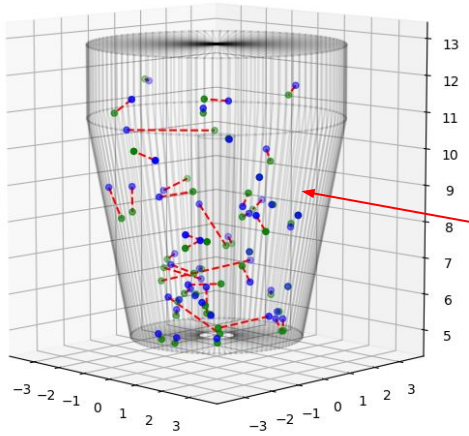
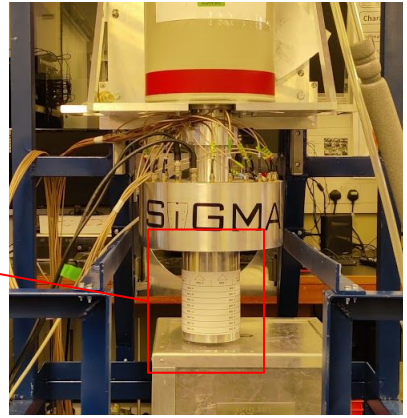
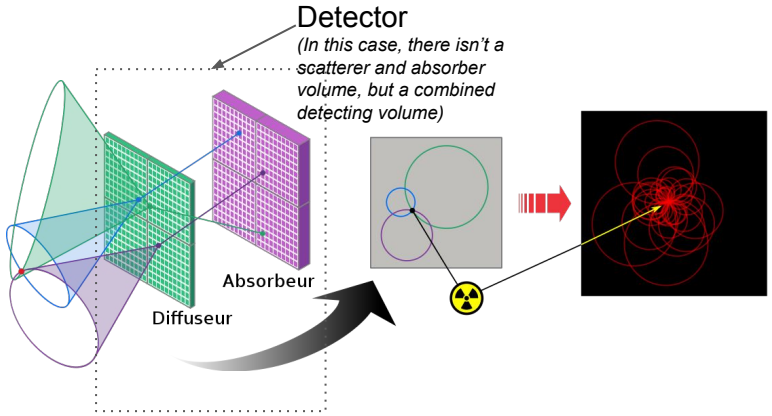
What is SIGMA?

- ‘Next-gen’ HPGe detector.
- Point Contact -> ✔ Energy Resolution
- Unique Geometry -> ✔ Positional Resolution of an interaction
- These lead to promising Gamma ray imaging (GRI) capabilities, which can be used in a huge variety of applications.

I’m here to focus on the GRI capabilities.





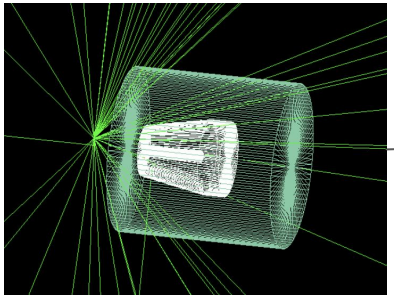


A brief overview of GRI:

- We have a gamma ray interacting twice in the detector.
- We know the energy deposition and position of these two interactions.
- We can work out the incoming angle of the gamma ray.
- The gamma must have originated somewhere where this ‘cone’ intercepts the slice.
- Combine a lot of these cones on the same plot/slice.
- Look at the pretty image from the gamma camera, showing the origins of radiation.

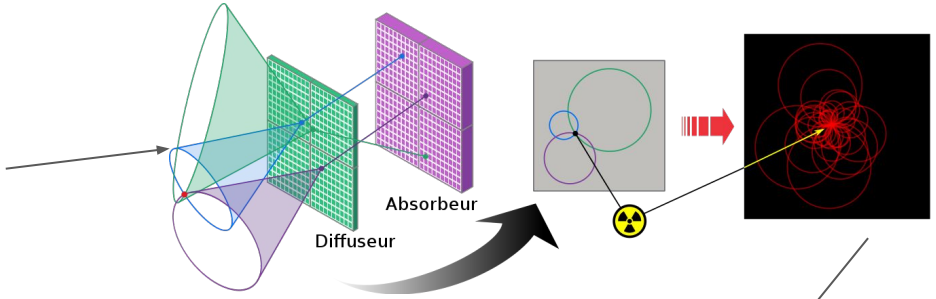
What I hope to do…(1)

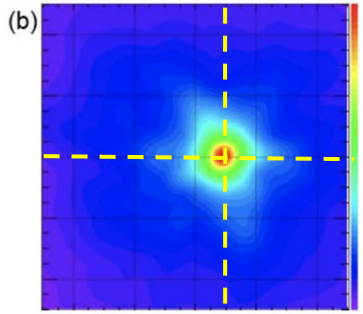
Geant4 (Simulation)

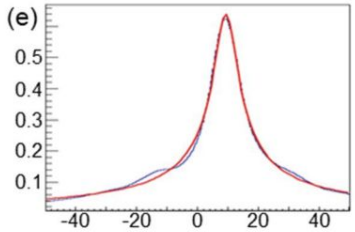


Split a large output into (banded) subsets containing certain type of events

Do the GRI thing to this categorised data







GRI Input GRI Result

Energy Split (E1/E2)	Dist Interaction (mm)	Segments	FHWM
10/90%	10-20	1,15	0.7
10/90%	180-200	9,18	0.5
50/50%	5-10	10,16	0.1
70/30%	5-10	7,10	1.1
…	…	…	…

What I hope to do…(2)

Train a network on this tabular dataset containing early parameters and their corresponding GRI result - in hopes that the network will learn from the parameters what events contribute towards a good image.

New events processed are assigned a score (1=Great, 0=Poor) by the network. (Or maybe a FWHM estimation?)

During image reconstruction of this new data, I will place more emphasis on events which scored well - improving the final image quality.

NB:
I can vary the number of inputs & what are the inputs (anything Geant4 is capable of outputting), but I understand less columns is better for lower number of data points?

GRI Input

GRI Result

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70/30%	5-10	7,10	1.1
…	…	…	…

New events

ML Score

Energy Split	Dist Interaction	Segments	Score
12/88%	38	1,15	0.8
32/68%	62	9,18	0.8
48/52%	104	4,16	0.5
2/98%	4	13,13	0.1
…	…	…	

My queries for this event…

- I don't know what architecture/type of network to use?
  - Can I use a GNN? Do I need another type of NN for this tabular data?
  - I am not knowledgeable here so any and all pointers are helpful!

- Limited data: I perform the image reconstruction manually to get the GRI result. Hence the training data might be limited (~300 rows?).
  - Is this enough data to be able to use NN? Totally unfeasible?
  - Does less data effect which NN to use?

  I have considered automating the GRI step, as it would totally eliminate the limited data issue. I have my separate concerns but if it's necessary then I will look more seriously into it.

Notes from after the summer school.

I did consider keeping the Geant4 data as a node for each interaction with all of the tabular data (energy, position, interaction type, segment etc) as features, but I struggle to comprehend if its then possible to link the GRI output (FWHM for example) to the GNN.

Each GRI output consists of hundreds->hundreds of thousands of cones/pairs of nodes, as it relies on cone overlaps to produce Images. Would I need to group many nodes together in hypergraphs which would have a corresponding GRI output?

If so, I would then be unsure which events to select to form hypergraphs (random selection? Subcategories such as the previous slides?). Additionally I'm not certain how I'd pull out the information from the GNN about which events contributed to good images if i had grouped them in hypergraphs.

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Im hoping to apply NN somewhere in my research, but this is all very new to me, so apologies if this is just wishful thinking! :)