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on behalf of the VHMPID collaboration: *Bari-Budapest-CERN-Chicago-Mexico-New Haven-Pusan*

VHMPID: a new detector for the ALICE experiment at LHC

1. The LHC and the ALICE experiment

The Large Hadron Collider at CERN (Geneva, Switzerland) started its physics program at the end of 2009. It opens the possibility to carry out researches in a wide range of topics related to particle physics. The ALICE experiment is dedicated to study Pb-Pb collisions in the hope to learn more about the peculiar phase of matter, the quark-gluon plasma (QGP). This knowledge is also vital to understand the evolution of the early universe. One way to gain information about the QGP is to measure jets and high momentum hadrons. This task requires dedicated detectors. When the presently running ALICE experiment was designed, the new results from the Relativistic Heavy Ion Collider (RHIC, Brookhaven, USA) were not yet known, namely that the high momentum hadrons carry the most important information about the dense and hot matter created in the collisions. To extend the particle identification into this region, the ALICE needs a new, specific detector, the "Very High Momentum Particle Identification Detector" (VHMPID).

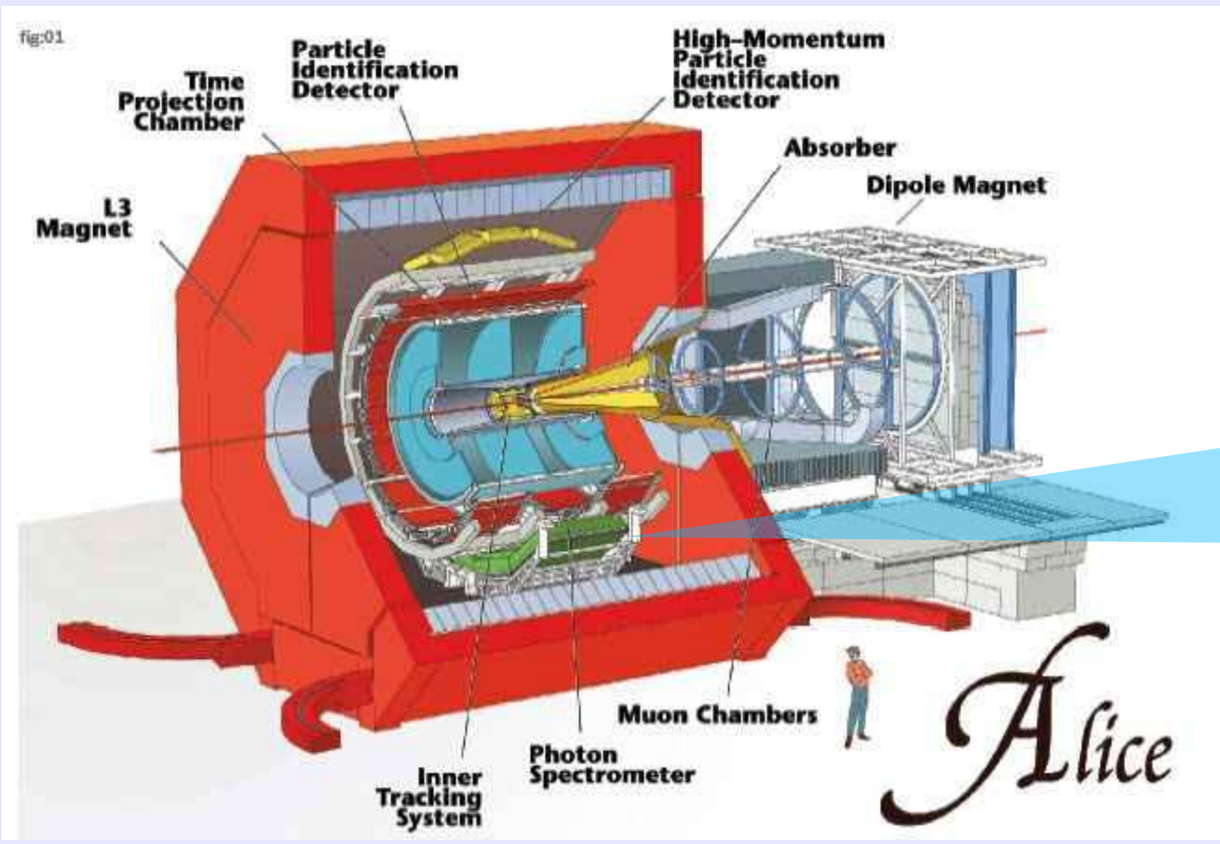

Figure 1.: The schematic view of the ALICE experiment

2. Physics motivation for the VHMPID

The VHMPID could provide the ALICE experiment with track-by-track charged hadron identity information in the 5 GeV < p_T < 25 GeV region which is not possible with the present ALICE setup. This information can be used to study jets in detail including their structure (intra jet momentum and flavor correlations), jet fragmentation fluctuations, parton energy losses and other medium modification effects. These studies are necessary to understand in detail the process of hadronization inside the QGP.

3. The principle of operation

The VHMPID is a Ring Imaging Cherenkov detector used to identify charged hadrons (mostly protons, pions and kaons). The high-momentum range is achieved by using gas (C_4F_{10}) as the radiator medium. The radiation is reflected and focused by a spherical mirror to a multiwire chamber with photo-sensitive CsI cathode which provides the information on the photons in digital form. During the reconstruction, the Cherenkov ring is fitted on the photon hits, from which the Cherenkov angle can be determined. Combined with the momentum measured by the tracking detectors, the particle can be identified.

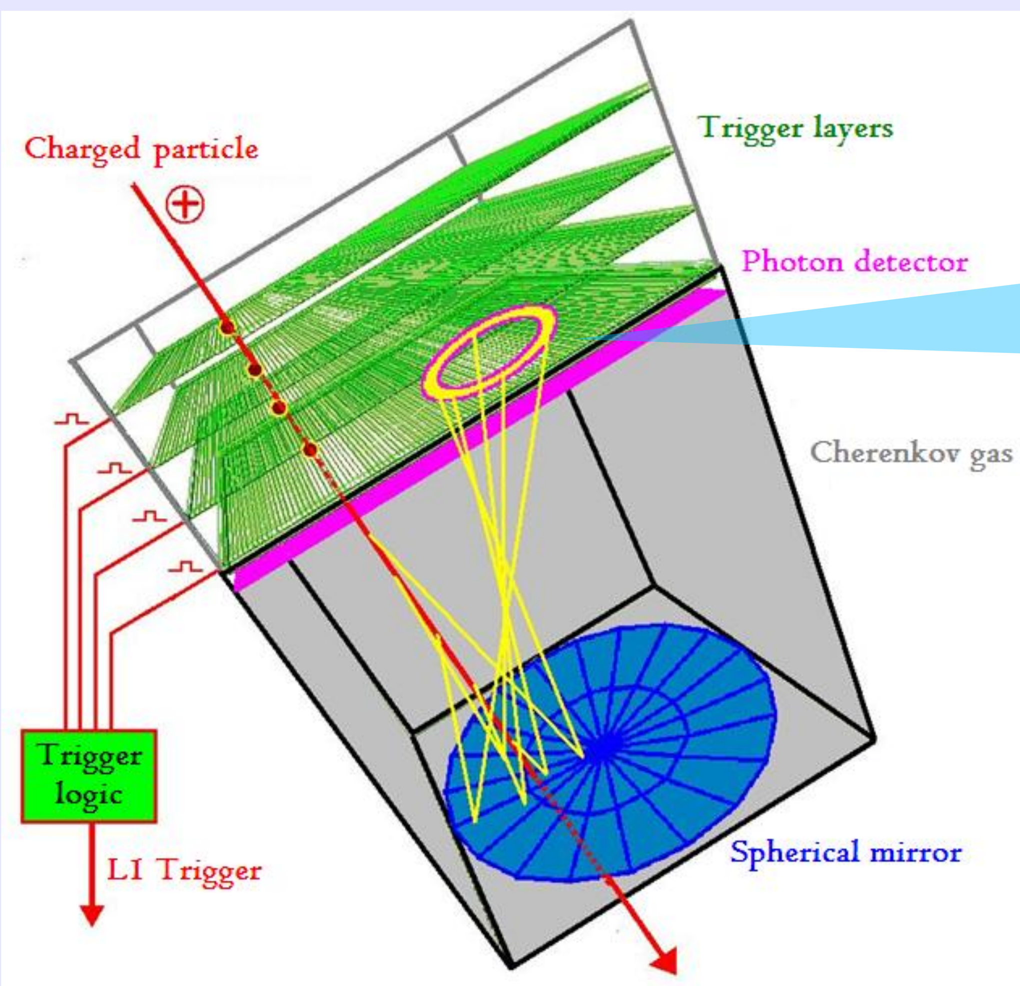

Figure 2.: Operation of the VHMPID detector

4. The high-momentum trigger system

The readout time of the tracking detectors (especially the TPC) is extremely long related to the time between successive collisions provided by the LHC. Furthermore, other technical constraints are preventing us from storing all the data from all the collisions, so we are forced to select the interesting events worth storing. For these reasons the VHMPID needs a dedicated high-momentum trigger that is provided by a special sub-detector that is in front of and behind the gas module, which could select the charged particles above a certain momentum threshold based on the bending of the incoming particle in the ALICE magnetic field.

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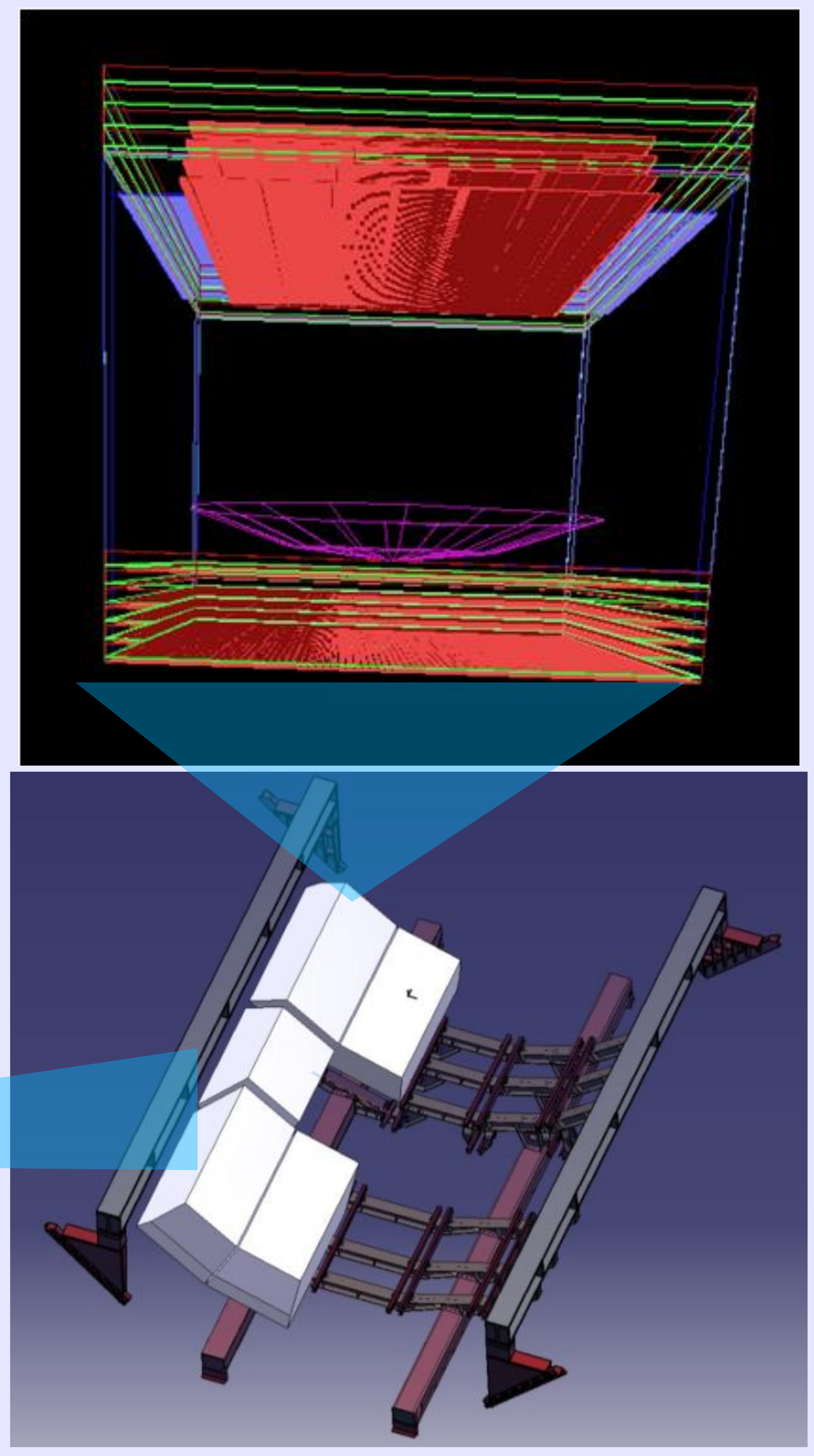

Figure 3.: Place of the VHMPID within the ALICE experiment (bottom) and the layout of one module (top)

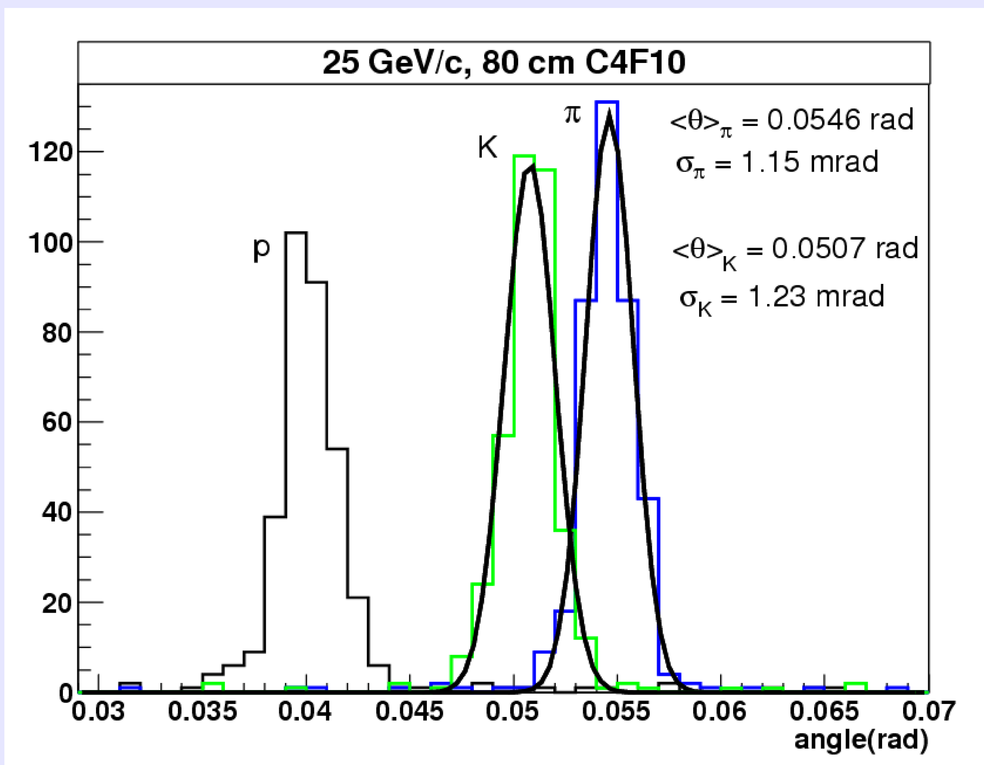

Figure 6.: Simulated Cherenkov angles for different particles

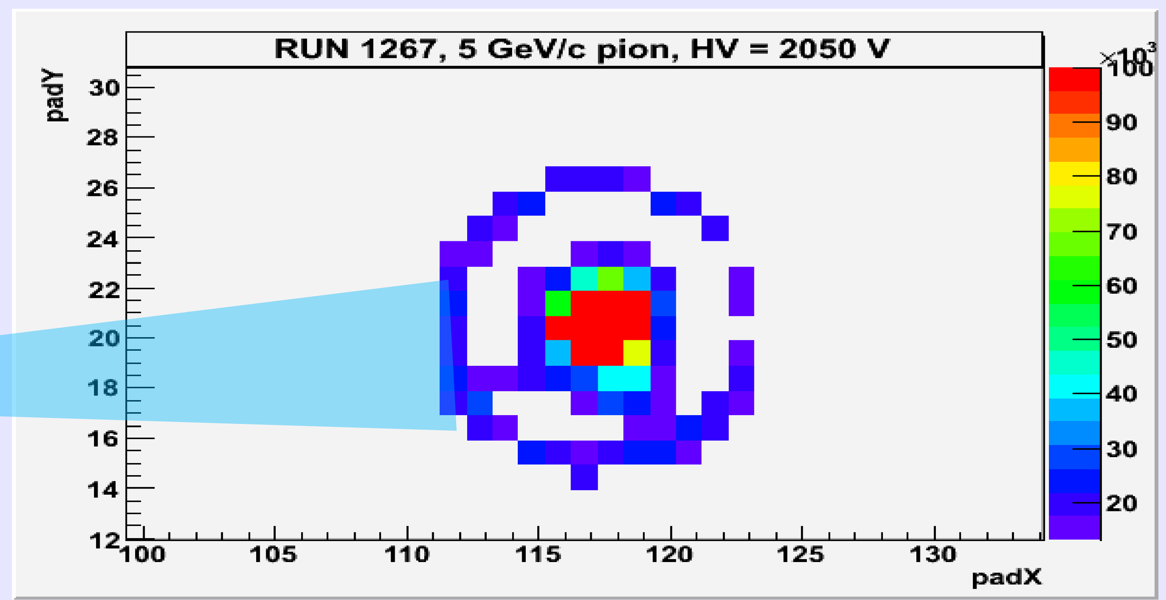

Figure 7.: 5 GeV/c pion crossing the prototype during the beam-test. Place of the incident particle is visible in the middle while the Cherenkov ring is located around it.

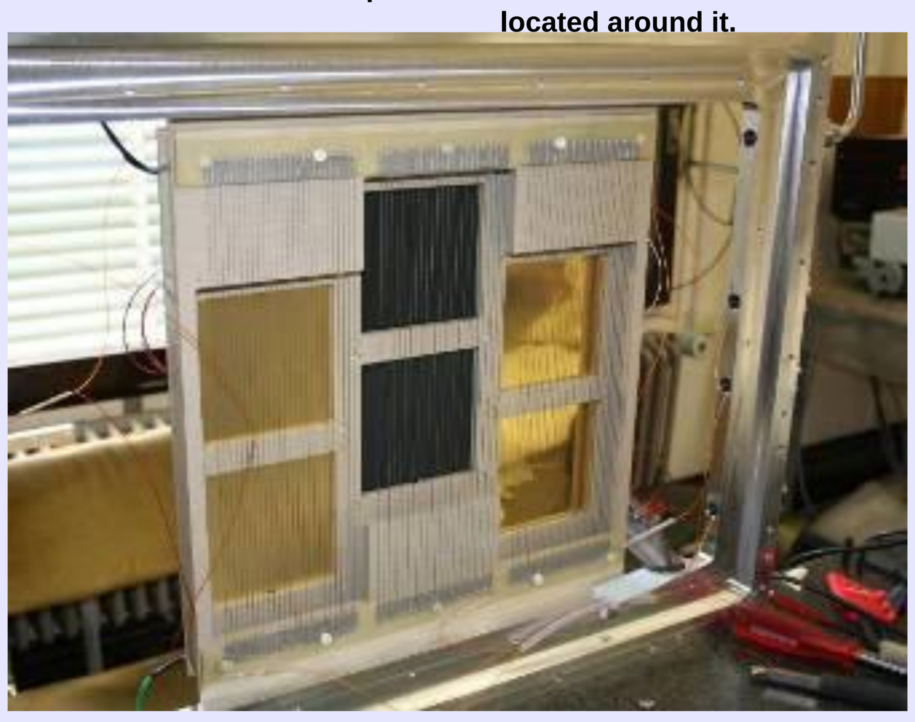

Figure 8.: Photosensitive GEM modules in the prototype (left) and it's back side with the radiator (right) and the mirror (below)

8. Conclusion

The ALICE experiment at LHC is in need for a new detector to identify very high momentum charged hadrons, so that it can carry out detailed measurements on the most interesting part of some new physics phenomena. This new detector, the VHMPID is being developed by an international collaboration consisting of scientists from CERN, Hungary, Italy, Korea, Mexico and USA scientists. The development is in an advanced stage and already passed a successful prototype test.

5. Design questions of the VHMPID

Manufacturing large area of photo sensitive surfaces is expensive therefore the focusing RICH arrangement is the preferable solution to minimize the sensitive area. This in turn needs large mirrors with good UV reflective properties, which is again not cost efficient, so it should be realized by a group of small mirror segments. In a segmented layout parts of the Cherenkov rings can be focused to different parts of the sensitive surfaces, leading to the need of a more sophisticated reconstruction algorithm. Also, the best segmentation layout should be selected to maximize the effective area of the detector. The multi-wire chamber's segmentation is also a crucial point in the final particle identification efficiency.

The construction materials must be chosen carefully: the optical properties of the gas module should be as weakly absorbing as feasible to preserve the small (few times ten) number of photons created by the incident particles.

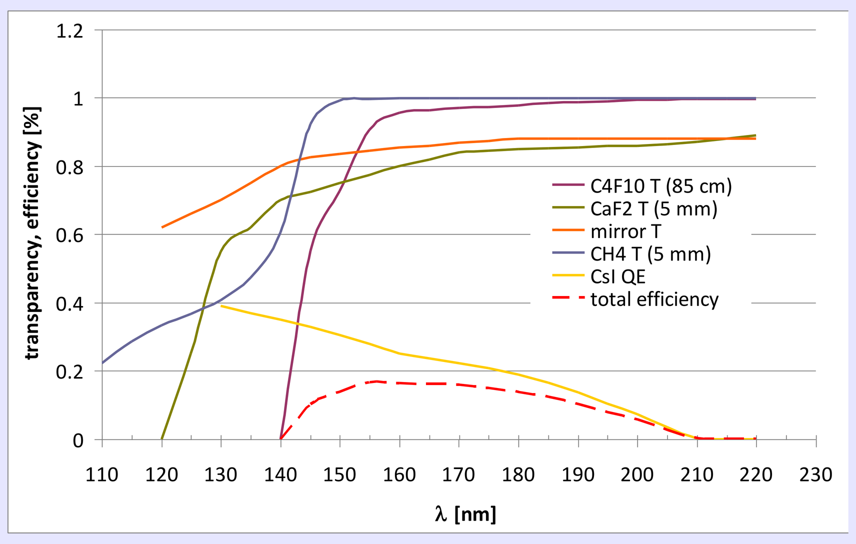

Figure 4.: Absorption and efficiency losses in different parts of the detector

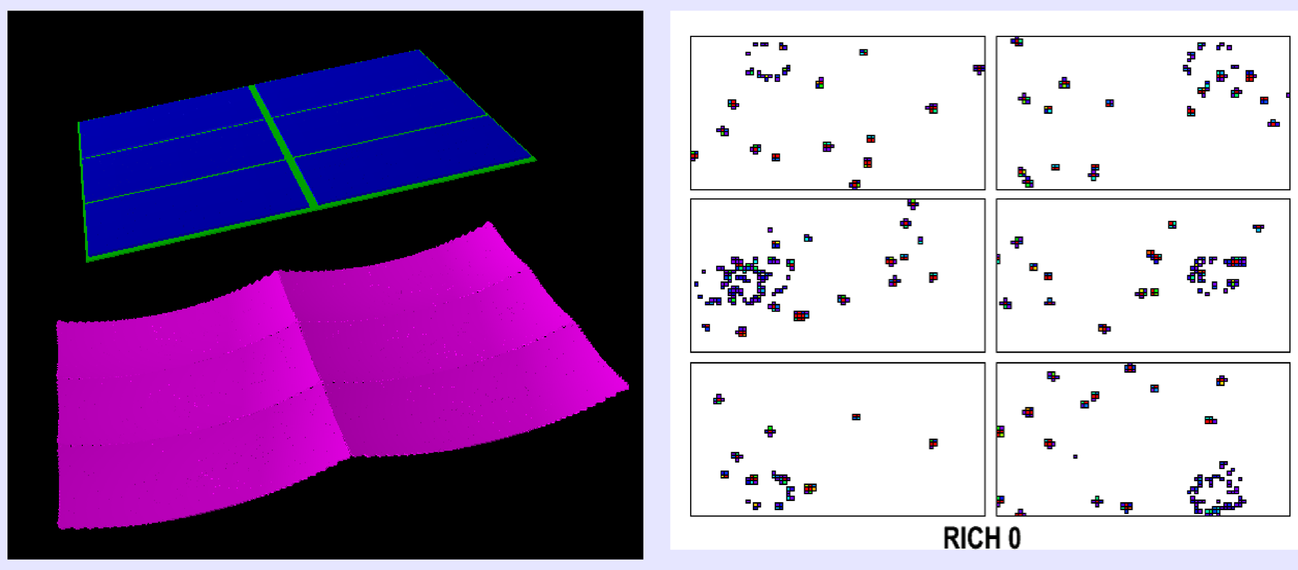

Figure 5.: Photosensitive multi-wire proportional chambers in the simulation (left) and a detected heavy ion collision (right) in a 6 mirror layout

6. Fine tuning the VHMPID with simulations

Building all the possible geometry layouts with all the available materials is impossible and expensive. These scenarios are investigated by detailed computer simulations, so the best candidates can be selected. The ALICE experiment has a unified system for these tasks: the AliROOT framework. With its help, the whole VHMPID with all the important materials can be tested in proton-proton or heavy ion collisions, including all the other detectors from the experiment. The whole process of the detection can be modelled and also the reconstruction of tracks and particle identities from the measured data. It can then be compared to the simulated particle properties to calculate the detector efficiency.

7. Prototype test and integration into the ALICE

Theoretical calculations and simulations help to choose the best layouts which can be built in reality to test with real particle beams to measure any differences from the predictions. Also the reconstruction algorithms can be tested on real data.

In the fall of 2009 a successful beam test of a prototype gas module was carried out in CERN. Three types of Gas-Electron Multiplyer (GEM) with CsI coating were tested for photon detection with 10 x 10 cm surface each. The detector has performed a stable operation and successfully detected Cherenkov rings.

The next prototype test is planned for the fall of 2010. There, many parameters are planned to be tested including different geometries, different window materials, performance at different radiator lengths, some technical aspects of construction processes and the C_4F_{10} gas system should be inspected. The reconstruction algorithms are going to be fine tuned with the raw measured data.

The first module being built for the ALICE experiment is planned to be installed during the 2012 LHC shutdown.

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