MARATHON ratio analysis

Tyler Kutz
Stony Brook University

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1. Introduction

2. Target density correction

3. Radiative correction

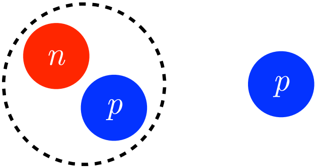
4. Tritium β-decay correction

5. Ratios

MARATHON

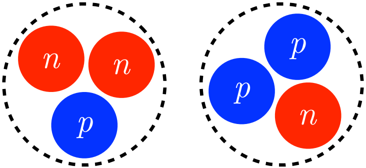
- **Measure $\sigma(^3\mathrm{H})/\sigma(^3\mathrm{He})$ to extract F_2^n/F_2^p**

Extraction from deuterium and proton...



- Sensitive to *absolute* magnitude of nuclear effects
- Large model dependence at high x

MARATHON extraction...



- Sensitive to *relative* magnitude of nuclear effects
- Reduced model dependence at high x

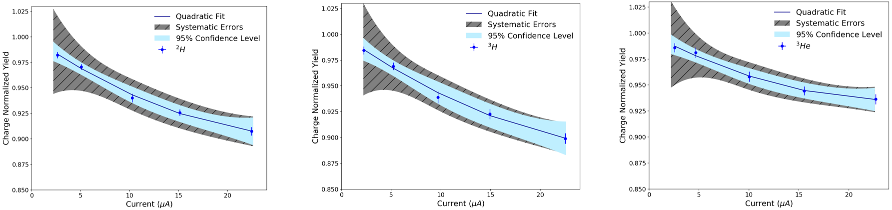
- **Measure $\sigma(^3\mathrm{H})/\sigma(^2\mathrm{H})$ and $\sigma(^3\mathrm{He})/\sigma(^2\mathrm{H})$ to observe EMC effect in A = 3 nuclei**

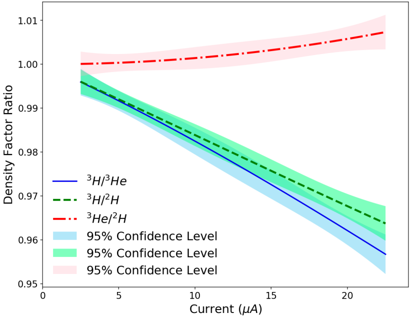
Status of ratio analysis

- Extracting three ratios:
  - ^{3}H/^{3}He (F_2^n/F_2^p, d/u)
  - ^{3}H/^{2}H, ^{3}He/^{2}H (EMC effect)
- Data covers range $0.2 < x < 0.8$
- Status of ratio analysis:
  - Ratios show good stability to changes in cuts, corrections
  - Converging on first results for APS April meeting

Density fluctuation

Credit: Nathaly Santiesteban, *et al.*





- Beam-induced density fluctuation parameterized by quadratic function
- Details: arXiv:1811.12167 (submitted to NIMA)
- Effect on ratios:
  - Correction $\leq 5\%$
  - Uncertainty $\leq 0.5\%$

Model input

Credit: Hanjie Liu

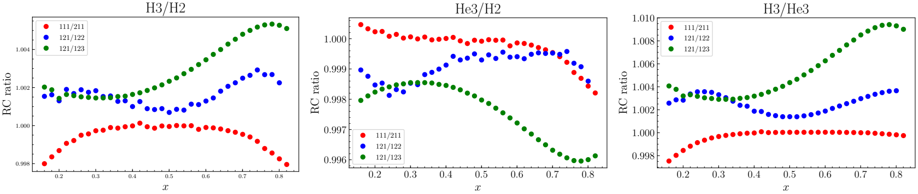
Radiative correction requires input model:

- F_2^d, F_2^p
  1. Bodek
  2. NMC 1995 (Phys. Lett. B364 107-115,1995)
- ^{3}H, ^{3}He EMC ratio
  1. Kulagin & Petti (no isoscalar corrections)
  2. SLAC EMC (isoscalar)
- SLAC EMC requires F_2^n/F_2^p to remove isoscalar correction
  1. $F_2^n/F_2^p = 1 - 0.8x$
  2. CJ15
  3. NMC 1992 (Nucl. Physics. B 371(1992) 3-31)[1]

Notation example:
122 = Bodek + SLAC EMC + CJ15

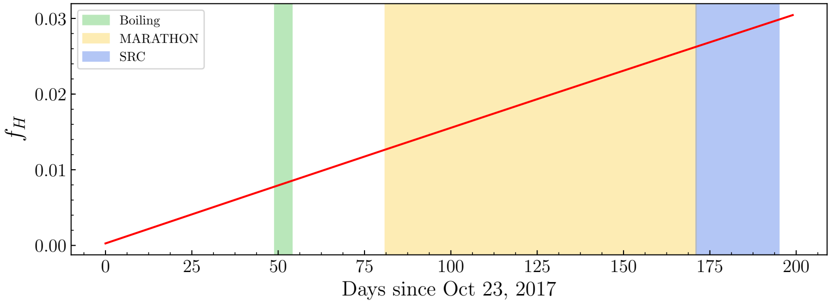
[1] Neglects nuclear effects in ^{2}H; not valid at high x

Model dependent uncertainty



- Model dependence of EMC ratios <0.5%
- Neglecting high-x NMC, model dependence of ^{3}H/^{3}He <0.5%

Target evolution



- Tritium β-decays with half life $\tau_{1/2} = 4500 \pm 8$ days
- Parameterize helium contamination by helium fraction:

$$f_H = \frac{n_H(t)}{n_{tot}} = \frac{n_H^0 + n_T^0(1 - e^{-t/\tau})}{n_{tot}}$$

- $f_H \approx 3\%$ by end of spring run

Correction and uncertainty

Can obtain pure tritium yield in terms of raw yield Y_{raw} and helium yield Y_H:

$$Y_T = Y_{raw}\left(\frac{1}{1-\langle f_H\rangle}\right) - Y_H\left(\frac{\langle f_H\rangle}{1-\langle f_H\rangle}\right)$$

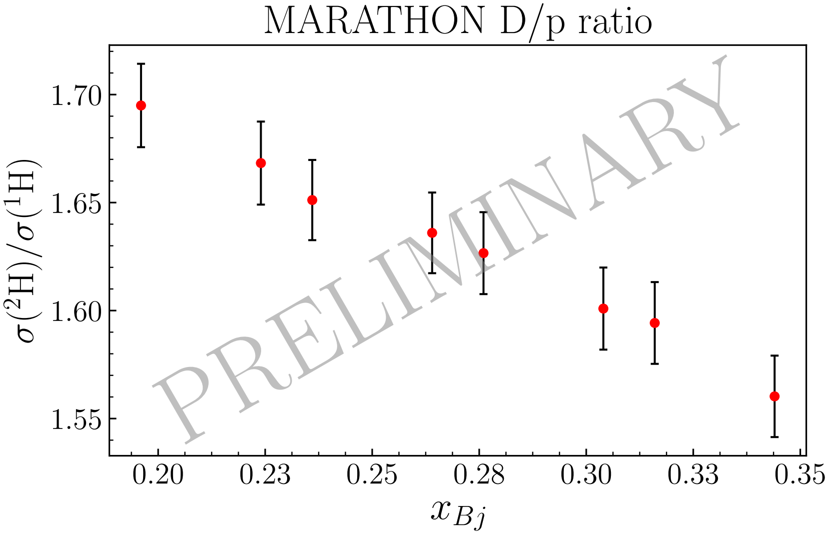
where $\langle f_H\rangle$ is charge-weighted helium fraction:

$$\langle f_H\rangle = \frac{\sum Q_i f_{H,i}}{\sum Q_i}$$

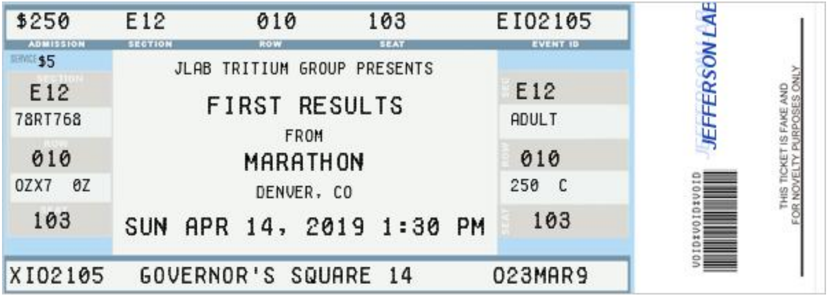
Effect on ratios:

- $\langle f_H\rangle \leq 2.5\%$
- Uncertainty $\leq 0.5\%$

D/p ratio


MARATHON D/p ratio
$\sigma(^2\mathrm{H})/\sigma(^1\mathrm{H})$
1.70
1.65
1.60
1.55
0.20
0.23
0.25
0.28
0.30
0.33
0.35
x_{Bj}
PRELIMINARY

A = 3 ratios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