Study of the Order-to-chaos transition in ^{174}W with the AGATA-Demonstrator

V.Vandone[a], S. Leoni[a], G. Benzoni[a], D.Assanelli[a], N. Blasi[a], A. Bracco[a], S. Brambilla[a], C. Boiano[a], F. Camera[a], A. Corsi[a], F.C.L. Crespi[a], A. Giaz[a], B. Million[a], R, Nicolini[a], L. Pellegri[a], O.Wieland[a], G. De Angelis[b], A. Gottardo[b], D. Montanari[b], D. R. Napoli[b], E. Sahin[b], J.J.Valiente-Dobon[b], D. Bazzacco[c], E. Farnea[c], S. Lenzi[c], S. Lunardi[c], R. Menegazzo[c], D. Mengoni[c], C. Michelagnoli[c] , F. Recchia[c], C.A.Ur[c], A. Gadea[d], P. Bednarczyk[e], A. Maj[e], M. Kmiecik[e], B. Fornal[e], J. Grebosz[e], W. Mecynski[e], J. Styczen[e], M. Zieblinski[e], A. Atac[f], S. Akkoyun[f], J. Nyberg[g], P. Söderström[g]

[a] Università degli Studi e INFN sezione di Milano, Via Celoria 16, 20133, Milano.
[b] INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy.
[c] Università di Padova e INFN, sezione di Padova, Padova, Italy.
[d] IFIC, Valencia, Spain.
[e] The Niewodniczanski Institute of Nuclear Physics, PAN, Krakow, Poland.
[f] Department of Physics, Faculty of Science, Ankara University, Ankara, Turkey.
[g] Department of Physics and Astronomy, Uppsala University

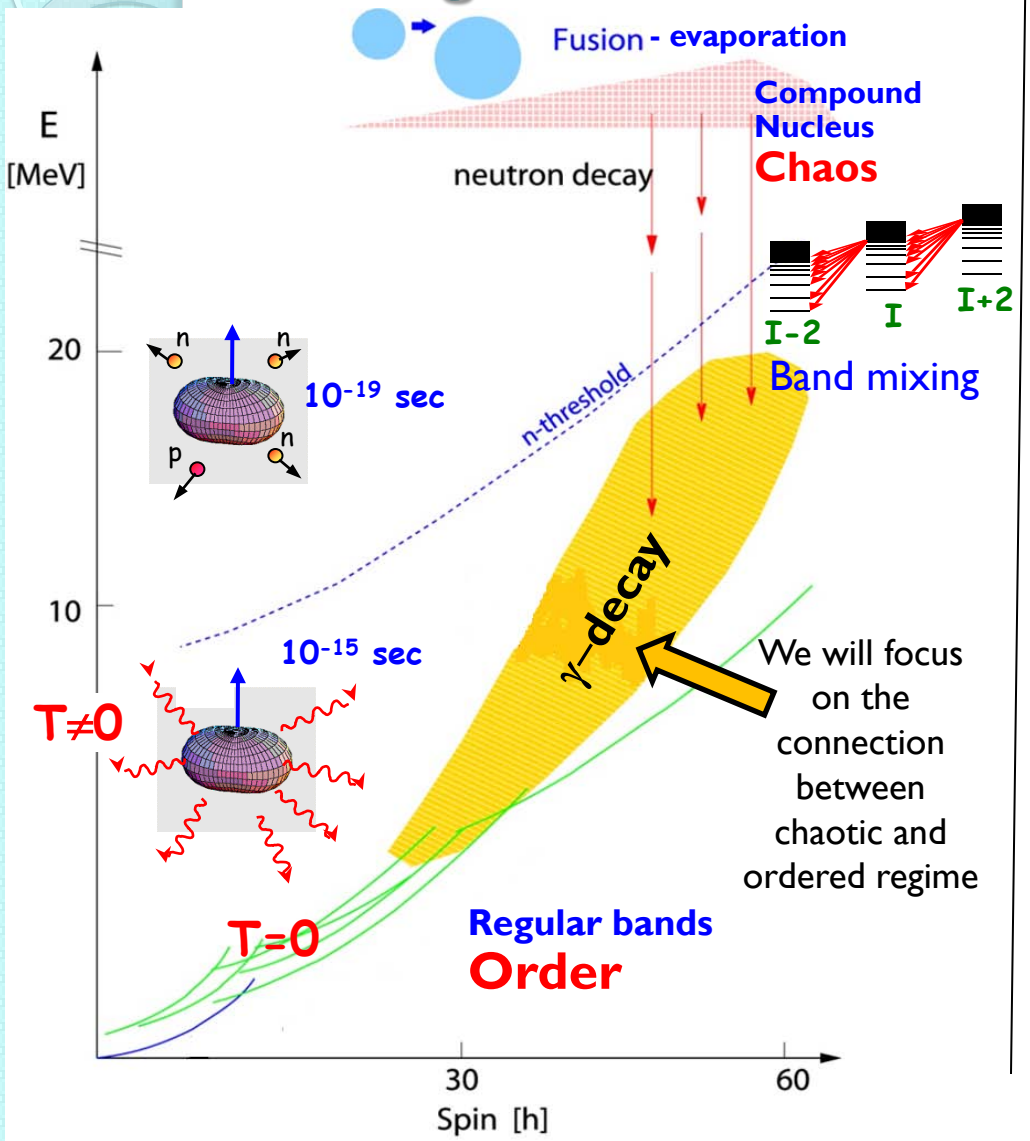
Outline

- Physics motivation
- Experimental setup & goals of the experiment
- Preliminary results of the data analysis
- Simulation
- Ankara collaboration

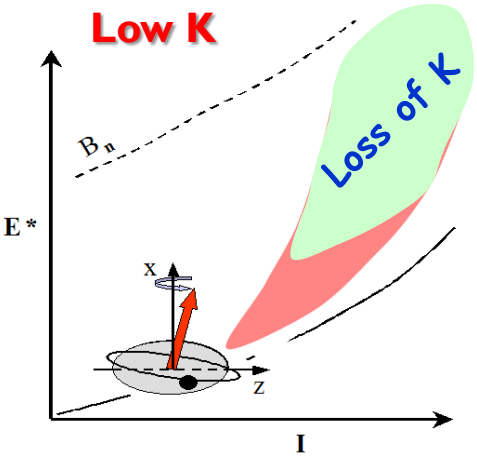
T ~ 0.5 MeV
I ≥ 20 ħ

Physics Motivation

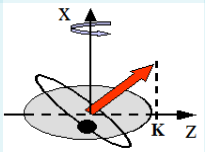
Warm rotating nuclei



Loss of selection rules on K with temperature

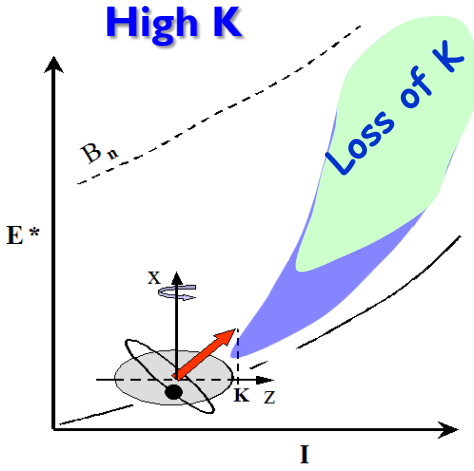


K-quantum number



K is robust at T=0 (K-isomers …)

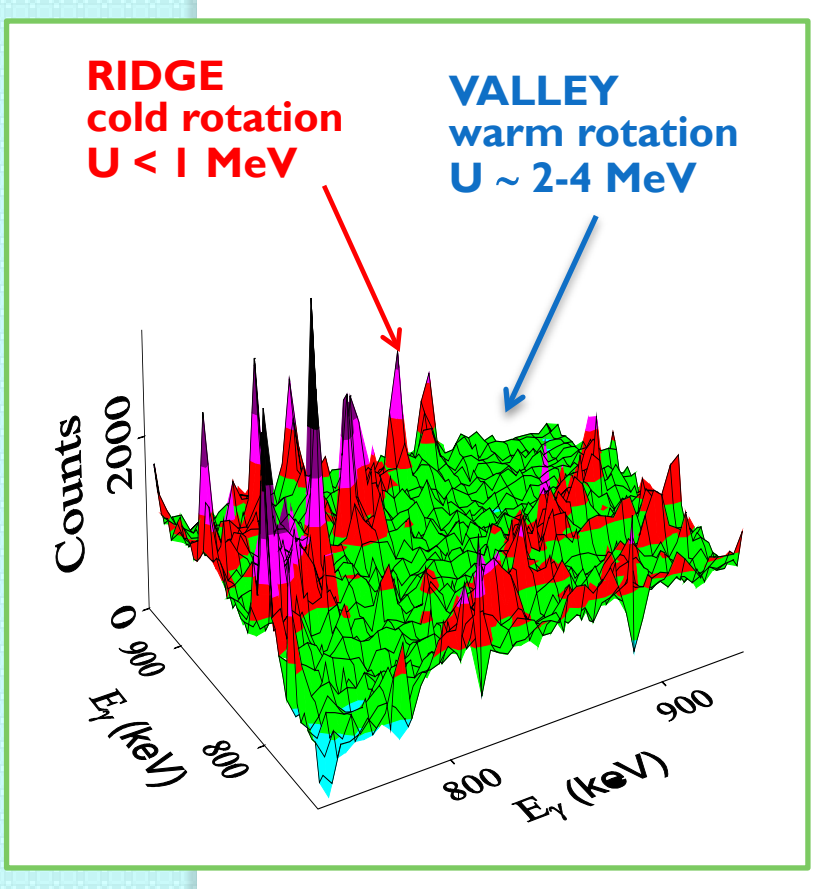
Comparative study of γ-decay flow gated by **Low-K** and **High-K** bands



Experimental analysis

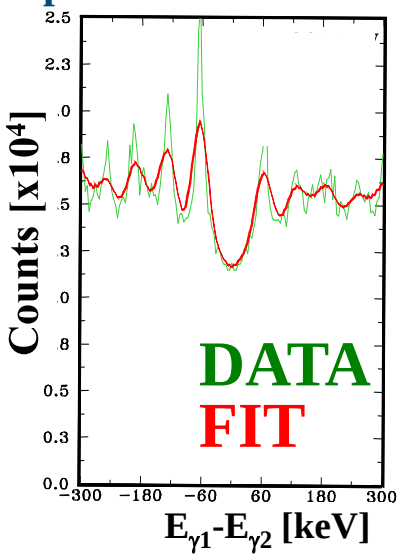
Quasi-Continuum
γ-γ coincidence spectra

possibility to separate contributions from:
-**Cold Rotation**
-**Warm Rotation**



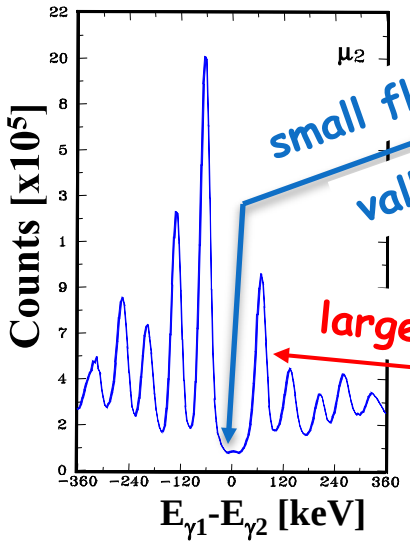
T. Døssing, S. Leoni et al., Physics Report 268 (1996)

Perpendicular Cuts



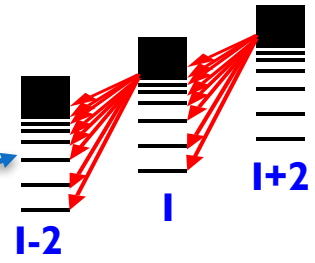
$\mu_2/\mu_1 = N_{eve}/N_{band} + 1$

quantitative information:
# of rotational bands

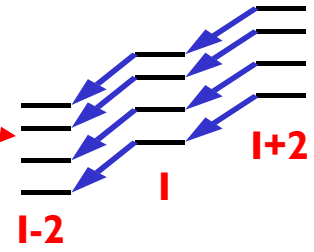


small fluct.
valley

large fluct.
ridge



many bands

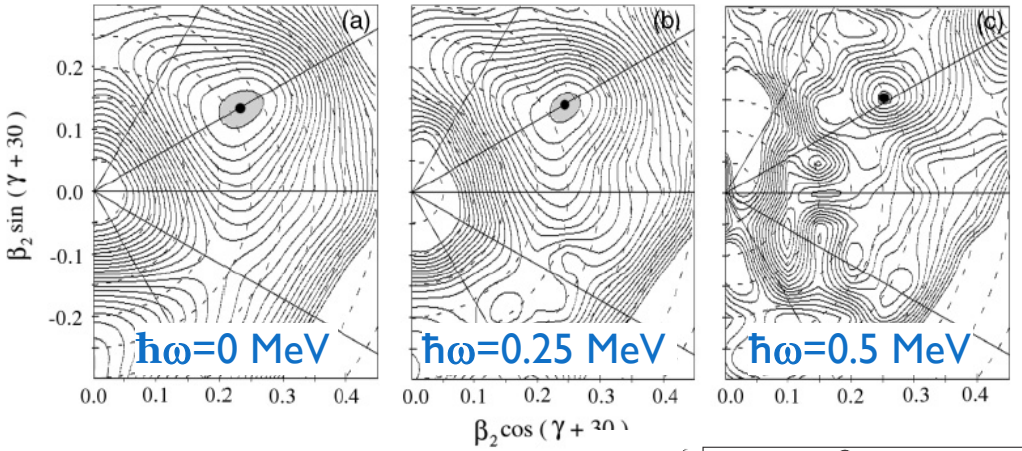


Few bands

Physics case: ^{174}W

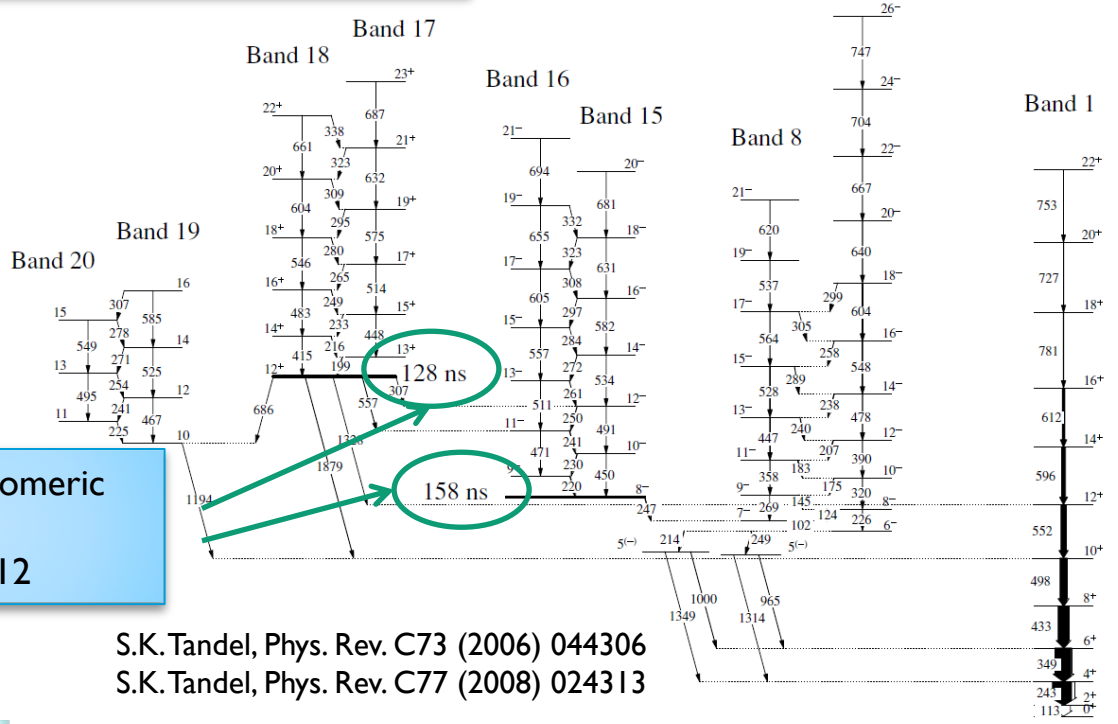
^{174}W

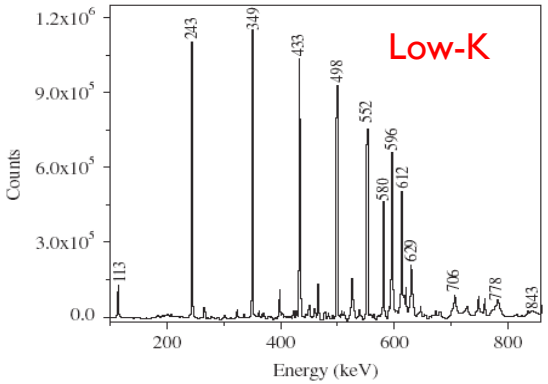
TRS Calculations:
Stable prolate rotor up to high frequency confirmed by experiments

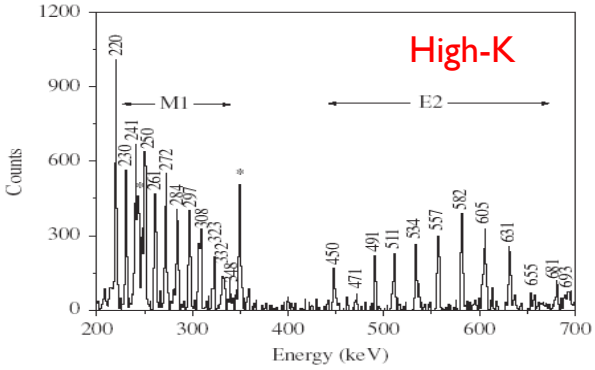


Fusion-evaporation reaction
^{50}Ti (@217MeV) + ^{128}Te → ^{174}W + 4n
Backed target experiment (^{nat}Pb)
Warm rotation up to U ~ 4 MeV
High spin ~ 60ħ

$^{174}_{74}W_{100}$







2 high-K isomeric states:
K=8 & K=12

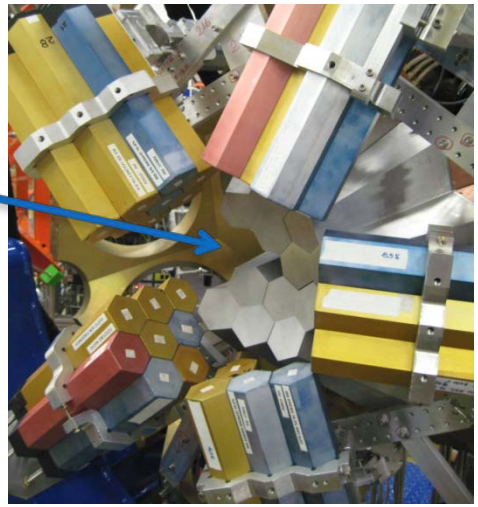
S.K. Tandel, Phys. Rev. C73 (2006) 044306
S.K. Tandel, Phys. Rev. C77 (2008) 024313

Experimental setup : AGATA + Helena

Experiment performed last July at Laboratori Nazionali di Legnaro of INFN

AGATA Demonstrator:
Distance from target = 14cm

2 and 3 folds: $\varepsilon_{2\gamma}$=30%, $\varepsilon_{3\gamma}$=10%
(M_γ = 30)



HELENA:
27 detectors – 5 clusters of BaF_2 (3"×3", exagonal)
Distance from target = 15cm
Total solid angle: 25% of 4 π
Total efficiency: 16% @ 500keV

Goals of the experiment

Populate ^{174}W at the **highest possible spins** (≥60ħ), in order to make:

- **Statistical analysis of the ridge-valley structures in the γ–γ matrices**, to estimate the number of low-K and high-K bands and their correlation;
- **Lifetime analysis of the excited rotational bands** (measure of the quadrupole moment of the quasi-continuum structures);

By-products:

- **Study of the dependence of the GDR-width on the angular momentum;**
- **Study of AGATA response to high energy γ–rays:**
  - **Tests on n-γ discrimination methods** developed by Ankara group
  - Investigations on the **possibility of improving HPGe detectors time resolution** through Pulse Shape Analysis techniques

Detectors calibration

Already show at AGATA week in Lion (Nov 2010)

AGATA calibration

AmBe(Ni) source
Energy calibration up to 9MeV using 20 gamma lines for the core and 7 for the segments.

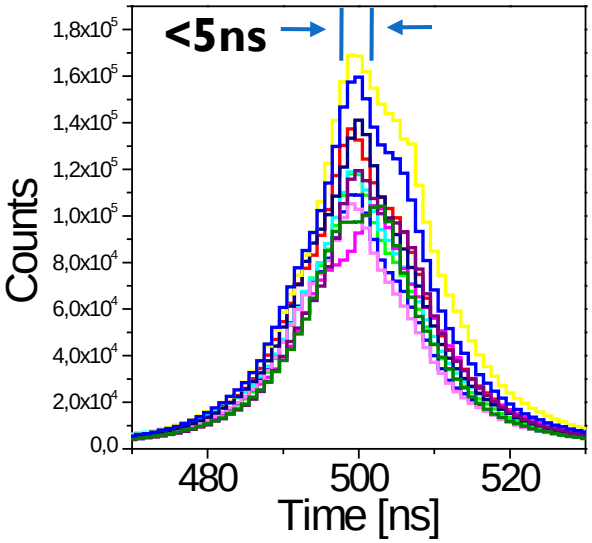
No gain fluctuation (within 3‰)
Very stable detectors in 7-days measurements

Time alignment of the AGATA detectors

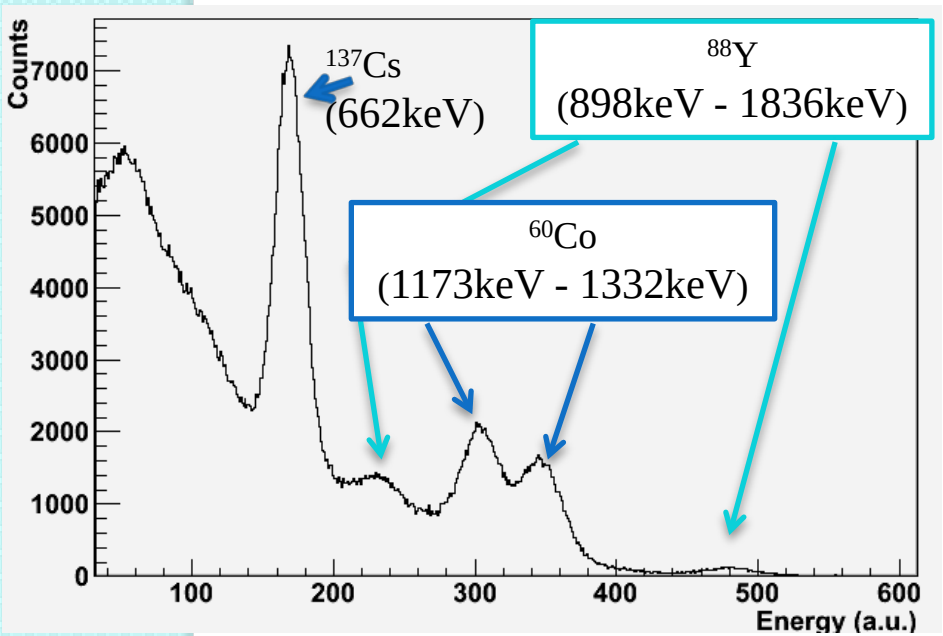
First alignment of Time spectra using the keyword *TimestampCorrect*

+

Fine alignment



Helena calibration



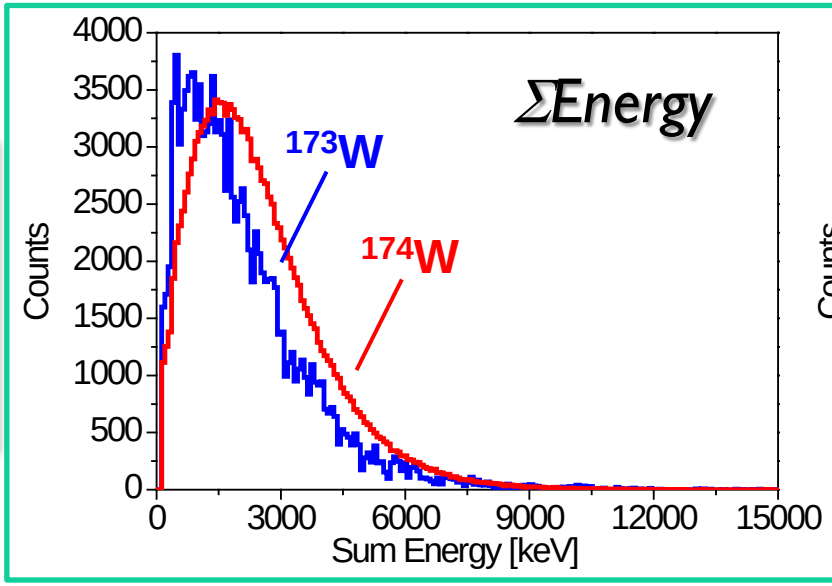
Calibration up to 9MeV using AmBe-Ni source

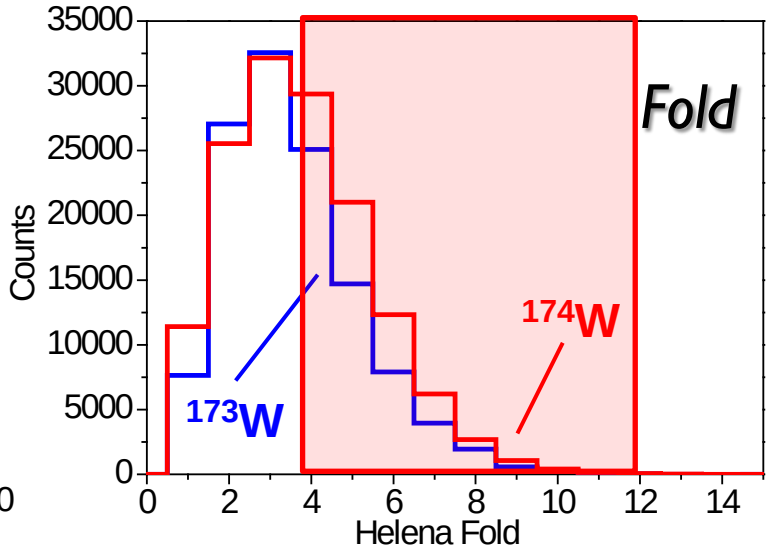
3 scintillators have large gain fluctuations (>10%) due to electronic instability

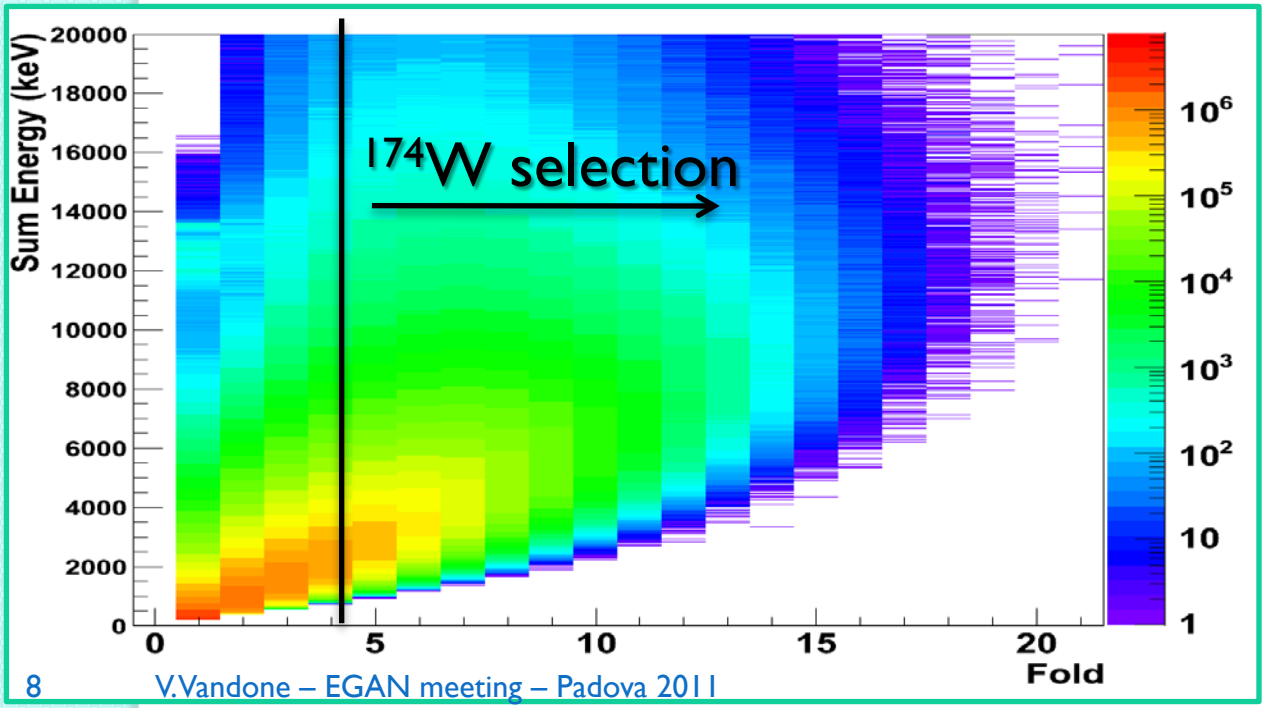
Added correction factors in the Sort Program

Helena BaF_2 Multiplicity Filter in AGATA

Separate the contribution of the 2 evaporation residues





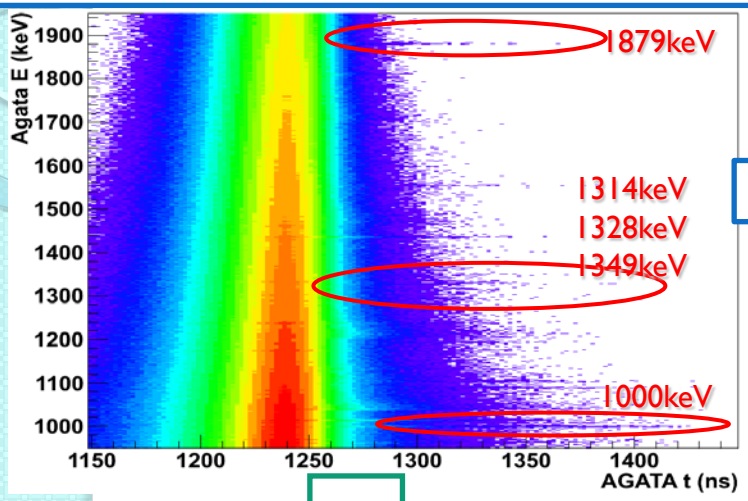


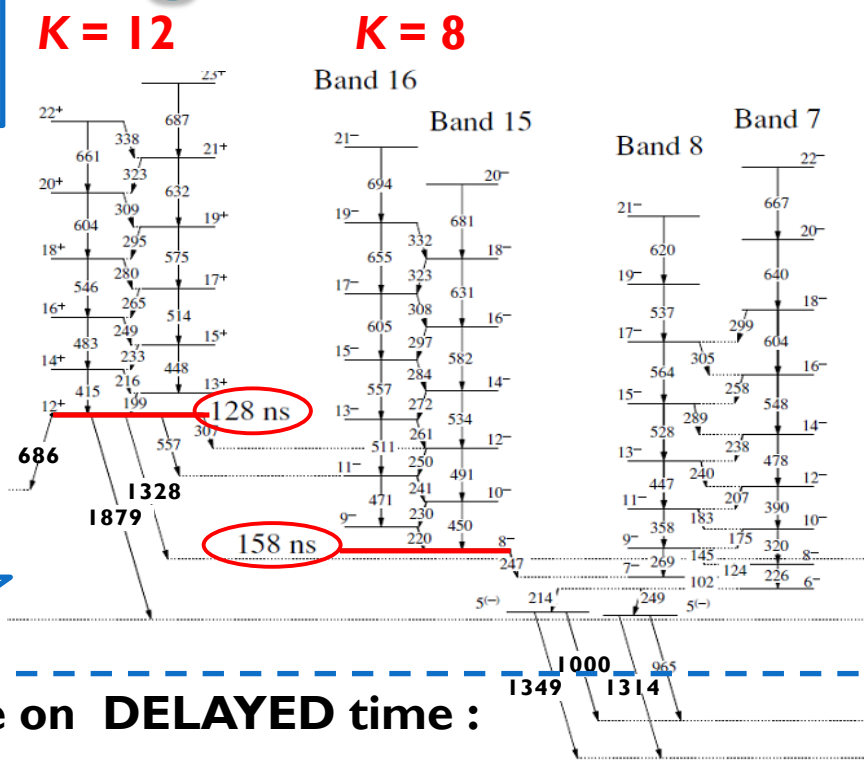
Condition to select ^{174}W:
Helena fold ≥ 4

Focus on high-spin, high-excitation energy

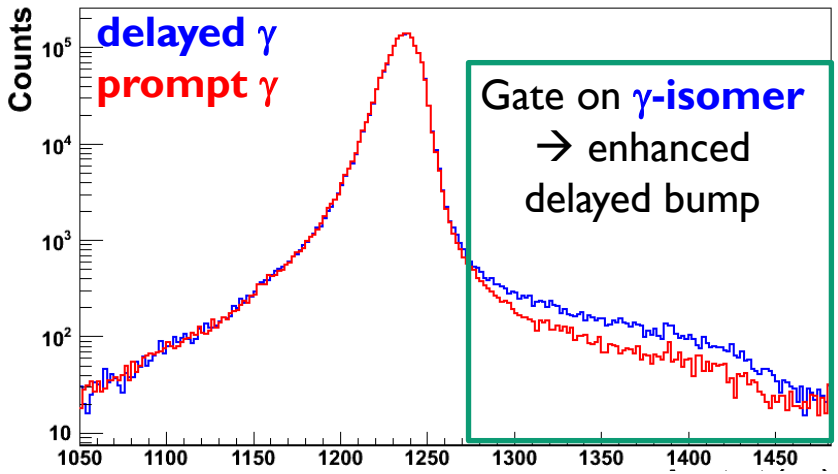
Time information for high-*K* selection

Selection of the high-K bands using time information: delayed gammas from isomeric states



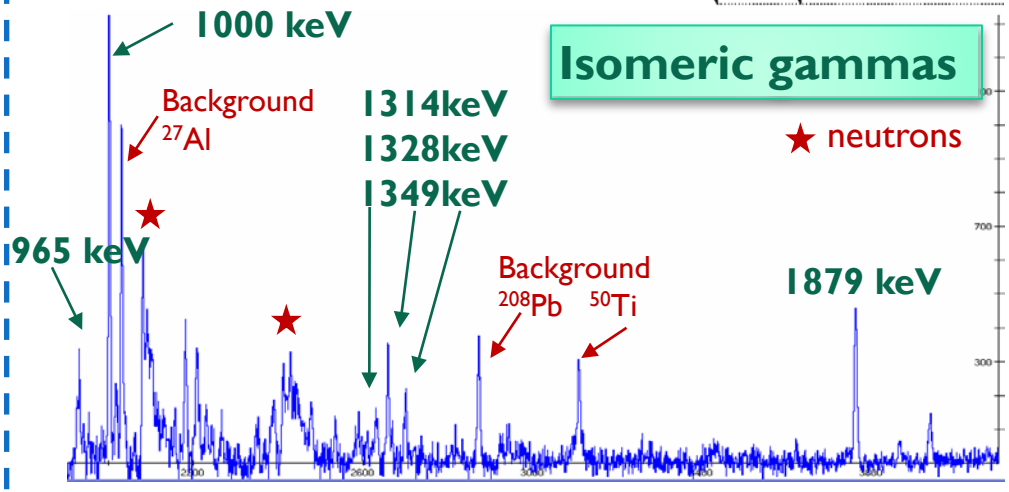


Gate on ENERGY :

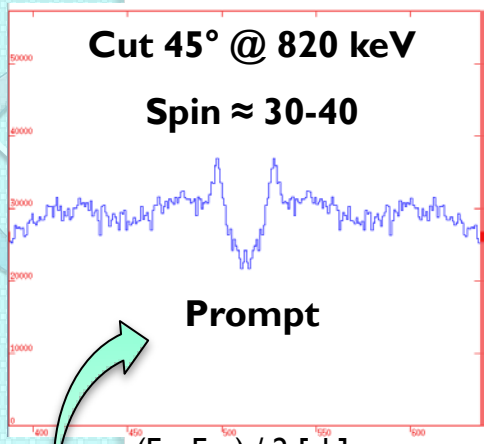


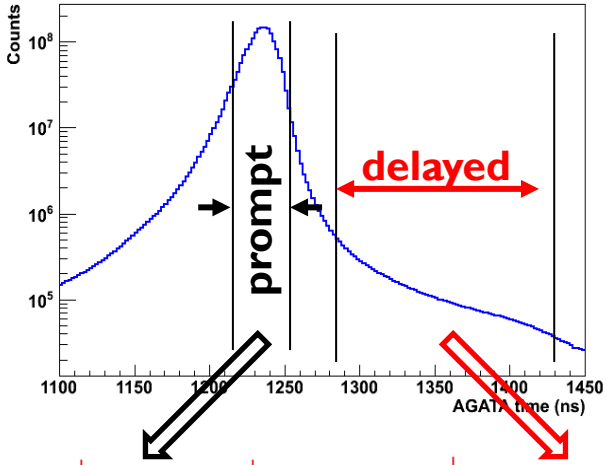
AGATA vs Helena time-spectrum

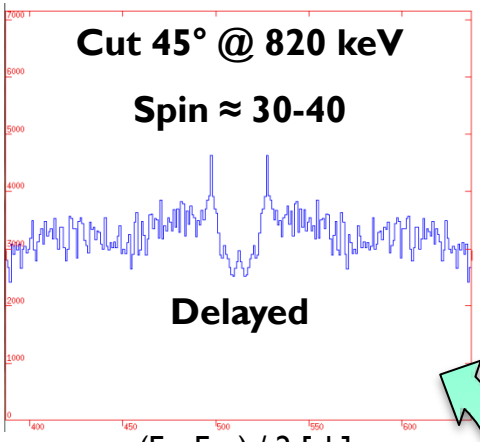
Gate on DELAYED time :

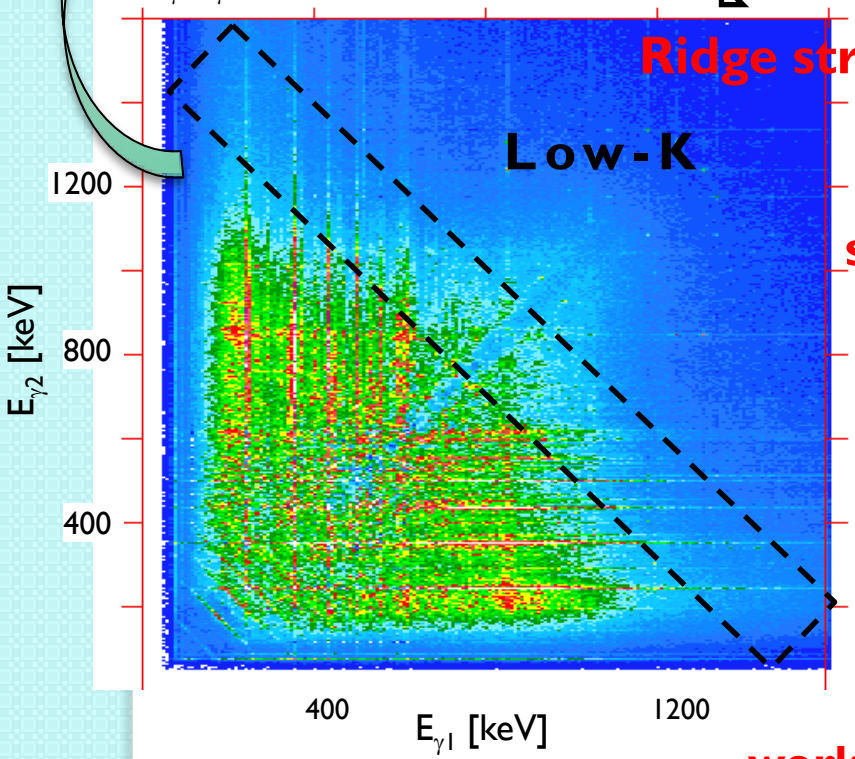


Quasi-Continuum γ-coincidence spectra





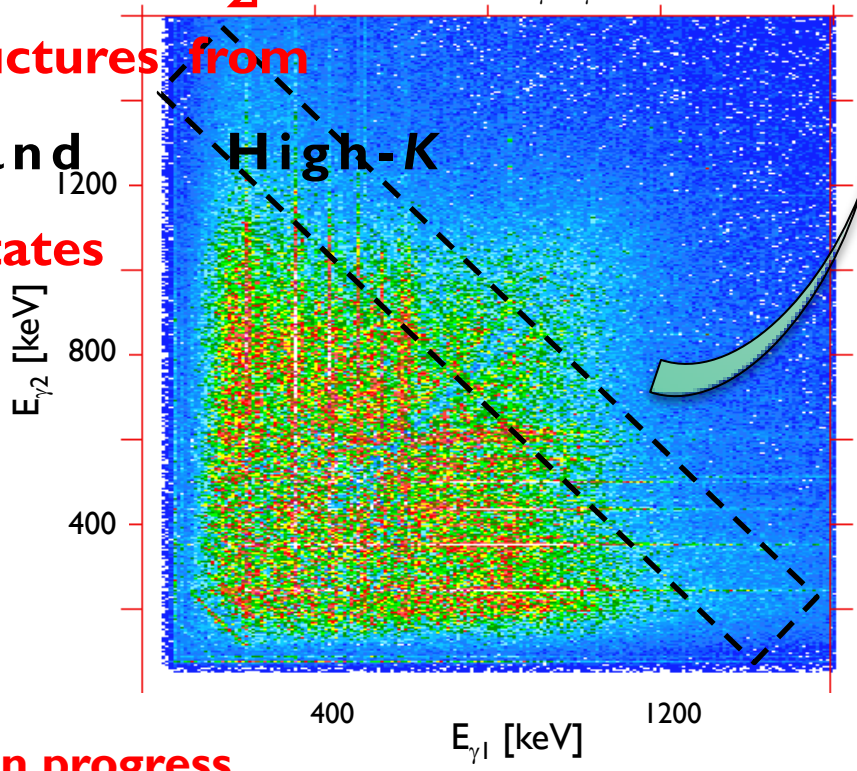




Ridge structures from

and

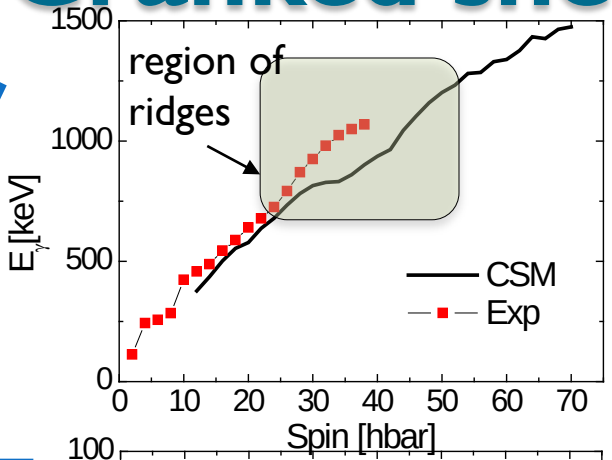
states

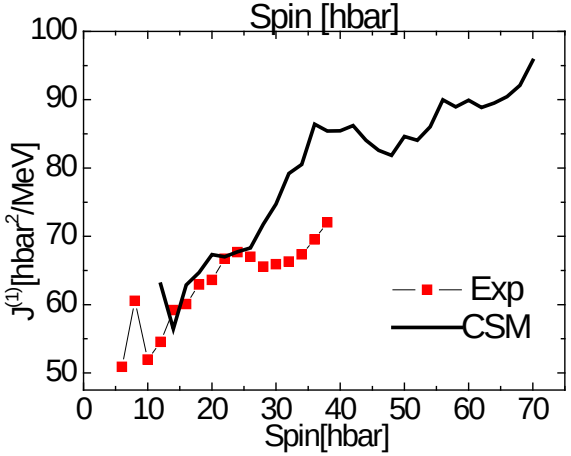


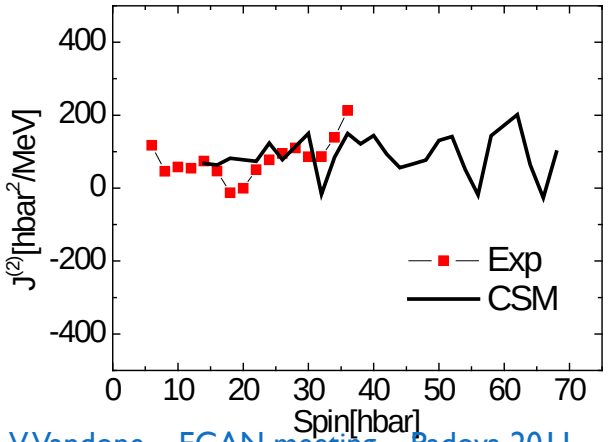
work in progress…

Cranked shell model calculations

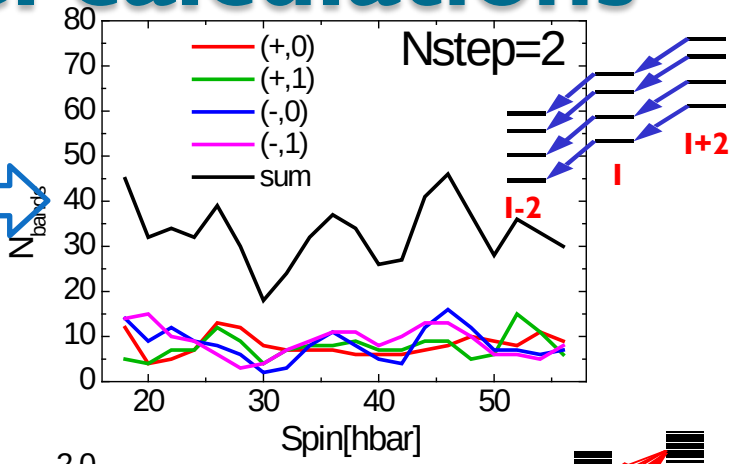
Nuclear structure features: input for the simulation



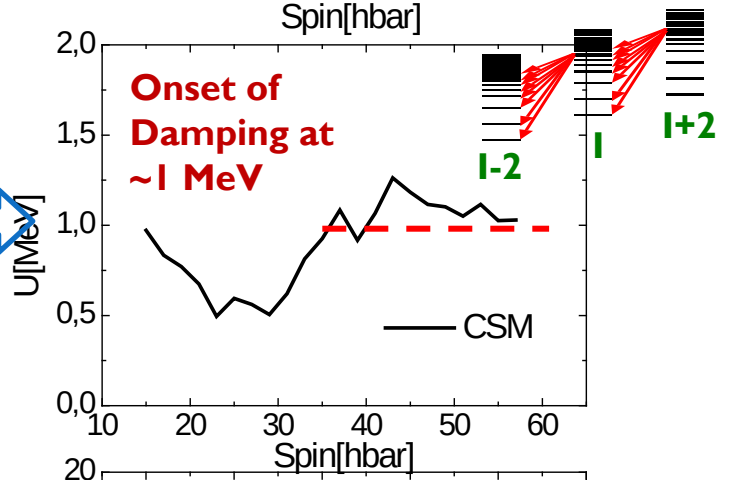




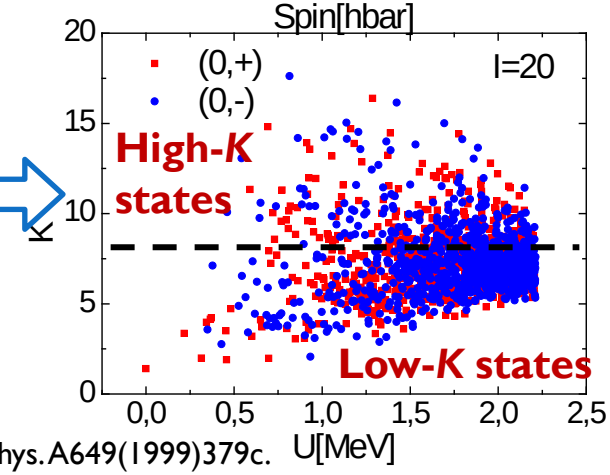
~ 8 bands / configuration Total: 30 bands up to 1 MeV



Ridge populated up to 1 MeV

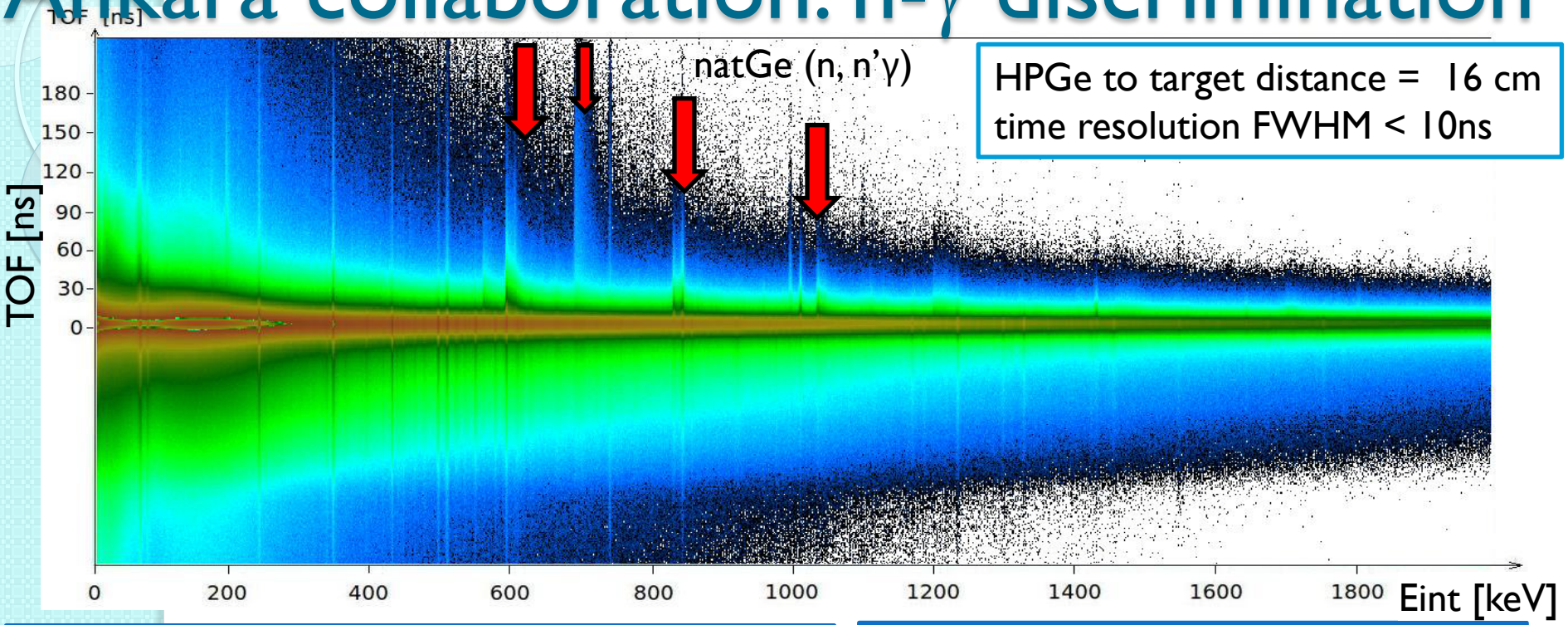


<*K*>≈6 with large fluctuation. U>1MeV *K*-mixing



M. Matsuo et al., Nuc. Phys. A649(1999)379c.

Ankara collaboration: n-γ discrimination



TECHNIQUES (see Senyigit's talk)

Combination of:

- **TOF gating** (Banana gate)
- rejection of neutrons through **Tracking** :
  - 1st interaction E-threshold (E_n < 50keV)
  - direction of incoming γ
  - Figure of merit (γ :0<F<1 while n:F>1)

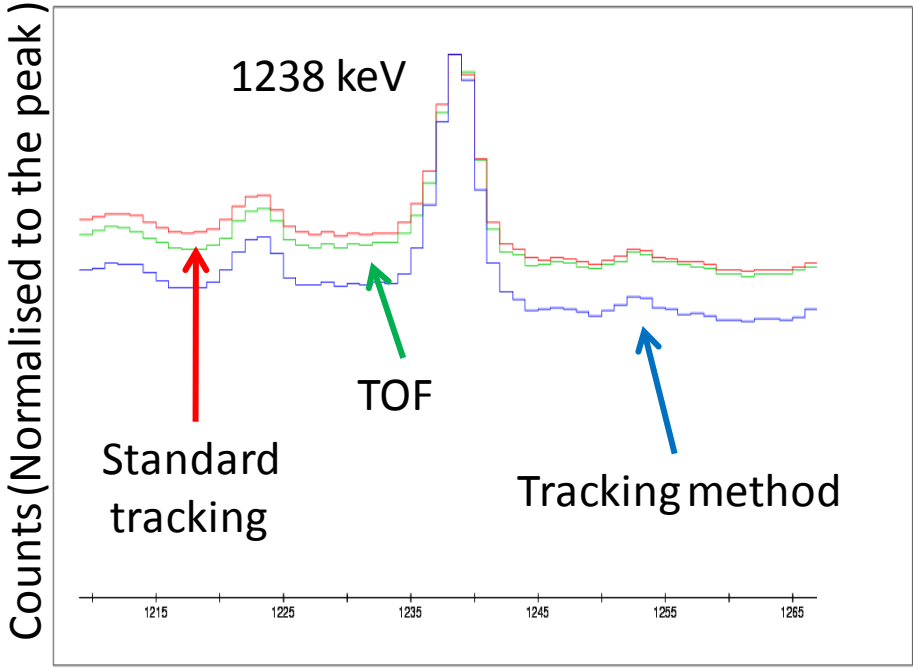
RESULTS

Only TOF gating P/B value is increased by a factor of 1.2 while keeping 80% of the ε. (due to small distances)

With tracking **P/B values are increased by a factor of 1.2 to 1.6 while keeping 95% and 60% of the photo peak efficiency (ε).**

S. Akkoyun, PHD Thesis, Ankara University - A. Atac et al. NIM A, 607 (2009)

Ankara collaboration: n-γ discrimination



HPGe to target distance = 16 cm
time resolution FWHM < 10ns

TECHNIQUES (see Senyigit's talk)

Combination of:

- **TOF gating** (Banana gate)
- rejection of neutrons through **Tracking** :
  - 1st interaction E-threshold (E_n < 50keV)
  - direction of incoming γ
  - Figure of merit (γ :0<F<1 while n:F>1)

RESULTS

Only TOF gating P/B value is increased by a factor of 1.2 while keeping 80% of the ε. (due to small distances)

With tracking **P/B values are increased by a factor of 1.2 to 1.6 while keeping 95% and 60% of the photo peak efficiency (ε).**

S. Akkoyun, PHD Thesis, Ankara University - A. Atac et al. NIM A, 607 (2009)

Summary

- Study of order-to-chaos transition in ^{174}W
- Setup: AGATA Demonstrator + Helena Array
- Fusion-evaporation reaction of ^{50}Ti on ^{128}Te target
- Preliminary results : evidence of ridge-valley structures both for low and for high-*K* bands
- Simulation at the very first stage

➢ Extract the number of low-*K* and high-*K* bands and their correlation

➢ Compare the experimental result with theory calculations

Thank you for your attention