Krypton 2s-1s analysis

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Outline:

- Self-normalized efficiency for Krypton

  -Yttrium cascade
  -Krypton cascade
  -Dealing with background

- Decomposing BG in the region of interest

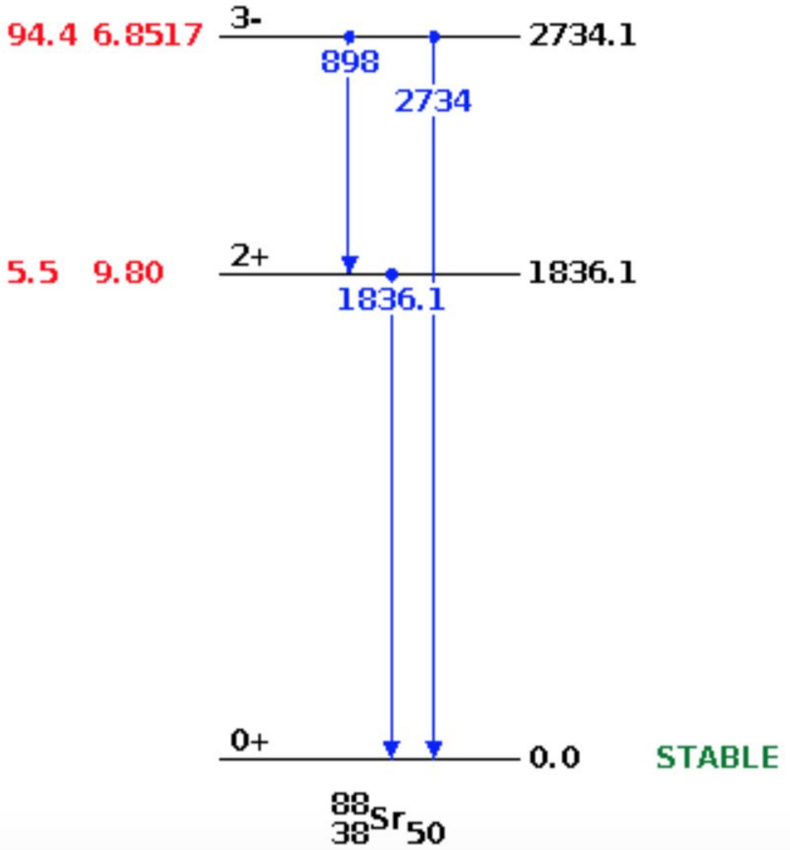
  -Different BG components
  -Various cuts applied
  -X-Ray background
  -Nuclear capture BG
  -Fitting the background

- 2s-level population enhancement with Hydrogen transfer

Self-normalized efficiency for Krypton

Self-normalized efficiency

- Example of self-normalized efficiency: Yttrium
- Every 898 keV has a succeeding 1836 keV line and vice versa
- Using the ‘SearchCoincidences’ method in the offline analyzer, coincident hits are found
- For example: Placing a ‘gate’ at 898 keV in one detector and looking for 1836 keV line in all the surrounding detectors with a short time frame
- Efficiency: $\frac{\text{no. of 1836 keV coincidences}}{\text{no. of 898 keV gate triggers}}$



Self-normalized efficiency for Krypton

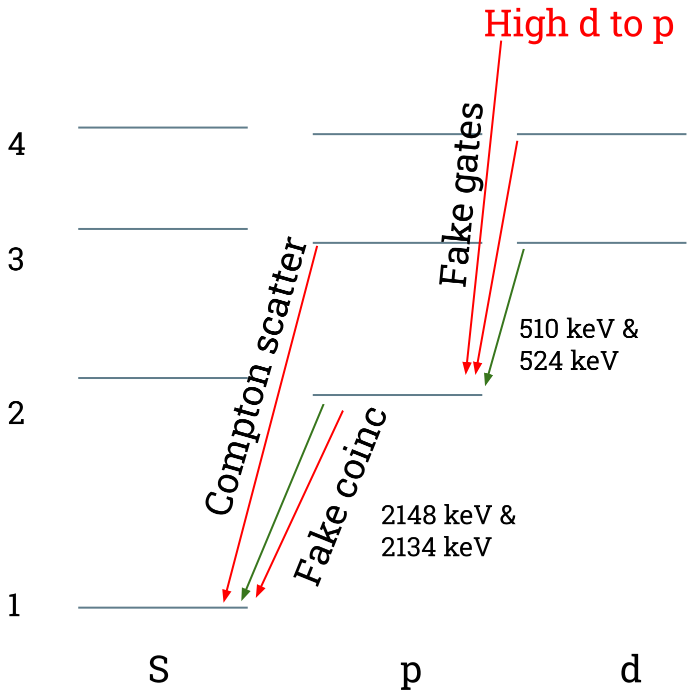
- For a cascade as complex as this, there could be more than it meets the eye

- There is Compton scattering, fake gates causing fake triggers which need to be taken into account

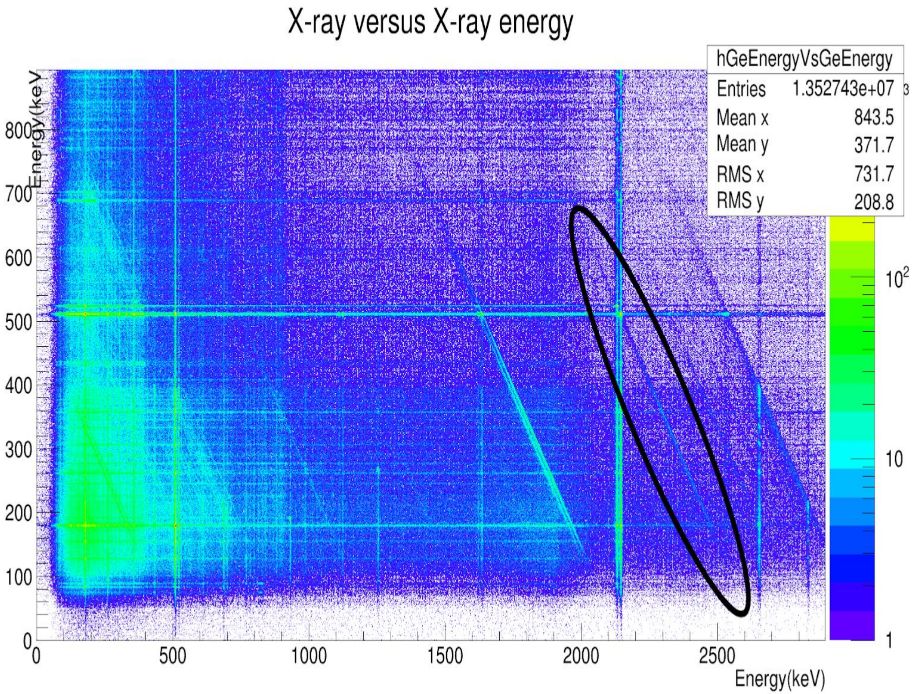
1. Compton scattering from 3p-1s X-rays leading to fake 2p-1s signals
   Eg: A 3p-1s X-ray leaves energy equal to 2p-1s in the detector, leading to an overestimation of the 2p-1s counts

2. Fake gates from higher d to p levels causing the 3d-2p gate trigger more

3. Fake 2p-1s from fake 3d-2p gate triggers



Self-normalized efficiency for Krypton

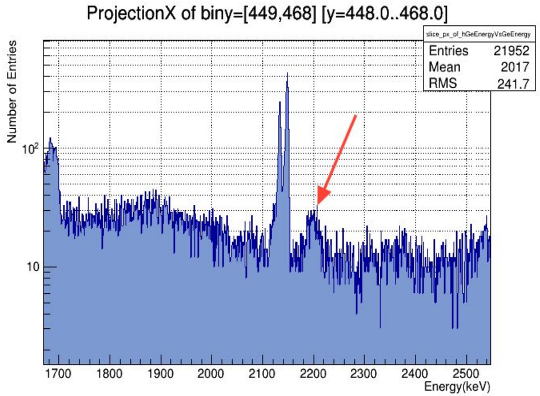


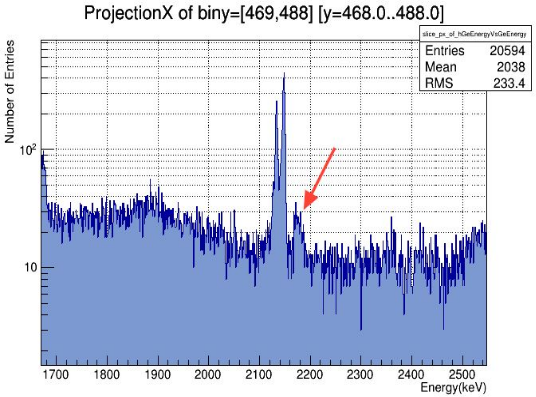
X-ray energy vs energy correlation plot (F. Wauters)

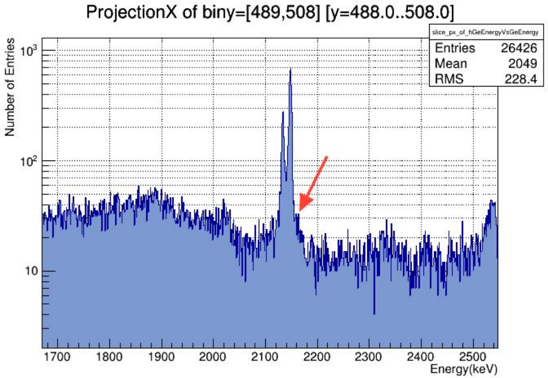
1. Compton scattering from 3p-1s

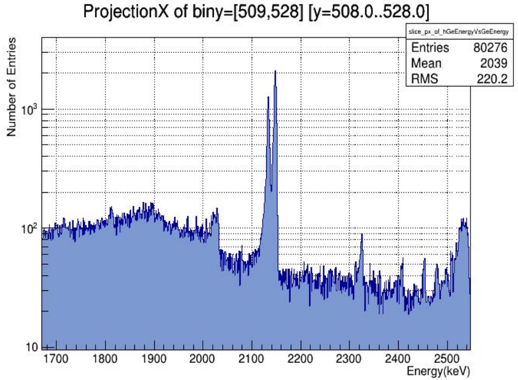
- Points where the horizontal and the vertical lines meet represent the expected coincidence energy when gated on the one of the two energies
- Any point on the diagonal lines in the ROI adds up to np-1s energy
- The Compton scattering from 3p1s (2653 keV) intersects 3d-2p (510 keV) to 2p-1s (2148 keV) gate leaving counts underneath the 2p1s peak

Self-normalized efficiency for Krypton



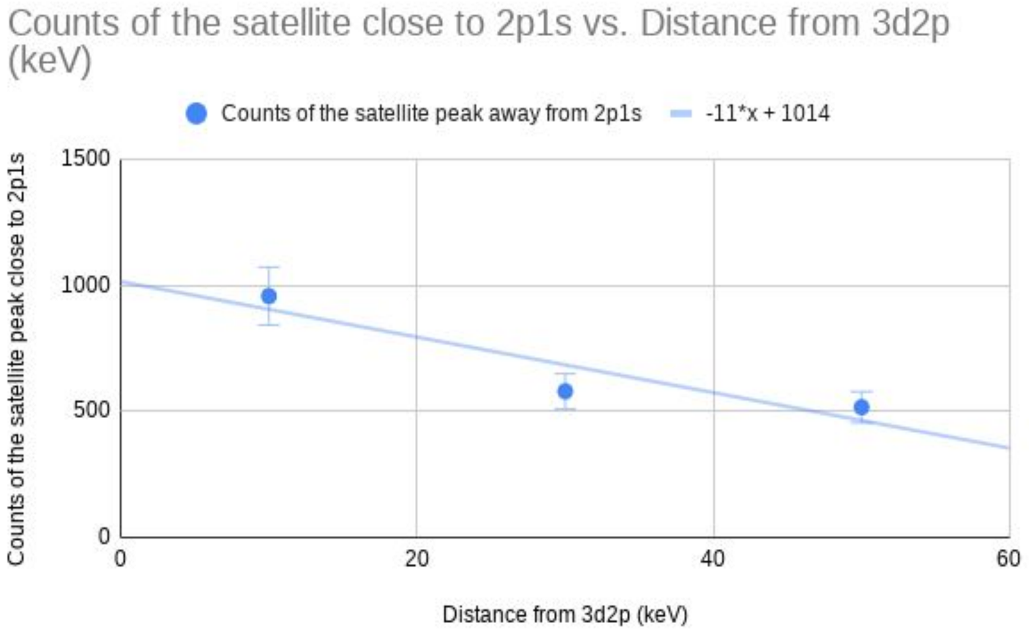






- The satellite peak moves towards the 2p1s peak as the gate approaches 3d2p and eventually gets engulfed by the 2p1s peak as the gate is exactly placed at 3d2p.
- This peak accounts for the 'extra' counts which need to be corrected for.

Self-normalized efficiency for Krypton



An example of estimating the ‘fake’ 2p1s counts because of the Compton scattered 3p1s line

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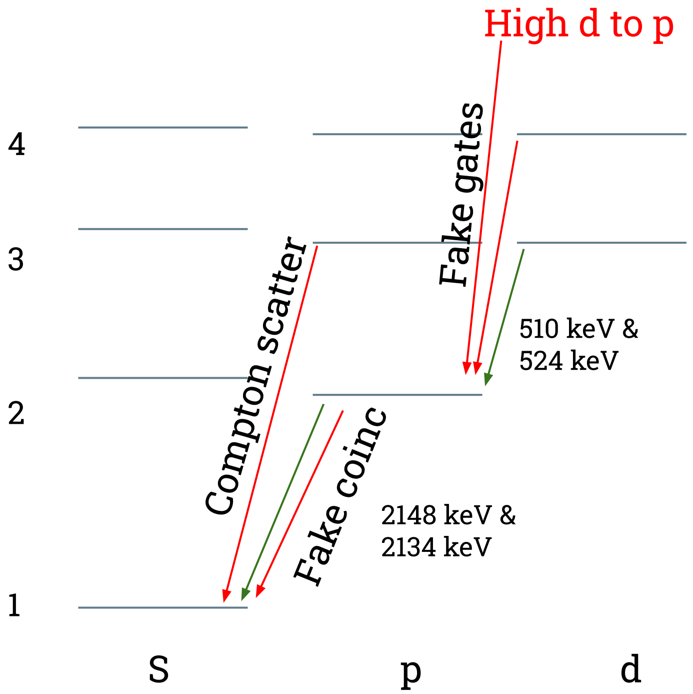
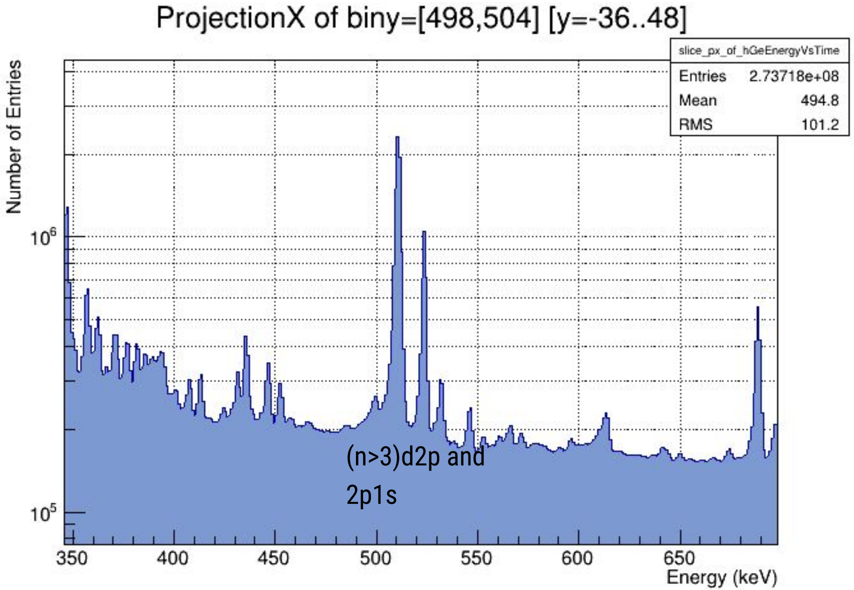
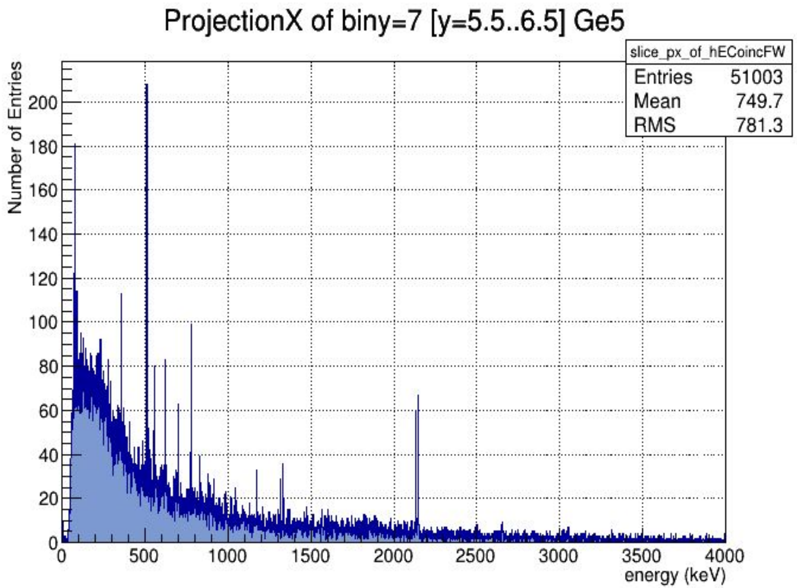


Self-normalized efficiency for Krypton

2. Compton scattered fake gates underneath 3d2p gate



Pure energy spectrum



Gate at 545 keV (right of 3d2p)
still shows the presence of 2p-1s

Self-normalized efficiency for Krypton

Self normalized efficiency for Krypton points:

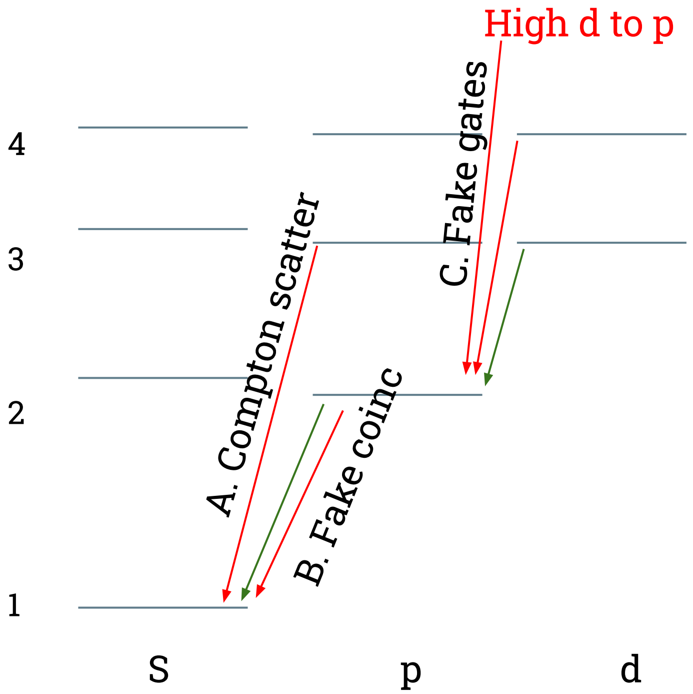
$$\text{Efficiency (2148 keV)} = \frac{\#\text{coincidences} - A - B}{\#\text{gate trigger} - C}$$

Where,

A = 2148 keV counts from 3p1s Compton correction

B = 2148 keV counts from fake (n > 3)d to 2p1s gates

C = fake gates from (n > 3)d to 2p and 2p1s



Decomposing BG in the region of interest

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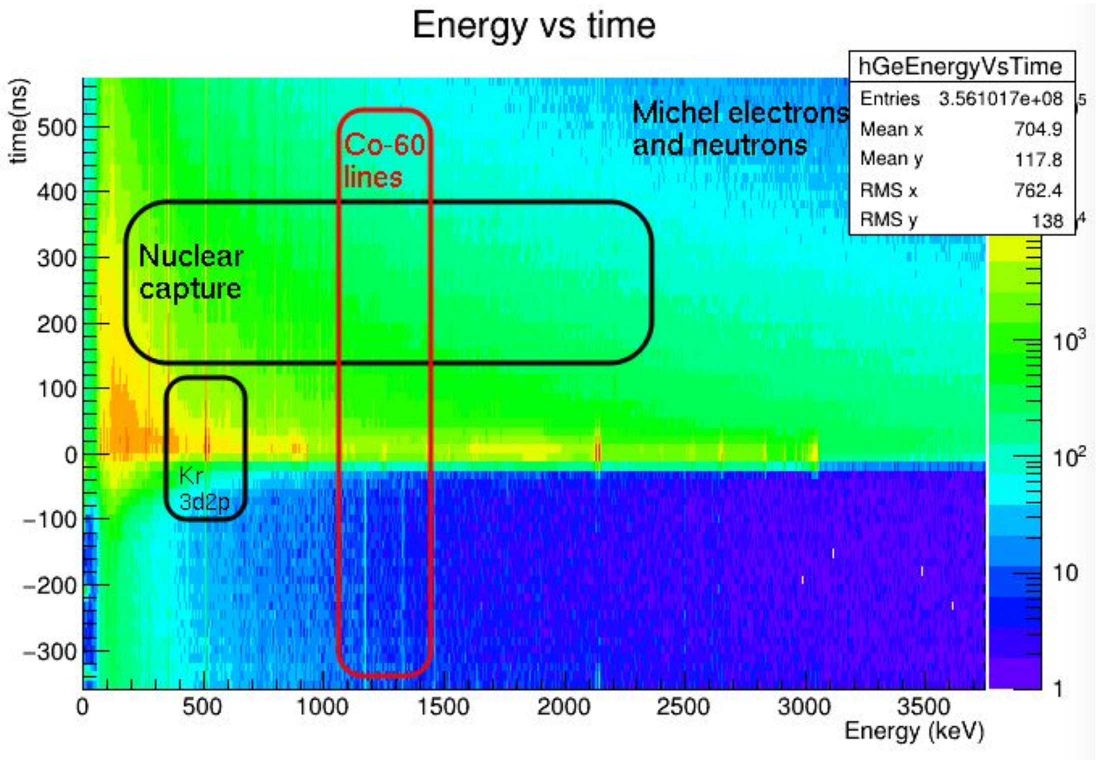
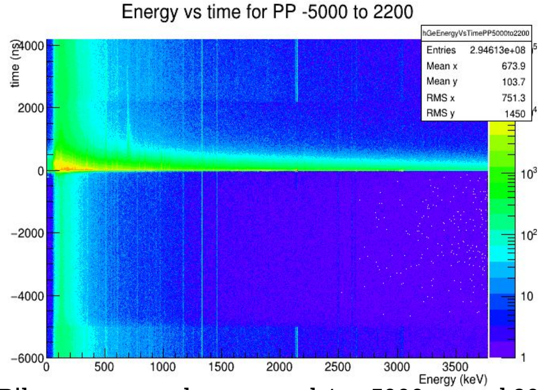


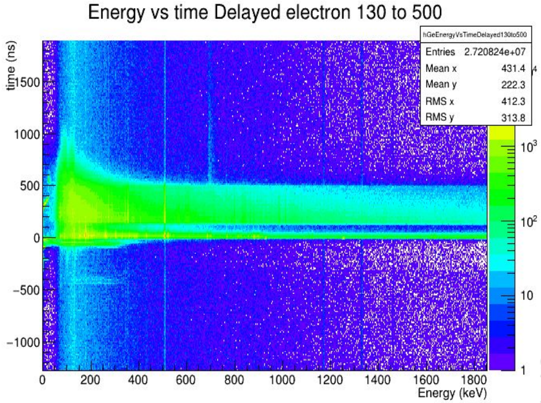
- Michel electrons from muon decay inside the atoms
- Nuclear capture BG, neutrons from muon capture inside the nucleus
- Bremsstrahlung from electrons
- Pile-up muons

Decomposing BG in the region of interest

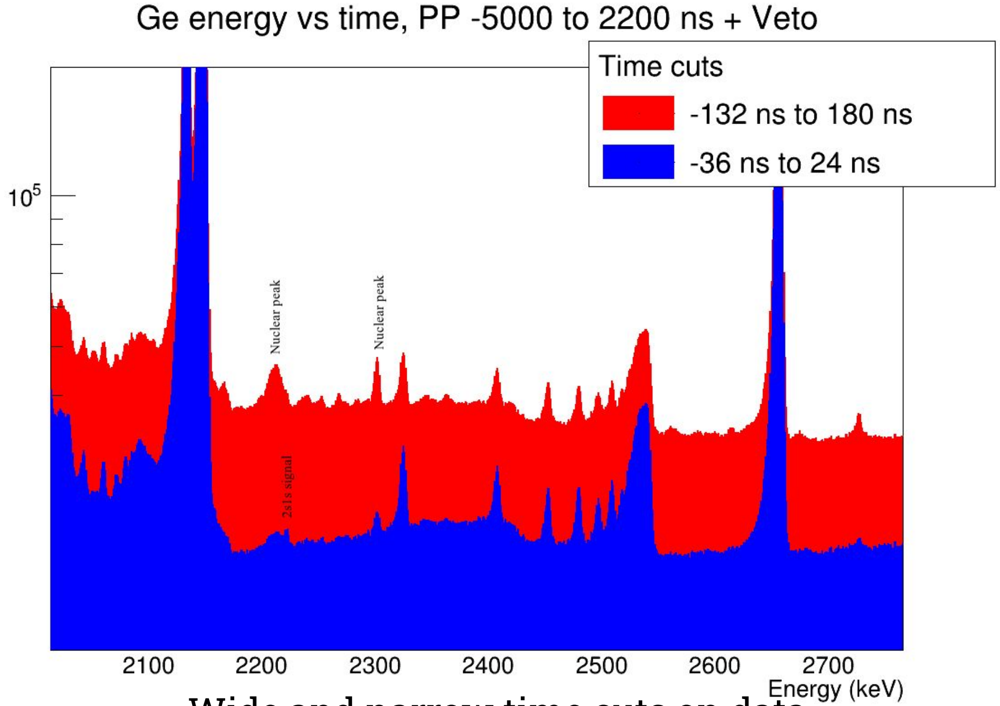
<u>Effects of different cuts in energy and time</u>



Pile-up protected muon cut b/w -5000 ns and 2000 ns

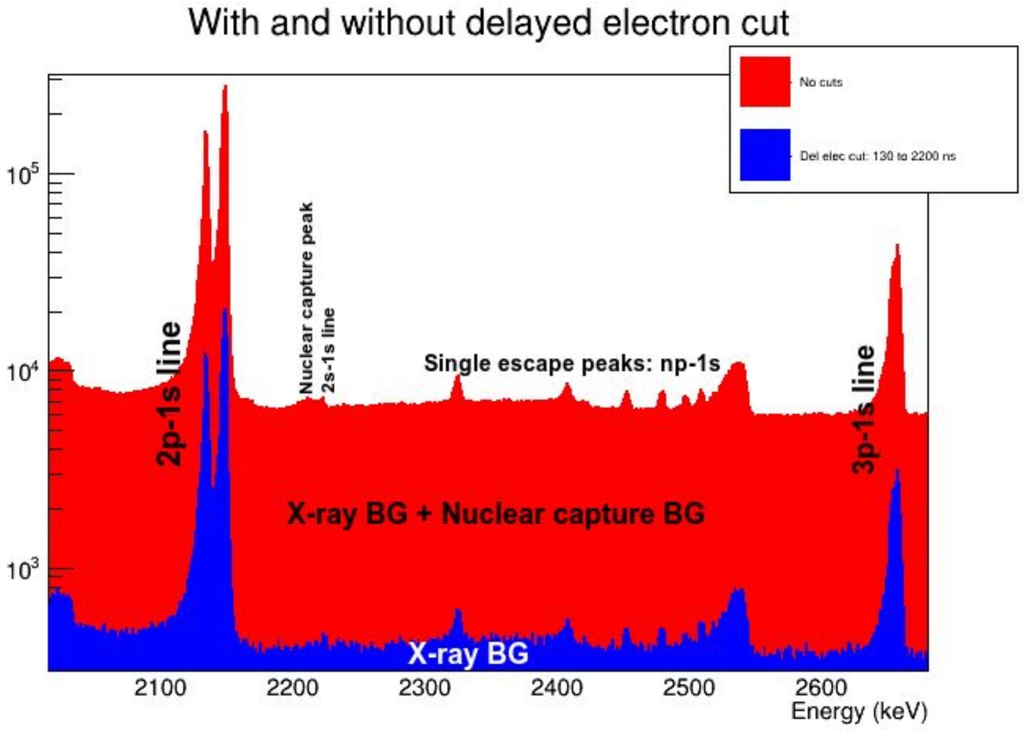


Michel electron cut between 130 ns and 500 ns



Wide and narrow time cuts on data

Decomposing BG in the region of interest



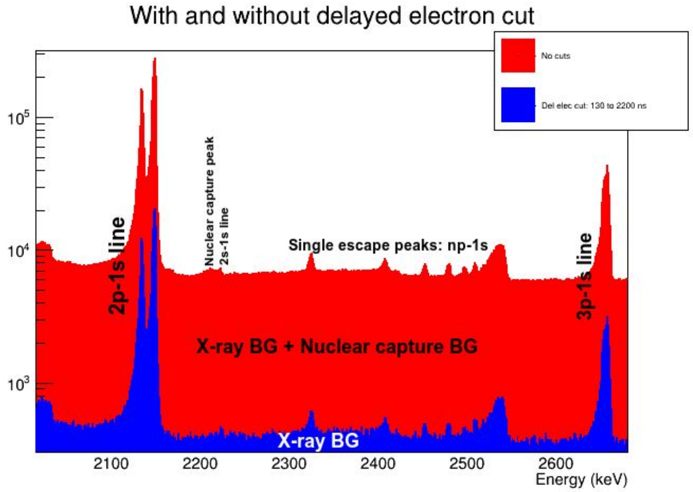
Blue spectrum is with delayed electron cut, red is with no cuts

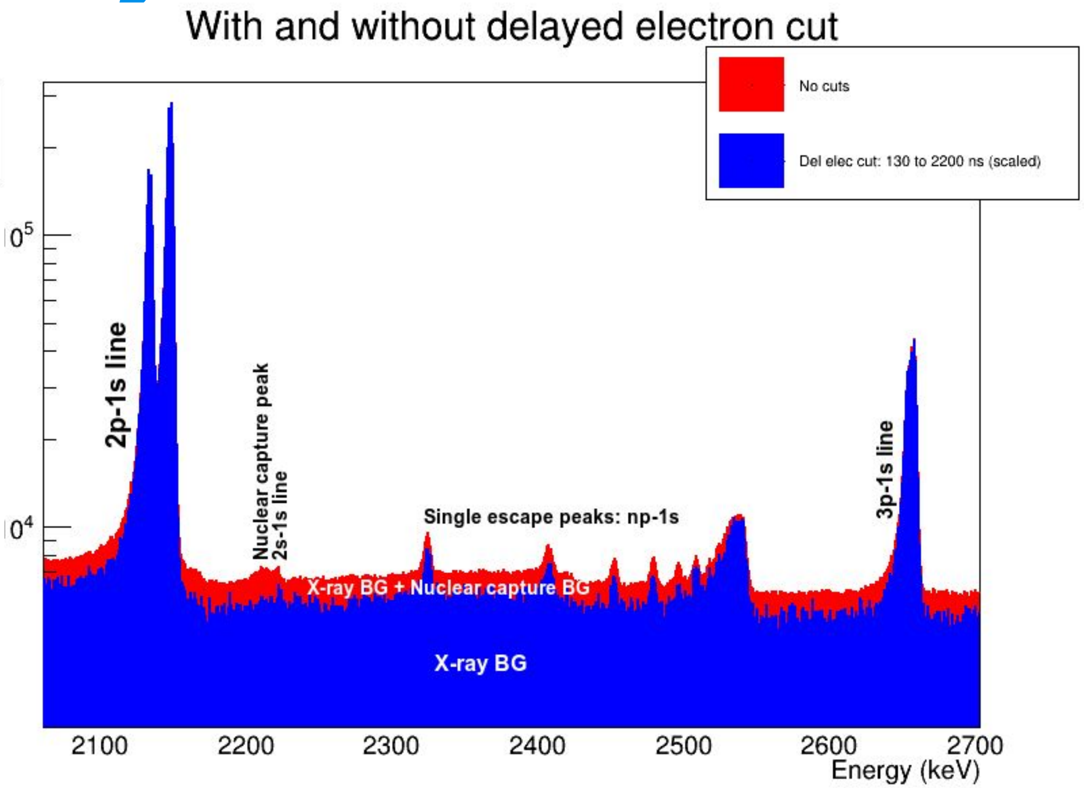
- Effect of delayed electron cut shows loss of statistics > 90%, not ideal to separate out the 2s-1s signal with a low branching fraction

- Background needs to be identified into it's components and modelled to have a final fit which should consists of:

1. An approximated X-ray background
2. Nuclear capture background
3. The 2s-1s signal fit with the lineshape model

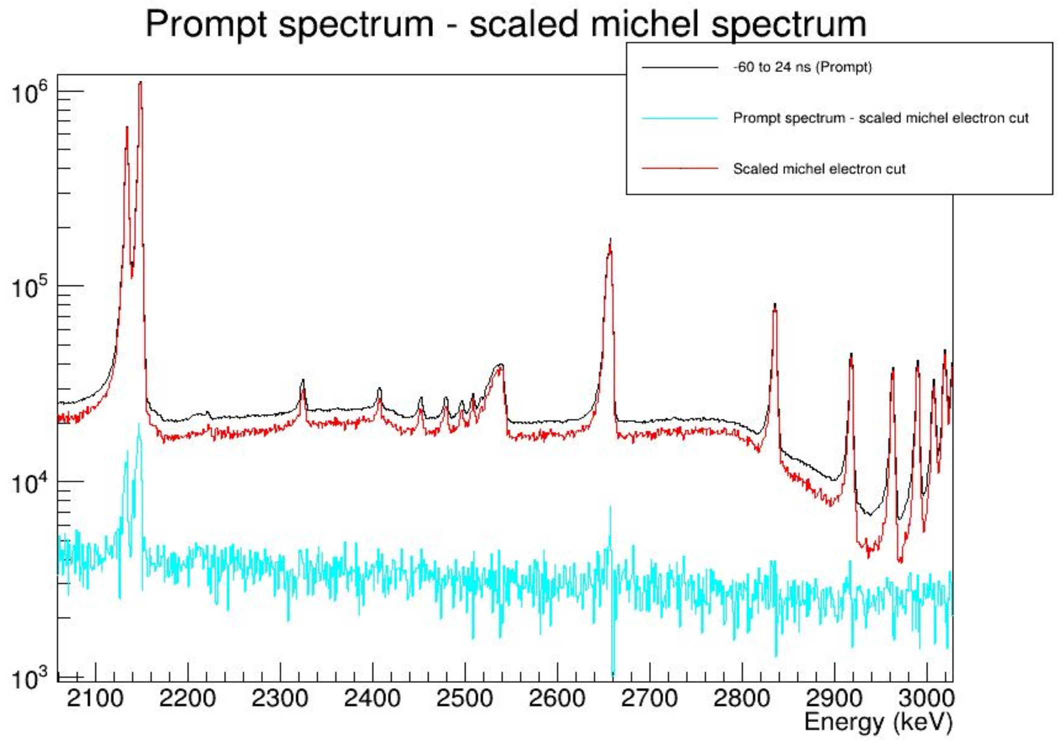
Decomposing BG in the region of interest





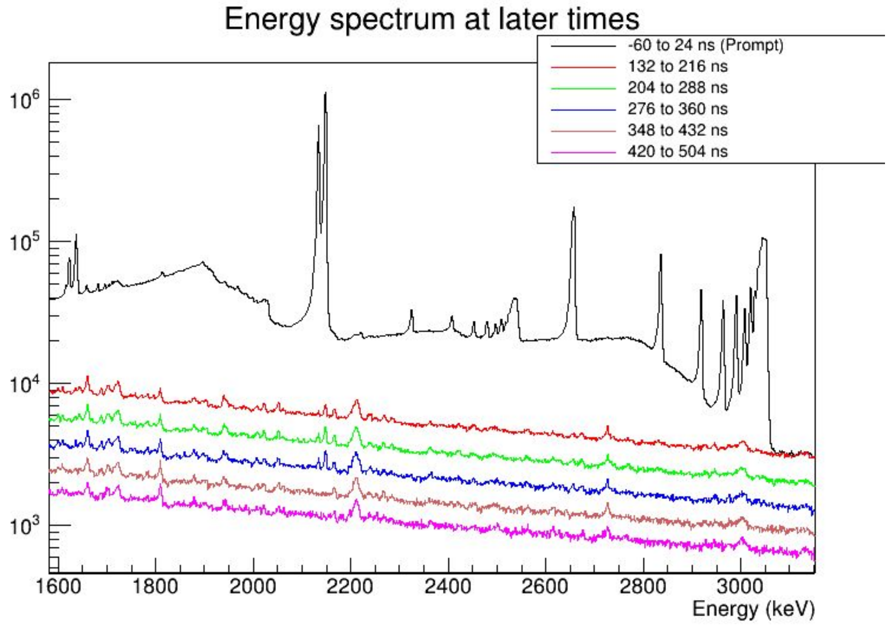
Scale the np-1s peaks to recover the lost X-ray peak counts with an average scaling factor:

Decomposing BG in the region of interest

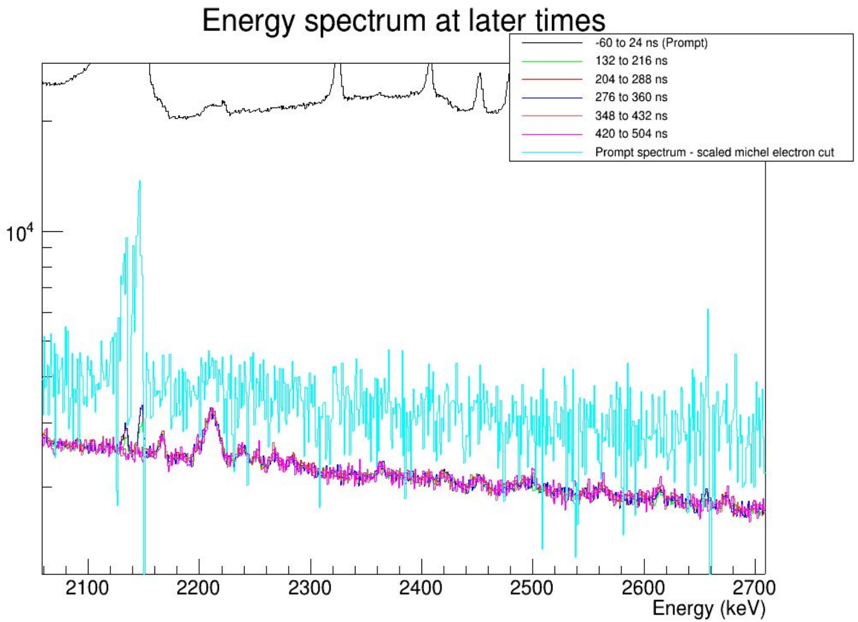


- Difference between the prompt spectrum and the scaled Michel electron spectrum contains the neutrons, nuclear capture gammas etc
- Expected to have the same features as the spectrum at later times
- The fluctuations in the Cyan spectrum are due to subtraction

Decomposing BG in the region of interest

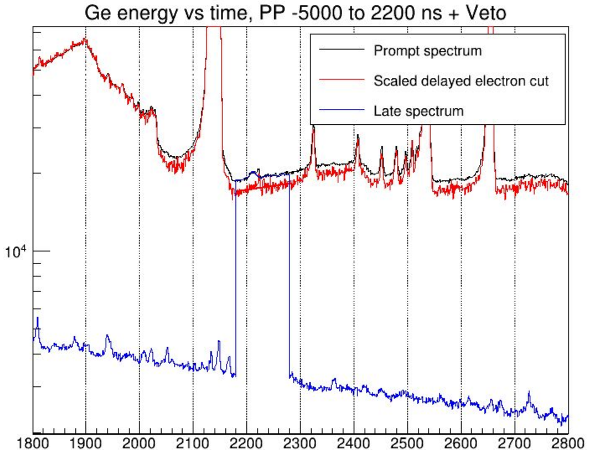


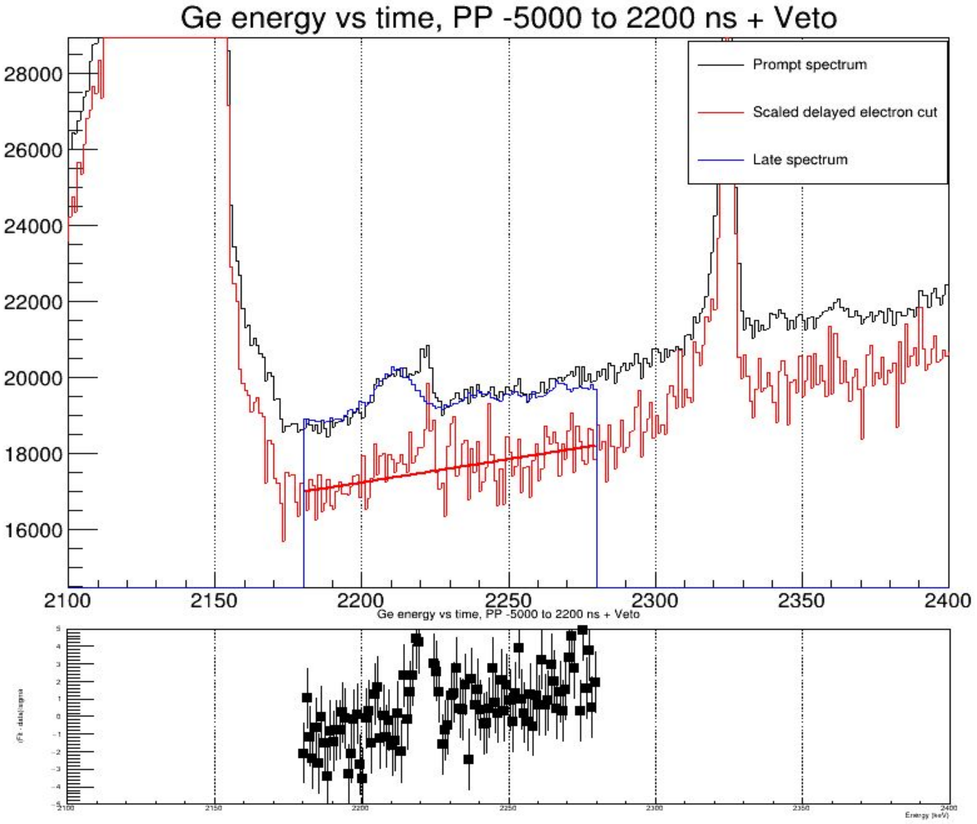
Late time cuts of the same energy spectrum



Late time cuts of the same energy spectrum, scaled on top of each other

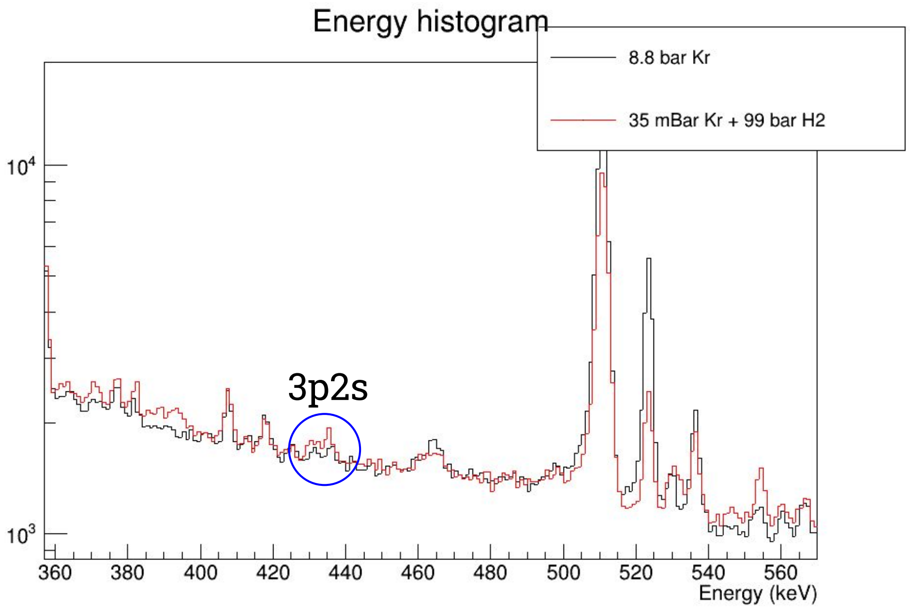
Decomposing BG in the region of interest

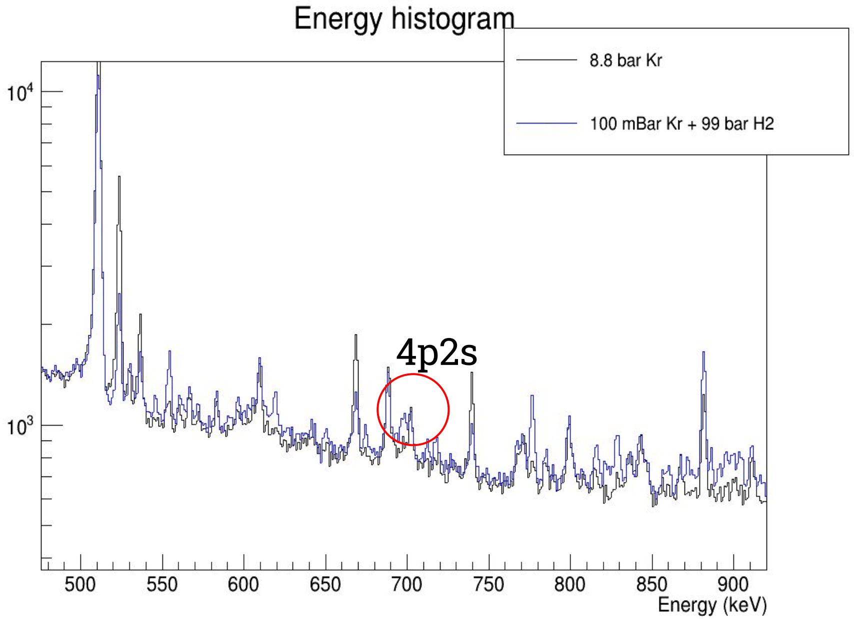




Adding late spectrum to scaled delayed electron cut which is approximated with a polynomial

2s level population enhancement





Energy spectra for Krypton with and without Hydrogen mixture in the target cell

Next things on the list..

- Find the 2s-level enhancement factor for Krypton by comparing data with and without Hydrogen mixture in Krypton
- Fit the 2s-1s signal with an error bar on the counts by varying the BG fit limit
- Determine the signal to BG ratio for the 2s-1s line
- Write...