Aging Tests of Full Scale
CMS Cathode Strip Muon Chambers

CMS Endcap Muon Collaboration

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Aging Test Goals

- Full Scale CMS ME1/2 chamber from production line
- Large (2/3) chamber area irradiated, accumulated dose > 30 LHC years
- Two rounds of ageing tests:
  - premixed gas, open loop gas system, 1 volume/day (2000)
  - closed loop gas system, 4 volume/day, 5% refresh gas (2001)
Endcap Muon System

CMS Detector

Endcap Muon Chambers

EMU System Parameters

- 540 Cathode Strip Chambers (largest 3.4m x 1.5m)
- 6000 m² sensitive area
- 65 m³ gas volume
- 2,500,000 anode wires
- 150 μm space resolution
- 25 ns bunch crossing resolution
Trapezoidal Six Layer Cathode Strip Chamber

**Chamber parameters:**
- 50/200 µm anode/guard wire diameter
- 3.12 mm wire spacing
- 4.75 mm gap (anode – cathode)
- 250/500 gr anode/guard wire tension
- High voltage segmentation

Gas mixture: 40% Ar + 50% CO₂ + 10% CF₄

Gas gain > 10⁵

High Voltage – 3.7 kV
Chamber Material:

Panels - FR-4 sheets + polycarbonate core
Gap bars, anode bars, spacers - FR-4
Anode wires - LUMA gold plated tungsten
Guard wires - gold plated CU-Be guard

Components:

Capacitors - ceramic, 1nF, 7.5 kV
Resistors - carbon composite
O-Ring - rubber fluorocarbon

Chemicals:

Epoxy - 2216, part A and B (contractual epoxy)
Epoxy - Epolite 5313 + hardener (wire gluing)
RTV - 41 + curing agent (outside chamber sealing)
Solder wire - Almit KR-19 SH RMA, Seika Corp. (new product)
Ageing Setup and Conditions

Gamma Radiation Facility (CERN):
$^{137}\text{Cs}$ ($E_\gamma=661$ keV), 740 GBq

Rate in the chamber
- ~ 100 times of that at LHC
- ~ 15-20 kHz/cm$^2$
- ~ 5 kHz/cm of wire

Radiation exposure (for planes 2,3,4,5):
- ~ 3 - 5 months (~40 LHC years)
- ~ 1 C/cm$^2$, or ~ 0.3 C/cm of wire
  (0.8 C/cm per 10 LHC years)
- Reference Planes (#1, #6) HV is off during irradiation
Aging Test at GIF

Chamber Test

ME1/2 Chamber at GIF
### Gas and Gas System

#### 2000

- **Gas mixture (premixed)**
  - $\text{Ar/CO}_2/\text{CF}_4 - 40/50/10$

- **Purity of components, %**
  - $\text{Ar} - 48$ (99.998)
  - $\text{CO}_2 - 48$ (99.998)
  - $\text{CF}_4 - 45$ (99.995)

- **Gas System**
  - Open loop
  - Flow rate 3 l/h (1 V/day)

- **Gas pipes:**
  - 23 m of copper tubes
  - 13 m of plastic tube (rilsan)

#### 2001

- **Gas mixture (premixed)**
  - $\text{Ar/CO}_2/\text{CF}_4 - 40/50/10$

- **Purity of components, %**
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<tr>
<td>$\text{CF}_4$</td>
<td>99.995</td>
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- **Gas System**
  - Closed loop
  - Flow rate nominal (12 l/h, or 4 V/day)
  - Fresh gas 5% of nominal (0.6 l/h)
  - Gas pipes (copper):
    - 50m input tube ($\phi$ 12 mm)
    - 50m input tube ($\phi$ 16 mm)
    - cleaned according to CERN spec.
Closed Loop Circulation Gas System
Monitored Chamber Parameters

- Anode Current during irradiation
- Anode GIF rates
- Dark current
- Anode noise rates
- Strip-to-strip capacitance
Chamber Gas Gain

Gas gain stayed constant

Gas Gain = $10^5$

at HV = 3.7 kV
Accumulated Charge per cm of anode wire (Part A)

10 LHC years = 0.08 C/cm
Gas Gain

Aging Test 2000

Relative currents:
- \(i_2^* \frac{2}{i_1+i_6}\)
- \(i_3^* \frac{2}{i_1+i_6}\)
- \(i_4^* \frac{2}{i_1+i_6}\)
- \(i_5^* \frac{2}{i_1+i_6}\)

Accumulated charge per cm of Wire (C/cm)

Aging Test 2001

Relative currents:
- Layer 2
- Layer 3
- Layer 4
- Layer 5

Accumulated charge per cm of Wire (C/cm)

Gas Gain remained unchanged
Dark current increased from ~1 nA to typically ~10 nA per plane
Dark Rates

Aging Test 2000

Aging Test 2001

Noise count remained unchanged for both runs in 2000 and 2001
Strip to Strip Resistance

Aging Test 2000

Aging Test 2001

Resistances between Strips

Changed from ~100 to ~10 – 100 GOhm during irradiation
Cathode Plane Deposits

Cathode planes:

- thin uniform layer of deposits:
- extends beyond the irradiated zone
- also, found on the last plane (along gas flow) that had HV off during irradiation
- Composition of deposits: O, F, Si
Anode Wires

Anode wires:

- Wires stayed fairly clean
- With some minor deposits, sporadically scattered
Summary

• Aging tests with two CMS Cathode Strip Chambers were performed

• In one of the two tests a closed loop gas system was used

• At accumulated dose of 0.3-0.4 C/cm (30 – 40 LHC years) no significant changes in chamber performance (dark current, noise count, gas gain, efficiency) were observed

• Strip-to-strip resistance decreased but stayed well within technical specification (> 1.0 MOhm)

• Accumulation of deposits on the cathode planes was observed while wires stayed fairly clean

All test showed that CMS CSCs with Ar/CO2/CF4 gas mixture could be run in the LHC environment without appreciable aging effects