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# GAMMA-RAY DETECTION WITH PbO GLASS CONVERTERS IN MWPC: ELECTRON CONVERSION EFFICIENCY AND TIME RESOLUTION

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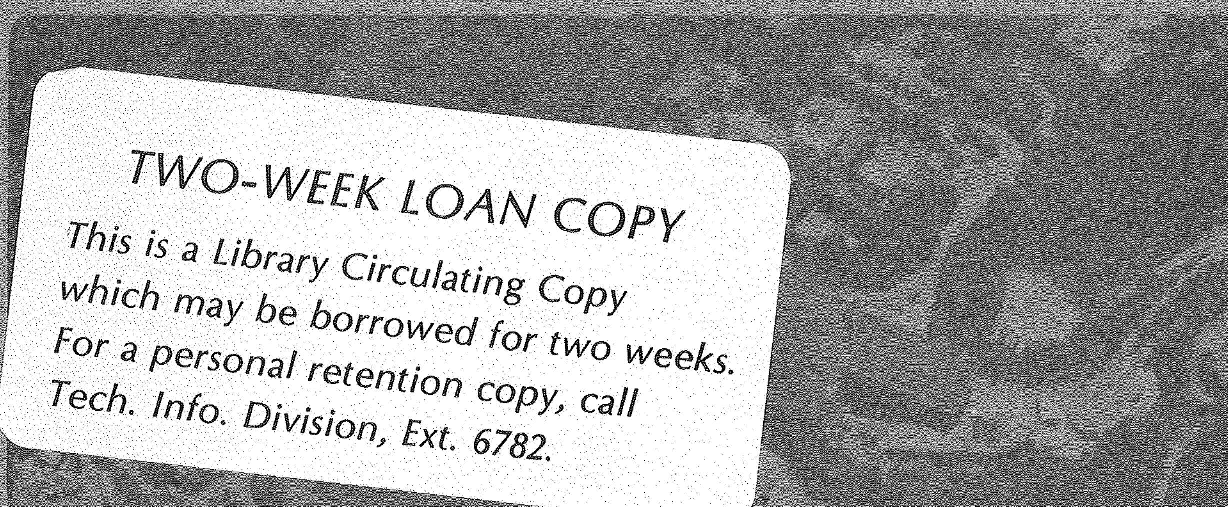





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Gamma-Ray Detection with PbO Glass Converters in MWPC: Electron Conversion Efficiency and Time Resolution, G.K. Lum, V.Perez-Mendez and B. Sleaford,* Lawrence Berkeley Laboratory, Berkeley, CA and Dept. of Radiology, University of California, San Francisco, CA-The development of glass tubing converters for efficient gamma-ray detection in multiwire proportional chambers (MWPC) has led to an investigation on the improvement of conductivity on glass surfaces and to an investigation of gas mixtures which will improve on the electron conversion efficiency and electron transit time within the tubes. Efforts to establish uniform electric field lines within small diameter tubes has resulted in an improved $H_2$ reducing treatment. For a 0.91 mm I.D., 1.10 mm O.D., 2 cm thick converter the electron conversion efficiency $\varepsilon$ was measured to be 9.0% and 10.4% at 511 keV, using Ar mixtures containing 10% $CF_4$ and 30% isobutane, respectively. The effects of gas mixtures on $\varepsilon$ and on $\tau$, the mean transit time on conversion electrons within the converter, and the projection of these results on the performance of a modified MWPC positron camera will be presented.

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# Gamma-Ray Detection with PbO Glass Converters in MWPC: Electron Conversion Efficiency and Time Resolution

## Summary

The detection of gamma rays between the energy region of 100 keV to 10 MeV for multiwire proportional chambers (MWPC) requires the development of special converters with large surface-to-volume ratios.[1,2,4] These converters are generally designed from high Z (atomic number) materials, such as lead, bismuth or tungsten. We have pursued this development by constructing converters from glass capillaries of high lead content (80% by weight, density of 6.2 g/cm$^2$) fused to form honeycomb matrices. The extraction of gamma-conversion electrons from the volumes of the tubes is obtained by making the glass surface uniformly conductive. When a voltage is applied between the ends of a converter, electrons can then drift along electric field lines to the wire planes of a MWPC. The layout of a MWPC converter system is shown in Figure 1.

Our continuing efforts to develop efficient gamma-ray PbO glass tubing converters has led us towards the use of tubes with smaller inner diameter and thinner wall thickness, e.g. 0.91-mm I.D., 0.096-mm wall[3], than those previously reported[4], i.e. 1.4-mm I.D., 0.129-mm wall. The smallness of the tubes has also led to an investigation of gas mixtures which improve the electron conversion efficiency and electron transit time within the tubes.

A conductive surface was developed on the glass by a hydrogen-reducing process which we investigated by adjusting the $H_2$-treating recipe for different conditions. It was determined that our previous treating process could be optimized to give maximum conductive uniformity within the tubes. If the conductivity of the glass surface were poor, the non-uniform electric

field lines channel poorly the conversion electrons out of the tubes. We found that by lowering the $H_2$-reducing temperature 50° from the 400°C previously used, the bulk resistance of a 5-cm by 5-cm by 2-cm thick (0.91-mm I.D., 0.096-mm wall) converter was actually reduced from 270 MegΩ to 300 KΩ! The applied voltage gradient measured with microprobes within the tubes was extremely constant. We also found that the period needed to $H_2$ fire the glass to achieve good surface conductivity could be reduced. Qualitatively, our results agree with those of Blodgett[5] that the $H_2$ reduction temperature has a range of about 100°C where conductivity can be maximized. For 80% PbO glass this temperature range is between 270 and 375°C.

The electron conversion efficiency $\varepsilon$ is measured with 511 keV gammas from a positron $^{68}$Ga source using a NaI detector coupled in coincidence with a MWPC converter system. The efficiency $\varepsilon$ was determined to be 9.0% and 10.4% when MWPC gas mixtures of (1% $C_2H_2$, 10% $CF_4$, 20% $CH_4$, 69% Ar) and (30% isobutane, 70% Ar), respectively, were used. We also found that for a 30% $CH_4$, 70% Ar mixture $\varepsilon$ was the same as that measured for a 1.4-mm I.D., 2-cm thick converter, namely 7.5%. However, when mixtures of (10% dimethoxymethane (methylal), 27% $CH_4$, 63% Ar) and (10% methylal, 27% isobutane, 63% Ar) were used, $\varepsilon$ rose to 10.2 and 10.6%, respectively. Figure 2 shows the electron efficiencies versus pulse amplitude threshold for the gas mixtures.

In the application of a medical imaging positron camera, a figure of merit for determining the rate of detecting gammas from electron-positron annihilations is $\varepsilon^2/\tau$, where $\tau$ is related to the mean transit time of converion electrons within a converter. Improvements to the rate occur when either $\varepsilon$ can be increased or $\tau$ be made small. The use of 1% $C_2H_2$, 10% $CF_4$, 20% $CH_4$, 69% Ar shows that $\tau$ can be made 50 ns smaller than a 30% $CH_4$, 70% Ar mixture. With the added feature of a higher $\varepsilon$ using the 10% $CF_4$ mixture than the 30% $CH_4$ mixture, $\varepsilon^2/\tau$ is improved by a multiplicative 1.5 factor. The effects of gas mixtures on $\varepsilon$ and $\tau$ and the projection of these results on the performance of a modified MWPC positron camera will be presented. Figure 3 illustrates the results of $\varepsilon^2/\tau$ for some of the gases used.

References

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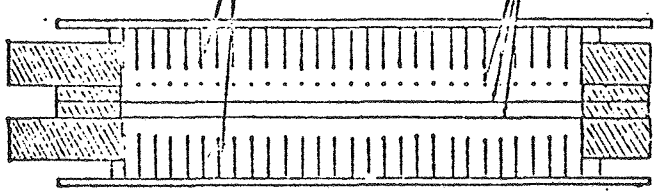


Fig. 1

Cross-sectional view of converters coupled to a conventional three wire plane MWPC.

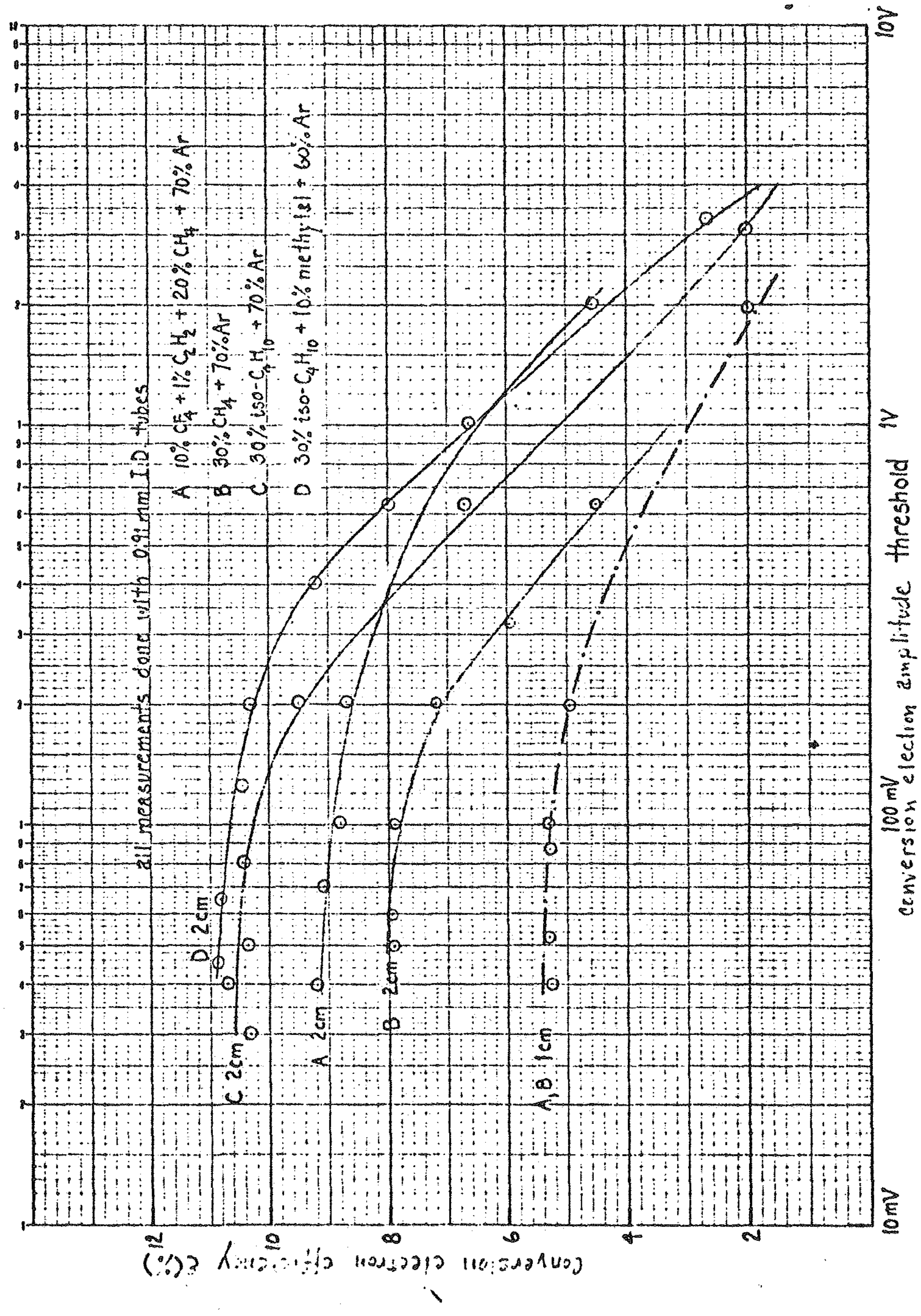
all measurements done with 0.91 mm I.D. tubes
A 10% $CF_4$ + 1% $C_2H_2$ + 20% $CH_4$ + 70% Ar
B 30% $CH_4$ + 70% Ar
C 30% iso-$C_4H_{10}$ + 70% Ar
D 30% iso-$C_4H_{10}$ + 10% methylal + 60% Ar
D 2cm
C 2cm
A 2cm
B 2cm
A,B 1cm
conversion electron efficiency ε(%)
conversion electron amplitude threshold
10mV
100 mV
1V
10V
12
10
8
6
4
2

*fig. 2*

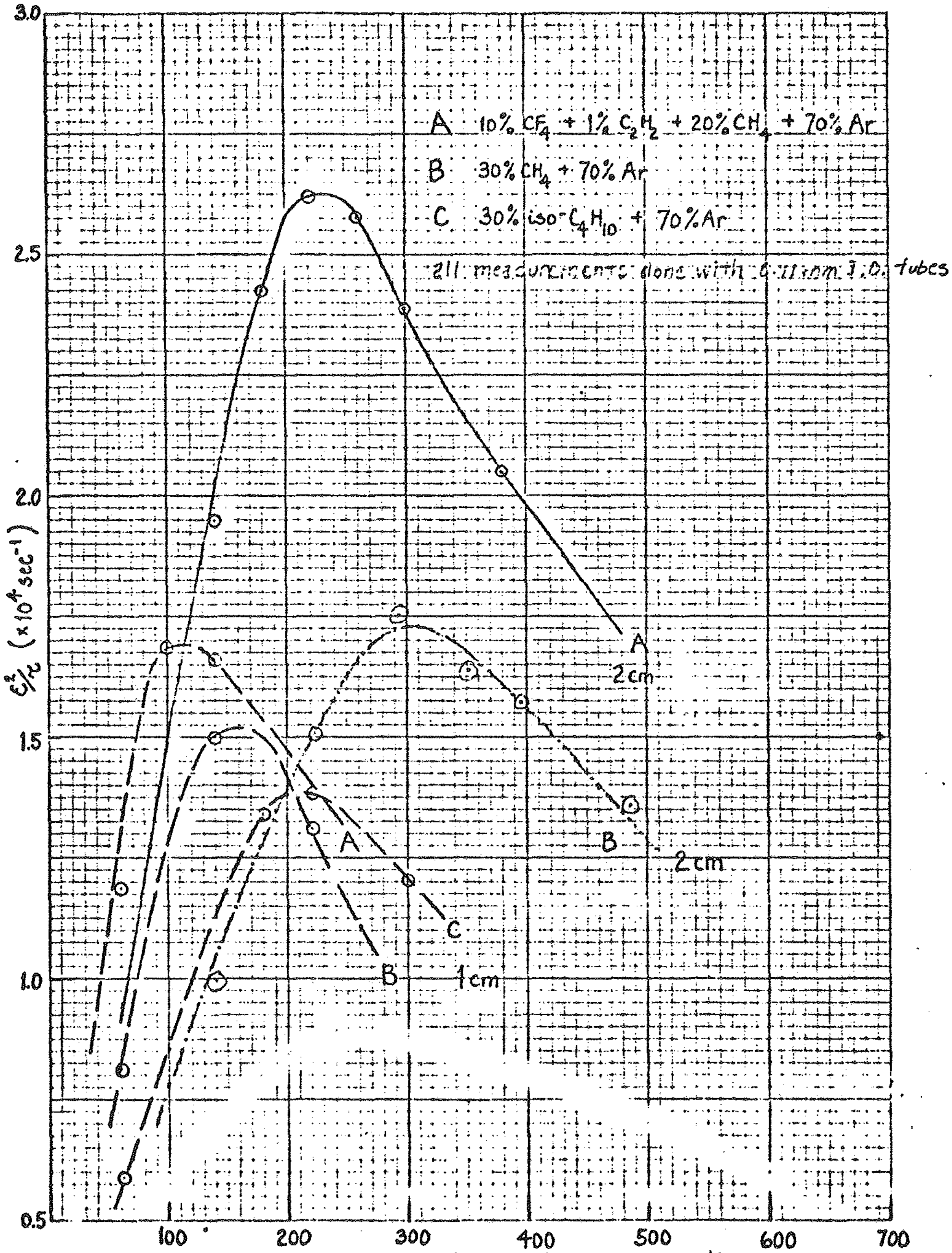
3.0
2.5
2.0
1.5
1.0
0.5
100
200
300
400
500
600
700
A 10% CF4 + 1% C2H2 + 20% CH4 + 70% Ar
B 30% CH4 + 70% Ar
C 30% iso-C4H10 + 70% Ar
all measurements done with I.D. tubes
A
2cm
B
2cm
A
C
B
1cm
ε²/τ (×10⁴ sec⁻¹)
τ (nanosec), resolving time

*fig. 3*