Data processing and analysis of the GERDA experiment

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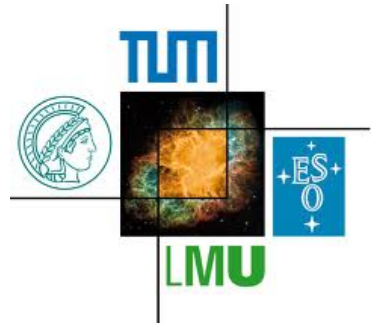
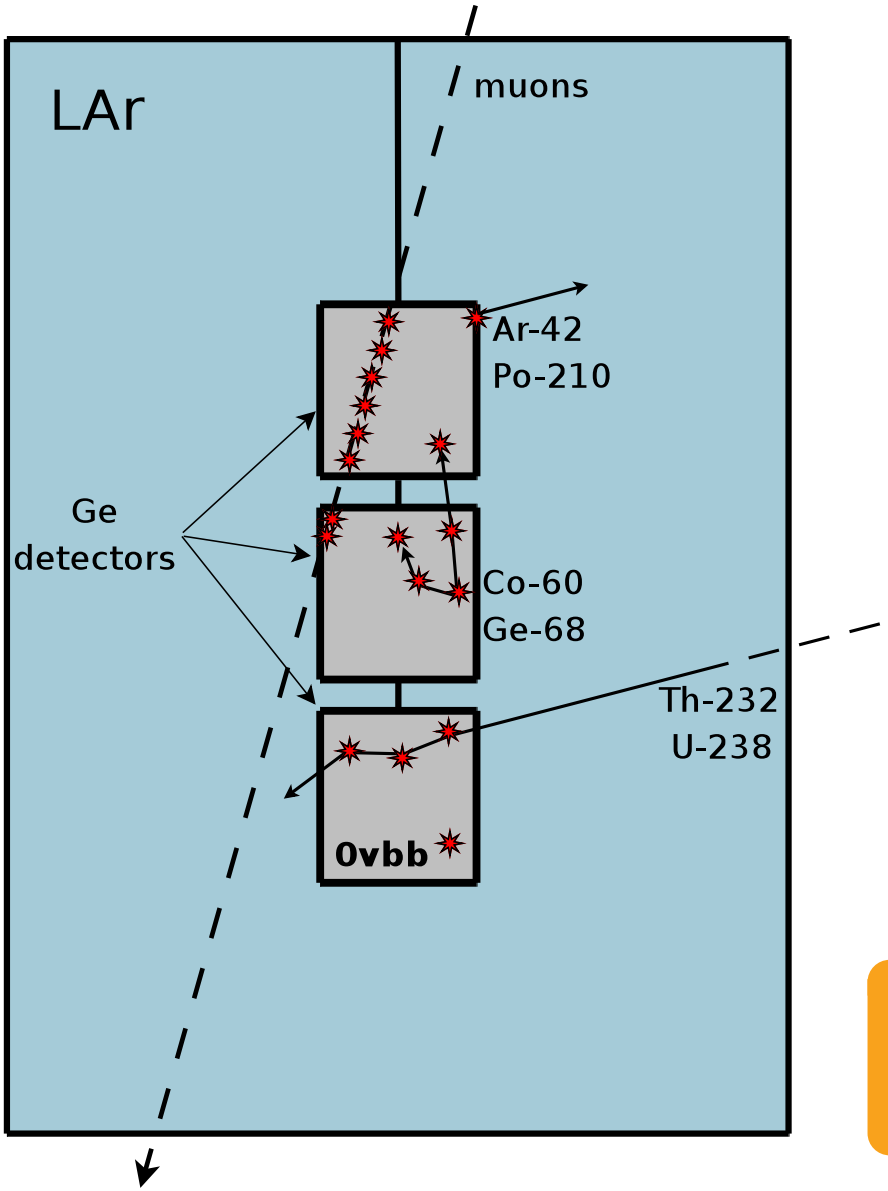


Outline

- Introduction
- Signal processing and analysis
- Data quality monitoring and selection
- Application to background decomposition

Ref: JINST 6 (2011) P08013
arXiv:1111.3582

Background sources and interaction topology



Main background sources:

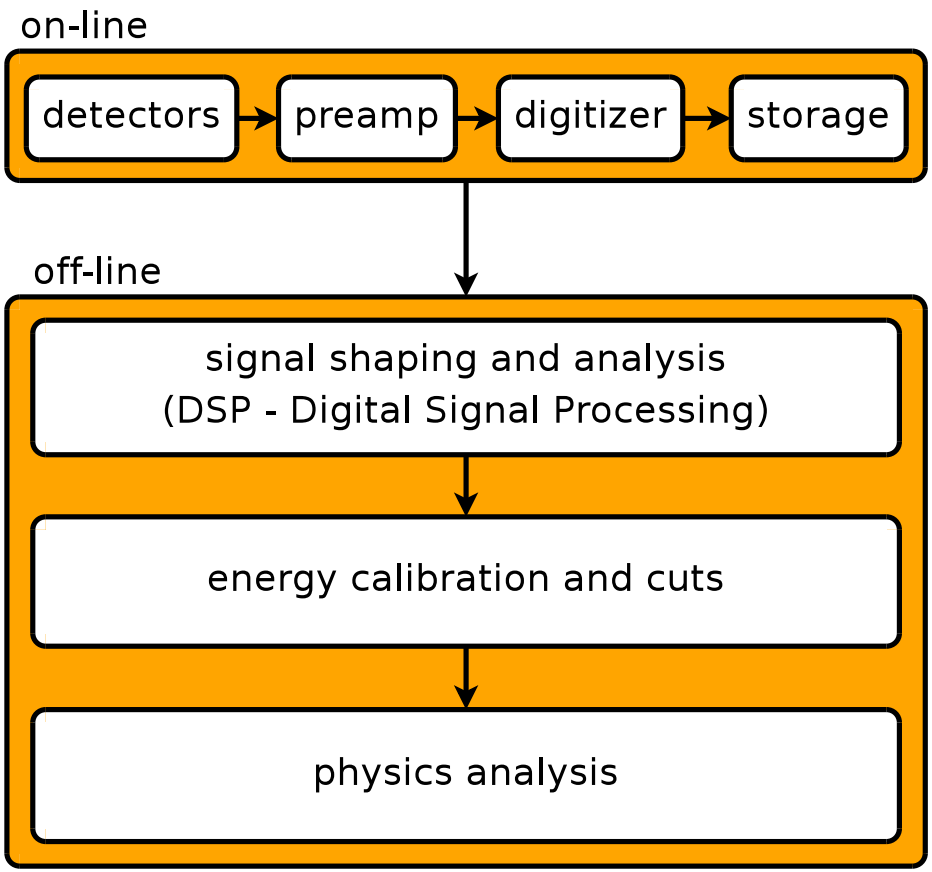
- γ from natural radioactivity (Th-232, U-238)
- γ from cosmogenic isotopes inside the detectors (Ge-68, Co-60)
- β from natural isotope of Ar (Ar-42)
- α from surface contamination (e.g. Po-210)
- non-vetoed μ

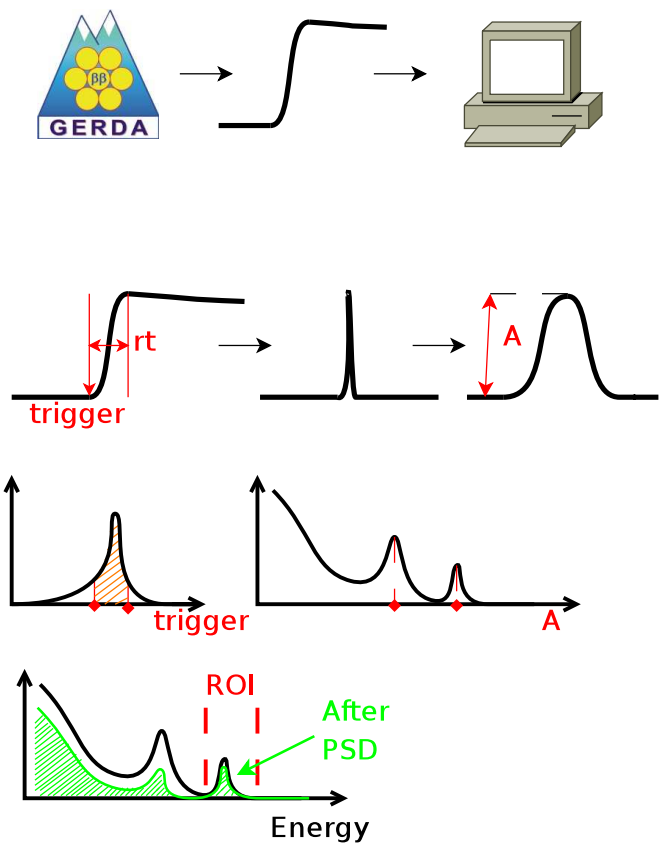
Different event topologies:

- multiple site interactions (μ, γ)
- surface interactions (α, β)
- point-like bulk-volume interactions (γ, $0\nu\beta\beta$)

Pulse Shape Discrimination (PSD) techniques based on the analysis of the signal time-structure can be used to identify background events

Data stream

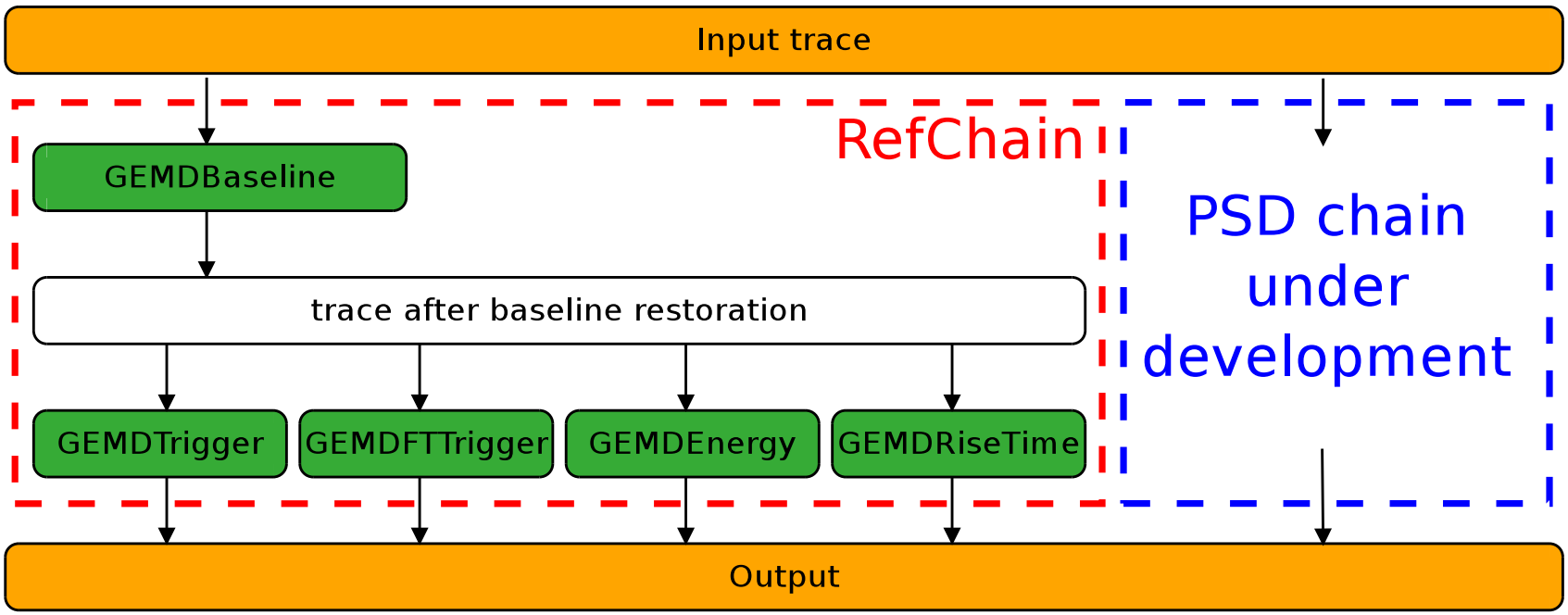




traces digitized @ 100 MHz 160 μs long

background	$\sim 10^2$ event/ch/h	$\sim$ 10 MB/ch/h
calibration	$\sim 10^6$ event/h	$\sim$ 10 GB/h

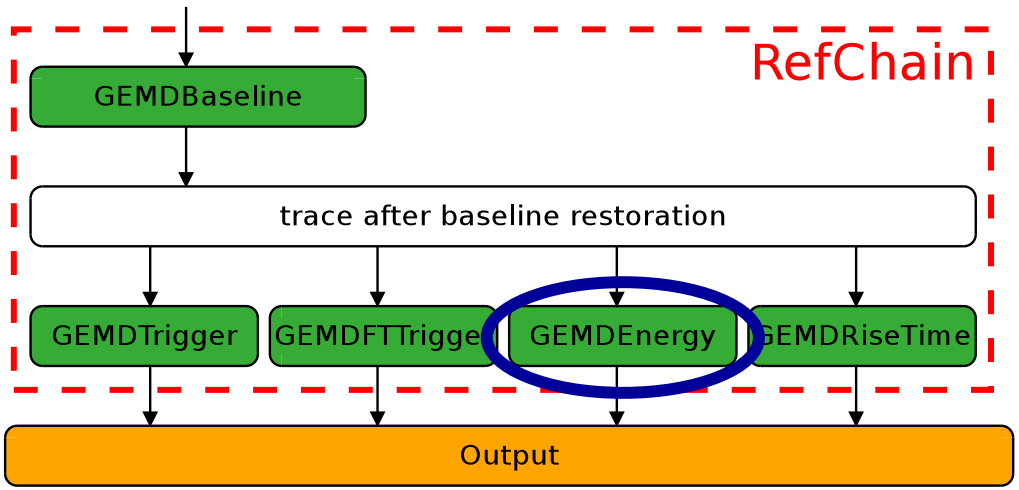
HPGe signal processing

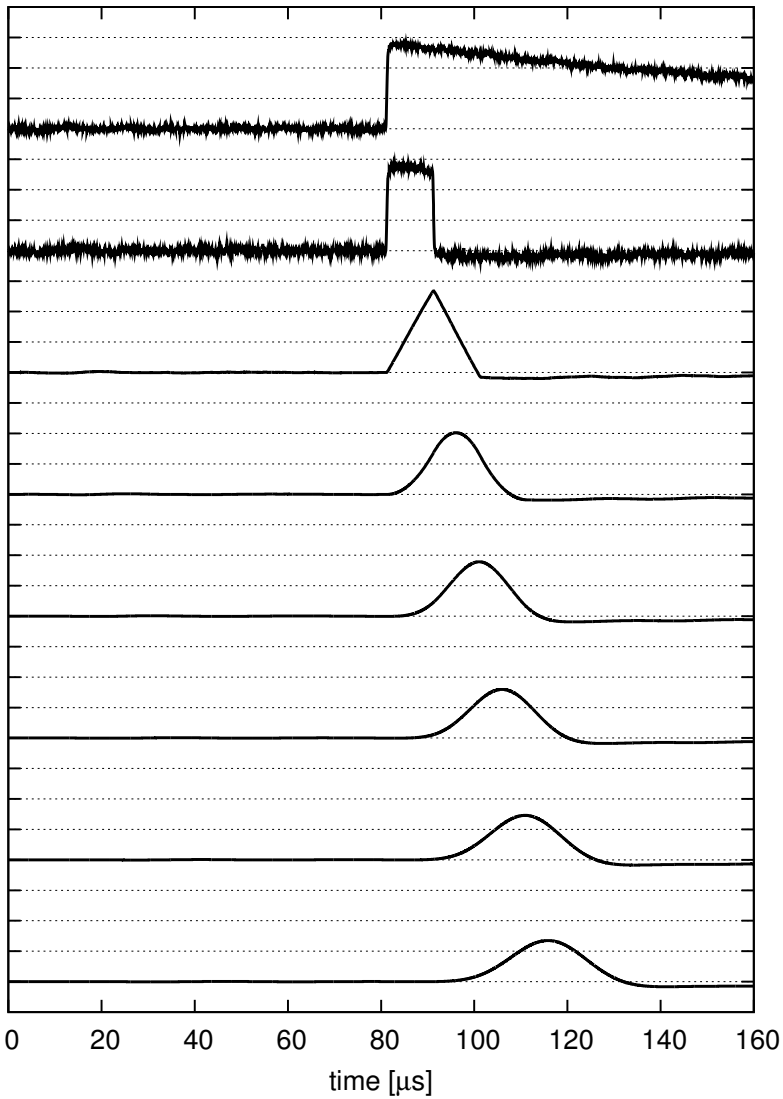


Modular analysis:

- each module implements a task of the DSP (trigger, energy...)
- computed info and traces can be used as input for other modules
- module chains and internal parameters set via ASCII file

Illustrative module: energy reconstruction

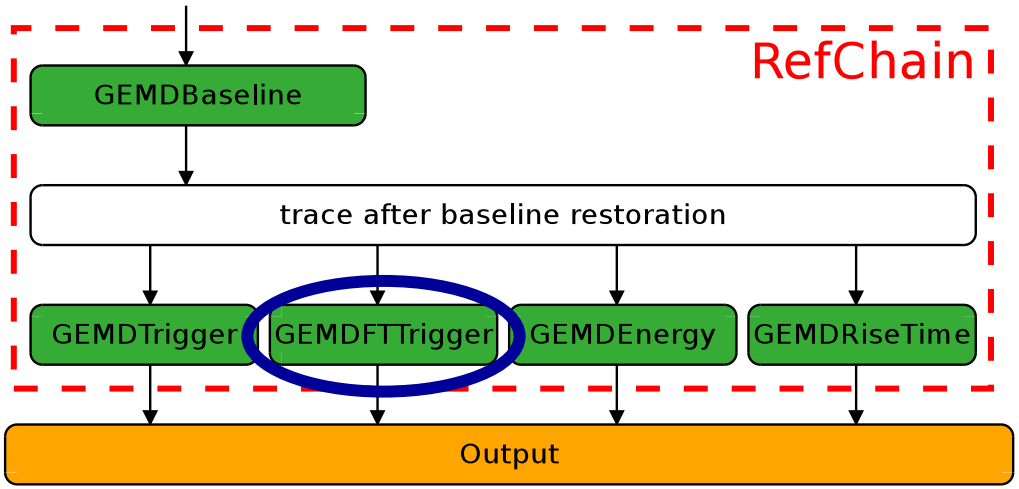


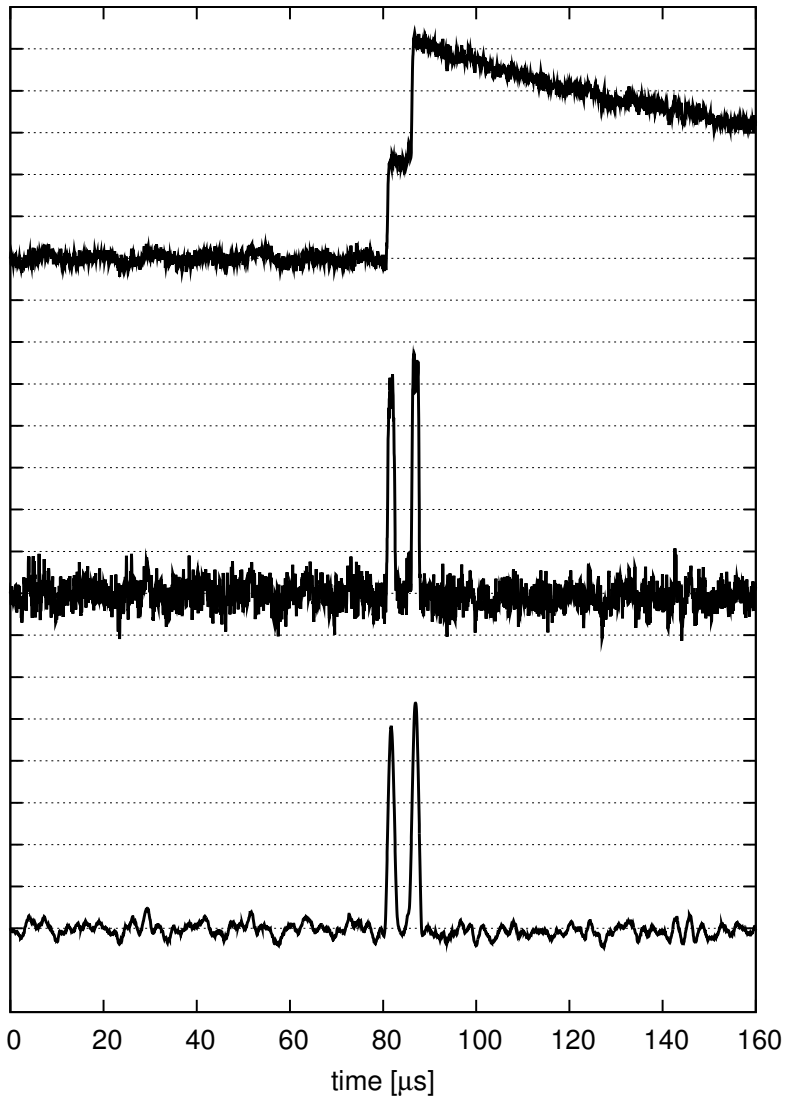


GEMDEnergyGauss (approx Guassian shaping)

1. 40 ns moving differentiation
2. 15 times 10 μs moving average
3. search for absolute max

Illustrative module: pile-up identification



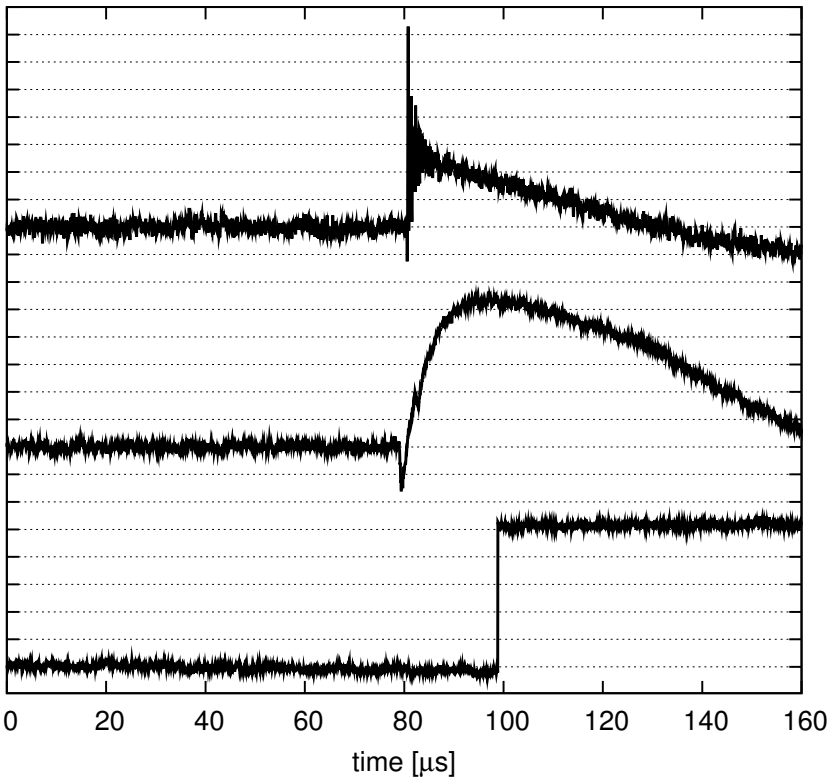


GEMDFTTrigger (fast trapezoid shaping)

1. 1.5 μs moving differentiation
2. 1 μs moving average
3. leading edge trigger: dynamic threshold (4 baseline sigma) + check time above the threshold (requested 1 μs)

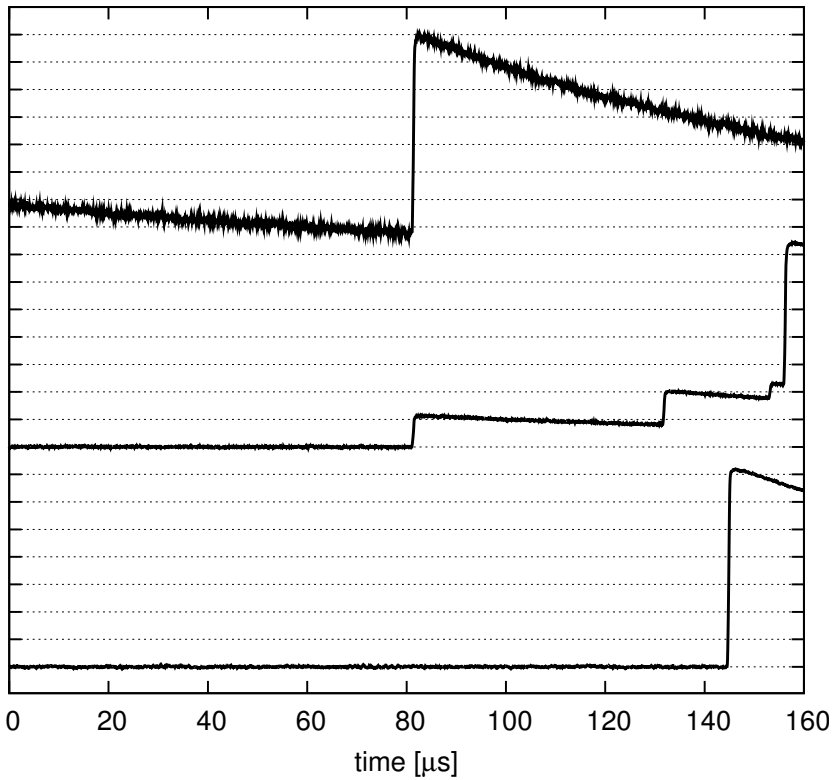
Pathological signals (bad signals + bad processing)

- Signals exceeding FADC dynamic range
- Non-physical events



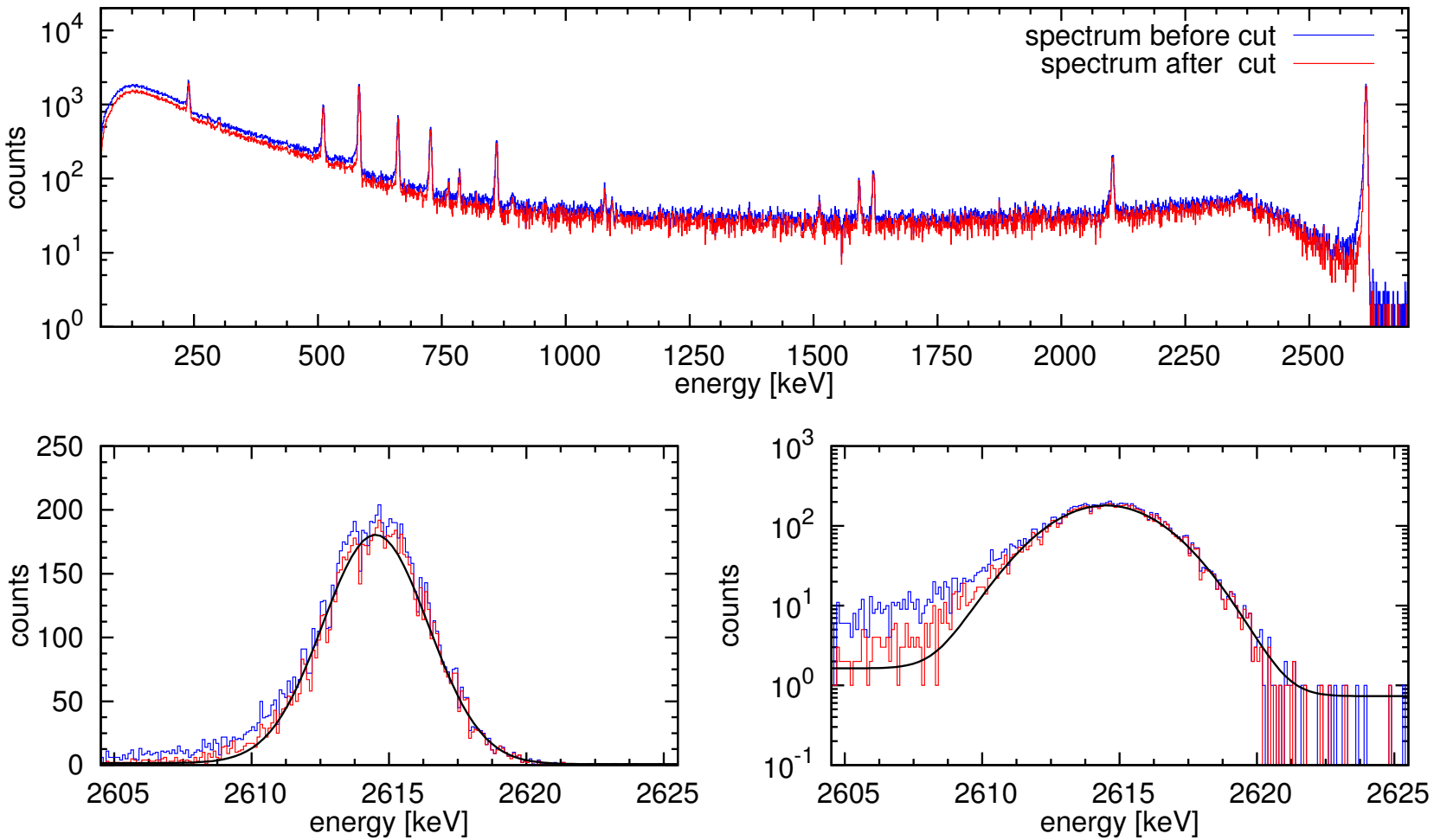
both in calibration and bkg data
(only a few events)

- Accidental coincidences
- Pile-ups



only in calibration data
(up to 15% of the total event number)

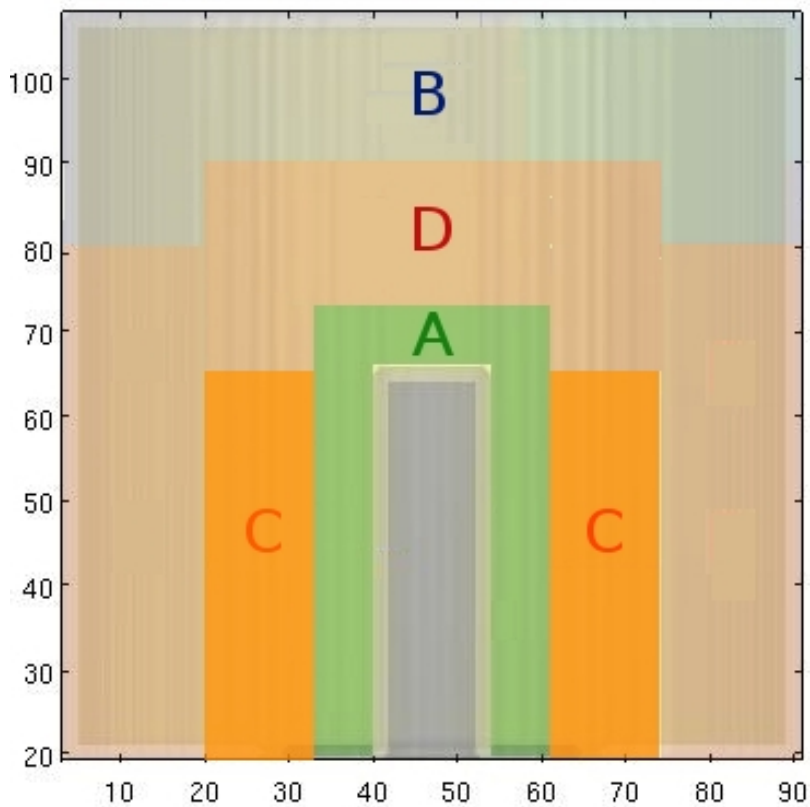
Data selection for calibration runs (Th-228)



The cuts remove up to 15% of the total events (up to 10% in the gamma-lines):

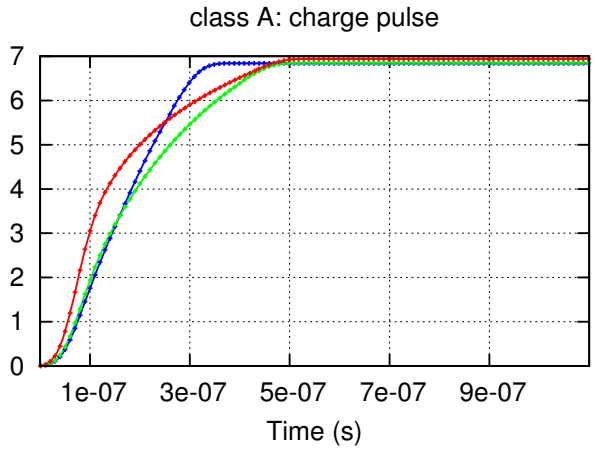
- pile-up rejection critical for comparing background and calibration data
- better agreement with the analytical function used for fitting the γ-lines results in more accurate energy calibration

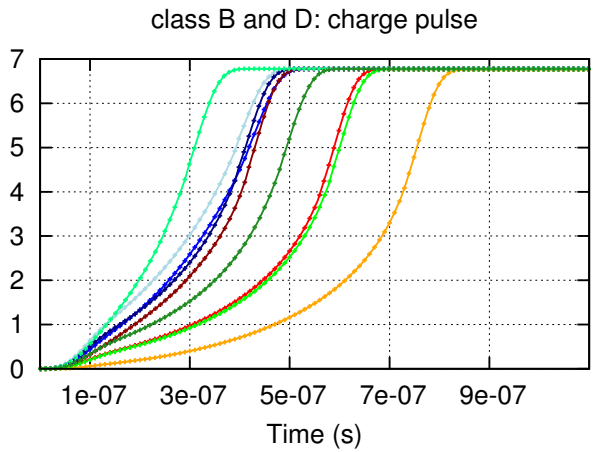
Signal modeling

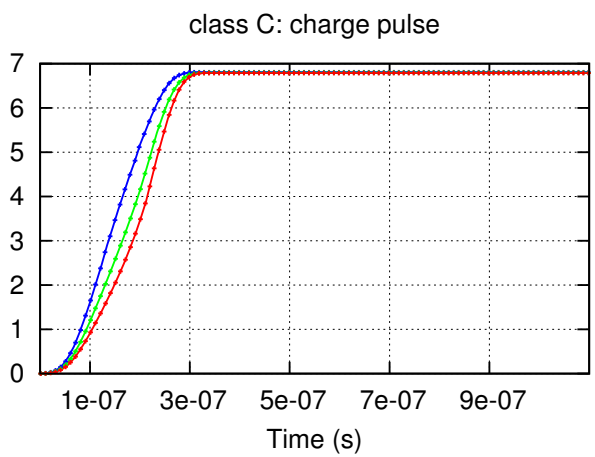


Pulse shape analysis for background deconvolution

alpha/beta emitters in the bore-hole ⇒ class A
K-42 on the n+ contact ⇒ class B/D

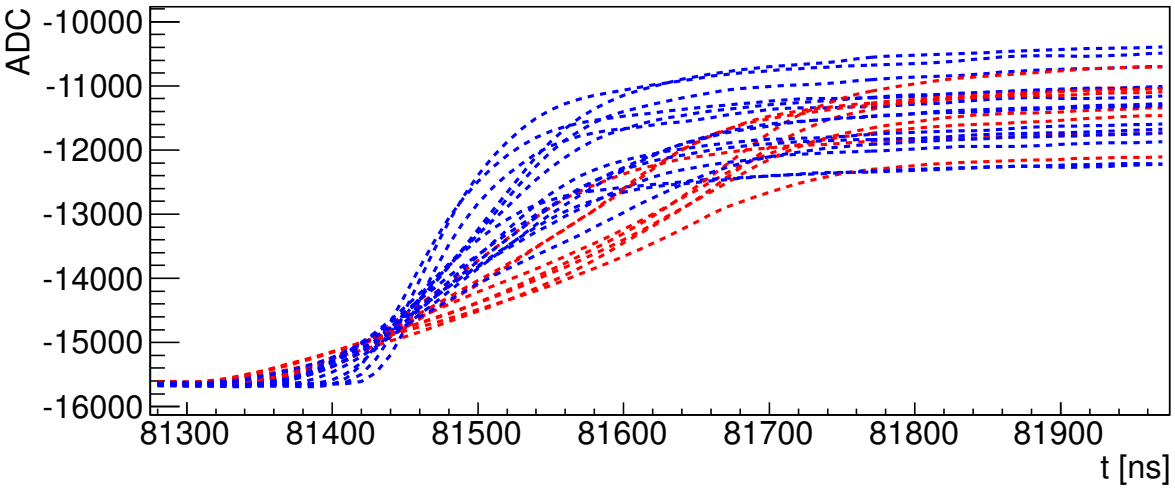






Application to background decomposition

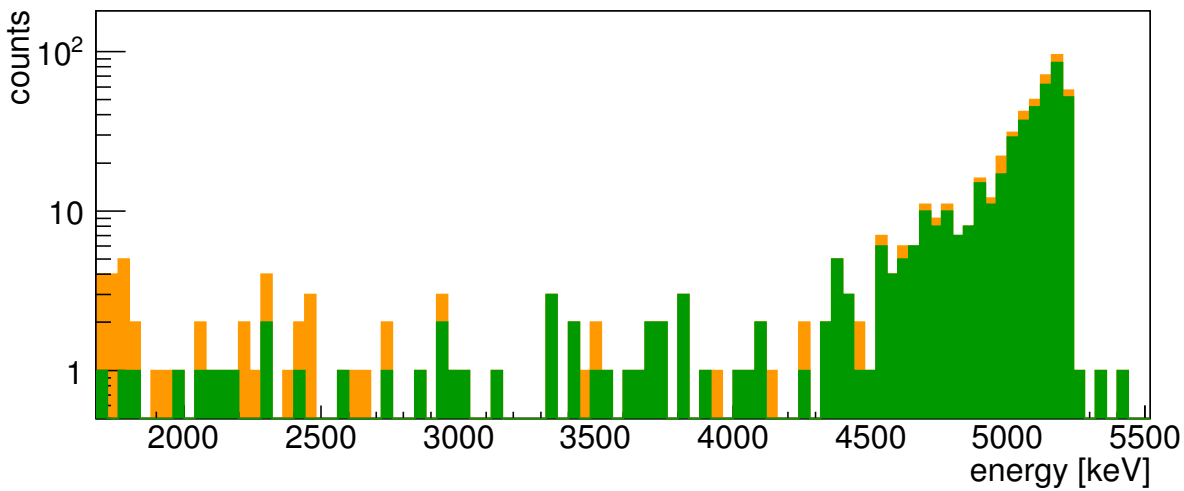
Alpha signal enhancement



Module evaluating the signal concavity:
blue $\Rightarrow$ class A
red $\Rightarrow$ class B,D

ANG3 alpha peak and tail:
orange $\Rightarrow$ all the events
green $\Rightarrow$ only class A events

powerful tool for estimating the alpha background in the ROI



Conclusions

- Developed new tool for digital signal processing and analysis
  - Modular approach
  - Shaping algorithms
- Signal processing flow defined and tested on commissioning data
- Identified parameters for data quality monitoring and selection
- GERDA Phase I data analysis ongoing