

CAPACITATI

Final activity report

- **Project title:** „*Design of a pan-European Infrastructure for Large Apparatus studying Grand unification, Neutrino Astrophysics and Long Baseline neutrino Oscillations*”
- **Contract no.:** 221 EU/24.07.2013
- **Final realization year:** 2014
- **Project period:** 13 months
- **Legal representative:** *Prof.univ.dr. Mircea DUMITRU, Rector of the University of Bucharest*
- **Project director:** *Prof.univ.dr Alexandru JIPA*

Summary of the activities performed in the frame of 221 EU Project

Introduction

The Universe research, of the origins and its evolution, as well as the connections with the hadronic and nuclear processes observed in complexes interactions represent interesting research directions at international level. Therefore, in the last years the European Union invested important financial resources in research projects having objectives related to these directions. Some of these projects have has major expectations the obtaining of the physical information using both the cosmic radiation and complex accelerator systems – where this is possible. Such project is those having as main objective the establishment of the necessary conditions for the building of a megadetector with sensitive volume of 10^5 - 10^6 m³. For accomplishing this goal, the European Union accepted the financing of the **FP7-INFRASTRUCTURES -2007** Project „*Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification and Neutrino Astrophysics*”. In this project 7 underground laboratories from Europe have been taken into account, placed in the following countries: United Kingdom, France, Spain, Finland, Italy, Poland and **Romania**. At this consortium participated a large number of European institutions and enterprises, including some institutions from Romania. Later, in 2011, the project was developed and it was approved with the new title, namely: „*Design of a pan-European Infrastructure for Large Apparatus studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations*”, having the acronym **LAGUNA-LBNO**. The project number was **284518**. In this project over 40 institutions were involved, including two from Romania, namely: the **Faculty of Physics** from the **University of Bucharest** and the **National Institute for Physics and Nuclear Engineering “Horia Hulubei”**.

CAPACITATI

In the frame of these projects the Romanian groups have had a few objectives, these involving a large problems spectrum, from the geological and radiological characterization of the rocks in the proposed place for megadetector location in Romania – Salt mine „Unirea” from Slănic-Prahova – to the scientific present problems, like establishment of the conditions for neutrino oscillations identification and the neutrino mass hierarchy.

Objectives in the project frame

The scientific program of the LAGUNA-LBNO Collaboration take into account many interesting aspects, including: testing of the grand unification theories, studies of different aspects in the Neutrino Astrophysics – with the consideration of the neutrino oscillations in very long bases (over 2000 km) - and the its implications on the Science, Education and society. Through the assumed objectives by the research group from the Faculty of Physics of the University of Bucharest, in the frame of the LAGUNA-LBNO Collaboration, in the present project, can be mentioned: (i) *identification of the neutrino background sources*, (ii) *improvement of the performances of the detection systems*, (iii) *investigations related to the neutrino oscillations detection*, (iv) *evaluations related to the neutrino mass hierarchy and detection possibilities*.

These objectives have been included in the general major problem of the detection of very rare events with megadetectors (for example, searches for proton decays with a sensitivity without precedent, in comparison with the existing experiments) and they take into consideration the possibilities offered by present Sciences and Technology for emplacement, underground, deeper and deeper, of some megadetectors, for a new programs generation in the Neutrino Physics.

In the projects LAGUNA and LAGUNA-LBNO, for the astroparticles' detection 3 detectors have been analyzed 3 detectors, namely: MENPHYS – with sensitive volume water, LENA – with sensitive volume liquid scintillator – and GALCIER – with sensitive volume liquid argon.

This project is organized in a few work packages. Among the most important work packages are those related to the cavity' designing and detector' building, safety in utilization, impact on the environment, social and economic influences, as well as those dedicated to the possible scientific achievements and to the perspectives.

Work methods evidencing methods of the interesting aspects

The first two major objectives of the project (*identification of the neutrino background sources* and *improvement of the performances of the detection systems*) permitted a few specific research activities, taking into account a few previous preoccupations, as well as the existing experimental set-ups. Previous measurements indicated that the salt rocks from the Salt mine „Unirea” from Slănic-Prahova have a extreme low level of radioactive isotopes (under 1 ppm), fact that assures very good conditions for detection and a significant decrease of the radiation background at underground measurements (*Claudia Gomoiu, Alexandru Jipa, Romul Mircea Margineanu, Ana-Maria Blebea-Apostu - Preliminary measurements of thermoluminescent response in salt rocks – Annual Scientific Session of the Faculty of Physics, June 22th, 2012, Măgurele (oral presentation)*). Also, the measurements of the muon fluxes – at the exterior and in underground – performed with the muon mobile detector (*B.Mitrică, R.Mărgineanu, Iliana*

CAPACITATI

Brâncuș, ..., I.Lazanu, ..Al.Jipa,... - *Romanian Reports in Physics* 62(4)(2010)750-757, B.Mitrică, R.Mărgineanu, ..., I.Lazanu, ..Al.Jipa,... - *Nuclear Instruments and Methods in Physics Research A*654(2011)176-183) permitted new estimations of the effective depth of the mine, in water equivalent meters.

In these conditions a few simulations using specific calculation codes and a few measurements for analyzing possible neutrino/antineutrino background sources from the nuclear research and power nuclear reactors from the geographical area of the mine have been done. The rocks cartography in the salt mine „Unirea” from Slănic-Prahova has been initiated. Taking into account that the surface of the salt mine is around 70000 m², the measurements of the muon fluxes have been done in 10 places, using muon mobile detector existing at IFIN-HH. *The experiments have been performed in collaboration with the group from IFIN-HH.*

The experimental data obtained in this manner have been used to establish the minima sizes of a detector permitting an enough and statistical significant counting rate. *The obtained data for the muon fluxes in underground can be used as a scientific support for the selection of the detector having liquid argon as sensitive volume like a optimum solution for not too deep places, around 1000 mwe.* In this period a few rock parameters have been obtained. These parameters have been used in the calculus of a large size cavity, having around 45 m height, 80 m length and 80 m width, ***cavity necessary for the GLACIER detector emplacement, with cylindrical form, having 75 m diameter and 30 m height, as an alternative at the basic selection of the collaboration for the mine placed around Oulu, Finland.***

In this stage of the project, some simulations for the investigation of the limits of the interaction cross sections for different systems (hadron-hadron, hadron-nucleus, lepton-hadron, lepton-nucleus and nucleus-nucleus) at different energies.

Also, some preliminary proposals for neutrino sources realization at the future experimental set-up ELI-NP, with the possibility of measurements in the underground laboratory, have been done. These imposed new activities related to the increase of the interesting performances of the accelerators and the extracted beams, as well as on the possible impurification from other sources and development of new detectors. The whole activity permitted to realize *a compilation of measured and simulated cross sections.*

During the year 2014 the other two major objectives of the project have been considered. First investigation direction, in this stage, was that related to the neutrino oscillations. The possible sources of these oscillations have been considered, in the context of the present models from the Particle Physics and Astroparticle Physics. The analyze done indicated that it is possible the investigation of these oscillations, both at very long distance, over 2000 km, as the Collaboration LAGUNA-LBNO proposed, and at very short distances, existing a non-zero probability for the investigation of these oscillations at these short distances, under 30 m. Particularly, such neutrino oscillations at very short distances could be investigated at the ELI-NP Laboratory from IFIN-HH, if the laser's energy will be enough high for obtaining a particles flux with high intensity permitting a count rate statistical significant in a enough short acquisition time.

In the research activities from this stage of the project the previous results obtained in the project, mainly those related to the *underground muon fluxes measurements, like a scientific support for the selection of the liquid argon detector as optimal solution for relative small depths, around 1000 mwe, the estimations for the investigation of the limits of the interaction cross sections for different systems (hadron-hadron, hadron-nucleus, lepton-hadron, lepton-nucleus and nucleus-nucleus) at different energies and for different neutrino sources.*

CAPACITATI

All these permitted some interesting estimations for *neutrino oscillations* and for the investigation of the *neutrino mass hierarchy*. Some of the results have been presented at national and international conferences or have been published in journals and proceedings (attached list).

As was mentioned previously, these efforts have been in agreement with the general efforts of the LAGUNA-LBNO Collaboration. The most important results of the collaboration have been included in the paper published in *Journal of High Energy Physics 05(2014)094*, as well as in the documents associated to the application for a new experiment at CERN, in the frame of the *CERN Neutrino Physics platform, application accepted by the CERN Scientific Council*, in June 2014 {*Preprint CERN-SPSC-2014-013, SPSC-TDR-004/31.III.2014, arXiv: 1409.4405V1[physics.ins-det]*}. In present at CERN there is the *Experiment WA-105*. This experiment has as major objective the building of a detector with a cubic shape having liquid argon as sensitive volume of around 200 m³, detector that will be a proximity detector for the pilot detector of 20 kt which will be placed in the Pyhasalmi mine (Finland). *The research group members from the present project are members of the Experiment WA-105, too.*

Appendix

List of published works and of the presented works at national and international conferences

Published works

1. Agarwalla, S. K.; Agostino, L.; Aittola, M.; ..., Călin, M;, Eșanu, T.; ..., Jipa, Al.; ..., Lazanu, I.; ... Ristea, C.; Ristea, Oana; ... et al (Group Author(s): LAGUNA-LBNO Collaboration) - The mass-hierarchy and CP-violation discovery reach of the LBNO long-baseline neutrino experiment - *Journal of High Energy Physics 05(2014)094*
2. Ristea, C.; Jipa, A.; Lazanu, I.; et al. – From Little Bangs to Big Bang – *Romanian Reports in Physics 65(4)(2013)1321-1327*
3. LBNO-DEMO: Large-scale neutrino detector demonstrators for phased performance assessment in view of a long-baseline oscillation experiment - L. Agostino, B. Andrieu, R. Asfandiyarov, D. Autiero, O. Bésida, F. Bay, R. Bayes, A.M. Blebea-Apostu, A. Blondel, M. Bogomilov, M.Călin, ..., T.Eșanu, ..., Al.Jipa, ..., I.Lazanu, ..., L.Niță, ..., C.Ristea, Oana Ristea et al - *CERN-SPSC-2014-013, SPSC-TDR-004 (2014)1-217, arXiv:1409.4405 [physics.ins-det]*
4. Future perspectives in neutrino physics: The Laguna-LBNO case - LAGUNA-LBNO Collaboration (M. Buizza Avanzini for the collaboration) - *Proceedings, 48th Rencontres de Moriond on Electroweak Interactions and Unified Theories: La Thuile, Italy, March 2-9, 2013 2013*, pages 551-554, Editors: Etienne Augé, Jacques Dumarchez, Jean Trân Thanh Vân

Works presented at national and international conferences

1. *On the perspectives of the Romanian involvement in LAGUNA-LBNO Project* - Al.Jipa, I.Lazanu, Oana Ristea, C.Ristea, M.Călin, Claudia Gomoiu, T.Eșanu, R.Mărgineanu, B.Mitrică, Ana-Maria Apostu-Blebea, D.Stanca, Daniela Cheșneanu, L.Niță, D.Stoian, Mihaela Sin, Tănase Alionte, C.Ristea – *Annual Scientific Session of the Faculty of Physics of the University of Bucharest, June 20th 2014, Bucharest, Nuclear and Elementary Particles Physics Section, W4.5*, - in *Program and Abstracts*, page 75, Granada Publishing House, 2014, ISSN 1843-6838
2. *Exploring the possibility of detecting reactions of interest in astrophysical applications using commercial superheated droplet detectors* - I.Lazanu, D.Tănase - *Annual Scientific Session of*

CAPACITATI

the Faculty of Physics of the University of Bucharest, June 20th 2014, Bucharest, Nuclear and Elementary Particles Physics Section, W4.5, - in Program and Abstracts, page 79, Granada Publishing House, 2014, ISSN 1843-6838

3. *Experiments for the study of neutrino oscillations – I.Lazanu, Al.C.Ene - Annual Scientific Session of the Faculty of Physics of the University of Bucharest, June 20th 2014, Bucharest, Nuclear and Elementary Particles Physics Section, W4.5, - in Program and Abstracts, page 83, Granada Publishing House, 2014, ISSN 1843-6838*

4. *On the detection limit determination of the cross sections for elements formation in Nuclear Astrophysics – Alina-Nicoleta Ionescu, Al.Jipa, Daniela Cheșneanu - Annual Scientific Session of the Faculty of Physics of the University of Bucharest, June 20th 2014, Bucharest, Nuclear and Elementary Particles Physics Section, W4.5, - in Program and Abstracts, page 88, Granada Publishing House, 2014, ISSN 1843-6838*

5. *Possible connections among experimental results in accelerator and non-accelerator major present experiments at high energies – Al.Jipa et al – plenary lecture at the opening of the Annual Scientific Session of the Faculty of Physics of the University of Bucharest, June 21th 2013, Bucharest, in Program and Abstracts, pages 9, 69, Granada Publishing House, 2013, ISSN 1843-6838*

6. *Thermoluminescence aspects of the salt from Slănic deposits – Claudia Gomoiu, Al.Jipa et al - Annual Scientific Session of the Faculty of Physics of the University of Bucharest, June 21th 2013, Bucharest, in Program and Abstracts, page 88, Granada Publishing House, 2013, ISSN 1843-6838*

Anexa 1 – RST

Indicatori de realizare ai proiectului

Nr. crt.	Denumirea indicatorilor	UM
1	Investiții noi în infrastructura CDI	Mii lei
2	Gradul mediu de utilizare a echipamentelor CDI	%
3	Număr de entități susținute pentru creșterea capacității de ofertare a serviciilor de experiment	Nr.
4	Număr de reviste finanțate, din care: - Co-editate internațional - Indexate ISI - Include în alte baze de date internaționale recunoscute	Nr . ??? Nr articole
5	Cărți, atlase, dicționare și alte produse cu caracter științific publicate anual, în țară și în străinătate	Nr.
6	Număr de conferințe organizate, din care internaționale	Nr.
7	Număr de expoziții finanțate	Nr.
8	Valoarea investiției în infrastructură și servicii de comunicații	Mii lei
9	Ponderele cercetătorilor care au acces la resursele de informare științifică on-line	%
10	Număr de reviste dedicate popularizării științei	Nr.
11	Număr de proiecte de comunicare știință-societate	Nr.
12	Număr de proiecte de studii prospective	Nr.
13	Număr de proiecte de pregătire a unor participări la programe internaționale	Nr.
14	Număr de participări în proiecte internaționale	Nr.
15	Valoarea apelurilor tematice comune lansate	Mii lei