

**EFINION:**

**The European Forum for Innovative applications of Nuclear  
ION beams and tools**

**an EC / FP7 – ENSAR Network**

**Karl Johnston (ISOLDE/CERN)**

**On behalf of**

**Sotirios V. Harissopulos (NCSD)**

## What is EFINION?

**EFINION** is one of the six ENSAR networks (NA06) aiming at:

- **Compiling and coordinating existing and future applications of socio-economic impact stemming from ENSAR facilities and research groups**
- **Identifying application-oriented synergies within ENSAR groups as well as between ENSAR and interested companies all over Europe**
- **Creating self-contained links beyond ENSAR between researchers and end-users**
- **Disseminating multi-disciplinary application-oriented research to the scientific community, the public and, especially, the policy makers.**



**Budget: 98 k€**

## EFINION Coordination Board

**S. Harissopulos** / NCSRD, Athens (**Coordinator**)  
**Ch. Scheidenberger** / GSI, Darmstadt – **Ch. Lemaître** / GANIL, Caen  
**S. Leray** / CEA-Irfu, Saclay – **G.-E. Körner** / NuPECC/PANS

## EFINION Member Institutions

<b>ALTO</b>	<b>GANIL</b>	<b>JYFL</b>	<b>LNS</b>
<b>CEA/Irfu</b>	<b>GSI</b>	<b>KVI</b>	<b>NCSRD</b>
<b>CIEMAT</b>	<b>ISOLDE</b>	<b>LNL</b>	<b>USC</b>

## EFINION Associated Partners

All ENSAR full or associated member institutions not listed above

## EFINION Pool of Experts

Experts not ENSAR affiliated

## Task 1: **Compilation**

### Aim

**Survey of applications-oriented activities at ENSAR laboratories.** Emphasis on exotic-beam research related to nuclear medicine, space applications, radiobiology and radioecology, climate research and environmental monitoring, as well as to astrophysics and materials and bio-physics.

### Method

**Questionnaires** - **Existing documentation** – **Expert contributions**  
- Workshop

### Deliverable

- Booklet: **Catalogue of multi-disciplinary applications-oriented research activities of ENSAR**
- Report on the **Workshop on “ENSAR applications - oriented research”**

## Task 2: **Intercession**

### Aim:

**Enhancing existing collaborations - Establishing links between different ENSAR groups** who run activities targeting similar applications or develop different applications using the same methodology.

**Intercessional activities between research groups and companies** interested in using scientific results towards development of end-user applications or adopting know-how in large project management and quality

### Method

**Website – Press releases – Workshop (of Task 1) – ENSAR Office for “Liaison Services”**

### Deliverable

**Report on “Synergies and collaboration opportunities in applications-oriented research with and within ENSAR”**

## Task 3: **Dissemination**

### Aim:

**Disseminating application-oriented research to the scientific community, the public and the policy makers.**

### Method

**Website – Press releases – Communication Day (Exhibition) at the EUROPEAN PARLIAMENT.**

### Deliverable

**Report on the Communication-Day “Nuclear scientists and policy makers communicate”.**  
The report will include, among others, also a catalogue of the exhibits as well as interviews given by the visitors.

## Task 1: **Compilation**

<b><u>Aim</u></b>	<b>Survey of applications-oriented activities at ENSAR laboratories.</b> Emphasis on exotic-beam research related to nuclear medicine, space applications, radiobiology and radioecology, climate research and environmental monitoring, as well as to astrophysics.
<b><u>Method</u></b>	<b>Questionnaires - Existing documentation – Expert contributions - Workshop</b>
<b><u>Deliverable</u></b>	<ul style="list-style-type: none"> <li>- Booklet: <b>Catalogue of multi-disciplinary applications-oriented research activities of ENSAR</b></li> <li>- Report on the <b>Workshop on “ENSAR applications - oriented research”</b></li> </ul>

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**

Requests for the compilation of catalogue were made among the partner institutes.







# Catalogue being prepared....but needs more input!!!!



## Radiation Effects Facility, RADEF

### Contact:

Prof. Ari Virtanen  
Ari.virtanen@ju.fi  
☎: +358505419401

Department of Physics  
P.O. Box 35 (YFL)  
FI-40014 University of  
Jyväskylä, Finland  
Street address:  
Survantie 9, Jyväskylä

### Researchers:

Ari Virtanen (JYFL),  
Heikki Kettunen (JYFL),  
Arto Javanainen (JYFL),  
Mikko Rossi (JYFL),  
Jukka Jaatinen (JYFL)  
and Veronique  
Ferlet-Carvois (ESA).

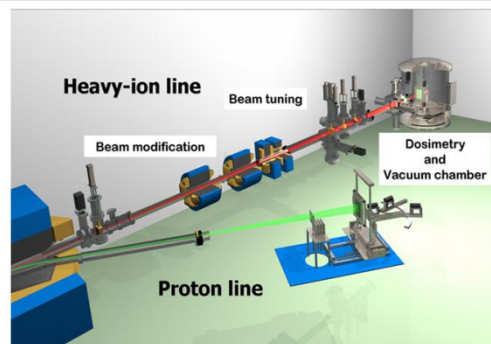
## Ion beams for space exploration

The increased demands for radiation testing in Europe attracted ESA to the JYFL-Accelerator Laboratory.

In 2004 an ESTEC/Contract No. 18197/04/NL/CP between ESA and JYFL was signed: "Utilisation of the High Energy Heavy Ion Test

Facility for Component Radiation Studies".

In the inauguration in May 2005, laboratory's RADiation Effects Facility, RADEF, was accredited to one of ESA's External European Component Irradiation Facilities (ECIF).



The RADiation Effects Facility at the Accelerator Laboratory of the University of Jyväskylä, Finland

The JYFL Accelerator Laboratory (<http://www.jyu.fi/accelerator>) is part of the Department of Physics. The laboratory consists of a modern cyclotron (since 1995), which is capable to accelerate large variety of light and heavy ions. The use of the cyclotron provides annual beam time of about 1400 out of the 7000 total beam hours for the industrial applications, preferably for RADEF. Since 2005 RADEF has been an accredited Single Event Effects (SEE) test facility of European Space Agency, ESA, and its main purpose is to serve the European space industry

by providing beam time for the radiation hardness studies of spacecraft electronics. During its operation RADEF has acted as a test site for 35 companies and space organizations. In addition to ESA, the list of national institutes includes NASA/JPL (USA), JAXA (Japan), INTA (Spain), CNES (France), CEA (France), SANDIA (USA) and ONERA (France). The biggest companies are e.g. EADS Astrium Space (France) and Space Transportation (Germany), Thales Alenia Space (France), RUAG (Sweden, Austria) and HIREX (France,

## RADEF: A world-leading facility

Since 2005 RADEF has grown to be a leading test facility in Europe for high penetration ions. Its specialty is to serve European Space Agency, ESA, and European satellite industry, but also NASA and JAXA (Japan Aerospace Exploration Agency) are regular users of RADEF. The active collaboration within the Radiation Effects Community, RADECS, and the users of the facility has created about 30 international publications, where RADEF group members have participated in as an first author or co-author. The RADEF-group also organized the RADECS conference in Jyväskylä in 2008. The conference welcomed 208 international participants from 29 countries. Also, 13 space related companies were presenting their products. RADECS'08 was also awarded by the Jyväskylä Convention Bureau for being the best international



## RADEF Features

**Innovative Aspects:** The only way to simulate space radiation environment on terrestrial level and hence to test the radiation hardness of satellite electronics cost-effectively. In addition, ECR-type (Electron Cyclotron Resonance) ion source and the cyclotron accelerator of JYFL is an ideal combination to provide so called beam cocktails for fast change of ion species. These are based on the fact, that in the ECR, the cocktail components can be ionized together and bring the ions with the same mass to charge-state ratio to the acceleration. Because the cyclotron acts as a mass separator it can choose the specific ion one by one to hit the component under test. In the year 2011 JYFL-application program won the first prize in an academic entrepreneurship competition, which is organized every year for Finnish universities. The organizers are the Finland Chamber of Commerce, Confederation of Finnish Industries and Federation of Finnish Enterprises. In the evaluation the jury gave special recognition to our strong innovativeness and yearly commercial productivity.

**Socio-economic impact:** The radiation hardness testing is crucial for ensuring the long-term operation of the European GPS-, remote sensing-, communication- and mission satellites.

**Multi-disciplinary character:** The application connects the researchers and engineers from space-, electronics- and human technology areas to work for a common goal.

**Links with "end-users":** RADEF also has

more than 50 annual visitors from satellite companies and institutes from all around the world. They all are the end users of the satellite planning and building projects.

**Uniqueness:** RADEF is the only place in Europe where the heavy ion tests with the energy high enough can be performed. Because of the new fabrication techniques this is needed for the tests of the modern components from the back side.

**Patents:** So far one patent for "A method and device to determine the intensity distribution of g-radiation field" accepted: FI-Patent nr. 20015052, US-Patent nr. 7,170,066 B2. A potential for further patents is clear.

**European added-value:** RADEF satisfies the need of SEE tests for European satellite industry. The corresponding tests can be done in US-facilities like in Texas A&M and in LBNL.

**Public Awareness:** Several articles and interviews have been done in the local and national newspapers and broadcasts. The solar activity occasionally highlights the importance of testing the spacecraft electronics. Also, some mysterious failures and loss of satellites can be explained by hits of solar- or cosmic rays in sensitive parts. The line width is going towards the nanoscale, which will make the components more sensitive against the radiation. For these reasons one can predict, that the RadHard issues are getting more common in the future. This increases the public awareness and interest in the subject.

RADEF includes heavy-ion and proton beam lines for irradiation of space electronics. It consists of vacuum chamber and equipment for beam quality and intensity analysis. The irradiations can be made either in vacuum or in air. A special beam cocktail and user interface has been developed for defining the ion, its energy, flux, fluence, beam homogeneity etc... All the data are monitored and stored during the test for the customers and data given to them after the campaign for more detailed analysis. RADEF provides both heavy ions and protons in the same facility. Its other specialty is the high penetration ion cocktail with the energy of 9.3 A MeV corresponding to the maximum energy of 1.22 GeV for xenon. The heavy ion beam cocktail is shown in table below.

The users can determine the measured LET- and range values of heavy ions in Silicon by choosing a projectile from the species within the heavy ion cocktail of RADEF and do the definitions with our ECIF Cocktail Calculator in RADEF web pages: <https://www.jyu.fi/fysiikka/en/research/accelerator/raDEF/index.html>

Ion	LET [MeV/mg/cm <sup>2</sup> ]	Range [μm]
<sup>15</sup> N	1.88	202
<sup>20</sup> Ne	3.64	146
<sup>30</sup> Si	6.73	130
<sup>40</sup> Ar	10.1	118
<sup>56</sup> Fe	18.5	97
<sup>82</sup> Kr	30.2	94
<sup>131</sup> Xe	55.3	89

LET=Linear Energy Transfer

## Still quite a lot to do!

### Task 2: Intercession

<u>Aim:</u>	Enhancing existing collaborations - <b>Establishing links between different ENSAR groups</b> who run activities targeting similar applications or develop different applications using the same methodology. <b>Intercessional activities between research groups and companies</b> interested in using scientific results towards development of end-user applications or adopting know-how in large project management and quality
<u>Method</u>	<b>Website</b> – <b>Press releases</b> – <b>Workshop</b> (of Task 1) – ENSAR Office for “Liaison Services”
<u>Deliverable</u>	<b>Report</b> on “ <b>Synergies and collaboration opportunities in applications-oriented research with and within ENSAR</b> ”

### Task 3: Dissemination

<u>Aim:</u>	<b>Disseminating application-oriented research to</b> the scientific community, the public and <b>the policy makers</b> .
<u>Method</u>	<b>Website</b> – <b>Press releases</b> – <b>Communication Day</b> (Exhibition) at the <b>EUROPEAN PARLIAMENT</b> .
<u>Deliverable</u>	<b>Report</b> on the <b>Communication-Day “Nuclear scientists and policy makers communicate”</b> . The report will include, among others, also a catalogue of the exhibits as well as interviews given by the visitors.

## But most importantly: the workshop!!!!

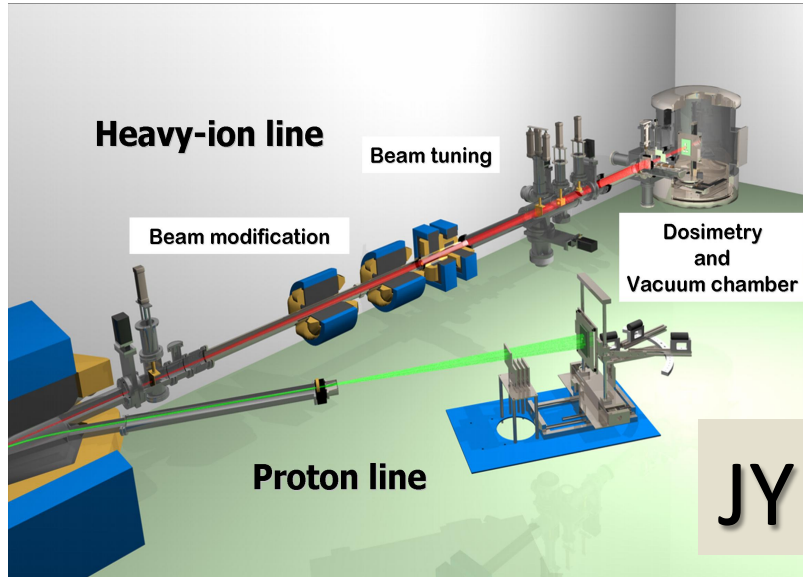
## Workshop

- **To be finalised at this meeting:**
  - Location? CERN?
  - Date 2<sup>nd</sup> week of October?
  - Duration: @ ~ 2 days (no need for week-long extravaganza)
  - At least one representative from the member institutions presenting the equivalent of what the original questionnaire sought.
- **Summary of the meeting with a view to the catalogue and the exhibition day in Brussels**
  - Before Christmas

- Exhibition day: May 2014? Optimistic?

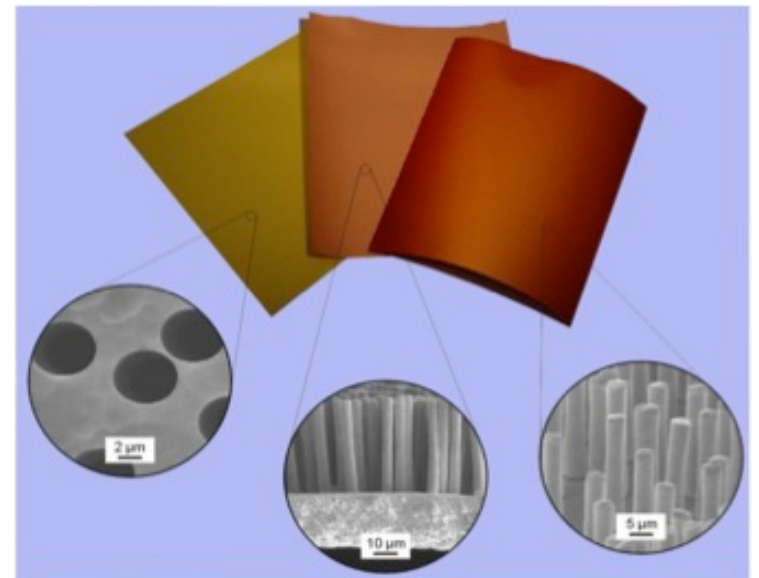


# Some examples

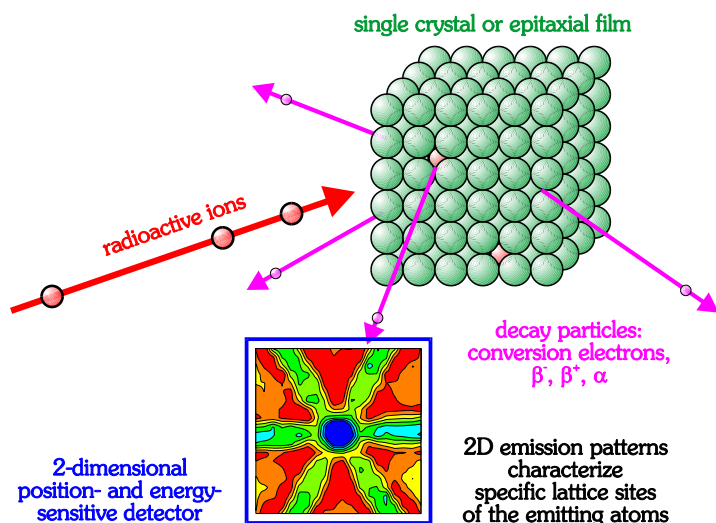


**JYFL**

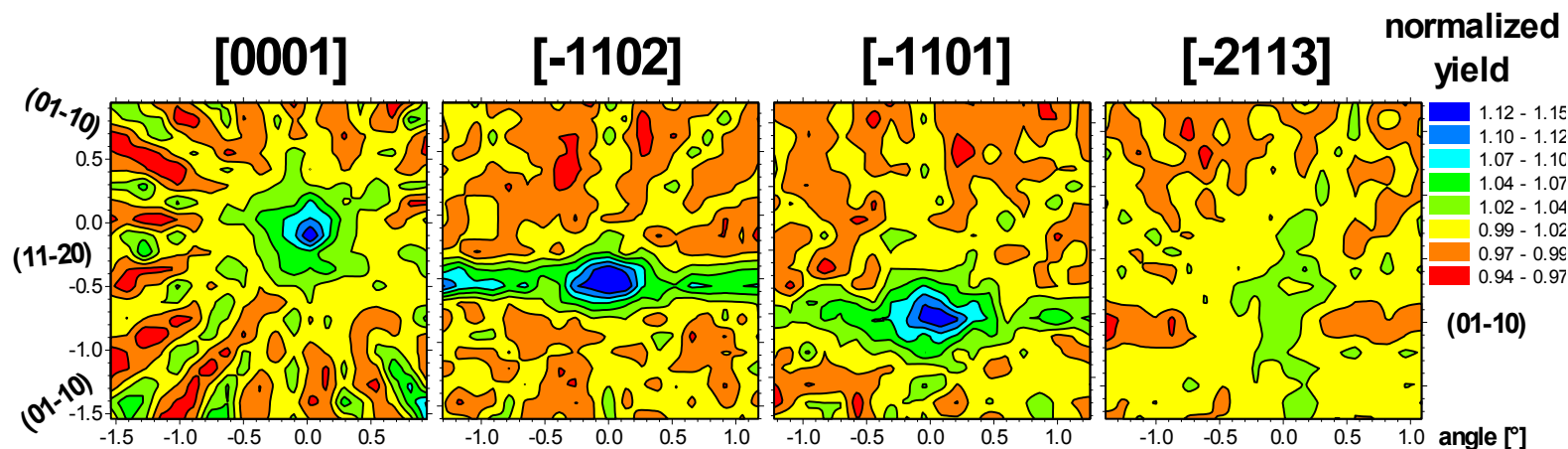
**GANIL**



# First emission channeling lattice location experiments with $^{11}\text{Be}$ (13.8 s)



- Example of intra-institutional synergy: **TimePix** detectors developed at CERN and adapted for use in solid state physics
- short-lived  $^{11}\text{Be}$  implanted into a single crystal of GaN (Be is an acceptor dopant in the nitrides)
- Aim to discover the location of this important impurity in GaN





- There have been some delays but the original programme is still feasible.
- Catalogue is crucial: still requires more input from partner before it can be finally compiled.
- To finalise the catalogue the workshop needs to be held in 4<sup>th</sup> quarter of 2013.
- EU day still foreseen in 2014 ... May?

Look towards ENSAR2: NucApp