Aging Effects in Wire Chambers: Some Remarks (I)

Description of aging rate by a single parameter: R=-1/G(dG/dQ) is not adequate

Initial stage of radiation tests usually performed in the laboratory (X-Rays, MIPs) does not offer full information, needed to give an estimation about the lifetime of the real detector

Clear evidence for aging dependence on:

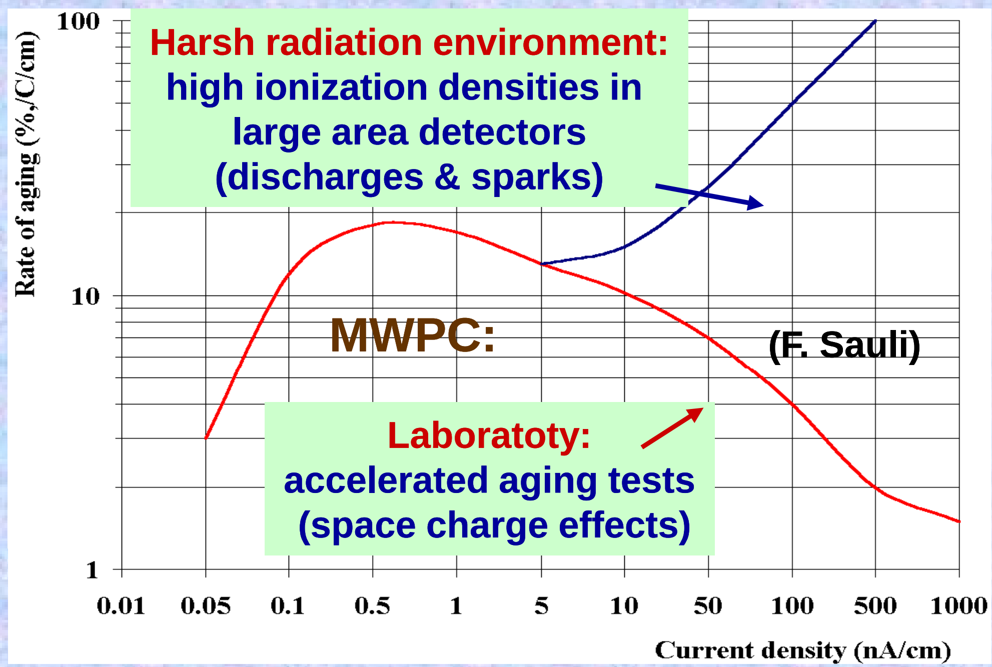
- size of irradiated area → aging as non-local phenomena
- irradiation rate
- ionization density
- high voltage (gas gain)
- particle type and energy

→ (irradiation rate … particle type and energy) Effect of microdischarges & Malter currents: increase in polymer production rate or production of new reactive species

- gas exchange rate

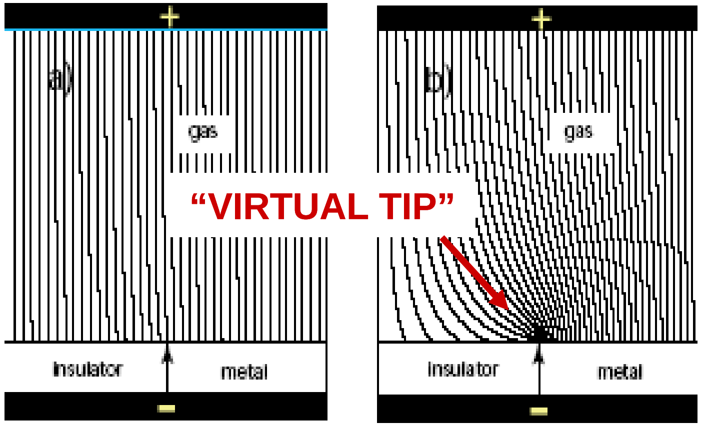
Systematic studies of space-charge effects & discharges on the aging performance in MPGD ?

What is the maximal "safe factor" to extrapolate aging results from small to large areas) ?



Aging Effects in Gas Detectors: Some Remarks (II)

AVOID "TRIPLE JUNCTIONS" at HIGH FIELDS:

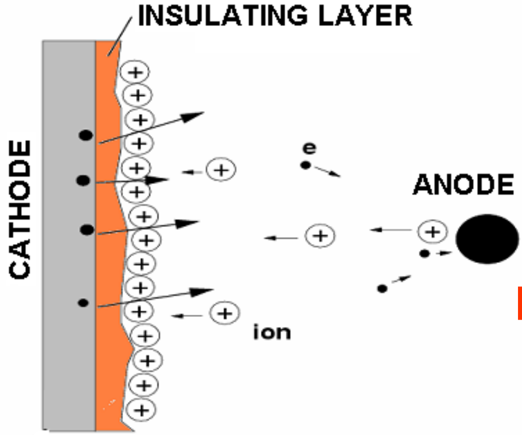


If conductivity of the gas becomes higher than insulator (under Irradiation)

ELECTRIC FIELDS ARE DETERMINED BY CAPACITIES AND CURRENTS

Proceedings of 2001 Aging Workshop, NIMA515

ADD INSULATORS WITH GREATEST CARE



Maximum Rate Capability: (to prevent charge build-up):

R_{max} ~1/(10RC) = 1/(10 ε_r ε_0 ρ_V)

DETECTOR WHICH USE INSULATORS MAY FACE RADIATION-INDUCED INCREASE OF SURFACE RESISTIVITY

→ **Development of common standards (careful control for any anomalous activity in the detector - dark currents, anode current fluctuation, unsual remnant activity in the chamber when beam goes away) to detect the appearance of aging effects at the very early stage ?**

→ **Are we limited to the aging resistant gases: noble gases, CF_4, CO_2, O_2, H_2O ?**

→ **Are hydrocarbons trustable in MPGD for long-term high rate experiments ?**

Summary of Aging Results in MPGD (I)

Table 2. Summary of aging experience with Micro-Pattern Gas Detectors.

Detector type	Mixture	Gain reduction $\Delta G/G$	Charge mC/mm^2	Current density, nA/mm^2	Irradiated area; Irradiation rate	Irrad. source
MSGC [65,104]	Ar/DME (90:10)	No	200	10	3 mm^2; 10^5 Hz/mm^2	6.4 keV X-rays;
MSGC [66]	Ar/DME (50:50)	No	40	63	0.3*0.8 mm^2; $8*10^5$ Hz/mm^2	5.4 keV X-rays
MSGC [66]	Ar/DME (50:50)	Anode deposit	50	9	0.3*0.8 mm^2; $2*10^4$ Hz/mm^2	5.4 keV X-rays
MSGC+GEM [66]	Ar/DME (90:10)	No	70	63	0.3*0.8 mm^2; $2*10^6$ Hz/mm^2	5.4 keV X-rays
MSGC+GEM [51]	Ar/DME (50:50)	No	5	2	~ 113 mm^2; $2*10^4$ Hz/mm^2	8 keV X-rays
MSGC+GEM [51]	Ar/DME (50:50)	Yes	0.5	1	~ 900 mm^2; 10^4 Hz/mm^2	8 keV X-rays
MSGC+GEM [51]	Ar/CO_2 (70:30)	No	10	2	350 mm^2 $2*10^4$ Hz/mm^2	8 keV X-rays
Double GEM [67]	Ar/CO_2 (70:30)	Slight gain loss	25	6	2 mm^2; $7*10^4$ Hz/mm^2	5.4 keV X-rays
Triple GEM [68]	Ar/CO_2 (70:30)	No	27	13	1.5 mm^2; $6*10^4$ Hz/mm^2	5.4 keV X-rays
Double GEM [69]	Ar/CO_2 (70:30)	No	12	4	200 mm^2; $5*10^4$ Hz/mm^2	6 keV X-rays
Triple GEM [70]	Ar/CO_2 (70:30)	No	11	10	1260 mm^2; $2*10^4$ Hz/mm^2	8.9 keV X-rays
Triple GEM [71,72]	$Ar/CF_4/CO_2$ (60:20:20)	< 5 %	230	270	1 mm^2; $5*10^5$ Hz/mm^2	5.9 keV X-rays
Triple GEM [72]	$Ar/CF_4/CO_2$ (45:40:15)	< 5 %	45	160	1 mm^2; $5*10^5$ Hz/mm^2	5.9 keV X-rays
Triple GEM [73]	$Ar/CF_4/CO_2$ (45:40:15)	Yes/ 55%	20	20	200*240 mm^2	25 kCi ^{60}Co
Triple GEM [72]	$Ar/CF_4/C_4H_{10}$ (65:28:7)	~ 10 %	110	160	1 mm^2; $5*10^5$ Hz/mm^2	5.9 keV X-rays
Triple GEM+ CsI [88]	CF_4 (100)	No	0.1	3	100 mm^2; 10^7 Hz/mm^2	Hg UV Lamp
Micromegas [74]	Ne/C_4H_{10} (91:9)	Yes/ 35 %	10	50	16 mm^2; 33Hz spark rate	5.3 MeV α's
Micromegas [75]	Ar/CF_4 (95:5)	No	2	10	--------	8 keV X-rays
Micromegas [76]	CF_4/C_4H_{10} (94:6)	No	1.6	25	20 mm^2; ~10^5 Hz/mm^2	8 keV X-rays
Micromegas [76]	Ar/C_4H_{10} (94:6)	No	18	20	20 mm^2; $2*10^5$ Hz/mm^2	8 keV X-rays
Micromegas+ GEM[77]	Ar/CO_2 (70:30)	No	23	17	3 mm^2	5.4 keV X-rays
MSGC+GEM DIRAC [64]	Ar/DME (60:40)	10 % eff. drop	0.01	0.05	100*100 mm^2; $3*10^4$ Hz/mm^2	24 GeV protons
3-GEM [78] COMPASS	Ar/CO_2 (70:30)	No	2.3	--	310*310 mm^2; $2*10^4$ Hz/mm^2	Compass Beam

(taken from arXiv: physics/0403055)

GEM and Micromegas demonstrated excellent radiation hardness in the earlier aging studies

Most of aging tests were perfomed by irradiating ~ cm^2 area
→ how can we use this data to evaluate MPGD large system performance ?

→ Can we get systematical inputs (pulse-height, efficiency maps, etc…) from large-area GEM & Micromegas operation in COMPASS?

Most of the studies done with X-Rays
→ need more studies at high ionization densities and large area irradiation

Summary of Aging Results in MPGD (II)

(taken from arXiv: physics/0403055)

Table 4. Basic parameters of the tracking detectors. For MPGD the spatial (σ_x) and time resolution (σ_t) are given for laboratoty (high intensity beam) measurements. The X_0 refers to the amount of material in one tracking station (two layers of straws are considered in one tracking station). (a) The rate capability of Si μ-strips is limited by properties of readout electronics.

Detector	Radiation Hardness	σ_x, μm	σ_t, ns	S/N	X_0, %	Rate capability Hz/mm^2	Size of detector
Straw tubes	**> 10 C/cm ($>10^{12}$ MIPs/mm^2)**	**100**	**50**	**15-20**	**0.2**	**~ 10^4**	**300*0.4 cm^2**
GEM	**> 20 mC/mm^2; (> 6*10^{11} MIPs/mm^2)**	**30(70)**	**5(12)**	**>20**	**0.4**	**~5*10^5**	**30*30 cm^2**
Micromegas	**20 mC/mm^2 (6*10^{11} MIPs/mm^2)**	**15(70)**	**5(10)**	**>20**	**0.4**	**~5*10^5**	**40*40 cm^2**
Si μ-strips (300 μm)	**3*10^{12} (24 GeV protons)/mm^2**	**< 10**	**~20**	**15-20**	**1.2**	**(a)**	**8*8 cm^2**

How do we deal with duality of units to classify aging effects in gas detectors (C/cm/wire in multi-wire chambers, mC/mm^2 in MPGDs) - ?

Can we try to find "common unit" to classify MPGD radiation hardness and to simplify comparison with other detector technologies - ?

(e.g. can we use the rate of charged particles – translated into MIP-equivalent flux & given gas gain (~10^4) → see table above)