The Performance of the ALICE HMPID Detector in pp, p-Pb and Pb-Pb collisions

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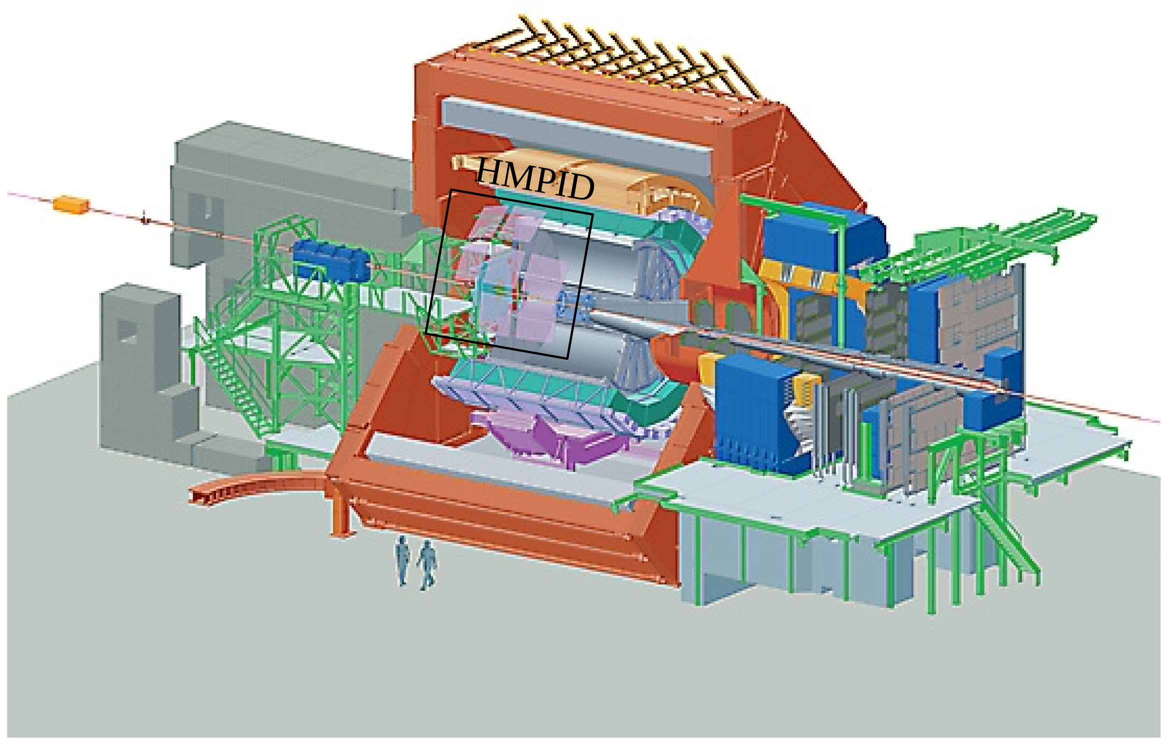
The High Momentum Particle Identification Detector

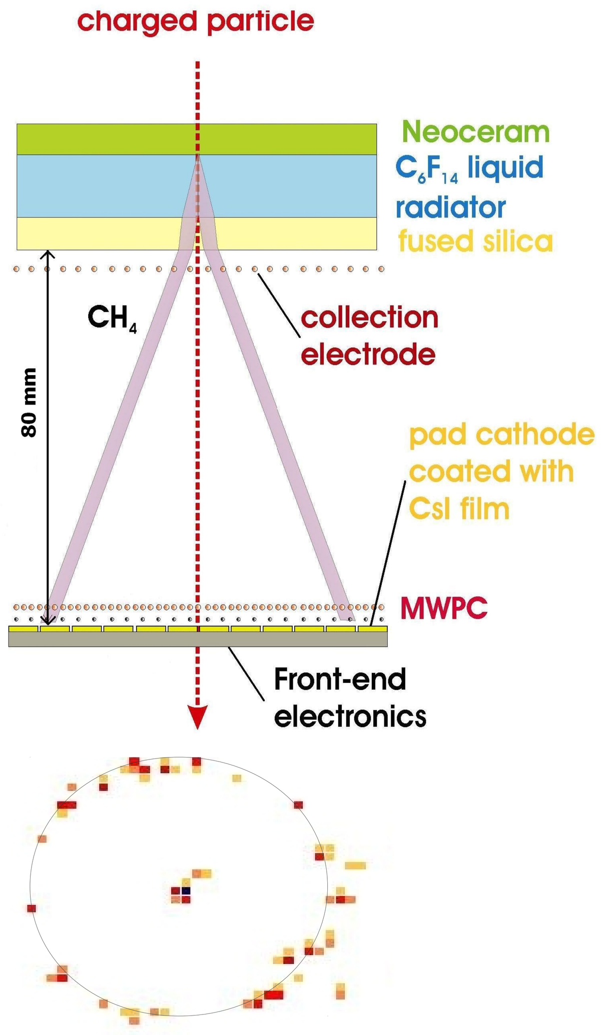
Physics with the HMPID

- Identified charged particle ratios versus transverse momentum can be measured
- Identified resonance production is observable in hadronic channels
- Jet fragmentation, identified hadron correlation can be studied
- Light nuclei (alpha, deuteron, tritium) production is observable

The HMPID performs track-by-track identification of pions, kaons up to 3 GeV/c and of protons up to 5 GeV/c.

The HMPID is based on Ring Imaging Cherenkov (RICH) technique and consists of seven modules [1, 2].



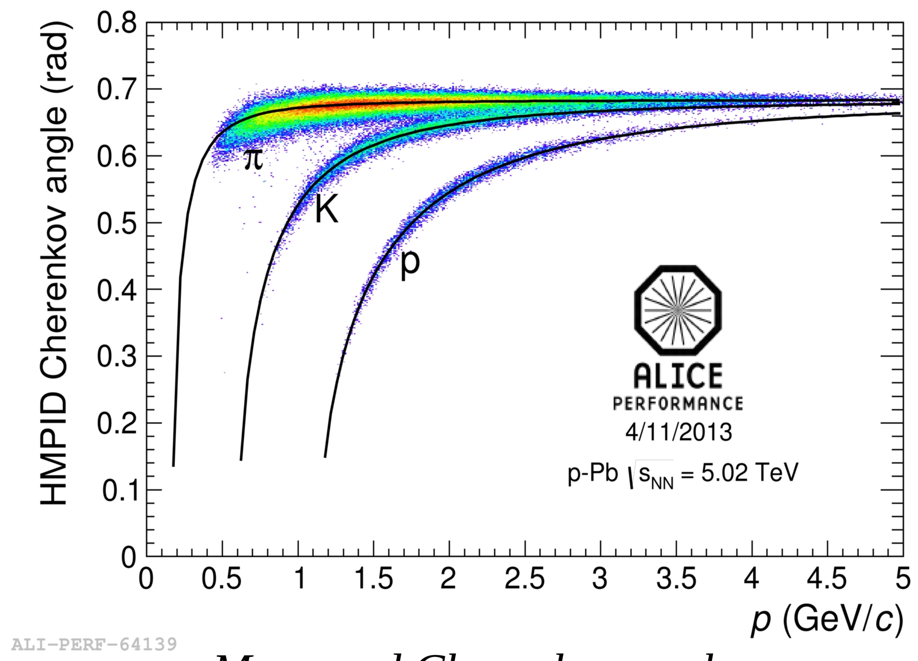


The ALICE apparatus with the HMPID (left) and the scheme of a RICH module (right).

The layout of the HMPID

- **Proximity focusing:** 80 mm gap
- **Photon converter:** Caesium Iodide (CsI): QE ~ 25% @ 175 nm, **11 m^2 of total surface → largest RICH**
- **Photoelectron detector:** MWPC filled with pure methane (CH_4), high voltage of 2050 V, gas gain ~ 4 x 10^4
- **Radiator:** 15 mm liquid perfluorohexane (C_6F_{14}), n ~ 1.2989 @ 175 nm, β_{th} = 0.77
- **Electronics:** Analogue pad readout

Particle Identification with the HMPID

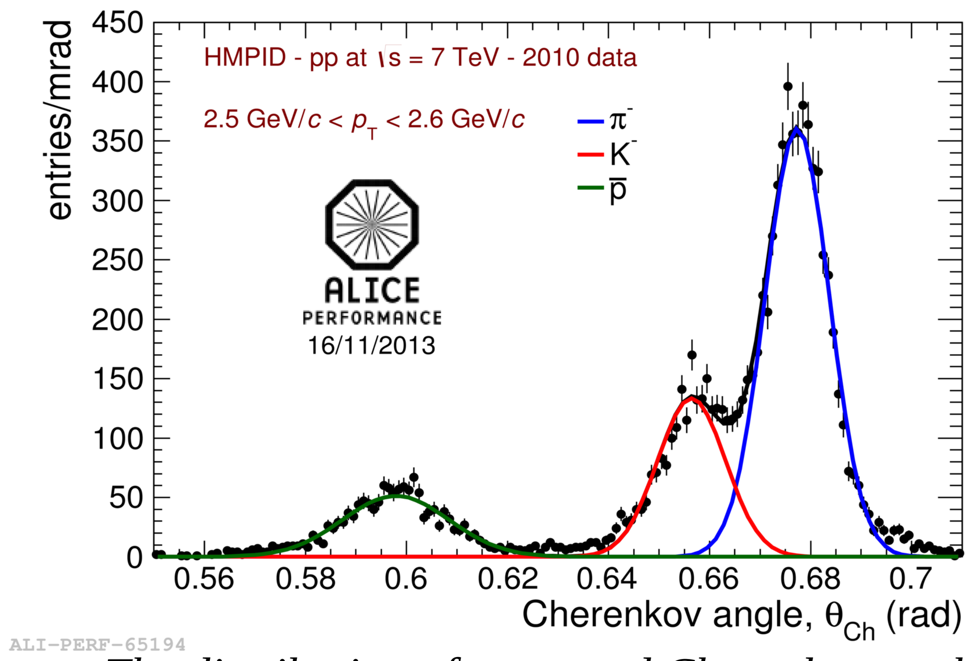


Measured Cherenkov angle in p-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV as a function of track momentum.

Cherenkov angle calculation algorithm uses the coordinates of MIP and photon hit points on the HMPID cathode planes. It also requires the track parameters provided by the ALICE tracking devices: the Inner Tracking System (ITS) and the Time Projection Chamber (TPC).

The signal is discriminated from the background using the Hough Transform Method (HTM) [3].

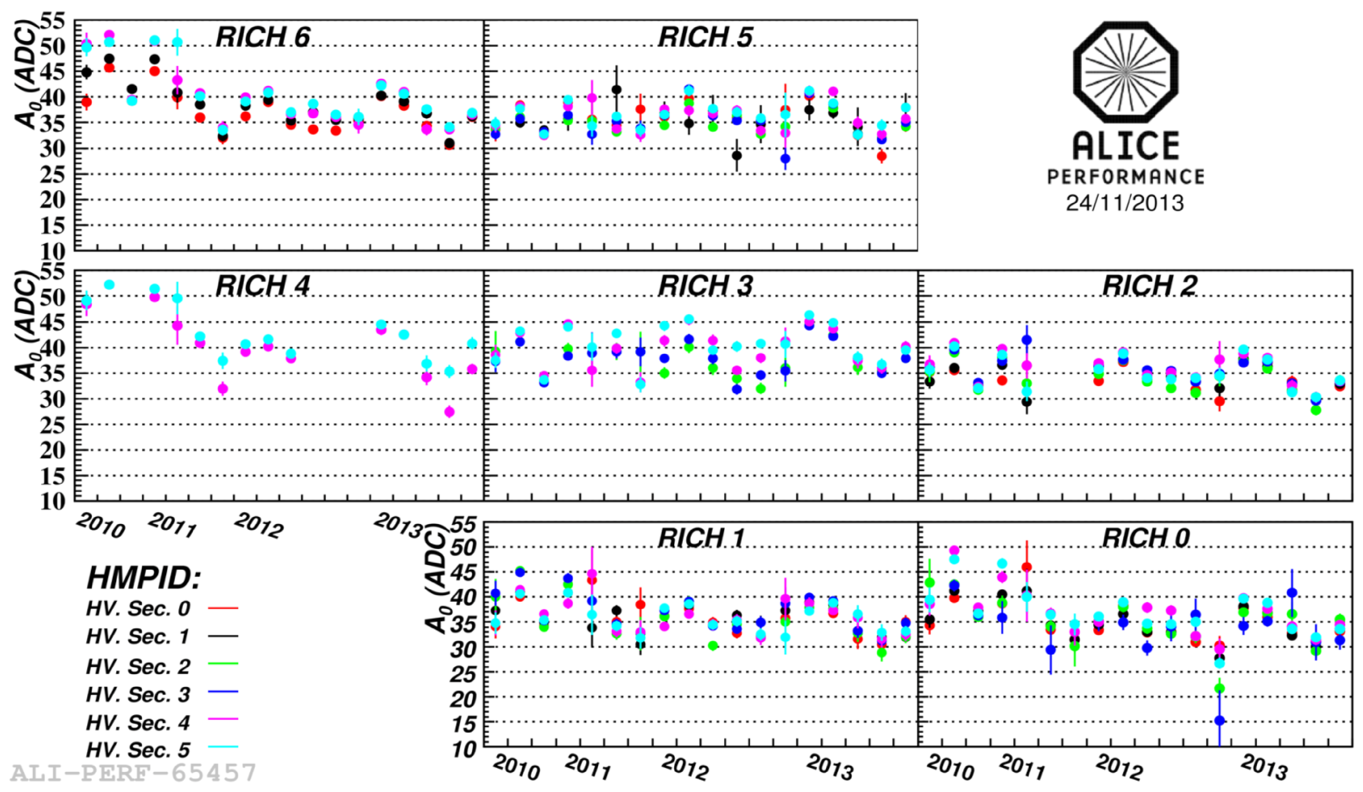
The HMPID measurements enable particles to be identified on both a statistical and a track-by-track basis.



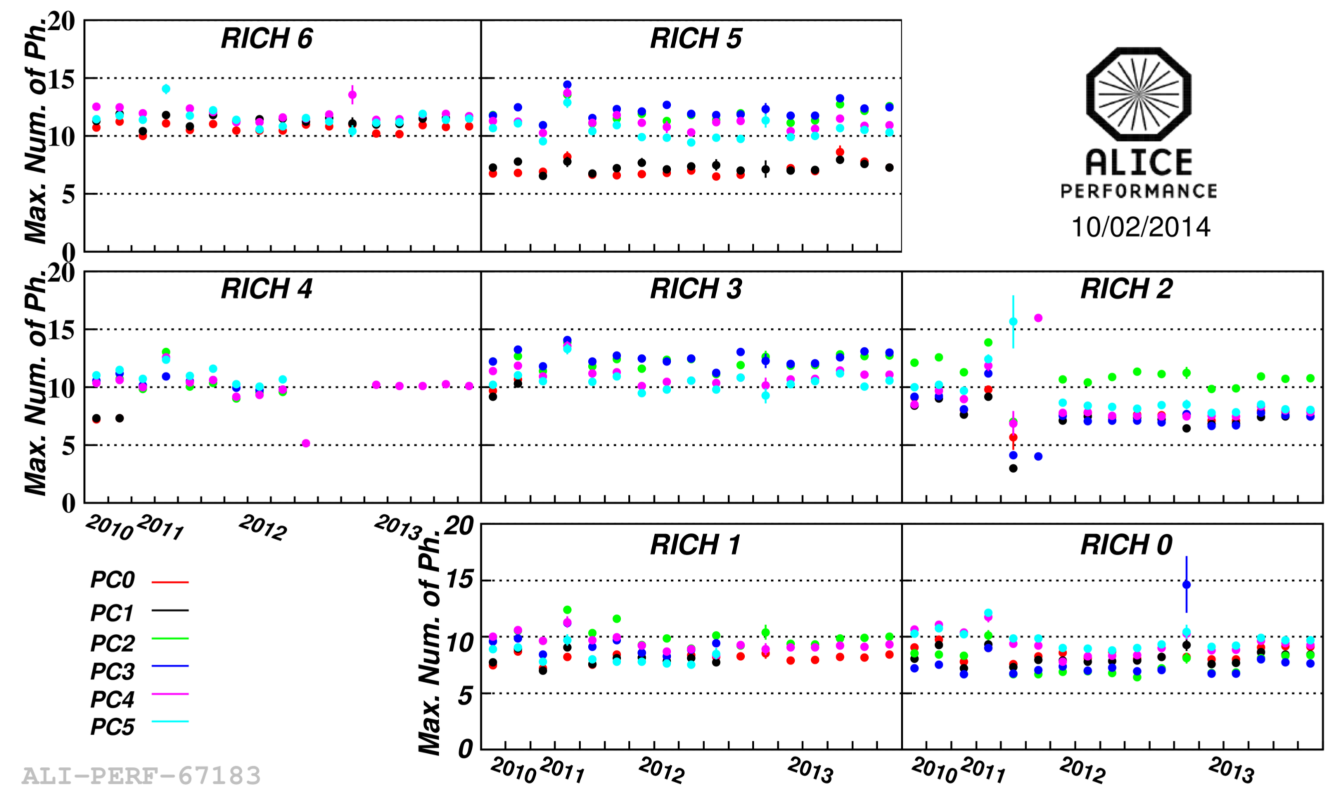
The distribution of measured Cherenkov angle in the transverse mometum range of 2.5 GeV/c - 2.6 GeV/c in pp at $\sqrt{s}$ = 7 TeV.

Detector Performance during the LHC Run 1 (2010-2013)

To study the stability of the detector performance during the LHC Run 1 period, the variation of the gain of chambers and the number of detected photons have been investigated. **No significant loss of the maximum number of detected Cherenkov photons have been observed.** This is consistent with the measured integrated charge dose of 0.015 mCcm^{-2} which is well below the threshold of 0.2 mCcm^{-2} for possible quantum efficiency loss of CsI photo-cathodes.



The variation of A_0 of different high voltage sectors in pp and p-Pb collisions during the LHC Run1.



Maximum number of reconstructed photon clusters per ring in pp and p-Pb collisions during the LHC Run1.

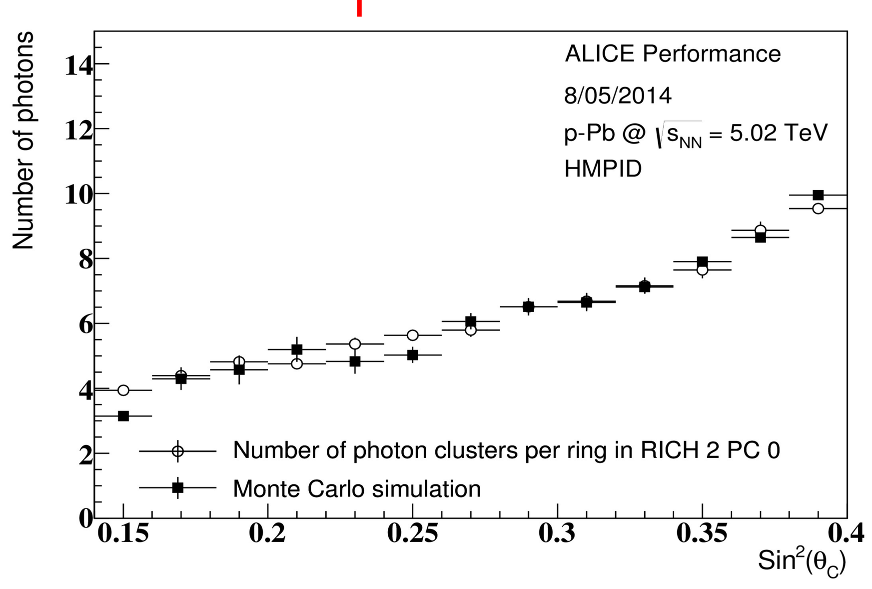
The **determination of quantum efficiencies of CsI photo-cathodes is ongoing by Monte Carlo (MC) simulation**. The MC simulation has three input parameters: chamber gain and radiator transparency are measured as well as the quantum efficiency versus photon energy function. The QE(E) function is modified until the number of detected photons from the simulation reproduces the measured one within the statistical uncertainties. The MC simulation is based on the following equations:

$$N_{\rm phel} = L \cdot N_0 \cdot \sin^2\theta_c$$

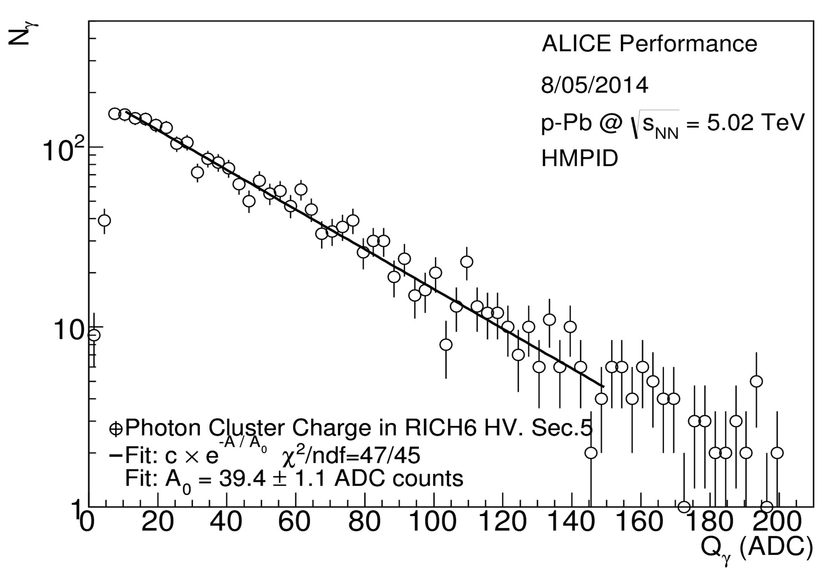
N_{phel}: Cherenkov photoelectrons
L: radiator thickness
θ_c: mean Cherenkov angle

$$N_0 = 370 \cdot \epsilon_{\rm det} \cdot \int \boxed{QE(E)} \prod_i T_i(E) {\rm d}E$$

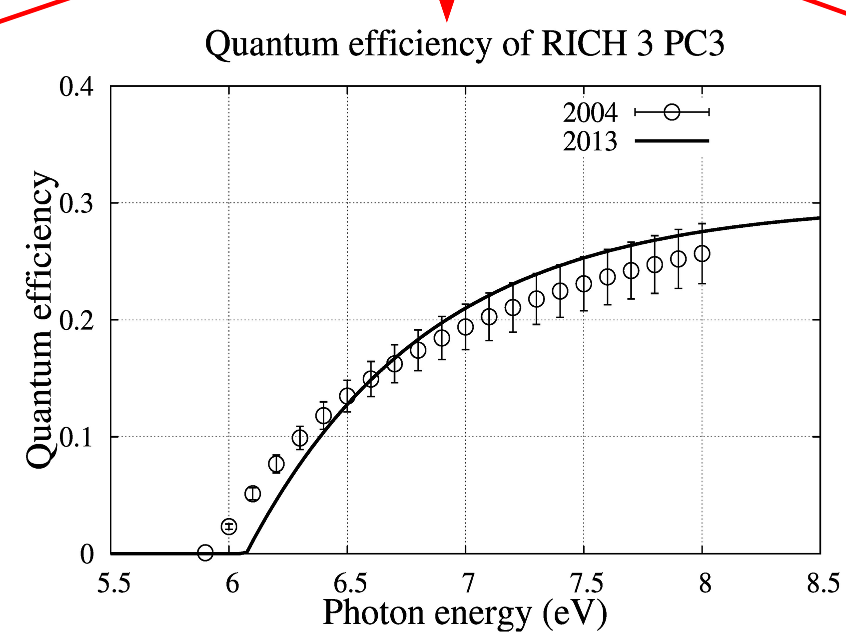
ε_{det}: single photon detection efficiency
QE: quantum efficiency
T_i: radiator transmission



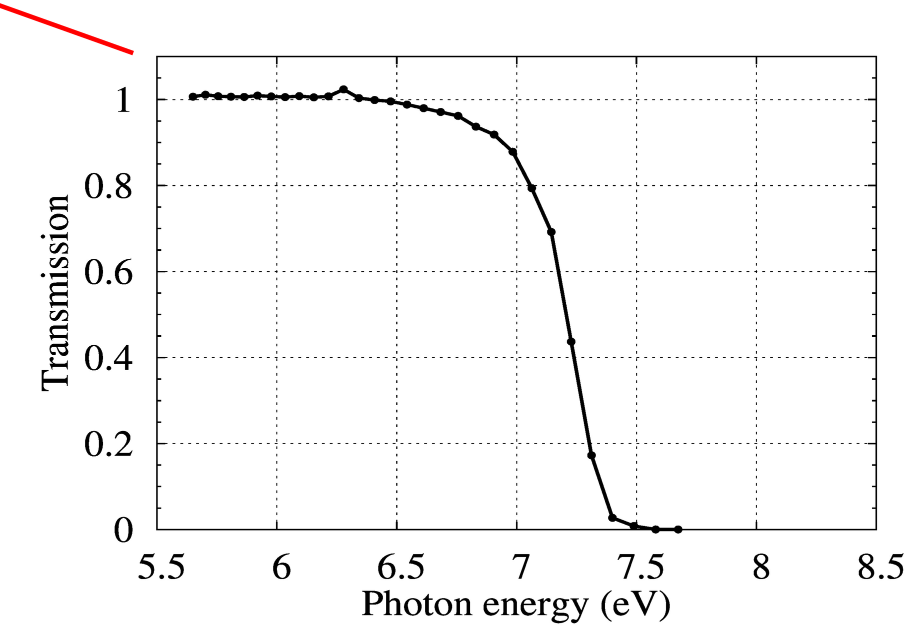
The number of photons versus $\sin^2(\theta_c)$ in p-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV.



Measured photon cluster charge distribution in p-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV.



The quantum efficiency of a CsI photo-cathode in 2004 and 2013.



Radiator transmission as a function of photon energy.

Present results prove that the **HMPID has operated reliably during LHC Run1 and that no limitations on the measurements are expected during LHC Run2.**

References: [1] CERN/LHCC 9819, ALICE TDR 1, 14 August 1998. [2] http://aliceinfo.cern.ch/Public/en/Chapter2/Chap2_HMPID-en.html [3] D. Di Bari [ALICE Collaboration], Nucl. Instrum. Meth. A 502 (2003) 300