ALICE Muon Spectrometer upgrade

The ALICE Upgrade program
Muon Tracking Upgrade
Muon Trigger Upgrade
Conclusions and Perspectives

The ALICE Upgrade

- **Motivations :** precision measurements of the QGP properties
  LoI for the ALICE Upgrade, CERN-LHCC-2012-012, http://cds.cern.ch/record/1475243

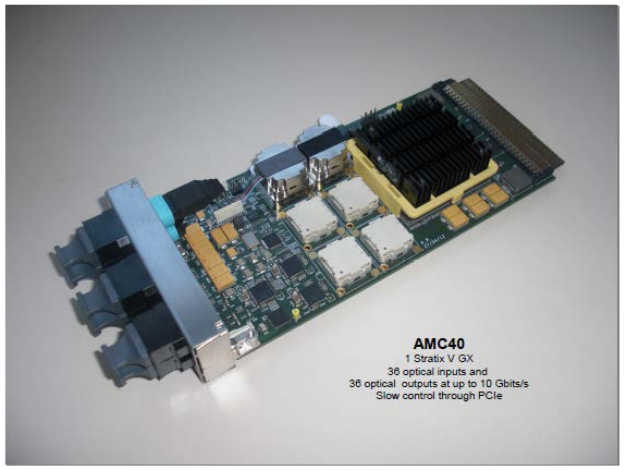
- **Conditions:** increase of the LHC luminosity
  - High interaction rate : 50 kHz in Pb-Pb (L_{peak}=6 10^{27} cm^{-2} s^{-1})
  - To be compared to 8 kHz peak during LHC run1

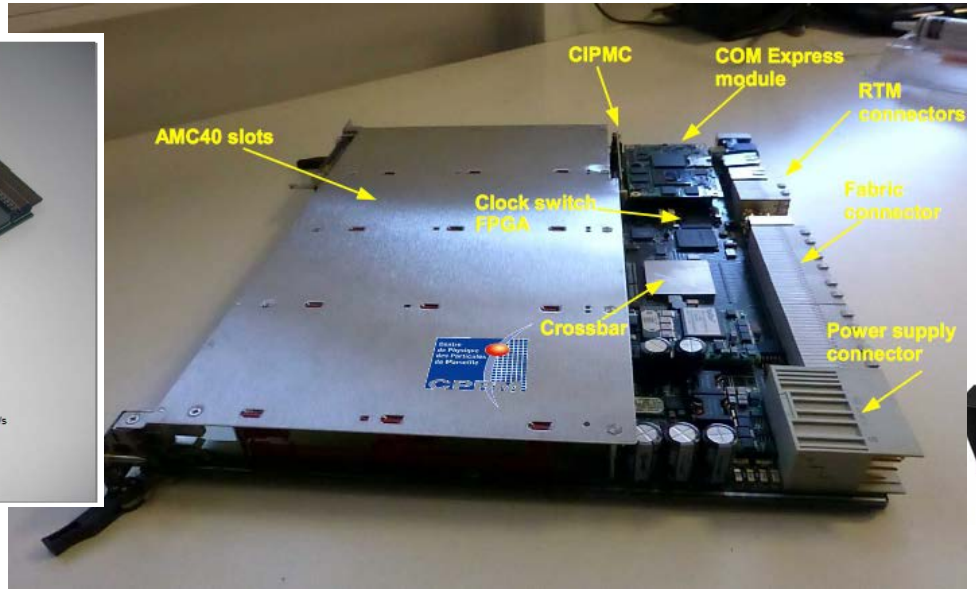
- **Strategy**
  - Hardware triggers not very selective in HI
    ⇒ readout all MinBias (MB) (~1 TB/s)
    ⇒ online reduction (O^2 project, 80 MB/s peak storage)
  - Large statistics : Pb-Pb at $\sqrt{s}$=5.5 TeV, L_{INT}~10 nb^{-1} (10^{11} MB events)
    ⇒ factor 10 as compared to approved program up to LS2

- **Upgrade program**
  - ITS, TPC chambers, online-offline (O^2), Muon Forward Tracker (MFT)
  - Readout and Trigger electronics, CERN-LHCC-2013-019, http://cds.cern.ch/record/1603472

- **Installation during LS2 (2018-2019)**, data taking during LHC run3 and run4

ALICE Common Readout Unit (CRU)



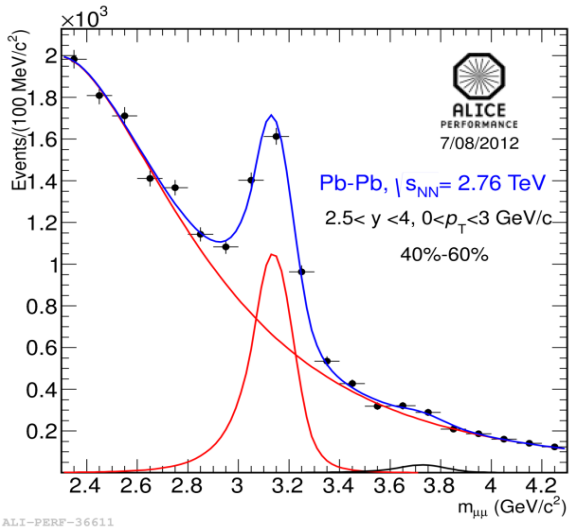


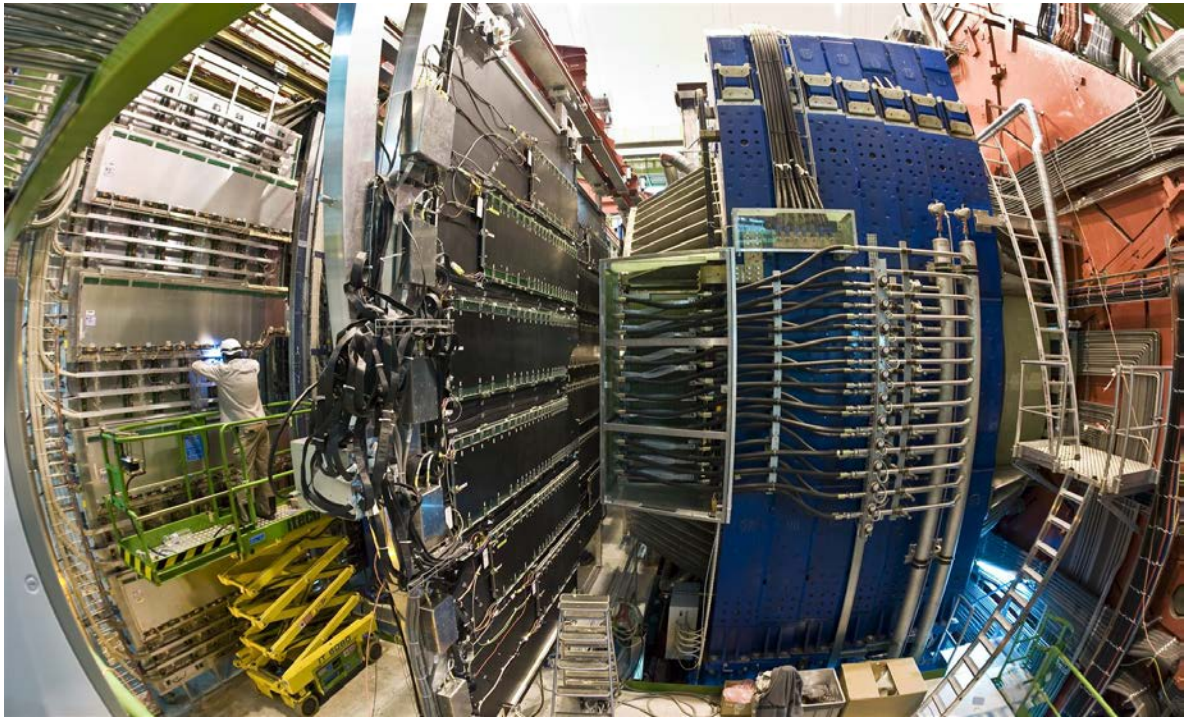
- For very large data flow readout
- Based on AMC40 (from LHCb)
- 1 AMC40 => 36 optical inputs + 36 optical outputs @ up to 10 Gbit/s each
- 4 AMC40 in 1 mother board
- 14 mother boards in 1 ATCA crate
- Trigger and timing distribution is via back plane

The ALICE Muon Spectrometer

- **Muon TracKing : cathode pad/strip chambers, 10 planes, 100 m^2, 1 Mch, spatial resolution < 100 μm**
- **Muon TRigger : 72 Resistive Plate Chambers, 140 m^2, 21 kch, muon p_T based trigger decision (LOCAL & REGIONAL cards)**
- **Dipole magnet : world largest warm dipole, 800 tons, 3 T.m., 4 MW**
- **Absorbers : 7 tons of tungsten, 11 tons of iron, 41 tons of lead**

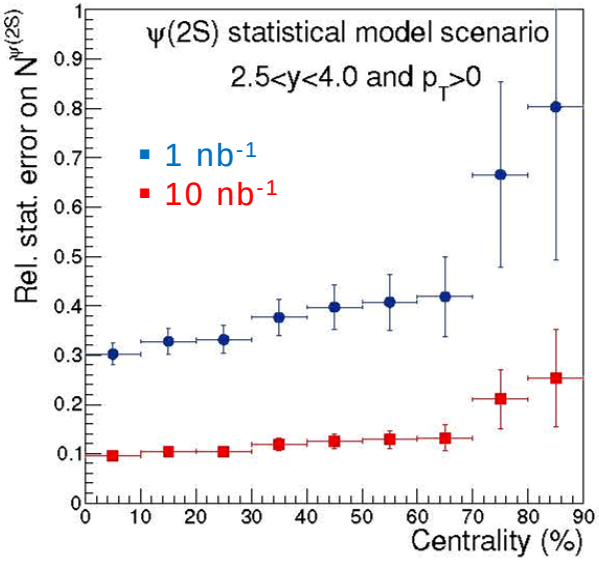
Nuclear Matter (QGP) study via quarkonia and open heavy flavor in muonic channel





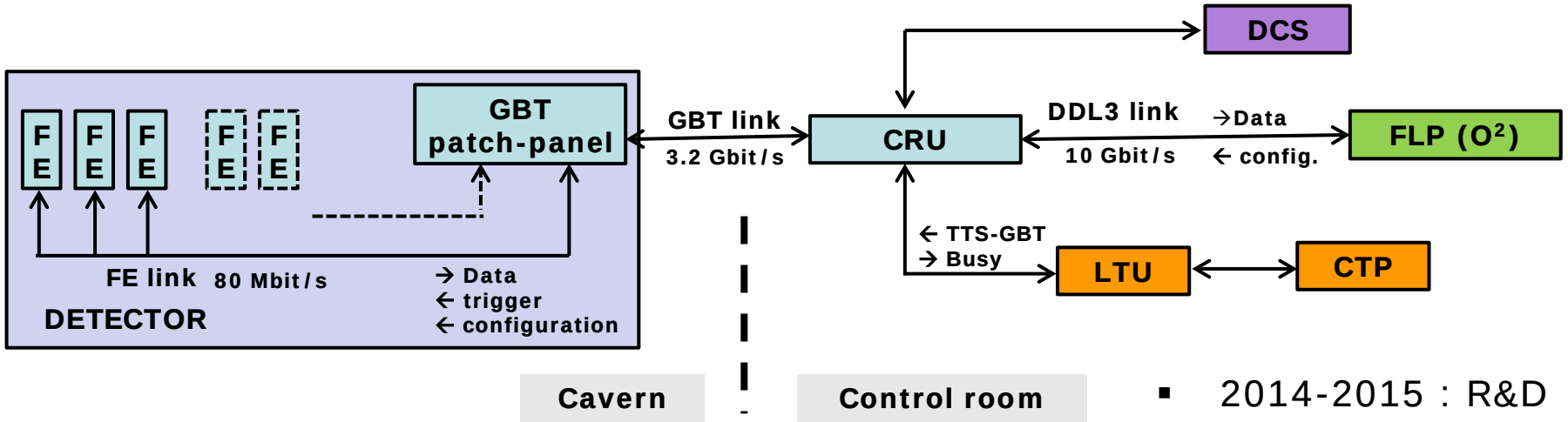
Muon Spectrometer Upgrade

- **Current Muon Spectrometer (MS)** = Muon TracKer (MTK) and TRigger (MTR)
  - Addition of the Muon Forward Tracker (MFT) during LS2, close to the IP, in the MS acceptance
- **Physics motivations**
  - J/ψ RAA, v2 and polarization (with large statistics), down to p_T=0
  - ψ(2S) (with large statistics), down to p_T=0
  - (with MFT) Prompt J/ψ vs. J/ψ from B meson decays, down to p_T=0
  - (with MFT) Open charm/beauty separation, down to p_T~1 GeV/c
- **Dead time free readout**
  - Up to 50 (200) kHz MB in Pb-Pb (p-p)
  - Front-End Electronics (FEE) upgrade
  - Readout Electronics upgrade
  - No detector upgrade foreseen so far



Muon Tracker Upgrade

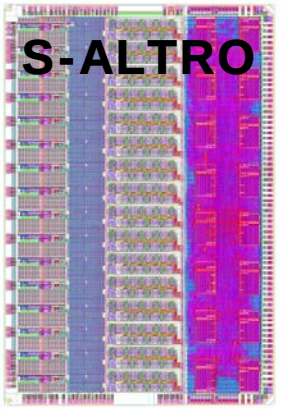
- **Dead time free readout up to 100 kHz in Pb-Pb MB (x2 safety)**
  - Present readout limit < 1 kHz
  - Max. expected data flow of 2.5 GB/s (design value = 200 GB/s)
  - All the FE and readout electronics must be replaced
- (wo spares) 17·000 FE cards (64 ch.) with 2 **SAMPA** ASIC each=> **1M channels**
- (wo spares) 34·000 SAMPA ASIC (common to MTK and TPC) 32 ch. each
- 500 GBT patch-panel
- 20 CRU



- 2014-2015 : R&D
- 2016-2017 : Production
- LS2 : Installation

Muon Tracker Upgrade : SAMPA ASIC

- **SAMPA** is evolution from PASA / ALTRO & S-ALTRO
  - Common to MTK and TPC
- **Baseline specifications**
  - 130 nm TSMC CMOS process
  - 32 channel amplifier-shaper-ADC-DSP
  - triggerless/continuous & triggered readout
  - On ASIC base-line correction and zero suppression
  - Bi-polarity input
  - 4 x 320 Mbit/s serial outputs
  - 10 bit ADC – 10/20 Msamples/s
- **Specific to MTK**
  - Input charge < 500 fC
  - Request noise < 2000 electrons
  - 330 ns shaping time
  - 10 MHz ADC sampling
  - Uses only 1 output link at 80 Mbit/s



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Continuous readout

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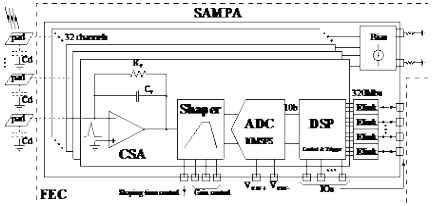
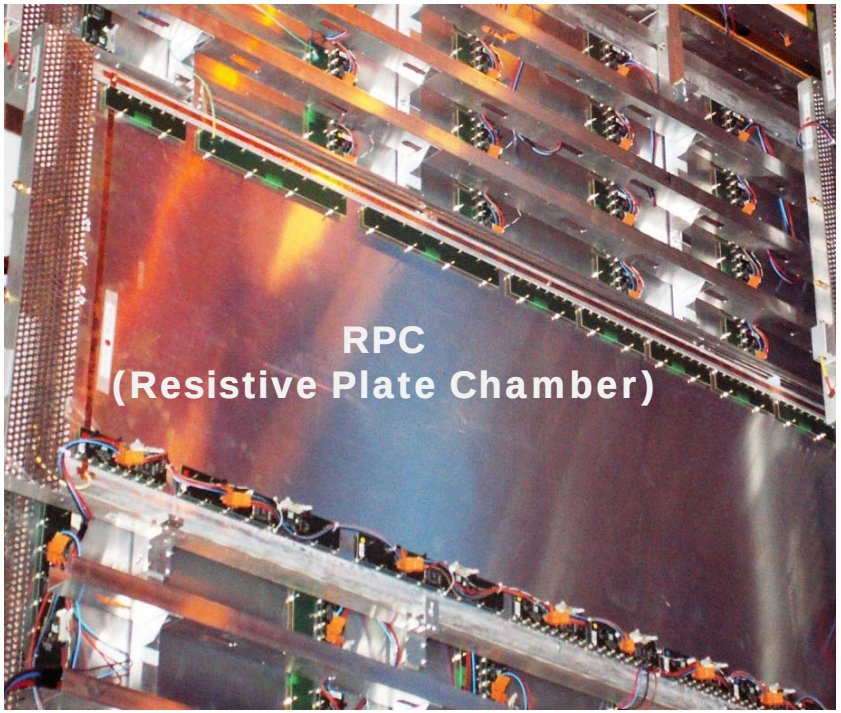
SAMPA



Muon Trigger Upgrade : FE electronics of the RPC detectors

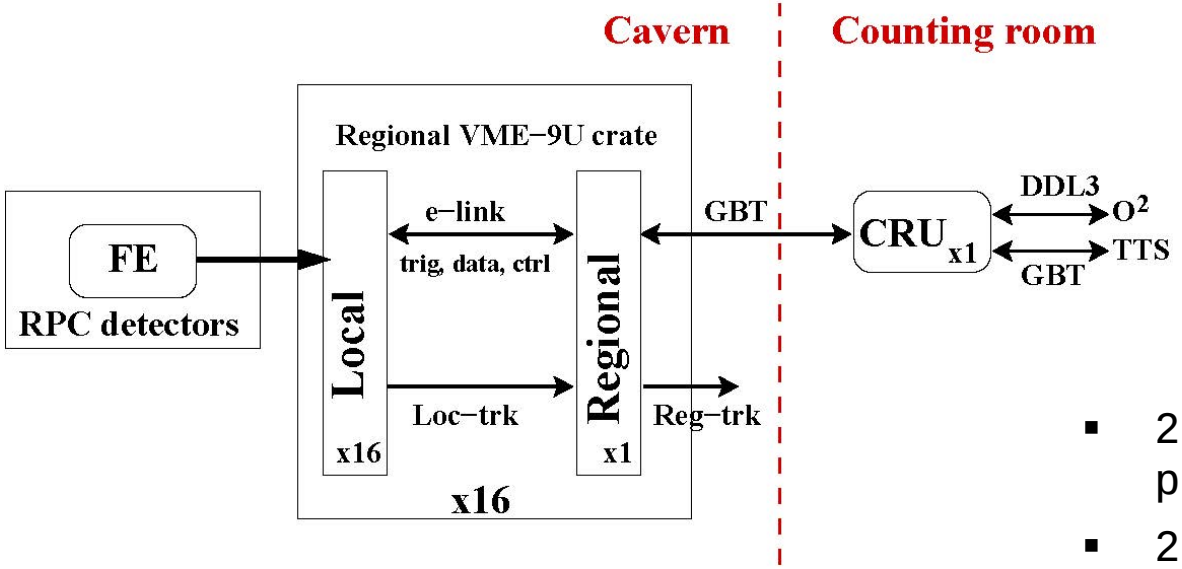
- **20992 ch, 2384 FEE cards**
- Present FEE : no amplification
- Future FEE ⇒ **with amplification**
  - Limit RPC aging (× 3-5)
  - Increase of the max. counting rate from ~50 Hz/cm^2 to 200 Hz/cm^2
- R&D program started in 2012
  - New ASIC (**FEERIC**) and FE card
  - ASIC 0.35 µm CMOS technology
    - 8 channels, bi-polarity input
    - Dynamic range from 20 fC < q < 3 pC
    - Resolution <500 ps for q > 100 fC

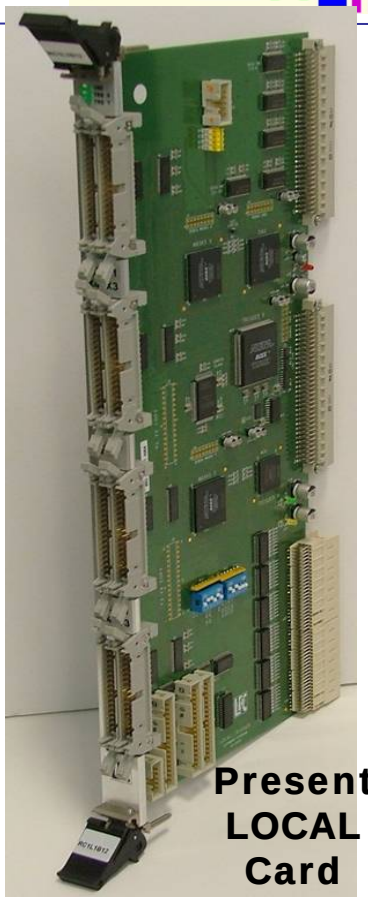


- LS1 : equip 1 RPC (/72) in the cavern with 40 FEERIC cards
- Run2: test in realistic conditions + production
- LS2 : installation

Muon Trigger Upgrade : readout electronics

- Dead-time free readout up to 100 kHz MB in Pb-Pb (x100 above present design), ~300 MB/s (expected)
- Muon Trigger hw decision not needed anymore=> **Muon Identifier** (MID)
- Replacement of the **234** LOCAL cards and of the **16** REGIONAL cards presently installed
- 1 CRU in counting room only





- 2014-2016 : LOCAL and REGIONAL prototypes
- 2016-2017 : Production
- LS2 : Installation

Conclusions and Perspectives

- **Muon TracKer and TRigger**
  - Dead time free readout up to 100 kHz MB Pb-Pb
  - Replacement of the front-end and readout electronics
  - Major online/offline implications
- **TDR :** http://cds.cern.ch/record/1603472
  - dec. 2013 : presentation to LHCC
  - march 2014 : endorsement by LHCC
  - june 2014 : approval (?)
- **Schedule :** R&D 2014-2016; Construction 2015-2017; Installation LS2
- **Involved countries :** Brazil, France, India, Italy, Korea
- **Estimated cost and human effort**

	Muon TracKer upgrade	**Muon TRigger upgrade**
Core cost (**kCHF**)	2852	780
Manpower (**FTE** up to LS2)	30	20

Backup slides