Preparing the ALICE-HMPID for the High-Luminosity LHC period 2021-2023

L-Università ta' Malta

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HMPID Detector

- The ALICE High Momentum Particle Identification Detector (HMPID) performs charged particle track-by-track identification by measuring the emission angle of Cherenkov photons, in conjunction with the momentum measured by the ALICE tracking detectors (ITS and TPC). The HMPID enhances the PID capability of ALICE and it has been designed to extend the useful range for the identification on a track-by-track basis of π and K up to 3 GeV/c, and of p up to 5 GeV/c.
- The HMPID consists of 7 identical proximity focusing RICH counters, split into left and right photocathodes, for a total photosensitive area of 10.7 m^2 of CsI (Fig. 1).
- **Radiator:** 15 mm liquid C_6F_{14}, **Photon Converter:** Reflective layer of CsI with QE ~25%, **Photoelectron Detector:** MWPC with CH_4 at atmospheric pressure and HV = 2050 V, with analogue pad readout.

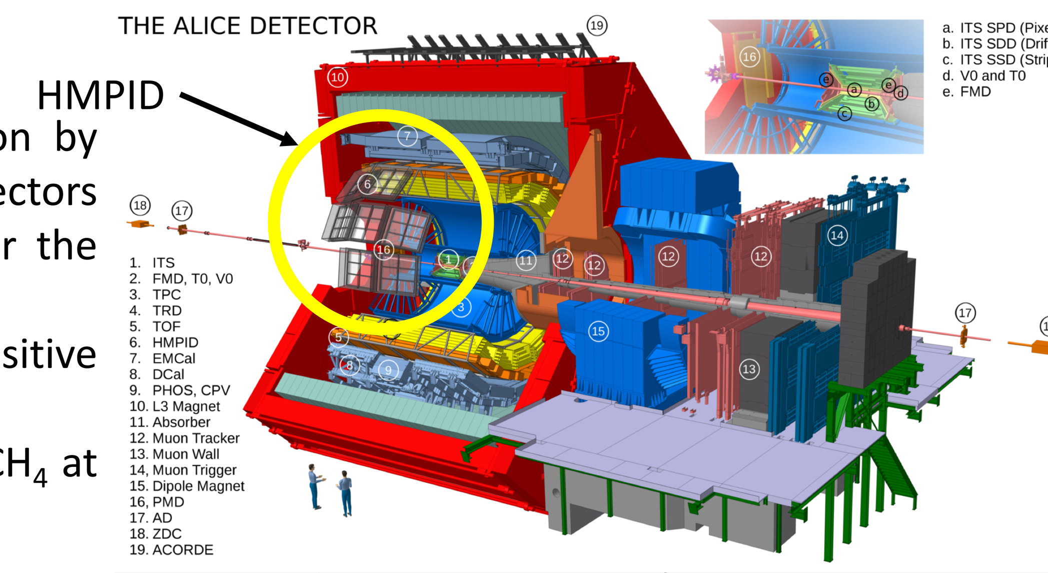
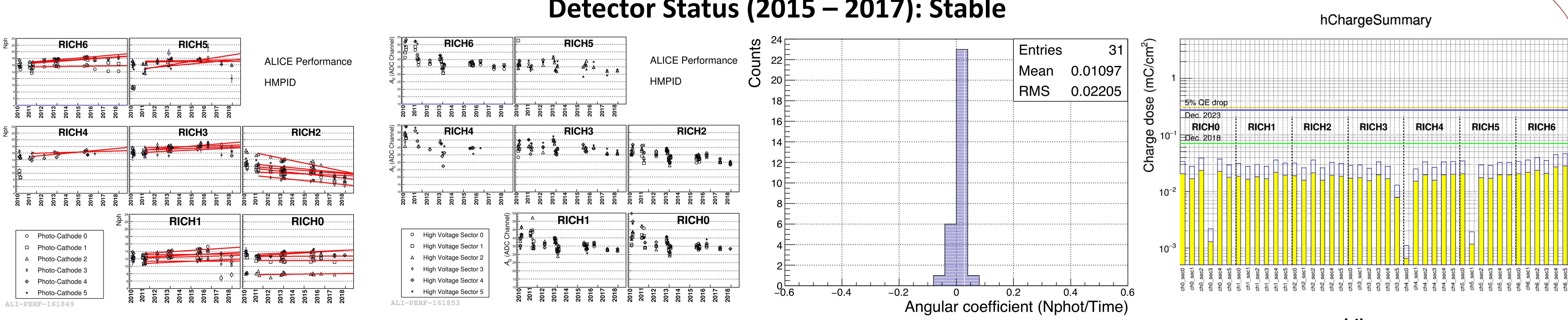


Figure 1: HMPID within ALICE

Detector Status (2015 – 2017): Stable

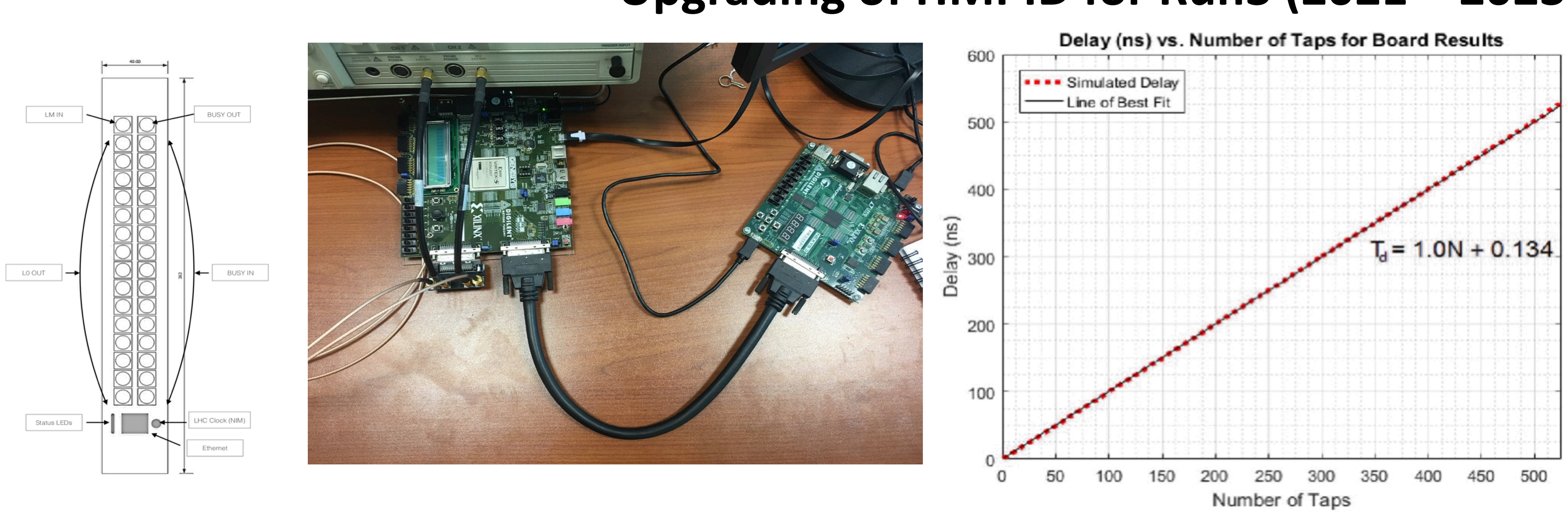


(a) (b) (c) (d)

Figure 2: (a) Average number of reconstructed photons per Cherenkov pattern (Nph) vs time (year) **(b)** MPWC gas gain (A0) vs time (year) **(c)** Distribution of Angular coefficient of linear fit of Nph **(d)** Charge dose on CsI photocathodes per HV Sector

- Failing HV Sectors and leaking C_6F_{14} radiator vessels have been excluded resulting in a reduced detector acceptance of 70%.
- In Fig. 2 (a) stable number of reconstructed photons (Nph) per Cherenkov pattern can be observed. Nph and gas-gain (Fig. 2 (b)) reduction in RICH2 is now under investigation.
- The almost symmetric distribution of the angular coefficient (gradients) (Fig. 2 (c)) of the linear fit of Nph is still compatible with a stable CsI QE, in the period 2010 – 2018. The slight asymmetry comes from the contribution of RICH2 where 2 photocathodes were re-evaporated in 2005.
- O_2 and H_2O levels in CsI layer were measured at ~10 ppm which is well within safety margin.
- Charge Dose plot of CsI induced by bombardments of CH_4 ion avalanches per high voltage sector (Fig. 2 (c)) shows that the charge density expected for 2018 leaves a sufficient margin to maintain a stable QE until the end of Run3 (2023).

Upgrading of HMPID for Run3 (2021 – 2023): In progress and on track



(a) (b) (c)

Figure 3: (a) Schematic of the Fan-In/Fan-Out module **(b)** prototype testbench **(c)** results showing linear delay-control response

Trigger Fan-in/Fan-Out Module

- A new Fan-In/Fan-Out module is being developed to **receive** Level-0 trigger, **delay** it, and **distribute** it to the 14 readout control boards (2 per RICH module).
- Remote-control and monitoring of the module
- In addition, the new module also receives 14 BUSY signals and ORs them into 1 BUSY for handling by the CTP.
- Preliminary prototypes have been tested in Malta and at CERN.

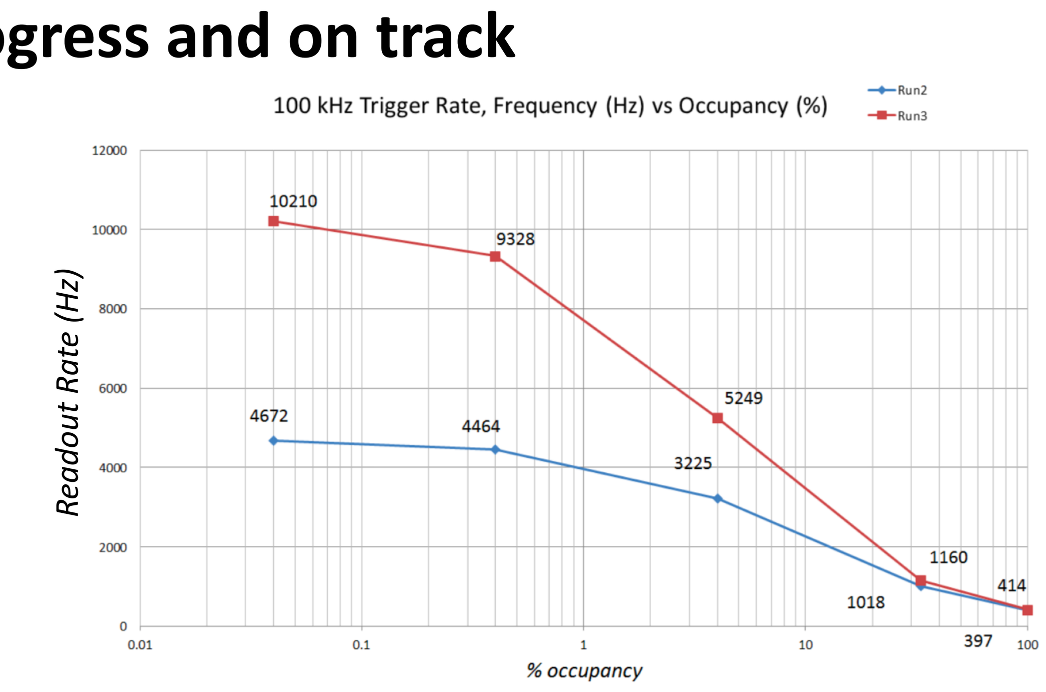
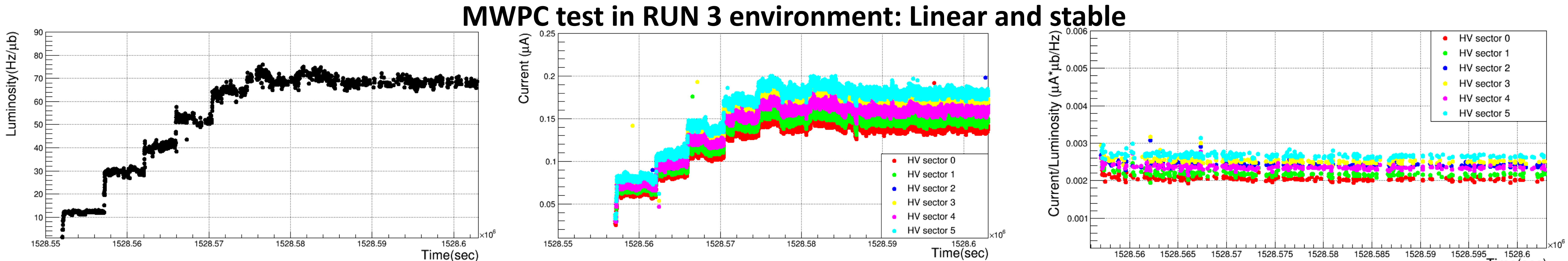


Figure 4: Readout rate vs the percentage occupancy in detector

ReadOut Firmware

- A new firmware is required for RUN3 operation.
- A prototype firmware has been developed that removes the dependency on L1 and L2 triggers.
- Firmware for each RICH half-module is remotely programmable, with an EtherBlaster used to upload firmware remotely via Ethernet.
- Preliminary tests of the firmware show that at an occupancy of 0.3%, the event readout rate was **doubled** from 4.5 kHz (Fig. 4 blue) to 9.3 kHz (Fig. 4 red).

MWPC test in RUN 3 environment: Linear and stable



(a) (b) (c)

Figure 5: (a) Instantaneous Luminosity vs time **(b)** Anode Current in RICH5 vs time **(c)** Current/Luminosity ratio vs time

- A luminosity of 70 Hz/μb (Fig. 5 (a)) in ALICE in pp collisions produces a track-load equivalent to 50 kHz in Pb-Pb collisions expected during Run3.
- Fig. 5 (b) shows that the anode currents in RICH5 increases linearly with charged particle rate (luminosity).
- In Fig. 5 (c) it can be seen that linearity and its stability is preserved along the test up to 70 Hz/μb with no gas gain saturation or space/charge effects.
- The same behavior was observed for all 7 RICH modules.

Perspectives of HMPID Operation in Run3 (2020 – 2023): Ready to GO!

The stability of the number of photons per Cherenkov pattern, the charge dose on the CsI photocathodes per HV Sectors, and the MWPC linearity make us confident that HMPID is ready for Run3 operations (2020 – 2023) at the High-Luminosity LHC at CERN.

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