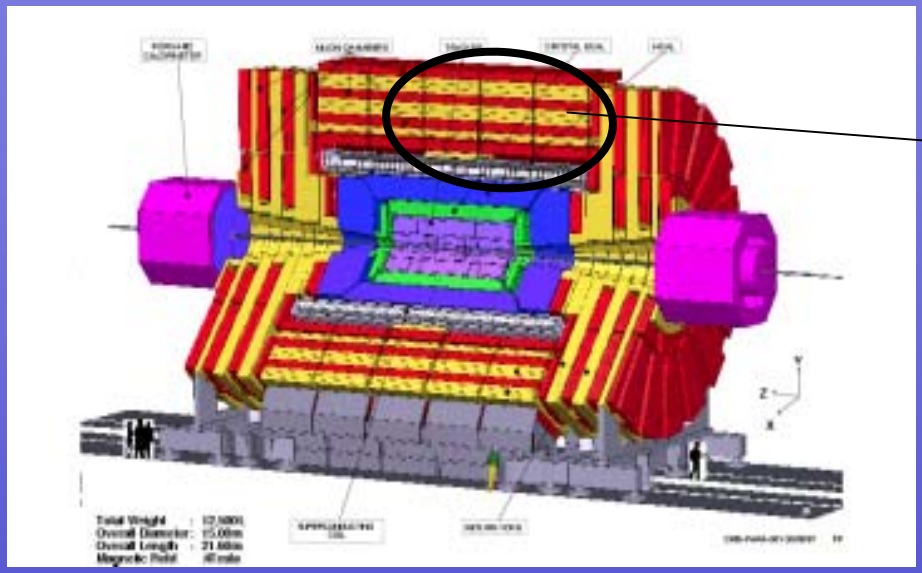
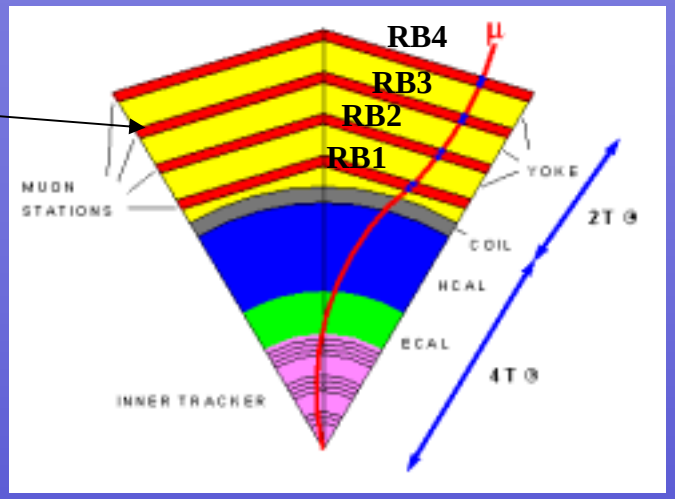
Quality control tests for the CMS Barrel Resistive Plate Chambers

The CMS RPC Barrel collaboration
Bari, Napoli, Pavia, Sofia, Bejing

Presented by G. Pugliese

The CMS experiment





CMS muon trigger

2 complementary and independent systems

•RPC: fast dedicated trigger detectors for bunch crossing assignment (25 ns spaced b.x.)

•DT-CSC: wire chambers for precise muon p_T measurement (also used in the trigger)

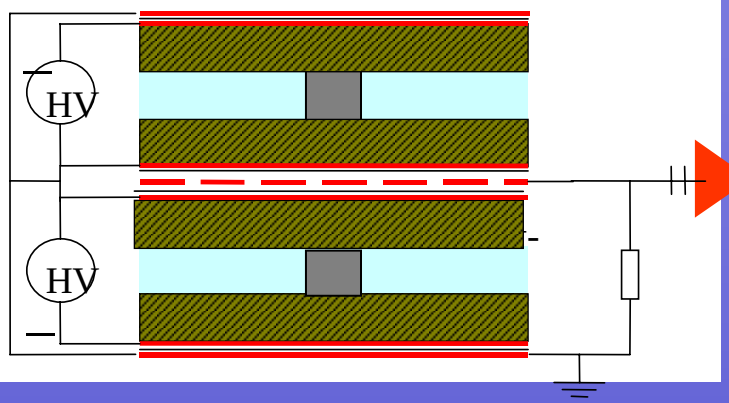
CMS Barrel environmental conditions:

• severe timing (25 ns b.x.)

• long term operation (>10 years) under neutron and gamma irradiation (up to 1 Gy)

• expected maximum rate about 10 Hz/cm^2

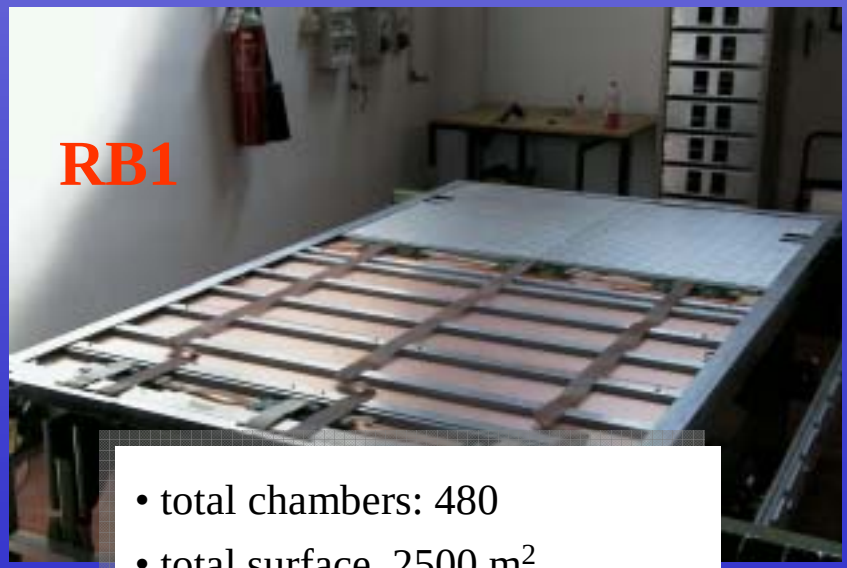
The CMS RPC design



- Bakelite thickness 2 mm
- Bakelite bulk resistivity ρ = 2-5 x 10^{10} Ωcm
- gas gap width 2 mm
- Gas mixture: 96.2% $C_2H_2F_4$ + 3.5% $isoC_4H_{10}$ + 0.3 SF_6
- # gaps 2
- avalanche mode

Chamber dimension:

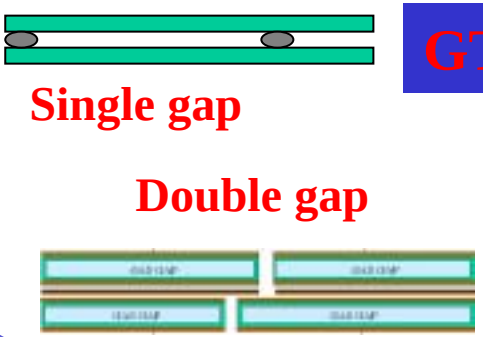
120 RB1: 2 x 2.5 m^2
120 RB2: 2.5 x 2.5 m^2
120 RB3: 1.5 x 2.5 m^2
120 RB4: (1.5 ÷ 2.5) x 2.5 m^2

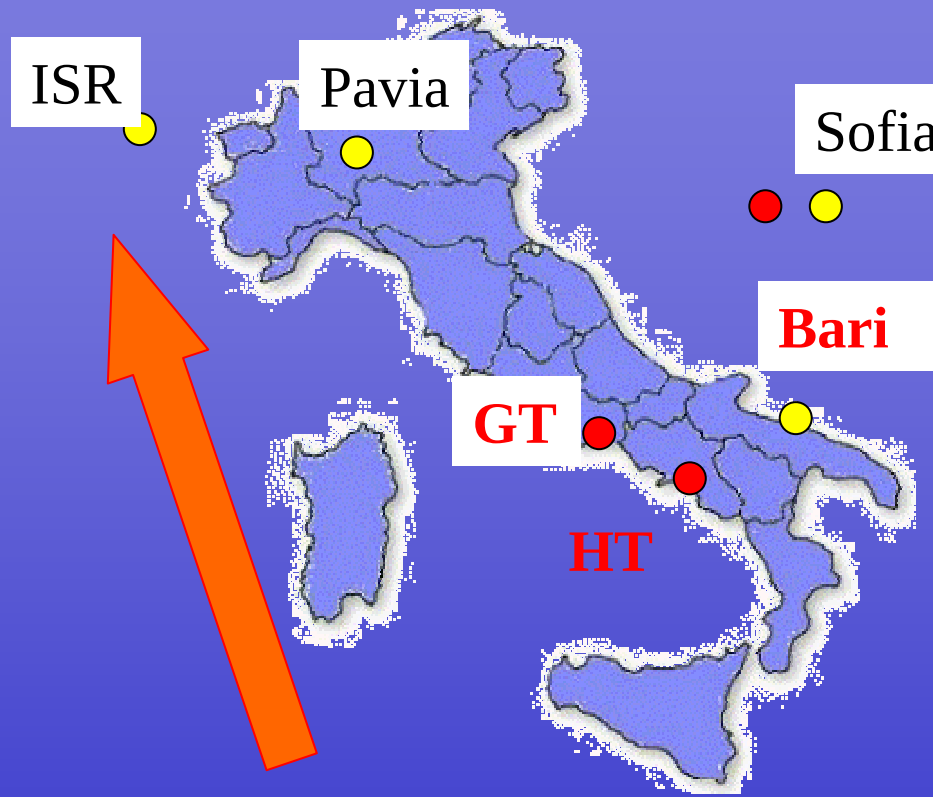


- total chambers: 480
- total surface 2500 m^2
- 80.000 electronic channels

RPC Barrel Production & Test Sites

Chamber production and quality certification involve several steps.





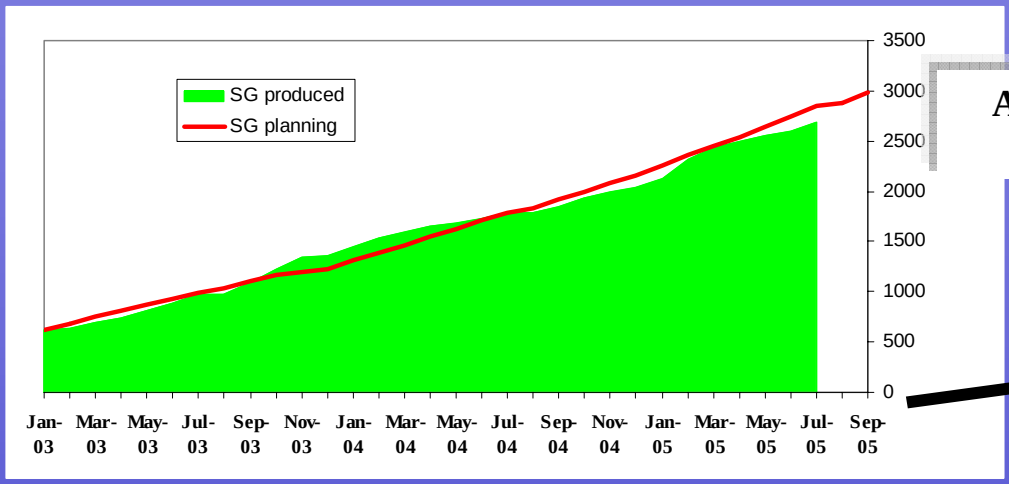
Chamber assembling Sites

120 RB1 at HT & GT
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)

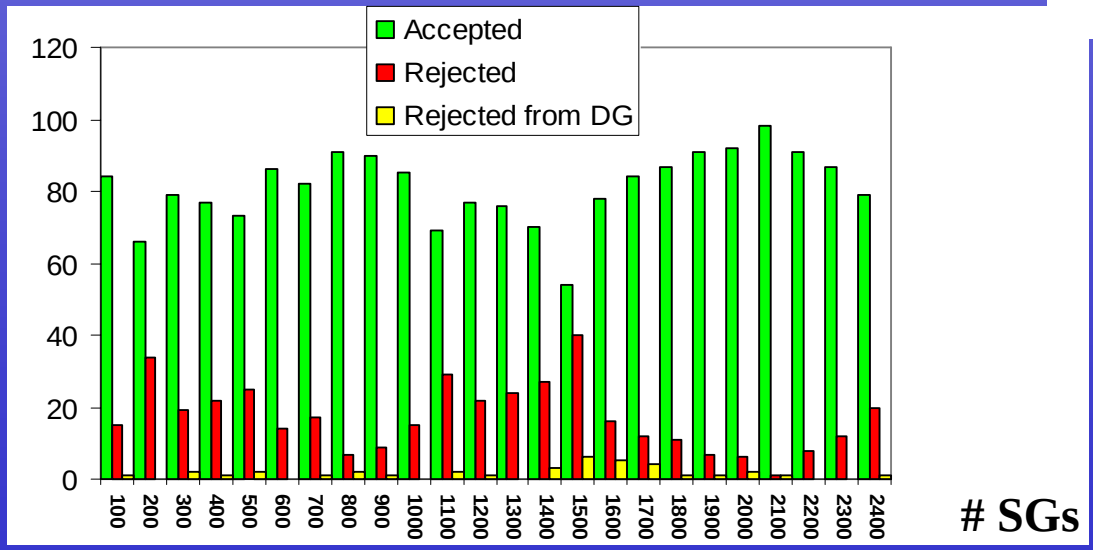
Single gap production and test



About 1.5 month delay

Finish SG production in December 05

Accepted/to install = 87 %

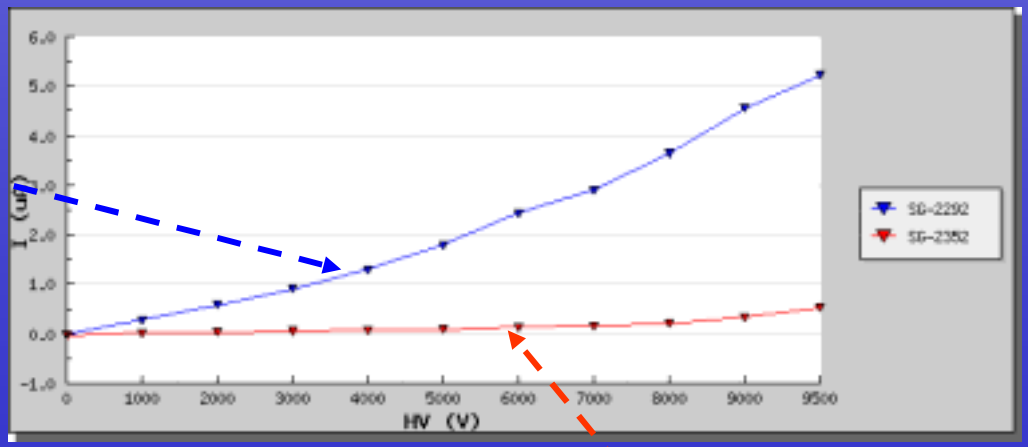


Full tested	2395	
Accepted	1983	**83 %**
Rejected	412	**17 %**

Single gaps production and test

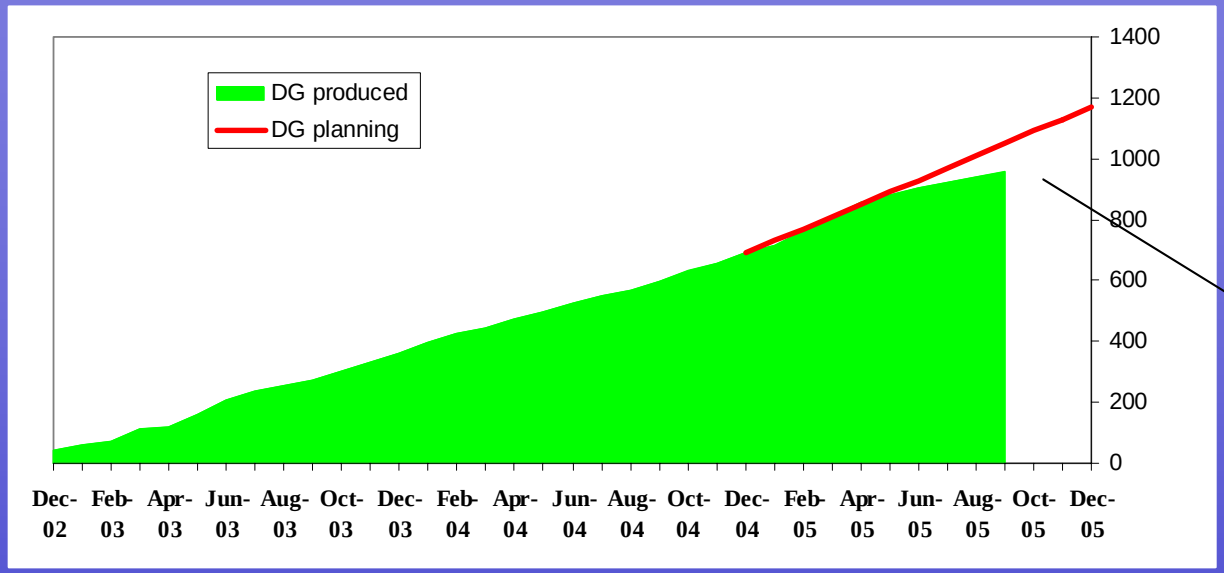
Test	Acceptance criteria
Leak test & Spacers test	20 mbar overpressure: visual inspection. **All spacers properly glued** **Stable pressure for 15 minutes**
Current test	✓ I vs HV (1 kV step every 15 min) ✓ Current monitoring for about 12 hours at 9.5 kV **I < 5υA per gap at 9.5 kV**

Rejected SG



Accepted SG

Double Gap Production and test



About 2 month delay

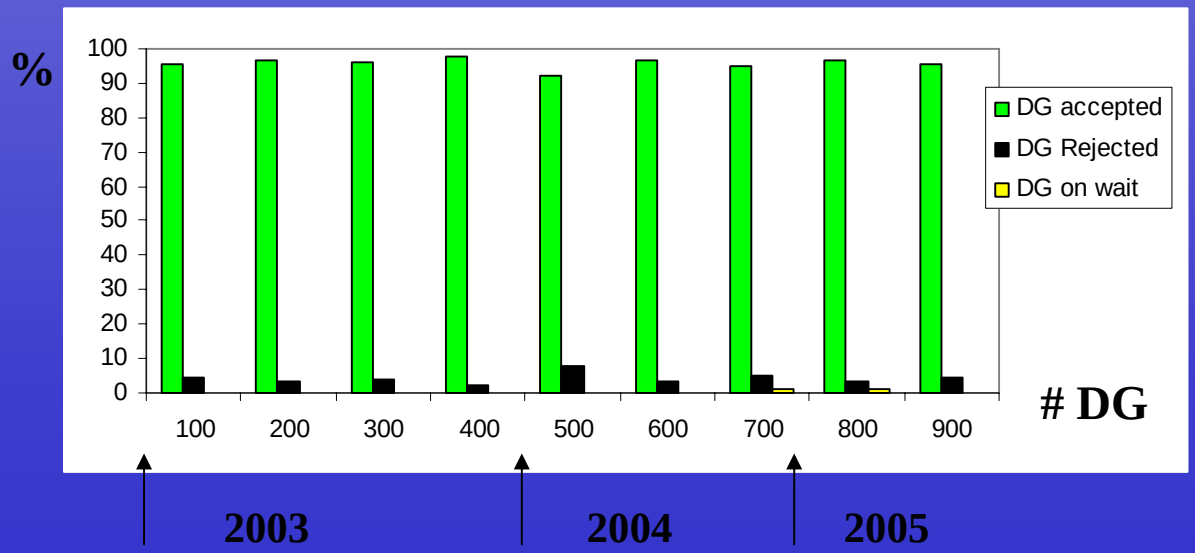
Finish production in February 06

So far 77 % of the needed DGs have been accepted

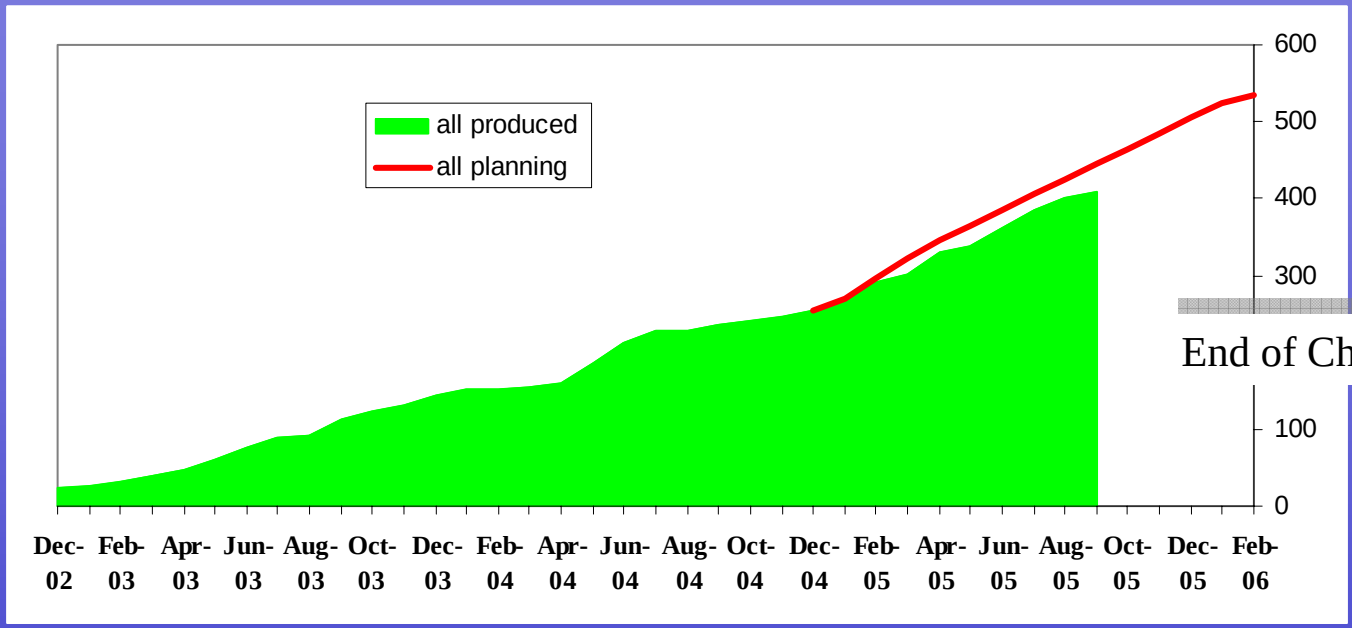
Total Produced	**956**	
Accepted	917	**95.9 %**
Rejected	39	**4.1 %**

Double Gap Production and test

Test	Acceptance criteria
Leak test	5 mbar overpressure: **Stable pressure for 15 minutes**
Current test	✓ I vs HV (1 kV step every 15 min) ✓ Current monitoring for about 12 hours at 9.5 kV **I < 5uA per gap at 9.5 kV**

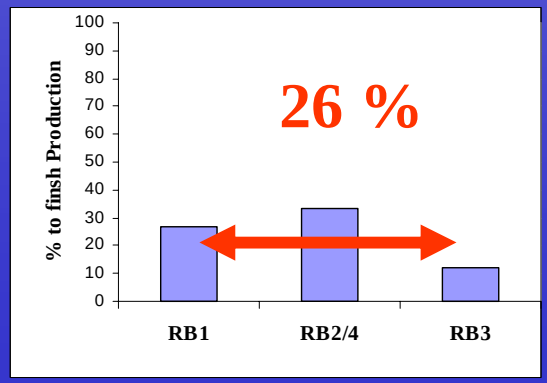


Chamber Production



End of Ch production: March 06

CH type	RB1	RB2/4	RB3	All
Built	101 (74%)	182 (68%)	118 (89%)	401 (74 %)
To be built in total	36	90	16	142



Test at production sites

Production sites (HT-GT-SOFIA)

- Leak test- Cooling test
- Strip connectivity and LV test
- Current vs High Voltage
- Current monitoring at fixed HV for 12-24 hours

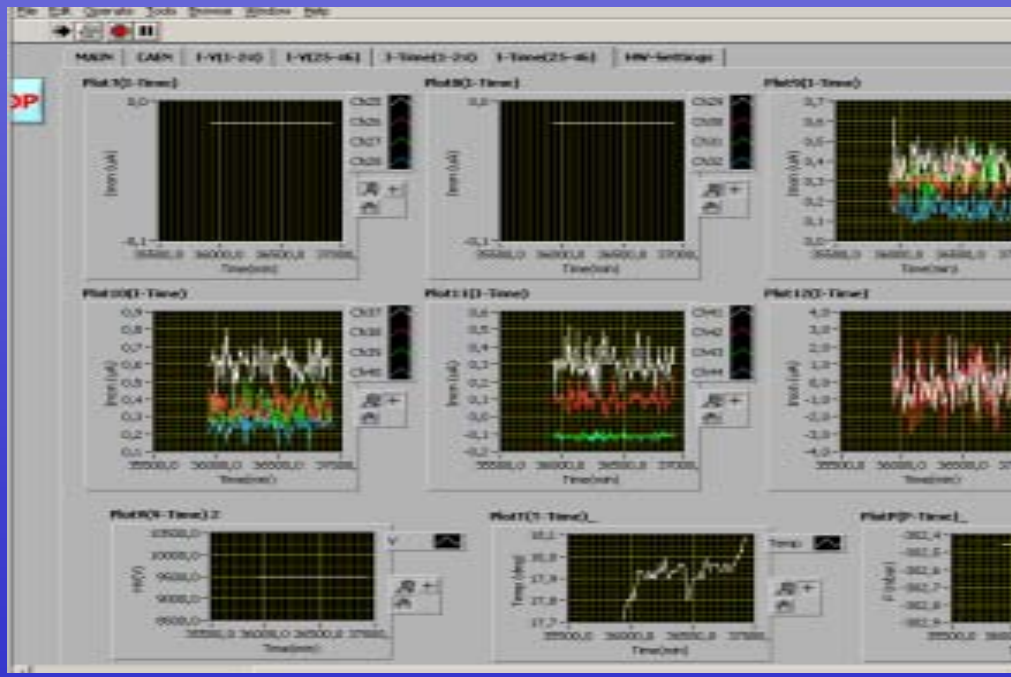
Chamber accepted if:

- I(@9.5 kV) < 5 μA per gap
- I steady for about 1 day

One day automatic test sequence (Labview based software)

✓ I vs HV

✓ Monitor of current at 9.5 kV



Test with cosmics

Sofia

Pavia

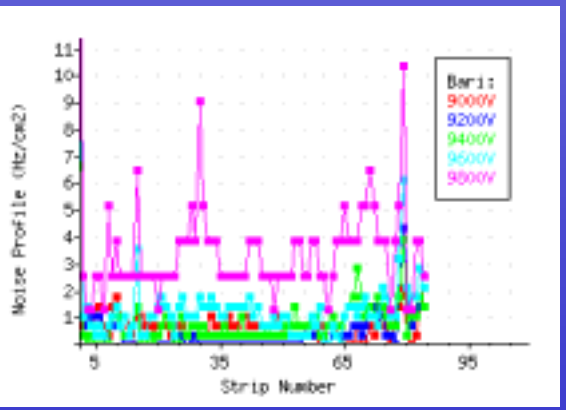
Bari

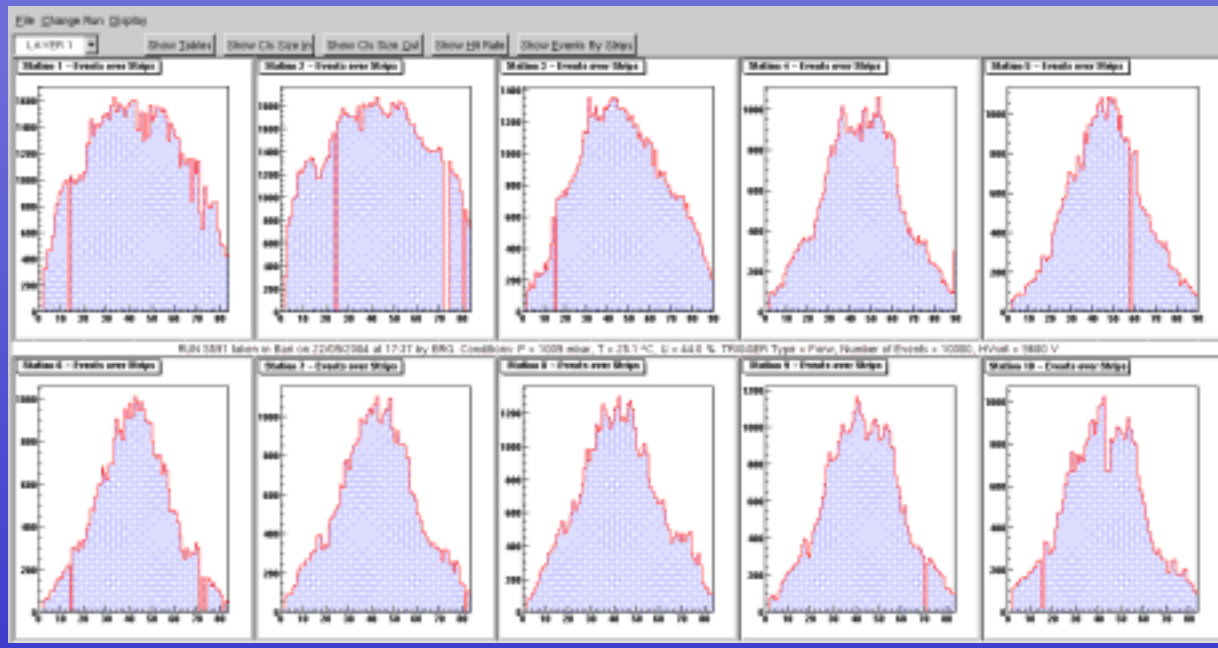
- **Leak test**
- **Current vs High Voltage**
- **Chamber performance**: efficiency, noise, cluster size in single and double gap
- **Current monitoring** (at 9.6 kV) for about 10 days

Scintillators used for trigger

Preliminary debug

- Set the threshold values (compromise between noise rate and efficiency)
- Check the strip profile to find dead strips or disconnected cables.

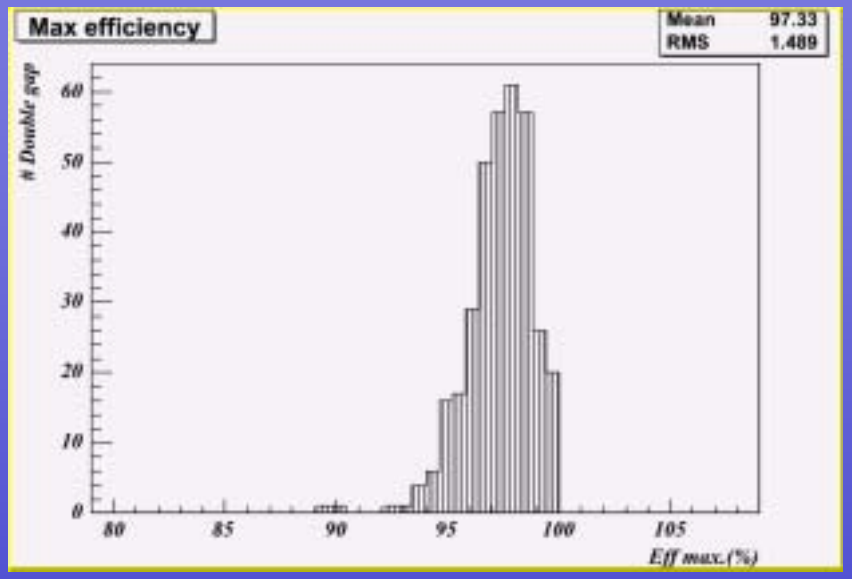




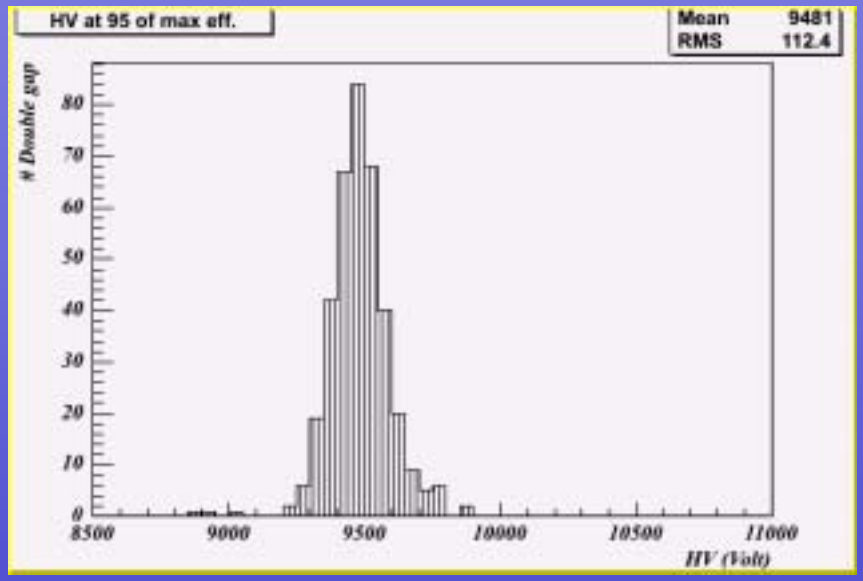
Typical chamber noise profile

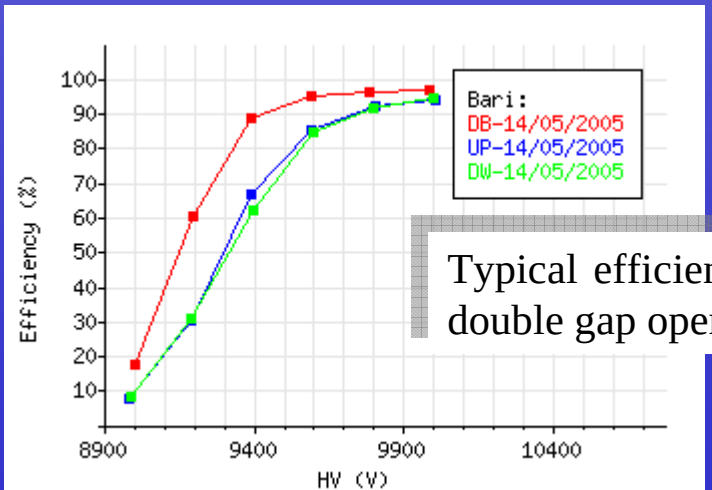
Efficiency

Distribution of max. efficiency



HV distribution at 95 % of max efficiency

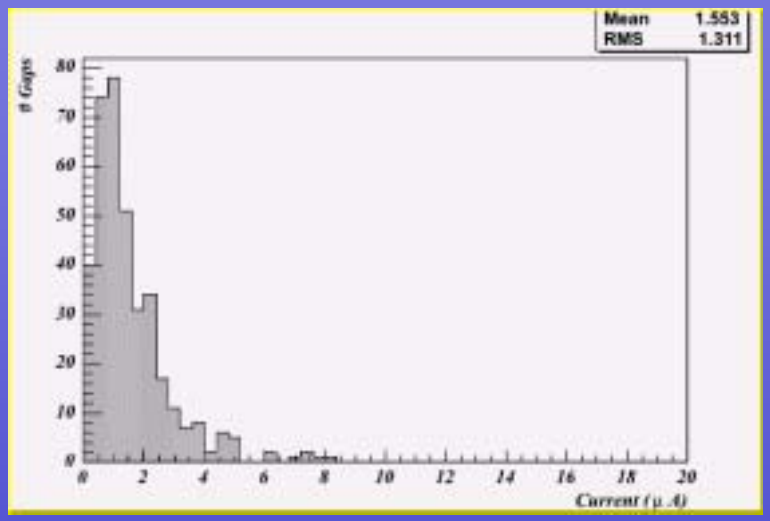


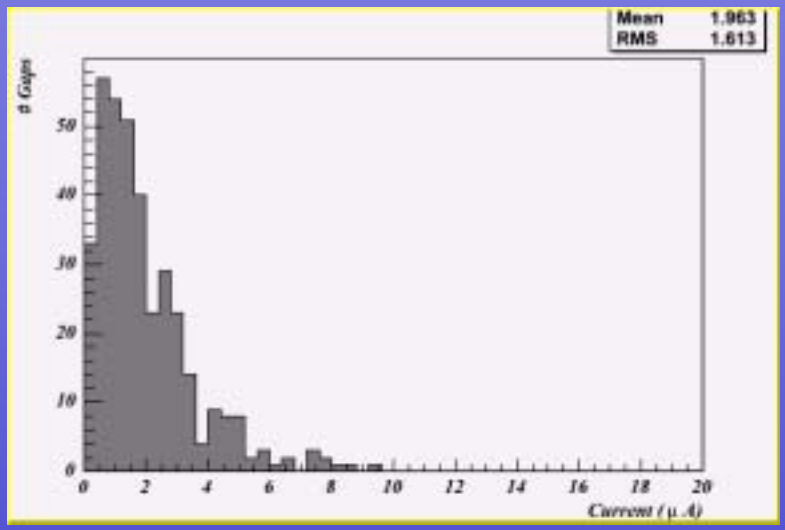


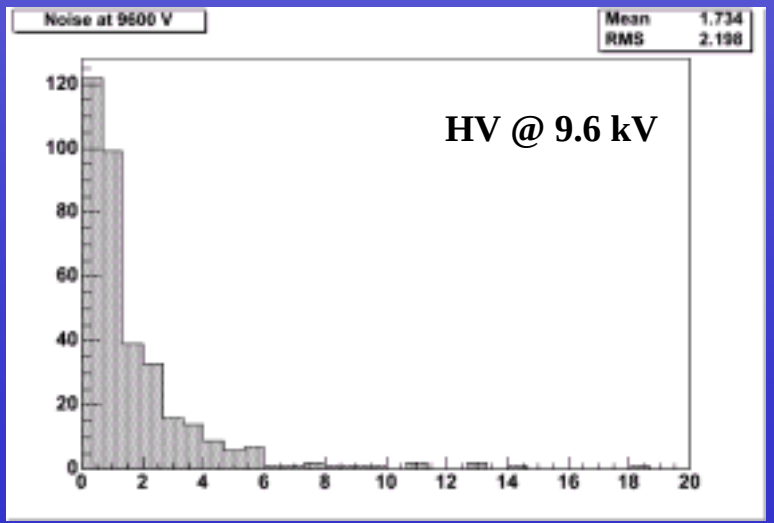
Typical efficiency curve in single and double gap operation mode

Current & noise

Current UP & DW distribution at 95% of max efficiency

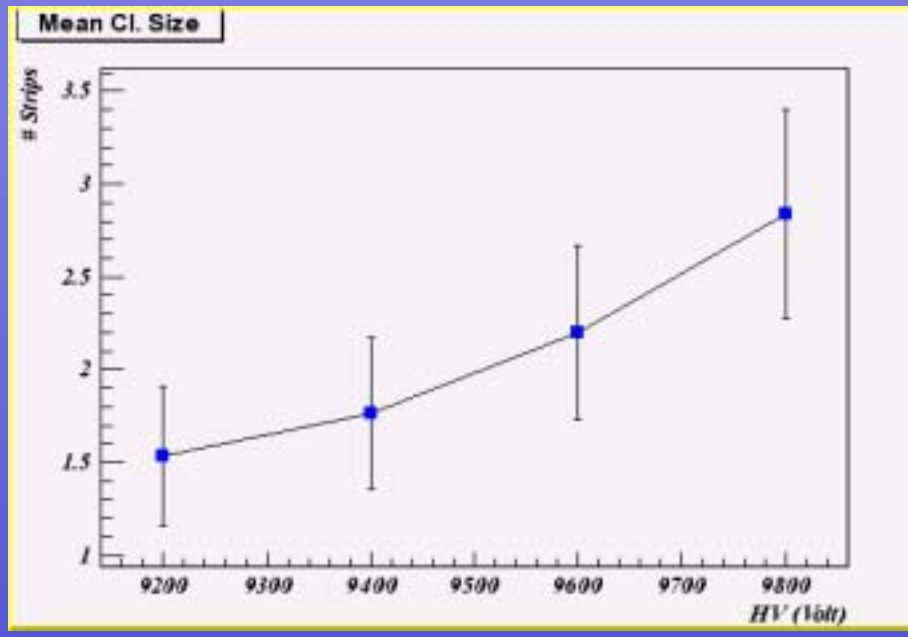




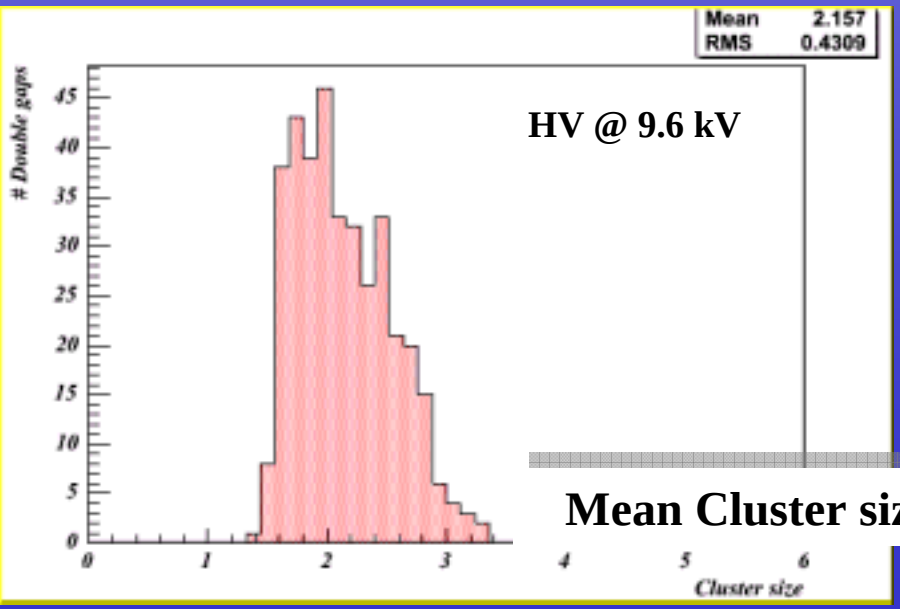


Chamber cluster noise rate

Mean Cluster Size



Mean Cluster size vs HV



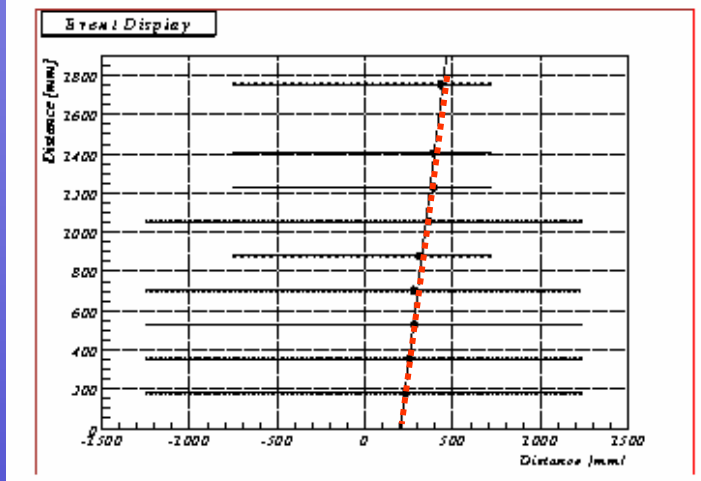
HV @ 9.6 kV

Mean Cluster size distribution

Muon Reconstruction

X = strip position
Y = chamber position in tower

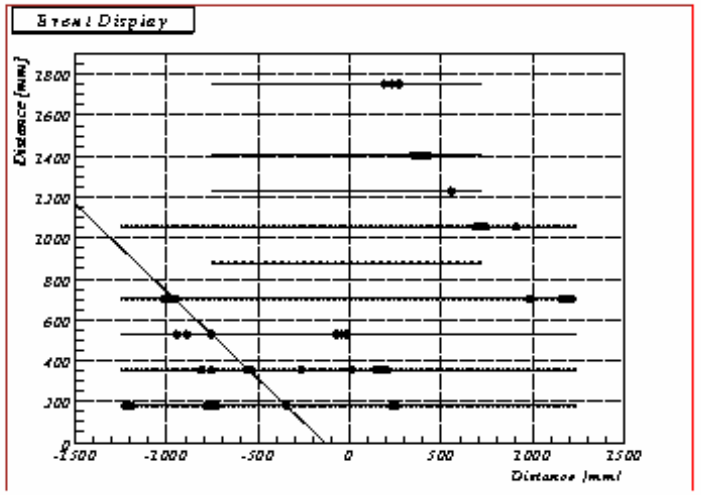
Y



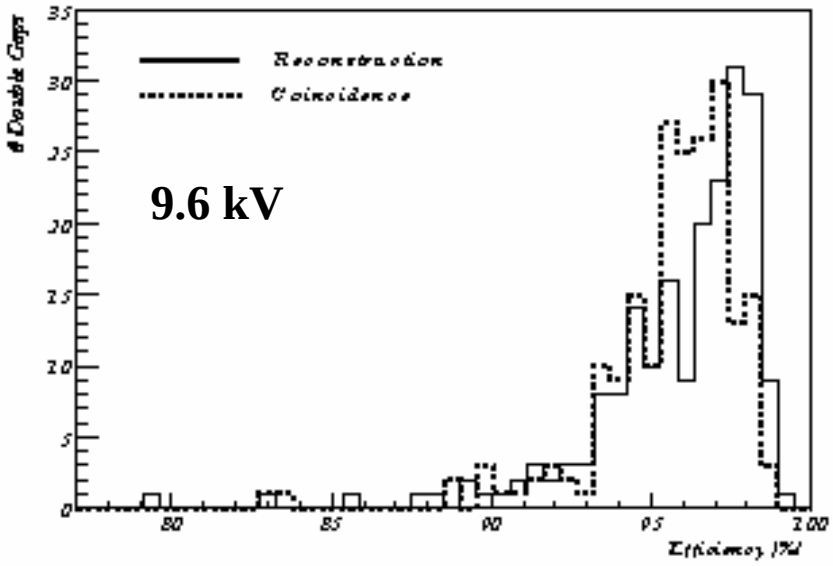
X

Reconstruct clean μ events using the chambers in the telescope. Study performance of a single chamber to the extrapolated track

The method allows the rejection of fake triggers

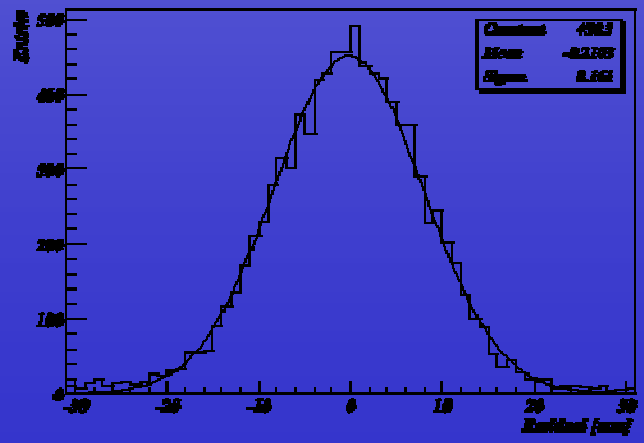


Muon Reconstruction



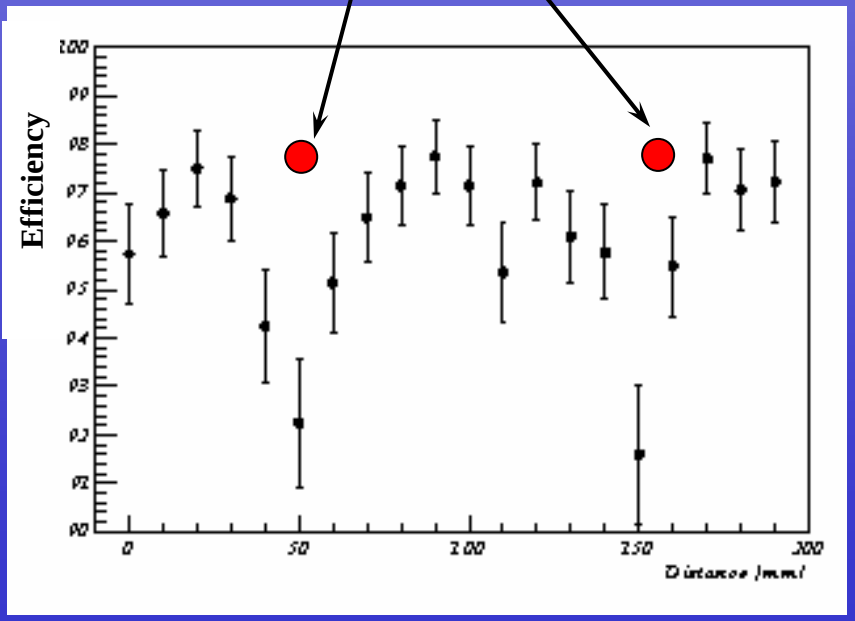
Comparison between the efficiency obtained by coincidence and the reconstruction method

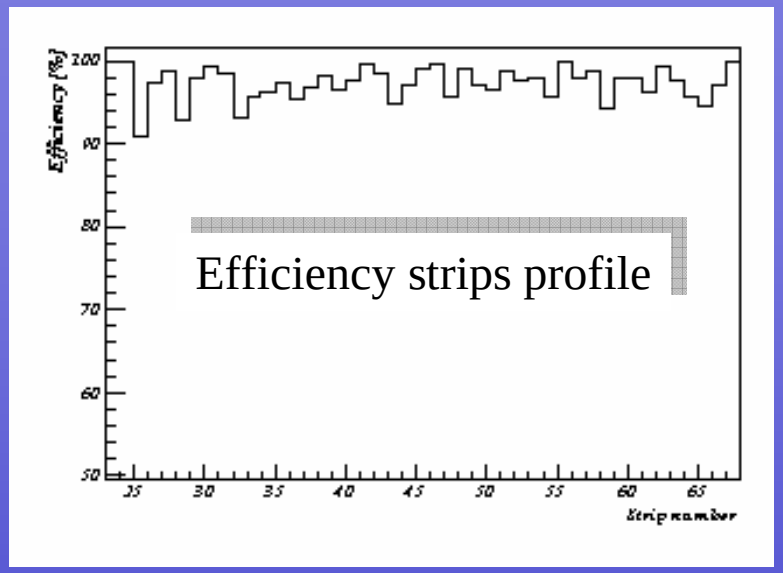
Spatial resolution ~ 8.1 mm evaluated using the residual distribution (distance between muon impact point and the nearest cluster center). In good agreement with the theoretical one (~7.9 mm).



Muon Reconstruction

Local inefficiency due to spacers





After superimposing data from different aligned slices, the 100 mm spacers structure is visible (local inefficiency)

Test at ISR

Detector control

- Gas leak
- Threshold setting and reading
- Current vs HV
- Long stability current test (15-20 days @ 9200 V)

Performance

- Single rate (hits count.) vs. HV
- Noise rate (cluster count.) vs. HV

Chambers passing the tests are ready for the coupling with DT and installation!!

Test at SX5

The functionality tests (gas leak, HV test, threshold setting-reading, strips connectivity) are repeated at SX5

- before installation
- after installation

2 wheels installed → 156 chambers

Conclusion

The construction of the CMS trigger detector represents one of the largest ever done production of RPCs. An extensive quality control program has been developed to certify the production. Very selective acceptance protocols have been used at all steps (single gap, double gap and chamber).

The performance of a large fraction of final detectors has been studied and results are very encouraging.

Average results:

max efficiency = 97.3 %

mean noise rate = 1.7 Hz/cm^2

mean cluster size = 2.2 strips

mean current = 3.6 μA