contributions to the future of GANIL

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Nuclear structure from electron-ion collisions

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We propose to address fundamental questions on the structure of unstable nuclei with a focus on nucleon density distributions. Densities were investigated using electron-stable target scattering and give rise to a set of data founding our knowledge of the nuclear shape in the valley of stability. Similar detailed and precise information could be obtained for exotic nuclei with an electron-Radioactive Ion (RI) collision machine. These measurements could be done at GANIL. A project proposal on the question of the charge densities of radioactive nuclei will remain pertinent in the next decades. This project would make GANIL a world competitive machine with unique observables. It would attract in situ the international e-RI community for common experimental programs. The main challenge is to have the electron machine and the instrumentation designed for the e-RI collisions. The purpose of the current proposal is to outline the objectives of the project and the work tasks to be done in the next years. Applications of an electron accelerator at GANIL are also underlined.

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Search for New Physics beyond the Standard Model with precision measurements in nuclear beta decays

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Nuclear Physics has played a major role in establishing the laws of physics at the most fundamental level and in shaping the Standard Model of elementary particles (SM). Notable examples include the discovery of maximal violation of spatial inversion symmetry, *P*, the left-handed vector axial-vector (*V-A*) nature of the weak interaction and the conservation of the vector current. Today, the SM still leaves open questions such as the masses of neutrinos, the nature of dark matter, the baryon asymmetry etc⋯and most efforts are dedicated to the search for New Physics (NP), i.e observations that would reveal deviations from the SM predictions. This search is a strong motivation for experiments carried out both at the high energy frontier, with the most powerful particle colliders, and at the precision/intensity frontier, in low energy processes such as beta decay. A recent theoretical approach, based on effective field theories, enables a relevant comparison between results obtained at low and high energies highlighting their complementarity at a given level of precision. The development of new and always more advanced technologies suggests that unprecedented precisions should be reached in future low energy measurements, which require the control of systematic effects at equivalent levels of precision. Analysis and interpretation of results must also include higher order effects which have thus to be determined or computed with the appropriate accuracy. In this context, key experiments, a large part of which could be performed during the next decade with specific nuclei and using well defined experimental methods, can be identified. The projects and experiments carried out by French laboratories involved in the field focus on three specific topics summarized in this contribution.

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Contribution to the future of GANIL / 13

How GANIL facilities and their programs improve our knowledge in neutron data related to heavy ions interactions, radioprotection, nuclear safety, calculation codes management and environment sciences

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A. Thick Target Neutron Yields for radioprotection, Monte Carlo codes benchmarks and heavy ion accelerators operation and control
The neutrons are the major hazards in particle accelerator facilities. These neutrons are emitted by the interaction of accelerated ions (light or heavy) with different components of the accelerator (dipole, walls, Faraday chambers, Current measurement instruments ⋯). The neutrons are emitted following a continuous spectrum that depends on several factors (nature of the incident particle, its energy, angle emission). The intensity of the neutron flux depends on the accelerated ion current but also on the energy of this ion, its nature and the emission angle. In order to quantify the hazards of these neutrons and, in consequence, the necessary biological protection to establish in the facility, we need to characterize the double differential (angle, energy) neutron flux generated by the interaction of the ion on thick targets. Some Monte Carlo codes (MCNP, PHITS, FLUKA) allow modelling these interactions and are able to calculate these neutron fluxes. But often we find serious disperancies between these models. So to accomplish these characterizations, GANIL facilities give us exceptional experimental environment to make the neutron measurement with incident heavy ions for a wide energy interval [3 ; 95] MeV/n and within an important interval mass [12 ; 238]. These neutron data are of a great interest to manage the radioprotection in accelerator environment and especially to dimension radio-biological shielding but also for the operation of the accelerators (determination of the maximum of particles intensity that could be used in experiments). These data are also important to benchmark Monte Carlo codes used for modelling and simulation of heavy ions and to improve physics models that are implemented in these codes. These were and are the main goals of a program developed in GANIL called TTNY (Thick Target Neutron Yields).

B. Calculation platform
The different projects of GANIL during ten last years allowed to not only to develop an important scientific expertise in Monte Carlo calculation and simulation but also to install and test techniques adapted to new needs in calculation, to manage the safety of the access to these codes. To cover the needs of calculation GANIL installed several calculation cluster for different usages (High performance calculation, parallel computation). It appears that the current needs are now focused on grid computational clusters that allow the larger types of uses. In the coming next years, we need to keep and develop the acquired competences, as well as our expertise in data storage and management, and to steer towards new innovative fields like machine learning or deep learning.

C. Radioprotection, nuclear safety and environment
Radioprotection is a major element in the operation of nuclear facilities. GANIL is a very specific nuclear facility since it is the unique accelerator classified as an INB (Installation Nucléaire de Base) with big radioprotection and nuclear safety constraints. To respect these constraints, Radioprotection and nuclear safety teams, during last decades, developed several specific systems dedicated to the control access in the facility and/or to the calculation of dose rates generated by high energy neutrons which are induced by the interaction of heavy ions with different materials. These calculation tools allow namely to control the effectiveness of biological protections. Furthermore, among the control systems we mention UGA (access control unit) which is linked to UGB (gamma, X-rays and neutrons radiations detectors control unit) and SAAF (beam stop unit). As a matter of fact, GANIL is a major facility with a strong expertise, in heavy ions radioprotection, acquired during the last 30

years. Moreover, this expertise is reinforced on the occasion of every new enlargement project and new facilities (SPIRAL 2 LINAC, DESIR, ⋯).

Another example is the BLM system that was recently developed for the new facility (LINAC of SPIRAL2) in collaboration with some European partners. One of the real problems that we meet in accelerators is the loss of the beam which induces direct consequences on radioprotection and nuclear safety. The BLMs will allow to monitor the operation of the LINAC regarding the measurement of beam losses. It is the first time that a such system is used in GANIL and even in France. This system was verified under weak power during the commissioning of the LINAC last months. More verifications will be done during next months, even next years, when the accelerator reaches higher powers. One the great interests of this system will be the benchmarks of some Monte Carlo codes used in nuclear simulation of light and heavy ions transport.
As for the radioprotection and nuclear safety, the environmental issues in GANIL are also specific and they ask specific manners to deal with. As an example, we mention the air activation that it is generated by high energy neutrons. So, the calculation of the neutron flux produced by the interaction of the beams with the materials in experimental areas is now necessary to complete the National Radioactive Waste Agency's (ANDRA) requirements in terms of nuclear wastes characterization. The National Agency is particularly aware about the pure beta emitters presents in the materials. Consequently, the methods used by environment teams depend strongly on nuclear data and the quality of the precision of these data (cross sections, decay modes and half-lives⋯).

Contribution to the future of GANIL / 14

Future of GANIL –SPIRAL 2 as a radioactive ion beam facility

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In this contribution, the nuclear physics community presents conceptual ideas for the evolution of GANIL. Given the time needed to bring such ideas to fruition –typically 10-15 years –it is clear that the work towards a future upgrade or new facility needs to begin soon. Two scenarios are outlined in the following. While the studies of each are at a very preliminary stage we believe each of them has the potential to provide GANIL with unique capabilities and a long term future in an international context.

Contribution to the future of GANIL / 15

Continue and impove the high-energy beams for radiation biology in GANIL

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This is the letter from the teams using LARIA platform and the high energy beam lines in GANIL for Radiation Biology

Contribution to the future of GANIL / 16

Support letter from the EMIR&A federation

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Support Letter from the EMIR&A research federation

Contribution to the future of GANIL / 17

Interdisciplinary research in Laboratory Astrophysics: studies of irradiation effects on molecular ices in different space environments

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Interdisciplinary research in Laboratory Astrophysics:
studies of irradiation effects on molecular ices in different space environments
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Importance and uniqueness of the GANIL facility

Ices, mainly composed of simple molecules such as H2O, CO, CO2, NH3 and others are ubiquitous in space: they are present in comets, satellites of planets (e.g Jovian moons) and on the grains of the dense molecular clouds in the Inter Stellar Medium (ISM). They are constantly exposed to complex and diverse radiation fields due to interactions with solar/stellar winds, magnetospheres or/and cosmic rays (UV, X-rays, electrons, H, He and heavier ions).

Since several decades, laboratory studies are performed extensively to investigate energetic processing of astrophysical ice analogues. However, for a long time, those investigations were mainly focused to evaluate effects induced by weakly ionizing radiation such as UV photons and keV-MeV light ions (H, He) thanks to the use of relatively small and more common keV to MeV proton accelerators. Large scale installations, such as GANIL, open a new energetic window to simulate interaction with swift heavy ions from Galactic Cosmic Rays. Such studies extend the domain of the ion-matter interaction applied to astrophysical contexts.

Since more than ten years, several beam lines of GANIL (IRRSUD, SME and LISE) were used to simulate the interaction of cosmic rays with ices. Some specific heavy ion effects due to the high energy deposition, e.g. concerning sputtering and fragmentation, were found to be of great importance. This energetical domain extends that of weakly ionizing radiation triggering a growing interest in the astrophysical community.

The radiolysis (fragmentation/destruction of molecules) of molecular ices leads to formation of new molecular species including complex organic molecules. The origin of primitive organic matter is a central issue of modern astrophysics. Organic matter precursors are observed in dense ISM phases. These molecules are injected in protoplanetary disks and evolved under radiations (UV, X-rays and ions) in their cold and dense phases. Primitive organic molecules are also constantly formed at the surface of small bodies (asteroids and comets). These different organics components are constantly transported from interplanetary space to planets via e.g. micrometeorites and carbonaceous meteorites. Therefore, these primitive organics molecules contributed to the building blocks of prebiotic molecules on the young Earth. Thanks to state-of-the-art equipment developed at CIMAP in collaboration with the community and financed by various funding sources (including ANR, FEDER), chemical or physical evolution during irradiations can be followed in situ with analytical facilities including Fourier Transform Infrared Spectroscopy (FTIR),visible-ultraviolet spectroscopy (Vis-UV) and mass spectrometry. The instrumental facilities developed on GANIL beamlines is highly competitive providing dedicated apparatus for such inter-disciplinary research on heavy ion large scale accelerators.

A further important and unique feature of GANIL is the possibility to perform experiments on different beamlines covering several regimes of microscopic energy deposition mechanisms, from elastic collisions to electronic excitation, including regimes were both come into play, allowing to mimic effects by ion collisions in different astrophysical environments (evaluation of surfaces in Solar System icy objects, molecular clouds, ⋯). This allows to establish scaling laws for different processes (e.g. sputtering, amorphisation, compaction, fragmentation) and in turn to estimate times scales for compaction and amorphisation, desorption/sputtering rates, and molecular survival times in space.

It is worth to underline, that more than 60 papers in refereed journals have been published and numerous invited talks in prestigious conferences covering atomic and molecular physics and astrophysics such as ICPEAC, HCI, ECLA, ICACS, SHIM, IAU (to name only a few) have been given, resulting from ion irradiation of astrophycial ices studies at GANIL from 2009 to 2020. Since the first exploratory experiments in 2008, the number of users has strongly increased.

Future needs and evolutions

The key facilities for our research in the domain of Laboratory Astrophysics and Astrobiology are and remain the ECR sources and in particular the cyclotron ion beams with their corresponding beamlines ARIBE (ECR Hall D), IRRSUD (C0), SME (CSS1) and HE (CSS2) and the available in situ experimental set-ups which can be used at the different beamlines.

The large demand (a third of the proposals made at last IPAC came from our international community alone) for beam time clearly points out the need for sufficient available beam time. In the future, it could be interesting to advance toward studying mixed radiation fields as in space searching for synergy effects. It would be interesting to add UV, x-ray, and electron radiation sources.

Furthermore, to simulate the complete cosmic ray fields, simultaneous or subsequent irradiation with proton beams would be a major unique advancement to expand the possibilities of the future GANIL. Within the EMIR network, a proposal was made to add a H/He accelerator with the possibility of dual beam irradiation. One could also think about dedicated space irradiation simulation beam line(s) for our community.

Through laboratory simulations of expected radiation effects in icy space environments, showing how to detect them and what observations to search for, the GANIL beam line facilities could significantly contribute to prepare future space missions like the ESA JUICE or the NASA Europa Clipper (exploration of the jovian moons) as well as to interpret the future data for which the GANIL has a unique position in the international community. The experiments performed at GANIL are essential to predict and interpret the observations by such space probes, and also of telescope based observations from the ground (VLT on KBO's). There will be also relevant for the future space telescope JWST in which ESA and European scientists are engaged. Some of the involved PIs are already performing prospective experiments at GANIL.

Contribution to the future of GANIL / 18

Swift heavy ions at GANIL, an indispensable tool to understand the evolution of radiolysable materials, to nanostructure them and to ensure the nuclear power industry safety

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This document is aimed at presenting how Swift heavy ions at GANIL are used in the framework of basic research and industrial research on radiolysable materials and why it is highly important to maintain a viable beam access on the IRRSUD, IRASME and IRABAT lines.

Contribution to the future of GANIL / 19

RFQ injector A/Q = 7 for the production of exotic nuclei using fusion-evaporation and multinucleon transfer reactions

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Having a Q/A = 1/7 or 1/6 injector available as soon as possible is essential for S3 to be competitive for heavy and super-heavy nuclei studies. A higher intensity can be obtained for the heaviest beams with an injector Q/A = 1/7 compared to 1/6, but will not benefit to S3 in the medium term due to the limitations of the S3 electric dipole. In the longer term, it is imperative to increase the variety of beams on offer for the long-term future of GANIL and SPIRAL2: radioactive beam production method different from fission, alternative to the CSS cyclotrons, and new associated instruments. An energy limitation of the injector Q/A = 1/7 compared to 1/6 is not prejudicial in this perspective, whereas the highest intensities of the heaviest beams are an advantage in the 1/7 case. This is illustrated with the case of multinucleon transfer reactions produced using a target-ion source followed by a post-acceleration. Such an experimental complex would make it possible to have competitive beams for a unique physics.

Contribution to the future of GANIL / 20

support letter from the LSI

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support letter from the LSI

Contribution to the future of GANIL / 21

Contribution to the Spiro Committee on the Future of GANIL

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GANIL was established some 40 years ago and has a long history of contributions to nuclear and heavy-ion physics and related applications. Over the last decade, GANIL has traversed a difficult period, in particular through delays to SPIRAL2, the cancellation of Phase 2 and the inevitable competition from facilities elsewhere. In this submission we provide some observations and recommendations concerning the future of GANIL in terms of its management, its integration with the national community and its evolution within a European and broader international context. We make these suggestions in the belief that GANIL has a clear potential to be an internationally leading facility again, building on the soon to be completed SPIRAL2 installation. We also believe, however, that to advance in such a direction requires change and reform.

Contribution to the future of GANIL / 22

Atomic and molecular collision physics: application to hadrontherapy

Auteur: CIMAP laboratory and collaborators[None]

See the attached file.

Contribution to the future of GANIL / 23

Reacceleration of radioactive ions beams at Ganil

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This document aims at describing the different physics programs that could be driven within the reacceleration stage of Radioactive Ions Beams (RIB) at GANIL in the future.

Contribution to the future of GANIL / 24

Addendum to the Contribution to the Spiro Committee on the Future of GANIL

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In this submission a brief addendum is provided to discussions of possible scenarios for the future of GANIL, in terms of its evolution within a European context.

Contribution to the future of GANIL / 25

A new Interdisciplinary Irradiation Area at SPIRAL2

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This contribution proposes an evolution of the current SPIRAL2 Phase 1 facility toward 1) a multiuser facility, 2) a broader scientific scope and 3) an increase of interdisciplinary applications with a potential high societal impact.

Contribution to the future of GANIL / 26

Interdisciplinary research at GANIL

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Since the creation of GANIL, the use of swift heavy ions by communities other than nuclear physics has been considered. Thus the CIRIL laboratory was created to host interdisciplinary experiments. In 1989, the construction of the medium-energy line (SME) renewed the interdisciplinary research, by allowing the addition of about 3000 hours of beam time for material irradiation and collision physics to the 10% of high-energy beam time. Since then, the GANIL beamline possibility was greatly enriched first with the creation of a multicharged low-energy ion line in 2000 (LIMBE, which has

evolved since 2005 with the ARIBE installation having several beam lines), and then the IRRSUD line (2002) which takes advantage of the presence of two compact cyclotrons (the "free"cyclotron is used for interdisciplinary research. The ion energy of this beamline is exactly those of fission products and the lowest energy allows having high electronic stopping power but without activation of the samples, which makes easier the characterization after irradiation).

Contribution to the future of GANIL / 27

Nuclear physics for basic science and applications

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In this contribution, the DPhN presents its priorities for the evolution of GANIL. Saclay physicists are currently conducting experiments along three main scientific axes:
1) properties of nuclei at the extremes of isospin asymmetry, excitation energy and shape,
2) heavy and super-heavy nuclei at extreme masses,
3) neutron-induced reactions notably for the study of fission in actinides, with applications for nuclear data.

Regarding the scientific future of GANIL, DPhN physicists propose along these three axes the construction of three new scientific tools, which will ensure that GANIL will continue to be a worldwide competitive facility:
• An installation for studying nuclear structure with electron-ion collisions, that will provide a new original probe to study charge distributions in radioactive nuclei,
• a facility capable of delivering a wide range of radioactive beams, both on the neutron- and proton-rich sides, at energies up to ~ 60 A.MeV, and
• the construction of an RFQ A/Q = 7 injector for enhancing the intensity of ion beams ranging up to U. This upgrade will be vital for the long-term programme of S3 and will also allow the production of new neutron-rich nuclei through multi-nucleon transfer.

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Contribution to the future of GANIL / 28

Atomic and molecular collision physics at GANIL

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Since about 35 years, the community of atomic and molecular collision physics has widely used the GANIL facility for countless experiments performed within numerous national and international collaborations. Recent reviews of the advances achieved at GANIL in this field are available here: X. Fléchard et al JPCS 629 (2015) 012001 and H. Zettergren JPCS 629 (2015) 012003. These experiments have been focusing on the study of the interaction of ions with dilute matter ranging from isolated atoms and molecules to molecular clusters, as well as nanoparticles nowadays. Thanks to the wide range of projectile energies and species available on the different beam lines of the GANIL facility, elementary processes such as electron capture, ionization and excitation have been extensively studied. Since the last years, the relaxation processes of the collision partners after the collision have been another specific source of interest.

Contribution to the future of GANIL / 29

S3 at SPIRAL2/GANIL

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see the attached file

Contribution to the future of GANIL / 30

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Contribution to the future of GANIL / 31

Letter of Intent

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The Future of GANIL: A Contribution from Material Science

Contribution to the future of GANIL / 32

Support letter of GSI for non-nuclear and cross-disciplinary sciences

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Support letter of GSI for non-nuclear and cross-disciplinary sciences

Contribution to the future of GANIL / 33

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The Future of GANIL: A Contribution from RADIATE

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NFS: a powerful tool for Nuclear Data Measurements ready for operation

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This contribution to the on-going prospective on the future of GANIL/SPIRAL-2 aims at detailing the potentialities of the SPIRAL-2/Neutrons for Science (NFS) [1] facility for nuclear data measurements.

Applied nuclear physics is omnipresent in our daily lives and has many strong links to the Sustainable Development Goals set up by the United Nations [2]. From energy to health applications, through environmental, space and societal applications, nuclear data are basic inputs for these fields [3]. Also the NUPECC Long Range Plan 2017 - perspectives in Nuclear Physics, realizes this and a wide range of nuclear physics applications in need of nuclear physics knowledge is described. To this end, great efforts are still conducted all over the world to increase our basic nuclear physics knowledge and enable us to produce modern nuclear databases which will be quality assured and at the accuracy level needed by the applications.

The nuclear physics knowledge needs from the applications are often very advanced, e.g. in the energy and medical sector. Reasons are, among others linked to safety and economy. Therefore, they need well-understood, traceable and reproducible nuclear data input with well-defined uncertainties. To meet this goal we need to improve our theoretical understanding of nuclear physics and develop reliable nuclear model codes. Such efforts need in turn high-quality experimental data and it is here where the unique capabilities of the NFS facility come into play.

Neutron induced reactions play an important role in a wide range of applications including nuclear power reactors, accelerator driven systems (ADS), fusion technology, medical diagnostics and therapy, radio-isotope production, materials research, non-destructive testing, dosimetry and dose effects, radiation damages and upsets in electronic devices as well as in basic nuclear physics. As an example, research and development on nuclear reactors both for optimization of current generation or for study of next generation plants require highly detailed and sophisticated simulations. Indeed, reactor operation and safety parameters, fuel burnup, nuclear waste production, etc. can be studied by simulation with Monte Carlo or deterministic codes. These codes simulate the fundamental interaction of multi particles with matter and use as inputs nuclear data like reaction cross sections, angular distributions, fission yields, decay constants, etc. These inputs are called evaluated nuclear data. They are compiled in evaluated nuclear databases and determined from experimental data and complemented by state of the art nuclear reaction models. The increase of calculation power allows today precise sensitivity studies, which reveal that the limiting factor for accuracy simulations of

reactor parameters is the accuracy of input evaluated nuclear data. International community is thus continuously working on the improvement of evaluated nuclear data libraries like the European - JEFF (Joint Evaluated Fission and Fusion), the US - ENDF (Evaluated Nuclear Data File), Japanese - JENDL (Japanese Evaluated Nuclear Data Library) and some others. The quality of evaluated nuclear data with their variance-covariance matrices can be improved with efforts both from the experimental and theoretical sides, as reliance on nuclear models is common today for nuclear data evaluation. In some cases, where experimental data are scarce or known with low precision, new measurements are mandatory to provide new and relevant constraints for nuclear modeling. To help experimentalists and theoreticians to stimulate and guide their research, a reference tool has been created by the OECD/NEA, the High Priority Request List (HPRL)[4] which compiles requests for new measurements, selected after rigorous sensitivity studies for various applications (fission, fusion, dosimetry, standard and others) and for which a target accuracy is specified.
There is a large demand on fast-neutron induced-reaction data as well as proton and deuteron induced-reaction in the energy range between 1 and 40 MeV. For many cases, like (n,fission), (n,n'), (n,xn), (n,Light Charged Particle), (p,X), (d,X) reactions, the cross sections are unknown or known with insufficient precision. In this context, the new NFS facility with its various beams (charged particles and quasi mono energetic or continuous neutron beams) and tools (flight path areas, irradiation station, pneumatic transfer system and more) is ready to play a significant role in the field to produce new nuclear data relevant for applications.
The particle induced activation reactions have a great interest for the assessment of induced radioactivity in the accelerator components, targets, beam stoppers and biological shielding, which is an important matter for safety aspects during facility operation and also for decommissioning operations including identification of the right waste repositories [5]. This is particularly true for the radioactive inventories in activated parts with high contribution from pure beta emitting radioisotopes that are very difficult to measure. Therefore, their contribution to the total activity, which strongly influences the further waste management, can only be calculated by activation codes using evaluated nuclear data libraries. Neutron beams available at NFS will allow validating the calculation tools by irradiating samples in well-known conditions and therefore improve the decommissioning strategies and reduce the associated costs. There is an increasing demand from the industry on this matter especially for medical accelerators (radiation therapy and isotope production for medical applications) considering the large number of facilities in operation (more than 4000 in Europe and 500 in France, with an increasing rate of 14% over the last five years).
EUROfusion/ENS (Early Neutron Source project)[6] or the SPIRAL-2 facility itself need such kind of data for estimation of the potential radiation hazards from the accelerating cavities and beam transport elements. Some important cross sections are needed in the energy range from the activation reaction threshold 2 - 10 MeV up to 40 MeV both for deuterons and protons, while the account of particular processes as the deuteron breakup needs at the same time a suitable knowledge of the corresponding data for breakup-neutrons/protons induced reactions within the related energy ranges.
Monoenergetic neutron spectra with variable energy up to 31 MeV enable the measurements of differential cross sections and thus direct validation of theoretical models and evaluated libraries for given energies, i.e. leading to excitation functions of the reactions of interest. There are thus pointing out and eventually endorsed issues of the reaction-mechanism energy dependence while the emission-spectra analysis concerns firstly the excitation-energy dependence of various nuclear structure questions.
The high neutron fluxes with large and tunable energy spectra available with energy up to 40 MeV at the NFS facility as well as the pulsed beam and the long time-of-flight area are very attractive to obtain accurate data. The high neutron fluxes would allow the measurements of small reaction cross-sections and/or with very small targets, which might be rare, expensive, and in some cases radioactive. The energy range and conditions offered by the NFS time-of-flight facility is complementary to other facilities in Europe, notably GELINA at JRC-Geel, Belgium and the n_TOF facility at CERN. Working at GANIL-SPIRAL2 in the same environment with physicists engaged in cutting edge research in nuclear physics and astrophysics and using forefront experimental devices will be an important asset for the entire nuclear data community.
NFS was strongly supported by the physicists of the nuclear data community and was involved in the former CHANDA European project [7] and is now in the ARIEL European project [8], where its role will be strengthened by an important nuclear-data production from experiments.
Most of the experiments mentioned above can be performed at NFS, whose characteristics (neutron flux, energy, sample purity and/or possibility of using actinide targets) are well adapted. There is an opportunity for GANIL-SPIRAL-2 to welcome a new community of physicists working on nuclear data and contribute significantly to the international effort for high quality nuclear data measure-

ments. NFS is ready to become a reference facility in this field and thus fulfill entirely one of the missions for which it was built. This will only be possible if a significant part of the beam time is dedicated to these measurements. These experiments must be examined by the Program Advisory Committee (PAC) of GANIL-SPIRAL-2 on an equal basis with the long-established physics themes of GANIL, and also taking into account their above-mentioned own physics context. NFS can in this way play an important role in the future of GANIL.

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Contribution to the future of GANIL / 35

Material Science (inorganic) at GANIL

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In materials science, many studies use GANIL ion beams to simulate irradiation conditions encountered in harsh, radiative environments, such as those in nuclear reactors, in accelerators or even in space. Another field for which GANIL beams are frequently used is defect engineering or, more generally, the use of swift heavy ions to modify materials in a beneficial (and controlled) way. What is essential for any application is the consequences of the irradiation-induced structural modifications on the functional properties (electrical, mechanical, chemical···) of the materials. Therefore, there is a crucial need for the development of a multiscale predictive approach to better understand the irradiation effects induced in materials and even to predict those. For this purpose, there is a crucial need in experimental data: the beamlines and the in-situ set-ups should be maintained and developped.

Contribution to the future of GANIL / 36

Efforts towards the internationalization of GANIL

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Efforts towards the Internationalization of GANIL
Submitted by the IDEAAL working group on internationalization of GANIL

This contribution aims at bringing to the attention of the committee the efforts made in the framework of the IDEAAL contract towards the internationalization of GANIL.