Characterisation: Plans and discussion

AGATA collaboration Scanning tables

- Liverpool
  - Conventional singles and Coincidence
  - used to commission PSCS
  - validate other tables
- Orsay
  - Singles and Coincidence
- GSI – 511 keV coincidence upgrade plan defined
- IPHC Strasbourg scanning table based on the PSCS technique
- Salamanca Scanning table (SALSA)
  - 511keV coincidence and PSCS

Characterisation

- Impact of electronics on signal shape
  - Digitiser: AGATA v2 vs TNT2 vs Caen v1724 etc
  - Preamplifier and grounding: single vs triple etc
- Validation of PSCS methodology
- ADL validation and questions (good progress)

- Acquire data from one detector with different DAQs
- Acquire data from one detector at two different scanning centres

Pulse Shape Analysis

Factors influencing PSA performance

- Field and Weighting Potential:
  - Overall impurity concentration
  - Longitudinal impurity gradient (Linear? Nonlinear?)
  - Radial impurity gradient?
  - Hole diameter; hole depth; etching cycles; lithium thickness
  - Neutron damage (p-type)
- Charge carrier mobilities as a function of electric field

Factors influencing PSA performance

- Crystal axis orientation (~ 5 degrees from maker)
- Crystal temperature
- Cross-talk (differential and integral)
- Neutron damage (trapping)
- Impulse response of 37 preamps
- Charge cloud size
- Digitizer nonlinearity

Observations: Clustering of points distributed inside detectors

GRETINA Decomposition Basis Observations

Courtesy David Radford

- Signal decomposition algorithm appears to work very well
  - Validated using simulated signals
- Most issues with the decomposition results appear to come from the fidelity of the signal basis
- Poor fidelity results in
  - Too many fitted interactions
  - Incorrect positions and energies
- Already included
  - Integral cross-talk
  - Differential cross-talk
  - Preamplifier rise-time
  - Differential cross-talk signals look like image charges, so they strongly affect position determination

PSA objectives

- The implementation of the existing AGS algorithm will be optimised for performance throughput.
  - Include the addition of the export of PSA position uncertainties from the AGS algorithm to the Gamma-ray tracking algorithm.
  - This will potentially allow performance improvements in the gamma-ray tracking.
- The PSA algorithm will be upgraded* to include the handling of multiple interactions in a segment. The performance of this algorithm will be evaluated and a decision on implementation during phase 2.
- An exploration into the use of other (non AGS) PSA algorithms for future implementation.
  - The focus is on the possibilities available using machine learning and will build on initial work that has started within the collaboration.

*with AGS/Gretina SD

PSA tasks going forward

- Pristine basis generation with irregular basis using SIG-GEN
- Optimised basis with experimental corrections (from ^{60}Co flood data)
- Development of an integrated data set of two interactions/segment using collimated scanning data
- Development of an integrated data set of two interactions/segment using collimated scanning data from AGATA digitisers
- New PSA algorithm development

PSA tasks going forward

- Implementation of multiple interaction algorithm for testing in beam
- Inclusion of positon uncertainties in PSA output
- Including regular/irregular basis and ADL/SIG-GEN
- Multiple interaction algorithm implementation
- Tracking: use of uncertainties propagated from PSA

Perspectives

- Availability of AGATA capsules for characterisation
- Continuity of available personnel to implement PSA algorithms

Yesterdays talks - discussion

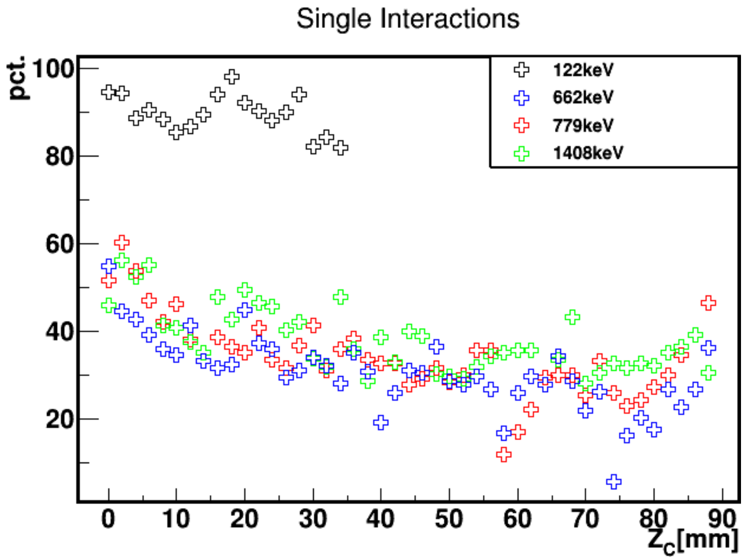
- AGATA detector PSCS simulations & first 2D scan with ^{152}Eu: B. De Canditiis (IPHC Strasbourg)
- Self-calibration of gamma-ray tracking arrays: S. Paschalis (Uni. Of York)
- Error Estimates for Pulse shape analysis: M. Siciliano (CEA Saclay)
- Machine learning approaches for PSA: F. Holloway (Uni. Of Liverpool)

AGATA detector PSCS simulations and first 2D scan with 152Eu

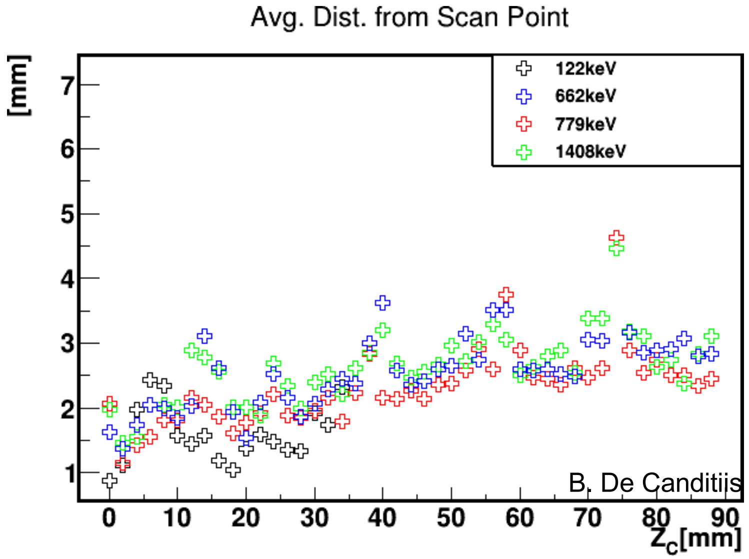
20th AGATA week and 4th PSeGe Workshop
LNL, Legnaro – 16-20 September 2019

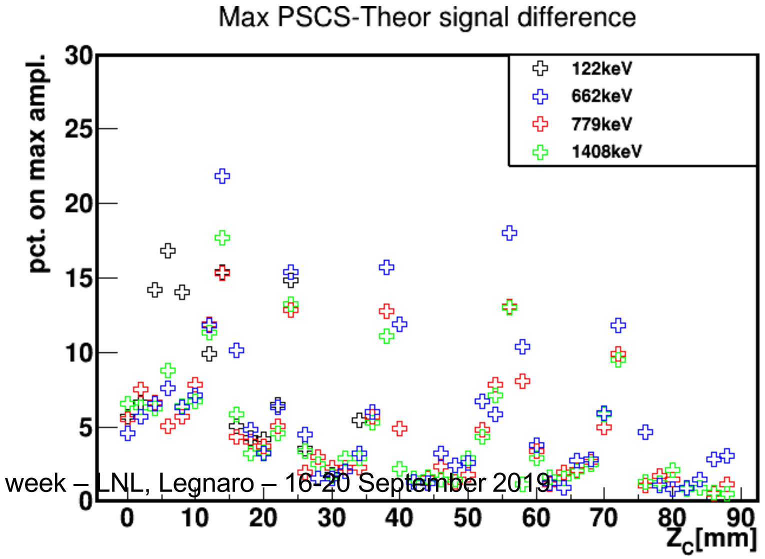
B. De Canditiis, G. Duchêne, F. Didierjean, M. Filliger, M.H. Sigward

Simulations on A-type detector: different energy scans



The parameters are overall independent from the energy of the incident gamma ray...





Next steps...

- Full volume scan with ^{137}Cs source (**Vertical done**)
- Full volume scan (of a sector) with ^{152}Eu source (**Vertical ongoing**)
- Comparison between simulations and real data scans

On the self-calibration capabilities of γ-ray energy tracking arrays

Stefanos Paschalis

20th AGATA Week and 4th PSeGe Workshop

Outlook: implementation

Measurements:

- The cleanest experimental data set would be with one hit segment per crystal (e.g. can set crystal multiplicity trigger >=2 to reduce also the data size)
- Statistics and calibration timescales (currently estimated to be about a weeks time but a more careful estimate is needed)
- Maximum Crystal rate for “safe” pulse shape ?
- Appropriate high-energy source (^{88}Y) or stick with monoenergetic for simplicity (^{137}Cs), or in-beam data if clean enough

Analysis:

- Pulse-shape comparison code
- Basic tracking code to select and order initial data
- Adapt the current self-calibration code to work with experimental data

Conclusions

- A novel self-calibration method for γ-ray energy tracking arrays is proposed and evaluated with Geant4 simulations
- A basis generation with 1 mm RMS fidelity is possible with realistic statistics (based on this simulation)
- The method promises *in situ* calibration of the arrays in realistic timescales
- Next steps and challenges towards implementation and experimental validation

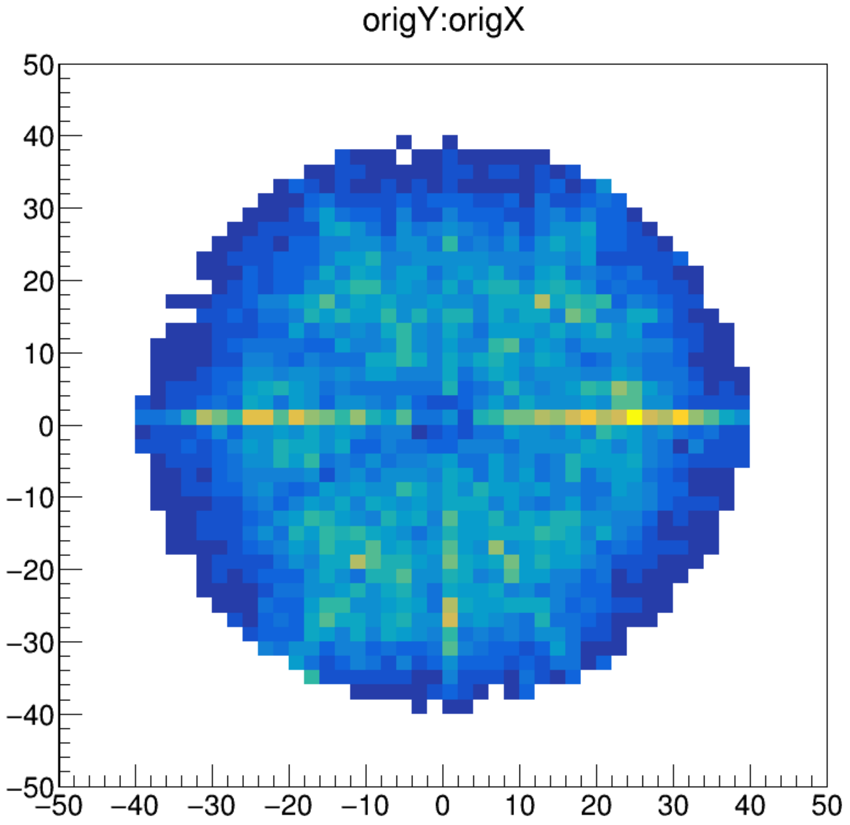
PSA uncertainties estimation via bootstrap technique

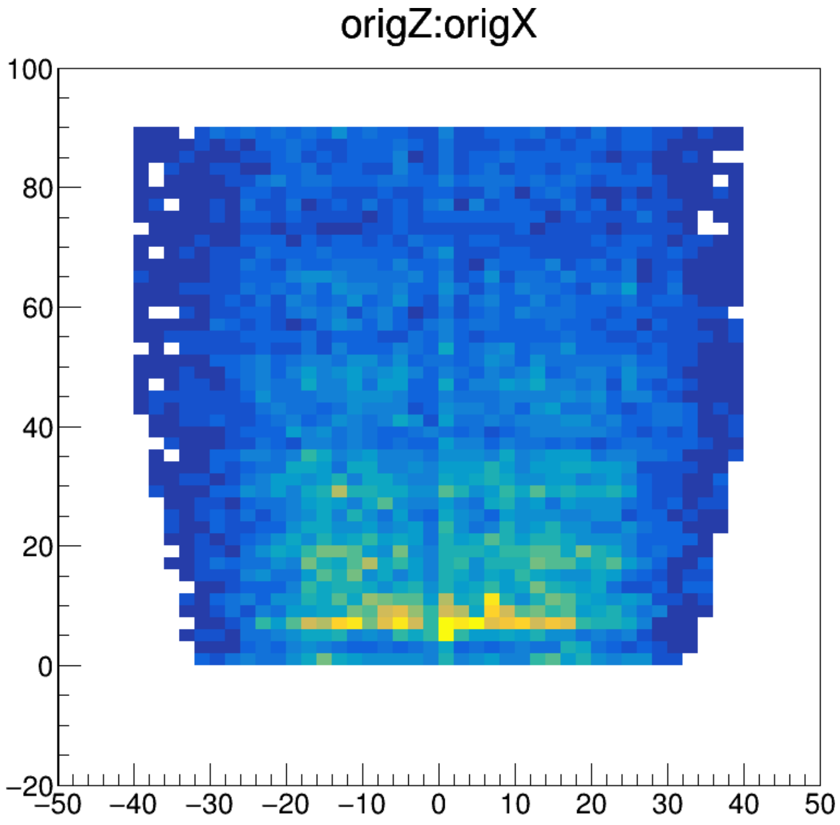
Marco Siciliano

Irfu/CEA, Université de Paris-Saclay, Gif-sur-Yvette, France

20th AGATA week
4th Position Sensitive Germanium Detectors and Application
Legnaro, 16-19 September 2019

PROBLEMS
Accumulation Areas?





- Some detectors present accumulating areas for X=0 and Y=0
  - ➢ Twice the intensities of the closest coordinates

In the ADL bases
different segments have same coordinates

CONCLUSIONS

- Bootstrapping is an established procedure that can help in identifying PSA features
  - ➢ **PSA code is a jungle!**
  - ➢ In order to have enough statistics, the procedure requires large disk space

- Problems in defining the error on the position (?)

- **Preliminary results** highlight the expected energy dependence of PSA-position fluctuations

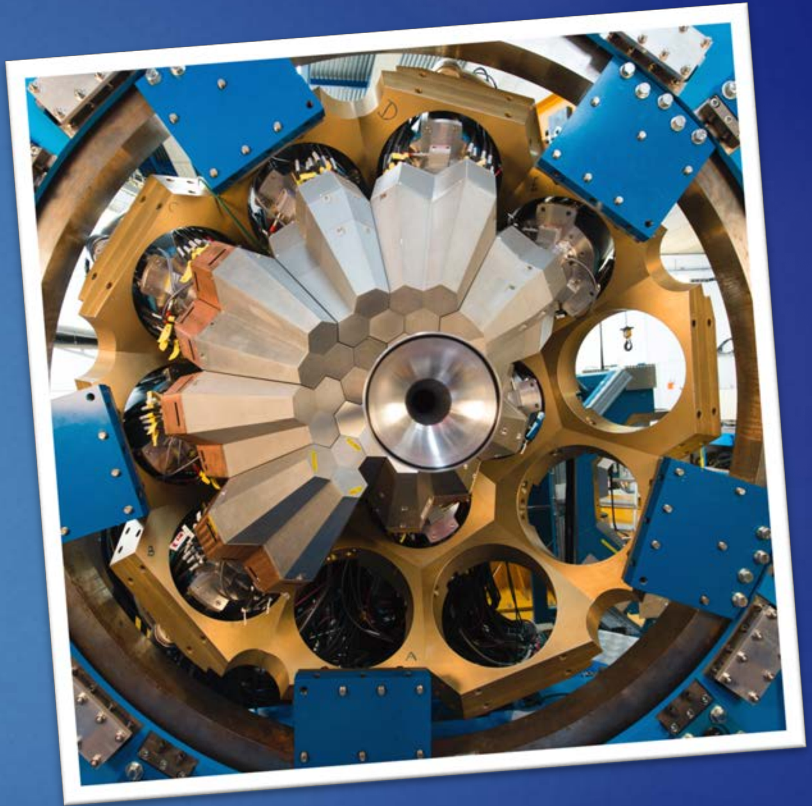
- **Preliminary results** highlight that fluctuations are position dependent
  - ➢ Defining a map of uncertainties

- By knowing uncertainties dependencies, the PSA procedure can be simplified and it would make the online/offline data process much faster

AGATA Week 2019

Machine Learning and Topological Data Analysis for Pulse Shape Analysis

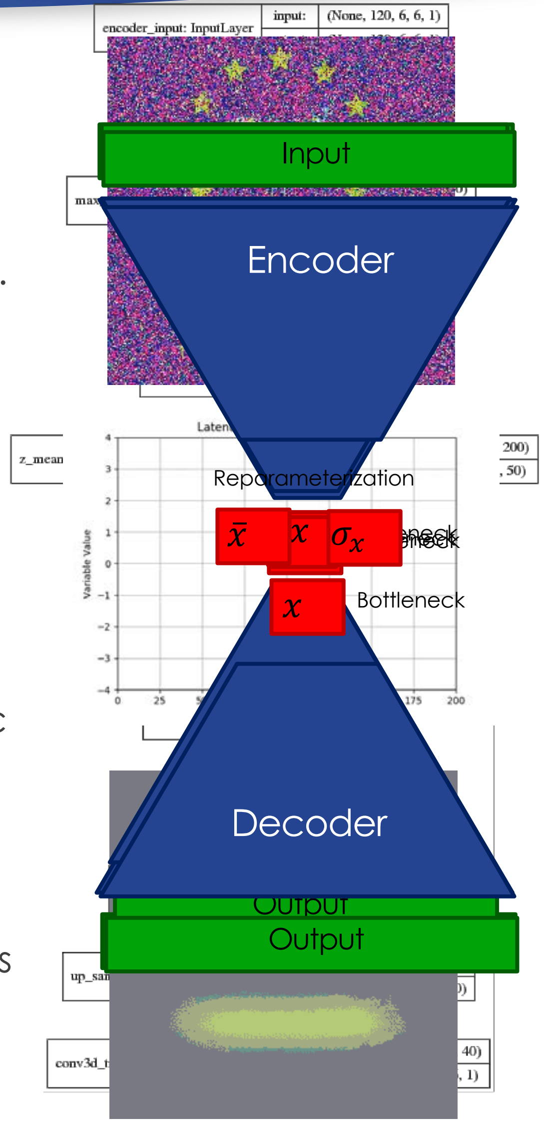
Fraser Holloway



UNIVERSITY OF LIVERPOOL
LIV.DAT
Science & Technology Facilities Council
AGATA ADVANCED GAMMA TRACKING ARRAY

Autoencoders for Tagging & Compression

- Autoencoders combine two separate networks to function:
  - Encoder: converts input to a learned latent space via feature extraction.
  - Decoder: converts latent space into a reconstructed output.
- As a whole the network replicates a denoised input.
  - Signal is intelligently denoised, small transients are unaffected.
- Autoencoders become more useful when split into parts:
  - The Encoder and Decoder compress data far better than traditional methods.
  - The latent representation can be used to express parametric trends.
    - This requires disentangling the latent space (difficult)
    - Can this be used for tagging?
- Compression isn't necessarily bad, oddly the reconstructed pulses could end up being better than the inputs due to denoising.



Conclusion

- GPUs have advanced significantly over the last decade, likely to continue in the future.
  - Definitely should be revisited considering future projections.
- Tree-based search methods are incredibly efficient but difficult to adapt to high fold.
  - Very applicable for Fold-1 regardless.
- ML approaches offer good learned relationships but need adaptions to high fold.
- We have a good standing for more ambitious ML techniques.
  - Discrimination
  - Regression
  - Auto-tagging / Fingerprinting
  - Compression
  - Basis Correction
- I can't take all these methods to completion