ALICE-HMPID performance in pp and Pb-Pb collisions at $\sqrt{s}$ = 13 TeV and $\sqrt{s_{NN}}$ = 5.02 TeV during 2015-2016

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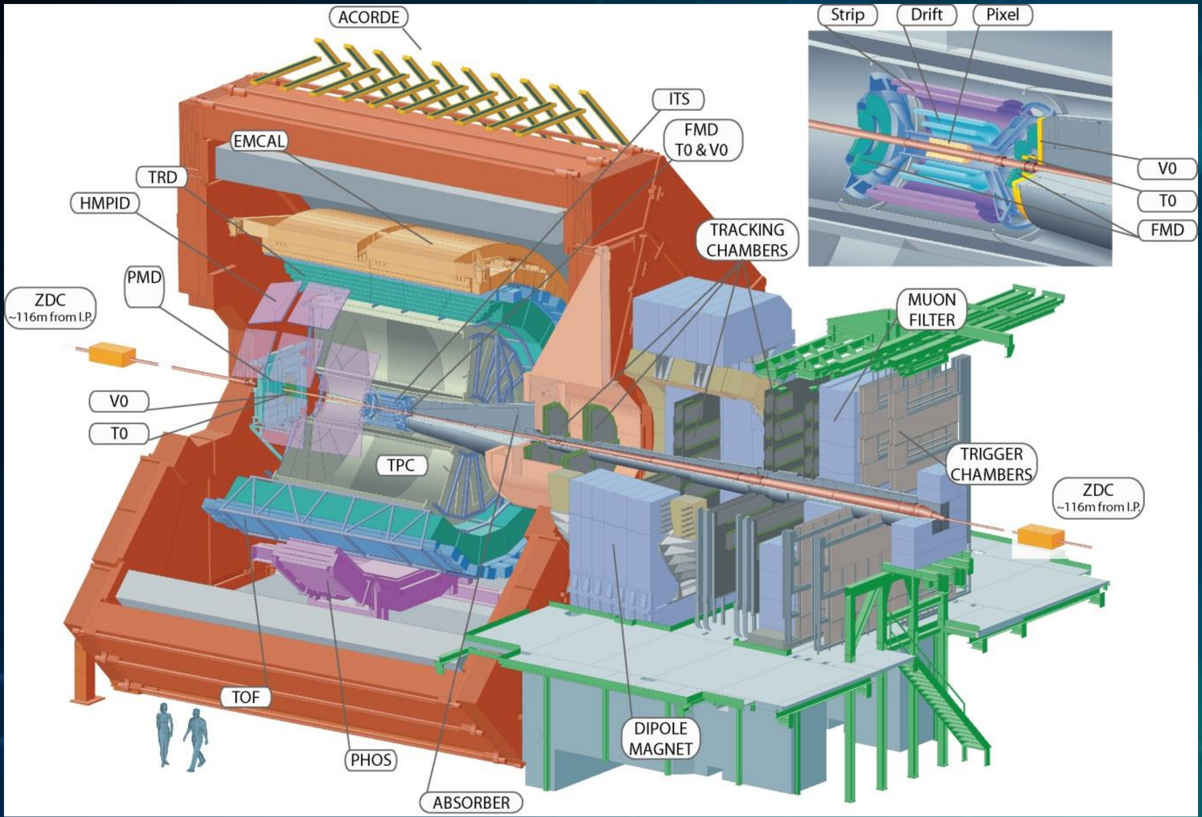
ON BEHALF OF THE ALICE COLLABORATION

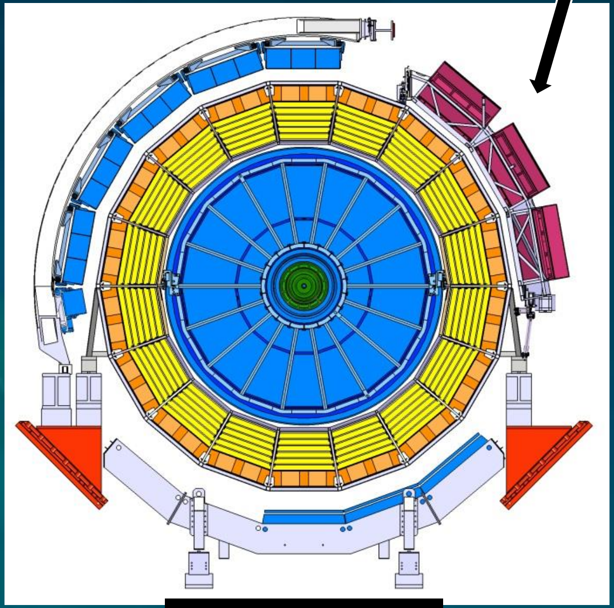
Outline

- ALICE -HMPID description,
- Detector performance
- PID performance
- Perspectives for the HMPID in LHC Run3 (2021-2023)
- Summary

ALICE-HMPID



ALICE:
A
Large
Ion
Collider
Experiment



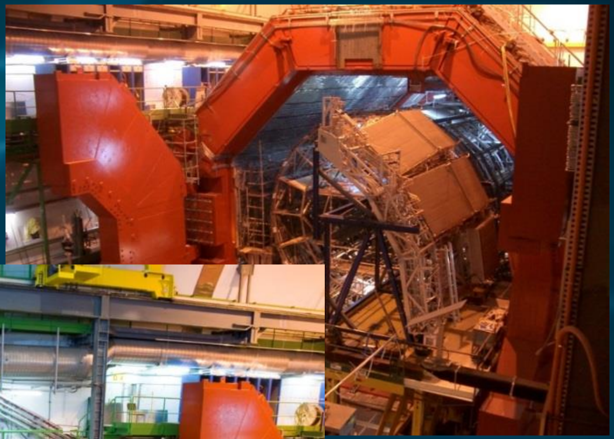
A-side view

- ALICE was built to characterize the high density, high temperature phase of strongly interacting matter known as Quark-Gluon-Plasma state;
- Excellent PID capabilities are required.

HMPID: High Momentum Particle IDentification detector

PID range:
1 < p < 3 GeV/c π, K
1.5 < p < 5 GeV/c   p

7 RICH modules ~1.3 x1.3 m^2 for a total CsI active area of ~11 m^2
September 2006: HMPID installation in the ALICE magnet!



Institutions:
INFN and Dip. Of Physics, Bari (Italy);
Politecnico of Bari (Italy);
CERN Geneva (Switzerland);
Wigner Research Institute Budapest (Hungary);
University of Malta, Msida, (Malta).

HMPID basic elements

Proximity-focusing geometry;

$\cos\theta = 1/n\beta$

Cherenkov Radiator

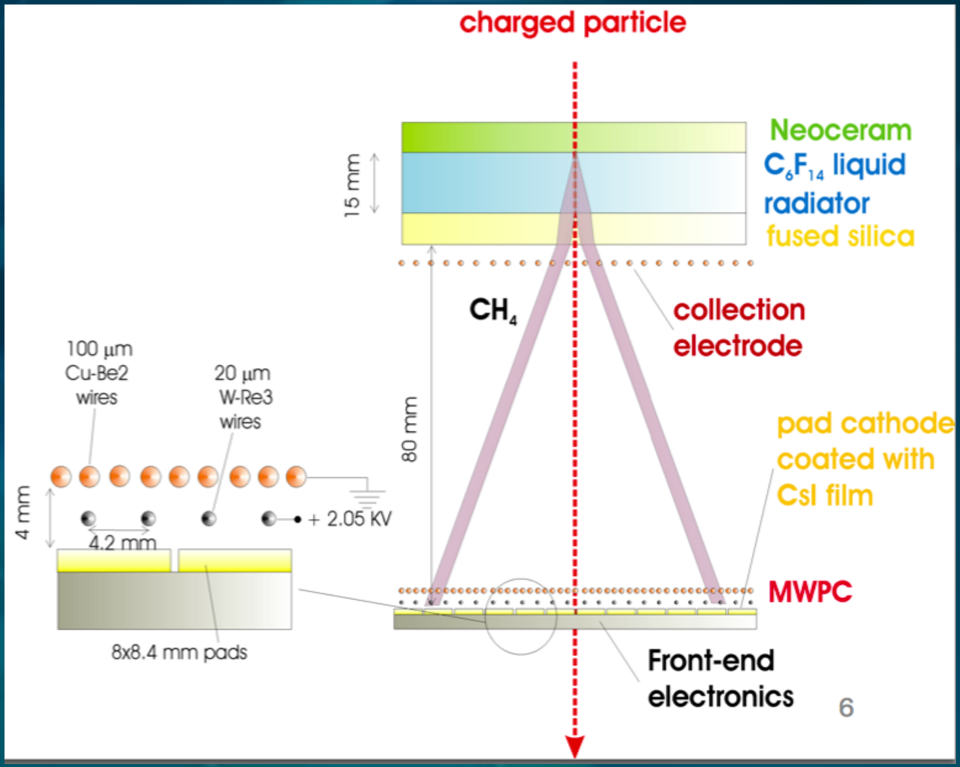
- 15 mm C_6F_{14}; n=1.2989 @ 175 nm;

Photon converter:

- 300 nm thick reflective layer of CsI; QE ≈ 25% @ 7.1 eV (175 nm)

Photoelectron detector:

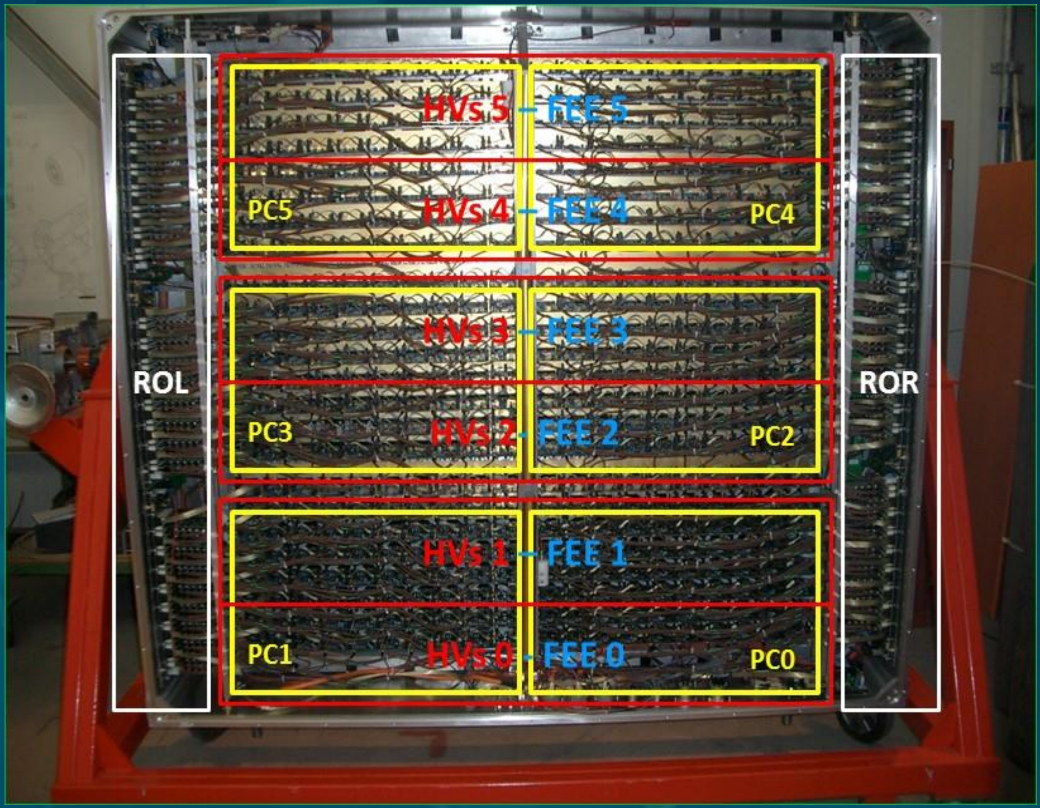
- MWPC 2,2-2.5 mm asymmetric gap with CH_4 at atmospheric pressure, gas gain ≈ 4 10^4 ;
- analogue pad read-out (pad size = 8x8.4 mm^2), total number of channels ≈ 160 K.



Detector performance in Run2

Sub-system segmentation in one RICH module

- 6 CsI pad Photocathodes (PC's);
- 6 x HV sector of 48 anodic wires (HV's);
- 6 x FEE sectors (FEE's);
- 2 RO sectors (ROR-L)
- Details : CERN/LHCC 98-19 ALICE TDR 1 14 of August 1998.



C_6F_{14} circulation and purifying systems

- Safe C_6F_{14} circulation by gravity flow;
- Stable transparency to Č photons;
- Separated control for each radiator vessel;
- C_6F_{14} : 3M PF5060DL.

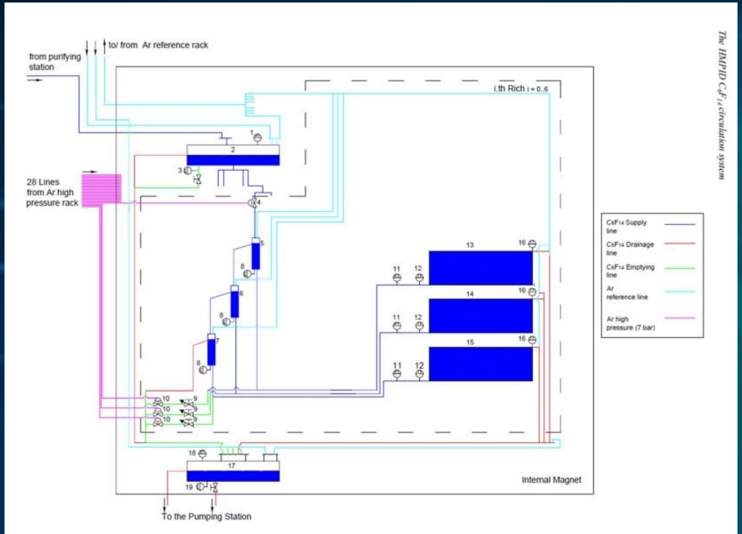


Fig 10 Schematic of the distribution station for one module.

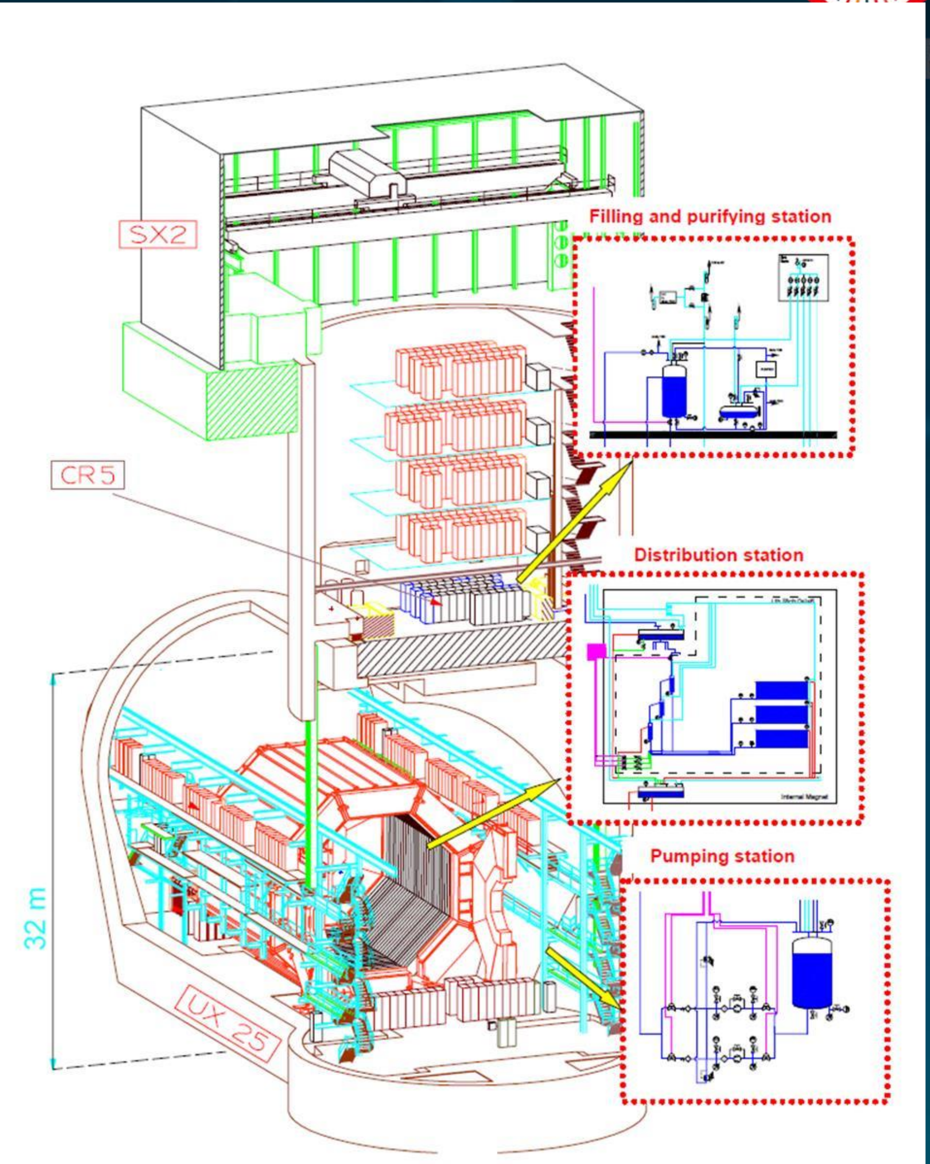
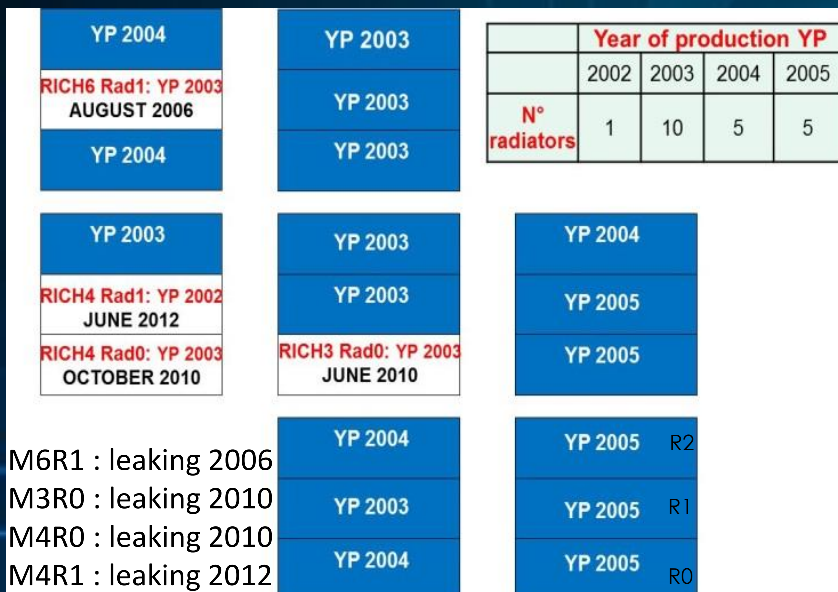


Fig. 6 Location of the three units of the HMPID liquid system in the experimental cavern.

Detector status

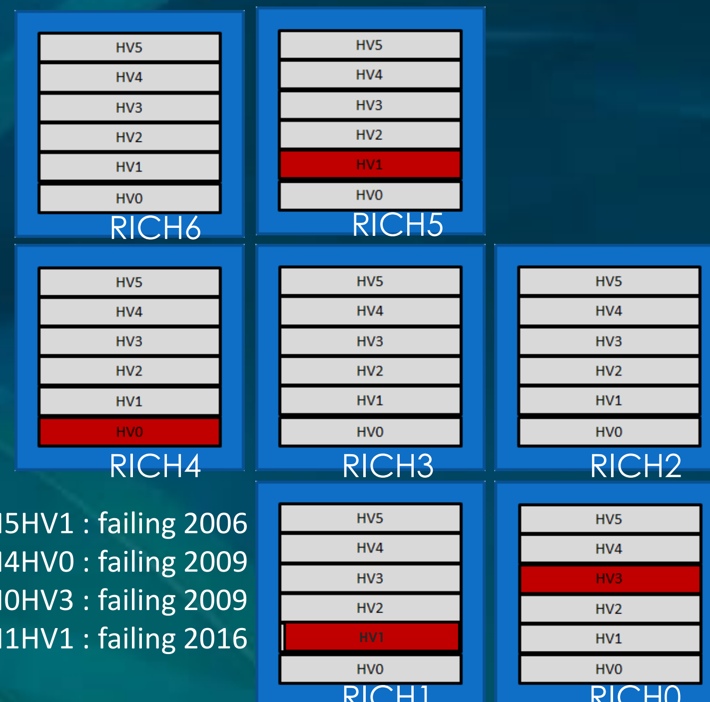
Leaking radiator vessels



	Year of production YP			
	2002	2003	2004	2005
N° radiators	1	10	5	5

M6R1 : leaking 2006
M3R0 : leaking 2010
M4R0 : leaking 2010
M4R1 : leaking 2012

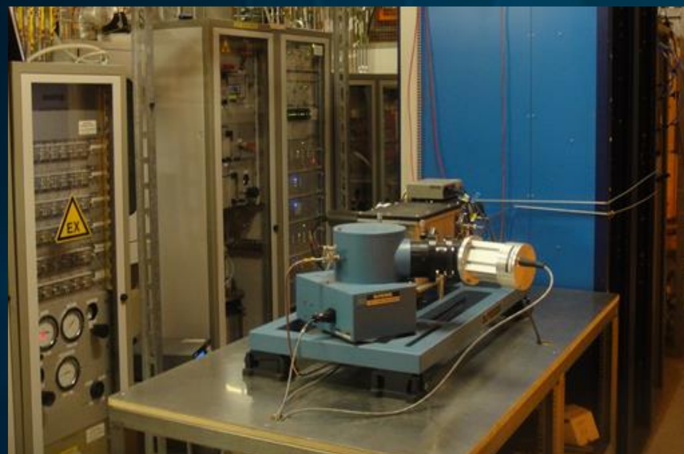
HV failing sector

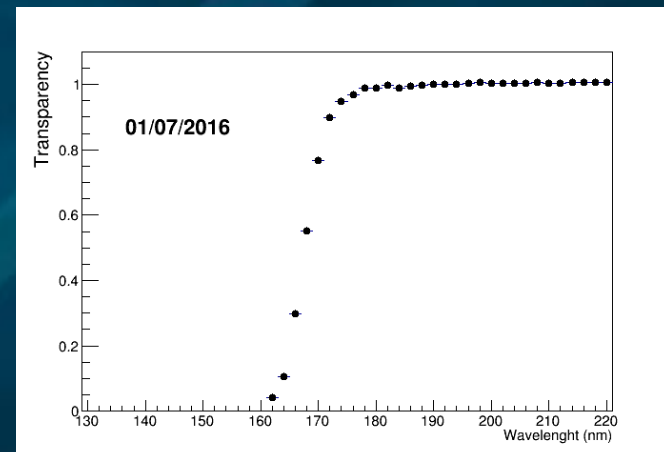


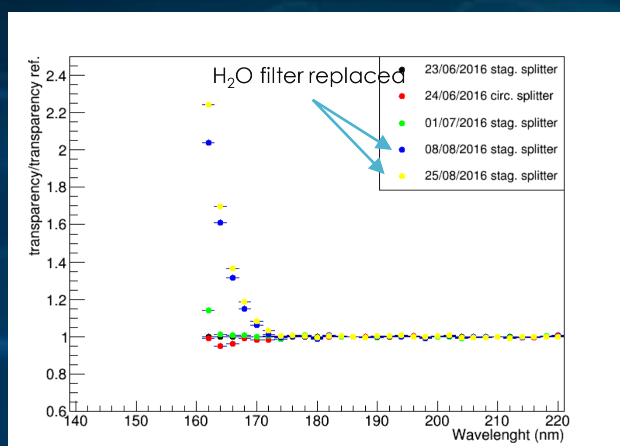
M5HV1 : failing 2006
M4HV0 : failing 2009
M0HV3 : failing 2009
M1HV1 : failing 2016

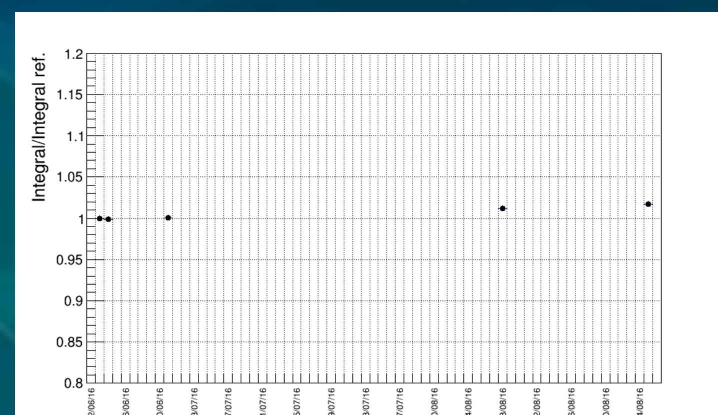
Faulty sub-system segments:
Combining leaking vessels and failing HV sectors, the detector acceptance is ~ 70% after 10 years of operation.

C_6F_{14} Transparency monitoring



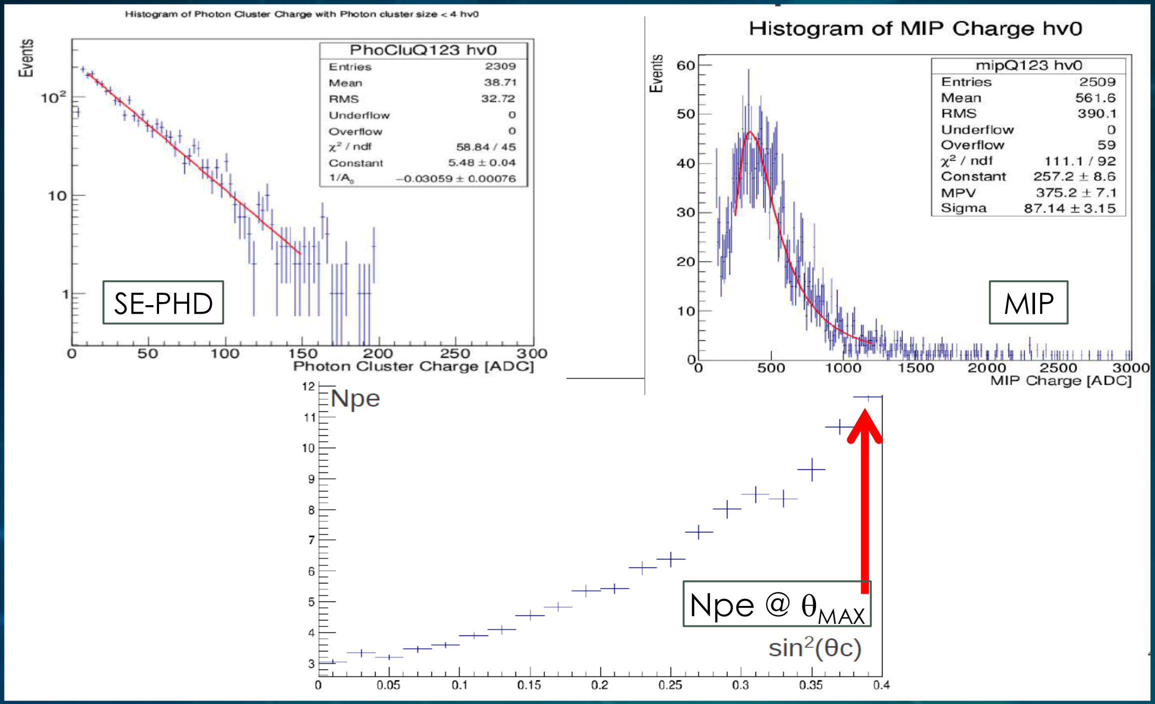






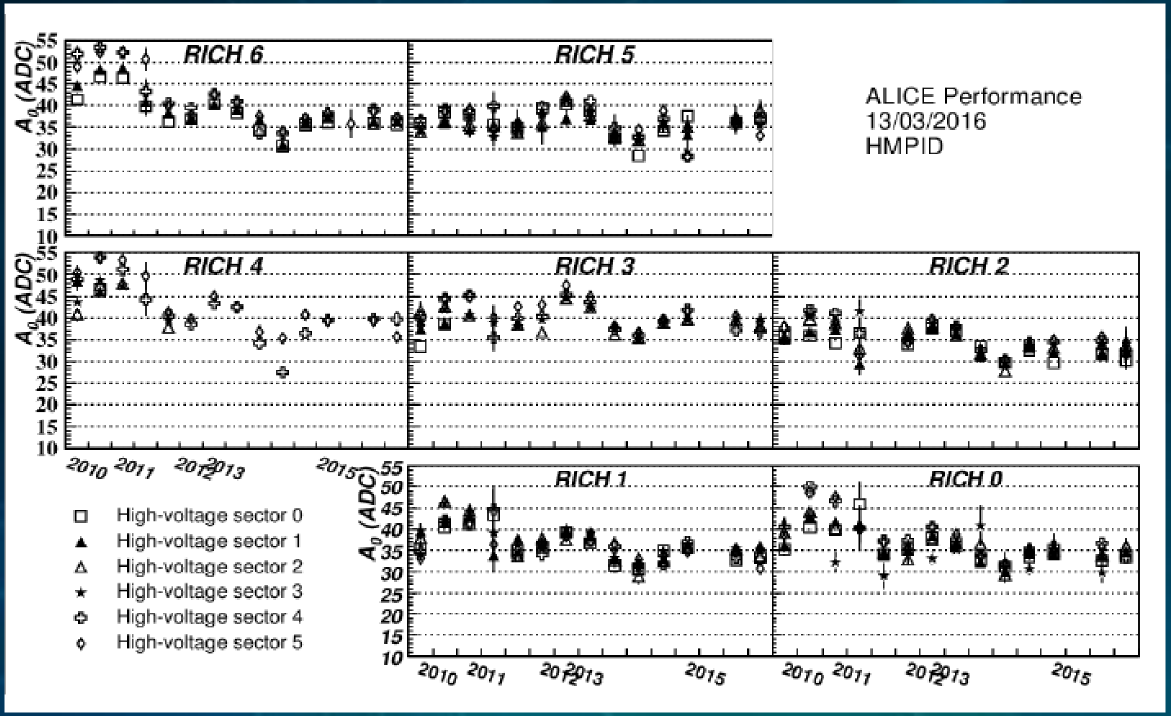
On August the 4th , after replacement of H_2O molecular severs , the transparency improved around the water absorber peak of 165 nm. Anyway no Npe variation expected.

MWPC SE-PHD , MIP and Npe @ θ_{MAX}



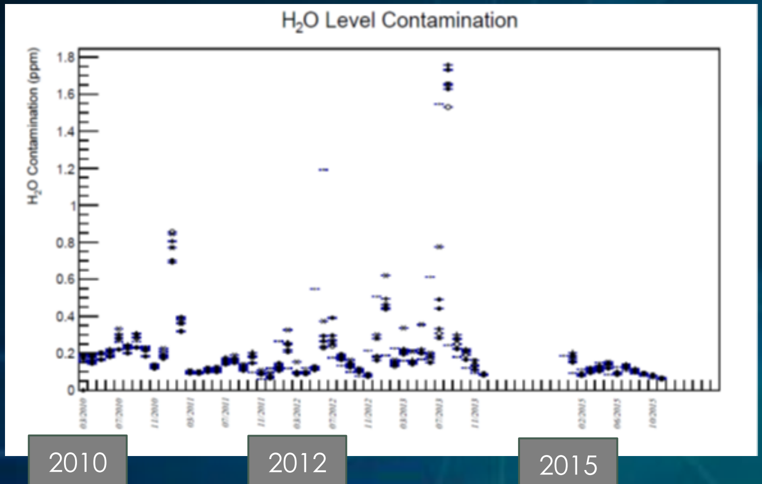
Npe at θ_{MAX} (β=1) depends only from the optical property of the radiator: $\cos\theta_{MAX} = 1/n$

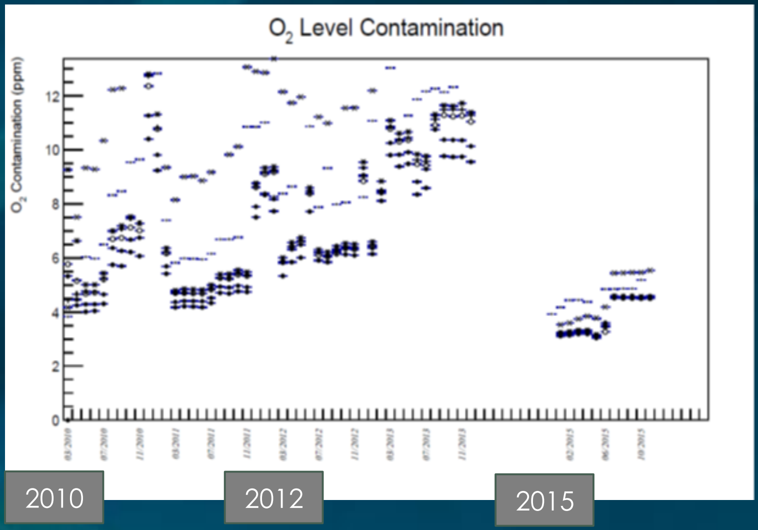
MWPC gain monitoring



- HV equalization (Sept. 2011) to set $A_0 \approx 35$;
- Gain variations ≈ ± 15%;
- A reduction of 20% on A_0 -> photoelectron detection efficiency loss of 3% ($A_{th}/A_0 \approx 4/35$) . No effects on the PID performance.

Monitoring of CH_4 contaminants

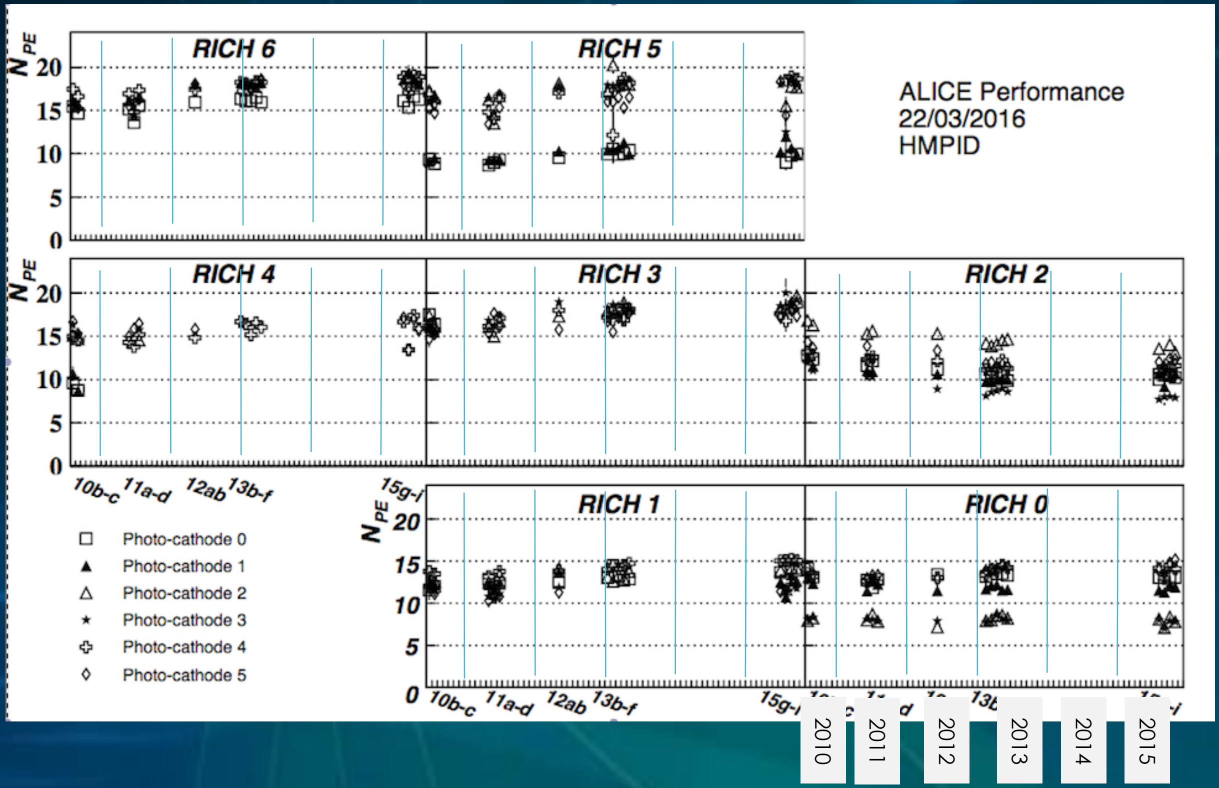




H_2O and O_2 in the MWPC CH_4 can degrade the UV transmission and damage the hygroscopic CsI layer;

At he level of few ppm they are well below the threshold to impact the detector performance.

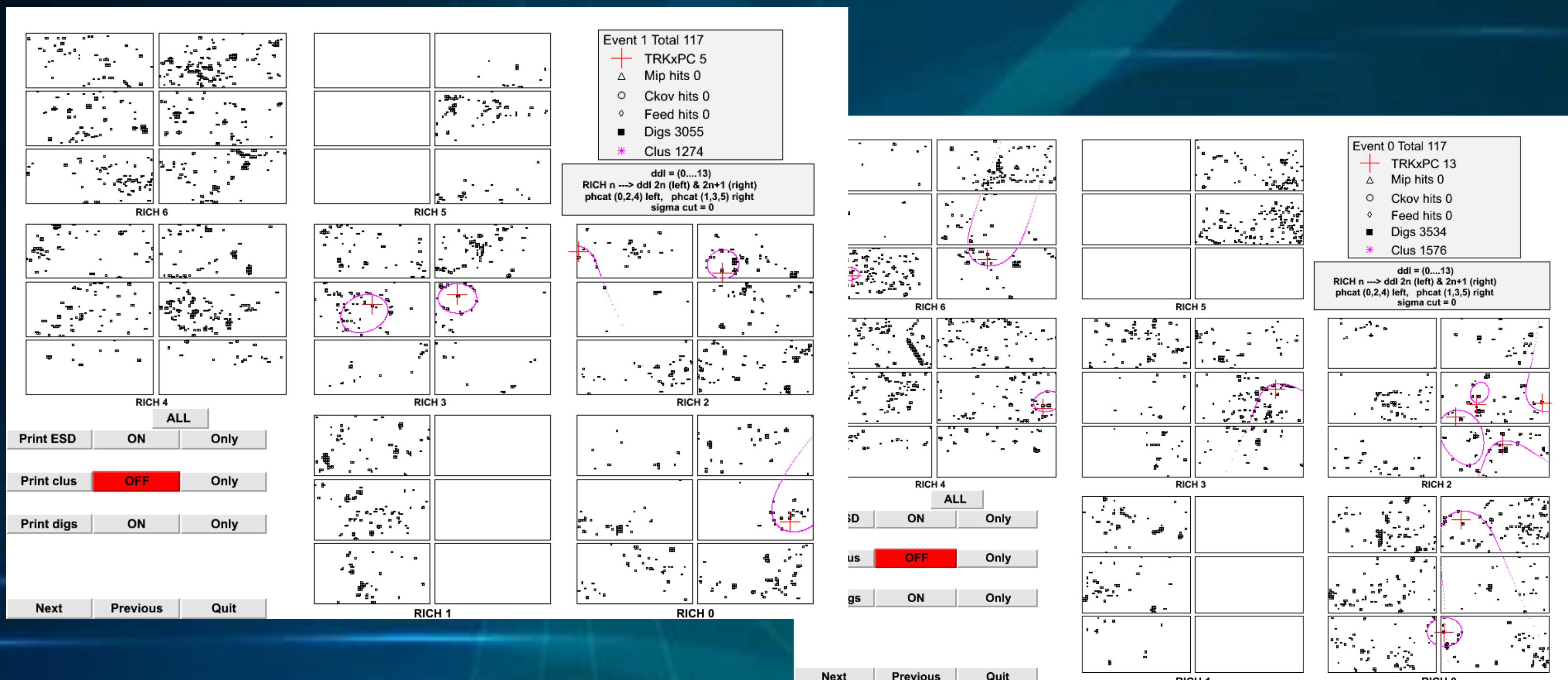
Monitoring of N_{PE} stability



- Good Npe stability infers a CsI QE stability;
- Except RICH2 PC 2 and 3 with a drop of 30%. After cleaning, PC's were re-evaporated during 2005, maybe procedure not optimised;
- Empty space between blobs represents LHC technical stops from 2010 up to 2015.

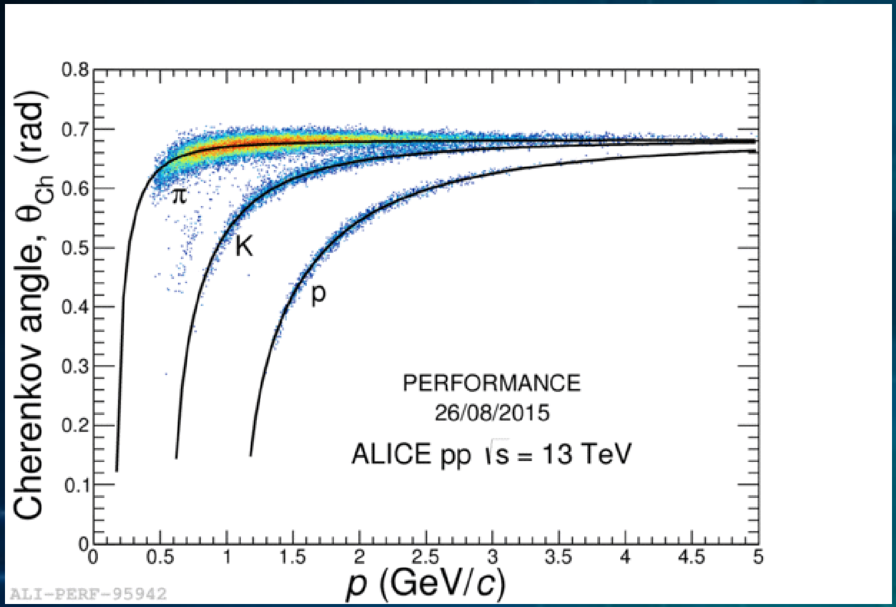
PID performance in Run2

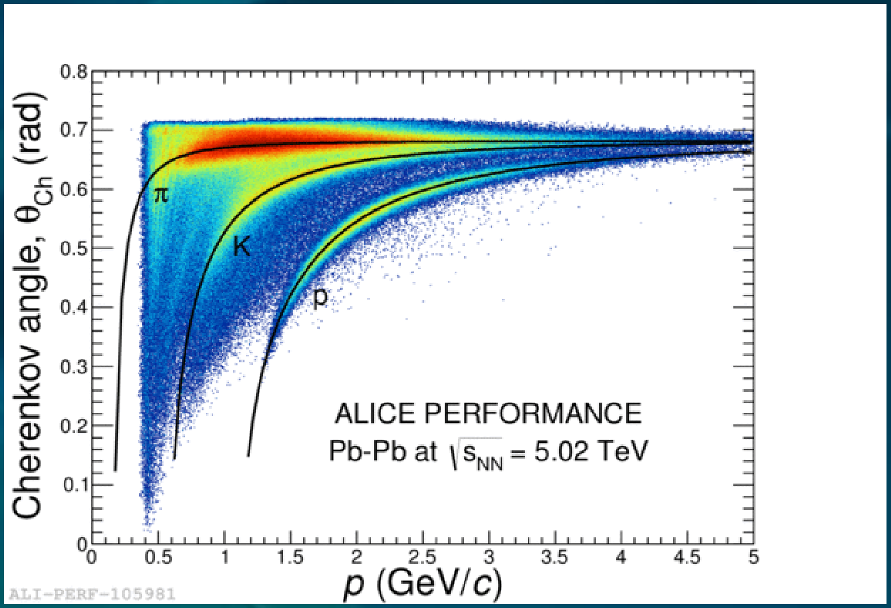
Pb-Pb events at $\sqrt{s_{NN}}$ = 5.02 TeV/c



- HMPID Calot-like design optimized for 0.2 Tesla but experiment operation @ B=0.5 Tesla;
- Deformation/opening of the circular Cherenkov patterns. Some degradation of the angular resolution anyway PID performance ensured (3σ separation in the momentum ranges).

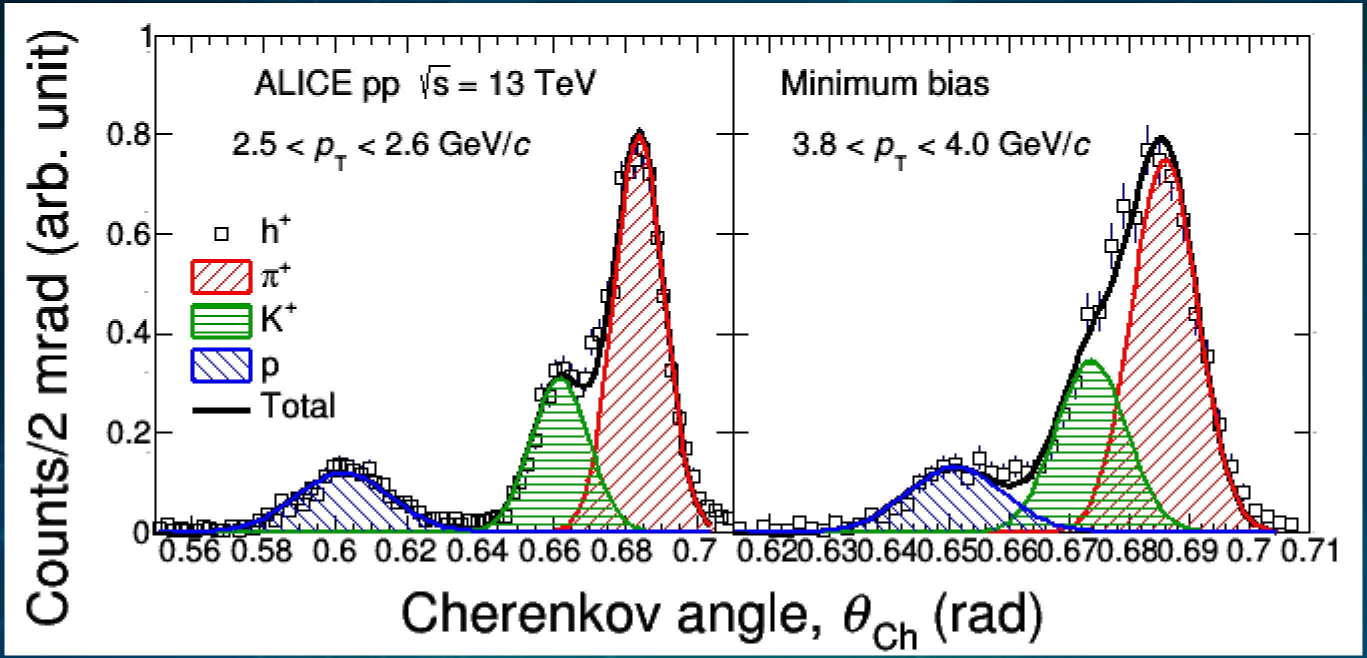
PID performance on pp $\sqrt{s}$ =13 TeV and Pb-Pb $\sqrt{s_{NN}}$ =5.02 TeV





- HMPID Cherenkov angle vs track momentum for pp $\sqrt{s}$ =13 TeV (left panel) and Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV (right panel);
- Continuous lines represent theoretical Cherenkov angle values vs. track momentum.

Statistical PID in pp collisions



- Two PID techniques possible: statistical (Gaussians fits as in figures) or event-by-event which needs an effective background rejection;
- For the contribution of HMPID to the ALICE physics see G. Volpe presentation, session Pattern recognition and Data Analysis.

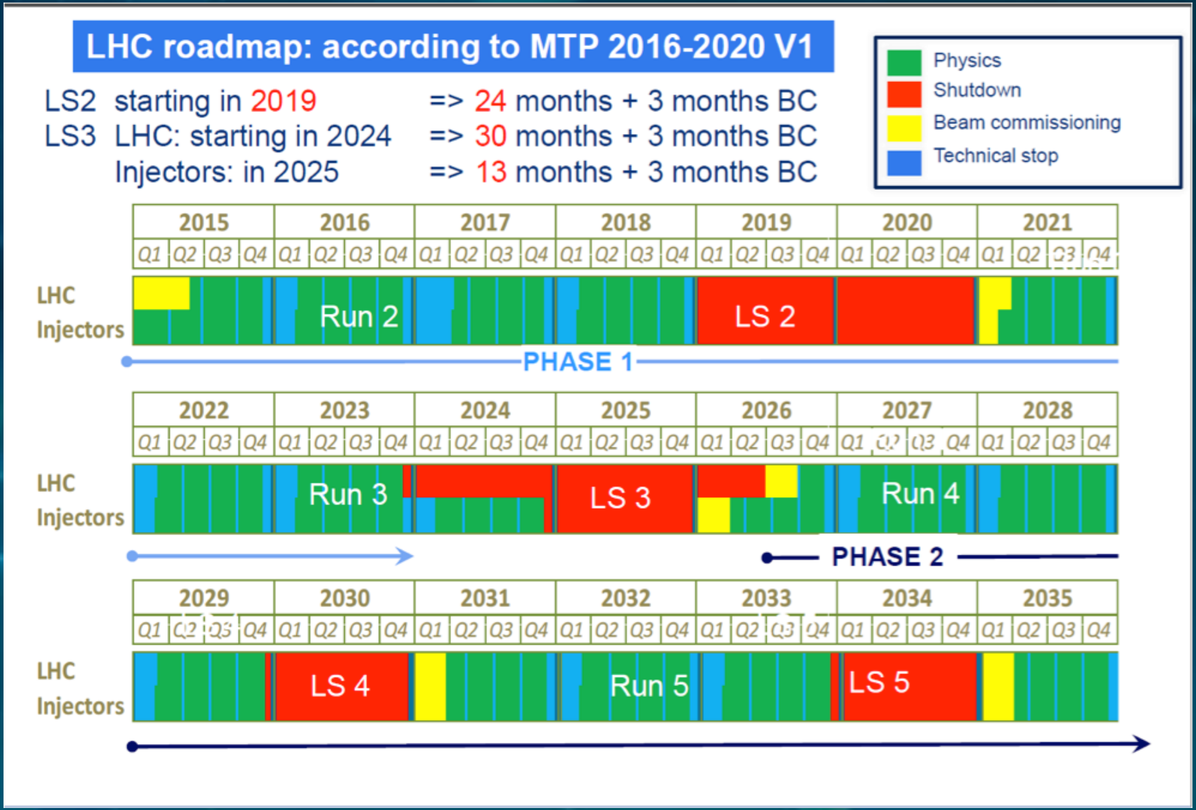
Perspectives for the HMPID in HL-LHC Run3 (2021-2023)

LHC long term program

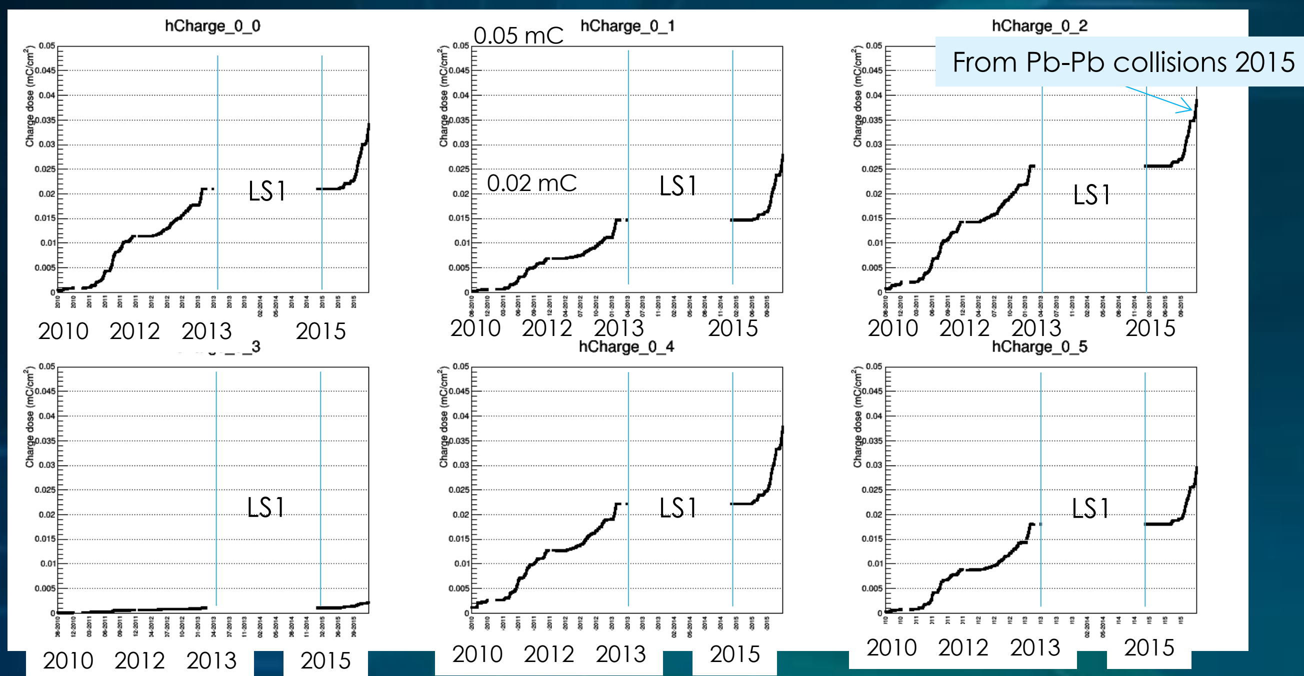
LHC Run 1: 2010-2013

LHC Run 2: 2015-2018

HL-LHC Run 3: 2021-2023

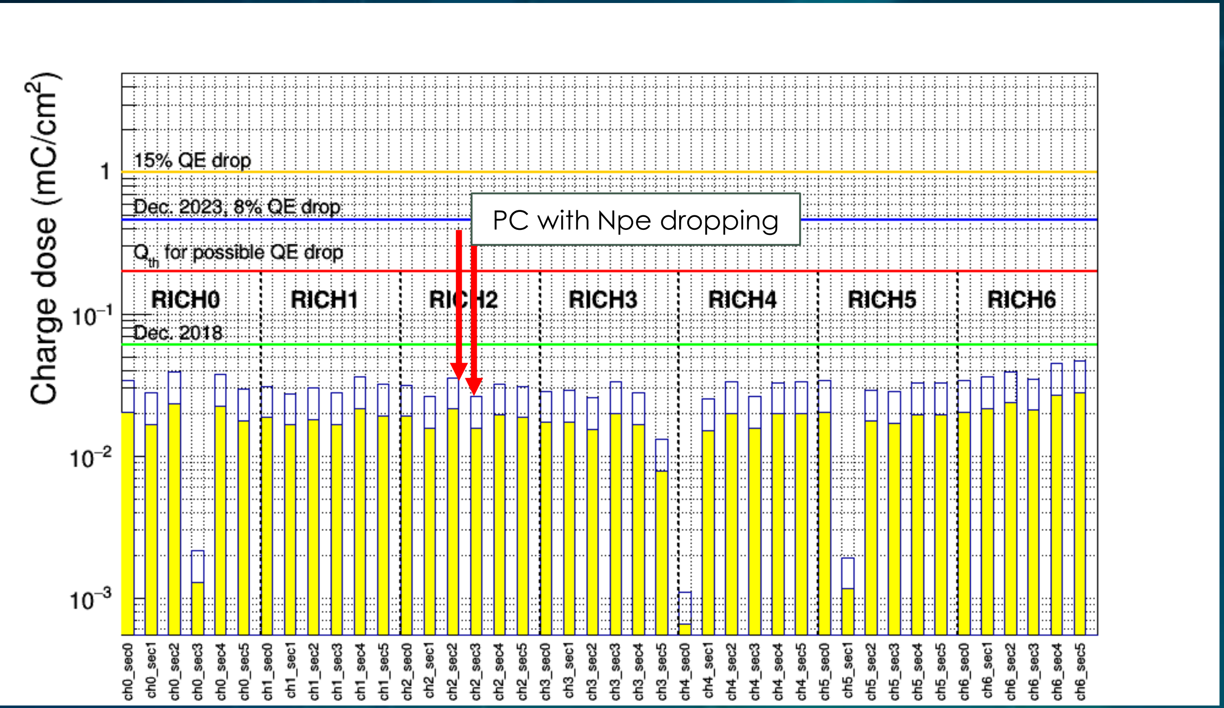


Specific charge dose vs. time



- Study of charge dose for potential CsI ageing by avalanche ions;
- During Run2, ~70 % of charge dose from pp collisions and ~30% from Pb-Pb.

Charge dose on the CsI photocathodes



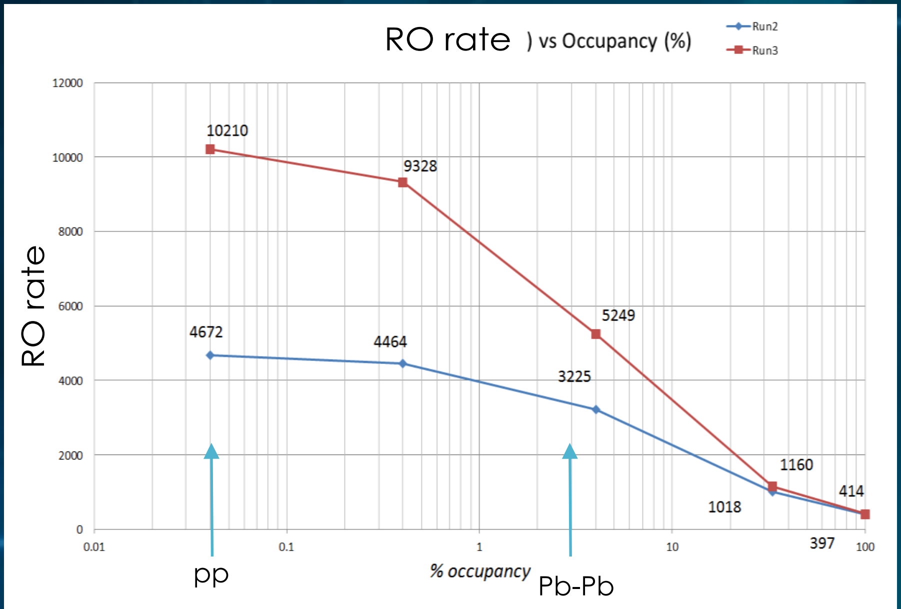
- Charge dose threshold (Qth red line) for possible CsI QE loss: 0.2 mC/cm^{2};
- Still far during Run2;

Delivered luminosity in ALICE and charge dose

	Delivered Lumi in pp	<Specific Charge dose>	Npe	CsI QE loss
2010-2013 End of Run1	15 pb^{-1}	0.013 mC/cm^2		0
2015 (Run2)	7.1 pb^{-1}	0.007		0
2016 (Run2)	~15 pb^{-1} (expec. 10/2016)	~ 0.013		0
2017 (Run2)	~15 pb^{-1}	~ 0.013		0
2018 (Run2)	~15 pb^{-1}	~ 0.013		0
End Run2		~ 0.059		0
2021-2023 HL LHC (RUN3)	450 pb^{-1}	~0.4		
End Run3		~0.46		8%

- Qth=0.4 mC/cm^2 Expected at the end of Run3 with a possible CsI QE reduction of 8%.

New trigger schema and HMPID Read-out rate



During Run3:

- Detectors with continuous read-out @ 50 KHz in Pb-Pb collisions;
- HMPID still triggered detector;
- Preliminary tests results with RO firmware Run3 compliant: 10KHz and 6 KHz respectively in pp and Pb-Pb collisions, two times higher than in Run2 (four times w.r.t. LHC Run1);
- New trigger modules, Run3 compliant, already under development.

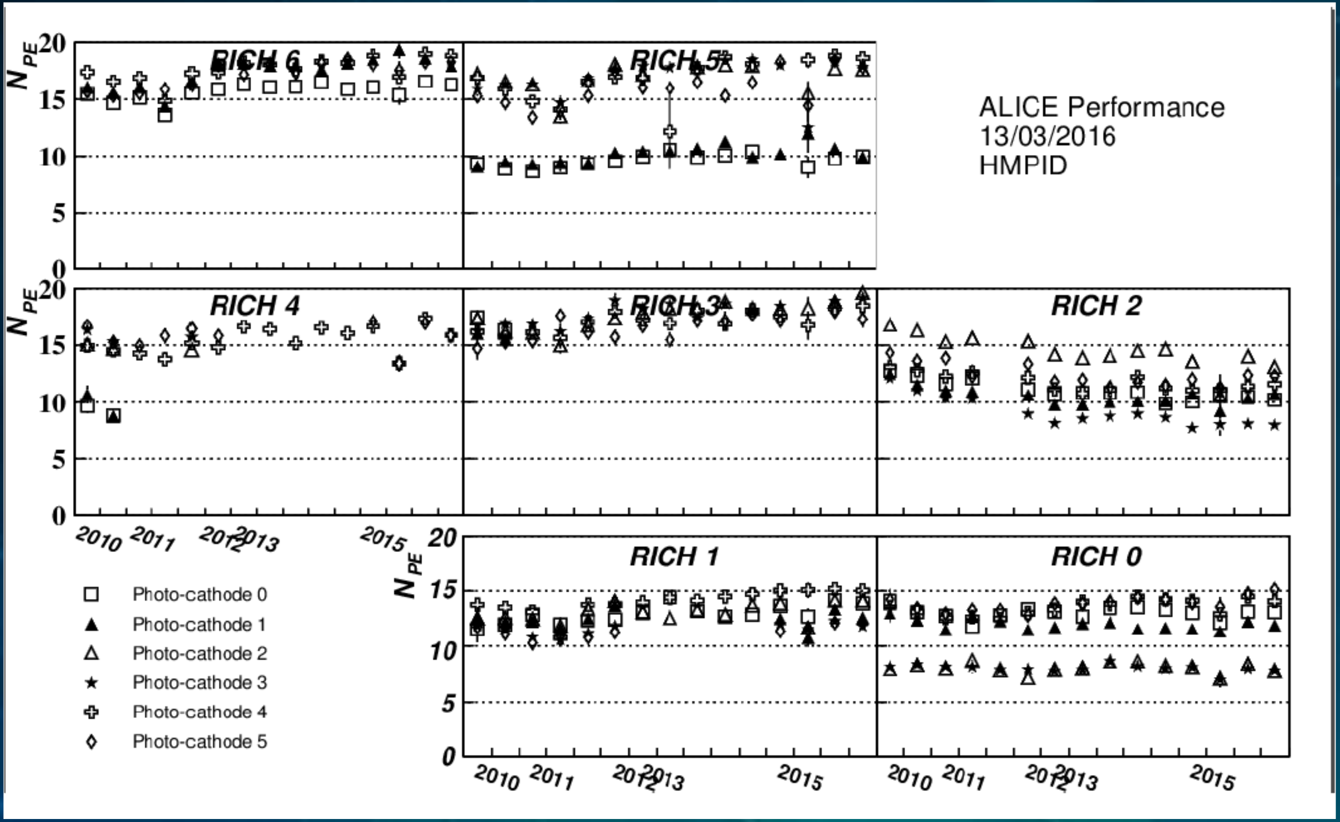
Summary

- **Detector status**: stable since LHC Run1(2010-), a small further acceptance loss 72% -> 70% in 2016 (one HV sector OFF);
- **Number of detected photoelectrons** per ring stable ($<N_{PE}>$=~14). No ageing effects of CsI photocathode observed, except evidences on the re-evaporated RICH2, PC2 and 3;
- **Specific charge dose** from ion bombardment: at the end of Run2, well below the threshold of 0.2 mC/cm^2 for possible CsI QE loss. At the end of Run3, a QE loss of 8% is expected;
- Very good preliminary results with new RO firmware:10KHz and 6 KHz in pp and Pb-Pb collisions. RO rate doubled w.r.t. Run2 (four times w.r.t. LHC Run1);

Good perspective for the HMPID operation in LH-LHC Run3!

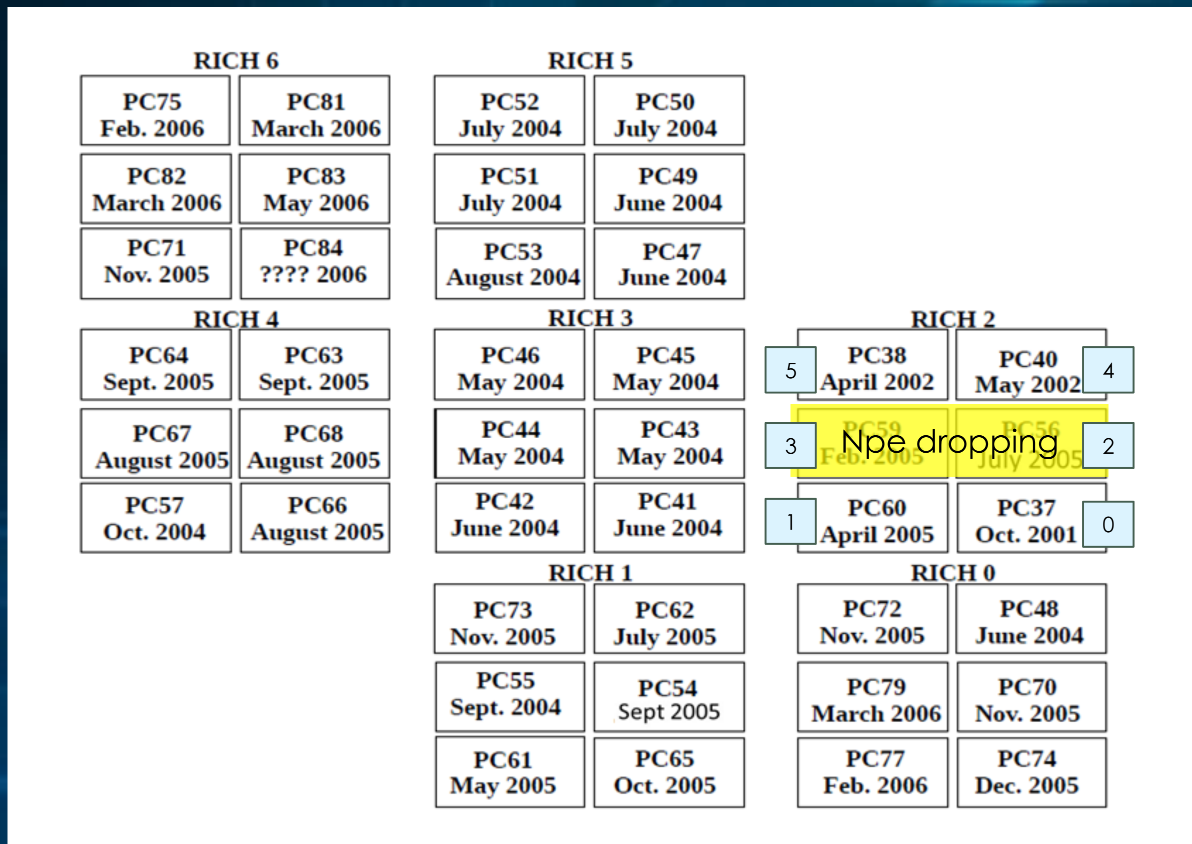
Back-up slides

N_{PE} vs. ALICE run periods



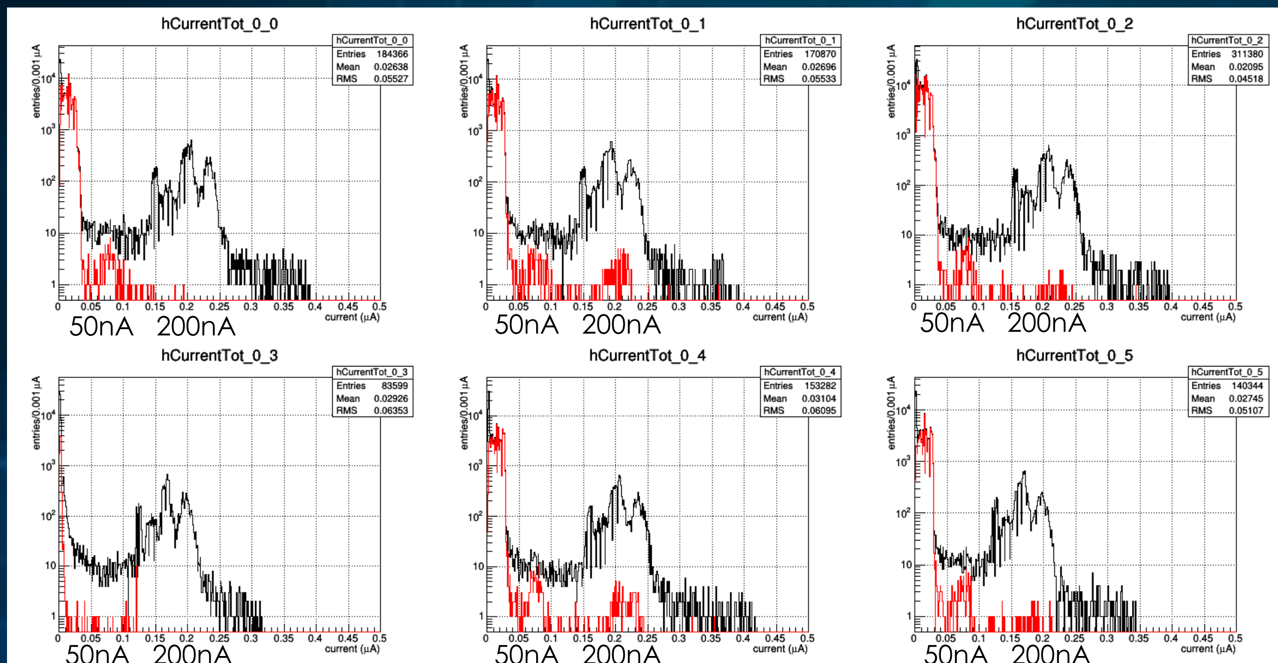
Good Npe stability inferring a CsI QE stability.
Except RICH2, PC 2 and 3, with QE drop of ~30%

Year of production of the CsI PC's



- Production date of the CsI photo-cathodes and location in the RICH modules

MWPC anodic current 2010-2016



- Black curve: MWPC anode current I_a in the six HV sectors of the RICH0 during 2010-2016;
- Black curve double peak: I_a distribution during HV setting between STANDBY -> BEAM TUNING and BEAM TUNING -> READY (charging of cables and capacitors);
- Red curve: I_a with HV sectors at the nominal value of 2050 V during collisions.