DAQ Stack

Coincidence Processor

For XIA Pixie16 Data Acquisition System

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Background

- A Gama ray detector has been bought by the MANDELAB in the physics department.
- This detector has been setup and development is underway to acquire the data coming from this detector setup as well as processing it for future experiments by the scientists.
- An experiment has been booked at iThemba labs in October in which this system will be used for data acquisition.
- This system will ultimately be used for the development of a PET scanner. For this reason, the system is needed to identify coincidence gamma ray data.

What has been done

- In the process of developing the prototype
- I have co-authored 2 research papers. 1 which has been accepted by the journal and is waiting to be published and another which has already been published and can be found at doi.org/10.1007/s10751-019-1607-6
- I have also discovered an issue with the PAASS-LC framework with respect to the way the XIA DAQ was writing data. I have submitted this issue to the PAASS-LC development team, and it has since been fixed in the current release

Prototype Design-Hardware

- Data coming from the scintillators are digitized by the XIA system, vie the Pixie-16.
- The DGF Pixie-16 is a 16-channel all-digital waveform acquisition and spectrometer card [2].
- These digitized signals are then interpreted by the XIA system.
  - Currently the system uses leading edge trigger for finding gamma events incident on the detector.
    - Leading edge triggering: This means that the time stamp of the event is logged when the signal crosses a specified threshold.
  - For this experiment sub-clock-tick timing precision is required.
  - For final version of the product we will need to implement a constant fraction discriminator (CFD) triggering algorithm, as described in [1].
    - For CFD triggering the processed signal is modelled by the CFD algorithm and the time stamp is taken where the model crosses the zero-point amplitude

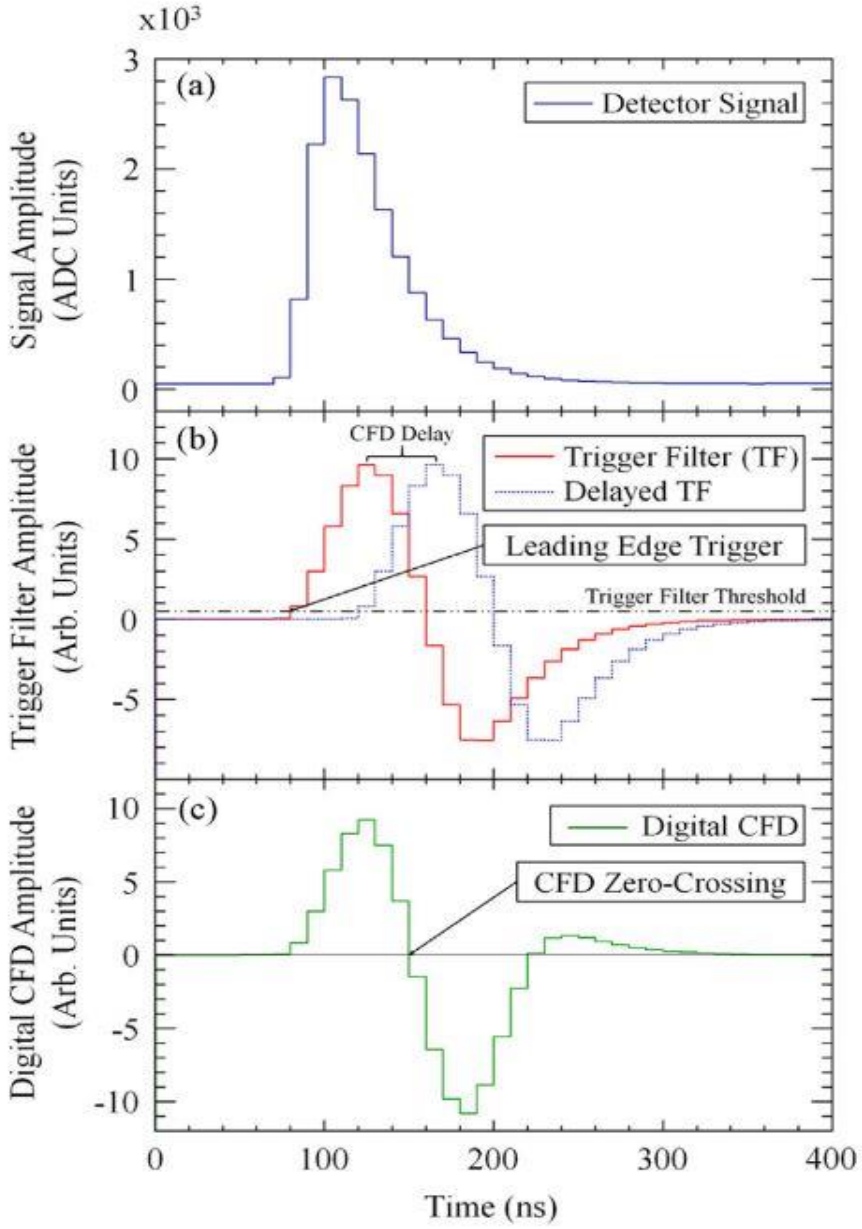


Fig1: Example illustrating DDAS triggering [1].

Prototype Design Software

- Only the processing code has been developed.
- Less emphasis has been placed on timing as leading-edge triggering has been chosen for its ease of use.
- A processor code has been built and implemented within the PAASS-LC framework which reads events recorded by the XIA DAQ it then generates spectrograms for the left (Fig2) and right (Fig3) detectors.
- It also generates a Coincidence spectrogram (Fig 4) using a basic time window gate.
- This processor code works as a module inside of the PAASS-LC framework.
  - All properties required to compute Figures 2-4 are supplied by PAASS-LC in an event summary object.

Spectrograms

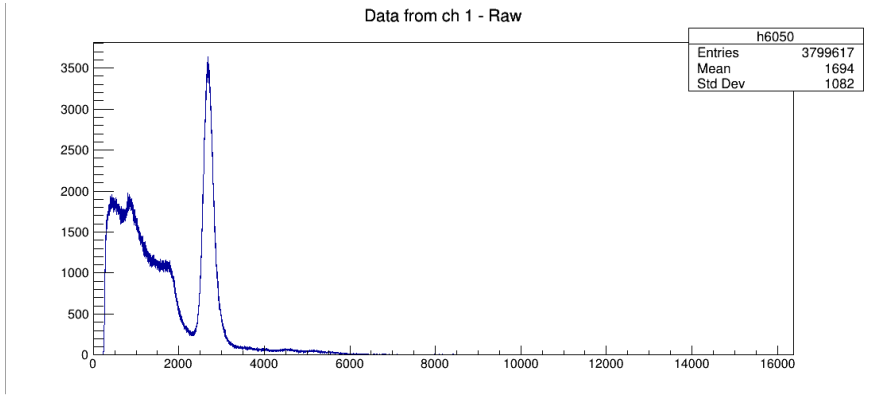


Fig 2: Raw Event counts from Ch1

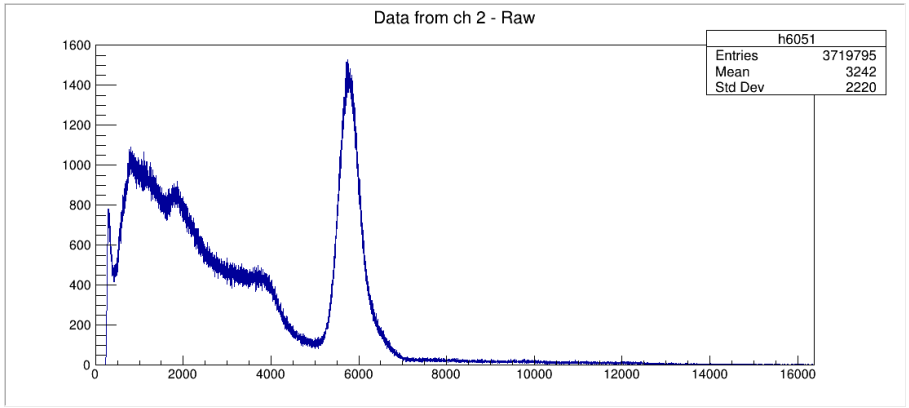


Fig 3: Raw Event counts from Ch1

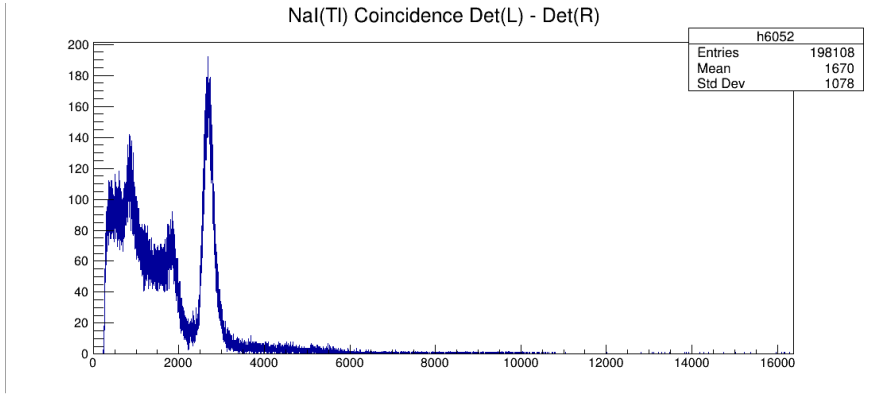


Fig 4: Processed Coincidence counts from Ch1 and ch2. Channel specified by Ch 1.

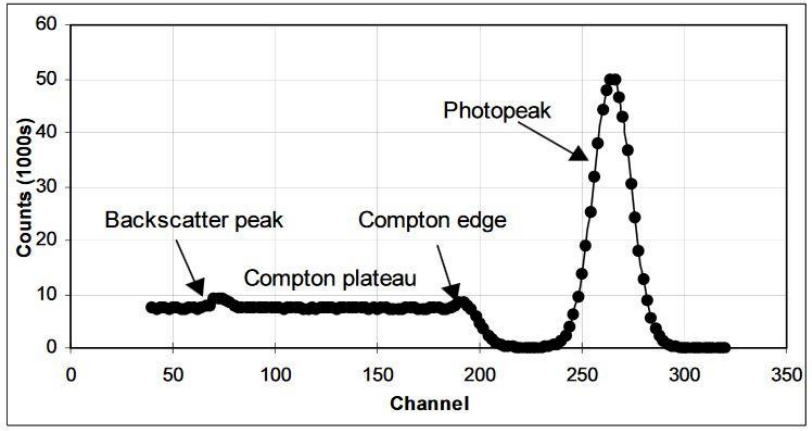
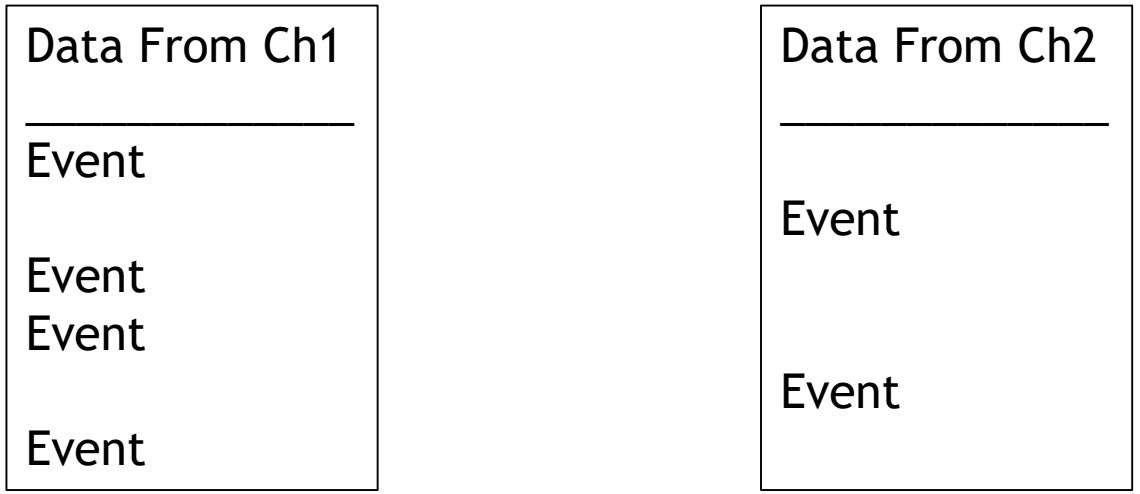


Fig 5: Parts of a gamma spectrum of A monochromatic gamma-ray source [3].

Algorithm

- Due to the sequential nature of the XIA DAQ only one event may be captured at a time this results in data being captured in a fashion such as:



- A While Loops goes Through both channels and checks if the first event's (oldest in time) are in coincidence, if they are both of the oldest events are removed. If not the oldest of the 2 are removed

Prototype

- What Is Working
  - Data can be read from the Gama detectors
  - Data is interpreted by PAASS-LC (Some What)
  - Coincidence code is complete
    - Can generate graphs which are viewed in root
    - Can also export data to a csv file to be processed by separate plotting software
      - For use with the DAQ Stack GUI

Final Product

- What needs to be done
  - The digital signal processing needs to be optimised
  - This optimization will allow for the use of high-resolution timing data to be extracted from traces.
  - Once reliable data can be extracted from the XIA system
    - Need to rewrite the Prototype coincidence processor to use this high-resolution timing data
    - Need to be able create the DAQ stack GUI
    - Will be a web UI that will allow you to upload a configuration file as well as a data file.
    - This data will be processed, and the response will be returned to the researcher.

References

- [1] http://dx.doi.org/10.1016/j.nima.2015.04.052
- [2] http://www.phys.utk.edu/expnuclear/LeRIBSS/Pixie16_UserManual1.0.6.pdf
- [3] https://www.phys.ufl.edu/courses/phy4803L/group_I/gamma_spec/gamspec.pdf