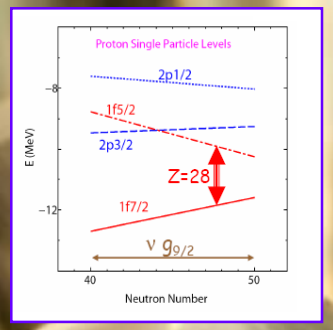
AGATA Status

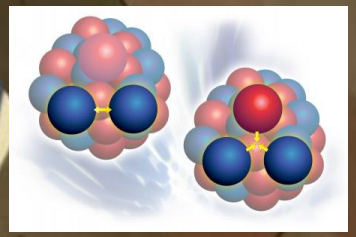
Emmanuel Clément (GANIL)
on behalf of the AMB, LNL and Padova local team

2024 GCM - MoHo

Nuclear gamma ray spectroscopy

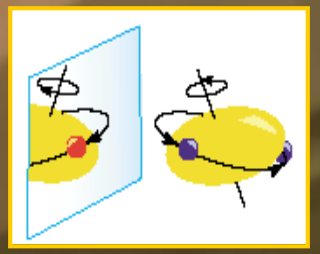
Nuclear structure



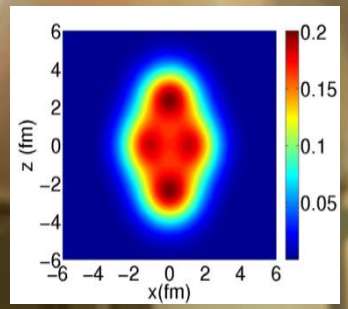


3-body force

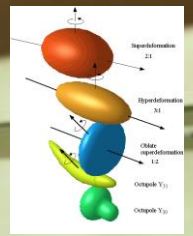
Mirror symmetry



Clusters

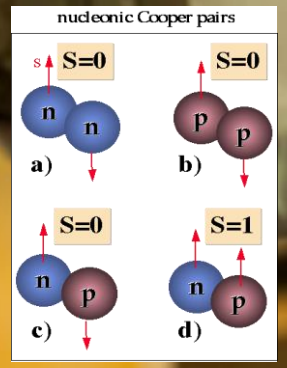


Nuclear deformation

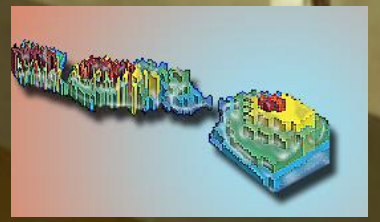


Nuclear γ-ray spectroscopy from 10 keV to 10 MeV at 1 ‰ resolution, from low to high multiplicity event is a unique tool to study many aspects of the nuclear matter

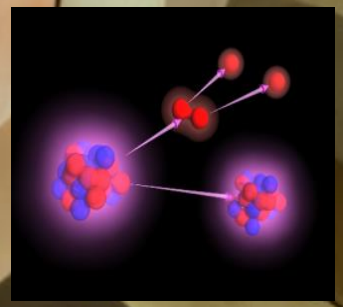
Pairing



Super Heavies

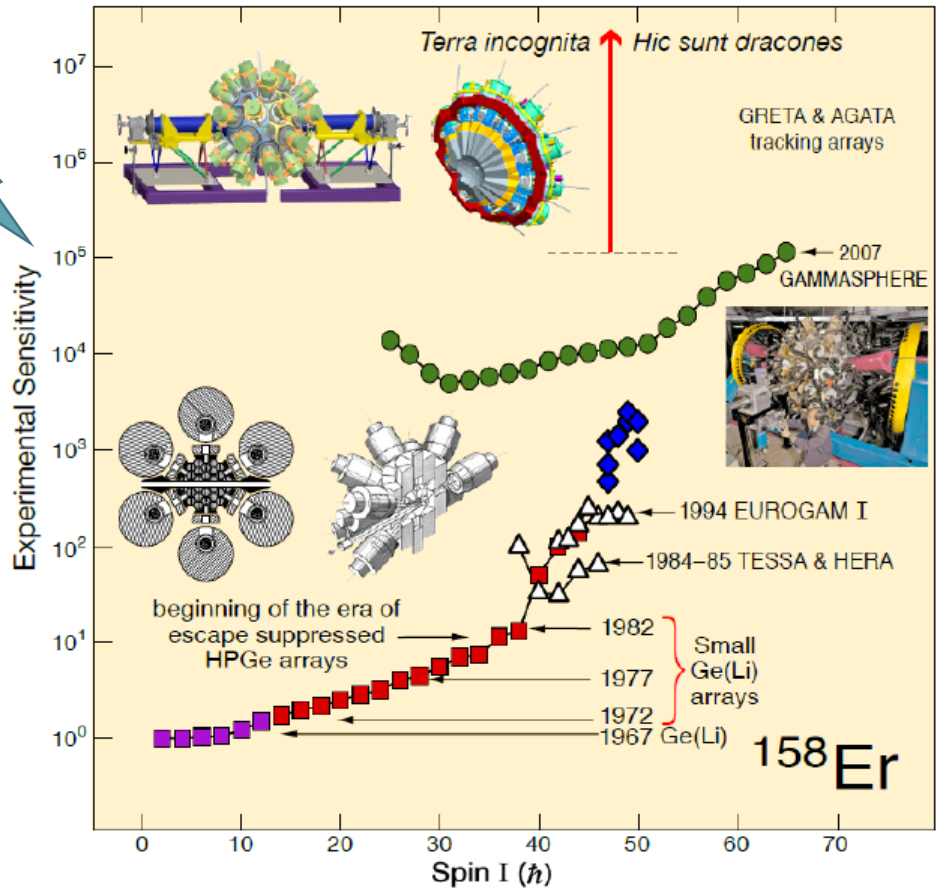


Astrophysics



Coupling to the continuum

Fundamental concepts of AGATA

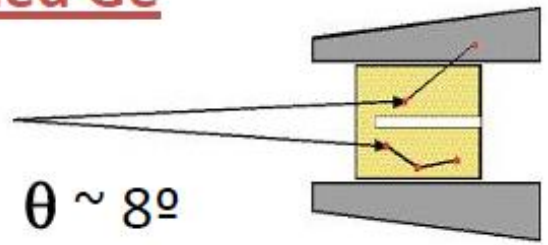


Compton Shielded Ge

ε_{ph} ~ 10%

N_{det} ~ 100

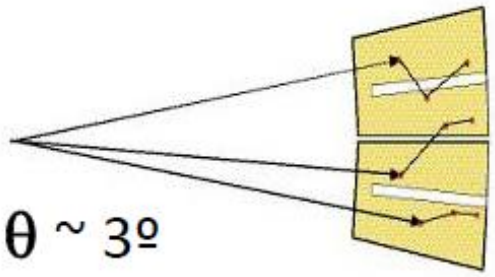
Ω ~40%



Ge Sphere

ε_{ph} ~ 50%

N_{det} ~ 1000

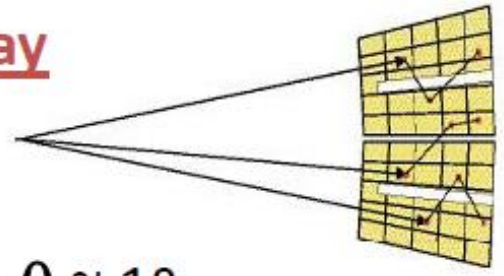


Ge Tracking Array

ε_{ph} ~ 50%

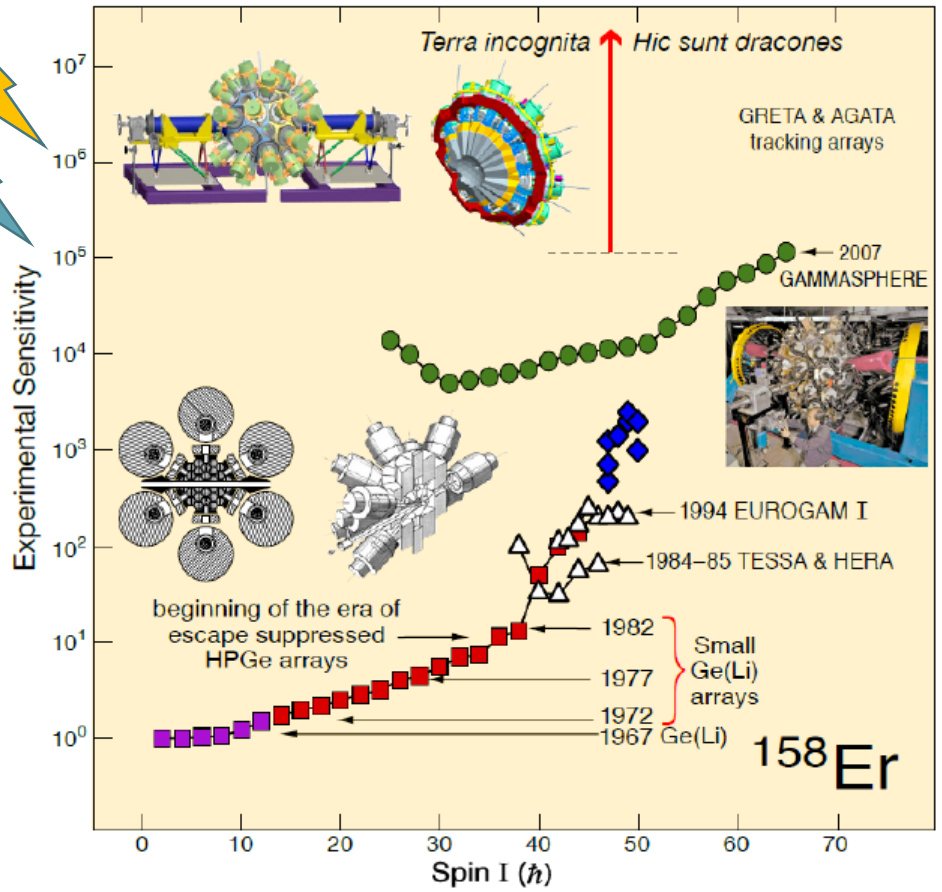
N_{det} ~ 100

Ω ~80%



Higher granularity and efficiency

Fundamental concepts of AGATA

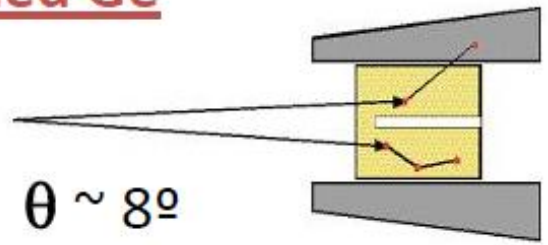


Compton Shielded Ge

ε_{ph} ~ 10%

N_{det} ~ 100

Ω ~40%

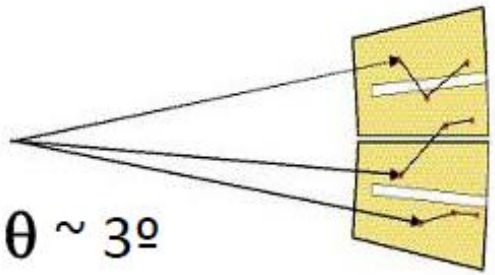


θ ~ 8º

Ge Sphere

ε_{ph} ~ 50%

N_{det} ~ 1000



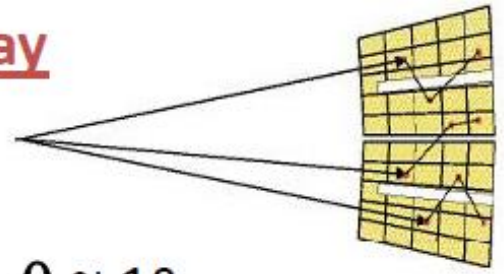
θ ~ 3º

Ge Tracking Array

ε_{ph} ~ 50%

N_{det} ~ 100

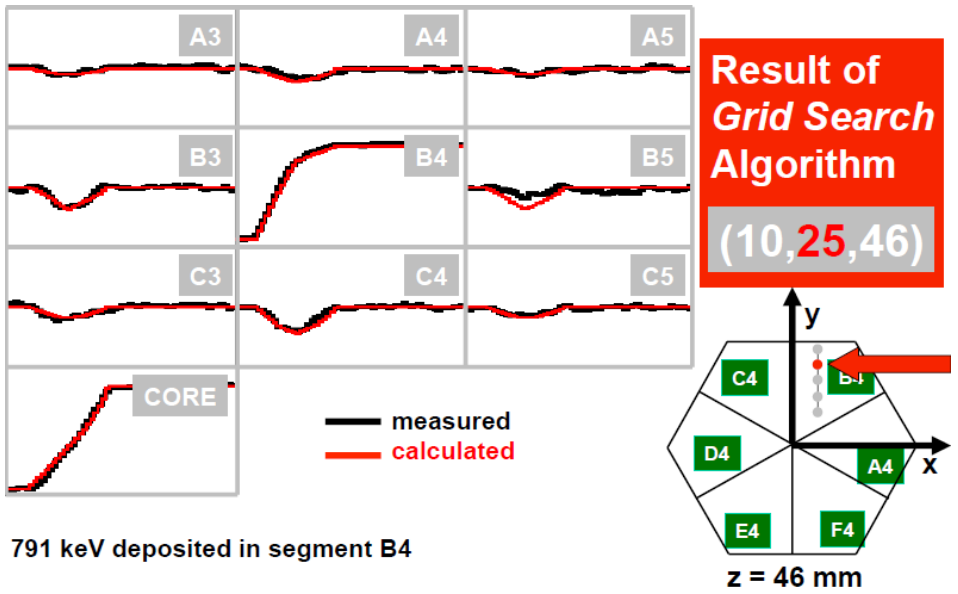
Ω ~80%



θ ~ 1º

Higher granularity and efficiency

Fundamental concepts of AGATA



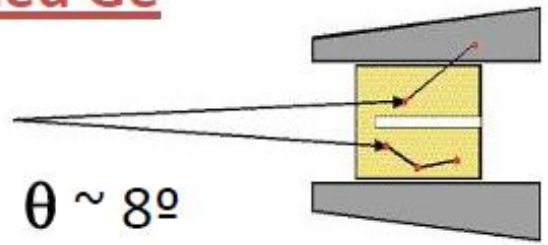
Higher granularity and efficiency

Compton Shielded Ge

ε_{ph} ~ 10%

N_{det} ~ 100

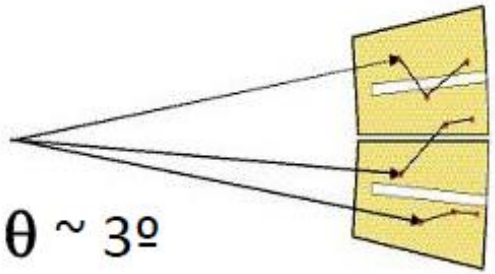
Ω ~40%



Ge Sphere

ε_{ph} ~ 50%

N_{det} ~ 1000

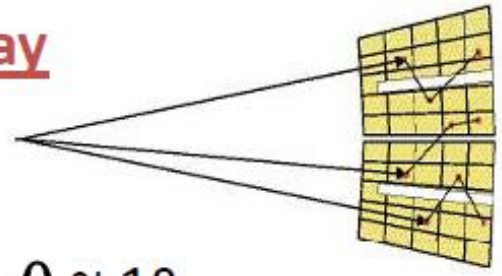


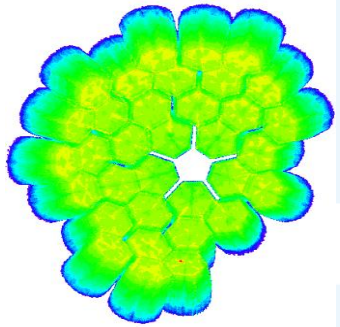
Ge Tracking Array

ε_{ph} ~ 50%

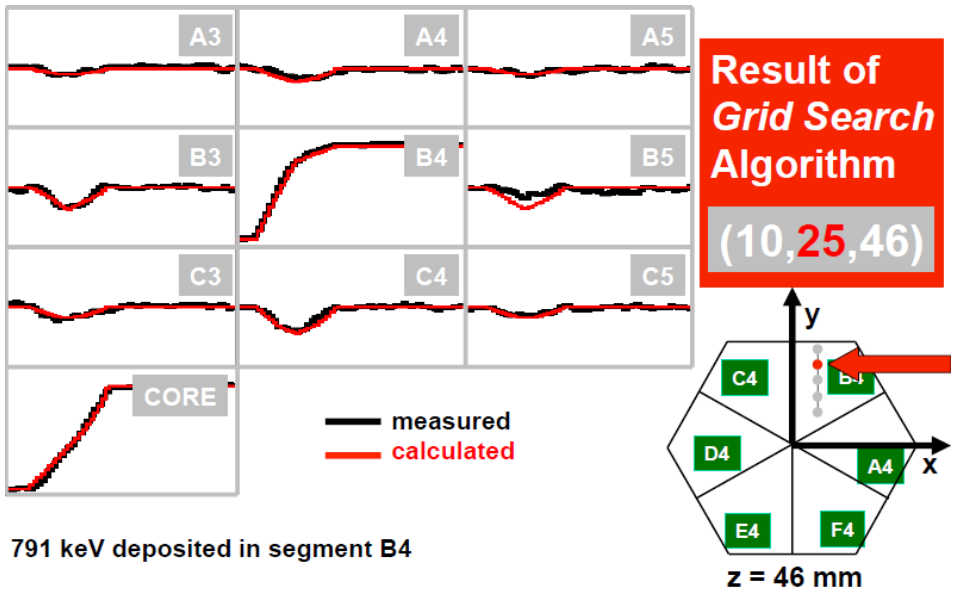
N_{det} ~ 100

Ω ~80%



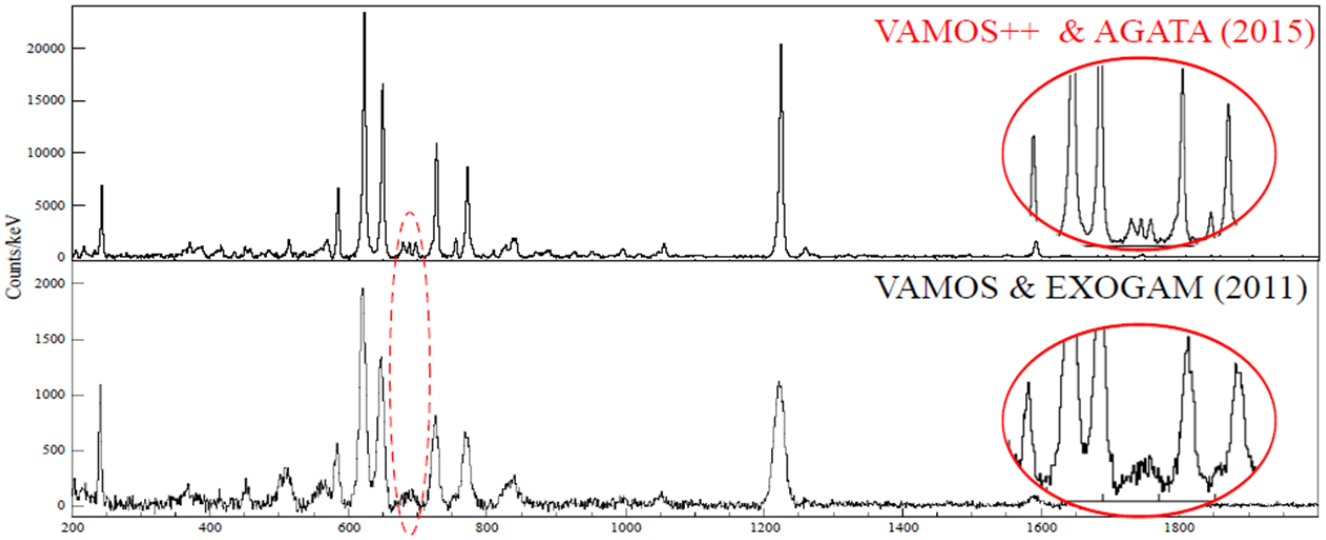


Fundamental concepts of AGATA

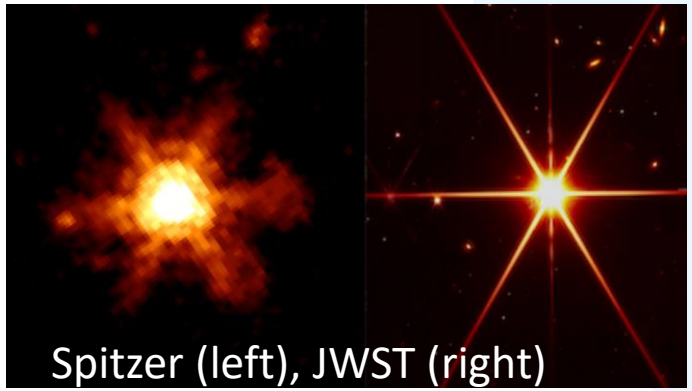


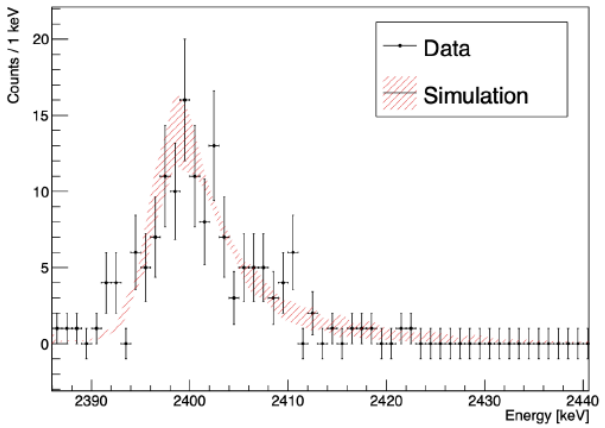
791 keV deposited in segment B4

J. Dudouet et al (IP2I)



Higher granularity and efficiency





I. Zanon, et al.
Phys. Rev. Lett. 131, 262501 (2023)

The AGATA project : THE ultimate spectrometer

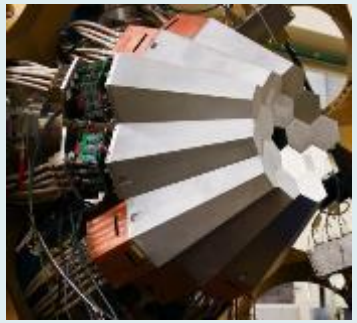
1st AGATA Steering Committee and Management Board (2002)

MoU Phase 1 + Addendum

March 2022

MoU Phase 2

2010-2012
Legnaro, Italy
Intense stable beams
15 detectors

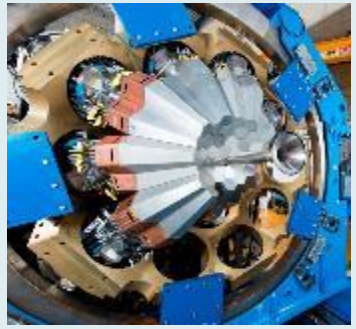


AGATA Demonstrator + PRISMA at LNL

2012-2014
GSI, Germany
Fast fragmentation beams
25 detectors

AGATA at GSI

2014- 2021
GANIL, France
ISOL and stable beams
approaching 1π (45)

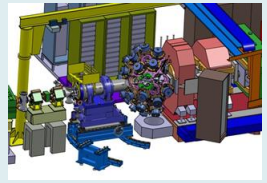


AGATA at GANIL

2021- 2028
LNL, Italy
Stable beams
EXOTIC beams

LNL 2.0

2028- 2030(+1 ?)
GANIL, France
ISOL beams from
SPIRAL1



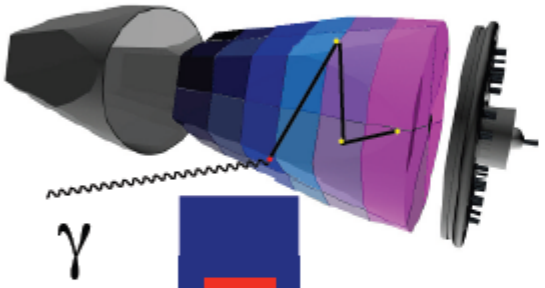
GANIL 2.0

2031 –
LNL, SPES, Italy
FAIR, Germany
ISOLDE, CERN

AGATA Data Process

1

Highly segmented HPGe detectors



2

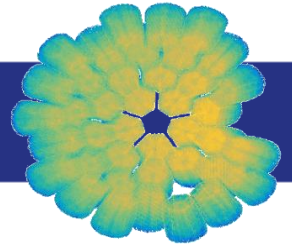
Digital electronics to record and process segment signals

3

Identified interaction points

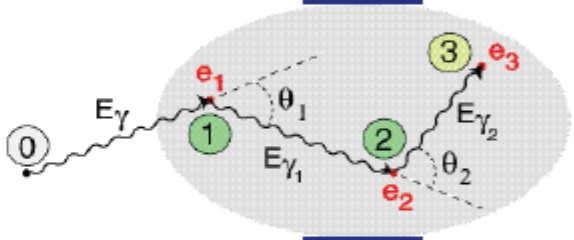
$(x,y,z,E)_i$

Pulse Shape Analysis to decompose recorded waves



4

Reconstruction of scattering sequence from Compton vertices



$$E_{\gamma'} = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_0 c^2}(1 - \cos\theta)}$$

Reconstructed gamma-rays

5

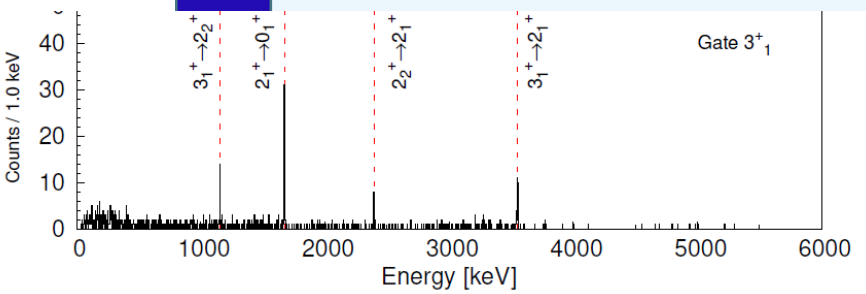
Complementary Detectors

β, θ, ϕ, E^*

6

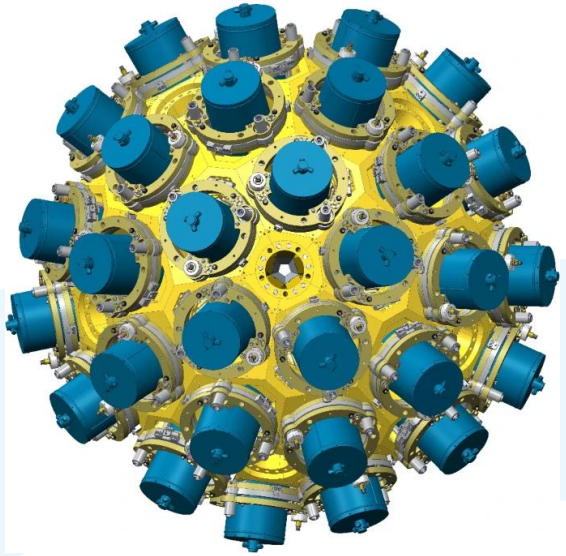
Doppler Correction

I. Zanon, E. Clément, et al.
Phys. Rev. Lett. 131, 262501 (2023)



The AGATA project : THE ultimate spectrometer

www.agata.org



Topical Issue EPJA : https://epja.epj.org/component/toc/?task=topic&id=1878

The European Physical Journal A
AGATA: Advancements in Science and Technology

Editors : Nicolas Alamanos, Maria Jose Garcia Borge, Angela Bracco, Emmanuel Clement, Andres Gadea, Wolfram Korten, Silvia Leoni and John Simpson

Topical Issue on AGATA: advancements in science and technology

1) Preface
Editors: E. Clement, A. Gadea, S. Leoni, W. Korten

2) Science advancements with AGATA

2.1 Nuclear structure advancements with multi-nucleon transfer reactions
Lead Author: A. Gadea

2.2 Nuclear structure advancements with fission
Lead Author: A. Lemasson

2.3 Nuclear structure advancements with fusion reactions
Lead Authors: J. Nyberg, J.J. Valiente-Dobon

2.4 Nuclear structure advancements direct reactions
Lead Authors: W. Catford, D. Beaumel, D. Mengoni

2.5 Nuclear structure advancements with relativistic beams
Lead Authors: M. Bentley, G. Benzoni, K. Wimmer

2.6 Nuclear structure advancements with high energy gamma rays
Lead Author: F. Camera

3) Technical advancements with AGATA

3.1 Mechanical implementations and infrastructures
Lead Authors: J. Simpson, B. Million

3.2 Electronics
Lead Authors: A. Gadea, E. Clément

3.3 Software developments
Lead Authors: O. Stezowski, J. Dudouet

3.4 Detector technology
Lead Authors: *H. Hess, P. Reiter*

4) Performances of AGATA

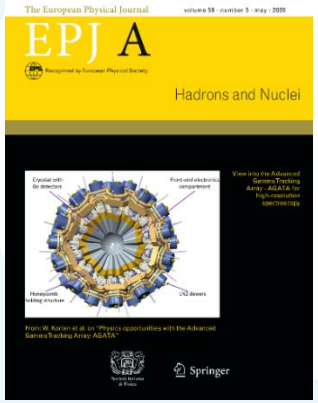
4.1 Review of the last decade Pulse Shape Analysis activities
Lead Authors: A. Boston, P. Reiter

4.2 Performances of tracking algorithms
Lead Authors: J. Ljungvall, F. Crespi

4.3 System performances under different conditions
Lead Authors: A. Korichi, A. Goasduff

4.4 Simulations of AGATA response and couplings with ancillaries
Lead Author: M. Labiche

4.5 Organization of the collaboration and physics campaigns
Lead Author: E. Clement



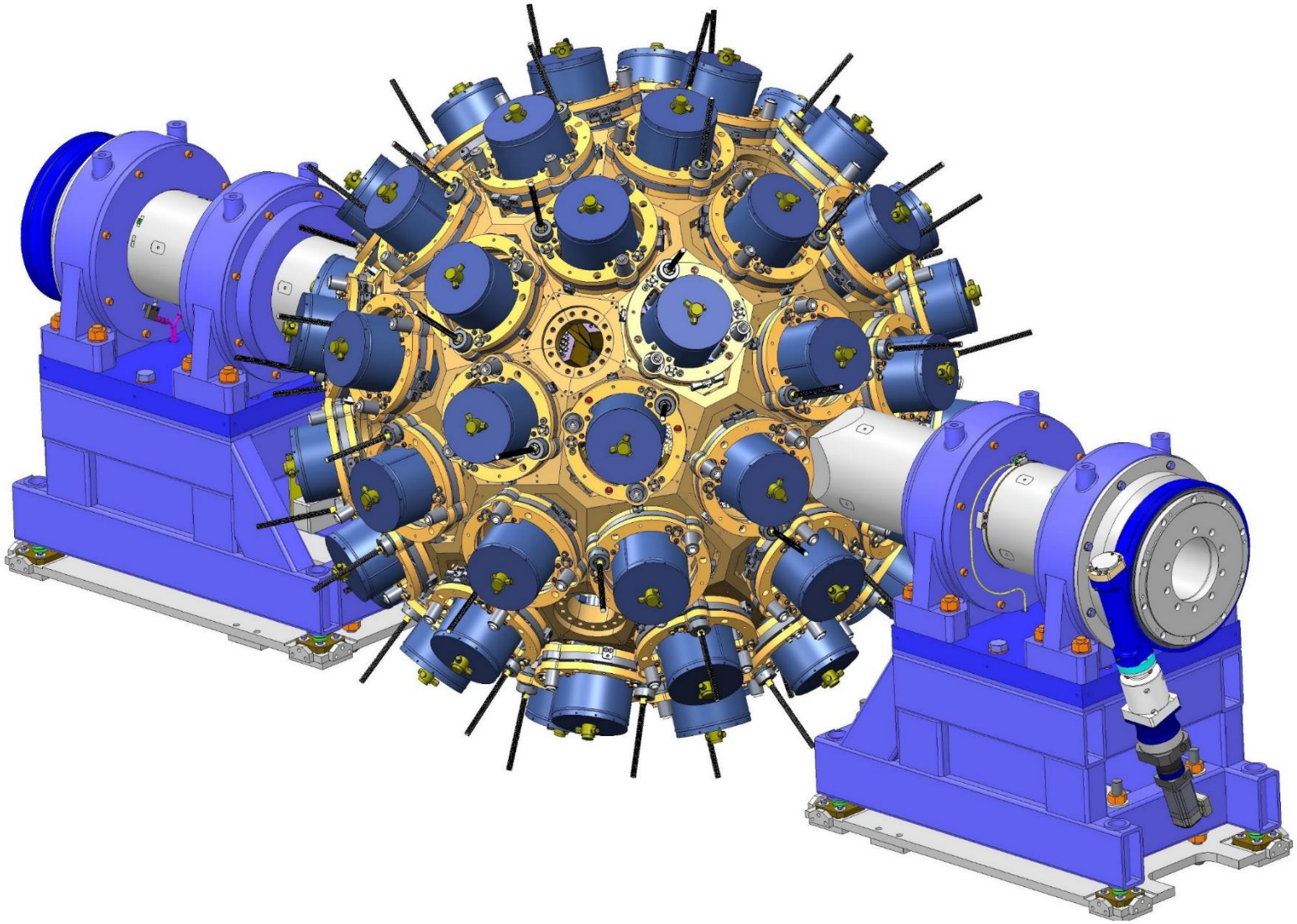
AGATA White Book : W. Korten et al, Eur. Phys. J. A (2020) 56:137
S. Akkoyun *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 668, 26 (2012).

We have started a new phase of the Project : Phase 2

The objectives of Phase 2 funded by the MoU are :

- Acquiring 78 Asymmetric segmented HPGe capsules – 3π available for experiments
- Acquiring 26 AGATA Triple cryostats
- Acquiring 1 Po storage disk
- Acquiring Data Acquisition Infrastructures such as network switches and blades for services
- Acquiring a computer farm (HPC) for the PSA on-line treatment of 135 capsules
- Acquiring a Detector Support System for 135 capsules, Low and High voltages supplies, LN2 auto-fill system and related cables.
- Maintaining An up-to-date Data Base
- Developing and maintaining a set of software algorithms for on-line and off line data processing
- Developing, maintaining and distributing a framework for Data Analysis
- Designing and constructing a unique mechanical structure holding 45 AGATA Triple cryostats
- Developing and maintaining a unique Front and back electronic for 135 capsules (Analog preamps, digitizer DIGOPT12, Processing PACE-STARE with clock and trigger functionalities (GTS/SMART)) and its software control.
- Developing, maintaining and distributing a state of the art simulation package and performances control.

The AGATA Project includes a continuous R&D activities which is included in each Working Group structures but not funded by the MoU.



AGATA Phase 2 funding

MoU / AMB

Core investments

For material investments
- Detectors
- Electronic
- Mechanics
- Data acquisition
- Infrastructures

Shared between countries (Major countries Fr, Ge, It 20%, UK 15%)

ASC and funding agencies discussion (inc. ARRB) and agreement via MoU

Operation Costs

For repairs, replacement of broken or obsolete material for the Core items

Shared between countries and scaled and re-evaluated annually with capital investments and real cost
Endorsed by ASC via MoU

Host Lab installation

For all local services and interfaces for all material from the Core investments needed to host and operate AGATA

Fully covered by the Host Laboratory and managed within the local host project breakdown structures

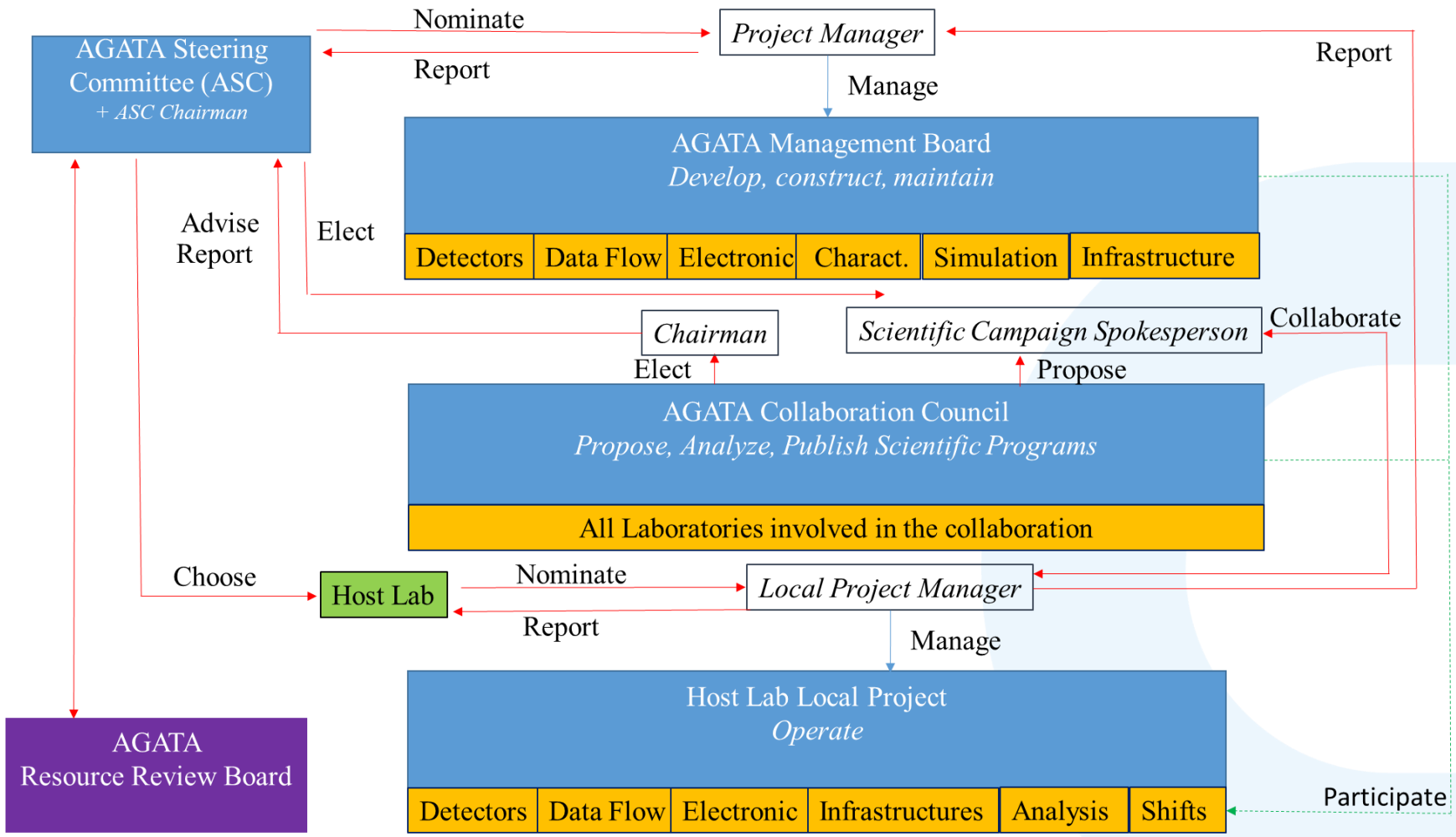
R&D and Travels

For travels between partners institutions and to the host laboratory, annual meetings, workshops, Post-docs, PhD and Techincal Short Terms contracts, Technical or scientific R&D

Not financed by the collaboration. National Grant (ERC, National Grant, EU support, TNA etc …)

International ASC - ARRB

Phase 2 Management



Data Policy & DMP

https://www.agata.org/physics_publication_submission
https://www.agata.org/acc/data_policy

•Access to the data is to be controlled by the AGATA collaboration.

•The AGATA Spokesperson delegates this control to P.I for 5 years

•The data for exploitation will be then made available to the wider AGATA collaboration

•All bona-fide members of the AGATA collaboration will have access to the data to improve the operation of the instrument, for example to monitor and improve detector performance

• CCIN2P3 – CNAF (40To/week -2017 ; 100 To/week - 2030)
• Improved version of the DMP toward « FAIR » & « Open science »

•The ACC must be informed of the reference for publications relating to AGATA within three months of the publication date.

•The experimental collaboration should acknowledge the work of the wider AGATA collaboration and the host laboratory in any publication.

• Scientific submission must include the Core List Authors

All AGATA technical and instrumentation manuscripts must be sent to the AMB for review before being submitted to a journal.

Project Plan Phase 2

The detailed Project Plan : ATRIUM-563607, ATRIUM-563609

The present project plan, conceived technically for a 4π array, foresees the construction of a 3π array with capital investment from 2021 to 2030, consistent with the MoU,

Total cost : ~22 M€

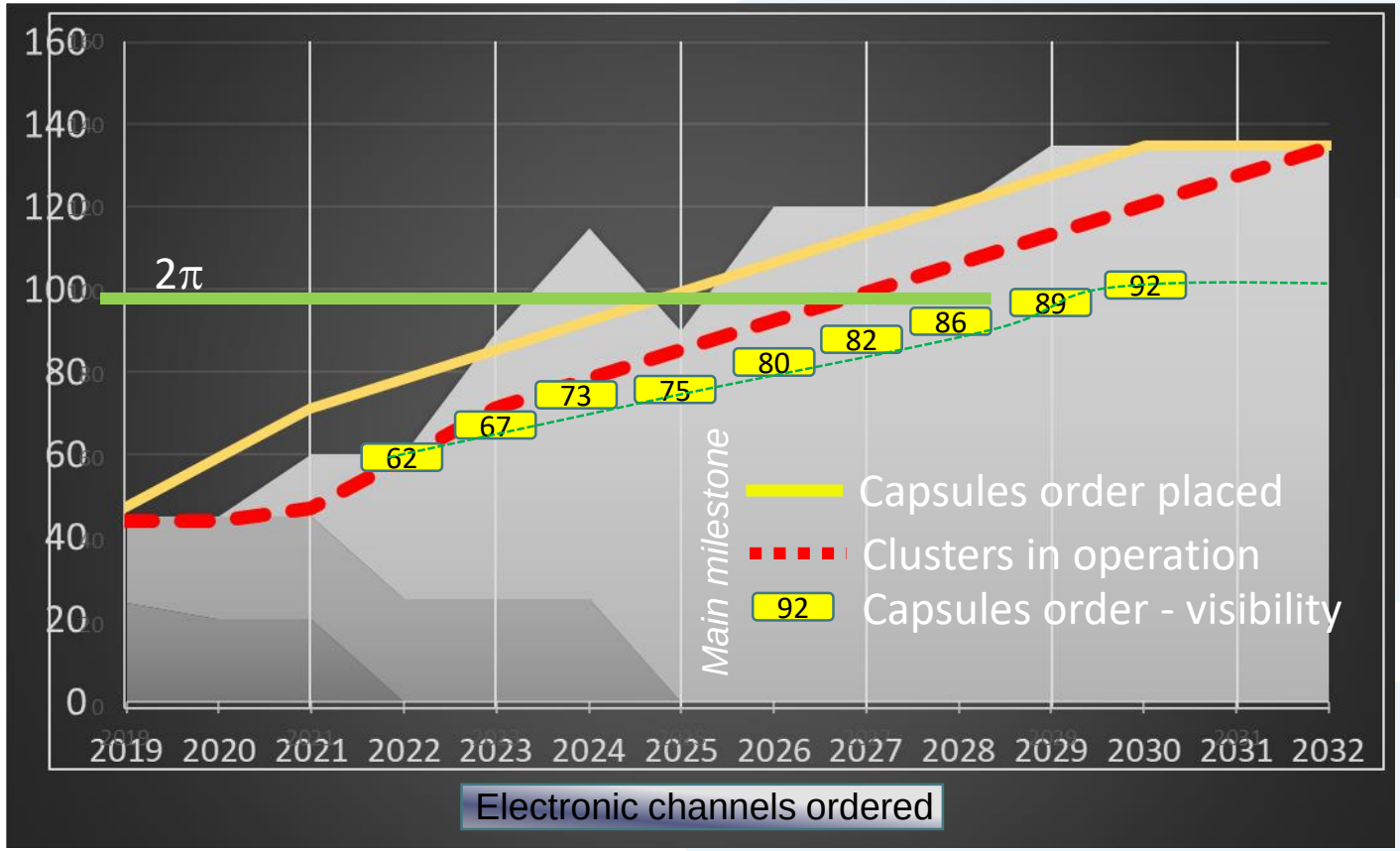
The production of the Triple Clusters constrains the project

The project plan is based on an annual production of 2-3 Triple Clusters (ordered, produced, assembled and tested)

→ A 2π system available by the end of the LNL campaign (>2028)

In 2025, the project will be reviewed by the funding agency to allow the signature of the Phase 2 MoU [2026-2030]

MoU funding scheme (section 3.6)

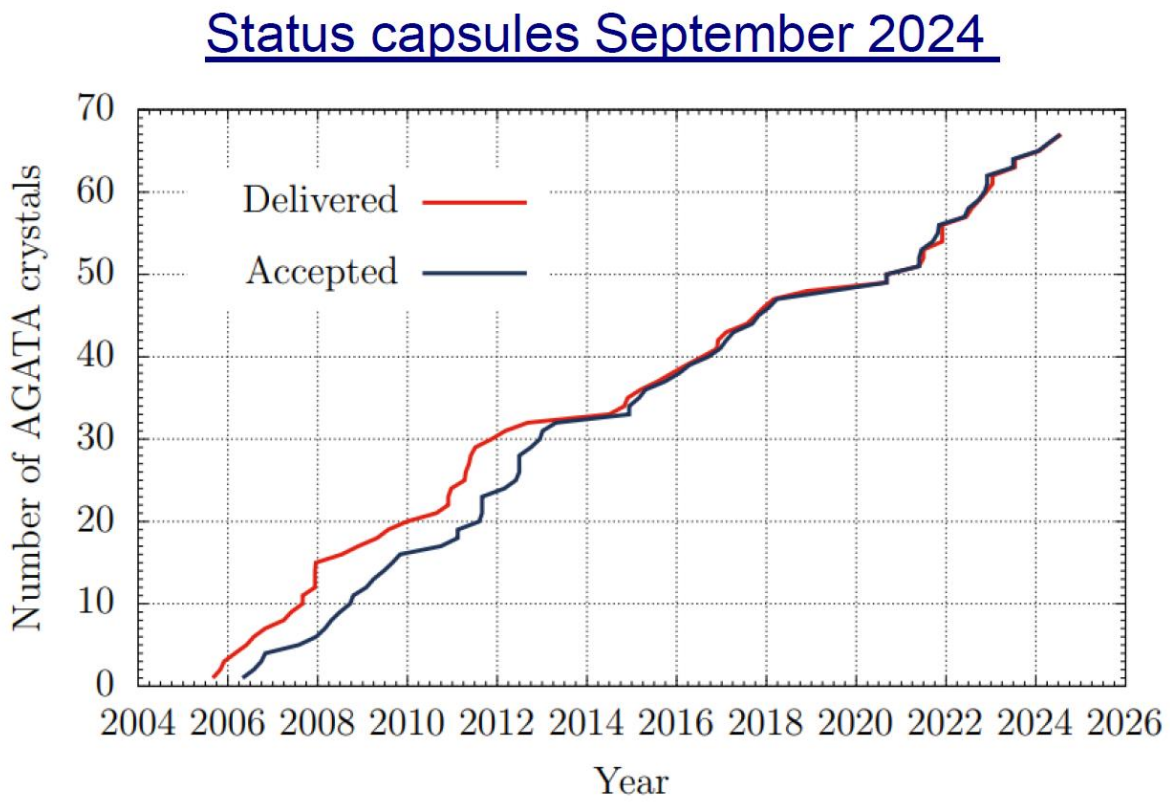


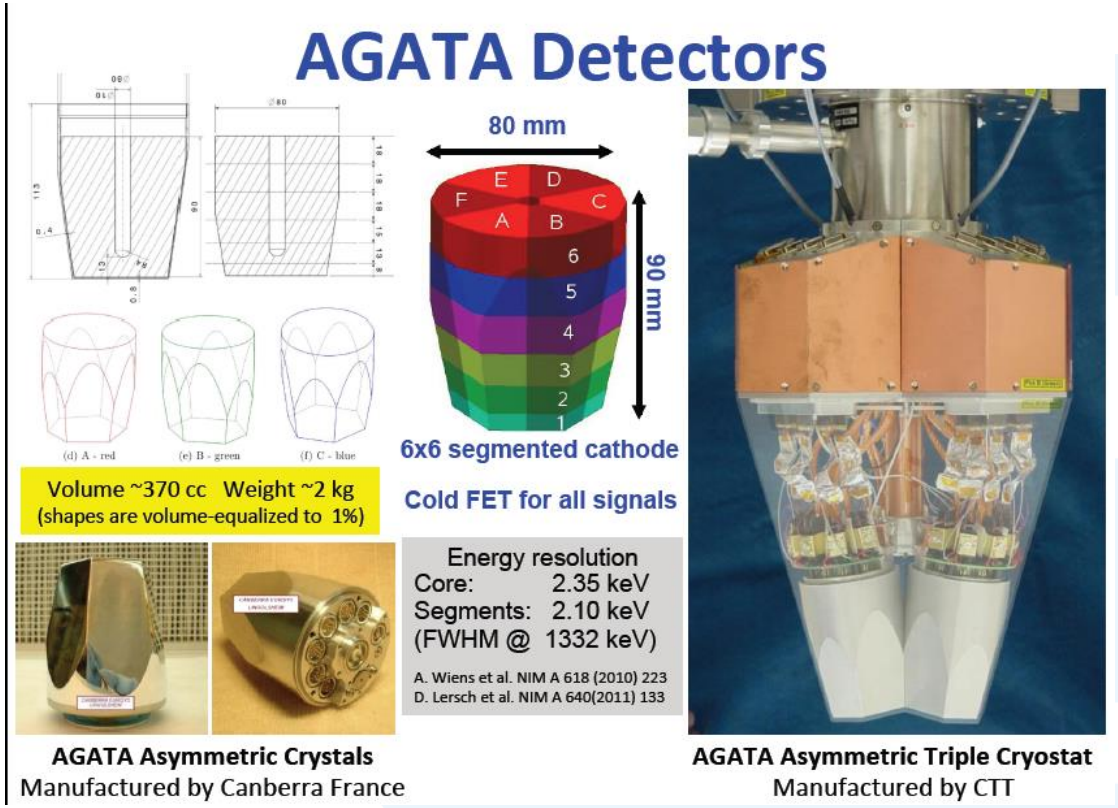
Recent related workshops

4th Machine learning workshop was organized by J. Ljungvall
OASIS AGATA AI workshop 2024, 13th of May https://indico.in2p3.fr/event/32733/

Detector status (9th September 2024)

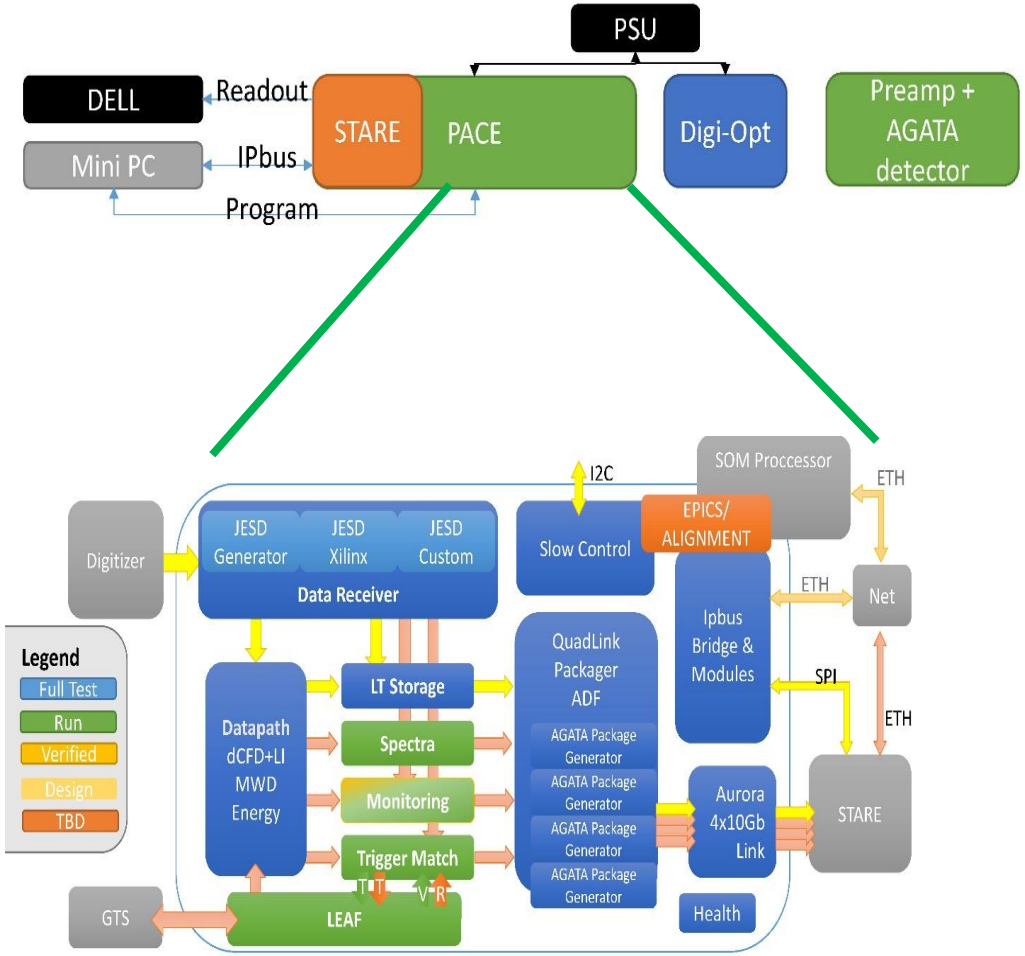
The total number of delivered AGATA capsules is **68, 7 more in the production line**

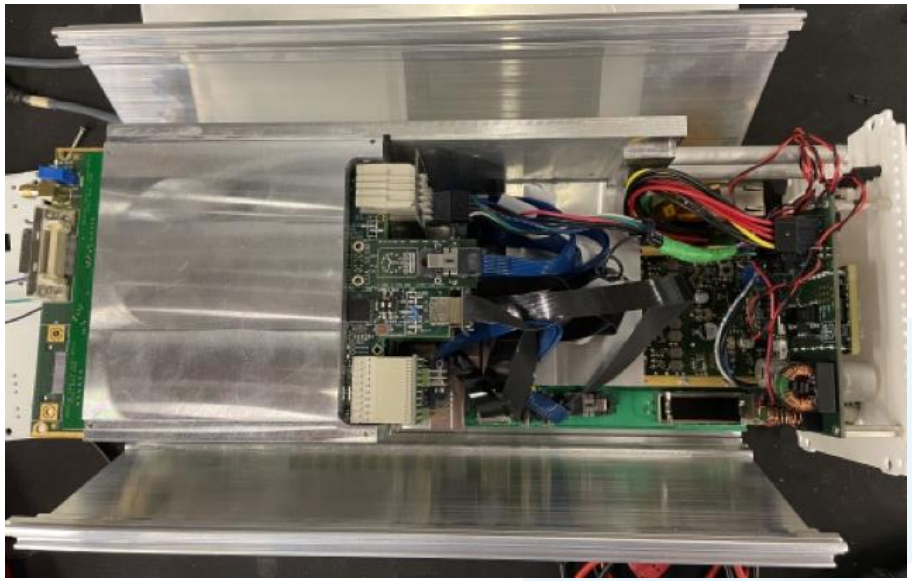




The Detector task is budget driven

Phase 2 FEBEE status





Status :

Full data path using an AGATA detector
+ DIGOPT12 (INFN, IFIC)
+ PACE and its firmware (IFIC, GANIL, IPHC)
+STARE (IJCLab)
+readout (IJClab-IP2I) running at LNL – Data integrity stress by IP2i
On 5th of March we agreed to proceed with the production of STARE.
On 16th of May, we agreed on the production of the PACE board.
DIGOPT12 are currently delivered
Completion of the final firmware (2025)→ the present bottleneck.
The FEBEE task is HR driven

→ The equivalent of ~30 clusters electronic chains are in the production line

Data flow and Acquisition

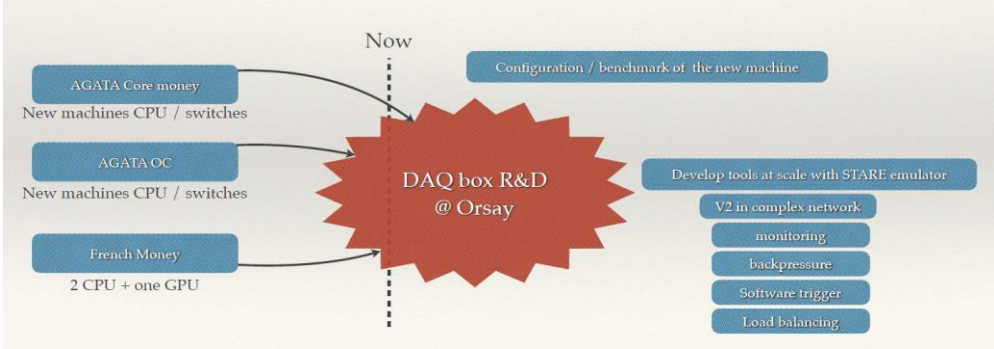
- Mini daq box for data flow R&D setup in Orsay for prototyping our new architectures
- Preparing the increase of Tb production from the 0° campaign

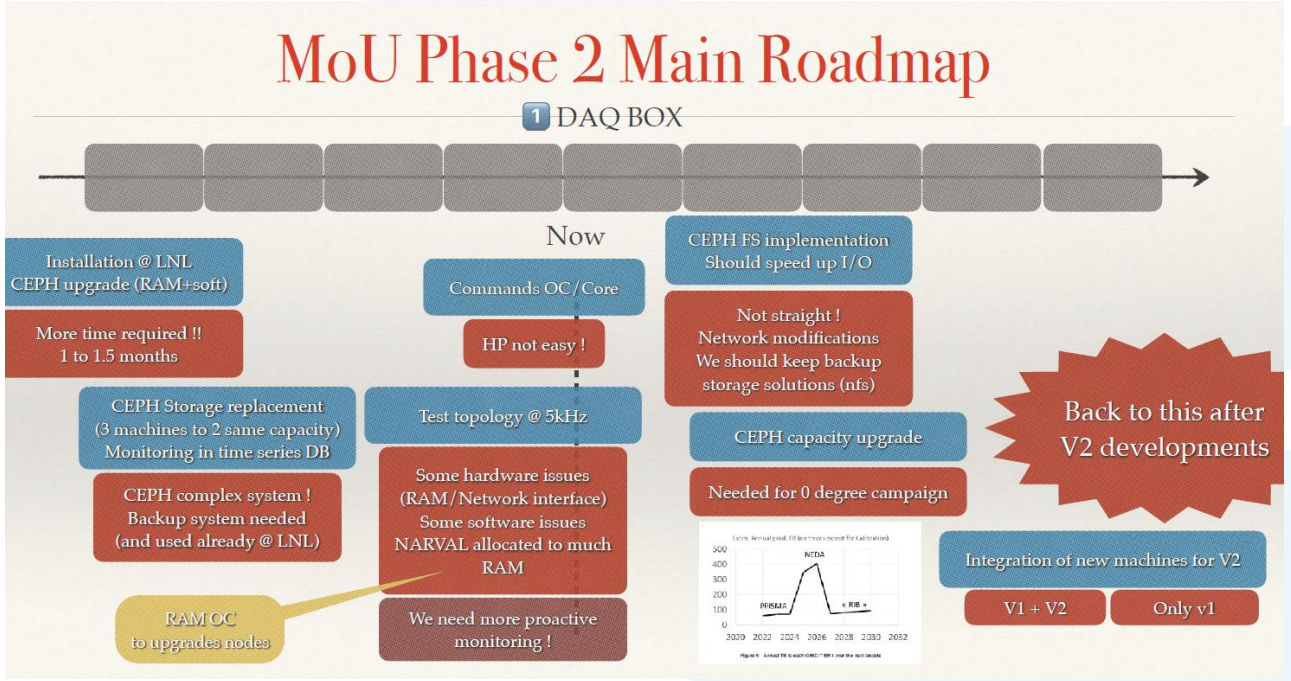
- Maintaining the present system with upgrades of the CEPH (1 Po), switches, Analysis machine, anodes, DCOD etc ….

- Most of the V2 pipe line is ready
- Both using an V2 emulator and real data taken in LNL, stress of the data pipeline

- The data analysis process is part of the WG activities. Steps forward in continues integration, gitlab, updates, FAIRNESS, metadata, catalogues, benchmarks,…. Goals are a reliability, easy access to code and data (GRID)

- Data monitoring : “graphana”, Spy, integrity, “big data” management
- Data processing eco-system became a major activity in the WG with respect to phase 1
- Improvements in accessing the data from GRID





 September 11, 2023

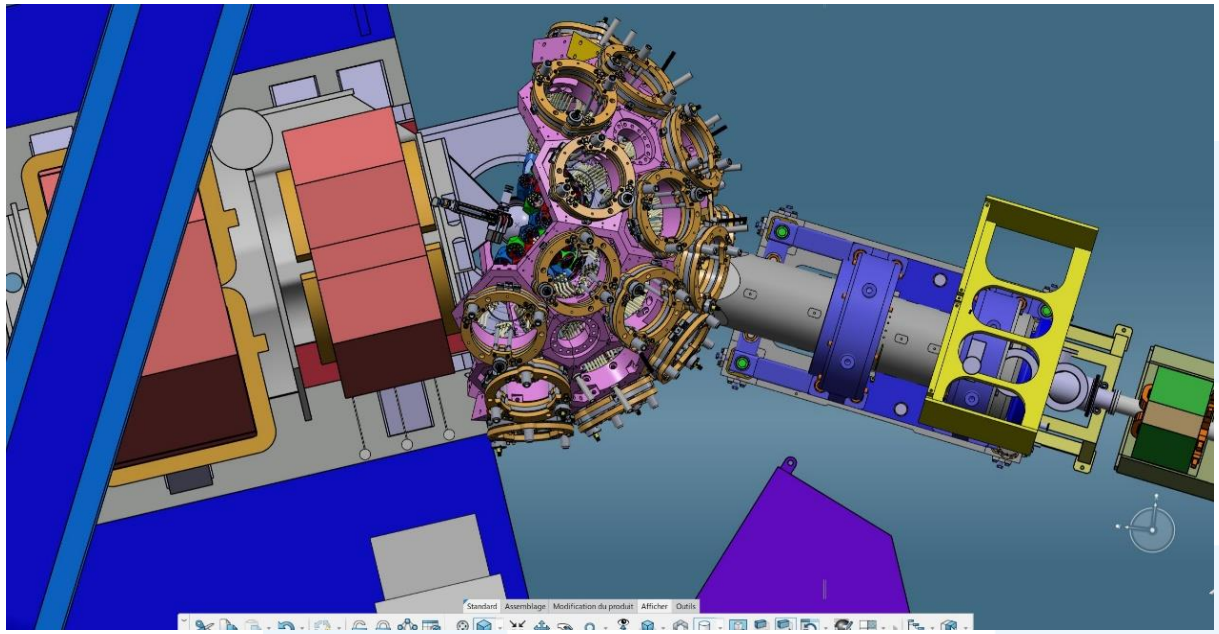
Road map for AGATA Computing model

O. Stézowski & E. Clément with the AGATA collaboration

Full document ATRIUM-902780

Infrastructures

Detector Support System (IRFU)

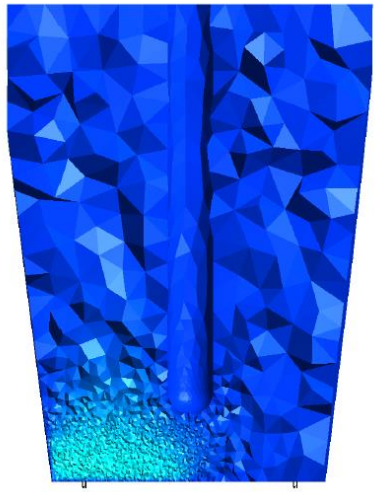


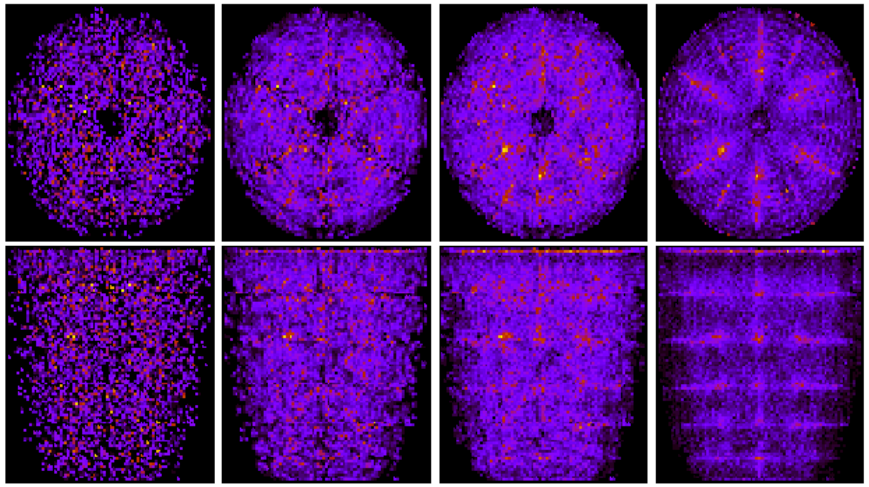
Open issue : final design of GRIT and CryoTarget

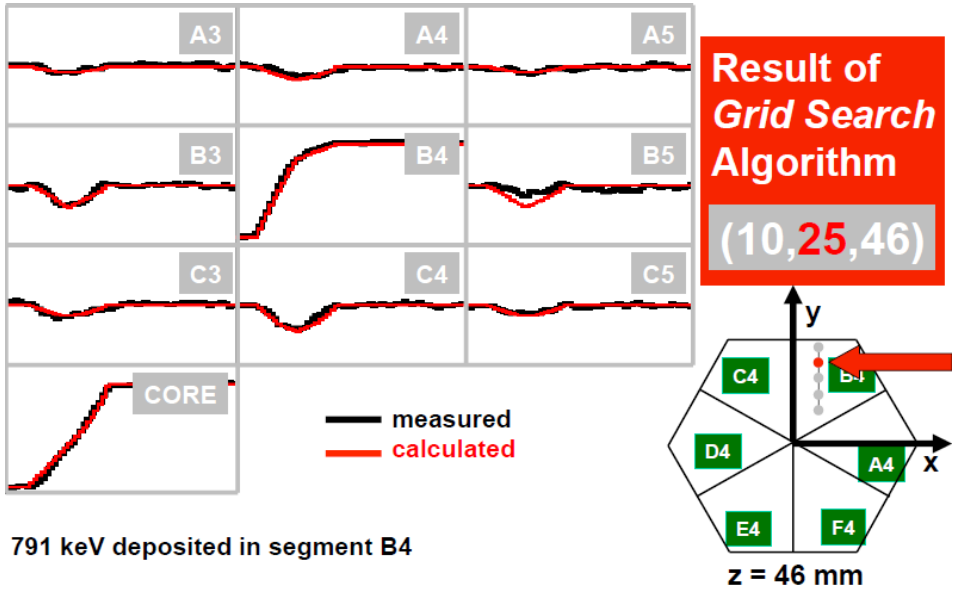
2π is covered infrastructures are delivered and installed in LNL

PSA-Tracking R&D

Simulation

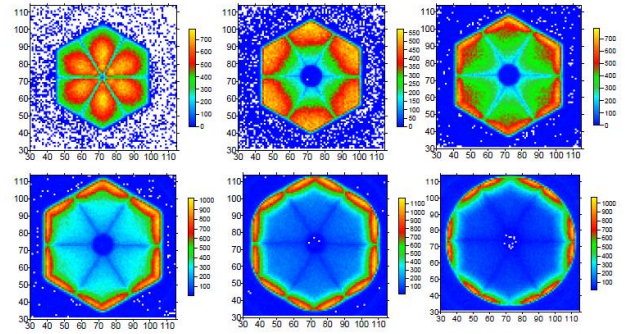






Scanning

AGATA Scan Setup



PSA-Tracking R&D

Implementation of the multi-interaction PSA grid search using the GRETINA approach :
This has been fully implemented in AGAPRO and works.
→ Tested on our ^{98}Zr (GANIL-Fission-VAMOS) data benchmark → 40% more statistics in the photopeak

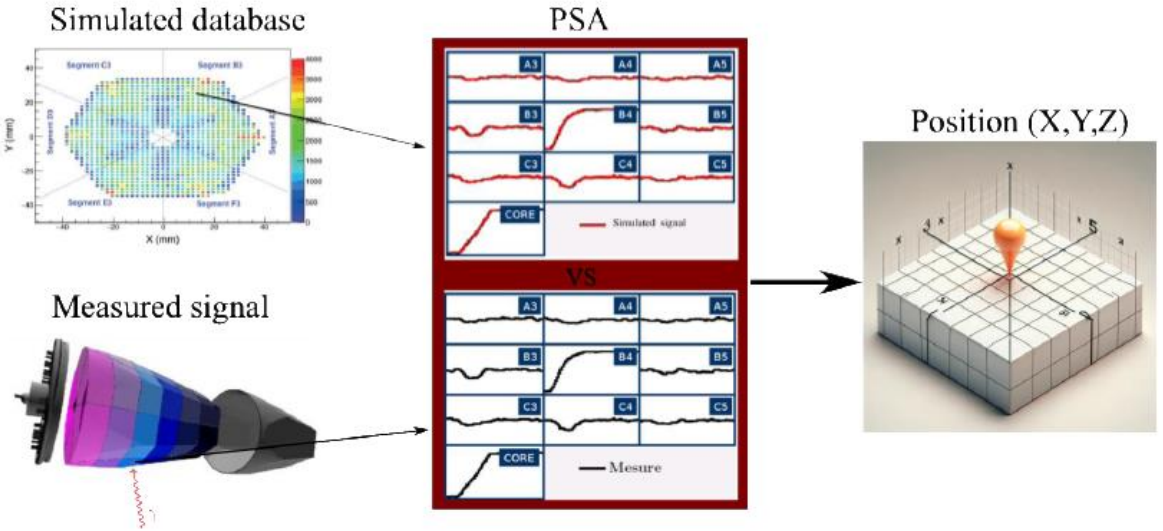
Strasbourg Scanning table **On the request of AGATA's Performances and PSA Teams, scan of the A005 detector to determine for the first time in 3D various properties of large-volume segmented Ge crystals; strong French involvement in data analysis (IPHC, IJCLab, GANIL, Lyon)**. Full 2x2mm scans have been performed and analysed on NN approach. Reprocessing of the PSA based on NN basis, AGATAGeFEM, ADL. Tomography reports. A step is made with this approach (ie using the scanning table). Much more to come

PSA-Tracking R&D

➤ The Pulse Shape Analysis algorithm (PSA)

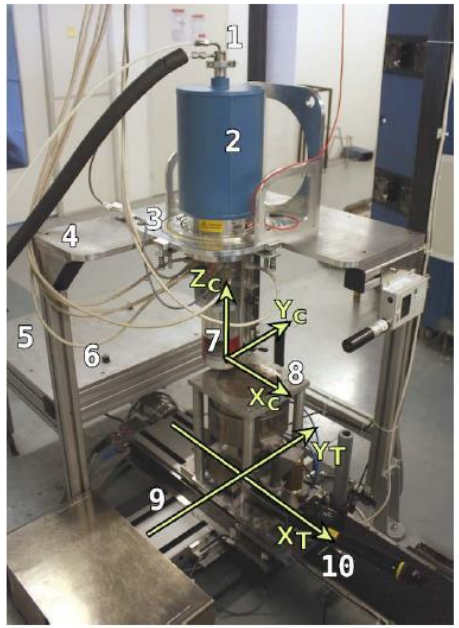
Simulated databases available:

- ➤ Agata Detector Library (ADL):
  - ➥ Used by default online.
  - ➥ No more ADL experts in the collaboration.
- ➤ AGATAGeFEM:
  - ➥ Results as good as ADL have been shown
  - ➥ Recently developed by J. Ljungvall



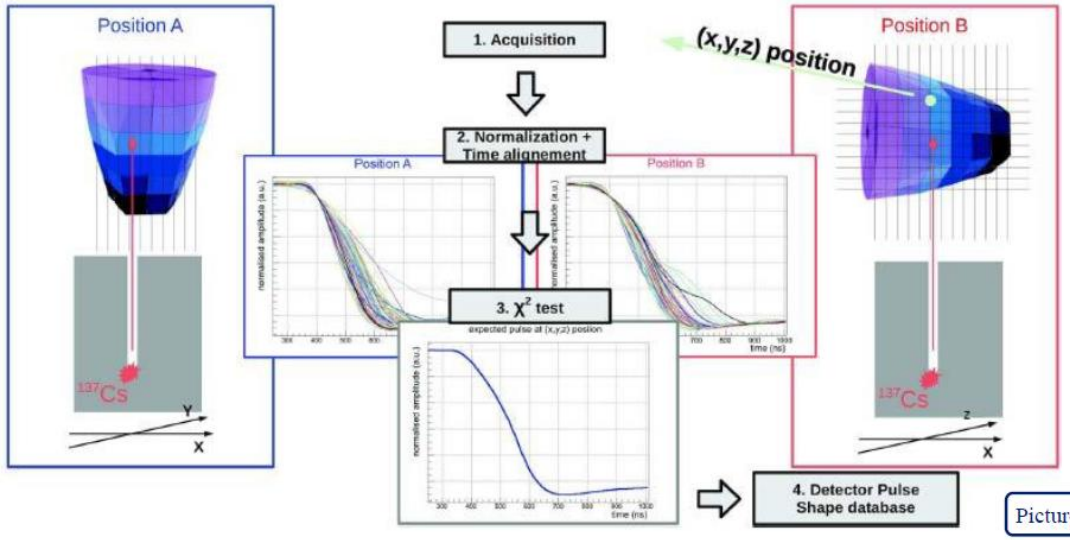
J. Dudouet et al (IP2i)

- Scanning capabilities:
  - motorized collimator with a precision of 10 µm
  - system allowing the placement of the detector in vertical and horizontal position
  - laser alignment system
  - digital electronic (TNT2)
- Scanning concept:
  - not performing a real 3D scan (too long), but two 2D scans (vertical and horizontal)
  - 3D basis obtained by Pulse Shape Comparison Scanning (PSCS) method
- Detector scanned:
  - S001: a prototype symmetric detector
  - A005: scan finalized this summer



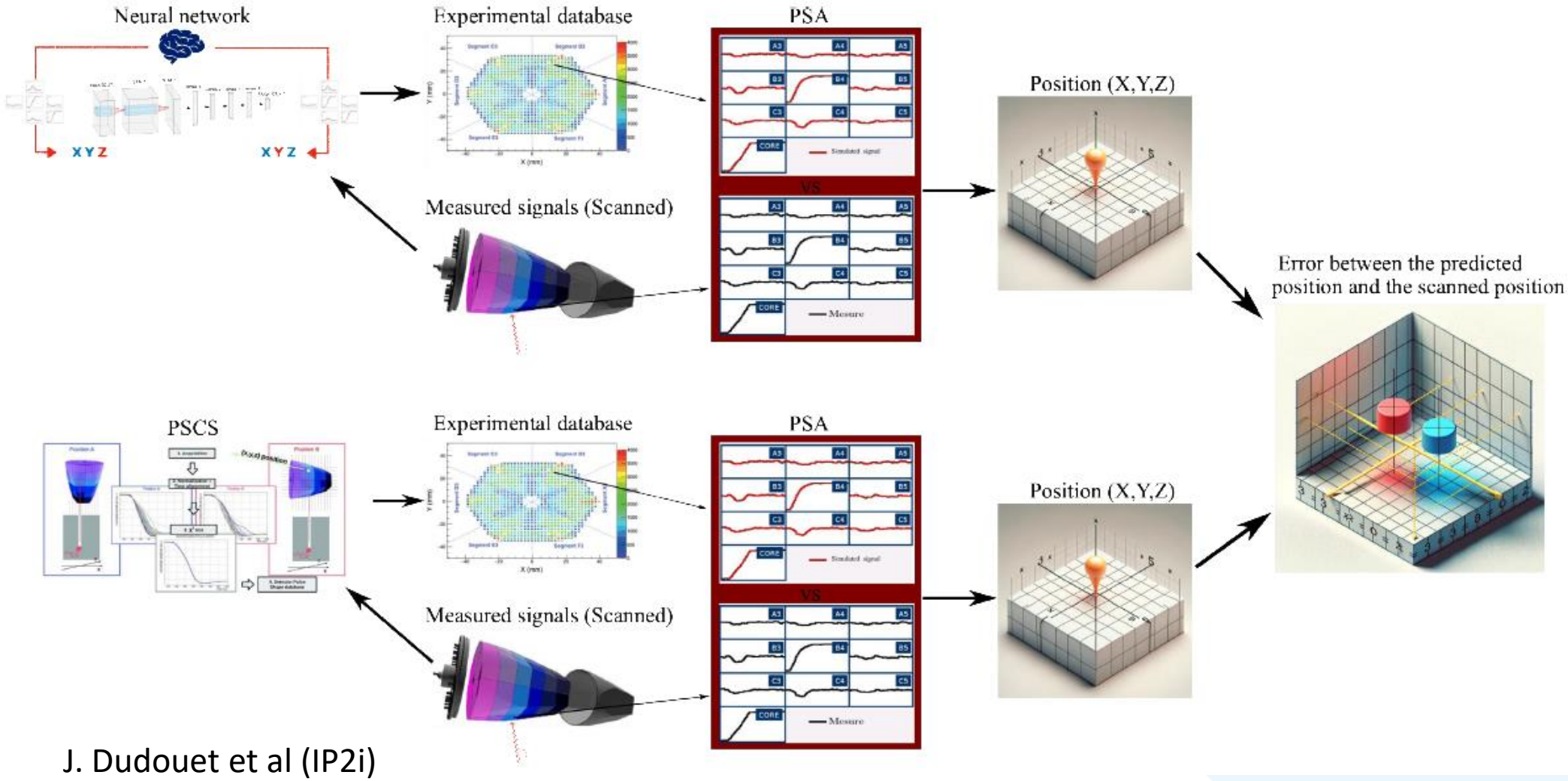
- 1 horizontal scan + 1 vertical scan,
- the 3D basis is obtained by a combined analysis of both data-sets.
- Validated and published method, but time consuming (5 days for the PSCS analysis)

B. De Canditiis et al., Eur. Phys. J. A 57 (2021), B. De Canditiis and G. Duchêne, Eur. Phys. J. A 56 (2020)



Picture from Michael Ginsz's PhD thesis

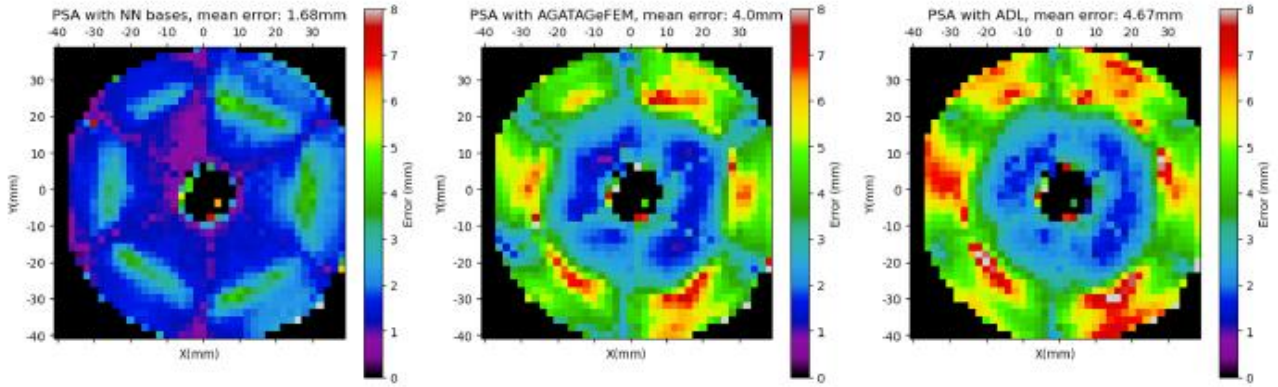
J. Dudouet et al (IP2i)



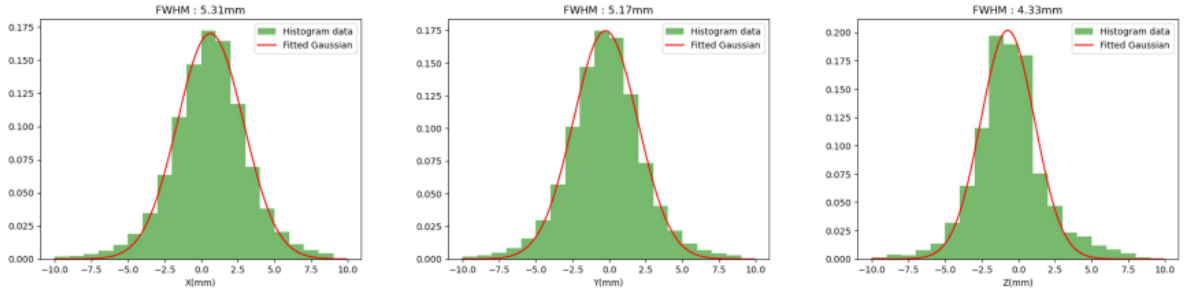
J. Dudouet et al (IP2i)

- Comparison between PSA basis compared to NN predictions (assumed to be more precise than scanning):
  - NN experimental basis
  - AGATAGeFEM basis
  - ADL basis

Layer 5



- Average PSA Position resolution (FWHM):
  - NN: **2.4 mm**
  - AGATAGeFEM **4.3 mm**
  - ADL **4.9 mm**



J. Dudouet et al (IP2i)

PSA-Tracking R&D

"We choose to go to the Moon!

We ~~choose to~~ go to ~~the Moon~~ in this decade and do the other things, not because they are easy, but because they are hard."

should

a full ML/NN PSA ←→ Tracking flow trained from in-beam data

Two different configurations

LNL: new data centre, new targets ^{9}Be, ^{232}Th, ^{238}U and new ^{238}U beam

Nuclear Inst. and Methods in Physics Research, A 1049 (2023) 168040

Contents lists available at ScienceDirect

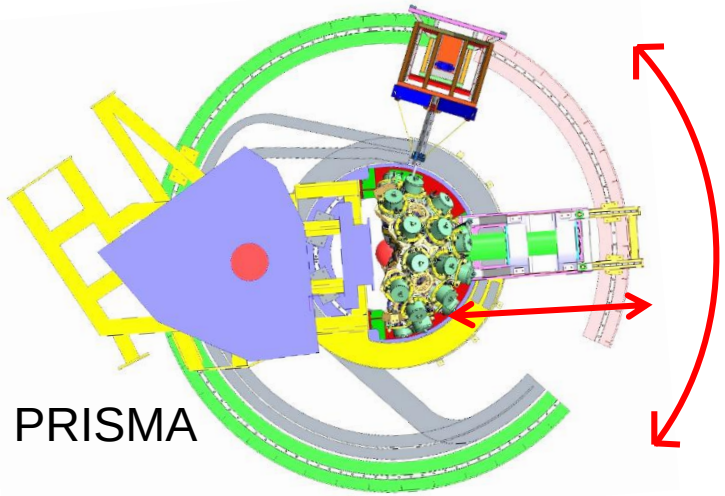
Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Full Length Article

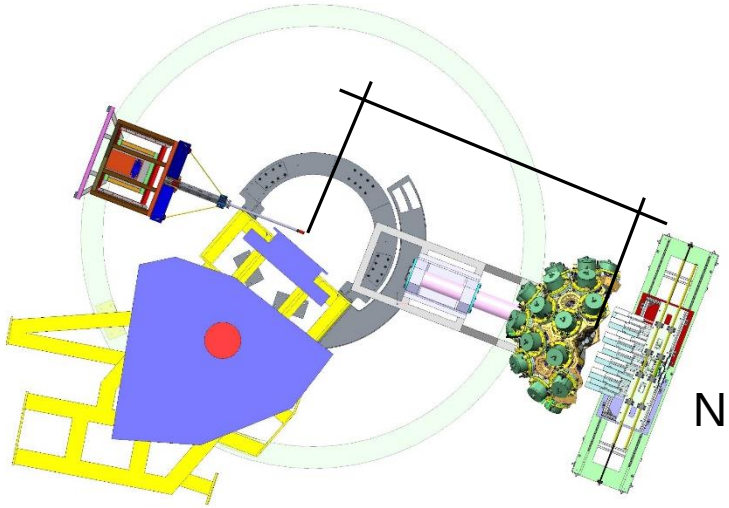
Conceptual design of the AGATA 2π array at LNL

AGATA coupled with PRISMA



Current configuration

AGATA zero degrees



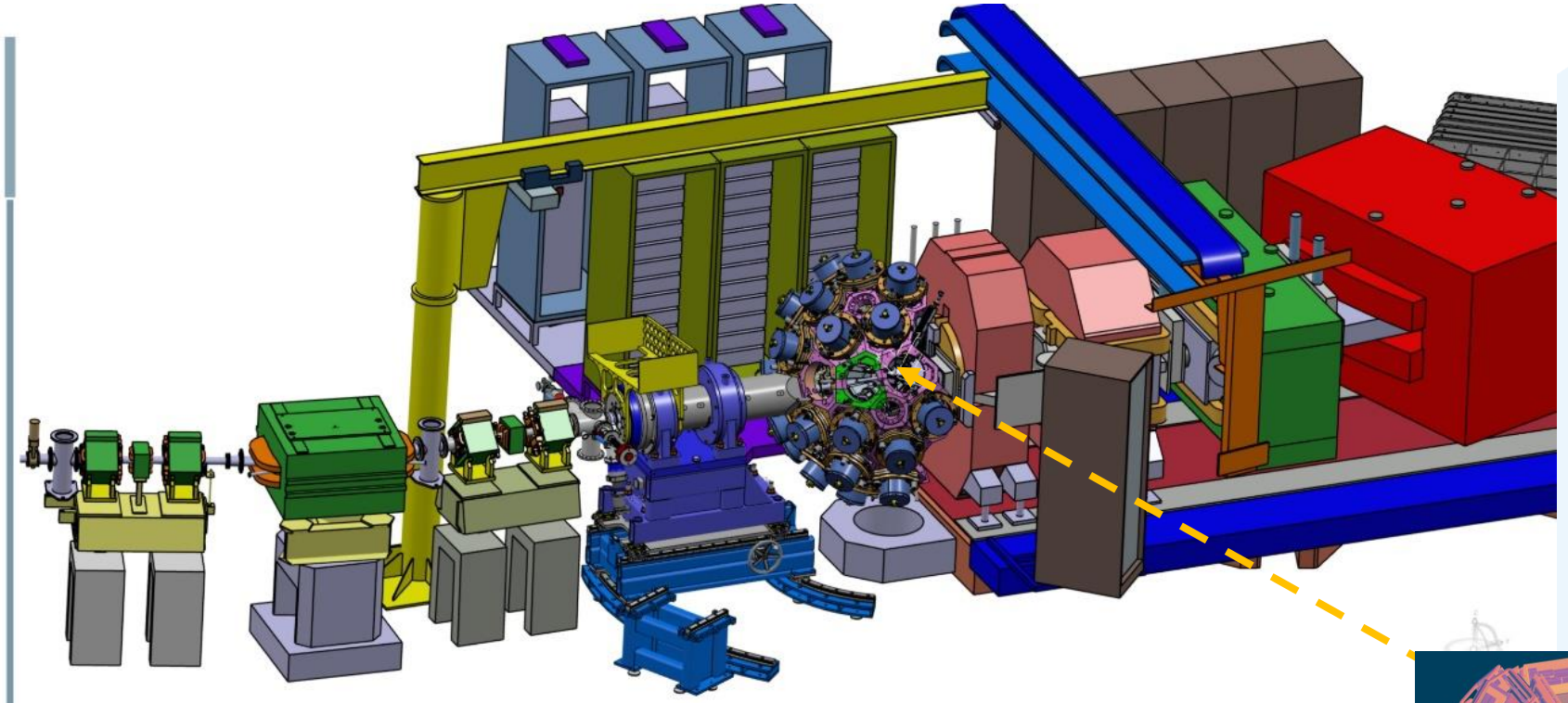
J.J. Valiente Dobon (LNL)

The strength of AGATA@LNL

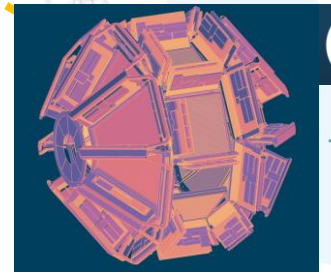
The tower of Babel: 10 different nationalities!

J.J. Valiente Dobon (LNL)

Next is AGATA@GANIL.2 from mid-2028



www.agata.org



https://grit.in2p3.fr/

Thanks to all AGATA contributors
++ The local team LNL/PD