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## GANIL - Grand accélérateur national d'ions lourds

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agence d'évaluation de la recherche  
et de l'enseignement supérieur

Section des Unités de recherche

## AERES report on the research unit

Physics Group of Grand Accélérateur National d'Ions

Lourds (GANIL)

From

University of Caen

CEA

November 2010



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Le Président de l'AERES

Didier Houssin

Section des unités  
de recherche

Le Directeur

Pierre Glorieux

November 2010



## Research Unit

Name of the research unit : GANIL Physics Group

Requested label

N° in the case of renewal

Name of the director : Mr Sydney GALÈS

## Members of the review committee

Committee chairman :

Mr Mohsen N. HARAKEH, KVI, University of Groningen, the Netherlands

Other committee members :

Mr Piet Van DUPPEN, Katholieke Universiteit Leuven, Belgium

Mr Karl-Heinz SCHMIDT, GSI, Germany

Mr Wolfgang TRAUTMANN, GSI, Germany

Mr Hubert FLOCARD, CSNSM, Université de Paris 11 Paris-sud, France

Mr Eric PLAGNOL, APC, Université Denis Diderot Paris 7, France (CoNRS)

## Observers

AERES scientific advisor :

Mrs Anne RENAULT

University, School and Research Organisation representatives :

Mrs Patricia ROUSSEL-CHOMAZ, CEA, France

Mrs Barbara ERAZMUS, CNRS-IN2P3, France



# Report

## 1 • Introduction

- Date and execution of the visit

The visit took place on 24-25 November 2010 at GANIL, Caen.

- History and geographical localisation of the research unit, and brief presentation of its field and scientific activities

GANIL (Grand Accélérateur National d'Ions Lourds) was founded in Caen in 1975 by CEA/DSM and CNRS/IN2P3, on equal terms. Its legal form is an Economic Interest Group (GIE). The construction of the facility started in 1979, the first beam was delivered in November 1982, and the first experiment took place in January 1983. GANIL has been classified as a European Large Scale Facility since 1995.

GANIL is a heavy-ion accelerator complex delivering stable and secondary radioactive beams in the energy range between a few keV to 100 MeV per unit mass. It is equipped with a complete set of experimental equipment for nuclear physics but also for atomic and condensed-matter physics as well as radiobiology, and is a host laboratory for a large community of users : around 700 scientists half of them foreigners from EU, Russia, Japan, India, U.S., etc.; 500 of them are coming at least once a year, and about 250 from outside France. The permanent staff amounts to 262 persons at the end of 2009 : 28 physicists, 112 engineers or administrative officers, 122 technicians or employees.

The present evaluation concerns the physics group of GANIL, which pursues research along four topics/research lines by four research teams. The topics are: 1- Dense and hot nuclei, 2- Nuclear structure and astrophysics, 3- Fusion, fission and super-heavies, and 4- Theory.

- Management team

GANIL has a Board of Directors composed of 10 members, nominated in equal numbers by the two funding institutions CEA/DSM and CNRS/IN2P3. This Board nominates the GANIL Director, presently Mr Sydney GALES, and Deputy-Director, presently Mr Marcel JACQUEMET, for a period of 5 years. They are supported by a Secretary General, Mr Patrice VINCENT, and Under-Secretary General, Mr Antoine KAHWATI. The GANIL Directorate is responsible for the laboratory activities. The Physics Group at GANIL is led by Mr Olivier SORLIN and his deputy is Mrs. Christelle STODEL.

In the Ganil management team, the deputy director Marcel Jacquemet is also project leader of SPIRAL2 and Marek Lewitowicz is the scientific coordinator of SPIRAL2. Mrs Heloise Goutte is the coordinator of the on-going GANIL scientific program.



- Staff members (on the basis of the application file submitted to the AERES)

Total group	Past	Project
N1: Number of researchers with teaching duties (Form 2.1 of the application file)	1	1
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	26	24
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	43 <sup>a</sup>	5
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	4.5 <sup>b</sup>	4.5
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	12 <sup>c</sup>	
N7: Number of staff members with a HDR or a similar grade	11 <sup>d</sup>	12

<sup>a</sup> This number includes in addition to 41 visitors (3-12 month) also two fixed-term researchers who worked on technical developments for SPIRAL1&2, who are not included in the four topics presented below

<sup>b</sup> This number includes one secretary, the library service as well as two technicians of the physics group working almost equally on Topics 1, 2 and 3.

<sup>c</sup> One PhD student works on SPIRAL2 beam developments, he was therefore not included in the physics topics.

<sup>d</sup> This number differs by one unit from the one presented in the Table 2.3 of physicists, as G. GRINYER is not HDR. The present value is the true number to consider.

## 2 • Overall appreciation on the research unit

- Summary

The Physics Group at GANIL is outstanding with an excellent track record in scientific accomplishments : the publications are of high quality, and the large number of invitations to international conferences and schools speaks of a high international standing. The future technical projects of the Group are state of the art, and their scientific programmes are on the cutting edge. The opportunities for excellent research in the future are many both at GANIL with SPIRAL2 and at sister institutes abroad. GANIL with SPIRAL2 figured in the first ESFRI list of 2006 as one of the top 2 institutes for nuclear physics and one of the top 5 institutes in physics and astronomy in Europe. It also is one of the top 5 institutes in "low-energy nuclear physics" world-wide. The subfield of "low-energy nuclear physics" is a top priority in France as affirmed by the funding agencies CEA/DSM and CNRS/IN2P3.

- Strengths and opportunities

The Physics group at GANIL has an outstanding and relatively young permanent staff. It has been successful in attracting excellent postdocs and PhD students. The Committee has been informed by these young scientists that they find the scientific atmosphere within the Group very stimulating. The students get excellent supervision with high accessibility of the supervisors, and the post-docs get the room to develop their own ideas and small projects.

The Group has strong networks and national and international collaborations. These form a source of strength for GANIL because the collaborations are not only based on contributions to the scientific programmes but also to the



technical developments increasing the possibilities for research at GANIL. This is direly needed because of the limited human and financial resources available to GANIL.

Another aspect of strength is the collaboration between the members of the theory and experiment teams leading to joint projects and publications.

The developments of ion sources for SPIRAL lead to new opportunities of research with the present facilities. These opportunities will multiply by a large factor with the realisation of SPIRAL2.

- **Weaknesses and threats**

The Committee agrees with the analysis that a major threat to the physics group is its relatively small size especially that in two years from now the first phase of SPIRAL2 will be operating fully. An efficient exploitation of the new facility will require an increase in the supportive role of the group to external users jeopardising in the process its own scientific programmes.

Another major threat could be the delay in funding of major equipment such as S3 which is foreseen to be operative at the start of SPIRAL2. Such a delay could have a damaging effect on the optimal use of SPIRAL2 facility during the first years of its operation as well as on the motivation of the scientists who are impatiently waiting to use the high-intensity stable and radioactive beams to be provided by LINAG and SPIRAL2, respectively.

Especially worrying is the number of postdocs that has decreased strongly in the recent years.

The increase in paper and administration work of the members of the Physics Group risks jeopardising the core business of research.

- **Recommendations**

On basis of the need created by SPIRAL2, a modest increase of the experimental subgroups by 2-3 permanent staff members and several postdocs could be fully justified. These will be very much needed to run efficiently the expanded facility and optimise the division between the supportive role and pursuing own scientific programmes.

The Committee urges the Board of Trustees to ensure funding of S3 with highest priority and other instruments for SPIRAL2 as soon as possible to ensure efficient exploitation of the SPIRAL2 facility upon start of operation.

The Committee strongly advises the Physics Group to seek ways to reduce the paper and administration work and concentrate on the core business of research.

The Committee urges the Physics Group to advise their PhD students to seek appointments to teach at the University. This would be very important for their careers later if they decide to find employment at a university.

The Committee advises the GANIL Directorate and the Board of Trustees to seek a contractual management plan with University of Caen and/or other universities to allow for appointment of senior GANIL researchers as Professors at these universities and involve them in the educational activities.

- **Production results**

(cf. [http://www.aeres-evaluation.fr/IMG/pdf/Criteres\\_Identification\\_Ensgts-Chercheurs.pdf](http://www.aeres-evaluation.fr/IMG/pdf/Criteres_Identification_Ensgts-Chercheurs.pdf))

A1: Number of permanent researchers with teaching duties (recorded in N1) who are active in research	25
A2: Number of permanent researchers without teaching duties (recorded in N2) who are active in research	5
A3: Ratio of members who are active in research among staff members $[(A1 + A2)/(N1 + N2)]$	1
A4: Number of HDR granted during the past 4 years (Form 2.10 of the application file)	1
A5: Number of PhD granted during the past 4 years (Form 2.9 of the application file)	13



### 3 • Specific comments

- **Appreciation on the results**

In spite of the relatively small number of the physics group staff and their essential role in providing support to external users with the detector systems and experimental setups at GANIL, they have managed to set up a vibrant programme of their own. They have ensured good maintenance and running of the various instruments in an efficient way by assigning dedicated members of the experimental subgroups to these facilities. At the same time, the GANIL physics group pursues its own cutting-edge research addressing topics of much current interest. The research is at the forefront dealing with various aspects of low-energy nuclear physics including nuclear structure of exotic nuclei, nuclear astrophysics and hot and dense nuclear matter. They have been very active in publishing their results in refereed journals of high impact. The quantity of the publications is high and the quality is excellent as witnessed by publications in *Phys. Rev. Letters* (19 during the evaluation period). A good measure of the high standing of the members of the Physics Group is the large number of invitations to give talks at international conferences (on the average of 25 per year) and lectures at schools (28 during the evaluation period). An important aspect in this is the strong collaboration between the members of the theory and experiment groups, which enhances the research output both in quality and in quantity. During the evaluation period 14 PhDs were defended under the full supervision of the Physics Group and 11 more are now in preparation. This is excellent for a small group of researchers who are also spending much of their time supporting external users. The number of PhDs defended at French universities and abroad on research performed at GANIL is, of course, much larger.

- **Appreciation on the impact, the attractiveness of the research unit and of the quality of its links with international, national and local partners**

The present infrastructure at GANIL is well advanced with the ability to deliver beams from  $^{12}\text{C}$  to  $^{238}\text{U}$  in an energy range from a few keV/u to 95 MeV/u and radioactive beams by the ISOL method via the SPIRAL facility with energies of 2-25 MeV/u or via fragmentation in flight using at present the LISE spectrometer. As an (inter-) national user facility with its own research groups, GANIL has a transparent organisational and managerial structure. This is geared towards a user community, which is large and international. The Review Committee (hereafter Committee) is fully satisfied, e.g., with the procedure for proposing experiments at GANIL and the process through which such proposals are evaluated scientifically and also technically for feasibility.

The above two aspects make GANIL very attractive for external users and for national and international groups to forge alliances with the excellent GANIL Physics Group. This has made it easy to recruit excellent post-docs and graduate students many of whom come from abroad. Even at the senior level the Physics Group has a number of excellent non-French members. The attractiveness of GANIL can also be witnessed by the large number of high-level scientists visiting for short or longer periods of time every year.

The Physics Group members have been very successful in applying for competitive funding. They participate in seven funded ANR projects, some of which have a GANIL project manager. They have raised EU funds via several instruments of the EU Framework Programmes. One of the latest is the project ENSAR in which the Physics Group participates in several network and R&D activities and for which GANIL acts as the managing institute. The group members participate in many networks and have strong scientific and technical collaborations with many groups world-wide. Especially the collaborations to build instruments for the SPIRAL2 facility are to be noted.

The staff members of GANIL have received more than 30 scientific prizes over the years recognising their outstanding research achievements. This is also reflected in the large number of invitations to international conferences and symposia, as mentioned above.

The Committee notes that 25% of the beam time in the period 2006-2009 has been used for interdisciplinary research mainly in atomic physics, condensed-matter physics and radiobiology. This is in accordance with a consensus among European research infrastructures that encourages use of the facilities by multidisciplinary users. This is also reflected in NuPECC's Long-range plans and in the Integrating Activities of the nuclear physics community within the European Framework Programmes.

The role of GANIL in Normandy and its outreach activities are to be applauded. GANIL acts not only as an incubator for new companies using technologies developed at GANIL but also provides beam time for companies to test equipment for radiation effects and also for producing micro-porous membranes. The outreach activities are





varied and successful in attracting a large public. They have the aim to reach and enthuse the public about nuclear physics research and its applications.

- **Appreciation on the management and life of the research unit**

The heavy duties in supporting external users and in carrying on their own research programmes have not prevented members of the physics group to be involved in educational activities by teaching at the universities of Caen and Orsay as well as giving lectures at various nuclear physics schools. This is a key role to play in order to educate and train a younger generation in nuclear physics and ensure new excellent members could be attracted to the scientific staff of GANIL. This is indicative of the outstanding quality of the members of the group who perform all these tasks efficiently.

GANIL has access to good advice regarding its facilities and scientific programmes through the SPIRAL2 Scientific and Technical Advisory Committees and Scientific Council composed of members drawn from the (inter-)national scientific communities. They meet on a regular basis to consider internal as well as external developments that may affect the scientific and technical activities at GANIL. Nevertheless, the management calls sometimes ad hoc committees to consider urgent issues regarding future perspectives, such as has been the case with the "Prospective Study of GANIL 2015". The recommendations of this ad hoc committee have later been considered and endorsed by the other permanent GANIL advisory bodies.

- **Appreciation on the scientific strategy and the project**

The full realisation of the SPIRAL2 project will provide exciting opportunities for a broad physics programme with radioactive beams. This will entail investigating nuclear structure of exotics nuclei,  $r$  and  $p$  processes in nuclear astrophysics, and role of isospin in dynamics of nuclear reactions. It will also enhance the possibilities to study nuclear structure of super-heavy nuclei and to fulfil the promise of synthesising even heavier systems with  $Z=120$  and beyond. It will allow study of fission dynamics with excellent experimental conditions. This will go hand in hand with theoretical developments to address the interesting palette of proposed experimental projects. The Committee is pleased with the challenging but very interesting proposed broad scientific programme.

The Physics Group members have embarked as part of their strategy on developing state-of-the-art detection equipment to exploit the fantastic potential for cutting-edge research that will become possible with SPIRAL2. These technical projects and scientific programmes are of the highest relevance and are feasible for a much longer term than 4 years. Within GANIL the available resources are allocated prudently. For the larger projects requiring large investments, funding from CEA/DSM, CNRS/IN2P3, ANR and other foreign funding agencies participating in the projects is crucial. GANIL with SPIRAL2 figured in the first ESFRI list of 2006 as one of the top 2 institutes for nuclear physics and one of the top 5 institutes in physics and astronomy in Europe. It also is one of the top 5 institutes in "low-energy nuclear physics" world-wide. The Committee after talking with the Board of Trustees of GANIL (CEA/DSM and CNRS/IN2P3), who affirmed the highest priority given to this institute and that the subfield of "low-energy nuclear physics" is a top priority in France, urges that the financing of these large technical projects be given the highest priority as well in order to make the most of the research potential of SPIRAL2.



## 4 • Appreciation team by team and/or project by project

### Topic 1: Dense and hot nuclei

Topic 1: Dense and hot nuclei	Past	Project
N1: Number of researchers with teaching duties (Form 2.1 of the application file)	0	0
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	4.8	5.5
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	5	1
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0.6	0.6
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	3	
N7: Number of staff members with a HDR or a similar grade	1	2

- Introduction

The GANIL group working on “Dense and Hot Nuclei” is well embedded into the large international community interested in this subject. The scientists of the group are highly respected members of the international scientific community and are frequent speakers at international conferences and workshops. The GANIL beams are attractive for outside users and the GANIL physicists are welcome as collaborators at other laboratories offering beams for reaching higher densities or temperatures than presently possible at GANIL. GANIL physicists are, furthermore, part of the international initiative aiming at extracting information on the nuclear equation of state of asymmetric nuclear matter from heavy-ion reactions. One of the benchmark systems,  $^{40}\text{Ca}$  and  $^{48}\text{Ca}$  in symmetric and cross bombardments, has recently been studied at GANIL at an energy of 35 MeV per nucleon.

- Appreciation on the results

With the INDRA detector, the GANIL physicists together with their colleagues have placed themselves into a prominent position in the field of heavy-ion reactions at intermediate energies during the nineties and have maintained this role with a continuing series of very detailed analyses. INDRA data represent the world standard regarding reaction mechanisms in the intermediate regime, for Au+Au up to 150 MeV per nucleon incident energy, the highest energy at which this system was studied with INDRA at GSI. Because of their completeness, the data sets are still being used for analysing questions and problems appearing in current discussions. First results from the most recent campaigns focusing on isotopic effects in the reaction processes have been presented, and new insights are to be expected from the ongoing data analysis.

- Appreciation on the impact, the attractiveness of the team and of the quality of its links with international, national and local partners

The scientific results obtained with INDRA data have been very stimulating and have initiated important discussions, in particular also on how to sharpen the interpretations of the experimental findings within the wider context of phase transitions in small systems. An initiative of GANIL and LPC physicists has led to the multi-author review ‘Dynamics and Thermodynamics with Nuclear Degrees of Freedom’ published as a Topical Volume in Eur. Phys. J. 30 (2006). The INDRA collaboration has also succeeded in expanding their open collaboration meeting ‘Atelier INDRA’ into a biennial forum, jointly organised with the CHIMERA collaboration and recognised by the community world-wide.



- **Appreciation on the scientific strategy and the project**

The prominent role of Nuclear Structure in the more recent research performed at GANIL has reduced the capabilities of the reaction groups of supporting the complex experiments with their multi-detectors. This has increased the dependence on initiatives from the outside but has, nevertheless, permitted the GANIL groups to widen the scientific programme and to explore the possibilities of experimenting with radioactive beams, e.g., krypton isotopes from SPIRAL, of coupling INDRA or parts of it with other instruments, e.g., VAMOS, and of applying correlation techniques developed for reaction studies for the investigation of unbound resonances in exotic nuclei as, e.g.,  $^{10}\text{C}$ . With these collaborations, borders have been crossed, neighbouring fields have profited, and a high potential for unique new experiments has been developed.

After the completion of a series of campaigns of systematic measurements with stable beams, the INDRA collaboration has not only started to broaden their experimental programme as shown above but also to explore novel techniques for a new instrument, FAZIA. An important activity is the development of pulse-shape techniques for silicon detectors which has been shown to improve the mass identification for slow heavy fragments. The impressive resolutions obtained with prototype modules will allow unprecedented measurements even long before the full detector FAZIA will have been realised. With its high acceptance, the INDRA/FAZIA instrument is well suited for experiments with rare isotopes from SPIRAL and SPIRAL2. The high resolution and identification power for slow fragments is also adapted to studies of quantum effects in reactions near or below the barrier, a field currently pursued experimentally and theoretically at GANIL with interesting prospects for the future.

- **Conclusion**

- Excellent research results obtained in experiments at GANIL and elsewhere; high international reputation.
- The integration within international activities is essential in order to exploit the new possibilities provided by SPIRAL2.
- The present number of physicists in the group represents an absolute lower limit.
  - Strengths and opportunities :
    - The GANIL group is an integral part of present international initiatives.
    - New research opportunities will be available with FAZIA at SPIRAL2.
    - A high potential for unique new experiments has been developed.
  - Weaknesses and threats :
    - The small number of physicists in the reaction group threatens the full exploitation of their new opportunities.
  - Recommendations :
    - It is important that the group remains an active part of the international projects and initiatives associated with the development of FAZIA and the study of the Equation-of-State of asymmetric nuclear matter.
    - The full exploitation of the new opportunities at SPIRAL2 requires a strengthening of the presently very small reaction group.



## Topic 2: Nuclear Structure and Astrophysics

Topic 2: Nuclear Structure and Astrophysics	Past	Project
N1: Number of researchers with teaching duties (Form 2.1 of the application file)	0	0
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	13.2	11.5
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	16	2
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0.6	0.6
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	4	
N7: Number of staff members with a HDR or a similar grade	6	5

- **Appreciation on the results**

The research activities within the nuclear-structure and astrophysics themes resulted in an excellent scientific output. This statement is based on the number of publications in highly ranked scientific journals including a substantial number of Letter publications, on the number of invited talks at international conferences and workshops and on the activities of several members of the physics group giving expert advice in several international advisory boards of accelerator facilities, research institutes and conferences. Most work, if not all, is performed within large (international) collaborations making efficient use of the available expertise, instrumentation and beams. The topics investigated and the questions addressed are original, important and at the forefront of contemporary nuclear-structure physics research. The astrophysics programme that is to a certain extent intertwined with the nuclear-structure programme dealt with a number of interesting questions. Parts of it suffered from the limited availability of intense and pure Radioactive Ion Beams (RIBs) at SPIRAL but the Committee appreciated the group's response by creating the GANISOL group/project that focuses on the development of new beams and includes physicists, engineers and technicians. The fundamental interaction programme focuses on a challenging project to study beta-neutrino correlations in the decay of trapped  $^6\text{He}$  ions and recently a study of superallowed Fermi transitions has been started. Finally, it should be noted that the continued efforts to maintain and upgrade the existing instrumentation and to develop and construct new instrumentation clearly pays off.

- **Appreciation on the impact, the attractiveness of the team and of the quality of its links with international, national and local partners**

Members of the physics group have a high visibility on the international scene as reflected in, e.g., the number of invited talks and the membership of advisory bodies. Most of the research is performed within larger international collaborations and there exists a strong link with other French research institutes for instrumentation development as well as the physics programme. The in-house group has an open spirit and is organised in an efficient way that creates a competitive and stimulating environment. Members of the team are embedded in international networks (e.g. ENSAR-JRA activities, AGATA collaboration).

- **Appreciation on the scientific strategy and the project**

The team proposes a broad, original and excellent programme in nuclear-structure and astrophysics research that is at the forefront of nuclear-physics research and is, more globally, in line with the recommendations of the different long-range plan exercises performed world-wide. The team makes hereby use of the outstanding



opportunities of the SPIRAL2 facility. Members of the team are very successful in acquiring funding, but at the price of a strongly increased administrative burden.

The team might consider reflecting on the competitiveness and impact of part of the nuclear astrophysics programme that requires extended beam time periods and the fundamental interaction programme, especially in relation with the activities ongoing or planned worldwide. The Committee appreciates the continued involvement of some of the team members in activities elsewhere as this will result in an added value for the research programmes at the home facility. Finally, as stated above, the Committee appreciates the fact that the physics group is involved in the development of new beams via the GANISOL group and considers this essential to enlarge the palette of RIBs at SPIRAL, especially when implementing the singly charged ion options, which should include resonance laser ionisation, combined with charge breeding. The Committee has some concern about the heavy load for the group in the transition period between now and SPIRAL2 and thereafter when the new facility will be fully operational.

- **Conclusion**

- Very good research output, outstanding opportunities with SPIRAL2, world-wide highly appreciated scientific activities.
- It might become challenging to combine an on-going strong scientific programme with the preparation for the future projects.
- An increase in the number of post-docs is desirable.
- The increased administrative overload is a potential danger and risks to decrease the scientific output.

- Strengths and opportunities :

- Unique research opportunities with SPIRAL2, broad coverage of the research field, strong research group, several members are internationally recognised leaders in nuclear-structure research.

- Weaknesses and threats :

- Future of the fundamental interaction programme (6He trapping).
      - Administrative overload.

- Recommendations :

- The fundamental interaction research programme should be evaluated in view of the international competition.
      - An enduring involvement in the GANISOL group for target-ion source developments and resonant laser ionisation is recommended.



### Topic 3: Fusion, fission and super-heavies

Topic 3: Fusion, fission and super-heavies	Past	Project
N1: Number of researchers with teaching duties (Form 2.1 of the application file)	0	0
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	4.8	5.5
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	5	1
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0.6	0.6
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	3	
N7: Number of staff members with a HDR or a similar grade	1	2

- Introduction

While the research at GANIL was concentrated on relatively light nuclei during the last years, an increased activity in the study of heavy nuclei can be observed, strongly favoured by the recent successful efforts to improve the performance of the VAMOS spectrometer. Besides the existing programmes, several very promising experiments have just started.

- Appreciation on the results

Fission-time measurements with the blocking technique were performed with a  $^{238}\text{U}$  beam. This experiment profited from the presence of the INDRA detector at GANIL that helped to distinguish the different reaction channels. Evidence for long lifetimes ( $t > 10^{-18}$  s) of a  $Z=124$  compound nucleus has been extracted. This result is considered to be an important contribution to the understanding of the shell stabilisation of super-heavy nuclei. It resulted in a publication in Physical Review Letters (PRL).

The study of fission induced in multi-nucleon transfer in the  $^{12}\text{C}+^{238}\text{U}$  reaction is a new experimental programme at VAMOS, which is now able to identify all fission products in mass and atomic number. This kind of experiment represents a major step in the study of nuclear fission : For the first time, the nuclide yields of all fission fragments produced from a well-defined compound nucleus with known excitation energy can be measured.

The full nuclide identification of the fission fragments by the VAMOS spectrometer was also exploited for gamma-spectroscopic studies in these very neutron-rich nuclei representing an essential and very important progress in this field of research. GANIL is presently the only place world-wide where prompt gamma spectroscopy can be performed with fully identified (in  $A$  and  $Z$ ) nuclides in the whole fission-fragment range.

A pioneering experiment on the giant system  $^{238}\text{U}+^{238}\text{U}$  was performed in 2006. The results motivated a theoretical study. A common publication appeared in PRL.

An unusual behaviour was observed in the fusion of loosely bound halo-nuclei  $^8\text{He}$  with gold nuclei below the Coulomb barrier in comparison with that of the tightly bound  $^4\text{He}$ . Whereas the probability for fusion increases strongly in going from  $^4\text{He}$  to  $^6\text{He}$  by adding two loosely bound neutrons, it does not increase further by yet adding another two loosely bound neutrons  $^8\text{He}$ . This totally unexpected result generated much interest and had high visibility through publication in PRL.



- Appreciation on the impact, the attractiveness of the team and of the quality of its links with international, national and local partners

The experimental programme on fission lifetimes is widely recognised. It was lately honoured by the offer to the principal investigator to write a review article about the research in this field.

The investigation of fragment distributions from fission induced in nucleon-transfer reactions represents a major step in determining the influence of nuclear structure (shell effects and pairing correlations) on the fission dynamics. The results will be very important for the understanding of nuclear dynamics and for nuclear technology. This experiment is carried by a large international collaboration and got support from grants of the European Union.

First spectroscopic studies on prompt gamma emission of  $^{238}\text{U}$  fission fragments are extremely promising. The fact that any gamma line of any fission fragment can be attributed to a specific nucleus is unique and opens a wide field for new results on nuclear structure.

- Appreciation on the scientific strategy and the project

Initiated by a group of physicists, the operation domain of VAMOS, which had been foreseen for the identification of light reaction products in particular with SPIRAL beams, was essentially extended. These efforts considerably improved the general performance of VAMOS and expanded the research potential in this field.

The future installations of SPIRAL2 will offer new possibilities for the research on heavy nuclei. Experiments are in the project phase on reaction studies, on the production of super-heavy elements, and on spectroscopy of trans-fermiums with the extremely intense LINAG beams at the S3 spectrometer. Prompted by the attractive of the future facilities and the excellent group at GANIL, very prominent physicists from world-wide leading laboratories have engaged themselves in these research fields by their participation together with GANIL physicists in submitting a number of letters of intent to the SPIRAL2 Scientific Advisory Committee.

The experimental programme on fission studies will profit from the production of exotic actinide targets using the NFS high-intensity neutron beam and by performing experiments at REX-ISOLDE and at GSI, which are complementary to the VAMOS experiment on transfer-induced fission in inverse kinematics.

- Conclusion

GANIL physicists have strongly intensified their research activities on the properties of the heaviest nuclei and on experiments with heavy beams, optimising and utilising the specific experimental equipment available at GANIL. The growth in the number of outstanding publications testifies to the very recent huge progress in this field.

In the field of fusion, fission and super-heavy nuclei, the position of GANIL is among the 4 leading institutes in Europe, together with JINR Dubna, GSI Darmstadt, and the University of Jyväskylä. With the future installations of SPIRAL2, GANIL will certainly strengthen its position among the leading laboratories in Europe in this field.

– Strengths and opportunities :

- The combination of heavy-ion beams up to  $^{238}\text{U}$  at energies well above the Coulomb barrier with the upgraded VAMOS spectrometer offers unique and excellent possibilities for nuclear-reaction studies and spectroscopy in both the heavy-element regime and mid-mass neutron-rich nuclei.
- SPIRAL2 will strongly enhance the research opportunities in these fields by intense radioactive beams, very intense stable LINAG beams and the powerful S3 spectrometer.

– Weaknesses and threats :

- According to the large diversity of the research subjects in the field of fusion, fission and heavy elements, the activities are promoted rather independently by several very engaged small groups.
- The decreasing number of post-doc positions and the increase in administrative work are particular threats for future success in this field, since planning of the experiments and data analysis mostly rely on GANIL physicists.



- Production of new elements beyond  $Z=118$  strongly depends on the availability of suitable materials for beams and targets. This might require close international collaborations and the willingness of partner institutes for providing the suitable isotopes in sufficient amounts.

– Recommendations :

- The progress in the technical development of the experimental installations at GANIL and the extension of the research capabilities for fusion, fission and heavy elements are highly appreciated. Exploring new possibilities, e.g. the gas-filled mode of VAMOS and the current efforts to develop new equipment for experiments at SPIRAL2, are strongly supported. The Committee advises the group to continue on these paths.
- Strengthening the personal situation by pursuing intense nation-wide and international collaborations and a sufficient number of post-docs will be particularly important for the future progress in this field.

## Topic 4: Theory

Topic 4: Theory	Past	Project
N1: Number of researchers with teaching duties (Form 2.1 of the application file)	1	1
N2: Number of full time researchers from research organizations (Form 2.3 of the application file)	4	4
N3: Number of other researchers including postdoctoral fellows (Forms 2.2, 2.4 and 2.7 of the application file)	11	1
N4: Number of engineers, technicians and administrative staff with a tenured position (Form 2.5 of the application file)	0	0
N5: Number engineers, technicians and administrative staff without a tenured position (Form 2.6 of the application file)	0	
N6: Number of Ph.D. students (Form 2.8 of the application file)	3	
N7: Number of staff members with a HDR or a similar grade	3	4

- Introduction

It is the belief of the Committee that the theory group at GANIL is intrinsically of the best quality. Despite its small size, it is also adequately composed to be a good match to present and future GANIL activities. On the other hand, it is important that it should be kept at least at the present size and coverage of fields. It should also be provided with the means to stay as well connected to the international nuclear theory community as it is today. This is a necessary condition for its remaining efficient at fulfilling its missions within GANIL. It is satisfying to note that the policy of the laboratory as demonstrated by its support to training and exchange programmes has taken the full measure of the importance of maintaining high-level theory activities within a leading experimental facility such as GANIL.

- Appreciation on the results

Each of the personalities belonging to the theory group is well embedded in both the French and the international theory community of their field of interest. This is visible from the lists of names of their collaborators within the country and abroad. It is also clear that, via the addition of its scientific contributions, the group brings its own share of support to the advances of nuclear theory. The fact that members of the group are regularly invited to conferences to present the work of the international community of theorists they work with is a good indication that they are as much leaders as they are collaborators.





Although most of their production has to do with theoretical advances, on several occasions they have produced specific articles analysing experiments or reviews in collaboration with experimental colleagues.

- **Appreciation on the impact, the attractiveness of the team and of the quality of its links with international, national and local partners**

The group benefits from its being located within a major facility of the discipline. On the other hand, its attractiveness as measured by the number of graduate students and post-docs cannot be explained by this fact alone. The physicists are fully playing their part in the progress of the field. The level of publications in the best ranked peer reviewed journals of the discipline (PRL, PLB, PRC and NPA) is excellent. They produce forefront work with the best physicists of the domain. Their participation in exchange programmes with European countries, Japan and the US maintains this lab as one of the most active nuclear theory labs in the world. The group has trained a number of young graduates and postdocs which have spread their ideas and techniques into the best laboratories world over and are very often still collaborating with them.

- **Appreciation on the scientific strategy and the project**

There are five permanent physicists in the GANIL theory group. With such a small number, the departure or the arrival of a single person has necessarily a strong impact as far as scientific orientations are concerned. In this respect, the departure of one member of the group, Ph. CHOMAZ, and the arrival of another, H. GOUTTE, have significantly modified the balance giving more weight to low-energy nuclear structure (exotic nuclei, spectroscopy, heavy and super-heavy nuclei). This is well in line with the expected growth of these themes within the lab as soon as SPIRAL2 starts operating.

The group appears more as a set of highly competent personalities leading their own research with a good measure of independence with respect to the activities of their colleagues than a more traditional focused and hierarchical structure.

On the other hand, what may be considered a structural weakness in any other laboratory appears to the Committee well suited to a facility like GANIL. Indeed the main mission of the lab is to serve visiting scientists who come here to perform top class experiments on a broad spectrum of themes. These visitors, while they are on the site, may wish to discuss their own work with a theorist informed of the most advanced aspects of the theory relevant to their experiment. Despite the evolutions associated with ingoing and outgoing fluxes in the GANIL theory group, there has been (and there will be) a good match between the coverage of nuclear physics fields handled by the group and the main experimental physics themes explored at GANIL. There is no doubt that in spite of the small number of theorists, most teams planning or performing an experiment at GANIL will find within the lab if not necessarily theory support at least the means to get acquainted with the best available theory they may need.

The GANIL theorists take part and sometimes even lead European or international networks. Most noticeable is the US-French FUSTIPEN programme in which GANIL coordinates efforts with the DOE to facilitate the exchanges of young physicists and the visits of more established scientists (mostly but not exclusively theorists) in order to enhance transatlantic collaboration. Other ambitious exchange and training programmes within either France or Europe (EUTIPEN which plans to associate the major, existing or under construction, large infrastructures of the continent) are also in progress. It seems important to the Committee that the position of EUTIPEN with respect to ECT\* (a NUPECC member) be clarified. Obviously the theory group is taking very seriously the coordinating role which falls to it because of its being inside one of the main European facilities of the discipline.

- **Conclusion**

The research output is outstanding. The group is adequately geared to provide a good match to the experimental opportunities offered by the coming SPIRAL2 project including the many scientific tasks required during the preparatory phase before the commissioning of the accelerator and the targets.

Given the fact that there is no strategic reason to make the permanent theory staff much larger inside a laboratory whose main mission is to foster world-leading experimental research, the challenge for the GANIL directorate over the coming years, when vacancies occur (transfers or retirements), will be to insure a recruiting at the present top level while maintaining a correct balance between the different needed subfields.



– Strengths and opportunities

- Highly competent people with a spectrum of competences well adapted to the scientific ambitions of the laboratory in particular those which will grow in importance with the start of SPIRAL2. The attraction of SPIRAL2 on international experimental and theory communities obviously gives this group a unique chance to remain a centre of the best research on low-energy nuclear physics. There are clear indications that it will not miss this unique opportunity.
- The group is well integrated into the activities of the national and international theory communities.

– Weaknesses and threats

- The recent evolution of the competences within the group weakens its potential for providing a theoretical support on the subject of hot and dense nuclear matter.
- The administrative responsibilities attributed to Mrs GOUTTE within the laboratory organisation may distract her from the pursuit of her research on large amplitude collective dynamics in medium and heavy nuclei, a domain in which her recent past production has acquired a world unique status.

– Recommendations

- The present support in terms of postdocs and students should as much as possible be preserved. Only this can warrant the preservation of today's thematically broad scientific output as well as an efficient "usage" of such a highly competent but otherwise small and diverse set of physicists.
- The laboratory should pursue its support to the involvement of the group within international structures such as FUSTIPEN and possibly EUTIPEN.
- Given the present first-class contributions of the group to the progress of nuclear theory, the laboratory should encourage a higher level of direct collaboration with home or visiting experimental teams.



Intitulé UR / équipe	C1	C2	C3	C4	Note globale
UPR3266 - Grand accélérateur national d'ions lourds	A+	A+	A+	A+	A+
<i>Dense and hot nuclei</i>	A+	A+	Non noté	A+	A+
<i>Nuclear structures and astrophysics</i>	A+	A+	Non noté	A+	A+
<i>Fusion, fission and super heavies</i>	A+	A+	Non noté	A+	A+
<i>Theory</i>	A+	A+	Non noté	A+	A+

C1 - Qualité scientifique et production

C2 - Rayonnement et attractivité, intégration dans l'environnement

C3 - Gouvernance et vie du laboratoire

C4 - Stratégie et projet scientifique

## Statistiques de notes globales par domaines scientifiques

(État au 06/05/2011)

### Sciences et Technologies

Note globale	ST1	ST2	ST3	ST4	ST5	ST6	Total
A+	6	9	12	8	12	11	58
A	11	17	7	19	11	20	85
B	5	5	4	10	17	8	49
C	2	1	2				5
<b>Total</b>	<b>24</b>	<b>32</b>	<b>25</b>	<b>37</b>	<b>40</b>	<b>39</b>	<b>197</b>
A+	25,0%	28,1%	48,0%	21,6%	30,0%	28,2%	29,4%
A	45,8%	53,1%	28,0%	51,4%	27,5%	51,3%	43,1%
B	20,8%	15,6%	16,0%	27,0%	42,5%	20,5%	24,9%
C	8,3%	3,1%	8,0%				2,5%
<b>Total</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>

## Intitulés des domaines scientifiques

### Sciences et Technologies

ST1 - Mathématiques

ST2 - Physique

ST3 - Sciences de la terre et de l'univers

ST4 - Chimie

ST5 - Sciences pour l'ingénieur

ST6 - Sciences et technologies de l'information et de la communication

JM/EA/VK/110149DIR

Monsieur Pierre Glorieux  
Directeur de la section des  
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AERES  
20 Rue Vivienne  
75002 Paris

Paris, le 31 mars 2011



Objet : Observations de l'IN2P3 sur le rapport d'évaluation du GANIL

Monsieur le Directeur,

J'ai pris connaissance du rapport d'évaluation du Grand Accélérateur National d'Ions Lourds (GANIL). Je remercie le comité d'évaluation pour la qualité du travail accompli.

Les conclusions du rapport représentent un guide précieux pour la politique scientifique future du laboratoire. Outre deux corrections factuelles signalées séparément, vous trouverez en annexe deux remarques du directeur du laboratoire sur la nécessité d'augmenter les effectifs chercheurs du laboratoire, notamment pour ce qui est du groupe de Théorie et sur la mention explicite des nombreuses collaborations internationales sur les instruments nouveaux utilisables sur SPIRAL2.

Recevez, Monsieur le Directeur, l'assurance de ma considération

Jacques Martino,  
Directeur de l'IN2P3

*Direction*

Caen, le 1<sup>er</sup> avril 2011

Réf. : DIR\_2011\_038

Objet : Remarques du GANIL sur le rapport AERES

1) **Commentaires sur le texte du rapport concernant l'évolution de la taille du groupe de physique, la place du projet SPIRAL2 et les recommandations sur la physique théorique, son rôle et son évolution :**

**Page 6 Recommandations** Groupe de physique et Spiral2 :

"A modest increase of the experimental subgroups by 2-3 permanent staff members" proposed by the Committee is really at the limit. We will have 3 completely new and big experimental halls so 3 new permanent staff members is really a strict minimum (see below comments of theory).

**Page 7 Commentaires** sur le Groupe de physique-Collaborations Internationales nouveaux Instruments SPIRAL2 :

"Especially the collaborations to build instruments for the SPIRAL2 facility are to be noted." It is worth to add explicitly the collaborations for new instruments in which physicists of GANIL strongly contributes: ACTAR, AGATA, DESIR, EXOGAM 2, FAZIA, GASPARD, NFS, NEDA, PARIS and S3. Among these instruments: DESIR, NEDA, PARIS, GASPARD and ACTAR are not mentioned in the document at all, AGATA and NFS are mentioned once on physics programs and involvement of GANIL physicists. More in general, there are very few sentences in the report on the future physics program with SPIRAL 2 and no remarks on the links between Physics Group and SPIRAL2 Project (two deputies of scientific coordinator of SPIRAL2)

2) **Commentaires sur le groupe théorie (section 2 and p. 19) :**

GANIL feels that the overall appreciation (Sect. 2) does not recognize properly the place and role of the theory group even though it contributes to about 30% of the scientific output of GANIL and to a significant part of the training of the PhD-students.

AERES report says: "Given the fact that there is no strategic reason to make the permanent theory staff much larger inside a laboratory whose main mission is to foster world-leading experimental research, the challenge for the GANIL directorate over the coming years, when vacancies occur (transfers or retirements), will be to insure a recruiting at the present top level while maintaining a correct balance between the different needed subfields. »

*Direction*

In our view, the new challenges to nuclear theory in exotic nuclei require a fast reorientation of the interest of theorists. Labs like GANIL have a great role to play in this evolution by initiating a development of new, relevant models/theories, by providing a coordination and orientation for theory groups in France, Europe and in the world.

To correct for the past trend, leading experimental facilities, like GANIL/SPIRAL2, should be focused on theory to a much higher degree by funding the project-oriented theory initiatives, supporting existing university theory groups, and creating new, project-oriented theory positions at the universities. FUSTIPEN has been initiated by GANIL physicists. Future initiatives to coordinate European efforts in nuclear theory cannot be thought without the strengthening of a group by new staff members and project-oriented initiatives (post-docs)

To play such a strategic role by the GANIL theory group, it is mandatory to strengthen its present staff by one new member.



Pr. Sydney GALES  
Directeur



Direction des sciences de la matière  
Le Directeur

Monsieur Pierre Glorieux  
Directeur de la section des Unités de recherche

AERES  
20 rue Vivienne  
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Saclay, le 21 Mars 2011

N/Ref: DSM/Dir-11-0332-YC/LB

Objet: Observations de la Direction des Sciences de la Matière du CEA sur le rapport d'évaluation du Grand Accélérateur National d'Ions Lourds (GANIL)

Monsieur le Directeur,

J'ai examiné le rapport préliminaire d'évaluation mis en ligne le 14 Mars 2011 pour le Grand Accélérateur National d'Ions Lourds (GANIL).

Je tiens tout d'abord à remercier l'AERES et le Comité d'évaluation pour le travail accompli et pour la qualité du rapport.

En tant que Directeur de la DSM, j'ai très peu de commentaires à apporter sur ce rapport très positif pour nos équipes.

Je prends bonne note des recommandations du Comité et je peux vous assurer que je prêterai la plus grande attention à la mise en œuvre des actions, en particulier vis-à-vis de l'Université, qui permettront de les suivre le mieux possible.

Il convient de noter qu'une des menaces identifiées dans le rapport est d'ores et déjà écartée, grâce à l'importante contribution au financement de l'équipement S3 obtenue dans le cadre des Equipements d'excellence.

Pour ce qui est du nombre de physiciens et de post-docs, la DSM doit faire face à un budget très contraint en particulier en ce qui concerne les Très Grandes Infrastructures de Recherche. Dans ce contexte, la DSM fait un effort tout particulier pour le GANIL en maintenant l'effectif pratiquement constant, après l'avoir significativement augmenté pour le projet SPIRAL2.

Veuillez agréer, Monsieur le Directeur, l'expression de mes cordiales salutations.



Yves Caristan