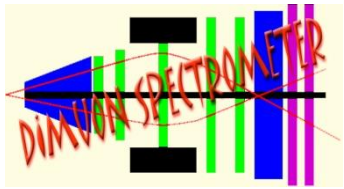
The Muon Trigger upgrade



- The Muon Spectrometer needs an important upgrade in view of operating in the context of the high luminosity expected at the LHC after 2018
  - Larger signal + background rates
  - Larger trigger rates

- For the Muon Trigger, two main upgrades are presently considered
  - Front-End Electronics
  - Readout Electronics

- TDR sections
  - Expected counting rates (instantaneous and integrated) and aging of the RPCs
  - Expected data flow
  - FEE upgrade
  - RO upgrade
  - Budget, schedule, involved institutes, …

- Main previous presentations
  - TB january 2013: https://indico.cern.ch/conferenceDisplay.py?confId=229958
  - Muon Meeting, Barolo, Mai 2013: https://indico.cern.ch/conferenceDisplay.py?confId=245772

Expected counting rates of the RPCs and data flow (prel.)

	PbPb √s=5.5 TeV, 100 KHz		p-p √s=14 TeV, 2 MHz	
	RPC counting rate (mean)	RPC counting rate (max)	RPC counting rate (mean)	RPC counting rate (max)
	75 Hz/cm²	**125 Hz/cm²**	60 Hz/cm²	150 Hz/cm²

** Assume cluster size=1 => conservative (by ~30%)*

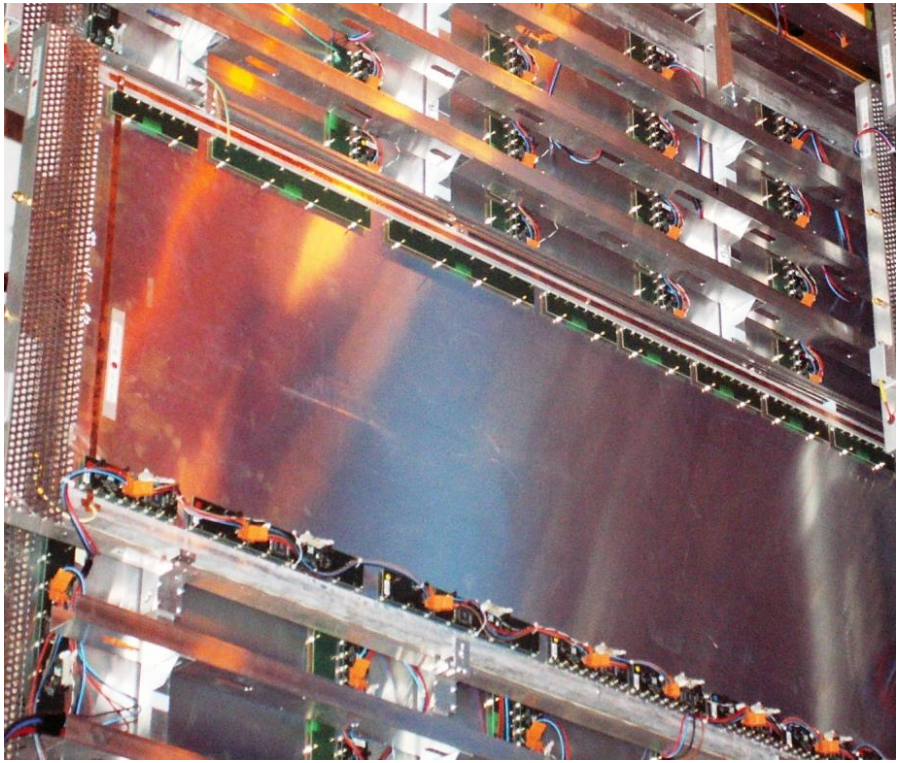
	PbPb √s=5.5 TeV, 100 KHz			p-p √s=14 TeV, 2 MHz		
	Total data flow	MAX data flow per link		Total data flow	MAX data flow per link	
With zero suppression** @Mbias rate	2.5 MB/s TRK < 600 MB/s BCKG*	LOCAL => REG **< 20 Mbit/s (3%)**	REG => DAQ **< 100 Mbit/s (15%)**	1 MB/s TRK < 500 MB/s BCKG*	LOCAL => REG **< 15 Mbit/s (3%)**	REG => DAQ **< 75 Mbit/s (15%)**

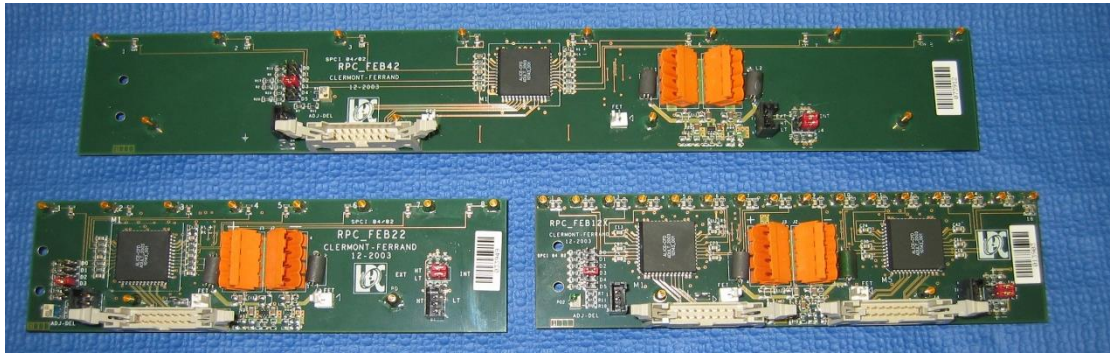
** Assume ALL BCKG in the BC corresp. to the Mbias (extremely conservative !) => evalution from Raw Data ongoing*
***Only strip patterns # 0 (without further coding), no header, no scalers*

UPGRADE of the Muon Trigger Front-End Electronics

Present Front-End Electronics

- **20992 strips**
- **2384** (+ spares) **FE Boards**
  - 10 types of FEB (8 or 16 ch/board)
  - For 2 different signal polarities
  - 5 possible delays to compensate for cable lengths between 14 and 20 m
  - 8 ch **ADULT ASIC** designed at LPC-Clermont
- Main functionalities of ADULT
  - Discrimination (two thresholds)
  - Signal delay (compensation of the different cable lengths)
  - LVDS driver
  - **No amplification**





FEE upgrade: goal and strategy

- Goal => **Limit RPC aging** in the severe expected conditions of the future operation
  - Present RPC counting rate limitation ~50 Hz/cm^2 (short period)
  - 50 mC/cm^2 certified wo major aging effects

- Possible Solution => **FEE with amplification** (RPC in avalanche mode, like in ATLAS & CMS)
  - Total charge (mean): Q~20-30 pC (goal) vs. 100 pC presently
  - Fast charge on the strip @FE-threshold: q~50-100 fC (goal)

  ⇒ **RPC aging expected to be reduced**

- No existing ASIC with all requested functionalities

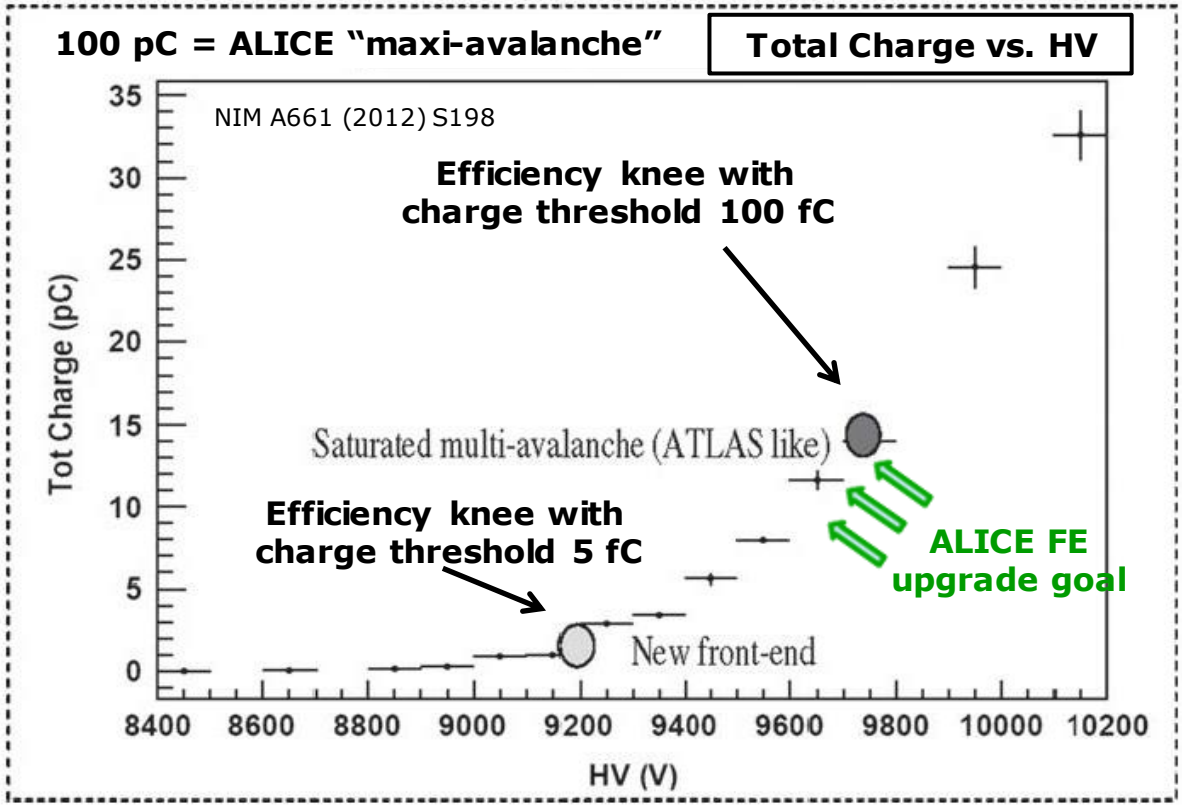


Fig. 4. Average total charge per pulse delivered in the gas vs. applied voltage.

FEE upgrade: R&D status and perspectives

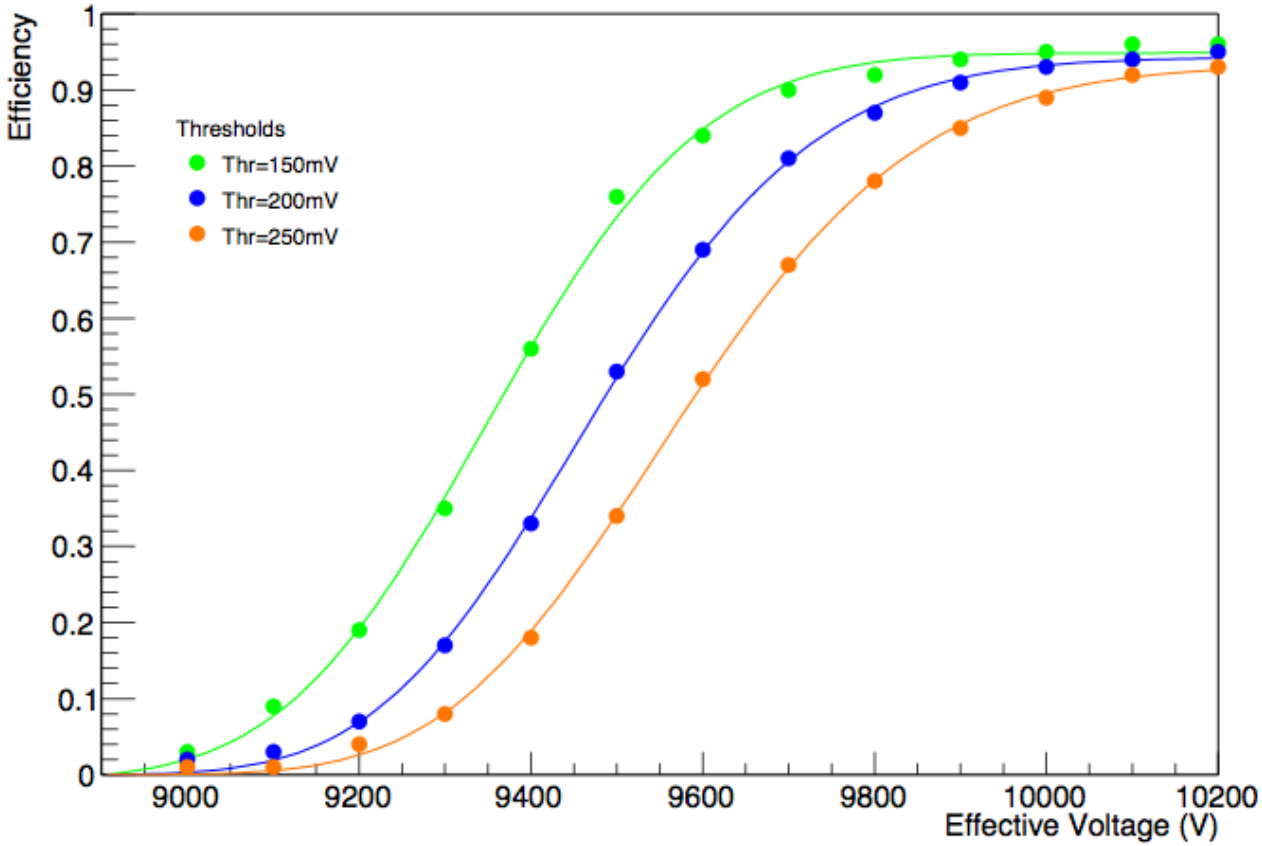
- **Various FE card prototypes with amplification are built for evaluating the performance that can be achieved in ALICE RPC signal pickup conditions**
  - Efficiency curves, pulse charge, total charge, single counting rate, time resolution, cluster size, …
  - vs. threshold level (and determination of noise level)
  - ⇒ Tests ongoing on the Torino RPC test bench

- **FE card prototypes with the CMS ASIC : BARI-FE**
  - Description and functionalities => talk of Baptiste@Barolo
  - 8 cards of 8 channels each : ready
  - Installation on the Torino RPC test bench on may 09th

- **Measurement of the background level in ALICE cavern**
  - Threshold just above noise => 25-50 fC
  - => promising …

BARI-FE card

FEE upgrade: Very First results



Torino RPC test bench

Efficiency curves with BARI-FE on Torino RPC test bench

- ***Shift of the efficiency curves towards lower HV for smaller thresh. Values as expected***
- ***Shift of 600 (750) V for thresh=200 (150) mV as compared to present conditions of operation in ALICE***

FEE upgrade: R&D status and perspectives (3)

- **Design of a dedicated ASIC => FEERIC**
  - Main requirements
    - ✓ Dynamic range 20 fC – 5 pC; noise < 2 fC
    - ✓ Consumption < 100 mW/ch (OK with present LVPS)
    - ✓ Time resolution < 1 ns
    - ✓ Bipolar input signals
    - ✓ LVDS output signals
    - ✓ 8 channels

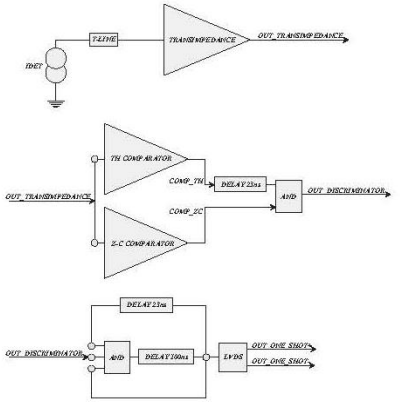


Fig. 1. One channel block diagram of FEERIC.

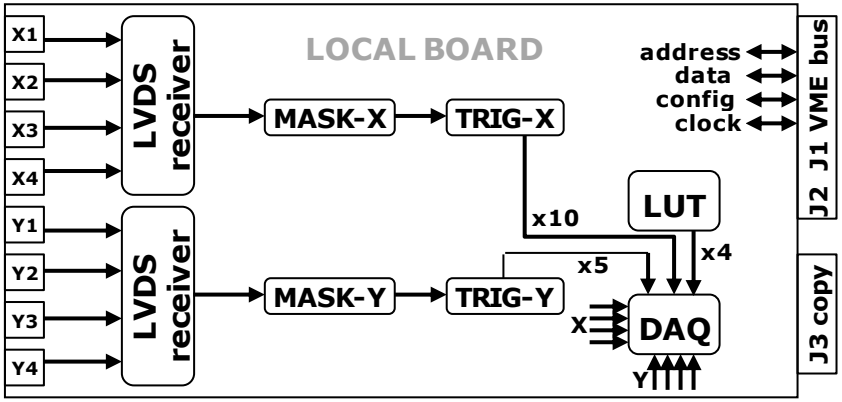
  - Status, functionalities, performance => talk of Baptiste@Barolo
  - First prototype sent to foundry end of May 2013 (delivery mid of August)

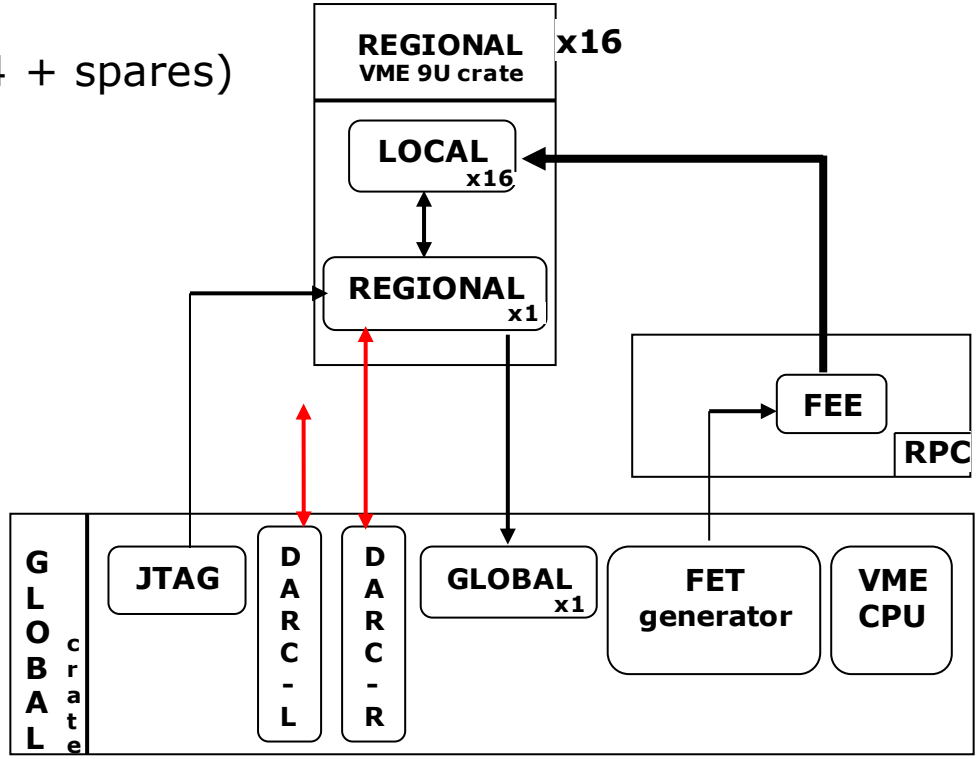
- **Design of the production test bench (just started…)**
  - Design will benefit from our experience gained with the ADULT test bench
  - Speed up the test of the FEE production: few cards tested in parallel
  - Portability: FE cards support, LVPS, pulse generator, ouput signal analyzer, visualization, … integrated on the test bench
  - Measurement/archiving
  - PC running Labview

UPGRADE of the Muon Trigger Readout Electronics

Present electronics architecture

The LOCAL are the most numerous cards (× 234 + spares)





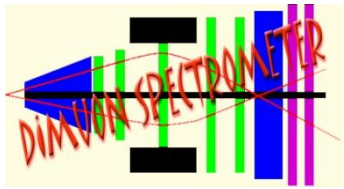
LOCAL event info

- Strip-patterns X and Y => 4 × 32 bits
- Decision + board address => 32 bits

} **=> ~7 kB/evnt, no zero-suppression**

- Scalers (readout only with software triggers)

Readout upgrade



- **<u>Goal</u> => Dead Time free readout**
- **ALICE upgrade LOI (August 2012)**
  - Proposal to keep the Muon Trigger decision @ L0 in order to reduce the Muon Spectrometer readout frequency and hence DT
    - ✓ Concerns regarding L0 trigger latency !
  - Proposed upgrade solution, wo changing the LOCAL cards
- **After the ALICE upgrade LOI**
  - Decision to readout the Muon Spectrometer at the Mbias L0 rate which means that **Muon Trigger decision @ L0 is not needed anymore**
  - **Muon Trigger => Muon Identifier**
    - ✓ Dramatic reduction of the hadron contamination in the muon spectrometer for matched tracks (~20-30% => less than 2%)
    - ✓ Event pile-up suppression in the muon spectrometer when matching is required, thanks to the excellent RPC timing properties which allow to separate 2 BCs @25 ns interval
  - **Need a new strategy for the upgrade of the Muon Trigger readout since the readout frequency is ~10 time higher in this scenario as compared to LOI**

Readout upgrade: proposed solution (preliminary)

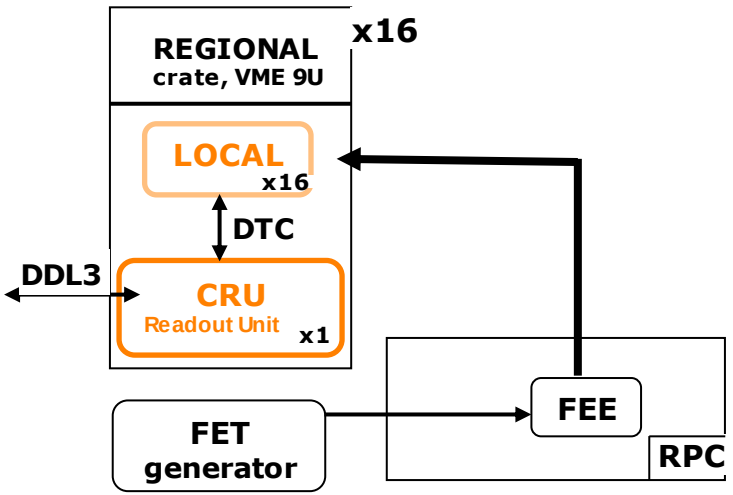
- The 16 Regional cards are replaced by **16 CRU** (Common Readout Unit) developed by ALICE
- **New LOCAL (×234 + spares)**
  - Receipt and Latch signals from FEE, masks, scalers, zero-suppression, …
  - Compensation of the delays introduced by the cables of different lengths coming from the FEE => previously performed at FE level
  - Communication via DTC e-links (RJ45, tbc) with CRU: data, trigger, clock, config.
  - 8 large front connectors per LOCAL => proposal to **keep VME 9U crates** for LOCAL card support and powering
- More details in the talk of Christophe@Barolo

Advantages

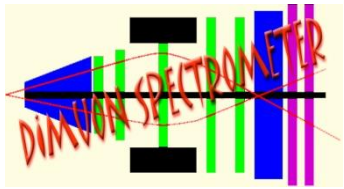
- Dead time free
- Simple architecture (reliability, test, ..)
- New electronics => less risks of breakdown from e.g. aging and radiation damages

Drawbacks

- **Muon Trigger hw decision lost**
- Budget increased vs. LOI



Conclusions/perspectives



- **R&D relative to the upgrade of the FEE (2400 cards + spares) has started**
  - Planning (prel.)
    - ✓ Summer 2014 : FE cards prototypes with FEERIC + test bench prototype
    - ✓ Before end of LS1: equip 1 RPC in ALICE cavern (pre-production test)
    - ✓ 2015-2016 : production
- **Proposal for a dead time free readout electronics**
  - Muon Trigger hw decision lost => Muon Identifier
  - Need to change the LOCAL cards (×234 cards + spares)
  - Planning (prel.)
    - ✓ 2013-2014 : test the DTC e-link (tbc)
    - ✓ 2014-2016 : R&D and production of the new LOCAL
- **Total cost estimate of the MTR upgrade : from 450 k€ (LOI) to ~550 k€**
  - FEE, detector/gas: 300 k€
  - Readout: 250 k€ (vs. 150 k€ in LOI)
- **TDR :** ongoing …
- **Involved institutes (open) :** FEE (Clermont+Torino+Gangnung-Konkuk), LOCAL + CRU interface (Subatech), RPC/gas (Torino)

Backup slides