Improving tracking at low energies and tracking efficiency

A. Lopez-Martens
CSNSM

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Outline

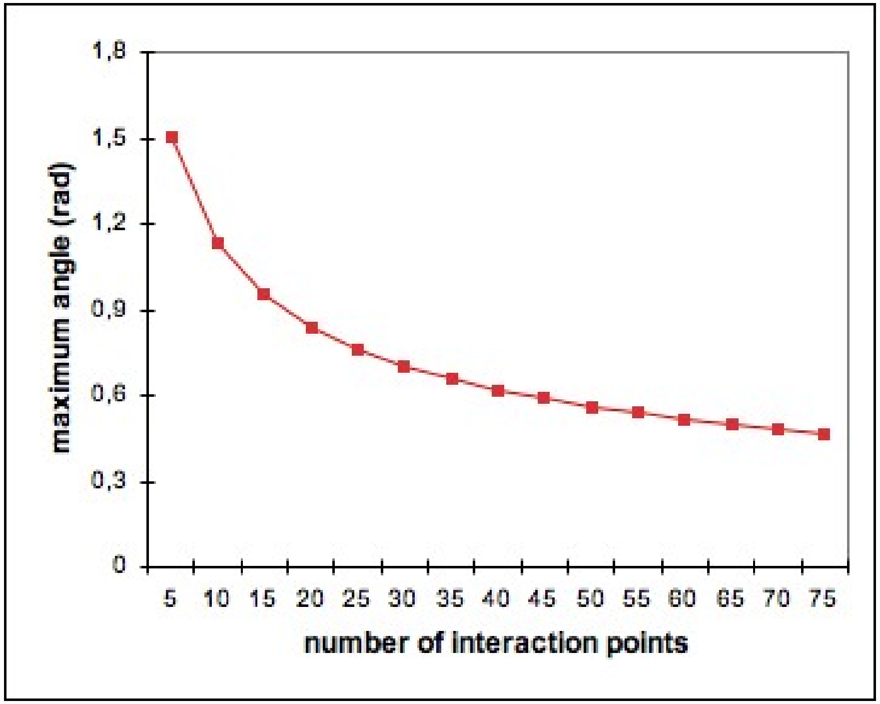
- Details of the Orsay Forward Tracking code
- Tracking results (performance & issues)
- Perspectives

Basic steps of OFT (1)

1. Create cluster pool

- Computes the maximum angular separation α_{max} between points in a cluster

$$\alpha_{max} = \cos^{-1}\left(1 - \frac{2}{\left(\left(n_{int}+2\right)/3\right)^{0.9}}\right)$$



- Assigns interaction points i and j to the same cluster if their angular separation is < α (k_{max}= 7 interaction points per cluster)

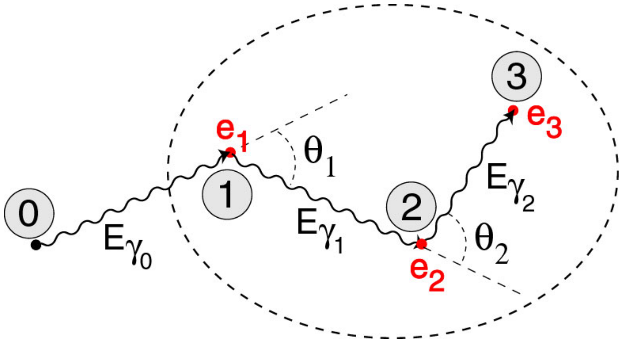
- Loops on $\alpha < \alpha_{max}$ and find m different clusters (α_{min}=0.05, rad, $\delta\alpha$=0.1 rad)

Basic steps of OFT (2)

2. Find most probable sequence of interaction points for each cluster

Which sequence satisfies best the Compton scattering rules ?

$$L = \prod_{n=1}^{N-1} P_n \exp^{-a\left(\frac{E_{\gamma n} - E_{\gamma n,pos}}{\sigma_E}\right)^2}$$



Probability for Compton or photoelectric interaction and for travelling a given distance in Germanium

Depends on energy resolution e_{res} and position resolution σ_θ (same in x,y,z and independent of e_i and the position in the detector)

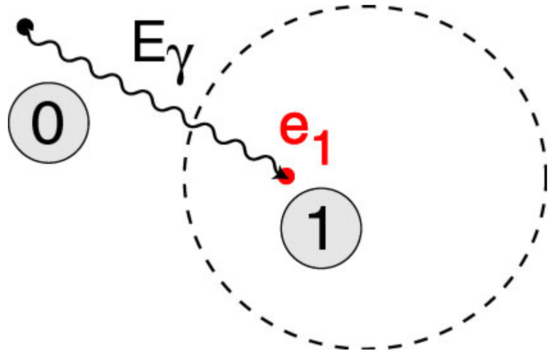
$$er\cos = \sigma_\theta \sqrt{\left(\frac{\partial \cos\theta_1}{\partial x_0}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial y_0}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial z_0}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial x_1}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial y_1}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial z_1}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial x_2}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial y_2}\right)^2 + \left(\frac{\partial \cos\theta_1}{\partial z_2}\right)^2}$$

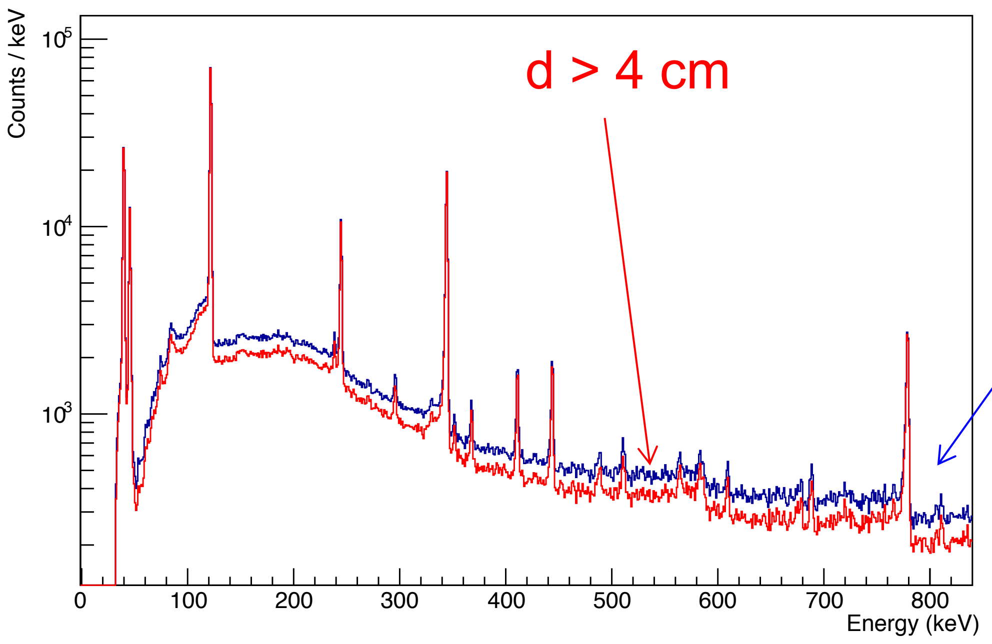
3. Accept or reject clusters on the basis of (2xN-1)th root of L

Single interaction points

- Does the interaction point satisfy photoelectric conditions (interaction depth, energy)

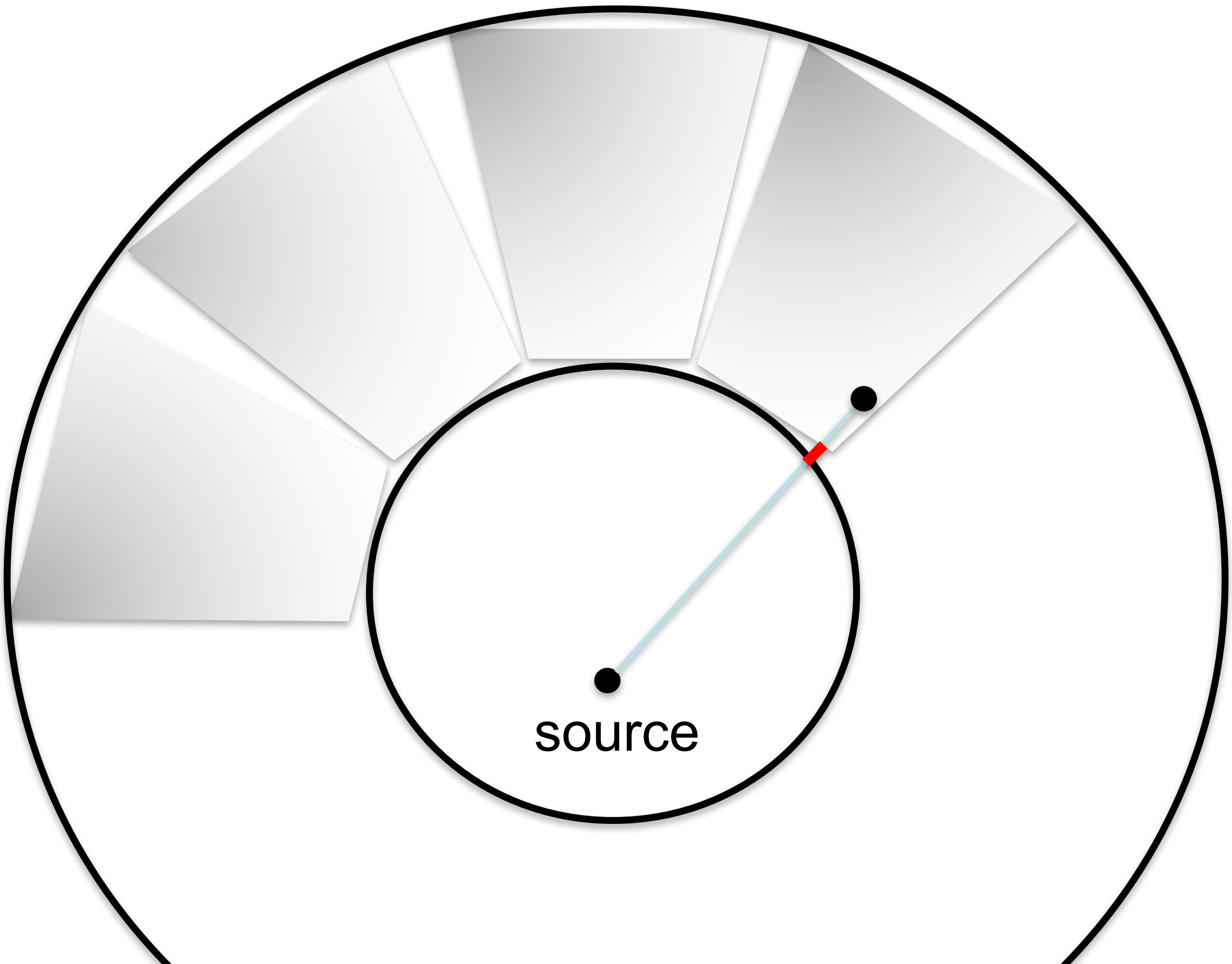
- Is the interaction point sufficiently isolated from other points ?



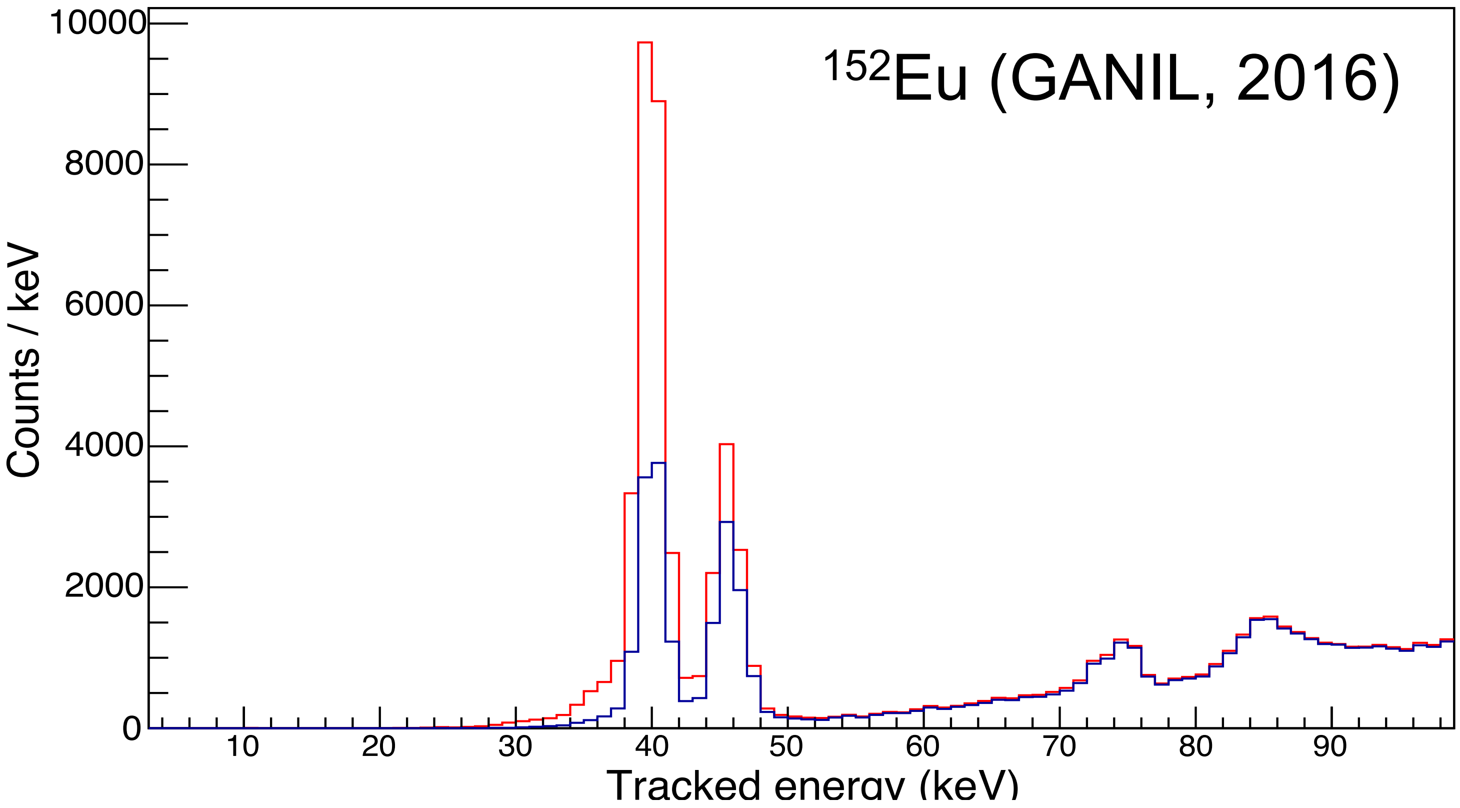


Setting d=4cm has very little effect on efficiency

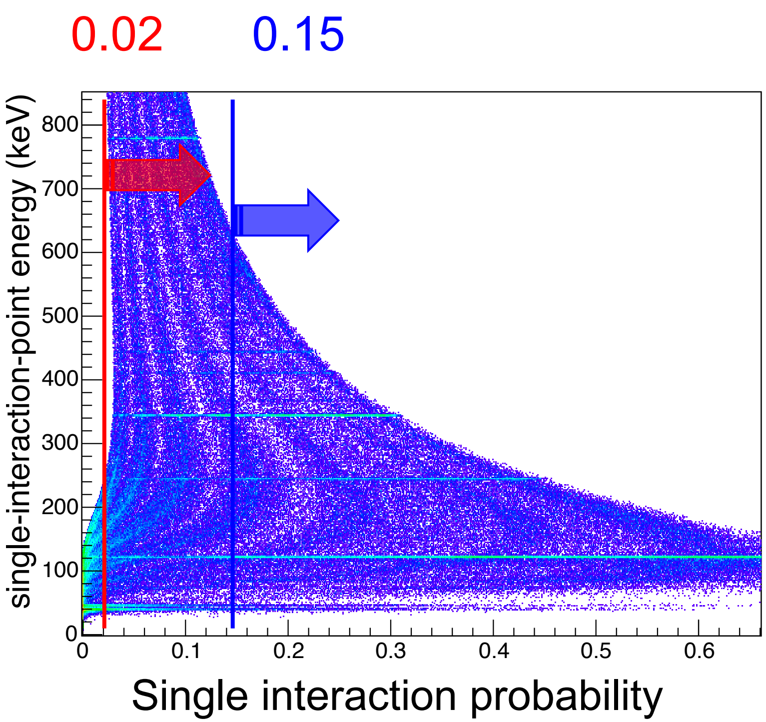
Ge sphere approximation for very low energies



Low-energy efficiency

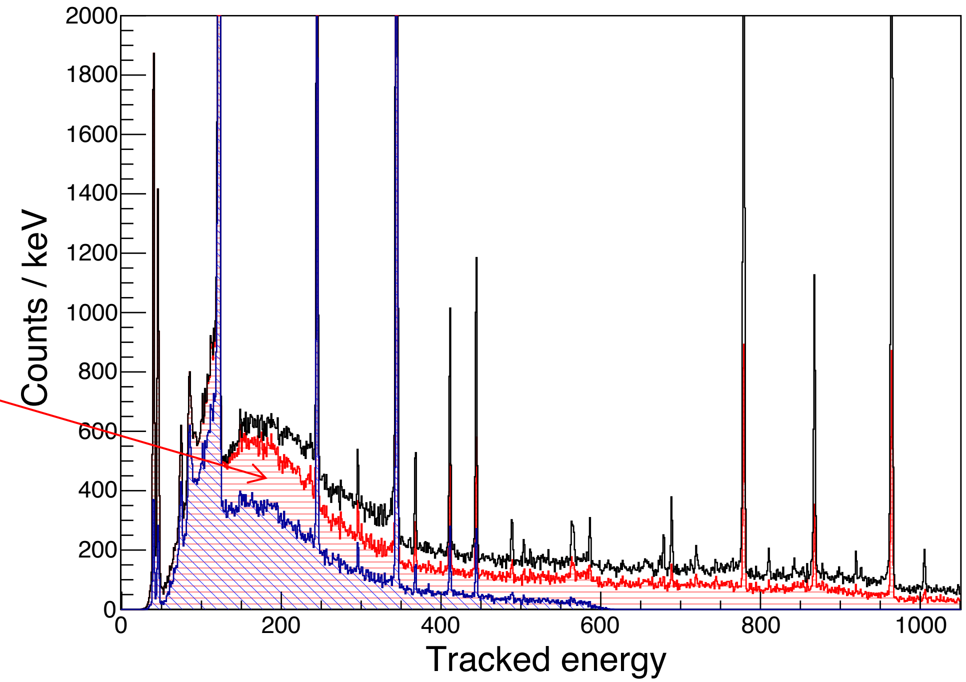


Fine tuning single interactions



Energy (keV)	Fraction of core total absorption (%)
121	95
344	48
778	27
1408	21

Peak recovered at high energy but the single interactions account for 2/3 of the total background !

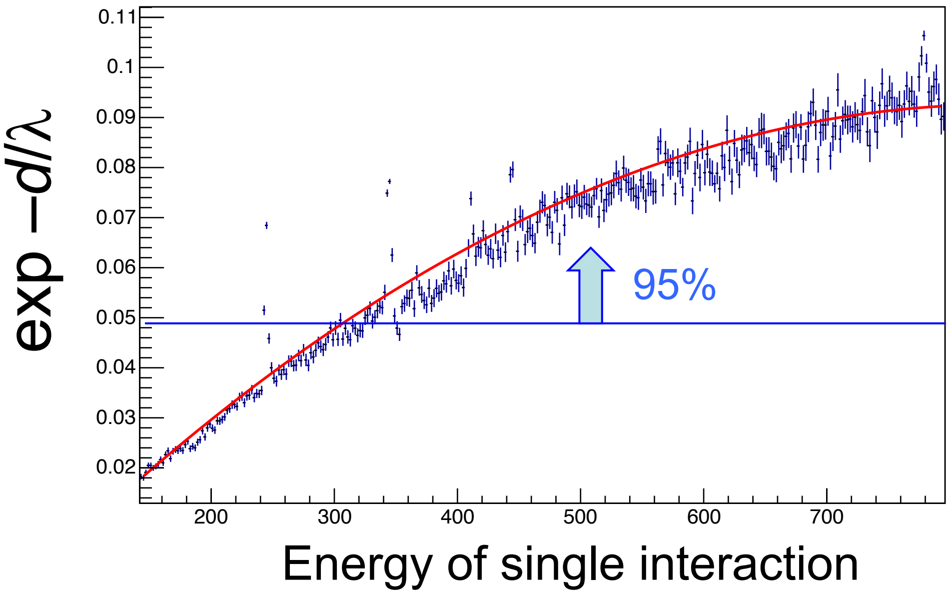


How to validate single interaction points ?

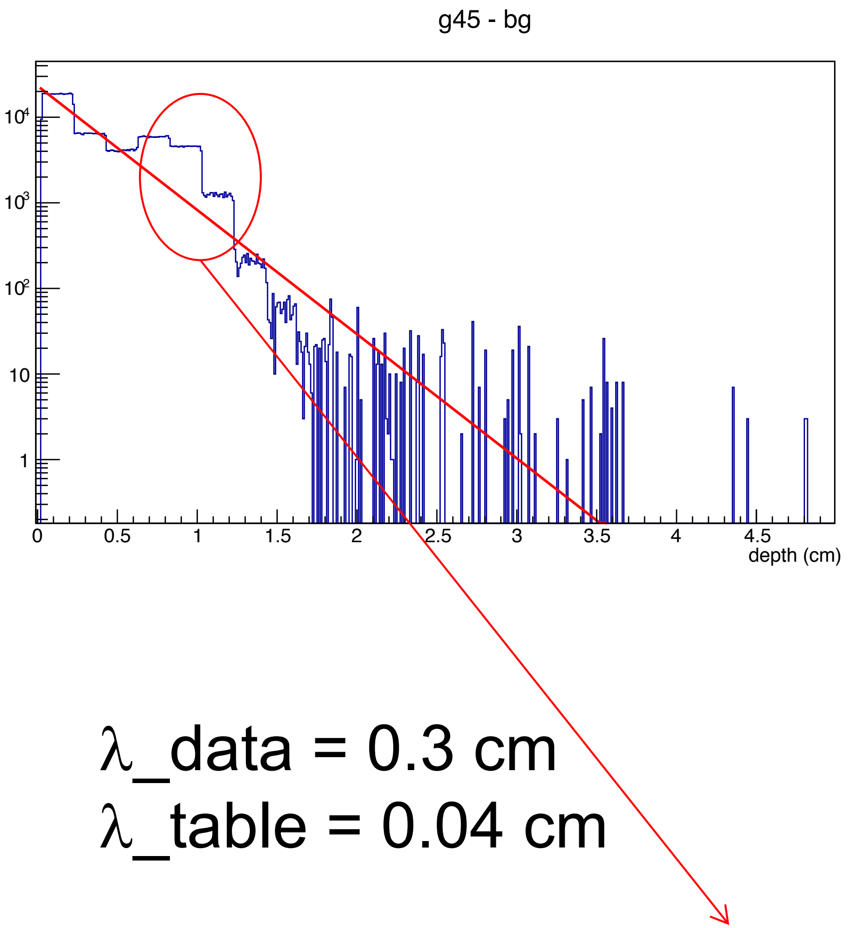
- OFT standard: Probability (range in Ge) x Probability (photoelectric int.)

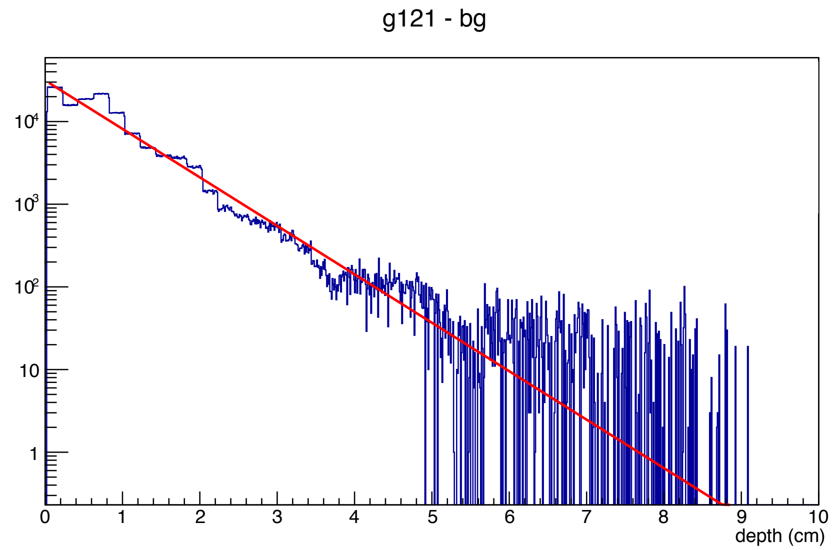
- Range only: distance *d* in Ge from source corresponds to 85,95-99 % absorption probability, i.e *d* ~2,3-4.6 interaction lengths λ

- New: use the data



Why ?





λ_data = 0.3 cm
λ_table = 0.04 cm

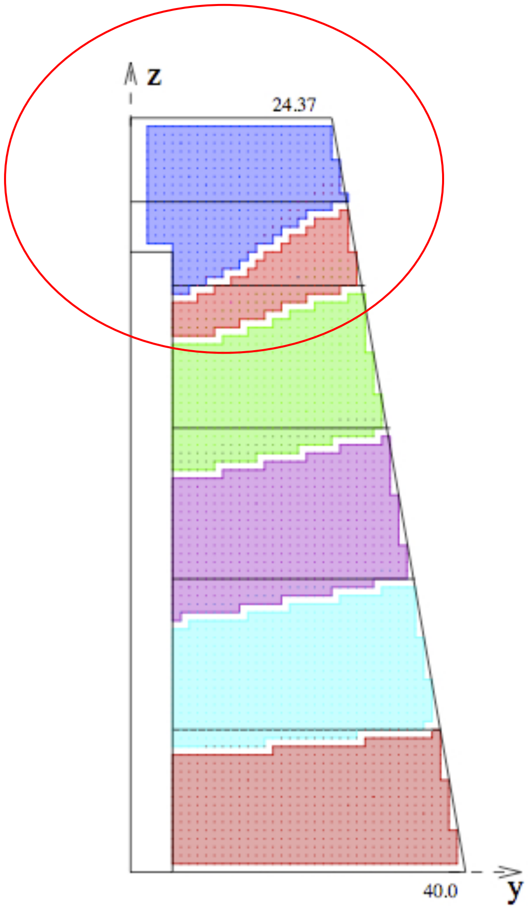
λ_data = 0.74 cm
λ_table = 0.85 cm

$\exp(-1.2/0.04) = 10^{-14}$!!!

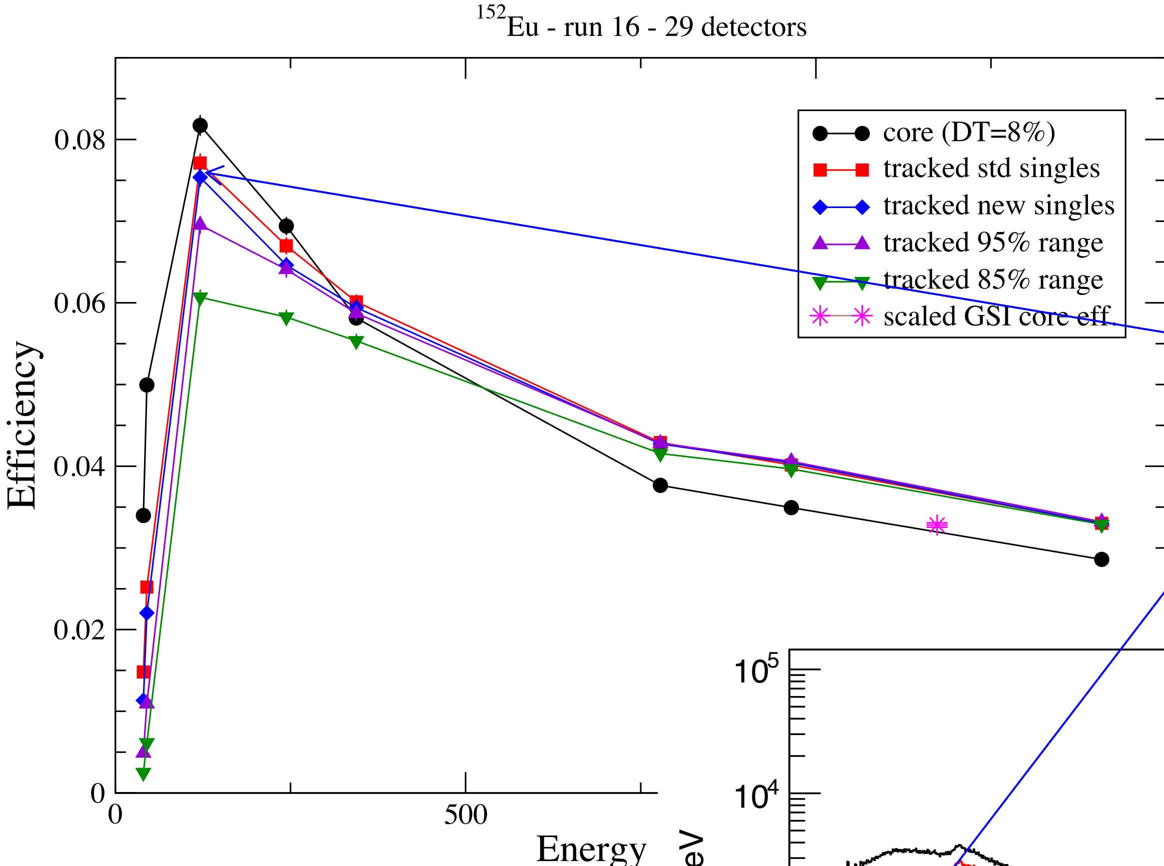
How does a 45 keV photon interact at 1 cm ?

What do the signals look like ?

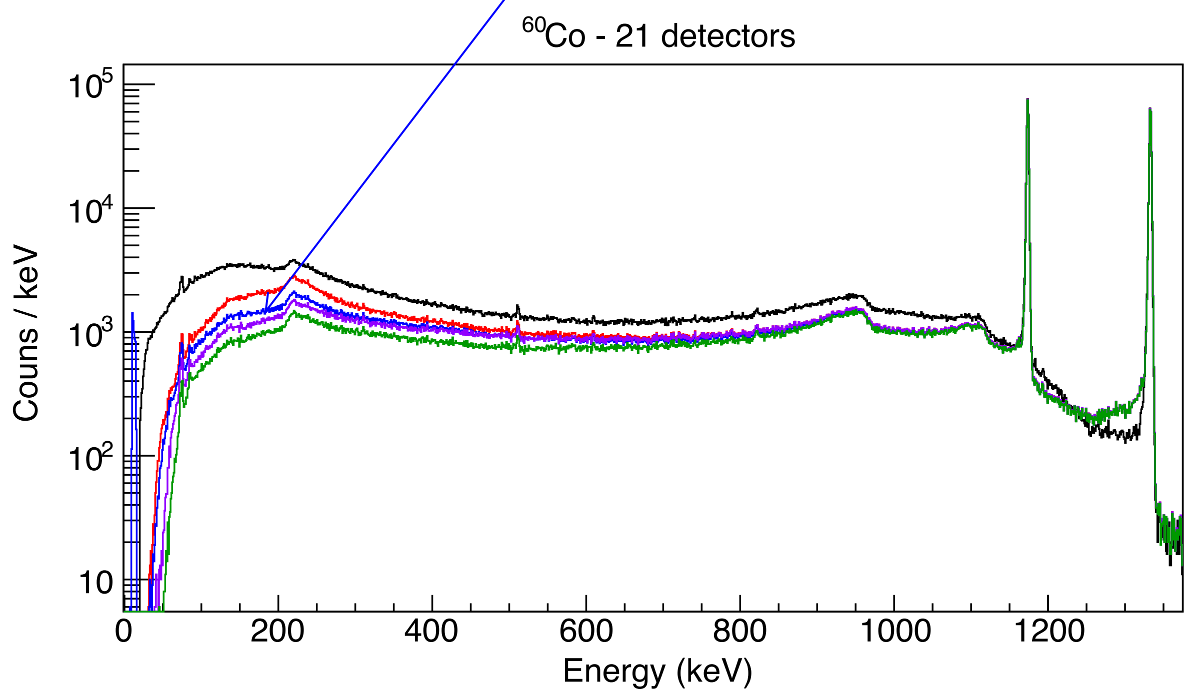
Is it noise related ? Or is the effective segmentation different ?



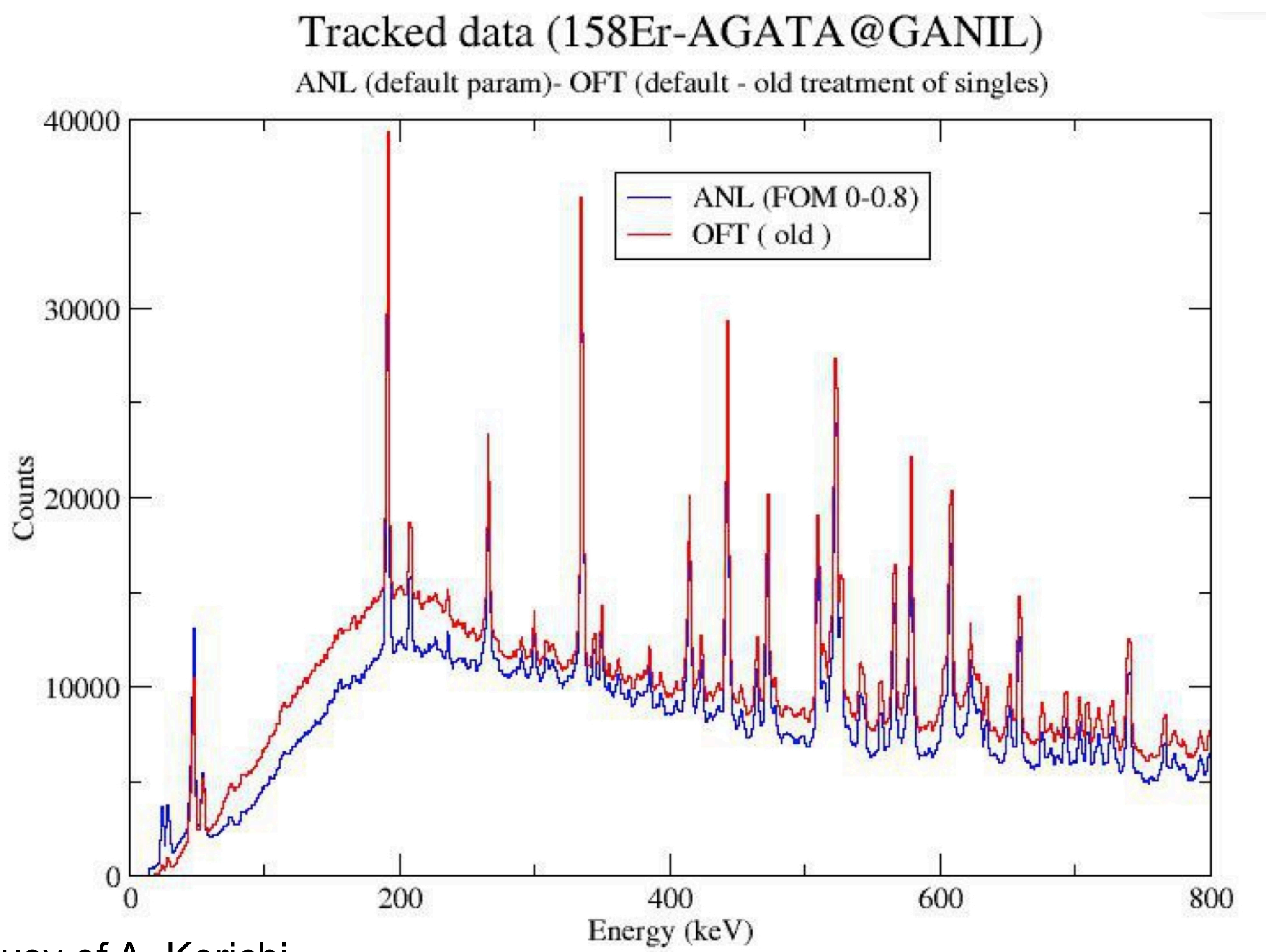
Compromise between P/T and efficiency



New routine performs well

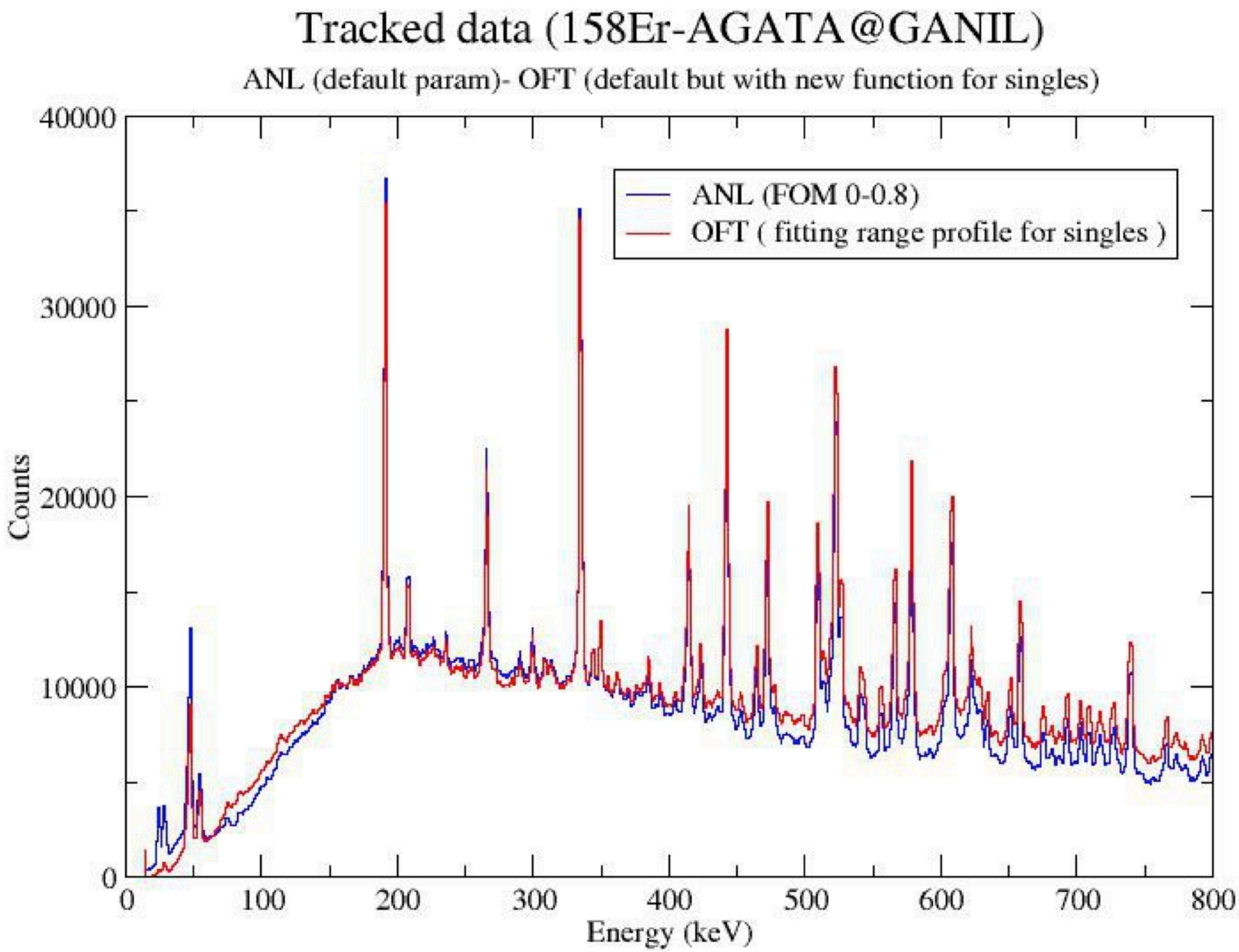


In-beam improvement



Courteousy of A. Korichi

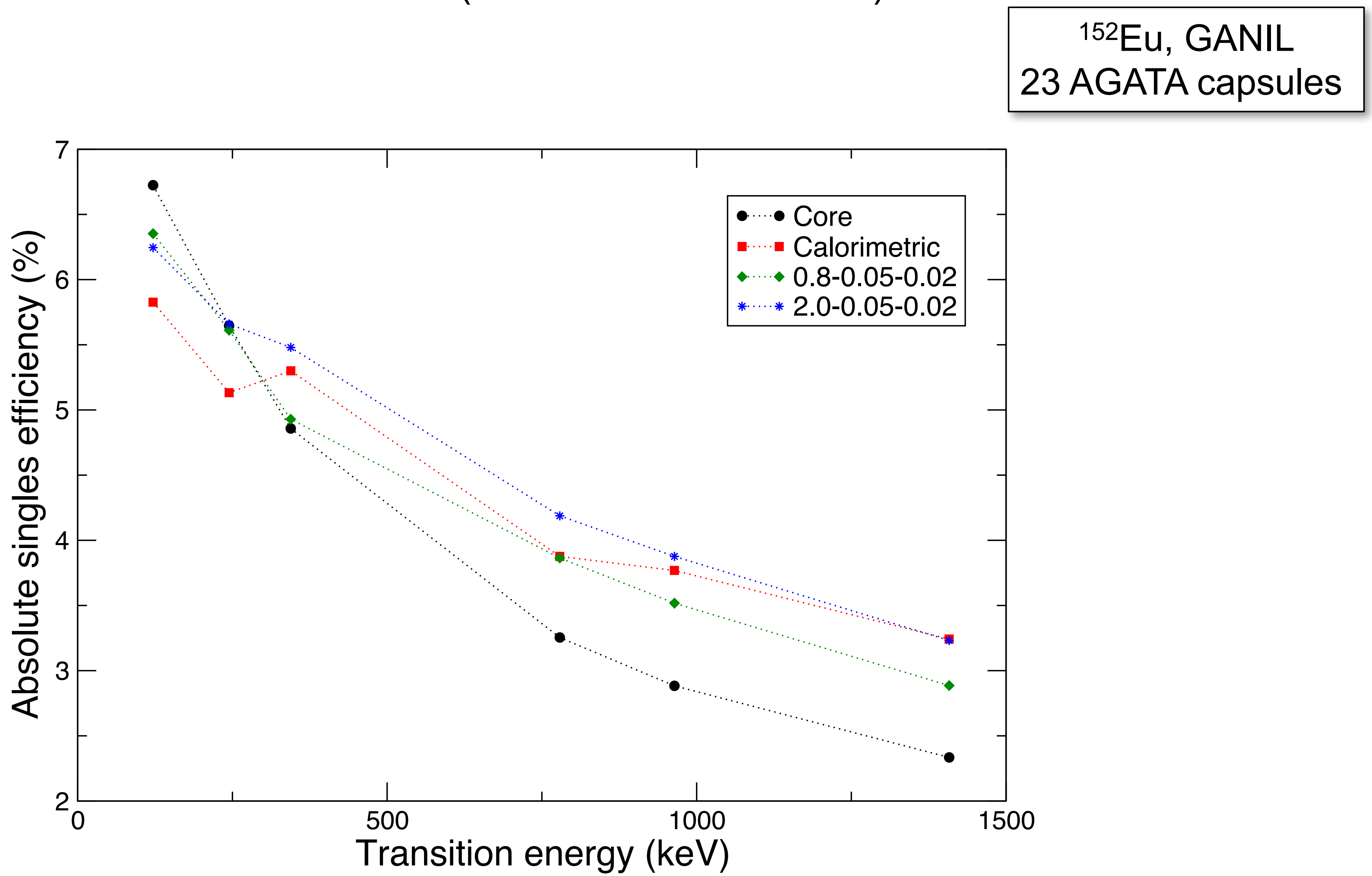
In-beam improvement



Courteousy of A. Korichi

Absolute efficiency

(known source method)



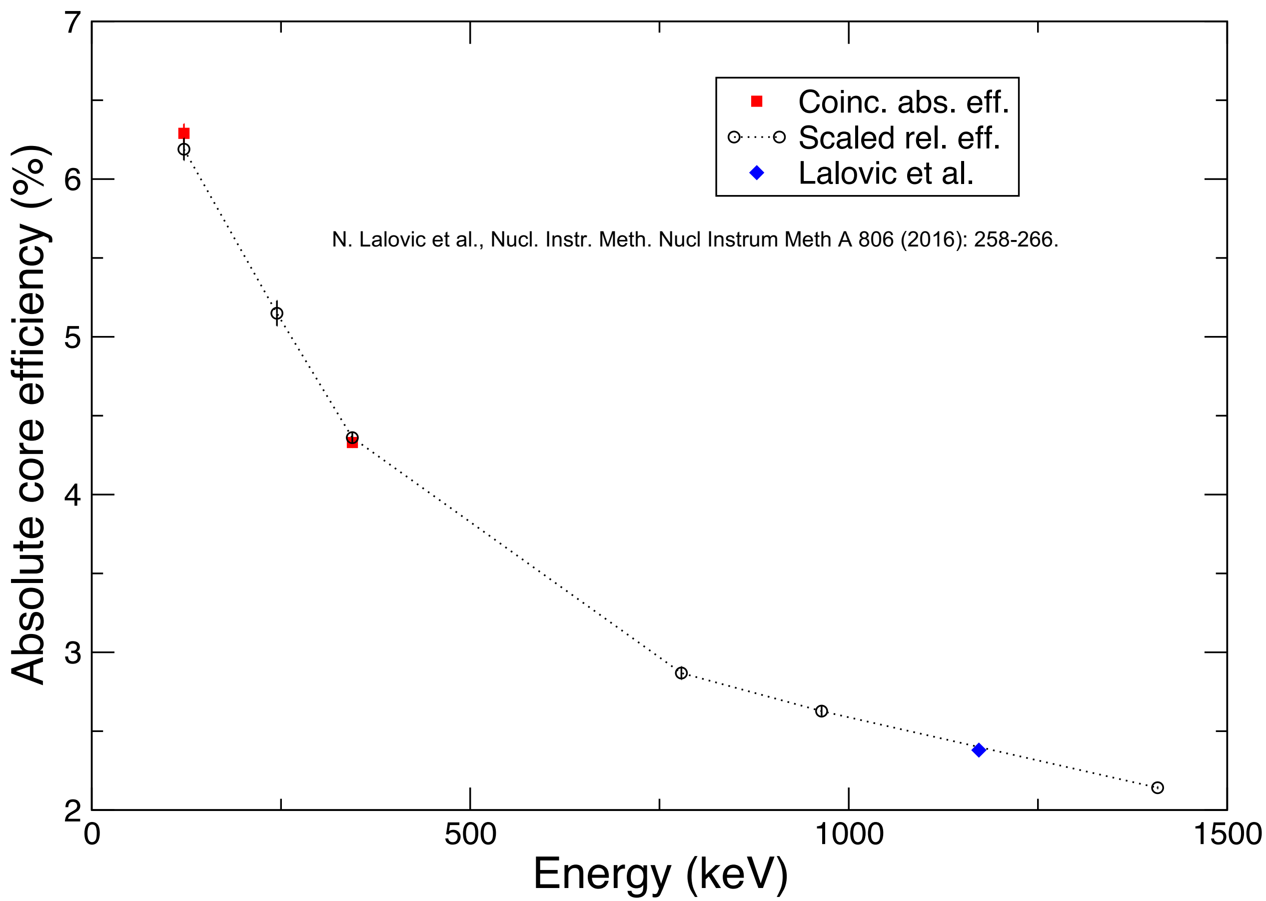
Absolute Efficiency

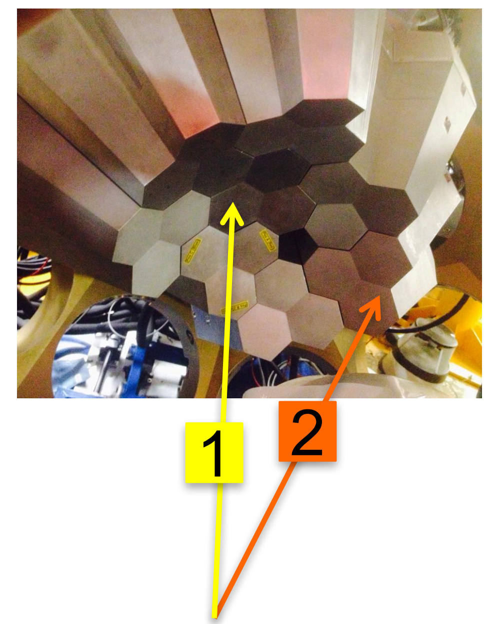
(coincidence method)

Core efficiencies:

$N_{det,singles} = N_{emit}$ x AliveT x $1/(1+\alpha_{tot1})$ x efficiency(E_1)

$N_{det,coinc} = N_{emit}$ x AliveT x $1/(1+\alpha_{tot1})$ x efficiency(E_1) x $1/(1+\alpha_{tot2})$ x efficiency(E_2) x $W(\theta)$ x (N-1)/N





Absolute Efficiency

(coincidence method)

^{152}Eu, GANIL
23 AGATA capsules

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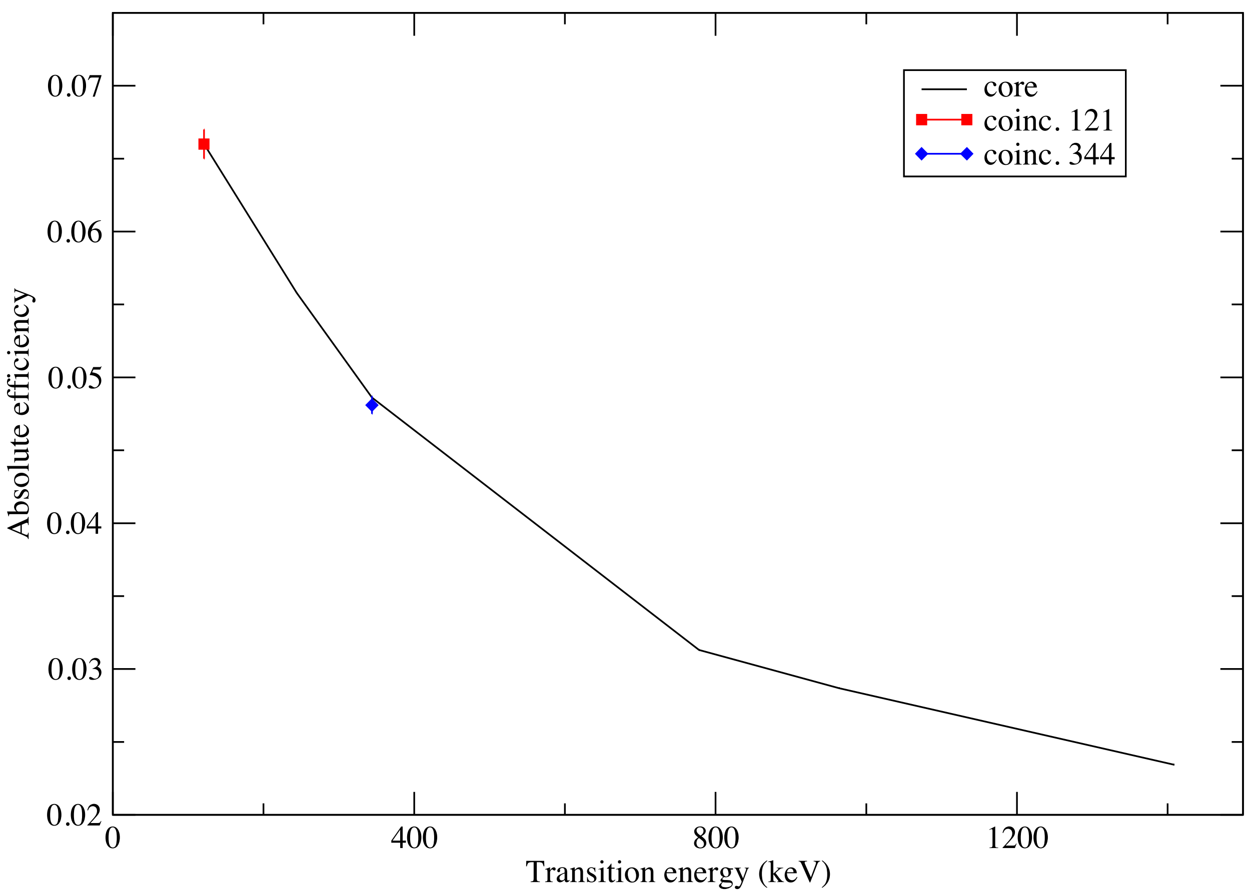

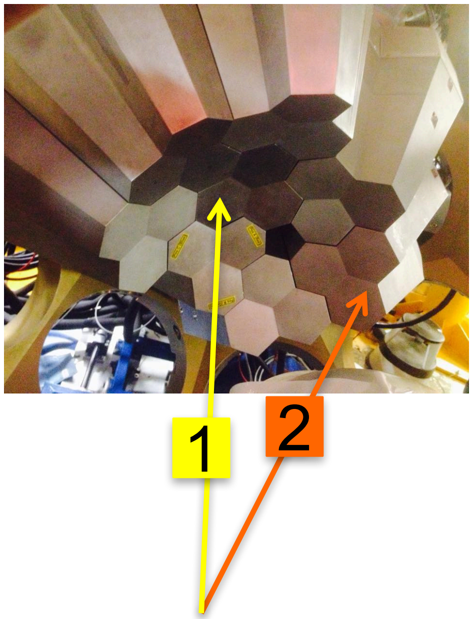

Absolute Efficiency

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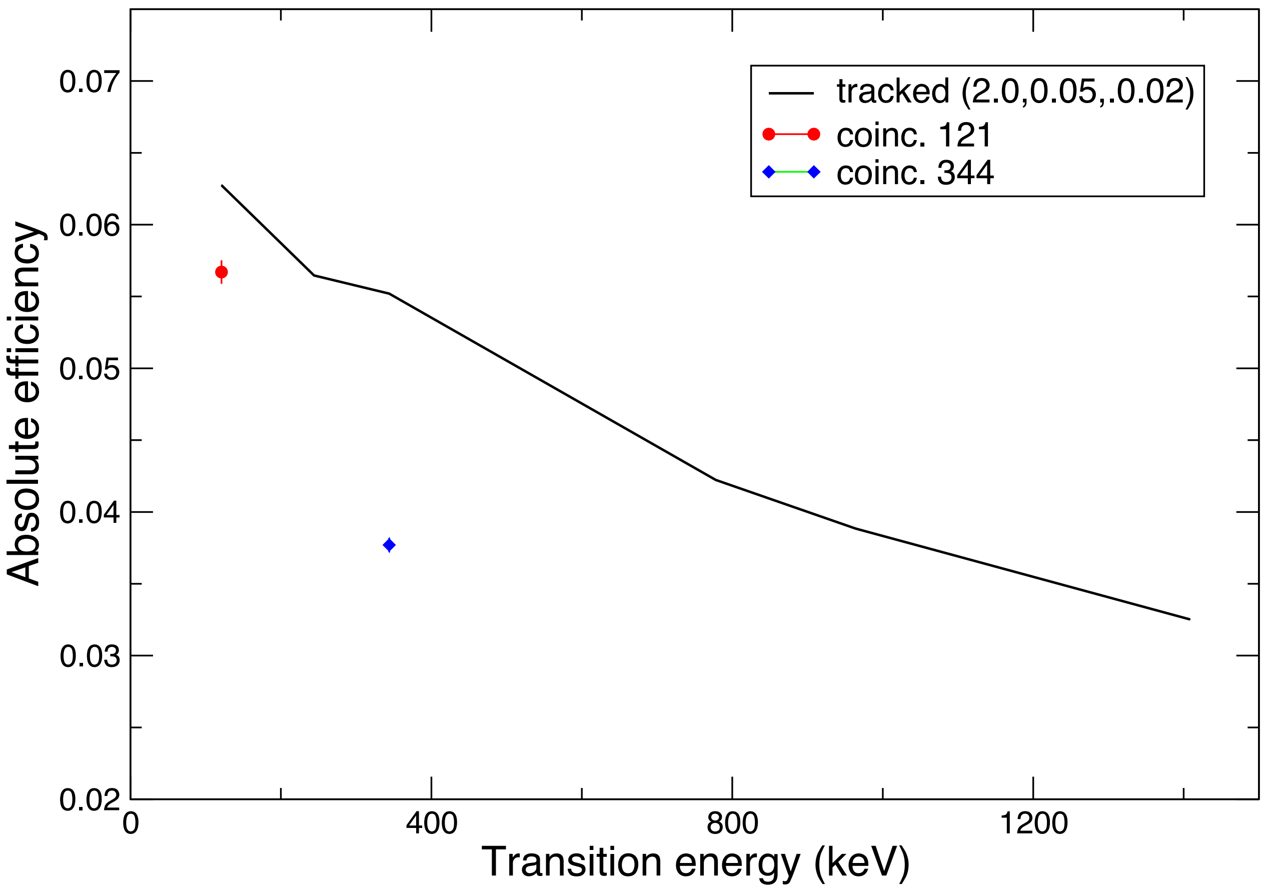
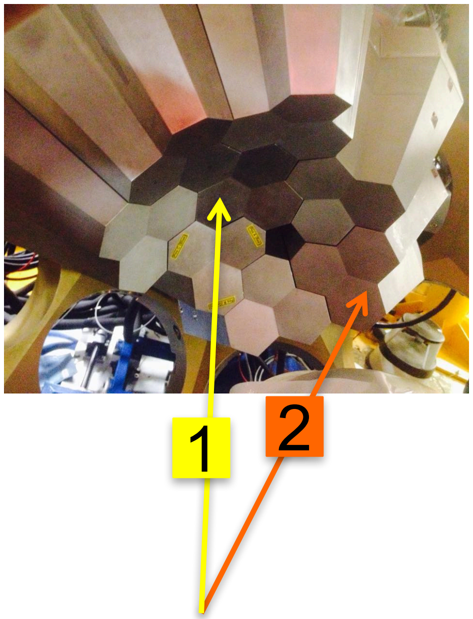
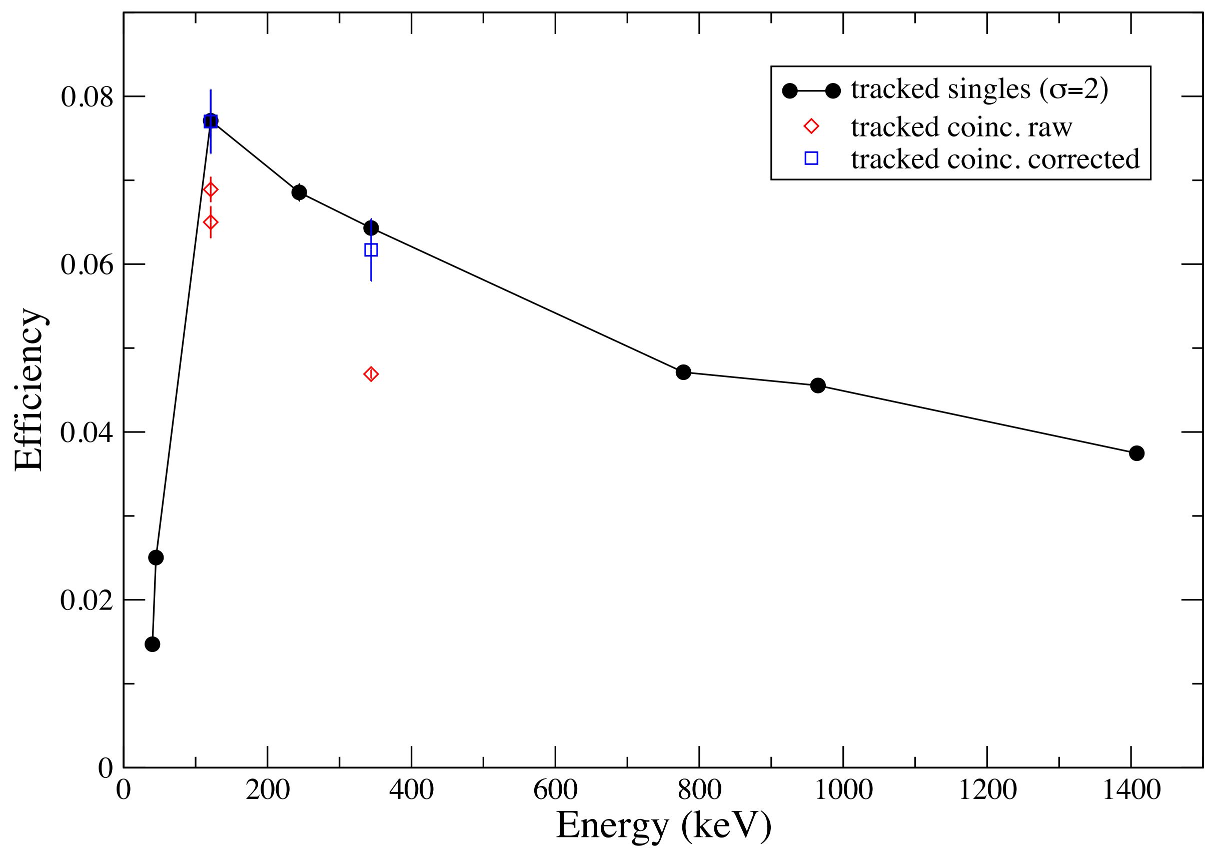




Dependence on coincident energies and OFT parameters

^{152}Eu, GANIL
29 AGATA capsules



Dependence on coincident energies and OFT parameters

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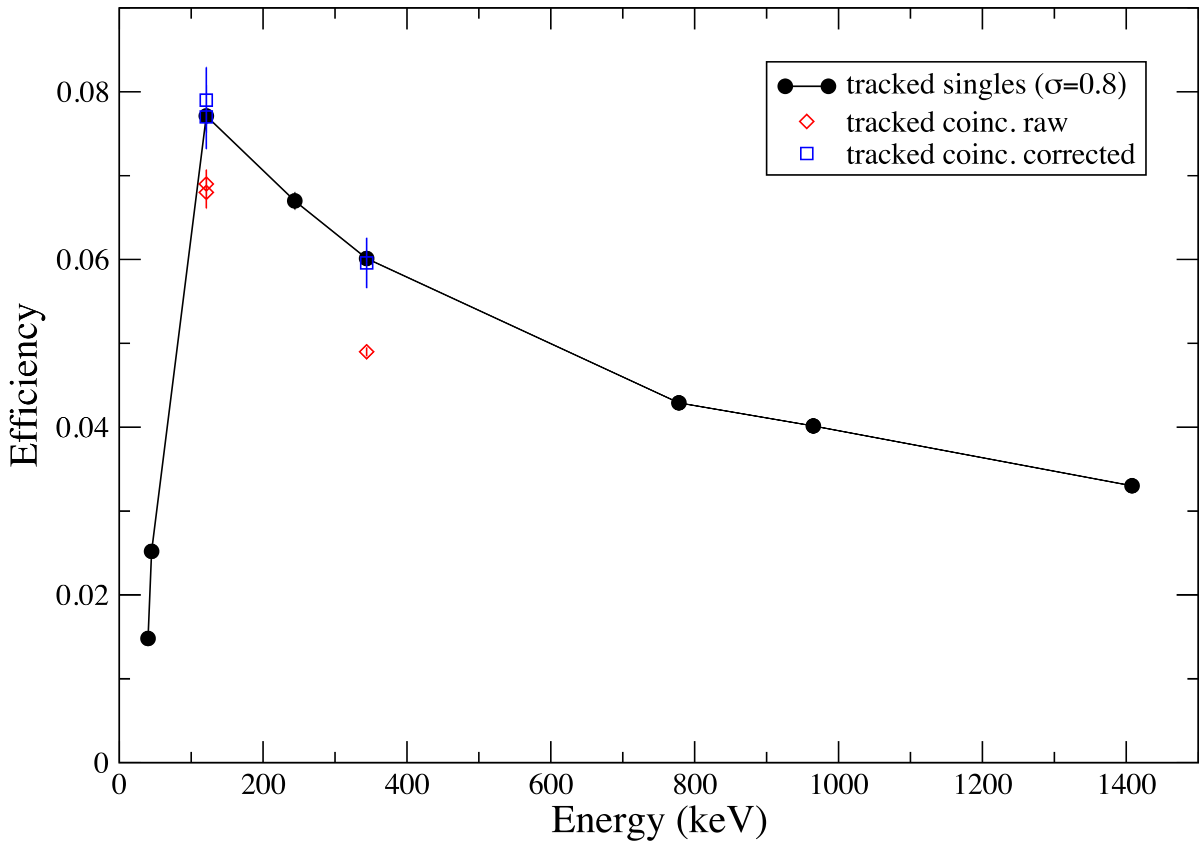
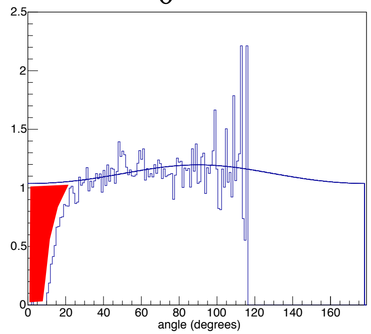
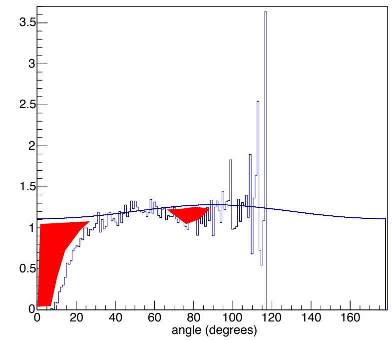


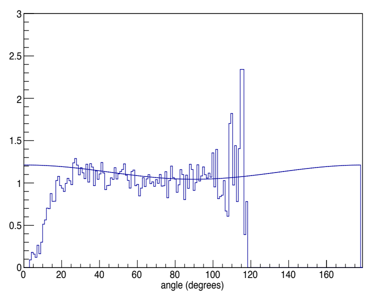
What does « corrected » mean ?

σ_θ=0.8 σ_θ=2

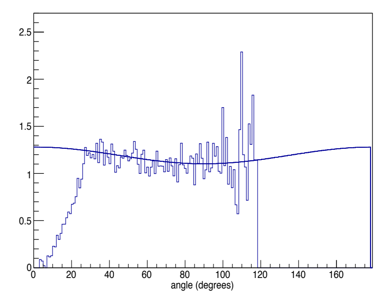


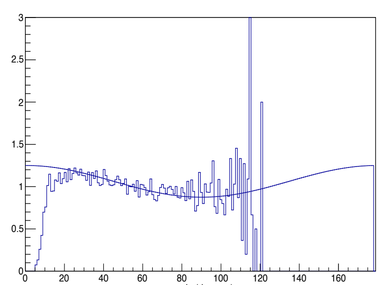
344-778



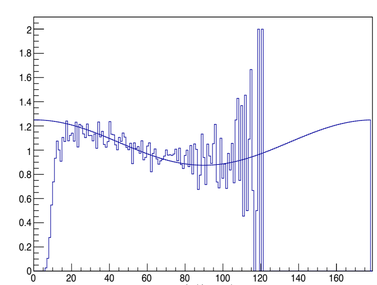


121-244



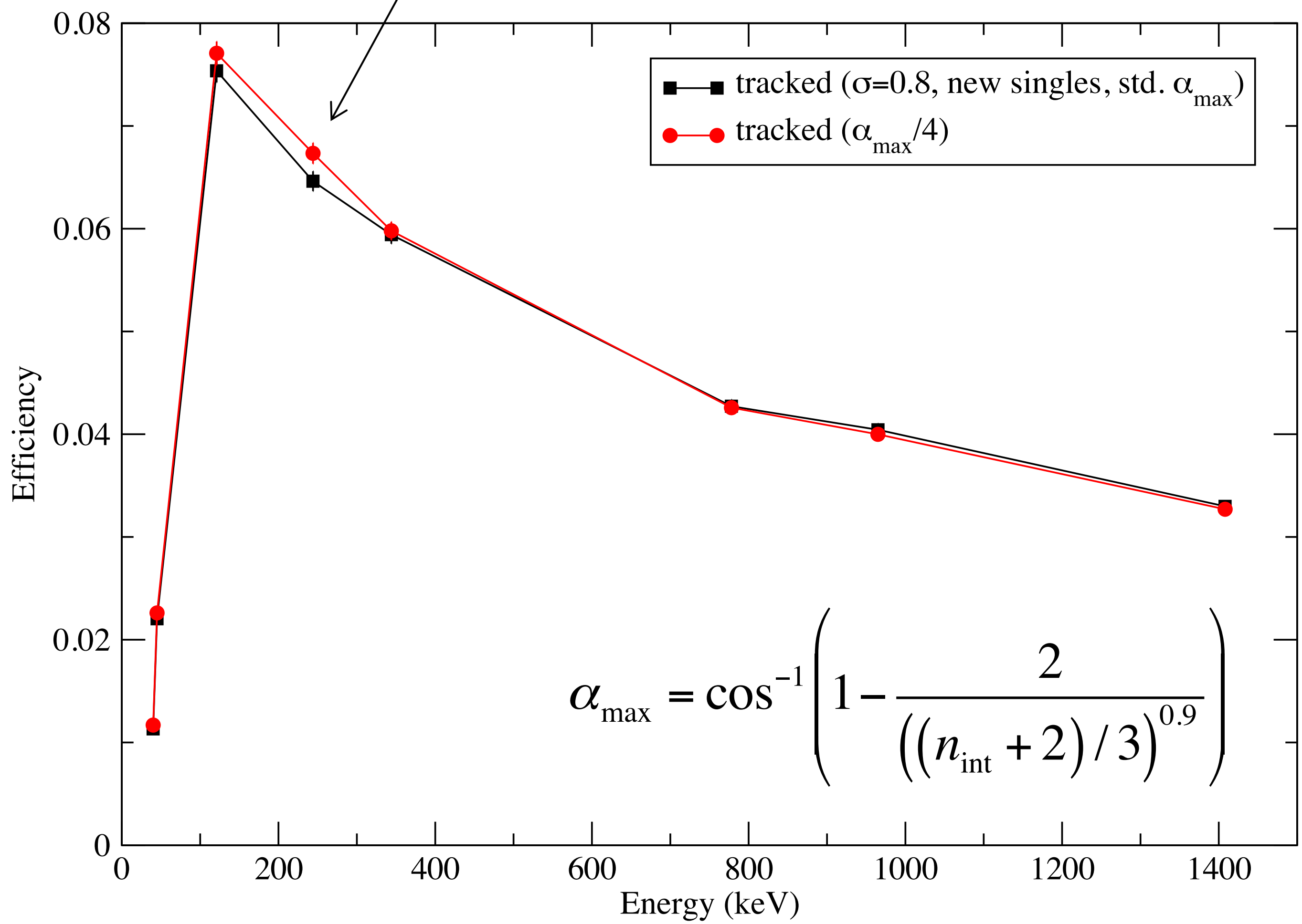


121-1408



Fine tuning the maximum clustering angle

Efficiency from 121-340 keV is increased to « standard » OFT level



➔Need to adjust $\alpha_{max}(n_{int})$ for every experiment

Perspectives

- OFT works well
- Some improvements can be made: energy dependent σ_θ (or even use the χ^2 from PSA ?) evaluate Compton & single-interaction-point clusters at the same time
- Issue of the shape of the efficiency curve obtained from coincidence data which might not follow the shape of the singles curve
- Worse input quality than previously simulated

=> Fine tuning the parameters yields more efficiency at low energy and better P/T

- Need for better PSA