Lifetime measurements of excited states in neutron-rich C and O isotopes: a stringent test of the three body forces with the AGATA+PARIS+VAMOS setup

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Milano – Krakow collaboration
Local Contact: G. DeFrance, M. Ciemala
AGATA+PARIS+VAMOS collaboration

Experiment Performed in July 2017
13 days (but 5 days lost …)

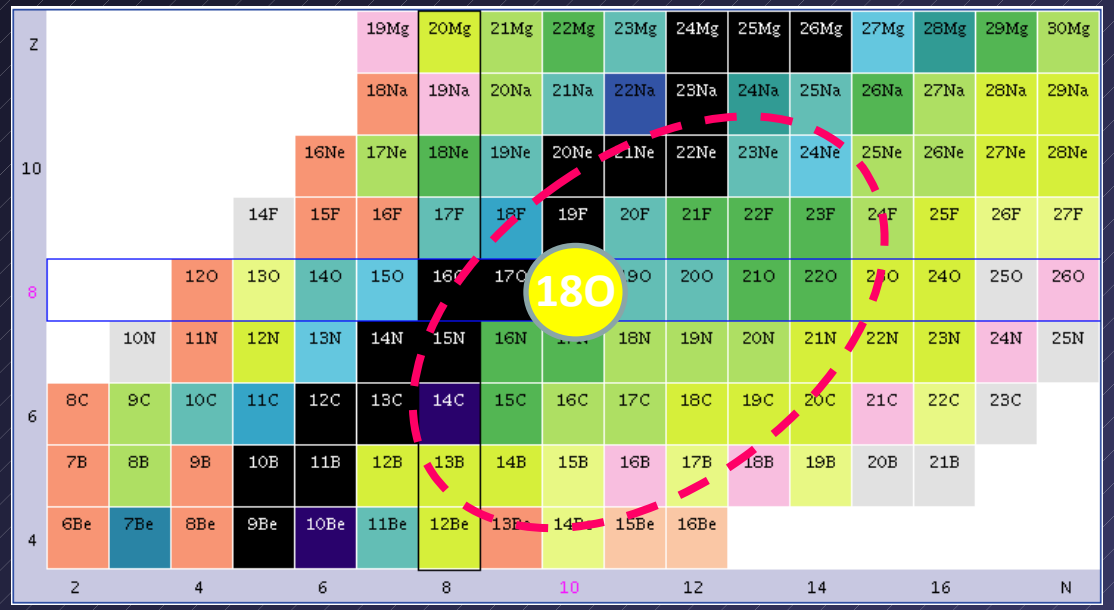
- PHYSICS CASE

  Spectroscopy of N-Rich B-C-O-F Nuclei by Multi-Nucleon Transfer Reactions

  In particular

  τ of the second 2+ in even-even nuclei

  16,18C and 18,20O



Strong Sensitivity to details of ab-initio calculations (NN and NNN interactions)

- REACTION

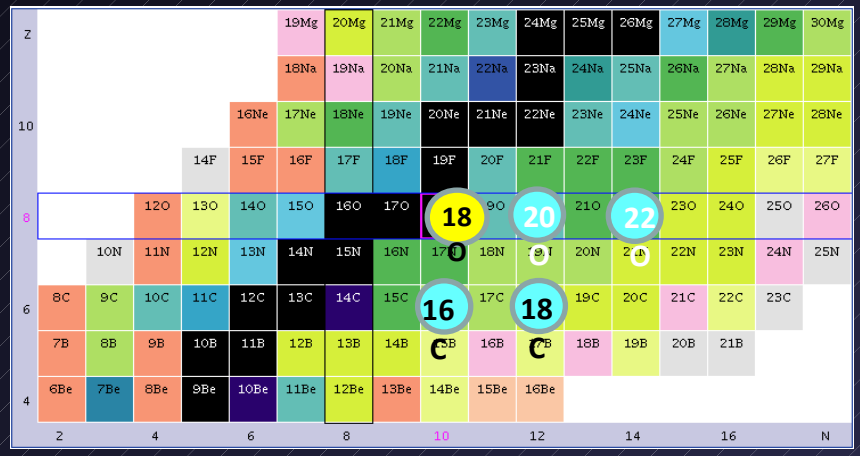
  18O (7 MeV/A) + 238U target (10 mg/cm2) → 181Ta target (6 mg/cm2)

- EXPERIMENTAL SETUP

  AGATA + PARIS + VAMOS + Plunger → experiment run with NO Plunger

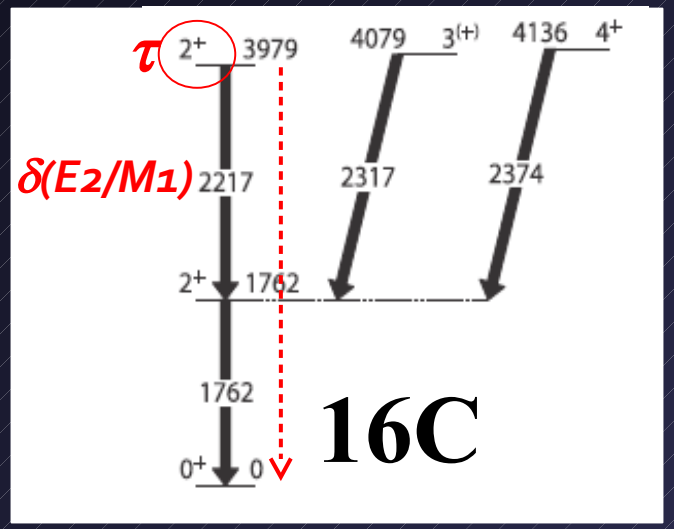
  Lifetimes measurements by DSAM and Plunger **τ = 100 fs – 10's ps**

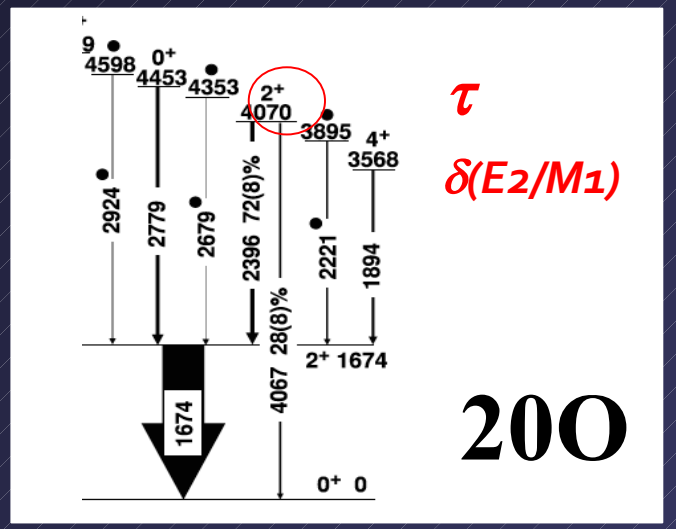
Physics Cases – among the most interesting **16,18C, 20,22O**



Ab initio NCSM calc.

NN	NNN
0.25 ps	0.08 ps
0.30	0.08





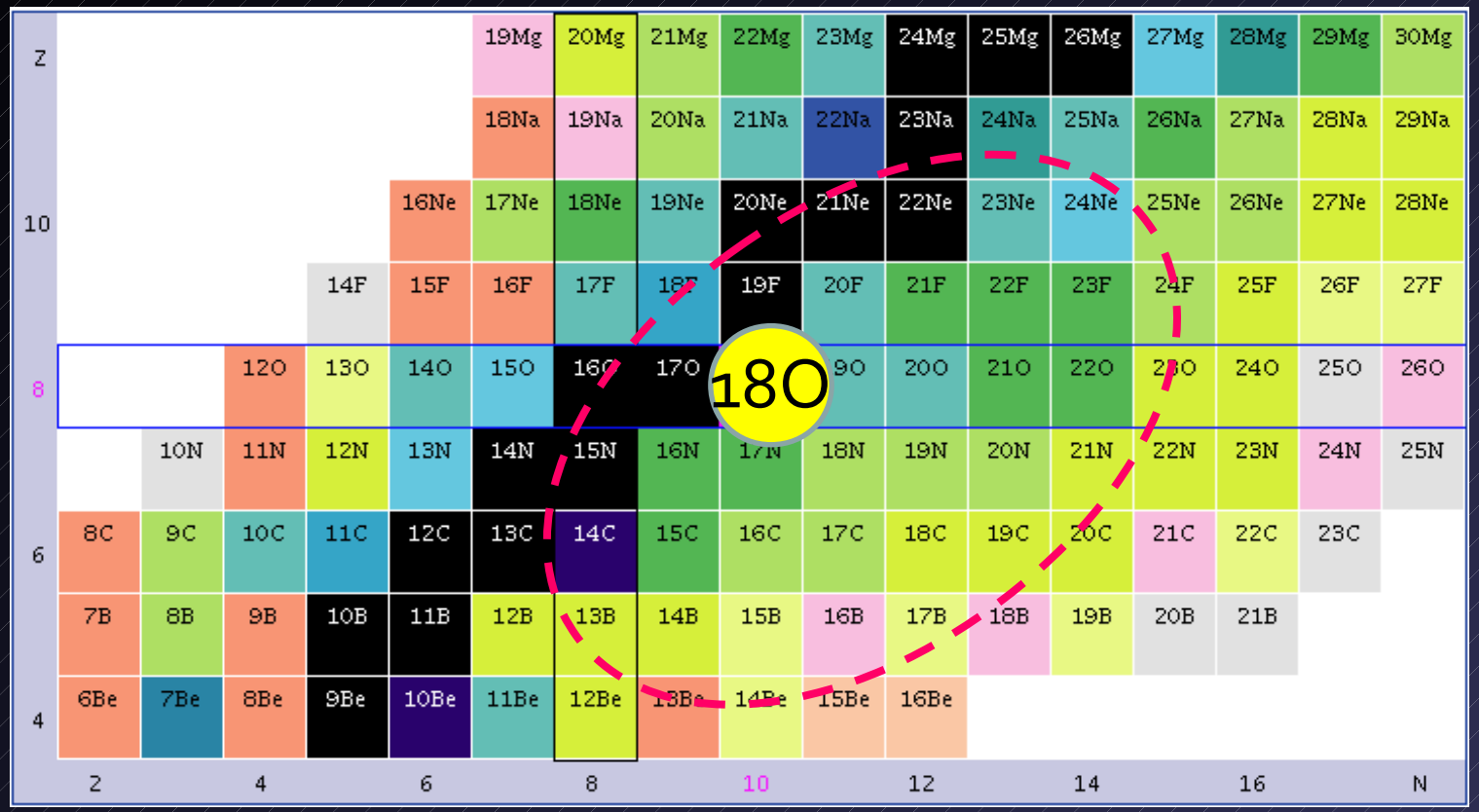
Ab initio NCSM calc.

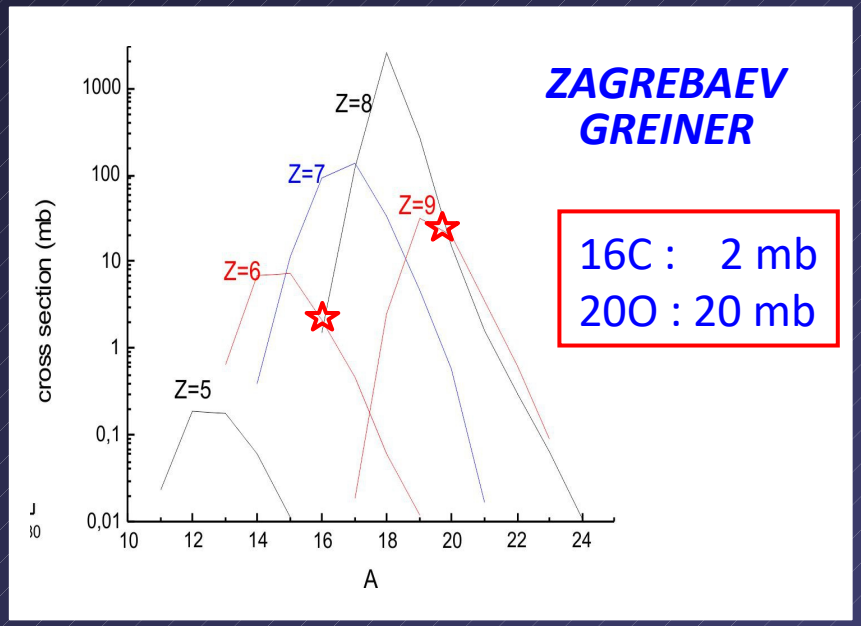
NN	NNN
0.32 ps	0.20 ps
0.24	0.04

1. Lifetimes of Excited states: DSAM and Plunger
2. Decay Branchings: PARIS, high efficiency
3. E2/M1 Mixing Ratio: AGATA angular distributions

18O (7 MeV/A) on 181Ta (6 mg/cm2) - VAMOS @ 45°

θGRAZING = 45°, > 1.5 Vcoulomb → *16C (-2p), 18C (-2p+2n), 20O (+2n), 22O (+4n)*



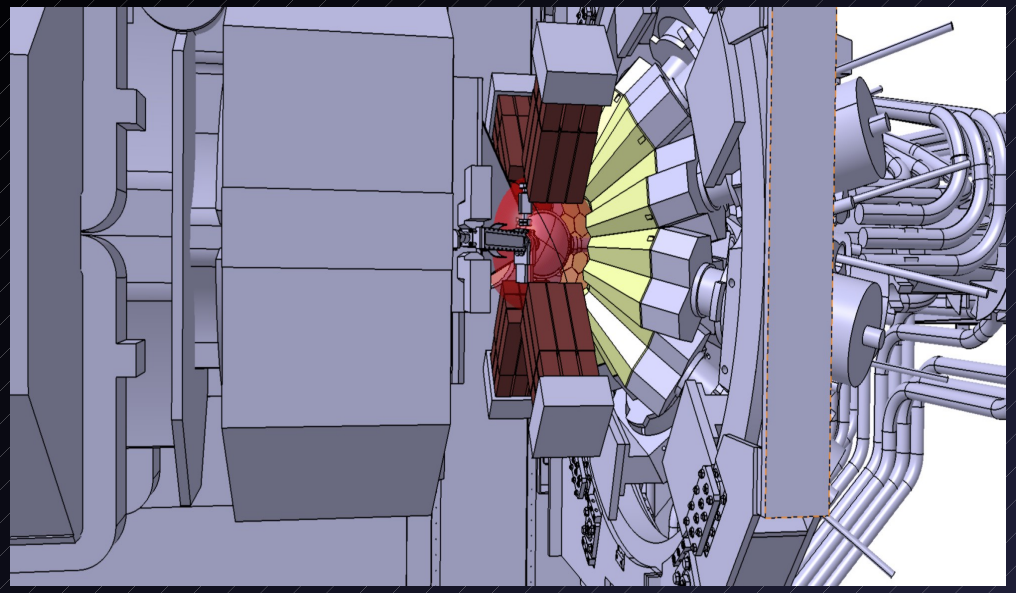


Limited Spectroscopic Information

(especially for lifetimes of excited states)

Never Studied in details by Multi Nucleon Transfer

EXPERIMENTAL SETUP



AGATA (8TC+4DC=32 crystals) → **31 crystals**

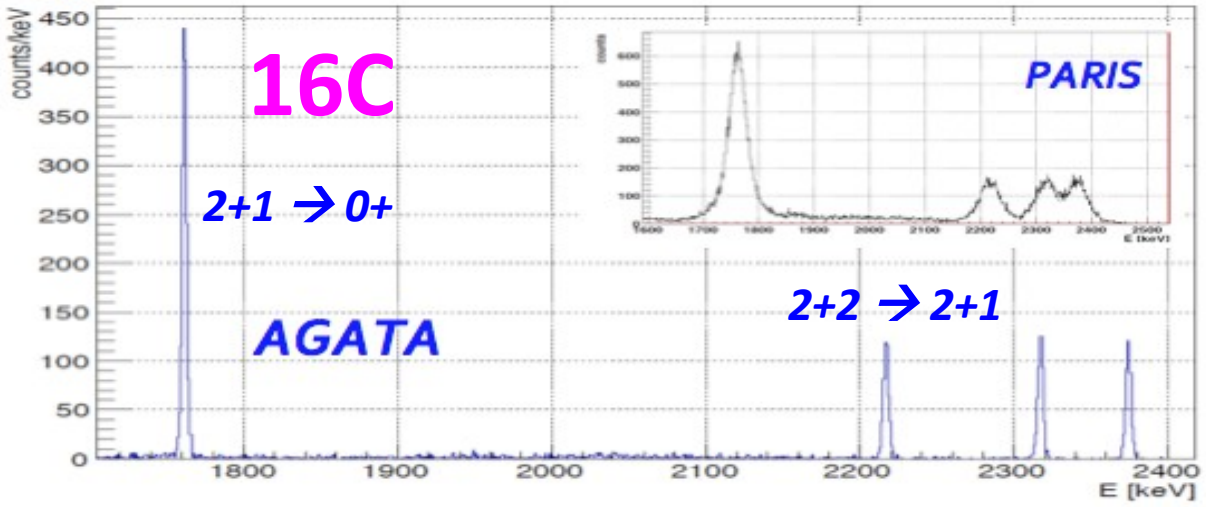
PARIS-Demonstrator
(4 Clusters) @ 90°, 23 cm → 2 Clusters + 2 Big LaBr3

VAMOS @ 45°

PLUNGER (Cologne) → NO Plunger

Simulations for 16C, a -2*p* product

AGATA@GANIL Simulations Package



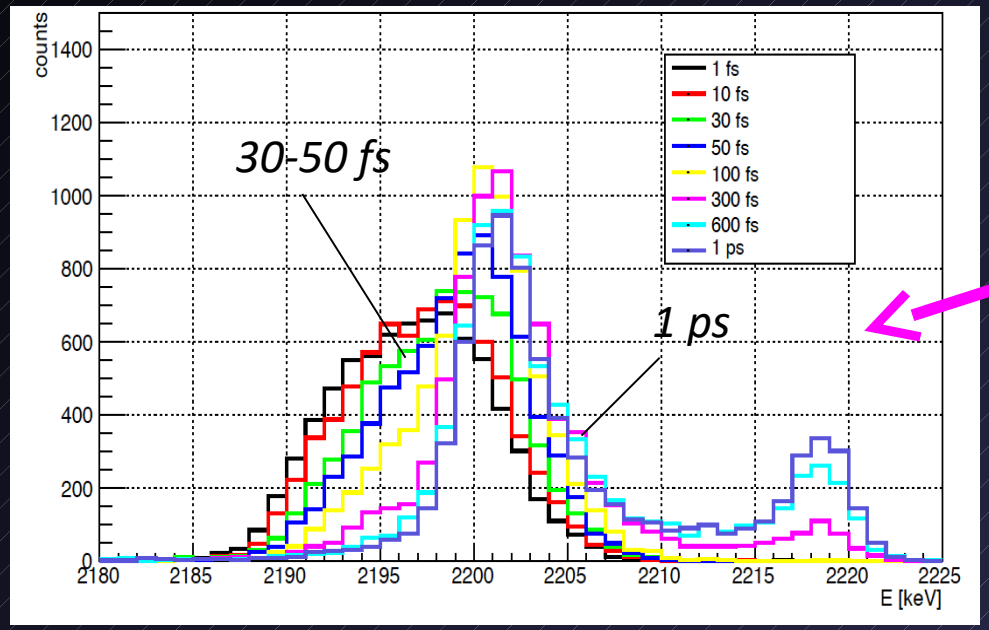
v/c ≈ 12%
(Ekin,θLAB) from GRAZING

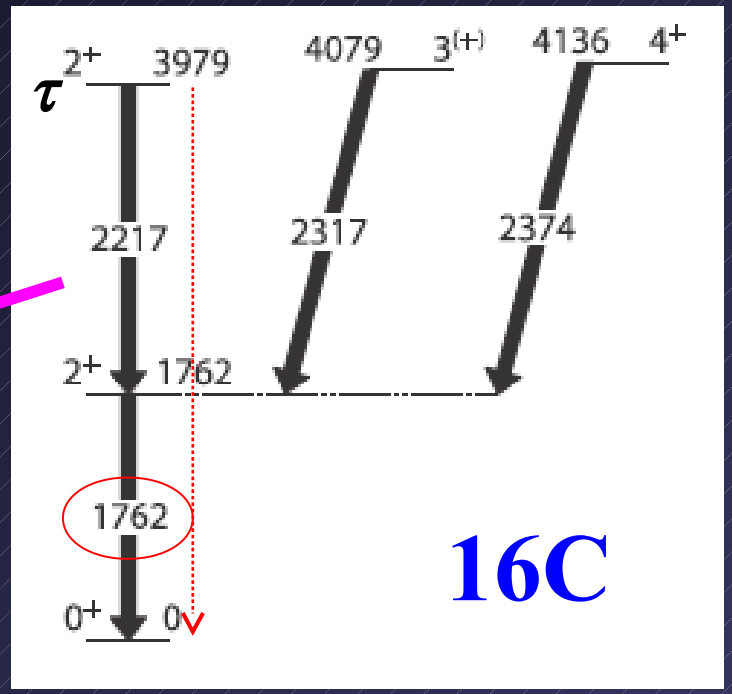
VAMOS Transmission ≈ 30 %
ε(AGATA) @ 1.8 MeV = 5.2 %
ε(PARIS) @ 1.8 MeV = 6 %

by M. Ciemala

Lineshape Analysis (DSAM)

10 mg/cm2 238U, v/c ≈ 12%





Lifetime range τ = 30 fs – 1 ps

238U (10 mg/cm2):

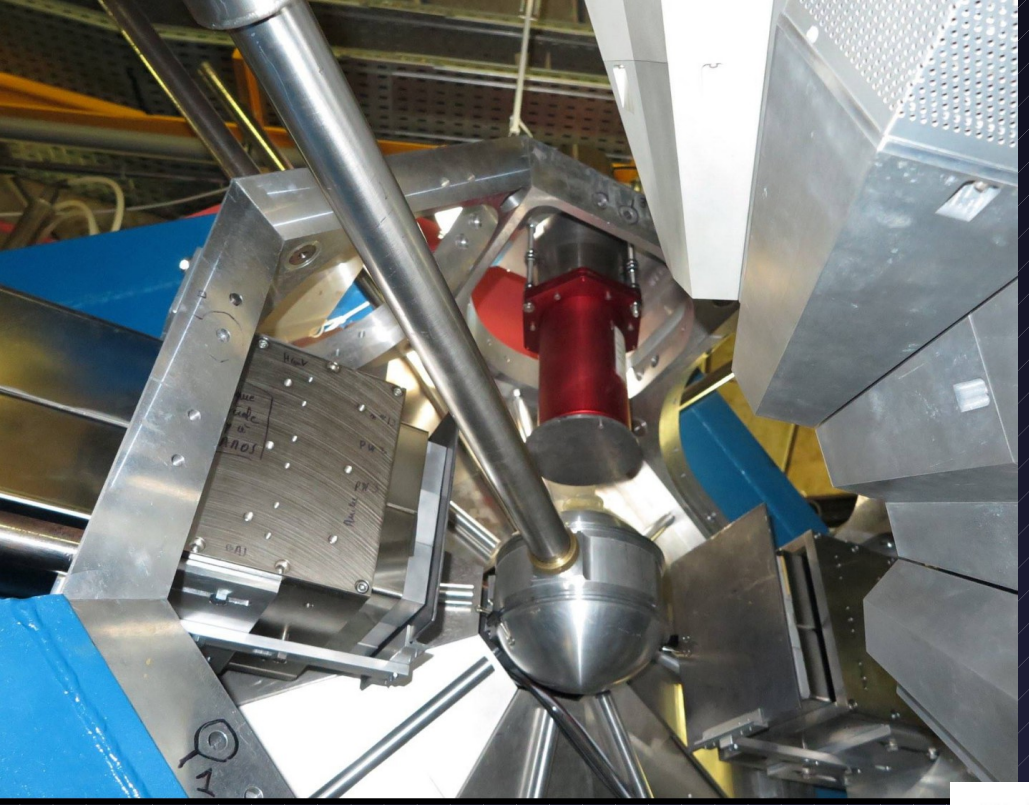
ΔE/dx (18O @ 8 MeV/A) = 12 MeV

93Nb degrader (10 mg/cm2)

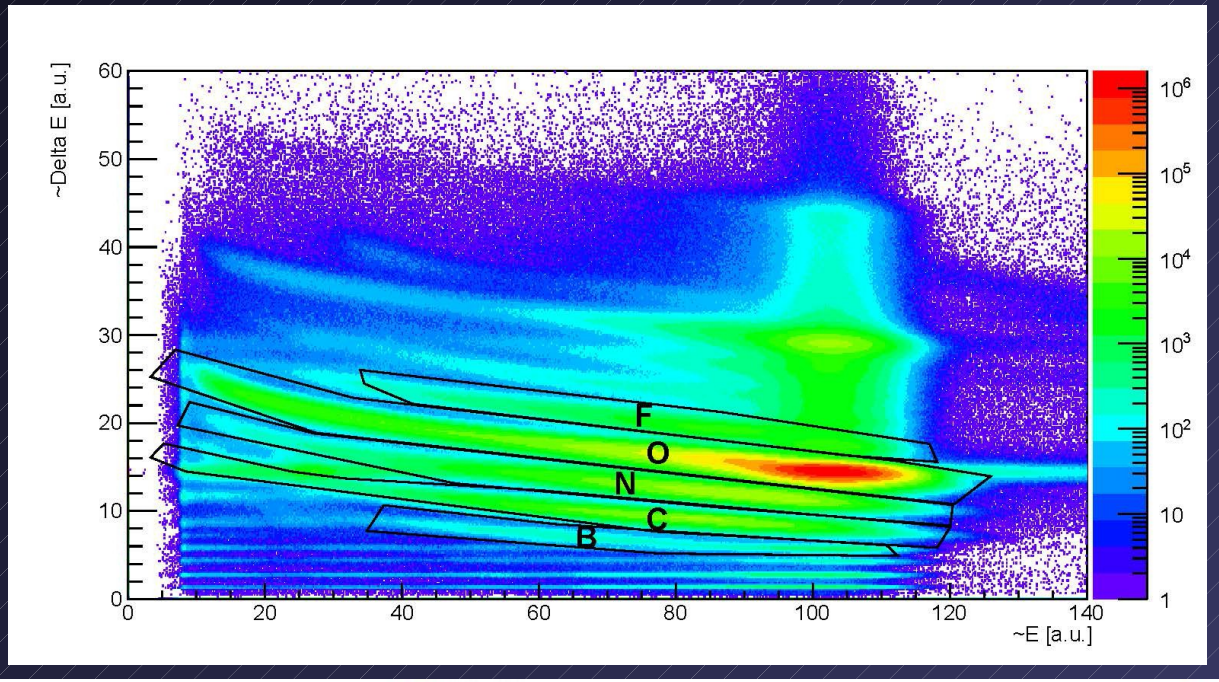
Coincidences AGATA-PARIS:

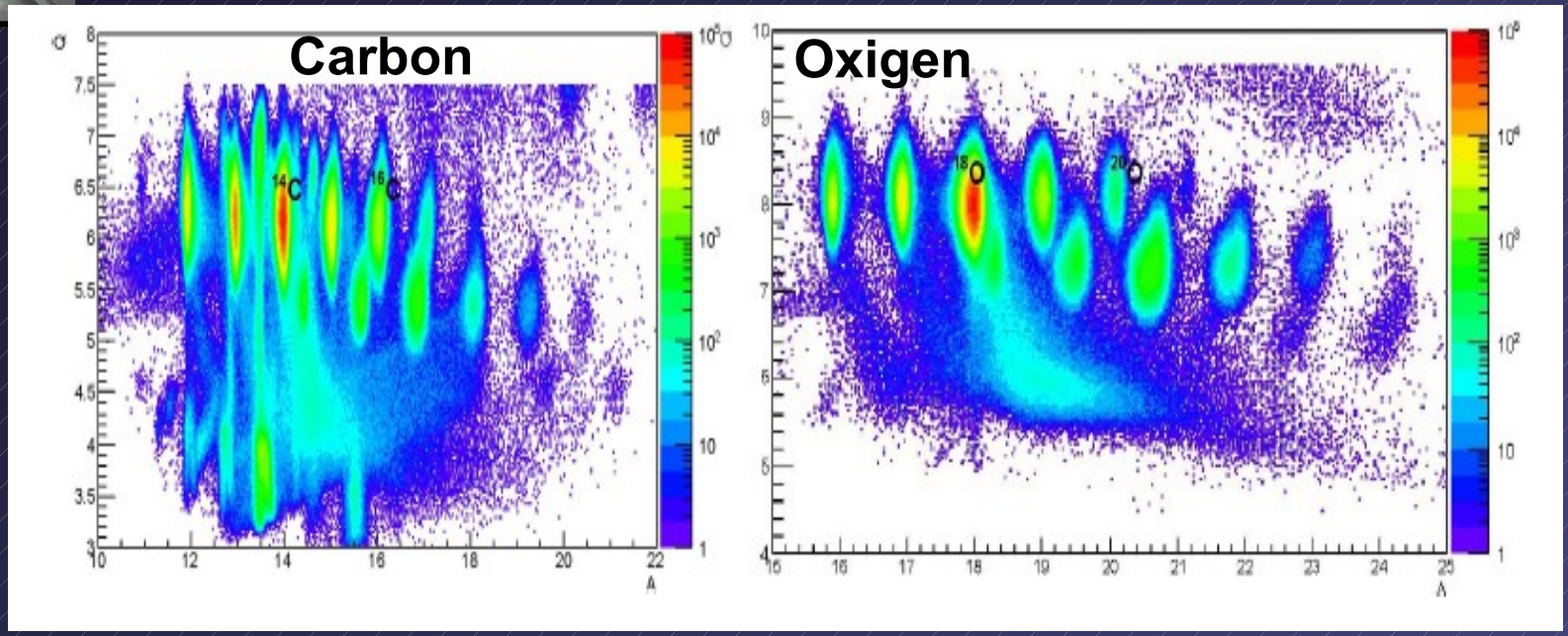
gates on γ-rays detected in PARIS !!!

- background reduction
- enhanced sensitivity to tail



VAMOS identification plots





20O … very promising

16C … promising

+ additional others …

STRATEGY for Preliminary DATA ANALYSIS

PRESORTING
(Detector Calibration, Gain Matching, Gates on VAMOS …)

- **KRAKOW** (Michal Ciemala): VAMOS Analysis, PARIS Analysis

- **MILANO** (Fabio Crespi and Sara Ziliani (Master student))**:** AGATA

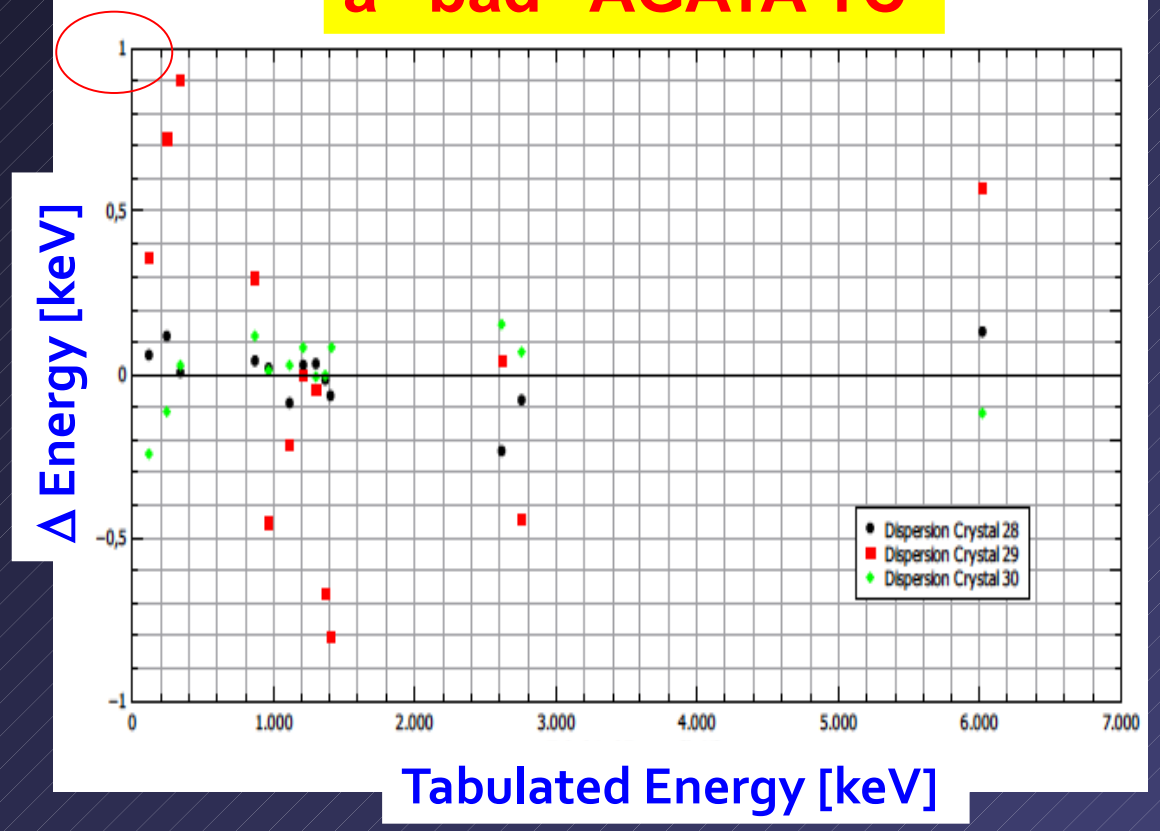
  - very careful calibration of individual crystals (152Eu and AmBe souces)
  - Time gates (after alignment of AGATA and VAMOS time stamps)
  - Replay of entire data set

Some results from MILANO Analysis of AGATA data

Careful AGATA crystals calibration (152Eu, AmBe, stopped lines)

Energy [keV]	
121,7817	(152Eu)
244,6974	(152Eu)
344,2785	(152Eu)
867,38	(152Eu)
964,057	(152Eu)
1.112,076	(152Eu)
1.212,948	(152Eu)
1.299,141	(152Eu)
1.368,626	(24Mg, beta decay of 24Na - neutron activation of 23Na)
1.408,013	(152Eu)
2.614,511	(208Pb)
2.754,007	(24Mg, beta decay of 24Na - neutron activation of 23Na)
4.948,2	(56Fe - AmBe)
6.017,8	(57Fe - AmBe)

a "bad" AGATA TC



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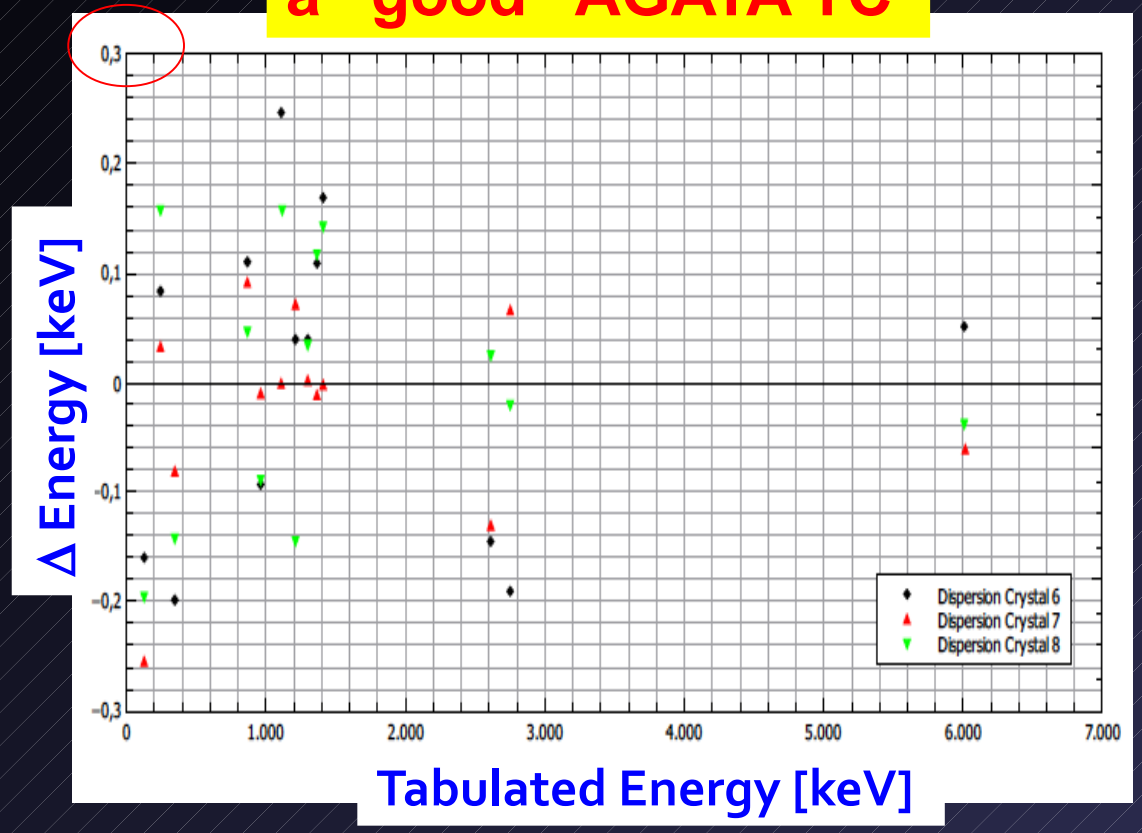
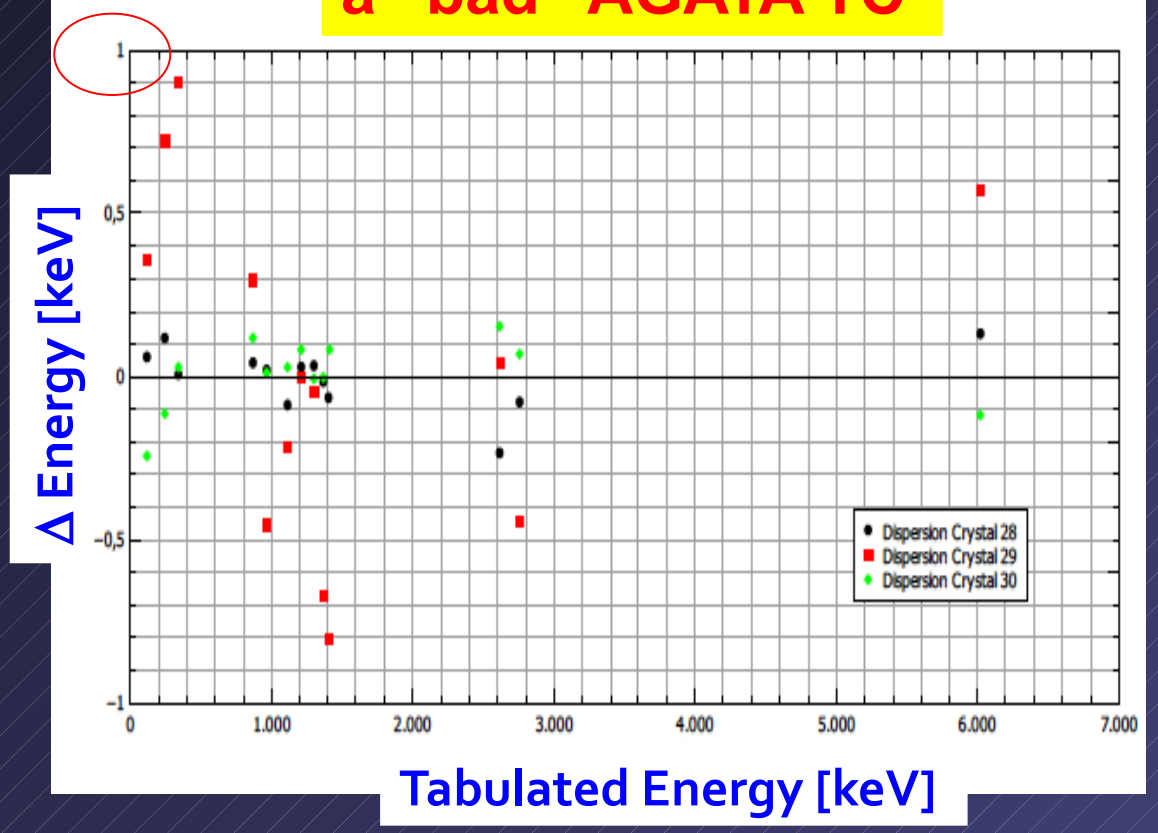
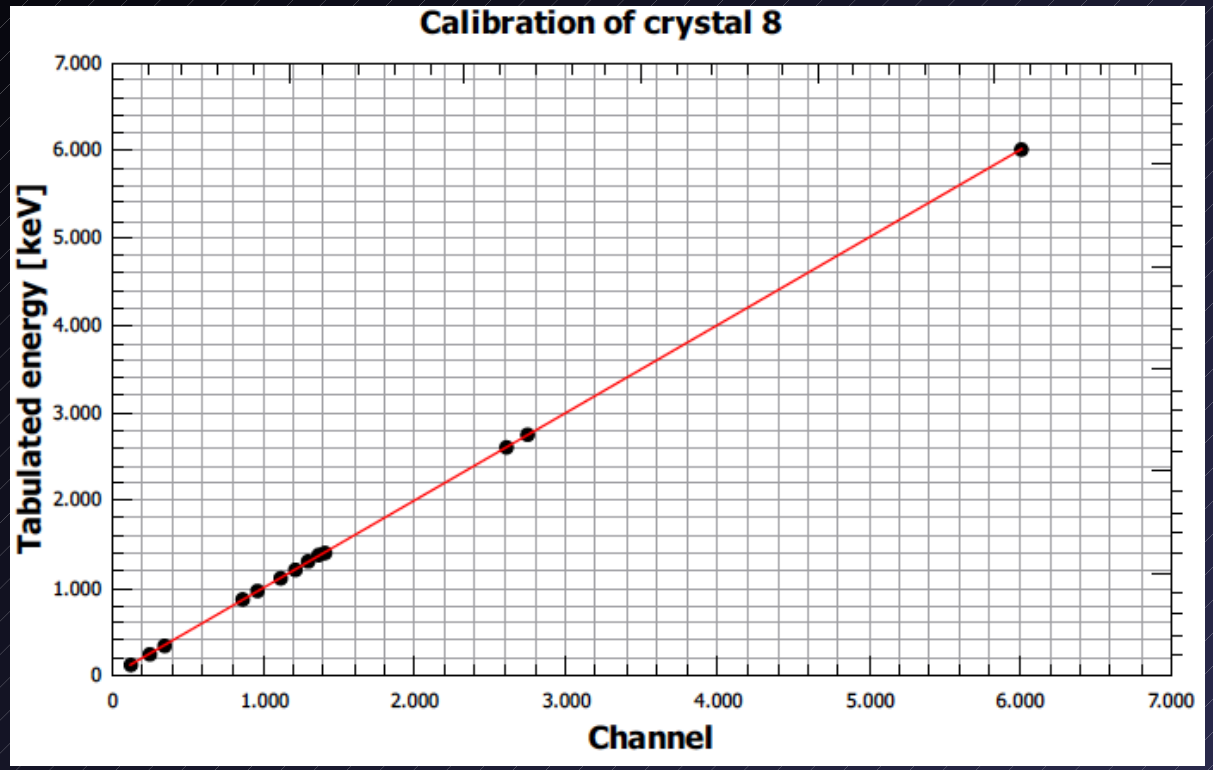


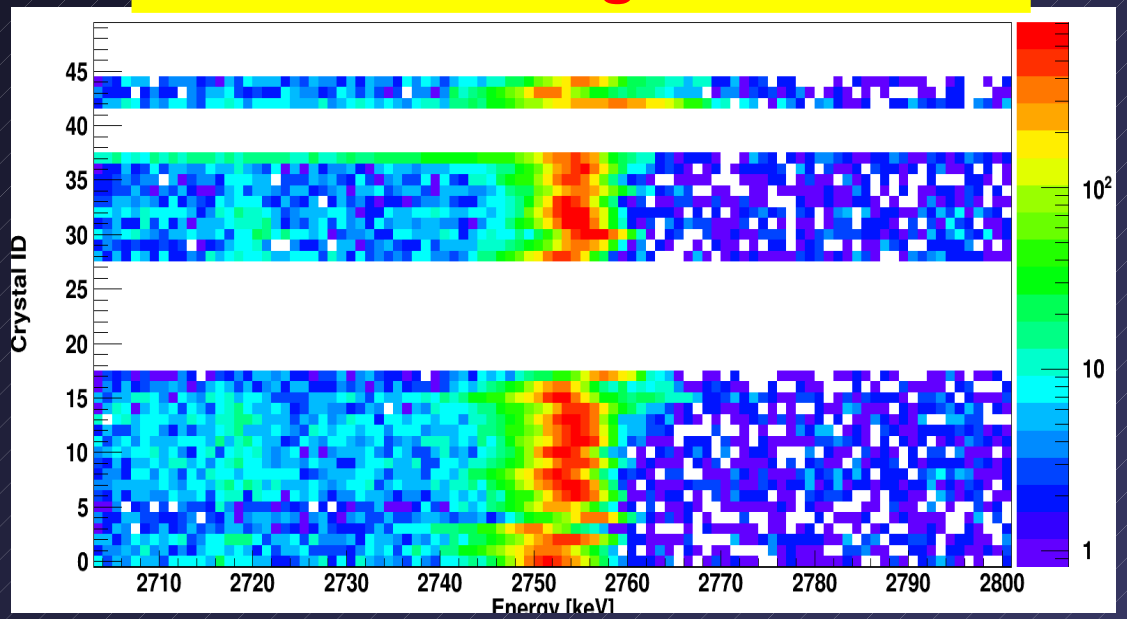
a "bad" AGATA TC

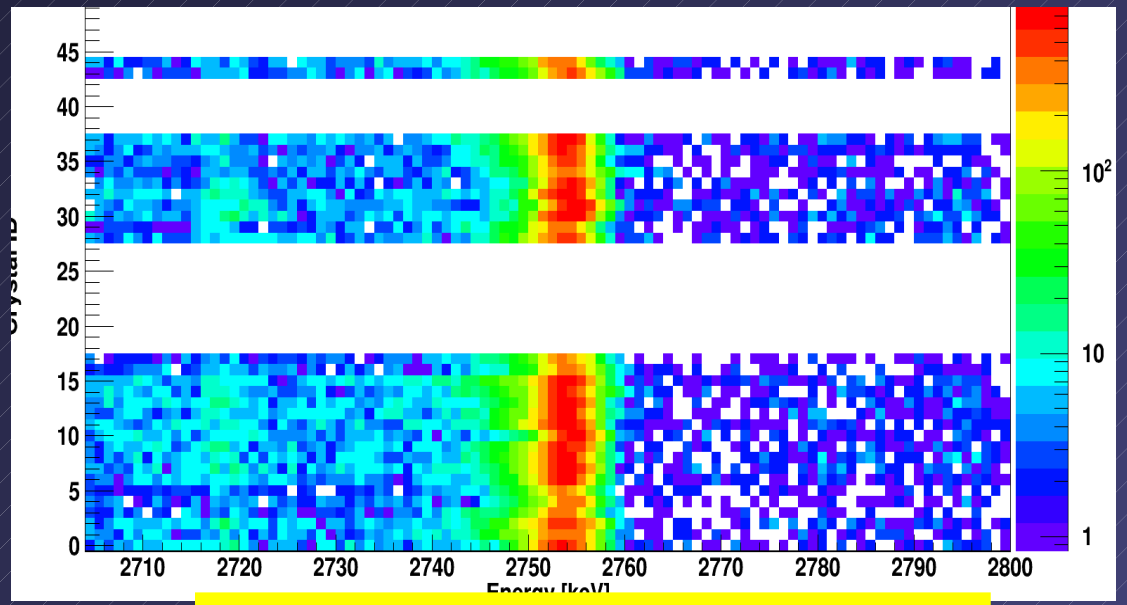


Example of typical linear calibration curve



Nearline sorting coefficients

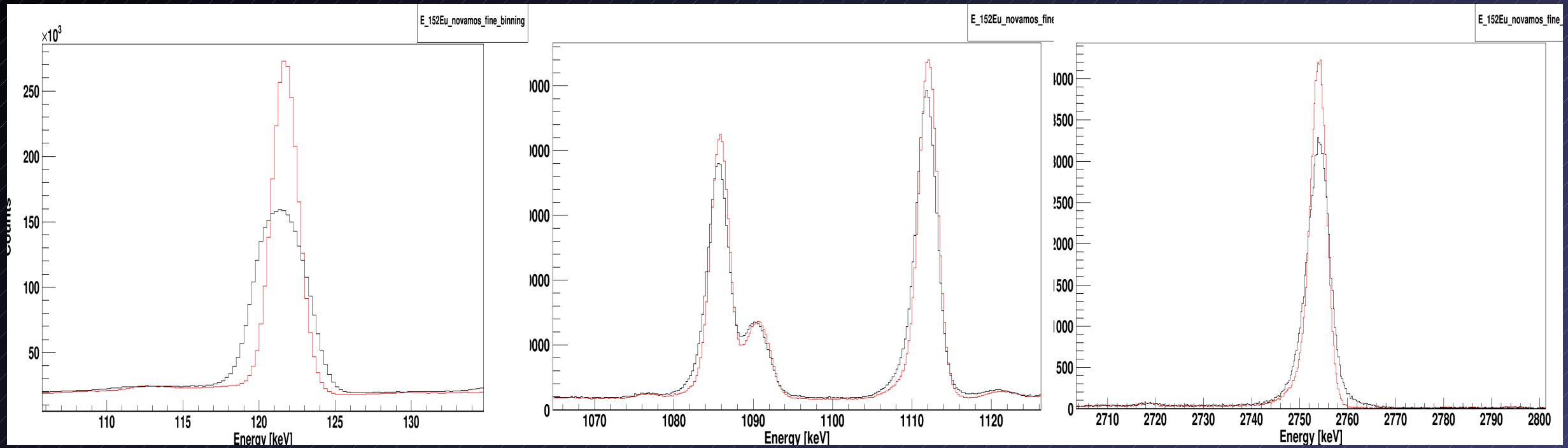




NEW sorting coefficients

A significant improvement in Energy resolution

Source Spectra (end of the experiment)



Nearline CAL	FWHM 3.61 keV	FWHM 3.29 keV	FWHM 6.12 keV
New CAL	FWHM 2.11 keV	FWHM 2.94 keV	FWHM 4.36 keV

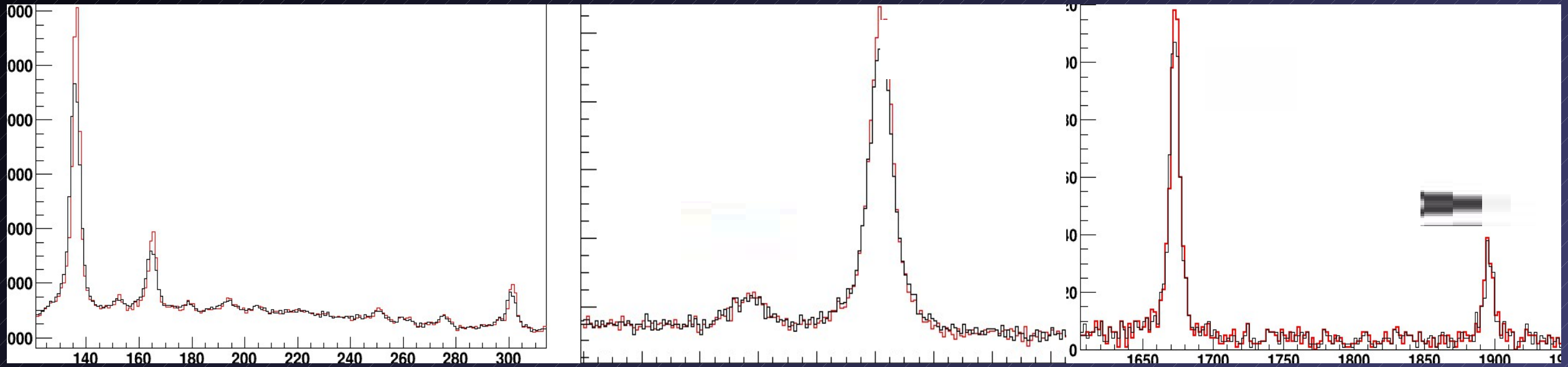
A significant improvement in Energy resolution

In-beam Spectra (partial statistics: ≈ 7%Total)

18O
stopped lines

18O
Doppler corrected

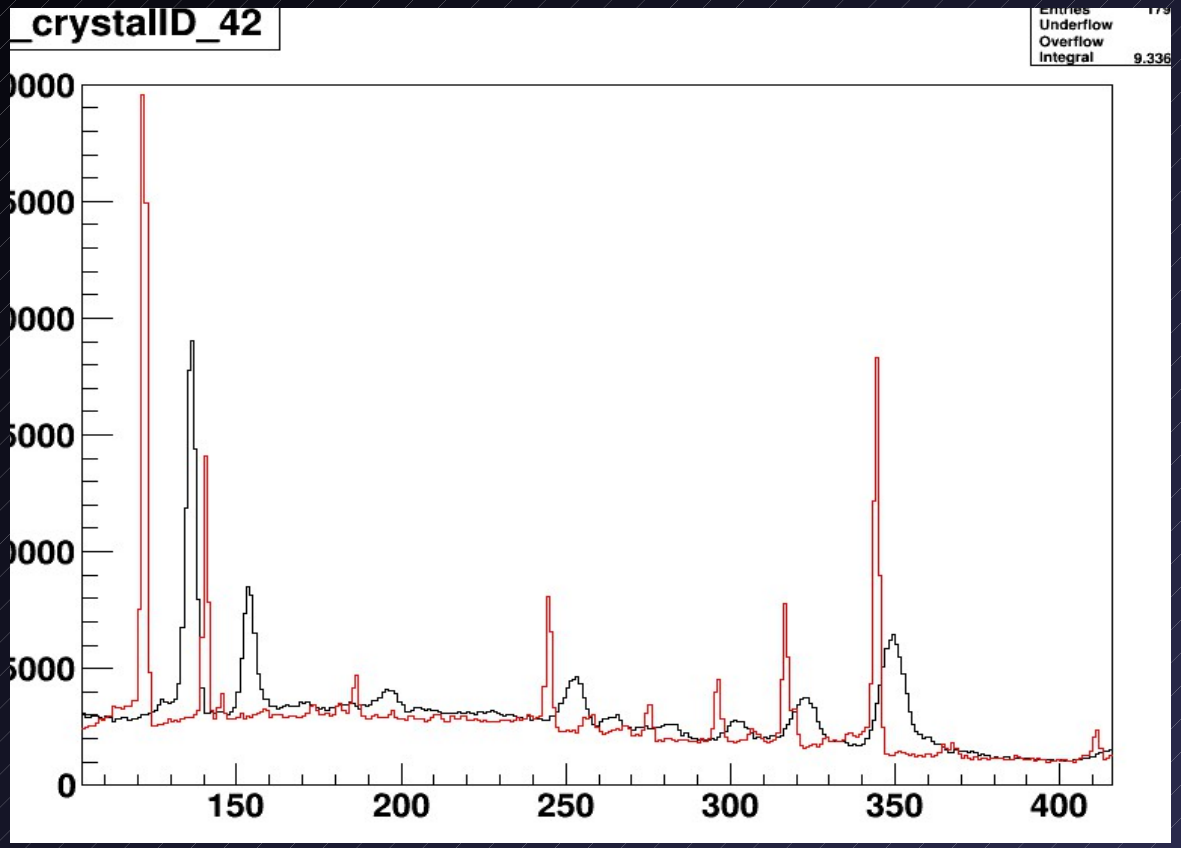
20O
Doppler corrected



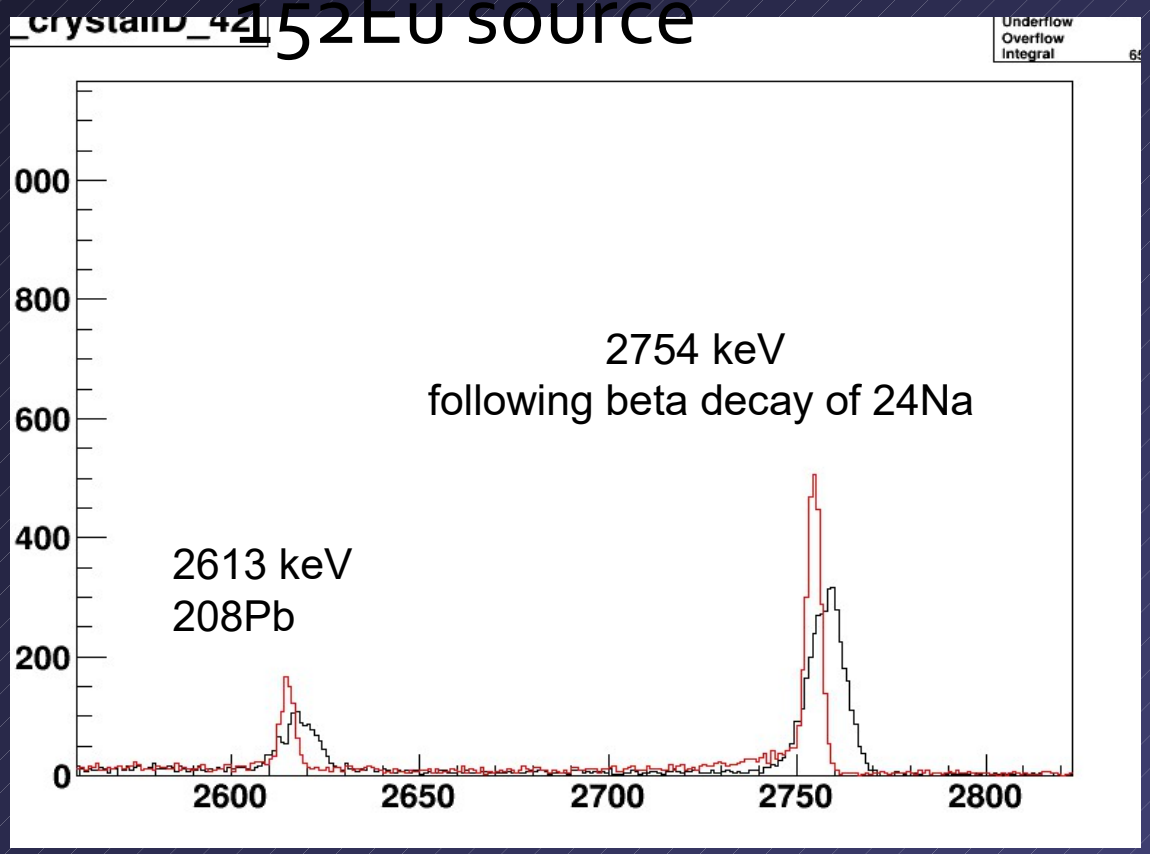
Recovery of one AGATA crystal (#42 – bad CORE signal)

Fitting of individual segments

152Eu source



152Eu source

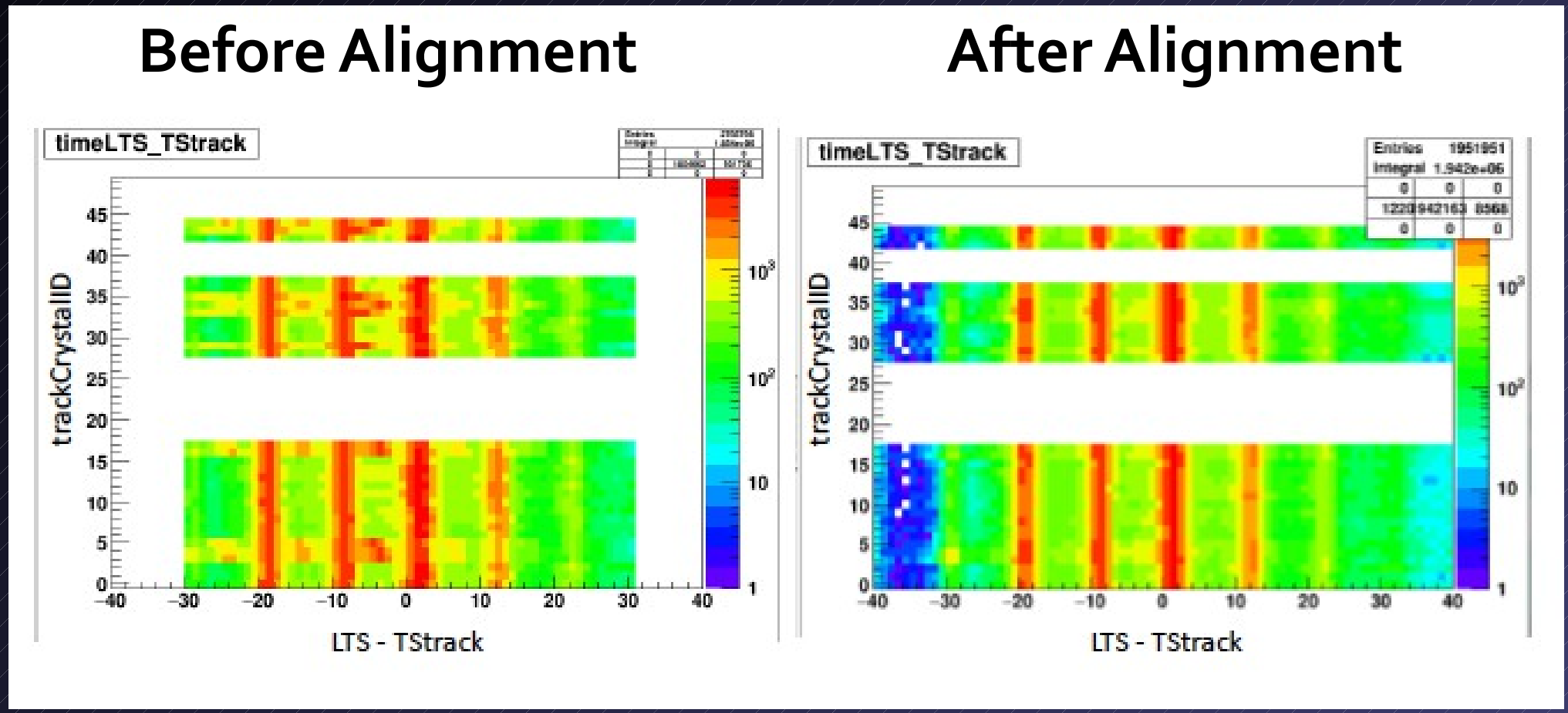


Energy from core of crystal #42

(corrected) Energy from segments of crystal #42

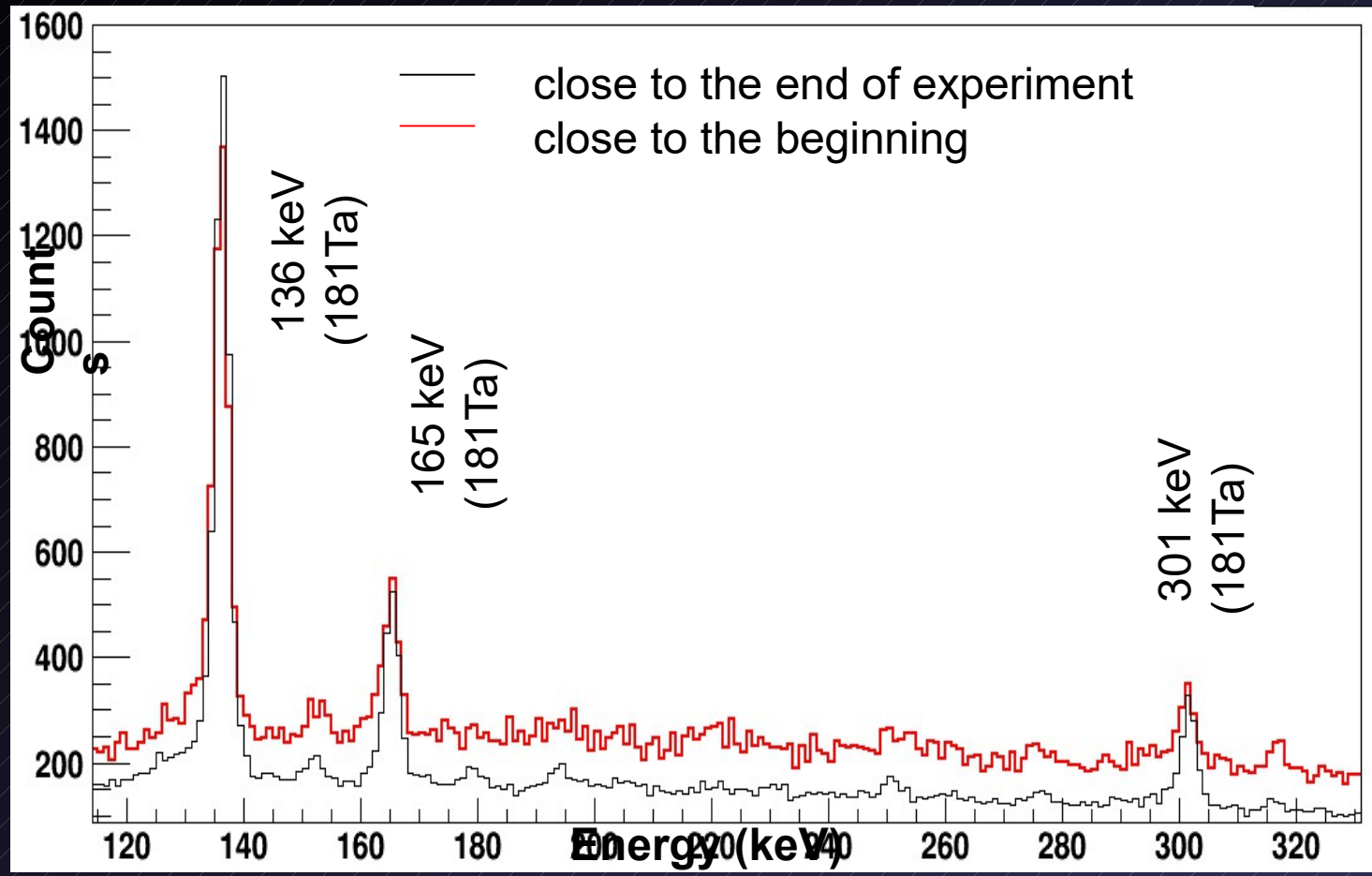
TIME alignment of AGATA crystals vs. VAMOS time signal

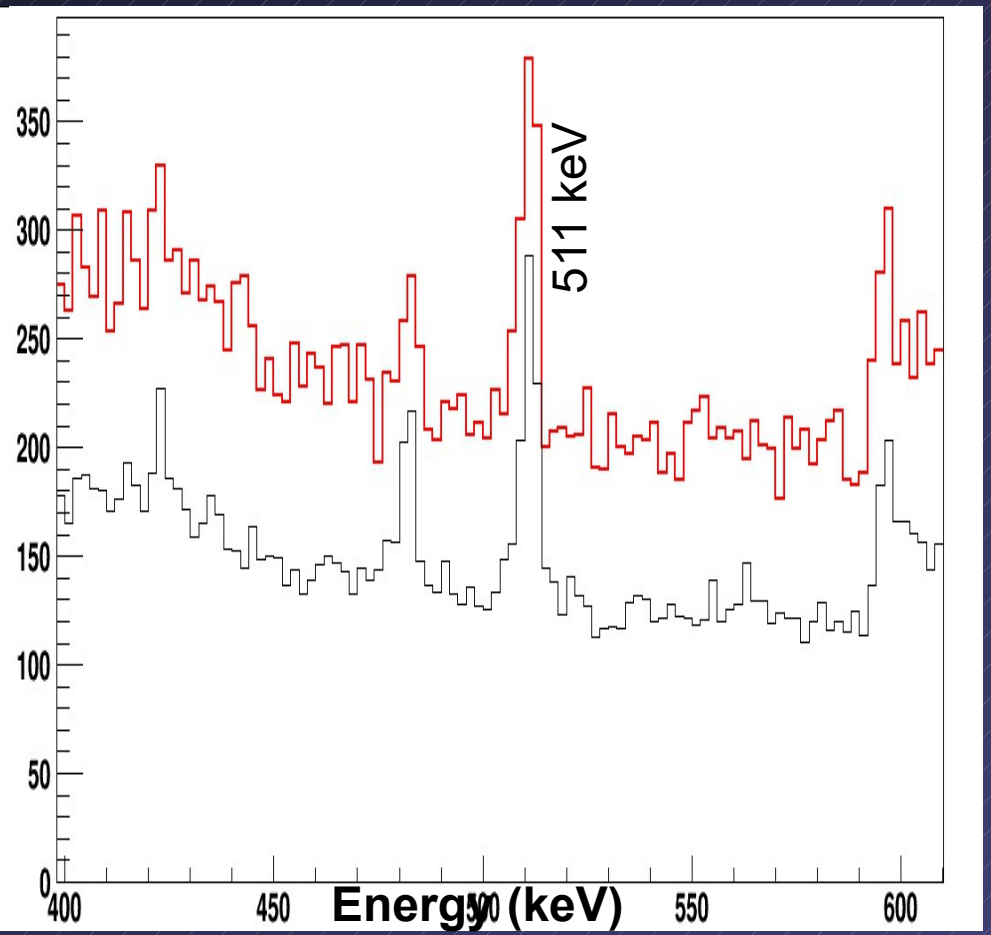
More precise gate on prompt coincidence – **better peak/background**



Time stamp (VAMOS) – Time stamp (AGATA)

NO evidence for drift over time for the energy spectra !!!





We are ready for a FULL sorting of the data ….