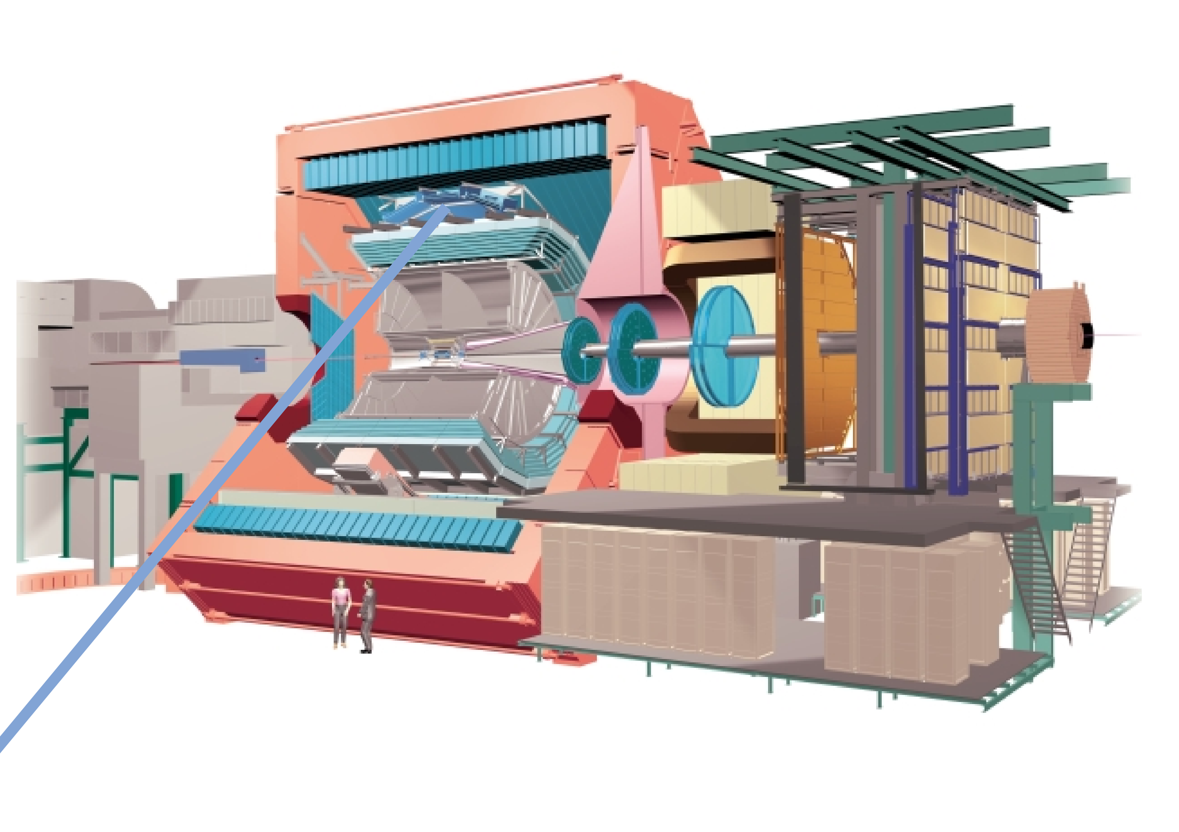
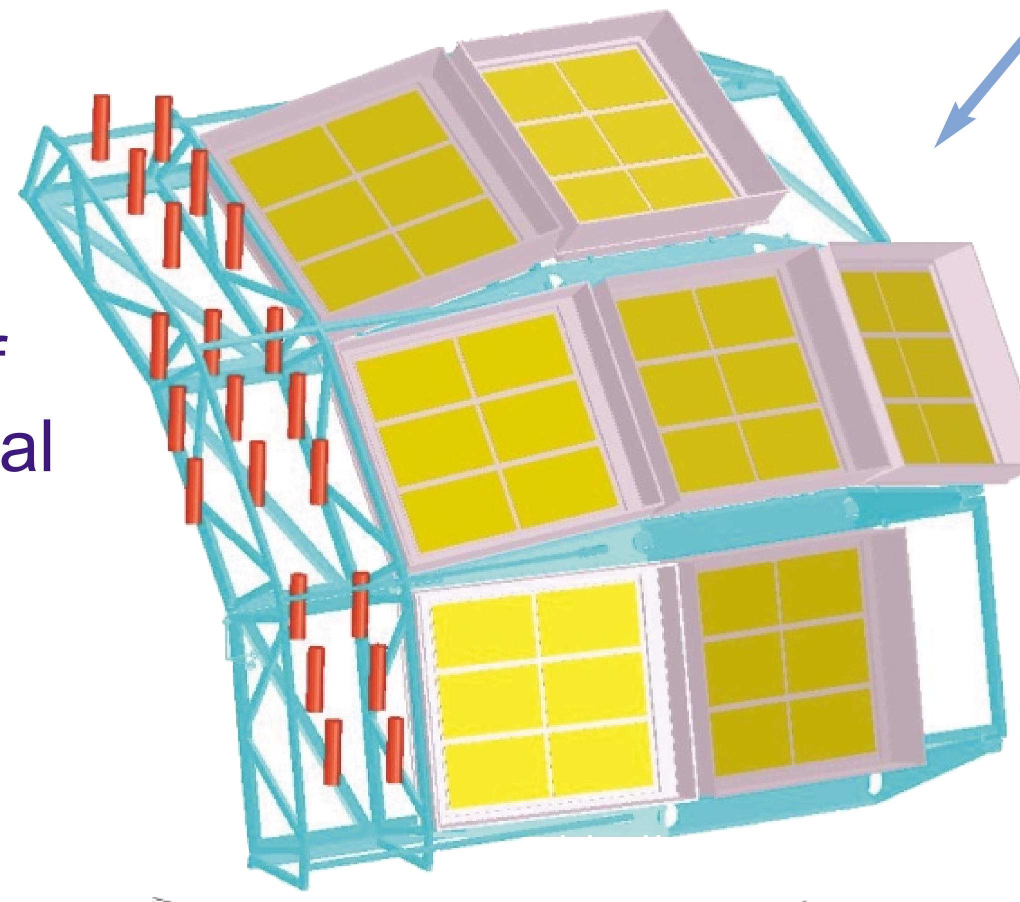
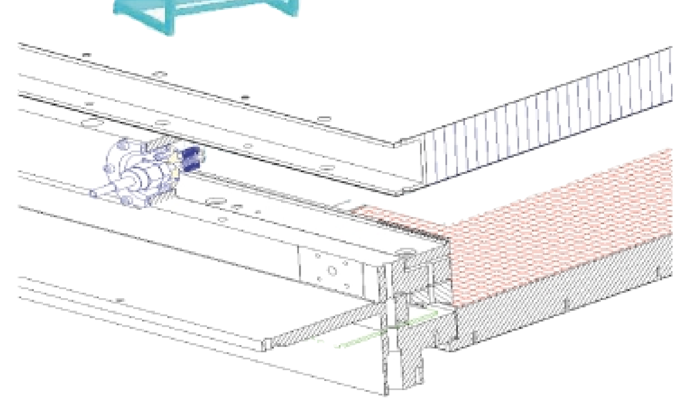
ALICE HMPID RICH

Particle identification plays a key role in the complete understanding of heavy-ion collisions in ALICE at the LHC. The High Momentum Particle IDentification (HMPID) system will enhance the PID capability of ALICE beyond the momentum range allowed by the energy loss measurements (ITS and TPC) and by the TOF. The HMPID detector has been designed to extend the useful range for the identification of π and K up to 3 GeV/c and of p up to 5 GeV/c, on a track-by-track basis.
It will provide inclusive particle ratios and transverse-momentum spectra in the region relevant for the study of phenomena connected with the pre-equilibrium stage of the nucleus-nucleus collisions.
The low rate of high momentum particles in Pb-Pb collisions at the LHC energy regime justifies the single-arm geometry of the HMPID covering about 5% of the central barrel phase space.



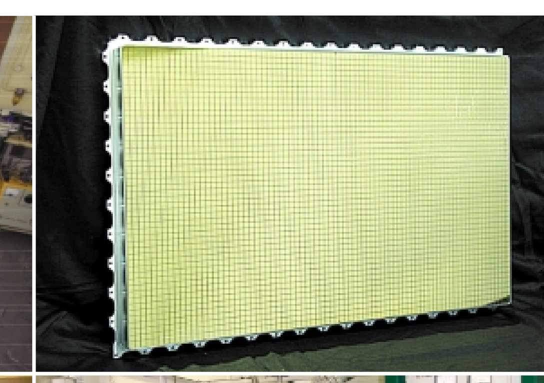


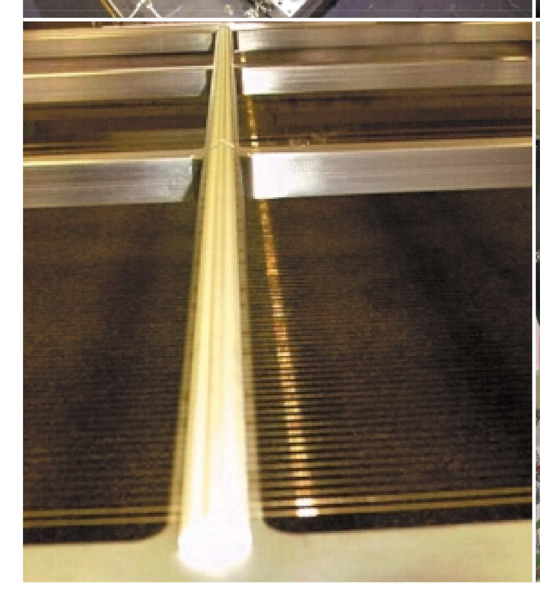


3-d cross-section of an HMPID Module

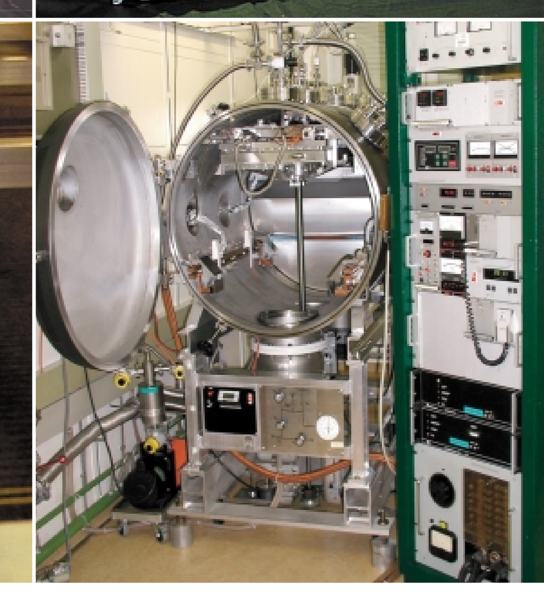
The radiator trays of the HMPID proto-2

The photocathode pad plane



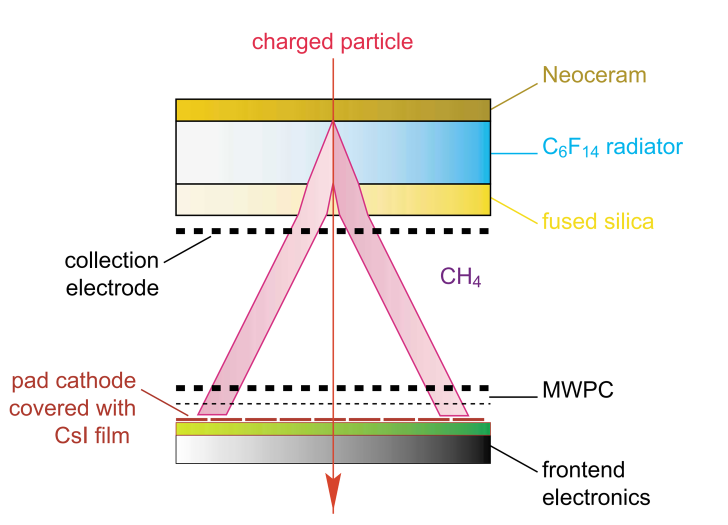


The anode wires and the Macor support lines



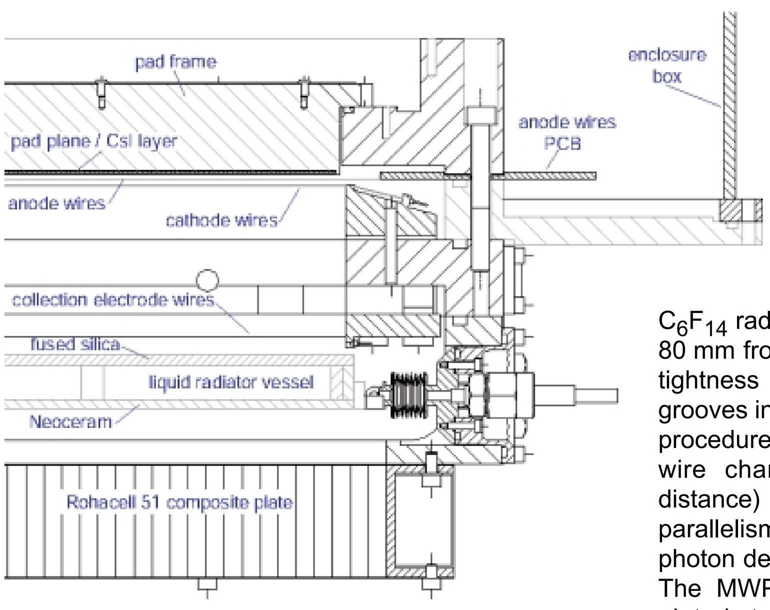
The CsI photocathode coating station

Cherenkov rings in the HMPID proto-3 (64×40 cm^2, 1/6 of an HMPID module). The colour coding represents the signal induced on the pads.



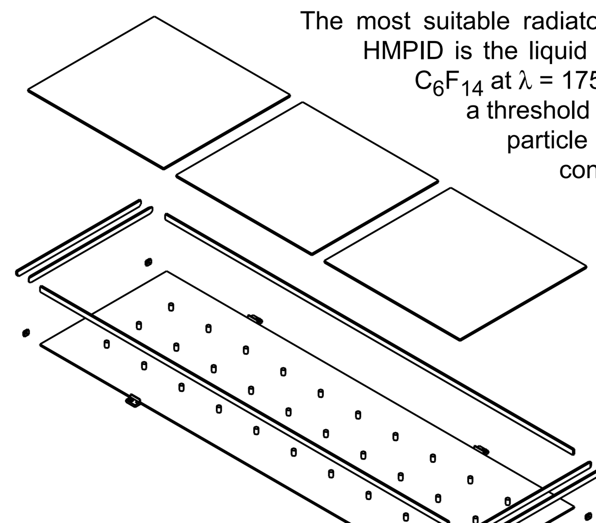
The ALICE HMPID is based on proximity focusing Ring Imaging Cherenkov (RICH) counters and consists of seven modules mounted in an independent support cradle, which will be fixed to the space frame, at two o'clock position.
Cherenkov photons, emitted when a fast charged particle traverses the 15 mm thick layer of liquid C_6F_{14} (perfluorohexane), are detected by a photon counter, which exploits the novel technology of a thin layer of CsI deposited onto the pad cathode of a multiwire proportional chamber (MWPC). The HMPID, with its surface of about 12 m^2, represents the largest scale application of such a technique.
The Cherenkov photons refract out of the liquid radiator and reach the CsI-coated pad cathode, located at a suitable distance (the 'proximity gap') that allows the contribution of the geometrical aberration to the Cherenkov angle resolution to be reduced. The electrons released by ionizing particles in the proximity gap, filled with CH_4, are prevented from entering the MWPC sensitive volume by a positive polarization of the 'collection' electrode close to the radiator.

The CsI Photodetector



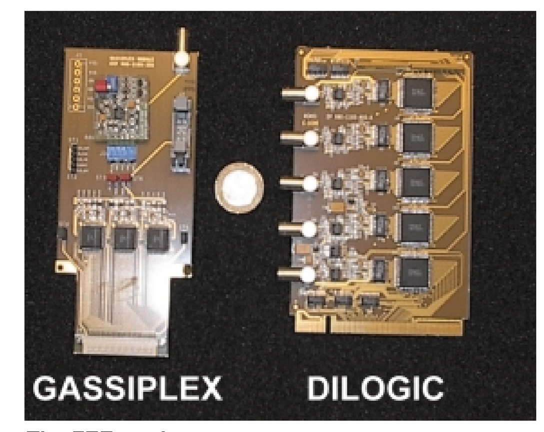
The photodetector, filled with pure methane at ambient temperature and pressure, is closed on one side by an end-flange where six independent CsI photocathode boards of size 64×40 cm^2, segmented into pads of 8×8.4 mm^2, are installed. On the opposite side, a honeycomb panel supports three C_6F_{14} radiator vessels placed at a distance of 80 mm from the photocathode plane. The gas tightness is ensured by soft o-rings placed in grooves in the chamber frames. The assembly procedure of module elements ensures the wire chamber gap (2 mm anode-cathode distance) with a precision of 50 µm and the parallelism between the radiator trays and the photon detector to better than 100 µm.
The MWPC anode plane is made of gold-plated tungsten-rhenium wires of 20 µm diameter, with 4 mm pitch, soldered on a G-10 printed board with a precision of 0.1 mm and a tension of 47 g. On both edges of the anode plane, thicker guard wires are installed to resist the boundary discontinuity of the electrostatic field. At half-length of the module a Macor insulating support structure is placed between the pad cathode and the anode plane in order to minimize the sag of the sensing wires due to the electrostatic force. Cathode and collection wire planes are made out of 100 µm diameter gold-plated Cu/Be wires, stretched at 200 and 50 g/wire, respectively, by using crimping pins. A positive voltage of 2050 V applied to the anodes, while cathodes are grounded, provides a total gas gain of 8×10^4, allowing the detection of ionizing particles and Cherenkov photons with single e^- detection efficiency of 90%.
The pad cathode is built by gluing together two printed circuit boards to achieve a stiff and flat plane made out of light materials. The photosensitive layer is obtained by depositing 300 nm of CsI onto the Cu-clad printed circuit boards, electrolytically coated by 7 µm thick Ni layer followed by a 0.5 µm thick Au layer and accurately pre-polished through mechanical and chemical treatments. The photocathodes are prepared at CERN in the large evaporation station, equipped with four DC heated tungsten crucibles operated simultaneously to achieve a uniform CsI layer.

The Radiator



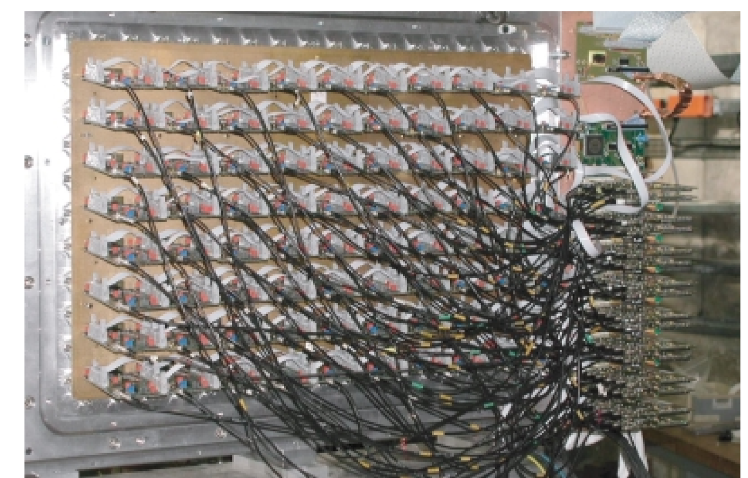
The most suitable radiator for the momentum range to be covered by the HMPID is the liquid perfluorohexane, C_6F_{14}. The index of refraction of C_6F_{14} at $\lambda = 175$ nm is $n = 1.2988$, corresponding to $\beta_{min} = 0.77$ (i.e. a threshold momentum p_{th}(GeV/c) $= 1.21\, m$, with m equal to the particle mass in GeV/c^2). The liquid radiator containers consist of trays of 1330×413 mm^2 made of a glass-ceramic material (NEOCERAM), thermally compatible (thermal coefficient 0.5×10^{-6}°C^{-1}) with the fused silica plates used as UV transparent windows. The thickness and dimensions of the tray elements have been carefully studied to reach the best compromise between minimizing the detector total radiation length and maximizing the mechanical strength to withstand the perfluorohexane hydrostatic pressure. The result is that the quartz window is 5 mm thick, while the NEOCERAM base plate is 4 mm thick. They are strengthened by 27 cylindrical spacers glued between the NEOCERAM bottom plate on one side and the quartz window on the other side. Spacers consist of fused silica rods with a diameter of 10 mm placed in three rows of nine equi-spaced elements. Radiator trays are supported by a stiff and light composite panel (less than 0.02 X_0) made out of a sandwich of a 50 mm thick plate of Rohacell 51 (density 0.0513 g/cm^3) between two 0.5 mm thin foils of aluminium. Radiator connections to the external liquid circuit are made via stainless steel bellows glued to the inlet and outlet points. The inlet (lowest point) and outlet (highest point) are located in opposite corners of the NEOCERAM tray.
A liquid circulation system is required to purify bulk C_6F_{14}, fill, recirculate, and empty the 21 radiator trays independently, remotely, and safely. Because of the inaccessibility of the detector during running and the fragility of the radiator trays, a system based on the gravity flow principle has been chosen, owing to its safe nature. Since C_6F_{14} is not available in a high-purity grade form, filters are implemented in the circulation system in order to remove contaminants (mainly dissolved water and oxygen) and achieve the best transparency in the UV region where the RICH detector operates.

The Front-End Electronics



The FEE cards

The readout of the HMPID modules is organized according to a parallel/serial architecture and is based on the VLSI GASSIPLEX chip, specifically developed to enable the determination of the hit coordinates by centroid measurement. It is characterized by a filtering scheme designed to cope with the shape of the signal delivered by MWPCs and by a long peaking time (1.2 µs) suitable for an external event trigger. An average noise of 1000 e^- has been measured on detector. The 16-channel preamplifier/shaper GASSIPLEX chips, uniformly distributed on the back side of the cathode pad planes, are operated in analog multiplexed 'Track and Hold' mode, storing the electric charge into internal capacitors in coincidence with the arrival of a trigger signal.

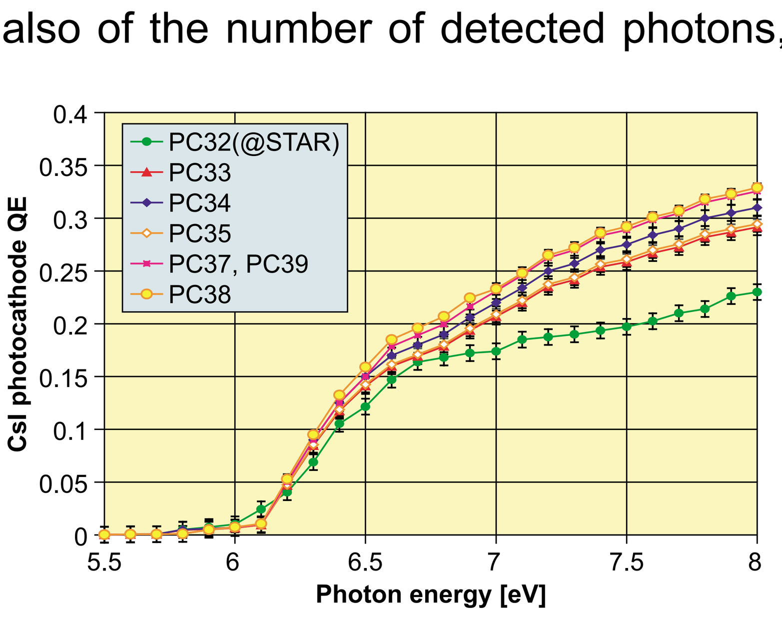


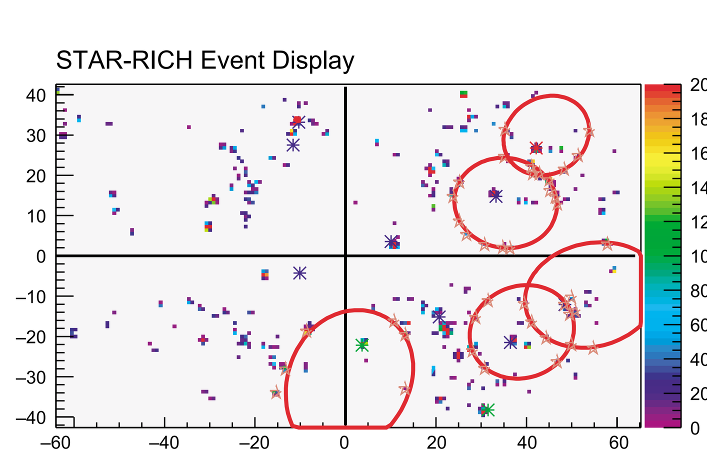
Proto-3 fully equipped with the final FEE

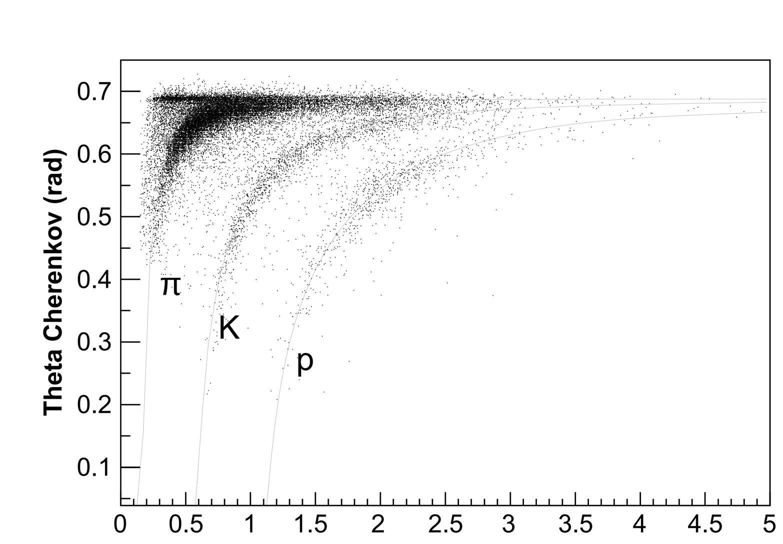
Each HMPID module is divided into two halves, in turn segmented into 24 rows of 10 daisy-chained 3-GASSIPLEX (3-G) cards. Each 3-G card performs a serial readout of 48 pads at 10 MHz multiplexing frequency and the corresponding signals are sequentially sent to a commercial 12-bit ADC (for analog-to-digital conversion) and to the DILOGIC, an ASIC chip specifically designed for zero-suppression.
For Pb-Pb central events, an occupancy of 15% has been estimated, corresponding to a total readout time not larger than 200 µs.

Detector performance

The HMPID has been designed to measure the Cherenkov angle with an accuracy of few mrad, required to discriminate π, K and p in the relevant momentum range. Moreover, the chosen pad size and the analog readout allow charged tracks to be detected with good spatial resolution and high multi-hit recognition efficiency. The Cherenkov angle resolution per track is a function not only of the chromatic, geometric and localization errors but also of the number of detected photons, being inversely proportional to the square root of that number. Therefore much effort has been made to successfully develop a standardized procedure of manufacturing CsI photocathodes of large area with a reproducible high QE. Presently, an average of 19 reconstructed photon hits per Cherenkov ring are obtained with $\beta = 1$ particles yielding an overall resolution (intrinsic plus pattern recognition) of about 3 mrad per track at a pad occupancy of 15%, corresponding to 50 particles/m^2.
A 1.2 m^2 prototype (2/3 of an HMPID module) was installed in the STAR experiment at BNL and took data for two years since the start-up of RHIC Au-Au interactions. Its successful operation yielded not only invaluable expertise for the realization of the HMPID array in ALICE but also important physics results.







CERN–DTP
January 2003