

Bulgarian participation in the CMS experiment

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RDMS meeting, Varna, 2006



Introduction



- Members of the CMS since 1991
- Members of RDMS – since 1994
- Two teams
 - ✓ INRNE - 13
 - ✓ University of Sofia – 15
- Activities
 - ✓ Hadron calorimeter
 - ✓ Muon system
 - ✓ Computing and software
 - ✓ Physic simulations

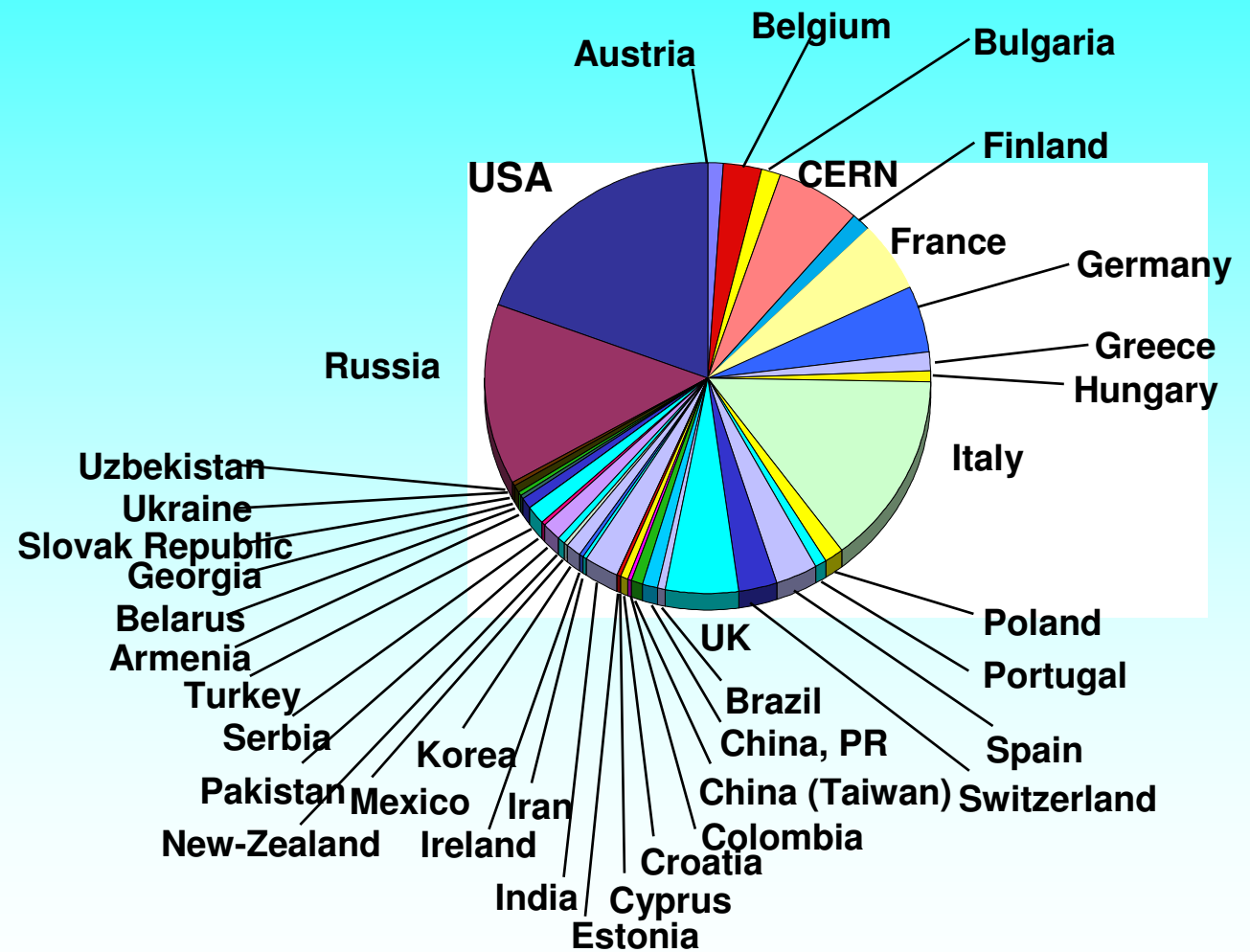


The CMS Collaboration



	Institutions
Member States	61
Non-Mem. States	64
USA	49
Total	174

	Scientists
Member States	1055
Non-Mem. States	428
USA	547
Total	2030

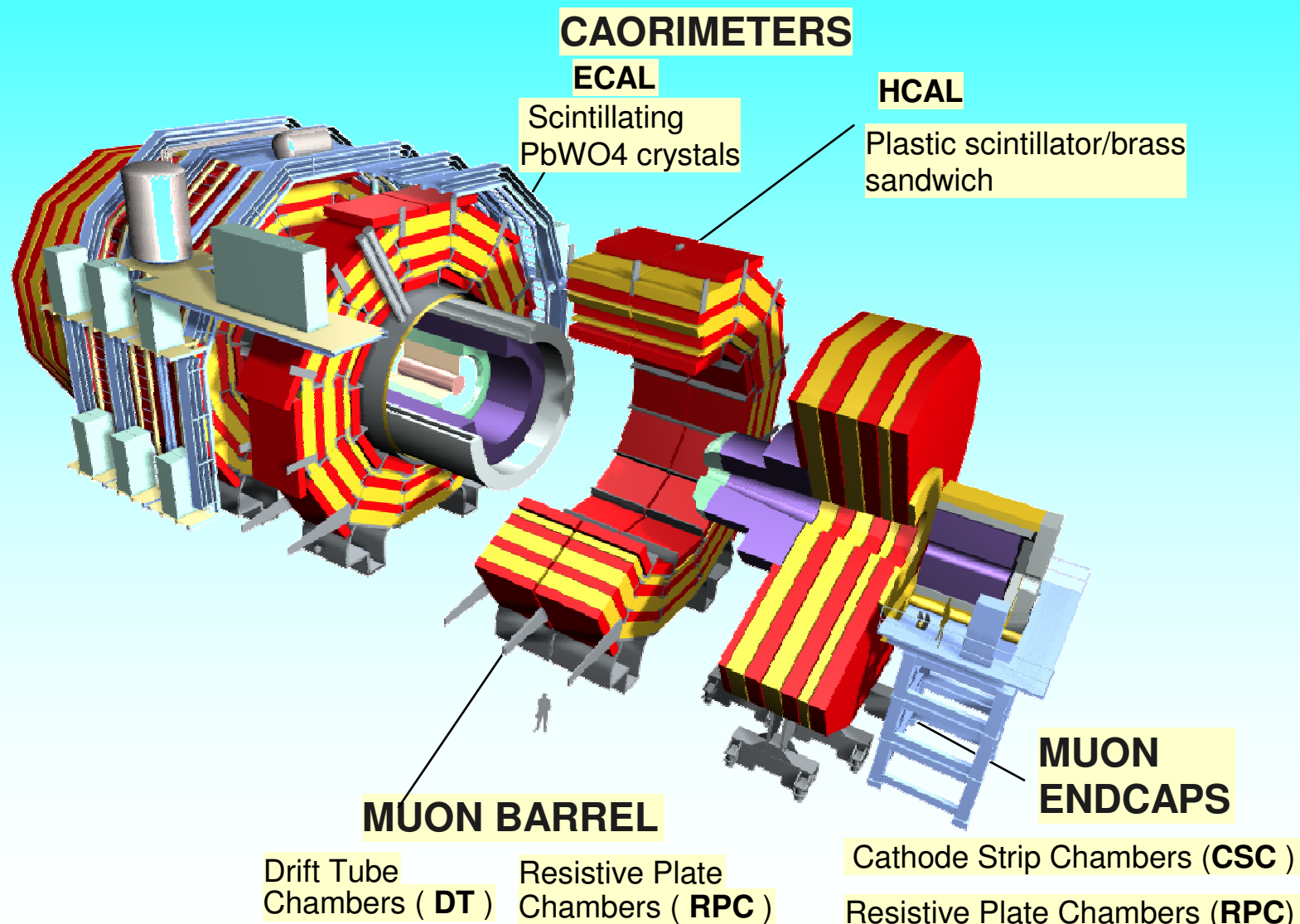


Associated Institutes	
Number of Scientists	46
Number of Laboratories	8

2030 Scientific Authors, 38 Countries, 174 Institutions



The CMS detector





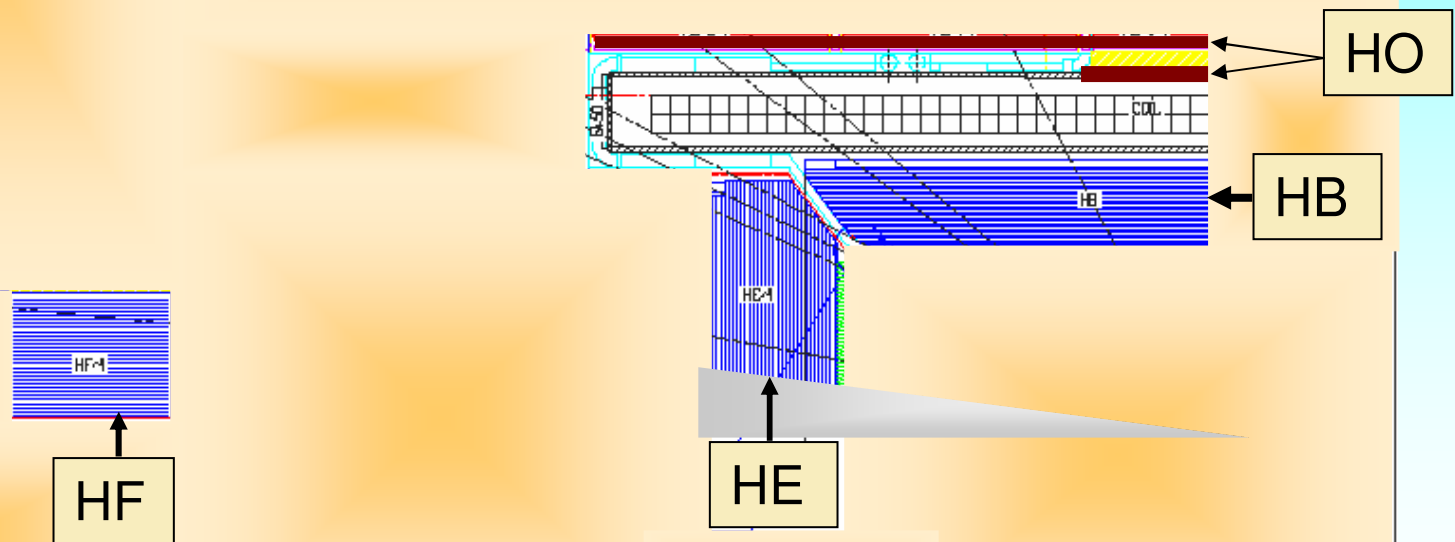
Hadron Calorimeter



Hadron Calorimeter: HCAL



Had Barrel: HB
Had Endcaps: HE
Had Forward: HF
Had Outer: HO



HB & HF: Brass Absorber and Scintillating tiles.
HO: Scintillator “catcher”. HF: Iron and Quartz fibers



HCAL



- **Design and simulation of the HCAL**
 - ✓ Design of the sampling (absorber thickness)
 - ✓ Design of the geometry – HB-HE
 - ✓ Development of fast simulation tools
- **Prototype production and beam test**
 - ✓ Production and tests of the first prototypes
 - ✓ Production of the first full size absorber plate for HB
 - ✓ Test of APD detectors as photo detector for HCAL
 - ✓ Participation in the tests in the H2 beams



HCAL



- Test beam data analysis and calibration
 - ✓ Influence of the magnetic field
 - Observation of change of the scintillator light yield
 - Change of the measured EM component of hadron shower
 - ✓ Source calibration –
 - development of algorithm for data analysis
 - Development of data base
 - ✓ Calibration in hadron beams
 - Data analysis
 - Simulation and validation of hadron generators

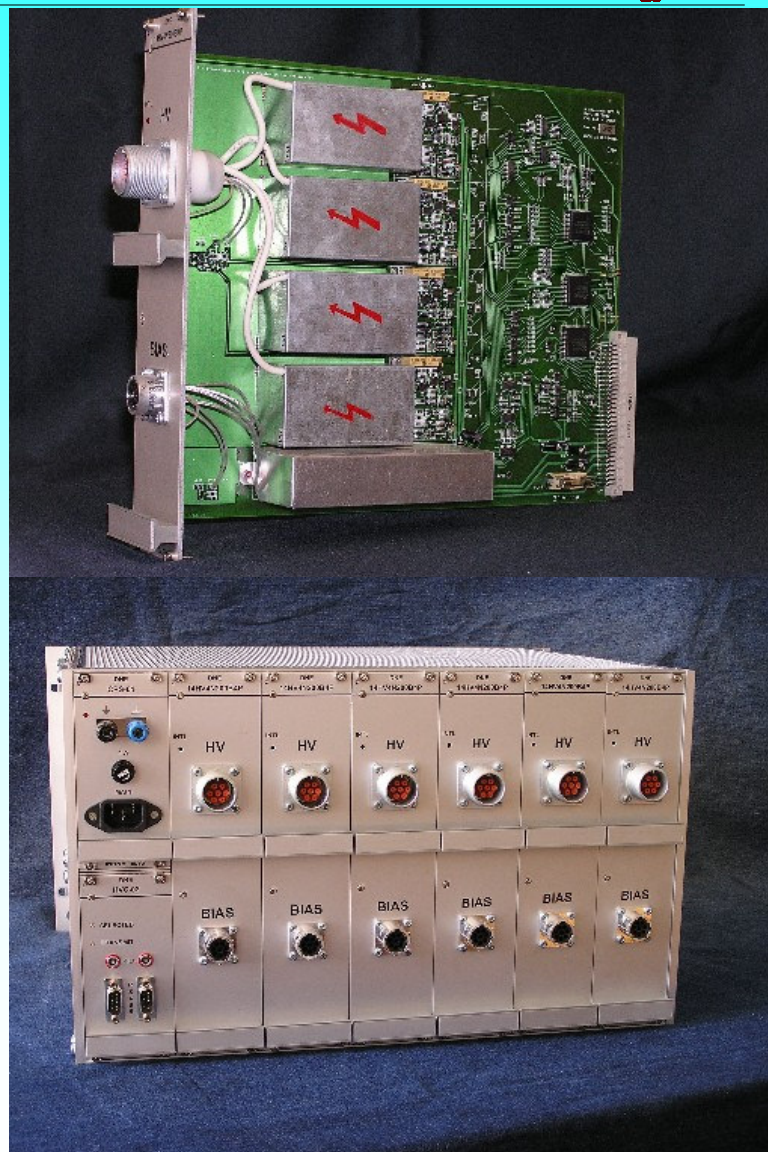
Basic parameters of: High voltage channel

Output high voltage	0 ÷ 14000 V
Polarity	negative
Output current	0 ÷ 40 μ A
Temperature stability	< 100 ppm/0C
Long time stability	< 0,1%;

Low voltage channel:

Output voltage	0 ÷ 200 V
Polarity	positive
Output current	0 ÷ 10 μ A
Temperature stability	< 100 ppm/0C
Long time stability	< 0,1%;

22 crates ; 125 modules





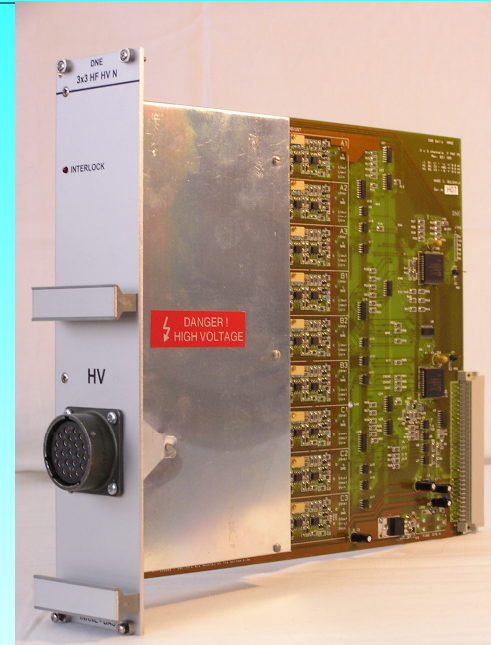
HF high voltage suppliers



72 channels - 9/modul
 A group of PMT is supplied by 1 cluster
 3 ch/cl – 1-6 dynode , 7 dynode, 8 dynode

voltage	2000	800	400
current	0.8	0.8	0.8

2 crates with 4 modules/crate
 1 spare crate with 2 modules





HCAL



- Production of almost full barrel absorber
- Development of algorithms for energy reconstruction
 - ✓ Goal –
 - improve the energy resolution
 - Linearity
 - Reduce the non Gaussian tiles
 - ✓ Two different methods
 - Nonlinear detector response function
 - Neural network
 - Particle identification (e , h , jet)
 - Energy reconstruction



HCAL – Energy reconstruction with NN



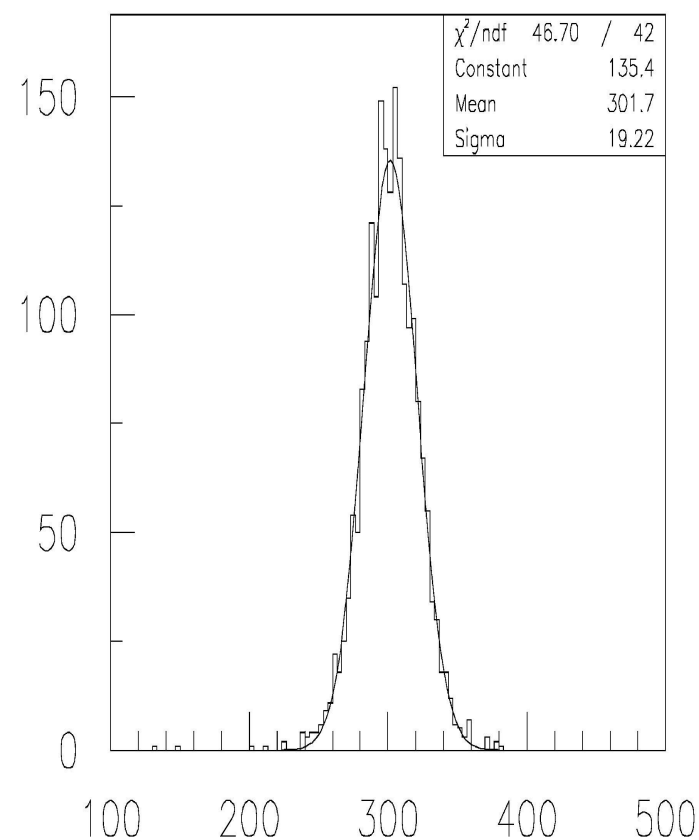
NN performance

Energy distribution - Gaussian

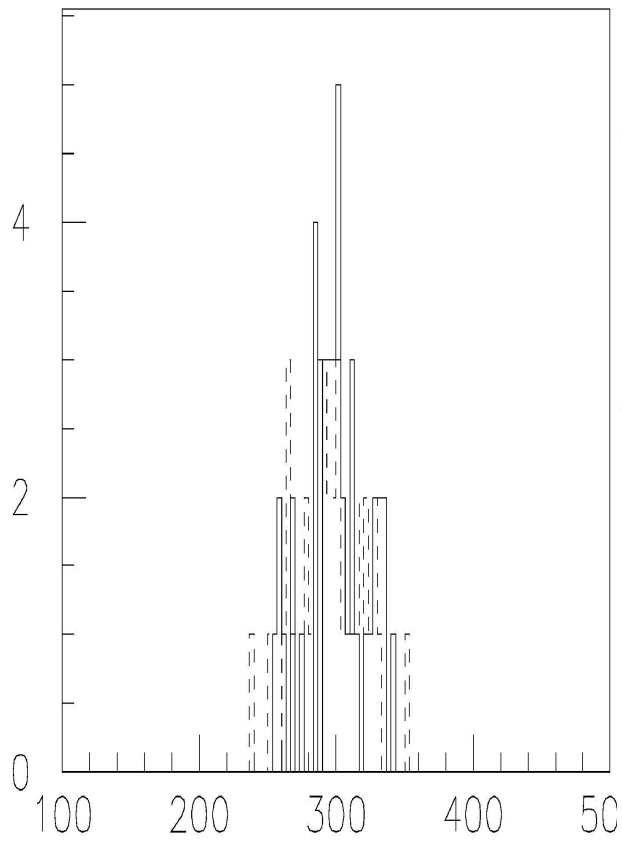
NN performance – energy is well reconstructed

jet \rightarrow h

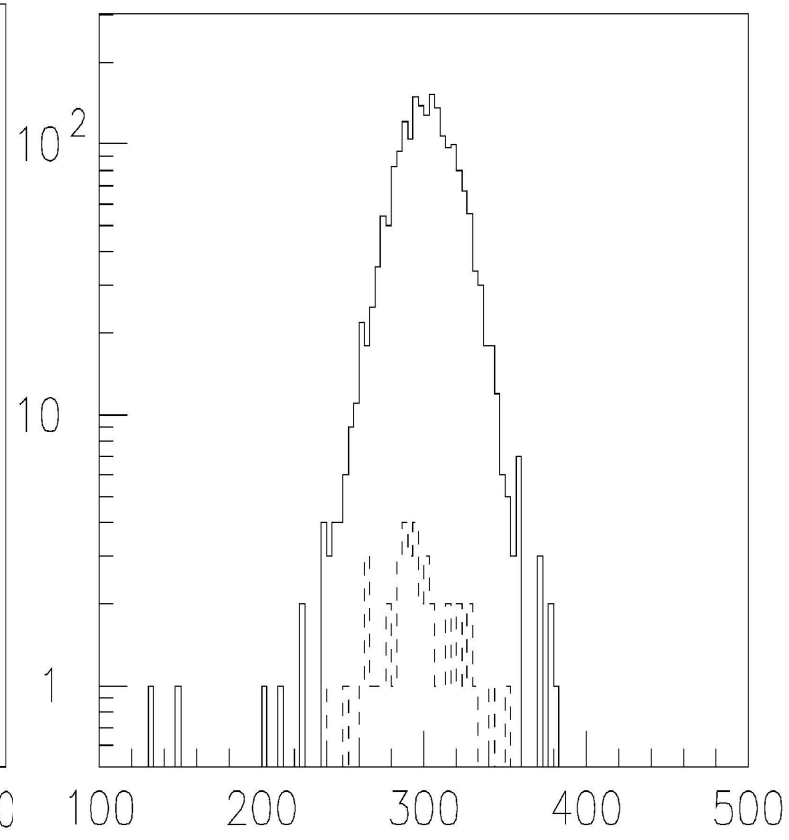
jet \rightarrow e



Energy



300 GeV



300 GeV



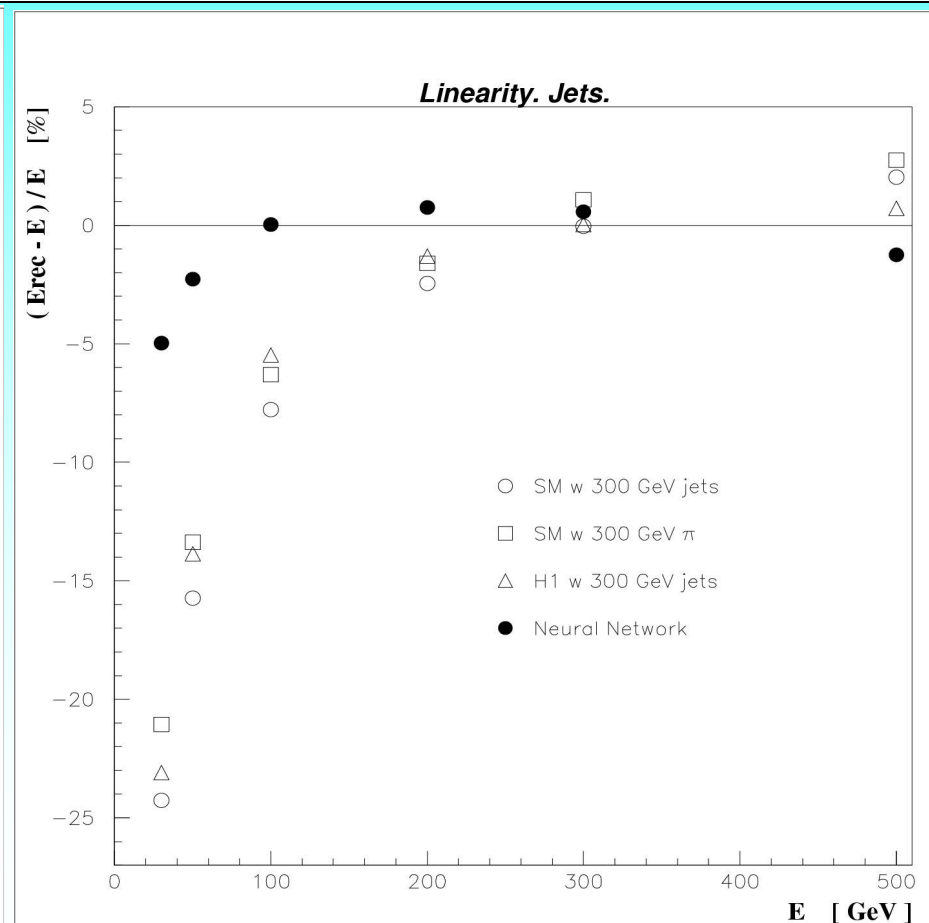
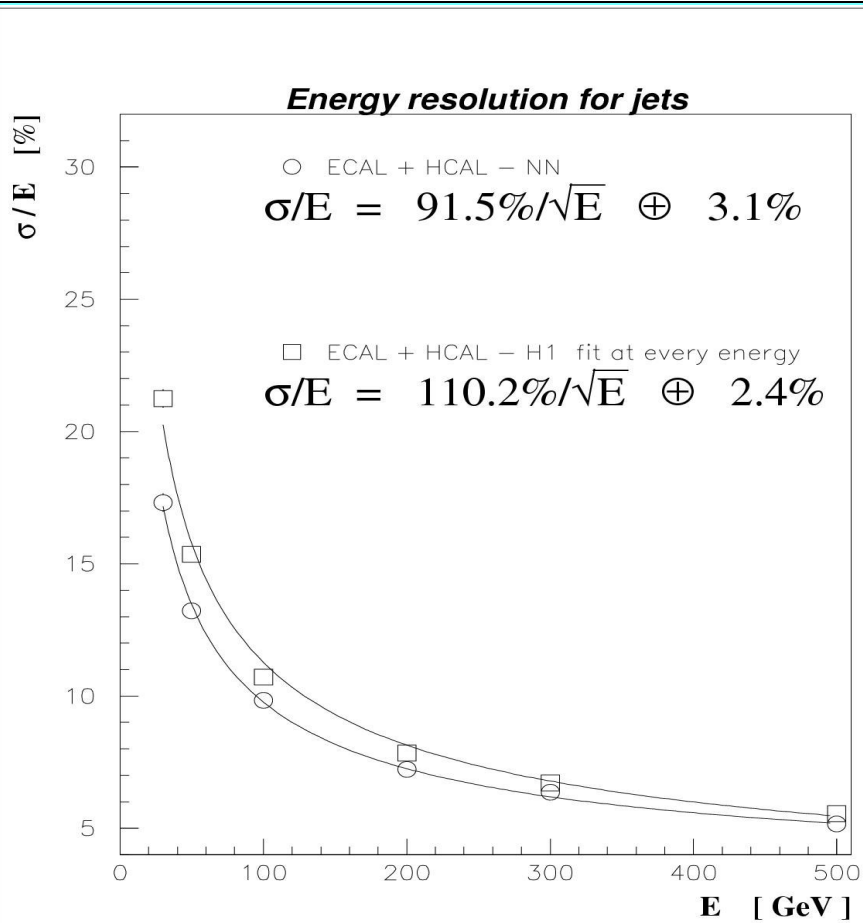
HCAL – Energy reconstruction with NN



Neural Network performance

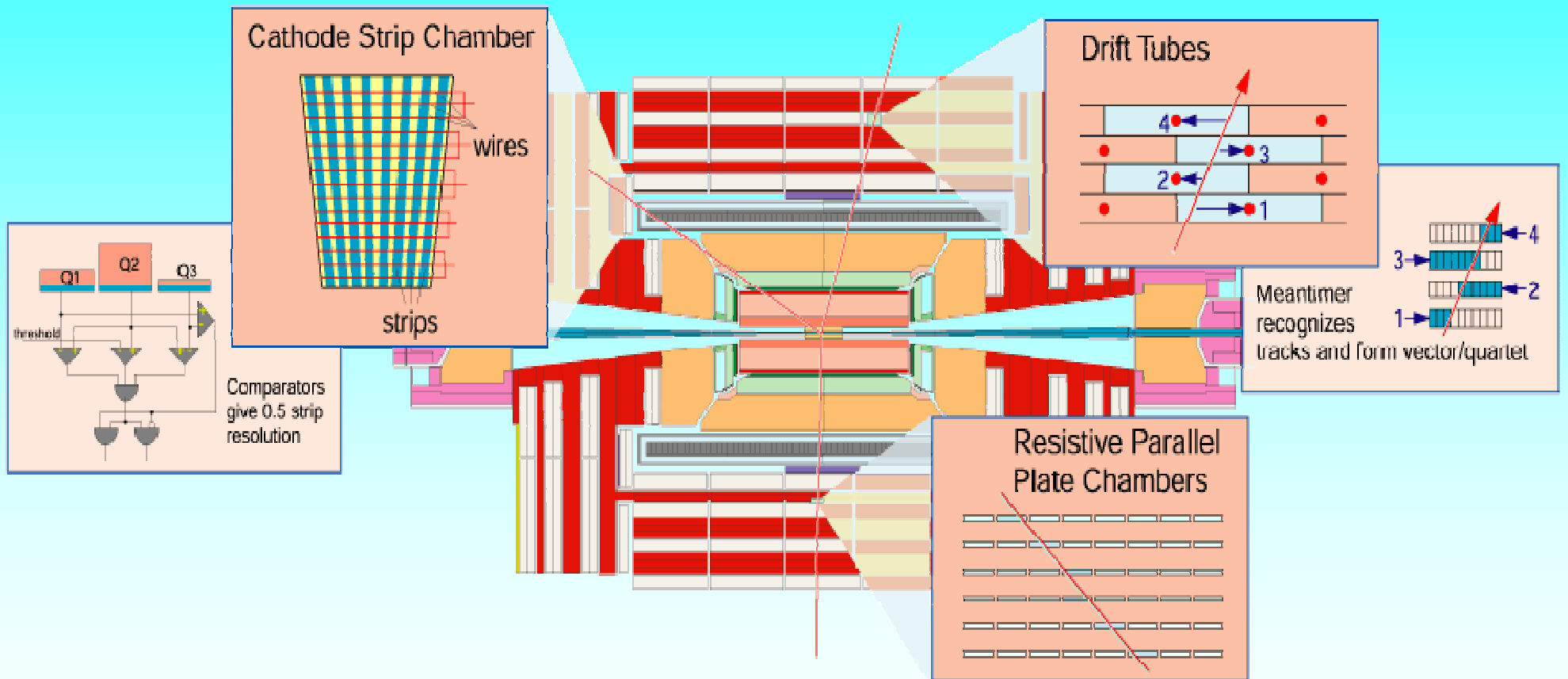
Energy resolution for jets

Linearity





Muon system





High voltage supplies for ME1/1

Parameters of 1 channel:

Voltage	0 ÷ 4000 V
Polarity	positive
Current	0 ÷ 0,4 mA
Temperature stability	< 100 ppm/0C

modul

Number of channels	12
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Crate:

Number of modules	6
Number of channels	72
Crate controller	1

Produced – 3 crates containing 3 modules every one



Resistive Plate Chambers



CMS RPC



Fast detectors for the first level trigger of the experiment

Considerably good space resolution

Able to work in areas with background $\sim 10^3$ Hz/cm²

Price – as low as possible

Requirements

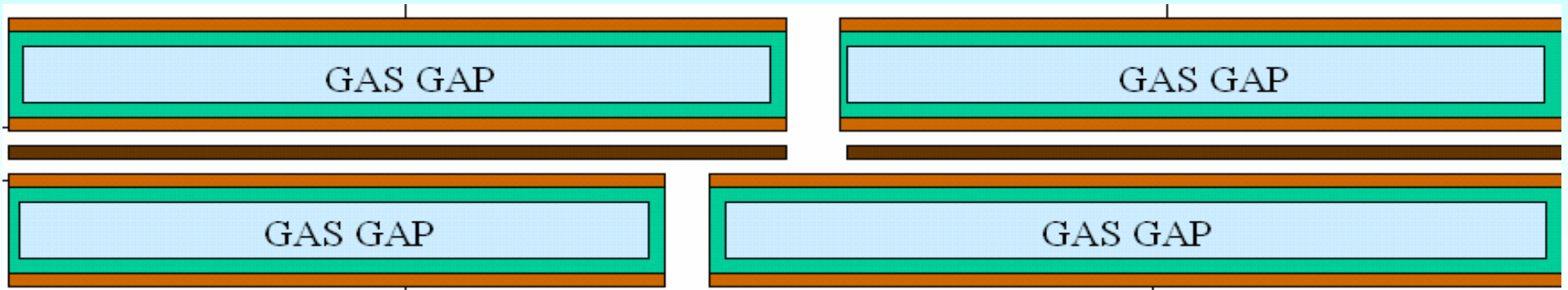
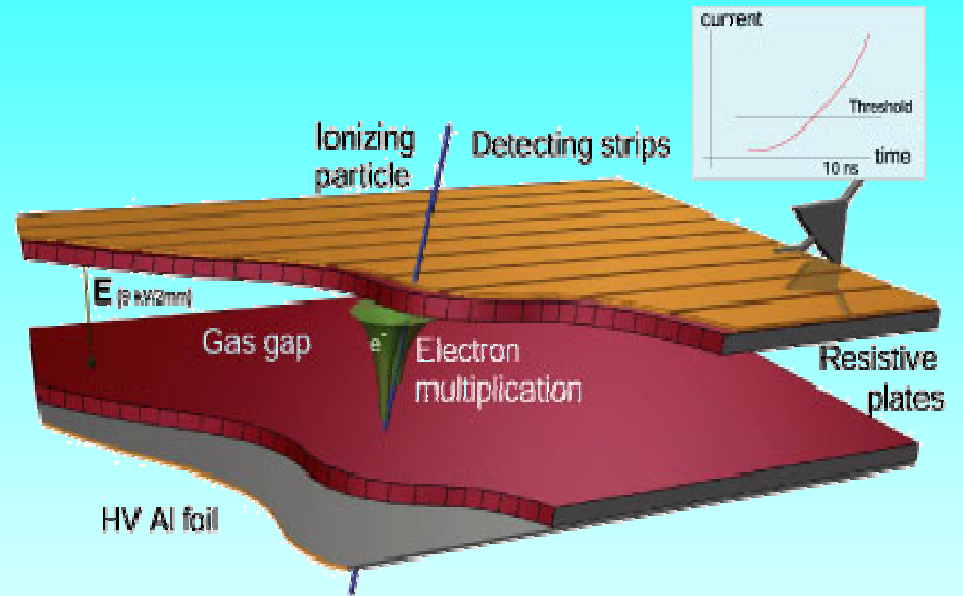
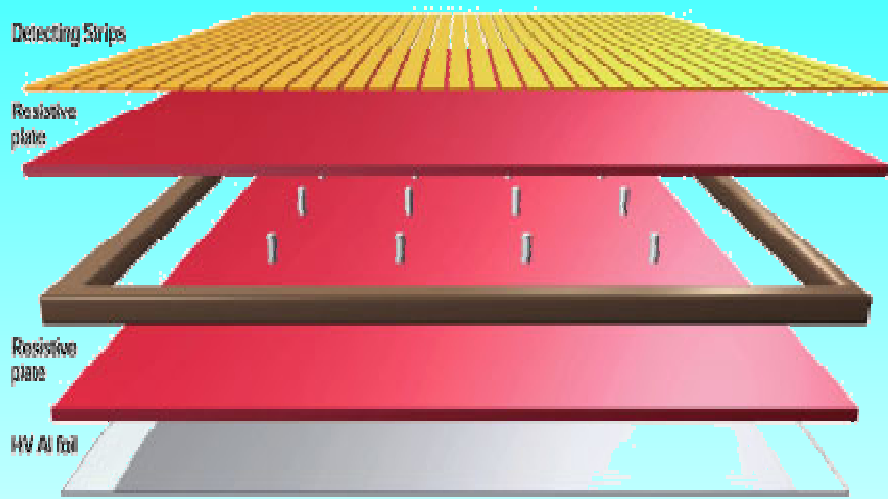
Time resolution ≤ 1.8 ns
(98 % within 20 ns)

Efficiency > 95 %

Rate capability ≤ 1 kHz/cm²

- Average cluster size < 2 strips
- Number of streamers $< 10\%$
- Operation plateau > 300 V
- Power consumption 2-3 W/m²
- Operational voltage 8.5 – 10 kV

Resistive Plate Chambers

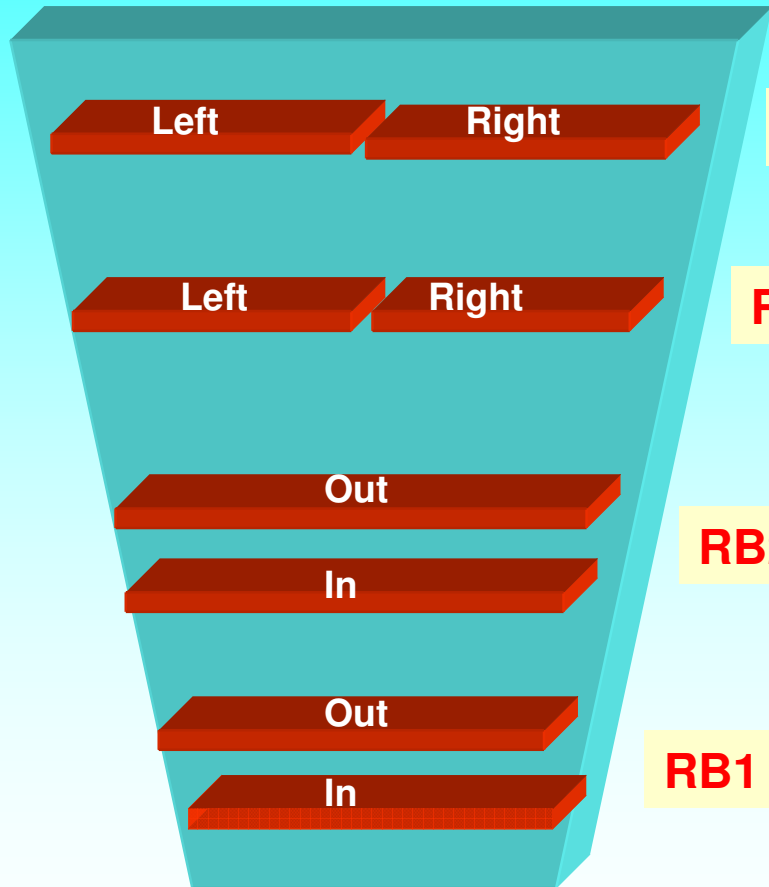




Main Barrel RPC Types



Length: 2.455 m



RB4

Width: 1.5, 2.0 , 2.5 m
Pitch: 40.8, 40.6, 41.0 mm
Strips for Gap: 48, 36, 48, 60

RB3

Width: 1.48 m
Pitch: 34.8 mm
Strips for Gap: 42

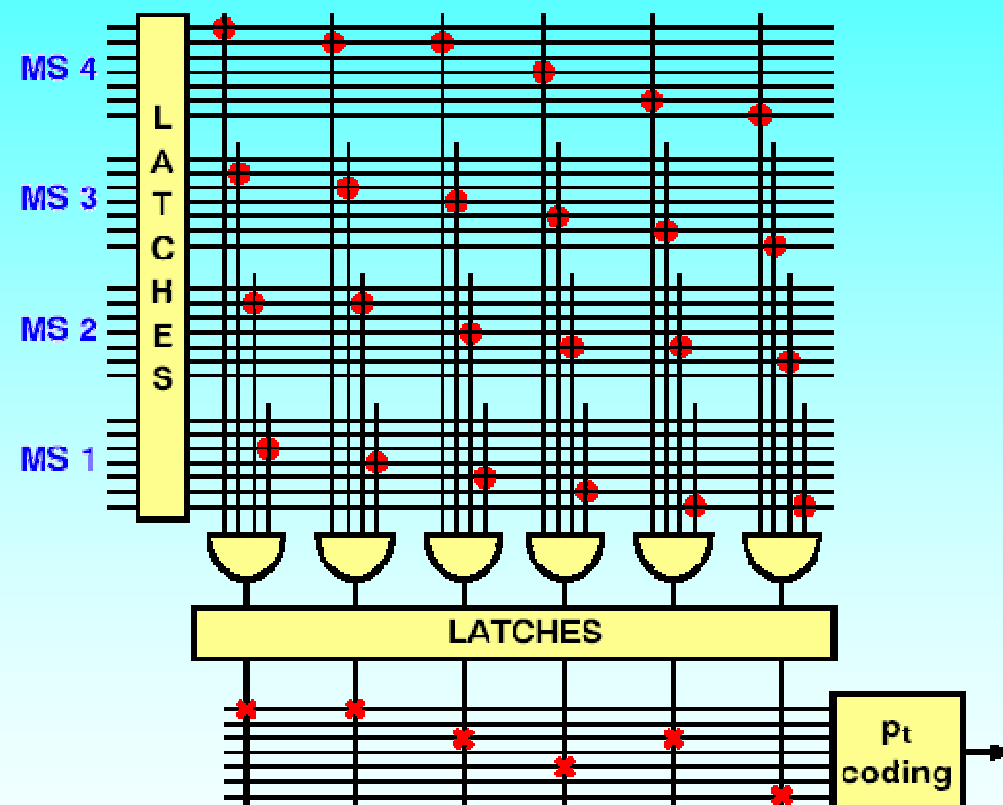
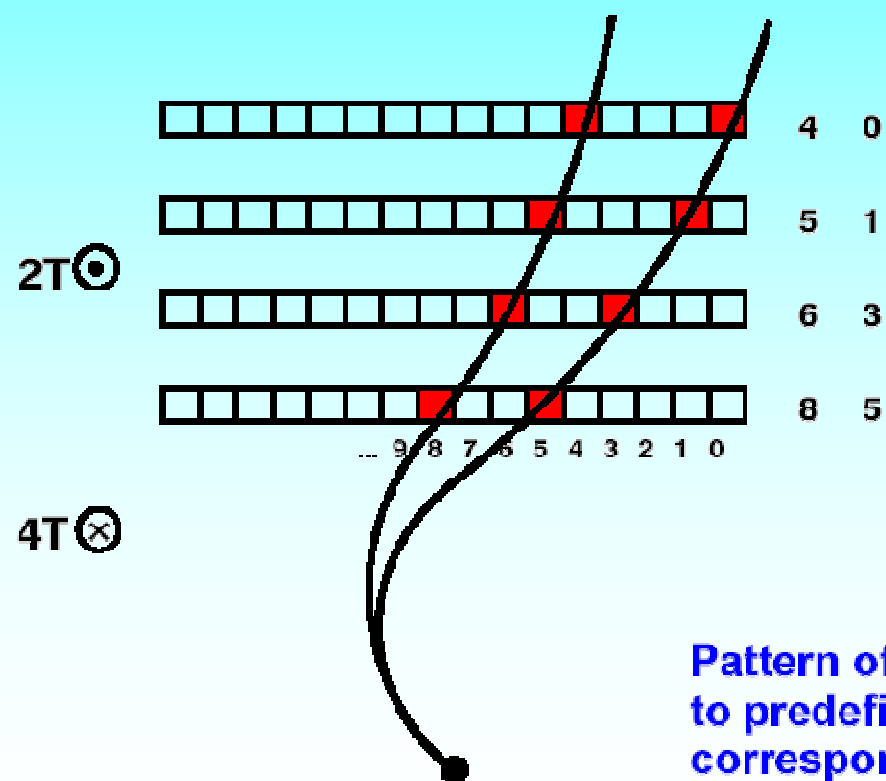
RB2

Width: 1.5, 2.0 , 2.5 m
Pitch: 27.3, 29.3 mm
Strips for Gap: 84, 90

RB1

Width: 1.5, 2.0 , 2.5 m
Pitch: 22.7, 24.3 mm
Strips for Gap: 84, 90

- recognizes muons
- measures their momenta
- selects most energetic ones
- passes them to Global Trigger



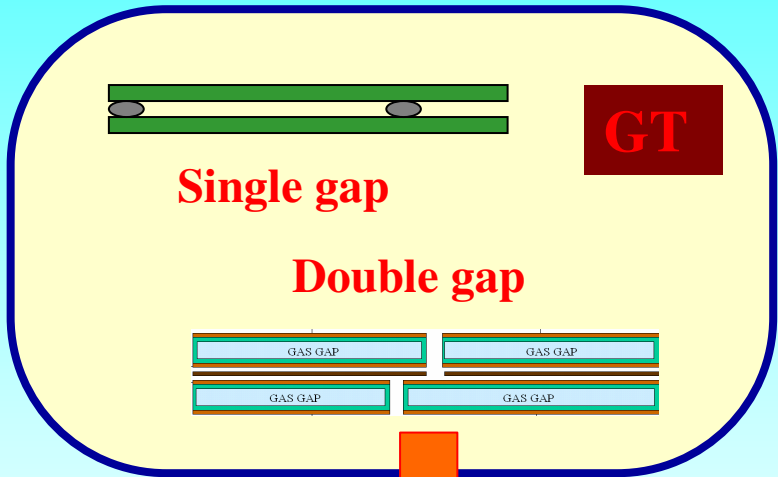
Pattern of hit strips is compared to predefined patterns corresponding to various momenta



Barrel RPC Production

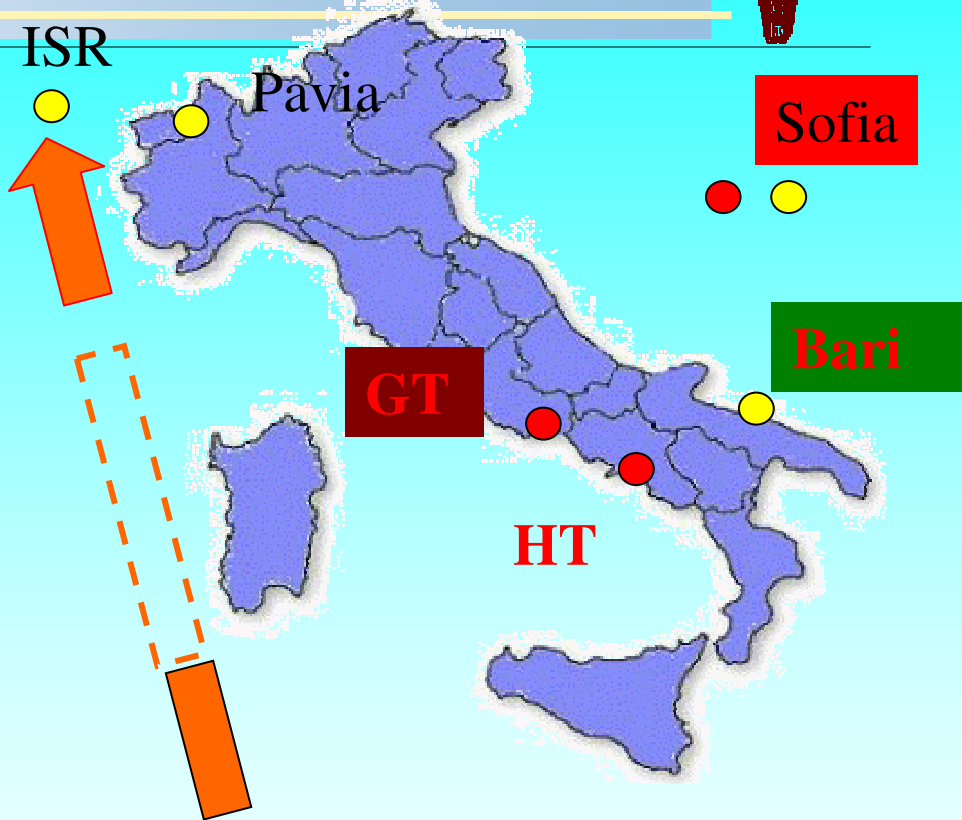


Chambers production and quality certification involve several steps.



Chamber assembling Sites

120 RB1 at **HT**
 240 RB2 and RB4 at **GT**
 120 RB3 in Sofia (& Bari)



● Chamber test Sites

RB1 in Pavia
 RB2 & RB4 in Bari
 RB3 in Sofia (& Bari)





RPC



➤ **Responsibilities:**

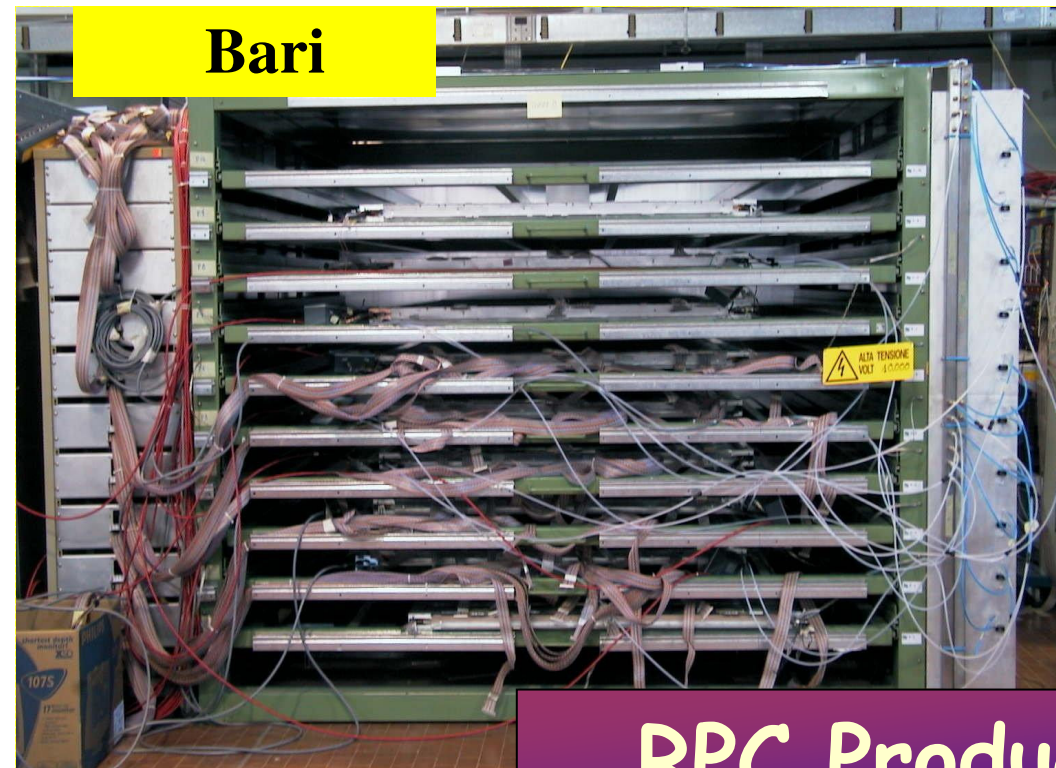
- ✓ Design and production of all mechanical elements for stations RB2, RB3 and RB4 (375 chambers)
- ✓ Assembly and tests of all RB3 chambers (125 chambers)
- ✓ Transportation of the chambers to CERN and their tests at ISR
- ✓ Installation of the RPC in the CMS
- ✓ Commissioning
- ✓ Test of RB2 and RB4 at Bari
- ✓ Establishment of test site at CERN and tests of all Endcap RPC

Bari

Sofia

RPC Production Sites

Pavia





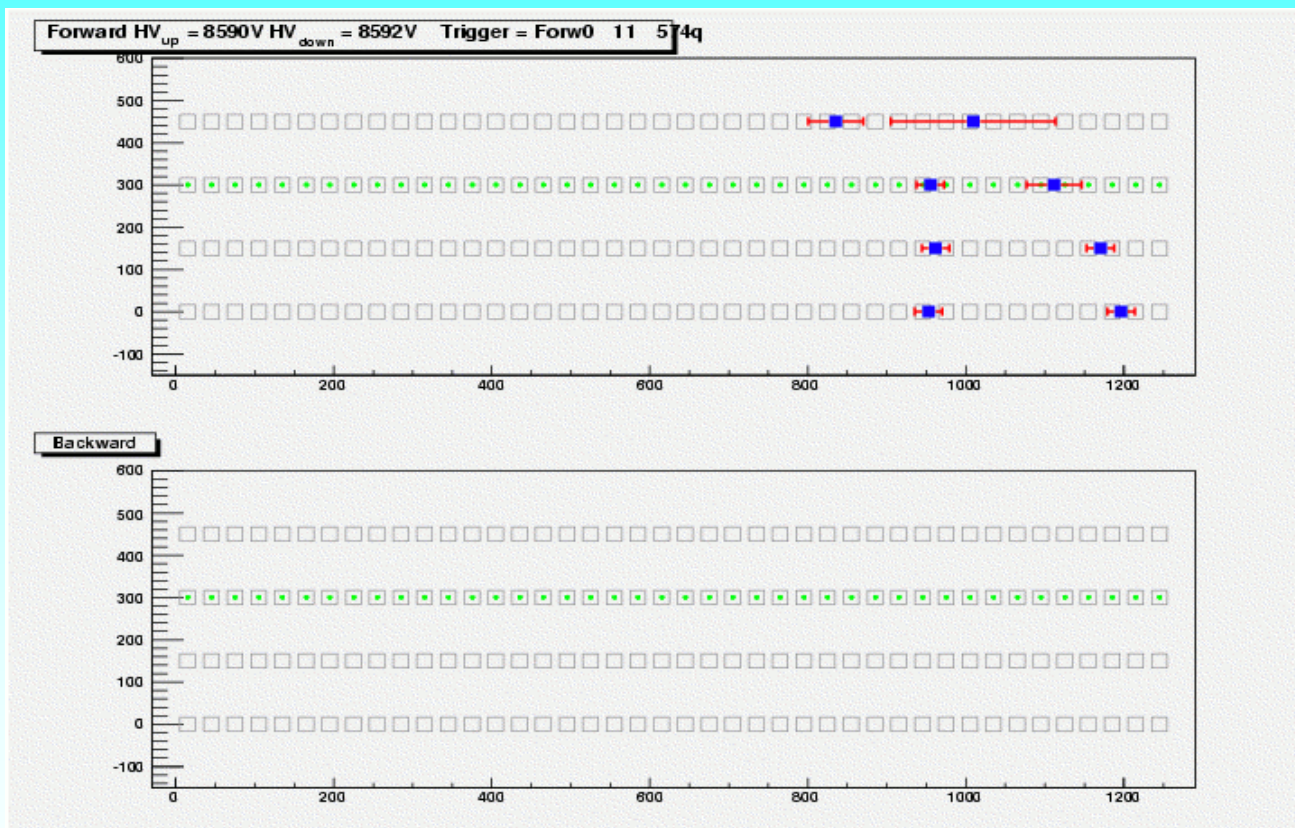
Track Reconstruction - Sofia

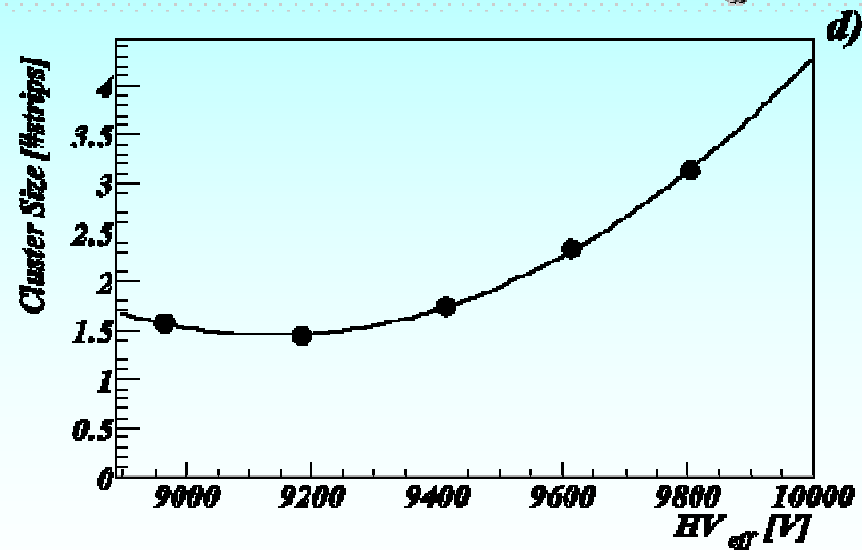
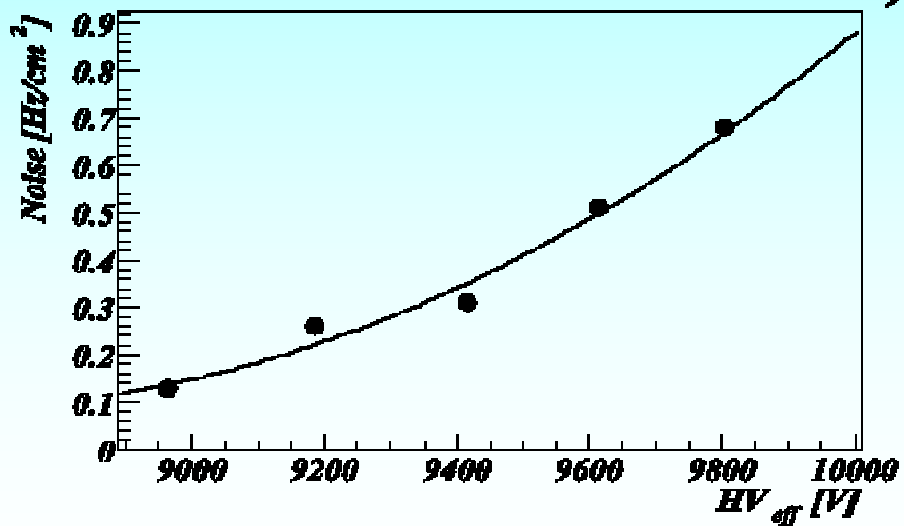
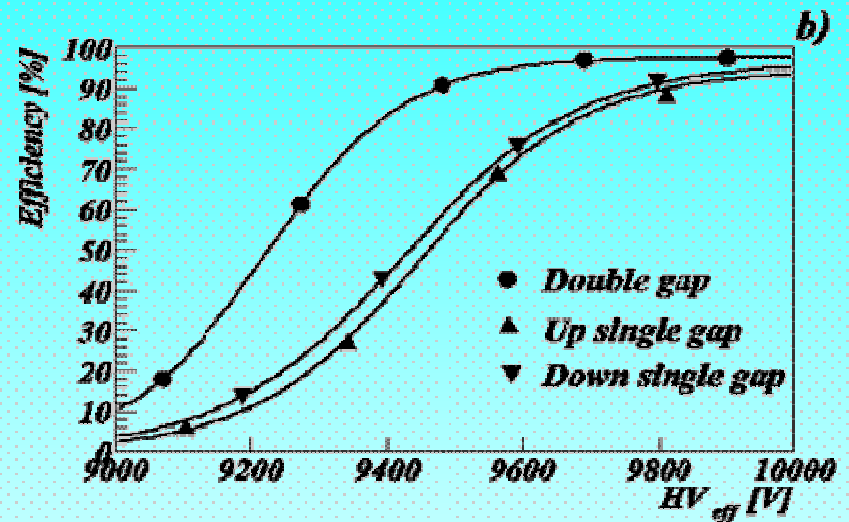
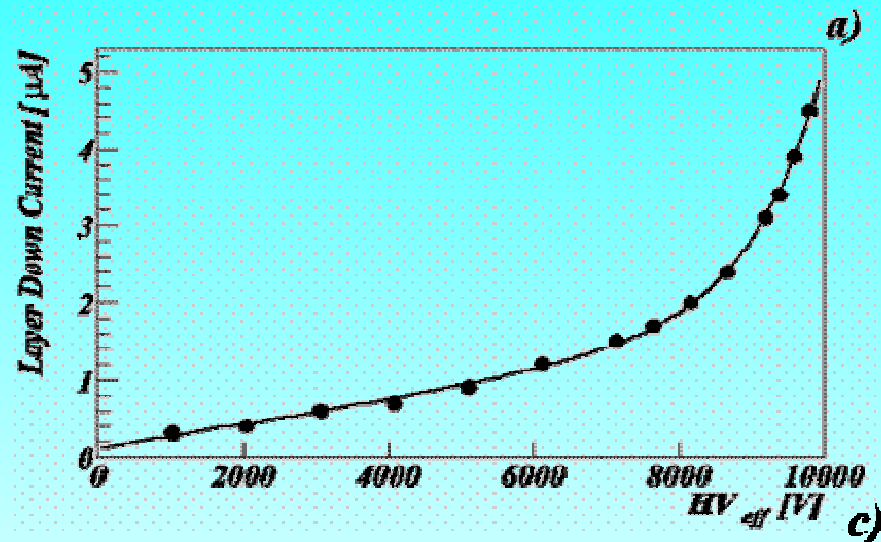


Number of stations = 4

Only one cluster with size < 7 in every reference station

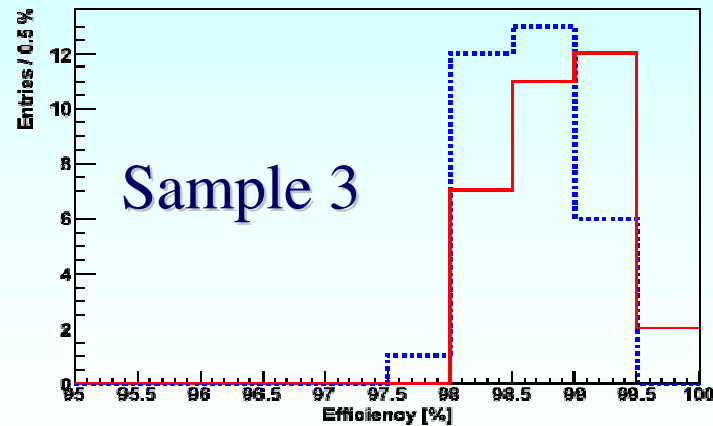
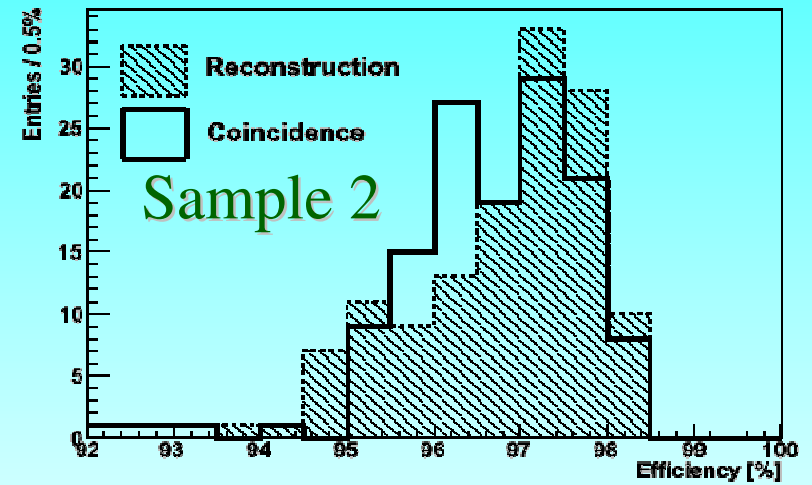
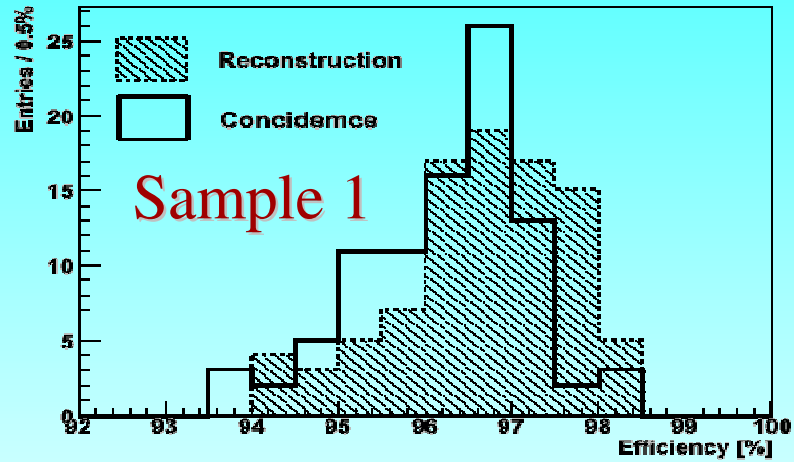
Track is reconstructed if the clusters are compatible







Efficiency @ HV=9600V

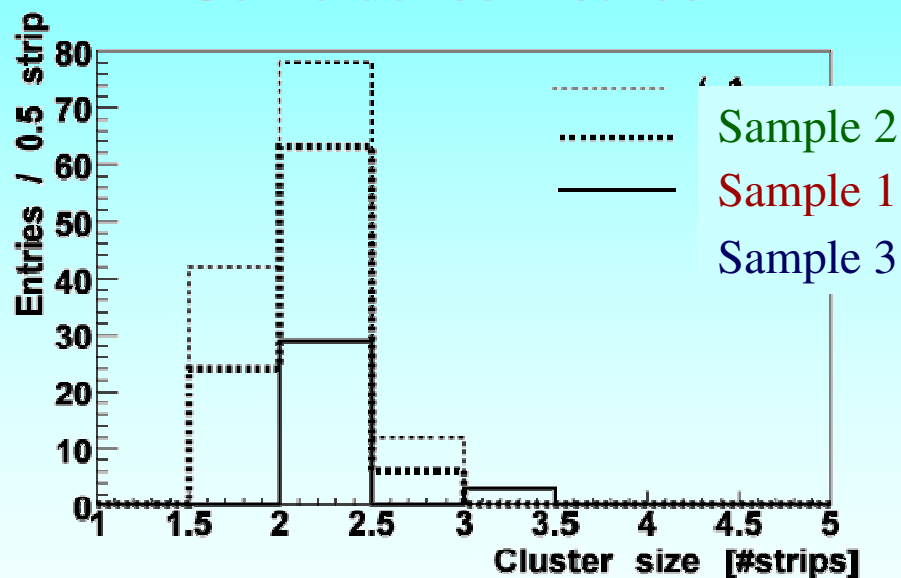




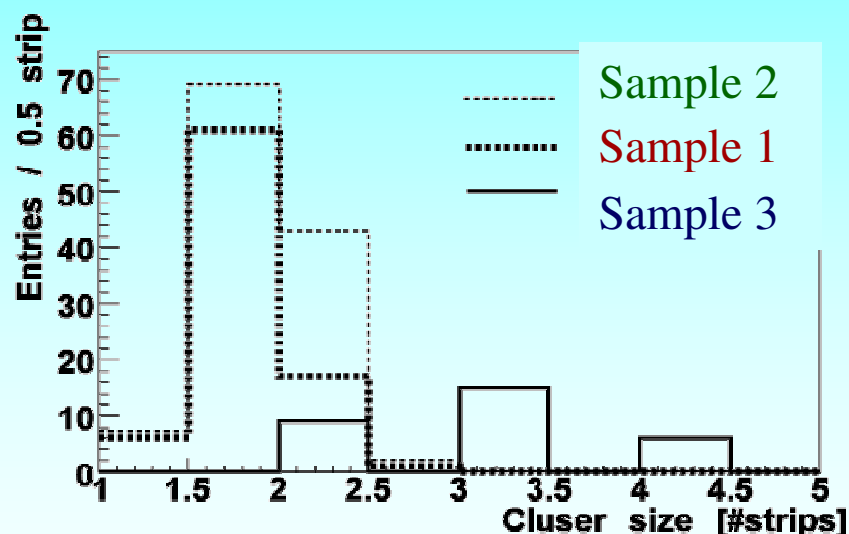
Average Cluster size distribution HV=9600V



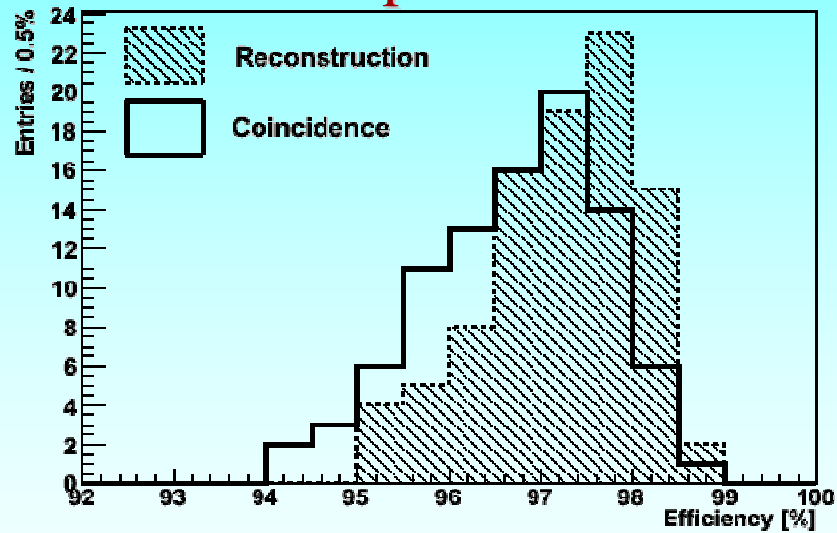
Coincidence method



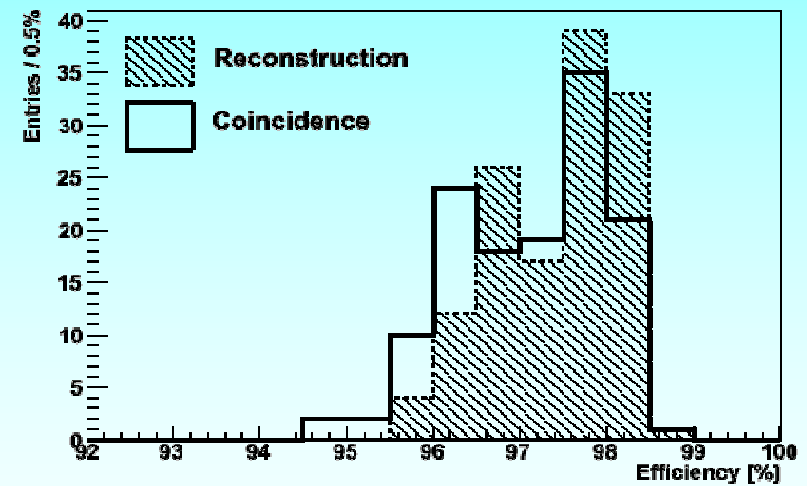
Reconstruction method



Sample 1



Sample 2

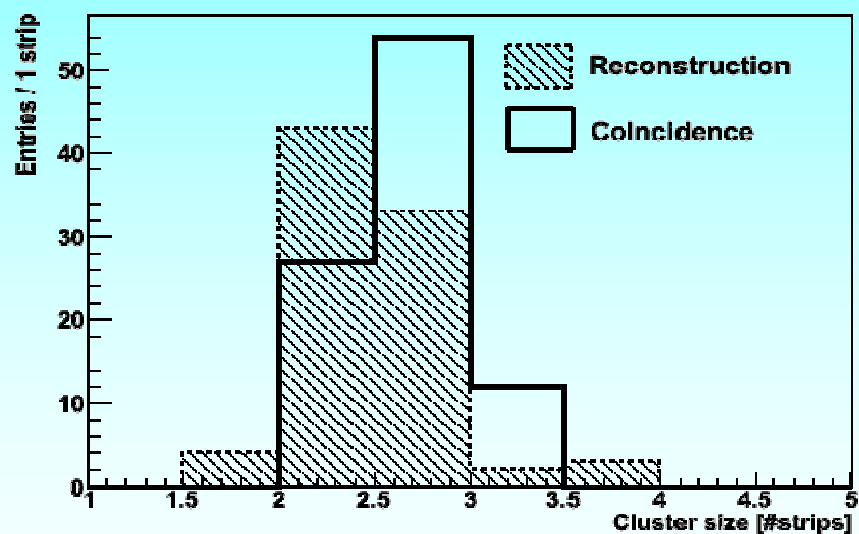




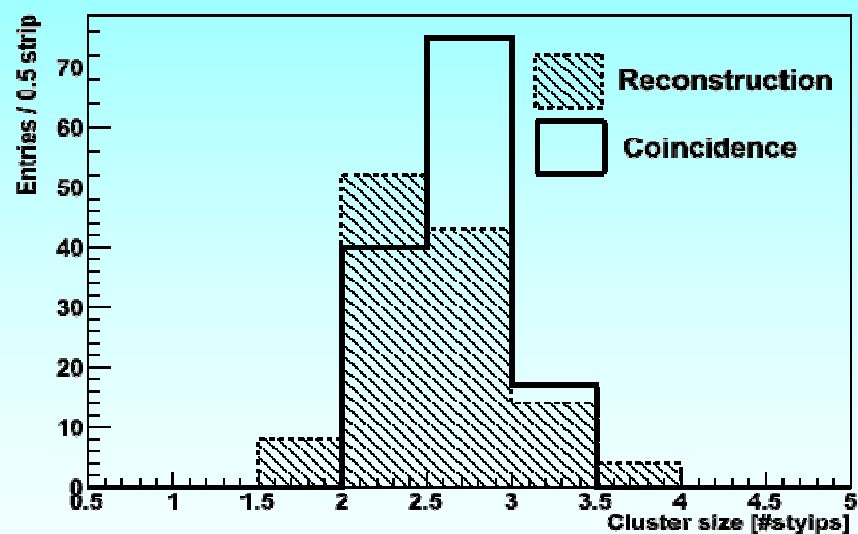
Average Cluster size distribution HV=9800V



Sample 1



Sample 2

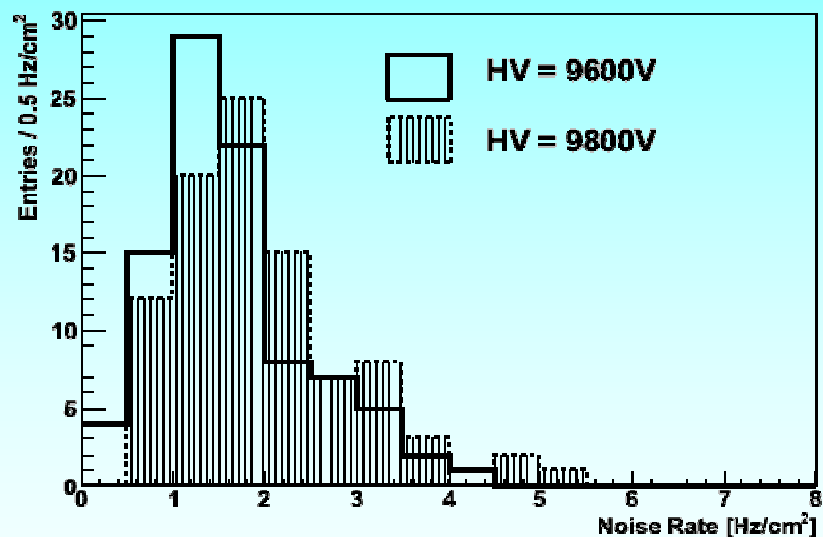




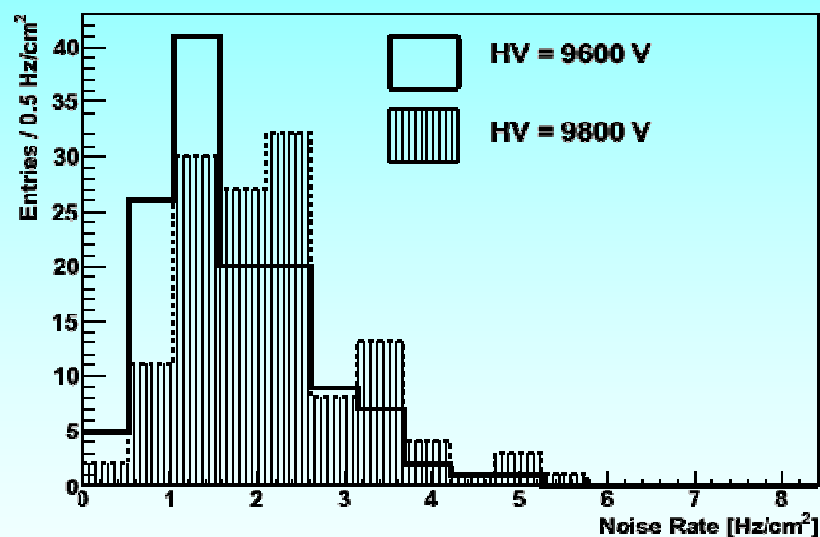
Noise Rate Distribution



Sample 1



Sample 2





RPC tests at ISR



ISR RPC storage and test area

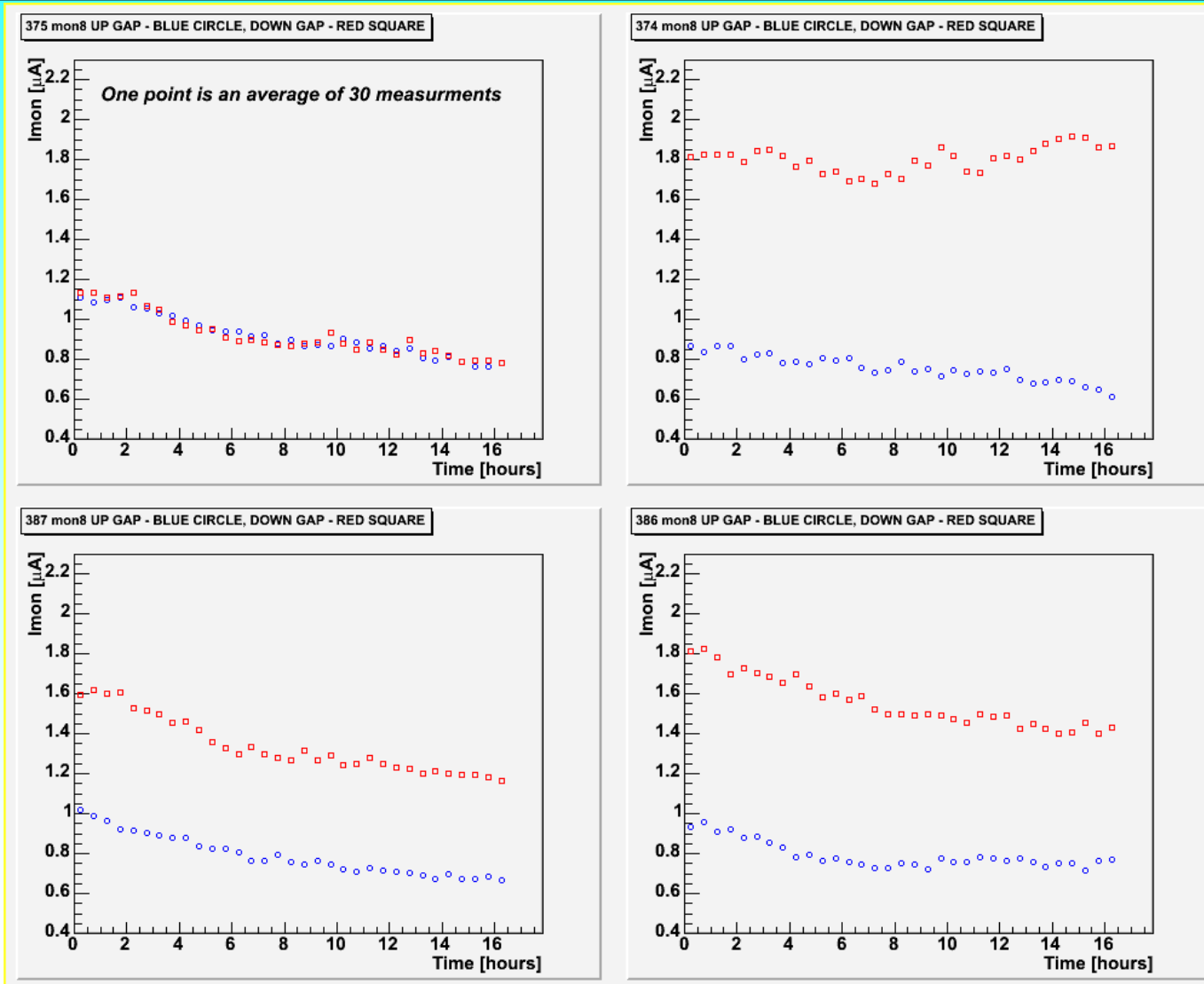
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Bulgarian Participation in the CMS experiment

11th RDMS meeting, Varna, September 2006



PRC – current stability





Coupling with DT



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Bulgarian Participation in the CMS experiment

11th RDMS meeting, Varna, September 2006



Installation of DT and RPC



At ISR

Coupling RPC to DT

Fast test

Transportation to SX5(CMS surface hall)

At SX5

Installation in the CMS Detector



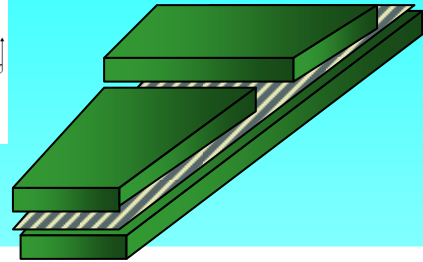
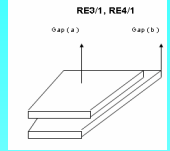




Endcap RPC



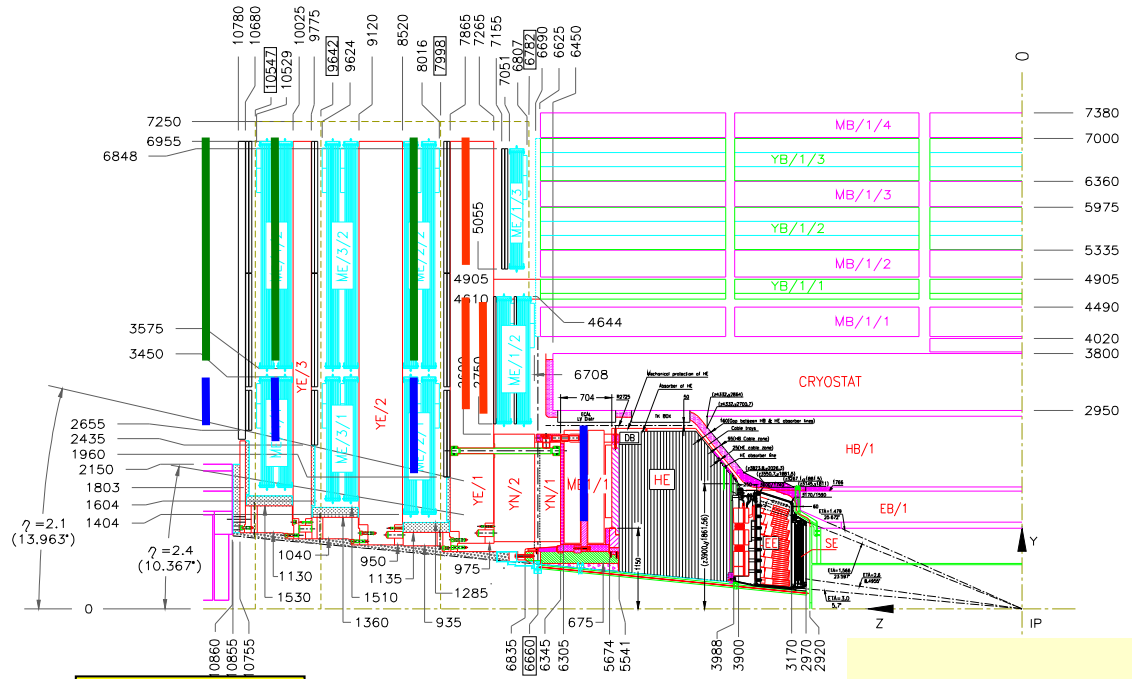
- China
- Korea
- Pakistan



CERN
Project Co-ordination
ISR Assembly Station

Gap production
Korea

Front-end electronics
Pakistan



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

Korea

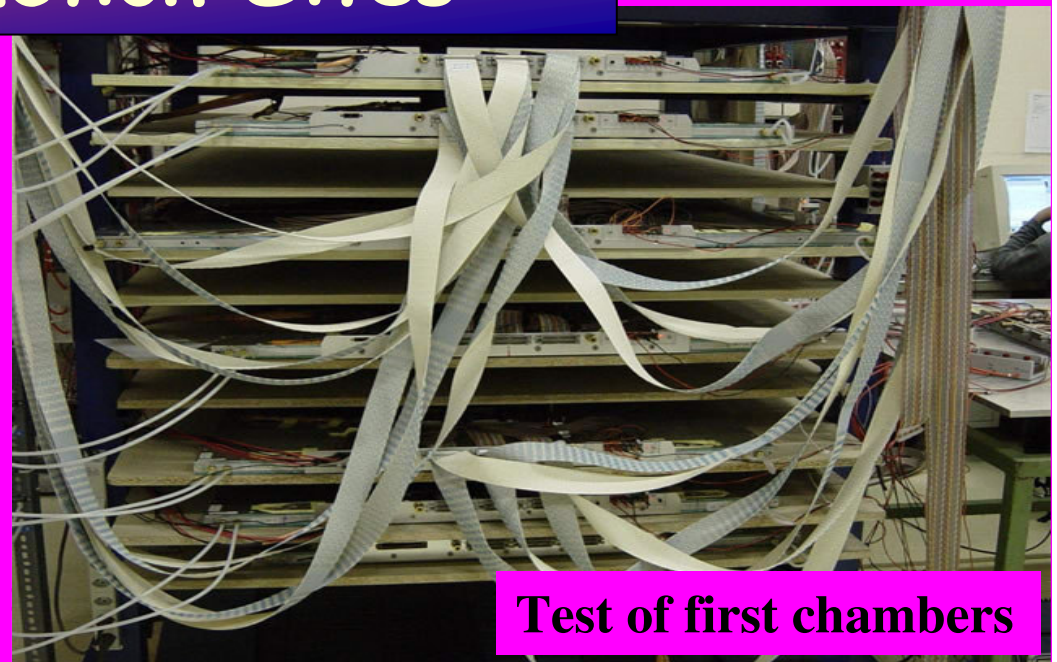
Pakistan

RPC Production Sites

ISR Lab

2004 7 14

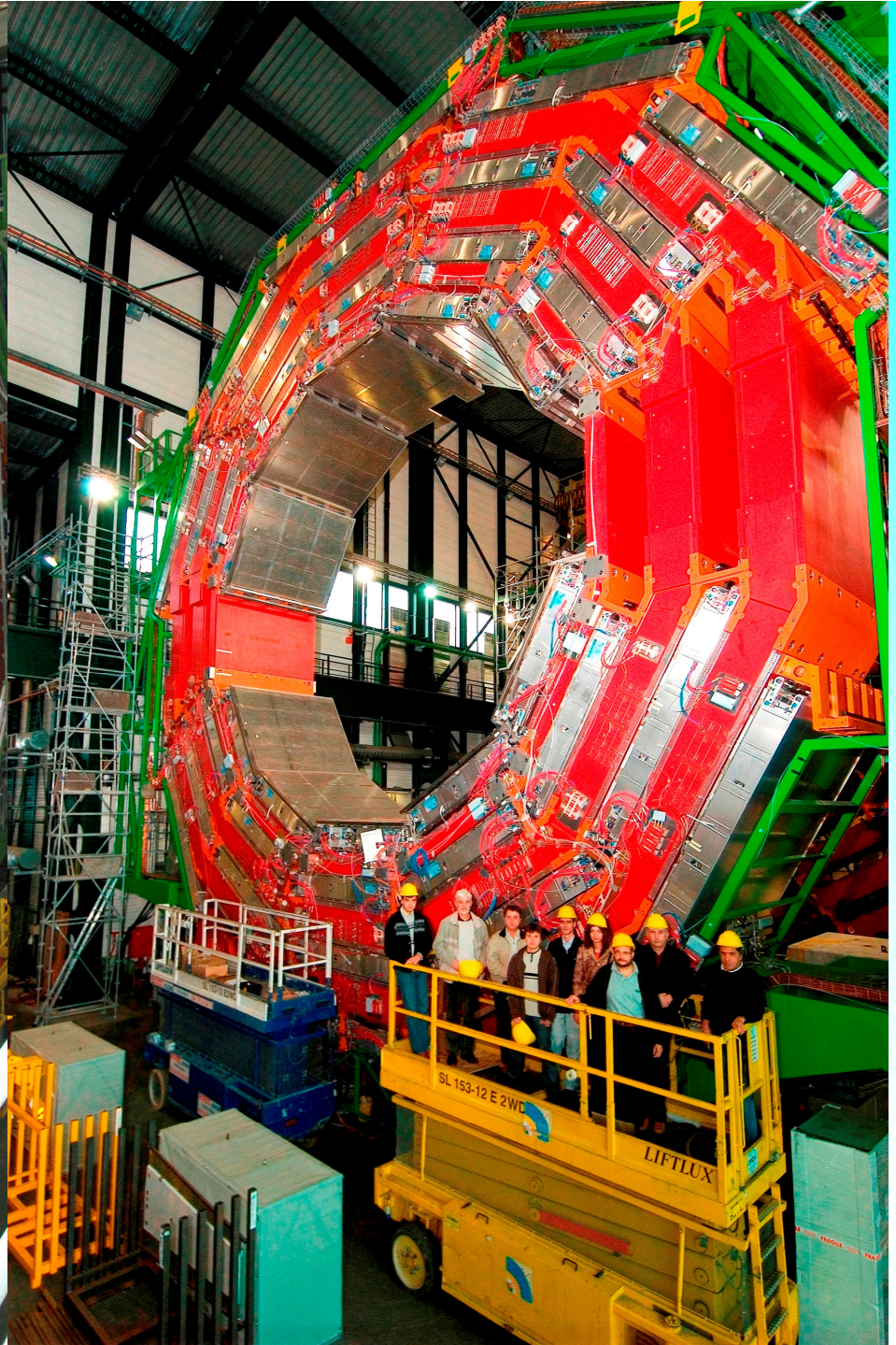
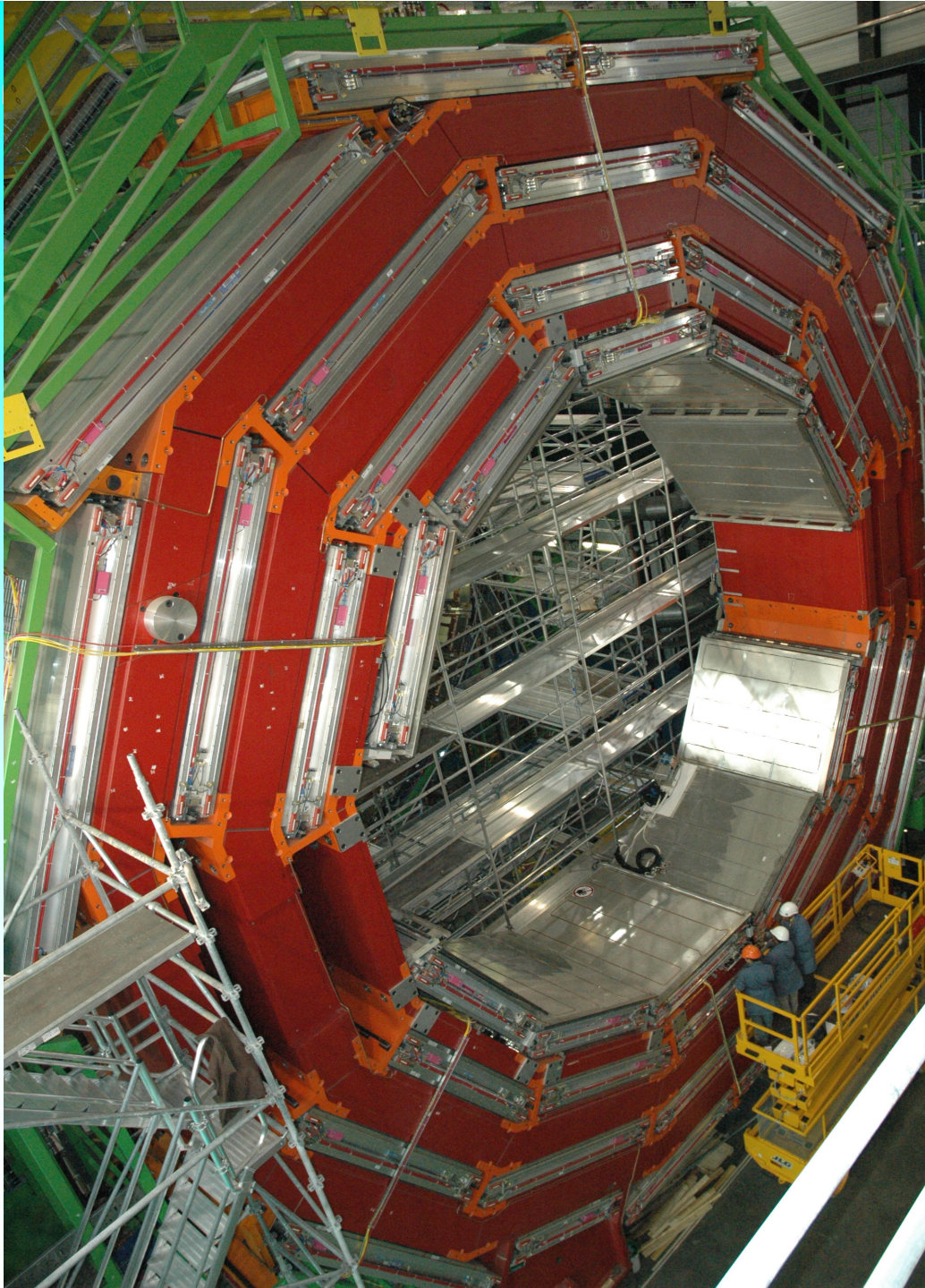
Test of first chambers



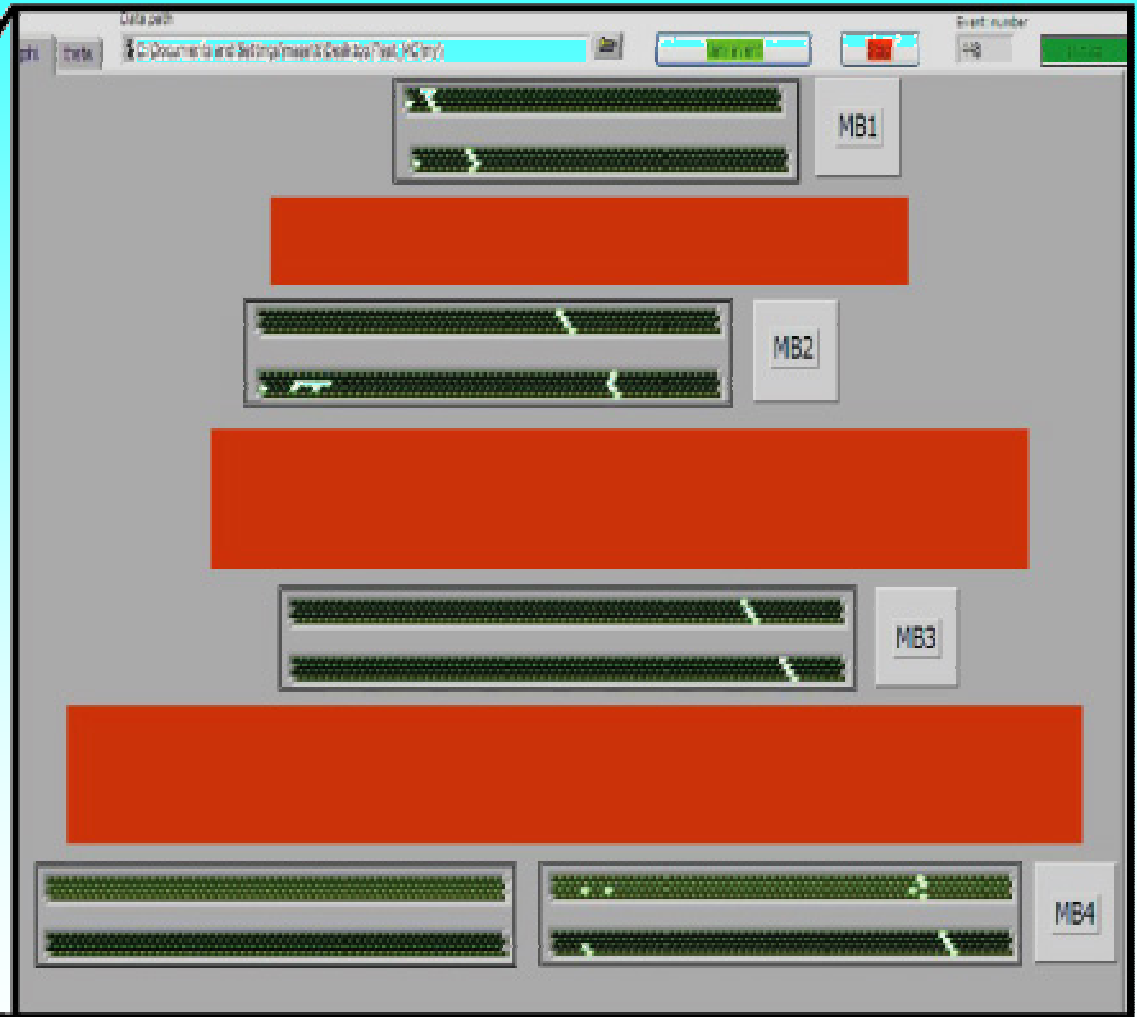
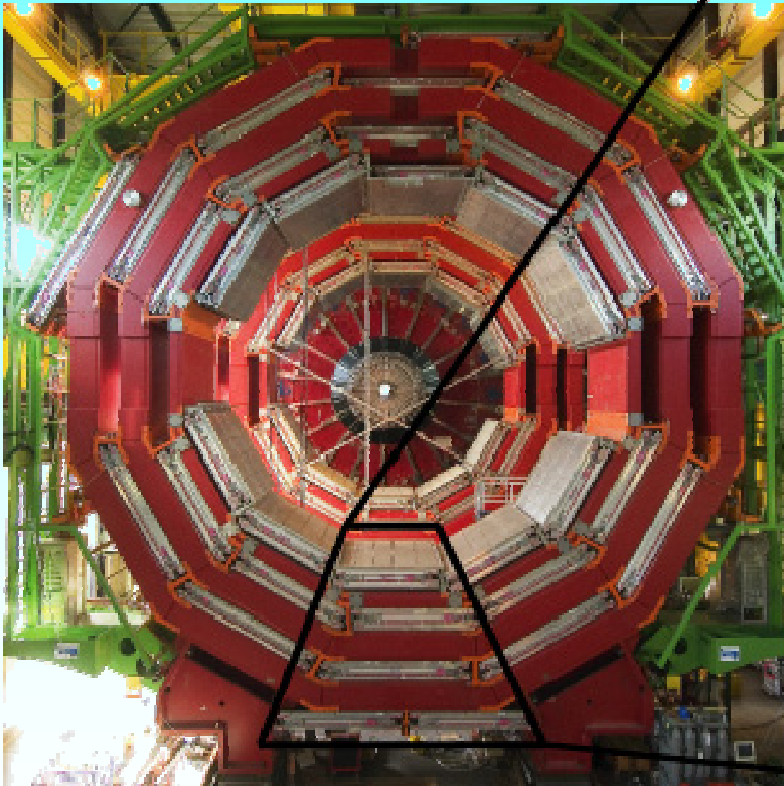


Muon system

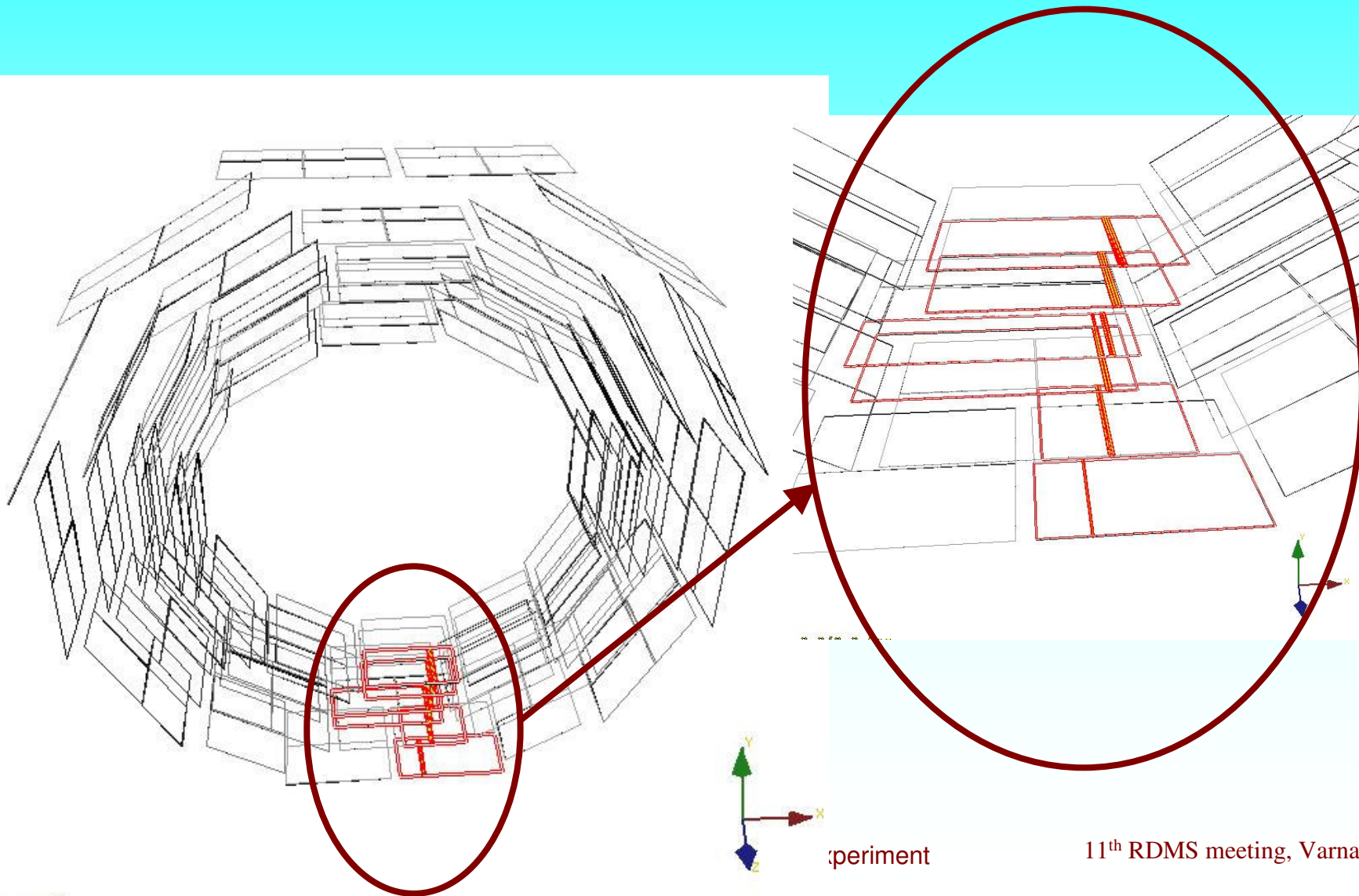




First muon event at SX5



Cosmic event in the RPCs

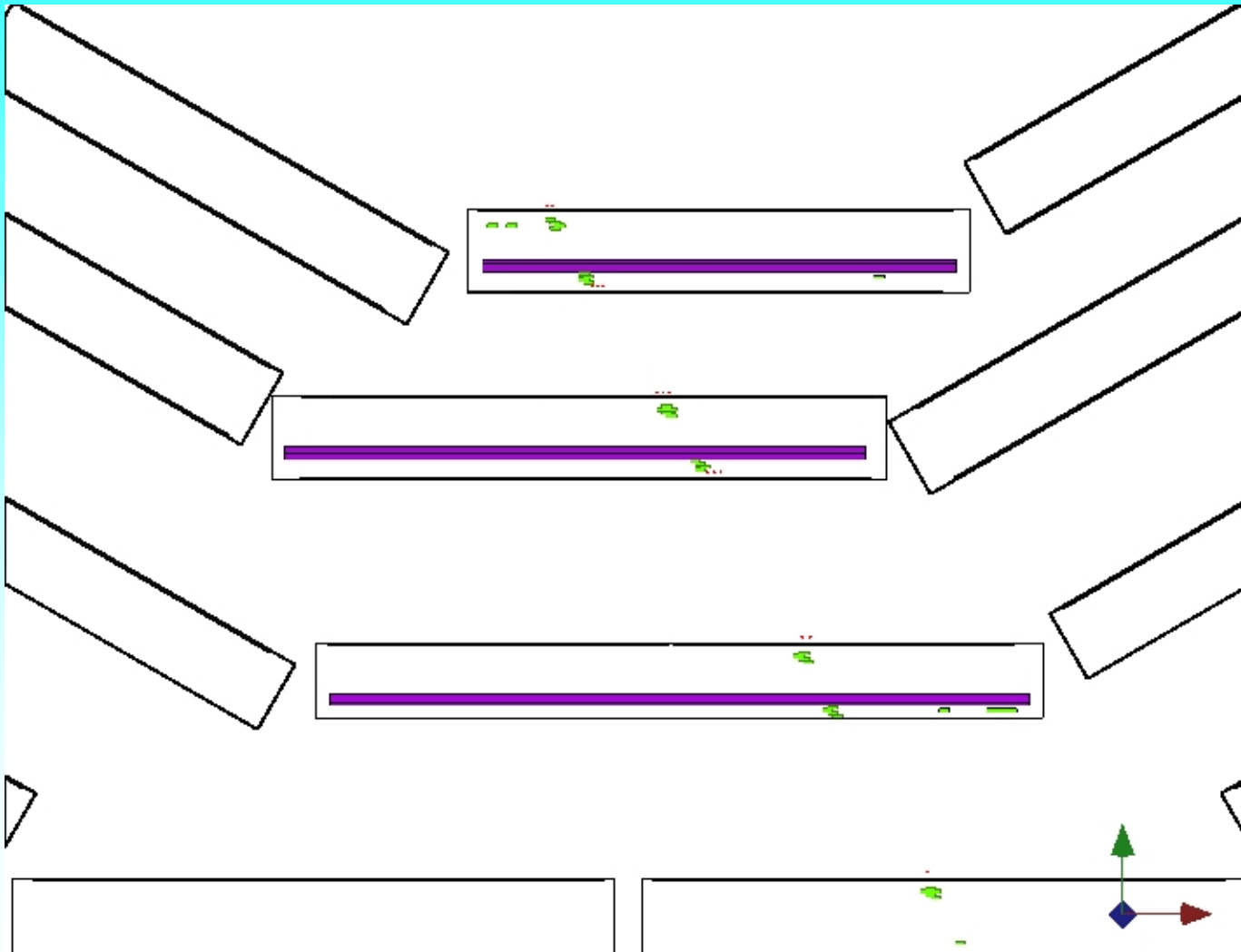


Experiment

11th RDMS meeting, Varna, September 2006



Barrel Event (DTs + RPCs)



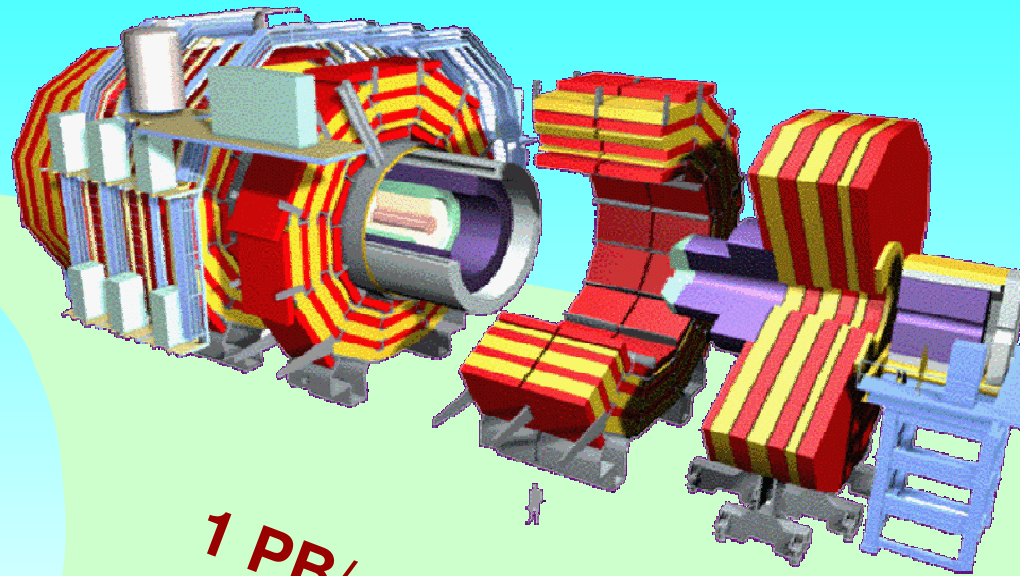
RPC
DT
DT



Computing



Data processing



1 PB/sec

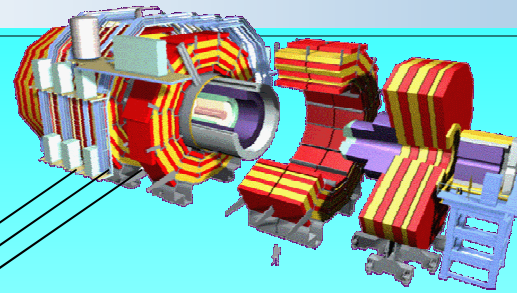
Filtering in real time:

Selection of interesting events and data compression

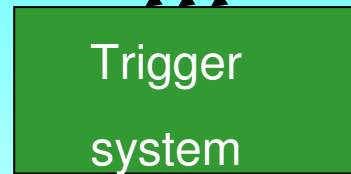
1 PB per year



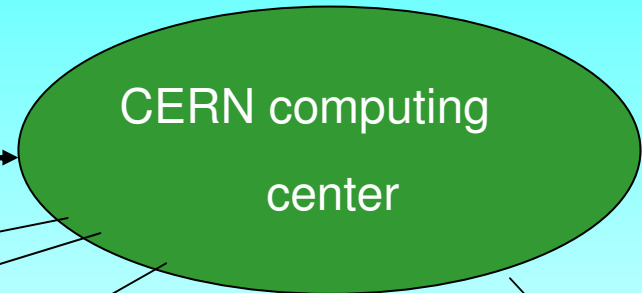
LCG



Level 0



0.1-1.5 GB/sec

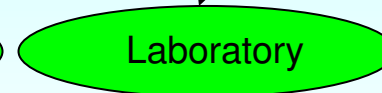


Level 1



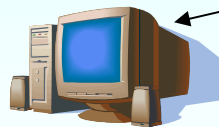
~40Gb/sec

Level 2



1-2.5 Gb/sec

Level 3



1-10 Gb/sec



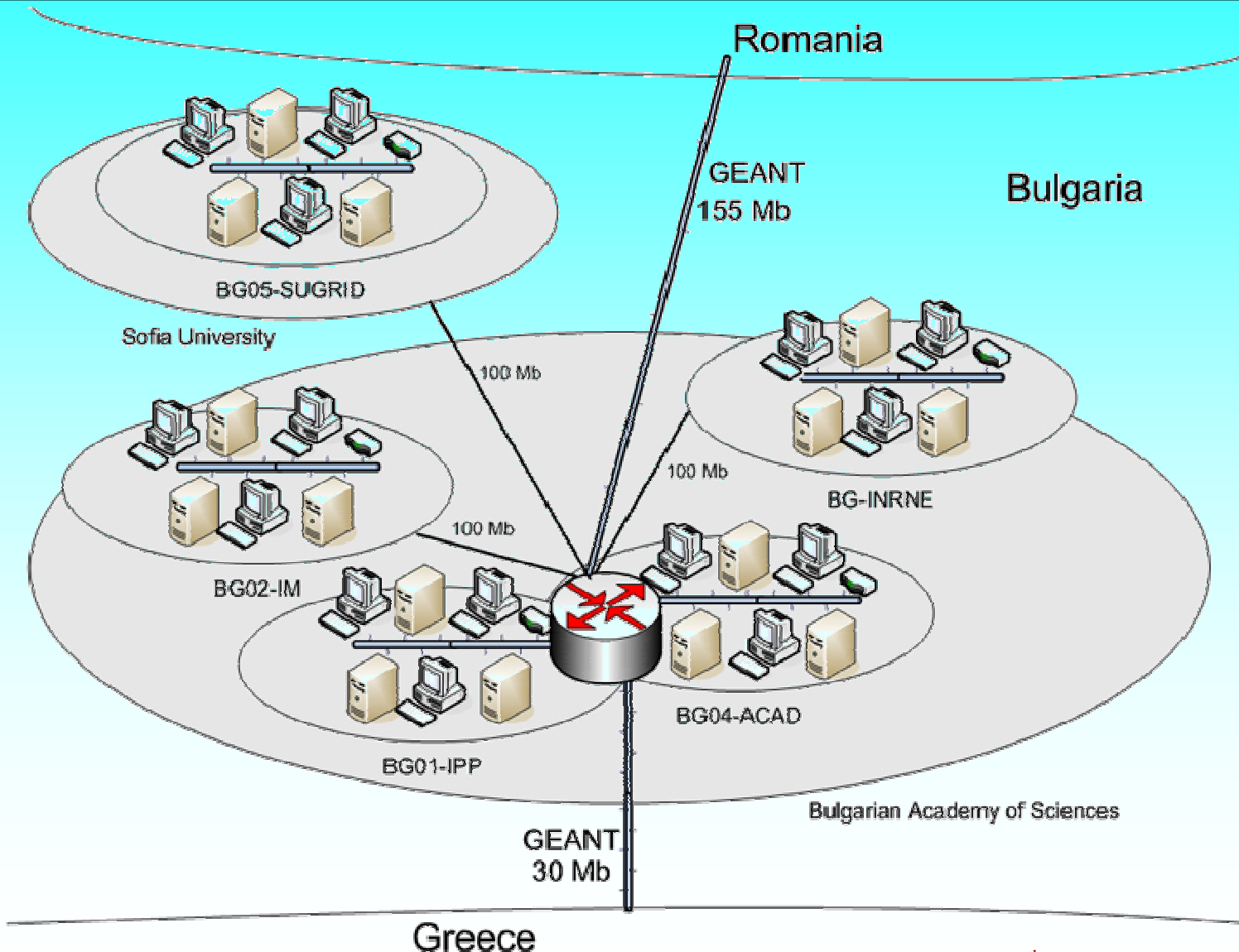
BG Grid



- Participation in EGEE
- Participation in SEEGrid
- Participation in LCG
 - ✓ Test of Jlite
 - ✓ Registration of virtual organizations
- Close collaboration with JINR
- Support and development of CMS data bases
- Development of Grid tools to support distributed CMS analysis
- Goal
 - ✓ Building of a big (~ 512 CPU) Grid site at the level of Tier 2
 - ✓ Improving connection between Grid sites in the country
 - ✓ Improving connection with GEANT – expected 600GB at the end of the year



BG Grid

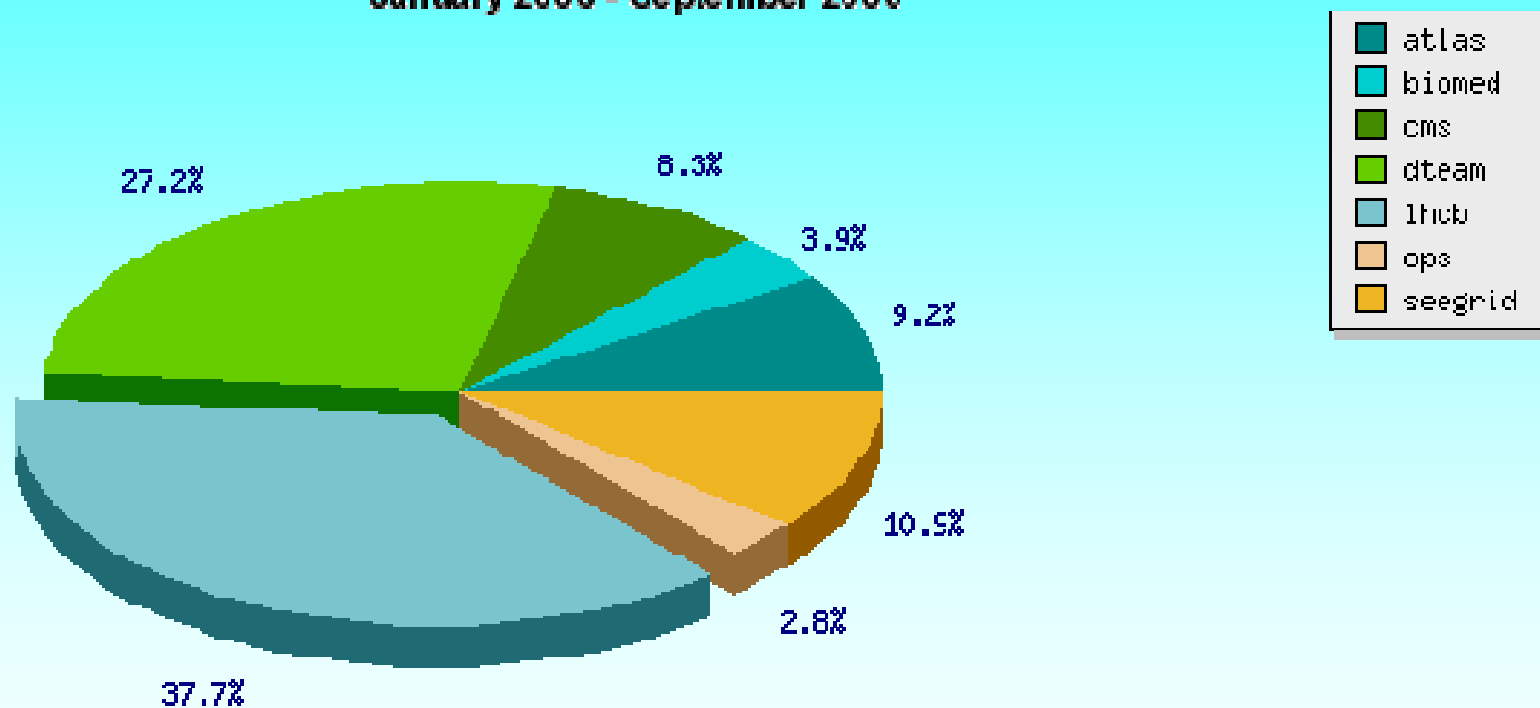


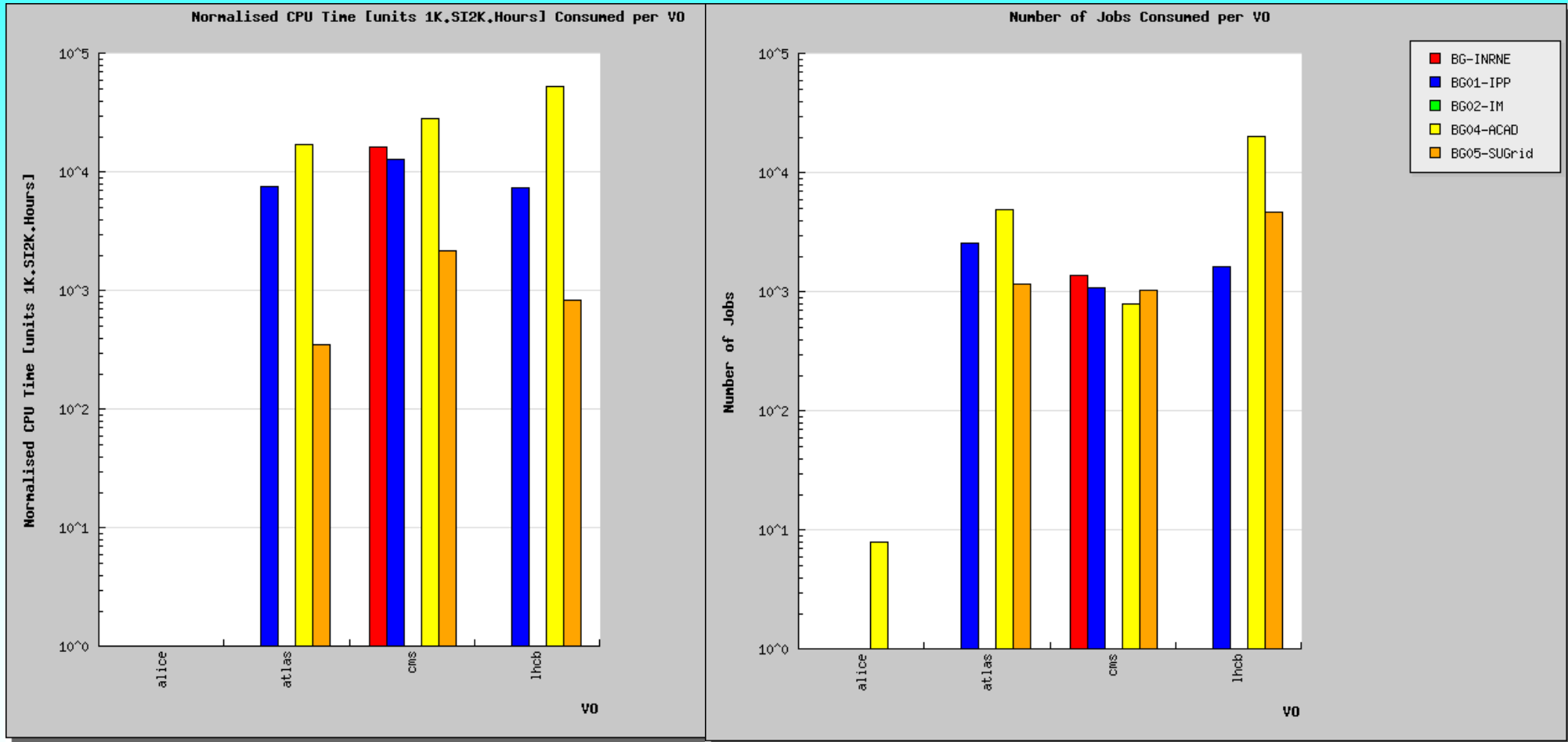


BG Grid



Total number of jobs
January 2006 - September 2006







Physics simulations



➤ Standard model H-boson

- ✓ $H \rightarrow \gamma\gamma$
- ✓ $qqH \rightarrow WW^* \rightarrow l\nu l\nu, t\bar{t}$

➤ SUSY + Extra Dimensions

- ✓ Production of low mass (130 GeV) H in black holes decays (two jet spectrum)
- ✓ Split SUSY
 - Search for long and short living gluinos
 - Search for R – hadrons
- ✓ Test of RS type models



Conclusions

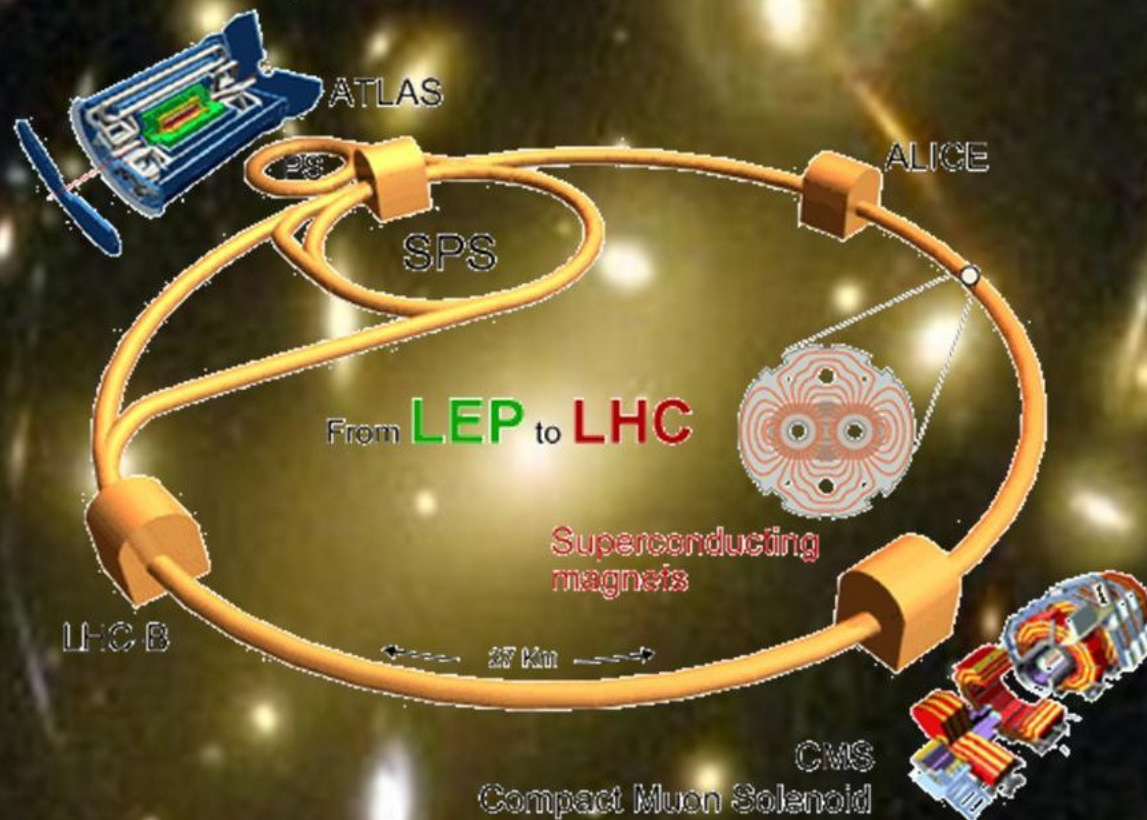


We are working hard to make a reality and

**get prepared for the incoming new
era in particle physics**

The Big Quest

for secrets of the Universe



Starts 2007