STABILITY OF DIFFERENT MICROSTRIP PLATES ON IONIC AND ELECTRONIC CONDUCTING GLASS

G. Cicognani, P. Convert, A. Oed, J. Pannetier
ILL B.P. 156X, F-38042 Grenoble Cedex, France

Abstract

A procedure, in the following called thermal ageing, is presented to study the long term behaviour of an MS-plate in the lapse of a few hours. This procedure was used to investigate the stability of various MS-plate structures on different substrates.
Plates on electronic conducting glass (Schott S8900) showed absolutely stable behavior after this treatment , whereas plates on ionic conducting substrate experienced a permanent gain modification. Two solutions were investigated to improve the stability on ionic conducting substrates.

The type of metal used for the electrodes is of importance for the long term stability. With MS-plates made of silver strips on Desag D263 no change in the amplification was detected after a thermal ageing corresponding to approximately three years of operation at room temperature. The adherence of silver on glass however is not very good.

The influence of the changes in the substrate surface between electrodes can be reduced with an MS structure which has an extremely small distance (10µm) between anodes and cathodes. With such a design no change of the amplification was measured after the thermal ageing procedure, but the maximum amplification is limited to about 40; solutions to overcome this limit are suggested.

1. Introduction

One of the major difficulties affecting the microstrip detector on ionic conducting substrates is the instability of the gas amplification due to changes within the substrate; we can distinguish between:

1. Short term instabilities: they occur immediately at the detector's polarisation, and they are due to the sticking of the avalanche ions to the substrate surface; if these ions are not neutralised, the electric field in the neighbourhood of the electrodes is modified and consequently the gain of the chamber. This can be partially avoided by using slightly conducting substrate materials and by choosing proper potentials on the electrodes.
2. Long term instabilities: in standard glasses, the conductivity is ensured by the movement of the alkaline ions and for that reason they are called ionic conducting glasses. Their typical resistivity is 10^{12}-10^{16} Ω cm (at 20°C), which is sufficiently low to avoid charge collection on the surface. However, during long term operation, the alkaline ions migrate towards the cathodes by the high electric field between the electrodes and leave a depleted layer close to the anodes. The glass experiences an electrolytic decomposition which leads to a permanent increase of the surface resistivity. Ionic conducting glasses therefore suffer from long term instabilities.

2. Thermal Ageing

The permanent modification of the glass structure (cf. point 2 of the introduction) is not immediately detected, as it occurs only when the plate is kept continuously under polarisation for several months. It is evident that it is inconvenient and expensive to test each new plate in such conditions. But the long term behaviour of a plate can be studied in the lapse of a few hours by heating the plate under vacuum and by applying the operating voltage [2,3].

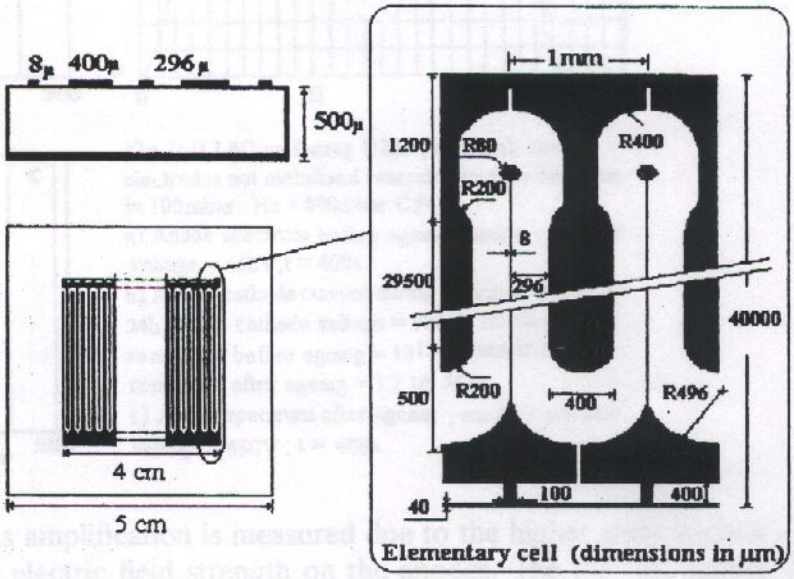

Fig.1: MS-structure of ILL 6C

A higher temperature enhances the ion mobility and therefore the current between anodes and cathodes increases considerably.
The high voltage is applied to the anodes and the current is measured at the cathodes by means of a Fluke 45 Dial Display Multimeter. A PC interface allows direct visualisation on the computer screen as well as recording the results. During the heating the vacuum has typical values of 10^{-5}- 10^{-6} Pa (10^{-7}- 10^{-8} mbar). A comparison was made between one plate aged

with this thermal ageing procedure and another one kept under polarisation for 8 months at room temperature; both of them exhibited the same change of amplification and counting dependent peak shift and on both plates sodium drops were observed at the cathodes.

Fig.2b shows the anode-cathode current measured during thermal ageing (at 100°C for 24h) of the ILL6C structure of fig.1 with chrome electrodes on the ionic conducting glass Desag D263 : the current increases gradually during the heating to a value which is 10^3 times above the value at room temperature; once the stabilised temperature is reached, the current steadily decreases. As the applied voltage is kept constant, a permanent increase of the glass resistivity is measured . Fig.2a and 2c show the spectra of the n(^{3}He,^{3}H)p + 770keV reaction, recorded before and after the thermal ageing, , measured under the same experimental conditions.

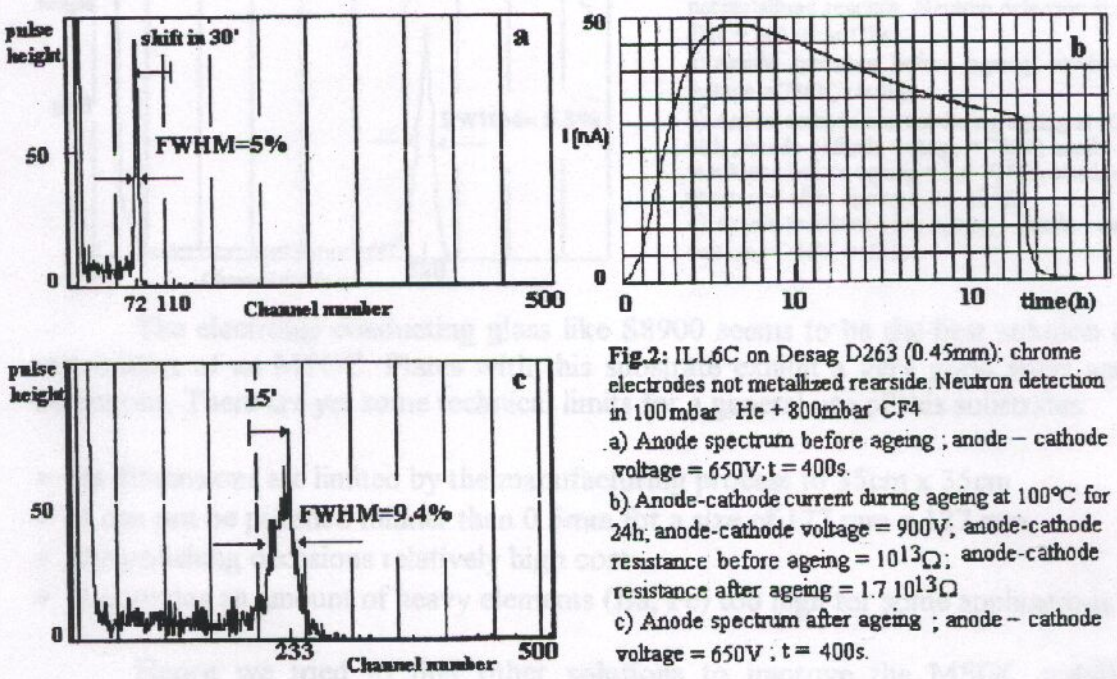

Fig.2: ILL6C on Desag D263 (0.45mm): chrome electrodes not metallized rearside. Neutron detection in 100 mbar He + 800mbar CF4
a) Anode spectrum before ageing ; anode – cathode voltage = 650V; t = 400s.
b) Anode-cathode current during ageing at 100°C for 24h; anode-cathode voltage = 900V; anode-cathode resistance before ageing = $10^{13}\Omega$; anode-cathode resistance after ageing = $1.7\ 10^{13}\Omega$
c) Anode spectrum after ageing ; anode – cathode voltage = 650V ; t = 400s.

After the ageing, a higher gas amplification is measured due to the higher glass surface resistivity which results in a higher electric field strength on the anodes. The thermal ageing modifies the plate behaviour: it leads to an increased but not uniform amplification, and which is much more serious, this amplification becomes count-rate dependent.

3. The Schott S8900 glass

One way to overcome these long term instabilities is the use of glass with electronic conductivity: the Pestov glass, which was first introduced for MSGC by the group in Novosibirsk and by the CERN group [1-3]. The thermal ageing procedure was applied to a plate on an electronic conducting glass Schott S8900 (0.5mm thick, resistivity = $1.1\ 10^{11}\ \Omega$cm at 20°C) with the chromium structure ILL 6C. As shown in fig.3b, after the heating, the current between anodes and cathodes is stable, and the spectra measured before (fig.3a) and

after (fig.3c) ageing did not change. The slight amplification change is due to a difference in the gas mixture pressure. The charge travelling from anodes to cathodes during this thermal ageing corresponds to a charge collection in 100 days of operation at room temperature.

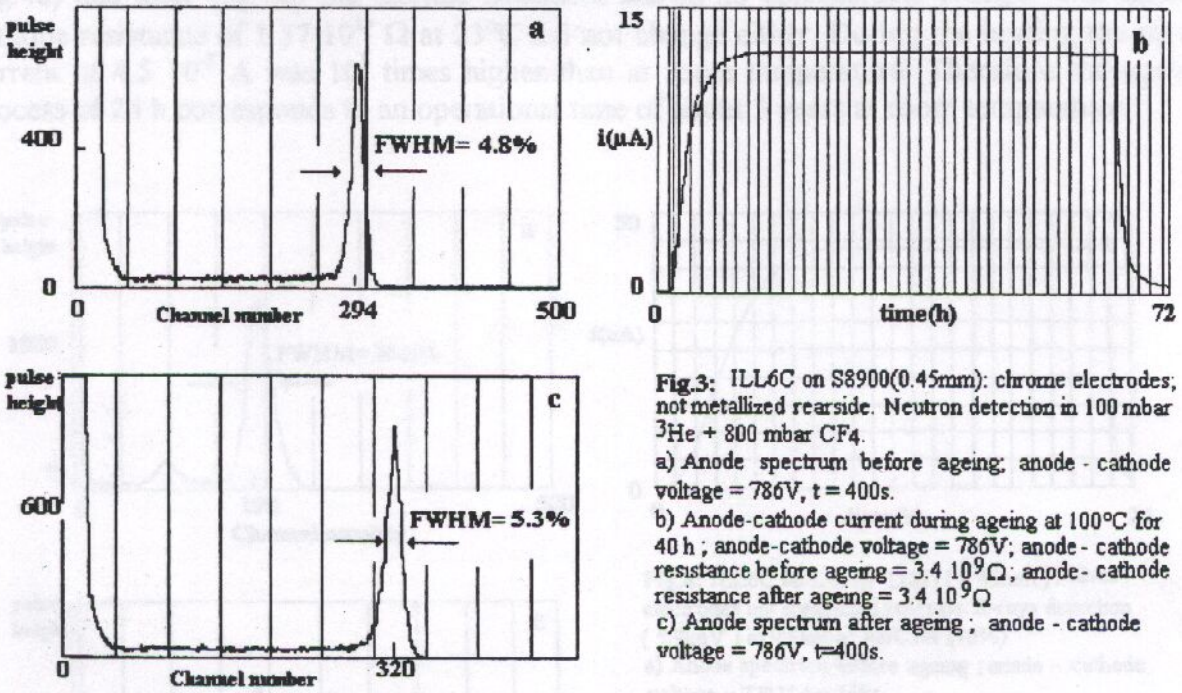

Fig.3: ILL6C on S8900(0.45mm): chrome electrodes; not metallized rearside. Neutron detection in 100 mbar ^3He + 800 mbar CF_4.
a) Anode spectrum before ageing; anode - cathode voltage = 786V, t = 400s.
b) Anode-cathode current during ageing at 100°C for 40 h ; anode-cathode voltage = 786V; anode - cathode resistance before ageing = 3.4 $10^9\Omega$; anode - cathode resistance after ageing = 3.4 $10^9\Omega$
c) Anode spectrum after ageing ; anode - cathode voltage = 786V, t=400s.

The electronic conducting glass like S8900 seems to be the best solution to avoid the instabilities of an MSGC. Plates with this substrate exhibit a very good short and long term behaviour. There are yet some technical limits for a general use of this substrates:

- its dimensions are limited by the manufacturing process to 35cm x 35cm
- it can not be polished thinner than 0.5mm for a size of 127 mm x 127 mm
- the polishing occasions relatively high cost
- it contains an amount of heavy elements (Ba, Fe) too high for some applications

Hence we tried to find other solutions to improve the MSGC stability on ionic conducting substrates.

4. A microstrip plate with silver electrodes

The type of metal used in the fabrication of the electrodes also plays a role in the MS-plate stability [4]. Therefore a plate with 150nm silver electrodes of the structure ILL6C on the ionic conducting D263 substrate (0.45mm thick.) was prepared.

Fig. 4a shows the spectrum of the ^{55} Fe 5.9keV x-rays in 900mb of Ar/CH_4 (10%). After switching on the operating voltage, the peak position became stable after 30min .The relative peak shift in this time was 22%. As shown in fig.4b during the complete heating period the anode-cathode current (with an anode-cathode voltage of 780V) is stable in contrast to fig.2b for the similar plate with chromium layers. The comparison between the signal before

(fig.4a) and after (fig.4c) the thermal treatment shows no considerable change. The anode-cathode resistance of 1.37 10^{13} Ω at 23°C did not change either. During the heating the mean current of 4.5 10^{-8} A was 10^3 times higher than at room temperature. Therefore the ageing process of 24 h corresponds to an operational time of about 3 years at room temperature.

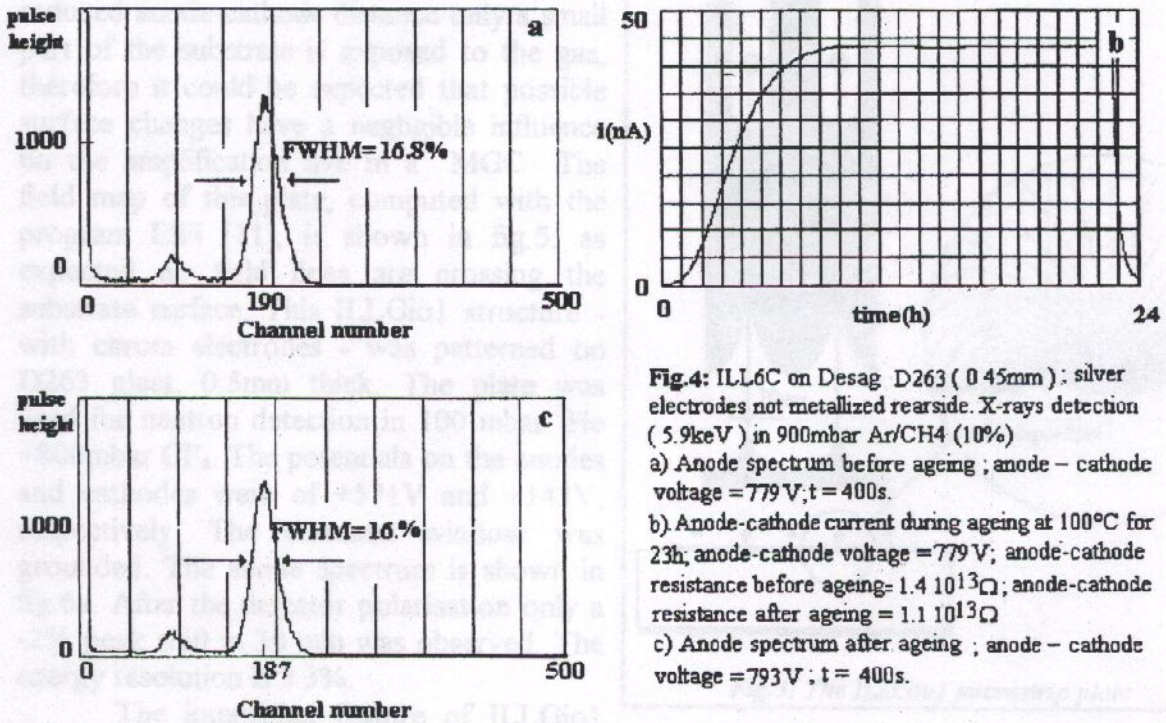

Fig.4: ILL6C on Desag D263 (0 45mm) ; silver electrodes not metallized rearside. X-rays detection (5.9keV) in 900mbar Ar/CH4 (10%)
a) Anode spectrum before ageing ; anode – cathode voltage = 779 V; t = 400s.
b) Anode-cathode current during ageing at 100°C for 23h; anode-cathode voltage = 779 V; anode-cathode resistance before ageing= 1.4 $10^{13}\Omega$; anode-cathode resistance after ageing = 1.1 $10^{13}\Omega$
c) Anode spectrum after ageing ; anode – cathode voltage = 793 V ; t = 400s.

These results demonstrate that an MS-plate with silver electrodes on an ionic conducting substrate can operate without long time gain modifications. The different behaviour with silver strips compared to plates with chromium layers can be explained: while the sodium ions migrate towards the cathodes, the silver iones of the anodes enter into the bulk and maintain a constant conductivity between the electrodes. The analysis with an electronic microscope proved this hypothesis, as traces of silver (a few ppm) were found in the thermally treated D263 substrate , which originally contains no silver at all, up to a depth of 300 nm from the surface in-between the anode-cathode gap. Silver has, however, the drawback of a poor adherence to the substrate. For that reason we used a plate provided with a very thin (3nm) chromium layer between silver electrodes and substrate. The Results were deceiving, because this thin layer acted as a diffusion barrier for silver. The plate behaves like the above chromium strip on ionic conducting glass,. One possible solution could be to use an even thinner chromium layer, which has not yet been investigated.

5.The ILLGio1 plate

All the observed instabilities with ionic conducting glasses are in the last created by changes of the substrate surface in the region between anodes and cathodes (the gap). Therefore an MS-plate, named ILLGio1, with a very reduced distance between electrodes, has been designed (Fig.5): The space between anodes and cathodes is only 10µm. The idea for this option is based on the construction of the micro gap chamber MGC [10],where no influence of the insulator ,which separates the anode from the support, has been reported. With a reduced anode-cathode distance only a small part of the substrate is exposed to the gas, therefore it could be expected that possible surface changes have a negligible influence on the amplification like in a MGC The field map of this plate, computed with the program ElFi [11], is shown in fig.5: as expected no field lines are crossing the substrate surface. This ILLGio1 structure - with chrom electrodes - was patterned on D263 glass, 0.5mm thick. The plate was used for neutron detection in 100 mbar ^{3}He +800mbar CF_4. The potentials on the anodes and cathodes were of +571V and +143V, respectively. The entrance window was grounded. The anode spectrum is shown in fig.6a. After the detector polarisation only a -2% peak shift in 30 min was observed. The energy resolution is 3.3%.

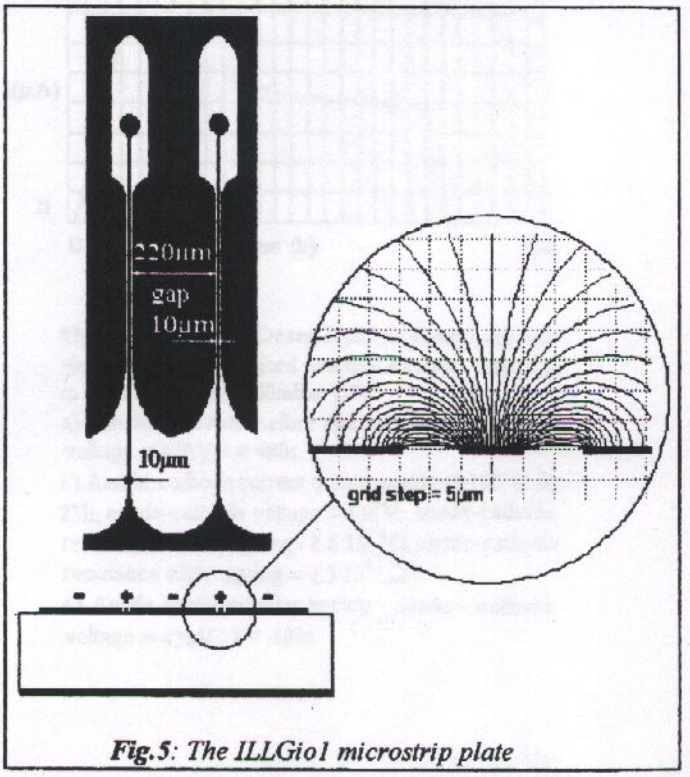

Fig.5: The ILLGio1 microstrip plate

The interesting feature of ILLGio1 plate is its behaviour in long term operation. The described thermal ageing procedure was applied and the plate was heated in vacuum for 24h at 100°C with an anode-cathode voltage of +430V; The anode-cathode current during the ageing is shown in fig.6b: the decreasing slope is characteristic of ionic conducting glass The measured mean anode-cathode current was about 380 times greater than at room temperature, so that the ageing corresponds to a unbroken operation of 380 days.. After the ageing the neutron spectrum was measured again under the same conditions . As shown in fig.6c, the spectrum has not changed, in contrast to the ILL 6C structure on ionic conducting substrates. These results demonstrate that the gain do not suffer in long term operation when the uncovered substrate surface is very small as compared to the cathode width.

One big limit of this plate is its small gain: the maximum achievable amplification is only 40, which is sufficient for neutron detection, but not for x-rays. The reason for this limitation is probably to be sought in the relatively high electric field strength at the cathode borders which produces electron emission. One way to overcome this limit is a further reduction of the anode width. Computer simulations show that the gain is doubled when reducing the anode width of a factor two. Another solution could be to engrave the metallic

electrodes inside the substrate itself: this way, one can hope to avoid the sparks on the borders of the cathodes. Plates of this kind, patterned on Desag D263, have been ordered (IMT Masken und Teilungen AG, Switzerland).

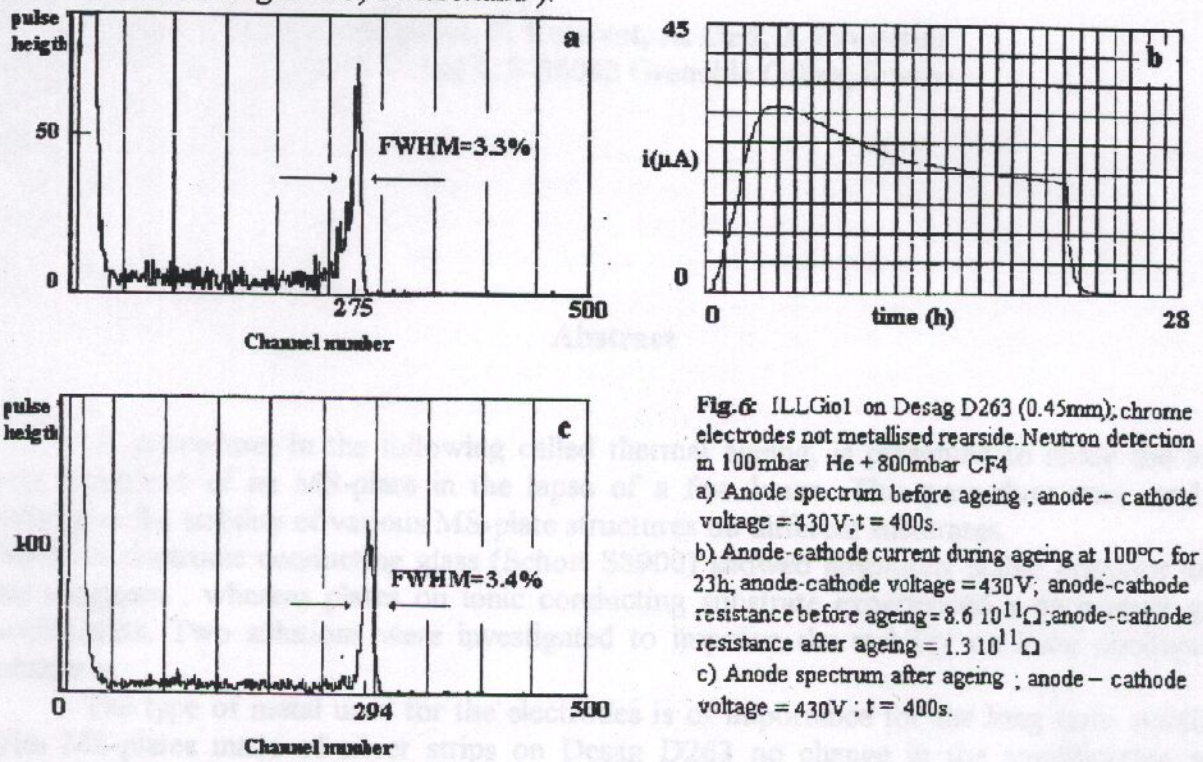

Fig.6: ILLGio1 on Desag D263 (0.45mm); chrome electrodes not metallised rearside. Neutron detection in 100mbar He + 800mbar CF4
a) Anode spectrum before ageing ; anode – cathode voltage = 430V; t = 400s.
b) Anode-cathode current during ageing at 100°C for 23h; anode-cathode voltage = 430V; anode-cathode resistance before ageing = $8.6\ 10^{11}\Omega$; anode-cathode resistance after ageing = $1.3\ 10^{11}\Omega$
c) Anode spectrum after ageing ; anode – cathode voltage = 430V ; t = 400s.

6. Conclusions

It has been reported that a stable operation is possible for MS-plates on ionic conducting substrate if the surface is covered with a thin conducting layer [7-8]. We have also tested some plates coated with different kinds of layers. But in all cases an important change of amplification was detected after the thermal ageing procedure. We therefore tried other ways to improve the stability of MS-plates on ionic substrates, and checked their long term behaviour with the helpful tool of thermal ageing.

References

[1] Y. Pestov et al., Nucl. Instr. and Meth. A338 (1994) 368
[2] R. Bouclier et al, Nucl. Instr. and Meth. A332 (1993) 100
[3] L.I.Shekhtman et al, Nucl. Instr. and Meth. A326 (1993) 566
[4] A. Oed, Nucl. Instr. and Meth. A367 (1995) 34
[5] S. Schmidt and al, Nucl. Instr. and Meth. 344 (1994) 558
[6] S. Brons et al, CERN / PPE 93-194 (1993)
[7] M. Salomon et al, Nucl. Instr. and Meth. A351 (1994) 313
[8] S. Brons et al, Nucl. Instr. and Meth. A342 (1994) 411
[9] M.R. Bishai et al, Report (1994) CERN RD-28 project
[10] Angelini et al., Nucl.Instr.and Meth. A335 (1993) 69
[11] S.Schmidt et al, Nucl.Instr.and Meth.A337 (1994) 382