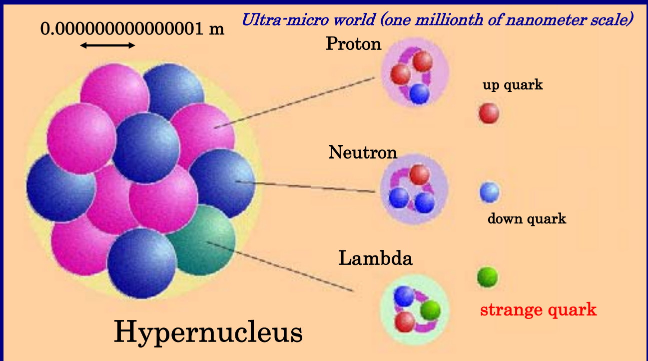
JLab Open House 16th April 2005

Hypernuclear Spectroscopy through the $(e, e' K^{+})$ Reaction
E01-011 / E02-017 (HKS Collaboration)

What is a hypernucleus?



It is difficult to put nucleons deep inside of a nucleus as a probe

A nucleus is already densely filled with protons and neutrons (a neutron star is a single gigantic nucleus and nuclear density is the same as that of a neutron star.) Furthermore, protons and neutrons repel the same kind of particles (protons and neutrons) which try to occupy the same quantum state. This is known as *Pauli exclusion*. However, it is not the case for the Lambda. The Lambda is a different particle from the nuclear components, thus it is free from *Pauli exclusion.* We can use Lambda as a probe to study deep inside of the nucleus.

Ordinary nucleus : Protons and Neutrons (Nucleons)

Gold : 79 protons + 118 neutrons

Lead : 82 protons + 125 neutrons

Remove 3 protons and 7 neutrons from lead, and you will be the greatest alchemist!

Transforming one element to another was a dream of ancient alchemists, however, it was never achieved. But this is not difficult for modern nuclear scientists.

Here in JLab's Hall C, we try to produce hypernuclei, which are more exotic than gold.

Hypernucleus : Protons, Neutrons and Hyperon (such as Λ)

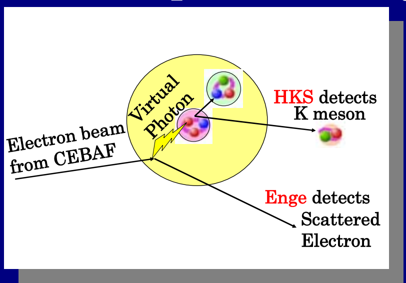
No natural hypernuclei on Earth!

Natural hypernuclei might exist only in hyper-dense material, such as a neutron star (1000000000000 pounds per 1cm^3.)

> 5000 x

Neutron stars are the most dense material in the Universe. If this candy was piece of a neutron star, it would be 5000 times heavier than the full loaded USS Kittyhawk!

How to produce a hypernucleus?



When the electron beam hits the target nucleus, the electron beam is scattered and detected by the ENGE spectrometer. The electron emits a virtual photon which reacts with a proton in the target nucleus and converts it to a Lambda particle. Since the Lambda particle has a strange quark, an anti-strange quark is pair-produced simultaneously. This anti-strange quark is emitted in a form of K^{+} meson (kaon) and it is detected by the High resolution Kaon Spectrometer (HKS).

A hypernucleus exists only for 0.0000002 sec on Earth, but it is enough time for our state-of-art detectors to detect its production and to measure its energy levels precisely. The High resolution Kaon Spectrometer (HKS, 250 tons) is designed and fabricated in Japan and traveled 6500 miles oversea to JLab. You might notice that the ENGE electron spectrometer is tilted by 8 degrees. It is our special trick to reduce ultra high-rate background noise by a factor of 10000. Ask near-by scientists what kind of detectors are used for the hypernuclear study.