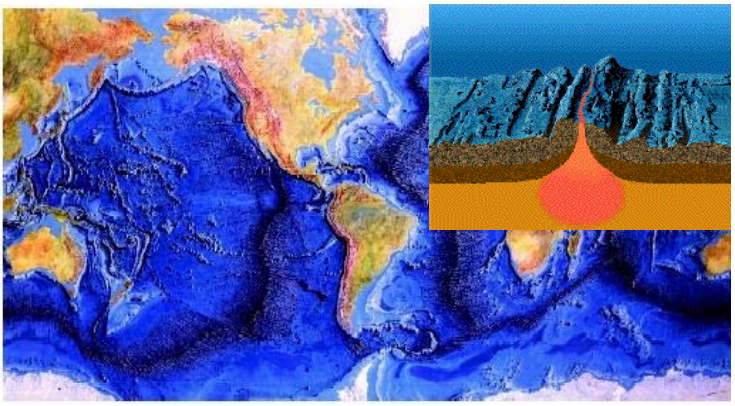
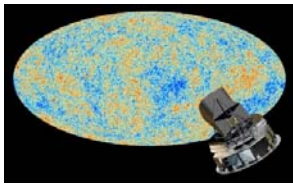
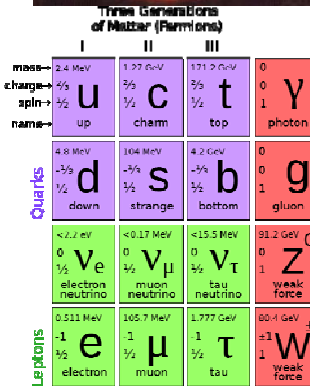


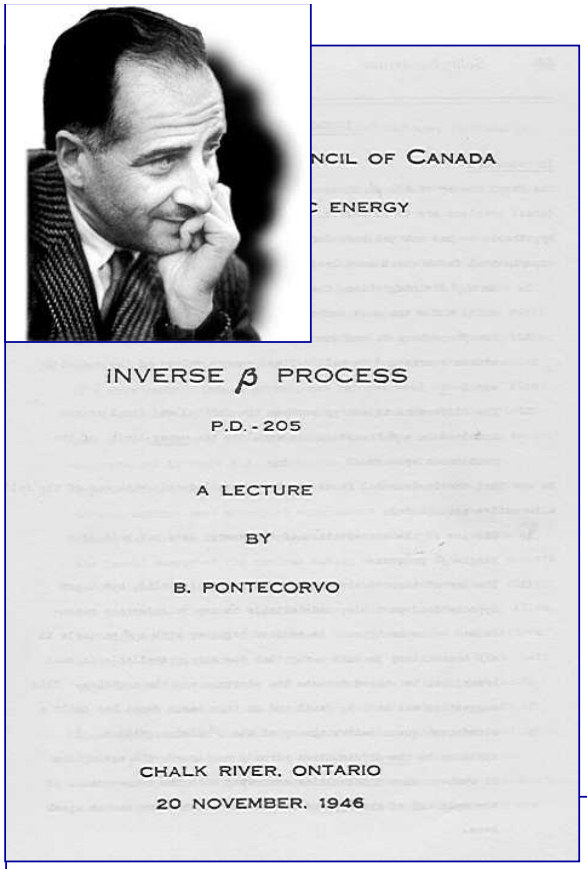
Gianni Fiorentini, An Introduction to the nuclear and subnuclear world





- **Scope** (Vision) of school: much like new oceanic crust grows at the boundary between tectonic plates, so new science grows at the boundary between disciplines
- **Problem/ goal** : share a common language/background between scholars from different disciplines
- **Content of my lectures**

  1. A 14 billion years journey in time
  2. The building block of the universe and their interactions
  3. Neutrinos: properties and sources
  4. Some misteries in the universe



- Neutrino sources (sun, reactors, accelerators)
- The Cl-Ar method
- Neutrino oscillations

Bruno Pontecorvo

Neutron Well Logging - A New Geological Method Based on Nuclear Physics, Oil and Gas Journal, 1941, vol.40, p.32-33.1942.

- An application of Rome celebrated study on slow neutrons, the neutron log is an instrument sensitive to water and hydrocarbons.
- It contains a (MeV) neutron source and a (thermal) neutron detector.
- As hydrogen atoms are by far the most effective in the slowing down of neutrons, the distribution of the neutrons at the time of detection is primarily determined by the hydrogen concentration, i.e. water and hydrocarbons.

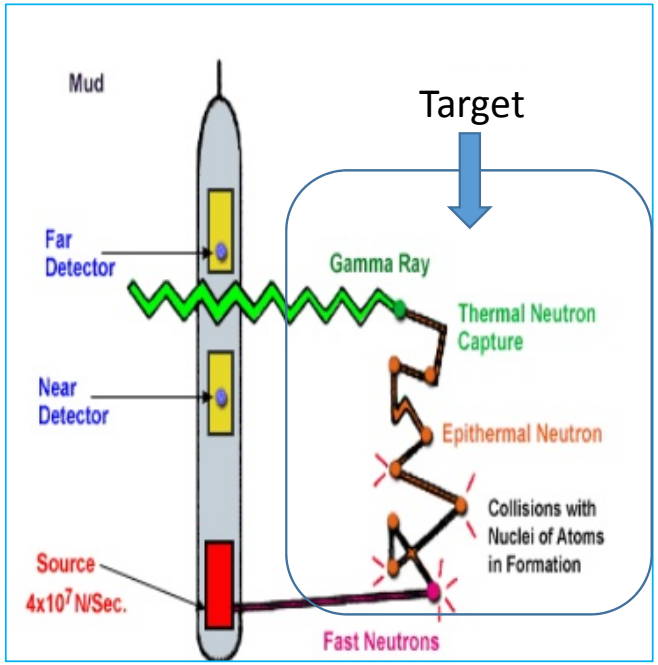
The Panisperna boys: from pure physics to applied geosciences

- **Billiard physics**: in an elatic collision between a body m1, energy E1, and m2, at rest, the energy transfer ΔE Is maximal when when m1=m2
- Since water contains hydrogen it is the most efficient material to slow down neutrons
- **Quantum physics**: low energy neutrons interact more strongly
- This effect was used by Fermi to use slow neutrons for transforming elements in Rome
- Same effect was used by Pontecorvo in order to characterize hydrogen containing substances underground

Three trips:

- LIFE: From Via Panisperna in Rome to Pulsa, Oklahoma
- DISCIPLINE: From physics to geology
- GOAL: From pure to applied science

The magic three of physics experiments/instruments (at least in nuclear and subnuclear physics)



The neutron log is just an example. Logically it contains three elements:

- **Source**
- **Target/interaction**
- **Detector**(s)

- Most physics instruments, at least in nuclear and subnuclear physics, work on such a triad……

Questions, problems and additional readings

Some exercises

- Problem 1

-in an elatic collision between two bodies m1, energy E1, and m2, at rest, calculate the highest energy transfer ΔE (knock on collision)

-show ΔE is maximal when m1=m2

- Problem 2 - On the average, in a collision between equal mass particles ½ of the kinetic energy is transferred to that at rest. Compute how many collisions are needed for a 2.5 10^6 eV neutron to reach room thermal energy (1/40 eV= 2.5 10^{-2} eV)
- Problem 3 Atoms and molecules have sizes of order 10^{-8}cm. Starting from a cherry (1cm size) how many cuts you need to reach the "cherry atom"

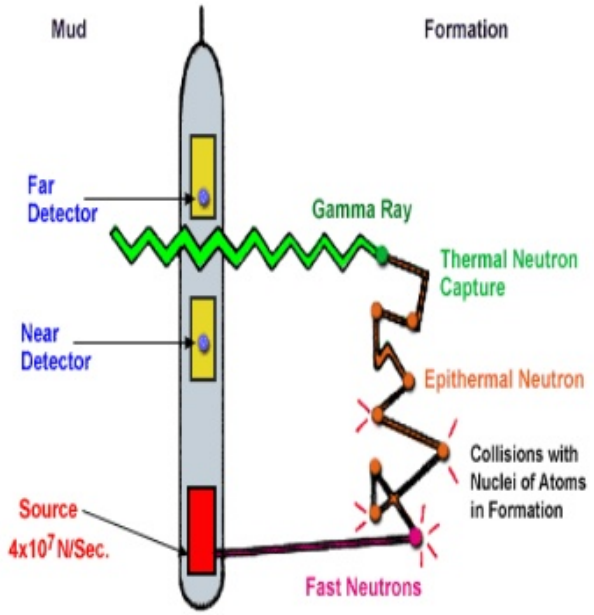
Applications:
slow down of fast neutrons, maximal in water and/or light elements
-nuclear reactor moderation
- Search of dark matter

Applications:
-The size of a nuclear reactor core,
- The range which can be explored with a neutron log

Applications:
-any phenomeno characterized by expondential law
(from decay of radioactive substances, … to growth of tumors.)

More readings on neutron logging

- The Neutron Log is primarily used to evaluate formation porosity, but the fact that it is really just a hydrogen detector should always be kept in mind
- It is used to detect gas in certain situations, exploiting the lower hydrogen density, or hydrogen index
- The Neutron Log can be summarized as the continuous measurement of the induced radiation produced by the bombardment of that formation with a neutron source contained in the logging tool which sources emit fast neutrons that are eventually slowed by collisions with hydrogen atoms until they are captured (think of a billiard ball metaphor where the similar size of the particles is a factor). The capture results in the emission of a secondary gamma ray; some tools, especially older ones, detect the capture gamma ray (neutron-gamma log). Other tools detect intermediate (epithermal) neutrons or slow (thermal) neutrons (both referred to as neutron-neutron logs). Modern neutron tools most commonly count thermal neutrons with an He-3 type detector.



- See e.g. http://petrowiki.org/Neutron_porosity_logs