Aging measurements in wire chambers

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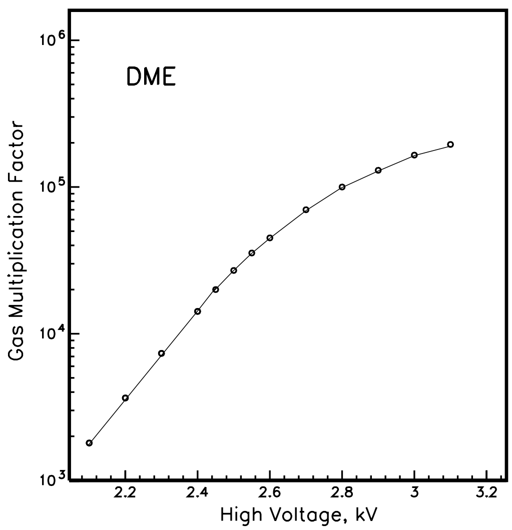
Outline

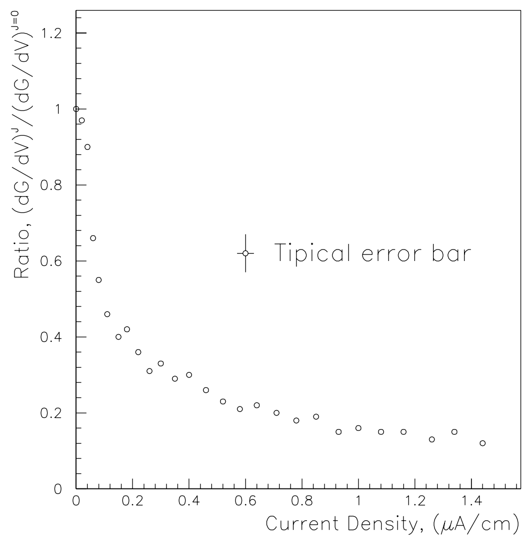
- **Procedure dependence of aging rate measurements (Nucl. Instr. and Meth. A419 (1998) 676)**
- **Aging tests with DME and other gases**
- **Effects of materials on aging**
- **Influence of sense wire surface quality on aging**
- **Conclusion**

Procedure 1 (60% of publications)

- **Anode wire current is monitored over period of test**

$$\mathbf{R = -\frac{1}{I_0} \cdot \frac{\Delta I}{\Delta Q}, \quad \%/(C/cm)}$$





$$R \sim \frac{dG}{dV} \quad \Rightarrow \quad \begin{cases} V = const, & R = f(I) \\ I = const, & R = k(G) \end{cases}$$

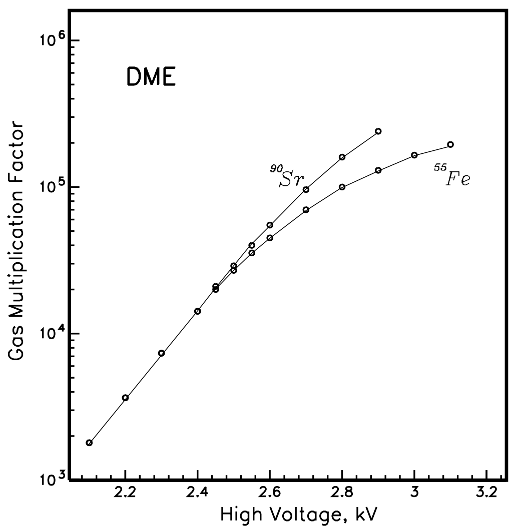
J.Kadyk et al., IEEE Trans. Nucl. Sci. NS-36(1) p419

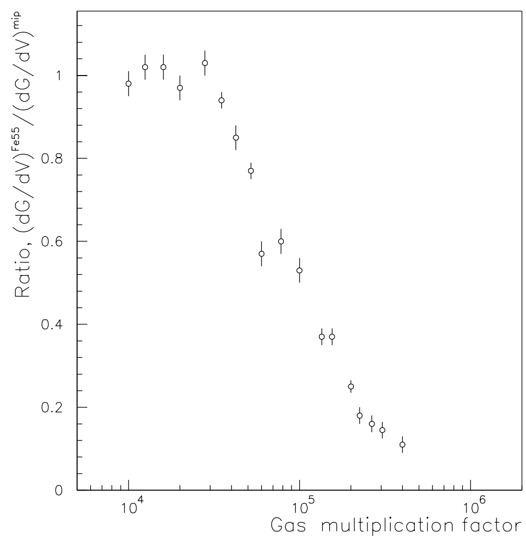
R decreases with increasing current density
R decreases with increasing gas gain

Procedure 2 (40% of publications)

- **Gas gain is monitored by measurement of peak from low intensity ^{55}Fe**

$$\mathbf{R} = -\frac{1}{A_0} \cdot \frac{\Delta A}{\Delta Q}, \quad \%/(C/cm)$$





R.Kotthaus. Nucl. Instr. and Meth. A252 p531

$$\mathbf{R_{str}/R_{prop} \simeq 0.5}$$

Our procedure

- **Irradiation: ^{90}Sr**
- **Gas gain is monitored by low intensity ^{55}Fe**
- **HV was lowered, before taking pulse height spectra**

Procedure for aging rate measurement

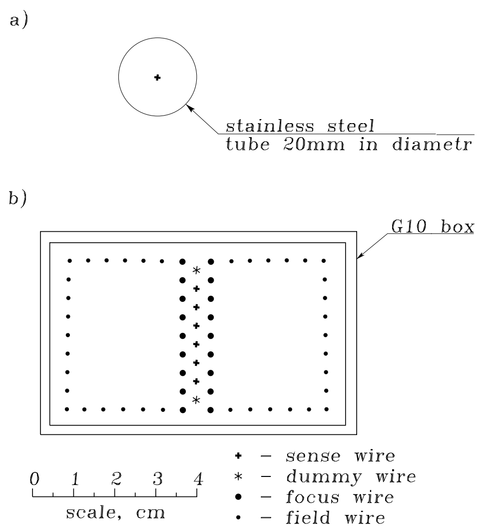
- **Irradiation: ^{90}Sr**

- **Gas gain is monitored by measurement of peak from low intensity ^{55}Fe**

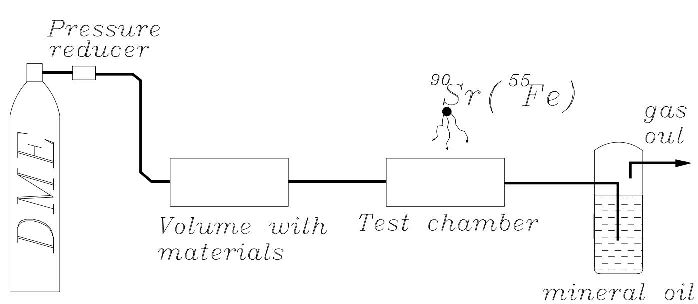
- **HV was lowered, before taking pulse height spectra**

$$\mathbf{R} = -\frac{\mathbf{1}}{\mathbf{A_0}} \cdot \frac{\mathbf{\Delta A}}{\mathbf{\Delta Q}}, \quad \mathbf{\%/(C/cm)}$$

Test chambers



Gas system



Test of dimethyl ether ($(CH_3)_2O$) gas

1. **DME** (99.7%) **(Ukraina): R $= (1.7 \pm 0.5)$ %/(C/cm)**
2. **DME** (99.8%) **(Russia): R $= (0.7 \pm 0.3)$ %/(C/cm)**

- **R was measured for all tubes and only tubes with $R < 1$ %/(C/cm) are selected for the tests of materials**

Material tests with DME gas

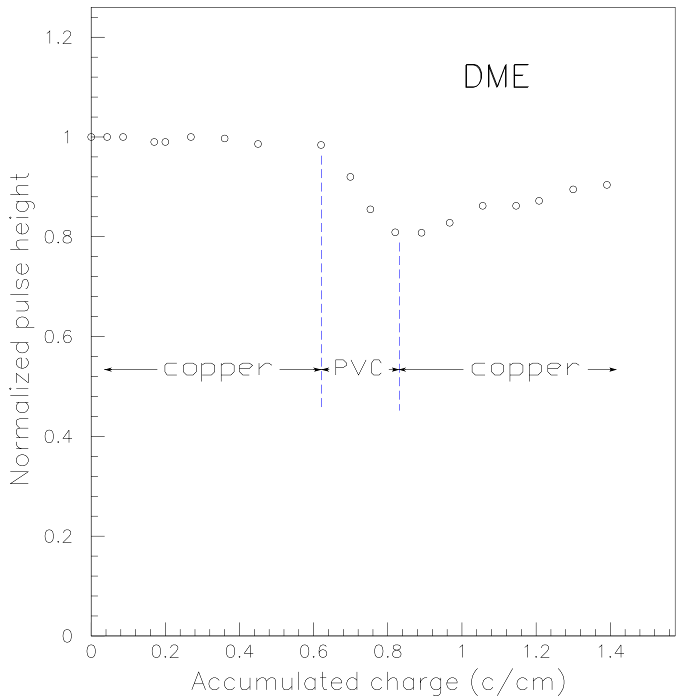
Chamber type	Tested material	Charge dose $C/cm]$	R $[\%/(C/cm)]$
DC cell	before material selection	0.6	490
Tube	without material	2.8	0.7
	PVC tube (black)	0.1	95.0
	PVC tube (black) after cleaning	0.4	1.2
	PVC tube(medical)	2.8	0.8
	Teflon tube	1.1	5.5
	gas seal paste(1)	0.8	6.0
	gas seal paste(2)	0.6	2.0
	gas seal paste(3)	0.5	22.6
	gas seal paste(4)	0.5	66.2
	silicon oil	3.0	1.2
	mineral oil	3.0	0.4
	fiber glass/epoxy	0.95	9.5
	epoxy	0.95	5.4
	α-naphtylamine	0.6	1.4
DC cell	after material selection	1.0	45.0

Test of the KEDR drift chamber

$$\mathbf{R}_{DC}=(\mathbf{7.3} \pm \mathbf{2.8})\ \%/(C/cm)$$

$$\mathbf{R}_{DCcell}=(\mathbf{45.0} \pm \mathbf{2.7})\ \%/(C/cm)$$

Effect of soft PVC on aging rate

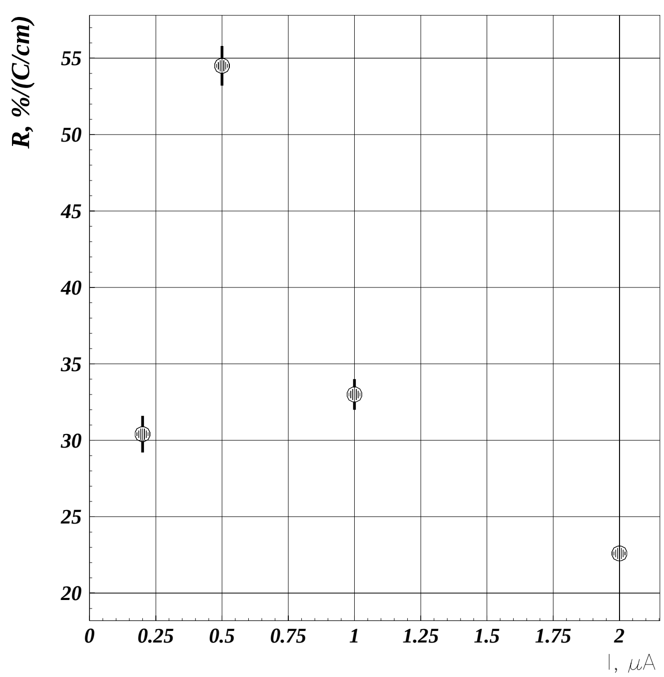


Tests of other gases

- $CO_2/Isobutane$ **(85/15),** $R = 210\ \%/(C/cm)$
- Ar/CO_2 **(92/8),** $R = 31\ \%/(C/cm)$
- **DME,** $R = 0.7\ \%/(C/cm)$
- Ar/CO_2 **(92/8) + PVC,** $R = 95\ \%/(C/cm)$
- **DME + PVC,** $R = 95\ \%/(C/cm)$

Effect of gas gain

(DME + Vikcint), f=2.5l/h in all measurements



How to do aging processes more controllable

1. **Test the working gas mixture**

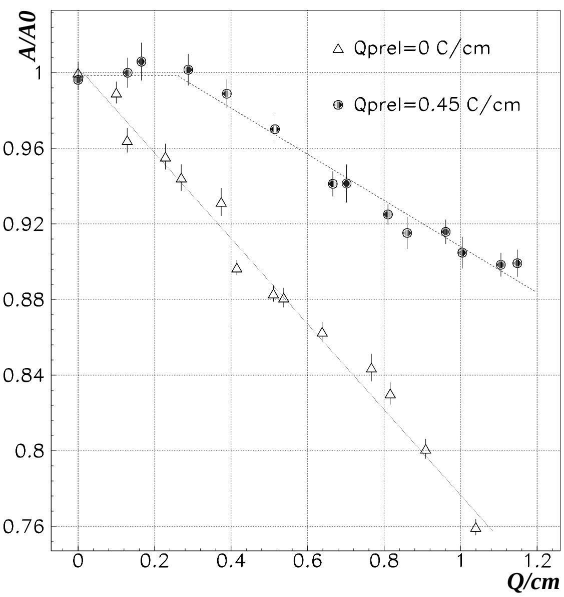
2. **Test the materials of drift chamber and gas system having contact with working gas and exclude bad materials**

3. **Test the gas system of the drift chamber with the proportional tube and exclude bad pollution from gas system if result is negative**

4. **After installation of drift chamber into detector to measure aging rate with the proportional tube introduced to gas system downstream of the chamber**

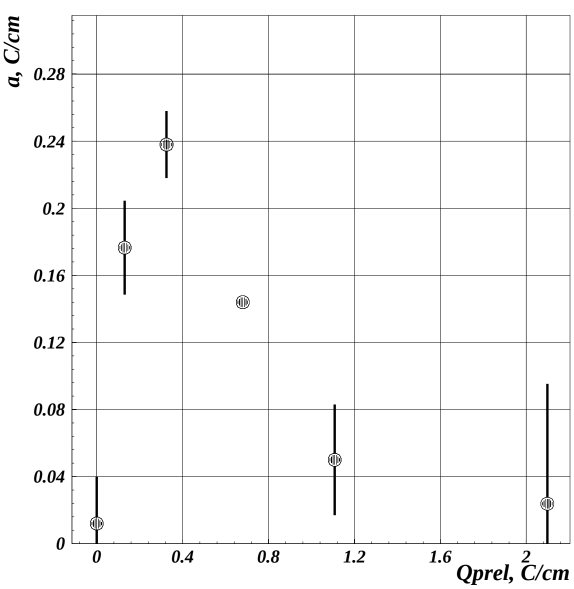
5. **It would be useful to continual monitoring of the aging process on the gas line downstream of the drift chamber with prototype chamber. This measurement would be integrate all variation in working conditions: variations in the level and composition of impurities, appearance of the pollution in gas system, variation in the gas mixture and so on.**

Influence of preliminary irradiation on aging

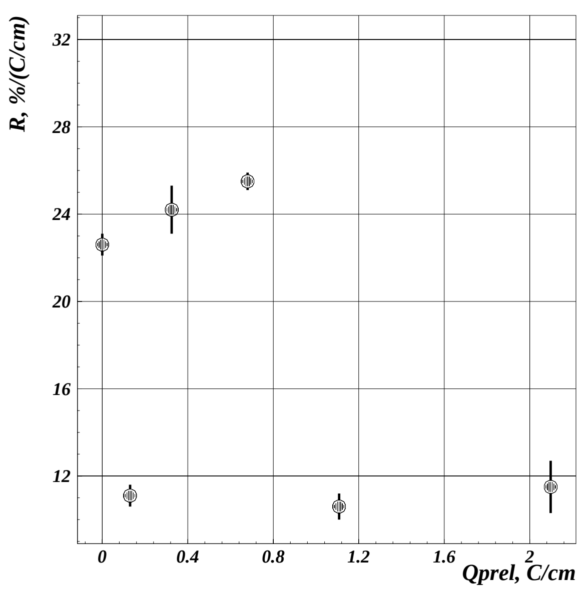


(Vikcint, fiber glass/epoxy, epoxy)

(DME + Vikcint), f=2.5l/h, $I_{sw}=2\mu A$ in all measurements

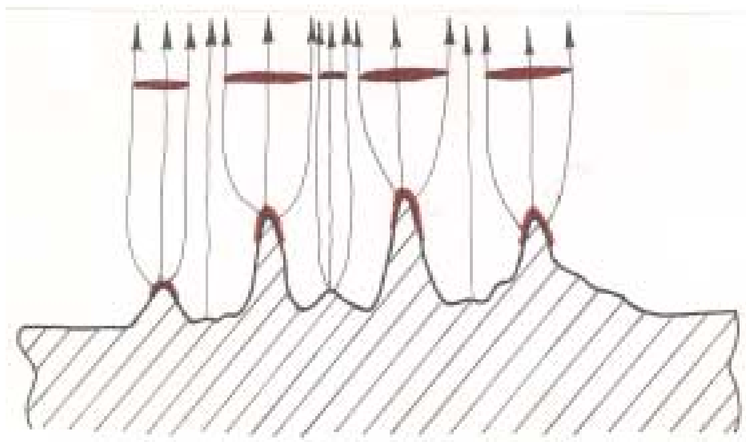


Size of plateau vs Q_{prel}



Aging rate vs Q_{prel}

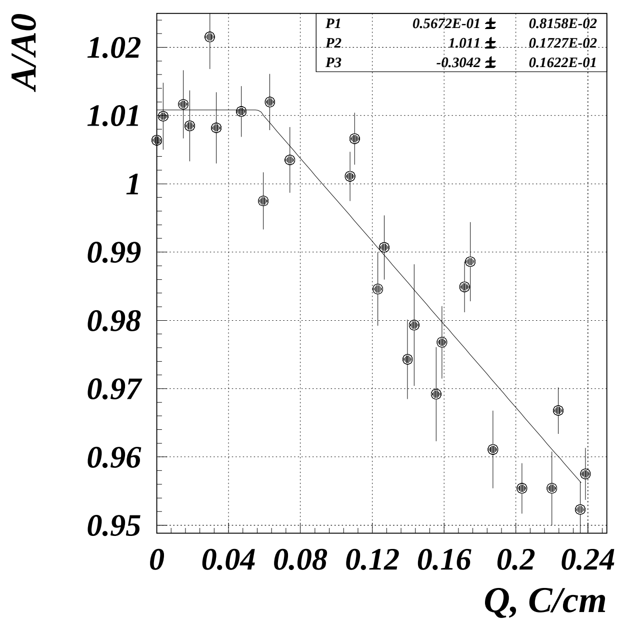
Model of film creation and growth



1. **The main part of electrons and negatively charged polymers from avalanche reach sense wire surface on peaks and process of polymer film formation start on the surface of peaks in the regions with highest electric field strength.** $(S_{eff} << S_{wire})$

Polymers fibers on early stage of growth

2. The probability for polymers stick to the metal surface is small. After creation of first mono-layer of polymers the probability increase in many times and thickness of the film start to increase rapidly and the amplitude from the sense wire start to drop.

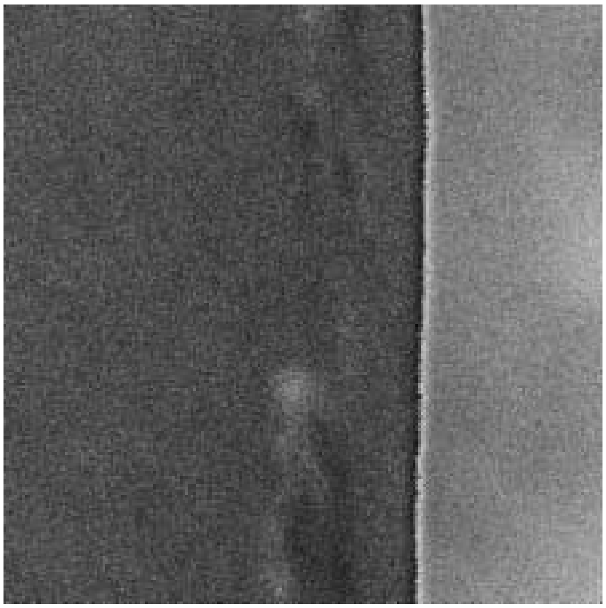


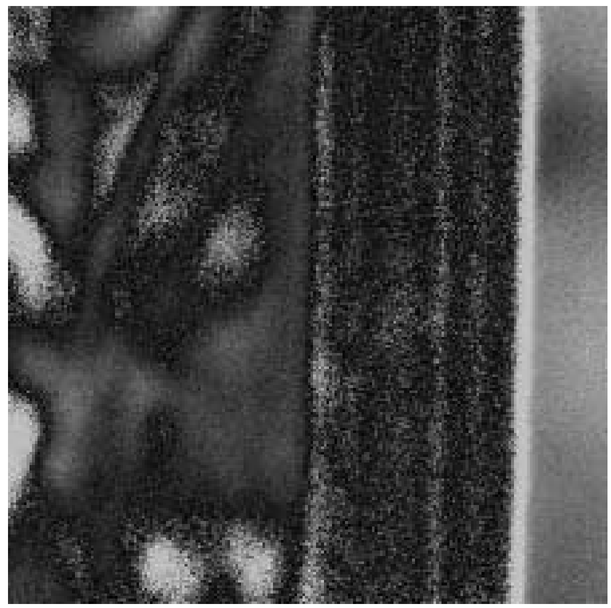
$$\mathbf{Q}_{prel}\mathbf{=0.0\ C/cm,}\quad \mathbf{a=}(0.057 \pm 0.008)\mathbf{C/cm}$$
$$\mathbf{Q}_{prel}\mathbf{=0.3\ C/cm,}\quad \mathbf{a=}(0.240 \pm 0.020)\mathbf{C/cm}$$

3. The preliminary irradiation in clean conditions with the non-polymerizing DME gas to polish the surface of sense wire and increase the average radius of the tips and decrease the difference in the altitudes of the picks. The field lines are distributing on the larger area of the sense wire surface. $(S_{eff}^{before} < S_{eff}^{after})$ **The bombardment intensity decrease and it is necessary larger dose of radiation or mass of polymers for creation of continuous film on the surface of tips.**

Influence of preliminary irradiation on sense wire quality

$2\mu m$ $2\mu m$





Before, Q_{prel}=0.0 C/cm **After, Q_{prel}=0.5 C/cm**

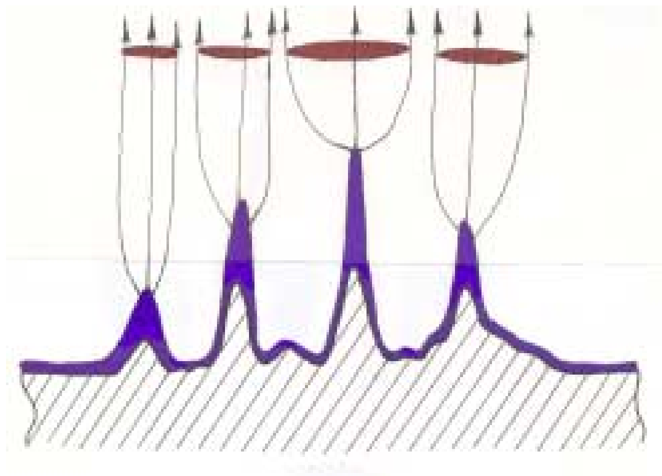
Plateau size at high dose of preliminary irradiation

$$Q_{prel} > 1.0 \text{ C/cm}, \quad a \rightarrow 0.0 \text{ C/cm}$$

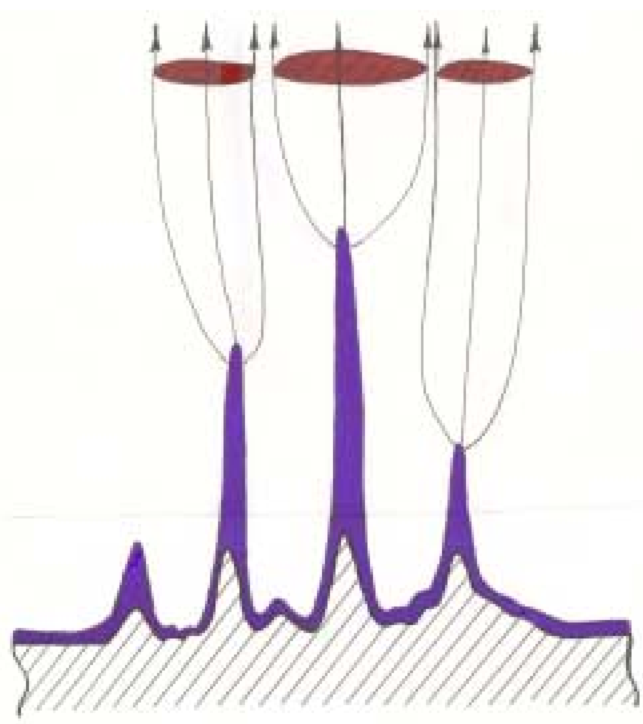
- **At high dose of irradiation the concentration of polymerizing impurities in DME to be enough for creation of the polymer film in process of preliminary irradiation. Therefore, growth of polymer film start at a moment when testing material was introduced into gas system and as a consequence plateau size decreases to zero.**

Growth of polymer film

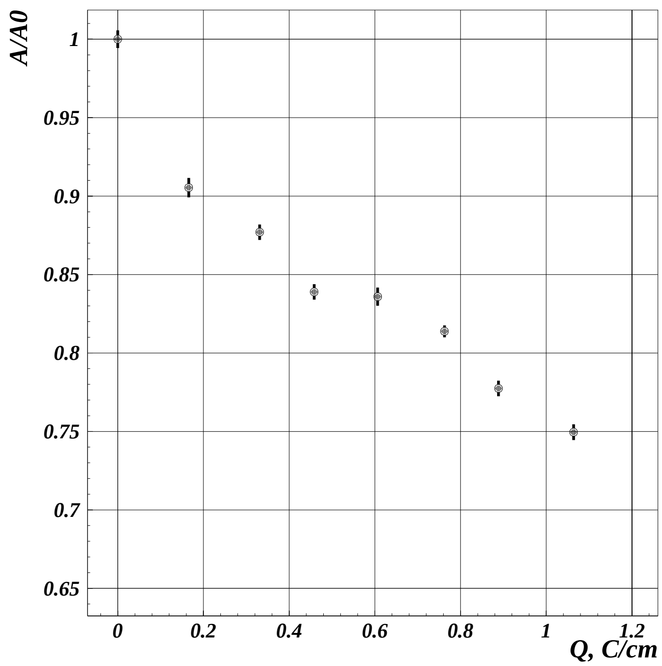
4. The number of field lines and polymers collecting on the fiber increasing with increasing the length of fiber.



- **After some dose practically all field lines and polymers will be collecting on the ends of fibers and the growth of film on the sense wire surface and on fibers with smaller length to stop.**



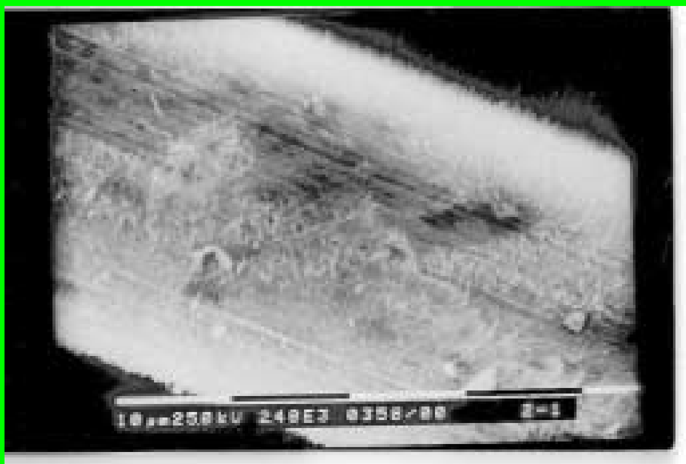
• After that the effective radius of sense wire and drop of the gas gain as a result of aging process depends on the length of fibers and number of fibers per surface unite. Therefore, it can be some peculiarity in amplitude behavior from sense wire that was really found.



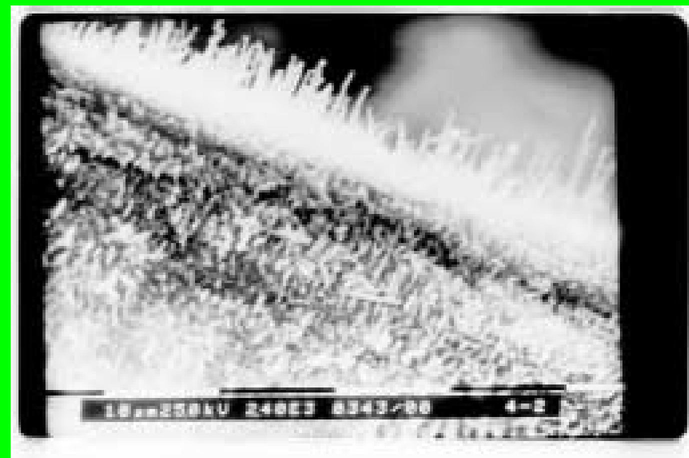
Influence of preliminary irradiation on aging rate

• The preliminary irradiation in clean conditions smooth the radii and the altitudes of picks. As a result at a moment when all field lines are collecting on the ends of fibers the number of growing fibers per surface unite increase and as a consequence average length of fibers decrease. Therefore, the effective radius of sense wire and drop of the amplitude from the sense wire are smaller at the same dose of irradiation.

Examples of deposits



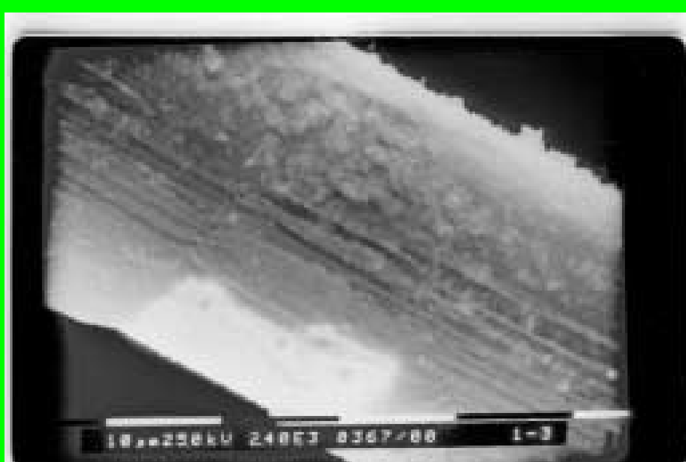
DME+Teflon



DME+epoxy

CO_2/Isobutane

CO_2/Isobutane+PVC



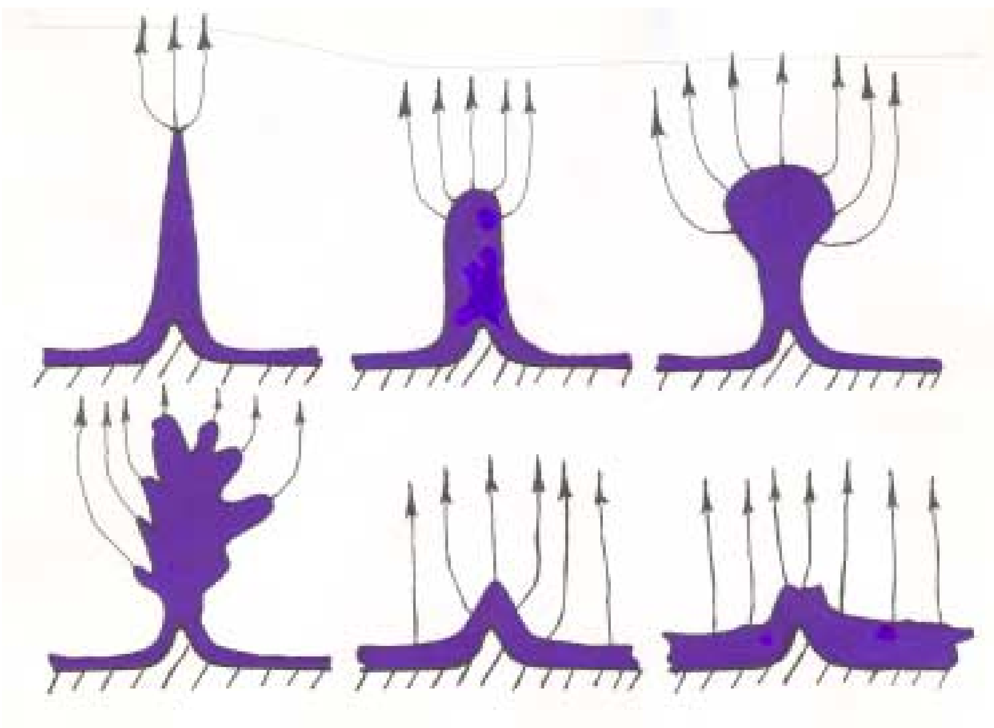
DME+PVC

DME+gas seal paste(1)

How conductivity influence on fibers growth

i_- - is a function of gas gain and irradiation intensity
i_+ - depend on a conductivity of polymer

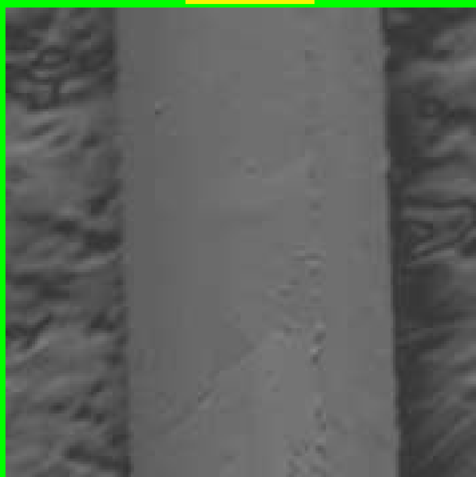
$$i_- = const$$



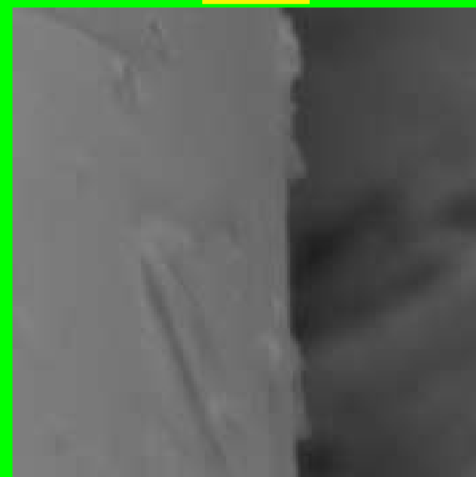
- **At constant conductivity the fibers length, form and as a result effective sense wire radius and as a consequence aging rate can depend on sense wire current density!**

Sense wires before irradiation

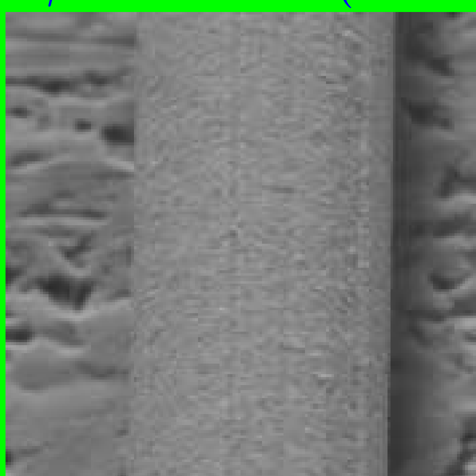
40μm **8μm**



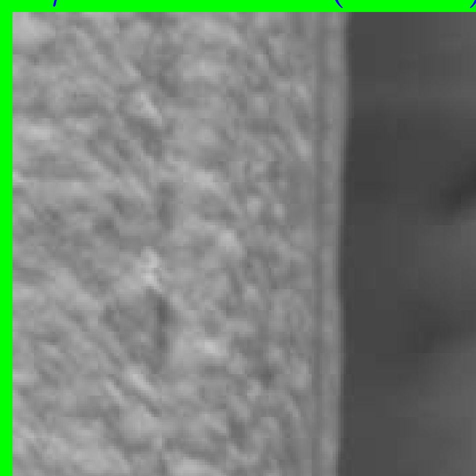
20μm anode wire (Russia)



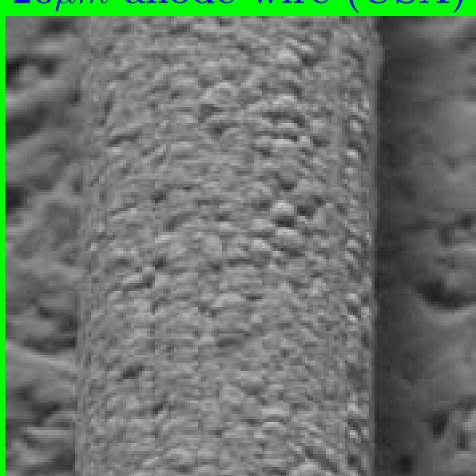
20μm anode wire (Russia)



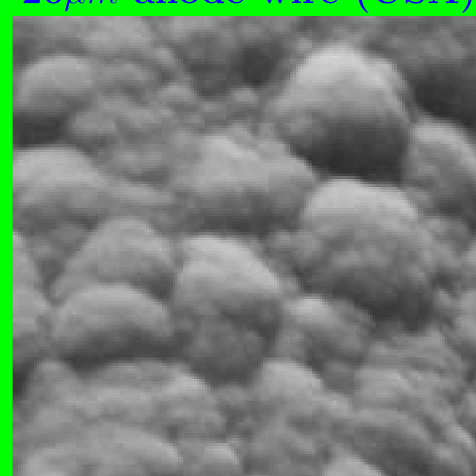
20μm anode wire (USA)



20μm anode wire (USA)



25μm anode wire (Italy)



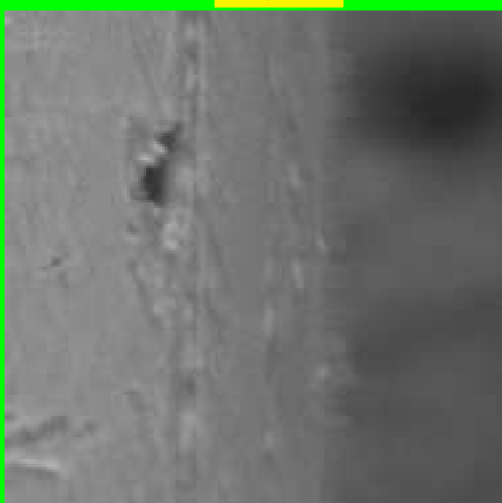
25μm anode wire (Italy)

(DME+Vikcint), $\mathbf{I}_{S.W.}$=2.0μA

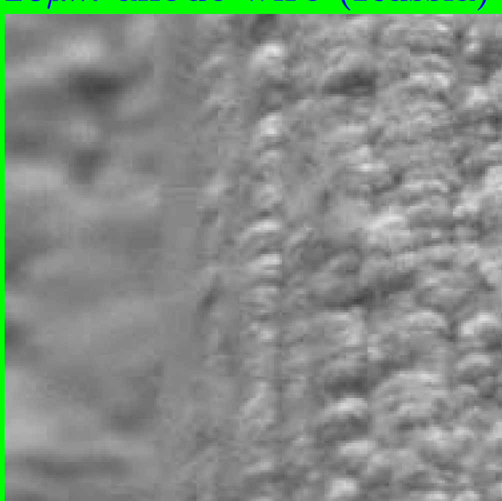
Producer	R, %/(C/cm)	a, C/cm
$20\mu m$ Russia	32.0 ± 1.0	0.054 ± 0.013
$20\mu m$ USA	88.1 ± 2.0	0.027 ± 0.006
$25\mu m$ Italy	106.7 ± 1.6	0.036 ± 0.001

Sense wires after irradiation

20μm

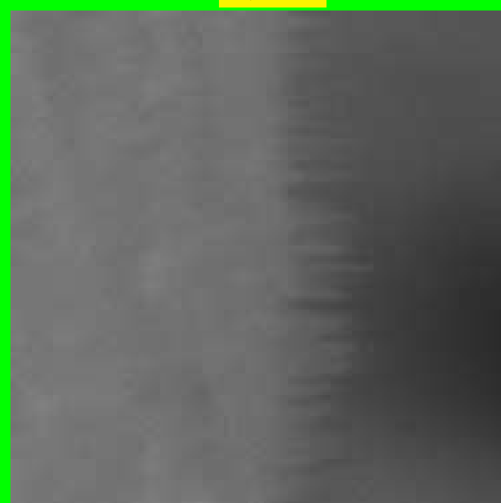


20μm anode wire (Russia)



25μm anode wire (Italy)

8μm



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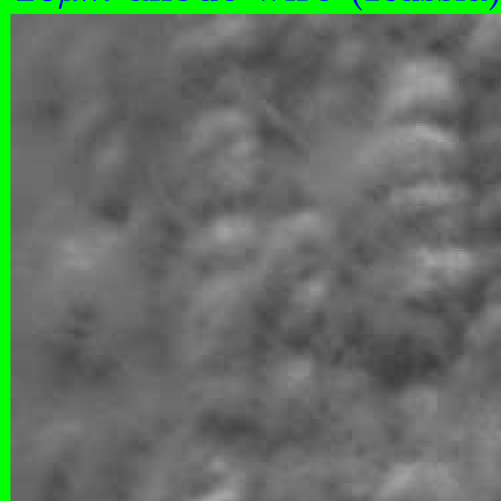

25μm anode wire (Italy)

Conclusion

- **It was found that commonly using procedures for aging rate measurement substantially reduces the aging rate. A more correct procedure for aging rate determination was proposed.**
- **Using this procedure DME gas has been tested. ($R = (0.7 \pm 0.3)$ %/(C/cm)). DME looks very attractive as a gas for the high precision drift chambers, but the problem of aging exists.**
- **It was found that contaminations in the gas define aging rate of DME. The influence of different DC construction materials and gas seal pastes on aging rate has been investigated. ($R = (1 - 95)$ %/(C/cm)).**
- **The gain dependence of the aging rate with DME was measured.**
- **The radiation hardness of the KEDR drift chamber cell with DME was increased by an order of magnitude by selection of drift chamber and tubing materials.**
- **The aging rate of the KEDR drift chamber has been measured ($R = (7 \pm 3)$ %/(C/cm)).**
- **The influence of the sense wire surface quality on aging properties was found.**
- **For explanation of this results a model of polymer film formation and growth has been proposed and tested.**
- **Based on this results we can conclude that improvement of sense wire surface quality can increase the size of zero aging region and decrease the aging rate.**