

First results with PARIS array

Michał Ciemala (IFJ PAN Krakow) et al.

(on behalf of the PARIS collaboration)

Colloque GANIL, 16.10.2017



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PARIS Project Manager

(nominated by PSC)

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Working Groups and their Coordinators

(proposed by PPM and approved by PSC):

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Detectors: **O. Dorvaux** (Strasbourg)

Electronics and DAQ: **P. Bednarczyk**
(Krakow)

Mechanical integrations: **I. Matea** (Orsay)

Data analysis: **S. Leoni** (Milano)

New materials: **F. Camera** (Milano)

New Physics case: **I. Mazumdar** (Mumbai)

PARIS Management Board:

PARIS Project Manager + WG coordinators

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Mihai Stanoiu (IFIN-HH Bucharest, Romania)

Jonathan Wilson (IPN Orsay, France)

Campaign Spokespersons

GANIL: C. Schmitt / M.
Ciemala

IPN Orsay: I. Matea

IFJ PAN Kraków: M. Ciemała

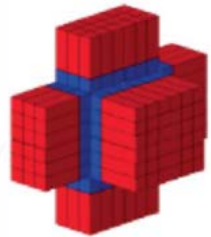
Photon Array for studies with Radioactive Ion and Stable Beam



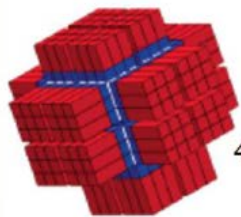
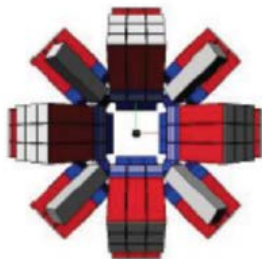
Single cluster



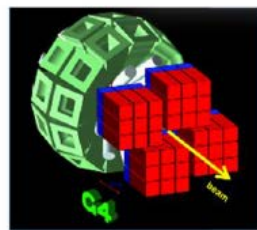
PARIS demonstrator



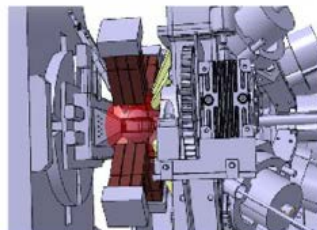
2π



4π



PARIS with v-Ball

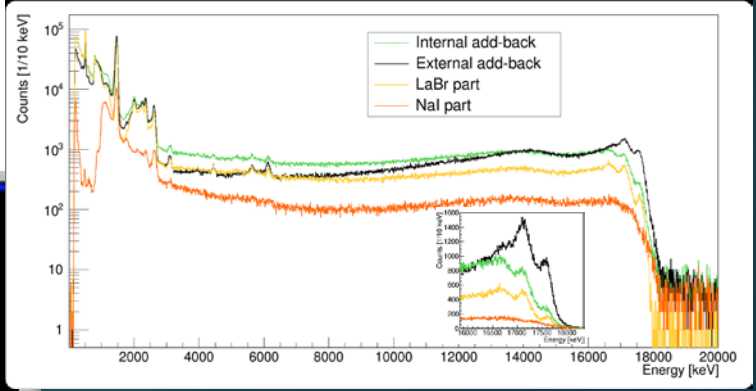
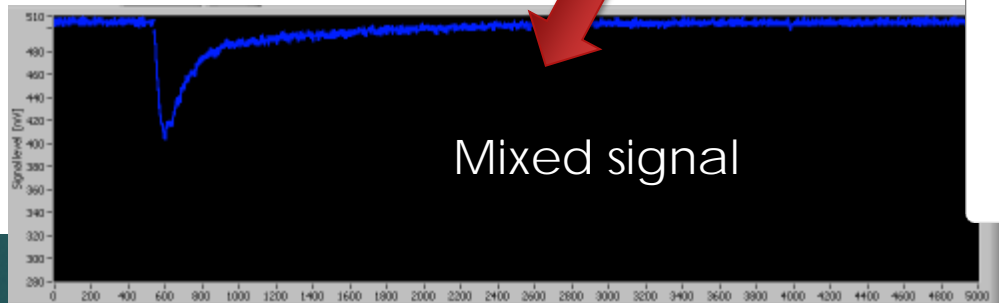
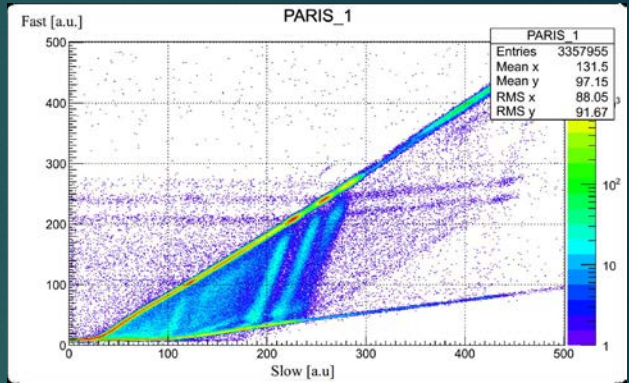
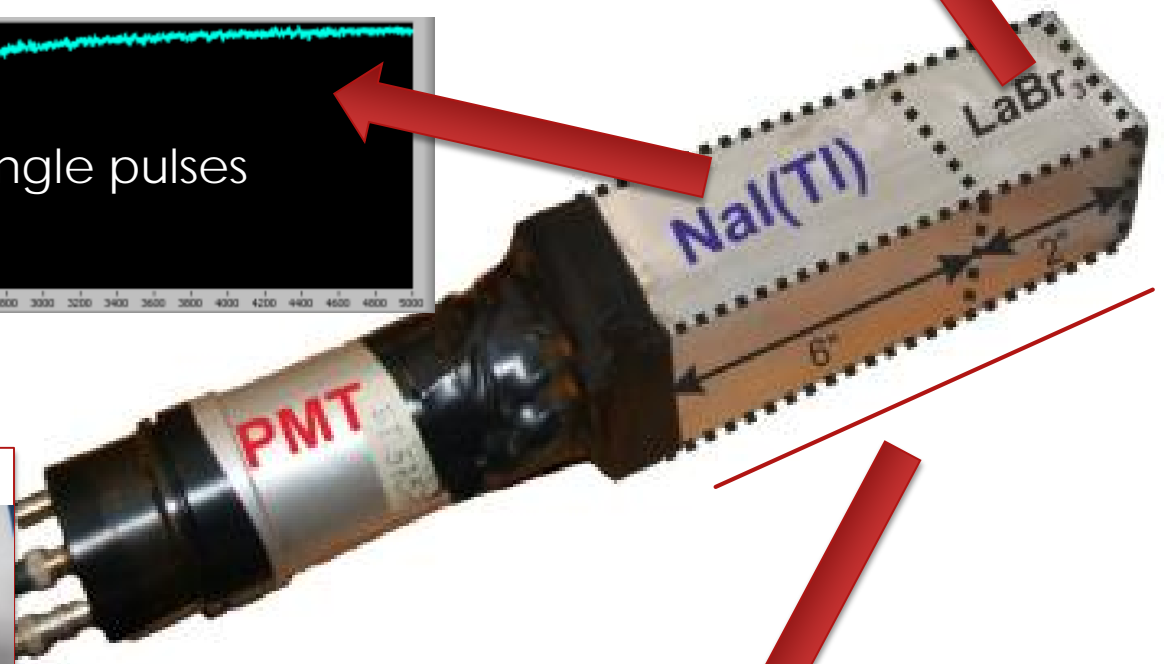
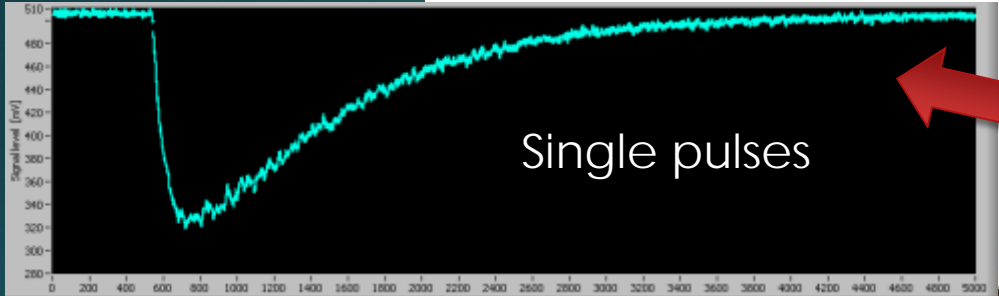
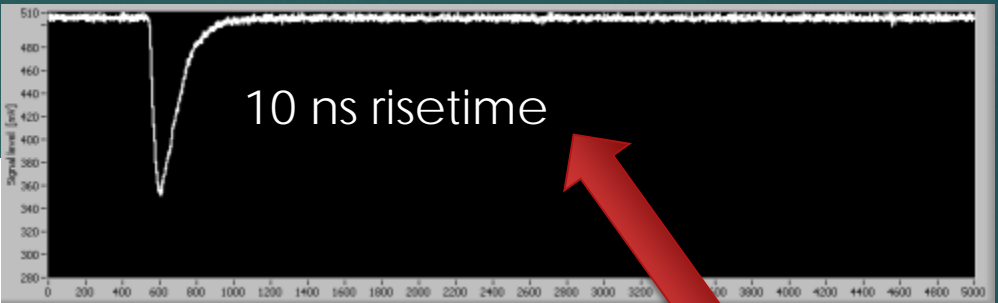


PARIS with AGATA

- Calorimeter
- 4π solid angle
- High efficiency
- High time and energy resolution
- Clusters of nine

**PARIS to be made of clusters:
Cluster = 9 phoswiches
This allows, in its final phase,
cubic or semi-spherical geometry
with 24 clusters (216 phoswiches)**

The PARIS PHOSWICH at work



First PARIS experiments

Experiments at IPN Orsay:

1. M. Lebois et al. "Prompt gamma and neutron emission for ^{238}U fast neutron induced fission as a function of incident neutron energy" (April 2016) (IC, LaBr₃, BAF₂, PARIS)

2. A. Kozulin et al. "Prompt γ -rays as a probe of nucleardynamics" (June 2016)

Motivation and Goal: Challenging fission around the interaction barrier (CORSET + ORGAM + PARIS).

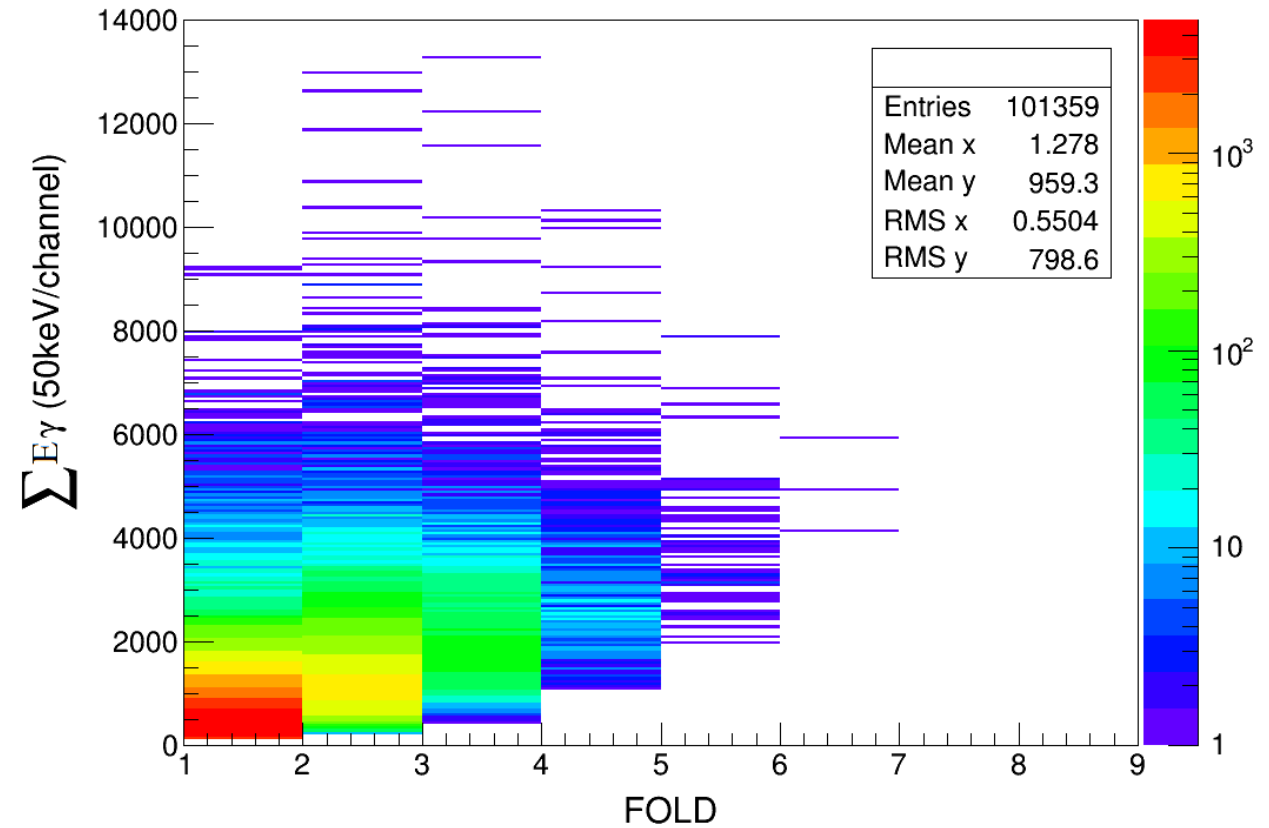
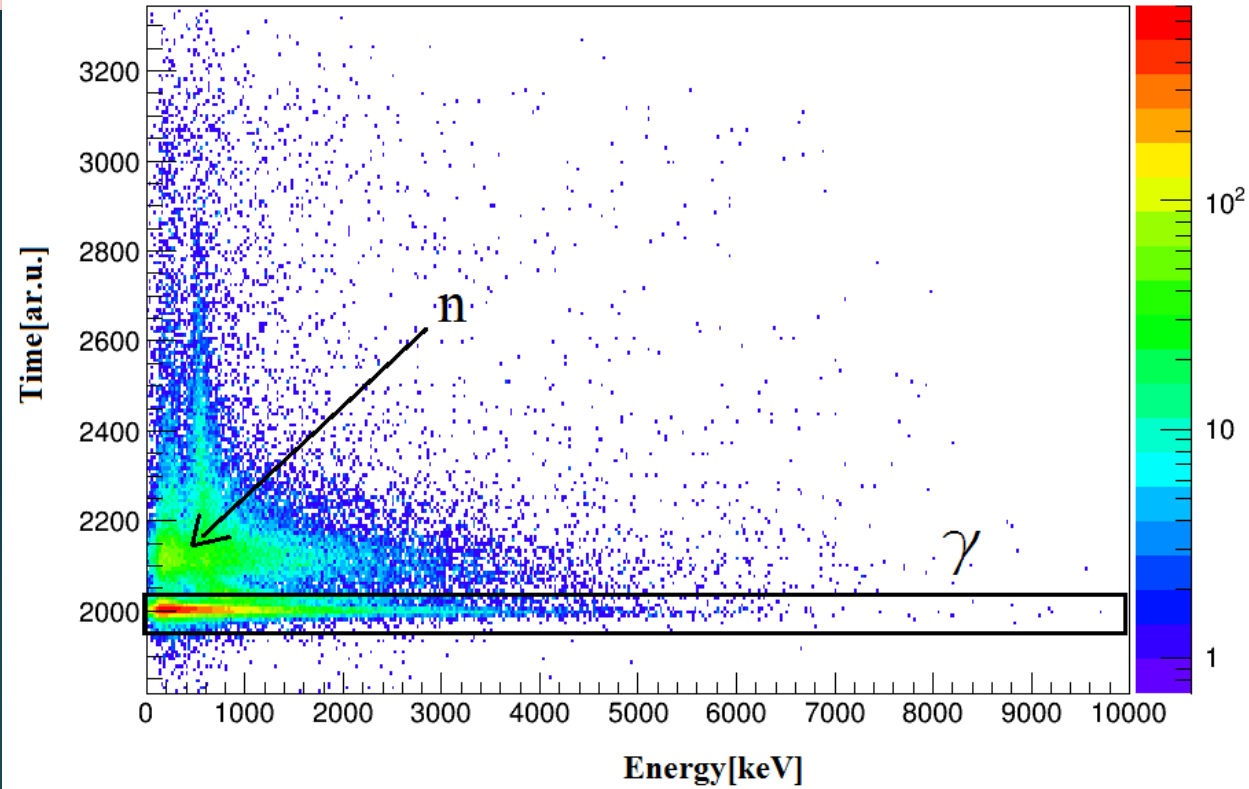
Experiment at CCB, Krakow:

F. Crespi, M. Kmiecik, et al. „Studies of gamma decay of GQR ($E_{\text{GQR}}=10.6$ MeV) and GDR ($E_{\text{GDR}}=13.9$ MeV) in ^{208}Pb with 85 MeV protons on ^{208}Pb target" (March 2017), (PARIS, HECTOR, KRATTA).

Experimenta to be performed at IPN Orsay:

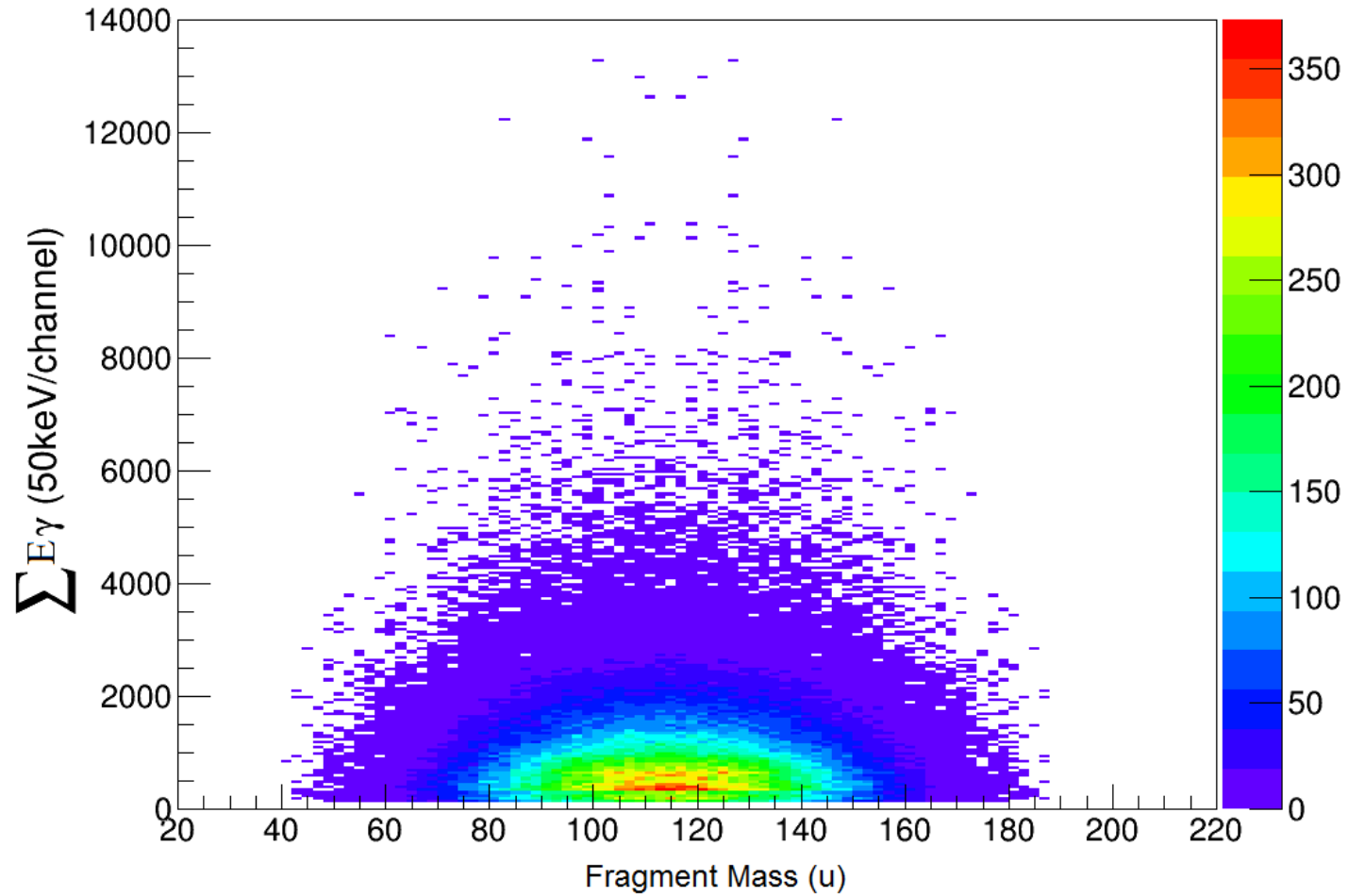
1. B. Blank et al., „Measurement of the super-allowed branching ratio of ^{10}C ”.
2. P.J. Napiorkowski et al., „Coulomb excitation of super-deformed band in ^{40}Ca ”.
3. M. Kmiecik, F. Crespi, J. Wilson et al., „Feeding of low-energy structures in ^{188}Pt of different deformations by the GDR decay: the nuBall array coupled to PARIS”.

γ - Coincident with FF: CORSET + ORGAM + PARIS

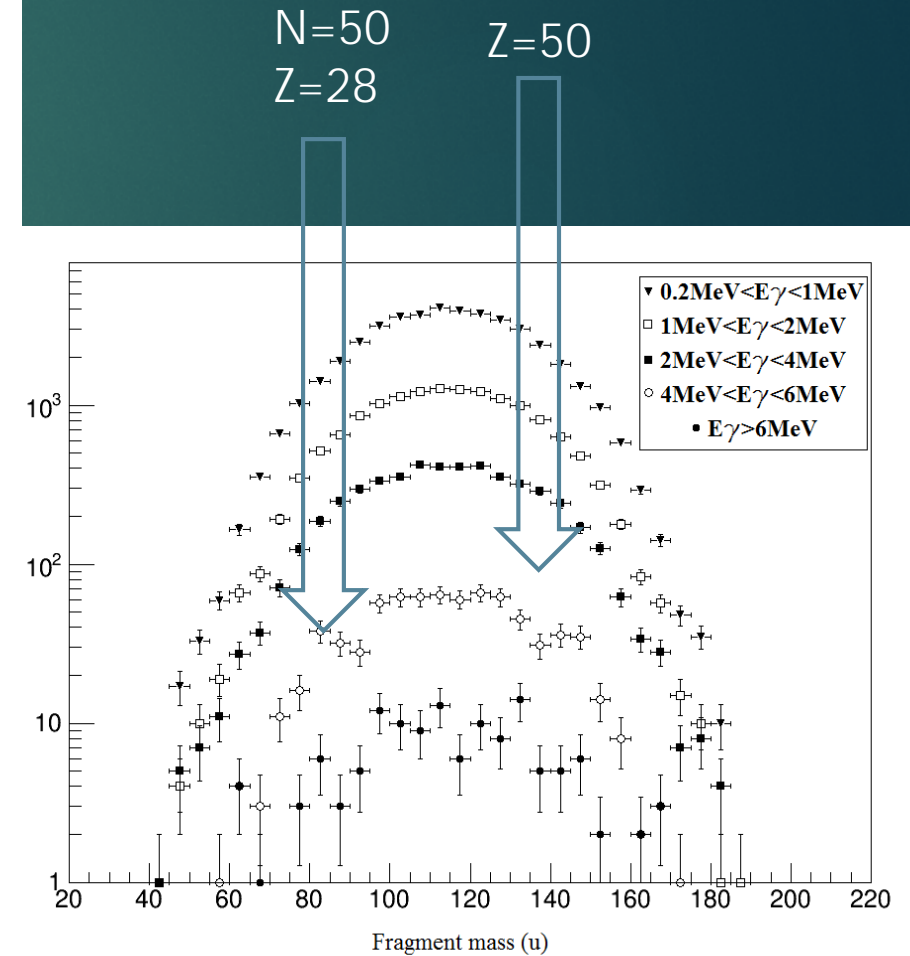


- ▶ Good time resolution allowing discrimination of γ -rays against neutrons.
- ▶ Wide energy range.
- ▶ Able to accept a high counting rate.

γ -rays– Coincident with FF: CORSET + ORGAM + PARIS



sensitivity for nuclear structure effects at spherical and deformed shell closure proximity

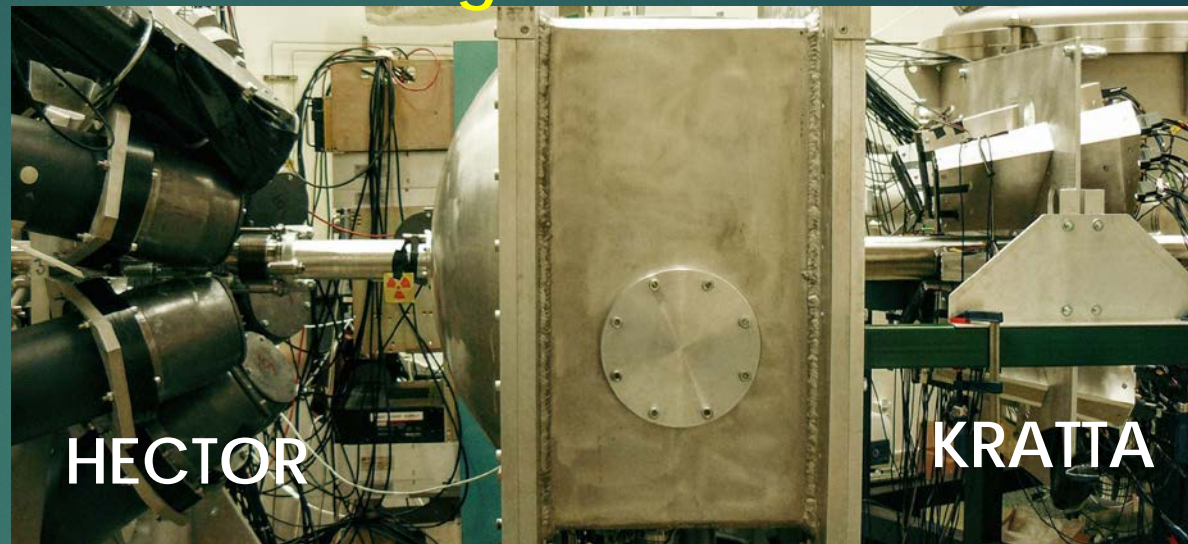
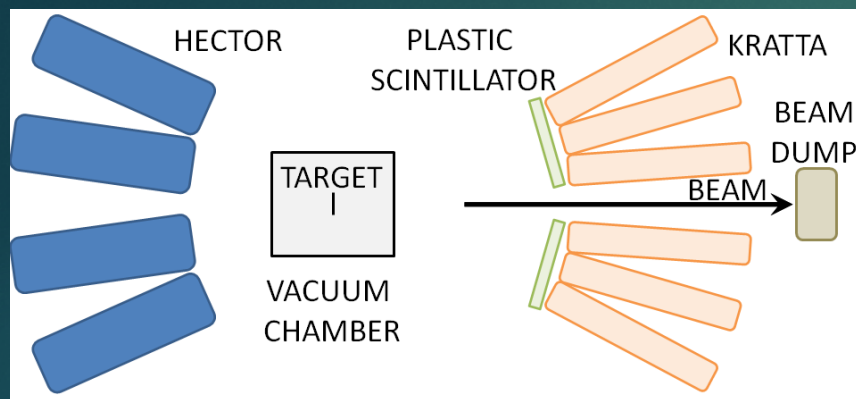


Lol: Studies of resonance states in nuclei using high-energy proton beam in p,p' reactions at forward angles

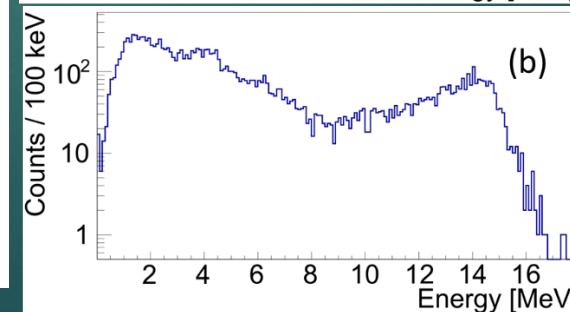
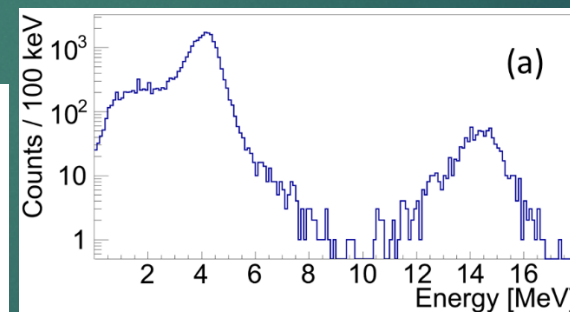
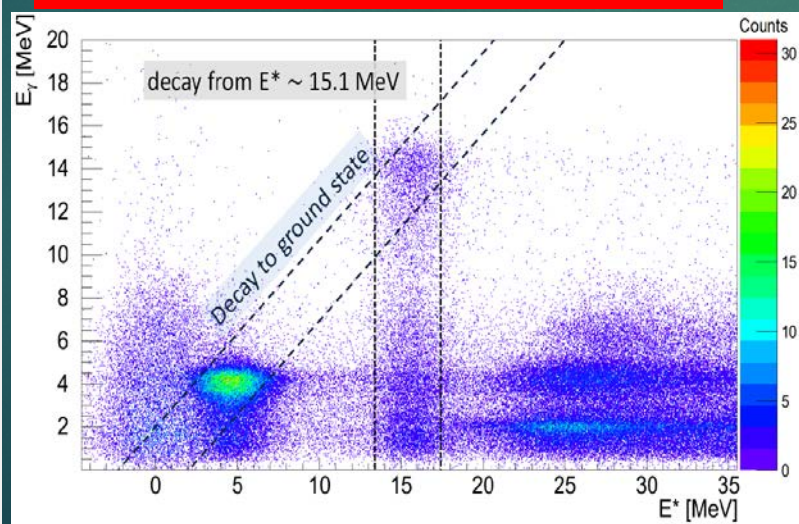
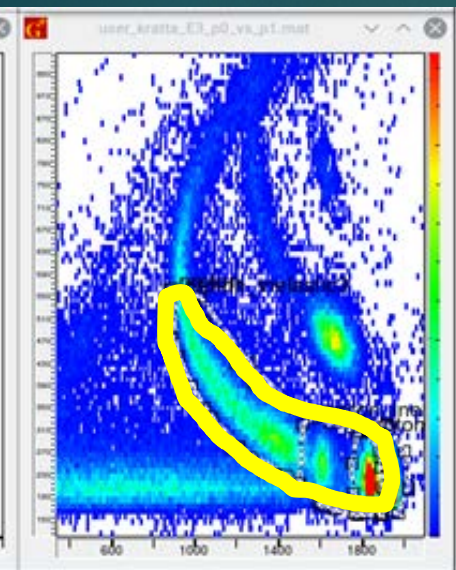
F. Crespi, M. Kmiecik et al.

HECTOR, PARIS, KRATTA

Very preliminary
Courtesy of
Basia
Wasilewska

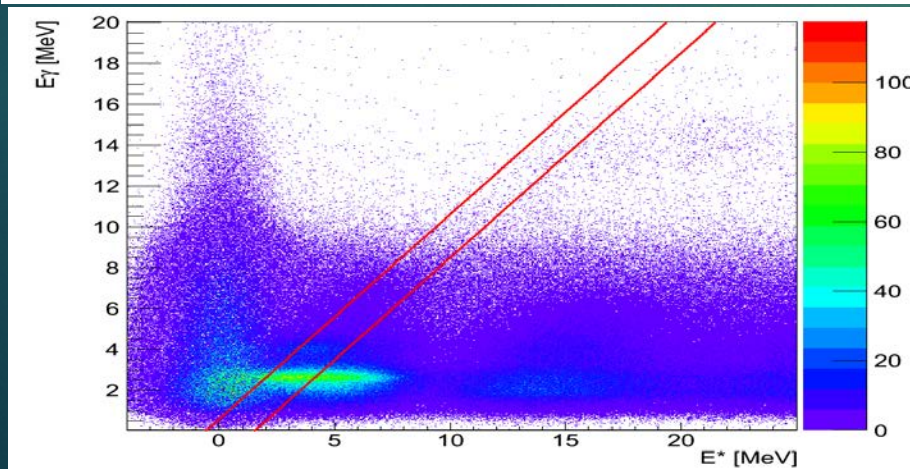
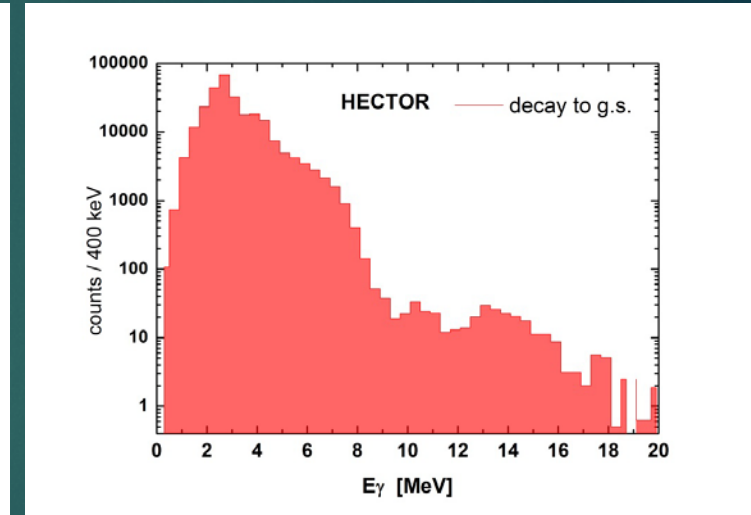
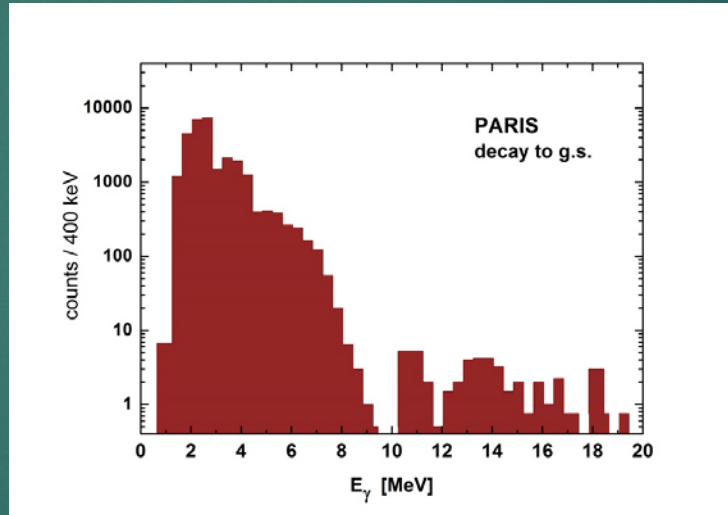
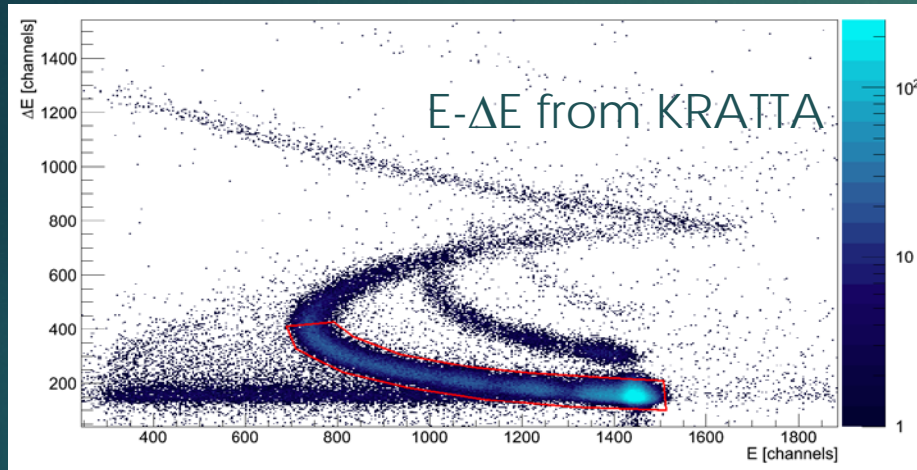


85 MeV p on ^{12}C - calibration



First experiment (March 2017): Studies of gamma decay of GQR ($E_{\text{GQR}}=10.6$ MeV) and GDR ($E_{\text{GDR}}=13.9$ MeV) in ^{208}Pb

85 MeV protons on ^{208}Pb – preliminary results



Excitation energy from measured scattered proton energy and angle

First PARIS experiments in GANIL (July 2017 and tbd.)

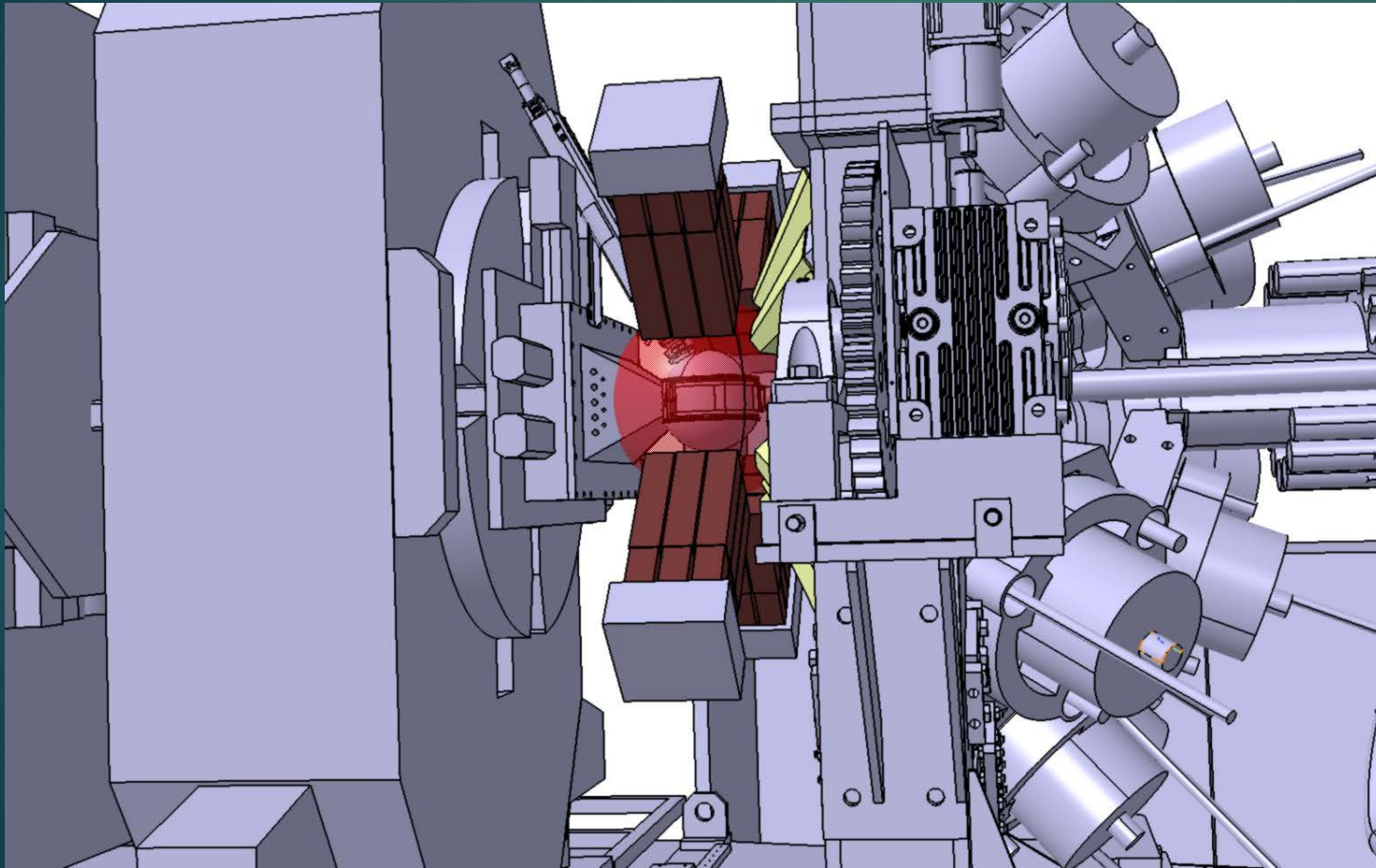


PARIS coupled to AGATA@GANIL

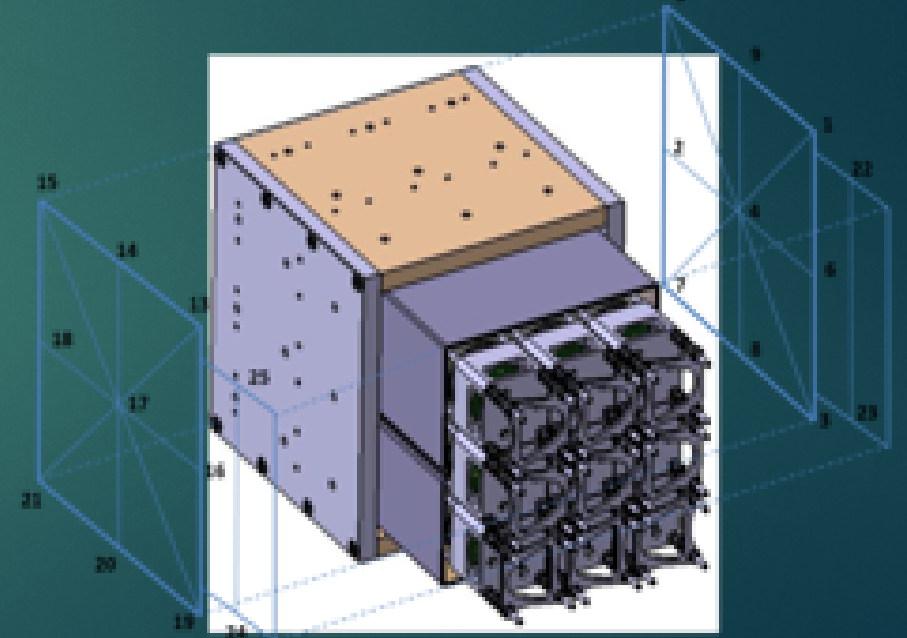
3 proposals accepted by the GANIL PAC

- S. Leoni, B. Fornal, M. Ciemala et al., **Lifetime measurements of excited states in neutron-rich C and O isotopes** (2 clusters + 2 large LaBr₃), **AGATA, VAMOS**, **(DONE! 11-23 July 2017, E676)**
- P. Bednarczyk, A. Maj et al., **Investigation of a high spin structure in ⁴⁴Ti via discrete and continuum γ -spectroscopy** with **AGATA, PARIS** (4 clusters) and **DIAMANT**
- B. Fornal, S. Leoni, M. Ciemala et al., „**Gamma decay from near-threshold states in ¹⁴C: a probe of clusterization phenomena in open quantum systems**”, **AGATA, PARIS** (4 clusters), **NEDA, DIAMAND, DSSD**

Experimental setup:
AGATA, VAMOS, PARIS



A shield for VAMOS
magnetic field needed!



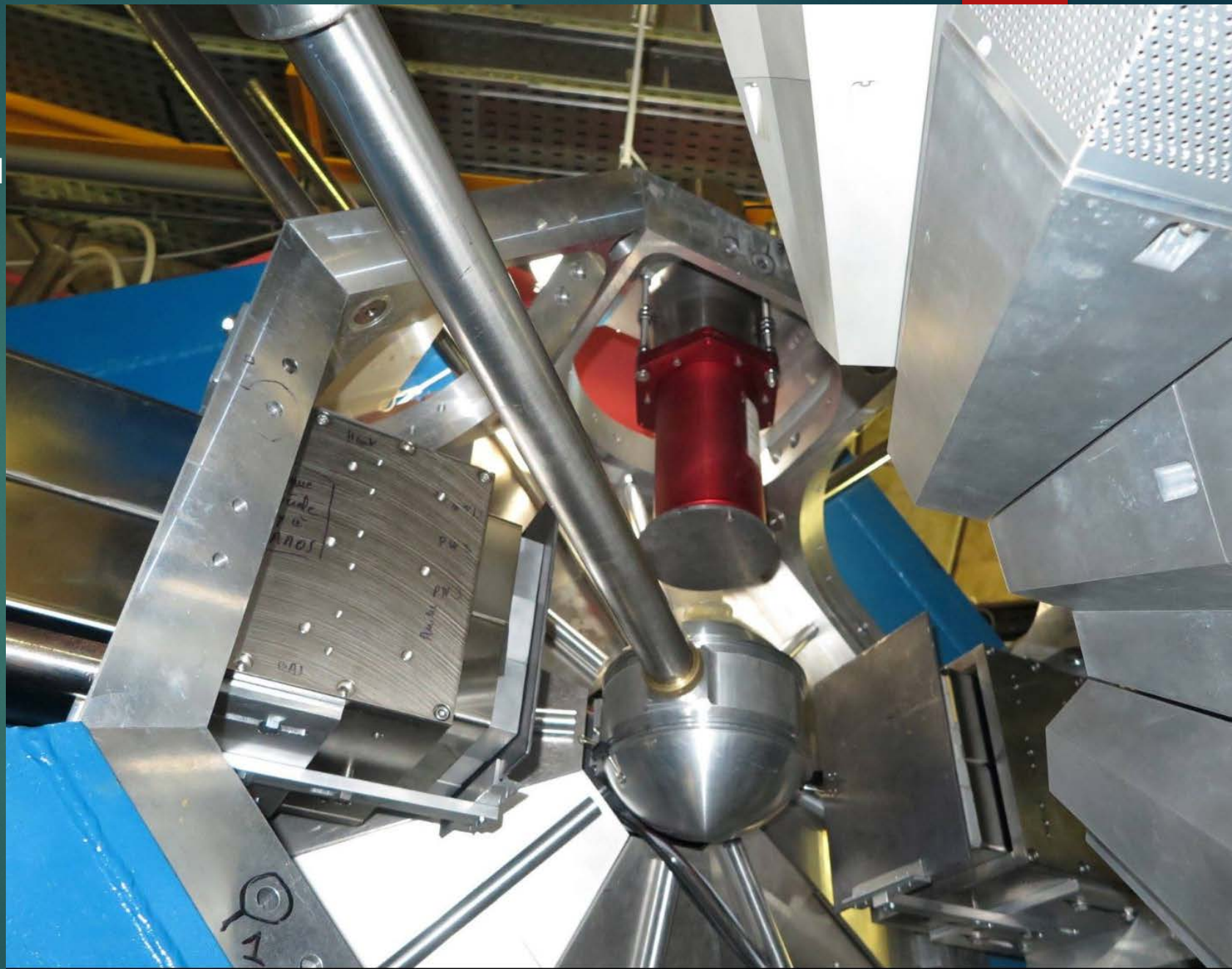
PARIS setup

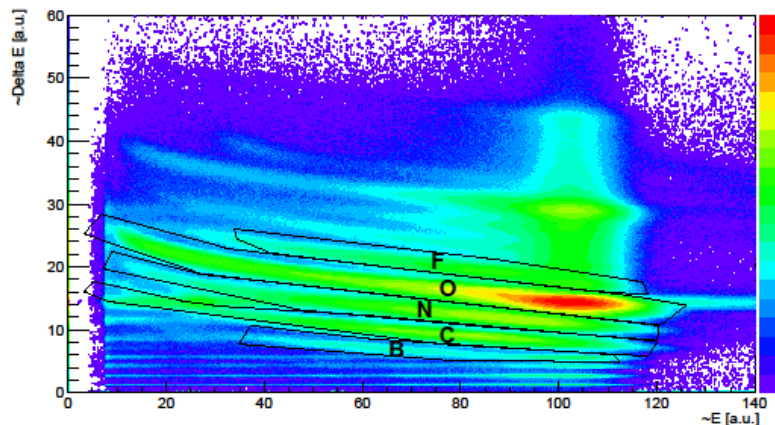
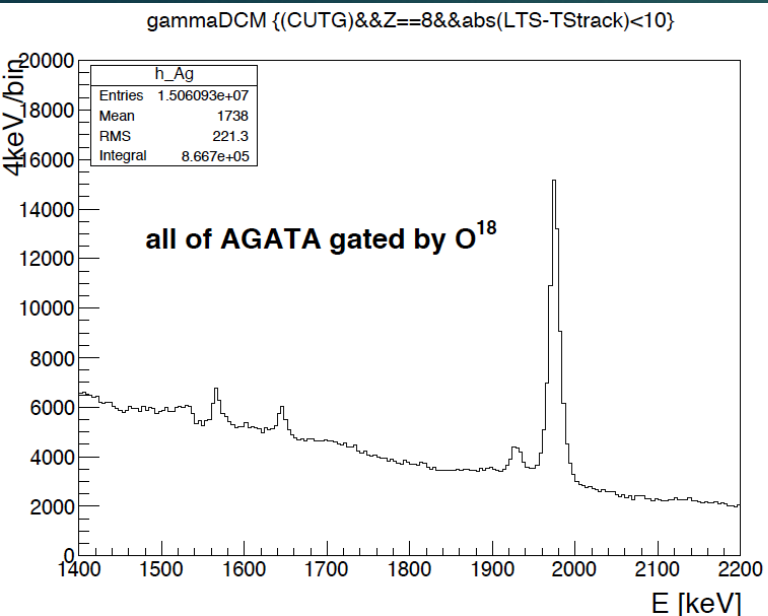
- 1 LaBr₃-NaI cluster in magnetic shield
- 1 CeBr₃-NaI cluster in magnetic shield
- 1 big LaBr₃ in magnetic shield
- 1 big LaBr₃ without magnetic shield

Electronic used for PARIS:
PARIS Pro module (amplification +
CFD) with FAST (LaBr₃) and SLOW
(NaI) outputs, readed by TDC, ADC
in VAMOS VME crate,
Limited CR to ~7kHz.

¹⁸O 7.0 MeV/A beam,
¹⁸¹Ta (4 μm thick)

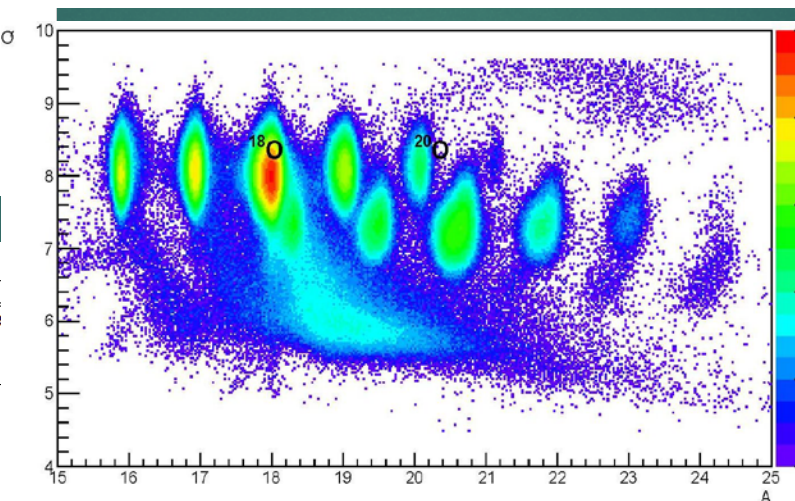
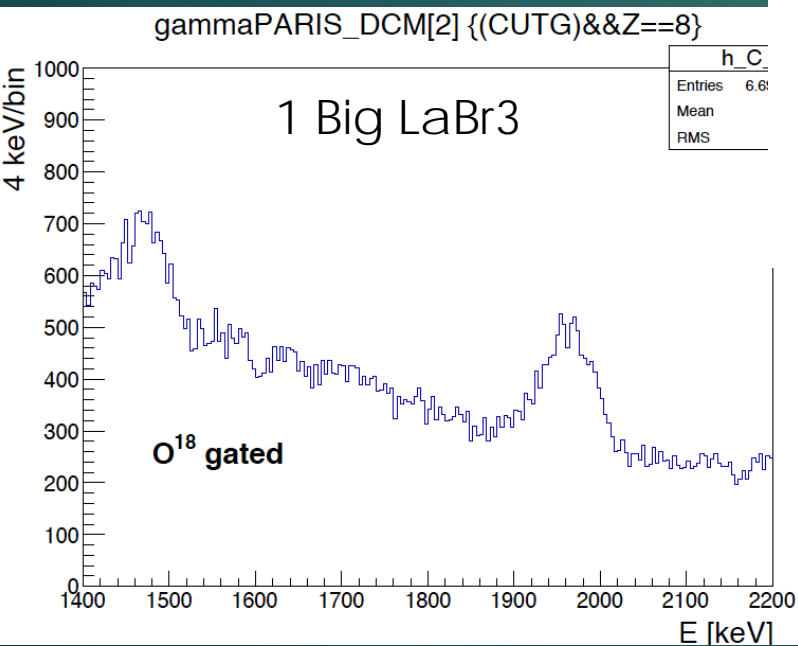
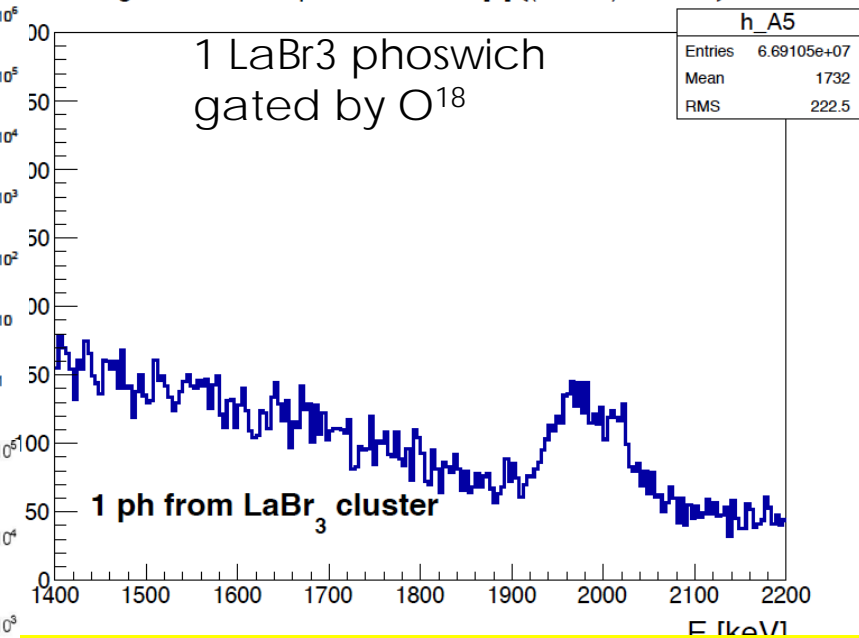
VAMOS++ at 45 degree



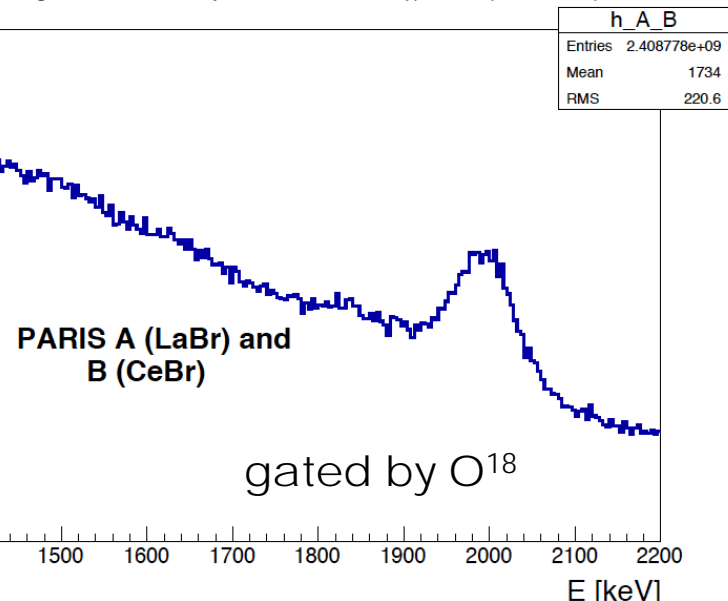


gammaPARIS_phoswich_DCM[5] {(CUTG)&&Z==8}

1 LaBr₃ phoswich
gated by O¹⁸



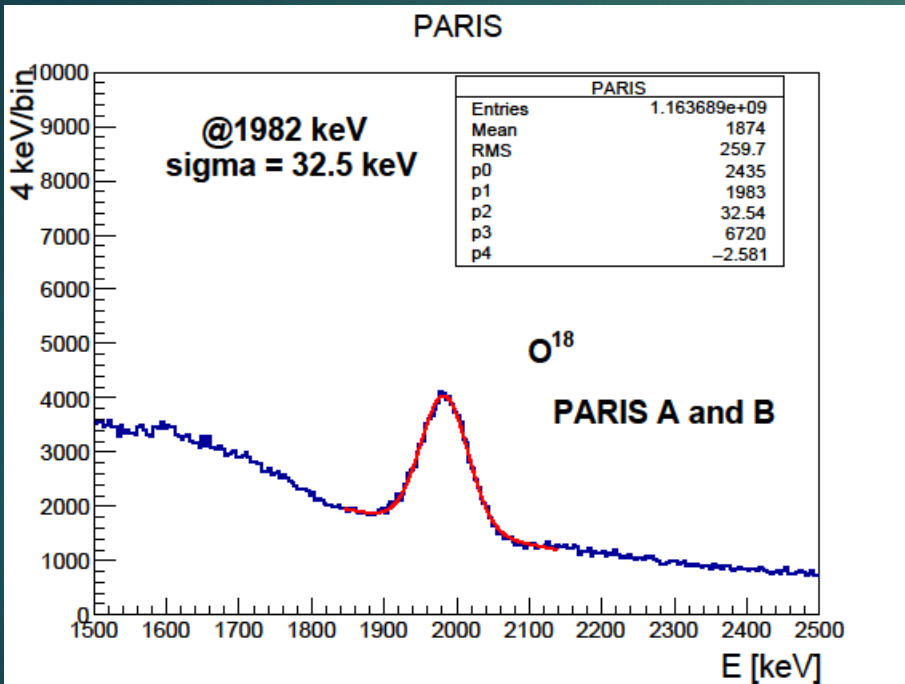
gammaPARIS_phoswich_DCM {(CUTG)&&Z==8}



Ratio of nr of counts in peak in
PARIS to nr of counts in peak in
AGATA = 0.92

PARIS

FWHM/E = 5.0% (@ 662 keV)
with magnetic field switched on;
4.7% with switched off

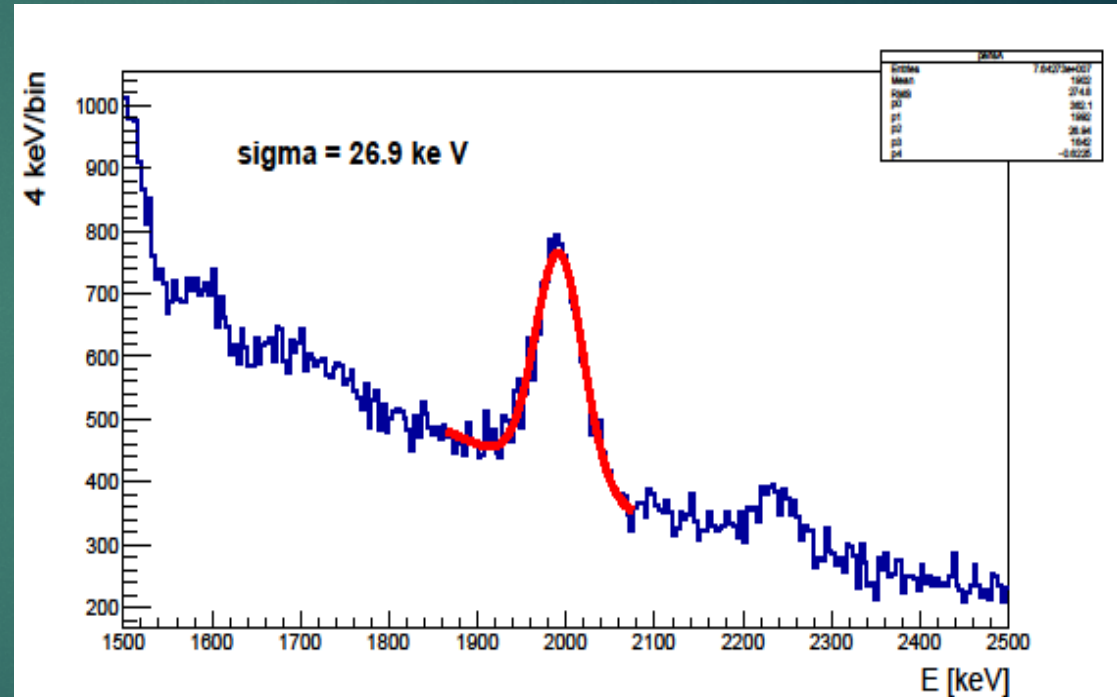


PARIS 2 cl. LaBr₃ and CeBr (2" square shape)

Doppler corrected gamma spectrum
emitted by ^{18}O with beta = 0.1c, sigma = 32.5
keV
FWHM/E = 3.9% (@ 1982 keV)

Big LaBr₃

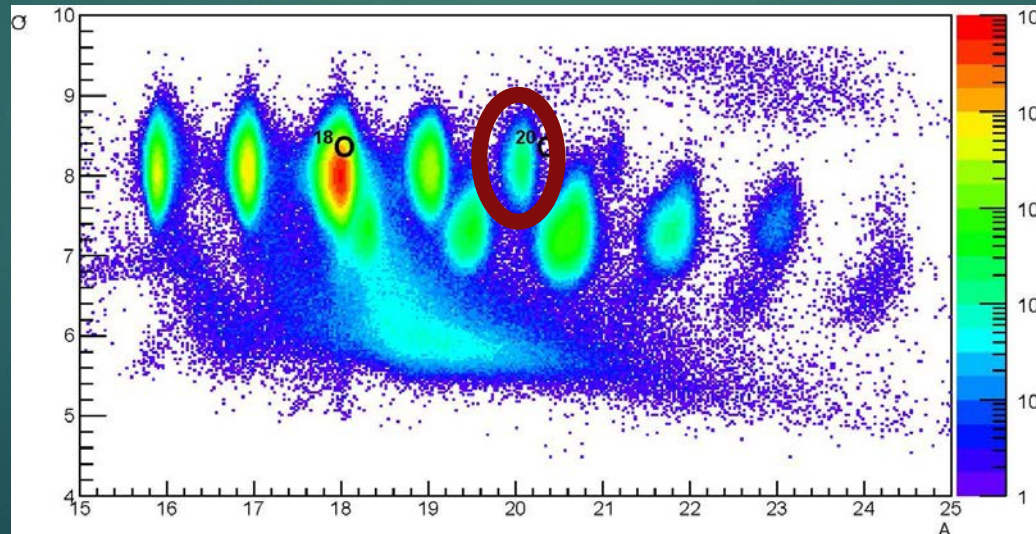
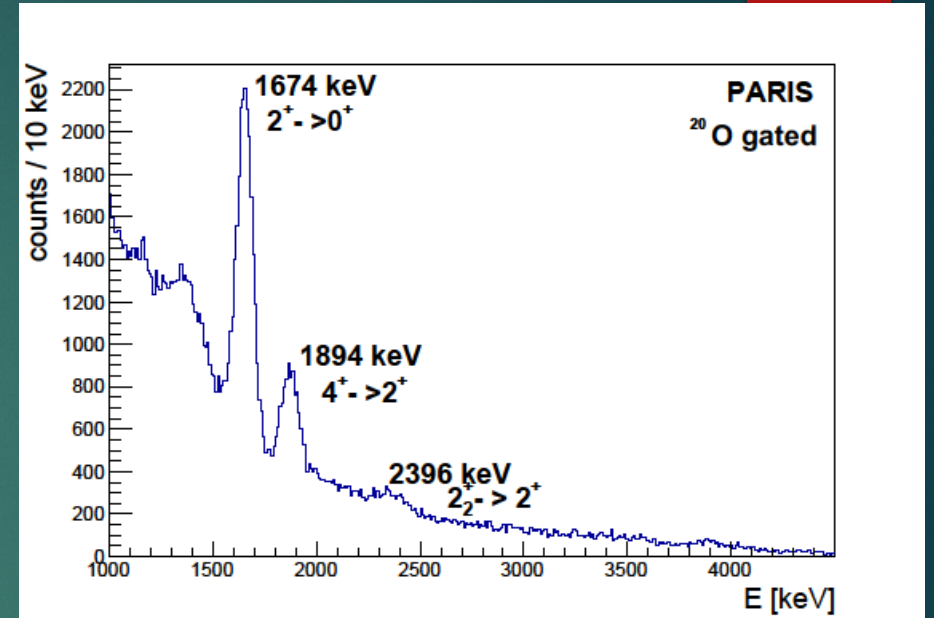
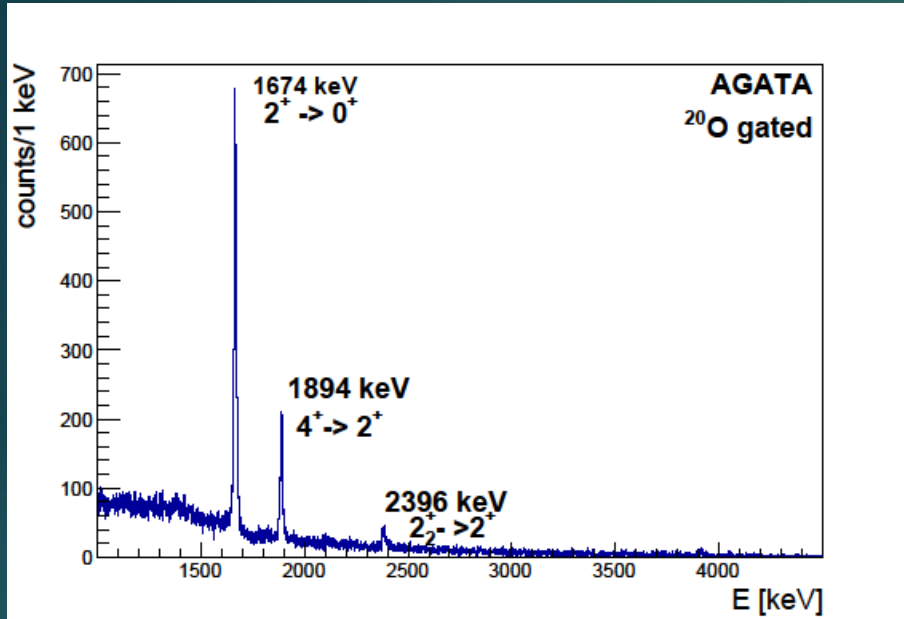
FWHM/E = 3.5% (@ 662 keV)
with magnetic field switched on;
3.3% with switched off



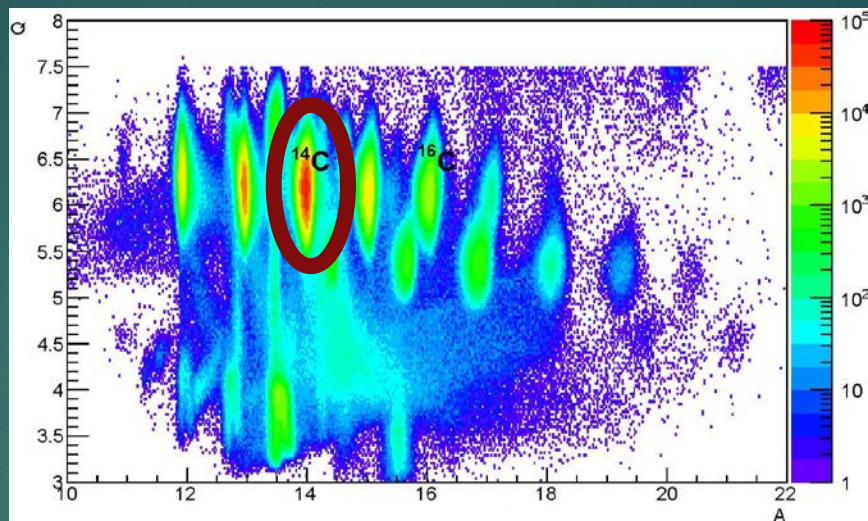
Big LaBr₃ (Diameter 3.5"), sigma = 26.9 keV,
FWHM/E = 3.2% (@ 1982 keV)

Granulation of PARIS helps in Doppler broadening
correction

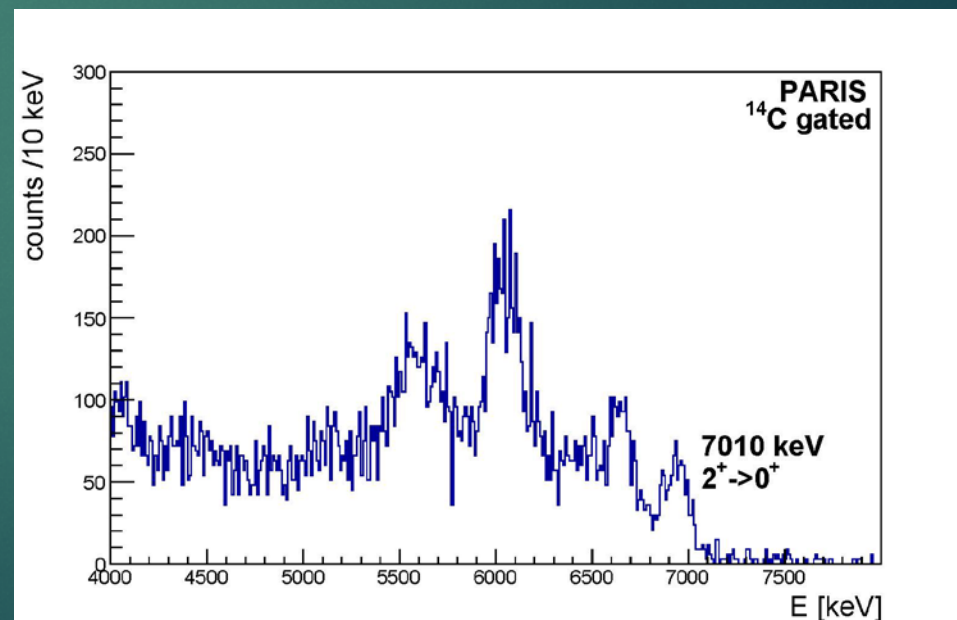
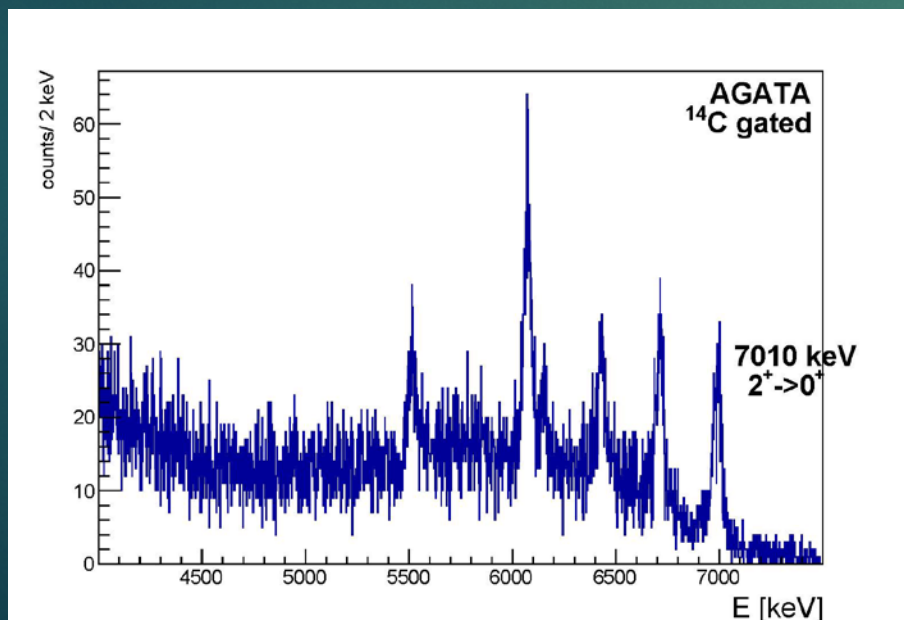
^{20}O spectra



^{14}C spectra



Ratio of nr of counts in peak in
PARIS to nr of counts in peak in
AGATA = 1.5, @7010 keV





Conclusions

- ▶ $\text{LaBr}_3/\text{CeBr}+\text{NaI}$ phoswich is a viable solution for the elements of the PARIS calorimeter, also in terms of its meeting the requirements for energy and timing resolution
- ▶ Presently we explore the performance of 1 cluster of 9 phoswich detectors. Source and in-beam testing were done recently
- ▶ First experiments with 1 cluster were done in 2 TNA facilities: IPN Orsay and CCB at IFJ PAN Krakow.
- ▶ **Experiment in which PARIS was coupled to AGATA was done in GANIL– PARIS performs very well.**
- ▶ PARIS possesses at present 2 clusters. 4 clusters are expected to be operational beginning 2018.

Acknowledgements



- ▶ A. Maj, M. Kmiecik, B. Wasilewska, B. Fornal, P. Bednarczyk (IFJ PAN Kraków)
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- ▶ O. Dorvaux, C. Schmitt, S. Kihel (IHPC Strasbourg)
- ▶ M. Lebois, Q. Liqiang, J. Wilson, I. Matea (IPN Orsay)
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- ▶ J. Harca (JINR Dubna)
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- ▶ M. Lewitowicz, E. Clement, A. Lemasson, M. Rejmund (GANIL)
- ▶ V. Nanal, C. Gosh, B. Dey, I. Mazumdar et al. (India)
- ▶ D. Jenkins et al. (York)
- ▶ M. Stanoiu (Bucharest)
- ▶ J. Dudek (Strasbourg)

- ▶ Technical staff of IPN Orsay, IFJ PAN Krakow, GANIL Caen

- ▶ *H2020 project ENSAR2 (TNA support) and COPIN support*