D)

STRASBOURG

CRN 96-13

Substrate effects on Microstrip Gas Chamber behaviour under irradiation

A. Pallarès [a], R.A.B. Devine [b], J.C. Fontaine [c], A.M. Bergdolt [a], J.M. Brom [a],
J. Coffin [a], H. Eberlé [a], M.H. Sigward [a], S. Barthe [d], J.P. Schunck [d]

[a] *Centre de Recherches Nucléaires, 23 rue du Loess, BP 28, 67037 Strasbourg Cedex 2, France*
[b] *France Télécom-CNET, BP 98, 38243 Meylan, France*
[c] *Université de Haute Alsace, GRPHE, 61 rue Albert Camus, 68093 Mulhouse Cedex, France*
[d] *Laboratoire PHASE (UPR 292 du CNRS), 23 rue du Loess, BP 28,*
67037 Strasbourg Cedex 2, France

Presented at the International Worskshop on Microstrip Gas Chambers
Lyon, 30/11 - 2/12/1995

Sw9645

CENTRE DE RECHERCHES NUCLEAIRES
STRASBOURG

IN2P3
CNRS

UNIVERSITE
LOUIS PASTEUR

Substrate effects on Microstrip Gas Chamber behaviour under irradiation

A. Pallarès[a] [1], **R.A.B. Devine**[b], **J.C. Fontaine**[c], **A.M. Bergdolt**[a],
J.M. Brom[a], **J. Coffin**[a], **H. Eberlé**[a], **M.H. Sigward**[a],
S. Barthe[d], **J.P. Schunck**[d]
[a] *Centre de Recherches Nucléaires, 23 rue du Loess, BP 28, 67037 Strasbourg Cedex 2, France*
[b] *France Télécom-CNET, BP 98, 38243 Meylan, France*
[c] *Université de Haute Alsace, GRPHE, 61 rue Albert Camus, 68093 Mulhouse Cedex, France*
[d] *Laboratoire PHASE (UPR 292 du CNRS), 23 rue du Loess, BP 28, 67037 Strasbourg Cedex 2, France*

1. INTRODUCTION

At the present time, Desag D263 glass is widely used for Microstrip Gas Chamber (MSGC) fabrication. We have studied its sensitivity to radiation and linked this study to the detector behaviour under irradiation.

An argument for the use of glass in a hostile environnement is its intrinsically disordered nature. Glasses embody random atomic arrangements but ordered electronic arrangement [1]. Under irradiation, electron-hole pairs will be created in the glass structure, most will recombine but a small fraction will be trapped on structural flaws preexisting in the glass structure or radiation induced by atomic displacement. Spin-unpaired charges are paramagnetic defects. From the electronic point of view, these defects are located between valence and conduction bands, so there are fixed charges present in the bulk glass [2,3].

A minimum ionizing particle fluence of $1.3 \times 10^{16}/r^2$ per cm^2 and per year is expected during LHC running (r is the position of the detector with respect to axe of the beam direction). An ionizing particle leaves a minimum of 200 keV in the substrate. Depending on its position, in 10 years of LHC running, a MSGC substrate will accumulate a dose of 10 to 40 kGy (1 to 4 Mrad).

A well known MSGC phenomena is local gain loss under irradiation commonly attributed to gas polymerisation [4]. One might also suspect the radiation induced charges to perturb the electromagnetic field and so avalanche and charge evacuation phenomena. The primary aim of this study is to verify this latter source of gain degradation.

2. GLASS STUDY

2.1 Electronic spin resonance

The technique used here to detect unpaired electrons in a bulk material is electron

---

[1] Corresponding author. E-mail : anne@crnhp3.in2p3.fr

spin resonance (ESR). It consists of exposing a sample in a fixed frequency microwaves electromagnetic field and a continuous magnetic field and recording the absorption spectrum of the unpaired electrons therein as a function of the magnitude of the externally applied magnetic field. The double integral of the observed derivative absorption spectrum allows to estimate the number of unpaired electrons which represents the paramagnetic defect concentration.

2.2 Experimental results

Glass samples were irradiated using a ^{60}Co source at the rate of 10 kGy×h^{-1} (1 Mrad×h^{-1}). Glass probes of D263 (500 μm thick) and of pure silica (200 μm thick) were studied.

Since the D263 glass showed no ESR signal before irradiation, it can be conclued that it contains no intrinsic unpaired spin states. Following irradiation, a strong signal was observed. Figure 1 shows ESR spectrum of D263 before (a) and after irradiation (b). One can clearly see a lack of signal before irradiation. The nature of the observed defects is related to the chemical composition of the glass.

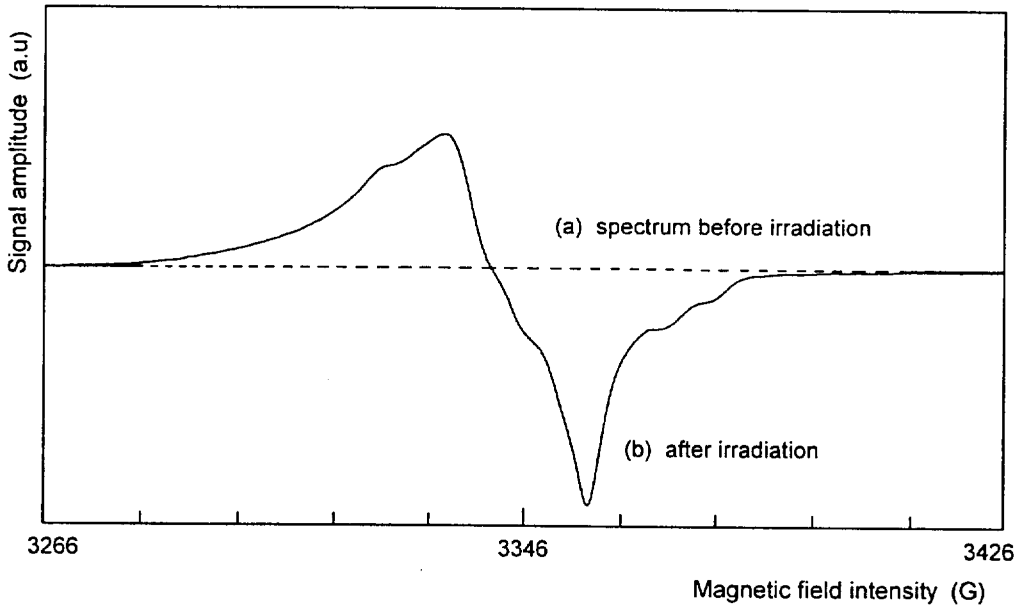
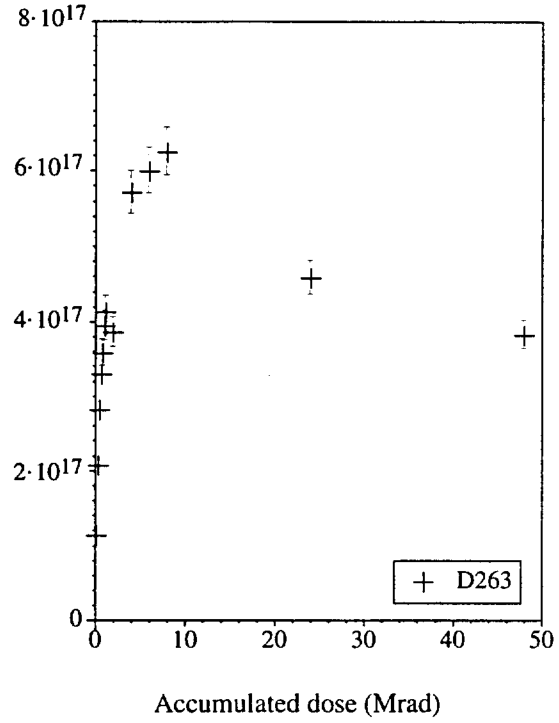


Figure 1: ESR spectrum of D263 glass

We studied evolution of total defect density as a function of accumulated dose. The experimental growth law is given Figure 2. One notices a rapid increase of defect density until reaching a maximum of 6×10^{17} defects×cm^{-3} at 80 kGy (8 Mrad). After that maximum, the number of defects slowly decreases as a function of accumulated dose.

Figure 3 shows the comparison with pure silica. We recover the well known radiation



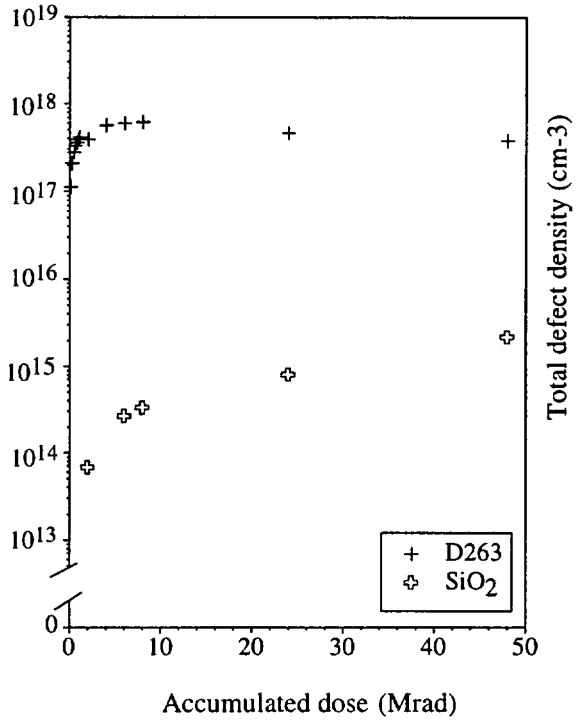


Figure 2: Total defect density in D263 as a function of accumulated dose

Figure 3: Total defect density in D263 and pure silica as a function of accumulated dose

dependent behaviour of defects in pure silica : essentially linear growth the defect density as a function of the accumulated dose (at least for the dose range considered) [5]. There are no defects at zero dose, 3.3×10^{14} at 60 kGy (6 Mrad) and 2.2×10^{15} defects$\times$cm^{-3} at 480 kGy (48 Mrad).

The ESR data show that Desag D263 glass is much more radiation sensitive than regular fused silica; at equivalent dose, its sensitivity can be 10^4 times larger.

This result is also supported by observations of the optical properties of irradiated samples; this is demonstrated figure 4. The first samples (A4 and B16) are identical D263 glass slides exposed to different radiation doses. As the dose increases we observe a darkening consitent with the presence of radiation induced colour centres. The second pair of samples (5 and B5) have received the same radiation dose but sample 5 is pure silica and sample B5, D263 glass. Clearly, the pure silica sample contains many less colour centres than in the irradiated D263 sample.

2.3 Conclusions

Our experiments show that Desag D263 is very radiation sensitive. At 10 kGy (1 Mrad), which is the minimal expected substrate dose, we have a total paramagnetic defect density of 3.5×10^{17} defects$\times$cm^{-3} which corresponds to a charge of 60 mC$\times$cm^{-3} if each

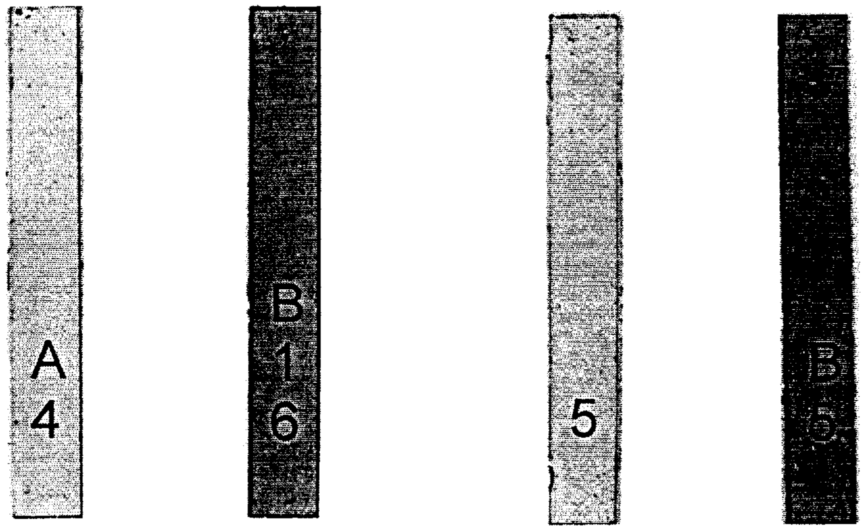


Figure 4: Irradiated glass samples

defect has unit electronic charge. At 80 kGy (8 Mrad), an accumulated dose value for which the defect density is a maximum, we have 6×10^{17} defects$\times$cm^{-3} corresponding to a charge up to 100 mC$\times$cm^{-3}. Electric field perturbation of the MSGC can be expected from such a stored charge.

3. DETECTOR STUDY

3.1 General

Detectors used in this study were made on 500 μm thick Desag D263 glass slides and were manufactured at the PHASE laboratory. Metal strip electrodes were made of aluminium (0.80 μm) on titanium (0.15 μm). Cathodes and anodes were respectively 70 μm and 9 μm wide. The pitch of the electrodes was 200 μm.

Using a beam current of 20 μA, whole detectors were irradiated with 2.2 MeV electrons. Two irradiation campaigns, containing each three detectors, were carried out. One irradiation was done to an accumulated dose of 10 kGy (1 Mrad, minimal dose during LHC running). The other was to 80 kGy (8 Mrad), dose for which we have the maximum glass response to radiation (in terms of defect creation).

During irradiation, only strips of the detector were polarized. Substrate polarization may influence the defect growth law with dose. In this way, this parameter is taken in account.

No gas mixture was used. Under air, the detector and surrounding materials are stable and do not generate organic polluants. Therefore we avoided gas polymerisation phenomena during irradiation.

3.2 Gain measurements

We performed gain measurements on the same detector before and after irradiation. With regard to the previous points, if a difference in gain is observed, it will be mainly related to substrate effect.

The gas mixture used was the classical Ar/DME (90%-10%) mixture, detector polarization was identical for all measurements : $V_{cathodes} = -420V$, $V_{anodes} = OV$, $V_{drift} = -1200V$ and $V_{backplane} = 0V$. These potentials give small gain (about 800 a.u.) but very stable work conditions. The gain measurements were made through a slow cathode readout chain (Ortec 142A preamplifier, Schlumberger amplifier, Inel Cato multichannel analyser). Gain was monitored using the spectrum of a ^{55}Fe source (5.9 keV X-rays).

Different measurements give knowledge about gain evolution. Gain measurements made on a line, at several points, perpendicular to the strip direction allow us to estimate the gain of the different strips. Measurements made parallel to an anode enable appreciation of detector homogeneity and gain evolution along a strip. We also looked at the gain behaviour with time after brutal polarization. We always took care using the same test procedure and the same timing for each detector we measured.

3.3 Experimental results

In Figure 5, we show the results obtained for one detector at 10 kGy (1 Mrad) irradiation. The results obtained for the other two were identical. The first graph shows the gain as a function of the position of the source perpendicular to anodes. No gain difference is observed before or after irradiation. The second graph shows the gain as a function of the position parallel to anodes. As before, no difference of gain is observed. The last graph shows the gain behaviour with time : gain measured after irradiation is smaller than before but still within the accuracy limits. The shape of the curve is the same before and after irradiation. We therefore concluded that there is an effect of either temperature or pressure variation between measurements.

Figure 6 shows the results obtained after a 80 kGy (8 Mrad) irradiation. All are identical to those observed for the 10 kGy (1 Mrad) irradiation. In this case, we also have a smaller gain with time. As before, this measurement took a full day and was made another day as was the gain measurements across the detector.

3.4 Conclusions

Concerning the gain across the detector, no noticeable variation is observed following irradiation. For the gain variation with time, we observe small gain variations within 10%. Otherwise, the gain behaviour is identical. Due to the fact that all measurements were not made on same day, these variations are probably related to the changes in external parameters such as temperature and pressure which are not controlled in our experimental set-up.

An essential conclusion from our work is that no gain perturbation directly related to the presence of bulk charge in the glass is observed.

4. GENERAL CONCLUSIONS

We have demonstrated that radiation induces paramagnetic defects in the Desag D263 glass bulk. A unusual result is the decrease in defect number as a function of radiation dose after a maximum defect density. An explanation for this phenomena may be annealing of defects during irradiation. However, D263 is very radiation sensitive : a large density of defects is created in the bulk glass for irradiation doses expected at LHC.

The second part of our work demonstrates that these defects seem to have no influence on the MSGC gain behaviour. With respect to accuracy limits, the detector's gain remains identical before and after massive irradiation. So, this is the first experimental evidence that bulk phenomena seems to have no significant effect on MSGC. This is another argument which supports the hypothesis that MSGC gain behaviour is mainly related to surface effects.

The primary objectif of this work was to study the possibility of gain degradation resulting of radiation induced defects in the detector substrate. Our result clearly demonstrate that, over the range of radiation doses used, radiation induced bulk charging is not significant.

REFERENCES

[1] D.L. Griscom, E.J. Friebele, *Rad. Effects*, **65** (1982) 63.

[2] D.L. Griscom, *J. Appl. Phys.*, **58** (1985) 2525.

[3] E.J. Friebele, D.L. Griscom, *Treatise on material science and technology, Vol. 17*, Ed. M. Tomazawa, H. Doremus, Academic Press 1979.

[4] R. Bouclier, C. Garabatos, G. Manzin, G. Million, F. Sauli, T. Temmel, L. Shekhtman, *Nucl. Instr. and Meth.*, **A348** (1994) 109.

[5] H. Imai, K. Arai, J. Isoya, H. Hosono, Y. Abe, H. Imagawa, *Phys. Rev. B*, **48** (1993) 3116.

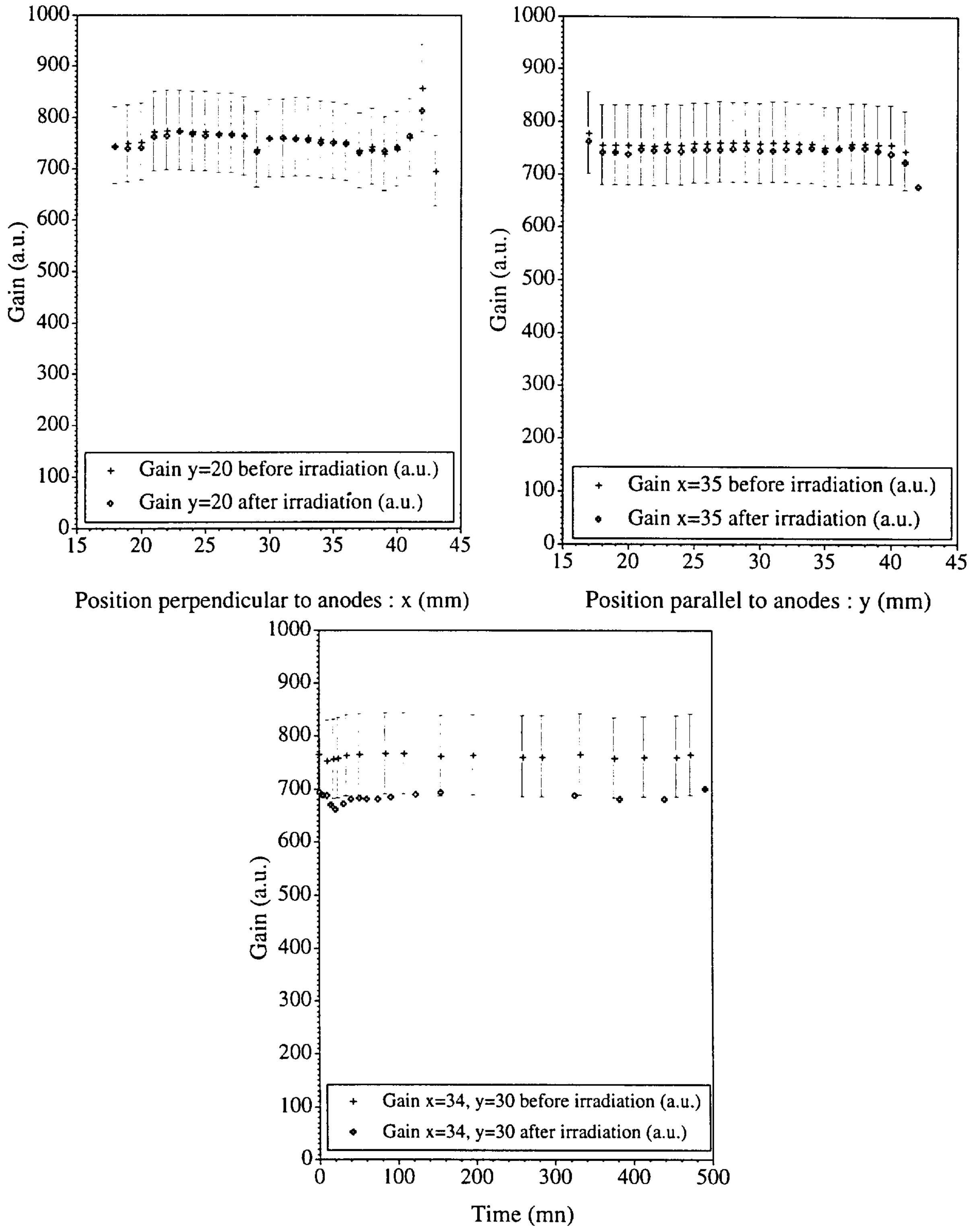


Figure 5: Results for 10 KGy (1 Mrad) irradiation

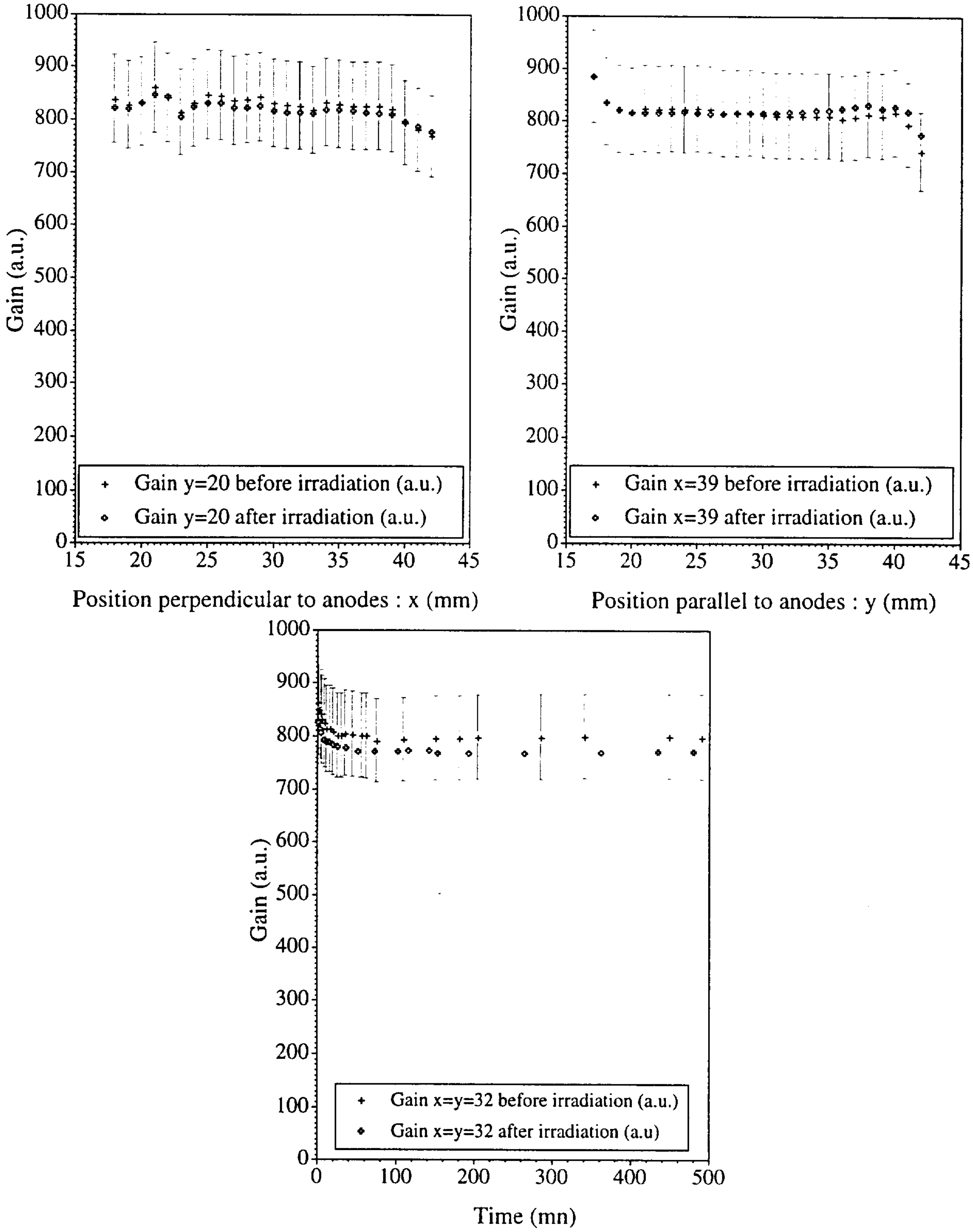


Figure 6: Results for 80 KGy (8 Mrad) irradiation