

# **The DESIR facility**

## ***Désintégration, excitation et stockage d'ions radioactifs*** ***(Disintegration, excitation and storage of radioactive ions)***

### **Status report for the SPIRAL2 Scientific Advisory Committee meeting on November 26, 2007**

The DESIR collaboration, formed after the SPIRAL2 workshop on low-energy physics at GANIL in July 2005, proposes the construction of an experimental facility to exploit the low-energy beams from SPIRAL and SPIRAL2. Nuclear physics as well as fundamental weak-interaction physics and astrophysics questions will be addressed using laser spectroscopy techniques, decay spectroscopy of radioactive species, mass spectrometry and other trap-assisted measurements.

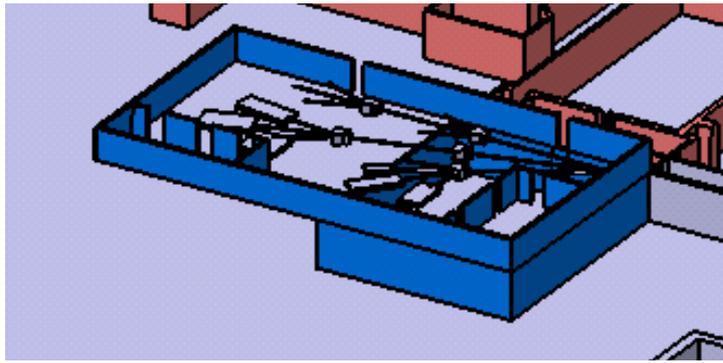
From experience at other ISOL facilities (e.g, ISOLDE and ISAC) it is stressed that ion beams with a high degree of purity are needed to push experiments towards the limits of stability. The most efficient and universal way of achieving isotopically pure beams is a high-resolution mass separator in combination with a high-efficiency cooler and buncher and, if possible, with element-selective ion sources. An even higher degree of purity can be achieved by using Penning traps to clean the beam. However, the clean samples prepared by a Penning trap system are paid off with a loss of intensity due to transmission and decay losses. Nonetheless DESIR will use both methods to provide beams as clean as necessary for the different experiments envisioned.

In order to reduce the amount of activity transported and the contamination level in the DESIR experimental hall, the first cleaning stage, i.e. the RFQ cooler and buncher and the high-resolution separator (HRS), will be installed in the SPIRAL2 production building. Beams from both production caves, the red and the yellow one, will be fed into the RFQ-HRS system. DESIR will thus provide proton-rich as well as neutron-rich exotic species for experiment at ISOL energies.

Since the submission of the Letter of Intent for DESIR, significant progress has been made in turns of the design of the DESIR building, in the setting up and the study of the RFQ cooler, in the study of the HRS, with respect to setups permanently or temporarily installed at DESIR as well as on the financing of the different parts of DESIR and its equipment. We will discuss the most important of these items in the following.

#### **The DESIR hall**

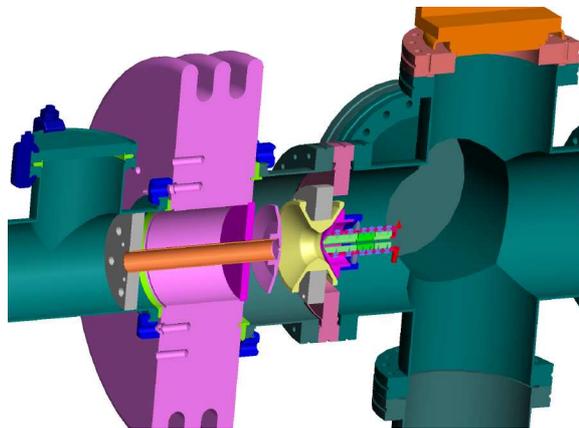
In the course of the detailed definition of the LINAG and the AEL buildings, the general layout of the production building as well as of the DESIR building has been refined. Figure 1 shows a sketch of the DESIR building. It is foreseen that the DESIR hall will have a size of about 1500m<sup>2</sup>. Close to the hall, there will be a control room, an electronics and acquisition room, a meeting room as well as a kitchen. Most likely in the basement, several experimental rooms, clean rooms, workshops and storage rooms will be provided. A more detailed description is given in appendix 1.



*Figure 1: Schematic layout of the DESIR experimental hall and its basement as envisioned today.*

### **The RFQ cooler and buncher**

A prototype of the RFQ cooler and buncher SHIRAC (Spiral2 High Intensity Radiofrequency Cooler) has been setup originally at CSNSM Orsay and was recently transferred to LPC Caen for further development. The project aims at the development of a high-voltage (20 kV), high-frequency (20 MHz) quadrupole for strong confinement of microampere beams (see figure 2). Using smaller geometries for higher confinement requires extra care in the design of the electrode surfaces to avoid electrical discharges. Also, a new injection geometry using a mass-dependent quadrupole field has been developed.

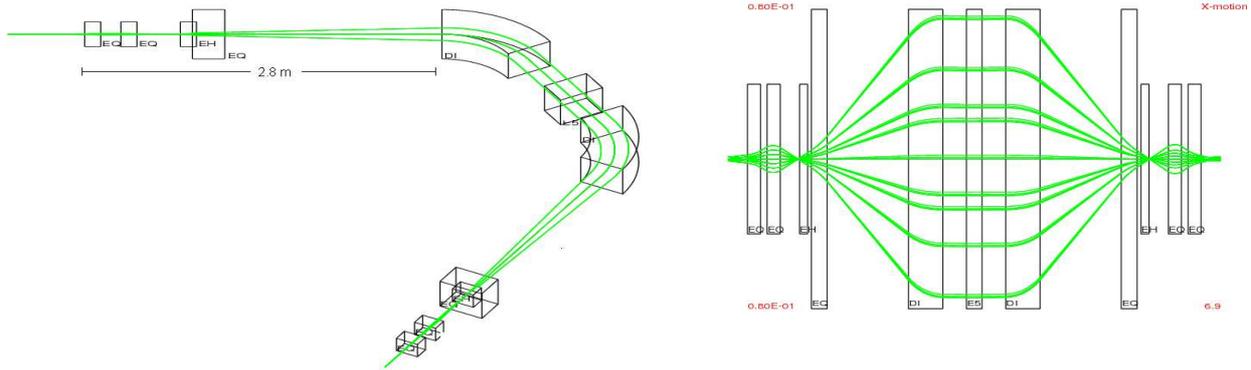


*Figure 2: Details of the hyperbolic injection electrodes (operated with DC voltages) and the first trapping segments (operated at radiofrequency voltage). The final system will comprise about 30 segments and similar extraction geometry.*

### **The high-resolution separator**

The proposed HRS design consists of two magnetic dipoles (D), six quadrupoles (Q), two sextupoles (S) and a multipole (M) with the configuration QQHQMDDQHQQ as shown in Figure 3. This symmetric design is inspired by the CARIBU HRS at Argonne National Laboratory and helps to minimise aberrations. Since we are seeking to separate isobars, the dispersion should be maximised. Large mass dispersion and small aberration coefficients are

obtained by increasing the incident and exit angles at the boundary of the magnets. Two  $60^\circ$  bending dipoles with  $23^\circ$  both incident and exit edge angle were chosen. Quadrupoles are used to focus the beam along the  $y$ -direction and to defocus it along the  $x$ -direction. This brings about two advantages simultaneously: A high transmission and a small image magnification to attain high resolution. The small  $y$  size minimise  $y$ -aberrations and the large  $x$ -area in the dipoles gives mass dispersion. The reverse matching section transforms the ribbon-shaped beam back to a circular cross-section at the focal plane. The two sextupoles and the central multipole (sextupole, octupole, decapole and duodecapole) allow correcting aberrations to 5<sup>th</sup> order. This separator is in the design phase and will be incorporated in the production building as soon as the general layout of the building and the HRS are fixed.



**Figure 3:** Left: General layout of the high-resolution separator for DESIR. The design is largely inspired by the CARIBU separator at Argonne. The symmetric shape allows minimizing certain optical aberrations. Right: Beam envelope calculations in  $x$  direction for a beam emittance of  $1 \pi \text{mm mrad}$ . The aperture of the central elements is  $1 \text{ m}$ .

### Experimental setups for DESIR

In the following we give a list of equipments which will be installed more or less permanently in the DESIR hall or which will come at least temporarily to DESIR. The institute given in parentheses is the main investigator. Many other laboratories will contribute as well. These set-ups are/will be financed by the contributing institutes.

- MLL trap system (LMU Munich)
- $\beta$ -delayed charged particle setup (Bordeaux, GANIL, Strasbourg, Orsay, Madrid)
- $\beta$ -NMR setup (Leuven)
- Collinear laser setup (Manchester, Birmingham, Orsay, Leuven)
- MOT trap (KVI Groningen)
- TAS setup (Valencia)
- TETRA neutron set-up (Dubna, Orsay)
- Neutron energy set-up (LPC Caen)
- LPC trap (LPC Caen)

### Possible connection between the S3 separator and the DESIR hall

The S3 collaboration proposes the construction of a high-intensity two-stage separator for in-flight separation of fusion-evaporation or deep-inelastic reaction products. At the exit of this separator, a gas catcher will allow to thermalize the reaction products in order to use them

at ISOL energies for mass measurements, collinear laser spectroscopy, etc. The experimental set-ups needed for this kind of physics will be to a large extent available at DESIR. Therefore discussions started to inquire whether a connection of the exit of S3 with DESIR can be envisioned. If this option is considered interesting, care should be taken from the beginning to facilitate this possibility.

### **Organisational structure of the DESIR collaboration**

The DESIR collaboration is organised as follows:

- a spokesperson
- a GANIL liaison person
- a DESIR Collaboration Committee (about 10 persons)
- the members of the DESIR collaboration (about 100 scientists)

### **Financing of central parts of the DESIR facility**

Set-ups as mentioned above will be financed by the different groups interested in the physics program. However, the central parts of the DESIR facility like the DESIR building, the RFQ cooler, the HRS and the beam lines have to be financed by a common effort.

For the moment, the situation is such that the RFQ cooler will be financed via the French CPER contract between the France and the region of Normandy. The same source will also contribute to about 50% for the DESIR experimental hall. Therefore, half of the DESIR building (about 3 MEuros), the HRS (816 kEuros), and the beam lines (3.6 MEuros) have still to be financed.

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## Appendix: Details about the DESIR building

LOCAL	surface	DESCRIPTIF GENERAL DU LOCAL
RFQ cooler	16 m <sup>2</sup>	Salle équipée du RFQ Cooleur et du HRS
High-resolution separator	50 m <sup>2</sup>	Salle équipée du RFQ Cooleur et du HRS
Experimental hall (50 * 30 )	1500 m <sup>2</sup>	Hall d'expérience DESIR comprenant les installations LUMIERE, BESTIOL et autres
Laser room	30 m <sup>2</sup>	Salle équipée de Laser (expériences)
Test source stand	15 m <sup>2</sup>	Préparation faisceaux ions stables + point d'entrée FRs (Bât. Prod.)
Control room	20 m <sup>2</sup>	Salle pour réglage à distance des: RFQ, HRS, lignes de faisceaux et expériences
Data acquisition room	30 m <sup>2</sup>	Salle comprenant les baies électroniques et PC d'acquisition.
Meeting room	25 m <sup>2</sup>	Salle avec table centrale pour réunir 20 personnes environ
Kitchen	12 m <sup>2</sup>	Salle comprenant des équipements ménagers standard de cuisine: four, réfrigérateur, point d'eau
Mechanics workshop	40 m <sup>2</sup>	Atelier d'usinage comprenant: fraiseuse, tour perceuse à colonne...
"Gray" room 1	15 m <sup>2</sup>	Salle de montage et de test pour collage, ouverture de chambre, manipulation de détecteurs fragiles
"Gray" room 2	25 m <sup>2</sup>	Salle de montage et de test pour collage, ouverture de chambre, manipulation de détecteurs fragiles
Experiment setup room 1	25 m <sup>2</sup>	Salle pour montage à blanc des expériences avant installation dans salle d'expérience DESIR
Experiment setup room 2	30 m <sup>2</sup>	Salle pour montage à blanc des expériences avant installation dans salle d'expérience DESIR
Experiment setup room 3	40 m <sup>2</sup>	Salle pour montage à blanc des expériences avant installation dans salle d'expérience DESIR
Storage room	40 m <sup>2</sup>	Salle pour stockage des matériels ayant servis et pouvant être réutilisés pour des expériences futures sur site
Electronics room	30 m <sup>2</sup>	Baies électroniques pour le contrôle commande des pompes, diagnostiques, etc...
High-voltage room 1	30 m <sup>2</sup>	Salle comprenant les armoires d'alimentation HT et aimants de ligne
High-voltage room 2	30 m <sup>2</sup>	Salle comprenant les armoires d'alimentation HT et aimants de ligne
Electronics of equipment	10 m <sup>2</sup>	Salle comprenant les baies d'alimentation automate et diagnostique
Electricity room	15 m <sup>2</sup>	Salle comprenant le tableau d'alimentation électrique
Liquid nitrogen	citerne	Exterieur - pas de local dédié
Radioactive gas collection	balloons	Salle comprenant des ballons de stockage gaz reliés à la cheminée d'extraction du GANIL