# Electron Scattering on A=3 Nuclei from MARATHON

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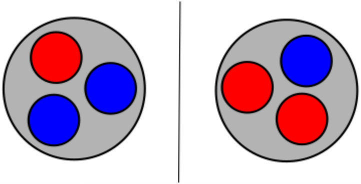
# The MARATHON Experiment

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.



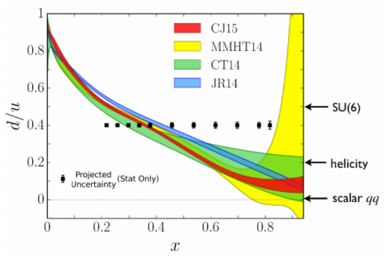
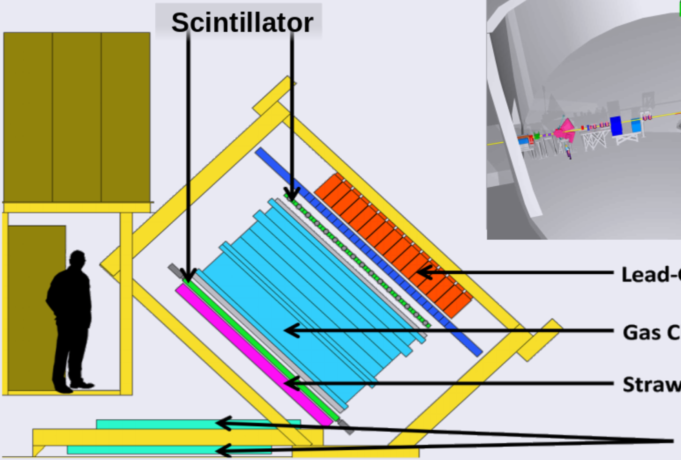
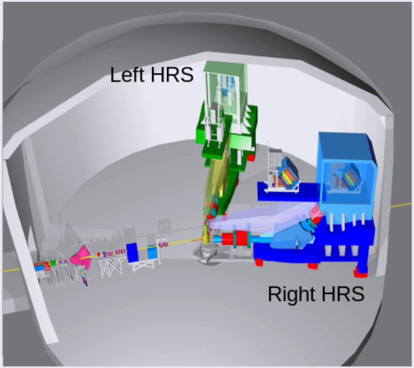



Figure: d/u quark distribution ratios

- 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

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

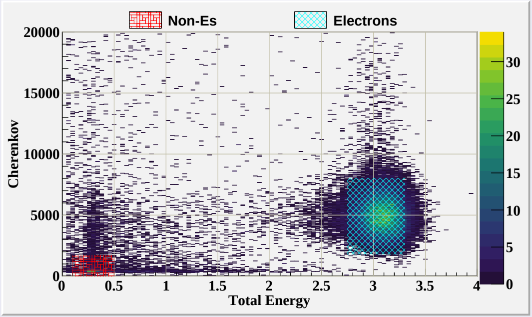
$$Yield_{MC} = L * \sigma^{mod} * (\Delta E' \Delta\Omega) * A(E'\theta) \quad \frac{d\sigma}{d\Omega dE'} = \sigma^{mod} * \left[\frac{Yield_{data}(E',\theta)}{Yield_{MC}(E',\theta)}\right]$$

# Electron selection

## Counting Electrons

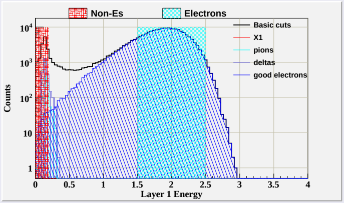
- Electron ID is done via the Cherenkov and two layers of a total calorimeter.
- Deposit large percentage of its energy into the total calorimeter system.
- Trigger significant amount of cherenkov radiation

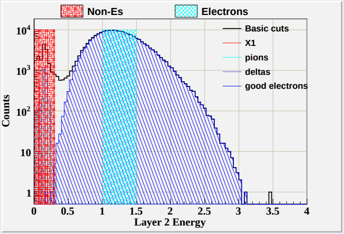
**Cherenkov vs. Total energy absorbed**



# Efficiency of the selection

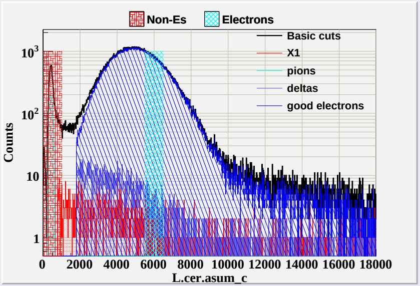
**First and second layer of calorimeter with electron and non-electron sampling**




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

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

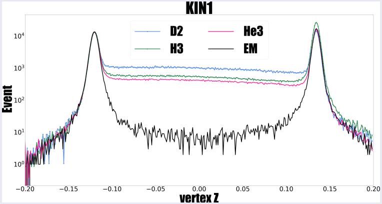
- Pion contamination
- Charge Symmetric Back ground
- End Cap contamination
- Beta Decay of Tritium

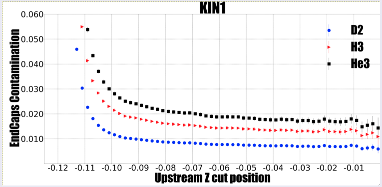
- Pion contamination is corrected for via the PID efficiency $< 1\%$
- Beta Decay of Tritium to Helium was discussed by Tyler Kutz - Stony Brook University

# 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

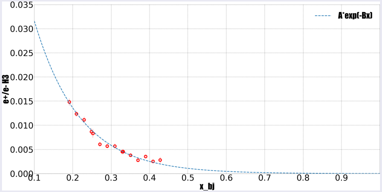


# Charge Symmetric back ground

- 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 $x_{Bj}$ kinematics.
- Images from Tong Su

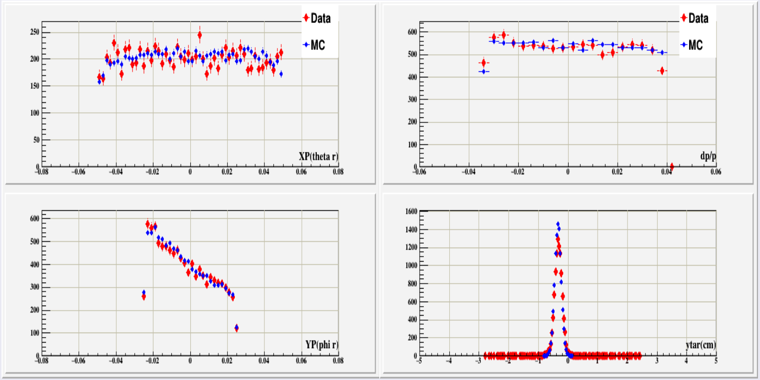
**Tritium positron contamination**



# Monte Carlo Comparison

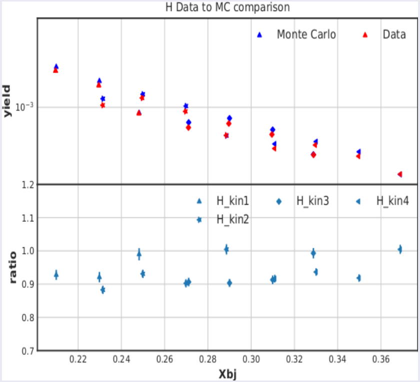
## Compare Monte Carlo to Data

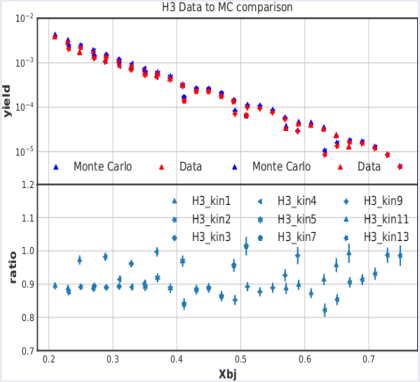
Spectrometer acceptance variables.




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

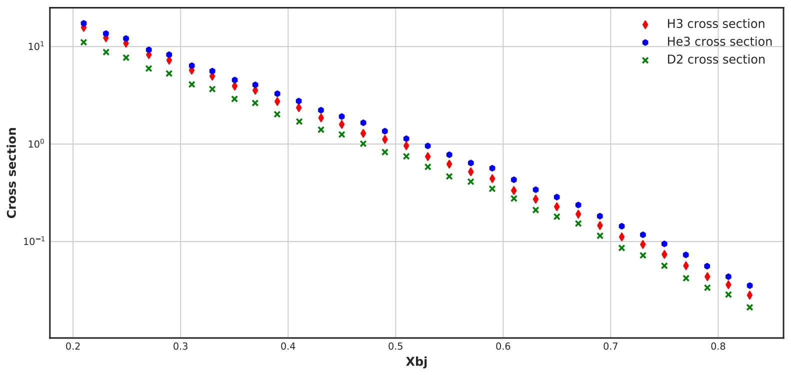
## Data to Monte Carlo ratio



# 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