Methods for pulse height measurement

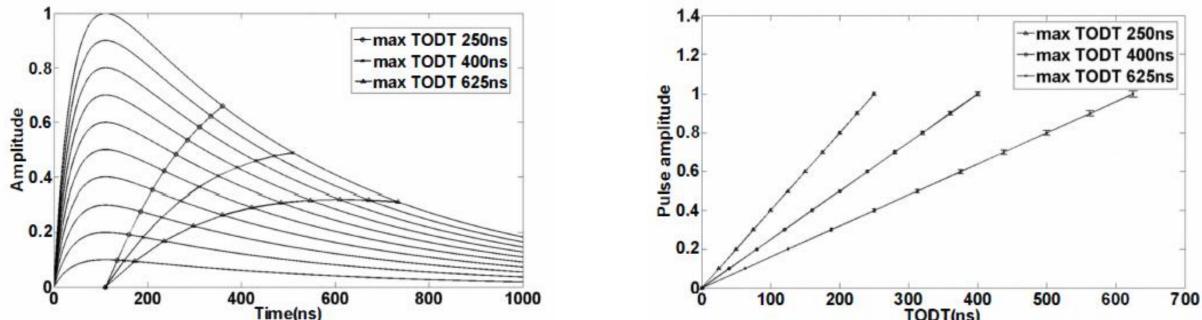
ADC:Hign precision, but with high-cost and limited Integration level.

TOT(Time-Over-Threshold)method:

Circuit would be much more simpler since only one comparator would be needed. But it has lower precision.

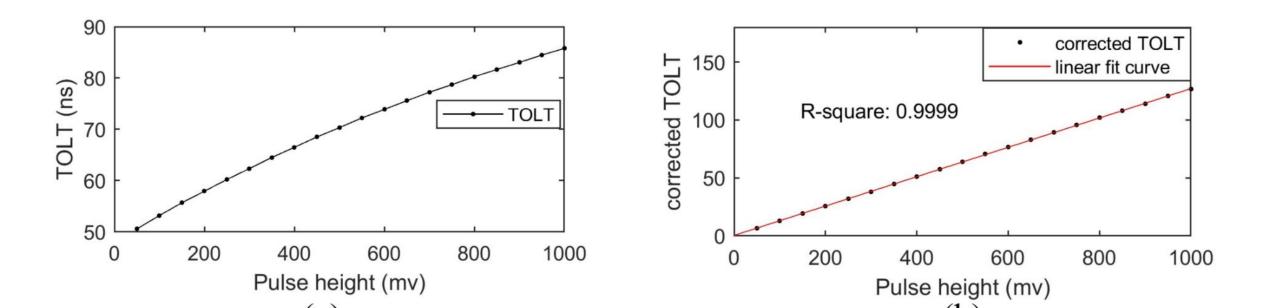
TODT(Time-Over Dynamic Threshold)method:

Deliberately designed DT can linearize the Time over DT and height, hence we can achieve high precision height measurement



Complexity of circuit for deliberately designed DT generation could set a limit to higher channel count. Generating linear ramping threshold would be much easier and related circuit could be simpler. Simple correction would be implemented so TOLT method can reach high precison of height measurement.

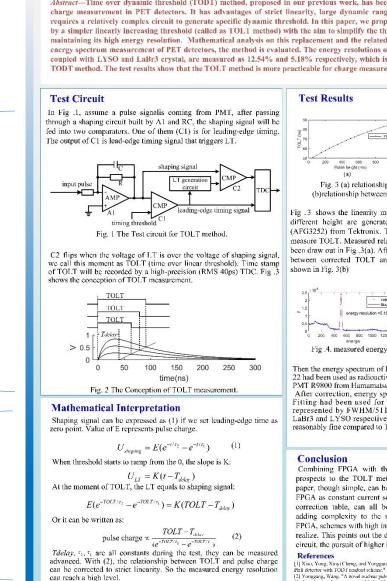
With this method, we can achieve both high precision and channel count with lower cost.



Title: Nuclear Pulse Charge Measurement with a Method of Time Over Linear Threshold

circuit for verification of time over liner threshold

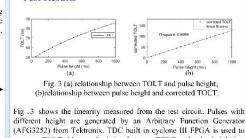
The math behind this method to illustrate why it can reach high precision



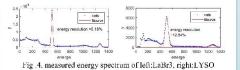
Nuclear Pulse Charge Measurement with a Method of Time Over Linear Threshold Zhengqi Song, Yonggang Wang, Yong Xiao, Qiang Cao Department of Modern Physics, University of Science and Technology of China, Hefei Anhui, China



Abstract-Time over dynamic threshold (TODT) method, proposed in our previous work, has been successfully used for nuclear pulse charge measurement in PET detectors. It has advantages of strict linearity, large dynamic range, and better energy resolution, but requires a relatively complex circuit to generate specific dynamic threshold. In this paper, we propose to replace the dynamic threshold by a simpler linearly increasing threshold (called as TOLT method) with the aim to simplify the threshold generation circuit meanwhile maintaining its high energy resolution. Mathematical analysis on this replacement and the related realization circuit are presented. By energy spectrum measurement of PET detectors, the method is evaluated. The energy resolutions of PET detectors, composed of a PMT coupled with LYSO and LaBr3 crystal, are measured as 12.54% and 5.18% respectively, which is equivalent to the result obtained by TODT method. The test results show that the TOLT method is more practicable for charge measurement of nuclear detectors.



measure TOLT. Measured relation between TOLT and pulse height has been draw out in Fig. 3(a). After correction had been performed, relation between corrected TOLT and pulse height yields strict linearity as



Then the energy spectrum of LaBr3 and LYSO had been measured. Na-22 had been used as radioactive source, gamma rays will be detected by PMT R9800 from Hamamatsu, which outputs pulses to our test circuit. After correction, energy spectrums are shown in Fig.4. Gaussian Fitting had been used for peak at 511Kev. Energy resolutions, represented by FWHM/511Kev, equals to 5.18% and 12.54% for LaBr3 and LYSO respectively. The measured energy resolutions are reasonably fine compared to TODT method.

Combining FPGA with the front-end circuit brought some new prospects to the TOLT method. The LT generation circuit in this paper, though simple, can be simplified further by using I/O port on FPGA as constant current source. Other components, like TDC and correction table, can all be easily constructed in FPGA without adding complexity to the system. To fully exploit advantages of FPGA, schemes with high integration and low cost would be easier to realize. This points out the direction to our future work: in front-end circuit, the pursuit of higher integration level will never stop.

[1] Xiao, Yong, Xinyi Cheng, and Yonggang Wang. "Preliminary performance of a continuous crystal PE1 detector with TOD1 readout scheme." Real Time Conference (R1), 2016 IEEE-SPSS, IEEE, 2016 [2] Yonggang, Wang. "A novel nuclear palse digitizing scheme using time over dynamic threshold." Vuclear Science Symposium and Medicel Imaging Conference (NSS/MIC), 2011 IFEE, IFFE, 2011.

Test result