AGATA

The Advanced Gamma Ray Tracking Array at Radioactive Ion Beam facilities

- Introduction: The *AGATA* project
- Current status of the *AGATA*; towards the "demonstrator"
- Exploitation of *AGATA*: demonstrator and beyond

Next generation γ-ray spectrometer based on gamma-ray tracking

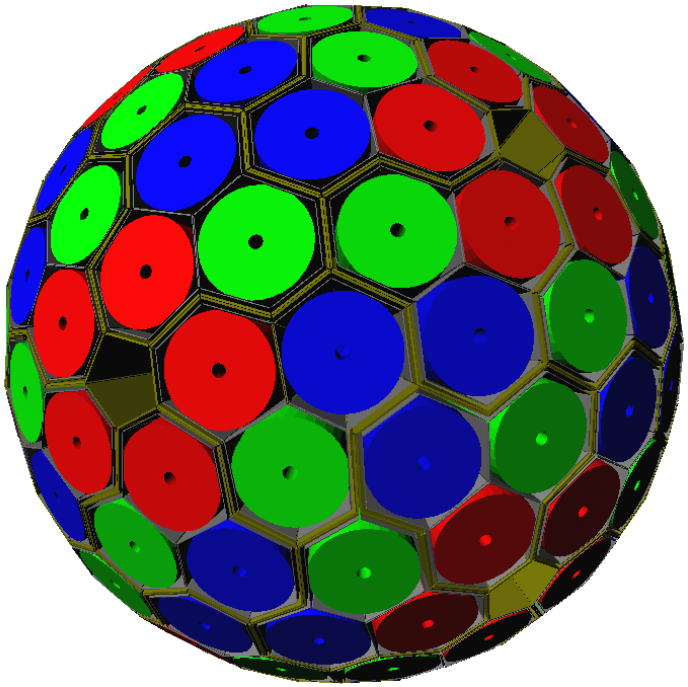
First "real" 4π germanium array ➔ no Compton suppression shields

Versatile spectrometer with very high efficiency and excellent spectrum quality for radioactive and high intensity stable beams

AGATA

Design and characteristics

4π γ-array for Nuclear Physics Experiments at European accelerators providing radioactive and high-intensity stable beams



Principal design features of AGATA

Efficiency: 40% (M_γ=1) 25% (M_γ=30)
today's arrays ~10% (gain ~4) 5% (gain ~1000)

Peak/Total: 55% (M_γ=1) 45% (M_γ=30)
today ~55% 40%

Angular Resolution: ~1° →
FWHM (1 MeV, v/c=50%) ~ 6 keV !!!
today ~40 keV

Rates: 3 MHz (M_γ=1) 300 kHz (M_γ=30)
today 1 MHz 20 kHz

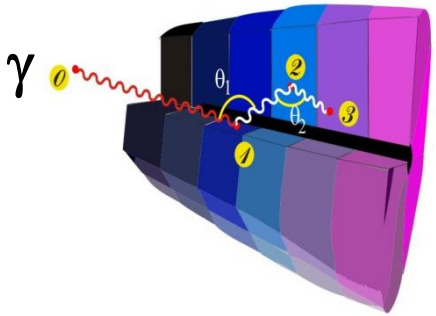
- 180 large volume 36-fold segmented Ge crystals in 60 triple-clusters
- Digital electronics and sophisticated signal processing algorithms (PSA)
- Operation of Ge detectors in position sensitive mode → γ-ray tracking

Ingredients of γ-ray Tracking

AGATA
ADVANCED GAMMA TRACKING ARRAY

1

Highly segmented HPGe detectors



2

Digital electronics to record and process segment signals

3

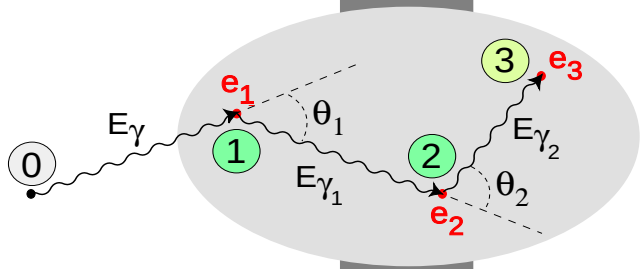
Pulse Shape Analysis to decompose recorded waves

4

Identified interaction

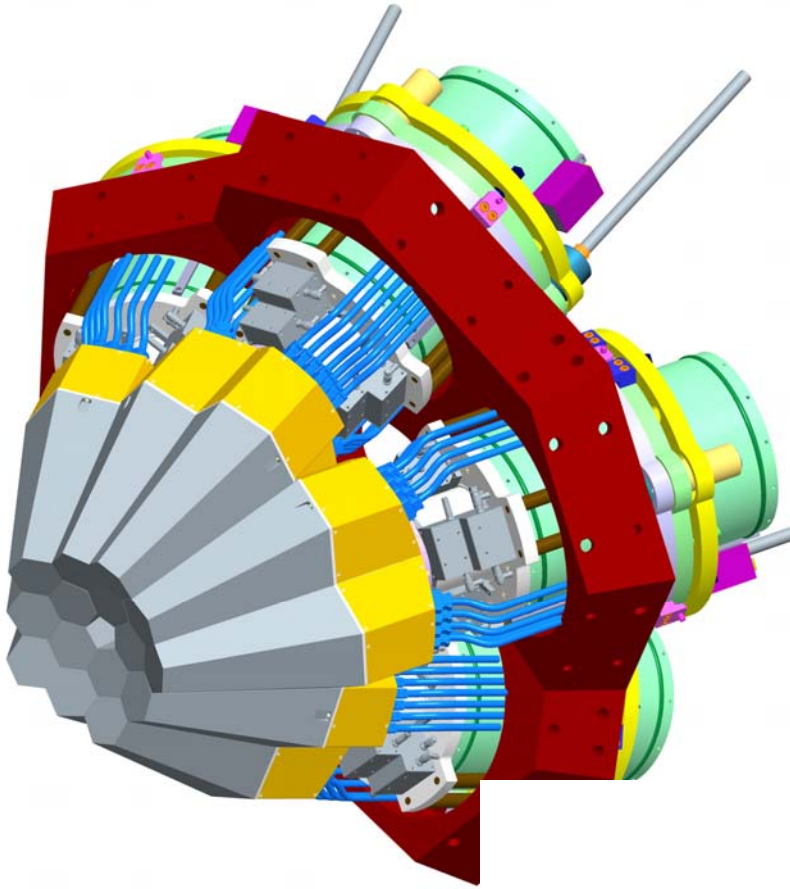
$(x,y,z,E,t)_i$

Reconstruction of tracks e.g. by evaluation of permutations of interaction points



reconstructed γ-rays

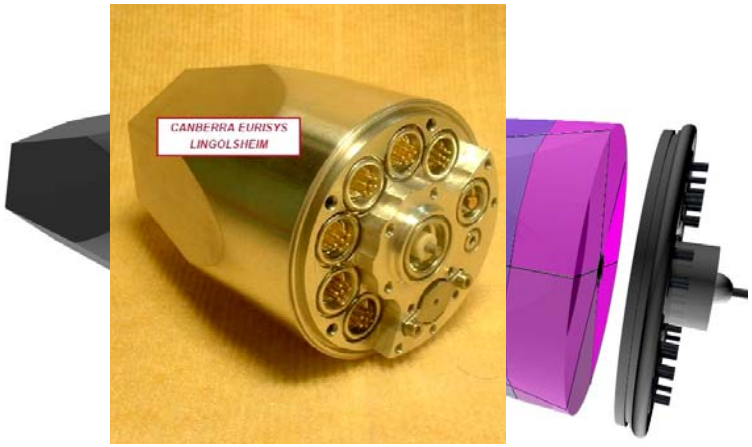
The First Step:
The AGATA Demonstrator
Objective of the final R&D phase 2003-2008



1 symmetric triple-cluster
5 asymmetric triple-clusters
36-fold segmented crystals
540 segments
555 digital-channels
Eff. 3 – 8 % @ $M_\gamma = 1$
Eff. 2 – 4 % @ $M_\gamma = 30$
Full **EDAQ**
with on line PSA and γ-ray tracking
In beam Commissioning
Technical proposal for full array

Cost ~ 6 M € Capital

AGATA Detectors



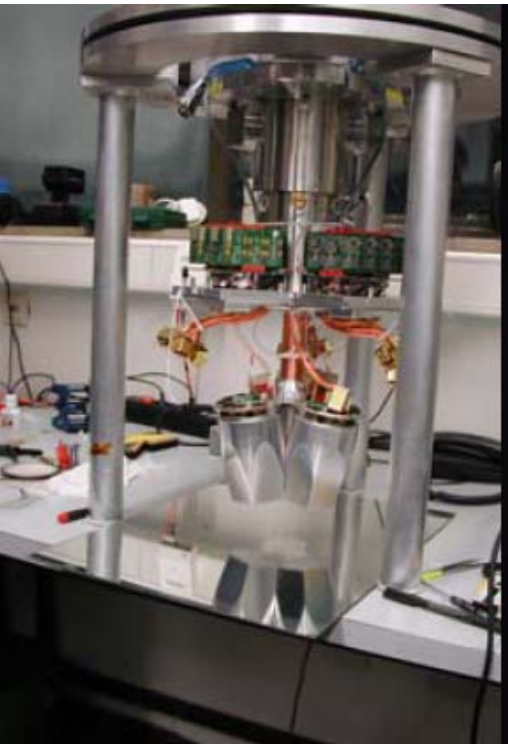
Hexaconical Ge crystals
90 mm long
80 mm max diameter
36 segments
Al encapsulation
0.6 mm spacing
0.8 mm thickness
37 vacuum feedthroughs

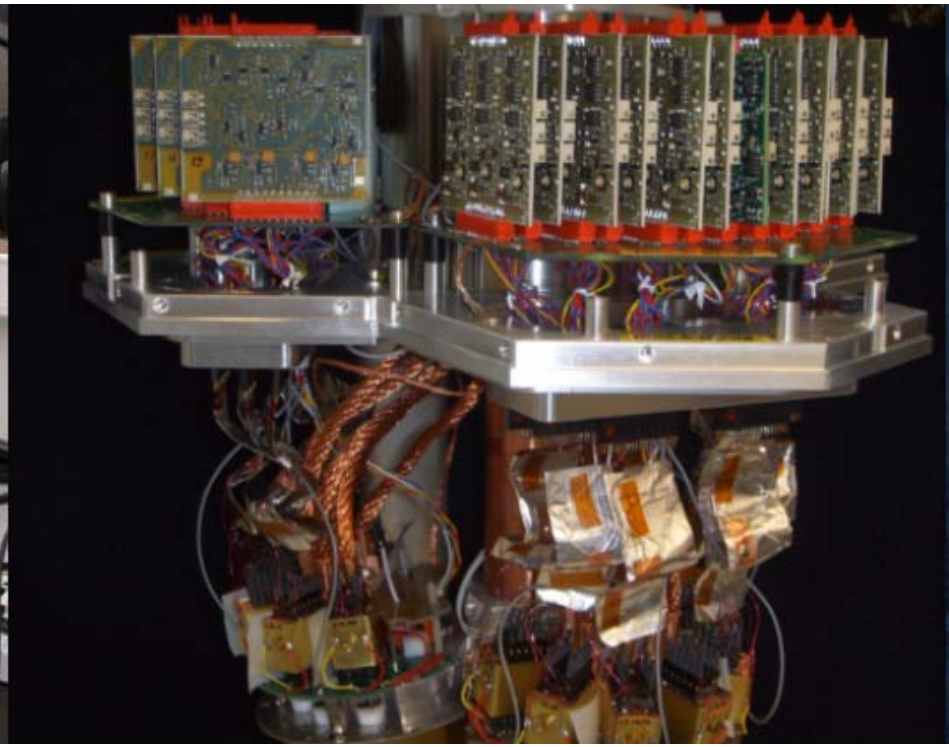
- Symmetric detectors
  - 3 delivered
- Asymmetric detectors
  - 17 ordered (~9 accepted, 3 under test,
  - 3 under repair, 2 to be delivered 2008)
- Preamplifiers available
  - Core (Cologne); Segment (Ganil & Milano)
- Test cryostats for characterisation
  - 5 delivered
- Triple cryostats
  - 5 ordered
  - Assembly in progress

AGATA triple-detector module

3 encapsulated Ge crystals in one cryostat
111 preamplifiers with cold FET
~230 vacuum feedthroughs
LN_2 dewar, 3 litre, cooling power ~8 watts

1st triple assembled at U. Köln,
fully operational with all signals
2nd triple under assembly
3rd triple summer 2008



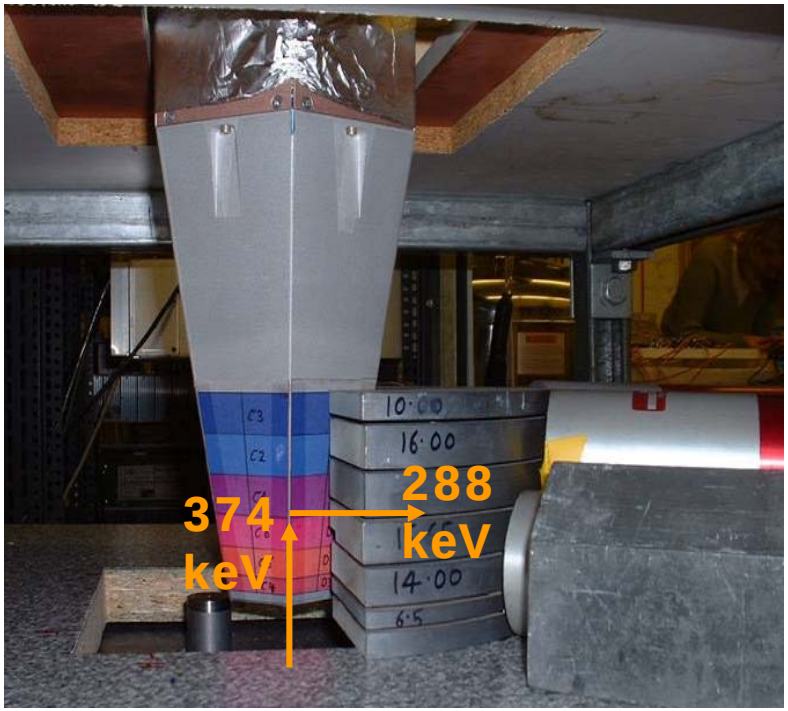


AGATA triple-detector module

Results of acceptance tests
➔see talk by Bart Bruyneel

Characterisation and Scanning

Comparison of real and calculated pulse shapes. Validate codes.



Coincidence scan needed for
3D position determination
➔ very long procedure

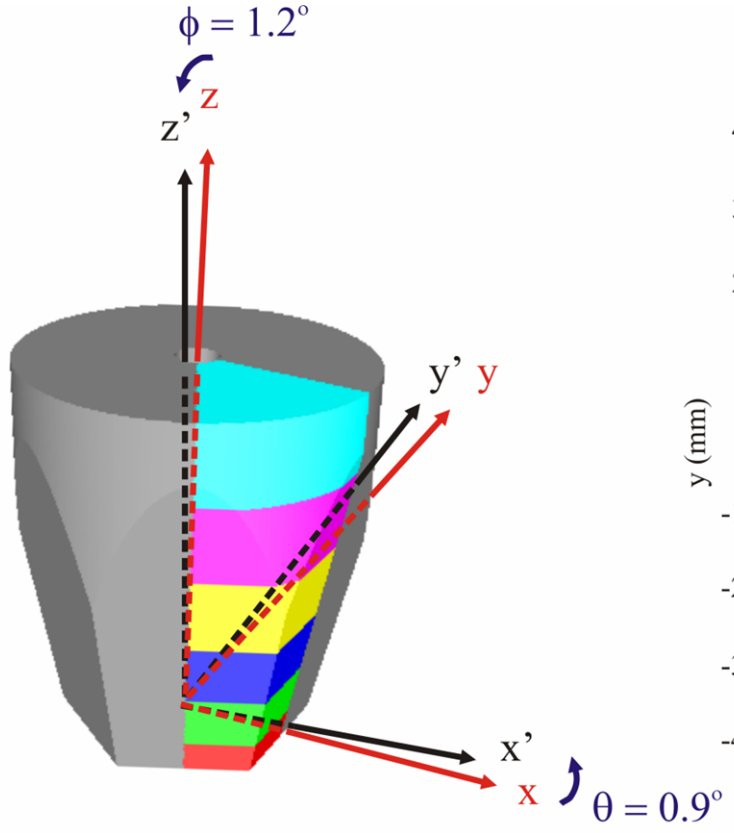
Liverpool scanning system
Two symmetric capsules scanned
First assymetric capsule in progress
➔ see talk of A. Boston

Commissioning of further scanning systems in progress at IPN Orsay & GSI

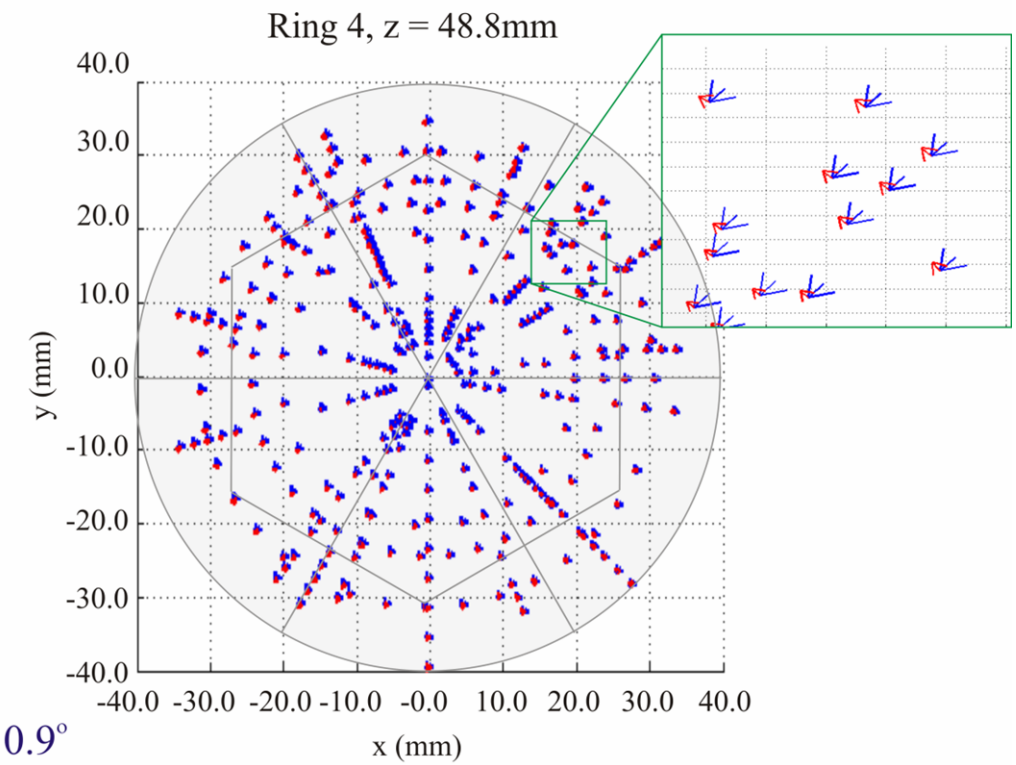
Offset from scanning table

Find the correct positioning of the Ge detector

➔ Correct for slant and tilt



a) Schematic model of the S002 detector - scanning table offset



b) S002 correction vectors, z = 48.8mm

M.Dimmock (U. Liverpool)

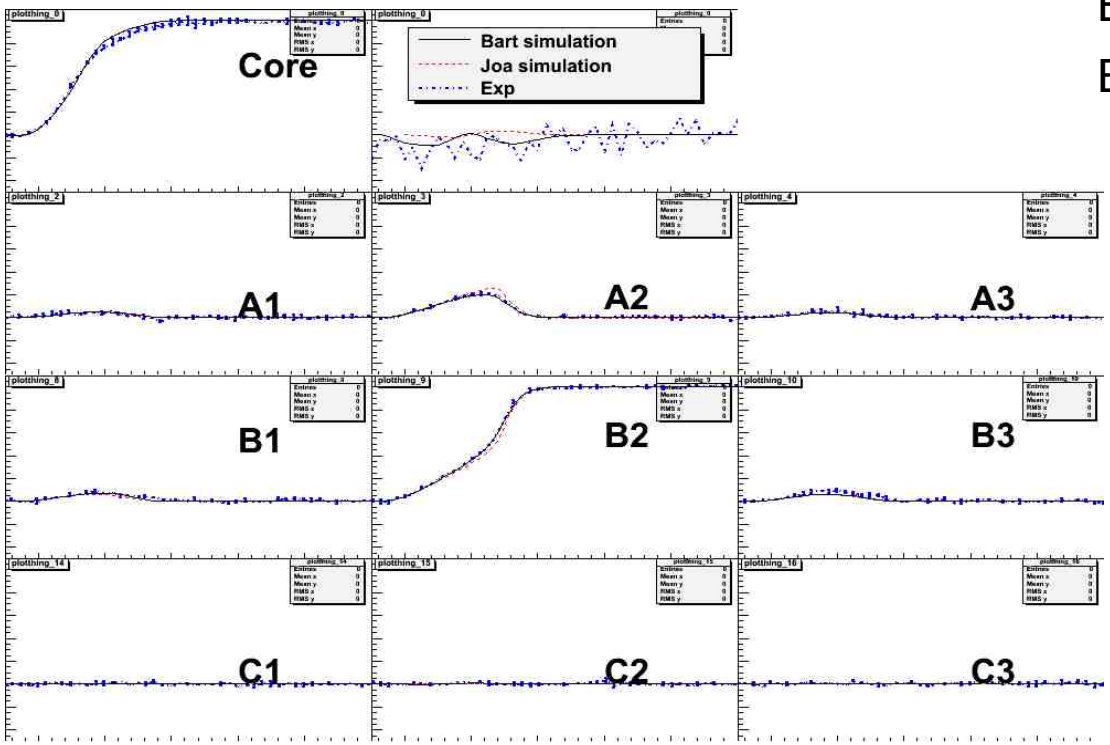
Comparison of measured and calculated pulse shapes

Generally good agreement once detectors parameters are correctly chosen

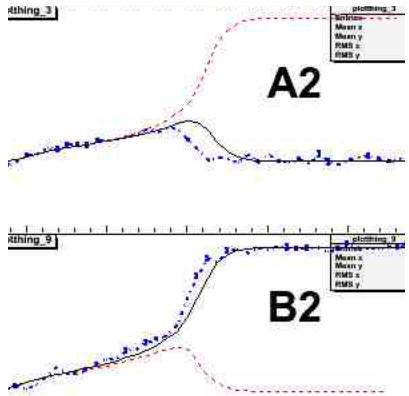
e.g., crystal axis orientation, impurity concentration, …, a few open problems

➔ Location of segment boundaries – Field interpolation

➔ Derivative crosstalk



Effect of unknown segment Boundaries – Field interpolation

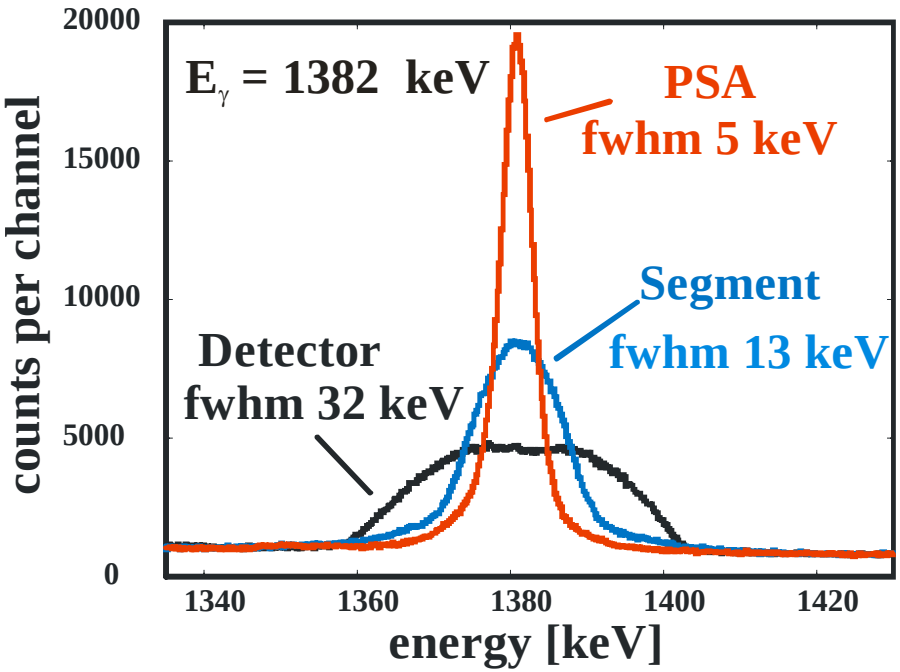


Data from S002-scanning at Liverpool

Pulse-Shape Analysis: current status

Results from the analysis of an in-beam test with the first triple module, e.g. Doppler correction of gamma-rays using PSA results

d(^{48}Ti,p)^{49}Ti, v/c ~6.5%

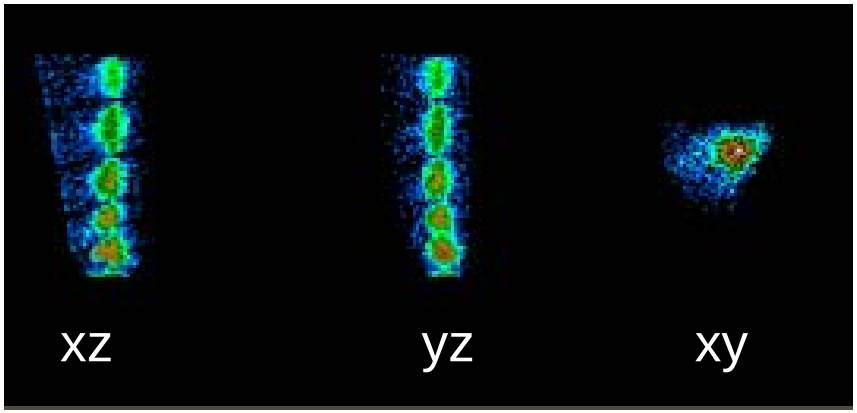


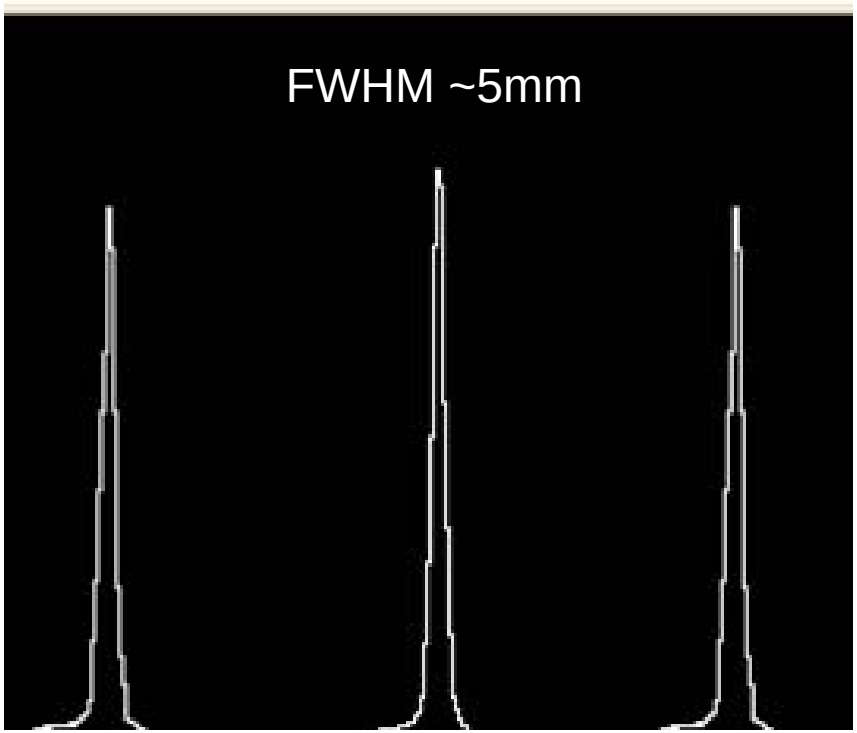
Results obtained with *Grid Search* PSA algorithm (R.Venturelli et al.)

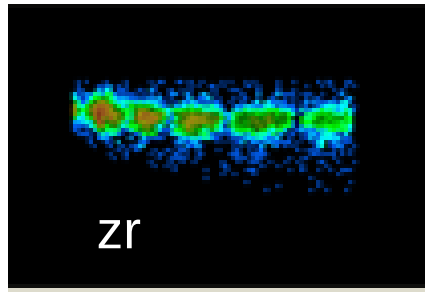
Position resolution ~4.4mm

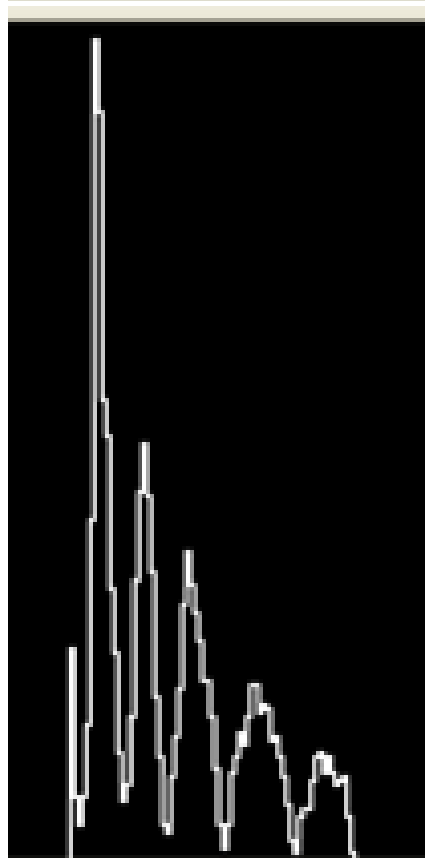
Grid-Search PSA

distribution of hits inside the S001 detector from a ^{137}Cs + ^{60}Co 2D-collimated source









M_{seg} = 1
1 mm
Log color scale

GATE on first 5 segments crossed by gamma beam

Distribution along the z-axis is ~exponential

R.Venturelli

Pulse-Shape Analysis: ongoing developments

- **PSA implementation for Demonstrator**
  - Algorithms tested using a C/C++ Narval emulator (J.Ljungvall, D.Mengoni)
  - Pre-processing of data: calibrations (time, energy, traces) and “proportional” cross-talk corrections (B. Bruyneel)
  - Qualify alternate PSA Codes (see poster Nr. 1)
  - Implement Grid Search PSA (R.Venturelli, J.Ljungvall)
- **Qualification of calculated signal basis**
  - Liverpool scans confirm “derivative” cross-talk (M.Dimmock, B.Bruyneel).

AGATA Digitiser Module

36+1 channels, 100 MhZ, 14 bits

(Strasbourg - Daresbury – Liverpool)

- Mounted close to the Detector *5-10 m*
- Power Dissipation around 400W
- Water Cooling required
- Testing in Liverpool (December 2006)
- Production in progress (for 18 Ge crystals)

First production digitizer at Daresbury

AGATA pre-processing electronics

(INFN Padova, IPN Orsay, CSNSM Orsay)

ATCA carrier

2 off final prototype (V2.1)
delivered beginning of April

GTS mezzanine

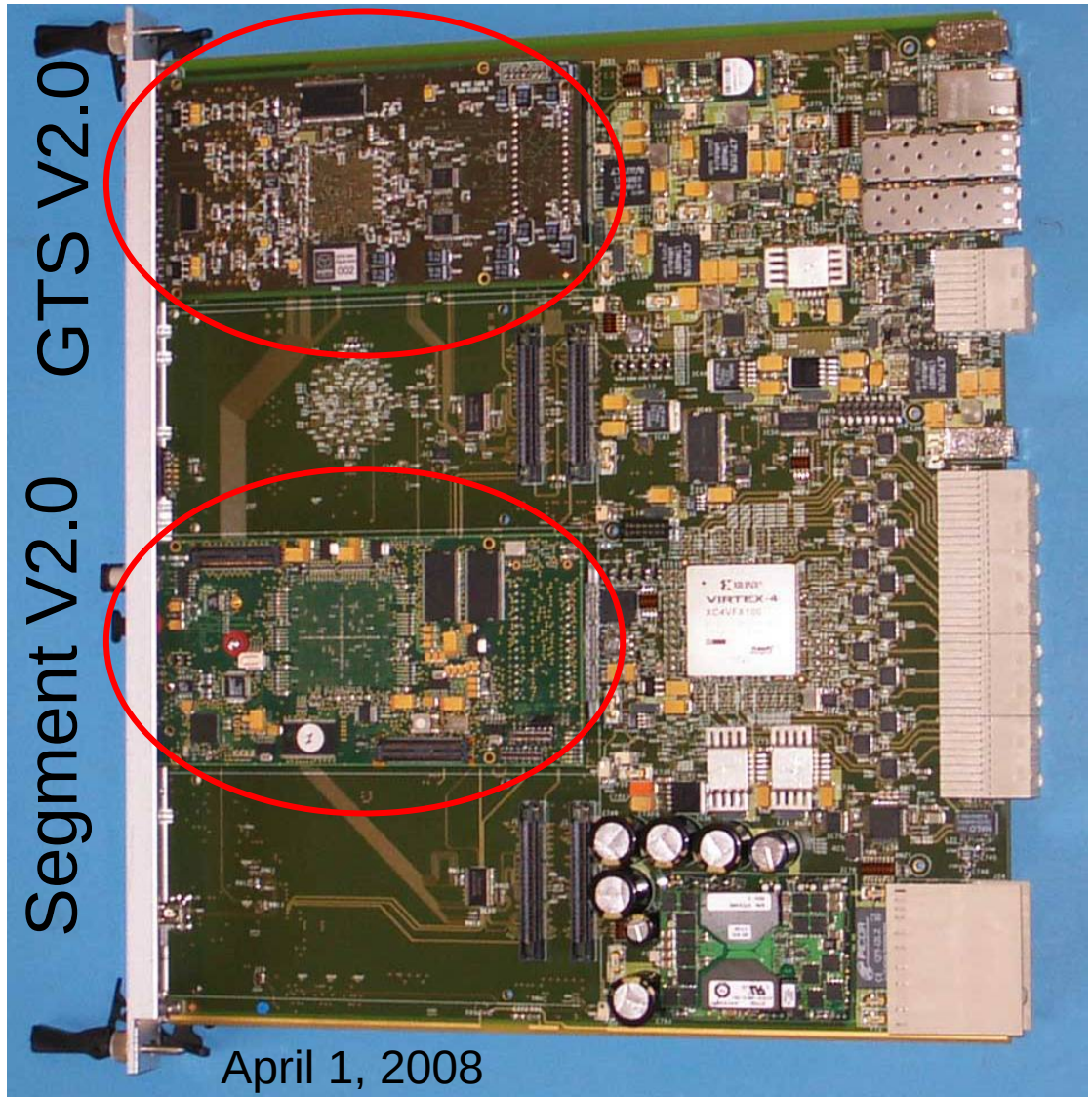
V2.1 under final rework

Segment Mezzanine

10 off final prototype (V2.1)
delivered beginning of May

Core Mezzanine

3 off new (V2) version
delivered beginning of April

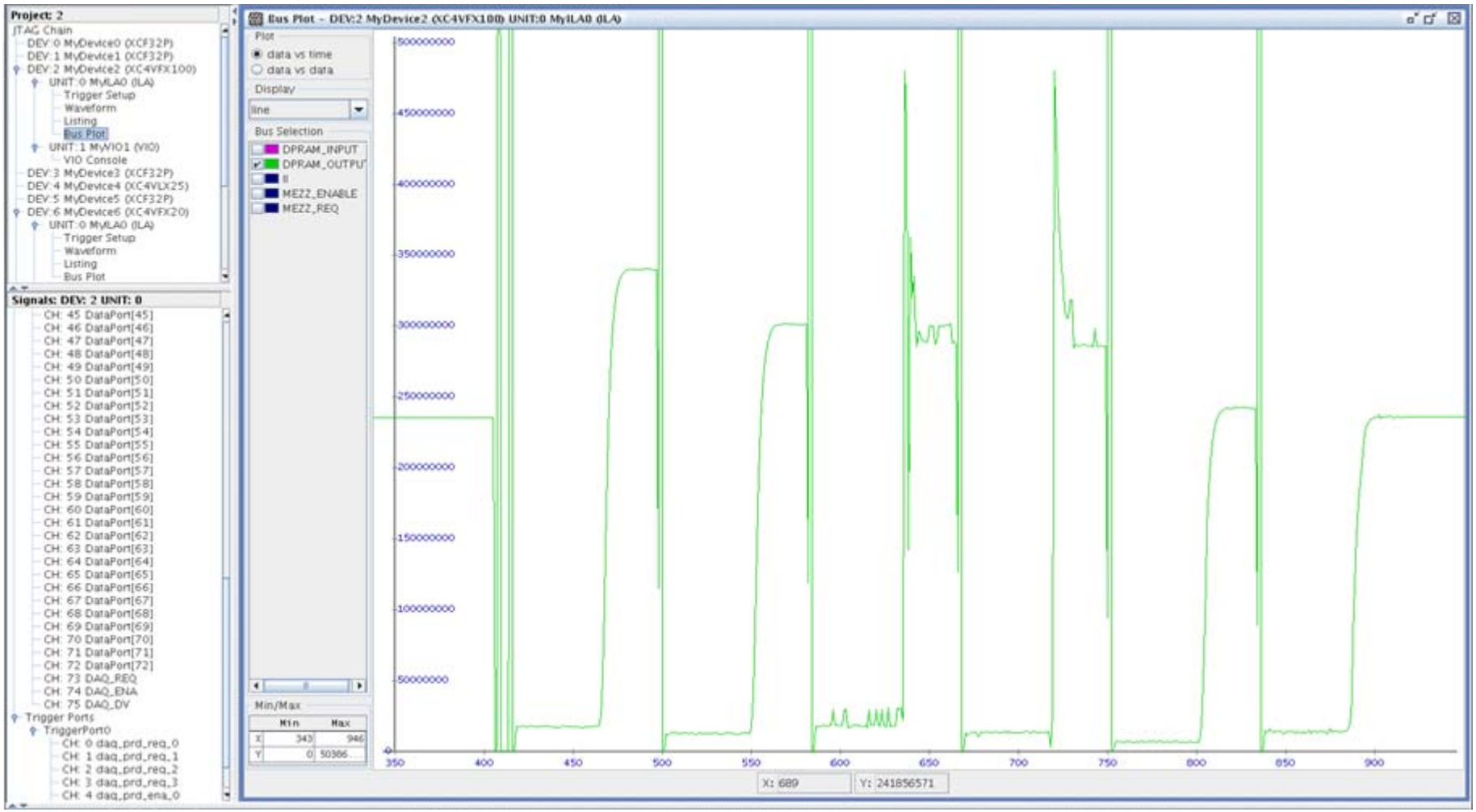


AGATA processing mezzanines

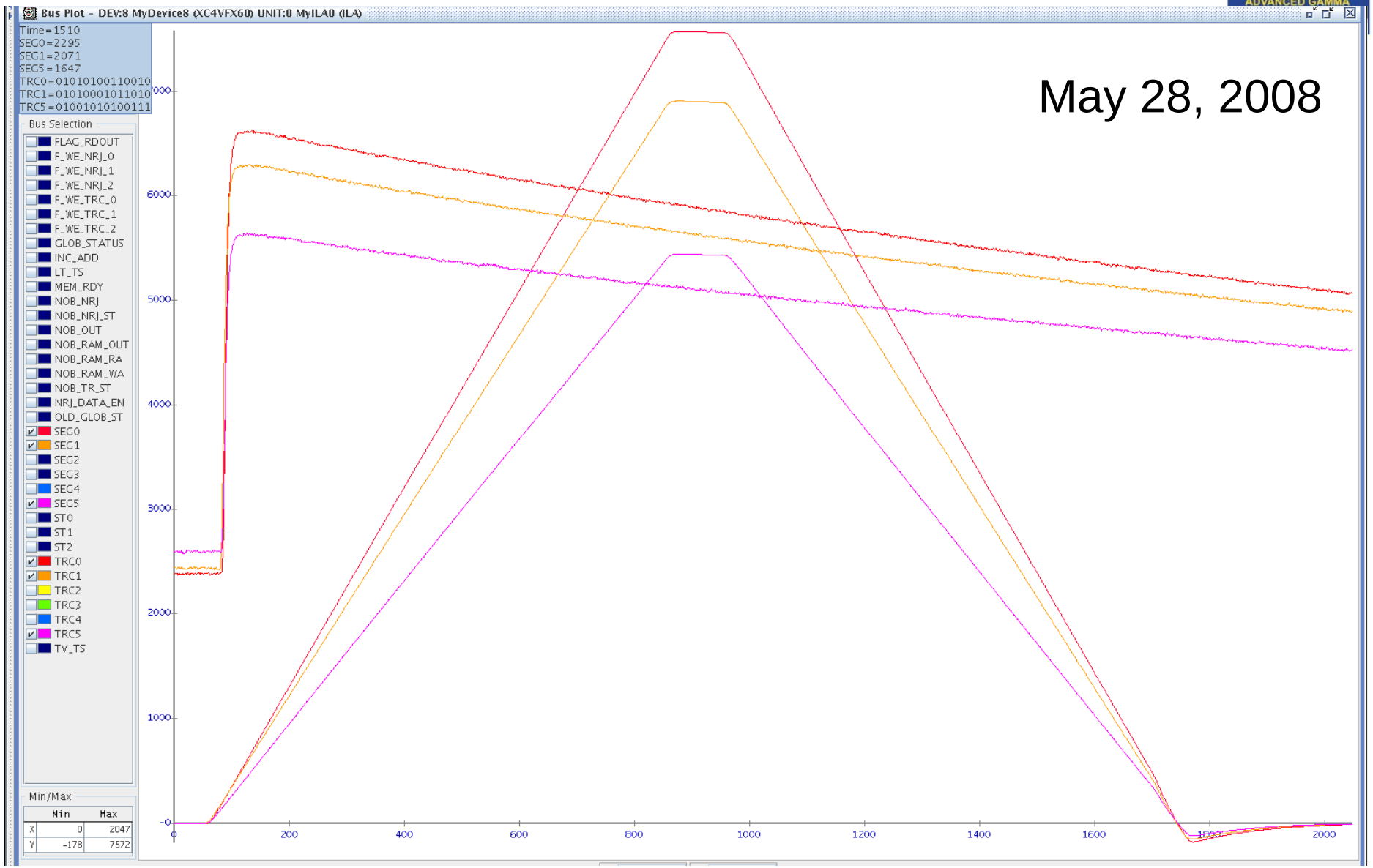
Carefully attended by the LLP team, on May 22, 2008,

THE FIRST AGATA TRACE

made its way from the digitiser to the ATCA carrier, via segment mezzanine.



Digitized, optically-transmitted and pre-processed AGATA traces

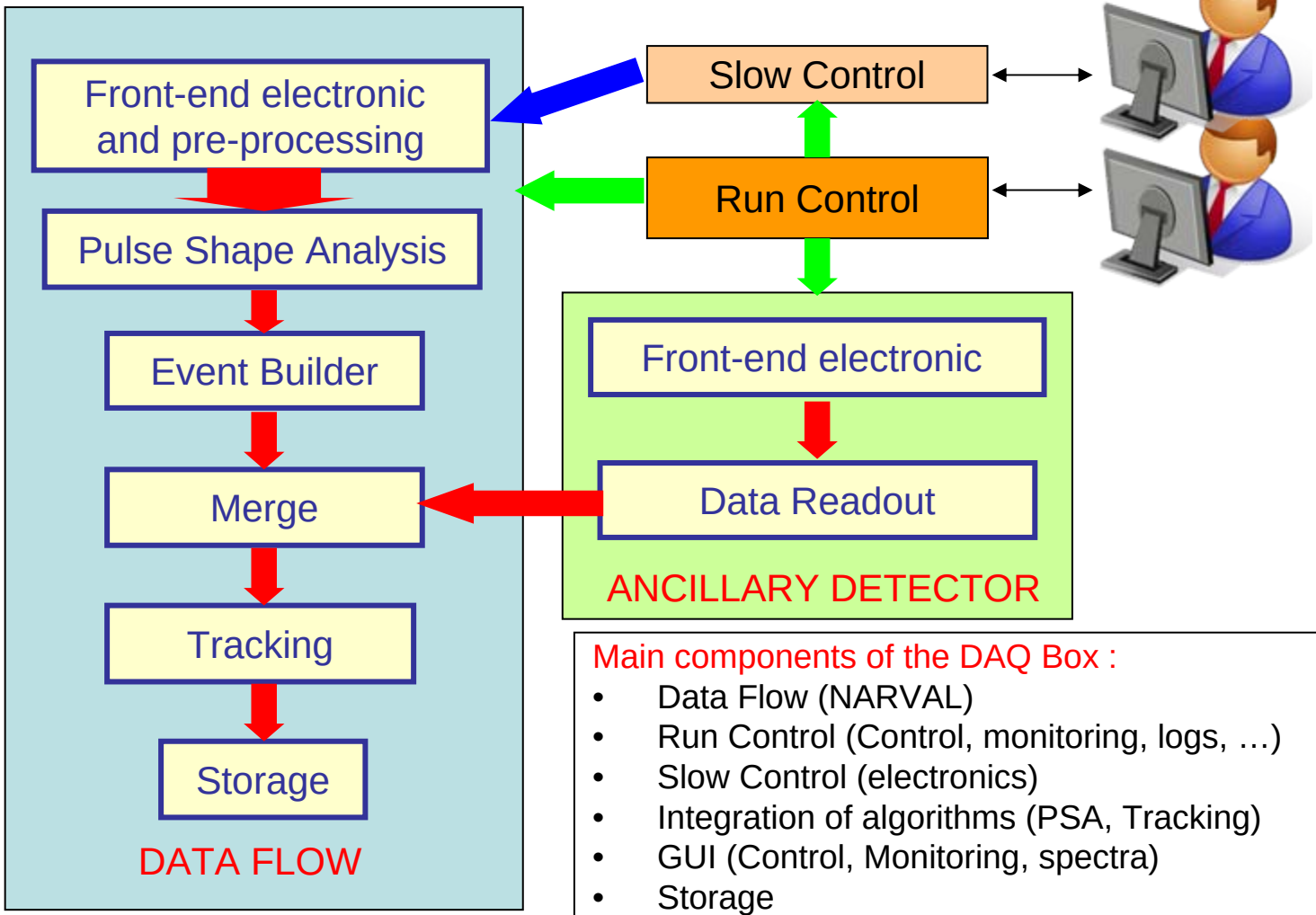


System integration – ongoing developments

Hardware + Firmware + Software

- Next step: readout to PSA computer
  - asap, using PCI express
- Taking data from one capsule
  - June
- Taking data from one Triple Cluster
  - October
    - 6 ATCA carriers
    - 3 Core mezzanines
    - 18 Segment mezzanines
    - 4 GTS mezzanines
- Instrumentation of full demonstrator
  - Sping 2009

AGATA DAQ



Main components of the DAQ Box :

- Data Flow (NARVAL)
- Run Control (Control, monitoring, logs, …)
- Slow Control (electronics)
- Integration of algorithms (PSA, Tracking)
- GUI (Control, Monitoring, spectra)
- Storage

Implementation :

- 1 U “pizza boxes” 8 cores servers (9 + 1/cristal)
- 100 TB Raid Disk

Status of AGATA DAQ

- Data flow, Run Control, GUI operational. Software integration in progress.
- Hardware being purchased and installed. Installation at Legnaro early June.
- Monitoring and maintenance procedures defined and being implemented
- Ancillary detector integration in progress

- **Full DAQ operational in summer 08**

Status and Evolution

AGATA demonstrator 2003-2008

Assembly of array and infrastructure summer 2008
Commissioning of sub array at Legnaro autumn 2008
(see presentation of A. Gadea)

Physics campaigns and build up towards full array

First physics campaign at LNL from April 2009
Further campaigns at GANIL then GSI

New MoU for AGATA construction almost final

Next aim is to operate 20 Triples within four years
New capital investment: ~12 M€ (2009-12)

The AGATA Collaboration

Open collaboration with currently 40 institutes from 10 countries
New Memorandum of Understanding (2008-15): Construction and Exploitation

Bulgaria: Univ. Sofia, INRNE - Bulgarian Academy of Sciences

Finland: Univ. Jyvä

France: GANIL Caen, LPSC [illegible] IPN Lyon, CSNSM Orsay, IPN Orsay, CEA-DSM-IRFU Saclay, [illegible]asbourg

Germany: GSI Darmstadt, TU Darmstadt, [illegible]öln, TU München

Italy: INFN Firenze, INFN Genova, INFN Leg[illegible] Milano, INFN Napoli, INFN Padova, INFN Perugia [illegible]

Poland: IFJ-PAN Krakow, Univ. Warsaw (HIL)

Romania: IFIN-HH Bucarest

Sweden: Chalmers Univ. of Technology Göteborg, Lund Univ., Royal Institute of Technology Stockholm, Uppsala Univ.

Turkey: Univ. Ankara, Univ. Istanbul, Technical Univ. Istanbul

UK: Univ. Brighton, STFC Daresbury Laboratory, Univ. Edinburgh, Univ. Liverpool, Univ. Manchester, Univ. Surrey, Univ. West of Scotland, Univ. York

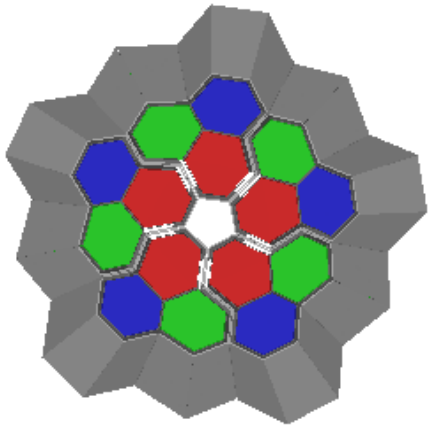
If you are not yet in, now is the time to join !

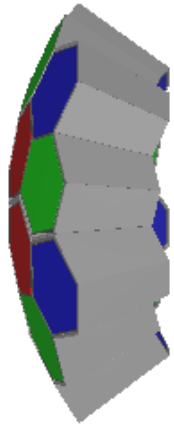
Memorandum of Understanding 2003 - 2008 (Research and Development) also Denmark and Hungary

The Phases of AGATA

5 Clusters 2009

Demonstrator





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

Replace/Complement

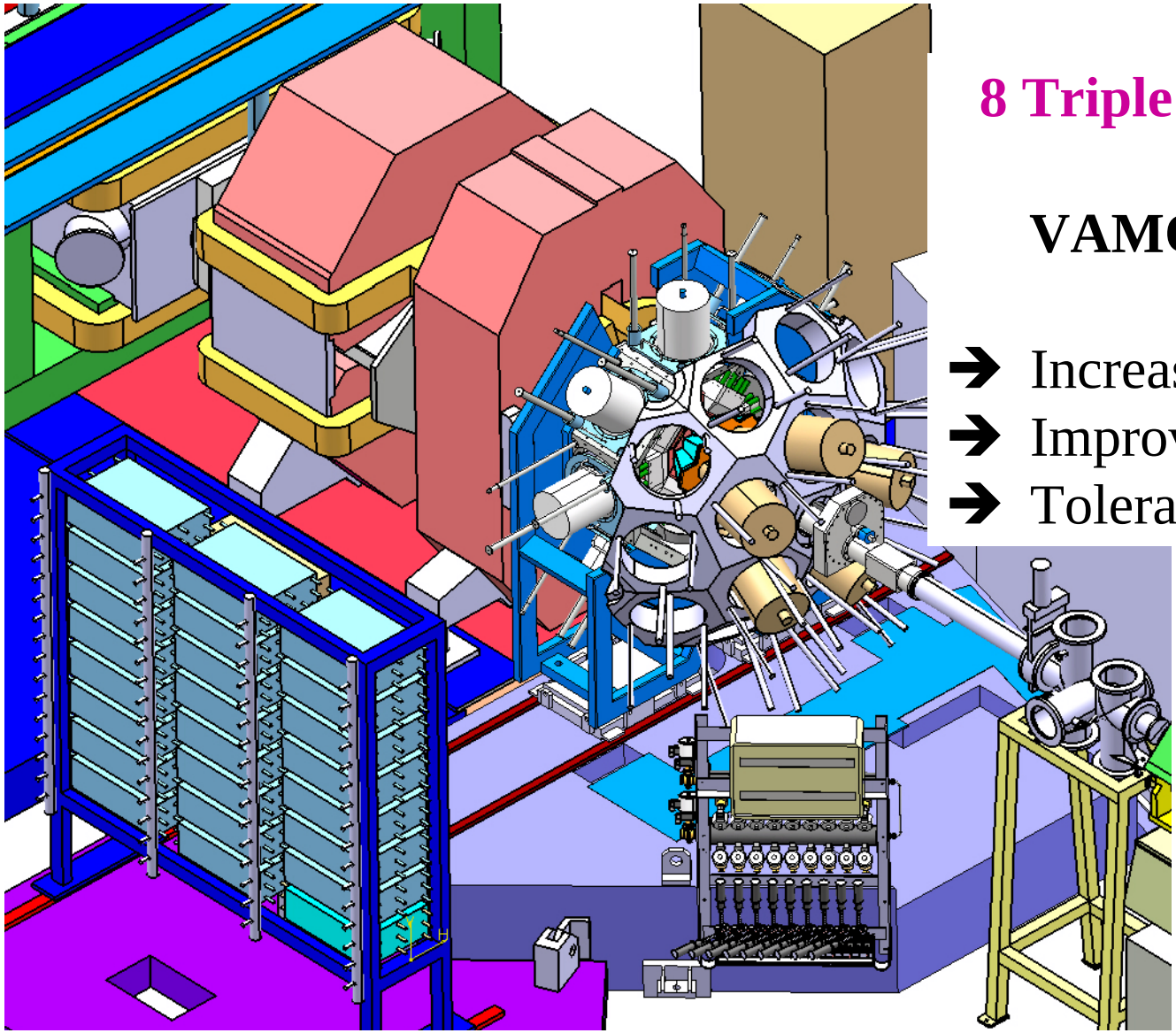
LNL	2009/10	PRISMA	CLARA
GANIL	2010/11	VAMOS	EXOGAM
GSI	2011/12	FRS	RISING

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

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

AGATA at GANIL

(~2010/11)



8 Triple clusters at 130mm

with

VAMOS & EXOGAM

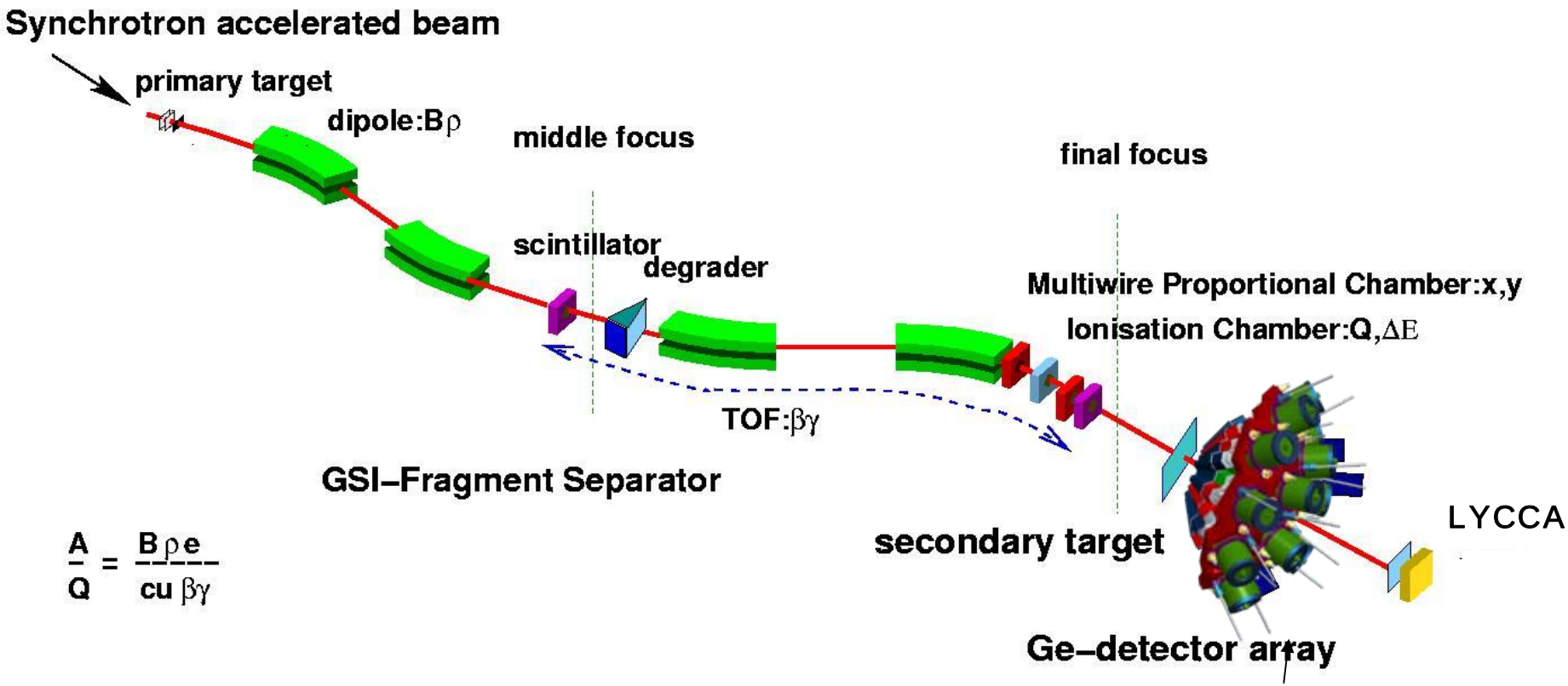
- ➔ Increase efficiency
- ➔ Improve resolution
- ➔ Tolerate higher rates

AGATA at GSI-FRS

(~2011/12)

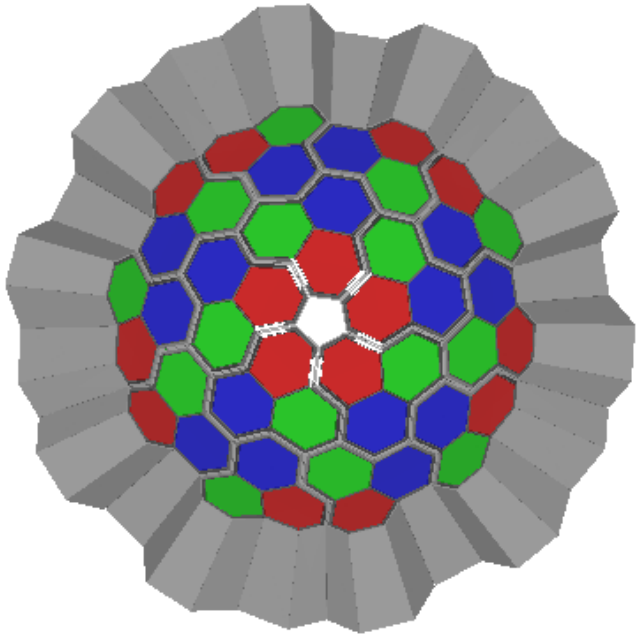
Up to 15 Triple clusters

at the current FRS

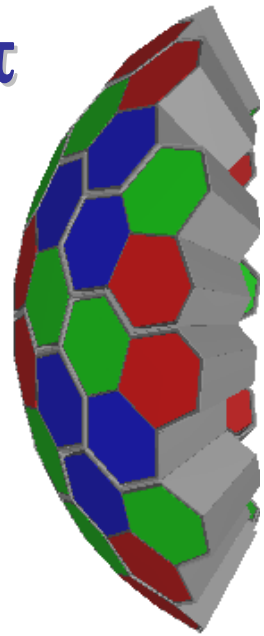


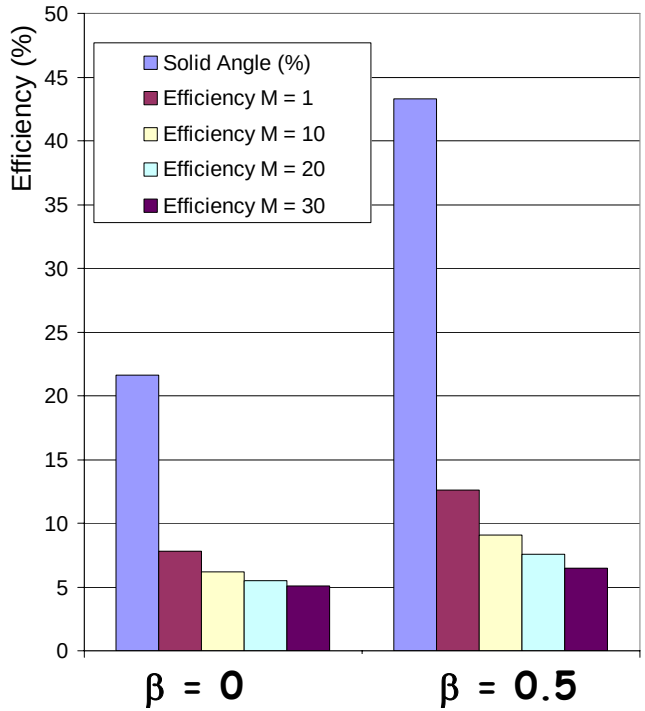
The Phases of AGATA

15 Clusters 2011



1π





The first "real" tracking array

Used at **FAIR-HISPEC**, **SPIRAL2**, **SPES**, **HIE-Isolde**, …

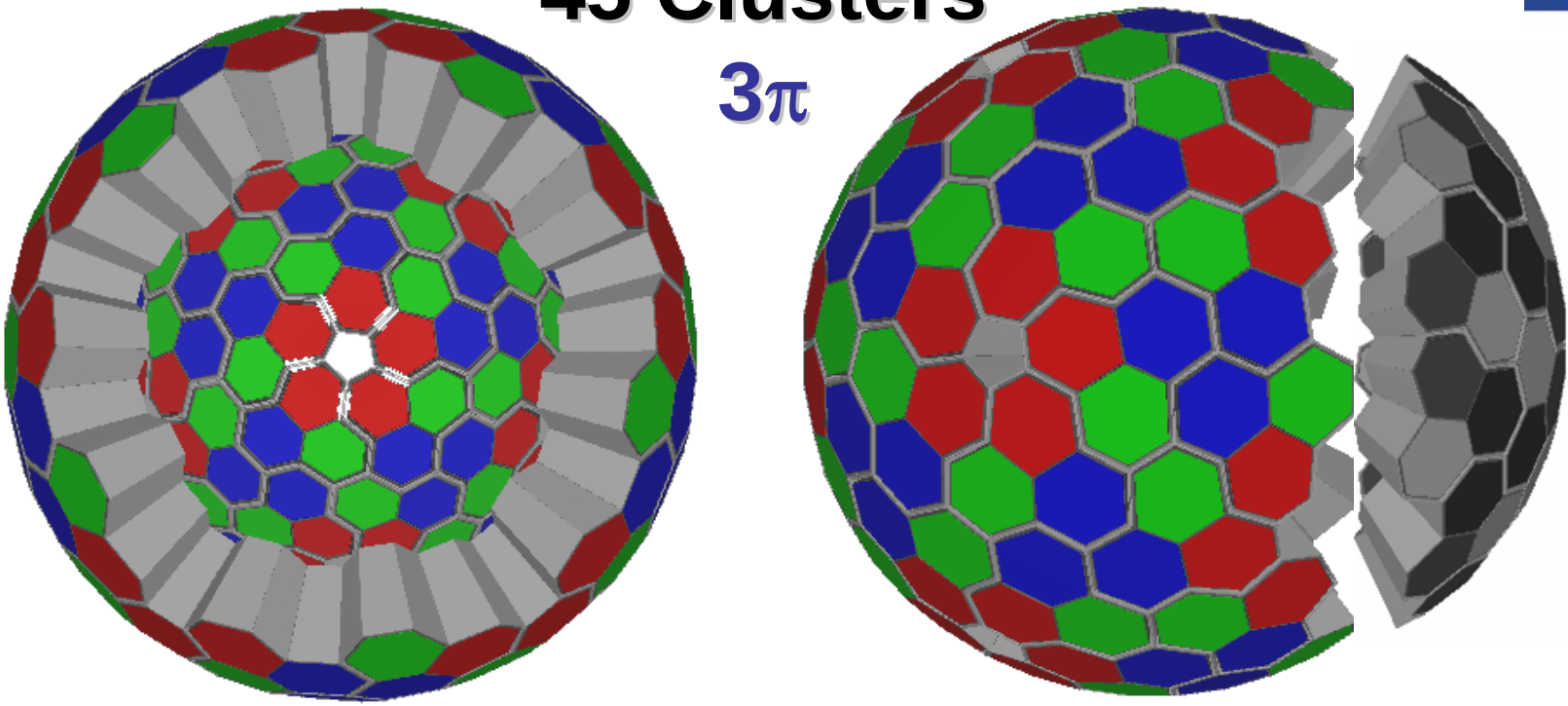
Coupled to spectrometer, beam tracker, LCP arrays …

Spectroscopy at the N=Z (^{100}Sn), n-drip line nuclei, …

The Phases of AGATA

45 Clusters

3π



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

Ideal instrument for FAIR / EURISOL

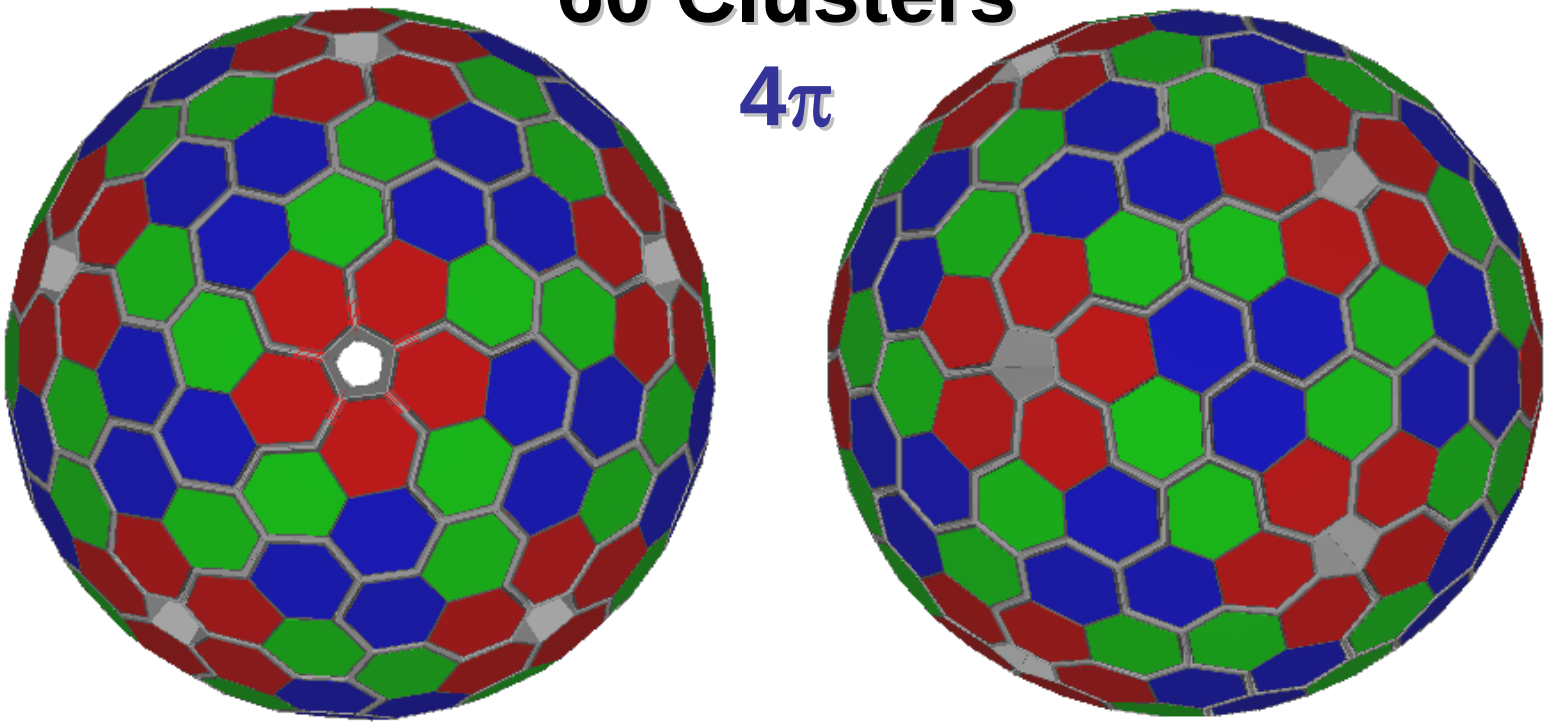
Also used as partial arrays in different labs

Higher performance by coupling with ancillaries

The Phases of AGATA

60 Clusters

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

The AGATA Organisation

AGATA Steering Committee

Chairperson: W.Korten (and EURONS) Vice Chairperson: P.J. Nolan

lis, A.Atac, F. Azaiez, D.Balabanski, D.Bucurescu, B.Cederwall, J. C R.Julin, W.Meczynski,, M.Pignanelli, G.Sletten, P.M.Walker

AGATA Management Board

impson (Project Manager)

D.Bazzacco, G.D Reiter, A. Gadea, J.Nyberg, Ch. Theisen

A king Groups

Detector module P.Reiter	**Front-end Processing D.Bazzacco**	**Data Acquisition Ch. Theisen**	**n and ure G.**	**Ancillary detectors and integration A.Gadea**	**Simulation and Data Analysis J.Nyberg**

AGATA Teams

Detector and Cryostat B. Bruyneel	**Digitisation P.Medina**	**Data acquisition X.Grave**	**Mechanical design J.Strachan**	**AQ P. Bed**	**Gamma-ray Tracking A.Lopez-Martens**
Preamplifiers A.Pullia	**Pre-processing I.Lazarus**	**Run Control & GUI G.Maron**	**Infrastructure P.Jones**	**Devices for k Experiments N.Redon**	**sics & exp. ation**
Detector Characterisation A.Boston	**Global clock and Trigger M.Bellato**		**R & D on gamma Detectors D.Curien**	**Impact on performance M.Palacz**	**D data K.Hausch**
	PSA R.Gernhaeuser/ P.Desesquelles			**Mechanical Integration J. Valiente Dobon**	**Data analysis O.Stezowski**

Many thanks for working very hard, but keep going !