Nuclear structure research at ISOLTRAP

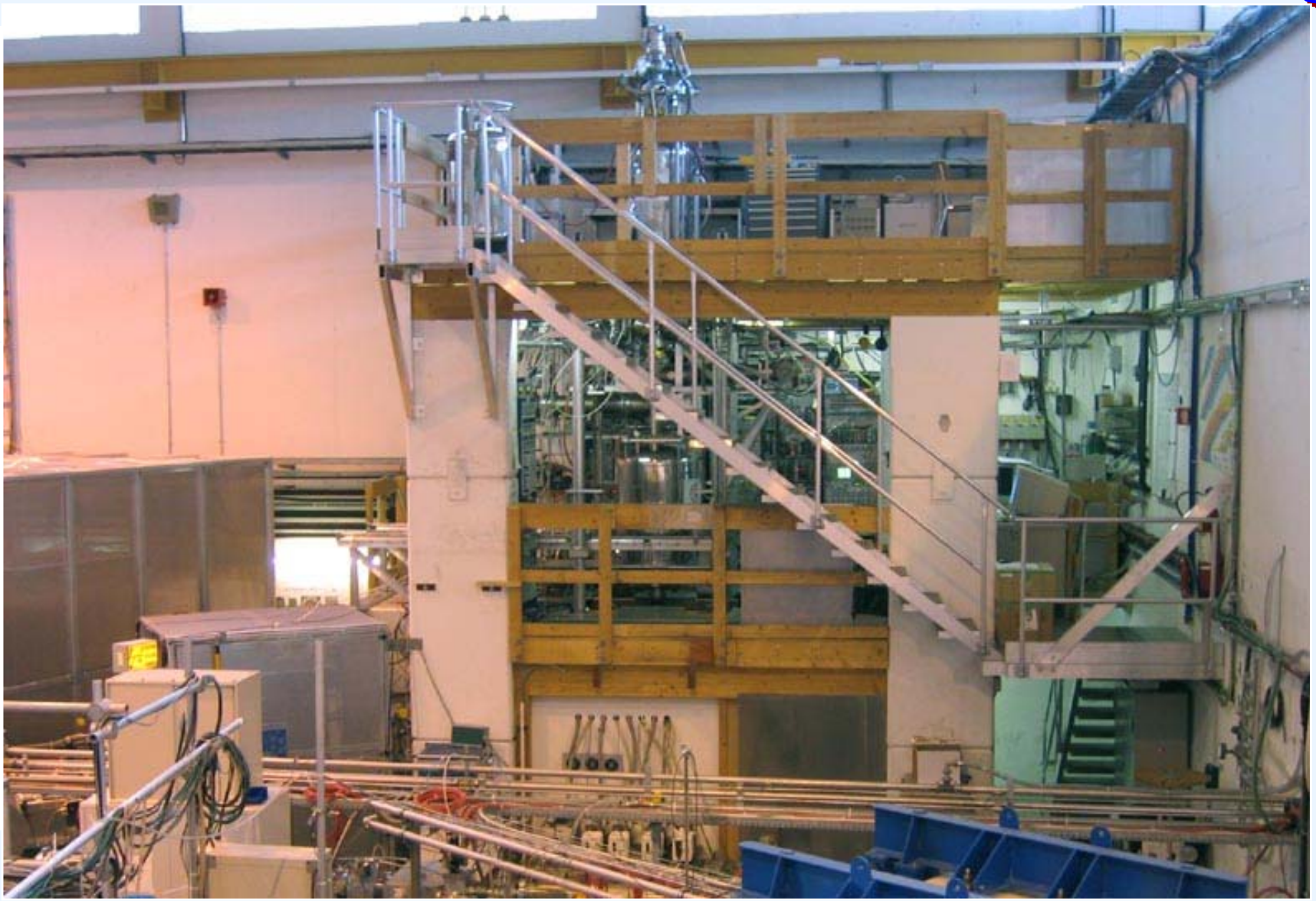
17th of November 2008

Dennis Neidherr
University of Mainz

Outline:

- Motivation for our measurements
- Xe/Rn results
- Interpretation of the results
- Discovery of ^{229}Rn

ISOLTRAP setup



Motivation

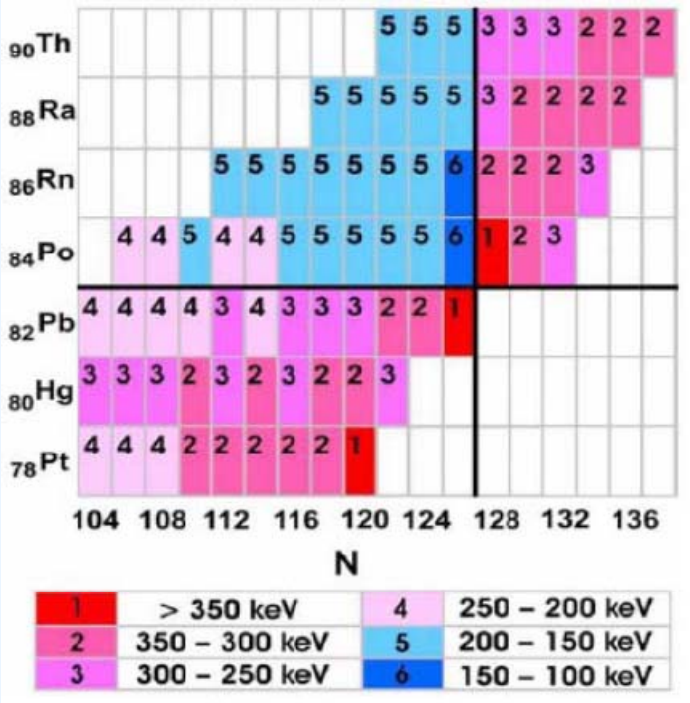
Empirical correlation between δV_{pn} values and growth rates of collectivity:

Interaction between the last proton(s) and neutron(s):

$$\delta V_{pn}^{ee}(Z,N) = \frac{1}{4}\left\{\left(B_{Z,N} - B_{Z,N-2}\right) - \left(B_{Z-2,N} - B_{Z-2,N-2}\right)\right\}$$

$$\delta V_{pn}^{eo}(Z,N) = \frac{1}{2}\left\{\left(B_{Z,N} - B_{Z,N-1}\right) - \left(B_{Z-2,N} - B_{Z-2,N-1}\right)\right\}$$

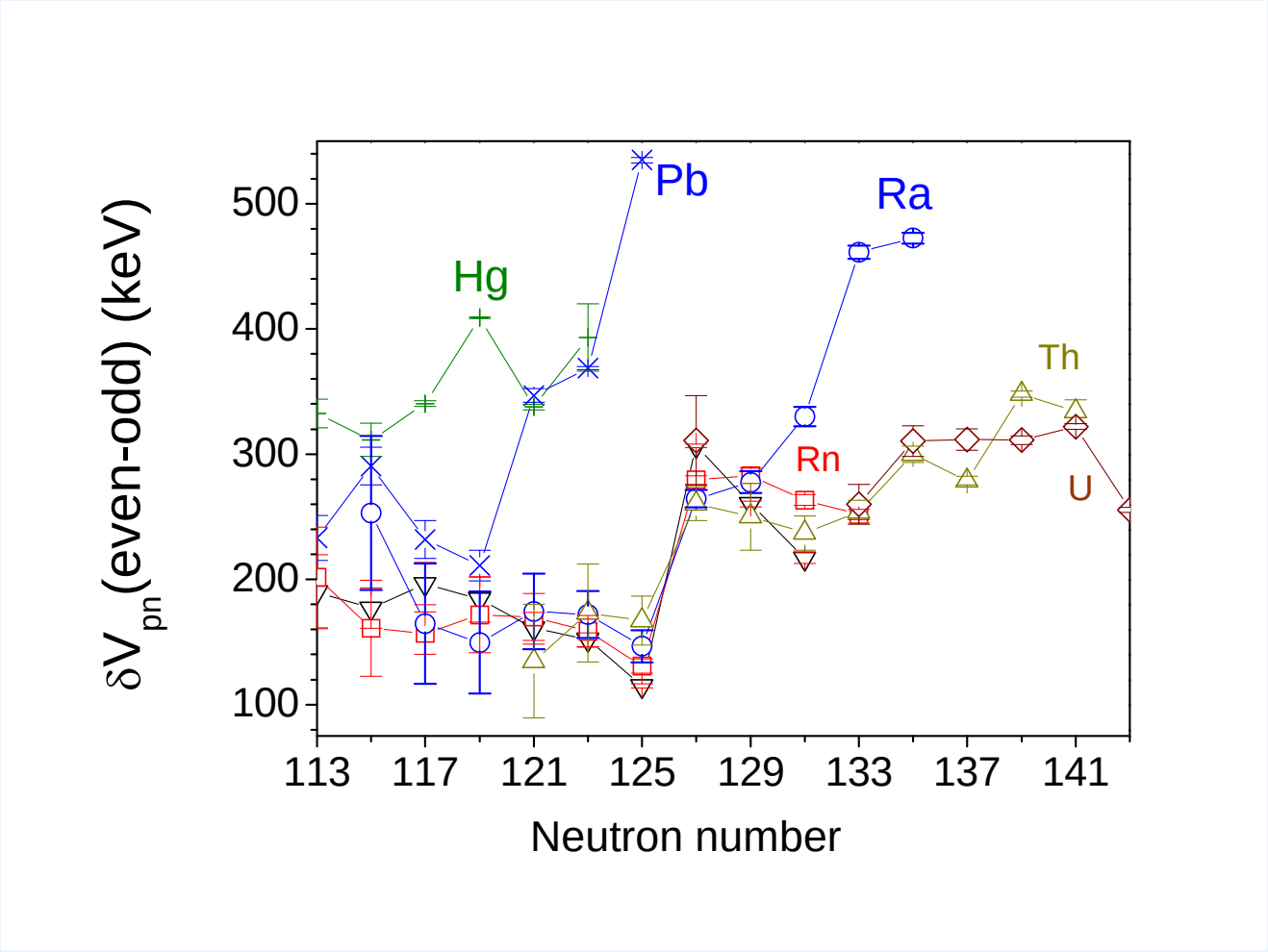
^{228}Ra β⁻=100%	^{229}Ra β⁻=100%	^{230}Ra β⁻=100%
^{227}Fr β⁻=100%	^{228}Fr β⁻=100%	^{229}Fr β⁻=100%
^{226}Rn β⁻=100%	^{227}Rn β⁻=100%	^{228}Rn β⁻=100%



In the vicinity of closed shells the p-n interaction is expected to be large if protons and neutrons are filling similar orbits.

Motivation Rn measurements

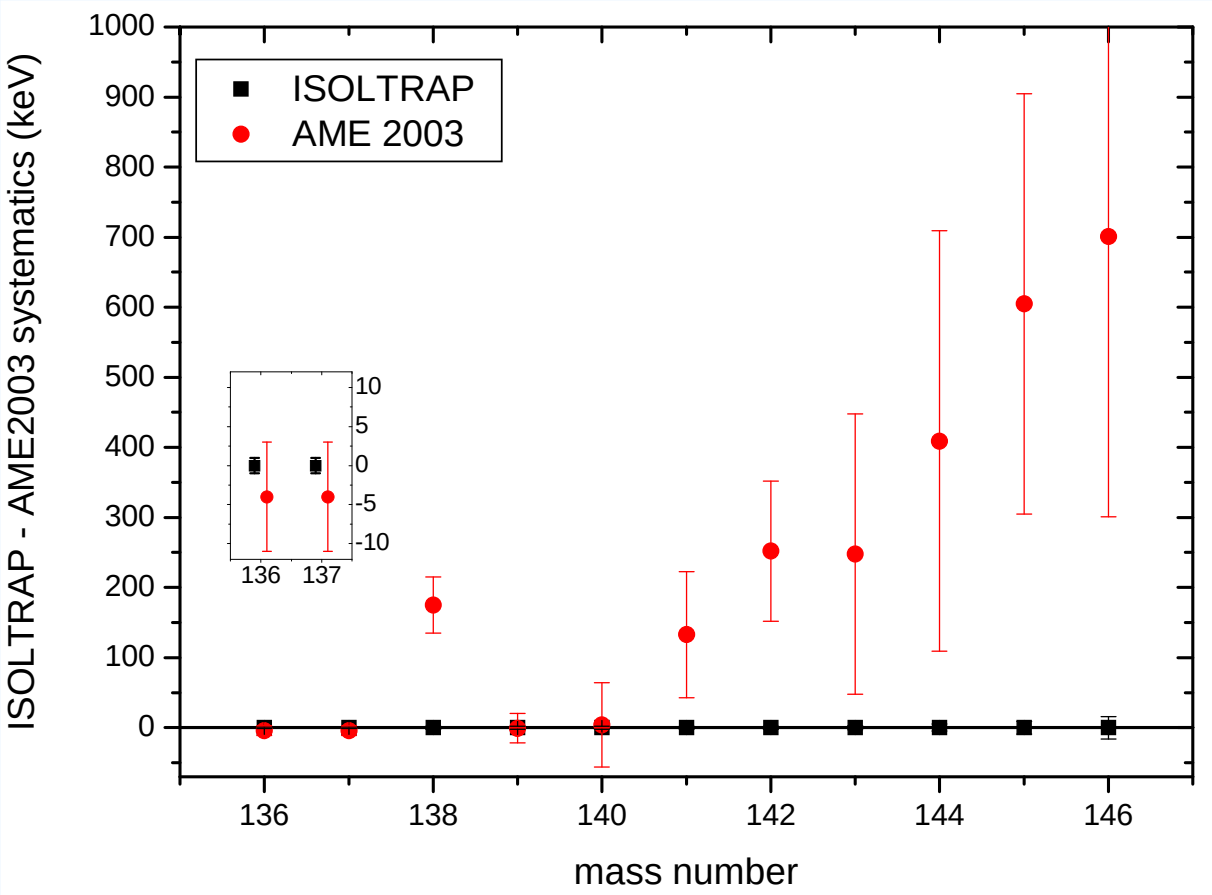
δV_{pn} values around A ~ 220:



Whereas the very large value for ^{208}Pb is well understood, the sharp peak for Ra is still under investigation

N-rich Xe data

Masses of $^{136\text{-}146}$Xe:

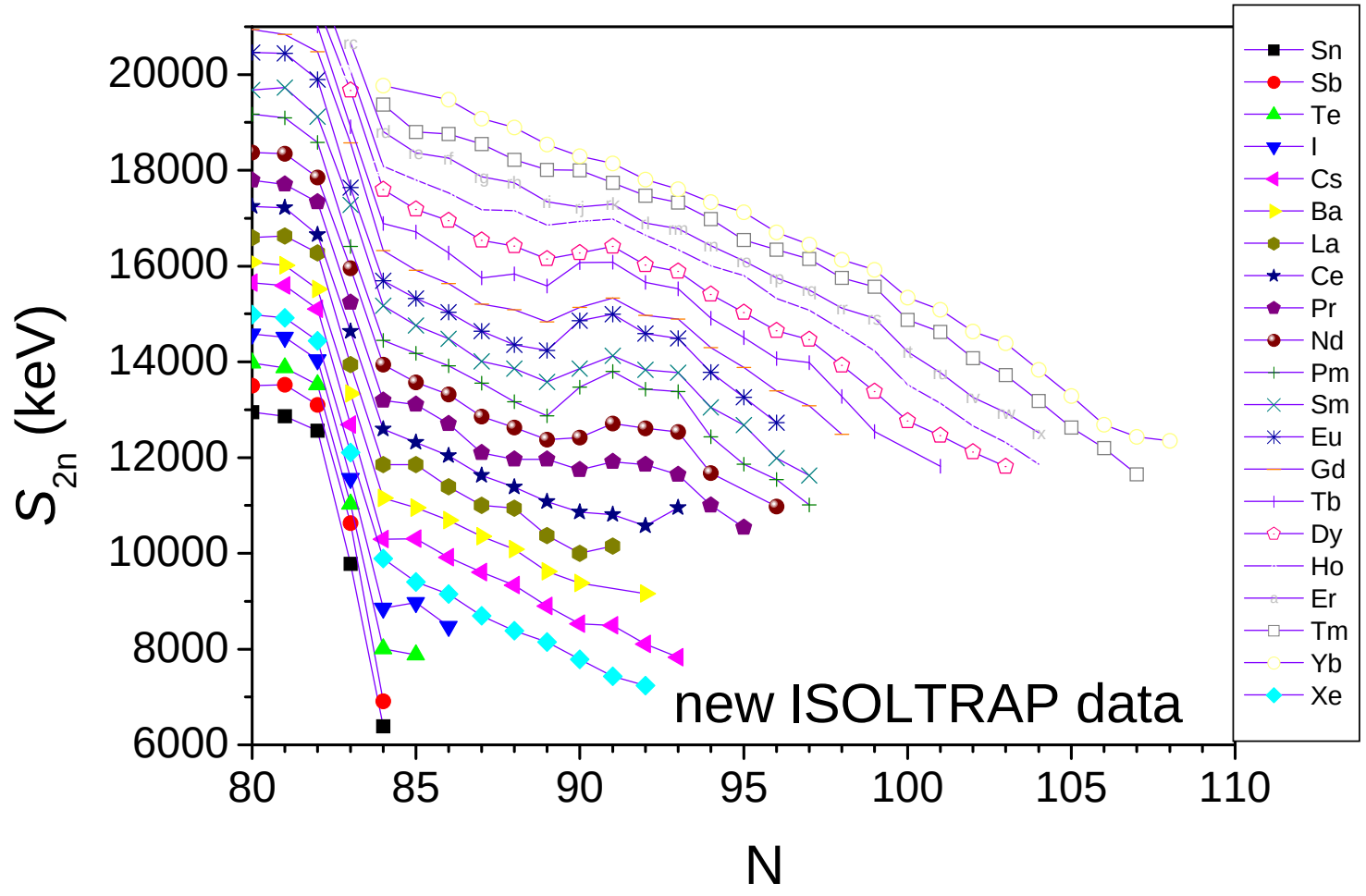


- For $^{143\text{-}146}$Xe only extrapolations were known so far
- ^{147}Xe would have also been possible, but we had no time to try it; ^{148}Xe was never observed at any experiment
- We obtained also some resonances of ^{138}Xe, without influence of the expected contamination ^{138}Ba
- The uncertainty of our measurements is in the order of 2-20 keV

Neidherr et al, in preparation

N-rich Xe data

2-neutron seperation energies of $^{136\text{-}146}$Xe:



N-rich Rn data

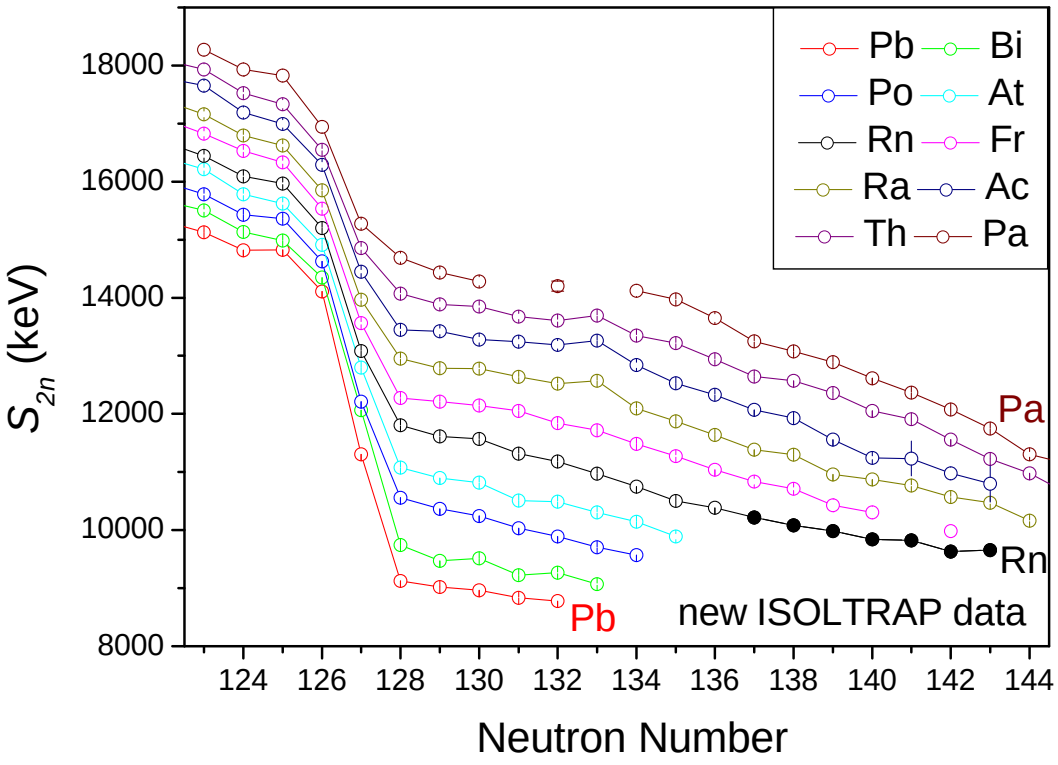
Masses of $^{223\text{-}229}$Rn:

6 masses were measured directly for the first time.

All these mass values were only extrapolated up to now.

Our uncertainties are always below 20 keV.

^{220}Rn was used as a cross-check.



Neidherr et al, submitted to PRL

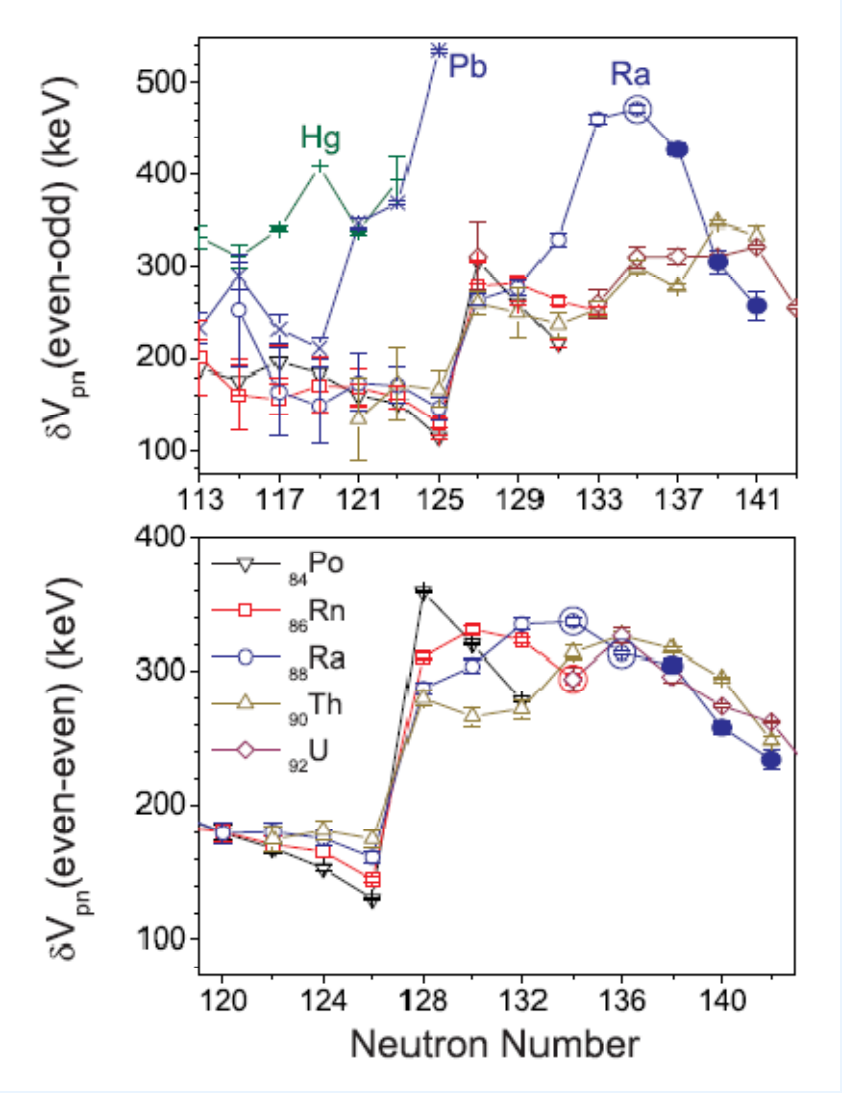
Interpretation of δV_{pn}(Ra) data

For the Ra isotopes with an odd number of neutrons a very sharp peak at N=135 is visible.

This could be a hint for octopole deformation or a sub-shell clusure around N=134.

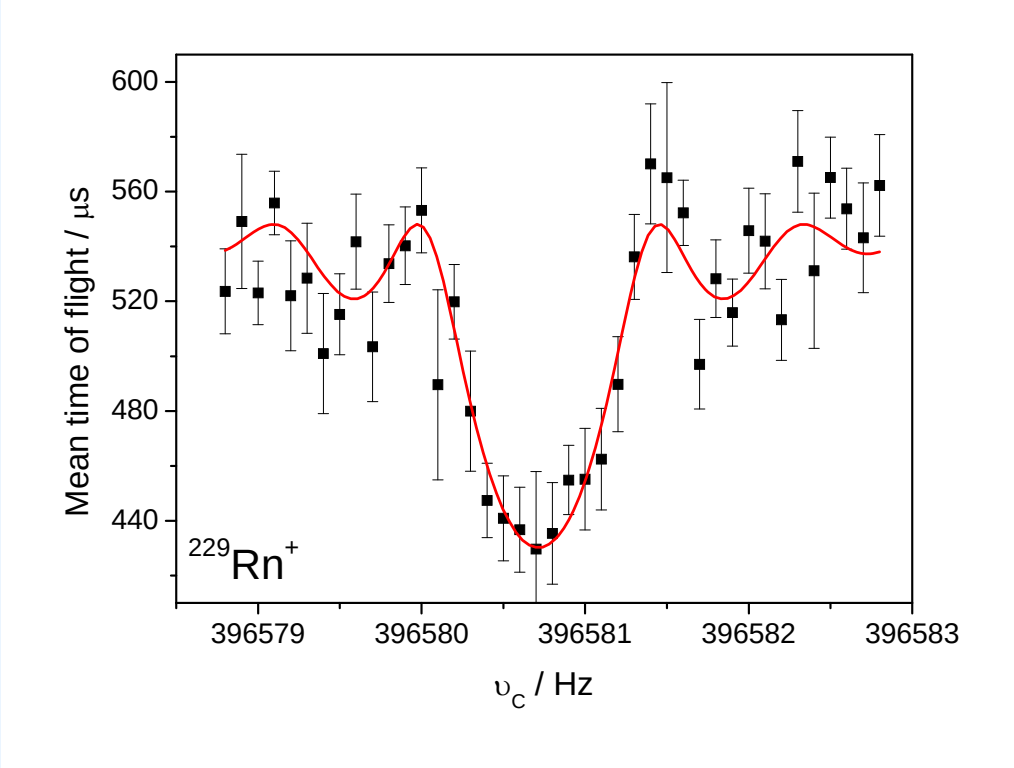
Here, the δV_{pn} values for neighboring elements have similar behavior, but they are systematically shifted to the right for each successive Z.

A similar behavior is only known in the rear-earth region where it appears near mid-shell.



^{229}Rn

The question is, if this resonance is really ^{229}Rn (which was never seen before at any measurement):

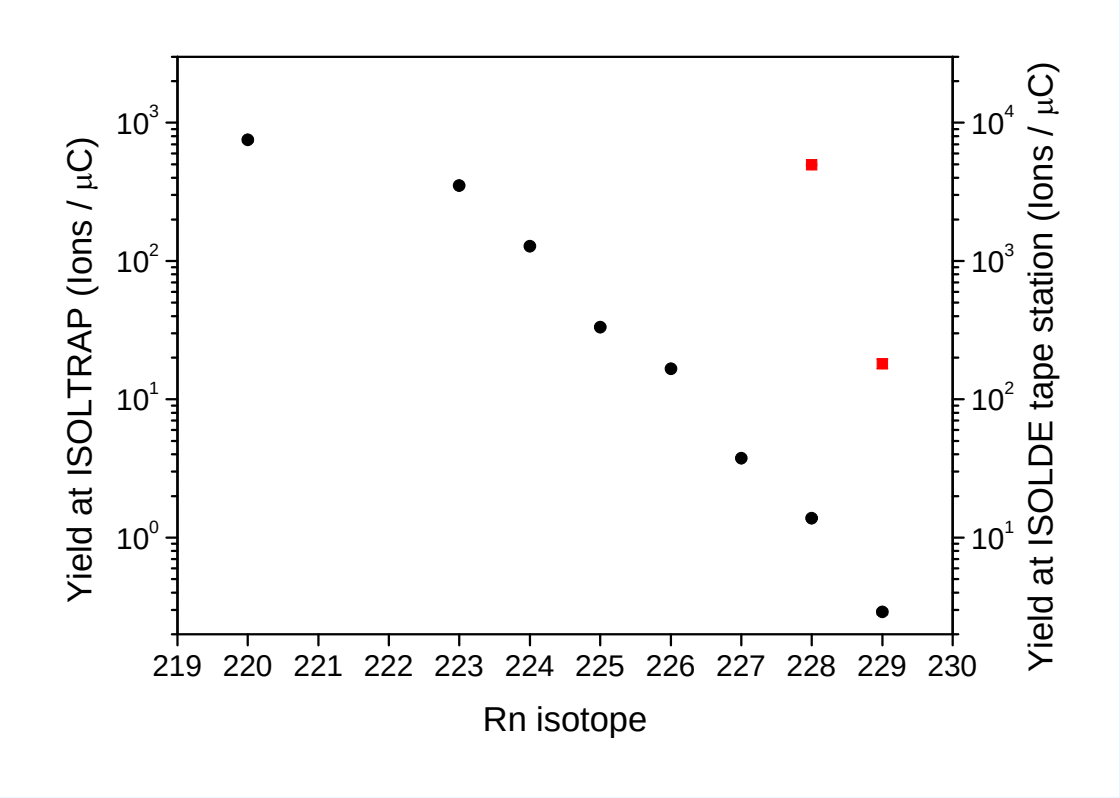


We have several proofs that it is indeed ^{229}Rn:

i. The resonance was quite clean, so no contaminations were visible (which would lead to a decrease in the TOF effect)
ii. All possible molecular contaminations with up to three different species in the range of +/- 2 Hz can be excluded.

^{229}Rn (2)

iii. The yield is exactly behaving like expected. We saw roughly one order of magnitude less ^{229}Rn than ^{228}Rn.



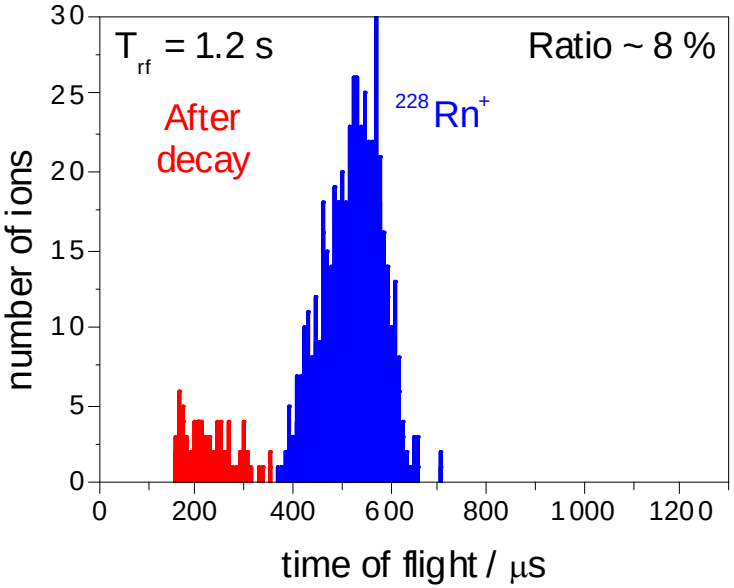
The black circles show the yield in our trap, whereas the red rectangles show the yield at the ISOLDE tape station

New arc-discharge ion source increased the ionization efficiency for nobel gases by a factor of 5 to 20.

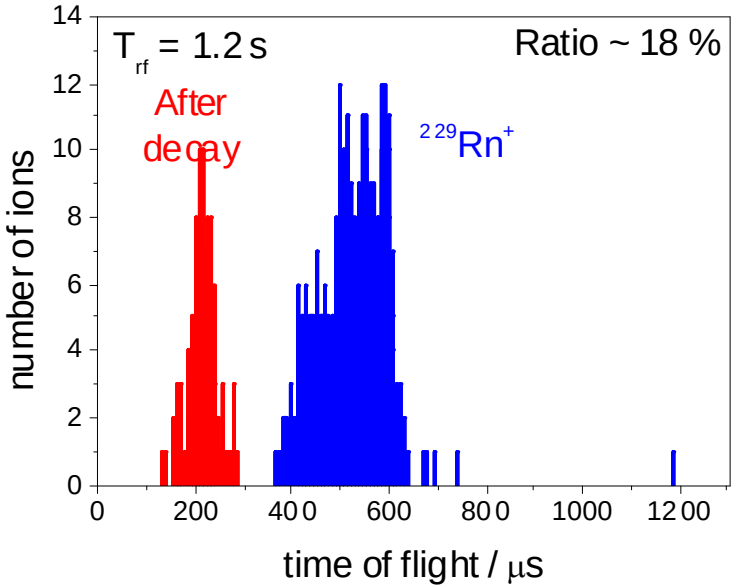
Talk by L. Penescu, Wednesday 11:50 am

^{229}Rn (3)

iv. Also the half-life of ^{229}Rn was measured at the ISOLDE tape station. And it fits very well with the theoretical predictions.



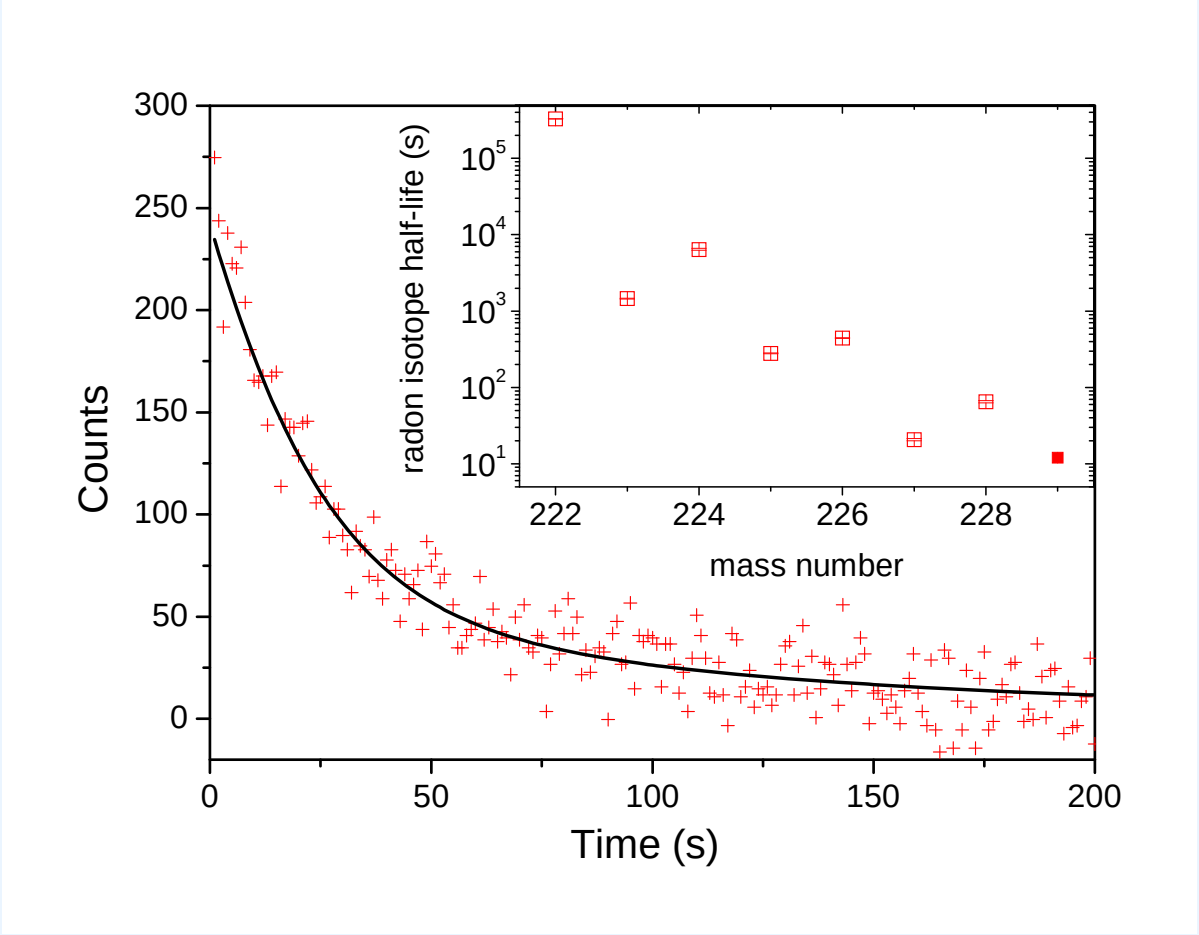
$T_{1/2}$ (^{228}Rn) = 65 s



$T_{1/2}$ (^{229}Rn) < 65 s

^{229}Rn (3)

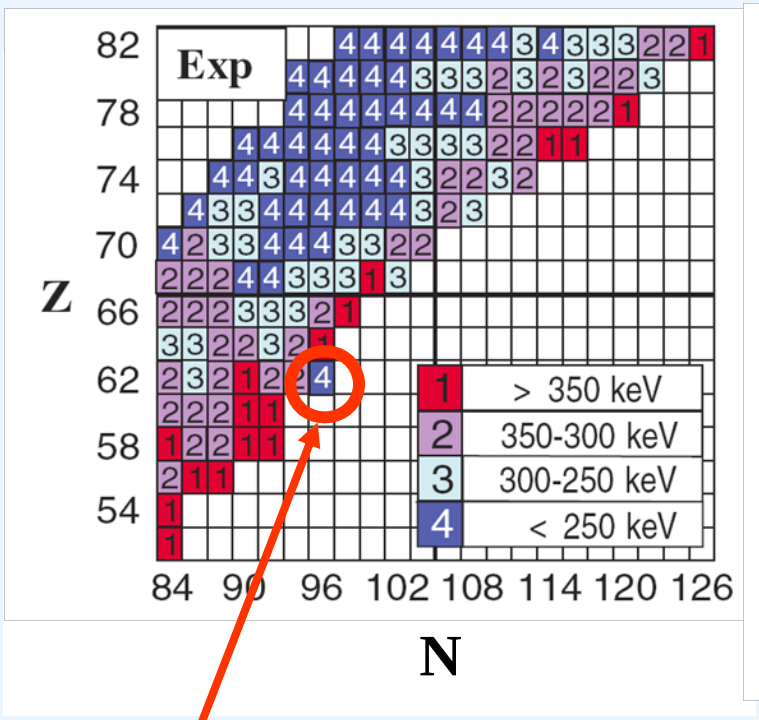
iv. Also the half-life of ^{229}Rn was measured at the ISOLDE tape station. And it fits very well with the theoretical predictions.



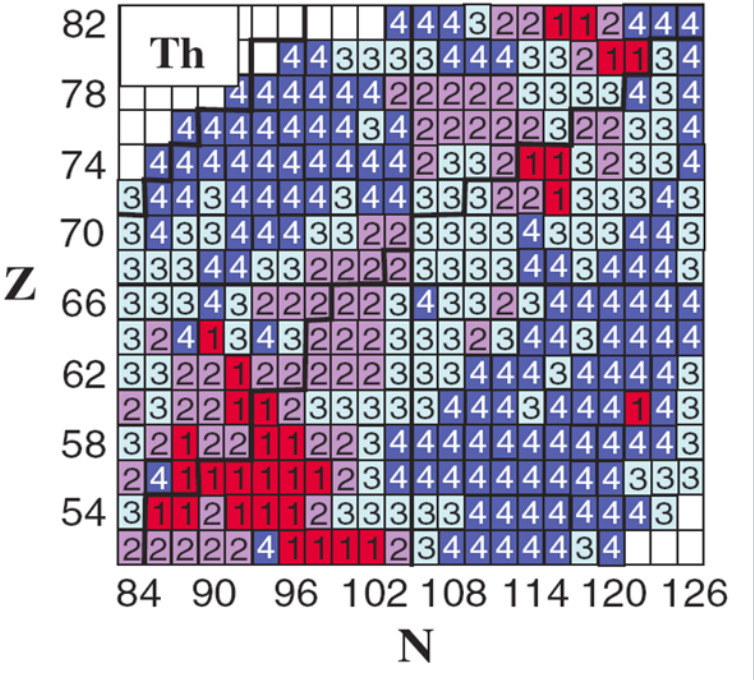
Result from the fit: 12 s (+1.2 s, -1.3 s)

Outlook:

AME2003 data



DFT calculations



Next steps:

- ^{158,160}Sm:

  A RILIS ionization scheme will be maybe tested this winter

- ^{154,156}Nd:

  an ionization scheme has already been tested

- ^{116,118,120}Pd:

  Determination of Cd-δV_{pn} values, too low yield, so also further target development necessary

Talk by V. Fedosseev, Tuesday 09:00 am

Thanks to:

- *ISOLTRAP collaboration:*

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- *And to:*

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Thanks a lot for your attention!