

Aging Tests of Full Scale CMS Cathode Strip Muon Chambers

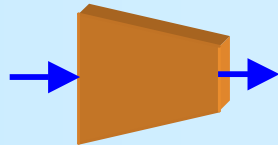
CMS Endcap Muon Collaboration

Oleg Prokofiev

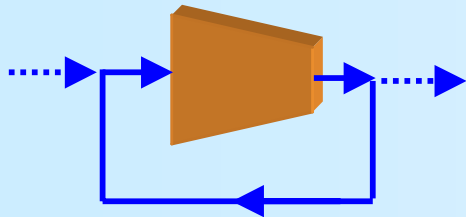
Fermilab, Batavia, IL, USA

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:



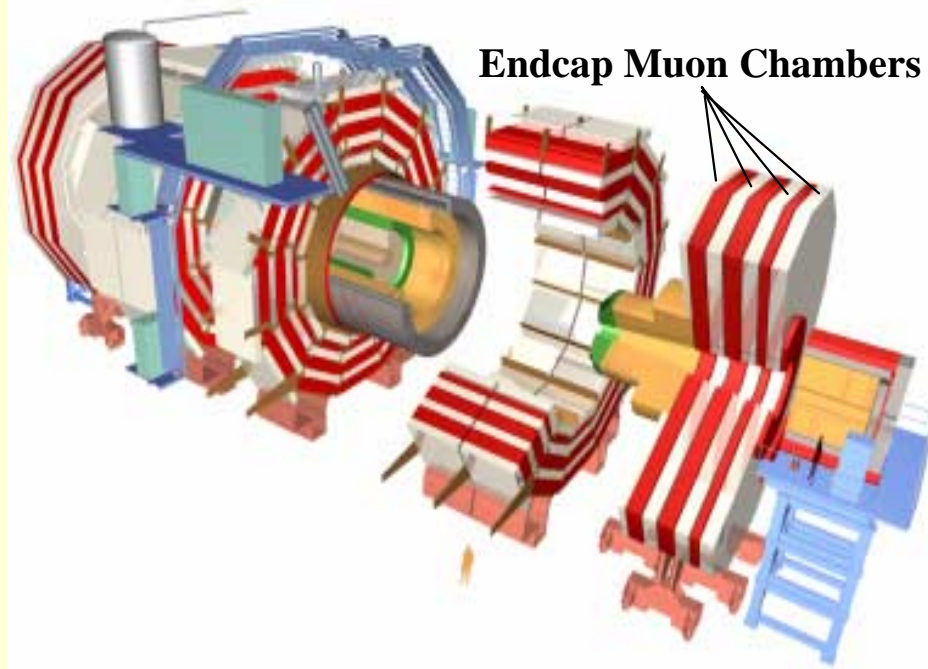
premixed gas, open loop gas system,
1 volume/day (2000)



closed loop gas system, 4 volume/day,
5% refresh gas (2001)

Endcap Muon System

CMS Detector

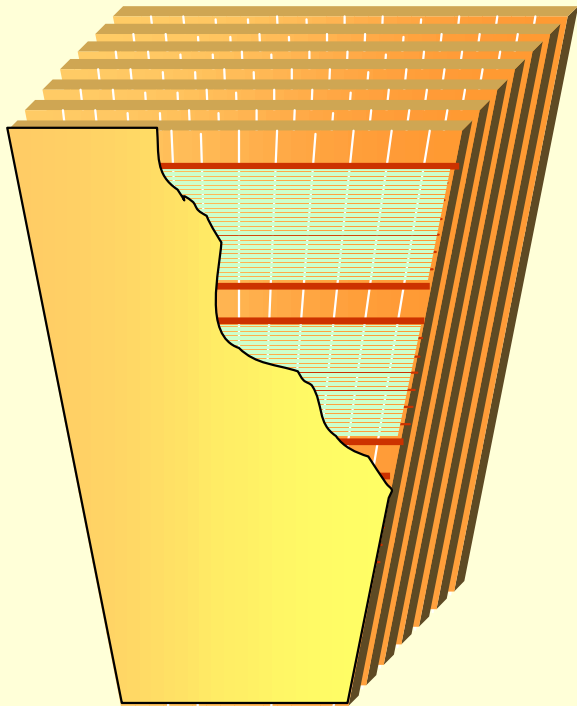


EMU System Parameters

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

Chamber Design

Trapezoidal Six Layer Cathode Strip Chamber



Chamber parameters:

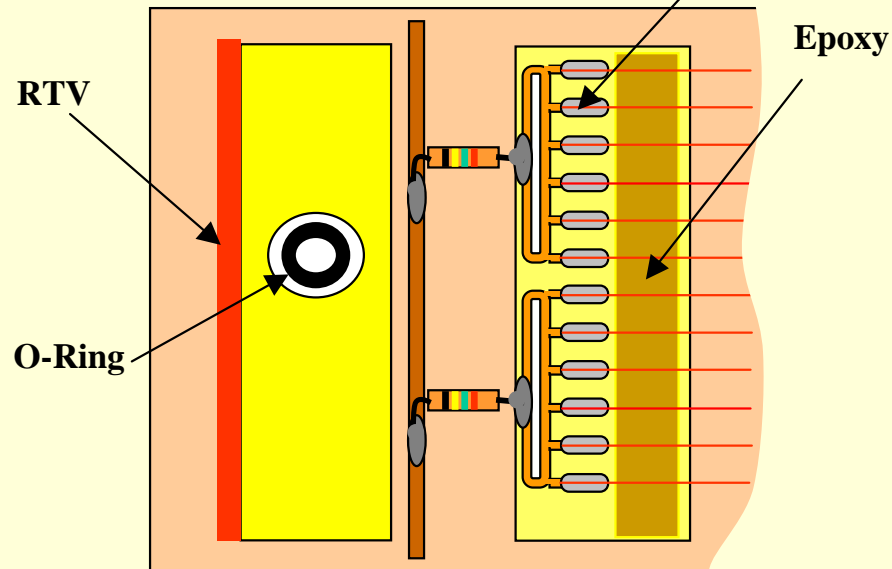
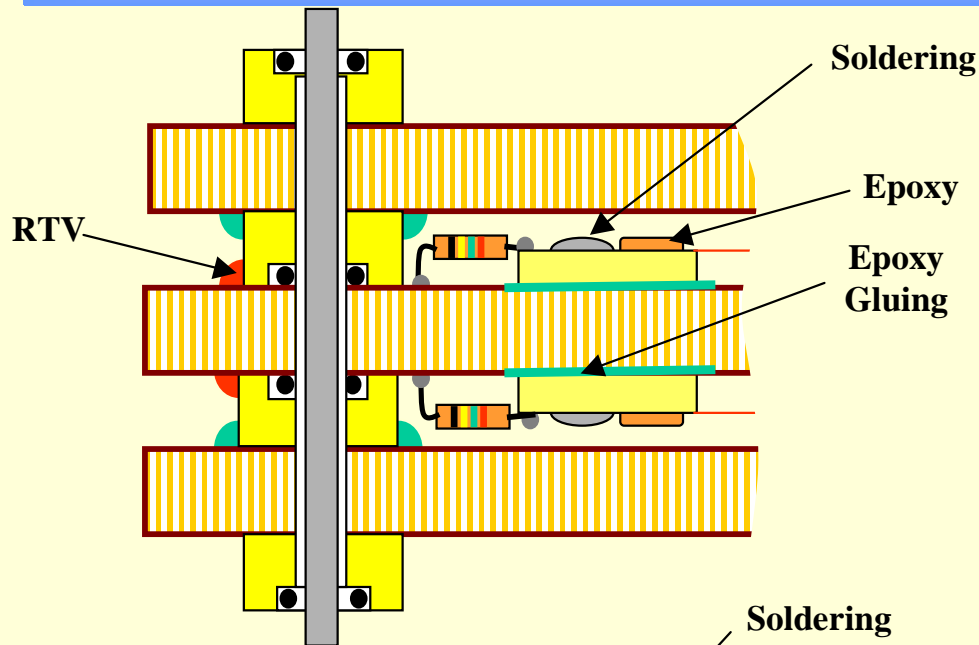
- 50/200 μm anode/guard wire diameter
- 3.12 mm wire spacing
- 4.75 mm gap (anode – cathode)
- 250/500 gr anode/guard wire tension
- High voltage segmentation

Gas mixture: 40% Ar + 50%CO₂ + 10%CF₄

Gas gain > 10⁵

High Voltage – 3.7 kV

Chamber Materials, Components and Chemicals



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)

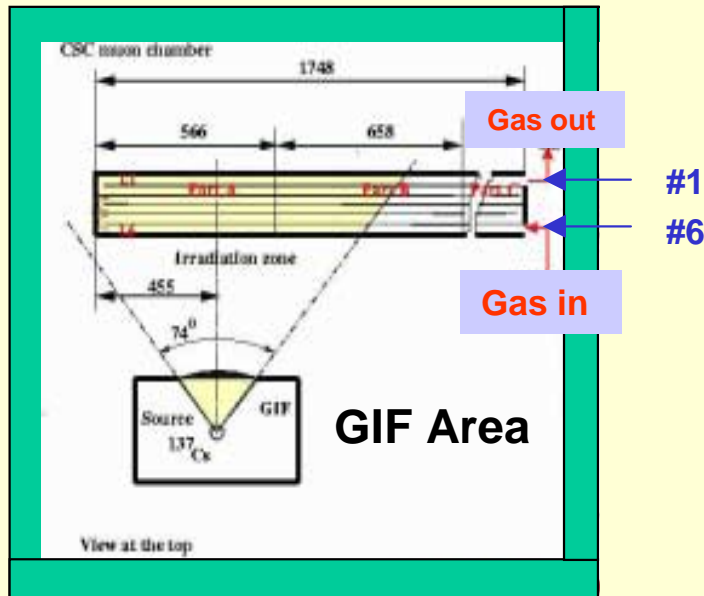
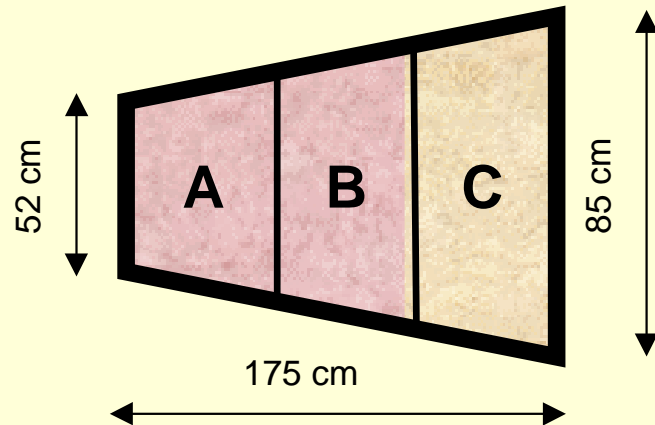
RTV - 41 + curing agent (outside chamber sealing)

Solder wire Almit KR-19 SH RMA ,

Seika Corp. (new product)

Ageing Setup and Conditions

Irradiated Area



Gamma Radiation Facility (CERN):

^{137}Cs ($E_\gamma=661$ keV), 740 GBq

Rate in the chamber

- ~ 100 times of that at LHC
- ~ 15-20 kHz/cm²
- ~ 5 kHz/cm of wire

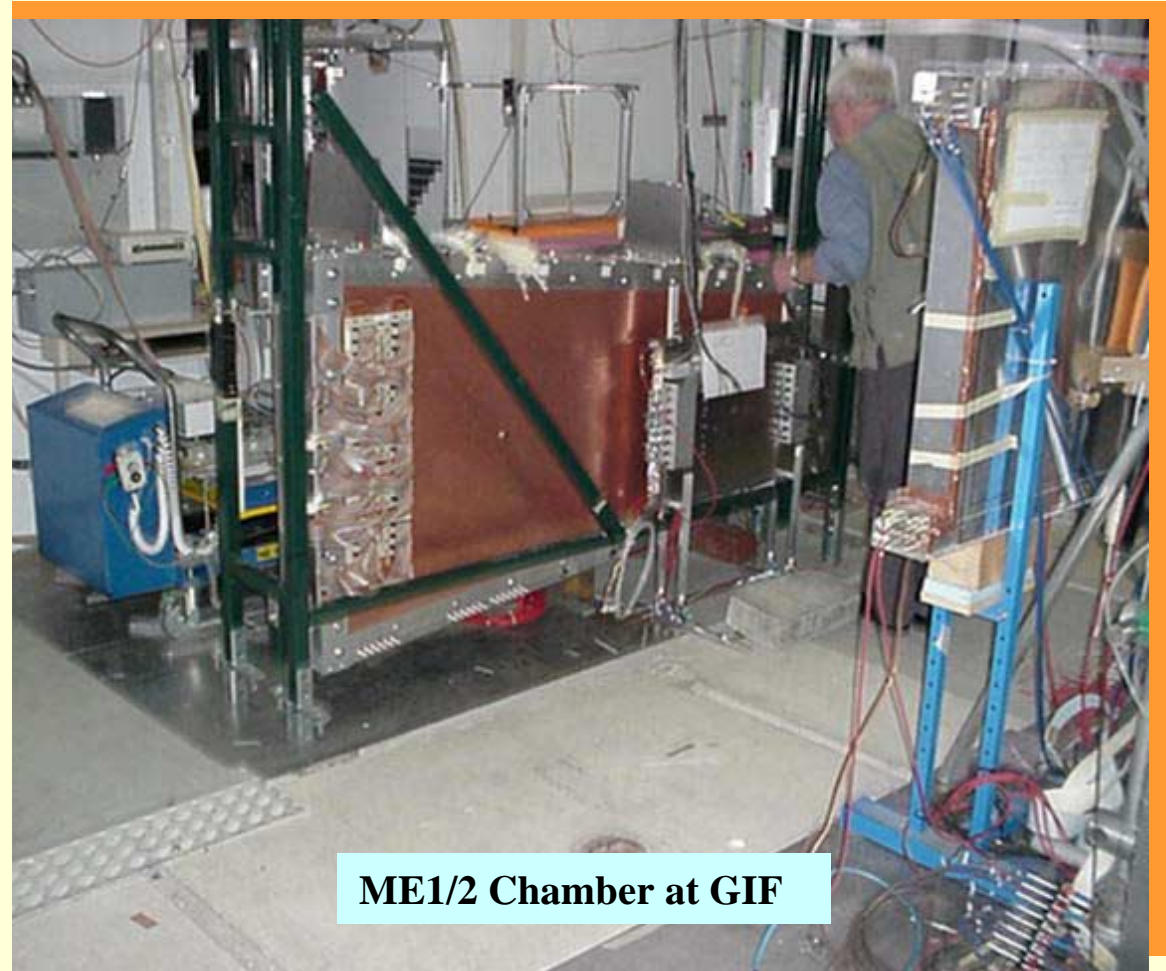
Radiation exposure (for planes 2,3,4,5):

- ~ 3 - 5 months (~40 LHC years)
- ~ 1 C/cm², 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)**

Ar/CO₂/CF₄ - 40/50/10

- **Purity of components, %**

Ar - 48 (99.998)

CO₂ - 48 (99.998)

CF₄ - 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)**

Ar/CO₂/CF₄ - 40/50/10

- **Purity of components, %**

	1	2
Ar	99.998	99.996
CO ₂	99.998	99.990
CF ₄	99.995	99.995

- **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):**

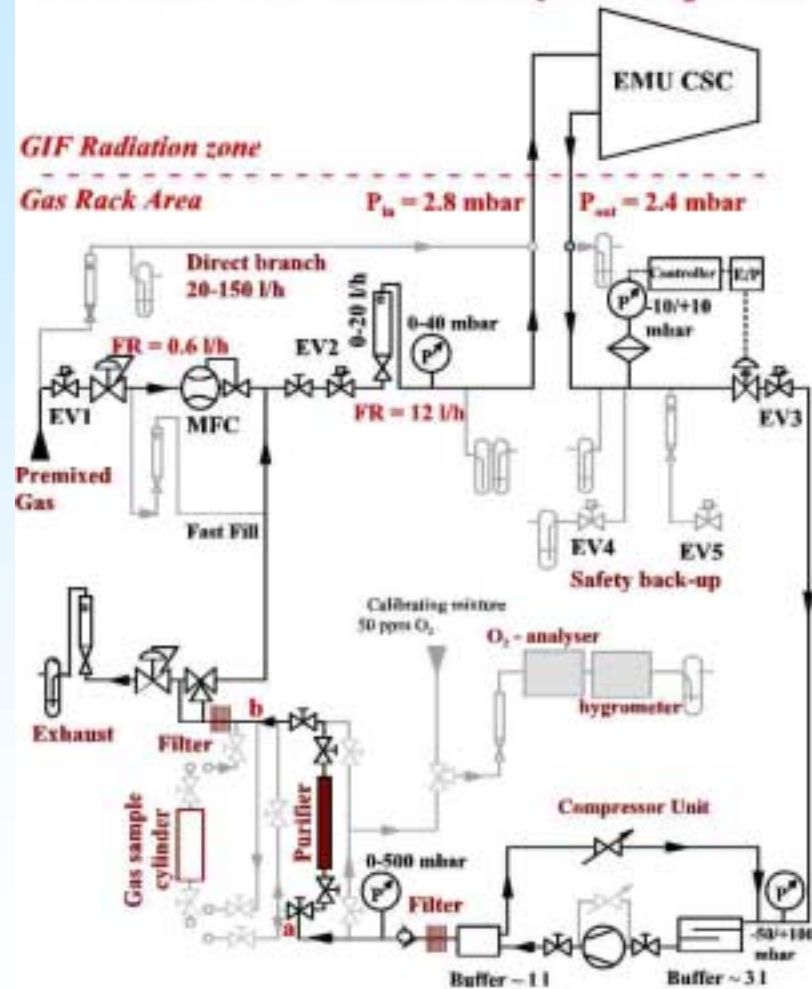
- 50m input tube (∅ 12 mm)

- 50m input tube (∅ 16 mm)

- cleaned according to CERN spec.

Closed Loop Circulation Gas System

CMS EMU CSC Closed Loop Gas System

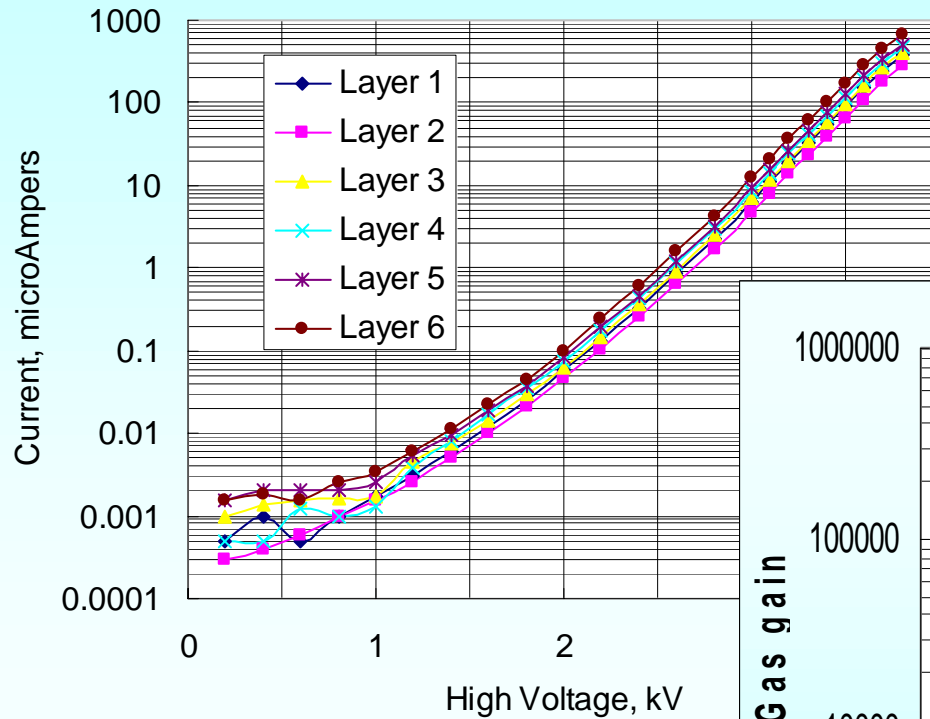


Monitored Chamber Parameters

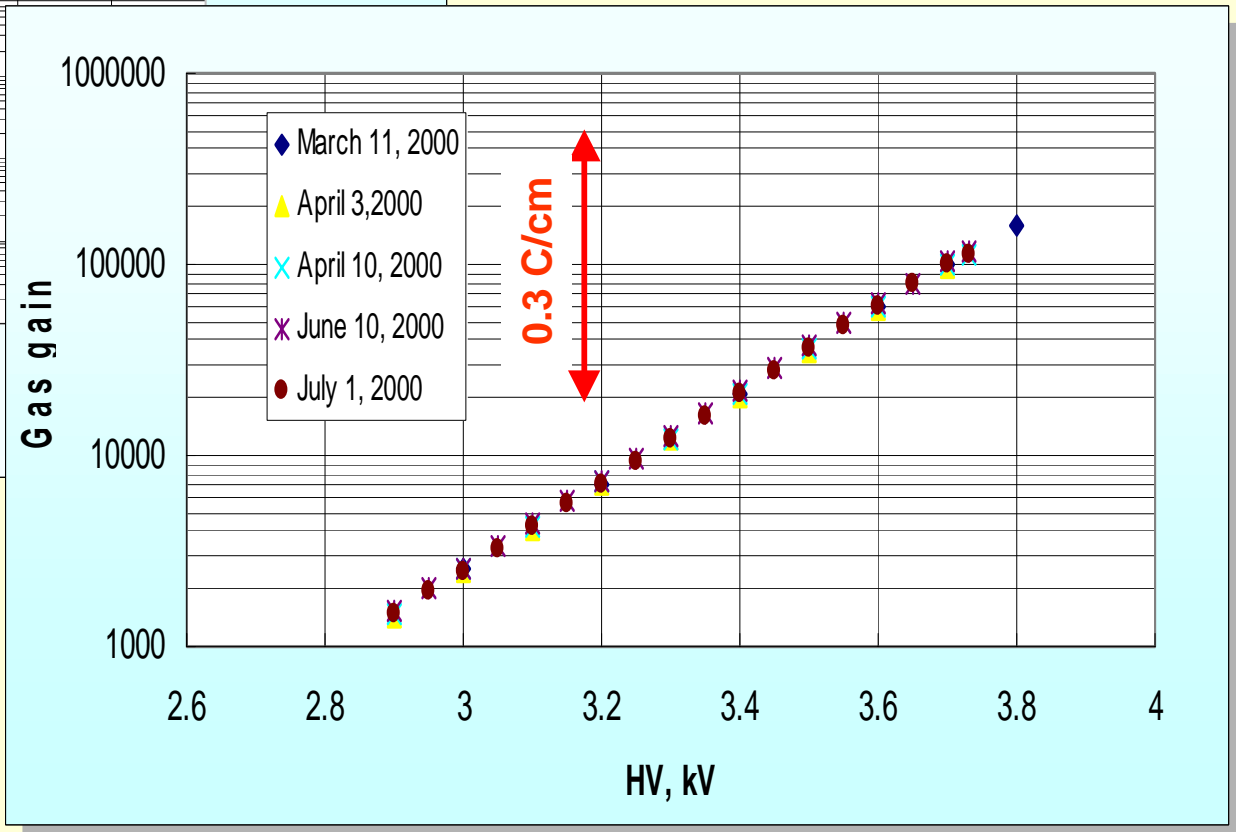
- **Anode Current during irradiation**
- **Anode GIF rates**
- **Dark current**
- **Anode noise rates**
- **Strip- to-strip capacitance**

Chamber Gas Gain

Chamber Cathode Current

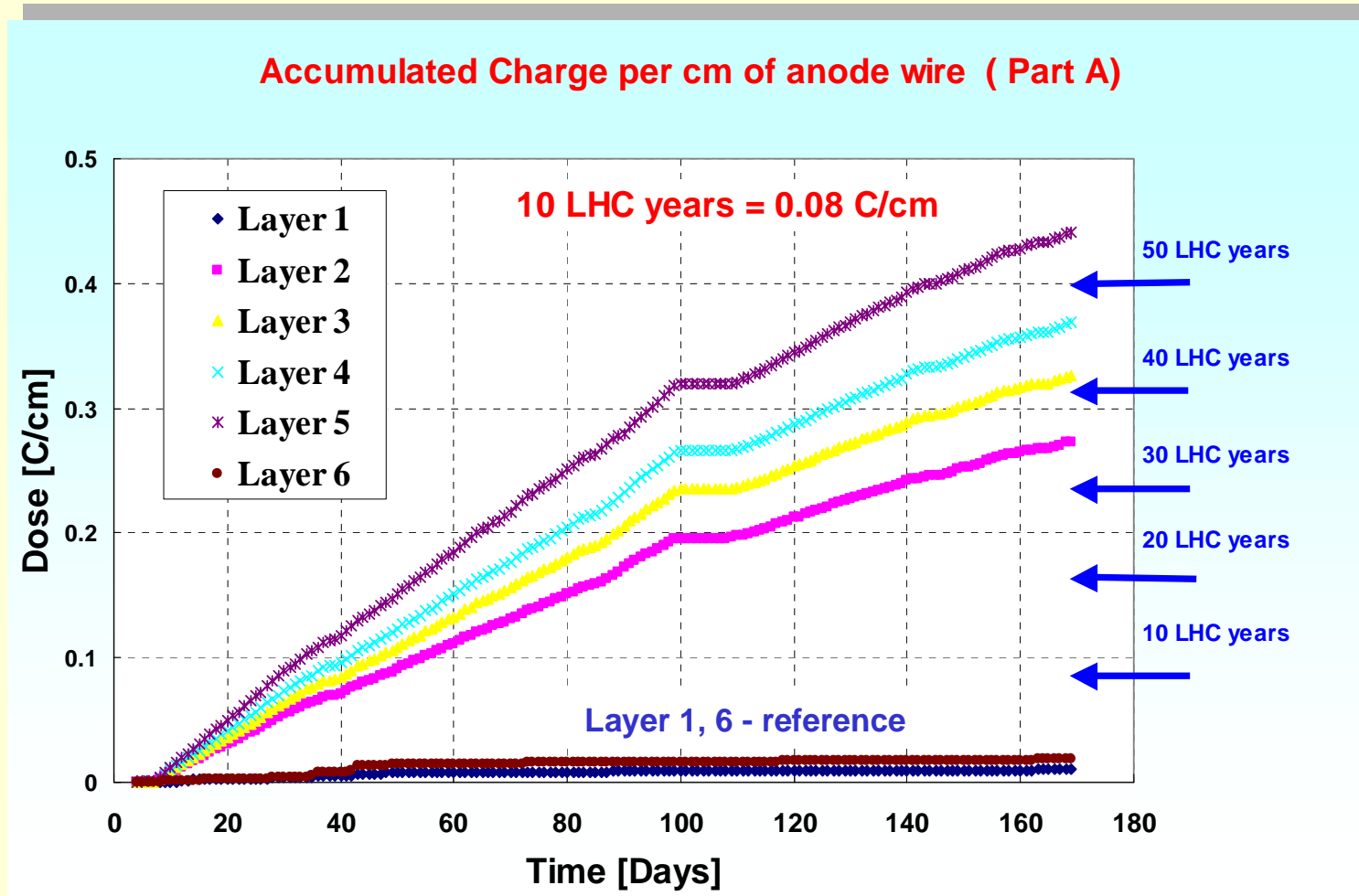


Gas Gain = 10^5
at HV = 3.7 kV



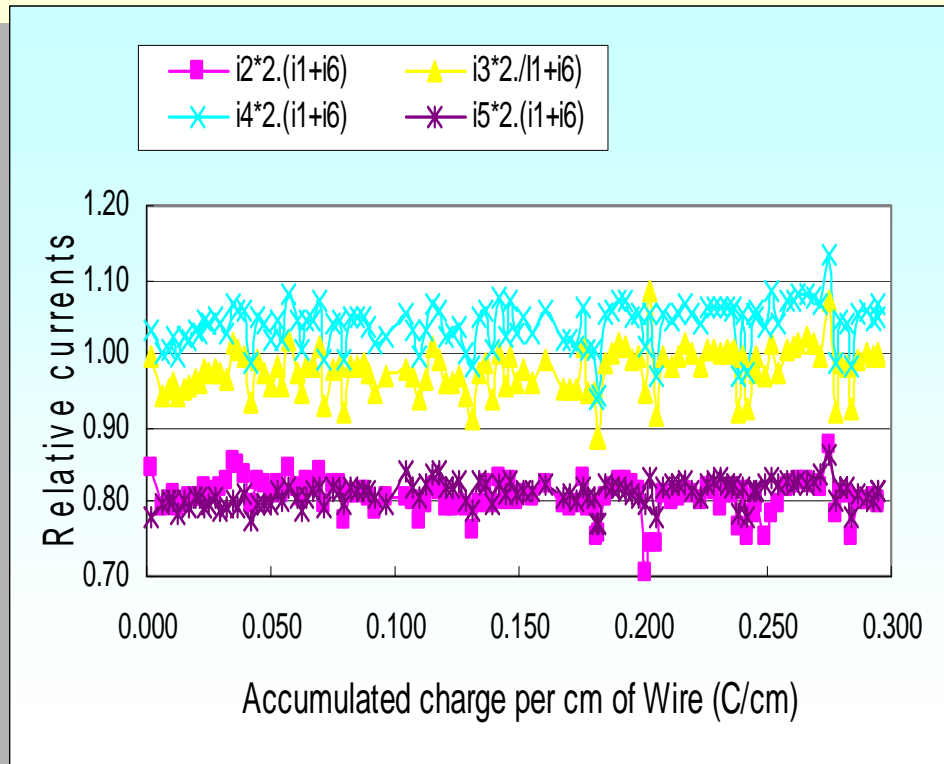
Gas gain stayed constant

Aging Test 2001 Accumulated Charge

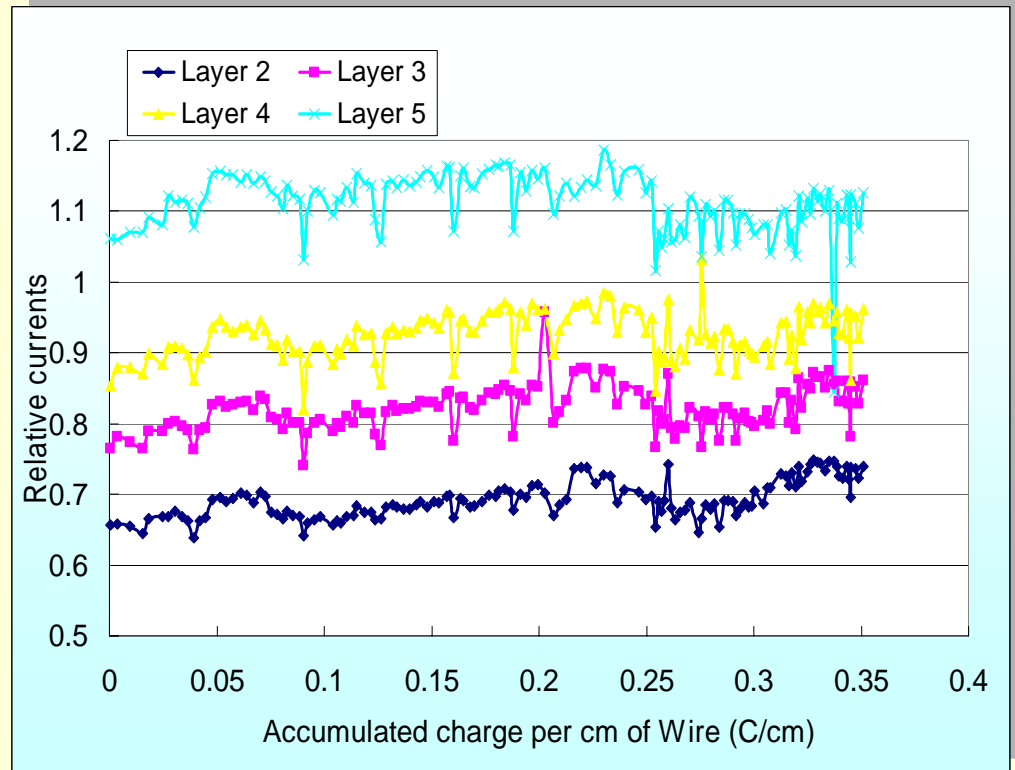


Gas Gain

Aging Test 2000



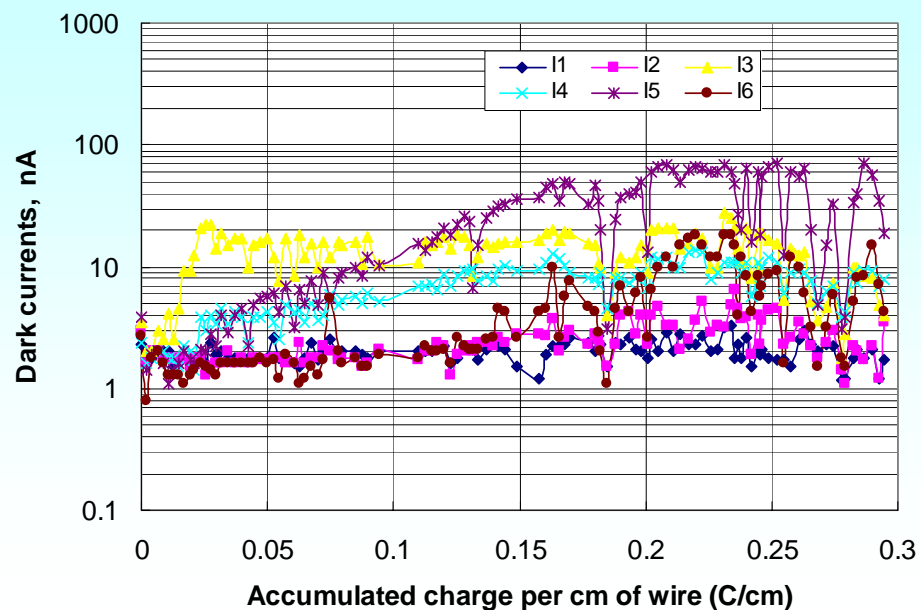
Aging Test 2001



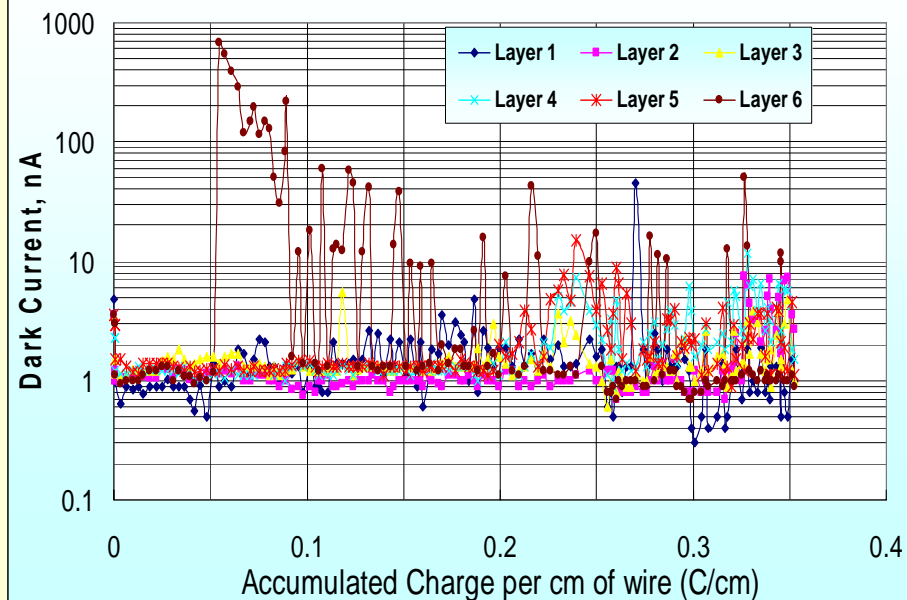
Gas Gain remained unchanged

Dark Current

Aging Test 2000



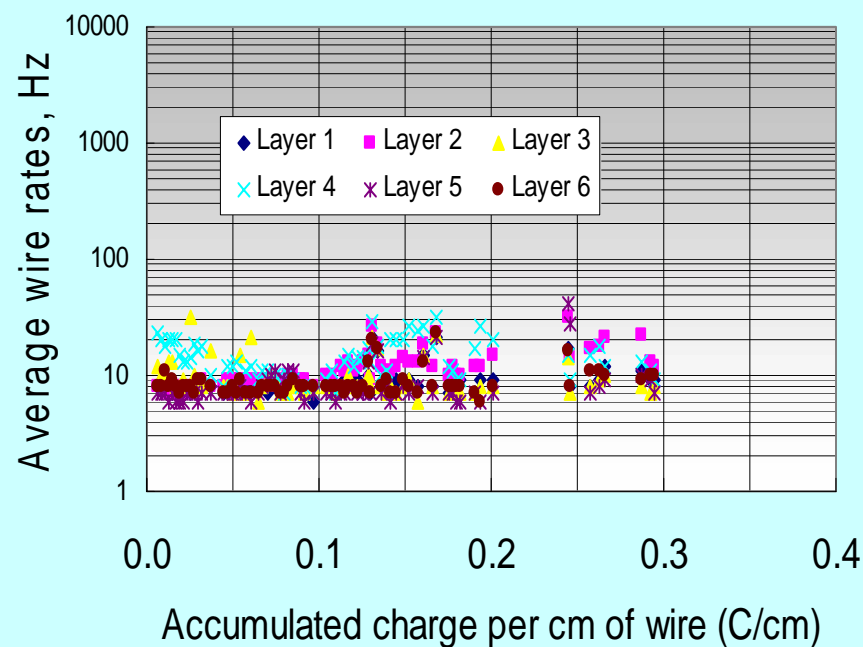
Aging Test 2001



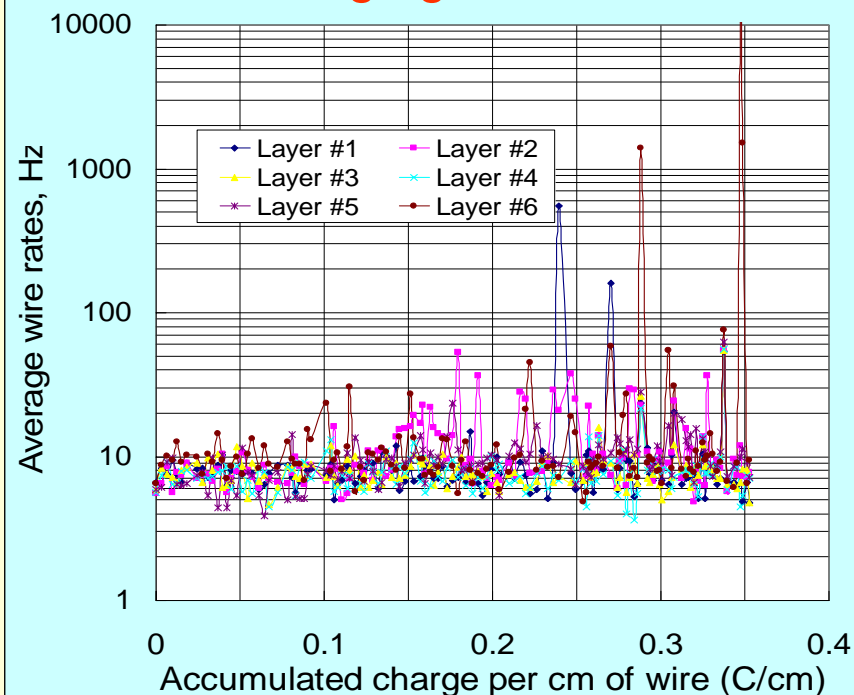
**Dark current increased
from ~1 nA to typically ~10 nA per plane**

Dark Rates

Aging Test 2000



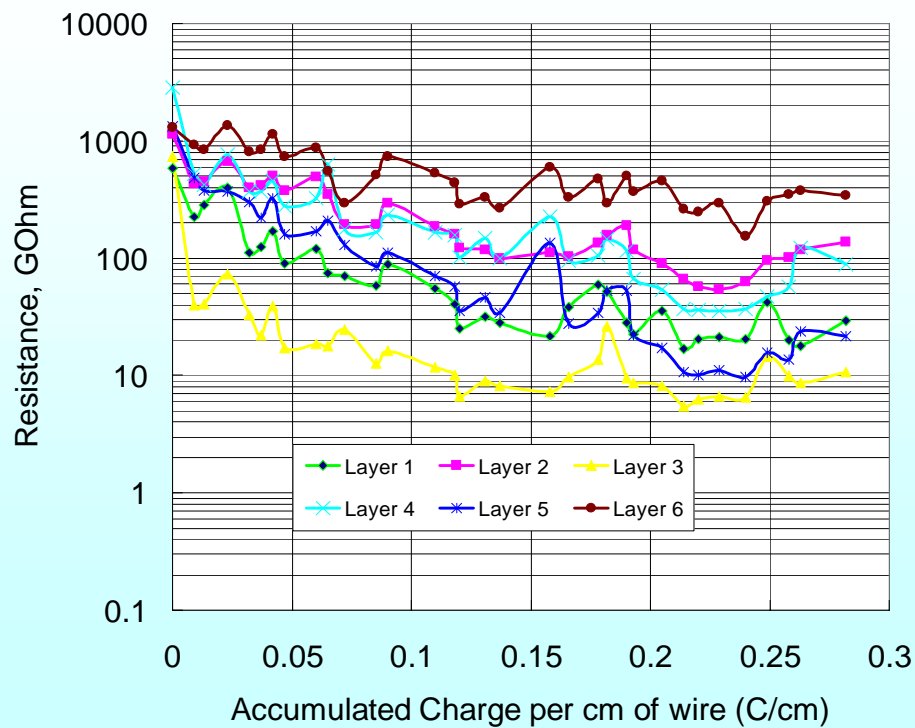
Aging Test 2001



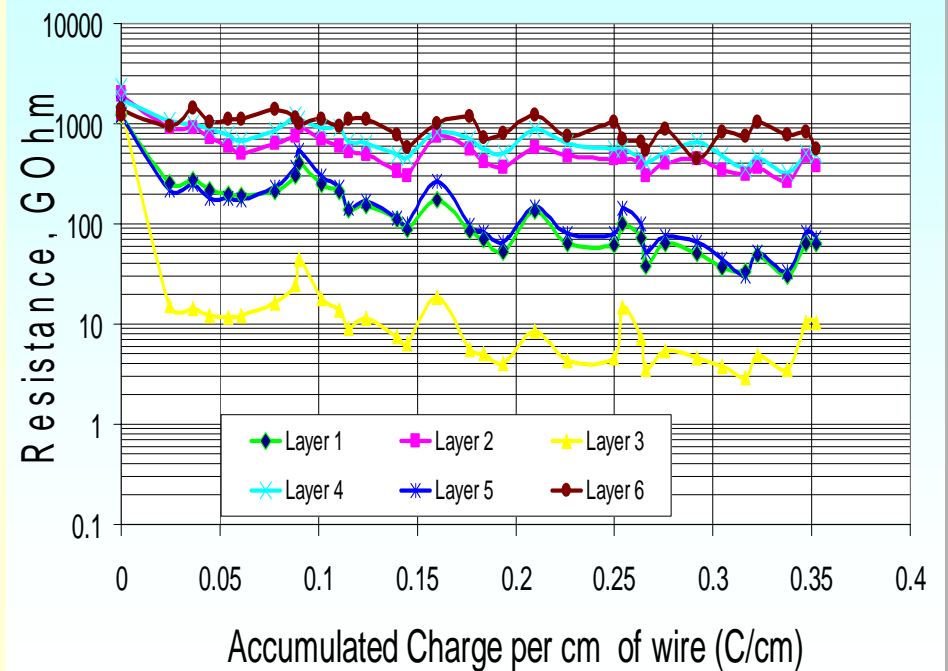
**Noise count remained unchanged
for both runs in 2000 and 2001**

Strip to Strip Resistance

Aging Test 2000

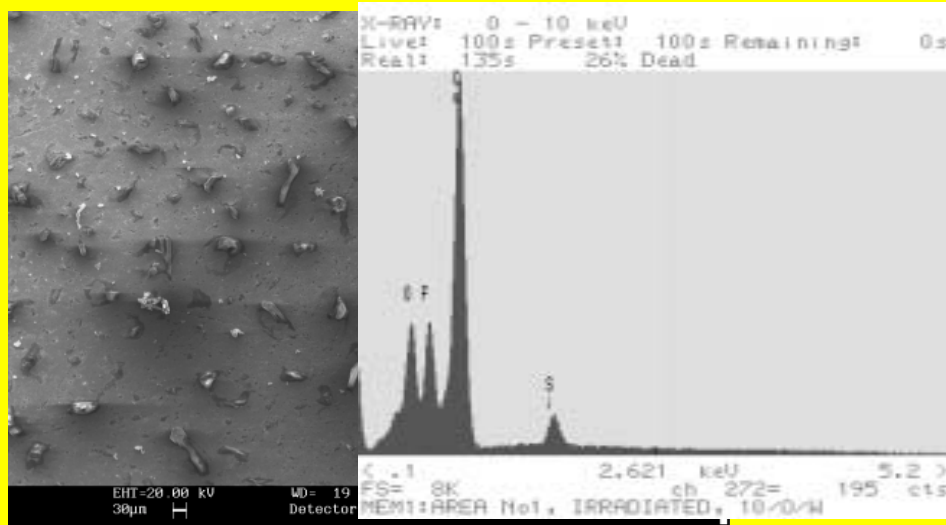


Aging Test 2001



**Resistance between Strips
Changed from ~100 to ~ 10 – 100 GOhm during irradiation**

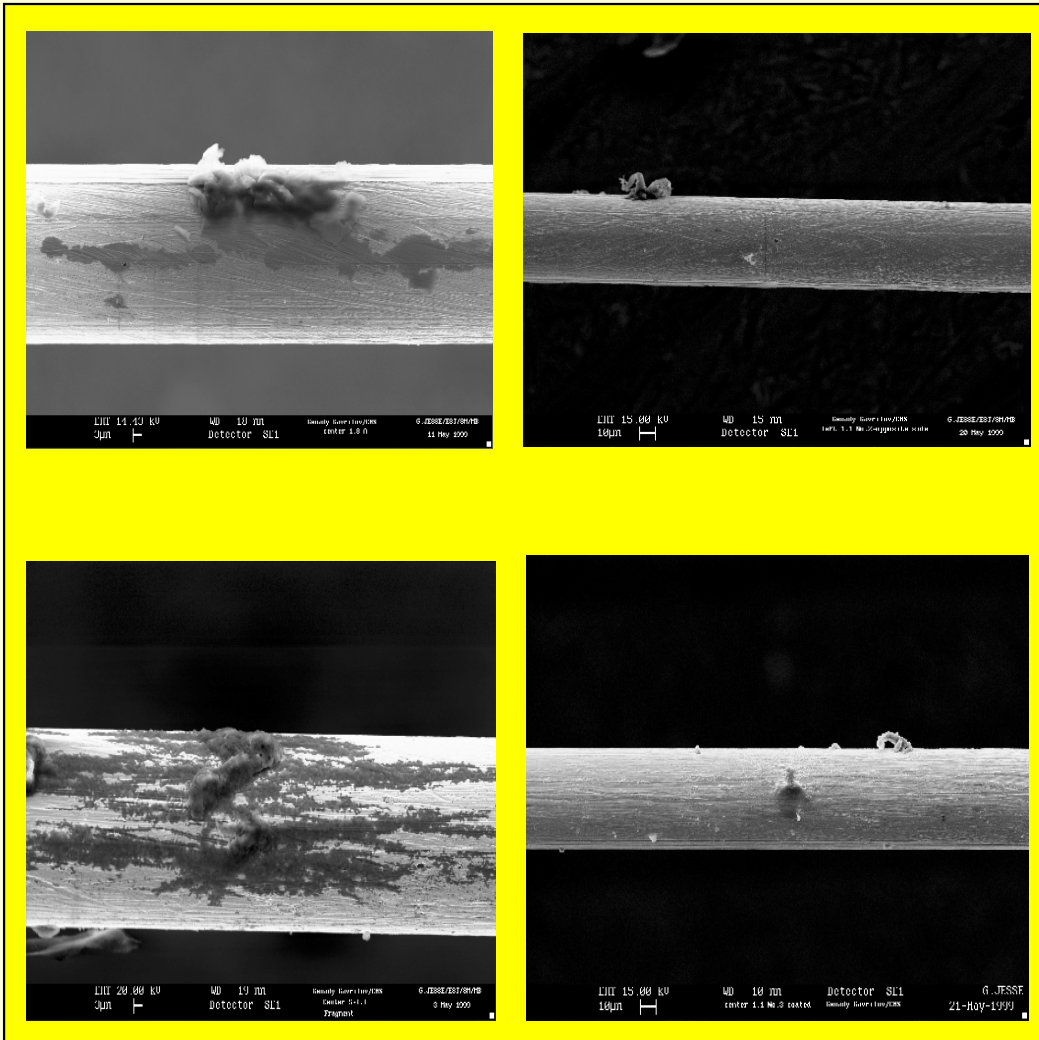
Cathode Plane Deposits



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