Towards SPIRAL2 and EURISOL

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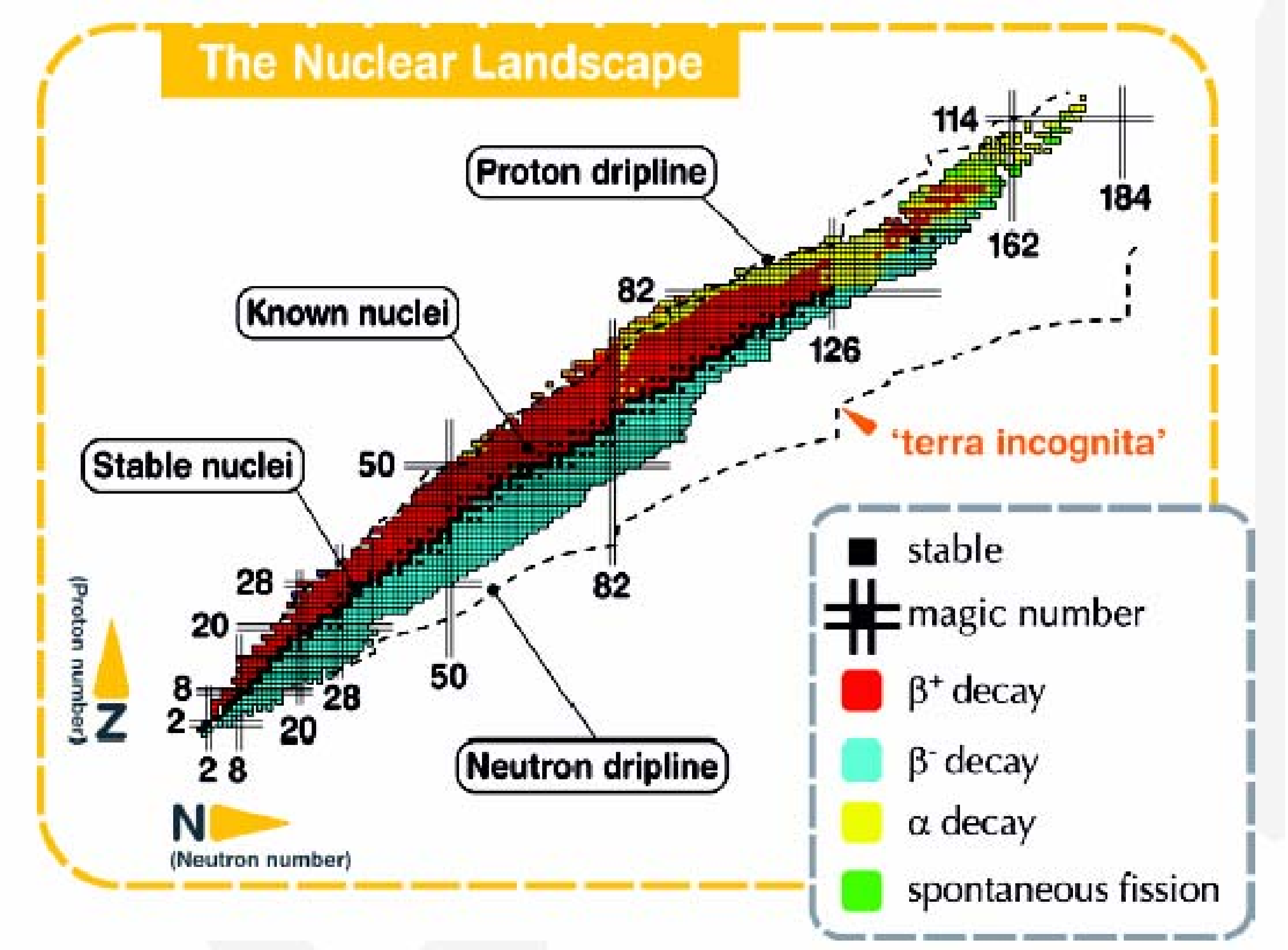
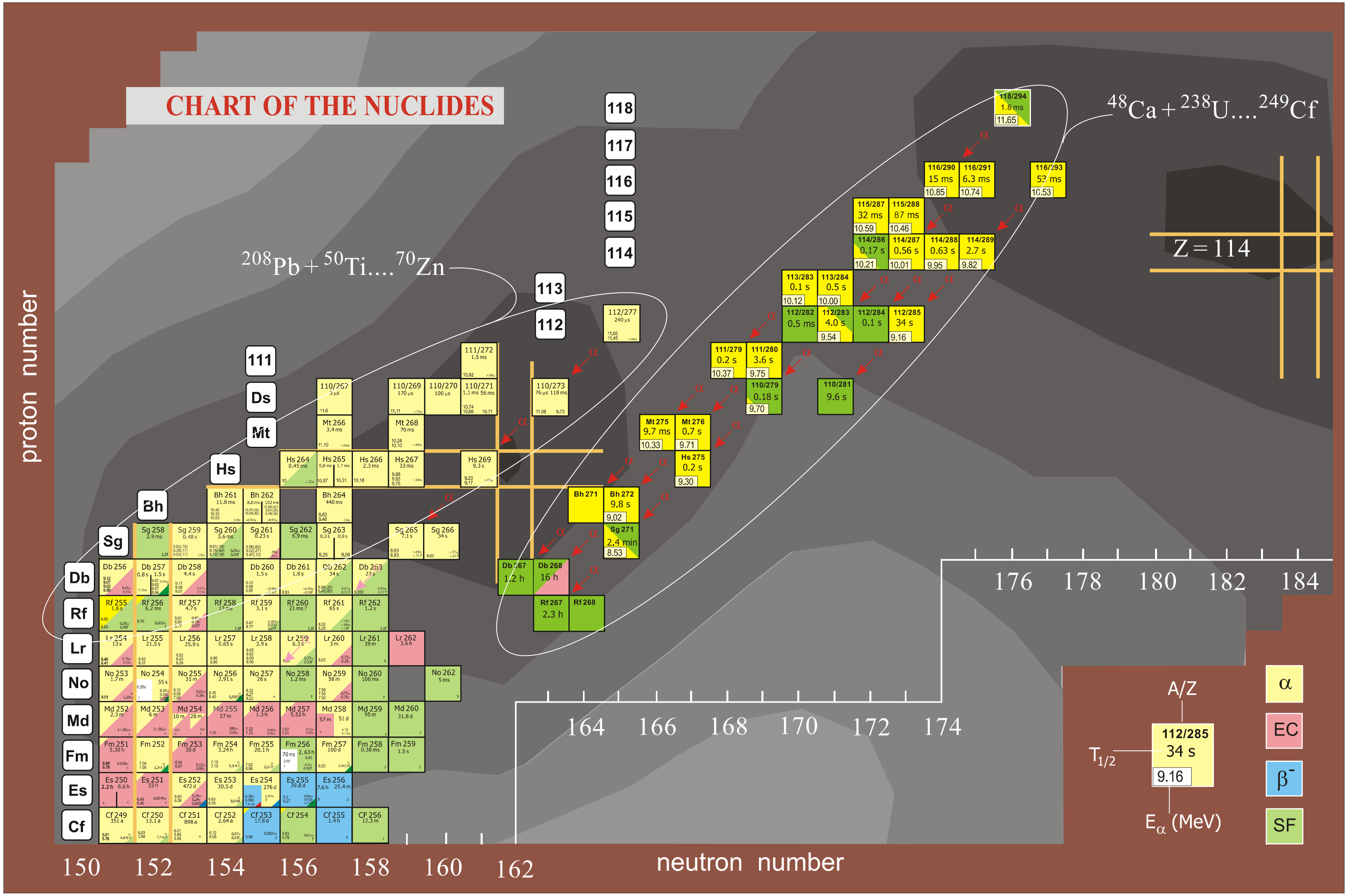
INN Vinca

Limits of stability



SHE-JINR Dubna/LLNL



Berkeley, GSI, Dubna, Riken, Ganil, Jyvaskyla, EURISOL…

Challenges

- Beams/Targets?
- Cold fusion?
- Hot fusion?
- Inverse fission?
- RNB: Cross section?
- Microscopic details
- Spectroscopy
- SHE identification

- Magic numbers?
- Masses?
- Half-lives?
- Fusion dynamics
- Fission barrier
- Fission path
- Shell effects
- Deformation effects

Promising reaction systems

- **Inverse fission**: nuclei close in charge and mass to the most probable cold fission fragments of the SHE may have enhanced fusion caused by shell structure properties
- **Heavy projectiles**: higher Coulomb barrier but lower excitation, i.e. higher survival probability
- $^{76}Se + ^{238}U \rightarrow ^{314}126$ (SPIRAL)
- $^{64}Ni + ^{248}Cm \rightarrow ^{312}124$(DUBNA)

- **RNB(DUBNA)**: 132Sn close to the shells

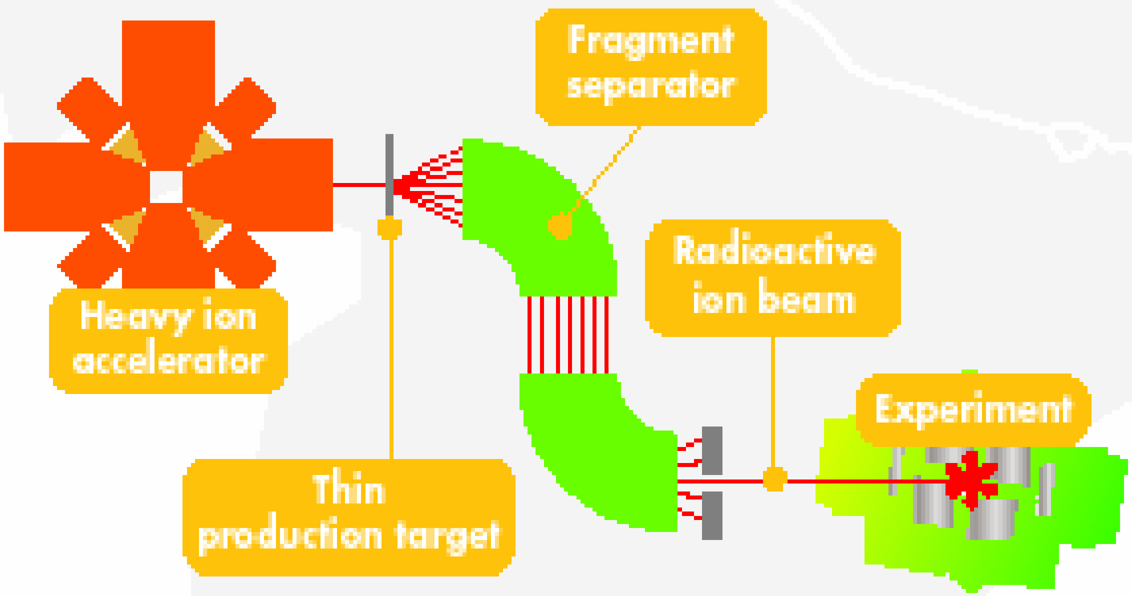
Z=50 and N = 82

$^{160}Gd(^{132}Sn,n)^{291}114$

at1pμA and cross-section of order of 10 pb

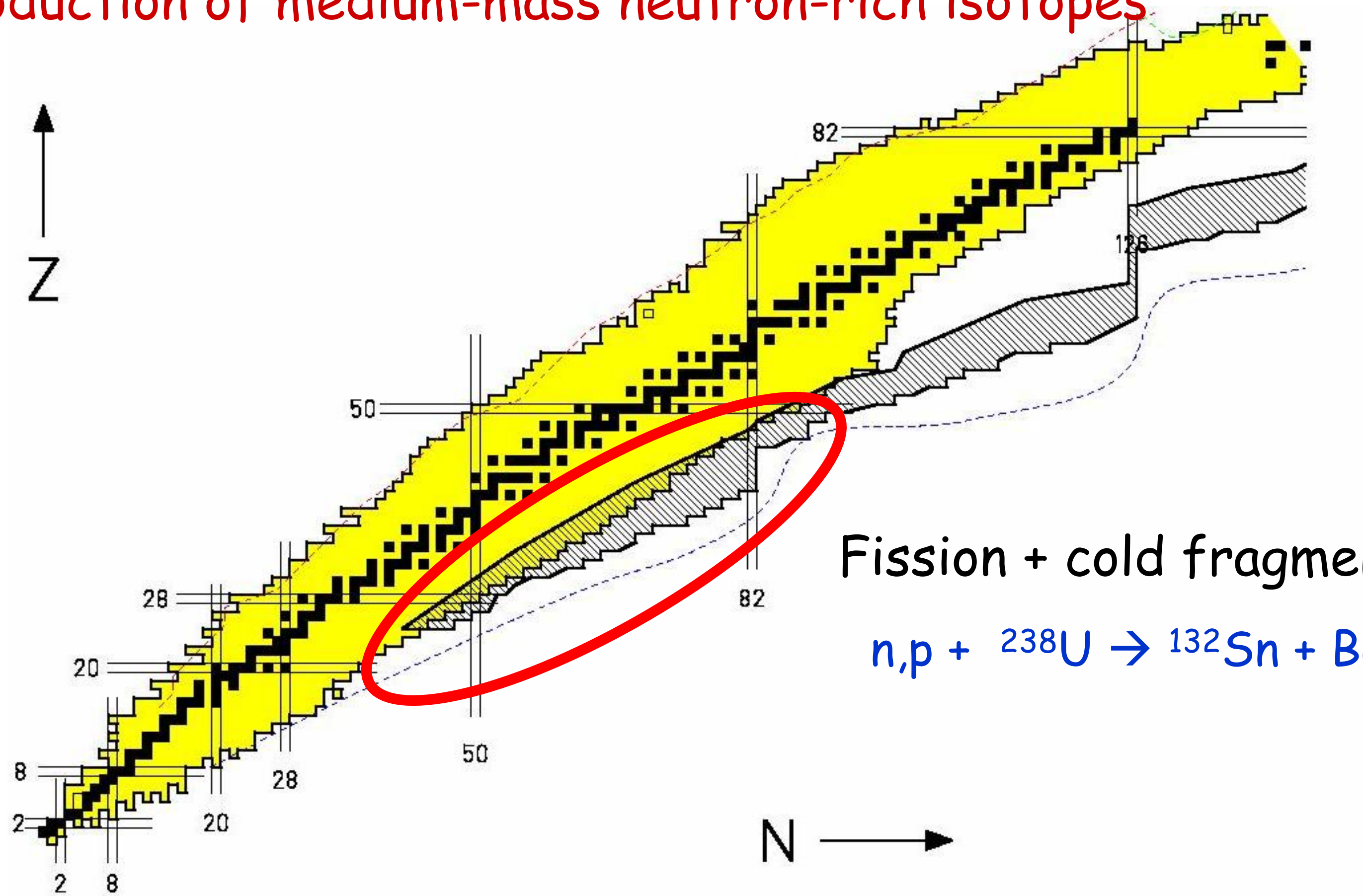
Fragmentation

The RIBs are produced by fragmentation of a projectile on a thin target. The radioactive nuclei created are separated in flight. The secondary beam has high energy and high selectivity, but low intensity.



GSI-Darmstadt/November 2006

- Production of medium-mass neutron-rich isotopes

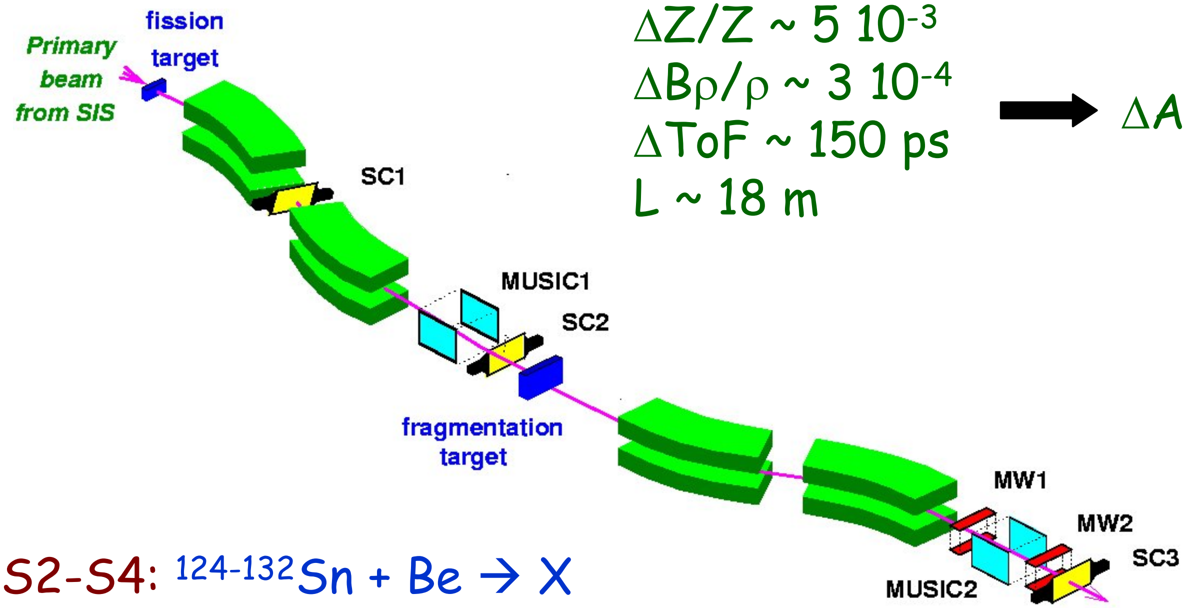


Fission + cold fragmentation

n,p + $^{238}U \rightarrow {}^{132}Sn$ + Be → X

Experimental details

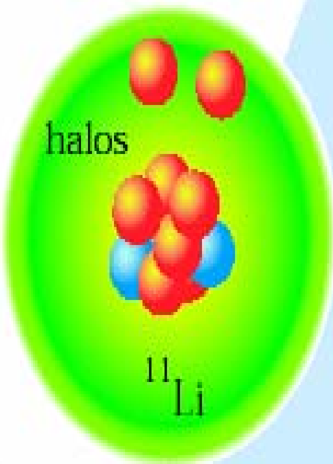
S0-S2: ^{238}U(950 A MeV)+Pb → $^{124-132}Sn$

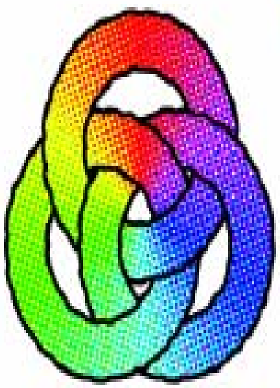


$\Delta Z/Z \sim 5\ 10^{-3}$
$\Delta B\rho/\rho \sim 3\ 10^{-4}$
$\Delta ToF \sim 150$ ps
$L \sim 18$ m
→ $\Delta A/A \sim 4.5\ 10^{-3}$

S2-S4: $^{124-132}Sn$ + Be → X

$\Delta Z/Z \sim 7\ 10^{-3}$
$\Delta B\rho/\rho \sim 3\ 10^{-4}$
$\Delta ToF \sim 150$ ps
$L \sim 36$ m
→ $\Delta A/A \sim 2.4\ 10^{-3}$



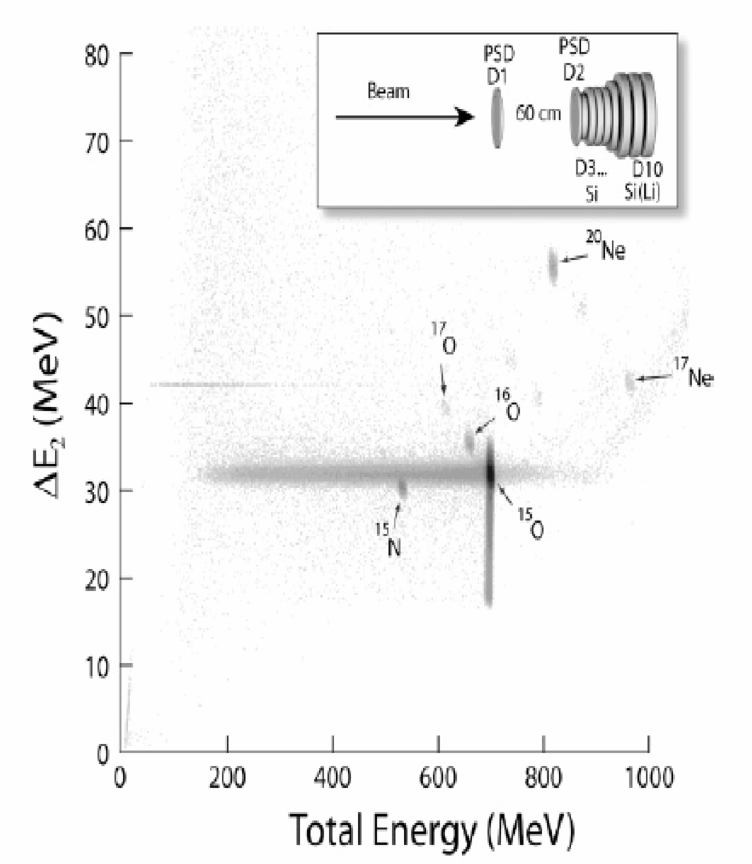


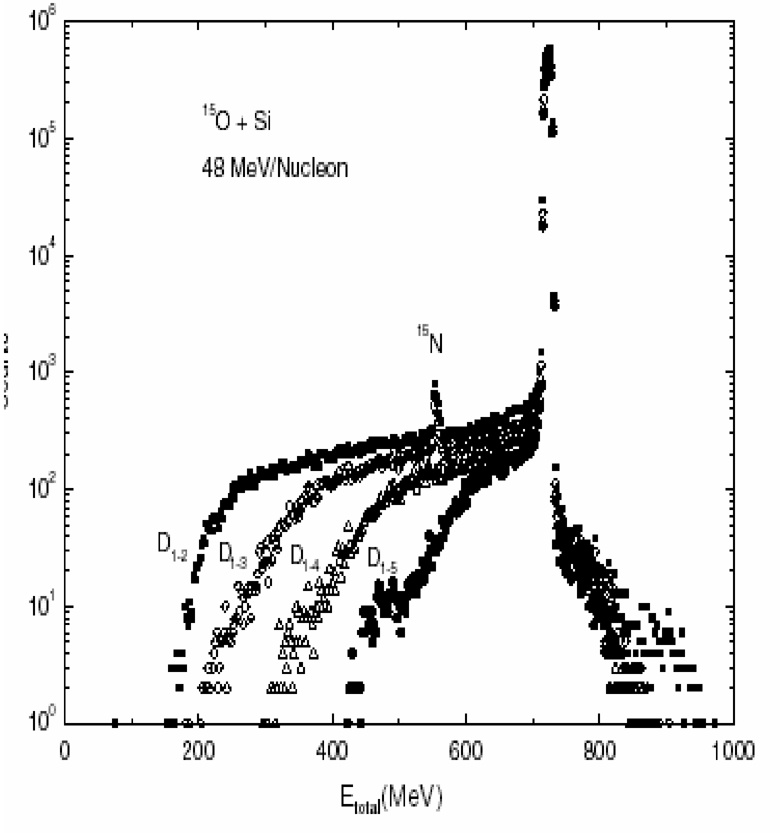
The 3-body "borromean" system ^{11}Li composed of 2 neutrons and a ^{9}Li core. When one bond is broken the system falls apart, just like the rings of the Borromean family crest.

Neutron halos

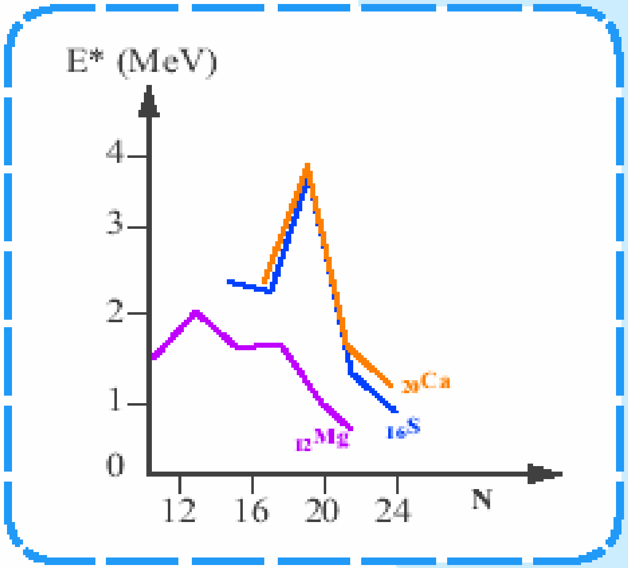
The most neutron-rich among the light nuclei, such as ^{11}Li, ^{14}Be, ^{22}C, present a halo structure, one or more of their neutrons orbiting around a core. They have a very large spatial extension, ^{11}Li with only 11 nucleons being as big as ^{208}Pb. Only interactions in the continuum make these nuclei bound. To fully understand the structure of halo nuclei, researchers will need better detection techniques, more intense beams, and also access to heavier nuclear systems. In this field, EURISOL will provide many new opportunities.

NSCL-Michigan State/2006

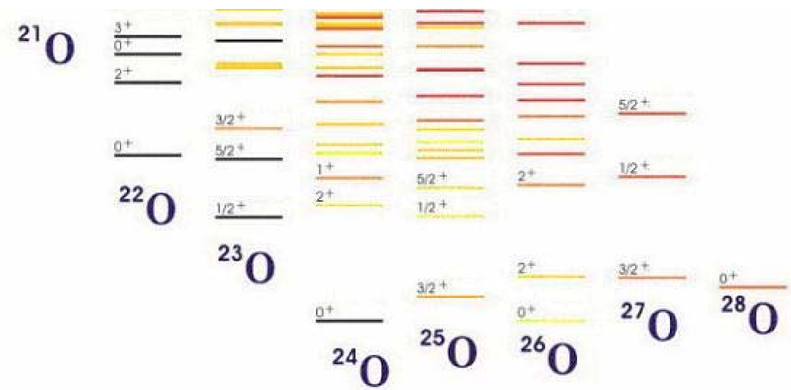




INFN Legnaro/March 2007



Energies of the first excited states of nuclei. A high energy indicates a magic number, here N=20, which vanishes for ^{32}Mg located far from stability.



Exotic radioactivity

The targets at the EURISOL facility will allow a number of hitherto unknown exotic nuclei to be produced. One interesting possibility is to continue a systematic investigation of their radioactive decay. Recently a new type of radioactivity has been discovered in very neutron-deficient nuclei, where two protons are emitted simultaneously by the nucleus.

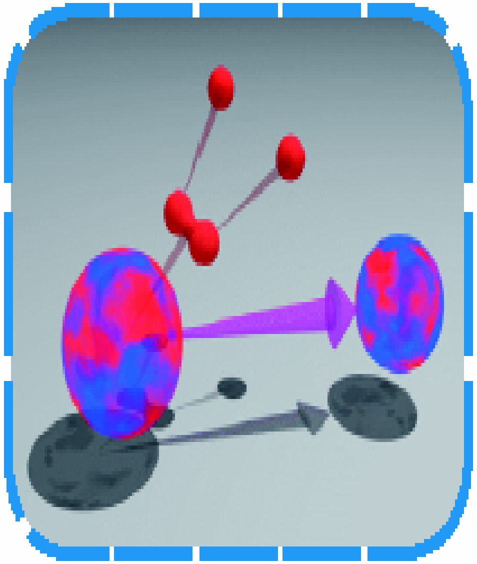


Illustration of the mechanism for 2p radioactivity.

GANIL/October 2007

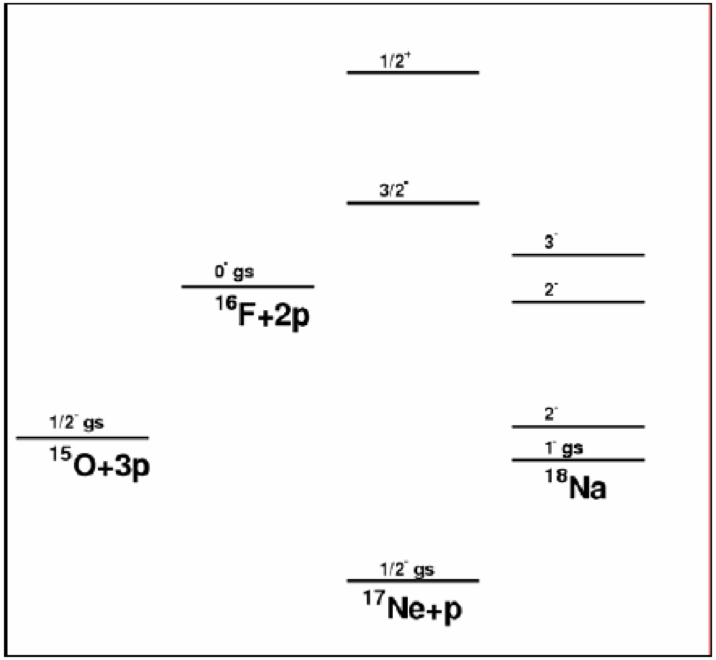
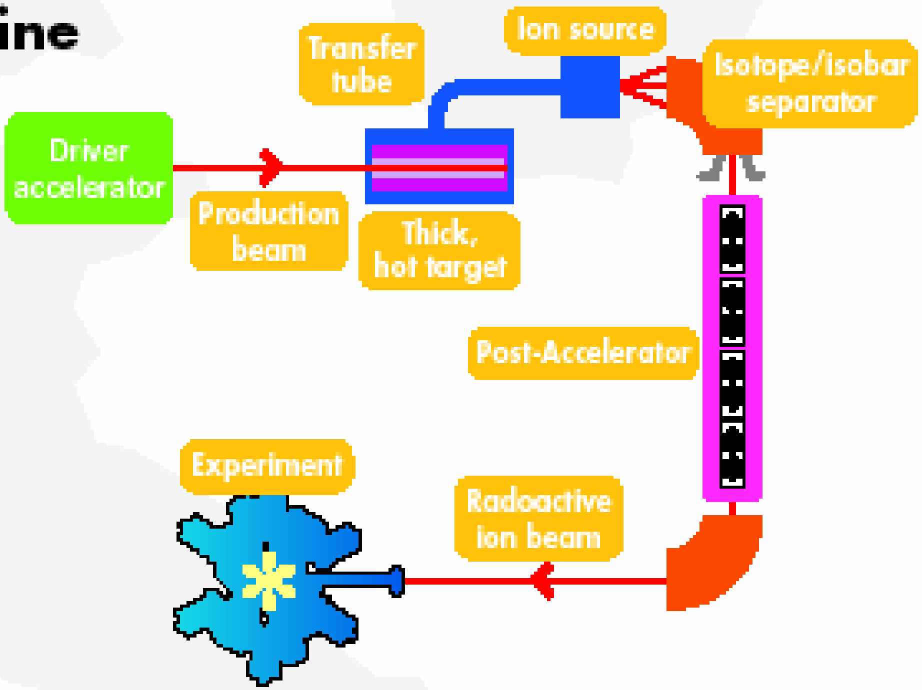


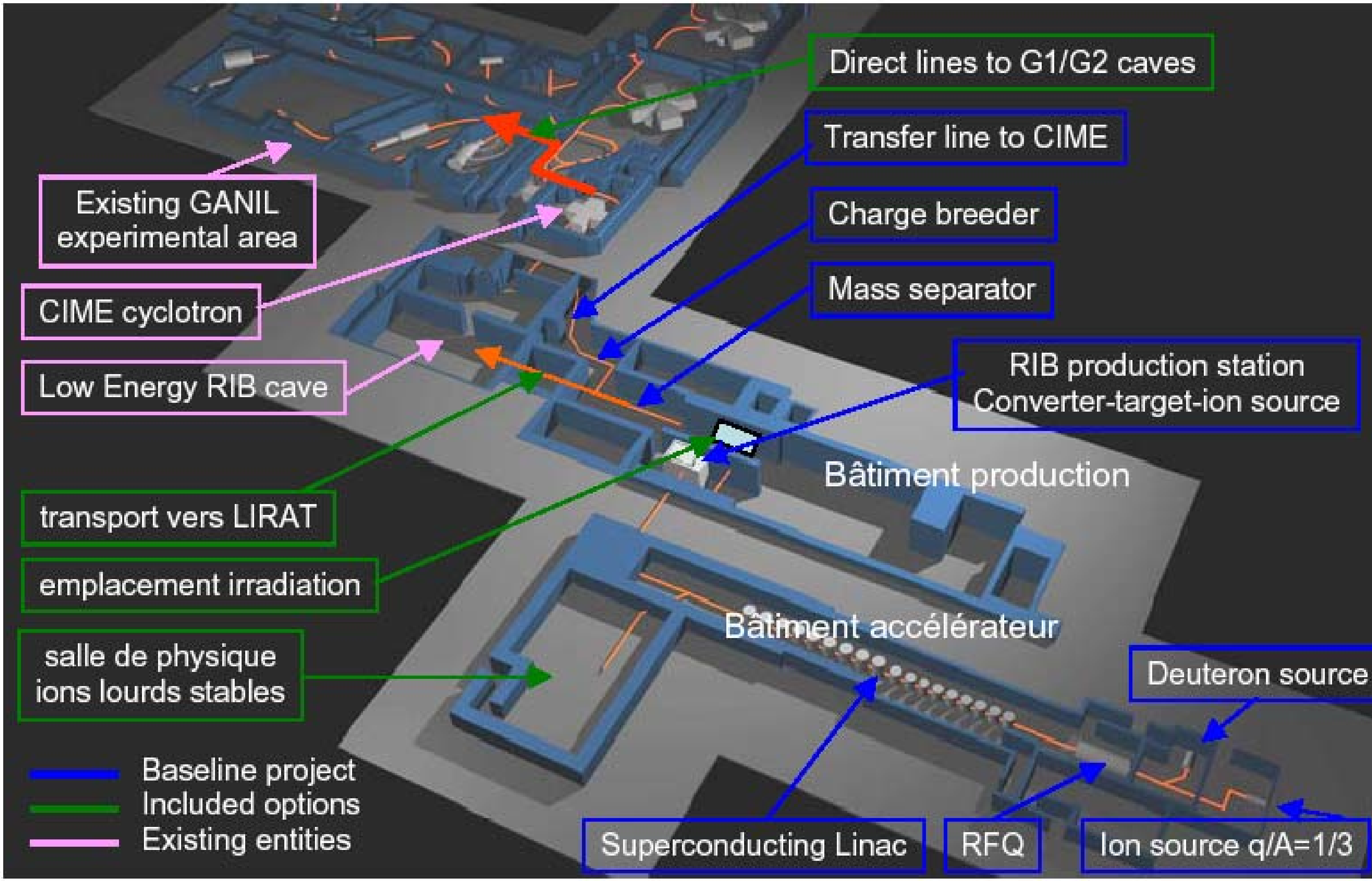
Figure 1: Levels scheme of the predicted low lying states.

ISOL: Isotope Separation On-Line

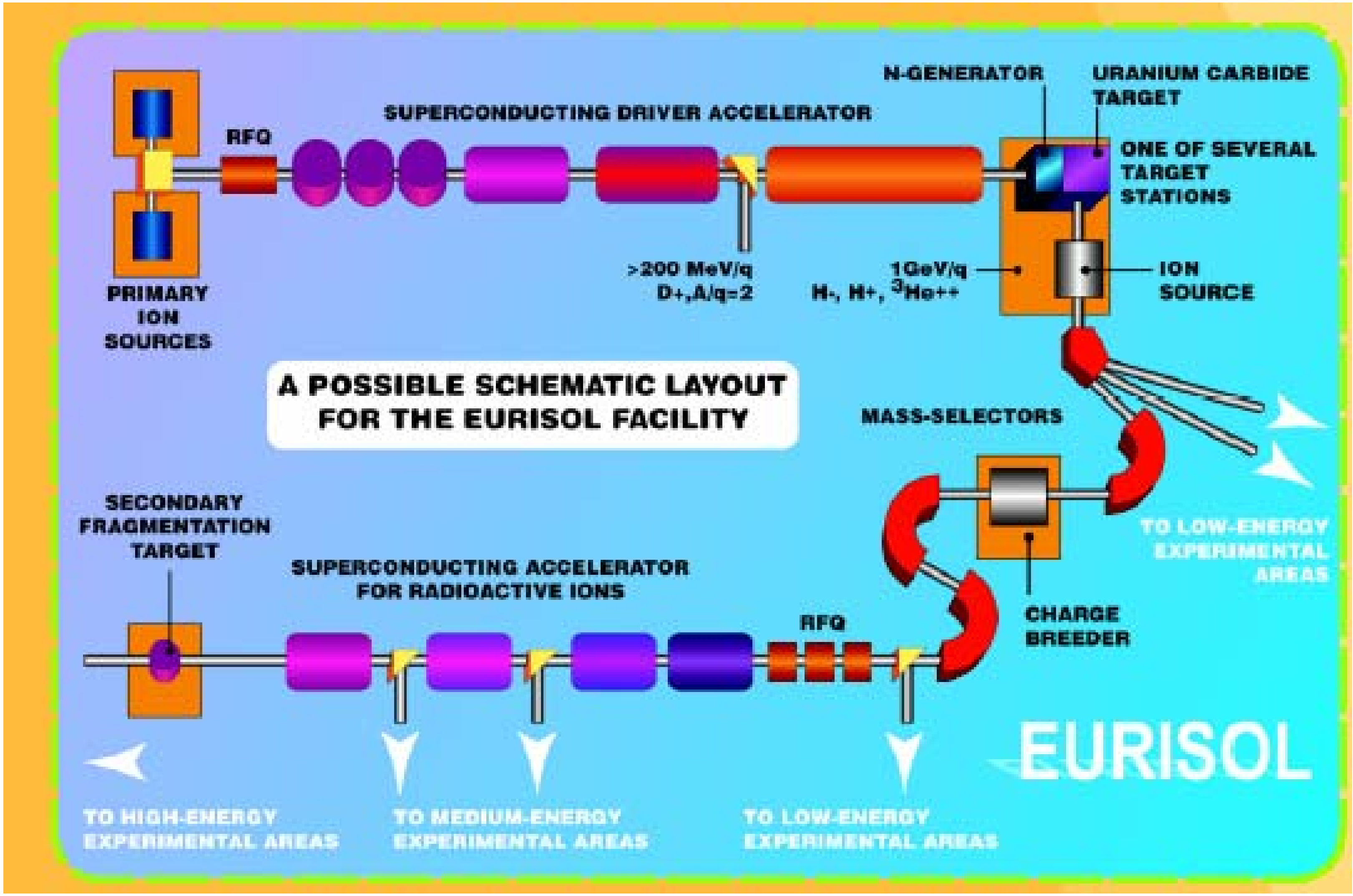
Radioactive nuclides are produced by spallation, fission or fragmentation reactions of a projectile with a thick target. The products of these reactions diffuse out of the target, are ionized, separated on-line, and reaccelerated. The secondary beams are very intense.



SPIRAL2


Direct lines to G1/G2 caves
Transfer line to CIME
Charge breeder
Mass separator
RIB production station
Converter-target-ion source
Existing GANIL
experimental area
CIME cyclotron
Low Energy RIB cave
transport vers LIRAT
emplacement irradiation
salle de physique
ions lourds stables
Bâtiment production
Bâtiment accélérateur
Deuteron source
Baseline project
Included options
Existing entities
Superconducting Linac
RFQ
Ion source q/A=1/3

EURISOL



N-GENERATOR
URANIUM CARBIDE TARGET
SUPERCONDUCTING DRIVER ACCELERATOR
RFQ
ONE OF SEVERAL TARGET STATIONS
>200 MeV/q
D+,A/q=2
1GeV/q
H-, H+, 3He++
ION SOURCE
PRIMARY ION SOURCES
A POSSIBLE SCHEMATIC LAYOUT FOR THE EURISOL FACILITY
MASS-SELECTORS
SECONDARY FRAGMENTATION TARGET
TO LOW-ENERGY EXPERIMENTAL AREAS
SUPERCONDUCTING ACCELERATOR FOR RADIOACTIVE IONS
RFQ
CHARGE BREEDER
EURISOL
TO HIGH-ENERGY EXPERIMENTAL AREAS
TO MEDIUM-ENERGY EXPERIMENTAL AREAS
TO LOW-ENERGY EXPERIMENTAL AREAS

Beta beam

Neutrinos come in three varieties. One of the major discoveries of the last decade is spontaneous oscillations between these neutrino families, which imply that neutrinos are not massless as previously assumed. In order to learn more about these elusive particles and perform stringent tests of quantum symmetries, neutrino physicists need a new type of neutrino beam called beta-beam. The neutrinos would be produced by the radioactive beta decay of massive amounts of unstable nuclei, for example ^{6}He and ^{18}Ne, accelerated close to the speed of light. The seed nuclei would be produced by EURISOL and the beta-beam facility, elaborated within the Design Study, would be a natural extension of EURISOL.

KVI-Physics beyond the Standard Model

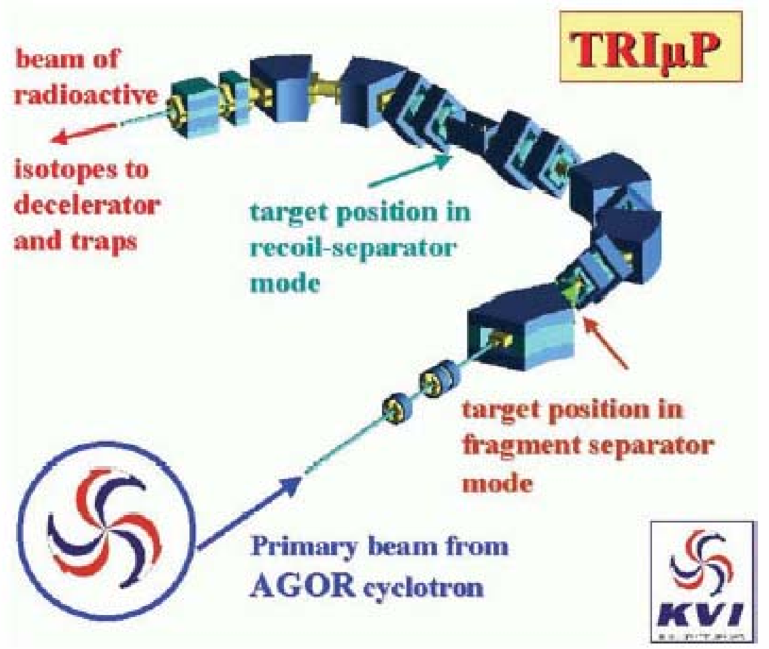


Fig. 1. The TRIμP combined fragment and recoil separator. It is designed to access a large variety of proton-rich isotopes.