

Coulomb Excitation of Pear-shaped Nuclei

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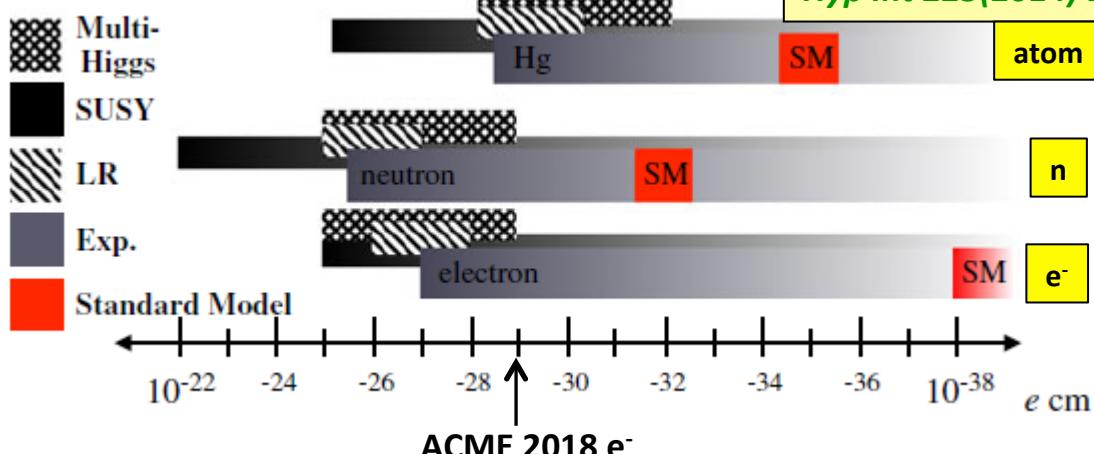
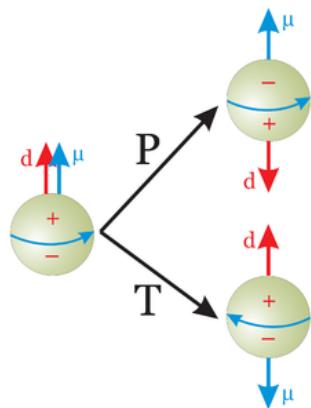
Measure level schemes in $^{224,226}\text{Rn}$
- unknown so far.

Relevant to EDM searches

Investigate B(E3)s in $^{222,(224)}\text{Rn}$, $^{222,228}\text{Ra}$
(previously measured ^{220}Rn , $^{224,226}\text{Ra}$)

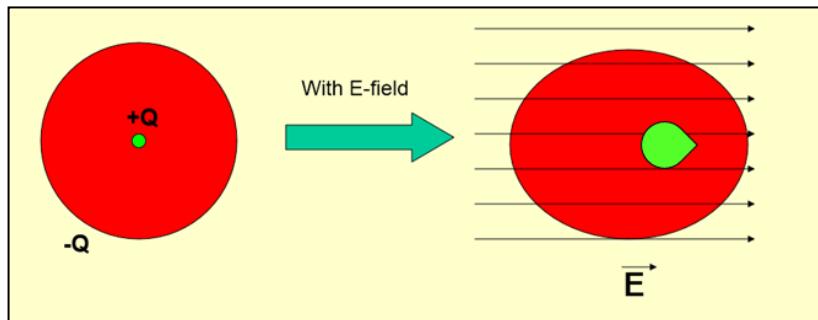
Search for other cases of static octupole deformation

Pear-shapes and EDMs



CP-violation
(matter-antimatter asymmetry in universe)

atomic
EDM



^{225}Ra [Argonne]

$\Delta E \sim 50 \text{ keV}$
 Q_3 known for $^{224,226}\text{Ra}$

Schiff Moment

$$S = -2 \frac{J}{J+1} \frac{\langle \hat{S}_z \rangle \langle \hat{V}_{PT} \rangle}{\Delta E}$$

related to Q_3 P,T-violating interaction

energy splitting of parity doublet

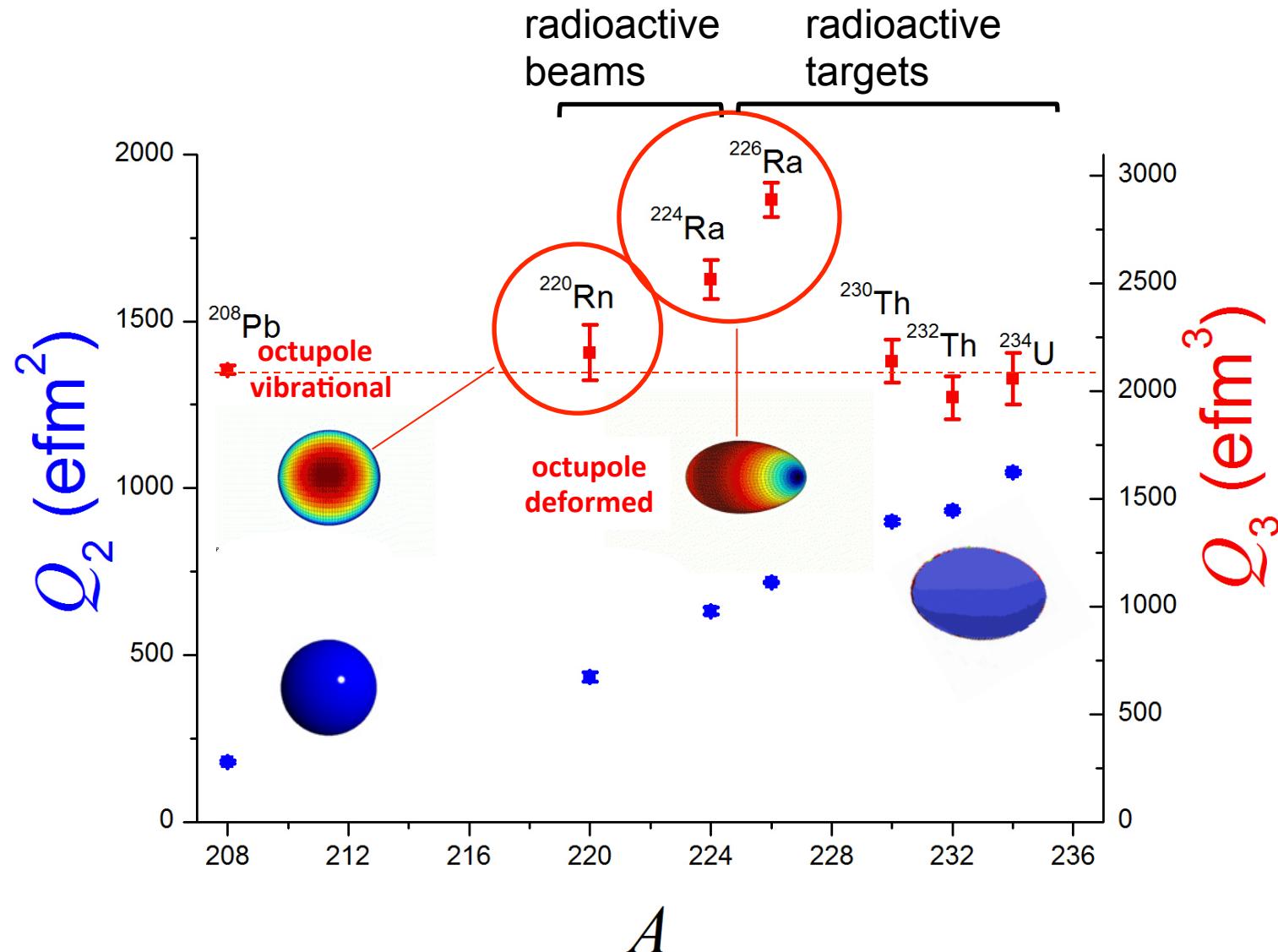
**^{223}Rn
[TRIUMF]**

ΔE not known
 Q_3 known for ^{220}Rn

E2 and E3 moments for heavy nuclei

LP Gaffney et al ^{220}Rn , ^{224}Ra
Nature 497 (2013) 199

HJ Wollersheim et al ^{226}Ra
NP A556 (1993) 261



Some experimental details: beams

HIE-ISOLDE + MINIBALL+CD July-August 2018

radon from ThC target; ionised using VADIS with cooled transfer line; separated in GPS

^{222}Rn 51⁺ 4.23 MeV/u $6 \cdot 10^5$ /s

^{224}Rn 52⁺ 5.08 MeV/u $1.1 \cdot 10^5$ /s

^{226}Rn 52⁺ 5.08 MeV/u $2 \cdot 10^3$ /s

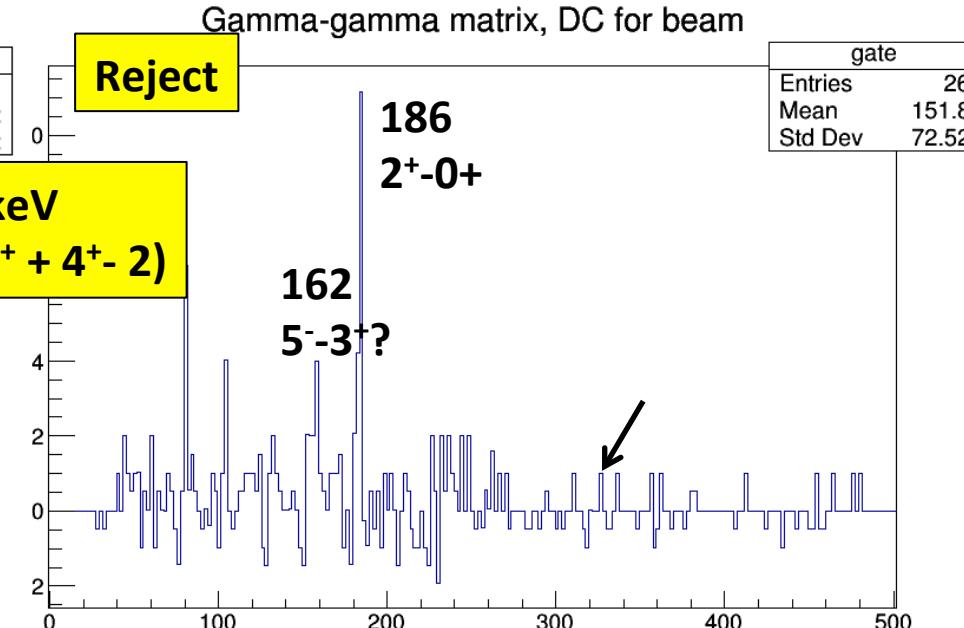
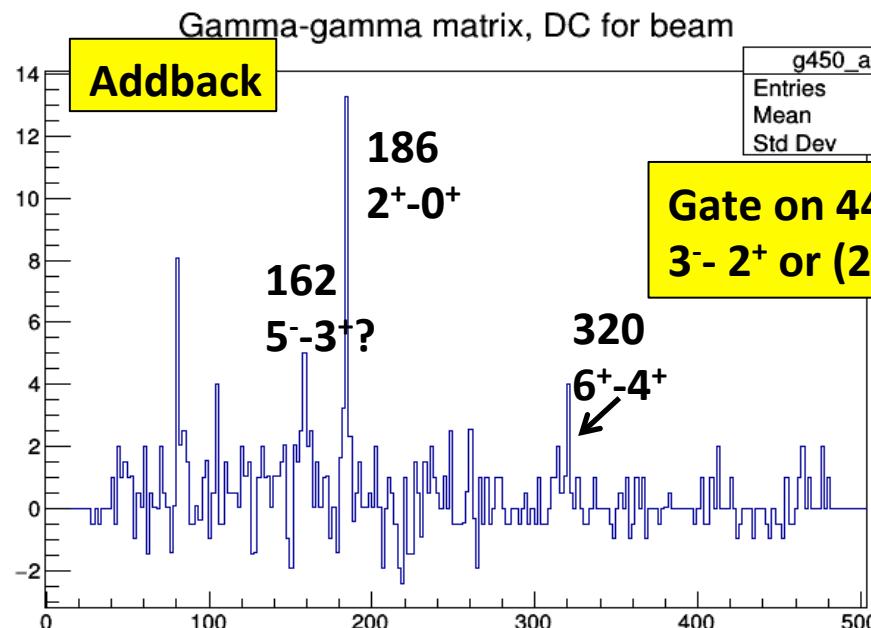
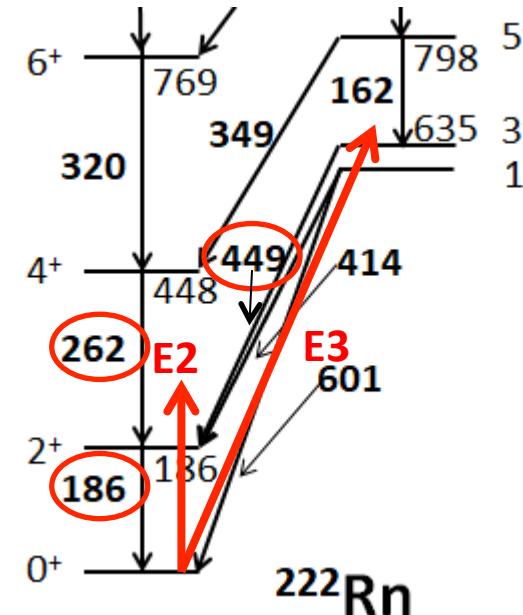
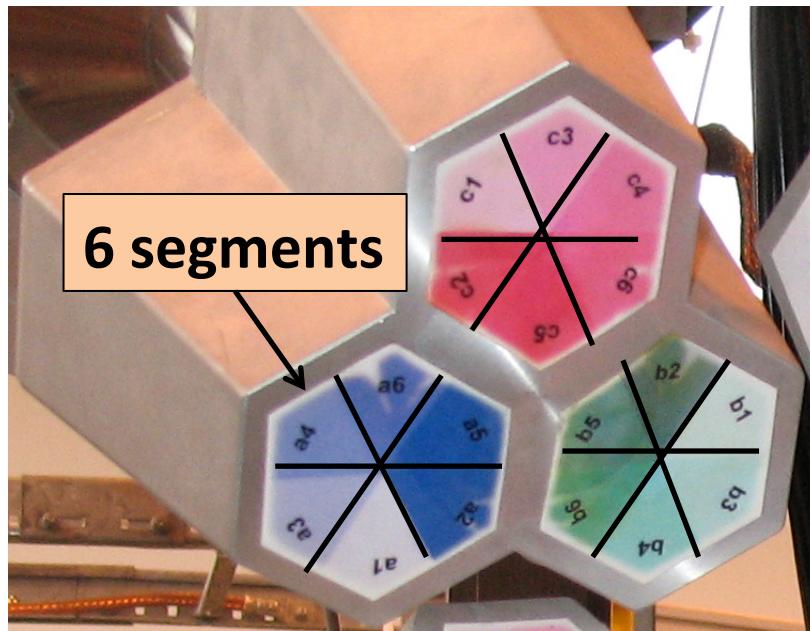
radium from UC target; ionised using W surface ion source ; separated in HRS

^{222}Ra 51⁺ 4.305 MeV/u $6 \cdot 10^5$ /s

^{228}Ra 53⁺ 4.31 MeV/u $6 \cdot 10^5$ /s

EBIS breeding time 500-700 ms

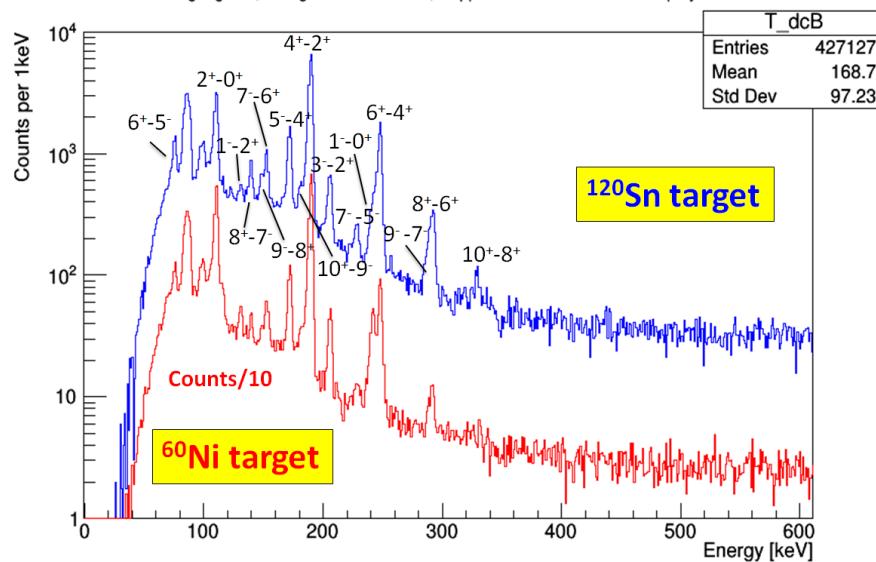
Some experimental details: Miniball operation



γ -ray spectra: Coulex of $^{222,224,226}\text{Rn}$, $^{222,228}\text{Ra}$

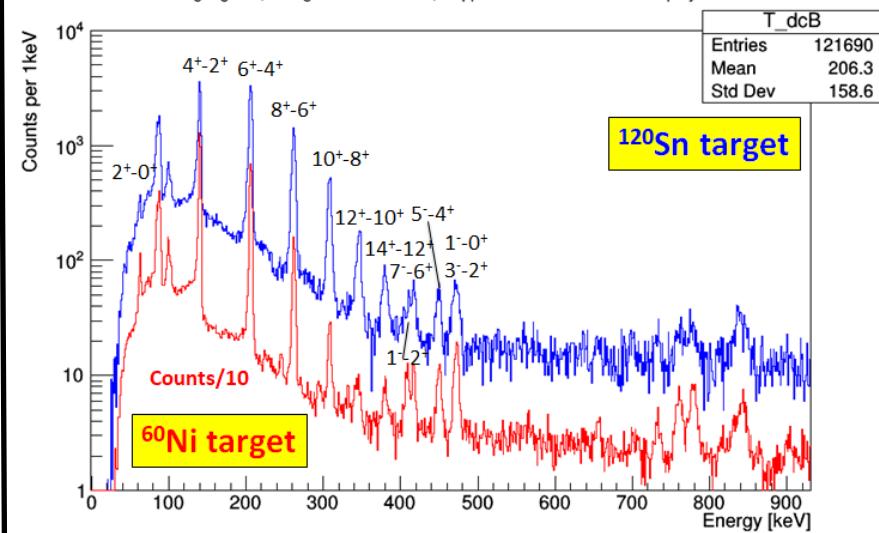
^{222}Ra beam – segments, all runs

Target gated, background subtracted, Doppler corrected for scattered projectile



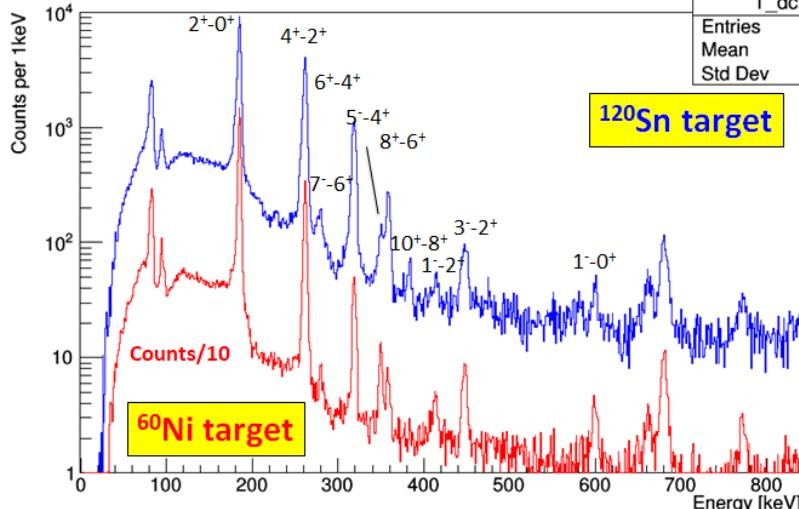
^{228}Ra beam

Target gated, background subtracted, Doppler corrected for scattered projectile

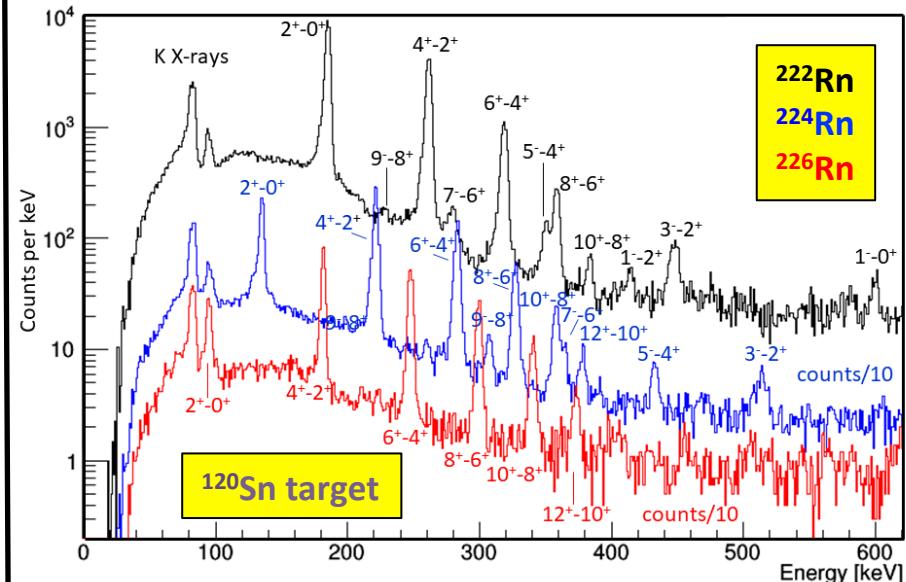


^{222}Rn beam

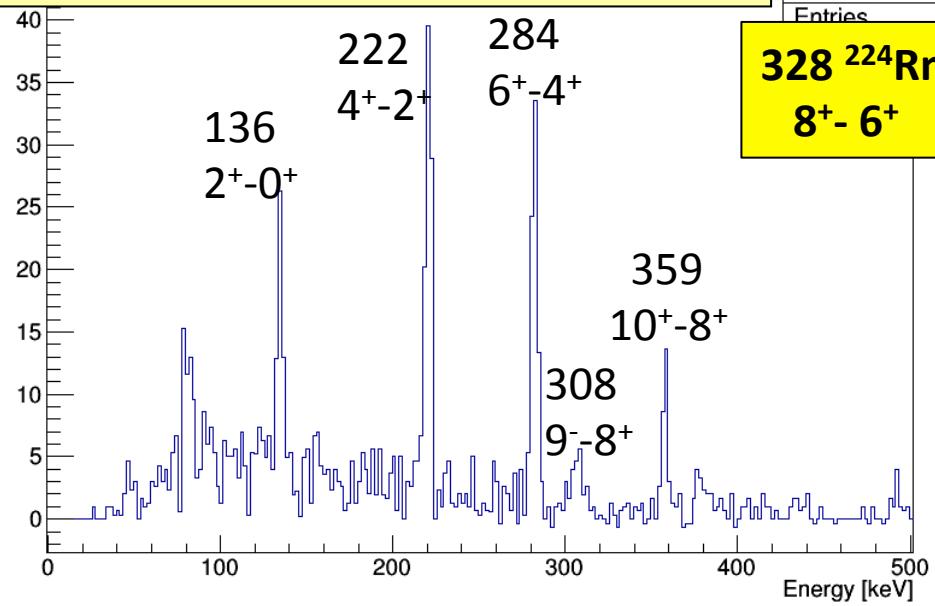
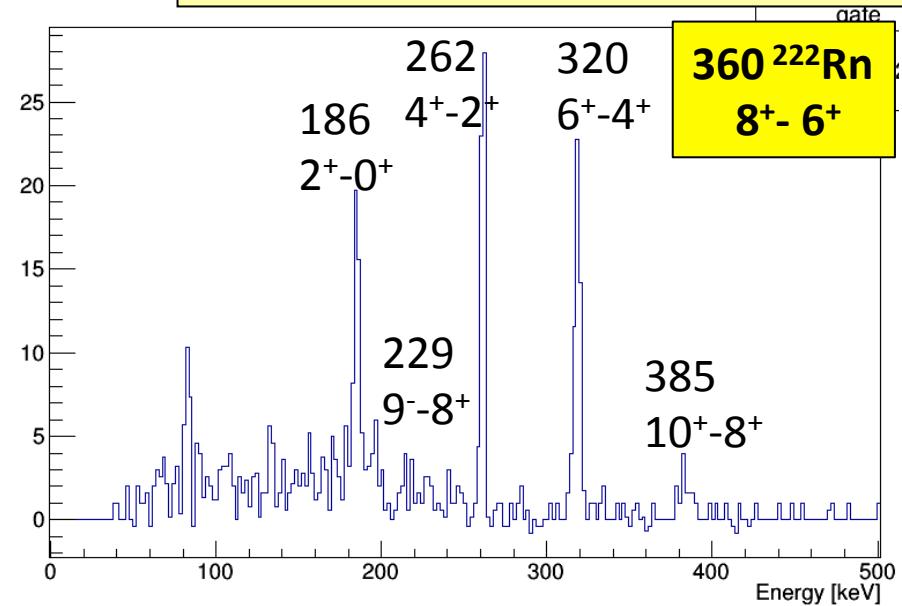
Target gated, background subtracted for scattered projectile



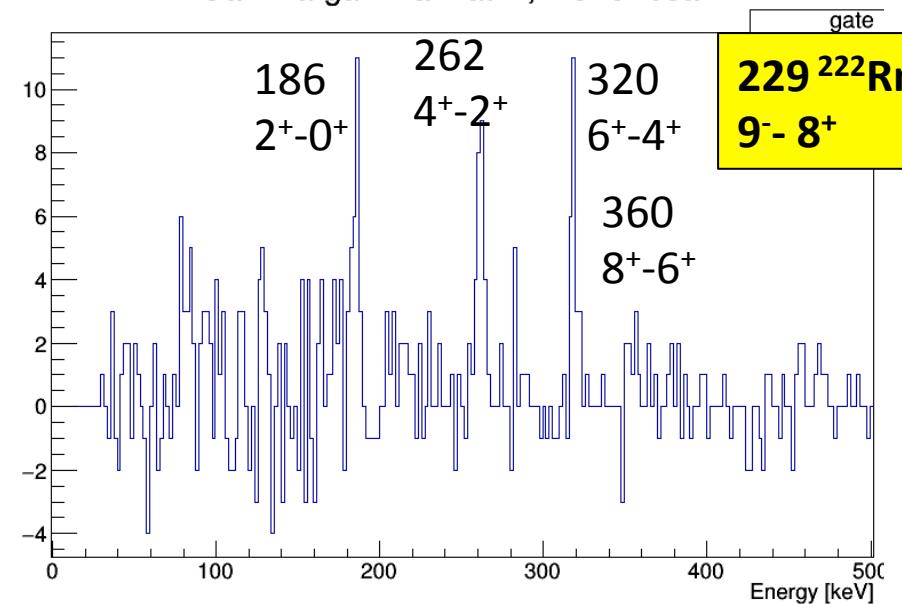
^{222}Rn
 ^{224}Rn
 ^{226}Rn



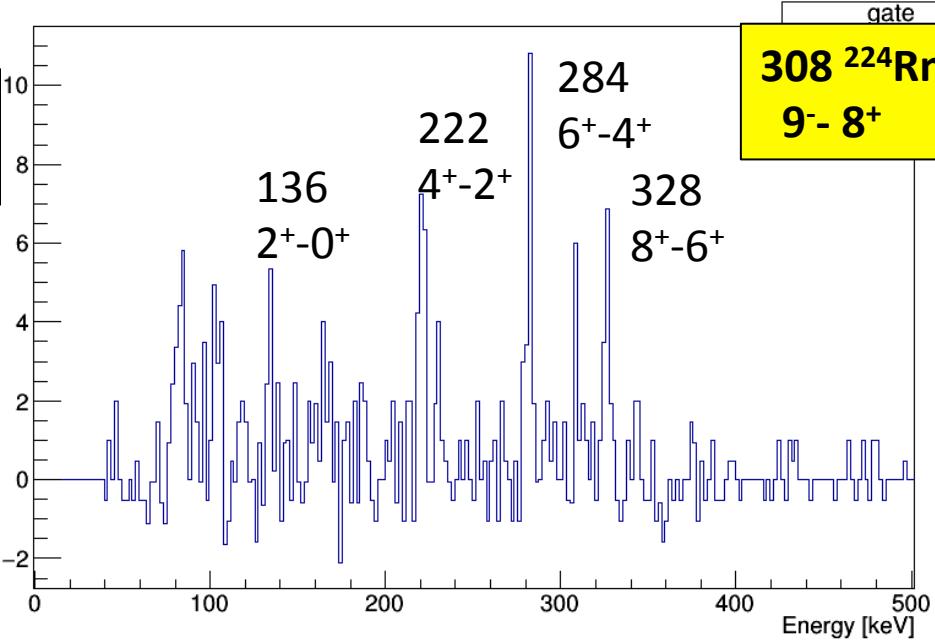
γ - γ spectra: gates on transitions in $^{222,224}\text{Rn}$



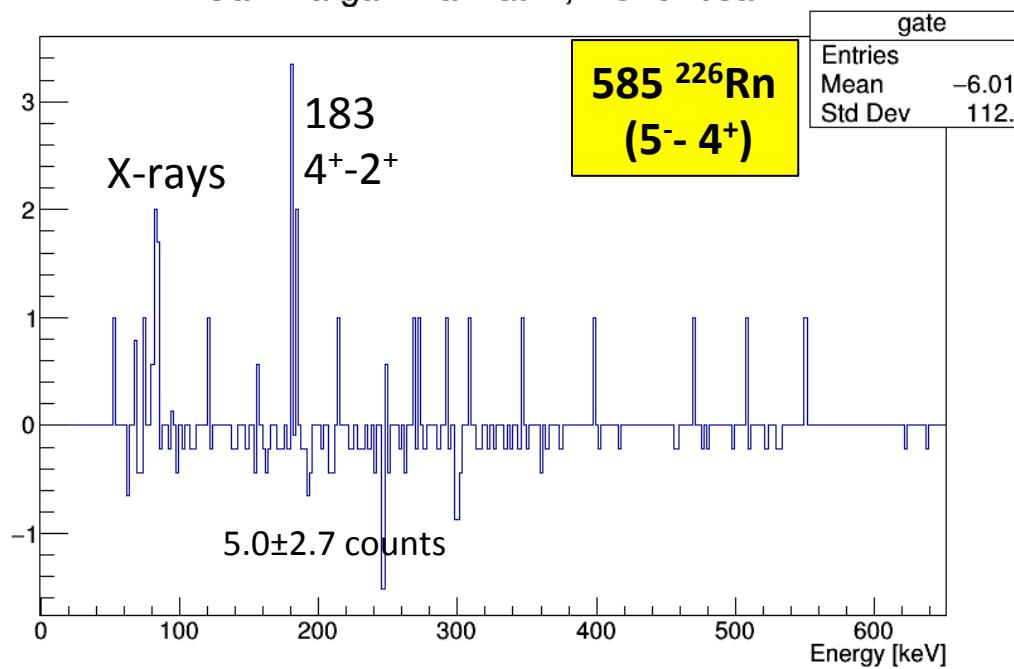
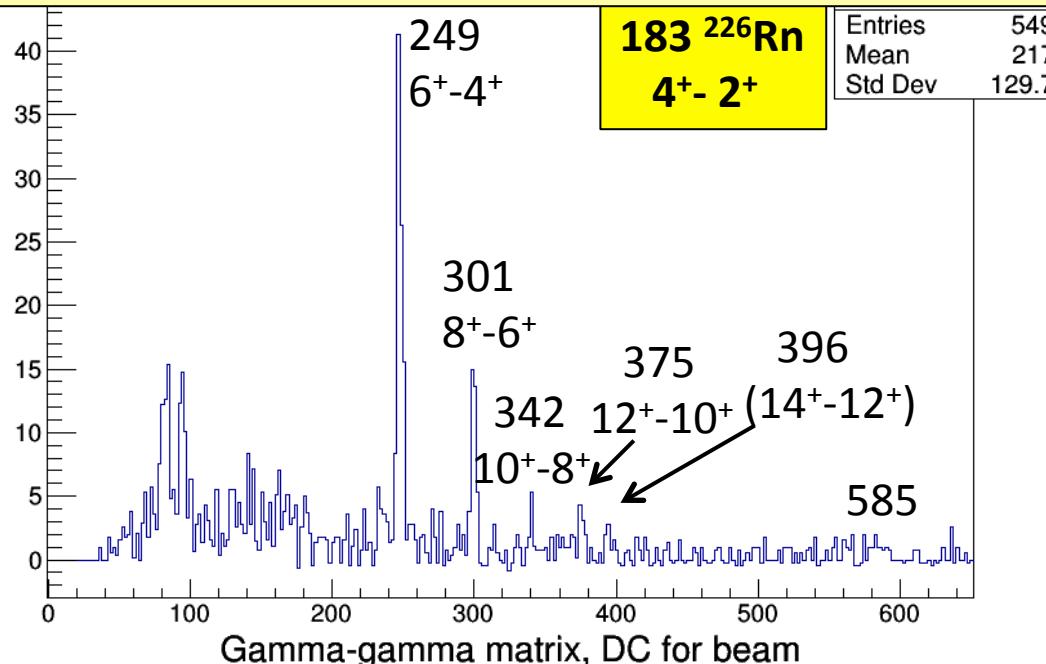
Gamma-gamma matrix, DC for beam



Gamma-gamma matrix, DC for beam

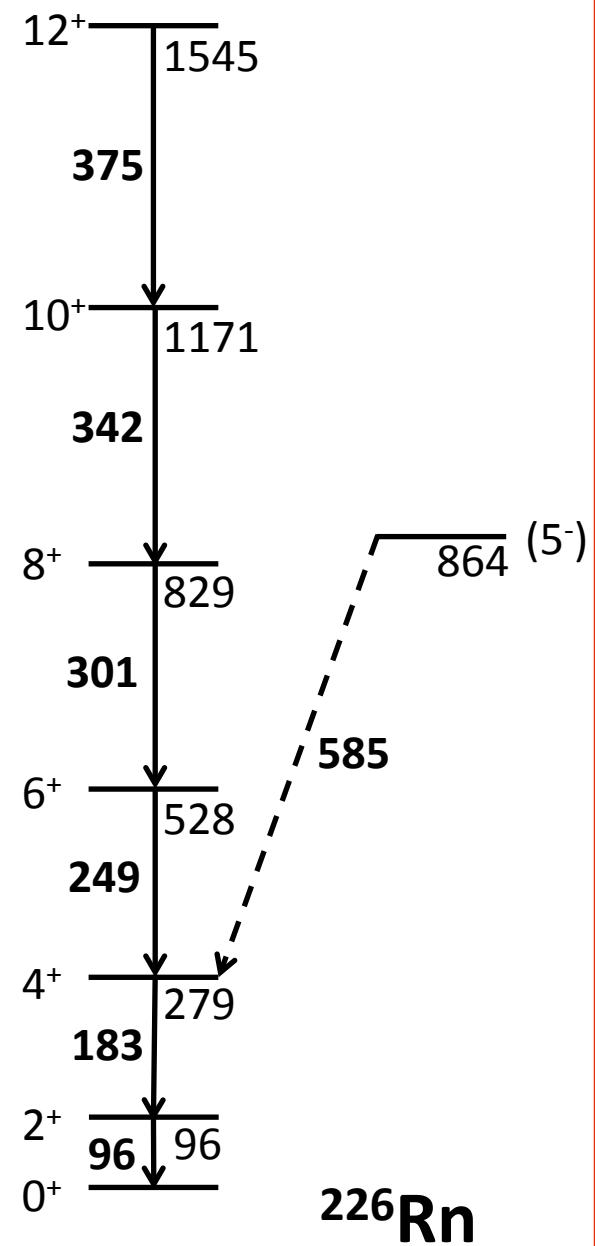
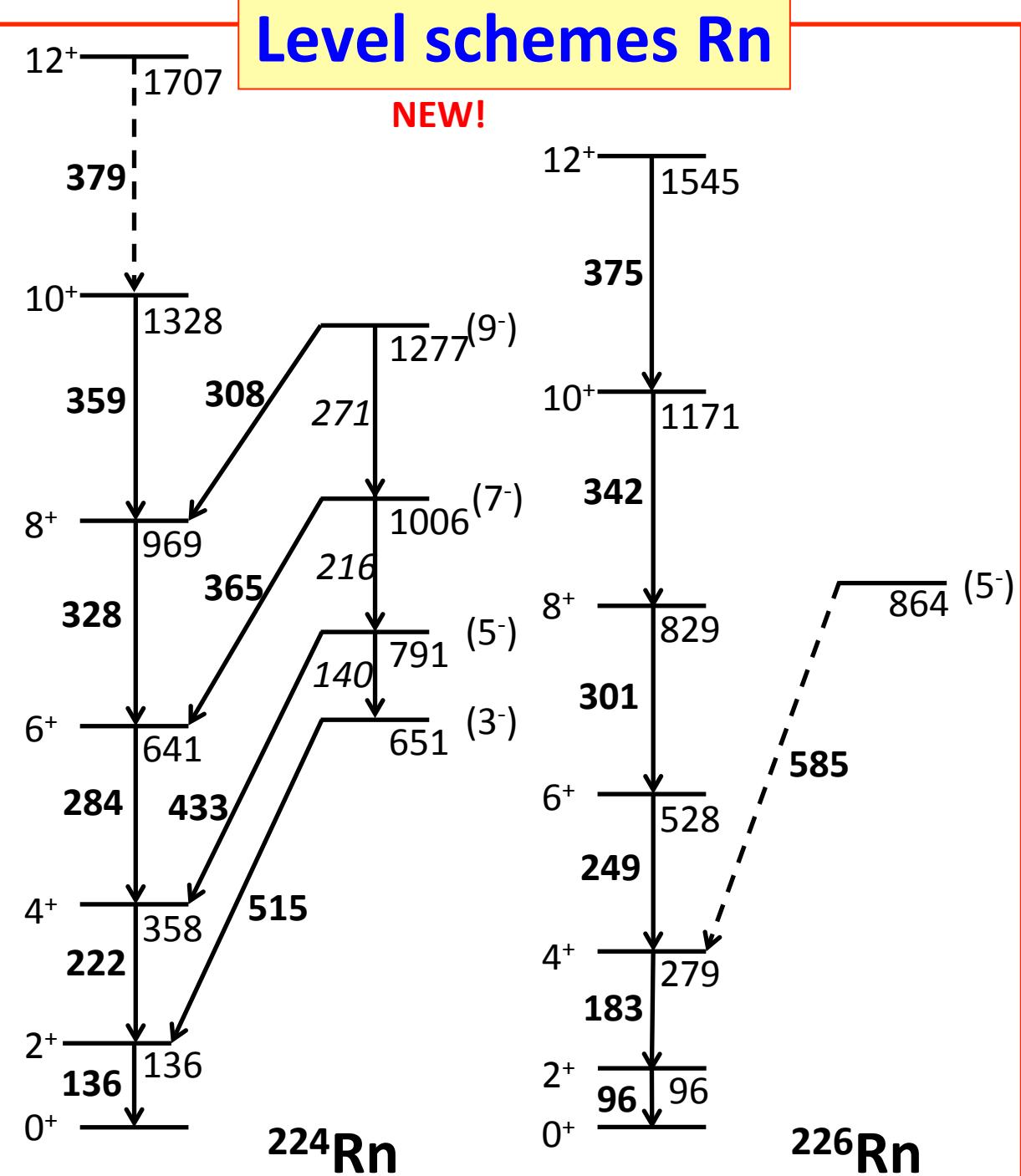
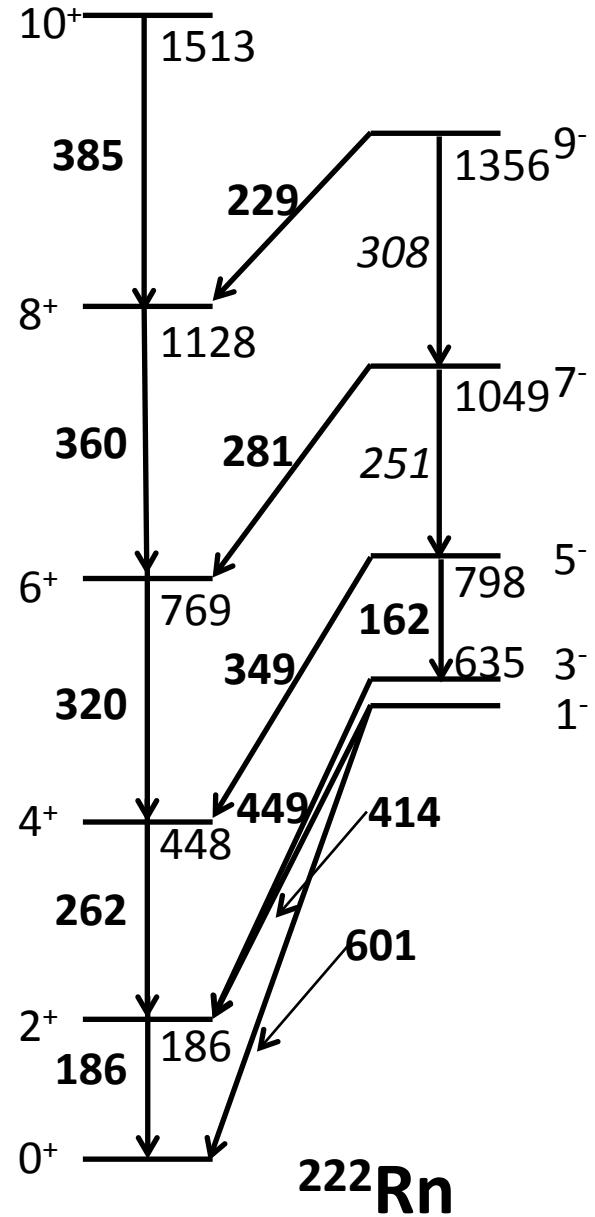


γ - γ spectra: gates on transitions in ^{226}Rn

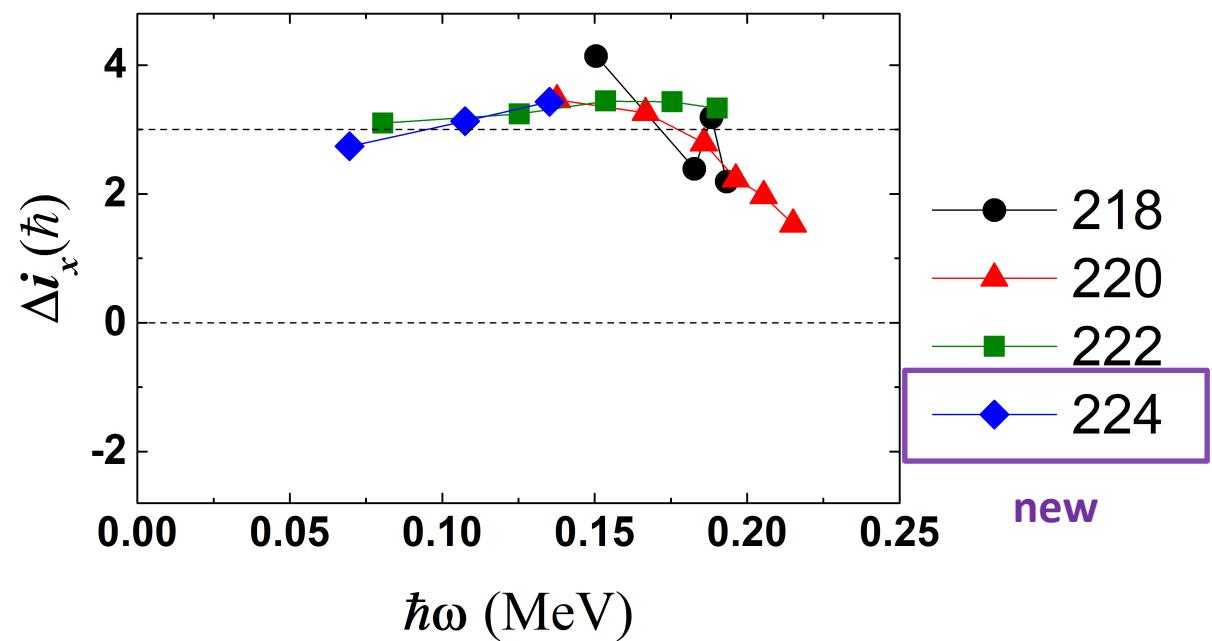
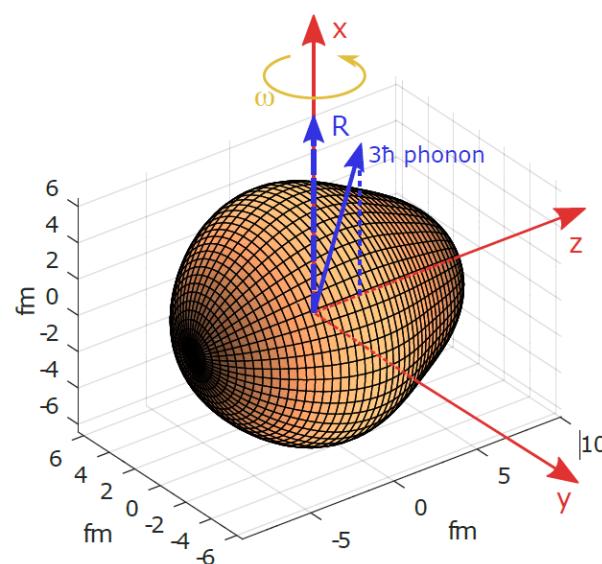
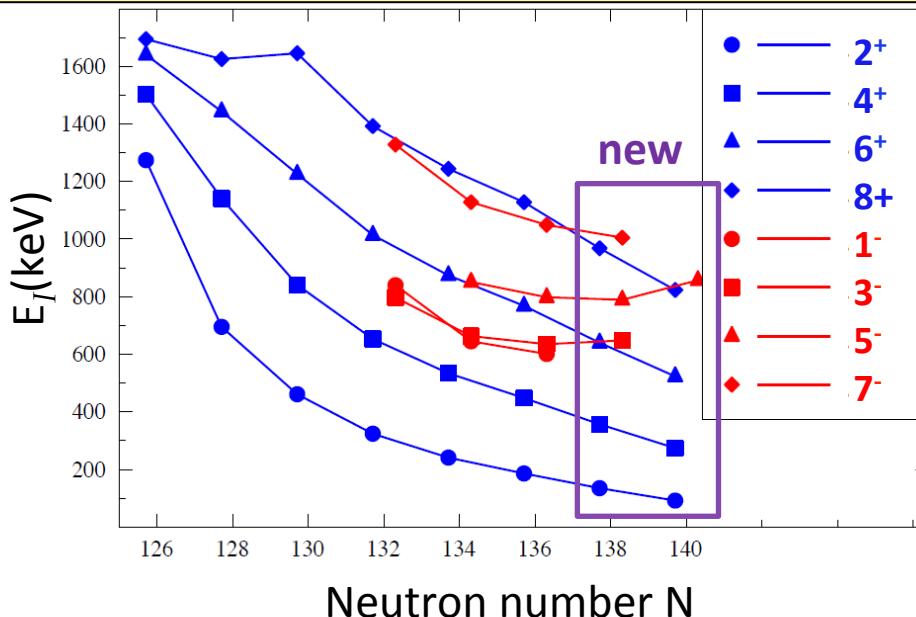


Level schemes Rn

NEW!

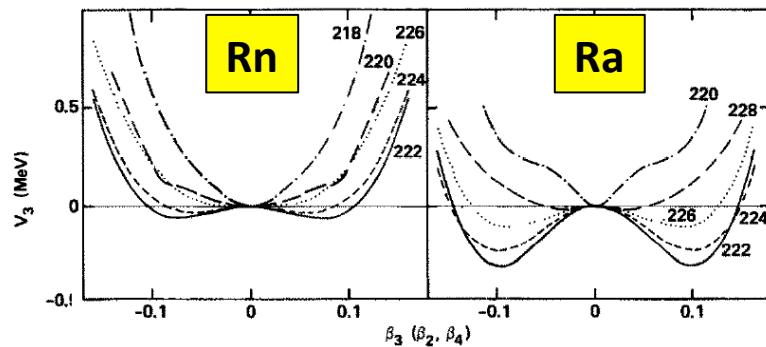


Systematics of states in rotating Rn nuclei

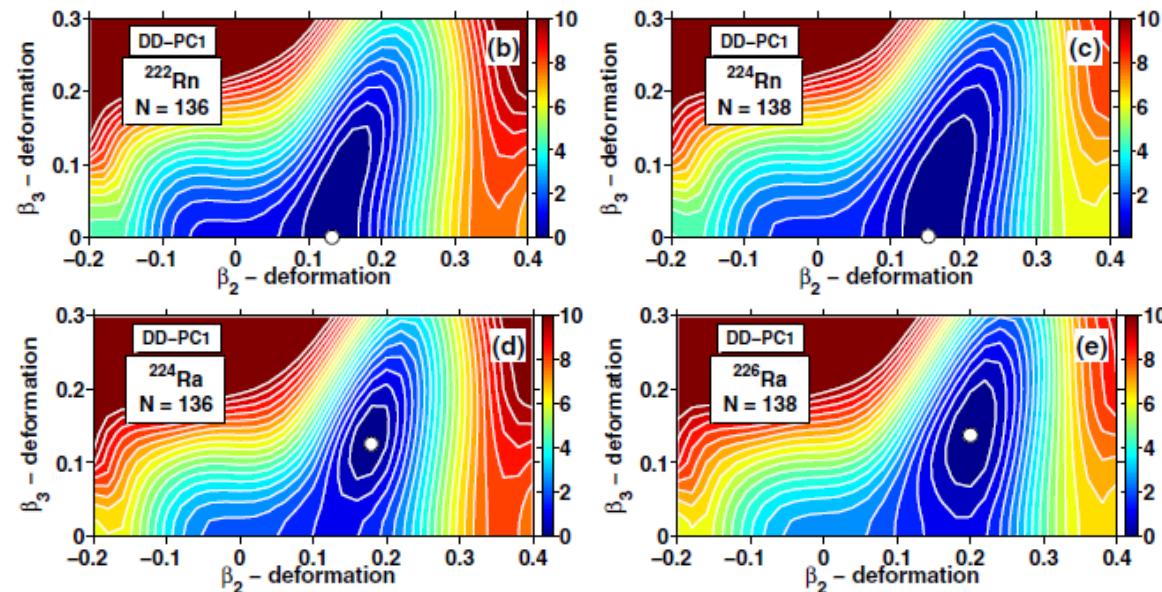
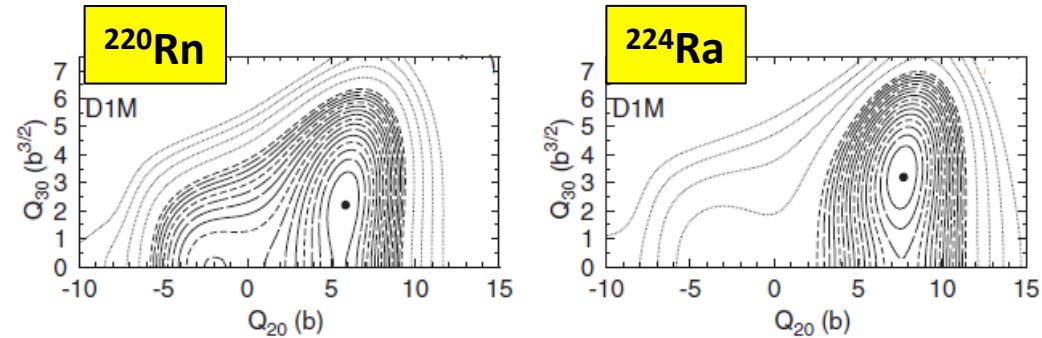


Theory

*Nazarewicz et al. Strut. WS
NP A429 (1984) 269*



*Robledo & Butler HFB Gogny
PRC 88 (2013) 051302*



*Agbemava et al. Rel. HFB
PRC 93 (2016) 044304*

Conclusions #1

**Radon even-even nuclei are octupole vibrational,
minimum around ^{222}Rn**

Very unlikely that parity doublets will be observed for odd-A Rn

**Schiff moment for candidate EDM search ^{223}Rn will not have the
same enhancement as for ^{225}Ra .**

co-authors

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Systematics of states in rotating Rn, Ra,Th

