# A Multi-Threshold Method for TOF-PET Signal Processing


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## 1. Introduction

The advantages of the early digitization of PET signal.
- allow sophisticated information processing
- easy to upgrade
- inexpensive, high-performance digital components are common

A idea of multi-threshold method.
Apply several different thresholds to the PET signal.
Timing info. from discriminator used for pulse shape reconstruction.

Multi-threshold discriminator was implemented and tested.
2 boards with 4channels each with programmable threshold level.
Used ADCMP851 comparators.
Timing output at leading and falling edges.

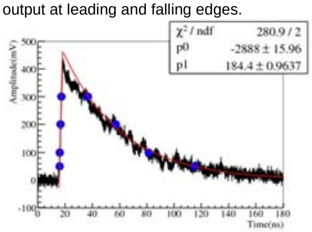


Fig. 1. PMT output by 20GS/s oscilloscope superimposed with timing readouts by the Multi-threshold board+HPTDC.

## 2. Experimental Setup

Two Hamamatsu R9800 photomultiplier tubes (HV = -1,300V)
Coupled with LSO crystals( 6.25x6.25x25mm3).
Separated 5cm apart.
Na-22 used for positron source located at the center.
Multi-threshold board:
- Inputs from 2 PMT signals
- Thresholds : 50, 100, 200, 300mV

Readout :
- TDS6154 oscilloscope with 20GS/s(Tektronix)
- HPTDC( 8chs, 25 ps/bit, developed at CERN, LBL)

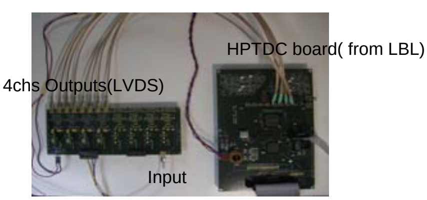


Fig. 2. Multi-threshold board with HPTDC module.

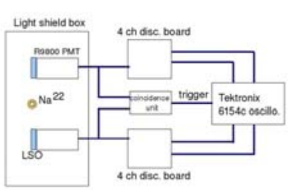


Fig. 3. A Block diagram of the test setup.

## 3. Results

a. Time offset and resolution of discriminator

Time offset between the discriminator output
Measured with the TDS6154 oscilloscope
Offset correction for pulse reconstruction.
Time resolution of single channel : ~13.3ps(FWHM)

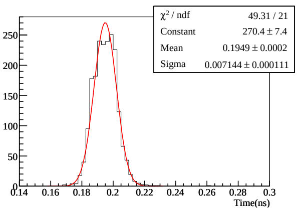


Fig. 4. Time offset between two channels of the Multi-threshold discriminator.

b. Pulse reconstruction (HPTDC)

Select the gamma coincidence events.
Event with 4 hits from each.
Reconstructed pulse shape
Linear fit on the leading edge.
Exponential fit on the falling edge.

511keV gamma energy was measured.
Integrated charge from fig. 1

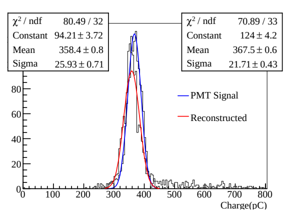


Fig. 5 Energy distribution of 511keV gamma

Energy resolution (FWHM)
Multi-threshold : 18%.
20GS waveform : 14%.

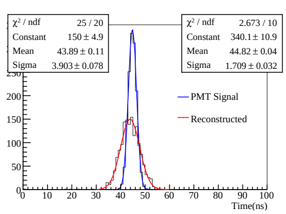


Fig. 6. The decay time constant from the exponential fit on the tail( Fig. 1).

Multi-threshold : 44ns with 9ns width.
20GS waveform: 45ns with 4ns width.

c. Coincidence timing resolution

Select the coincidence events.
Least square fit to the leading edge timings.
Use two leading edge timings with100, 200mV thresholds.
Extrapolated at 0mV( t1 & t2 for each board)
The time difference, t1-t2 (FWHM)
- Oscilloscope : 330ps
- HPTDC : 350ps

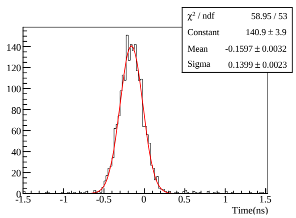


Fig. 7. Time difference of coincidence events

## 4. Summary

Multi-threshold board with adjustable thresholds was developed and evaluated to implement the early digitization for the signal from PET detector.

The signal from LSO+R9800PMT to the gamma coincidence was fed to the multi-threshold board.

Time resolution of the discriminator board was measured ~13ps in FWHM.

The pulse shape was reconstructed using the digitized timing from the multi-threshold board. 18% of energy resolution was obtained for the reconstructed.( 14% using 20GS waveform)

The decay time constant was measured 44ns and compared To 45ns using 20GS waveform.

The 330ps of coincidence time resolution was achieved and compared to ~300ps using CFD.

## References


1.Q. Xie et al, NSS/MIC 2007, p4271, "Potential advantages of Digitally sampling scintiallation pulses in timing determination in PET"