# Creating a Database of Pulse Waveforms for Scintillator-based Gamma-ray Detectors

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## INTRODUCTION

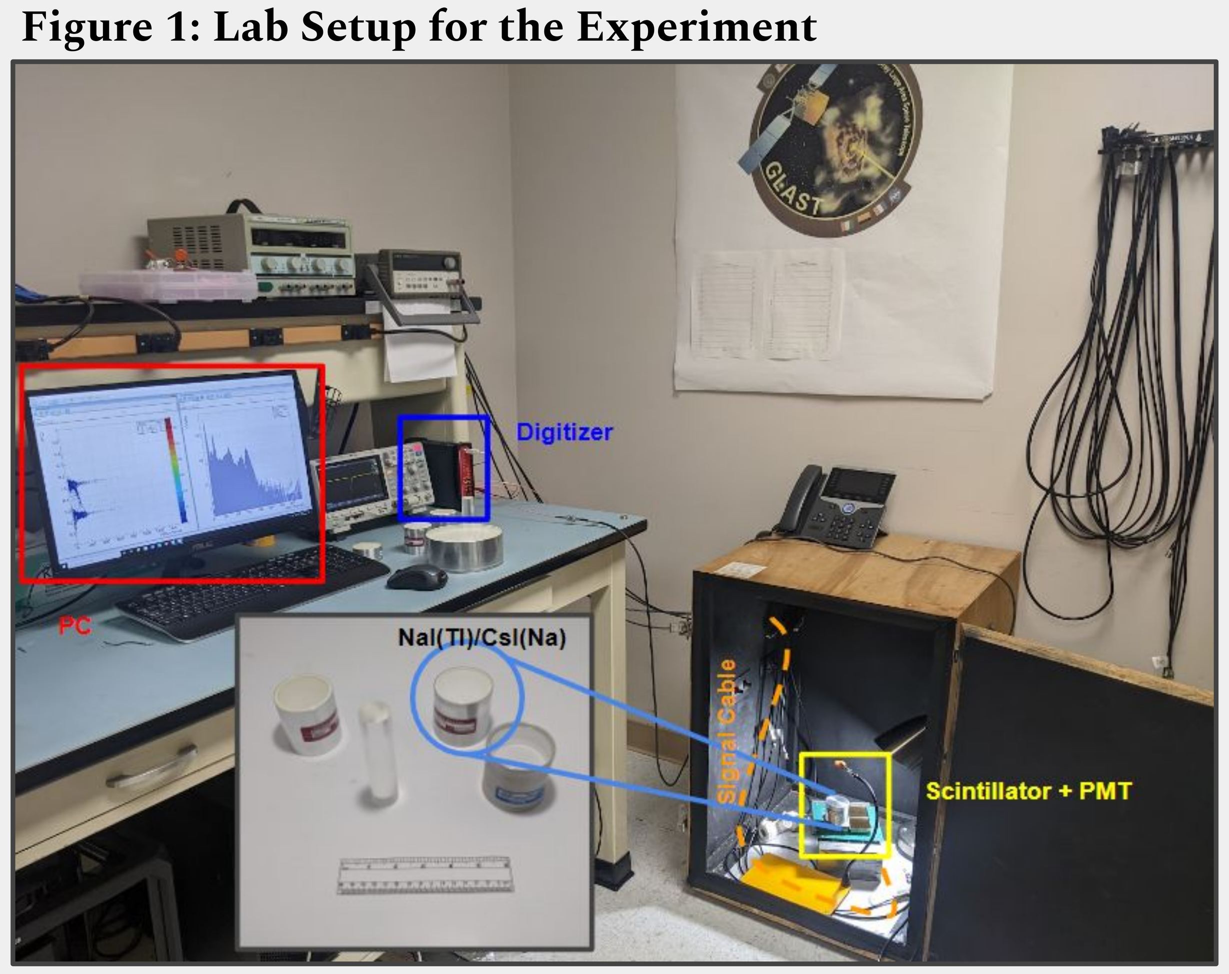
We are creating a database of pulse waveforms for scintillation detectors over gamma-ray energies from 30-1000 keV. This work will aid research teams around the globe who are focused on building the next generation of instruments for gamma-ray astronomy.

This poster provides initial results from the database using a Hamamatsu R12699 flat panel photomultiplier tube (PMT) coupled to NaI(Tl) and CsI(Na) scintillators.

## BACKGROUND & SETUP

- A scintillator crystal emits photons in the visible spectrum when hit with high-energy photons [1].
- A photosensor accepts these photons and sends an analog signal to the digitizer.
  - Our photosensor is a Hamamatsu R12699 flat panel PMT.
- The digitizer then outputs a digital signal of the waveform to the computer to be saved.

**Figure 1: Lab Setup for the Experiment**




## METHODS

- For our work, we use a "phoswich" style detector, which couples two scintillators to a single photosensor, because it allows us to acquire waveforms for two scintillators at once.
- The first graph returned *(Figure 2.1)* is an energy histogram of Ba-133 for both scintillators in the NaI(Tl)/CsI(Na) phoswich, which we then need to separate based on individual pulse shapes.
- We separate energy values for each scintillator by integrating the pulse shape over two timescales, defined by long and short energy gates. Following reference [2], we then formulate a pulse shape discrimination (PSD) variable as a ratio and produce the graph displayed in Figure 2.2.

$$PSD = \frac{\text{(Long Gate - Short Gate)}}{\text{Long Gate}}$$

  - Smaller values of PSD correspond to faster scintillator pulse shapes.
- Selecting energy values from the population of smaller PSD values yields a spectrum for NaI(Tl) alone. We can see that there are three major peaks in the light curve *(Figure 2.3)*. These peaks correspond to Ba-133's most common energy levels [3]:
  - 30 keV
  - 81 keV
  - 356 keV
- Sorted waveform data is used to plot the average waveform at the energy parameters for the desired scintillator *(Figure 2.4)*.

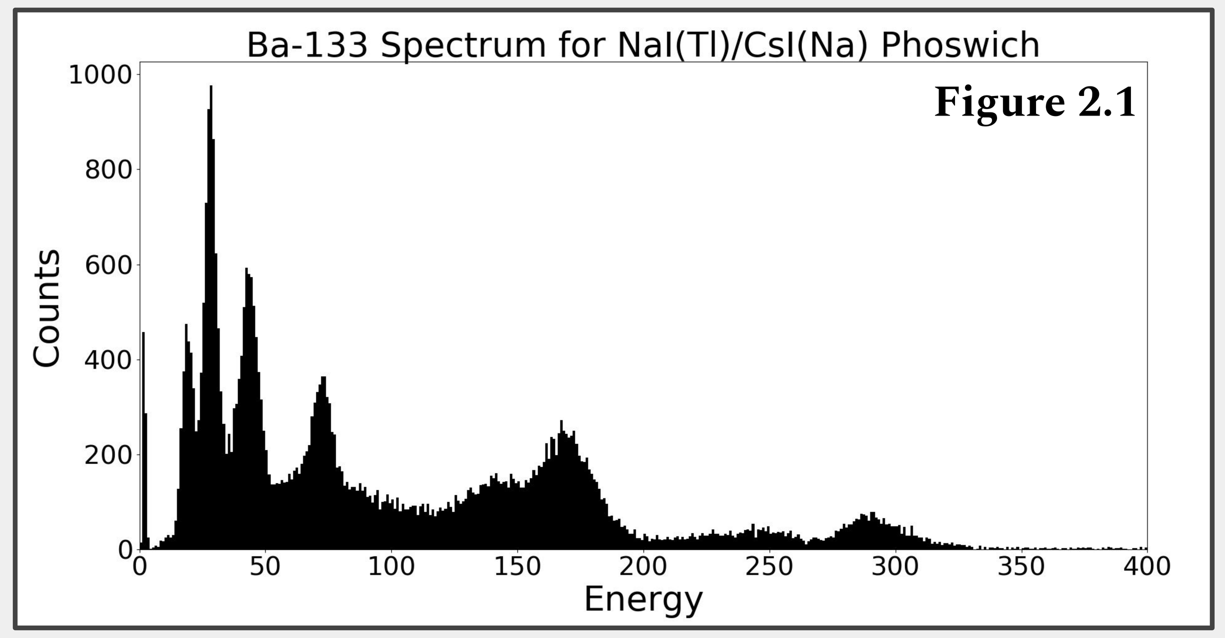



**Figure 2.1**

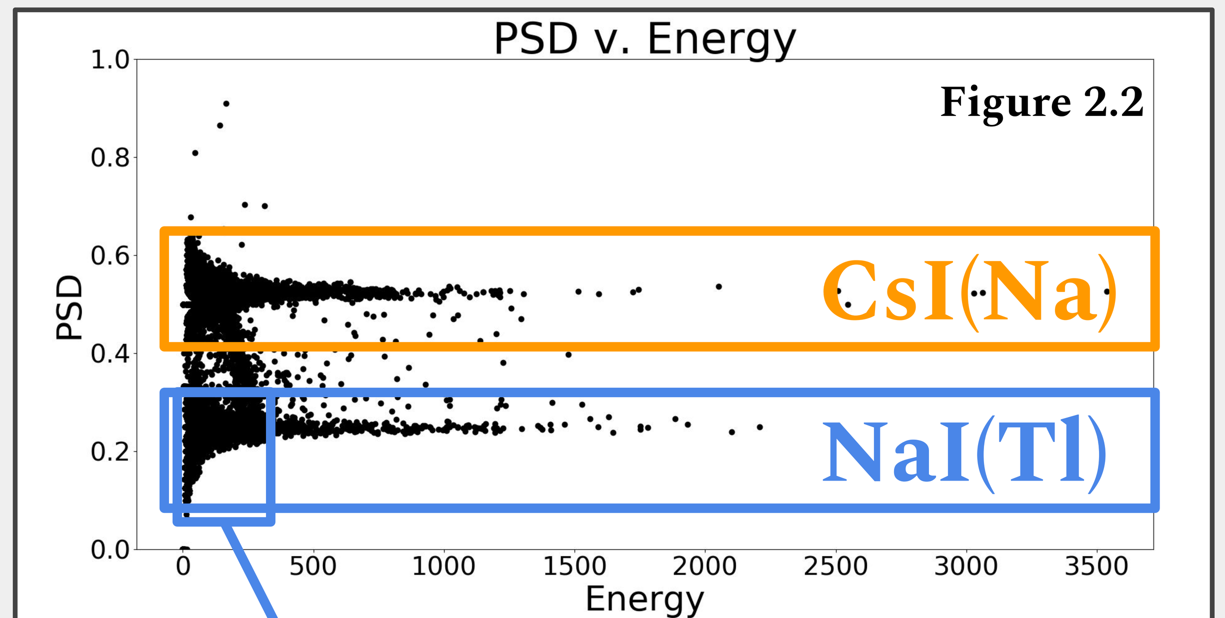



**Figure 2.2**

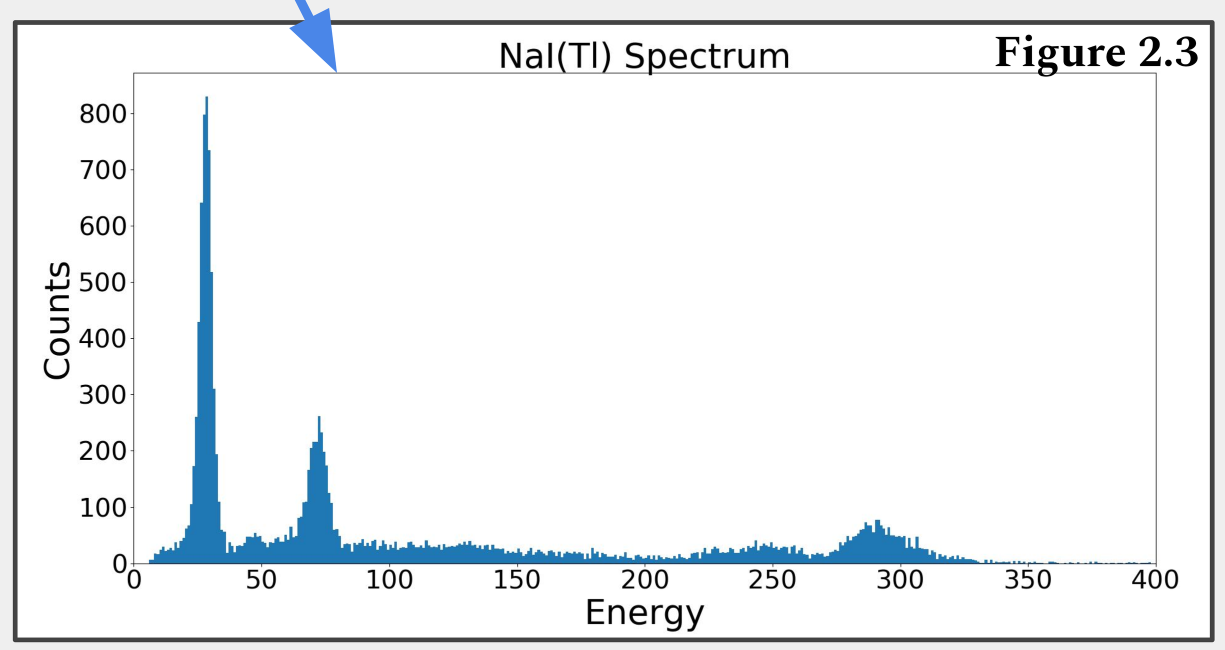



**Figure 2.3**

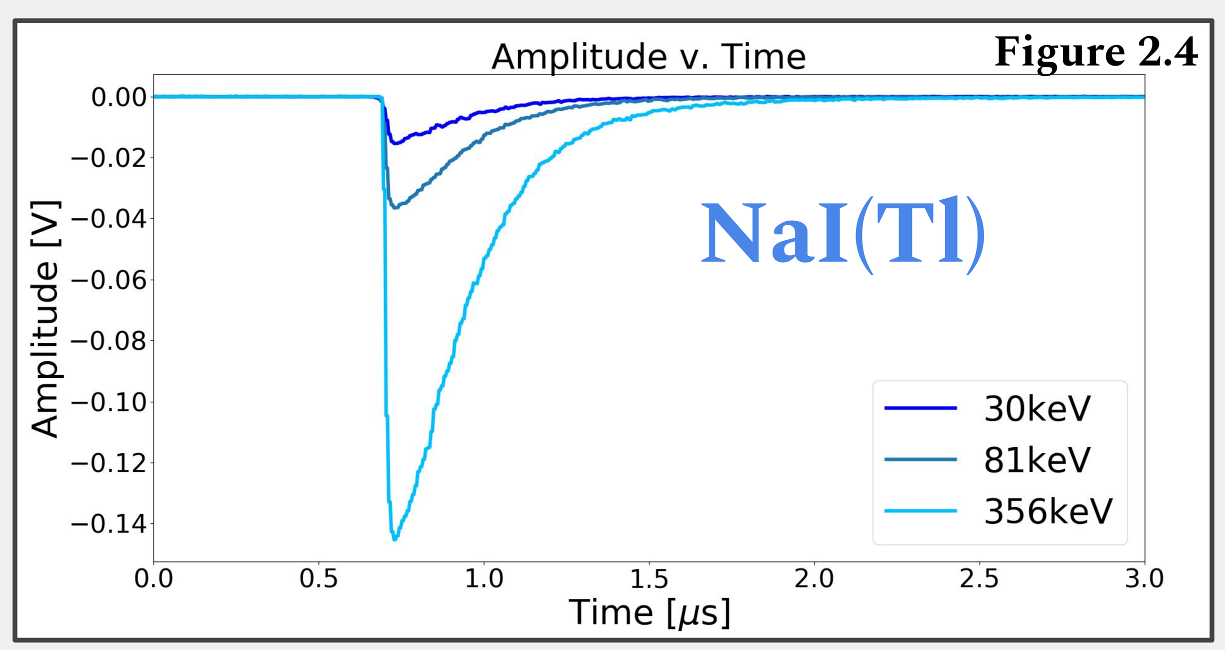



**Figure 2.4**

## RESULTS & CONCLUSIONS

- We can compare the waveforms of the different scintillators at the same energy to estimate the minimum energy thresholds *(Figure 3)*.
- For instance, since CsI(Na) has a lower peak amplitude than NaI(Tl) at the same energy, only NaI(Tl) would register for a threshold set at the level of the blue line.
  - So, if we wanted to capture energy events higher than 0.05 V, a NaI(Tl) scintillator would be desired over CsI(Na).

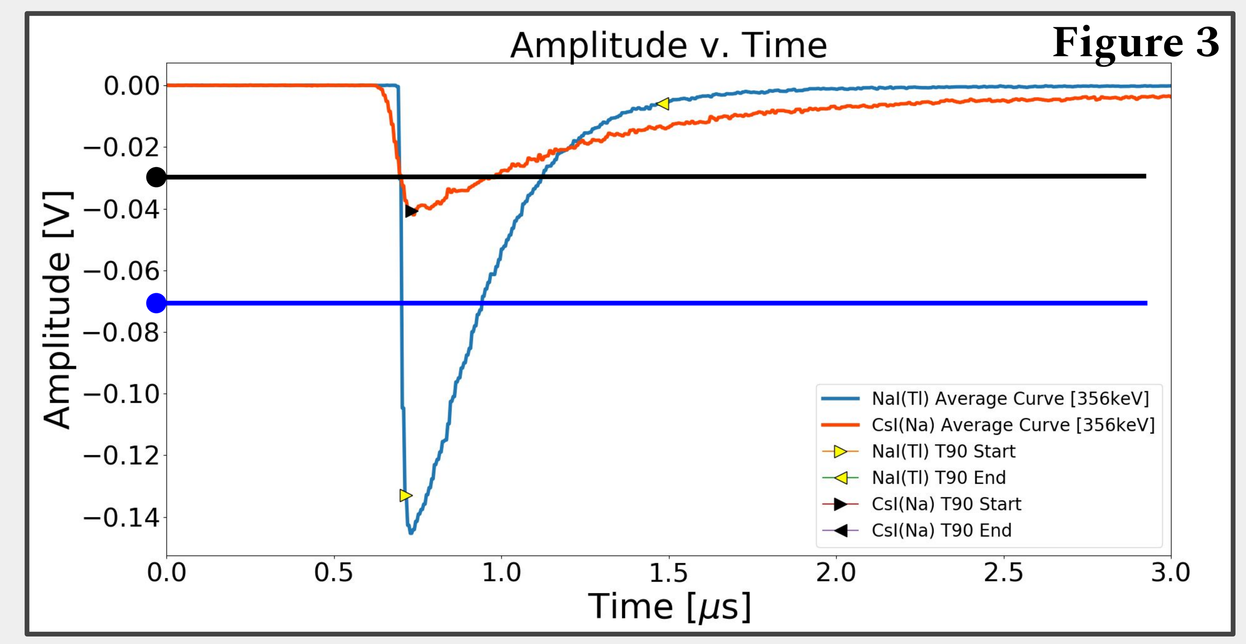



**Figure 3**

## CITATIONS

[1] G. Knoll, *Radiation Detection and Measurement*, 3rd ed., 2000.

[2] UM5960 - CoMPASS User Manual, Revision 14, CAEN, 2021.

[3] S.Y.F Chu et al., The Lund/LBNL Nuclear Data Search, ver. 2.0, 1999, http://nucleardata.nuclear.lu.se/toi/perchart.htm.

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