Deliverable D6.1

WP06 – NA06 – EFINION

Preliminary survey of past and present multidisciplinary and application-oriented research in ENSAR

Among the goals of EFINION, one of the six networking activities of ENSAR, is to make aware of the wide spectrum of the application-oriented research conducted, primarily, at the trans-national access facilities integrated in ENSAR. A first step to achieve this is to conduct a survey of applications-oriented activities at ENSAR laboratories based on ion-beams, stable and unstable, as well as on advanced radiation detectors and simulation tools. For this purpose a proper questionnaire was prepared and distributed (see in Appendix I) among the ENSAR laboratories that incorporate in their program also applications-oriented research. Filled questionnaires aimed also at the production of "the EFINION Catalogue", i.e., a brochure containing most of the innovative applications developed and/or running at ENSAR institutions. The catalogue should be prepared for non-experts. Though, EFINION's goal is to document all applications running at ENSAR institutions, for the final composition of the catalogue following criteria have to apply:

- Innovative aspects of the application
- Socio-economic impact
- Multi-disciplinary character
- Existing links with "end-users"
- Involvement of radioactive beams in the application
- Uniqueness
- Sustainability beyond ENSAR's termination
- Potential for patents
- European added-value
- Potential for public awareness

The Questionnaire was forwarded to contact persons engaged in applications at ENSAR labs as listed in Appendix II. A first draft of the EFINION Catalogue is about to be completed. Sample pages of the Catalogue, referring to the part of the survey presenting the activities at the JYFL facility, are shown in Appendix III

Appendix I

EFINION Questionnaire (please fill the attached Word file – Do not send a pdf).

PART A

A.1	**Name person filling the questionnaire**	
A.2	**Affiliation**	
A.3	**Email**	

PART B

B.1	**Activities presented here refer to institution:**	*Enter name of ENSAR institution on behalf of which information is provided in the questionnaire*
B.2	**Contact person of your institution for EFINION matters**	*To be assigned by the institution director / head*
B.3	**Email**	

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. Please keep in mind that for the final composition of the catalogue following criteria have to apply:

- *Innovative aspects of the application*
- *Socio-economic impact*
- *Multi-disciplinary character*
- *Existing links with "end-users"*

- *Involvement of radioactive beams in the application*
- *Uniqueness*
- *Sustainability beyond ENSAR's termination*
- *Potential for patents*
- *European added-value*
- *Potential for public awareness*

PART C

TOPIC #1

C.1	**Provide in this field a general title for your application** *e.g.* Hydrology studies based on laser and ion-beam simultaneous irradiations
C.2	**Describe in this field in "scientific language" the application you are referring to!** (max 1 page). If necessary, use references but the minimum possible.
C.3	**In this field, present your application for non-experts, preferably for policy makers and the public in general** (max. 1 page) No references here!
C.4	**Insert in this field any picture/drawing etc. of your setup or of a similar one** *(use a proper picture resolution allowing for a professional use later – max. space for your pic ½ page)*
C.5	**Insert in this field any picture/drawing etc. you judge as proper for raising awareness/attracting "non-experts"** *(use a proper picture resolution allowing for a professional use later – max. space for your pic ½ page)*
C.6	**Comment on the presented application in terms of the aforementioned 10 criteria for including it in the EFINION Catalogue.** *(no space limitation)*
C.7	**Provide any other information you judge relevant for EFINION purposes** *(no space limitation)*
C.8	**Name of person in charge of the activities relevant to the presented application with Email and contact details**
C.9	**Research Group members working on the application and their affiliation (also external collaborators)**
C.10	**Do you intend to participate in the EFINION Workshop to present the application?** **If YES, which person will (tentatively) do this?**

If you want to include in the EFINION survey more than one application please continue by copying the latter table (C1-C10) below and filling it accordingly.

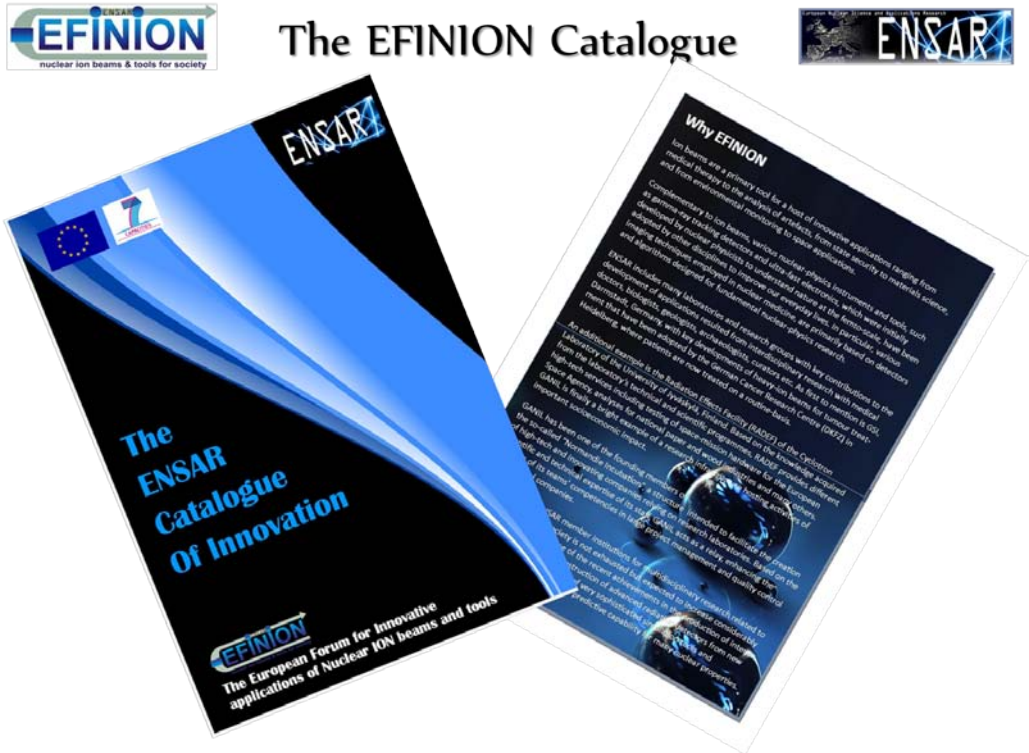
Appendix II

EFINION Contact Persons and Laboratories

	ENSAR Laboratory	Contact person	Email
1	GSI – Darmstadt, DE	Tobias Engert	T.Engert@gsi.de
2	JYFL – Jyväskylä, FI	Ari Virtanen	virtanen@jyfl.jyu.fi
3	GANIL – Caen, FR	Ketel Turzo	turzo@ganil.fr
4	CERN/ISOLDE, CH	Karl Johnston	karl.johnston@cern.ch
5	INFN/LNL-Legnaro, IT	Valentino Rigato	valentino.rigato@lnl.infn.it
6	INFN/LNS-Catania, IT	Giovanni Ciavola	ciavola@lns.infn.it
7	CNRS/IPN-Orsay, FR	Martin Chabot	chabot@ipno.in2p3.fr
8	IFJ PAN – Krakow, PL	Adam Maj	Adam.Maj@ifj.edu.pl
9	IFIN-HH, Bucharest, RO	Constantin Mihai	cmihai@tandem.nipne.ro
10	KU Leuven, BE	Nathal Severijns	Nathal.Severijns@fys.kuleuven.be
11	KVI – Groningen, NL	Emil Van der Graaf	e.r.van.der.graaf@rug.nl
12	U. Santiago de Compostela, ES	Jose Benlliure	j.benlliure@usc.es
13	RBI – Zagreb, HR	Milko Jaksic	jaksic@irb.hr
14	ATOMKI – Debrecen, HU	Attila Krasznahorkay	kraszna@atomki.hu
15	NPI Rez, CZ	Jan Dobes	dobes@ujf.cas.cz
16	NCSRD, Athens, GR	Andreas Karydas	karydas@inp.demokritos.gr
17	INRNE, Sofia, BG	Dimiter Balabanski	balabanski@inrne.bas.bg

Appendix III

The EFINION Catalogue (first draft): Sample pages



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Sample pages for JYFL

Ion beams for space exploration

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

Radiation Effects Facility, RADEF

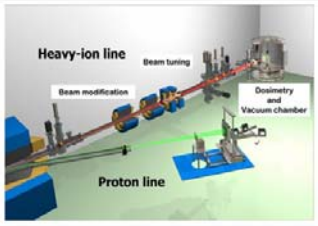
Contact:
Prof. Ari Virtanen
Ari.j.virtanen@jyu.fi
☎: +358505419401

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

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

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 1.400 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 speciality 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 2000. The conference welcomed 200 international participants from 29 countries. Also, 13 space related companies were presenting their products. RADECS'00 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 at 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 accelerators. 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 organised 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 a 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 Rad-Hard 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 detail analysis. RADEF provides both heavy ions and protons in the same facility. Its other speciality 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/cm²]	Range [µm]
^{15}N	1.88	202
^{22}Ne	3.64	146
^{40}Si	6.73	130
^{84}Kr	10.1	118
^{129}Xe	18.5	97
^{84}Kr	30.2	94
^{129}Xe	55.3	89

LET=Linear Energy Transfer