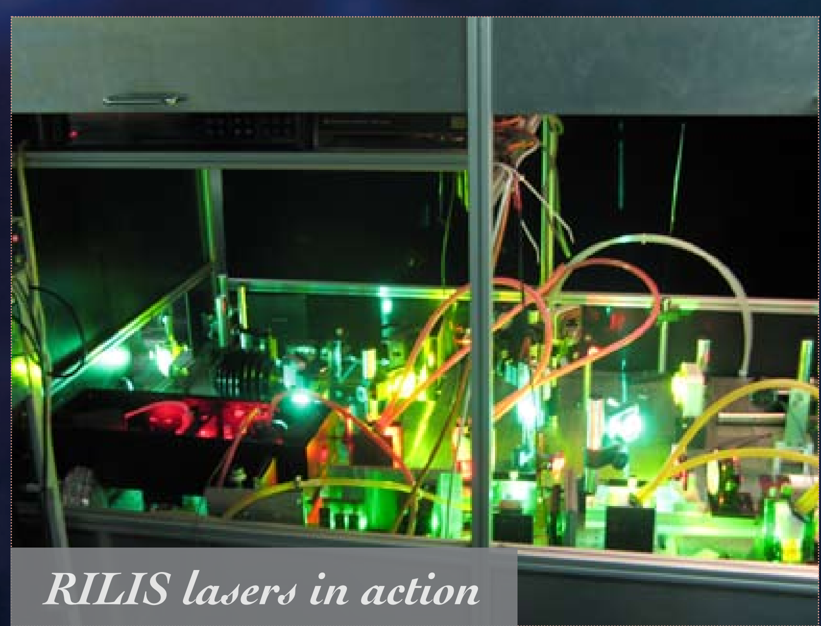
ISOLDE

ISOLDE uses protons from the PS-Booster to produce exotic nuclei. Many areas of science profit from the facility, from nuclear physics to astrophysics, including particle physics, atomic physics, condensed matter physics and radiobiology. ISOLDE belongs to a worldwide network of radioactive beam facilities.

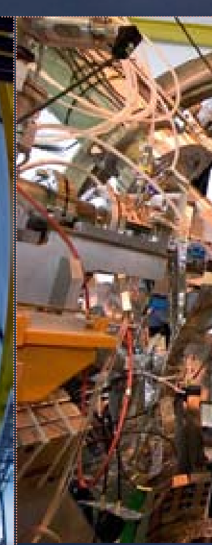
ISOLDE beamlines

Target handling with robots



RILIS lasers in action

The REX accelerator



Production

ISOLDE produces its nuclei via spallation, fragmentation, and fission reactions induced by 1.4 GeV protons delivered by the PS booster. Combining different target materials and ion sources gives ISOLDE the largest variety of beams available at any such facility worldwide: over 700 isotopes of more than 70 different elements ranging from helium up to uranium. These beams can be delivered at low energy or post-accelerated up to 3 MeV per nucleon with the REX linear accelerator.

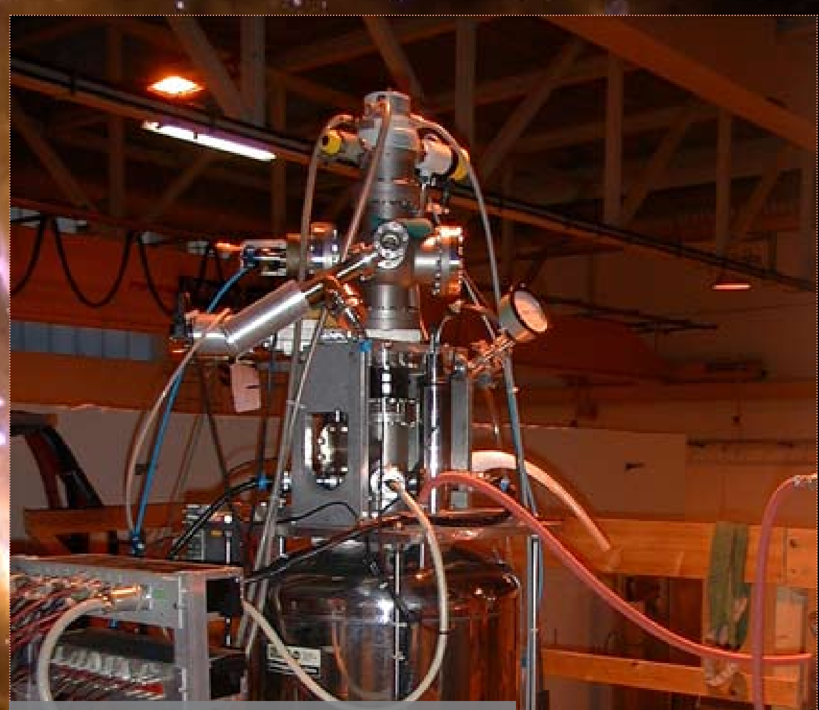
Selection

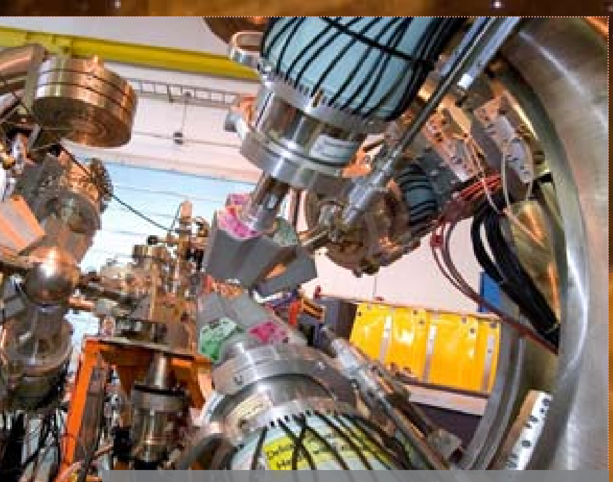
ISOLDE has pioneered a resonant laser ionization technique (RILIS) which has been used to selectively extract the nuclei of 27 elements. One of the first laser ionizations was performed on the silver and beryllium chains, relevant respectively for nuclear astrophysics and the changing nucleon shell structure. The most recent development is production of neutron-rich zinc isotopes using a temperature-controlled quartz transfer line located between the target and the ionization source.

Acceleration

A new acceleration stage – REX ISOLDE - began operation in 2001. By 2009 REX had delivered beams of over 90 isotopes of 26 elements, from lithium up to uranium. Its main users are the gamma-ray detector MINIBALL and teams studying exotic decays of light ions. The next stage for REX is a High Intensity and Energy upgrade (HIE-ISOLDE) planned for 2014. This will increase the energy of the radioactive ions up to 10 MeV per nucleon, opening the door to many new experiments.

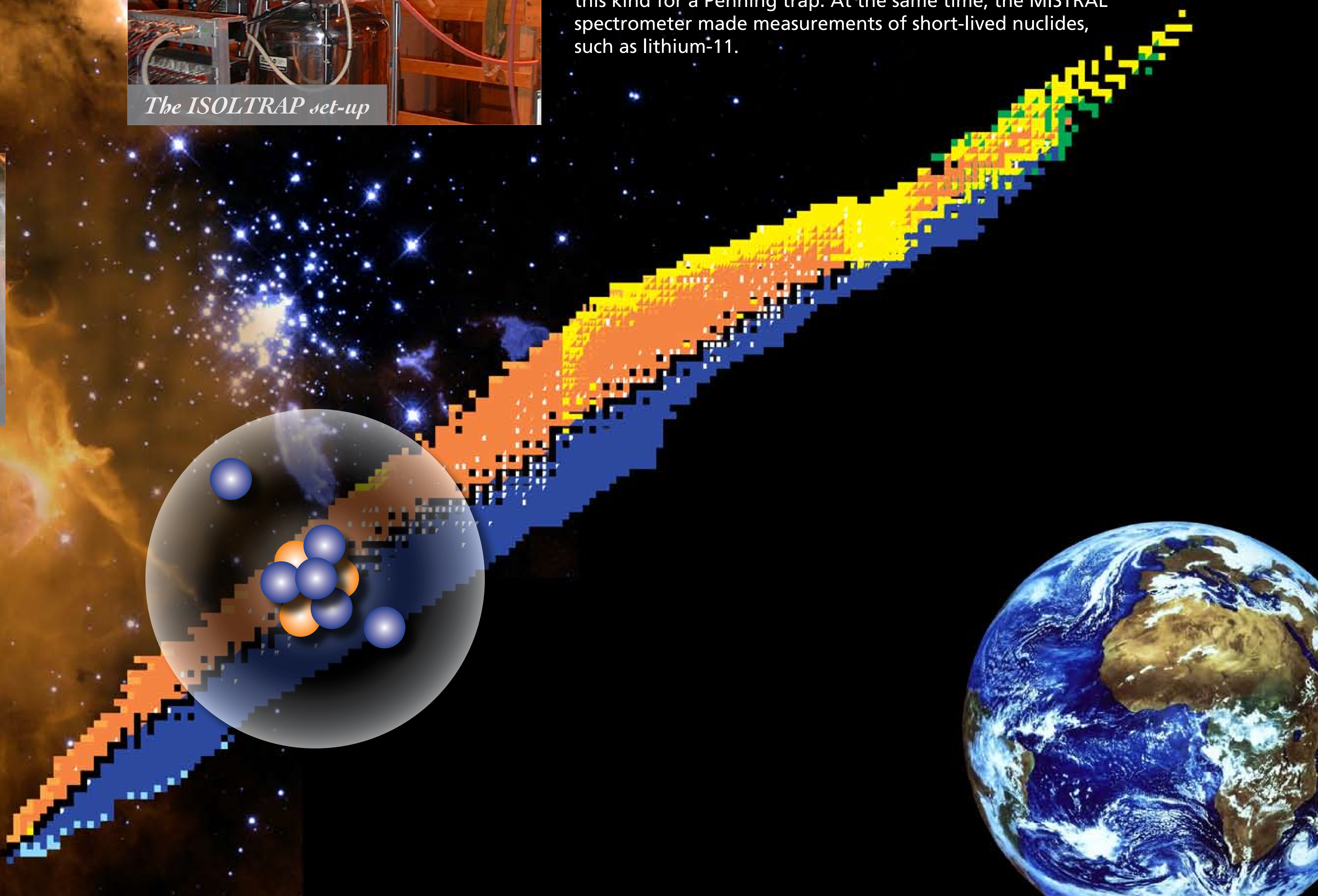
discoveries


The ISOLTRAP set-up


The MINIBALL array

Nuclear mass surface

Accurate measurements of nuclear masses are important for theoretical models of the atomic nucleus, studies of fundamental symmetries and also for astrophysics. An early highlight at the PS was the discovery of the 'island of inversion' where the magic number N=20 disappears. In 1987, the Penning trap mass spectrometer ISOLTRAP joined the quest for ever more precise measurements and has since determined the masses of over 400 radio-nuclides, some of them with half-lives as short as 100 ms and production rates as low as 100 ions/s. A new nuclide, radon-229, was identified in 2008. It was the first discovery of this kind for a Penning trap. At the same time, the MISTRAL spectrometer made measurements of short-lived nuclides, such as lithium-11.

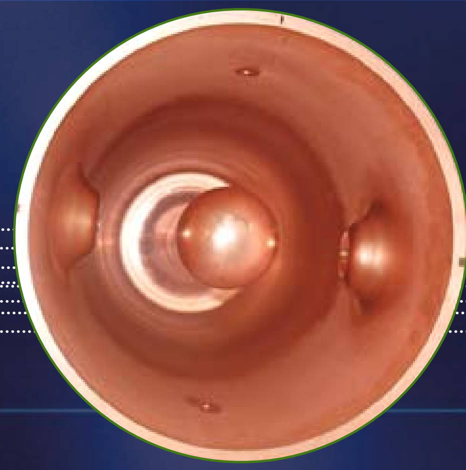


1967 **SC-ISOLDE I**

1974 **SC-ISOLDE II**

1992 **PSB-ISOLDE**

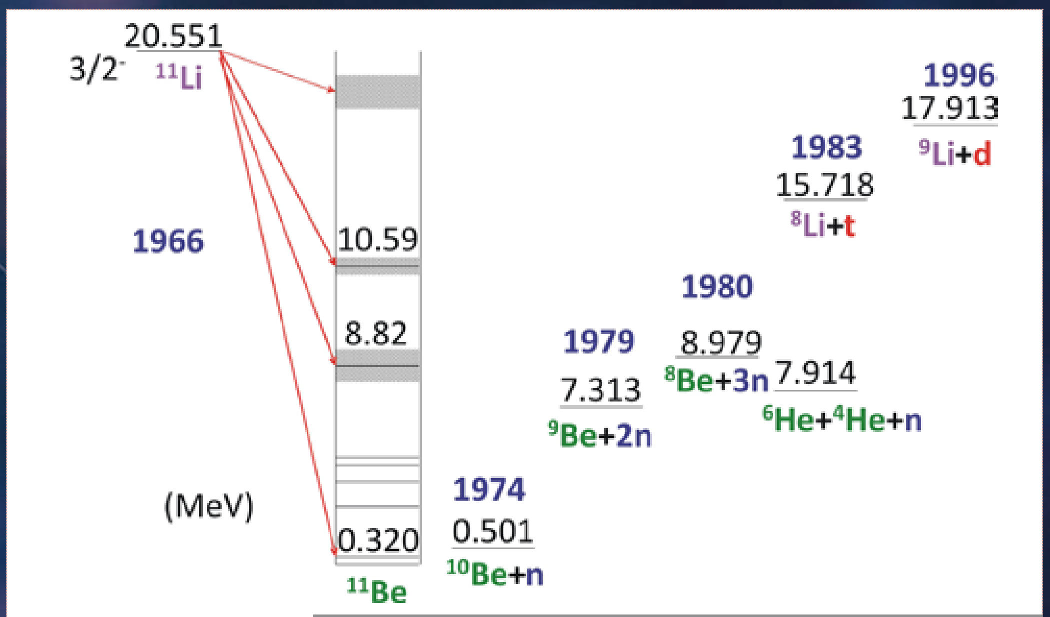
2001 **REX-ISOLDE**



2014 **HIE-ISOLDE**

Sizes and shapes

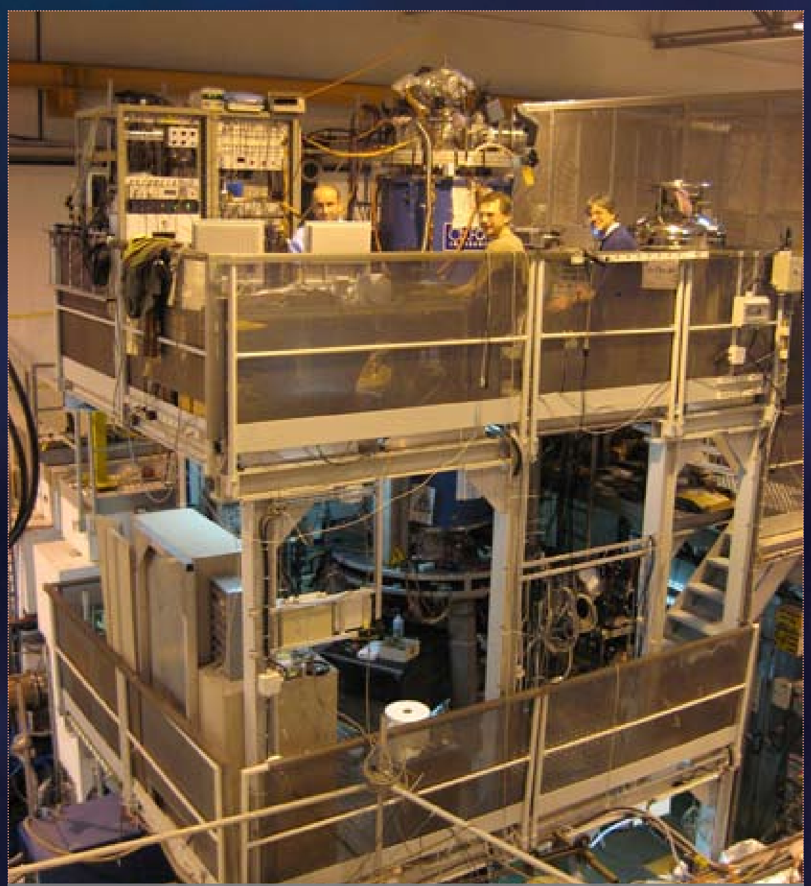
Nuclei come in a variety of sizes and shapes, from spherical to deformed- prolate, oblate and even tri-axial shapes - all can be studied at ISOLDE. One that has been studied thoroughly over the years is lithium-11, which has two valence neutrons far from its core. ISOLDE has measured its spin, electromagnetic moments and decay channels. At the other extreme of the nuclear chart, large deformations are a common sight. Using intense mercury and polonium beams from REX, the MINIBALL detector is presently studying the shapes of the short-lived excited states.



Decay channels of lithium-11

Fundamental symmetries

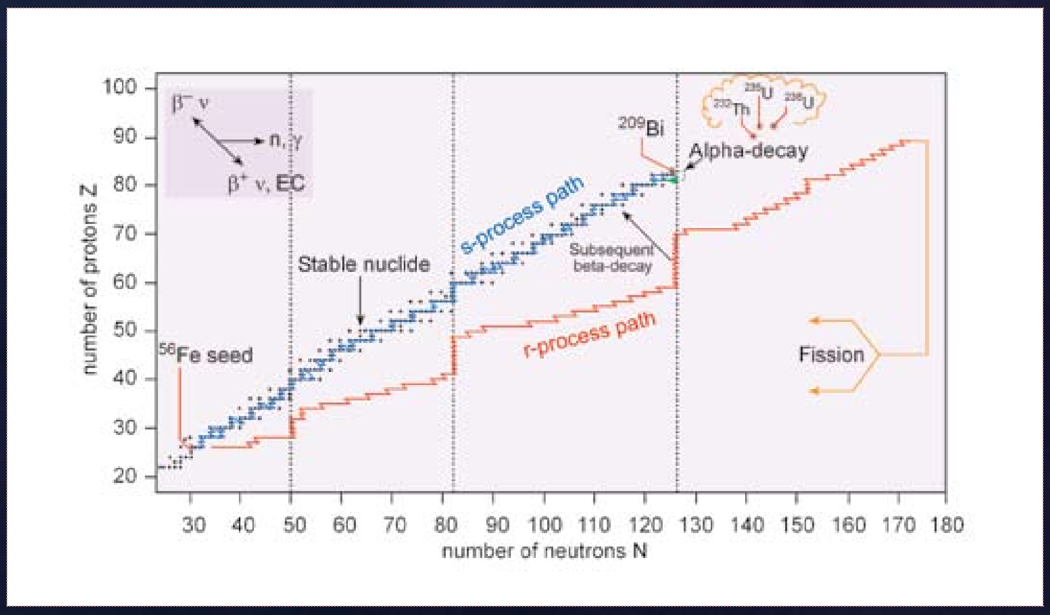
Exotic nuclei can provide an interesting microscopic laboratory for low-energy tests of the Standard Model of elementary particle physics. The recently commissioned WITCH spectrometer will study the electroweak interaction in detail.



The WITCH spectrometer

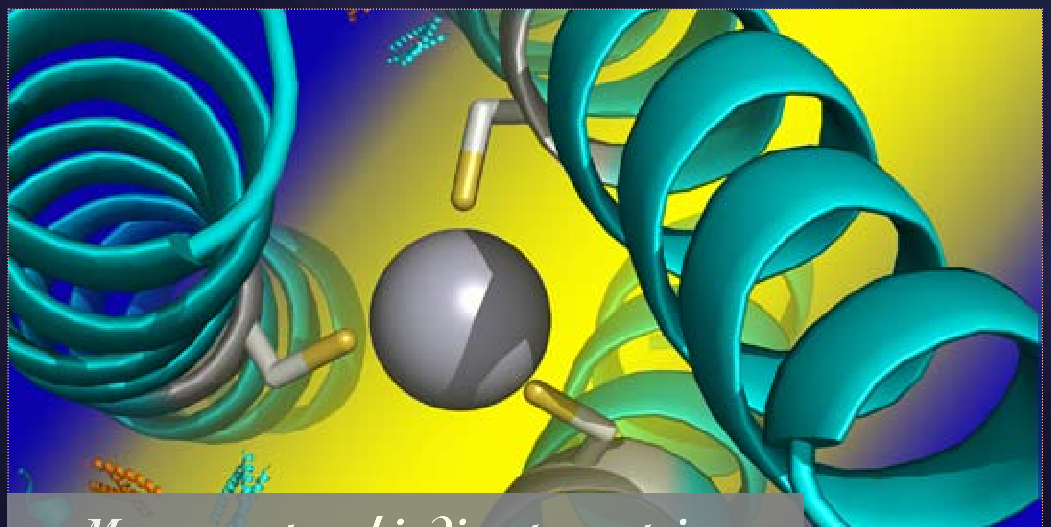
Nuclear astrophysics

One of the biggest mysteries of nuclear physics is how elements from iron to uranium actually formed. Nuclear reactions occurring in stellar explosions, such as supernovae are believed to play an important role in the synthesis of these heavier elements. The reaction pathways include short-lived exotic radioactive nuclei which are studied at ISOLDE. These include the half-lives of silver-129 and cadmium-130, crucial in stellar rapid neutron capture, and the excited states in the element of life carbon-12.

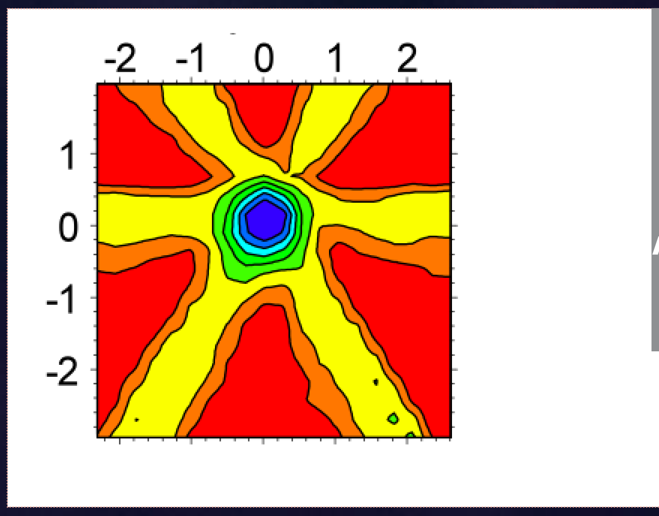


Condensed matter and biophysics

Radioactive elements serve as femto-sized sensors for probing phenomena at nanoscopic scales. This research at ISOLDE has implications for our understanding of semiconductors, metals, high-Tc superconductors and ceramic oxides. There could even be applications for heavy metal elimination or indeed as bio-vectors for treating tumours.



Mercury atom binding to proteins



Radioactive nuclei implanted in a target crystal reveal their position inside the lattice.