DPG Frühjahrstagung

Münster, 21. - 25. März 2011

Erste Ergebnisse des Advanced GAmma Tracking Array

- Motivation
- γ-ray tracking
- Detector performance
- First results
- Outlook

P. Reiter, B. Birkenbach, B. Bruyneel,
J. Eberth, H. Hess, D. Lersch,
G.Pascovici, A. Wiens
Universität zu Köln

New Facilities, New challenges

SPIRAL2 - HIE-ISOLDE - EURISOL - ECOS

Relativistic exotic beams …

- Low beam intensity
- High backgrounds
- Large Doppler broadening
- High γ-ray multiplicities
- High counting rates

…Need :

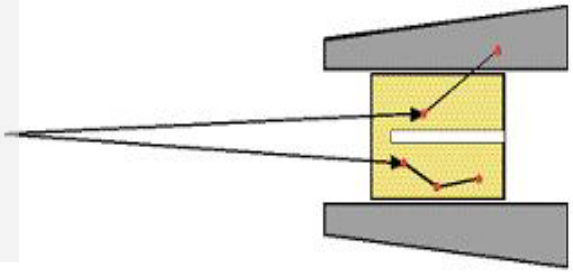
- High efficiency
- High sensitivity
- High position resolution
- High Peak/Total
- High throughput

The idea of γ-ray tracking

Compton Shielded Ge

ε_{ph} ~ 10%
N_{det} ~ 100

Ω ~ 40%
θ ~ 8º



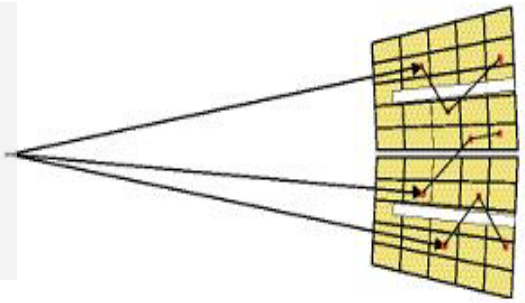
large opening angle means poor energy resolution at high recoil velocity.

Previously scattered gammas were wasted.
Technology is available now to track them.

Ge Tracking Array

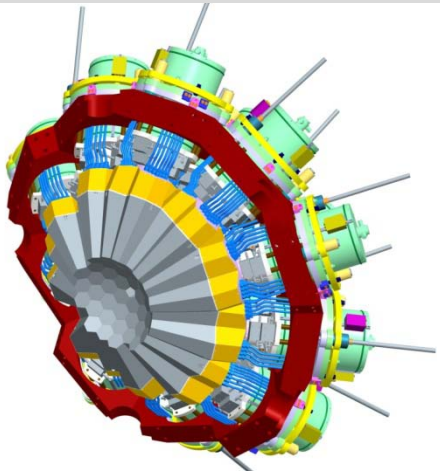
ε_{ph} **~ 50%**
N_{det} ~ 100

Ω ~ 80%
θ **~ 1º**



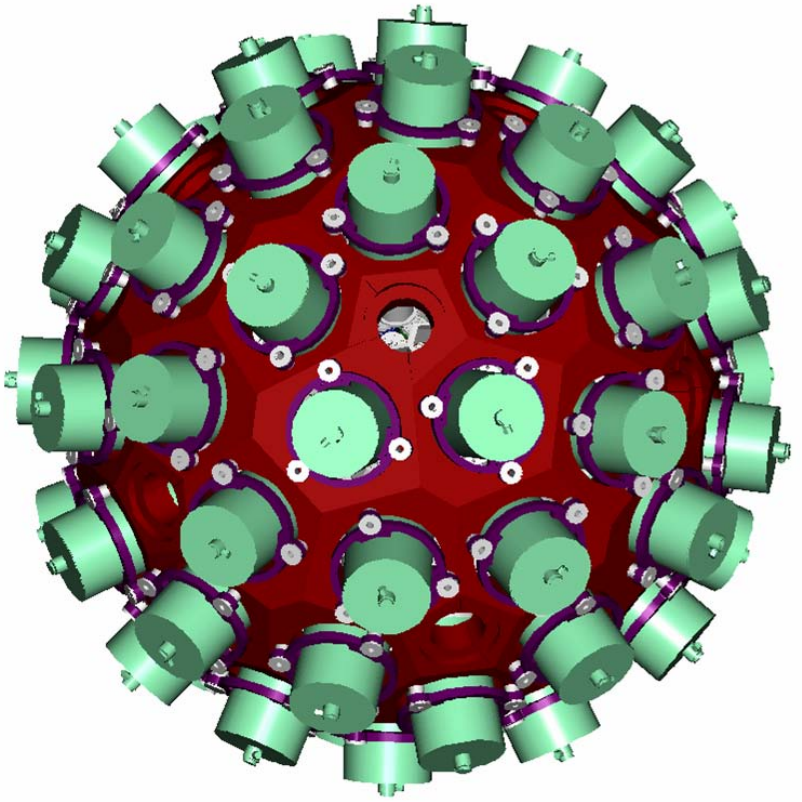
Combination of:

- segmented detectors
- digital electronics
- pulse processing
- tracking the γ-rays

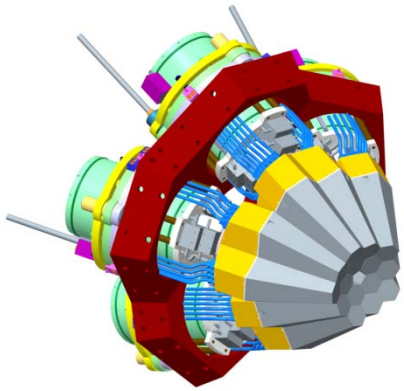


AGATA / GRETA

Advanced GAmma Tracking Array



180 hexagonal crystals	3 shapes
60 triple-clusters	all equal
Inner radius (Ge)	23.5 cm
Amount of germanium	362 kg
Solid angle coverage	82 %
36-fold segmentation	6480 segments
Singles rate	~50 kHz
Efficiency:	43% (M_γ=1) 28% (M_γ=30)
Peak/Total:	58% (M_γ=1) 49% (M_γ=30)



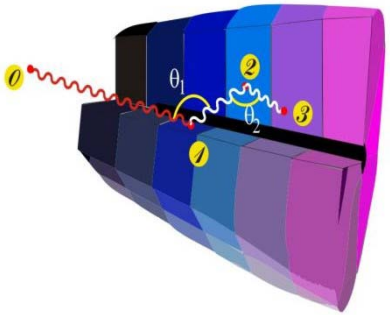
New γ-ray detection method

- 6660 high-resolution digital electronics channels
- Coupling to ancillary detectors for added selectivity

Ingredients of Gamma-Ray Tracking

1

Highly segmented HPGe detectors



2

Digital electronics to record and process segment signals

3

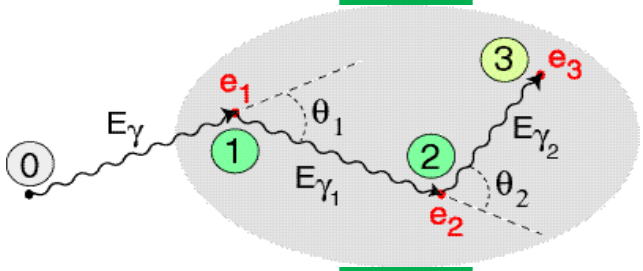
Pulse Shape Analysis to decompose recorded waves

Identified interaction points

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

4

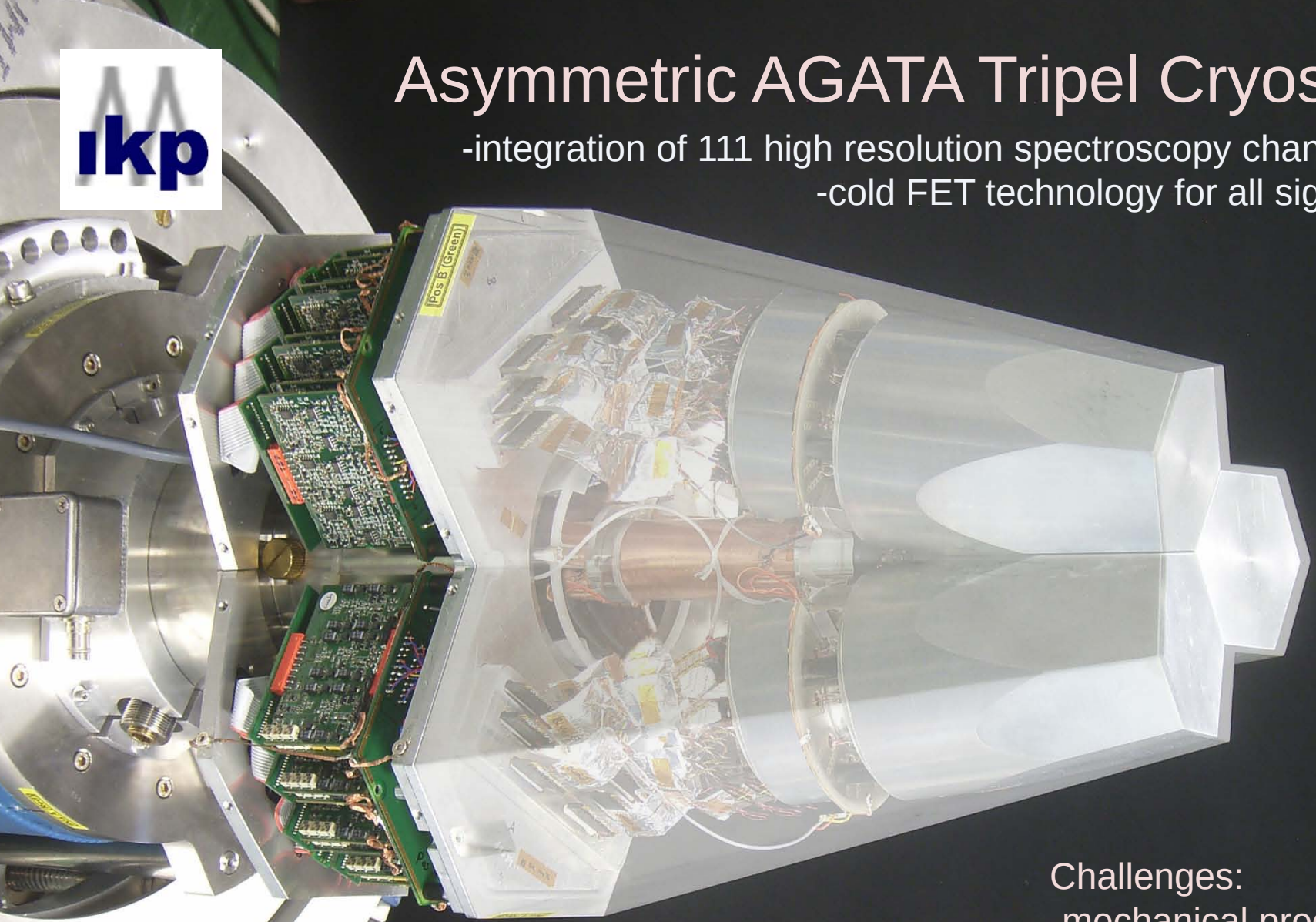
Reconstruction of tracks evaluating permutations of interaction points



Reconstructed gamma-rays

Asymmetric AGATA Tripel Cryostat

-integration of 111 high resolution spectroscopy channels
-cold FET technology for all signals

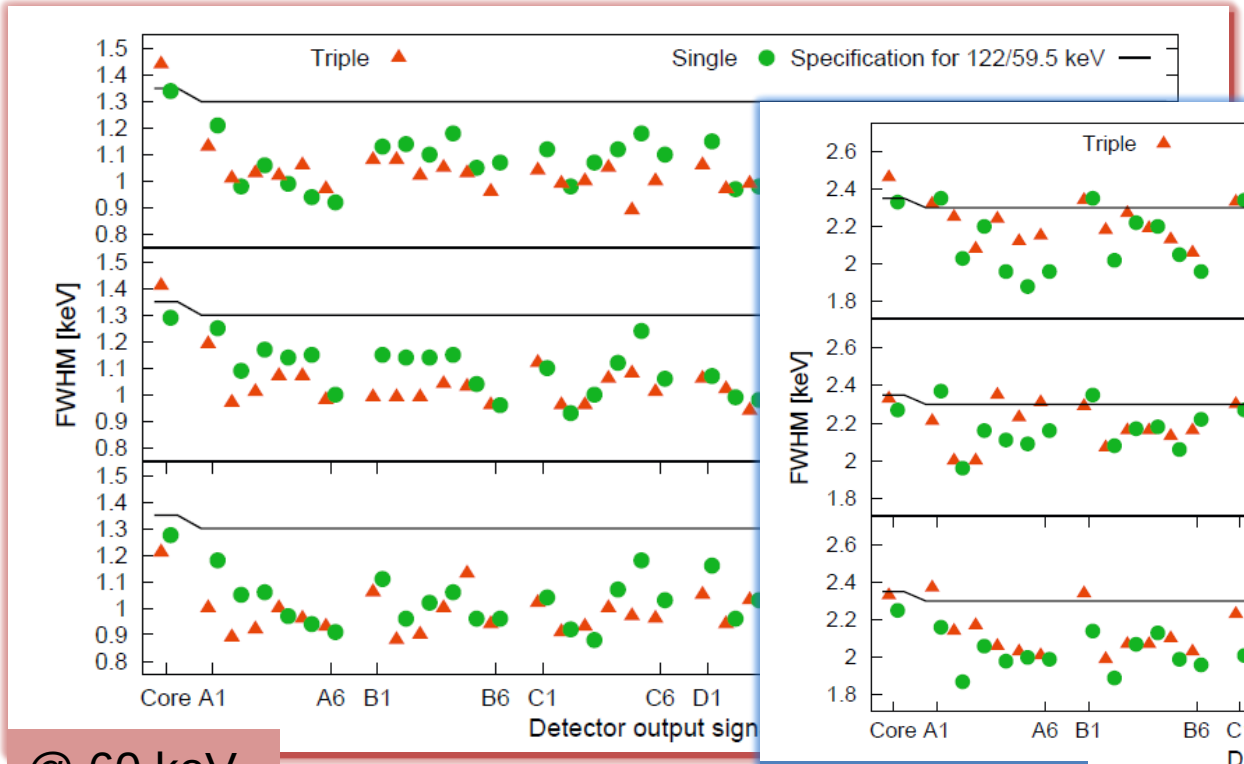


- A. Wiens et al. NIM A 618 (2010) 223–233
- D. Lersch et al. NIM A (2011) in press

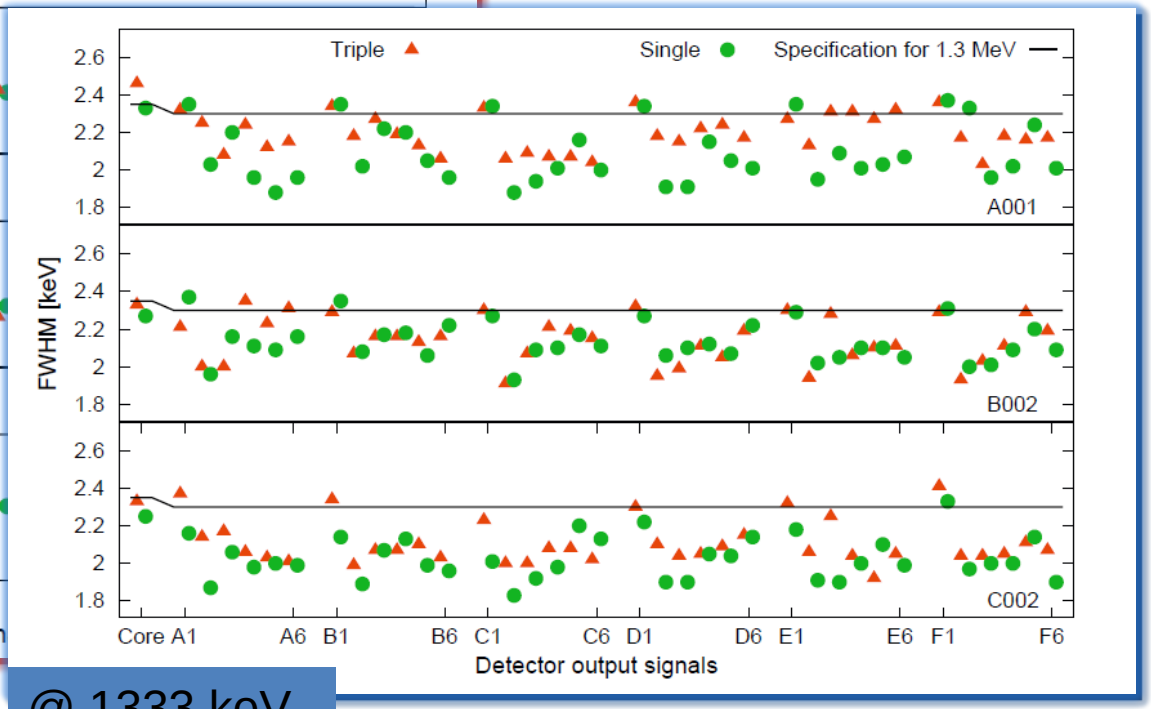
Challenges:
-mechanical precision
-microphonics
-noise, high frequencies
-LN2 consumption

Performance: Energy resolution

A. Wiens, et al. HK 39.33



@ 60 keV



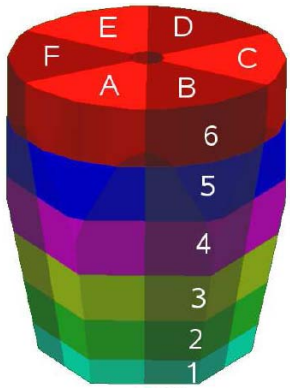
@ 1333 keV

Averages of the segment resolutions
@ **60 keV :**

A001:	1011 +/- 53 eV
B002:	1039 +/- 70 eV
C002:	965 +/- 63 eV

Averages of the segment resolutions
Measured in Köln and Legnaro
@ 1333 keV :

	IKP	/	Legnaro
A001:	2,19 keV	/	2,00 keV
B002:	2,09 keV	/	1,98 keV
C002:	2,1 keV	/	1,94 keV

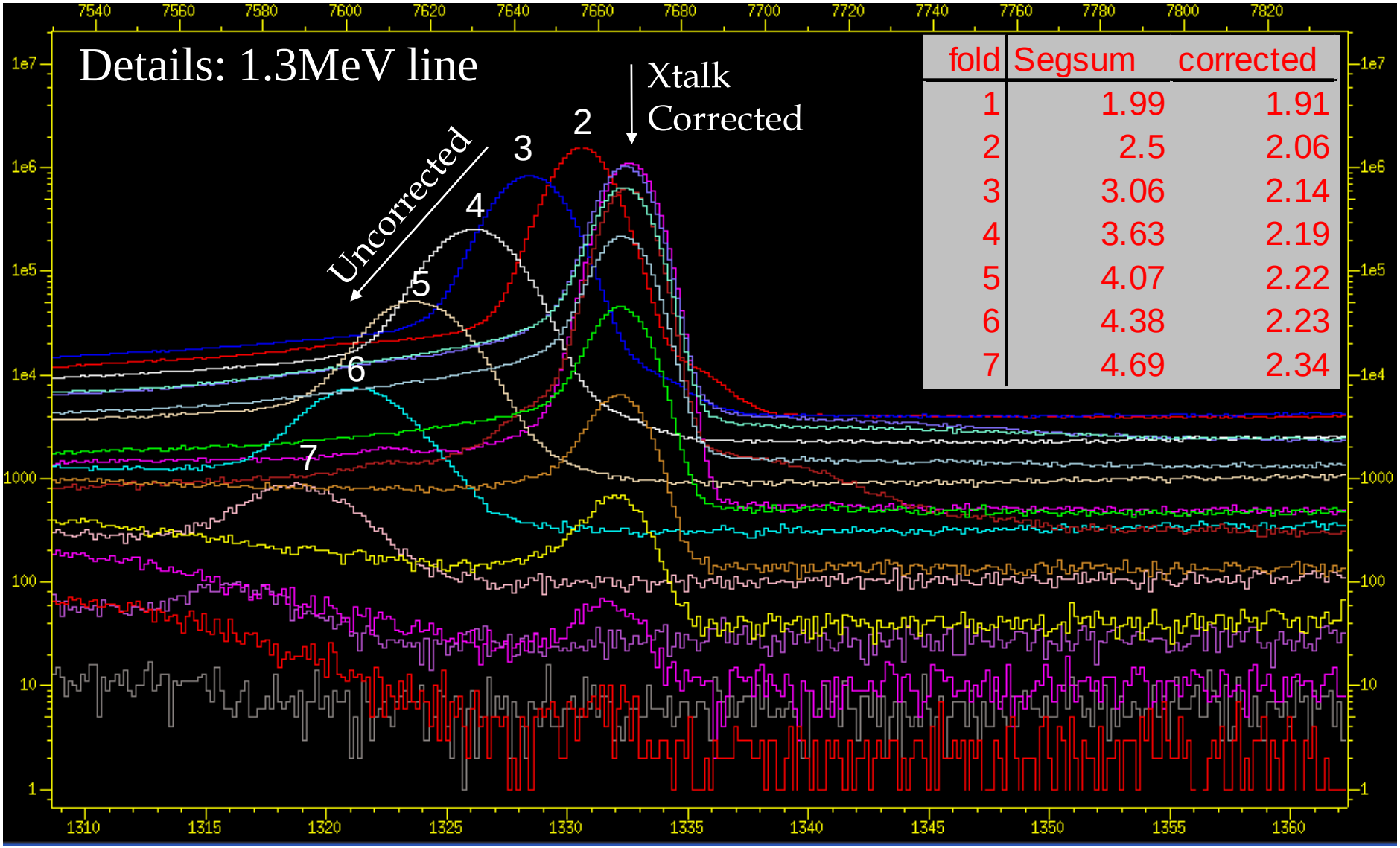


Segment labeling

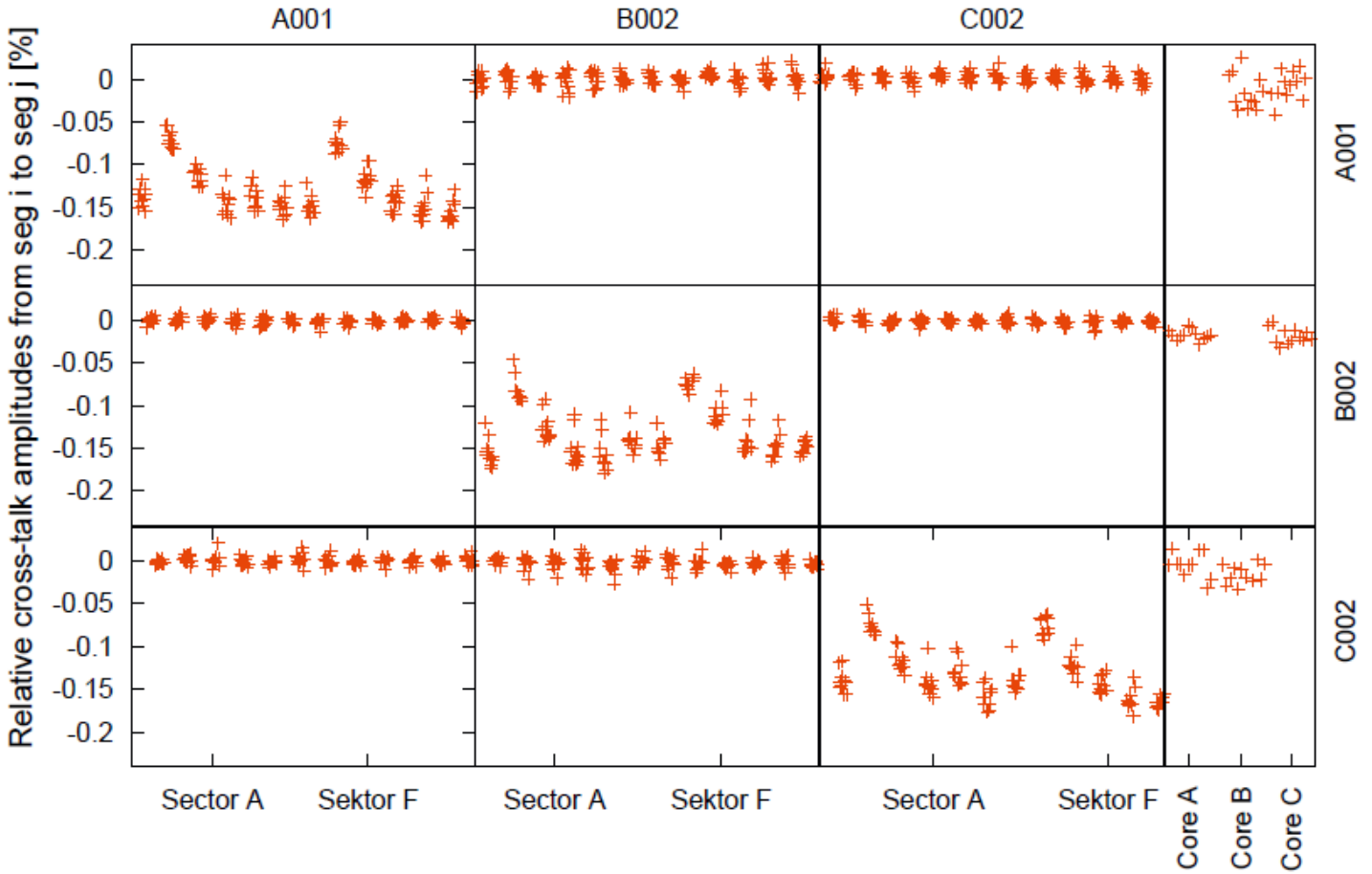
On line Cross Talk Correction

B. Bruyneel et al., NIM A 608 (2009) 99

FWHM 60keV: 1.20 → 1.02 !



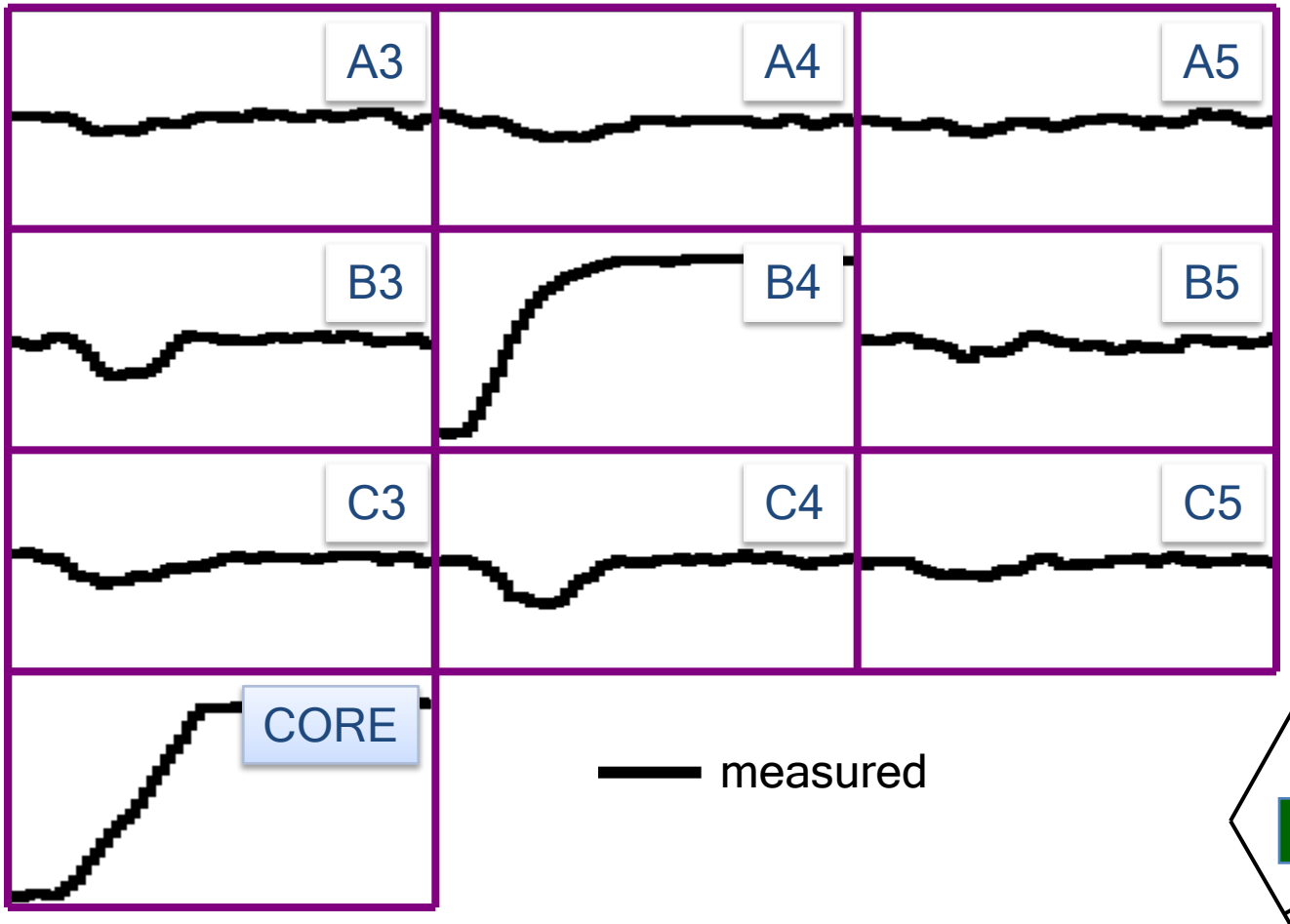
Performance: Crosstalk



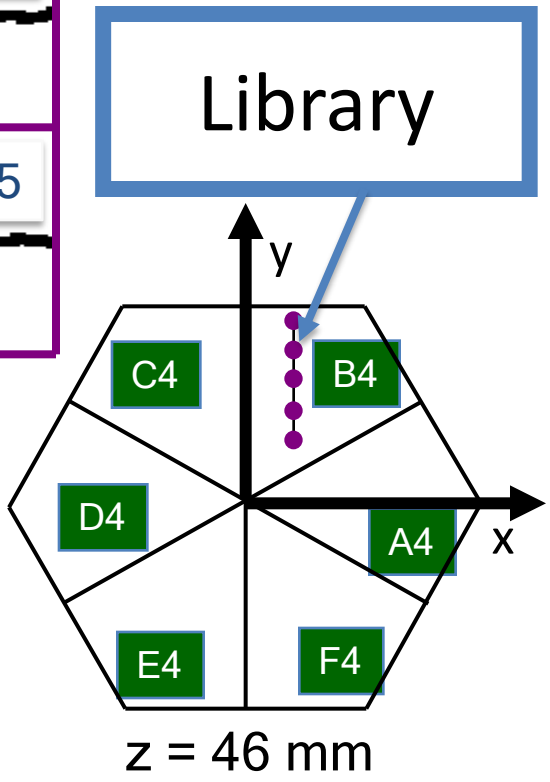
- No crosstalk observed between detectors
- Within one detector, the theoretical crosstalk limit is reached
- Online cross talk correction implemented

B. Bruyneel et al., NIM A 599 (2009) 196

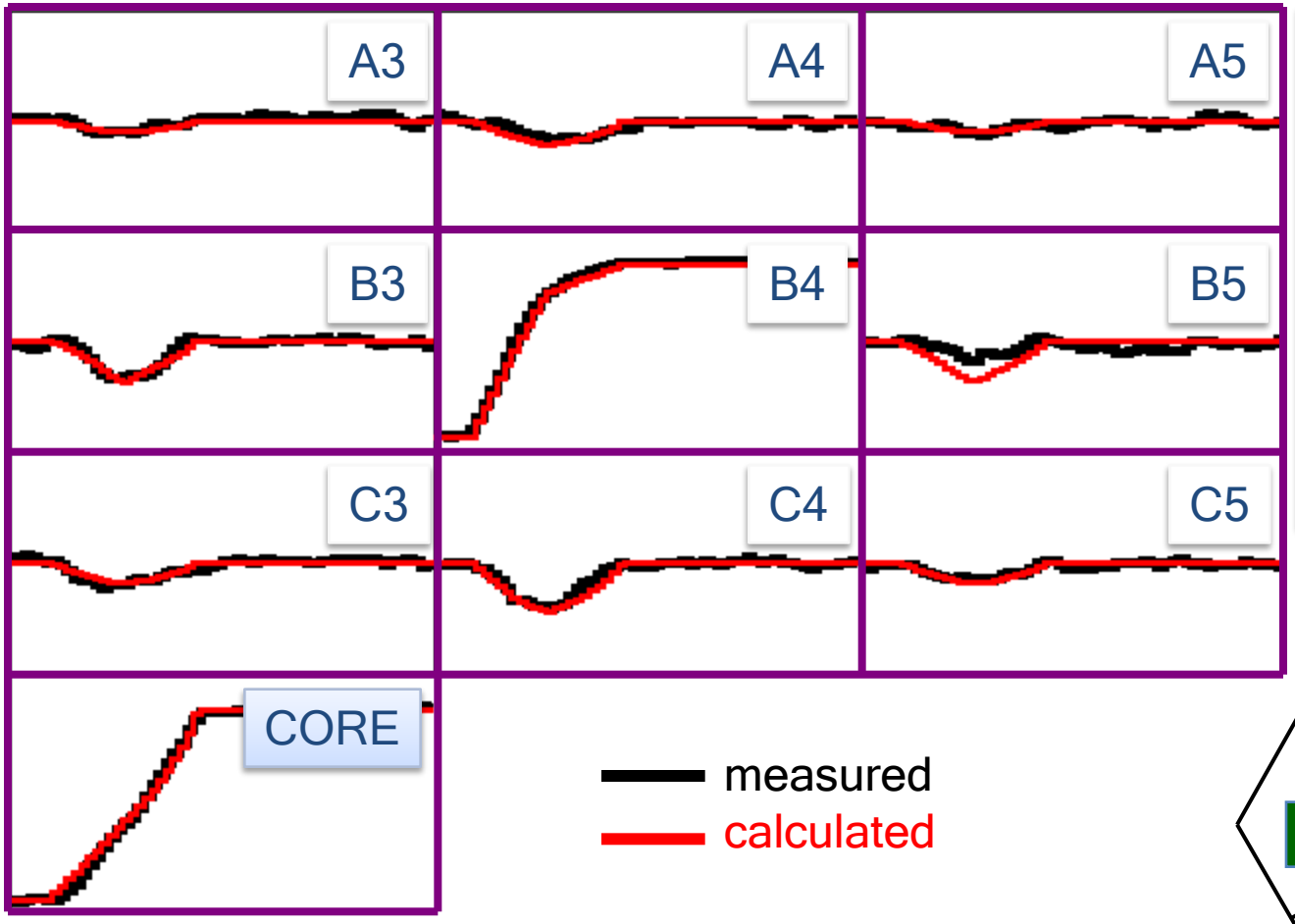
Pulse Shape Analysis Concept



791 keV deposited in segment B4



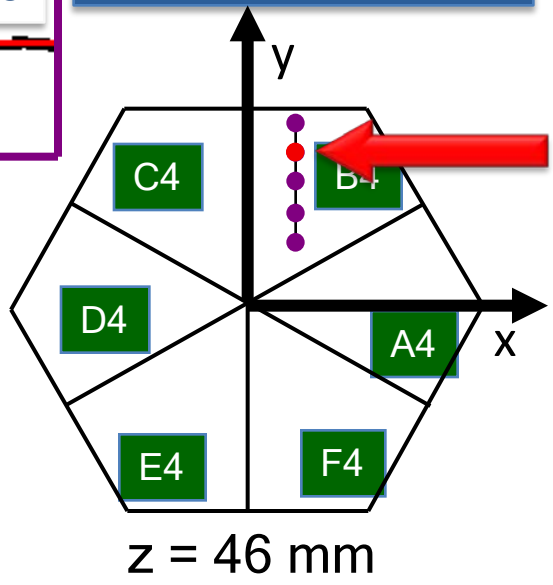
Pulse Shape Analysis Concept



Result of *Grid Search* algorithm

R. Venturelli

(10,25,46)



z = 46 mm

791 keV deposited in segment B4

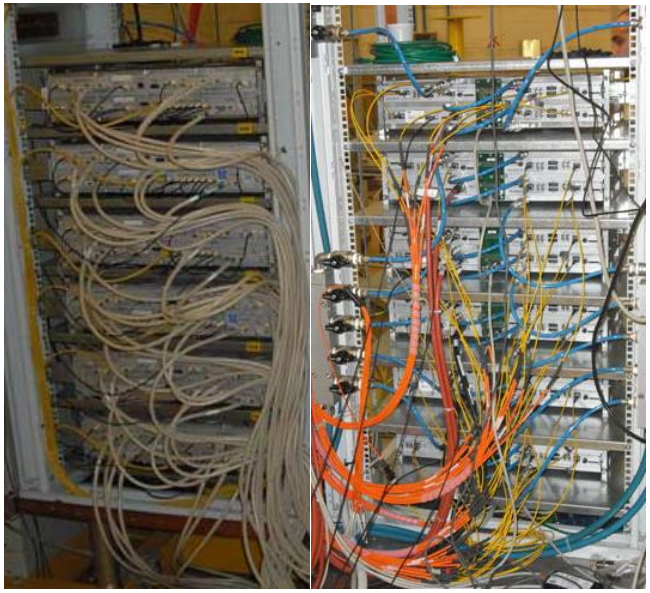
B. Bruyneel et al., NIM A 569 (2006) 764, NIM A (2011) in press
B. Birkenbach et al., NIM A (2011) in press

HK 54.2
PSA with wavelets HK 54.5

AGATA: Digital Electronics

Digitisers
in the experimental hall

10 m long MDR cables

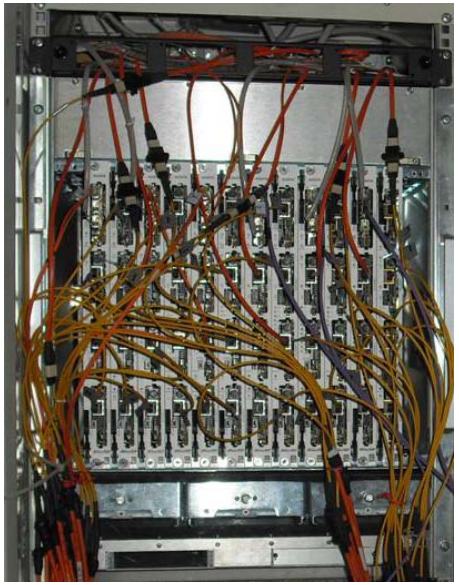


100Mhz, 14 bit
Synchronous &
continuous

(7.6GB/s/crystal)

80 m long optical fibers

Digital proc. electronics
in the users area

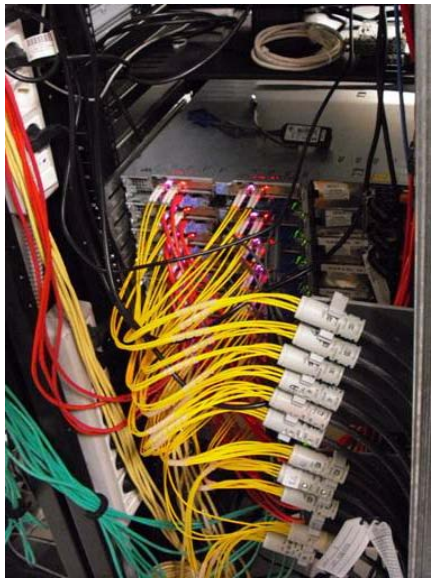


Triggering
Energy
Trace capture

(10 kB/evt/crystal)

20 m long optical fibers

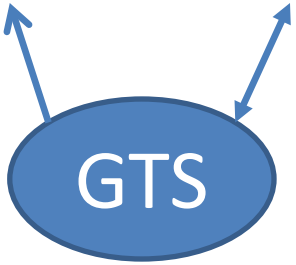
Computer farm
in the computing room



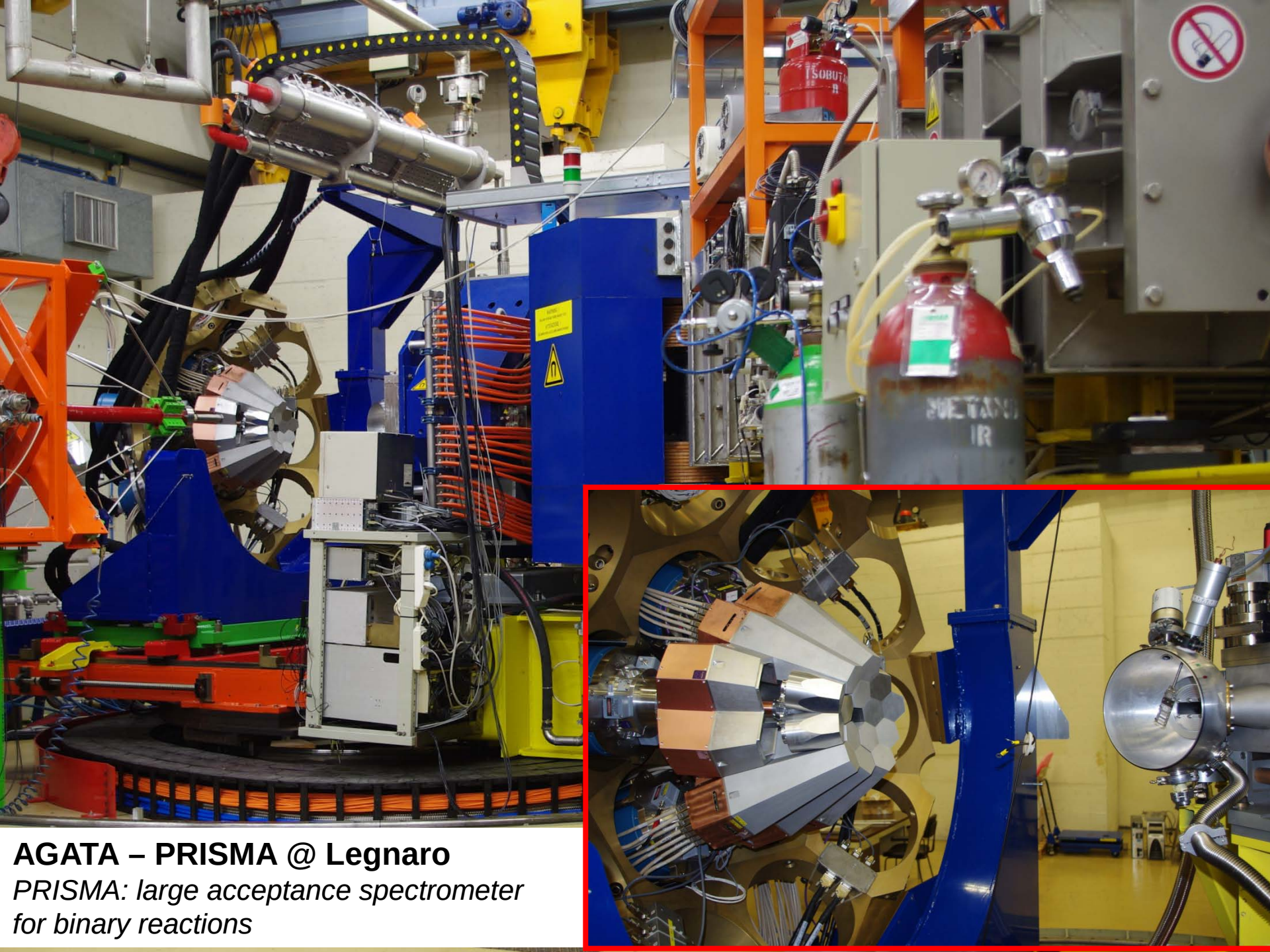
Preprocessing
PSA
Tracking

LAN to the disk servers

Global
Triggering
System



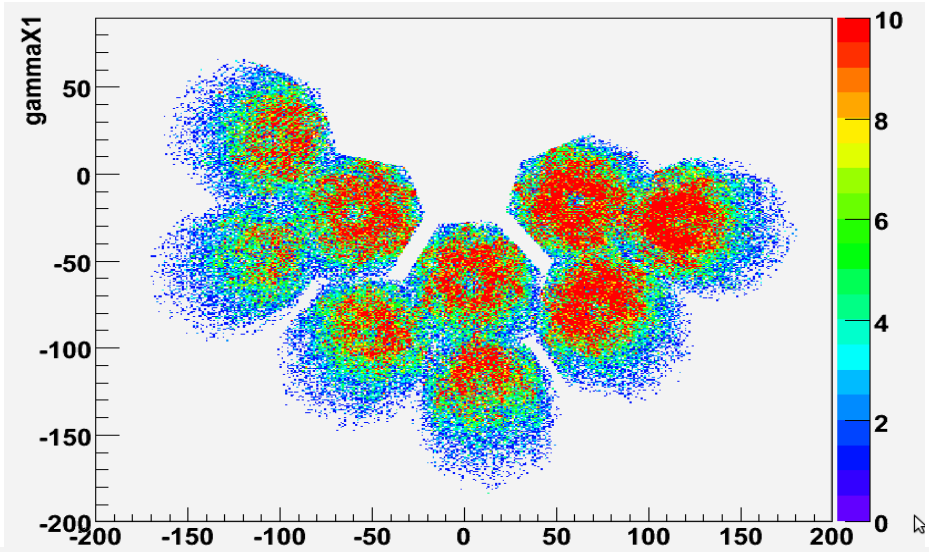
Clock &
Trigger validation

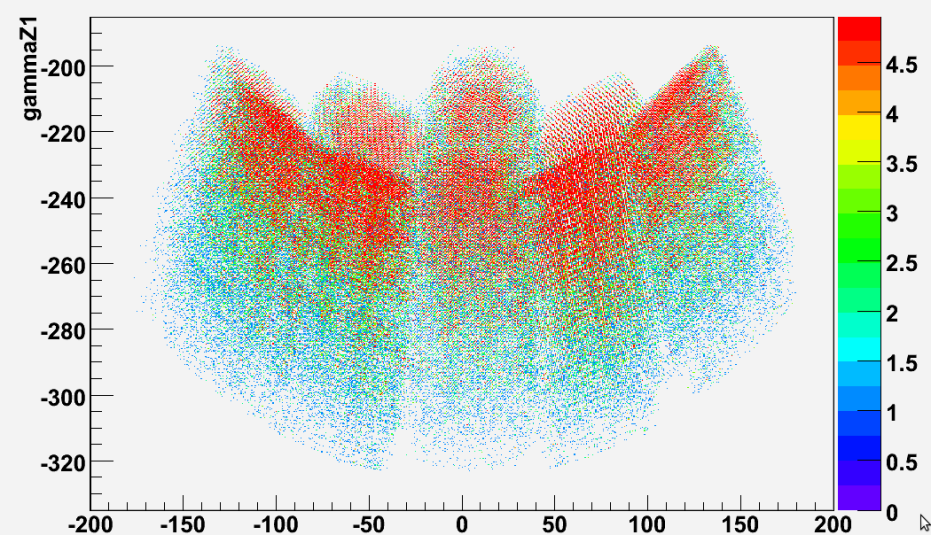


AGATA – PRISMA @ Legnaro

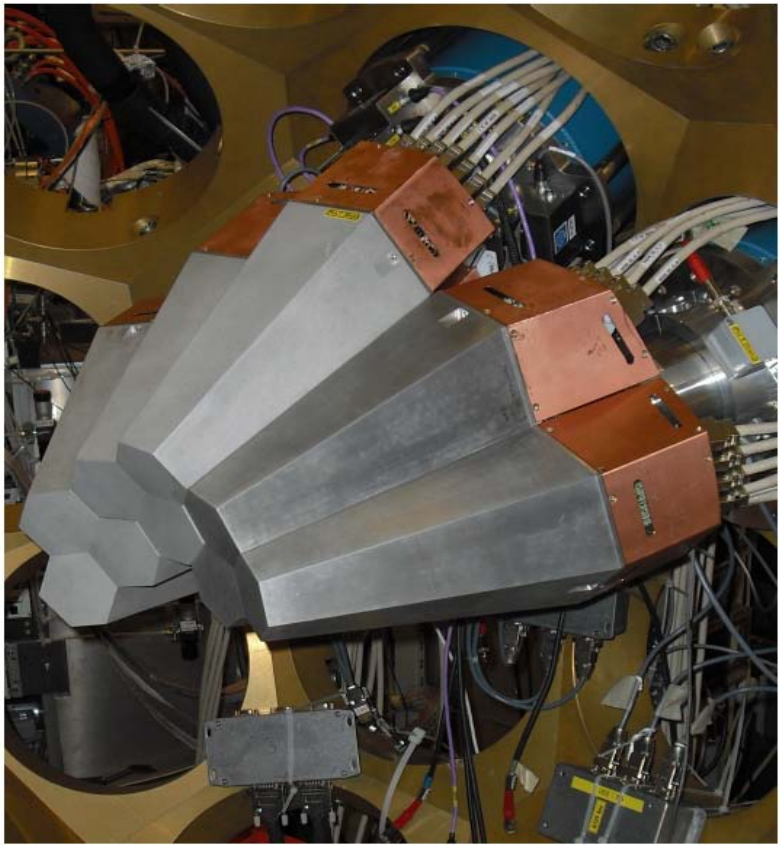
PRISMA: large acceptance spectrometer for binary reactions

AGATA online



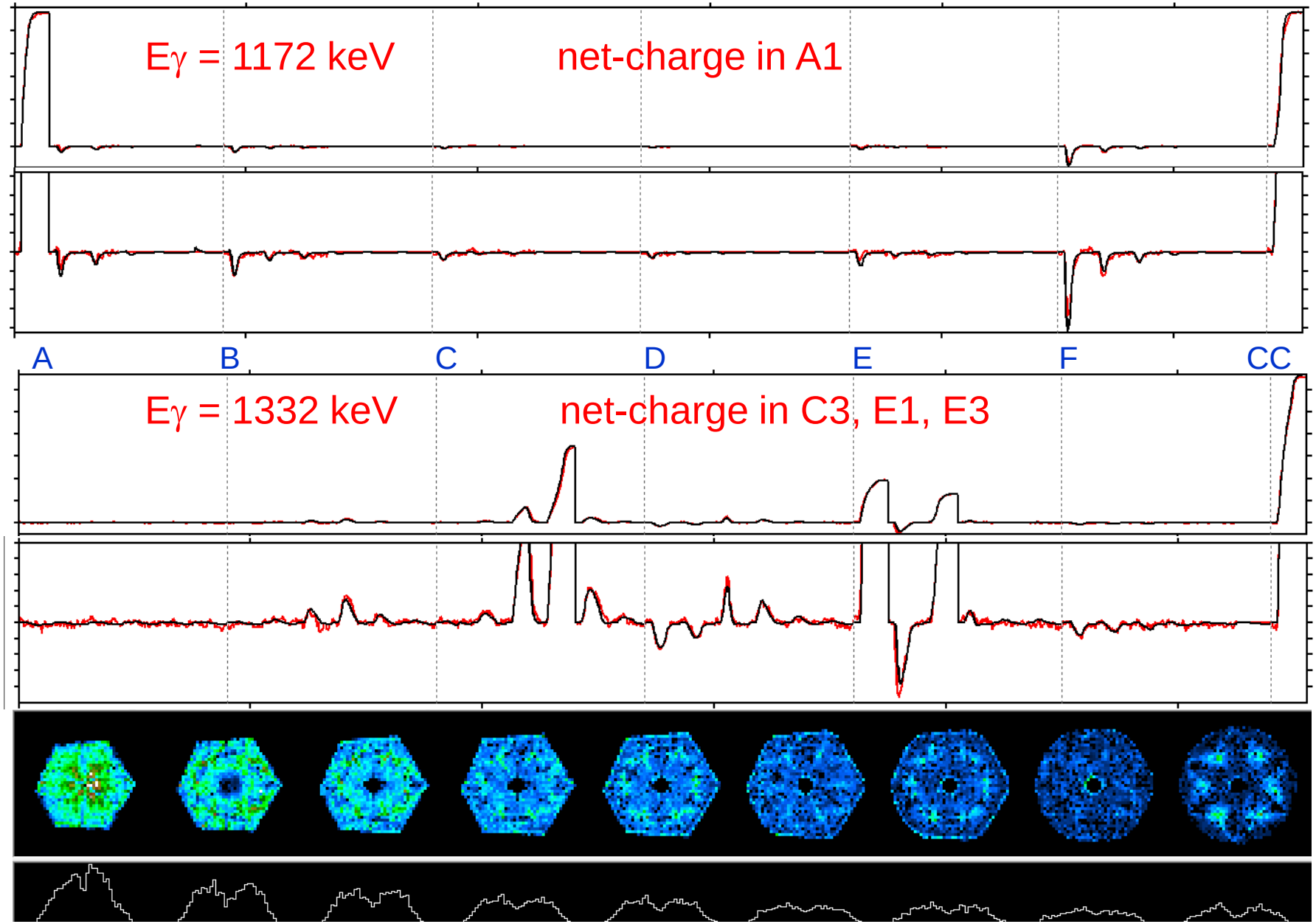


1st experiment with AGATA (18/02/10)



- < 4 mm FWHM resolution obtained
- psa online at rates > 5kHz per crystal

AGATA signal decomposition

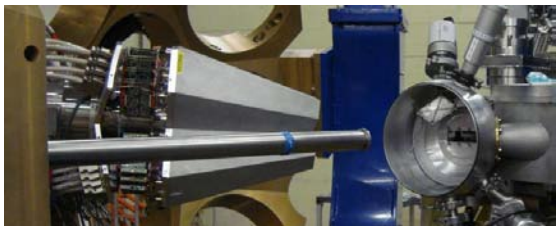


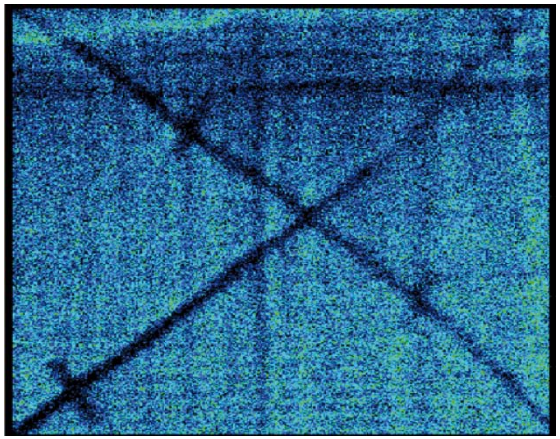
AGATA position resolution

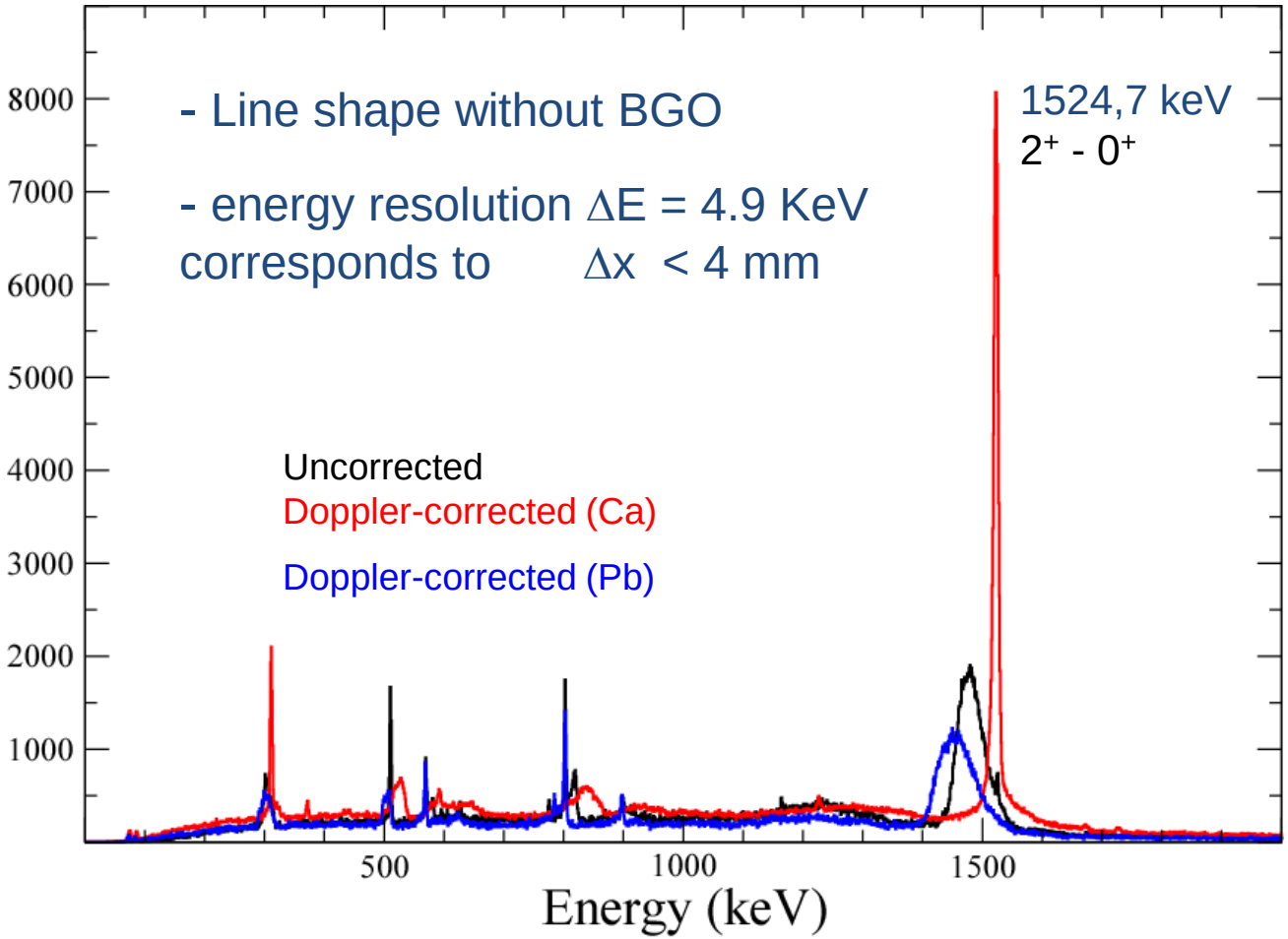
^{42}Ca@170MeV + ^{208}Pb

Kinematical coincidences

Position sensitive MCP







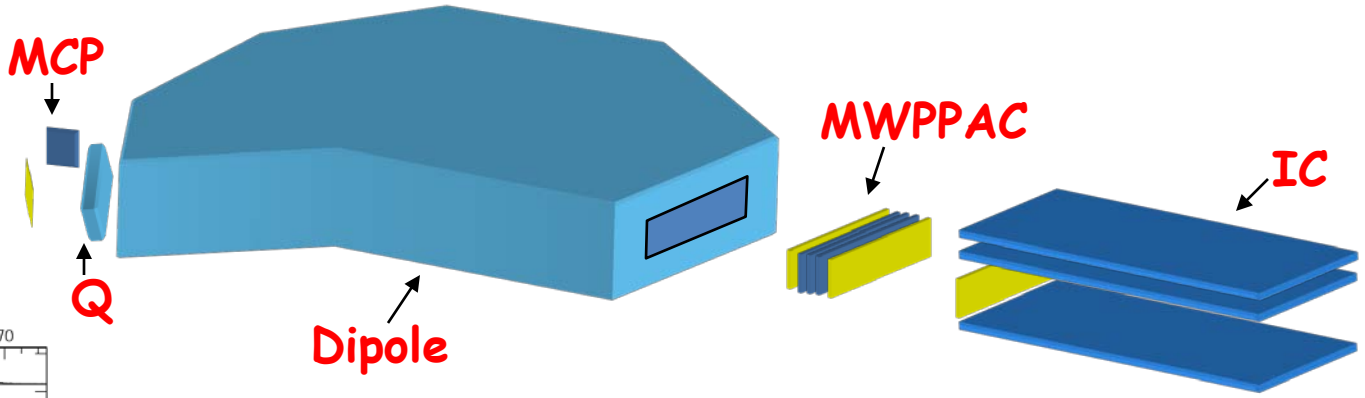
AGATA position resolution

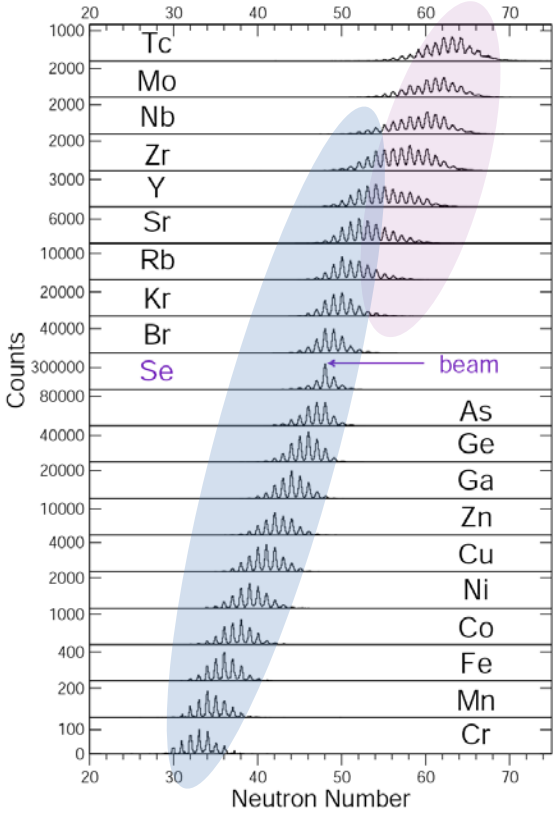
Δx FWHM	Method	
5.2 mm	Doppler corr. meas.	F. Recchia et al. NIM A (2009)
4.0 mm	Doppler corr. meas	P.-A. Söderström et al. NIM A (2011) in press
3.5 mm	511keV source meas.	S. Klupp, M.Schlarb, R. Gernhäuser (HK 54.1)

The PRISMA Magnetic Spectrometer

Large-acceptance magnetic spectrometer

$\Delta\Omega$ = 80 msr
$\Delta Z/Z \approx 1/60$
$\Delta A/A \approx 1/190$
ΔE ±20%
$B\rho$ = 1.2 T.m





PRISMA spectrometer designed for:
- reactions at grazing angle
- deep inelastic reactions

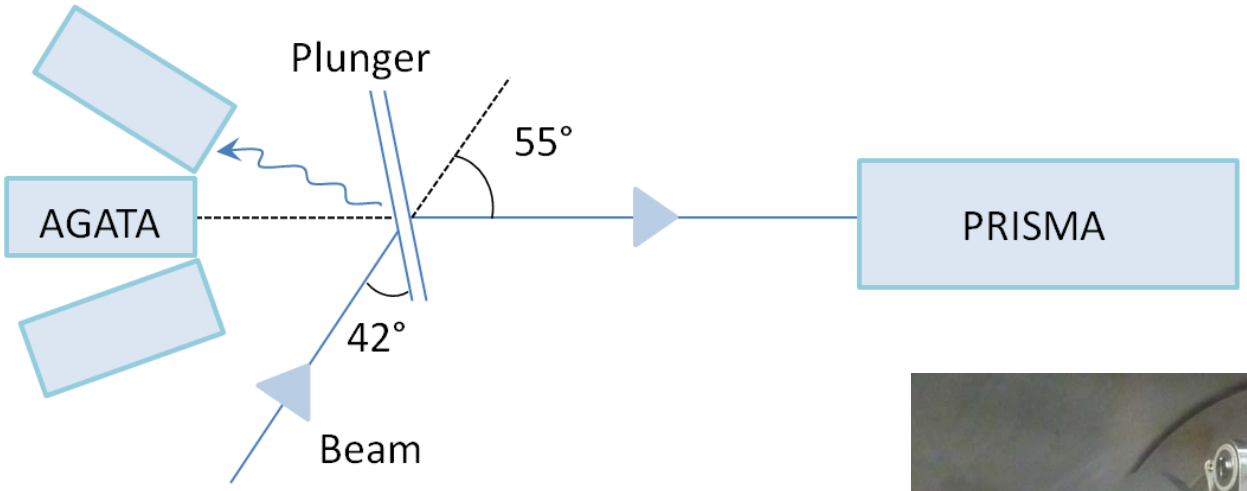
Production of projectile-like and target-like nuclei
Production of n-rich nuclei ~200

PRISMA: high selectivity

AGATA: high efficiency, high resolution, high throughput

& …

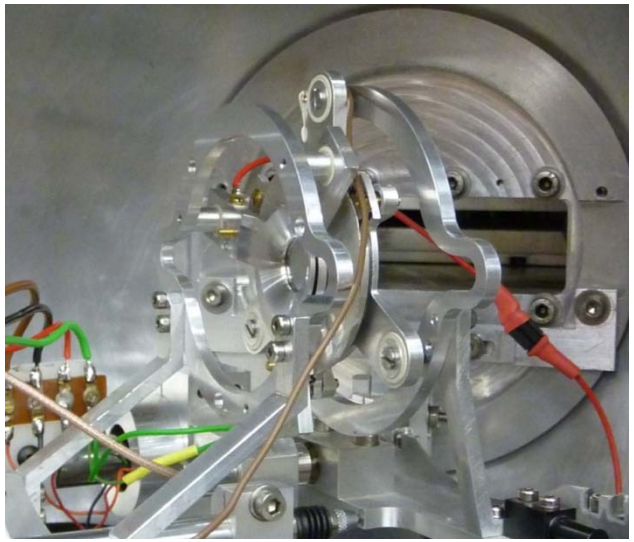
Lifetime measurement in neutron-rich Ni, Cu and Zn isotopes



AGATA + PRISMA + Cologne plunger

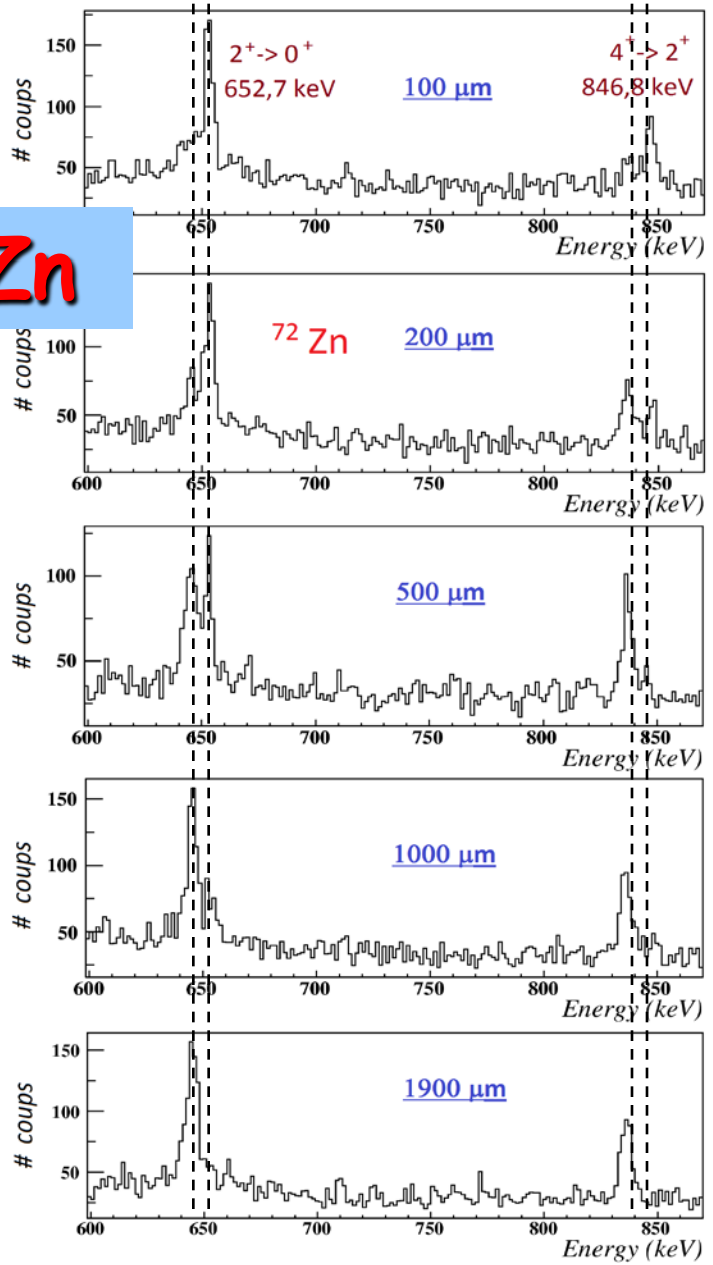
^{76}Ge(577MeV) + ^{238}U, Nb degrader

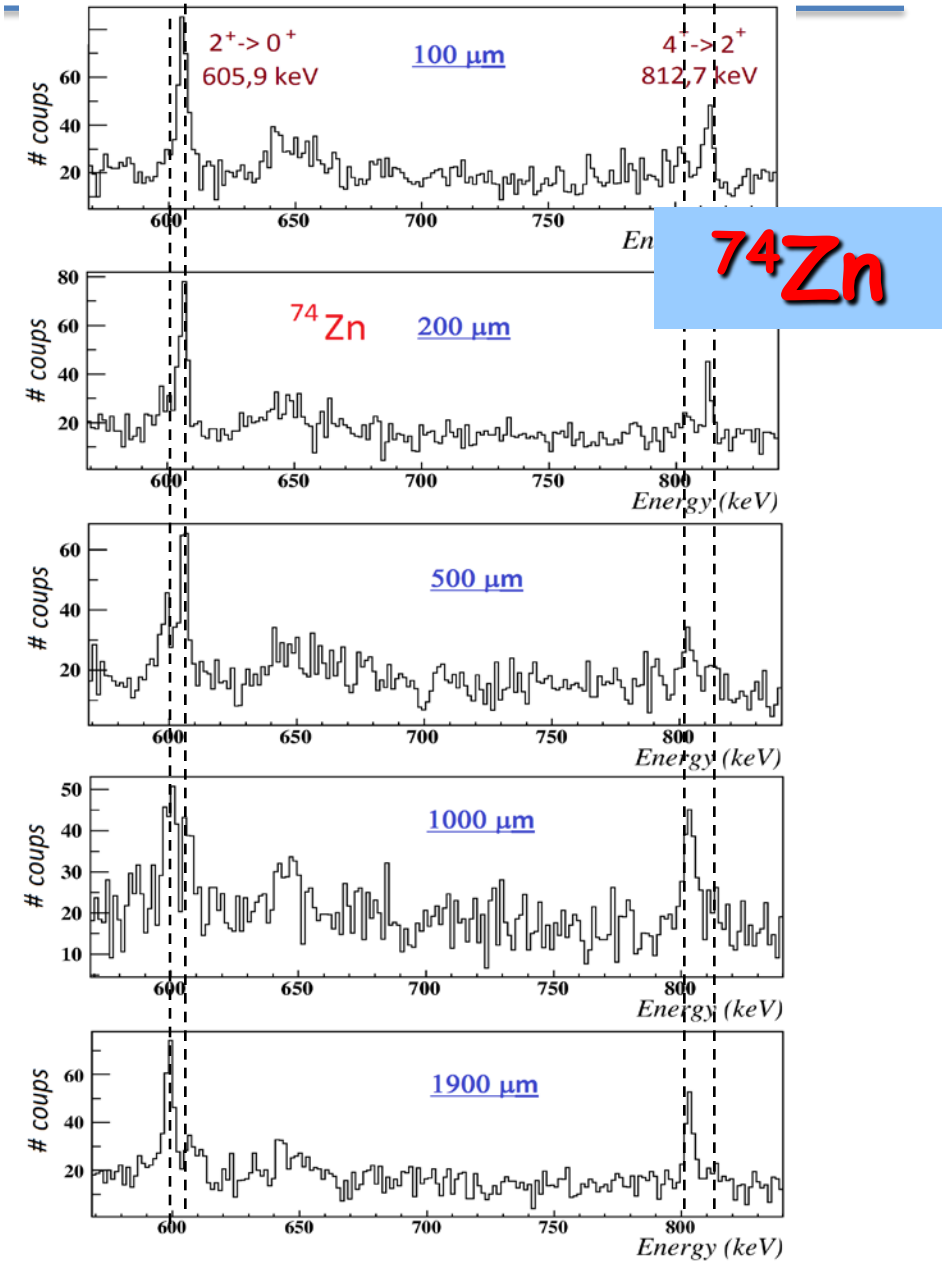
v/c ≈ 10%



Preliminary data from C.Louchart, E.Sahin, M.Doncel, A.Goergen

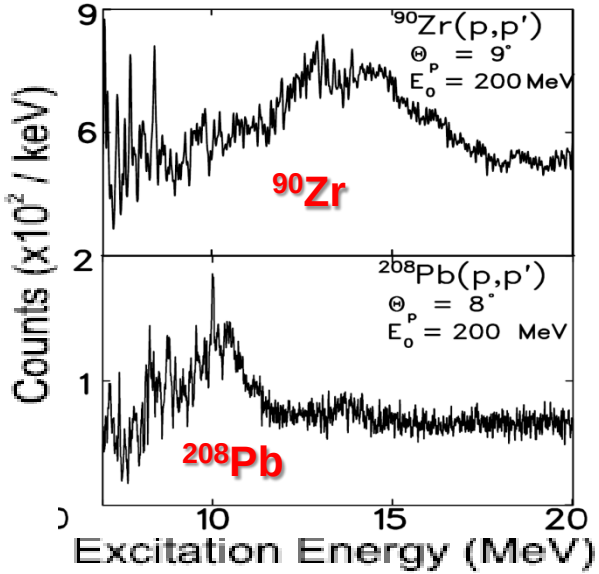
Lifetime measurement in neutron-rich Ni, Cu and Zn isotopes





Search for γ-decay of Pygmy and GQR states in ^{208}Pb and ^{90}Zr

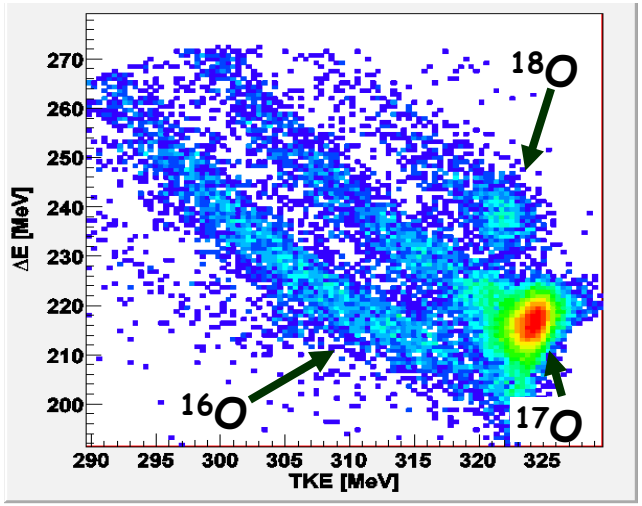
Pygmy Dipole **Giant Quadrupole**



Fine Structures observed in (p,p') and (e,e')

Shevchenko PRL93(2004)

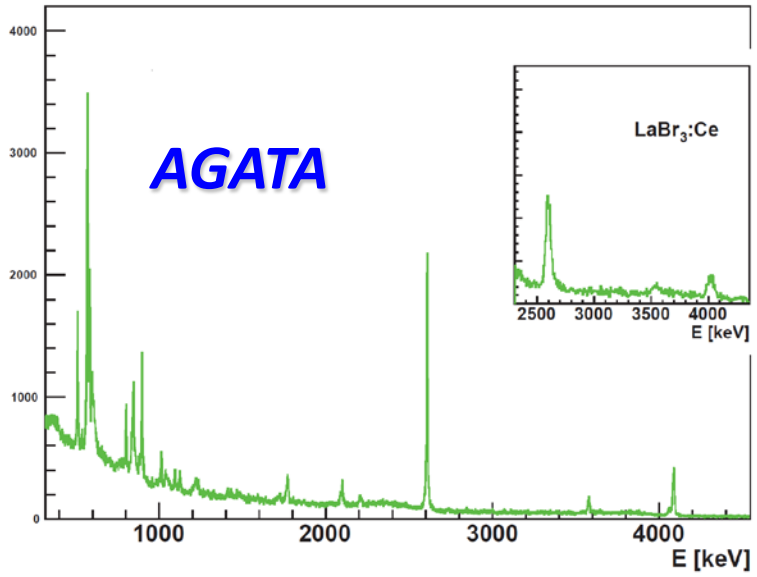
Inelastic Scattering ^{17}O @20 MeV/A

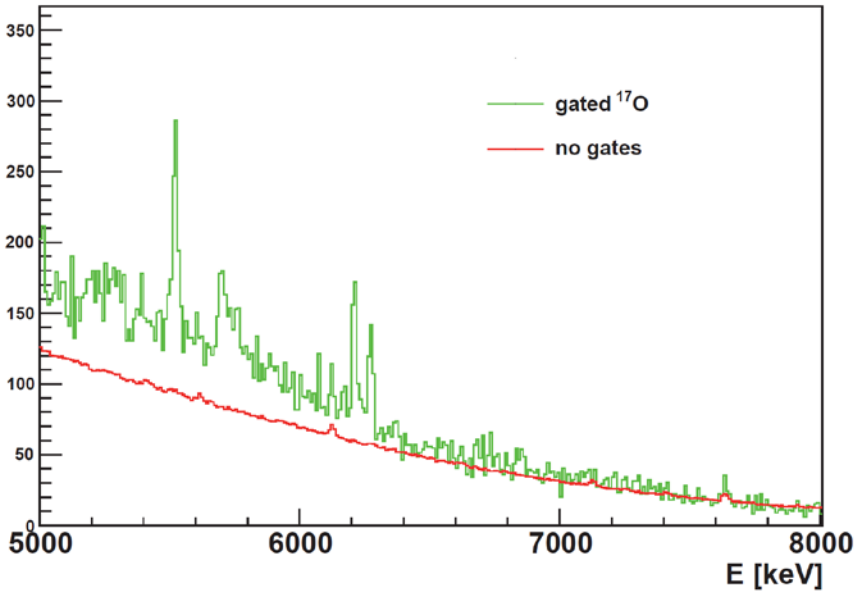


Si-PAD
Clean
Isotope
Separation
Energy
Resolution
< 1 MeV

Preliminary data R. Nicolini, A. Bracco, D. Mengoni

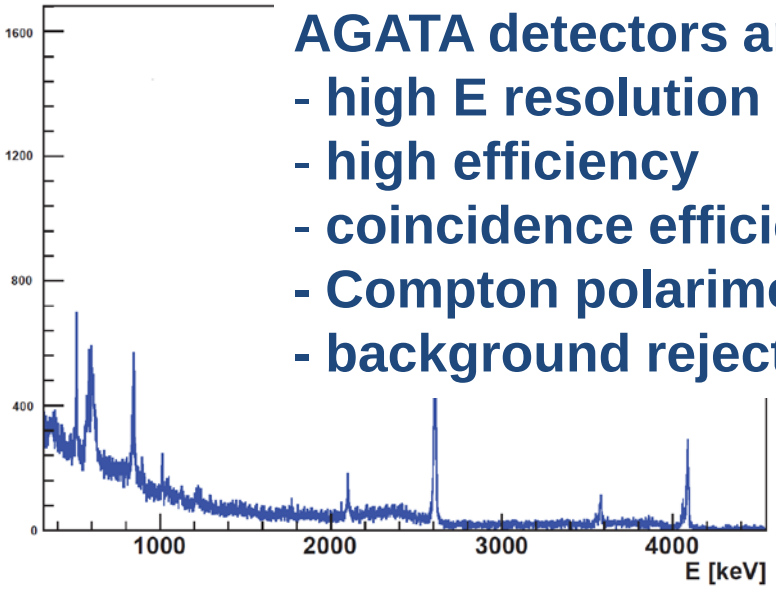
Preliminary results for ^{208}Pb

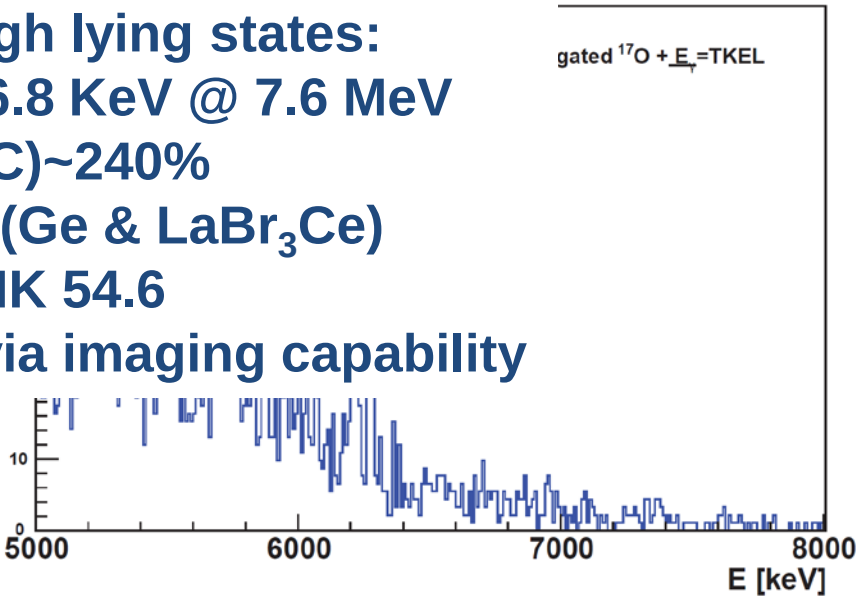




AGATA detectors and high lying states:

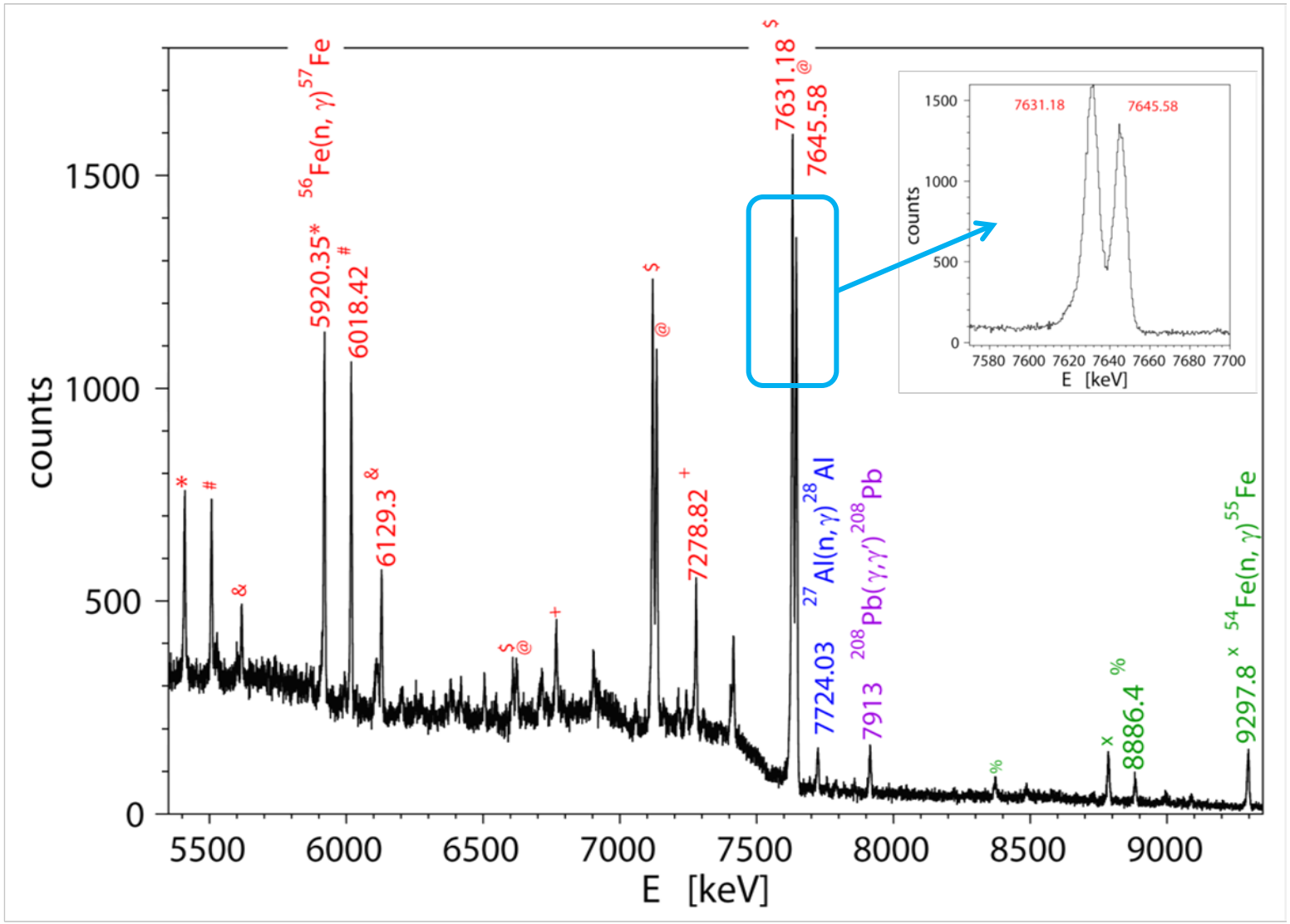
- **high E resolution ΔE=6.8 KeV @ 7.6 MeV**
- **high efficiency ε(ATC)~240%**
- **coincidence efficiency (Ge & $LaBr_3Ce$)**
- **Compton polarimeter HK 54.6**
- **background rejection via imaging capability**



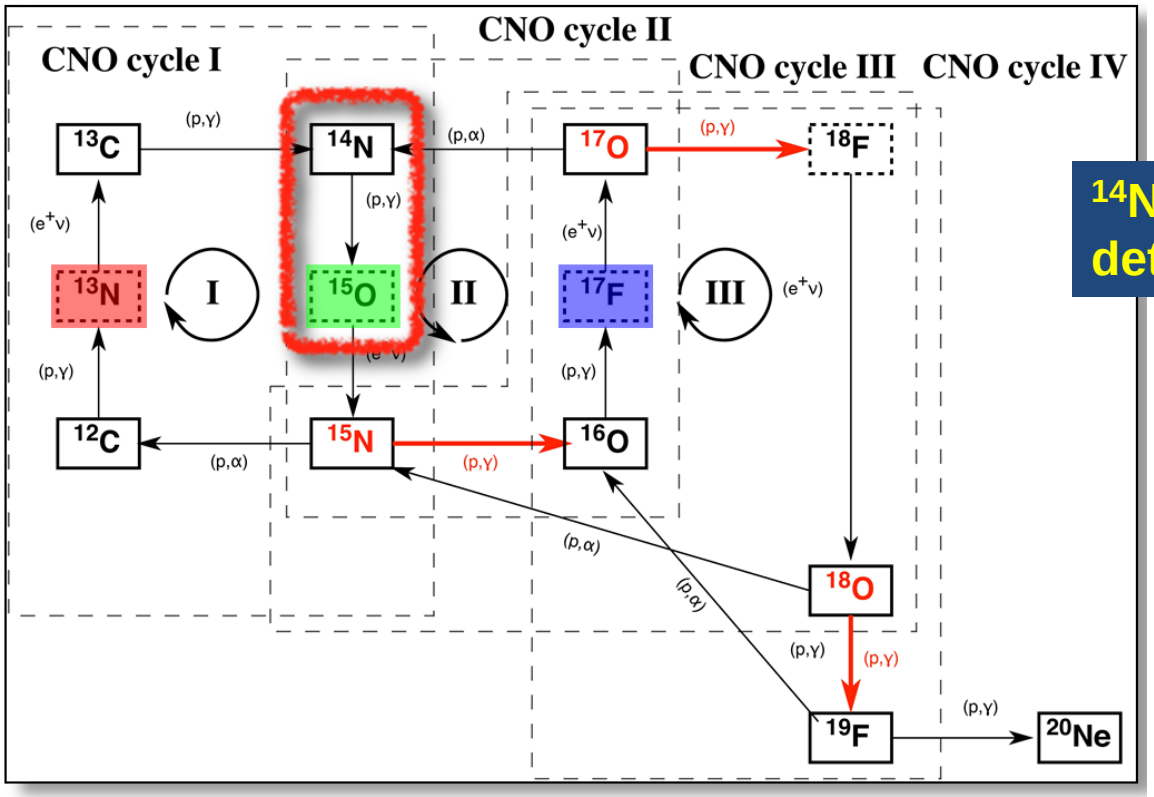


AGATA high γ-ray energy detection

^{241}AmBe + Fe source to monitor gain instabilities
- $\Delta E/E = 8 \cdot 10^{-4}$ at 7.6 MeV
- no gain fluctuation (within 3‰), stable detectors

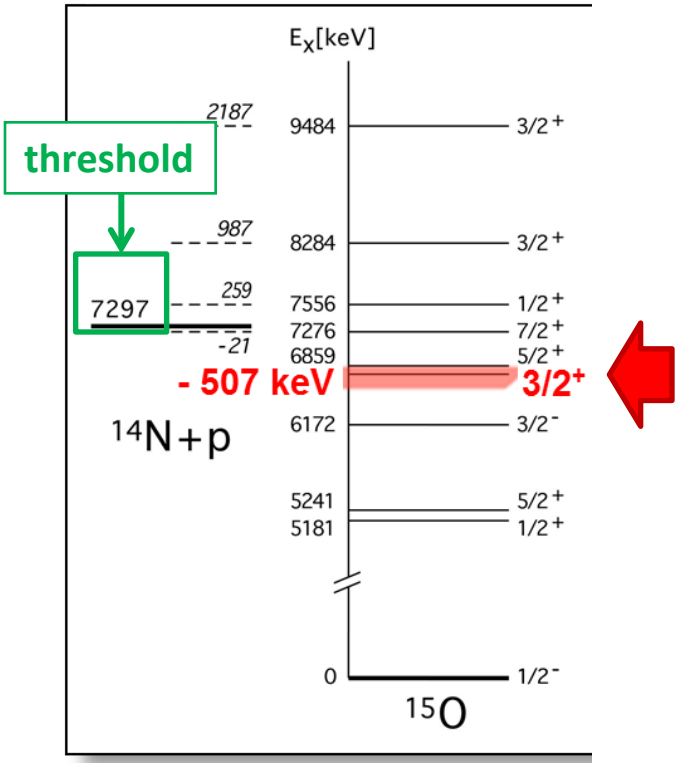


Stellar burning rates and the $^{14}N(p,\gamma)^{15}O$ reaction



(C. Broggini et al., Annu. Rev. Nucl. Part. Sci. 2010. 60:53–73)

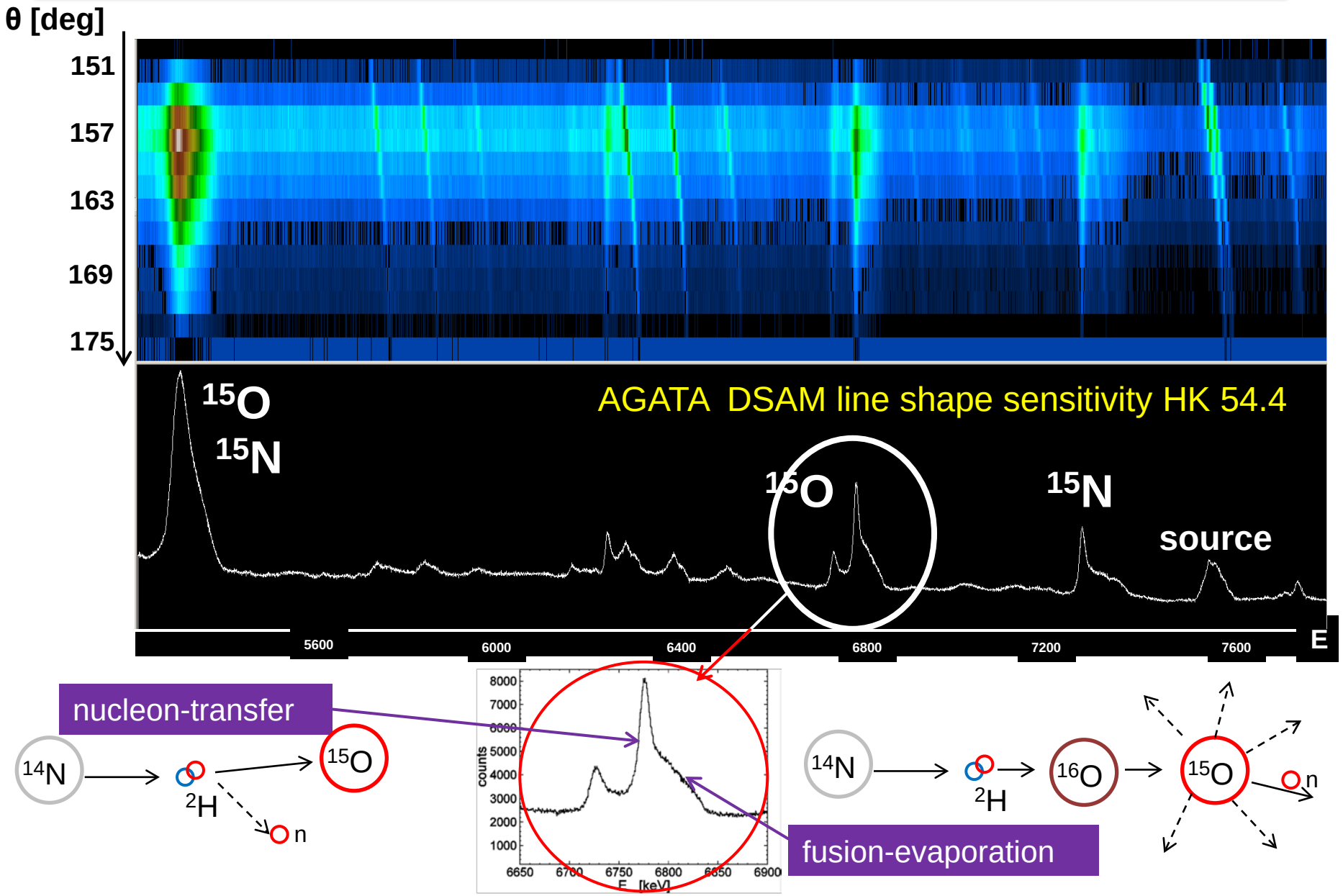
$^{14}N(p,\gamma)^{15}O$ reaction is slowest, determines the overall rate



- **cross section (astrophysical S-factor) in Gamow peak region relies on sub-threshold resonances**
- **corresponding to bound states in ^{15}O**
- **first excited 3/2+ state in ^{15}O is predicted to play dominant role**

width of the resonance ⟺ lifetime of the excited nuclear level

Lifetime of the 6.792MeV state in ^{15}O



Summary

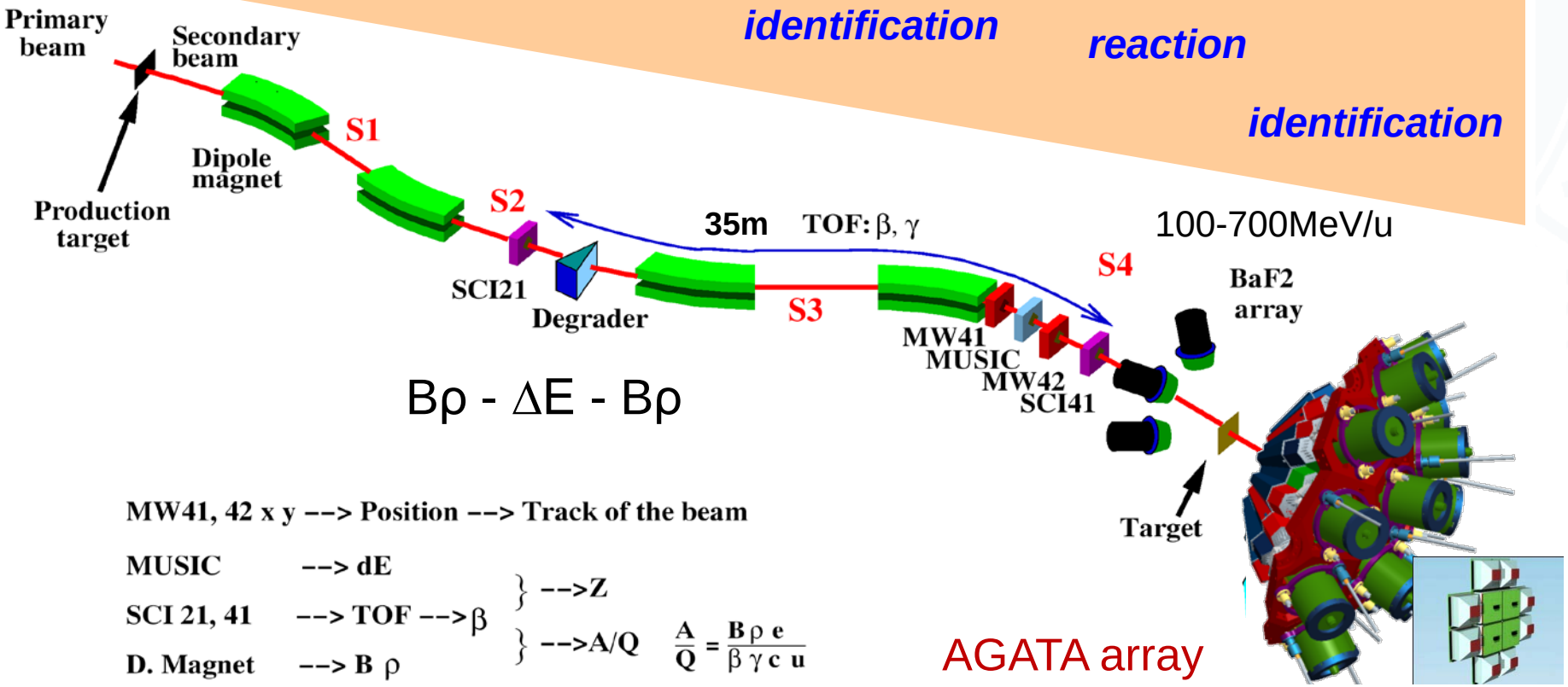
- AGATA components:
  - ✓highly segmented HPGe Detectors
  - ✓digitizer & front-end electronics
  - ✓Pulse shape analysis & γ-ray tracking
- Position sensitive γ-ray detection: $\Delta x \sim 3\text{-}4$ mm
- Ongoing campaign at Legnaro in 2011
- Near future AGATA@GSI

AGATA set-up at GSI

In flight high resolution γ-spectroscopy at the FRS

production *selection* *identification* *reaction* *identification* *spectroscopy*

<1GeV/u



Bρ - ΔE - Bρ

MW41, 42 x y --> Position --> Track of the beam

MUSIC --> dE

SCI 21, 41 --> TOF --> β } --> Z

D. Magnet --> B ρ } --> A/Q $\frac{A}{Q} = \frac{B\rho\, e}{\beta\, \gamma\, c\, u}$

AGATA array

LYCCA

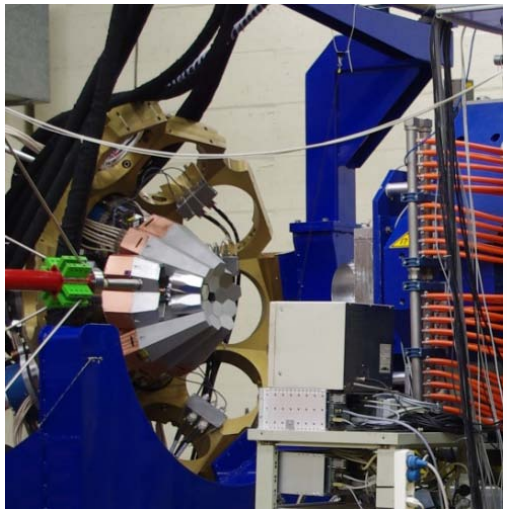
HK 33.5, HK 46.4

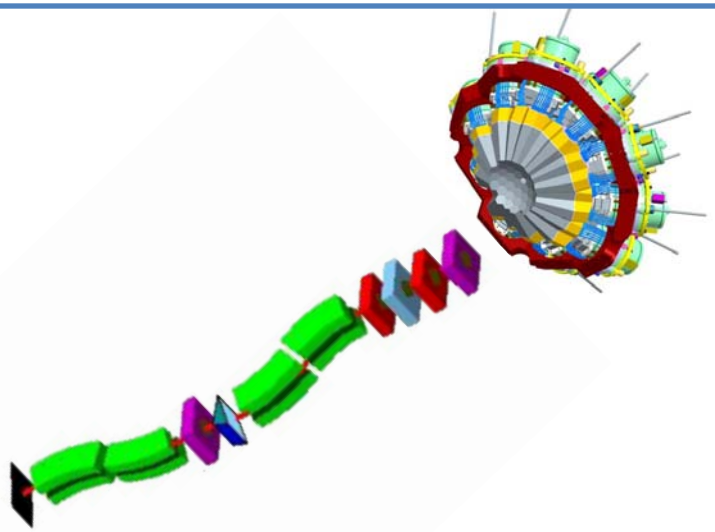
OUTLOOK: Plans for the next few years

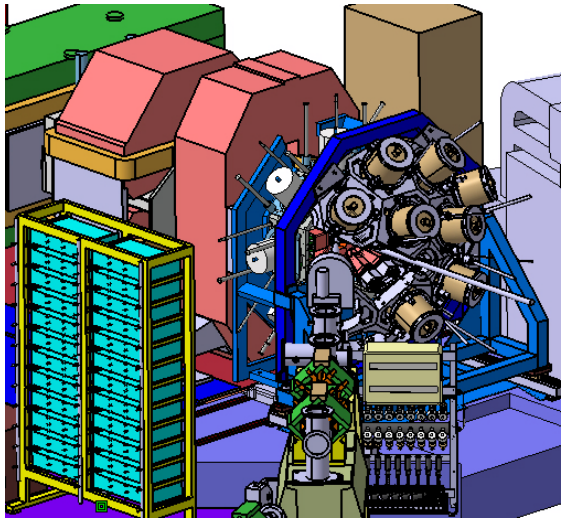
LNL: 2010-2011
5 TC
Total Eff. ~6%

GSI: 2012-2013
≥ 8 TC
Total Eff. > 10%

GANIL: 2014-2015
15 TC
Total Eff. > 20%





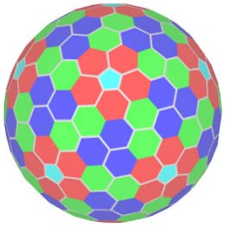


AGATA D. + PRISMA

AGATA + FRS

AGATA + VAMOS

The AGATA Collaboration



13 Countries
>40 Institutions

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
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
Spain:	IFIC Valencia, IEM-CSIC Madrid, LRI Univ. Salamanca