



LONG TERM STABILITY AND PERSPECTIVE OF THE ALICE-HMPID DETECTOR AT LHC DURING RUN 3

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OUTLINE

- ▶ ALICE-HMPID description
- ▶ HMPID readiness for the LHC Run 3 period (2022-2025)
- ▶ Short review on physics objectives in Run 3
- ▶ Summary



HMPID: HIGH MOMENTUM PARTICLE IDENTIFICATION DETECTOR

7 RICH modules $\sim 1.3 \times 1.3 \text{ m}^2$ for a total
CsI active area of $\sim 11 \text{ m}^2$;
Proximity-focusing RICH;

PID range:

$1 < p < 3 \text{ GeV}/c$ π, K ;
 $1.5 < p < 5 \text{ GeV}/c$ p ;

Participating Institutions:

INFN and Dep. Of Physics, Bari (Italy);

CERN Geneva (Switzerland);

Wigner Research Institute Budapest
(Hungary);

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Institute of Engineering and Transport
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HMPID basic elements

Cherenkov Radiator

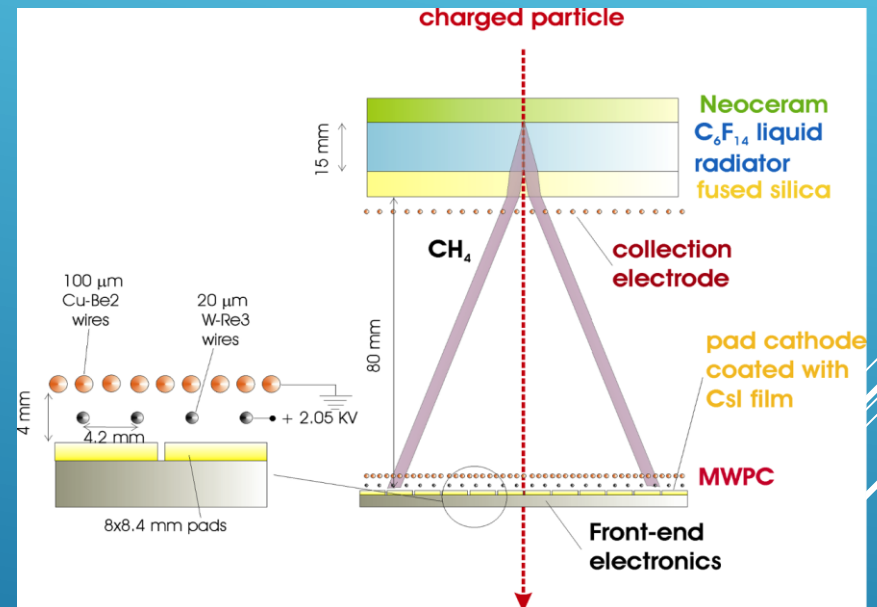
- 15 mm liquid C_6F_{14} ; $n=1.2989$ @ 175 nm;
 $\beta_{th} = 0.77$.

Photon converter:

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

Photoelectron detector:

- MWPC 2,2-2.5 mm asymmetric gap with CH_4 at atmospheric pressure, gas gain $\approx 4 \cdot 10^4$;
- analogue pad read-out (pad size = $8 \times 8.4 \text{ mm}^2$),
- total number of channels $\approx 160 \text{ K}$.



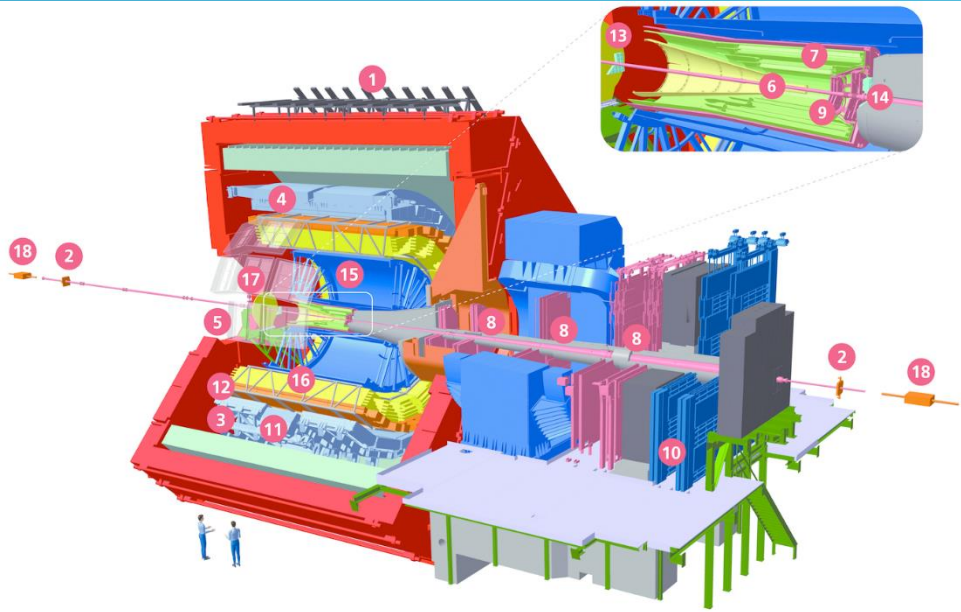


ALICE-HMPID

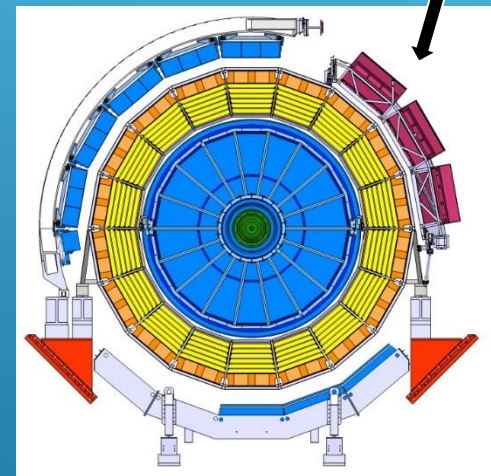


ALICE:
A
Large
Ion
Collider
Experiment

HMPID



- 1 ACORDE | ALICE Cosmic Rays Detector
- 2 AD | ALICE Diffractive Detector
- 3 DCal | Di-jet Calorimeter
- 4 EMCal | Electromagnetic Calorimeter
- 5 HMPID | High Momentum Particle Identification Detector
- 6 ITS-IB | Inner Tracking System - Inner Barrel
- 7 ITS-OB | Inner Tracking System - Outer Barrel
- 8 MCH | Muon Tracking Chambers
- 9 MFT | Muon Forward Tracker
- 10 MID | Muon Identifier
- 11 PHOS / CPV | Photon Spectrometer
- 12 TOF | Time Of Flight
- 13 T0+A | Tzero + A
- 14 T0+C | Tzero + C
- 15 TPC | Time Projection Chamber
- 16 TRD | Transition Radiation Detector
- 17 V0+ | Vzero + Detector
- 18 ZDC | Zero Degree Calorimeter



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.

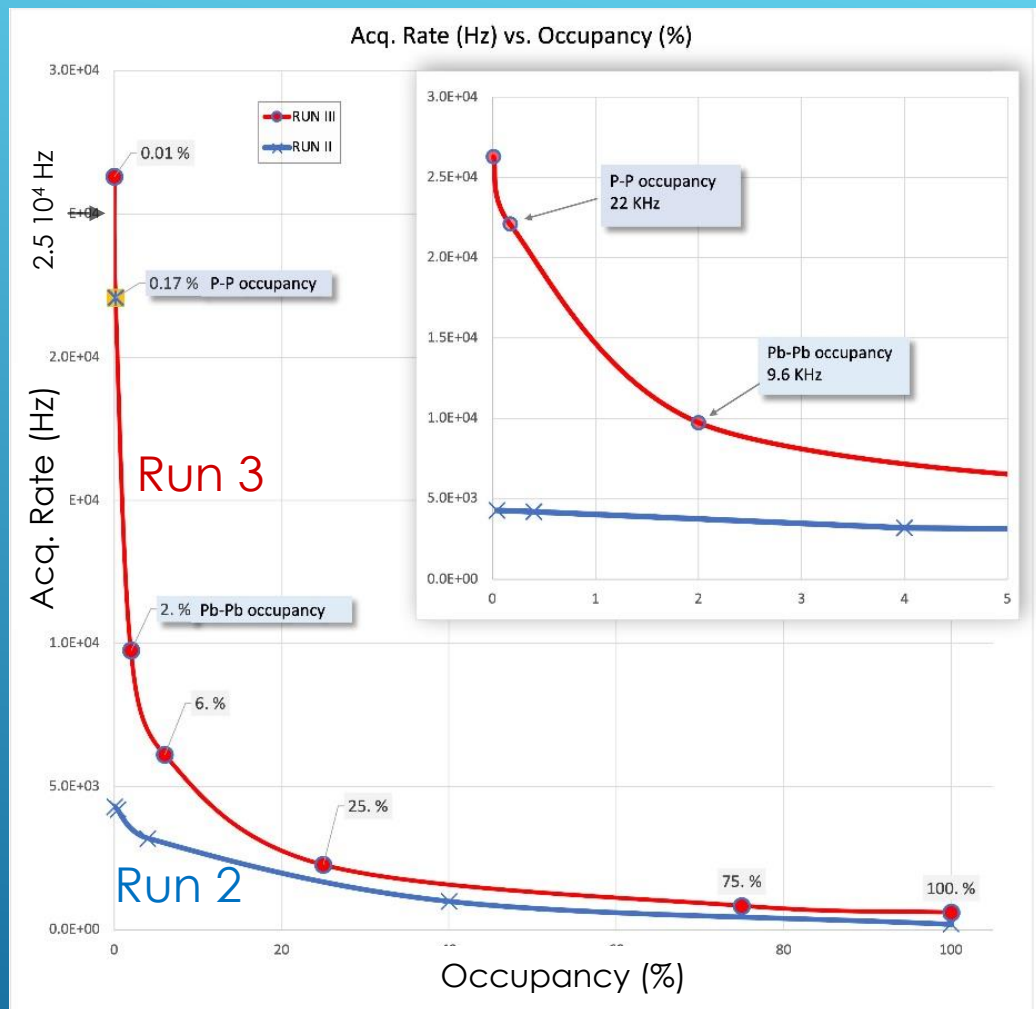


HMPID readiness for the LHC RUN 3 period (2022-2025)

- Upgrading and performance of the HMPID RO electronics;
- The Charge dose on the CsI photocathodes ;
- C_6F_{14} radiator vessels and HV sectors at beginning of LHC Run 3;
- The Landau distributions of MIP's during the LHC proton fill 7920 of July 2022;
- C_6F_{14} transparency.
- Integration in the O2 (Online-Offline) computing system;

Readout rate vs. occupancy

- The new RO firmware, the QC and DCS tools are the key components of the excellent performance of the event readout rate;
- These components allow effective and rapid detector configuration and calibration.





QC AND DCS TOOLS COMPONENTS

The screenshot displays the ALICE DCS monitoring interface. At the top, the status bar shows 'ALICE STATE: COSMICS / NO SAFE' and 'PROTON PHYSICS NO BEAM'. The main area is divided into sections for 'MONITO', 'LIQUID', and 'OLD UI'. A large table shows the status of various detector components (Eqi:0 to Eqi:13) across 24 channels. Below this, there are 'SAVE' and 'LOAD' buttons. On the right, a 'COMMIT' list shows various commit numbers (0-13) with their corresponding hex values. A 'SETUP' panel is also visible, showing a list of selected components and their enabled status. At the bottom, there are 'REQUEST' and 'RESULT' fields, and a 'PED/THR MAPS' button.

Some of QC and DCS components for the detector monitoring and calibration

Detector status 2022

Leaking radiator vessels

YP 2004		YP 2003		Year of production YP				
RICH6 Rad1: YP 2003 AUGUST 2006		YP 2003			2002	2003	2004	2005
YP 2004		YP 2003		N° radiators	1	10	5	5
YP 2003		YP 2003		YP 2004				
RICH4 Rad1: YP 2002 JUNE 2012		YP 2003		YP 2005				
RICH4 Rad0: YP 2003 OCTOBER 2010		RICH3 Rad0: YP 2003 JUNE 2010		YP 2005				
M6R1 : leaking 2006	YP 2004	YP 2004		YP 2005 R2				
M3R0 : leaking 2010	YP 2003	YP 2003		YP 2005 R1				
M4R0 : leaking 2010	YP 2004	YP 2004		YP 2005 R0				
M4R1 : leaking 2012								

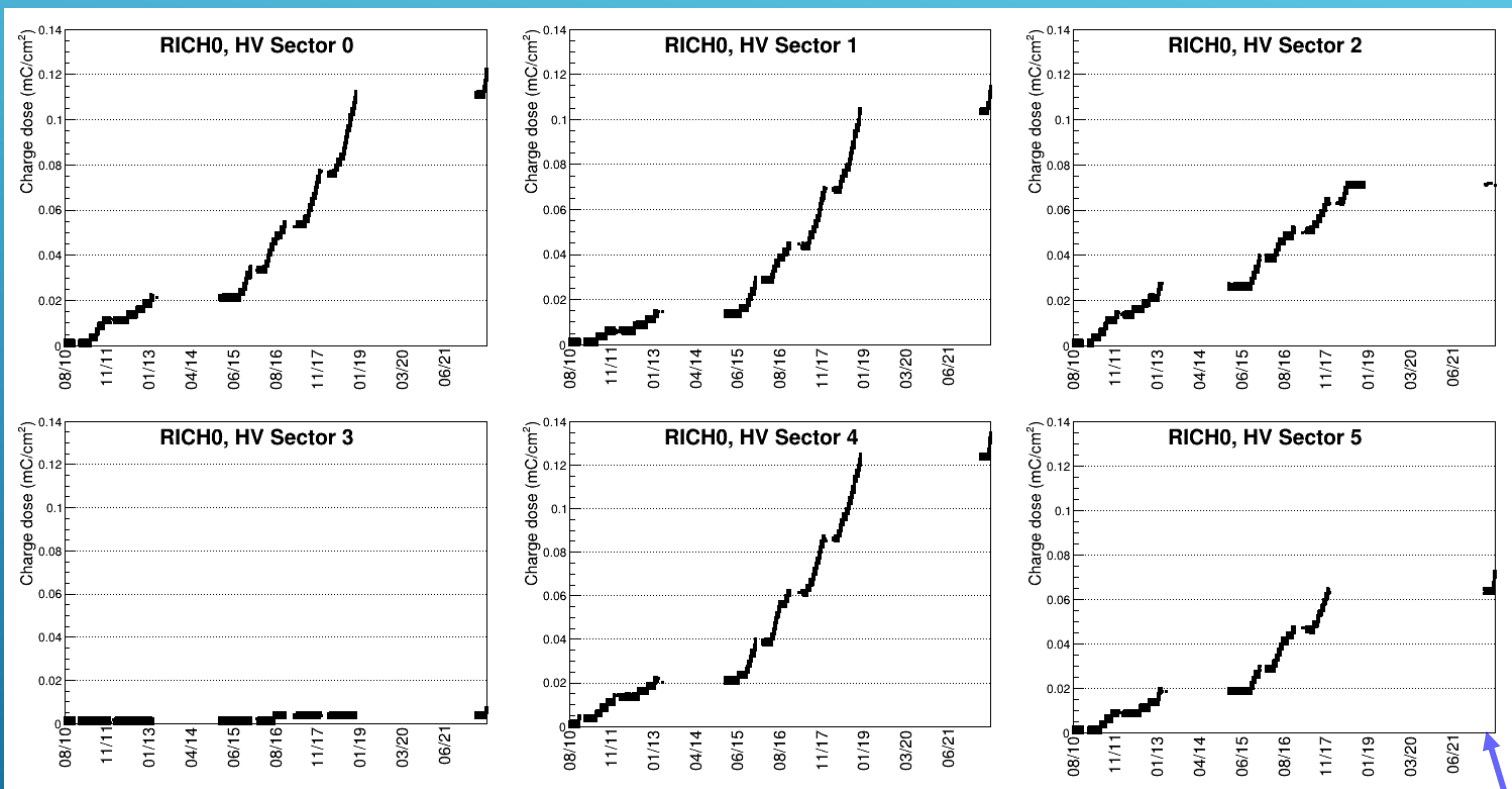
HV failing sector

M6, M5, M4, M3, M2, M1, M0

M5HV1 : failing 2006
M4HV0 : failing 2009
M0HV3 : failing 2009
M1HV1 : failing 2016
M5HV4 : failing 2022
M0HV2 : failing 2022

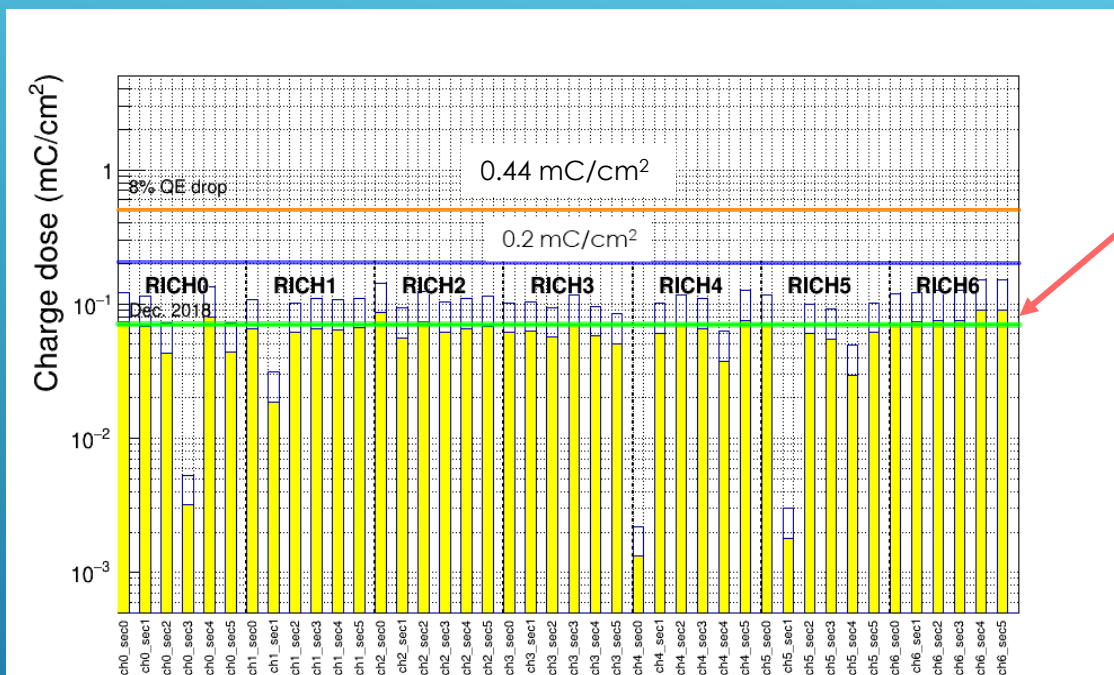
Faulty sub-system segments:
Combining leaking vessels and failing HV sectors, the detector acceptance is ~ 65%

Specific charge dose vs. time



2022
10

Specific Charge dose on the CsI photocathodes



Since RUN1, Expected CsI charge dose at the end of RUN 2.

- Full yellow bars: measured CsI charge dose end of RUN 2 ; Empty bars: total anode charge.
- **Bleu line:** dose limit for possible CsI QE loss: 0.2 mC/cm²; [NIM A553 (2015), NIM A574(2007)]
- **Orange line:** 0.44 mC/cm² Expected charge dose end RUN 3. Possible CsI QE loss of 8%.



The specific Csl charge dose vs. LHC program

Specific Csl charge dose RUN 1-2

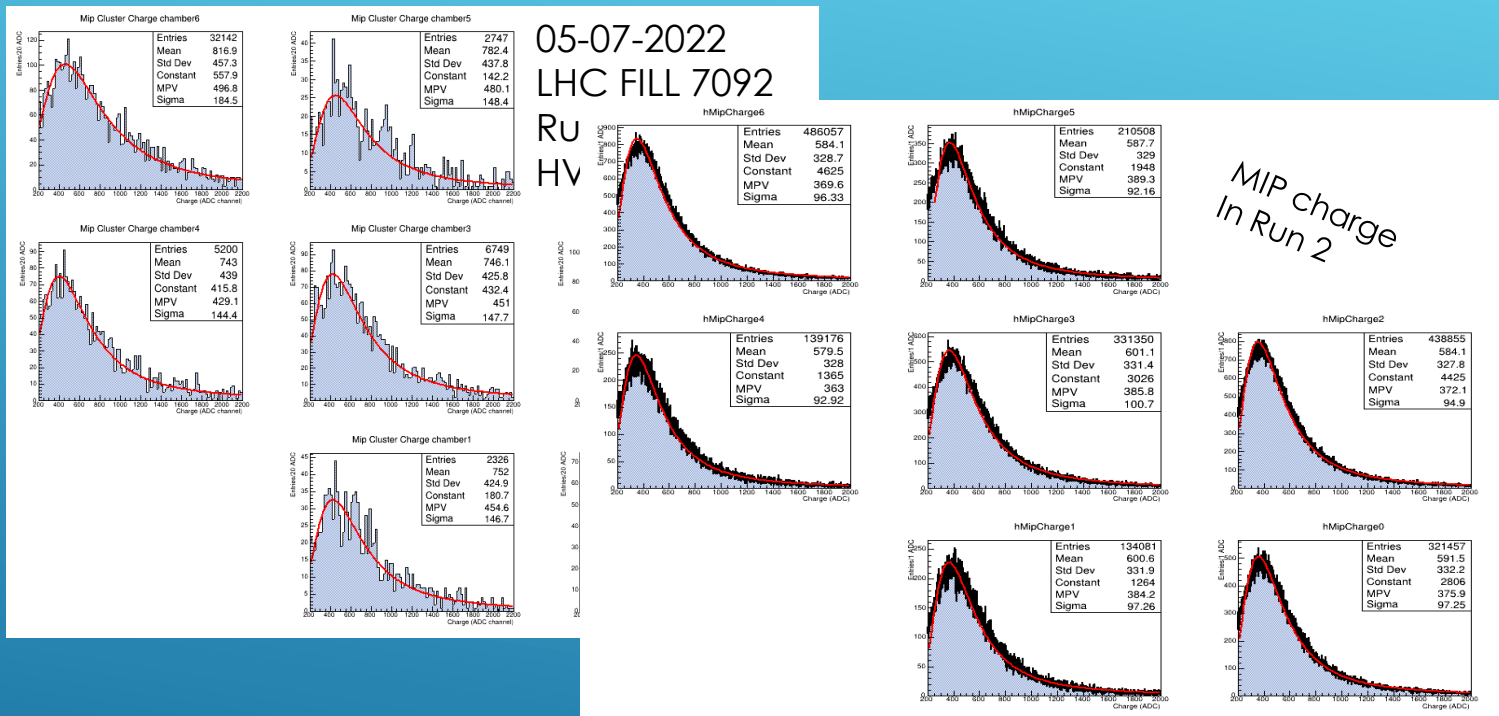
	Delivered Lumi	Measured <Specific Charge dose> mC/cm ²	Measured <Total charge doose> mC/cm ²	Expected Csl QE loss %
2010-2013 End of Run1	pp+Pb-Pb	0.002		0
2015 (Run2)	(pp) 7 pb ⁻¹ (Pb-Pb) 0.43 nb ⁻¹	0.01 ~0.005	0.017	0
2016 (Run2)	(pp) 13 pb ⁻¹ (p-Pb) 43 nb ⁻¹	0.015 0.005	0.037	0
2017 (Run2)	(pp) 18.9 pb ⁻¹ (Xe-Xe) 0.16 nb ⁻¹	0.025 0.001	0.053	0
2018 (Run2)	(pp) 27 pb ⁻¹ (Pb-Pb) 0.9 nb ⁻¹	0.036 0.01	0.089 0.099	0
End Run2			~0.1	0

Expected Csl charge dose RUN 3

	Delivered Lumi	Measured <Specific Charge dose> mC/cm ²	Measured <Total charge doose> mC/cm ²	Expected Csl QE loss %
End Run2			0.1	0
2022 (Run 3)	(pp) 40 pb ⁻¹ (Pb-Pb) 3 nb ⁻¹	0.054 0.034	0.188	
2023 (Run 3)	(pp) 40 pb ⁻¹ (Pb-Pb ??) 3 nb⁻¹	0.054 0.034	0.276	5
2024 (Run 3)	(pp) 40 pb ⁻¹ (Pb-Pb ?) 3 nb ⁻¹	0.054 0.034	0.364	6
2025 (Run 3)	(pp) 40 pb ⁻¹ (Pb-Pb) 3 nb ⁻¹	0.054 0.034	0.452	8
End Run3			~0.452	

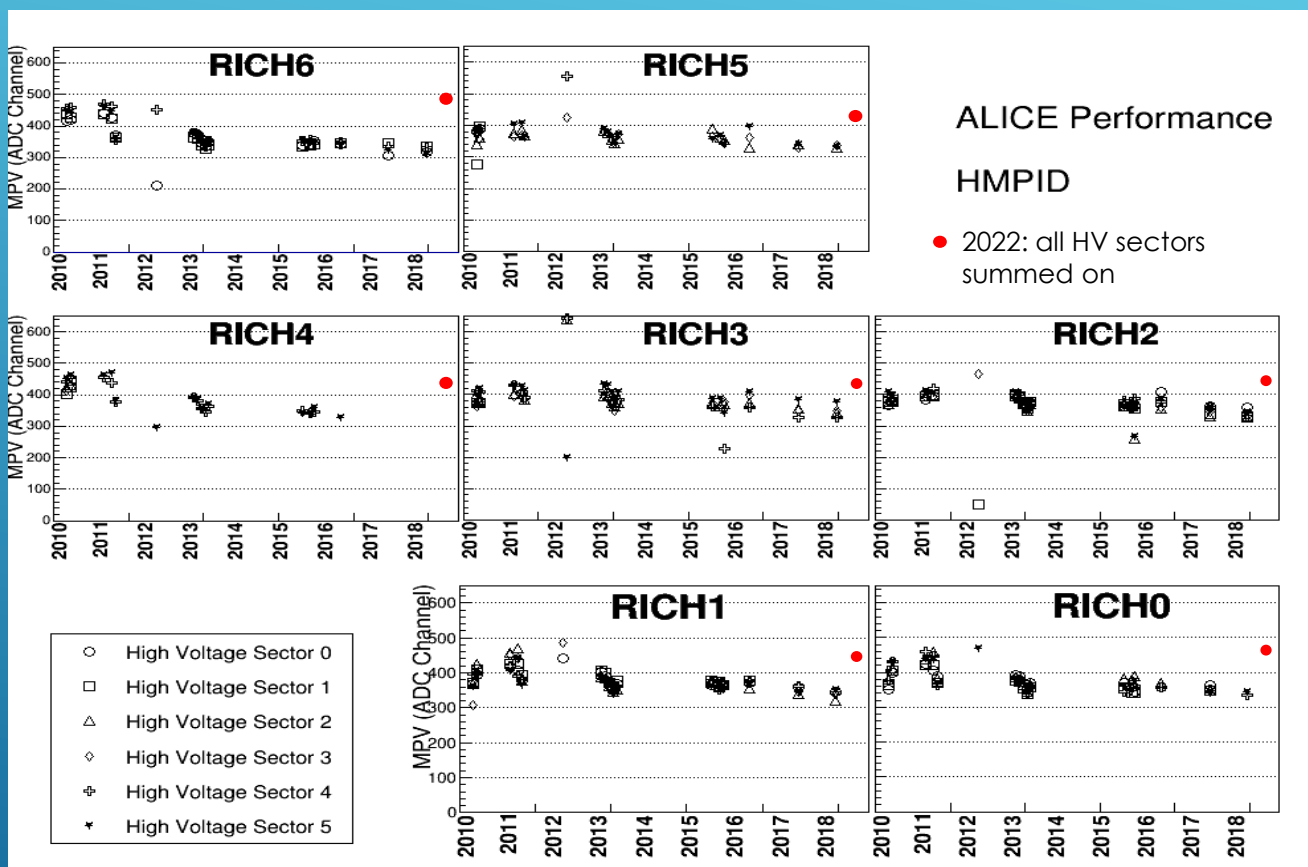


LHC RUN 3 FILL: MWPC'S LANDAU DISTRIBUTIONS!

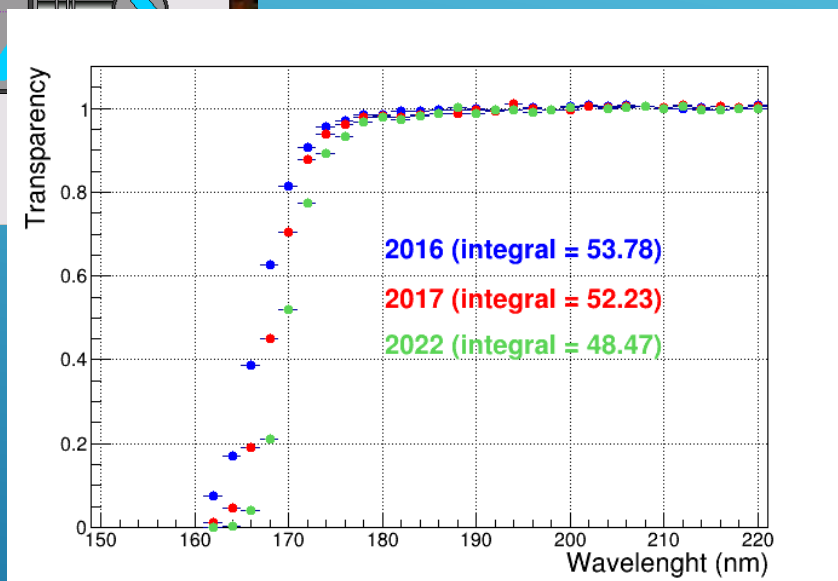
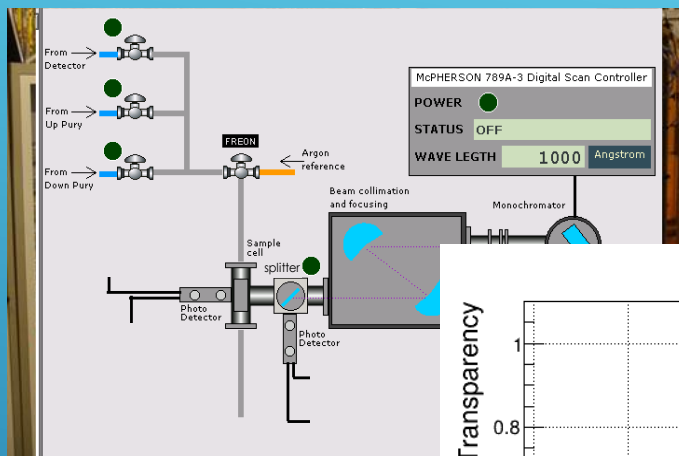


- MPV systematic higher value w.r.t. Run1-2: The selection criteria of MIP is not yet based on TPC tracks;
- The actual result is a successful check of the readout and data analysis chains.

LANDAU MPV VS. TIME



C₆F₁₄ TRANSPARENCY MONITORING



We expect the C₆F₁₄ transparency to improve with further re-circulation through the H₂O molecular severs, around the water absorber peak of 165 nm.



ECS integration and Grafana monitoring



The image displays two browser windows. The top window shows the ECS 'Environment details' for a 'Readout' environment. It lists several components and their data rates: StfBuilder (111 MB/s), StfSender (111 MB/s), TFBuilder (110 MB/s), DPL in (109 MB/s), CTF Writer (110 MB/s), and CTF Writer (16.3 MB/s). The 'Run Number' is 524240. The 'Detectors' section lists 'HMP' with a count of 2, which is circled in blue. A list of parameters is visible below.

The bottom window shows a Grafana dashboard for 'Readout'. It displays the 'Run All' status for run number 524240, with a total readout data volume of 166 GB and a current data rate of 62.8 MB/s. The dashboard includes several time-series plots: 'Readout data since SOR', 'Readout data rate since SOR', and 'Global readout rate'. The plots show data starting around 12:00 and continuing to 12:30.



Short review on physics objectives in Run 3

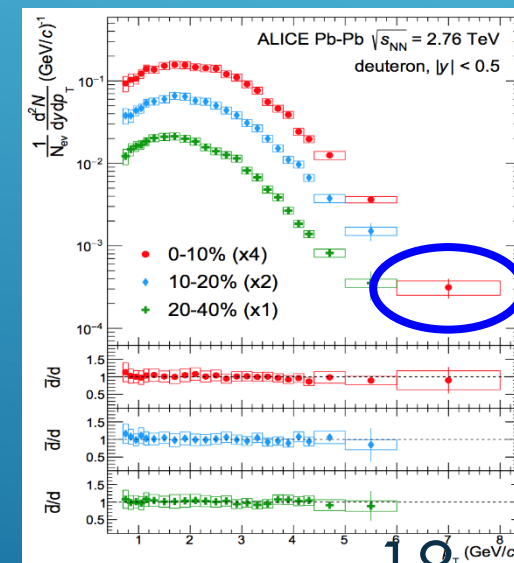
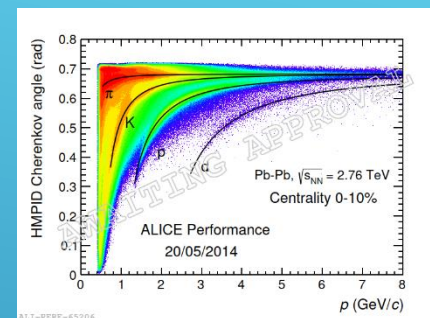
LIGHT NUCLEI DETECTION

▶ pp collisions

- ▶ In Run 3, $\sim 10^{10}$ events are expected in the HMPID acceptance,
- ▶ the **8 GeV/c** momentum bin for the **deuteron** can be filled in. This spectrum extension is of interest for the example in the quest of establishing the composition of the X(3872) particle;

▶ Pb-Pb collisions

- ▶ In Run 1 (2010-2013), HMPID filled in the **8 GeV/c** momentum bin for deuteron in 0-10% centrality interval (figure on the right);
- ▶ The data analysis of the 2018 Pb-Pb data is not yet done. With its statistical abundance we expect to fill in the deuteron momentum bin at **10 GeV/c** (0-10% centrality);
- ▶ In 2022, (with $B=0.2$ T) we expect also the **12 GeV/c** bin can be filled in. Contribution in other centralities, possible;
- ▶ Triton and ^3He spectra up to 7 GeV/c using central collisions can also be measured. Cross-check with TPC-TOF measurement to be done.

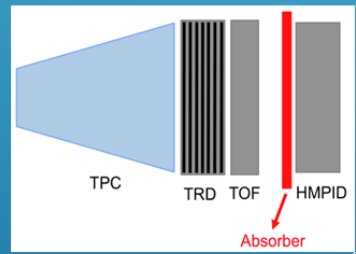


18

INELASTIC CROSS SECTION FOR ANTI-DEUTERONS

- ▶ Interesting for cosmic anti nuclei, multi-baryon state production...

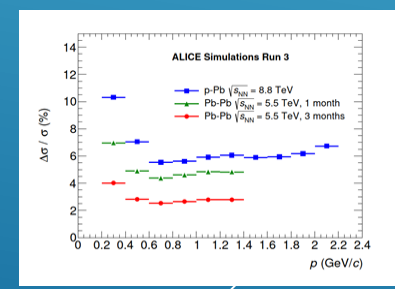
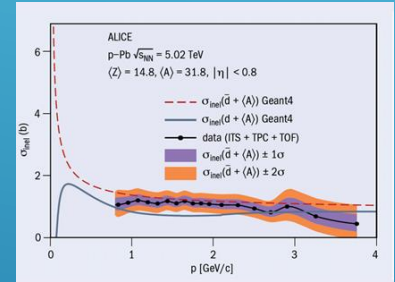
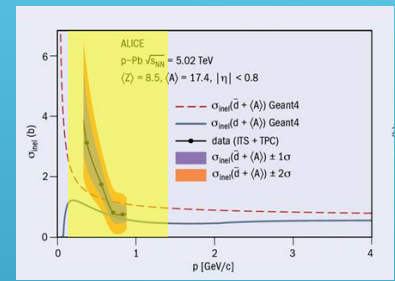
$$N = N_0 \times e^{-\frac{\Delta x}{\lambda_i}} \quad \text{with} \quad \lambda_i = \frac{A}{\rho N_A \sigma_h}$$



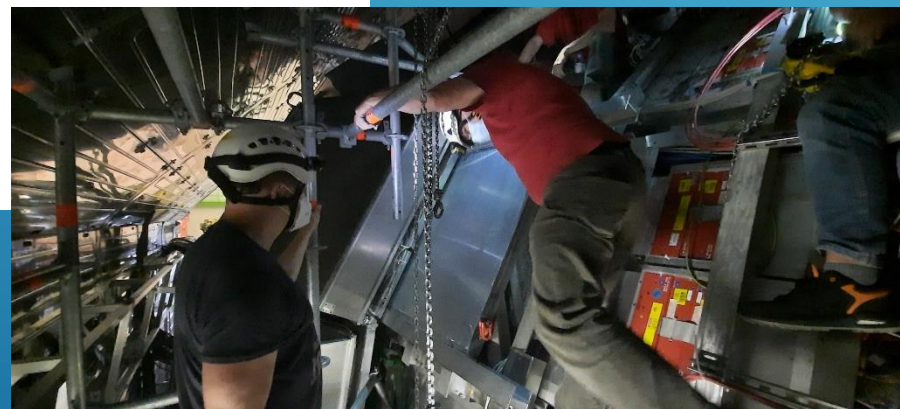
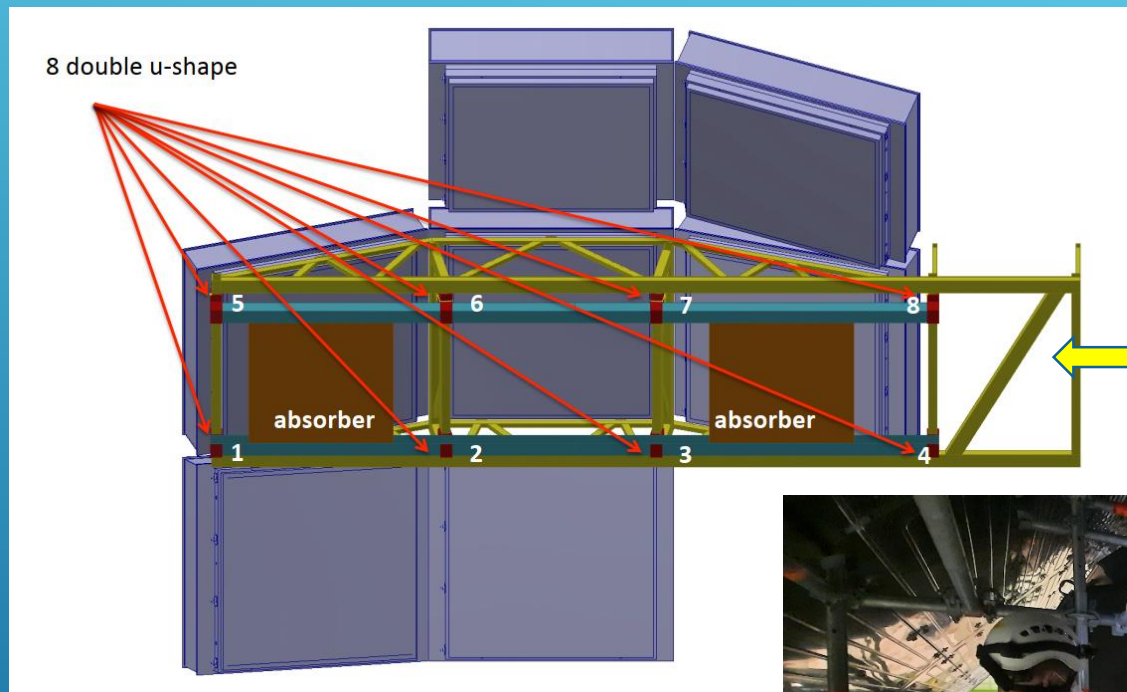
e.g.: 8 cm thick aluminium slab ($0.5 \lambda_i$)

$$N_A^{HMPID} = (N_{A, \text{present}}^{TPC} \times 0.05 \times f) \times \epsilon \times 10 \text{ (new acq.rate)}$$

- ▶ expected statistical precision 2-4% in the momentum interval $0.2 < p < 1.4$ GeV/c for Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5$ TeV (Run 3)
- ▶ A systematic uncertainties of 5.5% is expected based on conservative estimate (<https://alice-notes.web.cern.ch/node/1015>);



May 2021: installation of the absorbers





SUMMARY

- ▶ HMPID readout rate @20 KHz in pp collisions and 9 KHz in Pb-Pb, 10 times higher the rate limited by the triggered TPC in Run 1 and 2.
- ▶ Detector compliant with the new Online and Offline ALICE data taking and analysis environment (O2). Now the TPC is on continuous RO!!
- ▶ First Landau distributions for MIP's successfully measured in July 2022 in the LHC fill 7092, ALICE RUN#520145;
- ▶ The physics objectives in Run 3, were also mentioned.



AFTER RUN 1 AND RUN 2,
NOW SAILING IN RUN 3!!



Motto of Italian training ship
"Amerigo Vespucci"

Motto: A word or phrase chosen as
a symbol of beliefs or ideals guiding
an individual, family, or institution



Thank you for your attention!!



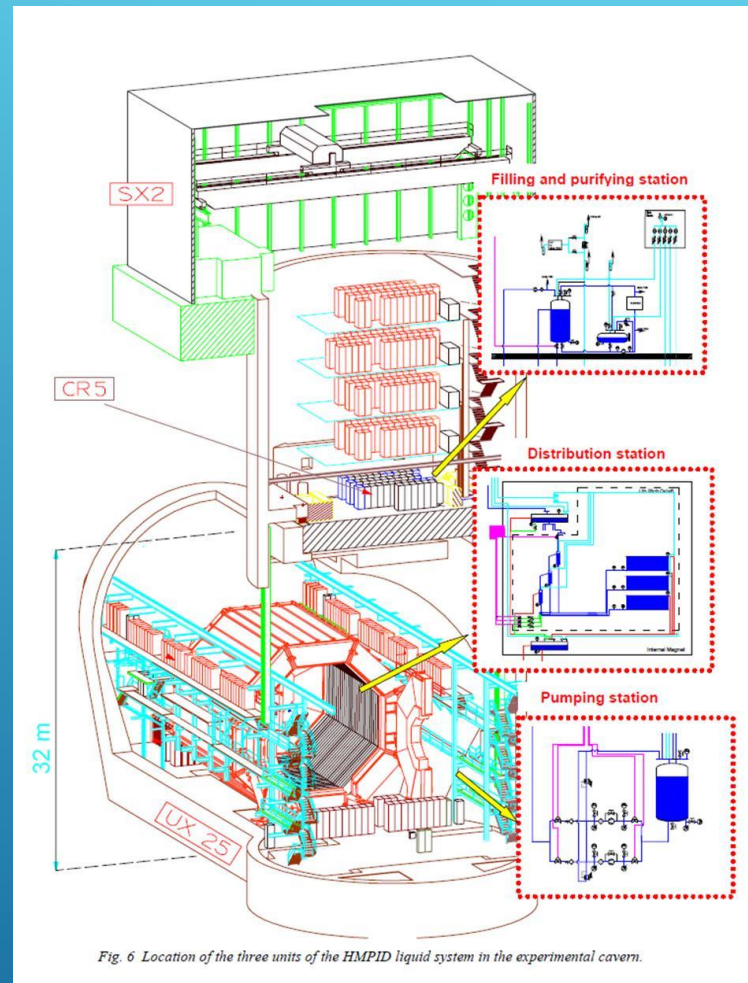
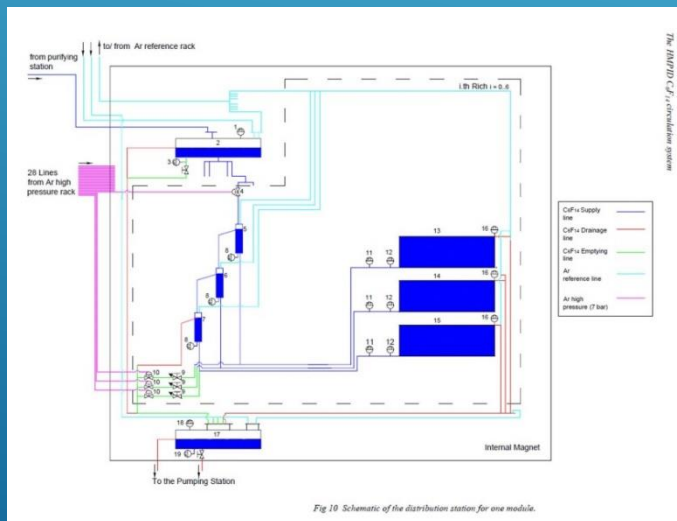
CE



BACKUP SLIDES

C₆F₁₄ CIRCULATION AND PURIFYING SYSTEMS

- C₆F₁₄ : 3M PF5060DL;
- Safe C₆F₁₄ circulation by gravity flow;
- Separated control for each radiator vessel;



ESTABLISHING THE COMPOSITION OF THE X(3872) PARTICLE

