Practical applications of nuclear physics

Electric power generation (nuclear fission / fusion reactors)

National Security (nuclear weapons stockpile)

Medical Diagnosis (PET, MRI)
cancer treatment with proton or heavy-ion beams

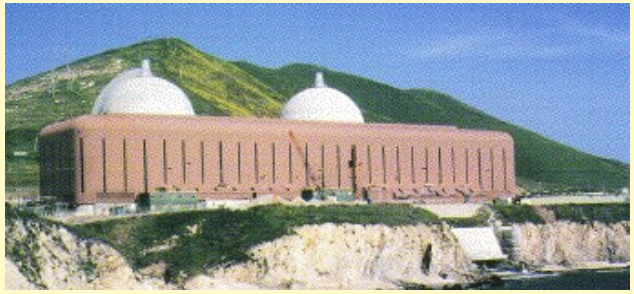
Radioactive dating (geology, paleontology, archeology, art)
carbon-14 and uranium / thorium “clocks”

Interplanetary spacecraft powered by nuclear energy
(e.g. Pu-238 α-decay used by Mars rover “Curiosity”)

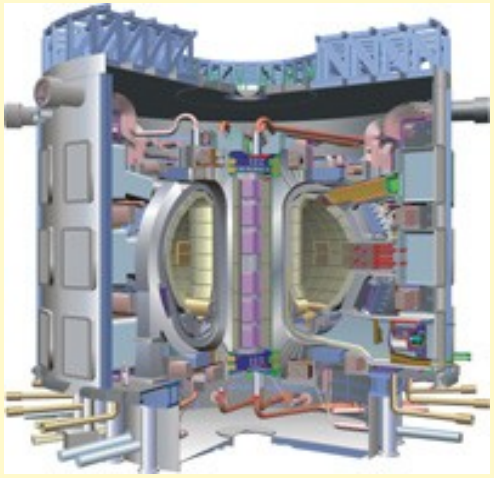
Household (smoke detectors, americium-241 α-decay)

Electric power generation with fission and fusion reactors

Energy source: binding energy difference between nuclei before and after reaction



Diablo Canyon Fission Reactor, San Luis Obispo County, California

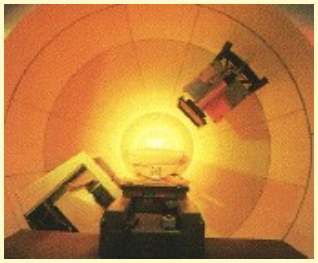


International Fusion Reactor in Cadarache, France

Medical Diagnosis and Therapy

Radioisotope tagging --> functional diagnosis of organs

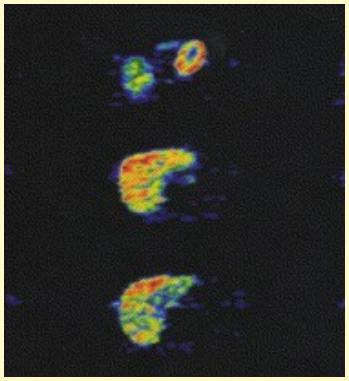
Particle beams (protons, heavy ions) --> treatment of cancer



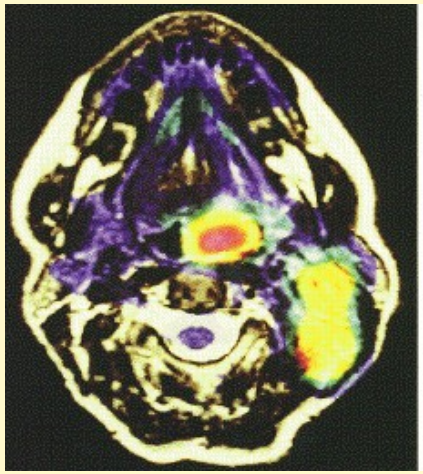
Irradiation with proton beam

Medical Diagnosis and Therapy

Positron Emission Tomography (PET)
study metabolism, brain and heart functions
uses radioisotopes (positron emitters such as fluorine-18)



beating heart



brain scan

Medical Diagnosis and Therapy

Magnetic Resonance Imaging (MRI)

splitting of atomic levels due to nuclear spin
in strong external magnetic field (several Tesla)

application: study of brain functions and heart

Radioactive dating (archeology): carbon-14 “clock”

carbon-14 (β^- decay): $T_{1/2}$ = 5,730 years

Egyptian mummy

Determine the age of ancient organic (carbon-based) materials such as wood, bones or cloth. Useful for times $t < 10 * T_{1/2}$ (about 50,000 years).

Radioactive dating (geology, paleontology)
uranium and thorium "clocks"

U-238 decay series (8 α and 6 β decays) → Pb-206 : $T_{1/2}$= 4.5 billion years

basic approach: look for rocks containing U-238 and determine the relative abundance of the parent nuclei U-238 and daughter nuclei Pb-206

http:/www.nasa.gov

Mars rover “Curiosity” powered by nuclear energy (http://www.nasa.gov)

Mars Rover Curiosity powered by nuclear energy

RTG

A radioisotope thermoelectric generator (RTG) powers the Mars rover "Curiosity". It generates power from the radioactive α-decay of Pu-238 (half-life = 88 years). Kinetic energy of α–particles will be transferred to a series of thermocouples (metal will heat up) which transform heat into electricity. About 100W of continuous power.