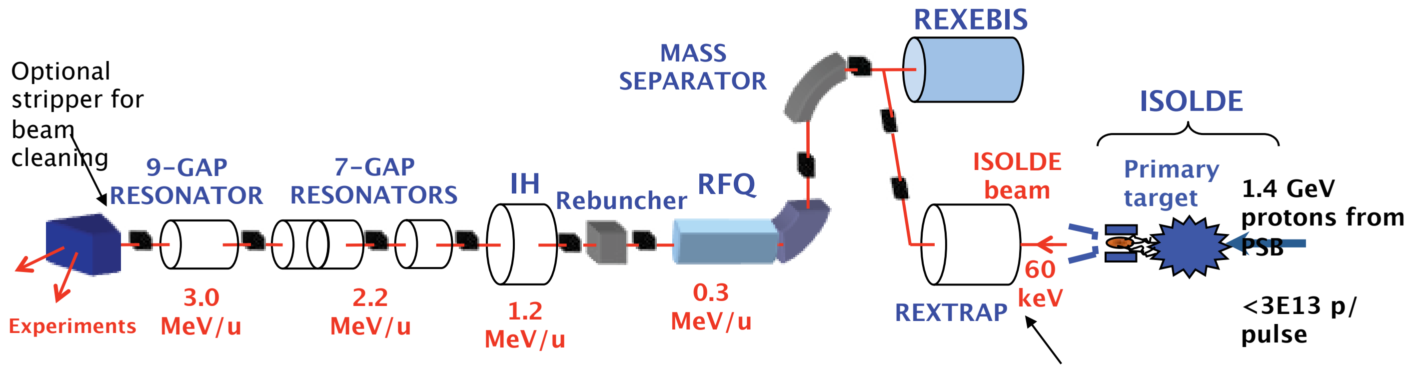
Condensed matter physics at ISOLDE

aims at the study of structural, electrical, optical, magnetic and transport properties in a variety of technologically and fundamentally relevant materials, including semiconductors, metals, high-temperature superconductors and ceramic oxides.

Biophysics and life sciences at ISOLDE

aim at the study of the structure, bonding and transport mechanisms in a variety of biological molecules such as proteins and amino-acids.

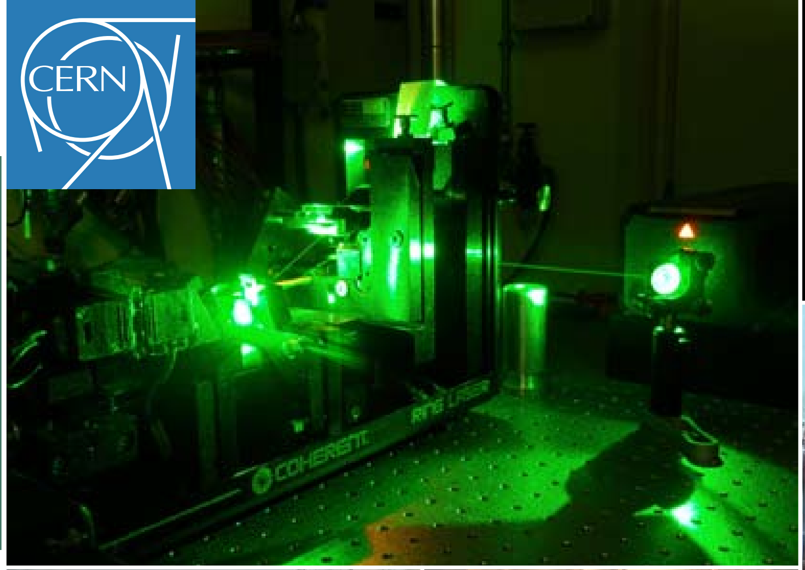


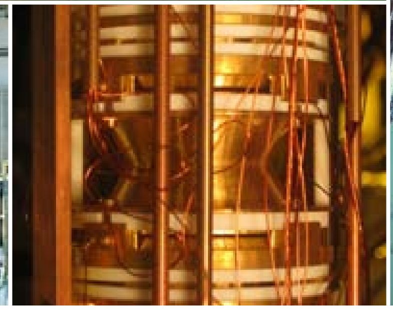
CERN
European Organization for Nuclear Research
CH-1211 Geneva 23

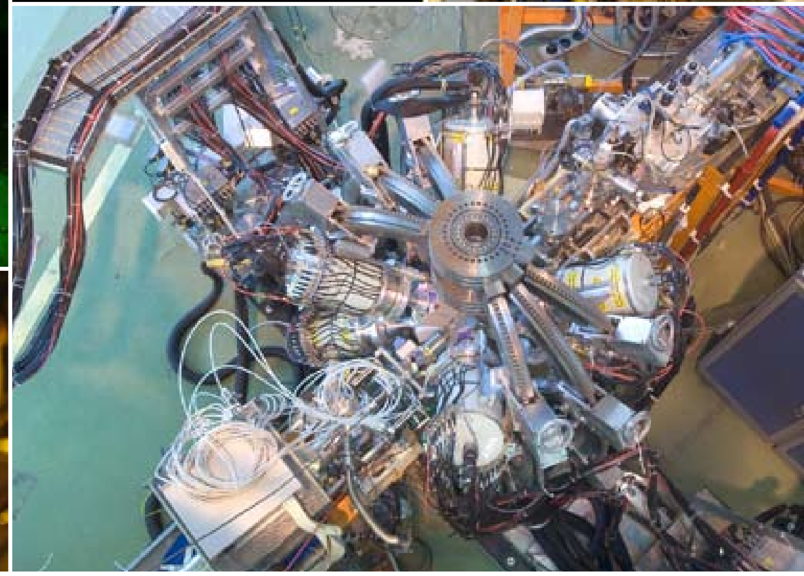
Communication Group, June 2009
CERN-Brochure-2009-007-Eng

CERN, the European Organization for Nuclear Research, was founded in 1954. It has become a prime example of international collaboration, with currently 20 Member States. It sits astride the Franco-Swiss border near Geneva and is the biggest particle physics laboratory in the world.

Photos: CERN Photo Service

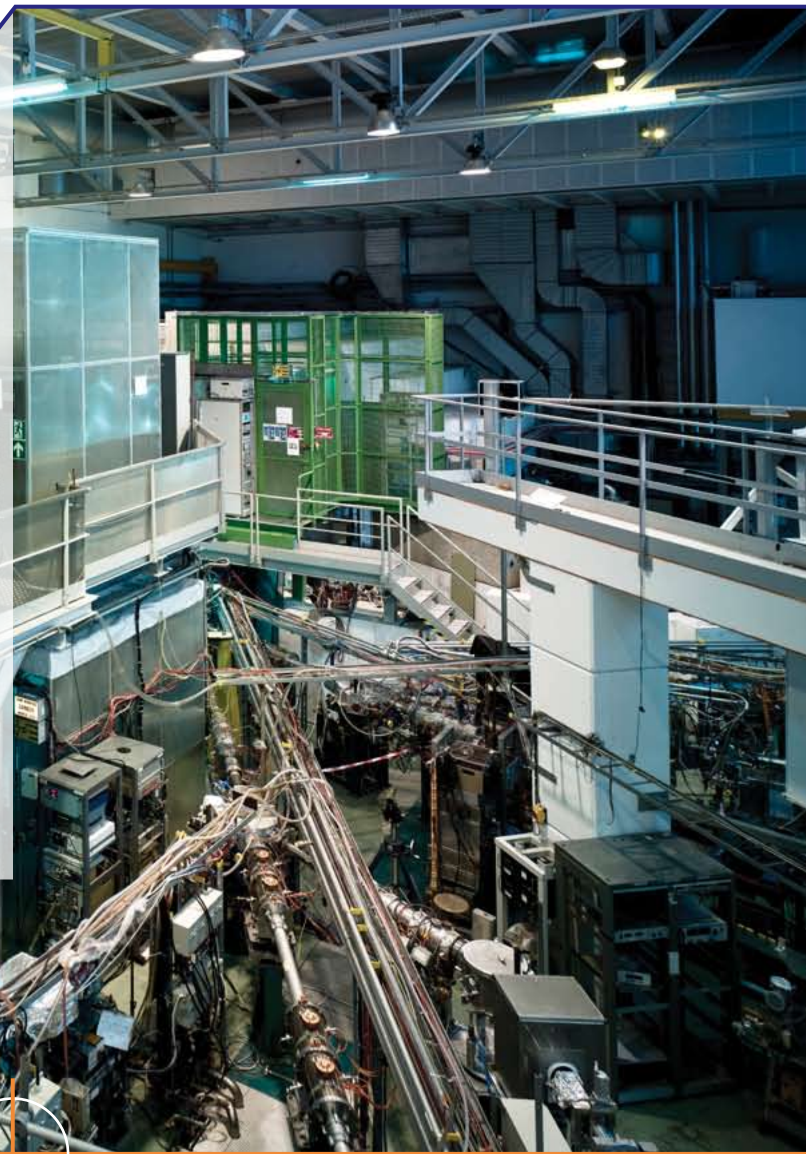






ISOLDE

Exploring exotic nuclei



All atoms contain a nucleus, which consists of specific numbers of protons and neutrons. The number of protons characterizes the element, while the number of neutrons determines stability against radioactive decay. The "exotic" nuclei produced at ISOLDE are so called because they are very different from stable atomic nuclei in the number of neutrons they contain. This makes them unstable and very short lived. While they do not exist on Earth, such nuclei play a major role in the life and death of stars.

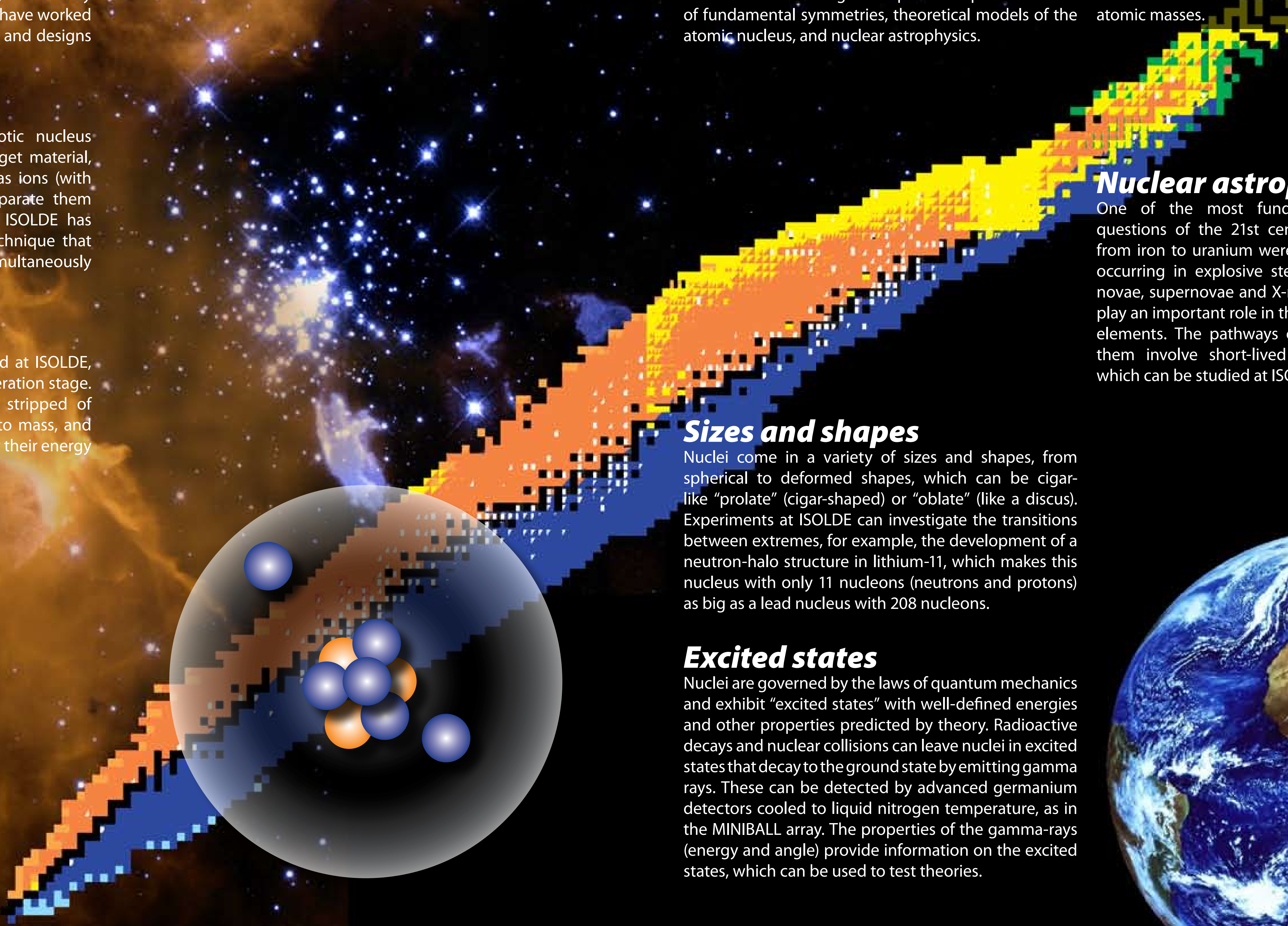
The ISOLDE facility uses protons from CERN's accelerator complex to produce exotic nuclei of most of the elements. These radioactive nuclei are used for basic research in many areas of science: nuclear physics, nuclear astrophysics, atomic physics, condensed matter physics, radiobiology, and elementary particle physics. ISOLDE belongs to a network of radioactive beam facilities in Europe that advance our knowledge of these exotic nuclei.

Exploring *exotic nuclei at ISOLDE*

Production
ISOLDE produces radioactive nuclei in reactions between protons at 1.4 GeV energy and nuclei in a variety of special targets. Several different types of reaction can take place, making a broad range of elements available. The targets are heated so that the new radioactive species diffuse out quickly before they decay. Scientists and engineers at ISOLDE have worked for decades to develop the best materials and designs for the targets.

Selection
To produce a beam of a chosen exotic nucleus requires not only the right choice of target material, but also methods to extract the nuclei as ions (with fewer electrons than atoms) and to separate them electromagnetically from other species. ISOLDE has pioneered a very selective ionization technique that uses several wavelengths of laser light simultaneously to pick out specific elements.

Acceleration
To make the most of the nuclei produced at ISOLDE, the REX-ISOLDE system provides an acceleration stage. Here the nuclei are trapped, bunched, stripped of remaining electrons, selected according to mass, and finally fed into a linear accelerator to boost their energy to 3 MeV per nucleon.



Nuclear mass surface
Ions that are confined almost at rest in devices called Penning traps can have their masses measured with very high precision. The large variety of nuclear species available at ISOLDE allows a comprehensive survey of the "nuclear mass surface" – in effect a map of the many nuclear masses. This gives important input for studies of fundamental symmetries, theoretical models of the atomic nucleus, and nuclear astrophysics.

Sizes and shapes
Nuclei come in a variety of sizes and shapes, from spherical to deformed shapes, which can be cigar-like "prolate" (cigar-shaped) or "oblate" (like a discus). Experiments at ISOLDE can investigate the transitions between extremes, for example, the development of a neutron-halo structure in lithium-11, which makes this nucleus with only 11 nucleons (neutrons and protons) as big as a lead nucleus with 208 nucleons.

Excited states
Nuclei are governed by the laws of quantum mechanics and exhibit "excited states" with well-defined energies and other properties predicted by theory. Radioactive decays and nuclear collisions can leave nuclei in excited states that decay to the ground state by emitting gamma rays. These can be detected by advanced germanium detectors cooled to liquid nitrogen temperature, as in the MINIBALL array. The properties of the gamma-rays (energy and angle) provide information on the excited states, which can be used to test theories.

Fundamental symmetries
The nuclei produced at ISOLDE, with proton-to-neutron numbers varying over a wide range, provide an interesting microscopic laboratory for low-energy tests of the Standard Model of elementary particle physics. The high quality of the beams allows high-precision measurements of beta decay, particle correlations and atomic masses.

Nuclear astrophysics
One of the most fundamental and challenging questions of the 21st century is how the elements from iron to uranium were created. Nuclear reactions occurring in explosive stellar environments, such as novae, supernovae and X-ray bursters, are believed to play an important role in the synthesis of these heavier elements. The pathways of the reactions leading to them involve short-lived radioactive exotic nuclei, which can be studied at ISOLDE and REX ISOLDE.