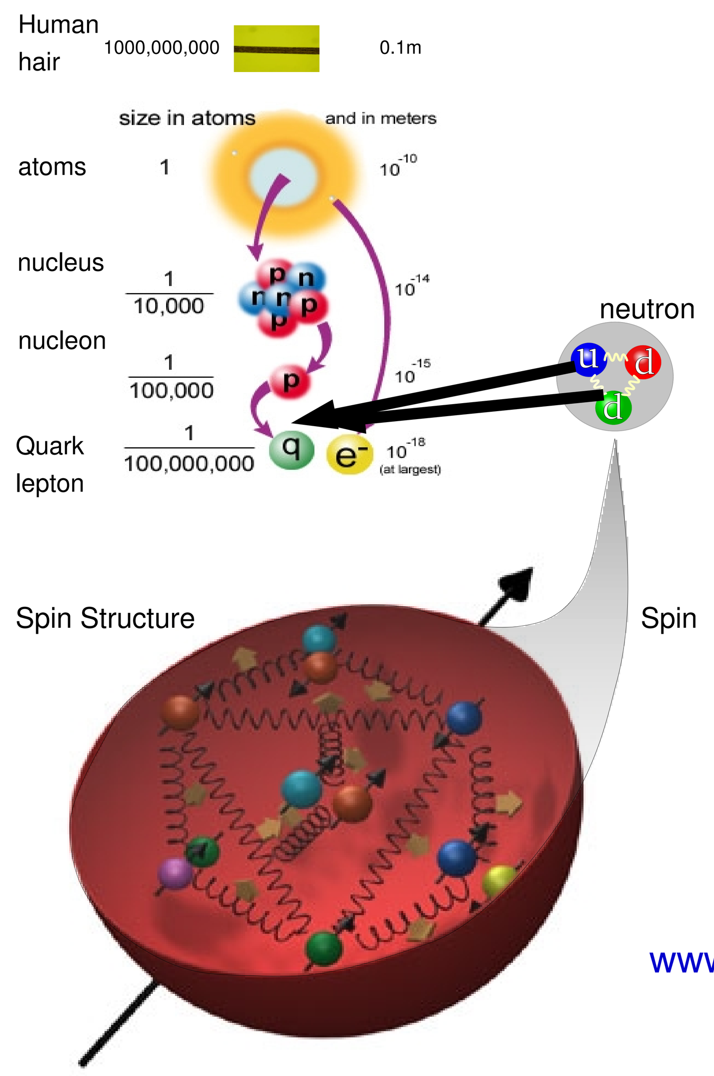
Precision Measurement of the neutron d_2

Understanding the spin structure of the neutron

What is matter made of?



Pictures from
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We know that nucleons (ie. neutrons and protons) are not fundamental particles. They are made of even smaller particles called quarks and are held together by something called the Strong force which involves the exchange of another type of particle called a gluon. Jefferson Laboratory studies this sub-nuclear structure by shining a high intensity, high energy electron beam onto targets (made up of neutrons and protons) and precisely measuring what comes out. JLab is particularly well suited to measuring nuclear properties related to the spin structure and strong force interactions inside the nucleon

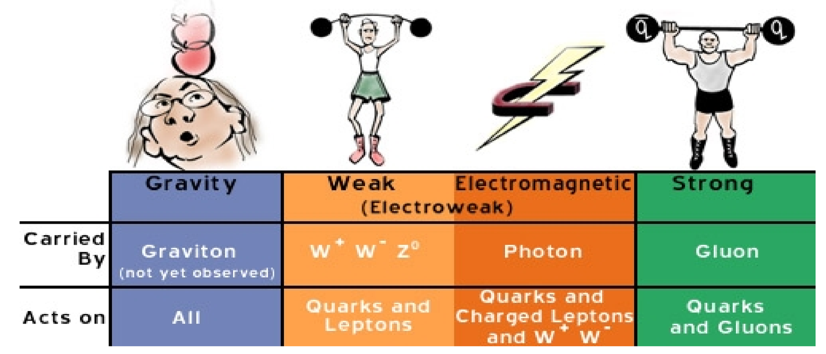
The Strong Force: You may know that atoms and molecules are held together by the electromagnetic force (the same force that sticks a magnet to the fridge and holds a static-charged balloon to the wall). Nucleons are held together by a completely different type of force called the strong force. It exerts a pull more than 100 times stronger than the electromagnetic force and has six types of charge named after colors: red, green, and blue, and their opposites: anti-red, anti-green and anti-blue. (The electromagnetic force has only two types of charge: positive and negative.)

Spin: Spin is a bizarre but important physical quantity. Large objects like planets or marbles may have angular momentum and a magnetic field because they spin. Since particles (ie. quarks and gluons) also to appear have their own angular momentum and tiny magnetic moments, physicists called this particle property spin by analogy. (The term can be misleading however, since the particles aren't actually rotating like a top – instead spin is "built-in" to the particle itself and not tied to its motion.)

Spin Structure. A nucleon has a spin of ½ and that spin must be due to the sum of the spins and angular motion of the quarks and gluons that make up that nucleon. By measuring this spin-structure we learn about the quarks, the gluons, and the force that ties them all together.

d_2 (what we are going to measure) is connected with the Color polarizabilities of the neutron. When neutron is placed in a sufficiently strong magnetic field its component quarks and gluons will respond by rearranging themselves so that the total neutron spin will align with that field (analgous to the way a compass needle lines up with the Earth's magnetic field). The degree to which the quarks and gluons rearrange themselves inside the neutron is called the polarizability of the neutron and is dependent upon the details of the strong force that holds them together. Measuring d_2 is one way to "see" what is going on inside the neutron.

What holds it together?



	Gravity	Weak (Electroweak)	Electromagnetic	Strong
Carried By	Graviton (not yet observed)	$W^+ W^- Z^0$	Photon	Gluon
Acts on	All	Quarks and Leptons	Quarks and Charged Leptons and $W^+ W^-$	Quarks and Gluons

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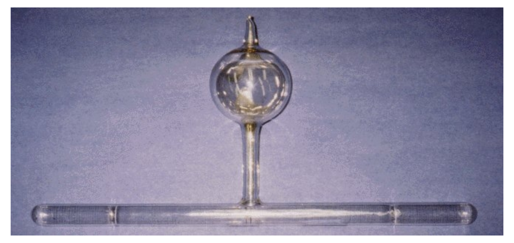
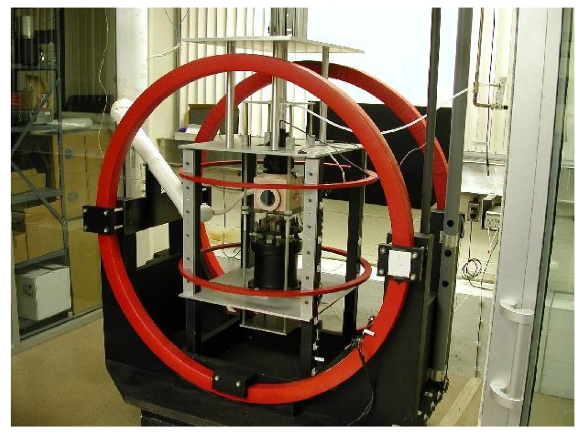
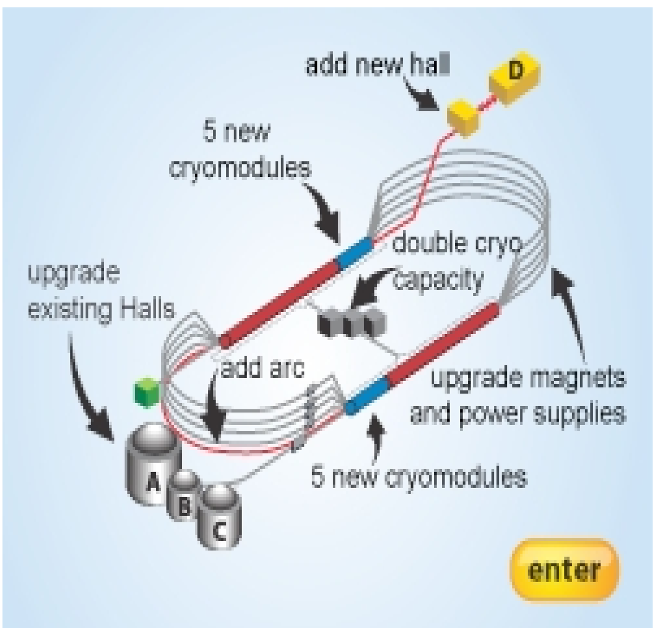
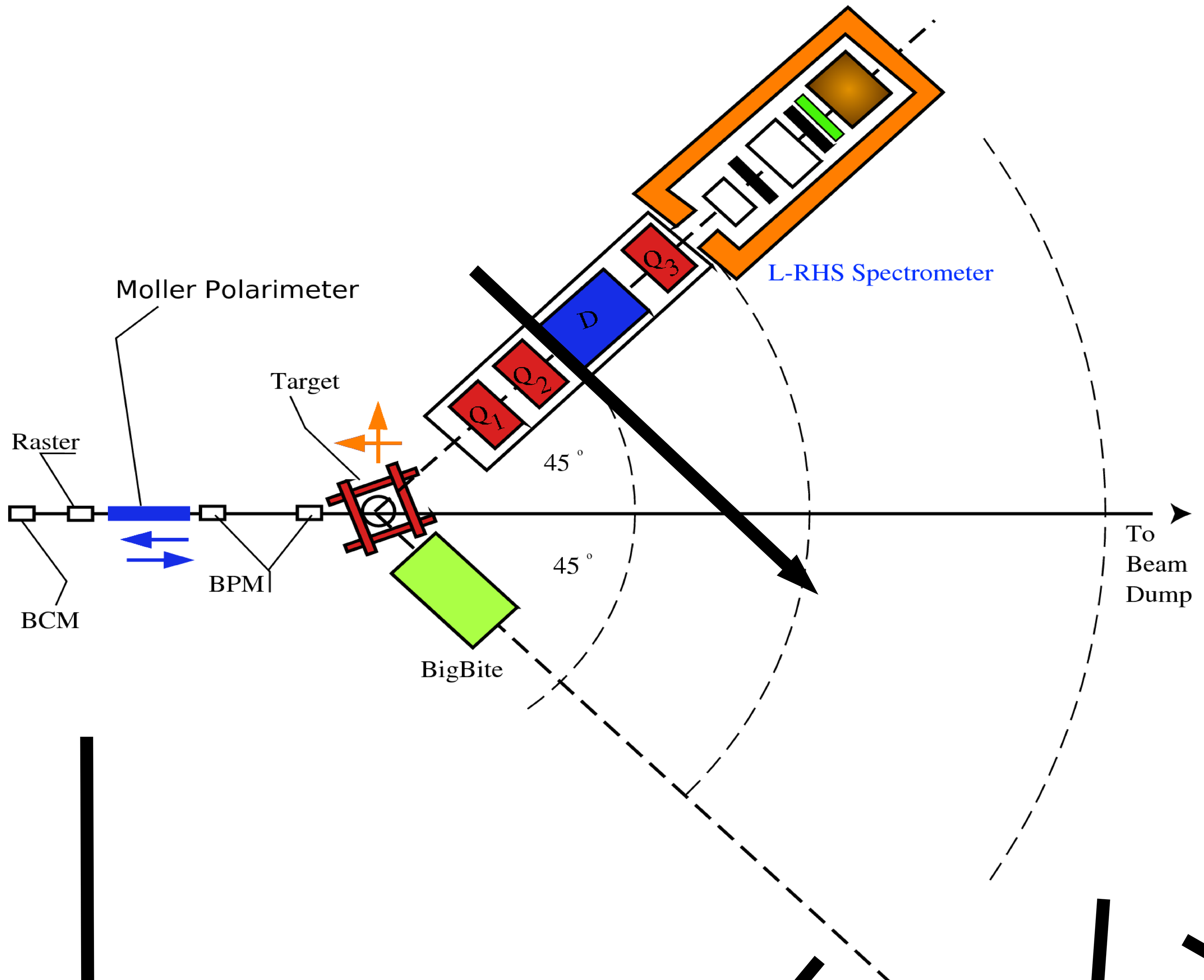


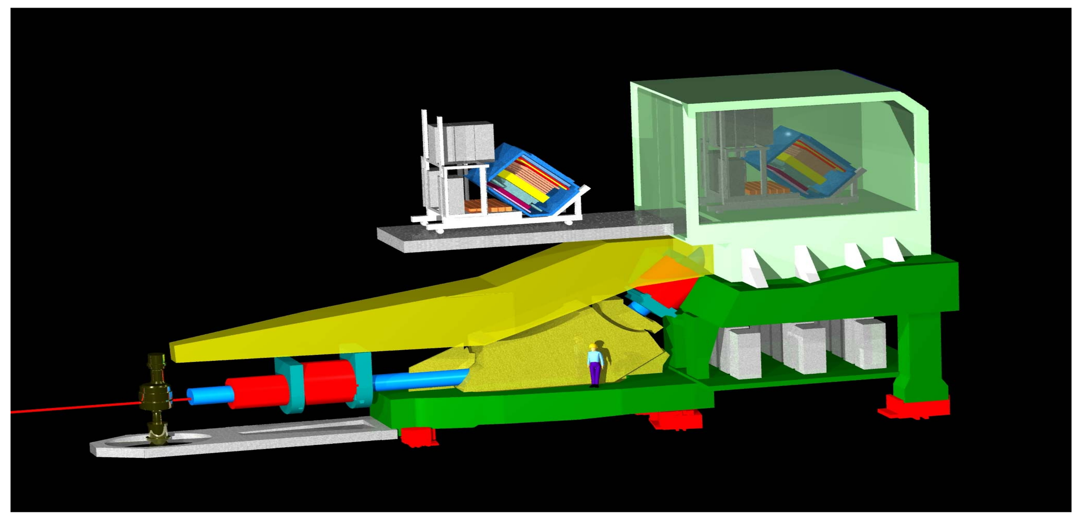
The real target is the gas in the cell.



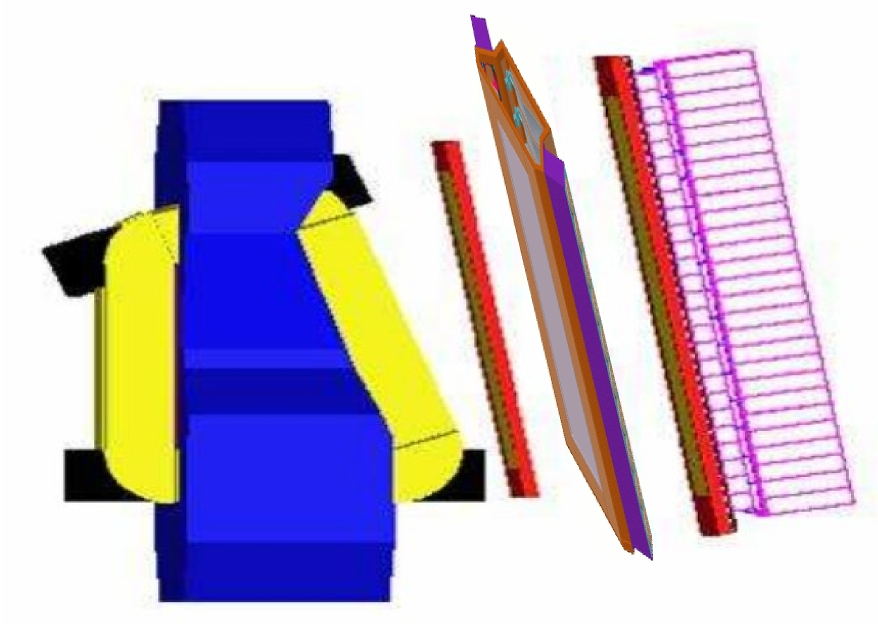


Accelerator:Provide High Energy Electron





LHRS: One Detector to detect scattering electron



BigBite: One Detector to detect scattering electron

Dipole Magnet: Change direction of scattering electron

Multi-Wire Drift Chamber: Mainly Tracking electron

Shower: Mainly Measure energy of electron

Gas Cherenkov: Mainly Identify the electron

Use Two Detectors to get different quantities we are going to use to calculate final result d2.

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