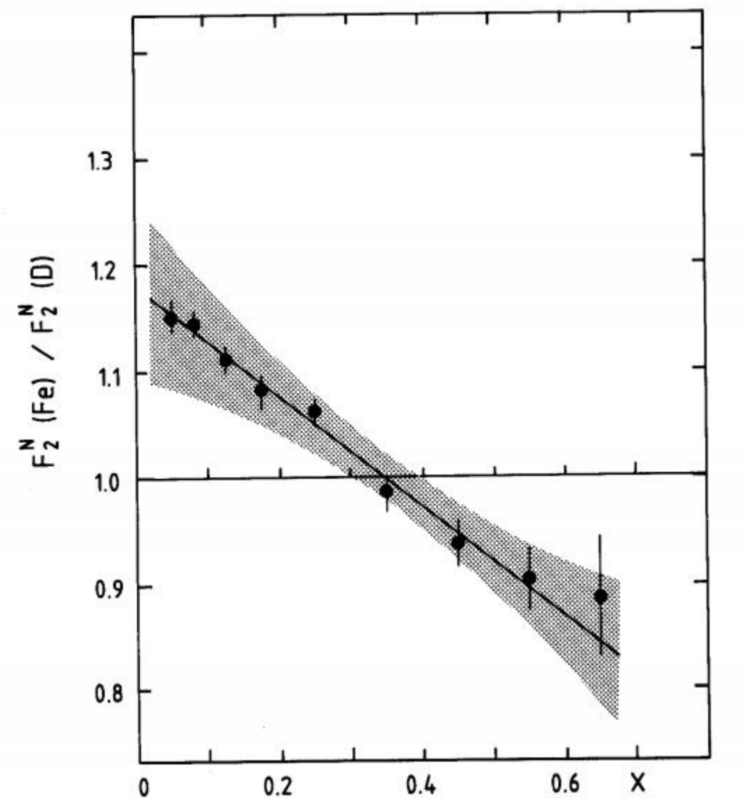
Plot courtesy of Tong Su

EMC Effect

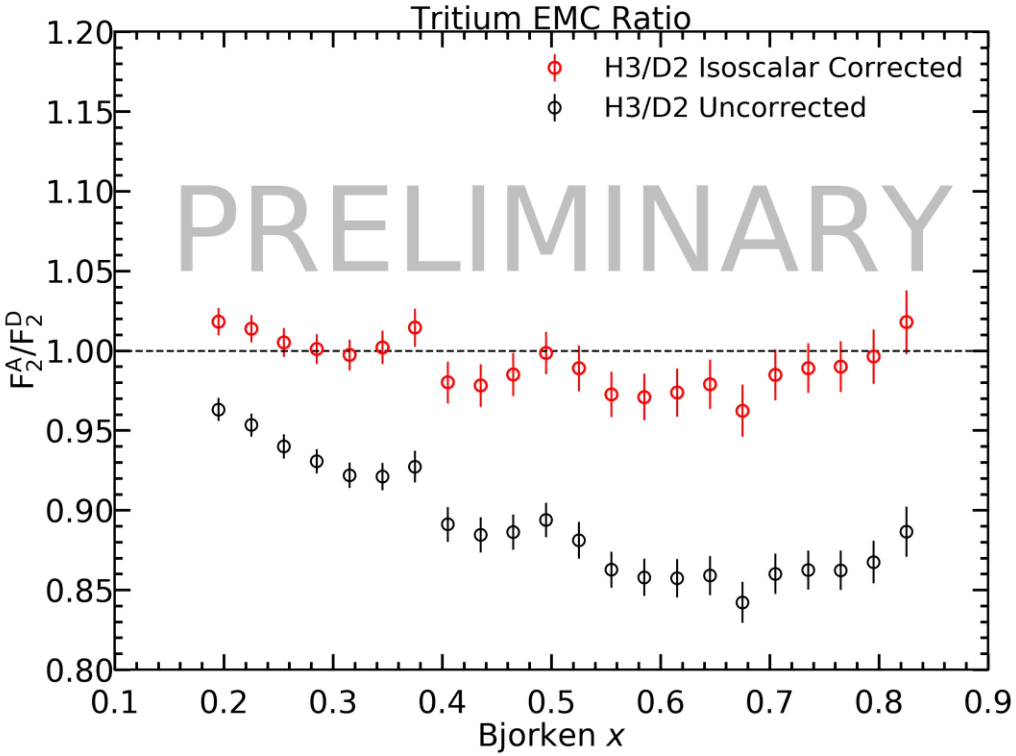
- Prior to 1983, it was assumed that nucleons were quasi-free in the nucleus:

$$F_2^A = ZF_2^p + (A - Z)F_2^n$$

- The European Muon Collaboration (EMC) measured the structure functions of hydrogen, deuterium, and iron
- After neutron excess corrections, the F_2 ratios greatly deviated from the expectation of unity

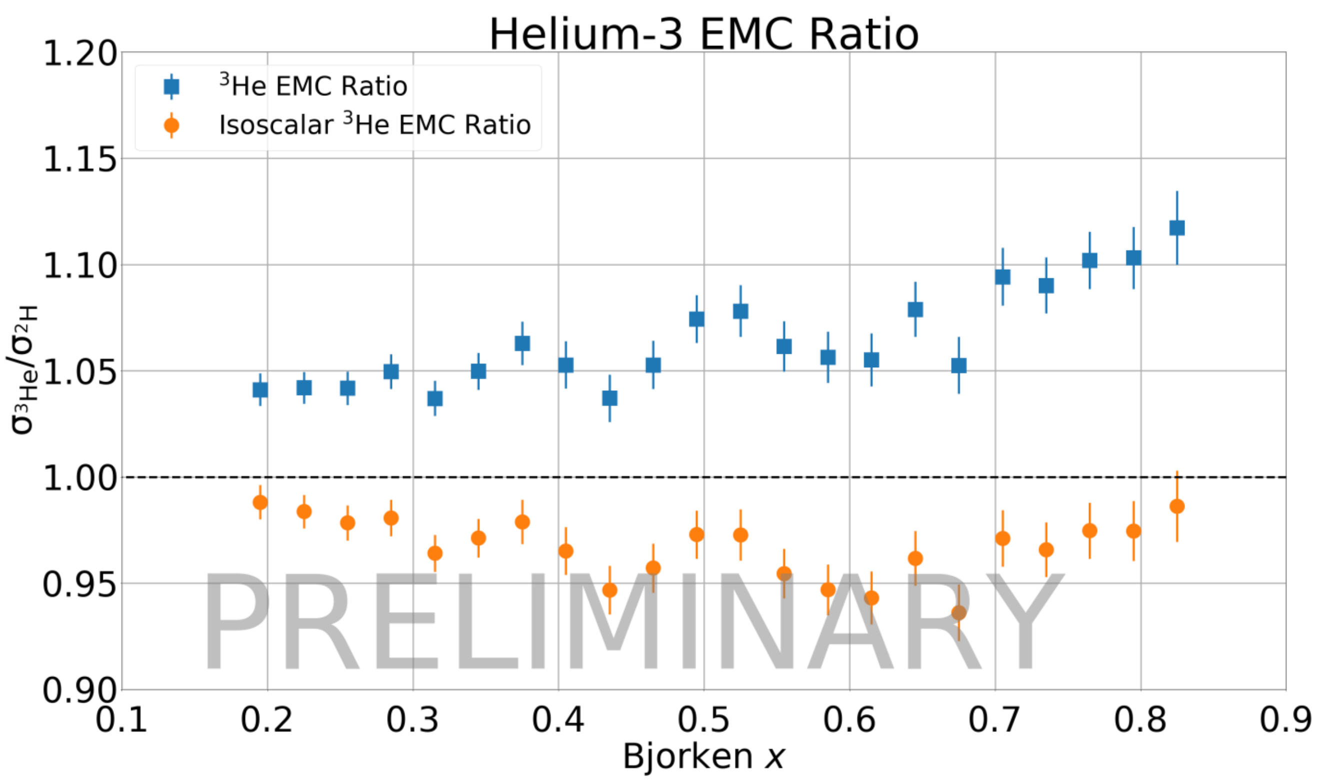


Raw ^{3}H EMC Ratio



Plot courtesy of Michael Nycz

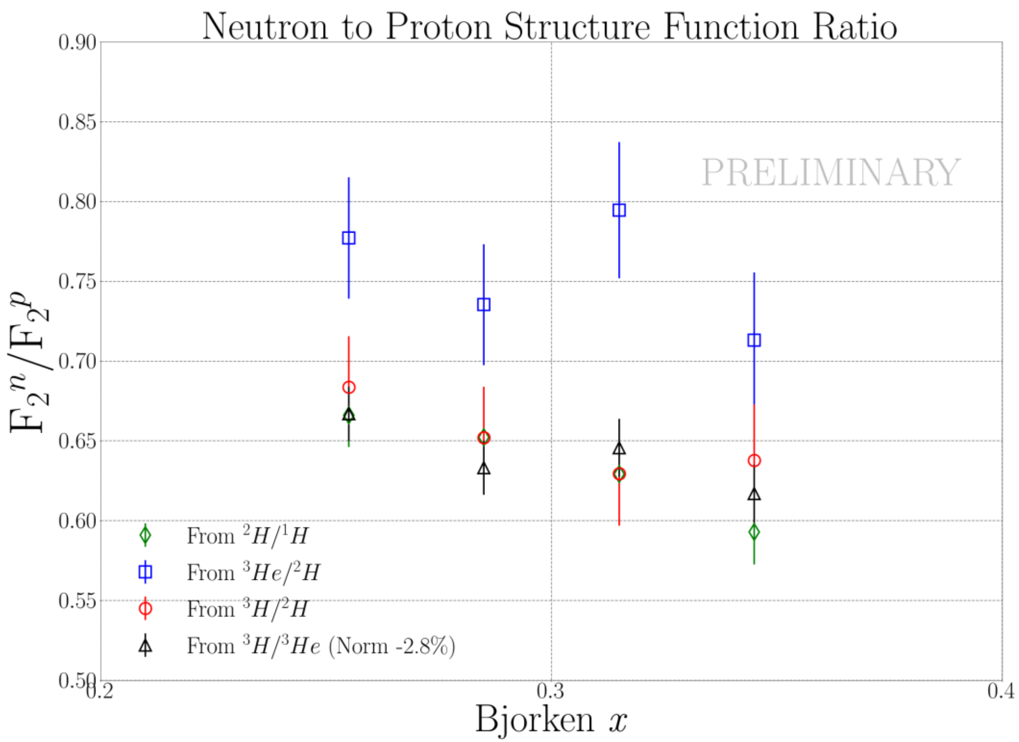
Raw ^{3}He EMC Ratio



A look at normalizing

- F_2^n/F_2^p from $^3H/^3He$ does not agree with F_2^n/F_2^p from $^2H/^1H$
  - This was rectified by normalizing $^3H/^3He$ down by 2.8%
  - This was determined by calculating χ^2 for the points around x=0.3, where nuclear effects are at a minimum
- A documented feature of the EMC effect is a unity crossing of the isoscalar ratio near x=0.3
  - ^3He does not have this feature
  - We can look to F_2^n/F_2^p from the non-isoscalar corrected EMC ratios to determine a correct normalization
  - Nuclear effects are at a minimum in the region of x=0.3, so the extractions should agree here

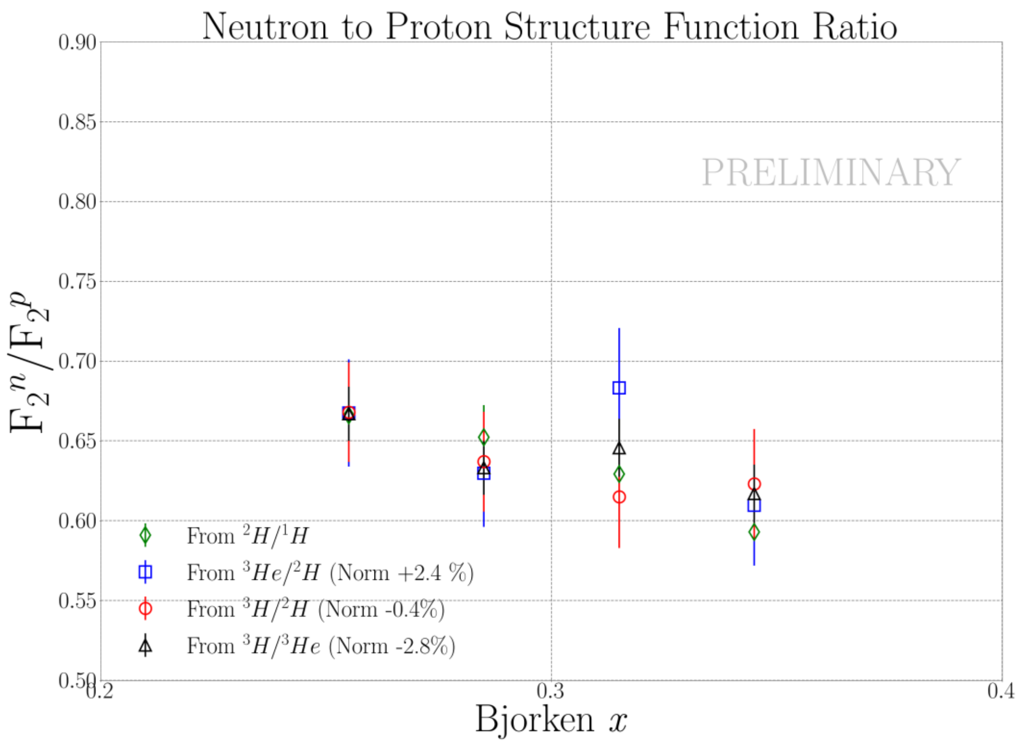
F_2^n/F_2^p Extractions



Plot courtesy of Tong Su

We see, especially in $^3He/^2H$, a discrepancy here. We use χ^2 to determine a normalization.

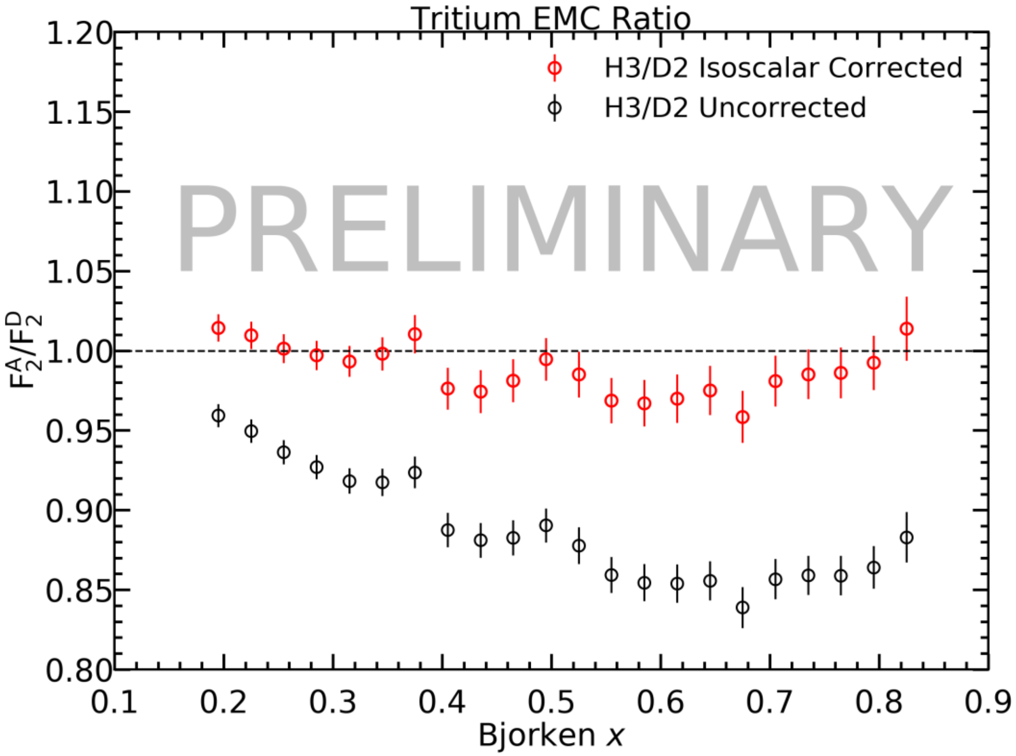
Normalization Results



Plot courtesy of Tong Su

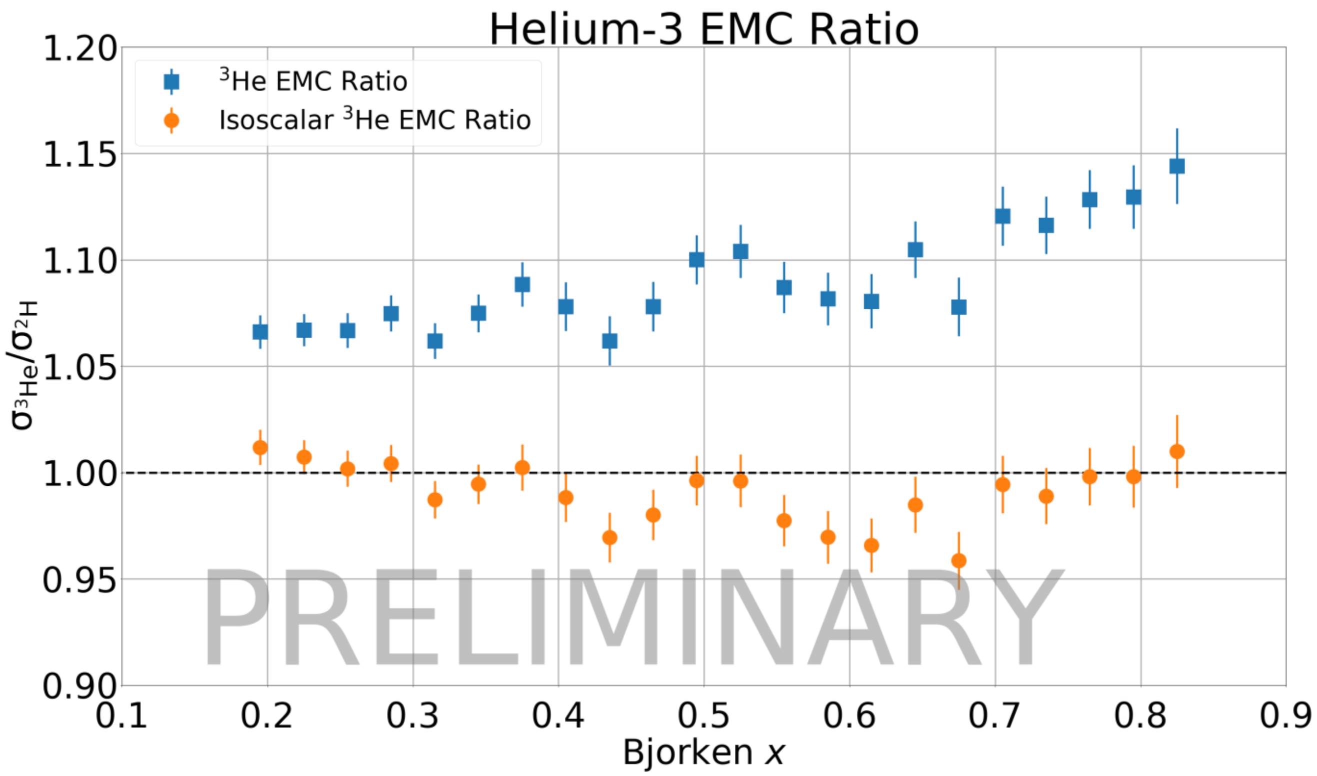
A +2.4% normalization is applied to ^{3}He and a -0.4% normalization is applied to ^{3}H.
This is consistent with the 2.8% normalization applied to ^{3}H/^{3}He.

^3H EMC Ratio



Plot courtesy of Michael Nycz

^{3}He EMC Ratio



Thank you!