Optimising the characterization of an AGATA capsule in the SALSA setup by simulation

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XV CPAN DAYS
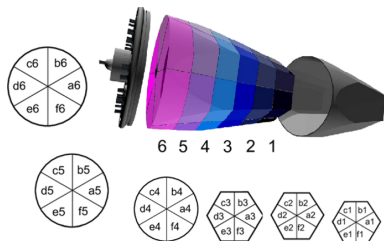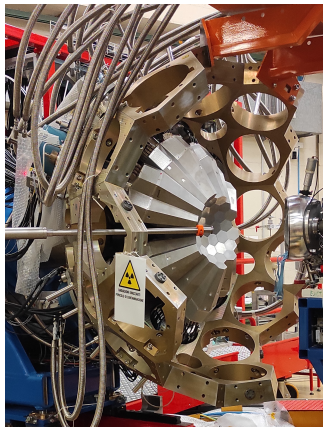2 - 6 October 2023

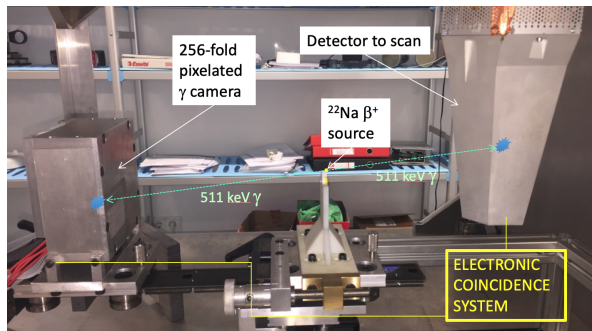VNiVERSiDAD D SALAMANCA

Laboratorio Datación
Radiaciones Ionizantes
LDRI

Contents

1. Introduction: AGATA capsule and spectrometer

2. 3D Scanning: SALSA setup

3. Current work

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- 4π γ spectrometer.
- Position-sensitive detectors.
- Electric segmentation technology.
- Tracking to reconstruct the position.
- Efficiency and resolution improvements.

3D Scanning
SALSA setup

256-fold pixelated γ camera

Detector to scan

^{22}Na $β^+$ source

511 keV γ

511 keV γ

ELECTRONIC COINCIDENCE SYSTEM

Main objective of characterization

Building an experimental database which relates the position in the crystal with the pulse shape.

3D Scanning
SALSA setup

1. Position in γ-camera: 2D-Adjustment.
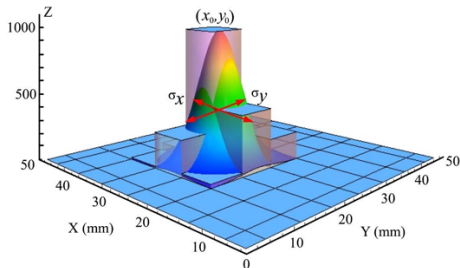
$$f(x,y) = Ae^{-\frac{1}{2}\left(\frac{(x-x_0)^2}{\sigma_x^2} + \frac{(y-y_0)^2}{\sigma_y^2}\right)}$$

	σₓ (mm)	σᵧ (mm)
ZK0021	3,321	3,305
ZK0079	3,334	3,313
ZK0084	3,336	3,314
ZK0065	3,315	3,305

2. Position in AGATA crystal: Tracking algorithms + time matching.
3. From two positions: intersection of trajectories.
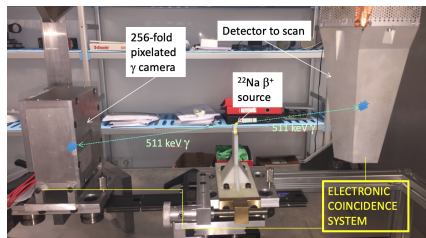4. Same pulse shape, same position: PSA.

3D Scanning
SALSA setup

1. Position in γ-camera: 2D-Adjustment.
2. **Position in AGATA crystal: Tracking algorithms + time matching.**

The interaction in the γ-camera and the position of the source provide the one in AGATA.

Time matching is performed to associate the event in AGATA crystal with its respective trajectory.

3. From two positions: intersection of trajectories.
4. Same pulse shape, same position: PSA.

3D Scanning
SALSA setup

1. Position in γ-camera: 2D-Adjustment.
2. Position in AGATA crystal: Tracking algorithms + time matching.
3. From two positions: intersection of trajectories.

The intersection of the trajectories from two different spatial configurations gives the interaction point in the AGATA crystal, the sought position.

4. Same pulse shape, same position: PSA.

3D Scanning
SALSA setup

1. Position in γ-camera: 2D-Adjustment.
2. Position in AGATA crystal: Tracking algorithms + time matching.
3. From two positions: intersection of trajectories.
4. Same pulse shape, same position: PSA.

PSA techniques based on the idea that a specific interaction position in AGATA produces a unique set of pulses in the segments. Induced signals are generated in adjoining segments.

Current work
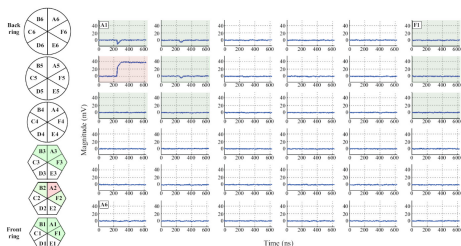
1. System set-up: γ-camera, electronics.
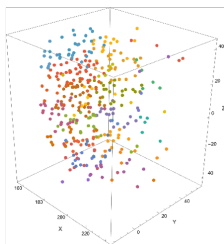2. Tracking algorithms and analysis software.
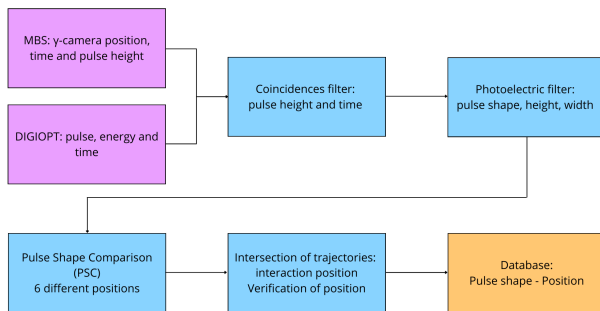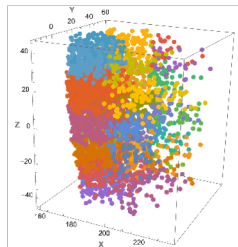

3. Simulation to optimise the scanning.

Optimization of scanning by simulation
Positions and angular distribution

N = 300000

N = 3000000

Rotation is required.

N = 6000000

ÁNGULO 0º

SLICE	SEGMENT					
	1	2	3	4	5	6
1	0,419	1,425	2,781	2,306	1,244	0,405
2	0,447	1,621	3,549	3,410	1,565	0,419
3	0,713	2,292	5,632	5,590	2,166	0,601
4	0,783	3,354	7,909	6,917	2,739	0,852
5	0,769	3,200	8,217	7,029	3,088	0,922
6	0,461	2,404	6,610	5,310	2,012	0,838

ÁNGULO 90º

SLICE	SEGMENT					
	1	2	3	4	5	6
1	1,999	2,504	1,823	0,527	0,395	0,659
2	2,746	3,735	2,592	0,439	0,483	0,857
3	4,855	5,624	3,888	0,813	0,769	1,186
4	6,525	8,194	5,075	1,186	0,791	1,736
5	6,656	8,238	5,097	1,472	0,659	1,428
6	4,438	6,173	3,625	0,813	0,483	1,516

ÁNGULO 120º

SLICE	SEGMENT					
	1	2	3	4	5	6
1	2,804	2,728	1,327	0,501	0,401	0,976
2	3,104	3,755	1,352	0,375	0,626	1,477
3	5,607	5,307	2,228	0,501	0,676	2,103
4	8,085	7,384	2,503	0,876	1,051	2,929
5	7,935	7,785	2,904	0,876	0,901	3,104
6	5,507	6,834	1,852	0,501	0,701	2,428

ÁNGULO 210º

SLICE	SEGMENT					
	1	2	3	4	5	6
1	2,444	0,783	0,439	0,376	0,595	2,695
2	3,729	1,285	0,752	0,439	0,439	3,855
3	5,954	2,100	0,971	0,564	0,627	7,082
4	8,273	2,946	1,128	0,721	0,752	9,307
5	8,775	3,008	1,254	0,564	0,877	9,809
6	7,051	1,880	0,940	0,439	0,627	6,518

Optimization of scanning by simulation

Casuistry: number of Comptons and photoelectric processes

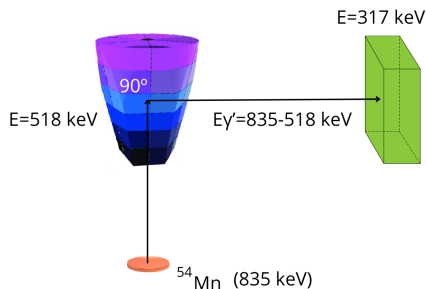| Case	N. Compton	N. Ph. Absorp.	Incidence * $(N/N_T *1000)$	Incidence ** $(N/N_T *1000)$
0	0	1	0,341	0,266
1	1	0	1,849	0
2	1	1	0,746	0,377
3	2	0	0,890	0
4	2	1	0,943	0,324
5	3	0	0,370	0
6	3	1	0,762	0,179
7	4	0	0,137	0
8	4	1	0,459	0,082
9	5	0	0,047	0
10	5	1	0,204	0,023
11	6	0	0,011	0
12	6	1	0,082	0,007
13	7	0	0,003	0
14	7	1	0,022	0
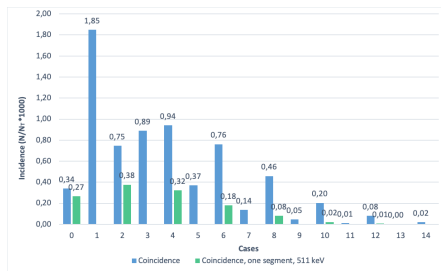
N = 6000000 events.

* Coincidence.

** Coincidence, 511 keV, one segment.
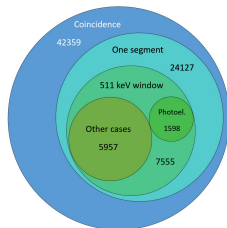
Future perspective

- Measuring stage, after cooling and vacuuming of the capsule.
- Development of algorithms for data analysis.
- Experiment to test the shape of the pulses in the segments when 511 keV are deposited on the AGATA detector (equivalent to photoelectric effect).

E=317 keV

90°

E=518 keV   Eγ'=835-518 keV

^{54}Mn (835 keV)

Thank you very much for your attention