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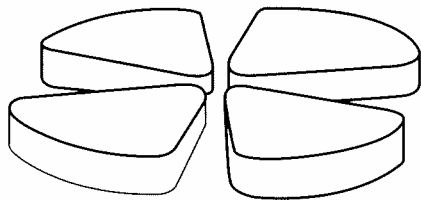
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# **GANIL**



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L. Maunoury, T. Been, B.A. Huber, H. Lebius, D. Leclerc, A. Lepoutre, V. Mouton, J.M. Ramillon,  
R. Vicquelin  
CIRIL, Unité mixte CEA-CNRS-ISMRA, BP 5133, 14070 Caen Cedex 5, France

R. Leroy, J.Y. Pacquet  
GANIL, bd Henri Becquerel, BP 5027, 14076, Caen cedex 5, France

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# THE LIMBE FACILITY AND THE ARIBE PROJECT

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## Abstract

The goal of this paper is to present the facility LIMBE built at GANIL and our extension project ARIBE. This facility is dedicated to the Ion-Surface, Ion-Atom, Ion-Cluster and Ion-Molecule research. It is composed of an ECR ion source called Supershyptic and two beam lines. We will describe the ECRIS, the beam lines and we will give the performances of the facility.

In a second part, we will expose the ARIBE project. The objective is to improve the performances of the LIMBE facility by implementing four new beam lines and a CAPRICE ECRIS mainly dedicated to furnish beams of ions with high charge states for the very low energy physics. We will show the performances of the deceleration system built and tested at AIM (CEA/Grenoble).

We will conclude giving our choices to increase the source performances.

## 1 NOWADAYS : THE LIMBE FACILITY

The LIMBE facility “Ligne d’Ions Multichargés de Basse Energie” or in English “Low Energy Beam Lines for Multiply Charged Ions” [1] was built up and tested during 1999 and 2000. Figure 1 shows a schematic view of this facility. It runs since the middle of 2000. This facility is open to a large kind of experiments using low energy ion beams which cover a range from 1.5 keV/q up to 25 keV/q.

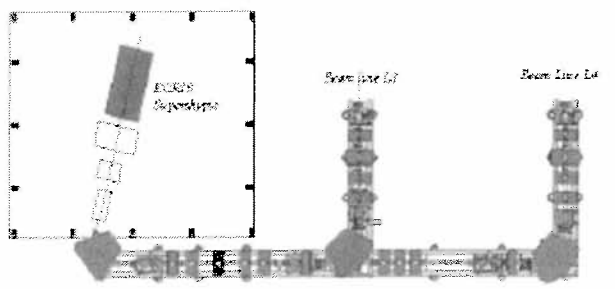


Figure 1: Layout of the LIMBE facility.

At present, about 15 teams are asking for beamtime and many experiments have been performed successfully at the facility. The demanding teams are coming from all over Europe. The LIMBE facility belongs to a European network called LEIF [2] which stands for “Low Energy Ion beam Facilities”. The proximity to the accelerators of GANIL [3] allows the experimentalists to extend the useful energy to very high values (up to 95 MeV/nucleon)

### 1.1 The ECRIS Supershyptic

The ECRIS Supershyptic [1] is an evolution of the ECR4M source. The originality of this source is due to the new conception of its axial magnetic field. It is made by electromagnetic coils and permanent magnets which produce an adjustment of the main profile (fig 2). The sum of these magnetic contributions creates an axial magnetic field which allows to reach a high mirror ratio of about 2.1. The diameter of the plasma chamber is 64 mm for a plasma length of about 250 mm.

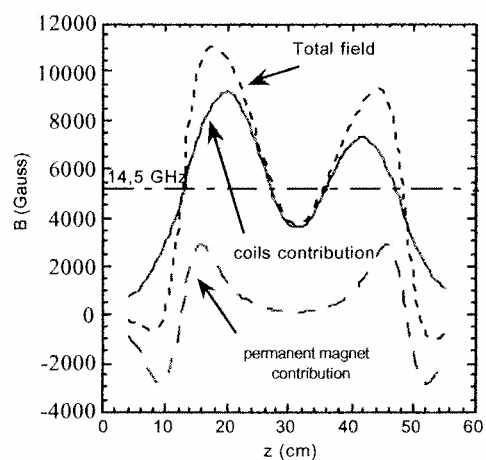


Figure 2: Axial magnetic field profile of the ECRIS Supershyptic

The performances improved thanks to the extension of the hexapole field by two permanent magnet rings. This

extension creates a larger plasma volume and thus higher performances. In Table 1, we show the intensities of the high charge state beams measured after the analysing magnet. Concerning the extraction system, the diaphragms of the plasma and puller electrodes are 12.5 mm and 20 mm wide, respectively, positioned at a distance of 40 mm.

Ion	Intensity (eμA)	Ion	Intensity (eμA)
He <sup>+</sup>	1500	Ar <sup>8+</sup>	250
He <sup>2+</sup>	1500	Ar <sup>14+</sup>	23
C <sup>4+</sup>	250	Ar <sup>16+</sup>	1.9
O <sup>6+</sup>	450	Ar <sup>17+</sup>	0.08
O <sup>7+</sup>	140	Ar <sup>18+</sup>	4.10 <sup>-4</sup>
N <sup>7+</sup>	3.5	Kr <sup>16+</sup>	50
Ne <sup>8+</sup>	170	Kr <sup>24+</sup>	5.2
Ne <sup>9+</sup>	14.5	Xe <sup>23+</sup>	11
Ne <sup>10+</sup>	1.2	Xe <sup>27+</sup>	4.2

Table 1: Beam intensities measured in a faraday cup located after the analysing magnet behind 12 mm slits

### 1.2 The beams lines

At LIMBE (fig 1), there are two beam lines available for the physicists. As the first beam line, named L3, is closer to the source than the second one (L4). It is dedicated mainly for high charge state ions beams : Ar<sup>17-18+</sup> for example. As charge exchange becomes important with increasing pressure, we keep the vacuum at several 10<sup>-9</sup> mbar.

The transmission between the faraday cup located after the analysing dipole and the faraday cup placed at the end of each beam line is 80% and 60% for L3 and L4, respectively. The magnetic rigidity is limited by the analysing dipole to 0.05 Tm which corresponds to a <sup>129</sup>Xe<sup>22+</sup> beam with energy of 20 keV/q or 440 keV of total kinetic energy.

The shape and dimension of the beam, at the focal plane of each beam line, can be varied with the aid of different optical elements. This allows to change the beam size and its shape within the limit of the emittance conservation principle.

## 2 TOMORROW : THE ARIBE PROJECT

### 2.1 The ARIBE project

After the shut-down of the AIM facility in Grenoble , the available equipment has been moved to CIRIL in Caen. It has been decided to improve the performances of the LIMBE facility by integrating the Grenoble devices. Thus the ARIBE project has been created. ARIBE means: "Accélérateurs pour les Recherches Interdisciplinaires avec les Ions de Basse Energie" or in English

"Accelerators for the Interdisciplinary Research with Low Energy Ions Beams". This facility will provide four additional beam lines, one will be dedicated to furnish very low energy beams in a range of a few eV/q.

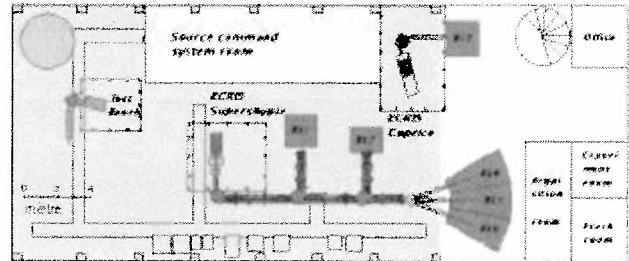


Figure 3: Layout of the ARIBE facility

Figure 3 shows the scheme of the new facility. The clear part represents the extension of the actual building planned to be constructed during the first half of 2003. In the following, we will briefly describe the ECRIS CAPRICE and we will present the first results obtained with the deceleration system.

### 2.2 The ECRIS CAPRICE

The ECRIS CAPRICE (figure 4) is an ECR ion source upgraded from 10GHz to 14.5GHz [4,5]. It is composed of two regular coils for the axial magnetic field and one sextupolar magnet of 1.2 T radial field. The mirror ratio of 2.5 inside the plasma chamber allows to get high performances.

The puller electrode (φ = 16 mm) is fixed and the whole source can be moved to change the extraction gap. The Table 2 summarises the performances of this source. As can be seen, many metallic elements and even fullerene ions have been produced with non negligible intensities.

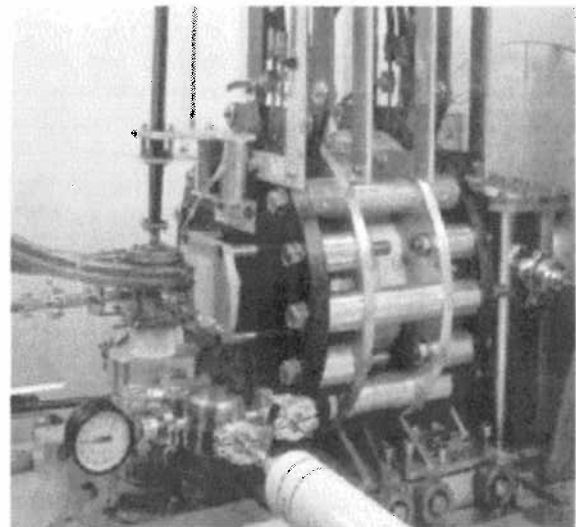


Figure 4: Picture of the CAPRICE ion source

The CAPRICE source will be remounted in the framework of the ARIBE project at the end of 2003. We

will improve the control system by replacing the manual operation by a computer controlled system programmed with the LabVIEW software.

Ion	Intensity (eμA)	Ion	Intensity (eμA)
C <sup>4+</sup>	75.0	Ar <sup>17+</sup>	2.4 10 <sup>-2</sup>
N <sup>7+</sup>	6.0	Ar <sup>18+[5]</sup>	1.6 10 <sup>-4</sup>
O <sup>8+[5]</sup>	1.1	Kr <sup>16+</sup>	9.5
F <sup>7+[5]</sup>	33.0	Xe <sup>30+</sup>	0.4
Ne <sup>9+[5]</sup>	2.3	Xe <sup>31+[5]</sup>	1.8 10 <sup>-1</sup>
Se <sup>8+</sup>	9.5	Ge <sup>10+</sup>	1.3
Er <sup>13+</sup>	3.3	C <sub>60</sub> <sup>27+[5]</sup>	3.0 10 <sup>-3</sup>

Table 2: Beam intensities measured in a faraday cup located after the analysing magnet behind 10 mm slits

### 2.3 The deceleration system

In 2001, a deceleration system has been developed and built up by the AIM group which will be described in more detail in a forthcoming paper [6]. It is made of two stages. The former is composed of five electrodes and allows to slow down the ions by a ratio of 100 and the later is made of three electrodes decreasing the energy by another ratio of 200. This choice has been taken because it allows to slow down the ions and, at the same time, to focus them. Figure 5 shows a picture of this system recorded at the AIM facility. The white part corresponds to the insulators of the first stage.

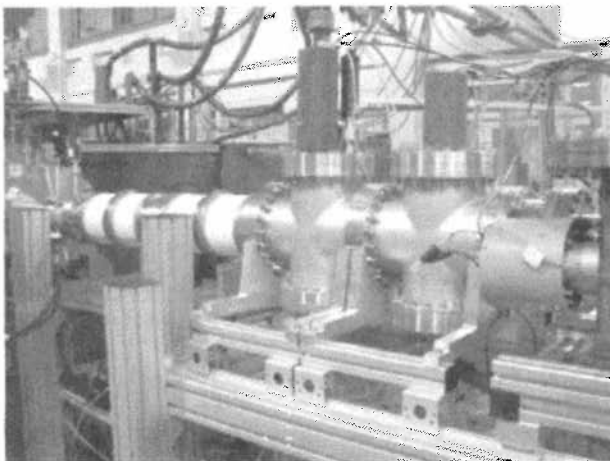


Figure 5: View of the deceleration system

The tests have been performed in July 2001 at the AIM facility with the CAPRICE beams. We have used a standardised LEIF faraday cup. The beam is defined by a

set of two diaphragms (2 mm of diameter) separated by a 50 mm distance, located just in front of the faraday cup.

The measurements showed that the developed system is able to deliver ion beams at energies of several eV/q with reasonable intensities. As an example, Ar<sup>16+</sup> ions have been slowed down to energies of ~ 2 eV/q with intensities of ~ 200 pA and an emittance of the beam which is smaller than 20 π.mm.mrad. The ion beam energy spread descends to less than 1 eV/q for high charge states.

### 3 CONCLUSION

At present, LIMBE is operated with two beam lines and more than 20 experiments have been successfully performed. The upgrade of this facility to ARIBE will open new fields of activities, especially by the implementation of an ECR ion source and a deceleration system for producing very low energy beams. It is then possible to produce beams of highly charged ions at the GANIL site with kinetic energies ranging from 10 eV to 6 GeV. The ARIBE beams will be available at the end of 2003.

The request for highly charged ion beams requires to further improve the ion source performances. Two developments will be initiated concerning the Supershyptie ECRIS. The extraction side should be modified in order to enhance the beam transport which is actually quite low : between 10% and 40% depending on the ion extracted current. We want also to replace the actual microwave injection part by a system which allows for the injection of two frequencies [7] (14.5 GHz and 10 GHz). This will mainly improve the distribution of the high charges states.

We will adapt the "MONO1000" [8] ion source to LIMBE in order to deliver high intensity singly charged ion beams as required for specific experiments.

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