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Deign, Development and Characterization of Liquid Organic Scintillation Detector

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Abstract : We propose an experiment to deign and development of the liquid organic scintillation detector and characterization using the photo-multiplier tube for scintillation counting, and high energy particle detection through the liquid organic scintillation solution. we also plan to find out the desired condition for long stability, low background noise, high gain and high signal to noise ratio, resolution of energy sources, fast response of pulse and good plateau characteristics. using the liquid organic scintillation material solution and so on check the environment radiation levels. and gamma ray photo peak given the material presence and calibrations.

1.0 INTRODUCTION

In HEP experimental lab we are trying to properties make liquid organic scintillation detectors ideal for a wide range of applications including nuclear physics research, cosmic and gamma ray detection, neutrino detection, dark matter searching, medical imaging, environmental monitoring, and security screening because many people are performing this experiment in the different right way for our application and find the different commercial and industrial used of that experiment that's why we have also try to used different packages of PMT assembly and continuous change the liquid organic solutions and try to find the perfect penetration of U.V -range of wavelength in short time using the wavelength shifter. And try to find the different sources energy calibration using SCA and MCA module so propose an experiment to design and development of the liquid organic scintillation detector and characterization using the photo-multiplier tube for scintillation counting, and high energy particle detection through the liquid organic scintillation solution. we also try to study the characteristic of PMT at high operating voltage and also plan to find out the desired condition for long stability, less background noise, high gain and high signal to noise ratio, resolution of energy sources, fast response of pulse and good plateau characteristics. Using the liquid organic scintillation material solution and so on check the environmental radiation levels. And the present material gamma ray photo pick and calibrations.

2.0 NEED OF THE STUDY.

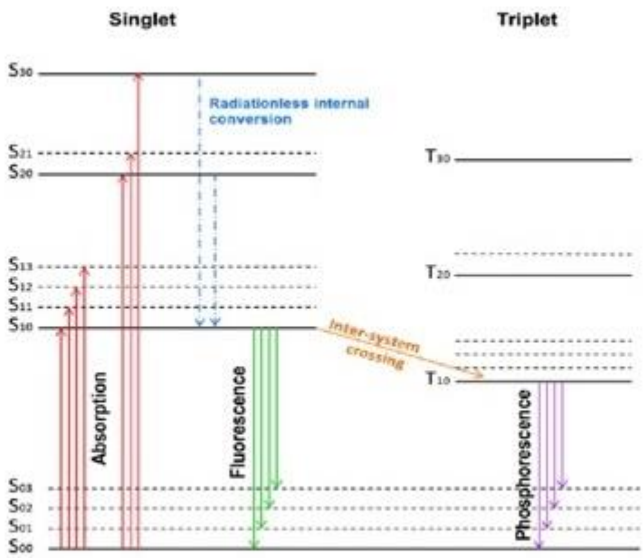
The future developments to make a Liquid Organic Scintillation Detectors more efficient, and user-friendly, versatile, broadening and try to application scope and improving performance across various scientific, medical, and industrial fields and used for the scintillating counting. So in future we can use the liquid organic scintillation detector for developing new organic compounds that produce more light, improving sensitivity and resolution, and creating the materials that resist radiation damage, extending the lifespan of detector and developing detector for ultar-low-level radiation detection in environmental applications and creating smaller detector for portable radiation monitoring, pocket dosimeter and we can also used for environmental monitoring and radiation safety.

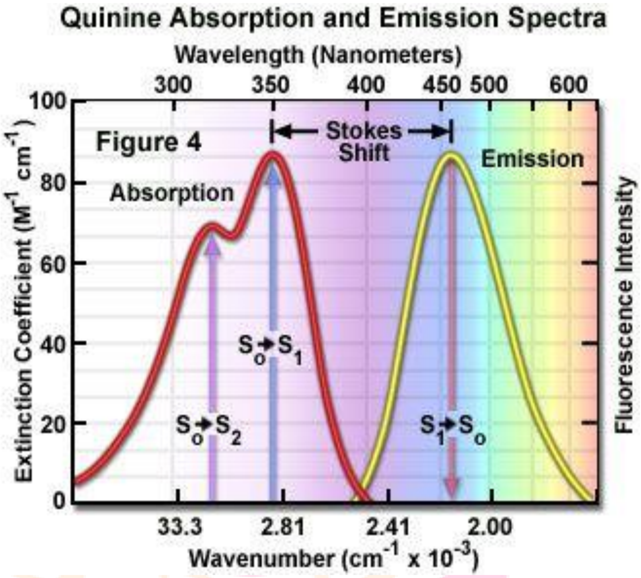
Combining liquid organic scintillation with other detection technologies to improve efficiency and resolution. Using wavelength shifter material to optimize the match between scintillation emission and photo-detector sensitivity and designing wearable scintillation detectors for continuous radiation exposure monitoring and initially used in large-scale experiments JUNO for detecting neutrinos, Implementing advanced DSP techniques for more better signal clarity and letting faster data and try to used for utilizing machine learning process to analyze scintillation signals, improving the accuracy of radiation type level identification and energy estimation, Integrating scintillation materials with semiconductor chips for compact and better efficient detection systems, and also used for space missions and adding wireless communication capabilities for real-time data transmission and remote monitoring.

3.1 Scintillation and Ideal Scintillation

It's only happen that when high energy particle incident on atom and do that excitation and de-excitation of the electron energy state level at atom then after few second ~ nano second come to ground state and deposit the energy and produce the gamma-ray photon.
1. Scintillation material density and atomic number should be high for the high gamma-ray detection of efficiency.
2. Using the preset time / decay time would be sufficient small than give the fast pulse response.

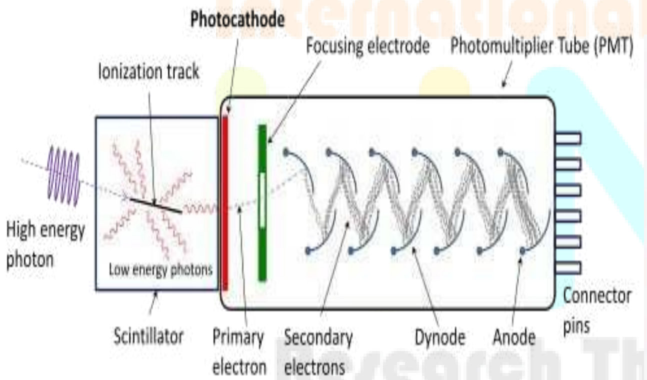
3. Scintillation material given photon wavelength should be near the UV-rang same (nm) for PMT response.
4. And radiation refractive index should be near the glass ~1.5 then found the better transmission of light yield on the Photo-multiplier tube.
5. Ideal Scintillation convert the charge particle K.E into the detectable light yield with high efficiency.
6.During the energy conversion of the particle should be linear and light yield also proportional to deposit energy of scintillation.

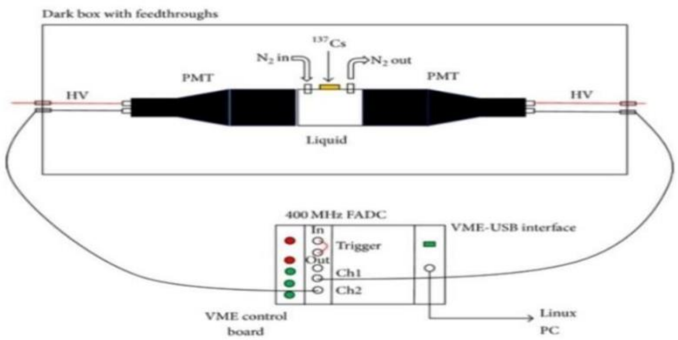




3.2 PMT and Photo diodes

PMT is a photo-multiplier tube mean do work on the principle of multiplier the photon and give the sufficient electric voltage pulse height of photon and it is photo emission device in which that do has absorption or emission of electron in whole process photon strike on the PMT smooth surface then after scintillation primary electron strike on the dynodes and give the bunch of more secondary electron , so increasing the channel that is proportional to the initial electromagnetic radiation coming on the pmt then anode do collective all electron and finally give the electric pulse And in these PMT dynodes connect in the series between the photo-cathode and photo anode, and every node connect the resistance in parallel. do has create the voltage drop down every nodes and between them accelerate the electron continue repeat this phenomena for used that more nodes as per required and increase the K.E of electron heat on and produce the more no of electron and so finally can achieved the good electric pulse as a signal on the digital oscilloscope because dynodes work as a reflection and transmission of secondary electron as type of dynodes in this structure. But there are very difficult to find the particular find the K.E energy particle then how much power drop down and selection of capacitor material properties.





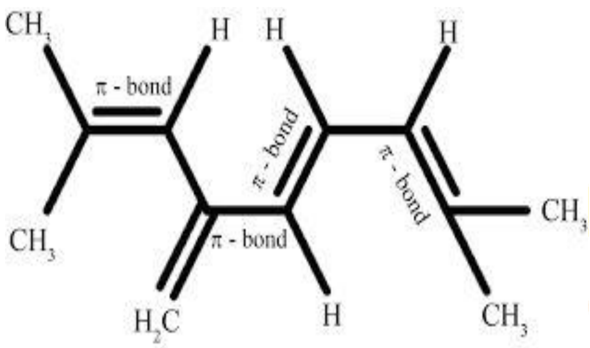
3.3 Dark Chamber

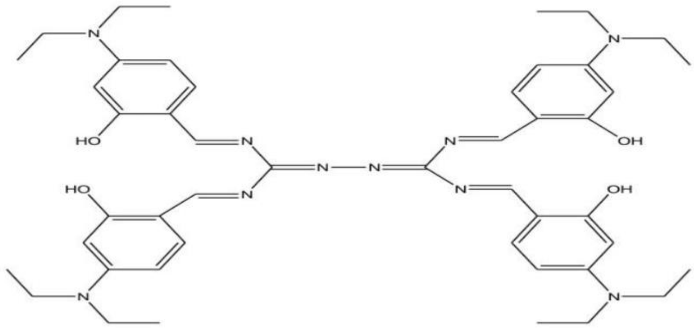
First of all we have choose the light transmission glass which similar of refractive index of ~1.5 suitable size of cylindrical shape and check the light visibility when radiation coming on the solution site and heat on the PMT at that on the glass chamber, Size of chamber we have cover three dimensionally by the aluminum foil very sharp folding around the glass chamber because this aluminum foil work as a light refraction in that chamber and stop the all producing light by the organic liquid solution after that second layer cover with the insulating paper with the around of chamber as according of aluminum foil, Then use the black paper for absorbing the outer dark wooden box light and it may be produced few heat and create or new light then insulating paper work as for it and finally chamber cool temperature and maintain the initial state of solution.

3.4 Organic material Selection

There are sigma bond not participate in the cyclic hydrocarbon resonance into the benzene series and any other more cyclic series only participate of pi-electron in the change of resonance because it do to resonance will possible energy transition in ground state to the more excitation stats and then give the gamma-ray photo peak as electric voltage pulse height, It also based on the stock shift which material we have used in that experiment for emittance the photo peak,.

Organic scintillation given by the hydrocarbon compound and creation through the benzene-ring resonance structure, It has also many type of organic scintillator are
1.PURE ORGANIC SCINTILLATION
2.LIQUID ORGANIC SCINTILLATORS
3.PLASTIC SCINTILLATORS
In the pure organic scintillation only use the pure hydrocarbon polymer composition include as a anthracene, stilbene and naphthalene, These crystal decay time is approximately ~10 nsec and most of this type of material use of the detection of beta particle,There are we have use the following chemical formation for the fluorescent chemical are tetra(3-diethylaminophenol)-1,2-hydrazinecarboximidaimine and try to find the photo peak wavelength and comparatively check the similarity in new dissolving composition with known solution ,because we know that organic liquid scintillator given that good attenuation length and these Hydrocarbon solvent are flammable and low flashpoint





2.3.1-Tetra(3-diethylaminophenol)-1,2-hydrazinecarboximidaimine

4.0 RESEARCH METHODOLOGY

First of all we have do Literature Review and Problem Definition, Gather and synthesize existing knowledge on liquid organic scintillators, their properties, and applications and our sources are scientific journals, books, patents, and conference papers and target focus Areas on types of organic scintillators and their chemical compositions, Mechanisms of scintillation in organic materials, Previous designs and their performance metrics, Current limitations and challenges in the field.

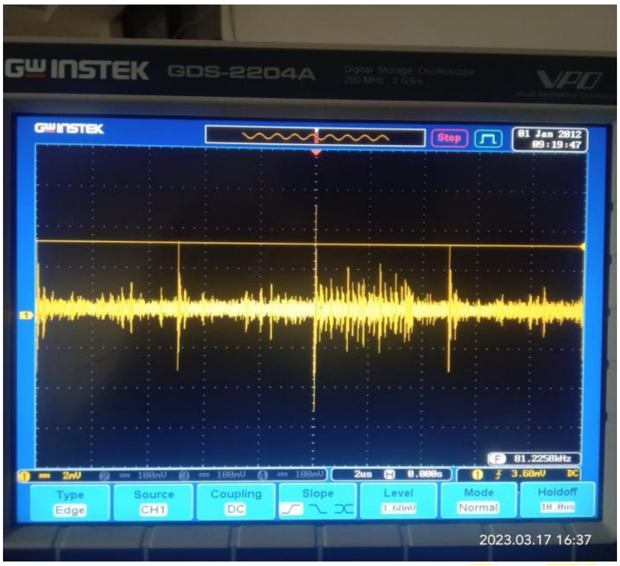
For the scintillation mechanism study the process of energy absorption and photon emission in organic scintillators and radiation Interaction understand how different types of radiation interact with organic scintillators then develop models to predict light yield, energy resolution, and time resolution based on scintillator composition and design, Select organic compounds such as Tetra(3-diethylaminophenol)-1,2-hydrazinecarboximidaimine and determine optimal concentrations of primary and secondary fluorophores to maximize light yield and energy resolution after that design the detector prototype, including the scintillator container, light collection system, and readout electronics and select materials for the container that are chemically compatible with the scintillator and do not absorb emitted light so design an efficient light collection system using photomultiplier tubes (PMTs) or silicon photomultipliers (SiPMs) further manufacture the scintillator container with appropriate materials and dimensions, And integrate the scintillator, container, and photodetectors into a functional prototype.

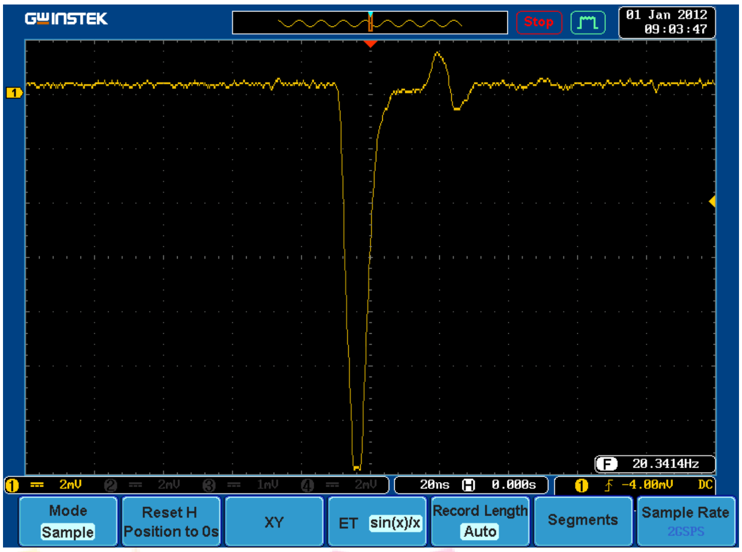
For characterization and testing measure the amount of light produced per unit of absorbed radiation using standardized light sources and evaluate the detector's ability to resolve different energy levels of incident radiation, Assess of the speed of the scintillation process and the response time of the detector and then test the detector's performance under various temperature and humidity conditions to ensure robustness and use the known radiation sources (e.g., gamma rays, beta particles) for controlled testing, and for the data Analysis and Optimization develop and apply algorithms for processing and analyzing the signals from the photodetectors, calibrate the detector using known standards to ensure accurate measurements and identify and quantify sources of error in the detection process, and refine the design according the adjust the scintillator composition, container design, and electronic components based on performance data for continuous Improvement conduct multiple rounds of testing, analysis, and refinement to enhance detector performance.

Publish findings in peer-reviewed journals and present at scientific conferences, file patents for novel designs, compositions, or methods developed during the research and this methodology provides a structured approach to developing a liquid organic scintillator detector, ensuring thorough investigation and continuous improvement throughout the research process.

5.0 RESULTS AND DISCUSSION

Measurement of the number of photons produced per unit energy deposited by radiation and expected results found in photons/MeV. And Determine of the detector's ability to distinguish between different energies of incident radiation. This is typically expressed as a percentage in Full Width at Half Maximum measurement of the detector's ability to resolve the time of interaction events. This is crucial for applications like time-of-flight measurements and try to find the efficiency of the detector for different types of radiation (e.g., gamma rays, neutrons, beta, muon, comic ray) and energy ranges and characterize of the detector's response to background radiation and methods to minimize it and ability to distinguish between different types of radiation (e.g., gamma rays vs. Neutrons, beta, muon, cosmic ray) based on the shape of the scintillation pulse. Energy resolution might range from 7% to 20% depending on the quality of the scintillation and the setup and time resolution in the range of nanoseconds 5-20ns for fast scintillation detector for lower efficiency for high-energy gamma rays and neutron detection and background measurements to identify and minimize noise sources use the shielding materials to reduce background noise and try to clear separation between different ray like gamma-ray and neutron pulses based on decay time different,





So finely we have do systematically design, develop, and characterize a liquid organic scintillator detector and obtain comprehensive results that demonstrate its performance and suitability for specific applications.

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