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Performance simulation of a MRPC-based PET imaging system

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Mathematical Physics, Theoretical Physics

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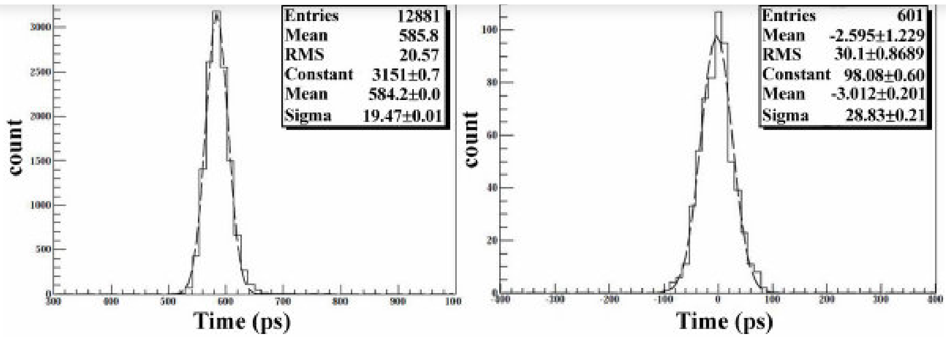

Figure 3: Detector Time resolution– *Left(a):*Single detector Time Resolution, *Right(b):* Pair Time Resolution.

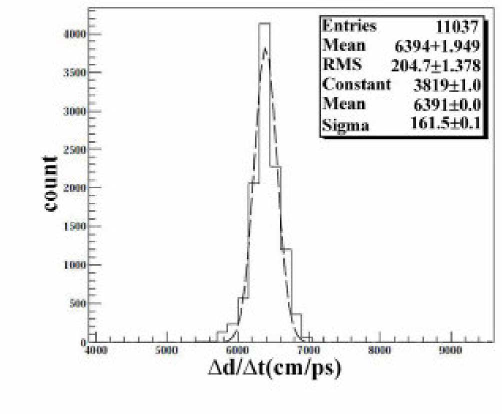

Figure 4: Ratio of the distance of the point of generation for the origin to the photon detection time by the system.

4 Experimental results

As a feasibility study a six-gap MRPC prototype of dimension 16 cm x 10 cm with 200µm gas gap each has been fabricated [13]. The module has been built with 600µm thick float glass obtained from GSI, Germany. The detector has been operated in the avalanche mode with a gas mixture of R-134a and iso-butane in the ratio of 95/5.

To measure the photon-pair detection efficiency, a ^{22}Na source emitting two 511KeV photons has been placed in between a plastic scintillator of dimension 5 cm × 1.2 cm and the MRPC, as shown in figure 5. The coincidence has been obtained between the signals from the scintillator and the MRPC strips with and without the ^{22}Na source. The coincidence count rate increases with the applied high voltage and the effect of the source is clearly seen from the figure 6(a).

The photon-pair detection efficiency, defined as the ratio of the two fold coincidence counts between the scintillator signal and the MRPC signal to the number of photons counted by the scintillator alone also increases with the applied voltage showing a tendency of saturation as shown

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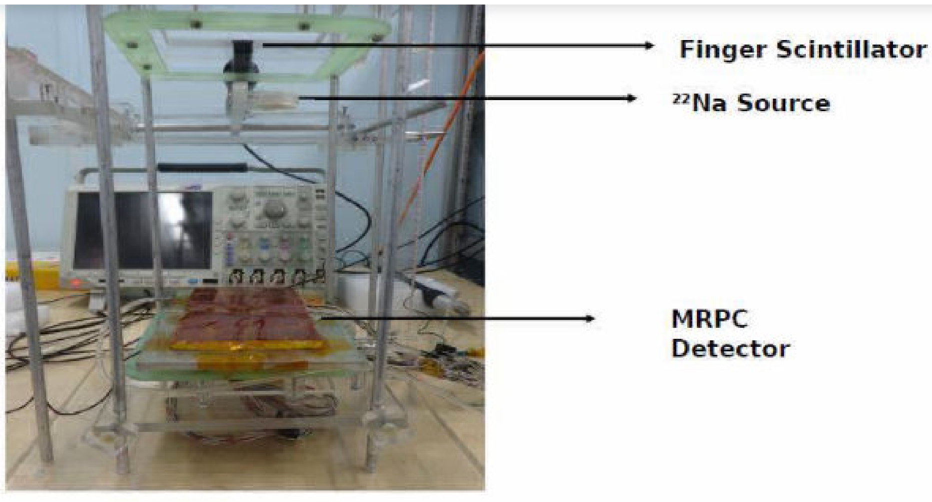
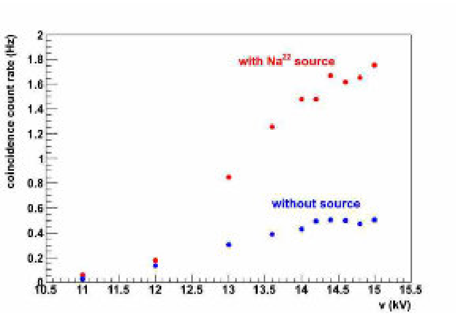
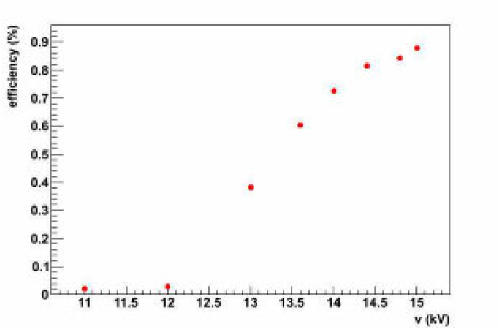


Figure 5: Experimental set-up.



(a) Count Rate as a function of high voltage.



(b) Efficiency as a function of high voltage.

Figure 6: Efficiency and Coincidence Rate

in figure 6(b). The pair-detection efficiency of 0.9% has been obtained for an applied voltage of 15 kV after the corrections for geometry and cosmic rays.

To locate the position of the source, we measured the time difference between the signals on the scintillator and the MRPC. The start and the stop signals have been obtained from the scintillator and the MRPC respectively. The distance between the scintillator and the MRPC has been fixed at 44.5 cm. The distance of the source has been measured from the MRPC. The time difference has been calculated as distance/30 - (44.5-distance/30), where the velocity of the photons has been taken as 30cm/nsec. It is seen from figure 7, that given the large error bars, by varying the source position, the time difference between the signals from the trigger scintillator and the MRPC is changing in an expected direction. The expected time difference from the measured distance has also been shown in the figure by filled dots.

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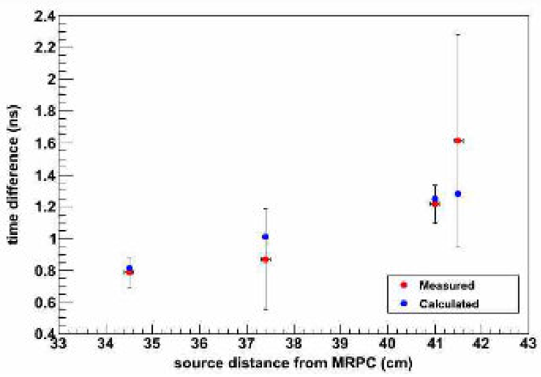

Figure 7: Time difference as a function of the source distance.

5 Conclusion and outlook

MRPC-based TOF-PET system is potentially an attractive alternative to the expensive scintillator-based system. In this work we have performed simulation for the detection of photon pairs by a converter-based layered RPC system. A number of gaps, each defined as the combination of lead-glass-gas have been used to detect 511 keV photon pairs. The photon conversion efficiency increases upto a saturated value of 30% for a 120 gap configuration. The simulated time resolution for the pair detection has been obtained to be 19 ps, which is considerably better that reported experimentally. The non-inclusion of several effects in simulation like, readout electronics, back-scattered electrons among others might be the reason of such a good time resolution. A six gap glass-based MRPC has been tested with photon pairs from ^{22}Na source. We observe a clear signal of photon pairs above background in presence of source as detected by a scintillator and MRPC coincidence. Further work on studying the sensitivity of the system is in progress.

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