

Annual Summary Document

1. Project team

- Prof. Dr. **Mihai Petrovici** (physicist) – **team leader**
- Senior researcher III **Daniel Bartos** (physicist)
- Senior researcher I Dr. **Ionela Berceanu** (physicist)
- Senior researcher III Dr. **Alexandru Bercuci** (physicist)
- Senior researcher II **Gheorghe Caragheorghopol** (electronics engineer)
- Senior researcher II Dr. **Vasile Catanescu** (electronics engineer)
- Senior researcher II Dr. **Florin Constantin** (physicist)
- Senior researcher II **Marin Duma**(mathematician)
- Senior researcher II **Viorel Duta** (mechanical engineer)
- Senior researcher II **Gheorghe Giolu** (mechanical engineer)
- Senior researcher II **Iosif Legrand** (physicist)
- Senior researcher III Dr. **Mariana Petris** (physicist)
- Prof. Dr. **Alexandrina Petrovici** (physicist)
- Senior researcher I Dr. **Amalia Pop** (physicist)
- Senior engineer II Dr. **Laura Radulescu** (mechanical engineer)
- Senior researcher II Dr. **Victor Simion** (physicist)
- Computing coordinator **Claudiu Schiaua** (physicist)
- Research assistant Dr. **Cristian Andrei** (physicist)
- Research assistant Dr. **Andrei Herghelegiu** (physicist)
- PhD student **Madalina Tarzila**
- Master student **Alexandru Balaceanu**
- Sub-engineer **Petre Zaharia**
- Technician **Valerica Aprodu**
- Technician **Lucica Prodan**
- Technician **Andrei Radu**
- Technician **Constanta Dinca**
- Financial coordinator **Georgiana Toma** (economist)
- Specific scientific focus of group
- Multiplicity and event shape analysis in pp collisions – subject proposed by our group within ALICE Spectra PAG – PWG-LF since 2009:
(<https://twiki.cern.ch/twiki/bin/view/ALICE/PWGLFPAGSPECTRAMultiplicityEventShapePP7>).
The aim is to evidence collective type phenomena in high charged particle multiplicity and close to azimuthal isotropy events in pp collisions at LHC energies.
- Summary of accomplishments in the last year
 - comparison of pp, p-Pb and Pb-Pb systems as a function of multiplicity and centrality
 - development of a new software
 - the comparison of the Bayesian PID procedure with other PID methods used in ALICE
 - the pile-up effect on charged particle spectra as a function of multiplicity
 - comparison of the experimental results with EPOS-LHC and EPOS3
 - TRD tracking activities
 - configuration of the NAF
 - upgrade of the Detector Laboratory
 - shifts in the re-commissioning period of ALICE.

2. Scientific accomplishments – Results obtained in the last year.

In the last year our group activity focused on:

- comparison of pp, p-Pb and Pb-Pb systems as a function of multiplicity and centrality.

The ALICE Collaboration has recently presented detailed results, obtained by us, on transverse momentum spectra of π^+ , K^+ and p measured at LHC in pp collisions at $\sqrt{s} = 7$ TeV as a function of charged particle multiplicity. The charged particle multiplicity was measured in the central pseudorapidity region $|\eta| \leq 0.8$ and the analysis was done in a narrower range of rapidity $|y| \leq 0.5$. The p_T spectra were analyzed from 0.2 GeV/c, 0.3 GeV/c and 0.5 GeV/c up to 2.6 GeV/c, 1.4 GeV/c and 2.6 GeV/c for π^+ , K^+ and p respectively and in eight bins of multiplicity up to ~ 50 measured charged particle multiplicity density per unit of pseudorapidity.

The p_T dependence of p/π for the second and highest multiplicity bins for pp and of $(p + p)/(\pi^+ + \pi^-)$ ratio for p-Pb in 60–80% and 0–5% multiplicity classes and for Pb-Pb at 80–90% and 0–5% centralities show a push of protons towards larger p_T values relative to pions with increasing centrality or multiplicity for all three systems. Quantitatively, the ratios of the p/π for the two bins show that the ratio for pp follows closely the p-Pb trend as a function of p_T .

Based on these similarities, information on collective type dynamics from the fits of experimental transverse momentum spectra using expressions inspired by hydrodynamical models were obtained. The average transverse expansion velocity ($\langle \beta_T \rangle$) and kinetic freeze-out temperature (T_{kin}) were obtained as fit parameters. The results of simultaneously fits on π^+ , K^+ and p spectra, in terms of $T_{kin} - \langle \beta_T \rangle$ correlation as a function of charged particle multiplicity were compared with the results obtained for Pb-Pb and p-Pb as a function of centrality and multiplicity classes, respectively. One could conclude that for pp collisions at 7 TeV, the $T_{kin} - \langle \beta_T \rangle$ correlation as a function of charged particle multiplicity has a trend rather similar with the one observed in heavy ion collisions, i.e. the freeze-out kinetic temperature decreases and the average transverse expansion velocity increases with charged particle multiplicity (pp) or increasing centrality (A-A). However, there is a quantitative difference between pp and A-A collisions, i.e. T_{kin} is systematically lower and $\langle \beta_T \rangle$ systematically larger than the pp values, the difference increasing towards higher centralities. Within the error bars, the results for p-Pb at 5.02 TeV are the same with the ones evidenced in pp. Such a correlation is not reproduced by PYTHIA for the pp case. Including the color reconnection mechanism it seems that the model starts to show a similar trend but with values of T_{kin} about 40 MeV lower. Another aspect worth to be mentioned is the correlation between the expansion profile (n) and $\langle \beta_T \rangle$. This clearly shows that all three systems follow exactly the same correlation. Towards the highest multiplicity in the pp case, the expansion velocity becomes linear as a function of position within the fireball. The $n - 1/T_{kin}$ correlation shows that the PYTHIA prediction is completely different than the experimental one.

However, a conclusion about similar mechanisms for the three systems has to be taken with caution. Detailed investigations based on theoretical approaches such as hydrodynamic models, parton based Gribov-Regge theory, Color Glass Condensate, Color Reconnection, will give insight to the underlying physics of this similar behavior observed at LHC energies.

- development of a new analysis software

The software mainframe used for data analysis followed in our department has suffered recently a major update to get aligned with the requirements of physics analysis put forward by the ALICE Offline Project - AliRoot. Thus the whole analysis was divided into 2 main parts:

- A general infrastructure used to gather all reconstructed data from the Event Summary Data (ESD) provided by the framework
- User specific tasks, following specific features of the generally derived reconstructed results.

- the comparison of the Bayesian PID procedure with other PID methods used in ALICE.

In order to test the possibility to extend the p_T range for the preliminary kaon transverse momentum distribution we analyzed approximately $19 \cdot 10^6$ inelastic pp collisions collected by ALICE during the 2010 run at the LHC (period LHC10d, pass 2), using a minimum-bias trigger, at an injection energy of $\sqrt{s} = 7$ TeV. The Bayesian PID framework with priors obtained from the data using the iterative procedure, was used for the identification of charged hadrons. The TuneOnData and EtaCorrection options were switched on. The particle species with the highest probability was selected, without applying any purity cut. The identification of charged hadrons is based on the information delivered by the TPC and TOF subdetectors in the ALICE central barrel in different momentum ranges.

In order to check the performance of the method, the final MB p_T distributions from this analysis are compared with the p_T distributions of preliminary 7 TeV pp MB spectra obtained by merging results from the $n\sigma$ method, the unfolding procedure and kinks. A very good agreement within the statistical uncertainties (the systematic uncertainties were only considered for the preliminary 7 TeV pp MB spectra) can be observed between the p_T spectra obtained using the two methods. Their ratios show an agreement within $\pm 5\%$. It must also be noted that this agreement was reached despite differences in the beam conditions between the periods under analysis.

- the pile-up effect on charged particle spectra as a function of multiplicity

The main activities were focused on refining the evaluation of systematic errors estimations as well as on decreasing the statistical errors of the charged particle transverse momentum distributions as a function of multiplicity. These two activities complemented each other and were done in parallel. The systematic errors were concentrated mainly on the pileup effect (more than one collision in each event) which could introduce an important bias in the charged particle transverse momentum spectra at high luminosities. Since the transverse momentum spectra have different shapes as a function of multiplicity, the effect of the pileup can be observed in the shape of the spectra and, therefore, the evaluation of the pileup effect was done by comparing the spectra in different multiplicity bins for runs recorded at different luminosities. The ALICE experiment recorded during the 2010 period also higher luminosity runs. This allowed us to investigate to which extent we could include in our analysis also runs with higher μ values. In the analysis were included all the runs for which μ was independently estimated. Adding more statistics to the data sample allow us to decrease the statistical errors and, also, expand the momentum and multiplicity range of the analysis without the need to rebin the histograms. This investigation has implications on the usage of the LHC10e period that includes a high multiplicity trigger and μ values up to 0.079. Once the LHC10e runs are validated and the high multiplicity trigger is shown to be unbiased, up to three extra multiplicity bins can be added to the standard analysis done using the minimum bias trigger. Since the statistical errors can be reduced by increasing the data sample analyzed, these studies have implications also on the evaluation of the statistical errors for high multiplicity and high transverse momentum bins. A rebin procedure was also investigated as a possibility to extend the p_T range after all the available statistics was used.

- comparison of the experimental results with EPOS-LHC and EPOS3 (low statistics)

EPOS is a sophisticated multiple scattering approach based on partons and Pomerons (parton ladders), with special emphasis on high parton densities. The latter aspect, particularly important in proton-nucleus or nucleus-nucleus collisions, is taken care of via an effective treatment of Pomeron-Pomeron interactions, referred to as parton ladder splitting. In addition, collective effects are introduced after separating the high density central core from the peripheral corona. EPOS is the successor of the NEXUS model.

EPOS LHC and EPOS3 codes have been implemented in our group. The p_T distributions for pions, kaons and protons in pp collisions at $\sqrt{s} = 7$ TeV have been compared with both versions of the models for MB and all the multiplicity bins. As a conclusion the EPOS LHC version provides a

slightly better overall description of the data as compared to EPOS3 version. Nevertheless, very accurate final experimental distributions which will be obtained by us and the comparison with theoretical predictions will contribute to the refinement of the EPOS3 model based on hydrodynamical calculations and to the answer of the question: Do we see collective radial flow in pp collisions at LHC?

In our studies it is important to use an unbiased multiplicity estimator. EPOS3 was used to build correlation matrices between different estimators in terms of the η range. Forward pseudorapidity estimators seem to introduce a saturation at high multiplicities.

- TRD tracking activities

In the advent of RUN 2 of LHC the installation of the Transition Radiation Detector (TRD) of the ALICE experiment was completed. Also preparations for RUN 3 have been started in few areas of interest in which our group is deeply involved. Given such expanding environment the requests on the TRD have reached their predefined targets namely the full participation in ALICE barrel tracking for RUN 2 and the active participation in the calibration of TPC for RUN 3. The efforts done in house for preparing the reconstruction of the TRD has scaled to this expectations as we hold the coordination position for the TRD tracking. In practice the contributions address 2 topics

- Demonstration of TRD capabilities in terms of tracking for improving the reconstructed high p_T resolution
- New TRD tracking prototype running on processed online data with un-calibrated TPC seeding

- configuration of the NAF

In this period, NAF (Niham Analysis Facility) was also configured with a computing capacity of about 2,000 cores and 1,8 PB storage, intensively used in the activities whose results were briefly mentioned above.

- upgrade of the Detector Laboratory

The upgrade of the Detector Laboratory for production and test of various gas detectors will ensure the technical conditions to build new types of detectors more sensitive and with highly complex materials, which can be accomplished only in and with ultra clean rooms and equipments and in stable environments from the climateric point of view. By analyzing the existent structure in the Detector Laboratory the necessary space for the new type of detectors accomplishment were established, space which suffered structural and functional modifications. Increasing the degree of cleanliness of the ambiental air was the main objective of the upgrade. The accomplishment of this technical request was done by completing with ventilation and filtration equipments in order to increase the the exchange rate of the recirculated air flux and the supplementary filtration of the air flux introduced in the laboratory by the existing air conditioning installation. The local illuminating conditions were improved. Following the upgrade action a modern laboratory with the following clean spaces was obtained:

- 37 m² class1000 (ISO6)
- 44 m² class 10000 (ISO7)
- 190 m² class 100 000 (ISO8)

The climateric conditions, temperature and humidity are stable and uniform in all the laboratory spaces, thus special conditions can be assured for constructing very complex and ultrasensitive detectors.

- shifts in the re-commissioning period of ALICE

The re-commissioning period of the ALICE detector is very important for the future measurements in Run2. In order to finalize the integration work for the detectors and the online systems and to perform a full validation of the operational procedures a shift period for 2014 was opened. Our group took 8 shifts at the DAQ+HLT+CTP system.

3. Group members

- List each member, his/her role in project and the Full Time Equivalent (FTE) % time in project. The FTE formula to be used is: $FTE = \text{Total number of worked hours in the last year} / 1020 \text{ hours}^1$;

Name	Analysis	R&D	Detector operation	Detector construction	Infrastructure Planning Financial issues Outreach Contracts
Mihai Petrovici	35%		5%		32.13%
Daniel Bartos		44.33%			
Ionela Berceanu	57.2%				
Alexandru Bercuci	51.8%		5%		
Gheorghe Caragheorgheopol		57.15%			
Vasile Catanescu		57.15%			
Florin Constantin		22.14%			
Marin Duma					
Viorel Duta					23.31%
Gheorghe Giolu					42.28%
Iosif Legrand					
Mariana Petris		56.8%			
Alexandrina Petrovici					10.54%
Amalia Pop	62.76%		20%		10.0%
Laura Radulescu		16.59%			10.0%
Victor Simion		57.15%			
Claudiu Schiaua			10%		48.94%
Andrei Cristian	41.8%		15%		
Andrei Herghelegiu	36.8%		20%		
Madalina Tarzila	36.8%				20.0%
Alexandru Balaceanu					
Petre Zaharia					41.87%
Valerica Aprodu		40.73%			
Lucica Prodan		25.00%			35.55%
Andrei Radu		30.00%			31.47%
Constanta Dinca		15.00%			21.22%
Georgiana Toma					56.81%

- List of PhD/Master students and current position/job in the institution.

Name	PhD student	Present status
Madalina Tarzila		Research assistant IFIN-HH

¹

1020 hours = 170 average monthly hours x 6 months

4. Deliverables in the last year related to the project:

- *Papers:*

- Suppression of $\Upsilon(1S)$ at forward rapidity in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, ALICE Collaboration, Phys. Lett. B (2014) 361-372
- Performance of the ALICE Experiment at the CERN LHC ALICE Collaboration, Int. J. Mod. Phys. A 29 (2014) 1430044
- Beauty production in pp collisions at $\sqrt{s} = 2.76$ TeV, measured using semi-electronic decays, ALICE Collaboration, PLB 738(2014)97-108
- Transverse momentum dependence of inclusive primary charged-particle production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, ALICE Collaboration, Eur. Phys. J. C 74 (2014) 3054
- Azimuthal anisotropy of D meson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, ALICE Collaboration, Phys. Rev. C 90 (2014) 034904
- Measurement of quarkonium production at forward rapidity in pp collisions at $\sqrt{s} = 7$ TeV, ALICE Collaboration, Eur. Phys. J. C 74 (2014) 2974
- Production of charged pions, kaons and protons at large transverse momenta in pp and Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, ALICE Collaboration, PLB 736 (2014) 196-207
- Centrality, rapidity and transverse momentum dependence of J/Ψ suppression in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, ALICE Collaboration, Phys. Lett. B 743 (2014) 314-327
- Measurement of charged jet suppression in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, ALICE Collaboration, JHEP03(2014)013
- J/Ψ production and nuclear effects in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, ALICE Collaboration, JHEP02(2014)073
- Two and Three-Pion Quantum Statistics Correlations in Pb-Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV at the LHC, ALICE Collaboration, Phys. Rev. C 89 (2014) 024911
- Upgrade of the ALICE Inner Tracking System - Technical Design Report, ALICE Collaboration, J. Phys. G. 41 (2014) 087002

- *Conferences:*

- Transverse Momentum Distributions of Identified Particles in p-Pb Collisions at $\sqrt{s_{NN}} = 5.02$ TeV, J. Anielski for ALICE Collaboration, 14th International Conference on Strangeness in Quark Matter (SQM2013), Journal of Physics: Conference Series 509 (2014) 012106, doi:10.1088/1742-6596/509/1/012106
- Identified charged hadrons production in pp, p-Pb and Pb-Pb collisions at LHC energies with ALICE, Giacomo Volpe for the ALICE collaboration, ICNFP 2014, 3rd International Conference on New Frontiers in Physics, to appear in Conference Proceedings(EPJ Web of Conferences) 28 July – 6 August 2014, Kolymbari, Crete, Greece
- Identified particle production in pp, p-Pb and Pb-Pb collisions measured with ALICE at the LHC energies, Raúl Tonatiuh Jiménez Bustamante (for the ALICE collaboration), XXXVII Symposium on nuclear physics, Cocoyoc, México, January 6-9 2014, to appear in Conference Proceedings (volume of the IOP Journal of Physics: Conference Series) <http://www.nucleares.unam.mx/7Esnp/Cocoyoc2014/abstracts/jimenez.pdf>
- Identified charged pion, kaon and proton production in pp, p-Pb, Pb-Pb collisions at LHC energies measured with ALICE, Peter Christiansen for the ALICE Collaboration, SPAATIND 2014, Nordic Conference on Particle Physics, January, 2-7, 2014 <http://indico.hep.lu.se//getFile.py/access?contribId=3&sessionId=0&resId=0&materialId=slides&confId=1361>
- Identified particle production in p–Pb collisions measured with the ALICE detector, Peter Christiansen, for the ALICE Collaboration, IS2013 — International Conference on the Initial Stages

in High-Energy Nuclear Collisions, Illa de A Toxa, Galicia, Spain, 8–14 September 2013, Nuclear Physics A 926 (2014) 264–269, <https://indico.cern.ch/event/239958/session/15/contribution/58>
- Light-flavour hadron production in p–Pb collisions measured with the ALICE detector at the LHC, F. Barile, for the ALICE Collaboration, IS2013 — International Conference on the Initial Stages in High-Energy Nuclear Collisions, International Conference on the Initial Stages in High-Energy Nuclear Collisions, Illa de A Toxa, Galicia, Spain, 8–14 September 2013, Nuclear Physics A 926 (2014) 177–185, <https://indico.cern.ch/event/239958/session/17/contribution/102/material/slides/0.pdf>

Talks of group members:

- Oral presentation at Quark Matter 2014, Darmstadt, Germany, 19-24 May 2014 :
Light flavor hadron spectra at low p_T and search for collective phenomena in high multiplicity pp, p–Pb and Pb–Pb collisions measured with the ALICE Experiment
C. Andrei for ALICE Collaboration, Nucl.Phys. A 20024, S0375
9474(14)00251-6 10.1016/j.nuclphysa.2014.08.002
- Invited lecture – Carpathian Summer School of Physics 2014 – Sinaia, Romania, July 13-26, 2014
Recent results and open questions on collective type phenomena from A-A to pp collisions
M. Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop
<http://cssp14.nipne.ro>; will be published in an AIP Publishing Volume

Internal notes:

- Multiplicity dependence of transverse momentum spectra for positive pions, kaons and protons in pp collisions at 7 TeV, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, M. Petrovici, A. Pop
https://twiki.cern.ch/twiki/pub/ALICE/PWGLFPAGSPECTRAMultiplicityEventShapePP7/Internal_Note_Paper_Proposal_300414_mp.pdf
- Evaluation of the Bayesian PID in the central barrel of ALICE
C. Andrei, P. Antonioli, F. Noferini, R. Romita, A. Rossi, K. Schweda, J. Wiechula, J. Wilkinson
<https://aliceinfo.cern.ch/Notes/node/310>

5. Further group activities

Collaborations:

- involvement in the TPC-ALICE upgrade – construction of at least 9 of OROCs based on GEM technology:

- A new architecture for the housing box of OROCs for X rays and in-beam tests and transport was proposed, designed and the construction is in progress.

- CBM Experiment at FAIR:

- Detailed in-beam tests of high counting rate RPC and high counting rate TRD prototypes realized in our group were carried out using reaction products and mixed beams at SIS18-GSI and PS-CERN, respectively.
- Version 2 of FASP-FEE designed was finalized, the CHIP was produced at AMS-Austria, the design of the associated motherboards is in progress and electronic and real signal tests will be performed in the near future.

Education – courses at the Doctoral School of the Faculty of Physics – Bucharest University

Outreach

- Numerous visits of students, local and foreign delegations.

On the occasion of CERN's 60th anniversary, IFIN-HH's 65th anniversary:

- oral presentation at special events organized on the occasion of CERN's 60th anniversary - July 19, 2014 - Sinaia – with the participation of Rolf Heuer – CERN DG

- September 26 – Bucharest – with the participation of Livio Mapelli, head of Physics Division at CERN

- posters

- movie

- booklet

- magic cubes

6. Financial Report for the last year

Financial Report
according to the regulations from H.G. 134/2011

		lei	
Type of expenditures		2014	
		Value	
		Planned	Realized
1	PERSONNEL EXPENDITURES , from which:	1.164.346,00	1.164.346,00
	1.1. wages and similar income, according to the law	910.705,00	919.883,00
	1.2. contributions related to salaries and assimilated incomes	253.641,00	244.463,00
2	LOGISTICS EXPENDITURES , from which:	345.773,08	345.360,12
	2.1. capital expenditures	74.827,17	74.275,48
	2.2. stocks expenditures	5.676,00	5.814,91
	2.3. expenditures on services performed by third parties, including:	265.269,91	265.269,73
	a) other services required for the project, stipulated in the financing contract (CERN contribution)	252.959,91	252.959,91
	b) other services	12.310,00	12.309,82
3	TRAVEL EXPENDITURES	86.027,72	86.261,46
4	INDIRECT EXPENDITURES – (OVERHEADS) *	606.585,96	606.765,18
TOTAL EXPENDITURES (1+2+3+4)		2.202.732,76	2.202.732,76

* Specify the rate (%) and key of distribution (excluding capital expenditures and excluding other services required for the project, stipulated in the financing contract (CERN contribution): 47,83 % from point (1+2.2+2.3)+3)

7. Research plan and goals for the next year

- The analysis along the lines mentioned above based on Run1 data will be finalized and redone once the new 2010 reprocessed data will be available

- Substantial statistics will be generated based on EPOS3 and EPOS-LHC models and comparison with experimental results will be done

- The influence of the phase space in which the charged particle multiplicity is selected on the obtained result

- Event shape selection based on different event shape global variables

- Contribution to the detector operation in Run2
- TRD tracking
- Operating NIHAM data centre – component of ALICE GRID at its standard efficiency
- Service task for PhD students
- Setting up the local infrastructure of the Detector Lab
- Starting the construction and tests of OROCs based on GEM technology for ALICE-TPC upgrade
- Outreach activities
- Summer Student Program
- Once the new data at the highest LHC energy will become available we will start similar studies as the ones at 7 TeV.