CRESST Data Analysis

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MPP

July 17, 2017

CRESST

Cryogenic **R**are **E**vent **S**earch with **S**uperconducting **T**hermometers

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- (Dark Matter) particle detection experiment
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- Detection by energy/heat deposition (Calorimeter/Bolometer)

CRESST Detectors - Modules

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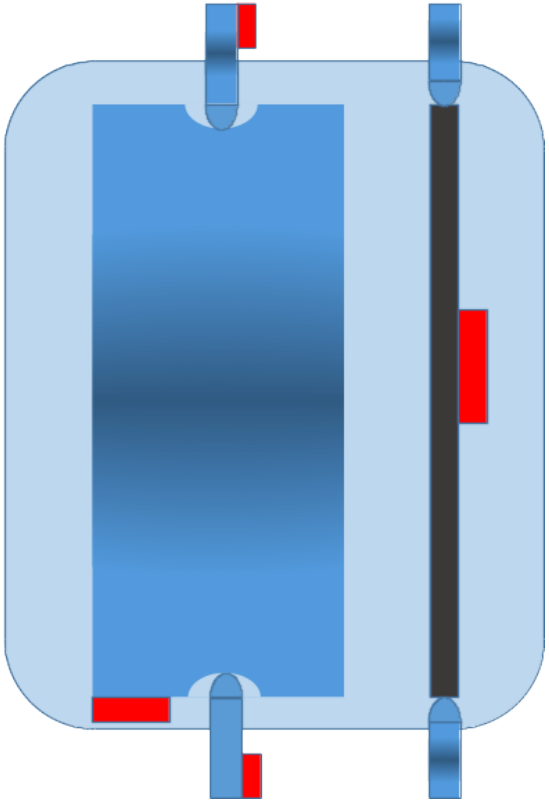

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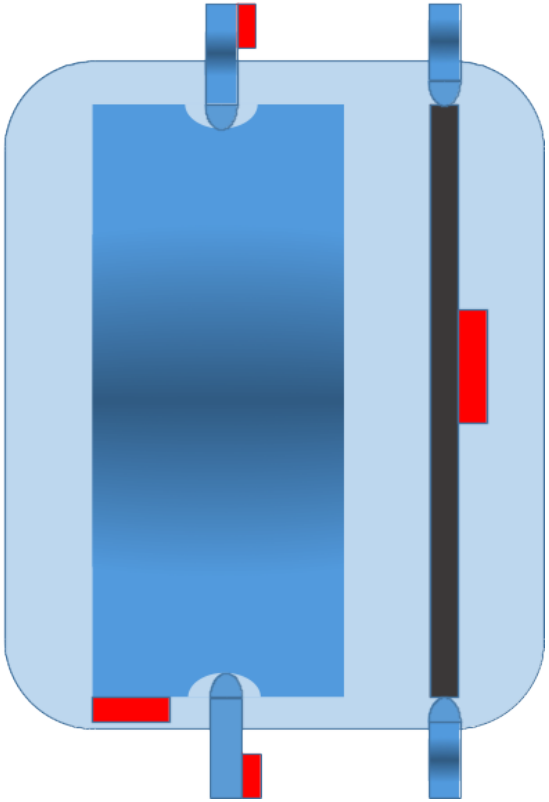

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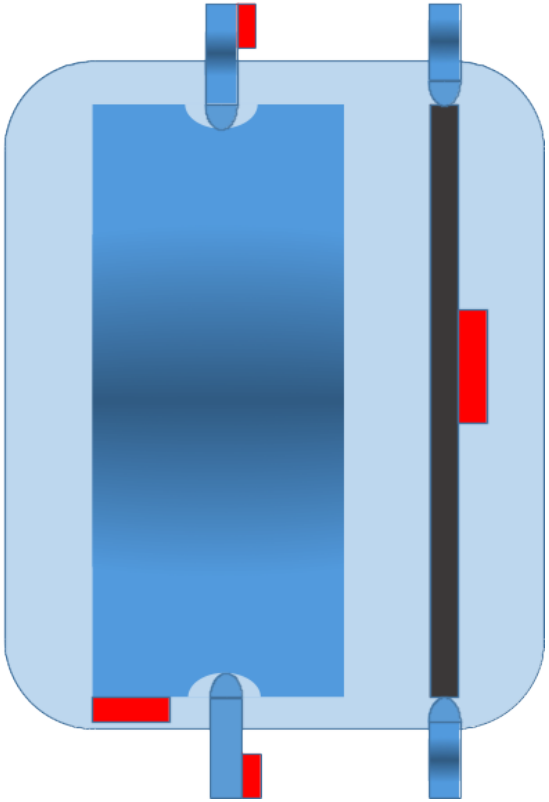

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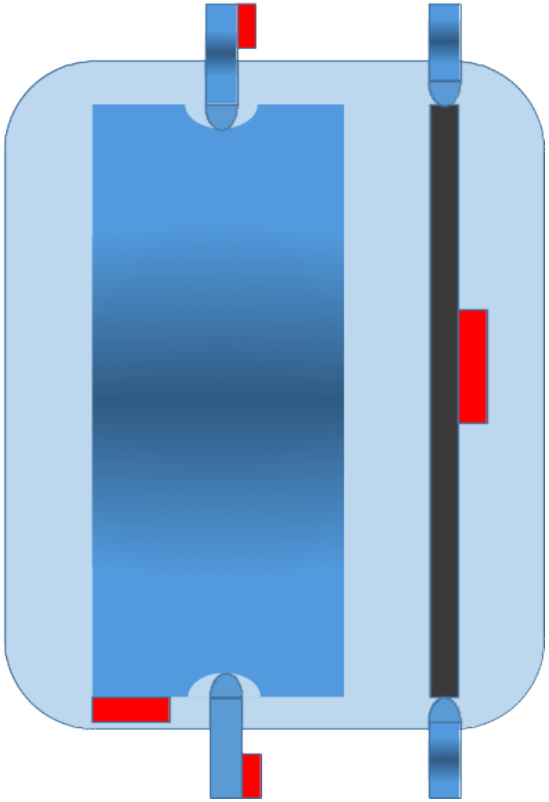

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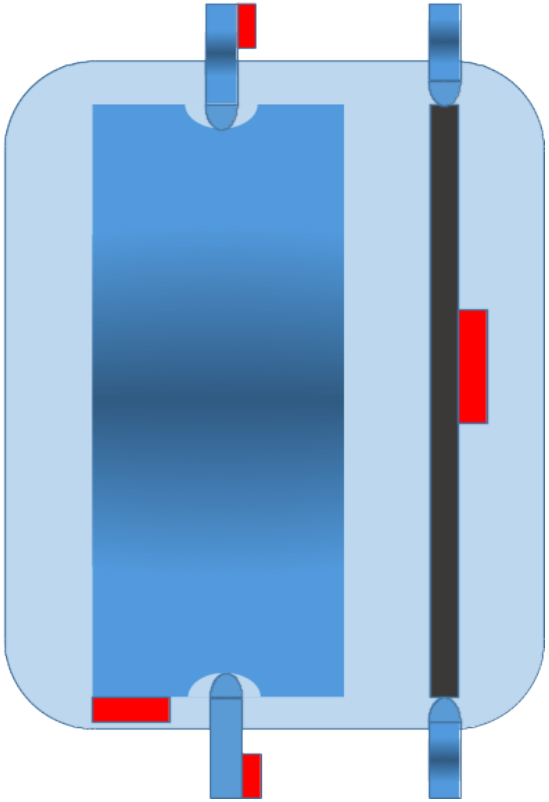

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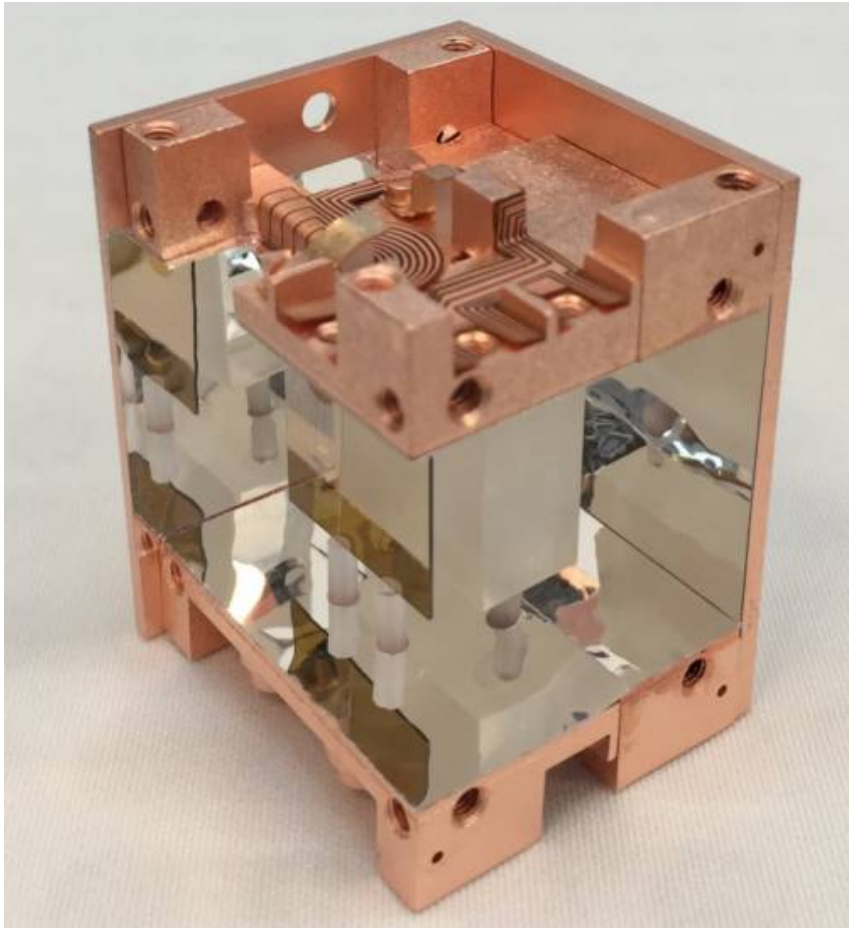

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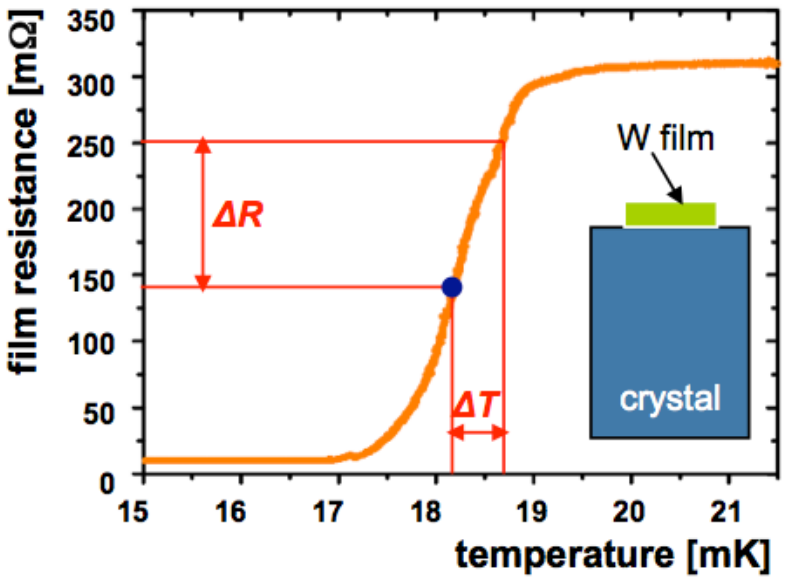

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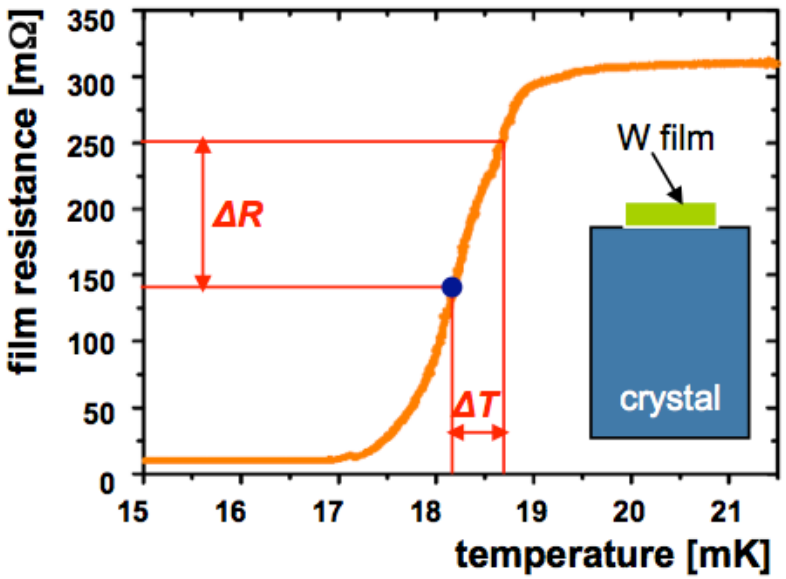

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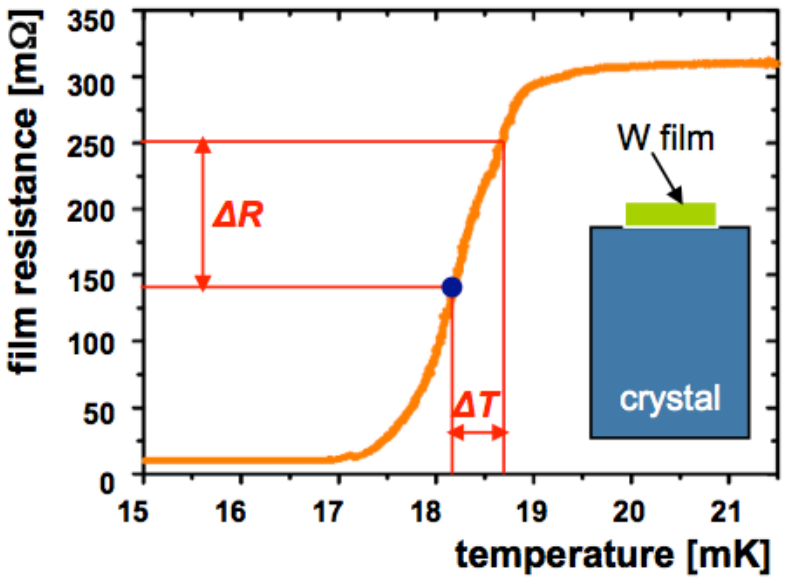

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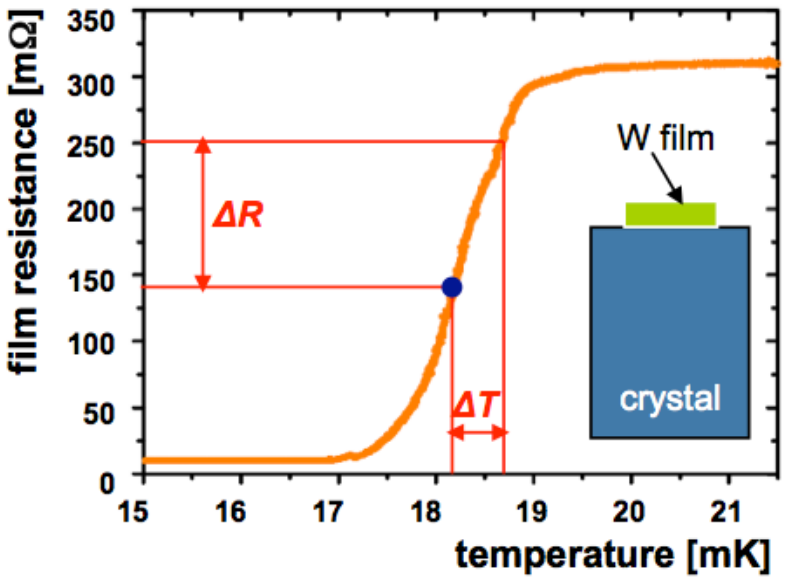

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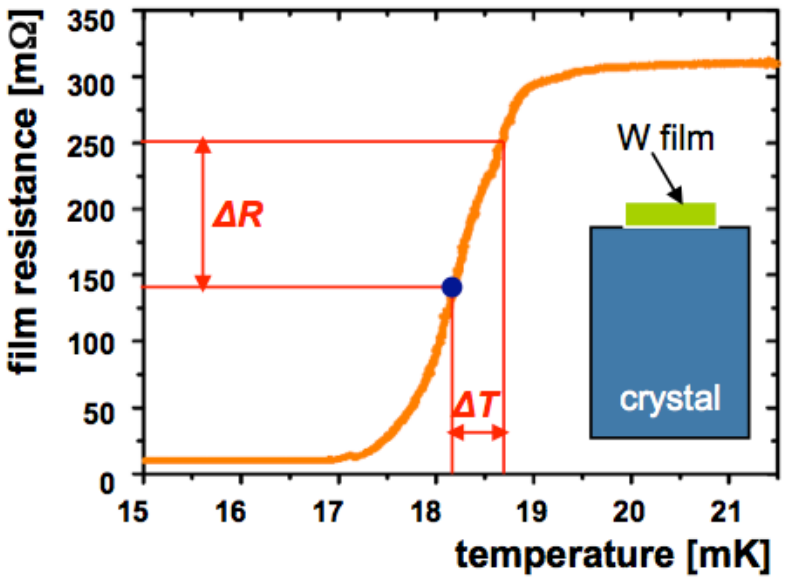

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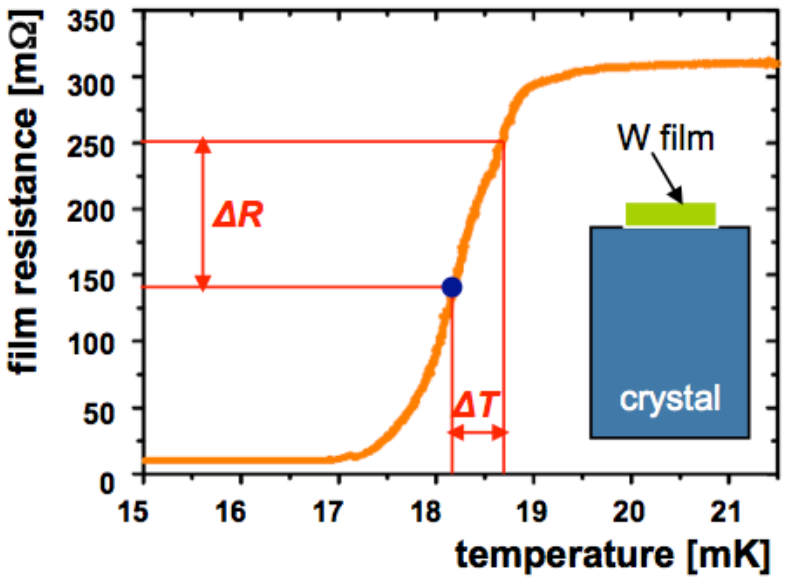

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- Limited linear and total dynamic range

Data shape

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- DAQ records the trace of triggered events

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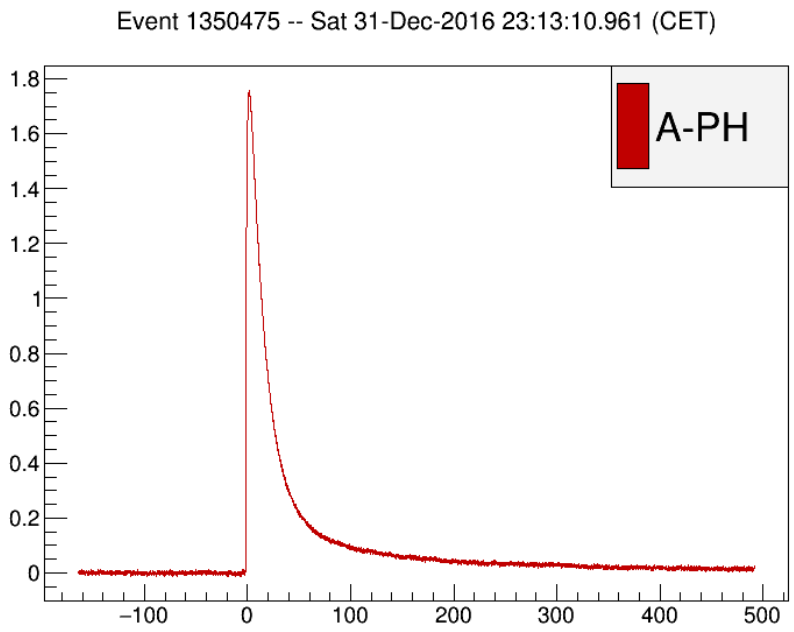

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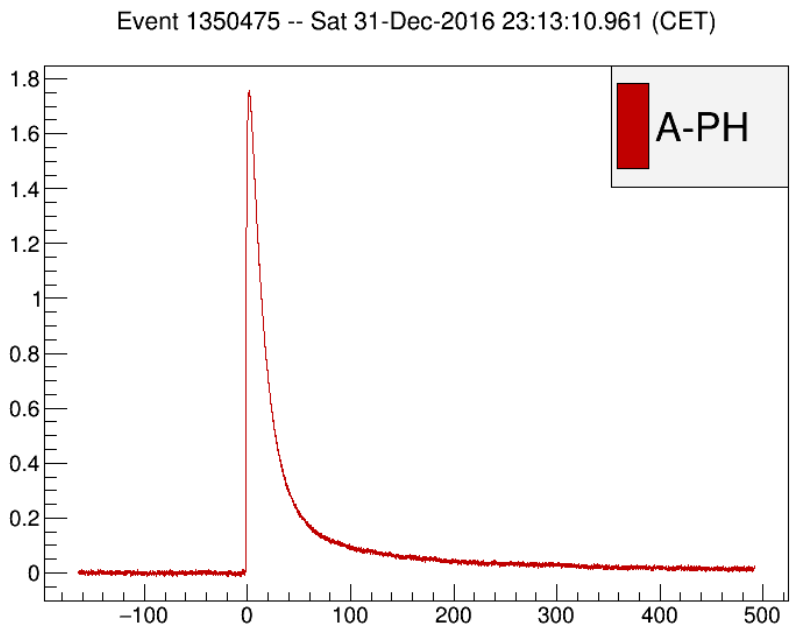

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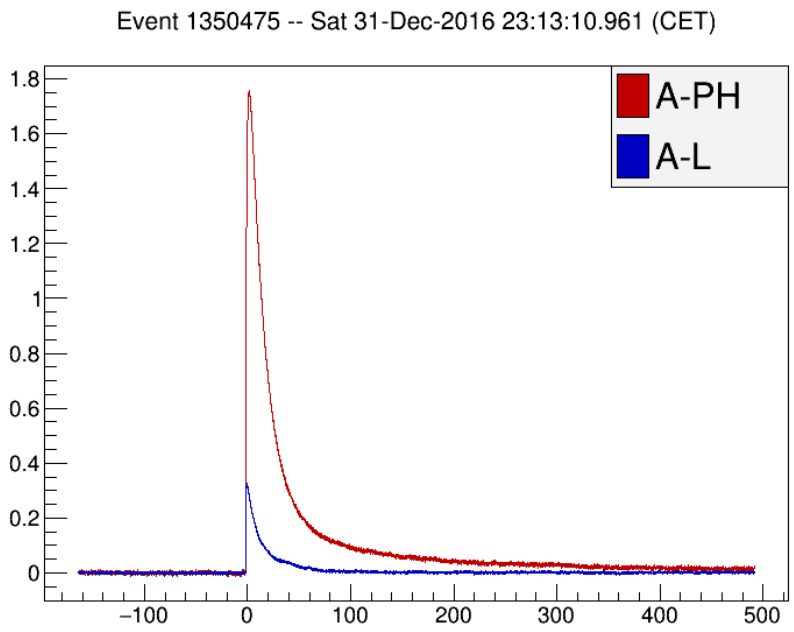

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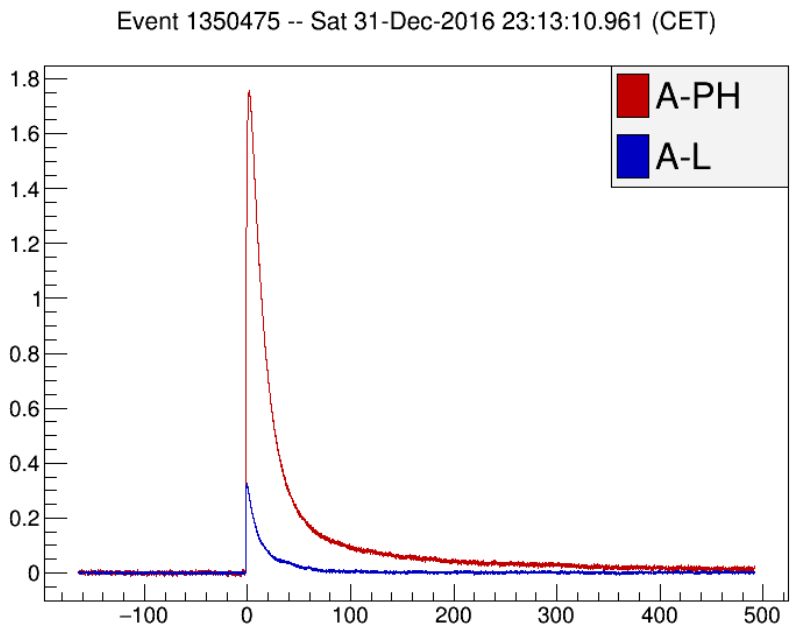

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- Two channels, phonon and light (2D information)
- Several parameters like pulse height, peak position etc. calculated

Two Channel Readout

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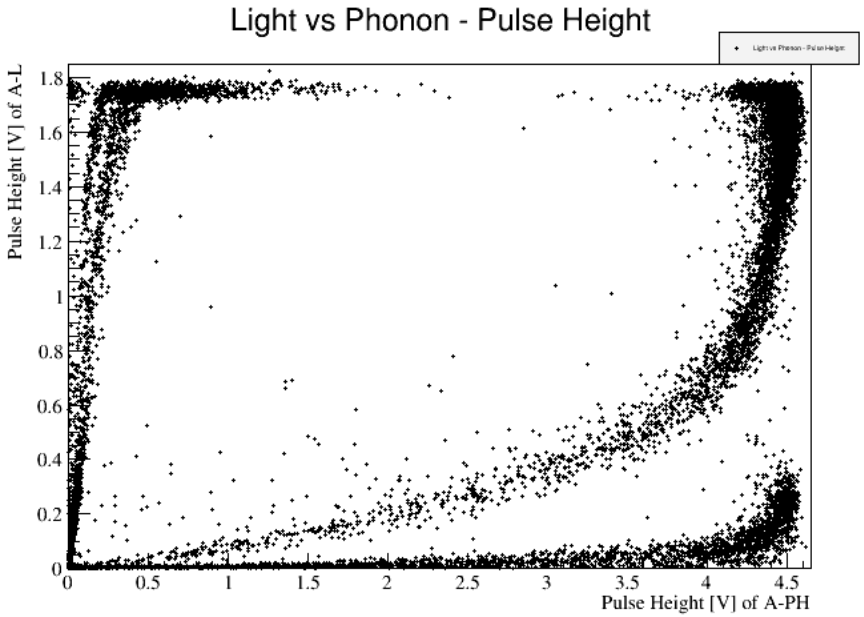

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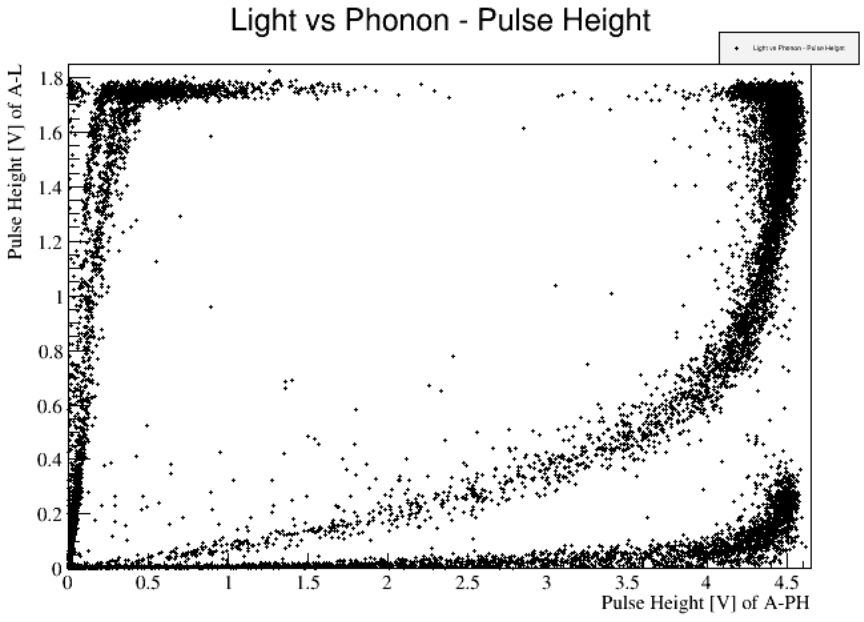

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- Different light output of specific event types leads to band structure

Cut types

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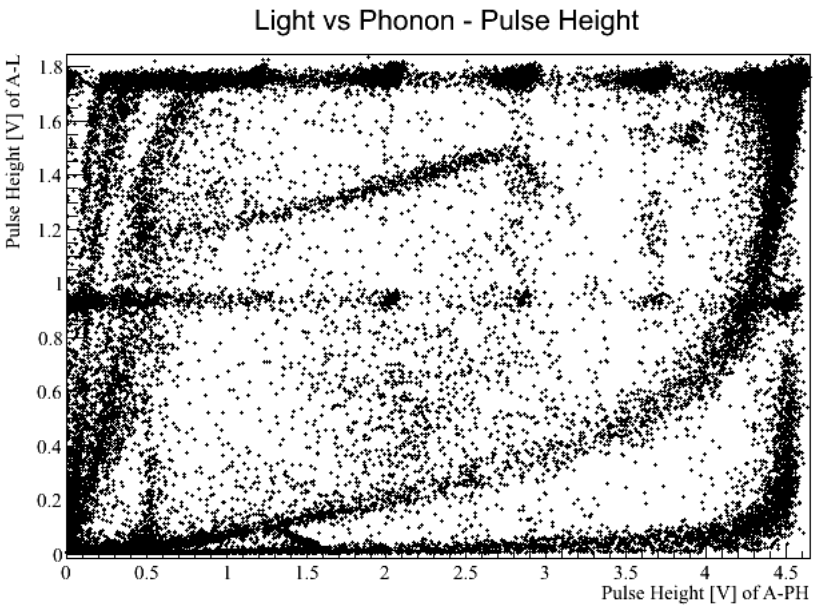
Background Cuts

They remove a certain type of background with an understood physical origin.

Event Distribution before Quality Cuts



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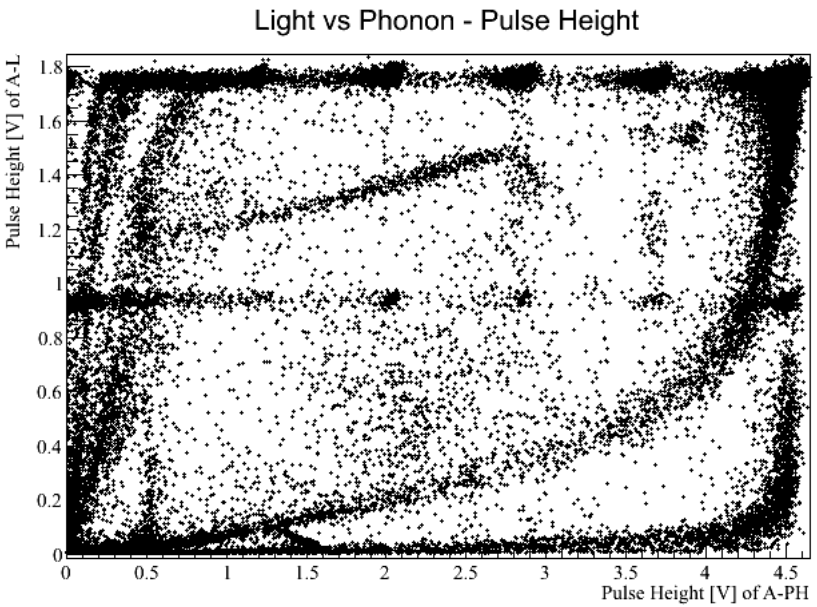

- Neutron Calibration Data

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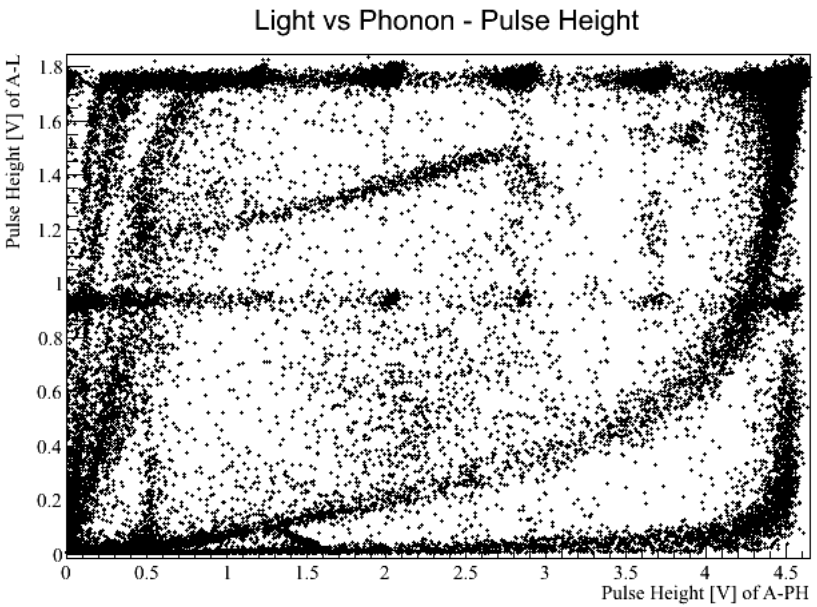

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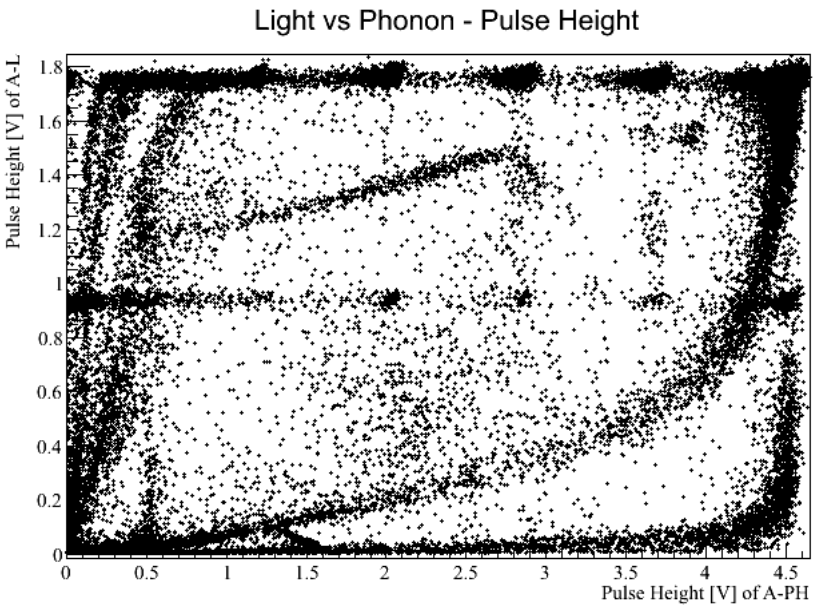

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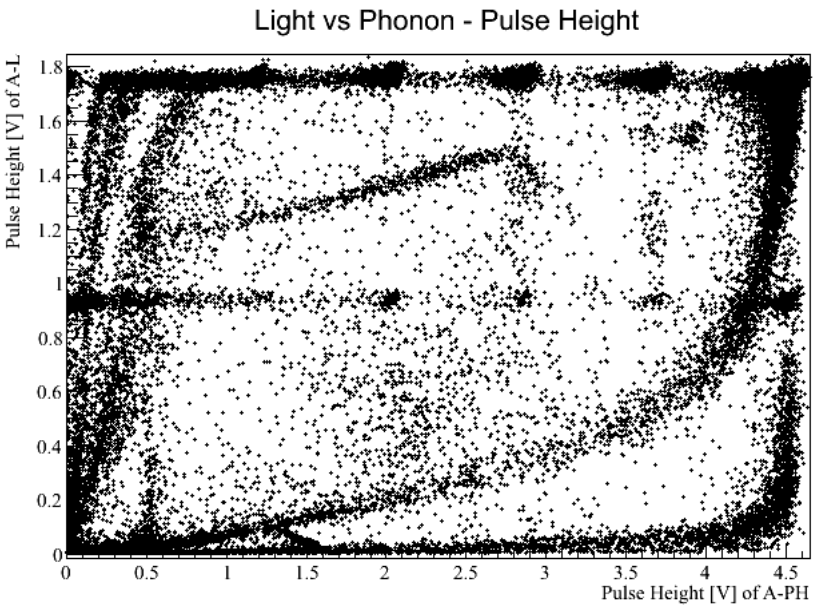

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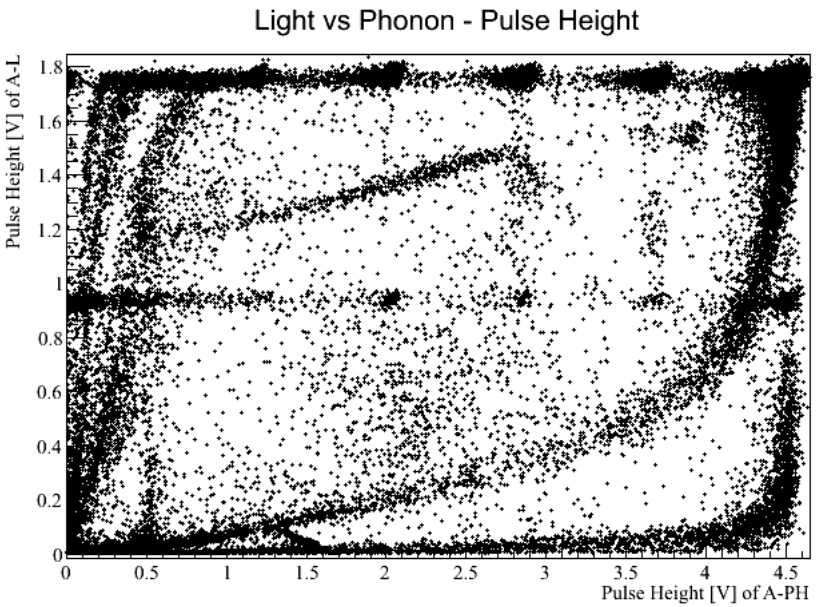

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Let's clean this up a little!

Example 1: Peak Position Cut

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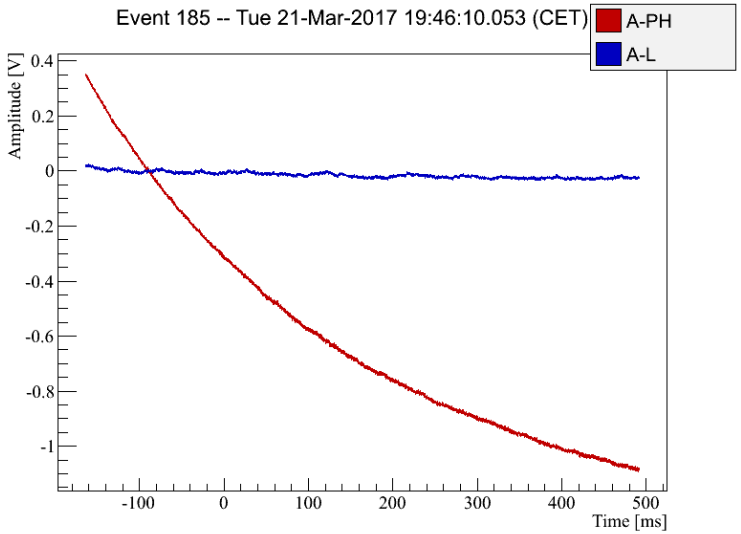

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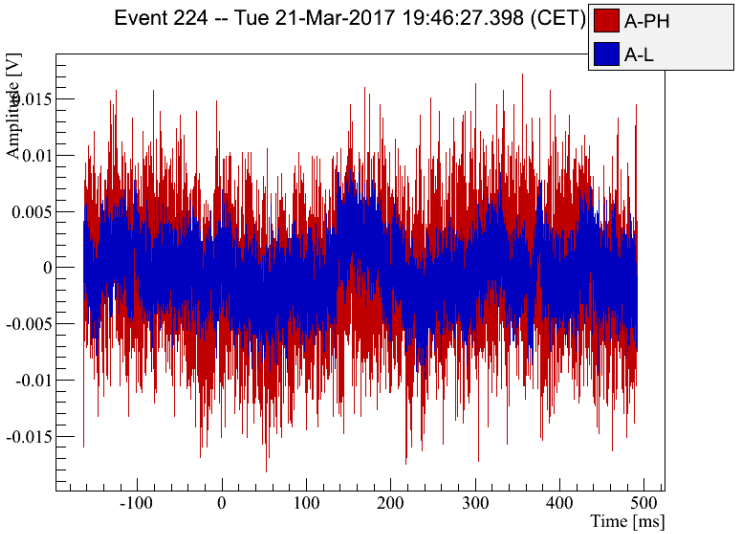

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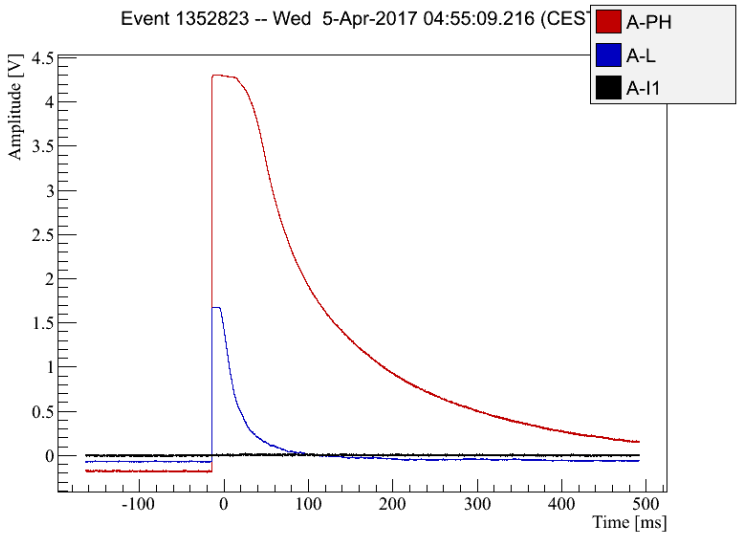

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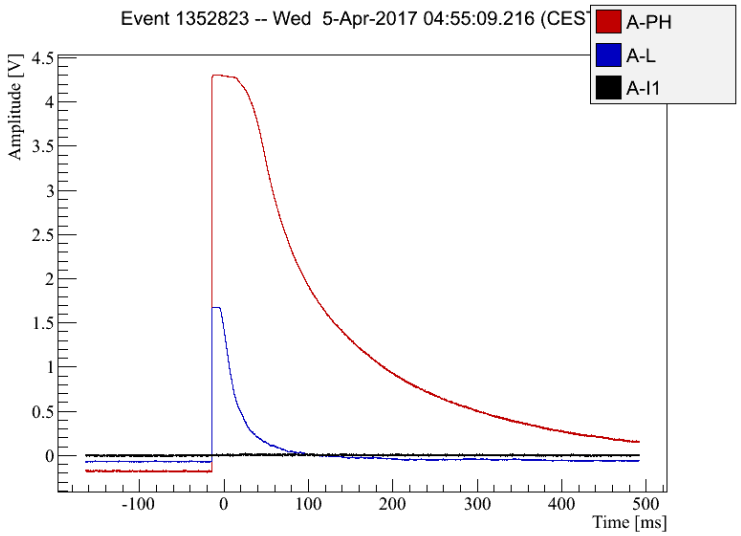

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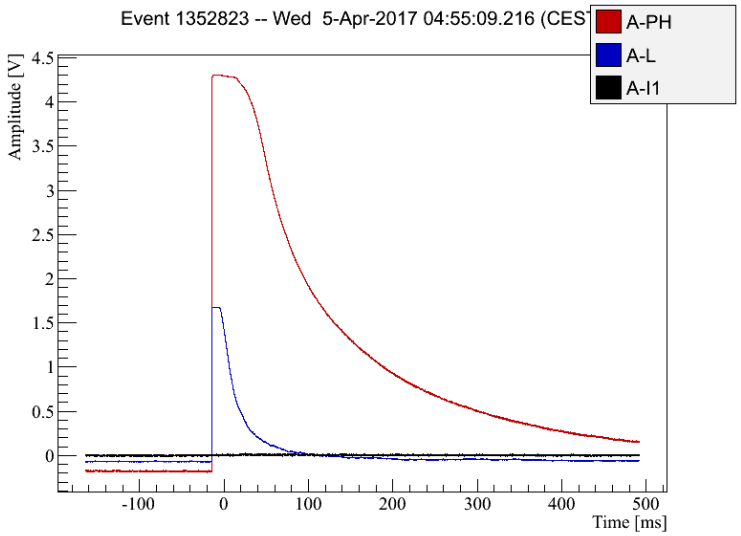

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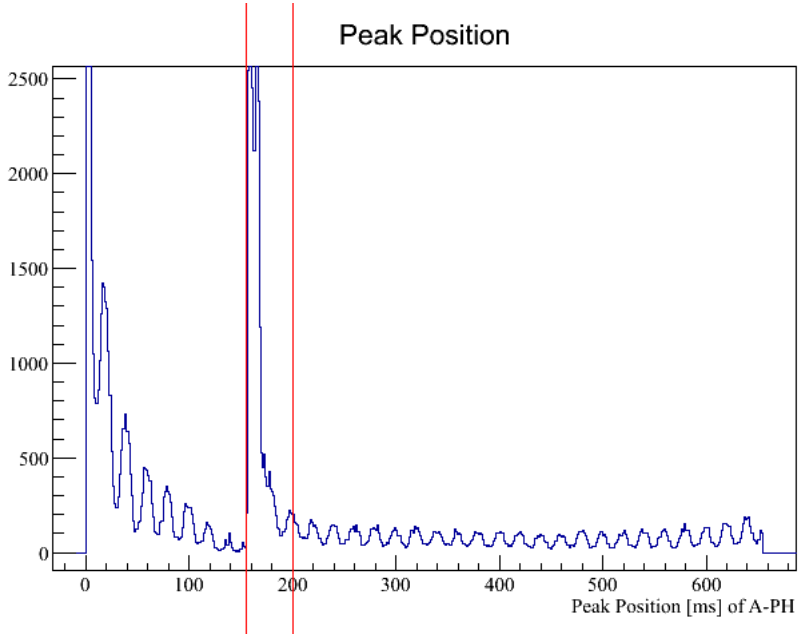

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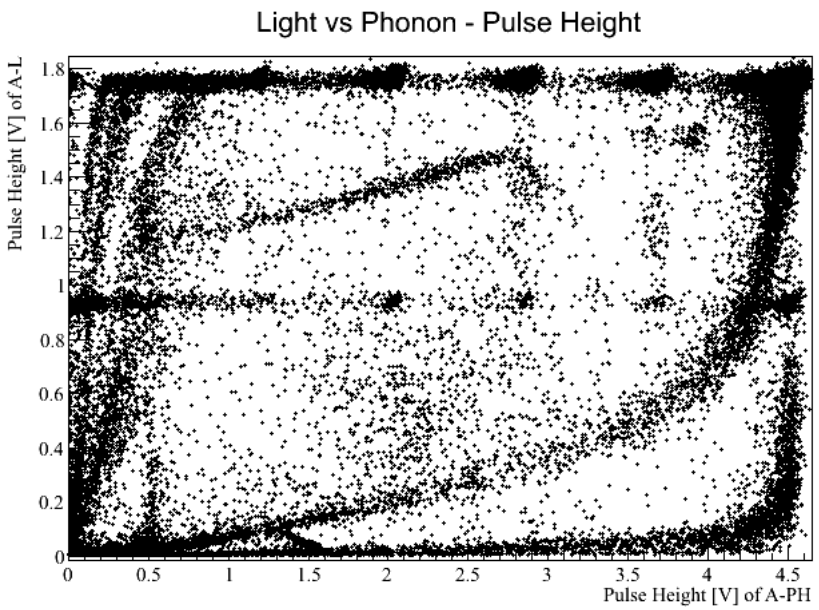

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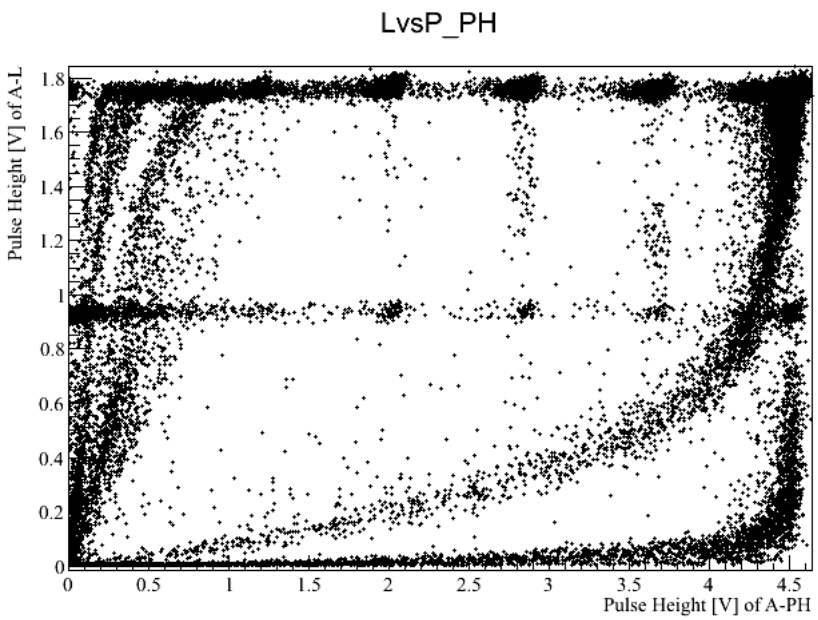

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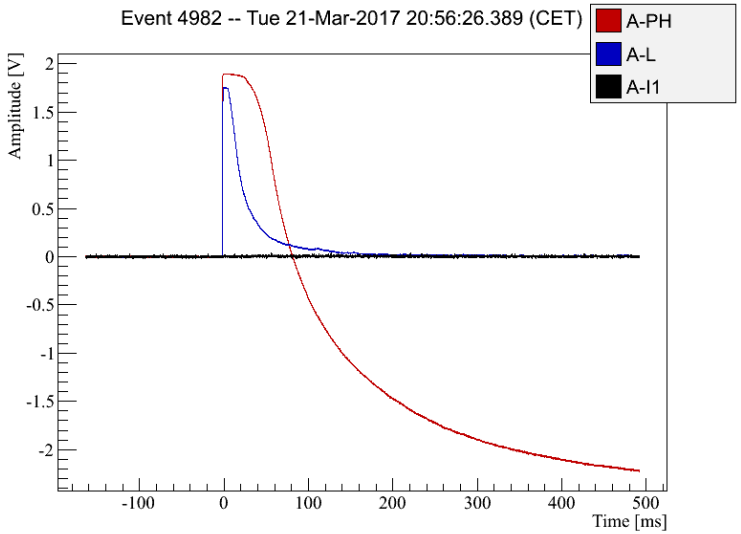

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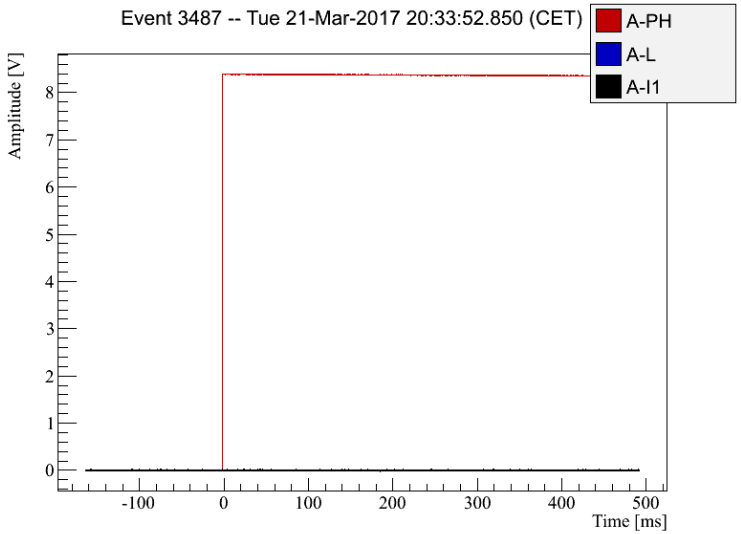

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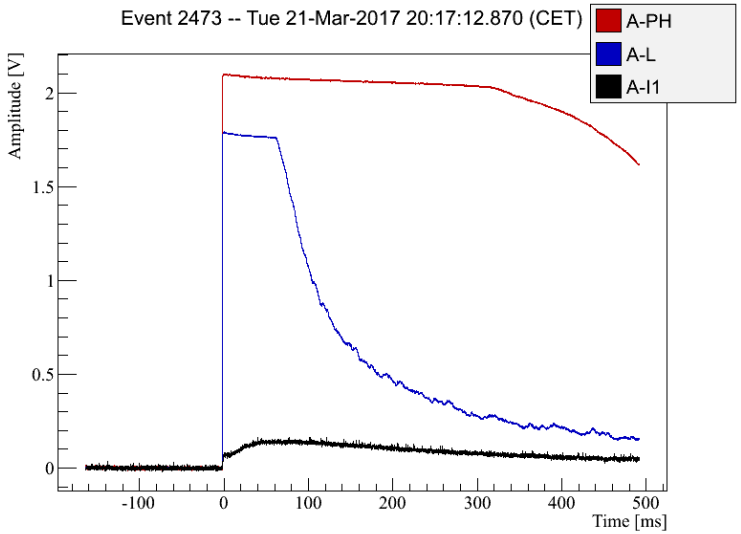

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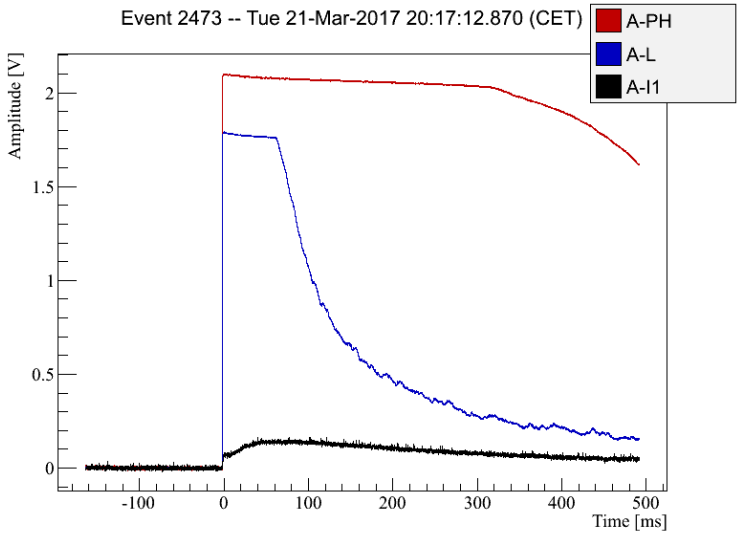

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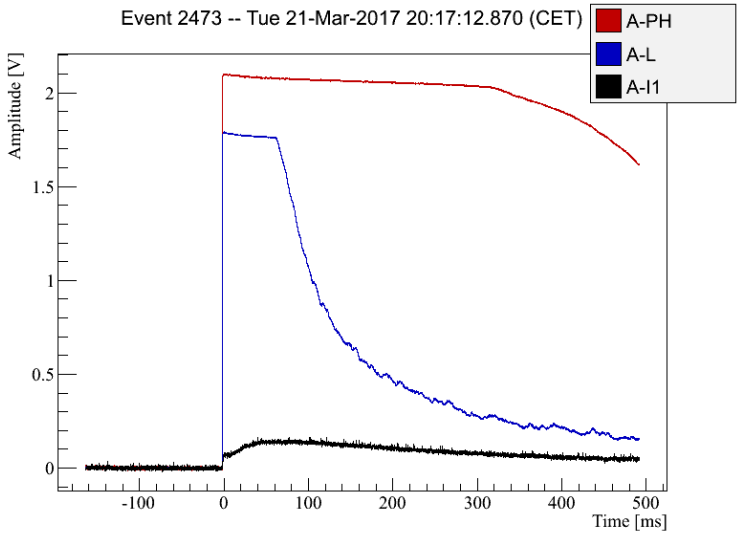

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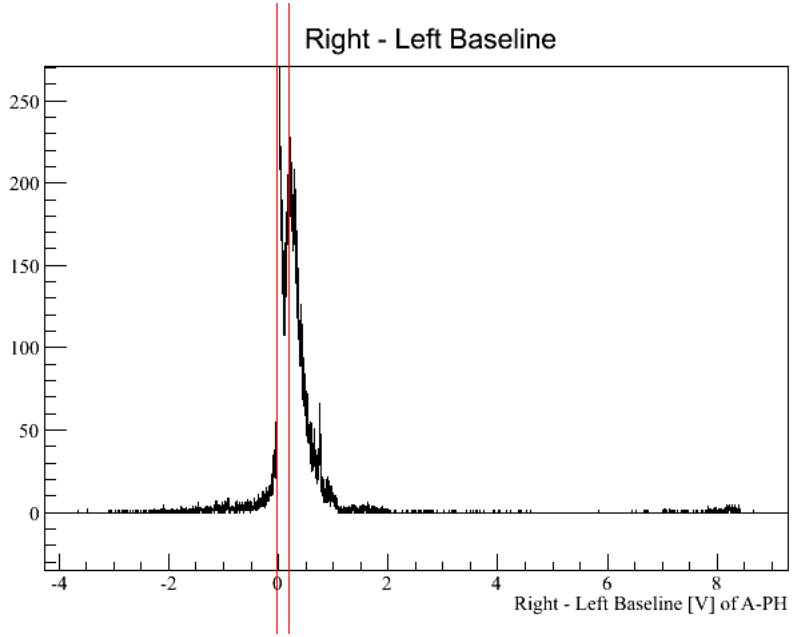

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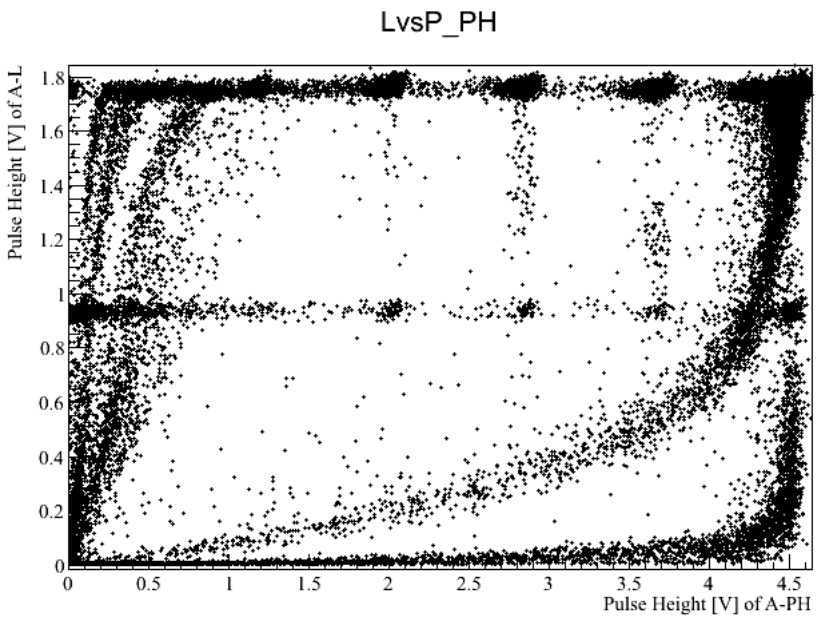

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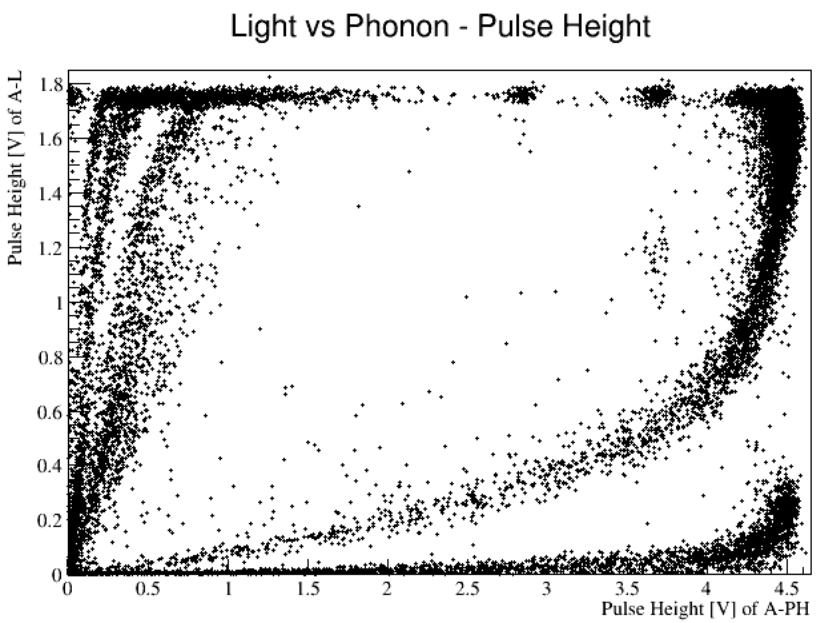

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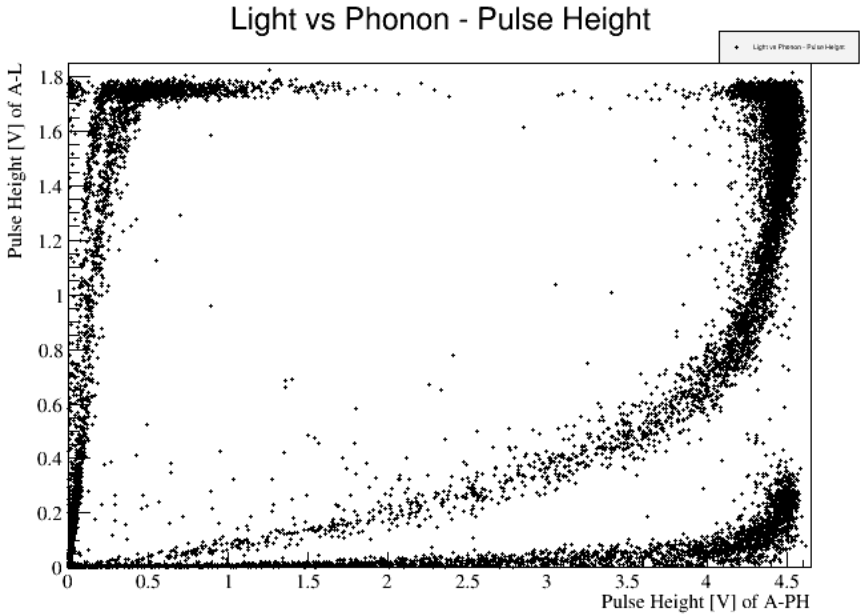

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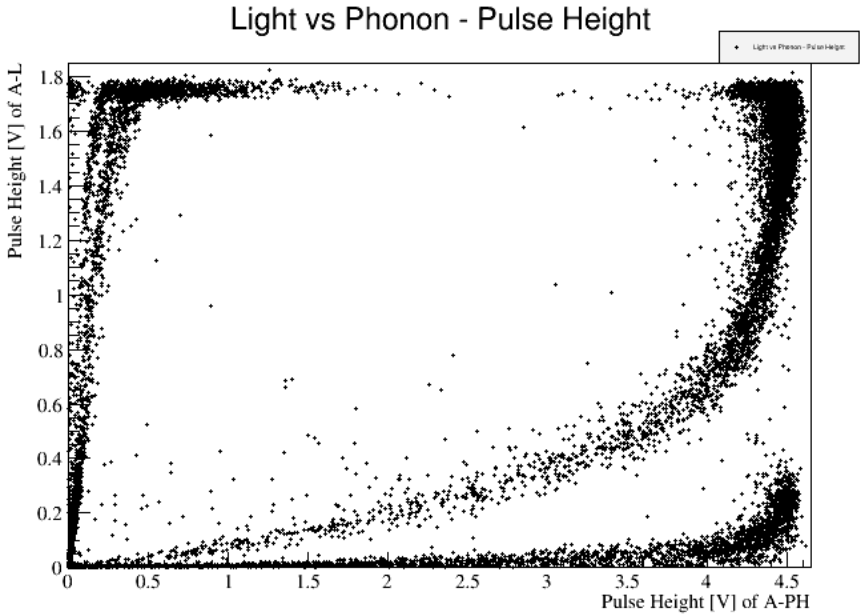

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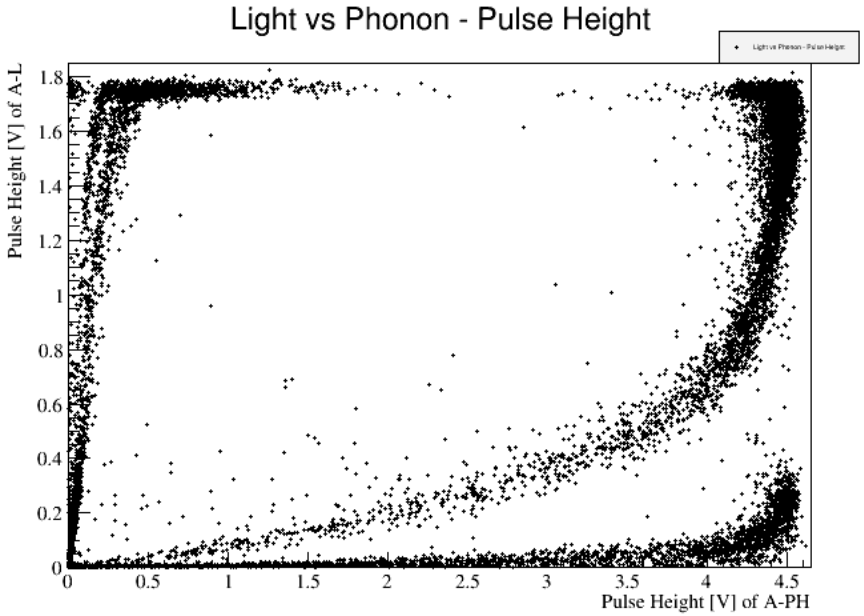

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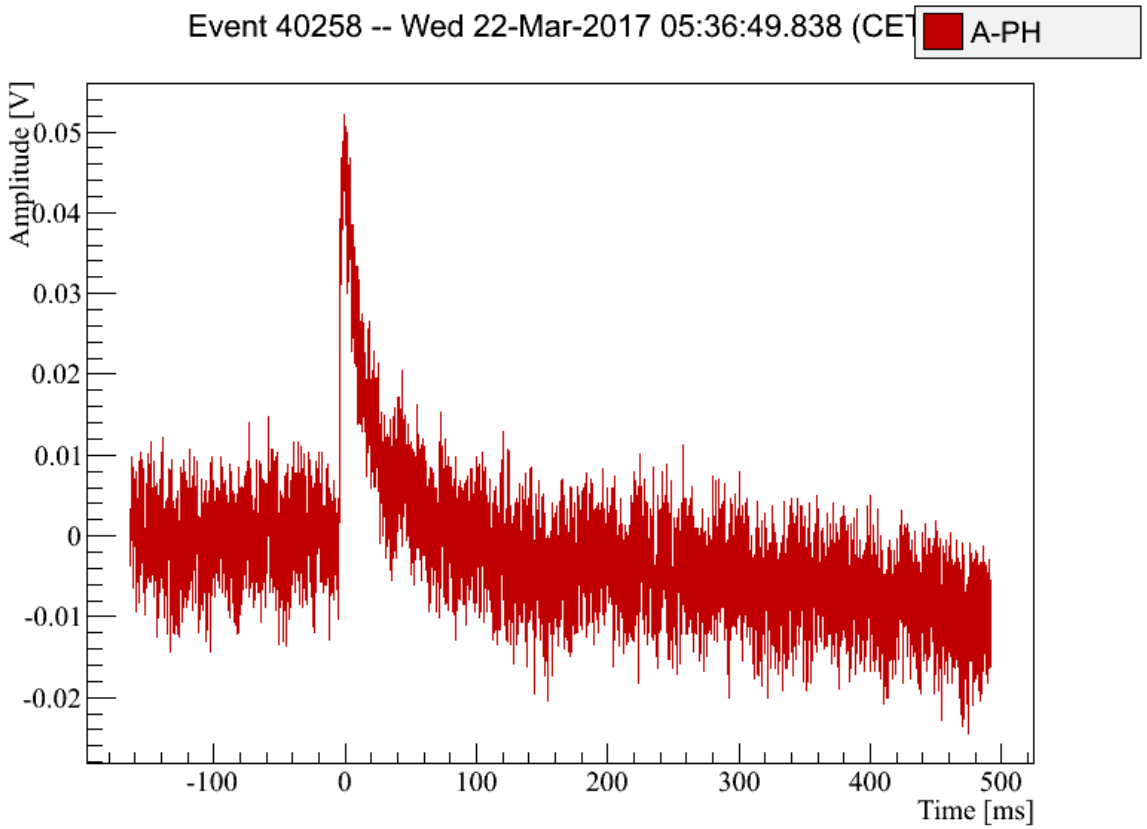

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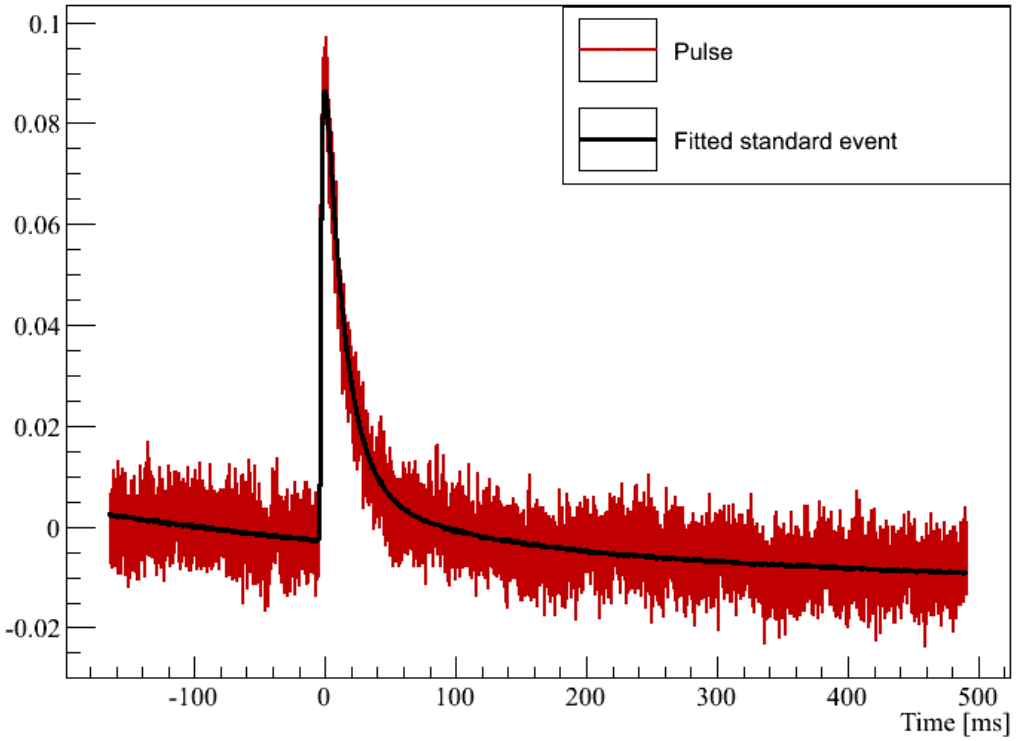

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High pulses exceed the linear range of the thermometer transition and therefore can only be fitted up to a certain truncation limit:

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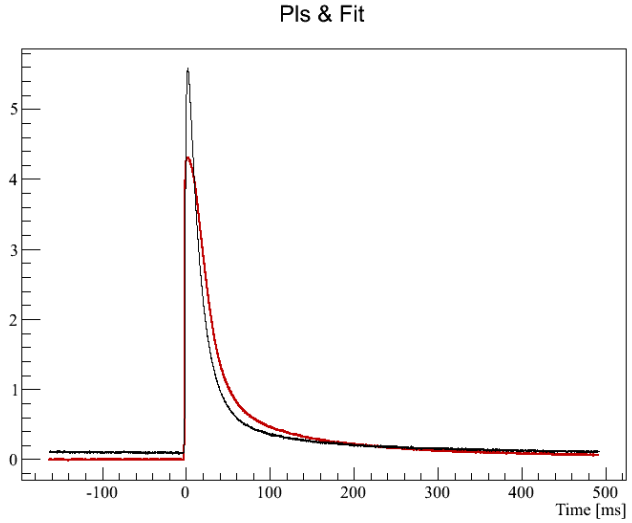

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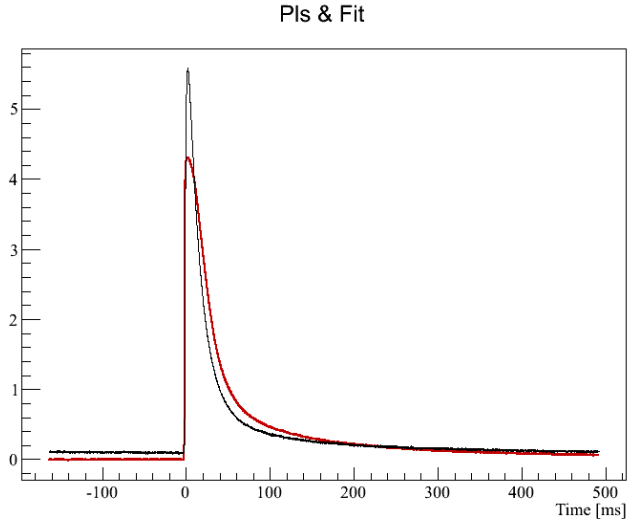

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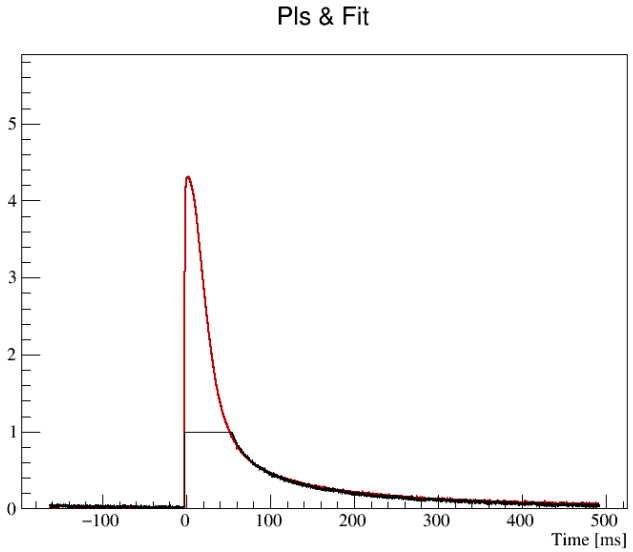

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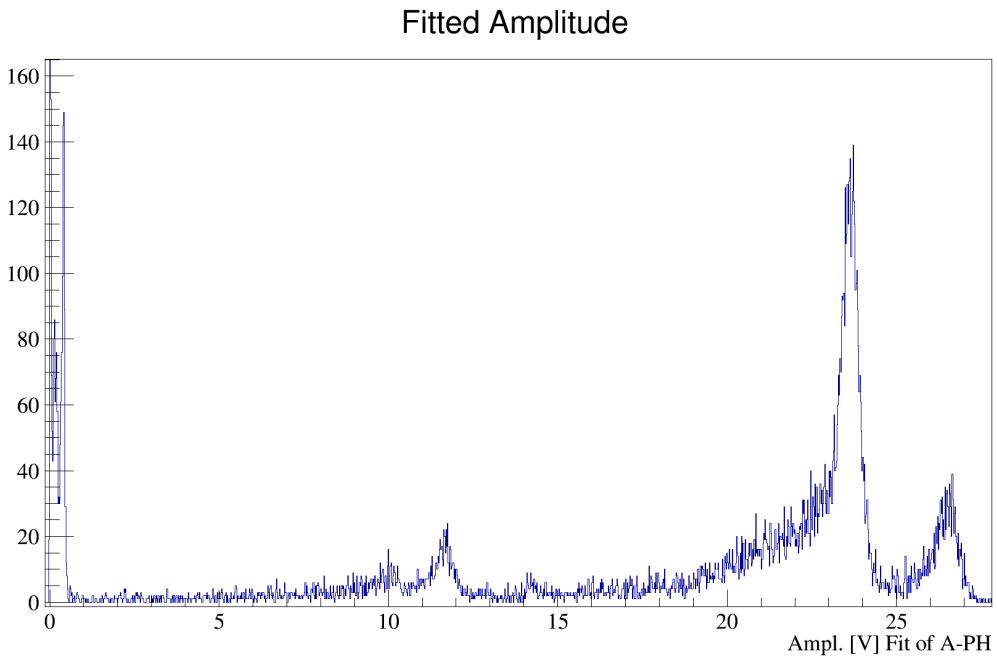


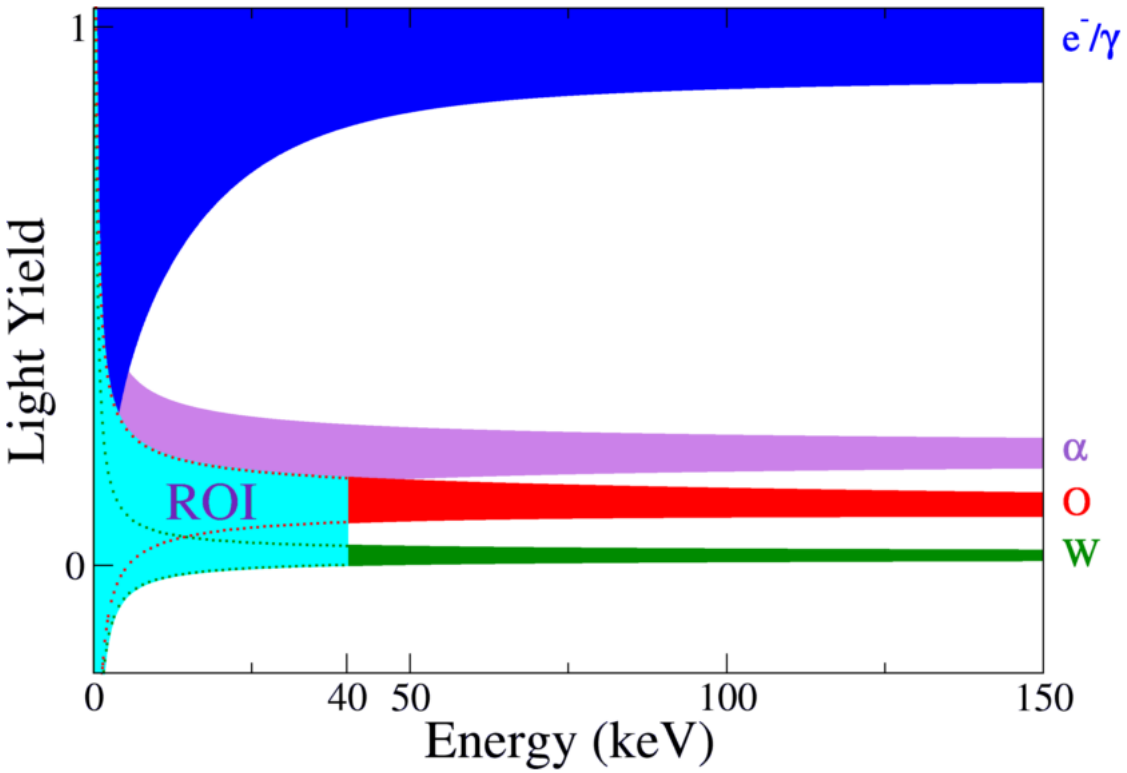
Light Yield

To exploit the phonon-light technique, typically our data is displayed in terms of **light yield** vs **energy**.

Light Yield

$$LY = \frac{E_{Light}}{E_{Phonon}}$$

Light Yield Plot and Region of Interest



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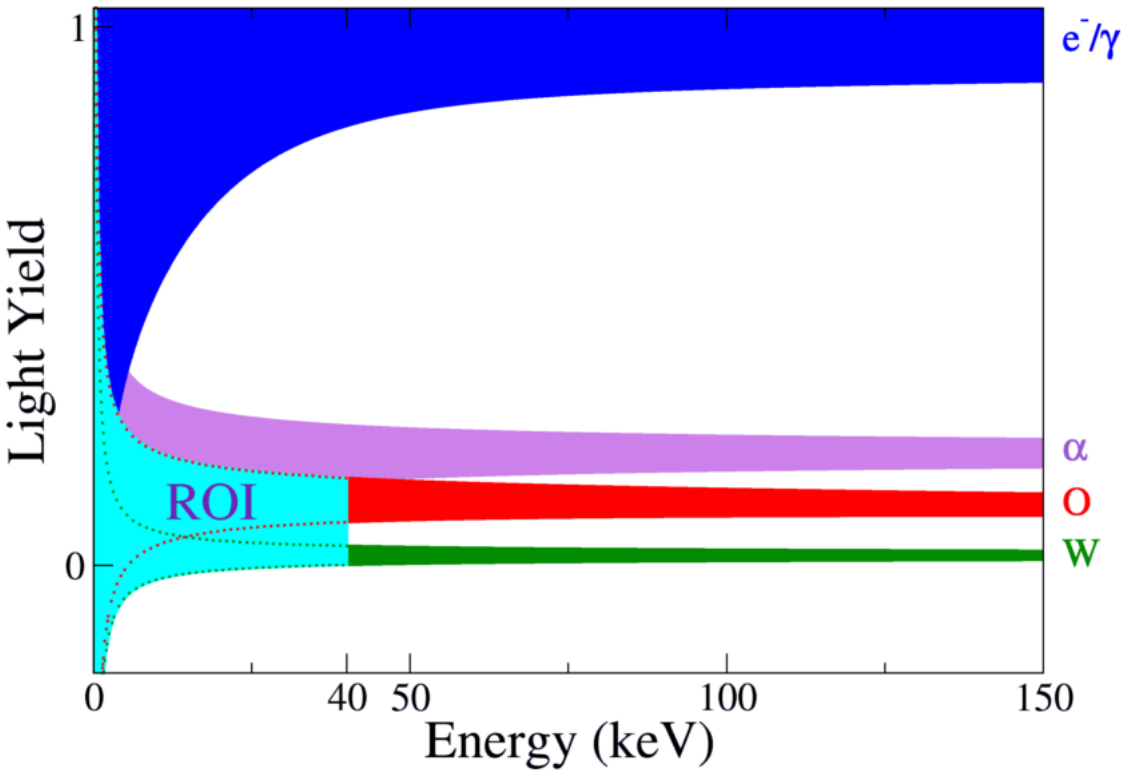

Dark matter recoils above threshold are expected only in the nuclear recoils bands.

Band Fit

A fit is used to determine the band positions and region of interest in the real data:

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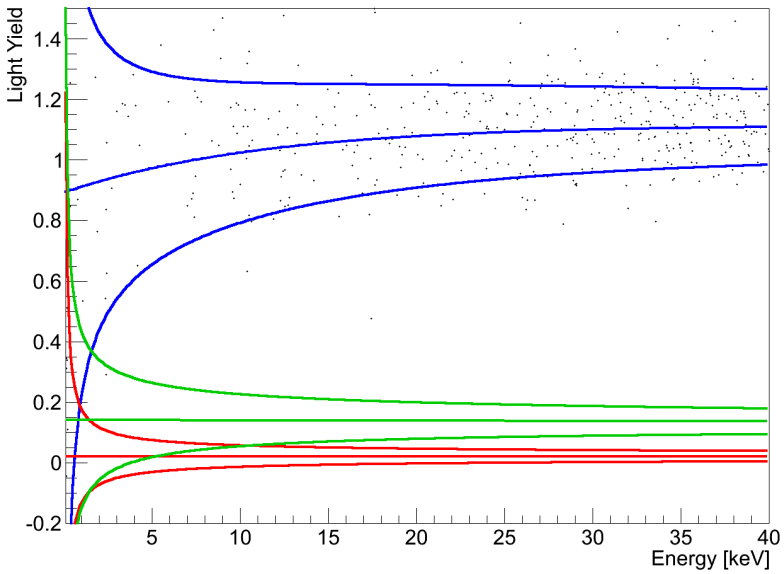

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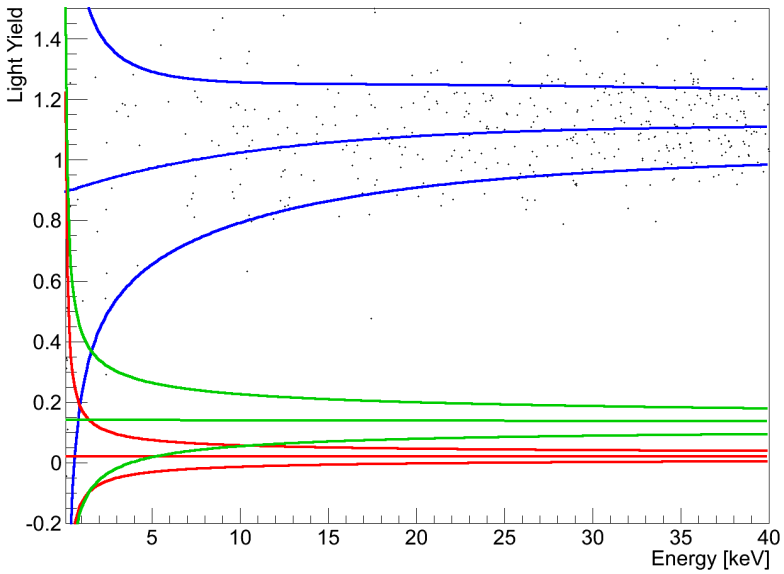

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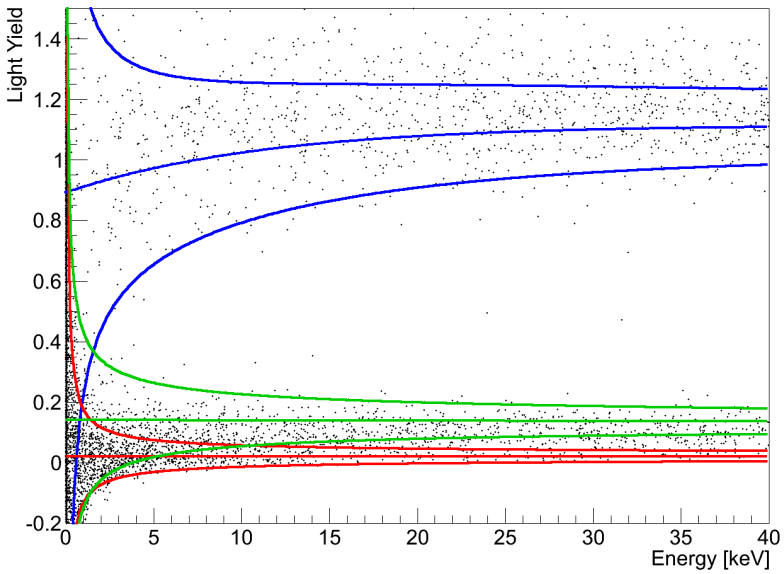

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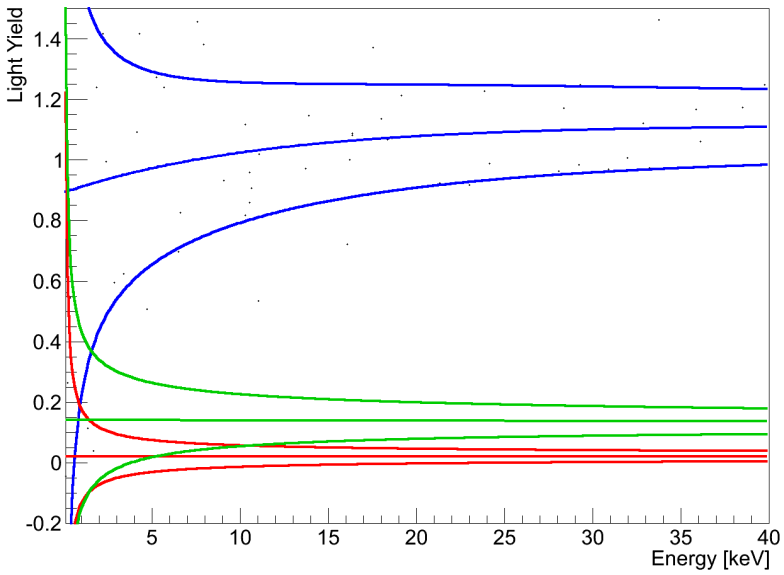

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- The nuclear recoils bands are fixed by their known relative light yield
- The band fit can be verified on the neutron calibration data
- Events within the region of interest can be identified in the background data

Event Simulation - Motivation

To estimate the probability of an event of interest to survive all of the cuts, such events are simulated with the help of empty Baseline.

Event Simulation - Method

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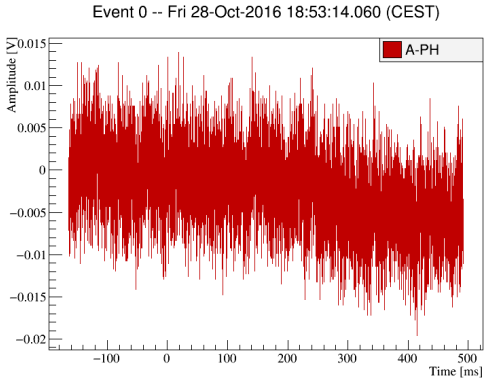
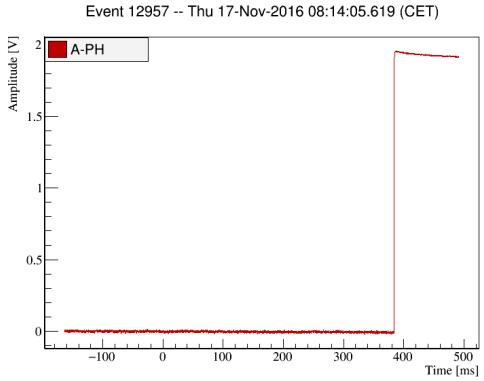


Randomly triggered "empty" baselines



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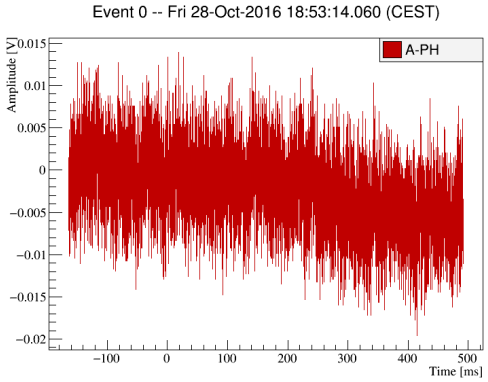

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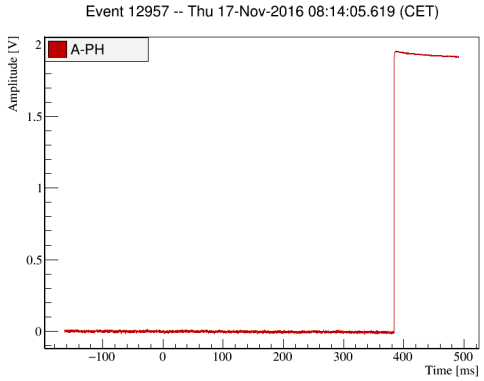

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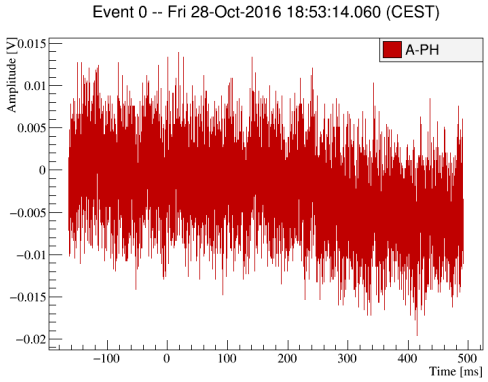

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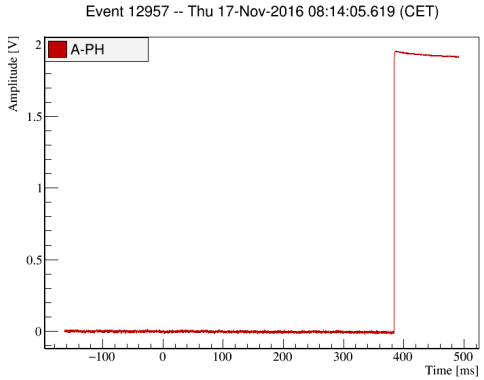

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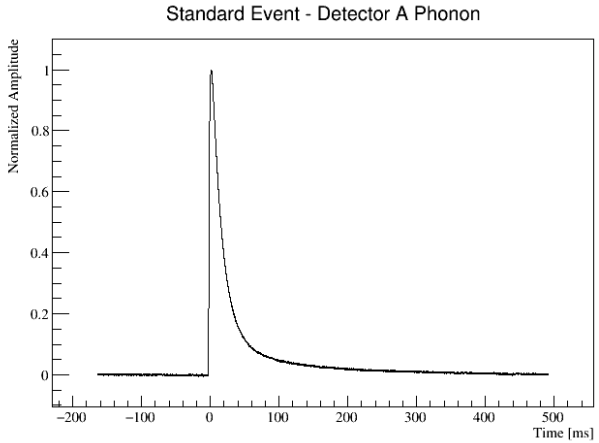

Standard event, scaled to the required energy.

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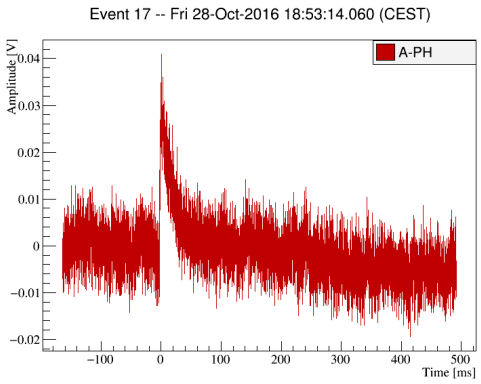

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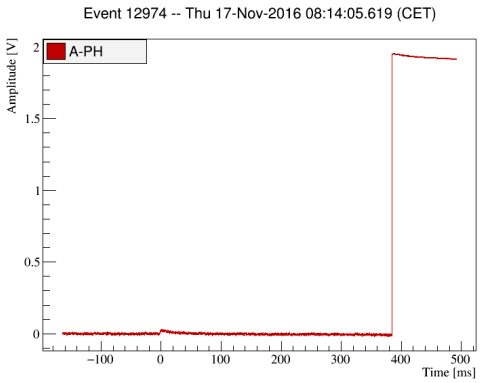
Simulated 100 eV events



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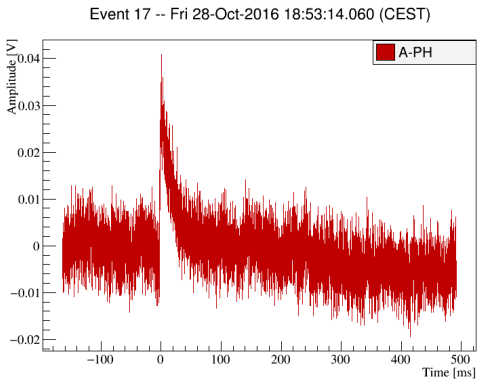

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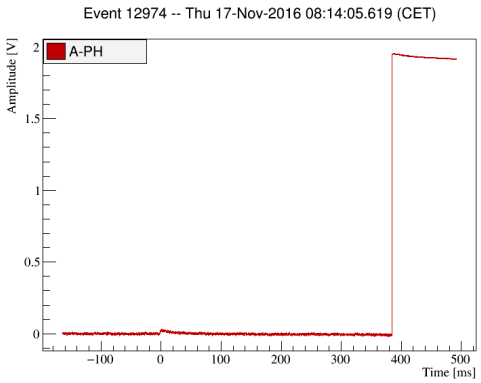

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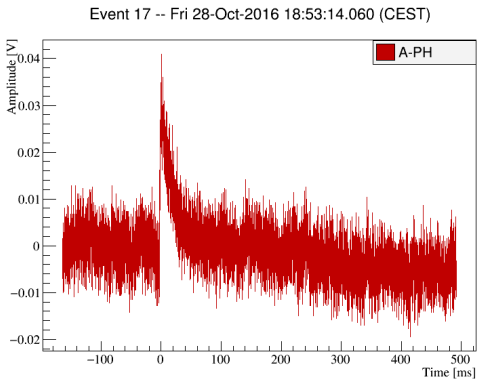

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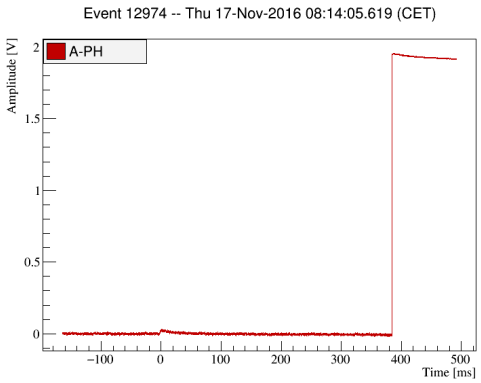

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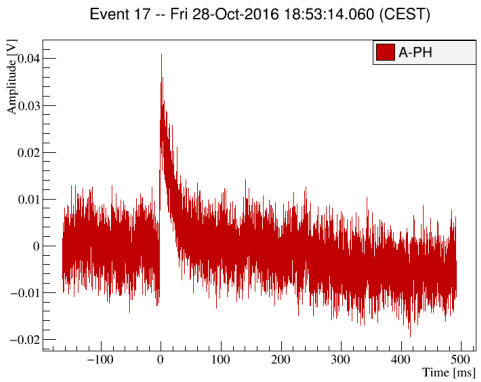

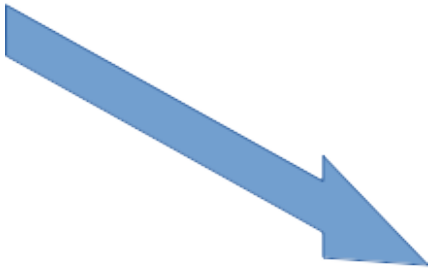

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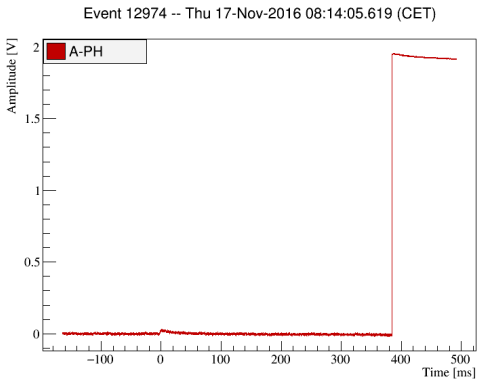

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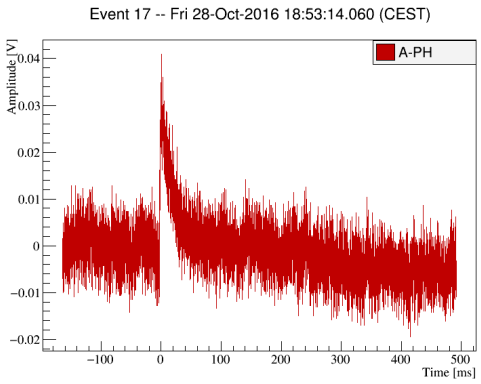

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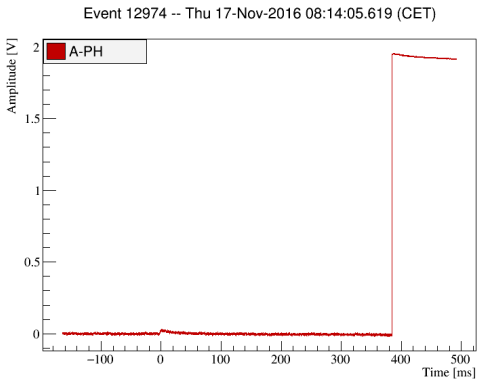

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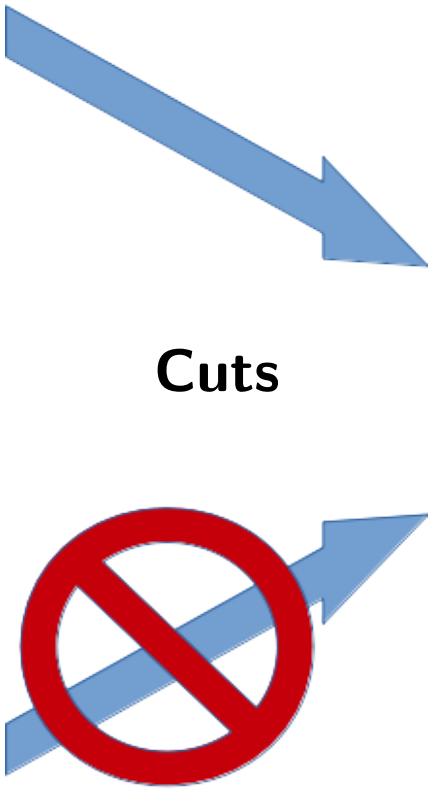

Signal survival probability / Cut Efficiency

Expected Signal

To calculate an exclusion limit the dark matter mass and interaction cross section, the observed event rate has to be compared to the expected rate of a dark matter signal.
Expected rate:

$$\frac{dN}{dE_R} = \frac{\rho_\chi}{2m_\chi \mu_N^2} \sigma_0 F^2(E_R) \int_{v_{min}(E_R)}^{v_\infty = v_{exc}} \frac{f(\vec{v})}{v} \, \mathrm{d}^3 v$$

Standard assumptions:

$$v_{esc} = 544 km/s$$

$$\rho_\chi = 0.3 GeV/cm^3$$

Fortunately this is all well implemented in software from the previous runs.

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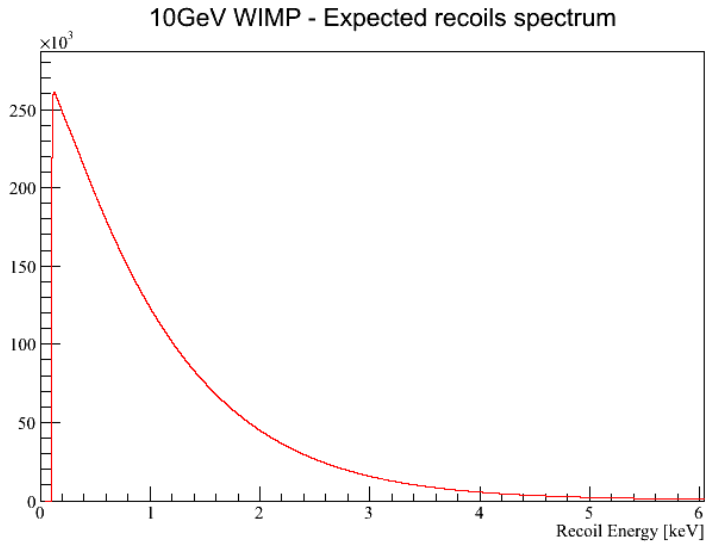

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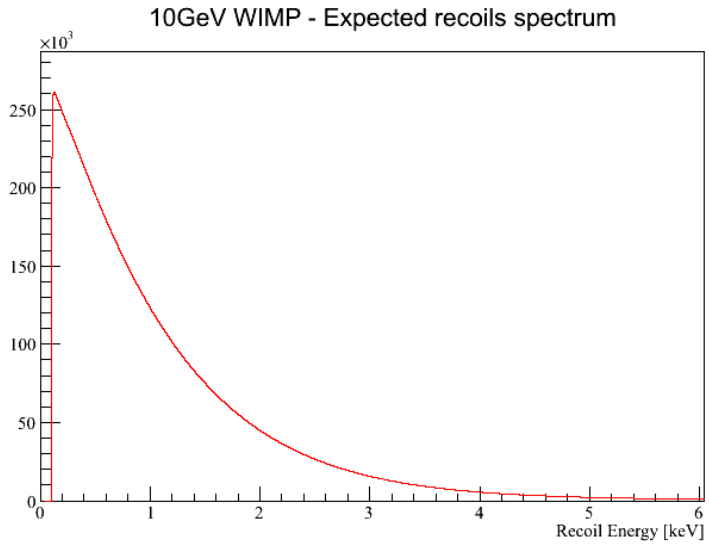
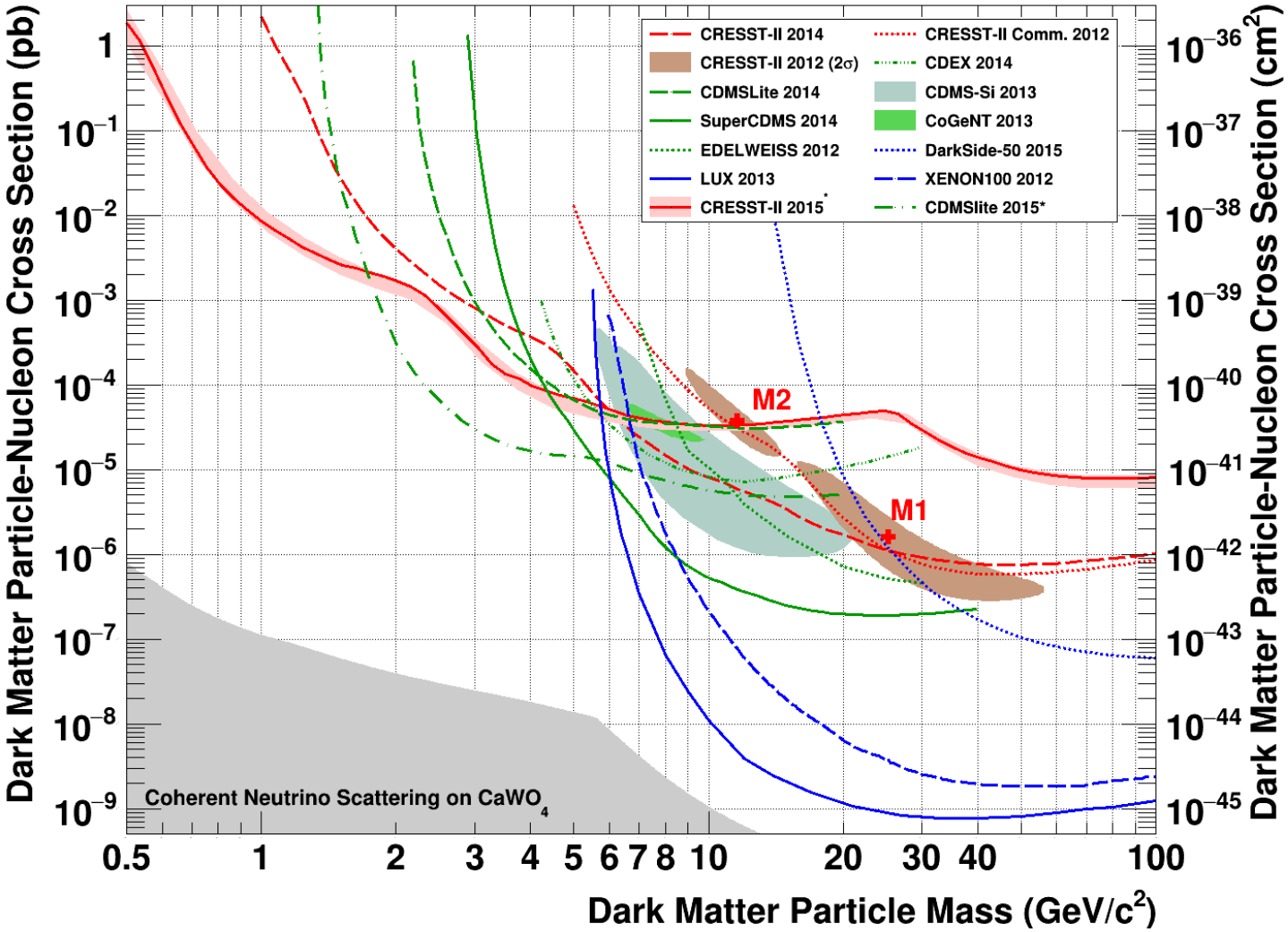


This is compared to the data using the **Yellin Method** which is quite robust, does not need a background model and takes the signal shape into account.



Explanation on the next slide

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