High purity Germanium detector in the study of neutrino as a milli charge candidate

S. Karmakar[1],* M. K. Singh[1], V.Singh[2], and H. T. Wong[3]
[1]Department of Physics, Institute of Applied Sciences and Humanities, GLA University, Mathura-281406, India
[2]Department of Physics, School of Physical and Chemical Sciences, Central University of South Bihar, Gaya-824236, India and
[3]Institute of Physics, Academia Sinica, Taipei -115201, Taiwan

Introduction

With the progress in nuclear physics like in neutrinoless double beta decay search along with the different modern sector of physics like, Dark Matter (DM) candidate search, search for different characteristics of Neutrino also with other exotic particle interaction, detectors which posses a very low threshold of detection nearly of the few hundreds eV_{ee} (electron equivalent) becomes one of the supreme need. High Purity Germanium(HPGe) detectors are proved one of the best technology as it has a good resolution with a low threshold[1, 3]. Worldwide different collaborations have used various configurations of this detector as per their experimental need. Ultra low energy and Point contact detector configurations have proven to have a very low energy threshold near the expected range. When we need good resolution like to study the low mass WIMP nucleon interaction ultra low energy configuration will be good to use. But the main problem with this detetor is that it have very low mass. For the the study of the redioactivity in the rock sample etc. coaxial detector can be used but resolution is the point of concern in this case. Where as the point contact configuration provides very good energy reolution, low detection threshold. Here in this present article we will present the work of the Taiwan EXperiment On NeutrinO (TEXONO) collaboration with the point contact HPGe detector configuration. More specifically we will focuses on the study of the milli charge $|\delta_Q|$ that could posses by the neutrino with the above stated configuration and also look the propsed limit which we are planning to achieve in near future with the updates on the detector cooling system etc [1, 3] .

*Electronic address: shuvadeepk@gmail.com

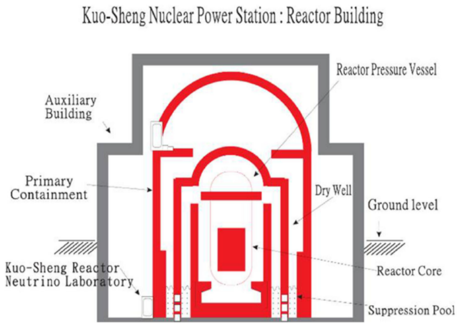

FIG. 1: Schamatic diagram of the KSNPS building.

Experimental details

On the northern shore of Taiwan at the Jinshan district KuoSheng Neutrino Laboratory (KSNL) is situated in Kuo-Sheng Nuclear Power Station (KSNPS-II) shown in Fig. 1. The nuclear reactor consists of two boiling water reactor cores, it was capable of producing nearly 6 GW thermal output. The power reactor basically operated with eighteen-month on and fifty days off data which provided a good opportunity to study neutrino physics. As we know that nuclear power plant is a good source of nuclear beta decay as well as the neutrino. The produced flux of antineutrino is approximately $6.4 \times 10^{12} cm^{-2} S^{-1}$ [1]. As our focus is to look at the rare event, suppression of the

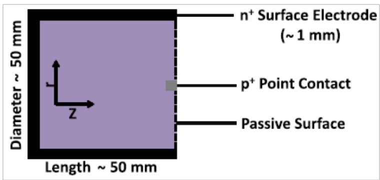

FIG. 2: p-type point contact Germanium detector

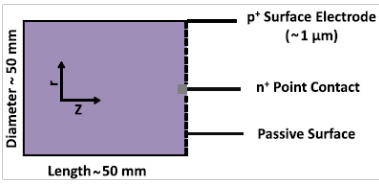

FIG. 3: n-type point contact Germanium detector

background event is one of the prime matters of interest. Various shielding for providing the best background suppression was used here along with the 30 m water equivalent overburden from the top of the reactor building. Mainly the shielding is divided into two parts Active shielding and passive shielding. From the component of the active shielding, we have taken data to separate the events generated by cosmic rays coming from the atmosphere. Further, the active shielding has two components one is the 16 plastic scintillator to work as the cosmic ray veto detector providing shielding from all sides except the lower part. The other part of the active shielding is the anticompton veto detector which provides the detector a 4π covering for the Ge detector system, NaI and CsI crystal have been used for this purpose. Passive shielding has four different layers the outermost one is the 15 cm thick lead layer used to stop ambient gamma. The innermost part is the oxygen-free high conductive copper having 5 cm thickness it provides very good absorption for the gamma from the intrinsic radioactivity for details see [1].

Result and Discussion

TEXONO collaboration has used p-type (Fig. 2) and n-type (Fig. 3) point contact configurations HPGe detector. Among them in terms of the energy threshold, the p-type point contactdetector has been able to achieve the very low value of 228 eV_{ee} whereas the n-type point contact detector has achieved the detection threshold of 285 eV_{ee} [2, 3]. But there is a limitation in the case of p-type is that there is a surface layer present in it. This surface layer present in the pPCGe creates anomalous surface events but the nPCGe is free of this. When an interaction occurs in the surface layer of material the created electron-hole pair will first try to diffuse through the layer then it will flow towards the electrode. Thus events created at the bulk of the material will have more drift towards the electrode. So that in the path of the journey some of them might get recombined. So the produced signal will also be weak [2, 4]. Now we know that the neutrino is one of the most puzzling particles. The presence of a fractional charge in neutrino could suggest that it is basically a Dirac particle. In the passage through the material, it might interact with the atomic ionization process. Which can be studied with different methods such as free electron approximation and equivalent photon approximation etc. based on the transferred energy. We have studied the neutrino as a milli charge candidate with point contact configuration the overall limit for the reactor neutrino was set at $|\delta_Q| < 1.0 \times 10^{-12}$ [2, 3].

Conclusion

Now we are working on the optimization of the detector with the electro-cooled technique. We have achieved the detection threshold of 200 eV and looking to optimize the background. With this, we are planning to reach the limit for millii charge of neutrino around $|\delta_Q| \sim 10^{-14}$.

References

[1] M. K. Singh et al., Indian J Phys. **91**, 1277 (2017).
[2] Jiunn-Wei Chen et al., Phy. Rev. D **90**, 011301 (2014).
[3] L. Singh et al., Phy. Rev. D **99**, 032009 (2019).
[4] H. B Li et al., Astropart. Phys. **56**, 1 (2014).