Project: **IFIN-HH Contribution to the ALICE Experiment at LHC**

Scientific Report 2012

The activities performed after the first ISAB meeting are presented following the objectives and activities foreseen in the "Proposal description" and "Project Workplan" of the above mentioned project.

Stage I-2012:

p+p , A+A, p+A, collisions experiments. High efficiency tracking algorithms for TRD. Studies of event shape variables selection performance for events of interest, analysis of Monte Carlo and experimental data.

Objective O3: Running ALICE experiment at LHC for p+p, Pb+Pb and p+Pb collisions.

Activity I.1
In beam p+p, A+A, p+A measurements using the ALICE detector./Shifts at ALICE experiment
Shifts at the Subdetectors and Central Subsystems of the ALICE experiment:

-2 blocks TPC+TRD (2011)
-2 blocks at Detector Control System
-3 blocks at Data Acquisition system+Central Trigger Processor+High Level Trigger
-1 block at Data Quality Monitoring (2011)
-5 shifts as Shift Leader in Matters of Safety

1 block=6 shifts

Results: Shift reports: https://alice-logbook.cern.ch

One should underline that NIHAM data center of our Department, component of the ALICE GRID reached and maintains a remarkable contribution to the ALICE Grid due to a competent and permanent activity of members of our group which by is no means less important as maintaining the ALICE experiment running and therefore should be correspondingly accounted and recognized.

Objective O4: Development of high efficiency tracking for TRD chambers.

Activity I.2
Development and improvement of high efficiency tracking algorithms for ALICE-TRD subdetector

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.1 and Fig.2 a remarkable agreement between the MC and data was obtained.

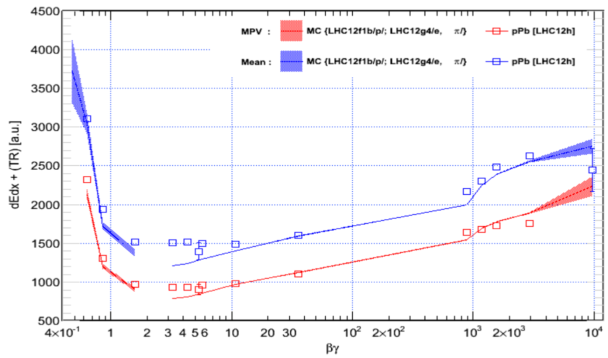


Fig.1

Fig.1 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.

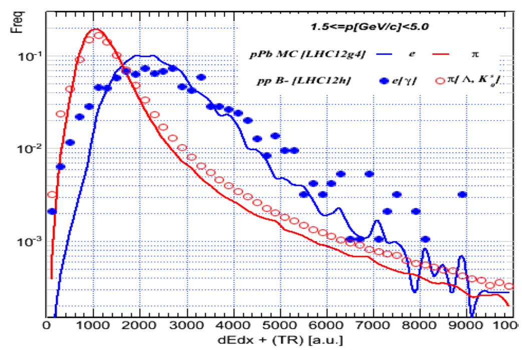


Fig.2

In Fig.2 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.

The quality of the tracking efficiency and its stability for different conditions (interacting systems and field polarity) as a function of run number can be followed in Fig.3 for 3 ingredients of TRD measurements namely the number of clusters per tracklet (blue) directly related to .dEdx+TR measurements and for tracklet/track (red) related to p_t resolution. The number of clusters per track (black) is a convolution of the previous 2. A slight dependence with the local multiplicity is identifiable in these trends as ramping up. These are correlated with accelerator fills and are mainly induced by TPC fakes. Development of algorithms to reject such fakes is in progress.

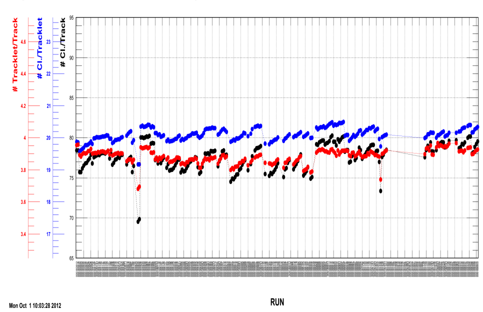


Fig.3

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 (see μ(Δy) Fig.4), z (see μ(Δz) Fig.4) and azimuthal angle (see μ(ΔΦ) Fig.4).
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.

An example of a QA performance plots in terms of above mentioned observables can be followed in Fig.4.

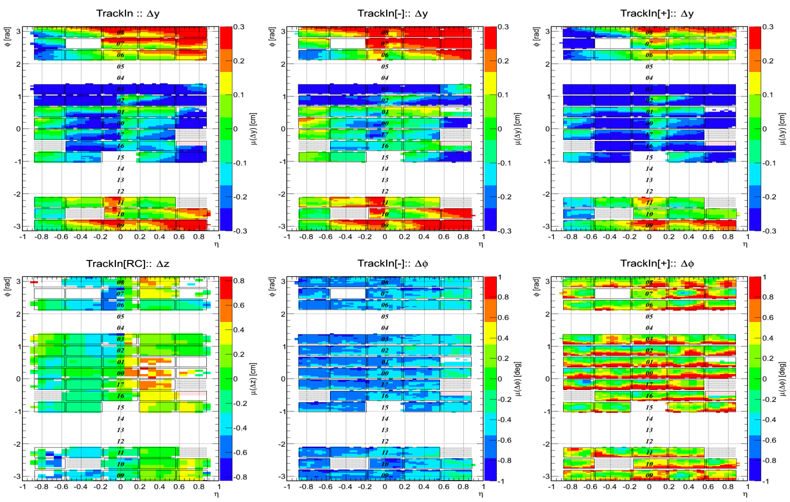


Fig.4

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:

- ITS-TRD tracking for ALICE upgrade
- Stand-alone TRD tracking

PWG Contributions

- Status of the TRD reconstruction
  A. Bercuci
  PWG-PP tracking and alignment meeting, November 3 2011

- Possibility of ITS-TRD matching
  A. Bercuci
  PWG-PP tracking and alignment meeting, January 19 2012

- TRD-ITS matching performance for Pb-Pb
  A. Bercuci
  PWG-PP tracking and alignment meeting, February 2 2012
- TRD alignment update
  A. Bercuci
  PWG-PP tracking and alignment meeting, March 22 2012

- Tracking PID non uniformity
  A. Bercuci
  PWG-PP tracking and alignment meeting, April 5 2012

- LHC12c,d: TRD
  A. Bercuci
  ALICE QA meeting, May 5 2012

- LHC12a,b TRD
  A. Bercuci
  ALICE QA meeting, August 7 2012

- TRD
  A. Bercuci
  ALICE Offline week, November 11 2011

Objective O4.

- Developing 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 in the selection of events.

Activity I.3

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. Analysis of experimental data.

Results:
a. studies of event shape variables selection performance for events of interest, analysis of Monte Carlo and experimental data p_T distributions of charged hadrons and pions, kaons and protons for high multiplicity and close to azimuthal isotropic events in p + p collisions at 7 TeV
b**.** internal notes, presentations at Spectra group and PWG2, 2 ISI journal publications
a.
<u>Motivation</u>

Selection of nearly azimuthal isotropic events using event shape global variables.

<u>Definitions</u>

Sphericity [1] is defined as:

$$S_{\perp} = \frac{2\lambda_2}{\lambda_2 + \lambda_1}$$

where $\lambda_1 > \lambda_2$ are the eigenvalues of the matrix:

$$S_{xy} = \frac{1}{\sum_i p_T^i} \sum_i \begin{pmatrix} {p_x^{(i)}}^2 & p_x^{(i)} \cdot p_y^{(i)} \\ p_x^{(i)} \cdot p_y^{(i)} & {p_y^{(i)}}^2 \end{pmatrix}$$

Directivity [2] is defined using the following formula:

$$D^{\pm} = \frac{|\sum_i \vec{p}_{t,i}|}{\sum_i |\vec{p}_{t,i}|}|_{\eta^{pos/neg}}$$

Since it was noticed that there are large discrepancies between the directivity values in the positive and negative η range, directivity can be redefined as the average of the D^+ and D^- in order to avoid jet-like signals in any of the two regions. Another possibility is to select events imposing conditions on both directivity values.

Thrust [3] is defined as the maximum value of:

$$T = \underbrace{max}_{\vec{n}_T} \frac{\sum_i |\vec{p}_{t,i} \cdot \vec{n}_T|}{\sum_i |\vec{p}_{t,i}|}$$

Modified Transverse Fox-Wolfram Moments [4] are defined as:

$$H_l = \frac{\sum\limits_{i,j} p_i p_j P_l(cos\phi_{ij})}{\sum\limits_{i,j} p_i p_j}$$

where p_i, p_j and Φ_{ij} are the momenta and the angle between the i-th and j-th particle in the event. P_l are the Legendre polynomials.

All the event shapes global observables are computed in the central region of the ALICE detector using simulated Pythia events at 7TeV. Events with isotropic azimuthal particle distribution are called isotropic or uniform.

<u>Examples</u>

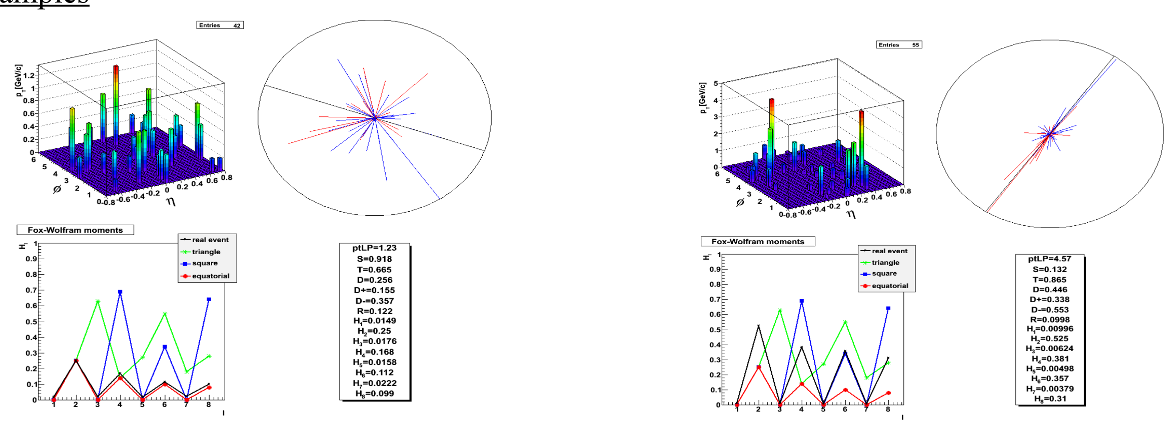


Fig. 5

Isotropic (left) and di-jet (right) event examples.

Two examples of events with quite different topology are shown in Fig. 5. In each of the examples, in the upper left plot, the particle transverse momentum distribution in the plane defined by the azimuthal angle and the pseudorapidity is plotted. The upper right plot represents the projection of the previous representation in the transverse plane relative to the collision axis. The length of each line represents the value of the corresponding transverse momentum normalized to the highest value in the event. Particles in the two regions of pseudorapidity are plotted with red and blue lines. The black line is the thrust axis. In the lower left plot, the Fox-Wolfram values corresponding to different event geometries are represented as graphs. The values for a real analyzed event are shown in black. The event shape observables in the left example correspond to the "uniform" (close to azimuthal isotropy) topology, while on the left is shown an example of shape selecting a two back-to-back jets type event. Several thousands examples were produced and examined as a first-hand check for the selection capabilities of the event shapes.

Multiplicity dependence

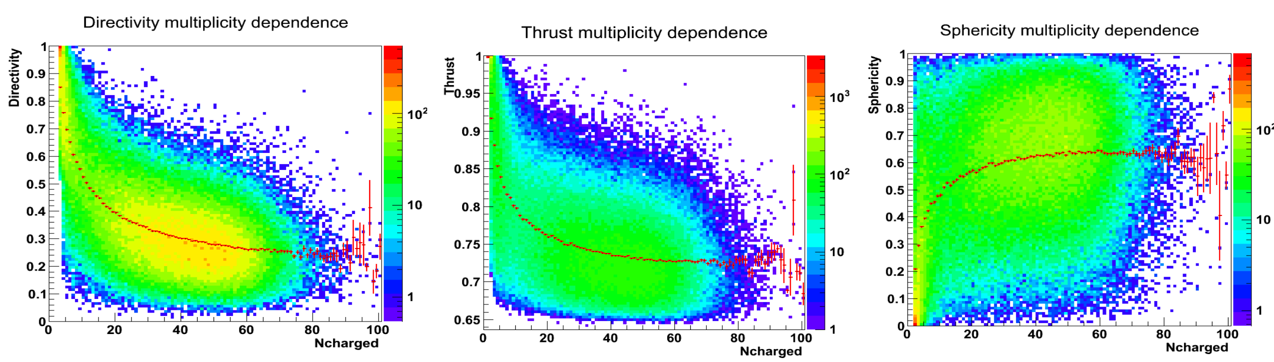


Fig. 6
Multiplicity dependence of directivity, thrust and sphericity

The multiplicity dependence of the directivity, thrust and spherisity is plotted in Figure 6. All the event shapes multiplicity dependence show a certain dynamics towards the uniform region for high multiplicity values, at least when considering average values (red dotted lines), without excluding the presence of jet-like events for the same high multiplicity values. At lower multiplicities, the non-uniform values of the event shapes are obtained mainly due to simple mathematical reasons (e.g. directivity will always be equal to 1 in events with one particle in each pseudorapidity region).

Selection performance evaluation

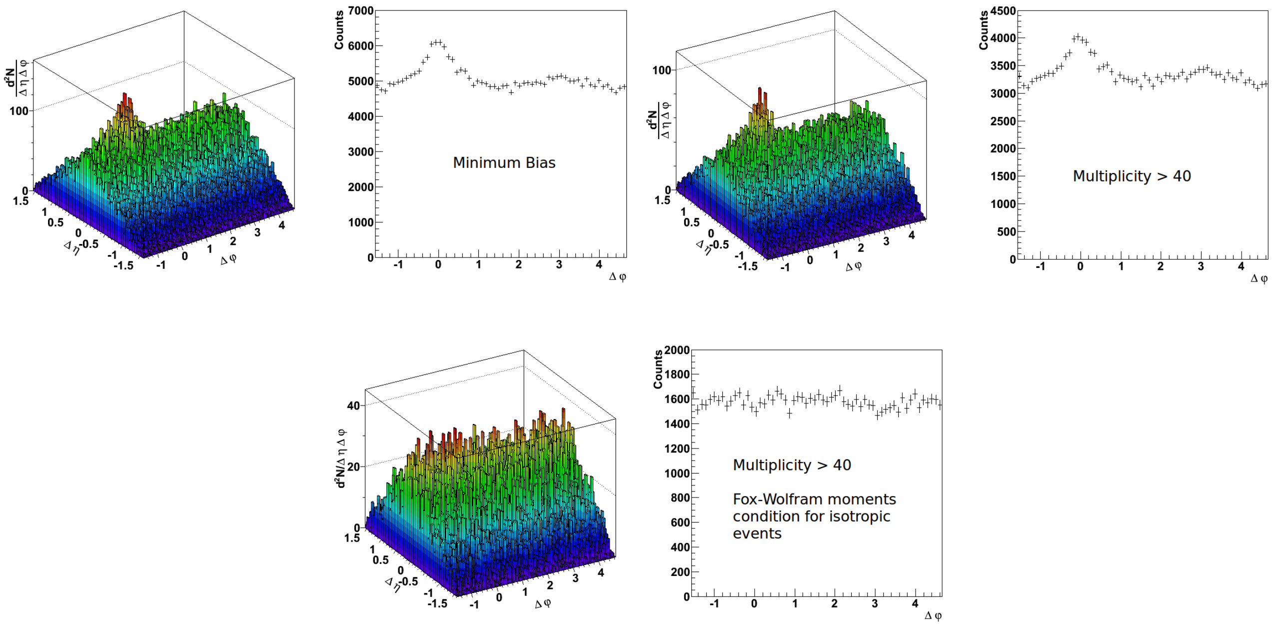


Fig. 7
Particle distributions relative to the leading particle in each event

Another method to investigate the selection capabilities of the event shapes is to build and evaluate the correlations relative to the leading particle in each event. The leading particle is defined as the particle with the highest transverse momentum. The reason to construct such distributions lies in the fact that jets contain high energy (momentum) particles confined in a relative narrow cone in the (η,φ) plane. This means that for jet events the correlations will exhibit a peak-like structure on the near-side and a correlated one on the opposite side as could be seen in the upper plots of Fig.7 in the case of minimum bias events (left side) or high multiplicity events without any condition on event shape (right side). On the other hand, isotropic events will show no correlation as it is possible to observe in the lower plot of Fig. 7 where only high multiplicity events passing the uniformity cuts for the MFWM are considered. The projection on the azimuthal plane is also plotted on the right side of each plot. One should mention that no background subtraction was performed on these plots.

Such studies and p_T spectra analysis for different classes of events selected using above described 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.

First, the experimental data is analyzed in order to extract the raw transverse momentum spectra. This implies selecting the relevant events (a proton-proton collision that takes place in the area where the detector provides the maximum coverage) and also applying numerous selection criteria on the corres-

ponding particles such as: being a primary particle (identified based on the distance of closest approach to the main vertex), having a pseudorapidity between -0.5 and 0.5 and also fulfilling a number of criteria which defines the quality of the reconstruction. Extra selection criteria can be applied for selecting events of a certain shape and in a certain multiplicity range.
Next, by running exactly similar procedure on Monte Carlo simulated events it is possible to determine the detector efficiencies and corrections that are necessary in order to obtain the final spectra. This enables the determination of the tracking efficiency (which accounts for the particles that are not reconstructed), the matching efficiency (particles might be detected or reconstructed only in some subdetectors), the Particle IDentification efficiency (the percentage of correctly identified particles) and the contamination generated by particles which are misidentified by the PID algorithm.
The behavior of all these corrections as a function of multiplicity and event shape must be also carefully studied. Presently we have implemented two completely different PID methods and this allows us to crosscheck very fast our results and also provides an estimation of the systematic errors which are generated by the PID procedure. The first method is based on the Bayesian approach which generates a probability for each possible identity of the considered particle. By setting a threshold for the highest probability one can obtain lower contamination but this has to be carefully used because a decrease of the efficiency also occurs. The second PID method implemented in the analysis procedure uses a 2 or 3 sigma band along the theoretical detector response predicted for each mass hypothesis in order to assign an identity to the considered particle.
Preliminary results have been obtained concerning the study of the various efficiencies and their multiplicity dependence, weak decays and material contamination corrections of the spectra as a function of multiplicity, charged particle spectra and average transverse momentum as a function of multiplicity. The comparison with MB spectra already obtained in the collaboration for charged particles and identified hadrons, was also carefully treated. This assures the consistent and correct analysis of data as a function of multiplicity and event shape.

Bibliography
[1] J.D. Bjorken and S.J. Brodsky, Phys. Rev. **D1** (1970) 1416.
[2] S. Brandt, Ch. Peyrou, R. Sosnowski and A. Wroblewski, Phys. Lett. **12** (1964) 57; E. Fahri, Phys. Rev. Lett. **39** (1977) 1587.
[3] P. Beckmann et al., Mod. Phys. Lett. A **3**, 163 (1987); J. P. Alard and the FOPI Collaboration, Phys. Rev. Lett. **69**, 889 (1992)
[4] G.C. Fox and S. Wolfram, Nucl. Phys. **B149** (1979) 413.

b.
PWG Contributions:

- Transverse momentum distributions of pions, kaons and protons vs. multiplicity and event shape in p+p collisions at 7 TeV
  C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, F.Noferini, M. Petrovici, A. Pop
  Spectra weekly meeting 10.11.2011

- Weighted efficiency correction for charged hadrons – preliminary results
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, , M. Petrovici, A. Pop
  Spectra weekly meeting 10.11.2011

- Transverse momentum distributions of pions, kaons and protons vs. multiplicity and event shape in p+p collisions at 7 TeV
  C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, F.Noferini, M. Petrovici, A. Pop
  PWG2 meeting 15.11.2011

- The status of the DCA-based correction for material a weak decays feed-down in multiplicity bins
  Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, M. Petrovici, A. Pop, C. Schiaua, F.Noferini
  PWGLF/Spectra weekly meeting 26.01.2012

- p_T distributions of charged hadrons and π, K and p for high multiplicity and close to azimuthal isotropic events in p + p collisions at 7 TeV
  C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, F.Noferini, M. Petrovici, A. Pop
  PWGLF/Spectra weekly meeting 05.04.2012

- pt distributions of charged hadrons and π, K and p for high multiplicity and close to azimuthal isotropic events in p + p collisions at 7 TeV
  C. Andrei, I. Berceanu, A. Bercuci, A. Herghelegiu, F.Noferini, M. Petrovici, A. Pop
  PWGLF/Spectra weekly meeting 12.04.2012

- Multiplicity dependence of the efficiency correction
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop
  PWGLF/Spectra weekly meeting, March 8 2012

- Transverse momentum distributions of charged particles in p-p collisions at 7 TeV as a function of multiplicity
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop
  PWGLF/Spectra weekly meeting, May 10 2012

- Transverse momentum distributions of charged particles in p-p collisions at 7 TeV
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop
  PWGLF/Spectra PAG weekly meeting, August 23 2012

- Transverse momentum distributions of charged particles in p-p collisions at 7 TeV
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop
  PWGLF/Spectra PAG weekly meeting, August 30 2012

- Transverse momentum distributions of charged particles in p-p collisions at 7 TeV
  A. Herghelegiu, C. Andrei, I. Berceanu, A. Bercuci, M. Petrovici, A. Pop
  PWG-LF ALICE mini-week, September 3 2012

Internal notes:

- https://twiki.cern.ch/twiki/pub/ALICE/PWGLFPAGSPECTRAMultiplicityEventShapePP7/coll_ph_pp_ALICE_internal_note_3_04042012.pdf
- https://twiki.cern.ch/twiki/pub/ALICE/PWGLFPAGSPECTRAMultiplicityEventShapePP7/coll_ph_pp_ALICE_analysis_note_4_04042012_v2.pdf

EUNPC 2012

- Poster: Event Shapes in p-p Collisions at √s=7TeV
  HERGHELEGIU, Andrei, ANDREI, Cristian, BERCEANU, Ionela, BERCUCI, Alexandru, PETROVICI, Mihai, POP, Amalia
- Poster: Deconfinement and Collectivity in Hadron Collisions?
  ANDREI, Cristian , BERCEANU, Ionela, BERCUCI, Alexandru, HERGHELEGIU, Andrei, PETROVICI, Mihai, POP, Amalia

Institute review: - 2 ALICE papers

ISI Papers:

- Underlying Event measurements in pp collisions at √s = 0.9 and 7 TeV with the ALICE experiment at the LHC , ALICE Collaboration, JHEP 1207 (2012) 116
- Femtoscopy of pp collisions at √s = 0.9 and 7 TeV at the LHC with two-pion Bose-Einstein correlations , ALICE Collaboration, Phys. Rev. D 84, 112004 (2011)
- Transverse sphericity of primary charged particles in minimum bias proton-proton collisions at √s = 0.9, 2.76 and 7 TeV, ALICE Collaboration, Eur. Phys. J. C (2012) 72:2124

Outreach:

- http://alicematters.web.cern.ch/?q=ifin-hh

  IFIN-HH, Romania - 'The Thinkers' of ALICE

- https://espace.cern.ch/alice-mgt-vipvisits/Romania/default.aspx

  Romania_and_ALICE_2012Feb_NIPNE

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.

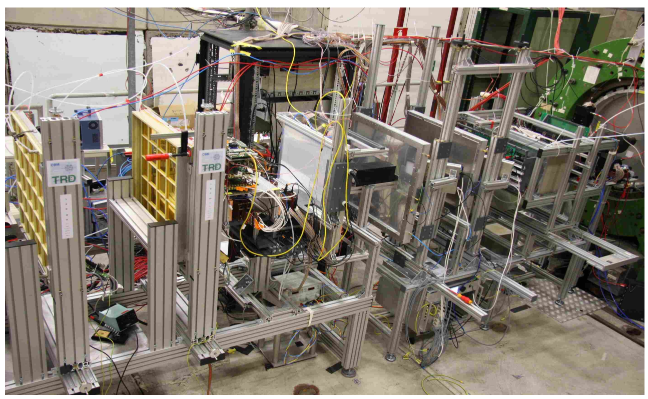
Summer Student Program – 3rd edition:

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



Finalizing the extension of HPD infrastructure:

NIHAM **A**nalysis **F**acility

New mechanical workshop

Foyer

Conference Hall

Others:

- This year we hosted a 3 month visit of Dr. Vasile Topor Pop from McGill University - Montreal. Based on HIJING modified model, detailed calculations of different observables studied by ALICE Collaboration were performed and the results will be published in the next period

- 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 Dr. Octavian Postavaru, theoretician, joined our group with the specific task of development phenomenological models for relativistic heavy ion collisions