GANIL STATUS REPORT

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Abstract : GANIL commenced operation in 1983 and continuous progress has been made since then in improving its performance. Most recently, the project to increase the maximum energy (O.A.E. - Opération Augmentation d' Energie) was implemented during a shutdown from January to June 1989. The medium-energy beam facility (S.M.E. - Sortie Moyenne Energie) was built at the same time.

The results after a year of operation are presented. Very heavy ions (Pb, U) are now accelerated and the improvement of the injector cyclotron [1] combined with the installation of the new source (ECR3) have resulted in an increase of the beam intensity.

New projects under development are described.

New equipment has been installed in the experimental area and the medium-energy beam facility has been in operation since the end of 1989.

Operation Statistics

From 1983 to the end of 1989

The last GANIL status report was presented at the BERLIN Conference in May 1989 [2]. The distribution of the running time from January 1983 to December 1989 is given in figure 1 ; the total running time of 30600 hours has been shared between :

- Physics and industrial applications 21 300 h (70%)
- Beam setting up 6 000 h (19%)
- Machine studies 3 300 h (11%)

Of the total of 21 300 h devoted to physics and industrial applications, 17 200 h have been effectively used on target, 3 450 h are accounted for by equipment failures and beam re-tuning and 650 h are accounted for by maintenance.

During the six months operation in 1989 considerable time was devoted to machine studies as may be seen in figure 1 ; this was due to the need to establish the new parameters of the machine. The operational efficiency for physics was 90.9% in 1989 (Equipment failures : 5.2% - Beam re-tuning 3.9%), nearly the same as for the previous two years.

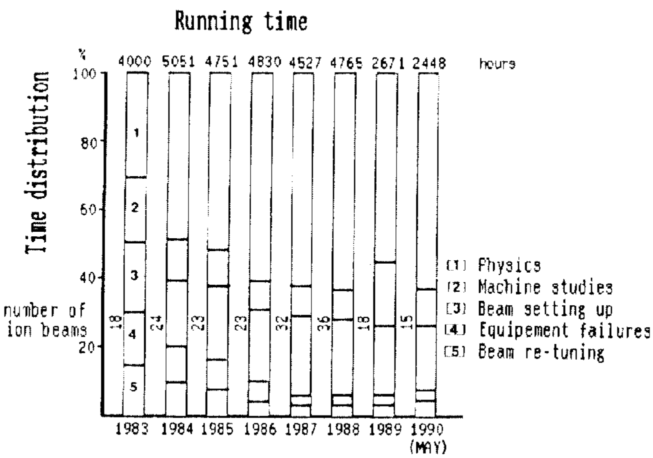

Fig. 1 : Seven years of operation

From July 1989 to June 1990 (after O.A.E. upgrading)

Owing to the ability of the ECR source to produce heavy ion beams of several microamperes with a charge to mass ratio twice as large as that of the PIG source, the O.A.E. modification became possible and was completed in July 1989. Figure 2 shows the new energy range of the accelerator which has been expanded for ions heavier than Ar.

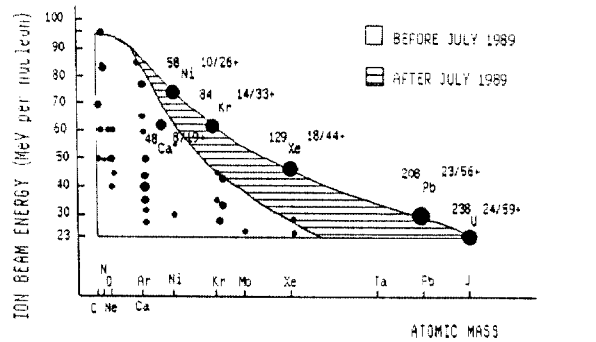

Fig. 2 : New energy range

The list of beams accelerated in the past year is given in table 1 with their characteristics. In addition to the energy increase, an intensity upgrade of a factor of ten is obtained for Kr and Xe. For light ion beams, the intensity is voluntarily reduced according to the radiation level permissible.

The beam time devoted to the heavy elements Kr, Xe and Pb now occupies 63% of the total beam time (figure 3). In the same figure is shown the beam time distributed among physics and the other items.

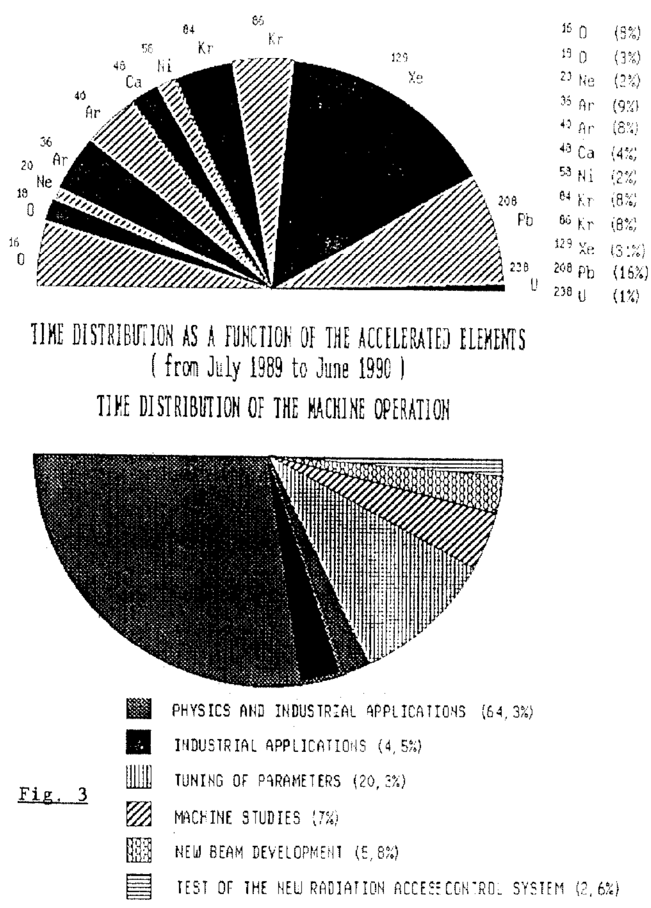

Fig. 3

Table 1 : ION BEAMS ACCELERATED AFTER THE OAE MODIFICATION (from July 89 to June 90)

ION/M	Charge state Before and after stripping	RF Frequency (MHz)	Maximum energy (MeV per nucleon)	Maximum intensity on target (5) (measured) pps (10^{11})	 enA	Beam characteristics (measured) ± ΔW/W half height (10^{-3})	 Bunch timing half height ns	 Intensity enA
O 16	3/8	11.76	70	11.7	1500			
O 16	4/8	13.37	95	11.7	1500		0.5	130
(1)O 18	3/8	10.10	50	11.7	1500			
Ne 20	3/10	9.893	48	21.87	3500	0.32		
(1)Ar 36	5/17	9.31	42	3.67	1000	0.50		
Ar 36	9/18	13.45	95	1.39	400		0.26	10
Ar 40	7/17	11.77	70	3.67	1000	0.79	0.5	340
(2) Ca 48	8/19	11.00	60.3	2.78	800		0.3	360
Ni 58	10/26	11.95	72.5	1.68	700			
(3)Kr 84	14/33	11.00	60	2.8	1500	0.59	0.6	900
(1)Kr 86	14/34	11.00	60	1.10	600			
Xe 129	14/37	7.55	27	0.42	250			
Xe 129	20/44	9.40	42.8	0.99	700			
(2)Xe 129	18/44	9.52	44	1.13	800	0.90	0.2	18
(4)Pb 208	23/56	7.82	29	0.050	45	0.61	< 1.9	30
(4)U 238	24/59	7.13	24	0.0068	6.4		< 1.7	5

(1) enriched 99% ; (2) enriched 70% ; (3) enriched 90% ; (4) natural
(5) for light ion beams, the intensity is voluntarily reduced according to the radiation level

Medium-Energy Beam Facility (S.M.E.) [3]

Since the end of 1989, an unused charge state of the stripped beam can be diverted down a new beam line and into a new experiment room dedicated to atomic and solid state physics. Ions from carbon to uranium are now available in an energy range from 13.8 down to 3.7 MeV/nuclon with a beam emittance of 10 π mm.mrad. From December 1989 to May 1990 approximatly 800 hours of beam have been delivered consisting of O^{7+}, Ar^{16+}, $^{48}Ca^{18+}$, Kr^{32+}, Xe^{42+} and Pb^{53+}.

Improvements

New Radiation Safety Control System

The old system proved too rigid to take into account new operational modes of the accelerator (for instance : S.M.E.). Hence a new control system named UGSII (Unité de Gestion des Sécurités), which is more flexible and evolutive has been installed and has been working satisfactorily since February 1990.

Computer Control System Renewal [4]

This control system is being renewed to meet the increasing demands of the accelerator operation. The new system is planned to be operational by the end of 1992. It is composed of distributed powerful processors (VAX6410, microVAX 3800) federated through Ethernet and flexible network-wide database access, 68K, VME standard front-end microprocessors, enhanced color graphic tools and workstation based operator interface.

Computerised System for the Survey of Cryogenic Pumps in the SSC2 (Separated Sector Cyclotron N°2) Vacuum Chamber

In order to determine the nature of the residual gas, the different partial pressures are measured with a mass spectrometer in the range of 1 to 200 AMU. This spectrometer has been interfaced with a computer located in the control room and is used to detect leaks or pumping malfunction.

Beam Pulse Suppressor

A bunch of ions corresponding to a single RF period can be selected by pulsing the voltage on two pairs of parallel plates between the injector cyclotron and SSC1. To feed these electrodes a double 2500 V pulse amplifier has been designed with a rise time of 50 ns, a duty cycle of 10% and a repetition rate up to 1.4 MHz. The previous duty cycle was 1.4% and it was possible to select only one bunch in 70 ; the new maximum rate is now one in 10.

Pepperpot for Beam Intensity Reduction with the Same Emittance

Two carbon plates with a transparency respectively of 5% and 25% have been placed in the beam line beetwen the first two cyclotrons.

Beam Profile Monitor Protection

These monitors are made with two gold-plated tungsten multiwire planes. The main problem is that the wires are fragile and are often destroyed by melting if the beam power is too high and by sputtering. When a profile monitor is introduced in the beam, the beam intensity modulator automatically reduces the beam intensity down to the permissible level.

New ECR Ion Source

The accelerator resumed operation in June 1989 with the new source ECR3-CAPRICE. Initially developed by B. Jacquot and R. Geller at GRENOBLE, this source has been built at GANIL. CAPRICE is a compact 10 GHz source with an electrical consumption of 40 kW for coils placed in an iron yoke and can produce metallic and gaseous ions with less electric power consumption, better emittances and higher beam intensities than the previous one (ECR1).

Machine Studies

Charge State Distribution after Stripping

A stripping carbon foil is placed in the beam line beetwen the two SSC. The energy spread ΔW/W generated by a carbon foil is a function of the thickness ; it should not be excessive, otherwise a part of the beam would be lost in the SSC2 injection. Therefore, the thickness used to obtain the maximum yield is less than the "equilibrium thickness". The charge state distribution of Ni, Kr, Xe [5], Pb and U with different carbon foil thicknesses have been measured.

Beam Transmission through Vacuum

Heavy ions are lost when they undergo charge exchange in collisions with the residual gas. The transmission has been measured with Pb [6] and U when the pressure is varied in the vacuum chamber of the cyclotrons. The results have been compared [6] with the predictions of the analytical formulae of B.S. (Betz and Schmelzer) and Erb.

Investigations of Beam Dynamics

Beam time has been devoted to such topics as orbit precession and phase compression in SSC1, longitudinal and transverse emittance measurements, and energy spread after the stripper or after slowing down in a target.

New Projects

New High Intensity Injection System (O.A.I. - Opération Augmentation d'Intensité)

In order to increase the beam intensities (mainly for metallic ions) delivered by the GANIL injectors, a new high efficiency injection system has been designed. It consists of a new beam line conducting the beam from an ECR ion source installed on a 100 kV platform to the first accelerating gap of the injector cyclotron C01. The completion of this system is planned for the beginning of 1991 [7].

SISSI Project (Source d'Ions Secondaires à Supraconducteurs Intenses)

The high energy beam is focused with a superconducting solenoid on a target producing a secondary beam with a large angular divergence which is focused by another superconducting solenoid. This equipment will be installed in 1992 in the beam line after the SSC2. The transmission factor should be ten times higher, thus increasing the useful production rate of exotic nuclei.
Primary beam emittance on target :
5 π mm.mrad = .2 mm x 25 mrad x π
Secondary beam emittance :
16 π mm.mrad = .2 mm x 80 mrad x π
Beam line acceptance 40 π mm.mrad
Solenoid characteristics { length : 80 cm-80 cm
magnetic field : 9.5 T-10.9 T

Experimental Area

LISE 3 Project (Ligne d'Ions Super Epluchés)

This spectrometer consists of three stages :
- two magnets (Av/Q selection)
- an achromatic slowing-down target between the two magnets (A^3/Z^2 selection)
- a Wien filter (v selection)

LISE 3 will be operating in June 1990 and will be used for identification and decay characteristic measurements of nuclei very far from the stability region.

INDRA Project (Identification de Noyaux et Détection avec Résolutions Accrues)

INDRA is a high resolution 4 π detector for light charged particles and nuclei detection. It consists of three detection stages : ionization chamber, Si and CsI. The beam line, the vacuum chamber and a part of the detectors will be installed in January 1991 ; total completion is scheduled for the beginning of 1992.

TAPS* (Two Arms Photon Spectrometer)

TAPS is a set of 361 BaF_2 detectors to analyse high energy photons. Each element has a hexagonal section (6 cm) and is 25 cm length. It was used at GANIL for the first time in February 1990.
* Joint collaboration of GANIL, Giessen, GSI, KVI and Münster Univ.

New GANIL Data Acquisition System

Since October 1989 a new acquisition system has been operational ; it is based on three interlinked components :
- Several VME microprocessors whose function is to read and sort the data coming from the ADC. The microprocessors are pre-programmed and are seen as such by the user.
- A cluster of four VAX (6310-6410) computers with a fast link (1 Mbits/s) to the VME bus, writes the data to tape or disk while controlling the experiment.
- A network of workstations from which the user may control the experiment and display the histogram originating from the host.

Conclusion

After a year of operation with higher energies we can say that the demand is increasing for heavy ions like Kr, Xe and Pb.

For light ions the intensity is voluntarily limited to 10^{12} pps according to the radiation and activation level. Next year the new injection system (O.A.I.) will enhance the intensity of heavy ions for which the yield from the source is low.

Medium-energy beams, diverted after the stripper have been permanently available since December 89 for non-nuclear physics.

A study group is now investigating a SSC3 booster for increasing the energy in the future.

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