CROSSING THE DRIP-LINE IN THE VICINITY OF ^{100}Sn

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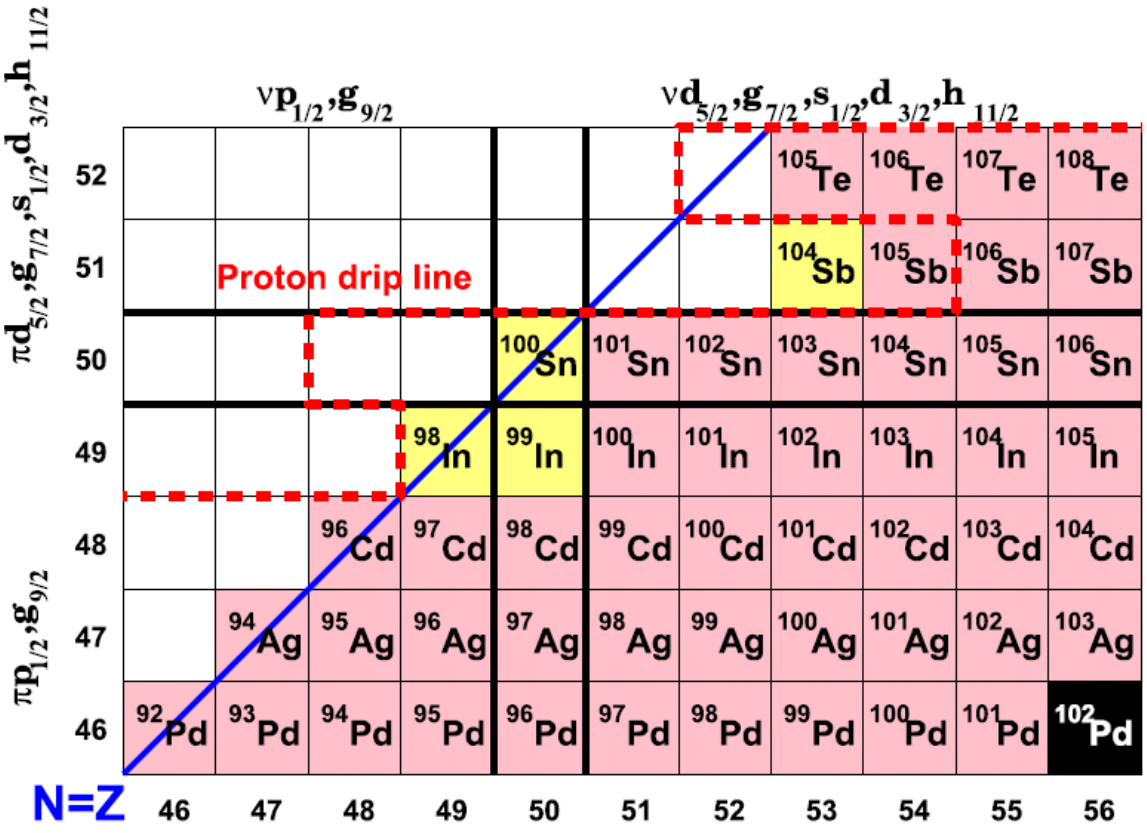
for the RIBF009 Experiment Collaboration

Motivation

T. Faestermann et al. / Progress in Particle and Nuclear Physics 69 (2013) 85–130



Mapping proton-drip line -> test of mass models

Search for:
New isotopes
New isomers
New proton emitters

Relevant to:
rp – process
βp and p – decay
$t_{1/2}$ and branching ratios

D. Bazin et al., Phys. Rev. Lett. 101, 252501 (2008)
C.B. Hinke et at., Nature 486, 341–345, (2012) **, and many others!**

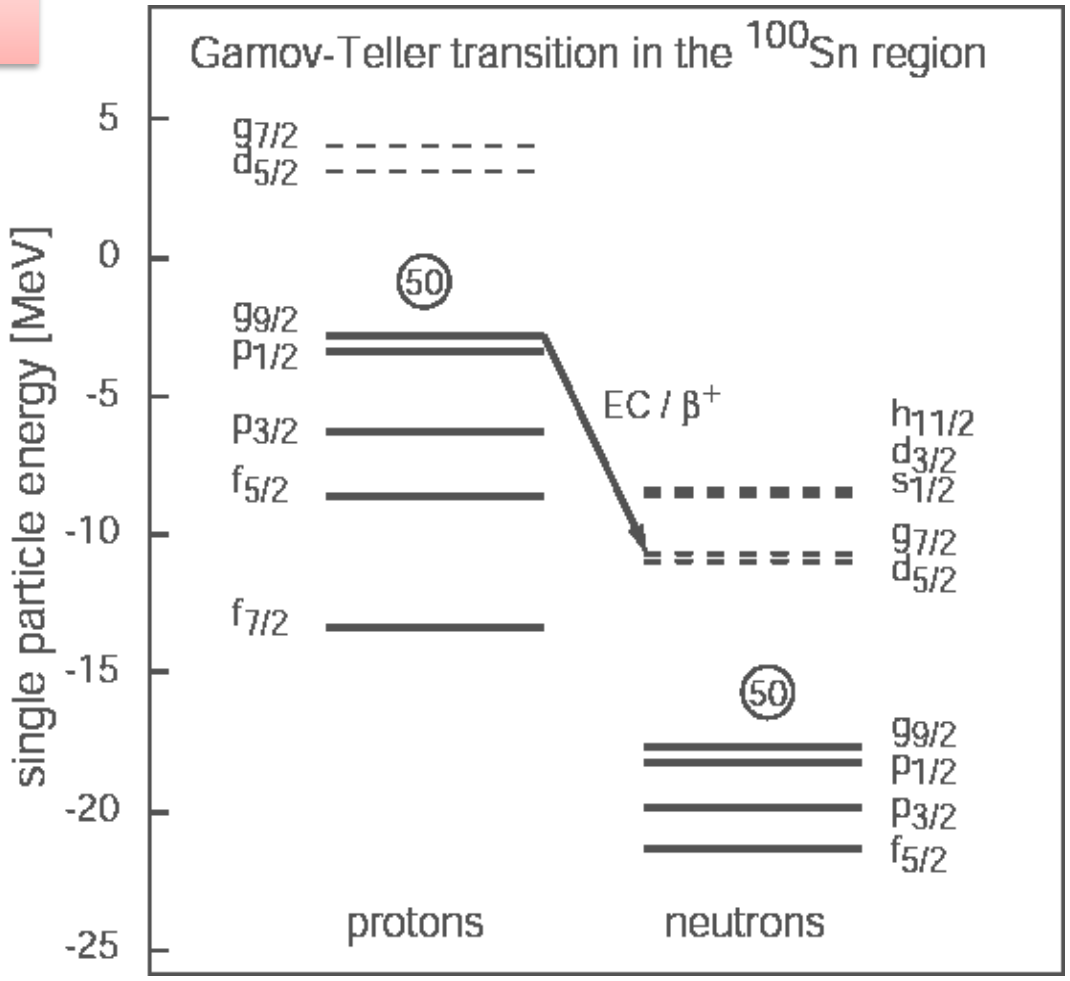
Motivation

Doubly Magic ^{100}Sn

Ideal testing ground
for GT-strength:

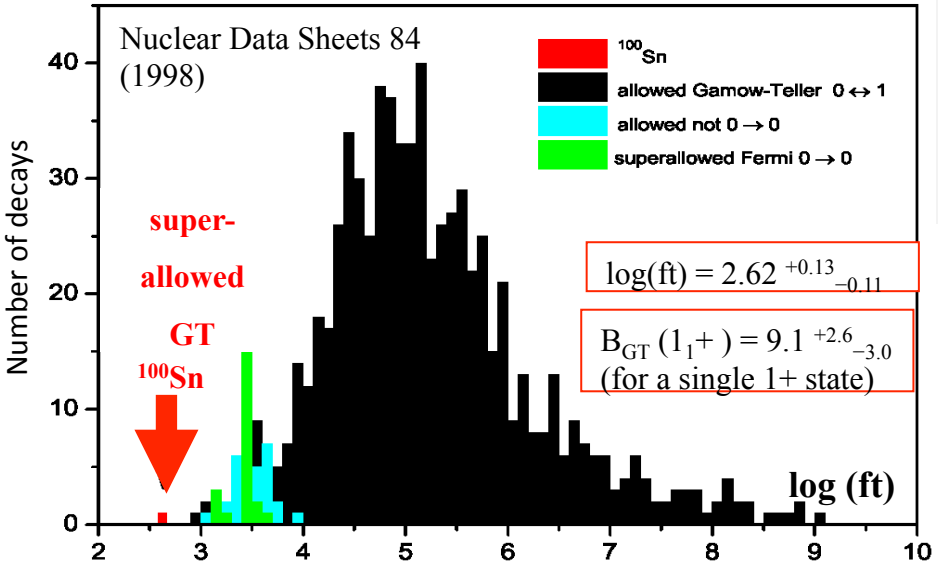
Pure spin-flip transition
$0^+ \Rightarrow (\pi g_{9/2}^{-1}\, \nu g_{7/2})1^+$
The purest GT transition
in the nuclear chart ?

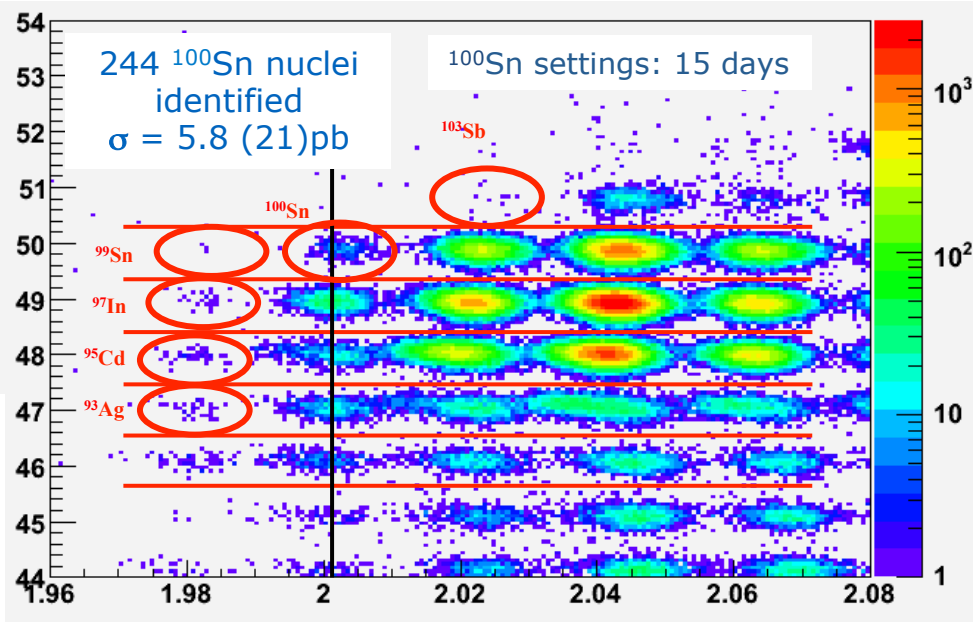
Large decay energy
=> most of GT resonance
in β - decay window

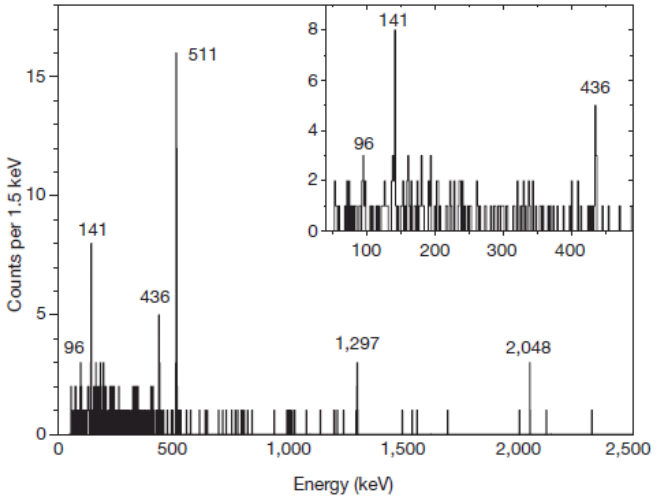


Previous Experiment at GSI

Superallowed Gamow–Teller decay of the doubly magic nucleus ^{100}Sn
Ch. Hinke et at., Nature 486, 341–345, June 2012



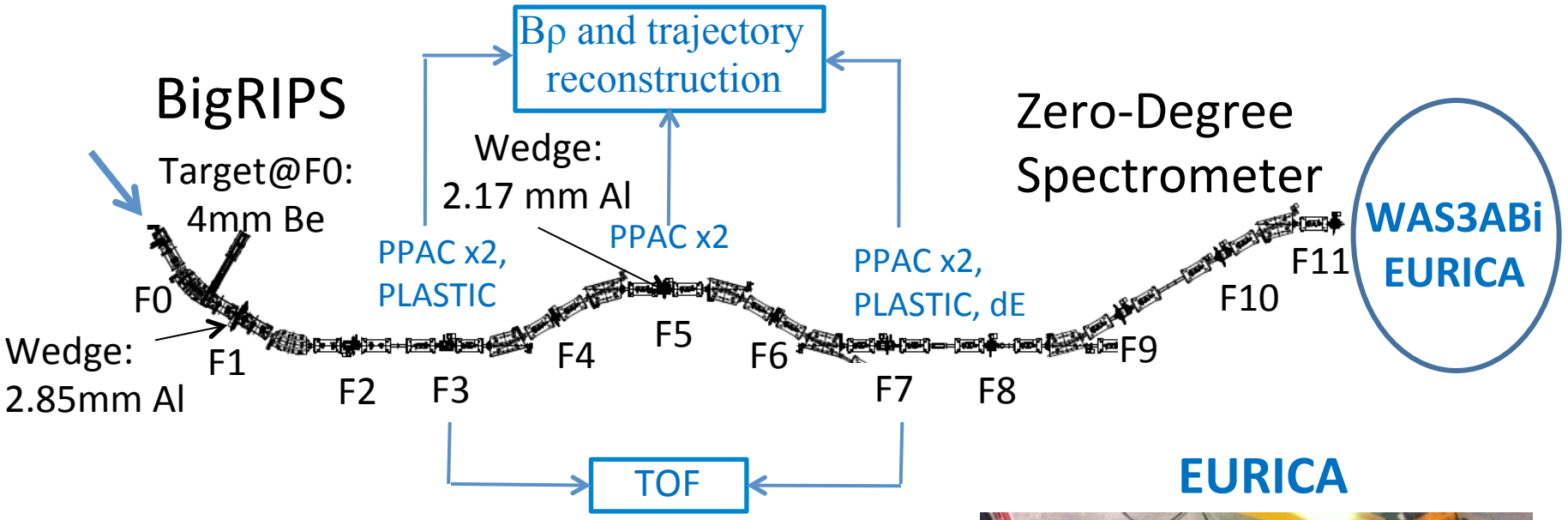




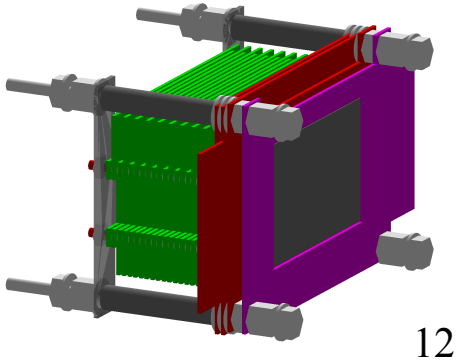
Decay γ spectrum of ^{100}Sn

Experiment

^{124}Xe 345 AMeV, 30 pnA, Be target, 12 days



WAS3ABi



3 layers of 1mm DSSSDs
(40-strips x 60 strips)
10 layers of 1mm SSSDs (7str)
design: TU-München/RIKEN

EURICA

12 EUROBALL Cluster; detectors, i.e. 84 Ge crystals but 40% not operational in the exp.

Particle identification and new isotopes

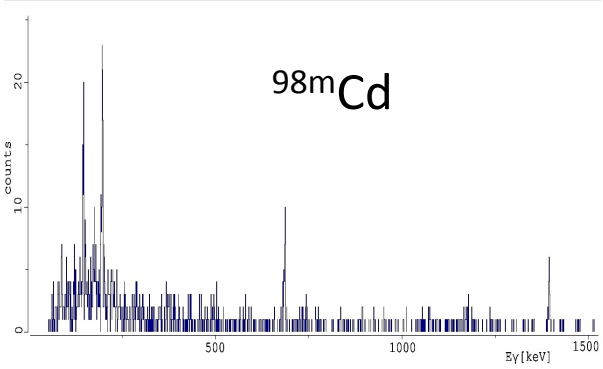
- ΔE – Bρ – TOF method:
  - from ΔE and TOF → Z

$$\frac{\Delta Z}{Z} = 0.41\%$$

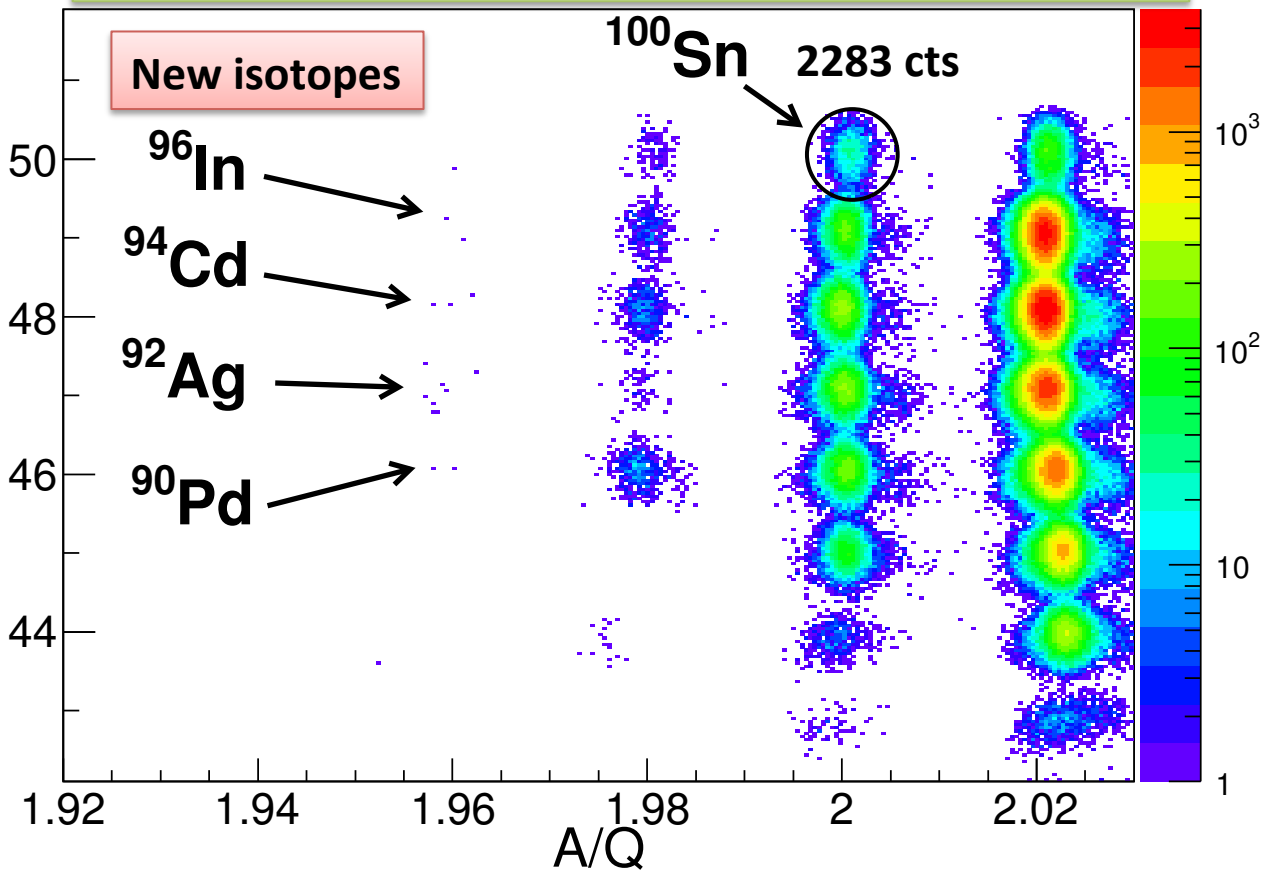
  - from Bρ and TOF → A/Q

$$\frac{\Delta A/Q}{A/Q} = 0.052\%$$

- Isotope identification confirmed by characteristic γ-rays from:

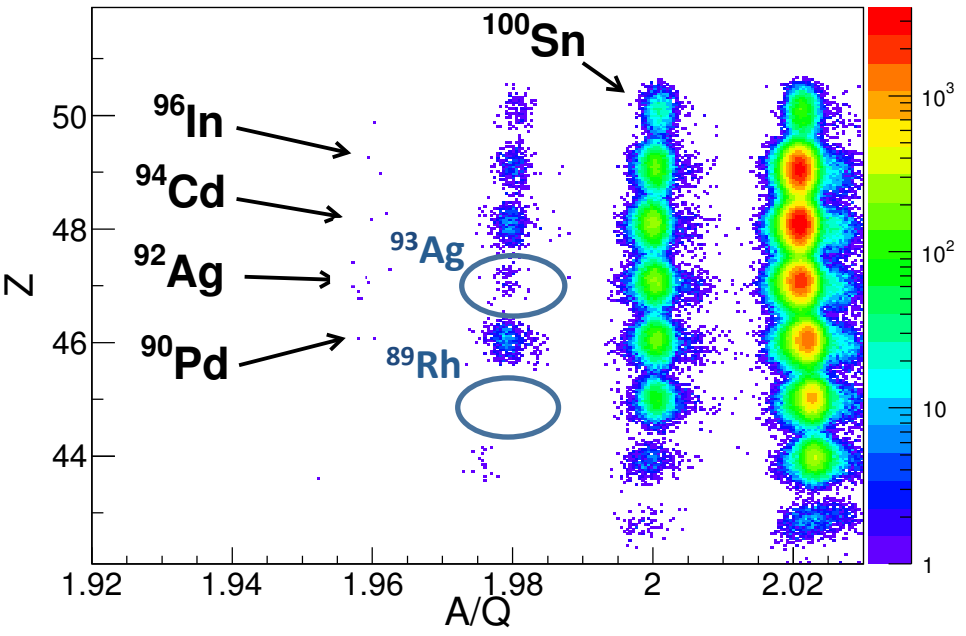


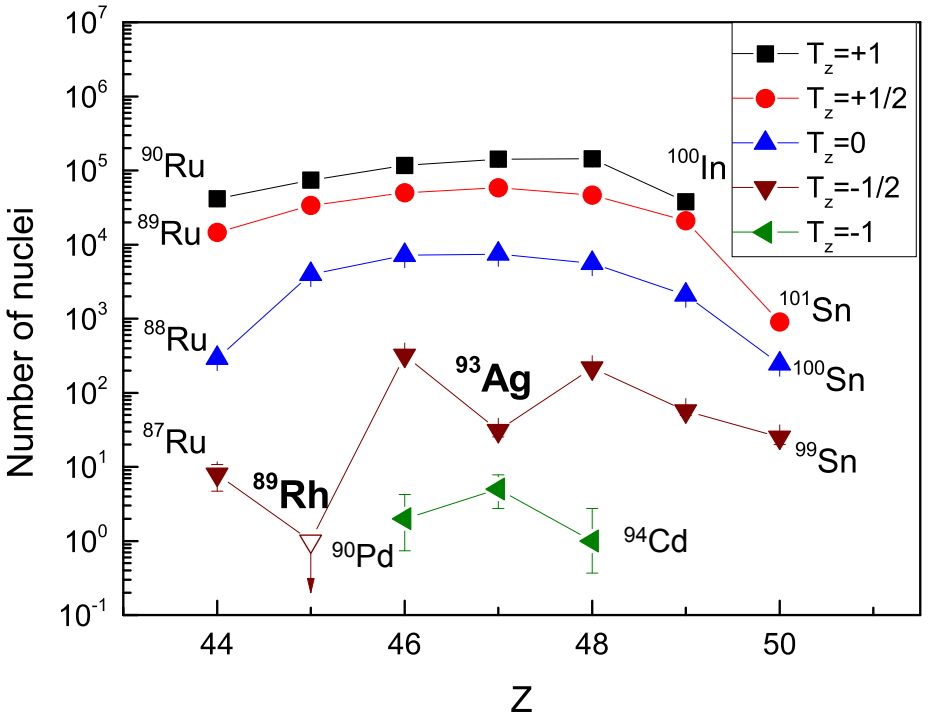
Identification plot
irradiation with 30 pnA ^{124}Xe beam during 203 h



Celikovic, I.; Lewitowicz M. et al., Phys. Rev. Lett. 116, 161102 (2016)

New proton emitters





- significant drop in number of detected ^{93}Ag and ^{89}Rh nuclei
  -> ^{93}Ag and ^{89}Rh: proton emitters

$T_{1/2}$ ~ TOF

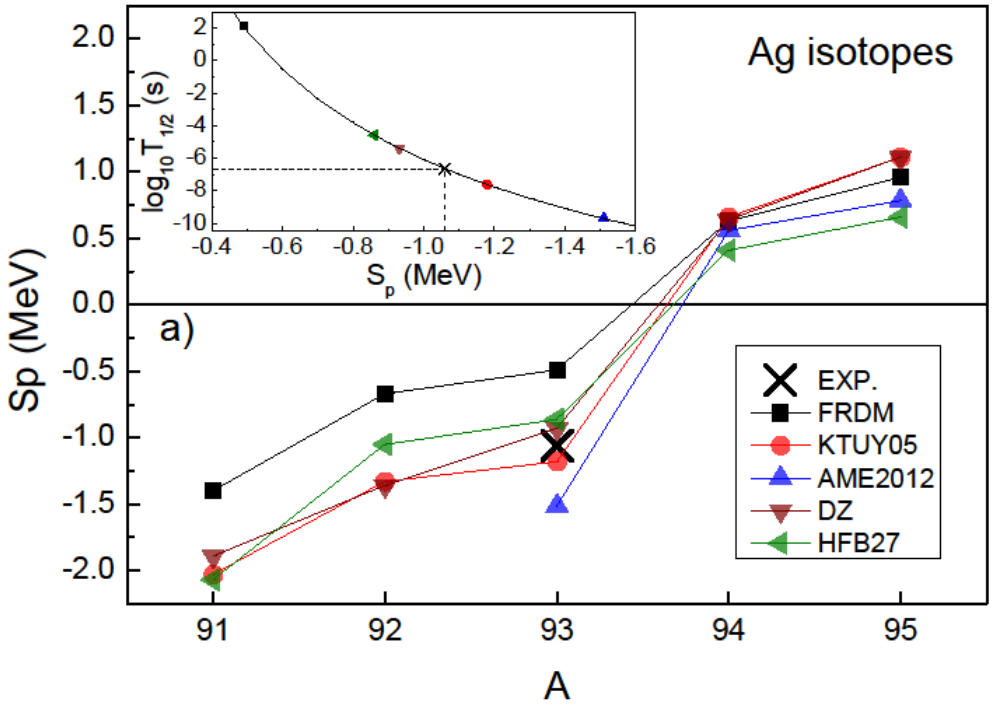
> 10σ confidence level

NB: all identified nuclei are stable against 2p and α emission

Celikovic, I.; Lewitowicz M. et al., Phys. Rev. Lett. 116, 161102 (2016)

New proton emitter ^{93}Ag

- Proton separation energies S_p deduced:
  - from measured half-lives,
  - using simple model of proton emission (S. Delion et al., PRL96 (2013) 072501)
  - assuming proton is emitted from $\pi g_{9/2}$ orbital

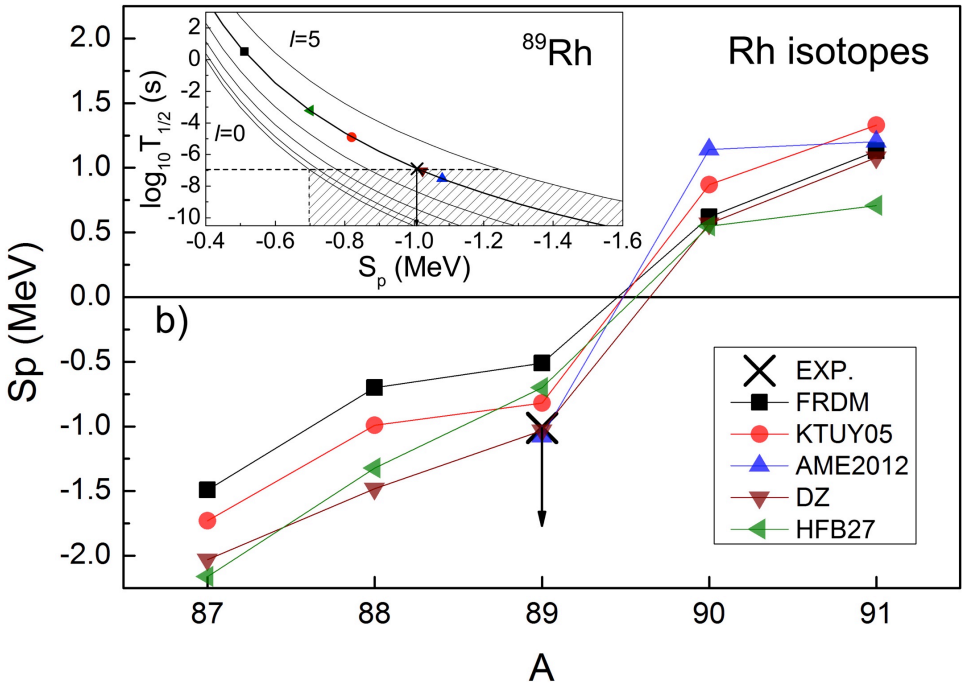


$$T_{1/2}(^{93}\mathrm{Ag}) = 228 \pm 16 \text{ ns}$$

$$S_p(^{93}\mathrm{Ag}) = -1060 \pm 30 \text{ keV}$$

Celikovic, I.; Lewitowicz M. et al., Phys. Rev. Lett. 116, 161102 (2016)

New proton emitters: ^{89}Rh



$$T_{1/2}(^{89}\mathrm{Rh}) < 120 \text{ ns}$$

$$S_p(^{89}\mathrm{Rh}) < -1000 \text{ keV}$$

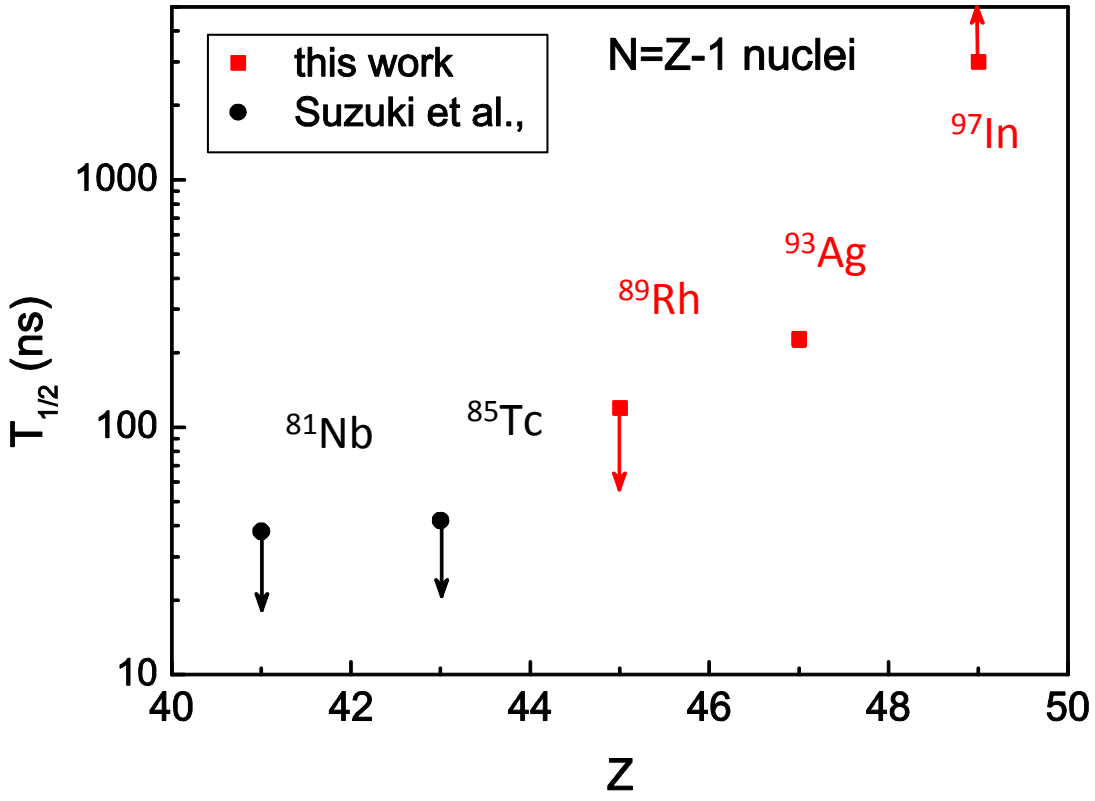
Good overall agreement between half-lives estimated in different ways for both ^{93}Ag and ^{89}Rh

Celikovic, I.; Lewitowicz M. et al., Phys. Rev. Lett. 116, 161102 (2016)

$T_{1/2}$ Systematics of N=Z-1 nuclei

$T_{1/2}$ (^{97}In) = 32 ± 6 ms *D. Lubos et al.*

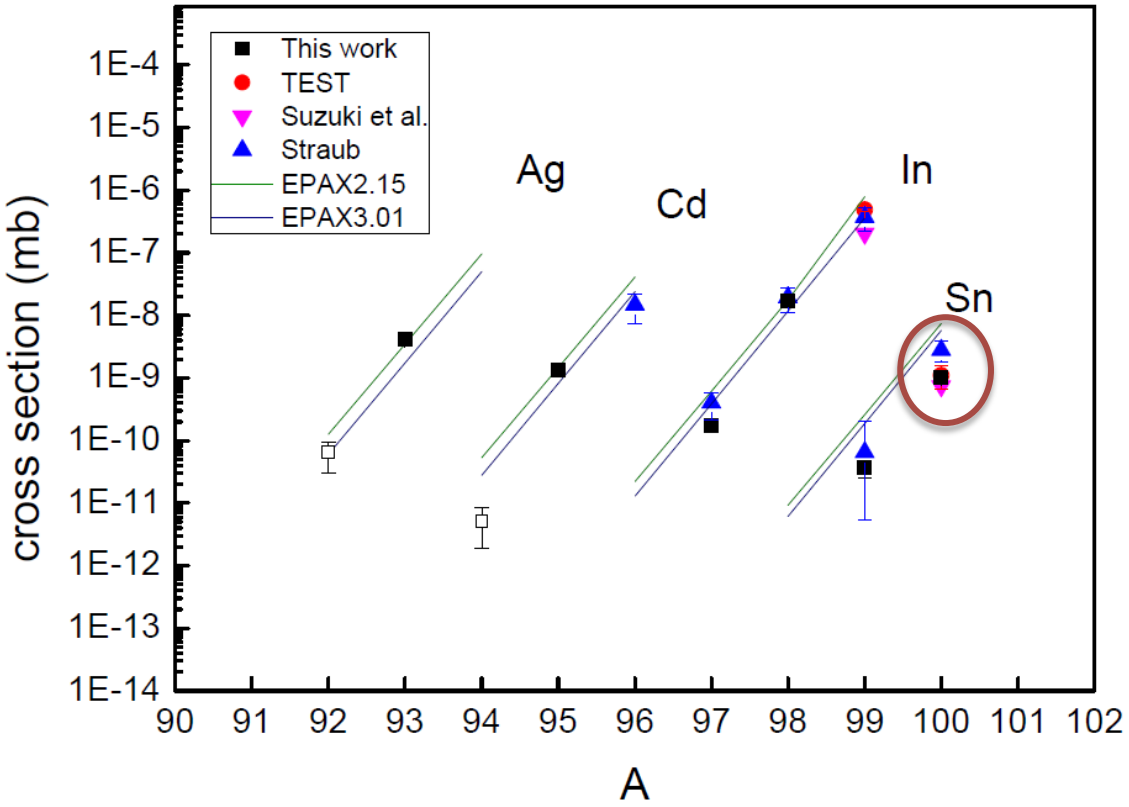
$T(p)_{1/2}(^{97}\mathrm{In}) > 3\ \mu s$



- Half-lives of N=Z-1 nuclei are increasing towards Z=50
- Systematics shows stabilising effect of the Z=50 shell closure

Production cross section

- Transmission: Monte Carlo from LISE++
- CS deduced for transmission > 5%
- Correction on effect of secondary reactions in target
- CS of ^{93}Ag: corrected for measured half-life



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^{100}Sn cross section: discrepancy between RIKEN, GSI and EPAX

- discrepancy between GSI and RIKEN ^{100}Sn production cross sections
- possible energy and/or target thickness dependence

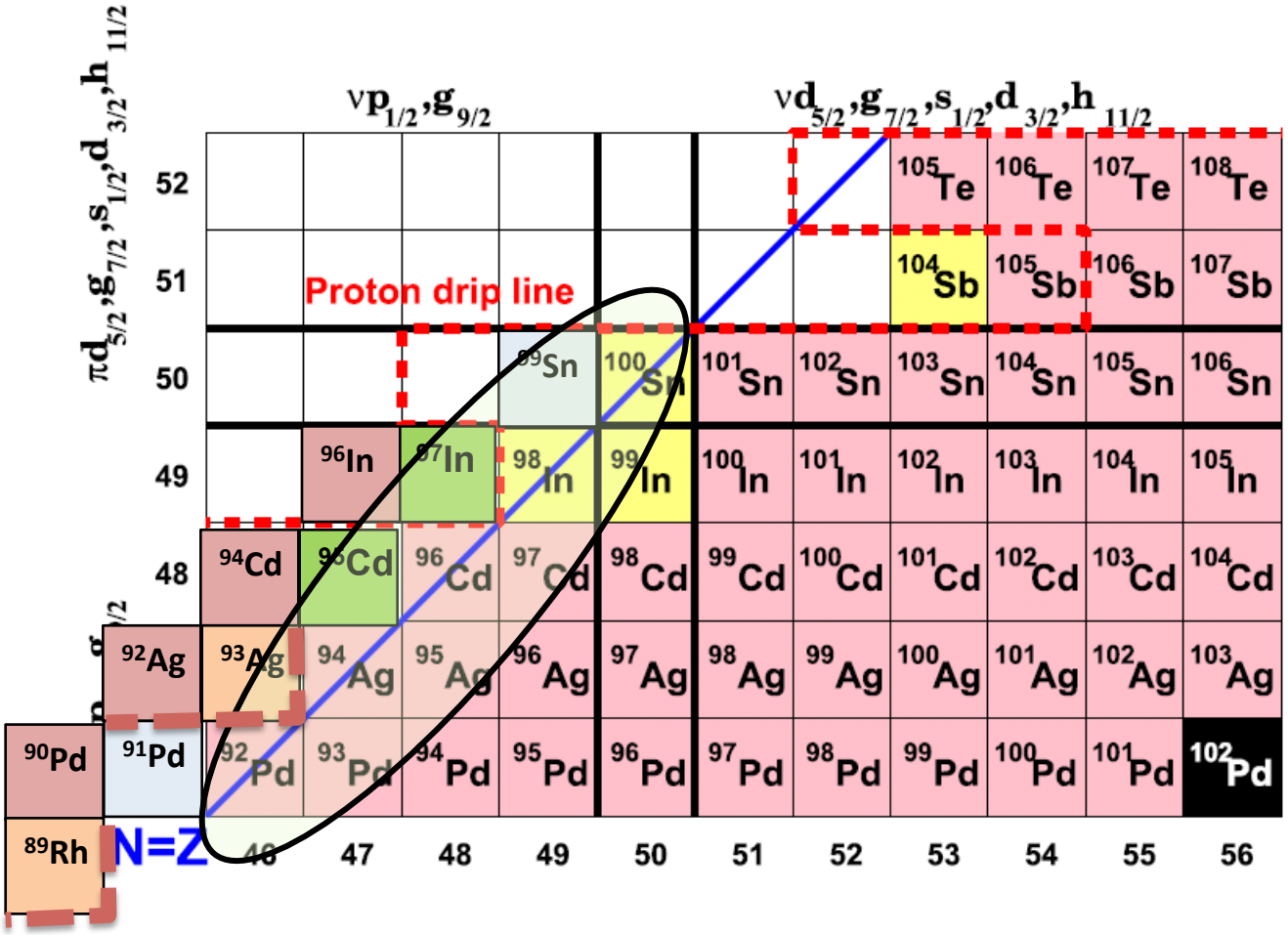
Experiment	Be target (mm)	Energy (MeV/u)	Production Cross section (pb)	
			Uncorrected	Corrected on Secondary Reactions in Target (EPAX3.01)
This work (RIBF)	4	345	1.16±0.09±3.5	1.00 ±0.08±0.30
C. Hinke et al, (GSI)	21.6	1000	5.8 ± 2.1	2.8 ± 1.0
EPAX 3.01			5.76	

x5 x2.8

- reduced discrepancy when correction on sec. reactions in target applied
- new results in neutron deficient region call for new EPAX parameterization

Celikovic, I.; Lewitowicz M. et al., Phys. Rev. Lett. 116, 161102 (2016)

Conclusion



This work

- Discovery – new isotopes
- new proton emitters
- new half live
- precise half live
- spectroscopy

- Further prospects opened with an important increase of the ^{124}Xe beam intensity at RIBF
- β tracking less efficient at RIKEN due to lower beam energy implying only 2π coverage for β-detectors

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Thank you for your attention