Digitization for the ALICE GEM TPC*

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The ALICE Collaboration is planning a major upgrade of its central barrel detectors to benefit from the significantly increased LHC luminosity beyond 2019 [1]. In order to record at an increased interaction rate of up to 50 kHz in Pb-–Pb collisions, the TPC, the main device for charged-particle tracking and particle identification (PID) in ALICE, will be upgraded with GEM-based (Gas Electron Multiplier [2]) readout chambers [3] allowing for continuous operation in an ungated mode. The increase in interaction rate and the requirements of a trigger-less, continuous readout demand for significant upgrades of the front-end cards, the computing system and the corresponding calibration, reconstruction and simulation framework.

Event generators, such as HIJING [4], are powerful tools to obtain a deeper insight into the particle production mechanisms at the highest energies, and the corresponding final state interactions. A meaningful comparison of such models to experimental data is, however, only possible when the full process of signal formation in the detector is properly modelled in the simulation. Consequently, the upgraded readout scheme of the ALICE TPC demands for a complete re-design of the *digitization*, in which these processes are handled.

The first step after the simulation of the incident particle traversing the detector and the conversion of the corresponding energy deposit into number of electron-ion pairs, is the electron transport in the active volume of the detector. The electrons drift up to 250 cm from the point of their creation until the readout chambers on both ends of the TPC, during which diffusion and attachment occurs. Having reached the readout chambers, the electrons are amplified in the stack of four GEM foils. Fluctuations of the amplification process are modelled according to the findings reported in [5]. A signal on the pad plane is induced once the electrons are extracted from the last GEM in the stack and drift towards the readout anode. Due to the charge spread in the GEM stack and the Coulomb field exerted by the resulting electron cloud, a signal may as well be induced on adjacent pads. These effects are incorporated in the *pad response function*, as displayed in Fig. 1. The latter is computed using a Garfield [6, 7] / COMSOL [8] simulation of the movement of the electrons in the field between the pad plane and the last GEM. The induced current for different starting positions of the electron cloud is calulated and normalized to that expected in the centre of the pad.

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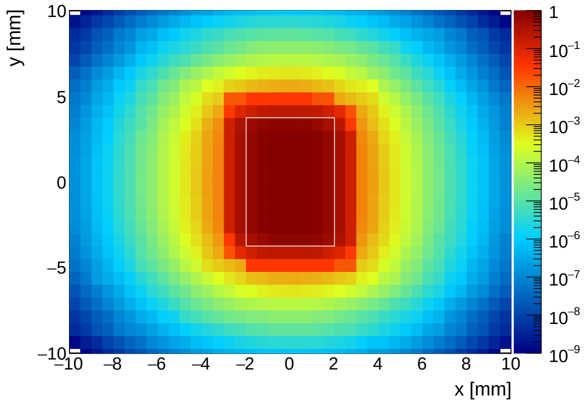

Figure 1: Pad response function of an Inner Readout Chamber of the ALICE GEM TPC for different start points of the electron avalanche. The white lines indicate the outline of the pad.

The bottom side of the last GEM couples capacitively to the readout anode and thus upon extraction of electrons from the GEM, a signal of opposite polarity is induced on all pads of the readout chamber. This *common mode effect* leads to an effective baseline shift and hence to additional noise in the system. Furthermore, the signal processing in the front-end cards is modelled, during which the avalanche is convoluted with the Gamma4 shaping function and the resulting signal sampled with 5 MHz. The final entity, a *Digit*, which is defined as an ADC value on a given pad and time bin, is then written to disk for further processing.

The simulation framework allows to run in triggered and continuous mode and its capabilities are constantly extended and improved. A first validation will be possible by comparison to data measured in a beam test at CERN in May 2017 with a final readout chamber and final front-end cards.

References

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