

- **Project team :**

- Prof. Dr. Mihai Petrovici (physicist) – team leader
- Senior researcher III Dr. Cristian Andrei (physicist)
- Master student Dana Avramescu (physicist)
- Senior researcher III Daniel Bartos (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 Viorel Duta (mechanical engineer)
- Senior researcher III Dr. Andrei Herghelegiu (physicist)
- Master student Amelia Lindner (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 (physicist)
- Technician Valerica Aprodu
- Technician Lucica Prodan
- Technician Andrei Radu
- Technician Constanta Dinca
- Financial coordinator Georgiana Rosu (economist)
- Visiting senior scientist Dr. Vasile Pop Topor (physicist)
- Lathe and milling machine operator, Gheorghe Dima (mechanical worker)

- **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 and understand their origin.

- **Highlights of accomplishments in the last year:**

Physics:

- Studies for obtaining p_T spectra simultaneously conditioned on multiplicity, directivity and within same-side, away side and in between relative to the leading particle for identified charged hadrons in pp collisions at $\sqrt{s} = 7$ TeV - close to be finalized

- Studies of two charged particles correlations as a function of multiplicity and directivity in pp collisions at $\sqrt{s} = 7$ TeV
PhD thesis finalized – presentations in the corresponding PAG and PWG on the way
- Studies on the core-corona interplay at LHC and RHIC energies based on experimental data and Glauber MC estimates - close to be finalized
- >40 presentations in ALICE meetings (TPCU)
- Contribution to 14 conference presentations
- Co-authors to 14 ALICE published papers
- On similarities as a function of system size in heavy ion collisions – invited lecture
M.Petrovici, A.Lindner and A.Pop
Carpathian Summer School of Physics, July 1-14, 2018, in print at AIP Proceedings
- Core-Corona and Geometrical scaling from RHIC to LHC energies, pp - (A-A) similarities
M. Petrovici, Light-Up Workshop, CERN, June 14-16, 2018
- IFIN-HH/HPD within ALICE and CBM
M. Petrovici, NuPECC Meeting - Bucharest, October 12, 2018
- Geometrical scaling from RHIC to LHC energies
A. Lindner, Anual Scientific Meeting, University of Bucharest, June 21st, 2018
- Geometrical scaling for energies available at the BNL Relativistic Heavy Ion Collider to those at the CERN Large Hadron Collider
M. Petrovici, A. Lindner, A. Pop, M. Târzila and I. Berceanu,
Phys. Rev. C98(2018)024904
- Multiplicity dependent p_T distributions of identified particles in pp collisions at 7 TeV within HIJING/BB⁻ v2.0 model
V. Topor Pop and M.Petrovici
[arXiv:1806.00359v2](https://arxiv.org/abs/1806.00359v2) [hep-ph]; accepted at Phys.Rev. - in print
- Geometrical scaling for pions, kaons and protons and strange particles in pp collisions at $\sqrt{s}=7$ and $\sqrt{s}=13$ TeV - preliminary results
- PC members - Multiplicity dependence of light-flavor hadron production in pp collisions at $\sqrt{s} = 7$ TeV
[arXiv:1807.11321v1](https://arxiv.org/abs/1807.11321v1) [nucl-ex]; provisionally accepted at Phys.Rev.C

ALICE upgrade:

- 2nd in-house test box was produced
- The extra drift electrode of one in-house box was changed such that a direct irradiation of the whole gas volume around the HV wires is now possible
- Many features of the in-house tests monitoring and the on-line representation of the results were implemented
- Components of three OROC in-house test boxes were produced
- 17 OROCs were successfully assembled and tested; 15 already transported at CERN, passing the upon arrival tests.

Computing:

- Maintaining NIHAM in a leading position among Tier2s ALICE GRID centers, NAF efficient management

ALICE shifts:

59.5 shifts booked (79% of the quota for our group) as Detector Control System, Data Acquisition Control System operators, Run Manager from which 41.5 shifts already done.

2. Scientific goals

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 A–A collisions, a number of genuine pp physics becoming of primary interest once the new data from the first experiments at $\sqrt{s}=7$ TeV became available. Multiparton interactions and re-scatterings 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.

The results obtained in Run1 at which our group had a significant contribution are supported by the results obtained in Run2 at $\sqrt{s}=13$ TeV.

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 highest 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. 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 is given to the comparison of dependence of different observables as a function of the collision violence among the three systems.

In order to extract signals originating from multiparticle interactions it is mandatory to remove, as much as possible, based on experimental information, the contribution coming from single collisions in case of Pb-Pb and p-Pb or low density hadronic matter overlap in case of pp, known as corona contribution. Systematic studies on core-corona interplay and the dependence on the centrality of the extracted core contribution for different observables will give the possibility to evidence different types of scaling suggested by QCD inspired models.

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., our team being involved in the ALICE-TPC upgrade program.

The amount of data will obviously 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

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} , the average transverse expansion velocity $\langle\beta_T\rangle$ and its profile n as a function of multiplicity has been shown to be similar with those obtained in heavy ion collisions. We started to extend these studies towards multi-differential analyses complemented by correlation studies.

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 pp 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 analysed species point to a similar boost type dynamics.

In the last year the group activity focused on:

- **Experimental data analysis and interpretation:**

- “Multiplicity dependence of light flavour hadron production in pp collisions at $\sqrt{s} = 7$ TeV” is provisionally accepted at Phys.Rev.C
- Two-particle correlation studies as a function of charged particle multiplicity and event shape selection based on directivity and sphericity for pp collisions at $\sqrt{s}=7$ TeV. Comparison with PYTHIA, PHOJET and EPOS predictions. A PhD thesis was finalized.
- We continued the investigations of core-corona interplay and presently we are working on extracting different observables attributed to the core in Pb-Pb at LHC and Au-Au at RHIC.
- Geometrical scaling suggested by the CGC model was studied in terms of $\langle p_T \rangle$, the slope of $\langle p_T \rangle$ mass dependence for pions, kaons and protons and the average transverse expansion $\langle\beta_T\rangle$ dependence on the charged particle density per unit of rapidity and unit of overlapping area starting from BES at RHIC up to LHC energies for Cu-Cu, Au-Au, Xe-Xe, Pb-Pb and pp collisions.

- **GRID activities**

NIHAM Data Centre continues to be one of the most efficient Tier2 components of ALICE GRID. This is a result of a continuous effort to improve the monitoring tools, in due time interventions, replacement of failing hardware components, efficient interaction with offline ALICE experts. Procurement of a rather significant computing and storage capacity and two cooling units were finalized.

- **TPC upgrade contribution:**

The assembling and test activities in our Department were very successful in many respects. The local infrastructure, expertise and know-how have been crucial in finalizing in due time the ambitious commitment of assembling and testing 50% of the outer readout chambers (OROCs) based on GEM technology. The results in terms of energy resolution, 2D gain distribution and its reproducibility, the results of the long term tests in high flux of X-ray were reported weekly in the ALICE-TPCU video meetings. 15 OROCs were already transported to CERN and the rest of 5 chambers will be finalized and transported to CERN in the next month.

- **Participation to detector operation**

In parallel with the above mentioned activities which are keeping rather busy all members of our group, we are trying to fulfill also the duties related to the shifts necessary to run the ALICE experiment. This year we booked 59.5 shifts (79% of the quota for our group) as Detector Control System, Data Acquisition Control System operators and Run Manager, 41.5 being done until now, according to the schedule.

4. Group members

Name	Analysis (%)	R&D (%)	Detector operation (%)	Detector construction (%)	Infrastructure Planning Financial issues Outreach Contracts (%)
Mihai Petrovici	7	4.69		7	10
Daniel Bartos		8		30.14	
Alexandru Bercuci	24.33		4		
Gheorghe Caragheorgheopol		6.63	35		
Vasile Catanescu		17.71	25		5
Viorel Duta			16.63	40	10
Mariana Petris			13.56	10	5
Alexandrina Petrovici					15.01
Amalia Pop	30.07		4		
Laura Radulescu			12.35	20	
Victor Simion			25.84	10	
Claudiu Schiaua					29.05
Andrei Cristian	20		6.48		
Andrei Herghelegiu	12		6.64		
Madalina Tarzila	50		7.10		
Amelia Lindner	60		7.15		
Dana Avramescu	7				1.3
Topor-Pop Vasile	13.04				
Valerica Aprodu				37.82	
Lucica Prodan				54.04	10
Andrei Radu					
Constanta Dinca					27.67
Gheorghe Dima				20	9.31
Georgiana Rosu					4.46

Total: 8.1 FTE

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

Name		Present status
Madalina Tarzila	PhD student	Research assistant Temporary employment
Dana Avramescu	Master student	Temporary employment
Amelia Lindner	Master student	Research assistant Temporary employment

5. Papers and talks in last year

Papers:

- On similarities as a function of system size in heavy ion collisions – invited lecture
M.Petrovici, A.Lindner and A.Pop
Carpathian Summer School of Physics, July 1-14, 2018, in print at AIP Proceeding
- Geometrical scaling for energies available at the BNL Relativistic Heavy Ion Collider to those at the CERN Large Hadron Collider
M. Petrovici, A. Lindner, A. Pop, M. Târzila and I. Berceanu^[1]
Phys. Rev. C98(2018)024904
- Multiplicity dependent pT distributions of identified particles in pp collisions at 7 TeV within HIJING/BB⁻ v2.0 model
V. Topor Pop and M. Petrovici
[arXiv:1806.00359v2](https://arxiv.org/abs/1806.00359v2) [hep-ph]; accepted at Phys.Rev. - in print^[1]
- PC members - Multiplicity dependence of light-flavor hadron production in pp collisions at $\sqrt{s} = 7$ TeV
ALICE Collaboration
[arXiv:1807.11321v1](https://arxiv.org/abs/1807.11321v1) [nucl-ex]; provisionally accepted at Phys.Rev.C

GRID (computation and storage) and detector operation support:

- Neutral pion and η meson production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV,
CERN-EP-2018-002

- Anisotropic flow in Xe-Xe collisions at $\sqrt{s} = 5.44$ TeV ,
Physics Letters B, 784 (2018) 82-95
- Constraints on jet quenching in p-Pb collisions at $\sqrt{s} = 5.02$ TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions,
Phys. Lett. B 783 (2018) 95-113
- First measurement of Ξ_c^0 production in pp collisions at
 $\sqrt{s} = 7$ TeV, Phys. Lett. B 781 (2018) 8-19
- Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV, Phys. Lett. B 781 (2018) 20-32
- Measurement of Z^0 -boson production at large rapidities in Pb-Pb collisions at $\sqrt{s} = 5.02$ TeV, Phys. Lett. B 780 (2018) 372–383
- D-meson azimuthal anisotropy in mid-central Pb-Pb collisions at
 $\sqrt{s} = 5.02$ TeV , Phys. Rev. Lett. 120 (2018) 102301
- Search for collectivity with azimuthal J/ψ -hadron correlations in high multiplicity p-Pb collisions at $\sqrt{s} = 5.02$ and 8.16 TeV,
Phys. Lett. B 780 (2018) 7-20
- Systematic studies of correlations between different order flow harmonics in Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV, Phys. Rev. C 97 (2018) 024906
- Constraining the magnitude of the Chiral Magnetic Effect with Event Shape Engineering in Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV, Phys. Lett. B 777 (2018) 151-162
- The ALICE Transition Radiation Detector: construction, operation, and performance ,
Nucl. Instr. Meth. A881 (2018) 88
- First measurement of jet mass in Pb-Pb and p-Pb collisions at the LHC, Phys. Lett. B 776 (2018) 249
- J/ψ production as a function of charged-particle pseudorapidity density in p-Pb collisions at $\sqrt{s} = 5.02$ TeV, Phys. Lett. B 776 (2018) 91
- Energy dependence and fluctuations of anisotropic flow in Pb-Pb collisions at $\sqrt{s} = 5.02$ and 2.76 TeV,
JHEP 07 (2018) 103

Conferences:

- Core-Corona and Geometrical scaling from RHIC to LHC energies, pp - (A-A) similarities
M. Petrovici, Light-Up Workshop, CERN, June 14-16, 2018
- IFIN-HH/HPD within ALICE and CBM
M. Petrovici, NuPECC Meeting - Bucharest, October 12, 2018
- Geometrical scaling from RHIC to LHC energies
A. Lindner, Annual Scientific Meeting, University of Bucharest, June 21st, 2018
- Systematics of $\langle p_T \rangle$ and their mass dependence as a function of a CGC inspired variable in ultra-relativistic heavy ion collisions
A. Lindner, IFIN-days, Bucharest, December 19, 2017
- 7th International Conference on High Energy Physics in the LHC Era (Universidad Técnica Federico Santa María, Valparaiso, Chile, 08/01/2018)
- The ALICE detector upgrade program
- Studying the bulk properties of matter under extreme conditions with ALICE
 - Constraining QCD Phase Boundary with data from Heavy Ion Collisions – In memory of Helmut Oeschler (GSI Darmstadt, 12/02/2018)
- Production of pions, kaons, protons, and (multi-)strange particles with ALICE at the LHC (Presenter: Kalweit, Alexander Philipp)
Rencontres de Moriond QCD and High Energy Interactions (Moriond (France), 17/03/2018) :
- Understanding particle production in high multiplicity pp collisions using event shape studies in ALICE (submitted as convener) (Presenter:)
QM2018 The 27th Int. Con. on Ultrarelativistic Nucleus-Nucleus Collisions (Venezia (Italy), 13/05/2018):
- Multiplicity and energy dependence of inclusive charged and identified particle production in pp collisions with ALICE at the LHC
- Upgrade of the ALICE central barrel tracking detectors: ITS and TPC

- Highlights from ALICE
- POSTER]- Energy dependence of transverse momentum spectra of primary charged particles in proton proton collisions measured by ALICE at the LHC
- POSTER - Production of pions, kaons and protons as a function of charged particle multiplicity in pp collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC (Prese Sixth Annual Conference on Large Hadron Collider Physics (Bologna, 04/06/2018):
- From small to large colliding systems: lessons learned and future perspectives
- The upgrade program of ALICE at the LHC
MESON2018-15th International Workshop on Meson Physics (Krakow (Poland), 07/06/2018):
- Energy and system dependence of light- and heavy-flavor hadron production in p-p, p--Pb, Xe--Xe and Pb--Pb collisions at the LHC
EuNPC - European Nuclear Physics Conference 2018 (Bologna, 02/09/2018):
- Light-Flavor Hadron Production from Small to Large Collision Systems at ALICE
Hard Probes 2018 (Aix-Les-Bains, 01/10/2018):
 - ALICE results on the production of charged particles in pp, p-Pb, Xe-Xe and Pb Pb collisions at the LHC

TPC Upgrade:

- ~ 40 presentations in ALICE TPCU meetings
- 15 OROCs finalized and already transported to CERN
- 5 OROCs will be finalized in the next month

6. Further group activities

- ***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

- 2 new RPC prototypes with the final architecture for CBM-ToF inner zone
- High rate free running mode tests of the 2D position sensitive TRD operated with FEE and DAQ designed and realized in our Department
- International Conferences and Meetings:
 - 10 presentations at CBM Collaboration meetings
 - 5 contributions to the CBM Annual Report

- 1 oral presentation at ICHEP 2018-10-2018

- Papers:

- Romanian Journal of Physics 63, 901 (2018);
- Journal of Physics: Conference Series, Vol. 1023(2018), 012007
- Nucl. Instr. and Meth. A – provisionally accepted

Summer Student Program:

Quite successful, i.e. 5 participants: 3 students from Birmingham University, 1 from Bucharest Technical University and 1 from Sherbone High School, England.

Outreach:

- Numerous visits of Romanian and foreign delegations, Romanian pupils winners of International Competitions in Physics
- “My experience within the ALICE experiment at LHC”, A. Herghelegiu, Summer School for pupils, prepared for International Competitions in Physics, Busteni, 18-26 July, 2018
- Interview for Romanian Radio Broadcast
- Visit of Paulo Giubellino – Scientific Managing Director of FAIR/GSI
- Visit of some SMEs of Magurele Tech. Park
- More details could be seen in:
<https://niham.nipne.ro>
<https://www.youtube.com/watch?v=OJd4fA0xUh0>
<https://www.facebook.com/Hadron-Physics-Department-211078852968333/>
<https://www.youtube.com/watch?v=ZHBgGKamUc8&feature=youtu.be>