MINISTRY OF EDUCATION, YOUTH AND SPORTS

Progress Report on the Implementation of the Large Research, Experimental Development and Innovation Infrastructure (LI)

CANAM in 2014

Full name of the LI: CANAM – Center of Accelerators and Nuclear Analytical Methods
LI's code: LM2011019
Recipient: Nuclear Physics Institute of the Academy of Sciences of the Czech Republic
Another participant/s of the LI: --
Principal investigator of the LI: Jan Dobeš
Resolution of the Government of the day, number: 29th of June, 2011; No 502
Start of the LI's financing: 9th of November, 2012

The main mission of the LI (max. 500 characters):

The mission of the infrastructure is utilization of energy ions and neutrons for fundamental research in physics, chemistry, biology, energetics and other scientific fields. CANAM integrates the large experimental facilities of the NPI ASCR – isochronous cyclotron, including a generator of fast neutrons (LC&FNG), an electrostatic accelerator Tandetron (LT) and the Laboratory of Neutron Physics (NPL), comprises facilities installed at irradiation channels of the LVR-15 research reactor in Řež.

A. Scientific and Technological Excellence

1. Research Team

List the members of research team (all persons that are paid via personnel costs), append brief job descriptions and classifications including their full-time equivalent (lowest, highest and average) and overall budget; distinguish as well between permanent and temporary staff.

A list of the research team members, including their work load, is attached in Annex No. 3. In the framework of the infrastructure, one agreement to perform an activity outside the employment relationship (identified in the Annex) has been concluded; all other members of the research team are regular employees.

Annex 3 – List of research team members

1. Scientific results

I. *Indicate the main scientific results achieved on the basis of the infrastructure's use during last period of time. Present single results according to valid methodology of CRDI (Council for Research, Development and Innovation), if possible J type results supplement with impact factor according to WoK or Scopus. Among these results specify 10 most important ones.*

II. *Indicate the main scientific results (not more than 10) achieved on the basis of the LI's use (its Czech branch in case of distributed research infrastructure) by its users, if possible to attest. Present single results according to valid methodology of CRDI (Council for Research, Development and Innovation), if possible J type results supplement with impact factor according to WoK or Scopus.*

Within the infrastructure was published in 2014:

- 61 Articles in journals
- 11 Proceedings papers

Note: square brackets [] refers to bibliographic information in Annex 4, assignment to proposals „CANAM id" can be found in Annex 5.

1. Most important scientific results achieved on the basis of the infrastructure's use:

1. In the paper were measured cross-sections for the proton-induced reactions on natural neodymium in energy regions 5–10 MeV and 30–35 MeV. Results revealed practical production thresholds and secondary maxima and minima in the excitation functions. It potentially allowed for more appropriate calculation of thick target yields and production rates of many longer-lived radionuclides.

[21] Excitation functions of proton-induced reactions on natural Nd and production of radionuclides relevant for double beta decay: Completing measurement in 5-35 MeV energy range.
Lebeda, O.; Lozza, V.; Petzoldt, J.; Štursa, J.; Zdychová, V.; Zuber, K.
Nuclear Physics A (2014), Volume 929, pages 129-142
Impact factor: 2.499, year: 2013, CANAM id: 13

2. The thick target neutron field of source reaction p + Be was investigated for a proton energy of 35 MeV. The spectral neutron flux at 0◦ for two target-to-sample distances was determined by using the dosimetry foils activation method. The present p(35)-Be white neutron spectra provided the suitable basis for irradiation experiments and integral tests of nuclear data.

[49] Neutron Spectrum Determination of the p(35 MeV)-Be Source Reaction by the Dosimetry Foils Method.

Štefánik, M.; Bém, P.; Götz, M.; Katovský, K.; Majerle, M.; Novák, J.; Šimečková, E.
Nuclear Data Sheets (2014), Volume 119, pages 422-424
Impact factor: 3.353, year: 2013, CANAM id: 80, 130

[29] High-flux white neutron source based on p(35)-Be reactions for activation experiments at

NPI.
Stefanik, M.; Bem, P.; Gotz, M.; Katovsky, K.; Majerle, M.; Novak, J.; Simeckova, E.
Radiation Physics and Chemistry (2014), Volume 104, pages 306-309
Impact factor: 1.189, year: 2013, CANAM id: 80, 130

3. In the paper were studied neutron diffraction properties of a double-crystal (+*n*,-*m*) setting, which contains a bent perfect Si(311) crystal in the fully asymmetric diffraction geometry with an output beam expansion and a bent perfect Si(220) crystal in the symmetric diffraction geometry. It was found that this setting provides a monochromatic neutron beam of rather large cross section (up to several cm^2) with very small divergence that can be used for various applications.

[47] Neutron diffraction studies of a double-crystal (+n,-m) setting containing a fully asymmetric diffraction geometry of a bent perfect crystal with output beam expansion.
Mikula, P.; Vrána, M.; Pilch, J.; Seong, B. S.; Woo, W.; Em, V.
Journal of Applied Crystallography (2014), Volume 47, pages 599-605
Impact factor: 3.950, year: 2013, CANAM id: 82

4. Uranium in coals of the Sokolov Basin with the content from 0.02 to 6 wt.% were studied using various analytical techniques, including Instrumental Neutron Activation Analysis . The aim was identification of changes in the structure of coal organic matter associated with the high contents of uranium in coal.

[2] A multi-instrumental geochemical study of anomalous uranium enrichment in coal.
Havelcová, M.; Machovič, V.; Mizera, J.; Sýkorová, I.; Borecká, L.; Kopecký, L.
Journal of Environmental Radioactivity (2014), Volume 137, pages 52-63
Impact factor: 3.571, year: 2013, CANAM id: 98

5. Instrumental neutron activation analysis with k_0 standardization (k_0-INAA) was employed for elemental characterization of individual components of electrical cables currently used in the safety systems of nuclear power plants (NPP). The analysis yielded information about the content of 35 elements. It has been found that the presently used cables would not satisfy the requirements of qualification set for the new generation of NPP, because the content of several elements exceeded the maximal admissible levels.

[17] Determination of elemental impurities in polymer materials of electrical cables of safety systems of nuclear power plants by k(0)-INAA.
Kucera, J.; Bartonicek, B.; Kubesova, M.
Journal of Radioanalytical and Nuclear Chemistry (2014), Volume 300, pages 685-691
Impact factor: 1.415, year: 2013, CANAM id: 98

6. A new method utilizing energy loss of ions enables the analysis of shapes of micrometer-sized pores in thin polymers and other materials. In the methods, the special MC codes are used for simulation of energy spectra of transmitted ions. For analysis of individual pores a microbeam with the spatial resolution (¬ 300 nm) was applied.

[62] Study of ion tracks by micro-probe ion energy loss spectroscopy.
J. Vacik, V. Havranek, V. Hnatowicz, P. Horak, D. Fink, P. Apel

Nuclear Instruments and Methods in Physics Research (2014), Volume 332, pages 308-311
Impact factor: 1.186, year: 2013, CANAM id: 93

7. In the paper were studied nanostructured optical materials for photonics and spintronics using ion implantation of ZnO monocrystals with Gd ions (up to a fluence of 5×10^{15} cm^{-2}) and their subsequent annealing (at 800 °C in various atmospheres). Using nuclear analytical methods with energy ion beams a detailed study of their structures and 3D composition mapping was performed.

[5] A study of the structural and magnetic properties of ZnO implanted by Gd ions.
Mackova, A.; Malinsky, P.; Sofer, Z.; Simek, P.; Sedmidubsky, D.; Mikulics, M.; Wilhelm, R. A.
Nuclear Instruments & Methods in Physics Research (2014), Volume 332, pages 80-84
Impact factor: 1.186, year: 2013, CANAM id: 16

8. The paper reports on the structural and compositional changes of $LiNbO_3$, Al_2O_3 and ZnO crystals, implanted with Er^+ ions at 190 keV with fluence of 1.0×10^{16} cm^{-2}. The chemical compositions and Er concentration-depth profiles were studied by RBS and RBS-channeling methods and compared to SRIM simulations. It was found that Er is located in $LiNbO_3$ and in Al_2O_3 preferably in interstitial positions, unlike ZnO, where the Er is mostly placed in substitutional positions. After annealing Er in ZnO significantly decreased in substitutional positions, in $LiNbO_3$ and Al_2O_3 the increase of Er in substitutional positions was observed simultaneously with the improvement of the quality of the host matrix. Further, after ion implantation $LiNbO_3$ samples had zero luminescence intensity, while ZnO and Al_2O_3 samples had one significant luminescence band at 1537 and 1530 nm, respectively.

[1] A comparison of the structural changes and optical properties of LiNbO3, Al2O3 and ZnO after Er+ ion implantation.
Mackova, A.; Malinsky, P.; Pupikova, H.; Nekvindova, P.; Cajzl, J.; Svecova, B.; Oswald, J.; Wilhelm, R. A.; Kolitsch, A. A.
Nuclear Instruments & Methods in Physics Research (2014), Volume 331, pages 182-186
Impact factor: 1.186, year: 2013, CANAM id: 9, 14

9. In the paper was studied twinning activity in random textured cast magnesium during monotonic, room temperature tension and compression tests by acoustic emission (AE) and neutron diffraction (ND). The AE detected higher twin nucleation activity in the tension than in the compression. The correlation of AE with the ND data indicates that in compression the nucleation of twins is followed by rapid growth, unlike in tension in which twin variants with limited growth were observed.

[63] Study of the loading mode dependence of the twinning in random textured cast magnesium by acoustic emission and neutron diffraction methods.
Čapek, J.; Máthis, K.; Clausen, B.; Stráská, J.; Beran, P.; Lukáš, P.
Materials Science and Engineering A-Structural materials (2014), Volume 602, pages 25-32
Impact factor: 2.409, year: 2013, CANAM id: 192

10. Evolution of microstructure of precipitates in thermally exposed superalloy was studied using neutron diffraction method.

[55] Precipitate microstructure evolution in exposed IN738LC superalloy.
Strunz, P.; Petrenec, M.; Gasser, U.; Tobias, J.; Polak, J.; Saroun, J.
Journal of Alloys and Compounds (2014), Volume 589, pages 462-471
Impact factor: 2.726, year: 2013, CANAM id: 34

Other scientific results achieved on the basis of the infrastructure's use:

11. In the paper was examined focusing and reflectivity properties of the dispersive double bent-crystal arrangement. It was found that two different bent perfect crystals in (+n,-m) setting can be good candidates for high efficiency neutron microfocusing, as well as high-resolution monochromatisation. Due to the (+n,-m) setting of two different bent perfect crystals, a high resolution is expected in both $\Delta(2\vartheta)$ (2ϑ is the scattering angle) as well as $\Delta\lambda/\lambda$ (λ is the neutron wavelength).

[25] Focusing and reflectivity properties of a parallel double bent crystal (+n,-m) setting.
Mikula, P.; Vrana, M.; Pilch, J.; Saroun, J.; Seong, B. S.; Woo, C.; Em, V.
IOP Publishing Journal of Physics: Conference Series (2014), Volume 528, Article number 012003
CANAM id: 162

12. In this paper, studies of the neutron diffraction properties of the double crystal (+n,-m) setting containing Si(220) and Si(311) bent perfect crystals (BPC) in symmetric and fully asymmetric diffraction (FAD) geometry with the output beam expansion (OBE), respectively, were performed. The attention was focused mainly on the properties of the FAD geometry of the BPC Si(311) crystal slab. It has been found that after a beam expansion this FAD geometry can provide a monochromatic beam of a rather large cross-section and of very small divergence with some possible application use.

[48] Neutron diffraction studies of a high resolution double crystal (+n,-m) setting containing Si(220) and Si(311) bent perfect crystals in symmetric and fully asymmetric diffraction geometry, respectively.
Mikula, P.; Vrána, M.; Seong, B.; Woo, W.; Em, V.; Korytár, D.
IOP Publishing Journal of Physics: Conference Series (2014), Volume 528, Article number 012004
CANAM id: 82

13. Banned irradiation of liquid acids in many nuclear reactors requires a transformation of these compounds into a solid substance to be able to perform the determination of impurities using instrumental neutron activation analysis. For this purpose, a novel, simple, and contamination-free procedure for the transformation of phosphoric acid into ammonium phosphate has been developed, which is based on isothermal distillation of ammonia vapors.

[16] Determination of elemental impurities in phosphoric acid by INAA employing a novel method of phosphate precipitation.
Kameník, J.; Amsil, H.; Kučera J.
Journal of Radioanalytical and Nuclear Chemistry (2014), Online First Article, DOI 10.1007/s10967-014-3499-x.
Impact factor: 1.41, year: 2013, CANAM id: 114

14. In the paper were synthesized nanostructures using a method of ion implantation of

selected elements into polymers. The resulted composites were analyzed by nuclear analytical methods. Coalescence of metallic particles was studied as a main issue, along with analysis of the optical and electrical properties of the resulting thin composite films.

[32] Characterisation of PEEK, PET and PI implanted with 80 keV Fe+ ions to high fluencies.
Mackova, A.; Malinsky, P.; Miksova, R.; Hnatowicz, V.; Khaibullin, R. I.; Slepicka, P.; Svorcik, V.
Nuclear Instruments and Methods in Physics Research (2014), Volume 176.
Impact factor: 1.186, year: 2013, CANAM id: 35

15. By the RBS method was characterized the depth profiling of Mn ions implanted into polymers. The depth profiles were compared with simulation by the SRIM 2012 and TRIDYN codes. Similarly, the depth profiles were also studied for the implanted foils after thermal annealing. It was found that the experimental profiles were broader (by the factor 2.4 x) than the theoretical forecasts, and interestingly, with the increasing fluence lower sheet resistance and characteristic absorption (band gap) was observed.

[33] Characterization of PEEK, PET and PI implanted with Mn ions and subsequently annealed.
Mackova, A.; Malinsky, P.; Miksova, R.; Pupikova, H.; Khaibullin, R. I.; Slepcka, P.; Gombitova, A.; Kovacik, L.; Svorcik, V.; Matousek, J.
Nuclear Instruments and Methods in Physics Research B (2014), Volume 325, pages 89-96
Impact factor: 1.186, year: 2013, CANAM id: 35

16. In the paper was studied a process of doping of monocrystalline materials by rare earth elements for application in photonics and laser technologies.

[71] The structural changes and optical properties of $LiNbO_3$ after Er implantation using high ion fluencies.
Mackova, A.; Malinsky, P.; Pupikova, H.; Nekvindova, P.; Cajzl, J.; Sofer, Z.; Wilhelm, R. A.; Kolitsch, A.; Oswald J.
Nuclear Instruments and Methods in Physics Research B (2014), Volume 332, pages 74-79
Impact factor: 1.186, year: 2013, CANAM id: 9, 14

17. In the paper was analyzed energy loss of ions in selected solids, validation of semiempirical models for energy loss evaluation, and simulation of charged particle passage through matter.

[70] The stopping powers and energy straggling of heavy ions in polymer foils.
Miksova, R.; Mackova, A.; Malinsky, P.; Hnatowicz, V.; Slepicka, P.
Nuclear Instruments and Methods in Physics Research B (2014), Volume 331, pages 42-47
Impact factor: 1.186, year: 2013, CANAM id: 72

18. In the paper were applied ion beam analytical methods for the study of multilayers prepared by plasma deposition with desired tribology properties.

[72] Tribological properties of nc-TiC/a-C:H coatings prepared by magnetron sputtering at low and high ion bombardment of the growing film.
Souček, P.; Schmidtová, T.; Bursíková, V.; Vašina, P.; Pei, Y.; De Hos, J. Th. M.; Caha, O.; Peřina, V.; Mikšová, R.; Malinský, P.
Surface & Coatings Technology (2014), Volume 241, pages 64-73
Impact factor: 2.199, year: 2013, CANAM id: 134

19. Beer is claimed to be an excellent source of bioavailable silicon that is believed to be essential, especially for the proper functioning of connective tissues. In the paper was studied the concentration of Si in various lager beer samples by instrumental neutron activation analysis, and the mass balance of silicon during the brewing process. The concentration of silicon ranged from 13.7 to 44.2 mg/l and was highly dependent on the type and quantity of the raw materials used, as well as on the brewing technology. The silicon mass balance showed that the main silicon source in beer is the barley malt and that the concentration of silicon in solution increases significantly after mashing, whereas it decreases after fermentation.

[37] Impact of the brewing process on the concentration of silicon in lager beer.
Krausova, I.; Cejnar, R.; Kucera, J.; Dostálek, P.
Journal of the Institute of Brewing (2014), Volume 120, pages 433-437
Impact factor: 0.84, year: 2013, CANAM id: 98

20. For thermoluminescence dating, the method of neutron activation analysis, X-ray fluorescence analysis and alpha counting were applied for the determination of dose rates of radionuclides ^{238}U, ^{235}U, ^{232}Th, members of their decay chains and ^{40}K in bricks from historic buildings. Various methods could be used for determining trace concentrations of these natural radionuclides and their contributions to the dose rate. The above mentioned methods were compared and enabled a decision of whether the simpler time- and cost-saving techniques introduced a level of uncertainly that is still acceptable.

[13] Comparative analysis of dose rates in bricks determined by neutron activation analysis, alpha counting and X-ray fluorescence analysis for the thermoluminescence fine grain dating method.
Bártová, H.; Kučera, J.; Musílek, L.; Trojek, T.
Radiation Physics and Chemistry (2014), Volume 104, pages 393-397
Impact factor: 1.189, year: 2013, CANAM id: 47

21. This paper studied an issue, how nuclear pore etching depends on Li^+ and F^- ions that indiffuse into etched pores from different sites and form insoluble precipitations LiF. The observation showed that the precipitations are formed along the etched tracks and may create inner membranes. Such membranes change the properties and functionality of polymers. They can be advantageously utilized in biosensors (the formation of inner membranes results in higher sensitivity).

[15] Coupled chemical reactions in dynamic nanometric confinement: V. The influence of Li+ and F- ions on etching of nuclear tracks in polymers.
Fink, D.; Muñoz, H. G.; Ruiz, N. L.; Vacik, J.; Hnatowicz, V.; Alfonta, L.; Kiv, A.
Radiation Effects and Defects in Solids (2014), Volume 169, pages 396-417
Impact factor: 0.6, year: 2013, CANAM id: 91

22. RBS depth profiling showed that the Ag and I atoms diffuse into HDPE, PI and PEEK polymers proportionally with time, but their diffusion process cannot be described using standard Fick's laws. The anomalies, observed in the paper, could be explained by radiation defects (caused by irradiation of polymers with electrons) that behave like effective trap centers for diffusing Ag

and I dopants.

[20] Diffusion of silver and iodine into polymers assisted by in situ electron irradiation.
Vacik, J.; Hnatowicz, V.; Dhole, S. D.; Mathakari, N. L.; Dahiwale, S. S.; Bogale, K. B.; Bhoraskar, V. N.
Radiation Effects and Defects in Solids (2014), Volume 98, pages 92-97
Impact factor: 0.6, year: 2013, CANAM id: 87

23. The study of Li diffusion into PEEK and PI polymers showed that the Li ions indiffuse proportionally with time of diffusion, but with different mechanisms. The Li depth profiles in the case of PEEK exhibit exponential forms for all times. This suggests that the diffusion quickly achieves the stabile phase. In the case of PI however, the depth profiles strongly depend on time of diffusion. For a longer time the profile consists of a part (close to the surface) that can be explained by the standard process with the Fick's laws, and a part (in the bulk) with an exponential form that corresponds to the nonstandard behavior of diffusion.

[40] Lithium diffusion in polyether ether ketone and polyimide stimulated by in situ electron irradiation and studied by the neutron depth profiling method.
Vacik, J.; Hnatowicz, V.; Attar, F. M.; Mathakari, N. L.; Dahiwale, S. S.; Dhole, S D.; Bhoraskar, V. N.
Radiation Effects and Defects in Solids (2014), Volume 169, pages 885-891
Impact factor: 0.6, year: 2013, CANAM id: 87

24. In the paper was developed a new strategy for the enhancement of the detection sensitivity of biosensors that are based on polymers with etched pores. The sensors are prepared by deposition of enzymes onto the walls of the pores that makes it possible to increase the amount of electrically charged reaction products in the confined volume of the micropores. The newly developed biosensor works as a frequency filter that can be useful in an environment with higher levels of electrosmog.

[11] Biosensors with nuclear tracks and embedded membranes.
Fink, D.; Vacik, J.; Arellano, H. G.; Munoz, G.; Alfonta, L.; Fahrner, W. R.; Hoppe, K.; Kiv, A.
Key Engineering Materials (2014), Volume 605, pages 83-86
Impact factor: 0.19, year: 2013, CANAM id: 91

25. This paper deals with the residual strain/stress measurements in the vicinity of electron beam welds of Charpy-V notched specimens by neutron diffraction. The specimens with welds on one side as well as with welds on two opposite sides were prepared by the reconstitution method.

[58] Residual stress investigations of electron beam welds on samples prepared by reconstitution method.
Vrana, M.; Mikula, P.
Applied Mechanics and Materials (2014), Volume 486, pages 147-150
CANAM id: 184

II. Main scientific results achieved on the basis of the infrastructure's use by external workers:

1. By energy ion irradiation fluorescent nanodiamonds (fNDs) with a high presence of

luminescent centers were synthesized. Nanodiamonds have been used for the construction of nanosystems for monitoring of biological processes (bioimaging) in vitro and ex vivo in real time.

[14] Comprehensive interrogation of the cellular response to fluorescent, detonation and functionalized nanodiamonds.
Moore, L.; Grobarova, V.; Shen, H.; Man, H. B.; Micova, J.; Ledivna, M.; Stursa, J.; Nesladek, M.; Fiserova, A.; Ho, D.
Nanoscale (2014), Volume 6, Article number 11712
Impact factor: 6.739, year: 2013, CANAM id: 152

2. In the paper was studied radiation resistivity of the Si pixel chips and components for innovation of a new inner tracking system of the ALICE detector (CERN).

[68] Technical Design Report for the Upgrade of the ALICE Inner Tracking System.
Abelev, B.; et al. (The ALICE Collaboration)
Journal of Physics G: Nuclear and Particle Physics (2014), Volume 41, pages 39-40
Impact factor: 2.838, year: 2013, CANAM id: 60

3. In the paper were analyzed cross sections of the $^{2}H(d,p)^{3}H$ and $^{2}H(d,n)$ reactions using the Trojan Horse method. For the first time it was determined the S(E) factor for the energy range 1.5 MeV – keV. It was found that both energy dependence and absolute value of S(E) differ (by more than 15%) from the available experimental data. As a direct consequence is seen a change in the rates of the reactions and alteration of the relevant astrophysical data.

[50] New Determination of the H-2(d,p)H-3 and H-2(d,n)He-3 Reaction Rates at Astrophysical Energies.
Tumino, A.; Sparta, R.; Spitaleri, C.; Typel, S.; Pizzone, R. G.; Tognelli, E.; Degl'Innocenti, S.; Burjan, V.; Kroha, V.; Hons, Z.; La Cognata, M.; Lamia, L.; Mrazek, J. et al.
Astrophysical Journal (2014), Volume 785, článek číslo 96
Impact factor: 6.280, year: 2013, CANAM id: 99

4. In the paper were studied the structural properties of graphene, prepared by chemical and thermal reduction of graphite oxide, using various techniques including neutron diffraction. The results showed that the diffraction (especially neutron diffraction) methods have a great potential for study of the size of particles in the bulky graphene.

[46] Neutron diffraction as a precise and reliable method for obtaining structural properties of bulk quantities of graphene.
Sofer, Z.; Simek, P.; Jankovsky, O.; Sedmidubsky, D.; Beran, P.; Pumera, M.
Nanoscale (2014), Volume 6, pages 13082-13089
Impact factor: 6.739, year: 2013, CANAM id: 97

5. Graphene is a 2D carbon allotrope with remarkable electrical, mechanical and optical properties that, however, depends on the content of impurities or incorporated dopants. In the paper was studied the concentration of elements with a set of nuclear analytical methods, and determination of the most suitable way to synthesize graphene with a high purity, or graphene doped with selected elements of certain concentrations.

[74] Uranium-and Thorium-Doped Graphene for Efficient Oxygen and Hydrogen Peroxide

Reduction.
Sofer, Z.; Jankovsky, O.; Simek, P.; Klimova, K.; Mackova, A.; Pumera, M.
ACS Nano (2014), Volume 8, pages 7106-7114
Impact factor: 12.033, year: 2013, CANAM id: 16

6. The chemical synthesis of graphene depends on applied chemical reagents. In the paper was shown (using nuclear analytical methods) that the chemical synthesis results in a high contamination of graphene by heteroatoms (N, B, Cl, S) and metals (Mn, Al). Contamination achieved the level of 3 at%. Such a high contamination rate significantly alters the electronic and catalytic properties of graphene.

[34] Chemical Preparation of Graphene Materials Results in Extensive Unintentional Doping with Heteroatoms and Metals.
Chua, C. K.; Ambrosi, A.; Sofer, Z.; Macková, A.; Havránek, V.; Tomandl, I.; Pumera, M.
Chemistry (2014), Volume 20, Article number 15760
Impact factor: 5.696, year: 2013, CANAM id: 16, 27

7. A new type of biosensor was prepared based on thin polymers with etched pores containing (clad on the walls) enzyme laccase. In the confined space of the pores enzymatic reactions can be triggered in the presence of specific phenolic compounds that cause changes in the electric resistivity of the sensor. It was proved that the sensor may detect biomolecules in the range of 9 orders down to the picomol level.

[52] Nuclear track-based biosensors with the enzyme laccase.
Arellano, H. G.; Fink, D.; Hernandez, G. M.; Vacik, J.; Hnatowicz, V.; Alfonta, L.
Applied Surface Science (2014), Volume 310, Article number 66
Impact factor: 2.538, year: 2013, CANAM id: 91

8. In the paper were studied B doped nano-crystalline diamond (B-NCD) layers grown over large areas and at low substrate temperatures using microwave plasma enhanced linear antenna chemical vapor deposition apparatus . B-NCD layers were grown in $H_2/CH_4/CO_2$ and H_2/CH_4 gas mixtures with added trimethylboron (TMB). The experimental results show the reduction of B acceptor concentration with increasing CO_2 concentration. Higher sp^3/sp^2 ratios were measured by Raman spectroscopy with increasing TMB concentration in the gas phase without CO_2.

[39] Large area deposition of boron doped nano-crystalline diamond films at low temperatures using MW PECVD with linear antenna delivery.
Taylor, A.; Fekete, L.; Hubík, P.; Jager, A.; Janíček, P.; Mortet, V.; Mistrík, J.; Vacík, J.
Diamond and Related Materials (2014), Volume 47, pages 27-34
Impact factor: 1.572, year: 2013, CANAM id: 89

9. There are numerous methods for the fabrication of synthetic graphene. The technique may, however, cause unpredictable contamination from metallic and other impurities, which have considerable impact on the electrochemical properties of graphene material, with wide-reaching implications on the potential applications. In the paper was analyzed (using INAA) the contamination of graphene (prepared with different methods) with the aim to select the optimal method of synthesis for each application.

[67] Synthetic routes contaminate graphene materials with a whole spectrum of unanticipated metallic elements.
Wong, C. H. A.; Sofer, Z.; Kubesova, M.; Kucera, J.; Matejkova, J.; Pumera, M.
Proceedings of the National Academy of Sciences of the United States of America (2014), Volume 111, pages 13774-13779
Impact factor: 9.809, year: 2013, CANAM id: 19

10. The activation cross sections of Cr, Mn, Fe, Co isotopes were studied in deuteron-induced reactions on natural Fe. In an extended analysis of deuteron interactions with natFe, all processes from elastic scattering, breakup, and direct reactions until the evaporation from fully equilibrated compound system have been taken into account. The strong effects of direct interactions have not yet been appropriately considered within previous deuteron activation evaluations.

[42] Low energy deuteron-induced reactions on Fe isotopes.
Avrigeanu, M.; Avrigeanu, V.; Bem, P.; Fischer, U.; Honusek, M.; Katovsky, K.; Manilescu, C.; Mrazek, J.; Simeckova, E.; Zavorka, L.
Physical Review C (2014), Volume 89, Article number 044613
Impact factor: 3.881, year: 2013, CANAM id: 48, 58

Annex 4 – List of publications
Annex 5 – List of proposals

3. Utilization of the LI

Describe utilization of the LI's capacity (according to the type and scientific field of the LI describe the percentage utilization, eventually number of accesses, volume of produced, stored or provided data, distribution of users by their affiliation – universities, public research institutions, industry). In case of construction of the LI describe the current status or data from performed tests or limited service providing, etc.

LC & FNG
Overall running time: 2 761 irradiation hours
Applicability of the cyclotron: experiments 94.2% (2 601 hours) / service and tests 5.8% (160 hours)
Statistic of utilization: university 1% / public research institutions 42% / industry 57%

LT
Overall running time: 1 790 hours
Applicability of the Tandetron: experiments 86% (1 540 hours) / service and tests 14% (250 hours)
Statistic of utilization: university 30% / public research institutions 68% / industry 2%

NPL
Overall running time: 155 days
Applicability of the reactor: experiments 49,9% / service and tests 50,1%
Statistic of utilization: university 23% / public research institutions 76% / industry 1%
Running capacity was reduced to about 74% of capacity in 2013 because of the shutdown of the reactor during October and December 2014.

4. Cooperation

I. *Indicate newly established or running cooperation within the Czech Republic and abroad with research institutions, industry and other entities using results of the LI.*

II. *Indicate newly established or running cooperation with other research infrastructures in the field, both Czech and foreign ones.*

I. In 2014, new cooperation was established with 30 foreign research institutions, 24 foreign universities and 3 industry-related companies. Cooperation was also newly established with 6 Czech research institutions, 3 Czech universities, 3 industry-related companies and 3 contributory organizations. Currently, the infrastructure cooperates with 156 entities.

- Newly established cooperation: 72
- Running cooperation: 84

A list of all cooperation is given in Annex 6.

II. Running cooperation with other research infrastructures in the field:

- ALICE Collaboration – A Large Ion Collider Experiment, Switzerland
- ATLAS Experiment – Argonne Tandem Linear Accelerator System, Switzerland
- ATOMKI – Atommagkutató Intézet, Hungarian Academy of Sciences, Hungary
- EC-JRC-IRMM - Joint Research Centre (JRC), Institute for Reference Materials and Measurements, IRMM - Confidence in measurements, Sweden
- ESS - European Social Survey, European Research Infrastructure Consortium, Belgium
- IFIN HH – Institutul de Fizica si Inginerie Nucleara, Horia Hulubei, Romania
- JIRN – Joint Institute for Nuclear Research, Russia
- LNS-INFN – Laboratori Nazionali del Sud, Instituto Nazionale di Fisica Nucleare, Italy
- NMI3 I3 – Neutron Scattering and Muon Spectroscopy (consortium of 13 European research infrastructures)
- SOREQ – Nucelar Research Center, Israel
- SPIRAL (will continue as SPIRAL2/NFS) - Système de Production d'Ions Radioactifs Accélérés en Ligne, France
- Ion Beam Center, Helmholtz Zentrum, Dresden – Rossendorf, Germany

Annex 6 – List of cooperation

5. Service to Science Community

Indicate the number of users (eventually number of accesses) of the LI from the Czech Republic and abroad. Indicate the number of conferences and seminars organized by the LI, including the number of participants from the Czech Republic and abroad. Indicate the number of meetings with users and the feedback results thus obtained. Indicate the number of agreements with other institutions (e.g. contracts, memoranda).

Number of users:
To date 31.12.2014 there were registered 225 users (11 Instruments Responsible, 72 Evaluators

and 142 Proposers - 75 from abroad).

In 2014 were submitted, carried out or completed 91 proposals of experiments, in which 164 users (including non-registered co-proposers) participated.

Number of seminars organized by the infrastructure:

- The 15th International Workshop on Targetry and Target Chemistry (WTTC15), 18. – 21.8.2014, Hotel Diplomat, Prague (participants: 12 Czech and 171 from abroad)
- CANAM – LEA NuAG Workshop, 21. – 22.7.2014, Vila Lanna, Prague (participants: 9 Czech and 8 from abroad)

Number of meetings with users and the feedback results: 2

- 20. – 24.10.2014 – Meeting with users from Horia Hulubei National Institute of Physics and Nuclear Engineering - IFIN HH Romania, feedback: two submitted proposals, establishing cooperation
- 7. – 12.12.2014 – Visit of users from Tsinghua University and Sichuan Institute China, feedback: continued cooperation on experiments at the NPL

Number of agreements with other institutions: 18

Annex 7 – List of international grants
Annex 8 – List of national grants

6. Internationalisation

Indicate the number of international research grants gained by research team, their names, a brief description and financial volume.

Number of international research grants: 7

Annex 7 – List of international grants

7. Multidisciplinarity

Indicate the number and titles of scientific disciplines that use the LI's services. Append particular results.

Number of scientific disciplines: 22

Titles of scientific disciplines:
AC - Archaeology, anthropology, ethnology
BF – Elementary particle theory and high energy physics
BG – Nuclear, atomic and molecular physics, accelerators
BH – Optics, masers and lasers
BL – Plasma physics and discharge through gases
BM – Solid-state physics and magnetism
BN – Astronomy and celestial mechanics, astrophysics

BO – Biophysics
CB – Analytical chemistry, separation
CF – Physical chemistry and theoretical chemistry
DD – Geochemistry
DI – Pollution and air control
EB – Genetics and molecular biology
EE – Microbiology, virology
EI – Biotechnology and bionics
GM – Food industry
JA – Electronics and optoelectronics
JB – Sensors, detecting elements, measurement and regulation
JI – Composite materials
JJ – Other materials
JK – Corrosion and material surfaces
JL – Fatigue and fracture mechanics

Particular results can be found in Annex 4 and Annex 5.

Annex 4 – List of publication
Annex 5 – List of proposals

8. Strategic Management of the Scientific Development of the Infrastructure

Indicate the main features of the scientific strategy of the LI, including plan for update of the technology used and plan of possible decommissioning.

Main characteristics of the scientific infrastructure strategy:

- maintaining full operation of the existing infrastructure facilities,
- their gradual improvement and modernization,
- effective utilization in basic and applied research,
- providing services to Czech and foreign institutions in the broad area of multidisciplinary research,
- education of graduate and postgraduate students and specialists (LT will hire a new bachelor student from UJEP, Ústí nad Labem),
- expansion of Scientific Selection Panels evaluating the designs of scientific projects of domestic and foreign users.

Main strategic infrastructure development:

- installation of a new TR 24 cyclotron, which will enhance the experimental possibilities for generating fluxes of fast neutrons and possibilities of conventional and unconventional radionuclides production for research and development of radiopharmaceuticals for nuclear medicine,
- modernization of cyclotron subsystems, improving parameters of accelerated beams and target technology according to the needs of users so that they could be incorporated in both domestic and international projects and co-operations,
- performance of initial successful tests for measuring neutron spectra using the TOF

method,
- software development for ADC digitizer,
- acquisition of two 2D position-sensitive neutron detectors,
- modernization of spectroscopic electronic routes: acquisition of a new control industrial computer with integrated multi-channel analyzers and new software for goniometer control and spectra acquisition; the system works under a new operating system and is part of the spectroscopic route and target chamber for RBS channeling analytics,
- purchase of vacuum components for scheduled construction of a new ion route – the installation of a new magnet onto the 0. channel of the Tandetron's dividing magnet created a basis for a new route onto which the ion implantation chamber will be placed in 2015 (which will make space for development of a new analytical ion route and target chamber),
- new goniometer, including new software which was developed in LT as a prototype in the LabView environment, was installed, tested and put into operation,
- Mathematica high-performance software was purchased and is primarily used for processing multi-parameter data measured on an ion microprobe, e.g., when processing the measurements of trace elements in aerosols for the identification of sources of pollution in the framework of environmental research or measurements obtained using the STIM (Scanning Transmission Ion Microscopy) method.

Plan of installation and commissioning of the acquired investment items of infrastructure:
- TR 24 cyclotron (LT & FNG) – commissioning in 2015
- deflection magnet (LT) – commissioning in 2015
- 2D position-sensitive neutron detectors (NPL) – completion, installation and commissioning in 2015

Other investment items acquired in 2014 have already been put into operation.

B. Stable and Efficient Management

1. The Efficiency of the Use of Funds

Describe and document by table the use of the provided grant for past period; primarily describe the personnel costs (e.g. number of jobs), overheads and investments. Describe the mechanism of calculation of overhead costs approved by the host institution. Indicate how the allocated funds are used in the context of the overall budget of the LI. Indicate the percentage of the budget of the LI that has been obtained from external international grants, in collaboration with industry or other entities using the LI's services.

Provided grant 40 000 000 CZK was used as follows:
- Personal costs: 13 860 000 CZK
  - Salaries, social and health insurance and SF of employees of the structure (48,83 FTE)
- Overhead: 4 320 000 CZK
  - 17,3 % of the non-investment grant (the indirect institute expenses ensuring the activity of the infrastructure)
- Current expenses 6 901 000 CZK

- current materials, computer technology, spare parts, mediums for the infrastructure operation, utilization of the horizontal channels at the reactor
- Investments 14 452 000 CZK
  - Investment items (Annex 10)

In 2014, 597 945 CZK (investment cost) + 49 038 CZK (current expenses) were allocated from the grant to the Targeted support fund.

To calculate overhead was applied constitutional directive "Methodics allocation of the actual eligible indirect costs for projects funded under FP7".

The entire budget of the infrastructure 77 136 000 CZK was divided as follows:

MEYS	51,8 %
NPI ASCR	27,1 %
International grants	3,1 %
Industry cooperation	18,0 %

Annex 9 – Metodics allocation of the actual eligible indirect costs for projects FP7
Annex 10 – List and description of investments

2. Stable Management

Describe your plan for human resources development. Describe your strategy for allocation of the LI's capacity. Provide an organizational chart of the LI, changes in staffing of the LI. Indicate the composition and any changes in the external advisory bodies (scientific and management focus). Describe new ways in addressing the challenges that have been implemented in the area of LI's management in the period.

Human resources development plan:

- training of specialists for the designs of accelerator subsystems and target systems,
- training of technical specialists for the design of elements for the accelerator and target system technology,
- preparation of technical and operating staff for the operation of the new TR 24 accelerator and getting them gradually acquainted with the technological units of the new accelerator,
- preparation of tender procedures for supplementing research workers of the electronic and physical group,
- implementing the program of basic and applied neutron research on the U-120M and TR 24 cyclotrons in cooperation with the Czech Technical University in Prague and the Faculty of Mathematics and Physics, Charles University, and the training of young scientific workers,
- establishment of a team to attend and operate the neutron generators of the U-120M cyclotron,
- training of operators to operate the Tandetron and related technologies (vacuum chambers, goniometers, electronic instrumentation of nuclear analytical methods, hardware and software for spectroscopy),

- regular updating of the subjects of diploma theses and PhD. theses at the Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague, the Institute of Chemical Technology, Faculty of Mathematics and Physics, Charles University, Jan Evangelista Purkyně University, etc.,
- management of diploma theses and PhD. theses – education of graduate and postgraduate students,
- maintaining or improving the age structure of the laboratory by admitting new members,
- designating one scientific worker responsible for the operation of one experimental piece of equipment (instrument responsible),
- utilization of experiences of young scientific workers after their return from research fellowships abroad.

Changes in personnel base:

The following changes were made in 2014:

- In LC & FNG, R. Běhal was hired as a design engineer to replace retired F. Veselý; S. Slovák was hired as a milling-machine operator to replace retired J. Diviš.
- In LT, a new position of 'post doc fellow' was created for Dr. Maria Cutroneo, University of Messina, Italy; a new cooperation was established with the foreign center and new research on implantation by laser radiation in cooperation with the Institute of Physics Prague and PALS system (Prague Asterix Laser System) was opened; the issues, where ion analytical methods are applied for offline analysis of samples implanted by multi-ion beams after intensive laser radiation, are unique; a project was filed with the Czech Science Foundation (GAČR) in the framework of cooperation.

Infrastructure capacity allocation strategy:

- allocation of operating time to experiments is made via "Open Access", where the scientific value of a particular project is evaluated by an international panel of evaluators (71 leading domestic and foreign specialists in the field); each project is evaluated by two evaluators,
- after the experiment's feasibility assessment and on the basis of the infrastructure's operating work load, positively evaluated projects are allocated operating time by the local panels: LC panel (convene twice a year), LT panel and NPL panel (convene as necessary),
- a user portal: http://users.canam.ujf.cas.cz is managed to administer and evaluate the designs of experiments,
- designating a particular scientific worker responsible for the operation of each individual experimental piece of equipment (instrument responsible).

New methods of dealing with challenges:

- preparation of gradual incorporation of the CANAM infrastructure into bilateral cooperative agreements with large IFIN HH (RO) and HZDR Dresden Rossendorf (D) infrastructures – LT members currently participate in the work in evaluation panels of ion centres of both infrastructures; a 'training site' for scientific workers from IFIN HH was implemented, as well as joint scientific experiments, and there was an intensive

exchange of know-how in the area of nuclear spectroscopic instrumentation (http://canam.ujf.cas.cz/),
- continuation of cooperation with the NMI3 European consortium,
- expansion of process procedures in the framework of design evaluation (scientific evaluation panel, feedback from users, etc.).

3. Progress towards Objectives and Compliance with the Timetable of the Realization of the LI

Indicate the comparison with the original plan of the realization of the LI stated in the LI's proposal approved by the Government; describe the progress in meeting LI's objectives and the compliance with the timetable of the realization of the LI. Indicate all changes (financial, personnel, etc.) in the realization of the LI and their explanation.

During the year, the project website (see http://canam.ujf.cas.cz) and the database system for submitting and administration of experiment designs (see http://users.canam.ujf.cas.cz) were modified and supplemented as necessary.

The modernization of equipment of the infrastructure was carried out according to the project's timetable.
The following steps were taken in the individual laboratories:

LC & FNG

- The work on the project of installation of the commercially supplied TR 24 cyclotron and coordination of work on the implementation of the building and essential technologies continued. The cyclotron (including all technological parts and equipment) was transported to NPI Řež in September 2014 and was successfully relocated to the basement floor of the new building. Final work on the completion of the building, technologies, networks and security systems (internet, electronic security system, electronic fire signaling, CCTV system, etc.) is currently in progress.
- The work on the implementation of a high-voltage pulse system for charging choppers in order to measure the energy of neutrons using the (TOF) Time Of Flight method continued.
- In order to monitor radiation fields of the brought-out accelerated ions of the U-120M cyclotron used to irradiate biological samples and test radiation resistance of electric components, a positioning device operating in an area of 200 x 200 mm^2 with a minimum step of 0.1 mm was designed and implemented.
- In order to measure the integral current of accelerated particles hitting the target and the overall charge, a new current integrator in the range from tens of nA to hundreds of μA was designed and implemented, including the recording of the current curve onto the control system server.
- For spectrometry of neutrons using the TOF method, the development of the system of digital processing of pulse response of scintillation detectors continued and experimental testing using the natural pulsation of the neutron field of the generator with a Li target on the U-120M cyclotron was performed. Software for processing the response from the scintillation probe and subsequent online and offline data processing into the TOF spectrum was developed. Software for conversion of the TOF spectrum

into the neutron spectrum was also developed.

- Li target online monitoring using IR sensors was tested.
- Tests of applicability of the thin Be target for a q-monochromatic source of neutrons was performed.

LT

- A new goniometer for simultaneous measurement using the RBS channeling, ERDA and PIXE channeling methods was installed and vacuum tested in a multifunctional channeling chamber. A software prototype (in the LabView environment) for the control and measuring automation was developed and tested for the goniometer. The equipment enables the analysis of crystalline materials modified by ion implantation and it significantly expands the possibilities of structural studies of positioning atoms in crystalline materials.
- A new ion route was constructed on the 0. channel of the Tandetron where the ion implantation route will be relocated.
- For microbeam, a program for focused creation of microstructures (ion beam writing) by focused beams of heavy ions was developed – based on a matrix defined by the program, it is possible to transfer the image of the structure into a 3D real matrix of the substrate.
- In accordance with the set objectives, experiments have been performed in cooperation with the external proponents in the areas of:
  - synthesis and characterization of nanostructures for optics, spintronics and photonics,
  - application of ion analytical methods to biocompatible materials and plasmatically deposited multi-layer structures with distinguished tribological properties,
  - characterization of progressive materials on the basis of a plasma polymer and metal using ion analytical methods,
  - characterization of materials for fusion reactors and technologies, profiling of hydrogen isotopes in functional materials for nuclear fusion,
  - element profiling in epitaxial films prepared by sputtering for applications in preparation of super-magnetic materials, information media, etc.
  - application of an ion microprobe for the preparation of microstructures in polymeric materials using the beams of focused heavy ions (it is a unique method within the European context).
- Fundamental studies of brake energy losses of medium-heavy ions, energy straggling and modelling of energy ion passage in materials attractive for dosimetry and microelectronics (synthetic polymers) and in materials for applications in ion detection instrumentation (on the basis of SiN) have taken place. Simultaneously, the modifications of irradiated materials were monitored by complementary methods with regard to changes in their composition, structure and chemical bond. The results are original and unique and will be included in the international database of empirical data for energy losses.
- Experiments have been performed using the STIM (Scanning Transmission Ion Microprobe) method and analyses of silver-plated microfibers have been made in order

to study their resistance and corrosivity. The structures are applicable both as thermal fabrics and for industrial use.

- Ion implantation of protons and nitrogen ions was applied to create defects in ZnO monocrystals for fundamental structural studies. This material was subsequently characterized by nuclear analytical methods.
- In cooperation with the 'University of Messina' (Italy), analyses of archaeological artefacts (coins more than two thousand years old) were performed using the PIXE, microPIXE and microPIGE methods. Also, in cooperation with PALS (Prague) and the University of Messina, thin polymeric targets were developed using the ion beam writing method for multi-ion implantations by laser beams.
- Irradiation of living cell cultures was performed for dosimetric studies.
- The shapes of ion pores in polymeric materials (latent, etched and dopant-filled) were analyzed using the ion loss spectroscopy method.

NPL

- Standard user operation has taken place on all equipment in the framework of "Open Access" which, however, was temporally limited by the scheduled shutdown of the LVR-15 reactor (October-December 2014).
- The User Portal was continuously improved and supplemented by information important for user access to CANAM equipment (safety, logistics).
- Equipment for X-Ray Fluorescence (XRF) for non-destructive fast element analyses, including elements with a low atomic number (Al, Si, P, S), was introduced among the user equipment accessible to external users.
- The positioning of the detector has become more precise and software interconnection of data for various positions of the detector on HK-9 (TKSN-400 diffractometer) was implemented; also, a new table under the analyzer on HK8 (MAUD diffractometer) was installed.
- During the down time of the reactor (October-December 2014), reconstruction of the SPN-100 diffractometer (installation of a new 2D position-sensitive detector, including its new massive screening, as well as replacement of monochromator motors and controllers) was implemented.
- Replacement of the detector on HK8 was commenced, including the replacement of screening (work is anticipated to be completed in 2015).

Personnel changes:

- LC & FNG – new designer (R. Běhal) and new miller (S. Slovák)
- LT – new Post-doc fellow (M. Cutroneo, University of Messina, Italy)

C. Socio-economic Impacts of the Infrastructure

1. Impact on the Economy

I. *Indicate the number of jobs in the LI (researchers/research staff/other).*

II. *Indicate the number and volume of contracts with industry concluded in the framework of public procurement to maintenance and renewal of the LI.*

I. Number of jobs in the infrastructure:
total (researchers / research staff / other)
individual: 93 (57 / 25 / 11)
FTE: 48,83 (28,62 / 13,32 / 6,90)

II. Number and volume of contracts with industry concluded in the framework of public procurement: 0

2. Impact on the Society

I. *Indicate the number of master and doctorate students using the LI.*

II. *Indicate the number of new textbooks, lecture notes and other practical outputs carried out in connection with the LI's operation, number and names of curricula whose students are using the LI.*

I. Number of master students: 15
Number of doctorate students: 36

II. Number of other practical outputs
Number of lectures and study programs utilizing the infrastructure: 11
Lectures on:

- Neutron Physics (56 hours / semester), Department of Physics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Physical Practicum (54 hours / semester), Jan Evangelista Purkyně University, Ústí nad Labem,
- Radionuclide Applications I (24 hours / semester), Applications of Natural Sciences program, Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Radionuclide Applications II (24 hours / semester), Applications of Natural Sciences programme, Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Instrumental Radioanalytical Methods and Their Application in Environmental Monitoring (24 hours / semester), Nuclear Chemistry program, Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Radioanalytical Methods (18 hours / semester), Geology program – General Subjects, Faculty of Science, Charles University in Prague,
- Radionuclide Preparation (26 hours / semester), Applications of Natural Sciences

study program, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Basics of Physics of Nuclear Reactions (52 hours / semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Experimental Neutron Physics (28 hours / semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Microdosimetry (28 hours / semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague,
- Radiology (28 hours / semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.

Number of bachelor, diploma and PhD. theses: 6

Other programs:
- Lectures in the 'Summer School for Mathematics and Physics Teachers' (organized by the Union of Czech Mathematicians and Physicists) for teachers and secondary school students, organizer: Jan Evangelista Purkyně University, Ústí nad Labem,
- preparation of publications in the collection of the 'Summer School for Mathematics and Physics Teachers', publisher: Jan Evangelista Purkyně University, Ústí nad Labem,
- seminar in LT by visitors from IFIN HH Bucharest, information on the Centrum of accelerators IFIN HH by Dr. Straticius (see http://canam.ujf.cas.cz).

3. Impact on Innovation

I. *Indicate the number of spin - off companies established on the basis of LI's operation.*

II. *Indicate the number of pilot plants, utility models, demonstrators made in connection with the operation of the LI, number of patents (including their names) recognized in connection with the operation of the LI.*

I. Number of running spin-off companies: 1 (RadioMedic, Ltd.)

II. Number of pilot plants, utility models, demonstrators and patents: 1
NPL – utility model No. 27164 (Deformation rig for neutron diffraction)

D. Annexes

1. Required:

Annex 1 - Table of Real Financial Costs of the Large RDI Infrastructure in 2014
Annex 2 - Table of indicators for monitoring of the implementation of the project

2. Optional:
Annex 3 – List of research team members
Annex 4 – List of publications
Annex 5 – List of proposals

Annex 6 – List of cooperation
Annex 7 – List of international grants
Annex 8 – List of national grants
Annex 9 – Methodics of allocation of the actual eligible indirect costs for projects FP7
Annex 10 – List and description of investments
Annex 11 – Organizational structure
Annex 12 – List of scientific and management focus

In Řež
Date: 6. 2. 2015

Signature of investigator: