

**НАУЧНАЯ СЕССИЯ  
ОТДЕЛЕНИЯ ФИЗИКИ ВЫСОКИХ  
ЭНЕРГИЙ**

**23 декабря 2009**



# **Проект CMS в 2009**

**В.Сулимов**

# LHC

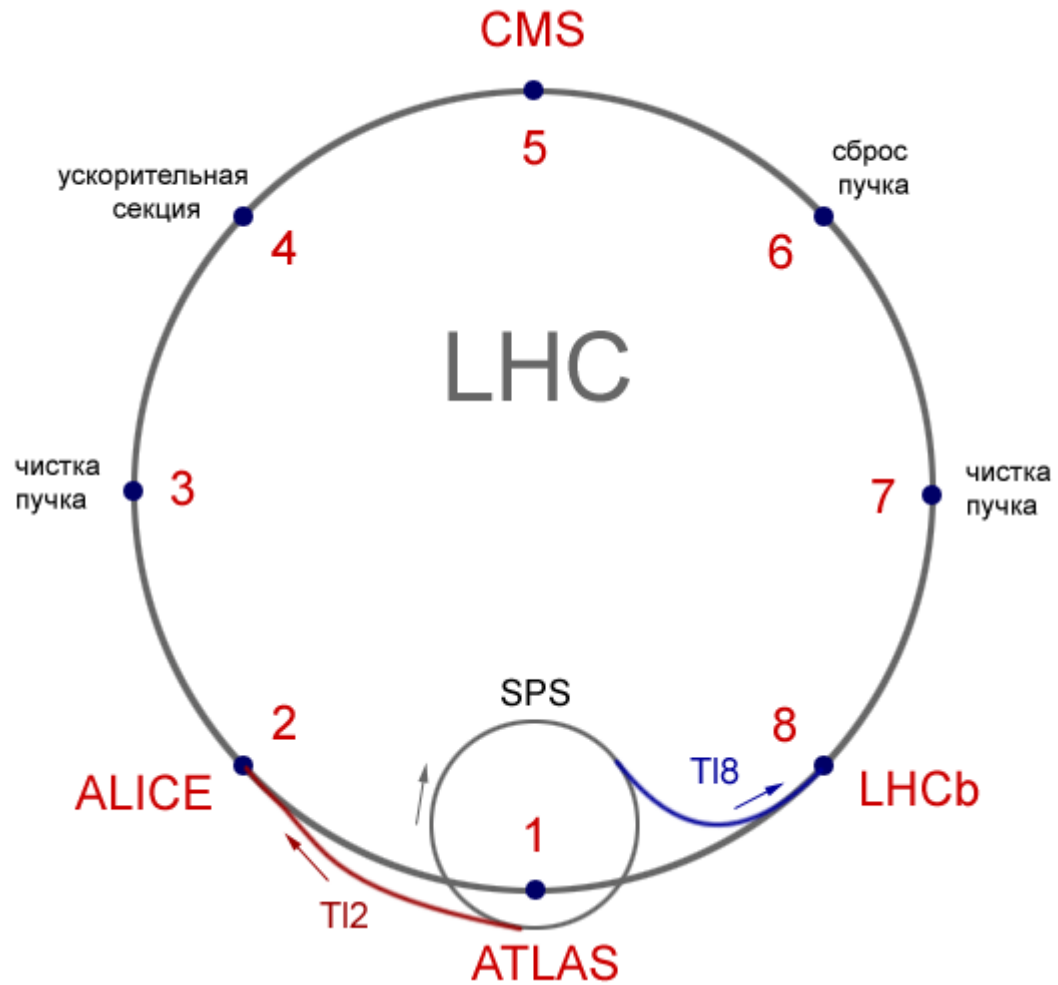


## Inauguration du LHC LHC Inauguration

CERN 21-10-2008



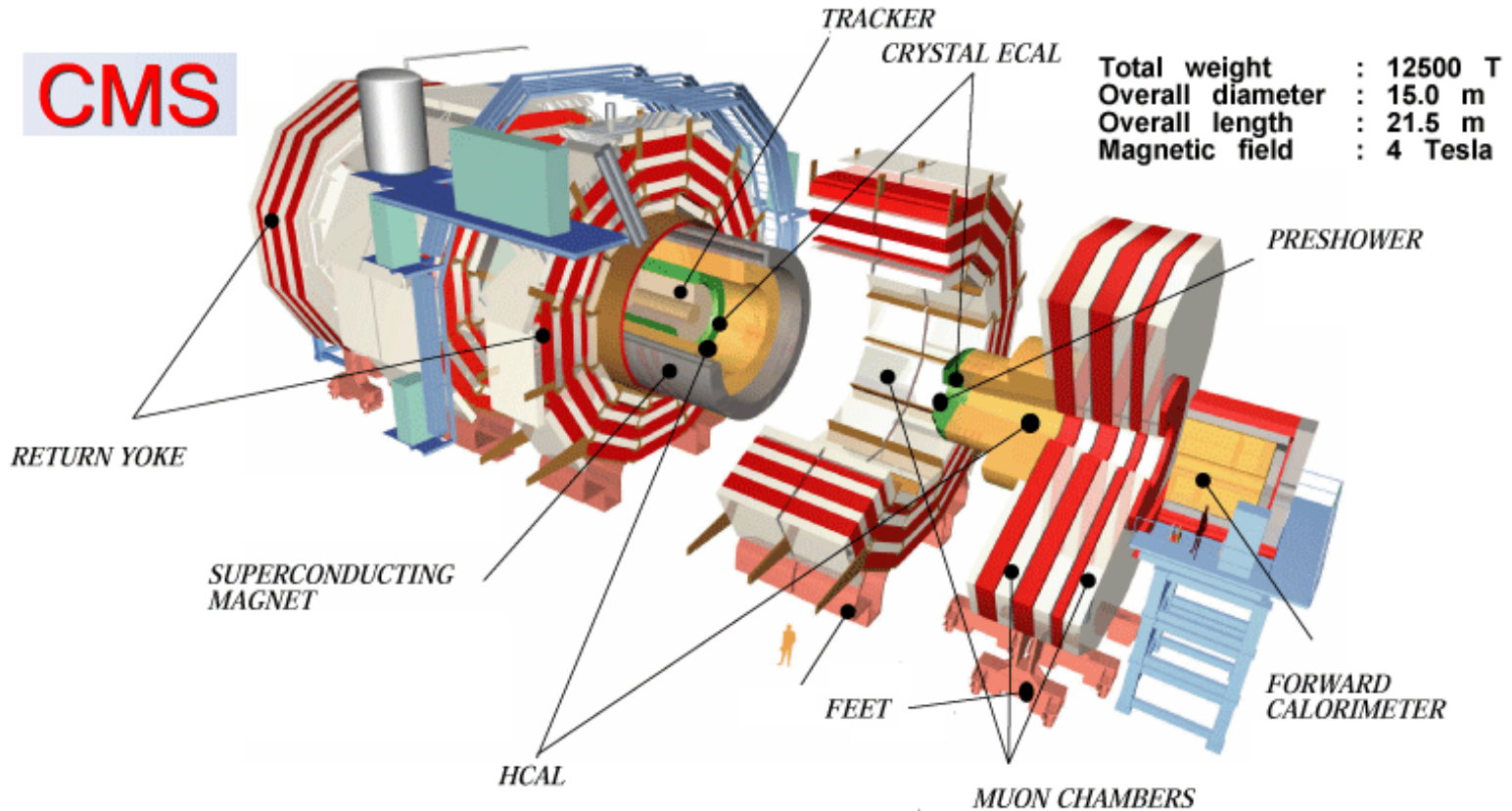
# LHC



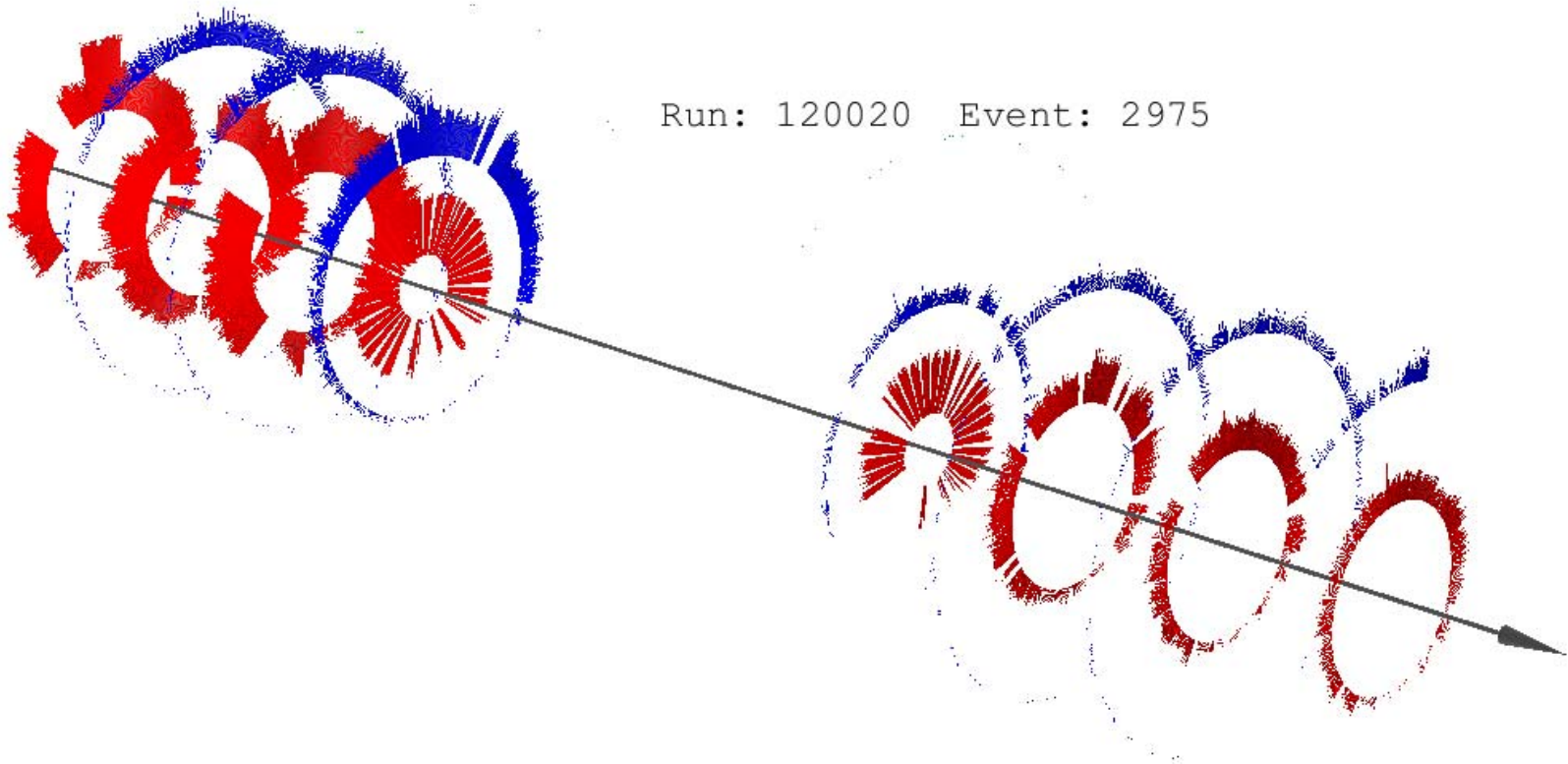
# Milestones

Date	Day	Achieved
Nov 20	1	Each beam circulating. Key beam instrumentation working.
Nov 23	4	<b>First collisions at 450 GeV. First ramp (reached 560 GeV).</b>
Nov 26	7	Magnetic cycling established (reproducibility).
Nov 27	8	Energy matching.
Nov 29	10	<b>Ramp to 1.18 TeV.</b>
Nov 30	11	Experiment solenoids on.
Dec 04	15	Aperture measurement campaign finished. LHCb and ALICE dipoles on.
Dec 05	16	<b>Machine protection (Injection, Beam dump, Collimators) ready for safe operation with pilots</b>
Dec 06	17	First collisions with <b>STABLE BEAMS, 4 on 4 pilots at 450 GeV, rates around 1Hz.</b>
Dec 08	19	Ramp colliding bunches to 1.18 TeV
Dec 11	22	Collisions with <b>STABLE BEAMS, 4 on 4 at 450 GeV, &gt; 10<sup>10</sup> per bunch, rates around 10Hz</b>
Dec 13	24	<b>Ramp 2 bunches per beam to 1.18 TeV. Collisions for 90mins.</b>
Dec 14	25	Collisions with <b>STABLE BEAMS, 16 on 16 at 450 GeV, &gt; 10<sup>10</sup> per bunch, rates around 50Hz</b>
Dec 16	27	Ramp 4 on 4 to 1.18 TeV. <b>Squeeze to 7 m.</b>

# CMS

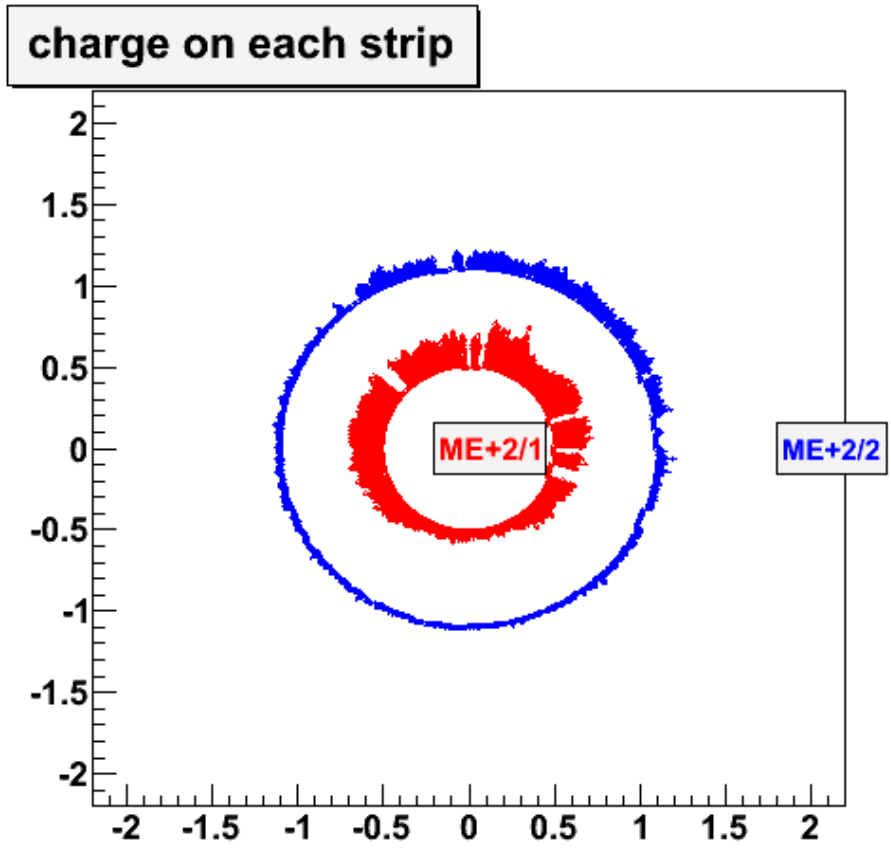


# The splash event seen by CSC in the standby mode



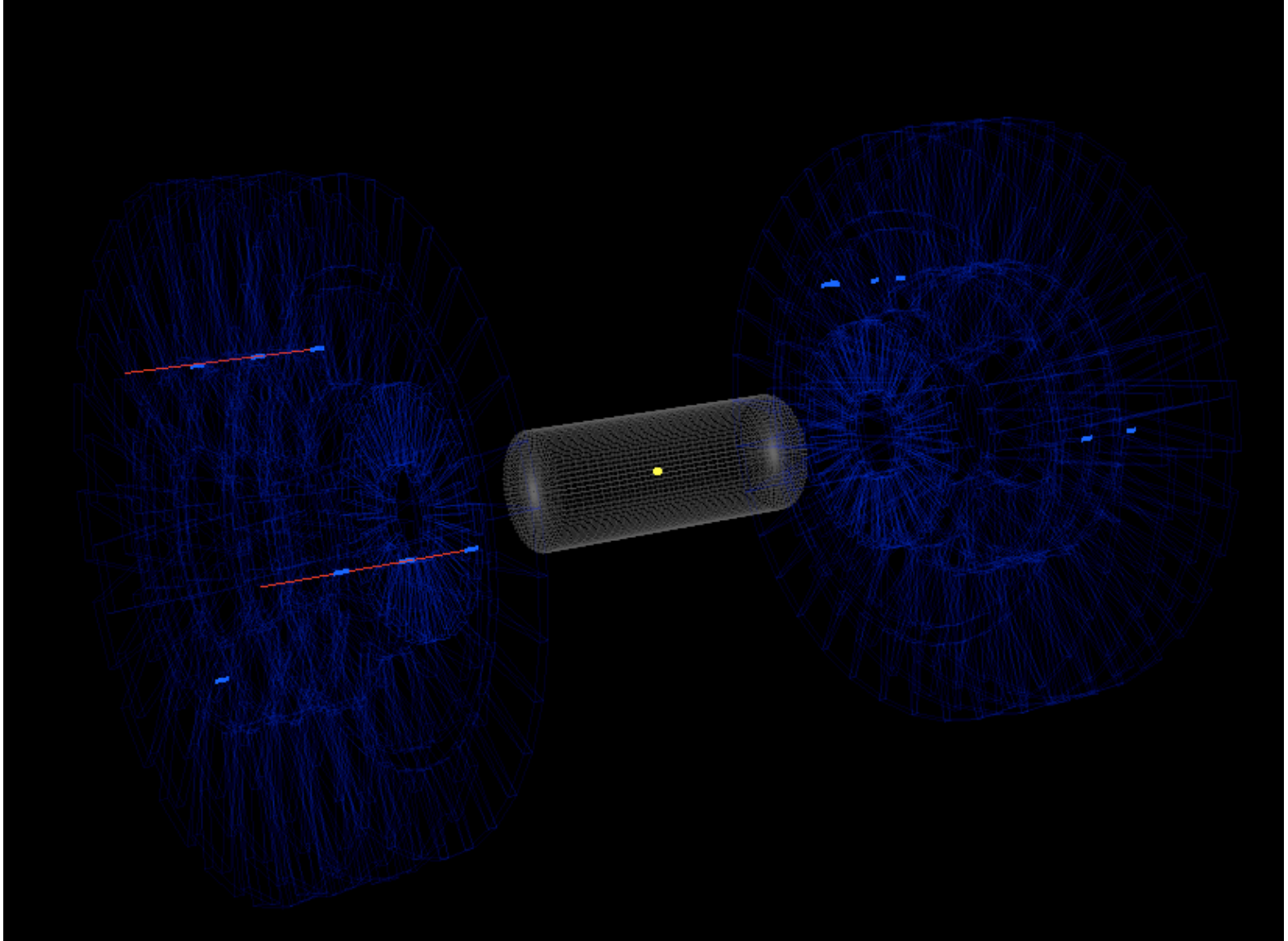
Arrow indicates beam direction





The length of the arrow is proportional to the charge on the strip. Radii contrived to show the rings clearly.

**Run 121964, event 112425 : two parallel muons**

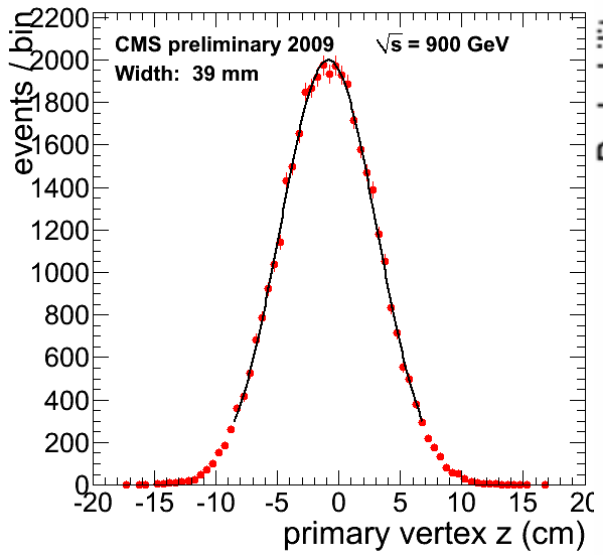




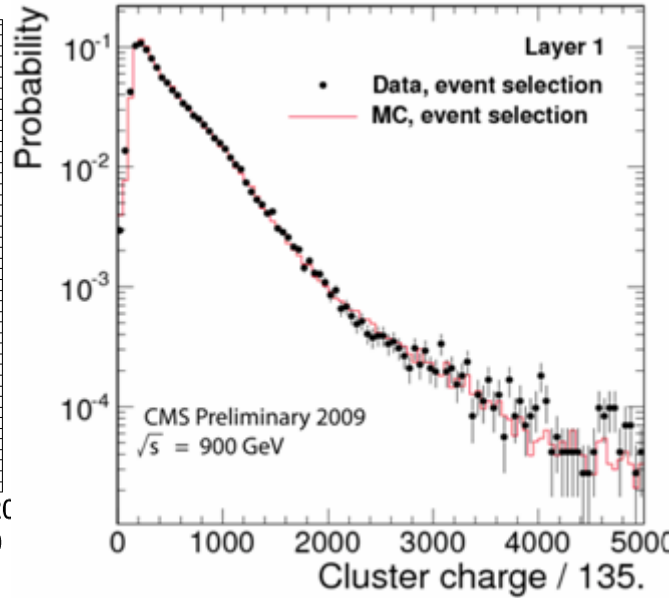
# Detector Performance :

## Tracking

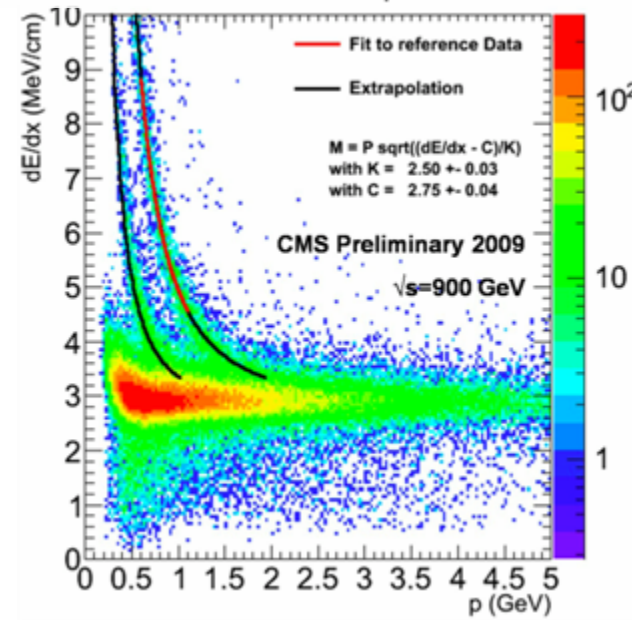
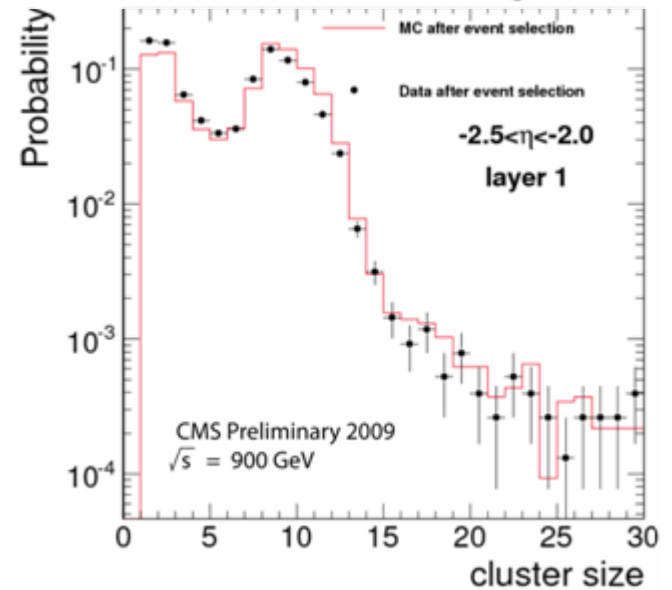
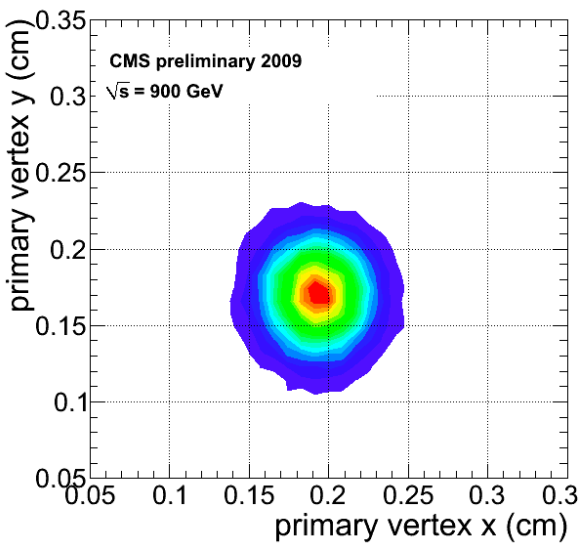
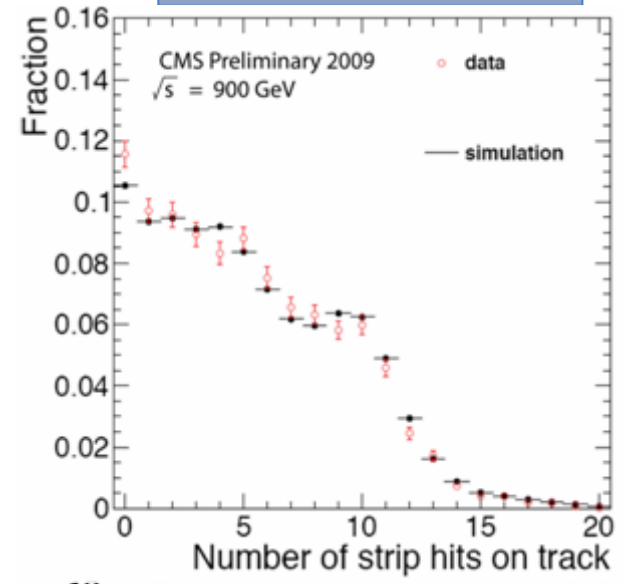
### Primary Vertex



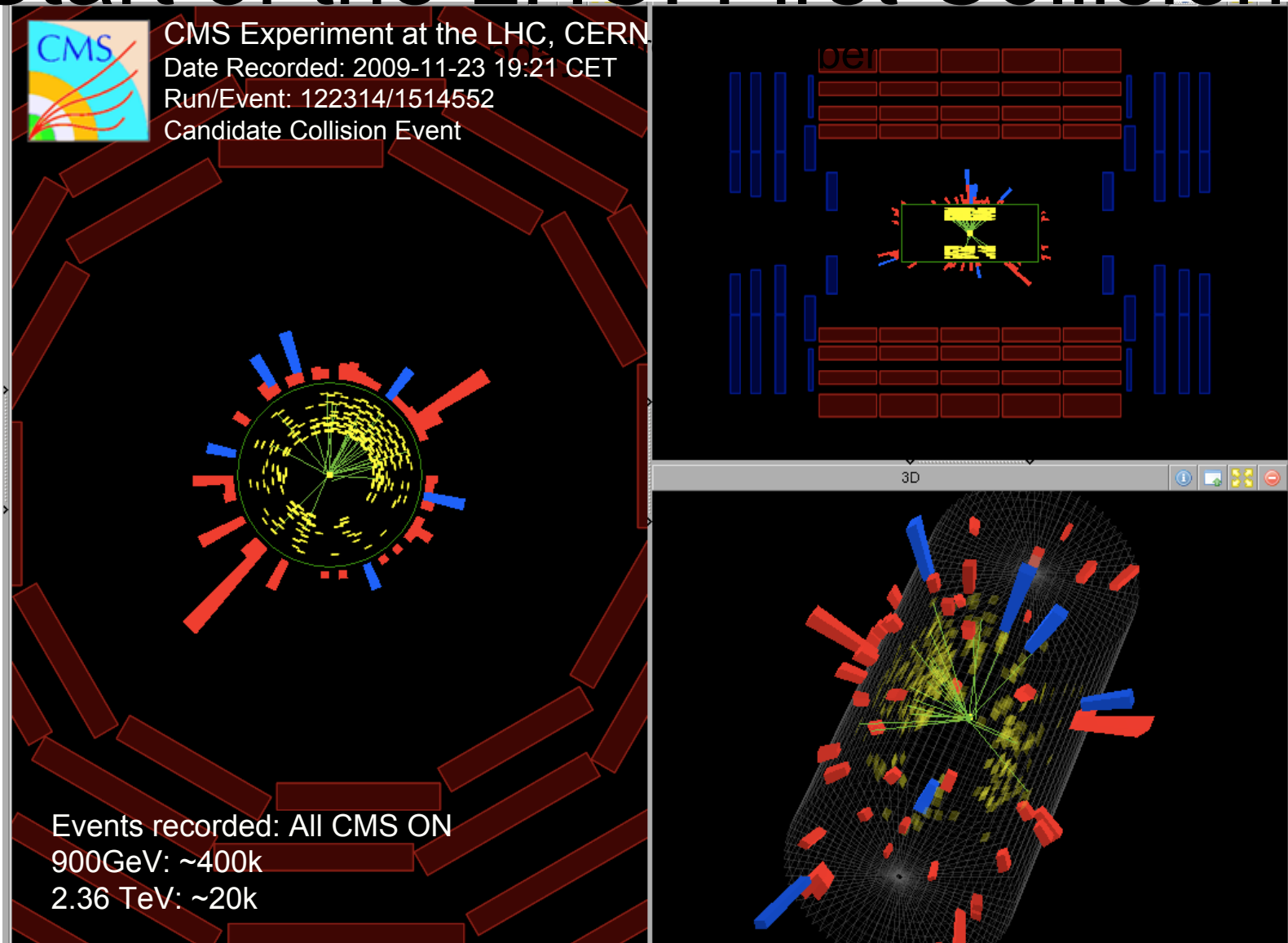
### Pixels Clusters



### Strip Tracker



# Start of the LHC: First Collisions



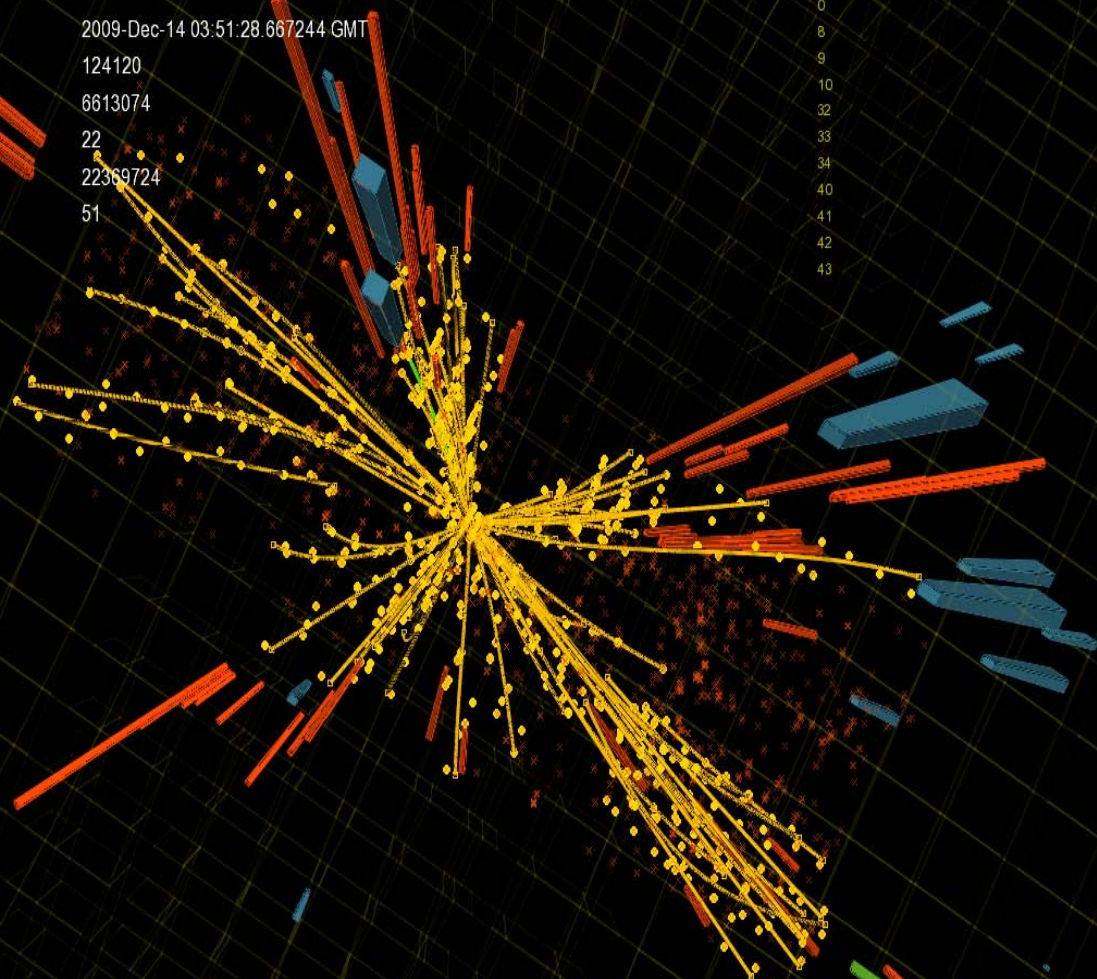


# CMS Experiment at the LHC, CERN

Data recorded: 2009-Dec-14 03:51:28.667244 GMT  
Run: 124120  
Event: 6613074  
Lumi section: 22  
Orbit: 22369724  
Crossing: 51

Tech Triggers:

- 0
- 8
- 9
- 10
- 32
- 33
- 34
- 40
- 41
- 42
- 43



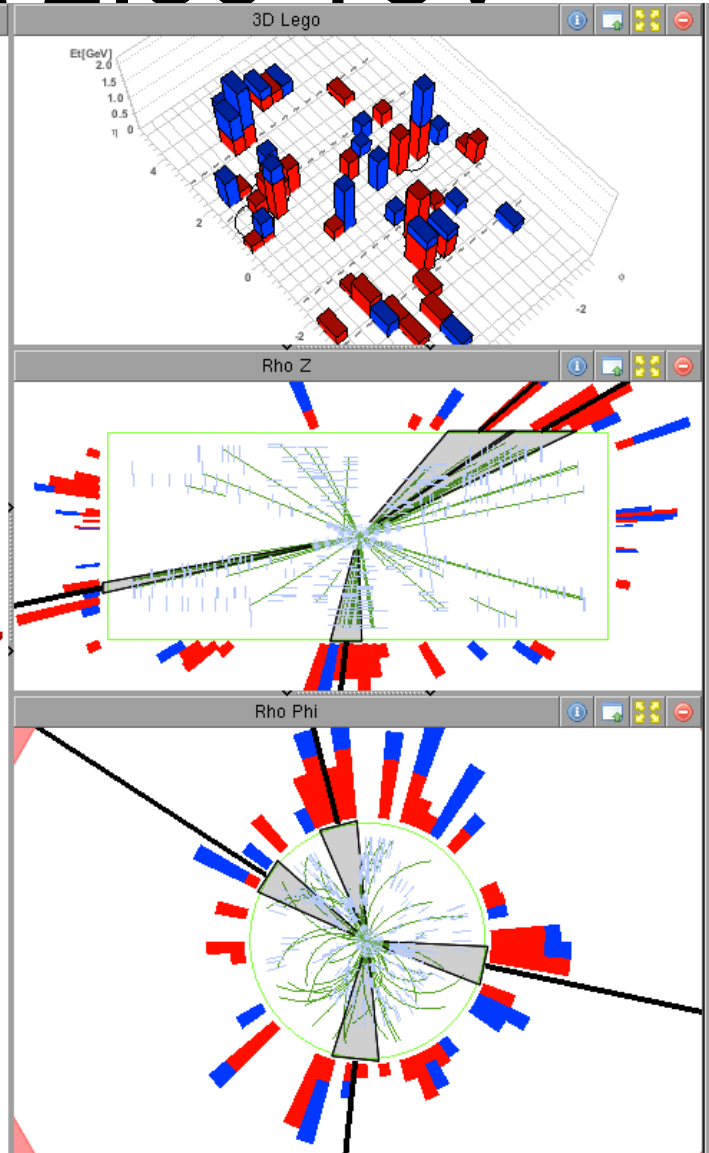
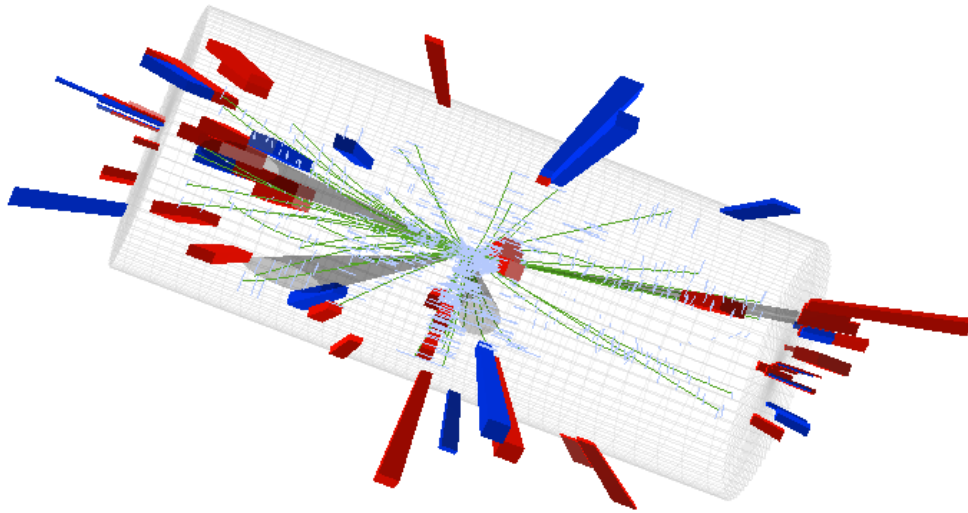
## Candidate Multi Jet Event at 2.36 TeV



# MultiJet Event at 2.36 TeV

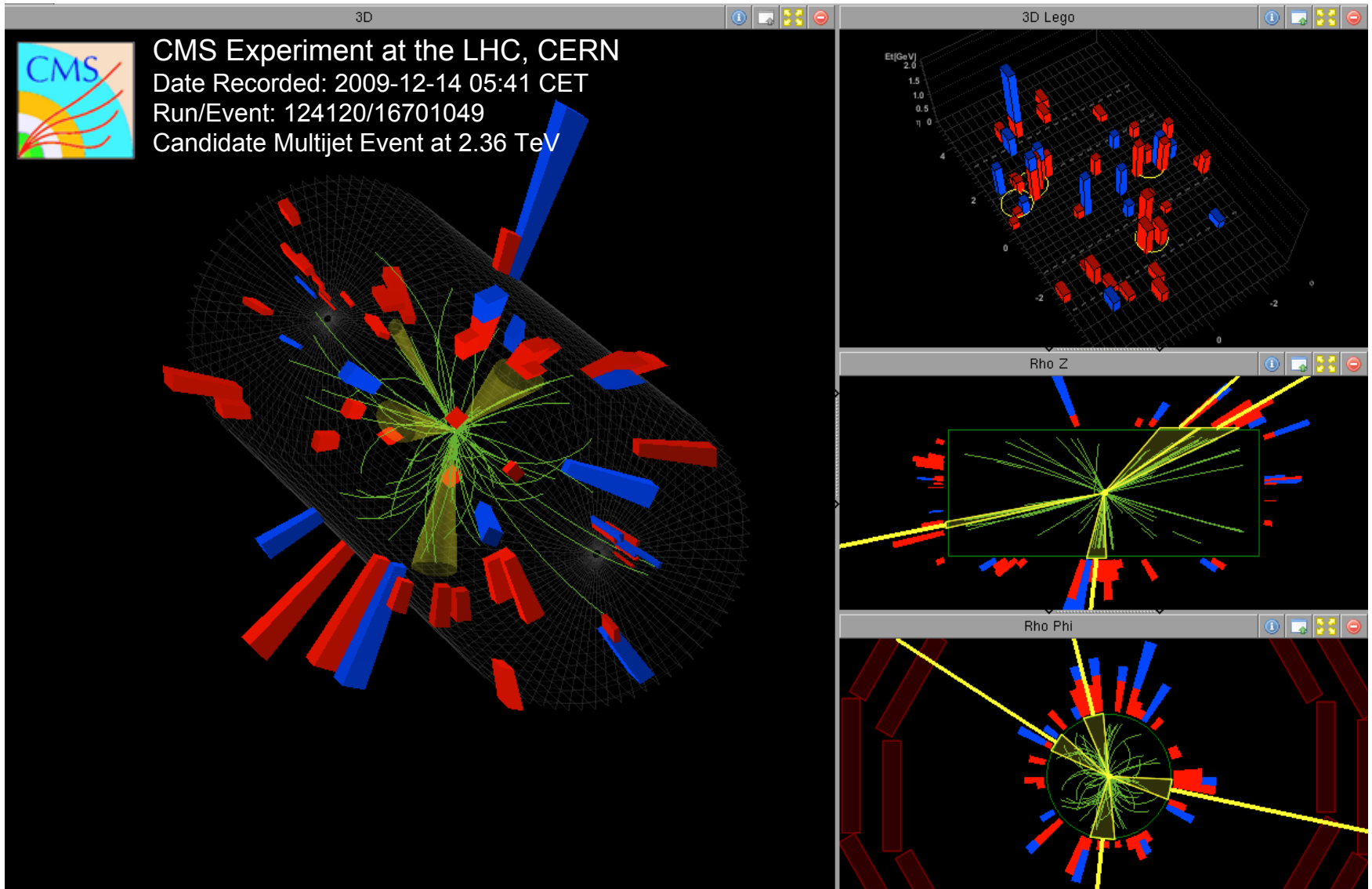


CMS Experiment at the LHC, CERN  
Date Recorded: 2009-12-14 05:41 CET  
Run/Event: 124120/16701049  
Candidate Multijet Event at 2.36 TeV

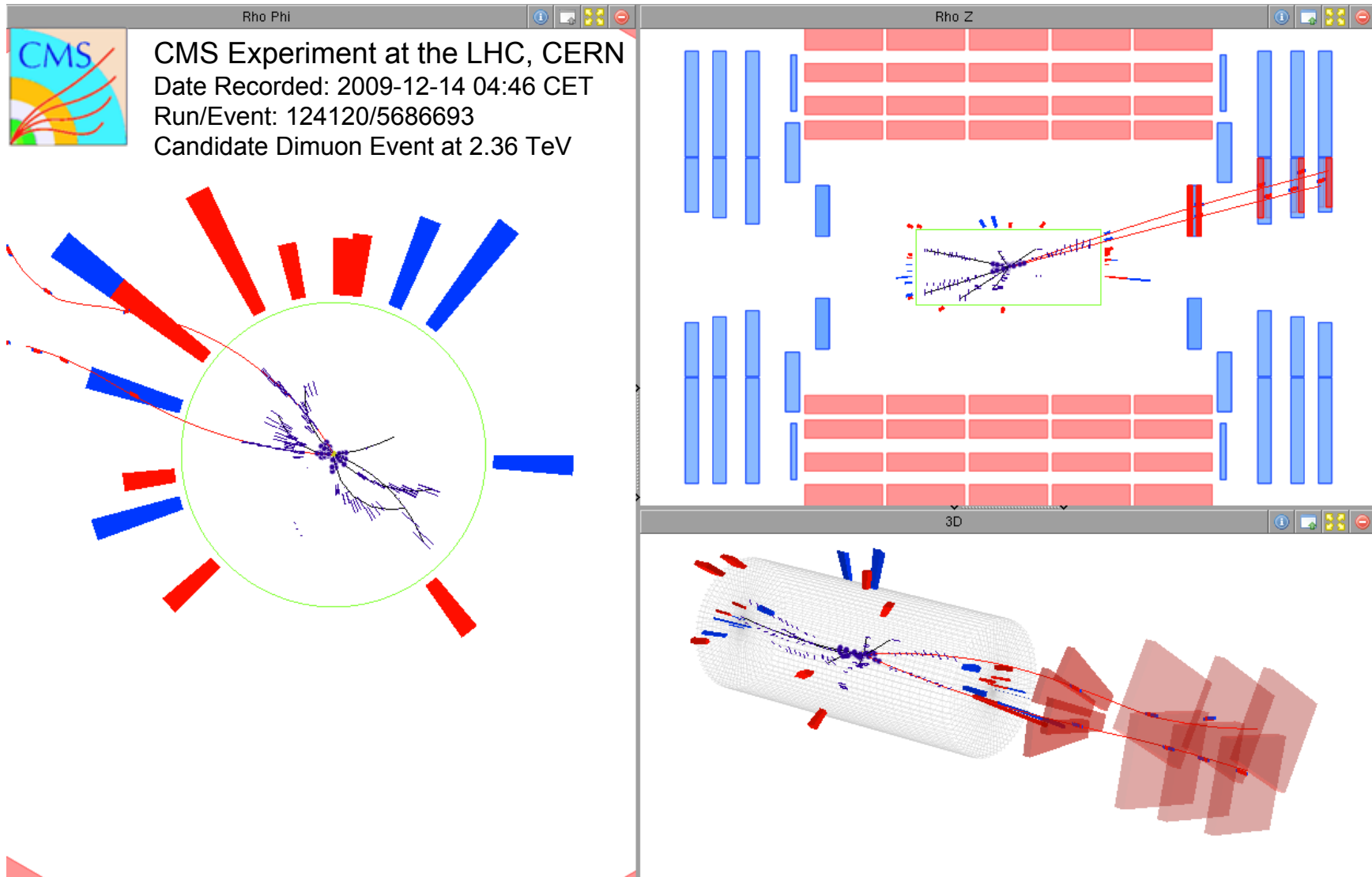


4 PFlow Jets  $E_T > 7$  GeV,  $p_T$  cut on tracks displayed  $> 0.4$  GeV

# MultiJet Event at 2.36 TeV



# Dimuon Event at 2.36 TeV

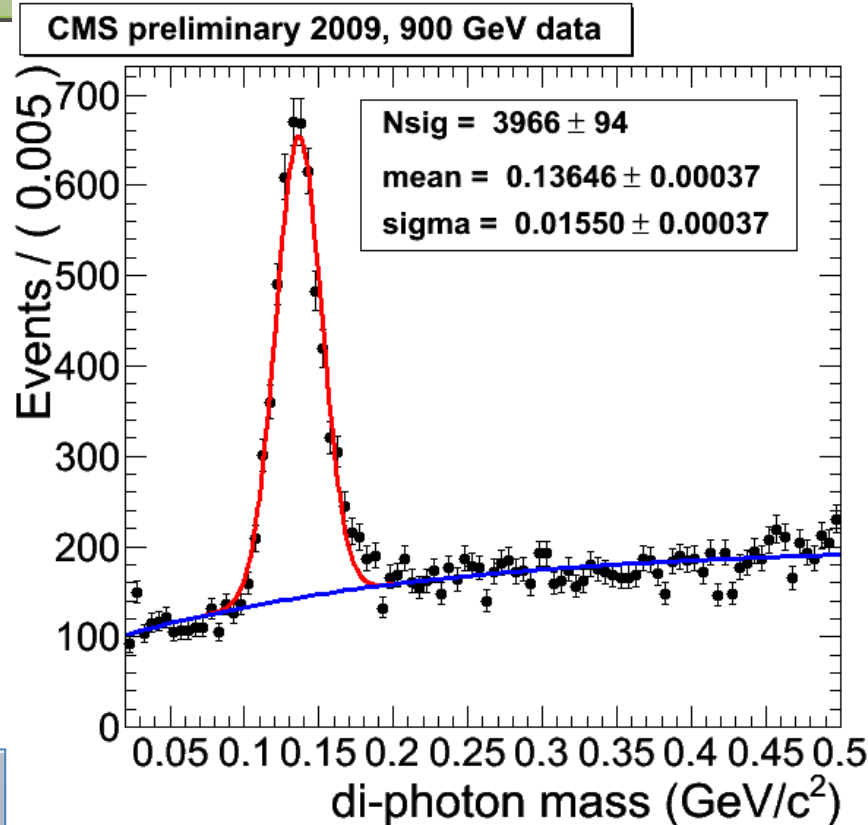
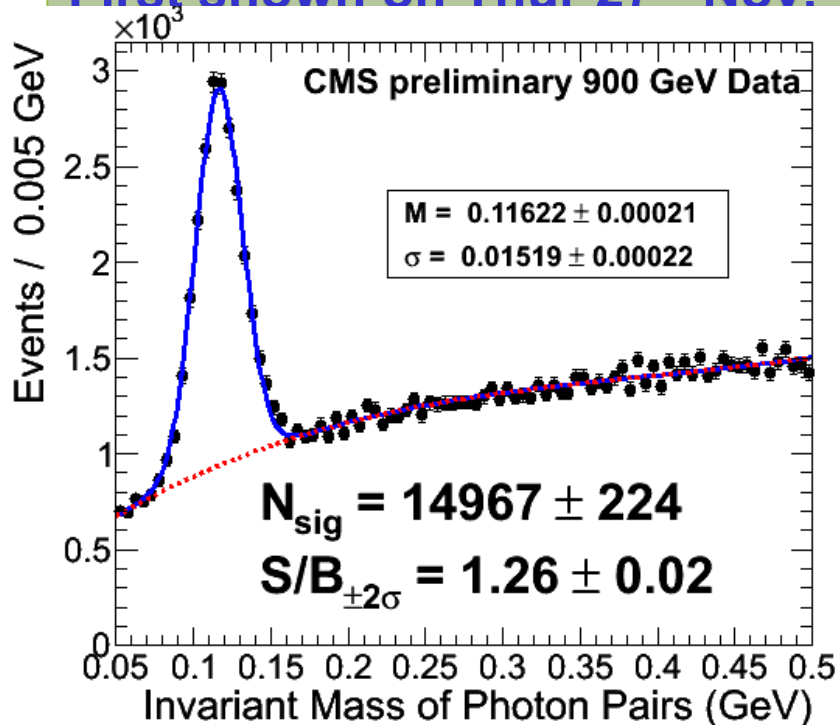


$$p_T(\mu_1) = 3.6 \text{ GeV}, \quad p_T(\mu_2) = 2.6 \text{ GeV}, \quad m(\mu\mu) = 3.03 \text{ GeV}$$



# First Di-photon Distribution in CMS

First shown on Thur 27<sup>th</sup> Nov. Today's distributions shown below



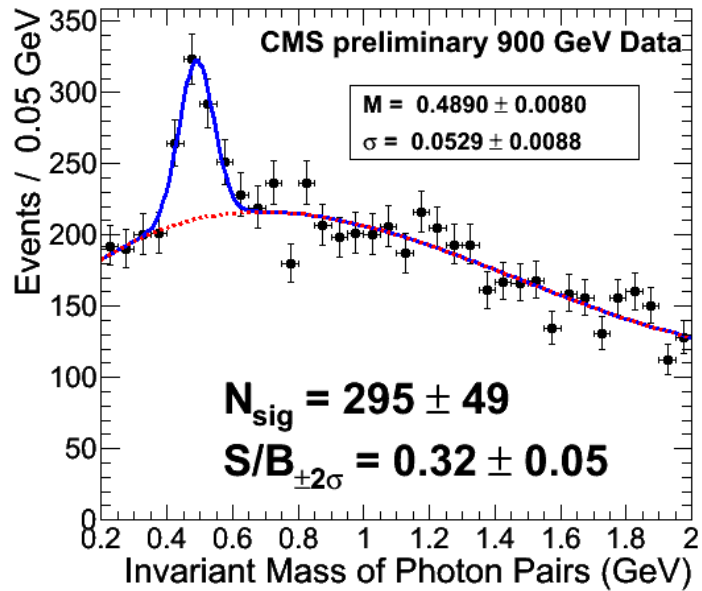
- Data and MC comparison (uncorrected distributions)
- Almost identical S/B, mass and width compatible
- $M(\pi^0)$  is low in both data and MC - Mostly due to the readout threshold (100 MeV/Crystal) and conversions

Using "out of the box" corrections

# Eta and Phi

$\eta$

CMS 2009 Preliminary  
Uncorrected



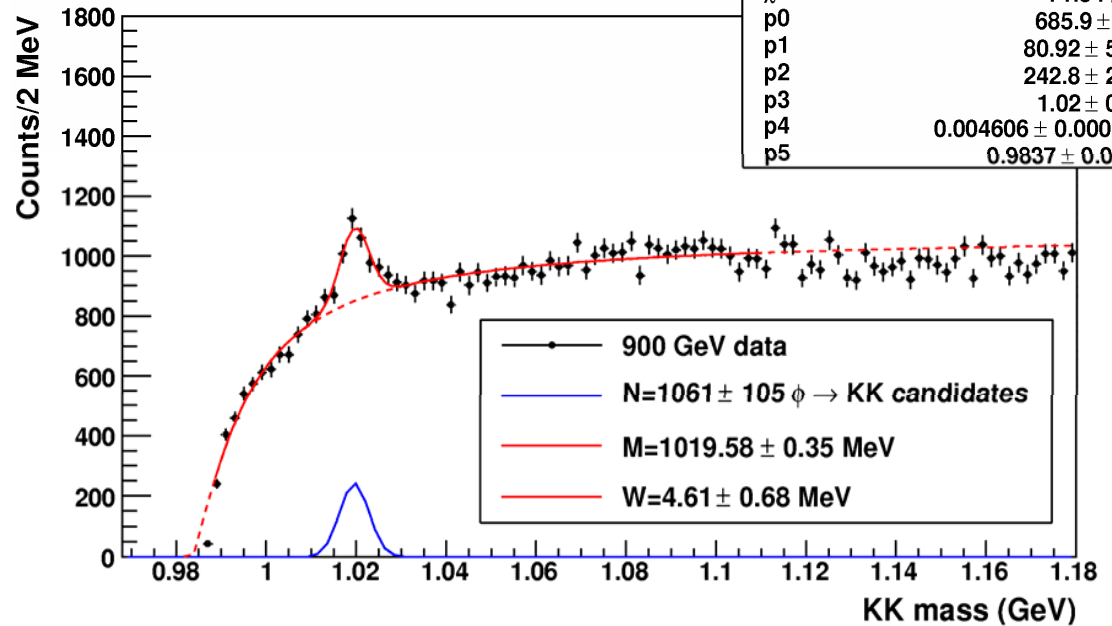
Data:  $N(\eta)/N(\pi^0) = 0.020 \pm 0.003$

MC:  $N(\eta)/N(\pi^0) = 0.021 \pm 0.003$

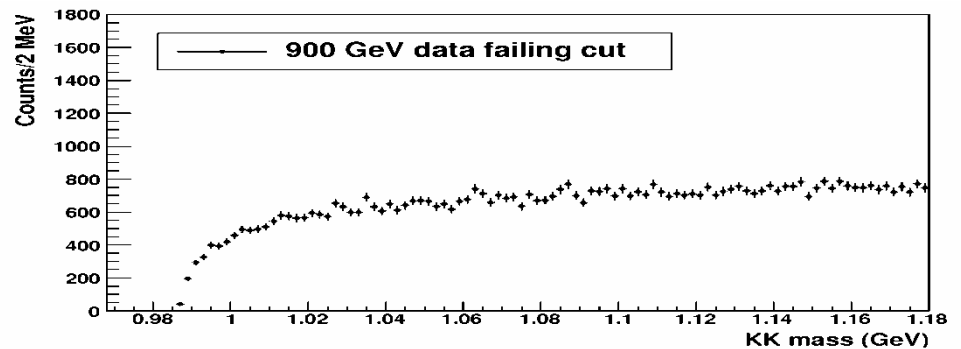
$\phi$

CMS 2009 Preliminary

Phi Candidates passing dE/dx cut



Entries	1185567
$\chi^2 / \text{ndf}$	71.54 / 55
p0	685.9 ± 6.2
p1	80.92 ± 5.74
p2	242.8 ± 24.7
p3	1.02 ± 0.00
p4	0.004606 ± 0.000676
p5	0.9837 ± 0.0006



# Rapid Analysis

**Sunday 6<sup>th</sup> Early Morning: First “Physics” Fill**

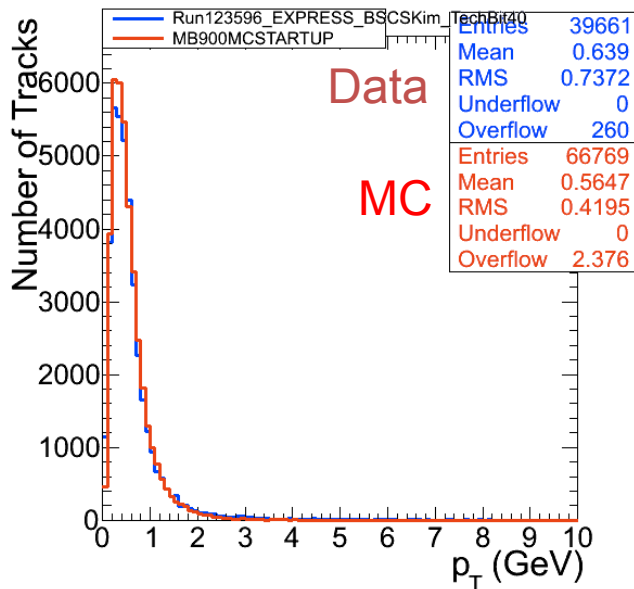
4x4 bunches,  $\Sigma \sim e10$  protons, Stable Beam Flag set for the first time

**Sunday 6<sup>th</sup> : 9am**  
LHC Run Meeting

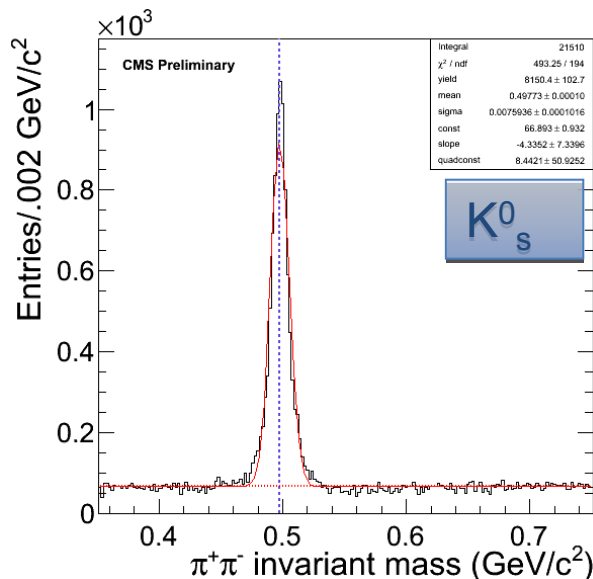
All of CMS was Switched ON

**Monday 7<sup>th</sup> : First  $K^0_S$  &  $\Lambda$**

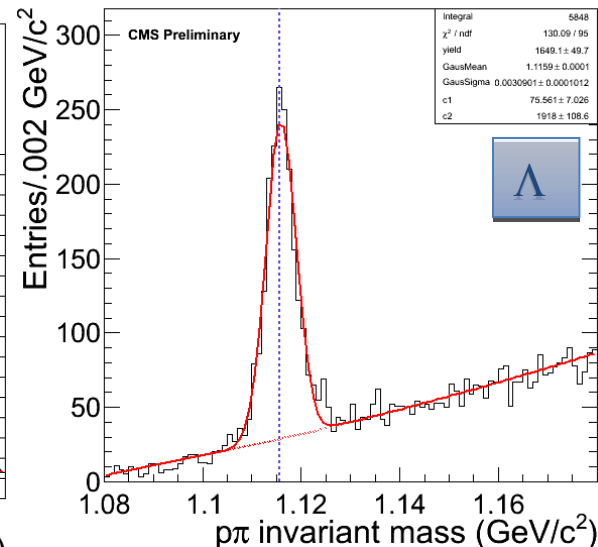
CMS 2009 Preliminary



Charged particle  
 $p_T$  spectrum

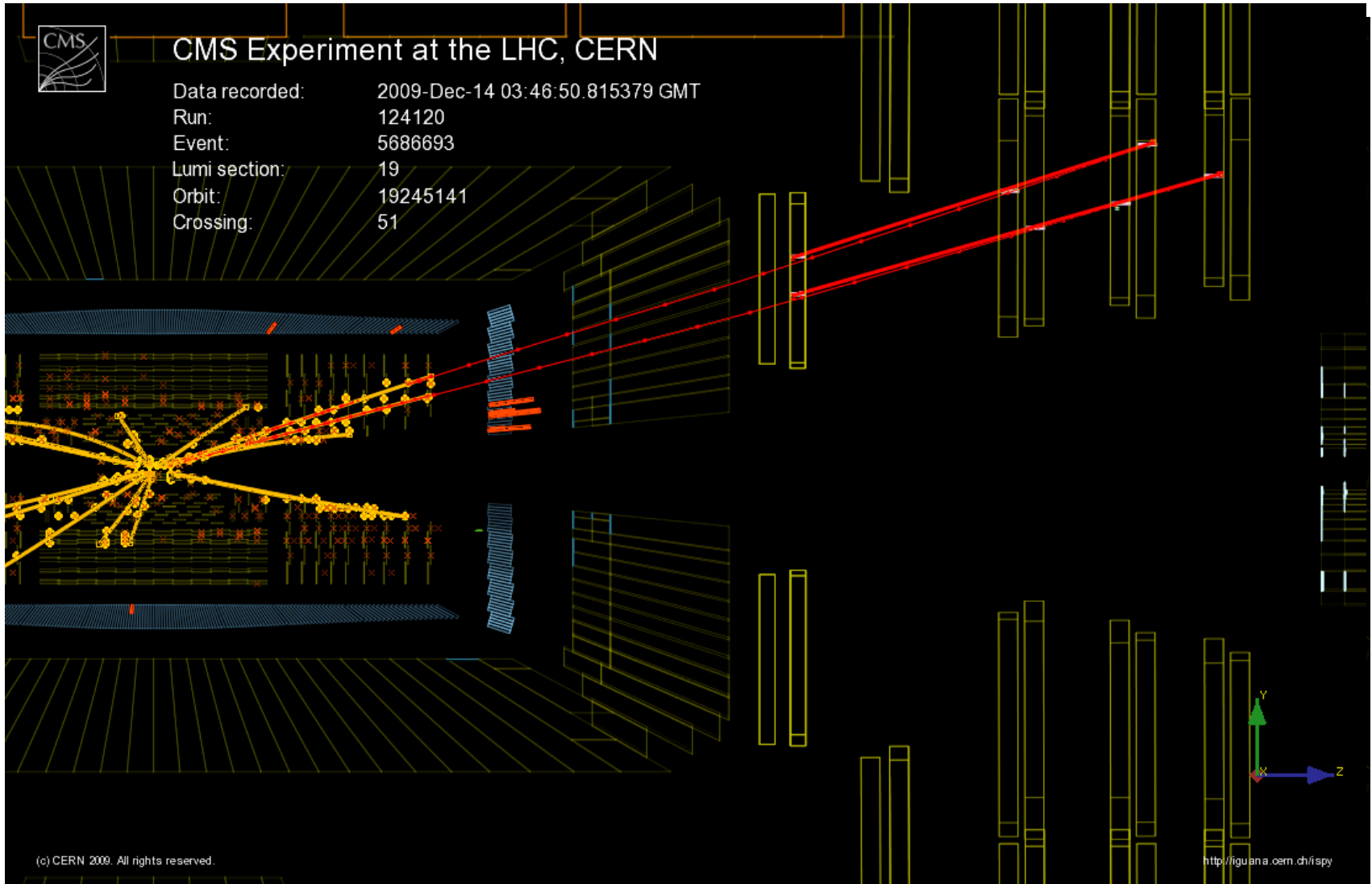


$M=497.7 \text{ MeV}/c^2, \sigma=7.6 \text{ MeV}/c^2$



$M=1.116 \text{ GeV}/c^2, \sigma=3.1 \text{ MeV}/c^2$

# Muons: A Dimuon Event at 2.36



$$p_T(\mu_1) = 3.6 \text{ GeV}, p_T(\mu_2) = 2.6 \text{ GeV}, m(\mu\mu) = 3.03 \text{ GeV}$$

# End-Cap Muon System

468 CSCs, not counting ME4/2

- 144 Large CSCs ( $3.4 \times 1.5 \text{ m}^2$ ):

- 72 ME2/2 chambers

- 72 ME3/2 chambers

- Small CSCs ( $1.8 \times 1.1 \text{ m}^2$ ):

- 72 ME1/2 chambers

- 72 ME1/3 chambers

- 72 ME1/1 chambers

- $20^\circ$  CSCs ( $1.9 \times 1.5 \text{ m}^2$ ):

- 36 ME2/1 chambers

- 36 ME3/1 chambers

- 36 ME4/1 chambers

- Frontend Electronics:

- 170K Cathode channels

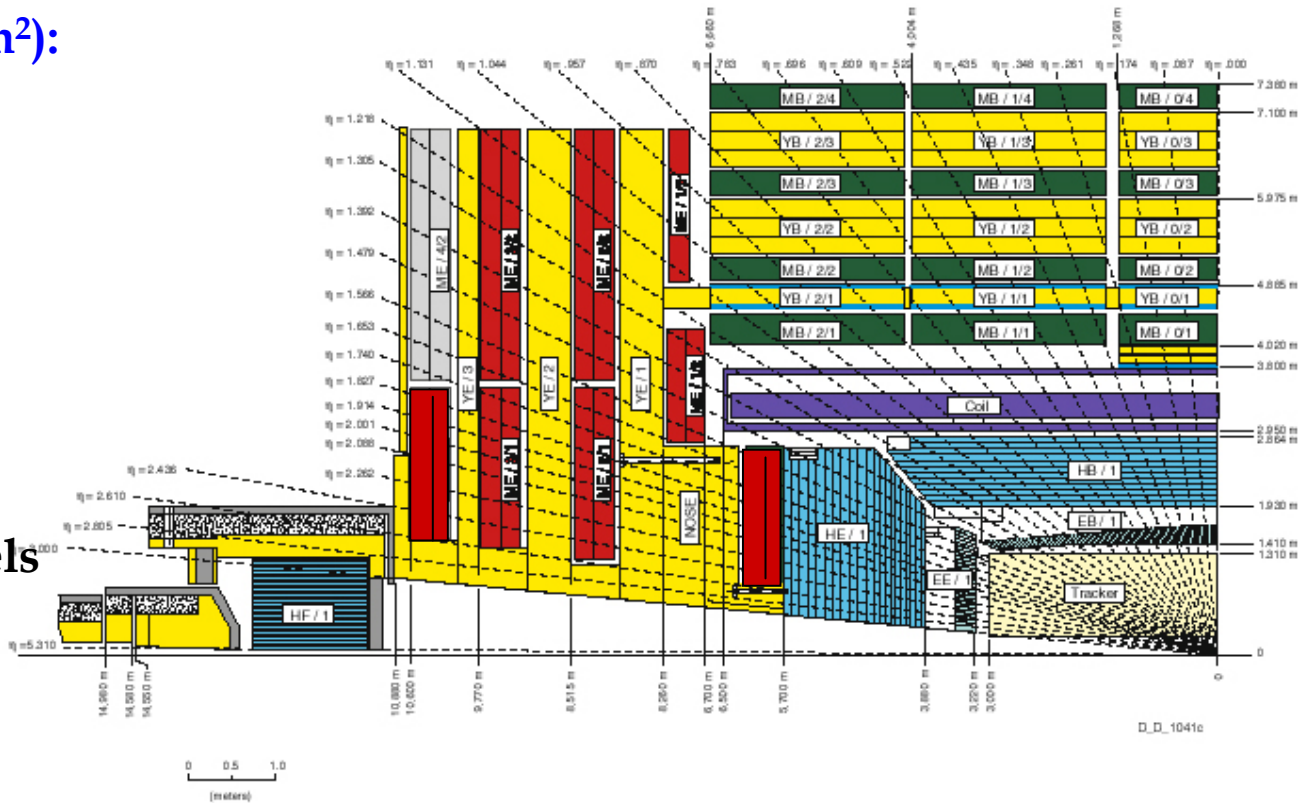
- 140K Anode channels

- Trigger & DAQ

- (on-chamber part)

- Alignment & Services

CMS DETECTOR



CMS-ARB 15 April 97

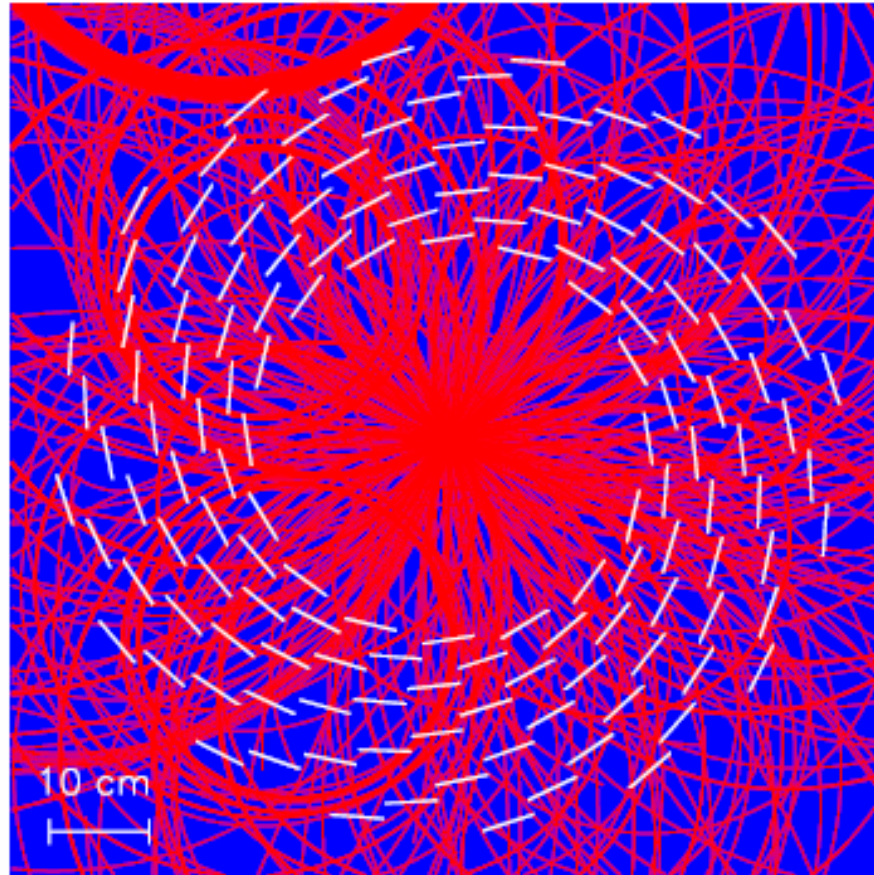
004



# Puzzle

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18 superimposed pp collisions,  
as seen by internal part of CMS silicon central tracker.  
Among them 4 muons from a higgs decay.



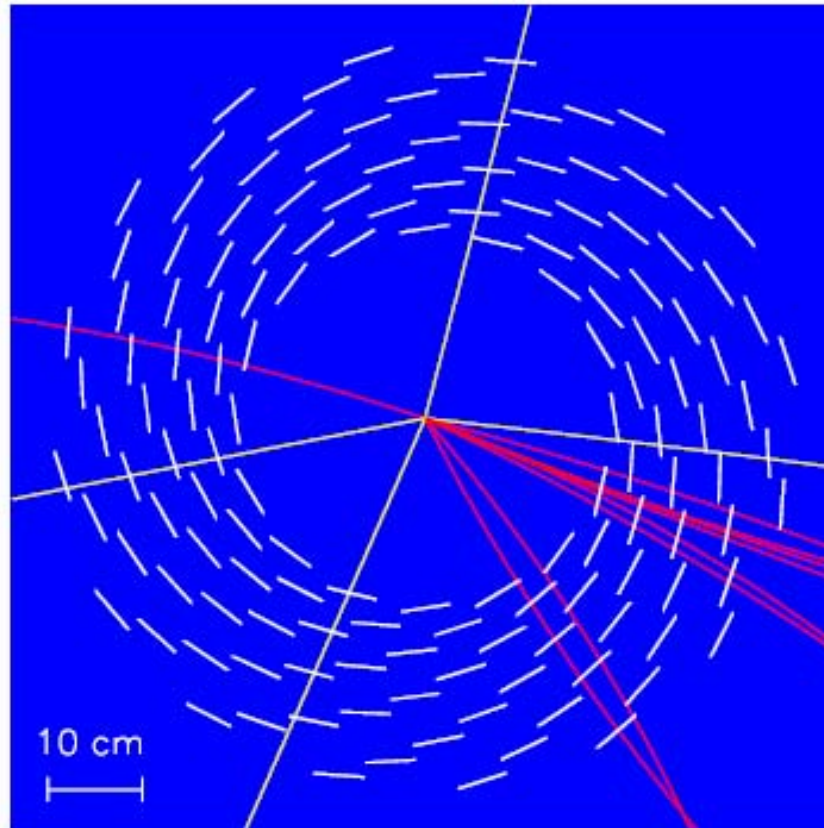
Find 4 straight tracks.



# Solution

Reconstructed tracks of  $p_t > 2 \text{ GeV}$ .

Among them well visible 4 muons from the higgs decay.



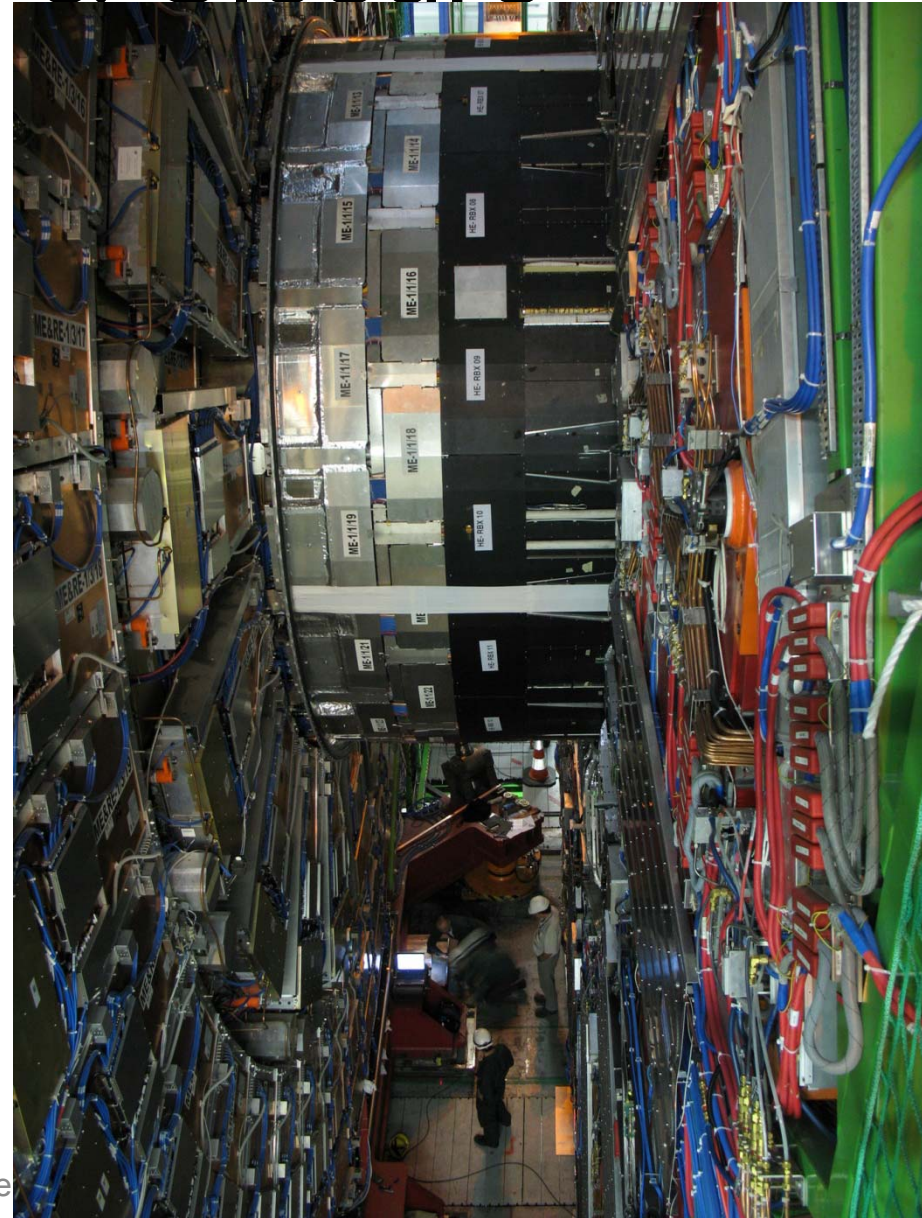
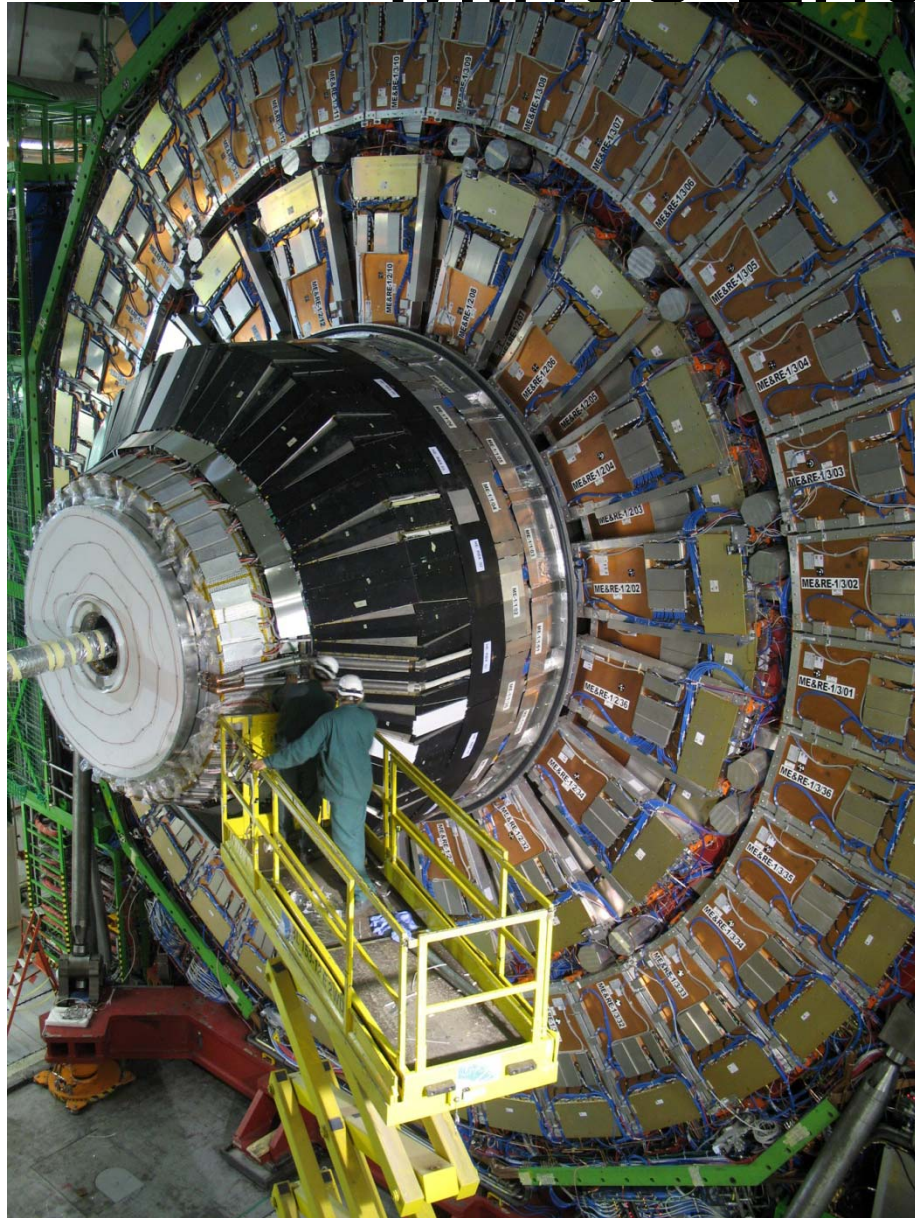
The solution is possible if detector occupancy  $\sim 1\%$

→ microstrip area  $\sim 1\text{mm}^2$

→  $>10^7$  readout channels

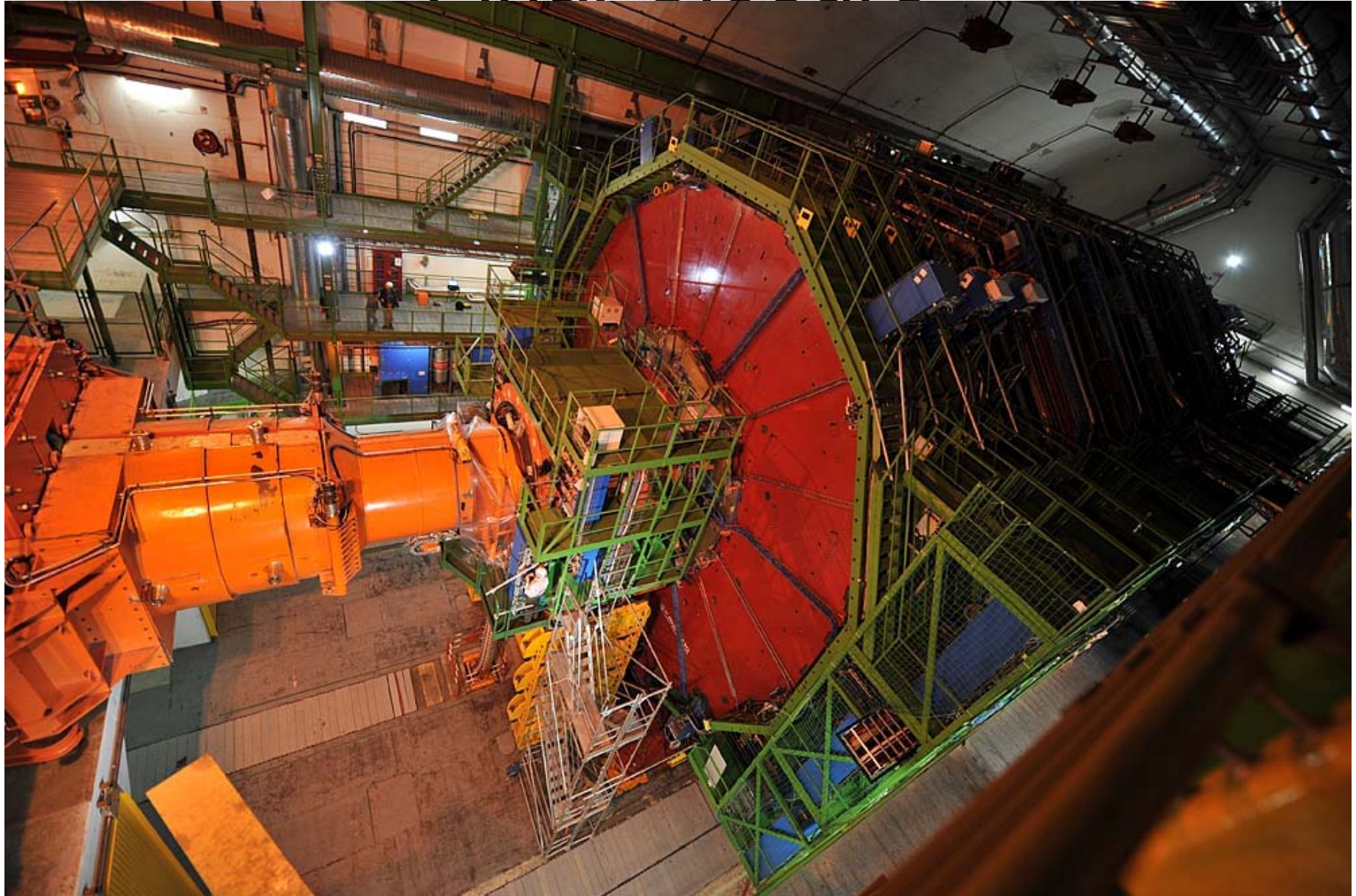


# Minus End & Closure





# Final Closure

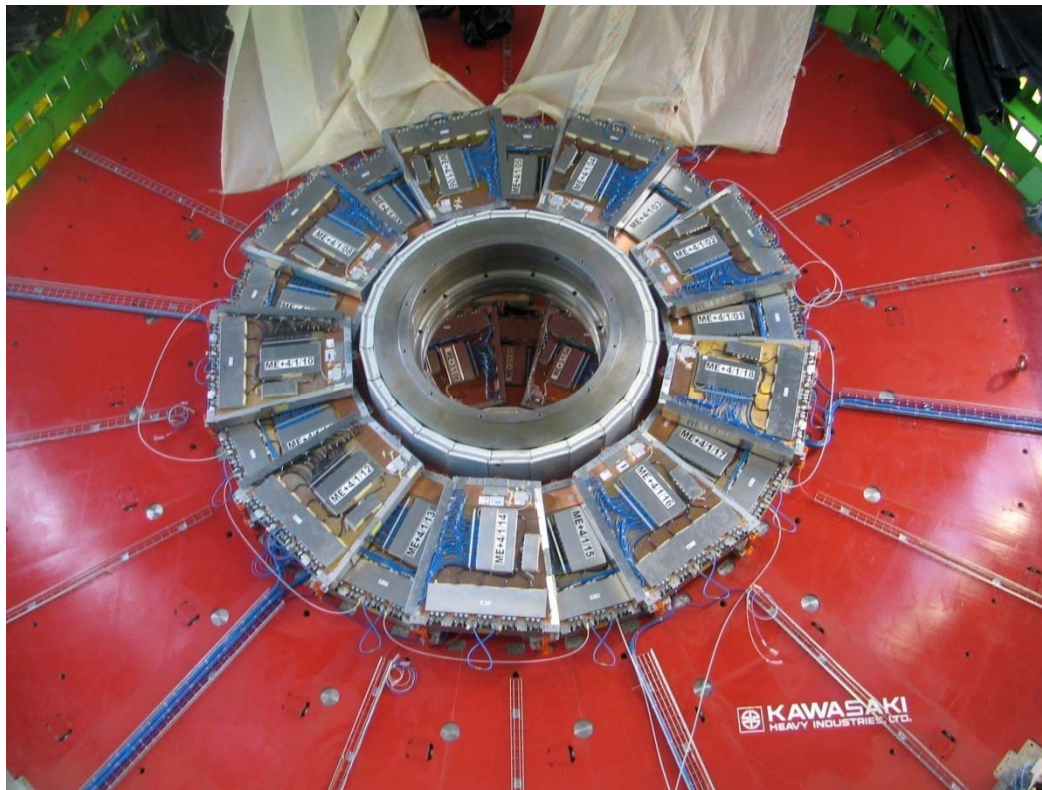




# ME4/2 Upgrade



**Expect R&D funding for '09**  
**Production of 72 chambers could begin in 2010**



# CMS TF Поток Данных



TMB- модули

MPC- модуль

30 cathode bytes /BX/chamber  
7 anode bytes /BX/chamber

12 bytes /BX/sector

SPO5- модули

MS- модуль

16 bytes /BX/CSC

TTC- модуль

1

AFE - карты

ALCT - модули

1

30 cathode bytes /BX/chamber  
7 anode bytes /BX/chamber

12 bytes /BX/sector

1

468

Chambers, On-detector Electronics

60

Peripheral  
Crate

Track Finder  
Crate

Global Muon  
Trigger

700 GByte/s

30 Gbyte/s

640 Mbyte/s

# HV system



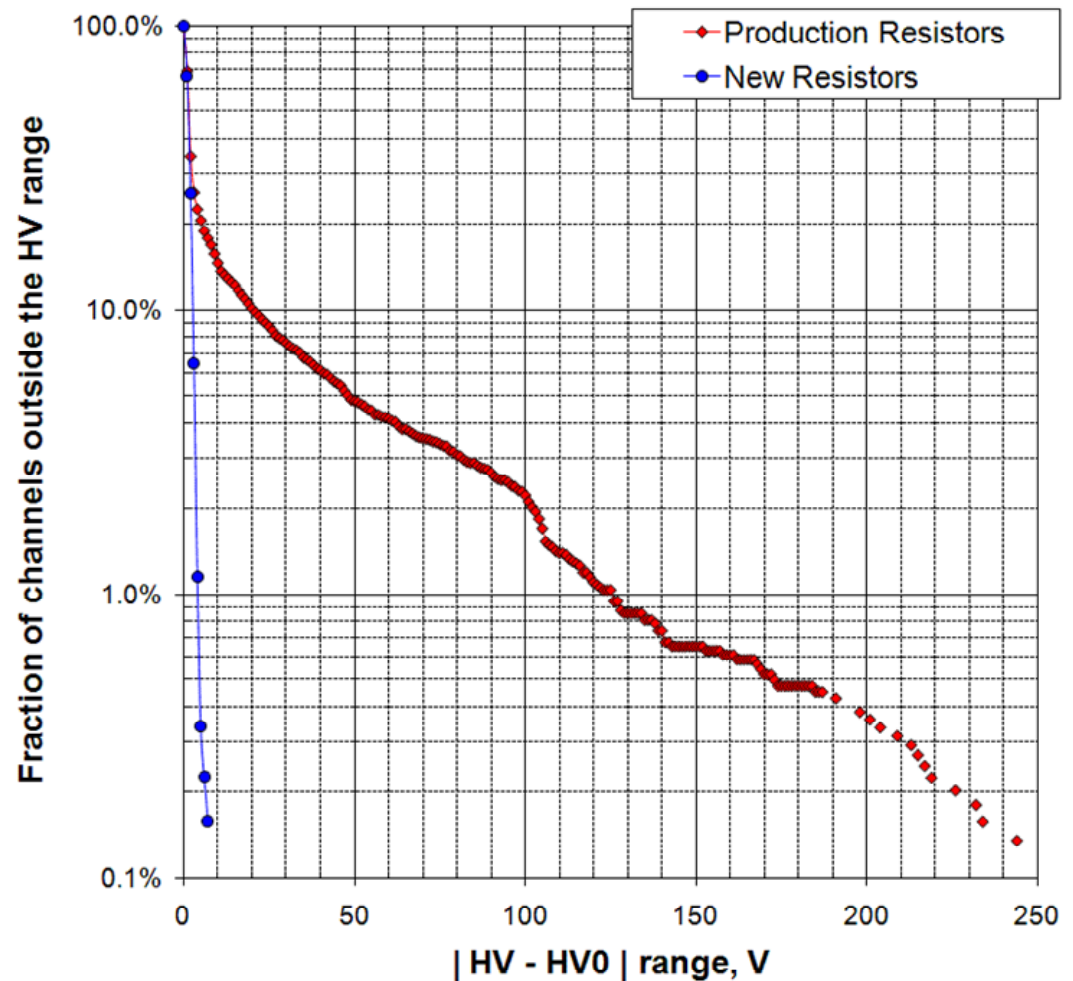


# HV system

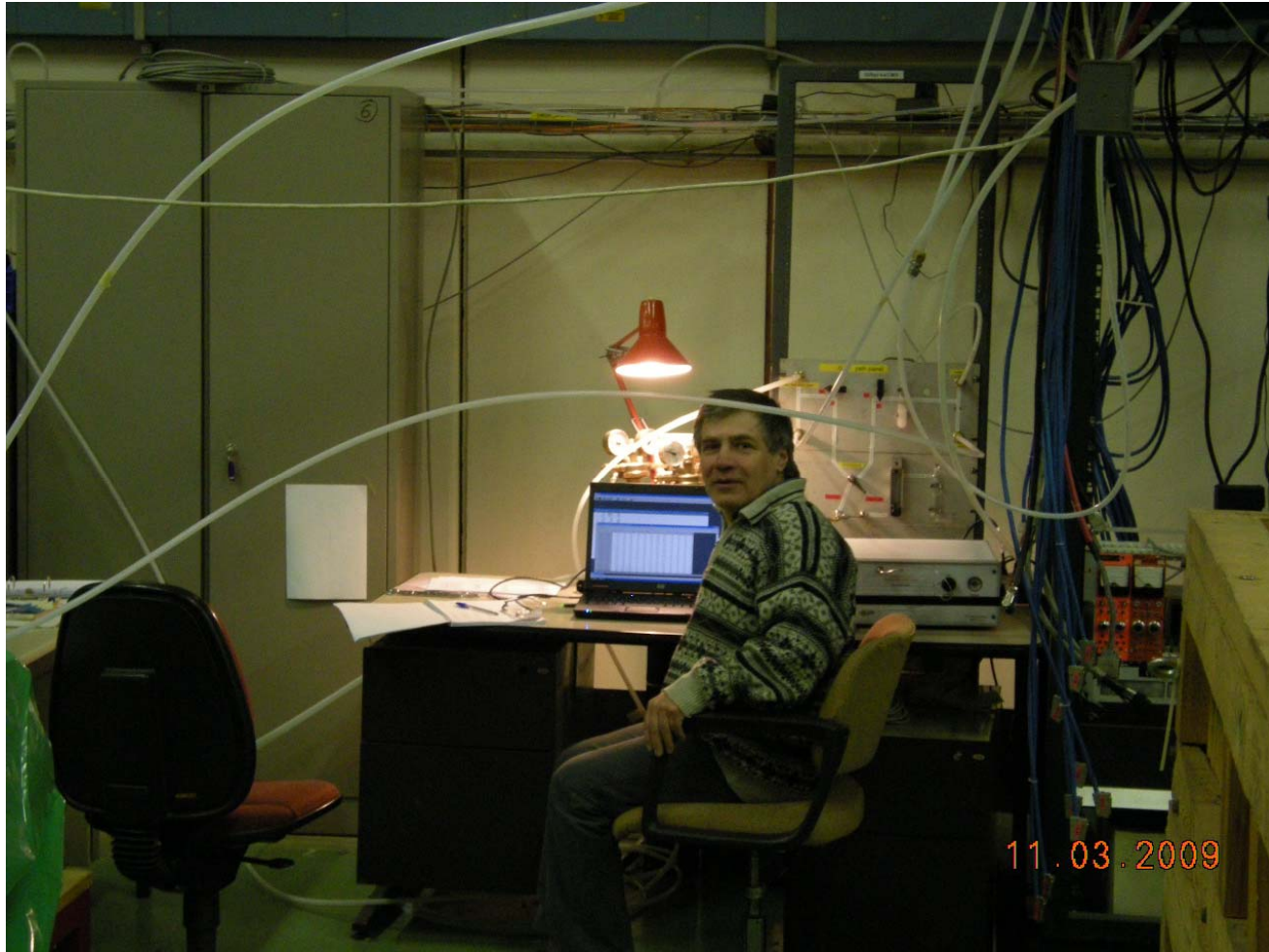


# HV resistor replacement

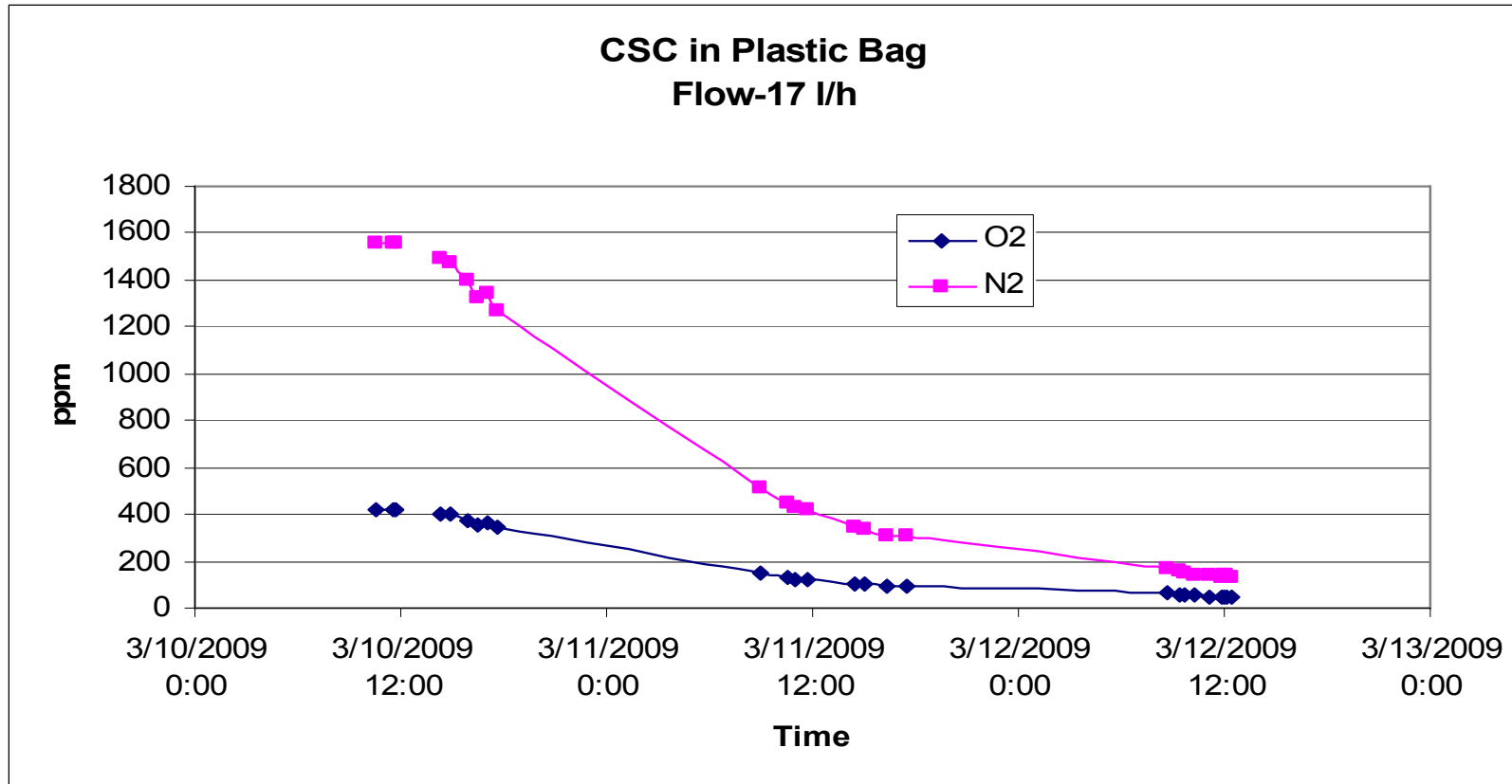
- Critical component – voltage feedback resistor in each channel
- Production HV resistors turned out to be defective – unpredictable changes in value after long operation
  - below rated voltage
- Complete replacement with another type of resistors in Jan-May 2009
- Dramatic improvement in voltage stability



# Gas system



# Air Intake in Plastic Bag with Ar





# ISR Fast Site

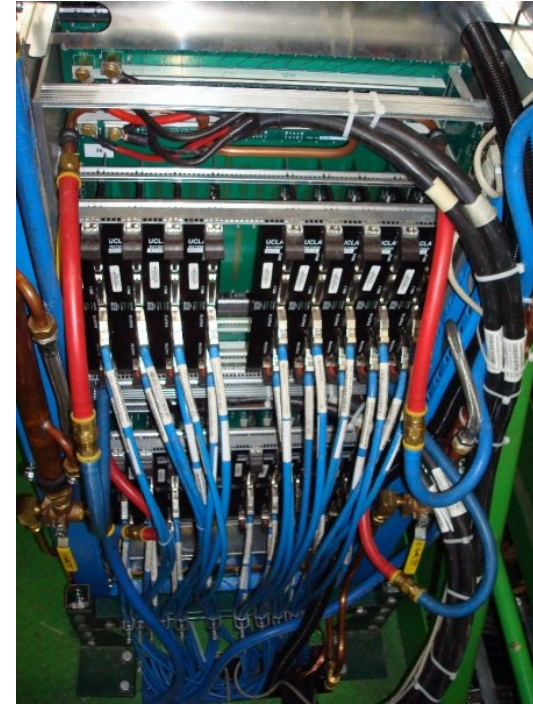






# Infrastructure

- Voltage
- Cooling
- Gas
- Cabling



- **All of this had to be in place before we could even begin commissioning...**
- **Without this, there is no experiment!**

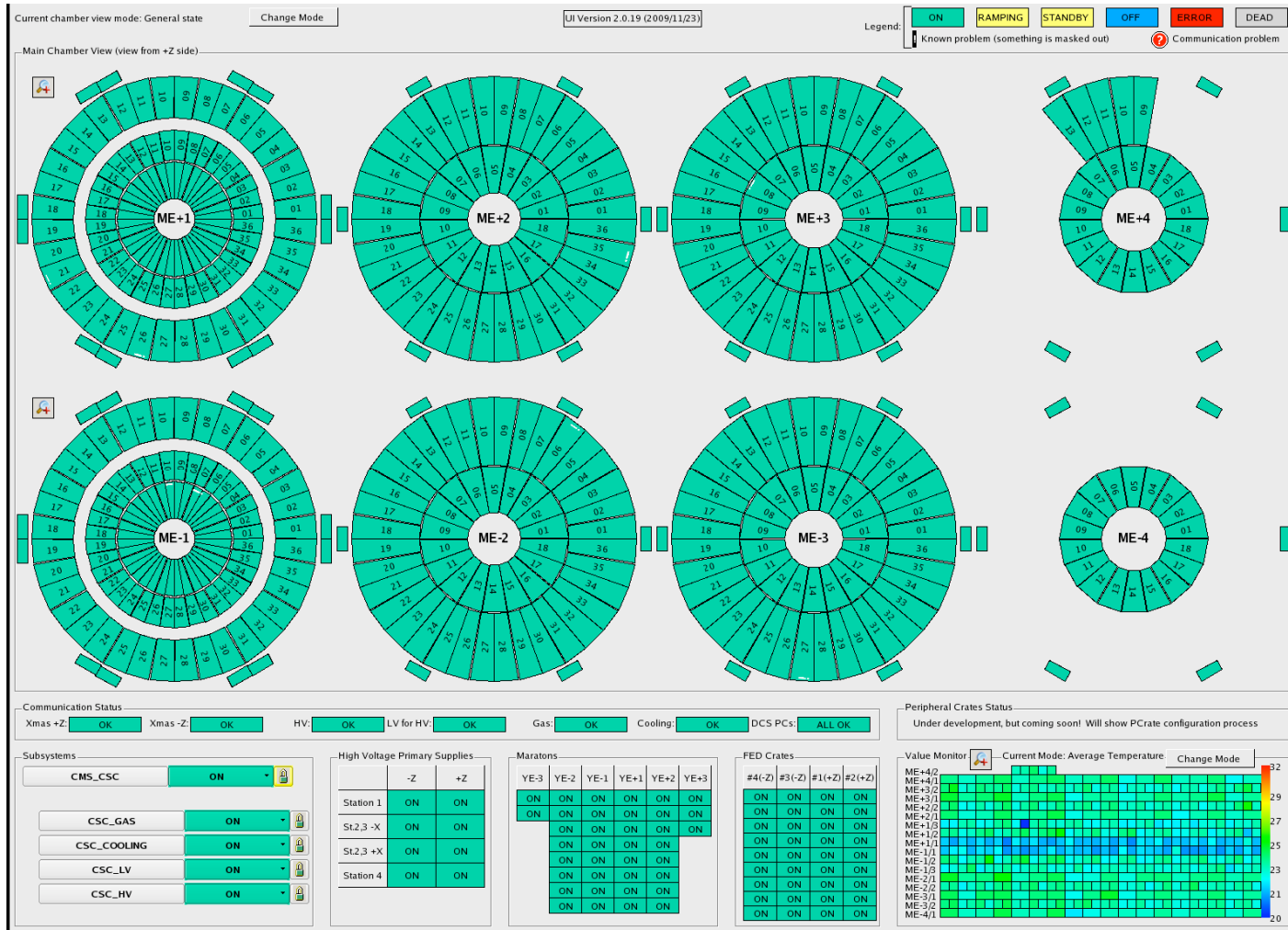
# CSC Shifts:

## The People Behind the Data

- CSCs began official, institution-based shifts on 1 September 2008
- Each subdetector manages its own shifts
- CSC shifts organization:
  - 3 time slots (day/swing/owl)
  - 2 people per shift
  - Institutions assigned a shift slot for **7 days**
  - Shifters are responsible for preparing for their shifts
  - by shadowing the previous week's shift



# DCS overall overview



**Most of the time a shifter sees this nice DCS GUI.**

# Winter Shutdown 2009-10

Estimated time-window: 18 Dec 2009 to Feb 2010.

Known activities:

Open detector

Repair of any major fault found during 2009 runs