

# Numerical correction methods of neutron damages in HPGe detectors

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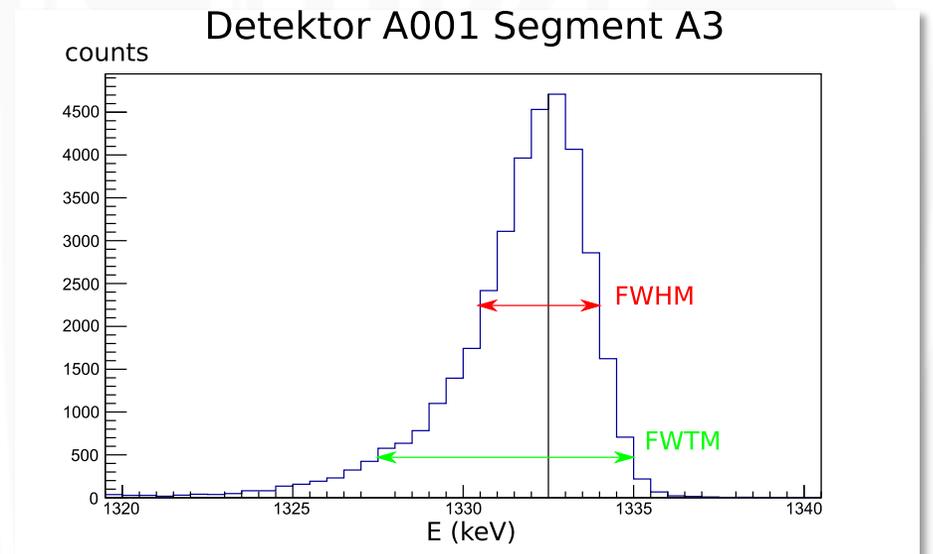
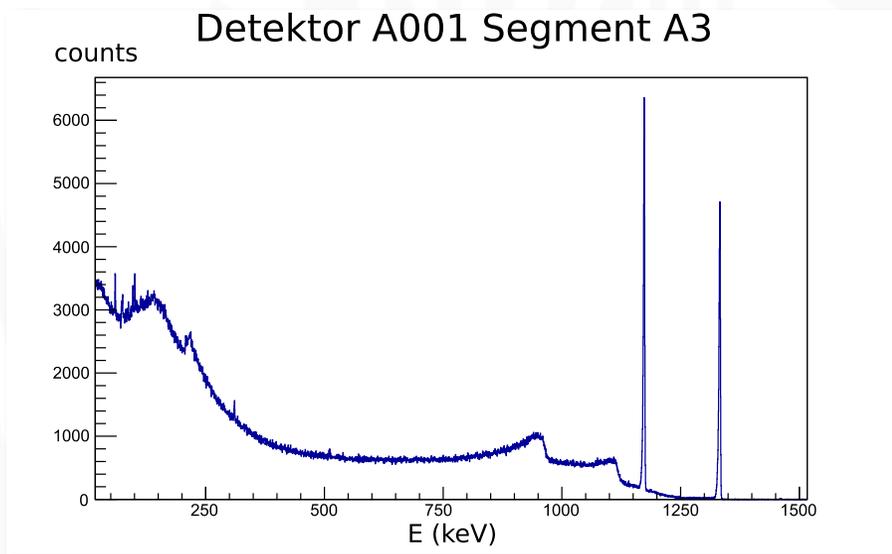
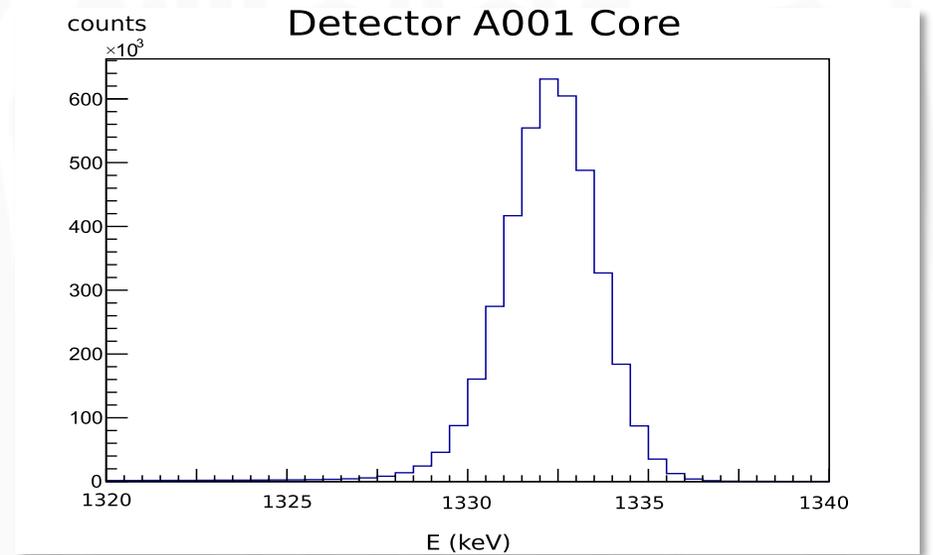
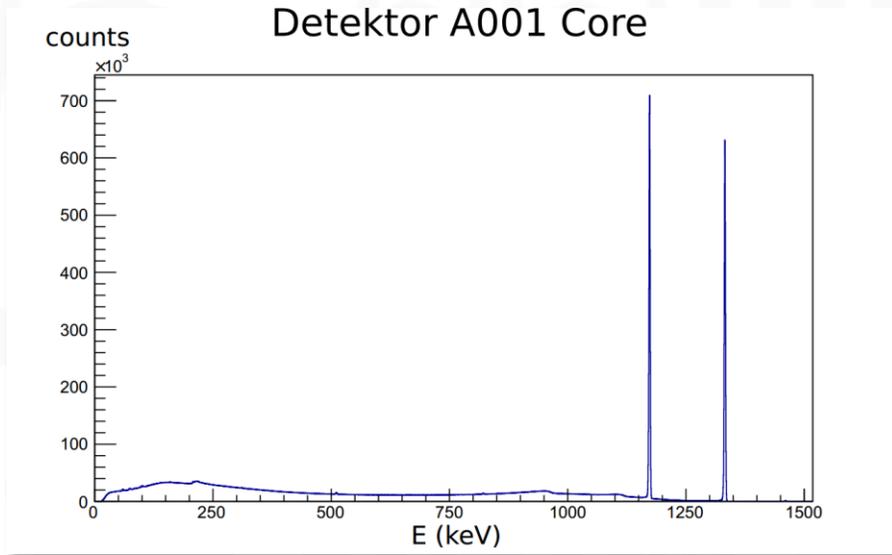


17th AGATA week  
Orsay  
5 Oct 2016



# $^{60}\text{Co}$ gamma-ray spectra

Source measurement (April 2016 GANIL)



# Numerical description of neutron damage

Amount of free charge carriers:

$$q_{e,h}(t) = q_{e,h}(0) \exp\left[-\int_0^t \langle \sigma v \rangle \frac{1}{\lambda_{e,h}} dt'\right]$$

Collection efficiency:

$$\eta_{e,h}^i = \left| \int_0^{t_{coll}} (\nabla \phi_i(x(t)) \cdot v_{e,h}) \frac{q_{e,h}(t)}{q_{e,h}(0)} dt \right|$$

Total collection efficiency:

$$\eta_{tot}^i \approx 1 + \left[ \frac{1}{\lambda_e} tSG_e^i(x_0) + \frac{1}{\lambda_h} tSG_h^i(x_0) \right]$$

**Position-sensitive trapping sensitivity in  $cm^3$**

$$E_{corr}(x) = \frac{E_0}{1 + \frac{tSG_e(x)}{\lambda_e} + \frac{tSG_h(x)}{\lambda_h}}$$

$\lambda_{e,h}$  inverse trapping centre density N in  $cm^3$

# Position dependence of trapping sensitivities

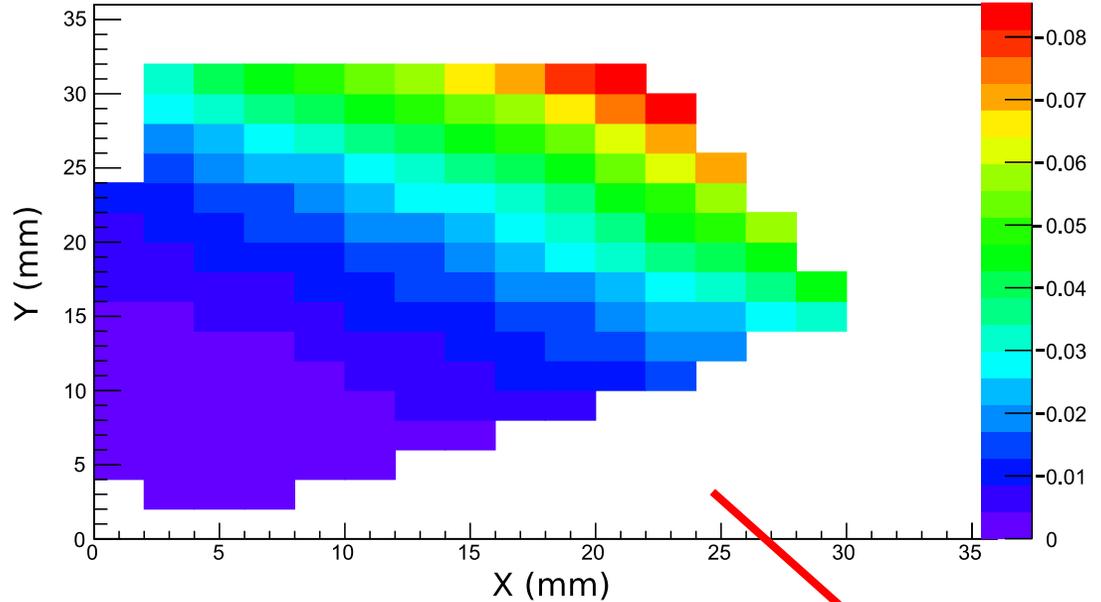
Electrons

using a fixed height

Holes

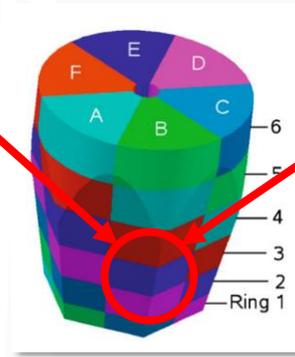
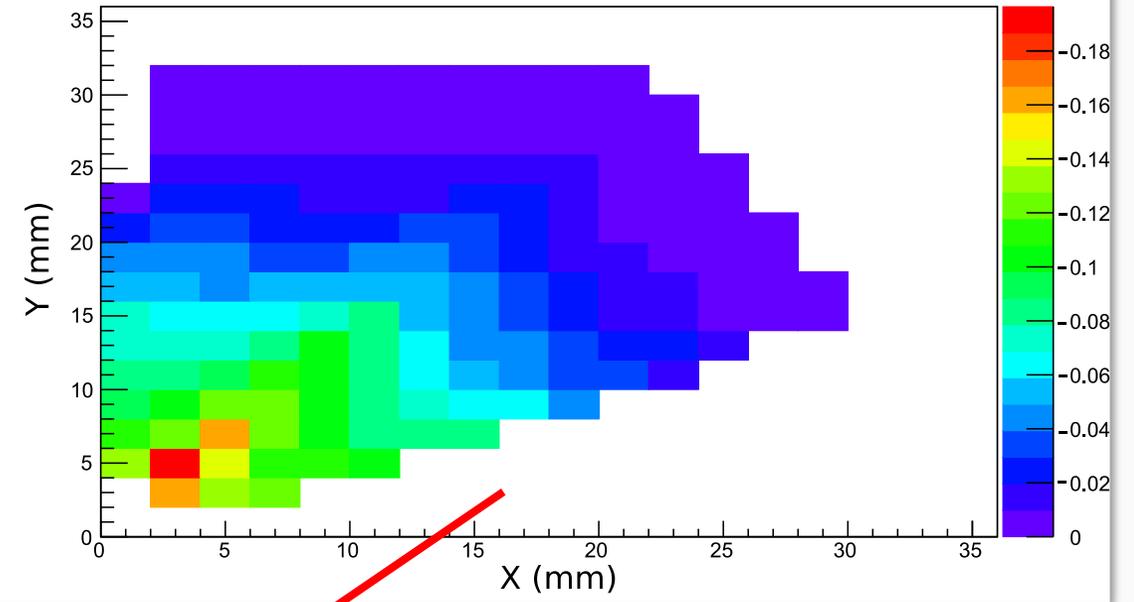
Detector C001 Segment B3

$tSG_e$  (cm<sup>3</sup>)



Detector C001 Segment B3

$tSG_h$  (cm<sup>3</sup>)



# Quality criteria

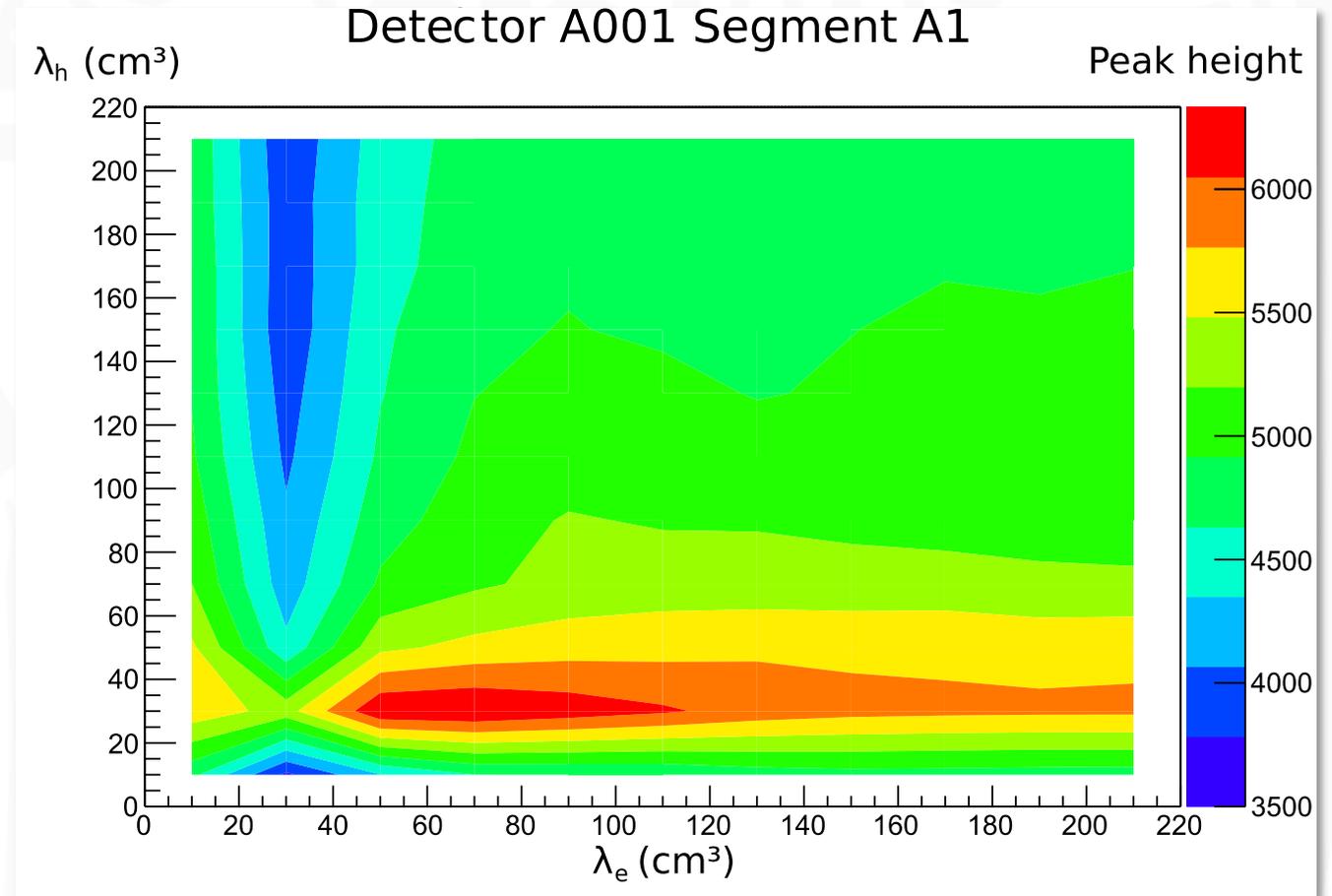
## Quality criteria for the correction method:

- Minimal Full width at half maximum (FWHM)
- Minimal Full width at tenth maximum (FWTM)
- Maximum peak height
- $\chi$

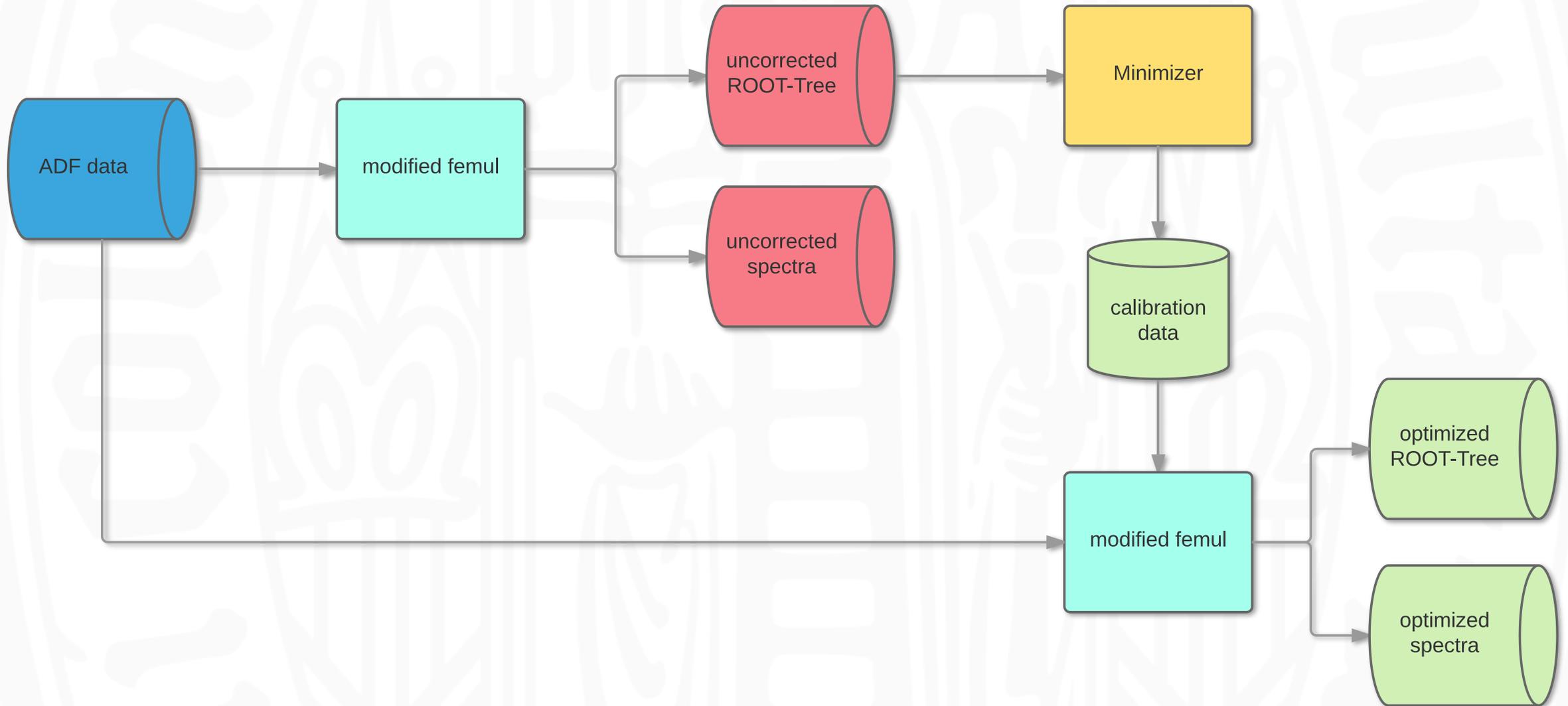
$$\chi = \frac{FWTM}{FWHM}$$

For a perfect Gauss we assume:

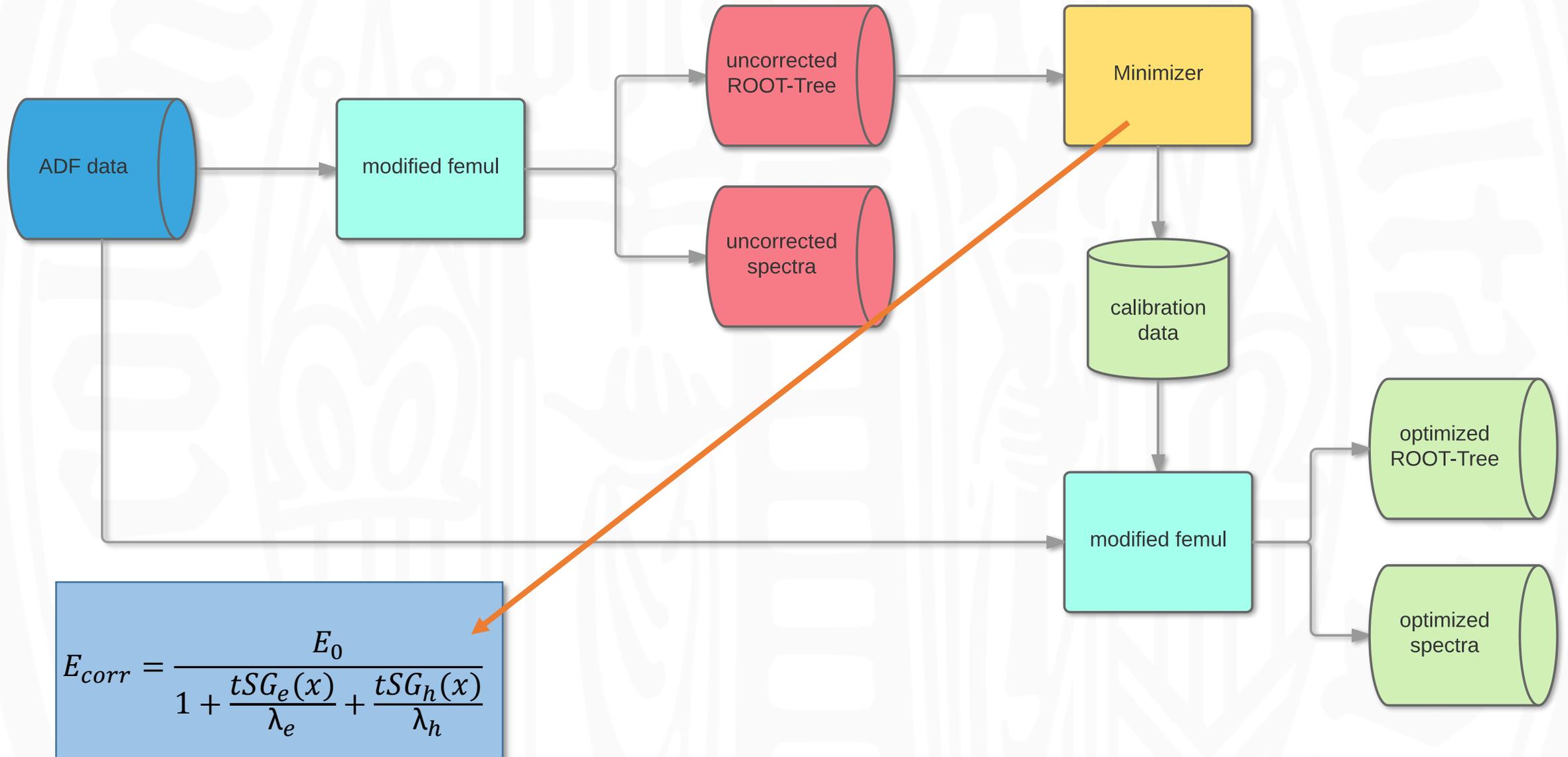
$$\chi \approx 1,823$$



# Minimization method



# Minimization method

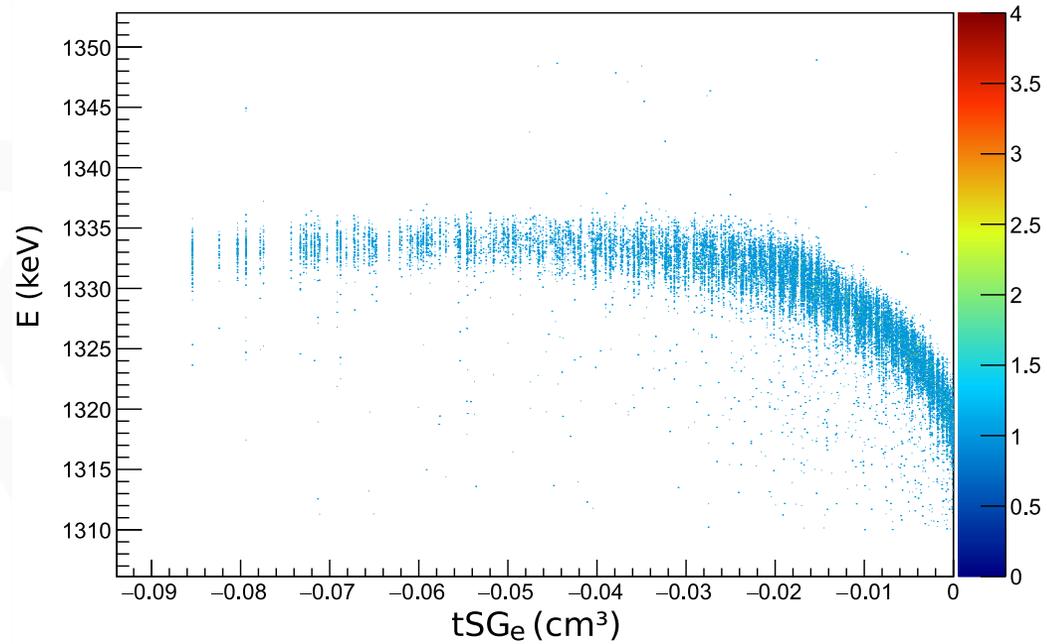


# Uncorrected energy $E$ in dependency of $tSG_{e,h}$

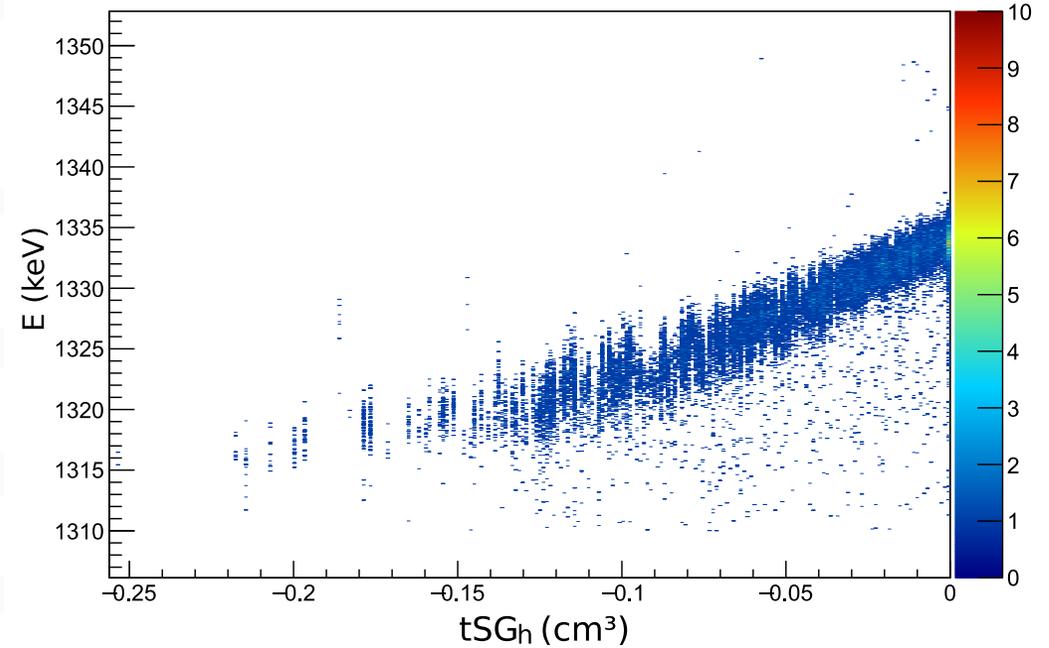
Electrons

Holes

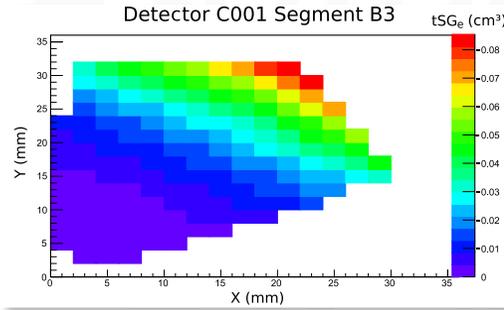
Detector C001 Segment B3



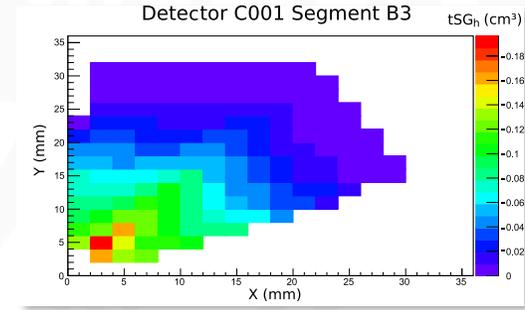
Detector C001 Segment B3



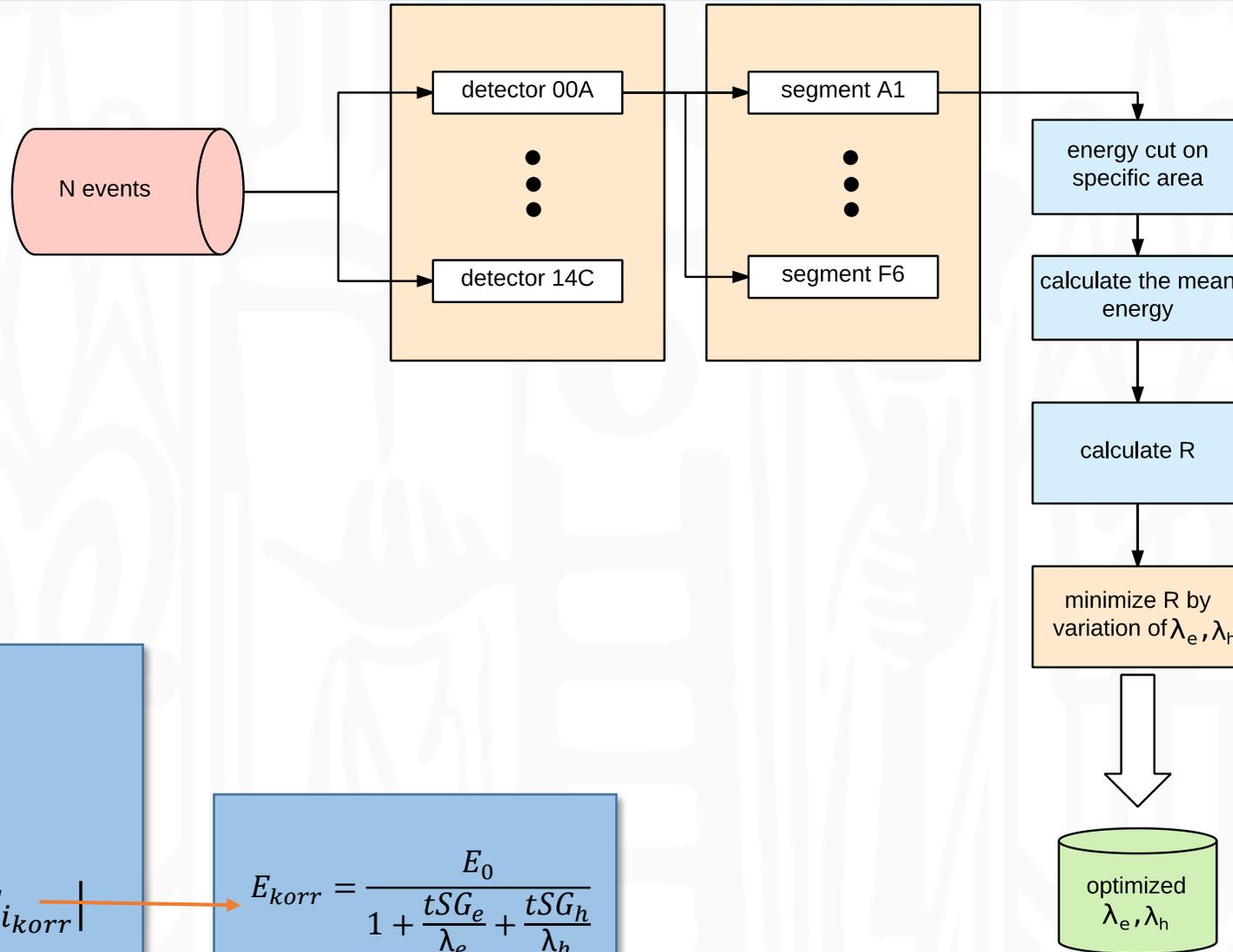
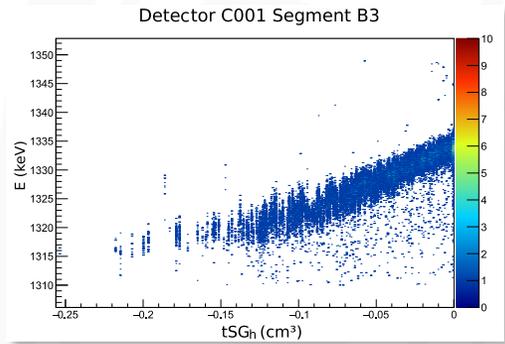
Detector C001 Segment B3



Detector C001 Segment B3



# Minimizer script

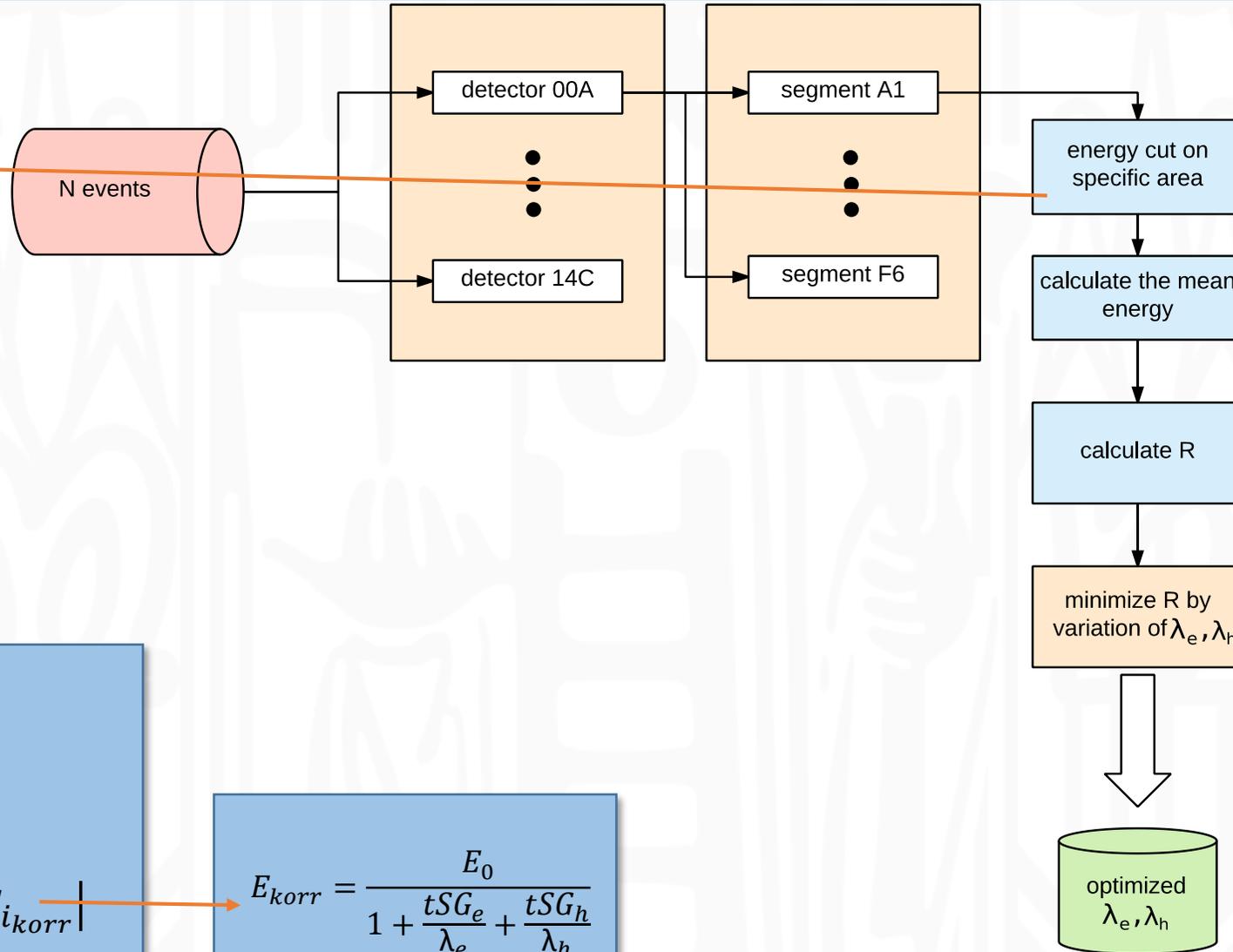
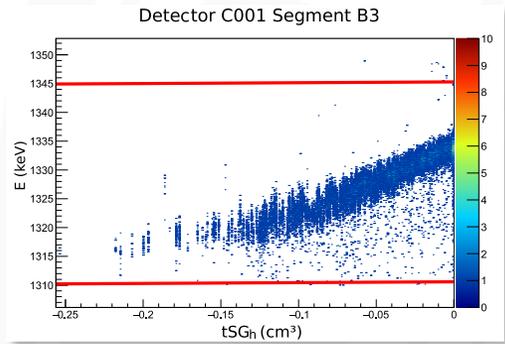


$$E_{mean} = \frac{\sum_{i=1}^N E_i}{N}$$

$$R = \sum_i |E_{mean} - E_{i_{korr}}|$$

$$E_{korr} = \frac{E_0}{1 + \frac{tSG_e}{\lambda_e} + \frac{tSG_h}{\lambda_h}}$$

# Minimizer script

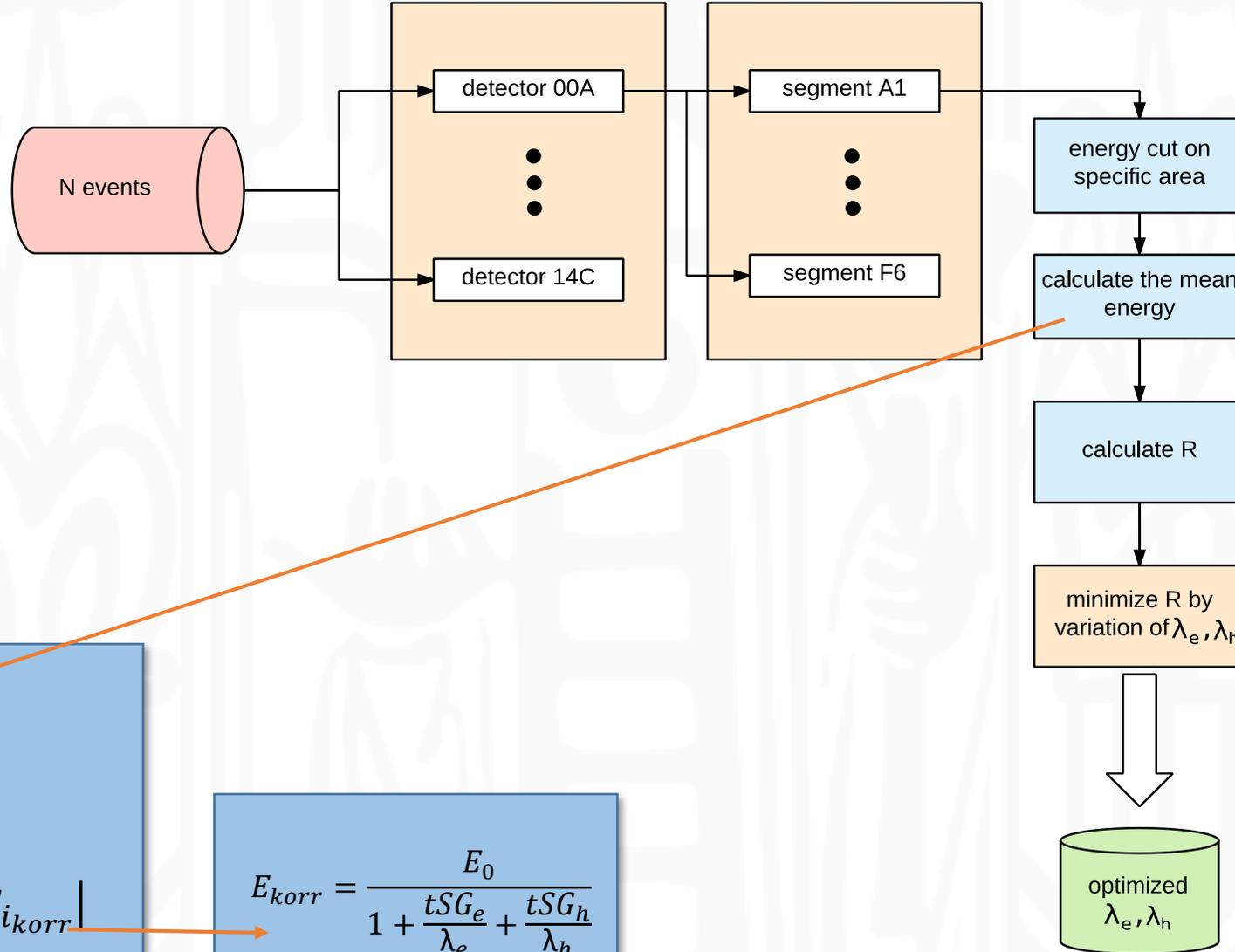
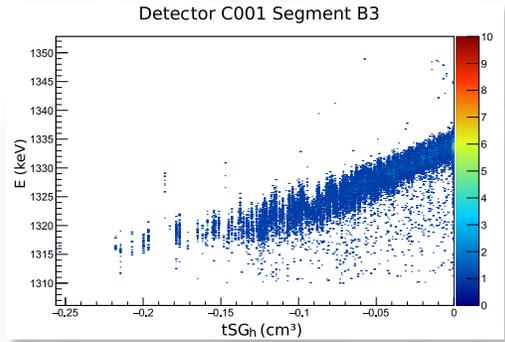


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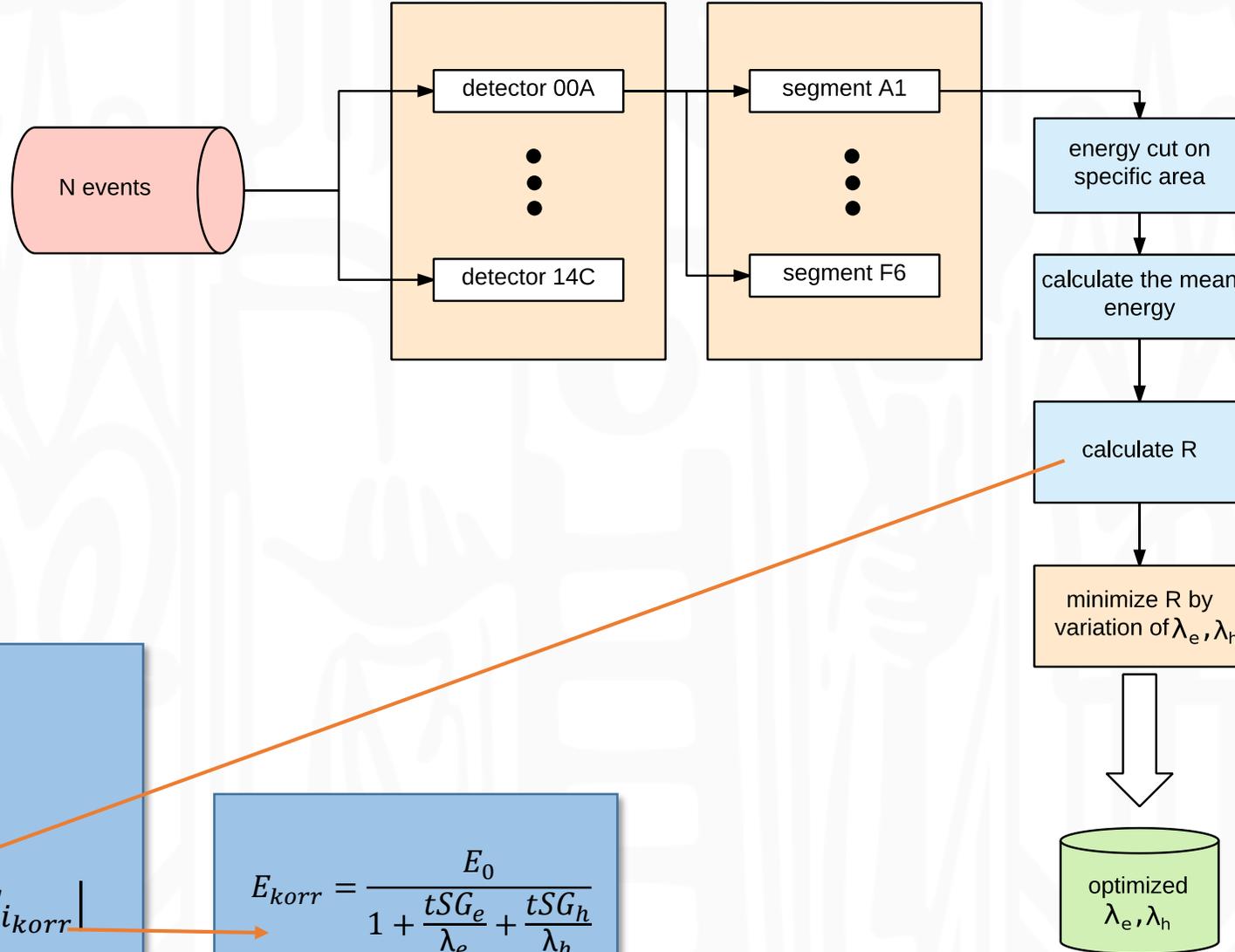
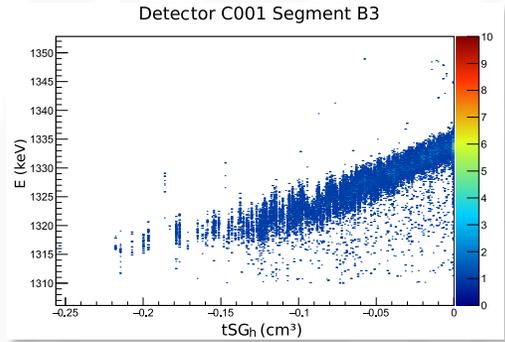
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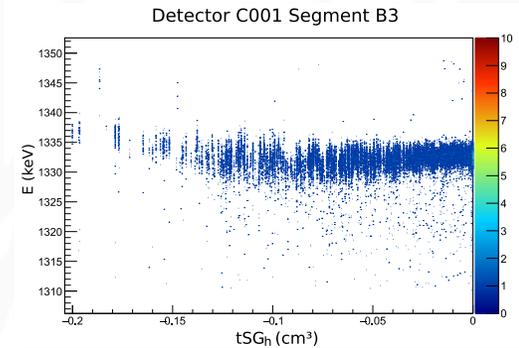
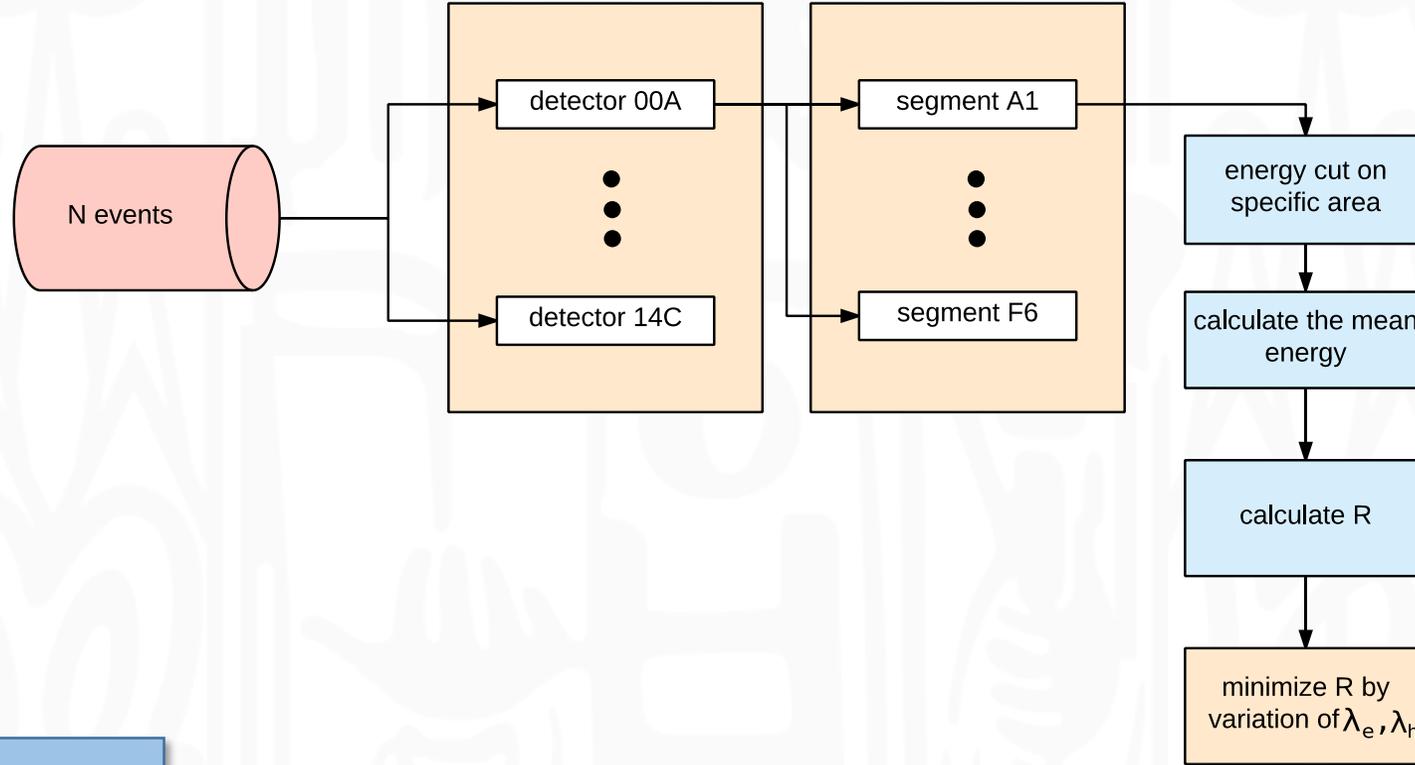
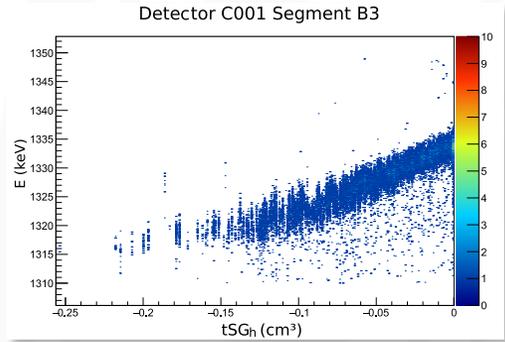


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# Minimizer script



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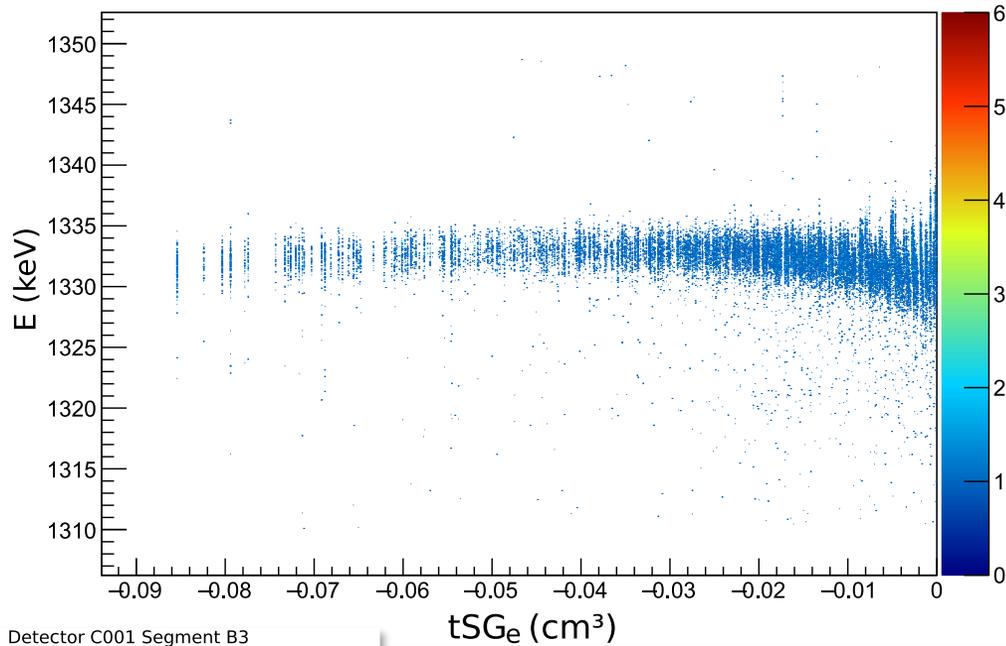
$$R = \sum_i |E_{mean} - E_{i_{korr}}|$$

$$E_{korr} = \frac{E_0}{1 + \frac{tSG_e}{\lambda_e} + \frac{tSG_h}{\lambda_h}}$$

# Corrected energy $E$ in dependency of $tSG_{e,h}$

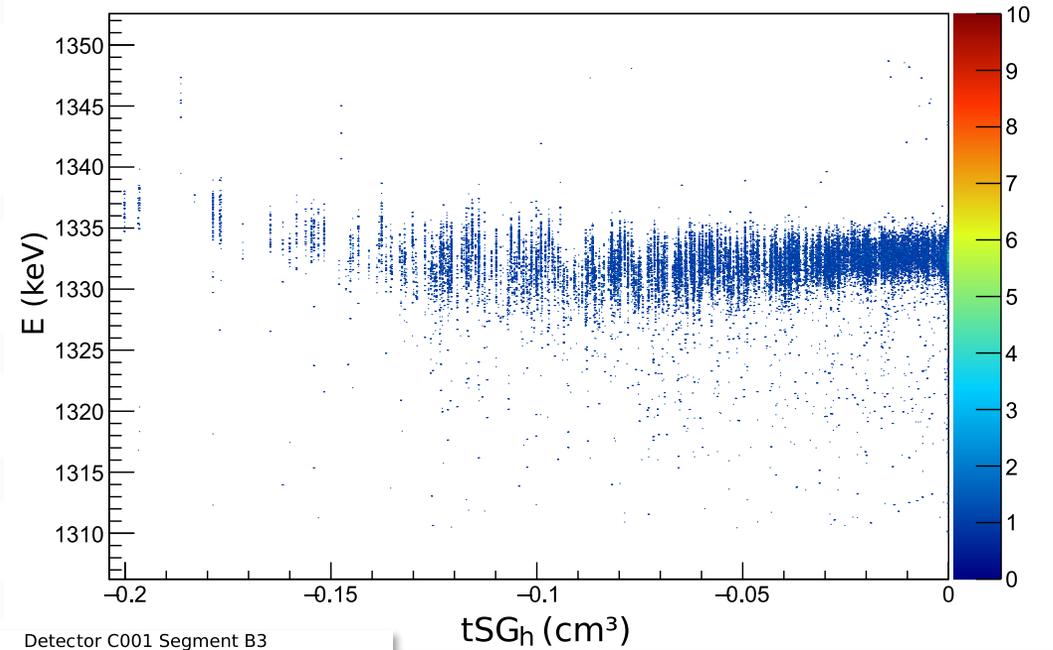
electrons

Detector C001 Segment B3

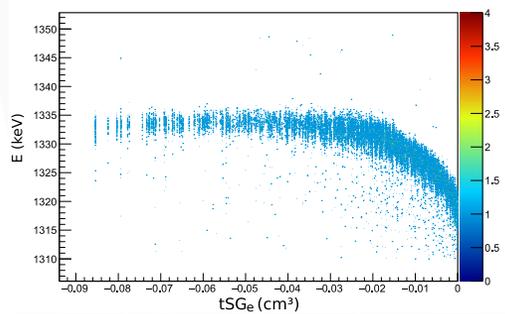


holes

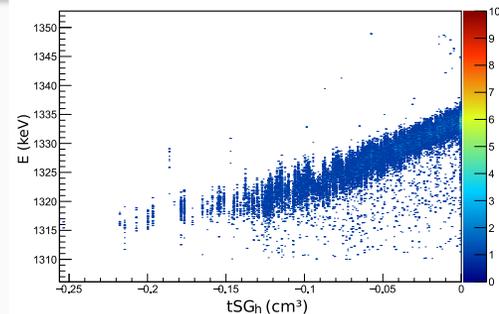
Detector C001 Segment B3



Detector C001 Segment B3



Detector C001 Segment B3

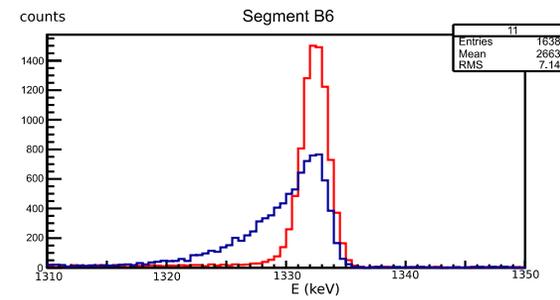
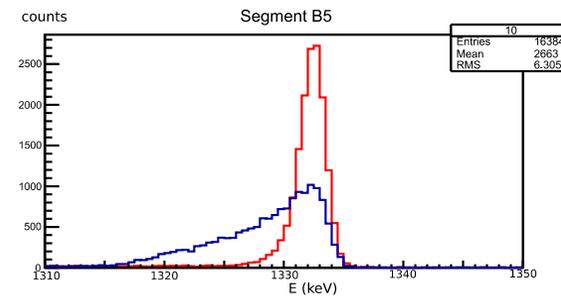
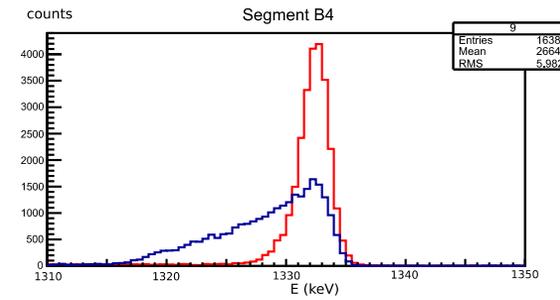
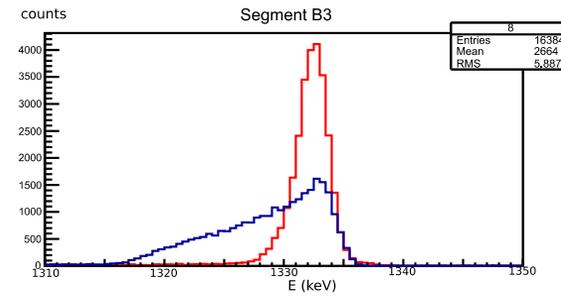
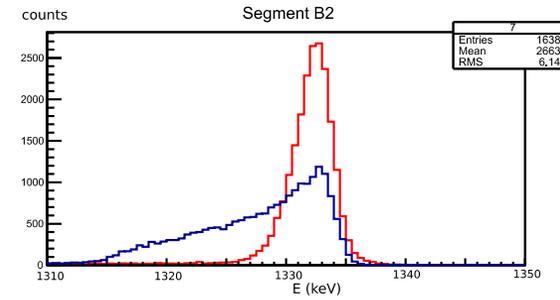
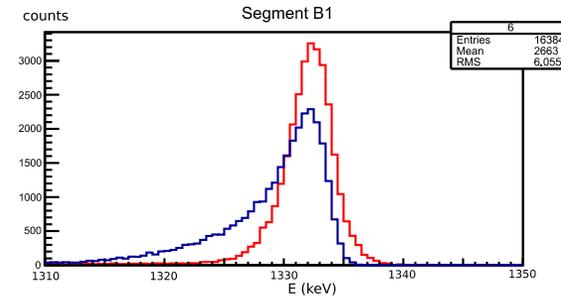
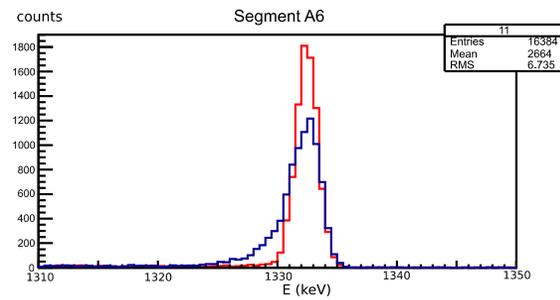
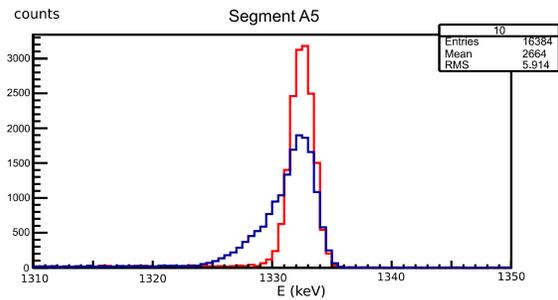
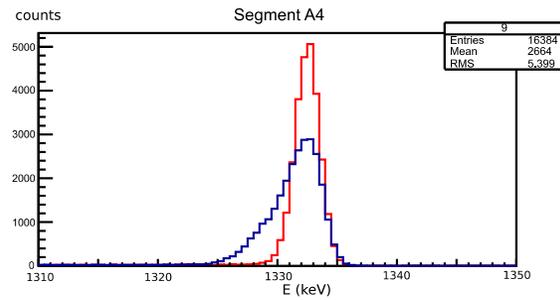
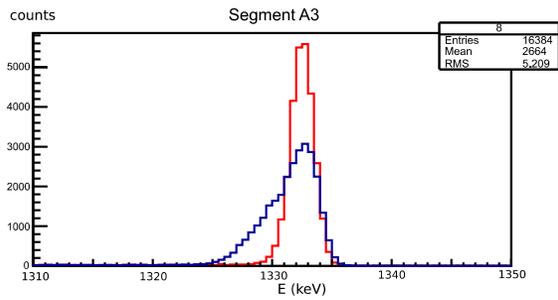
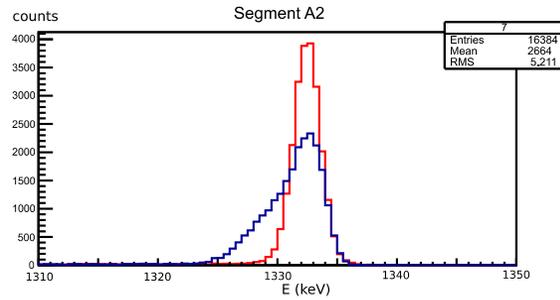
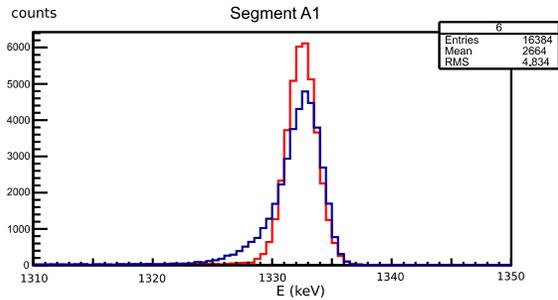


# Results detectors A001 and C001

■ original   ■ corrected

## Detector A001

## Detector C001



# Results detectors A001 and C001

original corrected

Detector A001 segment A3:

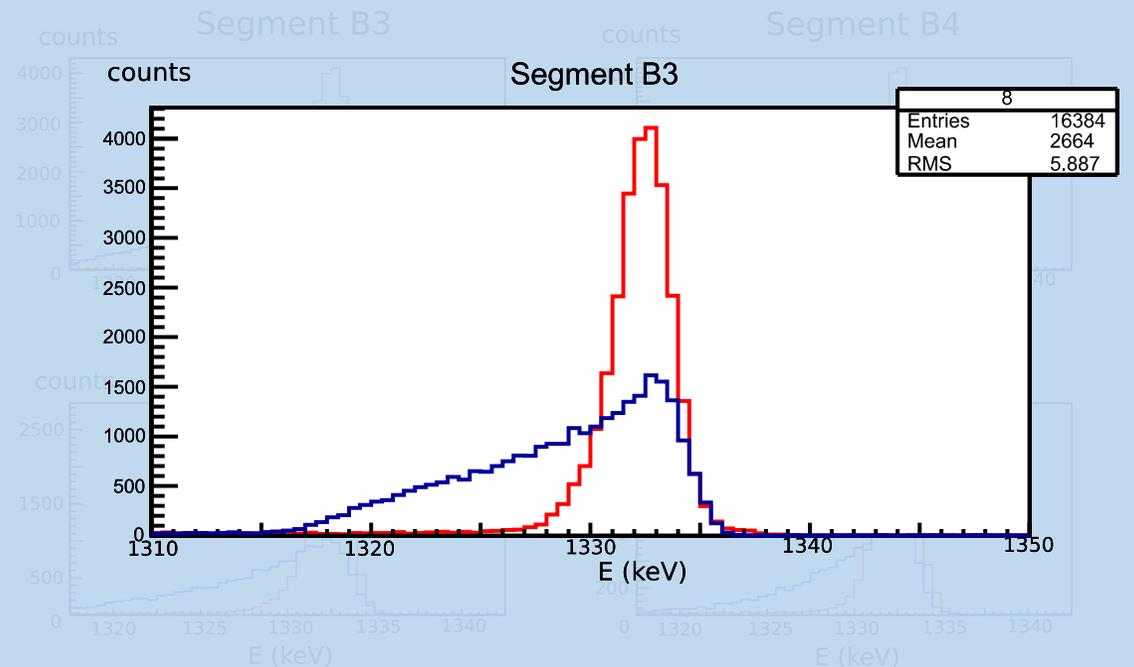
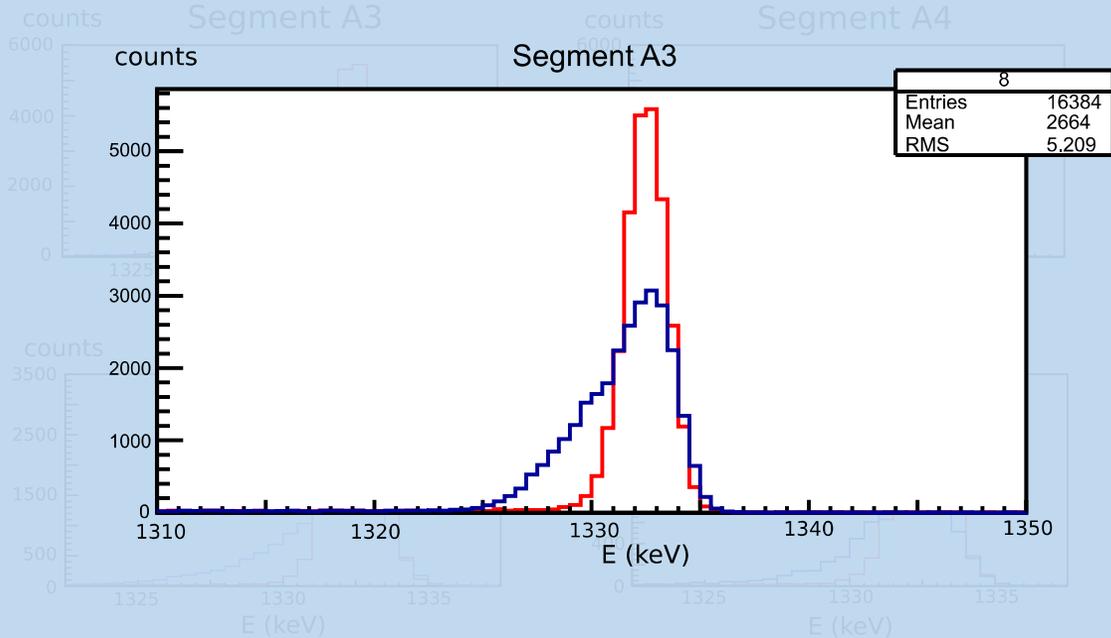
FWHM = 3,30 keV  $\chi = 2,58$

FWHM = 2,21 keV  $\chi = 2,04$

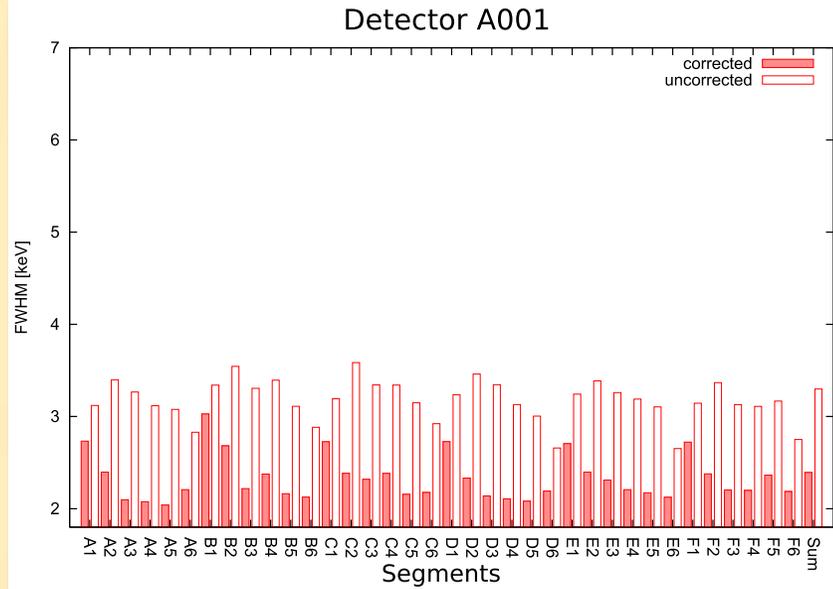
Detector C001 segment B3:

FWHM = 6,40 keV  $\chi = 2,91$

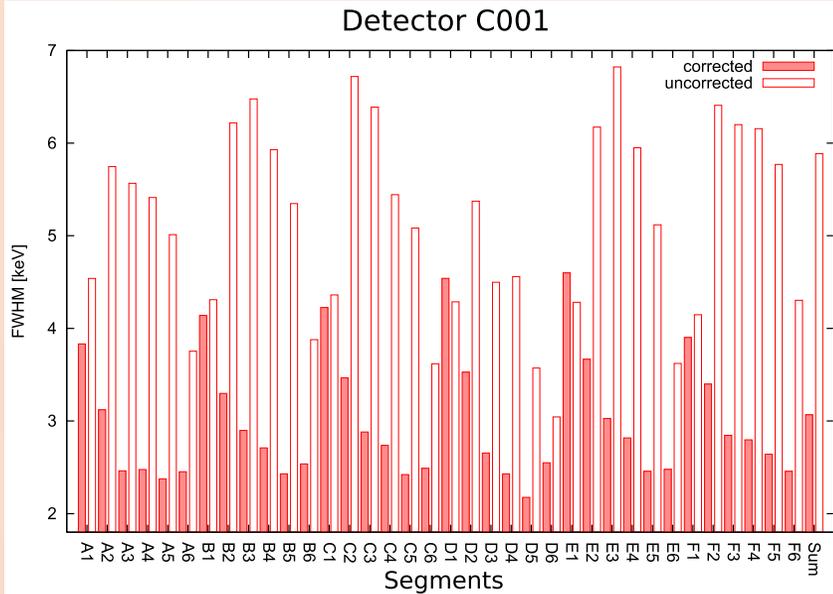
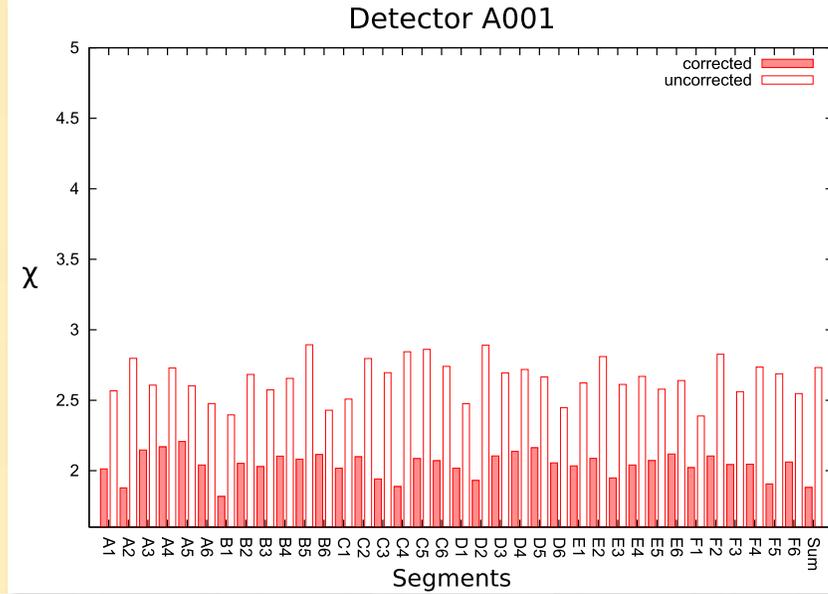
FWHM = 2,85 keV  $\chi = 2,08$



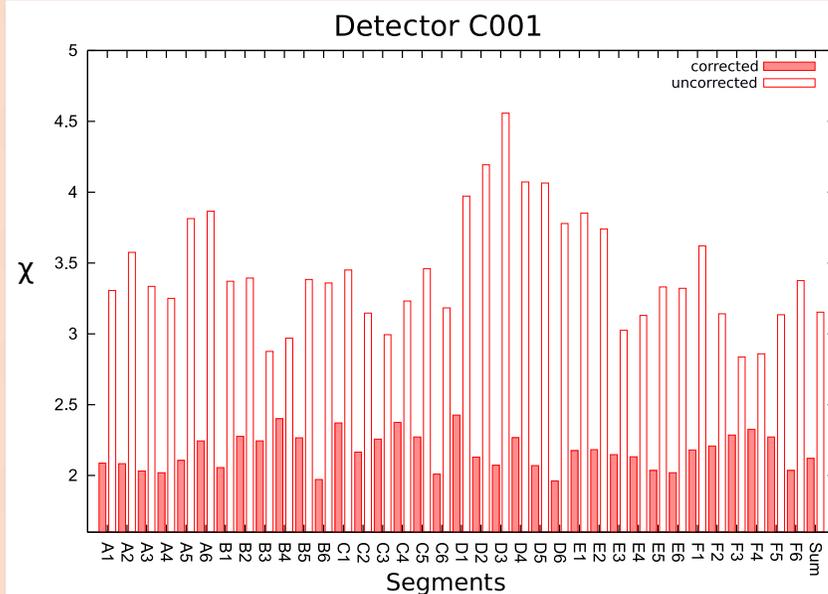
# Results detectors A001 and C001



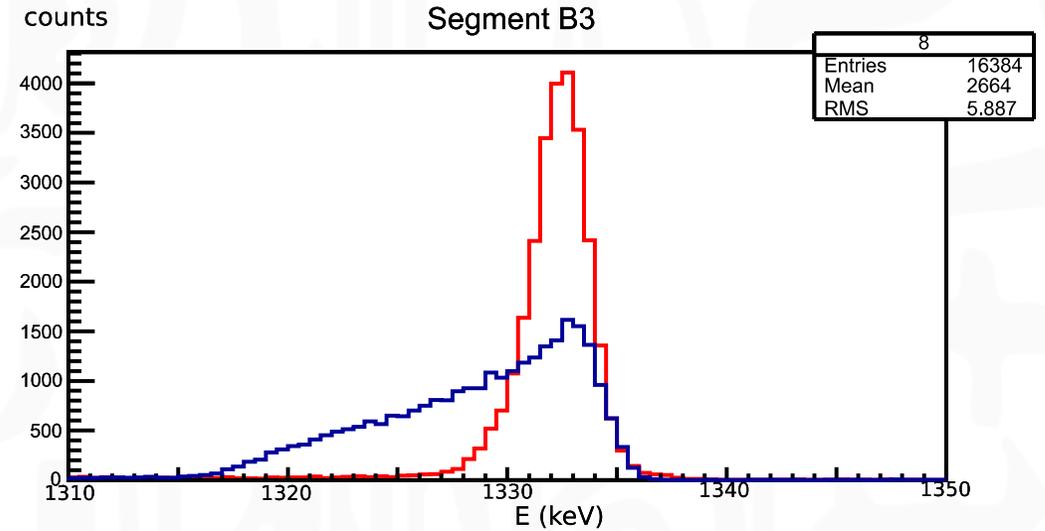
A001



C001



# Summary and outlook



## Summary:

- Novel fast correction algorithm applied
- Energy resolution improved
- Optimized peak shape

## To be done:

- Apply to the latest AGATA measurements

Thank you for your attention!



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