

# Status of the Efinion brochure

**Karl Johnston**



EFINION: The European Forum for Innovative  
Applications of Nuclear ION beams and tools





## Feedback from all the TNA labs: EFINION questionnaire



### EFINION QUESTIONNAIRE #1

please submit a Word file, including everything – not a PDF!

|     |                                       |   |
|-----|---------------------------------------|---|
| A.1 | Name person filling the questionnaire | dr. E.R. van der Graaf                              |
| A.2 | Affiliation                           | KVI-CART (Center for Advanced Radiation Technology) |
| A.3 | Email                                 | vandergraaf@kvi.nl                                  |

|     |  |   |
|-----|--|---|
| B.1 | Activities presented here refer to institution:        | KVI-CART (Center for Advanced Radiation Technology) |
| B.2 | Contact person of your institution for EFINION matters | dr. M.A. Hofstee, head cyclotron operations         |
| B.3 | Email  | m.a.hofstee@rug.nl                                  |

In the following table(s) please describe as clear as possible the application(s) running at your lab that, in your view, deserve to be included in the EFINION catalogue. Though, EFINION's goal is to document all applications running at ENSAR institutions, some major criteria for the final composition of the catalogue will be the following:

1. Innovative aspects of the application
2. Socio-economic impact
3. Multi-disciplinary character
4. Existing links with "end-users"
5. Involvement of radioactive beams in the application
6. Uniqueness
7. Sustainability beyond ENSAR's termination
8. Potential for patents
9. European added-value
10. Potential for public awareness

| Deliverable Number <sup>61</sup> | Deliverable Title  | Lead beneficiary number | Estimated indicative person-months | Nature <sup>62</sup> | Dissemination level <sup>63</sup> | Delivery date <sup>64</sup> |
|----------------------------------|--|-------------------------|------------------------------------|----------------------|-----------------------------------|-----------------------------|
| D6.1                             | Preliminary survey of past and present multidisciplinary and application-oriented research within EN | 16                      | 2.00                               | R                    | PU                                | 12                          |
| D6.2                             | Report on the Workshop on "ENSAR applications - oriented research"                                   | 16                      | 6.00                               | R                    | PU                                | 36                          |
| D6.3                             | "Catalogue of multidisciplinary applications-oriented research activities of ENSAR"                  | 16                      | 5.00                               | R                    | PU                                | 36                          |
| D6.4                             | "Synergies and collaboration opportunities in applications-oriented research with and within ENSAR". | 16                      | 6.00                               | R                    | PU                                | 36                          |
| D6.5                             | The EFINION's website  | 16                      | 5.01                               | O                    | PU                                | 6                           |
| D6.6                             | "Nuclear scientists and policy makers communicate"   | 16                      | 6.00                               | R                    | PU                                | 48                          |
|                                  |  | Total                   | 30.01                              |                      |                                   |                             |

# Efinion “Pre-workshop” CERN 20<sup>th</sup> Feb

Overview of the received information (at the time missing many labs)

Presentation and overview of similar projects from DidweDo agency (Lausanne)  
Schedule laid out....

Initial plan was finalising by ~ 16<sup>th</sup> June....this has slipped

# Structure of Brochure

## Brochure structure:

- Editorials of ENSAR coordinator and GA chair – 1 page (videos on the digital edition)
- What is ENSAR – 1 page
- ENSAR response to Society + **top success story** – 2 pages
- Map with facilities/beneficiaries (similar to NuPECC brochure) - 1 page
- Table/Map with labs vs. application fields – 1 page
- TNA facilities: success stories – 7x4=28 pages
- JRA & NA – 4 pages
- Interviews with “end-users” – 2 pages
- Forward look and future plans – 2 pages

## Main structure and content sections (option B – recommended)

according to 21/02/2014 CERN meeting

*INFORMATION: The interior number of pages of a publication (excluding the 4 cover pages, here in yellow) must be a multiple of 4.*

-  Cover
-  Introduction
-  ENSAR + Benefits of the project
-  Partners description
-  Conclusion
-  > the document must finish on one of these pages

|                     |                                   |                           |                           |                      |                      |                      |                                   |                            |                           |                          |                      |                      |    |
|---------------------|-----------------------------------|---------------------------|---------------------------|----------------------|----------------------|----------------------|-----------------------------------|----------------------------|---------------------------|--------------------------|----------------------|----------------------|----|
| BACK COVER          | FRONT COVER                       | inside FRONT COVER        | table of contents         | editorial            | ENSAR + GA chair     | What is ENSAR?       | ENSAR map                         | Added Value of the project | Success Stories by field  | Success Stories by field | TNA 01 GANL (F)      |                      |    |
|                     |                                   | 1                         | 2                         | 3                    | 4                    | 5                    | 6                                 | 7                          | 8                         | 9                        | 10                   | 11                   |    |
| TNA 01 GANL (F)     | TNA 02 GSI (D)                    | TNA 02 GSI (D)            | TNA 03 LNL (I)            | TNA 03 LNL (I)       | TNA 04 JYU-JYFL (FI) | TNA 04 JYU-JYFL (FI) | TNA 05 RUG-KVI (NL)               | TNA 05 RUG-KVI (NL)        | TNA 06 CERN-ISOLDE (CH)   | TNA 06 CERN-ISOLDE (CH)  | TNA 07 CNRS-ALTO (F) | TNA 07 CNRS-ALTO (F) |    |
| 12                  | 13                                | 14                        | 15                        | 16                   | 17                   | 18                   | 19                                | 20                         | 21                        | 22                       | 23                   | 24                   | 25 |
| TNA 05 RUG-KVI (NL) | TNA 05 RUG-KVI (NL)               | TNA 06 CERN-ISOLDE (CH)   | TNA 06 CERN-ISOLDE (CH)   | TNA 07 CNRS-ALTO (F) | TNA 07 CNRS-ALTO (F) | TNA 08 LNS (I)       | JRA (7 Joint Research Activities) | NA (6 Network Activities)  | Interviews with End users | After ENSAR              | inside BACK COVER    |                      |    |
| 26                  | 27                                | 28                        | 29                        | 30                   | 31                   | 32                   | 33                                | 34                         | 35                        | 36                       | 37                   | 38                   | 39 |
| TNA 08 LNS (I)      | JRA (7 Joint Research Activities) | NA (6 Network Activities) | Interviews with End users | After ENSAR          | inside BACK COVER    |                      |                                   |                            |                           |                          |                      |                      |    |
| 40                  | 41                                | 42                        | 43                        | 44                   | 45                   | 46                   | 47                                | 48                         | 49                        | 50                       | 51                   | 52                   |    |

“Flavour of content...”



## FINAL REPORT OF THE IOC COORDINATION COMMISSION

GAMES OF THE XXX OLYMPIAD, LONDON 2012





This vision – to use the power of the Games to inspire lasting change – went far beyond simply hosting a memorable 17-day event: it aimed to capture the imagination of young people, while also creating physical, sporting and social legacies.

This compelling vision for the London 2012 Olympic Games provided a clear direction for the Organising Committee, guiding its decisions and inspiring its stakeholders throughout the planning and preparation phase.

London's vision also helped the Organising Committee to create its Games masterplan, which shaped the image of the Games and provided the foundations for its various achievements and innovations, which included delivering a unique Games-time experience for all key client groups, including athletes and spectators.

LOCOG also successfully and consistently repeated key messages in a very disciplined and coordinated way, using every member of its organisation, every possible ambassador and every programme or activity deployed by the organisers. It communicated its Games vision to all key stakeholders, including the public and the media, which was crucial to spreading the message of the Games to young people around the world.

By consistently delivering against its vision throughout the planning phase, LOCOG was able to successfully deliver during the Games themselves and also looks set to realise its legacy ambitions.



Sebastian Coe, Chairman, London 2012 Bid Limited.



London 2012 – Delivering on a vision video



Digital Edition: Content can be embedded...



# Topics received

Socio-economic benefit  
Space electronics  
Ion sources



Space electronics  
Atomic collision  
physics: astrochemistry



RADEF(mostly)  
Pelletron



AGOR-FIRM



Solid state physics/biophysics  
Medicine



Ion beam radiotherapy  
Mass spectroscopy in everyday  
life  
Mine detection  
Algorithms: "bunny"



Ion beam writing  
Diamond biosensors  
Particle beam channelling  
Materials for Gamma/neutron  
detection

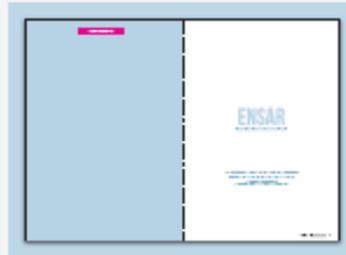


Hadron therapy  
Medical imaging

# Following some digestion, snapshot of a first look....



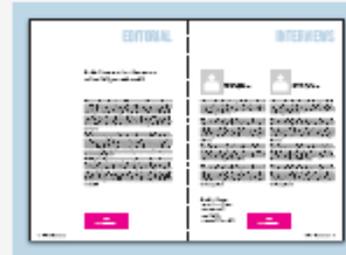
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2



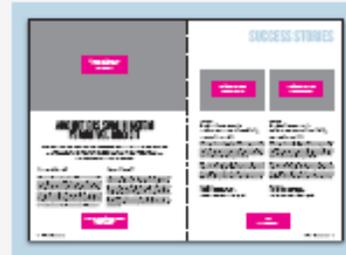
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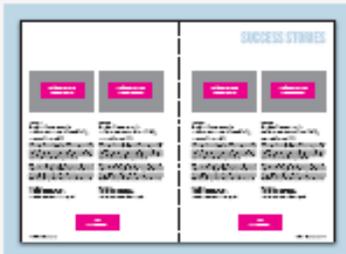
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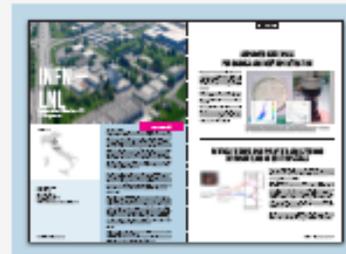
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10



11



12



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14



15



16



17



18

# ABOUT ENSAR

## The European Research Network on Nuclear Physics

The European ENSAR is divided in 10 sub-projects, also called workpackages

**7 TNAs**

Transnational Accelerator Activities

**7 JRAs**

Joint Research Activities

**6 NAs**

Networking Activities

Nuclear Physics is the study of the properties and behaviour of nuclei and particles, ranging from tiny quarks to giant explosions deep in space. Nuclear physics is important in a vast variety of situations, from understanding how the Sun provides the energy for life on this planet, to nuclear power plants and radiation therapy. Without nuclei, we simply would not exist, and it is important to understand why!

In order to carry out research at the forefront of fundamental nuclear science, our community of nuclear scientists profits from the diverse range of large research infrastructures existing in Europe. These infrastructures are particle accelerators that can supply different species of ion beams and energies. In this way, we can learn how the nuclear forces arising from the interaction between the building blocks of nucleons and protons manifest themselves in the rich structure of exotic nuclei, and how different isotopes of elements are synthesized in primordial stellar processes. Our community also has a long tradition of applying state-of-the-art developments in nuclear instrumentation to other research fields (e.g. archaeology) and to benefit humanity (e.g. medical imaging).

The large nuclear research infrastructures that exist in Europe are complementary, in their position of beams and address different aspects of nuclear structure. These European nuclear physics facilities are world-class and rival in comparison with facilities elsewhere in the world. Furthermore, the vibrant European nuclear physics community has made great efforts in the past to make the most efficient use of these facilities by developing the most advanced and novel equipment needed to pursue the excellent scientific programmes proposed there. This has been done under the auspices of NUPDEC (Nuclear Physics European Collaboration Committee) and obtaining support from previous framework programmes of the European Commission.

This community wishes to do the same in the future and has delineated the steps needed to pursue coherent research programmes at these facilities. This was done within the framework of the recent Long-Range Plan (LRP) of NUPDEC "Perspectives for Nuclear Physics Research in Europe in the Coming Decade and Beyond", which has been published in 2024. In this LRP, NUPDEC addressed future perspectives in its major subfields of research in nuclear physics and re-emphasised the role of the European Network of complementary, large-scale facilities where past achievements and future perspectives for research in nuclear physics also are excellent. In this LRP are also recommendations for future Pan-European facilities.

ENSAR is the scientific project for European nuclear scientists who are performing research in three of these major subfields: Nuclear Structure, Nuclear Astrophysics and Applications of Nuclear Science.

Its core aims to provide access to some of the complementary, world-class large-scale facilities: GSI (Germany), GANIL (France), JINR (Italy), JYFL (Finland), KVI (Netherlands), CERN-ISOLDE (Switzerland) and ALTO (France). These facilities provide ion beams of excellent qualities ranging in a large range of energies.

These facilities are offering access to a very large, wide and diverse user community. The size of the community of physicists in nuclear structure, nuclear astrophysics, and applications of nuclear science in addition to the staff that is involved in accelerator and detector development and in running the facilities ranges between 20-3000 scientists and highly qualified engineers according to recent surveys by NUPDEC. The facilities will provide an increased amount of beam time for applications of nuclear techniques.





**GSI**  
 Helmholtzzentrum für  
 Schwerionenforschung

**LOCATION**



**APPLICATIONS**

- ESA Laboratory
- Nuclear Physics
- Atomic Physics
- Biophysics
- Plasma Physics
- Molecular Research
- Accelerator Development

**DESCRIPTION**

The goal of the scientific research conducted at GSI Helmholtzzentrum für Schwerionenforschung is to reach a better understanding of the structure and behavior of the world that surrounds us. GSI operates a unique large-scale accelerator for heavy ions. More than 1,000 researchers from around the world use GSI's massive and diverse facilities each year for experiments that help them make fascinating discoveries in basic research.

In addition, they continually develop new and improve applications. Probably the best-known results are the discovery of all new chemical elements and the development of a new type of cancer therapy using ion beams. In the coming years, a new international accelerator center called FAIR (Facility for Antiprotons and Ion Research) – one of the largest research projects in Europe – will be built adjacent to GSI. The FAIR accelerators will accelerate protons to 100.

**FACILITIES**

- 170-meter-long linear accelerator UNILAC
- Ring accelerator SIS-18 at a circumference of 210 meters
- Isotopes and Heavy-Ion GSI
- Program separator FRS

**LABS**

- Detector Laboratory
- Target Laboratory
- Technology Laboratory
- Vacuum Technology
- Diagnosis
- High-Performance Computing

CANCER THERAPY  
**ION BEAM RADIOTHERAPY IS  
 PRECISE AND HIGHLY EFFECTIVE**



Together with physicians, scientists at GSI develop and deliver new forms of cancer treatment with carbon ions. The development was the result of many years of research in conjunction with GSI's large ion beam accelerator system.

Carbon ion therapy at GSI has been used on more than 1,000 patients for tumors in the head and neck region. The advantage of the new treatment modality is that the ion beam selectively damages tumor tissue while sparing the surrounding healthy tissue. The therapy with ion beams is precise, highly effective and very gentle for the patients. Subsequent monitoring of these patients over a half-year period revealed that the growth of the irradiated tumors was stopped in 70 to 90 percent of the patients, depending on the type of tumor. Side-effects requiring treatment occur rarely, if any, for these cases.

Since 2006, this type of cancer therapy is in routine clinical use at the Heidelberg Ion Beam Therapy Center (HIT). There, up to 1,000 patients can be treated annually. The accelerator facility and the technology for irradiation of HIT was developed and built by scientists and technicians at GSI.

Further developments aim to treat tumors which change their position constantly due to body movements, like breathing. Experiments show that it is possible to follow a movement of the tumor inside the body by adapting the ion beams stopping position in three dimensions. The implementation could expand the treatment to other organs like the lung or the liver. The method is continually improved by GSI scientists and their cooperation partners. Up to today, 300 patients benefited with this novel therapy technique from GSI's efforts.

## HEALTH TREATMENT IN NORMANDY

# NUCLEAR PHYSICS OPENS INNOVATION

At GANIL, it is necessary to adapt the facilities, to the right time for the right patient, to a personalized care environment.

In this regard, GANIL provides the most reliable, most ready functional solutions.

Nuclear medicine uses radioisotopes that are produced in reactors and accelerators. This is possible thanks to developments in nuclear physics. Therefore, nuclear physics and medicine are an expertise area, driven but complementary and linked.

The city of Caen gets a unique scientific, technologic and medical environment in nuclear physics for health. Thus, these skills are consolidated across the principal partners in Normandy-Normandie region.

#### A dynamic ecosystem

First of all, the hospital "Centre de Lutte contre le Cancer François Baclesse" (CLCC) and "University Hospital Center" of Caen (CHU) have cancer patients, they are also involved in research and education. The CLCC is one of the most efficient radiotherapy centres in France.

For fundamental research, on one hand, Caen hosts various research institutions in nuclear physics with a view to medical applications. The LPC group (Laboratoire de Physique Corpusculaire) called "Applications industrielles et médicales" is expert in beam control, simulation and dose calculations for radiotherapy. Now, GANIL is starting a research activity in medical applications. In fact, GANIL is one of the bigger laboratories in the world for research with an beam. Within the framework of the FRM2 (FAHRENHEIT) network part of French investments for the FAIR programme, GANIL adapted beam line to specific needs in hadrontherapy, and now is in use by associated researchers, starting in 2013. SPIRAL2, the new GANIL accelerator, is under construction now. The facility will provide the beam unique in the world. SPIRAL2 will also be used for R&D studies on radioisotope production.

On the other hand, CYCIRON, MEGEIE or GEMM are biomedical research centers. CYCIRON studies are essentially devoted to cancer studies and radioisotopes. This research institution has a medical imaging platform (including synchrotron). All of these facilities are involved in researches about radioisotopes, drug design, medical imaging.

Industry plays also an important role in nuclear and health. Cyclopharma laboratories, Perastech, IM, Adco... are important players in this area. Cyclopharma produces radioisotope (<sup>125</sup>I) for medicine and research.

All these laboratories and companies are some among all the participants in this world ecosystem at the frontier of Physics and Health in Caen area.

#### NUCLEOPOLIS: a nuclear cluster for health, energy and risk management

In the heart of this ecosystem, there is NUCLEOPOLIS. Its members are international industrial and research leaders as AREVA, CEA, CNRS, ILL or GANIL, successful and innovative small and medium enterprises, large research and training institutes. NUCLEOPOLIS gathers the available know-how in Normandy. The aim is to improve territorial cohesion for players, make the attractive aspect of Normandy, in this field more legible and strengthen its position on both national and international levels, act as a projects coordinator and facilitate the development of joint cooperation with a strong ambition to break new ground and create a new jobs.

Nucleopolis is the master of several collaborations between research and industry.

#### Radium future

In matter of Nuclear Physics for Health, Caen area has a bright future with AREVA, ILL and SPIRAL2.

AROMIE is a project for research and industry. In order to develop hadrontherapy, it will be built in the coming years. GANIL, CLCC, Institut LPC, Perastech, IM... are part of this project.

Now SPIRAL2, a collaboration is starting between Caen and Nantes, in France (GEMMA, Subatech). It concerns medical applications with SPIRAL2, in particular radioisotope production (R&D activities) etc.



# INFN LNL

Laboratori Nazionali  
di Legnaro

#### LOCATION



#### APPLICATIONS

Radiobiology  
Micro-diagnostics  
Detector developments  
Ion beam analysis  
Bulk and micro-materials and micro-fabrication

#### Visit to TDD LONG

#### DESCRIPTION

The Italian Institute of Nuclear Physics (INFN) main mission is the study of the fundamental constituents of the matter, conducting theoretical and experimental research in the field of sub-nuclear, nuclear and astroparticle Physics. INFN has a key role in the European framework as it regards particle accelerators and detector developments. Moreover, it is strongly involved in the application of the developed technology in several fields, as for instance medicine, superconductivity, cultural heritage and computing sciences. All these activities are carried out in collaboration with the academic world. Research activities at INFN are carried out within its complementary sites or facilities, the Devices, located at the Physics Departments or Universities, and the four National Laboratories, housing the major facilities.

The Laboratori Nazionali di Legnaro (LNL) is one of the four national laboratories of INFN, characterized to perform basic research in Nuclear Physics and Nuclear Astrophysics, together with applications in nuclear technologies. Its 6 accelerating machines are currently in operation as LNL-A, LNL-D, LNL-C, LNL-B and LNL-F. These facilities deliver approximately 1000 hours of beam time per year.

#### FACILITIES

Several facilities at the INFN LNL in Legnaro are devoted to applied and interdisciplinary physics projects. In particular, the micro-beam facility at the ANICO accelerator used for ion beam micro-writing and for elemental analysis of geological, archeological and environmental samples, the horizontal single-ion micro-beam facility for radiobiological single-cell irradiations installed at the LNL-D accelerator, and the material irradiation at the tandem and CH accelerators for radiation damage studies (bulk damage, ion dose and Single Ion Ion Trace) for detector development, micro-electronics and cultural goods applications.

#### LABS

A testing laboratory for the preparation of the coil surfaces to be used in radiobiology experiments.

Active fibre laboratory supports the user groups for the operation of the facilities to be installed by Ion Beam Analysis.

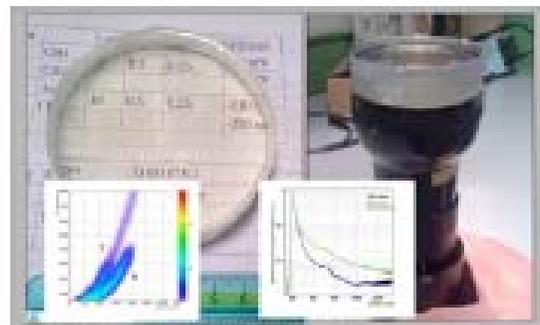
INFN - LNL

## ADVANCED MATERIALS FOR GAMMA AND NEUTRON DETECTION

Transparent polycrystalline scintillators are analyzed by TDD methods at the LNL-CH. A 4 MeV proton pulsed beam (3 MHz, 2 ns) impinges on a thin LiF target to obtain nearly mono-energetic 3.3 MeV neutrons.

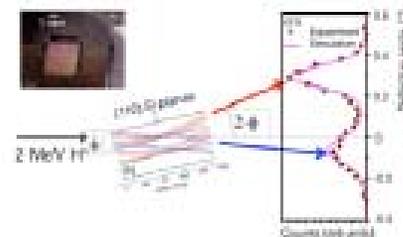
The sensitivity to fast and thermal neutrons and the scintillation pulse shape for the  $n$  gamma discrimination capability is analyzed.

Working with boron for the detection of thermal neutrons presented the scintillator transparency, while with suitable boron concentrations a good pulse shape discrimination has been obtained.



The polycrystalline scintillator CF detector for thermal neutron detection. In the right the detector is in operation connected to an ion beam and gamma ray detector. On the left the detector is in operation connected to a scintillator pulsed beam detector for gamma ray.

## PARTICLE BEAMS MANIPULATION AND STEERING BY CHANNELING IN BENT CRYSTALS



Channeling of MeV charged particles has found its application as a powerful tool for ion-beam analysis. In recent years, channeling in bent crystals made opened up new schemes for beam manipulation and steering of  $Ca^{2+}$  particle beams.

At the LNL-ANICO accelerator, it has been recently demonstrated that beam injection manipulation can also be performed at MeV energy by means of beam interaction with a thin mono-crystal. A 57 nm thick silicon membrane was installed by micro-machining. A 3.0 MeV proton beam interacts with the crystal planes along the membrane thickness with an incident angle  $\alpha = 0.5^\circ$ . The channelled particles make on average half an oscillation into the 57 nm crystal, therefore they are reflected by the lattice planes at the membrane at a good injection.

Deflected particle ion-velocity, detected in the opposite direction ( $180^\circ$  injection), angular distribution and position of the particle has been measured and perfectly agrees with Monte Carlo model.

Image quality....



Background info etc.

# KVI CART

Center for Advanced  
Radiation Technology

#### LOCATION

#### DESCRIPTION

Based at Consiglio Nazionale delle Ricerche (CNR), the largest scientific research organization in Italy, KVI-CART is a leading center for the development and application of advanced radiation technologies. The center is dedicated to the development and application of advanced radiation technologies in the fields of medicine, industry, and research.

#### INCLUSIONS

- 10000 sqm
- 10000 sqm
- 10000 sqm

#### APPLICATIONS

- 10000 sqm
- 10000 sqm
- 10000 sqm

10000 sqm





# CERN — ISOLDE

Isotope Separation  
Online Device

## LOCATION



## APPLICATIONS

- Development of new isotopes for medical diagnosis
- Development of new isotopes for cancer and disease treatment
- Medical applications

## DESCRIPTION

ISOLDE is a nuclear physics facility which is capable of producing 100 microamperes (10<sup>-6</sup> A) of various ion beams. The largest number of particles is produced through the ion-beam stripping programme at ISOLDE. In nuclear physics, the slow transfer of electrons off ions or ion-beam stripping is often called "stripping" simply due to the ion physics involved and theory.

Each year, ISOLDE brings together thousands of scientists from all over the world to work on the various experiments that are possible using ion-beams from ISOLDE. Each year, more than 1000 scientists from all over the world visit ISOLDE.

The various experiments at ISOLDE result in a number of scientific papers and reports, as well as a number of scientific publications in the field of nuclear physics and ion-beam physics.

## INCLUDES

Isotope separation

TECHNOLOGY IN MEDICINE

# INNOVATIVE WAYS OF DETECTING AND TREATING CANCER



Illustration of a medical device at the CERN-ISOLDE facility.

Scientists at ISOLDE are using the unique ability of proton-rich ions to search for new anti-cancer drugs or identify and destroy cancer. Because of the unique properties of ions, ISOLDE is able to go beyond the facilities that typically produce ions and produce beams with very low energy – in other words, low energy ions – which are used to study the structure and chemical composition of the ions.

**What is so great about ions?**  
Ions are the only atoms in the universe with a net electric charge. This gives them a unique ability to interact with other atoms and molecules, making them ideal for studying the structure and chemical composition of the ions. Ions are also used to study the structure and chemical composition of the ions.

The unique ion beams at the CERN-ISOLDE facility are used to study the structure and chemical composition of the ions. This gives them a unique ability to interact with other atoms and molecules, making them ideal for studying the structure and chemical composition of the ions.

The unique ion beams at the CERN-ISOLDE facility are used to study the structure and chemical composition of the ions. This gives them a unique ability to interact with other atoms and molecules, making them ideal for studying the structure and chemical composition of the ions.

**Terbium can serve as the "Swiss Army knife of Nuclear Medicine"**







TO SCOTOPES IN MEDICINE

## Innovative ways of detecting and treating cancer

Researchers at ISOLDE are using its capability to produce radioactive ions to search for new and innovative ways of detecting and treating cancer. Because of the variety of isotopes it can produce, ISOLDE is able to go beyond the facilities that hospitals presently offer, and explore isotopes which may, in the future - be considerably more effective in the treatment and detection of cancer, such as Terbium (Tb).

### What is so great about terbium?

Terbium (Tb) is the only element in Mendeleev's table offering not only a matched pair but one that already occurring in humans, with complementary nuclear decay characteristics covering all nuclear medicine modalities: isotopes <sup>152</sup>Tb for PET, isotopes <sup>151</sup>Tb for SPECT, isotopes <sup>149</sup>Tb for  $\beta^-$  particle therapy and isotopes <sup>152</sup>Tb for therapy with electrons ( $\beta^-$ , conversion and Auger electrons).

Thus, terbium can serve as the "Swiss Army knife of Nuclear Medicine", for fundamental studies of new radiopharmaceuticals and for detailed comparisons of targeted therapies.

So-called "matched pairs" of a diagnostic and a therapeutic isotope of the same chemical element are particularly valuable since their identical chemical properties assure identical in vivo behavior, enabling a precise determination and optimization of the radiation dose given to the tumor prior and during treatment. This opens the way for "theragnostics", where patients are first given a diagnostic isotope, then, based on the obtained patient-specific uptake of the radiopharmaceutical, the optimum therapy option is selected and applied. This type of personalized medicine assures best possible efficacy and minimum side effects since the therapy is tailored to the patient's needs.

### Terbium can serve as the "Swiss Army knife of Nuclear Medicine"

From several available terbium isotopes, the most suitable one is selected for the specific application. The isotopes are produced in a cyclotron and are then transported to the laboratory for further studies.



RESEARCH BENEFITS  
AT THE RESEARCH  
WITH BACKGROUNDED

# RESEARCH IN NUCLEAR PHYSICS BENEFITS TO ALL CITIZENS

EN - 20160 - 11/2016/EN/EN/14

## JRAs & NAs

**Joint Research Activities (JRAs)** are meant to be innovative and explore new fundamental technologies or techniques underpinning the activities and joint use of participating research infrastructures.

JRAs are in general coherent cross-disciplinary and help in integrating activities in the European research program.

The main objective of such activities is to provide an excellent quality working with the best personnel in the area to increase the training and learning of scientists and students for Science in partnership (SIP). The goal is to increase the impact and visibility of the activities and to foster the best for the opening European market for the EU. These are meant to be implemented by an activity to explore the best ways to use the participating infrastructures and to provide the best of the best in the participating countries to achieve the objectives of the SIP.

Supporting activities include the development of new scientific materials and the development of new scientific instruments for both education and research and to foster the best of the best in the participating countries to achieve the objectives of the SIP. The goal is to increase the impact and visibility of the activities and to foster the best for the opening European market for the EU. These are meant to be implemented by an activity to explore the best ways to use the participating infrastructures and to provide the best of the best in the participating countries to achieve the objectives of the SIP.

These developments will give a strong impetus to the emerging initiatives and that innovation and activities that are not yet fully developed. The objective is to foster the best of the best in the participating countries to achieve the objectives of the SIP.

EN - 20160 - 11/2016/EN/EN/14

**Networking Activities (NAs)** foster a culture of co-operation between the participants in the project, the scientific communities benefiting from the research infrastructures, industries and other stakeholders, and to help developing a more efficient and attractive European Research Area.

EN - 20160 - 11/2016/EN/EN/14

The main objective of such activities is to provide an excellent quality working with the best personnel in the area to increase the training and learning of scientists and students for Science in partnership (SIP). The goal is to increase the impact and visibility of the activities and to foster the best for the opening European market for the EU. These are meant to be implemented by an activity to explore the best ways to use the participating infrastructures and to provide the best of the best in the participating countries to achieve the objectives of the SIP.

Supporting activities include the development of new scientific materials and the development of new scientific instruments for both education and research and to foster the best of the best in the participating countries to achieve the objectives of the SIP. The goal is to increase the impact and visibility of the activities and to foster the best for the opening European market for the EU. These are meant to be implemented by an activity to explore the best ways to use the participating infrastructures and to provide the best of the best in the participating countries to achieve the objectives of the SIP.

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## AFTER ENSAR

### After ENSAR there will be ENSAR2, hopefully!

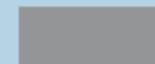
The scientific and technical activities in the European research area (ERA) are supported by various international activities, including the activities of the ERA in the field of research and development.

The European Commission issued in 2014 a new framework programme covering a wide range of scientific activities. This programme is called Horizon 2020 and will last until 2020. The programme is financed by the European Union. The scientific and technical activities in the ERA are supported by various international activities, including the activities of the ERA in the field of research and development.

The nuclear physics community is planning to propose a new initiative (ENSA2) program within the European Commission in 2014, with a possible second support from 2014 to 2020.

This new program is called ENSA2 and will provide an excellent working environment for the nuclear physics community. The program is financed by the European Union. The scientific and technical activities in the ERA are supported by various international activities, including the activities of the ERA in the field of research and development.

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STRONG MESSAGE  
AT THE BEGINNING  
WITH BACKGROUND IMAGE

# RESEARCH IN NUCLEAR PHYSICS BENEFITS TO ALL CITIZENS

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LAYOUT MAY CHANGE

COVER  
- FINAL LAYOUT STILL TO BE  
DEVELOPED -

**ENSAR**  
European Nuclear Science and Applications Research

To be thought about!  
Cover

From our side.....

What is still missing

- editorial and interviews (p.4-5)
- success stories – introduction text + 6 examples by theme (p.8-11)
- end users experience/interviews (p.46-47)

High quality images.....we need original jpgs (ideally 300dpi if possible)  
Also, some more pictures would allow for more varied output, or at least choice...

## Presentation of the TNAs: the core of the brochure

To be decided...- the order of the 7 TNAs → Alphabetical?

Italy...separate or together....- the two Italian facilities are separate, which may be confusing (8 TNA or 7?)

Layout presentation of each TNA (4 pages):

- 1 page is dedicated to "Facts & figures"
- 3 pages are dedicated to the presentation of success stories. One story is usually presented in a more important way. → choose the most successful success story

More info from KVI? Good description of facility, but no specific success stories...

Cover image and text: this is NOT a final version: we have to discuss together at the end about the image of the cover.

Logos/Contributors: where to locate logos and contributors etc. All collected at the end?

Typical delivery time....

About 3-4 weeks from final “finalising” of the text...

Printing takes about 2 weeks...