

# Pulse shape discrimination for reduction of alpha background in HPGe detectors

Krzysztof Szczepaniec

Tomasz Mróz

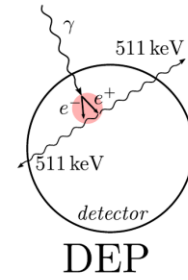
Grzegorz Zuzel



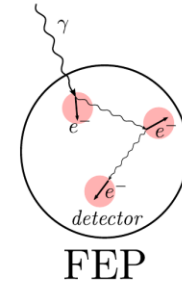
JAGIELLONIAN UNIVERSITY  
IN KRAKÓW

# Motivation

## High Purity Germanium detector



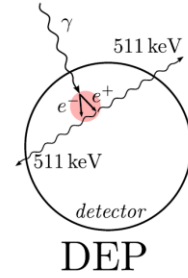
"Single-site event"



"Multi-site event"

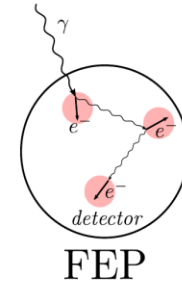
# Motivation

## High Purity Germanium detector



DEP

"Single-site event"



FEP


"Multi-site event"

LEGEND

Large Enriched  
Germanium Experiment  
for Neutrinoless  $\beta\beta$  Decay

$0\nu\beta\beta$  will be a "single-site" event



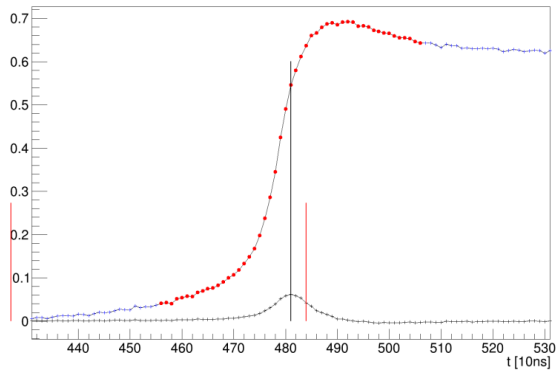
  
SIGNAL

  
BACKGROUND

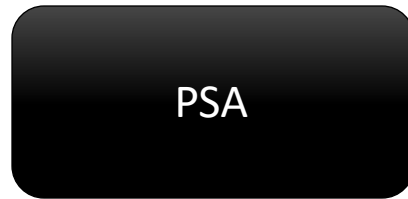
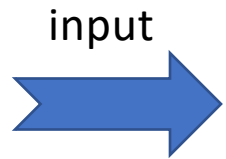
# Pulse shape analysis

## Classification problem

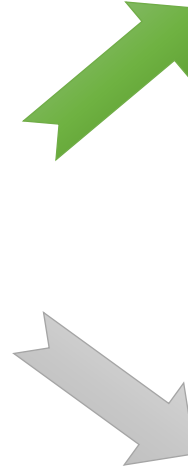
take every pulse...



Normalized waveform



output



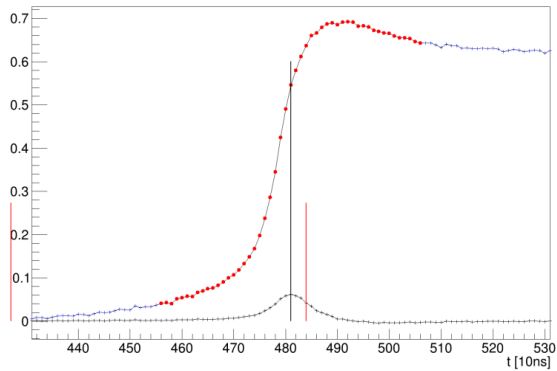
"This is a single-site event"

"This is a multi-site event"

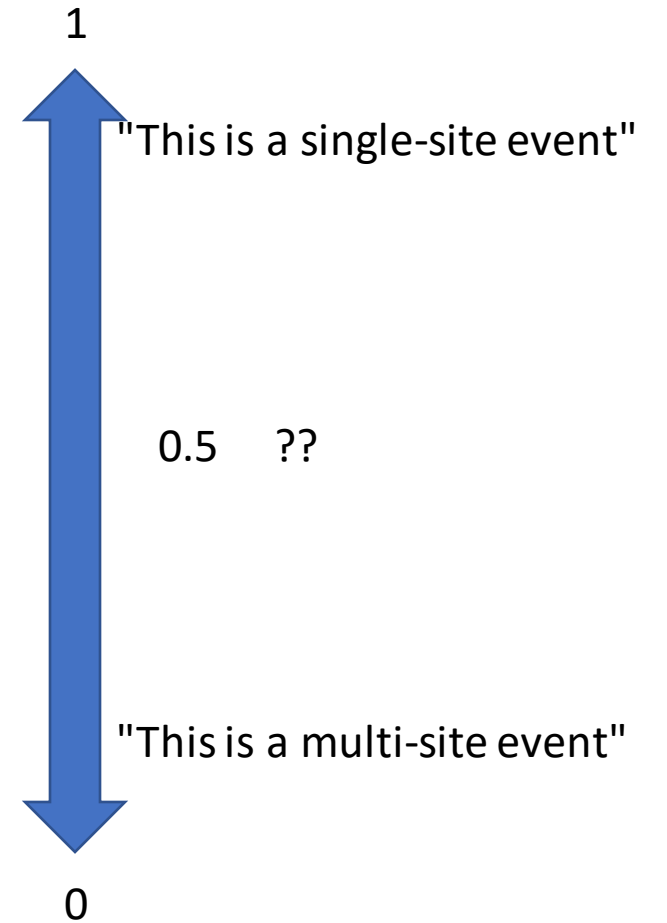
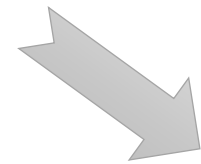
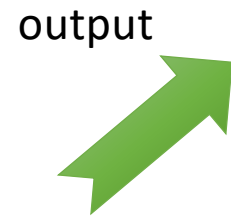
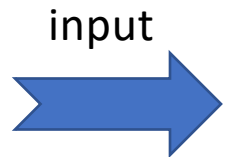
# Pulse shape analysis

## Classification problem

take every pulse...

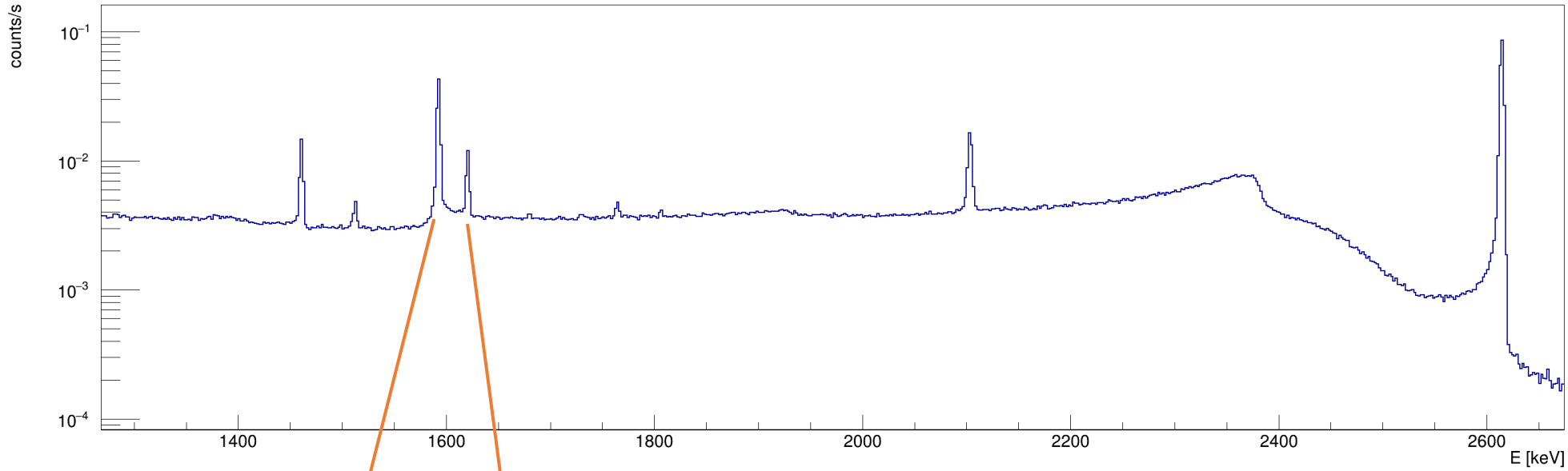


Normalized waveform

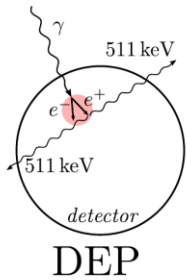


needs to be defined

needs to be "trained" beforehand



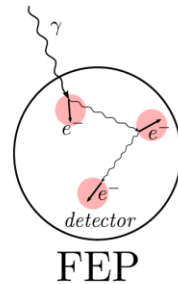
Tl-208  
1592.3 keV



DEP

SIGNAL

Bi-212  
1620.5 keV



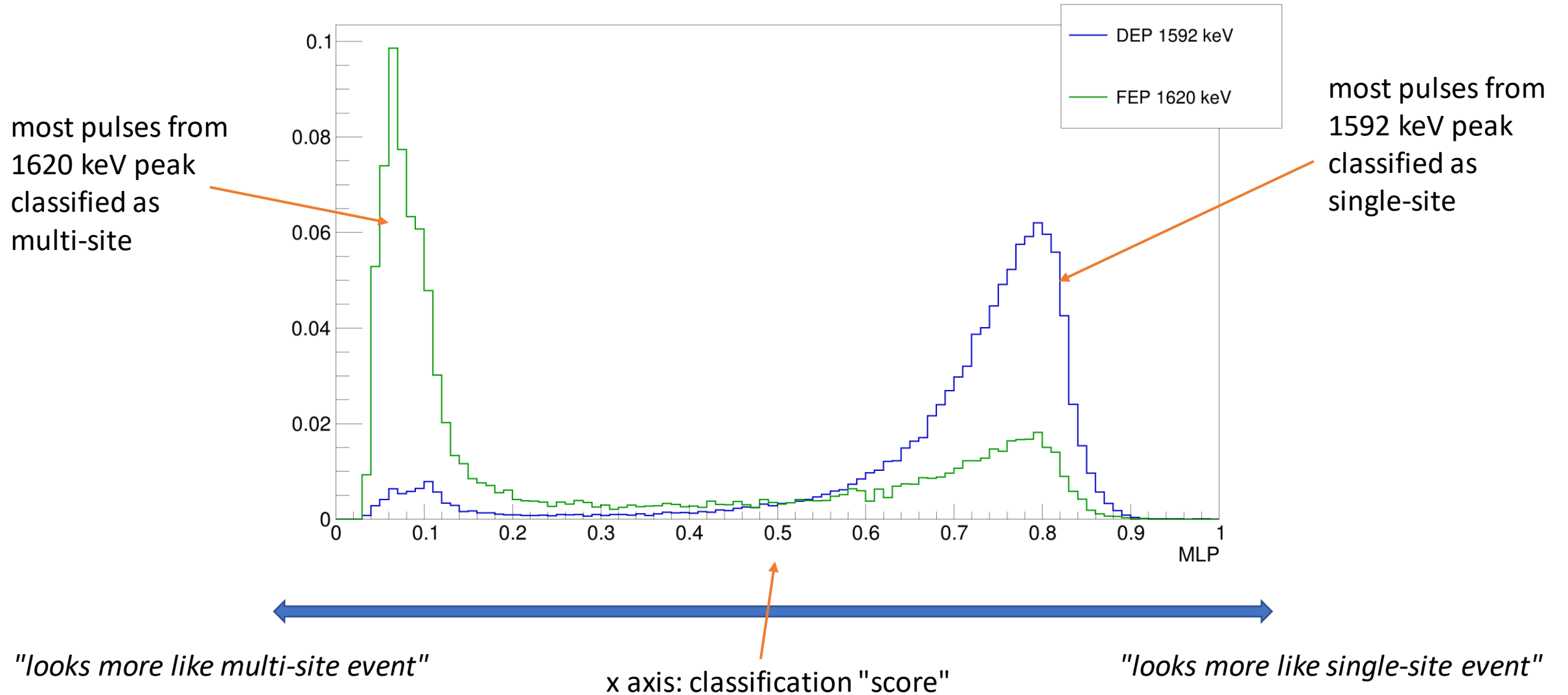
FEP

BACKGROUND

Th-228 source provides good sample  
of single-site and multi-site pulse classes

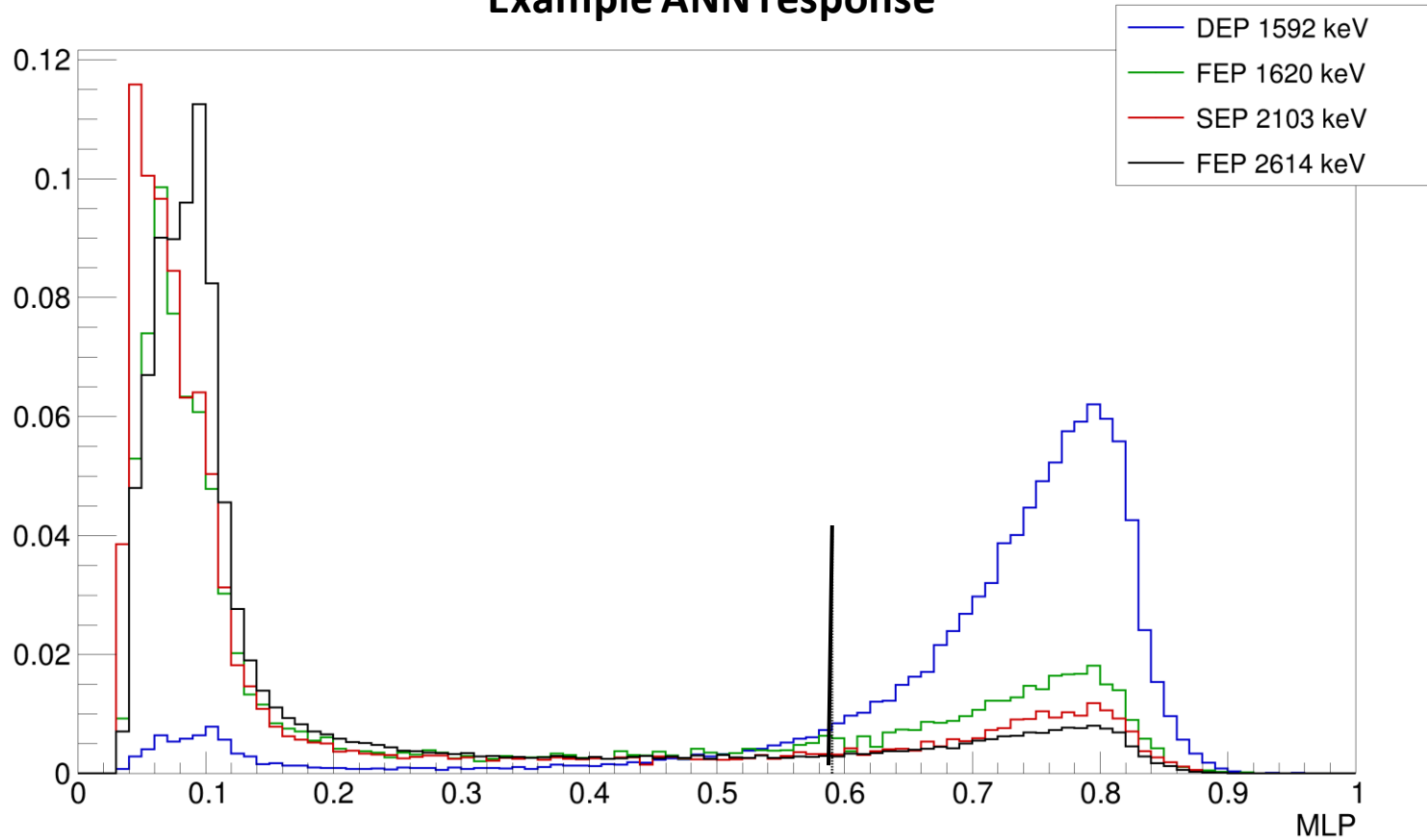
# Pulse shape analysis

## Example ANN response



# Pulse shape analysis

## Example ANN response



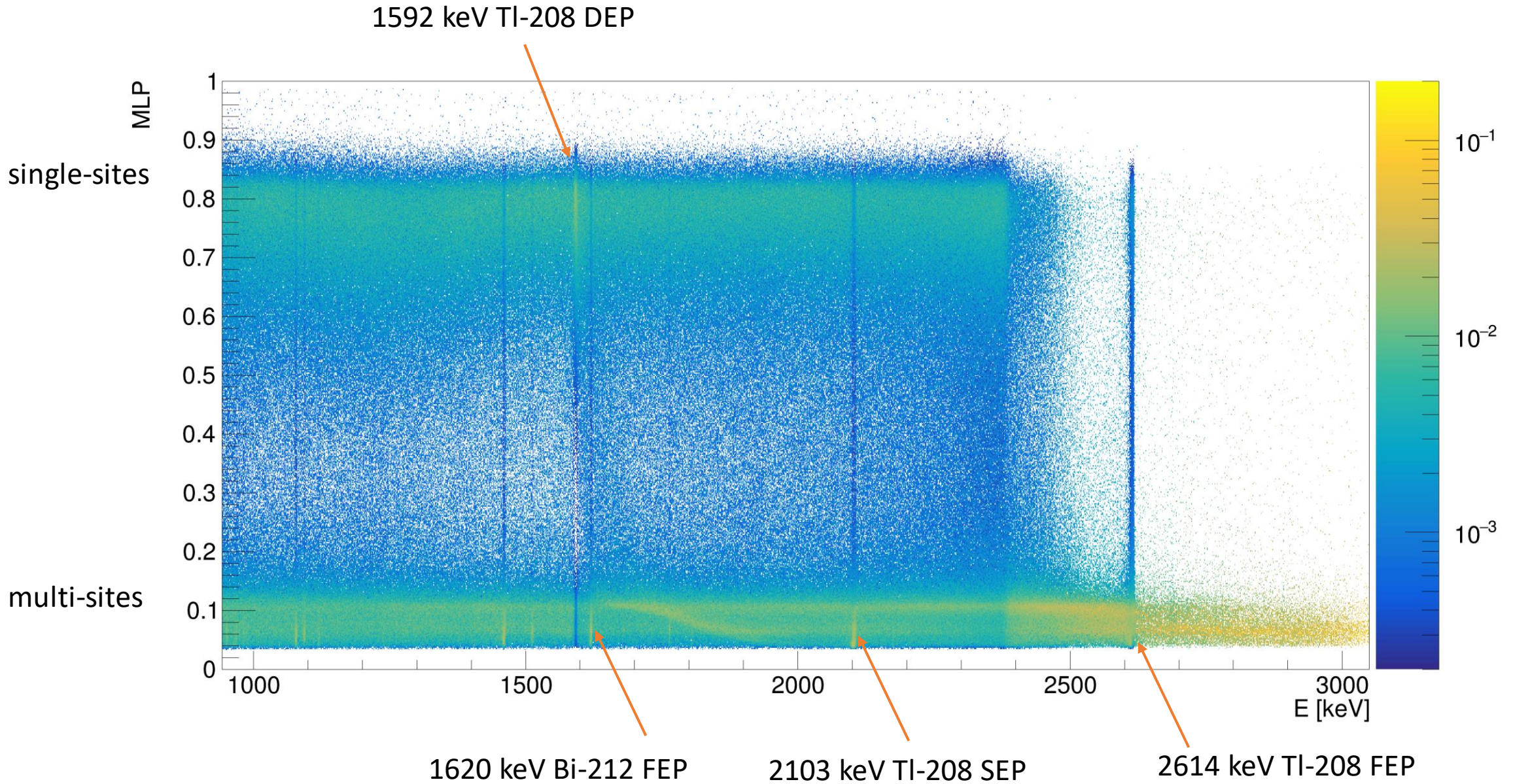
cut value is chosen arbitrarily  
for 90% DEP survival

	mlp > 0.59
DEP 1592 keV	<b>90.5 ± 0.6 %</b>
FEP 1620 keV	<b>15.9 ± 0.8 %</b>
SEP 2103 keV	<b>9.75 ± 0.7 %</b>
FEP 2614 keV	<b>13.6 ± 0.5 %</b>

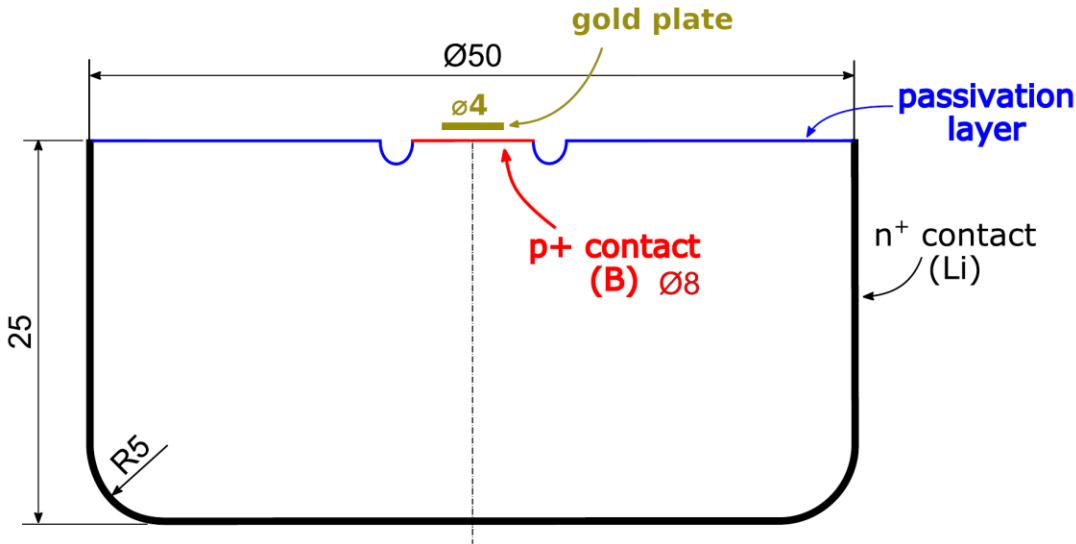
At this point, we have a tool that can be applied to any sample set...



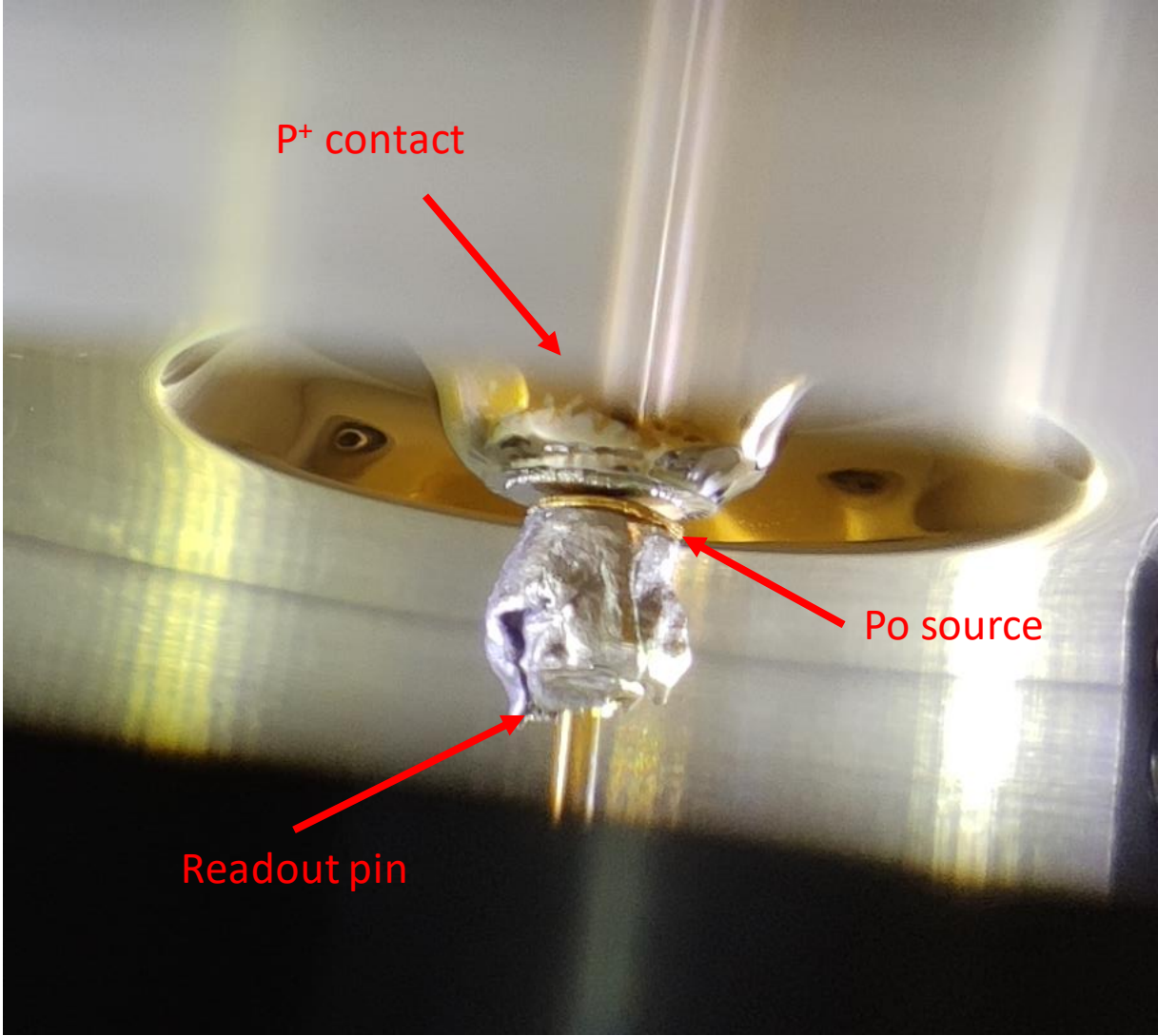
Pulse shape analysis  
ANN response – entire Th-228 spectrum



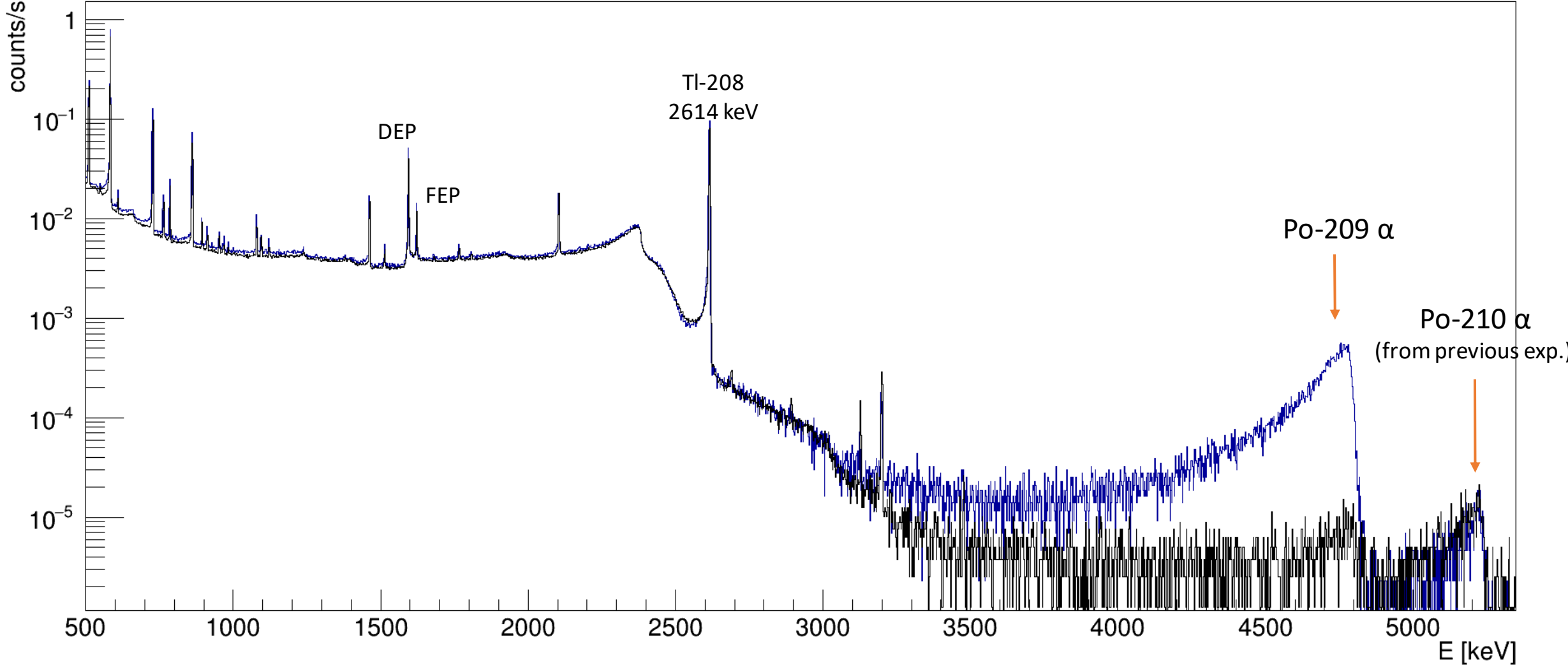
# $\alpha$ source



Point contact semi planar HPGe detector

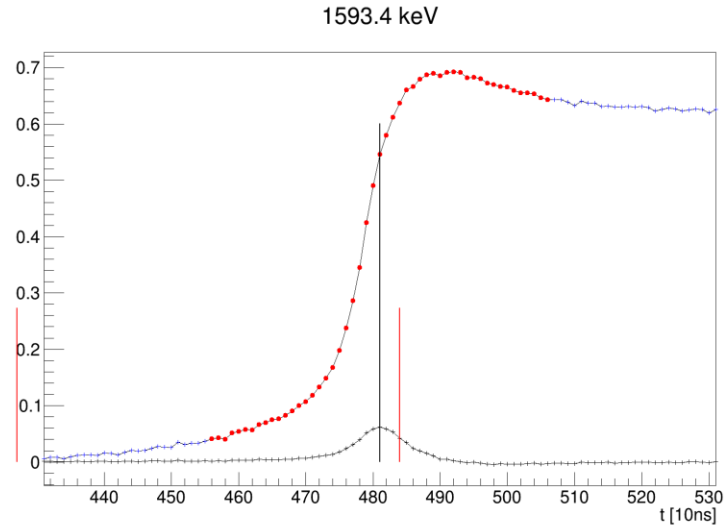


Th-228 source + Po-209

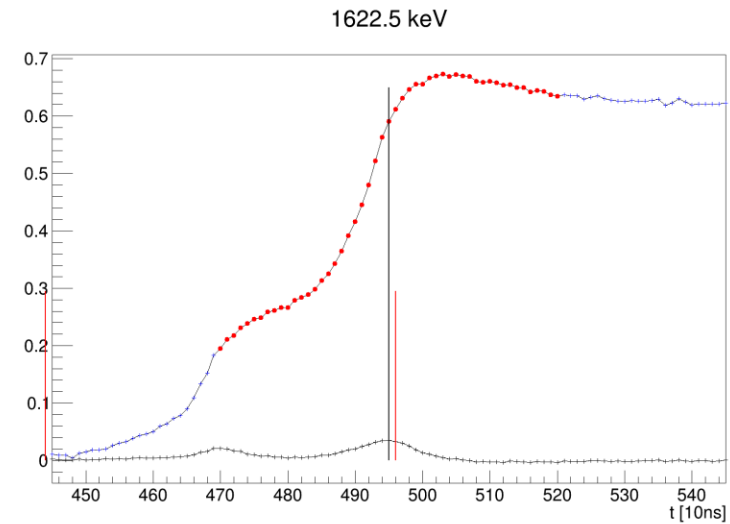




## back to pulse shape analysis



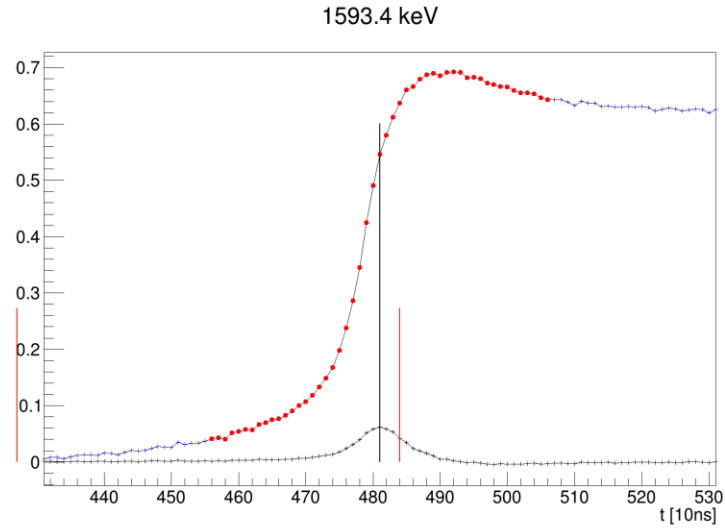
single-site event



multi-site event

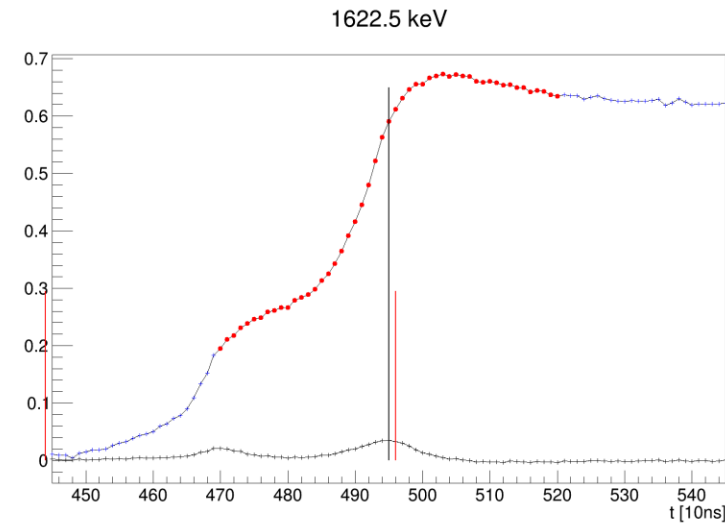
We only have these two classes  
to train and test anything

# back to pulse shape analysis



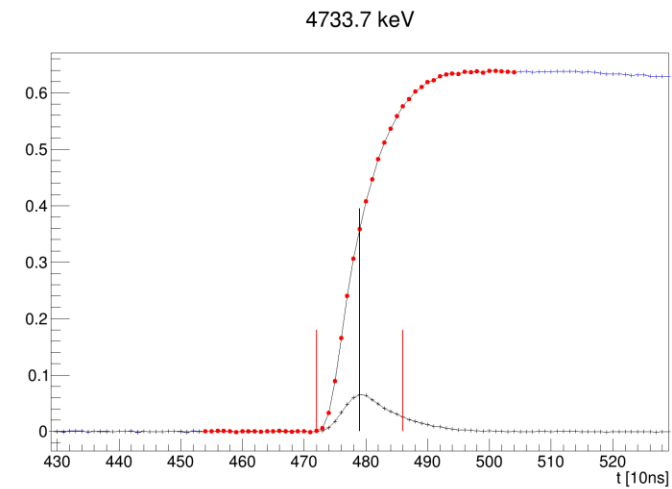
single-site event

We only have these two classes  
to train and test anything



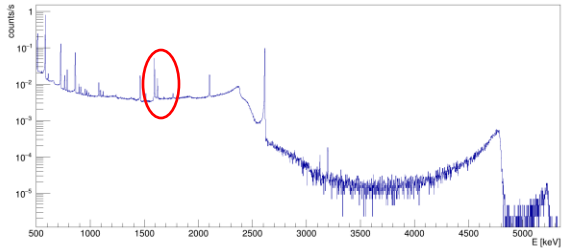
multi-site event

How will it work with 3rd class...

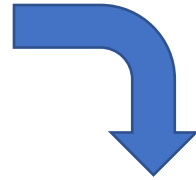


alpha pulse

## Procedure

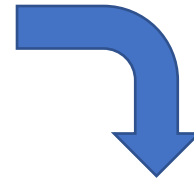


1. Take "signal" and "background" pulses sample from known peaks



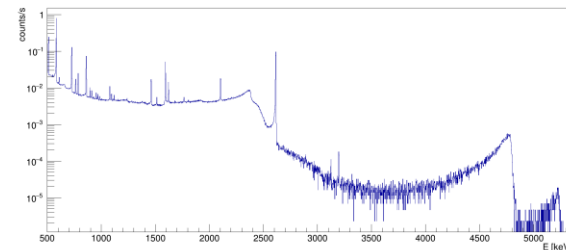
PSA

2. Use them to "train" the classifier and define cut value



## Tested PSA:

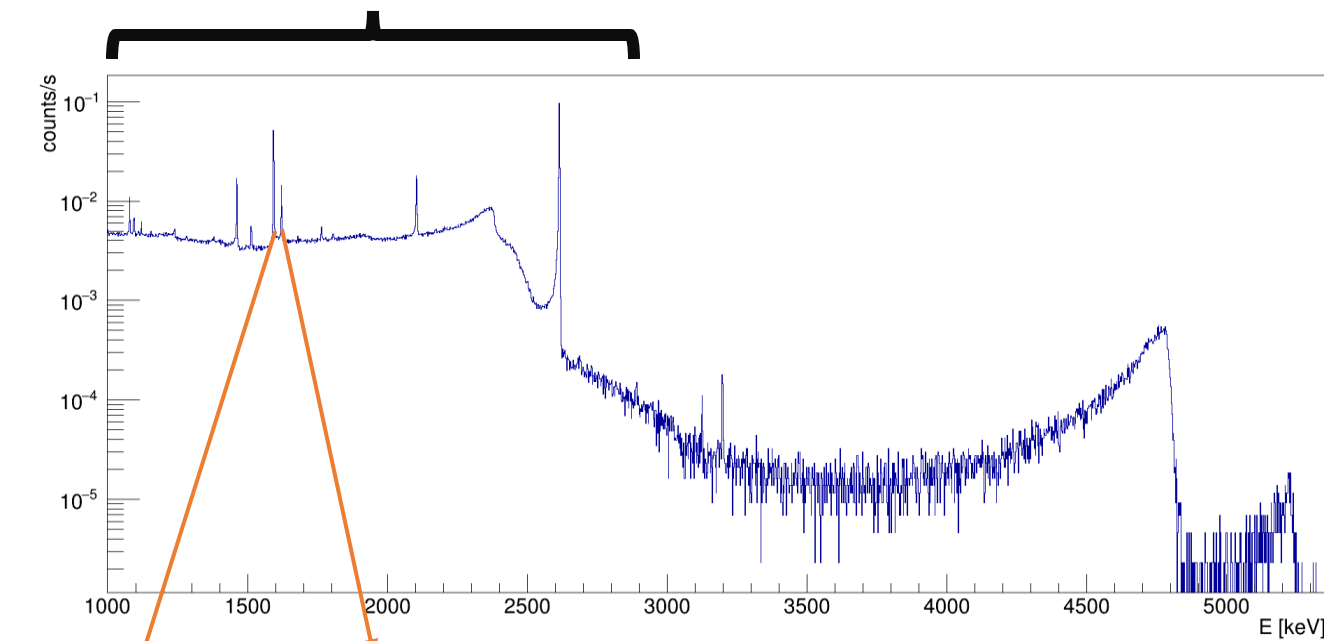
- ANN MLP
- Cern ROOT *projective likelihood*
- A/E



3. Apply "trained" PSA to entire spectrum, See what's left of alpha peak

# Th228 + Au/Po209 alpha source

Th-228 measured alongside for training sample



TI-208  
1592.3 keV  
22700 evts.

Bi-212  
1620.5 keV  
7300 evts.

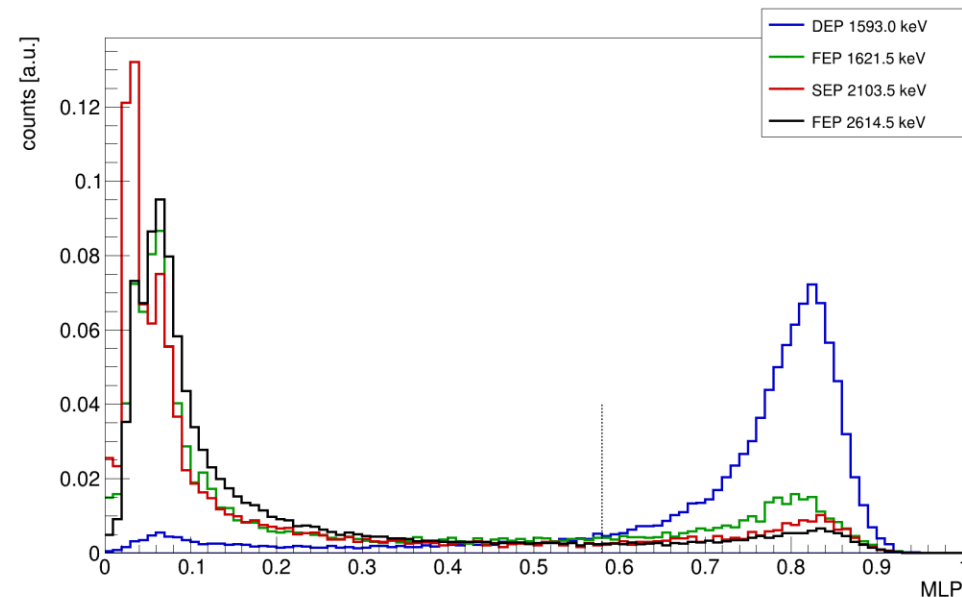
"SIGNAL"

"BACKGROUND"



cut value chosen arbitrarily  
for ~90% DEP survival

## ANN MLP response



	mlp > 0.58
DEP 1592 keV	<b>89.9 ± 0.8 %</b>
FEP 1620 keV	<b>14 ± 1 %</b>
SEP 2103 keV	<b>7.2 ± 0.5 %</b>
FEP 2614 keV	<b>11.2 ± 0.1 %</b>

results?

check the poster... :-)

