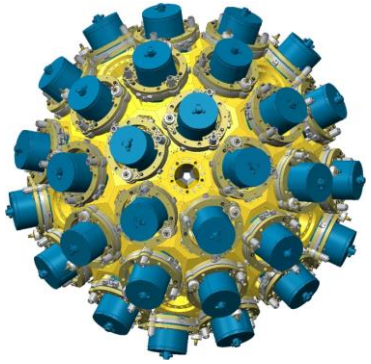
Project Manager Report

Emmanuel Clément (GANIL)
on behalf of the AMB

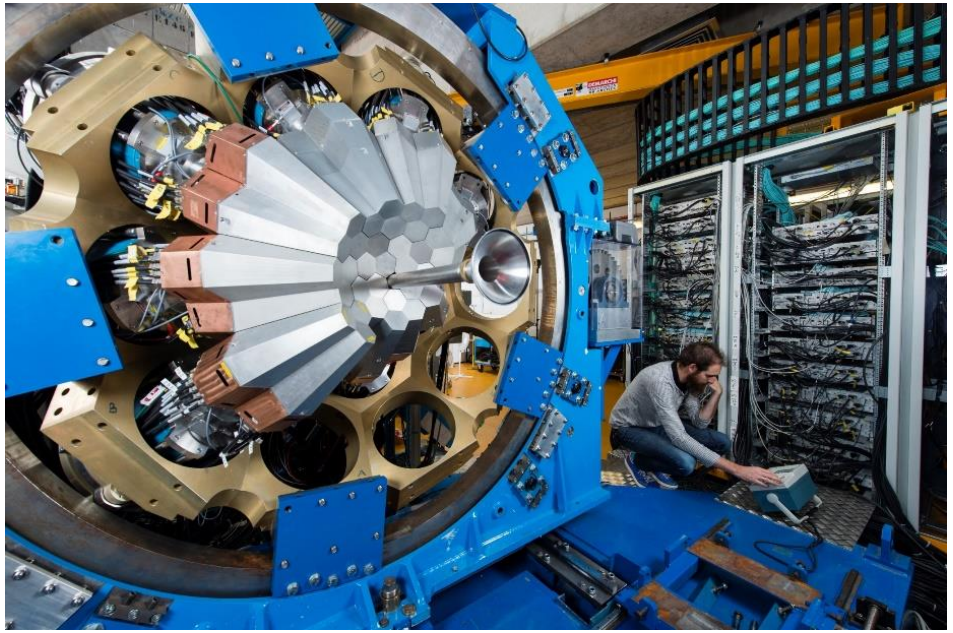
AGATA June 2023

The AGATA project : THE ultimate spectrometer

www.agata.org



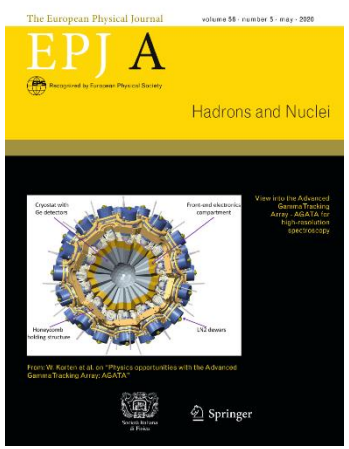
- 180 (60 triple-clusters) cristaux
- Masse de Germanium: 362 kg
- Couverture: 82 %
- Taux d'acquisition >50 kHz
- Efficacité: 43% (M_γ=1) , 28% (M_γ=30)
- Résolution angulaire: ~1º



Le projet est de construire le détecteur pour 2030

Combinaison de:

- ❑Détecteurs segmentés
- ❑ Analyse de la forme des signaux
- ❑ Algorithmes poussés
- ❑ Electroniques numériques



S. Akkoyun *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 668, 26 (2012).
E. Clément *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 855, 1 (2017).
AGATA White Book : W. Korten et al, Eur. Phys. J. A (2020) 56:137

The AGATA project : THE ultimate spectrometer

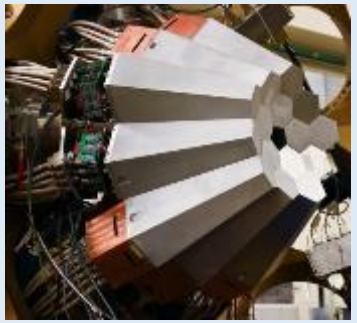
1st AGATA Steering Committee and Management Board (2004)

AGATA construit autour d'un Memorandum of Understanding

MoU Phase 1 + Addendum

MoU Phase 2

2010-2012
Legnaro, Italy
Intense stable beams
15 detectors

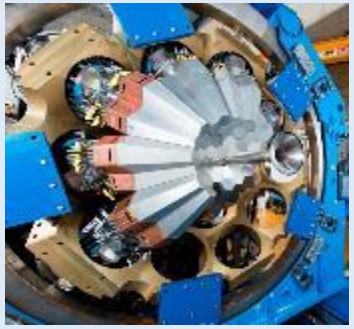


AGATA Demonstrator + PRISMA at LNL

2012-2014
GSI, Germany
Fast fragmentation beams
25 detectors

AGATA at GSI

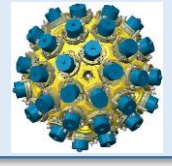
2014- 2021
GANIL, France
ISOL and stable beams
approaching 1π (45)



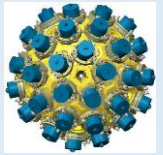
AGATA at GANIL

2021--
LNL, Italy
Stable beams
SPES radioactive beams

AGATA at LNL 2.0



>2026
LNL, SPES, Italie
FAIR, Germany
ISOLDE, CERN
GANIL, France
RIB at low and high energies



Signé le 25 Mars 2022

Changement de “ligue”

2022 correspond à une nouvelle phase du projet : Phase 2

2016 : G. Duchêne (IPHC) → A. Lopez-Martens (IJClab)
2019 : Création du MP AGATA

2019 : CS IN2P3 pour la phase 2
2020 : International review Juillet
2020 : KD2P Automne

2021 : Infrastructure de Recherche

Coordinateur Technique National 2022
Ph. Vallerand (IJCLab)

AGATA

Advanced GAmma Tracking Array

L'objectif de la collaboration AGATA est de fournir pour l'étude de la physique nucléaire un instrument de nouvelle génération, capable d'observer des événements rares avec une grande précision. AGATA permettra d'améliorer notre compréhension de l'interaction nucléaire grâce à la mesure des rayonnements gamma émis lors de différents processus nucléaires. Sa haute résolution et sa grande efficacité en font un outil puissant pour sonder les signatures électromagnétiques des différents comportements de la matière nucléaire, ainsi que leur impact sur les processus astrophysiques, les données nucléaires et le cycle du combustible. AGATA fédère une large communauté de 300 chercheurs en Europe. La collaboration Européenne a pour objectif de construire, maintenir et exploiter ce nouveau type de multi-détecteur au Germanium ultra pur, basé sur le concept de trajectographie gamma. Il s'agit d'une rupture technologique qui permet d'accéder à un pouvoir de résolution de un à deux ordres de grandeur meilleur comparé aux techniques conventionnelles. Outil convoité, sa conception permet qu'il soit itinérant afin de l'exploiter auprès des meilleures installations européennes de faisceaux relativistes (comme à FAIR, Allemagne) ou de faisceaux exotiques du GANIL ou du Laboratoire National de Legnaro (Italie) pour des mesures de haute précision.

Relations avec les acteurs économiques et/ou impact socio-économique

La construction et la maintenance des différents éléments du détecteur AGATA (des cristaux de Ge jusqu'aux éléments d'infrastructure) se font en collaboration avec des entreprises Européennes. AGATA est également un outil de formation pour les jeunes ingénieurs et physiciens dans des domaines de haute technologie (électronique, acquisition et gestion de données, algorithmes, physique du solide, physique et astrophysique nucléaire...).

Science ouverte et données

- Une partie des publications issues de projets utilisant l'infrastructure est en accès ouvert
- Les codes sources produits par l'infrastructure sont ouverts sur une forge logicielle https://gitlab.in2p3.fr/IPNL_GAMMA
- Production annuelle de données : 100 To
- Les données validées et décrites sont publiées sur un entrepôt de données https://cc.in2p3.fr

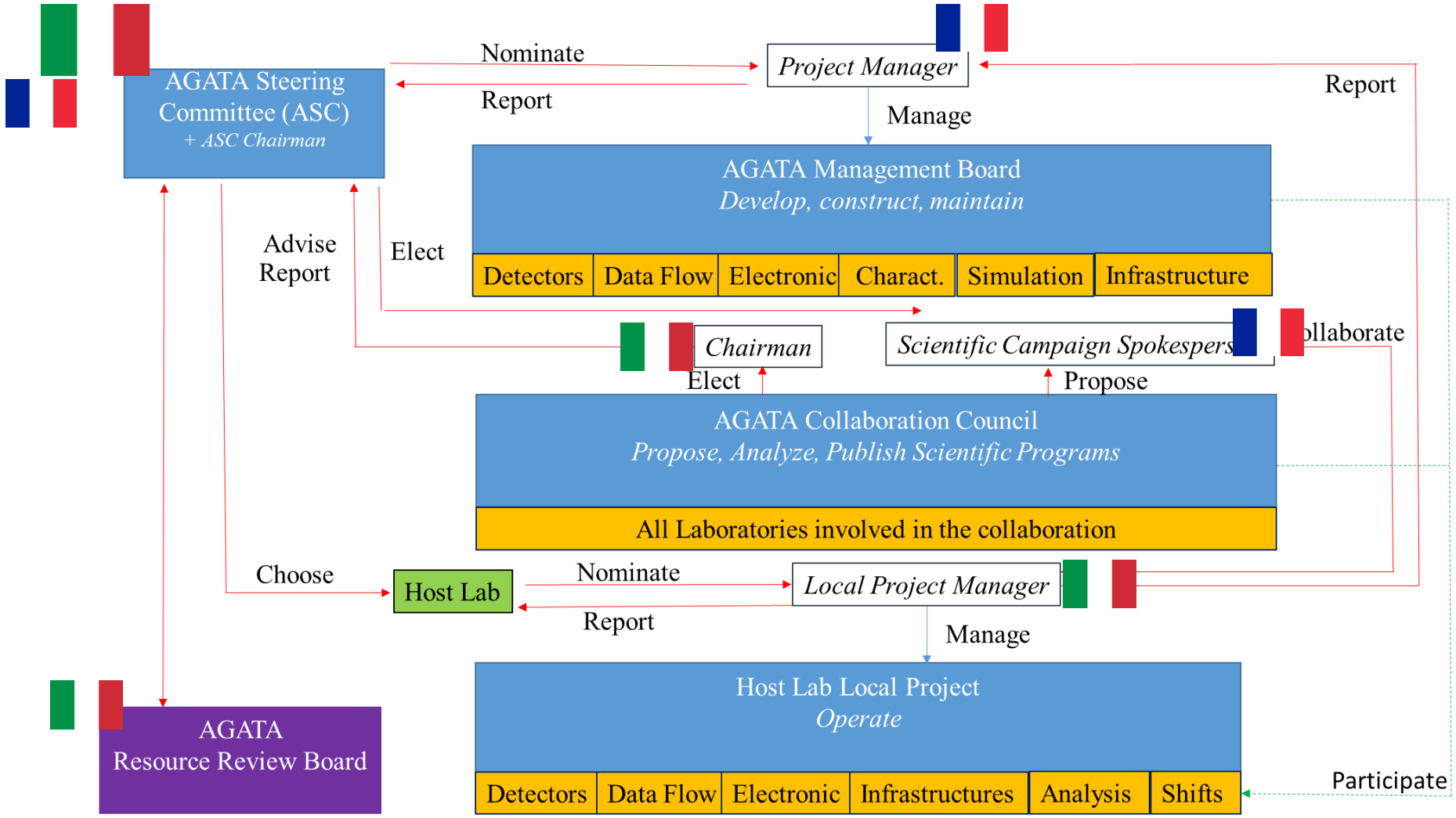
Catégorie : IR
Type d'infrastructure : distribuée
Localisation du siège de l'infrastructure (en France) : Caen
Établissement(s) français porteur(s) : CNRS-IN2P3, CEA-DRF

Directeur de l'infrastructure ou représentant(s) en France : Emmanuel Clément
Année de création : 2003
Année d'exploitation : 2014
Tutelles/Partenaires : GANIL, Université Claude Bernard - Lyon 1, Université Paris-Saclay, Université de Strasbourg
Contact en France : Emmanuel.Clement@ganil.fr
Site web : http://agata.in2p3.fr

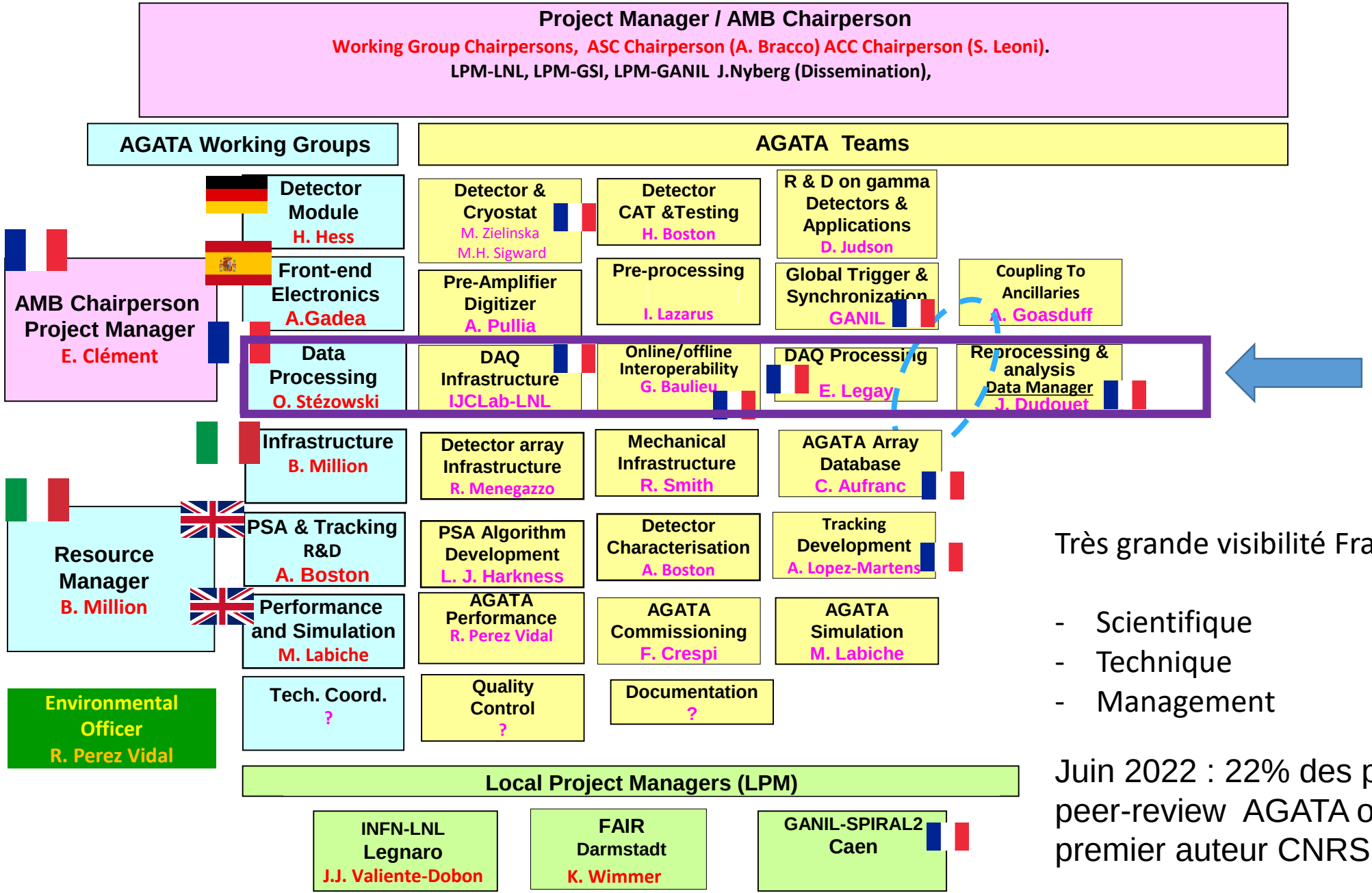
Dimension internationale

Responsable : John Simpson (président du comité de pilotage AGATA)
Pays partenaires : DE, BG, ES, FI, FR, HU, IT, PL, UK, SE, TR
Site internet : www.agata.org

Phase 2 Management



AGATA Management Board and Teams Phase 2



Très grande visibilité Française

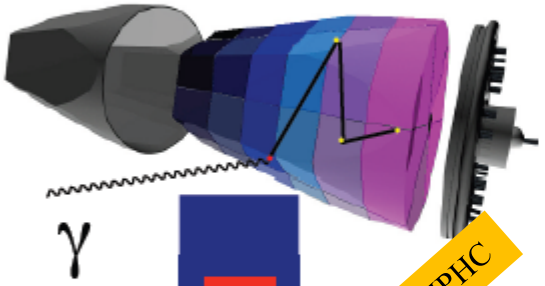
- Scientifique
- Technique
- Management

Juin 2022 : 22% des papiers peer-review AGATA ont un premier auteur CNRS ou CEA

AGATA Data Process

1 IPHC

Highly segmented HPGe detectors



γ

2 IJCLab, GANIL, IPHC

Digital electronics to record and process segment signals

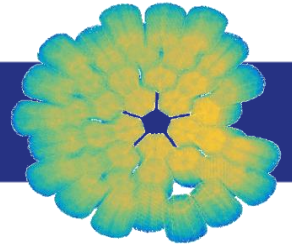
3

IJCLab, IPHC, IP2I

Identified interaction points

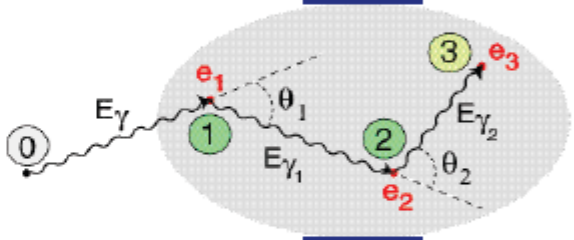
$(x,y,z,E)_i$

Pulse Shape Analysis to decompose recorded waves



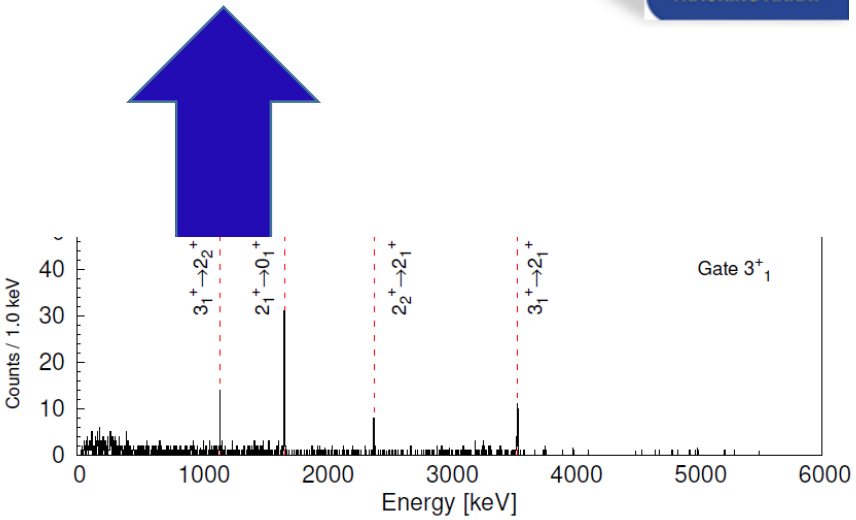
4 IJCLab, IP2I

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



6 IP2I

Doppler Correction

5

GANIL

Complementary Detectors

β, θ, ϕ, E*

AGATA Phase 2 funding

MoU

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

We are starting 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.

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,

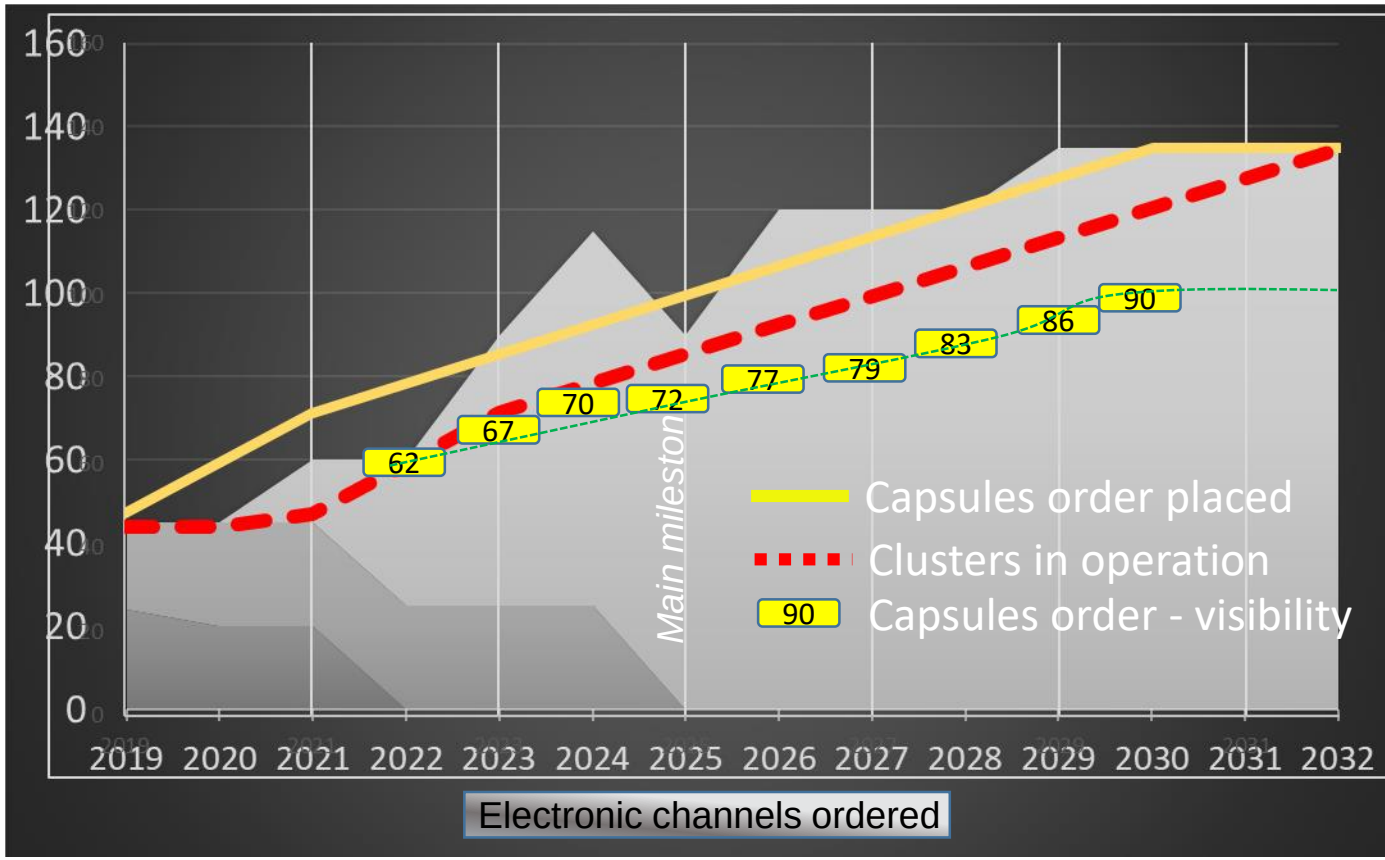
The production of the Triple Clusters constrains the project

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 (~ 2025-2026) and for the start of the next campaign >2026 (SPES, FAIR, GANIL, ISOLDE …)

→ Close to the 3π system delivered by the end 2028-2029
→ The project plan will evolve to the construction of the 4π array

MoU funding scheme (section 3.6)



Data and Publication Policy

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)
• Evolution en cours du DMP vers « FAIR » et « 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.

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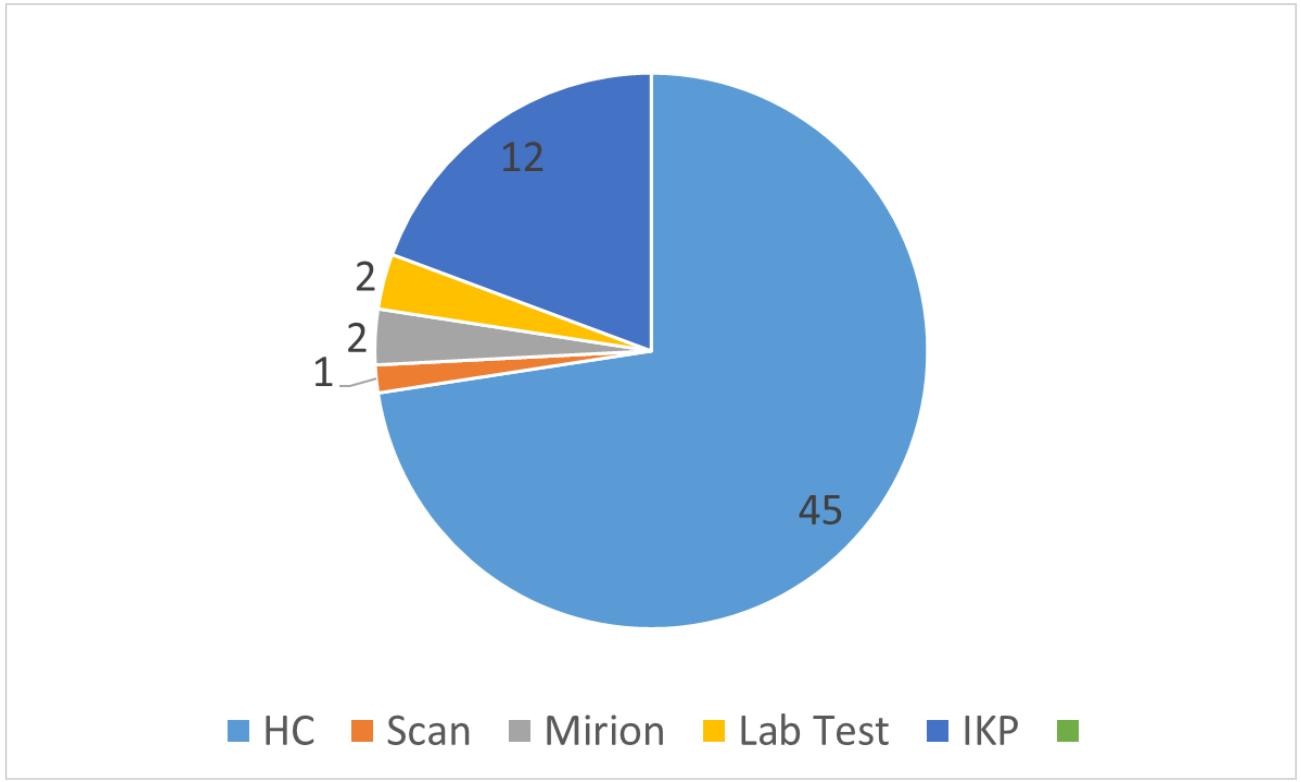
• Scientific submission must include the Core List Authors

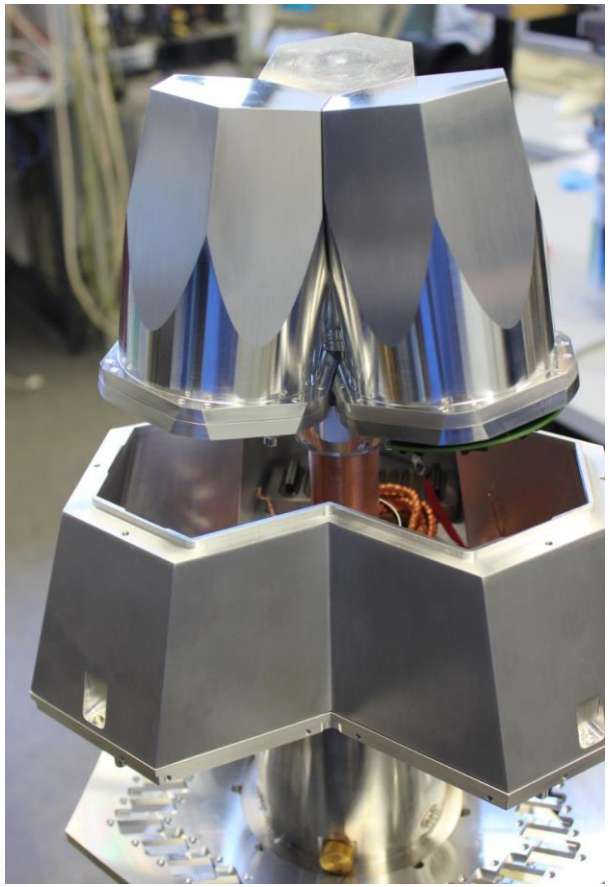
All AGATA technical and instrumentation manuscripts must be sent to the AMB for review before being submitted to a journal.

Detector status

The total number of delivered AGATA capsules is 62 (5 in prod.)

Capsules location – March 2023 (IRFU – IPHC)





Cluster Assembly and Maintenance 13 cluster available in the array

CTT is testing ATC21

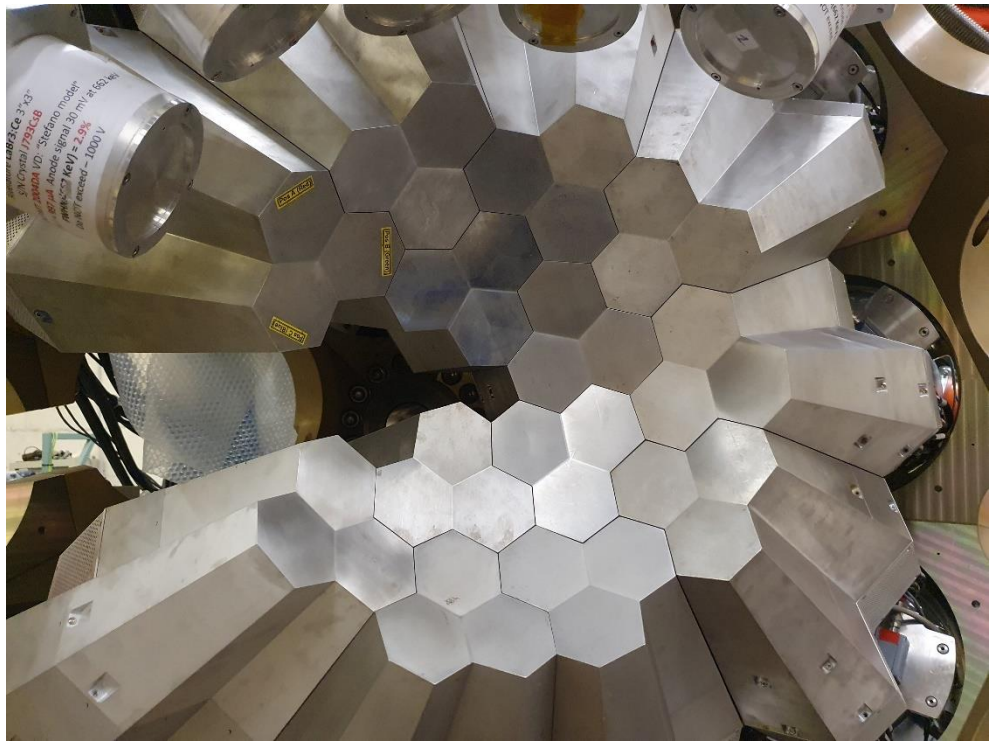
2 capsules are at MIRION for repair → excellent reliability of the detectors

Infrastructures

Mechanics :

Starting discussion with GSI team

Future implantation at GSI/FAIR:
for both mechanics and infrastructure installation the team has met the GSI team led by K. Wimmer and started to check the feasibility of installation at FAIR in the context of non-availability of the LEB cave.



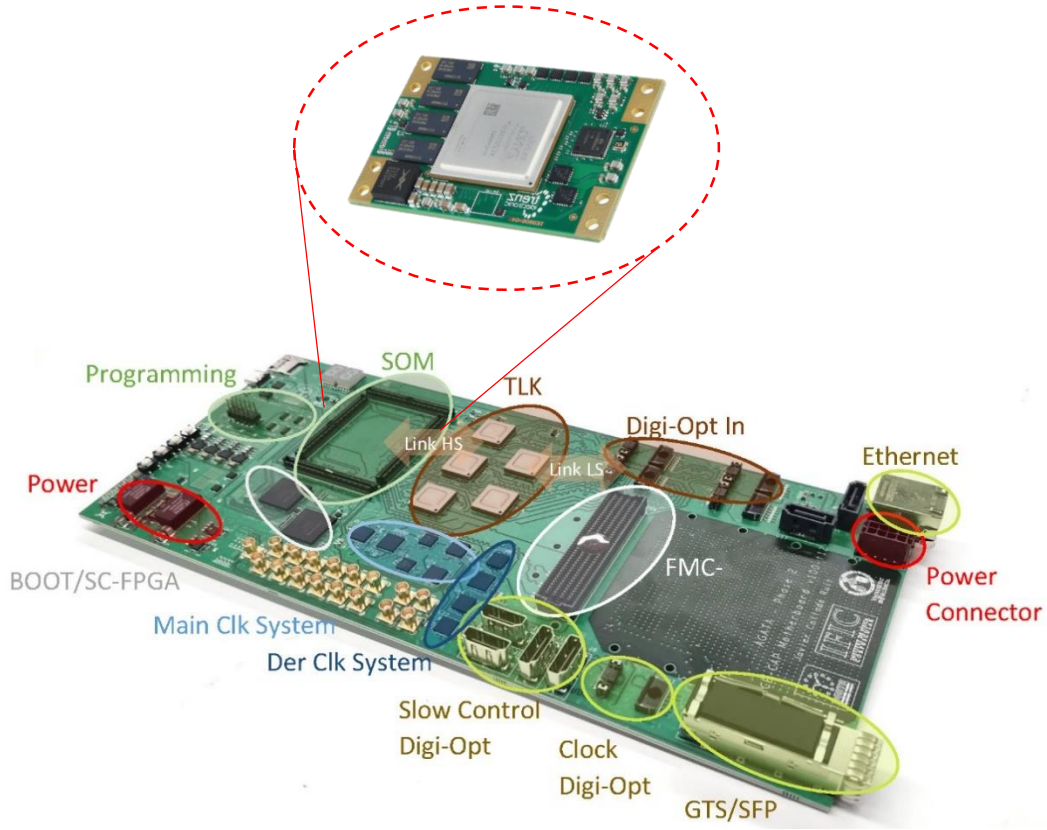
Detector Support System (IRFU)

Data Base : online Dashboard on agata.org (IP2I)

FEBEE status

The situation presently is:

- 39 channels of Phase 1 FEBEE (AGATA + GALILEO loan)
- DAQ is operational
- The GTS Trigger processor for 255 inputs operational



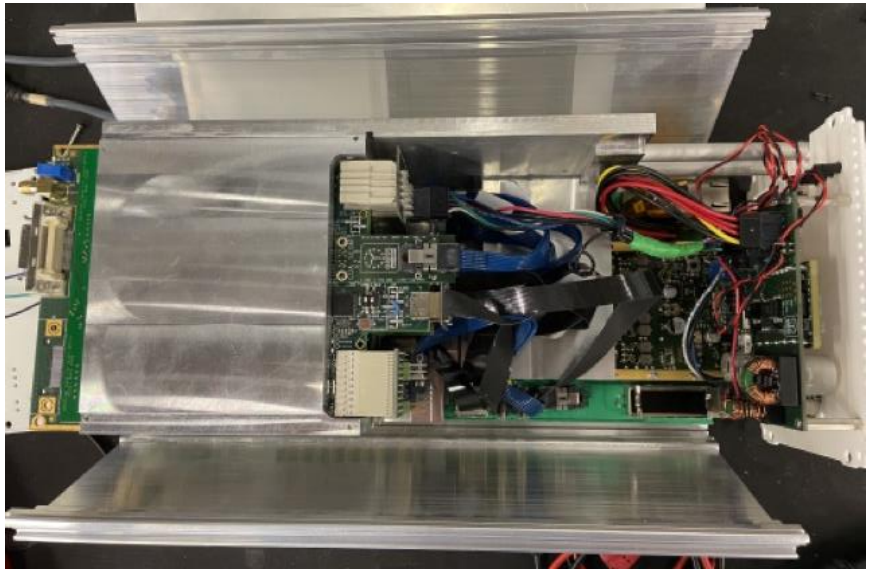
First full integration of a Phase 2 channel (DIGOPT12 – PACE- STARE) achieved at LNL in February-March 2022

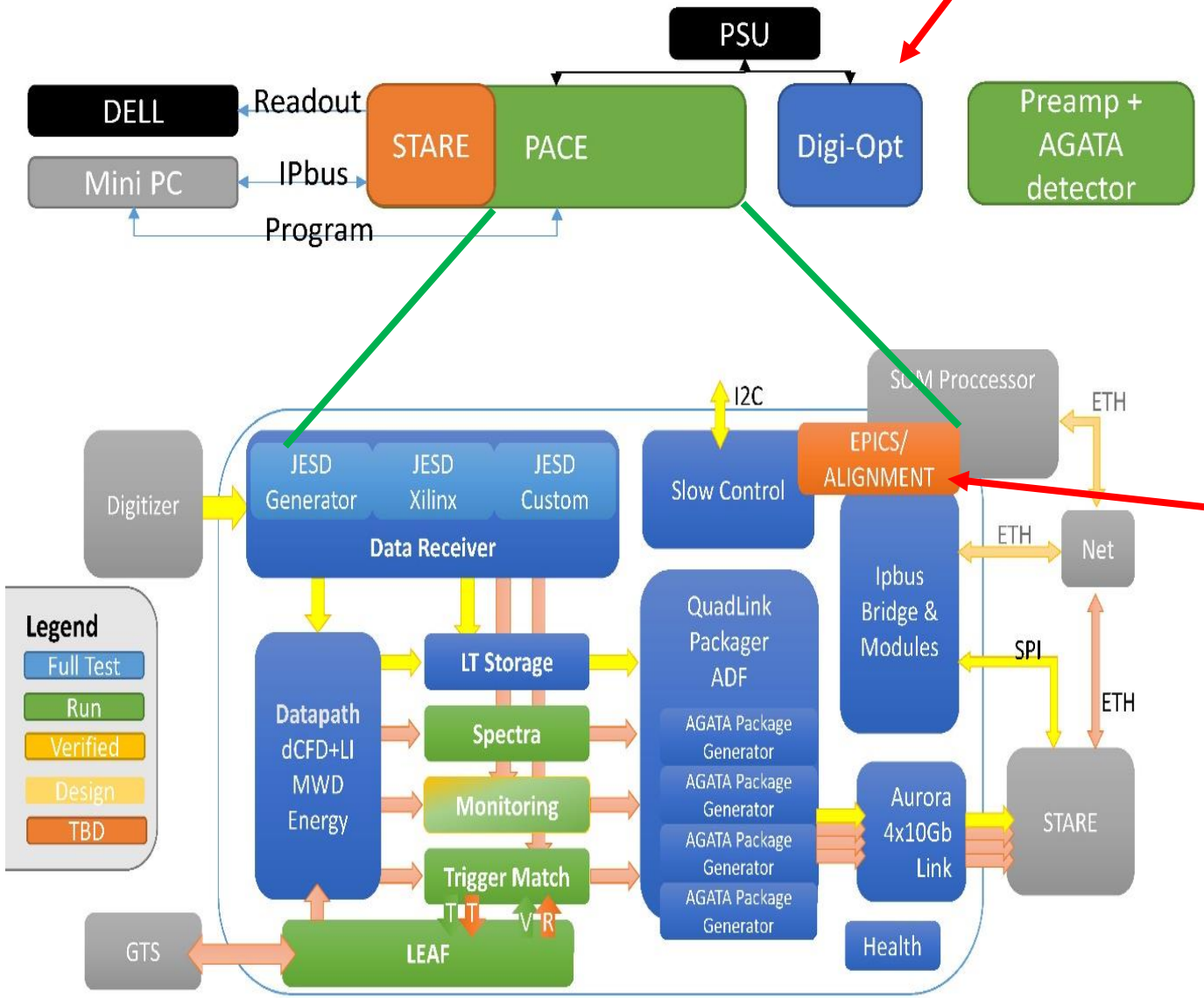
First Detector measurement achieved in October 2022

Since : GTS integration, performances checks and data taking

Phase 2 FEBEE status

The team is working on the DigiOpt12 ver 3.7 (mounting a Texas Instruments ADC32J44 flash ADC chip)



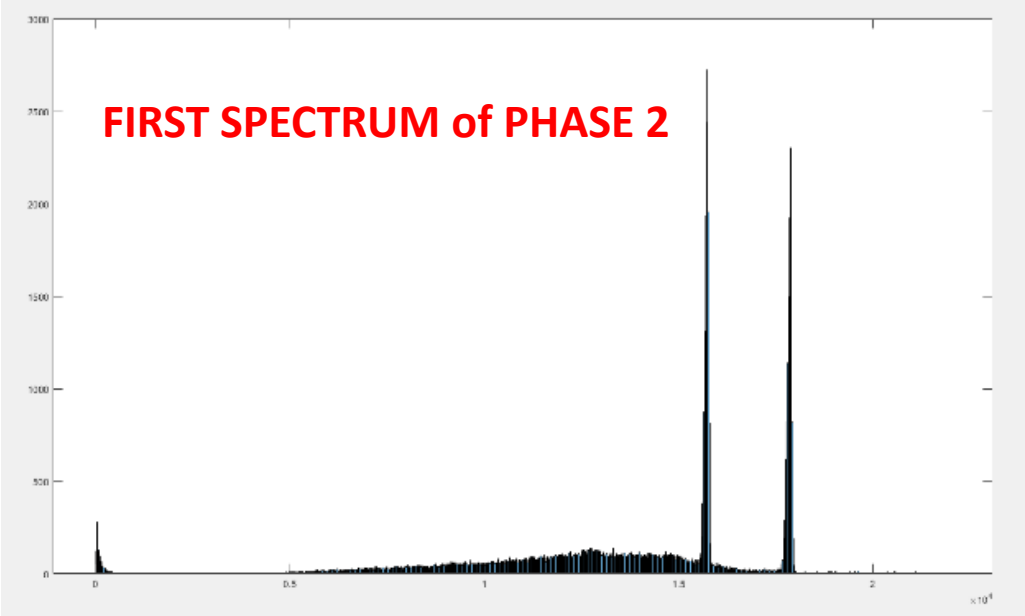


IFIC-GANIL for GTS and embedded linux implementation.

Status of the test bench@LNL

Full data path using an AGATA detector
+ DIGOPT12
+ PACE and its firmware (IFIC, GANIL, IPHC)
+STARE (IJCLab)
+readout (IJClab-IP2I)

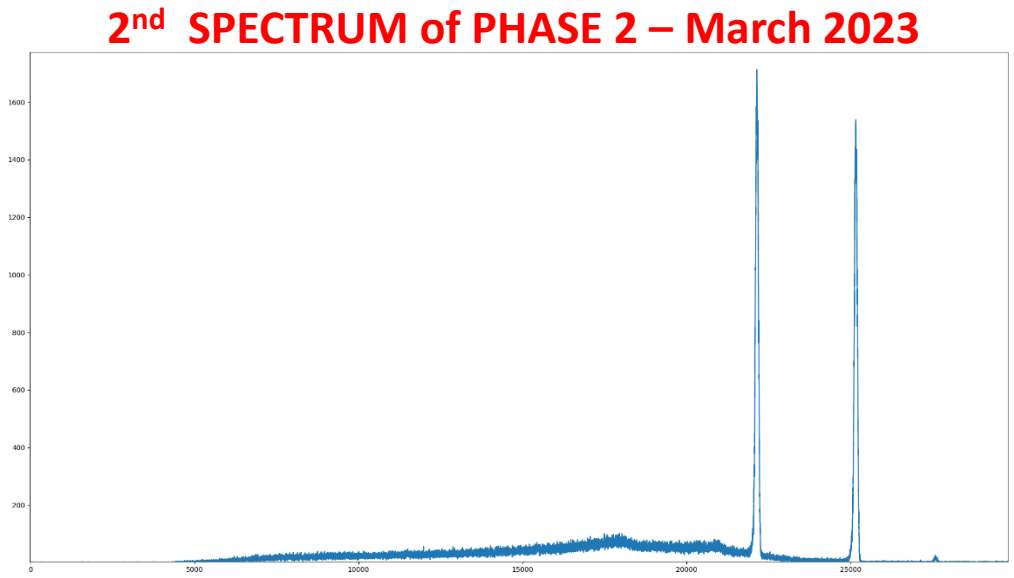
Phase 2 FEBEE status



1. The data transmission errors in the transfer of the samples through the DIGIOPT12-AGREGATOR-FPGA. The inversion in some bytes produced spikes in the data that are triggering the dCFD.

→A full report on the problem was prepared and a meeting was call on 22nd of February. Sloved the situation

2. The measured resolution is now ~2.9 keV at the ^{60}Co energies to be compared to 2.7 keV with an analogue electronic chain on the same detector; Tests will continue now with fully mounted and correctly grounded electronics. Implementation of the IPHC MWD (June 2023). Better results to be confirmed



3. Embedded Linux done

4. GTS alignment (July 2023 at GANIL)

5. Preparing the migration to SMART. First SMART Tree under production (GANIL)

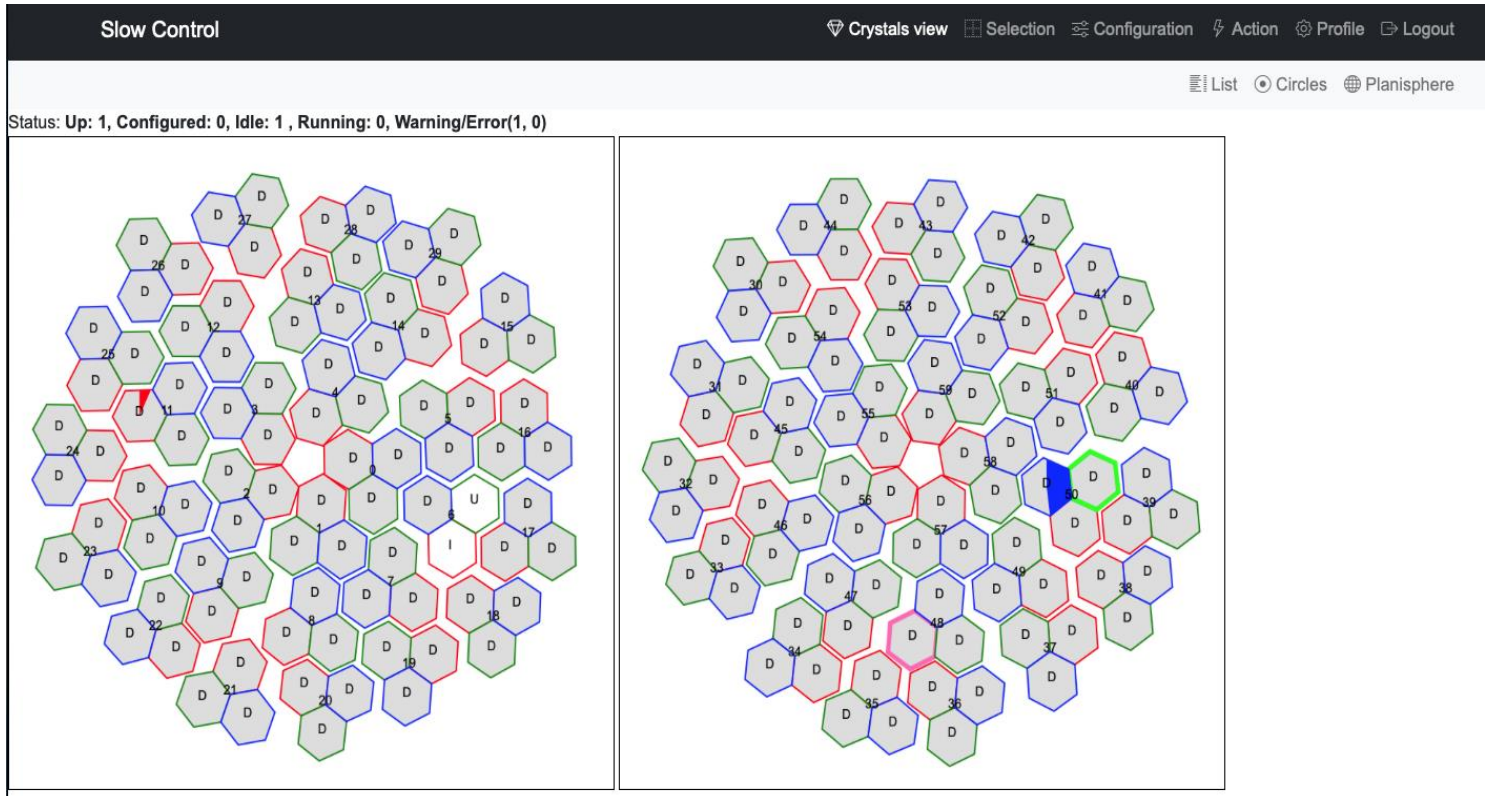
Phase 2 FEBEE status

Read-Out and Control Software (IPHC-IP2I)

A technical specification for the software has been distributed
https://gitlab.in2p3.fr/agata/daq/starecontrol/-/blob/master/doc/technicalSpecSlowControl.pdf

- ❑ Major progress have been done.
- ❑ Layout of the channels are done.
- ❑ Work on the connection to the IPbus also done with simulator.
- ❑ Server installed with the full systems ASAP.
- ❑ To be delivered by end of 2023.

The team has also in charge the development of the numerical oscilloscope.



Since 21st of March,IPHC can access a real STARE card @ Orsay ! Tests on-going

The current target for delivery of the first phase 2 batch is end of 2023 beginning of 2024.

A plan could be to use the 6 months of the 0° degree campaign installation to implement the Phase 2 in the running system. –to be discussed –

Data flow and Acquisition

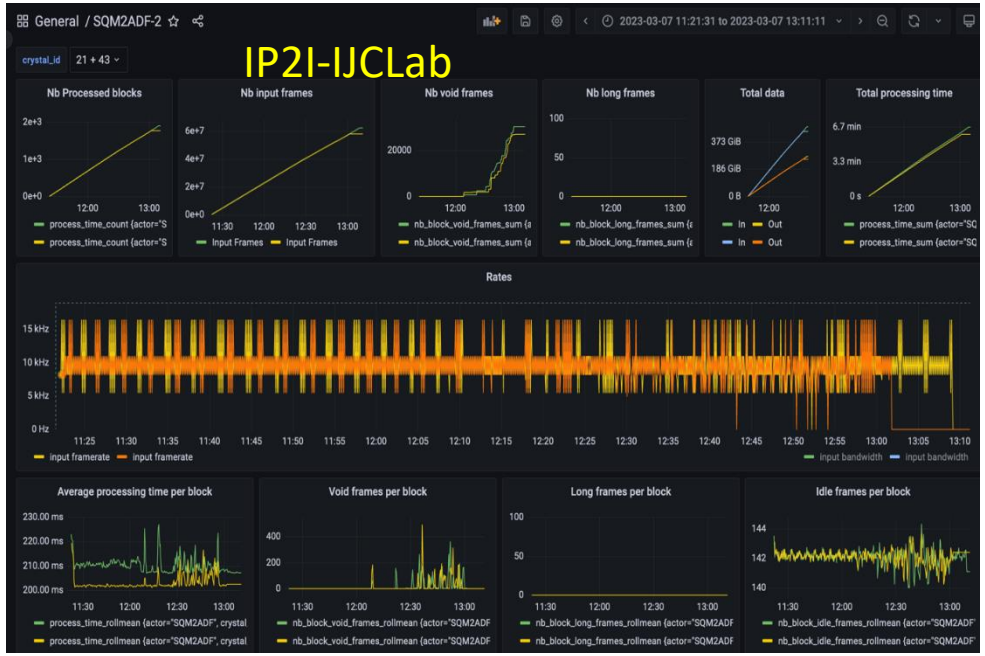
The chain STAREEmulator → SQM → MPH → SQM2ADF → Consumer has been integrated in a DCOD environment using the new C6400 machines (Debian 10).

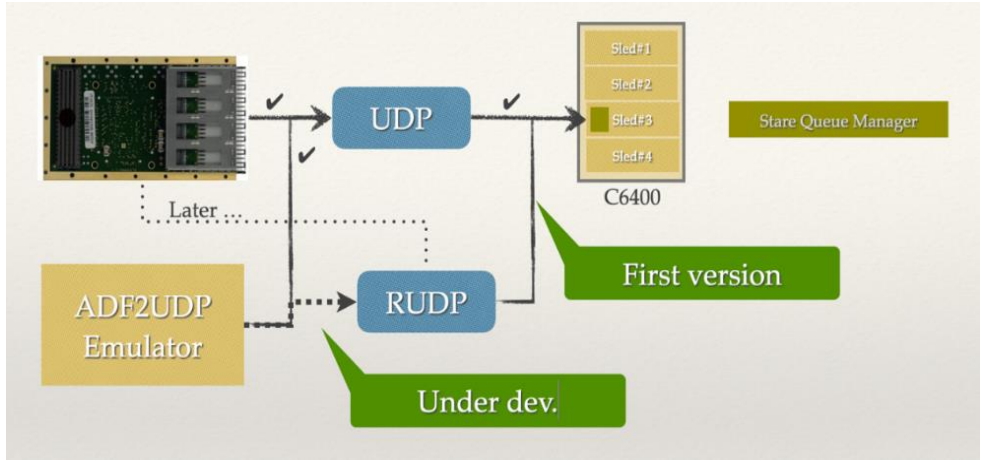
SQM2ADF benchmarked at 85 kHz 3 threads with frame compression.

The team has tested 2 STAREEmulators sending data to 2 SQM into 1 machine. Seems ok at < 50 kHz.

More monitoring, still under developments, added at the lowest level to new actors is under development.

→AGATA Analysis workshop 11-16 September 2023 at LNL - Save the date distributed





PSA-Tracking R&D

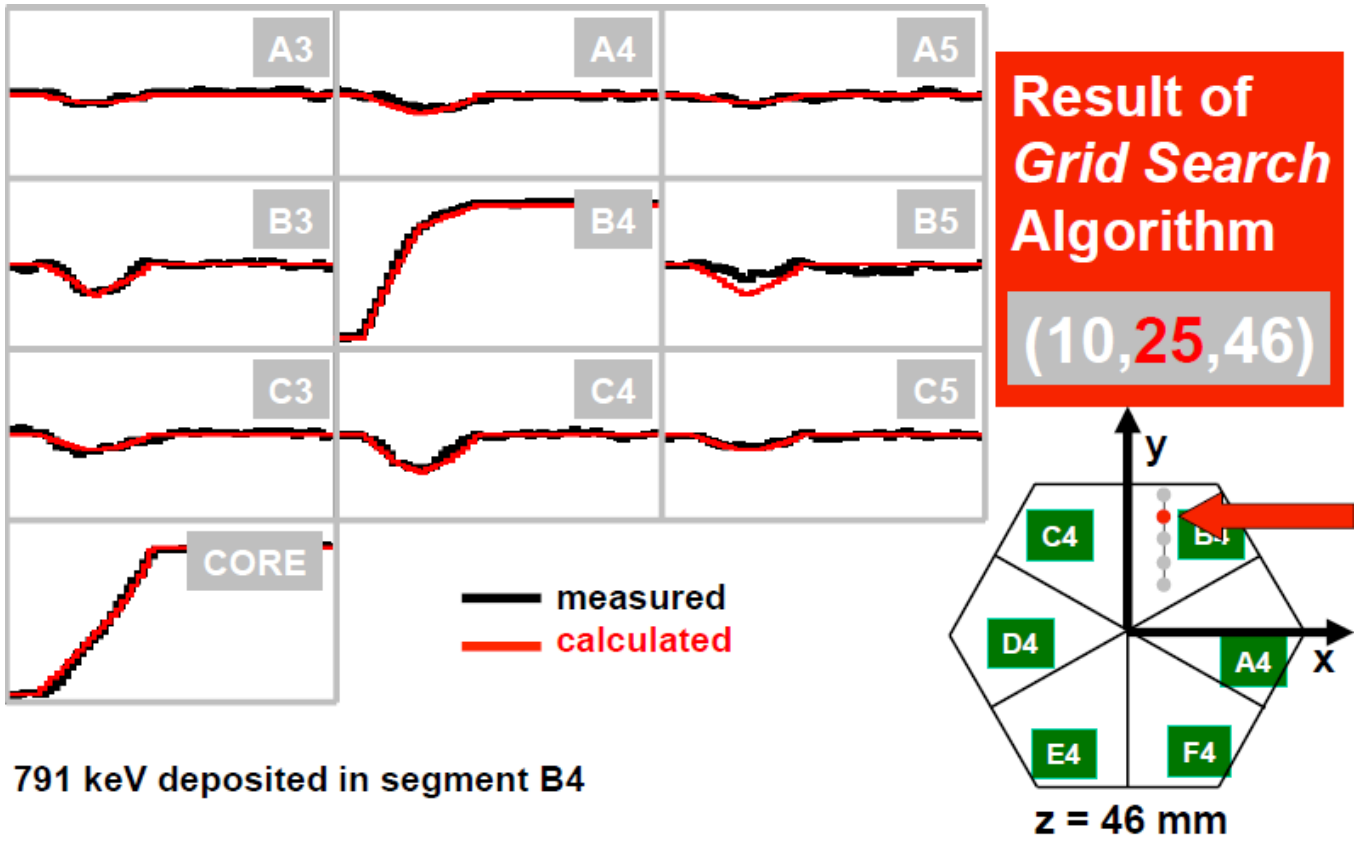
- ✓ 2nd Machin learning workshop was organized by J. Ljungvall on the 17th of January. https://indico.in2p3.fr/event/28625/
- ✓ Source measurement at LNL

Liverpool Scanning table

Strasbourg Scanning table

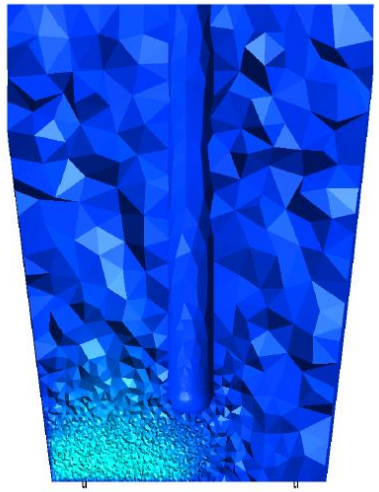
Salamanca Scanning table

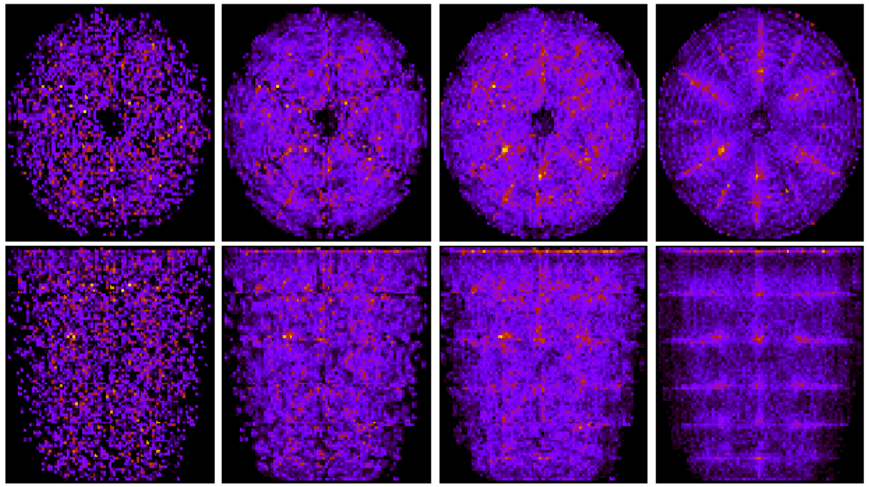
Lyon : preparing and contributing to the Strasbourg scan measurement



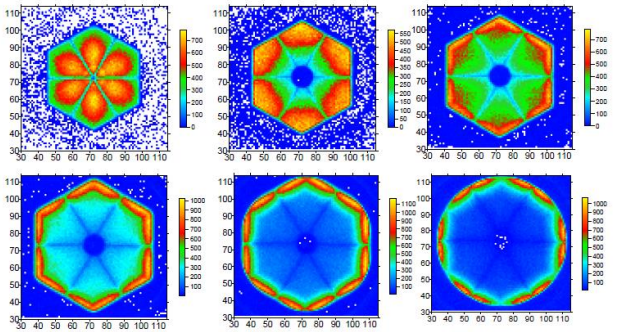
PSA-Tracking R&D

IJCLab A base de simulations, changer les paramètres du cristal





IPHC Scanner chaque détecteur



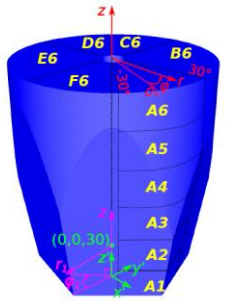
PSA-Tracking R&D

Machine learning

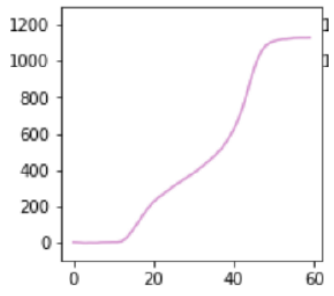
ip2i

Appliquer des auto-encodeur pour

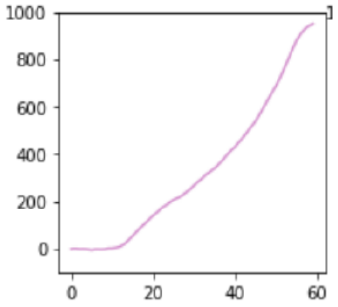
- Réduire les données
- Amélioré le signal sur bruit
- Détecter les anomalies



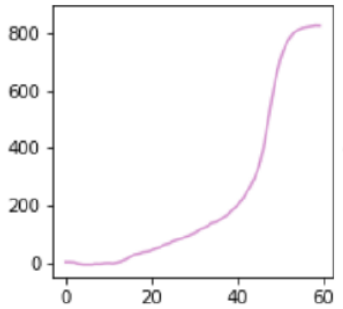
Cas 1



Cas 2



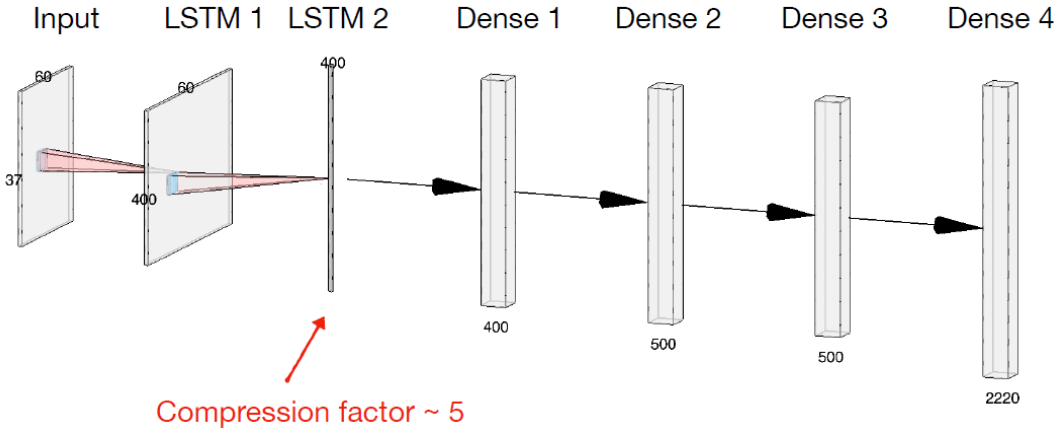
Cas 3



Empilement de signal ou Multiple interactions ?

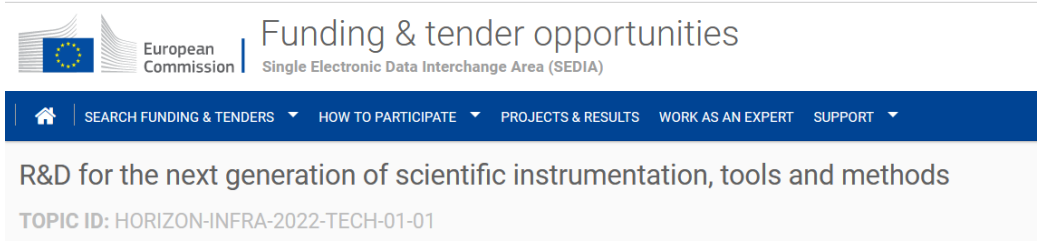
Un χ^2 donne une estimation pour la détection d'anomalie

Composition of the neural network:



NN entrainé sur les bases simulées

- Prochain jalon : détection des interactions multiples par segment
- Full PSA par ML
- Accélération PSA par GPU
- Un mix de ça



HORIZON-INFRA-2022-TECH-01-01

The INFRATECH initiative will be the seed for the R&D phase of the next decade in AGATA. These R&D's could be the technical specifications of a major upgrade of AGATA for Phase 3 [2030-2040]. The delivery of the INFRATECH proposal for AGATA will be a Super-AGATA cluster, from capsules to data processing, including all the new technologies we are willing to introduce. We propose four pillars.

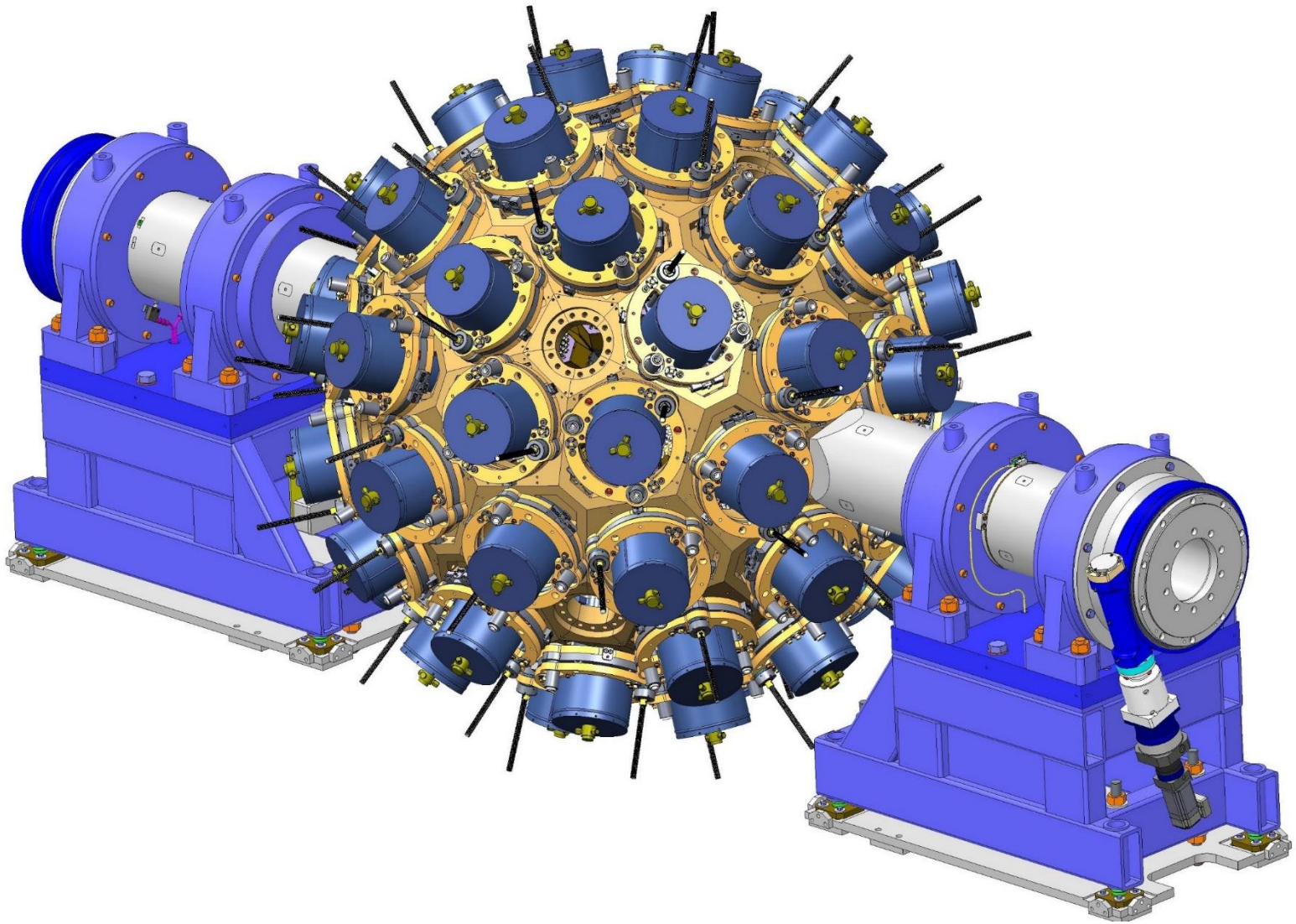
- Detectors developments (capsules and cryostat)
  - - p-type highly segmented encaspsulated HPGe (WG – Detector – INFN-CNRS-MIRION)
  - Improved cryostat with electrical cooling ((WG – Detector – IKP- CTT)
- Front-end electronic development
  - ASIC Preamplifier in the cold part of the cryostat (WG FEBEE - INFN-IFIC-CNRS- CEA)
- Computing and algorithms developments
  - New Algorithms (NN, IA, GPU) (WG DAQ -CNRS)
  - Reducing the power consumption for climate change
- Applications
  - Nuclear imaging for health, national security and nuclear waste fields

IMATRA –
IMAging and TRAcking of radiation for science and society
P.I Paul Greenless (Uni. Jyvaskyla)

Submitted on
20 April 2022 time → Rejected.

Horizon Europe -Work Program 2021-2022 – TNA ACCESS

→ EURO-LABS bid approved January 2022

→ TNA access for LNL (physics campaign)

→ "Optimal employment of travelling gamma detectors (INTRANS)"
Participants: GSI (coordination), IJCLab, LNL Legnaro
→ Technical support