THE CONSTRUCTION OF THE ALICE HMPID DETECTOR

B. BELIN* on behalf of the ALICE-HMPID group

Bari – INFN and Politecnico, CERN, Moscow – INR, *Istanbul -TUBITAK , Istanbul Technical University

INTRODUCTION

ALICE (A Large Ion Collider Experiment) is a heavy ion experiment designed to study especially Pb-Pb collisions at the CERN-LHC collider at a center of mass energy per nucleon pair of $\sqrt{s_{NN}}$=5.5 TeV and at a maximum luminosity of 10^{27} $cm^{-2}s^{-1}$. ALICE will detect and study both hadronic and leptonic signals over 3 orders of magnitude in momentum, from 100 MeV/c to 100 GeV/c.

The HMPID detector consists of seven RICH (Ring Imaging Cherenkov) counters 1.5 m x 1.5 m each**,** located at a radial distance of 4.7 m from the interaction point and covering 5 % of the ALICE barrel acceptance. Each module contains six CsI photocathodes of size 0.64m x 0.4m, for a total active area of $11 m^2$.

The HMPID identifies pions and kaons in the range 1< p < 3 GeV/c and protons and kaons in the range 2 < p < 5 GeV/c.

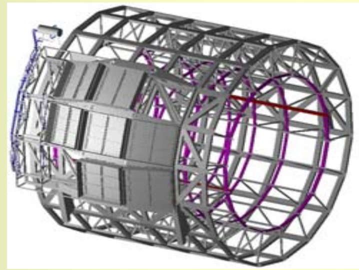

Fig.1. ALICE space frame with the HMPID support cradle and seven detector modules.

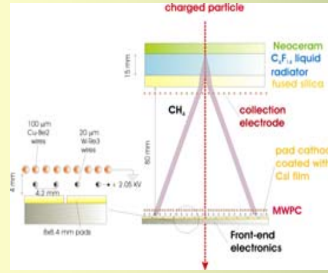

Fig. 2. Schematic cross-section of the HMPID RICH detector.

The liquid circulation system has to fill and drain the radiator vessel independently, remotely and safely, at a constant flow of 4 l/h. Given its intrinsic high degree of safety, gravity flow has been adopted to prevent accidental large hydrostatic loads in the fragile radiator vessels.

Fig. 3. Radiator vessels equipping one HMPID module.

Fig. 4. The cradle support structure with header tubes for the liquid circulation system.

Fig. 5. Test of the tension of cathode and anode wires in module 3.

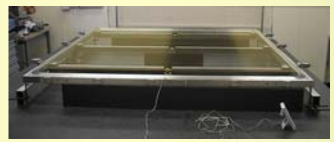

Fig. 6. The pre-deformation system for the cathode wires frame.

DETECTOR

The RICH has a 15mm thick C_6F_{14} (perfluoro-hexane) liquid radiator circulated in vessels having 5 mm fused silica windows nearly transparent to the Cherenkov radiation of interest. The C_6F_{14} refractive index n is 1.2989 at a wavelength of 175 nm.

Each module has a total volume of 200l and can be flushed up to 100 l/h with Ar or CH_4 during stand by or operation, respectively.

The readout of the HMPID modules is based on 2 chips**,** GASSIPLEX and DILOGIC. The GASSIPLEX chip is a 16 channel charge sensitive pre-amplifier and shaper while the DILOGIC chip is a digital processor.

Each module is equipped with three radiator vessels of 1330 mm x 413 mm x 24 mm made of NEOCERAM**,** a transparent ceramic having thermal coefficient very close to the fused silica plates used as UV-transparent windows.

The MWPC is a stack of four Al frames of 1.5 m x1.5m each, holding the different wire planes. It is closed on one side by the radiator panel support and on the other side by the CsI PCs. Viton O-rings are inserted between the frames to make a gas-tight vessel still dismountable. The gap between the anode wires, of 20 µm diameter, gold plated W-Re 3%, and the PC is 2 mm. They are tensioned at 47 g, about 70 % of the elastic limit, and soldered manually on the anode printed circuit boards with a pitch of 4.2 mm, using positioning marks resulting in a 50 µm accuracy. The second cathode plane is located at 2.45 mm from the anode plane and obtained by stretching 100 µm gold plated Cu-Be wires, with a pitch of 2.1 mm, at a tension of 210 g. Fig. 6 shows the cathode wire plane with the pre-deformation system and a detail of the comb structure used to hold the crimping pins. The final deformation, produced by the total wire tension of 140 kg, has been estimated and is applied to the frame prior to wire fixation to ensure the uniformity of the wire tension.

Finally the collection electrode located next to the radiator consists of 100 µm gold plated Cu-Be wires stretched at a tension 55 g with a pitch of 5 mm. During the assembly process a full set of quality control checks are performed, including metrology, wire tension measurements, leak rate measurements, HV tests under CO_2 and gain mapping with a Sr^{90} source under CH_4.

CsI PHOTOCATHODE

The CSI QE is affected by the choice of the substrate and its surface quality at microscopic level, as well as by the CsI deposition.The final PC processing, improved by several new tests on substrate types, preparation, heat conditioning, and use of a transfer system designed to avoid exposure to air, is in use since 2000, when the first pre-series photo-cathode was produced.

Double layer printed circuit boards (PCBs) with blind holes have been adopted to provide leak-tight connections of the cathode pads to the FEE connectors on the back of the PC. The PCBs are specially prepared to act as substrate for the CsI layer. The Cu pads, accurately polished by chemical and mechanical treatments are covered with a 7 µm layer of Ni and a 0.5 µm of Au. The first layer acts as a barrier preventing the reaction of CsI with Cu, the second was found to be suitable for CsI coating. A pad cathode panel composed of two such PCBs is glued onto a stiff Al frame (4 cm thick) using a vacuum table to achieve planarity better than 50 µm.

Fig. 7. CsI evaporation plant

Fig. 8. Glove-box preparation.

After the CsI deposition the PC is encapsulated under Ar in a sealed protective box and mounted on the detector by means of a large, custom-made, glove-box that can be attached directly to the HMPID module.

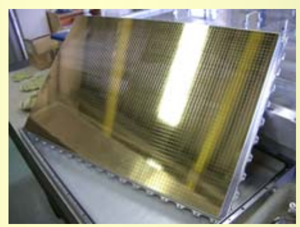

Fig. 9. A pad cathode plane (80 x 48 x pads of 8 mm x 8.4 mm) before the coating with CsI.

VUV SCANNER

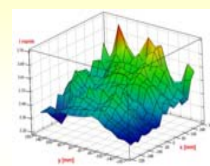

Fig. 10. The normalized photocurrent response mapping of PC45 characterized by an average of 3.5 over the full sensitive area.

In order to characterize the PCs during the mass production a VUV scanner system has been built and installed in a large vessel attached to the evaporation plant. After CsI deposition a PC is transferred under vacuum to the VUV scanner system, where the photocurrent induced by a collimated light beam from a deuterium lamp with MgF_2 window is recorded over the full photosensitive area . Fig. 10 shows the photocurrent mapping for PC45, normalized to the photocurrent of a reference PMT with a semi-transparent CsI photocathode. The average ratio is 3.5, corresponding to more than 20 photons detected for β=1 particles. The spread is 10% over the full area.

TEST BEAM

Module 1 has been equipped with pre-series CsI PCs and tested in 2003. Module 2, module 3 and module 4 have been tested during the 2004 summer.

The signal corresponding to a single photoelectron can be induced on one pad only or spread on a cluster of adjacent pads.

A typical event, produced by 120 GeV/c π^- is shown in Fig 14.

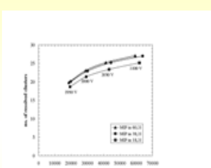

Fig.11. The number of resolved clusters in PC45 as a function of the gas gain for several MIP position.

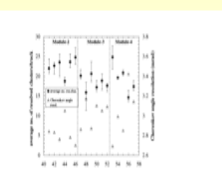

Fig.12. The average number of resolved clusters and the corresponding Cherenkov angle resolution for each PC produced so far @ 2050V.

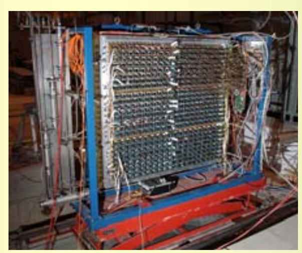

Fig. 13. Module 3 at the CERN/SPS-X5 test beam, fully equipped with the FEE and R/O electronics.

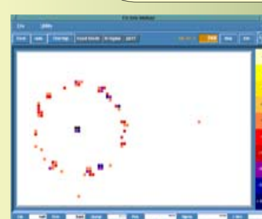

Fig.14. An event produced by 120 GeV/c π^-.

THE PRODUCTION

All the seven detector modules (MWPC + radiator vessels) have been completed and commissioned in laboratory and/or with test beam.

The mass production of the 42 photo-cathodes started in May 04 and 17 photo-cathodes have already been coated with CsI. All chips needed for the FEE, 10080 GASSIPLEX and 3360 DILOGIC chips have been mounted on cards and tested.