Testing and Optimization of Gas Ionization detector

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Introduction

Nuclear radiation viz. charged particles emitted from nuclear interactions are an important probe to identify the reaction mechanism. Measurement of the particle energy ,position and time of occurrence with good resolution forms the main objective of the experimentalist.
In low energy experiments requiring particle identification,gas ΔE detectors are of primary importance as solid state detectors thinner than 5 μm are not commercially available.
In this work we present the performance and optimization of a gas ΔE ionization detector[1].

Design of the detector chamber

The body of the detector is made of SS-304(Stainless Steel)with an active volume of $48 \times 98 \times 115$ mm^3. Two Teflon sheets were placed on the two opposite wall of the detector chamber. Each Teflon sheet has six channels at 5 mm distance of width 2 mm. The channels facilitate anodes to be placed at different distance. The anode plate is nine parallel conducting wire on a 1.5 mm thin copper clad G10 board of area 50 mm $\times$ 90 mm and have a rectangle hole of area 30 mm $\times$ 60 mm. All connection were brought out from the lid of the chamber and a nozzle was placed from the lid, for creates vacuum and gas charging.

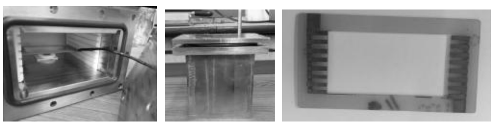

FIG. 1: Detector Chamber

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Experimental Setup

The anode plate is inserted in the 2nd slot of the Teflon channel. The source is placed inside the detector chamber using Teflon source holder. In this set up source to anode plate distance is minimum(7 mm) (Fig.2).

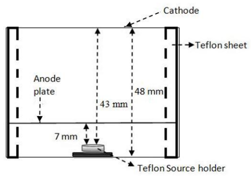
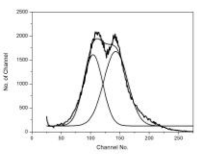


FIG. 2: Detector setup

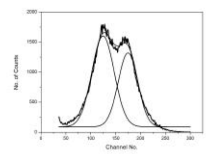
Bias is applied to the detector by a Mesytec Power Supply (MHV-4). The output of the detector was fed to Pre-amplifier (CANBERRA-2004) then to Spectroscopy Amplifier(CERN-N968). Finally, the signal was fed to a 2K ADC Multi Channel Analyser (ORTEC Maestro-32).

Result and Discussion

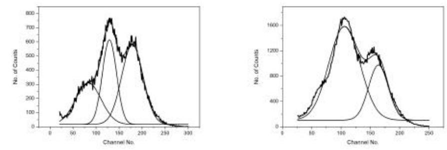
The detector optimization was done using Xenon and Isobutane. A ^{252}Cf source for fission fragments[2] and an alpha 3-line source was used for the experiment. The spectrum is shown in Fig.3. Isobutane shows a better quality resolution.



Pressure = 150 torr
Bias =75 Volt
Shaping time =3 μs



Pressure = 200 torr
Bias =100 Volt
Shaping time =3μs

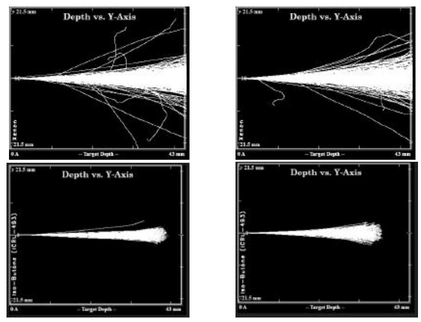


Pressure = 50 torr
Bias =100 Volt ,
Shaping time =3 μs

Pressure = 100 torr
Bias =200 Volt
Shaping time =2μs

FIG. 3: Fission spectrum of ^{252}cf for is Xenon and Isobutane gas at optimum pressure.

Optimum pressure for Isobutane gas is 50-100 torr and for Xenon gas it is 150-200 torr.
We observed from SRIM 2013[3] calculation that Isobutane has a higher stopping power than Xenon(Fig.4) and produces less straggling thereby having better resolution.

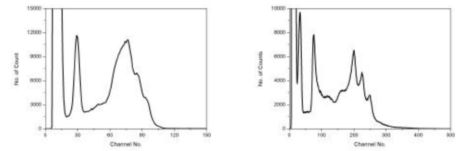


For Molybdenum

For Barium

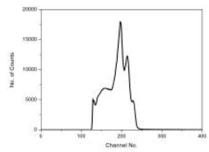
FIG. 4: Energy loss of Mo and Ba for Xenen and Isobutane gas within detector chamber at 150 torr pressure

We also observe that for a ΔE mode of operation. We need to know the energy loss of lighter and heavier fission fragments. It is found that unlike light ions the heavier fragments(lower energy) loses less energy and lighter fragment(higher energy) more energy.
We also use 3-line alpha source which is a mixture of three alpha emitting source: (i) ^{239}Pu (5.155 MeV), (ii) ^{241}Am (5.486 MeV) , (iii) ^{244}Cm (5.805 MeV). We can study the 3-line α spectrum for Xenon, Isobutane and P10 gas at optimum pressure and bias voltage(Fig.5).



For Isobutane

For Xenon



For P10

FIG. 5: α 3-line spectrum

Optimum pressure for Isobutane and Xenon is 500 torr and for P10 it is 750 torr. In these pressure 3 alphas are fully stopped inside the detector chamber(using SRIM software). So they loss full energy.

Conclusion

Ionization chamber is fabricated in the axial field configuration whose anode is similar to a MWPC (Multi wire proportional counter). We also optimized the gas pressure and Bias voltage for two different gases. For ^{252}Cf fission source detector behaves as a ΔE ionization chamber and for 3-line alpha source behaves as a E ionization chamber.

Acknowledgments

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References

[1] S. Adhikari et al., *IEEE transactions on nuclear science*, vol. 53, no. 4, pp. 2270–2275, 2006.
[2] D. C. Biswas et al., *Nucl. Instr. and Meth.*, vol. 340, no. 3, pp. 551–554, 1994.
[3] J. Ziegler, “Srim software,” *URL: http://www. srim. org*, 2013.