Romanian research projects at CERN

Progress Report 2012

Bucharest-Magurele, ROMANIA
2012

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Brief overview of the Romania-CERN cooperation

CERN, the European Laboratory for Particle Physics, was founded in 1954 and is one of the largest and most prestigious scientific research centers in the world. It is worth mentioning that the World Wide Web was invented at CERN in 1989. On 4 July 2012 the ATLAS and CMS experiments announced that they observed a new particle: a boson, most probably identifiable with the Standard Model Higgs boson.

Until 1989 the participation of Romanian researchers in CERN was done almost exclusively through the Joint Institute for Nuclear Research (JINR) in Dubna, Russia. A relevant moment of that time, in the attempt to establish official/direct relations with CERN, was the visit of CERN Director General to Magurele Physics Platform together with a delegation led by the CERN responsible for relations with non-member countries, in the spring of 1989. This event virtually opened up direct access to CERN for the Romanian researchers immediately after 1990; NA60 was the first experiment at CERN in which Romanian researchers officially participated. Currently, 40 Romanian specialists are working at CERN as employees, associates and fellows and their number has significantly increased in the last years.

The year 2010 marked an important step in strengthening the existing relationship between CERN and Romania by the Agreement on Romania's candidate status for accession to CERN, signed in Geneva on 11 February 2010. The Law 203/2010 lays down the conditions governing the collaboration between Romania and CERN, for a period of 5 years, with a view to preparing Romania's possible accession as a Member State of the Organization. In this regard, a new, important step was made in 2012. Within a restricted session of the Council, held in March 2012, CERN expressed for the first time, the desire to harmonize Romania's rights with the rights of the Associated States in the pre-accession phase to membership. Accordingly, an amendment to the Agreement between Romania and CERN was drawn up.

The research and development activities, performed in Romanian institutions relating to CERN programmes and projects, are carried out based on specific protocols. The funding is provided from the National Plan for Research, Development and Innovation in compliance with the specific regulations in force. The management of these activities is performed by the Institute of Atomic Physics (IFA) according to a financing contract concluded with the National Authority for Scientific Research.

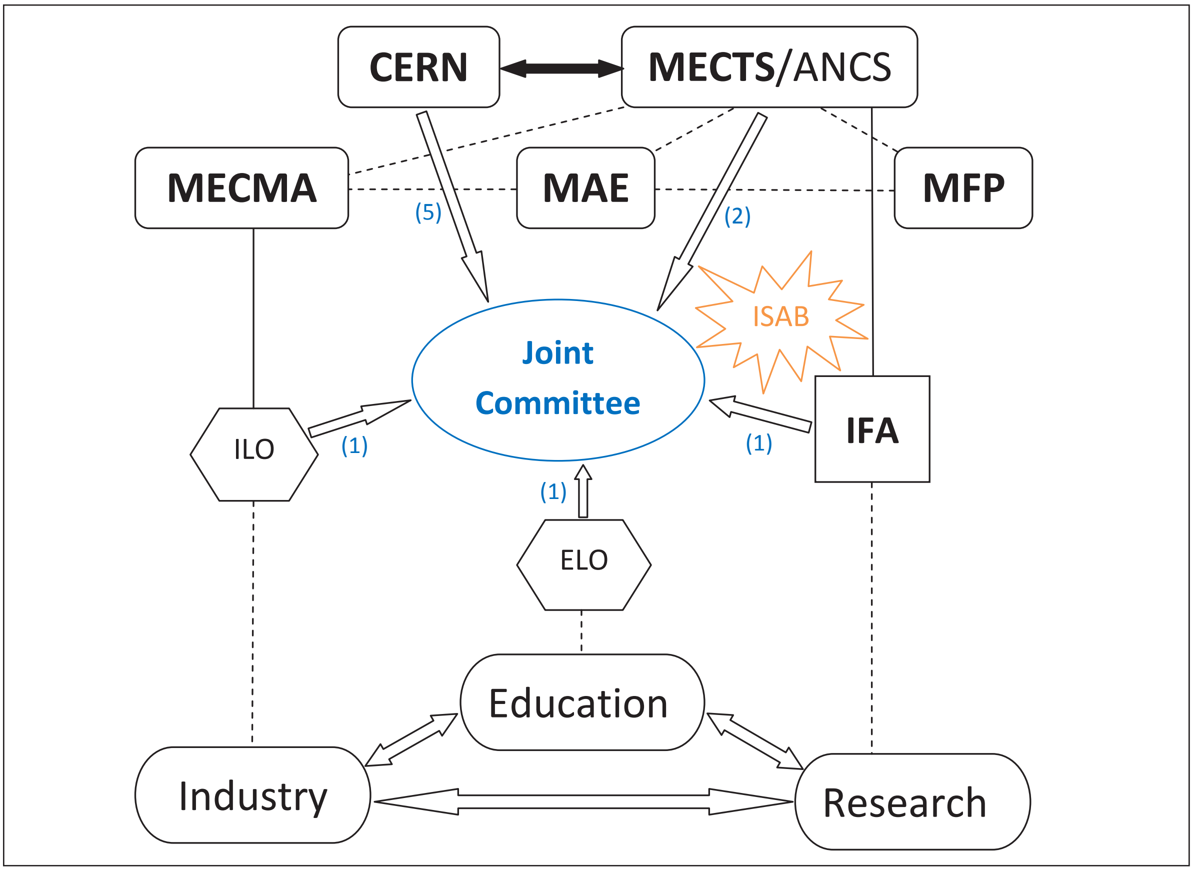
Romania-CERN (RO-CERN) programme began in 2011 as part of the CAPACITIES Programme within the National Plan for Research and Development for the period 2007-2013 (PN-II). The RO-CERN programme aims to stimulate and strengthen the participation of research institutions in the country in CERN's large experiments and scientific programmes in order to increase research capacity and scientific visibility in the field. The main objectives of the programme are: to strengthen the scientific and industrial cooperation (knowledge transfer and high technologies that facilitate economic and social development of the country); to stimulate economic and business environment (participation in the tenders and calls for proposals launched by CERN); to train young researchers; to increase the level of the communication and popularization of scientific results; to promote ethics and equal opportunities in research; to develop interfaces dedicated to the dialogue between science and society; to provide a platform for efficient communication between research, educational, industrial and economic institutions.

Brief overview of the Romania-CERN cooperation

According to the provisions of the Agreement on Romania's candidate status for accession to CERN a RO-CERN Joint Committee was founded. The RO-CERN Joint Committee is responsible with the monitoring of the developments regarding the RO-CERN cooperation. For the year 2012 the RO-CERN Joint Committee members were:

From Romania:
1. Nicolae Victor ZAMFIR, Director General NIPNE, Co-president of RO-CERN Joint Committee, scientific representative;
2. Ionel ANDREI, Director General ANCS, representative of the administrative authority;
3. Florin-Dorian BUZATU, Director General IFA, representative of the public institution responsible with the management of R&D activities related to CERN programmes;
4. Mircea IONESCU, Nuclear energy adviser, Ministry of Economy, Trade and Business, Industrial Liaison Officer;
5. Alexandru JIPA, Professor, University of Bucharest, Educational Liaison Officer.

From CERN:
1. Felicitas PAUSS, Head of International Relations at CERN, Co-president of RO-CERN Joint Committee;
2. Rolf LANDUA, Head of Education and Public Outreach Physics Department;
3. James PURVIS, Head of Recruitment, Programmes and Monitoring;
4. Anders UNNERVIK, Head of Procurement and Industrial Services;
5. Sigurd LETTOW, Director for Administration and General Infrastructure.



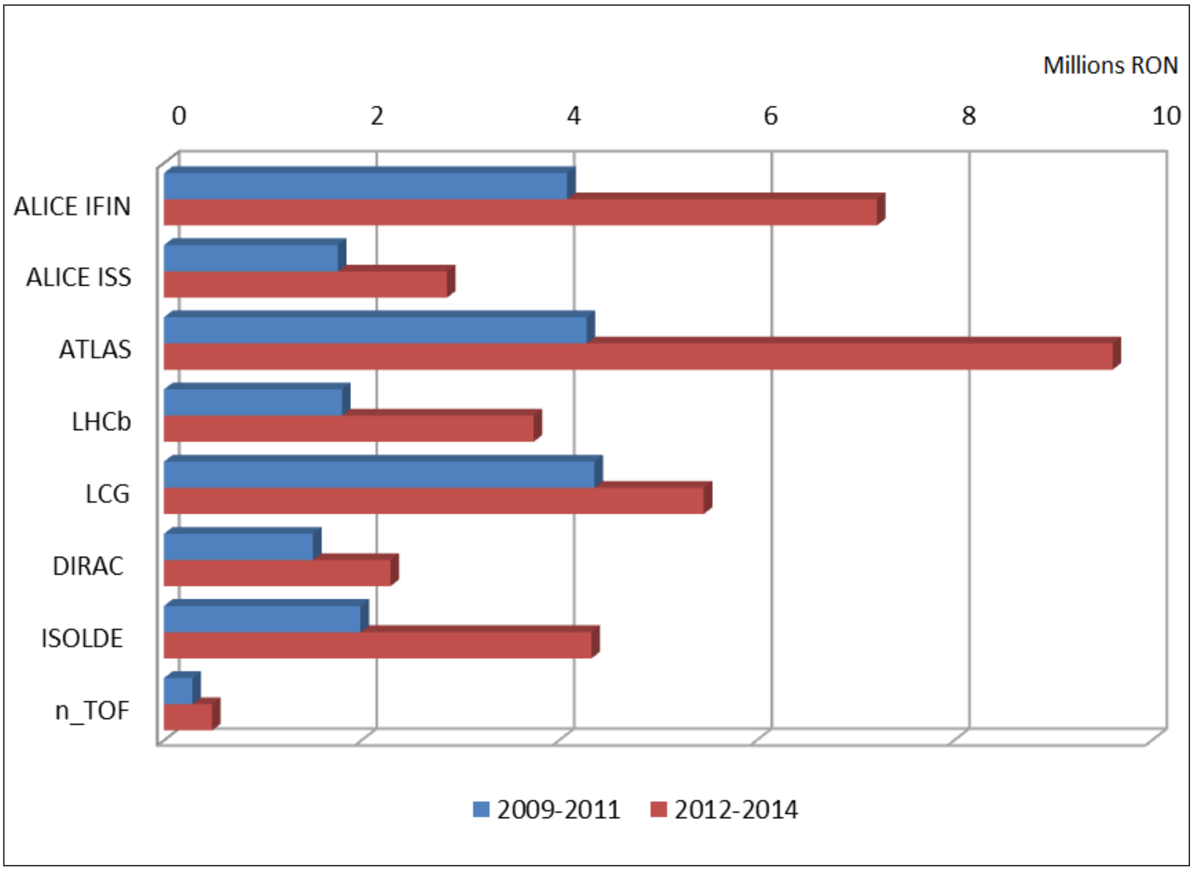
Institutions involved in RO-CERN programme

Brief overview of the Romania-CERN cooperation

In 2011 the International Scientific Advisory Board (ISAB) Romania-CERN was founded. Its mission is to support the Institute of Atomic Physics in the decision-making process regarding high energy physics related to CERN projects. Between 9-11 November 2011 ISAB held its first meeting at the Institute of Atomic Physics in order to evaluate the new project proposals on the participation of Romanian researchers in CERN experiments during the years 2012-2014.

The figure below shows a comparison between the budget allocated for Romanian R & D projects at CERN during 2009-2011 and 2012-2014. Starting with 1 January 2012 eight Romanian projects are funded, the total amount being of 12.000.000 RON/year for each of the next three years. These projects comprise approximately 150 specialists, most of them being researchers from Magurele Physics Platform, but also from other universities and research institutes in Bucharest, Iasi and Cluj-Napoca. The majority of Romanian researchers participating in CERN experiments come from the Horia Hulubei National Institute of Physics and Nuclear Engineering (NIPNE) and a smaller group from the Institute of Space Sciences (ISS).

On 28 September 2012 took place the “Passport to Science - Science Festival 2012” event, organized within the European “Researchers’ Night” event. At the same time, a “RO-CERN Duplex” was attended by collaborators from ATLAS and LHCb experiments.



Budget for Romanian R & D projects at CERN

IFIN-HH Contribution to the ALICE Experiment at LHC

Project Leader: Mihai PETROVICI
Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering
ALICE Collaboration: *http://aliceinfo.cern.ch/*
Project web page: *http://niham.nipne.ro/cap_M3_alice.html*

During 2012, ALICE experiment at LHC continued to take data for p+p and p+Pb collisions at $s^{1/2} = 8$ TeV and $s_{NN}^{1/2} = 5$ TeV. As in the previous years, members of our team had more than 9 blocks of shifts at different Subdetectors (TPC+TRD) or Central Subsystems (DCS, DAQ & LHT, DQM, Safety). NIHAM data center of our Department, component of the ALICE GRID reached and maintained a remarkable contribution to the ALICE Grid due to a competent and permanent activity of members of our group which is by no means less important as maintaining the ALICE experiment running.

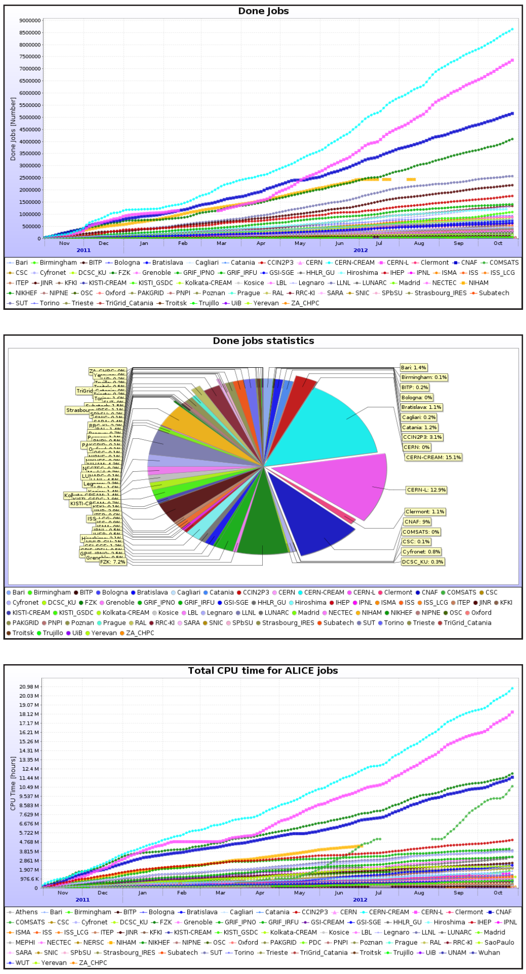


Fig.1: NIHAM performance in 2012

As it is well known, the TRD tracking is component of the ALICE barrel tracking, together with ITS, TPC and TOF improving p_T resolution for tracks and adding/expanding electron identification through dEdx+TR. Besides, due to its positioning at a large distance (>3m) from the vertex and beyond the main tracking device TPC, the TRD detector acts as a tracking analyzer for the 2 main systems which are feeding primary information for tracking i.e. ITS and TPC in rejecting fakes, identifying kinks, checking +/- eta symmetries etc.. As a result of the algorithms developed up to now, it was reached a good and stable efficiency and resolution for different interaction systems (p+p, p+Pb,Pb+Pb). As could be seen in Fig.2 and Fig.3 a remarkable agreement between the MC and data was obtained.

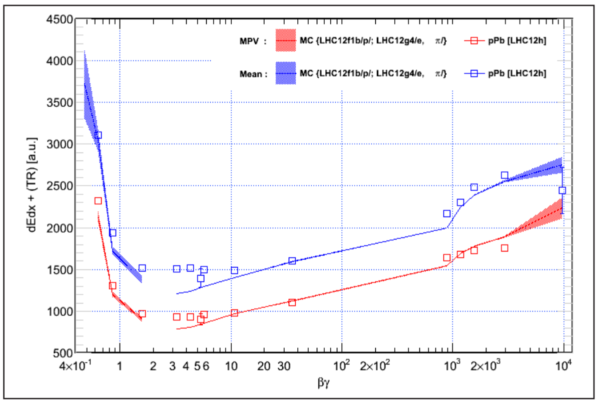


Fig. 2

Fig. 2 shows a comparison between MC in p+Pb and p+p systems and data for p+p in terms of most probable value and mean value of dEdx+TR distribution of electrons as a function of βγ.

In Fig. 3 is represented the dEdx+TR distribution for electrons and pions for MC continuous lines in case of p+Pb collision while by open red circles and blue dot points for p+p collisions data, the electrons being selected using gamma conversion and pions being chosen using Λ and K^0_s decays. A rather good agreement can be observed. As far as the TRD detector provides 3D spatial measurements, one could use this information to check calibration quality in- and inter-detectors, i.e. rρ , z and azimuthal angle.

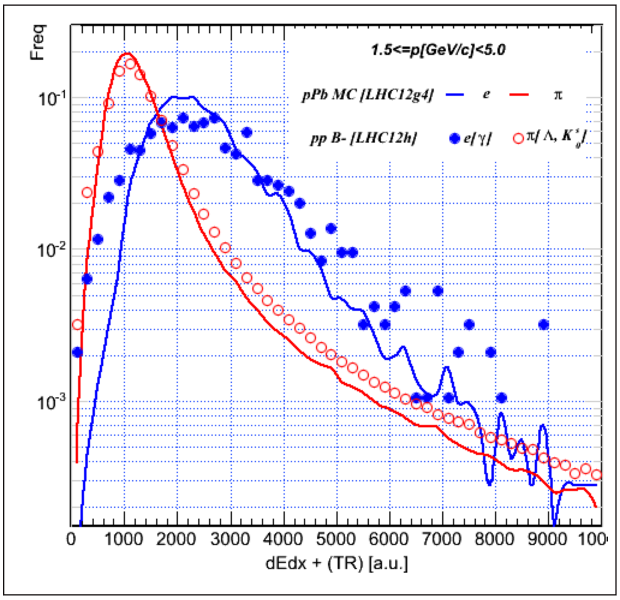


Fig. 3

Spatial resolution monitoring (μ(Δy)) can be used for alignment, efficiency, ExB effects, signal quality, etc., angular resolution monitoring (μ(ΔΦ)) is used for pt resolution, drift velocity, ExB effects, etc. while spatial resolution monitoring along the pads (μ(Δz)) for TPC drift velocity and pz resolution.

A diagnostic of TRD/barrel tracking is continuously developed along these characteristic features in order to provide ALICE wide quality check information for physics analysis and hints for various improvements of the main TRD tracking outcomes namely p_t resolution and electron identification.

One should underline here that this activity and the obtained results are essential for PID performance and tracking quality within ALICE Collaboration and many of the physics analysis are based on them.

Taking into account the ALICE upgrade program we foresee additional directions of general interest in which we could have a substantial contribution, i.e. ITS-TRD tracking for ALICE upgrade, Stand-alone TRD tracking. Obviously, the main target of all these efforts is to access high quality data and extract phyics information from data analysis. Related to this, an important segment of our activities was dedicated for development and improvement of the software environment for analysis and interpretation of the Monte Carlo simulated and experimental data concerning the flow phenomena in p+p collisions at 7 TeV - comparison of the performance for different event shape variables used for selection event shapes and analysis of experimental data. As an example, in Fig. 4 are shown two events from p+p collisions at 7 TeV of the same multiplicity but quite different event shape topology.

The left plot corresponds to a nearly azimuthal izotropic event while the right one to a jet-like event, selected using Fox-Wolfram moments. Such studies and p_T spectra analysis for different classes of events based on above different event shape global observables for data taken by ALICE Collaboration in p+p collisions at 7 TeV are in progress.

The studies reported above were performed for charged particles. Using the information from TOF subdetector it was shown that it is possible to discriminate the electrons and obtain similar information on charged hadrons. The analysis along this line is in progress.

The development of the analysis software used for obtaining the transverse momentum spectra for identified charged hadrons, i.e. pions, kaons and protons generated in proton-proton collisions at 7 TeV is an ongoing laborious process.

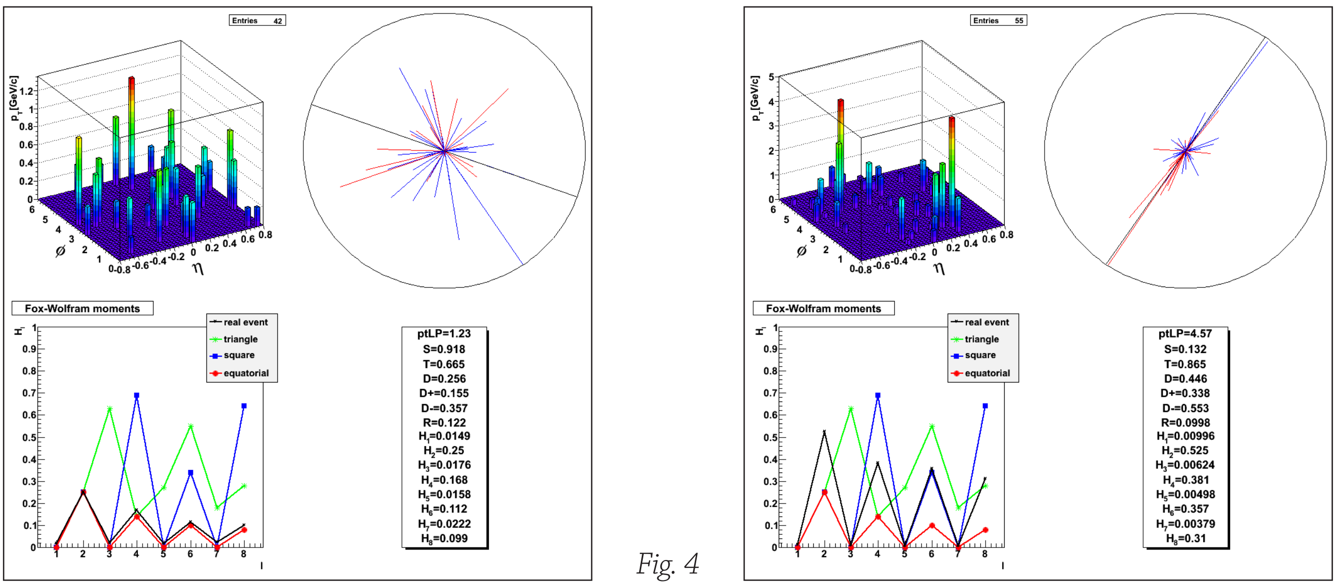


Fig. 4

ALICE upgrade: As it is well known our technical staff was involved in the last period in R&D activities for developing high counting rate TRD and RPC prototypes for CBM experiment requirements and a new peak sense CHIP as FEE for the new type of TRD. The prototypes realized up to now have been successfully tested showing high performance. Definitely the upgrade of the ALICE Central Barrel will improve the performance of the present device in many respects, especially in the segment of soft physics where ALICE should remain competitive relative to the other three experiments at LHC and we are interested in having a contribution. Taking into account all things, some of them briefly mentioned above, and the existing infrastructure and experience in our Hadron Physics Department of NIPNE, definitely we could take the load to build some of the components of the up-grade ALICE program, for example the read-out TPC chambers using GEM technology. This would be a substantial in-kind contribution which we could successfully join. In 2012 we organized the 3rd edition of the Summer Student Program and quite a few Romanian and foreign delegations visited our Department.

Finalizing the extension of HPD infrastructure:

NIHAM Analysis Facility

Conference Hall

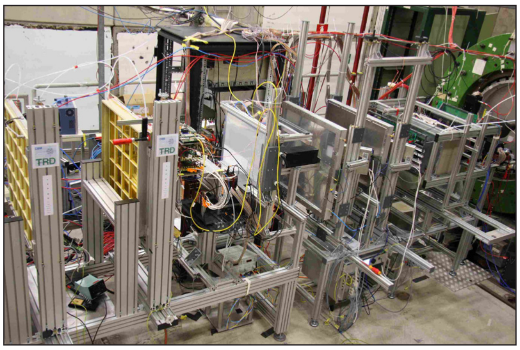
Foyer

Summer Student Program – 3rd edition

Numerous visits in DFH of Romanian and foreign delegations

Impact on other activities and collaborations:

Design, construction & in-beam tests of high counting rate MSMGRPC and TRD and their FEE for CBM Experiment at FAIR:



In-beam test configuration of the RPCs and TRDs prototypes at T9 – PS, CERN, Oct.-Nov. 2012

Others:

This year we hosted a 3 month visit of a visiting professor from abroad. Besides two PhD students which are involved in the analysis mentioned above, two master students recently joined the group and will be involved in the ALICE activities in the next period. Starting from February 2012 a theoretician joined our group with the specific task of development phenomenological models for relativistic heavy ion collisions.

Members of our team had about 19 presentations in the ALICE PAG, PWG-PP, PWG-LF meetings and are co-authors of 27 papers published in ISI journals.

ATLAS Experiment at the LHC

Project Leader: Calin ALEXA
Coordinator: Horia Hulubei National Institute of Physics and Nuclear Engineering
Partners: National Institute of Isotopic and Molecular Technologies Cluj-Napoca, University Politehnica Bucharest, Alexandru Ioan Cuza University of Iasi
ATLAS Collaboration: *http://atlas.web.cern.ch/Atlas/Collaboration*
Project web page: *http://www.nipne.ro/dpp/Collab/ATLAS/index.html*

Due to excellent performance of the LHC the 2012 run has progressed with excellent performance and high ATLAS data-taking efficiency (~93.6%) and approximately 18 fb^{-1} was recorded.

On 4 July, 2012, the ATLAS experiment presented a preview of its updated results on the search for the Higgs Boson. Preliminary results were presented to scientists on site and via webcast to their colleagues located in hundreds of institutions around the world. On 31 July, 2012, the ATLAS Experiment submitted a scientific paper describing the **discovery of a new particle consistent with the Higgs Boson** to Physics Letters B. The significance of observation is thus increased to 5.9σ. The mass of the new particle is measured as 126.0±0.4 GeV.

The Romanian ATLAS Cluster main activities during 2012 are summarized as follows:

- Tile calorimeter: DCS expert on call (30%), monitoring tools support and development
- TDAQ: DAQ Efficiency, Message Reporting System (MRS), IS publishing from HLT code, Control & Configuration plan for LS1, TDAQ deprecated packages
- physics studies: SUSY searches, SUSY software tools maintenance and development
- data analysis and processing infrastructures: maintenance and operation of RO-02-NIPNE Tier2 site, local analysis facility development – Tier3 with GRID services
- upgrade: Tilecal, TDAQ, new commitments – MAMMA (Muon ATLAS MicroMegas Activity) and NSW (New Small Wheel)
- outreach: two events, at Iasi and Cluj Napoca, main targets - high schools and public spaces

Our achievements during 2012 are:

- strengthening our contributions to the upgrade activities
- consolidation and focusing the physics studies, SUSY searches group - 2 PhD and 2 Postdocs
- improved visibility of our results: Physics at LHC, IEEE NSS, SUSY 2012, RO-LCG 2012
- reinforce the collaboration with educational entities
- promote science among the younger generation through outreach events
- first ATLAS Romania annual meeting was organized in Cluj Napoca
- 4 PhD students finalized their thesis

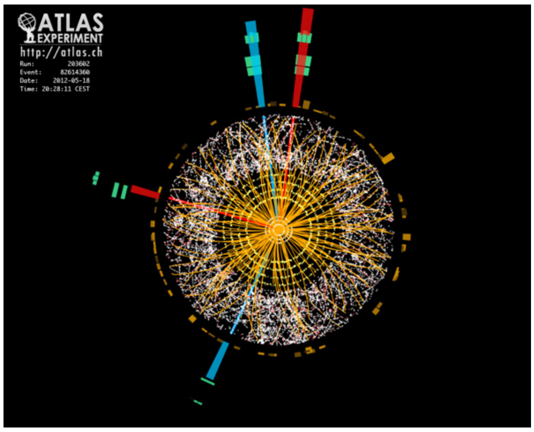


Fig. 1: Candidate Higgs decay to four electrons recorded by ATLAS in 2012.

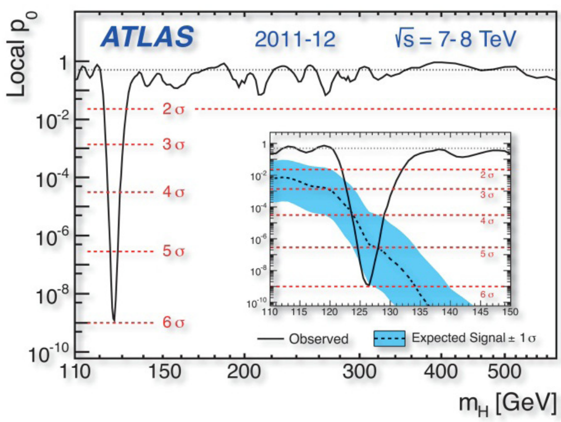


Fig. 2: Result of a statistical analysis of the ATLAS combined Higgs search.

Detailed analysis of jets in p-p and Pb-Pb collisions at ALICE experiment - JETALICE

Project Leader: Daniel FELEA
Institute of Space Sciences from Bucharest-Magurele
ALICE Collaboration: *http://aliceinfo.cern.ch/*
Project web page: *http://iss14.nipne.ro/projects/imotep/index_en.html*

The project is focused on deploying the necessary activities for data analysis from the ALICE experiment from CERN, belonging to the RO-CERN Programme of the R&D National Plan 2007-2013 (Module 3 direction). It pertains to the national strategy for supporting the Romania's participation in the frame of the international partnership regarding the fundamental and applied research activities. Therefore, the Institute of Space Science from Bucharest-Magurele is one of the Romanian institutes that assure the necessary continuity in maintaining the top position among worldwide laboratories that participate in the heavy ion programmes.

Overall objectives: The general objective of the project consists in the detailed analysis of the leading jet structure and the distribution in energy and hadronic content (particles – result of the hadronisation of parton showers). For reaching this goal we are using several models of jet formation. Implementing analysis techniques of simulated data and also, the analysis of proton-proton and Pb-Pb experimental data, are important stages for the project development.

Objectives – 2012: In the first stage of the project we study the energy loss of partons in QCD medium, in p-p interactions at 0.9 TeV, the partonic dynamics and the quenching of the leading jets in order to get a perspective on current theoretical and phenomenological models. Also, the properties of the background event (underlying event), a signature of final state interactions, will be studied. Comparison with model predictions, implemented in Monte-Carlo simulators, will provide information on modeling multiple collisions and scattering of the partons in the final state of the interaction.

Objectives – 2013: In the second stage, based on the analysis at 0.9 TeV p-p interactions, a comparative study of proton-proton interactions at 2.76 and 7 TeV will be made, and also, of the corresponding Monte Carlo data at these energies.

Objectives – 2014: The third phase will present a comparative analysis of the formation and evolution of hadronic jets in 2.76 TeV Pb + Pb interactions, for different tunings of Hijing and Pythia.

Main activities and results:

Physics – Adrian Sevcenco, Daniel Felea and Ciprian Mihai Mitu have finished the train analysis software structure for the proton-proton data analysis at the available energies, in parallel with the analysis of the Monte-Carlo reference data for the same energies. The analysis tasks (processes) have been adapted to the latest modifications from the jet analysis code and optimizations regarding the reading and data processing speed have been implemented. During the second half of the 2012, complex analyses have been performed on multiple data sets (for cumulating statistics). These analyses are related to both, information on the internal structure of jets obtained in collisions and as well, on the performance criteria of the parameters used in the jet finding algorithms. Studying both, the distribution of highest energetic particles for proton – proton interactions (Figures 1 and 2) and as well, the average radius in η-φ space containing 80% of the charged particles, as a function of the transverse momentum of the leading jet (i.e., the jet with the highest transverse momentum), one can distinguish a core with charged particles having R=0.2 within jets. The experimental results are compared with Pythia Monte Carlo simulations.

GRID – Adrian Sevcenco, Ionel Stan and Ion Sorin Zgura: A series of maintenance and optimizing operations have been performed : the EMI RO-13-ISS site has been upgraded to EMI2 middleware version. The AliEn middleware has been upgraded to the 2-19.181 version and both, the RO-13-ISS site, and the alien.spacescience.ro as well, have been updated to the software distribution version in the torrent mode. A data storage server with 75TB has been installed and also, a number of optimizing operations (automation

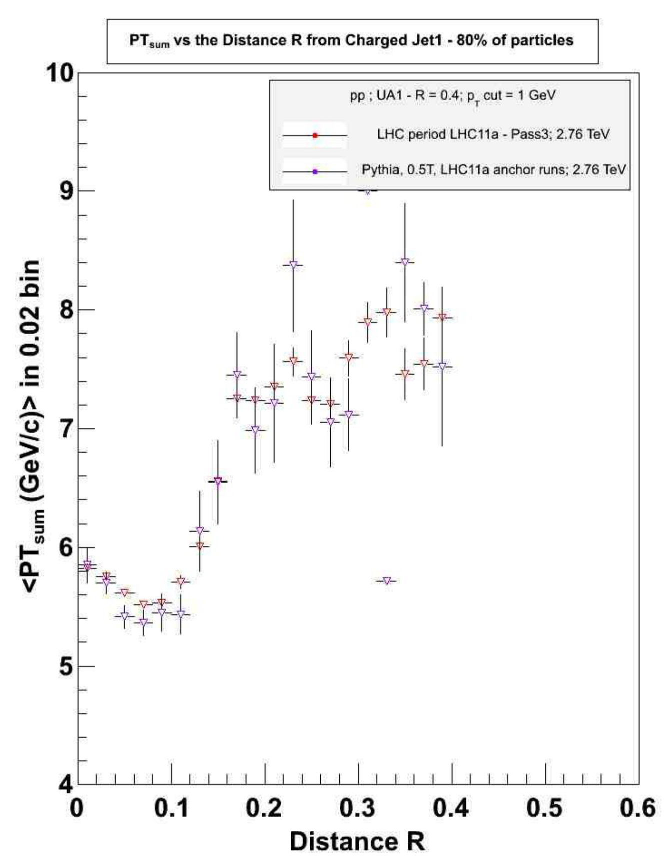


Fig. 1

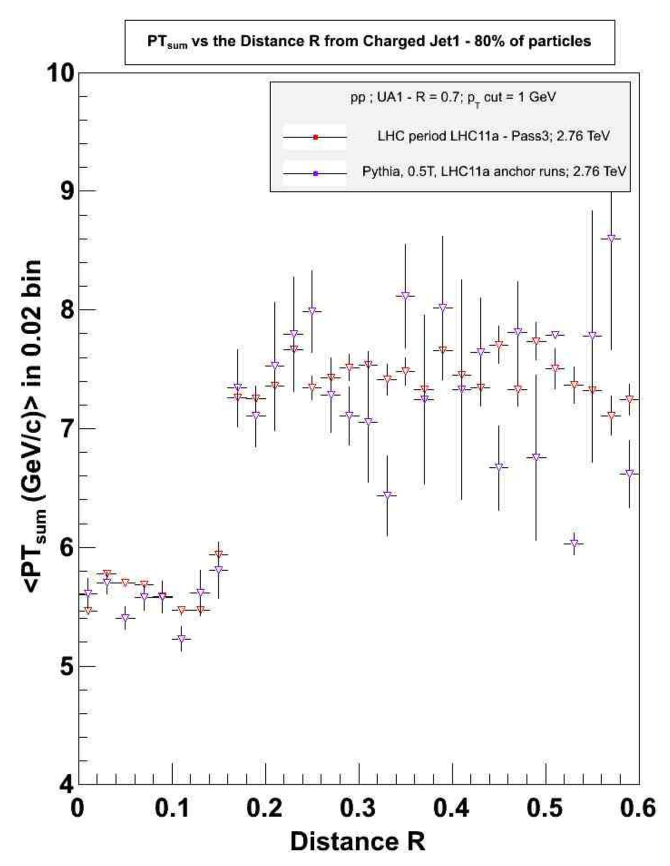


Fig. 2

scripts) and the upgrade preparation for new versions of clusterization systems have been achieved.

Offline – Mihaela Gheata : An important activity has been related to the proper functionality of „Quality Assurance train" in order to ensure the central productions quality corresponding to the acquired data in 2011 and 2012. Running of the central analysis trains and for filtering AODs has been streamlined. Mihaela Gheata has been participating in the development of a specific strategy of the ALICE experiment, linked to data preservation and „open access", within the general context of data preservation policy at the CERN level.

Offline – Mihai Niculescu : He was appointed the expert for the Alice Event Display and Online Event Display and has had a number of presentations during the ALICE Offline weeks and Online Event Display tutorials for the shifters. He is involved in the Online Event Display development and maintenance, contributing with several questions for the DQM Shifter Evaluation Test and participated at the ALICE MasterClasses for promoting Particle Physics for the high schools students.

Perspectives for the future collaboration with CERN: The obtained results regarding the jet analysis in proton-proton collisions are very important for the subsequent studies of jet formation and development in hot and dense medium, because these data represent the reference point for nucleus – nucleus interactions. The effort for the optimization of the geometrical modeler of detectors in the ALICE experiment will be continued as well.

Papers published: 12 ALICE papers (B. Abelev, ..., A. Danu, D. Felea, A. Gheata, M. Gheata, M. Haiduc, D. Hasegan, C.M. Mitu, A. Sevcenco, I. Stan, I.S. Zgura et al.)
Proceedings Papers (presented at international conferences): 1
Papers presented at the Offline Upgrade Forum: 1
Participations at GridKa School 2012 at the Karlsruhe Institute of Technology, Germany: 2

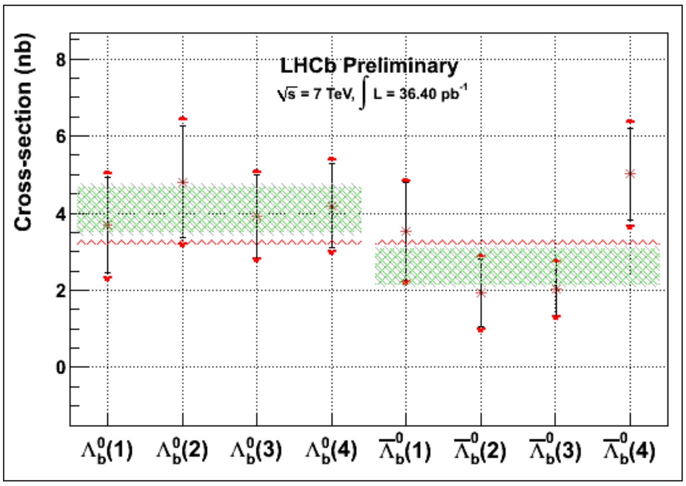
LHCb – from strangeness to b-physics and beyond

Project Leader: Raluca Anca MURESAN
Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering
LHCb Collaboration: *http://lhcb.web.cern.ch/lhcb/*
Project web page: *http://www.nipne.ro/dpp/Collab/LHCb/*

The LHCb experiment [1] is designed to put in evidence the physics beyond the Standard Model (BSM) by precise measurements of CP violation and rare decays, using hadrons that contain beauty (b) or charm (c) quarks. The sixty-seven articles and hundred conference contributions exploiting the recorded pp data made a significant impact on the flavour physics field and proved the excellence and uniqueness of heavy flavour studies performed with a dedicated experiment at a hadron collider. The precise vertexing and tracking, the excellent particle identification capabilities and the unique phase-space coverage among the LHC experiments, allowed LHCb to produce extremely interesting results also outside its core program: light particle and electroweak gauge boson production measurements, and searches for the long-lived new particles. The planned pA run will confirm the LHCb potential in this field of study. Following the strategy initiated at the beginning of the 2011, the Romanian LHCb group present involvement includes soft-QCD, b-baryons production and radiative decay studies. Another activity of our group is R&D work towards a choice of technology for the current RICH system upgrade. We also participate to service tasks and shifts to accomplish our obligations towards the LHCb collaboration.

The results of our studies of strangeness production performed at different energies, work in progress, will help to shed light on the hadronization process allowing to study the extrapolation in energy, as well as in the phase-space, of the existent soft-QCD models. Recently the cross-section measurement of Lb0 using the data recorded in 2010 [7] was finalized. The result was presented, on behalf of the LHCb collaboration, by one of our group members, together with some other results, to the international conference LHC days in Split. The analysis, the second of this kind published at LHC is extending the phase space in which the Lb0 cross-section is measured. towards high rapidity and low transverse momentum, having an important contribution to an almost uncharted territory. Based on the previous research of the LHCb radiative decay group, when one member of the IFIN-HH group worked on optimizing the B-meson candidate selection requirements and on background studies using samples of simulated events, an article was published on the radiative decay of at the beginning of the year [3]. One more article was already released this year by the radiative decay group, in which our members are active, superseding the measurement of the ratio of Bs®fg/Bd®K*g branching fractions and adding the measurement of the ACP for the Bd®K*g decay [4]. A talk was delivered on behalf of the LHCb collaboration, by one of the our group members, at the CIPANP-2012 international conference, and a conference proceedings was submitted for publication [5].

On the service-tasks side, the work on the integration of the RIVET mini component framework in the simulation software of the LHCb collaboration (GAUSS) was continued and commissioning of the software is currently being performed. The work on the improvement of the mechanism of storing and propagating of the control statistics for the simulation files produced by LHCb is on going, while we maintain the contribution of our group to the activity of the international LHCb subgroup that works on the interface of the PYTHIA 8 generator to GAUSS as well as to its subsequent optimization. We started this year a collaboration with the LHCb group from the CPPM, Aix-Marseille Université, CNRS/IN2P3,



Λ_b^0 cross-section measurement LHCb-CONF-2012-031

for extending the present functionalities of the software platform for distributed analysis DIRAC used by LHCb while continuing the successful exploitation of the local GRID clusters.

Following the Letter of Intent for the LHCb Upgrade [6], LHCb published this year a Framework TDR for the LHCb Upgrade [7], giving an overview of the time line, cost and expression of interest from physics institutes both in terms of physics studies and software and hardware contributions for the detector. Our interest goes towards participating to the upgrade of the Ring Imaging CHerenkov (RICH) sub-detector. One aims to replace the current dedicated photon detectors (pixel HPDs), which have a read-out frequency limited to 1 MHz by another system capable of supporting the 40 MHz rate foreseen after the upgrade. One such solution, under investigation in 2012, is based on using MaPMTs (Multi-anode Photo Multiplier Tube) which are connected to 64 input channel chips MAROC 3 in order to read the photon generated signal. Our colleagues participated to these studies as well as to the test beam in the autumn of 2012.

A series of outreach activities were organized by members of our group together with other Romanian groups from LHC collaborations or independently. Also, with great help from the LHCb outreach responsible, she was the host of a live webcast from the LHCb control room on the occasion of the festivities organized in Bucharest on the Researcher's Night (September 28, 2012). For this event we prepared the Romanian version of the LHCb promotional movie subtitles, movie that was screened during the event.

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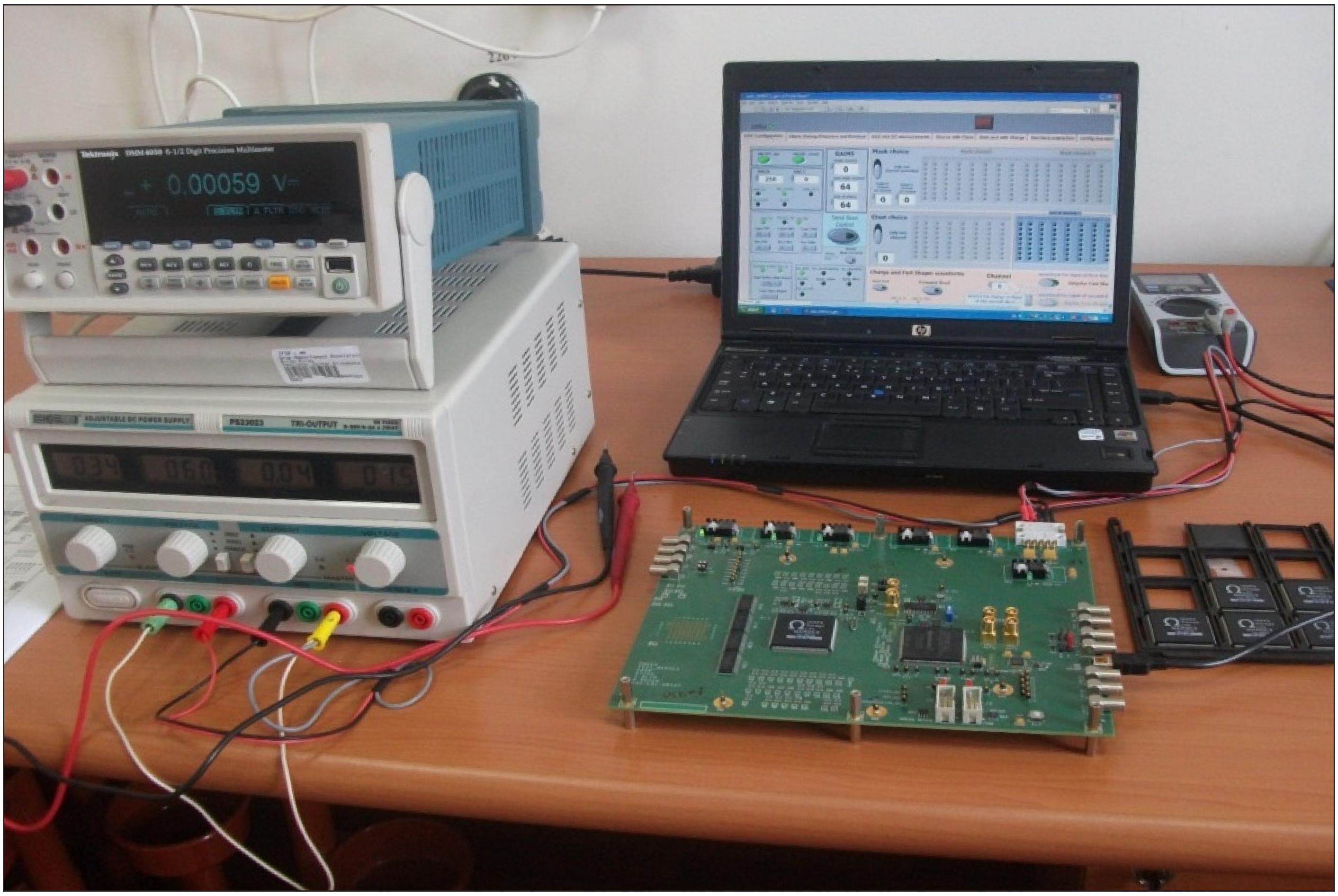

MAROC 3 chip and test board

National Contribution to the Development of the LCG Computing Grid for Elementary Particle Physics (CONDEGRID)

Project Leader: Mihnea DULEA
Coordinator: Horia Hulubei National Institute of Physics and Nuclear Engineering
Partners: Institute for Space Sciences, National Institute of Isotopic and Molecular Technologies Cluj-Napoca, Alexandru Ioan Cuza University of Iasi, University Politehnica of Bucharest.
LCG Collaboration: *http://lcg.nipne.ro/condegrid/*
Project web page: *http://lcg.web.cern.ch/lcg/*

As recently stated by Rolf-Dieter Heuer, CERN Director General, the discovery of the Higgs-like particle has only been possible because of the extraordinary achievements of the experiments, infrastructure, and the grid computing. The merits of the Worldwide LHC Computing Grid (WLCG, http:// http://wlcg.web.cern.ch/) in accelerating the scientific discovery have long been recognized by its main beneficiaries - the international community of researchers working in elementary particle physics. Within WLCG, since 2006 Romania contributes to the general effort of providing computing support for three LHC experiments through the Romanian Tier-2 federation (RO-LCG), which is a consortium of five institutions that host the grid centres involved in the collaboration with CERN (http://lcg.nipne.ro).

The coordination and the monitoring of the RO-LCG consortium is funded from the CONDEGRID project, whose main objective is the development and exploitation of the national Grid system for the storage, processing, and analysis of the data for ALICE, ATLAS, and LHCb experiments.

The main goals of the project are the optimization of the Grid infrastructure, the implementation of new technologies and new monitoring solutions aming at the enhancement of the performance, reliability and quality of the Grid services provided at the national level, and the overall increase of the participation in the computational support of the LHC experiments.

The specific objectives of the project, listed below, are strongly correlated to the requirements of the Memorandum of Understanding for Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid (MoU), which was concluded in March 2006 between CERN and the National Authority for Scientific Research.

- Fulfillment of the levels of hardware resources which are annually pledged, and the increase of the efficiency in providing Grid services
- Realization of the minimal levels of service availability which are specified by the MoU for the Tier-2 centres and federations of centres
- Development, implementation and operation of own software tools for monitoring and accounting of resources and services in RO-LCG
- Provision of support for the administration, operation, and maintenance of the grid centres
- Improvement of the RO-LCG management and of the communication within the consortium
- Access to and implementation of advanced technologies for improving the RO-LCG infrastructure
- Ensuring a better coordination between RO-LCG and the technical and organizational structures at the national and international level, and a greater visibility within the WLCG collaboration
- Dissemination of RO-LCG activities and of the results of the project.

The project has funded the development of new LCG centres in Cluj, Iasi and Bucharest, the upgrade of the distributed system of resources, and the modernization of the data communication infrastructure in order to support the traffic generated by the Grid production. Annual upgrades of the processing and storage capacities are performed for increasing Monte Carlo event simulation and for end-user analysis, according to the experiments request and following the MoU specifications. Also, various technical solutions are implemented in order to improve the Grid availability of these resources.

Today, RO-LCG counts 7 grid sites, which are connected through the 10 Gbps backbone of the NREN RoEduNet to the European GEANT network. Together, these sites dedicate to the WLCG collaboration more than 4800 logical CPUs and 1,8 PetaBytes of storage space, providing 98% of the total Grid production of the country.

Since the year of the first data taking by LHC (2010), more than 24 million LCG jobs were processed within RO-LCG, consuming 200 million normed CPU hours (expressed in HEPSPEC06 units). The growing of the RO-LCG performance is visible in the accounting data recorded by international databases. According to the data published by the EGI accounting portal (http://accounting.egi.eu), between July 2011 and June 2012 RO-LCG provided 3.54 % of the total number of jobs processed by all the Tier-2 centres worldwide, ranking 8th of 33 countries in the WLCG collaboration (Fig.1).

Given the planned increase of some experiments' trigger rates and of the LHC luminosity, which are expected to generate significantly larger amounts of experimental data, the project devises the right strategy for adapting the local infrastructure to the new specific conditions, such that the storage/processing capacities, and the throughput of data transmission across LCG and within the resource centres will increase. In this respect, the project is essential for the continuation of the contribution that RO-LCG should provide to WLCG in 2013-2014. Its main goals are the further optimization of the existing RO-LCG infrastructure, the improvement of the quality of service, and the implementation of new technical solutions for the handling, processing and reprocessing of the increasing amount of the analysis data which is generated during this period. Two stages are planned: a) the improvement of the Grid support for reprocessing and analysis of the LHC experimental data (2013); c) the adaptation of the RO-LCG Grid infrastructure to the new computing requirements of the experiments after the planned LHC break (2014).

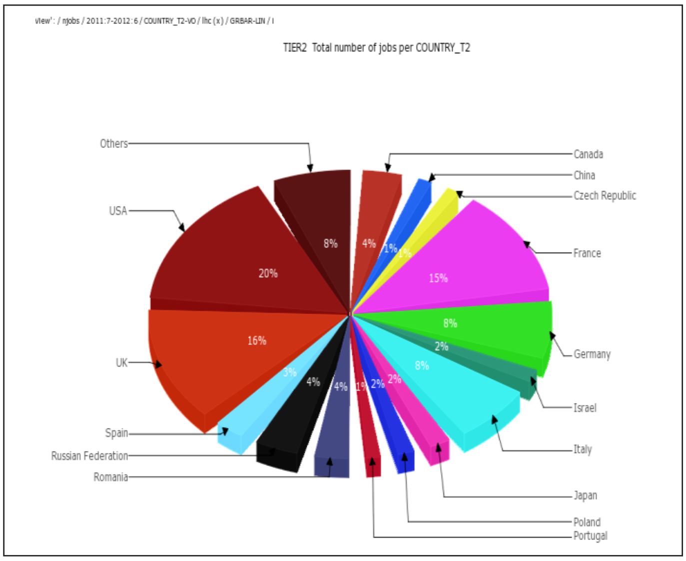

Fig. 1: The share of the total number of Tier-2 jobs per contry processed between Jul. 2011 – Jun. 2012.

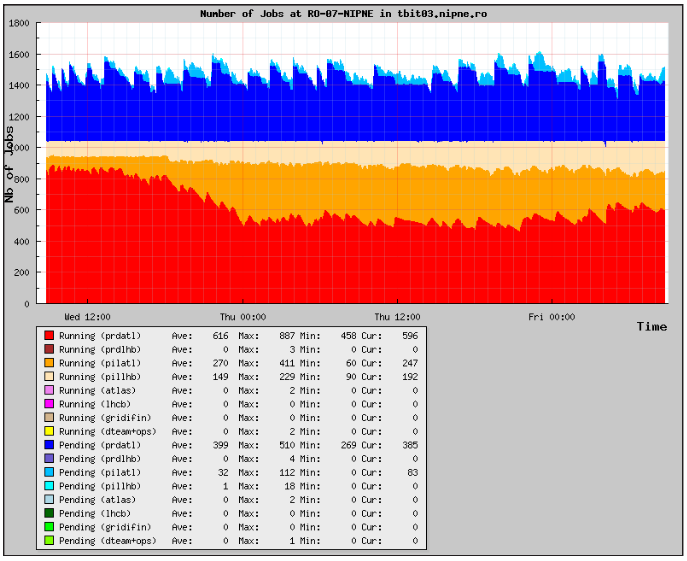

Fig. 2: Monitoring interface showing various groups of ATLAS and LHCb jobs run in a 48 hours interval.

Experimental and theoretical studies of exotic nuclei at ISOLDE (EXONTEX)

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Low-lying beta-decaying state in ^{80}Ga: Very recently a low excitation energy isomer with half-life larger than 200 ms was identified in ^{80}Ga in a collinear laser spectroscopy experiment at ISOLDE [B. Cheal et al., Phys. Rev. C 82, 051302(R) (2010)]. The excitation energy for this isomer was deduced to be within 50 keV from the ground state, and the spin/parity values for the ground state and the low-lying isomer were proposed to be either 3^- or 6^-. From the analysis of our IS441 ISOLDE data for the beta decay of ^{80}Zn it was possible to construct a detailed level scheme of ^{80}Ga, correcting and completing the level schemes previously proposed in the '80s (see Fig. 1).

The main result is the identification of the excitation energy of the low-lying isomer at 22.4 keV, fixing also the spin/parity values as 3^- for the isomer and 6^- for the ground state. The 22.4 keV isomeric state decays ß$^-$, therefore a direct measurement of its lifetime as well as that of the ground state would be of great interest for a future experiment, with implications in nuclear astrophysics.

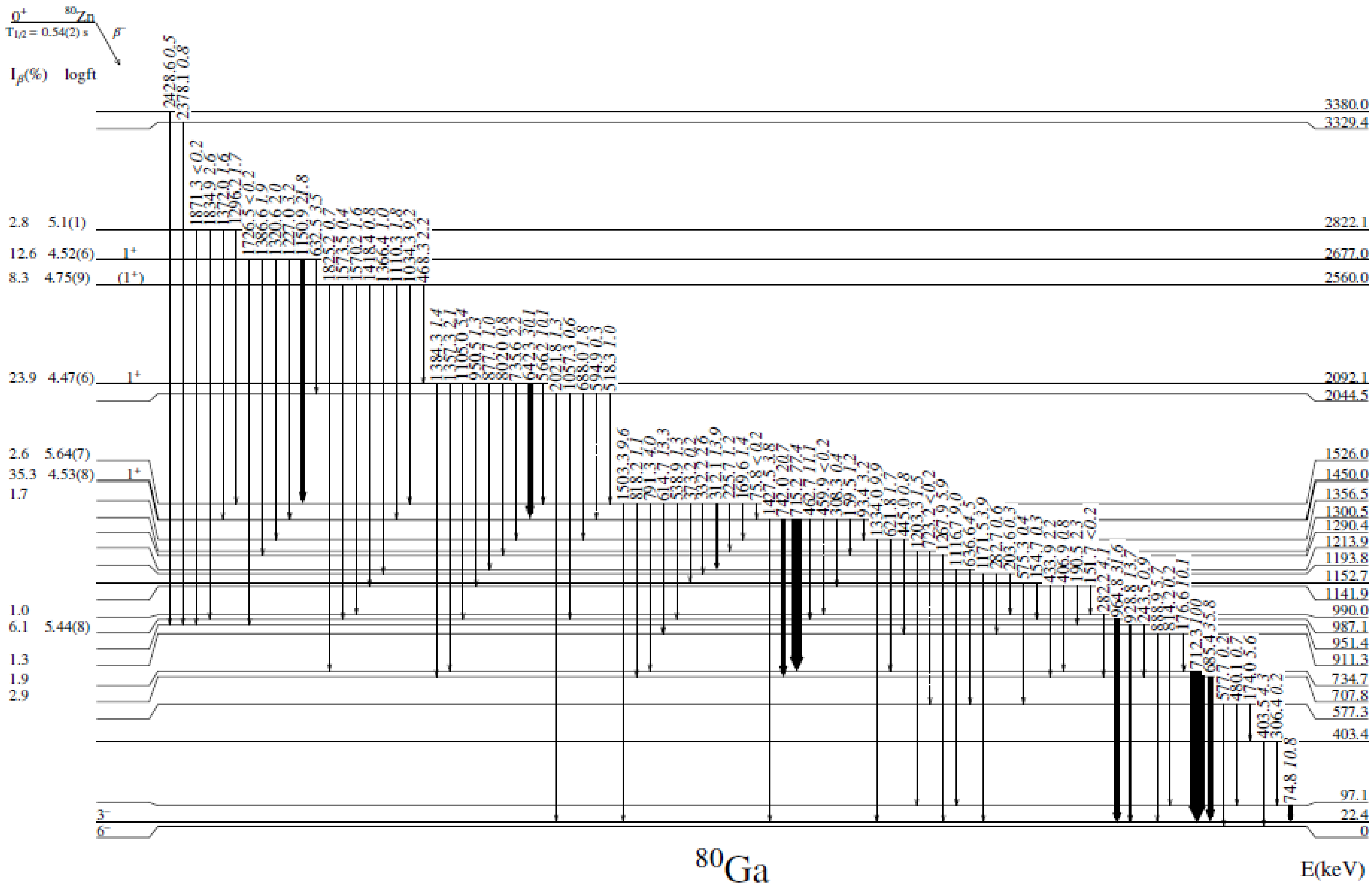


Fig. 1: The level scheme of ^{80}Ga deduced from the IS441 experiment's data, showing the isomeric state at 22.4 keV.

The ß⁻n branching ratio and the half-life of ^{82}Zn: This part of the IS441 experiment was difficult due to the low production rate of ^{82}Zn at ISOLDE and the significant contamination of the beam with isobars. However it was possible to observe clearly the gamma rays from the ß⁻n daughter ^{81}Ga and to deduce that ^{82}Zn has a half-life of 177(10) ms (see Fig. 2). Several new gamma rays with the same decay pattern were also observed, and a level scheme for ^{82}Ga is for the first time proposed.

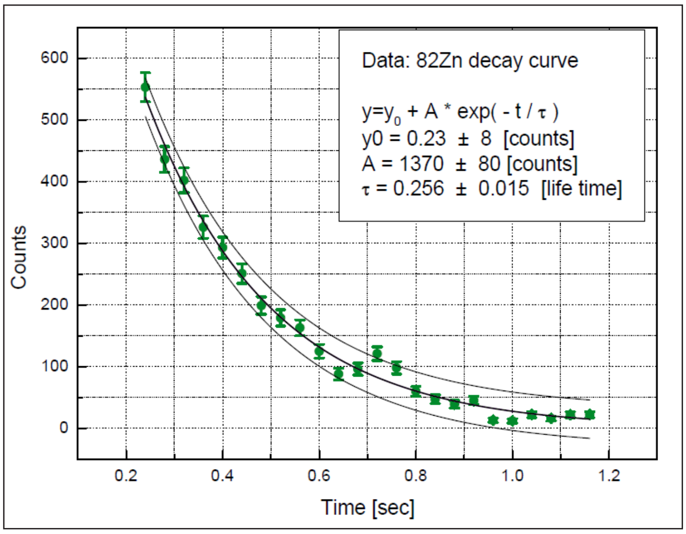
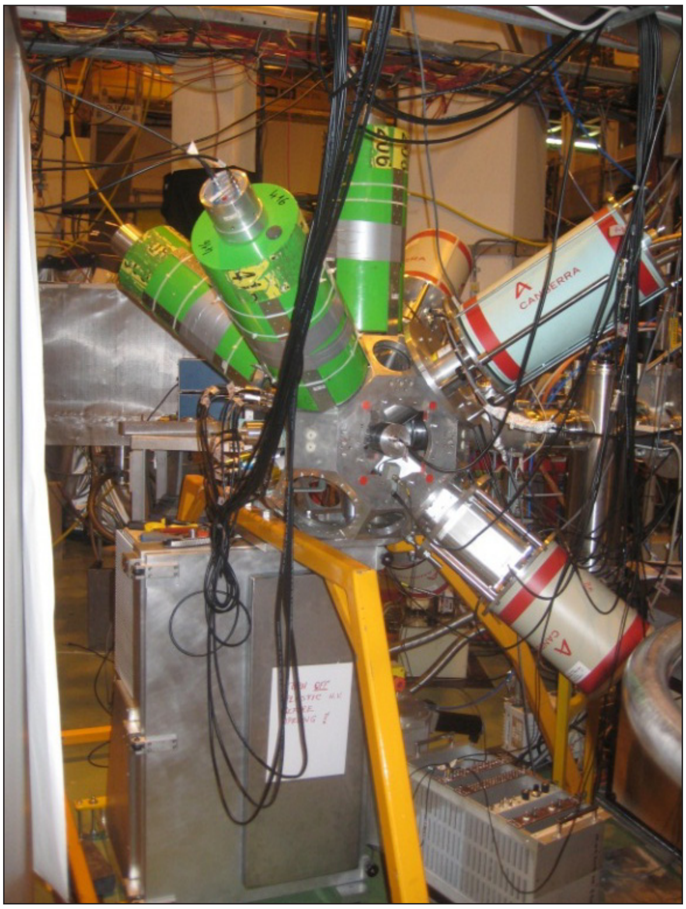


Fig. 2: The time distribution of the 351 keV gamma ray of ^{81}Ga, showing a half-life of 177(10) ms for the ground state of ^{82}Zn.



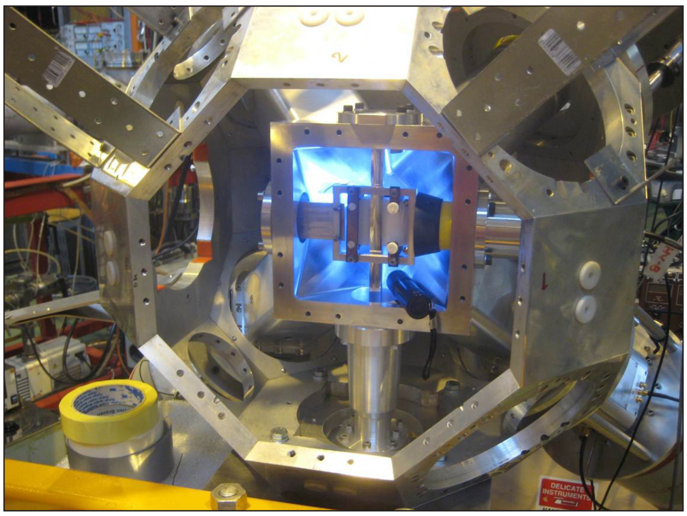
The ß⁻n branching ratio of 69(4)% was deduced from the intensities of gamma lines, and the implications for nuclear astrophysics are under study.

Isomeric states on the A=34 beta decay chain starting from ^{34}Mg: This experiment, labeled IS530, proposed at the INTC Meeting in October 2011 and with a first run performed at ISOLDE in September 2012, is aiming to study the structure of low lying states of neutron rich nuclei around the N~20 island of inversion in the sequential beta-decay of ^{34}Mg to ^{34}Al and ^{34}Si. The experiment was proposed by IFIN-HH, which also had the main contribution to its preparation and carrying out. The experiment team included researchers for France (CEN-Bordeaux, IPHC-Strasbourg, INP-Orsay, CEA-Arpajon), Hungary (ATOMKI-Debrecen), Italy (INFN-Legnaro) and Czech Republic (INP-Rez).

The ^{34}Mg radioactive beam delivered by HRS separator had a very good purity (>97%) and the intensity was higher than expected according to ISOLDE database for yields, such that good statistics was accumulated during the 15 shifts allocated from the total of the approved 21 shifts.

As detailed below, IFIN-HH contributed to all aspects: mechanics, vacuum, beam diagnostics at implantation point, detectors, electronics, acquisition programs, man-power for installation and setting-up all these components of experimental arrangement, while currently is performing the data analysis.

Fig. 3: An overall view of implantation set-up (left) and details (right) on 4π beta counter mounted inside the implantation chamber.



Romanian Participation at CERN – n_TOF Collaboration

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Project web page: *http://proiecte.nipne.ro/pn2/135-proiecte.html*

The outstanding features of the existing neutron time-of-flight facility n_TOF (with a flight path of 185 m), that has been operating at CERN since 2001, are the very high instantaneous neutron flux, excellent TOF resolution, low intrinsic backgrounds and coverage of a wide range of neutron energies, from thermal to a few GeV. These characteristics provide a unique possibility to perform neutron-induced cross-section and angular distribution measurements for applications in nuclear astrophysics, nuclear reactor technology and basic nuclear physics. In fundamental Nuclear Physics, neutrons have always been a precious probe to investigate the structure of nuclei, and the nature of fundamental forces. This neutron source in which neutrons are produced in a wide range of energies and in very intense beams allows precise measurements of neutron related processes that are relevant for several fields. One example is nuclear astrophysics where data produced by n_TOF are used to study the ordinary stellar evolution as well as supernovae. Intense neutron beams are also critical in the studies of processes of incineration of radioactive nuclear waste and for a better understanding of the effects of radiation in the treatment of tumors with beams of hadrons (hadrono-therapy).

Moreover, a study has been performed investigating the feasibility of new Experimental Area called EAR-2 [1] which, having a flight path of only 20 m from the existing spallation target (90 degrees with respect to the incoming proton beam), would fulfil the demands of the neutron science community for a neutron time-of-flight facility with a higher neutron flux [2]. The construction of the EAR-2 with a short flight path would offer the possibility of improving the quality of the data essential for nuclear energy applications, nuclear astrophysics, basic nuclear physics, dosimetry and radiation damage.

The Romanian n_TOF team joined the n_TOF collaboration for the 2010 campaign, being involved also in 2012 within activities concerning experimental and theoretical Basic Nuclear Physics.

Experimental activities. The main goal of the project is to produce, evaluate and disseminate high precision cross sections for the majority of the isotopes relevant to the waste incineration and the ADS design i.e. capture and fission cross sections for the minor actinides, capture cross sections for the main fission products and (n,xn). In this context we participated to the experimental activity dedicated to the determination of fission cross section for different isotopes of interest as Th-232, U-235, U-238, Np-237, U-234, U-236. The experimental set-up consists of nine target and the fission fragments are detected in coincidence in 2 parallel plate Avalanche Counters surrounding each target. To improve the efficiency, the targets are tilted with an angle with respect the neutron beam. This property, allows a full coverage of the angular distribution of the fragments. We participated also to measurement of neutron induced fission cross section by using a new fission tagging set up that combines a total absorption calorimeter with MicroMegas fission detectors.

Theoretical activities. For advanced systems involving the transmutation of nuclear wastes, it is necessary to improve the knowledge of fission cross-sections. The fission threshold and the sub-threshold resonance structure in some of the higher actinides allow for the studies of the fission barrier, as well as the structure (hyper-deformation) of the fission potential. Our group was focused on activities linked on new information on the basic mechanisms of nuclear fission. These can be obtained by mixing accurate experimental data with new theories that take into account the nuclear structure of the nuclear system during the whole disintegration process. For example, the new experimental values concerning the ^{234}U(n,f) cross-section, obtained in the n-TOF program, displayed a structure of supra-barrier resonances that are not of statistical nature. Phenomenological and statistical models based on the saddle density of state can not explain this rich resonant structure up to 20 MeV energies. New required methods were developed. Using di-nuclear mean field potentials of high complexity, the rearrangement of the intrinsic energy levels beginning from an initial just formed compound nucleus up to the asymptotic configuration of two separated fragments was obtained. The rearrangement of the nuclear levels in conjunction with constraints emerging from conservation of constant of motions is a cause for the existence of some microscopic effects. These dynamic effects manage the excitation of the nucleus. Each excitation gives rise to a specific fission barrier, and therefore to an associated resonance structure in the threshold fission cross section.

The Th anomaly could be explained in this context. Precise resonance spin and parities in the thermal region of the cross section could be obtained with our model, making possible comparisons with the fission fragment angular distributions measured in the framework of n_TOF-Ph2. Furthermore, the model allows also the determination of fission fragments yields. We expect that the experimental and theoretical coupling will lead finally to improved data evaluation. In this context, the first step is to determine theoretically the double humped fission barrier. For this purpose, the macroscopic-microscopic model was used. The macroscopic part is given by the Yukawa plus exponential model extended for binary systems with different charge densities. For the microscopic part, the shell and pairing effects are computed on the basis of the double center Woods-Saxon potential, The dynamic fission barriers were determined dynamically by taking into account the deformation energy landscape and the cranking inertia for systematics of nuclei of interest: U, Np and Th. For this purpose, the minimal action principle was used. By comparing our barrier heights with data obtained from experiment, a good agreement was obtained.

The results concerning the barriers lead us to analyze the excitation energy partition in fission fragments. Experimental direct indications about the excitation energies of the fragments are obtained by measuring their evaporated neutrons. Despite a similar temperature of the neutron velocity distributions, the experiment revealed that a larger excitation energy characterizes the light mass distribution in comparison with the heavy one. The shifting in the sawtoothlike behavior of the neutron multiplicity as a function of the parent excitation was attributed mainly to the deformation energy and not to the intrinsic heat. Motivated by these aspects, in our activities, the intrinsic excitation energy of the fragments are evaluated dynamically in terms of time-dependent pairing equations in the cold fission regime, The basic ingredients for the TDPE are the single-particle diagrams that must be computed from the initial state of the fissioning nucleus up the configuration given by two separated fragments. Using conditions that fix the number of particles in each fragment, it was possible to obtain for the first time the excitation energy of each nucleus issued in the fission process. A recent hypothesis that claims the excitation energy is not equilibrated between fragments was confirmed in the cold fission regime.

On the other hand, in order to obtain accurately the experimental data concerning the angular distribution of fission products it is required to know the partial cross section versus the spin. The sole theoretical model able to furnish this information belongs to our group: the hybrid two center. This model gives the rearrangement of single particle levels during the fission process and, thereof, the transition states as function of the spin. This model offers the possibility to characterize correctly the partial cross sections. The theoretical values should be used to unfold the experimental data in order to have a proper analysis. So our participation allows the analysis of experimental data.

At the same time, IFIN-HH group has been co-author of the expression of interest entitled *„Measurements of (n,xn) reaction cross sections for heavy target nuclei"* within the EAR-2 proposal [1], on the basis of a former already published study [4].

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Search for hadronic atoms at DIRAC-CERN

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Introduction

The DIRAC experiment [1,2,3,4,5] at CERN, with IFIN-HH group as founding member of the collaboration, since the launching of the project, aims to check some predictions of nonperturbative Quantum Chromodynamics (QCD) with hadronic atoms, to clarify the quark interactions at long-distance and in particular the vacuum nature of QCD. In the nonperturbative region of low momentum transfer $Q < 100$ *MeV/c*, *asymptotic freedom* is absent, and *quark confinement* with massive quarks takes place. Therefore, the *chiral symmetry* of QCD is *spontaneously broken*. The Chiral Perturbation Theory (ChPT) [6,7] as the non-perturbative QCD theory, is replacing the QCD *quark degrees of freedom* by *pion degrees of freedom*.

DIRAC Experiment in 2012:

Observation of $\pi^+\pi^-$ metastable states

In high-energy proton-nucleus interaction, the oppositely charged pions are produced. Their final state Coulomb interaction can produce atomic $\pi^+\pi^-$ bound states (see Fig. 1). Such $\pi^+\pi^-$ hadronic atoms, upon production, are moving inside target, interact with the electric field of the target atoms and with some probability will be excited and leave the target with orbital momentum $l \neq 0$. The main part of these

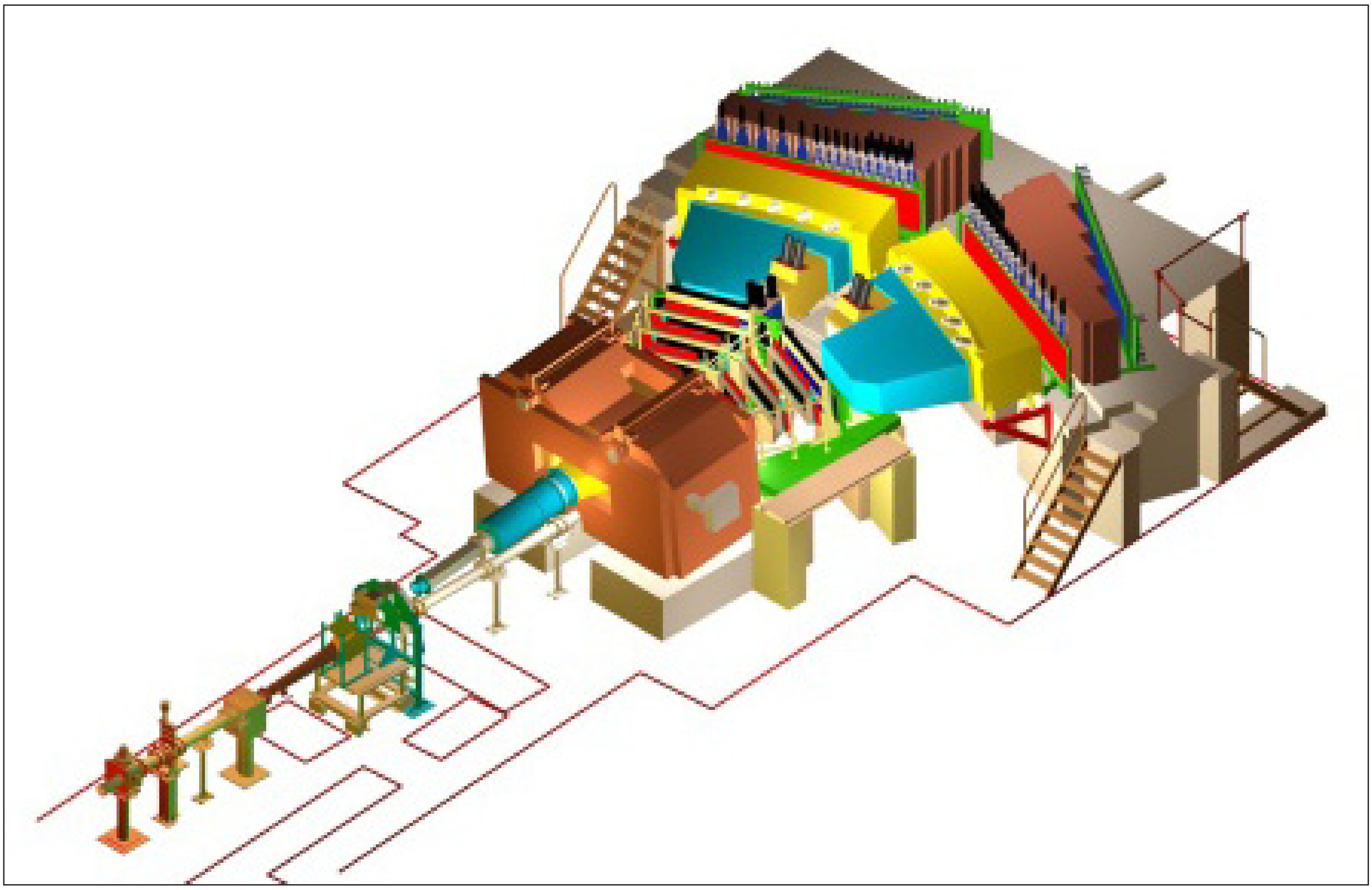


Fig. 1. The new DIRAC setup

atoms will be in the 2p-state. For $\pi^+\pi^-$ atoms in p-state the decay into $\pi^0\pi^0$ is forbidden by angular momentum conservation law.

For generating $\pi^+\pi^-$ atom in excited states it is used a high nuclear efficiency target as for example *Be* (100 μm). The *p-Be* interaction generates $\pi^+\pi^-$ atom in *ns* states as follows [8]:

$$W_{1s}=83\%,\ W_{2s}=10.4\%,\ W_{3s}=3.1\%,\ W_{>3s}=3.5\%$$

Passing through the *Be* target, about ~5.5% of $\pi^+\pi^-$ atoms will be excited into 2p, 3p, 4p, ... metastable states and enter into the vacuum part of the particle channel [8] (see Fig. 2). In the same time, another 6.3% of the $\pi^+\pi^-$ atoms will be ionized in the target, producing n_A^{Be} atomic pairs as background. The excited (metastable) $\pi^+\pi^-$ atoms will fly and breakup into the *Pt* foil (2μ*m*), providing an additional number of atomic pairs n_A^l (see Fig. 2). The separation of atomic pairs produced in the *Be* target n_A^{Be} and in the *Pt* foil n_A^l is done by a magnetic field placed between these two materials. After separation, the lifetime measurement of the excited $\pi^+\pi^-$ atom states is done similarly to that for the ground state.

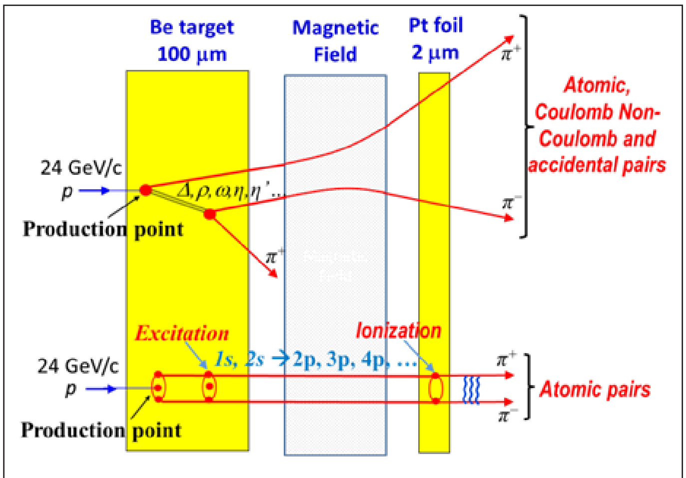


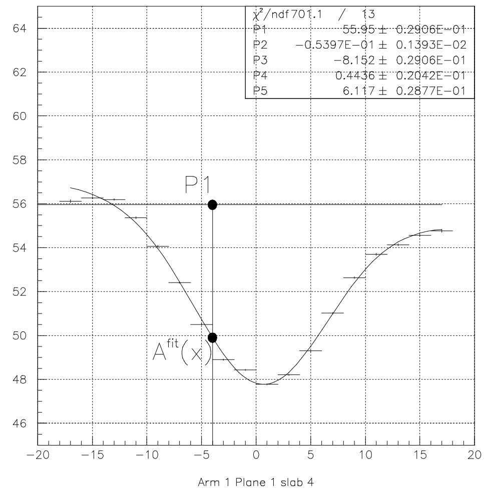
Fig. 2. Signal and background in $\pi^+\pi^-$ metastable states observation

The Romanian team results

Off-line data analysis for the Preshower amplitude signal corrections (2008-2011)

We realize description of the x- and y-coordinate dependence of the signal amplitude for all PSh slabs [9] and corrections (see **Fig. 3, 4**).

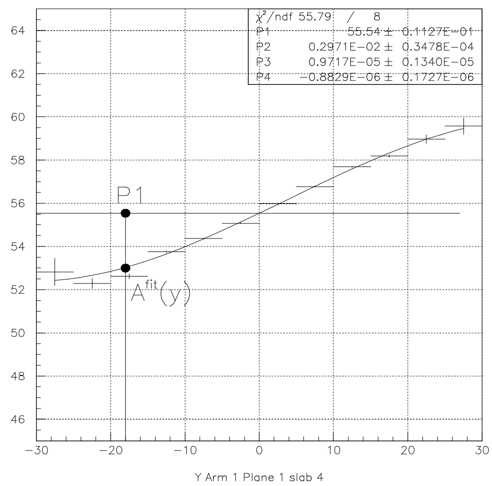
$$A^{fit}_{(x)} = a_x + b_x x + c_x e^{-\frac{(x-d_x)^2}{2\sigma^2}}$$



$$\delta_{(x)} = \frac{a_x}{A^{fit}_{(x)}} \qquad A^{cor}_{(x)} = \delta_{(x)} A^{raw}_{(x,y)} = \frac{a_x}{A^{fit}_{(x)}} A^{raw}_{(x,y)}$$

Fig. 3. x-dependence of the amplitude for one slab and the corresponding corrections

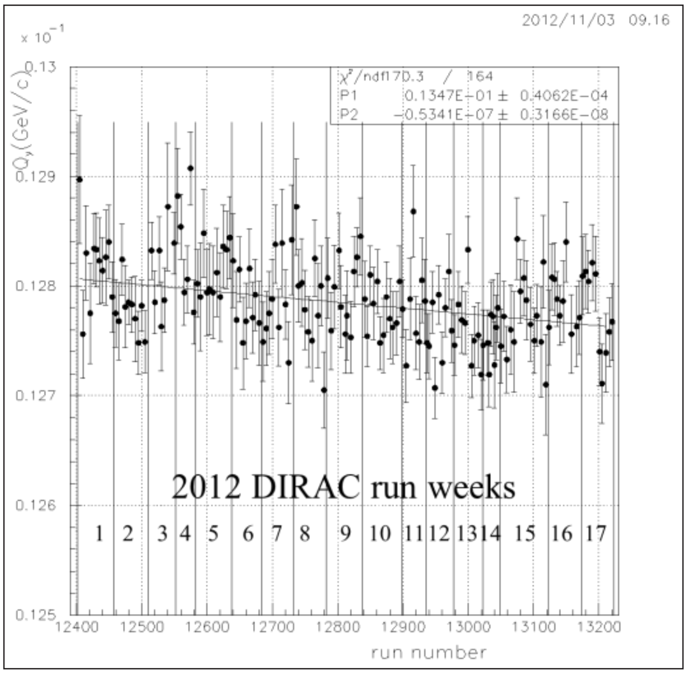
$$A^{fit}_{(y)} = a_y + b_y y + c_y y^2 + d_y y^3 + e_y y^4$$



$$\delta_{(y)} = \frac{a_y}{A^{fit}_{(y)}} \qquad A^{cor}_{(y)} = \delta_{(y)} A^{raw}_{(x,y)} = \frac{a_y}{A^{fit}_{(y)}} A^{raw}_{(x,y)}$$

Fig. 4. y-dependence of the amplitude for one slab and the corresponding corrections

Magnetic field monitoring 2012 DIRAC run



$\Delta Q_y/Q_y \approx 0.4\%$.

Fig. 5. Time variation of the relative momentum component Q_y for e^+e^- pairs as a measure of the magnetic field stability.

Experimental data processing

- Events preselection for experimental 2008, 2009, 2010 and 2011 data.
- Ntuple production for separation of particle pairs (e^+e, $\pi^+\pi^-$, $K^+\pi^-$, $K^-\pi^+$) 2008, 2009, 2010, 2011.

Simulation of π^+, π^-, K^+ and K^- production cross section at SPS energies

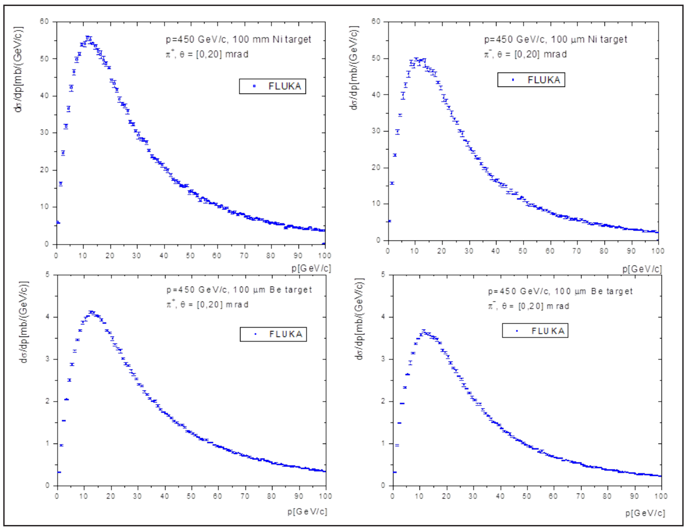


Fig. 6. Differential inclusive π^+ (left) and π^- (right) production cross section for p=450GeV/c, on Ni (up) and Be (down) targets

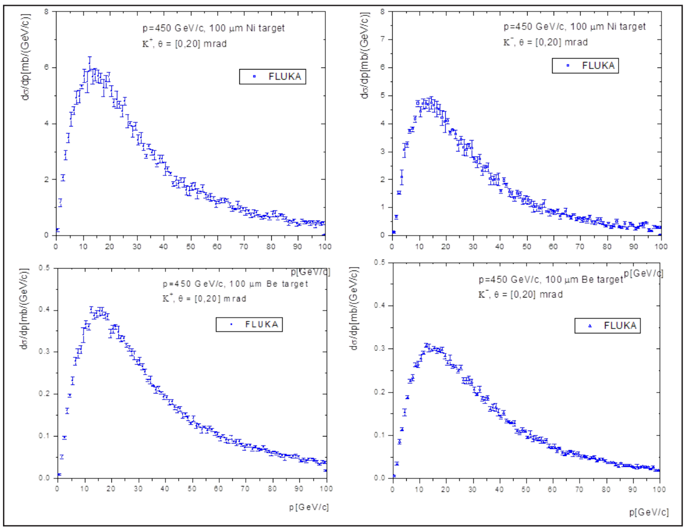


Fig. 7. Differential inclusive K^+(left) and K^- (right) production cross section for p=450GeV/c, on Ni (up) and Be (down) targets

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www.cern.ch

ANCS – Romanian Authority for Scientific Research
www.mct.ro

IFA – Institute of Atomic Physics
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