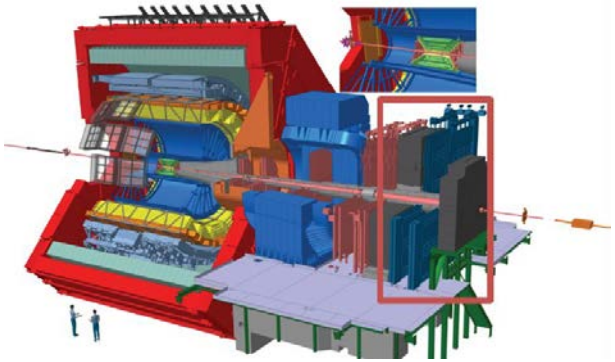
ALICE Muon IDentifier (MID) Status and Plans

- ***New Resistive Plate Chamber (RPC) detectors***
- ***New Front-End Electronics for the RPCs (FEERIC project)***
- ***Wireless FEERIC threshold distribution***
- ***Readout Electronics***

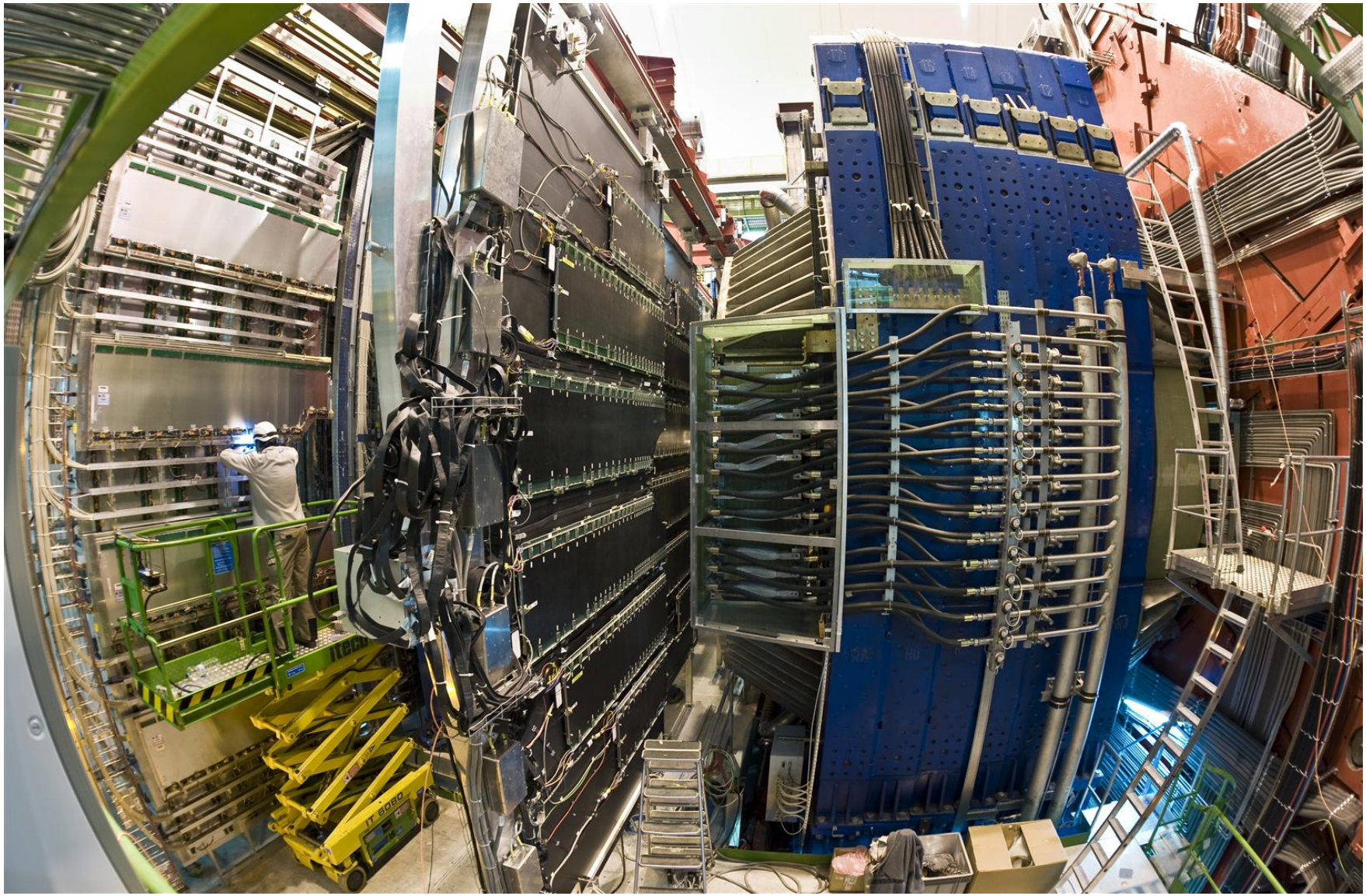
The ALICE Muon Identifier (MID) for LHC run3-4

- ***Motivations***
  - **P**recision measurements of the QGP properties during LHC run3-4
  - **LoI for the ALICE Upgrade,** CERN-LHCC-2012-012, http://cds.cern.ch/record/1475243



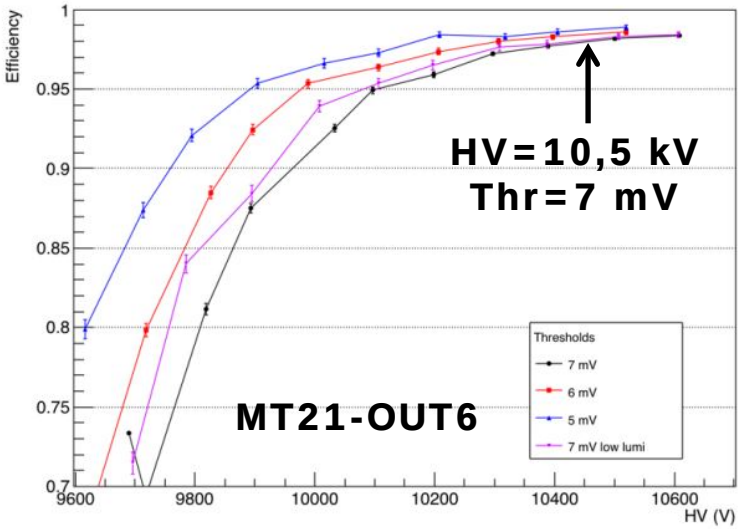
- ***Conditions***
  - High interaction rate after run2: 50 kHz in Pb-Pb
  - To be compared to ~10 kHz peak during LHC run2
- ***Strategy***
  - Hardware triggers not very selective in HI
    - ⇒ readout all Min-Bias and/or continuous readout
    - ⇒ online reduction (O^2 project)
  - Large statistics : Pb-Pb at $\sqrt{s}$=5.5 TeV, L_{INT}~13 nb^{-1} (>10^{11} Min-Bias events)
- ***Muon IDentifier (MID) = upgrade of present Muon TRigger (MTR) system***
  - Readout and Trigger electronics TDR, http://cds.cern.ch/record/1603472
  - **MTR :** 72 Resistive Plate Chambers (140 m^2), 21k FE ch., muon p_T based trigger decision
  - **MID**
    - ⇒ **Provides muon identification** (match with MFT/MCH tracks behind thick iron wall)
    - ⇒ Continuous readout (new Readout Electronics), very reduced trigger capabilities
    - ⇒ 1/3 new RPCs, new Front-End Electronics
- ***Installation during LS2 (2019-2020)**, data taking during LHC run3 and run4*

MTR picture



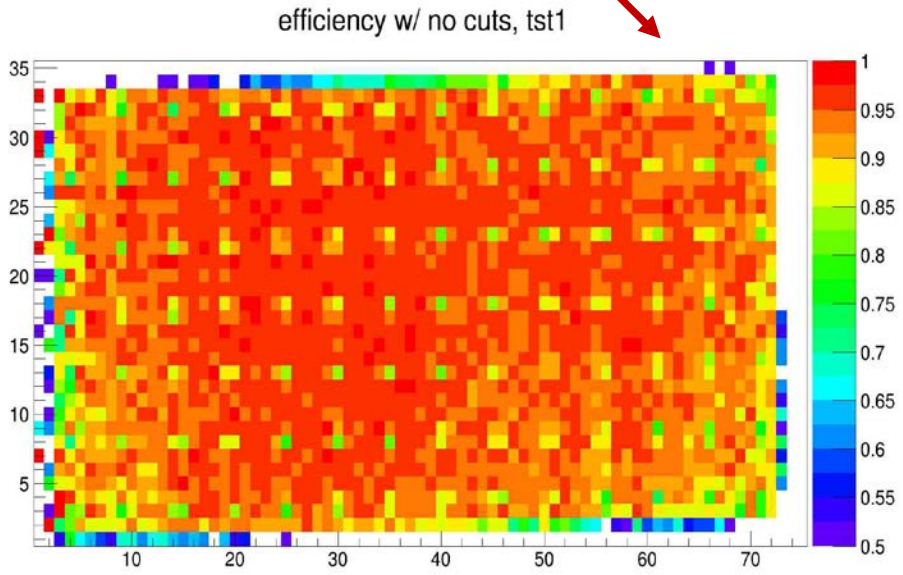
MID : new RPC production and tests

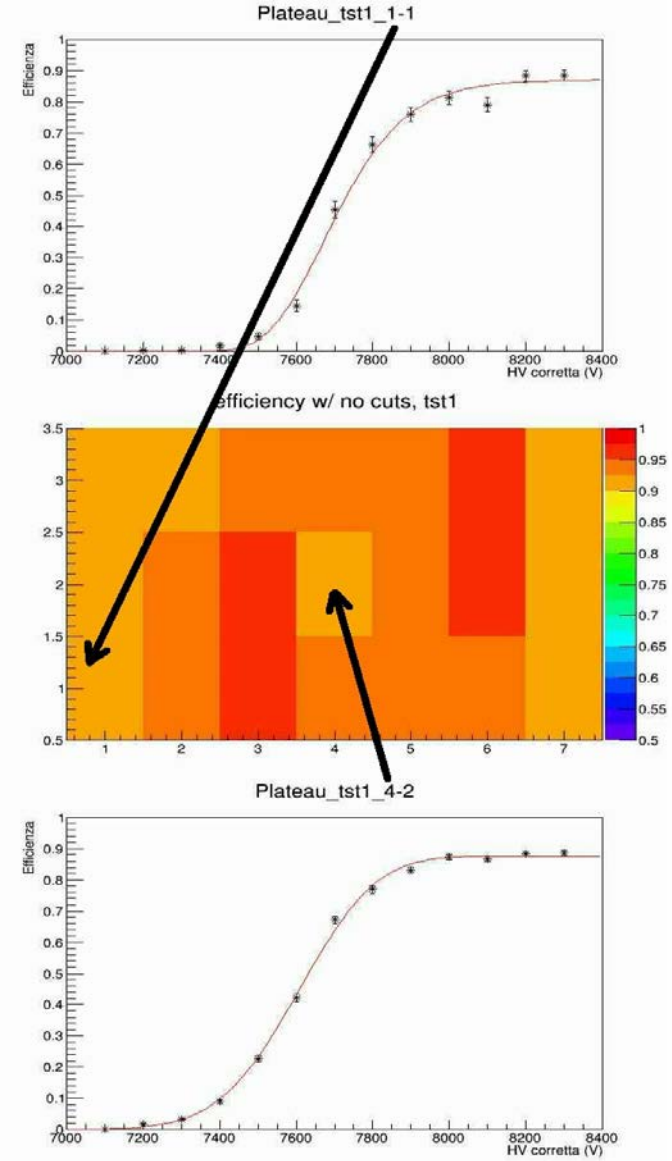
- ***Goal: replace the 24 most irradiated RPCs (out of 72) and other RPCs showing ageing at the end of Run2***
- ***Production status***
  - 30 RPCs produced so far
  - 20 more in production
- ***Test status***
  - Ongoing, 16 RPCs already tested
  - Present yield ~70%
  - Based on the final yield, we will consider building more RPCs → if late for installation, they will be kept as spares
- ***Two new RPCs installed in ALICE cavern (MT21-OUT6 and MT22-IN3) on 02/18 for long term tests in realistic conditions***
  - HV/threshold scan on 04/18
  - High efficiency and stability so far
- ***Plans***
  - Mass production tests (end): 12/18
  - Installation: few weeks during 2019



MID : characterization of new RPCs

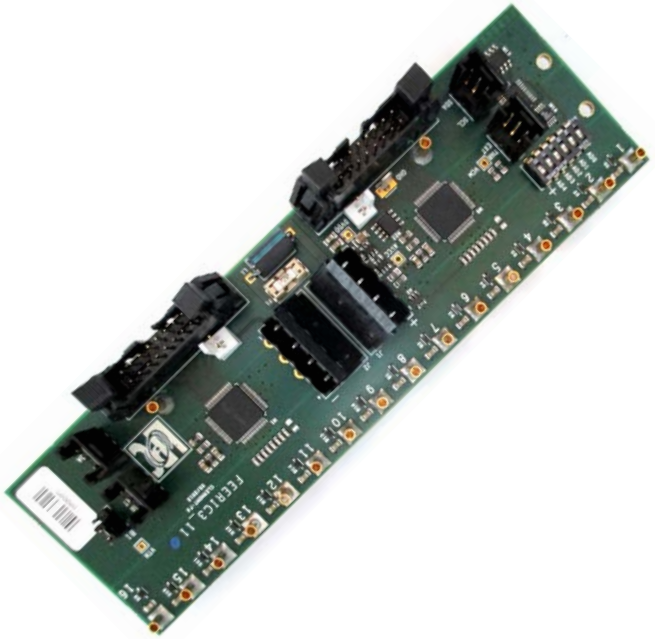
- ***Tests carried @ Torino cosmic bench***
  - The detection of possible gas leaks
  - The current-HV curve (ramp-up) and the detection of leakage currents
  - The efficiency-HV curve in cells ~20 x 20 cm^2
  - The noise map of the detector, with the auto-trigger method
  - The efficiency map at working HV with a granularity of ~2 x 2 cm^2





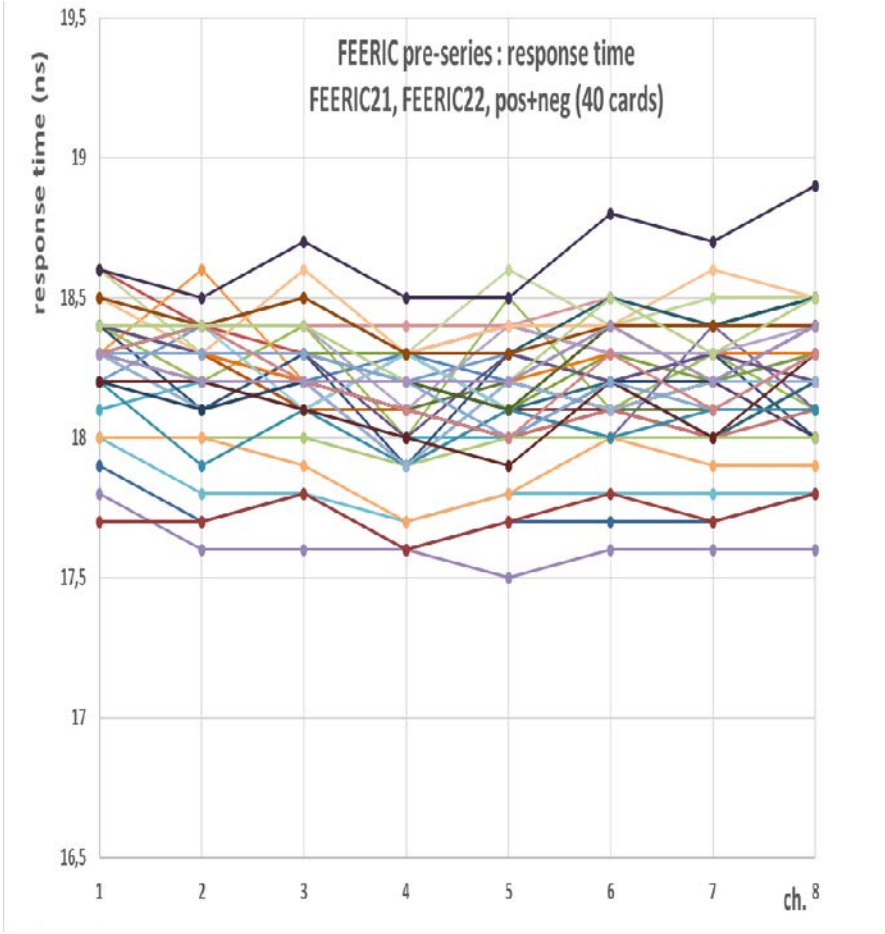
MID : FEERIC FE Electronics for the RPCs

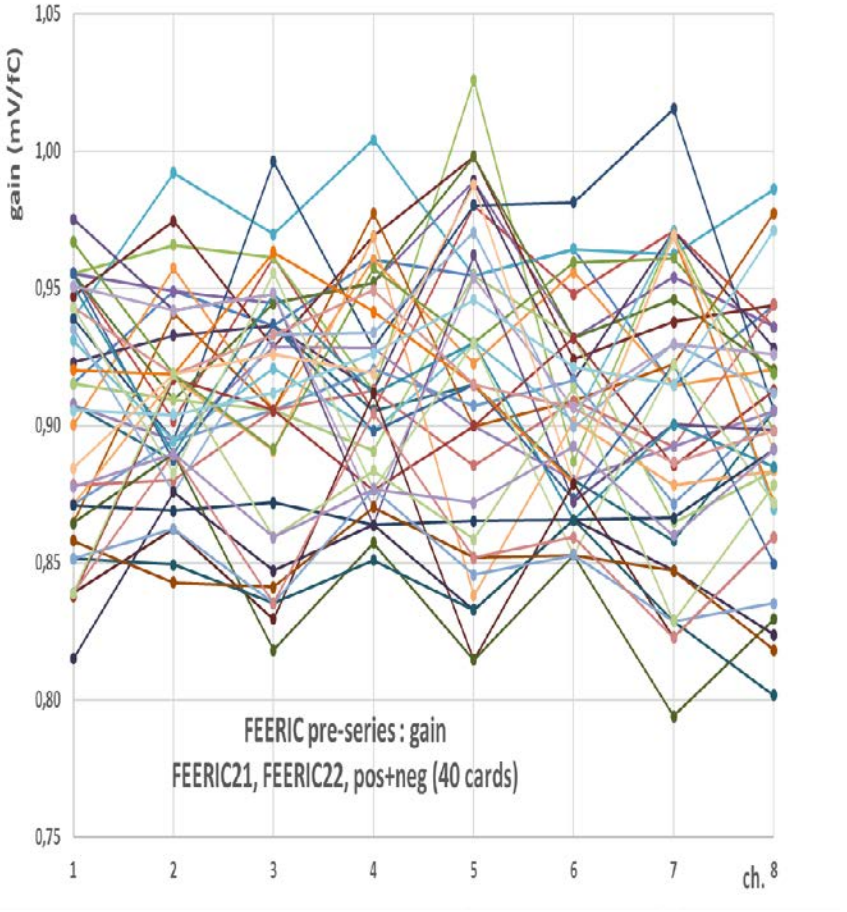
- ***Goal = slow down RPC aging after LS2***
  - 20992 ch., **2384 FE cards** (+14% spares)
  - Present ASIC ADULT: no amplification
  - Future ASIC **FEERIC with amplification**
- ***39 FEERIC cards on 1 (/72) RPC (MT22-IN3) in ALICE cavern since 02/15***
  - Very satisfactory performance and stability
  - **Factor 4 less charge released in the RPC gas with FEERIC => reduced aging**
  - **RPC from the new production since 02/18**
- ***ASIC production (x5000) validated in two weeks on 06/16 using the prod. test bench***
  - **Yield > 98%**, 60% spare ASIC available
- ***Card production***
  - CERN price enquiry DO-30313/EP/FEERIC
  - **Production completed** since 01/18
- ***Installation of new RPCs and FEERIC cards***
  - During 2019, ~3 months, not consecutive
  - Prepa. of installation (documents, tools) ongoing



Production test bench

MID : FEERIC *sample* performance
ex. of response Time and Gain dispersion





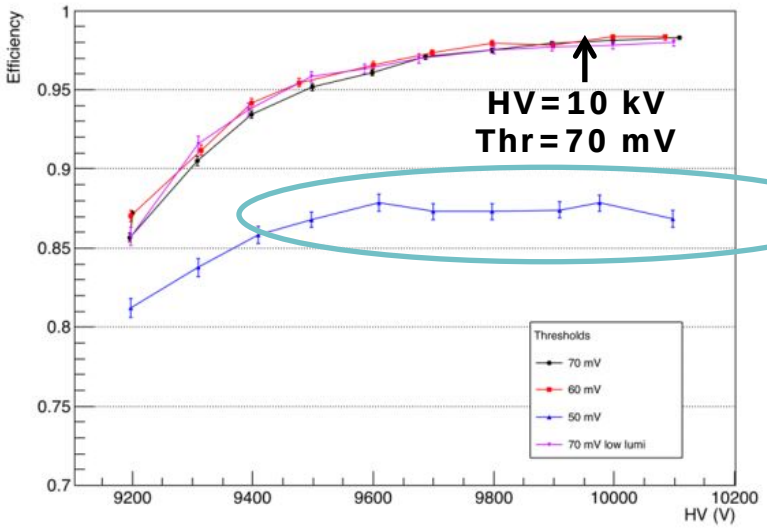
- Response time dispersion < 1,5 ns
- Response time dispersion assumed in PRR is 3 ns (for full prod.)

- Gain dispersion ~ ±10%

Thesis service task ongoing on analysis of **full production** dispersion

MID : FEERIC FE Electronics for the RPCs Efficiency and current@high luminosity

- ***HV/threshold scan (04/18) for the RPC (MT22-IN3) from the new production equipped with FEERIC cards in ALICE cavern***
  - High efficiency reached for thr=60 mV and 70 mV (in high and low lumi runs)

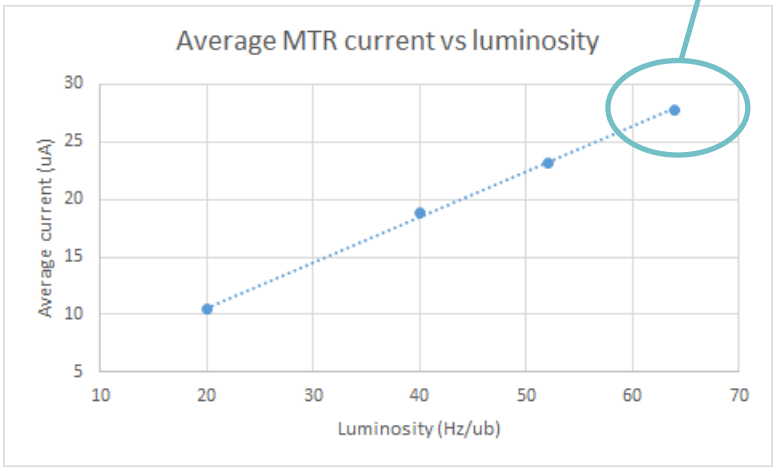


Noisy NBP area for thr=50 mV

=> drop of the overall plane efficiency

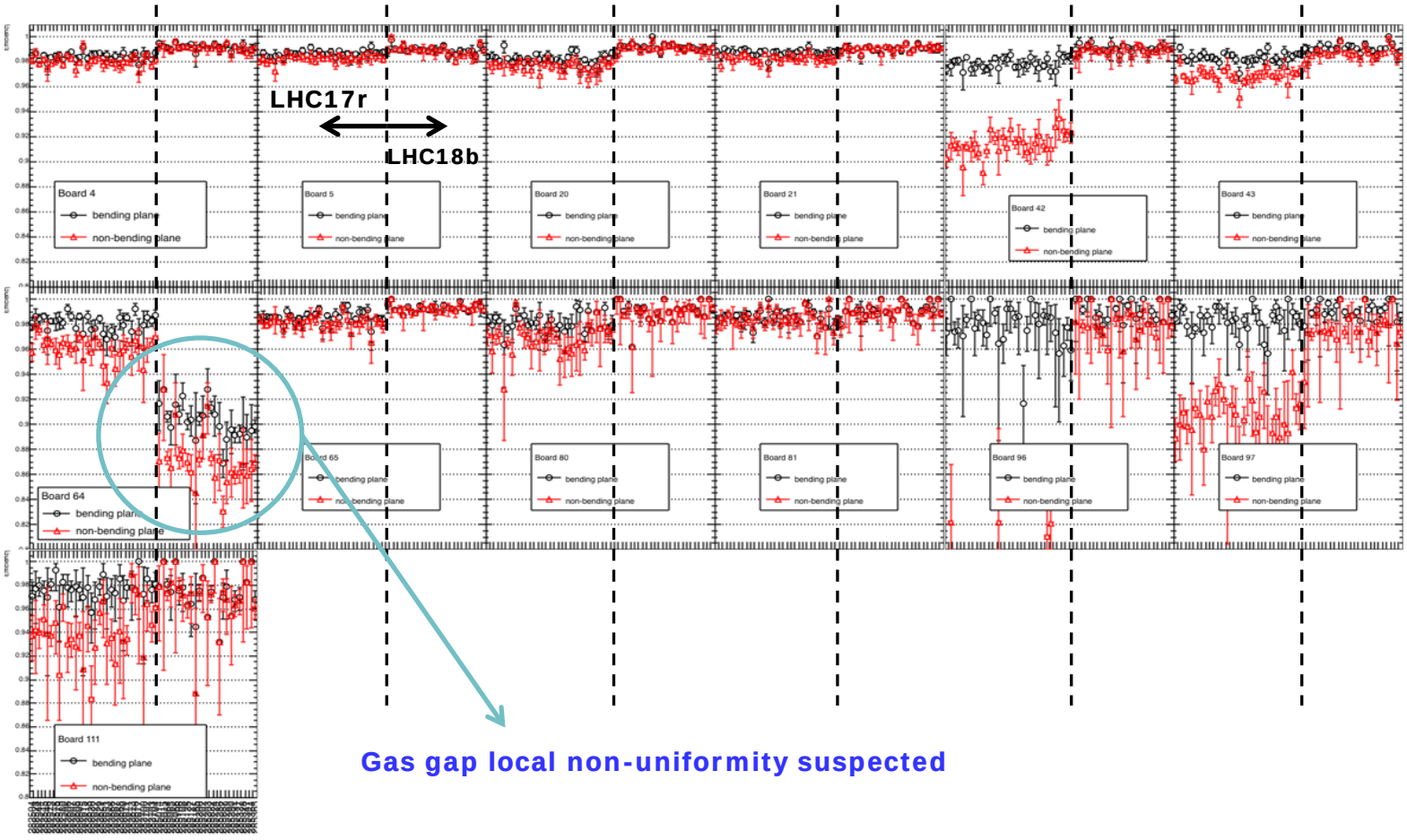
- ***Average RPC current during high luminosity test (june 2018)***
  - RPC HV run-3 equivalent (with FEERIC)
  - No trip, no spike, I_{RPC} linear vs. luminosity up to 50 kHz Pb-Pb equivalent

Equivalent to Pb-Pb 50 kHz



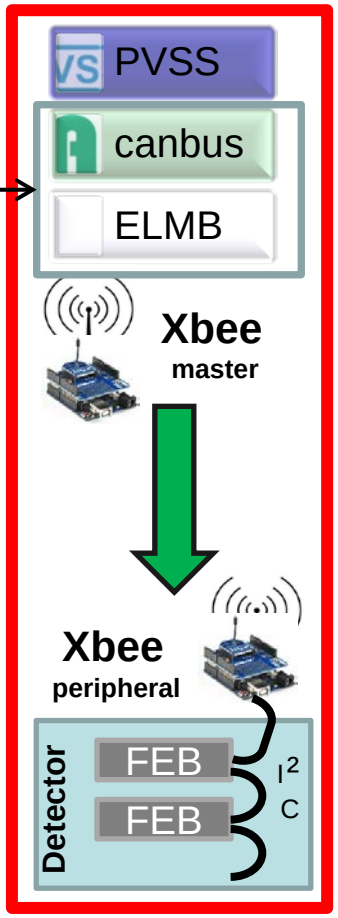
MID : FEERIC FE Electronics for the RPCs Efficiency (RPC in ALICE cavern)

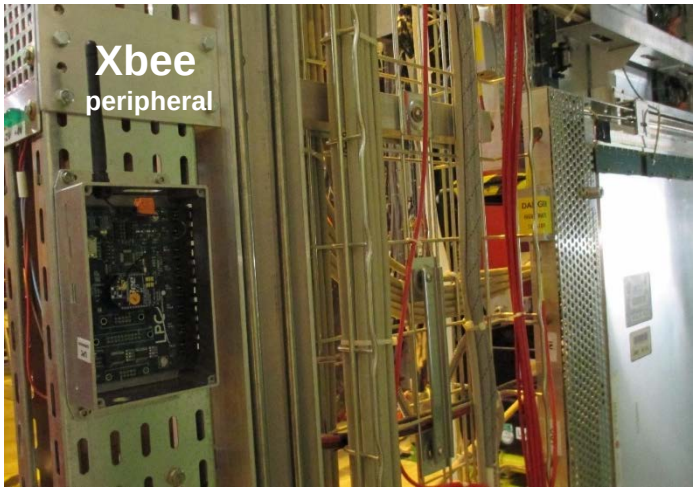
- ***Comparison of MT22-IN3 efficiency between LHC17r and LHC18b periods in standard conditions of operation (all RPC area)***
  - High efficiency reached with RPC from new production (LHC18b)



MID : FEERIC wireless threshold distribution

- ***Why going to new -wireless- threshold distribution ?***
  - Threshold setting per FEERIC card (vs. per RPC side in the present setup)
  - Possibility of fine tuning locally each RPC working point (common HV, threshold optimization)
- ***Technical choices*** (discussed at Dec. 2017 ALICE TB)
  - Zigbee high level protocol used (for wireless transmission)
  - SoftWare based on Arduino libs (I2C, SD and Xbee cards)
  - I2C bus between FEERIC cards on each RPC side
- ***Status***
  - Wireless threshold Hw/Sw prototype installed in Feb. 2018 on the RPC equipped with FEERIC cards in ALICE cavern
  - Long term performance and reliability tests in 2018
  - **R&D ongoing for ethernet link to Xbee master**

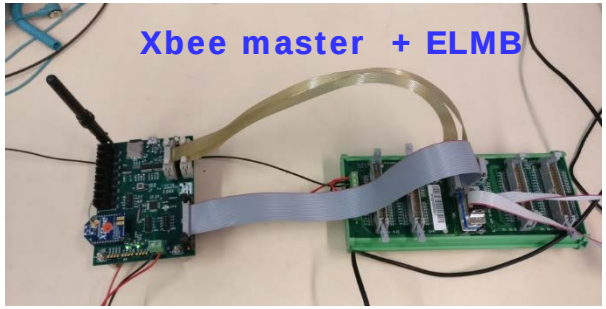




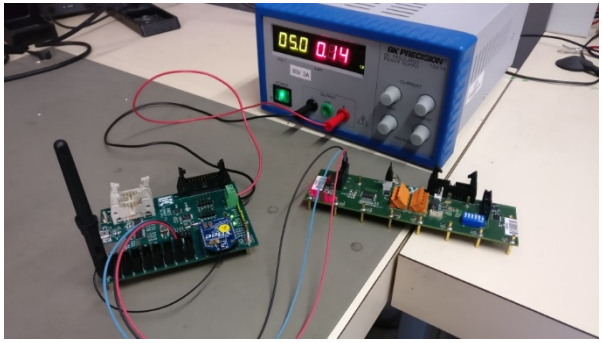
- **Small production**
  - 24 Xbee peripheral cards
  - 2 master cards
- **Production, installation**
  - end 2018, early 2019

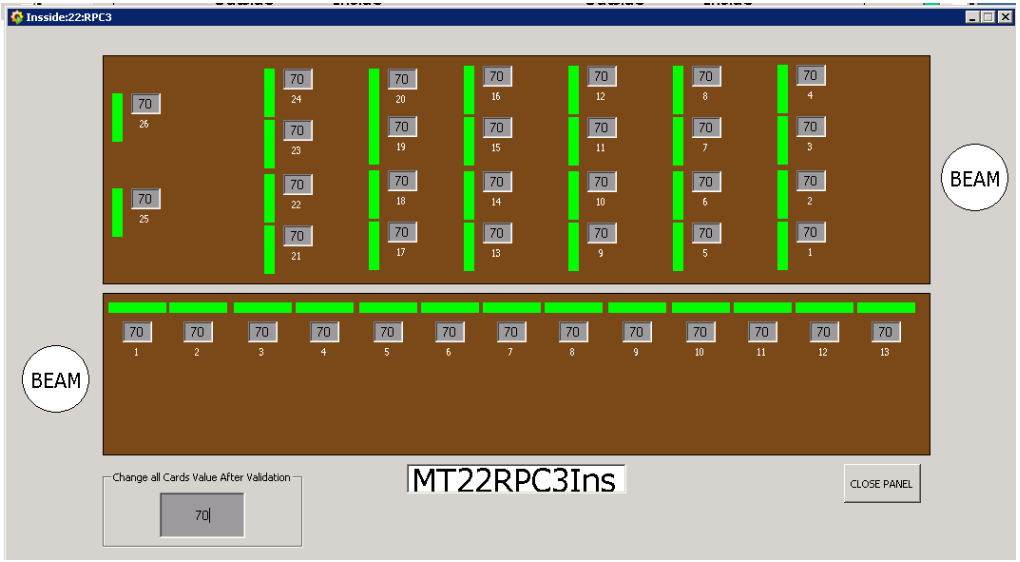
MID : FEERIC wireless threshold distribution

- ***Xbee card description and functionalities***
  - Same Xbee card for master and peripheral cards (1->12 in ALICE)
  - One single FirmWare: master/peripheral role is assigned by SoftWare configuration. By default, a board acts as peripheral
  - SD Card for initialisation
  - EEPROM for storing/re-loading last used threshold values in case of power cycle
  - Whole chain, hw+sw, operational, including PVSS software



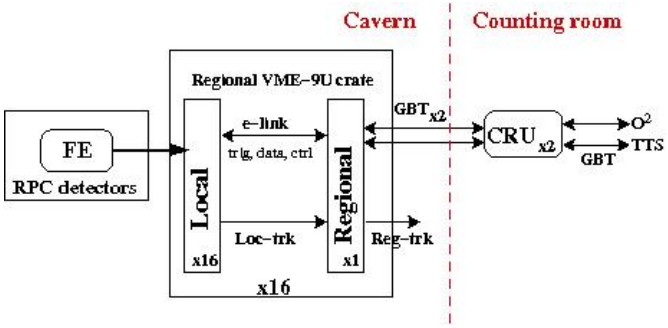
Xbee peripheral coupled to FEERIC board (threshold setting via I2C)



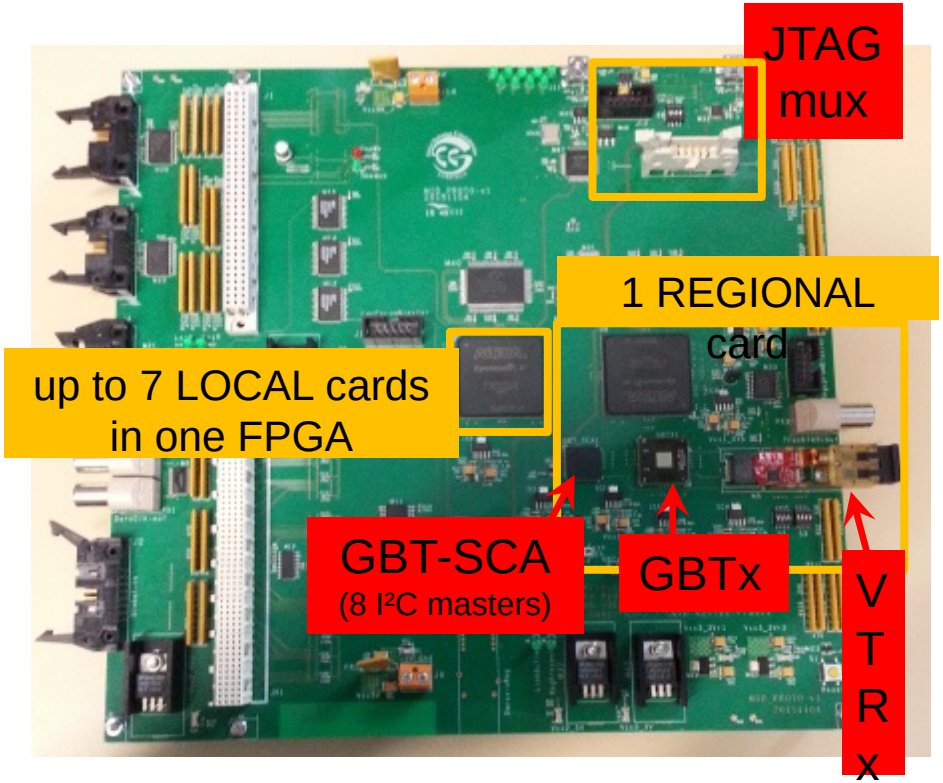


MID : Readout Electronics Prototype

- ***Readout electronics for continuous mode***
- ***Replacement of the 234 Local and of the 16 Regional cards presently in operation***

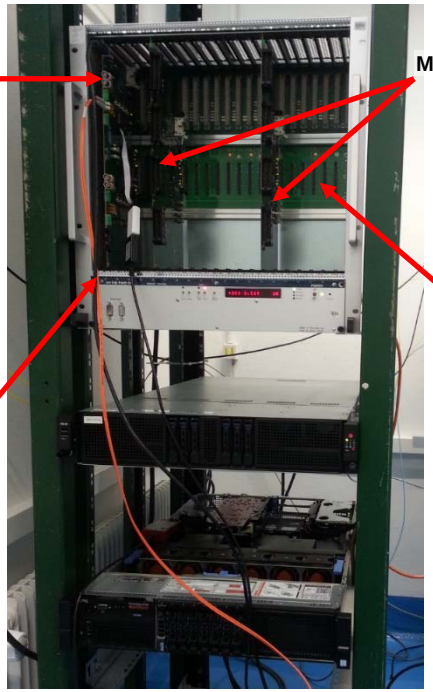


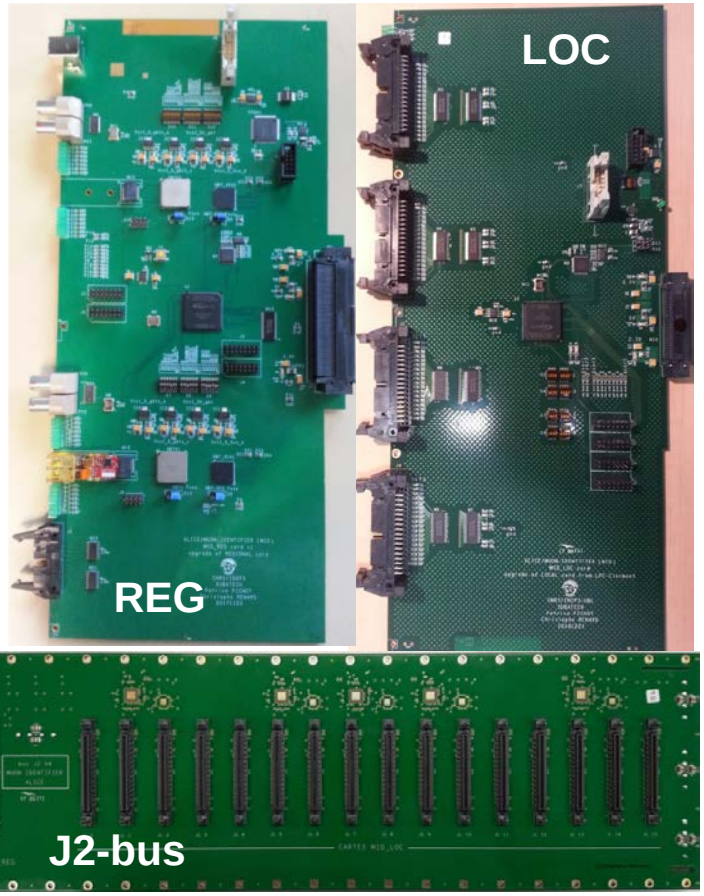
- ***Readout card prototype ready since early 2016 (EDR in June 2015) and fully operational***
  - Emulate, on the same card, 7 Local cards connected by e-links@320 Mb/s to one Regional card implementing one GBT@3.2 Gb/s (GBTx, GBT-SCA, VTRx)
  - FPGA programming and GBT config. OK
  - Tests of communication with G-RORC (as CRU emulator) validated in Jan. 2017
  - Slow control I2C (via GBT-SCA) OK
  - Advanced FPGA firmware ready
  - Response to HB triggers OK
  - Self-triggered events OK



MID : Readout Electronics
Pre-series cards

- ***Pre-series*** **: 3 samples of Local, Regional and J2-bus (between Loc-Reg) produced => full chain tests**
- ***PRR defended in April 2018*** ***(https://indico.cern.ch/event/719264/)***
  - Tests (signal transmission integrity mostly) and Local & Regional card layout to be finalized
  - Full crate (1/16 of total) still to be validated
  - **PRR follow-up meeting before production**





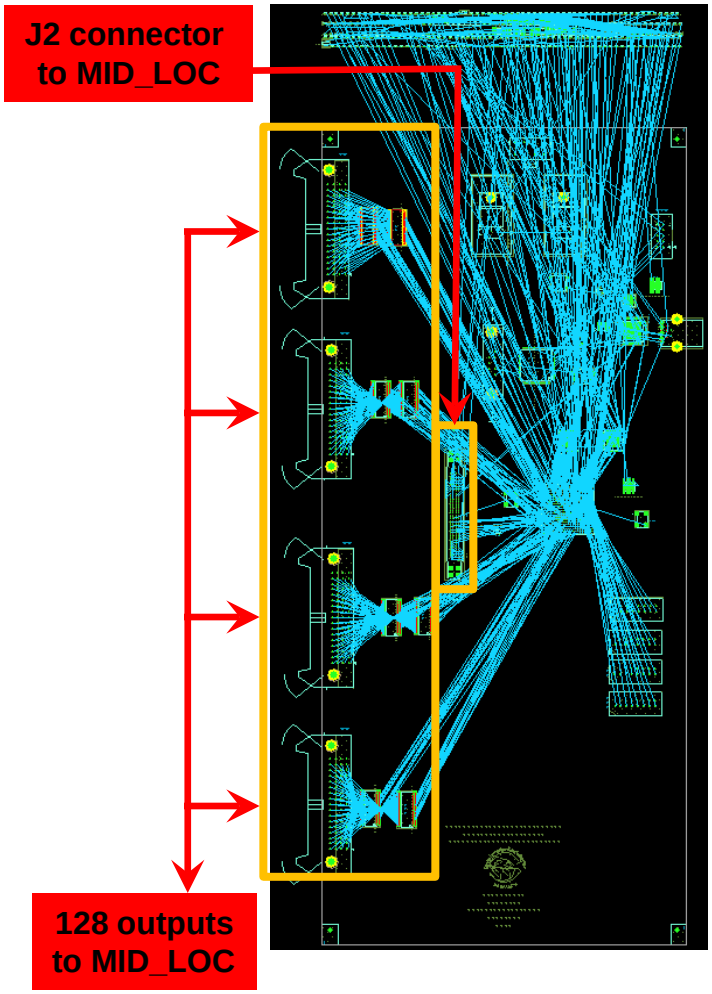
MID : Readout Electronics
Eye diagrams (June 2018)

- ***Eye diagrams : triggers and clock (downlink)***

MID : Readout Electronics
LOCAL test bench and FEERIC interface

- ***MID-TST-LOC***
  - Layout completed in Subatech
  - Routing, production ongoing at LPC

- ***MID-FE-LOC-INTERFACE***
  - Support for 8 FEERIC cards
  - Delivered by LPC to Subatech



MID : CRU (Common Readout Unit) interface

- ***ALICE team of South Africa has joined MID project in 2017***
  - In charge of MID CRU specific code development
  - Will be involved in full crate validation
  - A test bench has been set up (waiting for LTU, CRU+FLP for completion)
  - Output data format is discussed regularly with O2 experts
  - Input raw data format and segmentation was provided to SA team by MID readout electronics developer

- ***First release of MID user logics (up-link only) ongoing***

- ***MID CRUs***
  - 2 CRUS of type “24/24” in the counting room
  - 1 CRU+FLP from first batch in Subatech for tests of readout electronics (July 2018)
  - 1 CRU+FLP req. asap in SA for MID user logics

MID : Overall Schedule

V2.5 (Jan-18)	2015	2016	2017	2018	2019	2020
RPC produced and tested (12/18)				☺		
FEC EDR (3/15)	☺					
FEC PRR (4/16)		☺				
FEC produced and tested (1/18)				☺ ◆——◆		
RPC / FEC installation (01-12/19, 3 months)					☺	
RO EDR (6/15)	☺					
RO prototype finished (11/15)	☺					
RO pre-series protos, PRR (18/4/18)				☺		
RO 1(/16) full crate produced and tested (12/18)				☺		
RO produced and tested (06/19)					☺ ◆——◆	
RO installation (04/20, 15 days)						☺
Commissioning						→