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The September 1997 status of SPIRAL project and future developments

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Abstract. In this report I will give some information concerning the construction of SPIRAL. I will enumerate the new equipments suited for experiments with the low energy beams provided by SPIRAL, and finally I will give indications concerning the phase II of the project.

PROGRESS REPORT CONCERNING THE CONSTRUCTION OF SPIRAL

The status of the SPIRAL project at GANIL is based on the ISOL technique for production of Radioactive Ion Beams (RIB's). The construction of SPIRAL can be devised into three major operations, see ref. (1),(2).

i) Increase of the intensity of the primary beam up to 6kW for ions up to ^{40}Ar of 96MeV/u.

ii) Construction of the RIBs production system (target plus ionization source)

iii) Construction of a new cyclotron.

In the following, I will give some information concerning the present status of these operations.

i) Increase of the intensity of the primary beam or THI (transfert de haute intensité) project.

The aim of this project is to increase the beam intensity of the accelerator by a factor 15 at least for the light ions. For this it is essential to improve the transport of the high intensity beam through the second cyclotron up to the SPIRAL target, (verification of the majority of power supplies of the accelerator, reduction of the

phase width at the entrance of the cyclotron CSS2 using a new rebuncher, fast shut down of the beam if an abnormal intensity loss is detected,...). A test was performed recently to test the equipment of the THI project using a 2kW, 95MeV/u ^{36}Ar beam, (3). The results of this test are rather positive. The beam intensity (pps) in the source and the injector cyclotron is in agreement with the expectations. The transmission of the first cyclotron was of the order of 93.3%. The transmission of the second cyclotron CSS2 was 80% due to a failure of two magnetic extraction elements. Beam losses have been detected in the beam line L1 (between the injector and the first cyclotron) with 60% transmission. Beam losses have been detected also in the beam line L2 (between the first and second cyclotron) due essentially to the rotating stripper. The new rebuncher was also tested. The results are satisfactory although its effect on the transmission of the beam through the CSS2 could not be observed due to the mentioned problems. The beam loss detection system was also tested during this run, it seems to be extremely sensitive to unavoidable sparks generated by DC or RF voltages and to have a very short response time (less than 1 ms). Most of the problems encountered during this test run can be easily fixed. It is expected that new test runs, in the forthcoming months, would successfully validate the THI operation.

ii) Construction of the RIB's production system (target plus ionization source)

The primary beam accelerated by the GANIL cyclotrons will impinge on a production target, which will be at high temperature $\sim 2300\text{K}$. The radioactive species produced by nuclear reactions and released from the target will pass through a transfer tube into the ionization source. The radioactive atoms will be ionized to q/m ratio ranging from 0.09 to 0.40. After extraction from the source they will be injected into the new ($K=265$) compact cyclotron CIME (cyclotron de moyenne énergie). The production system will be located inside a well shielded cave.

The equipment of the source cave is now completed. The technology of the carbon target is under control. The target was tested successfully at Louvain-la-Neuve, in Belgium using a 6kW proton beam of 30 MeV. The characteristics of the Bragg peak (energy losses inside the target) for this beam are very similar to those of a ^{20}Ne beam at 100 MeV. The target withstood this power for long periods of time (two consecutive weekends). The first NANOGAN2 source was installed. Finally the remote-controlled pick-up and place-in robot will be installed very soon.

iii) Construction of the new cyclotron.

The CIME cyclotron has been installed at GANIL. The magnetic field mapping was completed and appeared to be in agreement with the theoretical predictions.

Acceleration of stable beams is expected in the forthcoming months, hopefully in November. The first test beam is ^{18}O at 10.6 MeV/u. This corresponds to the acceleration of 4+ charge state using the 3rd harmonics of 14.4 MHz RF.

NEW EQUIPMENTS FOR THE EXPERIMENTS WITH THE SPIRAL BEAMS

The SPIRAL international scientific committee has organized an ensemble of workshops in order to define the best suited experimental apparatus for the experiments with the SPIRAL beams. From the scientific discussions during these meetings it became clear that two new major experimental equipments are necessary in this domain. A high acceptance spectrometer for identifying the reaction products induced by the SPIRAL beams and a high efficiency γ -ray spectrometer.

i) VAMOS, a Variable Mode high acceptance Spectrometer for identifying products of reactions induced by SPIRAL beams

The technical requirements for VAMOS were formulated in three working meetings, each with around one hundred participants. Starting with the experimental needs expressed in the workshops, the following spectrometer properties have been defined in four meetings with around 15 persons.

- a) A very large geometrical acceptance, of the order of 100msr, which is equivalent to an angular acceptance of 200mr.
- b) A nominal dispersion which should not exceed 2cm/% over the focal length.
- c) A momentum acceptance of the order of $\pm 5\%$
- d) A velocity filter function
- e) The possibility to rotate the spectrometer around the target point by an angle close to 90° .

These requirements are met by an optical structure consisting of a :

Doublet of quadrupoles, a Wien filter and a variable angle dipole. A description of the project is given in ref. (4).

ii) EXOGAM, A γ -ray spectrometer for nuclear reaction studies at SPIRAL.

The design of EXOGAM is also based on the demands of the physics community. The beam intensity, at least at the start up of the facility is expected to be

much lower than with stable beams. EXOGAM must therefore be designed to maximize the total photo-peak efficiency at both low and intermediate γ -ray multiplicities. The radioactive nature of the beams is also a concern and shielding of the detectors becomes an important design criterion. The new γ -spectrometer has to be adapted to a variety of reaction mechanisms including compound nucleus formation, deep inelastic or transfer reactions and Coulomb excitation.

The design of EXOGAM comprises an array of 16 segmented germanium detectors, (5). Each segmented Clover detector consists of four co-axial n-type Ge crystals. Each individual crystal in the segmented Clover detector is electronically segmented into four regions. The main advantage of this segmentation is the reduction of the opening angle of the Ge crystals and consequently a reduction of the Doppler broadening.

The expected performance of this design for a (typical) γ -ray energy of 1.3 MeV are :

- a) An intrinsic resolution $\Delta E=2.3$ keV (FWHM)
- b) Photo-peak efficiency $\sim 20\%$
- c) Peak-to-total ratio P/T=47%

Both Projects are based on broad European collaborations. A Memorandum of Understanding is prepared for each equipment specifying also the financial contribution of the partners. The final decision is expected to be taken at the December meeting of the GANIL Board of Directors.

THE LETTERS OF INTENT

The international scientific committee of the SPIRAL Project has launched a call for letters of intent for the first experiments with SPIRAL. It had received 60 letters coming from about 350 scientists of 60 laboratories in 18 countries interested by the project. As a general conclusion, the committee noted the high scientific interest of many proposed programs. Many experiments can be made from the beginning, with noble gas beams of realistic intensities. From the analysis of the experimental requirements expressed by the letters of intent, the need of a highly efficient gamma ball and a charged-particle spectrometer is clear.

THE PHASE II OF SPIRAL

Discussions have already started about a possible phase II of SPIRAL. It is based :

- i) On the replacement of the actual NANOGAN2 source by a two steps solution ($1+/n+$). The primary ion source for the production of $1+$ ions will be

located in the production cave of SPIRAL. An ECRIS source (Electron Cyclotron Resonance Ion Source) outside from the production cave can be used for charge multiplication. The advantage of this solution is an increased reliability in the production of radioactive species and a low cost. The first results obtained at Grenoble for the production of Rb(9+) and Ar(8+) are encouraging, (6).

ii) The use of primary deuteron beams coupled with a thick U target for the production of fission fragments. Tests at the Orsay Tandem have been very successful. Secondary neutron-rich isotopes of the noble gases Xe and Kr have been rapidly released and collected at a detection station from a 20g Uranium target bombarded by 10 MeV neutrons. As a next step, IPN Orsay (collaboration leaded by A. Mueller) will connect an ion-source to the target and implant a small-scale experimental separator at the Tandem in order to investigate the efficiency and diffusion constants, with the goal to make very thick but fast targets. A fission target for SPIRAL will increase the possible radioactive beams.

The construction of SPIRAL is progressing towards its end. The experimental community around the accelerator is well identified and the first experiments are emerging.

ACKNOWLEDGMENTS

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