Using Exponential Fit Amplitudes as an Alternative Method of Pulse Shape Discrimination

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Abstract - Digitizers have made it possible to store pulse waveforms created from radiation interactions in a scintillator. The pulses are then analyzed to determine if a given pulse was generated by a photon or neutron interaction. This distinction is most commonly made by the charge-integration method of pulse shape discrimination (PSD) using the ratio of the tail to total pulse integral. Although PSD has its benefits, it can be inaccurate at times, especially at low energies. In this poster we present an alternate approach to PSD that uses the exponential fit of the decaying edge of the pulse. The amplitudes are pulled from the two-term exponential equation to form a ratio that creates a specific value for each pulse. The gamma-only calibration data that accompanies measurements is used to determine a discrimination line. This discrimination line is subsequently used as a threshold above which waveforms are considered neutrons and below are considered gammas. The amplitude ratio approach was found to be comparable to the charge integration method.

INTRODUCTION

• Pulse shape discrimination (PSD) allows for segregation of photon and neutron interactions.
• Charge-integration is a common method of PSD that determines the type of particle interaction by using the ratio of tail integral to the total pulse integral.
• The charge-integration method is not always accurate, especially at low energies.
• Misclassification of particles can lead to faulty results, so successful PSD is necessary.

METHOD

Pulse fitting

• The decaying edges of the pulses were fitted using MATLAB’s fit() function and are below Eq. 1.
• The values of b and d for gammas and neutrons were determined beforehand. Then when the actual fits were made, b and d were restricted by these values to ensure proper fits.

\[ \text{Pulse decaying edge} = Ae^{bx} + Ce^{dx} \]  

(1)

Results

• The Figure of Merit for the amplitude ratio approach is smaller than the Figure of Merit for PSD overall, but at low energies they are comparable.
• It can be seen visually that the discrimination line set by the gamma-only data fits on the mixed data sets.
• The amplitude ratio method assigns more particles to be neutrons than the charge integration method. At this point it is unclear which method is more correct.

<table>
<thead>
<tr>
<th>Pulse Height (V)</th>
<th>C/A FOM</th>
<th>PSD FOM</th>
<th>Number of gammas</th>
<th>Number of neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.1</td>
<td>1.035</td>
<td>1.032</td>
<td>20818</td>
<td>79182</td>
</tr>
<tr>
<td>0.1 - 2.0</td>
<td>1.375</td>
<td>1.580</td>
<td>982</td>
<td>1254</td>
</tr>
<tr>
<td>all</td>
<td>1.254</td>
<td></td>
<td>18032</td>
<td>81968</td>
</tr>
</tbody>
</table>

CONCLUSION AND FUTURE WORK

• The gamma-only calibration data is an effective way to set a discrimination line for mixed data sets.
• The amplitude ratio approach may be more accurate than PSD at lower energies. At this point the techniques are comparable, but more research is needed to verify that amplitude ratio actually is more correct.
• The pulse fitting technique can be refined and used in other applications such as: light output/quenching, pile up rejection, and pulse cleaning.

This work was funded in part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534