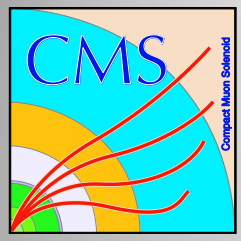


UNIVERSITEIT GENT

RPC2012

XI Workshop on Resistive Plate Chambers and Related Detectors

INFN Istituto Nazionale di Fisica Nucleare

INFN - Laboratori Nazionali di Frascati

5-10 February, 2012

The Phase-1 Extension of the CMS Endcap RPC System

Michael Tytgat

on behalf of the

CMS Collaboration

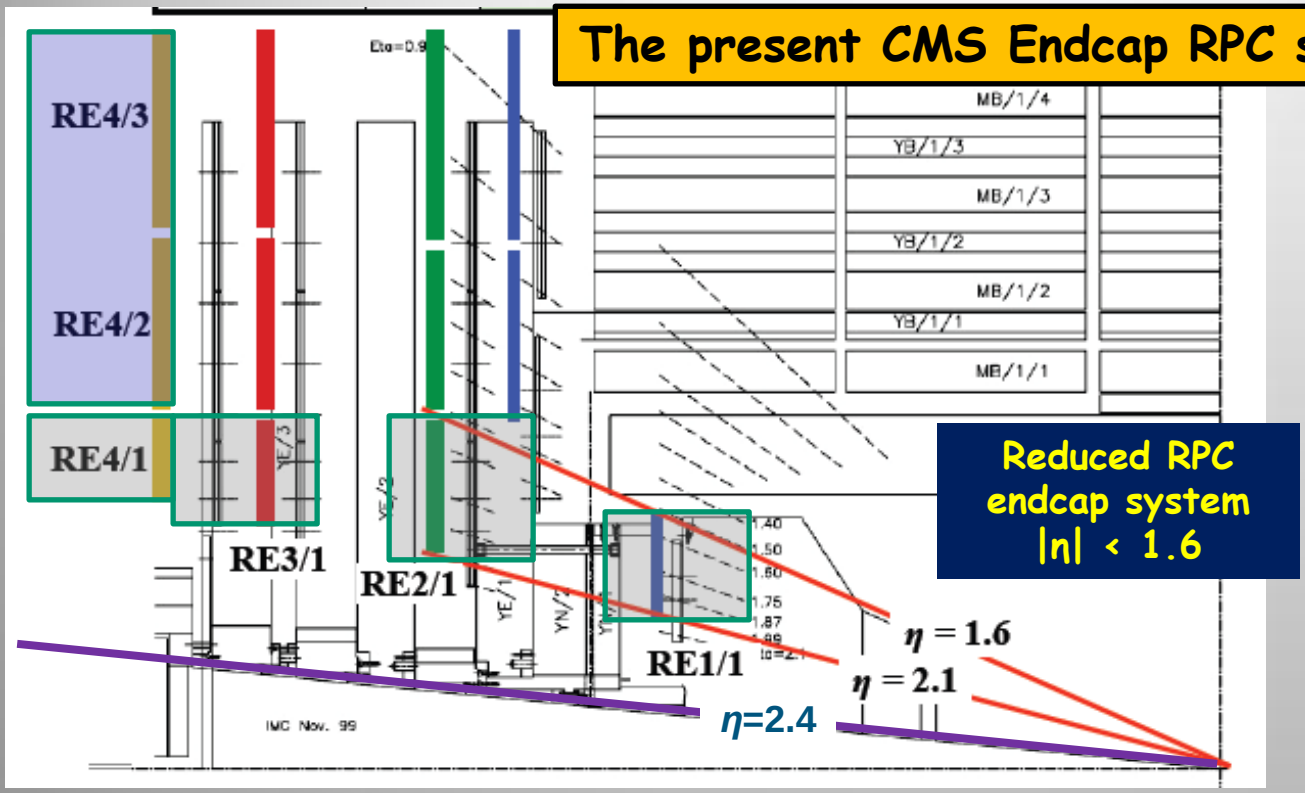
Outline :

- Introduction
- RPC Upgrade
- Simulation Studies
- Project status
- Outlook

Also check :

- Production RPC Gaps for the CMS Upgrade (S. Park)
- Construction and Tests of new RPCs for the Upgrade of the CMS Endcap System (L. Pant)

Introduction

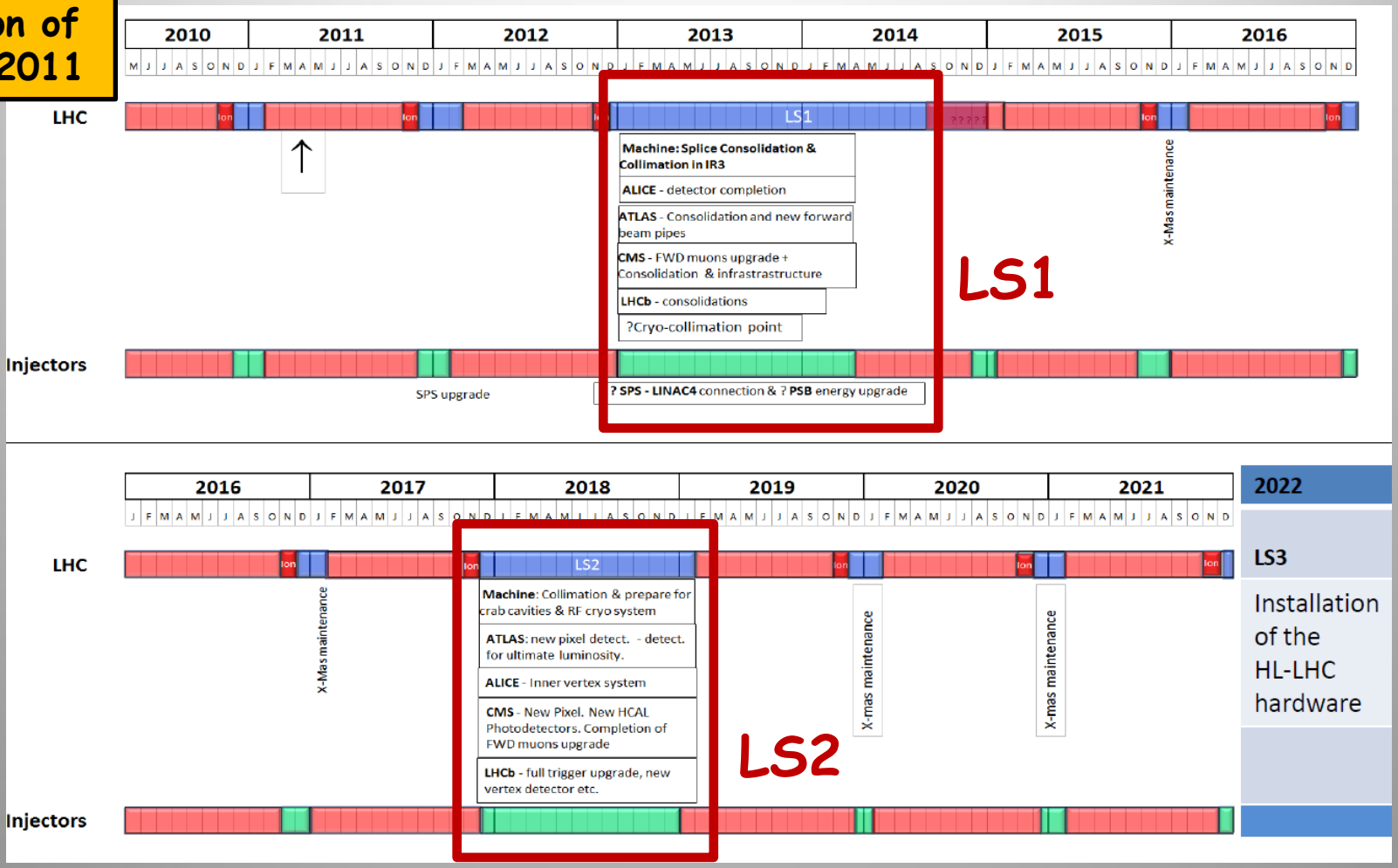


The CMS Forward Muon RPC system consists of 3 endcap disks and is equipped with chambers up to |η|=1.6, while the CMS Muon Technical Design Report describes a system with 4 stations and a detector up to |η|=2.1

STAGED →	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2

LHC Plan – Long Shutdowns

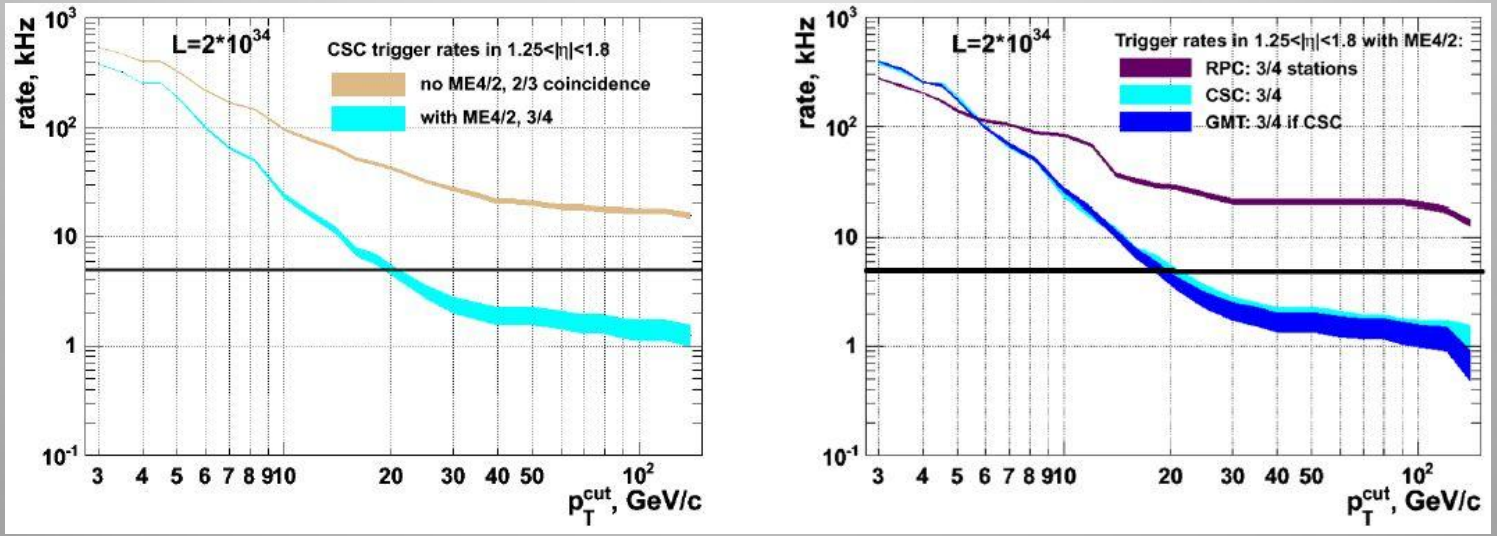
Version of June 2011



LHC Phase-I (2009-2021) : up to 2.2 x nominal luminosity
LHC Phase-II (2022-2030?): "High Luminosity LHC"

Phase-I Upgrade of CMS Muon System

By 2015, the luminosity will reach $10^{34}cm^{-2}s^{-1}$. The in-time pileup will be right at the edge of the CMS design envelope and will present special challenges for the Muon System to trigger on muons with high tranverse momenta, which represent one of the key indicators of interesting electroweak interactions



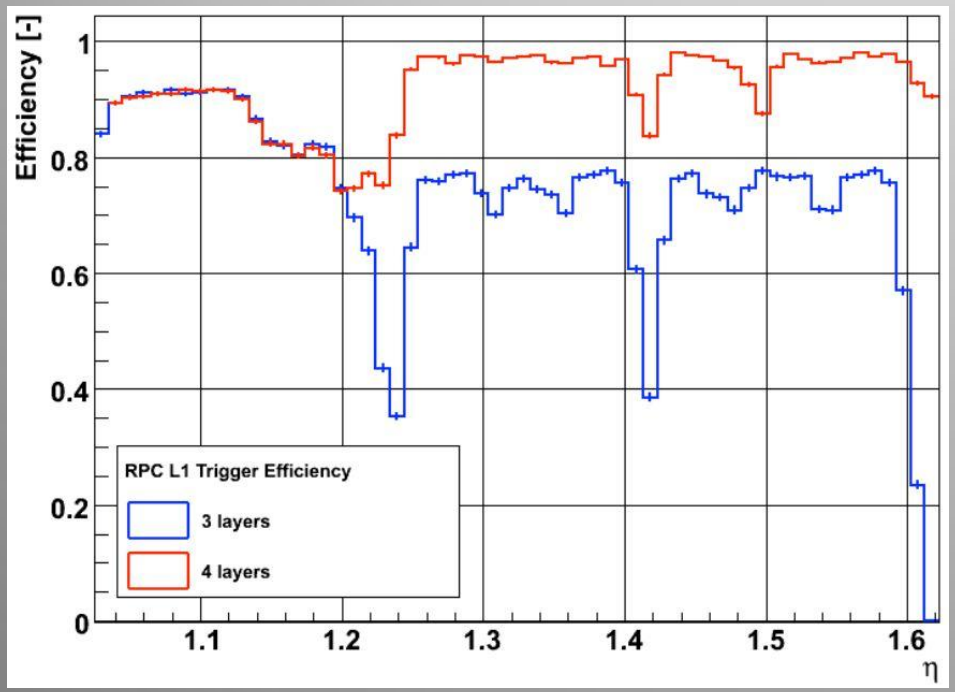
4th endcap station (CSC and RPC) required to move to a "3 out of 4" logic to maintain low trigger thresholds at high lumi

RPCs are needed for finer timing and redundancy of CSCs, improving muon reconstruction

RPC Endcap Upgrade

RPC upgrade activities :

1. The addition of a 4th layer of RPCs to extend coverage to $|\eta| = 1.6$ to preserve a low P_T threshold for the Level 1 Muon Trigger at high instantaneous luminosity
2. R&D to develop detectors that can extend coverage to the region $1.6 < |\eta| < 2.1$ or even higher. Possible technologies include RPCs optimized to handle high rate (*) or Micro-Pattern Gas Detectors

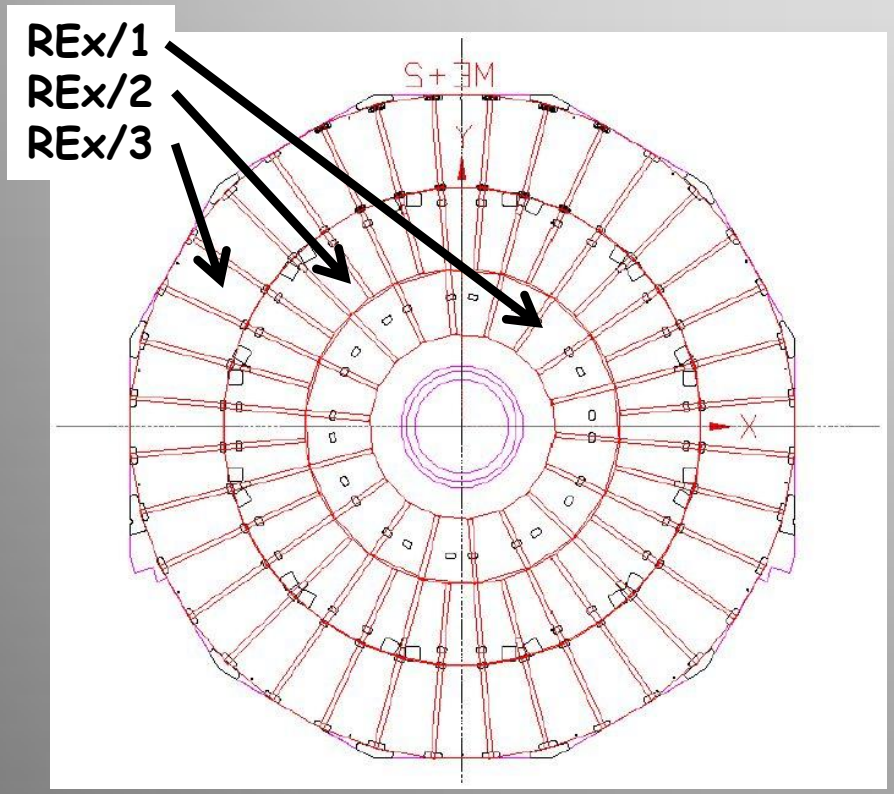


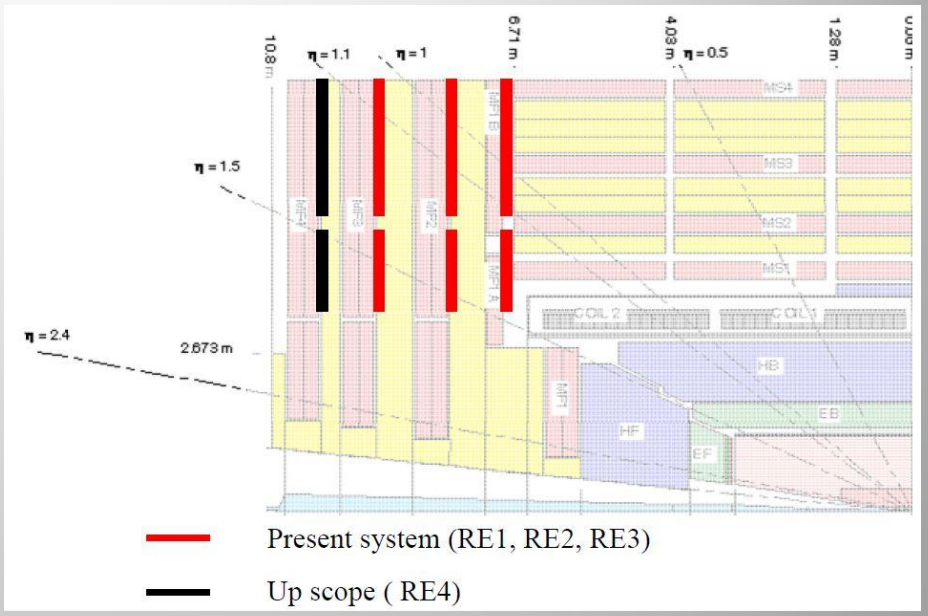
Simulated RPC L1 Trigger Efficiency for the present system with 3 layers, compared to a system with 4 layers

(*) Also check :
• Phenolic Multigap RPCs for High-Rate Particle Triggers in the CMS Experiment (K.S. Lee)

RPC Upgrade Step 1

Install 4th layer of RPCs during LHC LS1 (2013-2014) with detectors up to $|\eta|=1.6$.





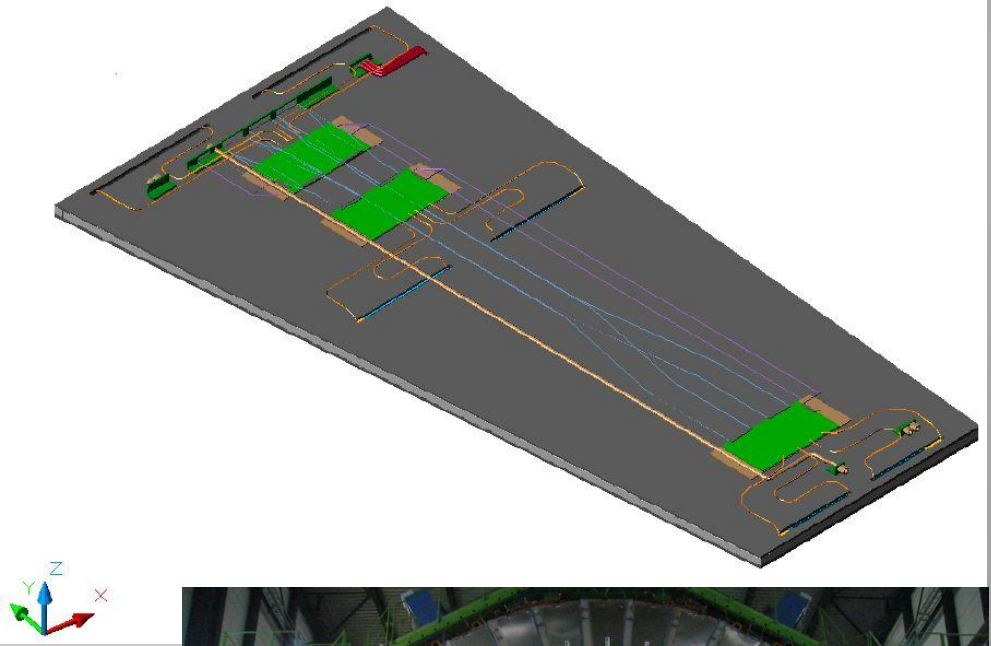
- 2 x (2 x 36) = 144 new chambers (RE4/2-3) needed to install 2 RE4 stations

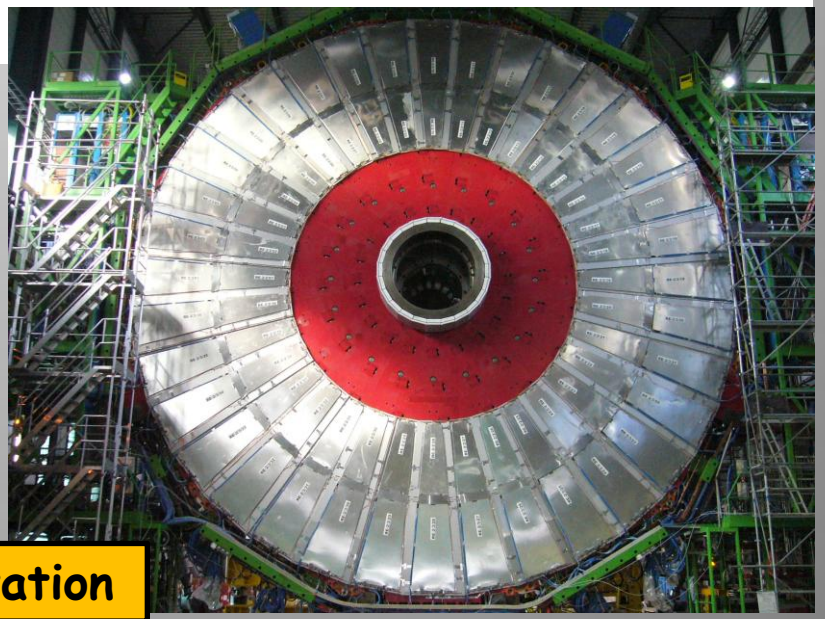
- Similar design as for existing endcap chambers, ie. 200 chambers will be build in total, including production of spares

Chamber Layout

Detector unit consists of :

- 3 HPL gas gaps
- readout strip plane
- 3 Front End Boards (FEBs), 6 Adapter Boards and 1 Distribution Board
- honeycomb support and protection box
- FEB support and screen box
- water cooling circuit
- detector gas circuit

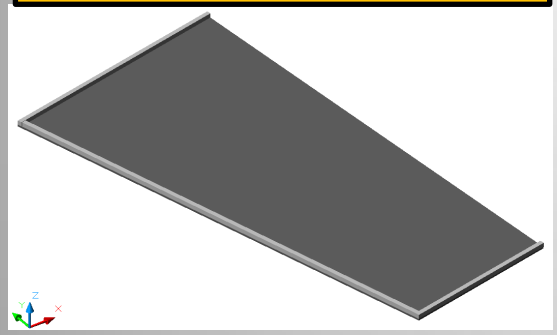




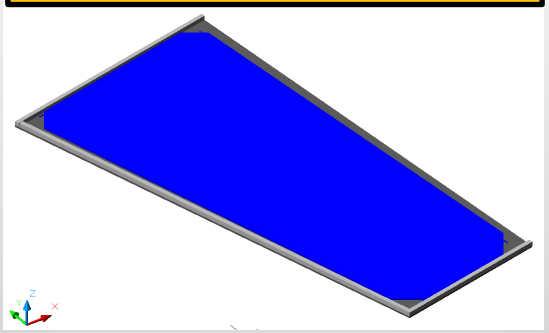
RE2 station

Crash Course in RPC Assembling

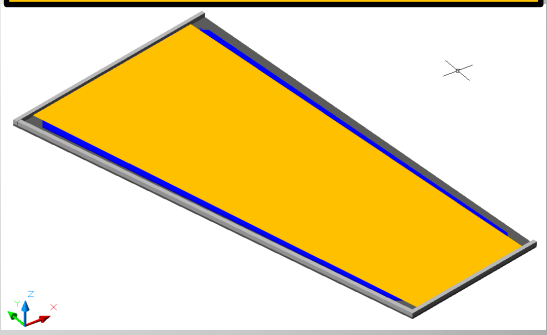
1. bottom honeycomb box



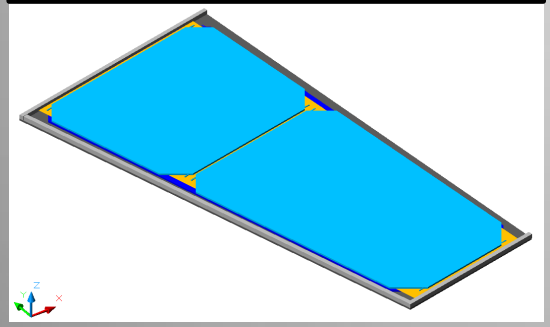
2. bottom gas gap



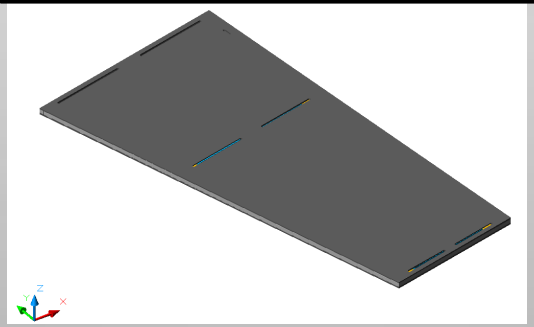
3. readout strip pattern



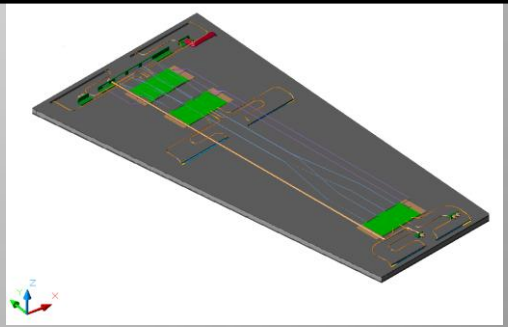
4. two top gas gaps



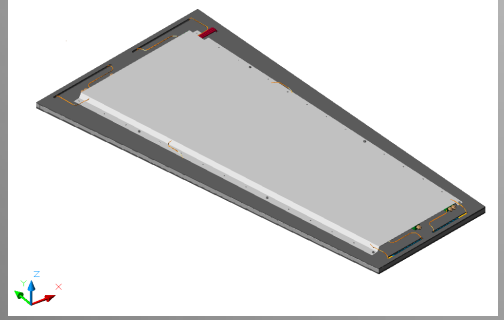
5. top honeycomb box



6. services & electronics



7. screen box



+

- Quality control of all components before assembly
- Quality control of assembled chambers

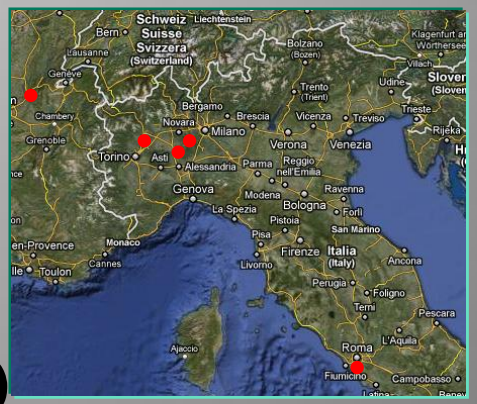
HPL Production

- New supplier of High Pressure Laminate (HPL) : Riva-Puricelli-GT firms (Italy) ; 600 foils of 1620 x 3200 mm^2 are needed for a total of 3421 m^2 (including 50% contingency)

- Well-defined industrial procedure for HPL high efficiency production fulfilling detailed CMS technical specs:
  - high uniformity in resistivity (inside each panel and panel-to-panel)

- Detailed specs on dimensions of sheets, surface quality, resistivity values … require HPL resistivity values within 1-6x10^{10} Ωcm @ 20°C

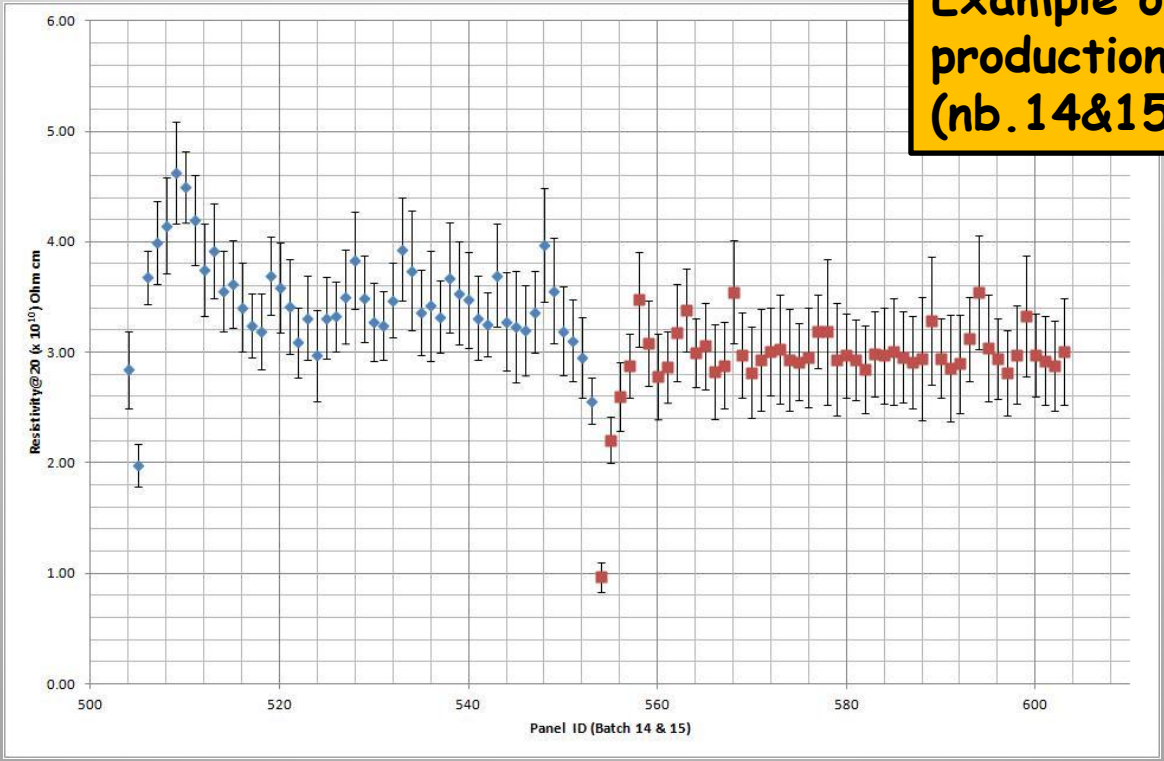
- HPL production line:
  - production at Puricelli (Milano)
  - QC at Pavia INFN
  - cutting at RIVA (Milano)
  - surface cleaning at General Tecnica (Frosinone)



HPL Measurements

- HPL Resistivity measurements done at Pavia University/INFN
- Resistivity average and spread (out of 9 measurement positions) for each panel :

Example of two recent production batches (nb.14&15)



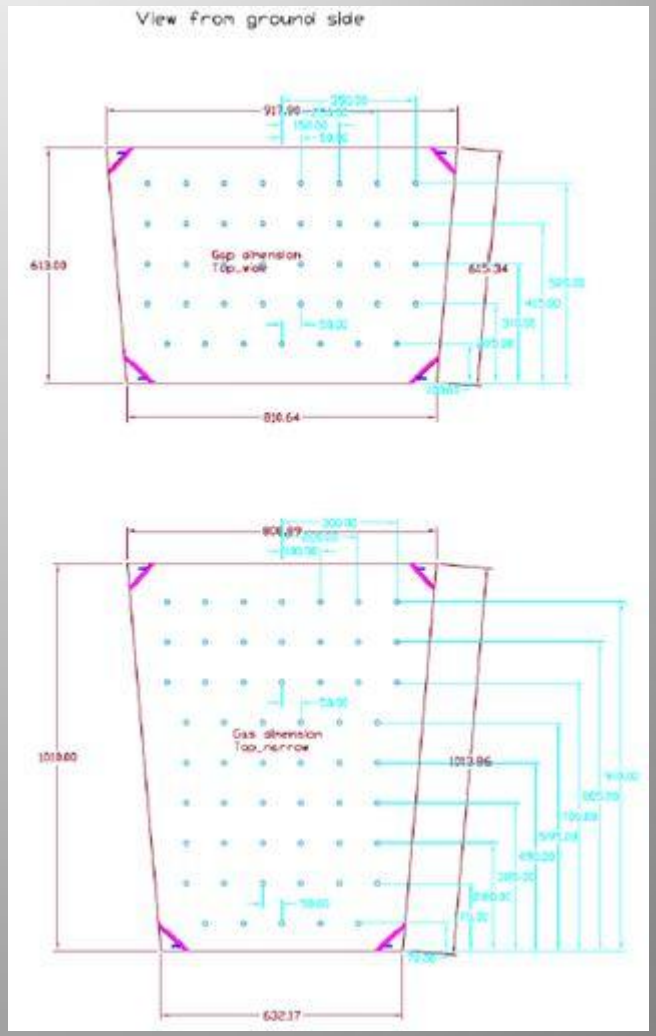
Latest production batches of high quality:
in each batch 50 panels produced in one go,
ALL with stable and uniform resistivity values inside CMS specs

Gas Gap Production

- Production of about 700 gas gaps at KODEL (Korea)

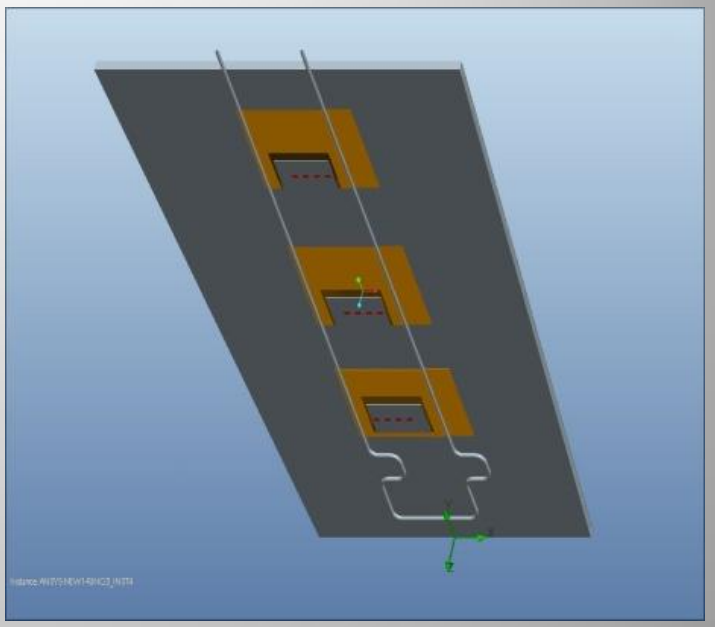
- Pilot production with "out of specification" HPL panels already achieved to re-start tools and procedures

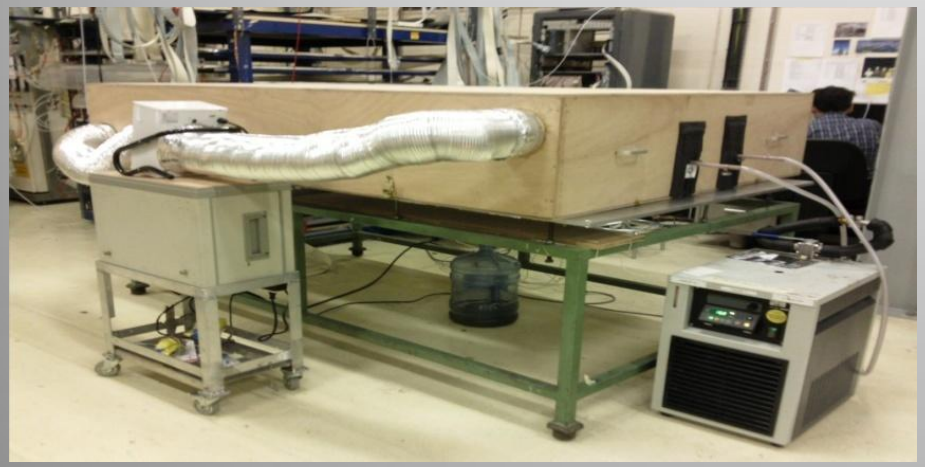
- Very accurate (with respect to the past) formalization of the technical specifications and QC protocols at KODEL

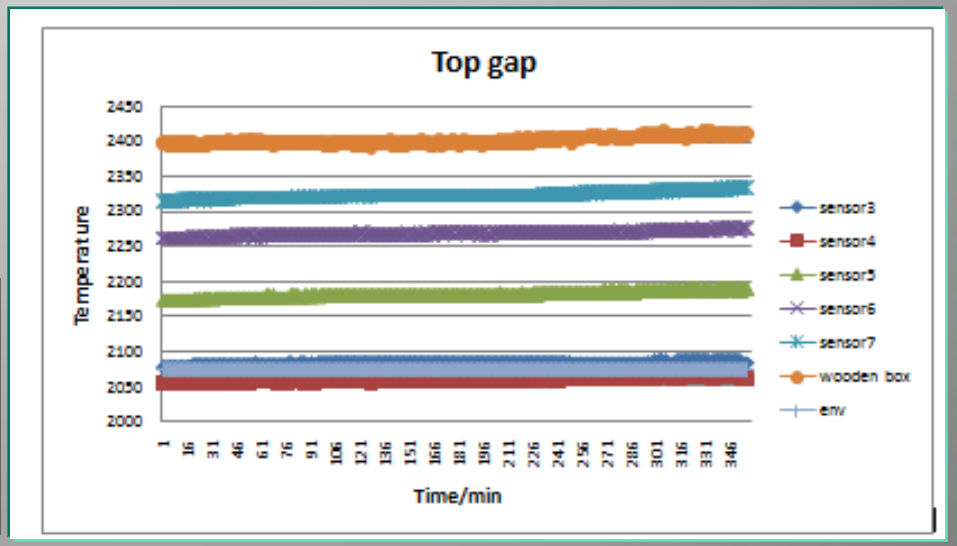


Revisiting Cooling Scheme

- RE4 chambers will face the CSC electronics; temperature effects could be important
- Improvement in the water cooling Cu circuit introduced to better stabilize chambers





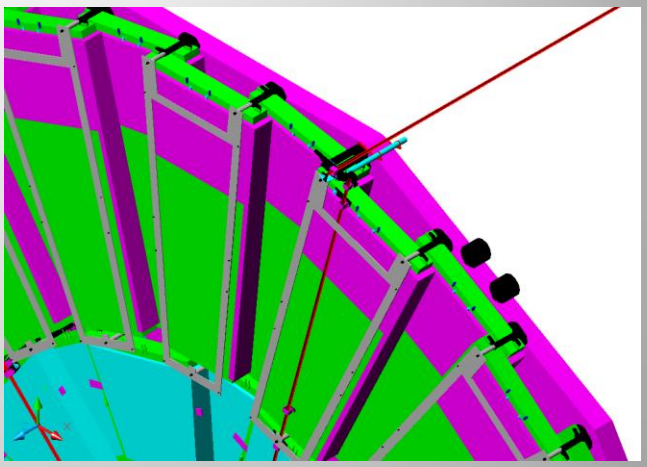


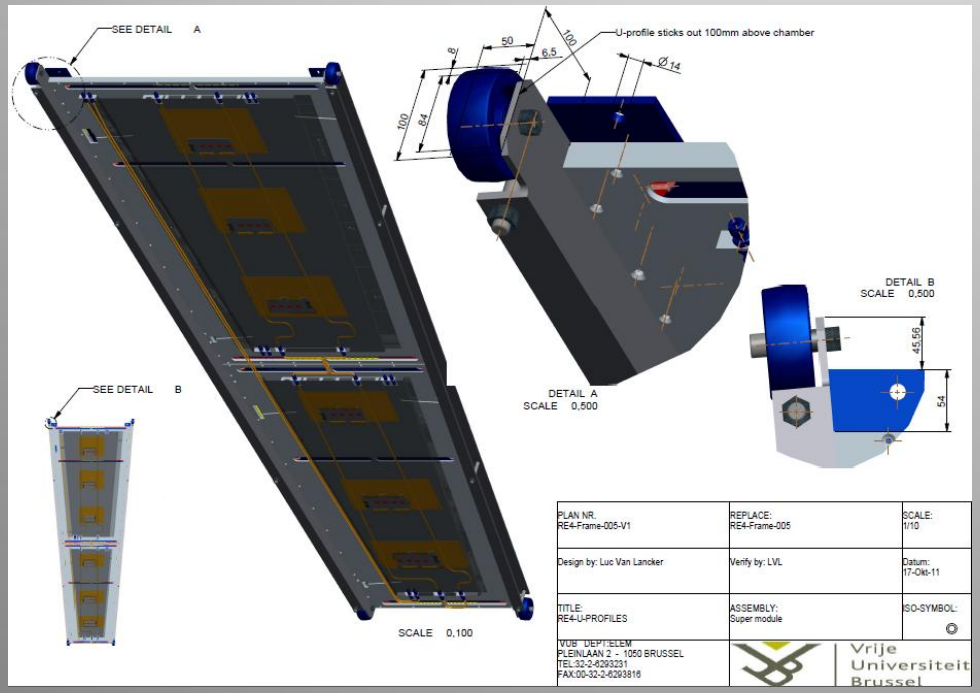
Extreme example :
- box temperature 24°C
- cooling temperature at 18°C

T_{gap} < 24 °C

RE4 Super Modules

- New chambers will be attached on CSC mounting posts on the back of YE3
- RE4/2 and RE4/3 will be pre-assembled in RE4 super modules with a handling frame
- Super modules cover a 10deg sector and should ease and speed up installation in CMS detector





Detector and Trigger Electronics

- Pakistan committed to procure
  - ❑ 650 Front End Boards
  - ❑ 250 Distribution Boards
  - ❑ 1350 Adapter Boards
  - ❑ Coaxial signal cables from readout strips to FEB

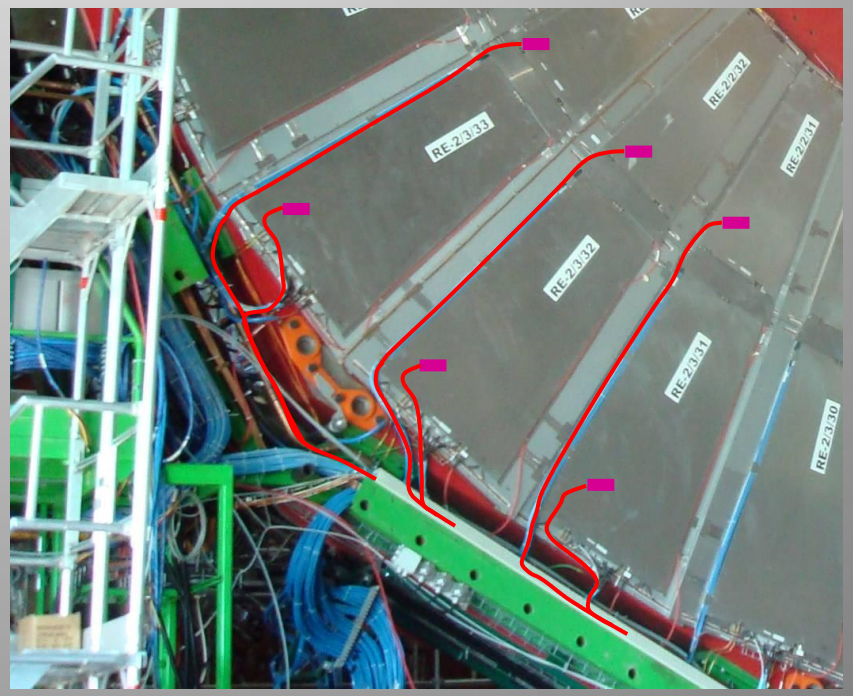
- New design of Link Board (LB) and Control Board (CB) for trigger is ready (INFN)
  - ❑ LV Regulator LHC4913 now on board for protection
  - ❑ CB includes CCU ring (Communication and Control Unit) protection circuit
  - ❑ prototypes were produced and tested

Temperature Monitoring

- **Working point of present system depends strongly on temperature**; need to keep temperature inside 21-23°C

- Each endcap chamber will be equipped with one **Fibre Bragg Grating (FBG)** sensor for temperature measurements; these sensors are radiation hard, insensitive to magnetic field, precise, no electrical noise, ease to install, minimal cabling and costs similar to the conventional sensor (Conventional sensors cannot be used because of cable routing space limitations)

One T-sensor per chamber, ie. 72 sensors per RPC station; will equip the full endcap



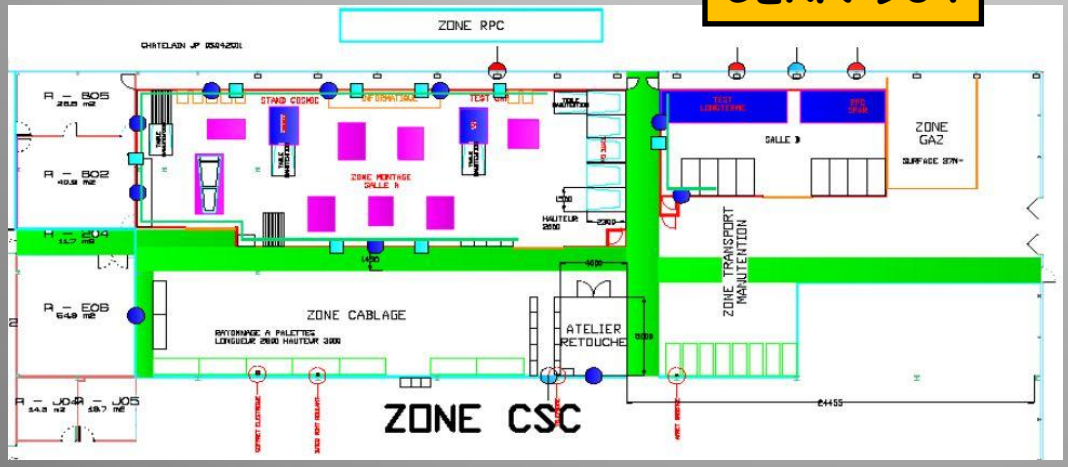
Assembly Sites

- The chamber production and quality control will be shared by three different sites : BARC/PU (India), UGent (Belgium) & CERN; additional 50 spare chambers will be assembled at CERN

- All sites will use common technical specifications and protocols for the chamber production and quality control

BARC/PU

CERN 904



UGent

Quality Control

Very detailed Quality Control protocol put in place for all components and chambers; most labor intensive part of the assembly

QC1 : Chamber components validation

QC2 : Gas Gap certification

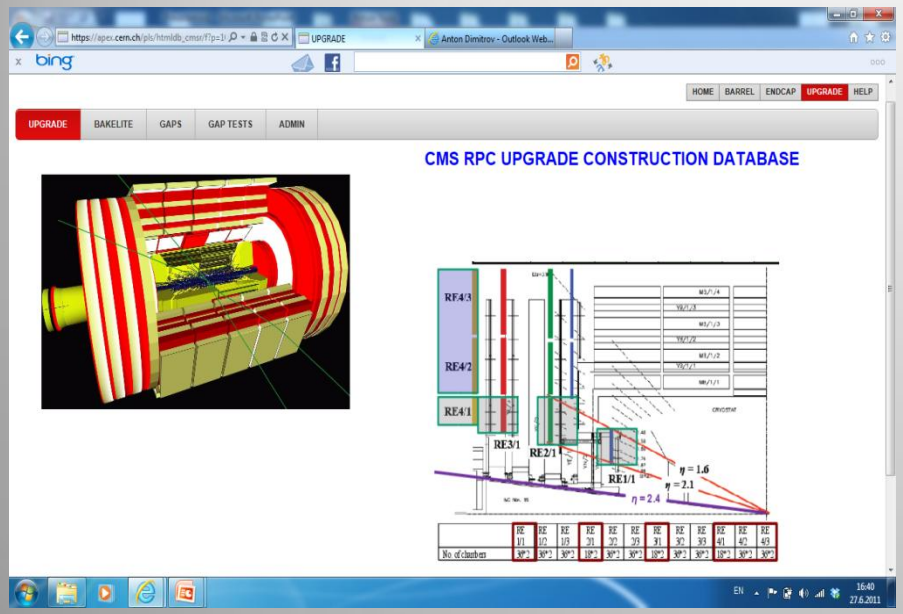
QC3 : Chambers tests at assembly sites

- QC3_A Chamber assembly validation
- QC3_B Tests on Cosmic stand

QC4 : Chamber reception and acceptance at CERN; Super Module assembly and final tests before shipment to CMS cavern

QC5 : Installation and commissioning in CMS detector

Upgrade Construction Database

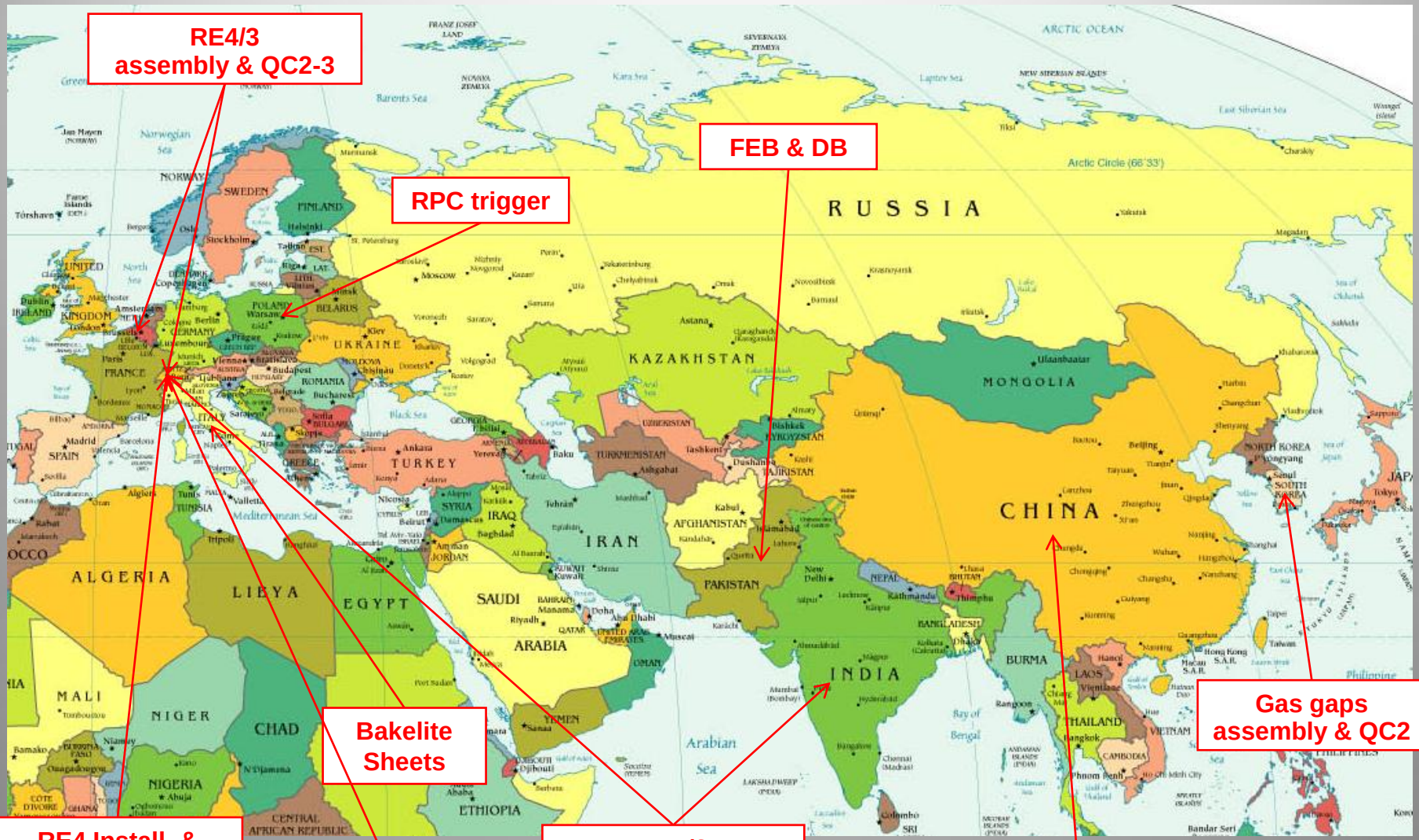


Oracle central database with web interface

Will store the full history of each chamber & component

- **Construction period:**
  chamber components, resistivity, conditioning, QC results
- **Cosmic test period:**
  efficiency, cluster size, noise, occupancy
- **Commissioning period:**
  current monitoring in time, noise
- **CMS operation period:**
  efficiency, cluster size, noise, dark current

The Fantastic Journey of the CMS RPCs...



Project Finances

- Total cost of CMS Phase I upgrade estimated at 64.4 MCHF

- Total cost of RPC Upgrade step 1 project estimated to be about 4.1 MCHF
  - ❑ Largest cost items are chamber components & new services in CMS cavern

- Costs of RPC upgrade project are shared by participating groups : Belgium, CERN, China, Colombia, Egypt, Finland, India, Italy, Korea, Pakistan

Summary & Outlook

- With the addition of a 4th endcap station CMS will upgrade its RPC system to be ready for the nominal LHC Phase I operating conditions

- 200 new RE4/2-3 Bakelite based chambers will be constructed in 2012-2013 and should be installed in CMS during the upcoming Long Shutdown I in 2013-2014

- Project preparations have largely been completed; all chamber components are under production; chamber assembly and quality control will start in Belgium, CERN and India in the next few months

We look forward to R&D projects for the RPC high-η upgrade during Long Shutdown II

Backup Slides

RPC Trigger / DAQ Electronics