MINISTRY OF EDUCATION, YOUTH AND SPORTS

Progress Report on the Implementation of the Project of Large Research, Experimental Development and Innovation Infrastructure CANAM in 2013

Full name of the project: CANAM – Center of Accelerators and Nuclear Analytical Methods
Project code: LM2011019
Beneficiary: Nuclear Physics Institute of the Academy of Sciences of Czech Republic
Principal investigator of the project: Jan Dobeš
Resolution of the Government of the day, number: 29th of June, 2011, No 502
Start of project financing: 9th of November, 2012
The main mission of the infrastructure (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 connects 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 or average) and overall budget; distinguish as well between permanent and temporary staff.

List of the members of research team is given in the Annex.

All members of the research team are permanent staff. Temporary agreements were not entered within the infrastructure.

In 2013, the research team had 92 individuals with a total 39.68 FTE-time.

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 main scientific results (not more than 10) achieved on the basis of the infrastructure's use (or perhaps its Czech branch) by external workers, 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.*

In 2013 there were published within the infrastructure:

- 36 Articles in journals
- 12 Proceedings papers
- 4 Abstracts in impacted journals
- 6 Abstracts in Book of abstracts

Note: square brackets [] refers to more detailed bibliographic information in Annex 4

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

1. Properties of the neutron monochromatic beams obtained by multiple Bragg reflections realized in bent perfect single crystals.
   [6] Mikula, P.; Vrana, M.; Saroun, J.; Krejci, F.; Seong, B. S.; Woo, W.; Furusaka, M., Some properties of the neutron monochromatic beams obtained by multiple Bragg reflections realized in bent perfect single crystals. Journal of Applied Crystallography 46 (2013) 128;
   [21] Mikula, P.; Vrána, M.; Šaroun, J.; Seong, B. S.; Woo, W., Double Bent Crystal Monochromator for High Resolution Neutron Powder Diffraction. Powder Diffraction 28 (2013) S351.
2. Data were reviewed on macro and trace elements and radionuclides in edible wild-grown and cultivated mushrooms. Great attention was paid to the occurrence of toxic elements As, Cd, Hg and Pb and radionuclides.
   [19] Falandysz, J.; Borovička, J., Macro and trace mineral constituents and radionuclides in mushrooms: health benefits and risks. Applied Microbiology and Biotechnology 97 (2013) 477.
3. The ion microprobe was used to obtain 3D elemental maps of biological and geological samples by the PIXE, PIGE and RBS methods. The microbeam, especially with heavier ions (C, N, O), was also used for ion beam writing and production of optical nanostructures as grating grids and waveguides.
   [30] Kratochvíl, T.; Pouzar, M.; Novotný, K.; Havránek, V.; Černohorský, T.; Zvolská, M., The use of laser-induced breakdown spectroscopy for the determination of fluorine concentration in glass ionomer cement. Spectrochimica Acta B 88(2013) 26;
   [31] Platkevič, M. - Jakůbek, J. - Havránek, V. - Jakůbek, M. - Pospíšil, S. - Semián, V. - Žemlička, J., Evaluation of local radiation damage in silicon sensor via charge collection

mapping with the Timepix read-out chip. Journal of Instrumentation 8 (2013) C04001;
[32] Jakůbek, M.; Jakůbek, J.; Žemlička, J.; Platkevič, M.; Havránek, V.; Semián, V., 3D imaging of radiation damage in silicon sensor and spatial mapping of charge collection efficiency. Journal of Insrtumentation 8 (2013) C03023.

4. Results were compared of Hg determination in contaminated soils that were obtained by atomic absorption spectrometry (AAS) using an AMA-254 device and radiochemical neutron activation analysis (RNAA) for samples with different masses and an excellent agreement was found.
   [23] Sysalová, J.; Kučera, J.; Fikrle, M.; Drtinová, B., Determination of the total mercury in contaminated soils by direct solid sampling atomic absorption spectrometry using an AMA-254 device and radiochemical neutron activation analysis. Microchemical Journal 110 (2013) 691.
5. We have performed experiments with the ion implantation in order to prepare nanostructures with distinctive optical and magnetic properties for a potential use in laser technologies and spintronics. The elemental composition and structural changes of implanted materials was studied by the RBS Channeling and ERDA methods.
   [36] Nekvindova, P.; Cajzl, J.; Svecova, B.; Mackova, A.; Malinsky, P.; Oswald, J.; Vacik, J.; Spirkova, J., Erbium diffusion from erbium metal or erbium oxide layers deposited on the surface of various LiNbO3 cuts. Optical Materials 36 (2013) 402;
   [9] Cajzl, J.; Nekvindova, P.; Mackova, A.; Malinsky, P.; Oswald, J.; Vacik, J.; Spirkova, J., Electric field-assisted erbium doping of LiNbO3 from melt, Scripta Materialia 68 (2013) 739;
   [25] Macková, A.; Malinský, P.; Sofer, Z.; Šimek, P.; Sedmidubský, D.; Mikulics, M.; Wilhelm, R. A., A study of the structural properties of GaN implanted by various rare-earth ions, Nuclear Instruments & Methods in Physics Research Section B 307 (2013) 446.
6. We have prepared composites and nanostructures onthe basis of polymer-metal with distinctive electric and magnetic properties for potential use in electronic devices. We have performed the MC (Monte Carlo) simulation of electronic transport in such structures as a function of morphology and number concentration of the metal nano-particles and various content of carbon alotropes. The nuclear analytical techniques were subsequently used, to study these complex nanostructures.
   [26] Macková, A.; Malinský, P.; Mikšová, R.; Pupíková, H.; Khaibullin, R. I.; Valeev, V. F.; Švorčík, V.; Slepička, P., Annealing of PEEK, PET and PI implanted with Co ions at high fluencies. Nuclear Instruments & Methods in Physics Research Section B 307 (2013) 598;
   [27] Macková, A.; Malinský, P.; Mikšová, R.; Khaibullin, R. I.; Valeev, V. F.; Švorčík, V.; Slepička, P.; Šlouf, M., The characterization of PEEK, PET and PI implanted with Co ions to high fluences, Applied Surface Science 275 (2013) 311;
   [28] Schaub, A.; Slepička, P.; Kašpárková, I.; Malinský, P.; Macková, A.; Švorčík, V.; Z. Kolská, Gold nanolayer and nanocluster coatings induced by heat treatment and evaporation technique. Nanoscale Research Letters 8 (2013) 248.
7. We have determined the elemental composition and concentration depth profiles of the multilayer structures with distinctive mechanical and electrical properties prepared by plasma deposition.
   [29] Jelínek, M.; Havránek, V.; Remsa, J.; Kocourek, T.; Vincze, A.; Bruncko, J.; Studnička,

V.; Rubešová, K., Composition, XRD and morphology study of laser prepared LiNbO3 films. Applied Physics A - Materials Science & Processing 110 (2013) 883;
[34] Vlček, J.; Steidl, P.; Kohout, J.; Čerstvý, R.; Zeman, P.; Prokšová, S.; Peřina, V., Hard nanocrystalline Zr-B-C-N films with high electrical conductivity prepared by pulsed magnetron sputtering. Surface and Coatings Technology 215 (2013) 186.

8. Effect of SHS conditions on microstructure of NiTi shape memory alloy was studied.
   [2] Novák, P.; Mejzlíková, L.; Michalcová, A.; Čapek, J.; Beran, P.; Vojtěch, D., Effect of SHS conditions on microstructure of NiTi shape memory alloy. Intermetallics 42 (2013) 85.
9. Controllable fabrication of amorphous an Si layer by energetic cluster ion bombardment has bean validated.
   [14] Lavrentiev, V.; Vorlicek, V.; Dejneka, A.; Chvostova, D.; Jager, A.; Vacik, J.; Jastrabik, L.; Naramoto, H.; Narumi, K., Controllable fabrication of amorphous Si layer by energetic cluster ion bombardment. Vakuum 98 (2013) 49.
10. Hg determination in Tycho Brahe´s sectioned hair samples by RNAA proved that the world- renowned Danish astronomer was not poisoned by mercury.
   [18] Rasmussen, K. L.; Kucera, J.; Skytte, L.; Kameník, J.; Havranek, V.; Smolik, J.; Veleminsky, P.; Lynnerup, N.; Bruzek, J.; Vellev, J., Was he murdered or was he not? - Part I: Analyses of Mercury in the Remains of Tycho Brahe. Archaeometry 55 (2013) 1187.

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

11. We have studied the structural and electrical properties of thin NiOx films prepared by ion beam sputtering of Ni and subsequent thermo-oxidation.
   [13] Horák, P.; Lavrentiev, V.; Bejšovec, V.; Vacík, J.; Daniš, S.; Vrňata, M.; Khun, J., Study of structural and electrical properties of thin NiOx films prepared by ion beam sputtering of Ni and subsequent thermo-oxidation. European Physical Journal B 86 (2013) 470.
12. Within the methods available in infrastructure we also carried out studies of the electronic behavior of micro-structured polymer foils immersed in electrolyte.
   [11] Souza, C. T.; Stori, E. M.; Fink, D.; Vacik, J.; Svorcik, V.; Papaleo, R. M.; Amaral, L.; Dias, J. F., Electronic behavior of micro-structured polymer foils immersed in elektrolyte. Nuclear Instruments and Methods in Physics Research B 306 (2013) 222.
13. We have determined teh "asymptotic normalization coefficient" reaction of the ^{18}O(d, γ)^{19}O through the study of reaction ^{18}O(d,p) ^{19}O by the ANC Method.
   [7] Burjan, V.; Hons, Z.; Kroha, V.; Mrázek, J.; Piskoř, Š.; Mukhamedzhanov, A. M.; Trache, L.; Tribble, R. E.; La Cognata, M.; Gulino, M.; Lamia, L.;Pizzone, G.; Puglia S. M. R.; Rapisarda, G. G. et al., Experimental study of the O-18(d, p)O-19 reaction and the ANC Method. Journal of Physics: Conference Series 420 (2013) 012142.
14. Tomographic Study Of Ion Tracks By Ion Energy Loss Spectroscopy has developed a new method of studying the 3D structure in thin films of polymers.
   [42] Vacik, J.; Havranek, V.; Hnatowicz, V.; Fink, D.; Apel, P., Tomographic Study Of Ion Tracks By Ion Energy Loss Spectroscopy. AIP Conference Proceedings (2013) 663.
15. Ion channeling study of lattice distortions in chromium-doped SrTiO3 crystals.
   [15] Lavrentiev, V.; Vacik, J.; Dejnaka, A.; Trepakov, B.; Jastrabik, L., Ion channeling study of lattice distortions in chromium-doped SrTiO3 crystals. Physics of the Solid State

55 (2013) 1431.

16. Boron and nitrogen doping of graphene via thermal exfoliation of graphite oxide in a BF3 or NH3 atmosphere: contrasting properties.
    [5] Poh, H. L.; Simek, P.; Sofer, Z.; Tomandl, I.; Pumera, M., Boron and nitrogen doping of graphene via thermal exfoliation of graphite oxide in a BF3 or NH3 atmosphere: contrasting properties. Journal of Material Chemistry A 42 (2013) 13146.
17. Cross-sections for the production of 43Sc, 44Sc, and 46Sc isotopes in the 45Sc + 3He reaction were studied.
    [37] Skobelev, N. K.; Kulko, A. A.; Penionzhkevich, Y. E.; Voskoboinik, E. I.; Kroha, V.; Burjan, V.; Hons, Z.; Mrazek, J.; Piskor, S.; Simeckova, E., Cross sections for production of 43Sc, 44Sc, and 46Sc isotopes in the 45Sc + 3He reaction. Physics of Particles and Nuclei Letters 10 (2013) 410.
18. Coupled chemical reactions in dynamic nanometric confinement: Ag2O membrane formation during ion track etching were studied.
    [12] Munoz Hernandez, G.; Cruz, S. A.; Quintero, R.; Garcia Areliano, H.; Fink, D.; Alfonta, L.; Mandabi, Y.; Kiv, A.; Vacik, J., Coupled chemical reactions in dynamic nanometric confinement: Ag2O membrane formation during ion track etching. Radiation Effects and Defects in Solids 9 (2013) 675.
19. Misfit in Inconel-type superalloy was analyzed.
    [58] Strunz, P.; Petrenec, M.; Davydov, V.; Polák, J.; Beran, P., Misfit in Inconel-type superalloy. Advances in Materials Science and Engineering 2013 (2013) 40834.
20. A set of analytical methods have been used to study electrochemistry and in situ Raman spectroelectrochemistry of low and high quality boron doped diamond layers in aqueous electrolyte solution.
    [10] Vlckova Zivcova, Z.; Frank, O.; Petrak, V.; Tarábkova, H.; Vacik, J.; Nesladek, M.; Kavan, L., Electrochimica Acta 87 (2013) 518.
21. High-temperature microstructure of superalloy IN738LC after fatigue testing was determined.
    [39] Strunz, P.; Mukherji, D.; Petrenec, M.; Gilles, R.; Schumacher, G.; Pigozzi, G.; Keiderling, U.; Geue, T.; Gasser, U.; Šaroun, J.; Rösler, J., Small-Angle Neutron Scattering contribution to development of some novel materials. Materials Structure in Chemistry, Biology, Physics and Technology. 20 (2013) 67;
    [43] Petrenec, M.; Strunz, P.; Gasser, U.; Heczko, M.; Zálešák, J.; Polák, J., Nanostructure characterization of IN738LC superalloy fatigued at high temperature. Proceedings of 5th International Conference NANOCON (2013) 1.
22. The first study was conducted according to the photoluminescence of Li-doped Si nanocrystals.
    [57] Klimesova, E.; Vacik, J.; Holy, V.; Pelant, I., Photoluminescence studies of Li-doped Si nanocrystals. Nanomaterials and Nanotechnology 3 (2013) 41456.

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

1. Development of technology for manufacturing of fluorescent nanodiamonds (fNDs) with a high proportion of luminescent NV centers and their subsequent utilization in construction of nanosystems for monitoring of biological processes (bioimaging) in vitro and ex vivo in real time were continuing. This result may be considered as an

exceptional success even in an international context, as the fNDs of these parameters are available only in a few institutions worldwide.

[20] Havlik, J.; Petrakova, V.; Rehor, I.; Petrak, V.; Gulka, M.; Stursa, J.; Kucka, J.; Ralis, J.; Rendler, T.; Lee, S. Y.; Reuter, R.; Wrachtrup, J.; Ledvina, M.; Nesladek, M.; Cigler, P., Boosting nanodiamond fluorescence: towards development of brighter probes. NANOSCALE 5 (2013) 3208.

2. Boron-Doped Graphene: Scalable and Tunable p-Type Carrier Concentration Doping.
   [4] Wang, L.; Sofer, Z.; Simek, P.; Tomandl, I.; Pumera M., Boron-Doped Graphene: Scalable and Tunable p-Type Carrier Concentration Doping. The Journal of Physical Chemistry C 117 (2013) 23251.
3. Design of a new lithium ion battery test cell for in-situ neutron diffraction measurements.
   [16] Roberts, M.; Biendicho, J. J; Hull, S.; Beran, P.; Gustafsson, T.; Svensson, G.; Edstrom, K., Design of a new lithium ion battery test cell for in-situ neutron diffraction measurements. Journal of Power Sources 226 (2013) 249.
4. Low-energy deuteron-induced reactions on 93Nb.
   [3] Avrigeanu, M.; Avrigeanu, V.; Bém, P.; Fischer, U.; Koning, A. J.; Mrázek, J.; Šimečková, E.; Štefánik, M.; Závorka, L., Low-energy deuteron-induced reactions on 93Nb. Physical Review C - Nuclear Physics 88 (2013) 14612.
5. Radionuclide 83Rb for testing of zeolite and implanted calibration sources for the KATRIN project was repeatedly produced. Long term measurements of the sources were accomplished and it was shown that the energy stability of conversion electrons satisfy the KATRIN limit required for monitoring.
   [24] Zbořil, M.; Bauer, S.; Beck, M.; Bonn, J.; Dragoun, O.; Jakoubek, J.; Johnston, K.; Kovalík, A.; Otten, E. W.; Schlosser, K.; Slezák, M.; Špalek, A.; Thummler, T.; Vénos, D.; Žemlička, J.; Weinheimer, C., Ultra-stable implanted Rb-83/Kr-83m electron sources for the energy scale monitoring in the KATRIN experiment. Journal of Instrumentation 8 (2013) P03009.
6. Conductivity of boron-doped polycrystalline diamond films: influence of specific boron defects.
   [1] Ashcheulov, P.; Šebera, J.; Kovalenko, A.; Petrák, V.; Fendrych, F.; Nesládek, M.; Taylor, A.; Vlčková, Z.; Frank, O.; Kavan, L.; Dračínský, M.; Hubík, P.; Vacík, J.; Kraus, I.; Kratochvílová, I., Conductivity of boron-doped polycrystalline diamond films: influence of specific boron defects. THE EUROPEAN PHYSICAL JOURNAL B 86 (2013) 41518.
7. The medical radionuclide 99mTc was prepared by activation of highly enriched 100Mo with 24 MeV protons. After separation from the target, the obtained Sodium (99mTc) pertechnetate was used to test its compatibility with commercially available kits for production of 99mTc-based radiopharmaceuticals.
   [47] Lebeda, O.; Ráliš, J.; Hradilek, P.; Hanč, P.; van Lier, E. J.; Zyuzin, A.; Moša, M., Cyclotron produced Tc-99m: testing compatibility with established kits. European Journal of Nuclear Medicine and Molecular Imaging 40 (2013) S424;
   [50] Zyuzin, A. - van Lier, E. J. - Sader, J. - Guerin, B. - Matei, L. - Lebeda, Ondřej - Ráliš, Jan - Hradílek, Pavel, Journal of Labelled Compounds and Radiopharmaceuticals 56 (2013) 470.
8. Residual stresses determination by neutron diffraction in a 100Cr6 chromium steel

bearing ring.

[40] Rogante, M.; Martinat, G.; Mikula, P.; Vrána, M., Kovové Materiály - Metallic Materials 51 (2013) 275.

9. Investigation of Twinning Activity in Magnesium Using Advanced In-Situ Methods.

   [44] Mathis, K.; Capek, J.; Lukas, P.; Brownd, D.; Clausen, B., Investigation of Twinning Activity in Magnesium Using Advanced In-Situ Methods. Material Science Forum - Light Metals Technology 2013 765 (2013) 532.

10. The DNA plasmid pBR322 was irradiated by protons with energies from 15 to 30 MeV on the cyclotron U-120M and the proportion between direct and indirect damage of the DNA biomolecule was studied. Experimental OH radical yield kinetics was compared to predictions computed by two theoretical models – RADAMOL and Geant4-DNA.

    [52] Michaelidesová, A.; Vachlelová, J.; Litvinchuk, A.; Falk, M.; Falková, I.; Havránek, V.; Štursa, J.; Vondráček, V.; Davídková, M., XXXV. Dni radiační ochrany, Sborník Abstraktů, 23.

Annex 4 – List of publications

3. Utilisation of research infrastructure

Describe utilisation of research infrastructure capacity (according to the type of research infrastructure describe proportionally utilisation, number of accesses, volume of produced, stored or provided data, distribution of users by their affiliation – university, public research institutions, industry). In case of construction of infrastructure describe the current status or data from performed tests or limited service providing, etc.

LC & FNG

Number of irradiation hours: 3 270 hours per year
Applicability of the cyclotron: 81.75%
Statistics of utilization – university / research institutions / industry: 2.19% / 46.28% / 51.53%

LT

Number of hours for ion beam analysis: 1 100 hours per year
Applicability of the Tandetron: 81% for experiments, 19% for maintenance
Statistics of utilization – university / research institutions / industry: 83% / 17% / 0%
(Total time was lower compared to 2012 due to extensive maintenance and installation of additional ion source HVE)

NPL

Operation of the LVR-15 reactor: 216 days
Applicability of the reactor: experiments / service, tests: 42.1% / 57.9%
Statistics of utilization – university / research institutions / industry: 20.7% / 75.5% / 3.8%

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 infrastructure.*

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

I. Number of newly established / running cooperation: 31 / 57
II. Number of newly established / running cooperation in the field: 4 / 8

Annex 5 – List of cooperations

5. Service to Science Community

Indicate the number of users of the infrastructure from the Czech Republic and abroad. Indicate the number of conferences and seminars organized by the infrastructure, 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 of the infrastructure total (from Czech Republic /abroad):
158 (73 / 85)

Number of conferences and seminars organized by the infrastructure:
1 (30 participants from Czech Republic / 5 abroad)

- Scientific seminar: The European Spallation Source ESS - An Opportunity for Czech Organisations and Companies.
  Vila Lanna, Prague, 18th September 2013.
  COLLABORATION AGREEMENT on the construction of a neutron scattering instrument at the ESS, European Spallation Source, ESS AB.

Number of meetings with users:
1 (44 participants from Czech Republic / 14 abroad)

- 1st Joint meeting of the Scientific Advisory Committee (SAC) and Scientific Selection Panels (SSP) and users of the CANAM infrastructure.
  NPI and Hotel Vltava, 15th October 2013, Vila Lanna, Prague, 16th October 2013.

Number of agreements with other instituttions: 27

Annex 6 - List of national grants
Annex 7 – List and characterization of international 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: 14

Annex 7 – List and characterization of international grants

7. Multidisciplinarity

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

Number and titles of scientific disciplines: 18
Particular results are appended in annex.

AC	Archeology, Anthhropology, Ethnology	[18] etc.
BF	Elementary Particles and High Energy Physics	[24]
BG	Nuclear, Atomic and Molecular Physics, Accelerators	[2] etc.
BM	Solid Matter Physics and Magnetism	[2] etc.
BN	Astronomy and Astrophysics	[7] etc.
BO	Biophysics	[22] etc.
CA	Inorganic Chemistry	[4],[5]
CB	Analytical Chemistry	[17] etc.
CC	Organic Chemistry	[20], [51]
CE	Biochemistry	[22] etc.
CG	Electrochemistry	[10]
DD	Geochemistry	[45]
EF	Botany	[19]
EI	Biotechnology	[35]
CH	Nuclear and Quantum Chemistry	[17] etc.
JA	Electronics and Optoelectronics	[1], [9], [36]
JI	Composite Materials	[11]
JJ	Other Materials	[4], [5], [33]

Annex 4 – List of publications

8. Strategic Management of the Scientific Development of the Infrastructure

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

Main characteristics of the infrastructure's scientific strategy:

- maintaining full operation of the existing facilities of the infrastructure,
- 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,
- expansion of scientific selection panels evaluating the designs of scientific projects of domestic and foreign users.

Main strategic infrastructure development:

- acquisition (first part of financing) of the new high-performance cyclotron TR 24 (the cyclotron will enhance the experimental possibilities for generating high flows of fast neutrons and possibilities of conventional and unconventional radionuclides for research and development of radiopharmaceuticals
- for nuclear medicine),
- acquisition of an auxiliary ion generator for the Tandetron allowing a significant improvement of parameters of ionic beams, an increase in the number of hours of operation by making the preparation of the desired ionic beams more effective,
- acquisition of 2 items of 2D position-sensitive neutron detectors.

Installation and commissioning plan of the acquired investment items of infrastructure:

- cyclotron TR 24 – 2015,
- auxiliary ion generator – 2014 (installed in 12/2013),
- 2D neutron detectors – 2014.

B. Stable and Efficient Management

1. The Efficiency of the Use of Funds

Indicate verbally and 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 infrastructure. Indicate the percentage of the budget of the infrastructure that has been obtained from external international grants, in collaboration with industry or other entities using the infrastructure's services.

Provided grant 40 000 000,- CZK was used as follows:

- Personal costs: 13 140 000 CZK
  - salaries, social and health insurance and SF employees of the infrastructure (~29,7 FTE)
- Overhead: 4 220 000 CZK
  - 17.7% of the non-investment grant (the indirect institute expenses ensures the activity of the infrastructure)
- Current expenses 6 430 000 CZK + 200 000 CZK from Target support fund
  - current materials, computer technology, spare parts, mediums for the infrastructure operation, utilization of the horizontal channels at he reactor
- Investments 16 210 000 CZK + 1 226 453 CZK from Target support fund
  - investment items see in Annex

No funds from the grant were in 2013.

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 82 765 000 CZK was divided as follows:

Ministry of Education, Youth and Sports	48.3%
Private (means NPI ASCR)	25.0%
International grants	3.7%
Industry Coorporation	22.9%

Annex 8 – Metodics allocation of the actual eligible indirect costs for projects FP7
Annex 9 – List and description of investments

2. Stable Management

Describe your plan for human resources development. Describe your strategy for transparent allocation of the infrastructure's capacity. Provide an organizational chart of the project, changes in staffing of the project. 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 the infrastructure's management in the period.

Human resources development plan:

- training of specialists for the design of accelerator subsystems and target systems (with knowledge of dynamics of the charged particles and simulation of processes during ion acceleration),
- training of specialists for the design of elements of the accelerator and target system technology,
- on-going and future programme of basic and applied neutron research,
- the gradual training of young scientific workers is supported on both accelerators, in cooperation with the Czech Technical University in Prague and Faculty of Mathematics and Physics, Charles University,
- start of generational replacement of technical workers and establishment of a team to attend and operate the neutron generators of the U-120M cyclotron,
- 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, the Faculty of Mathematics and Physics, Charles University, Jan Evangelista Purkyně University, etc.
- training of operators to operate accelerators and related technologies (vacuum chambers, goniometers, electronic instrumentation of nuclear analytical methods, hardware and software for spectroscopy),
- 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),
- management of diploma theses and PhD. theses - education of graduate and postgraduate students,
- utilization of experiences of young scientific workers after their return from research fellowships abroad.

Infrastructure capacity allocation strategy:

- allocation of operating time to the experiments is made through the "Open Access" system where the scientific value of a particular project is evaluated by an international panel of evaluators (62 leading domestic and foreign specialists in the field),
- after evaluating the feasibility of the experiment and based on operational utilization of the infrastructure, positively evaluated projects are allocated operating time by the local commissions - LC Commission (meetings held twice a year), LT Commission and NPL Commission (meetings held as necessary),
- the user portal http://users.canam.ujf.cas.cz is being adapted in order to manage and evaluate designs of experiments.

Changes in personnel staffing:
The following changes were made in 2013:

- change in the position of IR for MAUD (from 1 January 2013) – Vasyl Ryukhtin,
- new appointment was made in the position of IR for SPN-100 (from 1 October 2013) – Charles Hervoches.

New methods of dealing with challenges:

- preparation of incorporation of the infrastructure into bilateral cooperation with major infrastructures IFIN HH (RO) and HZDR Dresden Rossendorf (D),
- continuation of cooperation with the European consortium (NMI3 and ERINDA projects),
- extension of procedures in the framework of design evaluation (scientific evaluation panel, feedback from users, etc.).

Annex 10 – Organizational structure
Annex 11 – Scientific and management focus

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

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

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

On 14 – 16 October, 2013, the first joint meeting of members of the Scientific Advisory Committee (SAC) and members of the Scientific Selection Panels (SSP) of the CANAM infrastructure was organized. The Scientific Advisory Committee drew up the "Report with Activity Evaluation of the Infrastructure" containing the following key recommendations:

- prepare a strategic development plan for the period 2017-2022,
- expand the sponsoring of the infrastructure by new investors and grant agencies,
- create and implement a marketing strategy,
- define own research activities of the infrastructure,

- define the proportion of the infrastructure's own research and of the research of external users,
- define the proportion of utilization of the infrastructure for basic research and for industry.

The modernisation 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

- Completion of structural design and production of a new integral probe for accelerated beam measurement of the existing U-120M cyclotron. The probe allows for a new unique method of ion bombardment on internal rotational targets.
- Basic documents were prepared for tender procedures and implementation of the following stages of reconstruction of the building for the installation of the new TR 24 cyclotron:
    - cyclotron shielding vault made of high-density concrete including the TOF hall (both tender procedure and implementation successfully completed),
    - shielding entrance door system into the cyclotron hall (tender procedure closed, implementation in progress),
    - new building – enclosure, steel structure (tender procedure closed, implementation in progress) internal layout of the building, design of electrical equipment, air-conditioning and cooling technology (tender procedure pending).
- High project value of the TR 24 cyclotron proton beam intensity predetermines the accelerator, in addition to the radiopharmaceuticals programme, also for the preparation of an intensive neutron beam. In addition to the objective of comparative study of utilization of TR 24 and U-120M cyclotrons for fast neutron spectrometry using the time of flight measurement method (Time of Flight, TOF) was
    a) prepared physical design of the ion optic path with two external 'choppers', magnets and quadrupoles was drawn up for the TR-24 cyclotron,
    b) preliminary study of controlled pulsation utilization of the accelerated beam using the cumulative internal beam deflection method by the internal chopper was drawn up for the U-120M cyclotron. Currently, tests of a high-frequency high-voltage chopper power supply system are already in progress.
- For neutron spectrometry using the TOF method, development of the digital processing system of pulse response of scintillation detectors and its experimental testing using the natural pulsation of the generator neutron field with lithium target on the U-120M cyclotron was initiated.

LT

- In accordance with the development plan, installation of an auxiliary ion generator was performed which will significantly enhance the analytical possibilities of the laboratory, improve the beam parameters for the microprobe and, thus, allow for development of methodologies based on ion beam machining.
- The technical equipment of the laboratory was significantly expanded through installation of a new method of bombardment of samples by the external beam – this method was first applied during a study of bombardment effects on cells and allows for even bombardment of larger areas of biological materials in the air under extremely low ion fluencies.

- A two-axis goniometer was completed together with the control software which allows for structural studies (using the RBS, ERDA methods, as well as the PIXE method in 2014) of crystalline materials modified by ion implantation and significantly expands the possibilities of unique structural studies for the purposes of atom positioning in crystalline materials.
- A deflection magnet was designed in cooperation with Danfysik that will be installed, according to the plan, on the channel 0 of the Tandetron accelerator. The new ion path will be intended exclusively for ion implantation – this will allow full separation of the implantation path from analytical systems RBS, ERDA, PIXE and the microprobe which require a higher vacuum and different ion beam focusing.
- In accordance with the set objectives, experiments were performed in cooperation with the external proponents in the areas of:
    - synthesis of nanostructures,
    - ion beam machining,
    - characterization of progressive materials using ion analytical methods.
- Fundamental studies of energy brake losses and modelling of passage of energy ions through material have been made.

NPL

- In the framework of innovation of neutron diffraction units, two new 2D detectors have been acquired (it is expected that the detectors will significantly improve the technical possibilities of instruments including data collection software enhancement).
- A new PSD module, including massive shielding, has been installed on the TKSN-400.
- A new sample environment table has been installed on the MAUD diffraction unit.
- Continuation of the transition to the new stepping motor drives in other neutron diffraction units.
- The T-NDP instrument was equipped with a stabilised HV system to energize the laboratory furnace in the UHV chamber.
- Equipment for beta radiation measurements was acquired in order to supplement NAA experiments.

Personnel changes in the project solution:

- Engagement of the new Instrument Responsible NPL (Charles Hervoches).
- Change in the position of Instrument Responsible NPL (Vasyl Ryuktin).
- Engagement of new LC&FNG operators (Tomáš Voseček, Martin Rodák, Michal Gschray).
- Change in the position of the LC&FNG operator (Jaroslav Polák).
- Admission of new NPL doctorands (Gergely Farkas, Jan Čapek).
- Engagement of new technicians for NPL (Petr Januš) and LC&FNG (Vadim Glagolev).

Annex 12 – SAC report 2013

C. Socio-economic Impacts of the Infrastructure

1. Impact on the Economy

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

***II.** Number and volume of contracts with industry concluded in the framework of public procurement to maintenance and renewal of the infrastructure.*

I. Number of jobs in the infrastructure:

total (researchers/ research staff/ other)

individual: 98 (55/ 27/ 16)

FTE: 45.68 (21.46/ 13.56/ 10.66)

II. Number and volume of contracts with industry: 4 (44 487 000 CZK)

1. Construction works on building for new cyclotron 3 (40 287 000 CZK)
2. Two position-sensitive neutron detectors (4 200 000 CZK)

2. Impact on the Society

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

***II.** Indicate number of new textbooks, lecture notes and other practical outputs carried out on the basis of the infrastructure's operation, number and names of curricula using the infrastructure.*

I. Number of master and doctorate students:

Number of internal master/ doctorate students: 3/ 13

Number of external master/ doctorate students: 1/ 26 (18 abroad from total)

Internal master students: M. Lužová, H. Pupíková, I. Greňová

External master students: M. Gulka

Internal doctorate students: T. Vanat, J. Pospíšil, M. Slezák, V. Zdychová, A. Michaelidesová, L. Vyšín, M. Štefánik, R. Mikšová, P. Malinský, P. Horák, G. Farkas, J. Čapek, J. Kubrová

External doctorate students: Š. Dědek, V. Hubka, R. Effenberg, H. Raabová, J. Havlík, J. Šlegrová, A. Michalcová, V. Petráková

External foreign doctorate students : J. Petzold, M. E. Perillo, G. F. D. Betta, R. Mendicino, D. Palma, E. Voskobionik, G. L. Guardo, K. Voronina, N. Gubanova, T. Khanova, V. Zinth, E. Velichko, K. Ezdakova, L. Karge, S. Seidlmayer, C. Galinha, X. Yang, P. Ascheulov

II. Number of other practical outputs:

Number of lectures and study programmes utilizing the infrastructure: 14

- Neutron Physics lecture (56 hours/semester), Department of Physics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Radionuclide Applications I lecture (24 hours/semester), Applications of Natural Sciences programme, Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Radionuclide Applications II lecture (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 lecture, Nuclear Chemistry programme, Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Radioanalytical Methods lecture (18 hours/semester), Geology programme – General Subjects, Faculty of Science, Charles University in Prague.
- Radionuclide Preparation lecture (26 hours/semester), Applications of Natural Sciences study programme, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Basics of Physics of Nuclear Reactions lecture (52 hours/semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Experimental Neutron Physics lecture (28 hours/semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Microdosimetry lecture (28 hours/semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Radiology lecture (28 hours/semester), Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague.
- Introduction to Theory of Measurement lecture (13 hours/semester), Jan Evangelista Purkyně University, Ústí nad Labem.
- Physical Practicum lecture (39 hours/semester), Jan Evangelista Purkyně University, Ústí nad Labem.
- Atomic and Nuclear Physics lecture (20 hours/semester), Jan Evangelista Purkyně University, Ústí nad Labem.
- Atomic and Nuclear Physics lecture (65 hours/semester), Jan Evangelista Purkyně University, Ústí nad Labem.

Guidance of internal bachelor, diploma and PhD. theses:

- number of PhD. theses: 14,
- number of diploma theses: 1.

Other programmes:

- Lectures in the framework of 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 Summer School for Mathematics and Physics Teachers collection, publisher: Jan Evangelista Purkyně University, Ústí nad Labem.
- Study support prepared in the framework of the MeVaPox project (project of the Ministry of Education, Youth and Sports of the Czech Republic) http://mevapox.ujep.cz – prepared for the innovated course Atomic and Nuclear Physics – technological applications, Jan Evangelista Purkyně University, Ústí nad Labem.

3. Impact on Innovation

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

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

I. Number of running spin – off companies: 1 (RadioMedic, Ltd.)
II. Number of pilot plants, utility models, demonstrators and patents: 0

D. Appendices

1. Required:

Annex 1 - Table of the real financial costs of the infrastructure project in 2013
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 cooperations
Annex 6 – List of national grants
Annex 7 – List and characterization of international grants
Annex 8 – Metodics allocation of the actual eligible indirect costs for projects FP7
Annex 9 – List and description of investments
Annex 10 – Organizational structure
Annex 11 – Scientific and controlling authorities
Annex 12 – SAC report 2013

In Řež,
Date:

Signature of investigator: