Nuclear structure studies of the neutron-rich Rubidium isotopes using Coulomb excitation.

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and REX-ISOLDE and Miniball collaborations

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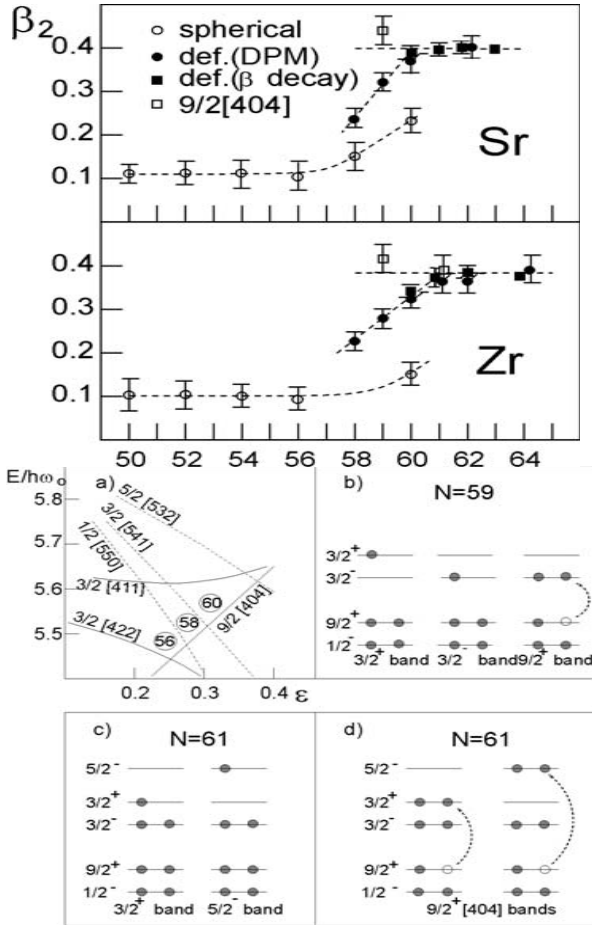
N=60 - from spherical to well deformed structures

Zr (Z=40) and Sr (Z=38)

→ clear shape change across N=60

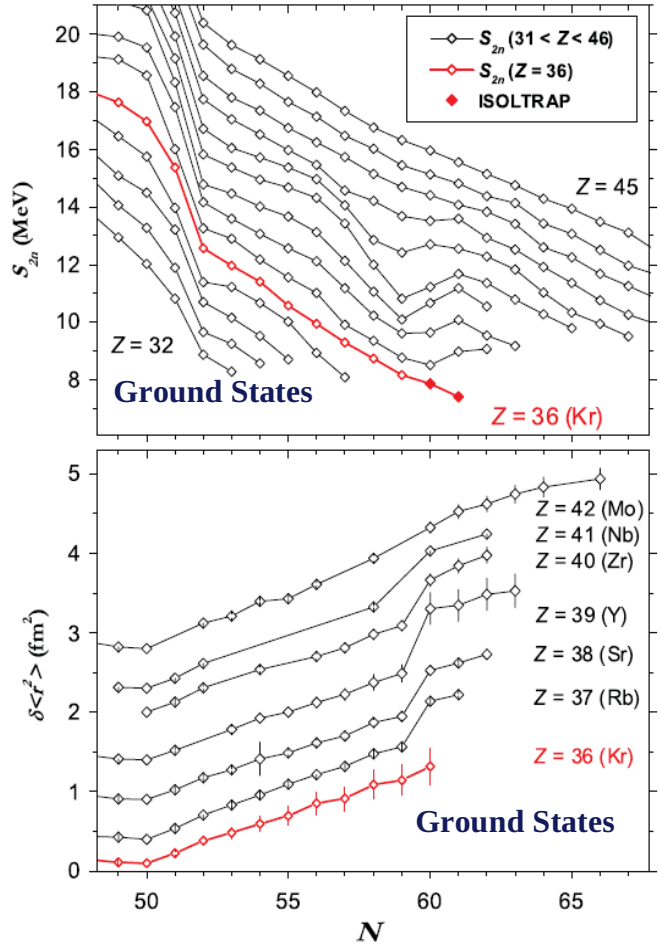
W. Urban *et al.*, Eur. Phys. J. A22, 241 (2004)



ν9/2⁺[404], ν1/2⁻[550], ν3/2⁻[541], ν3/2⁺[411]

Kr (Z=36) → NO onset of deformation for the ground states

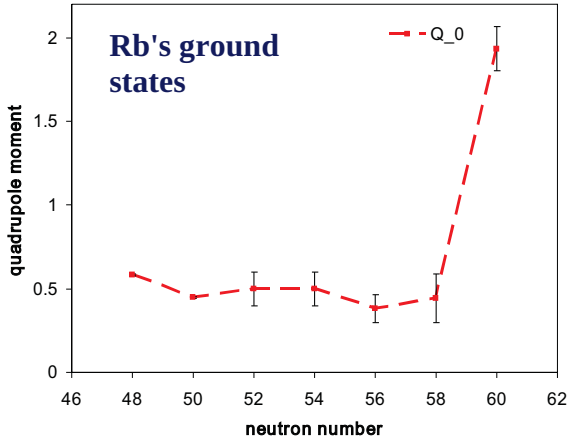
S. Naimi *et al.*, Phys. Rev. Lett. 105, 032502 (2010)

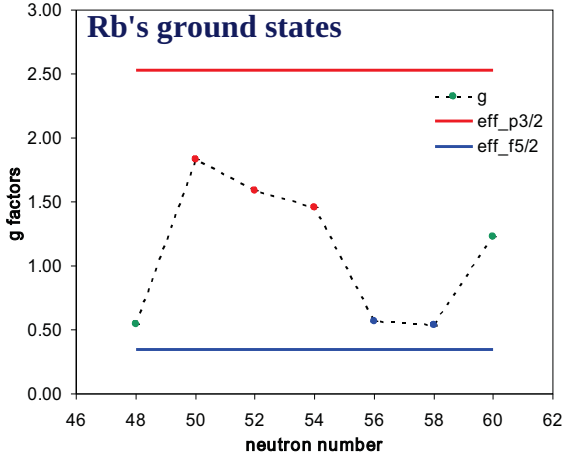


Mass and laser measurements seem to show that the Kr isotopes do not undergo a rapid shape change of their ground states from N=58 to 60

What is going on with the proton side? Rb's (Z = 37)

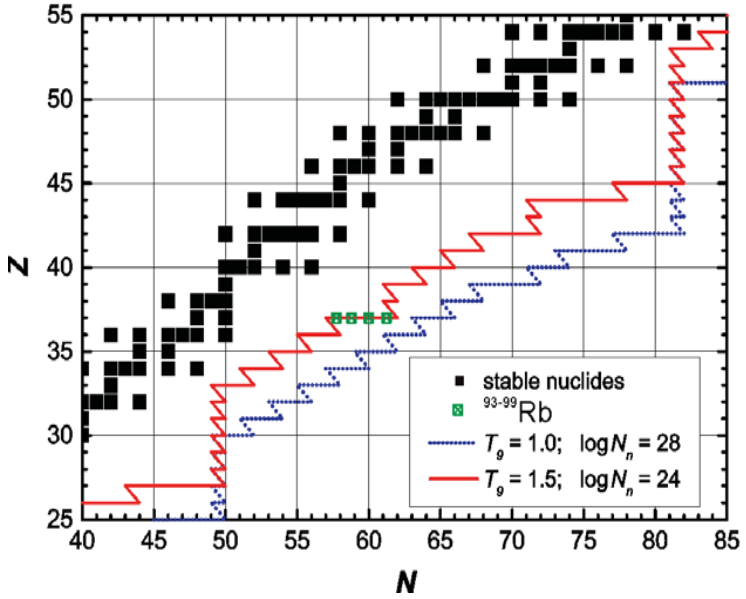
C. Thibault *et al.*, Phys. Rev. **C23,** 2720 (1981)





$\pi\, 3/2^-[312]$, $\pi\, 3/2^-[301]$, **$\pi\, 3/2^+[431]$**

PHYSICAL REVIEW C**74**, 034331 (2006)

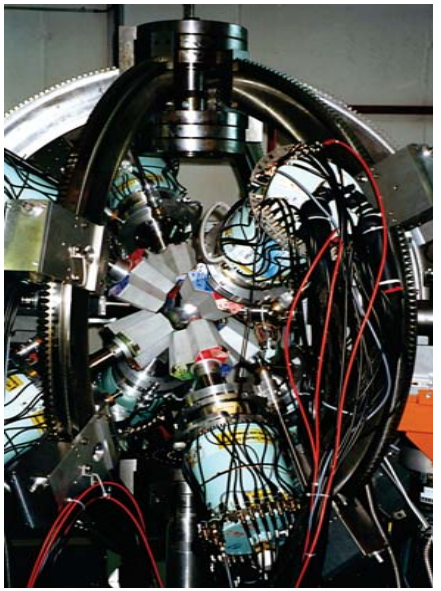


r-process path – according to one of the scenarios it can pass exactly through the ^{93,95,97,99}Rb nuclei

- The nuclei of interest (^{93,95,97,99}Rb) are very far from the stability valley.
- They are very difficult to access in beta-decay or spontaneous fission.

→ **Coulomb excitation might be easiest and cleanest way to study their excited states.**

Experimental details



Beam impurities

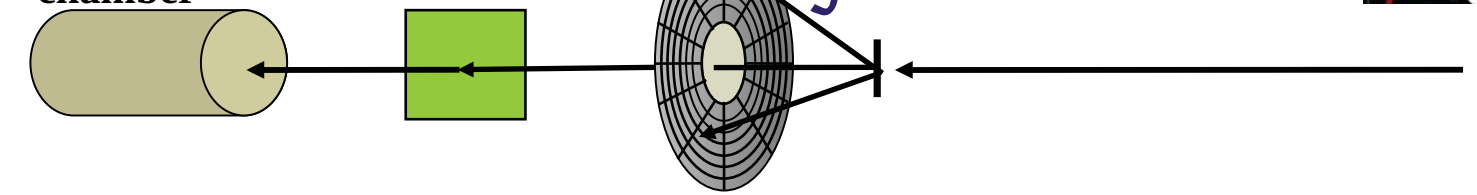
Beam monitor

Particles angles (16° – 53°)

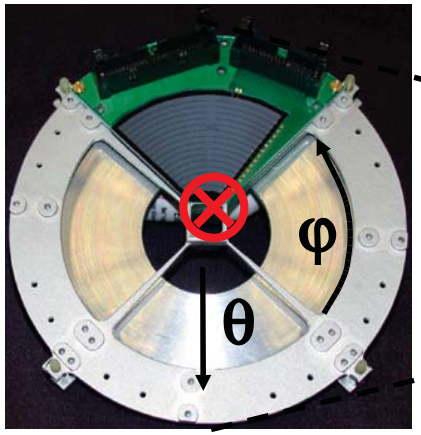
Ionization chamber

beam dump Ge detector

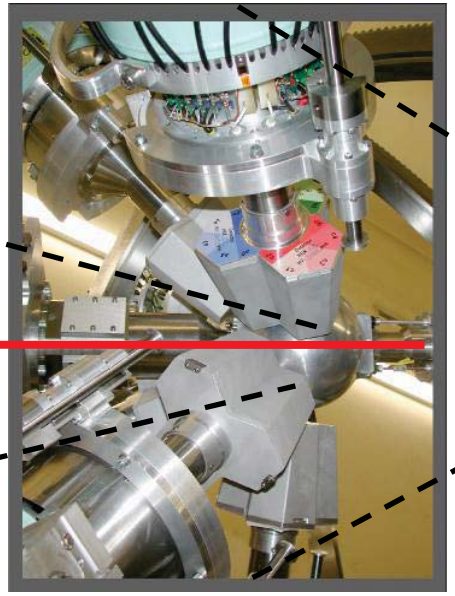
DSSSD



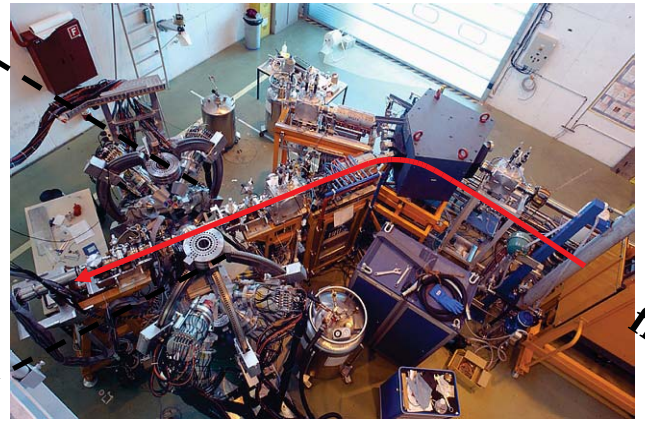
Beam from REX-ISOLDE @ 2.83 MeV/u



CD Detector



Reaction Chamber & Miniball cluster array

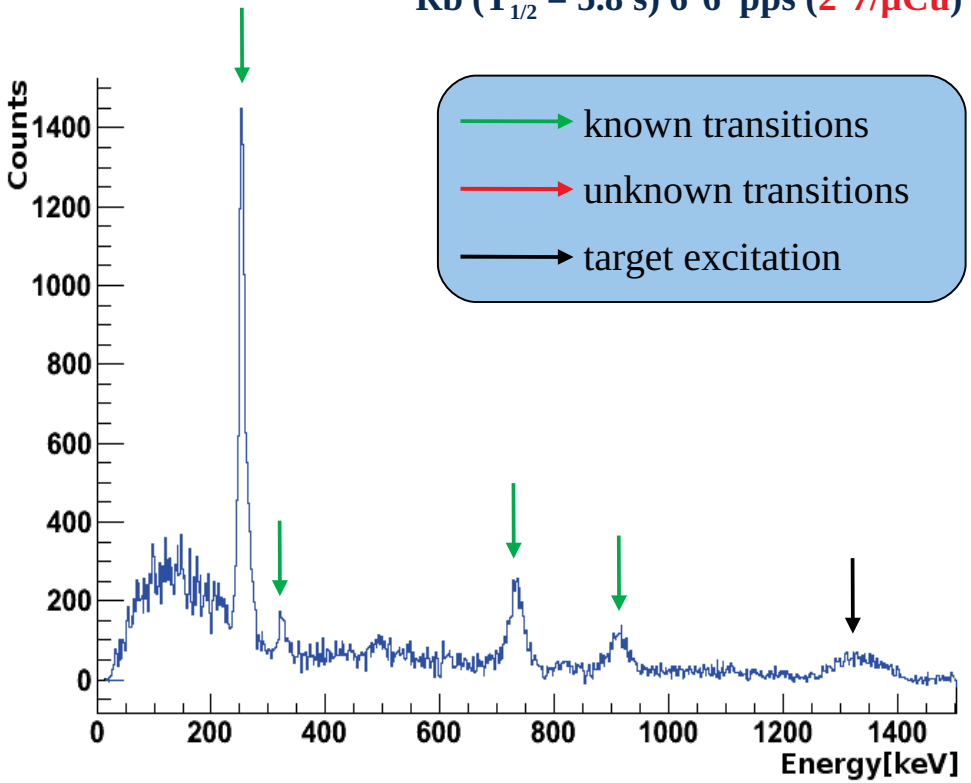


Rb beam from REX

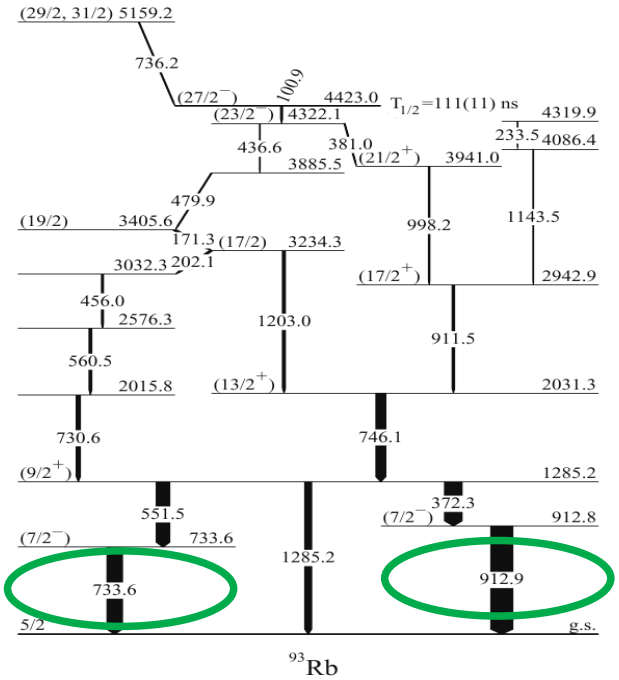
^{93}Rb preliminary results

^{93}Rb on ^{60}Ni @ 2.83MeV/u :

^{93}Rb ($T_{1/2}$ = 5.8 s) $6^{E}6$ pps ($2^{E}7$/µCu)



Prompt gamma spectra

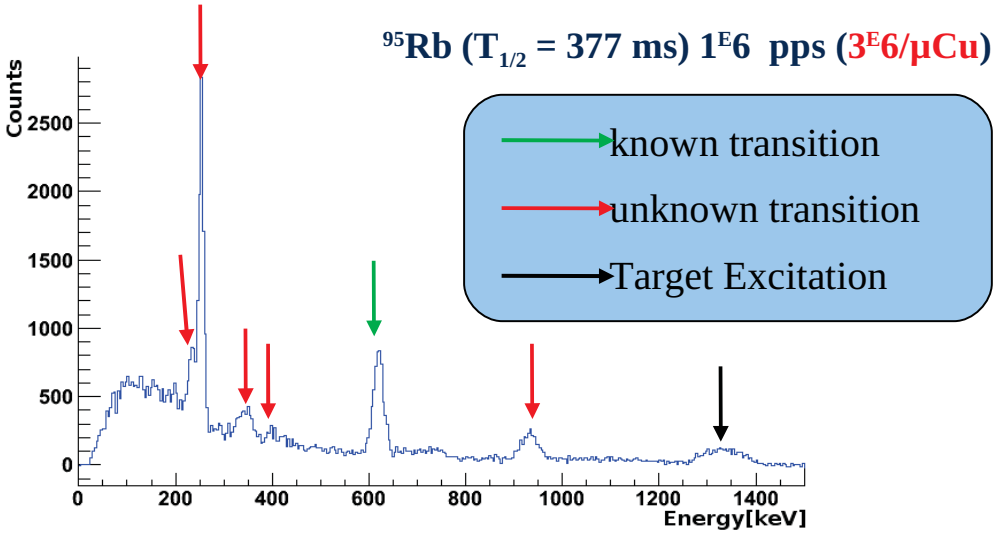


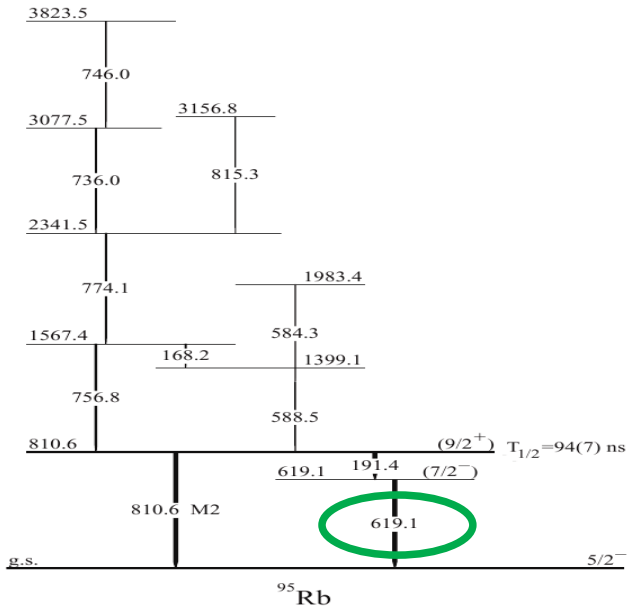
G. S. Simpson *et al.* Phys. Rev. C 82, 024302 (2010)

γ-transition energy	Type
254.5 keV	known
323.6 keV	known
734.1 keV	known
913.2 keV	known
1332.5 keV	target excitation

^{95}Rb preliminary results

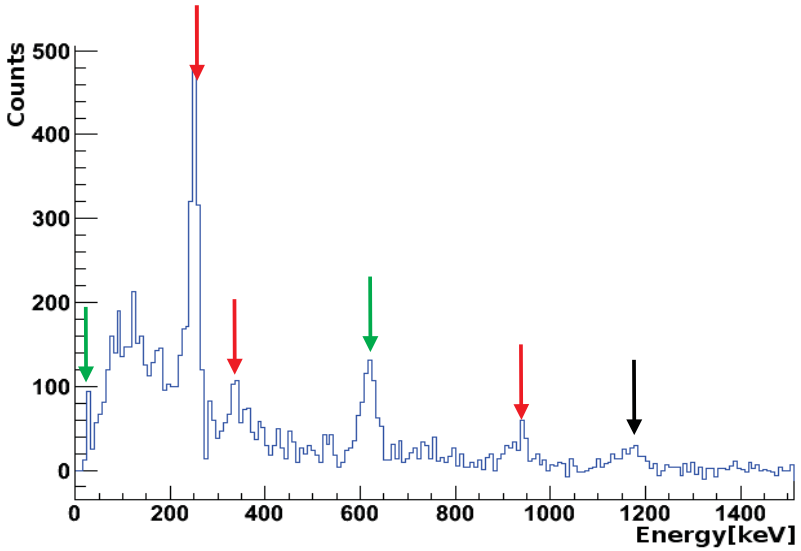
^{95}Rb on ^{60}Ni @ 2.83MeV/u :





G. S. Simpson Phys. Rev. C 82, 024302 (2010)

^{95}Rb on ^{120}Sn @ 2.83MeV/u :

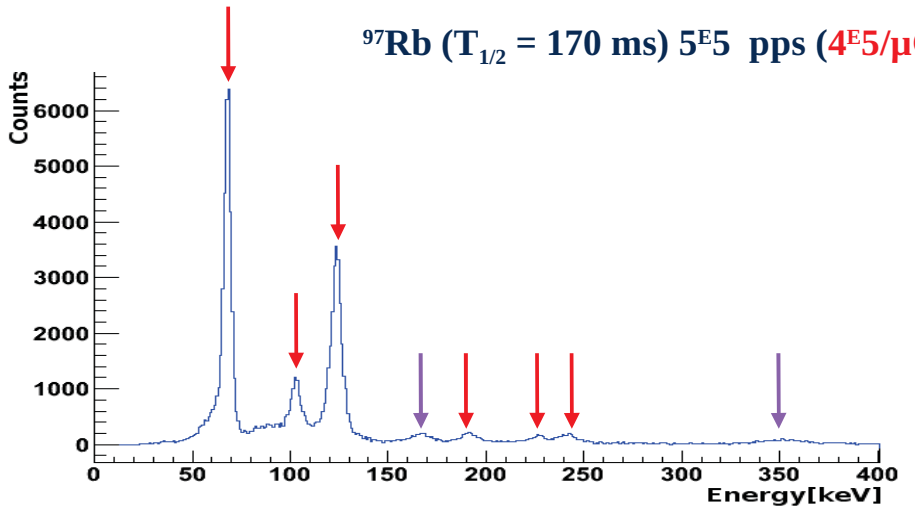


γ-transition energy	type
235.7 keV	unknown
253.9 keV	unknown
341.8 keV	unknown
391.9 keV	unknown
619.5 keV	known
933.6 keV	unknown
1171.3 keV	target excitation (Sn)
1332.5 keV	target excitation (Ni)

^{97}Rb preliminary results

^{97}Rb on ^{60}Ni @ 2.83MeV/u :

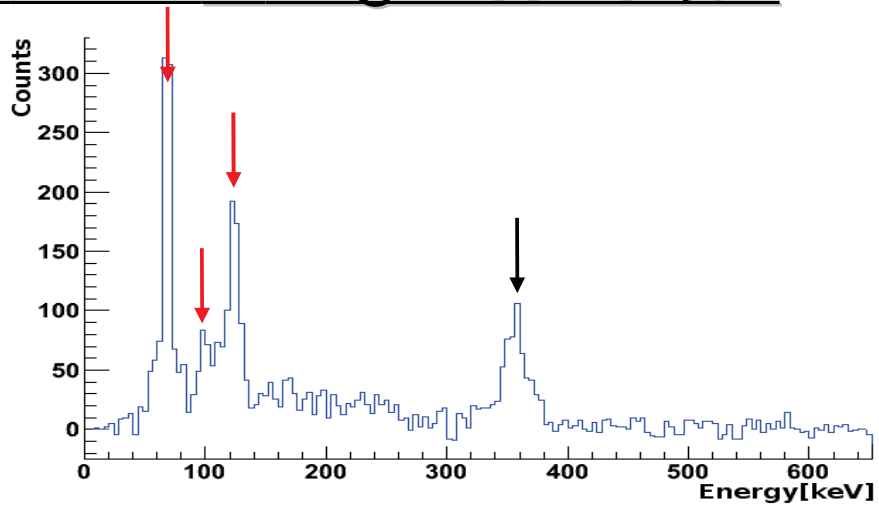
^{97}Rb ($T_{1/2}$ = 170 ms) 5^E5 pps (4^E5/µCu)



known transitions
unknown transitions
target excitation
contaminants (^{97}Sr,^{97}Y …)

First observation of excited states in ^{97}Rb

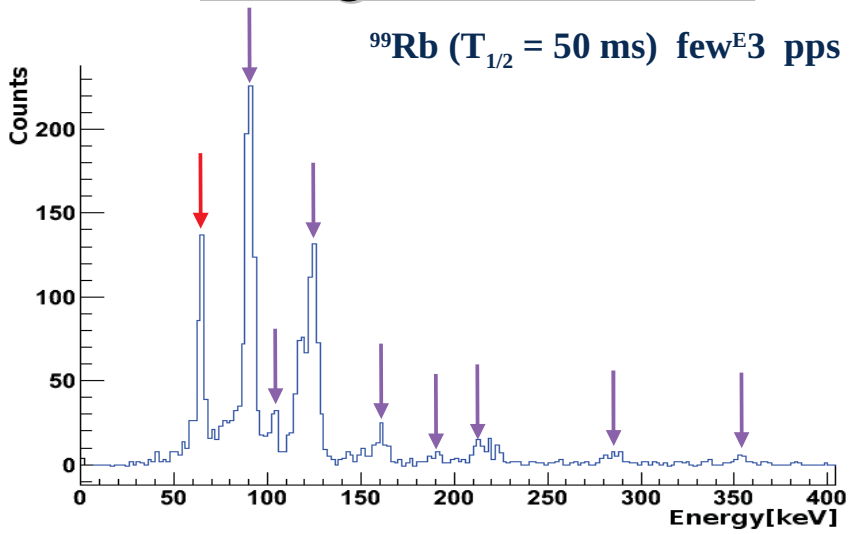
^{97}Rb on ^{196}Pt @ 2.83MeV/u :



γ-transition energy	type
67.8 keV	unknown
102.7 keV	unknown
123.5 keV	unknown
166.5 keV	^{97}Sr
191.3 keV	unknown
227.0 keV	unknown
241.2 keV	unknown
355.4 keV	^{97}Sr
355.68 keV	target excitation (Pt)

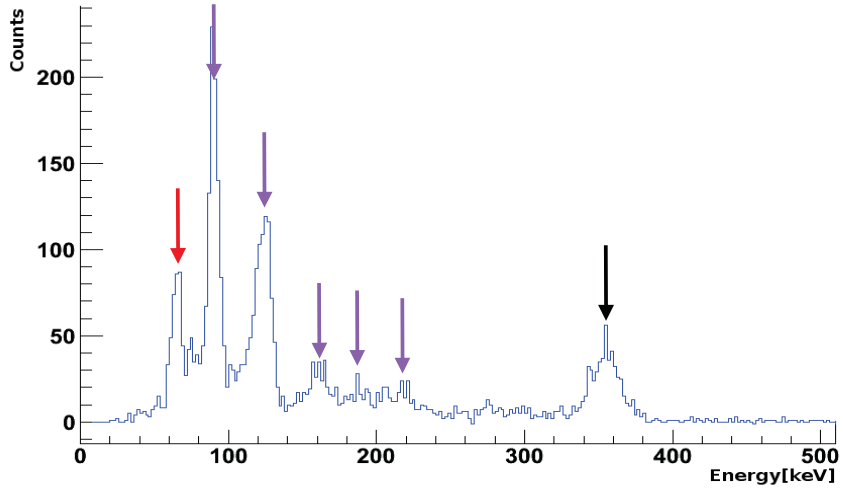
^{99}Rb preliminary results

^{99}Rb on ^{60}Ni @ 2.83MeV/u :



known transitions
unknown transition
target excitation
contaminants (^{99}Sr,^{99}Y …)

^{99}Rb on ^{196}Pt @ 2.83MeV/u :



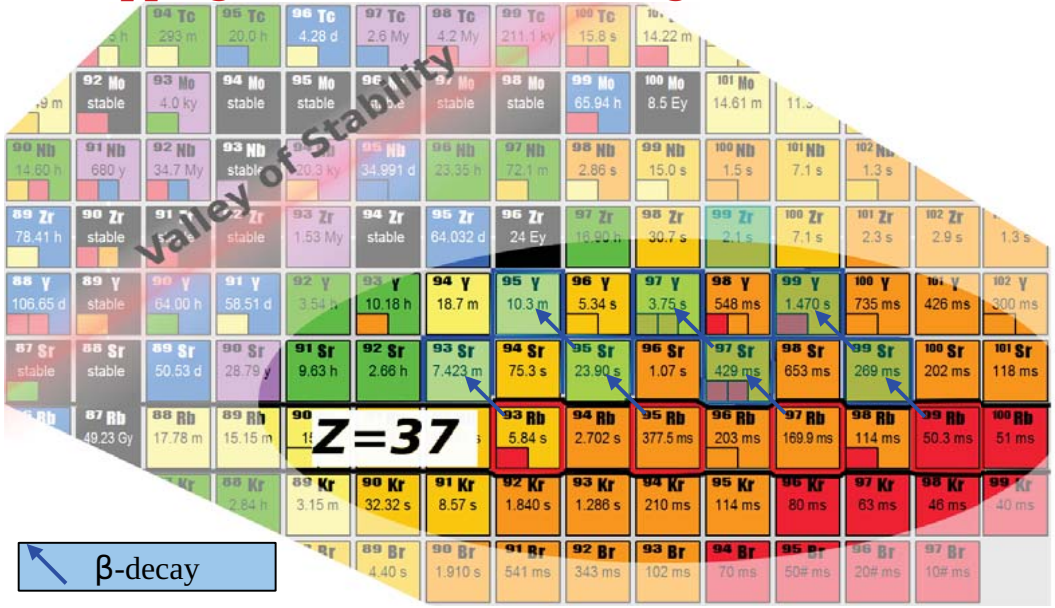
First observation of excited state in ^{99}Rb

γ-transition energy	type
68.1 keV	unknown
90.2 keV	^{99}Sr
106.8 keV	^{99}Sr, ^{99}Y
117.4 keV	contaminant
124.5 keV	^{99}Sr, ^{99}Y
160.6 keV	^{99}Sr, ^{99}Y
192 keV	^{99}Y
215 keV	^{99}Sr
294.5 keV	contaminant
355.68 keV	target excitation (Pt)

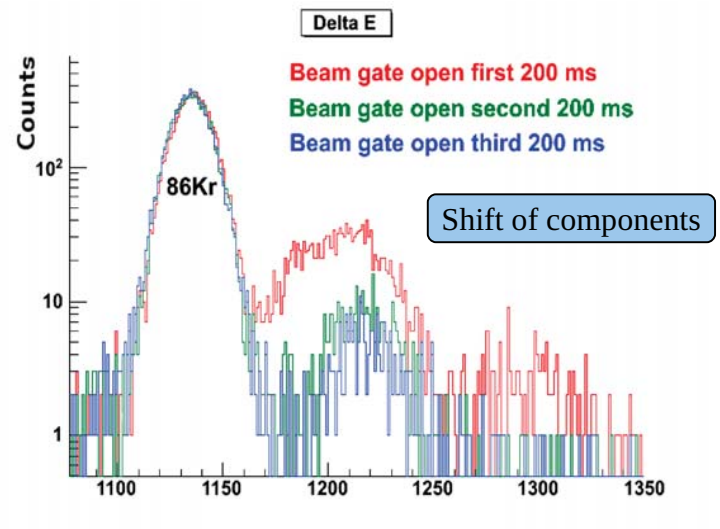
^{99}Rb – pushing the limits

^{99}Rb case $T_{1/2}$ = 50 ms;

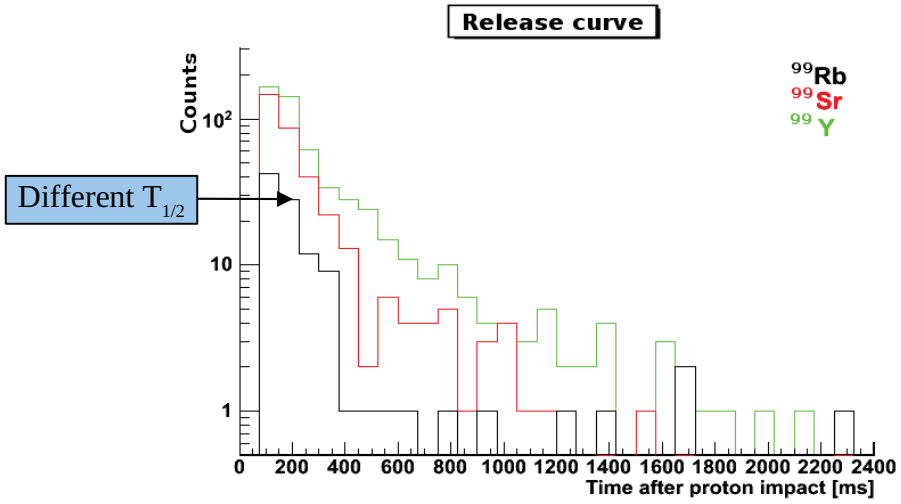
trapping time ~80 ms; breading time ~80 ms

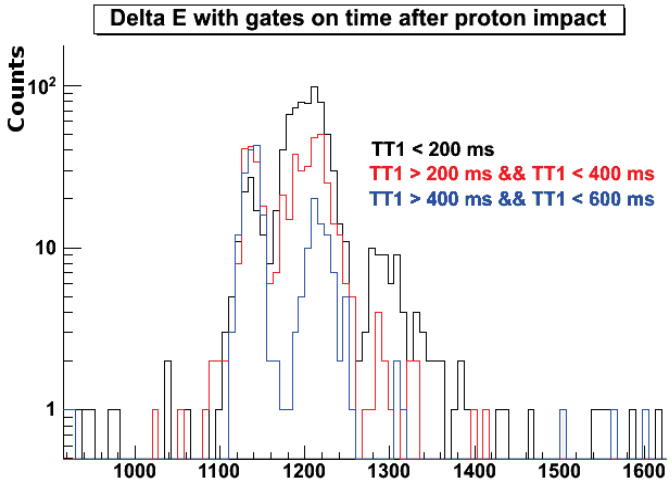


Ionization Chamber



Simulation trying to reproduce IC





Conclusions and Outlook

- The structure of the Rubidium isotopes is one of the keys ingredients needed to clarify the nature of the sudden shape changes around the neutron-rich N=60 region, giving an insight in the possible proton contribution to the process.

- Several transitions were populated by the Coulomb Excitation in supposedly spherical ^{93}Rb and ^{95}Rb. Moreover, some new transitions were discovered for ^{95}Rb. This constitutes a solid basis for the understanding of the deformed ^{97}Rb and ^{99}Rb.

- Gamma ray transitions in ^{97}Rb and ^{99}Rb were unambiguously identified providing the first information on excited states in those nuclei.

- B(E2) values should confirm the nature of those states (spherical or deformed).

Thank you for your attention.