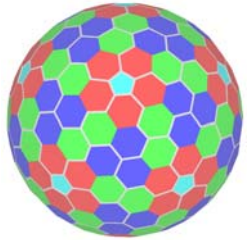
AGATA

The Advanced GAmma Tracking Array



Wolfram KORTEN, CEA Saclay
on behalf of the AGATA collaboration

Special thanks to all AMB members and specifically to D. Bazzacco (Padua)

HiSpec-DeSpec Meeting
Valencia - 15 /16 June 2005

HiSpec
experimental conditions

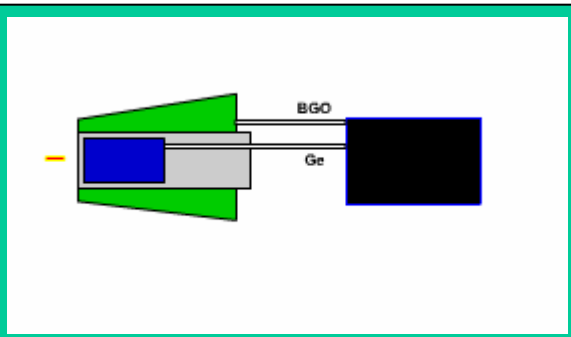
- Low intensity beams
- High background
- Large Doppler broadening (v/c ~ 0.4)
- High counting rates (low-E)
- High γ-ray multiplicities (low-E)

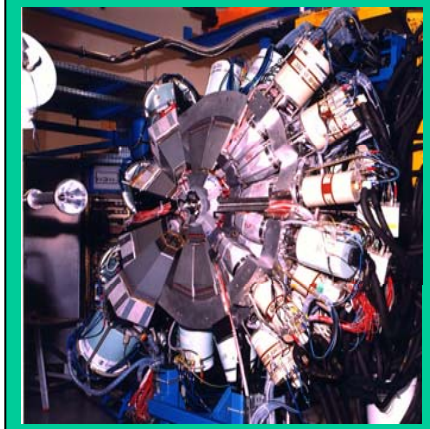
Need for an adequate γ-ray detection system

High efficiency
High sensitivity
High throughput
Ancillary detectors

Why a new type of gamma spectrometer ?

Gamma Arrays based on Compton Suppressed Spectrometers

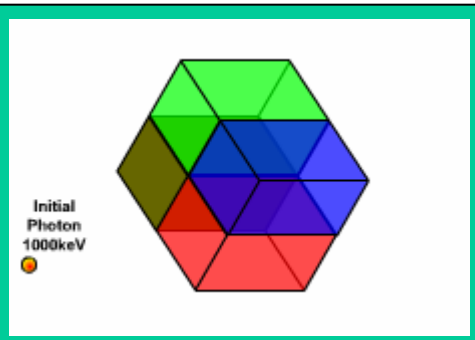


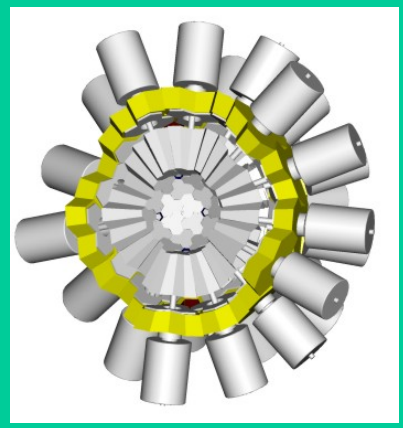


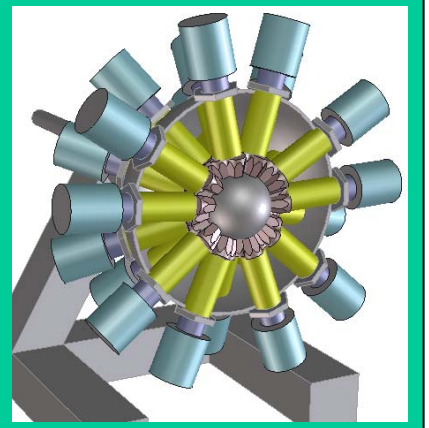
EUROBALL GAMMASPHERE

$\varepsilon \sim 10 - 7\ \%$
$(M_\gamma=1 - M_\gamma=30)$

Tracking Arrays based on Position Sensitive Ge Detectors



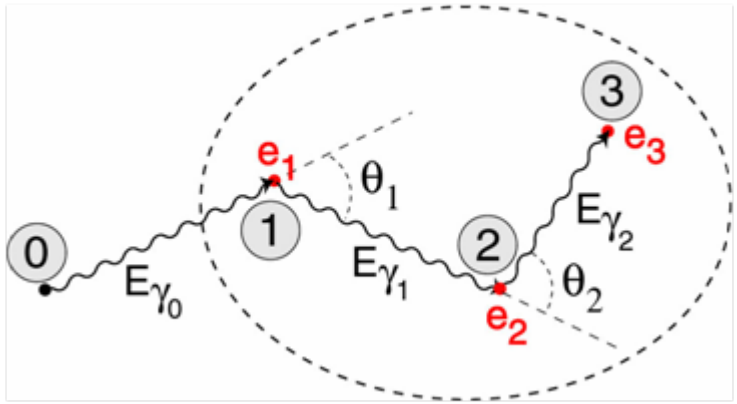




AGATA GRETA

$\varepsilon \sim 50 - 25\ \%$
$(M_\gamma=1 - M_\gamma=30)$

What is gamma-ray tracking ?

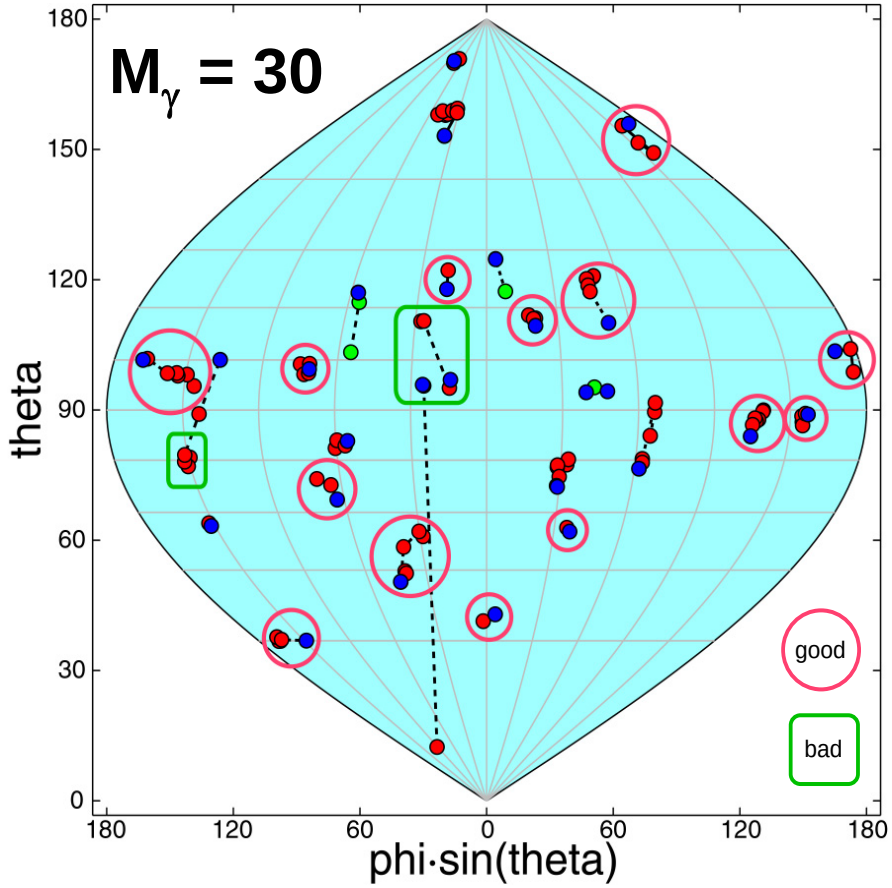


$$E_{\gamma'} = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_0 c^2}(1 - \cos\theta)}$$

1.33 MeV	$M_\gamma = 1$	$M_\gamma = 30$
ε_{ph} (%)	65	36
P/T(%)	85	60

Algorithms treat also photoelectric absorption and pair-production events

Simulation of a high multiplicity event detected by an ideal shell



~50% correct identification as long as Δ(x,y,z) < 5mm

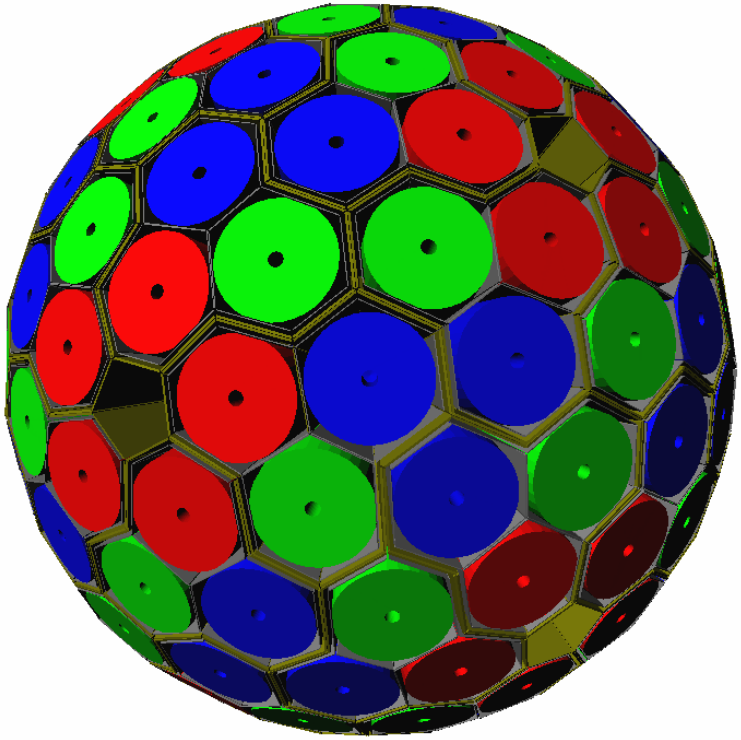
Ingredients for Gamma-Ray Tracking

- Highly-segmented HPGe detectors
  - 1.5 kg crystals, hexaconical, encapsulated, 36-pixel cathode
- Digital electronic to digitise segment signals
  - 100 MHz continuous sampling with 14 bit FADC
- Calculation/measurement of pulse shapes as a function of position inside the germanium crystal
  - Net and transient signals
- Pulse Shape Analysis algorithms to decompose pulses into positions and energies
  - Still a major problem for real time operation (but Moore's law helps)
- Reconstruction of "tracks" by likelihood methods
  - Performance depends on quality of PSA

Worldwide R&D activity since 1994
EU-TMR, **AGATA**, GRETA

AGATA

The Advanced GAmma Tracking Array



180 hexagonal crystals	36-fold segmented
	3 shapes
➔ 60 triple-clusters	all equal
Solid angle coverage	82 %
Inner radius (Ge)	23.1 cm
Amount of germanium	362 kg

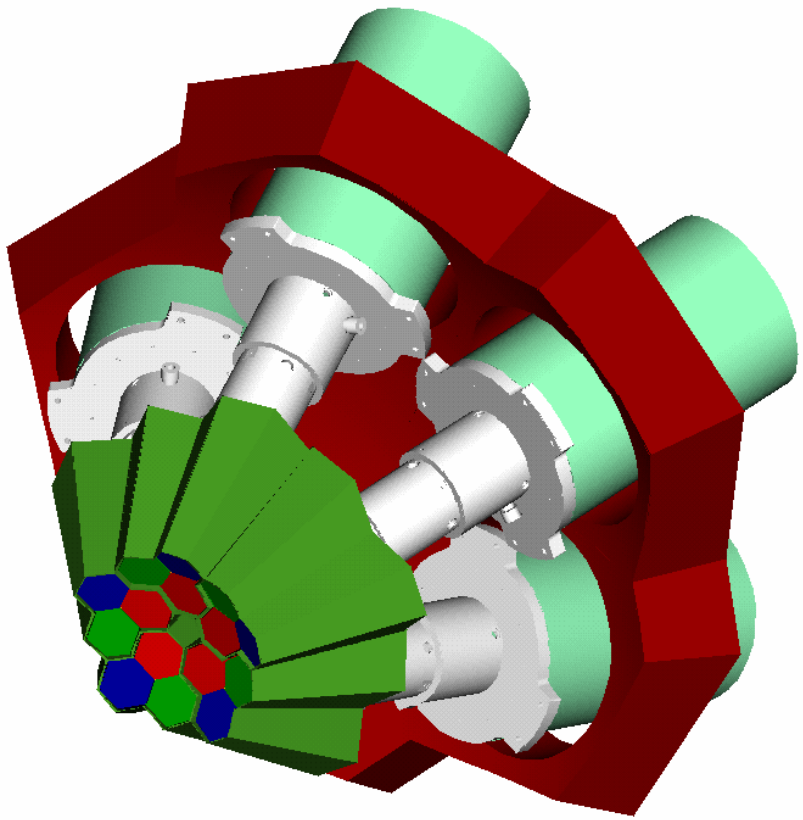
6480 segments and pulse-shape analysis

➔ Angular resolution	< 1°
Singles rate	< 50 kHz

Efficiency:	43% (M_γ=1)	28% (M_γ=30)
Peak/Total:	58% (M_γ=1)	49% (M_γ=30)

The AGATA demonstrator

Objective of the final R&D phase



1 symmetric triple-cluster

4 asymmetric triple-clusters

15 36-fold segmented crystals

540 segments

555 digital-channels

Eff. 3 – 8 % @ $M_\gamma = 1$

Eff. 2 – 4 % @ $M_\gamma = 30$

Full ACQ

with on line PSA and γ-ray tracking

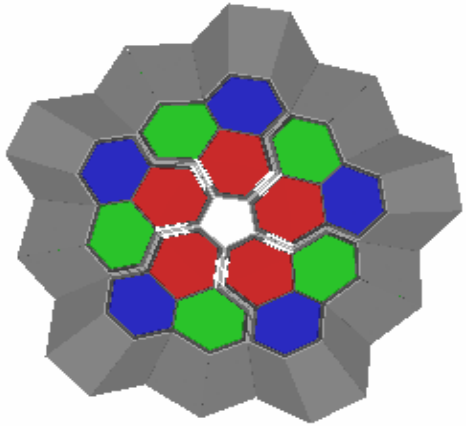
Possible "Test Sites":

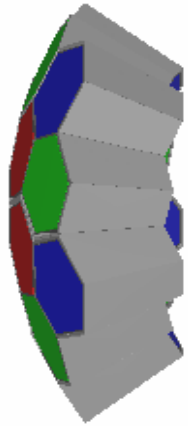
GANIL, GSI, Rex-ISOLDE, LNL, U. Jyväskylä, U. Köln

The Phases of AGATA 1

5 Clusters 2007

Demonstrator





Peak efficiency
3 – 8 % @ M_γ = 1
2 – 4 % @ M_γ = 30

Main issue is Doppler correction capability
→ coupling to beam and recoil tracking devices

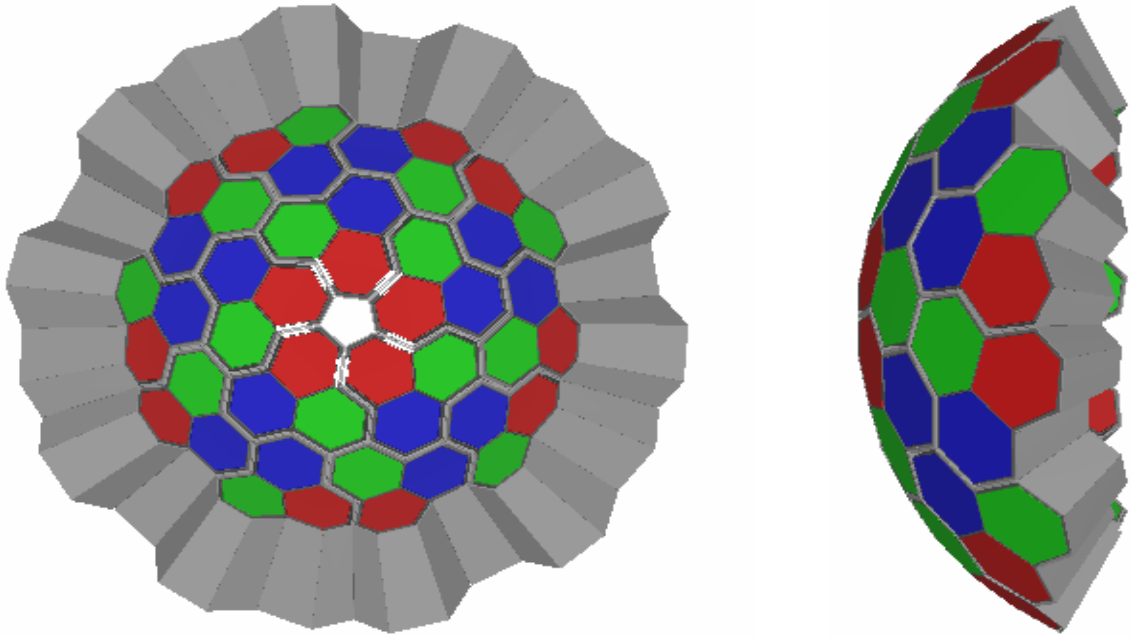
Replace/Complement

LNL	PRISMA	CLARA
GANIL	VAMOS	EXOGAM
GSI	FRS	RISING
JYFL	RITU	JUROGAM

Improve resolution at higher recoil velocity
Extend spectroscopy to more exotic nuclei

The Phases of AGATA 2

15 Clusters 1π 2010



The first "real" tracking array

Used at **FAIR-HISPEC**, **SPIRAL2**, **SPES**, **HI-Stable**

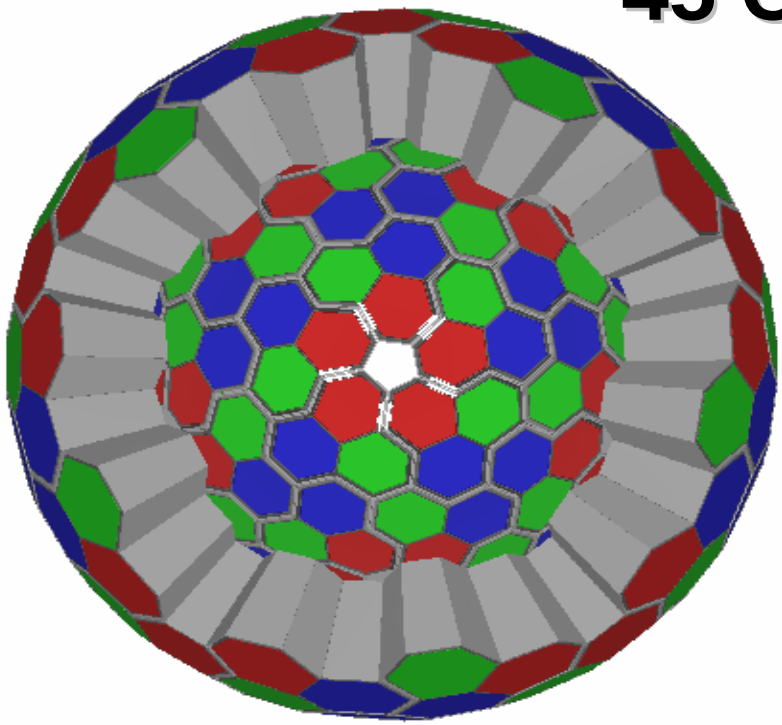
Coupled to spectrometer, beam tracker, LCP arrays …

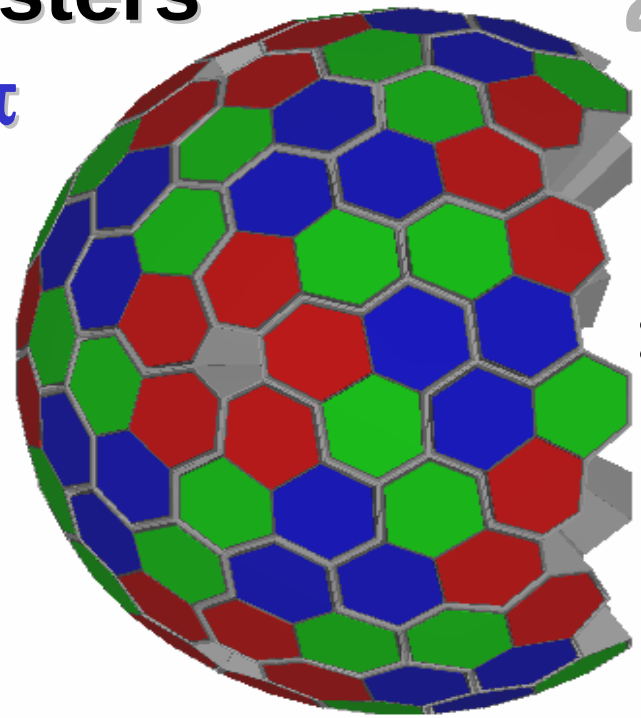
The Phases of AGATA 3

45 Clusters

2014

3π





Ancillary

Efficient as a 120-ball (~20 % at high γ-multiplicity)

Ideal instrument for FAIR / EURISOL

Also used as partial arrays in different labs

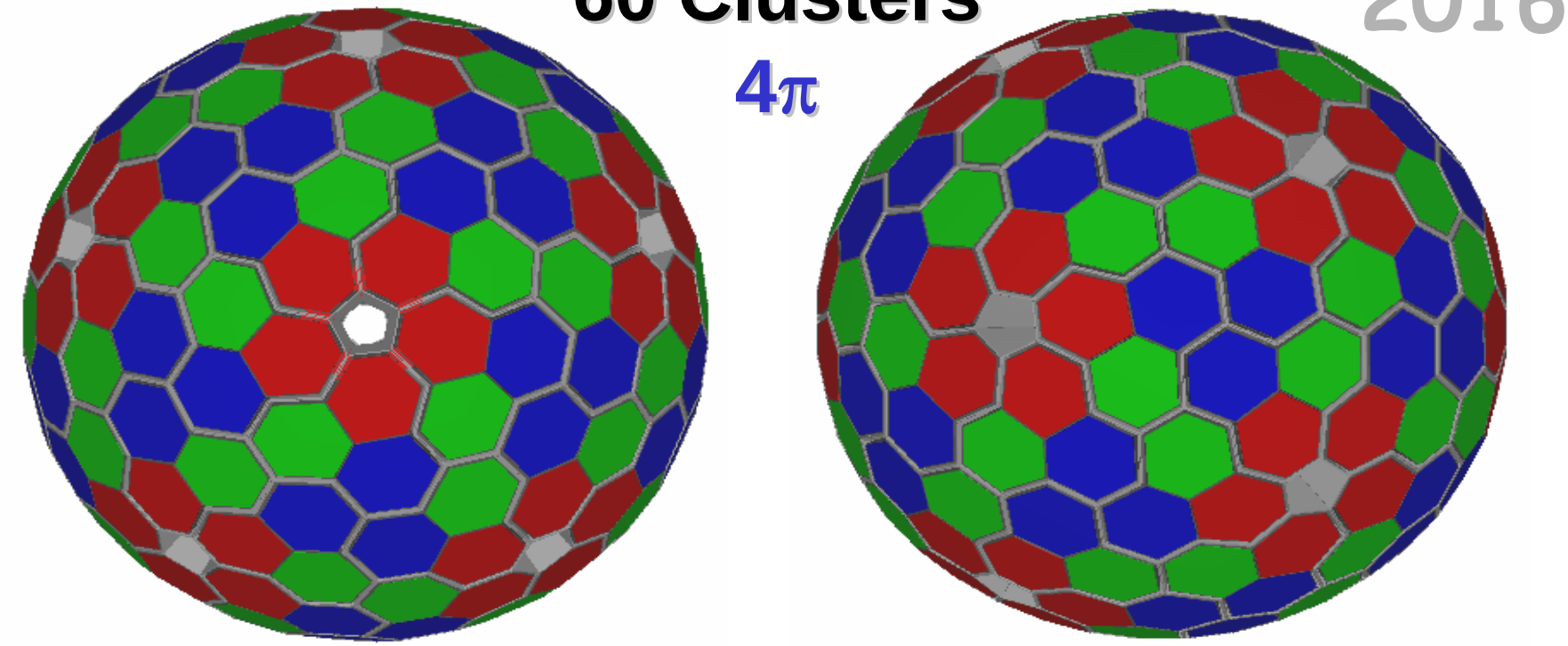
Higher performance by coupling with ancillaries

The Phases of AGATA 4

60 Clusters

2016

4π



Full ball, ideal to study extreme deformations and the most exotic nuclear species

Most of the time used as partial arrays

Maximum performance by coupling to ancillaries

Project Status

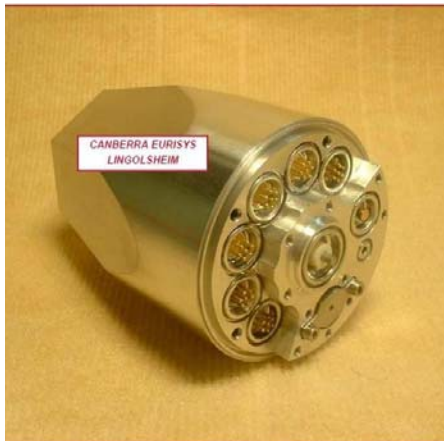
- Funding : 4.4 M€ firmly engaged (D,F,I,UK)
  - a 4 triple-clusters' system (12 crystals) secured (almost)
  - Sweden and Turkey each bidding for a triple cluster (0.75 M€)

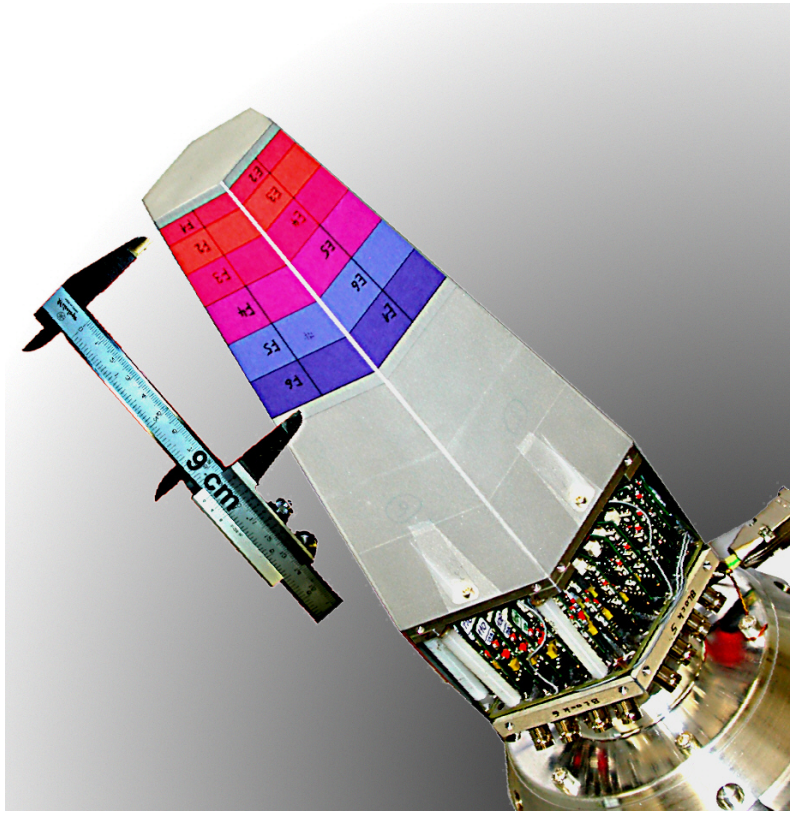
- Detectors
  - 11 of the 12 encapsulated Ge crystals ordered
  - 3 of them (symmetric) delivered and tested
  - partial coincidence scan for one detector done at Liverpool
  - first triple cluster being assembled for (in-beam) tests at Köln
  - delivery of asymmetric detectors from November 2005

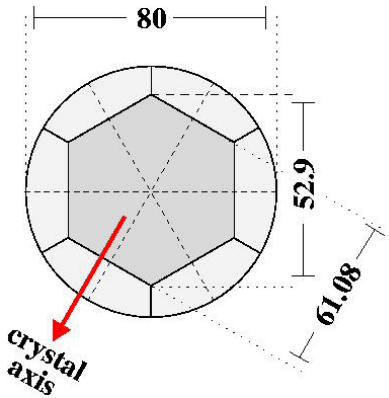
- Electronics and DAQ
  - design frozen at the last AGATA week (Feb. 2005)
  - development of modules ongoing (hardware and FPGA software)
  - first full chain for one detector to be tested in spring 2006

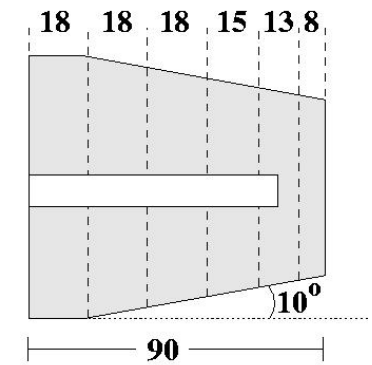
- Software developments and Tracking
  - full MC simulation of the system well advanced
  - pulse shape decomposition proceeding (but still a kind of bottleneck)
  - γ-ray tracking well advanced
  - simulation of experiments, including ancillary detectors, progressing well

36-fold segmented, encapsulated Ge detector









Encapsulation

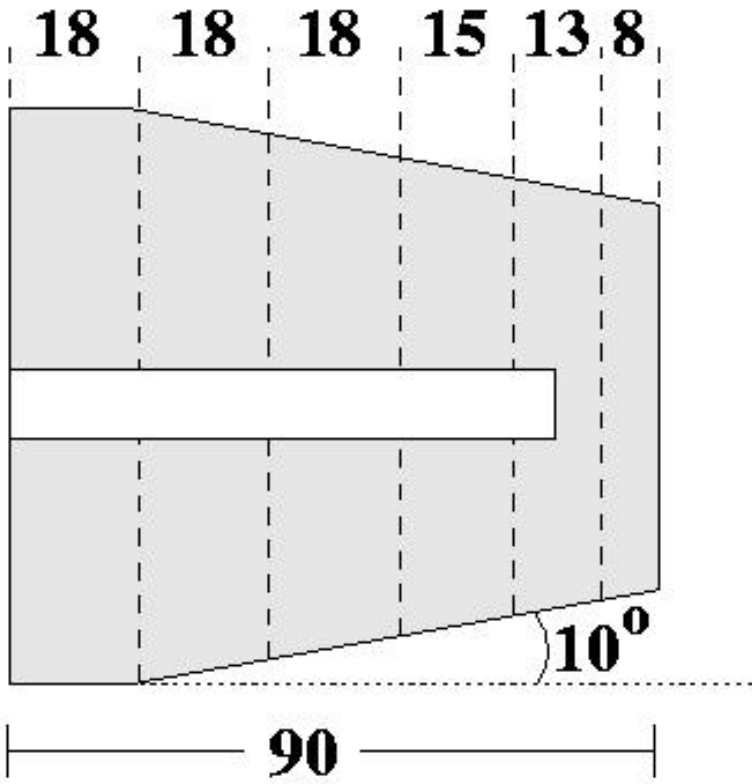
0.8 mm Al walls
0.4 mm spacing

MINIBALL-style cryostat
used for acceptance tests
"standard" preamplifiers

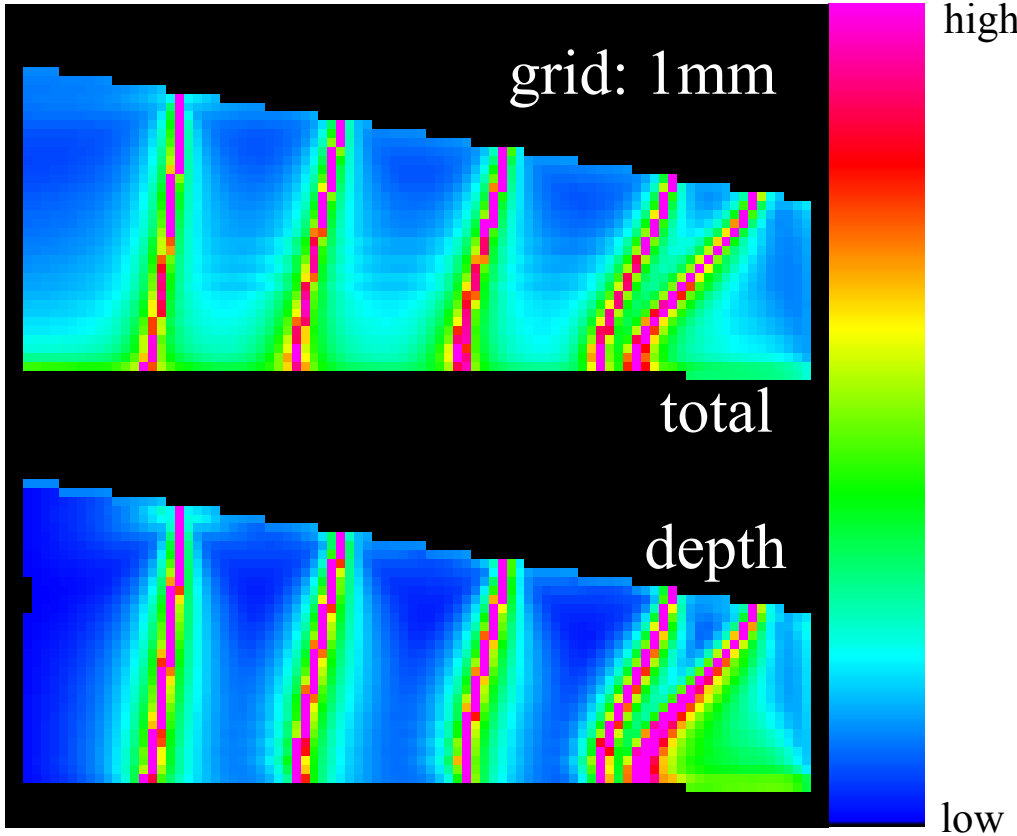
3 detectors with very good performance

Segmentation scheme and Pulse Shapes Analysis

Not a true coaxial geometry
Depth profile of interactions



Sensitivity for pulse shapes



A.Görgen (SPhN), T Kröll (TU Munich)

AGATA Cryostats

Individual, for tests

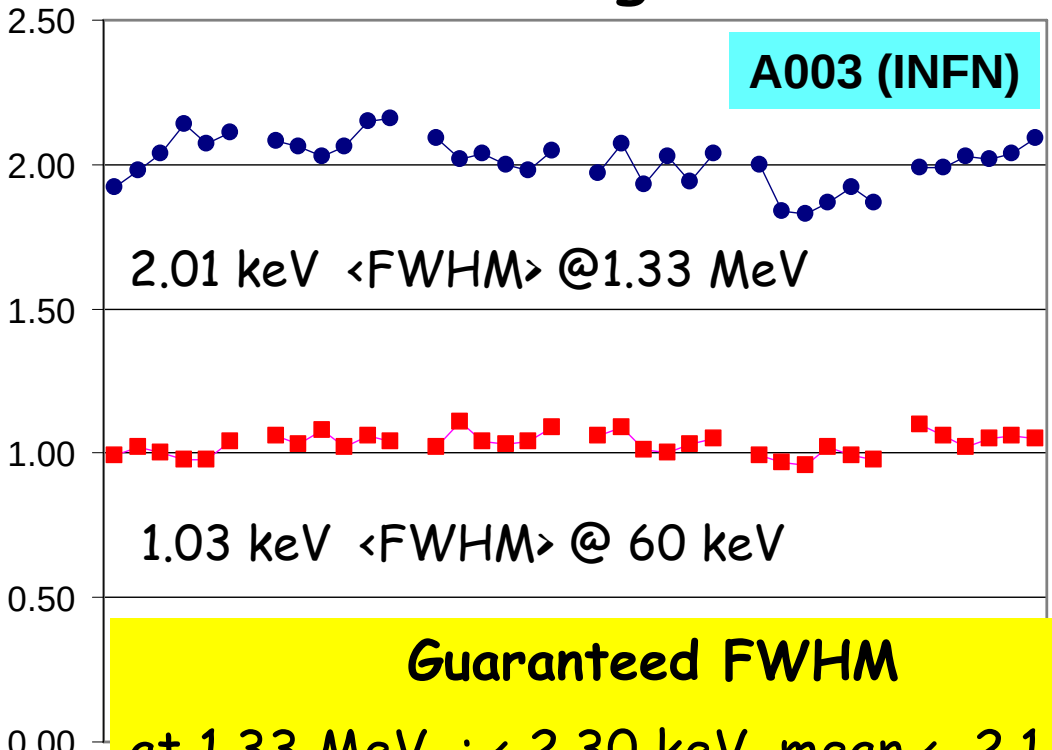
Triple, for experiments

differential-output preamplifiers with fast reset
of saturated signals (Ganil, Milano, Köln)

Energy Resolution

(measured with analogue electronics)

The 36 segments



Guaranteed FWHM

at 1.33 MeV : < 2.30 keV, mean < 2.1 keV
at 60 keV : < 1.35 keV, mean < 1.15 keV

Core

Measured FWHM

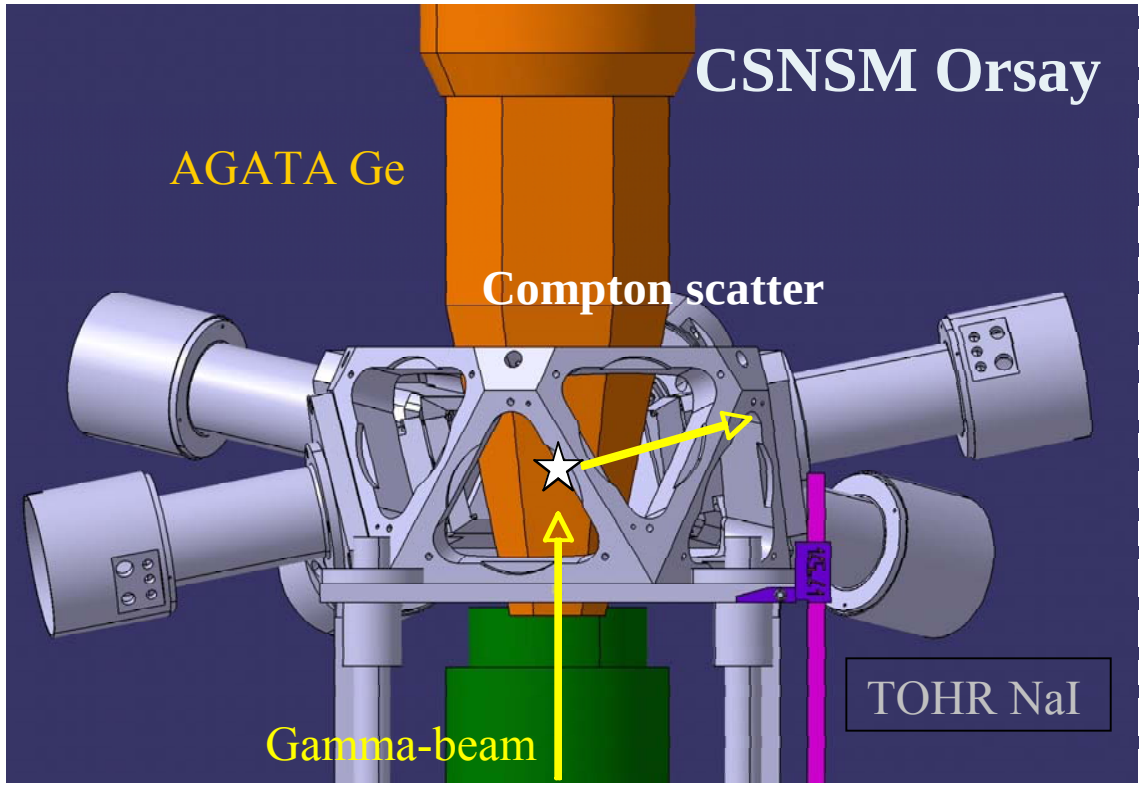
at 1.33 MeV : 2.13 keV
at 122 keV : 1.10 keV

Guaranteed FWHM

at 1.33 MeV : 2.35 keV
at 122 keV : 1.35 keV

The 3 detectors are very similar in performance

AGATA detector scanning

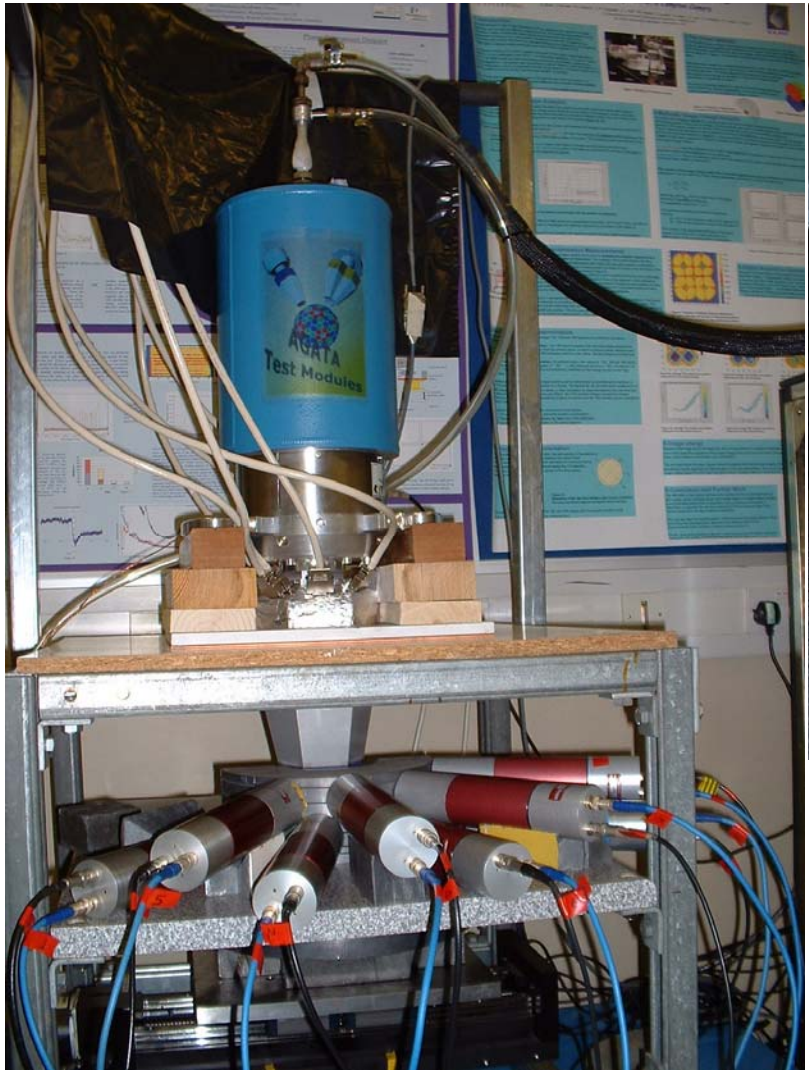


Three coincidence scanning systems are being developed

Liverpool, CSNSM Orsay and GSI

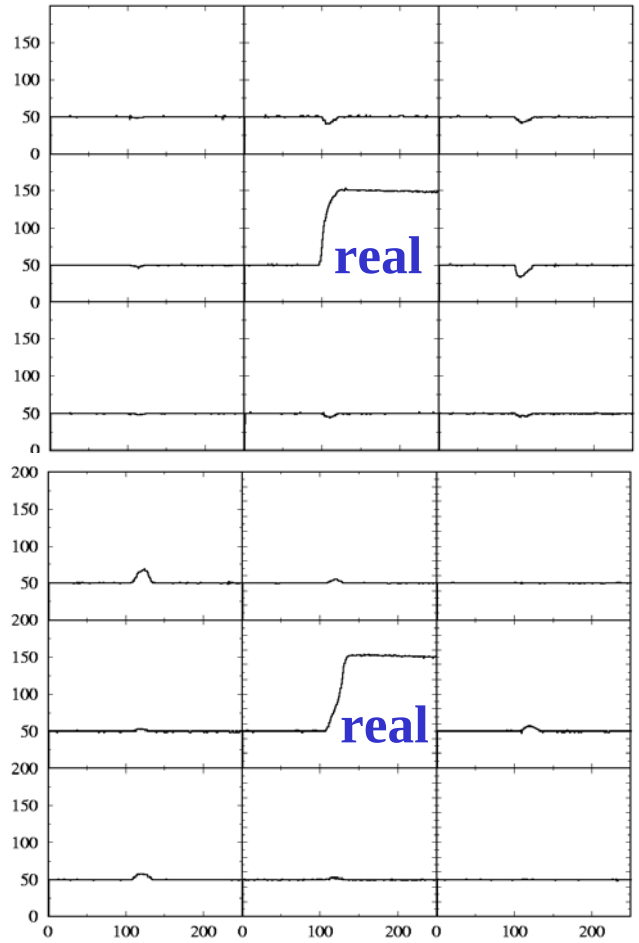
Full scan in 1 mm^3 grid almost impossible →
define characteristic points to calibrate calculations

AGATA detector scanning

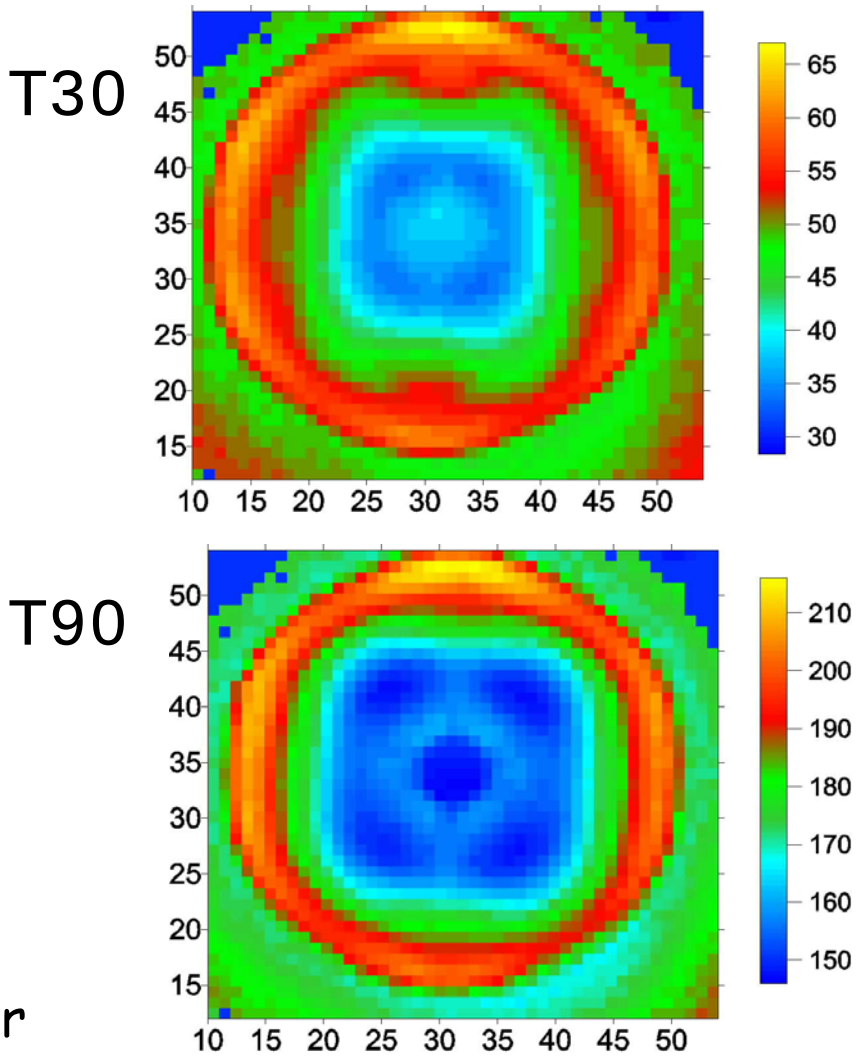


Liverpool coincidence setup with multileaf collimator partial scan of first prototype (spring 2005)

AGATA detector scanning results



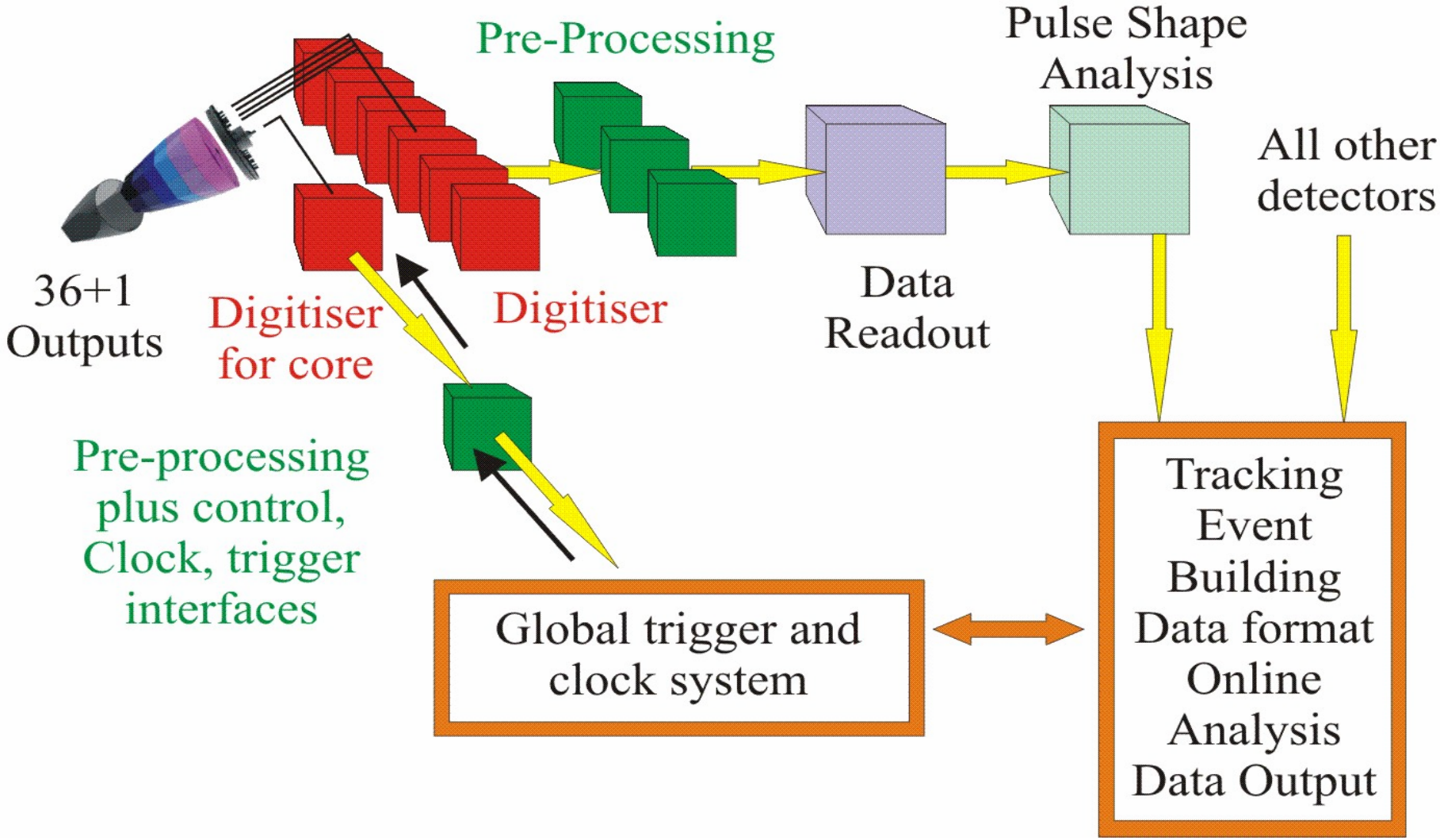
Map of rise times



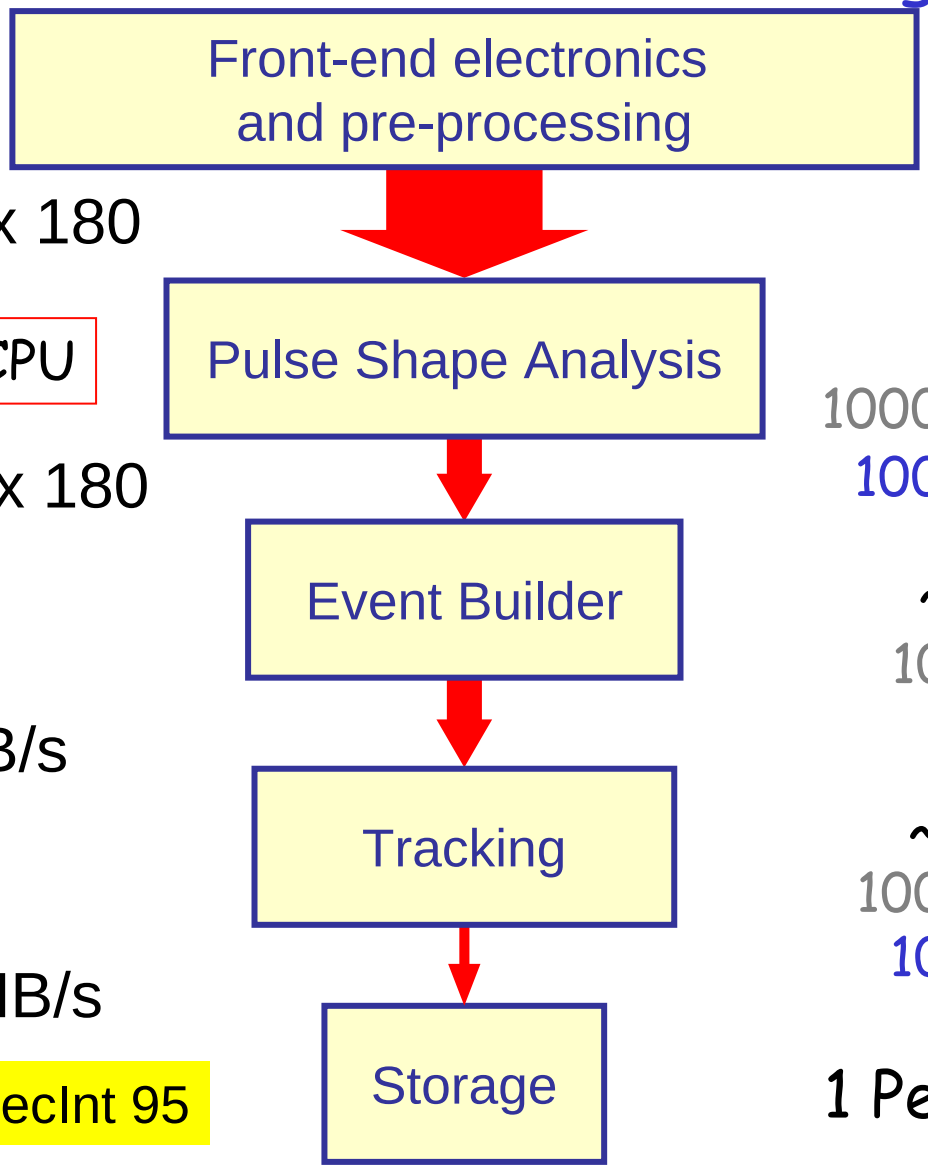
Real net charge and induced signals encode position of the interaction(s)

➔ Position calibration of the detector

Digital Electronics and Data Acquisition



Computing Requirements
(detectors at 50 kHz, no trigger)



SI95 = SpecInt 95

Status and Evolution

- Configuration with 180 Detectors chosen in 2004
- Construction of Demonstrator (2004-2007) : 4.4 M€
- EU Support from EURONS JRA (2005-2008) : 1.05 M€
- Prepar[illegible]005 ?)

  ➔ Bids

- MOU t[illegible]sters/year)
  - 1π
  - 2π
  - 4π

  [illegible]a (US)
  [illegible]L-2/FAIR
  [illegible]SOL ?
- FP7 su[illegible]. (ESFRI)

Timely c[illegible]lity of funds **and** the production capability of detector manufacturer

Country	Investment (k€)	Persons (FTE)
France	1269	26.3
Germany	1127	10
Italy	1250	20.8
Sweden	0	10.4
UK	725	6.8
TOTAL	4371	74.3

The AGATA Collaboration

Bulgaria:	Sofia
Denmark:	Copenhagen
Finland:	Jyväskylä
France:	GANIL, Lyon, Orsay (IPN & CSNSM), Saclay, Strasbourg
Germany:	Berlin, Bonn, GSI, Darmstadt, Jülich, Köln, München
Hungary:	Debrecen
Italy:	Padova, Milano, LNL, Firenze, Camerino, Napoli, Genova
Poland:	Krakow, Swierk, Warsaw
Romania:	Bucharest
Sweden:	Lund, Stockholm, Uppsala
Turkey:	Ankara, Istanbul
UK:	Daresbury, Brighton, Keele, Liverpool, Manchester, Paisley, Surrey, York

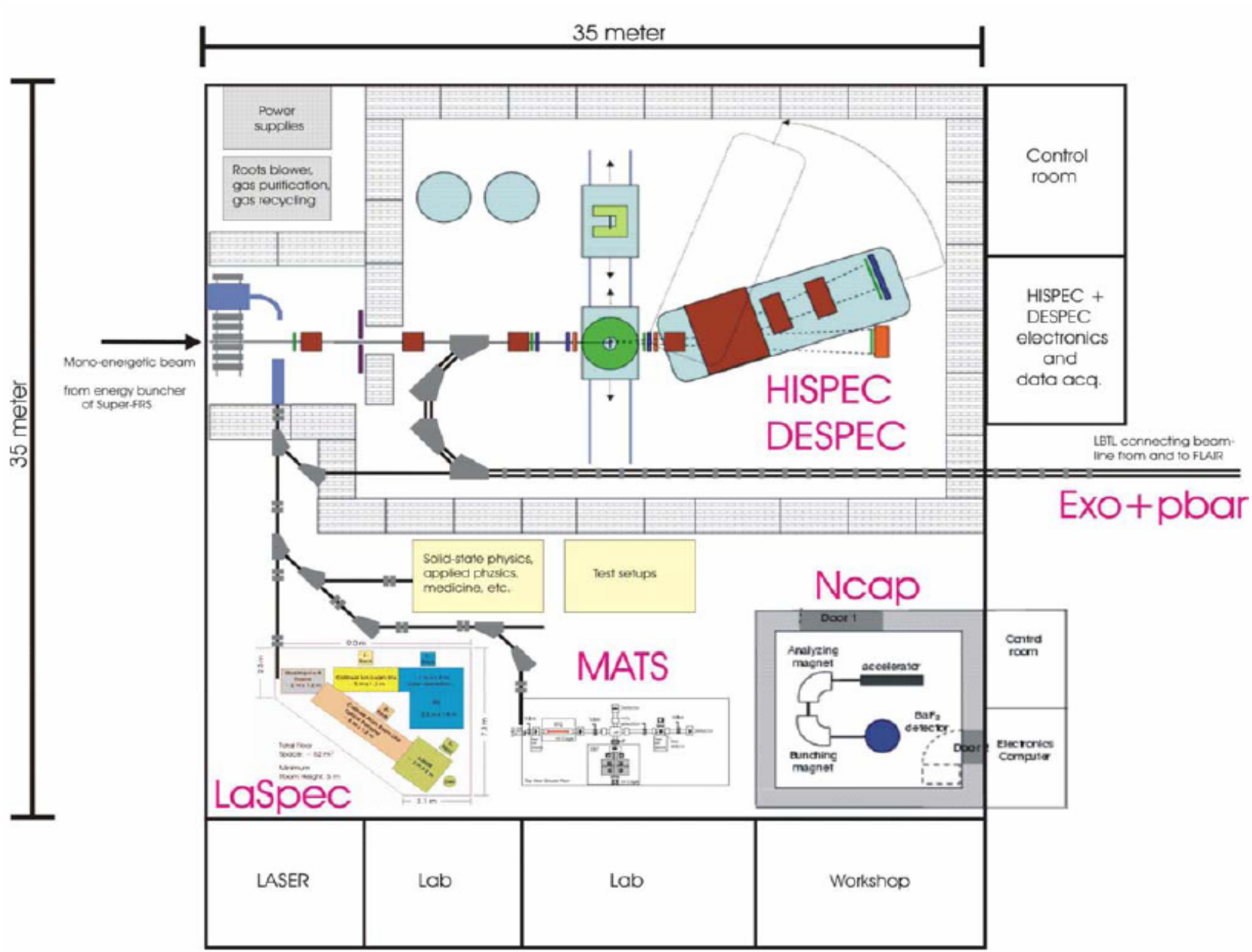


Fig. 1 Overview of the experimental area of the Low-Energy Branch

The AGATA Joint Research Activity

EURONS : EU-FP6 Integrated Infrastructure Initiative (I3)

45 contractors and 33 other institutions from 27 countries

27 activities: 8 Trans-National Access (TNA) to research infrastructures,
9 Joint Research Activities (JRAs), **e.g. AGATA**,
8 Networking activities

Contract and **consortium agreement** have been signed

Project started on 1.1.2005 and ends on 31.12.2008

- **Coordinator** and management team : GSI
- **Scientific manager** : A. Mueller (IN2P3)

Total EURONS budget : 14 M€

JRA AGATA : 18 contractors (e.g. IN2P3, INFN)

Budget : 1.05 M€ (Personnel and networking)

DAPNIA : 52 k€ (in addition to own investment of 300k€)

AGATA Organisation

AGATA Steering Committee

Chairperson J. Gerl, Vice Chairperson N. Alamanos

G. de Angelis, A. Atac, D. Balabanski, D. Bucurescu, B. Cederwall, D. Guillemaud-Mueller, J. Jolie, R. Julin, W. Meczynski, P.J. Nolan, M. Pignanelli, G. Sletten, P.M. Walker

AGATA Management Board

J.Simpson (Project Manager)

D.Bazzacco, G.Duchêne, J.Eberth, A.Gadea, W.Korten, R.Krücken, J.Nyberg

AGATA Working Groups

Detector Module J.Eberth	Detector Performance R.Krücken	Data Processing D.Bazzacco	Design and Infrastructure G. Duchêne	Ancillary Detect. and Integration A.Gadea	Simulation and Data Analysis J.Nyberg

AGATA Teams

Detector and Cryostat D.Weisshaar	Pulse-Shape Anal. R.Gernhaeuser/ P.Desesquelles	Digitisation P.Medina	Mechanical design K.Fayz/J.Simpson	Elec. and DAQ integration Ch. Theisen	Gamma-ray Tracking A.Lopez-Martens
Preamplifiers A.Pullia	Detector Characterisation A.Boston	Pre-processing I.Lazarus	Infrastructure P.Jones	Devices for key Experiments N.Redon	Physics & expt. simulation E.Farnea
		Global clock and Trigger M.Bellato	R & D on gamma Detectors D.Curien	Impact on performance M.Palacz	Detector data base K.Hauschild
		Data acquisition X.Grave		Mechanical Integration vacant	Data analysis O.Stezowski
		Run Control & GUI G.Maron			EURONS - JRA W.Korten