Optimizing charge breeding techniques for ISOL facilities in Europe: conclusions from the EMILIE project

P. Delahaye1,a), A. Galata2, J. Angot3, G. Ban4, J. F. Cam4, L. Celona5, J. Choiniski6, P. Gmaj6, P. Jardin1, H. Koivisto7, V. Kolhinen7, T. Lamy8, L. Maunoury1, G. Patti2, T. Thuillier3, O. Tarvainen7, E. Traykov1, R. Vondrasek8, and F. Wenander9

1GANIL, CEA/DSM-CNRS/IN2P3, Bd. Becquerel, BP 55027, 14076 CAEN Cedex 05, France.
2INFN - Laboratori Nazionali di Legnaro, Viale dell’Università 2, 35020 Legnaro (PADOVA), Italy
3LPSC, Université Grenoble-Alpes, CNRS/IN2P3 ; 53, rue des Martyrs - 38026 Grenoble Cedex, France
4LPC Caen, 6 bd Maréchal Juin, 14050 CAEN Cedex, France.
5INFN - Laboratori Nazionali del Sud, via S.Sofia 62, 95123 Catania, Italy
6Heavy Ion Laboratory, University of Warsaw, ul. Pasteura 5a, 02 093 Warsaw, Poland
7Department of Physics, University of Jyväskylä, PB 35 (YFL) 40351 Jyväskylä, Finland
8Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439, USA
9ISOLDE, CERN, 1211 Geneva 23, Switzerland.
a) Corresponding Author. Electronic mail: delahaye@ganil.fr.

Since the pioneering work of Tamburella et al. for the PIAFE project1, the charge breeding technique in ECRIS and EBIS sources has nicely evolved. The development of the PHOENIX ECR charge breeder at LPSC, and REX-EBIS at ISOLDE by the REX-ISOLDE collaboration, paved the way for many facilities which are now using or developing one or the other technique2. On the roadmap to EURISOL, SPES and GANIL/SPIRAL 1 plan to use a PHOENIX ECR charge breeder, while ISOLDE has upgrade plans for REX-EBIS. The EMILIE project3 gathers 8 European laboratories to tackle present issues of both charge breeding techniques for future facilities, for example:

- The low duty cycle of the EBIS beam, by the development of an EBIS beam debuncher
- The beam purity limitations of ECR charge breeders by using appropriate materials, vacuum and separation techniques
- The relatively low capture of light ions in ECR charge breeders, by optimizing the 1+ ion beam optics

During the EMILIE project, a number of experimental results have been obtained. These concern for example the study of the 1+ beam capture under different conditions using the Phoenix ECR charge breeder at LPSC4,5,6, the capture of light ions using the ANL ECR charge breeder7,8, and the charge breeding of carbon beams at LPSC9. A prototype of hot 1+ ECR source was also developed9. The SPIRAL 1 charge breeder has been upgraded to make use of UHV and pure Al components, optimized gas injection and improved 1+ beam ion optics8, and is now being tested at LPSC10. The ECR charge breeder for SPES, recently tested at LPSC, has shown very good performances for charge breeding of Rb and Cs ions11. The EBIS beam debuncher is being commissioned at LPC Caen and is about to produce first results. As a first milestone, the first trapping tests show that the Paul trap, on which the debuncher is based, can confine ions over periods longer than 100 ms.

This contribution intends to summarize the experimental results obtained in the frame of EMILIE, drawing conclusions on the studies undertaken so far, and discussing a possible optimized charge breeding scheme for future large scale radioactive ion beam facilities like EURISOL.

References

[5]: T. Lamy et al, ECRIS 2014 conference proceedings, JACoW
[6]: O. Tarvainen et al, Plasma Sources Science Tech., in print
[10]: L. Maunoury et al, contribution to this conference
[11]: A. Galatà et al, contribution to this conference