EMC Effect for A=3

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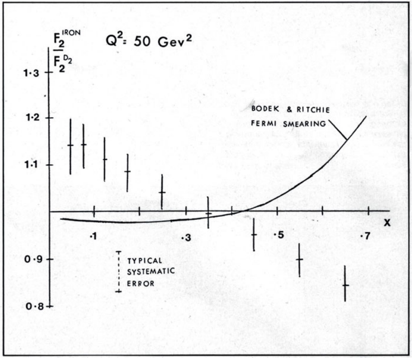
Outline

EMC Effect

European Muon Collaboration's (EMC) 1983 results for the lepton scattering experiment on Iron and Deuterium.

- Nucleon Structure Functions
- Sea-Quark Distributions e
- Gluon Distributions
- Expected $F_A = NF_2^N + ZF_2^P$
- Because the binding energies of the nucleons are several orders of magnitude smaller then the momentum transfer for an interaction in DIS region
- Fermi interaction causing differentiation at high momentum transfer.

Figure: EMC data of F_2^{Fe}/F_2^D from 1982 [Higinbotham D., 2013].



EMC Effect

European Muon Collaboration:

- Nuclear F2 structure function per nucleon different than that of deuterium
- Quark distribution functions modified in the nuclear medium
- Defined the magnitude of the EMC effect as the slope of the $\frac{A}{D}$ per nucleon cross section ratio from 0.3 to 0.7 in x.
- Current Explanations
  - Binding effects beyond nucleon Fermi motion
  - Enhancement of pion field with increasing A
  - Influence of possible multi-quark clusters
  - Change in the quark confinement scale in nuclei
- No unique/universally accepted theory for explanation of effect up to date.

EMC Effect

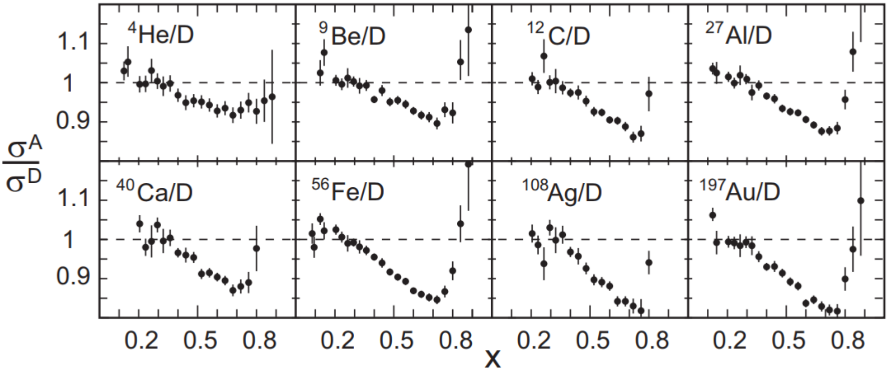


Figure: SLAC experiment E139 [J. Gomez et al., 1994].

EMC Effect

Figure: JLab experiment "EMC in light Nuclei" [J.Seely, A. Daniel et al].

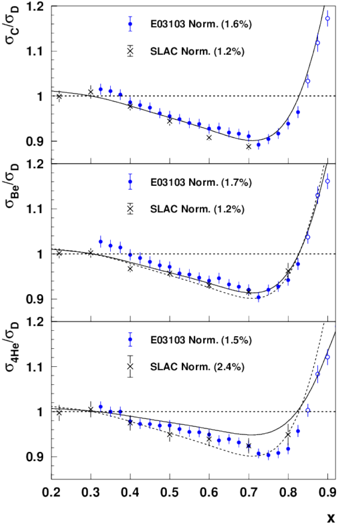
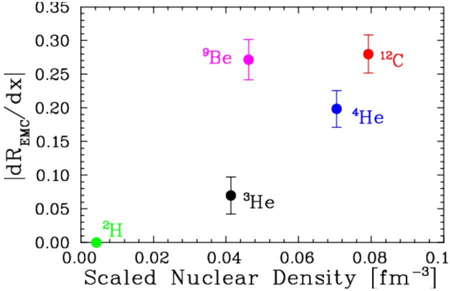
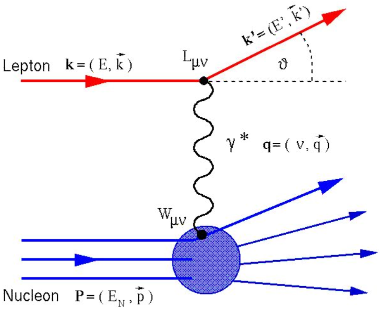


Figure: EMC as a function of Nuclear Density [J.Seely, A. Daniel et al].

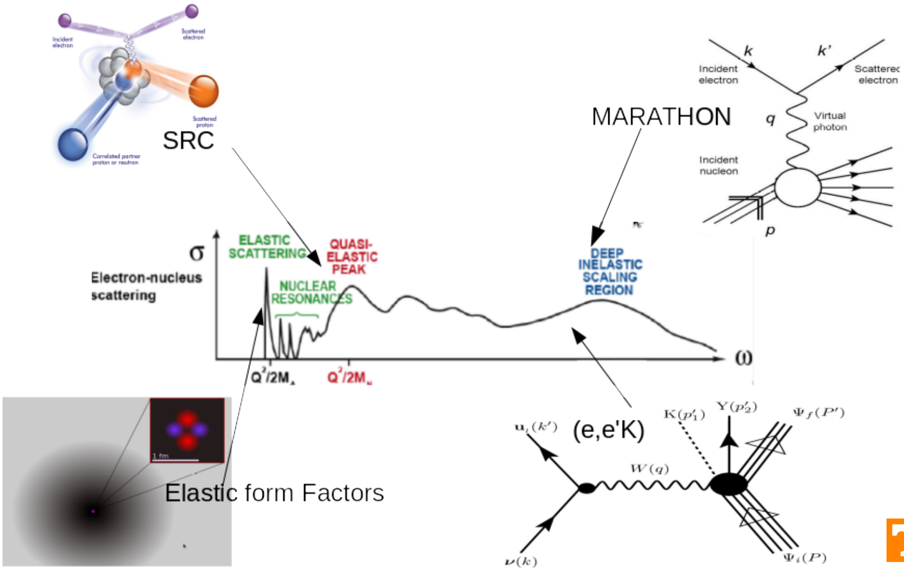


Deep Inelastic Scattering (DIS)



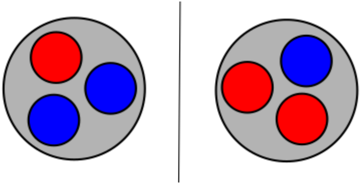
- Momentum Transfer
  $Q^2 \equiv 4EE' sin\frac{\theta}{2}$
- Bjorken X $(X_{bj}/x) = \frac{Q^2}{2\nu M}$
- $\sigma_{eN} = \frac{\alpha^2}{eE^2 sin^4(\frac{\theta}{2})}[\frac{F_2}{\nu} cos^2\frac{\theta}{2} + \frac{2F_2}{M} sin^2\frac{\theta}{2}]$
- Invariant Mass
  $W^2 = 2M\nu + M^2 - Q^2$
- $W^2 > 4 \rightarrow$ DIS

Tritium Experiments



MARATHON

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.



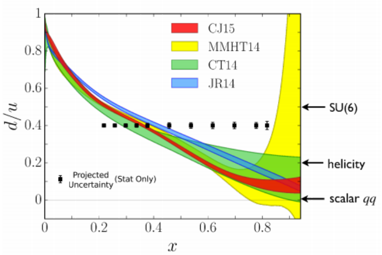


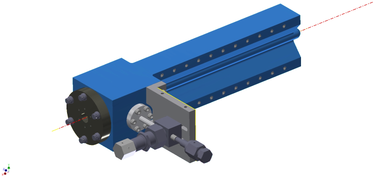
Figure: d/u quark distribution ratios

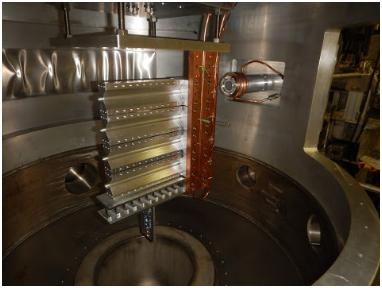
- Lightest and simplest mirror system
  - Number of protons in ^3H = neutrons in ^3He
- Differences in the nuclear effects are small
- Improve the current measurement and understanding of Fn2 to F p2 ratio
- Restrict the assumptions and parameters made in the model calculations of the down to up quark distribution ratio

Tritium Target Cell

First tritium target at JLab

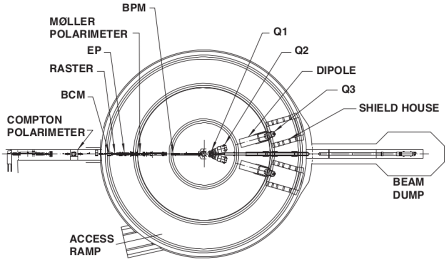
- Thin Al entrance and exit windows 0.01 inches
- 1090Ci of Tritium (0.1 g)
- 25 cm long
- Tritium Cell was filled in Savannah River
- 40 kelvin Helium is used to cool an attached heat sink

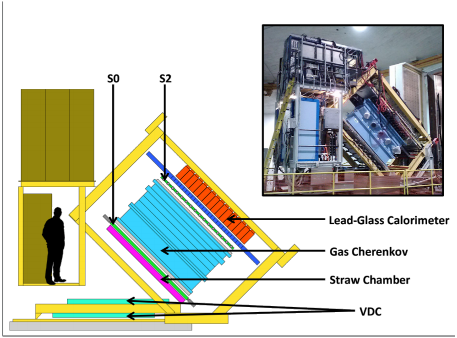




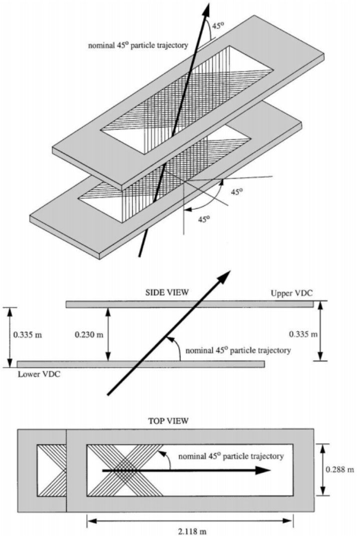
Hall A & The HRSs

Use CEBAF(Continues Electron Beam Facility) to provide 10.6 GeV beam for electron scattering.





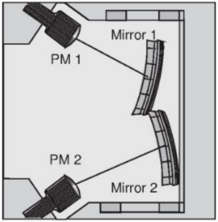
Vertical Drift Chamber(VDC)

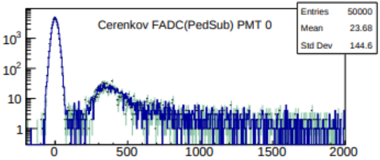


A dual VDC system is used to provide precise angular reconstruction of particle trajectories.

- U/V angle $\pm 45^{\circ}$
- 368 wired per plane
- 4.2mm spacing between wires
- Online Efficiency determined by nearest neighbor method [J. Alcorn et al.]

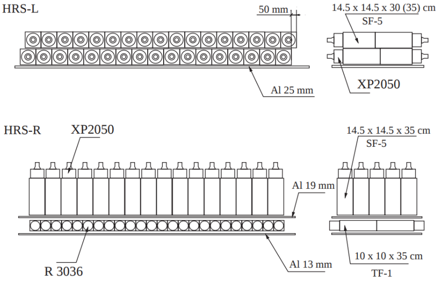
Gas Cherenkov

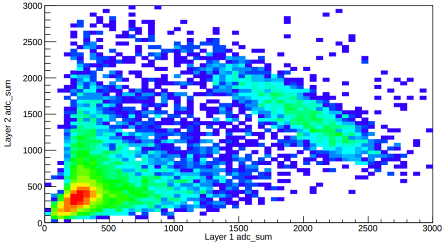




- Filled with CO_2
- Index of refraction of 1.00041 and operated at 1 atm
- Electron threshold of 0.017 $\frac{GeV}{c}$
- Pion/proton threshold of 4.8/32 $\frac{GeV}{c}$
- 1.5/1 m radiator length of left/right arm [J. Alcorn et al.]

Calorimeter

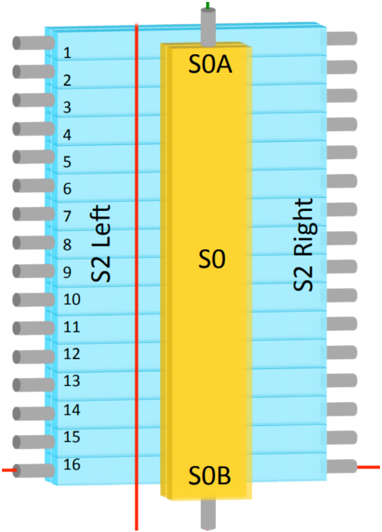




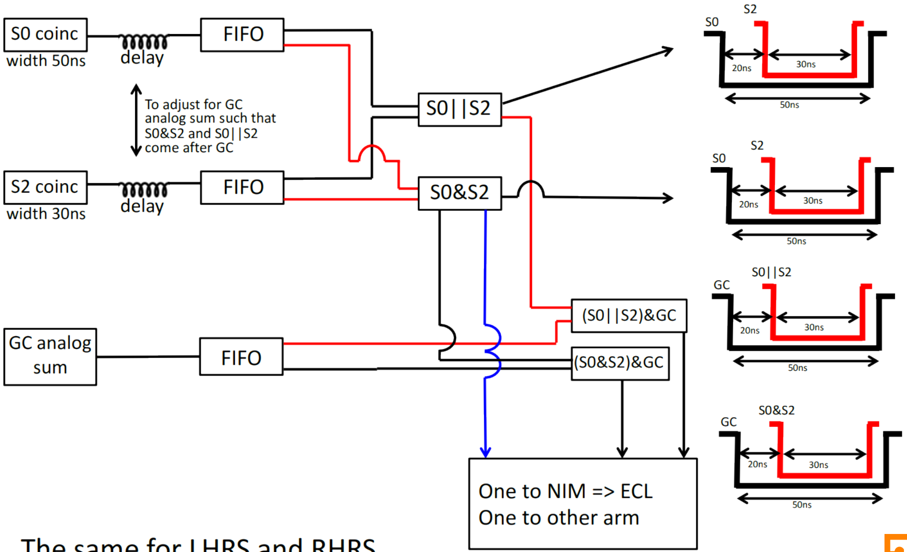
- Two layers of lead glass
- LHRS -Both layers are stacked perpendicular to beam direction.
  - 48 Blocks, 80 blocks
- RHRS -First layer perpendicular, second layer is parallel
  - 34 Blocks, 34 blocks
- With Chernenkov, pion suppression above $2\frac{GeV}{c}$ of a factor of $2E5$ [J. Alcorn et al.]

Scintillators

- Two Scintillating light detectors
  - S0 large acceptance and low resolution
  - S2 16 bars capped by PMTs
- Main source for trigger
- Provide TOF(time of flight) & Used to help identify hadrons [J. Alcorn et al.]



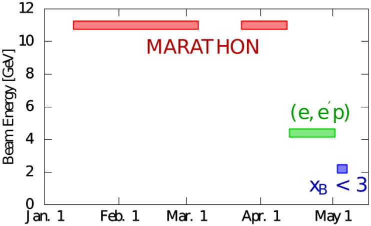
Single Arm Triggers (S0&S2); (S0&S2)&GC; (S0||S2)&GC



The same for LHRS and RHRS

Figure: By Florian Hauenstein

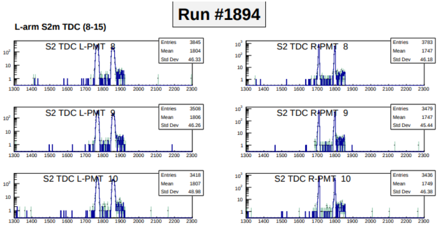
The Run Period



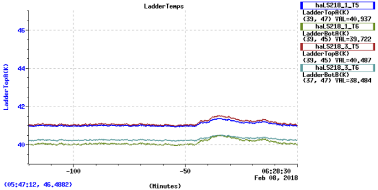
Rey Torres

- Ran from January 11th to April 12th
- Original Plan was to use mirror Kinematics on both arms marching them out in angle
- Right arm dipole failed, on the first day,
- Experts could not resolve the issue in a timely manner
- Changed to only use the left arm, and skip a few kinematics settings where the spectrometer acceptance overlaps.

The Run Period



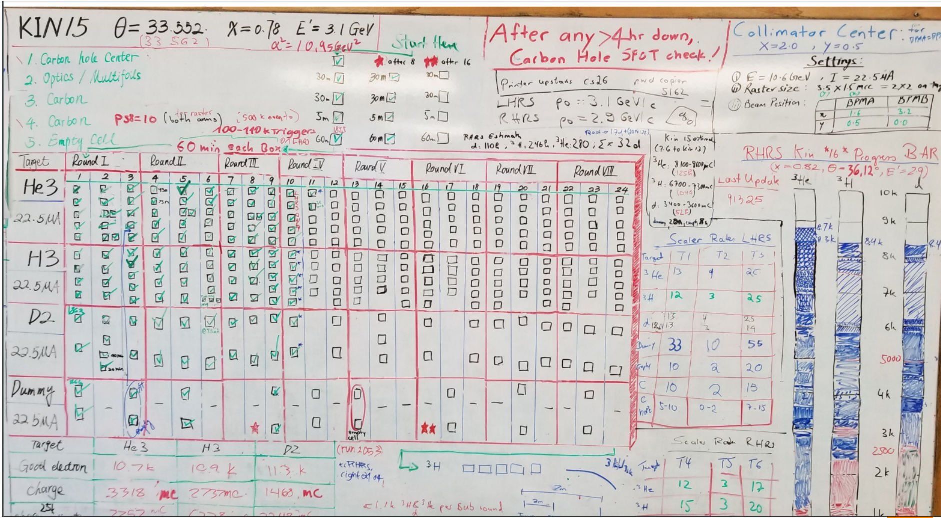
T1	1.27e+01	T2	2.99e+00	T3	2.49e+01
(S0||S2)R	3.01e+03	L1A_Remote	2.30e+01	Clock_RHRS	1.02e+03
Sh-Sum	3.37e+01	(S0||S2)L	2.48e+03	S2L	2.80e+03
(S0||S2)R	3.01e+03	ADC_gate	3.47e+01	L1A	1.76e+03



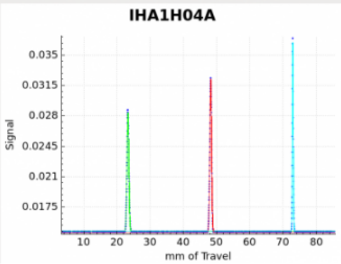
Shift Crew Task

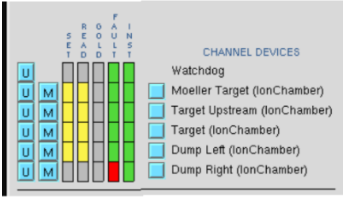
- Monitor Detector plots
- Record and observe event frequency
- Observe target response including the temperature sensor attached to the target ladder.

The Run Period



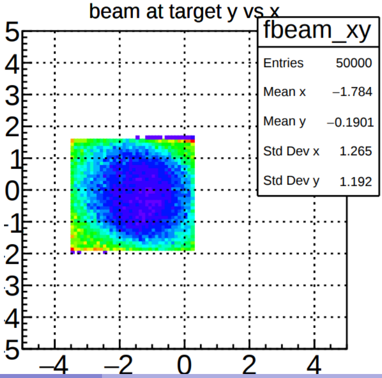
The Run Period





Tritium Safety Requirements

- Harp and BPM Check!
- Ion Chamber functionality test
- Beam Center
- Raster Size calibration.



The Run Period: Miscues

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The End