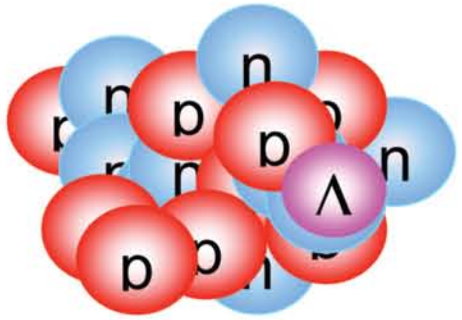
The physics of hypernuclei
FINUDA

WHAT ARE HYPERNUCLEI?
Hypernuclei are the result of a modification of the structure of a normal atomic nucleus. The nuclei of ordinary matter are composed of two types of particles, protons and neutrons, which are in turn composed of two types of quarks, up and down. In hypernuclei, a neutron is substituted by another type of particle called a lambda. The lambda is similar to the neutron, except for that it contains a strange quark in place of one of the down quarks. The strange quark is heavier than the up and down quarks; it is believed to have been abundant in the first few instants in the life of the Universe.

Like the neutron, the lambda particle has no electric charge, and its mass is only slightly heavier. However, the lambda is unstable, and instantly decays.



WHERE ARE HYPERNUCLEI FOUND?
Hypernuclei were discovered in 1953 by the Polish physicists Marian Danysz and Jerzy Pnieswski in observations of emulsions irradiated by cosmic rays. Today, hypernuclei can be produced in the laboratory by striking an ordinary nucleus with a particle called a K meson. In the collision, a neutron is substituted by a lambda particle. For a few moments - an infinitesimal time on any macroscopic scale - a new type of matter, different from ordinary matter, is created: strange matter. The study of the formation and subsequent decay of this strange matter, of which the nuclei of some particularly heavy stars might consist, would significantly deepen our fundamental knowledge of the interactions which bind quarks to the interiors of baryons (particles formed from three quarks, like protons and neutrons) and mesons (particles formed from a quark and an antiquark) and which determine how nuclear material binds together (via the strong force) and disintegrates (via the weak force). This occurs as a result of the weak interaction, the same force responsible for natural radioactivity. By studying these mechanisms, FINUDA can clarify as-yet obscure aspects of the weak interaction.

WHAT IS FINUDA?
FINUDA (FIsica **NU**cleare a **DAΦ**NE**)** is an experimental apparatus dedicated to the study of hypernuclei formed in collisions of K mesons (composed of a "u" antiquark and an "s" quark) with nuclear targets. The K mesons are produced in the decays of Φ mesons (composed of an "s" antiquark and an "s" quark), which are created in the collisions of electron and positron beams inside the DAΦNE accelerator.

WHAT IS FINUDA FOR?
FINUDA was designed to study both the formation and decay of hypernuclei, in order to understand certain aspects of the strong and weak forces, two of the four fundamental forces of nature.

By studying where the lambda particle is localized inside the nucleus, one can obtain new information about the structure of atomic nuclei. Protons and neutrons are held together inside the nucleus by the so-called strong force, but are also subject to the effects of the Pauli exclusion principle, which forbids identical particles, like protons or neutrons, from occupying the same nuclear energy level. In a hypernucleus, however, there is only one lambda particle. Therefore, the lambda is not subject to the exclusion principle, and its localization inside the nucleus is determined only by the strong force.

A second type of interesting information can be obtained because the lambda is unstable - after a very short while, it decays, transforming into a proton or neutron.

HOW IS FINUDA MADE?
The experimental apparatus is composed of a system of particle detectors - plastic scintillators, silicon microstrips, drift chambers, and straw tubes - inserted into a large, solenoidal superconducting magnet (4.2 m x 4.2 m x 2.4 m) that generates a uniform magnetic field of 1.1 T. The system of detectors, arranged in successive concentric layers, constitutes a magnetic spectrometer that allows the measurement of the quantities of motion of the different particles from the formation and decay of lambda (Λ) hypernuclei.