Characterisation of AGATA detectors

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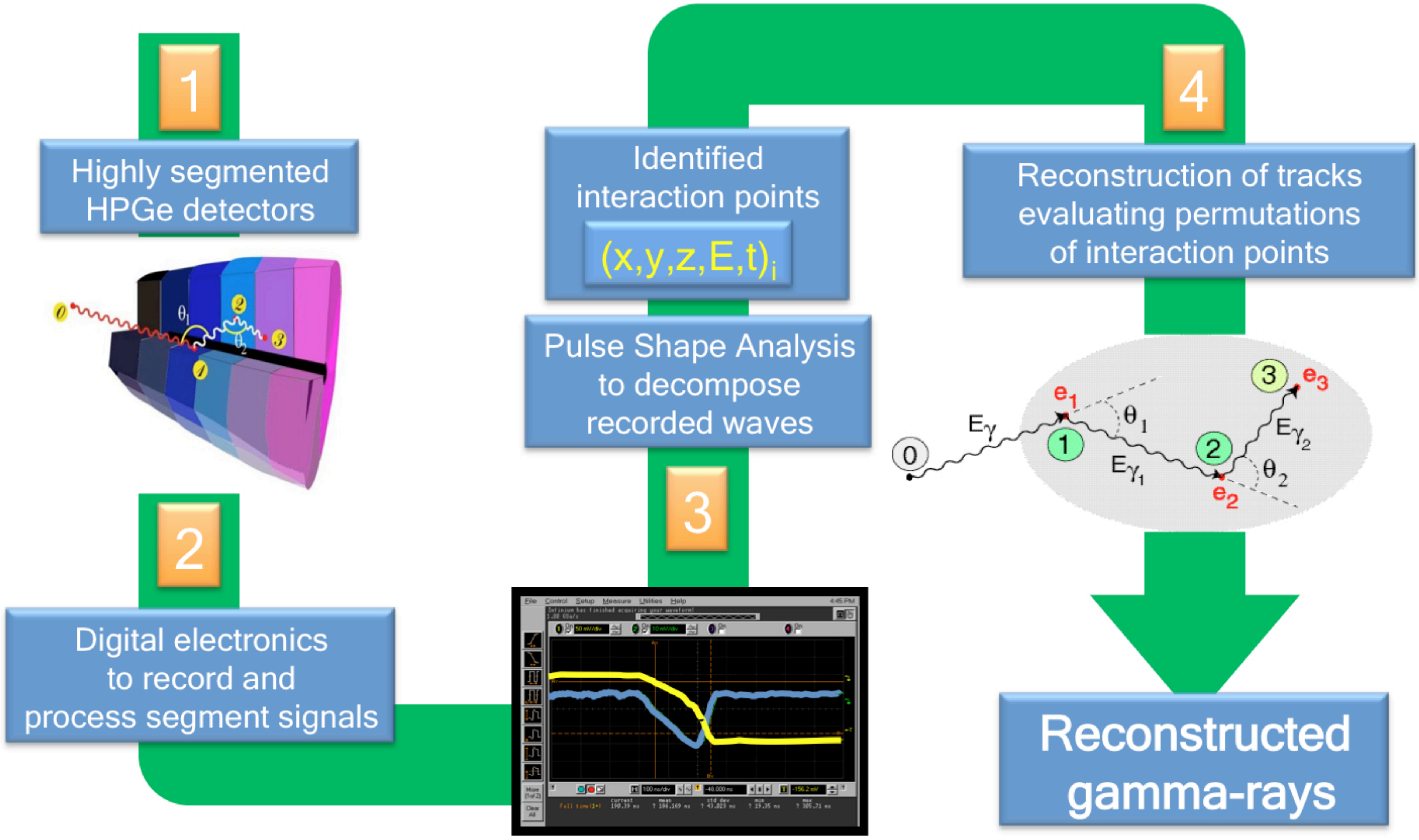
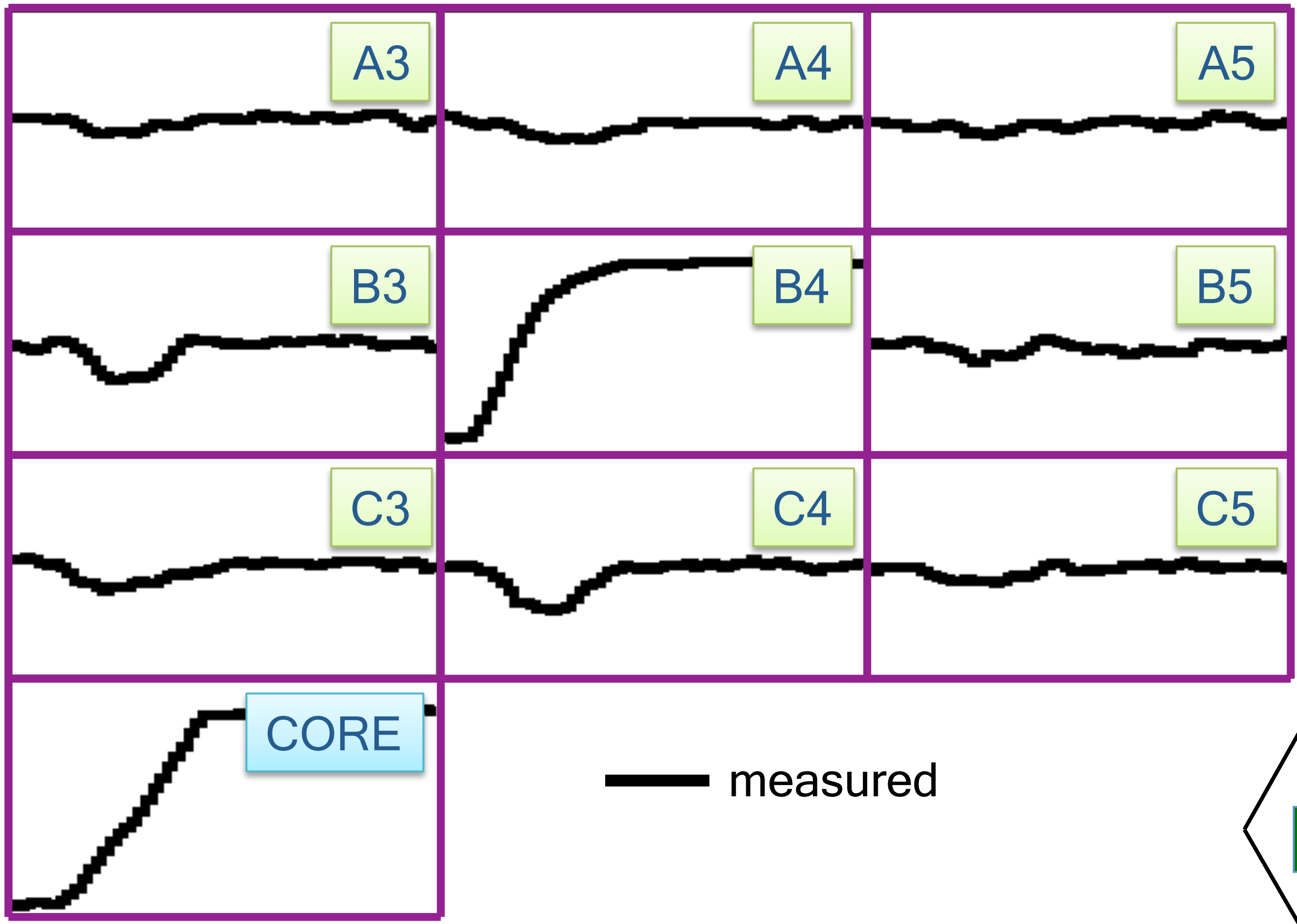
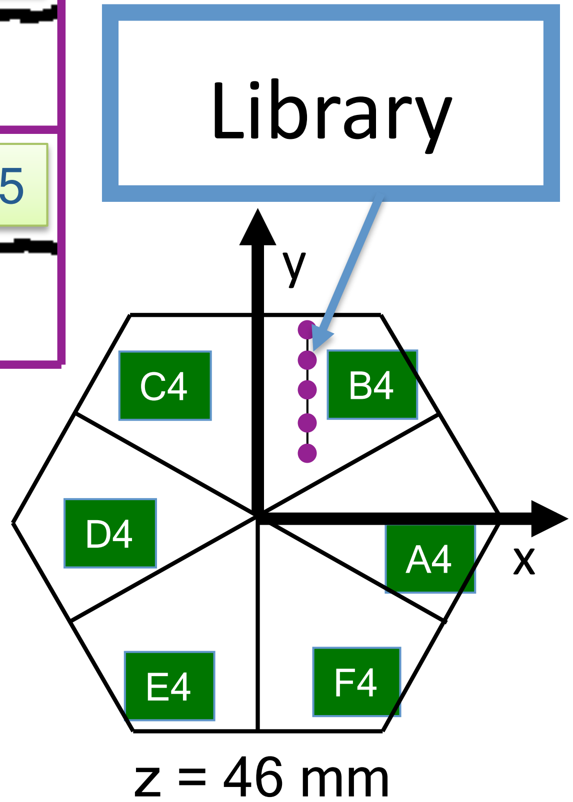
Universität zu Köln

Ingredients of Gamma-Ray Tracking



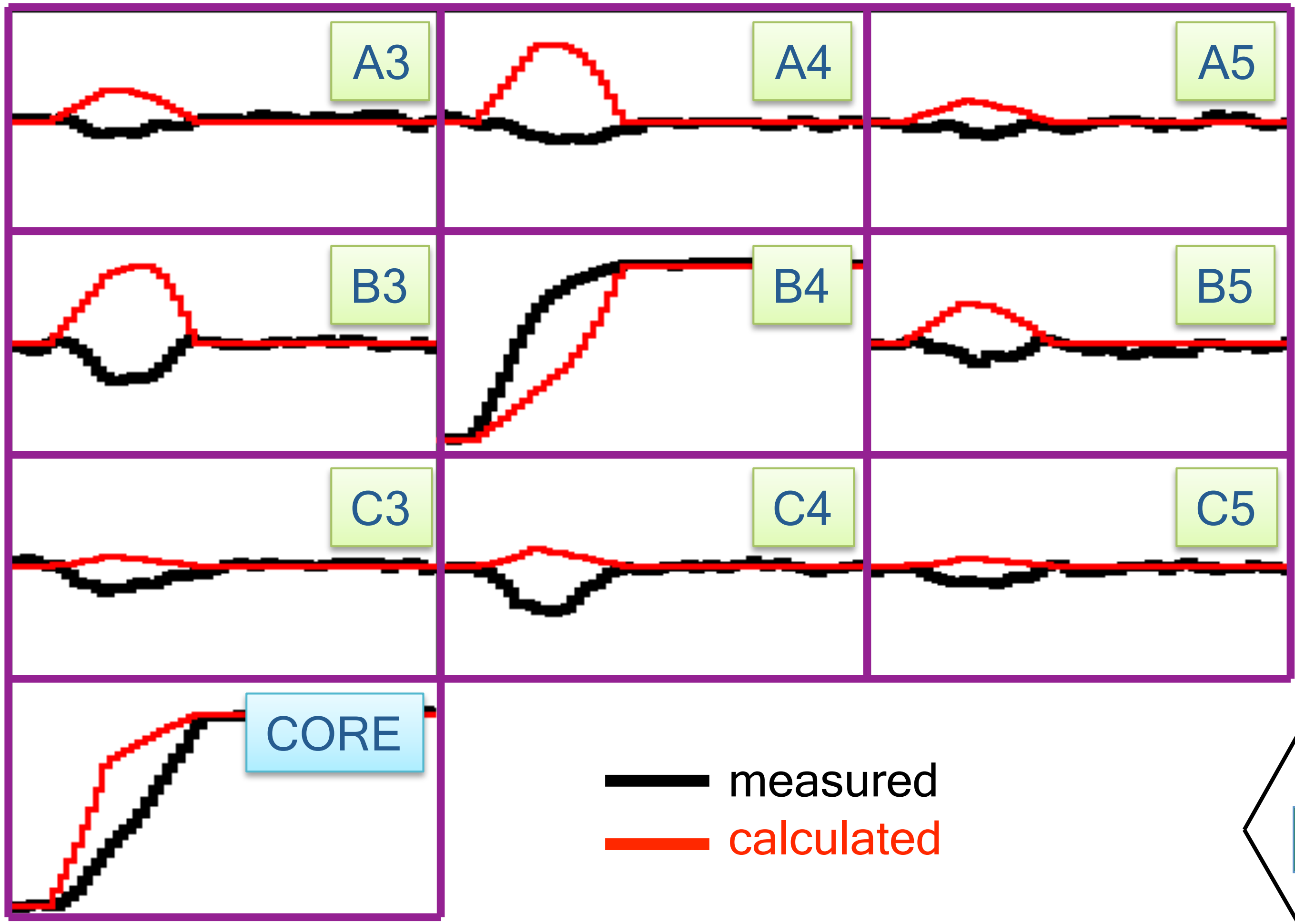
Pulse Shape Analysis Concept

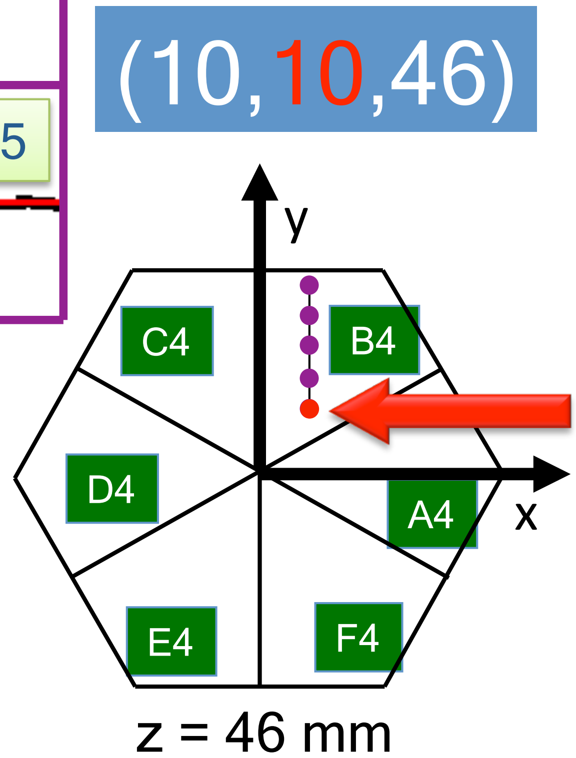




791 keV deposited in segment B4

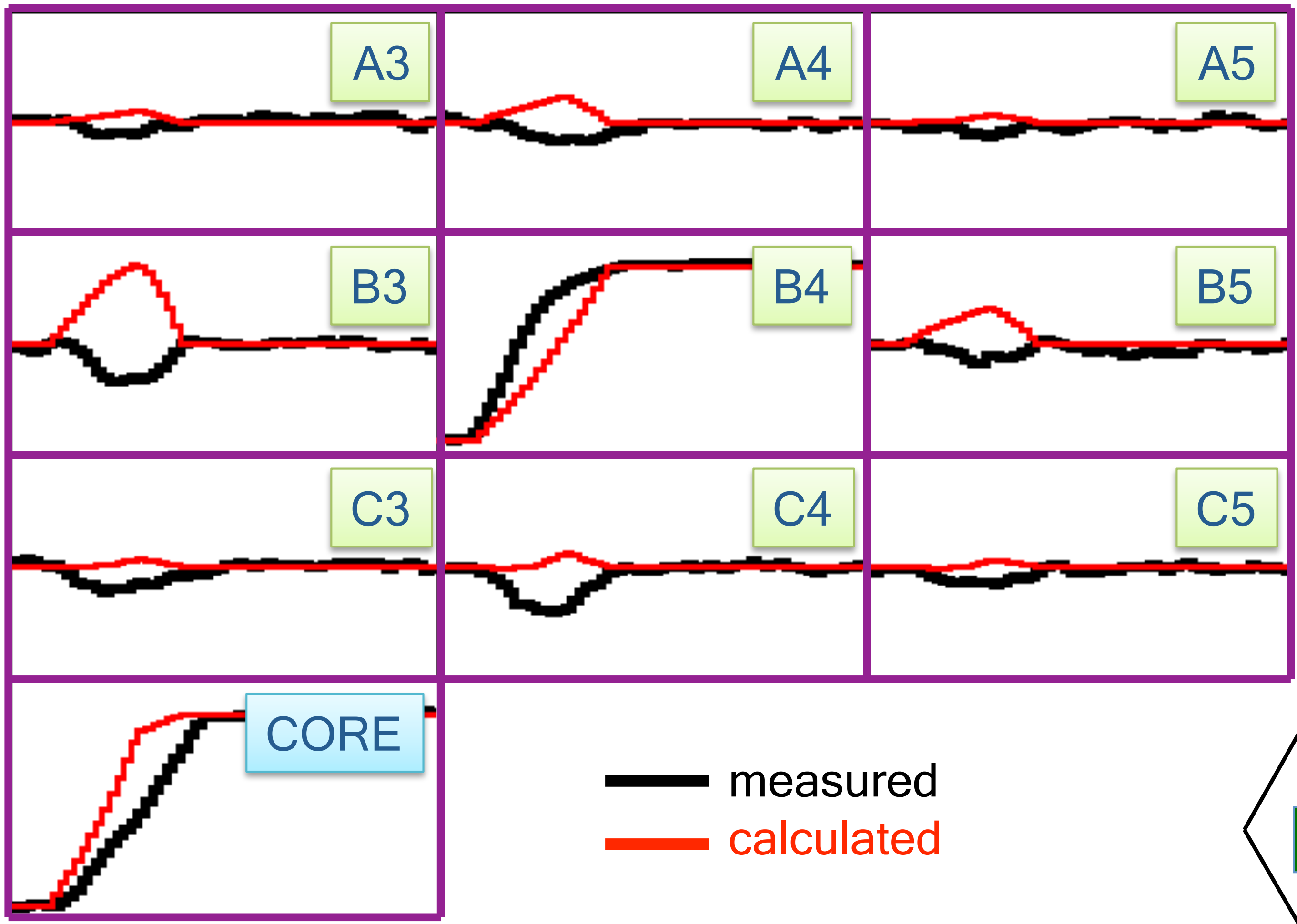
Pulse Shape Analysis Concept

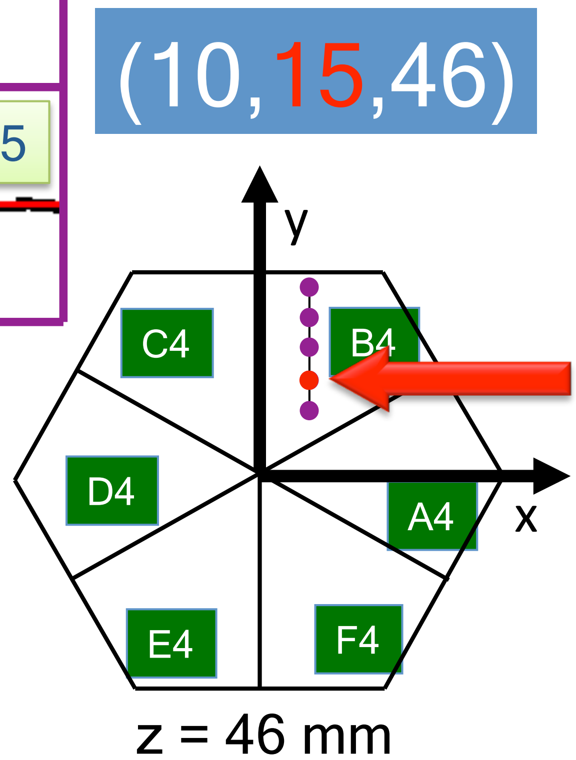




791 keV deposited in segment B4

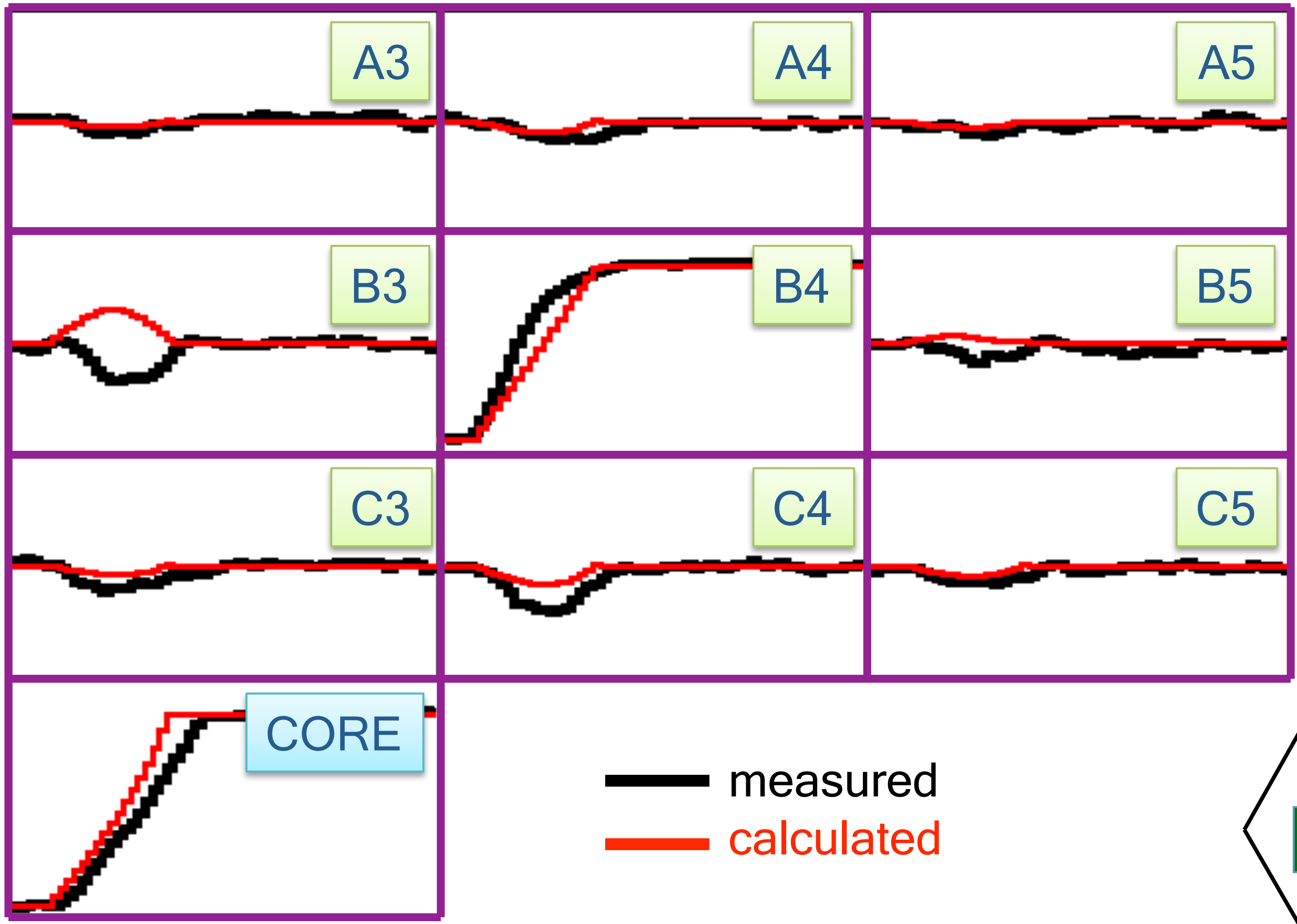
Pulse Shape Analysis Concept



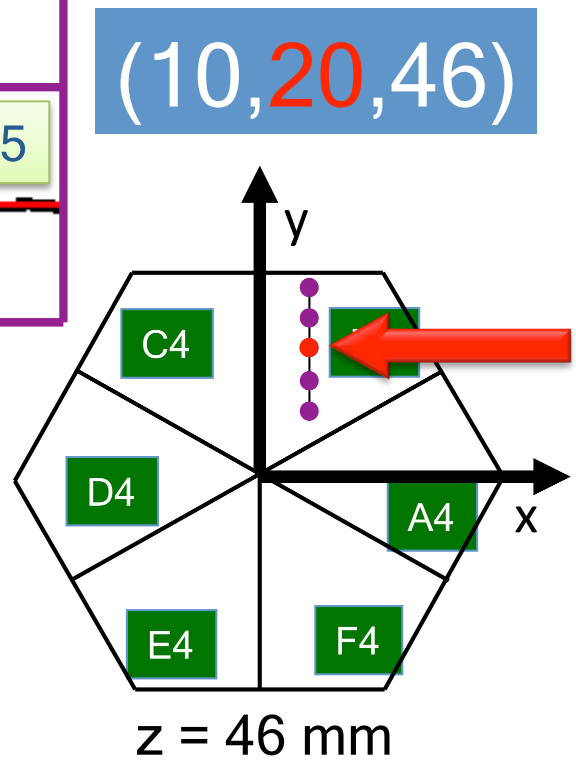


791 keV deposited in segment B4

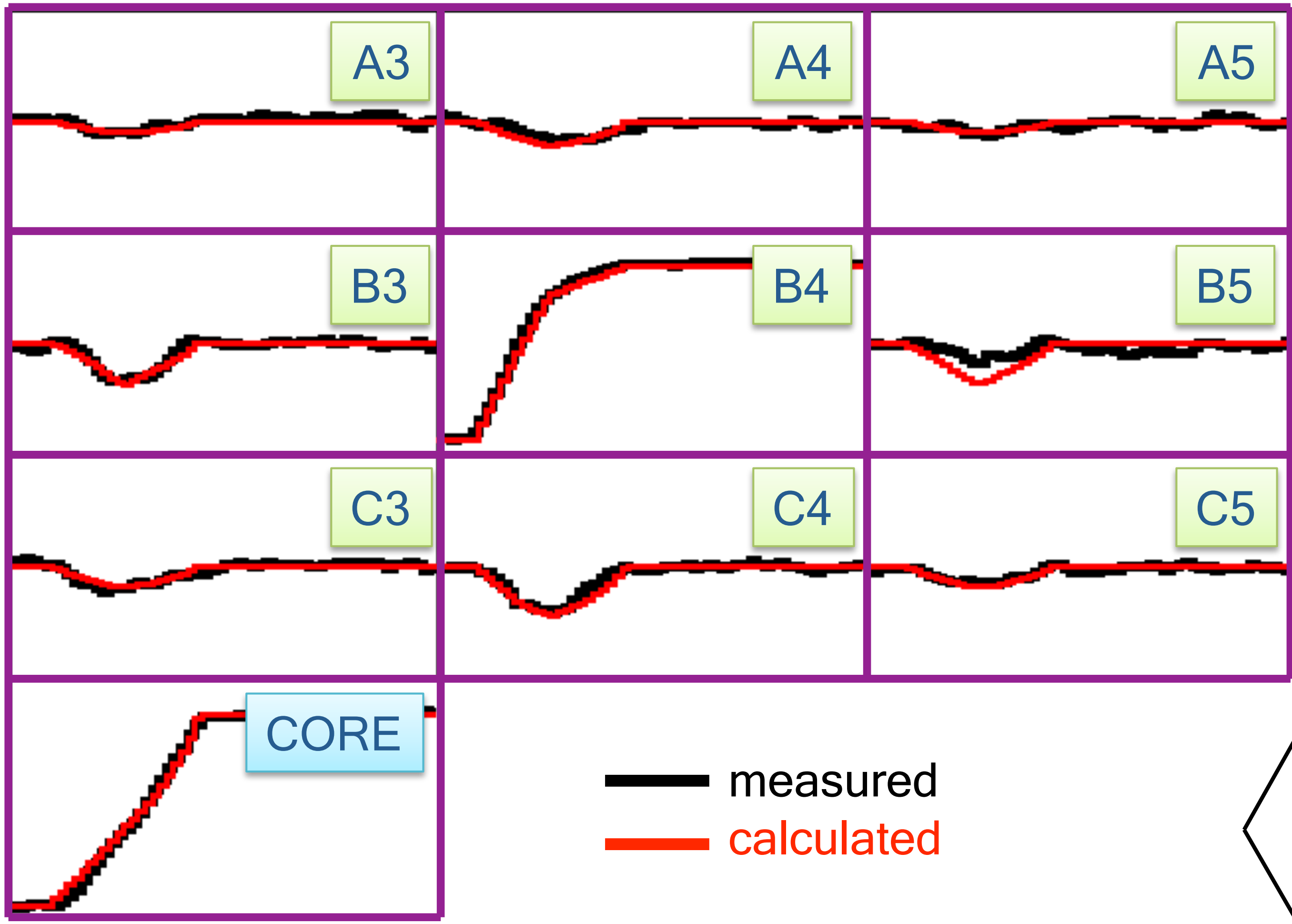
Pulse Shape Analysis Concept



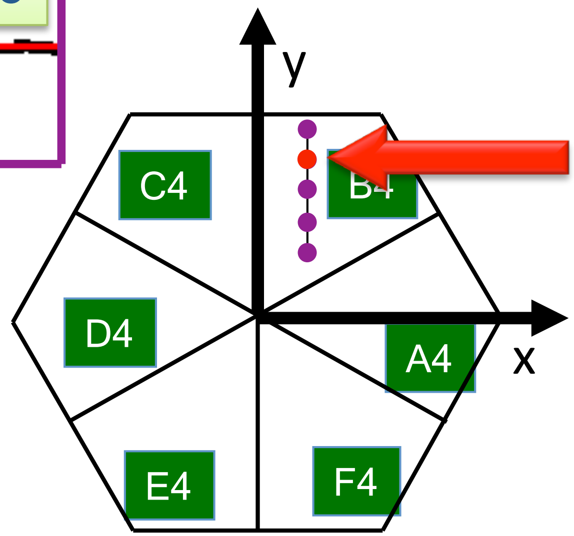
791 keV deposited in segment B4



Pulse Shape Analysis Concept



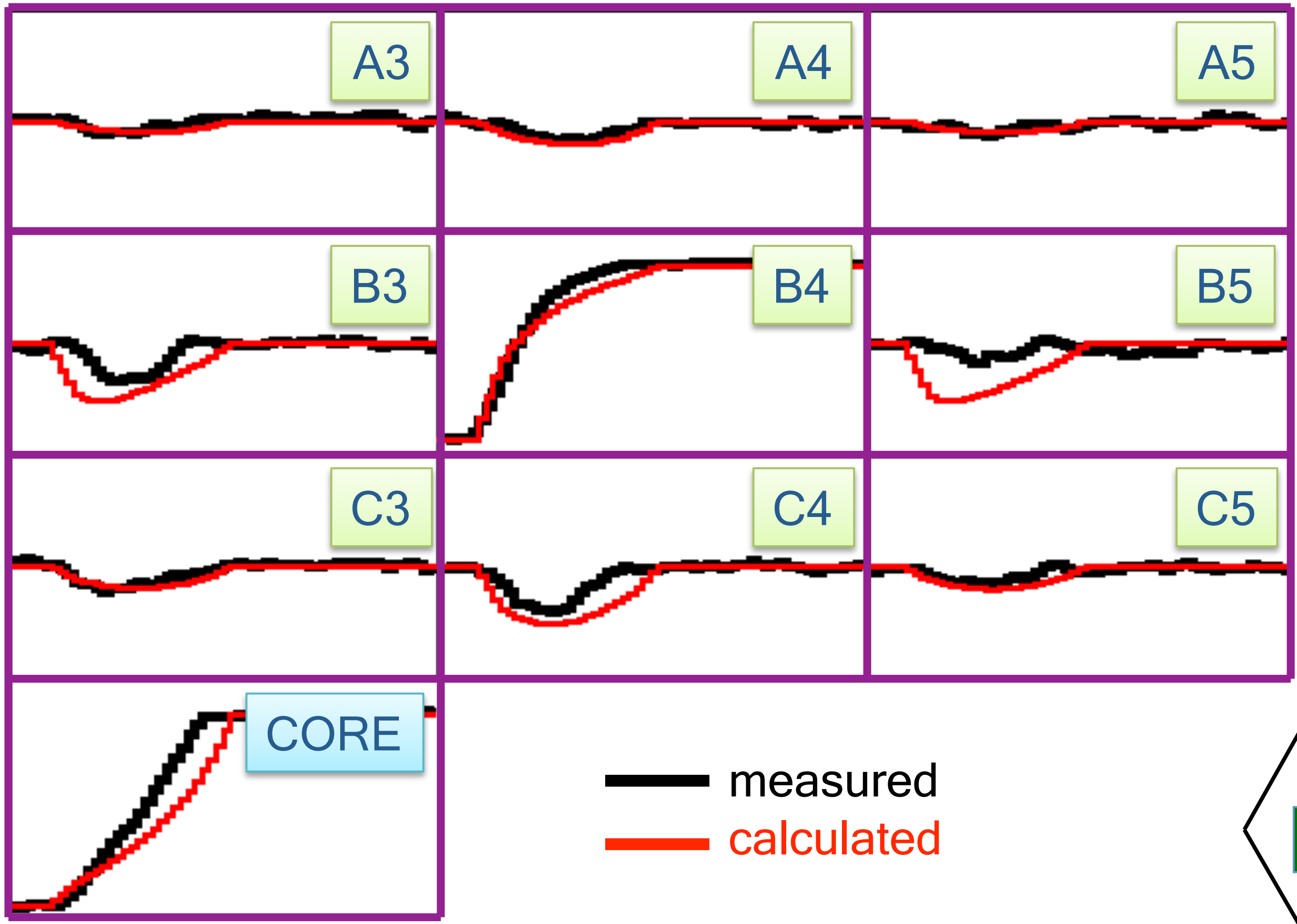
(10,25,46)

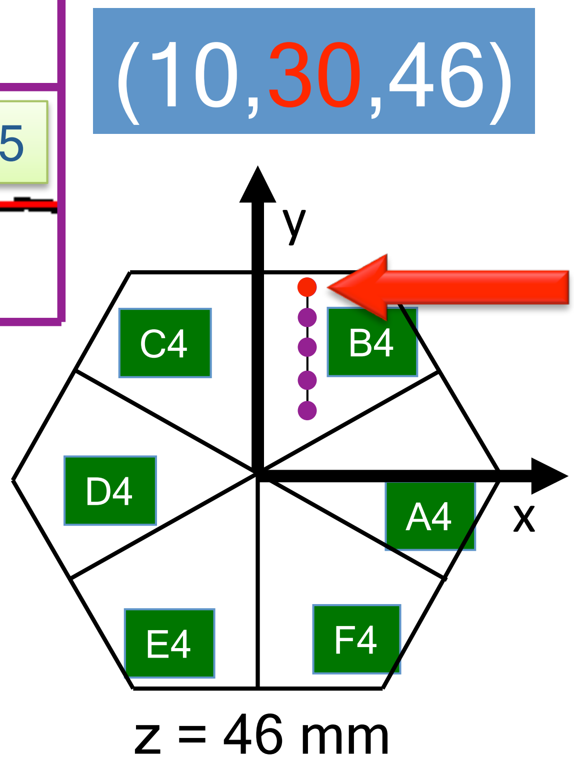


z = 46 mm

791 keV deposited in segment B4

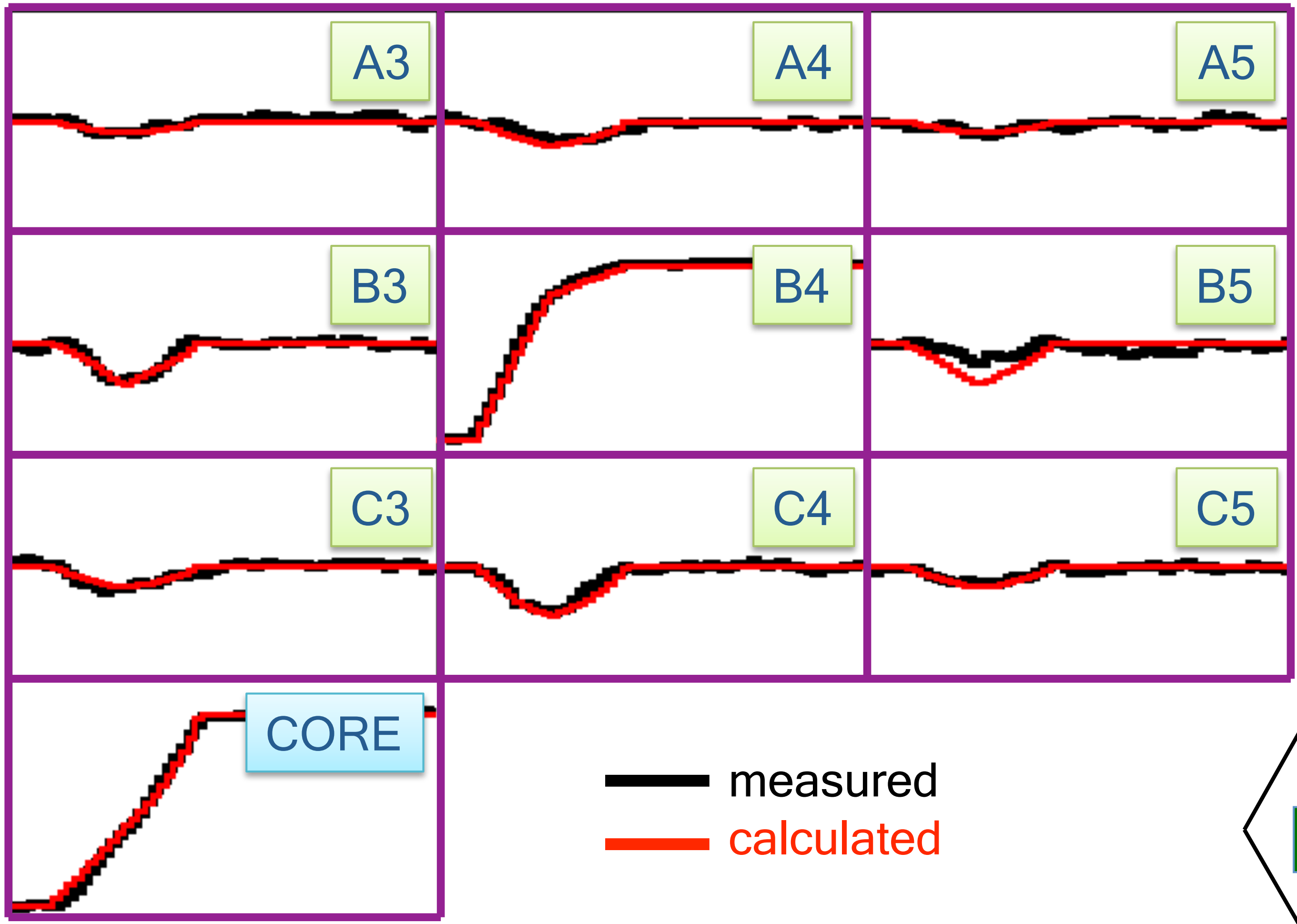
Pulse Shape Analysis Concept





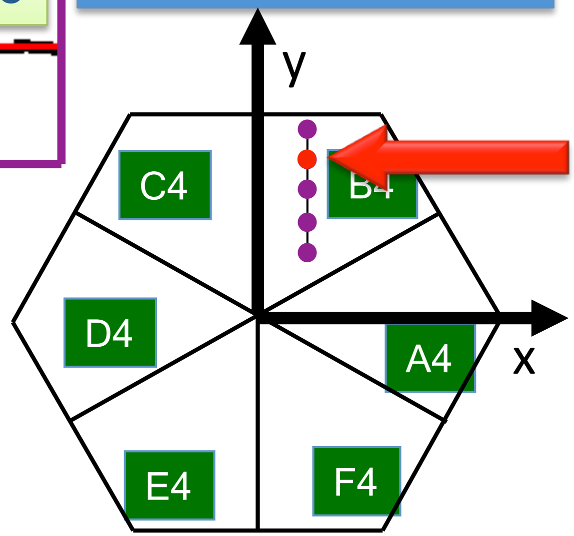
791 keV deposited in segment B4

Pulse Shape Analysis Concept



Result of
Grid Search
algorithm
R. Venturelli

(10,25,46)

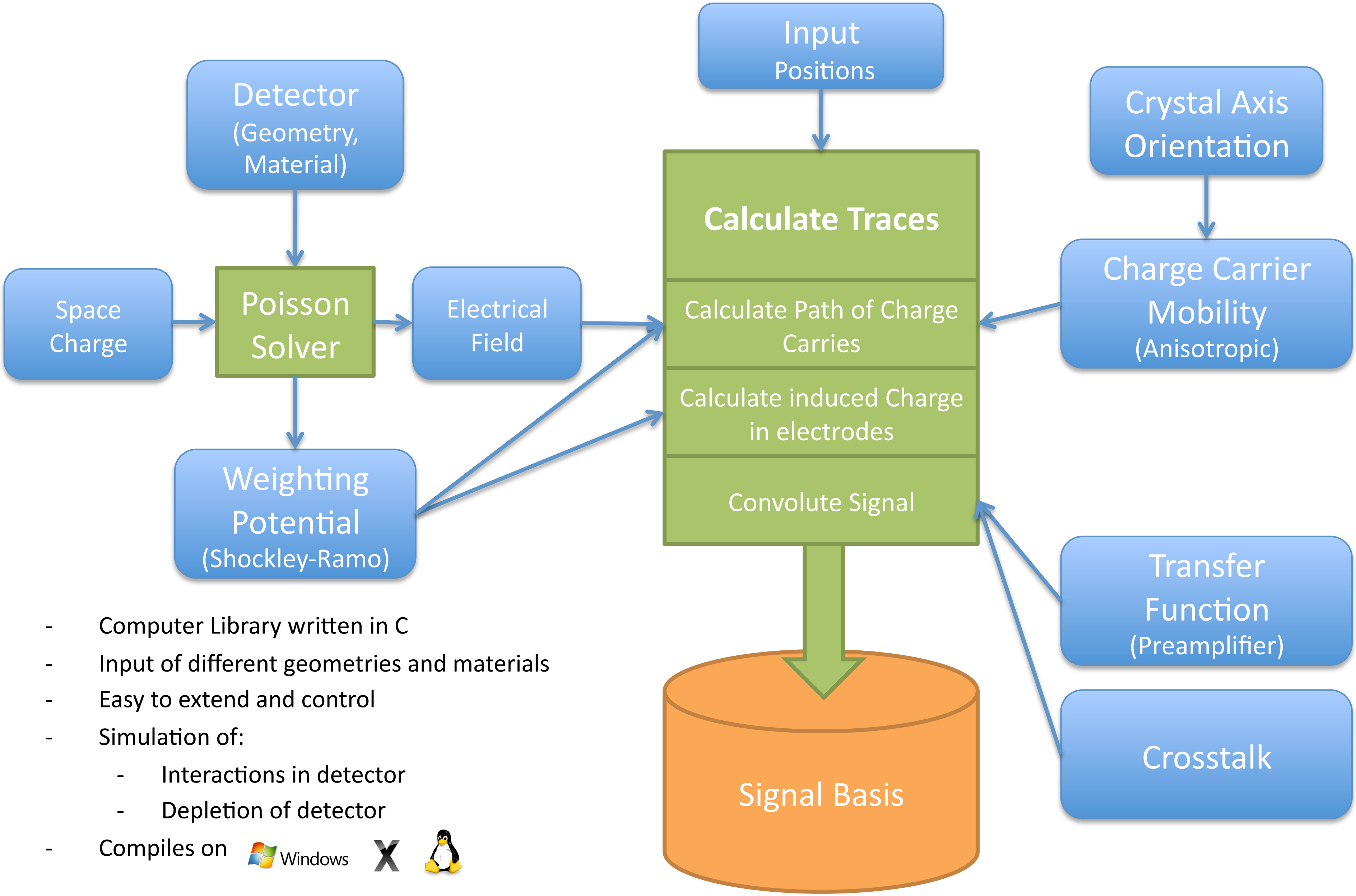


z = 46 mm

791 keV deposited in segment B4

Final position resolution depends crucially on the quality of the signal basis

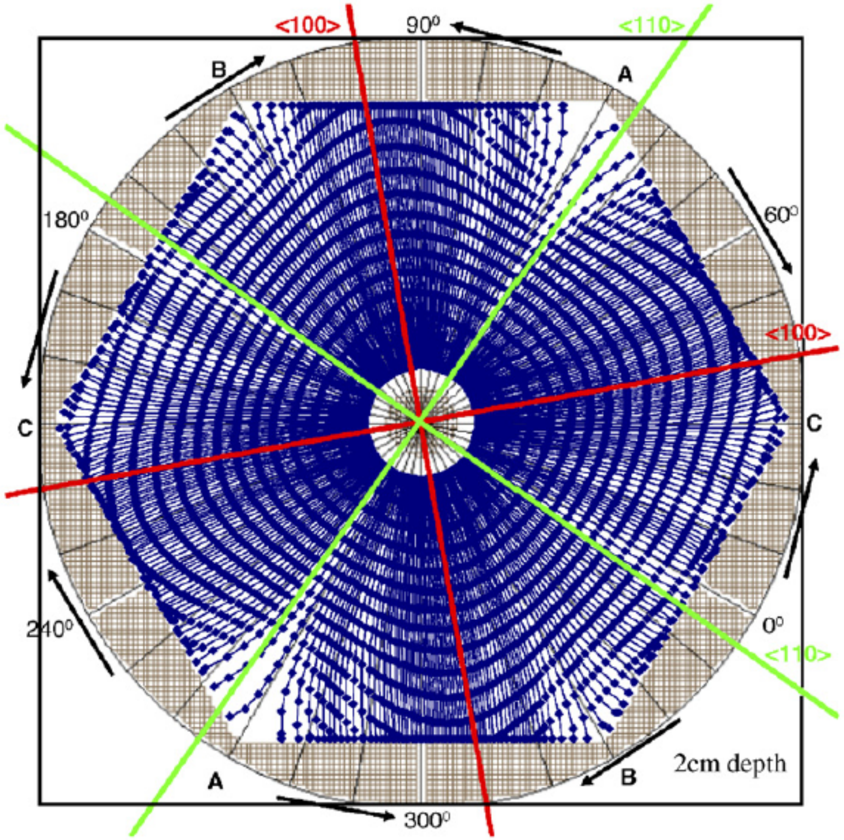
ADL – AGATA Detector Library



- Computer Library written in C
- Input of different geometries and materials
- Easy to extend and control
- Simulation of:
    - Interactions in detector
    - Depletion of detector
- Compiles on Windows X

Calculate Path of Charge Carriers

Charge Carrier Mobility
(Anisotropic)



+ Depends on:
  - applied electrical field
  - crystal axis orientation

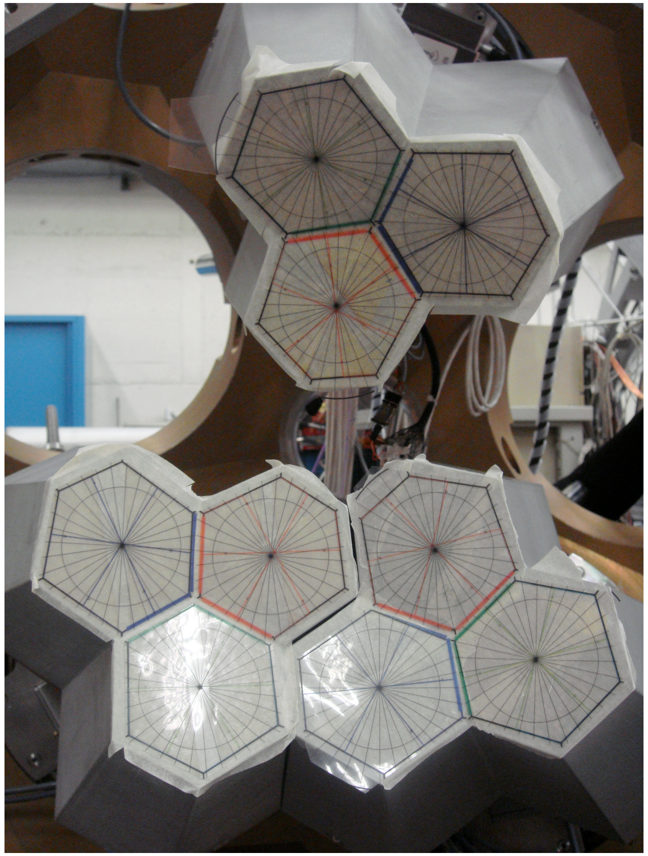
+ Different Mobility for:
  - electrons
  - holes

B. Bruyneel et al. NIMA 569 (2006) 764-773

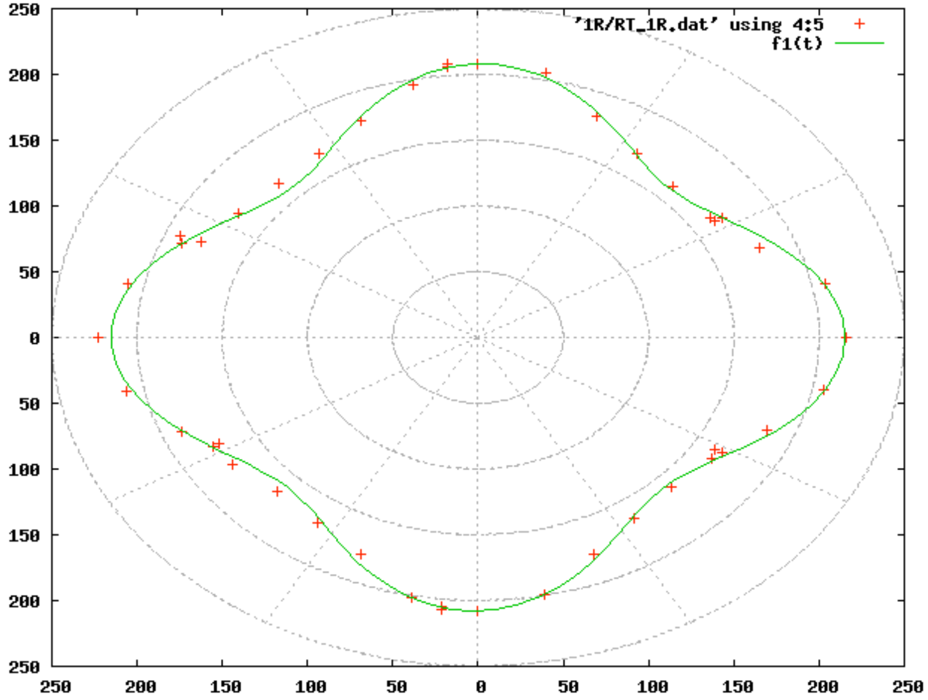
B. Bruyneel et al. NIMA 569 (2006) 774-789

Calculate Path of Charge Carriers

Crystal Axis Orientation

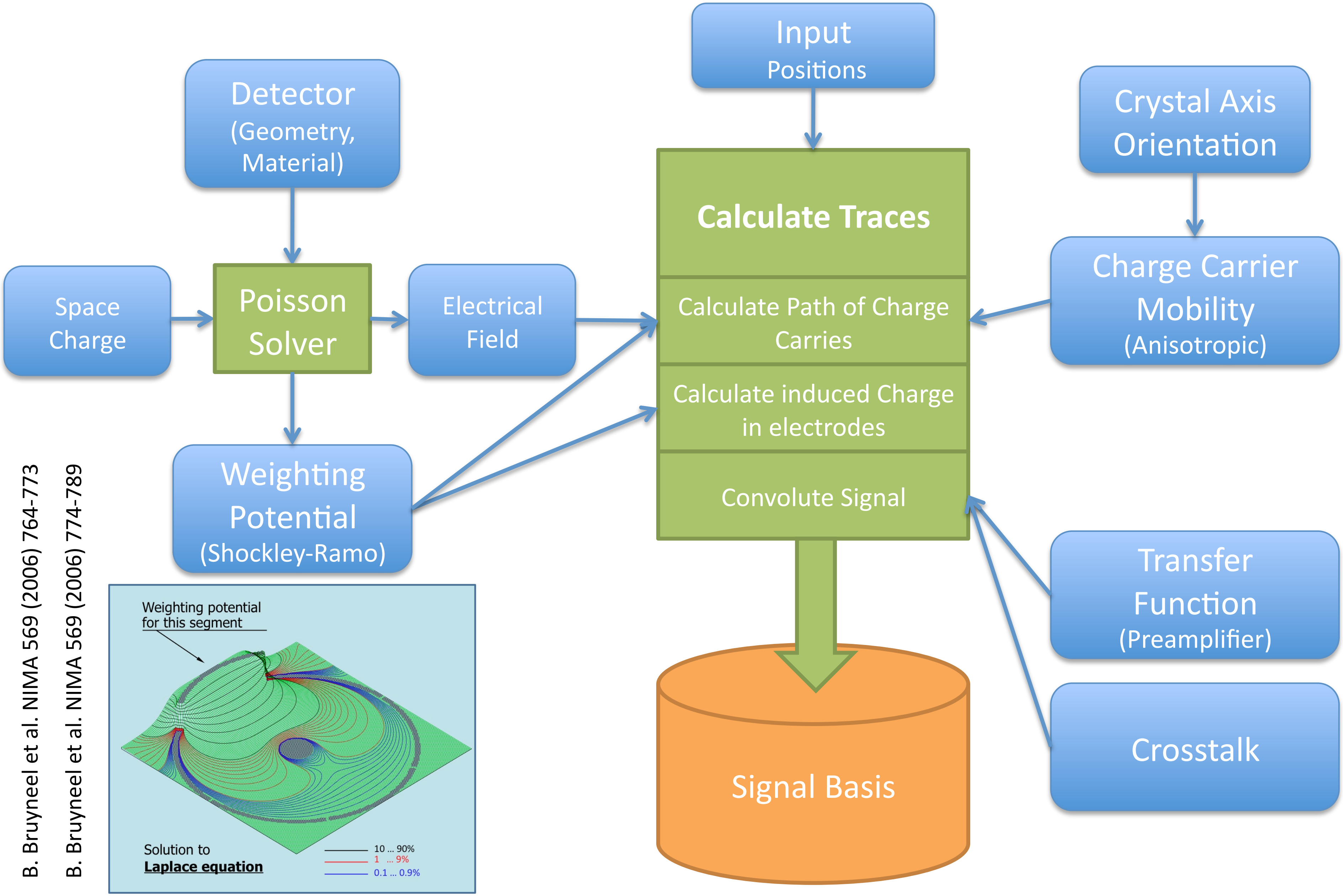


Rise time in ns for different angles



- 400kBq Am source +
- Lead Collimator: ∅ 1.5mm X 1cm
- Front Scan at ∅ 4.7cm: 300 cts/s

How to generate a signal basis?



B. Bruyneel et al. NIMA 569 (2006) 764-773

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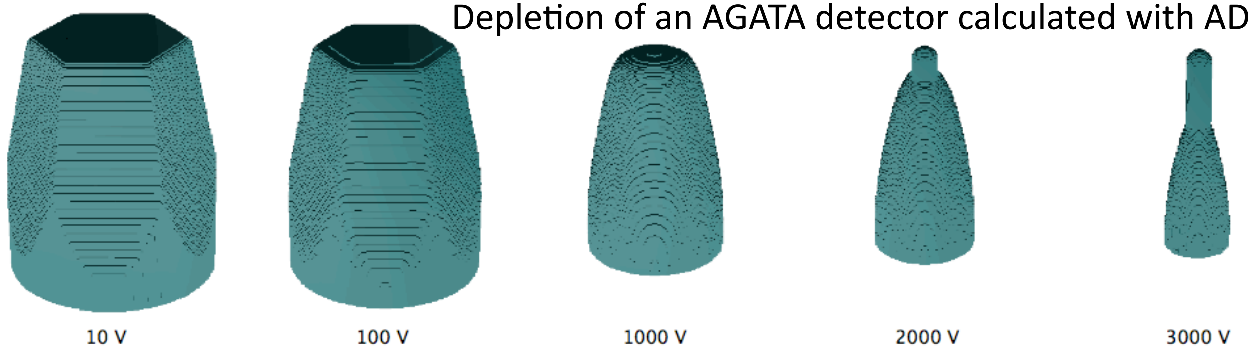
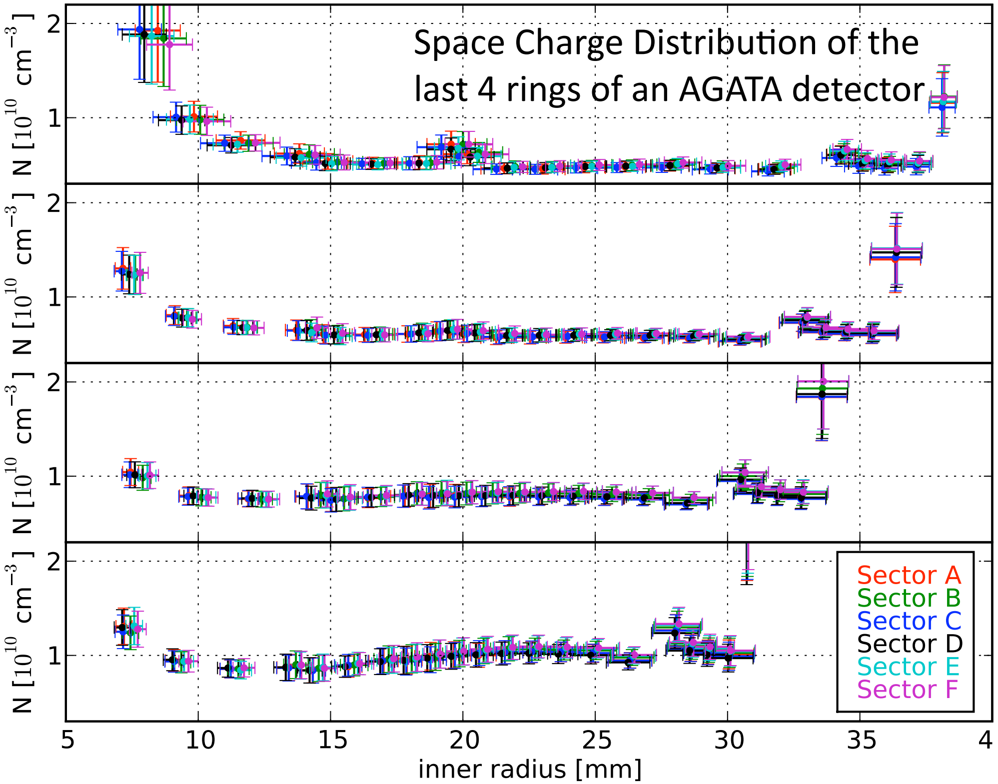
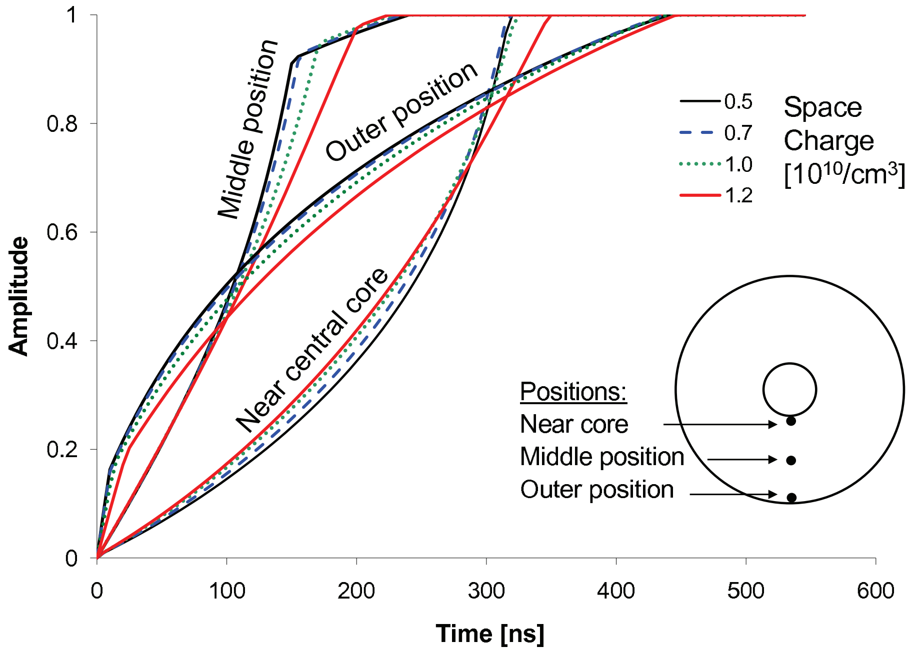
Calculate Path of Charge Carriers

Space Charge Distribution
(Electrical Field)

Depletion of an AGATA detector calculated with ADL



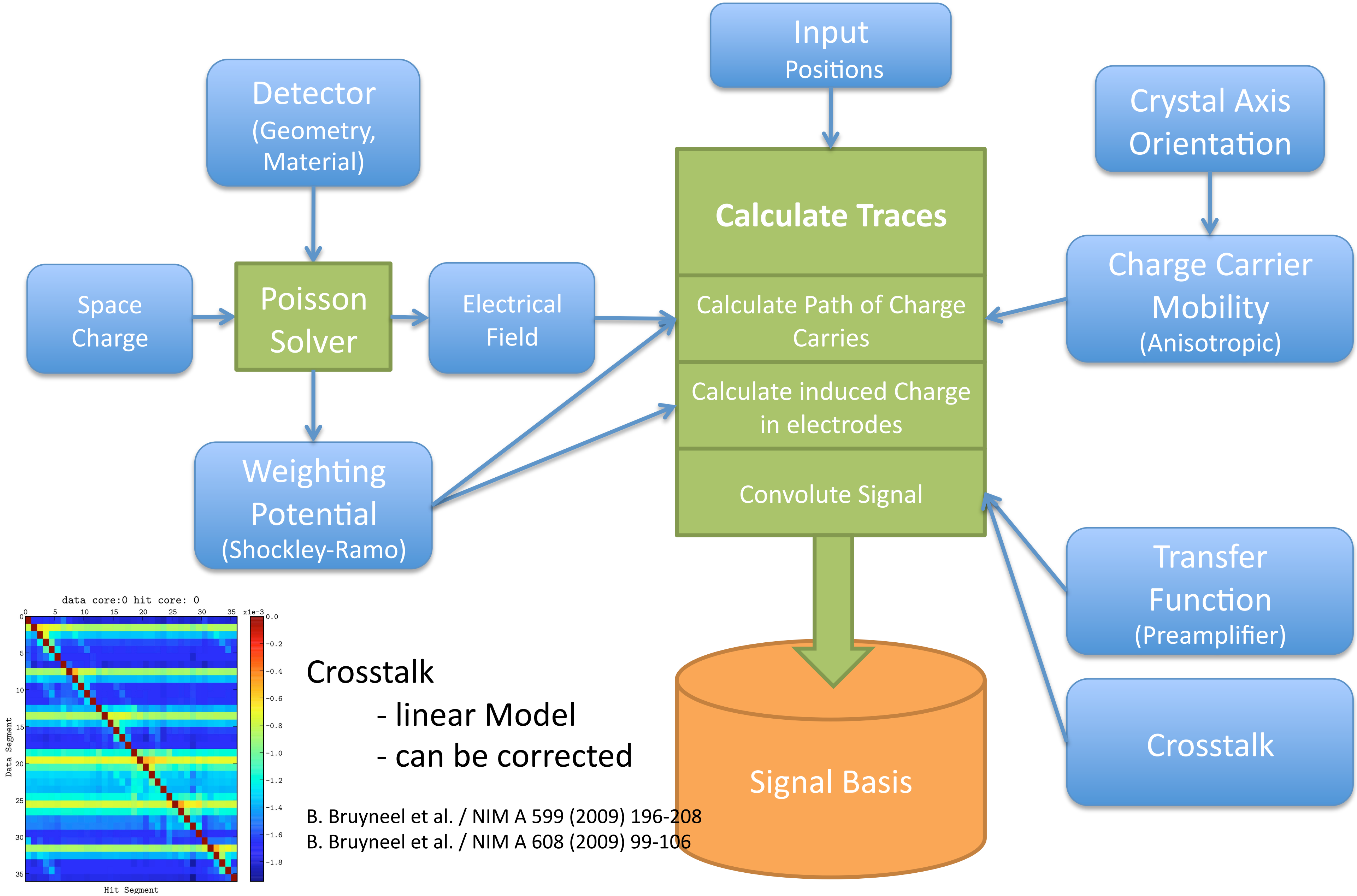




B. Bruyneel et al. accepted by NIMA (2011)

B. Birkenbach et al. accepted by NIMA (2011)

How to generate a signal basis?

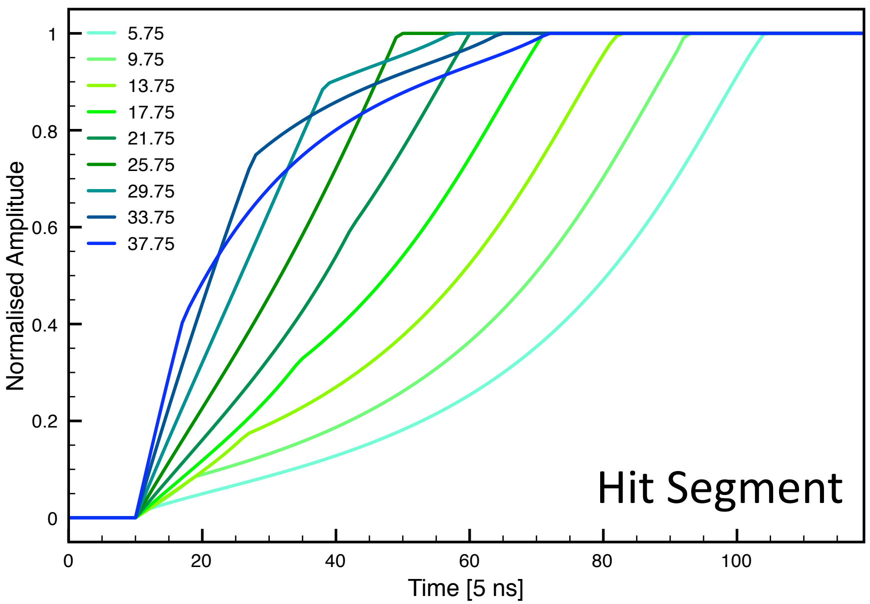


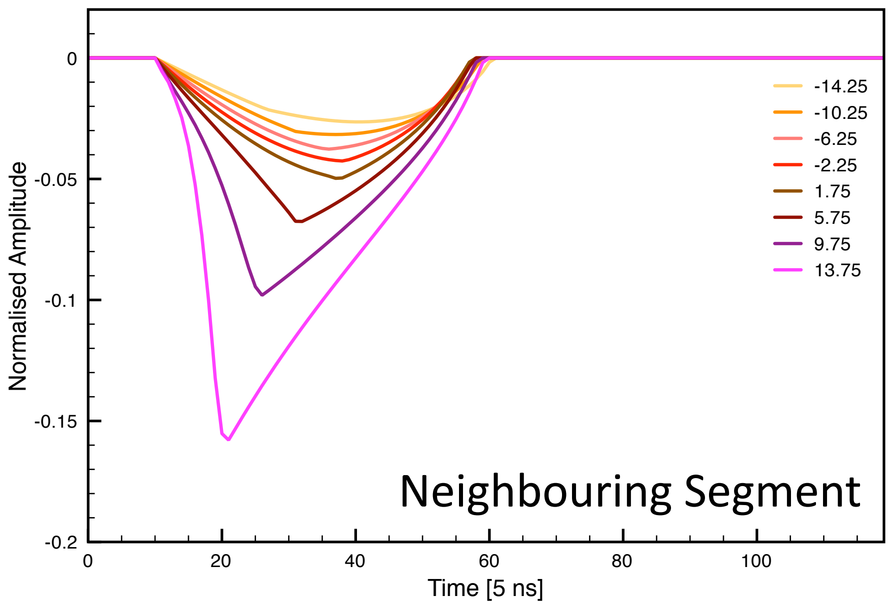
Crosstalk

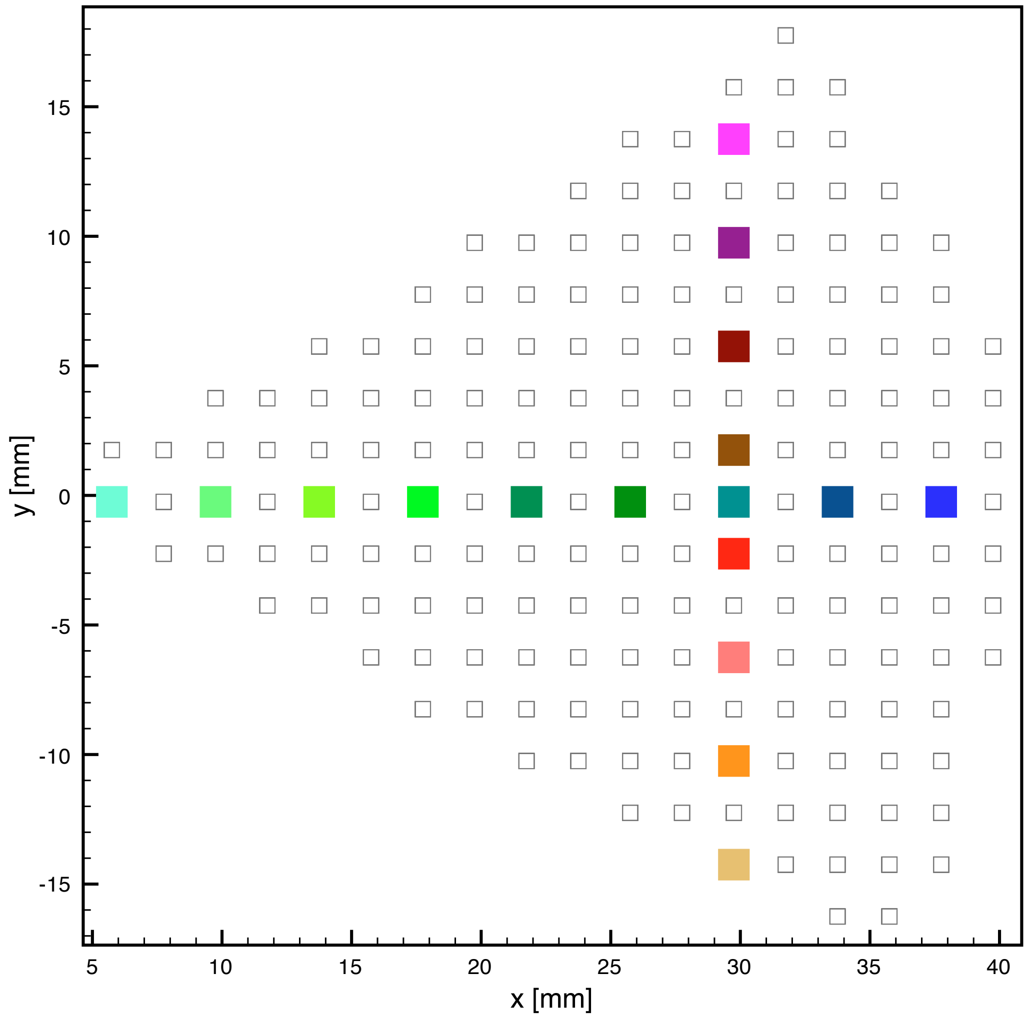
- linear Model
- can be corrected

B. Bruyneel et al. / NIM A 599 (2009) 196-208
B. Bruyneel et al. / NIM A 608 (2009) 99-106

Signal Basis calculated with ADL

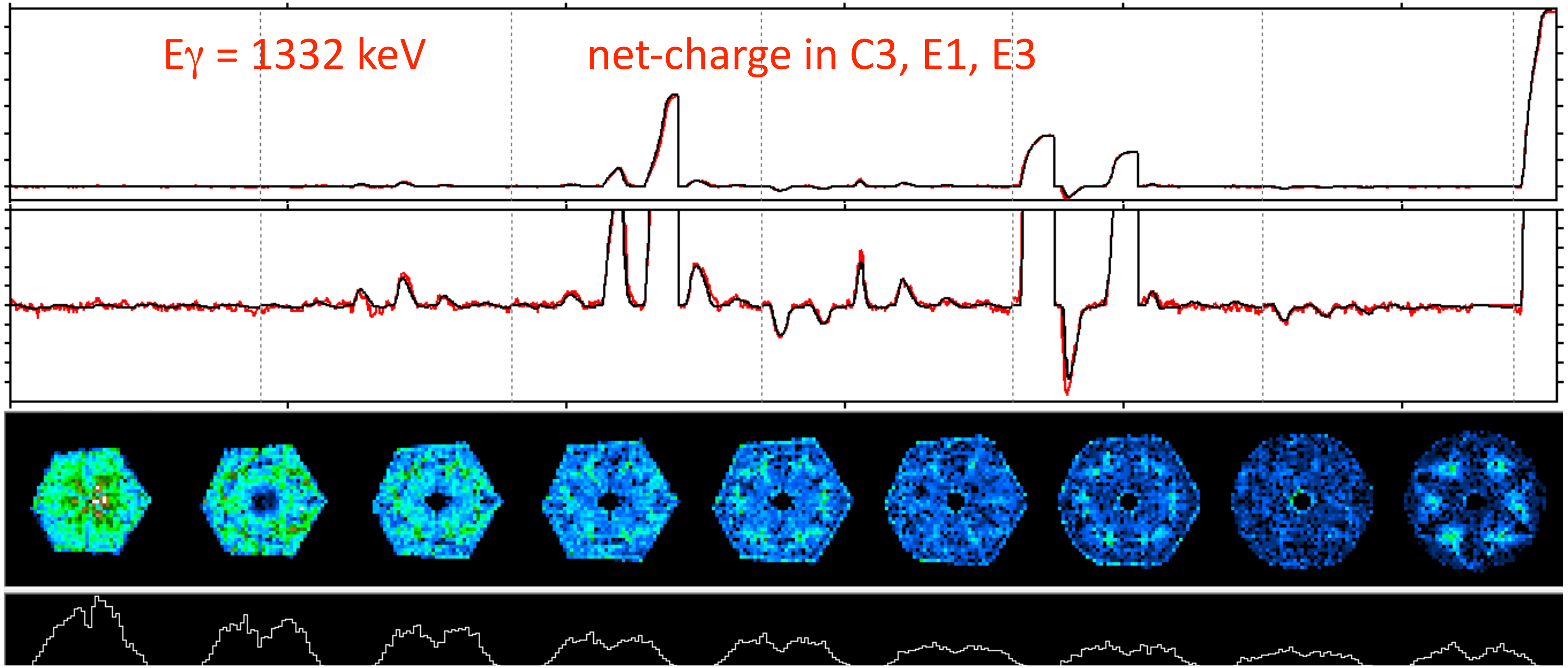






Performance of AGATA

FWHM	Method	Reference
5.2mm	Doppler correction meas.	F. Recchia et al. NIM A (2009)
4.0mm	Doppler correction meas	P.-A. Söderström et al. NIM A (2011)
3.5mm	511keV source meas.	S. Klupp, M.Schlarb, R. Gernhäuser (HK 54.1)



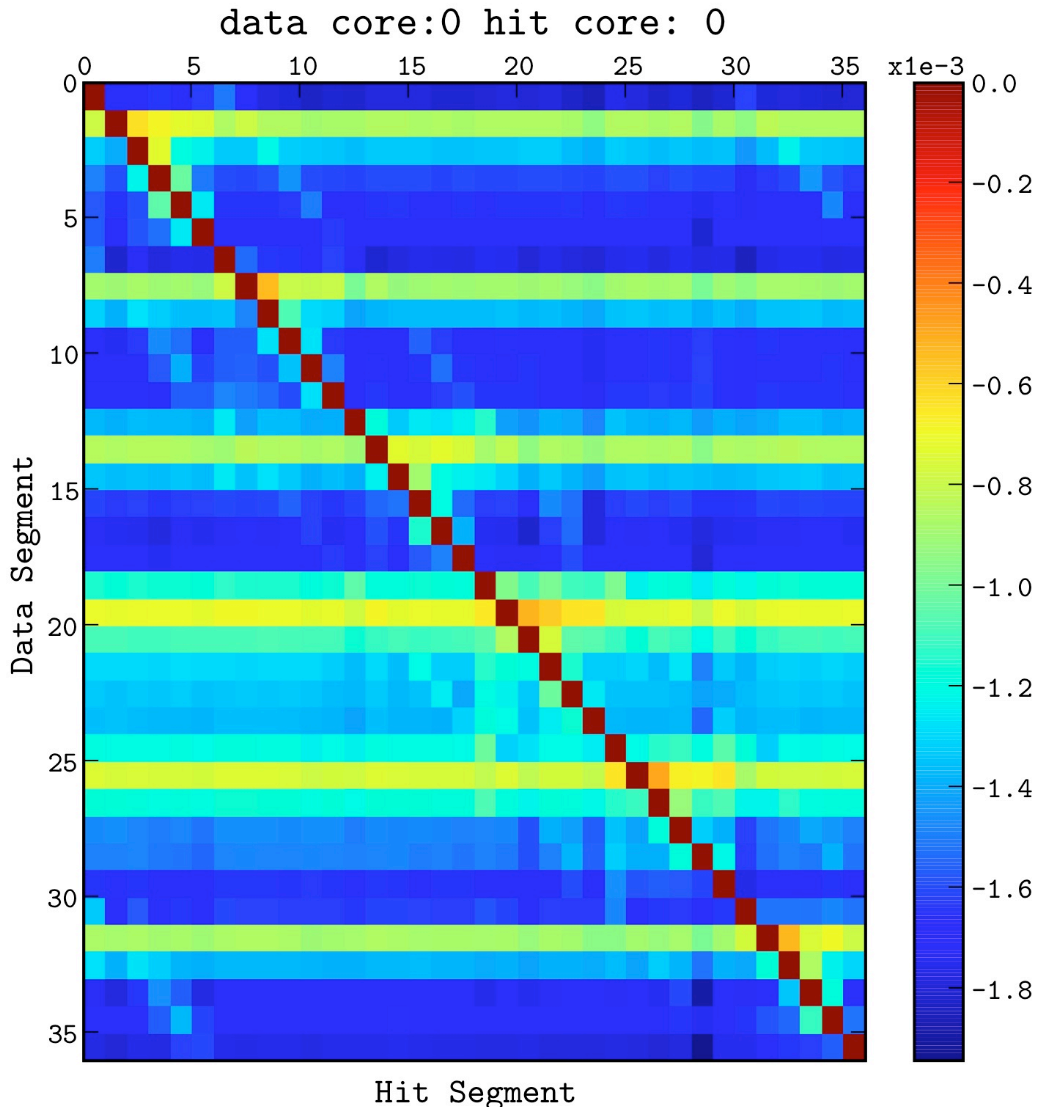
AGATA Collaboration

AGATA-Kollaboration
Benedikt Birkenbach[1], Bart Bruyneel[1], Juergen Eberth[1], Herbert Hess[1], Jan Jolie[1], Daniel Lersch[1], Gheorghe Pascovici1[1], Peter Reiter[1], Nigel Warr[1], Andreas Wiens[1], Andreas Zilges[1], Reiner Kruecken[2], Roman Gernhaueser[2], Michael Schlarb[2], Juergen Gerl[3], Tobias Engert[3], Tobias Habermann[3], Gilles de France[3], Ivan Kojouharov[3], Nikolaus Kurz[3], Stephane Pietri[3], Henning Schaffner[3], Plamen Boutachkov[4], Angel Givechev[4], Jörg Leske[4], Edana Merchan[4], Oliver Möller[4], Norbert Pietralla[4], Michael Reese[4], Christian Stahl[4], Andi Boston[5], Helen Boston[5], Samantha Colosimo[5], Fay Filmer[5], Dan Judson[5], Steven Moon[5], Mike Slee[5], Carl Unsworth[5], Paul Nolan[5], Johan Nyberg[6], Bo Cederwall[7], Carlos Rossi Alvarez[8], Dino Bazzacco[8], Marco Bellato[8], Damiano Bortolato[8], Enrico Farnea[8], Andres Gadea[8], Roberto Isocrate[8], Raluca Marginean[8], Roberto Menegazzo[8], Gabriele Rampazzo[8], Francesco Recchia[8], Calin Ur[8], Roberto Venturelli[8], Alberto Pullia[9], Francesca Zocca[9], Sylvain Broussard[10], Andreas Goergen[10], Wolfram Korten[10], Alexandre Obertelli[10], Julien Pancin[10], Christophe Theisen[10], Christian Veyssiere[9], Andr Bouty[10], Ange Lotode[10], Yannick Mariette[10], Alexandre Obertelli[10], Dominique Curien[11], Olivier Dorvaux[11], Gilbert Duchene[11], Benoit Gall[11], Patrice Medina[11], Cayetano Santos[11], Elmehdi Chambit[11], Laurent Charles[11], Remy Baumann[11], Francois Didierjean[11], Marie-Hlne Sigward[11], Alexander Buerger[12], Marc Labiche[13], Ian Lazarus[13], Roy Lemmon[13], Belen Gomez[13], John Simpson[13], Pierre Desesquelles[14], Pierre Edelbruck[14], Xavier Grave[14], Karl Hauschild[14], Amel Korichi[14], Joa Ljungvall[14], Araceli Lopez-Martens[14], Hoa Ha Mai[14], Christophe Oziol[14], Lounis Benallegue[15], Stephane Leboutellier[15], Sebastien Lhenortet[15], Denis Linget[15], Bruno Travers[15], Daniel Guinet[16], Nadine Redon[16], Olivier Stezowski[16], Tuyen Doan Quang[16], Serkan Akkoyum[17], Ayse Atac[17], Ayse Kaskas[17], Pete Jones[18], Jean Ropert[18] und Michel Tripon[18] — [1]IKP, Universität zu Köln, Germany — [2]TU München, Germany — [3]G.S.I. Darmstadt, Germany — [4]IKP, TU Darmstadt, Germany — [5]University of Liverpool, England — [6]R.I.T. University Uppsala, Sweden — [7]University of Stockholm, Sweden — [8]INFN Padua, Italy — [9]University of Milano, Italy — [10]Irfu Saclay, France — [11]IPHC Strasbourg, France — [12]ISKP Universität Bonn, Germany — [13]CCLRC Daresbury, England — [14]IPN Orsay, France — [15]CSNSM Orsay, France — [16]IPN Lyon, France — [17]Ankara University, Turkey — [18]JYFL Jyväskylä, Finland — [19]GANIL Caen, France

Thanks for Attention!

Crosstalk

Convolution



Ideal detector

$$\begin{pmatrix} E_{core} \\ E_{seg_1} \\ E_{seg_2} \\ \vdots \\ E_{seg_n} \end{pmatrix}_{meas} = \begin{pmatrix} 1 & 1 & \dots & 1 \\ 1 & 0 & \dots & 0 \\ 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1 \end{pmatrix} \cdot \begin{pmatrix} E_{seg_1} \\ E_{seg_2} \\ \vdots \\ E_{seg_n} \end{pmatrix}_{true}$$

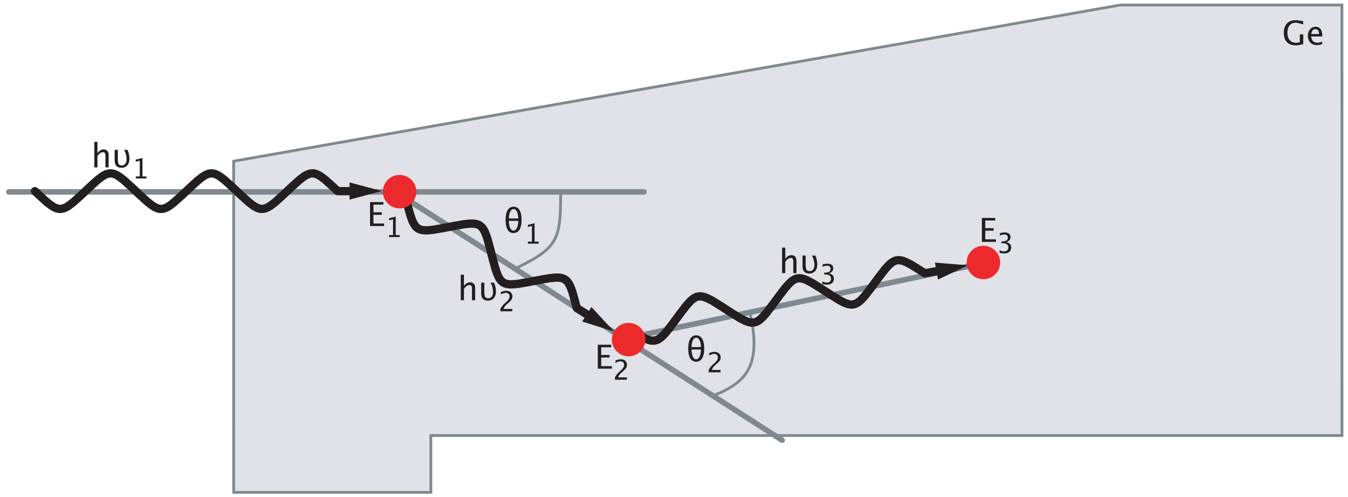
Realistic detector

$$\begin{pmatrix} E_{core} \\ E_{seg_1} \\ E_{seg_2} \\ \vdots \\ E_{seg_n} \end{pmatrix}_{meas} = \begin{pmatrix} 1+\delta_{01} & 1+\delta_{02} & \dots & 1+\delta_{0n} \\ 1 & \delta_{12} & \dots & \delta_{1n} \\ \delta_{21} & 1 & \dots & \delta_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \delta_{n1} & \delta_{n2} & \dots & 1 \end{pmatrix} \cdot \begin{pmatrix} E_{seg_1} \\ E_{seg_2} \\ \vdots \\ E_{seg_n} \end{pmatrix}_{true}$$

B. Bruyneel et al. / Nuclear Instruments and Methods in Physics Research A 599 (2009) 196–208

B. Bruyneel et al. / Nuclear Instruments and Methods in Physics Research A 608 (2009) 99–106

Principle of Tracking

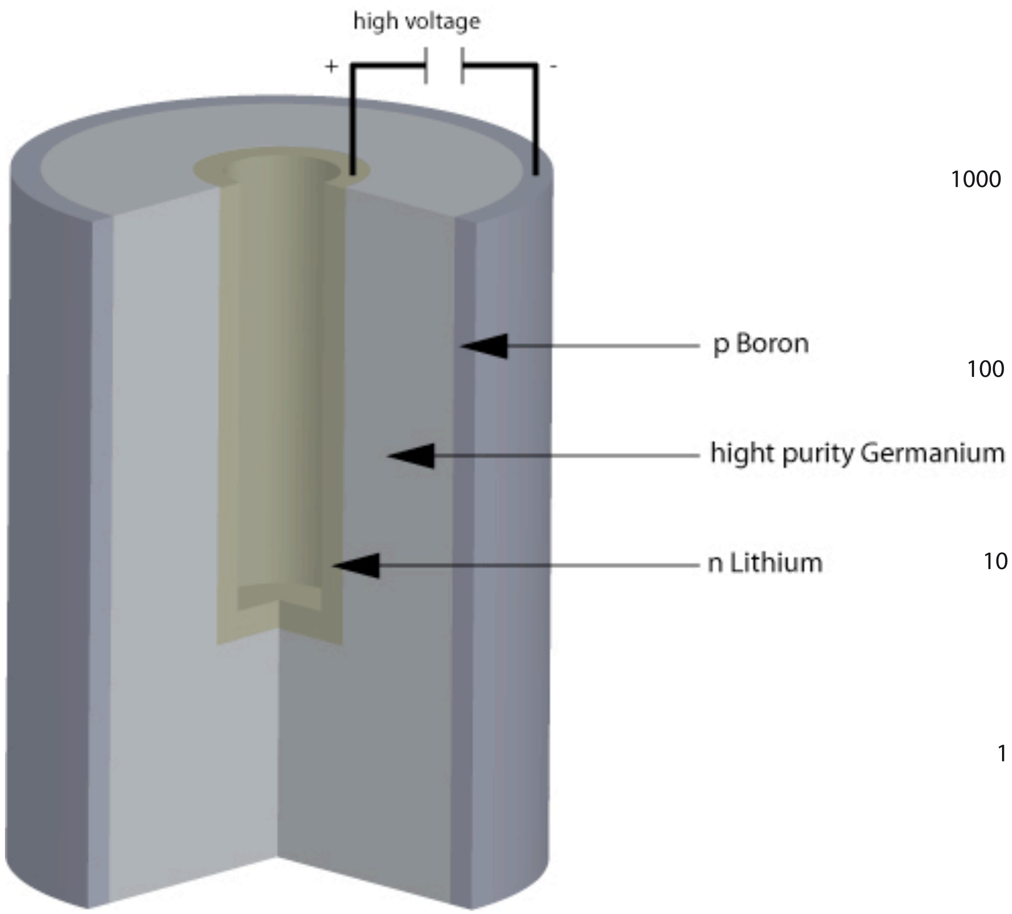


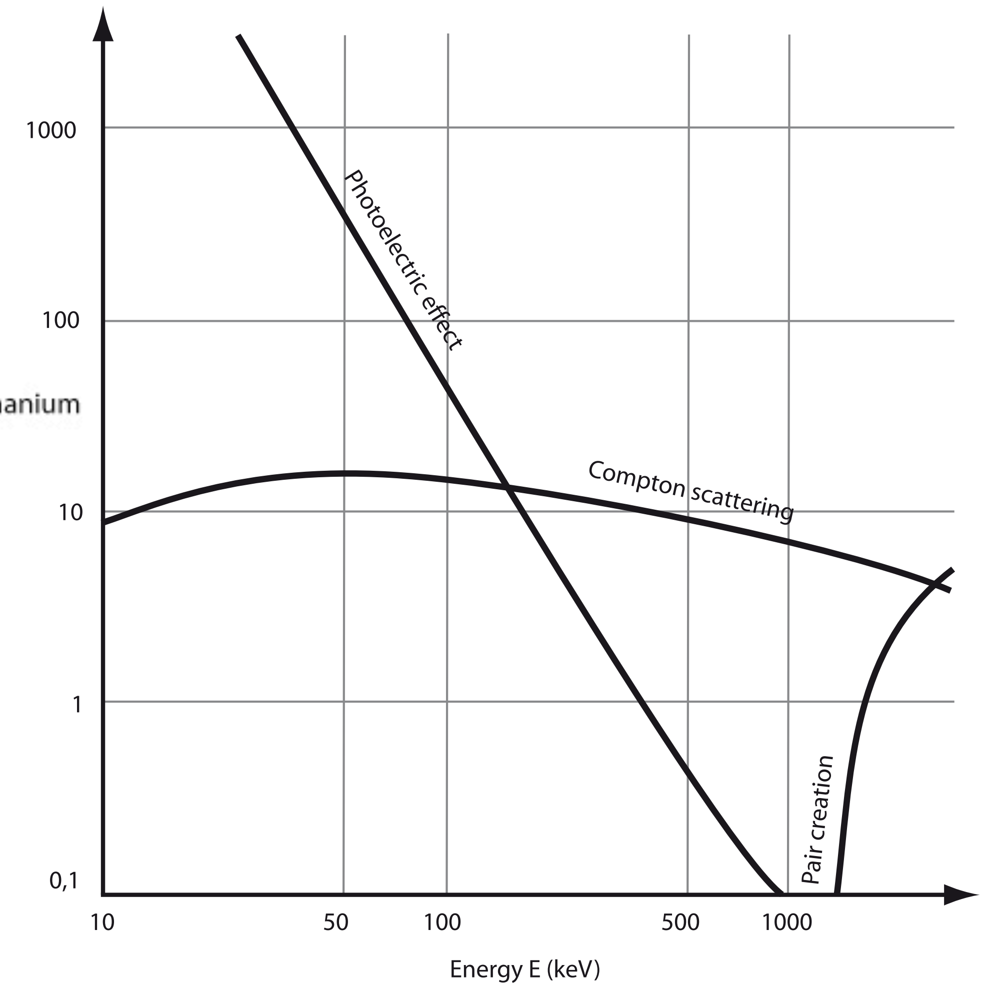
Compton formula

$$h\nu_2 = \frac{h\nu_1}{1 + \frac{h\nu_1}{m_0 c^2}(1-\cos\theta_1)}$$

- Energy
- Position
- Time

Detection of Gamma rays with HPGe Detectors





Performance of AGATA

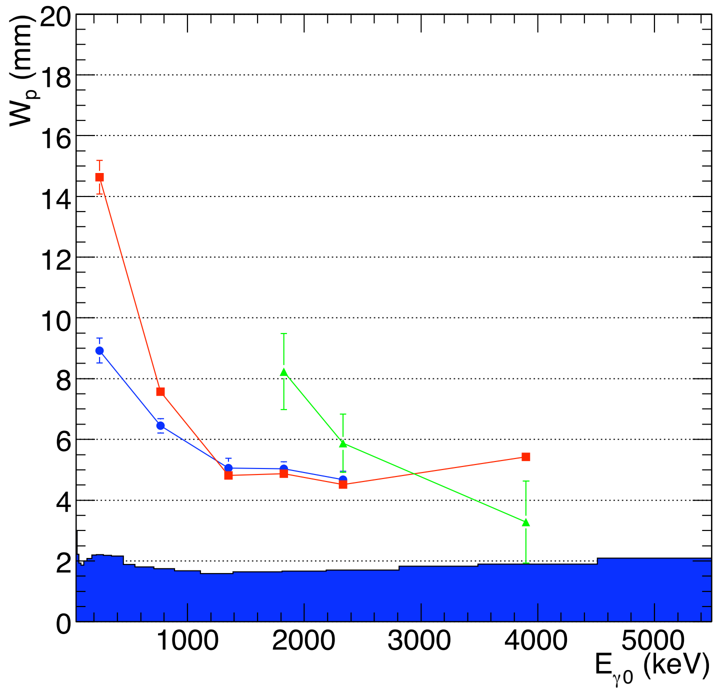


Figure 16: Interaction position resolution from the full data set without cut on (θ, ϕ) as a function of γ-ray energy for different interaction mechanisms: photoelectric effect (circles), Compton scattering (squares), pair production (triangles). The error bars due to statistical errors only. The estimated systematic errors are shown as the filled histogram (see text).

FWHM	**Method**	**Reference**
5.2mm	Doppler correction meas.	F. Recchia et al. NIM A (2009)
4.0mm	Doppler correction meas	P.-A. Söderström et al. NIM A (2011)
3.5mm	511keV source meas.	S. Klupp, M.Schlarb, R. Gernhauser, (HK 54.1)

Calculate induced Charges in electrodes

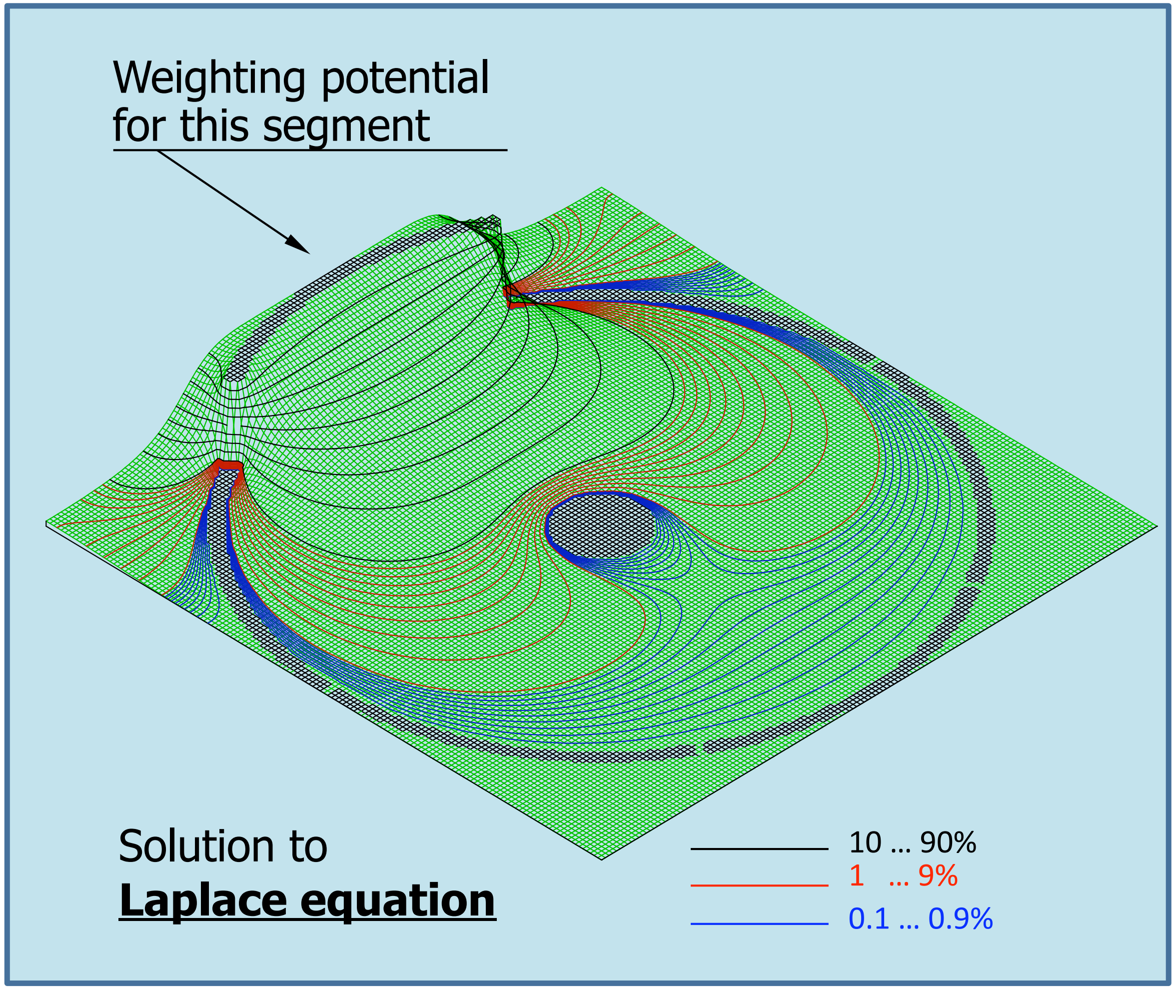
Weighting Potential
(Shockley-Ramo)

B. Bruyneel NIMA 569 (2006) 764-773

B. Bruyneel NIMA 569 (2006) 774-789

Induced charge from Electrons and Holes is given by:

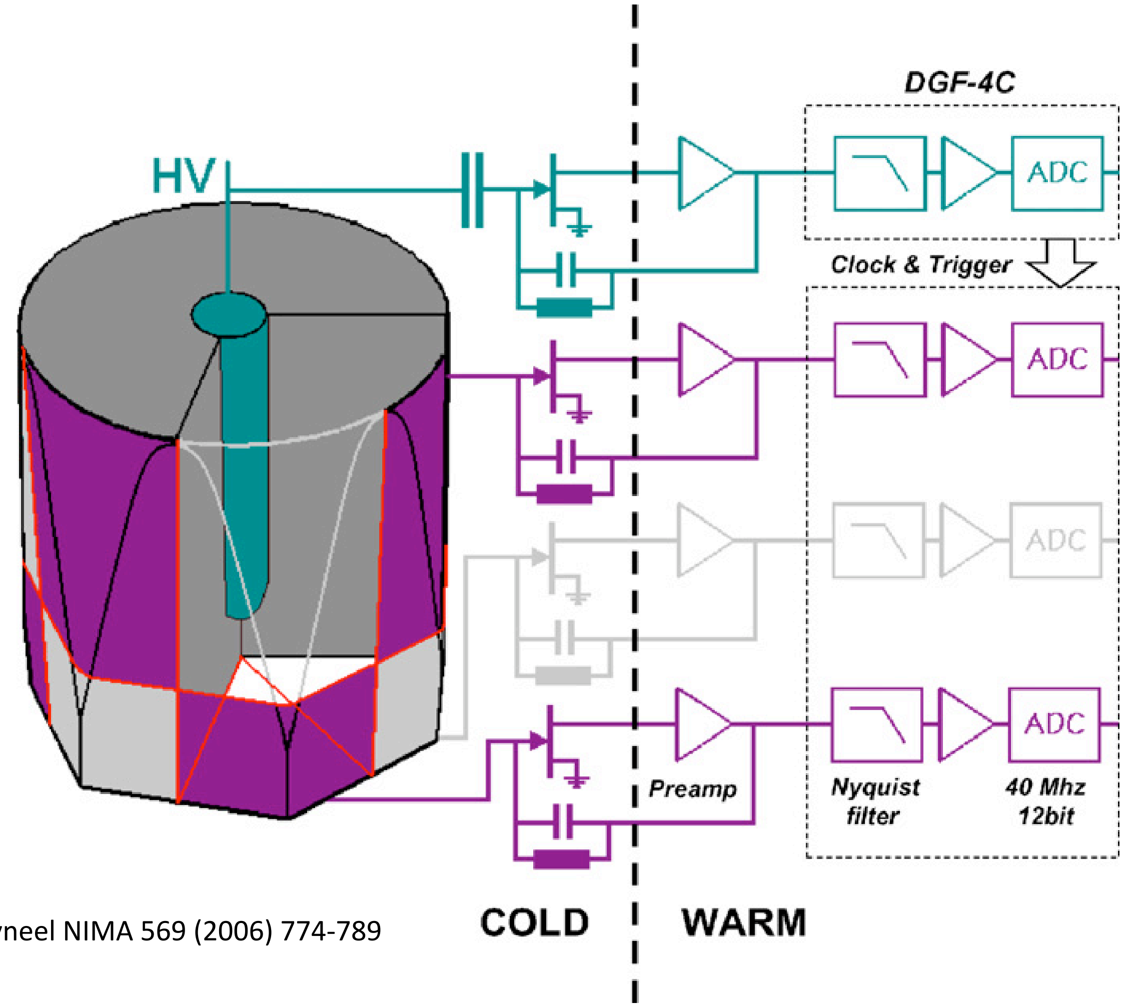
$$Q_{qi}(t)=q[\phi_i(x_e(t))-\phi_i(x_h(t))]$$



Transfer Function (Preamplifier)

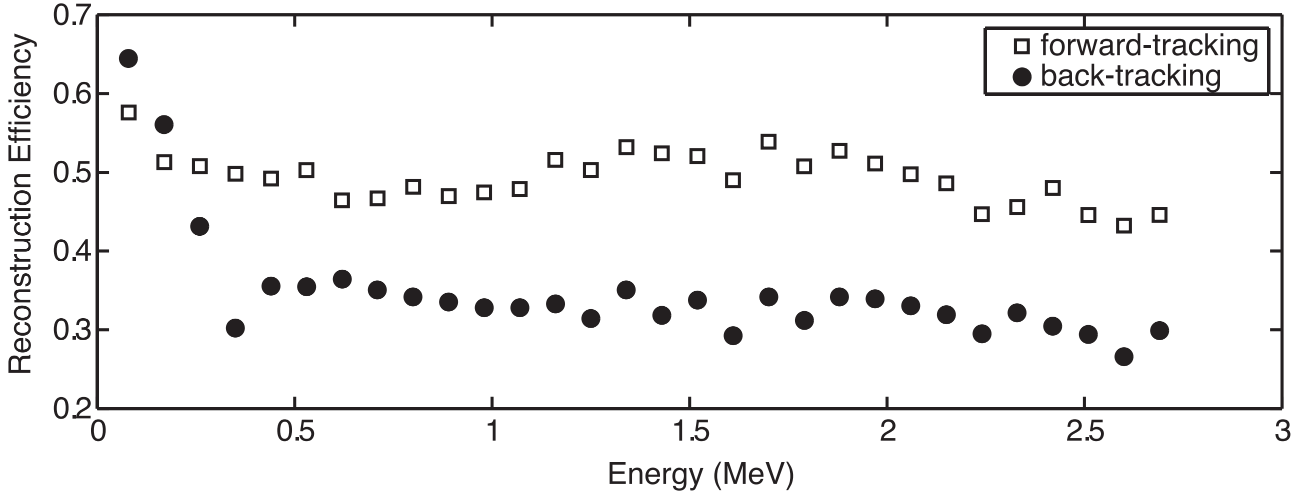
Convolution

Charge Sensitive Preamplifier × Nyquist Filter × Amplifier

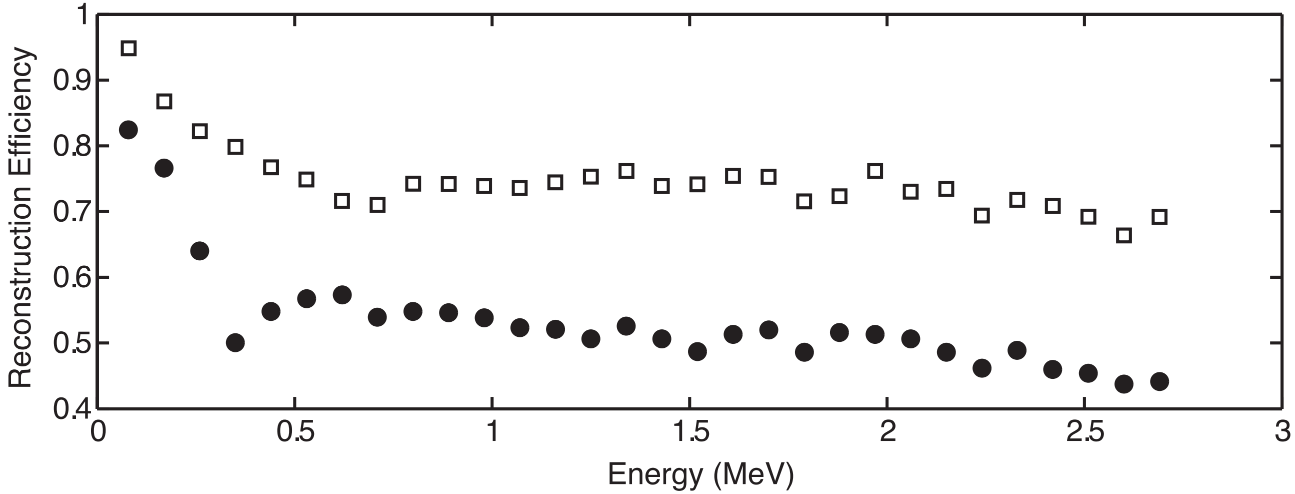


Picture taken from B. Bruyneel NIMA 569 (2006) 774-789

Different Tracking Algorithms



Multiplicity 30



Multiplicity 1

A. Lopez-Martens et al. / Nuclear Instruments and Methods in Physics Research A 533 (2004) 454–466