Evidence for enhanced collectivity near N=Z=50

Rauno Julin
on behalf of the
KTH Stockholm group
Mikael Sandzelius, Bo Cederwall, Arne Johnson et al.

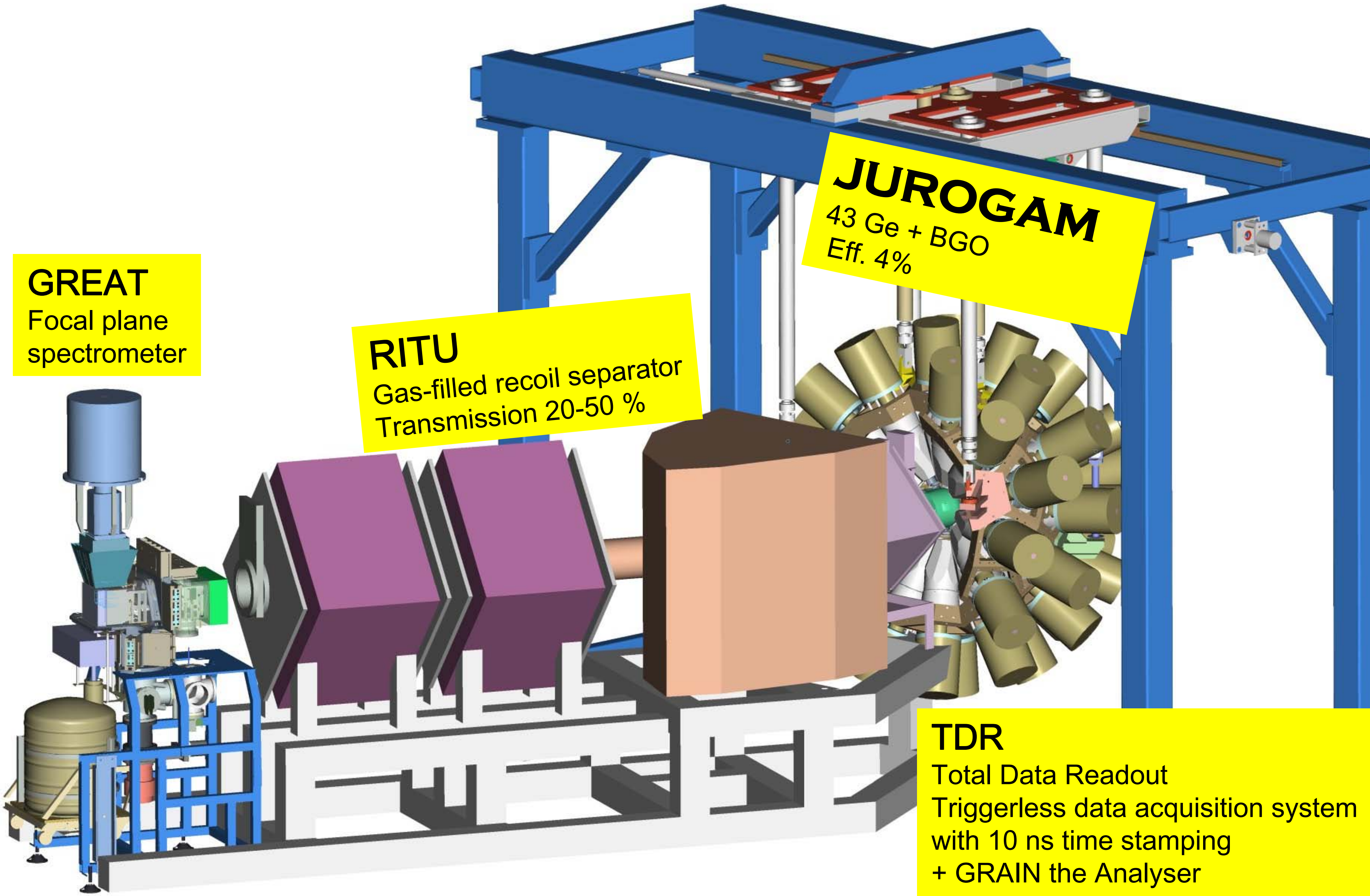
Gammapool Workshop
Paris
28 May 2008

Kungl Tekniska Högskolan

Outline

- Recoil-Decay-Tagging (RDT) of heavy vs. light nuclei
- RDT study of ^{106}Te (Z = 52, N = 54)
- RDT study of ^{110}Xe (Z = 54, N = 56) and ^{109}I (Z = 53, Z = 56)
- Level systematics $\rightarrow$ enhanced collectivity

RDT Instrumentation at JYFL



Recoil – Decay – Tagging of Heavy Nuclei vs. Medium-Heavy and Light Nuclei

Heavy nuclei - transfermiums

Produced in asymmetric cold-fusion reaction – $X(^{48}Ca,2n)Y$

→ ideal for RITU

→ Only one reaction channel open

→ Total compound cross-section down to 50 mb

→ I_{beam} up to 30pnA on a 0.5mg/cm^2 target in in-beam runs

Fission dominates: 100000 : 1

→ I_{beam} limited by the Ge rate

→ Very low focal-plane rate

→ Enables long $t_{1/2}$ – α – tagging

Medium-heavy and light neutron-deficient nuclei

Produced in symmetric fusion-evaporation reactions

→ Difficulties with a gas-filled separator

No fission – large number of fusion ev. reaction channels

→ High recoil rate ~ 1kHz/1pnA on a 0.5mg/cm^2 target

→ Keep the reaction cold !

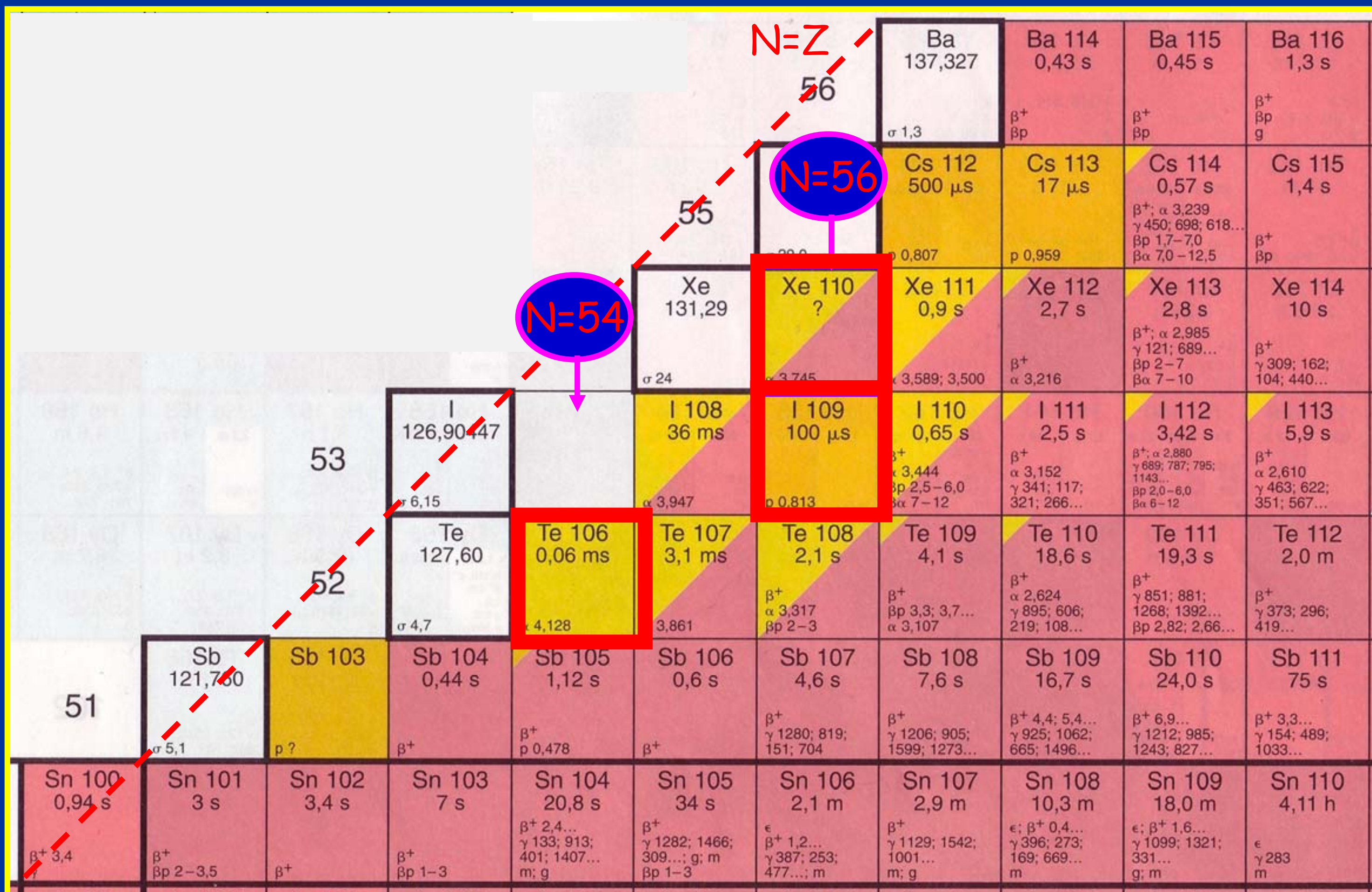
→ Limited possibilities for short-$t_{1/2}$ p- or α- or β tagging

Reminder:

In-beam gamma-ray experiment
→ 10 pnA on a 0,5 mg/cm^2 target

10 nanobarn
→ 4 reactions per hour !!

RDT experiments for ^{106}Te, ^{110}Xe and ^{109}I

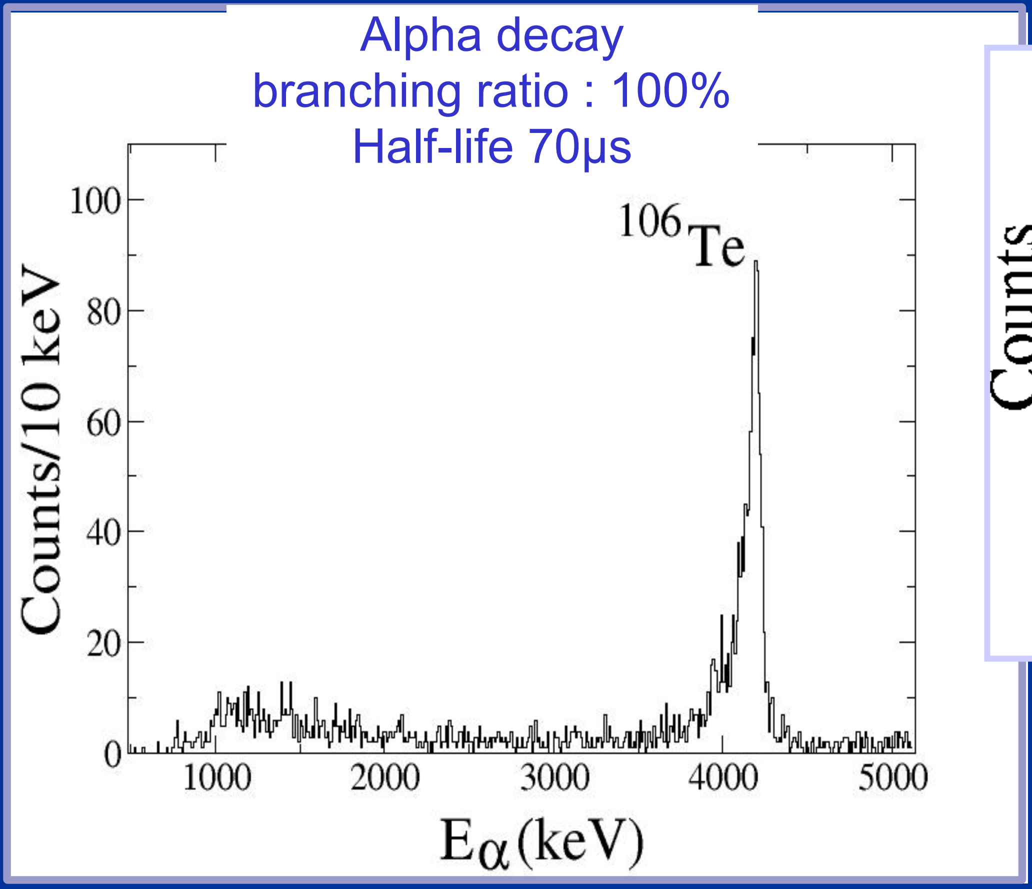


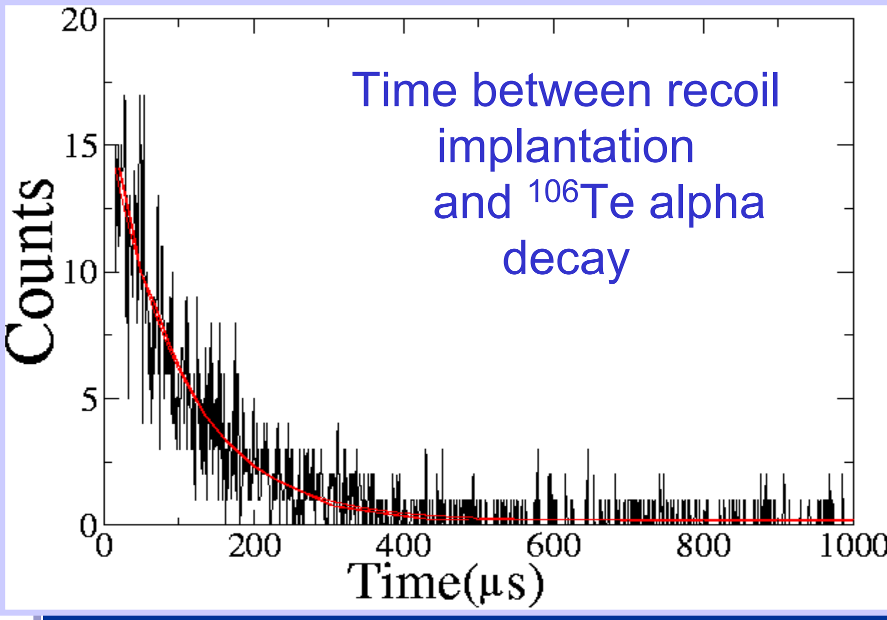
KUNGL TEKNISKA HÖGSKOLAN

$^{54}Fe + ^{54}Fe \rightarrow ^{106}Te + 2n$
(E_b= 182 MeV, I_b= 10 pnA, 5 days)

^{106}Te

RITU Focal plane:



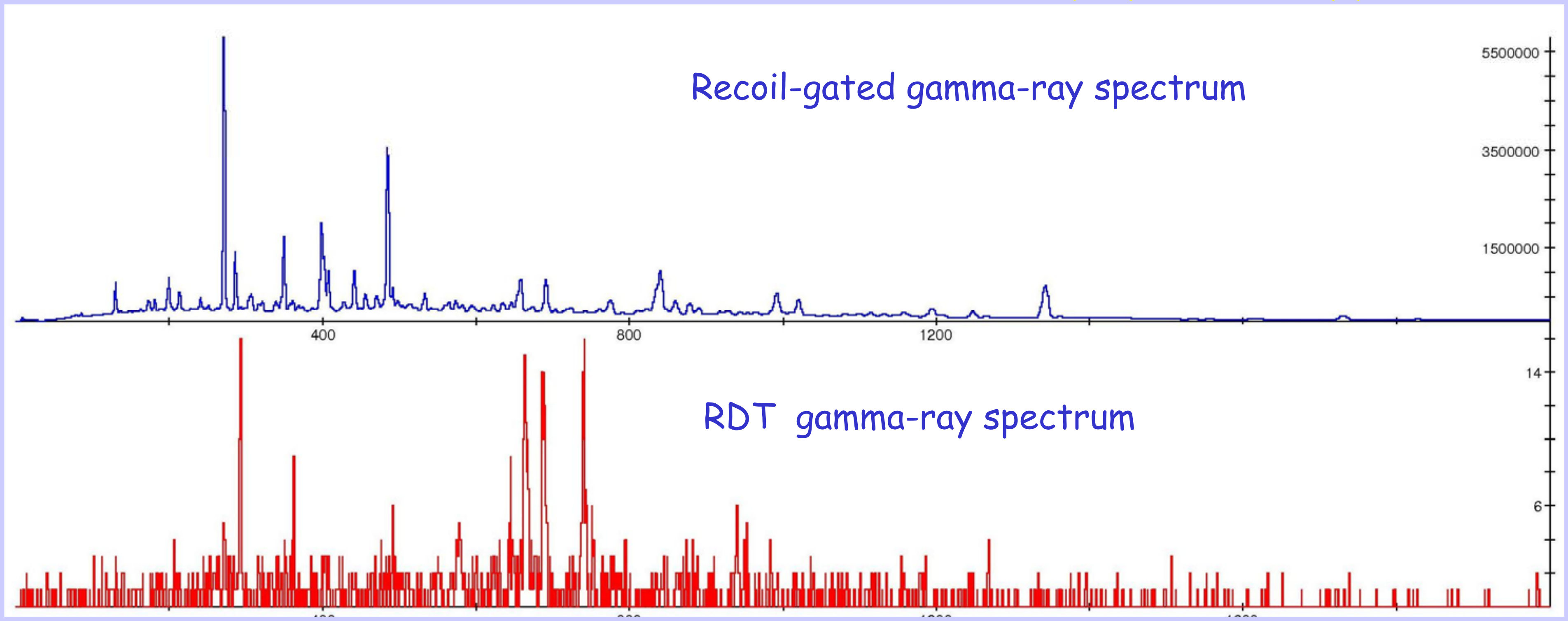


B. Hadinia, *et al.*, Phys. Rev. C 72, 041303 (2005)

^{106}Te gamma rays

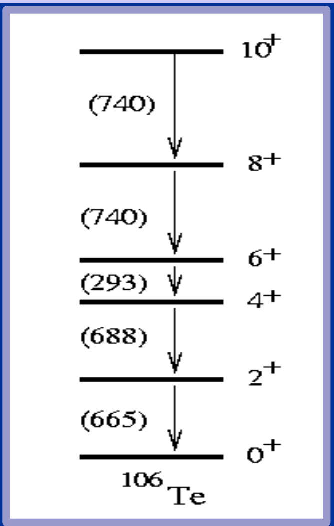
σ = 25 nb – (Then) a new limit for in-beam γ-ray spectroscopy!

^{106}Te



Selectivity: ~10^{-7}

Tentative level structure of ^{106}Te

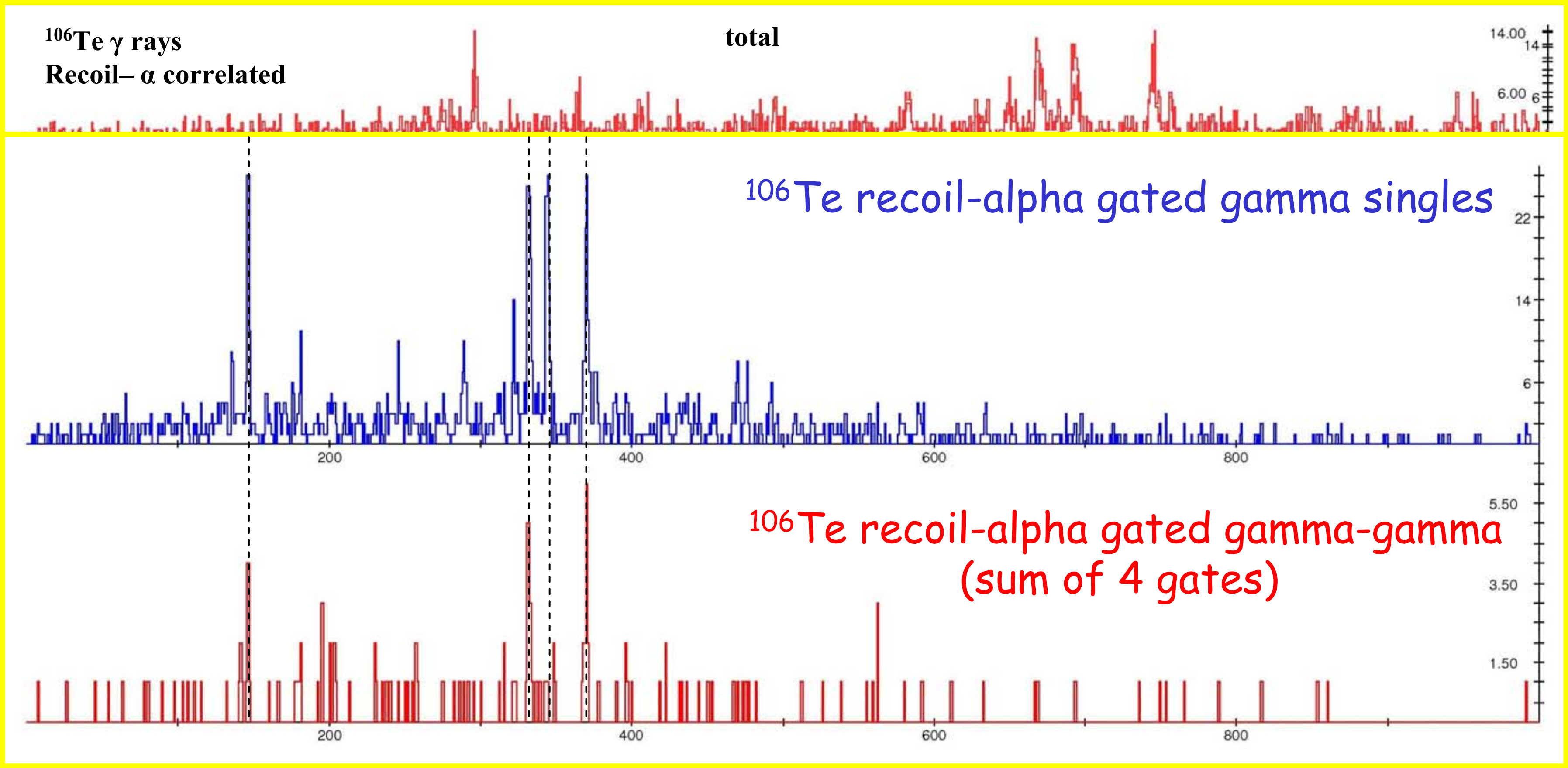


B. Hadinia, *et al.*, Phys. Rev. C 72, 041303 (2005)

KUNGL TEKNISKA HÖGSKOLAN

Gamma-gamma coincidences at σ ~ 25 nb

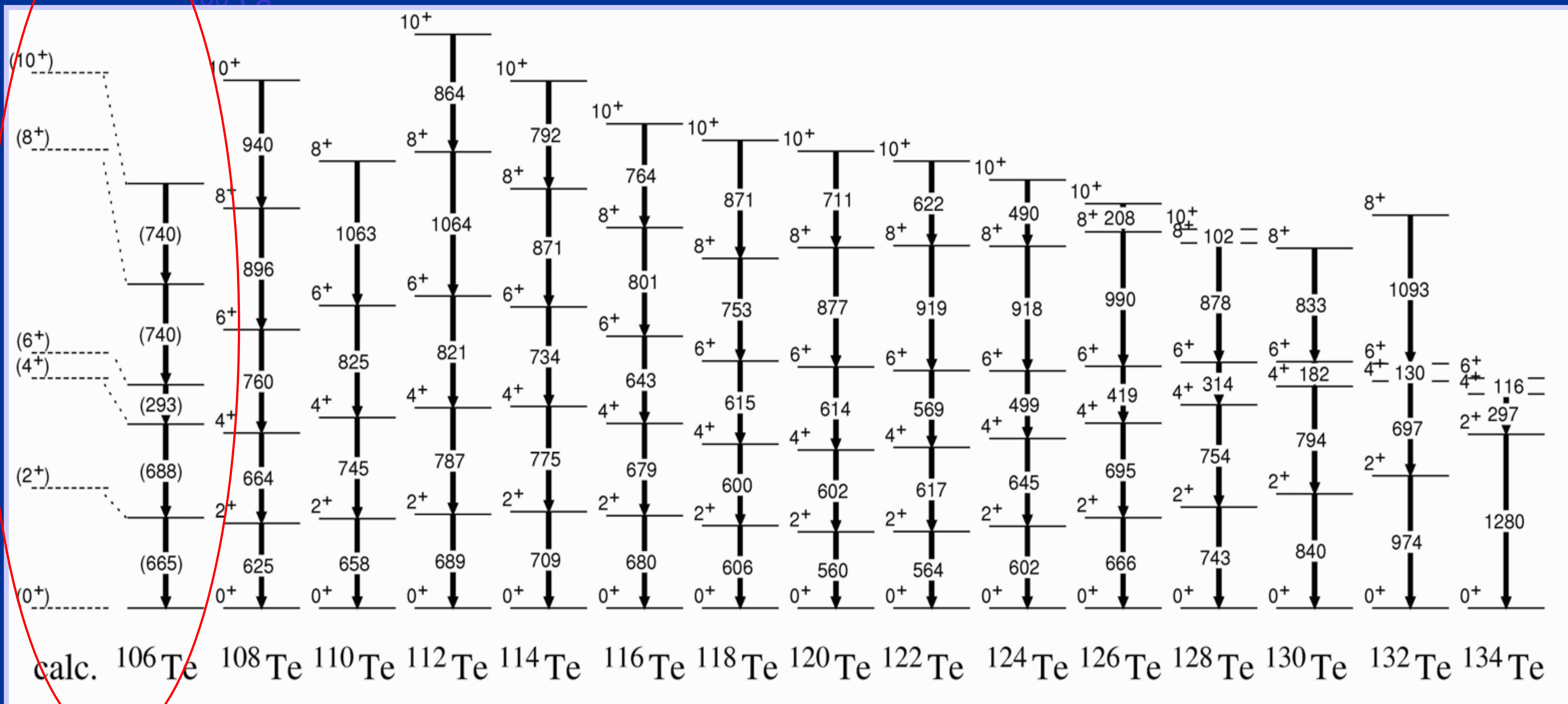
^{106}Te



B. Hadinia, *et al.*, Phys. Rev. C 72, 041303 (2005)

Te energy systematics and S.M. calculations

^{106}Te



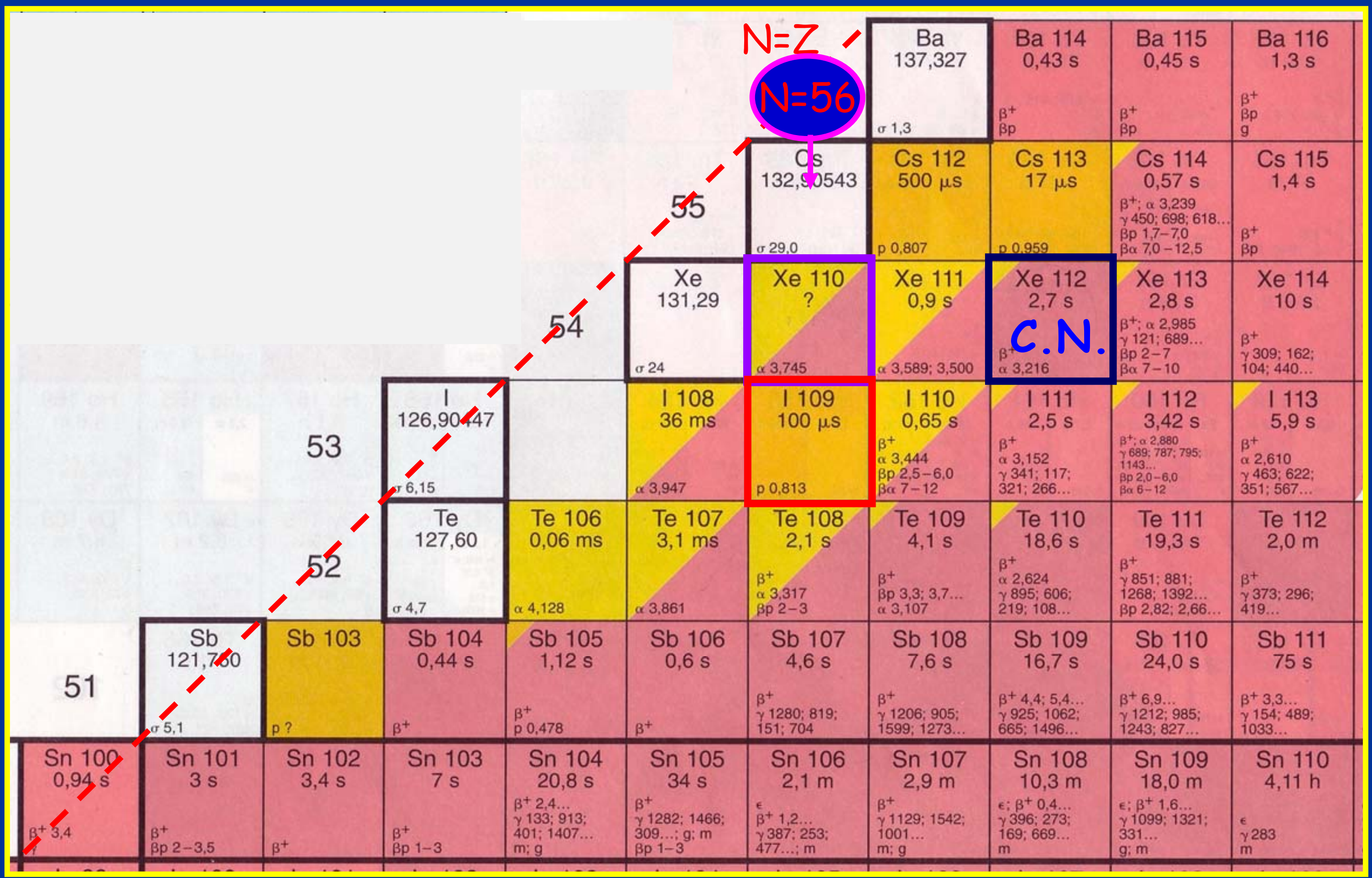
B. Hadinia, *et al.*, Phys. Rev. C 72, 041303 (2005)

$^{54}Fe + ^{58}Ni \rightarrow$ $^{110}Xe + 2n$ (σ ~ 50 nb)

^{109}I + p2n (σ ~ 10 μb)

(E_b = 195 MeV, I_b = 10 pnA)

^{110}Xe

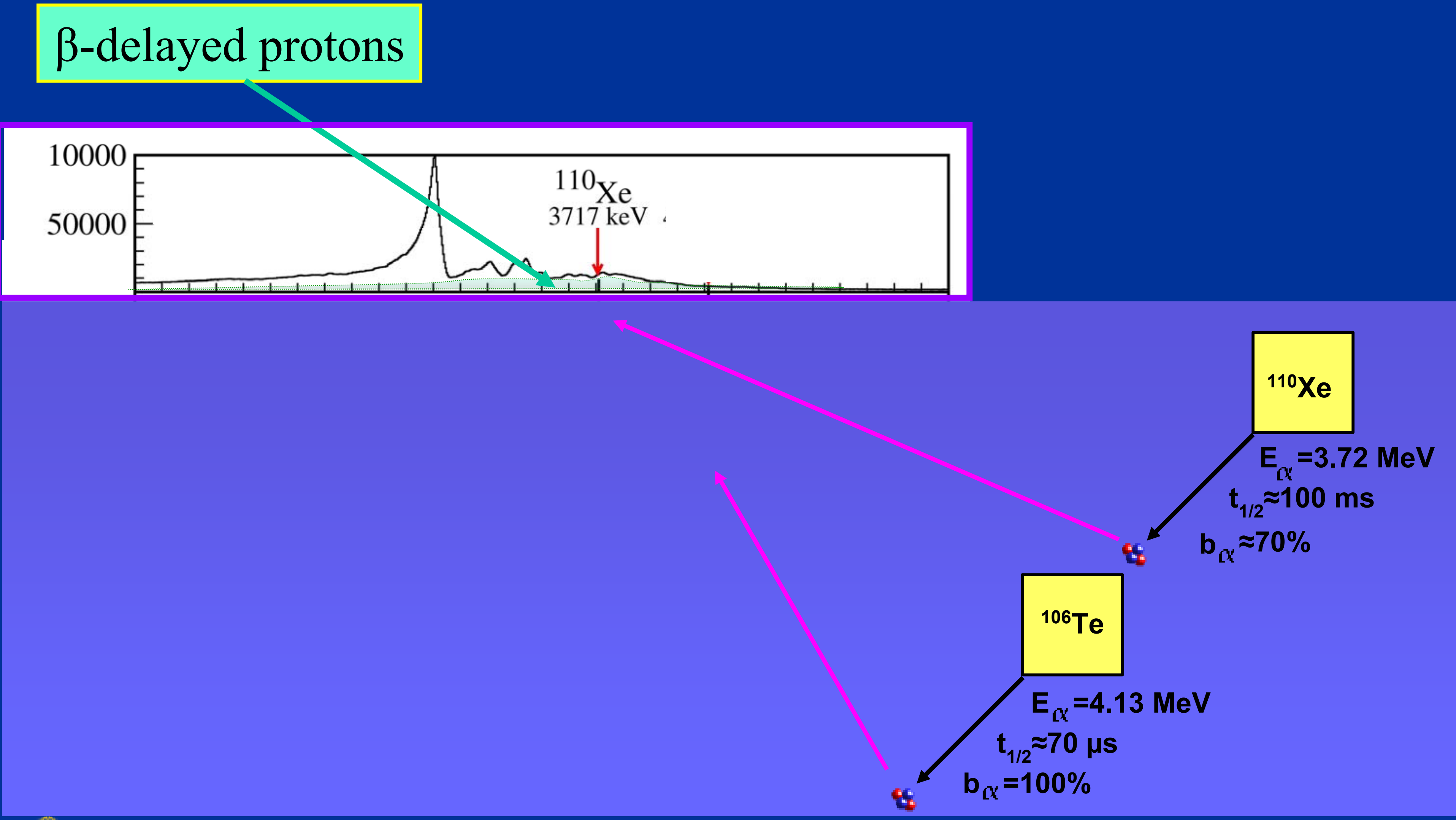


M. Sandzelius *et al.*, Phys. Rev. Lett. 99, 022501 (2007)

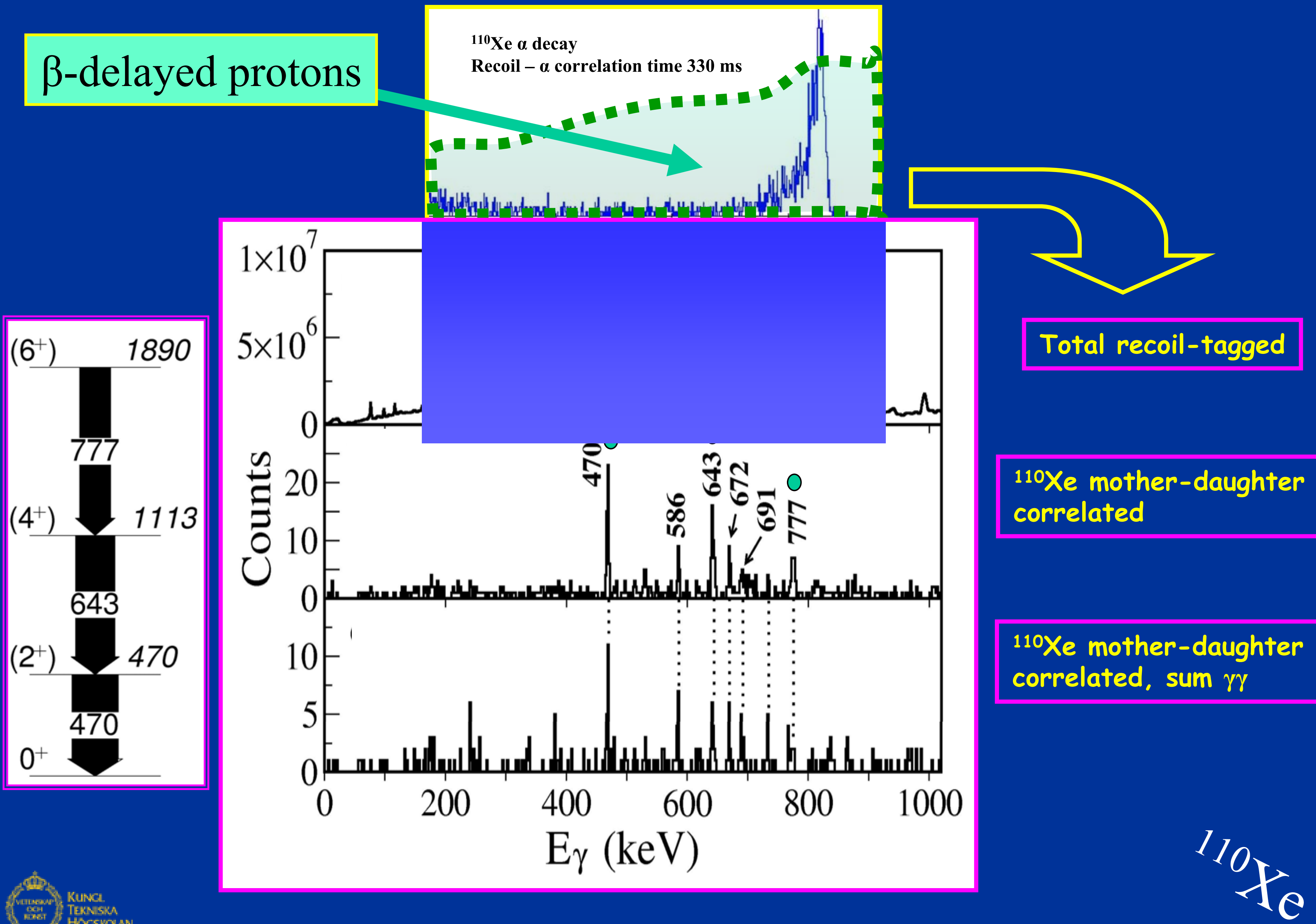
M. Perti et al. Phys.Rev. C 76, 054301 (2007)

KUNGL TEKNISKA HÖGSKOLAN

Identification of excited states in ^{110}Xe



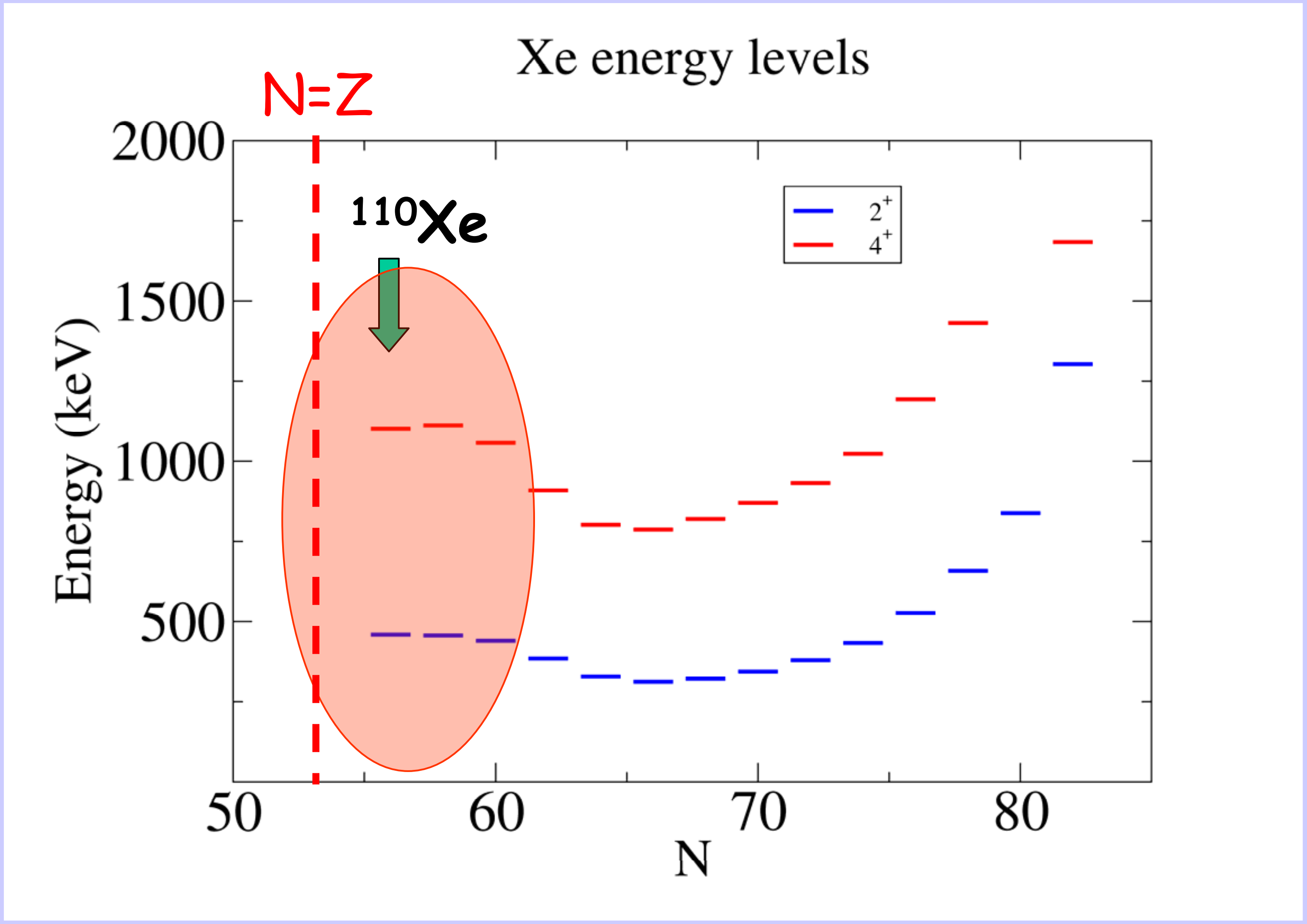
Clean mother-daughter correlations essential for selecting the ^{110}Xe nuclei



KUNGL TEKNISKA HÖGSKOLAN

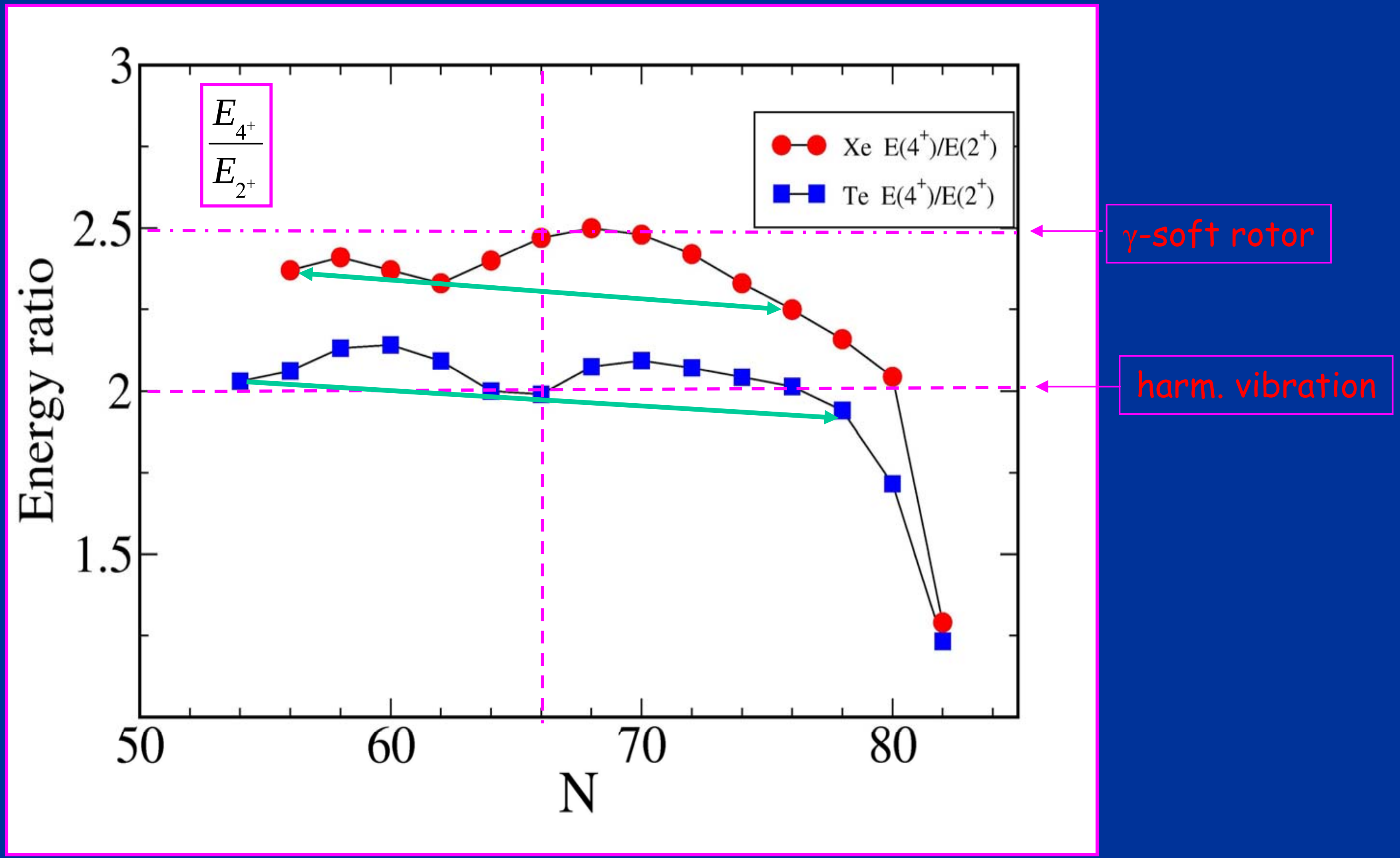
Xe experimental energy systematics

^{110}Xe

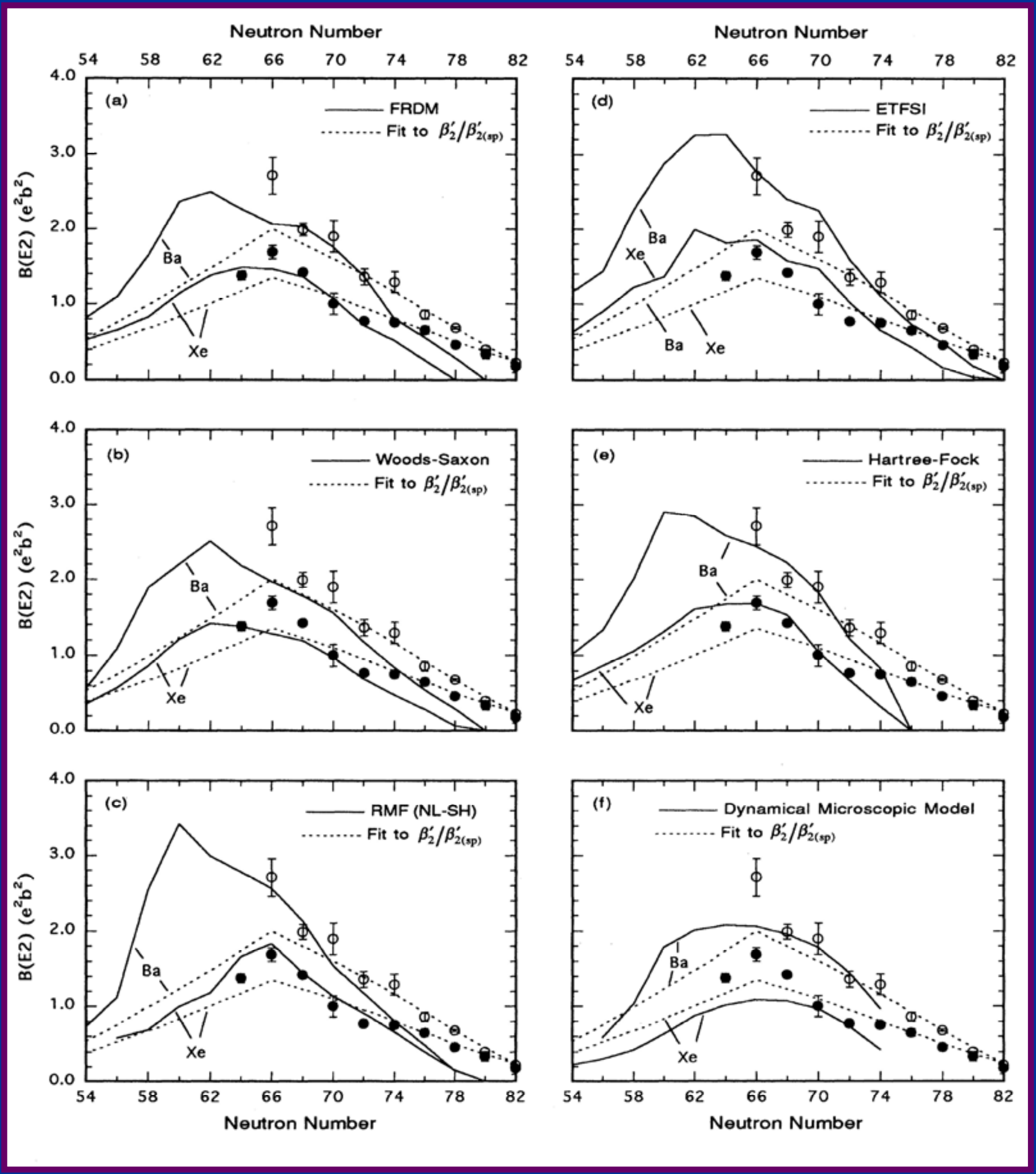


Evidence for enhanced collectivity near N=Z !

Xe and Te energy ratios

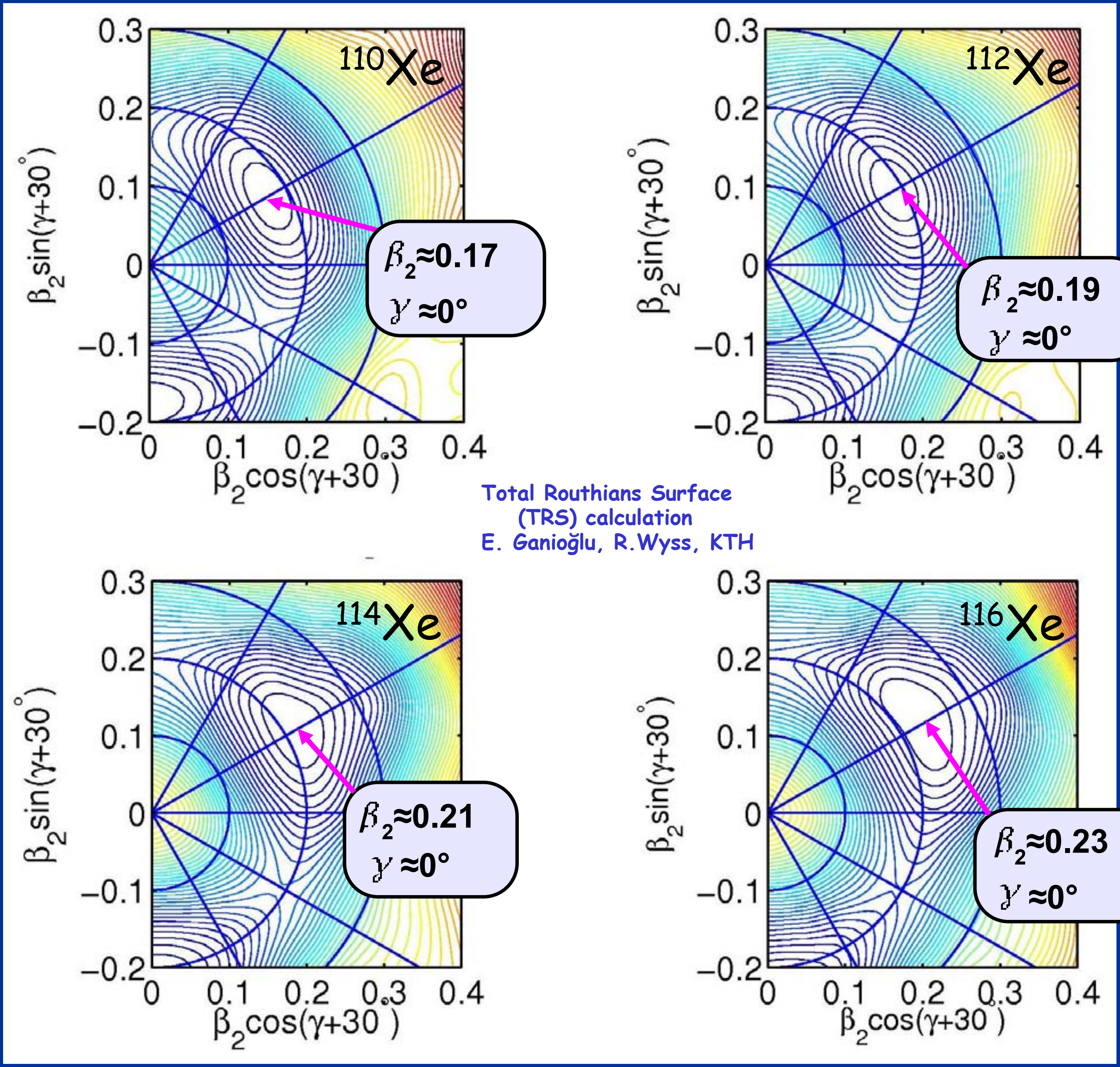


Comparing theory with experimental B(E2) values for Xe – Ba isotopes
Raman *et al.*, PRC '95



KUNGL TEKNISKA HÖGSKOLAN

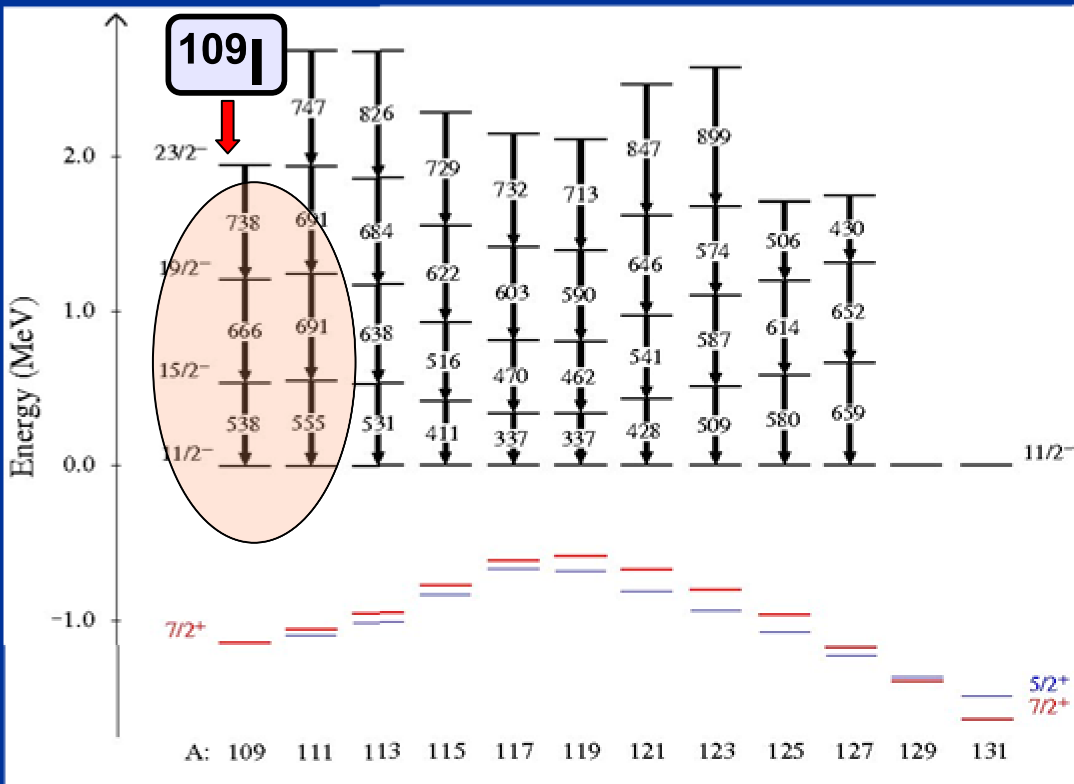
TRS calculations for neutron deficient Xe isotopes predict decreasing collectivity with decreasing N

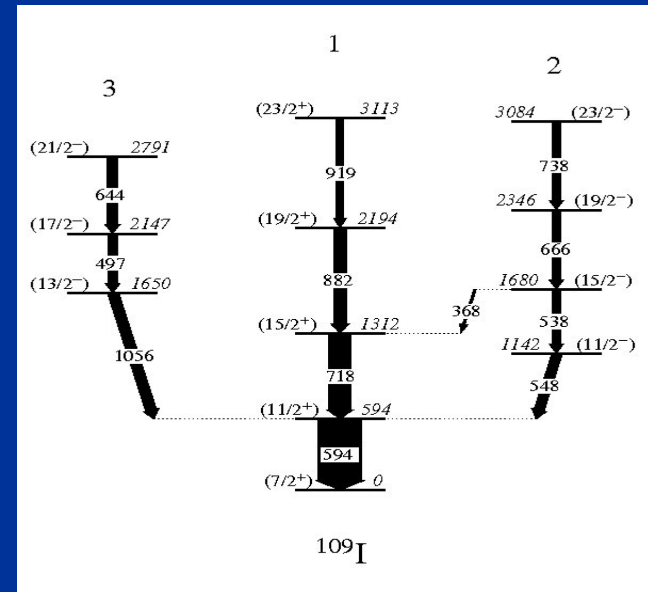


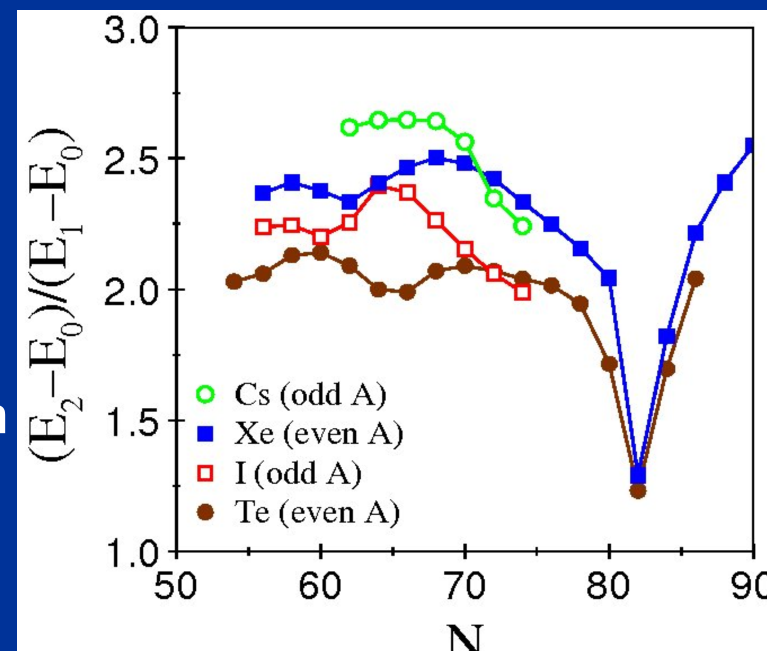
Kungl Tekniska Högskolan

Iodine energy systematics

^{109}I







Suggest a larger quadrupole deformation as the N=50 shell closure is approached

Conclusions and outlook

- In-beam gamma-ray spectroscopy is possible down to 10’s of nb x.s. using RDT and efficient Ge arrays

- Evidence for enhanced quadrupole collectivity in the Te, I and Xe isotopes as N → Z, against “common wisdom”

- np correlations (np pairing) driving the collectivity? (New effect, not considered earlier in quest for np pairing)

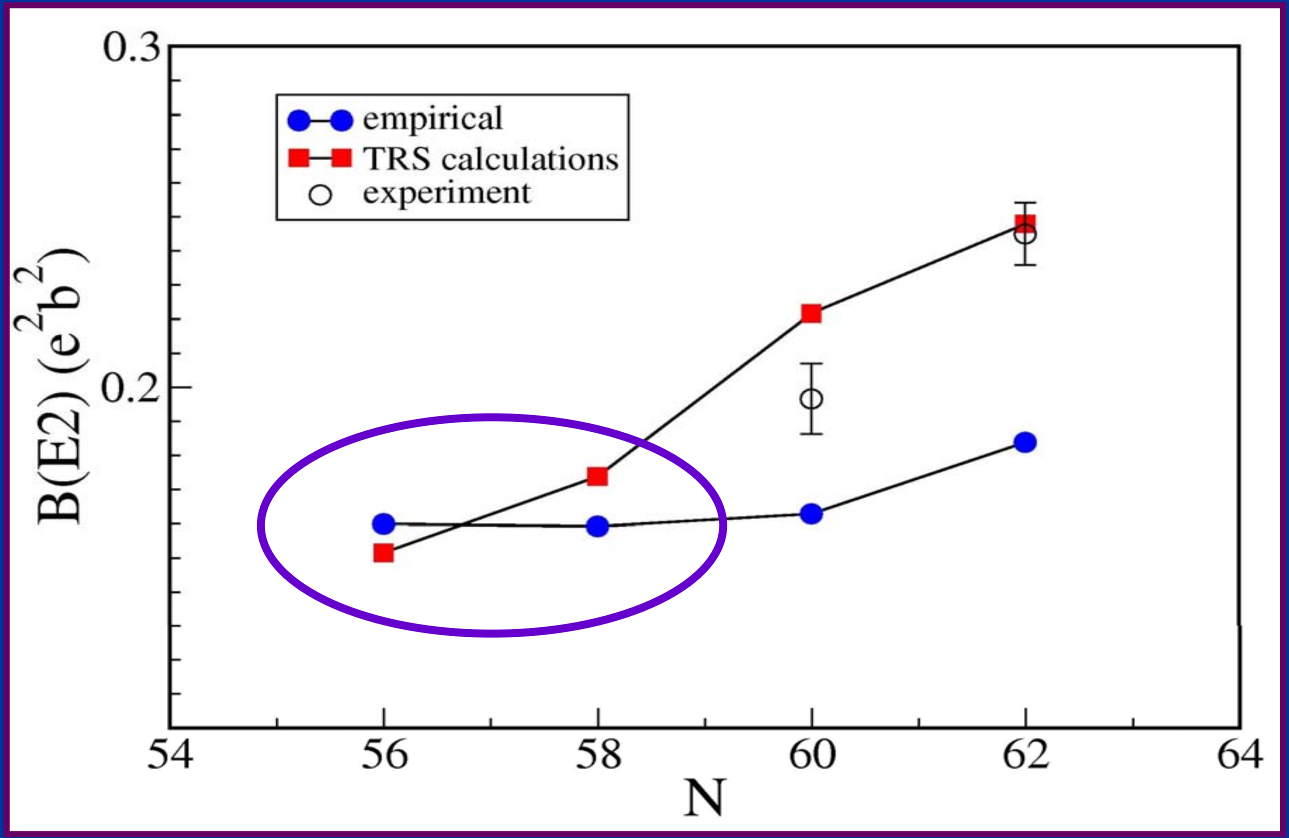
- Recent QRPA calculations (Delion, Liotta, Wyss et al.) confirm isoscalar pairing scenario for enhanced collectivity

- Theoretical models accounting for detailed dynamic coupling of protons and neutrons are needed.

Kungl Tekniska Högskolan


Thank you for your attentions

Comparing theory with experimental B(E2) values (Raman estimates) for extremely neutron deficient Xe isotopes

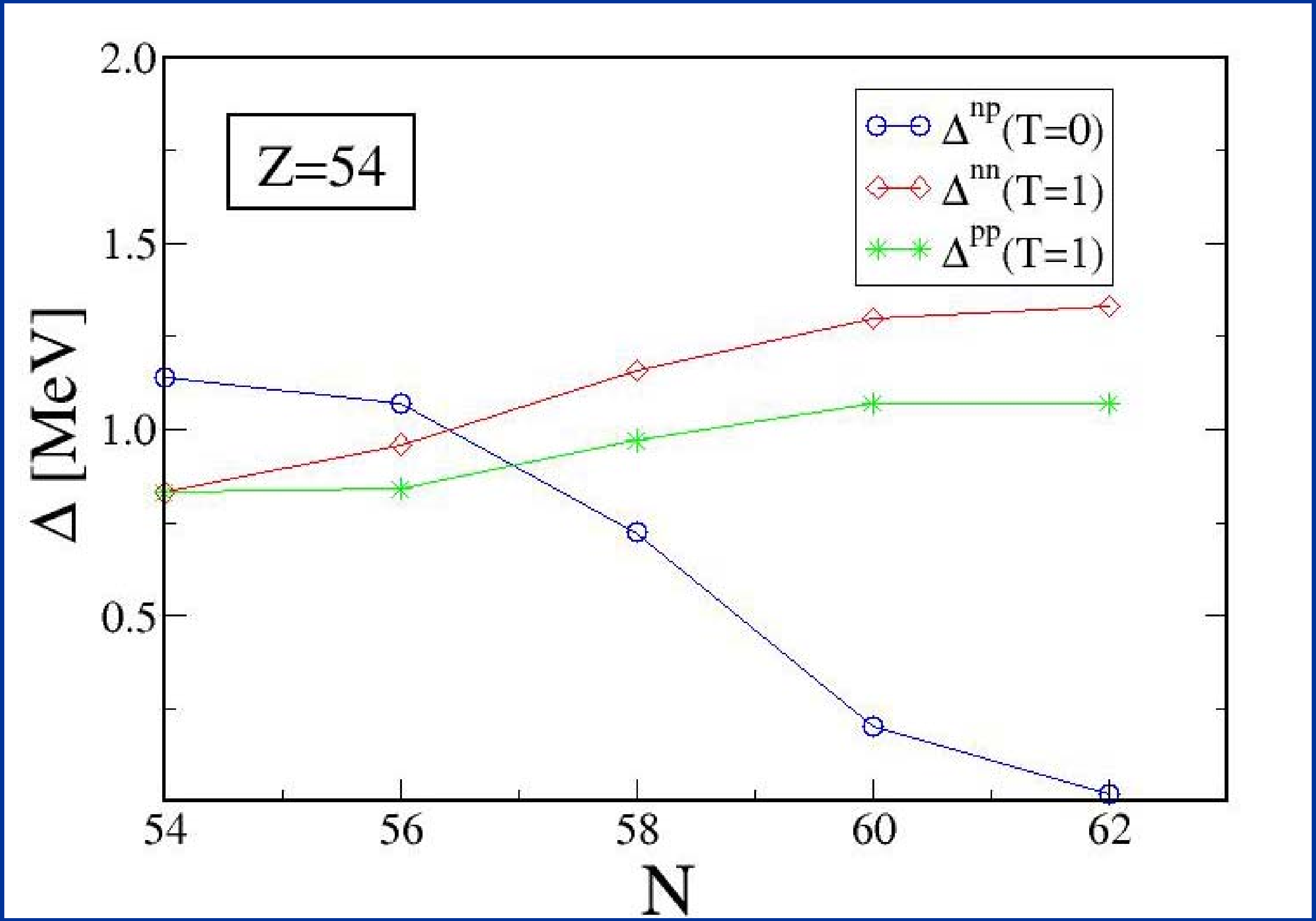


- *B*(E2) values are a measure of nuclear collectivity
- Theoretical models predict a *decrease* in *B*(E2) values for decreasing *N*
- The empirically deduced values*) reveal a leveling off and a even a small *increase* of the *B*(E2) value for ^{110}Xe

Kungl Tekniska Högskolan

$^{*)}\ B(E2; 2_1^+ \rightarrow 0_1^+) \approx 0.66 E(2_1^+)^{-1} Z^2 A^{-0.69}$

Light Xe isotope pairing gap systematics



D. Delion, R. Liotta, R. Wyss et al. (in preparation)