WP8: Transnational access: European Irradiation Facilities

Editor: Eduardo Cortina Gil (26/feb/2008), Beniamino Di Girolamo (27/02/2008)

Work package number	8		**Start date or starting event:**			M1		
Work Package title	Transnational access: European irradiation facilities							
Activity type	SUPP							
Participant number	3	33	13	6	41	37	38	
Participant short name	UCL	JSI	UNIKARL	IPASCR	UBRUN	UUpps	PSI	
Person-months per participant	5	1	1	1	1	1	1	

The objective of this work package is to provide access to the various existing irradiation facilities in Europe, used extensively in the past for High Energy Physics (HEP) detectors developments, notably for LHC, that imposed specific and tight constraints for radiation hardness of materials, detectors and electronics used in HEP. The sLHC program is a new challenge in this field because of the expected increase of 10 times in luminosity and five times in particle fluences respect to LHC. For any apparatus at the future linear colliders like ILC or CLIC, the radiation hardness issues will be less stringent than for hadron colliders; however radiation tests shall be performed, especially for detectors and systems that will operate in forward regions. Depending on the type of accelerator and its configuration around the beam collision point, the detectors will be exposed to radiation that has several contributions: from photons, electrons, charged hadrons and neutrons. Simulations have shown that the radiation field is dominated, at low radii, by charged particles, mainly pions, and, at larger radii, by neutrons. Both radiation fields have the same fluence at around 30-40 cm from beam axis. The table below illustrates both the composition and the expected fluences for 10 years of sLHC operations. Fluences are given in terms of a standard radiation field, 1-MeV neutron equivalent.

Radius (cm)	n (%)	p,□ (%)	Fluence (n_{eq}/cm^2)	Typical Detectors
<20	20	80	10^{16}	Pixels (Si)
20-60	50	50	10^{15}	Short strips (Si)
60-100	90	10	$5x10^{14}$	Long strips (Si)
>100	90	10	10^{14}	Calorimeters (Crystals)

The above table has been used as a reference, as the sLHC environment is the most challenging one.

The criteria established for the choice of different irradiation facilities are:

- Accessibility: readiness of the installation and existing links and experience with the High Energy Physics community.
- Fluences: irradiation facilities shall provide the above-sketched fluences in a reasonably short time (typically few hours).
- Irradiated area: irradiation should cover areas suited to the detector dimensions.
- Complementarities: the group of facilities shall provide all required radiation fields.

- Redundancy: each radiation field shall be covered by at least two facilities
- Uniqueness: facilities that provide a unique radiation field (both in terms of radiation type and/or fluence)
- Support to the users: during set-up and after irradiation.

Following these criteria seven irradiation infrastructures have been chosen. These facilities will receive support both for operation and user support.

Infrastructure short name	Installation number	Installation name	Source	Particle	Energy (in MeV)	□$_{Max}$ part $s^{-1}cm^{-2}$
CRC_Irrad	8.1	NIF	Cyclotron	Neutron	1-50 E_{mean}=20	7×10^{10}
		LIF	Cyclotron	Proton	5-60	5×10^{8}
		GIF	^{60}Co	Gamma	1.11 and 1,33	50 Gy/hr
JSI_Irrad	8.2	Triga	Reactor	Neutron	<15	4×10^{12}
UNIKARL_Irrad	8.3	Compact Cyclotron	Cyclotron	Proton	15-35	6×10^{13}
IPASCR_Irrad	8.4	NPL	Reactor	Neutron	<15	1×10^{14}
		U-120	Cyclotron	Neutron	4-35	6×10^{10}
			Cyclotron	Proton	10-37	1×10^{12}
		Microtron	Microtron	e/gamma	6-25	1×10^{12}
UBRUN_Irrad	8.5	High Rate	^{60}Co	gamma	1.11 and 1,33	150 Gy/hr
		Low Rate	^{60}Co	gamma	1.11 and 1,33	3 Gy/hr
UUpps_Irrad	8.6	QMNP	Cyclotron	Neutron	11-174 Mono-energetic	5×10^{5}
		WSNF	Cyclotron	Neutron	<180 White spectrum	1×10^{6}
		MPF	Cyclotron	Proton	20-175	1×10^{10}
PSI_Irrad	8.7	PIF	Cyclotron	Proton	10-250	2×10^{8}
		Pion/Muon	Cyclotron	Pion/muon	<300	1×10^{10}

Besides the installations listed above, there are other facilities that can be used by DevDet users in case of specific needs or geographic proximity. At time of writing this proposal these facilities are:

1. NCSR-Demokritos (Greece): Low energy monochromatic neutron beams.
2. Atomki (Hungary): Neutrons continuous spectra up to 18 MeV.
3. Legnaro (Italy): 14 MeV mono-energetic neutrons.
4. ELBE (Germany): 10-40 MeV electrons.

An updated table of these facilities will be maintained in the DevDet web pages. These installations will not receive support for operation nor for user access and travel.

As described in DevDet proposal, the potential users of the facilities, included in this work-package, shall apply for beam time to DevDet Steering committee, where all transnational accesses within DevDet will be coordinated, as described in WP1. All proposals will be submitted to the Scientific Advisory Board, that also acts as User Selection Panel. The latter will provide advices on priorities and will grant access to the facilities according to internal rules of different host institutions. Modalities of access will depend on different laboratories and are explained in detail in the description of each infrastructure. Outreach is managed centrally for DevDet and will be financially supported from WP1 and WP6. Additional local information source are mentioned in each infrastructure description

Task 8.1: Access to UCL, Belgium

Work package number	8.1	**Start date or starting event:**			M1	
Work package title	Access to CRC irradiation facility					
Activity Type	SUPP					
Participant number	3					
Participant short name	UCL					
Person-months per participant:	5					

Description of the infrastructure
Name of the infrastructure: *Centre de Recherche du Cyclotron*
Location (town, country): *Louvain-la-Neuve, Belgium*
Web site address: *www.cyc.ucl.ac.be*
Legal name of organisation operating the infrastructure: *Université Catholoque de Louvain*
Location of organisation (town, country): *Louvain-la-Neuve, Belgium*
Annual operating costs (excl. investment costs) of the infrastructure (€): 2120000

Description of the infrastructure:

Cyclotron Research Center (CRC) is a research unit attached to the Nuclear Physics (FYNU) department at UCL. The facility has three cyclotrons called CYCLONE110, CYCLONE44 and CYCLONE30, able to accelerate charged ions to kinetic energies up to 110, 44 and 30 times Q^2/M (in MeV). For irradiation purposes the most suitable one is the CYCLONE110. CRC offers annually around 2000 effective beam hours. Main activities of the center are: research in Nuclear (Astro)Physics experiments, industrial applications (membrane production), irradiation of electronic components and detectors and radiobiology experiments. In total around 2500 effective hours of beam are delivered to users during 35 weeks of operations.

In this proposal three areas are offered for access.

Neutron Irradiation Facility (NIF). Neutrons obtained impinging a 50 MeV deuteron beam on a Be target giving a continuous neutron spectrum up to 50 MeV with a mean energy of 20 MeV. The intensity of the beam can reach a flux of $7.3x10^{10}$ $ns^{-1}cm^{-2}$, providing a beam diameter ~4cm. This beam has been setup especially for detector irradiations at LHC and it has been extensively used by CMS collaboration. Mono-energetic neutrons with energies from 20 to 65 MeV can be obtained with a flux up to 10^6 $ns^{-1}cm^{-2}$, and an irradiation field of about 2.5 cm in diameter.

Light Ion Irradiation Facility (LIF). Mono-energetic protons with energies between 20 and 65 MeV. Beam size of ~10 cm diameter and maximum flux of $5x10^8$ $ps^{-1}cm^{-2}$.

Gamma Irradiation Facility (GIF). Cobalt 60 source providing gammas of 1.11 and 1.33 MeV. Dose rates up to 50 Gy/hr. This area is under construction and it is expected to be operational in spring 2008.

Services currently offered by the infrastructure:

CRC has a long experience in receiving external groups for material and electronics irradiation. Assistance from the CRC technical staff is assured along the experiment lifetime. During the scheduling and preparation phases, CRC engineers contact users providing relevant information about experimental areas, as well as reviewing the proposed set-up. During installation CRC technicians helps in placing and cabling the dispositive under test. Cables and power supplies can be provided. In case of need, the design office and mechanical workshops can be accessible for users.

During irradiation cyclotron operators assure beam stability and control. Irradiation areas are equipped with moving tables capable to place or remove devices under test (DUT) from beam, allowing the irradiation of several samples. Radiation monitors and dosimeters are connected to dedicated control systems giving on-line information about instantaneous and integrated fluxes. These systems also allow to stop irradiation once the total maximum flux has been achieved. Offline analysis allows also to study beam spot size and uniformity. All these information are provided to users after irradiations.

NIF beam line provides also a cryogenic box capable to cool DUT down to -20C during the whole process of irradiation and deactivation.

Radiation protection is assured both to persons and DUT. Handling, storage and transportation of irradiated samples are provided by CRC qualified personnel.

Description of work

Modality of access under this proposal:

In order to apply for access at the Cyclotron Research Center, the CRC Program Advisory Committee (PAC) shall approve the experiment proposal. This committee meets twice per year (January and July). Each request should include the proposal and the accompanying beam time request form filled out in English. Proposals must be sent at least one month before the meeting of the PAC to the CRC secretary.

Application form should include:

- A detailed proposal covering the following topics: general context and motivation for the experiment, proposed experiment, equipment, timing, and possible by-products of interest.
- A summary of the proposal (3 pages in the given format, including a list of publications of the spokesperson).

A template file can be downloaded from CRC web pages. Once the experiment has been approved, a complete set of instructions for access will have to be fulfilled as documented by CRC web pages.

Support offered under this proposal:

UCL cyclotron team has more than 40 years tradition in hosting external users experiments. The proximity of beam areas to Nuclear Physics department encourages interchange of ideas and experiences between users and UCL academic and scientific personnel.

Besides support to users listed above, for DevDet users CRC can offer access to clean rooms and test equipments, such as probe station, and a charge collection efficiency set-up. Special requests should be discussed with cyclotron engineers to study their feasibility

Outreach of new users:

Web pages describing the facility and CRC personnel participation to meeting, workshops and conferences.

Review procedure under this proposal:

Experiments should be accepted by CRC Program Advisory Committee as described above. Reports on results are also expected to be sent to CRC PAC.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
UCL	Beam hour	292	350	30	150	15

Unit of Access:

Beam hour: Includes effective irradiation time. Preparation, deactivation and dismantling time are not accounted in this unit.

Task 8.2: Access to Jozef Stefan Institute, Slovenia

Work package number	8.2	**Start date or starting event:**			M1		
Work package title	Access to Jozef Stefan Institute (Slovenia)						
Activity Type	SUPP						
Participant number	33						
Participant short name	JSI						
Person-months per participant:	1						

Description of the infrastructure

Name of the infrastructure: *J. Stefan Institute TRIGA Reactor*

Location (town, country): *Ljubljana, Slovenia*

Web site address: *http://www.rcp.ijs.si/ric/*

Legal name of organisation operating the infrastructure: *Jožef Stefan Institute*

Location of organisation (town, country): *Jamova cesta 39, Ljubljana, Slovenia*

Annual operating costs (excl. investment costs) of the infrastructure (€): 436.000

Description of the infrastructure:

The infrastructure consists of a TRIGA-Mark-II reactor with hot-cell laboratories and various neutron irradiation facilities. Reactor power is 250 kW, maximum total flux is $6x10^{12}$ $cm^{-2}s^{-1}$ (central channel). Reactor is equipped with several in-core and ex-core irradiation channels. Typical flux in the in-core channels is 1-6 $x10^{12}cm^{-2}s^{-1}$, and in the ex-core channels < $10^{11}cm^{-2}s^{-1}$. Typical thermal-to-total flux ratio is 1/8. Maximum uninterrupted irradiation time is 16h. Irradiation facilities (channels) are described in detail in

http://www.rcp.ijs.si/ric/description-a.html

The reactor is equipped for irradiation of various samples. Irradiation and manipulation is safe and simple. Hot-cell laboratory with manipulators for remote handling is available for highly radioactive samples, connected to the reactor by two automatic pneumatic transfer lines. Reactor staff is licensed for and experienced in performing the irradiations for scientific and other purposes.

The reactor is routinely used in the following research:

- Neutronics and reactor physics
- Activation analysis
- Neutron dosimetry and spectrometry
- Neutron radiography
- Activation of materials, nuclear waste and decommissioning
- Irradiation of materials for fusion reactors
    - irradiation of detectors, test structures and electronics for HEP

Services currently offered by the infrastructure:

Irradiation of neutron activation samples (1500 per year); irradiation of other samples (50 per year), neutron radiography, training of NPP operators and other reactor specialists (20 per year)

Description of work

Modality of access under this proposal:

Qualified JSI reactor staff will perform the irradiation of samples (inserting and extracting of samples, operation of the reactor). The users are expected to prepare the research part of the experiment (preparation of the sample, preparation of special equipment). The users (maximum 5) may assist in the irradiation, however under guidance of a qualified worker. They will receive the irradiated sample after the irradiation for further experimental work. They may use the hot-cell laboratory for handling the radioactive samples.

Irradiations will be performed according to reactor operation plan. Normally, reactor operates every day from 8am to 15pm. One 16h (overnight) irradiation is feasible per week. The users will have access to the reactor during normal operating hours. The operation plan can be fully adjusted to the needs of users.

Support offered under this proposal:

Scientific support: The external users may use the gamma spectroscopy laboratory at the reactor facility equipped with high sensitivity gamma detection system and corresponding software. Additional facilities (manual ultrasonic bonder, probe station, C/V-I/V characterization, CCE measurement) are available within the Experimental Particle Physics Department.

Local scientific staff is well experienced in neutron activation methods, neutron, gamma and alpha spectroscopy and characterization of neutron and gamma irradiation fields (Monte-Carlo calculations).

Complete radiation protection and health physics services are provided. Manipulation of the radioactive samples can be entirely performed by the reactor staff. The radioactive waste will be conditioned, stored and disposed by the JSI staff.

If necessary, assistance will be provided in preparing the radioactive samples for transportation.

Outreach of new users:

Basic information can be found on the web page: http://www.rcp.ijs.si/ric/. The reactor is included also in the IAEA information system and it is well known among the users in the nuclear technology field. However, the potential users outside the nuclear community are usually not aware about the research possibilities it offers. In this respect, new users are attracted mainly through personal contacts (conferences, visits, personal communication).

The reactor has been widely used by international users for neutron activation analysis purposes (several hundred samples per year, 2-3 visiting scientists per year), mainly in nuclear chemistry and environmental research. Recently, it has been widely used by scientists from CERN RD-48 and RD-50 collaborations who develop solid state particle detectors for application in extreme radiation fields in collaboration with JSI scientists form the Experimental Particle Physics Department of (several hundred irradiated samples per year, ~5 visiting scientists per year).

Review procedure under this proposal:

It is proposed that at least one of the members of the DevDet User Selection Panel will be familiar with reactor technology to be able to evaluate feasibility of the proposed research as well as the quality of the results from the aspect of reactor utilization.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
JSI TRIGA REACTOR	reactor operation hour	218 EUR	450	46	200	23

Unit of Access:

One hour of reactor TRIGA operation for the user (preparation, pre-operational tests, steady state mode irradiation). It includes all services necessary for reactor operation (operators, radiological protection, health physics). It includes insertion and extraction of samples.

Task 8.3: Access to FZK, Karlsruhe Universiteit, Germany

Work package number	8.3	**Start date or starting event:**		M1				
Work package title	Access to FZK							
Activity Type	SUPP							
Participant number	13							
Participant short name	UNIKARL							
Person-months per participant:	1							

Description of the infrastructure

Name of the infrastructure: *Compact Cyclotron*

Location (town, country): *Forschungszentrum Karlsruhe, Eggenstein-Leopoldshafen, Germany*

Web site address: *http://www.zyklotron-ag.de*

Legal name of organisation operating the infrastructure: *Zyklotron AG*

Location of organisation (town, country): *Forschungszentrum Karlsruhe, Eggenstein-Leopoldshafen, Germany*

Annual operating costs (excl. investment costs) of the infrastructure (€): 1 944 000

Description of the infrastructure:

The Compact Cyclotron can be adjusted to provide protons from 16 MeV to 30 MeV at currents from 10 nA to 200 µA. A 'standard' irradiation is performed at 26 MeV at 1-2 µA. The cyclotron is located in the Forschungszentrum Karlsruhe with many research institutes, e.g. the Institute for Material Science, which offers plenty of methods to investigate material properties and the Institut für Experimentelle Kernphysik, which has vast experience in silicon sensor qualification and execution of irradiation plans.

Services currently offered by the infrastructure:

In the last 5 years a strong collaboration with the Zyklotron AG was established and many improvements to the infrastructure have been made. There is a controlled movable stage carrying an insulated box, in which devices for irradiation can be fixed. The box can be temperature controlled by flushing with cold nitrogen and devices can be connected to instruments outside the bunker. Dosimetry is done via the activation of nickel foils.

The irradiation qualification for the CMS silicon strip sensors has been performed here, as well as irradiations for many R&D projects (RD50, SMART, BCM, diamond).

Description of work

Modality of access under this proposal:

The Institut für Experimentelle Kernphysik act as an intermediary for irradiations at the cyclotron, coordinate the beam time and provides the experimental setup at the beam area. A request for irradiation should be sent to the scientific coordinator of the Institut für Experimentelle Kernphysik at least four weeks in advance. A possible date can then be arranged within 1-2 weeks. Continuous time slots are of the order of 2-4 hours at cost of 450 Euro per hour.

Support offered under this proposal:

Experienced local staff in close cooperation with the user performs irradiation. Irradiated devices will be stored in restricted area until radiation level has dropped (cooled if necessary). Dosimetry will be provided. Irradiated devices can be tested on site using the existing equipment for the qualification of silicon strip sensors and detector modules respectively.

Outreach of new users:

Experienced local staff, web-page

Review procedure under this proposal:

The scientific coordinator and the head of the Institut für Experimentelle Kernphysik together with the advisory board as foreseen in the DevDet Project Management *Structure*

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
Compact Cyclotron	Beam hour	450	120	30	15	15

Unit of Access:

Beam hour: It includes effective beam irradiation time. Setup and dismantling are not included in this time.

Task 8.4: Access to Prague Irradiation Facilities, Czech Republic

Work package number	8.4	**Start date or starting event:**			M1	
Work package title	Access to Prague Irradiation Facilities					
Activity Type	SUPP					
Participant number						
Participant short name	NPI	CAS				
Person-months per participant:	1					

Description of the infrastructure

Name of the infrastructure:

Neutron Physics Laboratory, Light-water moderated nuclear reactor LVR-15

Cyclotron Laboratory, Isochronous cyclotron U-120M

Microtron Laboratory

Location (town, country): *Řež near Prague, Czech Republic*

Web site address:

http://www.nri.cz/eng/rsd_services.html - *Neutron Physics Laboratory*

http://mx.ujf.cas.cz/~ou-www/Cyclotron.html - *Cyclotron Laboratory*

http://mx.ujf.cas.cz/~ou-www/Microtronpps_soubory/frame.htm - *Microtron Laboratory*

Legal name of organisation operating the infrastructure:

Nuclear Physics Institute of the Academy of Sciences of the Czech Republic, public research institution

Location of organisation (town, country): *Řež near Prague, Czech Republic*

Annual operating costs (excl. investment costs) of the infrastructure (€):

Reactor LVR-15: 171 620

Cyclotron U-120M: 863 498

Microtron: 140 500

Description of the infrastructure:

Neutron Physics Laboratory (NPL)

It is a part of the Nuclear Physics Institute (NPI) of the Czech Academy of Sciences. It was founded with the aim to perform neutron physics experiments according to NPI research programme as well as to provide experimental facilities and research experience to external users.

The research activities of the NPL neutron physicists are located at the medium flux research reactor LVR-15 (10 MW mean power, thermal neutron flux in the core about 1×10^{14} $ncm^{-2}s^{-1}$) that belongs to the neighbouring Nuclear Research Institute, plc. (NRI, plc.). NRI, plc. operates the reactor LVR-15 on a commercial basis. The reactor serves predominantly as a radiation source for material testing, irradiation experiments and production of radiopharmaceuticals. The reactor operates on average about 170 days a year.

Corresponding information can be found also on:

http://www.nri.cz/eng/rsd_services.html

http://neutron.ujf.cas.cz/CFANR/access.html

In general, NPL offers particular instruments and techniques complementary with the ones existing at large centers, which can have an impact on the european research with neutrons. NPL operates 8 instruments installed at 5 radial horizontal beam tubes (for experiments in nuclear physics, solid state physics and materials research) and 2 vertical irradiation channels (for neutron activation analysis) hired from NRI, plc. Seven of these instruments have been currently offered also for external users: particularly

- High-Resolution Stress/Strain Diffractometer (TKSN-400),
- Double-Crystal SANS Diffractometer (DN-2),
- Multipurpose Double Axis Diffractometer (SPN-100),
- Medium Resolution Powder Diffractometer (MEREDIT, under construction, expected 06/2008),
- Neutron Activation Analysis (NAA),
- Thermal Neutron Depth Profiling (T-NDP),
- Thermal Neutron Capture Facility (NG) - suitable also for Prompt Gamma Activation,

At present, most of the neutron research carried out at NPL can be characterized as materials and interdisciplinary science. Only a negligible portion of the work is aimed directly to the industry. The majority of experiments are a part of research on materials with possible technological applications (shape memory alloys, two-phase stainless steels, high strength steels, superalloys, superplastic ceramics, thermal barrier coatings etc.), of surface studies (e.g. diffusion, sputtering corrosion) of technologically interesting materials used in electronics and optronics technology and of biological/biomedical studies (plant, animal and human tissue analyses), trace elements detection in an environmental samples as well as in biological, geological and metallurgical materials.

Isochronous cyclotron U-120M (U120M)

It is a versatile machine operated in both positive and negative regimes which can accelerate light particles with the mass to charge ratio: A/Z = 1 - 2.8. Accelerated beams and energy ranges are: p^+/10-37 MeV, H^-/10-37 MeV, D^+/10-20 MeV, D^-/10-20 MeV, $^3He^{2+}$/17-54 MeV, $^4He^{2+}$/20-40 MeV.

Beam line system consists of 4 lines in the experimental hall (extraction by the deflection system) and 1 line in the cyclotron hall (extraction by the stripping method).

Microtron

It is a cyclic electron accelerator; the facility allows for irradiation of various materials and samples in well defined radiation fields. Microtron makes possible the irradiation of various samples in homogeneous electron and bremsstrahlung fields in the upper energy range from 6 to 24 MeV and in mixed neutron and bremsstrahlung fields. The laboratory is equipped with facilities for precise dose, dose rate and integral electron current measurements.

<u>Services currently offered by the infrastructure:</u>

Neutron Physics Laboratory

The instruments belonging to the infrastructure have been widely available to the international users in connection with the Access action of NMI3 project (2004-2008, FP6). Within this NMI3 project, 25 experiments (roughly 200 beam days) carried out by 17 different groups all over the Europe and associated countries (particularly Belgium, France, Germany, Greece, Italy, United Kingdom, Hungary, Latvia, Poland, Slovakia, Israel) were successfully carried out. The non-conventional facilities offered for NPL Access have appeared to be beneficial for Europe’s scientific community.

Isochronous cyclotron U-120M

It has been operational for over three decades. It has been used for variety research activities both by in-house teams, and by a large number of collaborating research groups. The following summary of selected results in recent years illustrates both the quality of the research and versatility of the machine use.

For research in ADS (Accelerator Driven Systems) and fusion, several types of Fast Neutron Facilities (FNF) have been developed by Neutron group and installed on the cyclotron beams. The FNF together with U-120M is the only one fast neutron source with IFMIF (International Fusion Material Irradiation Facility) neutron spectrum. (Cooperation with: CEA Cadarach, ENEA Frascati, FZ Karlsruhe, UKAEA Culham).

A new method has been developed in astrophysics, for the indirect determination of the astrophysical S-factors (i.e. Method of Asymptotic Normalization Coefficients) by the Nuclear Reaction Department. The main test of ANC method was realized on U-120M using reaction 16O(3He,d)17F. (Cooperation: Texas University, INFN Catania).

For application in nuclear medicine, a variety of cyclotron based radionuclides (i.e. 67Ga, 201Tl, 111In, 211At, 123I) and radiopharmaceuticals (i.e. 2-18F-deoxy glucose, 81Rb/81mKr generator) have been developed including different types of targets for their production. In the last three years the focus was on production of new alpha emitting radioisotope 230U and positron emitters 86Y and 124I. (Cooperation: ITU Karlsruhe).

For radiation biophysics, the effects of ionising radiation on specific complexes between proteins and DNA have been studied in cooperation with Department of Radiation Dosimetry.

Microtron

Some of the most interesting achievements:

- online measurement of gamma radiation-induced absorption PbWO4 crystals intended to be used in the LHC experiment, CERN and in the framework of the development of scintillation crystals in the industry
- research of kinetics of induced absorption phenomena in YalO3:Ce scintillator
- radiation damage of light guide fibres in gamma radiation field – on-line monitoring of absorption centres formation (research and development connected with the COMPASS project)
- multi element analysis by gamma activation of geological samples (gold, rare elements content)
- development of production apparatus for 123I and Rb-Kr generator
- biological research (enzymes)
- radiation hardness of electronic components

Description of work

Modality of access under this proposal:

It is assumed that the annual plan of the work, as well as approximate schedule, will be agreed with the user. The concrete irradiation runs can be adjusted upon with about one month early notice.

For the scheduled period, the facility is fully reserved for the user experiment. The user is supposed to be present at NPL during the whole duration of the experiment. Depending on the type of the experiment, generally, the measurement time can be in the range from several hours to several days. If a tedious experiment is to be carried out or if a complex sample environment is to be used, two users can take part at the experiment. In special cases, samples can be sent to NPL and the responsible scientist can carry out the experiment without participation of the user.

Support offered under this proposal:

Neutron Physics Laboratory

At NPL, a considerable emphasis is placed on the provision of entire support, including permanent assistance of the responsible researcher, quality software for data analysis and preliminary data evaluation. This is an approach ensuring the cost-effective use of the instruments.

Each experiment is performed under a supervision of an instrument responsible person who organizes the user programme at that facility, trains and supports users during the experiment period, eventually helps with the pre-analysis of the received data. The facilities also have a responsible technician who deals with the maintenance of the instrument and sample environment.

Construction of simple mechanical elements necessary for the successful performance of the experiment is possible in the workshop. PCs, computer network, as well as software for basic data treatment are available as well. The NPL user programme administrator helps users with regard to their travel and accommodation requirements and provides other necessary assistance.

Isochronous cyclotron U-120M

The laboratory can provide base for arrangement of irradiated samples and devices. An ionization chamber with an electrometer for measurement the absorbed doses in radiation beams will be available. Access to a gamma spectrometry facility can be provided as well.

Microtron

The laboratory can offer precise dose and dose rate measurements in electron, gamma and mixed gamma-neutron fields. The upper limit of the bremsstrahlung gamma rays energy can be selected, the neutron fields spectra are similar to the fission spectrum without moderation, mean neutron energy about 2 MeV.

Outreach of new users:

NPL has a strong interest in promoting the use of neutron physics techniques and to encourage new users to enter the neutron physics field. Training periods are offered on an individual basis, in particular to students. NPL Access possibilities are disseminated using the following methods:

- The facilities opened for external users are listed in database at “The Neutron Pathfinder”, http://pathfinder.neutron-eu.net/idb , a facility-selection tool for European neutron instruments (see e.g. http://idb.neutron-eu.net/facilities.php)
- The local web page http://neutron.ujf.cas.cz/CFANR/access.html is frequently updated in order to inform the scientific community on the facilities available, on the research areas investigated using these facilities as well as on the organizational issues connected with the experiments.
- The potential users are informed on proposal submission deadlines via European neutron portal web pages, http://pathfinder.neutron-eu.net/idb/access .

Review procedure under this proposal:

Neutron Physics Laboratory

Before acceptance of the irradiation proposal, the responsible researcher will consider the technical feasibility. It can result in a request to modify the proposal according to the available equipment. The Access administrator assesses each accepted proposal on its eligibility for financial support. Irradiation of samples in the reactor core or in the vicinity of the reactor core, organization of special selection panel is not considered. The author of the possibly rejected proposal is notified, the reason for rejection is clearly stated and further actions to be taken are suggested (e.g. discussion with the instrument responsible on the feasibility, referee’s suggestions to improve proposal). After carrying out the experiment the user has to prepare an experimental report according to the standard rules.

Isochronous cyclotron U-120M

Research groups or individual scientists can apply for access to the cyclotron by submitting a research project or just a request for the irradiation time to the Department of accelerators. Each project proposal can only be considered for acceptance if it fits in the area of the management of radioactive waste or other activities in the field of nuclear technology and safety. Allocation of the beam time will depend on scientific or technological quality and will be approved by cyclotron experts or members of Cyclotron board.

Microtron

The responsible staff of the Microtron Laboratory will study each request from the point of view of its feasibility in the laboratory conditions and of the ability to achieve the requested dose and dose rates. The influence of the relatively high electromagnetic noise on electrical measurement apparatus will be considered as well.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
NPL	Beam hour	184 €	150	18	45	9
U120M	Beam hour	308 €	100	18	45	9
Microtron	Beam hour	100 €	50	10	25	5

We expect that the need of radiation tests will be uniform over all 4 years of the project. Better estimate is difficult to make now and such expectation is justified by experience from e.g. CERN RD50 studies.

Unit of Access:

Beam hour

Minimal irradiation run is 4 hours. The amount specified for unit cost covers:

- The reactor/accelerator operation and beam costs
- Costs for laboratory space, infrastructure and utilities
- Scientific and technical support for visiting scientists
- Modification and maintenance of equipment required for user’s experiments
- Consumables costs associated with user’s experiments
- Radiation safety support for visiting scientists
- Management costs

Task 8.5: Access to Gamma Irradiation Facility, Brunel U. United Kingdom

Work package number	8.5	**Start date or starting event:**			M1		
Work package title	Access to Brunel Gamma Irradiation Facility.						
Activity Type	SUPP						
Participant number	41						
Participant short name	UBRU						
Person-months per participant:	1						

Description of the infrastructure

Name of the infrastructure: *Gamma Irradiation Facility Brunel*

Location (town, country): *Uxbridge, UK*

Web site address: *http://www.brunel.ac.uk*

Legal name of organisation operating the infrastructure: *Brunel University*

Location of organisation (town, country): *Uxbridge, UK*

Annual operating costs (excl. investment costs) of the infrastructure (€):

Description of the infrastructure:

Two specialised installations each containing a strong gamma ray source (^{60}Co). Each installation is physically and operationally independent of each other, but both are located within a single geographical campus of Brunel University. One installation has an extremely strong source capable of giving doses in excess of 1kGy per hour. The location of this source is fixed within the facility and space around the source is limited to a volume of about 0.2 m^3. In the second installation the source is weaker by about a factor of 50 but the irradiation cell is designed to accommodate large pieces of apparatus (> $1m^3$). The source in the second facility has been designed such that it can placed freely within a part of the bunker (including inside apparatus) and can also be collimated to an extent by a dense tungsten shield. A 1 tonne hoist is available in this bunker. Both cells have some cabling infrastructure (AC mains, low voltage and signal) and the high-rate source has piping for transferring gases such as nitrogen to devices under irradiation. In both cells the ambient temperature is controlled to about 1C (24 hours). A Farmer air-ionisation chamber can independently measure the instantaneous dose-rate and total dose.

Supporting facilities that can be made available to users include electronic and optical laboratories and a class 10000 clean room.

Services currently offered by the infrastructure:

In recent years these two facilities have been extensively used by the international particle physics collaboration CMS. Primarily by members of the community building the electromagnetic calorimeter for irradiation testing of $PbWO_4$ crystals, electronic components, photo-detectors, signal and HV cables and connectors and structural components (e.g. Carbon-fibre alveolar). It has been used also by the CMS Tracker community during the tests of prototypes of a VLSI chip used for readout out of the silicon strips.

Other significant users include industrial manufacturers of CCD chips, industrial manufacturers of photomultiplier tubes, industrial manufacturers of scintillating crystals and work for NASA and Officine Galileo (Italy) on radiation damage to image sensors and optical lens assemblies for space missions to moons of solar system planets.

Description of work

Modality of access under this proposal:

Users can request short (24 hours) or long (weeks to months) access to the facilities. In many cases irradiations can be uninterrupted for periods exceeding 150 hours, interruptions to the radiation, should they occur, are likely to be limited to < 1 hour. Equipment provided by users can be left in-situ and powered up/read-out at all times during the duration of a complete irradiation experiment. Short irradiations can usually be accommodated without any problem into the normal operation of the facility. Longer irradiations can be arranged with some prior notice, but often there is considerable flexibility of scheduling available to users. Irradiation can continue during the formal closure of the University (Easter/Christmas) but access to the facilities themselves during these periods is not usually possible.

Support offered under this proposal:

Users can be offered a range of support. Technical support is mandatory since only a small number of local experts have the authorisation to access the irradiation facilities directly. Where this might conflict with a long-term irradiation which might require significant access training, access and individual dosimetry can be provided to users. Expert assistance and advice on setting up irradiations and dosimetry, including the use of GEANT4 Monte Carlo simulation is available. Access to electronic and optical characterisation of materials, sub-systems and components for pre and post irradiation comparison can be provided as well as assistance and training in the use of apparatus. The ability to interact with experienced scientists who have used the facilities over many years will enhance the user experience. Such support has already been provided to external users in the recent past.

Outreach of new users:

Web pages.

Review procedure under this proposal:

Users request should be send to head of the installation for approval.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
High-rate gamma facility	Beam-hour	20	1200	20	50	10
Low-rate gamma facility	Beam-hour	5	800	10	30	5

Unit of Access:

In each minimum quantity of access (24 hours) we include some technical assistance in using the sources. For longer (or repetitive) periods of access we would undertake to train external users to use the source and to provide them with individual personal dosimeters.

Task 8.6: Access to TSL, Uppsala University, Sweden

Work package number	8.6	**Start date or starting event:**			M1			
Work package title	Access to TSL							
Activity Type	SUPP							
Participant number	37							
Participant short name	TSL							
Person-months per participant:	1							

Description of the infrastructure

Name of the infrastructure: *Neutron and proton irradiation facilities at TSL*

Location (town, country): *Uppsala, Sweden*

Web site address: *www.tsl.uu.se*

Legal name of organisation operating the infrastructure:

The Svedberg Laboratory, Uppsala University

Location of organisation (town, country): *Uppsala, Sweden*

Annual operating costs (excl. investment costs) of the infrastructure (€):3 400 000 €

Description of the infrastructure:

Access is offered to the following irradiation facilities at TSL: the quasi-mono-energetic neutron facility, the white-spectrum neutron facility, the mono-energetic proton facility. All the listed facilities are driven by Gustaf Werner cyclotron at TSL and constitute a part of the beam line structure of the cyclotron. The other major activity at the cyclotron is proton therapy of cancer. Neutron and proton irradiations for industrial/scientific users share the available beam time with the proton therapy.

The quasi-monoenergetic neutron facility (QMNP)

It produces neutron beams with energy choosable by the user in the region 11 - 180 MeV, via interaction of accelerated protons with isotopically-pure ^{7}Li targets. The user can choose a size of the beam spot in the range from 1 cm to 1 m. The maximum available neutron flux is $5x10^{4}$ – $5x10^{5}$ cm^{-2} s^{-1}, depending on the energy and the beam spot size. The most recent description of the facility can be found at: A.V. Prokofiev, J. Blomgren, O. Byström, C. Ekström, S. Pomp, U. Tippawan, V. Ziemann, and M. Österlund, “The TSL Neutron Beam Facility”, Tenth Symposium on Neutron Dosimetry (NEUDOS10), June 12-16, 2006, Uppsala, Sweden; Rad. Prot. Dosim. (in press); doi: 10.1093/rpd/ncm006. The facility is unique in Europe due to the available energy range, beam spot size, and flexibility of beam parameters.

The white-spectrum neutron facility (WSNF)

It produces a neutron beam with continuous spectrum that extends from thermal energies to 180 MeV, via interaction of accelerated 180-MeV proton beam with a full-stop tungsten target. The shape of the resulting neutron energy spectrum is similar to the one encountered, e g, in the atmosphere of the Earth being irradiated by cosmic rays, or near high-energy accelerators. The user can choose a size of the beam spot in the range from 1 cm to 2 m. The maximum available flux of high-energy neutrons (> 10 MeV) is 10^{6} cm^{-2} s^{-1}. The facility was launched in 2007.There are very few facilities of this type in Europe.

The mono-energetic proton facility (MPF) produces beams with energy selected by the user in the region 20 - 180 MeV, the beam spot diameter up to 20 cm, and the homogeneity of the beam within the spot within ±10%. The maximum available proton flux is $5*10^{8}$ - $5*10^{9}$ cm^{-2} s^{-1}, depending on the energy and the beam spot size. There are few facilities of this type in Europe.

A common feature of all irradiation facilities at TSL is that the user can choose the beam parameters (energy, flux, size and shape of the beam spot) and flexibly control most of them during the campaign.

Services currently offered by the infrastructure:

- planning/scheduling of irradiation,
- area information, orientation and lodging,
- radiation protection training and supervision,
- logistics for users' equipment, including dosimetry control and storage of irradiated objects,
- access to counting rooms, auxiliary office space, meeting rooms, Internet and intranet, electronics pool, etc.
- user-oriented structures at the beam lines for mechanical support/alignment, electrical power, cables for analog and data connections, vacuum/gas equipment, radiation protection, etc.
- automated user's workplace for on-line control of the beam,
- on-line beam monitoring/dosimetry,
- beam characterisation data,
- a qualified cyclotron operator and an irradiation facility engineer on duty, both available at all times during user's irradiation.

Annually, the irradiation facilities are run during 30 weeks and visited by 20 user groups, some of which coming a few times during a year. More than 700 external users have visited TSL and worked at the beam lines so far. The most prominent areas of research/industrial activities at the irradiation facilities are: (1) accelerated testing, qualification, and optimization of electronic devices for harsh irradiation environments and critical applications, (2) development and calibration of dosimetry/monitoring devices, (3) measurements of nuclear data for fundamental science and applications. In the areas (1) and (2), user groups from CERN/LHC and collaborating institutions have had a number of campaigns at the irradiation facilities at TSL during last years, in the framework of Integrated Infrastructure Initiative/Transnational Access programme. According to our CERN/LHC liasons, radiation-resistance related issues may become crucial with the coming start-up of the LHC. In order to be able to quickly localize and solve possible problems, access to the irradiation facilities needs to be secured even in this phase.

Description of work

Modality of access under this proposal:

All interested users/user groups will be given possibility to submit applications to the Program Advisory Committee/User Selection Panel 4 times a year, with deadlines on January 15, April 15, July 15, and October 15. When an application is approved, the user is contacted by the Coordinator, and the scheduling of the user's campaign is agreed. The typical duration of user's visit/campaign is about 1 week.

Support offered under this proposal:

Uppsala University provides high-quality scientific environments with long-term traditions. The support/services listed above are already provided to external users. In addition, specific needs of users/user groups are normally accounted for.

Outreach of new users:

Web-page and Call for proposals have already been every-day instruments in our contacts with external users during a number of years. The number of international users is expected to increase as a result of this proposal. This expectation is based on the fact that our previous Transnational access funds has always been insufficient to accommodate all eligible user's requests.

Review procedure under this proposal:

As described above in Modality of access.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
TSL	Beam hour	576.7 €	150	24	60	12

Unit of Access:

Beam hour: Effective irradiation time. Setup and dismantling is not included in this time

Task 8.7: Access to PSI, Switzerland

Work package number	8.7	**Start date or starting event:**					
Work package title	Access to PSI						
Activity Type	SUPP						
Participant number	38						
Participant short name	PSI						
Person-months per participant:	1						

Description of the infrastructure

Name of the infrastructure: *Proton Irradiation Facility and PSI Secondary Beam Lines*

Location (town, country): *Villigen PSI, Switzerland*

Web site address: *www.psi.ch*

Legal name of organisation operating the infrastructure: *Paul Scherrer Institut*

Location of organisation (town, country): *Villigen PSI, Switzerland*

Annual operating costs (excl. investment costs) of the infrastructure (€):

Description of the infrastructure:

The Paul Scherrer Institute (PSI) is a multi-disciplinary research centre for natural sciences and technology. It is the largest national research institute with priorities placed in areas of basic and applied research that is conducted by about 1,200 members of staff. PSI develops and operates complex research installations, which require especially high standards of know-how and experience. It operates unique accelerators and adjacent facilities for more than 30 years and encompasses large expertise in scientific use and applications of protons, muons, synchrotron radiation and neutrons beams. The PSI facilities are: the synchrotron radiation source SLS, the spallation neutron source SINQ as well as pion and muon beams and the proton irradiation facility (PIF),. In particular, under the contract between European Space Agency (ESA) and the Paul Scherrer Institute (PSI) the Proton Irradiation Facility (PIF) was constructed for test and qualification of components and instruments operating in various radiation environments. The facility can realistically simulate space radiation environment as well as provide mono-energetic beams for dedicated tests and calibration of detectors, components and devices. PSI also provides beam time at its secondary beam lines for particle physics experiments including detector tests and development. Its unique specialty is very high intensity pion and muon beams of momentum up to a few hundred MeV/c. These secondary beam lines are maintained, jointly, by the Laboratory for Particle Physics and the Department of Large Research Facilities.

Services currently offered by the infrastructure:

PSI offers its dedicated beam lines to scientific users and other customers (including industrial partners) under certain conditions. The particle physics experiments are proposed in front of the research committee that strictly organizes the beam line access via a proposal procedure evaluation. Reach infrastructure including beam line support, radiation protection, vacuum, mechanics and electronics workshops are available for the users. Currently about 17 experiments with international participation are carried out in the PSI pion/muon areas. Detector test runs have bean already performed in several secondary areas. Test periods for all accepted proposals are scheduled during the accelerator users meeting organized twice a year. They have a variable duration of few weeks and provide the beam continuously with exception for setup and service days. Experiments at PIF facility are performed mainly during weekends after completing the biomedical exposures at

PROSCAN accelerator. Such short exposure tests have simplified application procedure. Moreover the time between the beam-time request and conducting of the experiment is much shorter. More than 44 test blocks were provided for users from 22 national and foreign institutes and companies visited the facility in 2007.

Description of work

PSI infrastructure can be of great importance for the detector developments activities allowing comprehensive tests and calibrations of the new instrument with unique and high quality particle beams. It allows an access to and a usage of numerous test facilities with different radiations and particles for detector development, characterizing and calibration. The PSI is in particular important for the development of particle physics and space experiments being itself involved in several large proposals (CERN, LHC, MAGIC, HERA etc.) and space missions (RHESSI from NASA or INTEGRAL, XMM-NEWTON, ROSETTA marked as ESA kern-stone observatories) and others.

Modality of access under this proposal:

The PIF facility is offered to the DevDet community as outlined within this proposal on the basis of a hourly rate given in the calculation sheet covering the personnel costs. The DEvDet community may consider that this research service of PSI is conditional on the availability of the PIF facility and the respective proton accelerator. It is the responsibility of the PIF beam line scientist to allocate the facility to the DevDet community. Therefore the DevDet community shall apply for its requested experiments at least 3 months in advance of possible deadlines for completion. The DevDet community's contact therefore at PSI is Mr. Wojtek Hajdas.

During the performance of experiments PSI also offers their computing utilities as well as internet access, remote control and printing facilities. The institute provides to its users a guest-house (if desired), restaurants and cafeterias as well as its meeting and conference rooms for discussions and gatherings.

The PIF beam line can provide up to 160-200 hours of beam time per year over a period of four years. The maximum beam time offered herein is 640 hours. Since PSI is accounting personnel costs only for this service to the DevDet community a report on the test results is expected from the user group in due time after each detector characterization project by acknowledging the PSI / PIF contribution to the result.

The access to the Pion and Muon beam line cannot be guaranteed within this proposal however PSI provides a way to apply for it to each member of the DevDet community. A party interested is invited to apply by providing a scientific proposal which will be evaluated by the respective international research committee in order to guarantee the scientific relevance and feasibility of the work. Under the accepted proposal, the user will get the access to the particular beam line without any additional costs.
For further information please consult our respective website:
http://ltp.web.psi.ch/user_information/call_proposal.htm.

Outreach of new users:

The PSI facilities are attended by the international community though there still is left some potential to increase the number of scientific users at some beam lines (e.g. PIF). All facilities offer both well prepared and information reach web-pages as well as general calls for proposals that are issued periodically. In case of the PIF facility the community funding of the experiments will make an access to its high quality beams much easier and faster. It will allow the new (and old) users to concentrate mainly on research and development aspects of their activities leaving the burden of financial and administrative duties aside. We anticipate an increase of the number of users by about 20-30%.

Implementation plan

Short name of installation	Unit of access	Unit cost	Min. quantity of access to be provided	Estimated number of users	Estimated number of days spent at the infrastructure	Estimated number of projects
PIF	Hour	245.70 (EUR)	250	15	80	10