What’s Inside the Neutron?

Jerry Gilfoyle, University of Richmond

“The Periodic Table”
What Do We Know?

From the Edge of the Universe to $10^{26}$ m

the Earth to ...

hominids to ...

the Atom to...

the nucleus to...

Protons and ...

... are made of quarks.

$10^{-15}$ m

$10^{-10}$ m

$10^7$ m

$10^{-15}$ m
The Periodic Chart

NIST Physics Laboratory Holdings by Element

[Image of the periodic table]

Instructions | Database Information
What Do We Know?

- The Universe is made of quarks and leptons and the force carriers.
- The atomic nucleus is made of protons and neutrons bound by the strong force.
- The quarks are confined inside the protons and neutrons.
- Protons and neutrons are NOT confined.
What is the Force?

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How Well Do We Know It?

• We have a working theory of strong interactions: quantum chromodynamics or QCD (B. Abbott, et al., Phys. Rev. Lett., 86, 1707 (2001)).

• The coherent hadronic model (the standard model of nuclear physics) works too (L.C. Alexa, et al., Phys. Rev. Lett., 82, 1374 (1999)).
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What Don’t We Know?


2. NEED TO FIGURE OUT QCD AT THE ENERGIES OF NUCLEI!!!
What We Knew and Now Know About the Neutron.

- Comparison with previous results. Note that $b$ and $r$ are conceptually different.

![Graph showing charge distribution and charge density of the neutron.](image-url)
Results - Comparison with Existing Data and Theory

\[ \frac{G_M}{G_D} \]

\[ Q^2 \text{(GeV/c)}^2 \]

- Lung
- Xu
- Anklin
- Arnold
- Kubon
- Bartel
- Anderson
Results - Comparison with Existing Data and Theory

![Graph showing comparison of CLAS Preliminary, Lung, Anklin, Xu, Arnold, Kubon, and Anderson data with Systematic Uncertainty.](image)
Results - Comparison with Existing Data and Theory

Figure showing a comparison of different datasets and models, including CLAS Preliminary, Lung, Anklin, Xu, Arnold, and Kubon. The figure also includes data points from Bartel, Miller, Guidal, and Lomon, with various line styles for different models.
More To Come

Experiments at Jefferson Lab
The CEBAF Large Acceptance Spectrometer (CLAS)
More on The CEBAF Large Acceptance Spectrometer (CLAS)

- Drift chambers map the trajectory of the collision. A toroidal magnetic field bends the trajectory to measure momentum.
- Other layers measure energy, time-of-flight, and particle identification.
- Each collision is reconstructed and the intensity pattern reveals the forces and structure of the colliding particles.