Overview of Korean Activities for the CMS Heavy Ion Program

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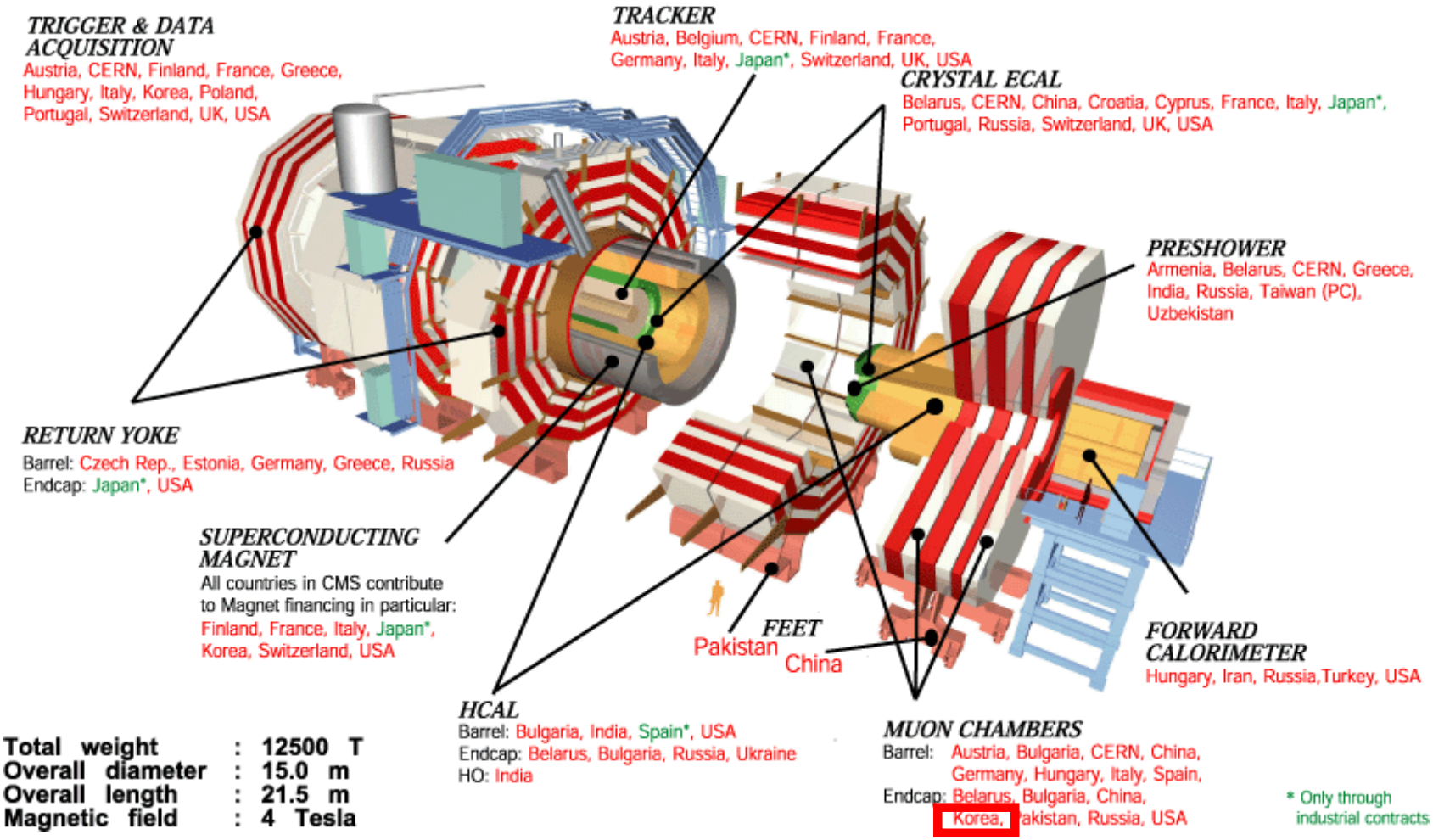
Korea University

Contents

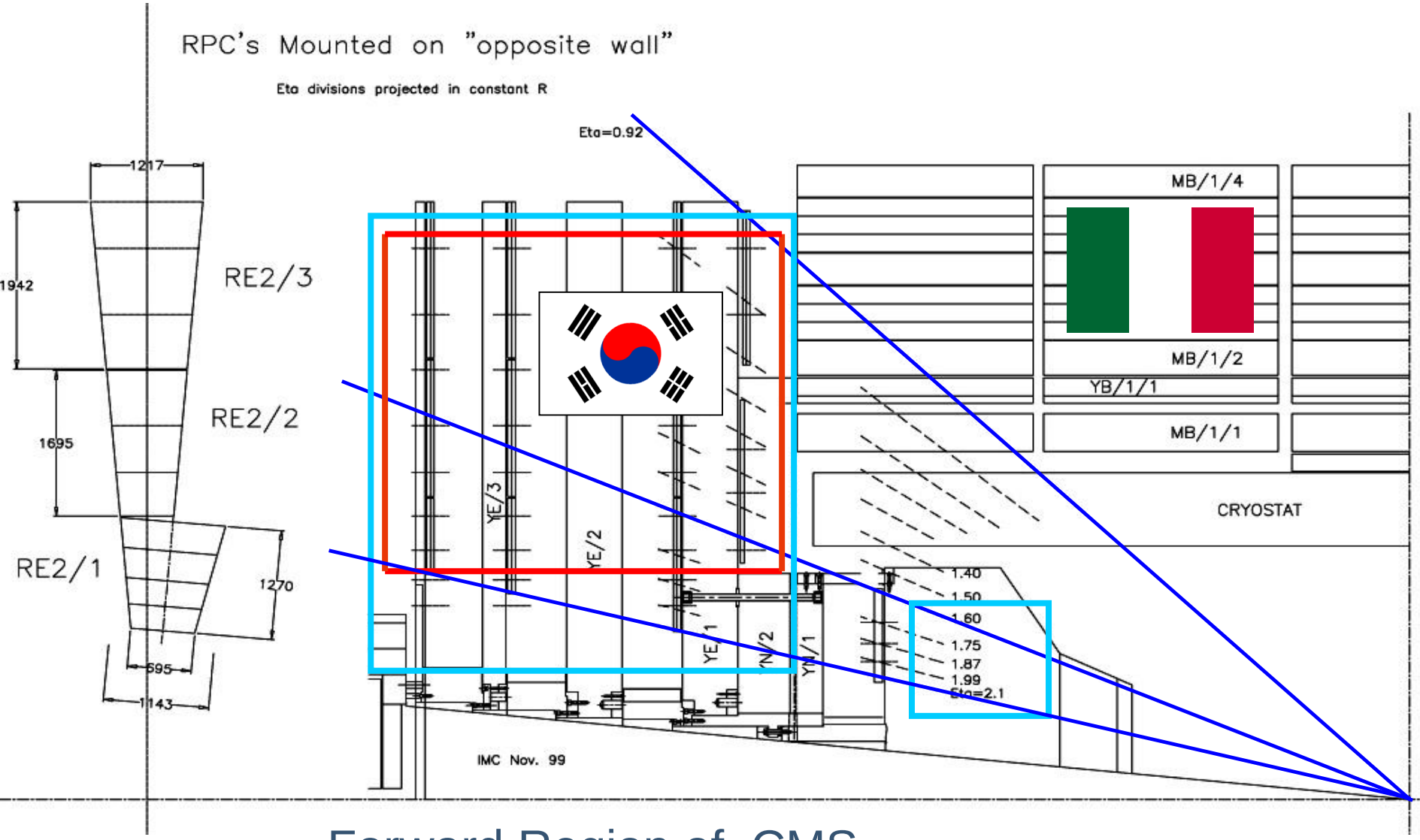
- Hardware contribution
  - CMS endcap RPC production
- Software contribution
  - Heavy-quark productions
- Computing contribution
  - Tier2 center dedicated to CMS Heavy ion program
- Summary

Korean RPCs in CMS

The nuclear & high-energy physics groups of Korea University have been active members of the CMS (Compact Muon Solenoid) of LHC at CERN since 1997.



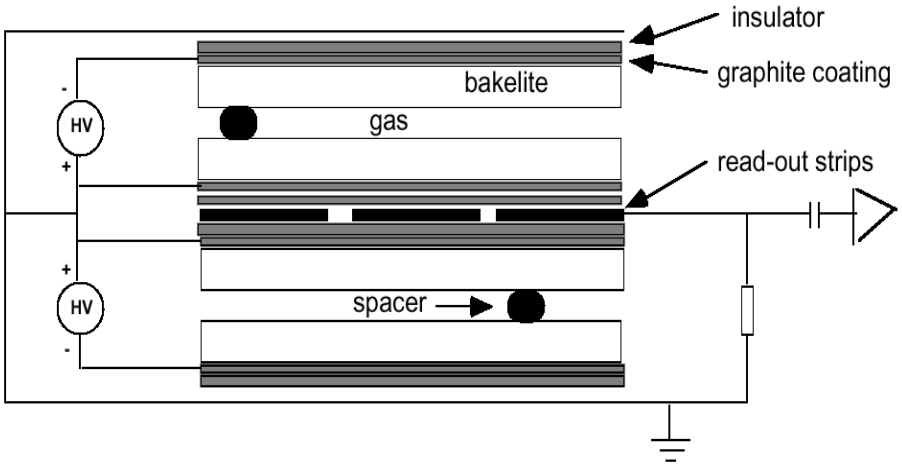
Korean RPCs in CMS

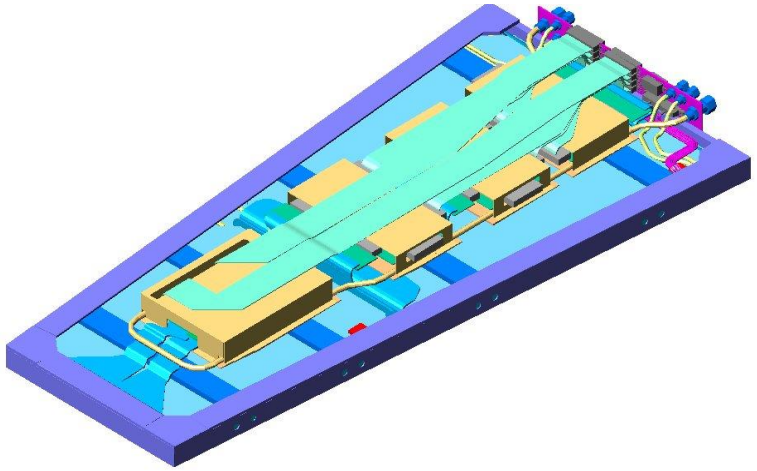


Forward Region of CMS

CMS Endcap RPCs

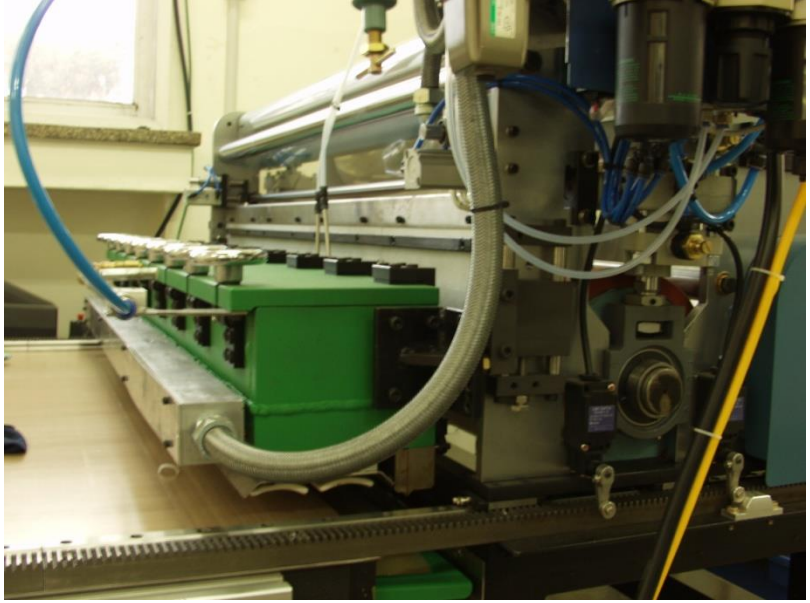
1. **Function : L1 muon triggers**
   - 2 wings (RE+, RE-)
   - 4 stations (RE1, RE2, RE3, RE4)
   - Pseudo rapidity coverage :
     - $0.9 < \eta < 2.1$ (1.6)
   - η segmentations : 10 (6)
2. **Total # of RPCs : 756 (432)**
   - Total # of FEBs : 2,268 (1,296)
   - Total # of channels : 85,248 (41,472)
3. **By March 2007,**
   - the gap production for phase I ($0.9 < \eta < 1.6$) was completed for the first operation of CMS in 2008.

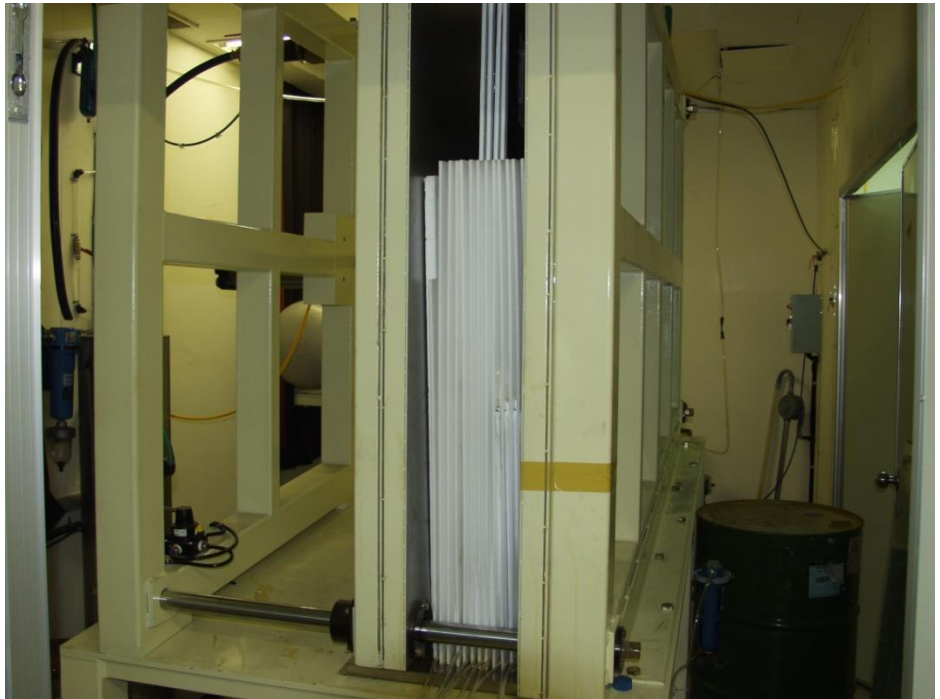




A Brief History

1. Fundamental studies to develop the endcap RPCs (1997~)
   1) Beam tests by using high intensity muon beams at CERN
   2) Cosmic muon tests at Korea Univ.
   3) Long term aging studies by γ's and neutrons at Korea Univ.
2. Design of double gap RPCs for the endcap region (2000~2003)
   1) Chamber designs
   2) Services for HV, LV, gas, electronics on the chamber level
3. Manufacturing the production facilities at Korea Univ. (2000~2003)
   1) Gap and chamber production facilities
   2) Testing facilities for the quality control
4. Mass production of the endcap RPCs (2004~)
   1) Phase I production ($0.9 < \eta < 1.6$, total 432 gaps) was completed.
   2) Phase II production ($1.6 < \eta < 2.1$) is expected to start this year.



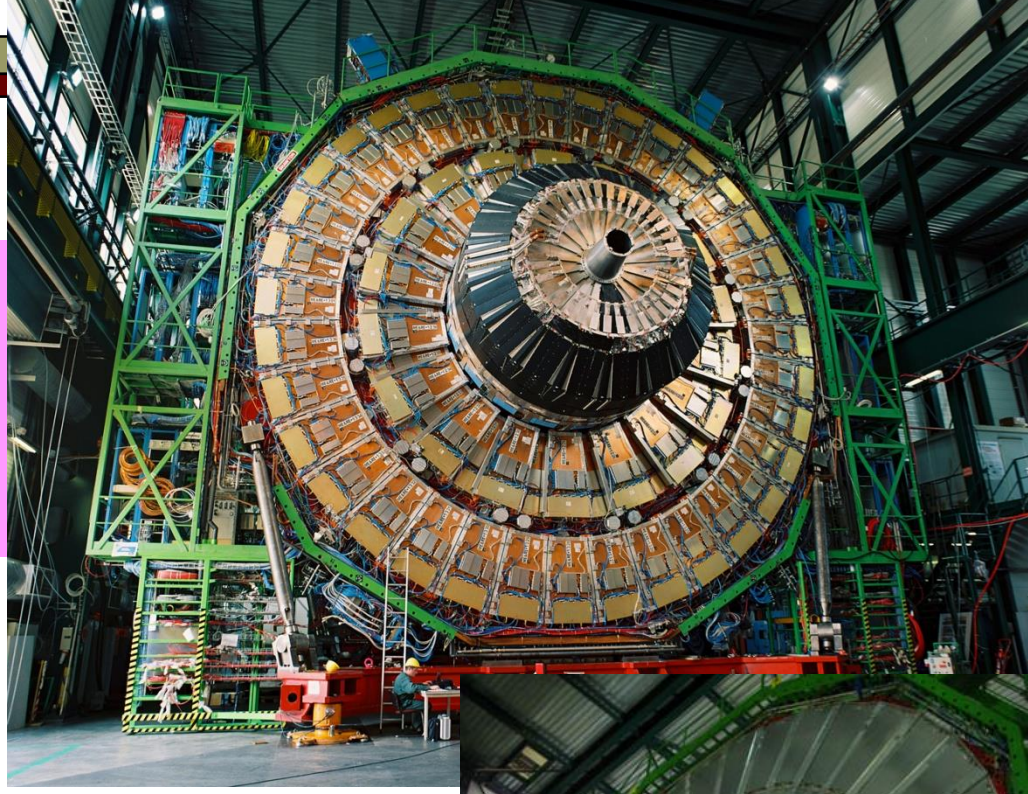


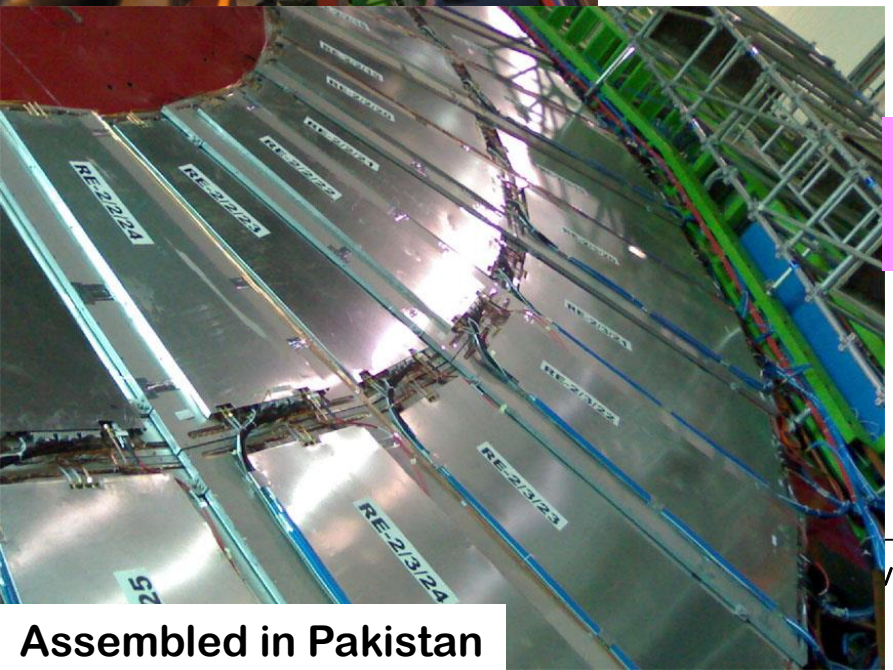
Performance of Korean RPCs

Characteristics	CMS Requirements	Test Results
Time Resolution	< 3 ns	< 1.5 ns
Efficiency	> 95 %	> 95 %
Rate Capability	> 1 kHz/cm^2	> 1 kHz/cm^2
Noise Rate	< 15 Hz/cm^2	< 10 Hz/cm^2
Plateau Region	> 300 V	> 400 V

Assembled by Chinese at CERN

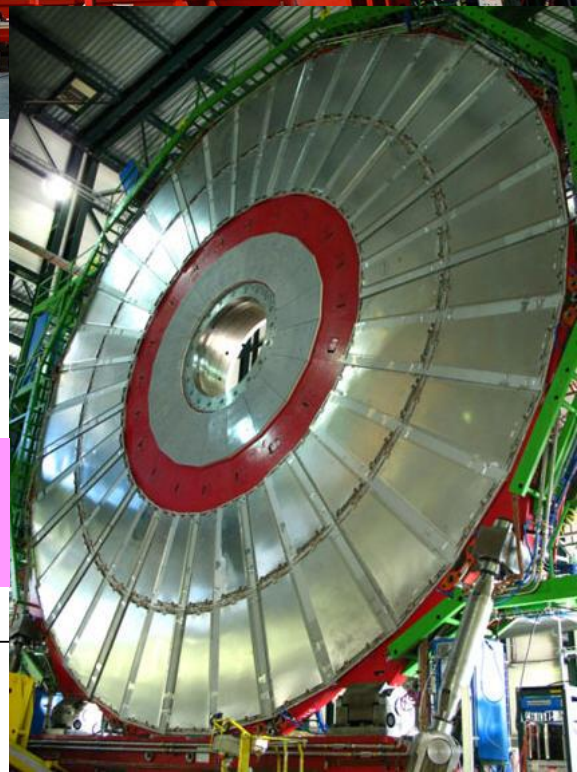
RPC1+ CSC1 on YE1 (front)





RPC2 on YE1(back)

RPC3 on YE3



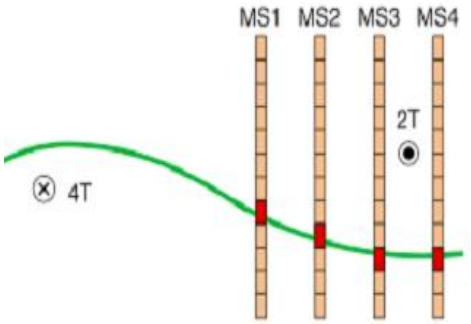
yy-Ion Meeting

Assembled in Pakistan

Phase II of Endcap RPC

1. Purpose

- Restore the full endcap RPC system as described in the TDR (LHCC/97-32)
- Extend the phase I endcap RPC system to $|\eta|$ = 2.1 with 4 trigger stations
- RE1/1, RE2/1 and RE3/1 RPCs in 1.6 < η < 2.1 (no RE4/1)
- Among them, RE1/1 has the highest priority



2. Plan by the end of 2009

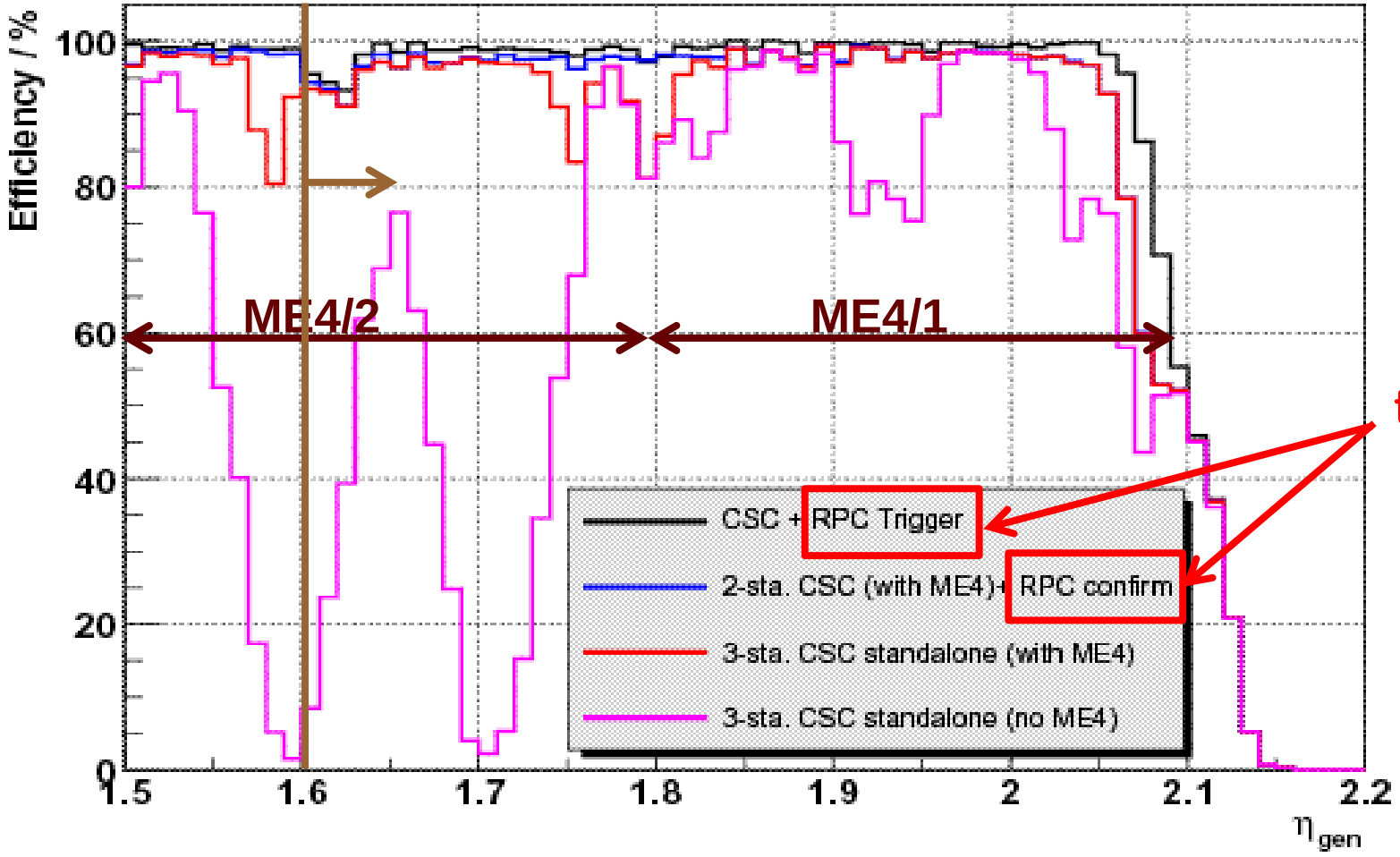
- Get the YE4 shielding walls to support station RE4
- Move the current RE2/2 and RE2/3 RPCs to the RE4 station
- Build the 5th RE station (additional RE2 layer)

  - to reduce the background and noise

3. How many RPCs do we need?

- Double layer RE2/2(144), RE2/3(144), and RE2/1(72) RPCs

Muon Trigger Efficiency

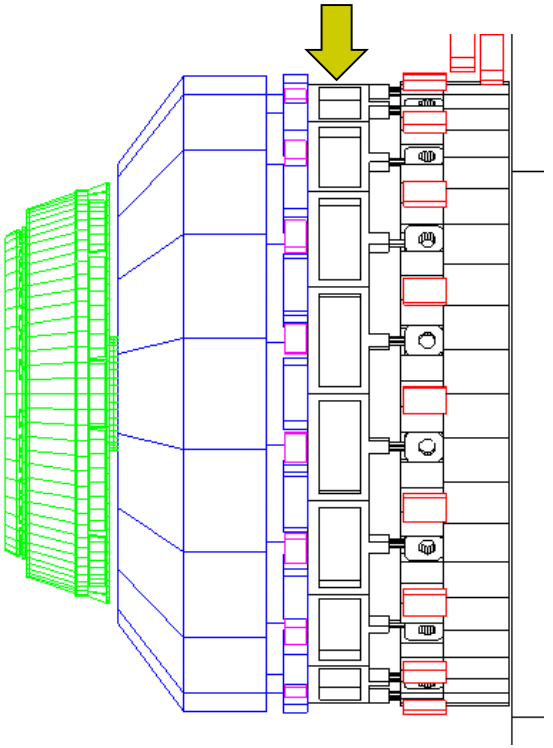


RE1/1 R&D

1. More compact (thinner + smaller)
   - Thinner co-axial cable
   - Gluing thinner copper sheet with spray
2. More complicated
   - Soldering area is very small
   - Inside structure of the gas distribution box
   - Complicated overlapped region
3. Higher particle rate
   - Check if the particle rate > 2 kHz/cm^2
   - Current 3 board (96 channels) configuration was modified to the 4 board (128 channels) configuration.

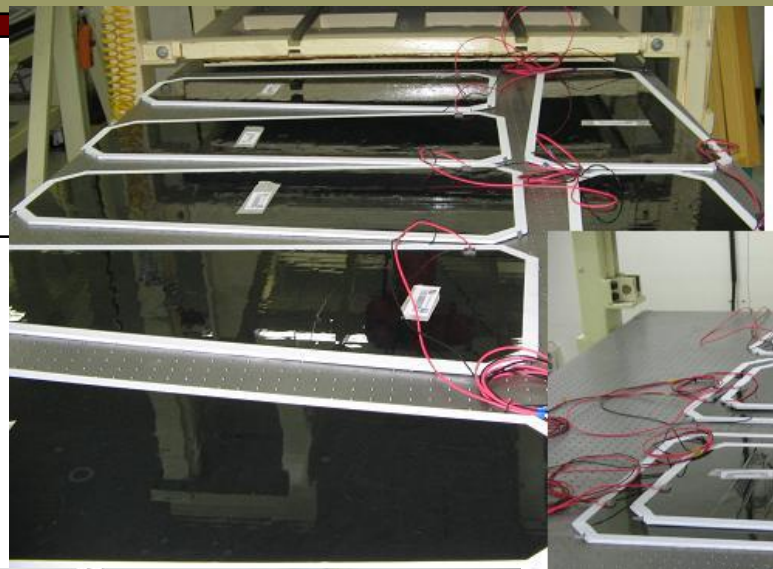
Insert in the endcap nose

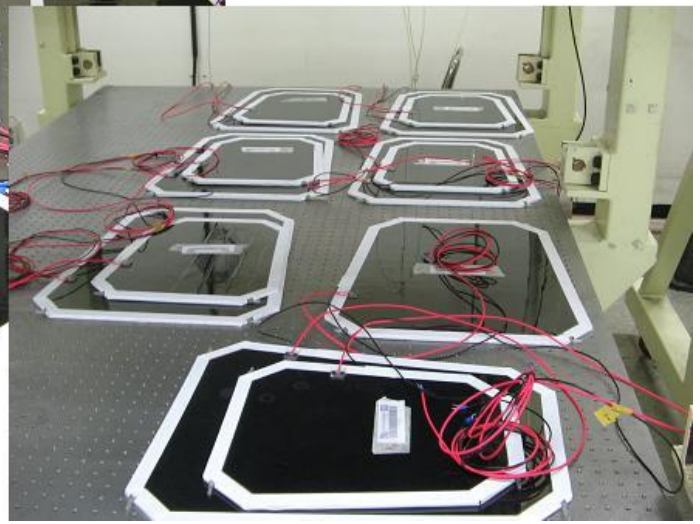
(only 96 cm available here)



RE1/1 R&D

Total 10 sets of RE1/1 gaps were constructed at KODEL (Dec. 2007).



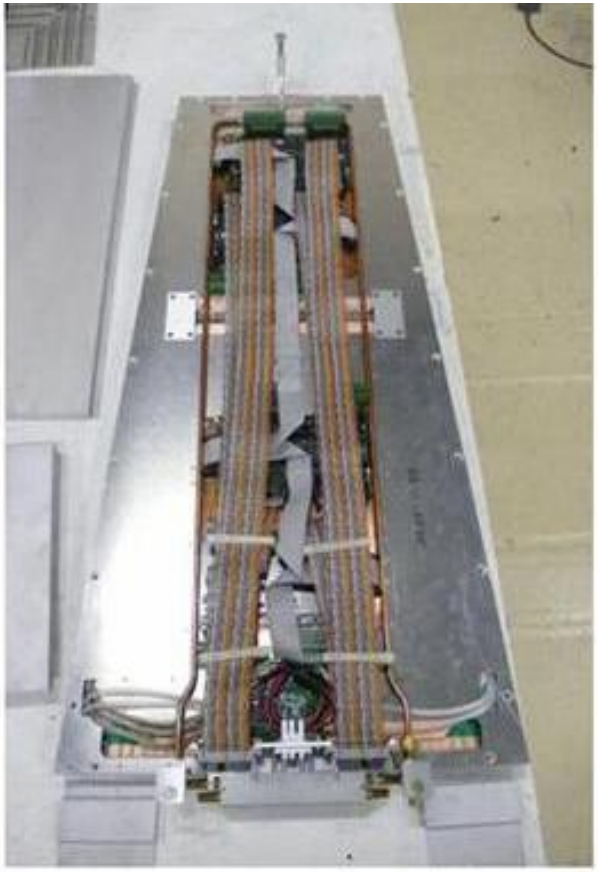


The readout strip panel for 4 sectors with 32 strips each, covering 4 η regions, were produced by etching.

RE1/1 R&D

Hyunchul Kim (Korea Univ.)

Covered by FEB shielding box

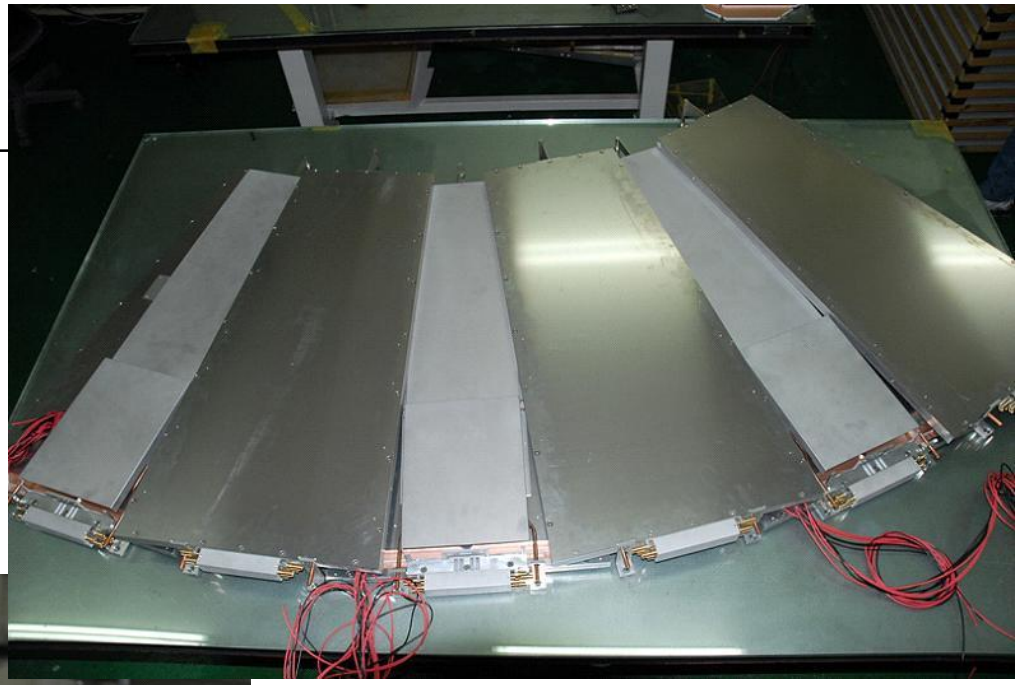


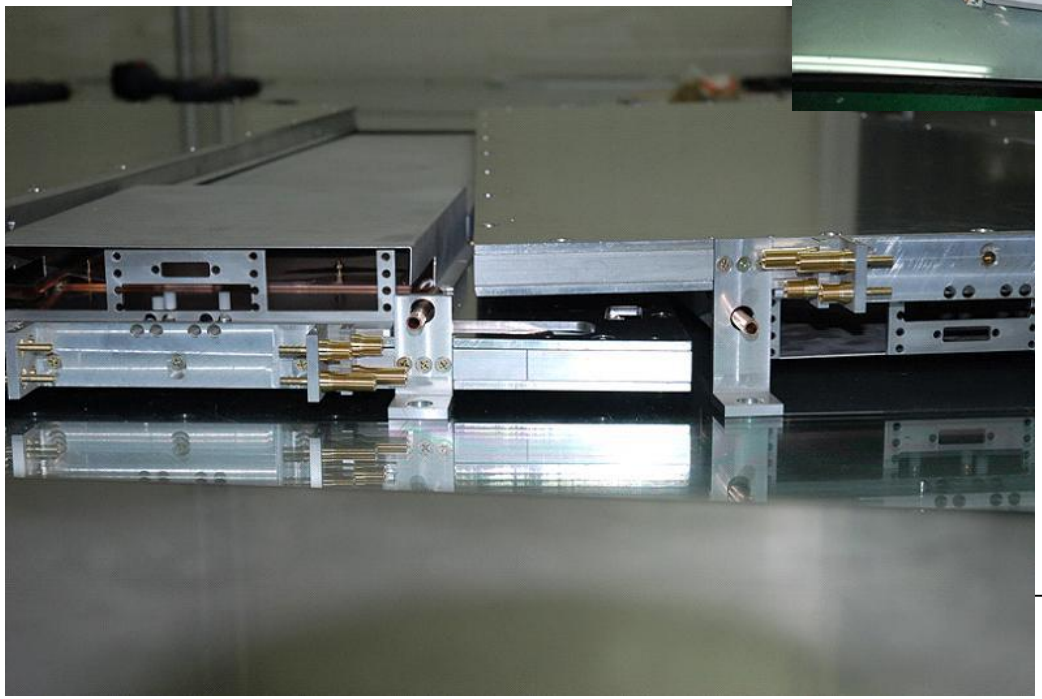
FEB flat cable layout

Signal cable layout

RE1/1 R&D

Check the configuration of 6 RE1/1 RPCs in the 60 degree sector

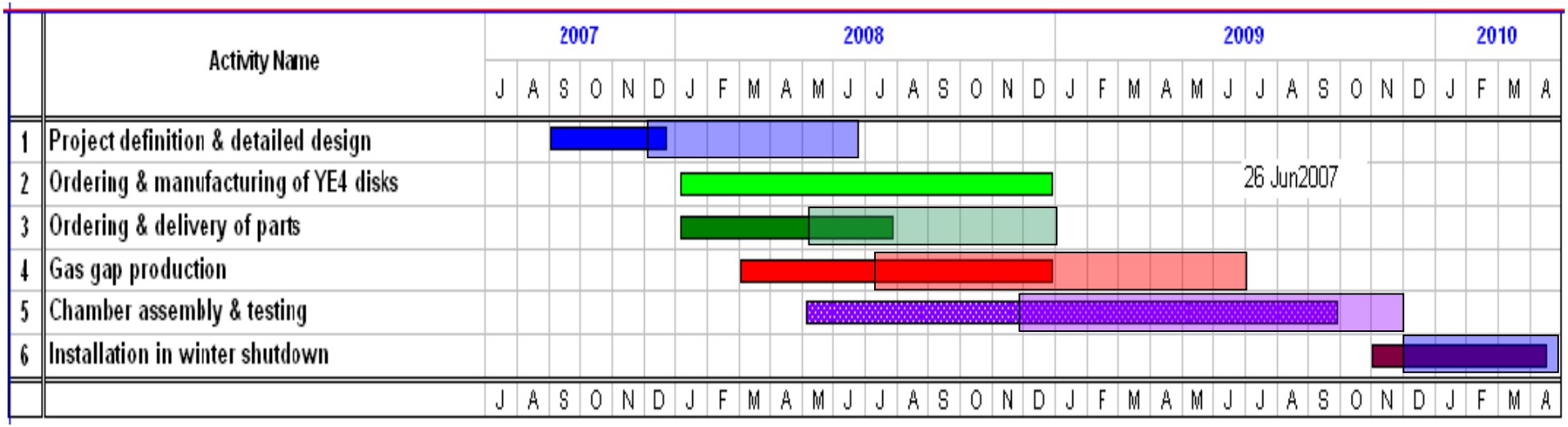




Check any interference among the cables, gas lines, and cooling lines in the overlapped RE1/1 region

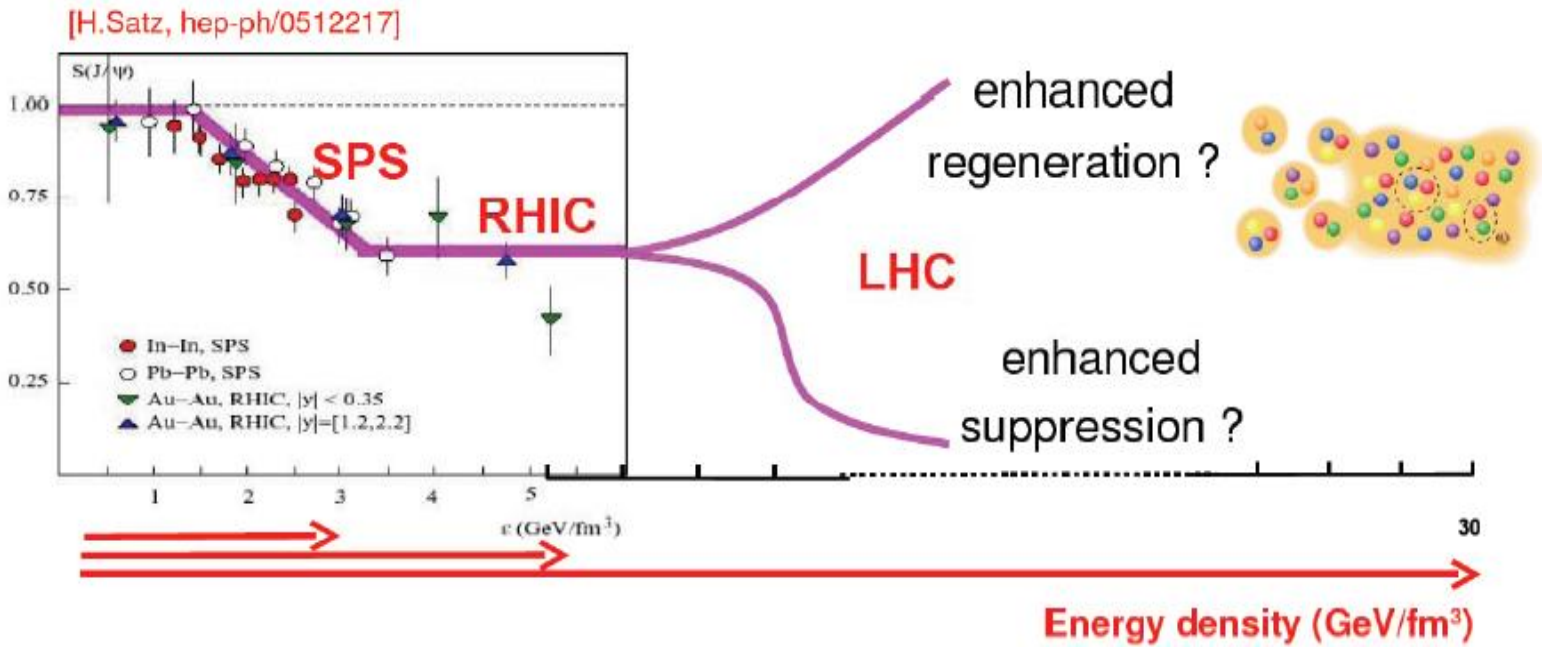
Schedule for Phase II Endcap RPCs

1. First 6 RE1/1 RPCs will be installed and ready for the first LHC beam test.
2. Design of the second layer RE2 will be ready by the end of June, 2008.
3. First delivery of the HPL from Italy in July 2008
4. Starting date of the gap production in July 2008
5. All gaps for the phase II RPC system should be built by June 2009.

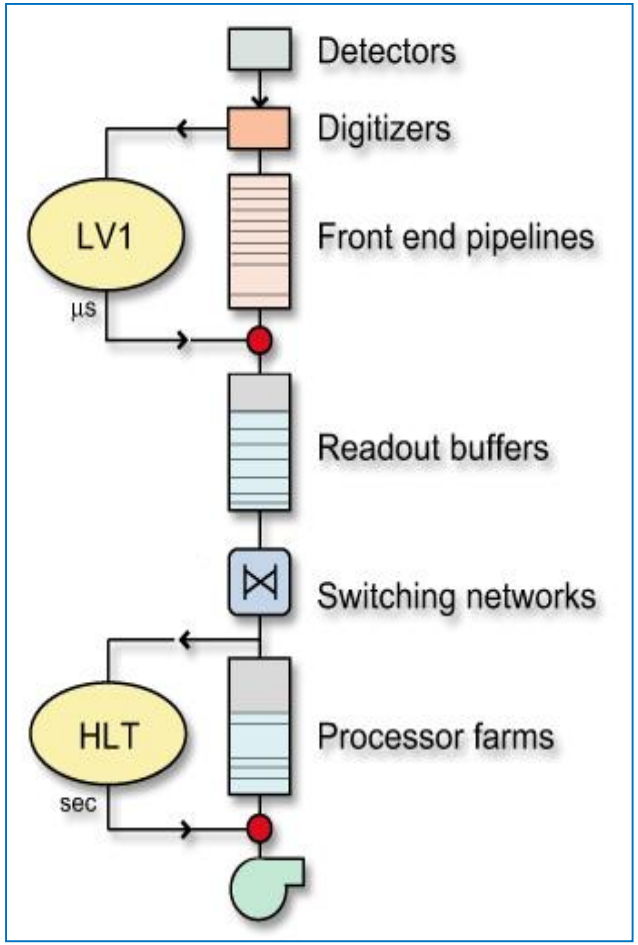


Software: Heavy Quark Production

- An interesting subject for the QGP formation
- Experimental probes
  - Quarkonium production
  - B-meson production via secondary J/ψ production



High Level Muon Trigger

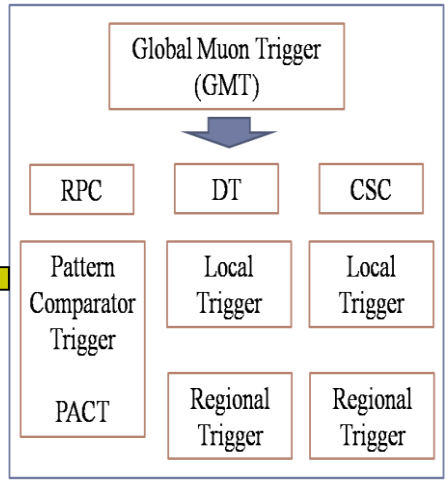


Raw events
1 GHz

L1
40 MHz

Single muon

$p_T > 5$ GeV/c



L2
100 kHz

Selecting the best trajectory among μ stations (standalone)

L3
100 Hz

Matching the muon chamber information and inner trackers

High Level Muon Trigger

(CMS IN 2003 – 002) tested the following 4 strategies based on ORCA

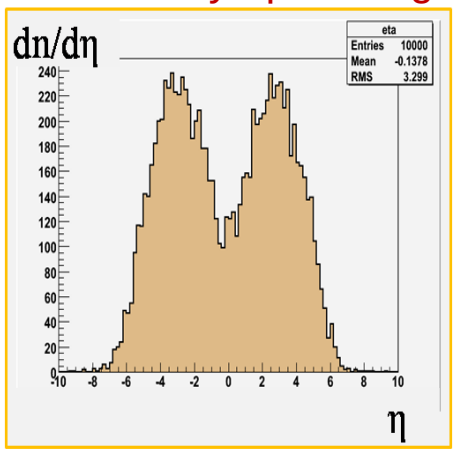
For the preselected muons in $|\eta| < 2.4$, decayed from J/ψ,

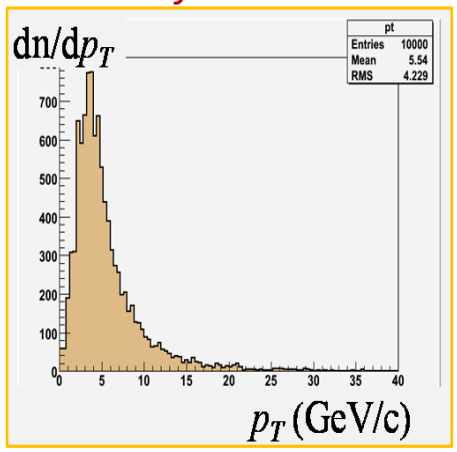
- Strategy 1: 2 opposite sign candidates with L1 only
- Strategy 2: 2 opposite sign candidates with L2 only
- Strategy 3: 2 opposite sign candidates with L1 & L2
- Strategy 4: 2 opposite sign candidates with either L1 or L2

Dongho Moon/Ji Hyun Kim (Korea Univ.) are testing them in the framework of CMSSW.

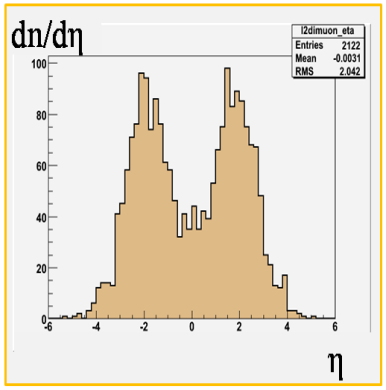
Performance of Muon HLT (an Example)

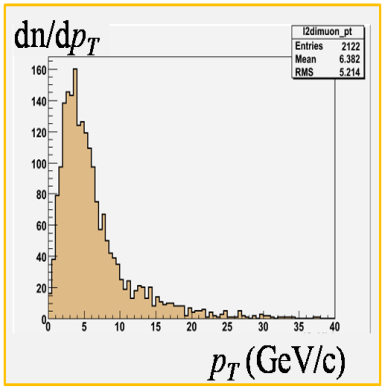
Primary upsilons generated by PYTHIA6



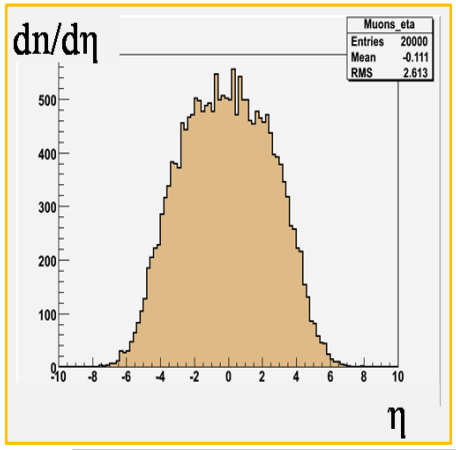


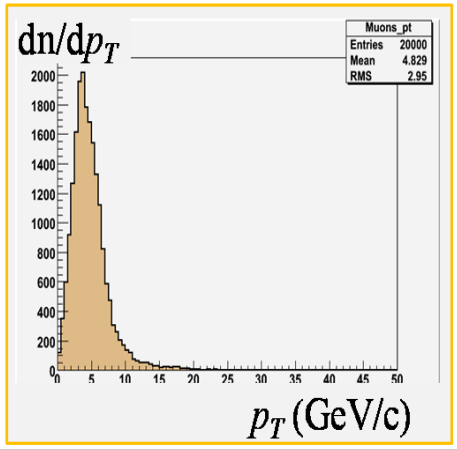
Strategy 2



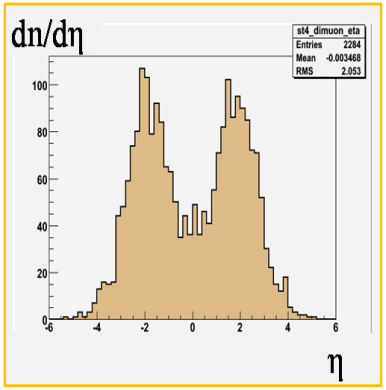


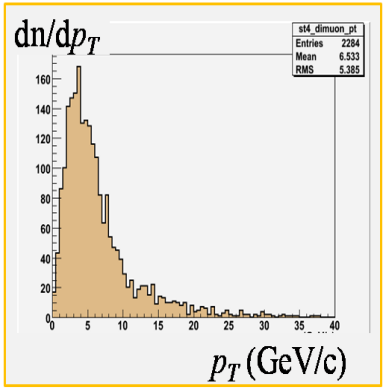
Decayed muons from primary upsilons





Strategy 4





CMS HI Computing

- Seoul Supercomputer Center(SSCC) was established in 2003
  - The center belongs to Seoul City, but located in the campus of Univ. of Seoul.
- Director: Inkyu Park + 6 Staffs + 3 Ph.D.
- Total of 256 CPUs + Giga switches + KOREN2

2007 upgrade

- + 10 Giga bps switch
- SE: Storage of 170 TB
  → 300 HDD of 500 GB
- CE: 128 CPU cores
  → MC generation
- + new 64 bit HPC
- + KREONET
- Operate OSG

- Interactive
  455 kSI2K
- Batch (CE)
  273 kSITK
- Storage (SE)
  172 TB

CMS Heavy Ion Tier2/Tier3 Setup

SSCC (City of Seoul)

dCache pool (200TB)

Nortel Passport 8800(Gb) 2ea

Extream BlackDiamond 8810(10Gb/Gb)

Foundry BigIron16(Gb) 2ea

Condor Computing pool(+120 CPUs)

Gate, Web, Condor-G dCache/gFTP, Ganglia

KREONET
(GLORIAD)
KOREN
(APII, TEIN)

1-2 Gbps

CMS-HI Tier2

20 Gbps

Analysis Tier3

SPCC (Physics, UoS)

64bit cluster (+100CPUs)

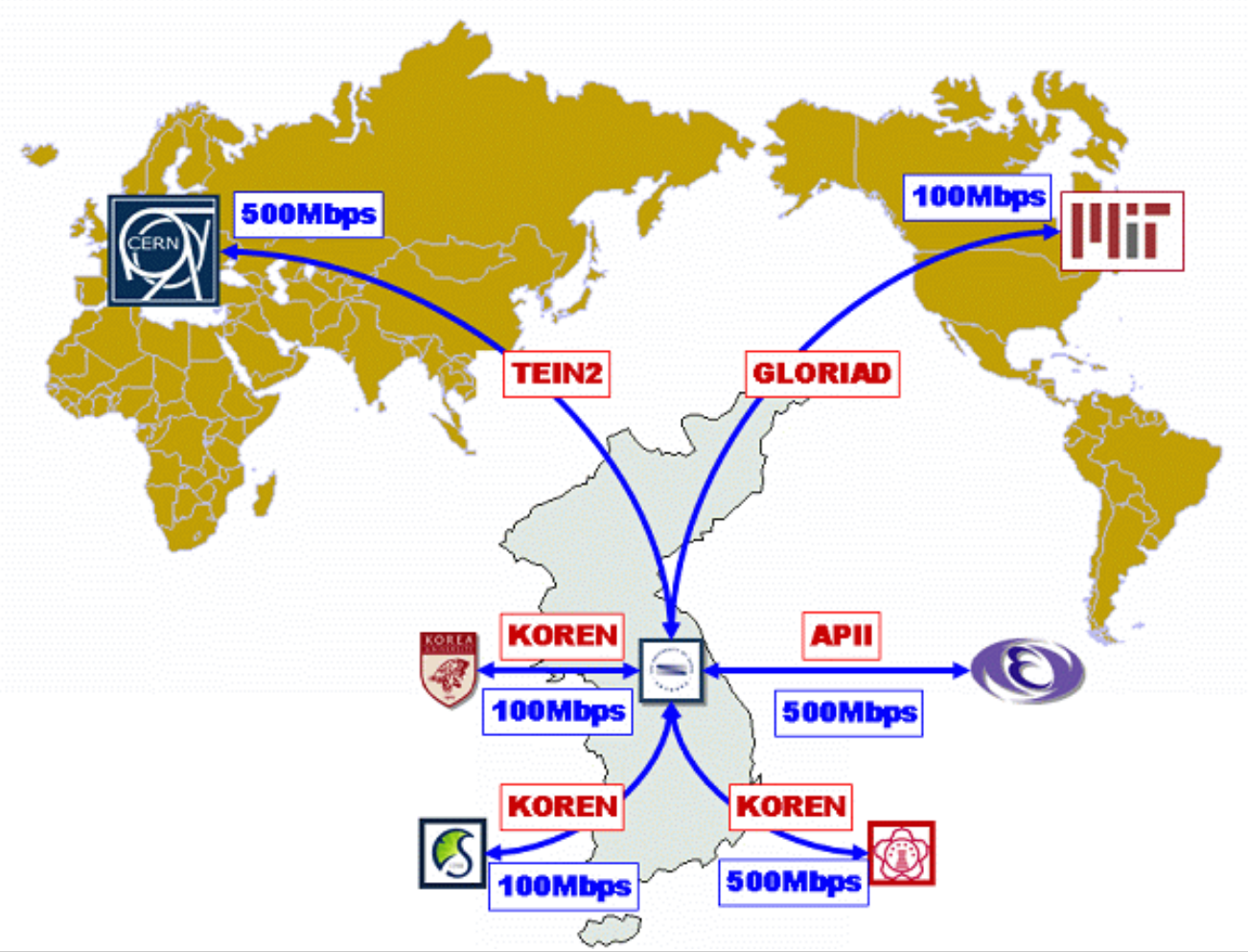
Extream BlackDiamond 8810(10Gb/Gb)

Nortel Passport 8800(Gb)

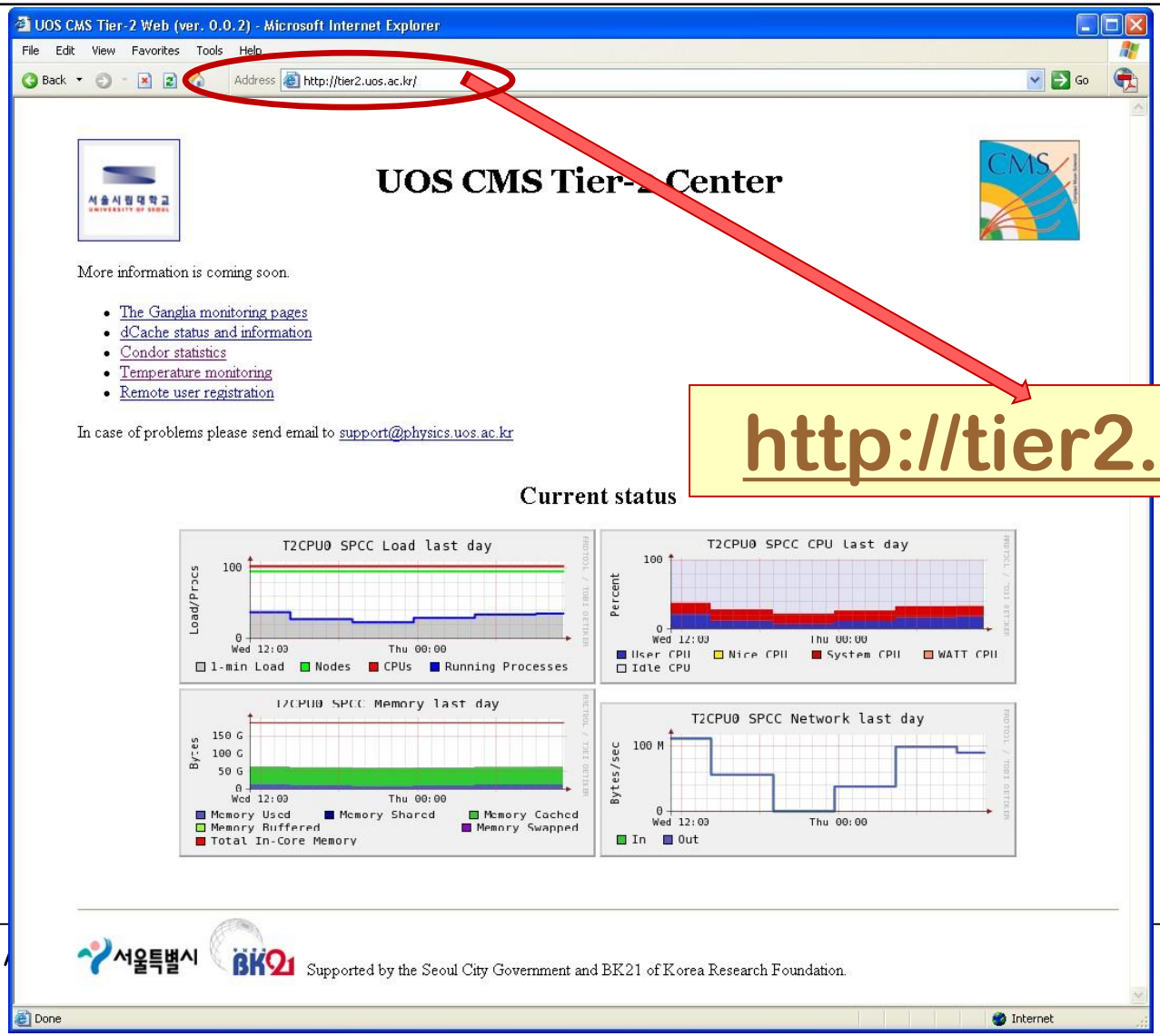
D-Link L3 Switch(Gb)

- 64 bit 3 GHz CPU
  - 64 machines
- 32 bit 2 GHz CPU
  - 32 machines
- 8 TByte Storage

Network Bandwidth Map



Tier2 Center Hompage



http://tier2.uos.ac.kr

Computing Contributions

- Coordinate the Korean CMS computing work
  - Short term goal: CMS service work and Local computing
  - Long term goal: 2-3 real computing experts

- Tier0 operation
  - Garam Hahn (UoS): DATA & Workflow management
  - Dr. Hyun Kwan Seo (SKKU): DQM (Data Quality Monitoring)

Summary

- Hardware Contribution
  - Endcap RPC production
  - Phase I construction completed/Phase II from this summer
- Software Contribution
  - Heavy-quark productions (primary & secondary J/ψ's)
  - Testing the performance of the muon HLT
- Computing Contribution
  - SSCC for the Tier2 center dedicated to CMS HI.
  - Involved in the Tier0 operation
- Participants
  - Korea University: B. Hong, ***H. C. Kim, J. H. Kim, D. Moon***, K.-S. Sim
  - University of Seoul: ***M. K. Choi, G. R. Han***, Y. S. Kim, I. C. Park, ***J. W. Park***
  - Chonbuk National University: E. J. Kim