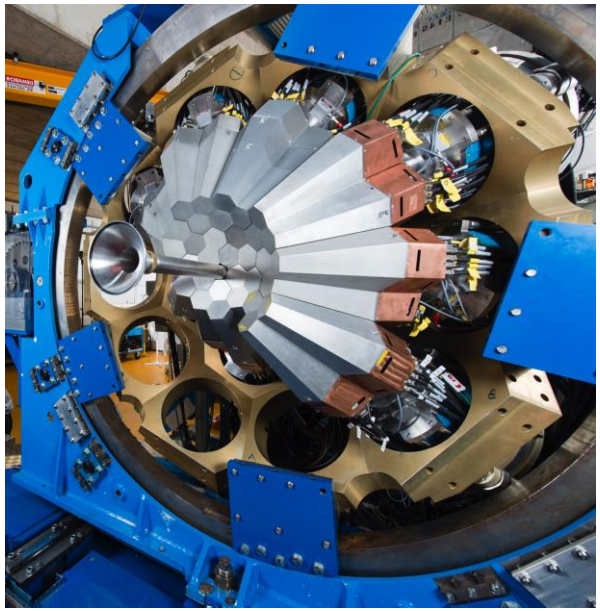
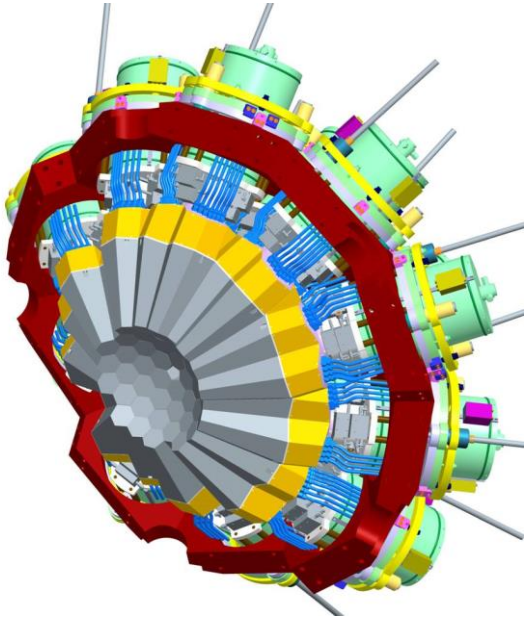
Towards AGATA 4π: Project Status and Next Phase of AGATA

Andres Gadea (IFIC-CSIC, Spain) on behalf of the AGATA Collaboration





19th AGATA Week 10th – 14th September 2018, IPHC, Strasbourg

IFIC INSTITUT DE FÍSICA CORPUSCULAR

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

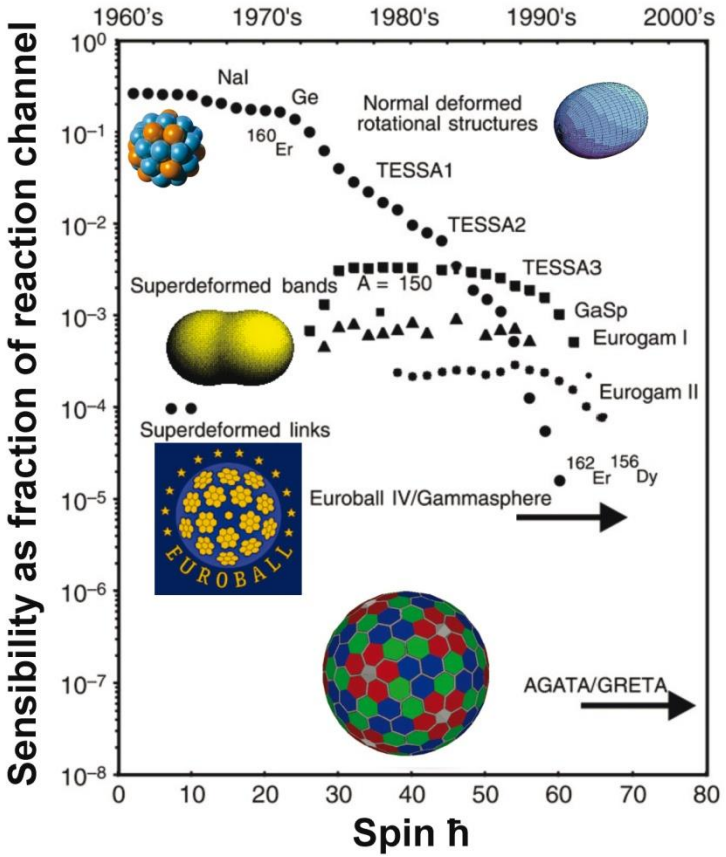
AGATA ADVANCED GAMMA TRACKING ARRAY

AGATA

(Advanced GAmma Tracking Array)

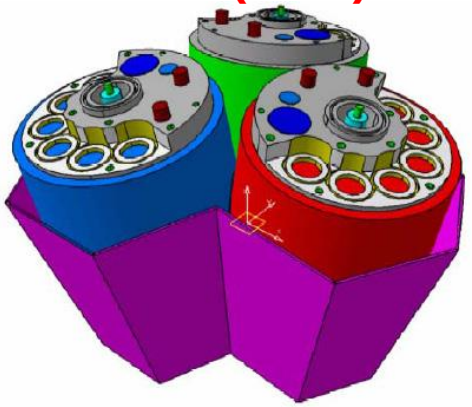


Encapsulation



180 hexagonal crystals:	3 shapes
3 fold clusters (cold FET):	60 all equal
Inner radius (Ge):	23.5 cm
Amount of germanium:	362 kg
Solid angle coverage:	~82 %
36-fold segmentation	6480 segments
Crystal singles rate	~50 kHz
Efficiency (Mγ=1 [30]):	35% [23%]
Peak/Total (Mγ=1 [30]):	55% [46%]

AGATA Collaboration NIM A 668 (2012) 26



6660 high-resolution digital electronics channels

High throughput DAQ / Capability to record sampled pulses

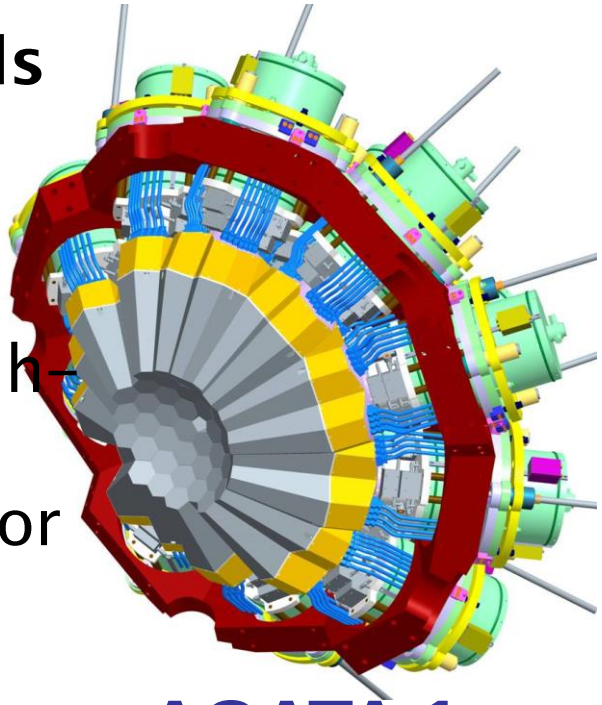
Pulse Shape Analysis → position sensitive operation mode

γ-ray tracking algorithms → maximum efficiency and P/T

From AGATA Phase 1 to AGATA 4π

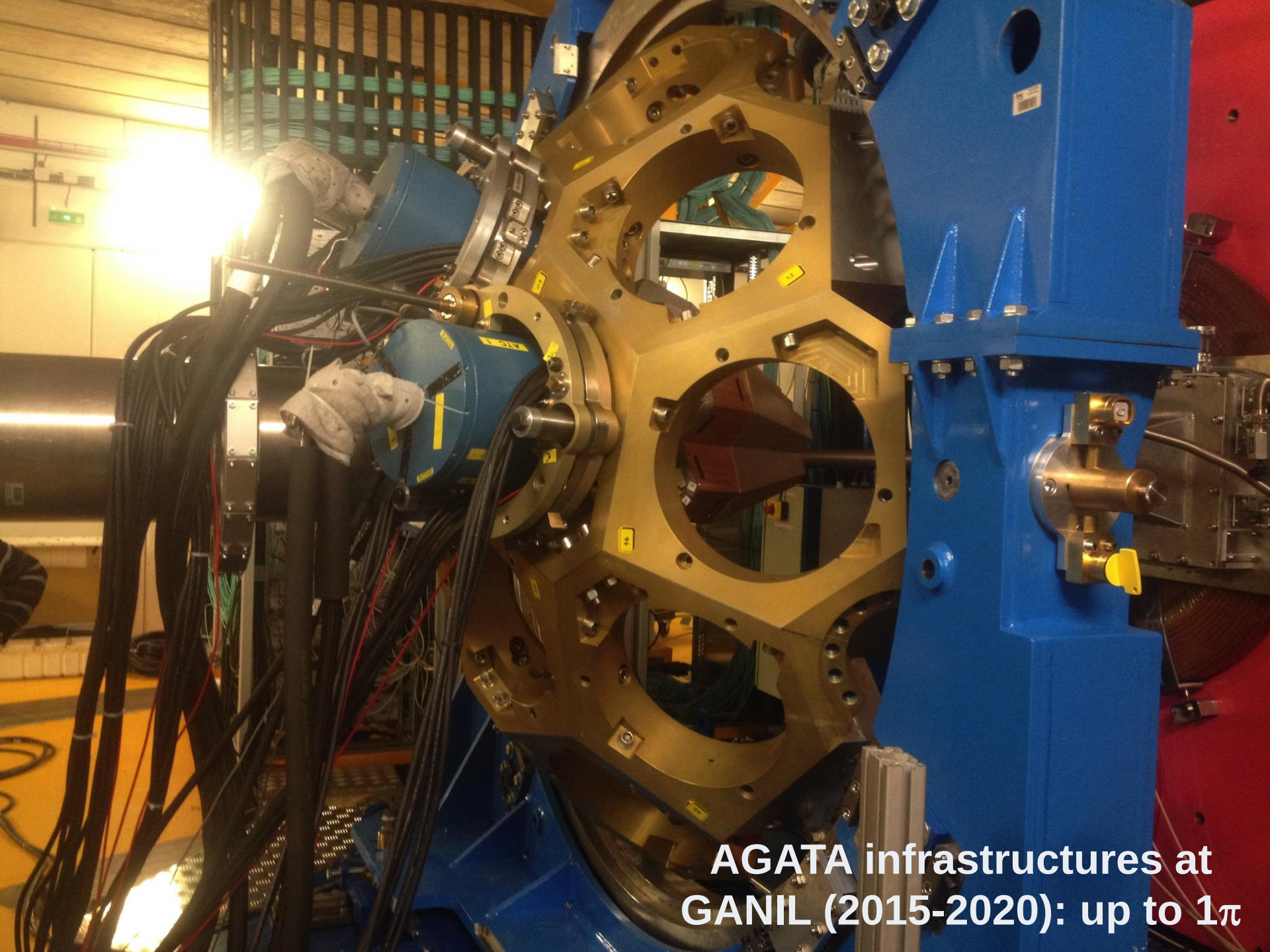
2009-2020 → 2021-2030

- **Phase 1 of AGATA (>1π)→ 60 crystals**
- **MoU ongoing, ~85 % achieved, Extended until 2020**
- **AGATA 4π:** aims to provide the best State-of-the-art position sensitive High-resolution detector array.
- Improving mobility and compatibility for the host labs. Foreseen Hosting Labs: FAIR/NUSTAR, GANIL/SPIRAL, HIE-ISOLDE, JYFL, LNL/SPES



AGATA 1π

- Sustainable growth of the AGATA subsystems from 60 to 180 Detectors.
- Achieving full Tracking Performance and optimizing the Position sensitivity.
- Improving performance of subsystems FEBEE, DAQ, etc…


AGATA infrastructures at
GANIL (2015-2020): up to 1π

AGATA Management Board and Teams

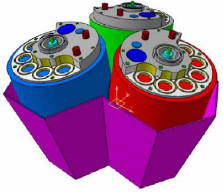
A. Gadea (Project Manager)

A. Boston, B. Million, A. Korichi, F. Recchia, H.Hess, P. Reiter (ASC) and W.Korten (ACC).
J. Gerl (LCM-GSI), E. Clement (LCM-GANIL)

AGATA Working Groups	AGATA Teams			
Detector Module H.Hess	Detector & Cryostat (tbd)	Detector CAT &Testing H. Boston	R & D on gamma Detectors & Applications	
AMB Chairman Project Manager A.Gadea	Front-end Electronics A. Gadea	Pre-Amplifier Digitizer A. Pullia	Global Trigger & Synchronization M. Bellato	Pre-processing I. Lazarus
Data Processing A.Korichi	Hard/Software DAQ Support G. Lalaire	Slow Control & FEE Monitoring E. Legay	Data Analysis & Tracking O. Stezowski A. Lopez-Martens	Data distribution and re-processing F.Crespi J.Dudouet
PSA & Characterization A.Boston	PSA Algorithm Development L. J. Harkness	Detector Characterisation (J.Simpson)		
Resource Manager B.Million	Infrastructure. Comp. Det. B.Million	Detector array Infrastructure R.Menegazzo	Complementary Detectors J.J. Valiente	Mechanical Infrastructure A.Grant
Performance and Simulation F.Recchia	AGATA Performance J.Ljungvall C.Michelagnoli	AGATA Commissioning P.R. John	AGATA Physics & exp. Simulation M. Labiche	
Technical Coordinator Engineering Advi.	Compatibility EMC, Interfacing	Specification control	Quality Control	Documentation

Local Campaign Managers (LCM)

INFN-LNL Legnaro	GSI Darmstadt J.Gerl	GANIL-SPIRAL2 Caen E.Clement



AGATA Detectors & Cryostats

47 AGATA capsules procured
43 available

A001 – A015 Delivered A005 on repairing

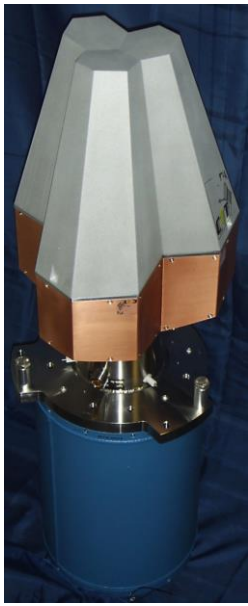
B001 – B016 Delivered, B009, 10, on repairing

C001 – C016 Delivered, C001 on repairing



4 Repairs Delivery Scheduled from July-August
4 New Capsules Being Ordered Finland (A016), Hungary (3): Delivery in 2019

- **Expected 35 capsules setup in 2018, 44/45 in 2019 (45 is 1π)**
- Maintenance performed by IKP, IRFU, GANIL and IPHC (H.Hess)
- 11 Triple Clusters and 1 Double Cluster available at GANIL
- 2 Triple Clusters under repairing or missing “C” Capsule
- 1 Triple cryostat ordered, delivery late 2018
- 1 Triple Cryostat and 1/3 being ordered by Hungary and Finland



And More:
- New encapsulation technique, develop by IKP-Cologne, now in use
- R&D detector technology ongoing ENSAR2 **PSeGe** JRA.

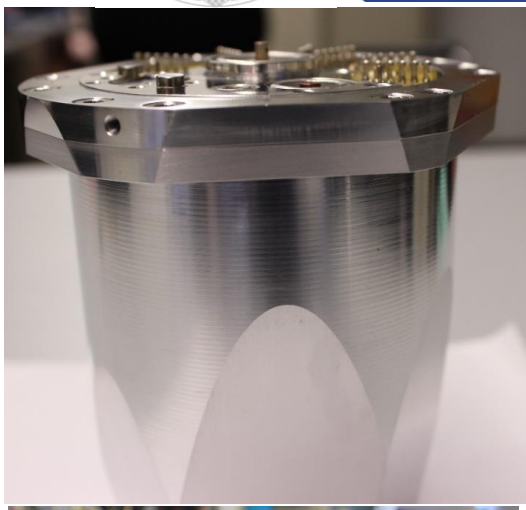
New Encapsulation Technology

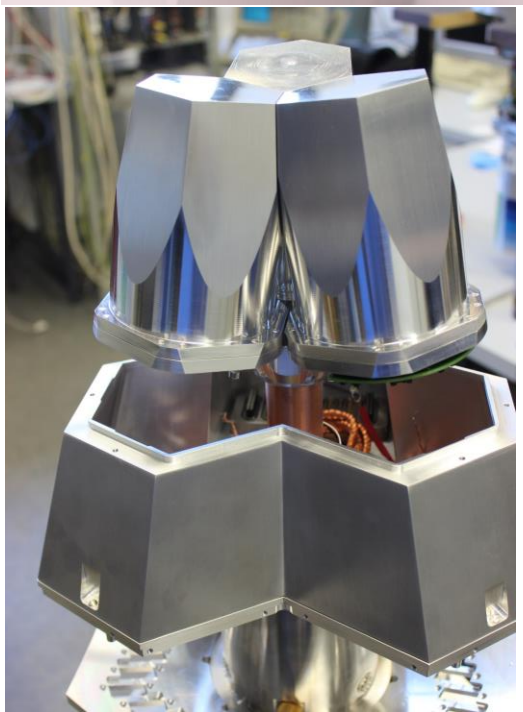
- A new encapsulation development has been performed at IKP-Cologne in collaboration with the IKP mechanical workshop and Mirion/Canberra (mainly for capsule lid).

- Early encapsulation was expensive on mechanics and welding at FZ-Jülich. The electron welding at could be done 3 times at most. Failure of the crystal frequently require a new capsule (>40k€ extra cost).

- The design of the new capsule allows to reuse it. New preamplifier plates developed. Mechanically compatible with previous ones. Mounting of crystal in capsule can be done now at Mirion →faster and surer.

- Four capsules successfully delivered, mounted with the new encapsulation. **Now all new capsules ordered with this new encapsulation**. This technique should be less costly than previous and repairs will be cheaper and faster (in principle).

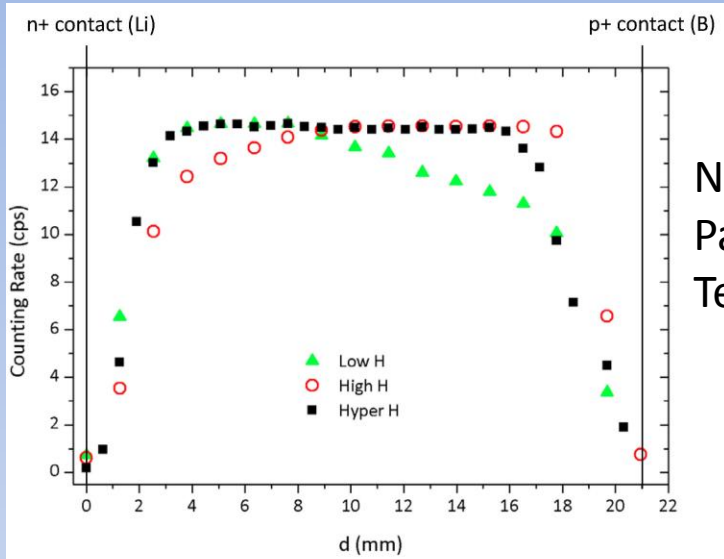




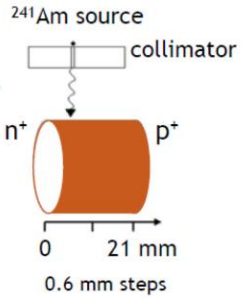
•PSeGe JRA Task 1: New technologies on passivation and segmentation

INFN-LNL and University of Padova, IKP Cologne

V.Boldrini:Thermally-induced defects and contamination in doping techniques.
W.Raniero: Ge detectors with new pasivation techniques.
F. Sgarbossa: P- Monolayer Doping in Germanium

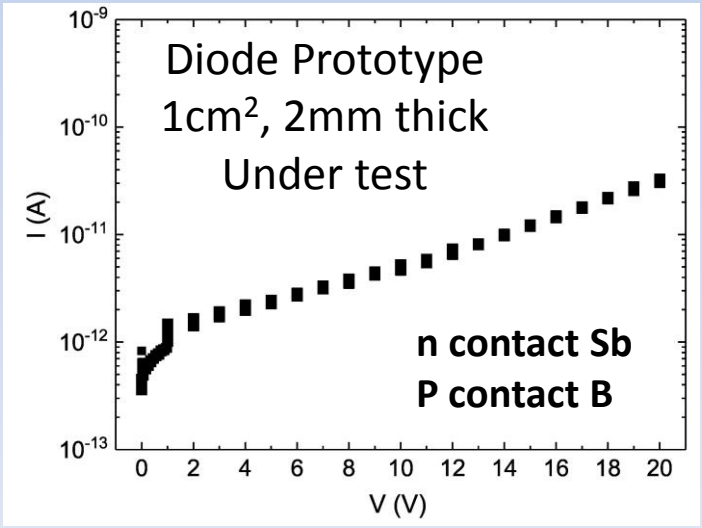


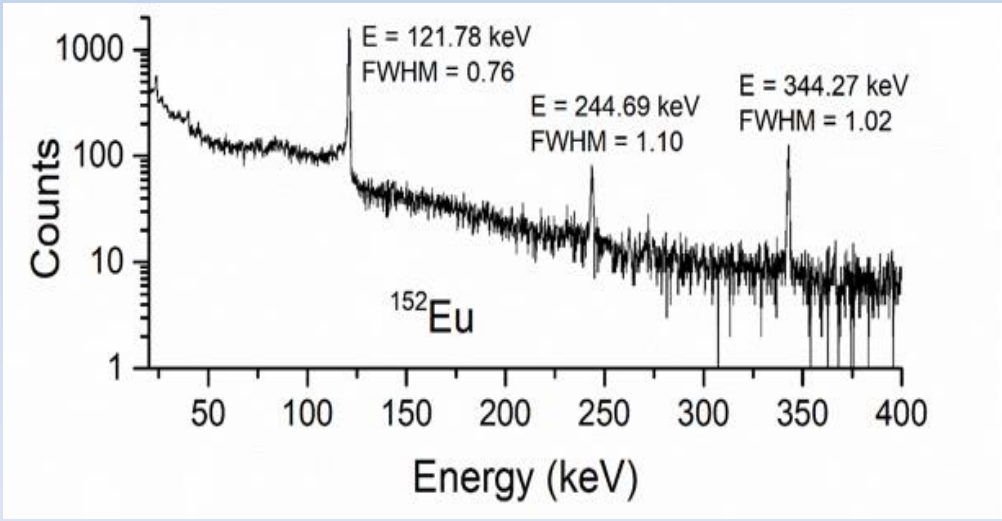
New Hydride Passivation Techniques



G. Maggioni et al. Eur. Phys. J. A (2015) 51: 141
S. Riccetto et al. to be submitted

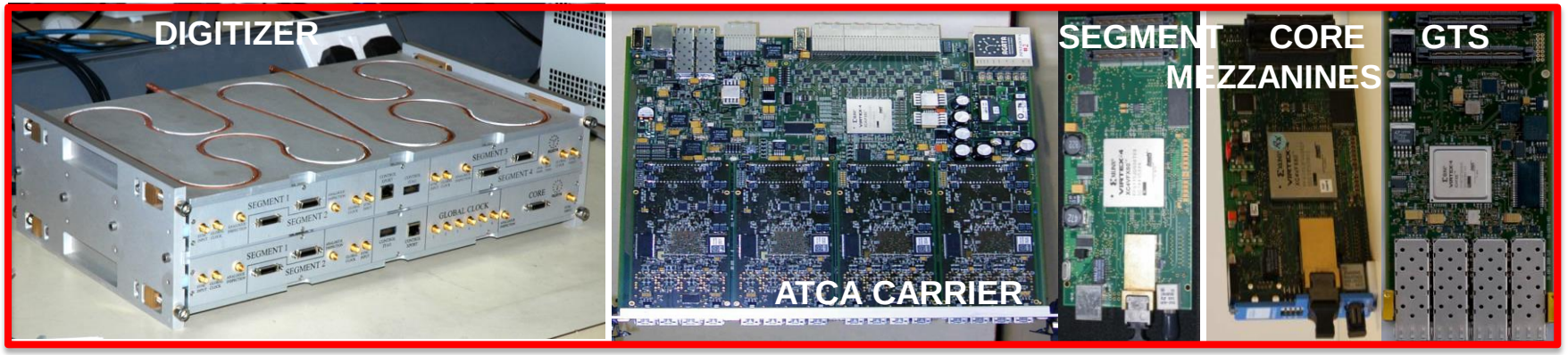
•PSeGe JRA Task 3: R&D on segmented p-type coaxial Ge detectors





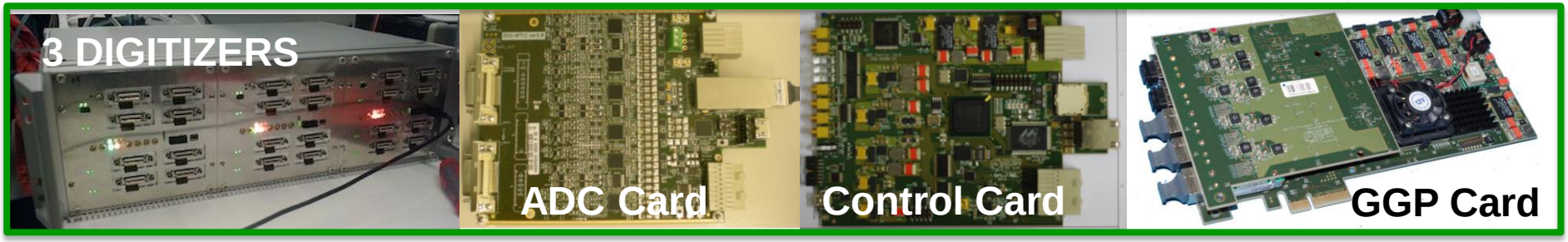
INFN-LNL and University of Padova, IFIC Valencia

AGATA Electronics Phase 0/Early1



24 channels available and working

AGATA Electronics Advanced Phase 1



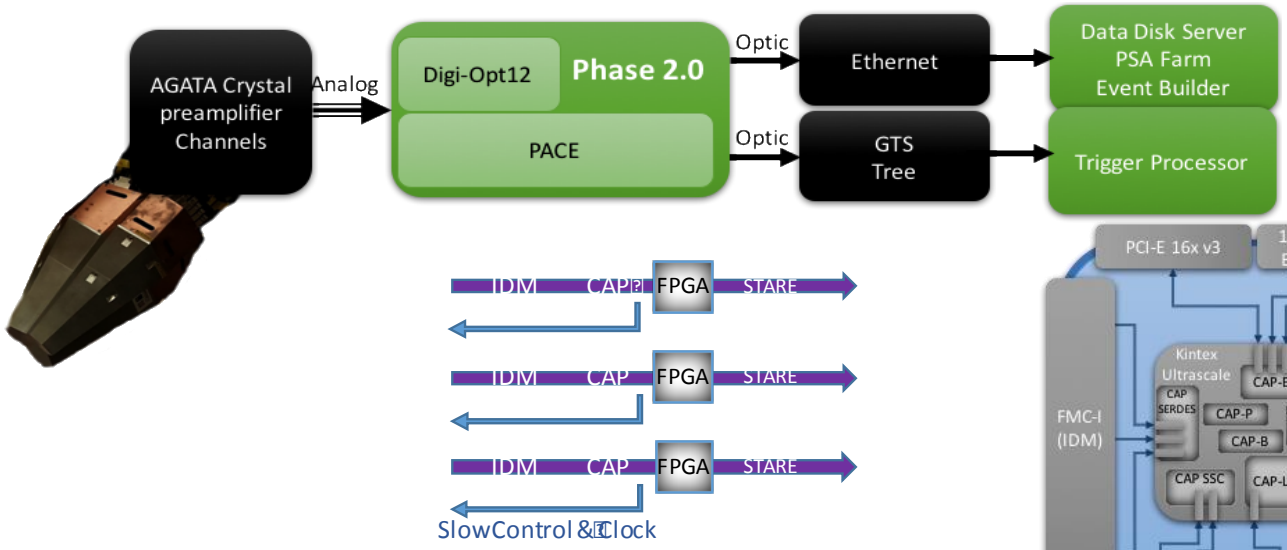
12 channels available and working (only 6 from AGATA)

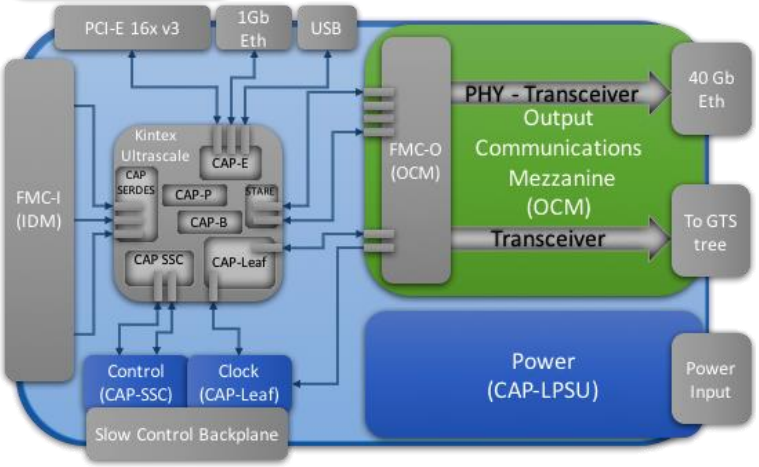
Production of 14 channels ongoing. 10 Digitizers & 9 GGP tested. Installation after summer 2018

IPHC Strasbourg Uni.Liverpool STFC Daresbury IPNO, CSNSM-Orsay INFN-Padova

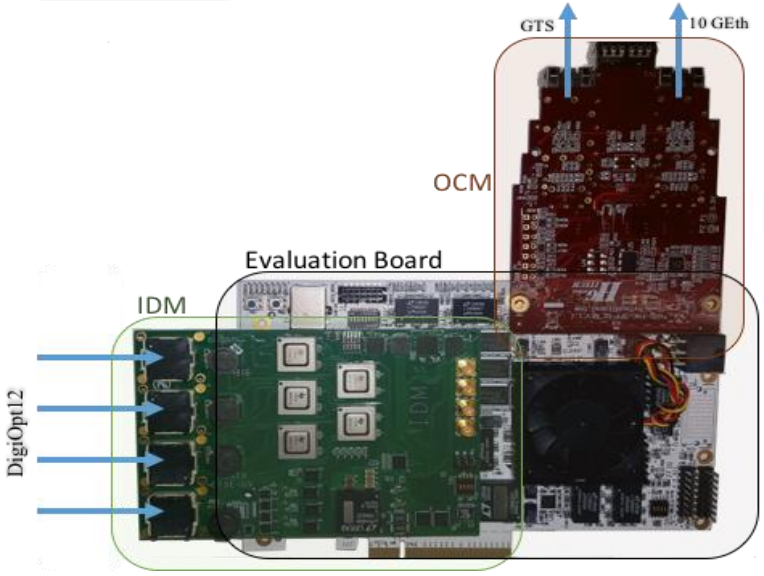
INFN-Milano INFN-Padova INFN-LNL IFIC-Valencia ETSE-Uni-Valencia

R&D on Mid-Term Electronics





- On going a medium term electronics R&D. Aiming for a higher processing capability and Ethernet readout.
- DIGITIZER based on DIGIOPT12 (INFN-Milano) Improved Differential linearity (Sliding Scale).
- Pre-processing to be tested on a Xilinx Kintex-7 evaluation board with the main processing FPGA. Optimized Input Data Module (IDM), Ethernet readout module (STARE) and GTS interface
- Firmware aiming to improve the triggering, processing and read-out capabilities.



INFN-Milano, CSNSM-Orsay, IPHC-Strasbourg, STFC-Daresbury, IFIC & ETSE-Valencia

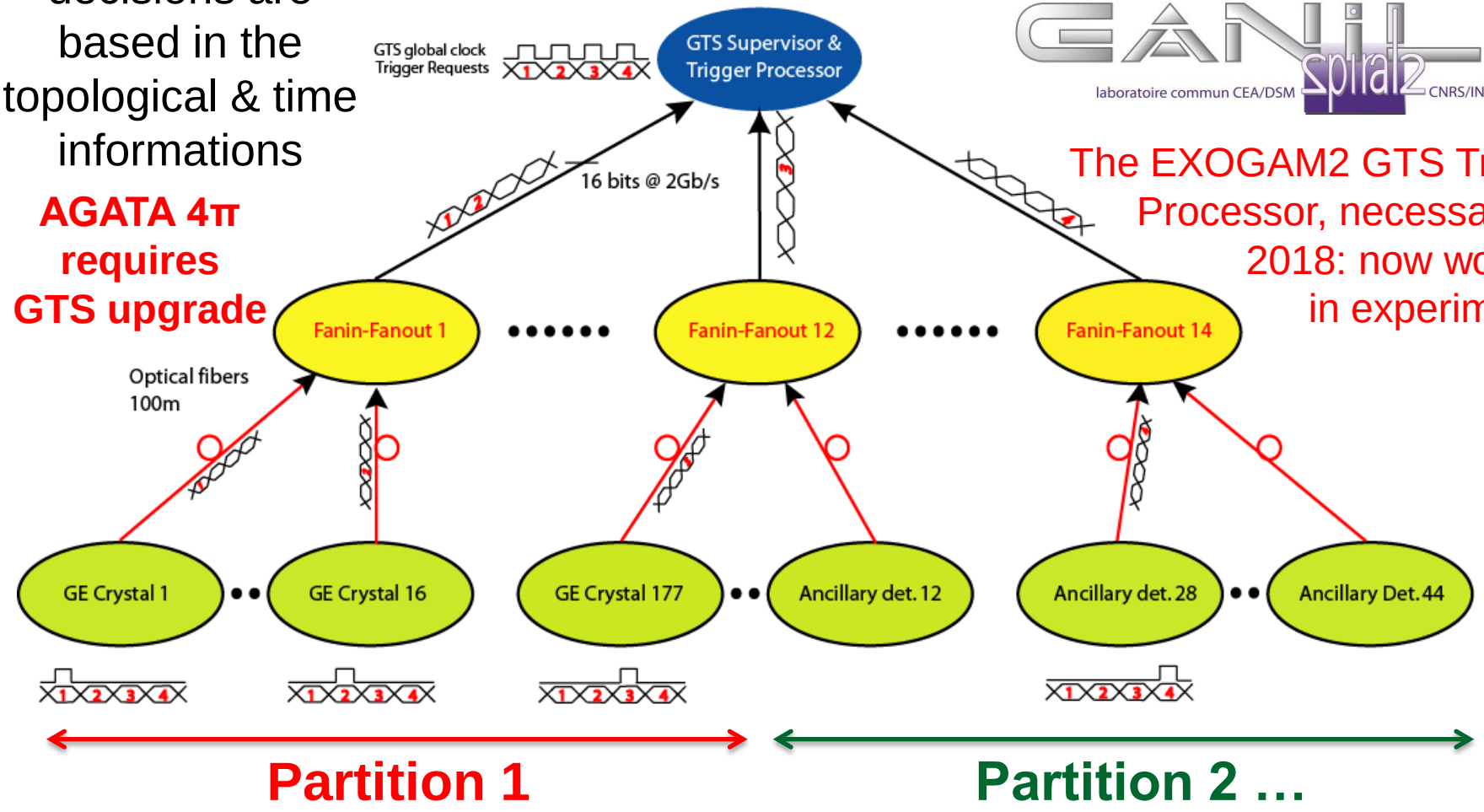
GTS Trigger & Synchronization Structure

GTS Trigger decisions are based in the topological & time informations

AGATA 4π requires GTS upgrade

Early AGATA GTS Trigger Processor limited to 40 TR (channels).

The EXOGAM2 GTS Trigger Processor, necessary for 2018: now working in experiments.



INFN-Padova GANIL

Phase 1 AGATA Data Flow NARVAL at GANIL

Hardware:

- New Hardware available, 10 servers devoted to GGP electronics. Control servers and switches also renewed.
- CEPH Cluster 122 TB & bandwidth x 6. Upgraded in 2017 on view of the 45 capsules sub-array. Backup for disk server available



- About 10 new servers required (only 5 funded) within 2018 to increase the number of channels form 35 to 45
- LINCO2 compatible servers are starting to have issues and are not repairable anymore

AGATA Data Flow NARVAL→ DCOD at GANIL

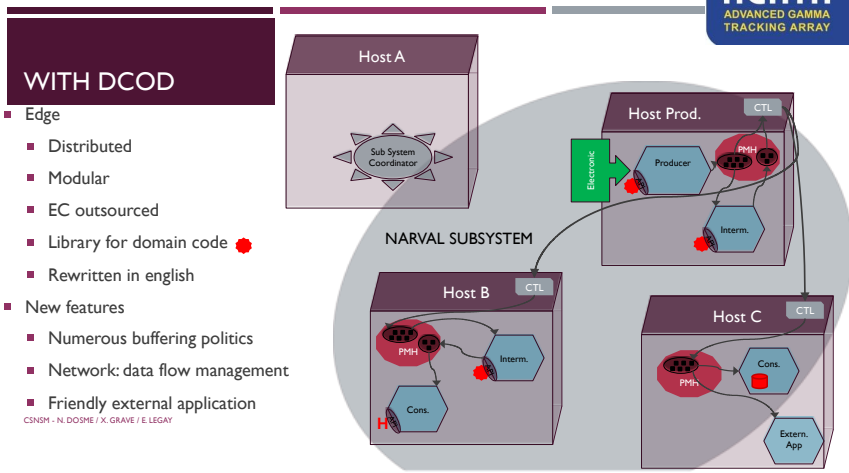
DAQ Software:

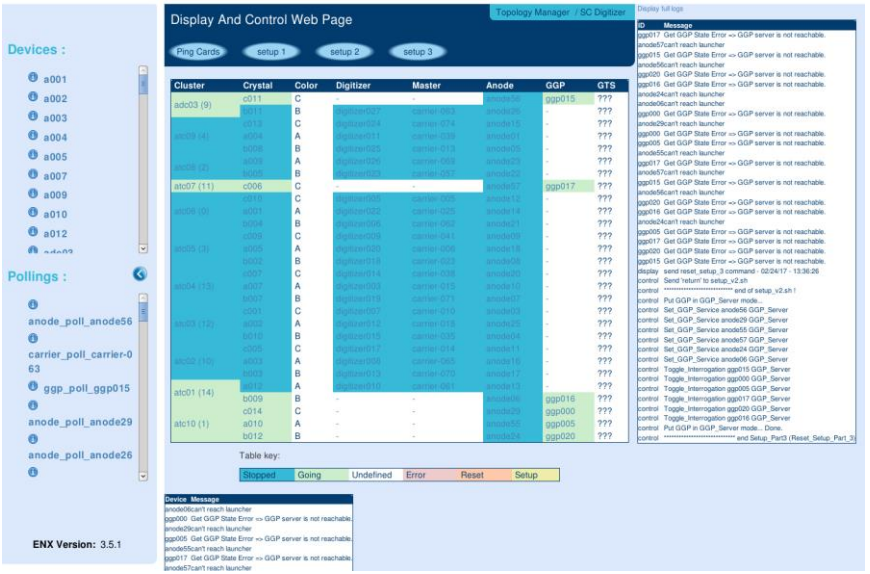
•Upgrade of the system to DCOD operational since January 2018.

•Now PSA data bases uploaded very fast as a feature of DCOD.

•Data Integrity checked with source runs.

•PSA can handle/process more events with DCOD : 4-5 kHz





GEC, RCC and Topology Manager:

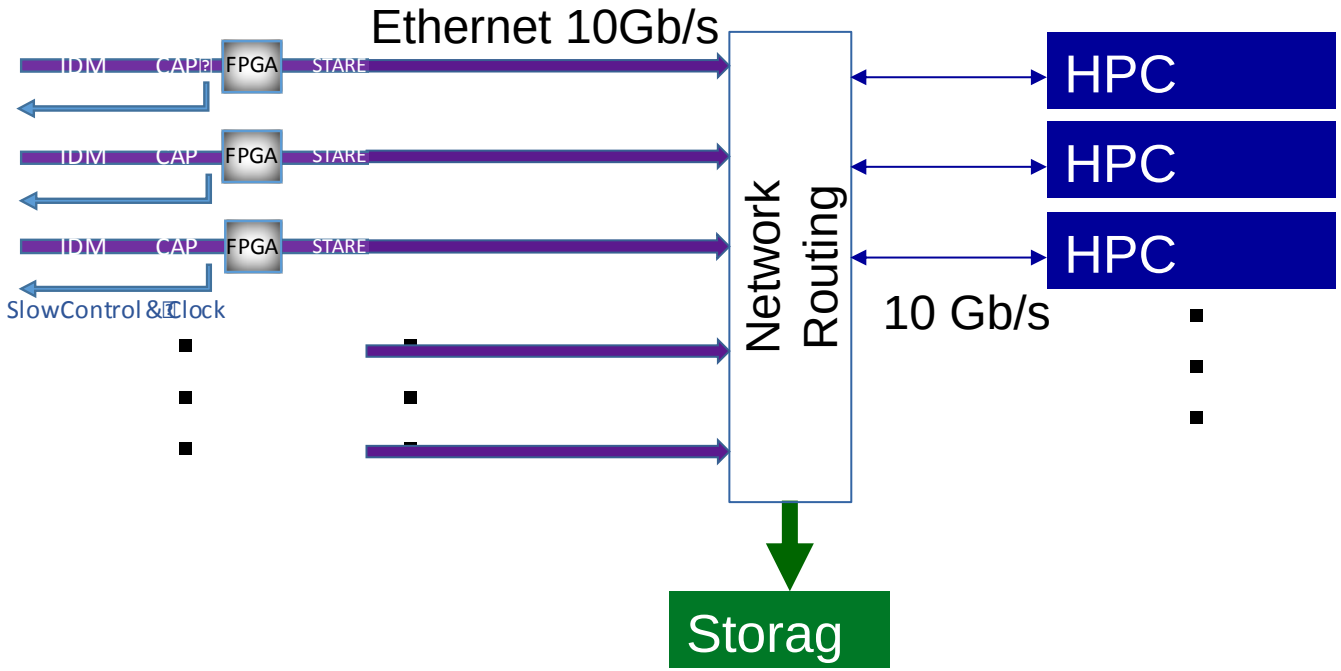
•Global Electronic Control and Topology Manager upgraded

•General AGATA display and control produced. Electronics status included. Ongoing the modification of the RCC and TM in order to control DCOD with the RCC.

CSNSM-Orsay, GANIL, IPN-Lyon, IPN-Orsay, INFN-LNL, IFJ-PAN-Crakow,

AGATA Data Flow NARVAL→ DCOD towards 4π

Present AGATA electronics is based on boards with point to point optical fiber connections. Future Electronics based on Ethernet standard



CPU can be distributed over High Performance Computer farms (HPC) :

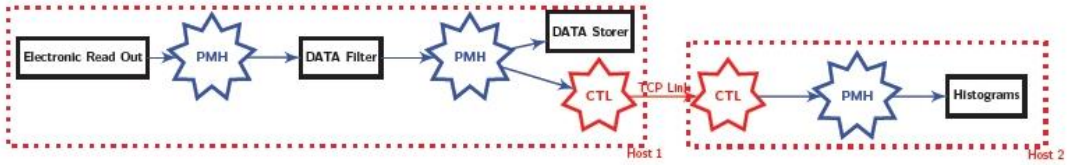
Not necessary 1 node/crystal with the load balancing and new technologies

Specially important if AGATA PSA is upgraded to more complex algorithms

DCOD (NARVAL+ Posix Memory Handler (PMH) + Common Transport Layer (CTL)):

Easy to upgrade from 1π to 4π

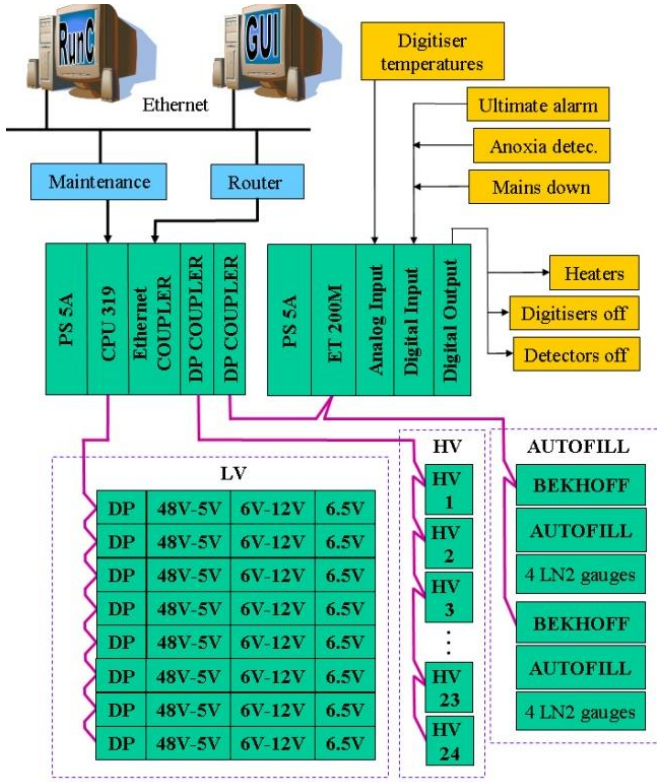
X.Grave, E Legay et al.
CSNSM-Orsay, GANIL,
INP-Lyon, IPN-Orsay

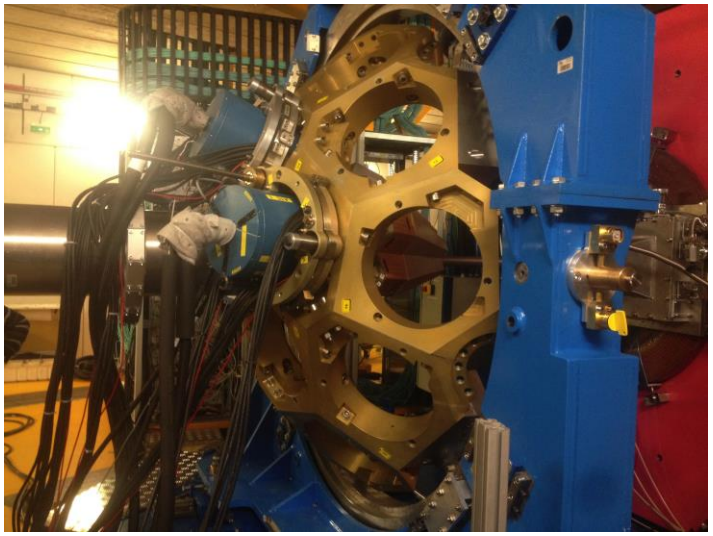


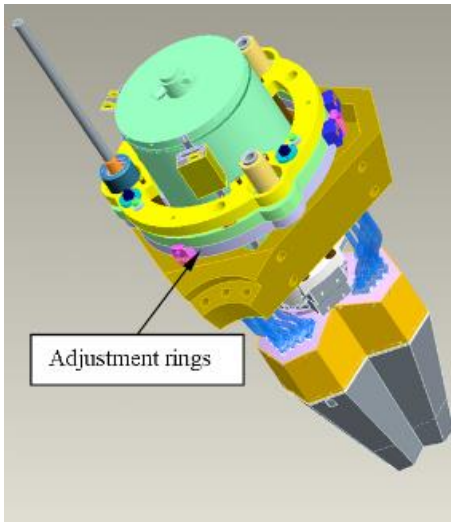
Infrastructure: Detector Support & Mechanical

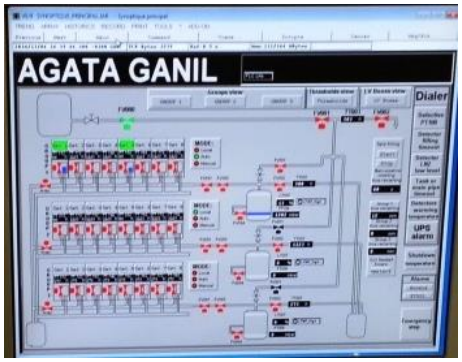
***LVPS**, **Patch boxes**, **HV System, Autofill system, Data and Power Supply Cabling,* Mechanics etc**

Ready for the 45 detector system (1π)







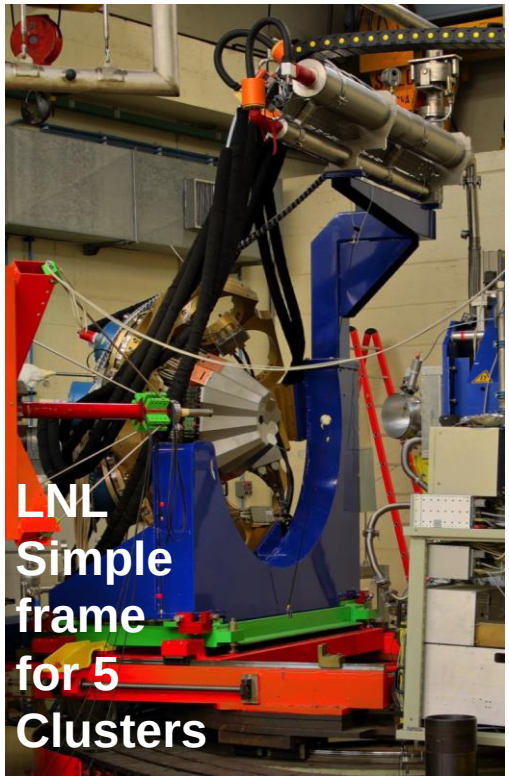




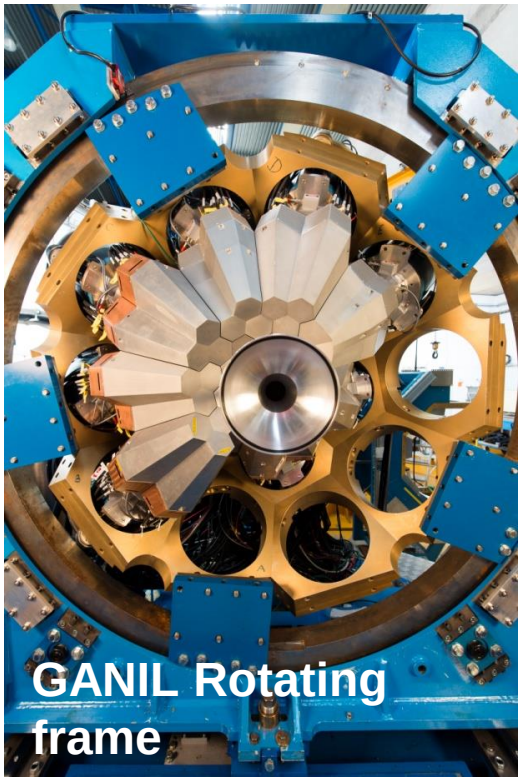
CEA Saclay, INFN-Padova, INFN-Milano, GSI, CSNSM-Orsay
STFC-Daresbury, IPHC-Strasbourg, GANIL, INFN-LNL, JYFL-Jyvaskyla,

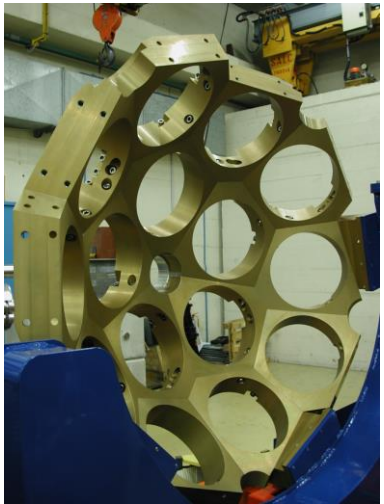
STFC-Daresbury

Mechanical Compatibility



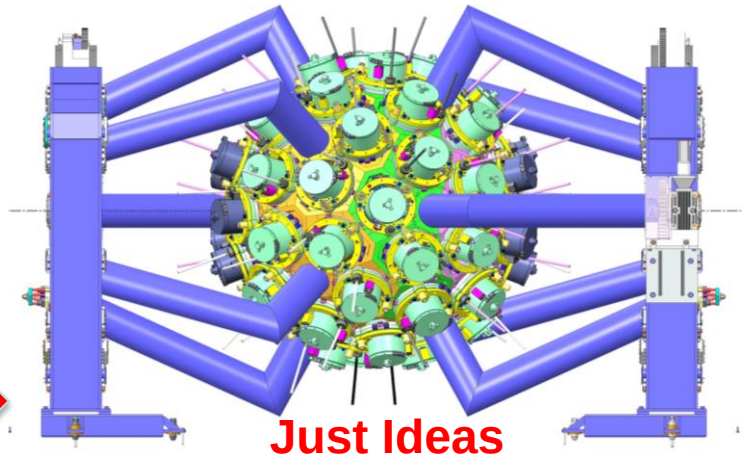






The AGATA Honeycomb is the core of the detector support mechanics. Each Host Lab has produced a Frame fulfilling the local requirements: beam-line height, space availability, array displacement.

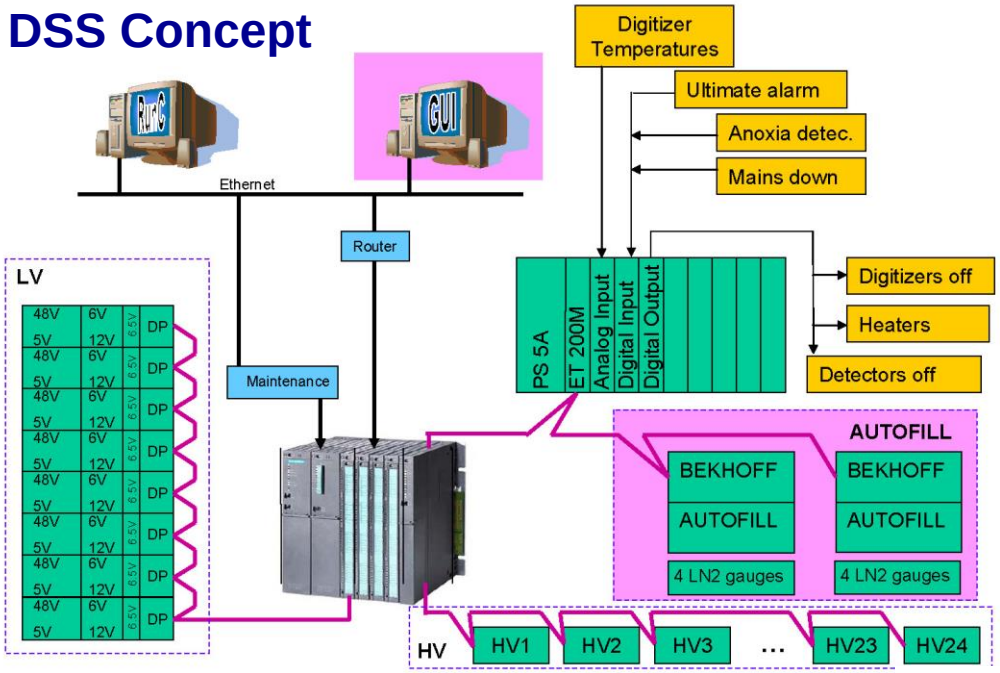
Now working on compatible mechanics



Just Ideas

Detector Support System

DSS Concept

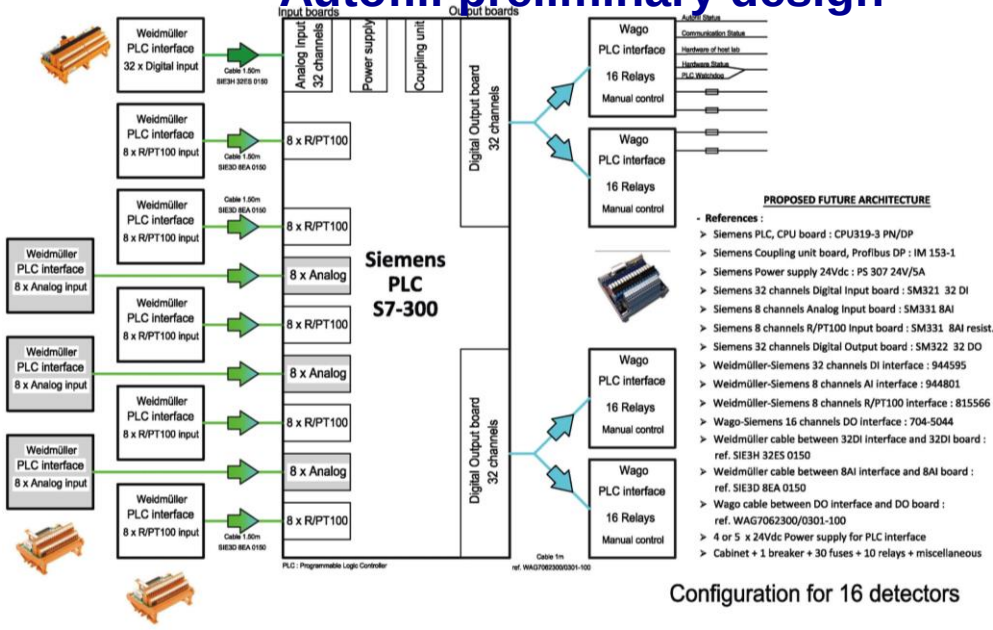


Detector Infrastructure W.G. with the future Host Laboratories experts and experts of the AGATA Subsystems (Detector, Electronics…) having Initial discussion on how to design the future LVPS, HV, Autofill and in general the DSS.

New components with reduced power requirements like DIGIOPT12 Digitizers (1/3 of the early Digitizers). LVPS 48V units should be redesign. The 6.5V modules have been already suppressed. The Pre-amplifier modules +6V/+12V and -6V/-12V will remain.

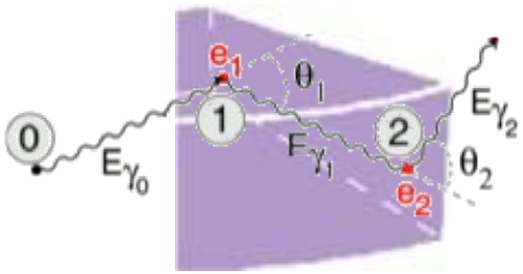
CEA Saclay, INFN-Padova, INFN-Milano, GSI, CSNSM-Orsay STFC-Daresbury, IPHC-Strasbourg, GANIL, INFN-LNL, JYFL-Jyvaskyla,

Autofill preliminary design



Configuration for 16 detectors

Position Sensitivity: Where we do Stand?

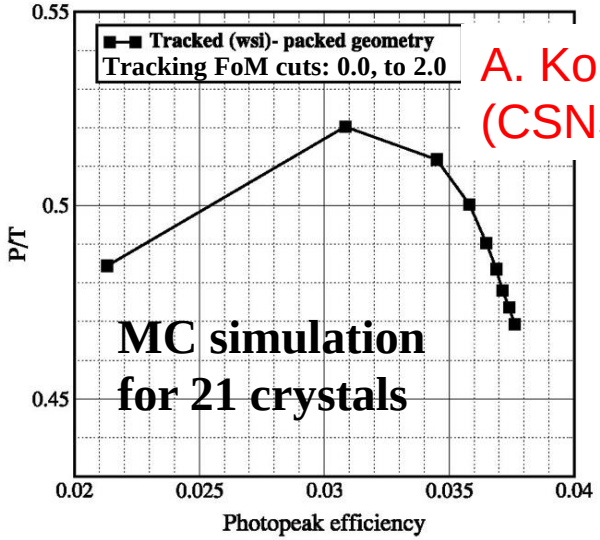


- In AGATA not possible to treat two interactions in a single segment: Work on-going (Coll. with GRETA)
- Modeling of charge and induced pulses still not "perfect": Characterizations and ADL studies Ongoing

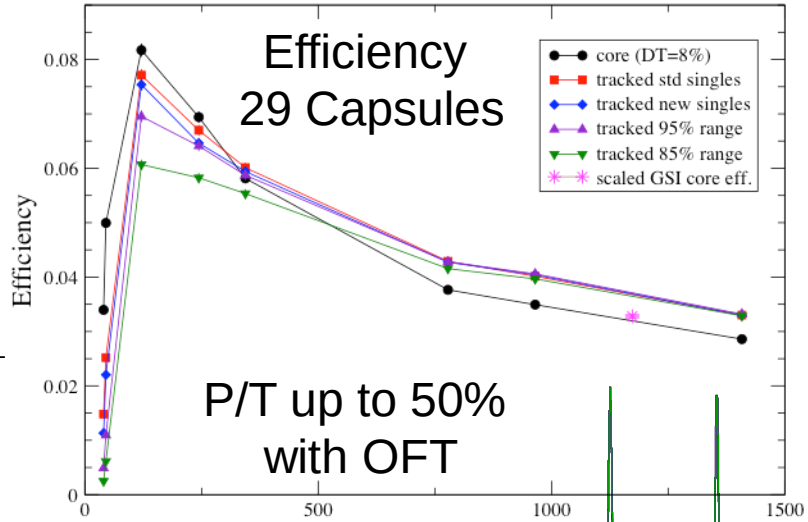
Tracking:

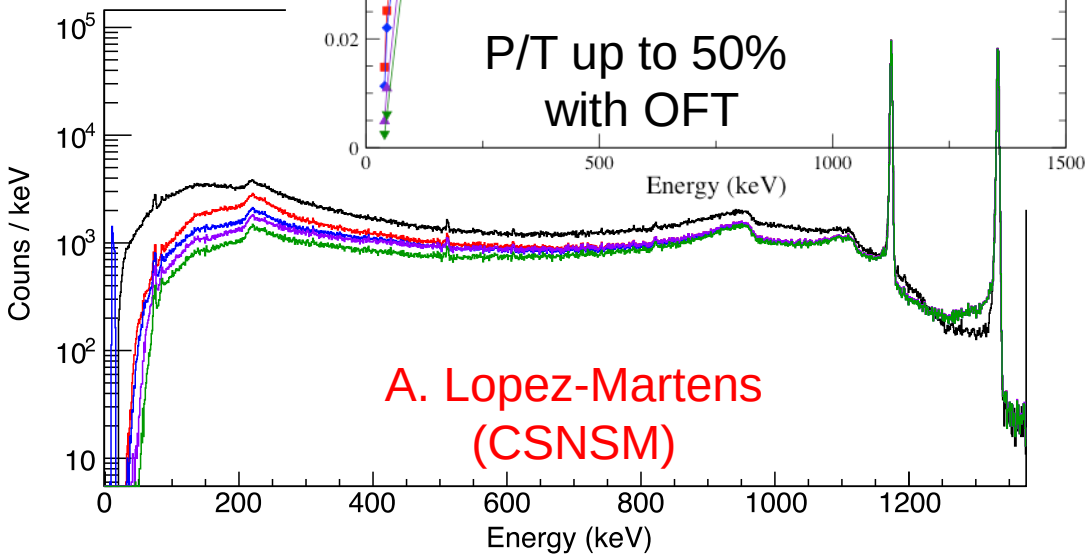
- Tracking Efficiency ~75% due to the unresolved 2 interactions in 1 segment.
- Balance between Efficiency and P/T.
- Inefficiencies due to Clustering, used to reduce processing time.

Minimization of a FoM



A. Korichi (CSNSM)



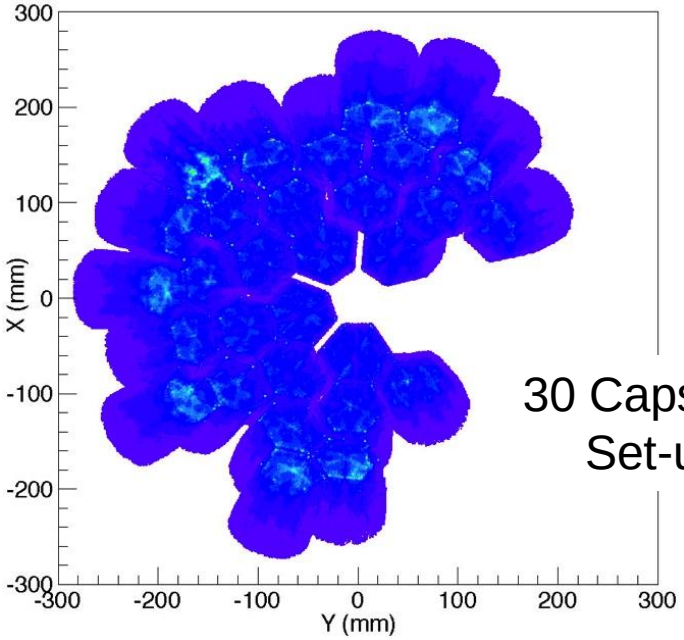


- impact of position uniformity on the algorithm performance.
- Include the position inaccuracy in the tracking procedure.

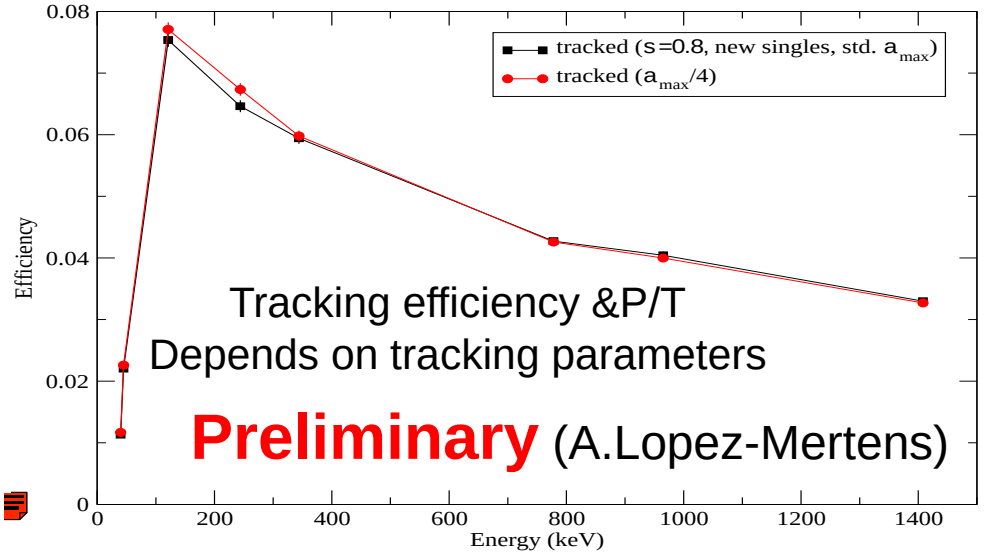
Uni. Liverpool, IPN-Lyon, GANIL, CSNSM-Orsay, INFN-Padova, IRFU-Saclay, TU-Munich

AGATA Performance measurements

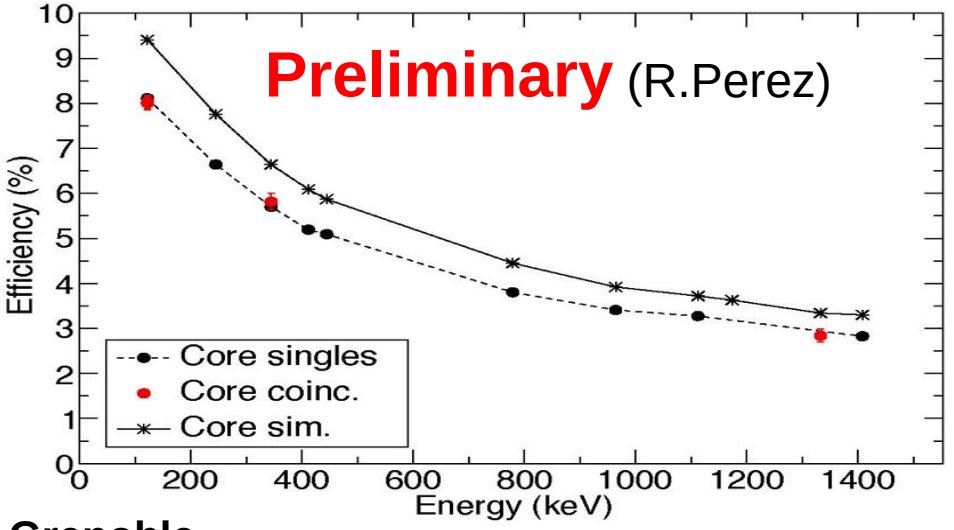
AGATA Performance Measurements Run at GANIL in 2016 for detailed evaluation of the AGATA Performance and comparison with simulations.



30 Capsules Set-up



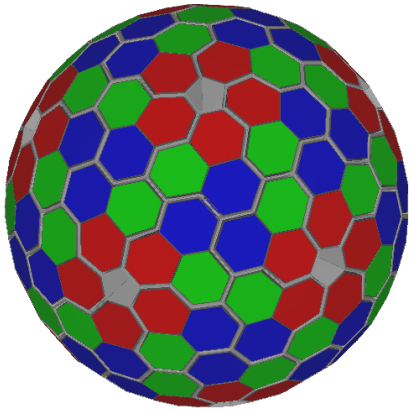
Estimated Efficiency for 30 capsules set-up at Eγ=1MeV tracked ~4% with AGATA at nominal position, i.e. 23.5 cm target-detector distance.
Expected up to 35% gain at 18.5 cm and up to 60% at 13.5 cm.
Agreement with simulations (M.Labiche)

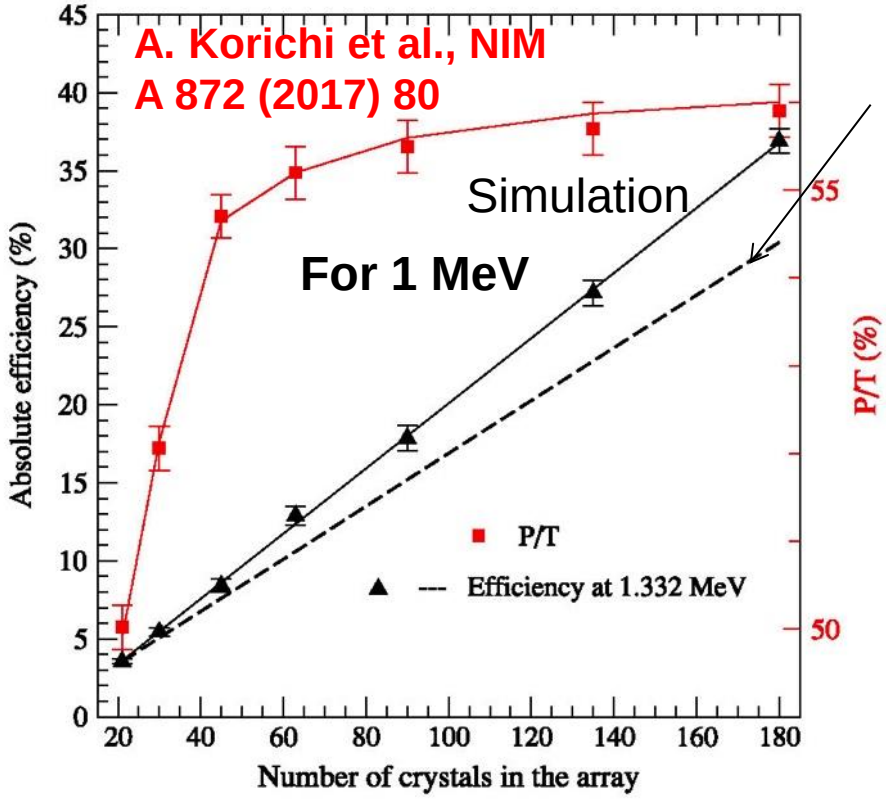


GANIL, CSNSM-Orsay, IFIC, INFN-Padova, ILL-Grenoble

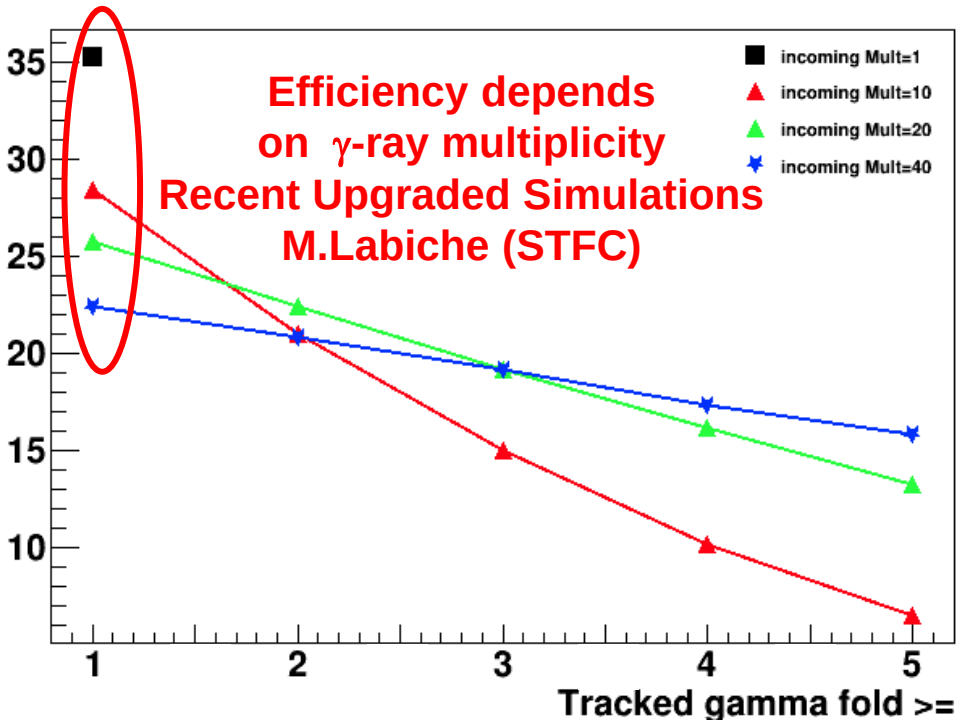
AGATA Performance simulations

Efficiency and P/T Monte Carlo simulations for the 180 Capsules set-up with Tracking





These expectations require the PSA improvements regarding the 2 interactions in one segment.



Future: coupling AGATA with ROOT to facilitate Data Analysis
More realistic simulation for all the experimental conditions

STFC-Daresbury, CSNSM-Orsay,

AGATA Data Analysis

Data Analysis

- The data analysis software required for the 2018 AGATA NEDA campaign of experiments has been prepared during the last months.
- A. Korichi, and T. Lauritsen working on the AGATA to GRETINA data format translation and good progress has been made. The software allows the conversion of AGATA trace data to GRETINA trace data and has been demonstrated to work with AGATA compressed traced data.
- Progress has also been made on the reverse conversion process led by O. Stezowski.
- Successful hands-on Data Analysis schools organized by GANIL.
- Data Flow & Data Analysis Working Groups prepared a document that allows AGATA users to run an experiment and perform the data analysis in a coherent manner.

Future:

Data storage : New options under investigation, DMP elaboration

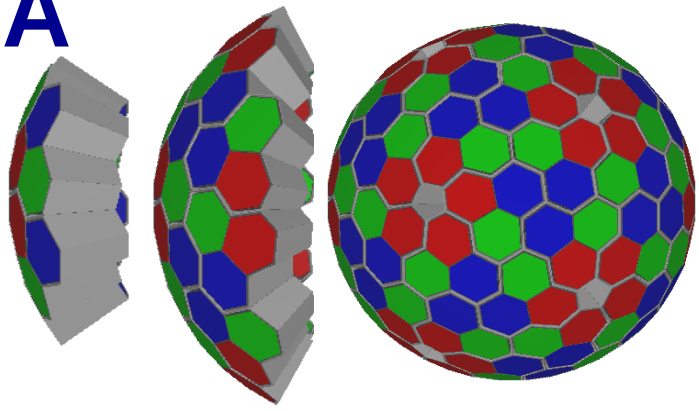
the GRID will/could be no longer the best

A better Data access and analysis for the users

Re-processing and data analysis : Online, Nearline and Offline :

New procedures for a better performance

Complementary Instrumentation with AGATA



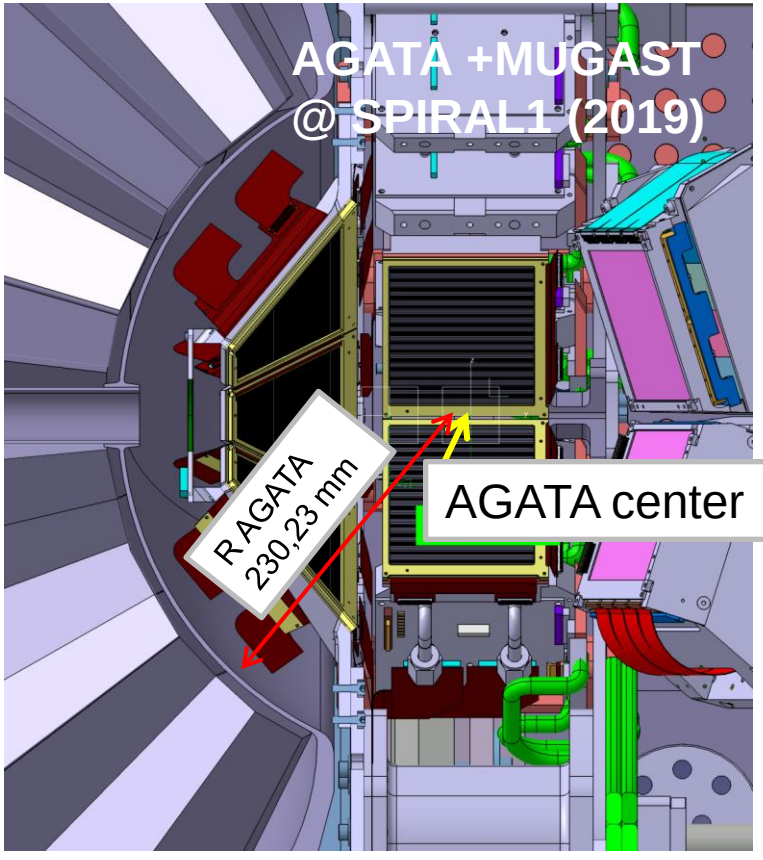
- Since the conceptual design, AGATA has been conceived as a flexible instrument to be combined with other instrumentation.

- Large inner-radius, possibility to select different configurations and electronics capable to interface with the AGATA Global Trigger and Synchronization

- Coupling with other instrumentation improves sensitivity providing reaction mechanism or tagging information.

- In addition, to exploit the full capabilities of AGATA is of paramount importance to get Information on the reaction kinematics with beam trackers, spectrometers, reaction product trackers or/and particle detectors.

E.Farnea et al. NIM A 621 (2010) 331



Summary:

- Subsystems of AGATA for 35 detectors installed at GANIL.
- Infrastructure ready for 45 detectors, i.e. AGATA 1π
- Electronics: 35 + spare channels installed and working. New batch of electronics produced 10 + 4 Spare channels. Estimated that will be installed by fall 2018
- Installed upgraded NARVAL to the DCOD version. Large Improvements in GEC and Topology Manager.
- Upgraded CEPH disk server for the 45 capsules setup.
- Improvements on simulations and performance determination
- Improvements ongoing on PSA, Tracking and Data analysis
- In preparation upgrades for AGATA 4π

Thanks' to all the AGATA Collaborators

Thank You For Your Attention!

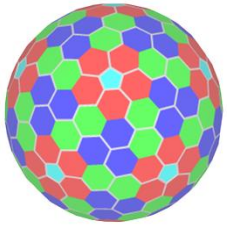
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MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

The AGATA Collaboration



>40 Institutions
>350 Collaborators

Bulgaria:	**Univ. Sofia**
Finland:	**Univ. Jyväskylä**
France:	**GANIL Caen, IPN Lyon, CSNSM Orsay, IPN Orsay, CEA-DSM-DAPNIA Saclay, IPHC Strasbourg, LPSC Grenoble**
Germany:	**GSI Darmstadt, TU Darmstadt, Univ. zu Köln, TU München**
Hungary:	**ATOMKI Debrecen**
Italy:	**INFN-LNL, INFN and Univ. Padova, Milano, Firenze, Genova, Napoli**
Poland:	**NINP and IFJ Krakow, SINS Swierk, HIL & IEP Warsaw**
Spain:	**IFIC, ETSE-UVEG Valencia, IEM-CSIC, UAM Madrid, USAL Salamanca**
Sweden:	**Univ. Göteborg, Lund Univ., KTH Stockholm, Uppsala Univ.**
Turkey:	**Univ. Ankara, Univ. Istanbul, Technical Univ. Istanbul**
UK:	**Univ. Brighton, CLRC Daresbury, Univ. Edinburgh, Univ. Liverpool, Univ. Manchester, Univ. West of Scotland, Univ. Surrey, Univ. York**