AGATA

LNL pre-PAC 1 - November 2021

THANK YOU ANDRES

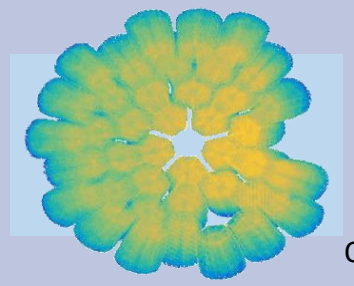
AGATA
ADVANCED GAMMA TRACKING ARRAY

GANIL
laboratoire commun CEA/DRF — spiral2 — CNRS/IN2P3

After 7 years of campaigns, on the 6th of September, AGATA left GANIL

- 29 experiments
- 558 To of data
- 6568 hours beam on target
- 14 034 elog entries
- 2386 days of LN2 surveillance
- 11,5 Tons of scientific equipment

Experiments performed in 2015-2021 at GANIL with AGATA



RIB

SHE Cross section $^{238}U+^{238}U$ in MNT

Search for Double Gamma decay in ^{137}Cs source

Reaction mechanism : Fission of Light Hg

Octupole – Quadrupole correlation in ^{112}Xe

^{208}Pb

Studies of excited states in $^{102,103}Sn$

Octupole correlation in ^{207}Pb

Evolution of collectivity around N=50: lifetime measurements $^{104,106}Sn$

Exploration of alpha-cluster : the unique case of ^{212}Po (^{208}Pb + α)

N=126 Xe+Pt spectroscopy after MNT

Evolution of collectivity around N=50: lifetime measurements ^{94}Ru

Shape transition in the neutron-rich W isotopes

Transition Quadrupole Moments in $^{166,168}Dy$.

Search for isoscalar pairing in the N=Z nucleus ^{88}Ru

^{100}Sn

$i_{13/2}$ single particle state in ^{133}Sn and high spin in ^{108}Zr

Isospin Symmetry Breaking in the A=63,71 mirror nuclei

^{132}Sn

Shape evolution in neutron rich fission fragments in the mass A~100 region

Above barrier narrow resonances in ^{15}F

^{68}Ni

^{78}Ni

Shell evolution around N=50: ^{81}Ga spectroscopy

Deter. the $\alpha+^{15}O$ radiative capture rate

Evolution of collectivity around N=52: lifetime measurements in $^{83,84}Ge$

Evolution of collectivity around N=40: lifetime measurements in $^{73,75}Ga$

^{48}Ca

Evolution of collectivity around N=40: lifetime measurements in ^{64}Fe

Proton-neutron interactions across the N = 28 shell closure via $^{47}K(d,p)^{48}K$

Lifetime measurements of excited states in neutron-rich C and O isotopes

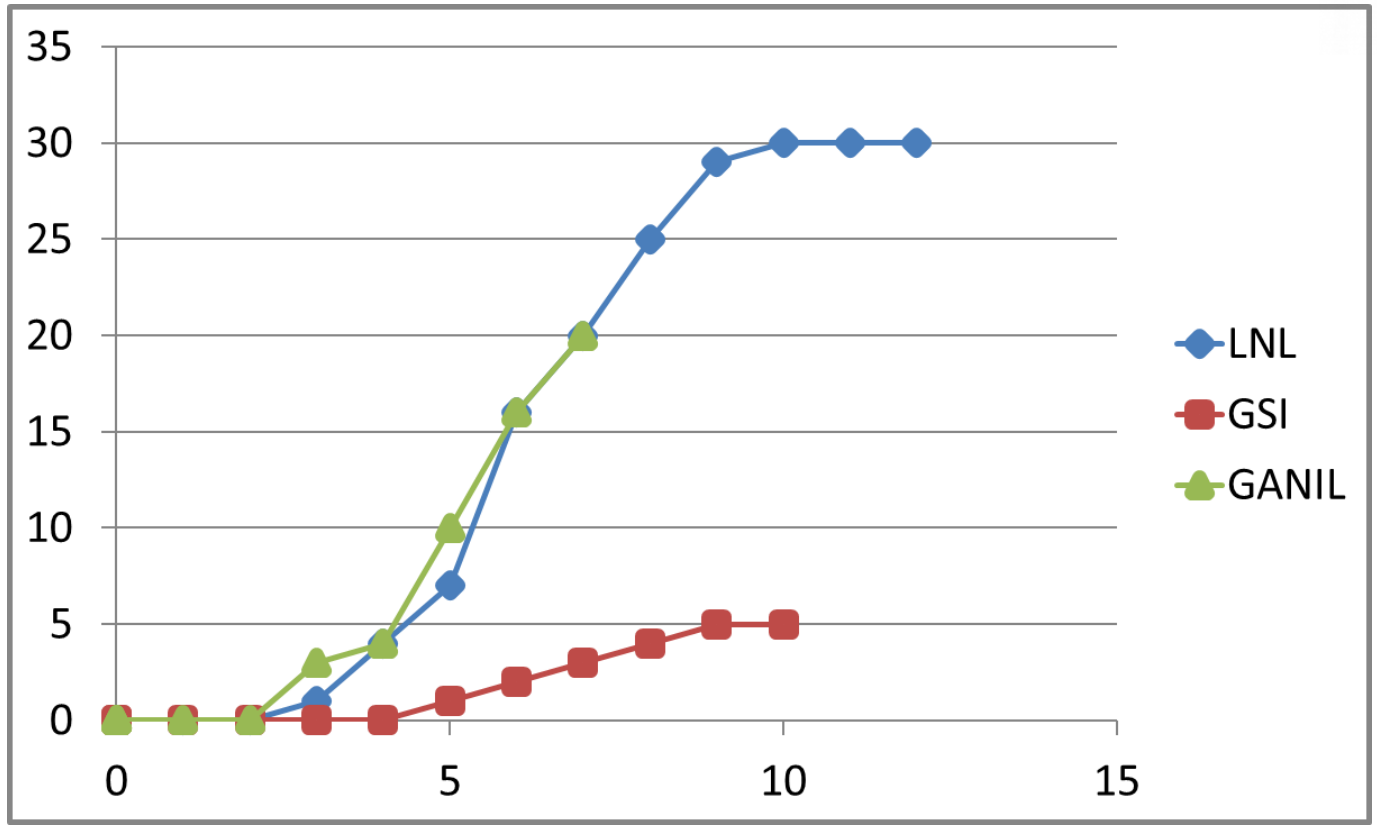
Evolution of the shell structure in the region of neutron-rich Ti isotopes

The lifetime in ^{23}Mg as a probe for classical novae models

3-body contribution in ^{20}O structure

Is there a problem with protons in N=28 nucleus ^{46}Ar ?

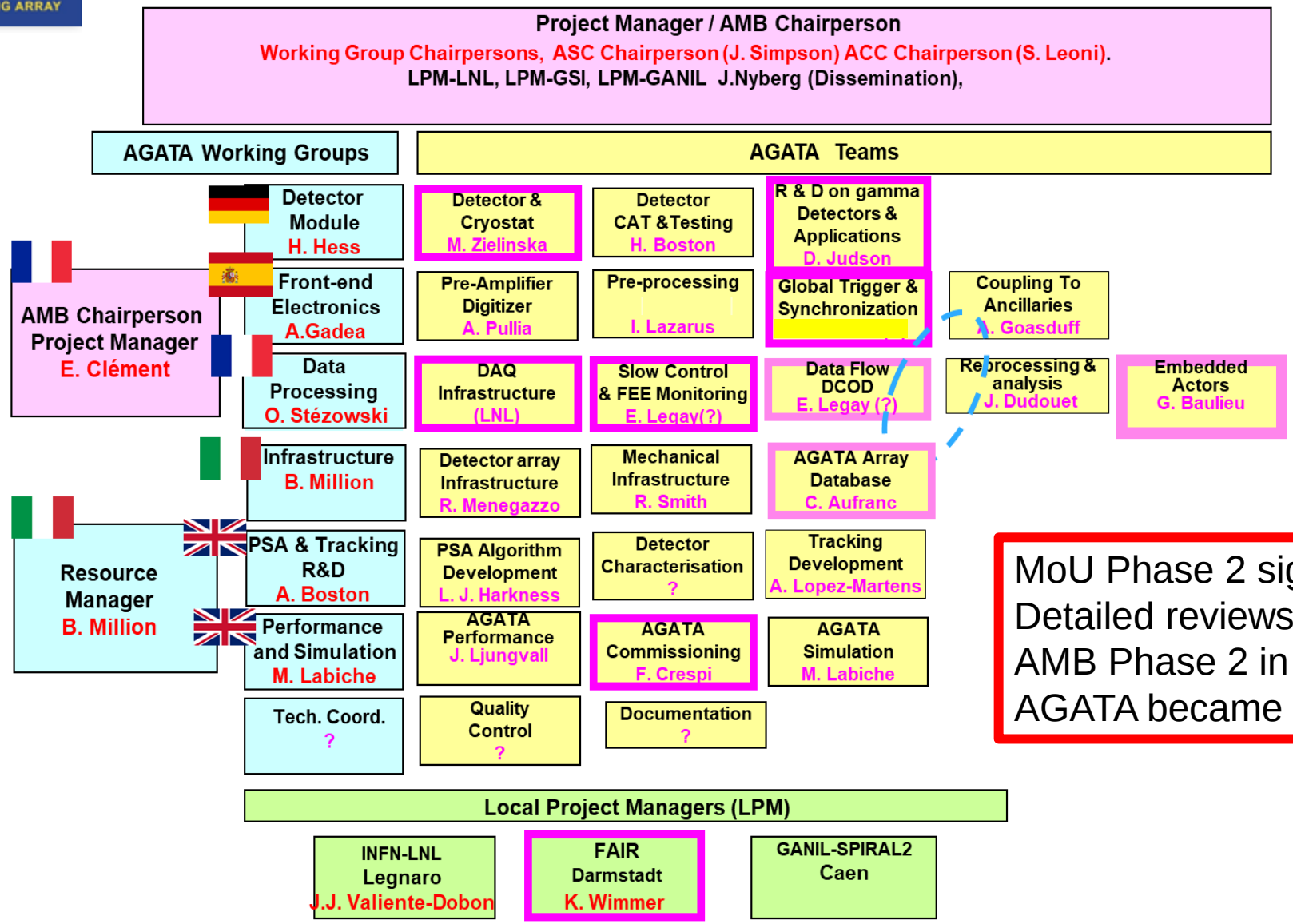
Integrated number of scientific papers



From [2015,2016,2017] fully analyzed experiments, we get 1.35 paper / experiment in average

In the corresponding years [2019, 2020, 2021], 40-50 % of the GANIL Nuclear Physics publication is AGATA

- Complete set of bound negative-parity states in the neutron-rich nucleus ^{18}N S. Ziliani *et al.* Phys. Rev. C 104, L041301 – (2021) (AGATA-VAMOS-PARIS)
- Accessing tens-to-hundreds femtoseconds nuclear state lifetimes with low-energy binary heavy-ion reactions M. Ciemała Eur. Phys. J. A (2021) 57:156 (AGATA-VAMOS-PARIS)
- Lifetime measurements in the even-even $^{102–108}$Cd isotopes M. Siciliano *et al.* Phys. Rev. C 104, 034320 – (2021) (AGATA-VAMOS)
- Evidence for enhanced neutron-proton correlations from the level structure of the N=Z+1 nucleus ^{87}Tc X. Liu *et al.* Phys. Rev. C 104, L021302 – (2021) (AGATA-NEDA-DIAMANT)

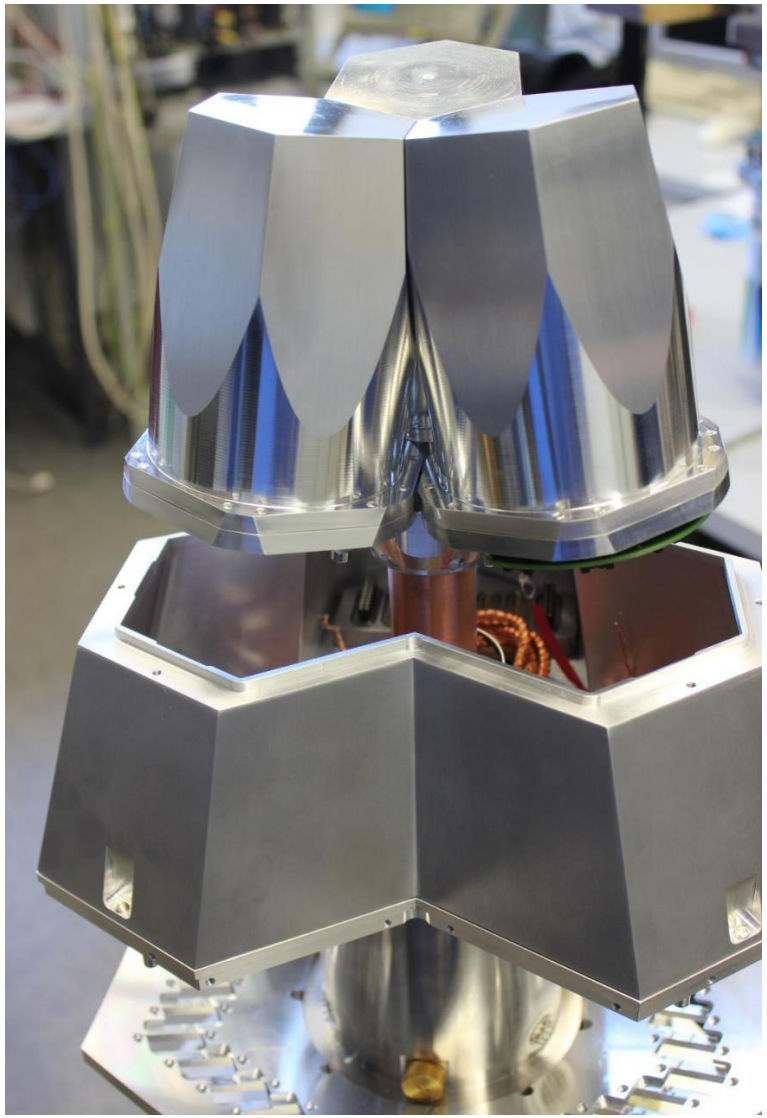


MoU Phase 2 signed by major countries
Detailed reviews successfully passed in 2020
AMB Phase 2 in place
AGATA became a « IR » in France

Detector status

The total number of delivered AGATA capsules is 54

1 x in Salamanca for scanning
10 x in IPHC Strasbourg for maintenance post GANIL
2 x in Liverpool for scanning
7 x Mirion for repair(1) + for annealing (6)
22 x in Cologne for maintenance post GANIL
12 x Legnaro



9 detectors are successful annealed by MIRION

Cluster Assembly and Maintenance
ATC17: assembly finished by CTT, delivered to Italy week 42
ATC18: assembly finished by CTT, delivered to Italy week 42
ATC01 & ATC07: refurbishment completed, delivered to Italy week 42
ATC08 equipped with (A006, B013, C006) tests ongoing
ATC06 equipped with new feedthroughs and cabling
ATC05 readjustment of cooling finger
ATC10, ATC11, ATC12 & ATC14 getter annealed, leak tests, tests of the electronics ongoing

→ Early 2022 target is 11(1) ATC in LNL.

Detector Infrastructures

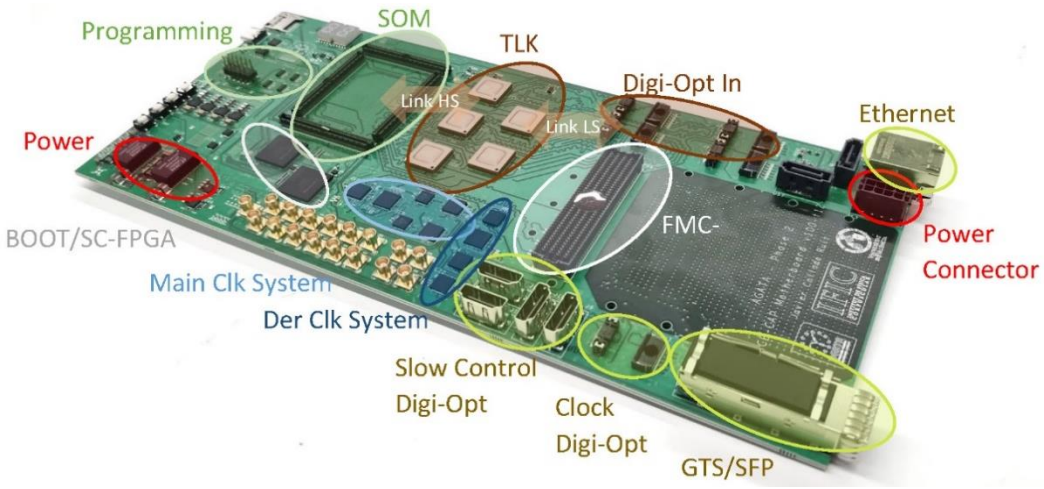
Mechanics :
Intense activity in the last week to assemble, align and deliver the 2π honeycomb and shaft

Long discussions on the alignment and test procedure

LVPS: prototype was tested in AXIS, Saclay and GANIL
AUTOFILL: mismatch between LN2 LNL Autofill project and IRFU timing.
→ delivery delayed to 6th-17th of December
HV: New HV system CAEN SY 4527 was bought
→ System available and operation for Christmas

FEBEE status

Initially the AGATA collaboration intended to install at least 10 channels of Phase 0 electronics and as much Phase 1 electronics as available for the starting of the AGATA campaign at LNL.



The emergency situation caused by the Sars-Cov-2 pandemic, difficult maintenance after 15 years, and the exclusion of triple coexistence of Phase 0-1-2 cancelled the possibility to start the campaign with the Phase 0 electronics installed.

The situation presently is:

-The Phase 0 electronics will not be installed at LNL
-The 28 channels of Phase 1 electronics belonging to AGATA will be used.
-The GALILEO LNL collaboration will lend 12 DIGIOPT12 Digitizers + 12 GGP to AGATA.
- Delays in the Phase 2 design and prototyping phase

In 2022 there will not be Phase 2 electronics channels (except for test) in the setup
AGATA will run with 40 channels based on the AGATA Phase 1 + GALILEO loan.

Data flow and Acquisition

https://agata-elog.ijclab.in2p3.fr:8989/

Intense work for the LNL preparation

- A DCOD Virtual Machine has been produced to test the coupling with the XDAQ LNL acquisition system for the coupling with the ancillary detectors.
- The VM has been receipted and is operational
- The very first step (readout of electronics) of the coupling AGATA-LNL is currently under investigation

Simple processing chain (Producer/filter/consumer) emulated to study GPU integration
The filter is based on a Neural Network working on traces

Organization of several meetings to discuss the writing of a Data management Plan (DMP) for the Phase 2.

A very light catalogue of the existing data sets {2010-2021} has been produced

The objective is to bring the so far collected data to the environment foreseen by the Data Management Plan for the Phase2.

PSA-Tracking R&D

Liverpool Scanning table

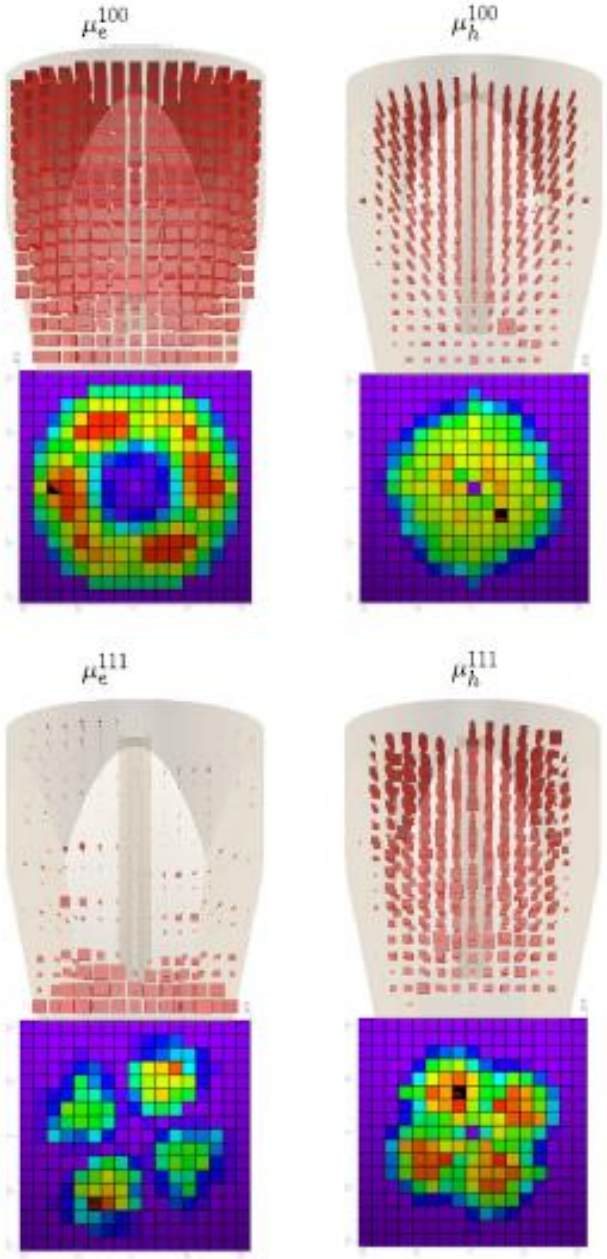
- A009 scanning
- ORTEC have supplied the key characteristics (Impurity Gradient etc) for their prototype detector crystal. This will allow the E-field simulation work to commence

Strasbourg Scanning table

- Limited capacity to work at the moment due to other commitments.
- Expect to be able to receive the A005 detector in late 2021/early 2022.

Salamanca Scanning table

- A005 detector mounted in the Salamanca test cryostat was received in early September and commissioning is underway.



Full-volume characterization of an AGATA segmented HPGe gamma-ray detector using a ^{152}Eu Source , B. De Canditiis, et al, EPJA volume 57, Article number: 223 (2021)

Pulse-shape calculations and applications using the AGATAGeFEM software package J. Ljungvall , EPJA volume 57, Article number: 198 (2021)

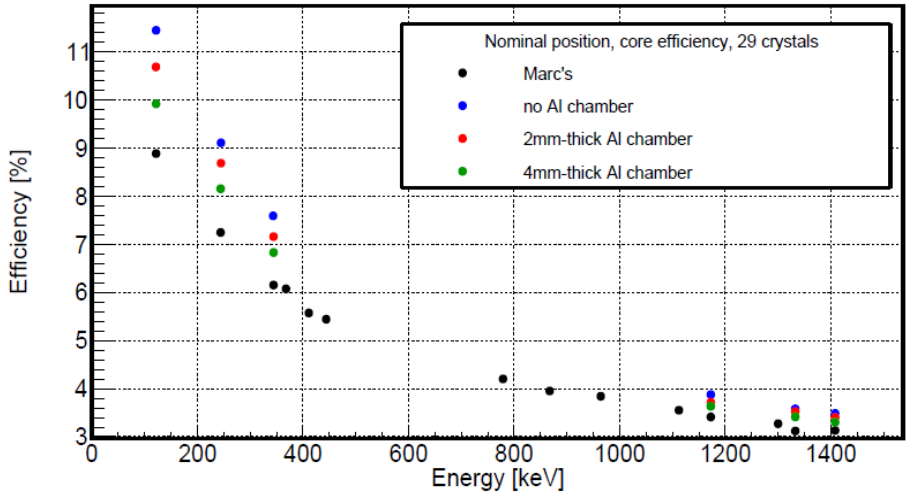
Position uncertainties of AGATA pulse-shape analysis estimated via the bootstrapping method M. Siciliano, et al EPJA volume 57, Article number: 64 (2021)

Simulation, performances and Commissioning

The simulation WG is now meeting on weekly basis to prepare the LNL campaign

On the agenda are:

- The array efficiencies curve at β=0 and β ≠ 0 for 15 and 13 clusters and for two configurations (Nominal and Compact)
- Example of Experiment simulation (AGATA+PRISMA or others)
- Simulation workshop/school (format and earliest date)



AGATA code users have reported a bug in the GEANT4 physics of GEANT4 for Compton events.
For ~7% of the Compton events, the Compton formula is not satisfied. This is being investigated by the WG. The AGATA physics list is being checked and the WG will make the corresponding Physics list class modular in that process.

A new leader for the Commissioning WG is needed following the departure of Ph. John in the industry sector.
F. Crespi is already involved in this commissioning group at LNL and is appointed

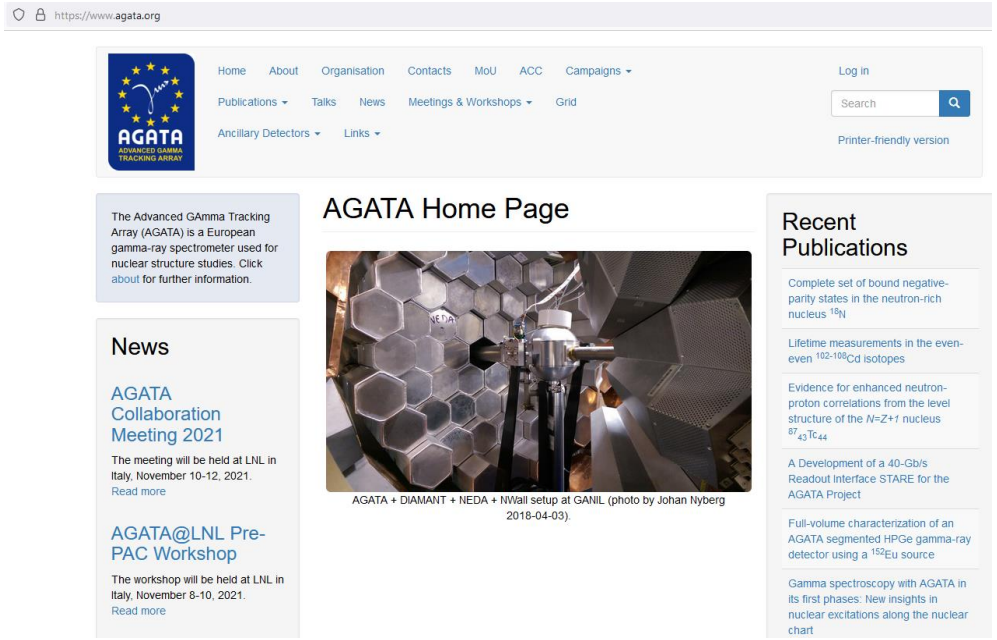
Dissemination

- **Technical Papers –**

Two technical papers have been published in the framework of the MUGAST campaign :
MUGAST reference paper : https://doi.org/10.1016/j.nima.2021.165743
The HECTOR 3He target : https://doi.org/10.1016/j.nima.2021.165830

- **Web pages**

During the summer 2021 the website of the AGATA Collaboration Council (ACC), which was hosted at STFC Daresbury and managed by John Simpson (JS), was moved to the website https://www.agata.org/, which is managed by Johan Nyberg (JN).

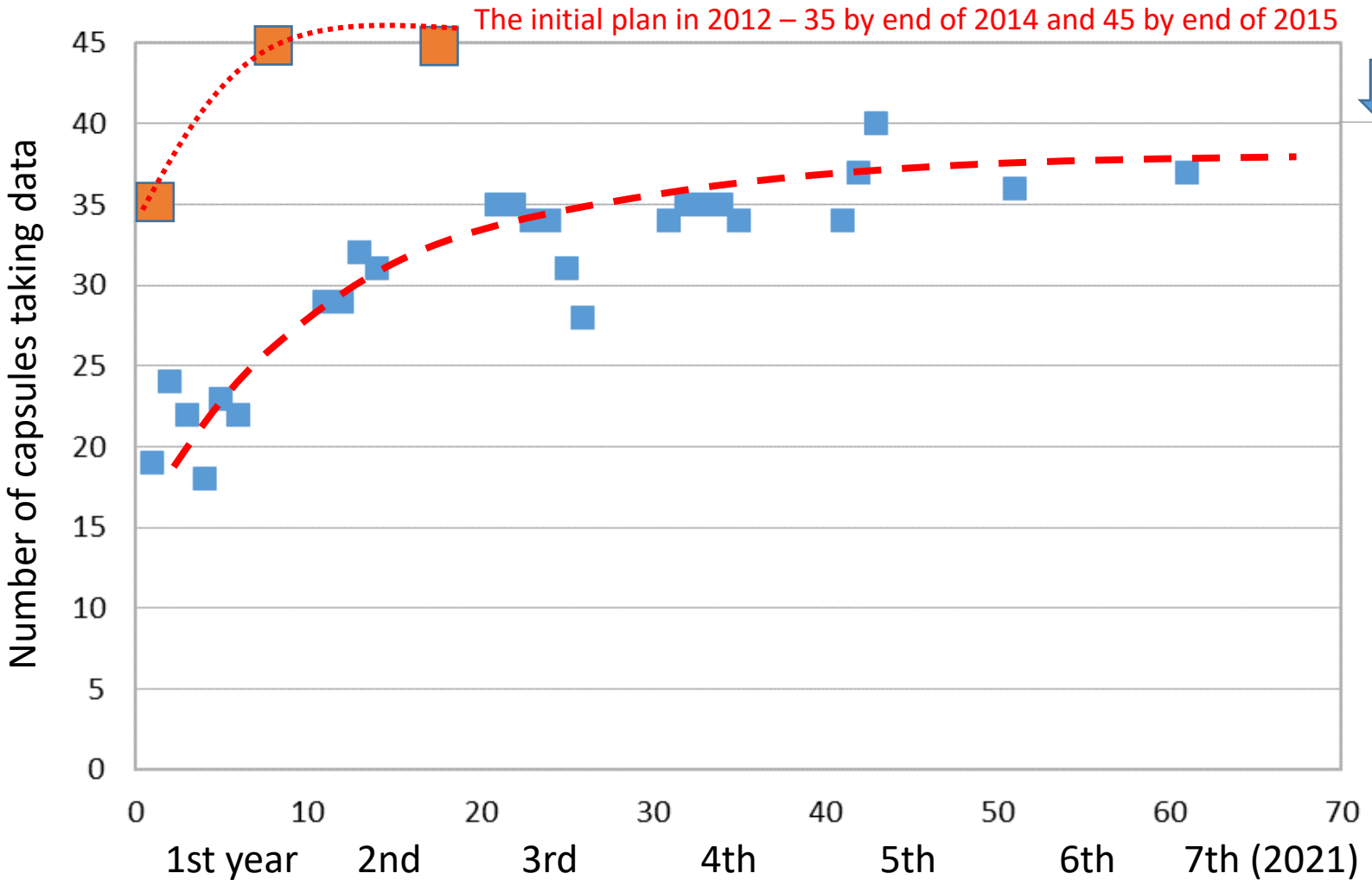


GANIL Campaign achievements

- No failure of the cryogenic part
- Complete change of technology in the data storage to CEPH technology (/agatadisks/)
- Data acquisition system major upgrade Narval → DCOD – Ready for phase 2
- Continues integration of femul and agapro
- New tools to make the data more « accessible » (AGASpy, femul::TreeBuilder, documentation)
- Phase 0 stabilization (ATCA fuses, no more LINCO1, cooling plates)
- Phase 1 (GGP) put on-line successfully
- Improved PCIe readout libraries (Crystal Producer) for both GGP and LINCO2
- Great progresses in the global understanding of the response function of the array (efficiencies, performances, data rate, angular correlation)
- New trigger processor
- Coupled to NEDA – DIAMANT (GTS based), VAMOS (VME→GTS/numexo), MUGAST, PARIS, DSSD …
- Successful integration of NUMEXO2 and its TP in AGATA via the GTS and the DCOD/TM/RCC systems
- GRID transfer is a routine
- Topology Manager
- Documentation (yes !)
- Data analysis schools
- We overcame the covid19 issue

GANIL Campaign feedbacks

efficiencies



Like a β-decay, new detectors compensated the detectors under maintenance

Rapid increase after the maintenance done post-GSI during the first 3 years

Saturated after ~5 years for simple failures like core FET broken or more rarely problems with cryostat due to the long operating time (some 7 years in a row)

A similar fast increase should be observed in the first years at LNL

GANIL Campaign feedbacks

efficiencies

Source efficiencies understanding made huge progress during the GANIL phase and we now understand the discrepancies

The in-beam efficiency is hard to estimate because the reaction σ is not known

Extrapolation from radioactive sources has no sense:

- Multiplicity effect if nominal → compact
- Pile-up effects in FEBEE
- Occasional hardware effects

GANIL Campaign feedbacks

efficiencies

Status Report e661 (juin 2016) Spectroscopy of fission fragments (32 capsules) in compact
02/02/2017
A. Lemasson et M. Rejmund (GANIL)

The gamma efficiency from $\gamma\gamma$ coincidence in [low activity ^{152}Eu] using 344 keV - 778 keV, gated from above, is at 344 keV ~ 10.4 %
at 1.4 MeV, F=1.5

Experimental data :
(Doppler corrected and isotopically identified ^{100}Zr),
the gamma efficiency from the $\gamma\gamma$ coincidence 352 keV – 497 keV, gated from above, is at 352 keV ~ 5.6%.
a 1.7 MeV F=1

GANIL Campaign feedbacks

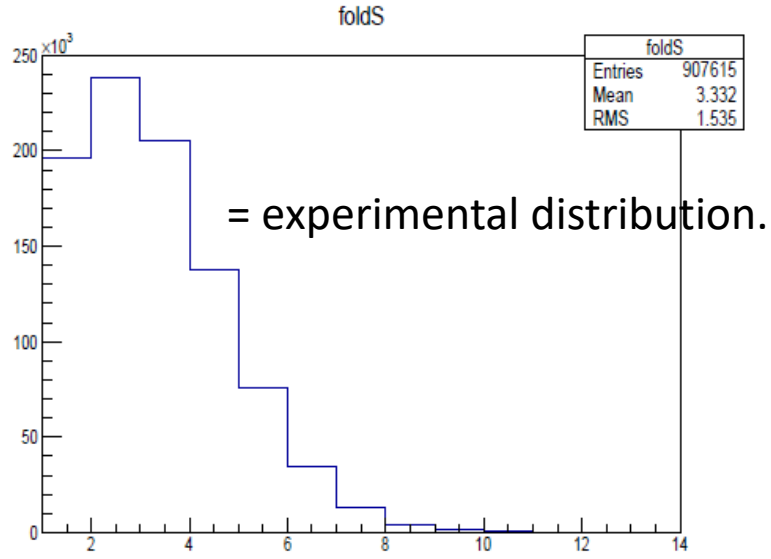
efficiencies

fission source in GEANT4 + exact geometry

/Agata/generator/gamma/band 200 300 8

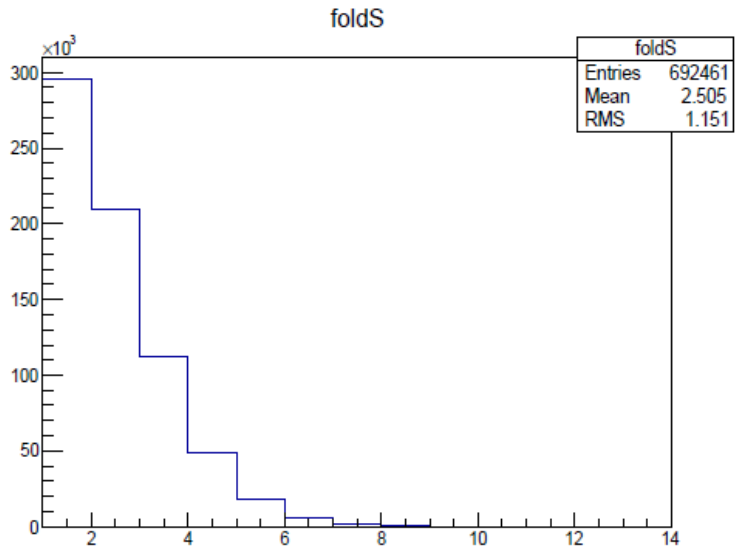
~^{100}Zr

Compact



= experimental distribution.

Nominal



GANIL Campaign feedbacks

efficiencies

fission source in GEANT4 + exact geometry

Table 11: Summary

Energy [MeV]	Config	Single	OFT (F)	MGT (F)
1.1	Nominal Mono Energy at Rest	4.4	6.1 (1.38)	6.2 (1.4)
1.1	Compact Mono Energy at Rest	8.1	11.3 (1.40)	11.4 (1.4)
1.1	Compact ^{60}Co at Rest	7.7	10.6 (1.37)	10. (1.33)
1.1	Compact Fission at Rest	7.5	9.6 (1.28)	8.1 (1.08)
1.1	Nominal Fission at Rest	4.2	5.7 (1.35)	5.1 (1.21)
1.1	Compact Mono Energy β=0.1	7.3	10.1 (1.38)	10.1 (1.38)
1.1	Compact Fission β=0.1	6.5	8.7 (1.26)	7.4 (1.07)
1.1	Compact Fission β=0.1 by $\gamma - \gamma$	6.1		

There is an obvious loss in compact configuration due to the multiplicity

ε 7.7% → 6.5%

F 1.37 → 1.26

GANIL Campaign feedbacks

efficiencies

A couple of FEBEE issues for a 10 days experiment at high rates → Including these losses in the G4 reading

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1.1	Compact Fission β=0.1 by $\gamma-\gamma$	6.1		
1.1	Compact Fission+FEBEE β=0.1	4.0		
1.1	Compact Fission+FEBEE β=0.1 by $\gamma-\gamma$	3.5		

54% losses between low activity source and in-flight fission source at high multiplicity and high counting rate (pile-up rejection, GTS bottleneck, backpressure from PSA limitations)
Addback Factor 1.38 → 0.94
E661 → 46% measured losses, F ~1

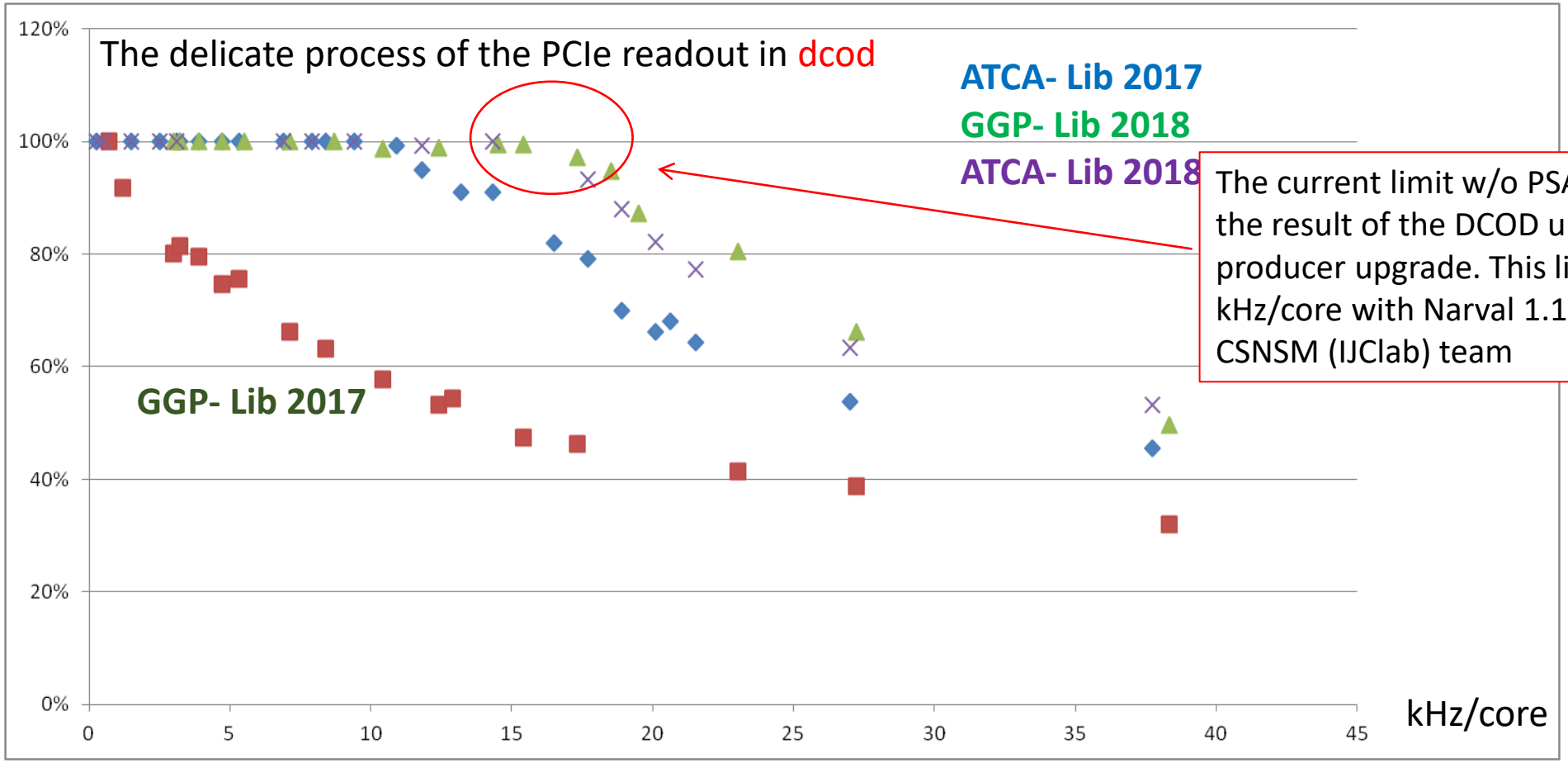
Message is that we understand the effects and we are able to simulate/reproduce the reductions.

GANIL Campaign feedbacks

Rate capabilities

Major release of the CrystalProducer in 2018 (D. Bazzacco)

→ Massive use of Threads in the DMA readout

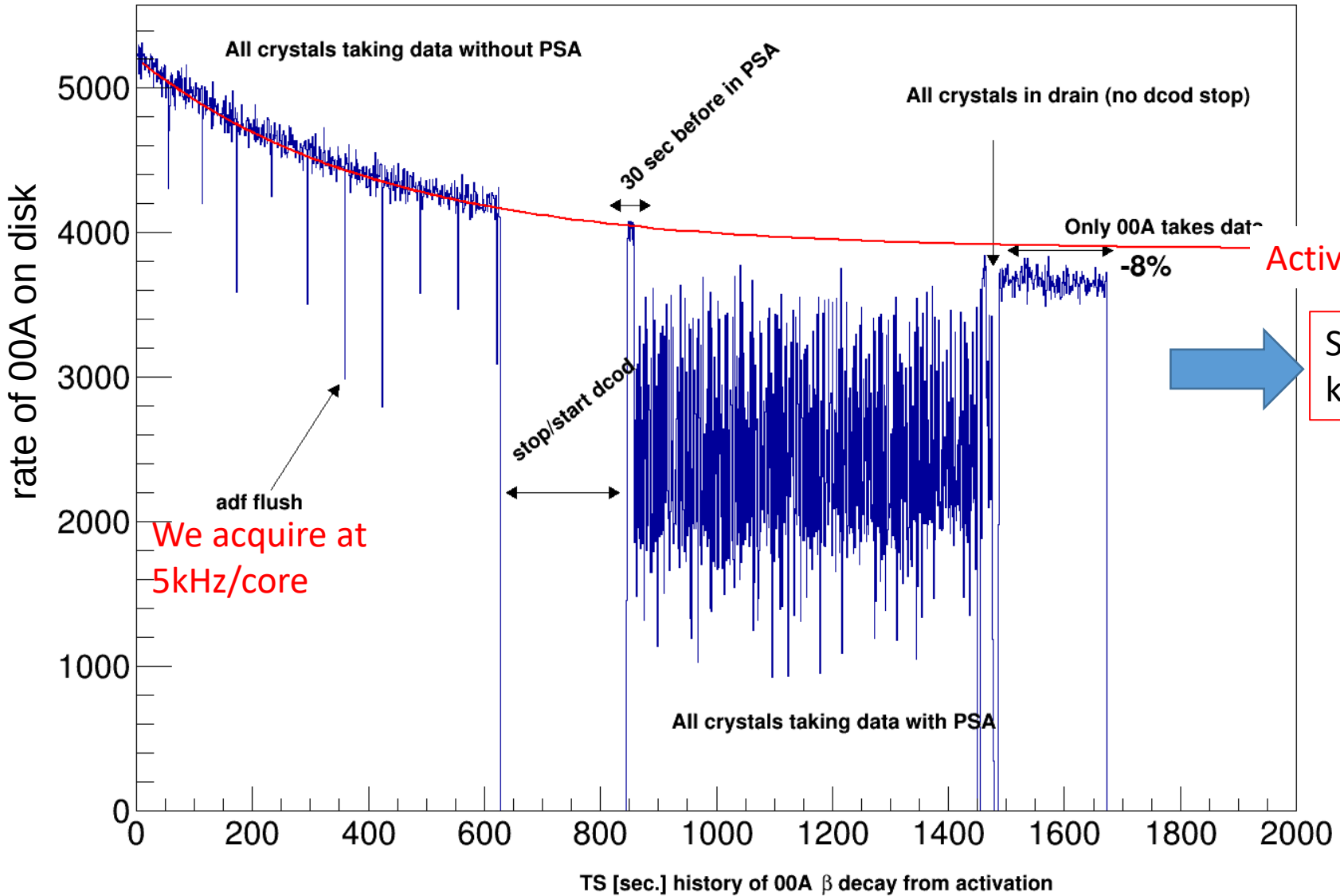


No Trace, no **PSA**, no Histo, only adf files ⇨ (We do not yet look at the limitation from the psa)

GANIL Campaign feedbacks

Rate capabilities

DCOD, β decay run from activation after beam stop.
All detectors acquire data



Stable conditions at 3.3 kHz/core validation

Conclusions

The main milestones of the past months are :

- The GANIL campaign has been completed.
- The AGATA dismounting has been done according to plan with the involvement of the Working Groups.
- AGATA has been transferred to LNL according to plan and the local installation has started.
- The Phase 2 HoneyComb and shaft have been delivered to LNL and installed.
- The maintenance of the detectors has reached its cruising speed
- All working groups are working for the LNL installation
- With the delays of the Phase 2 electronic, it has been decided to rely on the Phase 1 AGATA FEE (DIGOPT12-GGP) and LNL DIGOPT12_modified-GGP pool to equip a maximum of 40 capsules in 2022 for data taking.

GANIL Campaign feedbacks

Efficiencies at low energies

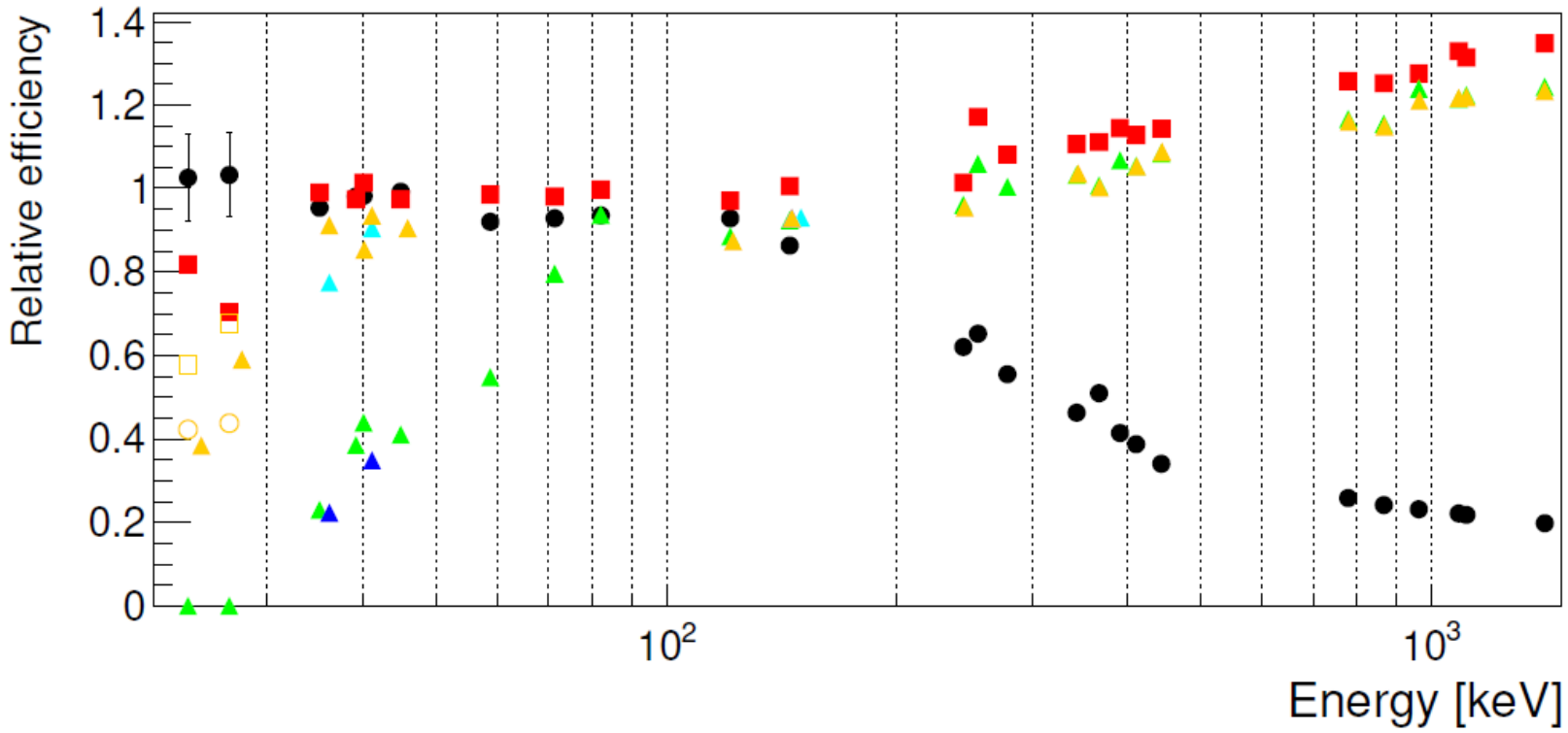


Fig. 1. (Color online) Relative efficiencies measurement as a function of the γ-ray energy (see text).

GANIL Campaign feedbacks

efficiencies

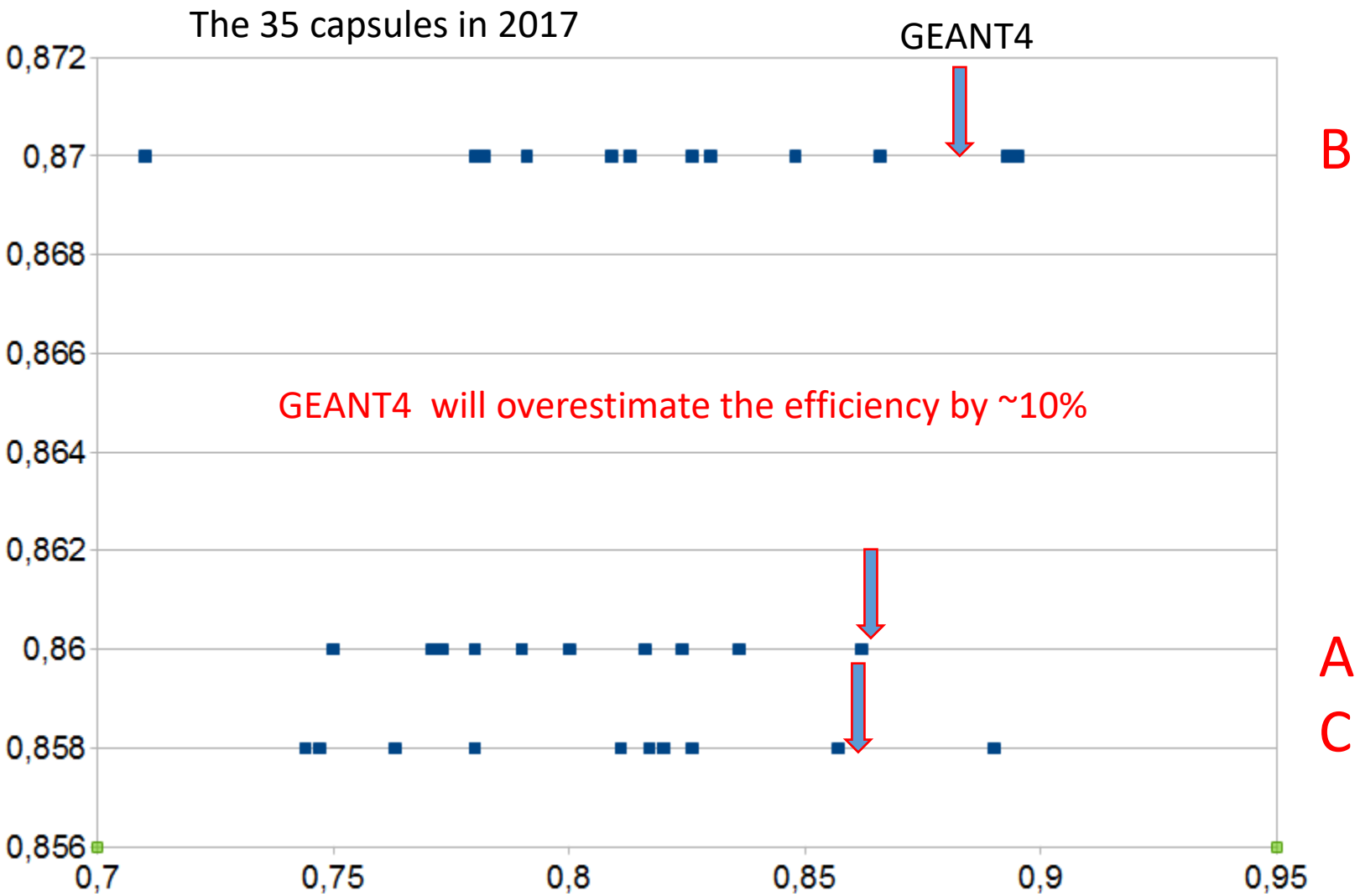
$$\varepsilon_{1.4\ MeV} = \varepsilon_{GEANT4}$$

In nominal : Crystal A-type = 0.106% = 86%
Crystal B-type = 0.117 % = 87%
Crystal C-type= 0.106 % = 85.8%

- The absolute efficiency is not a CAT criterium
- It is given in the CANBERRA technical sheet for each capsule delivered
- It is cross checked only in 30% of the CAT according to the reports. They often differ.

GANIL Campaign feedbacks

efficiencies



Canberra

GANIL Campaign feedbacks

efficiencies

$$\varepsilon_{1.4\ MeV} = \varepsilon_{GEANT4} \rightarrow \varepsilon_{GEANT4\ cor}$$

Run 78 E706 (2017) 35 crystal in nominal
(no trace, no histo, no PSA, ancillary.sh)

ε_{single} @1.4 MeV = 3.4(1)%

$\varepsilon_{single\ G4}$ = 3.8%

$\varepsilon_{single\ G4c}$ = 3.6%