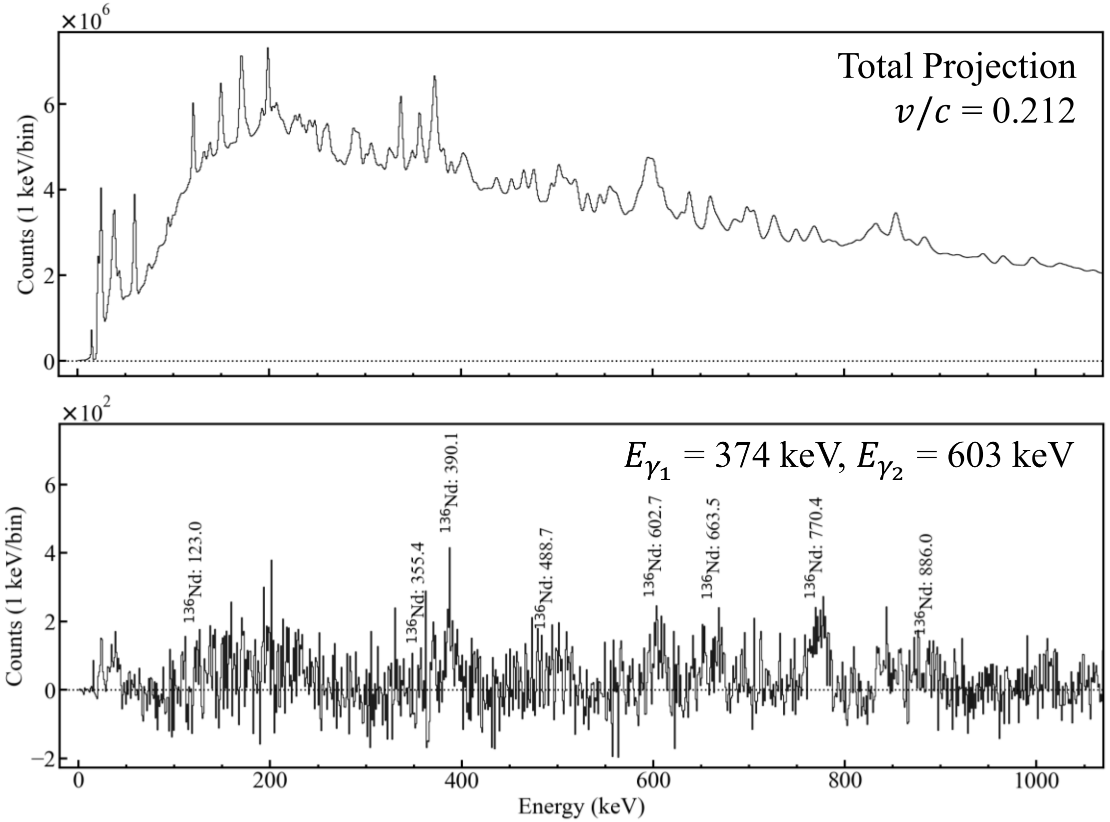
UNIVERSITY OF LIVERPOOL

Benchmarking 1π AGATA in Standalone and Coupled Configurations with ~~EUCLIDES~~: *SAURON* Exploring the Present Limits of High-γ-Multiplicity Experiments

Dr. Conor Sullivan – 19th September 2025

Introduction – The Problems & Solutions



- Spectra from EXP 23.015 (Linking γ rays in ^{136,137}Nd)
- Experiment suffered from **many systematic faults leading** to low "effective" absolute efficiency:
  - Buffer size in the DAQ limited rates to 1 kHz to disk per crystal; **resolved by expanding memory to handle 3-4 kHz per crystal**,
  - GGP backpressure signal triggered prematurely, processing only half of the events; **addressed in principle but needs thorough test**,
  - AGAVA couldn't manage high trigger rates from EUCLIDES, causing long dead-time; **mitigated by distributing the hardware validation across individual GGP's**,
  - Trigger processor struggled with high trigger request volume, causing dead time; **hardware validation mentioned above partially mitigates this but still some dead-time positively correlated with TP data rate.**

A test of AGATA's high-spin capabilities with these fixes is needed!!

What do we want from this experiment?

Do the implemented configuration solutions for the GGP's perform effectively under extremely high event rates?

What are the maximum rates achievable while still obtaining clean spectra and high-fold coincidence data?

What would this experimental setup look like?

How does the observed performance extrapolate to larger configuration?

Will the addition of more crystals exacerbate the problems we see here?

Electronics

Experimental Limits

2π-4π Performance

What is the dead-time at the trigger processor as a function of event rate?

What is the AGAVA/ancillary dead-time at the TP level?

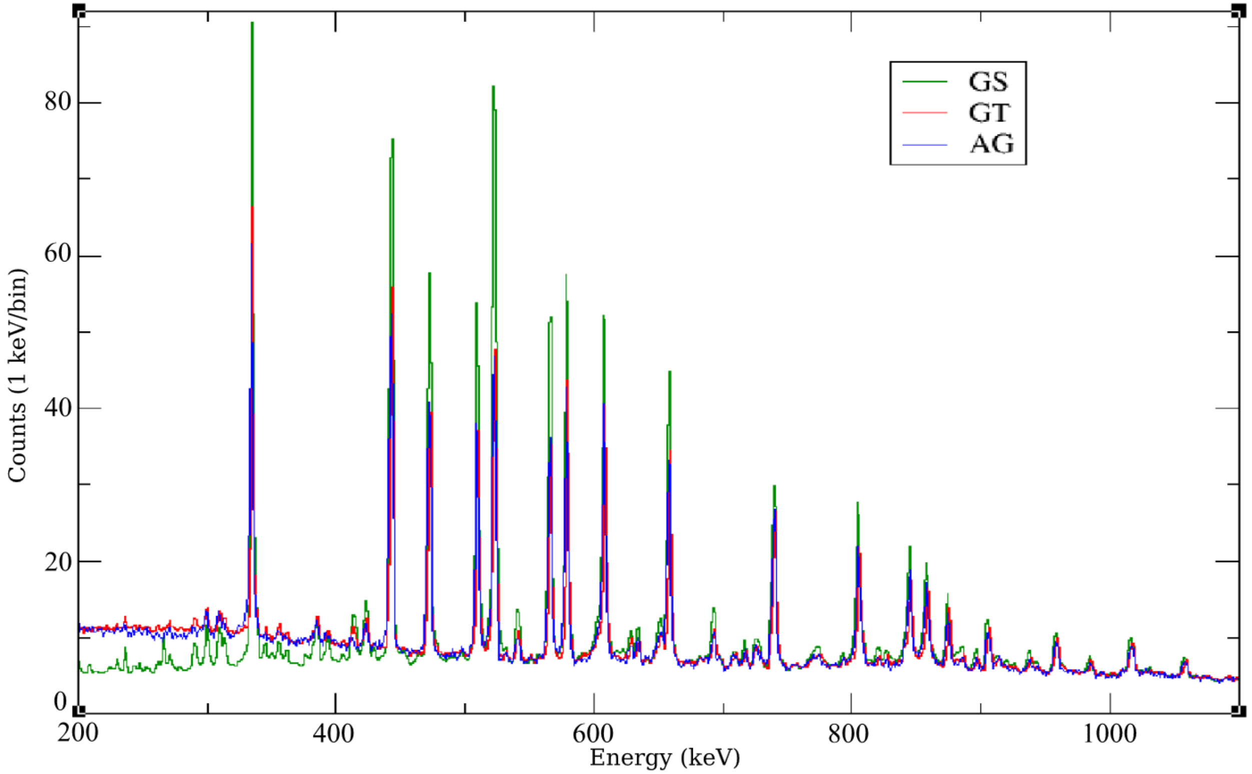
How does very high multiplicity affect the performance of PSA and tracking?

Can hardware-fold gating be selective?

How will the Phase 2 electronics improve on what we observe?

How does the observed hardware fold behave as a function of energy threshold at the core?

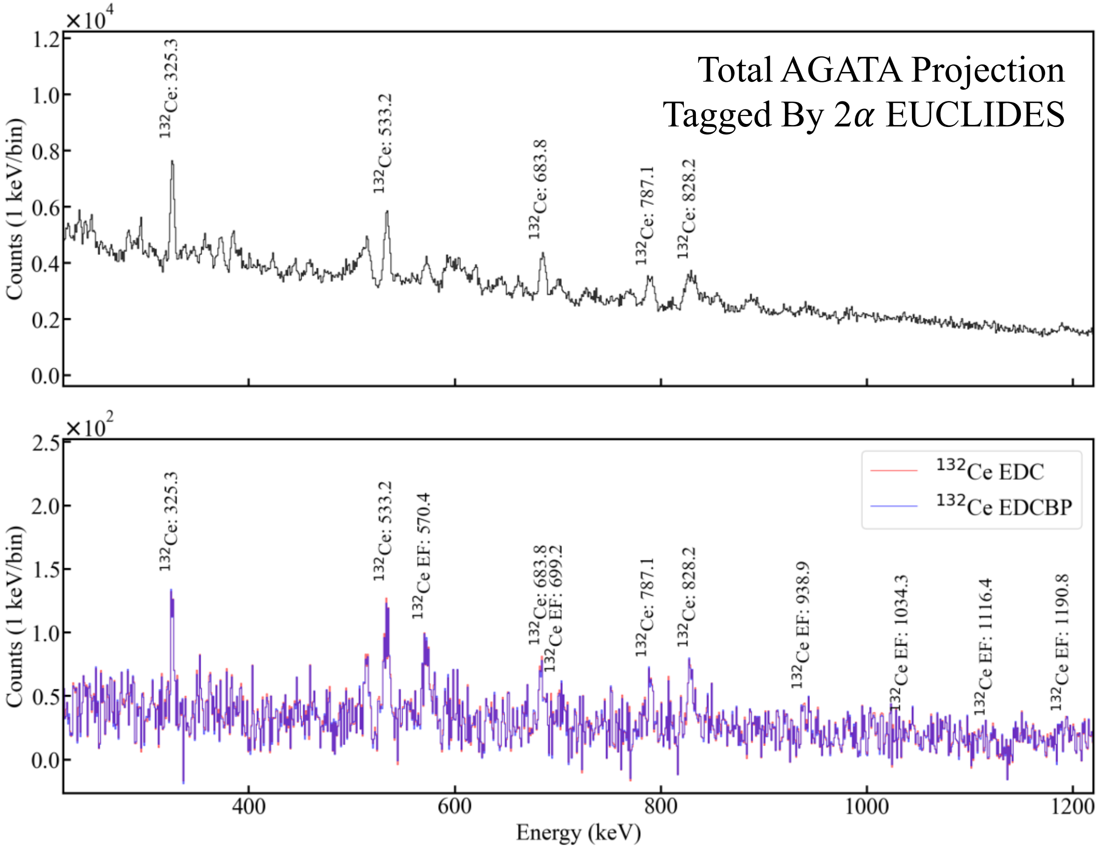
Why ^{158}Er?



- **Long, intense cascades of strongly populated rotational bands**
- **Relatively easy to produce with many beam + target combinations available**
- **Produced with large production cross-section**

- **Studied many times before using EUROGAM, GAMMASPHERE, GRETA and AGATA (at GANIL) spectrometers**
- **Comparison to historical datasets invaluable to improving AGATA beyond previous state-of-the-art:**
  - **Peak-to-background**
  - **Resolution**
  - **As functions of: energy, intensity (event rate), thresholds, tracking parameters.**

Why use ~~EUCLIDES~~ *SAURON*? Why ^{155}Dy?



- **Deadtime at TP expected to be limiting factor with AGATA standalone.** Objective: To minimise burden on TP, use ancillaries; we have seen this is very effective with PRISMA coupled to AGATA

- Spectra from EXP 23.015 (Linking γ rays in ^{136,137}Nd), with gate on **two α-particles** placed at EUCLIDES.

- **As well as enabling precise channel selection, SAURON as a hardware trigger would greatly reduce burden on trigger processor**

- Using the same reaction as before, ^{155}Dy produced in the $\alpha 3n$ channel with a production cross-section of ~20 mb

- ^{155}Dy also showcases long rotational bands, also has a weak SD band…

- Important to test AGATA standalone abilities but is anyone going to choose not to use an ancillary..?

Experimental Methodology – Part 1

- Test both setups (AGATA standalone, followed by AGATA+SAURON).
  - This allows us to truly stress the front-end electronics but also find the practical limit to beam intensities and counting rates with AGATA+SAURON in a realistic experimental scenario.

- Day 1: AGATA Standalone – ^{32}S beam @ 153 MeV, ^{130}Te target.
- Various beam currents to allow for characterisation of spectra as a function of event rate.

I (pnA)	Measurement Time (hours)	^{158}Er G.S Counts	$\gamma_n \geq$ Fold-3
0.5	13.4	8.6×10^5	232,000
1.5	4.5	8.6×10^5	232,000
2.5	2.7	8.6×10^5	232,000
3.5	1.9	8.6×10^5	232,000
4.5	1.5	8.6×10^5	232,000

Table 1: Predicted ^{158}Er counts observed at AGATA for a ^{130}Te(^{32}S, $4n$) reaction at $E_{\text{beam}} = 153$ MeV as a function of various beam intensities. Initial yields are estimated assuming a 200 mb production cross-section and a target thickness of 1.0 mg/cm^2. ^{158}Er ground-state counts have been calculated assuming an average detection efficiency for a single γ-ray at AGATA of 6%. The number of these counts within an event that consists of at least three tracked, coincident γ rays are then the G.S counts multiplied by 0.27, calculated according to Equation 1. The length of measurement time at each beam intensity has been scaled so approximately equal numbers of counting statistics are obtained for each intensity.

Experimental Methodology – Part 2

- Days 2 & 3: AGATA [illegible]DES – ^{32}S beam @ 140 MeV, ^{130}Te target.
- Hardware trigger [illegible] dE layer (E > 4 MeV), allowing only [illegible] Dramatic reduction in TP rates (~400 Hz @ [illegible]
- Various beam [illegible]ation of spec[illegible]

I (pnA)	M[illegible]	[illegible]	[illegible] ≥ Fold-3
0.5	[illegible]	[illegible]	20,520
1.5	[illegible]	[illegible]	20,520
2.5	[illegible]	[illegible]	20,520
3.5	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table 2: P[illegible] at AGATA for a ^{130}Te[illegible] 140 MeV. Initial yields a[illegible] 20 mb production cross-section a[illegible] mg/cm^2. ^{155}Dy ground-s[illegible]een calculated assuming an average detectio[illegible]ngle γ-ray at AGATA of 6% a[illegible]DES α-efficiency of 40%. The number of these counts wi[illegible] that consists of at least three t[illegible], coincident γ rays are then the G.S counts multiplied by 0.27, ca[illegible]ed according to Equation 1.

Experimental Methodology – Part 2

- Days 2 & 3: AGATA + SAURON – ^{32}S beam @ 140 MeV, ^{130}Te target.
- Hardware trigger set on SAURON Alpha Particles allowing only $x\alpha xn$ channels. Dramatic reduction in TP rates (~200 Hz @ 4.5 pnA)
- Run at maximum beam current permissible to make up for loss of angular coverage compared to EUCLIDES
    - constrained by maximum allowable rate at SAURON

Conclusion

- The last high-spin experiment performed using AGATA + EUCLIDES suffered from many problems, which have now been largely resolved.
- A thorough test of these fixes is required to ensure the operational readiness of AGATA at the highest threshold of its operational capability.
- To this end a two-part experiment is proposed to be performed over 3 days:
  - Day 1: Using ^{32}S beam @ 153 MeV on ^{130}Te target to test AGATA standalone through the measurement of in-beam gamma radiation from ^{158}Er
  - Days 2 and 3: Same beam, beam energy and target to test AGATA + SAURON through the measurement of in-beam gamma radiation from ^{155}Dy
- This experiment would be both timely and convenient owing to the downtime of the PIAVE-ALPI complex and before the implementation of AGATA 2π, AGATA at Zero Degrees and the version 2 electronics.

Thanks for listening!

C.M. Sullivan[1], G. de Angelis[2], A. Astier[3], H. Ayatollahzadeh[4], M. Balogh[2], M.A. Bentley[5], G. Benzoni[6], A.J. Boston[1], S. Bottoni[6], A.D. Briscoe[1], D. Brugnara[2], F. Camera[6], B. Cederwall[7], J.A. Chadderton[1], E. Clement[8], F.C.L. Crespi[6], D. Curien[9], F. Didierjean[9], G. Duchene[9], L.P. Gaffney[1], A. Goasduff[2], A. Gottardo[2], H. Hilton[1], B. Hogg[4], F. Holloway[1], P. Jodidar[3], D.T. Joss[1], J. Keatings[4], A. Korichi[3], M. Labiche[10], T. Lauritsen[11], S. Leoni[2], J. Ljungvall[9], A. Lopez-Martens[3], A. McCarter[1], D. O'Donnell[4], R.D. Page[1], E.S. Paul[1], J. Pellumaj[2], R.M. Perez-Vidal[12], C.M. Petrache[3], N. Redon[13], P. Reiter[14], M. A. Riley[15], M. Rocchini[16], J. Simpson[10], J.F. Smith[5], J.J. Valiente-Dobòn[2], T.D. Wonderley[1], L. Zago[2], I. Zanon[7], and M. Zielinska[17]