



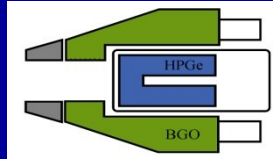
AGATA: Status and Future Plans; AGATA in an ECOS facility

A. Gadea (IFIC, Valencia)

**ECOS-EURISOL Joint Town Meeting- IPN Orsay, France
October 28-31, 2014**

HR γ -Spectroscopy Instrumentation for Nuclear Structure

Late 90's
Large γ -Arrays



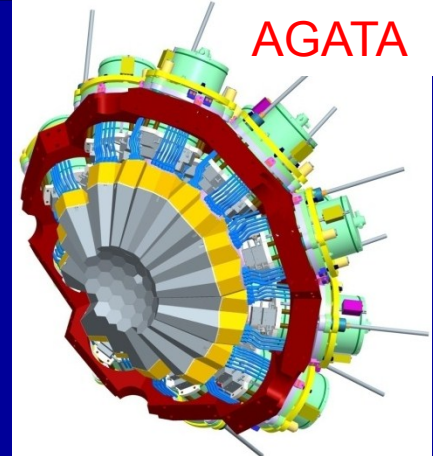
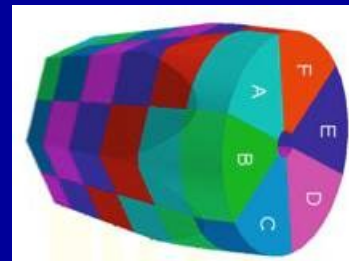
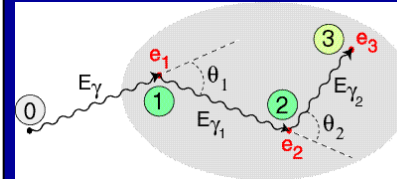
$\epsilon \sim 10 - 5\%$
($M_\gamma=1 - M_\gamma=30$)

Compact γ -Arrays optimized
Doppler correction, low M_γ



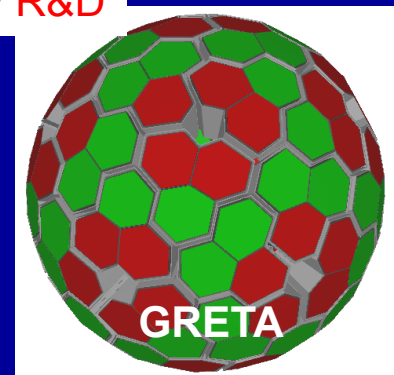
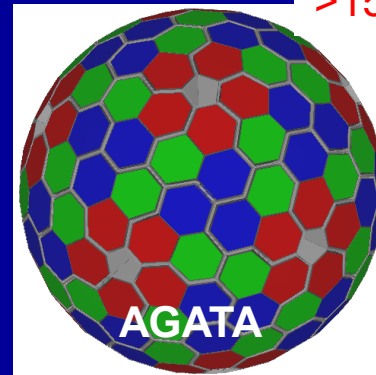
$\epsilon \sim 20\%$ $M_\gamma=1$

Tracking Arrays based on
Position Sensitive Ge Detectors



Two Tracking Arrays projects:
GRETA (USA) & AGATA (EU)

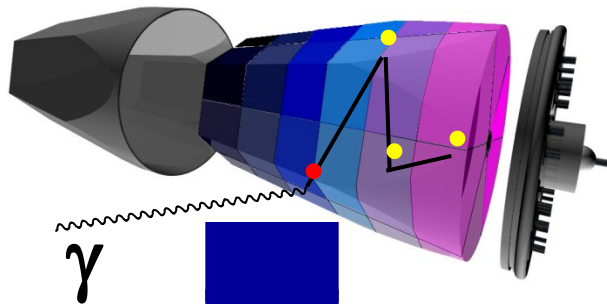
>15y R&D



$\epsilon \sim 40 - 20\%$
($M_\gamma=1 - M_\gamma=30$)

Concept of γ -Tracking

Highly segmented
HPGe detectors
NOVEL PRE-AMPS

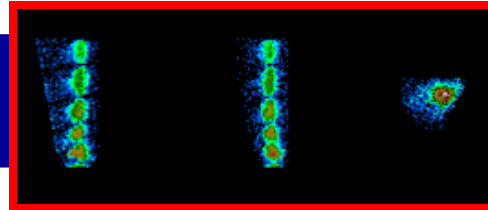
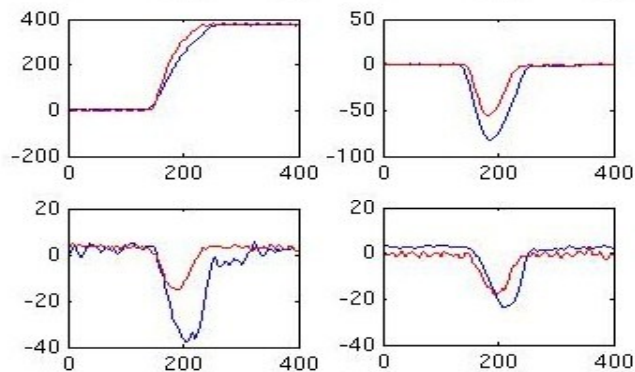


Synchronized digital
electronics
record and process
the segment signals
DIGITIZERS +
PRE-PROCESSING

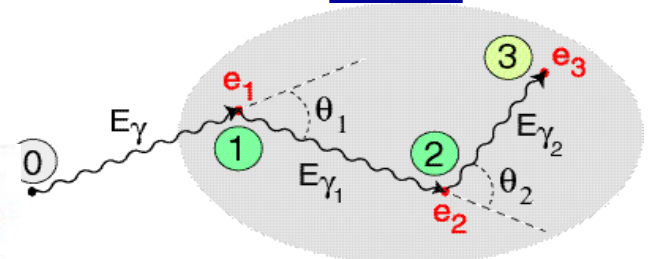
Identified
interaction points

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

Pulse Shape Analysis
to de-convolute the
recorded waves
DAQ PSA - FARM



Reconstruction of
interaction tracks
(tracking algorithms
on interaction points)
DAQ TRACKING-FARM



On-line reconstruction
of γ -rays

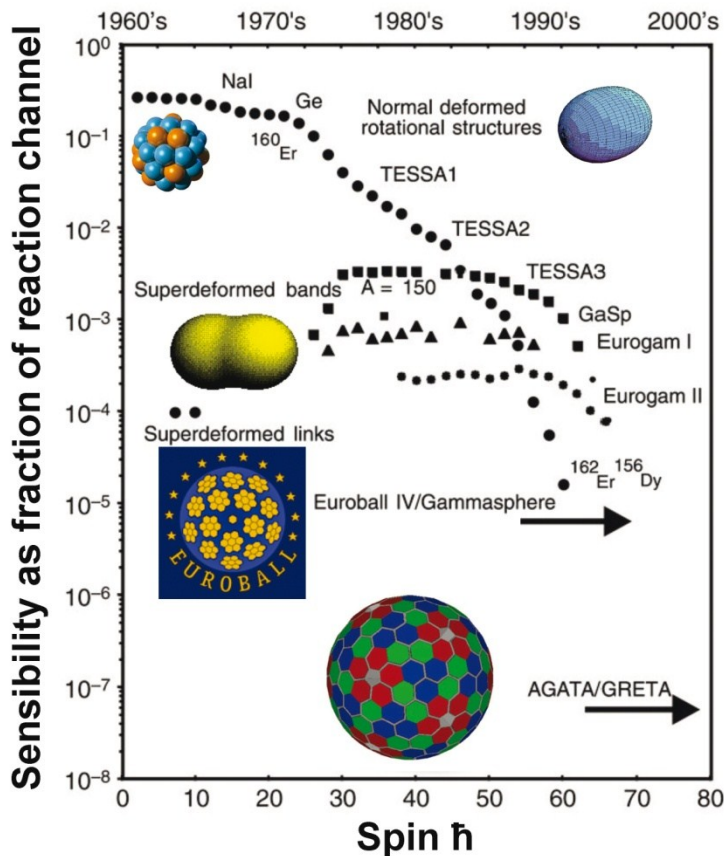


AGATA

(Advanced **G**amma **T**racking **A**rray)



Encapsulation



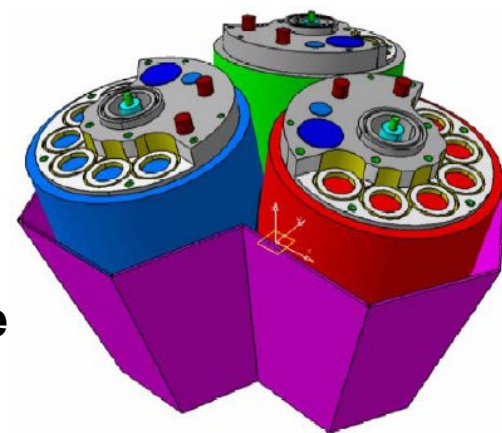
180 hexagonal crystals: 3 shapes
 3 fold clusters (cold FET): 60 all equal
 Inner radius (Ge): 23.5 cm
 Amount of germanium: 362 kg
 Solid angle coverage: 82 %
 36-fold segmentation 6480 segments
Crystal singles rate ~50 kHz
 Efficiency ($M_\gamma=1$ [30]): 43% [28%]
 Peak/Total ($M_\gamma=1$ [30]): 58% [49%]

6660 high-resolution digital electronics channels

High throughput DAQ

Pulse Shape Analysis → position sensitive operation mode

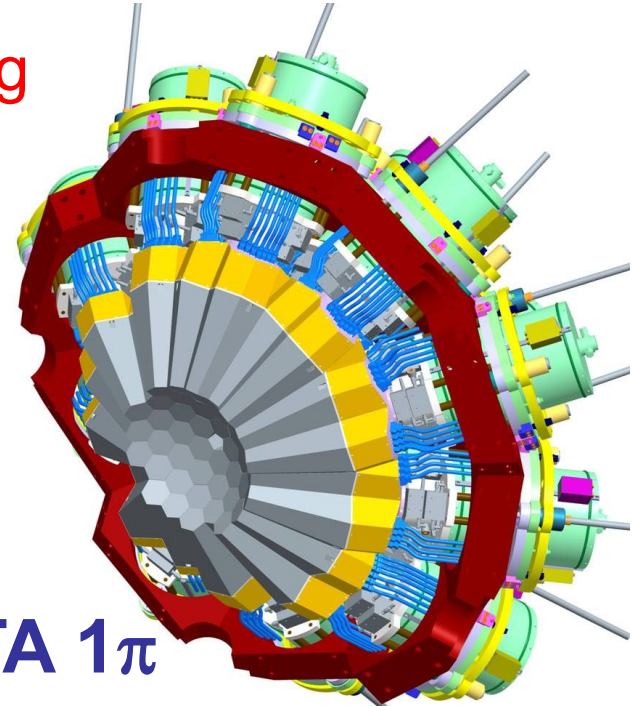
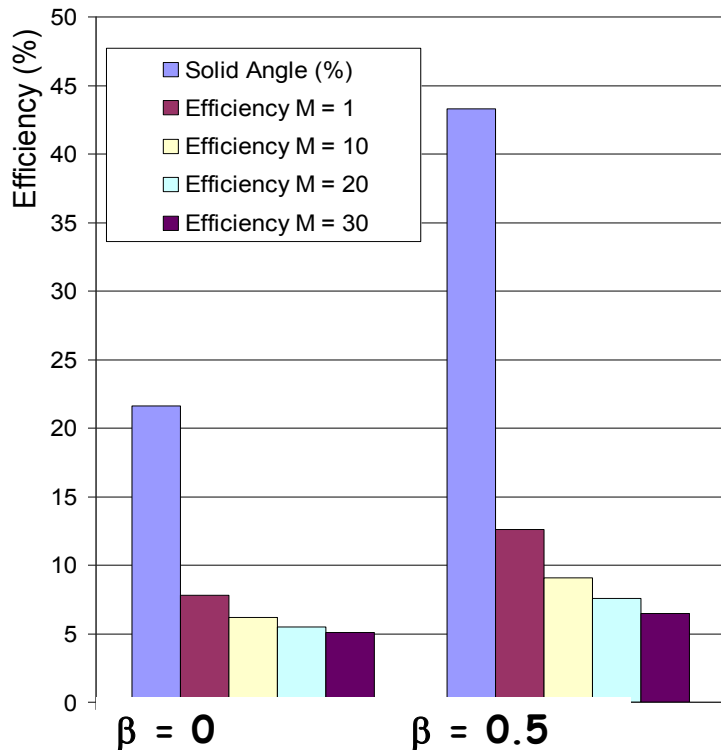
γ -ray tracking algorithms → maximum efficiency and P/T



The AGATA 1π

Objective of phase 1: 2009-2015

- Present phase of AGATA, **MoU ongoing**
- **Phase 1** ($>1\pi$) \rightarrow >45 crystals
- Triple and Double clusters
- The first “real” tracking array



AGATA 1π

To be used at RIB and High Intensity Stable beam facilities
(FAIR-HISPEC, GANIL, SPIRAL2, SPES ...)

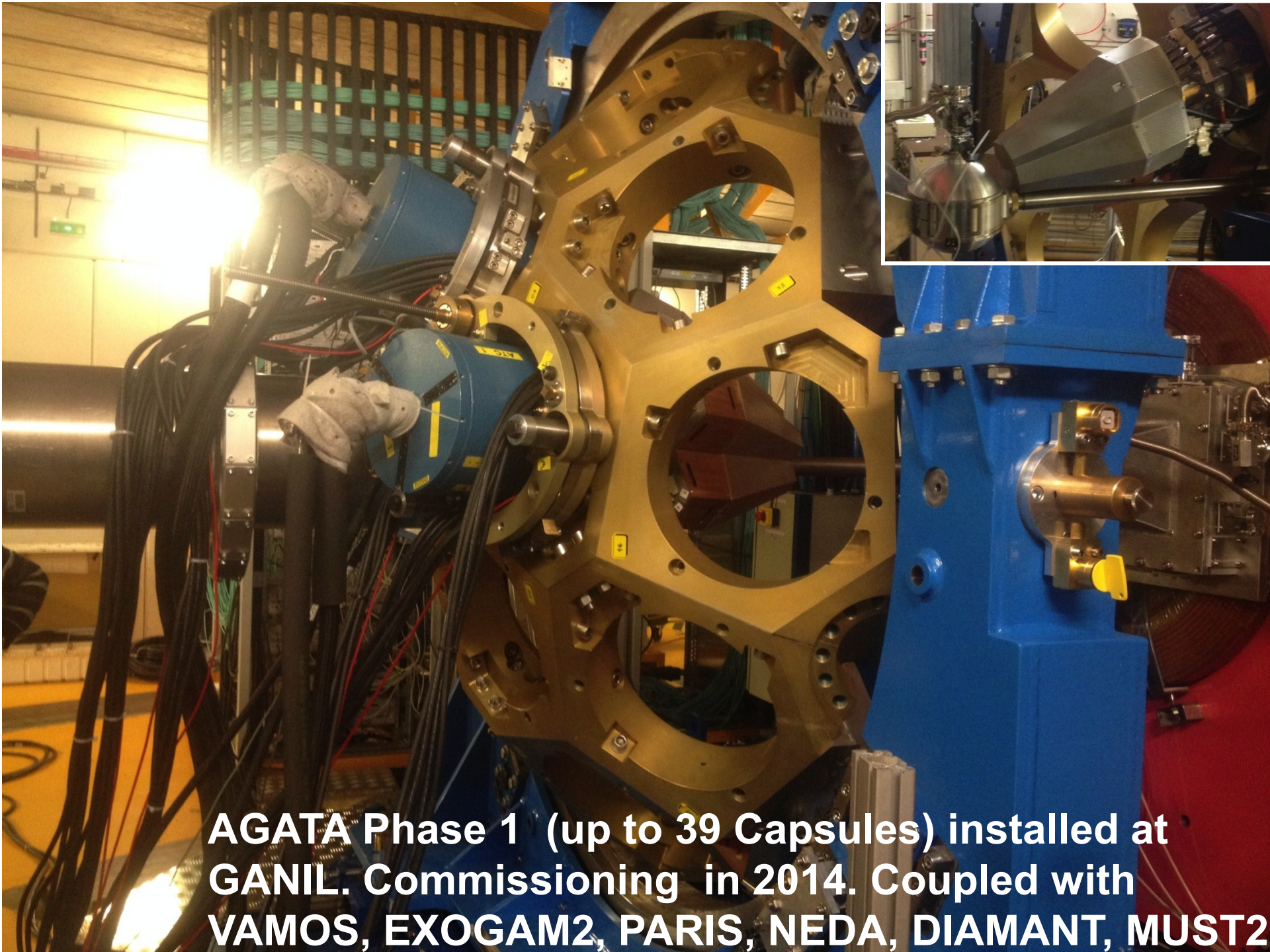
Coupled to spectrometers, beam tracker, LCP arrays ...

A photograph showing the AGATA detector installation. The detector consists of 15 aluminum capsules arranged in a fan-like pattern, mounted on a central support structure. The capsules are connected to a complex network of cables and electronics. The installation is housed within a large, blue-painted metal structure. The background shows a laboratory setting with various equipment and cables.

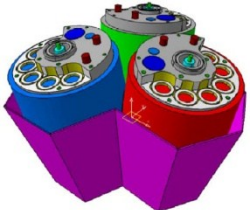
**The first implementation of
AGATA (15 Capsules) installed at LNL in 2010
coupled to PRISMA and HELENA, DANTE, TRACE**

A photograph of the AGATA Early Phase 1 detector installation at GSI. The detector is a large, complex piece of equipment with a prominent blue frame and a central gold-colored cylindrical component. It is surrounded by various cables, pipes, and structural elements of the facility. The background shows a typical laboratory environment with white walls, a green vertical pipe, and a metal ladder.

**AGATA Early Phase 1 (up to 23 Capsules)
installed at GSI in 2012 coupled to FRS & PRESPEC**



AGATA Phase 1 (up to 39 Capsules) installed at GANIL. Commissioning in 2014. Coupled with VAMOS, EXOGAM2, PARIS, NEDA, DIAMANT, MUST2



AGATA Detectors Summary



34 detectors delivered: 9 "A" + 13 "B" + 12 "C"

4 Detectors with failures: 1 "A" + 1 "B" + 2 "C"

1 Detector under CAT

2 "C" + 2 "A" + 1 "B" ordered to be delivered in 2014, 2015 and 2016

8 Triple + 3 Double Cluster Cryostats Delivered

3 Triples to be delivered: 2 in 2014 + 1 in 2015

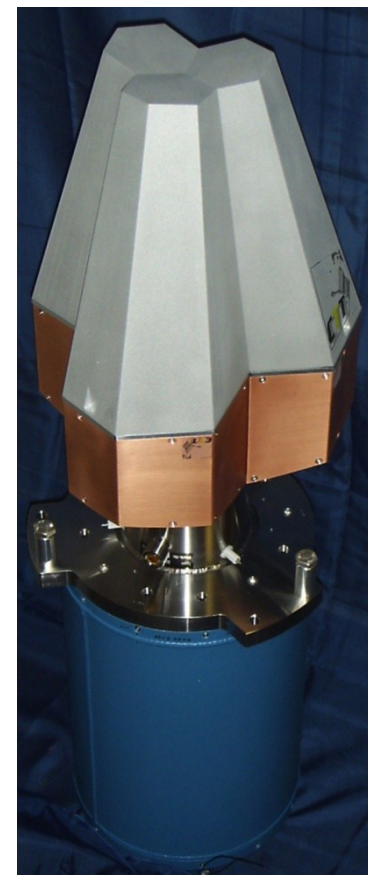
With the number of available capsules possibly:

8 AGATA Triple Clusters

2 (3) AGATA Double Clusters

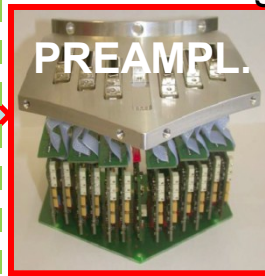
Aim: 30 Crystals in AGATA within 2015.

Work on improving reliability of detectors ongoing: feedthroughs, PA etc...



Structure of Electronics and DAQ

Digital preamplifier concept



Diff. Fast-reset-TOT
INFN-MI/GANIL/KÖLN

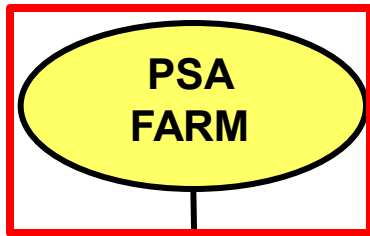


75.5db SNR 12.2 ENOB
IPHC/Liverpool/
STFC 200MB/s/
segment

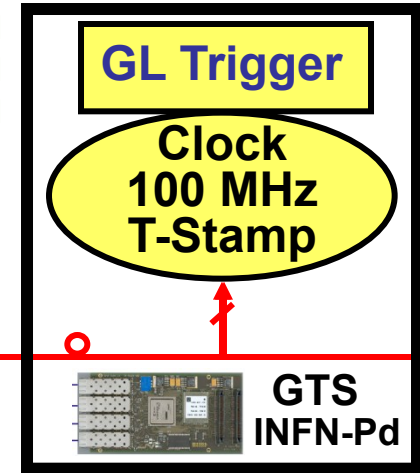
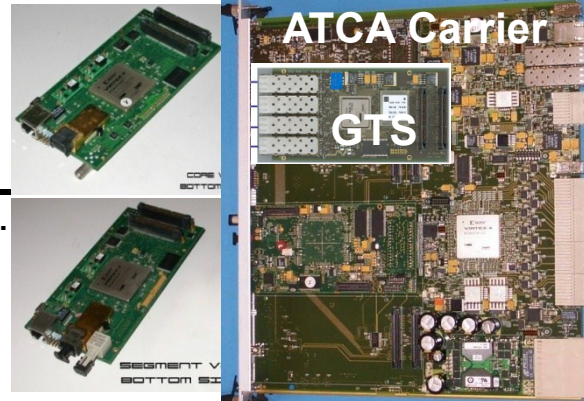
Fast 1st Level Trigger

Other Detectors

Detector
Level

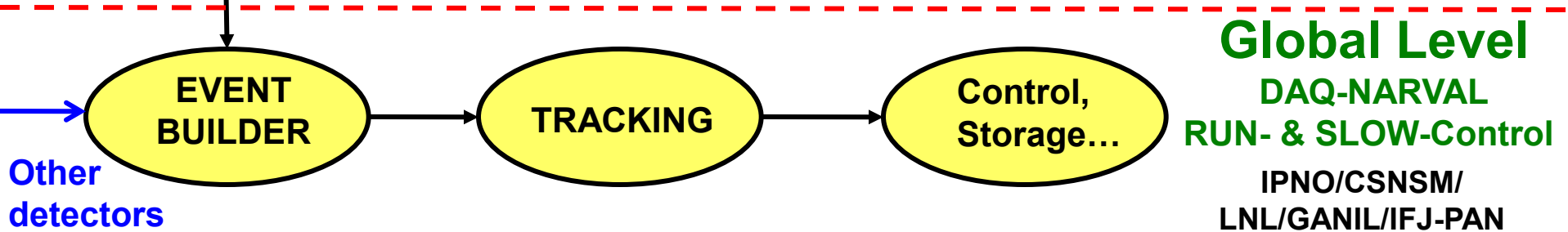


Core +
36 seg.
100MB/s/
detector



HIGH THROUGHPUT
PRE-PROCESSING
CARRIER / MEZZANINES
IPNO/CSNSM/INFN-Pd

Other
detectors



Global Level

DAQ-NARVAL
RUN- & SLOW-Control

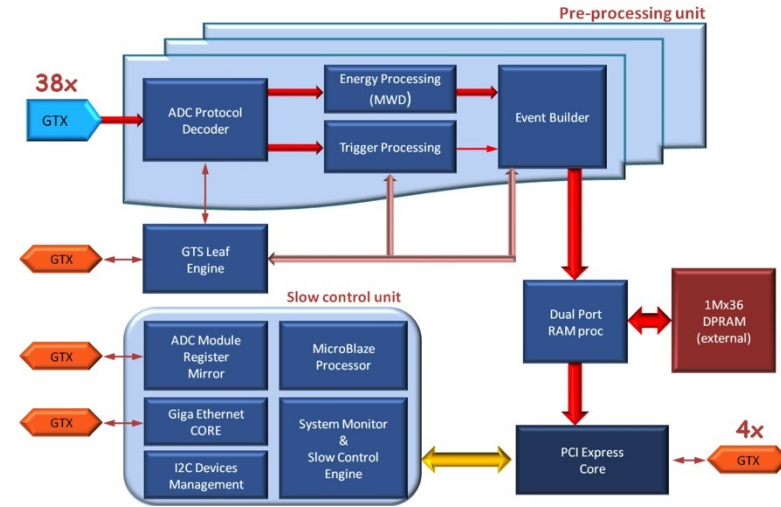
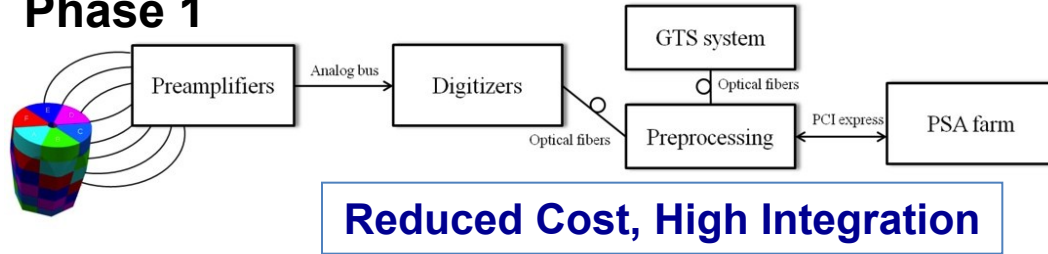
IPNO/CSNSM/
LNL/GANIL/IFJ-PAN

interface to GTS, merge time-stamped data into event builder, prompt local trigger from digitisers

Advanced Phase 1 Electronics

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

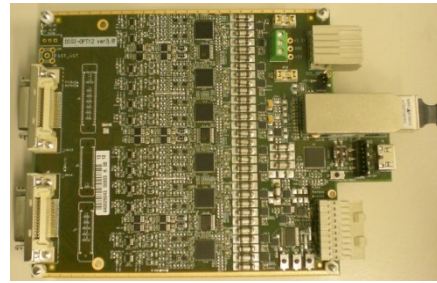
Phase 1



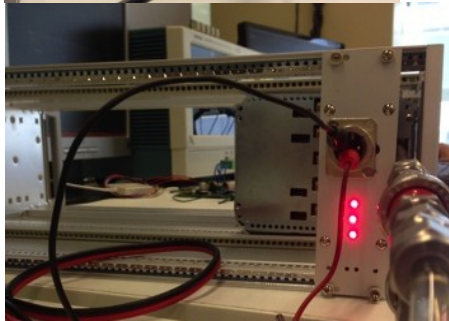
ADC Card mounting



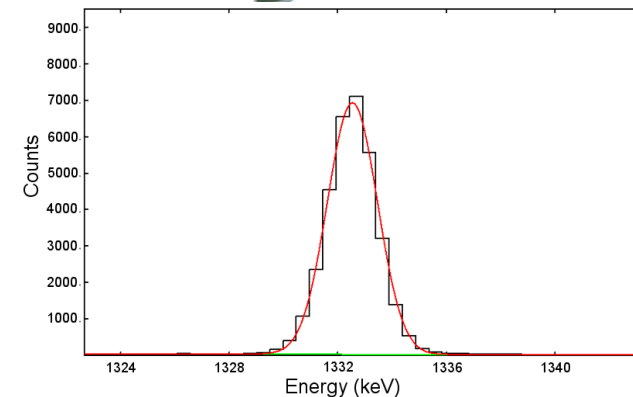
ADC Card



Control Card



Pre-Processing



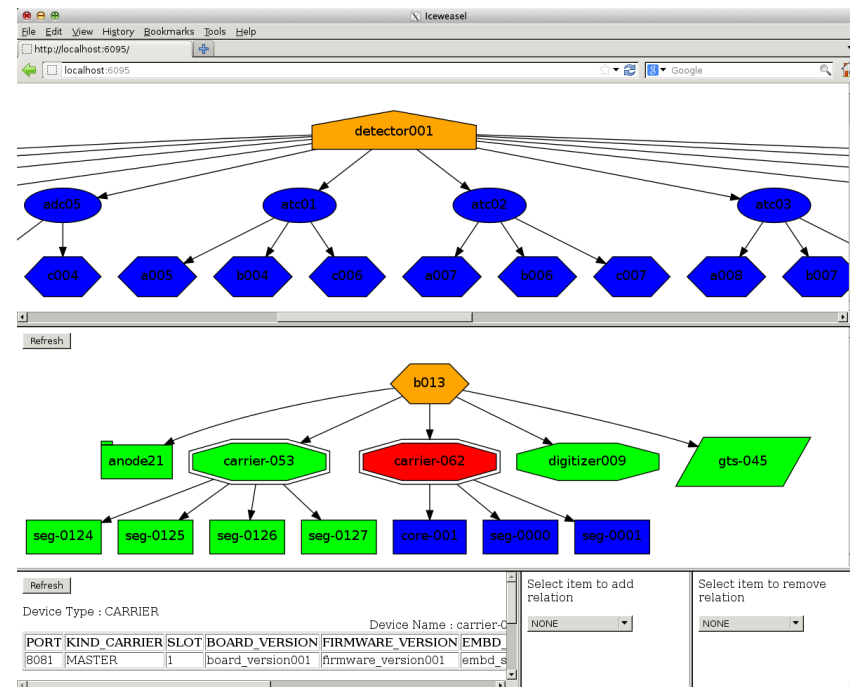
Further studies ongoing on higher processing capability and the Digital Pre-Amplifier concept for future phases.

Phase 1 AGATA Data Flow NARVAL at GANIL

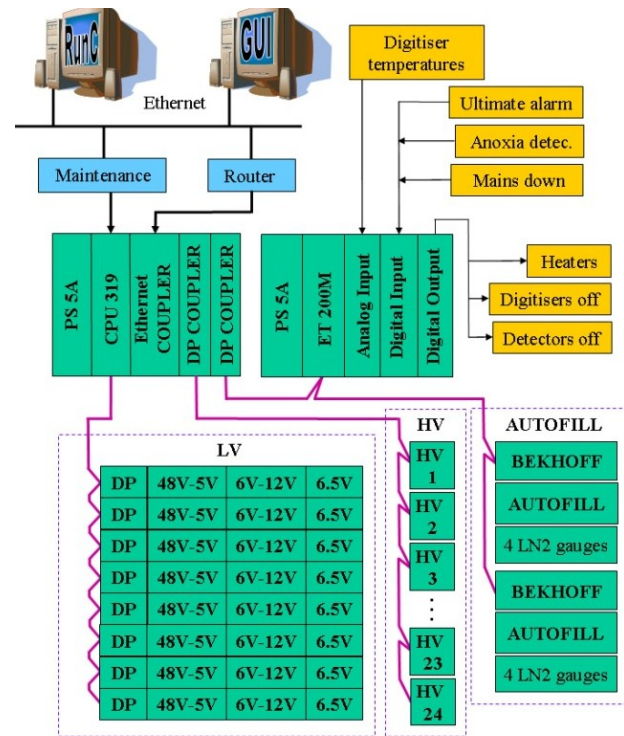


- Presently all the Data Flow items are fully installed at GANIL.
- Preparation for the GANIL phase ongoing. The GANIL Narval's version (1.14.3) has been debugged and is available in a repository
- Right now working on event builder and on-line analysis actors

The current GANIL RCC (Run Control Core) has adapted to AGATA RCC and Topology Manager connected. The GUI is operational and from now we can click on start-stop-pause button to launch Narval. Topology Manager has been reworked. The final goal of the GEC/Topology Manager is to centralize the control and setup for AGATA into a simple user friendly system. The package has been installed and tested at GANIL.



Infrastructure: Detector Support System



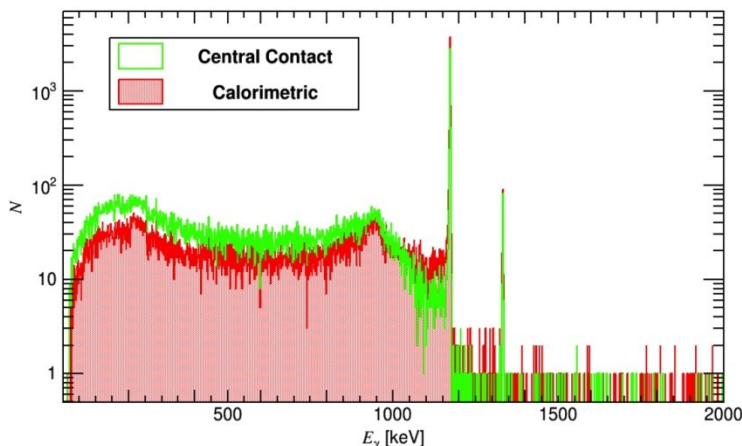
- AXIS LVPS:** Now all are mounted at GANIL and ready
- **Patch boxes:** the full prototype (LV filter, LN2 card, BSD card and 2 PT100 readings) has been tested on ATC5 by Cologne. Not introducing noise in the system. 9 patch boxes being prepared
 - **HV System R&D:** Tests being done on commercial HV CAEN and ISEG.

- Autofill system:** Installation and full commissioning completed by Saclay team and T. Haberman in GANIL on week 36, after LN2 pipes and manifold have been installed and connected and 3rd group PBC+VCC has been adjusted. IKP-Cologne will produce the bayonets/LN2 filling adapters for the GANIL campaign
- **GANIL EMC:** Primary EMC measurements @ GANIL on platform and mechanical infrastructure. Next will be made when the detectors are mounted. Present results are excellent.

Construction DataBase: huge help tracking material during transfer to GANIL.

Simulations, Experimental Commissioning and Performance

Preliminary Results



- Focus on ^{60}Co data
- Euroball detector counts total number of triggers
- Gate on 1.33 MeV-line
- PSA and tracking performed [3]



Efficiency obtained using different approaches

Experiment		
Input	Efficiency*[%]	Peak To Total [%]
Central Contact	2,3	18,2
Calorimetric	3,3	31,7
Add-Back	3,1	30,4
Tracked	2,5	34,4
Simulation		
Input	Efficiency [%]	PeakToTotal [%]
Central Contact	2,6	on going
Calorimetric	3,9	on going

*Efficiency values assuming isotropic angular distribution. Estimated angular correlation effects are 7% in average (to be taken into account and accurately determined by means of Geant 4 simulations)

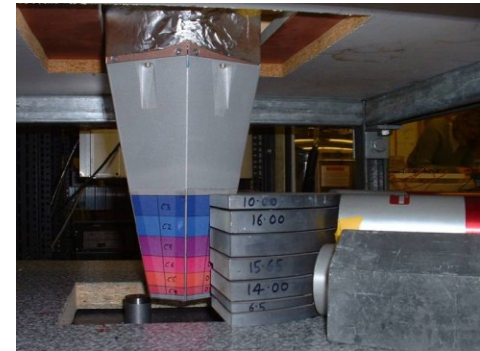
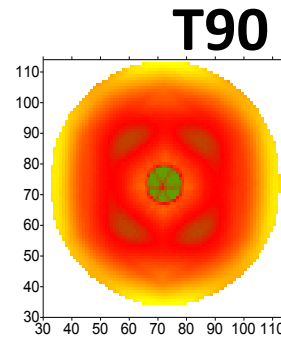
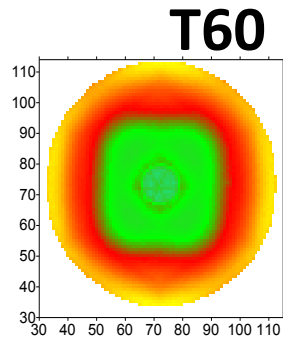
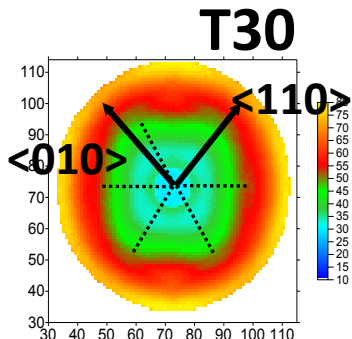
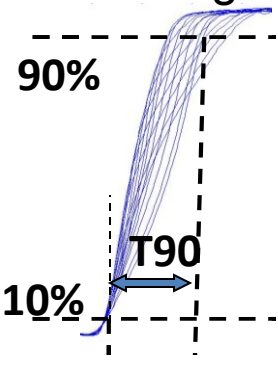
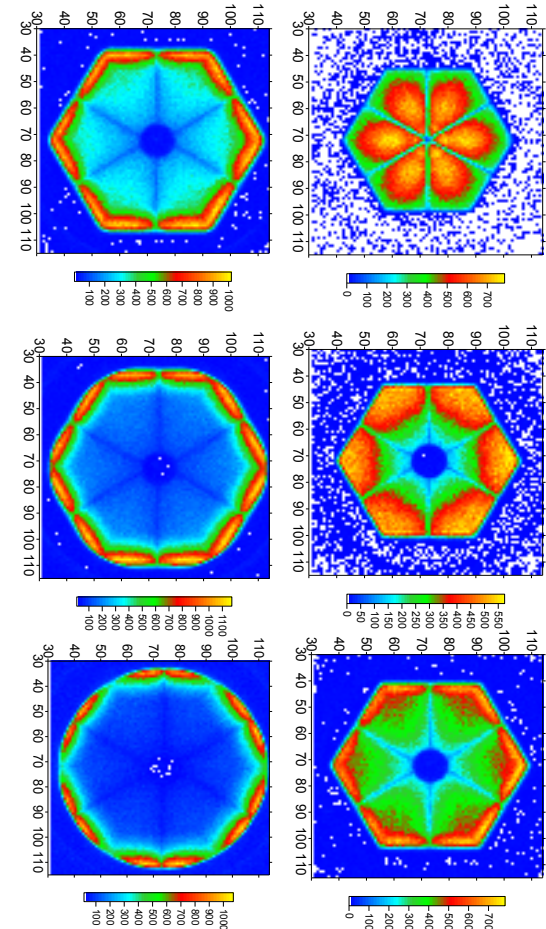
AGATA PSA & Detector Characterization

Pulse Shape Analysis: Two PSA codes are available.

- *Adaptive Grid Search algorithm:* There are no major changes to AGS algorithm. The biggest impact came from having the system response properly calibrated for energy and position. New PSA basis updates were provided to ensure this.
- *The Particle Swarm algorithm* was implemented in test form for single interactions. The present implementation can handle a single interaction in up to 5 segments. This version is running within the Narval emulator. The next implementation will handle multiple interactions in a single segment.

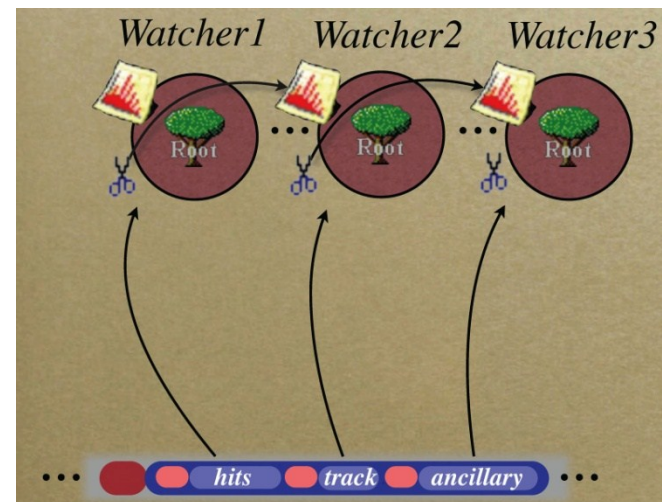
Detector Characterization:

Ongoing on several Labs. of the collaboration with Scanning tables



Data Analysis, Pulse Shape Analysis & Tracking

- AGATA Data Format , Including AGATA detector traces
- NARVAL emulator to reprocess data with Event Builder and PSA
- GAMMAware to create root trees for analysis



The 3rd EGAN School on AGATA Data Analysis

A third Data analysis school hosted in LNL October 2014.

The focus will again be on good practice in data analysis

Two previous school talks are on web site as requested (PSA, tracking and GRID).

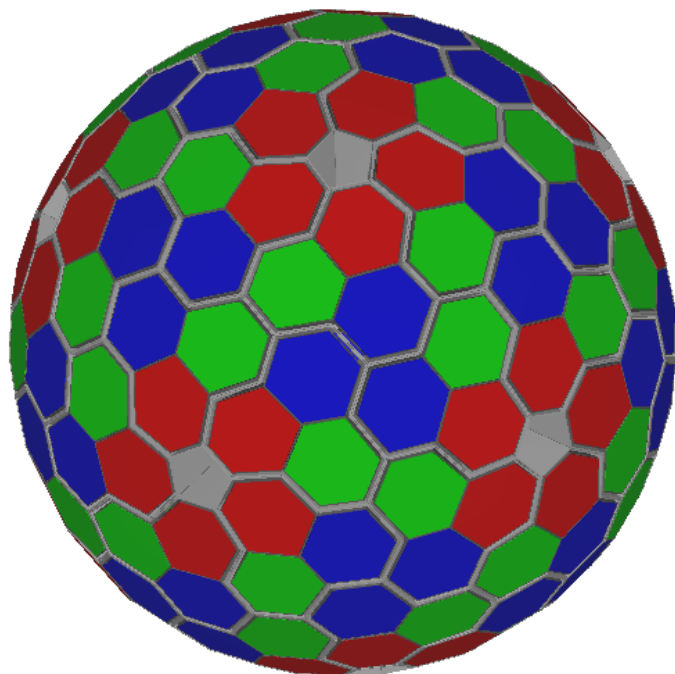
Liverpool: <http://ns.ph.liv.ac.uk/EGAN/programme-liv-school.html>

GSI: <http://ns.ph.liv.ac.uk/EGAN/programme.html>

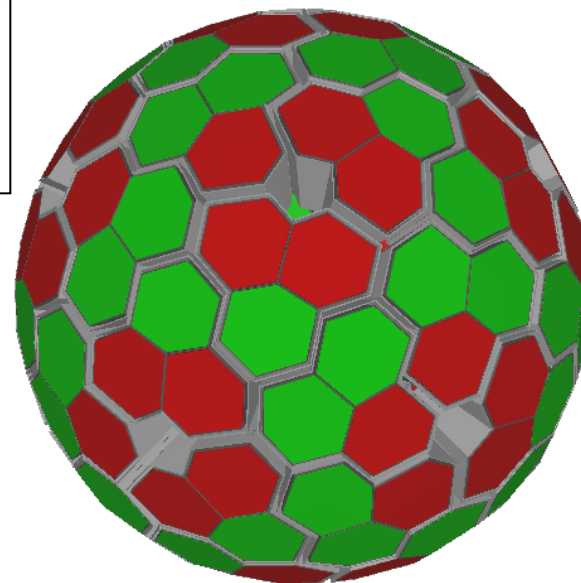
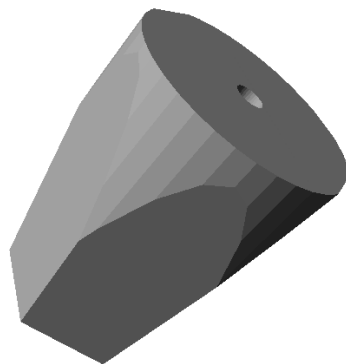


AGATA as an ECOS Detector array

Two configurations for tracking arrays



Ge crystals size:
length 90 mm
diameter 80 mm

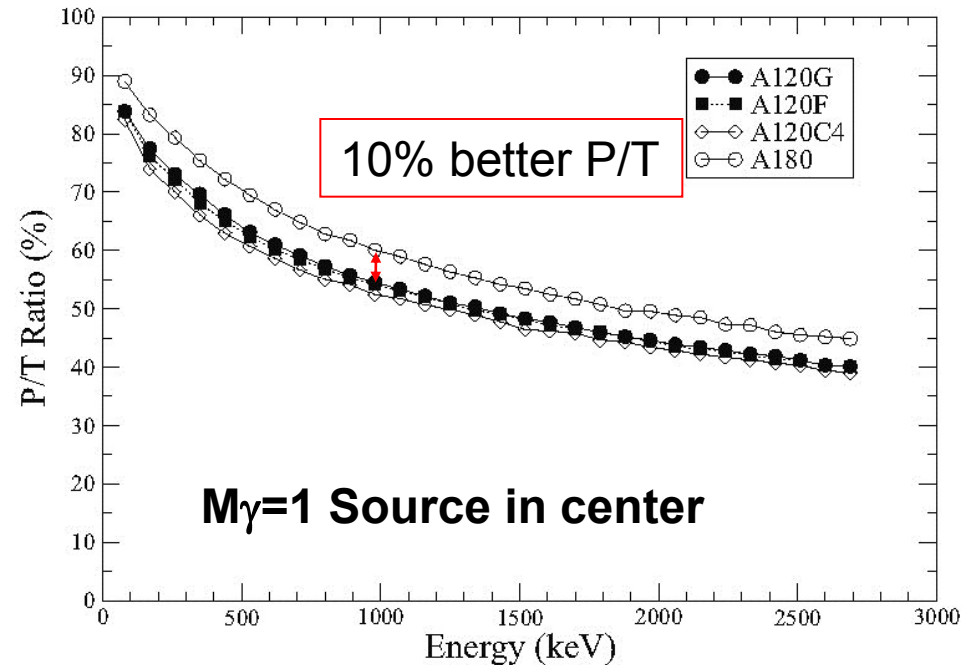
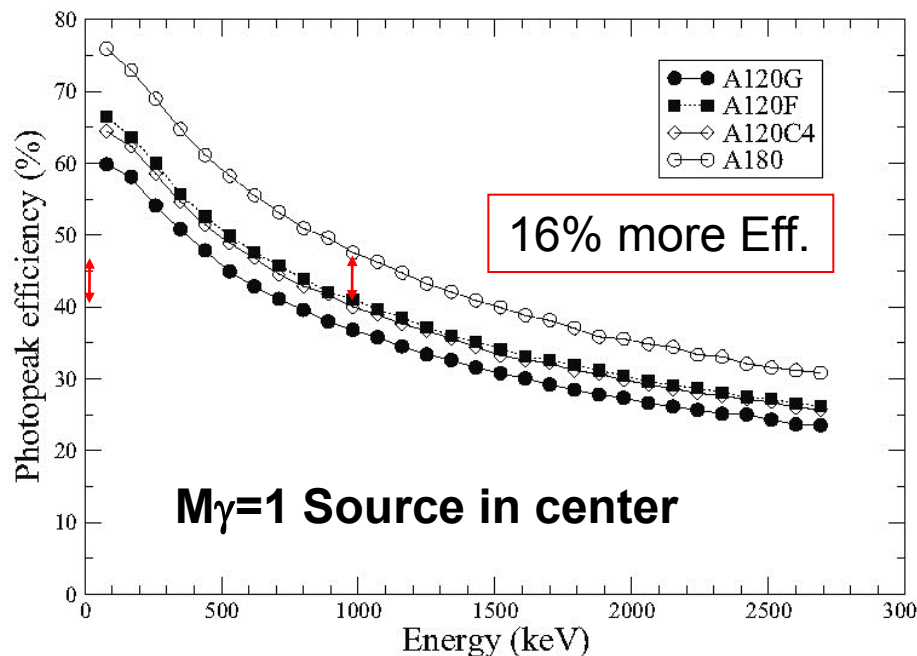


180 hexagonal crystals	3 shapes
60 triple-clusters	all equal
Inner radius (Ge)	23.5 cm
Amount of germanium	360 kg
Solid angle coverage	80 %
Singles rate	~50 kHz
6480 segments	
Efficiency:	43% ($M_\gamma=1$) 25% ($M_\gamma=30$)
Peak/Total:	58% ($M_\gamma=1$) 50% ($M_\gamma=30$)

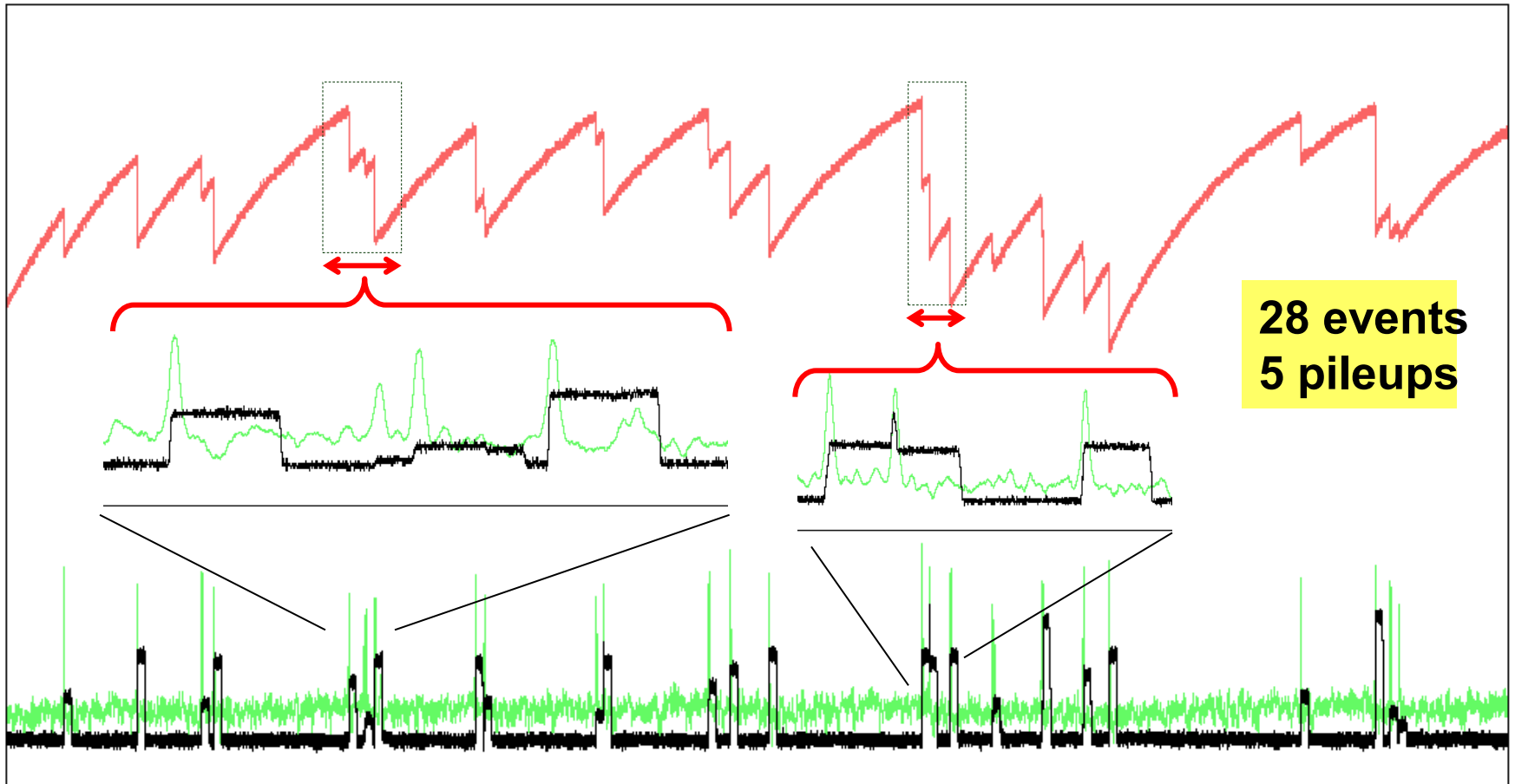
120 hexagonal crystals	2 shapes
30 Quad-clusters	all equal
Inner radius (Ge)	18.5 cm
Amount of germanium	230 kg
Solid angle coverage	78 %
Singles rate	~50 kHz
4320 segments	
Efficiency:	38% ($M_\gamma=1$) 21% ($M_\gamma=30$)
Peak/Total:	55% ($M_\gamma=1$) 47% ($M_\gamma=30$)

Comparison of the 2 configurations

	A120G	A120F	A120C4	A180
Number of crystals	120	120	120	180
Number of crystal shapes	2	6	2	3
Number of cluster types	2	2	1	1
Covered solid angle (%)	71	78	78	82
Volume of germanium (cm ³)	43590	42225	43160	67978
Final mass of germanium (kg)	232	225	230	362
Initial mass of germanium (kg)	289	289	289	434
Fractional loss of germanium (%)	19.7	22.1	20.4	16.5
Centre-to-detector face distance (cm)	19.7	18.0	18.5	23.5



The Central Contact at 40 kHz



28 events
5 pileups

Samples

SCC, MWD (width 5 μ s)

1 ms

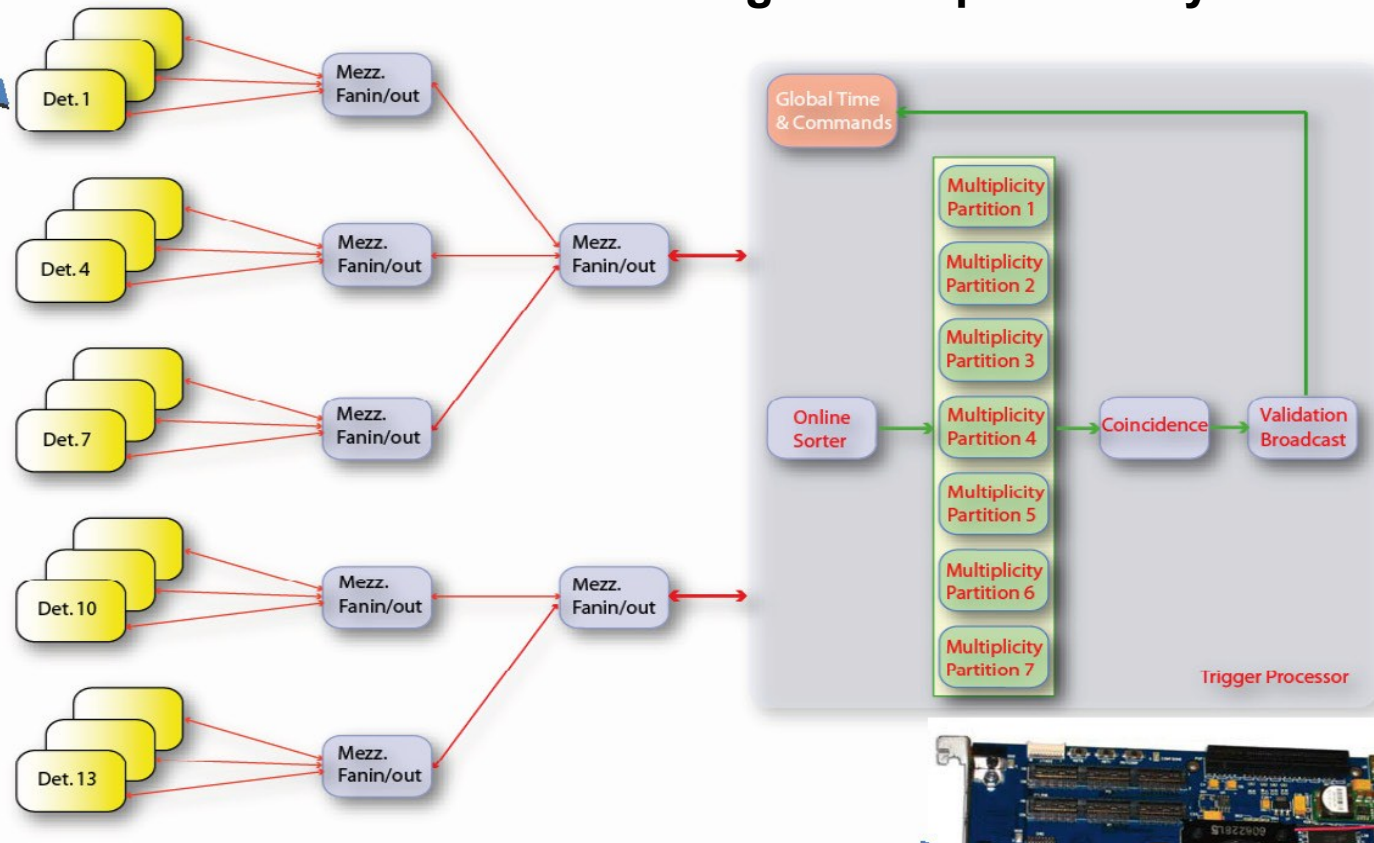
sampled at 100 Ms/s

& Fast-Reset Charge pre-amplifier to avoid saturation deadtime

Global Trigger Processor

Max 1 MHz trigger requests/channel

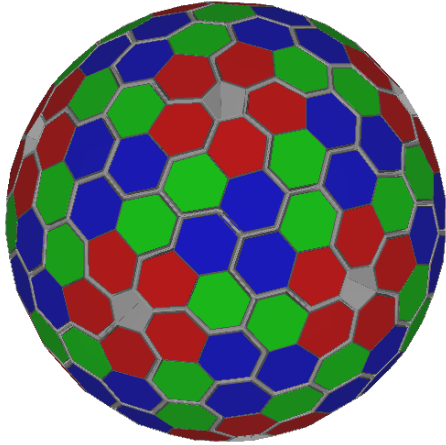
To be extended and enhanced to cope with digital complementary instrumentation



48 channels in a Xilinx Virtex-4 Fx100



Nevertheless...



Peak efficiency of the array is about 40% at 1.3 MeV with a Peak/Total = 58%. This gives a Total efficiency of about 70% at 1.3 MeV

The efficiency of each single capsule in the standard configuration is for peak ~0.23% and total ~0.39%.

The counting rate is limited to 50 to 70 kHz maximum due to pile-up losses.

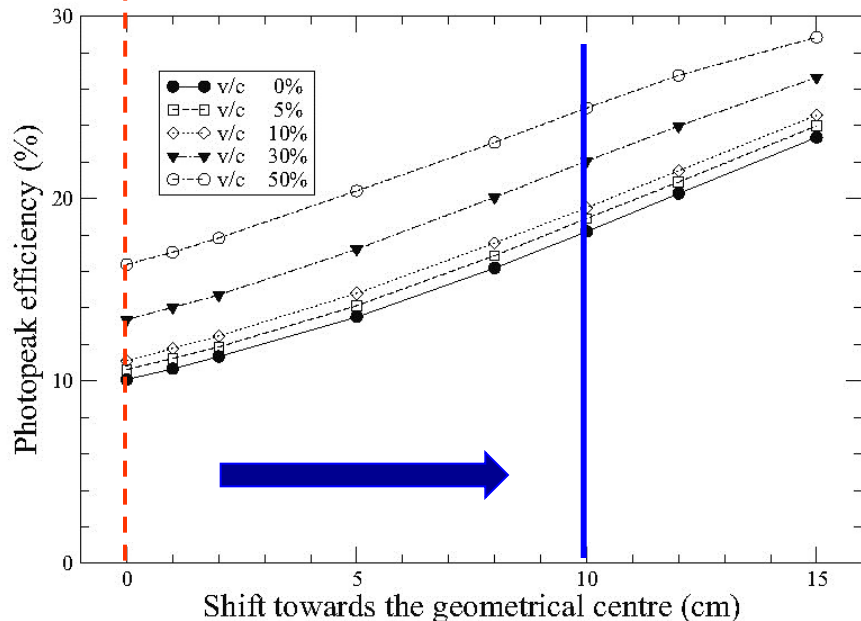
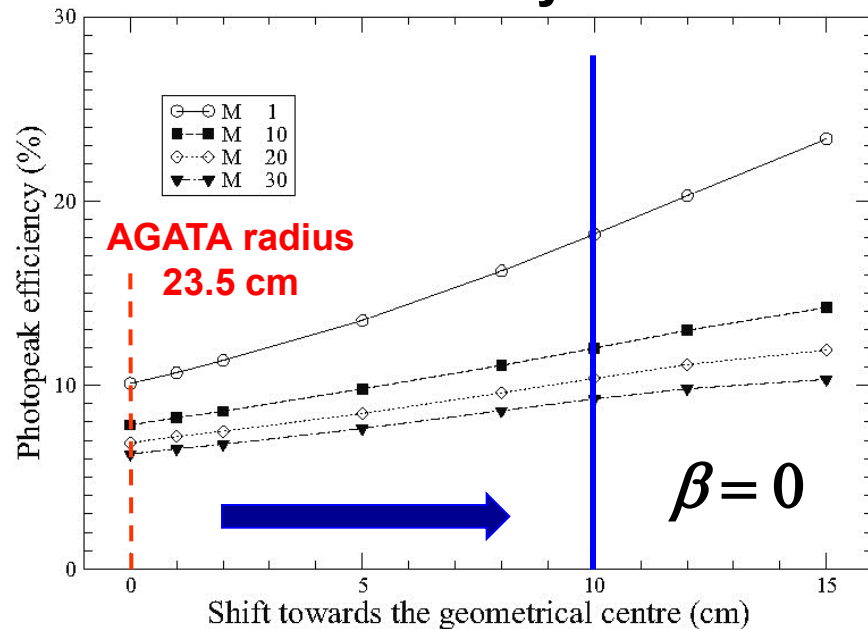
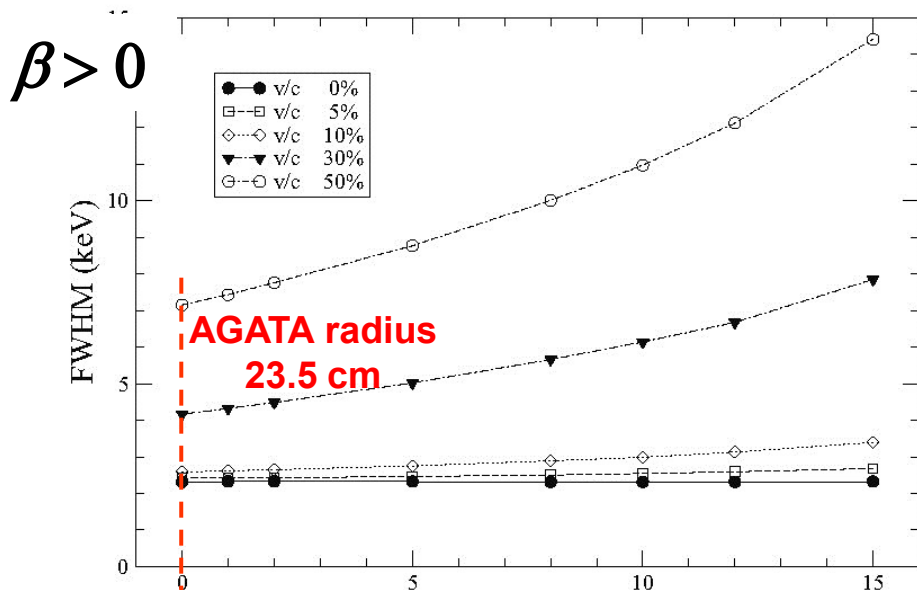


For a $1\text{mg}/\text{cm}^2$ target thickness, 1barn total cross section and average $M_\gamma \sim 10 \rightarrow$

maximum beam intensity ~ 100pA

The AGATA 1π performance figures

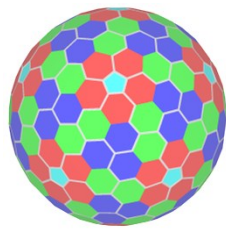
MC simulations by E.Farnea



In addition, moving AGATA, as we do nowadays to gain efficiency, unbalance the capsule efficiency by a factor of 3 or more. Such tricks should not be done in ECOS facilities



The AGATA Collaboration



Bulgaria:	Univ. Sofia
Denmark:	NBI Copenhagen
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
Romania:	NIPNE & PU Bucharest
Spain:	IFIC, ETSE-UEVEG 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

>40 Institutions



Outlook

- **Last part of the AGATA campaign at GSI performed from February to April 2014.**
- **Upgrade of several subsystems ongoing to reach >35 capsules in the setup during the GANIL campaign.**
- **Installation of AGATA at GANIL and commissioning ongoing.**
- **Campaign AGATA + EXOGAM2 + VAMOS + PARIS in 2015**
- **Campaign with other detectors (PARIS, NEDA, DIAMANT, MUST2 etc...) after 2015.**
- **GANIL campaign extended till 2018.**

Acknowledgement to AMB, AGATA Teams and Local LNL, GSI and GANIL – AGATA Collaborators

