Electron Scattering on A=3 Nuclei from MARATHON

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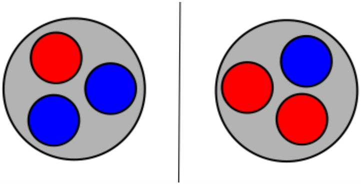
The MARATHON Experiment

MeAsurement of F_2^n/F_2^p, d/u RAtios and $A = 3$ EMC Effect in Deep Inelastic Electron Scattering off the Tritium and Helium MirrOr Nuclei.



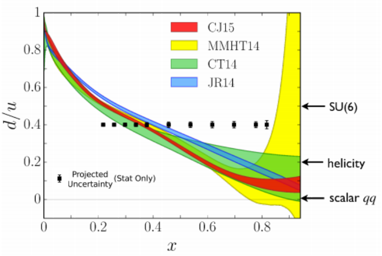
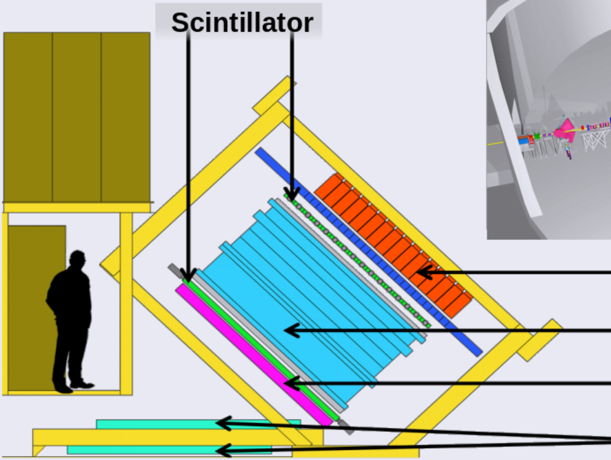
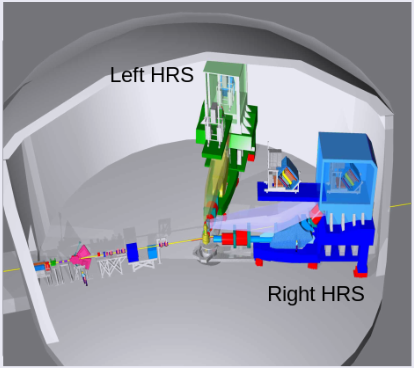


Figure: d/u quark distribution ratios

- Lightest and simplest mirror system
  - Number of protons in ^3H = neutrons in ^3He
- Differences in the nuclear effects are small
- Improve the current measurement and understanding of F_2^n/F_2^p ratio
- Restrict the assumptions and parameters made in the model calculations of the down to up quark distribution ratio
- 6 students from 4 universities

Jefferson Lab Hall A





Cross Section Analysis

Exacting Yield from Data

$$\frac{d\sigma}{d\Omega dE'} = \frac{Yield}{Luminosity} = \frac{Ne - BG}{Luminosity * \epsilon}$$

- Luminosity $\equiv$ # of electrons per scattering centers, needs correction due to density changes
- $\epsilon =$ efficiencies
- BG = Back Ground

Cross section by Monte carlo ratio

$$Yield_{data} = \frac{(N_e - BackGround)}{Efficency} = L * \sigma^{data} * (\Delta E' \Delta\Omega) * A(E'\theta)$$

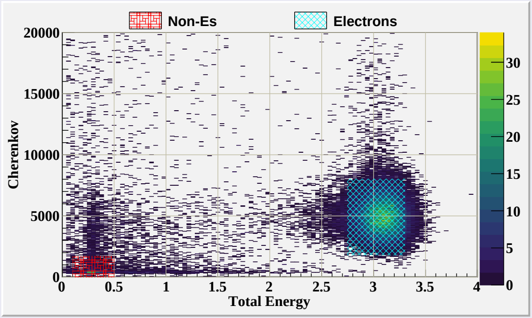
$$Yield_{MC} = L * \sigma^{mod} * (\Delta E' \Delta\Omega) * A(E'\theta) \quad \frac{d\sigma}{d\Omega dE'} = \sigma^{mod} * \left[\frac{Yield_{data}(E',\theta)}{Yield_{MC}(E',\theta)}\right]$$

Electron selection

Counting Electrons

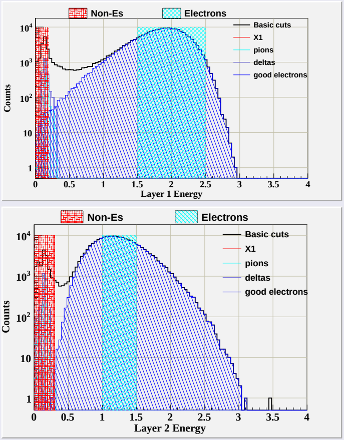
- Electron ID is done via the Cherenkov and two layers of a total calorimeter.
- Deposit large percentage of its energy into the total calorimeter system.
- Trigger significant amount of cherenkov radiation

Cherenkov vs. Total energy absorbed



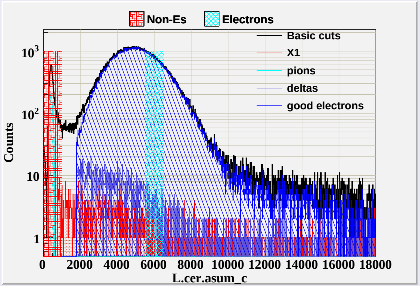
Efficiency of the selection

First and second layer of calorimeter with electron and non-electron sampling



Determine the Efficiency

- Electron sampling in two detectors
- Make threshold cut in the third
- Overall PID efficiency $> 98\%$



Total cerenkov ADC signal with electron and non-electron sampling

Back Ground

$$\frac{Ne - \mathbf{BG}}{Luminosity * \epsilon}$$

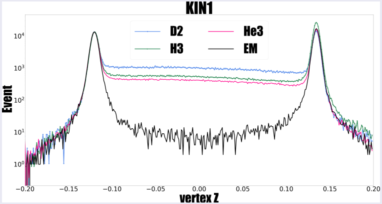
- Pion contamination
- Charge Symmetric Back ground
- End Cap contamination
- Beta Decay of Tritium

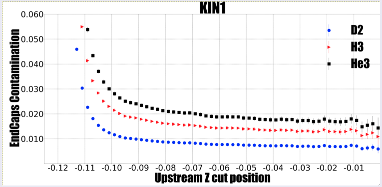
- Pion contamination is corrected for via the PID efficiency $< 1\%$
- Beta Decay of Tritium to Helium was discussed by Tyler Kutz - Stony Brook University

End cap Contamination

Contamination from Aluminum end caps

- Normalize end caps of Empty target to Gas filled target
- Normalized by measured thickness of end caps
- Scan Vertex Z location
- 3% at low x_{bj} for Helium-3 and Tritium
- Study by Tong Su and Tyler Hague
- images from Tong Su

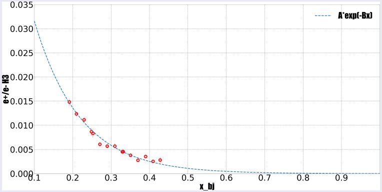




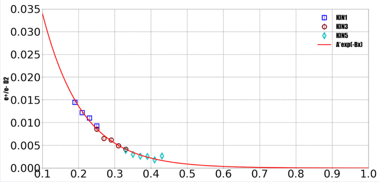
Charge Symmetric back ground

- High energy photons decay into an e^+e^- pairs
- Account for the pair produced e^- by detecting the pair produced e^+
- Used HRS positive polarity settings at kinematics 1,2 and 3
- Fit results with an exponential function to determine the contamination factor at high kinematics.
- Images from Tong Su

Tritium positron contamination



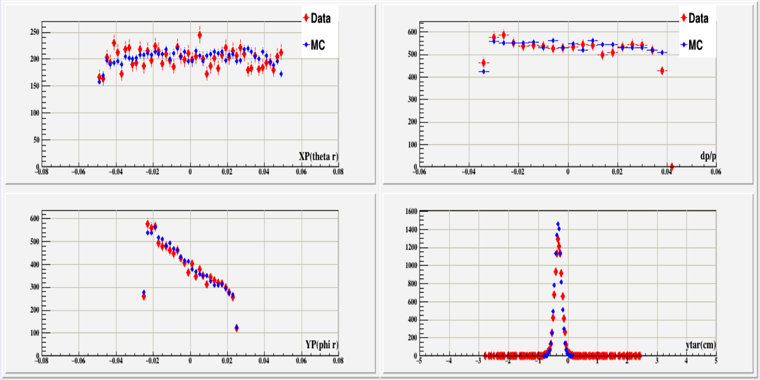
Deuterium positron contamination



Monte Carlo Comparison

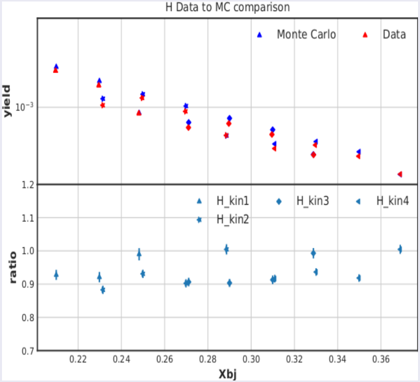
Compare Monte Carlo to Data

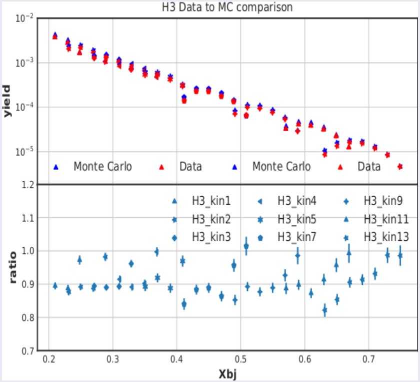
Detector acceptance variables.



Top Left :theta(out of plane angle in rads from center) Top Right: Dp(momentum % from center). Bottom Left :phi(in plane angle in rads from center) Top Right: Y target(vertex location in spectrometer coordinate frame).

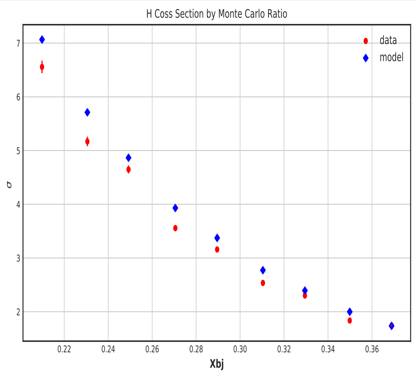
Data to Monte Carlo ratio

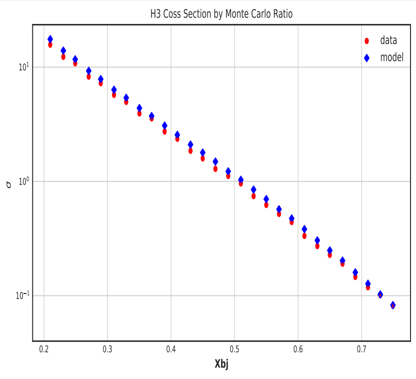




Cross section via monte carlo ratio

Cross Section





Conclusion

Task still in progress

- Complete Acceptance study and determine the systematics associated
- Study the systematic error from cross section model
- Finalize Absolute Cross section for Helium-3, Tritium, and Deuterium
- Study nuclear corrections and their systematics
- EMC effect for A=3 nuclei

Special Thanks

- JSA and University of Tennessee
- The MARATHON students
- The Tritium group
- Hall A Collaboration
- Nadia Fomin and Doug Higinbotham