HORIZON 2020

Research Infrastructures

H2020-INFRAIA-2014-2015

INFRAIA-1-2014-2015 Integrating and opening existing national and regional research infrastructures of European interest

ENSAR2

European Nuclear Science and Application Research 2

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LIST OF ACRONYMS AND ABBREVIATIONS

GANIL	Grand Accélérateur National d'Ions Lourds, France
FISCO2	FInancial and SCientific Organisation 2
NuPIA	Nuclear Physics InnovAtion
TNA	Trans National Access
NA	Networking Activity
JRA	Joint Research Activity
NuPECC	Nuclear Physics European Collaboration Committee
NUCNET	Independent Global Nuclear News Agency

EXECUTIVE SUMMARY

During ENSAR2 project, FISCO2 management group carried out research on impact of the ENSAR2 research infrastructures (direct and indirect, on social, environmental and economic levels). During this study, FISCO2 assessed not only the socio-economic and environmental rate of return of each research infrastructure but also the ENSAR-ENSAR2 projects fraction of the total impact on each research infrastructure.

An external enterprise (INNO TSD) was hired in order to help FISCO in this work.

A first draft of this report was written by Inno TSD. At the end of December 2018, it was submitted for comment and revision by all participants who worked on this study. Their input was integrated into a revised version that was submitted to FISCO2 management group in February 2019.

This final version was then prepared by FISCO2. For this report, FISCO2 made the choice to focus mainly on ENSAR-ENSAR2 projects' fallout. Nevertheless, concerning the environmental level, FISCO decided to present the environmental impact of the research infrastructures. Some general statements concerning the assessment of research infrastructures have also been left on this document as they pertain specific information which could help the understanding. Thus, the goal of this report is to be informative and provide advice to scientists and policymakers who are faced with very concrete, practical challenges related to future research programs: ie. bringing several countries together to jointly implement a large research facility.

Lastly, this report is the conclusion of 32 months of work which has been staggered by period of doubt, questioning and personal satisfaction. A great human adventure, fruit of many exchanges, this study embodies the state of mind we find among others in nuclear physics, namely knowledge sharing.

« It was Louis Pasteur who first noted that national science is, in fact, no science at all, and that true science is the property of all humankind ».

Allan Bromley (Nuclear Physics News, 5, 2, 1)

INTRODUCTION

This study constitutes the impact assessment of the transnational access of the *European Nuclear Science and Application Research"* (ENSAR) and "*European Nuclear Science and Application Research - 2" (*ENSAR2), European integrating activities for nuclear scientists. It also aims to identify the main scientific performance and economic spill over impacts of the participating research infrastructures.

ENSAR2 succeeded the ENSAR project, funded under the FP7 from 2010 to 2014. Regarding transnational access, ENSAR was aimed at opening the access to eight research infrastructures representing worldwide state-of-the-art facilities , in the field of nuclear research: ALTO (France), CERN-ISOLDE (Switzerland), GANIL (France), GSI (Germany), JYFL (Finland), KVI-CART (The Netherlands) and LNL-LNS (Italy).

ENSAR2 was launched in March 2016 for a duration of four years. The project sought to pursue some of the activities previously carried out and having long-term goals but also developed new initiatives via networks and new joint research activities and through enlarging access to new research facilities. ENSAR2 has integrated four additional research infrastructures, for enhancing transnational access and exchanges: IFJ Pan and HIL UW (referred to as NLC Krakow and NLC Warsaw) (Poland), IFIN-HH /ELI-NP (Romania) and ECT* (Italy)[1].

The central component of these facilities are focused on particle accelerators, hence called accelerator-based science facilities, capable of providing researchers with various types of ion beams– in a wide range of energies from keV to GeV, with, in addition, the rather unique features to deliver stable beams as well as secondary beams of very short-lived isotopes called "exotic beams", which considerably broaden the potential for unique science discoveries. It is worth noting here that a new facility funded by EU regional funds IFIN-HH/ELI-NP will provide a unique access to new probes for nuclear physics; namely laser-based acceleration of ions and the production of neutrons and photons as well as a new source of monochromatic and intense gamma rays in the multi-MeV range. ENSAR2 in contrast to ENSAR, offers access to a unique theoretical centre ECT* where experiments and theories are presented and discussed throughout the year via a programme of specialised workshops.

Table 1: List of the research infrastructures involved in the TNA of ENSAR and ENSAR2

Name of the research infrastructure	Country	ENSAR	ENSAR2
GANIL	France	YES	YES
ALTO	France	YES	YES
CERN-ISOLDE	Switzerland	YES	YES
GSI	Germany	YES	YES
JYFL	Finland	YES	YES
KVI-CART	The Netherlands	YES	YES
LNL	Italy	YES	YES
LNS	Italy	YES	YES
NLC (Warsaw)	Poland	NO	YES
NLC (Krakow)	Poland	NO	YES
IFIN-HH/ELI-NP	Romania	NO	YES
ECT*	Italy	NO	YES

ENSAR and ENSAR2 have both been coordinated by the "Grand Accélérateur National d'Ions Lourds" (GANIL) which has supervised this impact study.

ENSAR2 overarching project objectives are to:

- favour and enhance access to research infrastructures for small university research groups and countries who cannot offer such high-level research tools,

[1] NB : ECT* was involved in ENSAR but did not carry transnational access activities

- coordinate European research in the field and offer efficient use and access to state-of-the-art EU nuclear physics facilities concentrating on complementary aspects of the deliverable beams and accessible detectors and associated technologies,
- undertake more efficient R&D actions regarding new developments on issues at the frontier of knowledge via both new scientific ideas and related new technologies (new materials, new acceleration concepts, highly sensitive and efficient new radiation detectors),
- deliver spin-off applications for exploitation in other domains and contribute to other European societal challenges.

To achieve these objectives, the project implemented three activities (defined in section 1):

1 Transnational access of 12 research infrastructures (11 experimental infrastructures and ECT*);
2 Joint research activities;
3 Networking activities.

OBJECTIVES OF THE STUDY

The purpose of this study is to undertake a socio-economic and environmental impact assessment of the transnational access elements of the 12 research infrastructures embedded in ENSAR / ENSAR2 projects. The impact assessment is a requirement of the H2020 programme. The programme has elaborated an evaluation framework to measure the socio-economic and environmental impacts of all H2020 projects using standardised indicators. In addition to monitoring project performances, H2020 impact assessments aim to measure the capacity of each project to reach its objectives, to contribute to value creation for broader societal needs (scientific, technological and economic performance), and to contribute to the European commitments with regards to social and environmental performance.

As a result, the impact assessment categories "economic, social and environmental" were re-organised into the following six categories, which we believe will better reflect the project activities. This concerned both the project as such, as well as the overall activities undertaken by each of the research infrastructures. The new impact categories match the requirements of H2020 whilst also taking into account the specificities of fundamental research activities:

- Weighting variables[2];
- Development of new knowledge;
- Scientific and high technology skills;
- Competitiveness and employment;
- Social impacts;
- Environmental impacts.

As a result, the study sought to:

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[2] The weighting variables aim to characterise the various RIs and to assess to what extent they have an important weight on the overall results and when necessary to correct an excessive weight.

- Assess the socio-economic and environmental impact of each of the research infrastructures;
- Estimate the specific impacts of the TNA actions in the project ENSAR / ENSAR2.

IMPACT OF THE RIS

This introduction presents the main conclusions and key figures of the project.

An important heterogeneity of the RIs involved in the ENSAR2 project

The research infrastructures involved in the ENSAR2 programme are very different from one another. They vary in size (in terms of headcount), as well as governance (some RIs are part of larger research centres). Most of the facilities have particle accelerators, providing the researchers with various types of ion beams. Two RIs are not accelerator science-based facilities: ECT* is a theoretical research centre and IFIN-HH/ ELI-NP provides a laser-based acceleration of ions and the production of neutrons and photons as well as a new source of monochromatic and intense gamma rays in the multi-MeV range.

The diversity of ion beams provided by the various RIs considerably opens up the scope for possibilities of scientific discoveries. Nevertheless, the heterogeneity between the various RIs participating in the TNA constitutes a challenge for the impact assessment. Their perimeters are different and make the analysis more complex. Therefore, to enable comparisons between all RIs, two weighting variables were used during the study: the headcount and the available beam time provided by each RI.

The construction of new accelerators in some RIs impacted the results of the study

The results of this study were impacted by important construction work which occurred during the assessed period. Several RIs were building new accelerators during the assessment period, SPIRAL2 at GANIL, FAIR at GSI, HIE at CERN-ISOLDE, and SPES at LNL. The construction of these new accelerators has impacted the beam time provided by these RIs, as well as the number of experiments conducted. It explains why both the beam time and the number of experiments decreased, as of 2014.

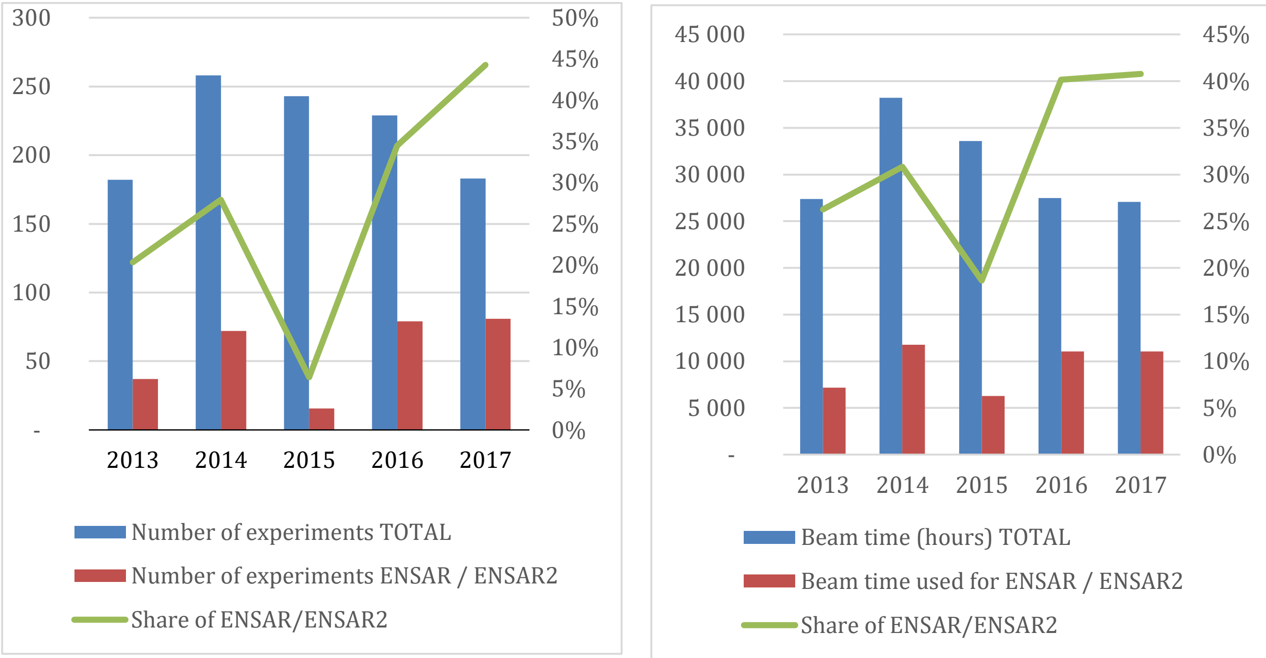

Figure 1: Number of experiments (on the left) and beam-time hours (on the right) provided in total and for ENSAR/ENSAR2

Building new accelerators has an impact on the activities of the RIs and affected directly or indirectly several indicators (e.g. spending, waste material production…). Therefore, some of the results do not reflect the usual activity of the RIs and should be interpreted cautiously.

Socio-economic and environmental impacts of the research infrastructures

The socio-economic and environmental impact assessment of the research infrastructures has enabled to highlight three main findings. First, the research infrastructures play a fundamental role in developing new knowledge in nuclear physics experimental science and in its dissemination. Second, their activity has a positive economic impact. Finally, the RIs have taken on board the importance of social and environmental issues and implement a range of targeted mitigation measures.

The RIs play a fundamental role in developing new knowledge in Nuclear Physics and disseminating it

Research infrastructures participating in ENSAR and ENSAR2 enabled researchers to conduct state-of-the-art researches and between 2013 and 2017, 1095 experiments were conducted in the 11 experimental infrastructures of the project. These experiments have enabled those involved to produce approximately 1300 publications per year, a figure stable over time.

The RIs participated actively in knowledge sharing through workshops (913 between 2013 and 2017), hosting external researchers, hence contributing actively to reinforcing the European Community of researchers.

The RIs contribute to building the capacity of staff, by training students through internships and supervise PhD candidates.

All RIs have implemented support actions to disseminate their work to the general public, either through annual actions such as open days, or by popularising their results and disseminating them through various communication tools (blogs, documentaries…).

The RIs create economic value and have a positive economic impact

The economic value of the research infrastructure may arise from different sources: employment, spending and valorisation of research.

In terms of employment, the latest data indicate that the RIs employed 2320 people. The induced employment (generated by the spending of the employees) is estimated to be between 520 to 600 employees. The procurement budgets of the research infrastructures have enabled the creation of an additional 325 to 385 jobs.

Regarding incomes, RIs are mainly funded through public funds (98%). The funds are coming mostly from national sources. European funds are also important to the RIs. RIs' funding models vary significantly from one RI to another.

In this study, research valorisation, related to patent activity for instance is part of another work package of ENSAR2, led by NuPIA.

The RIs have seized the social and environmental issues and implement mitigation measures

Regarding social issues, if women tend to be underrepresented in the RIs (25% of the staff), the number of women working in the RIs has significantly increased over time (+2.5% per year). Some research infrastructures implement support actions to enable more women to work in the field of nuclear physics, for example through addressing gender issues in their recruitment processes and through promoting science towards girls and women.

Additionally, all RIs work towards providing their employees with a safe and high-quality work environment, through the implementation of HSE policies and by organising social activities.

Concerning environmental impacts, research infrastructures have a *de facto* environmental impact through the energy and water resources they consume. This environmental impact is generated mostly by their scientific activities. The environmental impact of each RI is carefully monitored. Most of the RIs have adopted environmental policies to reduce, when possible, and without hindering scientific activities, their impact on the environment.

Impact of ENSAR/ENSAR2 projects and the specific position of the TNA

To evaluate the impact of the TNA, the study team sought first to identify the main expected or potential impacts of the project. Second, the team assessed whether or not each impact could effectively be confirmed on a quantitative and/or qualitative basis. When possible, the team measured the impact that was generated by the TNA activity.

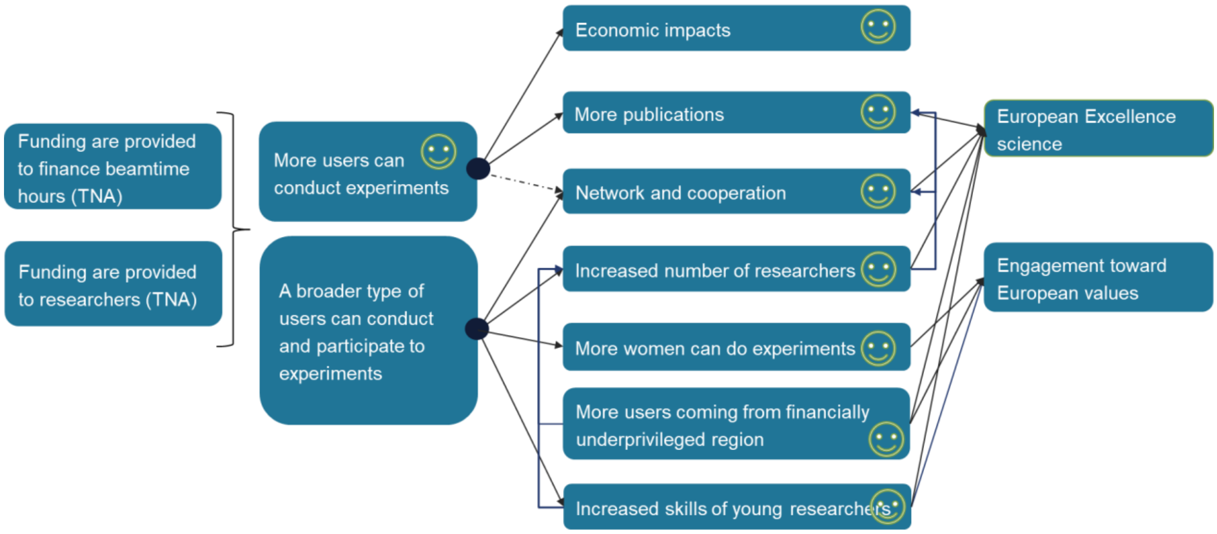

Figure 2: Synthetic view of the ENSAR/ENSAR2 impacts

All the expected effects have been confirmed by the analysis either from qualitative or quantitative basis. The main identified outcomes are:

More users can conduct experiments. We have seen that on average, an experiment conducted through ENSAR/ENSAR2 involves more users than other experiments. This result is confirmed by the qualitative exchange with the RIs. An interesting point is that, the study team has seen a reduction in the number of users funded per experiment. This result is explained by the choice of funding by the PAC. The funds are increasingly focused on researchers which could not have participated without financial support.

The TNA has thus allowed for:

- **An even higher excellence in research**, mainly through the possibility to fund the experiments that could not have been funded otherwise and to provide more users per experiment (a less significant effect).
- **More publications**: The experiments conducted in the TNA have led to new results in the nuclear physics field and thus to more publications. We have estimated that the TNA has enabled the publication of at least 340 publications since 2013.
- **Positive economic impacts**: We have estimated that ENSAR/ENSAR2 have safeguarded about 100 to 140 jobs due to this positive externality.
- **More networks and cooperation**: We have strong qualitative evidence supporting the premise that TNA has had an important impact on the development of networks and cooperation activities. The TNA has increased the number of users but more importantly, more various types of users are participating (young, users coming from financially disadvantaged countries, etc.).

An interesting aspect of the TNA concerns its focus on the users that need support the most, thus delivering a strong additionality impact:

- **Young users:** Typically, when funds are scarce and when funding an experiment in a different and overseas infrastructure, universities tend to prefer to allocate their resources to experienced researchers, in order to guarantee the best results. Young people are therefore more likely to be excluded. The way the TNA funds have been targeted means that TNA has both enabled and increased their participation. In ENSAR, they represented 61% of the beneficiaries. The funding thus appears to be an important factor to enhance their skills and to create future vocations for scientists. In the future, this focus might result in:
    - Increasing the skills of researchers and the total number of researchers in nuclear physics. Although such an effect is too indirect to be measured and is still hypothetical.
    - Increasing the share of women in the scientific community. We have evidence that women are more represented amongst TNA users than among overall staff members. These results can be linked to a societal evolution. However, by contributing to support the young researchers and help to create scientific vocations, the TNA will also contribute to increasing the share of women in nuclear physics/science. Again, this indirect effect cannot be precisely estimated, and is hypothetical.
- **Users coming from financially disadvantaged countries**: No quantitative evidence could be found from the available data, but much qualitative evidence point towards such an impact for these users. It appears that the TNA allows them to overcome the barrier of the cost of the experiments (funding of beam time as well as travel and living costs).

As a result, it is considered that the TNA is useful and has been a success. More in-depth analysis could be conducted to better estimate this impact.

Limits and challenges of the impact assessment

The dual approach of undertaking the impact assessment of the ENSAR/ENSAR2 projects and the individual research infrastructures (measuring the general impact of the research infrastructures on their environment and the share of this impact related to ENSAR and ENSAR2) constituted the main challenge of this study. Meanwhile, the broader impacts on the economy, society and the environment associated with the fundamental research activities are more long-term impacts and are at different stages of completion and/or maturity.

Therefore, to provide a more tangible grasp of the impact of fundamental research in nuclear physics on the European society, it was chosen to study concomitantly the research infrastructures and the ENSAR/ENSAR2 projects. To respect the tender specifications, measuring the share of ENSAR/ENSAR2 on the overall impact constituted one of the core elements of this study.

Another challenge concerned the data collection activities: the study specifications sought to procure a fully quantitative impact assessment exercise. To ensure the success of such a methodological objective, there was a need for complete, reliable and homogeneous data for all the research infrastructures. The choice of variables was elaborated concomitantly with the GANIL, as coordinator of the study.

These issues resulted in the need to implement an important adaptation of methodology which in itself constituted an additional challenge for this study and required to deeply modify the initial assessment plan. The changes affected the data collection method, the organisation of the study (phases were swapped) and the content of the deliverables.

SECTION 1 - ENSAR / ENSAR 2 – A KEY PROJECT FOR NUCLEAR SCIENCE

OVERVIEW OF THE FIELD OF EUROPEAN NUCLEAR SCIENCE – ACTORS AND CHALLENGES

Nuclear physics is a branch of physics which studies atomic nuclei as well as their constituents and interactions. This scientific field is different from atomic physics, which focuses on the atom as one entity, became a discipline when radioactivity was discovered by physicist Henri Becquerel, in 1896. This discovery and those that followed, enabled the scientists to discover the inner structure of the atom and its dynamics. At present nuclear physics research is being developed along four main lines:

- The structure of the nucleus, which aims to understand how the nucleons (protons and neutrons) interact to create the nuclei, and its fundamental properties (mass, spin, moments);
- The mechanisms of the nuclear reactions, which describe how the various nuclei interact (fission, fusion, scattering, etc.);
- Missing interplay between experiments and theory;
- The application domains associated to nuclear physics such as nuclear energy, radio-isotopes for imaging and medicine, cancer therapy, art and cultural heritage, space, etc.…

Theoretical nuclear physics research, seeks to develop new models based on fundamental theory of the strong and electro weak forces, whilst experimental nuclear physics, promotes experiments to validate or invalidate the models but also opens new avenues of research.

Particle accelerators are the machines which enable experiments on nuclei and their constituents to take place. They use electromagnetic fields to accelerate particles to nearly light speed and confine them in “beams”. There are several types of accelerators, which accelerate various types of beams. Each accelerator is very specific. They are usually built to answer one class of specific scientific questions and then reused for other applications.

Particle accelerators can be used as well for application-driven research and for technical and industrial use, which in fact constitute most of the usages of particle accelerators (according to Physics Today there were approximately 26,000 accelerators worldwide in 2010). There are, however, only a handful of accelerators dedicated to fundamental research. The ENSAR2 website identifies 30 fundamental research accelerators in Europe, of which 12 are part of the ENSAR2 project.

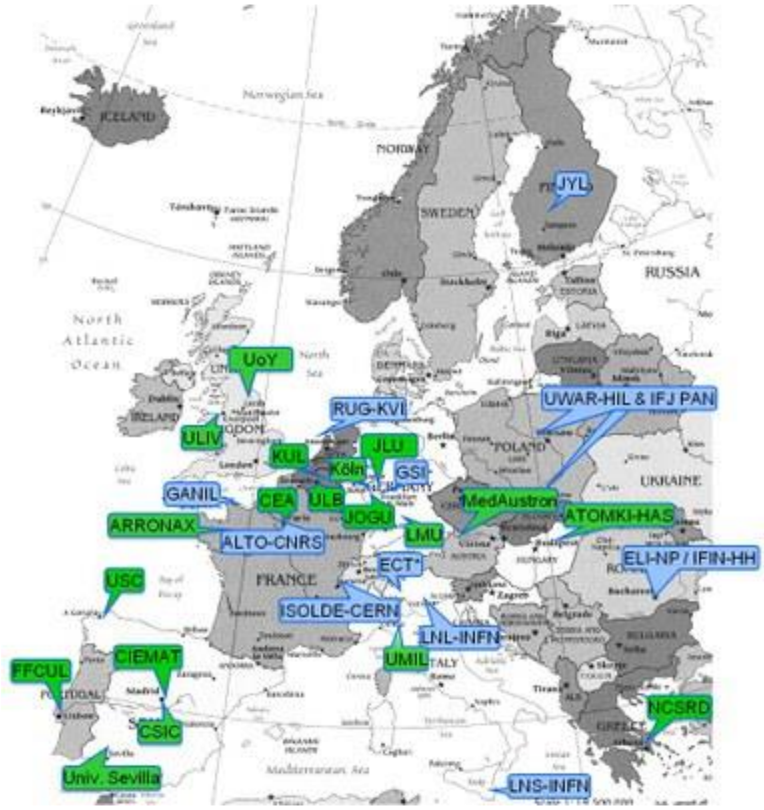

Figure 3 : European Basic research accelerators

There are several issues that characterise the field of fundamental research in nuclear physics: The knowledge about nuclear physics is expanding exponentially since the discovery of radioactivity. Scientific questions are more and more complex. This calls for a coordination of the various activities to take optimal advantage of the complementarity of the various research infrastructures.

The Nuclear Physics European Collaboration Committee (NuPECC) is one of the Expert Committees of the European Science Foundation. Its role is *"to provide advice and make recommendations on the development, organisation, and support of European nuclear research and of particular projects."* In its long-range plan published in 2017, it sets the research priorities in Europe and presents cooperation approaches: they have also defined what they regard as the most important questions to answer in physics and identify the priorities regarding the construction of new facilities, in line with the research questions: *"These fascinating topics in basic science require concerted efforts in the development of new and increasingly sophisticated tools such as accelerators and detectors".* The Independent Global Nuclear News Agency (NUCNET), a global news and information network for the international nuclear community, also stresses the need for collaboration and optimisation of EU resources.

ENSAR and ENSAR2 are projects which enable and strengthen collaboration between the various European research infrastructures.

Transnational Access is a key activity to promote broader access to the RIs for the nuclear physics community

ENSAR2 is a H2020 Integrating Activity project with a strong focus on supporting the research activities of nuclear scientists. The project seeks to enable research at the forefront of nuclear science, by providing the community of nuclear scientists with access to a wide range of large research infrastructures. As explained by NuPECC, *"these RIs can supply different species of ion beams and energies but are complementary in their provision of beams and address different aspects of nuclear structure, nuclear reactions and nuclear astrophysics".*
As explained before, the ENSAR2 project is organised around three sets of activities:

The joint research activities are constituted of seven collaborative research projects gathering international teams. The projects revolve around new and innovative technologies aimed at improving the operation of the facilities, in order to make them more efficient and effective.

The networking activities consist of seven networks on transversal topics linked to nuclear physics such as the Nuclear Spectroscopy Instrumentation Network or European Network of Small-scale Accelerator Facilities, for instance, and an eighth network, FISCO, for coordination and management.

The transnational access element lies at the heart of ENSAR and ENSAR2 and is the object of this impact assessment.

The transnational access is aimed at opening each of the ENSAR/ENSAR2 research infrastructures and coordinating European research in the field with efficient use of state-of-the-art EU nuclear physics facilities. It focuses on:

- Providing complementary beams, accessible detectors and unique technologies,
- Making R&D more efficient in relation to new developments on issues at the frontier of knowledge via new scientific ideas and related new technologies (new materials, new acceleration concepts, highly sensitive and efficient new radiations detectors), and
- Delivering spin off applications for societal use in Europe.

The transnational-access dimension entails, for each of the participating research infrastructures, providing a certain amount of their beam time to users from the ENSAR2 community. At the beginning of the project, the research infrastructures determined how many hours of beam time they can dedicate to the programme.

External European users can, in turn, apply to access the beam time and submit proposals to the Programme Advisory Committee (PAC) of the respective RI. Each RI has its application procedure. The projects are chosen based on their scientific and/or technical excellence, their selection by a PAC and their final approval by the facility directorate. The management team of the facility in turn, after discussion with the team, will propose a time slot for undertaking the proposed experiments. In addition, each project must be led by an international researcher and the team be composed of at least 50% of researchers from countries different from that of the facility where the research will be conducted.

Once a research team is granted beam time by the research infrastructures to conduct an experiment, the ENSAR2 project provides them with grants to cover their expenses during their experiments, after another dedicated application procedure. The number of funded ENSAR TNA teams is based on the number of teams who have successfully applied via approved proposals by the PAC. The grants are not necessarily given to all the researchers of the experiments. The precise characteristics of the refunding policy is left up to each individual research infrastructure to decide.

At the end of the reporting period, each infrastructure counts how many hours of beam time were dedicated to ENSAR2. They are funded through ENSAR2 based on the number of hours provided within the ENSAR2 project. The infrastructures receive funds to cover partly their expenses on the basis of the number of hours provided. The cost of the hourly rate is fixed per RI, in the grant agreement.

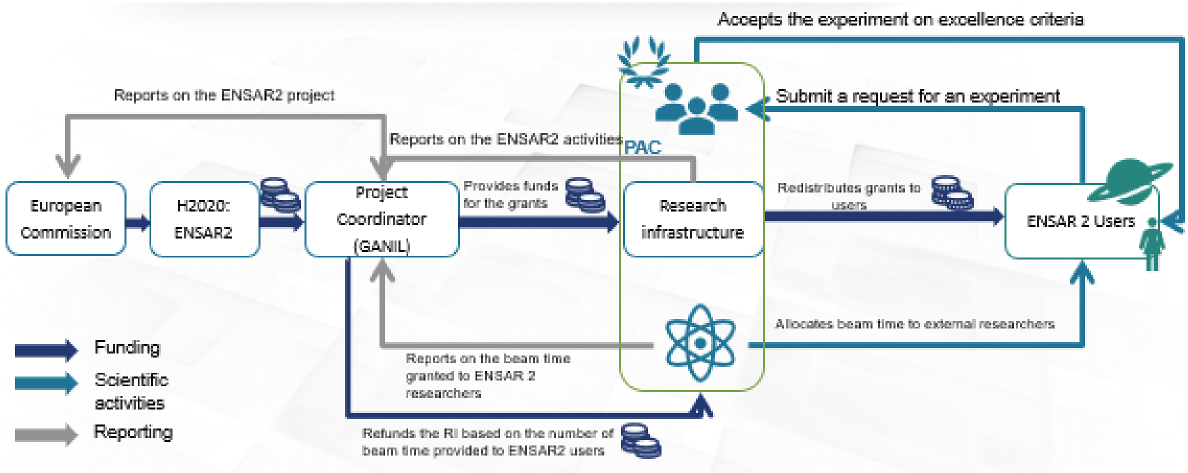

Figure 4: Overview of the ENSAR2 project

Research infrastructures receive a budget to cover the grants. A separate budget is granted to cover the use of the beam time provided to ENSAR/ENSAR2 users.

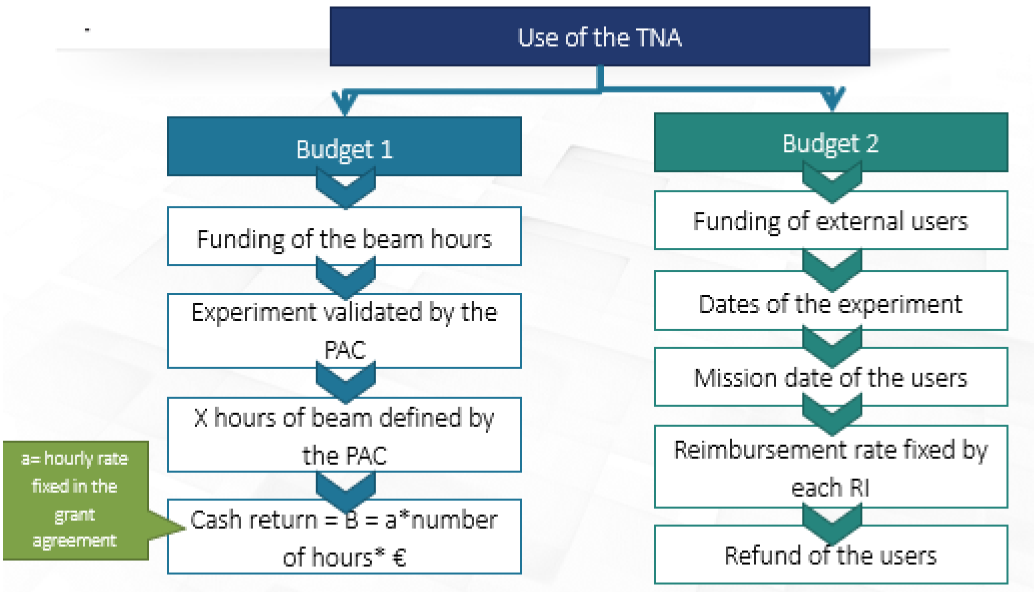

Figure 5 : Utilisation of the TNA funding

ENSAR has provided more beam time than originally estimated in the proposal: 34,400 hours instead of the 21,144 planned. This has enabled 1478 researchers to access beam time in the project's RIs. The objective of ENSAR2 is more ambitious with a target of 26,299 hours of beam time (in comparison to the 21,144 planned in ENSAR). To date, (December 2018) 27% of the expected beam time has been offered in the TNA, as detailed in the table "ENSAR2-TNA-31 months summary" transmitted by the GANIL on 24/10/2018.

SECTION 2 - FRAMEWORK AND METHODOLOGY OF THE EVALUATION

OBJECTIVES OF THE STUDY

The study objective is to conduct the socio-economic and environmental assessment of the ENSAR2 "*European Nuclear Science and Application Research – 2"* project. The project is funded by the H2020 programme on research and innovation of the European Commission.

As explained earlier, this impact assessment takes place within the context of H2020, which aims to systematise and standardise the impact assessments of the projects it funds. H2020 impact assessments aim at monitoring the projects as well as measuring their capacity to reach their objectives, to create value for society (scientific, technological and economic performance), and contribute to the European commitments with regards to social and environmental impacts.

Beyond the H2020 expectations in terms of impact assessment, the study also aims to assess scientific performance and economic spill-over effects of the assessed research infrastructures.

As a result, the overarching objective of the study is to:

- Assess the socio-economic and environmental impact of each of the research infrastructures;
- Estimate the share of the total impact related to ENSAR / ENSAR2.

SCOPE OF THE STUDY

SCIENTIFIC FIELD SCOPE

ENSAR and ENSAR2 are research projects which have the central goal to ensure the efficient coordination of use of the RI's engaged in the project, to support technical and scientific R&D within the thematic field and to facilitate the development of applications directed towards societal needs. ENSAR and ENSAR2 are research projects whose primary focus is to improve fundamental research on nuclear physics and its three subfields: nuclei structure, nuclear reactions and application domains.

Nuclear physics can be studied theoretically or experimentally: the accelerators are necessary tools to conduct the experiments, as they allow researchers to create the conditions to alter the structure of nuclei or to study the interaction mechanisms between two nuclei and/or nucleons.

SPATIAL SCOPE OF THE IMPACT ASSESSMENT

The impact assessment focuses on 12 research infrastructures, which belong to 10 different institutions. LNL and LNS, respectively, NLC Krakow and NLC Warsaw have a common government, one for each country (Italy respectively Poland), but all four of them have been studied separately for methodological convenience.

Table 2: List of the research infrastructures in the scope of the study

Name of the research infrastructure	Country	ENSAR	ENSAR2	Colour
GANIL	France	YES	YES	
ALTO	France	YES	YES	
CERN-ISOLDE	Switzerland	YES	YES	
GSI	Germany	YES	YES	
JYFL	Finland	YES	YES	
KVI-CART	The Netherlands	YES	YES	
LNL	Italy	YES	YES	
LNS	Italy	YES	YES	
NLC (Warsaw)	Poland	NO	YES	
NLC (Krakow)	Poland	NO	YES	
IFIN-HH/ELI-NP	Romania	NO	YES	
ECT*	Italy	NO	YES	

Two of the research infrastructures do not provide particle accelerators to the users: ELI-NP is a facility based on laser-ion acceleration and on unique brilliant and monochromatic gamma-ray beams.

ECT* is the European Centre for Theoretical studies and related areas located in Trento (Italy), a centre in charge mainly of the regular meetings between the experimental and the theoretical groups where interpretation of ENSAR/ENSAR2 experiments are discussed and where new theoretical models and advances are developed. ECT* offers buildings offices and meeting rooms to hold the workshops and collaboration meetings as well as computer facilities.

TIMELINE OF THE IMPACT ASSESSMENT

The impact assessment focusses on the impacts of both ENSAR and ENSAR2. ENSAR was launched in 2010 but it was decided that the assessment would only start as of 2013 Therefore, the assessment measures the impacts of the transnational access from January 2013 onwards. The end of the assessment period was initially planned to be March 2018. However, for methodological convenience, notably because the studies use full years, the end of the assessment period was adjusted to become end 2017. In the case of unavailable data, research infrastructures were asked to provide the first or the latest year available.

The ENSAR project was concluded at the end of 2014 and at that time the ENSAR2 project had not yet started. As a result, there were almost no activities conducted in 2015 in the framework of ENSAR/ENSAR2. The activities conducted in 2015 were run on the remaining budget left from ENSAR.

REFERENCE PARAMETERS FOR THE IMPACT ASSESSMENT

The impacts to be studied were designed in line with the requirement of the H2020 guidelines for impact assessment. These guidelines encourage standardised impact assessments, notably to facilitate the assessment of the whole of the H2020 programme. This standardisation led to the creation of three broad categories: economic impacts, social impacts and environmental impacts.

Impact Intervention Logic

As expressed in the presentation of the study, the objective of the evaluation are twofold:

- Assess the socio-economic and environmental impact of each of the RIs;
- Estimate the impact of ENSAR / ENSAR2.

Because of these objectives, two impact assessments were undertaken in this study:

- On the one hand, the impact of the RIs was assessed and analysed globally (as already mentioned this part will not be given in details in this report as FISCO decided to concentrate more specifically on the Impact of ENSAR/ENSAR2 projects)
- On the other hand, The impact of the TNA was analysed in detail. As a European project, the outcomes and impacts have been qualified and estimated. Some baseline elements have been defined when it is possible to assess what would have happened without the TNA. This cannot be done for all impacts since some contributions of the TNA cannot be dissociated from the various actions engaged by the RIs (especially for the impact provided through the RIs development).

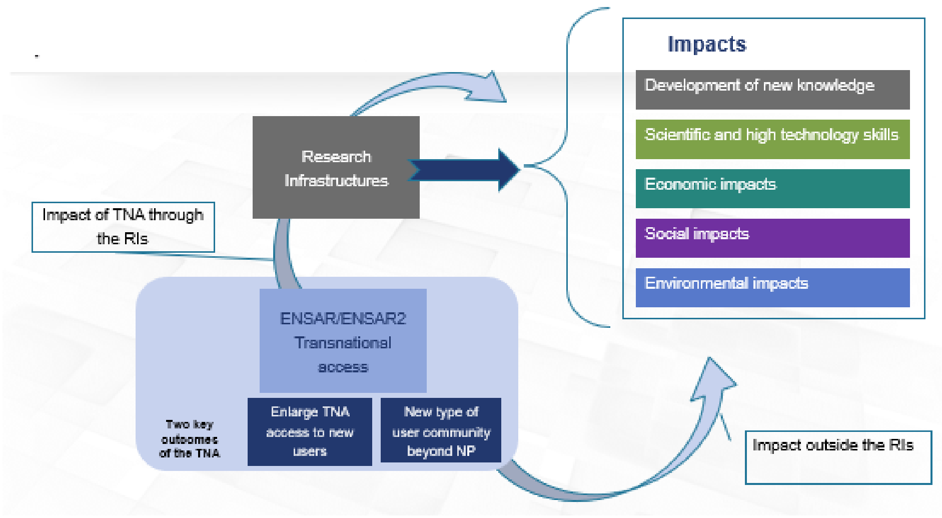

Figure 6: Presentation of the analysis of the TNA

Figure 6 describes the overall structuring of the impact analysis and presents the typology of impacts that were analysed at the inception of the study and subsequently validated. Based on this analysis a more detailed analysis in comparison with the economic / social / environmental analysis has been undertaken and as a result, the three categories mentioned above have been extended and become:

- Development of new knowledge;
- Scientific and high-technology skills;
- Competitiveness and employment;
- Social impacts;
- Environmental impacts.

An additional category "weighting variable" was created to control the important heterogeneity of the various RIs (Figure 7).

Figure 7: Family of impact indicators

ASSESSMENT INDICATORS

The indicators, allowing for the assessment of each of these impacts, have been designed following three rules: indicators must be simple, representative and operational.

- Simple: each of the indicators can be understood on its own and provides a relevant information, that can be understood easily;
- Representative: the indicators have been designed to be as the most objective, comprehensive and quantifiable as possible. Appropriate weightings have been designed specifically for this study, to compare research infrastructures of different size. When indicators cannot be quantified, a qualitative assessment has been chosen;
- Operational: The indicators must be easy to collect/complete. Hence, the indicators have been chosen in order to ease the data collection.

The list and description of the indicators is provided in the appendix 1 of this report.

Methodology

Overview of the methodology

<u>The study was structured in four phases</u>:

Construction of the impact assessment framework: At the outset of the study, the team defined the overall framework, including the list of all indicators, the source of data, the methodology for data collection, as well as the overall "perimeter" of the study.

Data-collection: To collect the data, various activities were planned: A data request was sent to the RIs detailing the expected databases they needed to provide. It was planned to complete the data received with a questionnaire, in the event of missing data. The data collection methodology was adapted during the study.

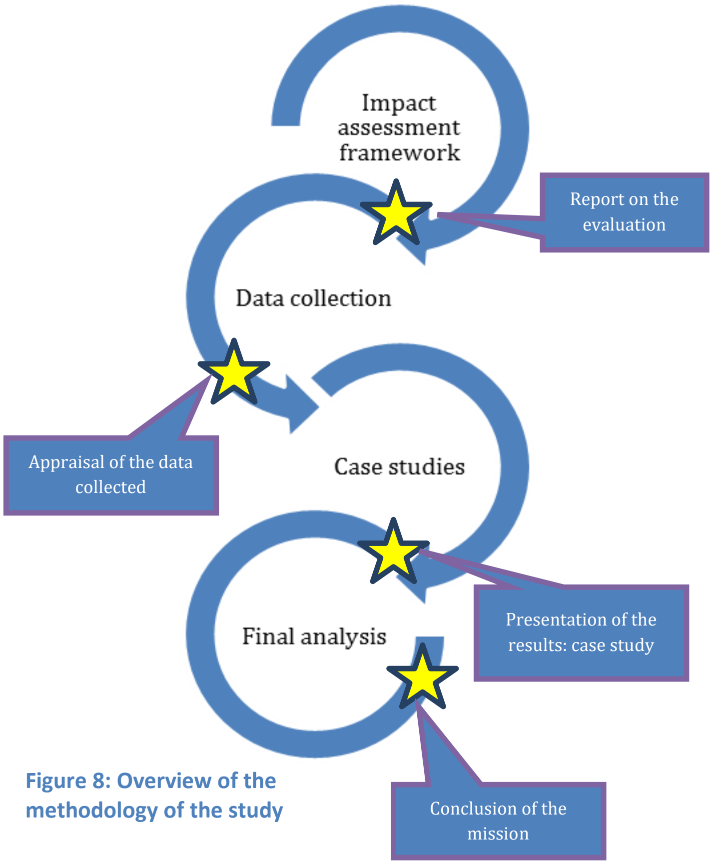

Figure 8: Overview of the methodology of the study

Case studies: Initially, based on the data collected, 12-15 case studies should have been conducted on each of the indicator categories (development of new knowledge, scientific and high-technology skills, competitiveness and employment, social impacts and environmental impacts) with a grouping of key relevant indicators. After completing the data collection, and with regards to the heterogeneity of the research infrastructures, it was decided, to prepare case studies for each RI, instead of by indicator category. These case studies enabled the team to gain a better understanding of the fundamental structural differences between the research infrastructures and make the final assessment clearer. The cross-analysis per category of indicator was therefore postponed to the final assessment.

The last stage of the study entailed the **cross referencing of all the analyses and data to characterise the overall impact of the RIs and of the TNA**.

Data collection methods and tools

As mentioned previously, the methodology for the data collection has changed during the study. This change was caused by two difficulties: first the lack of useable responses of some RIs, and second, the difficulty to conduct a purely quantitative assessment in this context.

Desk-based research

At the beginning of the data collection exercise, the consultants collected documents about the background of the project and about the research infrastructures themselves. These documents included key documents of the ENSAR/ENSAR2 project, notably the Grant Agreement, the state-of-the-art of each RI and a SWOT analysis of the project, as well as various online sources, notably the websites of each of the research infrastructures.

DATA REQUEST TO THE 12RESEARH INFRASTRUCTURES

Initially, the data request was supposed to be coordinated by the GANIL management (as coordinator of the ENSAR2 project) on behalf of the consulting team.

The process for collecting data from the research infrastructures that was initially deployed was the following:

- By the end of February 2018, a data request was prepared by the consultants to enable the calculation of the impact indicators, in line with discussions with the GANIL management.
- By mid-March 2018, an assessment of the data-collected thanks to the data request would be provided, enabling the consultants to analyse the data and collect the remaining information through a questionnaire.

The idea was that the requested data would be extracted from the research infrastructures' existing information systems and databases. The GANIL management was in charge of supervising the data collection. The following data request was sent to the research infrastructures.

Table 3: Overview of the data requested from the RIs

Data owners	Type of data requested
Research Department	• Beam usage, cost, and financing per source • Publications • Lectures / workshops and seminars held as part of ENSAR/ ENSAR2 • Research grants
Finance Department	• Operating and investment expenses • Provisioned decommissioning expenses
HR Department	• Staff register (including students and interns) • Staff visits to other Research Infrastructures part of ENSAR / ENSAR2 • Time dedicated to ENSAR / ENSAR2 • Same data for the various research laboratories represented on the research infrastructure's site
Procurement Department	• Supplier accounts with name of suppliers, location, purchased amounts, and supplier's activities • Identification of suppliers specifically contributing to ENSAR
Travels / site visits within ENSAR/ENSAR2 ***(data owner to be identified)***	• Visits from scientists from other institutions (number of days, employer…) • Visits of the Research Infrastructure's scientists to other infrastructures, by destination • Details of expenses incurred during visits (accommodation, food, transport…)

Data owners	Type of data requested
HSE Department	• Existing reports on electricity and water consumption • Existing reports on waste production and recycling • Details on production of dangerous waste • Means of transport used by staff for commuting • Description of initiatives for reducing environmental impacts (e.g., videoconferencing) and available results on the initiatives

Unfortunately, by mid-March, almost no data had been received from the partner RIs. This was due to a number of reasons including: lack of manpower within some of the RIs, a certain degree of reluctance of some of the RIs to share data considered confidential, as well as a lack of understanding of the data requested. In addition, all research infrastructures were different, and a number of them are characterised by complex governance structures. As a result, gathering information, initially considered to be a simple task, was in fact a complicated and time-consuming process for both the study team and the research infrastructures. The data received at this initial stage were therefore very partial and too heterogeneous to be of any real use to complete any form of consistent cross-analysis.

To overcome this difficulty, a set of new measures and data-collection techniques were implemented:

- The list of indicators was reviewed and focused on indicators that were considered most important, some of the variables were turned into qualitative assessments;
- The data request was restructured into 8 simple datasets to collect from the RIs (so-called simplified data request). The data request highlighted the essential variables, to ensure that all analyses could be performed for each of the RI;
- The indicators that would be assessed qualitatively were collected thanks to a four-step questionnaire;
- A complementary and bespoke questionnaire was designed for each of the RI, to collect the data that was not provided during the simplified data request.

This enabled the consultants to finally collect crucial data on most of the RIs.

QUALITATIVE ASSESSMENT

The difficulties in the data collection task revealed that each RI understood the variables very differently. This difference of understanding is, in particular, the result of wide disparities in the RIs themselves. Therefore, understanding the variables, the functioning of each infrastructure, and ultimately, the ENSAR / ENSAR2 projects, required the study team to interrogate each RI individually, using qualitative analytical tools. Therefore, individual calls were organised with all research infrastructures, following the data collection, and concomitantly to the preparation of the case studies to:

- Ensure the consultants correctly interpreted the data;
- Provide explanations if necessary;
- Complete the data when found to be missing;

- Comment qualitatively on the primary results.

This step, although time consuming, was a success: not only did it enable the consultants to elaborate solid case studies, even for the research infrastructures which had a lot of missing data, it also reinforced the study dynamics between the managers of the research infrastructures and the consultants. This trust was precious to engage in a dialogue, to ensure that the variables were correctly analysed.

To ensure the quality of the report, a further qualitative analysis was conducted during the last phase of the project, prior to writing the final assessment. Research infrastructures were asked to provide a qualitative feedback on ENSAR/ENSAR2. This feedback enabled the consultants to strengthen their analytical framework and verify the hypothesis made based on the quantitative analysis.

ANALYSIS AND DELIVERABLES

The analysis has been conducted in a step-by-step approach in order to fully exploit the data collected both for the quantitative indicators and the qualitative indicators.

CASE STUDIES ANALYSIS

The first analysis was based on the 12 RIs case studies. Each case study presents one RI and its impact regarding the 6 families of impact indicators (figure 7).

Through the case studies, the consultants have cross checked the data provided by the RIs and proceeded to correct data, together with the RIs, when necessary. They also added some qualitative information to better understand the RIs and identify best practices. With this aim, some interviews were conducted with the person responsible in each RI.

Figure 7: Family of impact indicators

IMPACT ASSESSMENT OF THE RIS

The impact assessment does not focus on a specific RI but intends to analyse the overall impact of the RIs, bringing forward the specificity of the RIs by comparative analysis and to highlight the specific impacts of ENSAR and ENSAR2.
The impact analysis concerning environment is presented in section 4.

IMPACT ASSESSMENT OF THE TNA

The impact assessment of the TNA was intended to qualify and quantify when possible, the impact of the transnational access programme. This programme opens research infrastructures and financially supports scientific teams during their experiments (living and travel costs funding; funding based on the beam time provided).

The TNA funding provides various benefits to the research infrastructures and to the nuclear physics scientific community. To conduct this assessment, we first listed, in a specific logical diagram, the main benefits that could be imagined for the project and secondly, we controlled if and to what extent the programme has indeed provided these benefits. Depending on the type of impact / benefits to be analysed, we used data estimation and / or qualitative assessments based on the interviews and questionnaires sent to partners.

AN IMPORTANT HETEROGENEITY OF THE RIS IN THE PROGRAMME

Summary: The RIs in the programme are very different, in terms of beam time provided or in the type of experiments that can be conducted. This heterogeneity is a strength for the TNA but implies some caution in the exploitation and interpretation of the data provided especially for indicators expressed as absolute values.

The TNA involves many RIs, each one bringing into the programme a specific asset .

SECTION 3 - SPECIFIC IMPACTS OF THE TRANSNATIONAL ACCESS

PRESENTATION OF THE EXPECTED IMPACTS

As described in section 1, the transnational access (TNA) provides two types of support to the consortium members and the nuclear physics community:

- Funds to cover the travel and subsistence costs of the users participating in a TNA-eligible experiment;
- Funds to cover partially the cost of the beam time for the RIs.

These funds provide a very broad range of benefits to the RIs, the community of nuclear physics and more generally, some economic, social and environmental impacts at the European Union level. The diagram below **Erreur ! Source du renvoi introuvable.**highlights the typology of the expected results and the potential impacts associated with them.

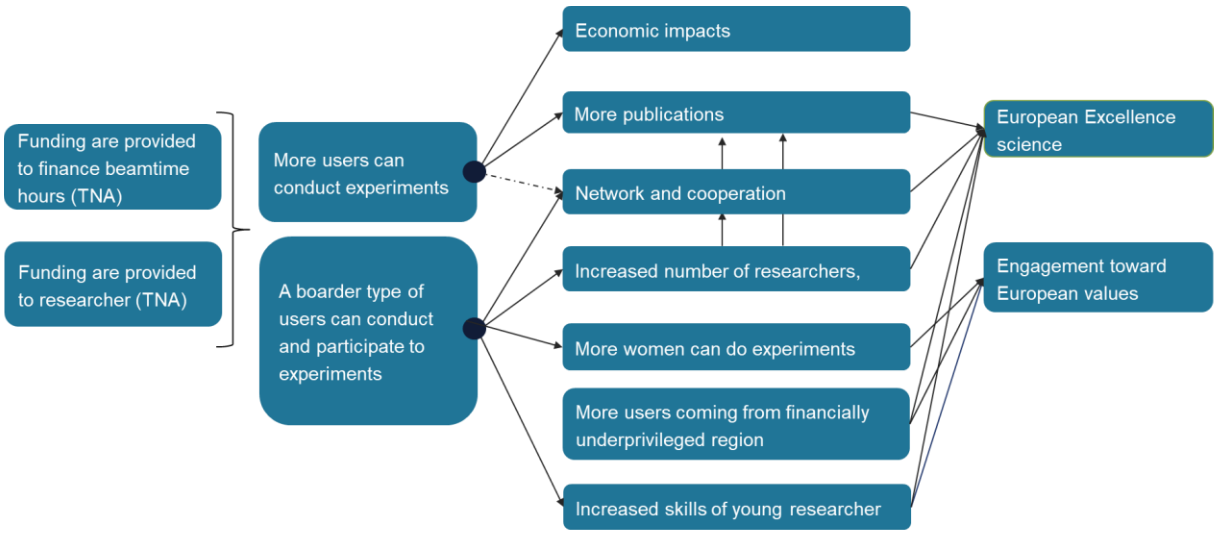

Figure 9: Possible impacts of the TNA

The TNA action:

- Opens the facilities to researchers outside the owner's countries
- Encourages new experiments in related science subfields
- Contributes very effectively to European science excellence, to networking and international collaborations
- TNA can finally lead to economical social impacts

Economic impacts:

- **Direct impact:** The TNA allows more users to participate in experiments. This activity (accommodation, transport) will have a direct impact upon the local economy of the RIs. This impact, although on a limited scale, contributes directly to sustain employment in Europe. Moreover, by contributing to the cost of beam time TNA directly contributes to the budget of the RIs and therefore to their economic impact.

- **Indirect impact:** The TNA may allow researchers from universities and research institutes with less financial resources to participate in experiments. This applies especially to young researchers that may not have participated in the experiment otherwise. By broadening the type of researchers allowed to conduct or participate in experiments, the TNA may help to support and increase the physics community in the short and medium terms.

Networks and cooperation:

- **Direct impact:** By allowing more researchers coming from various institutes and universities to conduct experiments, the TNA strengthens the networks of researchers in nuclear physics in Europe. Moreover, the TNA plays an important role of facilitating the coordination of groups and the efficient use of complementary accelerators and instruments in the network of TNA facilities leading to more efficient and targeted collaborations**.**
- **Indirect impact:** The development of the community presented above may have a snowball effect and increase networks and connections significantly.

Scientific results and publications:

- **Direct impact**: By allowing more users to conduct experiments, a higher technical quality of experiments is expected as well, with a direct impact on increasing the number of related publications.
- **Indirect impact**: By broadening the scope of users (younger researchers and researchers coming from less well-endowed universities and research institutes), the TNA may expand the community of researchers in nuclear physics. This would in turn lead to future research collaborations and publications. Moreover, by strengthening the links between researchers, the TNA may lead to future collaborative research projects which may also in turn generate more scientific results and publications.

Increased skills of young researchers:

- **Direct impact:** By allowing younger researchers to conduct experiments, the TNA may strengthen their skills and employment capacity.

Participation of women and gender equality:

- **Direct impact:** In the nuclear physics community, as within the scientific community as a whole, the large majority of researchers, engineers and technicians are males. The TNA, by allowing some younger researchers (and notably young women) to conduct and participate in experiments, may contribute to promote women in nuclear physics.

More participants coming from financially disadvantaged regions:

- **Direct impact:** Participating in an experiment is relatively costly for researchers coming from a financially disadvantaged region. By contributing to reduce these costs, the TNA contributes to train researchers from all over Europe and promote excellent research in these regions and contributes to reducing regional disparities across Europe.

These various impacts are in line with European expectations regarding excellent science, engagement towards European values and projects generating economic, social and environmental impacts.

The objective of the following part will be to test whether the expected results and potential impacts are confirmed, and to provide quantitative and qualitative evidences to illustrate these impacts and when possible, to estimate their importance.

IMPACTS RELATED TO THE AMOUNT OF USERS

MORE USERS CAN CONDUCT EXPERIMENTS

Since 2013, the number of users (cf. **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**) has regularly increased except in 2015 due to the shift between ENSAR and ENSAR2. We observe an average of 418 ENSAR/ENSAR2 external users in 2013 and 2014 (ENSAR years) and 474 ENSAR/ENSAR2 external users in 2016 and 2017 (ENSAR2 years).

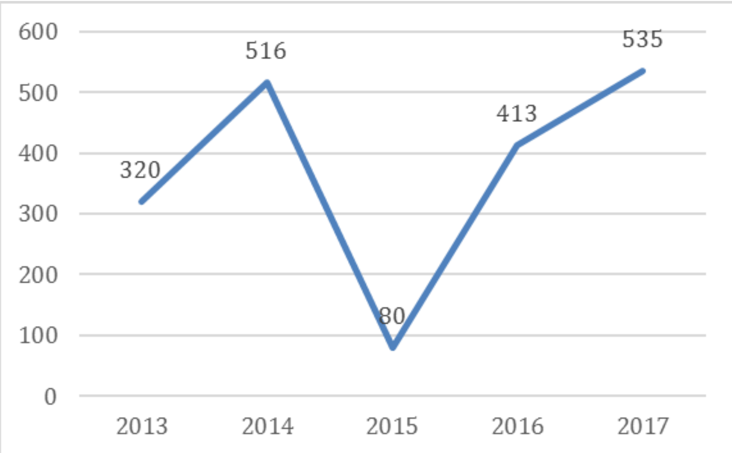

Figure 10: Evolution of the number of ENSAR/ ENSAR2 external users

The overall number of users is 13% higher in ENSAR2 in comparison to ENSAR. This increase appears probably underestimated because of the important work done to upgrade and build new facilities (CERN-ISOLDE, GANIL, GSI and LNL) and therefore the decrease of available beam time for RI entering in new construction projects.

It is estimated, based on the various feedbacks from the RIs, that the number of external users is higher thanks to the TNA. Indeed, the RIs have indicated that the funds were helping additional researchers to participate in experiments and that no substitution effect (funding of researcher who would have in any case participated in the experiment) is observed.

*RI Expression – CERN-**ISOLDE**: The ENSAR/ENSAR2 TNA projects have definitely contributed to the attractiveness of CERN-ISOLDE. Scientists who would not otherwise have been able to access the RI have participated in experiments and been able to get to know the facility. This has then motivated them to apply for other funding for future activities.*

*RI Expression – **ALTO**: First, ENSAR ensures the visibility of the ALTO facility at a European level. In addition, the travel costs, covered by the TNA, allows more researchers to come and participate in experiments.*

*RI Expression – NLC **Warsaw**: The HIL only receives TNA funds since the inception of ENSAR2. TNA support multiplies by four the number of international projects. Researchers from HIL perform measurements in other facilities too. They used TNA support within ENSAR and ENSAR2. The infrastructures of our interest are: CERN-ISOLDE, GANIL, LNL and LNS, and IFIN-HH/ELI-NP. Possibility of TNA support increases our external activity by 25-30%.*

*RI Expression – **KVI-CART**: Access to some users would have been much more difficult. In particular, we mention a group from GSI who has indicated that support by ENSAR2 has been instrumental for the execution of their research project at our facility.*

This qualitative evidence is confirmed by the partial data that could be exploited. Based on 2016 and 2017, for NLC Warsaw and GANIL, we observe that experiments involving ENSAR2 had a significant higher number of users (respectively +7 and +3,5 users) which represents an important effect (respectively +67% and +100% in the average number of external users).

To conclude, thanks to ENSAR/ENSAR2 more users can participate in experiments.

Economic impacts

The TNA allows users to access RIs by covering their travel and subsistence expenditures. Most of the time, users pay ahead for their expenses and are then refunded by the RI which has hosted them. Travel expenditures are refunded at their real costs. Regarding subsistence expenditures, generally a lump sum is defined by the RIs (or the government) for each night spent in the visited place and each meal taken during the visit. It is likely that other “local expenditures”, not eligible to reimbursement are made by the researchers. However, the study team did not have data to measure the impact of these expenditures.

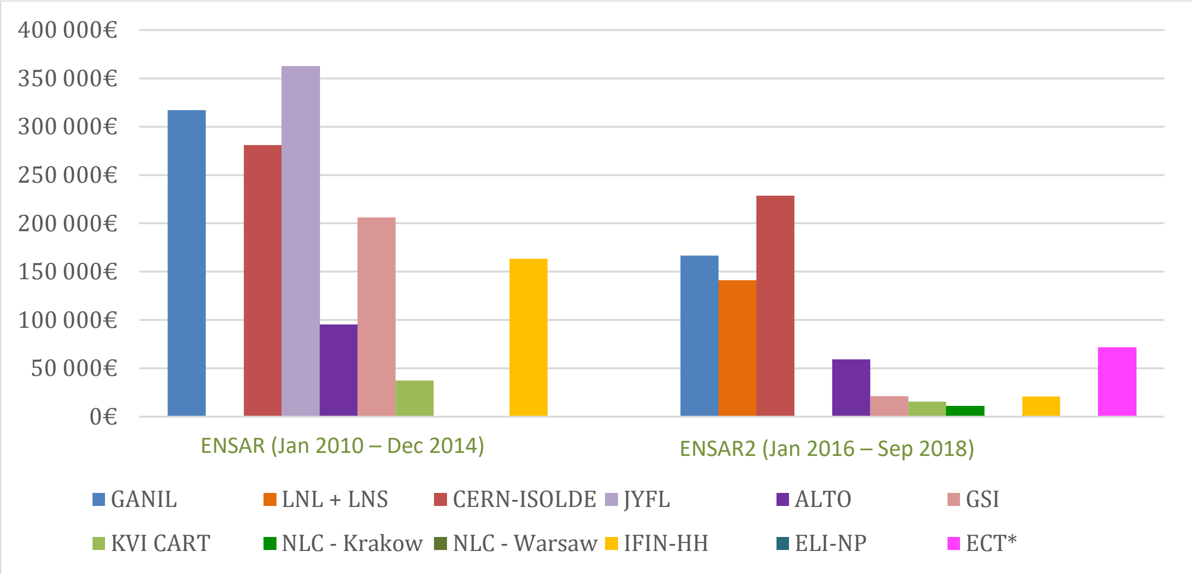

Figure 11 : TNA T&S costs refunding by RIs

TNA reimbursements for T&S represent at least ten thousand euros a year for each RI. During ENSAR (1 Sep 2010 - 31 Dec 2014), these costs reached approximately 1.5 million euros for all the RIs. For the period March 2016 - September 2018, ENSAR2 covered less than 0.8 million euros (cf. figure 11).

Nevertheless, it indirectly contributes to sustain the employment in Europe, particularly in both technical, maintenance and the accommodation/tourism sectors. Based on Eurostat data, it is estimated that ENSAR expenditures have sustained approximately 70 to 90 jobs and ENSAR2, 30 to 50 jobs.

Conclusion: The TNA allows users to benefit from the RIs services by reimbursing their travel and subsistence expenditures and/or, covers at least a part of the cost of using the corresponding beam time.

The funding of travel and accommodation expenditures sustains (even modestly) the employment in Europe (about 80 jobs).

In addition to these effects, it appears that the TNA can have a specific leveraging effect on the funds received by the RIs, hence having an additional impact on the RI's economic model.

*RI expression – **NLC Warsaw**: Financially: the contribution of ENSAR2 funds to HIL's budget is not significant (less than 5% of the total annual budget). Nevertheless, the participation in TNA encouraged the government to increase its participation: since the RI is part of ENSAR2, the government donation has been multiplied by three.*

*RI expression – **JYFL**: "Without the access funds for our users, we would receive less scientific proposals for beam time, our user base would be smaller, and the number of scientific publications and theses produced by the RI would be reduced. The funding model at the Ministry and University provides funding directly based on these numbers, so there would also be a secondary effect from these reduced numbers. Within the University and within Finnish funding bodies, the fact that we are* *involved in such high-profile EU projects is also considered a merit, which aids in securing other funding (when describing the supporting institute status, etc.).”*

The TNA contributes to European science excellence

Since 2013, the number of experiments eligible to TNA (cf. **Erreur ! Source du renvoi introuvable.** 13) has regularly increased in an even higher proportion than the number of users. The number of experiments eligible for TNA funding has increased by 61 % during the two years of ENSAR2 (2016 and 2017) in comparison to ENSAR (2013 and 2014). The number of users has also increased (+21 % in comparison between ENSAR 2 period and ENSAR period) but not at the same rate as the number of experiments. In consequence, the share of users who receive ENSAR2 grants per experiment had been reduced in 2016-2017.

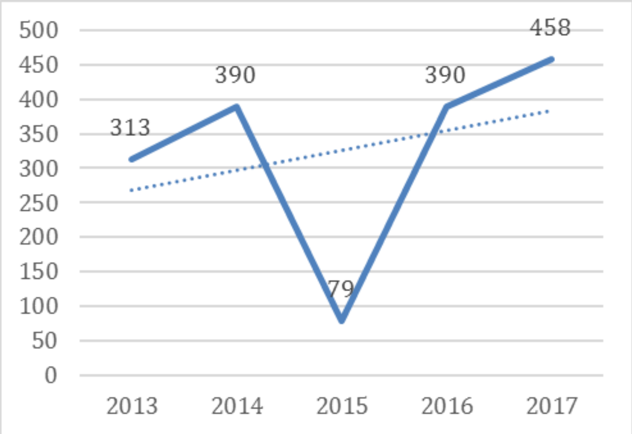

Figure 12: Evolution of the number of ENSAR / ENSAR2 external experimenters

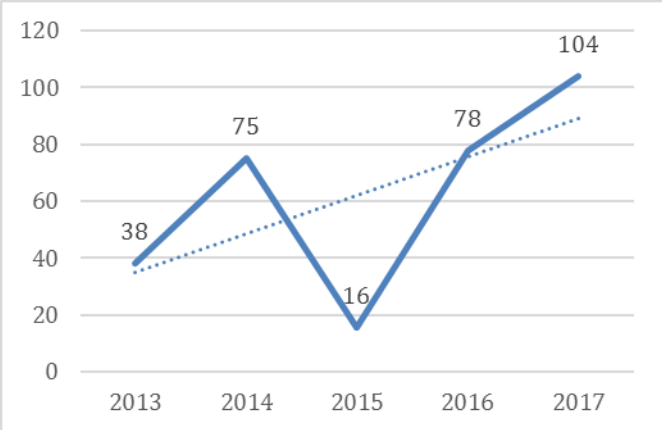

Figure 13 : Evolution of the number of ENSAR / ENSAR2 experiments

Note: data missing from GSI, KVI-CART, LNL, NLC Warsaw, not relevant for ECT.*

This increase in experiments and number of users indicates an important impact of ENSAR/ENSAR2:

- By allowing experiments that could not have been funded otherwise: *RI Expression – ALTO: At the beginning of 2018, ALTO hosted an experimental campaign: “nu-ball”. About one hundred researchers, PhD students and post-docs came to participate in several experiments. We could never have made so many people come without ENSAR2 and in particular two experiments (out of 10) have been entirely funded by ENSAR2 as the researchers didn’t have the resources in their own laboratory.*
- By enabling more users: *RI Expression – NLC Krakow: The grants (…) enable more users to run the experiments hence increase the quality of the experiments.*

The importance of these two impacts is subject to discussion. Regarding whether the experiments not funded otherwise could have priority, it should be noted that there exists in most RIs an important waiting time to receive beam time. Thus, **the TNA does not necessarily increase the number of**

experiments conducted but can provide an opportunity to fund excellent projects that did not have sufficient funding and to encourage the development within possibly new and associated science sub-fields, etc. It should also be noted that the volume of beam time and number of experiments were reduced between 2014 and 2017 mainly due to the construction of new accelerator facilities.

Regarding the benefit of more users from the quality or efficiency of experiments, this effect should be mainly relevant for understaffed experiments due to unexpected reasons (since it has been accepted by the PAC). For other experiments, additional staff can allow some additional analysis in the experiments, and more efficient work, but after discussion with some RIs it does not appear to be an important impact.

The TNA has contributed to European science excellence: It has permitted some experiments that would not have been funded otherwise to be undertaken, contributing to an even higher quality of research. Also, more users have been able to participate in experiments, which resulted in increasing impacts.

SCIENTIFIC RESULTS AND PLUBLICATIONS

Research results are mainly disseminated through publications. It is estimated that the TNA (ENSAR/ENSAR2) has resulted in at least 340 publications since 2014. This number of publications is based on the reporting produced by the RIs. In consequence, the data is of higher quality but only a part of ENSAR2 publications could be identified since the study assessment data only covers the first reporting period of ENSAR2 and because some publications may still be pending, as there is a time lag between the experiment and the actual publication.

IMPACTS RELATED TO THE OPENNESS FACILITATED BY THE TNA

NETWORK, COOPERATION AND VISIBILITY OF THE RIS

Even though, no baseline can be constructed to provide quantitative evidence related to the impact of the TNA on the development of networks and cooperation, enhancing the number of users participating in experiments undoubtedly helps the strengthening of networks, and hence cooperation.

This is illustrated by the expression of some RIs on the impact of the TNA:

RI Expression – ECT: Thanks to the ENSAR/ENSAR2 support, ECT* was able to increase the number of participants in workshops and collaboration meetings related to nuclear structure physics helping in this way to enhance the visibility of the theoretical nuclear structure physics field. Thus, it further strengthens this field. One of the main purposes of funding these events through ENSAR/ENSAR2 is to foster state-of-the-art discussions between nuclear theorists worldwide and interface with current experimental research programmes in Europe and elsewhere.*

RI Expression – KVI-CART: Globally speaking, there is a perceived benefit in participating as part of the consortium as this opens opportunities for networking and exploring scientific endeavours that we may have otherwise missed.

RI Expression – IFIN-HH: ENSAR2 project contributed to the visibility of ELI-NP. It also contributed to the enhancement of the user community.

RI Expression – NLC Krakow: More importantly, ENSAR/ENSAR2 projects bring a label to the research infrastructure. This European label is crucial to enhance the visibility and credibility of the RI abroad. ENSAR/ENSAR2 have enabled to increase the visibility of the RI in Europe, but also in Poland.

RI Expression – LNL-LNS: "The very important point is that, with ENSAR/ENSAR2, the Laboratories are embedded in a network of different facilities thus providing high integration and complementarity of the research lines pursued at European level."

In the case of GANIL: the ENSAR/ENSAR2 projects contributed to increase the number of cooperation projects of the RI:

- The networking activities that are incumbent to the TNA have a positive impact in terms of cooperation, as it allows researchers to create more projects.

- If an experiment is successful, thanks to the increased number of the researchers, it will enable them to go further in terms of research, hence generating the need for more experiments.
- There is a snowball effect related to cooperation in nuclear physics.

An interesting impact of ENSAR/ENSAR2 identified during the exchange with the RIs concerns the enhanced visibility provided by the project and funding actions. This visibility is important for the development of further cooperation and networks at a European level.

Conclusion: The TNA has contributed to support the development of networking in the nuclear physics community. It will contribute to support further collaborations, the attractiveness and visibility of the RIs at the European level.

INCREASED NUMBER OF RESEARCHERS IN THE FUTURE AND ENHANCED SKILLS OF YOUNG RESEARCHERS

A study conducted on the TNA users in 2013-2015 (GANIL) has indicated that young users represented 61% of the beneficiaries. More specifically, the main beneficiaries are the postgraduates (35% of users) and the post-doc (22%). The senior users only represent 39% of the beneficiaries.

RI Expression – GANIL: ENSAR/ENSAR2 contributed mainly to attract young researchers who would have performed less experiments without these funding.

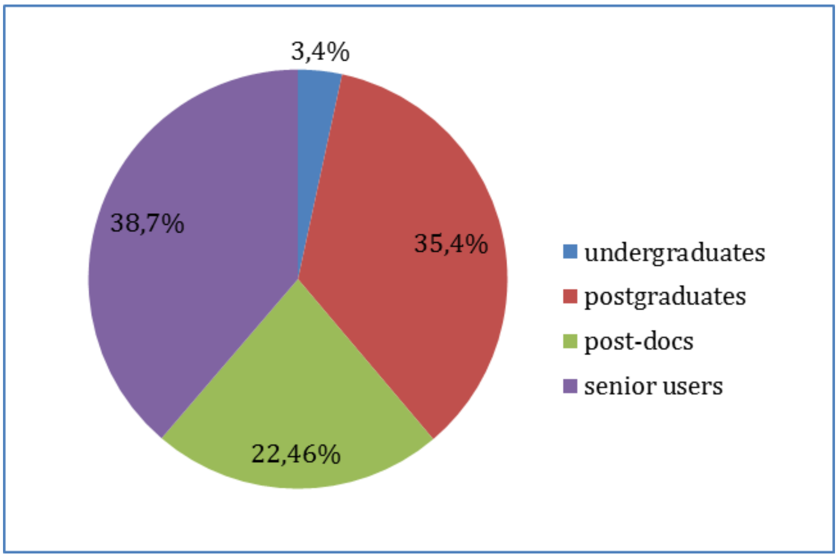

Figure 14 : Distribution of the ENSAR users

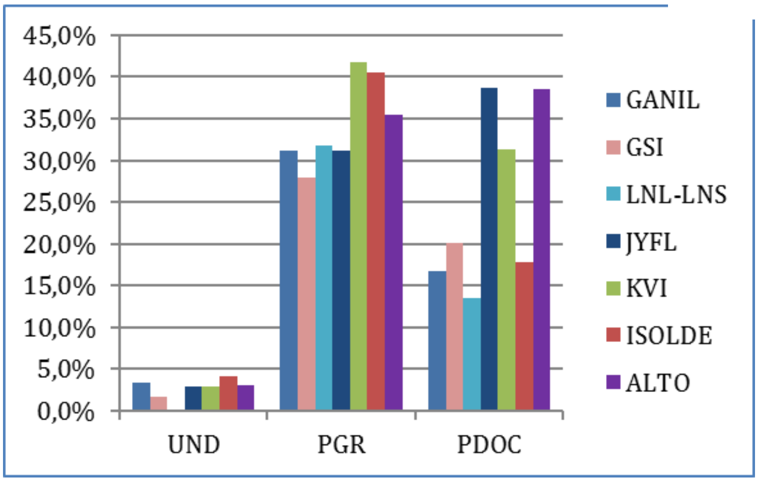

Figure 15 : Share of undergraduates (UND), Postgraduates (PGR) and Postdocs (PDOC) in the users of each ENSAR RIs (2013-2015).

This clearly indicates a strategic orientation in the use of the TNA funding. It provides additional evidence of the positive impact of the TNA on the number of external users participating in experiments.

This aspect is interestingly common across all the RIs (cf. Figure 15). All the RIs have a share of young users higher than 45%.

RI Expression – IFIN-HH: It was a net increase of the number of external students/young researchers participating in experiments. The ENSAR2 support facilitates also researchers from institutions with less financial resources to propose and perform experiments at the Tandem/IFIN-HH.

Conclusion: The TNA is supporting the development of the skills of young researchers and providing them with the opportunity to participate in experiments and build their capacity. This will encourage them to embrace a career in research.

More women can participate in experiments and be attracted to science

Measuring the number of women who received ENSAR/ENSAR2 funding is complicated as most of the data received about applicants was not gender specific[3]. As the data is partial, the results are to be taken with caution.

On average, 21% of ENSAR users are women, a share slightly below the overall share of women in the RIs (25%) but above the share of scientific women in the RIs (19%). Interestingly, this share increases significantly over the years from 14% in 2013 to 26% in 2017.

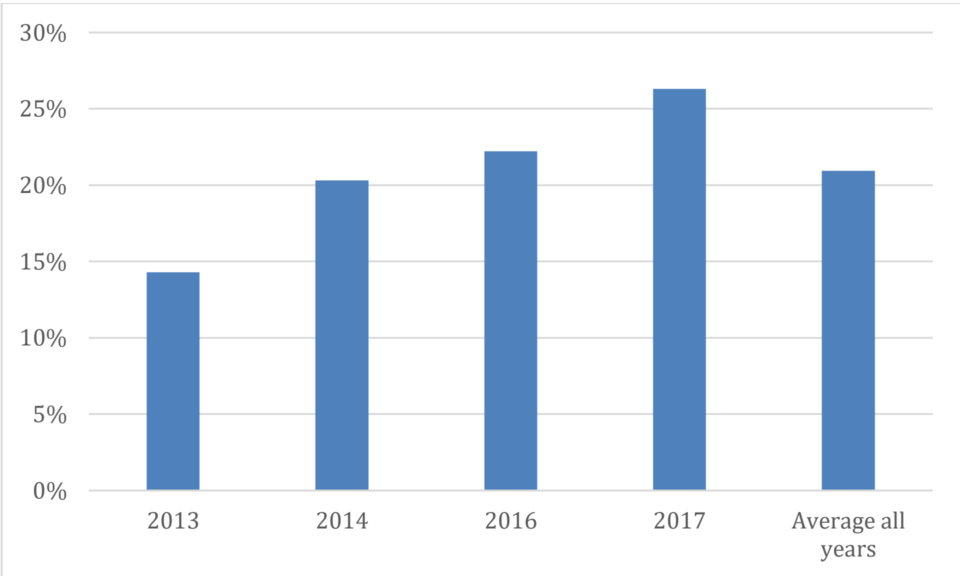

Figure 16 : Share of women who received ENSAR/ENSAR2 grants (data from GSI 2013-2017 and NLC Warsaw 2016-2017)

If in general, the share of women is still very low and reflects the underrepresentation of women in the field of nuclear physics research, the limited data that are available seem to show that there has been an increase of women ENSAR/ENSAR2 users. The increase of the women's share cannot be attributed to the TNA as such, but possibly to a general cultural trend and change of mind-sets within the community.

[3] Only two research infrastructures provided data about the ENSAR/ENSAR2 gender of the users: GSI (2013 – 2017) and NLC Warsaw (2016-2017).

However, by participating in ENSAR/ENSAR2 experiments, which are experiments of excellence, it is very likely that ENSAR/ENSAR2 will boost the career of these women, hence indirectly help increase the overall share of women in nuclear physics.

The TNA allows users coming from financially disadvantaged regions to participate in experiments

The overall cost and funding of experiments represents an important burden for some universities and research institutes that can indeed prevent their researchers from participating in experiments. As a result, the support provided via the TNA enables researchers from disadvantaged regions to participate in experiments. There is no quantitative evidence available to estimate the specific impact of the TNA on the access to the RIs. The calculation could be based on the comparison between TNA funded external users and external users with no funding as well as an analysis of the origin of the people using the TNA. Due to the limited data available, this calculation cannot be done. However, some strong qualitative evidence supports the view that an important impact on an enhanced participation of users from financially disadvantaged regions can be confirmed.

RI Expression – ECT: In particular, it would not have been possible to support participants coming from financially disadvantaged regions of Europe* without the TNA.

RI Expression – GSI: Transnational access to GSI in the framework of ENSAR/ENSAR2 is a very important contribution to the funding of the groups of users (more students and post docs coming to GSI). The groups can afford to come with enough people to GSI to cover night shifts and critical detector components essential for small university groups with limited funding. It also allows small groups or groups from eastern European countries to submit proposals.

RI Expression – LNL ENSAR or ENSAR2 provides a valuable way of funding people that have no easy access to other kind of funds (especially for young people, East Europe scientists etc...). In this sense the contribution of the ENSAR/ENSAR2 projects is of paramount importance to permit scientists to perform their research at the most appropriate research Infrastructures.

By alleviating this cost, the TNA is enhancing the participation of these researchers to the European community of physical science and is contributing to promoting excellent research in these regions.

SECTION 4 OVERALL IMPACT OF THE RESEARCH INFRASTRUCTURES

ENVIRONMENTAL IMPACTS

RESEARCH INFRASTRUCTURES CONSUME A LOT OF ENERGY RELATED TO THEIR SCIENTIFIC ACTIVITIES

ELECTRICITY

74,121MWh / year

Average electricity consumption for all RIs

The electricity consumption of the research infrastructures is an important factor when considering the environmental impacts since running the accelerators requires a lot of energy. On average, the eight RIs which provided data[4] consume 74,121 MWh per year. Considering that one house of four people consumes on average 13MWh per year, the overall consumption of the RIs equates to the consumption of 5700 households per annum.

The electricity consumption varies a lot from one research infrastructure to the other. The electricity consumption is closely related to the size of the RI and accelerator technology. Therefore, the highest electricity consumption can be observed for GSI and for GANIL.

[4] Eight research infrastructures out of twelve communicated results about their energy consumption (ALTO, ECT*, GANIL, GSI, KVI-CART, LNL and NLC Krakow).

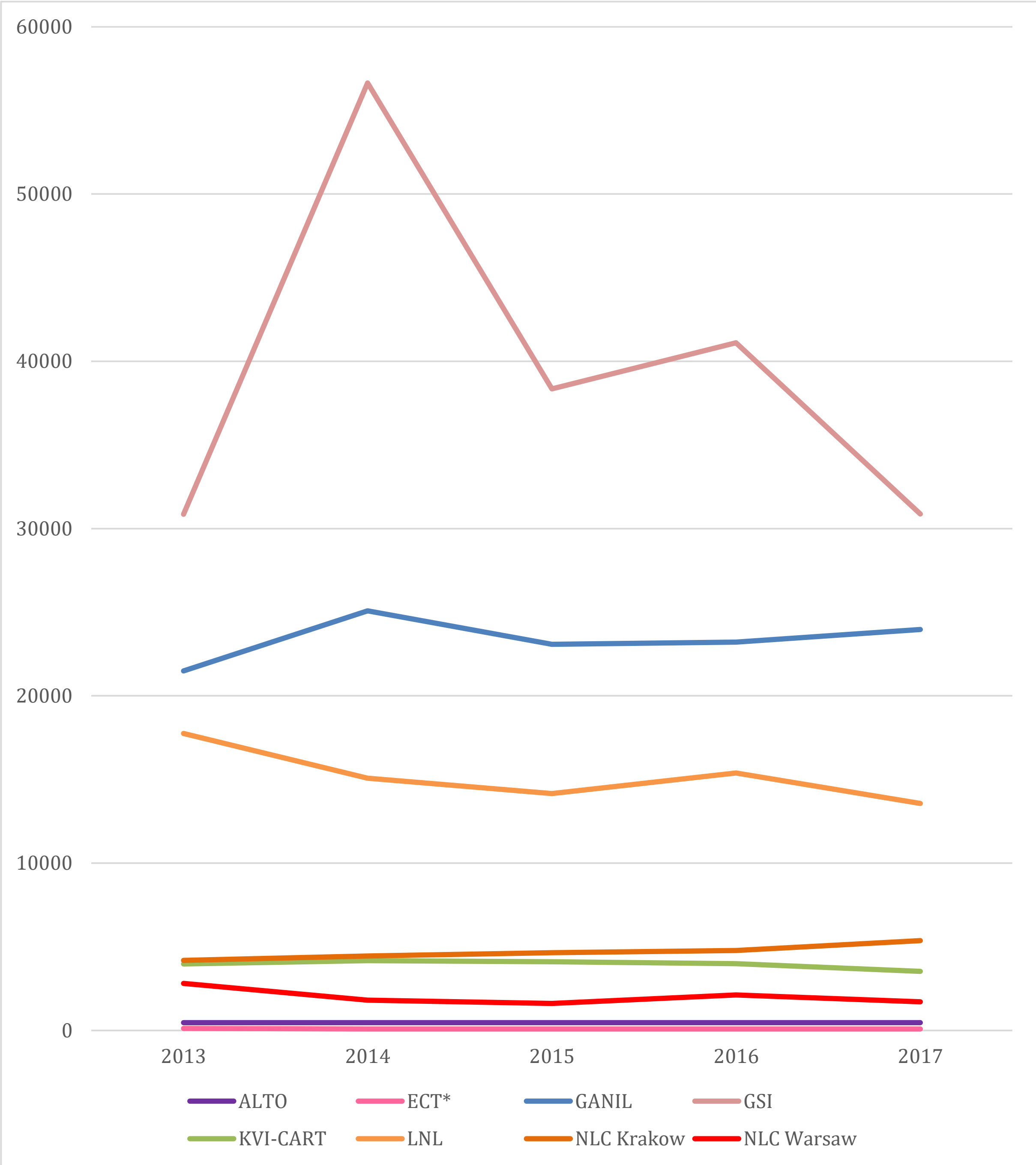

Figure 17 : Electricity consumption in MWh 2013-2017 (data from ALTO, ECT*, GANIL, GSI, KVI-CART, LNL, NLC Krakow and NLC Warsaw)

To measure the link between the use of the accelerator and the energy consumption, we have calculated a correlation coefficient between beam time and electricity consumption. This correlation coefficient is 0.82[5]. Therefore, it can be concluded that running the accelerators accounts for most of the energy consumption but not all, for example general lighting and heating of the respective RIs. As a result, in order to reduce the impact on the environment, energy savings can be considered in areas other than those associated with the use of the accelerator. It would be nonsensical to require energy savings from using the accelerators, as their use is a necessary prerequisite for undertaking the research experiments.

[5] The correlation coefficient was calculated based on the data of the five RIs, which provided figures both on their beam time and electricity consumption (ALTO, GANIL, GSI, LNL and NLC Warsaw). ECT* was voluntarily removed from the analysis as it does not have a particle accelerator.

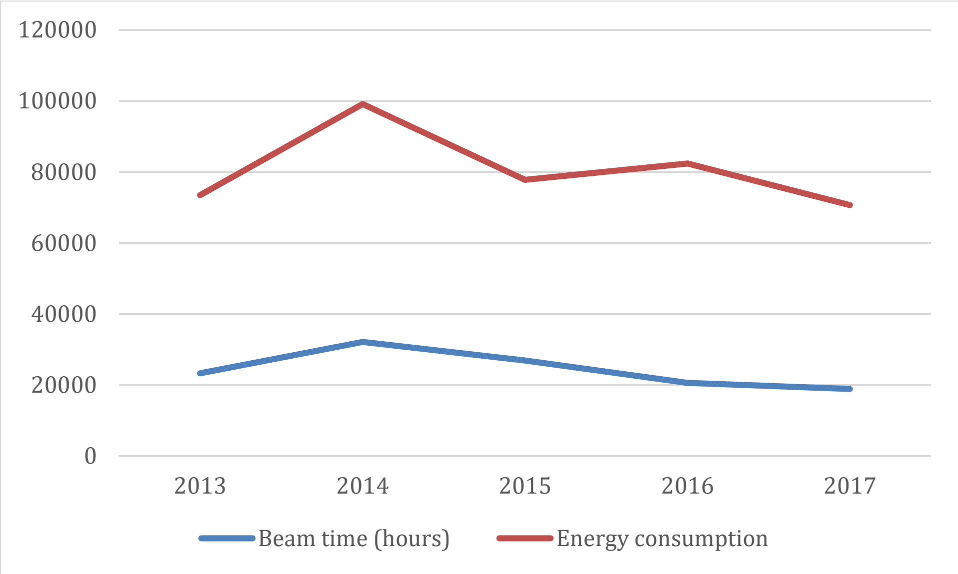

Figure 18: Correlation between electricity consumption in MWh and beam time in hours (data from ALTO, ECT*, GANIL, GSI, LNL and NLC Warsaw)

WATER

176,799 m3

Average water consumption for the RIs (Data from ALTO, ECT*, GANIL, GSI, LNL, NLC Krakow and NLC Warsaw).

Research infrastructures consume on average 176,799 m3[6] of water per year (2013-2017) for the seven research infrastructures with available data[7].

The water consumption of the RIs is also relatively high, but not as high in proportion as the use of electricity. Most of the water consumption concerns the biggest research infrastructures of the project: GSI and GANIL. NLC Warsaw also has a high amount of water consumption but no qualitative explanation was provided.

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[6] To clarify this statement, the comparison with the energy consumption of a household was replicated: one household of four people consumes on average 150 m3 per year. Therefore, the water consumption of the seven RIs equals 1,179 households per annum.

[7] Seven research infrastructures provided data about their water consumption (ALTO, ECT*, GANIL, GSI, LNL, NLC Krakow and NLC Warsaw).

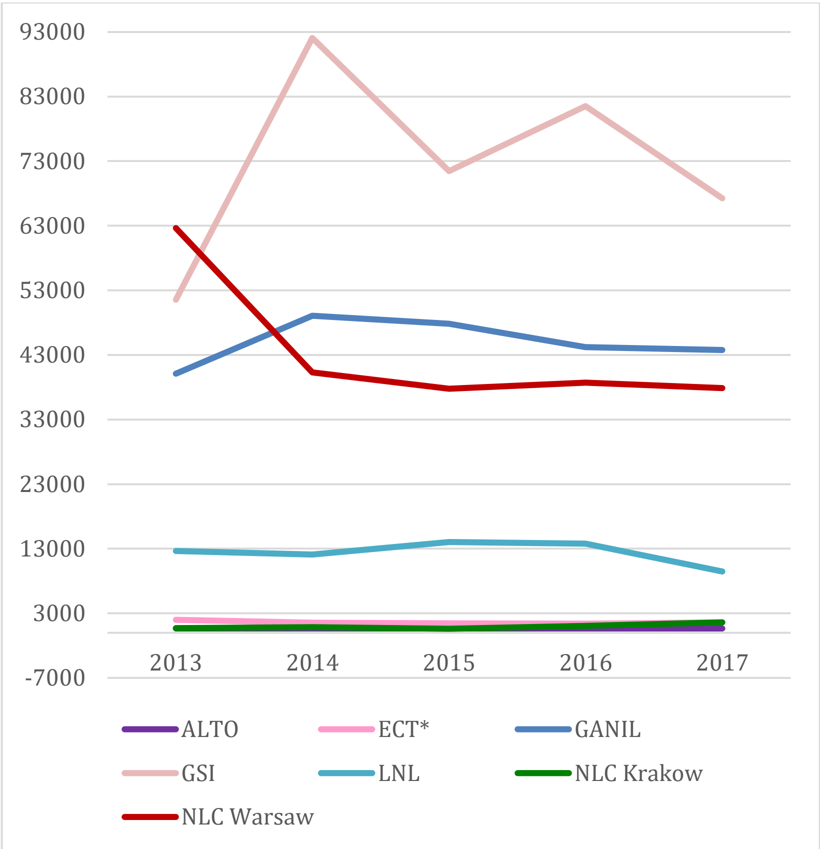


Figure 19: Water consumption in m³ (data from ALTO, ECT*, GANIL, GSI, LNL, NLC Krakow and NLC Warsaw)

There is a correlation between the RIs' activity (calculated by the hours of beam time and hours of use for ECT*) measured by the correlation coefficient: 0,79.

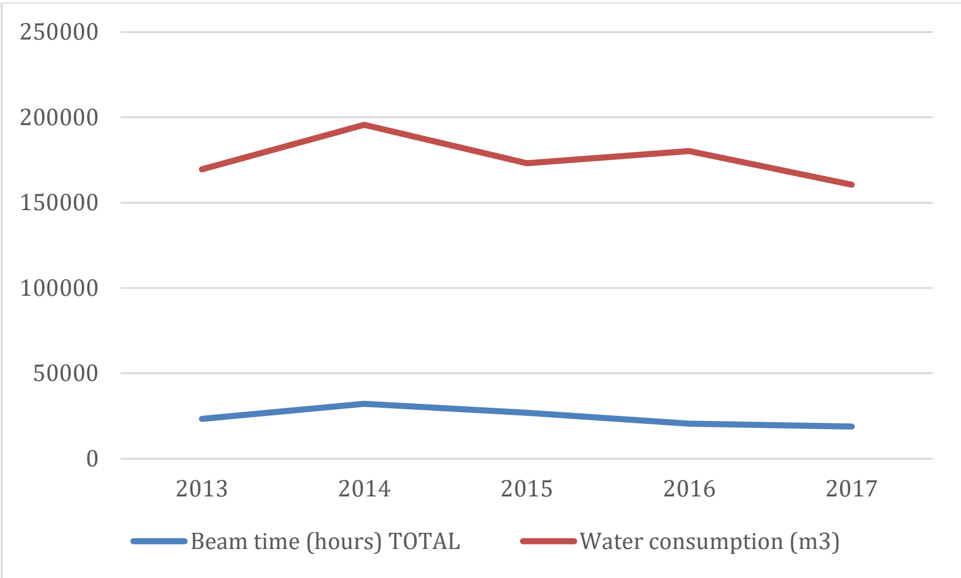


Figure 20: Water consumption in m³ and beam time in hours (data from ALTO, ECT*, GANIL, GSI, LNL and NLC Warsaw)

EVOLUTION OF ENERGY CONSUMPTION

Despite eight research infrastructures out of 12 reporting to be engaged in environmental protection actions, no clear trend can be observed with regards to reduced energy consumption over that period of time. The change observed in energy consumption reflects the evolution of the research infrastructure's activities. There are no data available enabling to measure the impact of energy saving policies.

ELECTRICITY

Overall, the consumption of electricity (MWh) is increasing by 1% each year between 2013 and 2017[8]. Looking into this trend in more detail reflects a more complex reality. As explained above, the electricity consumption is closely tied to the RIs' individual activity and no general trend can be observed. At the RI level, individual cases illustrate the differences; for example, Alto has less running beam time than the other RIs. Meanwhile the electricity costs in France are increasing and perhaps explains why GANIL has a higher growth in energy costs than energy consumption, GSI has

[8] The trend in electricity consumption is based on data provided by eight research infrastructures (ALTO, ECT*, GANIL, GSI, KVI-CART, LNL, NLC Krakow and NLC Warsaw).

implemented an energy-saving plan, NLC Krakow has run more beam time, whilst NLC Warsaw has run less beam time.

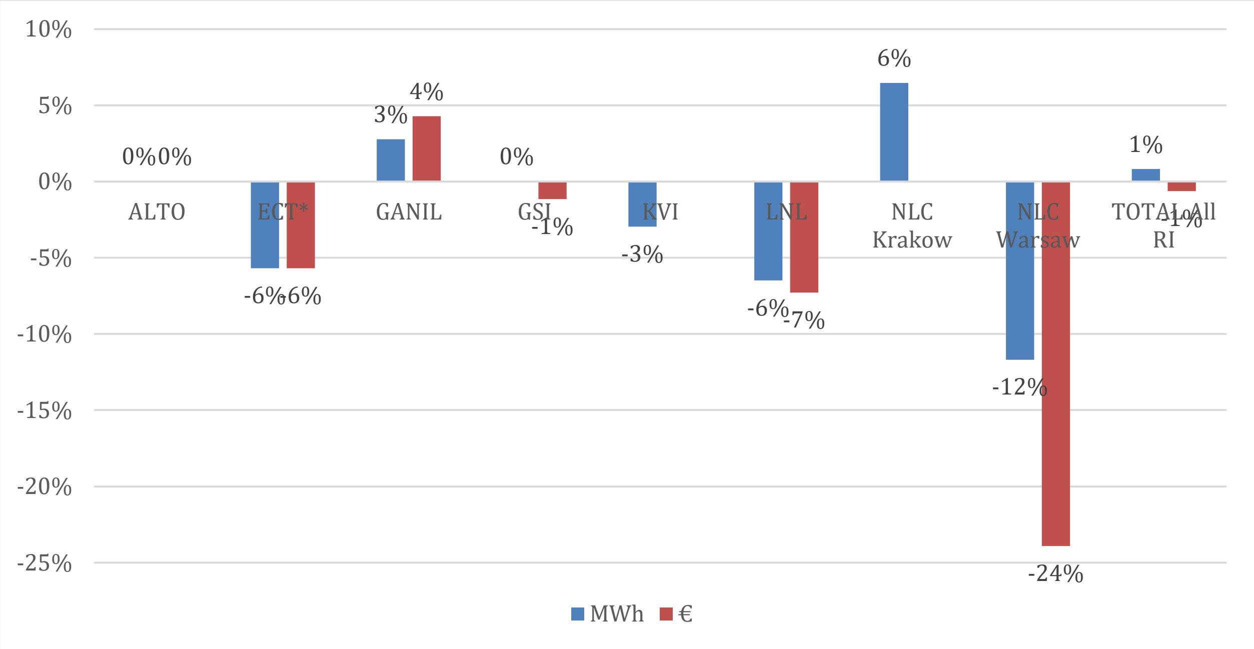


Figure 21: Growth of electricity consumption 2013-2017 (data from ALTO, ECT*, GANIL, GSI, KVI-CART, LNL, NLC Krakow and NLC Warsaw)

At the overall level, there is a small increase in electricity consumption (+1% per year) but this hides some quite significant differences between RIs.

WATER

Unlike electricity consumption, the overall water consumption of the research infrastructures has tended to decrease overtime, by on average 1% per year[9]. Nevertheless, this low figure does not really indicate a trend, as no patterns can be seen from the observations of the varied individual research infrastructures.

Figure 22: Growth of water consumption 2013-2017 (data from ALTO, ECT*, GANIL, GSI, LNL, NLC Krakow and NLC Warsaw)

The overall water consumption is decreasing year after year, but no clear pattern can be observed.

EFFORTS TO REDUCE WASTE ARE REFLECTED IN GLOBAL TRENDS

NON-HAZARDOUS WASTE

[9] The trend in water consumption is measured based on the variables provided by seven research infrastructures (ALTO, ECT*, GANIL, GSI, LNL, NLC Krakow and NLC Warsaw).

Based on the available data[10] the RIs produce 893,712 tons of non-hazardous waste per year. Analysing the waste production year by year of all five research infrastructures that provided data, there is a 1% decrease per year. This figure reflects a general trend of waste reduction. Nevertheless, the individual analysis of the research infrastructures shows that each of them follows different patterns.

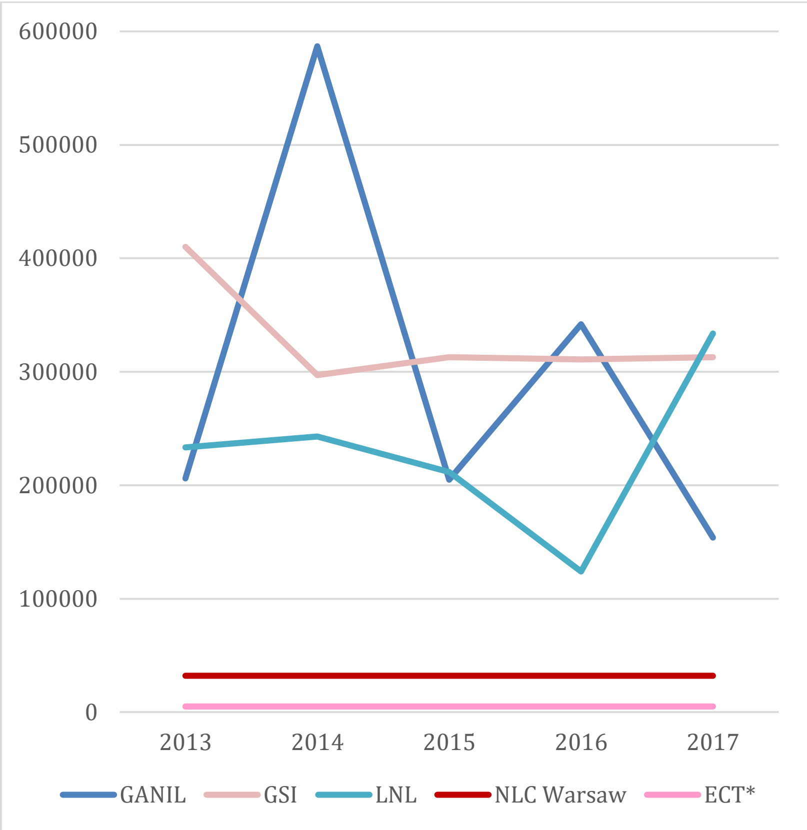


Figure 23: Production of non-hazardous waste in kg 2013-2017 (data from GANIL, GSI, LNL, NLC Warsaw and ECT*)

The peak observed for the GANIL in 2014 corresponds to the waste generated by the construction of the SPIRAL2 accelerator and does not reflect the normal activity of the RI. The reduction of waste at GSI (-7% per year) may partially be explained by a new policy: biodegradable waste is henceforth used for compost, to reduce the overall waste production.

Measuring the non-hazardous waste per person provides a better insight into the role of the staff members of the infrastructures in terms of waste management. Most research infrastructures, which provided data, have a similar waste production per staff, except for LNL, which waste production per staff is the highest. LNL is also building another accelerator, which possibly explains this abnormally high result.

[10] Five RIs provided data about non-hazardous waste (GANIL, GSI, LNL, NLC Warsaw and ECT*)

The graph below provides the number of kilogrammes of waste per employee. All RIs analysed produce a relatively similar amount of waste per employee. The result for LNL is abnormally high because it takes into account the waste generated by the construction work of SPES.

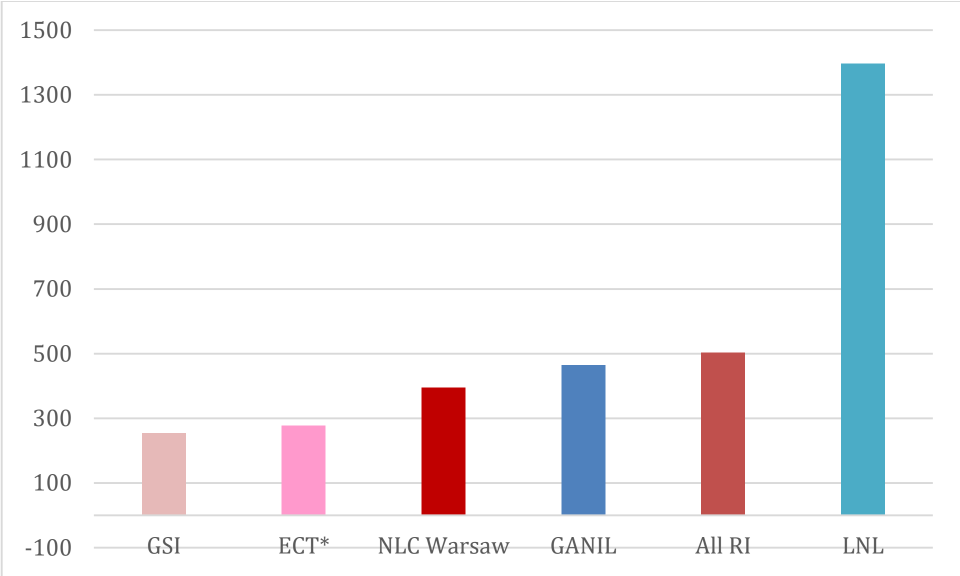


Figure 24: Waste production per employee (kg) (data from GANIL, GSI, ECT*, NLC Warsaw and LNL)

Overall, the waste production of the research infrastructures tends to decrease overtime, but this trend is not obvious when looking at the individual pattern of each RI.

Radioactive waste

All research infrastructures carefully monitor their radioactive waste, but the data are not always made public. Thus, only two research infrastructures provided data about their radioactive waste: GANIL and GSI. On average, GANIL produces 2862 kg of radioactive waste per year, whereas GSI produces ten times less waste, with on average 220 kg per year. In 2015, GSI had a peak of radioactive waste of 1900 kg, which was the result of stockpiling waste temporarily.

It is important to note that each country has its own definition of “radioactive waste”, explaining the important differences between GANIL and GSI figures, for instance. Clearance of radioactive waste, below a certain threshold of radioactivity, enables the radioactive waste to be reclassified as conventional waste. This “clearance” approach exists in all European countries except France.

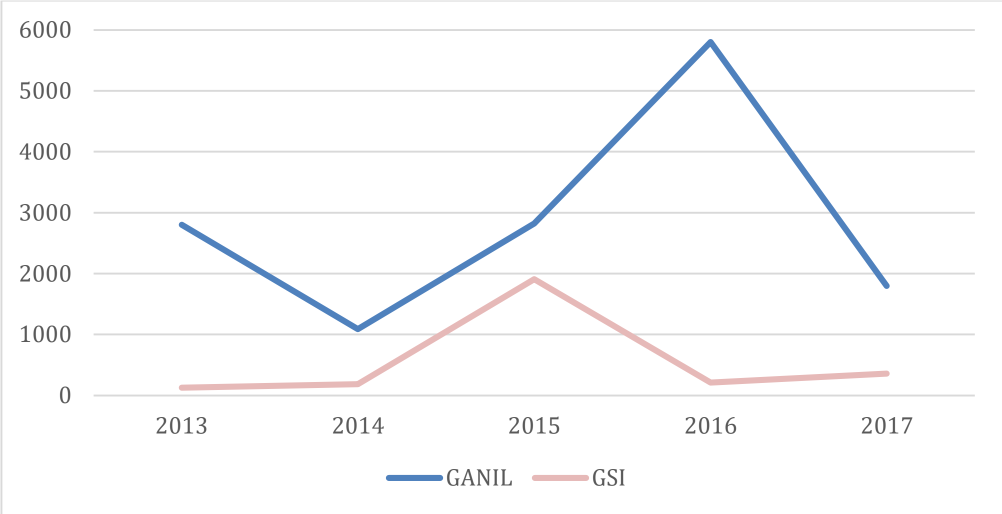


Figure 25: Radioactive waste in kg in the period 2013-2017 (Data from GANIL and GSI)

MOST RESEARCH INFRASTRUCTURES PROTECT THE ENVIRONMENT

Nine out of 12 RIs have put in place bespoke environmental policies. This high figure reveals that environmental protection is important for all the research infrastructures. Their scope and content vary widely from one research infrastructure to the other.

CERN-ISOLDE has a comprehensive environmental policy which tackles prevention and monitoring aspects and deals with most issues related to the protection of the environment, for example: ionising radiation, air protection, water protection, soil protection, hazardous substance, environmental noise, waste management, energy management, non-ionising radiation, prevention of environmental accidents and protection of natural resources. All these aspects are carefully monitored, and CERN-ISOLDE aims to become a role model in terms of the protection of the environment. CERN-ISOLDE is monitoring radiation through 136 monitoring stations. Its “contribution” to radiation is around 0.01 to 0.02 mSv, a very small amount in comparison with natural sources of radioactivity found in everyday living conditions (for instance, 0.35 mSv, estimated through Foods, 0.35 mSv, through Terrestrial radiation, 0.40 mSv through Cosmic rays).

GANIL has also put in place an environmental monitoring programme: it has installed 2 stations for radioactivity monitoring, dosimeters in 5 municipalities, and monitors radioactivity in grass, milk, and so on. Around 2600 measurements are performed each year.

LNL has a full team dedicated to monitoring the environment. Its policy is coercive, and like CERN-ISOLDE, encompasses a wide range of environmental domains, beyond ionising radiations. In addition, the research infrastructure is compliant with ISO14001, which pushes the RI to continuously reduce and enhance its impact on the environment.

Other types of measures implemented by the RIs: JYFL has a WWF Green Office status for the entire university, promoting green practices. ECT*, which is not concerned with ionising radiation, has committed to reduce its CO2 footprint. NLC Krakow has taken measures to modernise the building to ensure thermal insulation. The infrastructure is also managing the trees and open spaces around the facility.

All RIs monitor ionising radiation. In addition, most RIs have environmental policies, to monitor their activity and in some cases going much further and tacking their environmental impact comprehensively.

CONCLUSIONS

CONTEXT AND THE STUDY TERMS OF REFERENCE

Inno TSD and Collaborative People were mandated to:

- ✓ Estimate the impact of ENSAR / ENSAR2 TNA, and where possible the relative evolution of ENSAR/ENSAR2.

This exercise has been prepared in accordance with the new H2020 expectations related to impact assessment. It was a new exercise in the context of the ENSAR projects and thus all the processes implemented were experimental and potentially complex for all the stakeholders involved in the study.

This study was initially supposed to be based exclusively on data analysis of quantitative datasets provided by the research infrastructures. After several months of efforts dedicated to data collection (data requests, modified and simplified data requests, phone exchanges, two online surveys), the amount of "hard" data collected remained incomplete. Moreover, the simplification of the data requests to ensure at least some collection of data, has reduced the detail and depth of analysis that could be provided.

During the study, three main limits have been identified:

- ✓ Some indicators should be treated with caution given the high heterogeneity between the RIs and some low response rates. They represent an illustration or trend rather than a representative conclusion.
- ✓ Some RIs are considerably larger than the others (GSI in particular), their indicators can therefore have a very important influence on the aggregated data and thus, on the conclusions or emerging trends.
- ✓ Lastly, some of the data collected remains imprecise (due to different national interpretations or lack of precise definition of indicators, which might lead to minor errors).

Nevertheless, and despite the constraints associated with the data collection, the assessment team believes that some interesting results have emerged and provide a good insight into the impact assessment of the TNA actions delivered through ENSAR and ENSAR2.

This study work has undoubtedly benefited from the strong involvement of GANIL, the project coordinator. It has been the main contact point of the team in charge of the study and has played a key role in helping with the understanding of a very specific and complex scientific field and in encouraging project stakeholders to provide data.

THIS STUDY HAS ALSO BENEFITED FROM VERY INTERESTING COMMENTS AND SUGGESTIONS FROM THE RIS INVOLVED IN THE PROJECT: SYNTHESIS OF THE MAIN CONCLUSIONS

IMPACT RELATED TO THE RIS

The most significant impact of the RIs is their production of excellent science and knowledge dissemination, notably thanks to the various particle accelerators they provide.

The main conclusions that can be drawn from the data collected is that we can observe a reduction in some indicators on the scientific activity (mainly the number of experiments and beam time). However, it appears that the overall activity of the research infrastructures during the period have been hampered by financial and human resources for the purpose of upgrading existing RIs and the construction of new large-scale extensions of RIs (FAIR, SPIRAL2, SPES, HIE ISOLDE next projects) accelerator facilities, which in itself is a positive message, indicating the interest in pursuing research investments in these fields.

This trend is important because it can lead to an artificial reduction of some impact indicators related to knowledge production (publications). However, other indicators related to the scientific activity do not follow this trend despite being globally correlated to the activity of RIs and their accelerators:

- ✓ 1300 publications per year since 2013, with an overall stable trend;
- ✓ An increase in the number of workshops seminars and lectures (+ 14 % since 2013);
- ✓ An increase in the number of researchers who accessed the RI (+ 6 % since 2013).

As such, we can conclude that the scientific community, the openness of accelerators and more globally the performance in scientific activity has improved since 2013. This positive trend will benefit from the important upgrades/extensions of certain accelerators (construction of SPIRAL2, FAIR and HIE-ISOLDE, in particular).

The indicators related to enhancing skills were generally lacking and very partial (number of students, number of PhDs obtained, and teaching by the RI's researchers). The low response rate suggests caution when interpreting some indicators (number of students) and some specific conditions in some research infrastructures can also partially explain the result. Nevertheless, we consider that the result supports the need for deeper analysis explaining the decreasing trends resulting from these partial figures.

It is also interesting to see that most RIs are involved in outreach activities by raising science awareness of the general public through open days, production of documentaries and so on. We do not know if it is a specific characteristic of the RIs belonging to ENSAR/ENSAR2, but this is an interesting and important result.

During the impact assessment, we also observed that the RIs are globally evolving positively and in line with broader European societal values, especially regarding gender equality and the need for more gender positive policies. This change is not necessarily linked to a specific RI level policy (positive discrimination, directed sensibilisation, etc.) but mainly illustrates a societal tendency for a stronger involvement of women in science. Despite this tendency, it appears that the share of women in RIs is low and mostly centred on back-office and research support activities.

It should also be underlined that the RIs staff is increasing and is evolving towards more qualified jobs. The share of researchers rose by 2 pts across the period and the share of engineers by 1 pt.

The assessment focussed on other impacts, assimilated here to externalities:

- ✓ Economic impact: The economic impact of accelerators devoted to basic research in terms of valorisation has been explicitly excluded from the analysis since another impact study is conducted on this topic within the WP NuPIA (ENSAR2). Taking it into account in this study would therefore have simply duplicated the work for all project partners. As such, the main economic impacts studied concerns the consequences of the activities of the RIs on the economic fabric. Direct contracts for extensions and upgrades, development or maintenance, safety contracts, are a very important source of economic impact both locally and at national level for specialised industrial partners. We have estimated the number of direct, indirect and induced jobs generated by the RIs. There are about 2250 staff members in all the RIs (direct employment), the number of indirect employment (related to the procurement budgets of the RI) amounts to between 325 to 385 people and the induced employment (induced by the expenditure of the direct and indirect employees of the RIs) represents between 520 to 600 jobs. As such, the activity of the RIs supports about 3 000-3 150 jobs per year, with about one third being linked to indirect and induced jobs.
- ✓ Environmental impact: the activity of accelerators requires a lot of electricity and water and generates some non-hazardous wastes and hazardous wastes. To reduce their environmental footprint, most of the RIs have put in place strategies and engaged actions to protect the environment and reduce their environmental footprint (9 of the 12 RIs). It appears that environmental protection is an important issue for all the research infrastructures.

Impacts related to the TNA

The TNA is part of ENSAR/ENSAR2 and as a H2020 project, shall have its impact evaluated. To conduct this evaluation, we have identified the main expected or potential impacts of the project. The team then controlled whether or not each impact could effectively be confirmed on a quantitative and qualitative basis. When possible, we measured the amount of impact that could be generated by the TNA.

All the expected effects have been confirmed by the analysis either from qualitative or quantitative basis. The main identified outcomes are:

More users can conduct experiments. We have seen that on average, an experiment conducted through ENSAR/ENSAR2 involves more users than other experiments. This result is confirmed by the qualitative exchange with the RIs. An interesting point is that, we have seen a reduction of the number of users funded per experiment. This result is explained by the choice of funding by the PAC. The funds are increasingly focused on researchers which could not have participated without financial support.

The TNA has thus allowed for:

- **An even higher excellence in research**, mainly through the possibility to fund the experiments that could not have been funded otherwise and to provide more users per experiment (a less significant effect).
- **More publications**: The experiments conducted in the TNA have led to new results in the nuclear physics field and thus to more publications. We have estimated that the TNA has enabled the publication of at least 340 publications since 2013.
- **Positive economic impact**: We have estimated that ENSAR/ENSAR2 have safeguarded about 100 to 140 jobs due to this positive externality.
- **More networks and cooperation**: We have strong qualitative evidence supporting the belief that TNA has had an important impact on the development of networks and cooperation. The TNA has increased the number of users but more importantly, more various types of users are participating (young, users coming from financially disadvantaged regions/countries, etc.).

An interesting aspect of the TNA concerns its focus on the users that need support the most, thus delivering a strong additionality impact:

- **Young users:** Typically, when funds are scarce and when funding an experiment in a different and overseas infrastructure, universities tend to prefer to allocate their resources to experienced researchers, in order to guarantee the best results. Young people are therefore more likely to be excluded. The way the TNA funds have been targeted means that TNA has enabled to increase their participation. In ENSAR, they represented 61% of the beneficiaries. The funding appears to be important to enhance their skills and create future vocations for scientists. In the future, this focus might result in:
    - Increasing the skills of researchers and in the total, number of researchers in nuclear physics. Such an effect is too indirect to be measured and is still hypothetical.
    - Increasing the share of women in the scientific community. We have evidence that women are more represented amongst TNA users than among staff members. These results can be linked to a societal evolution. However, by contributing to support the young researchers and helping to create scientific vocations, the TNA will also contribute to increasing the share of women. Again, this indirect effect cannot be precisely estimated, and is hypothetical.
- **Users coming from financially disadvantaged regions/countries**: No quantitative evidence could be found from the available data, but much qualitative evidence points towards such an impact for these users. It appears that the TNA allows them to overcome the barrier of the cost of the experiments (funding of beam time as well as travel and living costs).

As a result, it is considered that the TNA is useful and has been a success. More in-depth analysis could be conducted to better estimate this impact. Therefore, the next section makes some recommendations for the next evaluation.

RECOMMENDATIONS FOR THE NEXT EVALUATION

Conducting the one-year impact assessment enabled the study team and the stakeholders to draw some lessons and develop them into recommendations for future assessments.

Regarding the overall impact analysis of the RIs:

- The question of the impact of the construction / upgrading of accelerators on the scientific activity seems to have been much more important than expected. In a future evaluation a specific work (and specific indicators) should be developed in order to better measure and control this effect on the overall scientific impact of the RIs.
- An in-depth qualitative assessment of the contribution of the RIs to excellent science should be prepared. This impact was mainly outside the scope of the study since it was focussed on quantitative data and thus had a socio-economic and environmental focus. A qualitative assessment focussing on the scientific results of the RIs and the role of the accelerators could be an asset.
- An in-depth analysis should be engaged on the question of networks. We have collected evidence of the development of networks, but a mapping of the cooperation and an analysis of the dynamics of the cooperation and network activities could be engaged in order to confirm the first results. Such analysis has been proposed by GANIL but the time and budget available has not allowed for this work to be undertaken.

Regarding the overall impact analysis of the TNA:

- For this evaluation, we have developed an impact logical diagram of the TNA based on our understanding of its impacts many years after the engagement of ENSAR For a further assessment, a baseline should be defined prior to the project in order to provide a more rigorous assessment.
- Also, more data should be collected to better understand the impact of the TNA on the openness of the RIs and regarding the diversity of users (young, users from university or institutes with low financial resources, etc.).

Regarding the data collection, a future evaluation should become a “shared process” between the evaluator and the partners of the project:

- Discuss with all the partners about the indicators and their importance for the overall evaluation; such a discussion has taken place before the study, which was a good idea. Involving the evaluator in the discussion could be a good way to go a step further to ensure a good and shared understanding of the indicators that can be estimated and their perimeter and therefore resulting in improved study terms of reference.
- The specific difficulty of confidentiality should also be addressed during the construction of the evaluation framework in close consultation with all the RIs. Some indicators and data have led to unexpected difficulties during the data collection (on HR for instance).
- Identify in the RIs various key contacts depending on the data needed (HR, Responsible for the accelerators, Finance department) would facilitate information flow.

- Organise some exchanges (even phone exchanges or a common webinar) in support of the data request to ensure that a common understanding is reached on the expectation and definition/scope of each indicator identified, before the potential difficulties occur. During this study, some phone exchanges have been conducted with this in mind but they were not planned at the beginning of the mission to address this difficulty.
- Organise some visits of the RIs to create an understanding of how the RIs work, what data can be collected and how the data from the different RIs can be compared.
- Create a regular flow and transmission of key data in order to reduce the burden at a precise time of the project and reduce the risk of missing data. The transmission time could be linked to the data production inside the RIs (for instance the annual report). GANIL has in this perspective, created a dedicated space to ATRIUM, an online secure repository, which has helped in this perspective the information transmission and could serve as a support for this regular future transmission.

APPENDIX

APPENDIX 1 - LIST OF INDICATORS

WEIGHTING VARIABLES

Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Weighting variables			* Beam time and/or Experiment /ENSAR and non-ENSAR / accelerator / RI * Average beam time/ experiment / accelerator / RI * Number of accelerator comprised in the ENSAR2 TNA / total number of accelerators in the RI [cf. grant agreement]
			* Headcount (researchers / engineers / technicians) * Total headcount

DEVELOPMENT OF NEW KNOWLEDGE

Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Development of new knowledge	Accessibility of the research infrastructure	Excellence knowledge	* Number of ENSAR external experimenters / year / accelerator
			* Number of publications / year
	Financial sustainability	Research	* Economic impact of one hour of beam time (for an internal / external experimenter) - cf. grant agreement

		Funding	* Volume of funding of the RI per source: public investment / cooperation projects (International / European level / national / regional) / private investors
		Overhead costs	* Personnel expenses, welfare costs, total procurements, national and local taxes, reimbursement of interest rates... * Estimated dismantlement costs (if available)
	Cutting edge research activities and knowledge diffusion	Excellence knowledge	*Number of organised workshops and lectures
			* Number of scientists in attendance during the workshops and lectures
	Research networks	Excellence knowledge	* Number of researchers who accessed the RI
			* Number of cooperation projects (contract, MoU) revealing the interconnection between the RI

SCIENTIFIC AND HIGH TECHNOLOGY SKILLS

Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Scientific and high technology skills	Reinforced skills of researchers and engineers	Training	* Number of teaching hours dedicated to nuclear physics taught in the laboratories attached to the RI
		Training	* Number of students trained per RI (interns, master students, PhD students)
		Training	* Follow-up of the student, one year after obtaining their PhD
		Training	* Number of PhD passed

	Attractiveness	Attractiveness	* Number of internal researchers who received an ERC award * Contribution of ENSAR / ENSAR2 to the attractiveness of the RI (qualitative)
	Diffusion of scientific culture	Access to the general public	* Open days (yes/no) + number of visitors * Organised visits and other events intended to the general public (+ number of visitors) * Documentaries (+ other actions relative to video-making) * Number of pedagogical or science popularisation articles published by the RI
		Making science attractive for the new generation	* Actions intended to the young people (exhibitions, presentations in schools)
		ICT for making science attractive for the new generation	* RI on social networks (types of networks + number of people attained)

COMPETITIVENESS AND EMPLOYMENT

Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Competitiveness and employment	Activities and economic spill-overs	Wealth distribution (wages, procurement, taxes…)	* Scheme of the "financial flows per stakeholder" with the wealth distributed to the employees, public authorities and suppliers
		Direct employment	* Contribution of the RI to employment
		Procurements in regional / extra-regional firms and indirect employment	* Figure of the procurement expenditures per geographic areas (local, national, EU, outside EU) * Employment supported by procurements
		Employment induced by the travels / visits of researchers in the context of ENSAR / ENSAR2	* Induced employment in the local economy (hotels, restaurants…)
		Other induced employment	* Employment induced by the consumption of the direct and indirect personnel of the RI

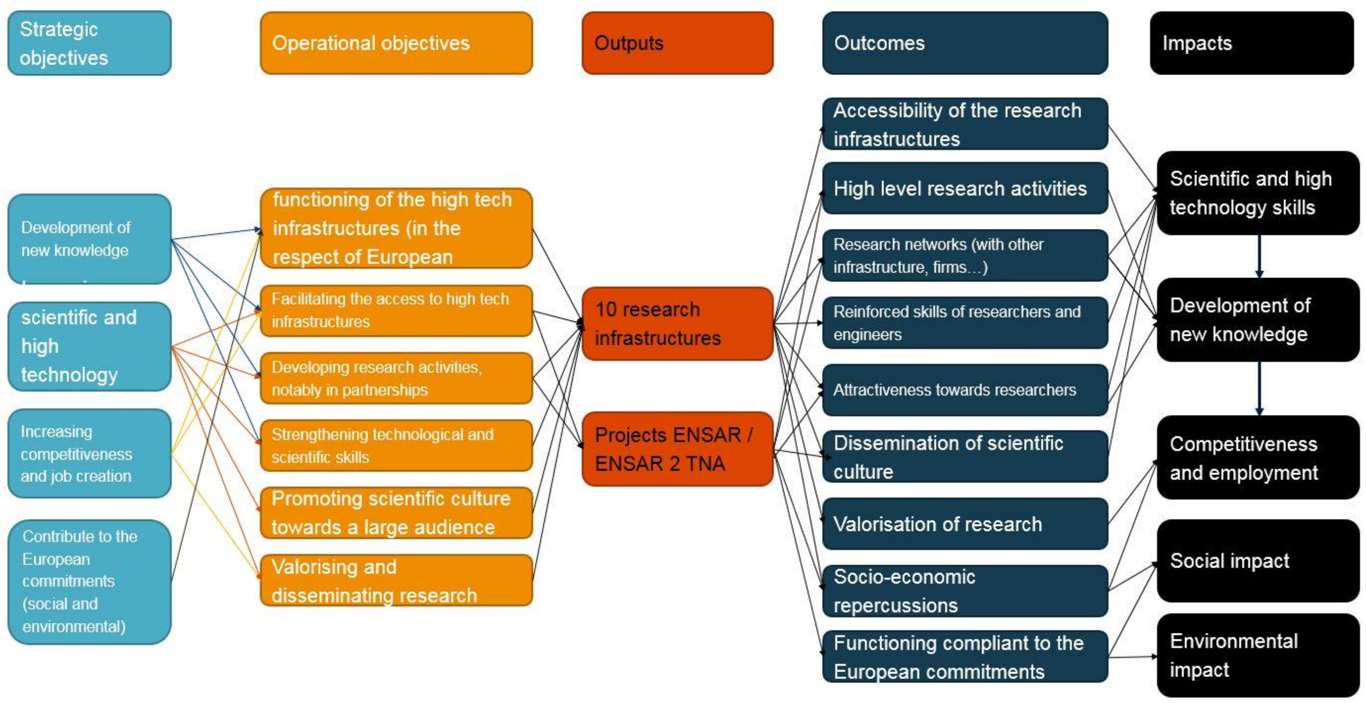
Social impacts

Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Social impacts	Fundamental and human rights	* Gender equality	* Share of women
	Life quality	Life quality	* Social and sport activities implemented by the RI * HSE policy

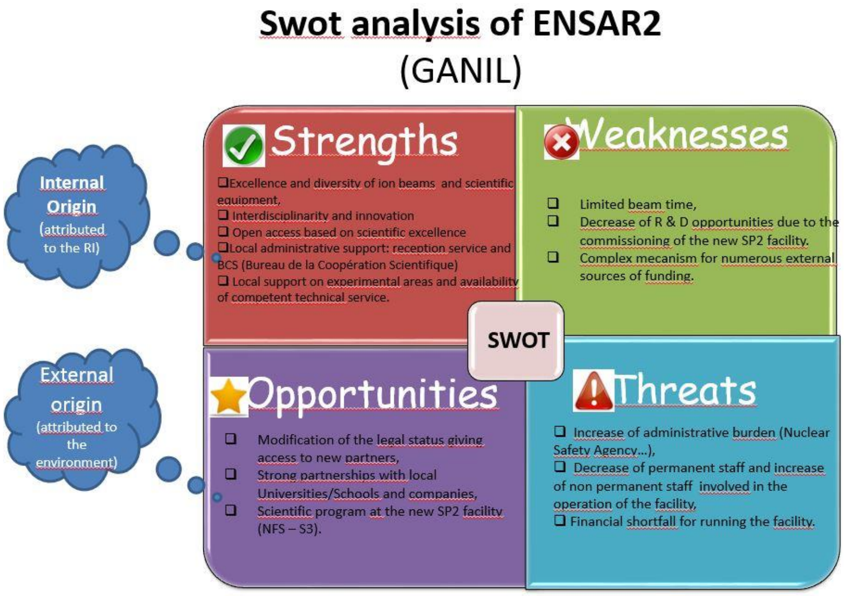
Environmental impacts

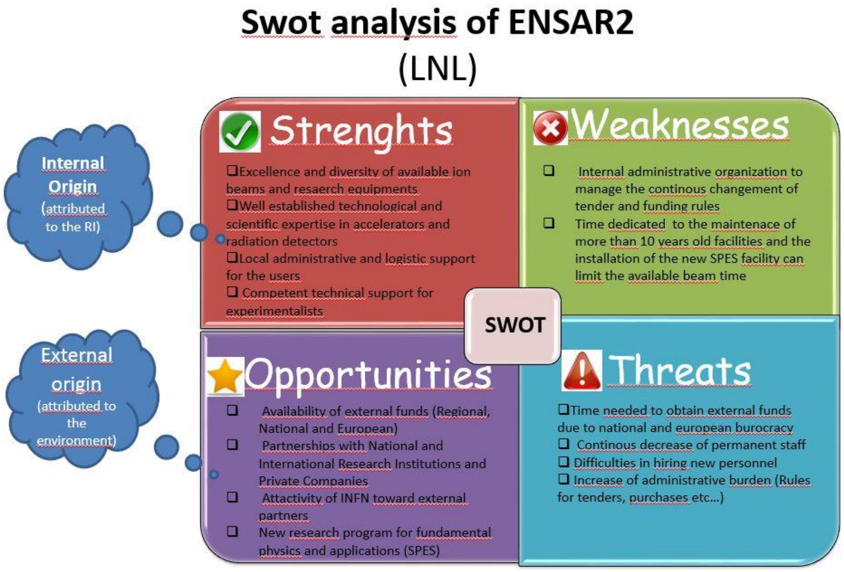
Impact category	Field of results	Associated indicator in the tender	Result or impact indicator
Environmental impacts	Energy efficiency	Energy efficiency	* Electricity consumption of the RI
			* Water consumption
			* Environmental policy
	Stockpiling / recycling	Stockpiling / recycling	* waste production (per type of waste) + focus on radioactive waste + link to environmental policy

Appendix 2 – Logical diagram



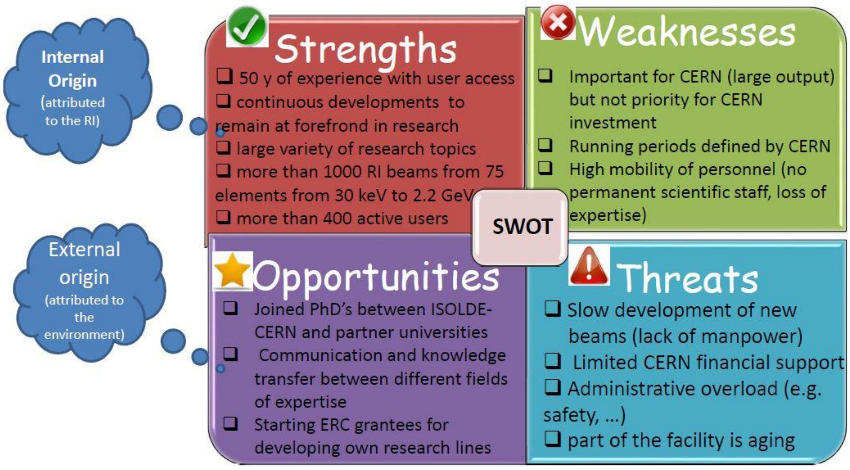
APPENDIX 3 – ENSAR2 SWOT ANALYSIS





Swot analysis of ENSAR2 (LNS)

Swot analysis of ENSAR2 (ISOLDE)



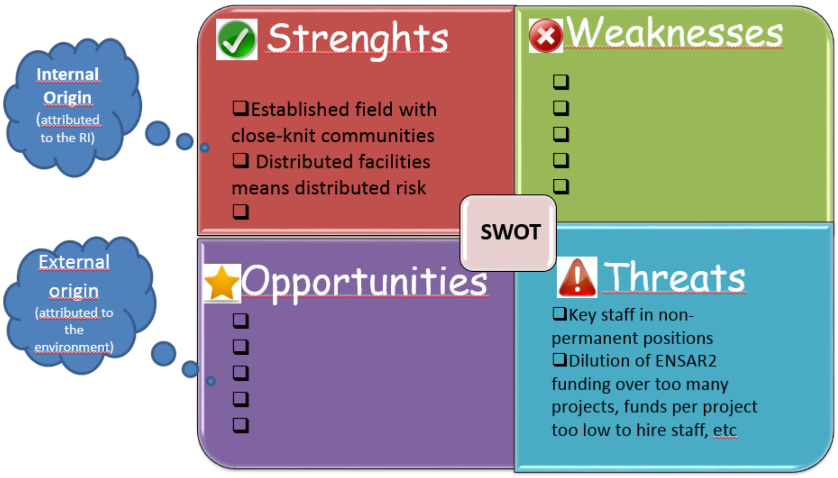
Swot analysis of ENSAR2 (ALTO)

Swot analysis of ENSAR2
(ECT*)

Swot analysis of ENSAR2
(NLC Krakow)

Swot analysis of ENSAR2
(NLC Warsaw)

Swot analysis of ENSAR2
(JYFL)



Swot analysis of ENSAR2
(IFIN-HH/ELI-NP)