

1. Cover Page

- Project team :

- Prof. Dr. Mihai Petrovici (physicist) – team leader
- Senior researcher III Dr. Cristian Andrei (physicist)
- Senior researcher III Daniel Bartos (physicist)
- Senior researcher I Dr. Ionela Berceanu (physicist)
- Senior researcher II 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 III Dr. Andrei Herghelegiu (physicist)
- Senior researcher II Iosif Legrand (physicist)
- Senior researcher II 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)
- PhD student Madalina Tarzila
- Technician Valerica Aprodu
- Technician Lucica Prodan
- Technician Andrei Radu
- Technician Constanta Dinca
- Financial coordinator Georgiana Toma (economist)

- Specific scientific focus of the 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.

- Highlights of accomplishments in the last year:

- Studies for obtaining p_T spectra simultaneously conditioned on multiplicity and directivity for identified charged hadrons in pp collisions at $\sqrt{s} = 7$ TeV.
- Charged particle p_T spectra as a function of multiplicity in pp collisions at $\sqrt{s} = 7$ TeV - final corrections. They will be included in the long paper on multiplicity dependence.
 - Bjorken energy density estimates for pp collisions at $\sqrt{s} = 7$ TeV.
 - A detailed comparison of pp ($\sqrt{s} = 7$ TeV), p-Pb ($\sqrt{s_{NN}} = 5.02$ TeV) and Pb-Pb ($\sqrt{s_{NN}} = 2.76$ TeV).
 - BGBW fits for Pb-Pb data on different species.
 - PRC members
- Two particle correlation studies as a function of multiplicity and directivity.

- Core-Corona effects in Pb-Pb collisions at 2.76 TeV
- TRD QA activities.
- GRID activities: maintaining NIHAM in a leading position among Tier2 ALICE GRID centers.
- TPC upgrade contribution – assembling and tests of the first OROC for PRR.
- Participation to detector operation : 12.4 blocks of shifts till now.
- Summer Student Program and outreach.
- 32 presentations in ALICE meetings ;
- 2 conference presentations ;
- 1 paper.

2. Scientific goals (2 pages) - narrative stating in more detail

As it is well known by now, A Large Ion Collider Experiment (ALICE) at CERN is a general-purpose heavy-ion experiment designed to explore the ultra-dense energy region of the Phase Diagram of Quantum Chromodynamics (QCD), far above the critical temperature where a transition to a deconfined matter, formed by its basic constituents, i.e. quarks and gluons, is predicted to happen in nucleus-nucleus collisions at LHC energies. In addition to heavy systems, the ALICE experiment is devised such that collisions of lighter combinations, p-A and pp, can be also studied. Such studies turned out not only to provide reference data for the nucleus-nucleus collisions, a number of genuine pp physics studies turned out to be of great interest once the new data became available from the first experiments at $\sqrt{s}=7$ TeV. multiparton interactions and rescatterings could contribute to a large energy transfer in a collision volume of proton size and a close to equilibrium deconfined initial state could be expected in very high energy pp collisions. A piece of matter of proton size, with a radius of few times larger than the mean free path of the constituents of a deconfined medium, expands hydrodynamically once the energy transfer is significantly large, i.e. low impact parameter - high charged particle multiplicity.

Preliminary results obtained in Run1 at which our group had a significant contribution seem to support such a scenario. Run2, with a gain in energy of a factor of two for pp and Pb-Pb collision and higher luminosity will create premises to perform such studies in a differential way, to extend them at even higher charged particle multiplicities and other species than identified charged hadrons and hyperons.

Another important aspect worth to be studied is the possibility to discriminate between hard and soft processes. Preliminary studies performed by us along the possibility to select events close to azimuthal isotropy using global event shape observables like Directivity, Sphericity, Thrust or Fox-Wolfram moments have shown their performance in selecting soft, nearly azimuthal isotropic events. Although the correlation of each of these global event shape variables with

multiplicity is rather good, at the largest multiplicities the global event shape variables have a rather broad distribution. Thus, a two dimensional condition in multiplicity and different event shape variables could significantly contribute in selecting events with specific azimuthal distribution for a given multiplicity and we shall move in this direction. Correlation techniques are powerful tools which can provide essential information on the nature of the medium produced in ultra-relativistic heavy-ion collisions. The idea is to select a sample of high p_T particles, referred to as leading particles or "triggers" and then to study the correlation between the leading particle and all other particles in the same event, called associated particles. The first studies of two-particle correlation functions in the highest-multiplicity pp collisions at the LHC performed by the CMS Collaboration showed an enhanced production of pairs of particles at $|\Delta\eta, \Delta\phi| \sim 0$, with the correlation extending over a wide range in $\Delta\eta$, a feature frequently referred to as a "ridge". These structures can be quantified by azimuthal Fourier coefficients, mostly of second (v_2) and third (v_3) order. Many of the physics mechanisms proposed to explain the pp ridge, include multiparton interactions, parton saturation and collective expansion of the final state.

This information plays a crucial role in understanding the features observed in p-Pb and Pb-Pb collisions at LHC energies. Therefore, a special attention will be given to the comparison of dependence of different observables as a function of the collision violence among the three systems.

In order to increase the ALICE capability for running in high luminosity conditions foreseen to be the case in Run3, a major upgrade program of the experiment is on the way. We embarked on two topics of the ambitious ALICE upgrade program, i.e.: the Time Projection Chamber (TPC) upgrade and new TRD online calibration software.

The amount of data obviously will increase and therefore a special attention will be given to the computing power and storage capacity delivered by the worldwide distributed ALICE-GRID infrastructure.

3. Scientific achievements in the last three years corresponding to the actual program funding (2 pages)

Up to now, our group proposed and worked out a physics topic, i.e. studies of hadrons transverse momentum distributions as a function of charged particle multiplicity and event shape in pp collisions, which turned out to be one of the most interesting phenomena to be studied in detail at LHC energies. Transverse momentum distributions and their ratios for π , K and p at mid rapidity ($|y| < 0.5$) for different charged particle multiplicities in pp collisions at $\sqrt{s} = 7$ TeV show an enhanced depletion of heavier species relative to the lighter ones in the low p_T

region with increasing charged particle multiplicity. The quality of simultaneous fits of the experimental spectra using a Boltzmann-Gibbs Blast Wave (BGBW) expression and the dynamics of the extracted kinetic freeze-out temperature T_{kin} , average transverse expansion velocity $\langle\beta_T\rangle$ and its profile n as a function of multiplicity have been shown to be similar with those obtained in heavy ion collisions.

In the last year the group activity focused on:

- *Experimental data analysis:*
 - Studies of efficiency corrections for obtaining p_T spectra for simultaneous cuts in multiplicity and directivity in order to select events with highly isotropic azimuthal distributions. Such conditioned p_T spectra for identified charged hadrons were obtained for pp collisions at $\sqrt{s} = 7$ TeV.
 - For charged particle p_T spectra as a function of multiplicity in pp collisions at $\sqrt{s} = 7$ TeV the main activities were related to the extended transverse momentum (p_T) range of the spectra, the systematic uncertainty evaluation using the VOM multiplicity selector, the comparison with the identified charged particle spectra, ratio of the multiplicity dependent spectra relative to minimum bias and the feed-down correction as a function of the VOM estimator. Thus the final spectra were approved to be included in the long paper dedicated to p_T spectra as a function of multiplicity for pp at $\sqrt{s} = 7$ TeV.
 - As far as the basic assumption of the Bjorken approach of "central-plateau" structure for particle production as a function of rapidity is fulfilled also for pp collisions at LHC energies, we made an estimate of the energy density as a function of charged particle density. Estimates of the Bjorken energy density for pp collisions as a function of charged particle density (VOM percentile) give values in the range of those estimated for Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. This could explain the similarities observed in the dynamics of the corresponding fireballs in spite of the large difference in their size.
 - A detailed comparison of pp ($\sqrt{s} = 7$ TeV), p-Pb ($\sqrt{s_{NN}} = 5.02$ TeV) and Pb-Pb ($\sqrt{s_{NN}} = 2.76$ TeV) based on ratios of p_T spectra at different multiplicity/centrality relative to the p_T spectra for the minimum bias p+p collision at the same collision energy, each of them normalized to the corresponding average charged particle density, free of any model assumption, has been done. The strong similarities between the three very different systems in the low region of p_T and the observed trends as a function of charged particle density/centrality and mass of the analyzed species, point to a similar boost type dynamics.
 - BGBW simultaneous fits of light flavour charged hadrons and hyperons p_T spectra for different centralities for Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV were done. The locus of the BGBW fit parameters $T_{kin} - \langle\beta_T\rangle$ is shifted by about 100 MeV towards higher T_{kin} if the fits are done simultaneously using only the hyperons (Λ , Ξ and Ω) relative to the case when the parameters are obtained performing a simultaneous fit only on π , K, p. This seems not to be the case for pp collisions at $\sqrt{s} = 7$ TeV.
 - The two-particle correlation function measured in terms of the relative pseudorapidity $\Delta\eta$ and azimuthal angle $\Delta\phi$ of selected particle pairs, $C(\Delta\eta\Delta\phi)$ was studied using the event mixing method for simultaneous cuts in multiplicity and directivity.

- TRD QA activities:

The quality of the acquired data is permanently monitored by the QA experts and reported in weekly or daily group meetings. Our group is in charge with the monitoring and quality assurance of the reconstructed tracks which belong to the charged particles crossing through the ALICE TRD sub-detector system. This task is performed within an existing software framework which was used for data quality monitoring and assurance during Run1. It was developed by including new software in order to get the necessary reconstruction information from the TRD in an efficient and comprehensive representations.

- GRID activities

NIHAM Data Centre continues to be one of the most efficient Tier2 components of ALICE GRID. This is a direct consequence of continuous efforts for permanent monitoring, in due time interventions, replacement of failing hardware components, efficient interaction with offline ALICE experts.

- TPC upgrade contribution:

The necessary infrastructure in terms of clearness of different labs., equipment, tools and specific consumables was finalized and the first OROC with two segments for PRR was assembled and successfully tested in our Department. It will be mounted in the ALICE cavern during the TS, beginning of November.

- Participation to detector operation

Although the above mentioned activities keep rather busy all members of the group, we are trying to fulfil also the duties related to the shifts necessary to run the ALICE experiment. This year we booked 15 blocks of shifts and made 12.4 till now.

4. Group members (table)

Name	analysis	R&D	Detector operation	Detector construction	Infrastructure Planning Financial issues Outreach Contracts
Mihai Petrovici	20%		3%	7%	8.23%
Daniel Bartos		38.23%			
Ionela Berceanu	38.23%				
Alexandru Bercuci	33.23%		5%		
Gheorghe Caragheorghopol		33.23%		5%	
Vasile Catanescu		33.23%		5%	
Florin Constantin		38.23%			
Marin Duma					
Viorel Duta			10%	10%	18.23%
Gheorghe Giolu				18%	28.23%

Iosif Legrand					
Mariana Petris		18.23%		20%	
Alexandrina Petrovici					38.23%
Amalia Pop	25%		8.23%		5.0%
Laura Radulescu		18.23%		10%	10.0%
Victor Simion		38.23%			
Claudiu Schiaua					38.23%
Andrei Cristian	30%		8.23%		
Andrei Herghelegiu	30%		8.23%		
Madalina Tarzila	25%		18.23%		5%
Valerica Aprodu		13.23%		25%	
Lucica Prodan		5.23%		25%	8%
Andrei Radu		10.00%		20%	8.23%
Constanta Dinca		3.00%		10%	25.23%
Georgiana Rosu					38.23%

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

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

5. Papers and talks in last year

- List papers (journal or conference proceeding or note) with role of group member(s) – split on categories, do not mix journal papers with conference notes etc.

- Papers:

p_T spectra of identified charged hadrons using the Bayesian PID:

- Particle identification in ALICE: a Bayesian approach, ALICE Collaboration, Eur. Phys. J. Plus 131 (2016) 168.

GRID (computation and storage) and detector operation support:

- Multiplicity dependence of charged pion, kaon, and (anti)proton production at large transverse momentum in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV,

ALICE Collaboration, Phys. Lett. B 760 (2016) 720

- Elliptic flow of electrons from heavy-flavour hadron decays at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV,
ALICE Collaboration, JHEP 09 (2016) 028
- Multiplicity and transverse momentum evolution of charge-dependent correlations in pp, p-Pb, and Pb-Pb collisions at the LHC,
ALICE Collaboration, Eur. Phys. J. C 76 (2016) 86
- Pseudorapidity dependence of the anisotropic flow of charged particles in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV,
ALICE Collaboration, arXiv: 1605.02035
- Higher harmonic flow coefficients of identified hadrons in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV,
ALICE Collaboration, arXiv:1606.06057 ; CERN-EP-2016-159
- Jet-like correlations with neutral pion triggers in pp and central Pb-Pb collisions at 2.76 TeV,
ALICE Collaboration, arXiv:1608.07201; CERN-EP-2016-195
- D-meson production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and in pp collisions at $\sqrt{s} = 7$ TeV,
ALICE Collaboration, arXiv:1605.07569; CERN-EP-2016-127
- Correlated event-by-event fluctuations of flow harmonics in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV,
ALICE Collaboration, arXiv: 1604.07663v1 CERN-EP-2016-102

Conferences:

- Multiplicity dependence of light flavour hadrons in small systems with the ALICE experiment
HQ2016: Hot Quarks 2016 (South Padre Island, TX, USA, 2016-09-12)
- Multiplicity dependence of identified particle production in proton-proton collisions measured with ALICE
XXXVII Encontro Nacional de Física de Partículas e Campos (Natal, Rio Grande do Norte, Brasil, 2016-09-03)
- Multiplicity dependence of light flavor hadron production in proton-proton collisions measured with ALICE
XII Quark Confinement and the Hadron Spectrum (Thessaloniki, Greece, 2016-08-29)
- Strangeness and light flavor production as a function of multiplicity in proton-proton collisions measured with ALICE
38th International Conference on High Energy Physics (Chicago, USA, 2016-08-03)
- Identified particle production in pp collisions at 7 and 13 TeV measured with ALICE
Strangeness in Quark Matter 2016 (UC Berkeley, 2016-06-27)
- Multiplicity dependence of light flavour hadrons in small systems with the ALICE experiment at LHC
XV Edizione di IFAE - Incontri di Fisica delle Alte Energie (Genova, 2016-03-30)
- Multiplicity dependence of identified hadrons production in pp collisions at $\sqrt{s} = 7$ TeV in the ALICE at LHC
The 6th Asian Triangle Heavy-Ion Conference (India International Center, New Delhi,

- India, 2016-02-15)
- Search for collective phenomena in high multiplicity pp and p-Pb collisions with ALICE
QCD Challenges at the LHC: from pp to AA (Taxco Guerra Mexico, 2016-01-18)

- List talks of group members (title, conference or meeting, date)
- From pp to AA ultrarelativistic collisions – invited talk,
M. Petrovici, C. Andrei, I. Berceanu, A. Herghelegiu, A. Pop, M. Tarzila
CARPATHIAN SUMMER SCHOOL OF PHYSICS 2016
Exotic Nuclei and Nuclear / Particle Astrophysics (VI). Physics with small accelerators, June 26 - July 09, 2016, Sinaia, Romania
- Multiplicity dependence of identified particle production in pp collisions
Search for collective phenomena
(presentation including results from ALICE, ATLAS and CMS Collaborations)
Cristian Andrei
LHC days in Split 2016, 19-24 September, Split, Croatia

ALICE PWG-s

Data Analysis:

- Charged hadron pt-spectra versus multiplicity pp 7 TeV, Spectra weekly meeting, 18 January 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Charged particle spectra 7 TeV pp versus mult, SPECTRA Weekly Meeting, 1 February 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Discussion on Spectra Modification, PID Spectra in pp-vs-mult: PC Meeting, 8 February 2016, M. Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila
- Update on charged hadron pT-spectra, SPECTRA Weekly Meeting, 22 February 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Discussion on Spectra Modification, PID Spectra in pp-vs-mult: PC Meeting, 22 February 2016, M. Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila
- Charged hadron pT-spectra versus multiplicity, SPECTRA Weekly Meeting, 29 February 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Discussion on Spectral Shapes and Boost-like Features, PID Spectra in pp-vs-mult: PC Meeting, 19 April 2016, M. Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila

- Update on the Inclusive Charged Analysis, PID Spectra in pp-vs-mult: PC Meeting, 30 August 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Multiplicity dependence of identified particle production in pp collisions (LHC days in Split), ALICE Hard Probes 2016 rehearsals, 16 September 2016, C. Andrei
- Core-corona studies, PID Spectra in pp-vs-mult: PC Meeting, 20 September 2016, M.Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila
- The core-corona approach, PWG-LF meeting, 3 October 2016, M.Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila
- Analysis update: charged particles pp @ 7 TeV, Spectra weekly meeting, 10 October 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Unidentified Analysis Update, PID Spectra in pp-vs-mult: PC Meeting, 21 October 2016, A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop, M. Tarzila
- Core-corona studies, PID Spectra in pp-vs-mult: PC Meeting, 21 October 2016, M.Petrovici, C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, A. Pop, M. Tarzila

TPC Upgrade:

- Status in Bucharest, TPC Upgrade planning meeting: pre-production, 4 February 2016, M. Petris, M. Petrovici
- Status in Bucharest, TPC Upgrade plenary meeting, 7 June 2016, M. Petrovici
- In the last period regular presentations in the weekly TPCU&P meetings

TRD QA:

- QA of latest productions, TRD Weekly Meeting, 18 January 2016, M. Tarzila
- TRD, ALICE QA meeting, 19 January 2016, M. Tarzila
- RM Report, RC weekly meeting, 12 April 2016, M. Tarzila
- TRD, ALICE QA meeting, 26 April 2016, M. Tarzila
- TRD, ALICE QA meeting, 3 May 2016, M. Tarzila
- TRD, ALICE QA meeting, 11 May 2016, M. Tarzila
- TRD, ALICE QA meeting, 17 May 2016, M. Tarzila
- Status Report on TRD QA, TRD Weekly Meeting, 27 May 2016, M. Tarzila
- TRD, ALICE QA meeting, 24 May 2016, M. Tarzila
- TRD, ALICE QA meeting, 8 June 2016, M. Tarzila
- TRD, ALICE QA meeting, 14 June 2016, M. Tarzila
- TRD, ALICE QA meeting, 21 June 2016, M. Tarzila
- TRD, ALICE QA meeting, 28 June 2016, M. Tarzila
- TRD, ALICE QA meeting, 5 July 2016, M. Tarzila
- TRD, ALICE QA meeting, 13 July 2016, M. Tarzila
- TRD, ALICE QA meeting, 27 July 2016, M. Tarzila

- Other deliverables (patents, books etc.)

6. Further group activities (1 page)

- Collaborations, local synergies, education, outreach

R&D activities for a new generation of high counting rate RPC and TRD detectors, associated frontend electronics and free running mode data processing

Summer Student Program:

Two students from Birmingham and Hamburg were involved in our activities in this summer.

Outreach:

- M. Petrovici - "Engineering Excellence in Basic Research"
DHBW Mosbach , February 4, 2016
- ALICE Matters - 31 August 2016
- Numerous visits of Romanian and foreign delegations, Romanian pupils winners of International Competition in Physics, students of the Romanian Physics Faculties network
- Presentation and Posters on the occasion of Romania becoming full member at CERN
- Poster at Researchers Night, September 2016