TNA03: TRANSNATIONAL ACCESS TO INFN LNL-LNS

PUBLICITY CONCERNING THE OPPORTUNITIES FOR ACCESS TO TNA03

A web site dedicated to the Transnational Access activity was built and published at http://www.lnl.infn.it/~ENSAR/ since 15 November 2010. It is continuously updated and contains all the useful information for the European research groups interested to apply in order to get the financial support foreseen by the grant agreement.

ENSAR opportunities were presented by the TNA scientific leader during the following meetings and conferences:

- ION BEAMS '12 Conference: Multidisciplinary Applications of Nuclear Physics with Ion Beams – 6-8 June 2012, LNL
  ENSAR: Transnational Access to LNL and LNS
- Meeting of the LNS User Community – 30 October 2012, LNS
  TNA03 – Transnational Access to LNL-LNS
- Incontro annuale tra i responsabili degli apparati sperimentali e la divisione acceleratori – LNL, 21 February 2013
  TNA03 – Transnational Access to LNL-LNS
  http://agenda.infn.it/getFile.py/access?resId=17&materialId=1&confId=4276

SCIENTIFIC COMMITTEES

During the second reporting period no change occurred in the composition of the LNL Program Advisory Committees (PAC). The LNS PAC was renewed with the replacement of 2 members. The new composition of the LNS PAC is available at:
http://www.lns.infn.it/index.php?option=com_content&view=article&id=477&Itemid=223) .

Please note that the LNL User Selection Panel was renamed User Selection Panel for Interdisciplinary Physics (USIP) and the new members have been appointed on 10 February 2012 by LNL Director. The USIP composition is available at http://www.lnl.infn.it/~lnldir/UE/PAC-USP.html.

Two members (Prof. A. Vitturi and Prof. G. De France) of the ENSAR User Selection Panel (ENSAR USP) have been replaced starting from 24 September 2012 (Disposizione Presidenziale N. 15254). The new composition is available at http://www.lnl.infn.it/~ENSAR/. The list of the ENSAR USP members for the reporting period can be found in Annex 1.

Calls for Proposals, both for the beam time request and for the EC support, during the reporting period:

- ***LNL PAC*** for experiments at Nuclear Structure and Dynamics Based Facilities (NSDBF)
  Deadlines: 1 April 2012 – 3 December 2012 – 10 June 2013;
- ***LNL USIP*** for experiments at Applied and Interdisciplinary Physics Facilities (AIPF).
  Deadlines: 12 July 2012 – 7 December 2012 – 10 June 2013;
- ***LNS PAC*** for experiments at NSDBF and AIPF
  Deadlines: 31 March 2012 – 31 March 2013;
- ***ENSAR USP***
  Deadlines: 31 March 2012 and 1 April 2012 – 3 December 2012 and 7 December 2012 – 31 March 2013 and 10 June 2013.

MEETINGS OF THE SCIENTIFIC COMMITTEES

The meetings of the Scientific Committees during the reporting period were held on:

- **LNL USP**: 12 March 2012;
- **LNL PAC**: 3-4 May 2012 – 17-18 January 2013 – 15-16 July 2013;
- **LNS PAC**: 11-13 June 2012 – 19-21 June 2013;
- **LNL USIP**: September 2012 via e-mail – 17 January 2013 – 9 July 2013;
- **ENSAR USP**: 11 July 2012 at LNS – October 2012 via e-mail – 24 January 2013 at LNL – 19 July 2013 at LNS – August 2013 via e-mail.

SELECTION CRITERIA

No change to the existing procedure, described in the previous report, was done in the second reporting period.

TRANSNATIONAL ACCESS ACTIVITY DURING THE REPORTING PERIOD

A brief report on the status of the LNL and LNS accelerators is provided in Annex 5.
Please find below details about the experiments supported during the reporting period.

NUCLEAR STRUCTURE AND DYNAMICS BASED FACILITIES (NSDBF) – Nuclear physics experiments at LNL have requested access to the large acceptance magnetic spectrometer **PRISMA**, the in-flight facility for the production of light exotic nuclei **EXOTIC**, the **electrostatic deflector**, the 4π charged particle detector **GARFIELD** coupled to the **Ring Counter**, and the **sliding seal scattering chamber**. The new beam line **LIRAS** mainly devoted to measurements of astrophysical interest has been installed at LNL in the II experimental hall of the Tandem/PIAVE-ALPI accelerator complex and a first experiment has been carried out. Finally, in-beam commissioning of diamond detectors and of the first complete **FAZIA** front-end electronics, detectors and mechanics were performed by using the **0° beam line** and the **Ciclope scattering chamber** at LNS.

In total during the reporting period:

- 36 proposals have been submitted to the LNL PAC Committee - 30 experiments were approved for a total of 157 days of beam time (263 requested days → average acceptance rate of about 60%);
- 18 proposal have been submitted to the LNS PAC Committee - 17 experiments were approved for a total of 119.3 days of beam time (170.4 requested days → average acceptance rate of about 70%);
- 24 projects asked for EU support - 19 were considered eligible and 16 of them were selected by the ENSAR USP.

Experiments performed and supported during the reporting period have covered the most up-to-date research fields.

Objectives and achievements of the funded experiments

Acronym	*Project Title*

LNL 11.24 – *$^{8}B+^{28}Si$ total reaction cross sections at near barrier energies*
To measure the total reaction cross section for $^{8}B+^{28}Si$ and to compare the conventional pile-up rejection techniques with the reconstruction of pulses via a Flash ADC (FADC) acquisition. The ^{8}B secondary beam has been produced by using the **EXOTIC** facility and the inverse kinematic reaction $^{3}He(^{6}Li, ^{8}B)n$. The $^{6}Li^{+3}$ primary beam was directed to a 5 cm long gas cell with 2.2 μm thick Havar windows, filled with ^{3}He at a pressure of 1 bar at temperature of 90 K corresponding to an effective thickness of 2 mg/cm^{2}.

Energy spectra were collected at 6 near barrier energies event by event by a conventional acquisition technique via a CAMAC ADC and in parallel by a VME FADC. The energy spectra were acquired in coincidence with the timing spectra of two beam profilers.

LNL 12.05 – *Probing nucleon-nucleon correlations via transfer of (±nn), (±pp) and (±np) pairs at sub-barrier energies in $^{92}Mo+^{54}Fe$*

To test pair-correlation properties in heavy ion induced reactions, populating at once (±*nn*), (±*pp*) and (±*n*p) channels with the ^{92}Mo+^{54}Fe inverse kinematic reaction and measuring transfer yields with the large solid angle magnetic spectrometer **PRISMA**. This reaction should allow to populate with similar strength both proton and neutron stripping and pick-up channels.

Excitation functions for multinucleon transfer channels have been measured for the inverse kinematic reaction ^{92}Mo+^{54}Fe from above the Coulomb barrier to about 10% below, collecting large statistics for each beam energy. Both proton and neutron stripping and pick-up channels have been populated with similar strength in this system. In this sense the main goal of the experiment has been fulfilled. The complex data analysis (the ion tracking through the spectrometer "event-by-event" for each measured energy) is in progress. The collected data look promising.

LNL 12.10 – *Search for signatures of transfer channels in the $^{40}Ca+^{58,64}Ni$ fusion reactions at energies below the barrier*

To measure high precision fusion excitation functions, from just above the Coulomb barrier down to the 0.1 μb level, for the reactions ^{40}Ca+^{58}Ni and ^{40}Ca+^{64}Ni and to search for signatures in cross sections and barrier distributions of transfer channels which have positive Q values only in the ^{40}Ca+^{64}Ni system.

Evaporation residues have been separated from the beam particles for both systems at energies ranging from E_{lab}=153.5 MeV to 104.75 MeV with the **LNL electrostatic deflector** around 0° in its upgraded configuration. Data analysis, in particular the extraction of precise fusion cross-sections for both systems and the search for possible effects of transfer channels in the ^{40}Ca+^{64}Ni system, is in progress at IPHC Strasbourg.

LNL 12.11 - *Indirect study of the $^{19}F(p,\alpha)^{16}O$ reaction through the Trojan Horse Method applied to the $d(^{19}F,\alpha^{16}O)n$ three-body reaction*

To derive the cross section for the ^{19}F(*p*, α)^{16}O reaction applying the so-called Trojan Horse Method (THM) to the ^{2}H(^{19}F, α^{16}O)*n* three-body reaction performed at E = 55 MeV. From the deduced α - ^{16}O relative energy under quasi-free conditions, the ^{19}F(*p*, α)^{16}O cross section will be derived in the 0 - 1 MeV energy range.

The ^{19}F(*p*, α)^{16}O reaction is the principal fluorine destruction channel in outermost, low temperature and proton-rich Asymptotic Giant Branch (AGB) star shells. Direct measurements of the cross section stop at about 500 keV and only theoretical estimates or spectroscopic studies are available below this limit, in particular in the energy range below 100 keV, that represents the typical burning temperature in these shells. At these energies direct measurements are very difficult as the cross section is severely hampered by the Coulomb barrier. To overcome these difficulties, the so-called Trojan horse method (THM) can be used to measure cross sections at energies of astrophysical interest.

The cross section of the ^{2}H(^{19}F,α^{16}O)*n* reaction at 55 MeV has been measured. Alpha particles and ^{16}O nuclei were detected in coincidence to reconstruct the α-^{16}O relative energy spectrum and, consequently, to investigate ^{20}Ne states contributing to the ^{19}F(p, α^{16}O) cross section at astrophysical energies. The first step of data analysis has been the detector calibration. **Four position-sensitive silicon detectors** (PSD) were used, **plus two ionization chambers** (IC) placed in front of the two PSDs at forward angles. Energy and position calibration of PSDs and of the ICs have been accomplished, as well as energy reconstruction to account for energy loss in the dead

layers. Channel selection, to single out the $^{2}H(^{19}F, \alpha^{16}O)n$ process from the total yield, is in progress.

LNL 12.12 – *Probing the statistical decay of light hot N = Z nuclei*

To check the entrance channel dependence in fusion-evaporation reactions involving light nuclei and to verify the persistence of alpha cluster correlations in even-even N=Z nuclei at high excitation energies. Light charged particles in coincidence with evaporation residues, populated in the $^{14}N+^{10}B$ reaction and identified in mass and charge, have been measured with the **Ring Counter** coupled to the **GARFIELD** setup, with a high angular and energy resolution and a nearly 4π coverage.

Two reactions have been measured:

- $^{14}N+^{10}B$ at 80 MeV beam energy;
- $^{14}N+^{197}Au$ at 80 and 65 MeV for calibration purposes.

Consistency with previous data set collected with the same experimental setup has been checked. Comparison to the previous measurements of reference systems is indeed fundamental for the data analysis.

LNL 13.06 – *Study of carbon-carbon burning by measuring excitation function of the $^{20}Ne+^{4}He$ resonant reactions*

To measure the excitation functions of the $^{4}He+^{20}Ne$ resonant scattering and the $^{4}He+^{20}Ne \rightarrow {}^{1}H+^{23}Na$ reaction at astrophysically relevant energies, by use of the 36, 44, 52, and 60 MeV ^{20}Ne beams and a thick ^{4}He gas target which stops the beam. Observed resonances in the excitation functions can be fully characterized in terms of spin, parity, width and partial widths using R-matrix calculations. A possible 0^{+} resonance would enhance reaction rate of the ^{12}C-^{12}C fusion while its non-observation would imply non-resonant nature of the C-C burning.

Unfortunately, PIAVE broke down four days before the experiment and it was not possible to deliver a ^{20}Ne beam to the experiment. In agreement with the coordinator of the Tandem/PIAVE-ALPI complex and the responsible of the LNL Accelerator Division in order to reduce financial damage (the equipment was already shipped to the LNL and more than 10 researchers from different countries were already at the LNL), another reaction has been used aiming at the same scientific goal. In particular, a ^{14}N beam on ^{12}C targets has been used to populate ^{24}Mg and to detect decay of its excited states. The experiment has been performed on the new beam line **LIRAS**. The reaction products have been detected in **highly segmented silicon strip detector telescopes** which make possible their clear identification. The data analysis is in progress at the Ruđer Bošković Institute.

LNL 13.08 – *Neutron rich nuclei populated via multinucleon transfer reactions: the $^{197}Au+^{130}Te$ system as a benchmark*

To measure with the large acceptance magnetic spectrometer **PRISMA** the final yields of both "light" and "heavy" fragments produced in the inverse kinematics reaction $^{197}Au+^{130}Te$. In particular, via the 2 proton stripping and 4 neutron pick-up channel one should be able to populate ^{132}Sn, which represents a benchmark neutron-rich nucleus for different physics cases. The obtained transfer cross sections for nuclei around ^{132}Sn will provide important inputs for reaction mechanism and for future nuclear structure studies.

Multineutron and multiproton transfer channels have been measured at two energies, E_{lab}=1070 MeV and 1300 MeV, using a ^{197}Au beam delivered by the PIAVE+ALPI accelerator complex and detecting with PRISMA, at two angles, both projectile-like and target-like ions. By measuring the yield distribution of heavy transfer products, the importance of secondary processes, which may significantly modify the final yields, was also investigated. The complex data analysis is in progress. The collected data look promising.

LNS FAZIA – *Commissioning of the first complete FAZIA front end electronics, detectors and mechanics at LNS*

To test the first complete **FAZIA** front end, detectors and mechanics in a two steps experiment (November 2012 with a ^{40}Ar beam at 25*A* MeV and December 2012 with a ^{84}Kr beam at 35*A* MeV delivered by the Superconducting Cyclotron at LNS). So far only prototype detectors have been tested. This first complete block results from the conclusions of the intense R&D program, achieved in 2011, for what concern detection capability and electronic design.

For November 2012, the final block was not fully ready (electronic building delay) so still previous R&D telescopes have been used. Due to an accelerator (cyclotron) problem the experiment benefited from only 2.5 BTUs on the 9 foreseen. In December 2012 the block was ready but due to cooling and optic fiber flange problems, it was not possible to achieve a good vacuum. So the previous telescopes have been used exploring effects of depletion voltage on pulse shape analysis. The detectors have been mounted inside the **CICLOPE** scattering chamber. Good results have been obtained on this item.

LNS TODD – *High-rate capable detectors for heavy ion tracking*

To test new designed large area segmented diamond films, synthesized through the chemical vapor deposition (CVD) method. This is a new development for high rate radiation tracking and timing detectors optimized for heavy ions.

A set of three different Diamond film detector types ranging from small monolithic to large area (5x5 cm^2) highly segmented detectors has been systematically tested on the **0° beam line** at LNS. A full set of TOF measurements at different distances should allow a precise determination of the achieved absolute resolution and its rate dependency. Already on-line the expected resolution better than 100 ps was measured. The evolution of tails in the TOF peak at the highest rates is currently investigated in a more detailed analysis which will be continued. Especially the complex relation of the rate dependent amplitudes and the TOF measurement has to be analyzed in more detail.

Details about the access for the selected user groups, performing experiments in the present reporting period, are provided in the following table.

Project Acronym	***Access (beam-on-target hours)***	***Person-days***	***Visits***	***Users***
LNL 11.24	129	37	5	5
LNL 12.05	206	70	7	7
LNL 12.10	119	22	3	3
LNL 12.11	227	16	3	3
LNL 12.12	140	6	1	1
LNL 13.06	128	86	11	11
LNL 13.08	170	73	8	8
LNS FAZIA	91	78	10	10
LNS TODD	42	15	4	4
	1252	**403**	**52**	**52**

APPLIED AND INTERDISCIPLINARY PHYSICS FACILITIES (AIPF) – Applied and interdisciplinary physics experiments mainly concerned the elemental analysis of archaeological and geological samples by using nuclear techniques based on the Ion-Beam Analysis (IBA) with the **micro-beam** facility at LNL, the ionization structure of the carbon ion track by using the **PTB ion counter** (recently installed at LNL) and radiobiological studies with the irradiation of cell cultures at the **0° beam line** and the **CATANA** facility at LNS.

In total during the reporting period:

- 173 proposals were presented to the LNL USP/USIP (169 experiments were approved for a total of 679 days of beam time (883 requested days → average acceptance rate of about 77%);
- 41 proposals have been submitted to the LNS PAC Committee (36 experiments were approved for a total of 70.7 days of beam time (115.8 requested days → average acceptance rate of about 61%);
- 16 projects asked for EC support – 16 were considered eligible and were selected by the ENSAR USP.

Projects carried out and supported during the reporting period have covered different fields of applications.

Objectives and achievements of the funded experiments

Acronym	*Project Title*

LNL USP12.39 – *Investigation of light-ion track structure (ILITS)*

To study with the **PTB ion counter** the physical characteristics of the microscopic structure of ionizing particle tracks, i.e. the sequence of the interaction types and interaction sites of a primary particle and all its secondaries, which reflects the stochastic nature of the radiation interaction. Taking the particle track structure into account is particularly important for the biological effects of ion beams, where the majority of radiation damage is mainly concentrated in the vicinity of the primary particle trajectory. In view of the upcoming radiation therapy with carbon ions, the ionization structure of the carbon ion track is of particular interest.

The ionization cluster size distributions generated by $^{12}C^{6+}$ ions of 96 MeV primary energy in 1.2 mbar C_3H_8 have been measured. The data analysis is still in progress.

LNL USIP12.03 – *Compositional investigations of Byzantine ceramics using LNL nuclear microprobe*

To characterize chemical composition of a set of Byzantine ceramics shards that were excavated on Romanian territory (Hârsova), dated to the 11th century A.D. by using the **micro-PIXE facility** at the AN2000 accelerator of LNL. The measurements also aimed at the identification of the chromophores employed for the decorations of the superficial layers (golden-yellow engobe and green glaze) of the ceramic wares.

The experiment allowed to measure 9 ceramics shards decorated with golden engobe (paste and decoration measurements), 7 ceramics shards decorated with green glaze (paste and decoration measurements), 7 samples of kaolin-based ceramics, 13 samples of common ceramics, as well as a clay sample from a kiln and another one from the walls of a house. Cross-sections of the decorated ceramics shards were measured using the micro-beam (5x5 μm^2). Thus, areas of 3000x3000 μm^2 were analyzed at the interface between the ceramic paste and the decorative layers, to obtain hints about the employed chromophores. In the case of yellow engobe, no copper compound (suspected by the archaeologist as the ion/metal responsible for the metallic shine of the golden engobe) was identified. On the other hand, large amounts of lead (tens of wt% PbO) were put in evidence in the green glaze decorative zones. Point spectra were acquired in zones belonging to the decorative layer only, to refine the information about the agent responsible for the coloring of superficial decoration. Using the micro-beam maps, a rough estimation of thickness of the green glaze was made, which turned out to range from roughly 70 μm up to 400 μm. The interpretation of the obtained results is in progress and it will be made in close collaboration with the archaeologist who found the Byzantine ceramics shards and by consulting the related literature.

LNL USP12.15 – *Micro-PIXE studies on archaeological samples (MicroArchaeoStudy)*

To determine the (micro)composition – major, minor, traces elements and micro-inclusions - of archaeological objects from Romanian museums: obsidian Neolithic tools, ceramics and glass mineral

pigments, bronze and gold items using the LNL **micro-PIXE facility**. Small samples from the objects have been analyzed using micro-PIXE map and point spectra. These measurements should allow to determine the provenance of the objects (geological deposits, metals mines, workshops) from the comparison with geological samples – obsidian, native gold, native copper – also routinely analyzed.

In total 10 samples of archaeological Neolithic obsidian (small blades) from Southern Romania sites (near Danube border between Romania and Bulgaria) and 10 samples of geological native gold from Transylvanian deposits (mines and alluvial) were analyzed. For obsidian, the preliminary data indicate for the region a model of obsidian trade route from Tokay Mountains (geological deposits now in Slovakia).

LNL USIP13.03 – *Contaminant Migration in radioactive waste repositories by Ion Beam Techniques (COMIBEAT)*

To measure radionuclide (RN) retention parameters on crystalline rocks being studied in Underground Research Laboratories (URL) in Europe. These experiments are included in the EC-CROCK Collaborative Project (Crystalline rock retention processes, CROCK; Fission-2010-1.1.2. FP7-269658, 2011-2013) whose aim is to identify main sources of uncertainties on radionuclide retention data on crystalline rocks that are used for performance assessment studies of deep geological repositories for high-level radioactive waste in Europe and worldwide. The experiment proposes the application of the ion beam techniques, Rutherford Backscattering Spectrometry (RBS) and micro-Particle Induced X-Ray Emission (μ-PIXE) – available at LNL –, to quantify both diffusion coefficients and retention parameters on selected minerals. Measurements have to be carried out in both oxic and anoxic conditions, especially for redox sensitive elements, as U and Se.

Granite samples contacted to Se solution, both under oxic and anoxic conditions were measured at the AN2000 accelerator (LNL **micro-PIXE** facility) by both techniques on several areas of the samples. The experiments were completed and the RBS and μPIXE spectra are now under analysis.

LNS BIOMAS-ARCoR – *BIOMAS-ARCoR Biochip for Organic Matter Analysis in Space: Antibody Resistance to Cosmic Radiations*

To study the effect of ^{12}C ions (62*A* MeV) on bio-materials (such as antibodies and aptamers) grafted on a surface. The search for extraterrestrial life is one of the greatest challenges in the astrobiology field. International space agencies (ESA and NASA) recommend the use of biochips as instrumental tools for the detection of biomarkers. Several international current projects (including the project BIOMAS) use antibodies as molecular recognition tools. No data are available concerning the resistance of antibodies to cosmic radiation. Moreover, another type of recognition tool seems to be of great interest for a space biochip: aptamers. Again, no data are available concerning their resistance to cosmic radiation.

The irradiation has been carried out on the **0° beam line** at LNS. There is no activity loss after irradiation when comparing irradiated antibody samples to non irradiated antibody samples ($n \geq 5$). There is no decrease in recognition capability when comparing irradiated aptamer samples to non irradiated aptamer samples ($n=3$). No effect of ^{12}C irradiations was observed neither on antibodies nor on aptamers. This study supplements a series of previous irradiation experiments with different particle types and energies and reinforces our knowledge on the irradiation effects of space particles on aptamers and antibodies. This experiment thus emphasizes our trust that so far, biochip-based instruments should resist cosmic radiations in an acceptable way during a planetary exploration mission.

LNS PIXE – *Proton-Induced X-ray Emission from metal targets for dose delivery optimization in proton therapy*

To prove the feasibility of using PIXE from metal markers for range verification in eye proton therapy. To optimise the experimental setup (detector parameters and geometry) and maximize the SNR. To assess the sensitivity of the technique on the metal area and proton fluence and to estimate the minimum detectable range error.

Irradiations of different metal targets have been performed at the LNS **CATANA** facility. The best setup includes a proper shielding system of the HPGe detector to prevent gamma emissions coming from the beam line to interfere with the useful signal. Silver has been found to be the most suitable metal with respect to gold and tantalum, even at clinical conditions (sizes and doses), allowing to detect range errors lower than 1 mm. Gold is not "visible" below 7 mm of diameter.

LNS HADMAC – *Radiobiological studies of human malignant cells after irradiation with 62 MeV/u ^{1}H and ^{12}C ions*

Considering that ionizing radiation produces a wide spectrum of DNA lesions, the accent is currently placed on DNA double strand breaks (DSB) that from the radiobiological point of view play the central role. One of the first steps in the cellular response to DSB is phosphorylation of histone H2AX at serine 139 (γ-H2AX). The quantification of these foci that appear at the damage sites containing DSB very soon after irradiation is suitable for the evaluation of radio-sensitivity. Their number is considered as one to one DNA DSB. Moreover, the rate at which such foci disappear provides the information on the efficiency of repair processes. It is the remaining number of foci that gives an indication of the amount of unrepaired damage.

After irradiation (**CATANA** and **0° beam line** at LNS) of the human malignant cell monolayers (melanoma and lung adenocarcinoma cells) by γ-rays, protons and carbon ions, the kinetics of the appearance and disappearance of the γ-H2AX foci was studied. The chosen time points covered the interval up to 24 h after irradiation (0, 30, 60 min, 2, 4, 6 and 24 h after irradiation). Detection and quantification of γ-H2AX foci was performed using immunohistochemical analysis and Western blotting. The data analyses are in progress.

LNS DNA-BRAGG – *DNA damage and cellular response along and around the Bragg curve of heavy ions*

To measure the Relative Biological Effectiveness (RBE) for U87 (cancer) and AG0 cells (normal) across a monochromatic and modulated 62 MeV proton beam (**CATANA** facility at LNS). To measure the DNA damage induction and repair as a function of depth along proton beams.

All runs were successfully performed and large amount of data was collected. Results have been analyzed and a manuscript is currently in preparation.

Details about the access for the selected user groups, performing experiments in the present reporting period, are available in the following table.

Project Acronym	***Access (beam-on-target hours)***	***Person-days***	***Visits***	***Users***
LNL USP12.39	24	18	4	4
LNL USIP12.03	52	12	4	2
LNL USP12.15	16	4	2	2
LNL USIP13.03	39	8	2	2
LNS BIOMAS-ARCoR	7	4	2	2
LNS PIXE	16	9	3	3
LNS HADMAC	94	48	12	5
LNS DNA-BRAGG	78	34	8	4
	326	**137**	**37**	**24**

During the reporting period, in total 17 projects have been supported, 1578 beam-on-target hours were provided, 76 users – 63 individual users and 27 new users - had access to the INFN/LNL-LNS research infrastructures and 540 person-days and 89 visits were allocated.

The list of user projects supported in the reporting period and the list of users can be found in Annex 2 and Annex 3 (Database).

For further information, we also report the overall data for the period June 2011 (start of the Transnational Access at INFN/LNL-LNS) - 31 August 2013:
30 projects have been carried out, 3755 beam-on-target hours were provided, 158 users had access to INFN/LNL-LNS research infrastructures, 1126 person-days and 177 visits were allocated.

SCIENTIFIC OUTPUT OF THE USERS AT THE FACILITIES

Publications gathering results from financed projects are constantly monitored: e-mails are periodically sent to the user group leaders inviting them to send any scientific useful detail concerning the funded projects (last e-mail 5 June 2013). Some results and news from the supported experiments are given below.

LNL 11.24

Fusion cross sections were measured for $^{8}B+^{28}Si$ at near-barrier energies by detecting by means of an active target technique the alpha particles produced in the evaporation process.

The measured cross sections were compared with previous fusion data obtained by various weakly bound neutron-rich light projectiles, either stable or radioactive ones, after they were appropriately reduced in energy and cross section. Despite its proton halo nature, ^{8}B fuses with ^{28}Si at near barrier energies, in the same way as other weakly bound but stable projectiles on the same or similar targets, following, in principle, fusion of two nuclei, described by one-barrier penetration tunneling. Small deviations are due to coupling channel effects. It is remarkable that the same conclusions can be drawn from the comparison of fusion cross sections obtained by various neutron-rich stable and exotic light nuclei with various medium or heavy targets. If the transfer channels are properly subtracted and if, for comparison purposes, reduced cross sections and energies are deduced properly, the above conclusion may be general for all light weakly bound projectiles (see Annex 5).

LNS FAZIA

The response of silicon–silicon–CsI(Tl) telescopes, developed within the FAZIA collaboration, to fragments produced in nuclear reactions $^{84}Kr+^{120-124}Sn$ at 35*A* MeV, has been used to study ion identification methods such as ΔE-E and digital Pulse Shape Analysis (PSA) for different mountings of the silicon detectors, i.e. rear (particles entering through the low electric field side) or front (particles entering through the high electric field side) side injection. The ΔE-E identification method gives exactly the same results in both configurations. The data analysis indicates that the rear side injection mode has to be chosen for a better ion identification.

Isotopically resolved fragments with $Z \leq 20$ have been studied with a high-resolution FAZIA telescope in a test run. The fragments were produced by the collision of a ^{84}Kr beam at 35*A* MeV with a neutron-rich (^{124}Sn) and a neutron-poor (^{112}Sn) target. The angular geometry of the setup (located close to the grazing angles for both reactions) allowed to detect products originating from the quasiprojectile decay (including the quasiprojectile residue itself) and also from a phase-space region (close to the center of mass of the system) where a sizable contribution of light ions produced in the neck zone is expected. The fragment isotopic content clearly depends on the neutron richness of the target and this is direct evidence of isospin diffusion effect , i.e., the transport of nucleons between projectile and target with different N/Z during the interaction phase. The observed enhanced neutron richness of light fragments emitted from the phase-space region close to the center of mass of the system can be interpreted as an effect of isospin drift in the diluted neck region (see Annex 5).

LNL USP11.58 (*supported in the previous reporting period*)
Results of first micro-scale analyses showed that uranium retention on Äspö diorite surface was heterogeneous. Uranium distribution and sample elemental concentration was analysed by the ion beam technique μPIXE. Quantitative distribution coefficients (Ka) on selected minerals were obtained by PIXE spectra analyses. Higher sorption values were generally observed on Fe-bearing minerals. The uranium results have been submitted to the 14th International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere (8-13 September 2013 – Brighton, UK), and a paper is in preparation: "U(VI) surface distribution on Äspö diorite under anoxic conditions".

LNS DNA-BRAGG
Biological effectiveness has been evaluated as a function of depth and dose for monochromatic and clinical proton configurations. Data used to evaluate the effective dose and assess how this changes with depth and beam configuration for possible clinical improvements. Senescence data indicate substantial sub-lethal damage caused by protons in both the plateau and SOBP region.
Results have been presented (oral invited presentation) at the Nano-IBCT conference (May 2013 – Sopot) and will be displayed (posters) at both the European Radiation research Meeting (Dublin – September 2013) and the Radiation Research meeting (New Orleans – October 2013).

LNL USP12.15
The compositional data for the native gold samples have been included in the paper "Studies on archaeological gold items found on Romanian territory using X-Ray based analytical spectrometry" B. Constantinescu, A. Vasilescu, D. Cristea-Stan, M. Radtke, D. Ceccato, E. Oberlaender-Tarnoveanu accepted for publication in J. Anal. At. Spectrom., DOI:10.1039/C2JA30158J.

LNL USP13.03
The selenium results were accepted to be presented within the Goldschmidt 2013 Conference (25-30 August 2013 – Florence, Italy) and expected to be submitted to Applied Geochemistry Journal: "Se(IV) uptake by Äspö diorite: micro-scale distribution".

The list of publications appeared in peer-reviewed journals (or peer-reviewed conference proceedings) resulting from the experiments carried out at LNL and LNS under the Transnational Access activity and supported through the EC grant agreement ENSAR (no. 262010) can be found in Annex 4. The list of publications resulting from projects carried out at LNL and supported through the EC contract EURONS (no. RII3-CT-2004-506065) within the Sixth Framework Programme can be found in Annex 6. These publications have been never reported in previous EURONS and ENSAR activity reports.

USERS MEETINGS

A user meeting was held on 30 October 2012 at LNS.

Moreover, several meetings and workshops, related to the Transnational Access activity, were also held at LNL during the reporting period (see table below).

Title of event	Venue	Date
V Scuola Nazionale "Rivelatori ed Elettronica per Fisica delle Alte Energie, Astrofisica, Applicazioni Spaziali e Fisica Medica	LNL	15-19 April 2013
Legnaro 50	LNL	8 June 2012
ION BEAMS Multidisciplinary Applications of Nuclear Physics with Ion Beams	LNL	6-8 June 2012
SNEAP 2012	LNL	30 September – 5 October 2012