CMS

RESISTIVE PLATE CHAMBERS

Content

Barrel single/double gap production and QC

Barrel chamber production and QC

Barrel production and installation schedule

Aging test

Extended documentation on each item can be found at

http://www.ba.infn.it/~iaselli/annual_review_2003/

Lecce, 25 September 2003
The sites involved in the RPC construction are:

- **gap** production  → General Tecnica
- **double-gap** prod  → General Tecnica
- chamber **assembling**  → Bari, Sofia*, GT and HT**
- chamber **test**  → Bari, Sofia* and Pavia***

* from the 2004
** from June 2003
*** from June 2003
SG assembled by GT

- Gas leakage test
  - Control the gap “bubbles” in 30 s
  - Overpressure test
  - Reach an inside overpressure of 20 mbar: check if spacers or frame detach

GT connects the HV wire. The SG type is assigned

Bring the SG at 9500V and measure the current: reject if I > 5 µA

2 SG validated by QC3

SG coupling

DG assembled by GT

- Gas leakage test
  - Control the gap “bubbles” in 30 s
  - Bring the DG at 9500V and measure the current: reject if I > 5 µA
Rejection is **slowing decreasing** ... SG are better quality now
HV failures distributed (significantly?) more frequently in the first SG Types produced: RB3 and RB1.
From Jan 15th, 2003 on, HV tests are performed up to 9500V, with a 96.5% C$_2$H$_2$F$_4$/3.5% iso-C$_4$H$_{10}$ gas mixture (*).

be as close as possible to real operating conditions

Some of the older SG retested

*Before Jan 2002 HV test were performed in pure C$_2$H$_2$F$_4$ up to 8 kV.
### SG Rejected/Accepted per type

<table>
<thead>
<tr>
<th>Type</th>
<th>Fully tested</th>
<th>Accepted</th>
<th>Rejected</th>
<th>Pressure Fail.</th>
<th>HV Fail.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB1</td>
<td>206</td>
<td>182</td>
<td>24</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>RB2-2</td>
<td>159</td>
<td>110</td>
<td>49</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>RB2-3</td>
<td>151</td>
<td>144</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>RB3</td>
<td>271</td>
<td>229</td>
<td>42</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td>RB4</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>No Type</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>0</td>
</tr>
</tbody>
</table>

![Bar chart showing rejected, pressure failure, and HV failure percentages for RB1, RB2-2, RB2-3, and RB3]
The first peak is mainly due to SG presenting **spacers already detached** at the beginning of the test ... When opened, sometimes, they presented small or missing glue on them.
SG Production Improvement

<table>
<thead>
<tr>
<th></th>
<th>Tested</th>
<th>Accepted</th>
<th>Rejected</th>
<th>Tested</th>
<th>Accepted</th>
<th>Rejected</th>
</tr>
</thead>
</table>
| May-Oct 2002 | RB1    | 101      | 85       | 16     | 83       | 78       | 5
| May-July 2003|        |          |          |        |          |          |
| Dic 2001-March 2002 | RB3   | 166      | 132      | 34     | 92       | 87       | 5
| March-June 2003   |        |          |          |        |          |          |

Comparison between production of the same kind of SG in different periods
DG Production Status

<table>
<thead>
<tr>
<th></th>
<th>Fully tested</th>
<th>Accepted</th>
<th>Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB1</td>
<td>93</td>
<td>89</td>
<td>4</td>
</tr>
<tr>
<td>RB2-2</td>
<td>55</td>
<td>52</td>
<td>3</td>
</tr>
<tr>
<td>RB2-3</td>
<td>60</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>RB3</td>
<td>120</td>
<td>115</td>
<td>5</td>
</tr>
</tbody>
</table>

Fully Tested: 311
Accepted: 96.10%
Rejected: 3.90%

Single/Double Gap
Production and QC

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**Discharges:** in some DG, a discharge between the gap edge and the copper ground plane has been found (mostly on the side were solderings with the termination resistors are made). This was evident at a later stage, when DG had already been included in CH.

From the production of the RB2 on, an additional “C” made of PET has been added; some of the older DG have been modified.

Average current absorbed by a SG (in DG) before PET: 2.32 µA @ 8 kV

Average current absorbed by a SG (in DG) after PET: 0.83 µA @ 8 kV
Chamber production status

Assembled chambers

<table>
<thead>
<tr>
<th>chamber type</th>
<th>number of assembled chambers</th>
<th>assembling site</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB1</td>
<td>11</td>
<td>HT</td>
</tr>
<tr>
<td>RB1</td>
<td>13</td>
<td>Bari</td>
</tr>
<tr>
<td>RB2</td>
<td>40</td>
<td>GT</td>
</tr>
<tr>
<td>RB3</td>
<td>50</td>
<td>Bari</td>
</tr>
</tbody>
</table>

Total = 114

Tested chambers

<table>
<thead>
<tr>
<th>Tested chambers</th>
<th>number of chambers</th>
<th>test site</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB1</td>
<td>3</td>
<td>Bari</td>
</tr>
<tr>
<td>RB2</td>
<td>26</td>
<td>Bari</td>
</tr>
<tr>
<td>RB3</td>
<td>45</td>
<td>Bari</td>
</tr>
</tbody>
</table>

Total = 74

20 RB1 chambers have to be modified (11 already modified at HT)
See later for the problem found

20 chambers ready to be tested

4 chambers under test at PAVIA

HT and Pavia in operation

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chamber
Production and QC

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QA/QC at assembly and test sites

**QC during assembly**
- Double gaps inventory
- Cooling system test
- Gas flow test
- LV system test
- Kapton-FEB connectivity test
- Check list filling

**QC after assembly**
- HV test: I vs HV, I vs time
- Noise rate strip by strip

**Chamber performances**
- Detector control
  - I vs. HV
  - I vs. time
  - Single rate vs. HV (strip by strip)
  - T, P, Humidity mon.
- Cosmic test
  - Efficiency vs. HV: single gap, double gap
  - Cluster size vs. Hv
  - Local efficiency with tracking

**HV connector mounting**
- DB update

**Go to CERN**
- ACCEPTED
- REJECTED

---

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chamber
Production and QC

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Current: summary

First 7 chambers assembled at HT
No SF₆ in gas mixture

Dark current at 9500 V

Dark current distribution at 9400 V.

Chamber production and QC
Efficiency: summary

HV at maximum efficiency

Lower efficiency due to systematic Effects.
Noise: summary

Noise rate of RB3 - ch3, ch4, ch5, ch6, ch7, ch8, ch12, ch14

Noise [Hz/cm²²]

HV [Volts]

accepted

rejected

Noise rate at 9.6 kV

Chamber production and QC

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Cluster: summary

Cluster size of RBA(FW-double) - ch10, ch16, ch19, ch21, ch24

Cluster size at 9.6 kV

Number of RPCs

Cluster production and QC

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Monitor of the Dark current for several days

Chamber 56 DW

Chamber 56 UP

Chamber stability
Final tests at ISR

Accepted chambers are sent to CERN and tested again at ISR.  
• I vs HV  
• I vs time  
• data taking with cosmics (work in progress)

About 70 chambers at ISR under test
The **new production schema** is based on the following assumptions:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>gap production rate</td>
<td>3/day</td>
<td>4/day</td>
<td>5/day</td>
</tr>
<tr>
<td>double-gap prod. rate*</td>
<td>6-8/week</td>
<td>8/week</td>
<td>10/week</td>
</tr>
<tr>
<td>chamber prod rate**</td>
<td>2-3/week</td>
<td>4/week</td>
<td>5/week</td>
</tr>
<tr>
<td>chamber test rate***</td>
<td>10/2weeks</td>
<td>10-5/2weeks</td>
<td>10-5/2weeks</td>
</tr>
</tbody>
</table>

* 6 bigaps/week if GT is assembling chambers too; 8 bigaps/week if not
** GT 2 chambers/week; Bari, Sofia and HT 4 chambers/week
*** Bari 10 chambers/2weeks; Pavia and Sofia 5 chambers/2weeks

**phase I** (from October 2003 to April 2004):  
24 sectors → 186 chambers → 396 bigaps → 792 gaps

**phase II** (from May 2004 to December 2004):  
13 sectors → 109 chambers → 248 bigaps → 608 gaps

**phase III** (from January 2005 to June 2005):  
13 sectors → 109 chambers → 248 bigaps → 608 gaps

**phase IV** (from July 2005 to April 2005):  
10 sectors → 80 chambers → 179 bigaps → 438 gaps
Gap production

- Production and installation schedule

- 3% of rejected bigap
  20% of rejected gap
  are included

- Gap production (all)

- 25 gaps/week
  10 bigaps/week
  5 chambers/week

- 20 gaps/week
  8 bigaps/week
  4 chambers/week

- 15 gaps/week
  6 bigaps/week
  3 chambers/week

- 20 gaps/week
  8 bigaps/week
  4 chambers/week

- Stoped

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Double gap production

3% of rejected bigap are included

6 bigaps/week

8 bigaps/week

10 bigaps/week

produced

planned

# of bigaps

date

gen-02  mar-02  mag-02  lug-02  set-02  nov-02  gen-03  mar-03  mag-03  lug-03  set-03  nov-03  gen-04  mar-04  mag-04  lug-04  set-04  nov-04  gen-05  mar-05  mag-05  lug-05  set-05  nov-05  gen-06

CMS   RPC group

G. Iaselli

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Production and installatin schedule
Chamber production

chamber production (all)

# of chambers

0 50 100 150 200 250 300 350 400 450 500

date

produced

planned

3 chambers/week

4 chambers/week

5 chambers/week

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Production and installation schedule

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Chamber production per site

Production and installation schedule

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CMS RPC group
G. Iaselli
## Installation sequence

### RPC chamber sequence installation

<table>
<thead>
<tr>
<th>name</th>
<th>wheel</th>
<th># chamber</th>
<th>when</th>
<th>done</th>
<th>to do</th>
<th>tot instal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB3</td>
<td>W+1</td>
<td>10</td>
<td>nov-03</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>RB2/2</td>
<td>W+1</td>
<td>5</td>
<td>nov-03</td>
<td>5</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>RB2/3</td>
<td>W+1</td>
<td>5</td>
<td>nov-03</td>
<td>5</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>RB3</td>
<td>W+2</td>
<td>10</td>
<td>nov-03</td>
<td>10</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>RB2/2</td>
<td>W+2</td>
<td>5</td>
<td>nov-03</td>
<td>5</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>RB2/3</td>
<td>W+2</td>
<td>5</td>
<td>dic-03</td>
<td>5</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>RB2/2</td>
<td>W-1</td>
<td>2</td>
<td>dic-03</td>
<td>2</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>RB2/3</td>
<td>W-1</td>
<td>2</td>
<td>dic-03</td>
<td>2</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>RB3</td>
<td>W-1</td>
<td>4</td>
<td>dic-03</td>
<td>4</td>
<td>0</td>
<td>48</td>
</tr>
<tr>
<td>RB1</td>
<td>W0 down</td>
<td>10</td>
<td>gen-03</td>
<td>7</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>RB2/2</td>
<td>W0 down</td>
<td>5</td>
<td>gen-03</td>
<td>5</td>
<td>0</td>
<td>63</td>
</tr>
<tr>
<td>RB2/3</td>
<td>W0 down</td>
<td>5</td>
<td>gen-03</td>
<td>0</td>
<td>5</td>
<td>68</td>
</tr>
<tr>
<td>RB3</td>
<td>W0 down</td>
<td>10</td>
<td>gen-03</td>
<td>10</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td>RB1</td>
<td>W+2</td>
<td>10</td>
<td>feb-04</td>
<td>0</td>
<td>10</td>
<td>88</td>
</tr>
<tr>
<td>RB1</td>
<td>W+1</td>
<td>10</td>
<td>feb-04</td>
<td>8</td>
<td>2</td>
<td>98</td>
</tr>
<tr>
<td>RB1</td>
<td>W-2</td>
<td>4</td>
<td>feb-04</td>
<td>0</td>
<td>4</td>
<td>102</td>
</tr>
<tr>
<td>RB2/2</td>
<td>W-2</td>
<td>2</td>
<td>feb-04</td>
<td>2</td>
<td>0</td>
<td>104</td>
</tr>
<tr>
<td>RB2/3</td>
<td>W-2</td>
<td>2</td>
<td>feb-04</td>
<td>2</td>
<td>0</td>
<td>106</td>
</tr>
<tr>
<td>RB3</td>
<td>W-2</td>
<td>4</td>
<td>feb-04</td>
<td>4</td>
<td>0</td>
<td>110</td>
</tr>
<tr>
<td>RB1</td>
<td>W-1</td>
<td>4</td>
<td>mar-04</td>
<td>0</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>RB4</td>
<td>W0 (9-10-11)</td>
<td>4</td>
<td>mar-04</td>
<td>0</td>
<td>4</td>
<td>118</td>
</tr>
<tr>
<td>RB4</td>
<td>W+1 (9-10-11)</td>
<td>4</td>
<td>mar-04</td>
<td>0</td>
<td>4</td>
<td>122</td>
</tr>
<tr>
<td>RB4</td>
<td>W+2 (9-10-11)</td>
<td>4</td>
<td>mar-04</td>
<td>0</td>
<td>4</td>
<td>126</td>
</tr>
</tbody>
</table>

---

### Critical path

- RB1: W0 up 10 apr-04 2 8 136
- RB2/2: W0 up 5 apr-04 5 0 141
- RB2/3: W0 up 5 apr-04 2 3 146
- RB3: W0 up 10 apr-04 10 0 156
- RB4 m: W0 up 8 apr-04 0 8 164
- RB4 l: W0 up 0 apr-04 164
- RB4 s: W0 up 4 apr-04 0 4 168
- RB4 m: W+1 4 0 4 172
- RB4 l: W+1 2 0 2 174
- RB4 m: W+2 4 0 4 180
- RB4 l: W+2 2 0 2 182
- RB4 s: W+2 2 0 2 184
- RB4 m: W-1 2 0 2 186
- RB4 l: W-1 0 186
- RB4 s: W-1 1 0 1 187
- RB4 m: W-2 2 0 2 189
- RB4 l: W-2 0 189
- RB4 s: W-2 1 0 1 190

---

**Critical path**

- RB1
- RB2
- RB3
- RB4

---

**Production and installation schedule**

**INFN Gruppo I**  
Lecce, 25 September 2003  
CMS RPC group  
G. Iaselli
What is ready

Chambers not classified “out” should be considered “in”. Chamber “out” have FEBs facing outside, while chambers “in” have FEBs facing the center of the wheel.

---

Production and installation schedule

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Lecce, 25 September 2003

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What is ready

RB2, RB3 YB+2 bottom     Ready
RB2, RB3 YB+1 bottom     Ready
RB2, RB3 YB-1  sec 8-9     Ready
RB3, RB2 YB0   bottom      November 03
RB1           YB0   bottom      December 03
RB1           YB+1 bottom      March 04
RB1           YB+2 bottom      March 04
RB3           YB-2 sec 8-9       Ready
RB2           YB-2 sec 8-9       October 03

RB1           YB-2 sec 8-9       March 04
RB1           YB-1 sec 8-9       March 04
RB4           YB0   sec 10       February 04
RB4           YB+1 sec 10       February 04
RB4           YB+2 sec 10       February 04
RB4           YB0   sec 9,11      March 04
RB4           YB+1 sec 9,11      March 04
RB4           YB+2 sec 9,11      March 04

Production and installation schedule

INFN Gruppo I
Lecce, 25 September 2003
Aim of the aging tests

Test the RPC under high gamma irradiation with and without the muon beam and monitor the performance for a collected charge equivalent to 10 years of operation at LHC condition.

Operation conditions in CMS Barrel

Rate: 30 Hz/cm² (safety factor included)

Average total charge: 30 pC

Effective operation time: 5x10⁷ s (10 LHC years)

The total expected charge is 5 10⁻² C/cm²

Two different systems under test:

• High statistics test with small single gap chambers

• Test of production chambers (RB1s)
Integrated charge

Accumulated charge by the two RB1

Chamber 25
0.028
down forw

Chamber 26
0.025
up forw

Accumulated charge by small gaps

Old gaps:
> 10 years LHC equivalent reached in the OLD gaps

New gaps:
~ 10 year LHC equivalent

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CERN 23 September 2003

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Aging tests
Performance of small gaps

V_{eff90\%} (Source On) - V_{eff90\%} (Source Off)

A slightly increase of DV during the time

HV constant = 10. kV

Aging tests

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Test with water on RPC #9

Motivation: Possible increase of the bakelite resistivity due to the high gas flux

Since May until Sept:
- **No gamma irradiation**
- **High gas flux rate** (3 l/hour) 6 gas change/hour!!

Since Sept. up to now: wet mixture

Full efficiency with source restored

Increase of rate with wet mixture

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Aging tests

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Performance of RB1s

Efficiency@ 9200V

Source OFF

Aging tests

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CERN 23 September 2003

CMS RPC group
G. Iaselli
Performances of RB1s

On 9 September the chambers were closer to the source

<table>
<thead>
<tr>
<th>Date</th>
<th>Rate (Hz/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Sept</td>
<td>about 800</td>
</tr>
<tr>
<td></td>
<td>Hz/cm²</td>
</tr>
<tr>
<td>29 June</td>
<td>about 200</td>
</tr>
<tr>
<td></td>
<td>Hz/cm²</td>
</tr>
</tbody>
</table>

Efficiency (%)

Aging tests

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CERN 23 September 2003

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G. Iaselli
Future plans

Minimize the effort at GIF and concentrate on gas issues. Continue aging with the gas close loop system now in operation at GIF.

Study the effectiveness of the filters to absorb all the impurities.

Optimise the following parameters versus impurities and chambers performance:
- percentage of gas recirculation
- gas flow rate
- percentage of humidity in the mixture
Conclusions

Barrel SG and DG production is going well and on schedule.

Barrel chamber production almost on schedule.

New assembly sites and test sites operational.

GIF test on the way. Satisfactory results so far.

Worst is coming!! Manpower to run in parallel assembly/test sites, ISR and GIF may not be available.