STABLE AND EXOTIC BEAMS PRODUCED AT GANIL

O. Kamalou, F. Chautard, A. Savalle, GANIL, Grand Accélérateur National d'Ions Lourds, CEA-DSM/CNRS-IN2P3, Bvd H. Becquerel, BP 55027 14076 Caen Cedex 5, France

Abstract

The GANIL facility (Grand Accélérateur National d'Ions Lourds) at Caen produces and accelerates stable ion beams since 1982 for nuclear physics, atomic physics, and radiobiology and material irradiation. Nowadays, an intense exotic beam is produced by the Isotope Separation On-Line method at the SPIRAL1 facility (being upgraded to extend the range of post-accelerated radioactive ions) or by fragmentation using LISE spectrometer. The review of the operation from 2001 to 2016 will be presented, with a focus on last year achievements and difficulties.

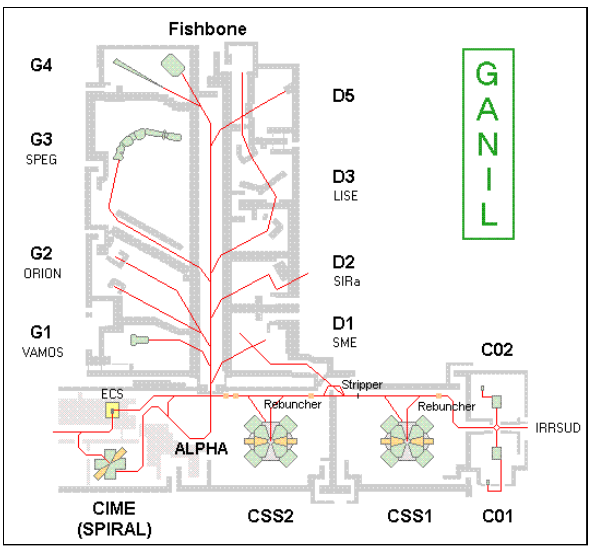

Figure 1: GANIL layout.

OPERATION REVIEW

Multi-beam delivery is routinely done at GANIL using its 5 existing cyclotrons (Fig. 1):

1. Beams from C01 or C02 are sent to an irradiation beam line IRRSUD (<1MeV/A).
2. A charge state of the ion distribution after the ion stripping foil downstream CSS1 is sent to atomic physics, biology and solid states physics line D1 (4-13MeV/A).
3. A high-energy beam out of CSS2 is transported to experimental areas (<95MeV/A), for nuclear physics and previous applications.
4. Finally, stable beams from SPIRAL1 source can be sent to LIRAT (<10keV/q) or post-accelerated by CIME and used for testing detector for example.

During radioactive beam production with SPIRAL1, the combinations are reduced to the two first (cases 1, 2), CSS2 beam is sent toward the SPIRAL1 target, and radioactive beam is sent to the experimental areas.

In addition, Ion sources are available in "hall D" building for atomic physics at very low energy.

2001-2016 GANIL OPERATION STATUS

Since 2001 (Fig. 2), more than 50172 hours of pilot beam time has been delivered by GANIL to physics, which correspond to 88.6 % of scheduled experiments.

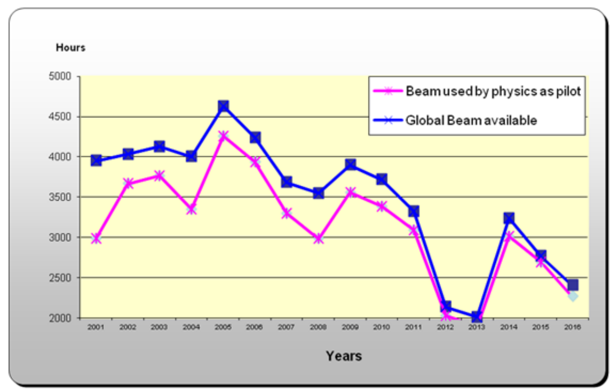

Figure 2: Beam time available for physics over 16 years.

On average, the number of beams delivered per year has increased until 2010. Owing to the construction and assembly of the new SPIRAL2 accelerator and upgrade of SPIRAL1, the running time has been shrinked to devote more human ressources to the project SPIRAL2, in particulier in 2012 and 2013 with only 2000 hours of experiments time (instead of 3500 hours per years).

Figure 3 shows the statistic running of the machine over 15 years. 67.2 % of beam time is dedicated to Physics and 12.4% for machine tuning.

In 2015 (March to July), the pilot beam time was 78%, the failure rate is only 8%. On the other hand, the SME and IRRSUD operation were decreased by several water leaks.

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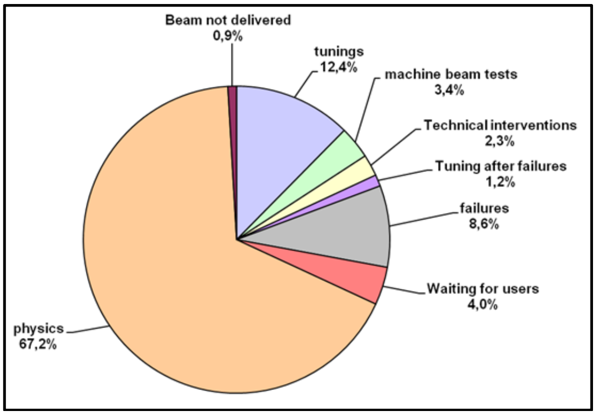

Figure 3: Statistic running of the machine between 2001 and 2016.

WATER LEAK PROBLEMS

The GANIL facility encounters water leak problems mainly on the RF cooling circuits (an example given in figure 4). The cavity of the injector C01 is out of order since March 2016 (Figure 5). A new cavity is under construction. The impact on the beam-time available for the physics is becoming visible. Therefore, in the frame of a preliminary study in 2011, several causes were identified that may induce corrosion or erosion of our circuits. An exhaustive check of the parameters of the water compared to the literature showed that some improvement can be done. Curative or preventive actions foreseen are under consideration:

Figure 4: an example of corroded pipe cooling.

1. Closing the water circuits and keep water free circuits and from any gas dissolves (Oxygen, CO2,…).
2. Go towards a pH above 7 and limit its reduction while being ensured to keep a high resistivity
3. Installation of new mixed beds equipped with electromagnetic sluice gates controlled by a regulation on the basis of measurement of the conductivity of water in order to maintain water with pH> 7.
4. Measure the proportion of sulphates and chlorides.
5. Decrease locally the water flow rate for cooling of power supplies and RF circuits.
6. Maintaining the temperature of the fluids as low as possible.

Figure 5: Electrode cavity of C01.

SPIRAL1 UPGRADE

The first Isotope Separator On Line System installed at GANIL, named SPIRAL1, has delivered radioactive ions for 13 years. Radioactive atoms produced by fragmentation of swift heavy ions on a carbon target are ionized in an ECR multi-charged ion source before being post-accelerated in a cyclotron. The cyclotron energy is 1.2 to 25MeV/A using harmonics 2 to 6.

Due to the design of the Target Ion Source System (TISS), mainly gaseous ions are produced. To satisfy the request of physics community for extending the choice of ions to those made from condensable elements, with masses up to Xe, an upgrade of SPIRAL1 has been undertaken [1]. Beams and technical options considered during the prospective phase have been sorted out. A schematic of the ongoing upgrade is presented in Fig. 6.

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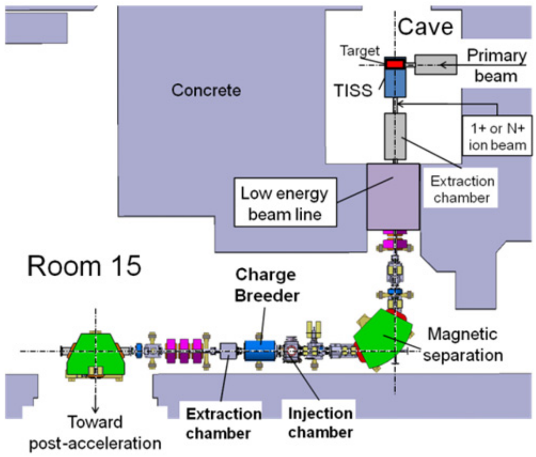

Figure 6: Schematic of the SPIRAL1 upgrade.

A new targets (Nb, SiC,..) and new type of Surface ionization, FEBIAD (Forced Electron Beam Induced Arc Discharge) or ECR (Electron Cyclotron Resonance) ion sources [2, 3] will be installed in the production cave after its modification to provide 1+ beam of condensable elements. Out of the cave and after mass separation, a Phoenix charge breeder will be installed on the present low energy beam line to increase the charge of the radioactive ions from 1+ to N+ for post-acceleration to get energy up to 25MeV/A using CIME accelerator [4].

In 2013 modifications of the production cave have been done in order to install different types of sources.

The charge breeder, based on the phoenix booster developed at LPSC Grenoble, has been used at ISOLDE to measure its performance. Several improvements have been done since. Beam optics, vacuum quality and beam purity are improved [5, 6].

The booster and its injection and ejection beam optics system have been tested at LPSC Grenoble in 2015.

Nuclear safety authorization was given on 11th of February 2015. The processes of installation and modification of the beam line will be finished soon (see Figure 7 before and after beam line modification). The commissioning with stable beam is scheduled by the end of 2016.

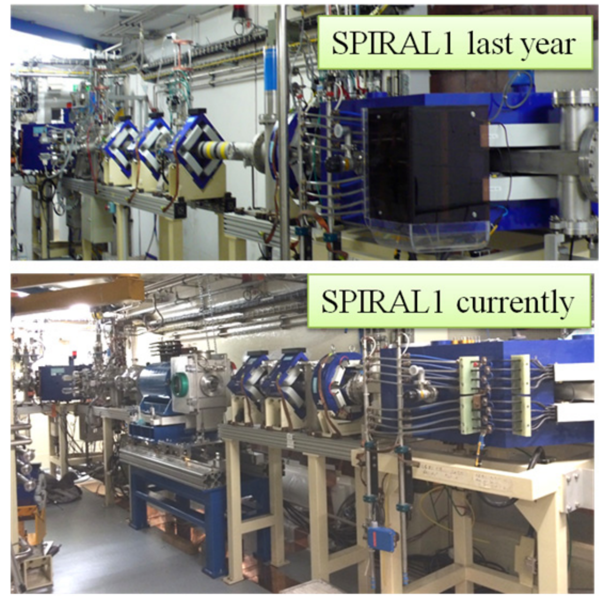

Figure7: Evolution of SPIRAL1 low energy p branch with the insertion of the charge booster.

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