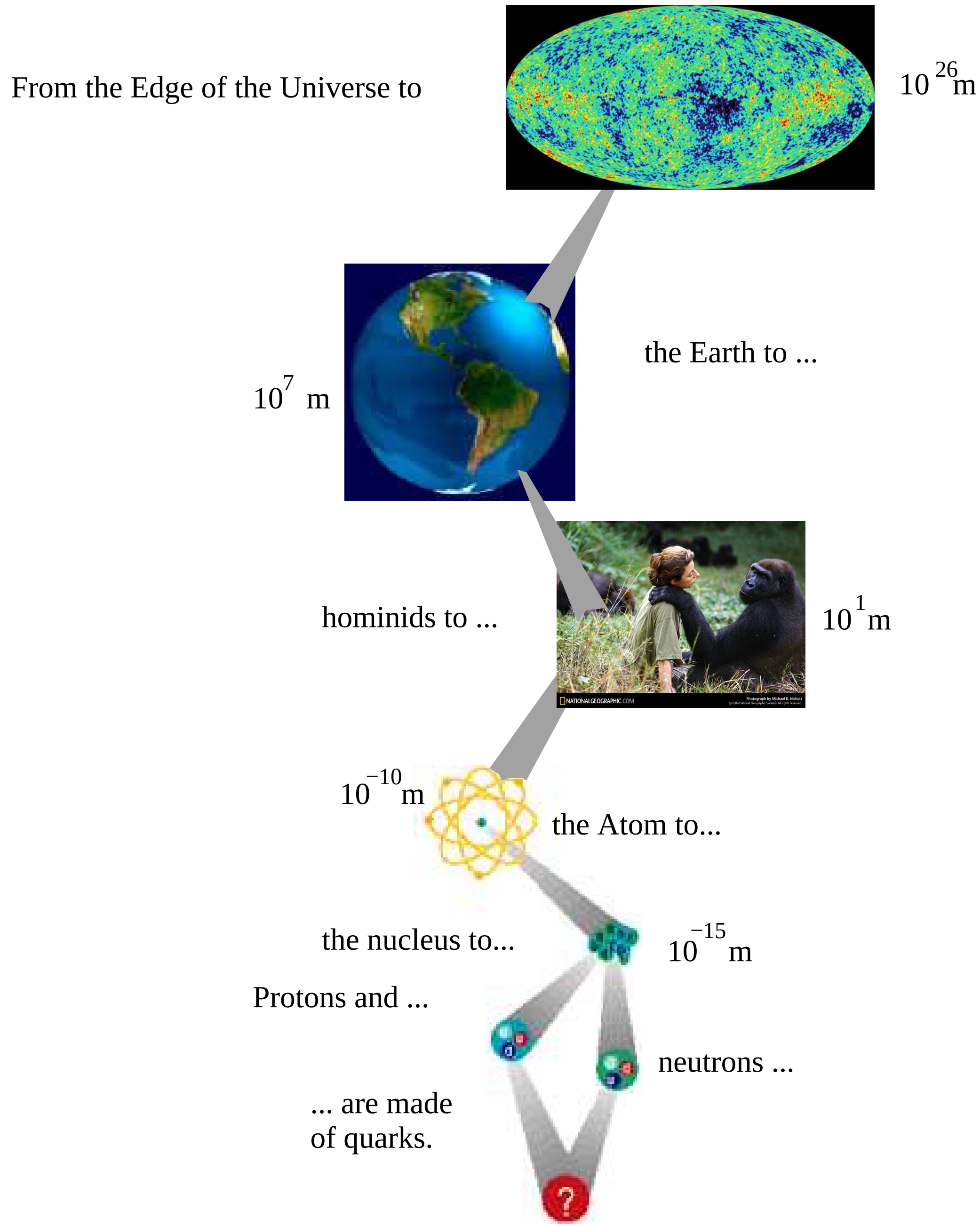
What's Inside the Neutron?

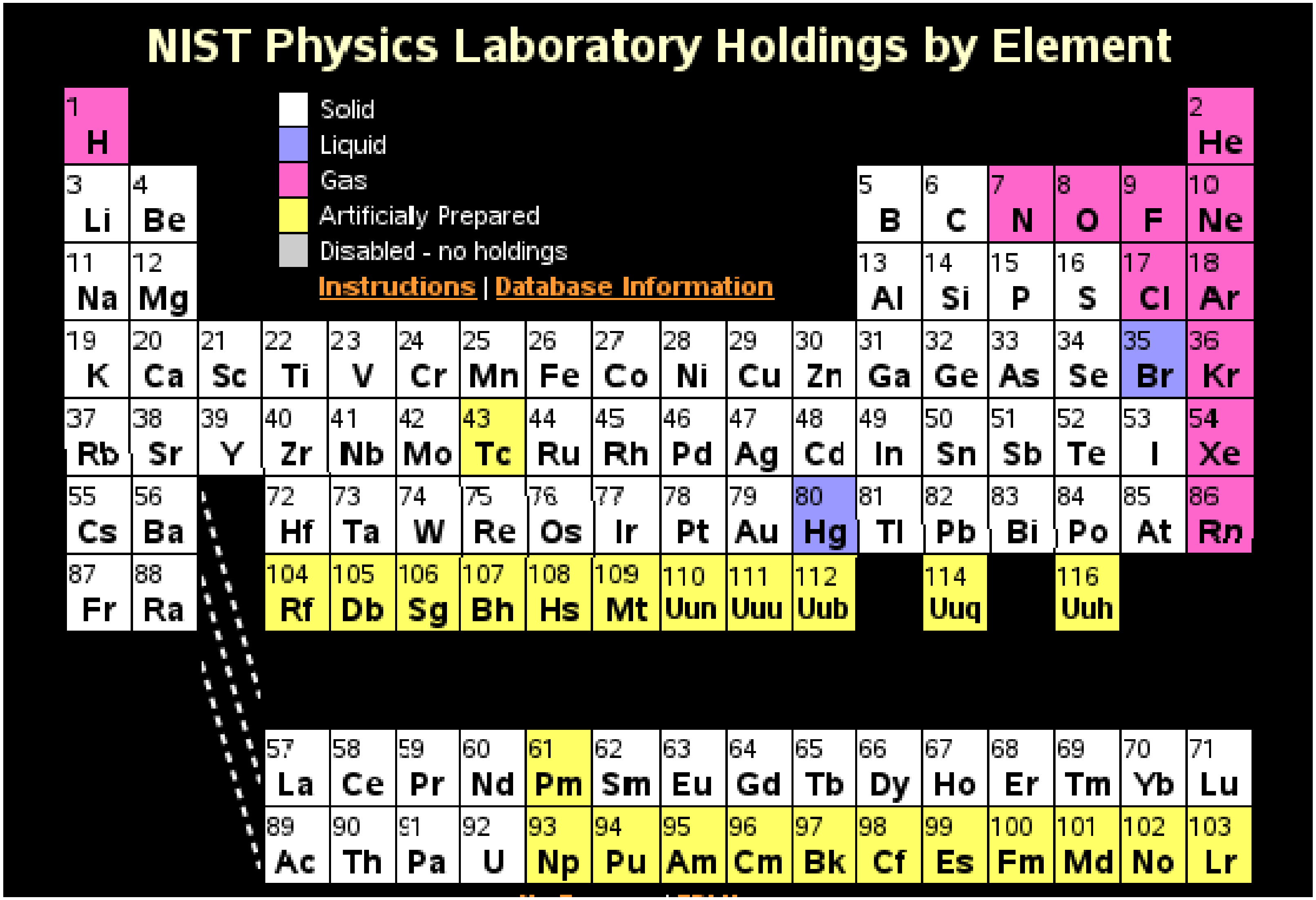
Jerry Gilfoyle, University of Richmond

"The Periodic Table"

What Do We Know?



The Periodic Chart



What Do We Know?

- The Universe is made of quarks and leptons and the force carriers.

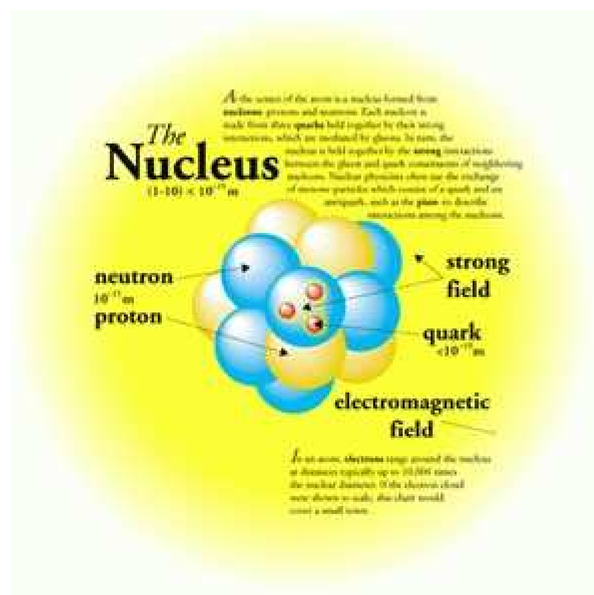
BOSONS force carriers spin = 0, 1, 2, ...

Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c^2	Electric charge	Name	Mass GeV/c^2	Electric charge
γ photon	0	0	g gluon	0	0
W^-	80.4	−1			
W^+	80.4	+1			
Z^0	91.187	0			

FERMIONS matter constituents spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c^2	Electric charge	Flavor	Approx. Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0	u up	0.003	2/3
e electron	0.000511	−1	d down	0.006	−1/3
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3
μ muon	0.106	−1	s strange	0.1	−1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	−1	b bottom	4.3	−1/3

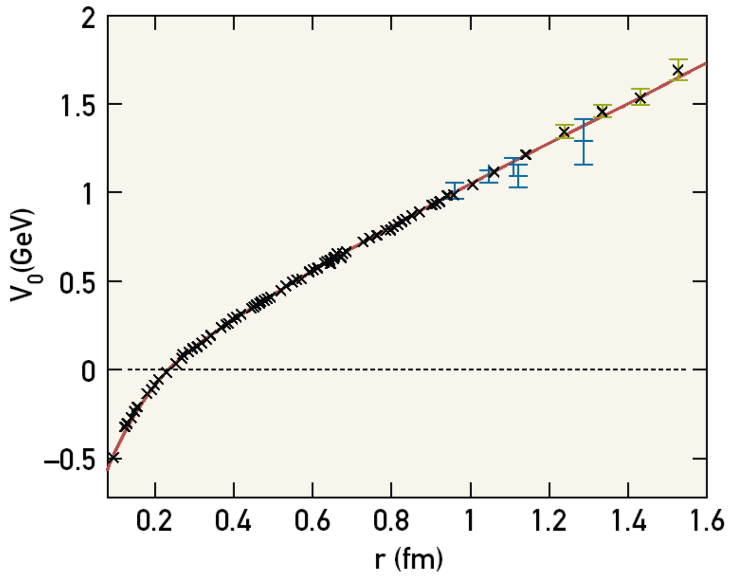
- The atomic nucleus is made of protons and neutrons bound by the strong force.



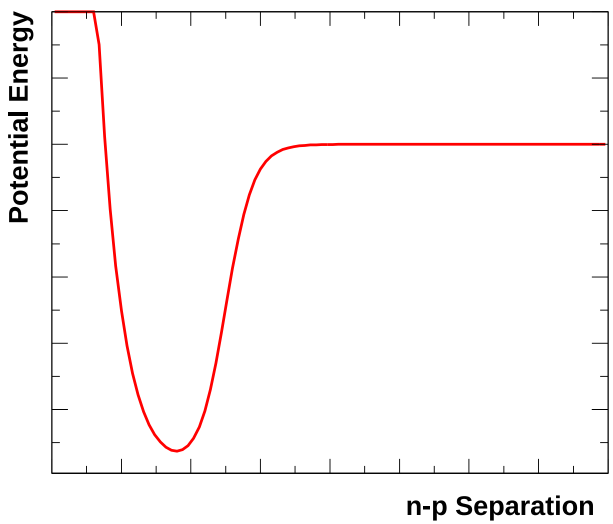
- The quarks are confined inside the protons and neutrons.
- Protons and neutrons are NOT confined.

What is the Force?

- Quantum chromodynamics (QCD) looks like the right way to get the force at high energy.



- The hadronic model uses a phenomenological force fitted to data at low energy. This 'strong' force is the residual force between quarks.



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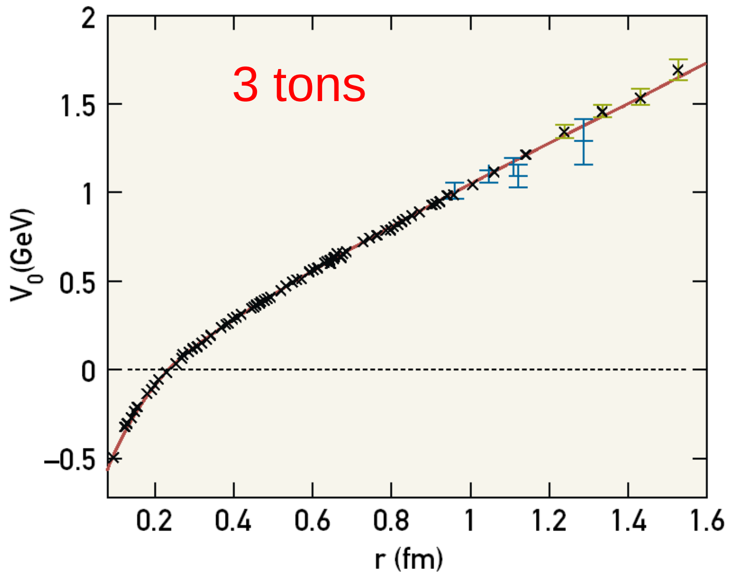

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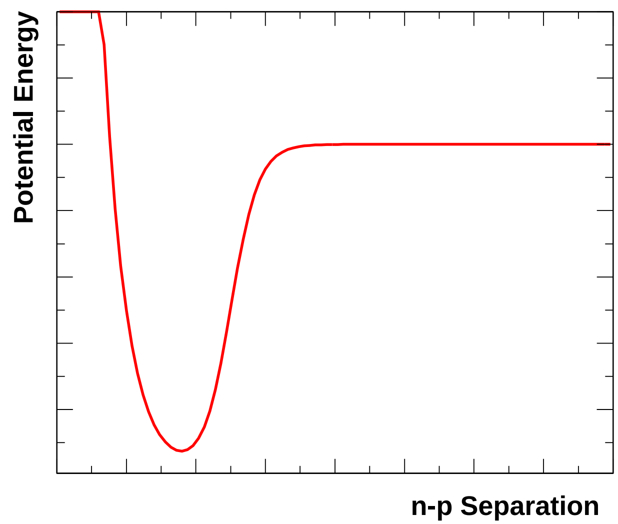
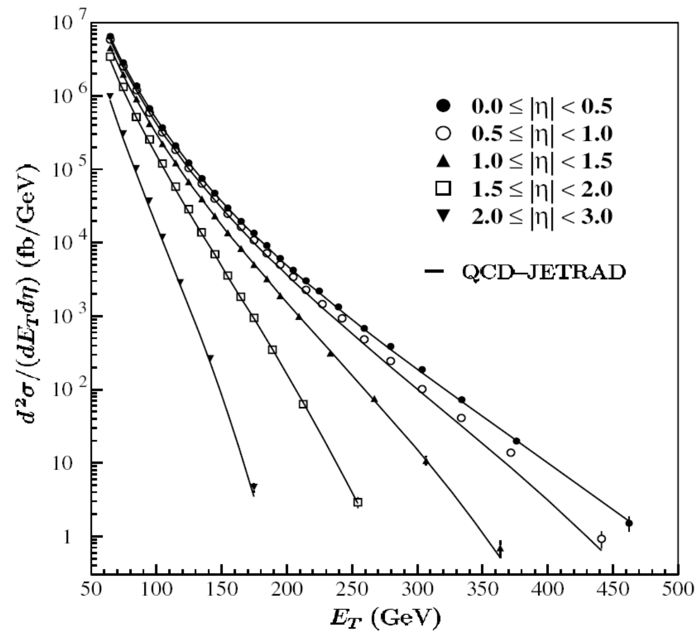
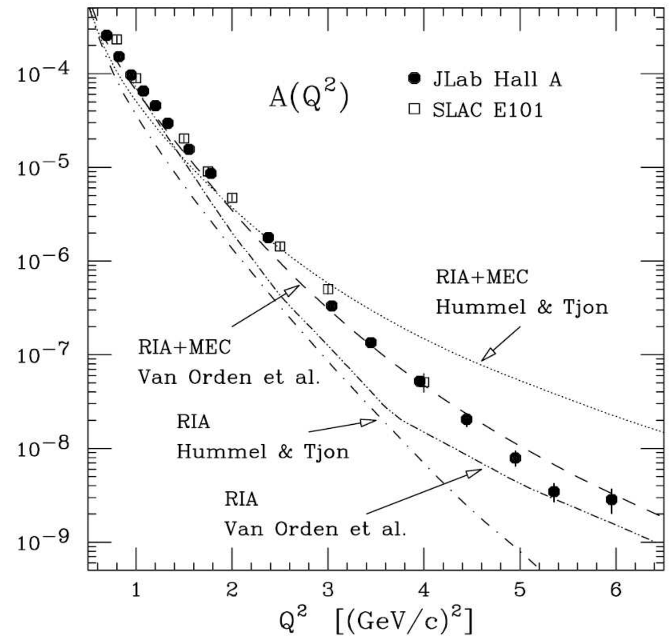


How Well Do We Know It?

- 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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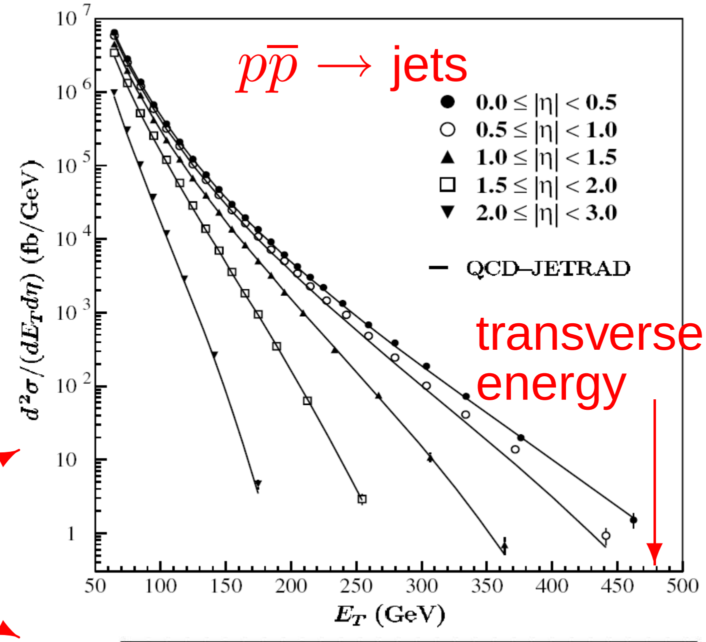

effective target area

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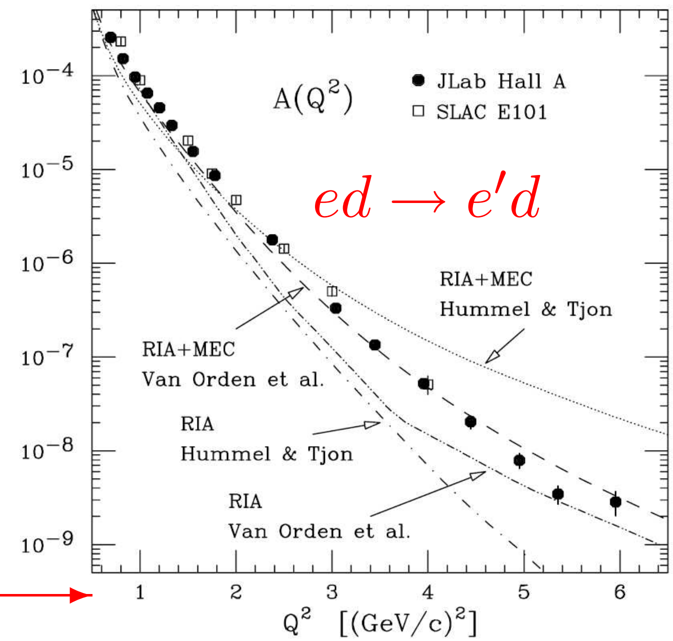
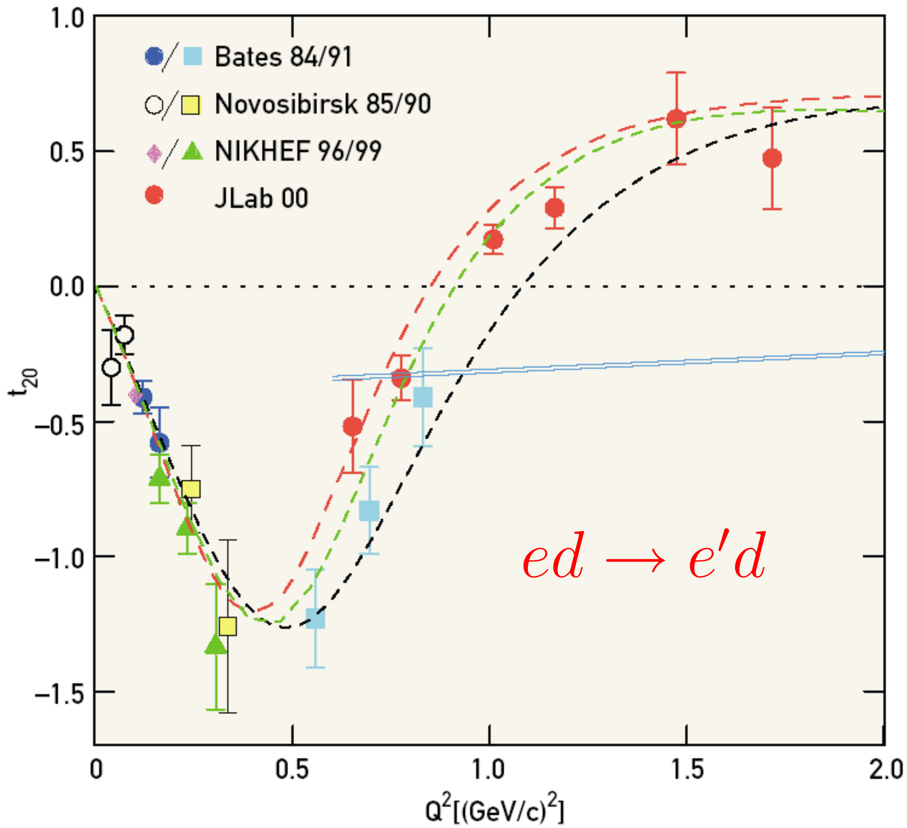


4-momentum transfer squared

What Don't We Know?

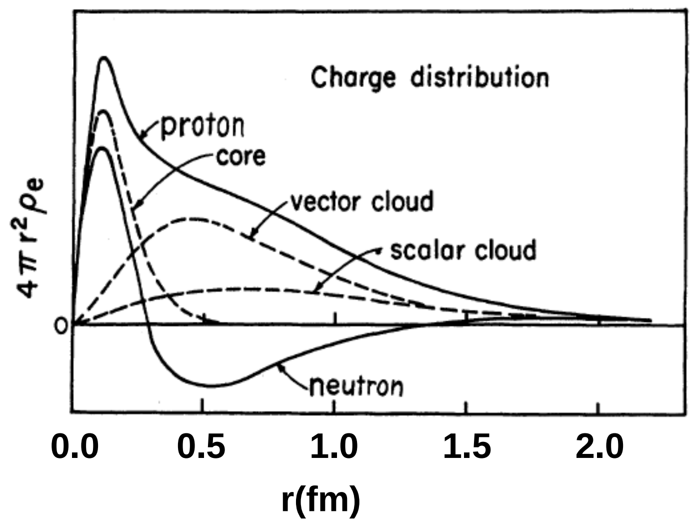
1. We can't get QCD and the hadronic model to line up. D. Abbott, *et al.*, Phys. Rev Lett. **84**, 5053 (2000).

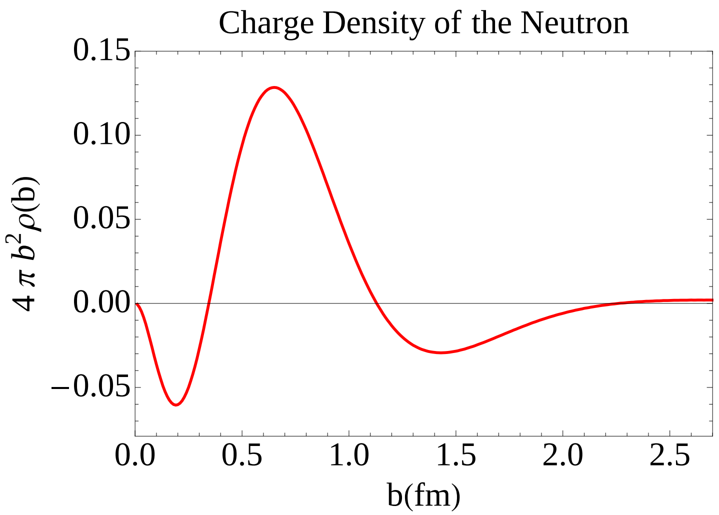
2. NEED TO FIGURE OUT QCD AT THE ENERGIES OF NUCLEI!!



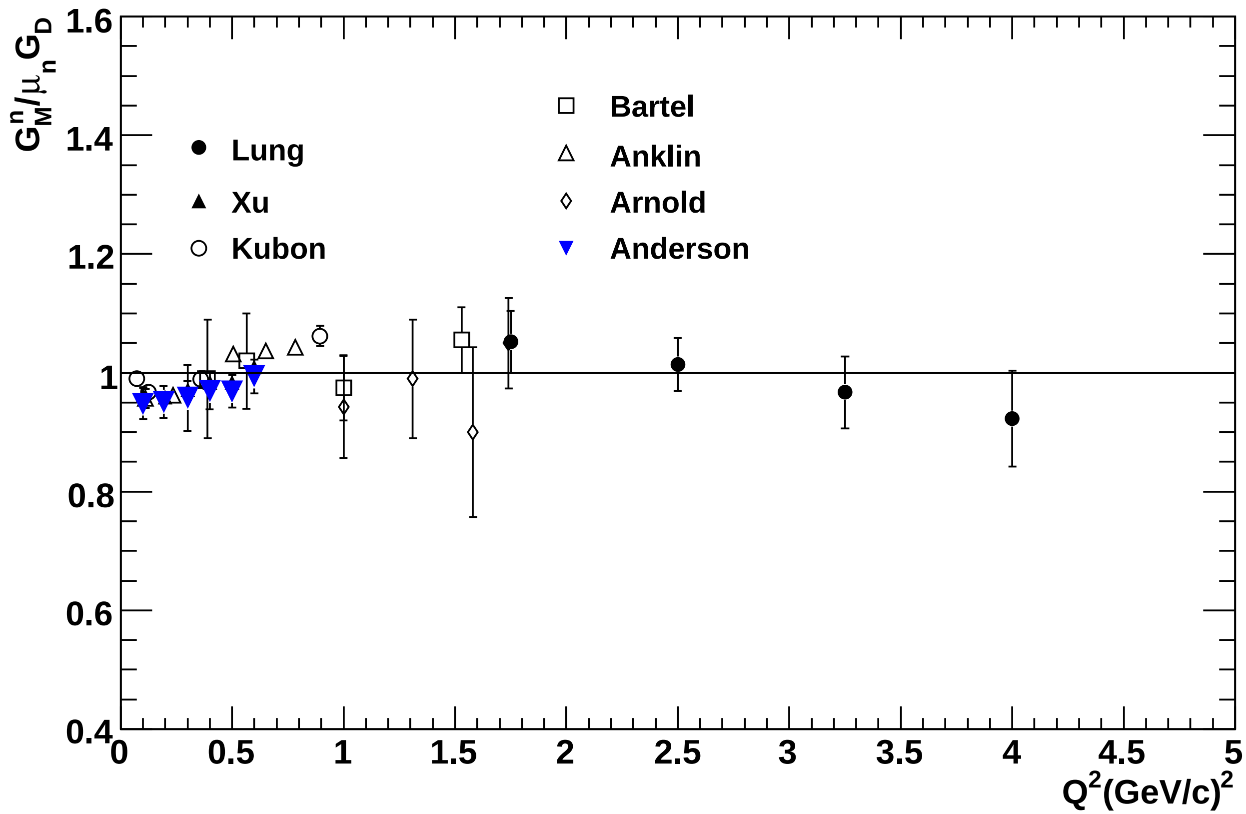
What We Knew and Now Know About the Neutron.

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





Results - Comparison with Existing Data and Theory



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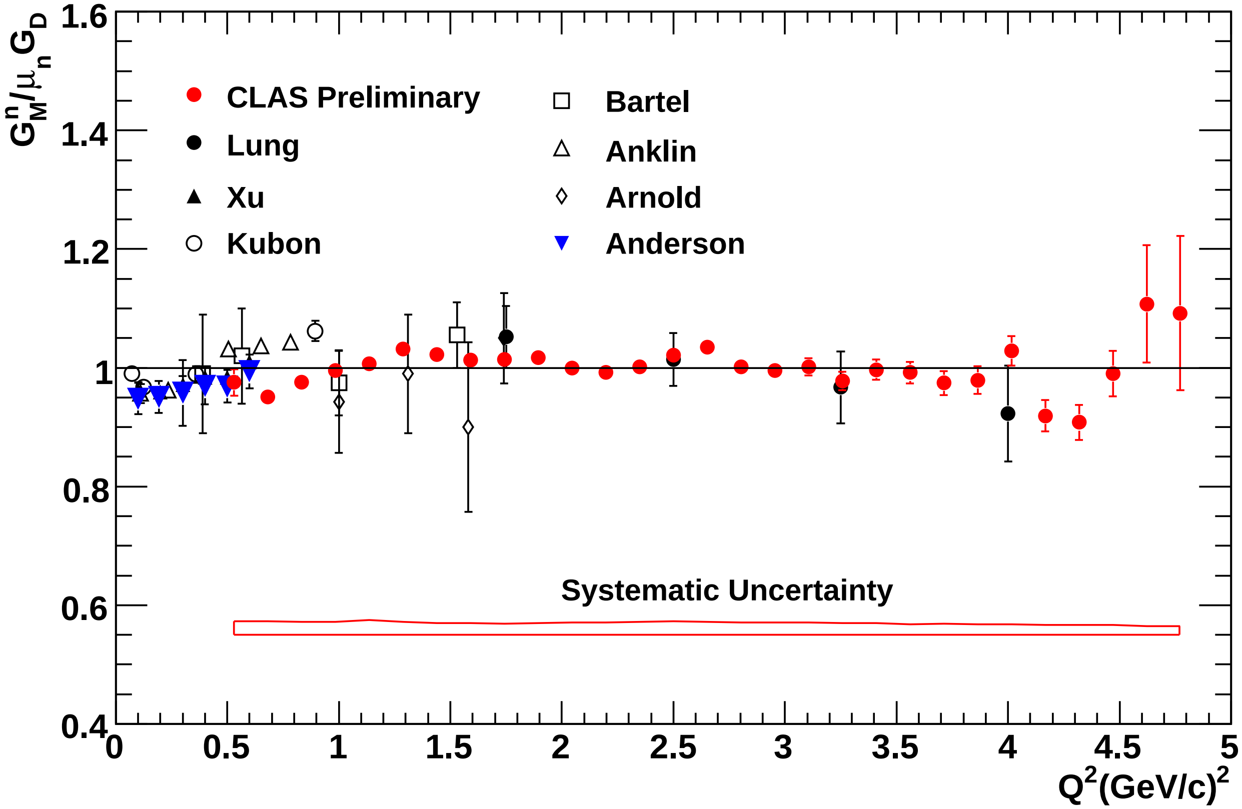

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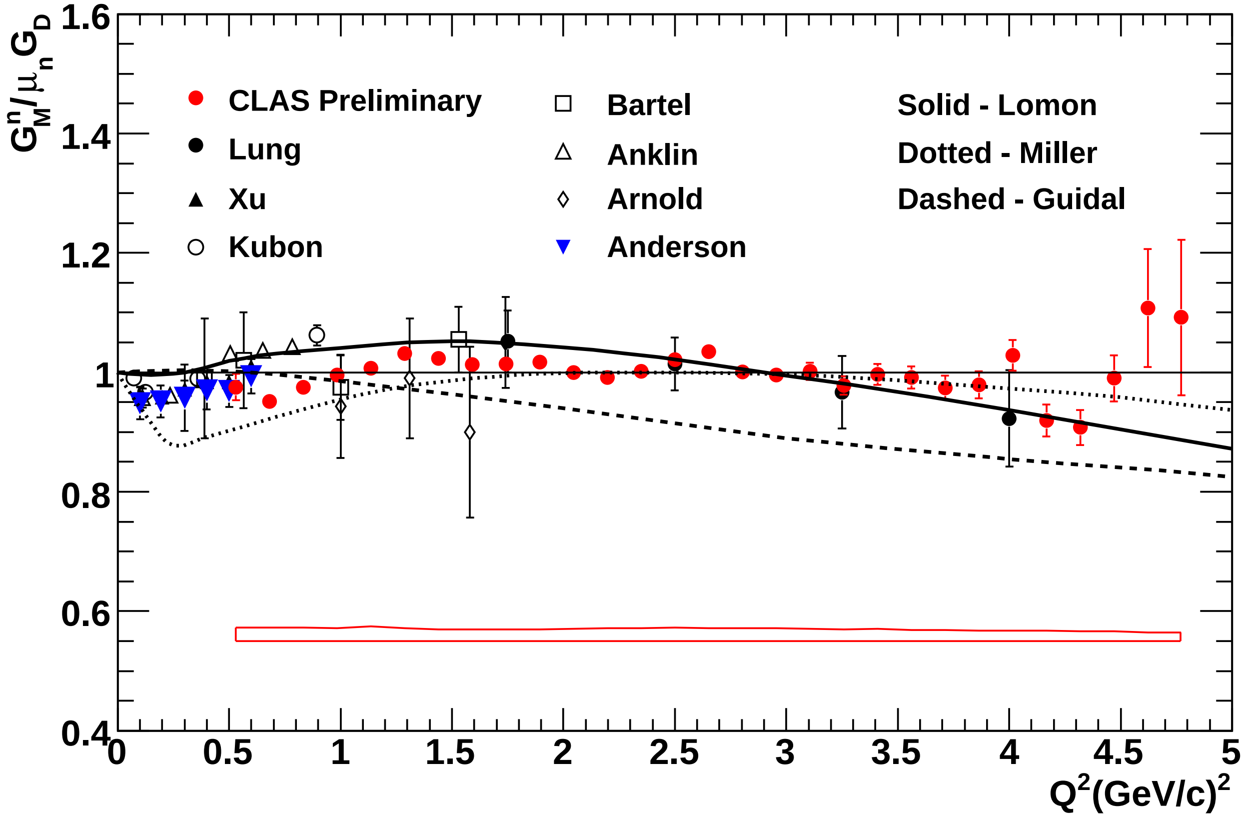
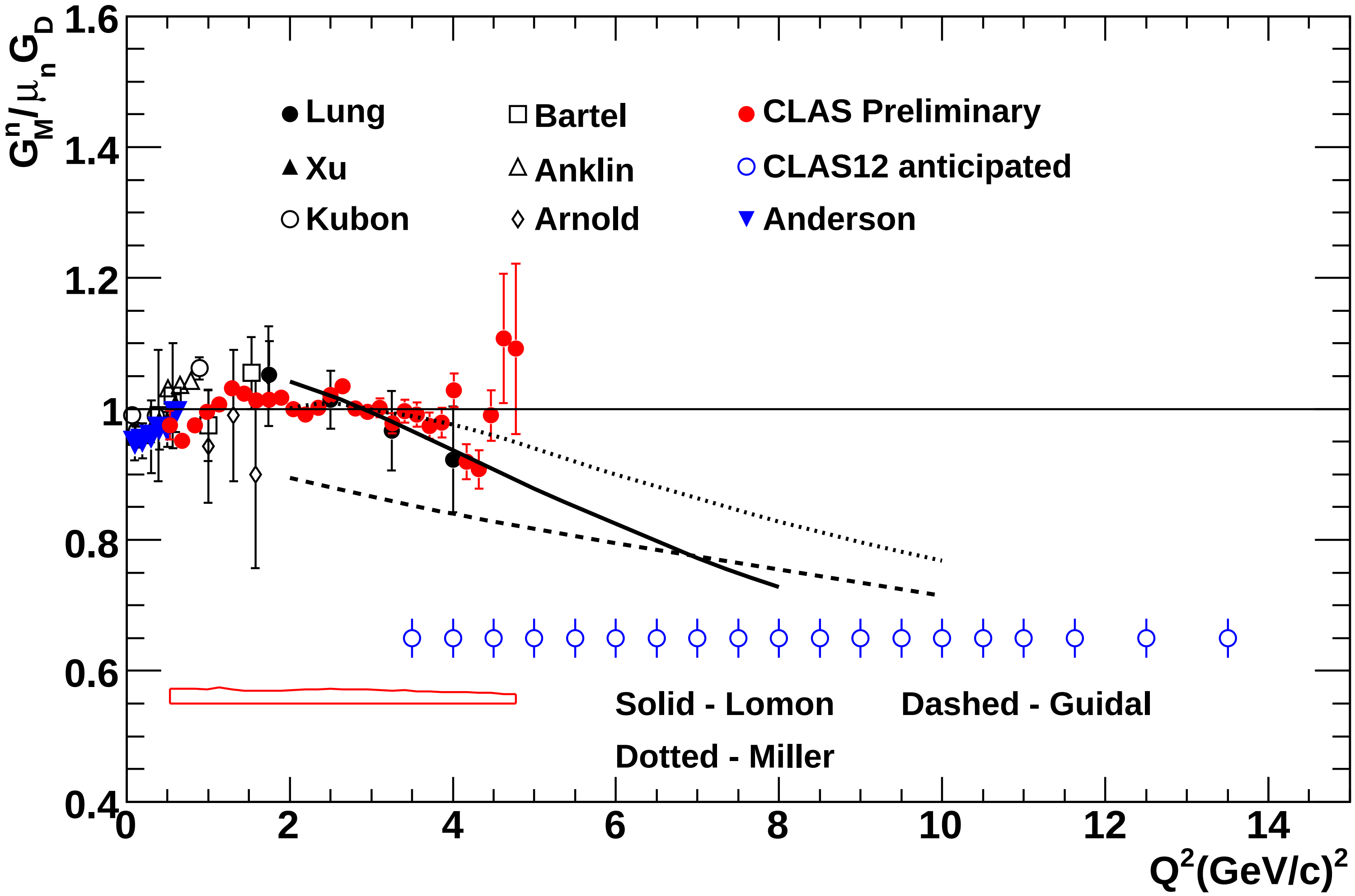
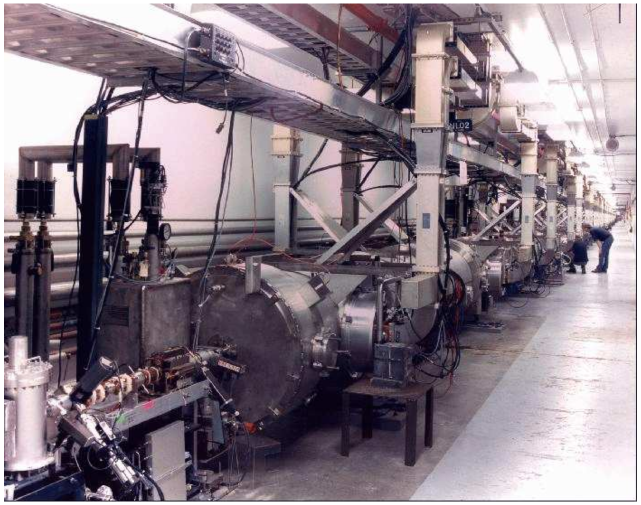


More To Come

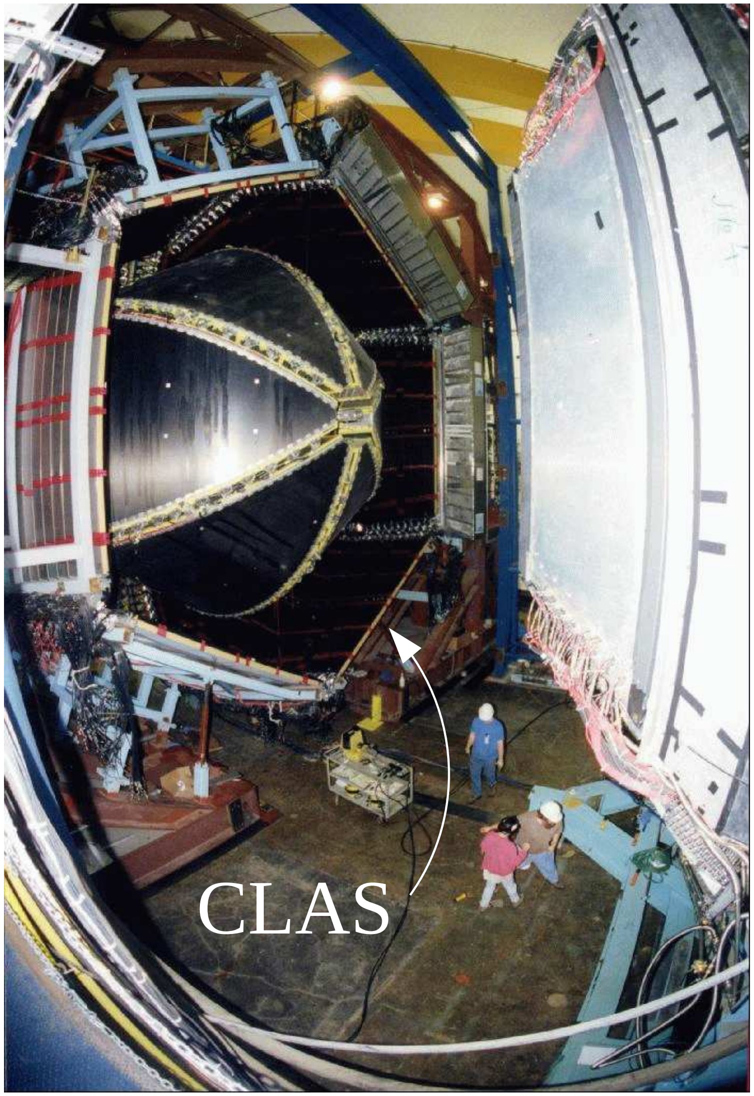


Lomon, Phys.Rev.C **66** 045501 (2002); G. MIller, Phys. Rev. C **66**, 032201(R) (2002); M.Guidal, M.K. Polyakov, A.Radyushkin, and M. Vanderhaeghen, Phys. Rev. D **72**, 054013 (2005).

Experiments at Jefferson Lab



The CEBAF Large Acceptance Spectrometer (CLAS)

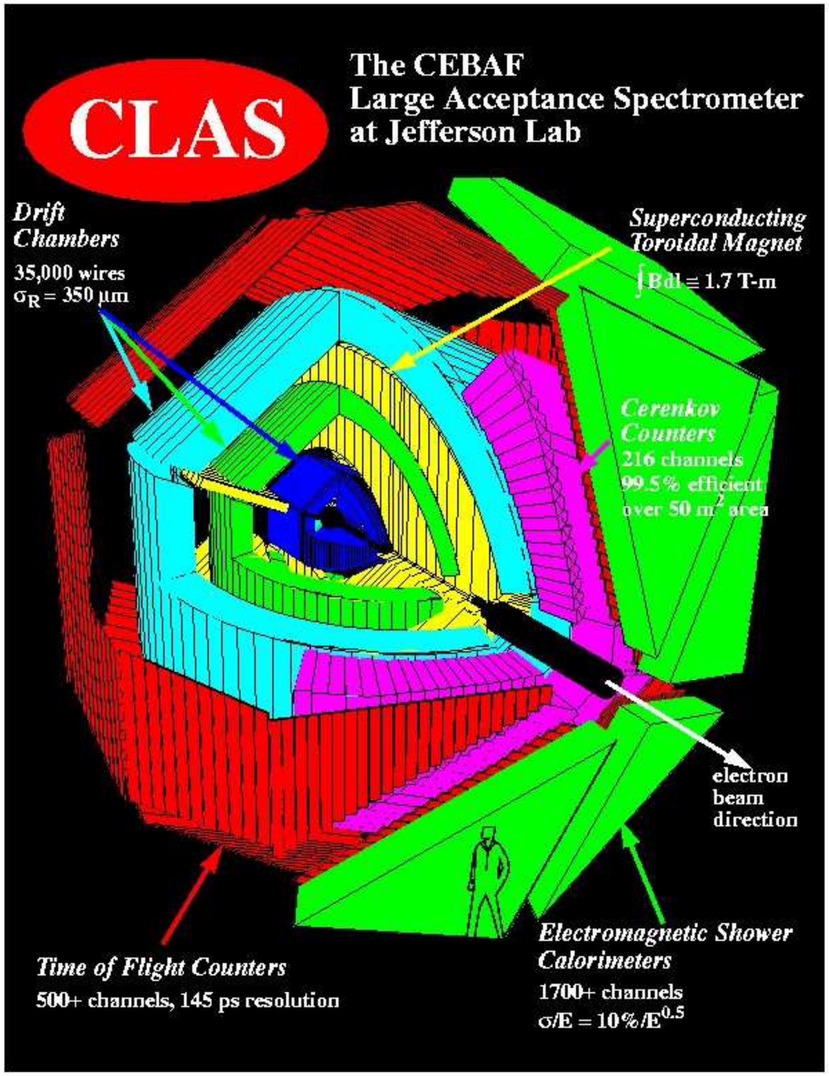


More on The CEBAF Large Acceptance Spectrometer (CLAS)

- 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.



Life on the Frontiers of Knowledge