Perspectives of the AGATA Project: Towards a 4π Array

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on behalf the AGATA Collaboration

AGATA Collaboration Council Meeting 27th -28th June 2019,
CSNSM and IPN Orsay, France

IFIC INSTITUT DE FÍSICA CORPUSCULAR

CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

AGATA ADVANCED GAMMA TRACKING ARRAY

AGATA 4π

(Advanced GAmma Tracking Array)

- Sustainable growth of the AGATA subsystems from a configuration of 60 to the one of 180 Detectors.

- Improving mobility and compatibility for the Hosting labs: FAIR/NUSTAR, GANIL/SPIRAL, LNL/SPES, HIE-ISOLDE, JYFL

- Achieving full Tracking Performance and optimizing the Position sensitivity.

- Improving performance and compatibility of subsystems: Detectors, FEBEE, DAQ, Infrastructure.

Necessary as well the upgrade of the already existing subsystems for the 60 detectors Phase 1. Parts belong to the early AGATA Demonstrator Phase, built more than 12 years and showing increasing issues.

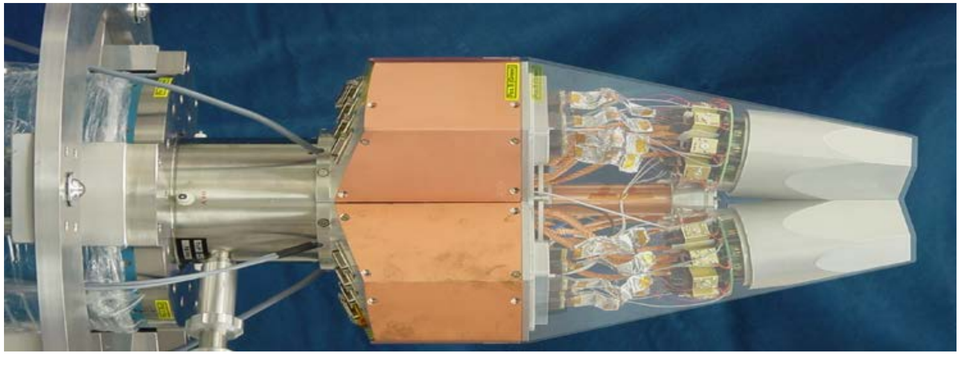
Detector Module
Cryostat & Electronics

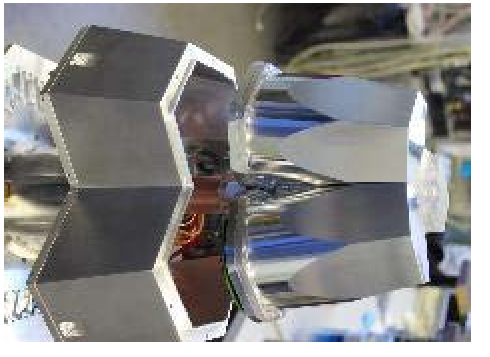
Foreseen modifications to improve the reliability of the cryostats:

- New feedthroughs: consist of gold-plated contact pins in insulators of aluminium-oxide ceramic.
- Improved vacuum getter material
- Getter installed in a flexible housing box on the cooling finger, that can be easily dismounted and annealed outside

No change in the pre-amplifiers is foreseen for the next phase.
Here potential difficulties due to obsolete electronic components and maintenance of the preamps is anticipated.

- Obsolete field effect transistor FET BF862 no longer produced.
- The same is true for the liquid nitrogen fill level meter.



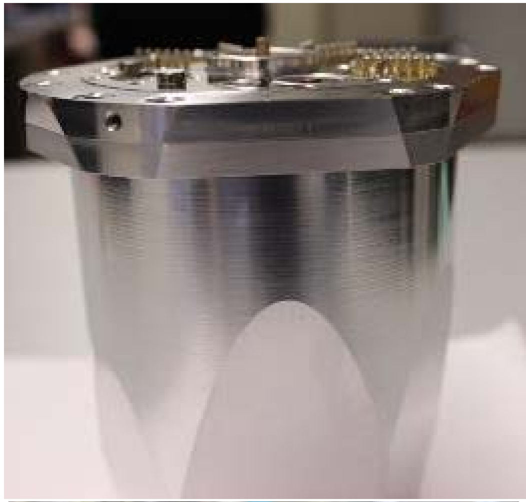


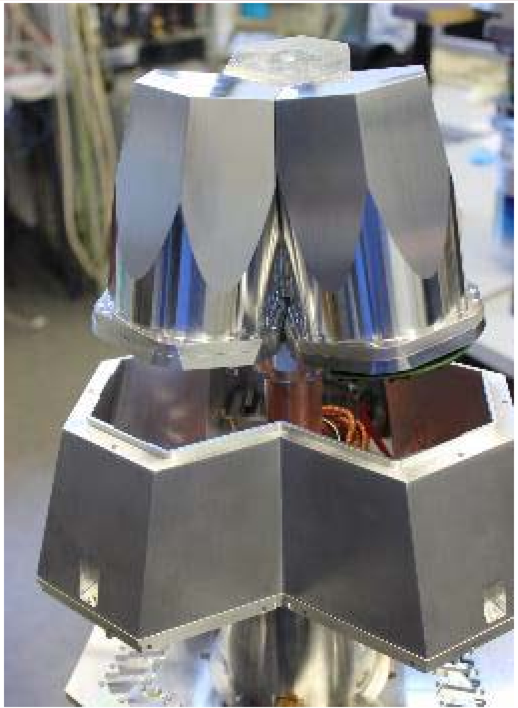
IKP-Köln, Uni. Liverpool, CEA IRFU-Saclay, GANIL, IPHC-Strasbourg

Detector Developments

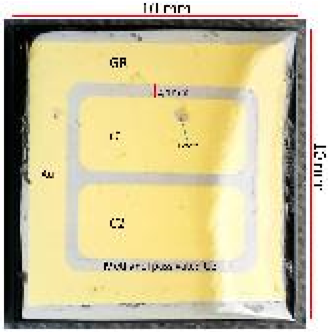
New Encapsulation, R&D on Ge detector

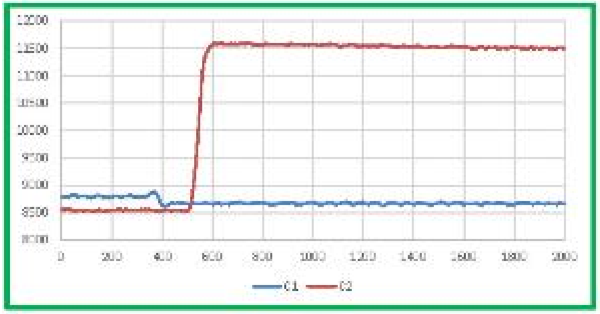
- A new encapsulation development has been performed at IKP-Cologne in collaboration with Mirion/Canberra.
- The design of the new capsule allows to reuse it. Fully compatible with previous ones. Mounting of crystal in capsule can be done now at Mirion →faster and safer.





- ENSAR2 JRA2 – PSeGe R&D on Position-Sensitive Germanium Detectors for Nuclear Structure and Applications: task 1 and 3
  - Task 1: New technologies on passivation and segmentation (INFN, IKP-Cologne):
  - Task 3: R&D on segmented p-type coaxial detectors (IFIC, INFN, Uni. Padova)

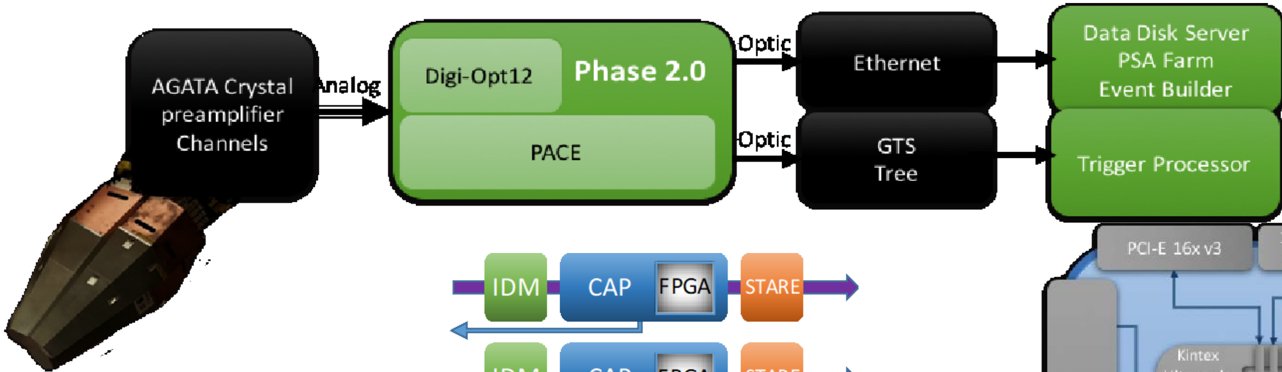




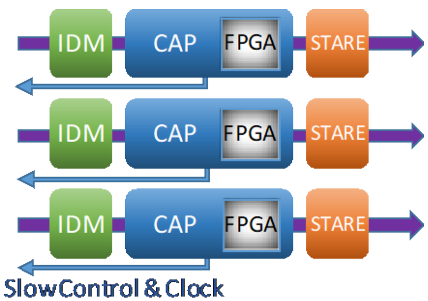
2mm thick p-type HP-Ge prototype. Gap 0.4mm next 0.2 mm

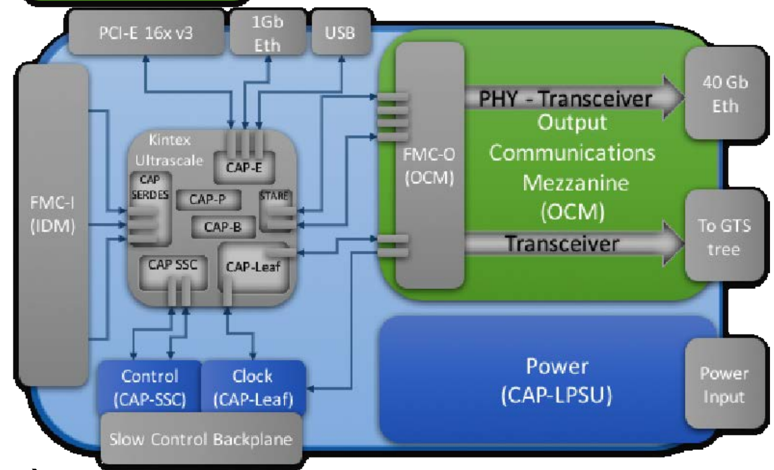
IKP-Köln, INFN-LNL, Uni. Padova, IFIC, Uni.Liverpool, IPHC, Mirion

R&D on Electronics

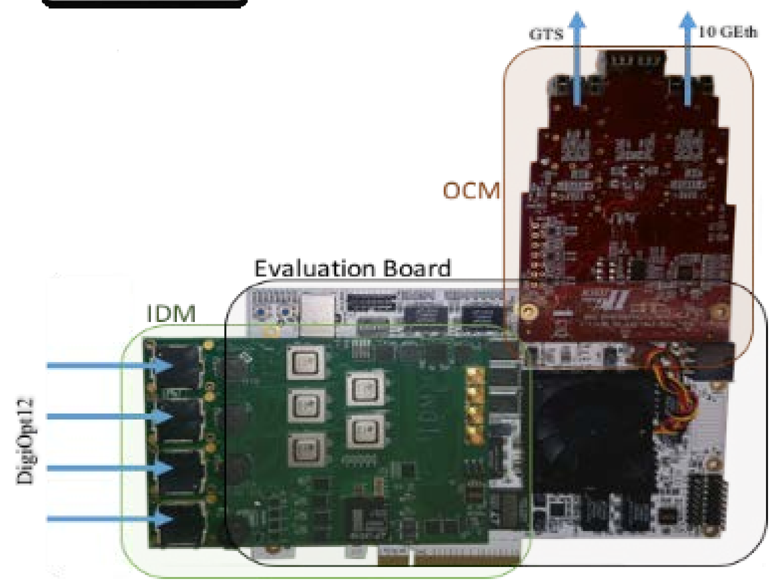


Higher processing capability.
Ethernet readout.





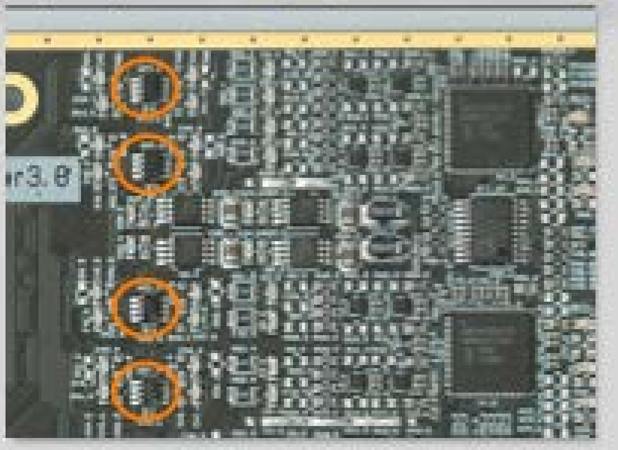
- Electronics R&D, aiming for a higher processing capability and Ethernet readout.
- DIGITIZER based on DIGIOPT12 (INFN-Milano) Improved Differential linearity (Sliding Scale).
- Pre-processing being tested on a Virtex Kintex or Zinq Ultraescale. SoM based solutions
- Optimized Input Data Module (IDM), Ethernet readout module (STARE) and GTS interface
- Firmware aiming to improve the triggering, processing and read-out capabilities.
- Inspection and monitoring information for diagnostic



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

DIGIOPT12 Digitizer

New opamps for analog signal conditioning

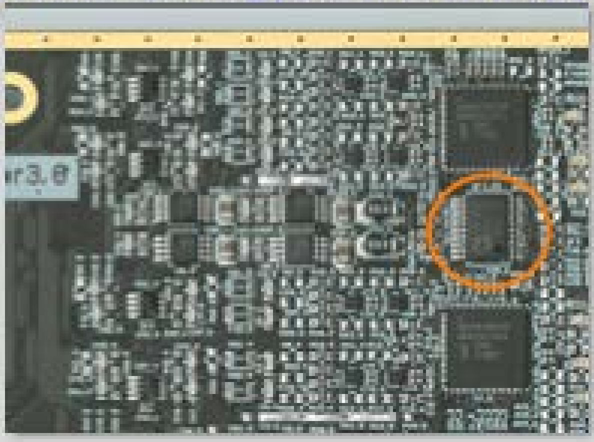


"Old" opamp: **AD8030**
e_n = 16.5 nV / Hz$^{1/2}$

"New" opamp: **LTC6247**
e_n = 4.6 nV / Hz$^{1/2}$

New opamps feature lower noise and larger bandwidth

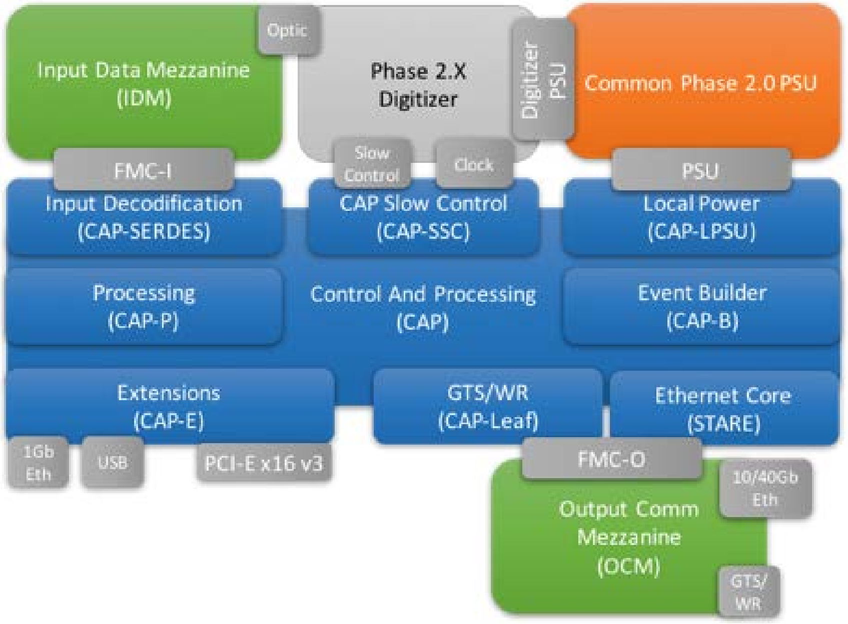
DACs instead than Digipots for ADC DNL characterization and sliding-scale correction optimization



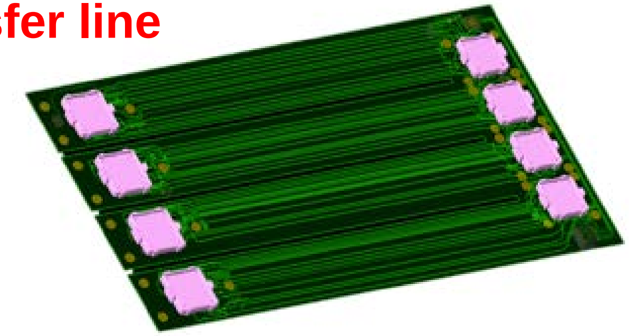
Use of DACs is envisaged in place of Digipots for high-resolution DC offset adjustment over the full ADC range.
The DC offset may then be dynamically changed in order to implement the sliding scale correction as a cure to ADC DNL.

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

Pre-Processing

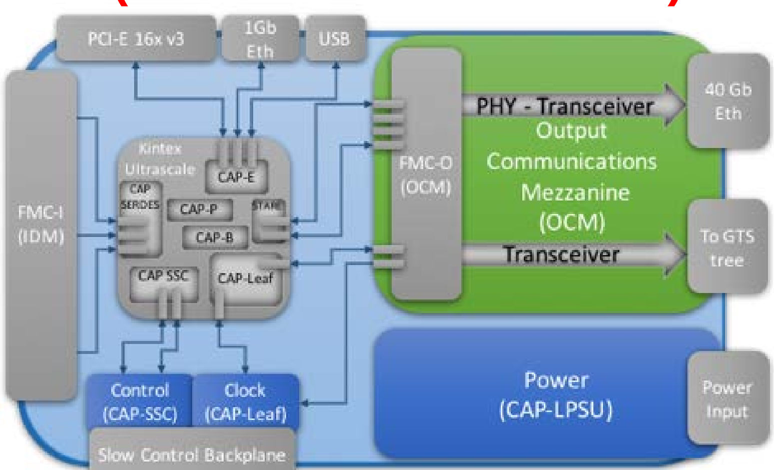


Data transfer line



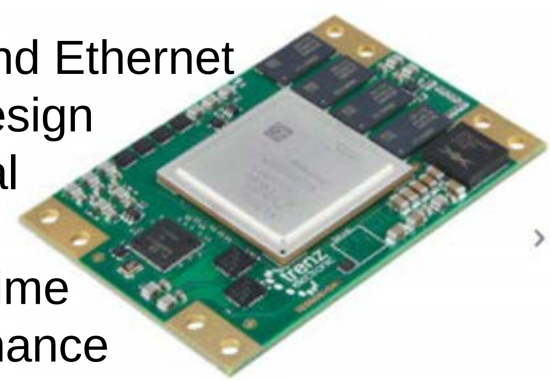
IDM Input Data Motherboard. Concentrator Board.

FPGA Processing and Control Board (Includes GTS Hardware)



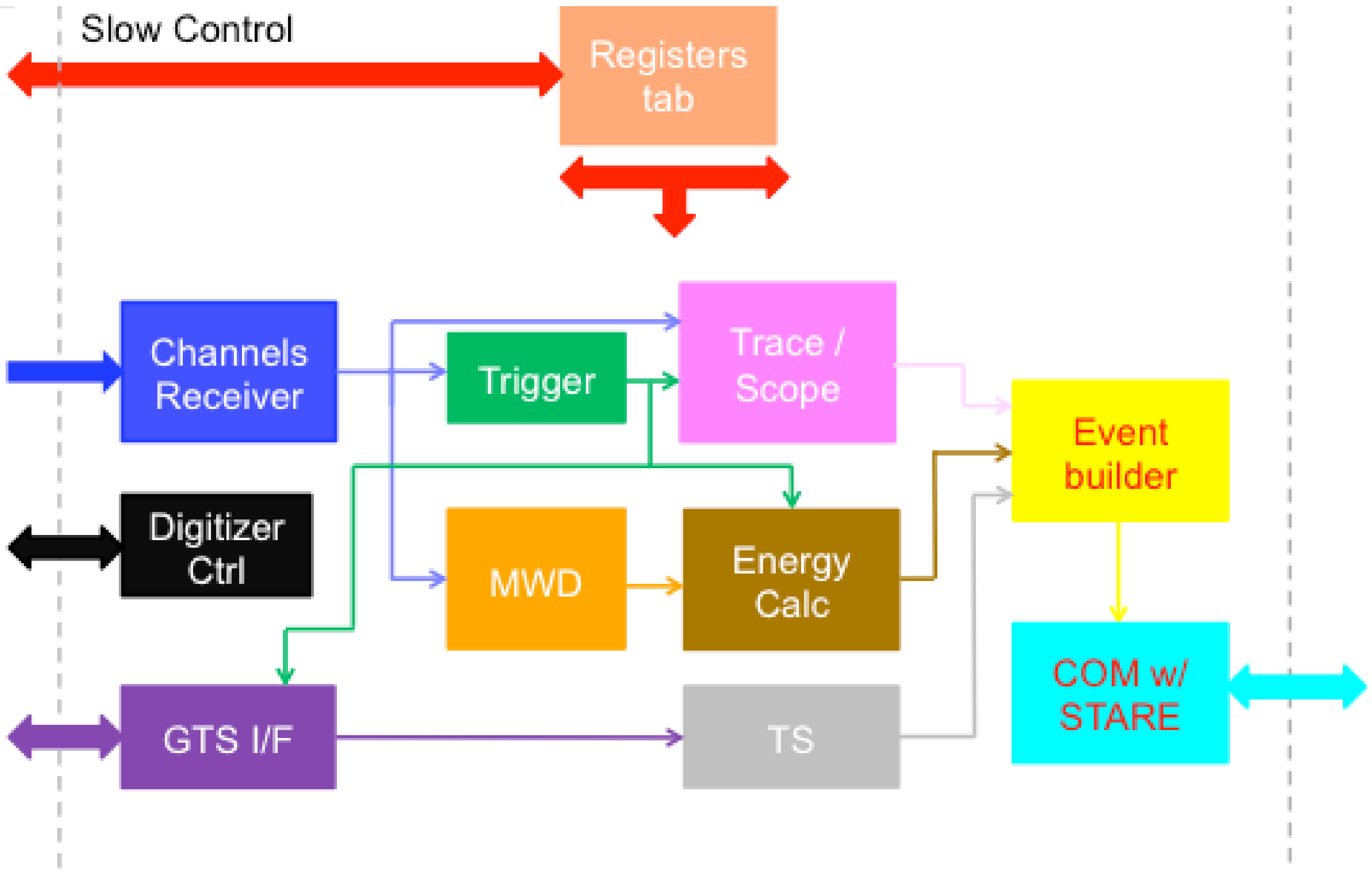
Data Processing and Ethernet Transfer boards Design on SoM commercial Mezzanines.

- Reduces Design time
- Increases Maintenance capability



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

CAP Processing Firmware

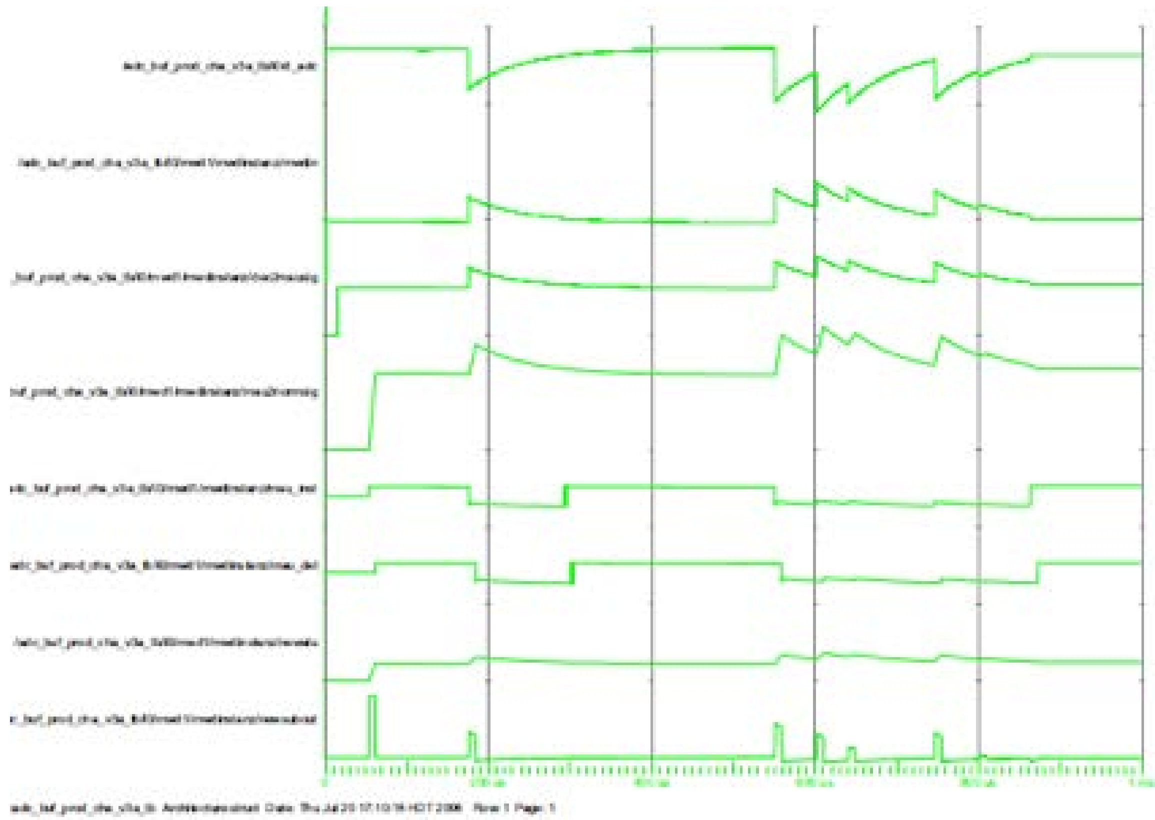


IPHC-Strasbourg, INFN-Milano, CSNSM-Orsay, STFC-Daresbury, IFIC & ETSE-Valencia

Visualization and Diagnostic

Proposal for inspection:

- •Visualisation of input signals.
- •Visualisation of MWD algorithm intermediate results (parameter adjustment).
- •Timing of signals from ancillary detectors.
- •Timing of trigger signals
- •Digital diagnostics for key GTS signals, readout signals

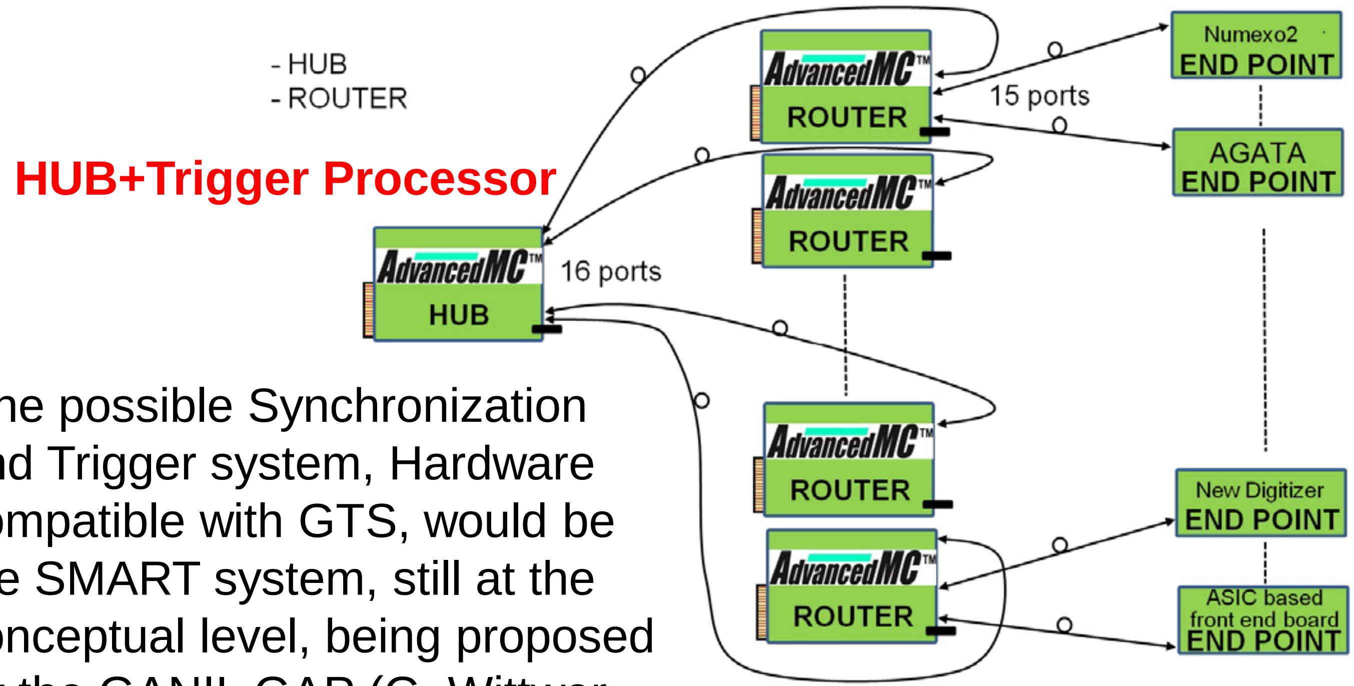


With a Friendly GUI

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

GTS → SMART

UPGRADE OR NEW SYNCHRONIZATION/TRIGGER SYSTEM



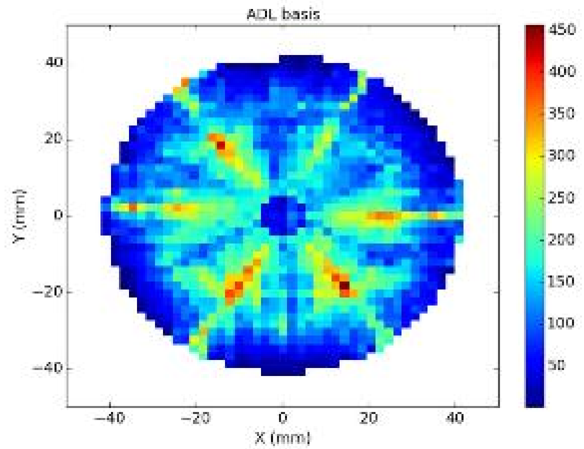
One possible Synchronization and Trigger system, Hardware compatible with GTS, would be the SMART system, still at the conceptual level, being proposed by the GANIL GAP (G. Wittwer et al.).

we expect to start in 2021 with the present GTS system but we would need to migrate towards a new system (SMART)system during he early years of the Phase 2.
Note that the pre-processing embedded GTS hardware is compatible with the SMART hardware.

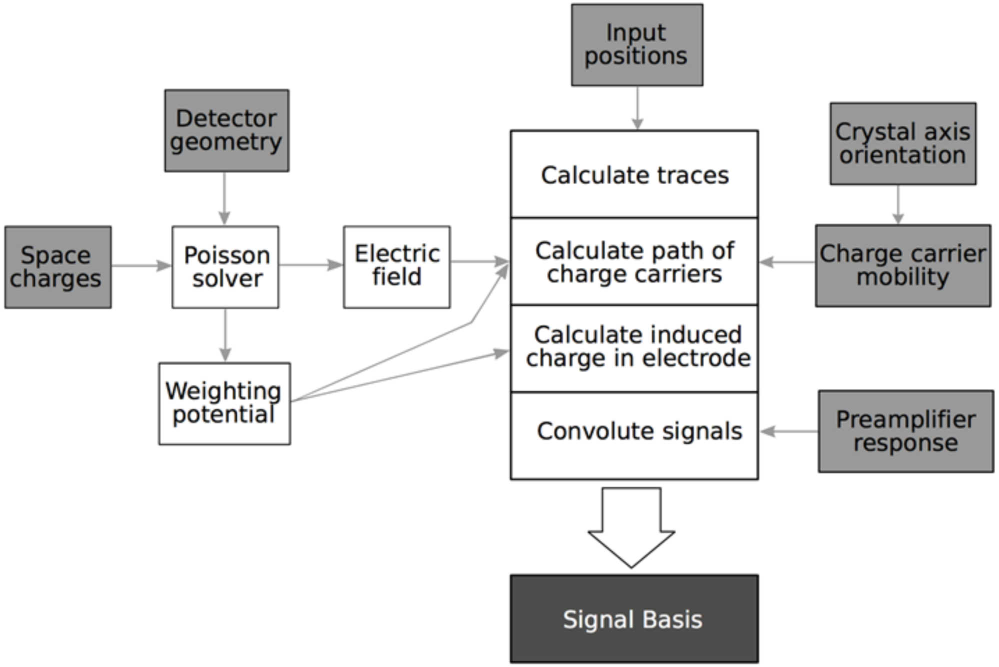
PSA & Characterization

Investigation of the dominant factors limiting the performance of the calculated basis. This would include:

- An evaluation of the impact of the temperature dependence of the mobility parameters
- The impact of a realistic charge cloud size
- Crystal dead layer related effects – the dead layer around the core electrode.
- Neutron damage limitations – how the degree of neutron damage influences the efficacy of the signal basis in addition to the energy resolution correction already implemented.
- The impact of the electronics signal chain (preamplifier, grounding/configuration)



"Clustering" of interactions with present PSA.



Uni.Liverpool, STFC-Daresbury, IPHC-Strabourg, CSNSM, GSI, Uni,Salamanca

PSA & Characterization Upgrades

The PSA:

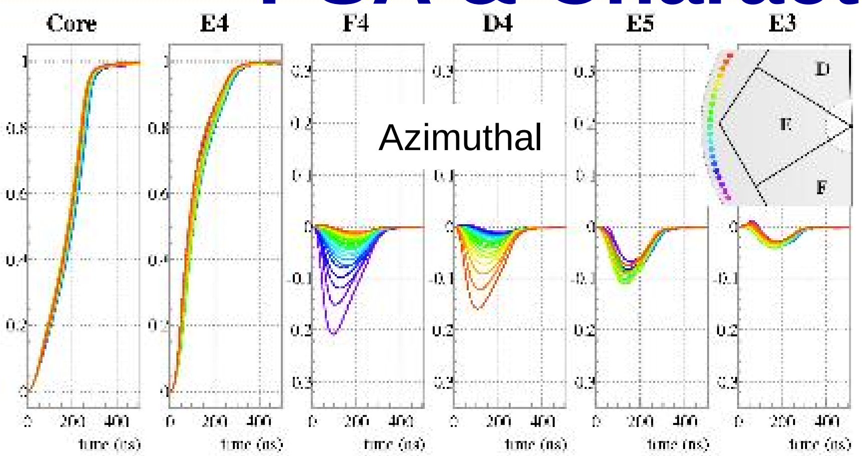
- on-going algorithm upgraded to include handling of multiple interactions in a segment.
- The performance of this algorithm will be evaluated for phase 2.
- Export of PSA position uncertainties from the PSA algorithm to the γ-ray tracking algorithm will be implemented → performance improvements in Tracking.
- An exploration into the use of other (non AGS) PSA algorithms for future implementation. Machine Learning Algorithms.

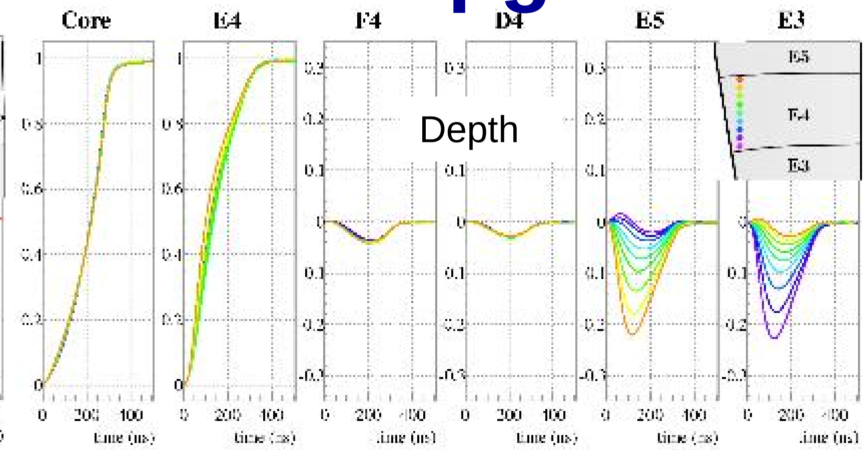
Implications on Data Flow and PSA Infrastructures

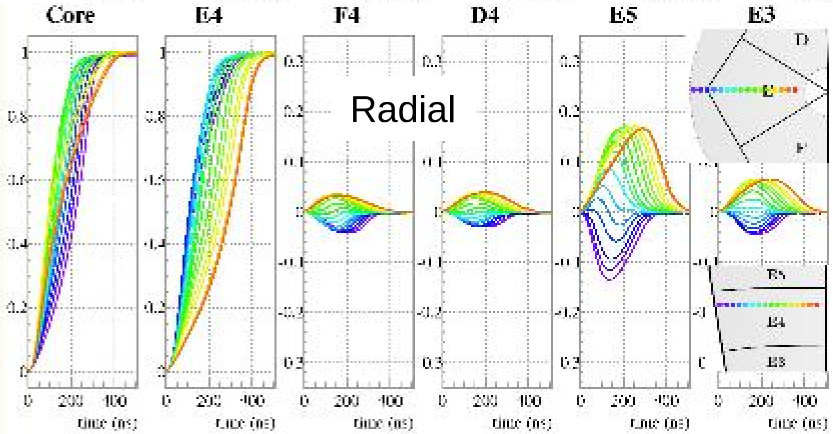
- The computation performance of the algorithm(s) needs to be optimised to run on highly parallel, multi-core nodes.
- The existing algorithm is limiting the count rate capability of AGATA phase 1.
- In AGATA phase 2, the algorithm(s) will be optimised to adapt to the new platforms and to allow flexibility in basis format, PSA outputs, and pre-processing options.
- To take advantage of the performance gains provided by massively multi-core processors these routines will need to be vectorized and multi-threaded.

Uni.Liverpool, STFC-Daresbury, IPHC-Strabourg, CSNSM, GSI, Uni,Salamanca

PSA & Characterization Upgrades







Induced current by the moving charge in the sensing contact: Ramo's Theorem. **E. Gatti, et al. NIM 193 (82) 651**

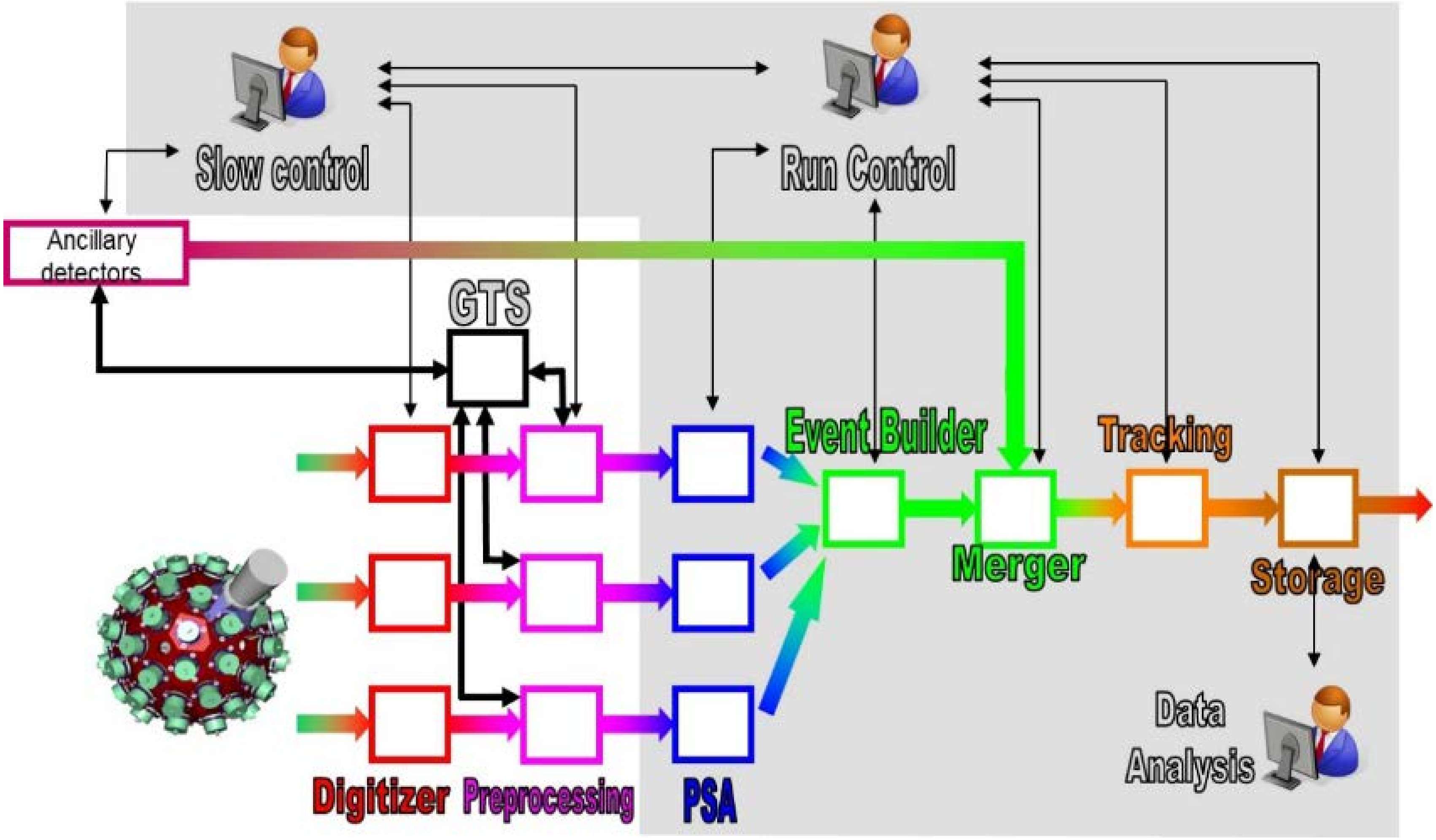
Figures courtesy of M.Ginsz, et al., IPHC Strasbourg

Fundamental tool for understanding the PSA are the Scanning Tables performing the Detector Characterization

- 5 scanning tables, and associated material (criostats, electronics, etc), existing in the collaboration Uni.Liverpool, IPHC, CSNSM, GSI, Uni.Salamanca.
- Recent Upgrade of the Uni.Liverpool and IPHC setups
- Campaign to validate the Pulse Shape Comparison Scan (PSCS) against conventional coincidence data and to obtain Pulses from n-damaged detectors.

Uni.Liverpool, STFC-Daresbury, IPHC-Strabourg, CSNSM, GSI, Uni,Salamanca

AGATA Data Flow, Control and Storage



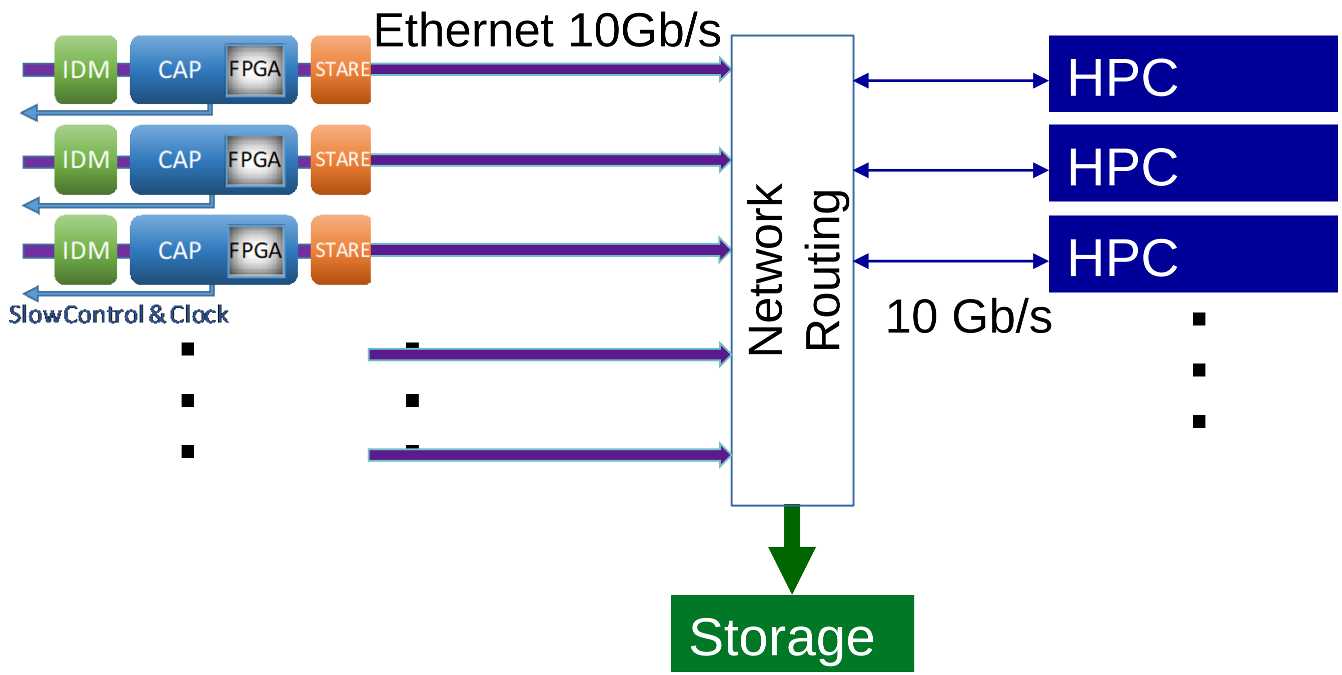
Producers (hand-out data), intermediaries (filters, mergers, …) and consumers (data storage into files, histograms, …).

No changes foreseen in the concept but in the infrastructure

CSNSM-Orsay, GANIL, INP-Lyon, IPN-Orsay

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) :

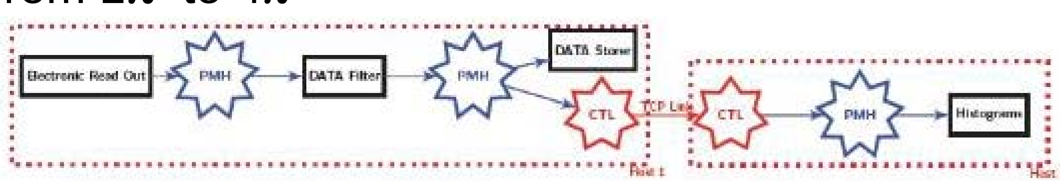
Not necessary 1 node/crystal with the load balancing and new technologies

Specially important if AGATA PSA is upgraded to more complex algorithms

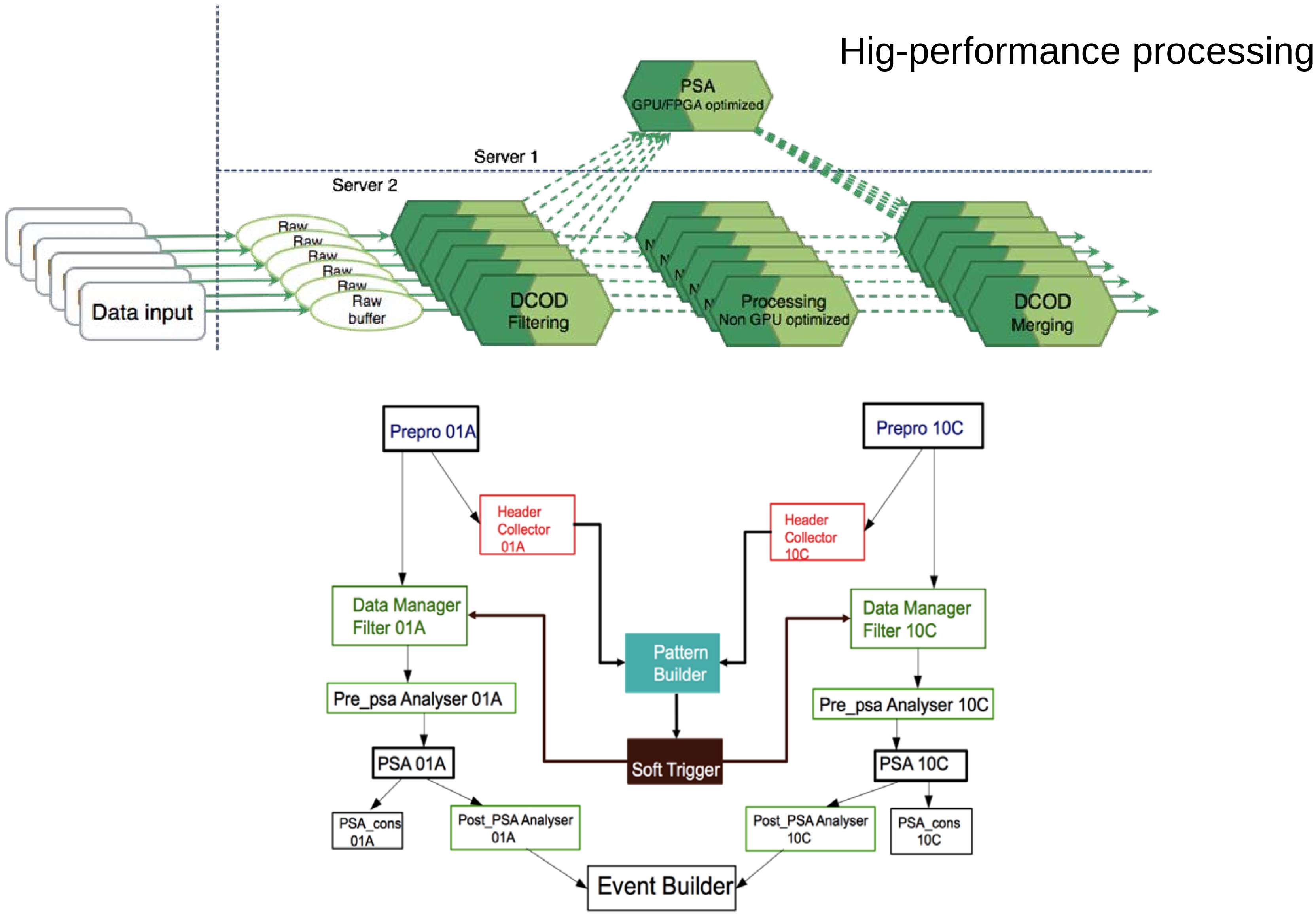
DCOD (NARVAL+ Posix Memory Handler (PMH) + Common Transport Layer (CTL)):

Easy to upgrade from 1π to 4π

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



AGATA Data Flow

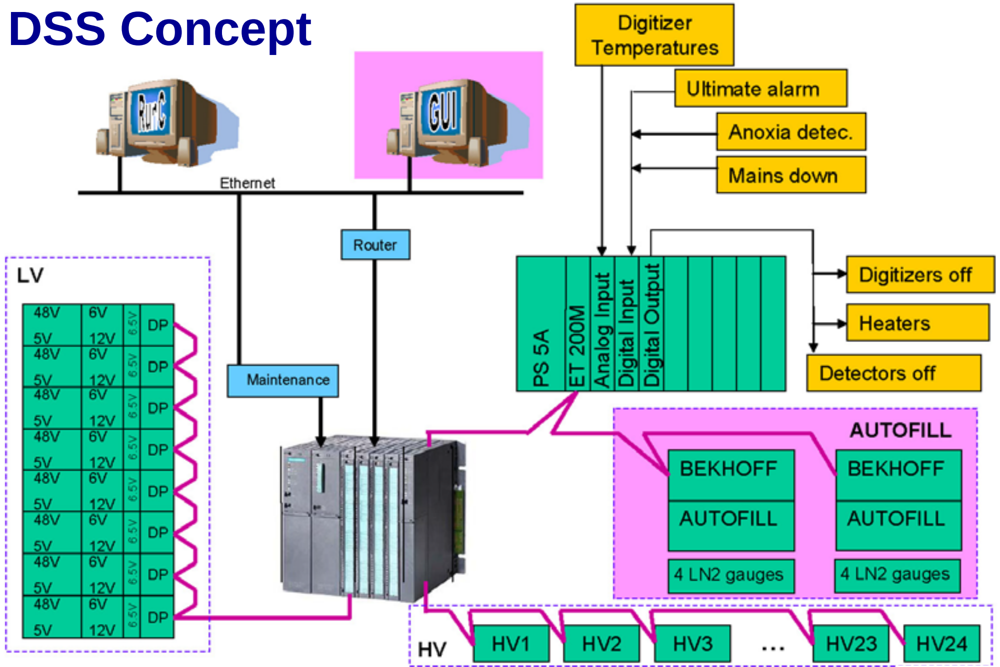


Possibility to combine the hardware trigger with a second high level Software Trigger

CSNSM-Orsay, GANIL, INP-Lyon, IPN-Orsay

Detector Support System

DSS Concept

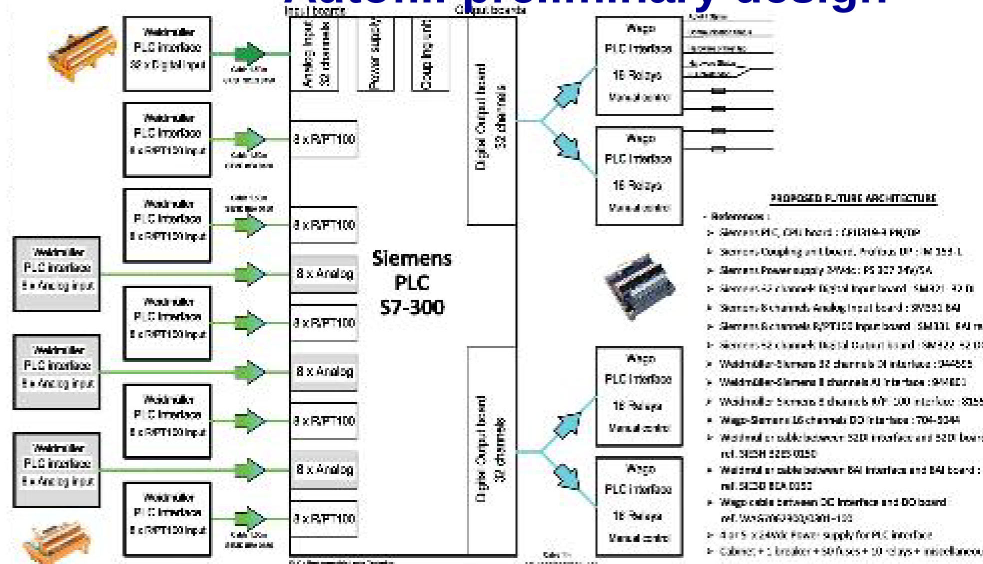


- Detector Infrastructure W.G. with the future Host Laboratories experts and experts of the AGATA Subsystems (Detector, Electronics…) having Initial discussion on how to design the future LVPS, HV, Autofill and in general the DSS.
- Not expected large changes for cabling and detector patch boxes

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.

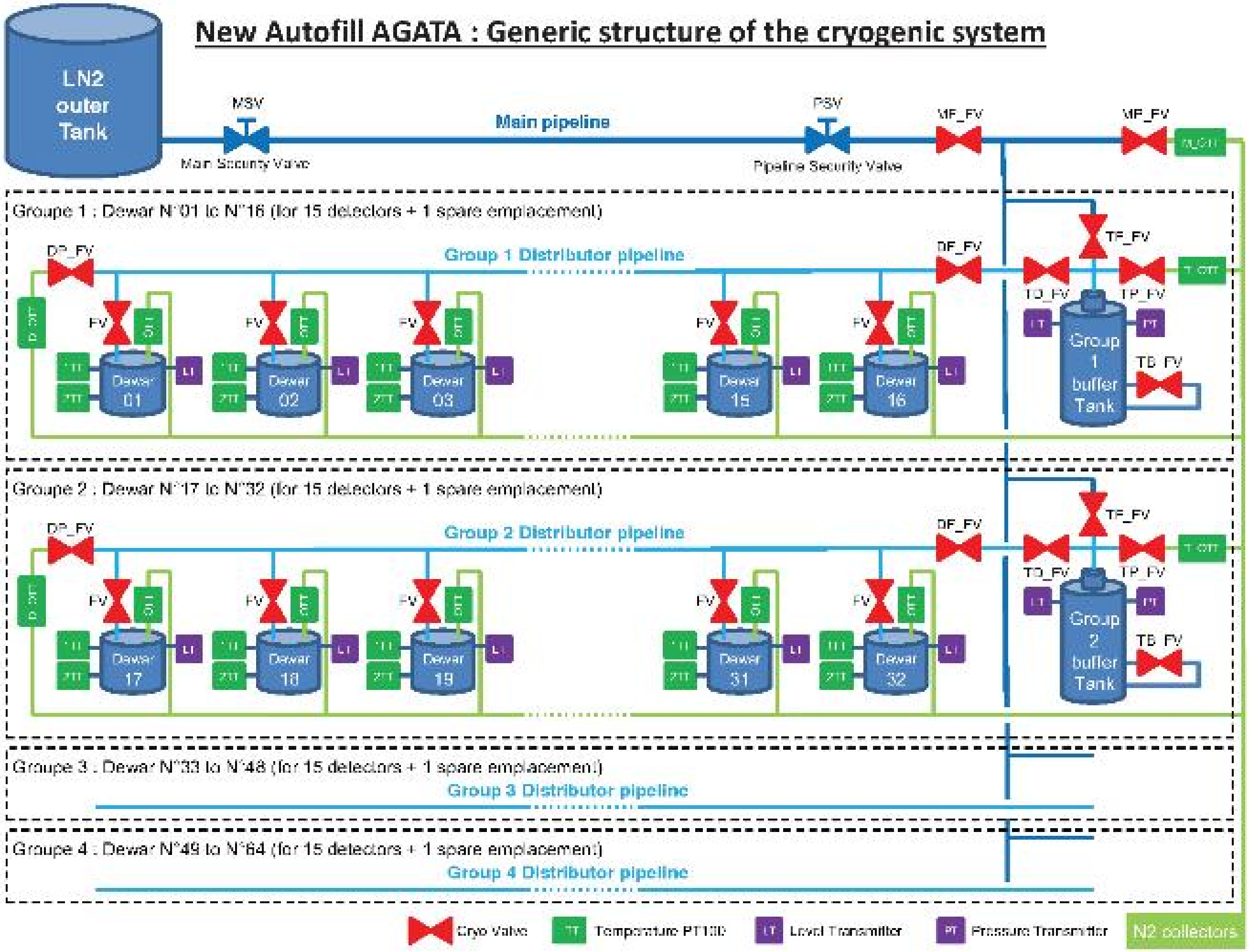
CEA Saclay, INFN-Padova, INFN-Milano, GSI, CSNSM-Orsay STFC-Daresbury, IPHC-Strasbourg, GANIL, INFN-LNL, JYFL-Jyvaskyla,

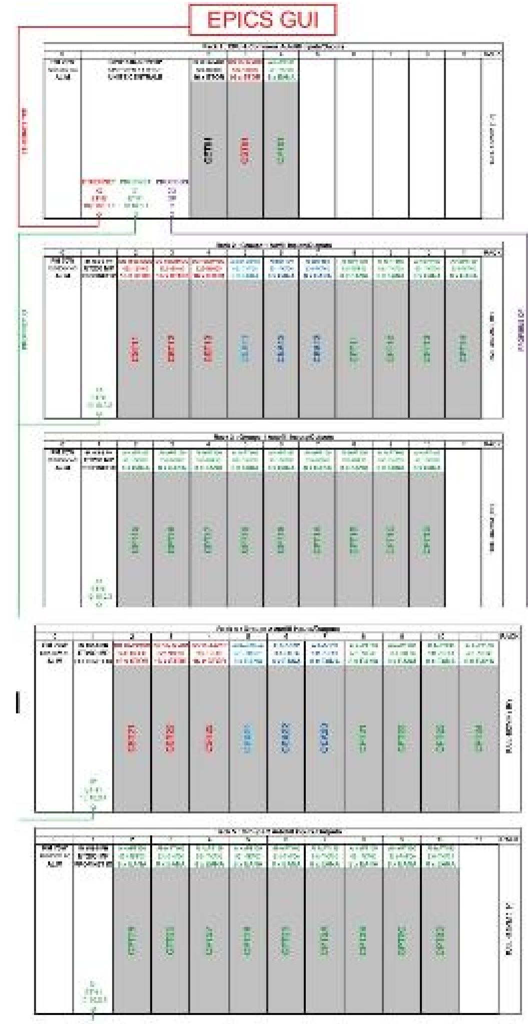
Autofill preliminary design



Configuration for 16 detectors

Detector Infrastructure: DSS Subsystems

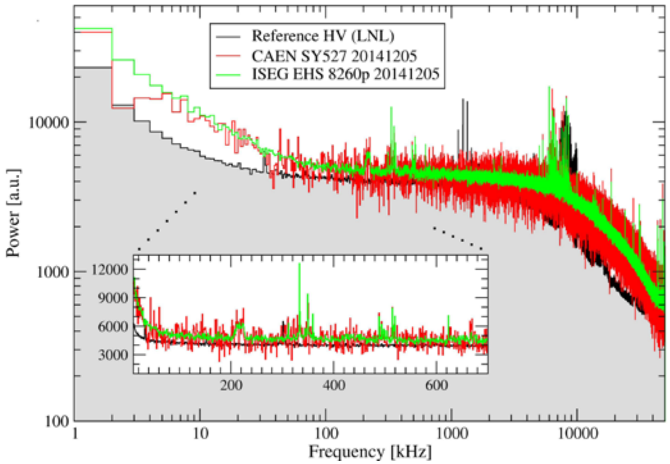




- Autofill upgrade. Extendable to manage 60 ATCs. Produced by IRFU, France.
- The upgrade of the new Autofill is based on a new PLC.
- The new GUI will be based on EPICS system, developer IRFU, France.

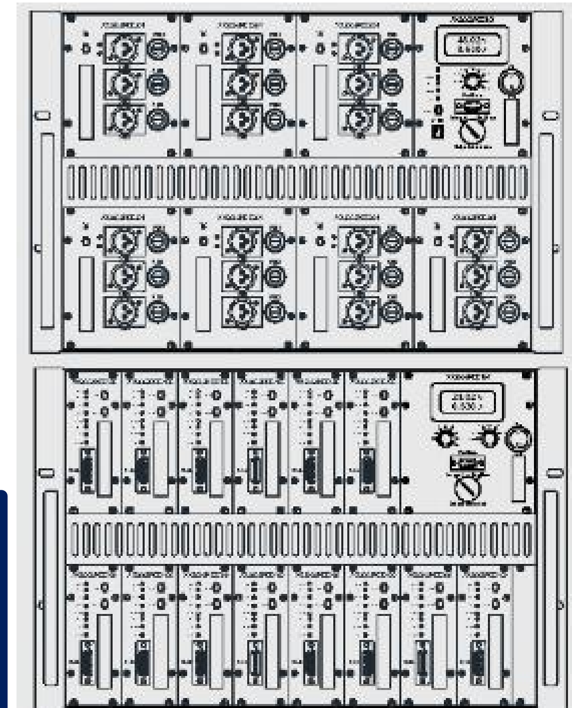
IRFU/CEA Saclay, INFN-Padova, INFN-Milano, GSI, CSNSM-Orsay
STFC-Daresbury, IPHC-Strasbourg, GANIL, INFN-LNL, JYFL-Jyvaskyla,

Detector Infrastructure: DSS Subsystems



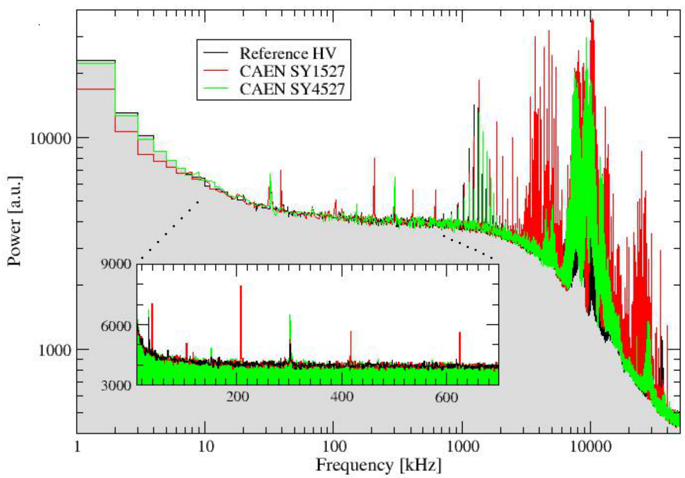
LVPS

1 ATC (2007 LVPS)



7 ATC (Phase 2 LVPS)
Developed by
IRFU/CEA Saclay

HV



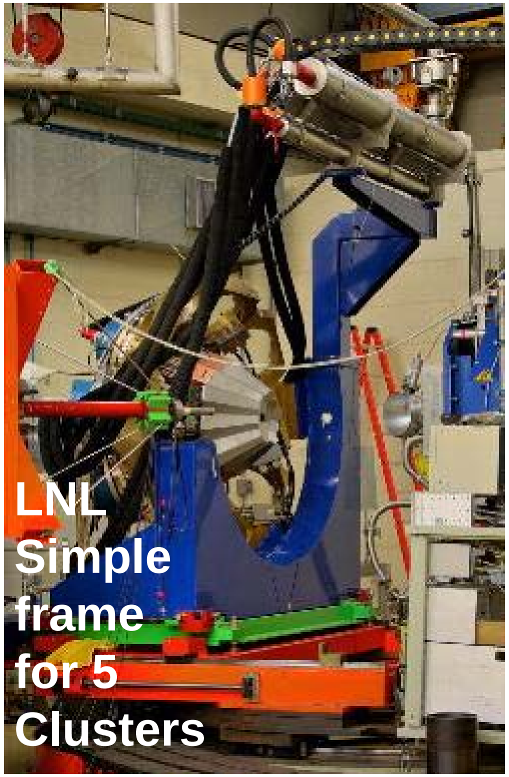
CAEN
SY4527 mainframe +
A1560H boards
ISEG
crate + EHS8260P boards

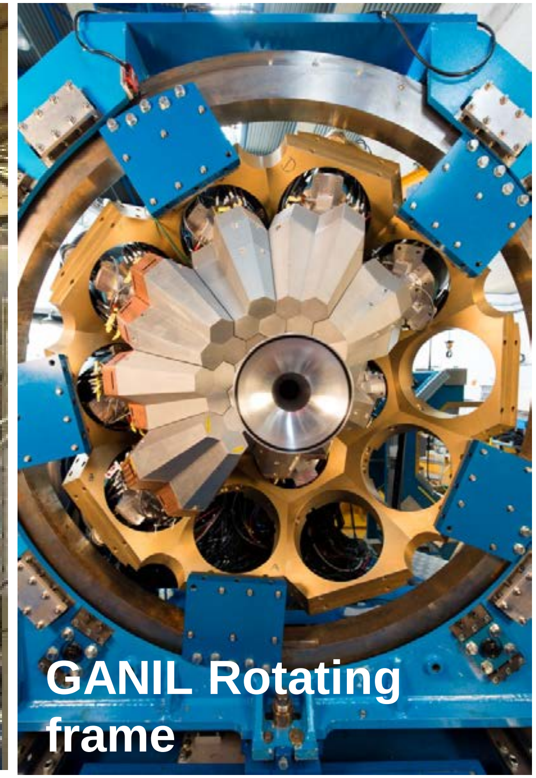
- similar performances
- excellent solutions for HPGe detectors

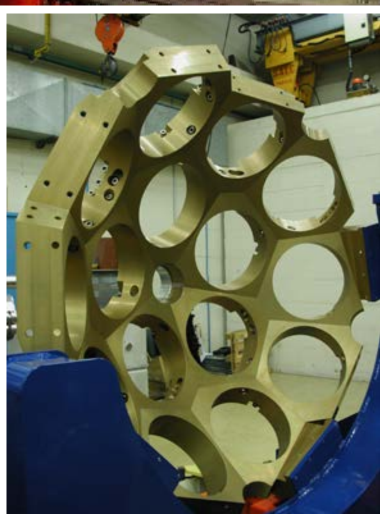
IRFU/CEA Saclay, INFN-Padova, INFN-Milano, GSI, CSNSM-Orsay
STFC-Daresbury, IPHC-Strasbourg, GANIL, INFN-LNL, JYFL-Jyvaskyla,

STFC-Daresbury

Mechanical Infrastructures





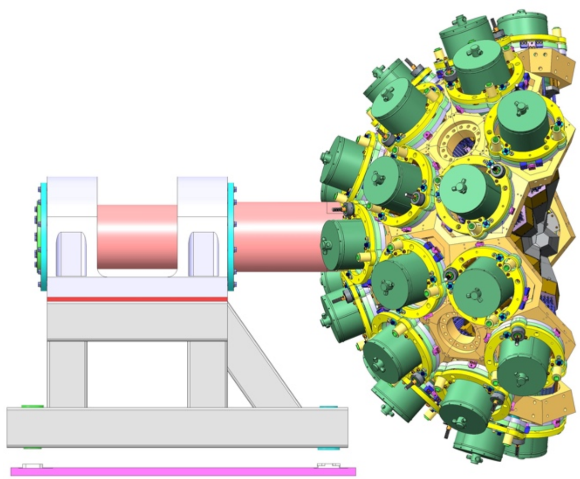


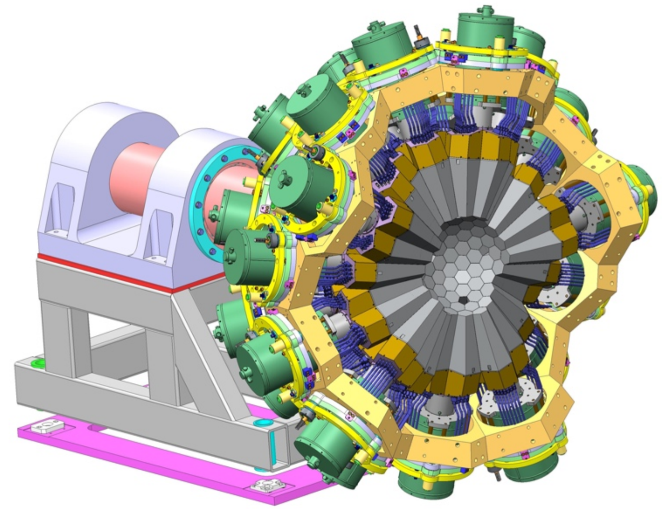
The AGATA Honeycomb is the core of the detector support mechanics. Each Host Lab has produced a Frame fulfilling the local requirements: beam-line height, space availability, array displacement.

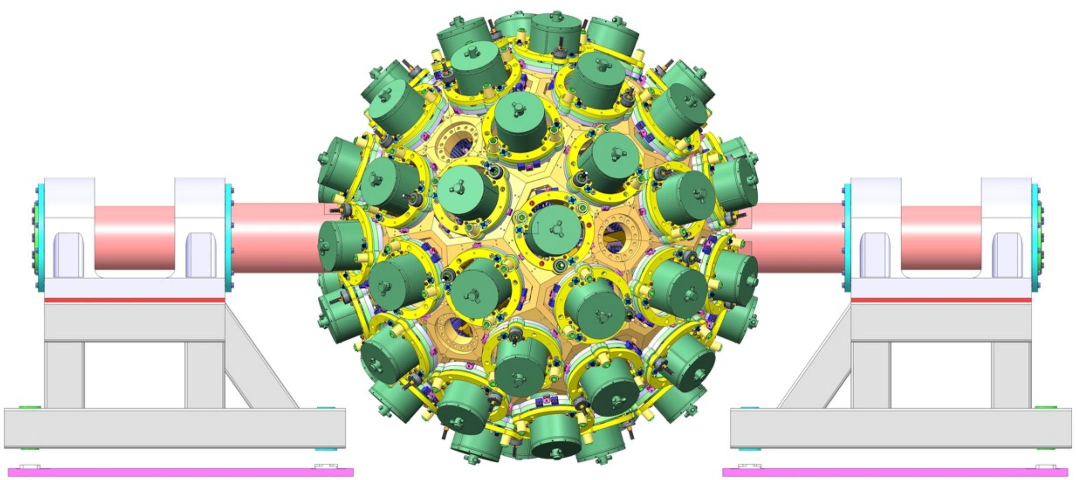
Now working on compatible mechanics

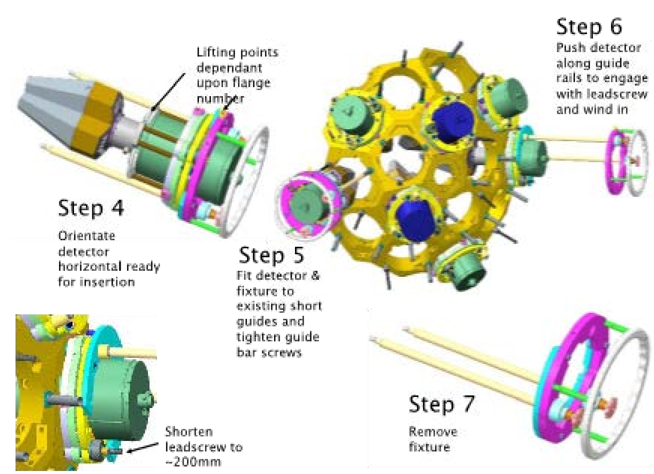
STFC-Daresbury, GANIL, INFN-LNL INFN-Milano, INFN-Padova

Mechanical Infrastructures









STFC-Daresbury, GANIL, INFN-Milano, INFN-Padova

AGATA Simulations

The development of the code will continue by coupling AGATA with ROOT. The following two options will be considered and at least one will be implemented:

- Migrate the AGATA code, including all its event generator/ancillary detector into an existing simulation and data analysis framework such as ENSARROOT, NPTOOL, STOGS.
- Develop the AGATA code from a pure geant4 simulation code to a GEANT4+ROOT.
- External algorithms based on ROOT to simulate time-stamped AGATA data already developed to produce AGATA Data Format ADF files.
- Additional work will be carried out to integrate this algorithm into the AGATA code. (Similar capabilities exist also within the STOGS framework and could be re-used for AGATA).

Additional work is also foreseen to develop and complete some event generators for realistic simulations. This includes generators for polarisation measurements and generators with simplified and realistic background estimate.

STFC-Daresbury, GANIL, INFN-Padova…

AGATA Commissioning and Performance

- Measurements with either radioactive sources or well-known in-beam reactions. Also to validate MC-simulation codes and tools,
- Calibrated radioactive source runs to carried out prior to a new campaign
- Consistency of the results should be compared with both simulations and previous measurements.
- Monitoring of performance in the long term is important and it will be crucial to quantify the radiation damage to each of the crystals.
- During the period 2021-2030 the angular coverage of AGATA will increase
  - To extract useful physical quantities from angular distributions and correlations
  - To perform measurements depending on the perturbation of the angular distribution/correlation, e.g. g-factor measurements
  - Thus understanding of the performance of AGATA is of paramount importance.
- Commissioning will allow to check the performance figures when coupled to complementary instrumentation

TU-Darmstadt, CSNSM-Orsay, GANIL, INFN-Padova, IFIC,

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)

AMB Chairman
Project Manager
A.Gadea

Resource
Manager
B.Million

AGATA Working Groups

AGATA Working Groups	AGATA Teams			
Detector Module H.Hess	Detector & Cryostat (tbd)	Detector CAT &Testing H. Boston	R & D on gamma Detectors & Applications	
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		
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	GSI	GANIL-SPIRAL2
Legnaro	Darmstadt J.Gerl	Caen E.Clement

Summary

- The AGATA collaboration is aiming now to complete the 4π array
- Several Subsystems sometimes design and build for the AGATA Demonstrator (2005-2007) require upgrade
- Redesign considering long-term maintenance and replacement using commercial parts when possible and increasing the standardization (e.g. replacing the point-to-point data transfer by Ethernet)
- Aiming as well to have Improvements on mobility, compatibility, data transfer and processing –to approach the full Tracking Array performance figures-.

Thanks' to all the AGATA Collaborators

Thank You For Your Attention!

UNIÓN EUROPEA
Cofinanciado por el Fondo Europeo de Desarrollo Regional
Una manera de hacer Europa

Supported by MINECO, Spain
Grant n. FPA2017-84756-C4

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