Results from cosmics and first LHC beam with the ALICE HMPID detector

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Abstract

The ALICE HMPID (High Momentum Particle IDentification) detector has been designed to identify charged pions and kaons in the range $1 \div 3$ GeV/c and protons in the range $1.5 \div 5$ GeV/c. It consists of seven identical proximity focusing RICH (Ring Imaging Cherenkov) counters, covering in total $11 \text{ m}^2$, which exploit large area MWPC equipped with CsI photocathodes for Cherenkov light imaging emitted in a liquid $\text{C}_6\text{F}_{14}$ radiator. The ALICE detector has been widely commissioned using cosmics and LHC beam from December 2007 until October 2008. During the cosmics data taking the HMPID detector collected a large set of data, using mainly the trigger provided by the TOF detector. We present here preliminary results of detector alignment using TPC tracking. The HMPID could be operated in a stable way, at a safe HV setting, also during LHC beam injection and circulation tests, when a very large occupancy (up to 50%) was achieved. Resulting gain mapping and overall detector performance will also be discussed.

1. ALICE-HMPID detector

The ALICE-HMPID detector performs charged particle track-by-track identification by means of the measurement of the Cherenkov angle, exploiting the momentum information provided by the tracking devices. It consists of seven identical proximity focusing RICH (Ring Imaging Cherenkov) counters. In Fig. 1 is shown a schematic view of one HMPID module. The radiator used is $\text{C}_6\text{F}_{14}$ (n $\approx 1.2989$ @ 175 nm, $\beta_{th} = 0.77$), 15 mm thick. The photon detection is provided by multiwire chamber coupled with pad-segmented CsI photocathode (CsI Q.E. $\approx 25\%$ @ 175 nm, pads size 0.8x0.8 cm$^2$). The amplification gas is CH$_4$ at atmospheric pressure, the anode-cathode gap is 2 mm and the operational voltage is 2050 V (gain $\approx 4 \times 10^4$). The 42 photocathodes are segmented in 3840 pads with individual analog readout. The Front-End and Readout electronics are based on GASSIPLEX and DILOGIC chips developed within the HMPID project. The noise level is 1 ADC channel (1000 e$^-$). HMPID performs charged hadron identification in the intermediate momentum region: $1 < p < 3$ GeV/c for pions and kaons and $1.5 < p < 5$ GeV/c for protons and can contribute to:

- Particle ratios vs. $p_T$ ($\bar{p}/p$, $p/\pi$, $K/\pi$);
- Jet physics: study jet fragmentation with the identification of particles in the jet and the flavor of the leading particle;
Figure 1: Left: schematic view of the ALICE-HMPID detector. Right: schematic section of one HMPID module.

Figure 2: Left: track matching TPC-HMPID, no alignment procedures have been applied. Right: clusters charge distribution selecting clusters corresponding to a track in the TPC (Landau MPV ≈ 860 ADC).

- Measurement of resonances production such as $\Phi_{(1020)} \rightarrow K^+K^-$;
- Light nuclei (alpha, deuteron, tritium) production.

2. Results from cosmic

A large set of data has been collected during the ALICE cosmic runs allowing a first evaluation of detector performance and alignment, using the trigger provided by the TOF (Time-of-Flight) detector, due to the most interesting trigger combination for such a kind of events. The data analysis has been executed in AliRoot [4], the official off-line framework of the ALICE experiment. In the left part of Fig. 2 the difference between the x and y coordinate of MIP cluster and the associated track impact point on photocathode vs $x_{mip}$ and $y_{mip}$ respectively, are shown. The matching with tracks reconstructed by means of Time-Projection-Chamber (TPC) is evident, nevertheless alignment procedures have not been applied. In the right part of Fig. 2 the charge distribution of clusters corresponding to a track in the TPC is shown. Despite the low statistics, the fit with a Landau distribution is quite good. Because of the cosmic rays spatial distribution, for the data taken with the trigger provided by TOF the probability to have Cherenkov ring is very low, anyway sometimes secondaries produced can generate Cherenkov signal. Fig. 3 shows the display for one event of HMPID chamber 3, where a Cherenkov ring pattern is present.
Figure 3: Left: display of HMPID module 3 for one cosmic event, cherenkov ring pattern is present. Right: display of HMPID module 3 for one event when the beam went through ALICE.

Figure 4: Left: total clusters charge distribution for chamber 2 for events from beam dump. Right: total clusters charge distribution for chamber 2 for events when the beam went through ALICE.

Figure 5: Clusters charge distribution selecting cluster with size less that 3. \( A_0 = -1/slope \).
3. Results from LHC injection test and MWPCs gain estimation

Data have been collected also during LHC beam injection tests. Fig. 4 shows the total cluster charge distribution for chamber 2. These data refer to high muon flux generated by the dump of the LHC 450 GeV/c proton beam. Because of the high particle flux expected the chamber voltage was set at 1860 V, to avoid trips. The occupancy was ≈ 50% on average. Fig. 5 shows the display for one event of chamber 3. In this case the beam is not dumped but it went through ALICE, and the chamber voltage was set at the normal operational value. The occupancy for these events has been of 12% on average. In Fig. 4 the total clusters charge distribution for chamber 2 is shown. It is important to point out that during the beam through ALICE, just beam-gas interaction events were expected, therefore very low particle multiplicity. The high particles multiplicity detected was due to beam screens present along the beam path.

For a MWPC with the same characteristic of the HMPID one, the single electron pulse height follows an exponential distribution [1]. From the data recorded when the beam went through ALICE, a rough estimate of the mean pulse height value ($A_0$) has been executed. According to test beam studies, single electron clusters have size less than 3 on average [1]. In Fig. 5 the charge distribution of cluster with that selection for chamber 2 is shown. In table 1, $A_0$ values in ADC units for all HMPID chambers are shown. Indeed, the values of the Landau distribution MPV (Fig. 2) and $A_0$ retrieved, do not correspond to the expected one at the HV values used. Investigation has been carried out and an error in the calibration of HV board has been discovered. The relation between the nominal HV value and the real one is $V_{out} = V_{set} + V_{set}*2.83*10^{-2}$, that corresponds to a positive bias of 58 V at 2050 V; according to this, the results obtained are consistent.

| module | $A_0$(ADC) |
|--------|------------|
| RICH0  | 46.9       |
| RICH1  | 41.1       |
| RICH2  | 41.2       |
| RICH3  | 38.7       |
| RICH4  | 43.5       |
| RICH5  | 36.8       |
| RICH6  | 47.1       |

Table 1. $A_0$ values for the different HMPID chambers

4. Conclusion

The results obtained from the cosmics and beam injection test have proven that HMPID works as expected. Nevertheless calibration and alignment with cosmics are not possible since high track statistics are necessary. A hardware problem has been detected and solved. HMPID is waiting for collisions at LHC.

References

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