First results from the HMPID detector in the ALICE experiment at LHC

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Abstract. The ALICE experiment is dedicated to the study of heavy-ion collisions at LHC energies. ALICE has a high-quality hadron identification system in the central region e.g. a Inner Tracking System, a large Time-Projection-Chamber, a Time-Of-Flight and the High Momentum Particle Identification Detector (HMPID). The ALICE HMPID detector has been designed to identify charged hadrons (π , K, p) in the momentum range $1 < p < 5$ GeV/c. Despite its limited geometrical acceptance, less than 10% of the central ALICE barrel, the HMPID detector has successfully accumulated enough statistics during the first proton-proton runs at LHC, to allow the detector alignment and to evaluate the calibration parameters needed to estimate its performance. Preliminary HMPID results from p-p collisions at $\sqrt{s} = 7$ TeV and its future contribution to the ALICE physics programme, will be presented.

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ALICE EXPERIMENT

The LHC’s physics programme envisages to collide lead ions with the aim to recreate the conditions of the universe just after the Big Bang under laboratory conditions. The data obtained will allow physicists to study a state of matter known as quark-gluon plasma, which is believed to have existed soon after the Big Bang. Among the LHC experiments, ALICE (A Large Ion Collider Experiment) [1][2] features an experimental layout optimized to study this physics topic. In particular, great care has been devoted to design a high-quality particle identification system in the central region exploiting the combination of several sub-detectors: the Inner Tracking System (ITS), the Time-Projection-Chamber (TPC), the Transition-Radiation-Detector (TRD), and the Time-Of-Flight (TOF). The central system is complemented by three small-area detectors: the High-Momentum-Particle-Identification-Detector (HMPID), the PHOTon-Specrometer (PHOS) and the electromagnetic calorimeter (EMCal) (Fig.1).

The HMPID detector

The ALICE-HMPID [3] (Fig.2) performs charged particle track-by-track identification by means of measurement of Cherenkov angle, exploiting the momentum information provided by the tracking devices. The HMPID enhances the PID capability of the ALICE experiment by enabling identification of particles beyond the momentum inter-

FIGURE 1. Event display of a p-p event in ALICE. The ALICE central system includes, from the interaction vertex to the outside, the Inner Tracking System (ITS), the Time-Projection-Chamber (TPC), the Transition-Radiation-Detector (TRD), and the Time-Of-Flight (TOF). The central system is complemented by the High-Momentum-Particle-Identification-Detector (HMPID), the PHOTon-Specrometer (PHOS) and the electromagnetic calorimeter (EMCal).

FIGURE 2. Left: view of the seven modules of the HMPID mounted on the cradle; Right: working principle of a RICH detector employing CsI thin films deposited onto the cathode plane of a MWPC. The Cherenkov cone refracts out of the liquid radiator of C_6F_{14} and expands in the proximity volume of CH_4 before reaching the MWPC photon detector. Electrons released by ionizing particles in the proximity gap are prevented to enter the MWPC volume by a positive polarization of the collection electrode close to the radiator.

FIGURE 3. MIP charge distribution for the seven chambers at $\sqrt{s} = 7$ TeV and $B=0$ T.

val attainable through energy loss (in ITS and TPC) and time-of-flight measurements (in TOF). The detector was optimized to extend the useful range for π/K and K/p discrimination, on a track-by-track basis, up to 3 and 5 GeV/c^{-1} respectively.

The HMPID is based on proximity-focusing Ring Imaging Cherenkov (RICH) counters and consists of seven modules of about $1.5 \times 1.5 \text{ m}^2$ each, mounted in an independent support cradle (see Fig.2). The cradle [4] is fixed to the space frame in the two o'clock position. The radiator, which defines the momentum range covered by the HMPID, is a 15 mm thick layer of low chromaticity C_6F_{14} (perfluorohexane) liquid with an index of refraction of $n = 1.2989$ @ 175 nm corresponding to $\beta_{\min} = 0.77$ (i.e. a momentum threshold $p_{th} = 1.21 m$, where m is the particle mass). The photons detection is provided by multiwire chamber coupled with pad-segmented CsI photocatode (CsI Q.E. $\approx 25\%$ @ 175 nm, pad size $0.8 \times 0.84 \text{ cm}^2$). The amplification gas is CH_4 at atmospheric pressure and the anode-cathode gap is 2 mm. A positive voltage of 2050 V, applied to the anodes, while cathodes are grounded, provides a total gas gain of almost few 10^4 . The 42 photocatodes are segmented in 3840 pads with individual analog readout. The noise level is 1 ADC channel ($1000 e^-$) and dead or noisy pads are less than 300 out of 161280.

FIGURE 4. Number of reconstructed photons at $\sqrt{s} = 7$ TeV and $B=0$ T.

Physics with HMPID

The main tasks of the HMPID are listed below:

- Extension of the π , K, p spectra to high momentum range;
- Particle ratios vs p_T (p -bar/ p , p/π , K/π);
- Measurement of resonance production such as $\Phi(1020) \longrightarrow K^+ K^-$;
- Jet physics:
 - Study of jet fragmentation with the identification of particle in the jet;
 - Study of the flavor of the leading particle;
- Identification of light nuclei (d , t , ^3He , α).

ANALYSIS AND RESULTS

ALICE has recorded data during the first LHC pp runs at $\sqrt{s} = 7$ TeV in March 2010 ($B=0.5$ T). The HMPID detector has successfully collected enough statistics to allow the detector alignment and to evaluate the calibration parameters needed to estimate its performance. In Fig.1 the event display of a p-p event in ALICE is shown.

In Fig.3 the distribution of MIP charge for the seven chambers corresponding to 10^6 p-p events at 7 TeV without magnetic field is shown. The distributions are well fitted by a Landau function with mean value of about 400 ADC. A cut on the distance of the MIP

FIGURE 5. Cherenkov angle distributions for π^+ , K^+ at $0.5 < p < 0.75$ GeV/c ($\sqrt{s}=7$ TeV - B=0.5 T).

FIGURE 6. Cherenkov angle distributions for π^- , K^- and $p\text{-bar}$ at $1.5 < p < 1.75$ GeV/c ($\sqrt{s}=7$ TeV - B=0.5 T).

FIGURE 7. Cherenkov angle as function of the track momentum ($0.5 < p < 2.75$ GeV/c).

to the extrapolated point on the HMPID chambers are applied ($d < 0.7$ cm). Using the same set of data the distributions of the number of reconstructed photons as a function of $\sin^2\theta_{Ch}$ (blue points) for the seven chambers have been extracted (Fig.4). Red points represent the same quantity corrected by taking into account detector acceptance (dead zones between CsI photocathodes). For the 7 TeV data with a magnetic field ($B = 0.5$ T), the analysis has been restricted to the momentum range $0.5 < p < 2.75$ GeV/c, due to the small statistics available at larger momenta. The Cherenkov angle distributions for nine sub-range of 0.25 GeV/c have been extracted. Fig.5 and Fig.6 show two examples of the Cherenkov angle distributions for $0.5 < p < 0.75$ GeV/c (particles) and $1.5 < p < 1.75$ GeV/c (antiparticles). The number of particles under single Gaussian and the mean value (with relative errors) have been evaluated. In Fig.7 the Cherenkov angle as function of the track momentum measured by the tracking devices is shown. The points correspond to the mean values of the Cherenkov angle distribution (Fig.5 and Fig.6). The theoretical curves (solid lines) fit well the experimental points for π , K, p.

CONCLUSION

The first results from the HMPID detector are presented. The MIP charge distributions for the seven chambers and the distributions of the number of reconstructed photons as a function of $\sin^2\theta_{Ch}$ show the predicted behaviour of the detector. In the first p-p collisions at $\sqrt{s} = 7$ TeV at $B = 0.5$ T the Cherenkov angle distributions and the Cherenkov angle as a function of track momentum ($0.5 < p < 2.75$ GeV/c) are evaluated. The HMPID detector is ready to contribute to the ALICE physics programme.

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