International Journal of Modern Physics B

EURISOL DESIGN STUDY: TOWARDS AN ULTIMATE ISOL FACILITY FOR EUROPE

Y. BLUMENFELD[a †], P. BUTLER[b], J. CORNELL[c], G. FORTUNA[d] and M. LINDROOS[a]

a *CERN, 1211 Geneva 23, Switzerland, yorick.blumenfeld@cern.ch*

b Oliver Lodge Laboratory, University of Liverpool, Liverpool L69 7ZE, UK

c GANIL (CEA/DSM-CNRS/IN2P3) BP 5027, 14076 Caen Cedex 5, France

d INFN, Laboratori Nazionale di Legnaro, Legnaro, Italy

Received Day Month Day
Revised Day Month Day

The European roadmap for nuclear physics advocates the construction of two next generation radioactive beam facilities: the projectile fragmentation facility FAIR at Darmstadt, Germany and the ISOL facility EURISOL. The EURISOL concept is being studied in the framework of a pan-european Design Study funded by the European Commission. The general design of EURISOL and the latest achievements in terms of modeling and prototyping are presented.

Keywords: Radioactive ion beams; Isotope separation on-line, superconducting linear accelerators, high power targets.

1. The European Roadmap for Radioactive Beams

There are two main methods to produce Radioactive Ion Beams (RIB): projectile fragmentation and Isotope Separation On Line (ISOL). The evident complementary nature of the two approaches has led NuPECC, the European Coordination Committee for Nuclear Physics, to advise building two next generation facilities in Europe, one fragmentation and one ISOL installation.[1] The fragmentation facility will be FAIR[2] in Darmstadt, Germany, while the ISOL facility is named EURISOL.[3] The start of construction of FAIR is imminent. The technical challenges for EURISOL were found to be too great to envisage rapid construction, and a European roadmap towards the ultimate facility EURISOL was proposed, consisting of the three following elements:

- Vigorous exploitation of the current ISOL facilities: EXCYT (Catania), SPIRAL, and REX-ISOLDE in order to further the scientific case for the field and train a generation of young scientists who will construct and utilize the facilities of the future.

[†]On leave from Institut de Physique Nucléaire, Orsay, France

- Construction of the intermediate generation ISOL facilities which will constitute a unique testing ground for many technical solutions to be implemented in EURISOL. Three such facilities are currently planned: HIE-ISOLDE at CERN, an upgrade of REX-ISOLDE, SPES at Legnaro and SPIRAL2 at GANIL, Caen, possibly the most ambitious.
- Produce detailed engineering designs and prototypes of the most challenging parts of the EURISOL facility in the framework of the EURISOL Design Study, a pan-European Research and Development project supported by the European Commission.

This roadmap is expected to lead to a detailed design of an ultimate ISOL facility for which construction could start during the next decade.

2. The EURISOL Design Study

The EURISOL Design Study was initiated by a call to all European laboratories involved in RIB physics to contribute their expertise to the design of EURISOL and to build and test prototypes of the most challenging elements. Twenty institutions and laboratories from 14 European countries bid to become full participants in the project. In addition, another 20 laboratories from Europe, Asia and North America agreed to take part as contributors conveying their unique know-how on specific points. The European Union agreed to support this study with a contribution of about 9M€, out of a total cost estimated at 30 M€. The participants in the Design Study are listed in table a.

TABLE (a). Participants in EURISOL Design Study

Participant	Country	Participant	Country
GANIL (coordinator)	France	**Inst. Physics Vilnius**	Lithuania
CNRS/IN2P3	France	**Warsaw University**	Poland
INFN	Italy	**Inst. Phys. Bratislava**	Slovakia
CERN	Europe	**U. Liverpool**	United Kingdom
U. C. Louvain	Belgium	**GSI Darmstadt**	Germany
CEA	France	**U. Santiago**	Spain
NIPNE	Romania	**CCLRC Daresbury**	United Kingdom
U. Jyväskylä	Finland	**Paul Scherrer Institute**	Switzerland
L.M.U. München	Germany	**Inst. Phys. Latvia**	Latvia
FZ Jülich	Germany	**Stockholm. U. MSL**	Sweden

In order to cover as efficiently as possible the studies of the various parts of the facility, the Design Study consists of 12 tasks, split into 5 topical areas. Each task is led by an institution, which organizes the collaboration between the participant and contributing laboratories with expertise in the field.

3. General Overview of the Facility

A baseline concept for the next generation ISOL facility has been devised and a schematic drawing of the concept is shown on fig. 1. The driver is a 1 GeV Continuous Wave superconducting LINAC which can accelerate a proton beam with an intensity of 5mA corresponding to 5MW power. Capability for accelerating ^{3}He, deuterons and A/Q=2 ions, will be included.

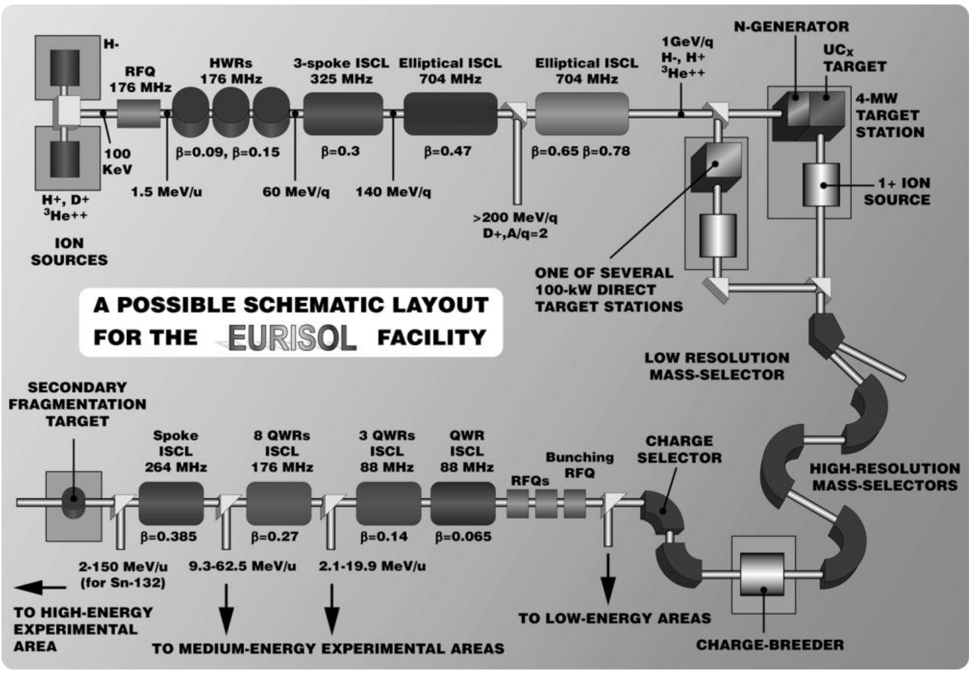

fig 1. Schematic view of the EURISOL Design

At the Multi MegaWatt (MMW) target station, the proton beam will impinge on a liquid Hg converter to produce a copious amount of neutrons in order to induce more than 10^{15} fissions per second in each of six UC_X targets, enriched in ^{235}U. Two different designs for the Hg converter are envisaged, and represented on fig.2. In the Coaxial Guided Stream (CGS) design, which is the baseline design, the mercury is kept under pressure and flows within a double walled tube with a proton beam window at one end. The mercury flows towards the proton beam in the outer part of the tube and along the p-beam in the inner part making a u-turn at the window. The so called Windowless Transverse Mercury Film (WTMF) target avoids the technical difficulties related to pressurized beam windows and is advantageous in terms of neutronics. Mercury flowing through the upper tube is guided into a vertical jet by sets of fins. Prototypes of the two systems have been built and are currently being tested at the IPUL laboratory in Latvia.

Fig 2 : Two designs for the MMW converter (see text)

EURISOL targets are derived from the concept proposed by the PIAFE project at ILL in Grenoble and the MAAF project in Munich. Conceptually, a target filled with ^{235}U or other actinide is inserted, through a channel created in the shielding, close to the neutron source at the position of maximum neutron flux. Each target module can be inserted, replaced and serviced by means of remote handling. A schematic view of a target module is shown on fig.3.

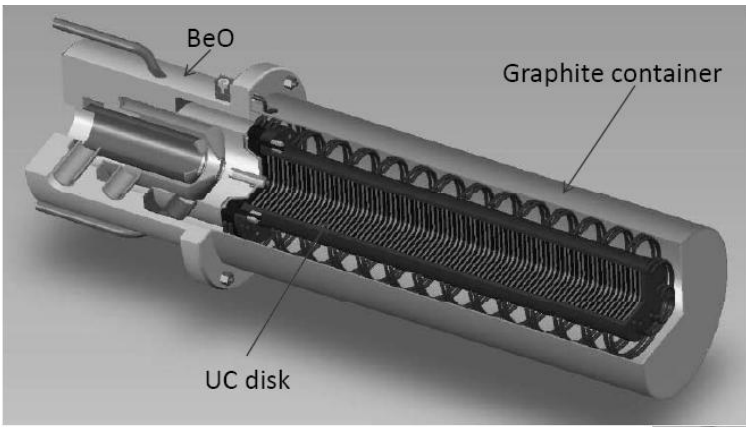

Fig.3 Schematic view of one of the UCx targets

Thanks to an original beam splitting system based on magnetic stripping, a small fraction of the beam (100 kW) will impinge directly on spallation targets. The beam from the target stations has to be prepared for the post acceleration with the merging, cooling, mass-separation and charge state multiplication of the six beams from the multi MW fission targets representing the biggest challenge. Preliminary studies have been performed of merging using a so-called arc ECRIS source which has geometry suitable for injection of several beams into an ECR plasma from which a single beam later can be extracted. The transverse cooling will be done in a newly developed high intensity RFQ cooler. The mass separation will be done with a classical dipole systems consisting of up-to four independent dipoles. The charge breeding will be done in either an ECR source or in a new high intensity CW EBIS source which is under development.

The beams will be reaccelerated by a superconducting LINAC with minimum beam losses. The design of the first stages of the LINAC is similar to that of the SPIRAL2 driver. The final energy of the RIB can be adjusted continuously from rest to 150A MeV for ^{132}Sn. EURISOL is designed to provide a large energy range for a wide selection of isotopes which will allow physicists to combine a unprecedented variety of complementary probes for the study of exotic nuclei.

4. Summary

An ultimate ISOL facility such as EURISOL holds broad scientific promise but represents a formidable technological challenge. A European roadmap has been established which includes building of 3 so-called “intermediate generation” ISOL facilities: HIE-ISOLDE which is a major upgrade of the current ISOLDE facility at CERN, SPES in Legnaro, Italy and the most ambitious which is SPIRAL2 at GANIL, Caen, France. These facilities, which are precursors to EURISOL will provide a ground for development and testing of many of the technological solutions outlined in the reports from the EURISOL Design Study realized by 20 laboratories representing 14 European countries. The community will then need to demonstrate the cohesion necessary to select a site and the determination needed to obtain the funding before the first exotic nuclei from EURISOL could be produced around the year 2020.

Acknowledgments

We acknowledge the financial support of the European Community under the FP6 “Research Infrastructure Action - Structuring the European Research Area” EURISOL DS Project Contract no. 515768 RIDS. The EC is not liable for any use that can be made of the information contained herein.

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