Including error on t0, an improvement? (and some AGATAGeFEM)

J. Ljungvall

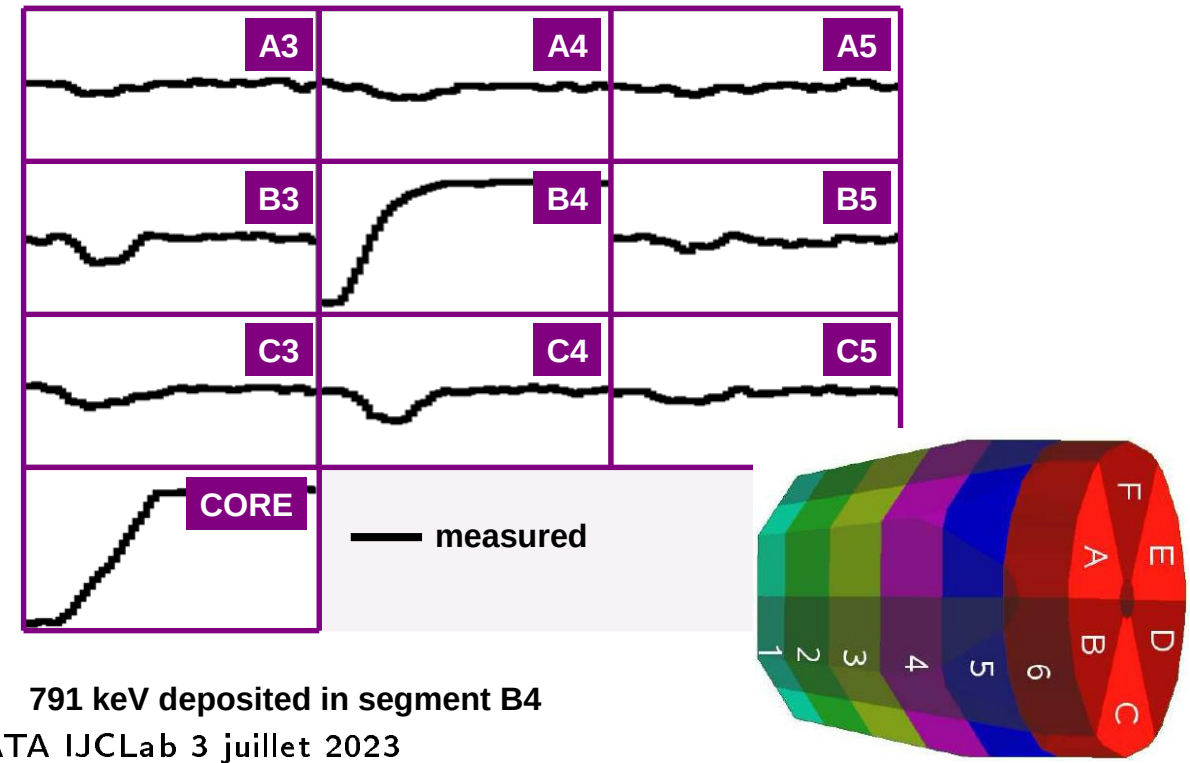
July 3, 2023

Pulse Shape Analysis (PSA) in AGATA

- Presently using a grid-search approach
- Comparison is made with the metric

$$\sum_i \left(|y_i^{exp} - y_i^{base}|\right)^{0.3}$$

Pulse Shape Analysis concept



791 keV deposited in segment B4

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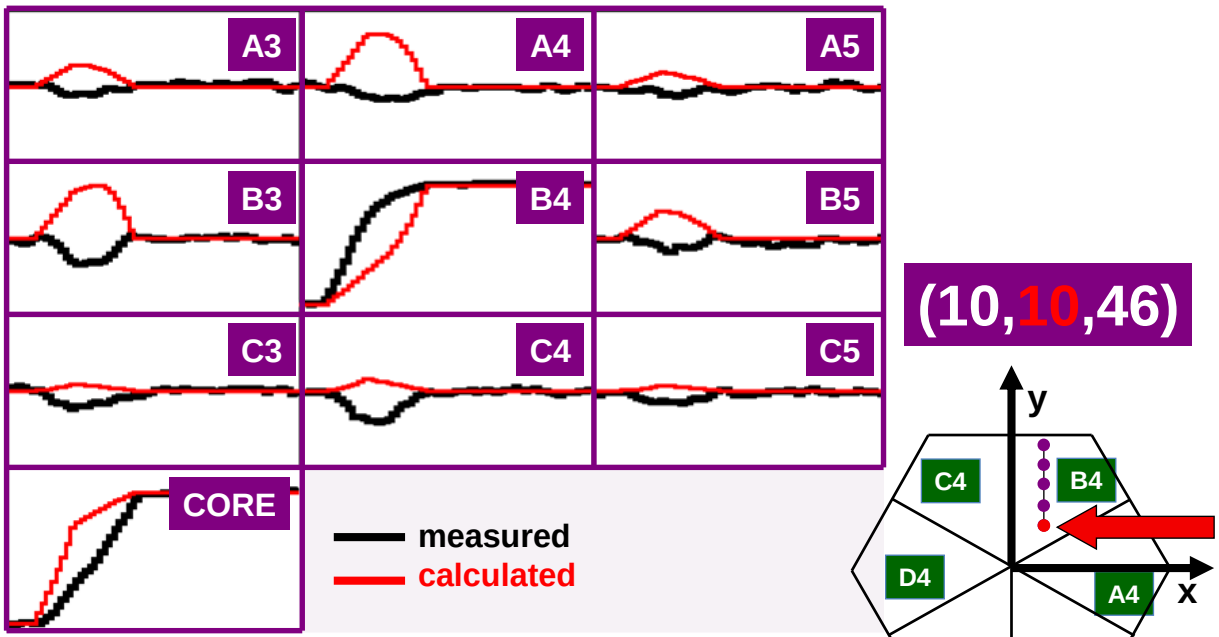

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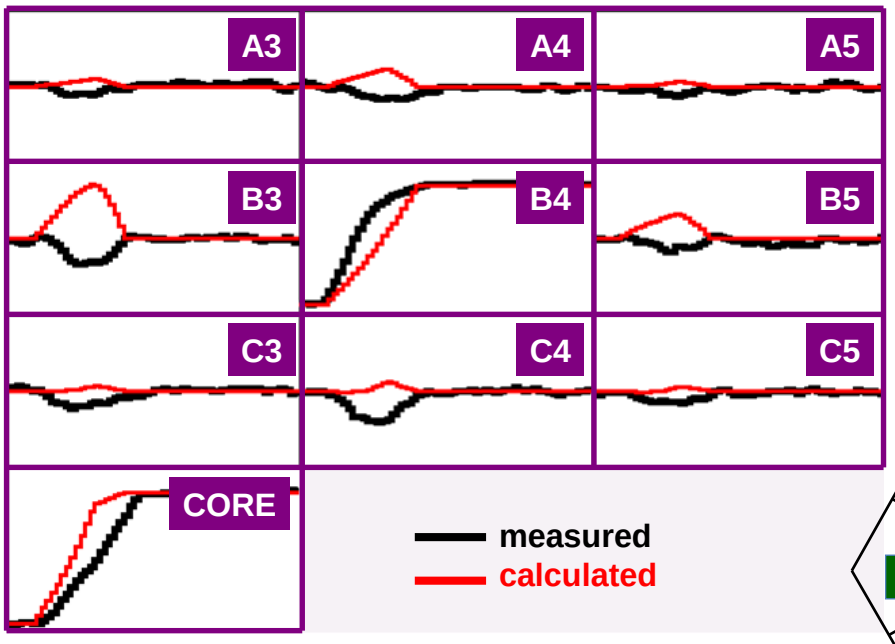

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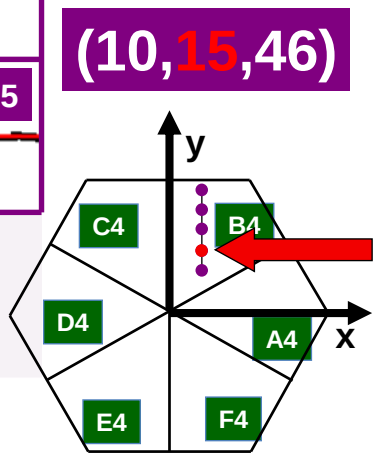

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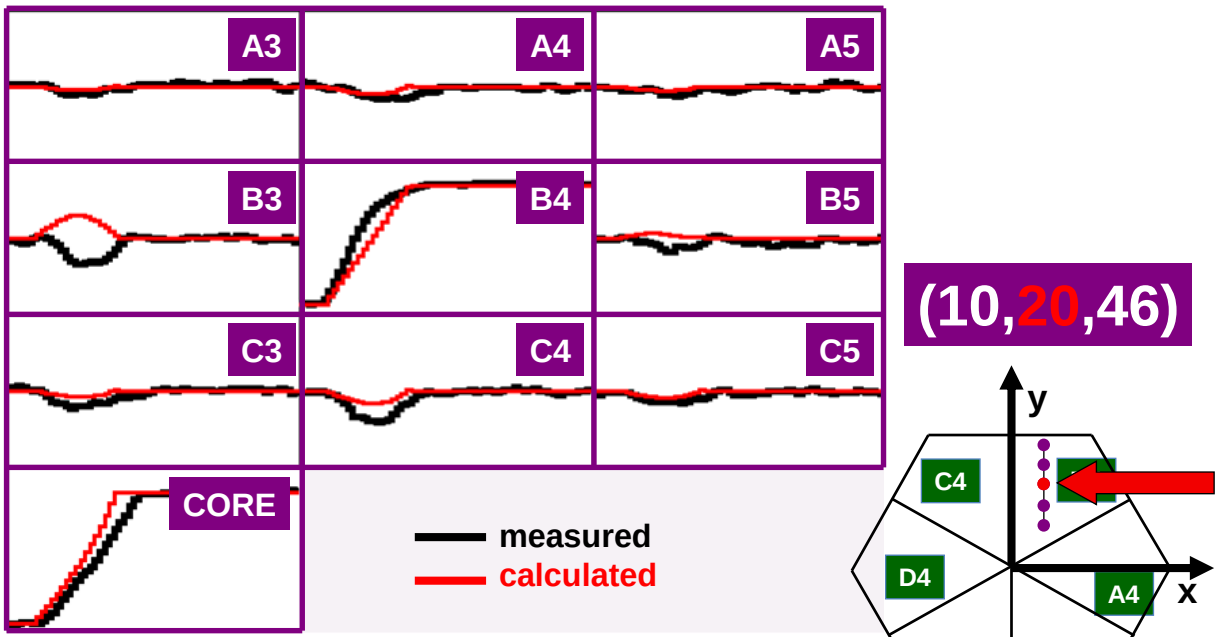

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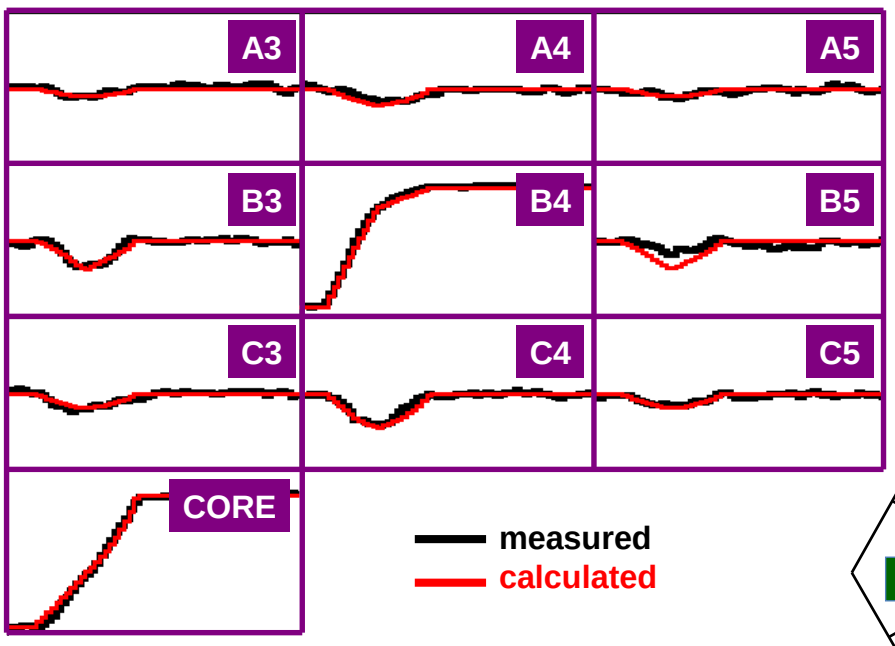

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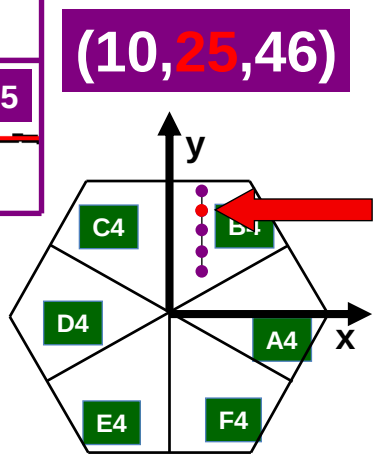

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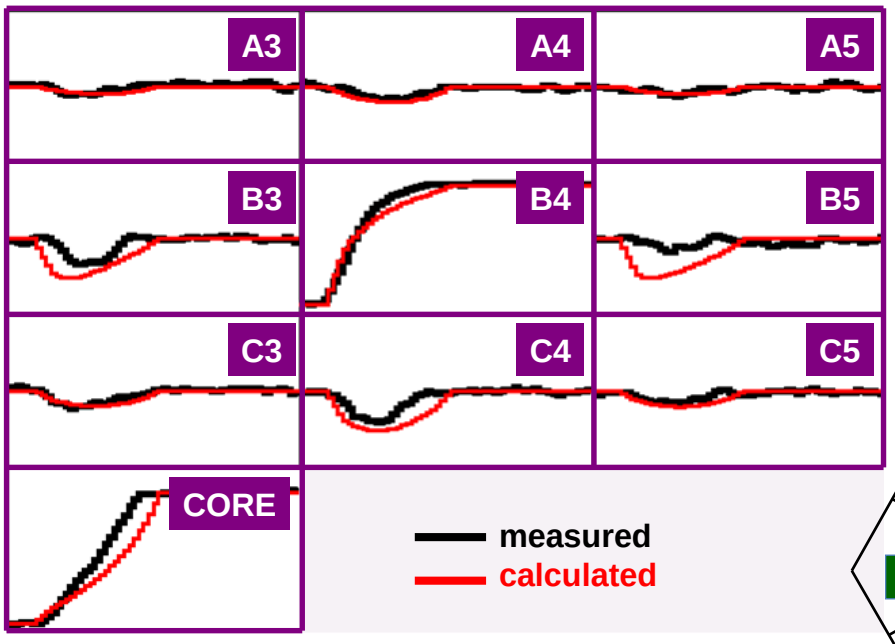

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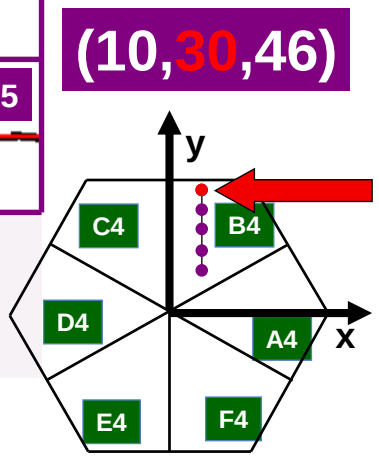

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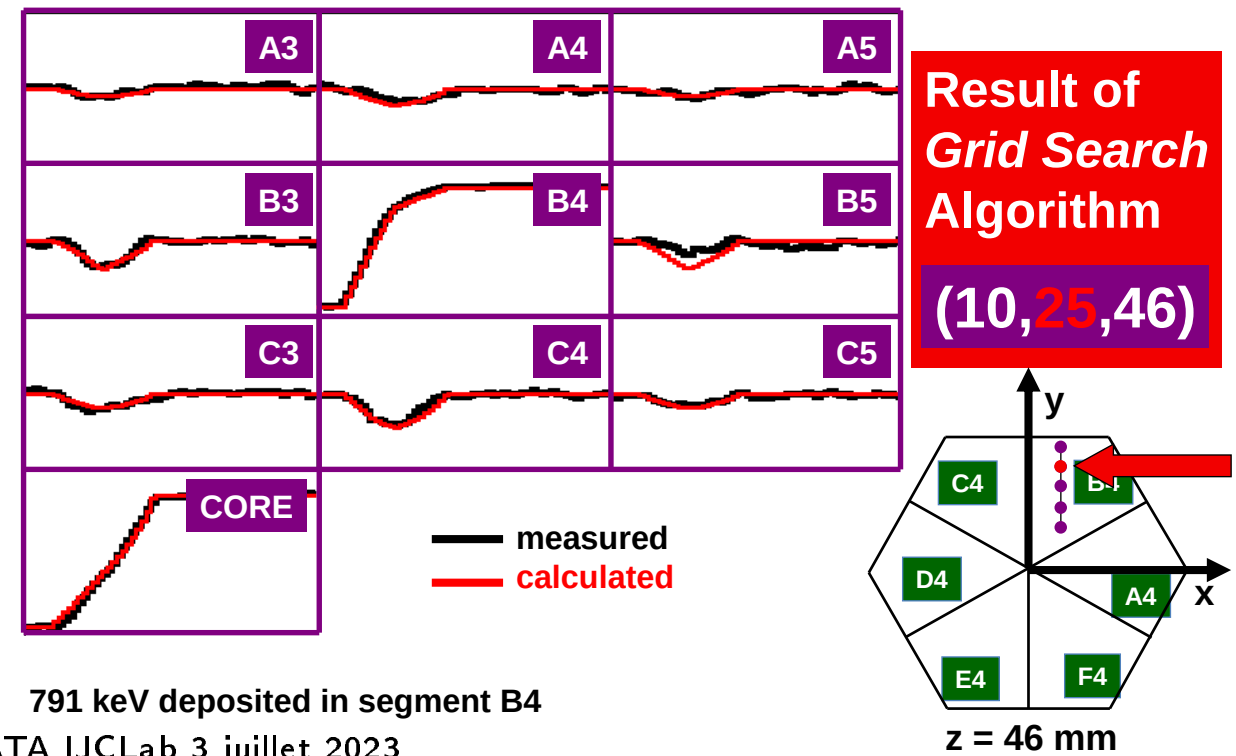

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We (I) would like to measure PSA performance with source

Reading about γ-ray tracking, I stumbled upon TANGO[1]

The energy of a γ ray that has interacted at least twice in AGATA can be estimated using the equation

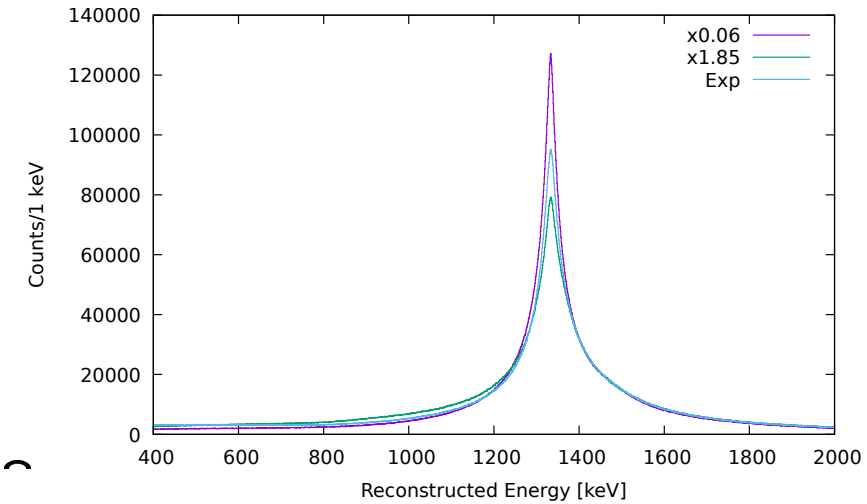
$$E_\gamma = \frac{E_1}{2} + \sqrt{\frac{E_1^2}{4} + \frac{E_1 m_e c^2}{(1 - cos\theta_1)}} \quad (1)$$

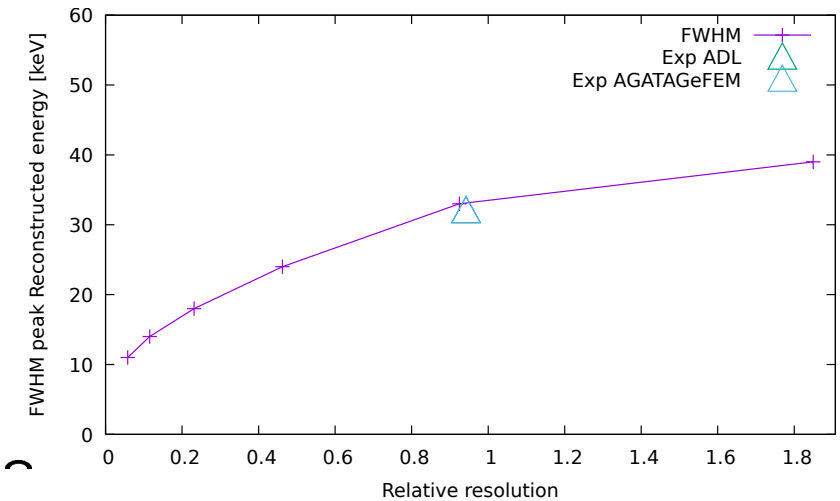
By selecting good 1332 keV γ rays (tracking or calorimetric) and using above formula I get an energy peak with a width that depends on the position resolution.

[1] S. Tashenov NIM A 622 (3) (2010) 592–601.

We (I) would like to measure PSA performance with source

Has been tried and does work





What is (might be) missing?

- As the noise has the same magnitude for all points, no Δy in square sum
- But, what about Δt (e.g. t_0)?

Normal solution

$$\chi^2 = \sum_i \left(\frac{y_i^{exp} - y_i^{base}}{\sqrt{(\Delta y_i)^2 + (\frac{dy}{dt}^{base}(t_i)\Delta t)^2}} \right)^2$$

Note, that noise level suddenly matters as it has a magnitude compared to error induced by t_0 determination. Idea is to implement this metric in PSA and test. [2]

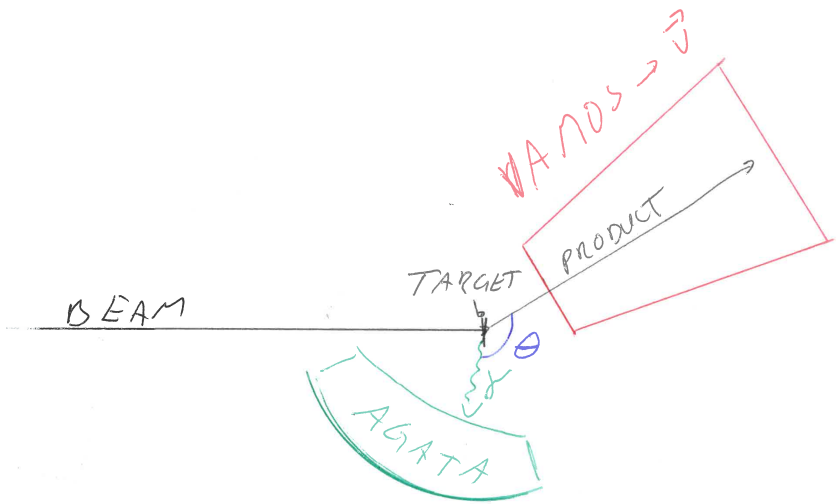
[2] Old news,see P Désesquelles et al 2009 J. Phys. G: Nucl. Part. Phys. 36 037001

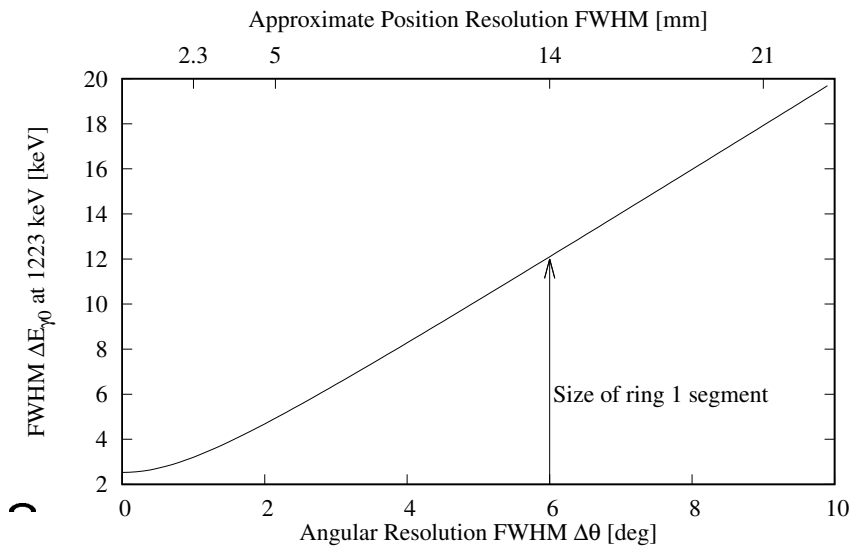
So I added error on the t_0 in the code

```
INLINE_ALWAYS float PSAFilterGridSearch::Chi2l
  {
    float chi2 = 0;
  #ifdef _PSATEST_
    double Dt =.5;
    //From gamma gamma data exp e680
    Dt=(exp(2.06-eCore*0.0175)+1.16)/sqrt(2);
     //Get mean
    double mean=0;
    for(int p=-DFROM; p<0; p++) mean+=pReal[p
    mean/=DFROM;
    //Get variance
    double svar = 0;
    for(int p=-DFROM; p<0; p++) {
      svar+=(pReal[p]-mean)*(pReal[p]-mean);
```

This has been tested using my "standard" in-beam data set

Relation between $\Delta\vec{r}$ and FWHM from geant4 simulations





$$E_\gamma = E_{\gamma 0}\,\frac{\sqrt{1-\beta^2}}{1-\beta\cos\theta} \qquad (2)$$

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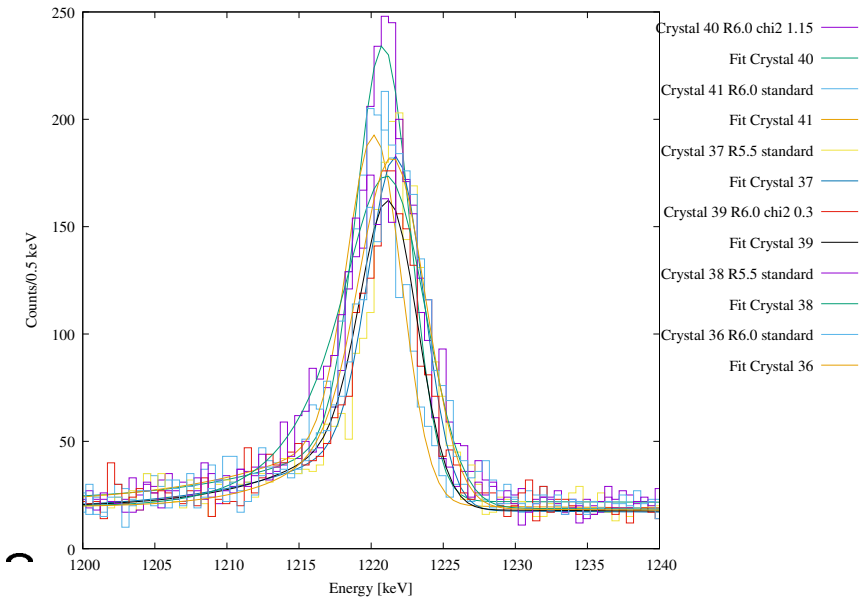

Crystal+Base +PSA	FWHM	χ^2/ NDF	FWHM FINAL EPJ A	χ^2/ NDF
A002 R6.0 std	5.3(2)	1.0	5.0(2)	1.1
B010 R5.5 std	4.5(2)	1.1	4.1(2)	1.2
C001 R5.5 std	5.5(8)	1.4	6.2(2)	1.2
A007 R6.0 χ^2 M=0.3	4.6(2)	1.2	4.7(2)	1.3
B007 R6.0 χ^2 M=1.15	4.3(2)	0.9	4.1(1)	1.3
C007 R6.0 std	4.4(2)	1.0	4.3(2)	1.4

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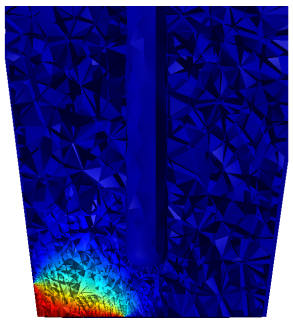
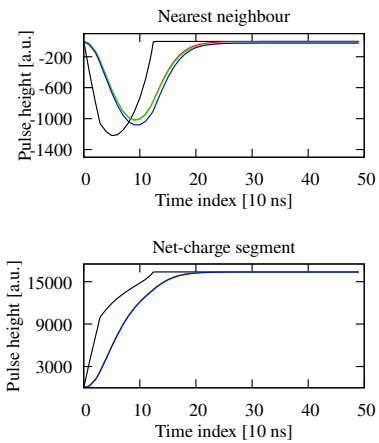
Conclusion is that even when including t_0 error we still don't get a χ^2 distribution and there is no improvement on the results.

AGATAGeFEM produces a good database but. . .

AGATAGeFEM





FEM based code with strong coupling to ROOT, geant4, and ADF.

Need to verify this using neutron damage corrections

- This is a bit tedious work. . .
- Calibrations. . .
- Tests. . .
- Calibrations. . .

All this has now been validated and AGATAGeFEM is fully capable complement/replacement for ADL

AGATAGeFEM produces a good database

AGATAGeFEM gives good Neutron Correction. Neutron Correction not sensitive to details of base.