A Comparison of Analog and Digital Pulse-Shape-Discrimination Systems for Organic-Liquid Scintillators

Charles Sosa (PhD Candidate), Dr. Marek Flaska and Dr. Sara Pozzi
Department of Nuclear Engineering & Radiological Sciences, University of Michigan, Ann Arbor, MI 48109

Project Overview

- Pulse-shape-discrimination (PSD) systems can used with some scintillators to discriminate between neutrons and gammas

- The motivation behind this work is to quantify the best PSD system that most accurately discriminates

- The PSD performance of a digital, charge-integration PSD system (CAEN V1720) is compared against an analog, zero-crossing PSD system (Mesytec MPD-4).

- Measurements were performed using an organic liquid scintillator (EJ-309) coupled with a photo-multiplier tube (ETL-9821B).

- A Cf-252 spontaneous-fission source was used to provide neutrons and gammas.

- Figures of merit (FOM) were used to assess and compare the performance of the PSD systems

- Under the measurement constraints, digital PSD system out-performed analog PSD by approximately 15%.
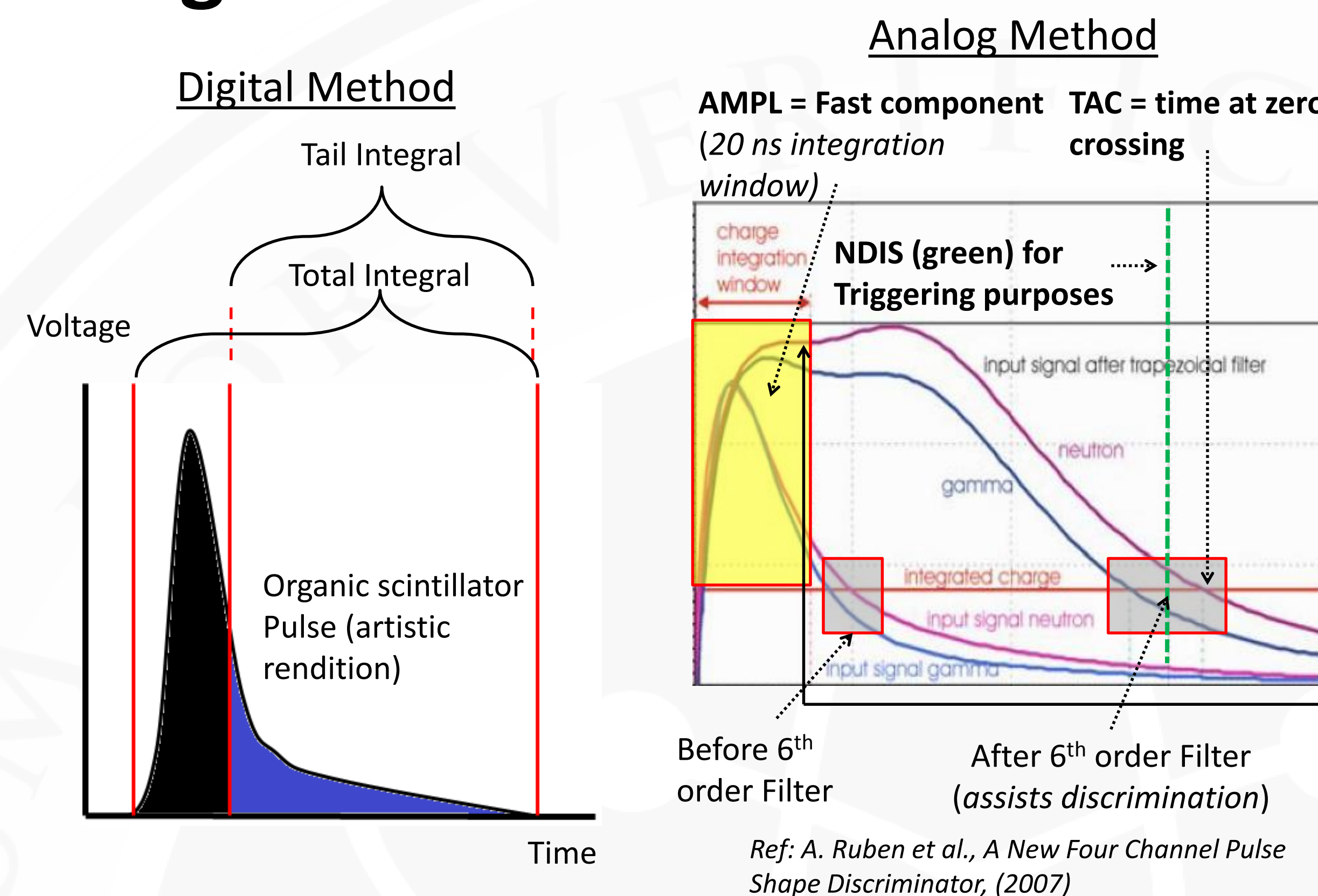
Background

Figure.1: Digital charge integration PSD   **Figure.2:** Analog zero-crossing PSD

Ref: A. Ruben et al., A New Four Channel Pulse Shape Discriminator, (2007)

Experimental Procedure

- MPD-4 settings were optimized in order to produce the best possible PSD performance (table 1) using the following FOM equation:

$$\text{FOM} = \frac{\text{Distance between gamma and neutron peaks}}{\text{FWHM}_{gamma} + \text{FWHM}_{neutron}}$$

Table.1: MPD-4 Settings (grayed rows not used)

| Parameter	Value	Range
WALK (influences curvature of clusters at low energies)	100 (default)	[50,150]
THRESHOLD (serves as an energy cut-off)	0	[0,255]
GAIN (influences curvature of clusters at high energies)	0	[0,15]
QWIN (affects walk parameter, manual suggests to avoid adjusting)	100 (default)	[0,200]
NDIS (moves TAC values up and down for discrimination purposes in fast mode (0.91V))	183	[0,255]

Measurement Results
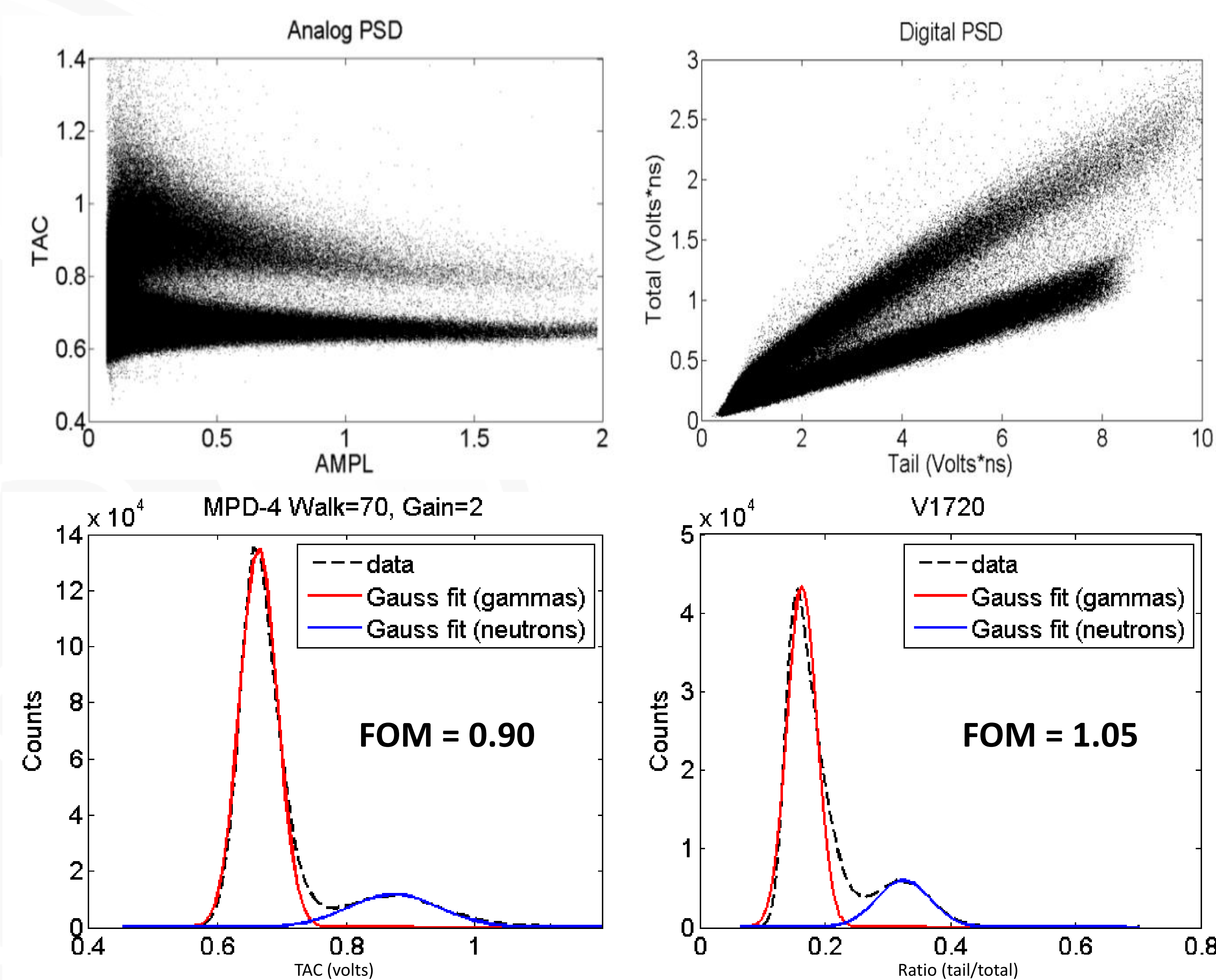
Figure.3: Comparison of analog (left column) and digital (right column) PSD plots, with the PSD images shown in the top row and PSD separation images shown in the bottom row. Analog PSD separation was done using a histogram of TAC values while digital PSD separation was done using a histogram of the ratio values (i.e., tail to total integral values)

Future Work

- The V1720 outperformed the MPD4 by 15% and future work will include using a larger dynamic range (8V instead of 2V)

Acknowledgements