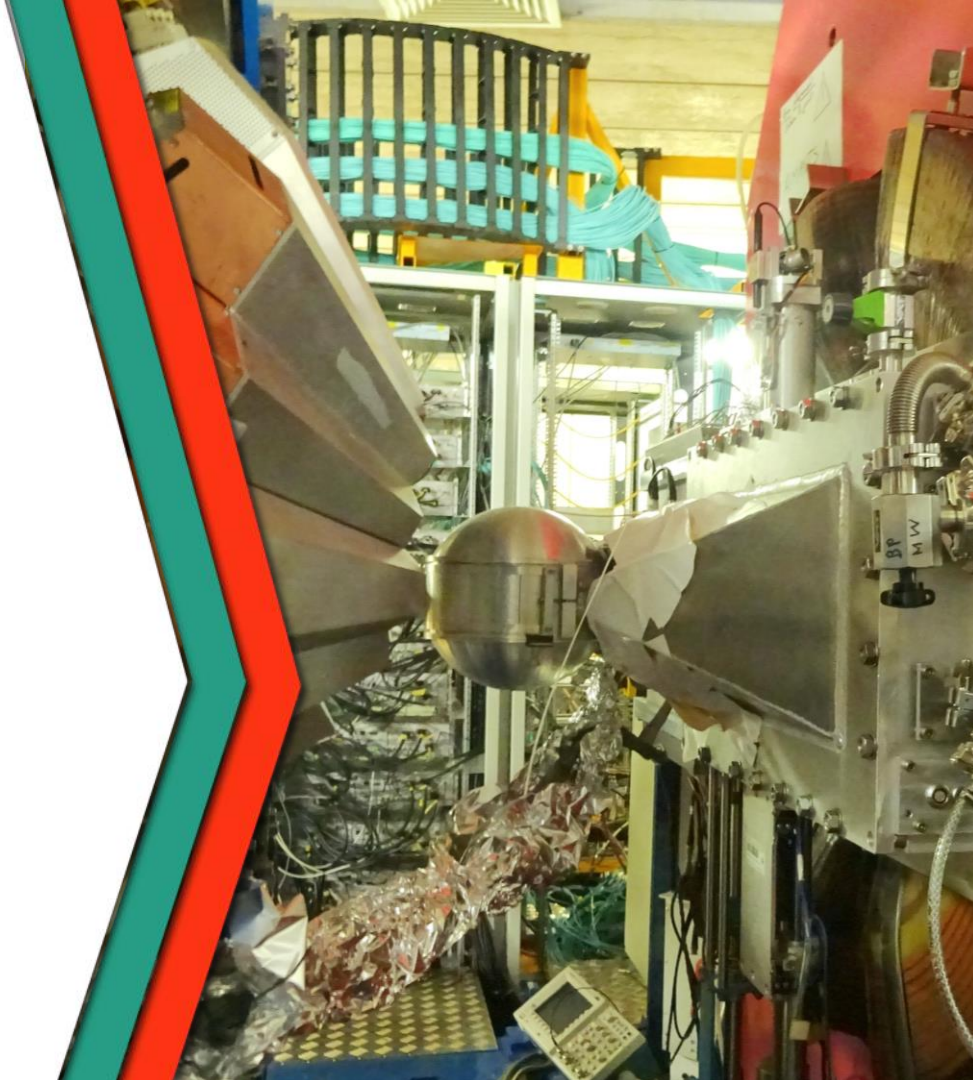
Seniority conservation along N=50: The neutron-magic ^{90}Zr, ^{92}Mo and ^{94}Ru

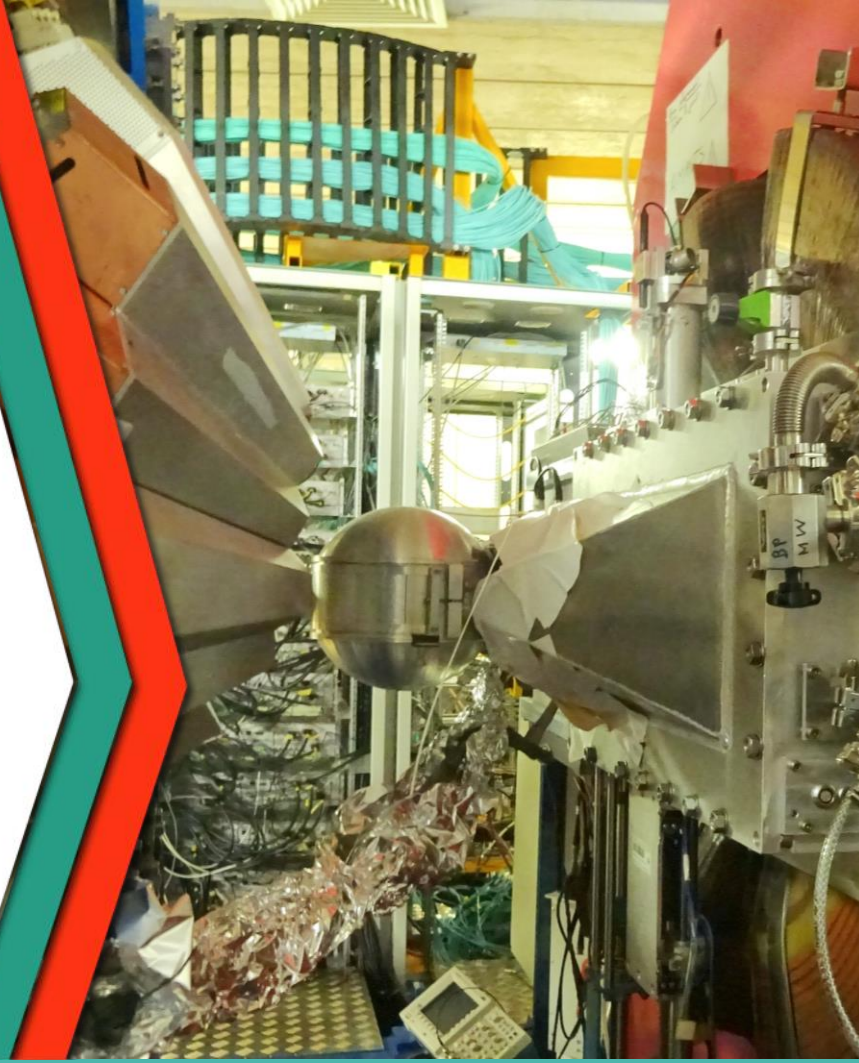
R.M. Pérez-Vidal
for the AGATA, VAMOS++ and IKP Plunger Collaboration



NuSpIn 2019 | Orsay, 24th-28th June 2019

Outline

- Physics Motivation
- Production Mechanism
- Experimental Setup
- Analysis
- Results
- Summary and Outlook



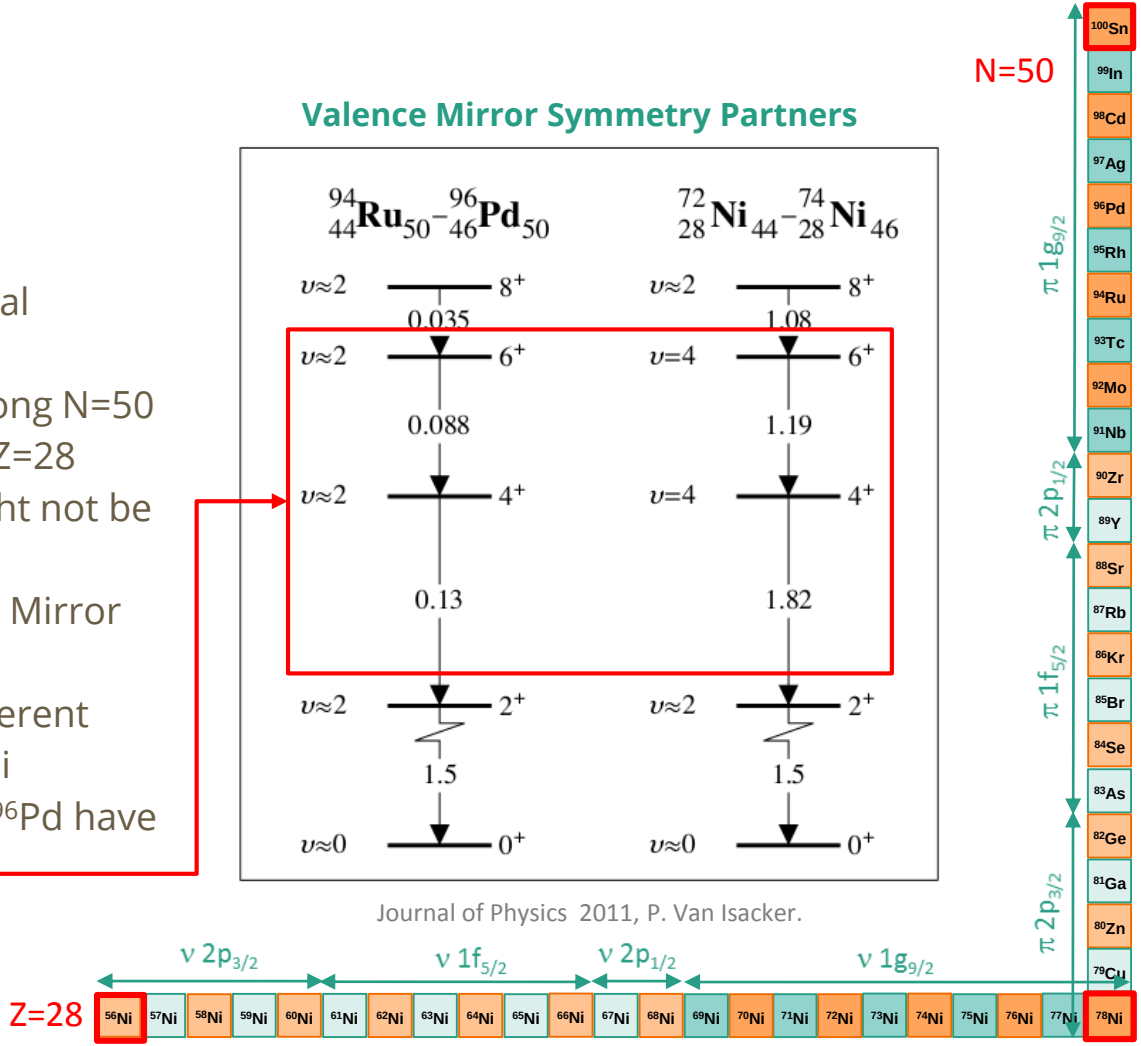
Physics Motivation

Seniority in the $g_{9/2}$ shell

- Seniority, υ, can be viewed as a partial dynamical symmetry
- Shell Model orbitals for valence π along N=50 are the same as for valence ν along Z=28
- $g_{9/2}$, first shell in which seniority might not be conserved
- Same nuclear structures for Valence Mirror Symmetry Partners (?)
- Effective two-body interaction is different along $g_{9/2}$ near ^{100}Sn and around ^{78}Ni
- Calculations suggest 4+ in ^{94}Ru and ^{96}Pd have υ=2 and 4+ in ^{72,74}Ni have υ=4

Valence Mirror Symmetry Partners

Journal of Physics 2011, P. Van Isacker.

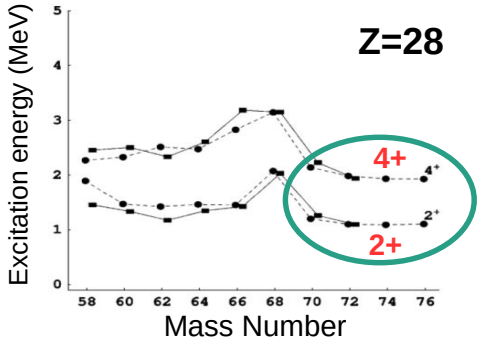


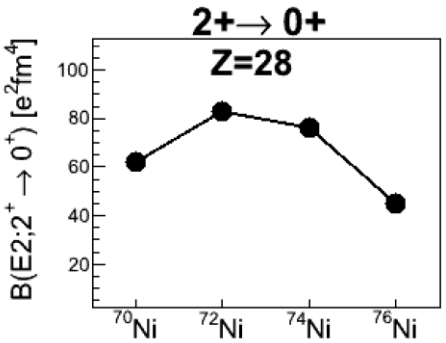
Physics Motivation

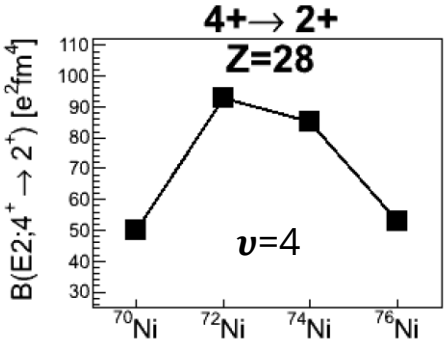
Shell model theory in the valence space

$f_{5/2}, p_{3/2}, p_{1/2}, g_{9/2}$

Ni Isotopes

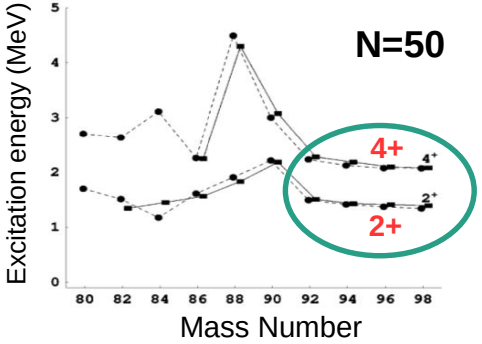


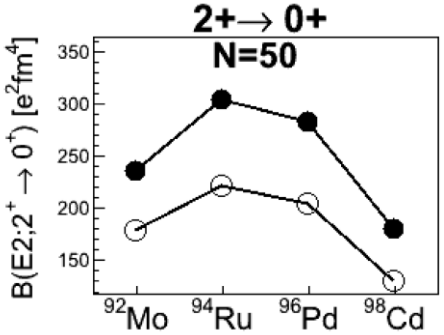


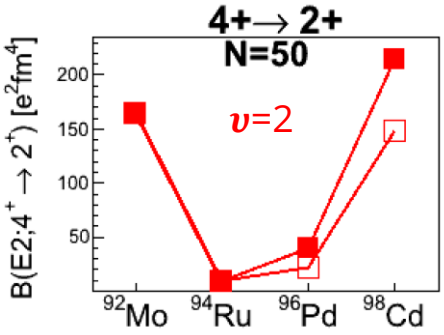


Valence Mirror Symmetry Partners

N=50 Isotones







Phys. Rev C 2004, A.F. Lisetskiy et al.

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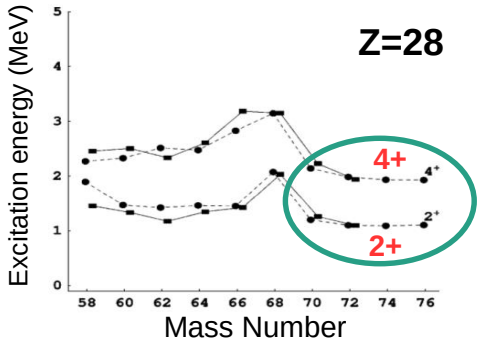
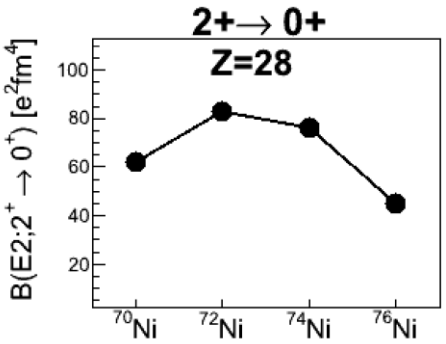
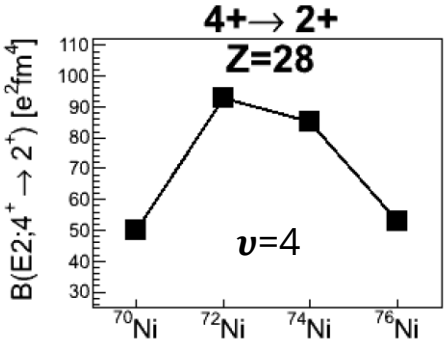
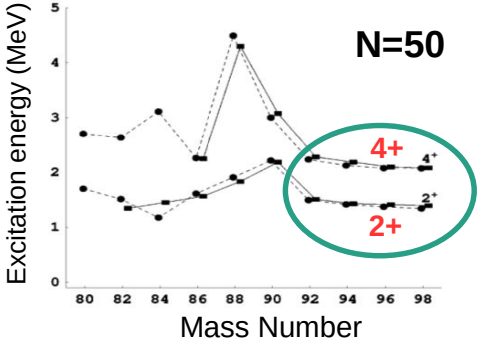


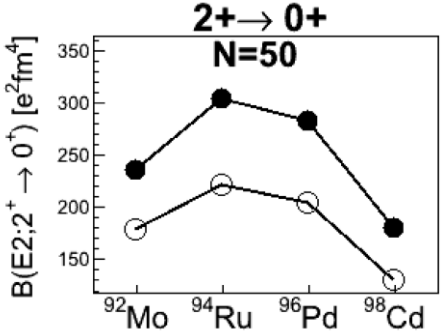


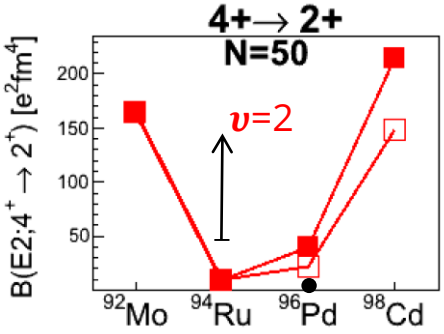


Valence Mirror Symmetry Partners

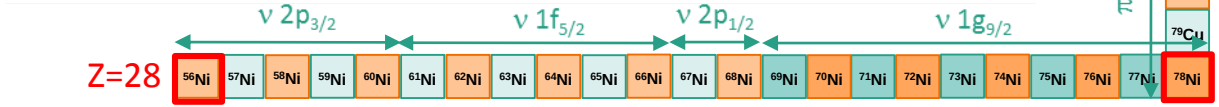
N=50 Isotones







● H. Mach et al. PRC 2017



Phys. Rev C 2004, A.F. Lisetskiy et al.

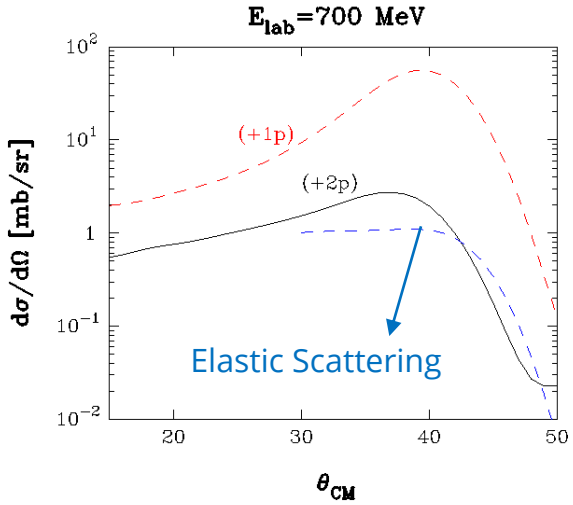
Production Mechanism

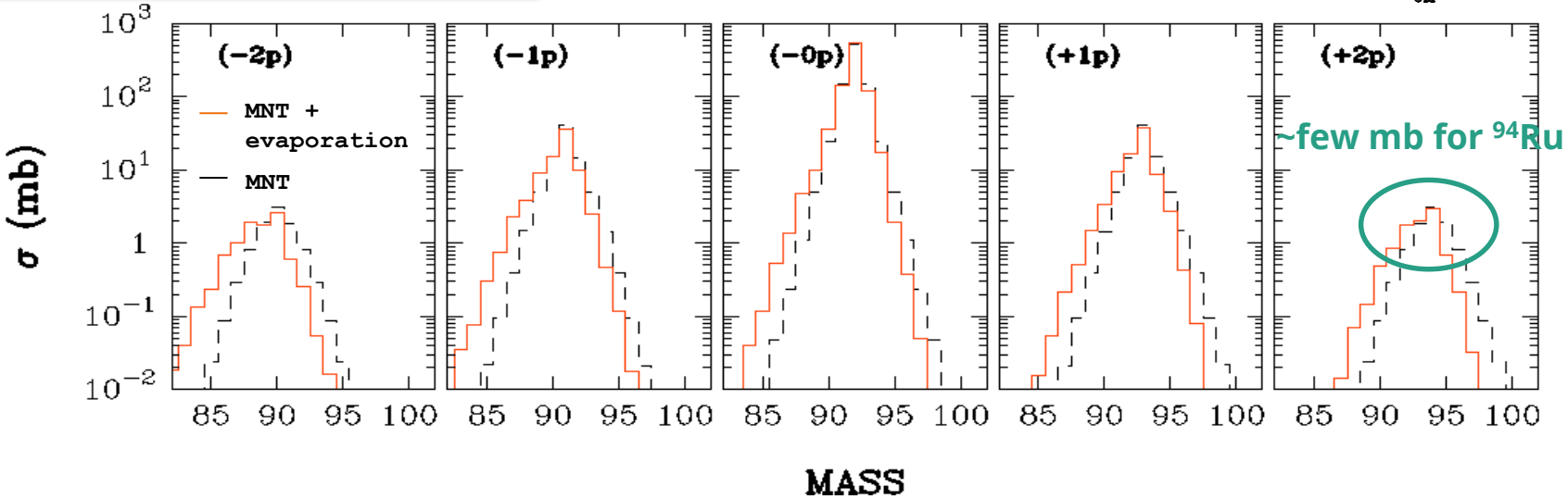
Multi-nucleon Transfer

Reaction $^{92}Mo+^{92}Mo$:
- **Beam energy: 716,9MeV**
- **Grazing angle LAB: ~23 °**
- **E_{CM}/V_B ~1.75**

Deep-inelastic reactions used since pioneering work of R.Broda et al. PLB 251 (90) 245

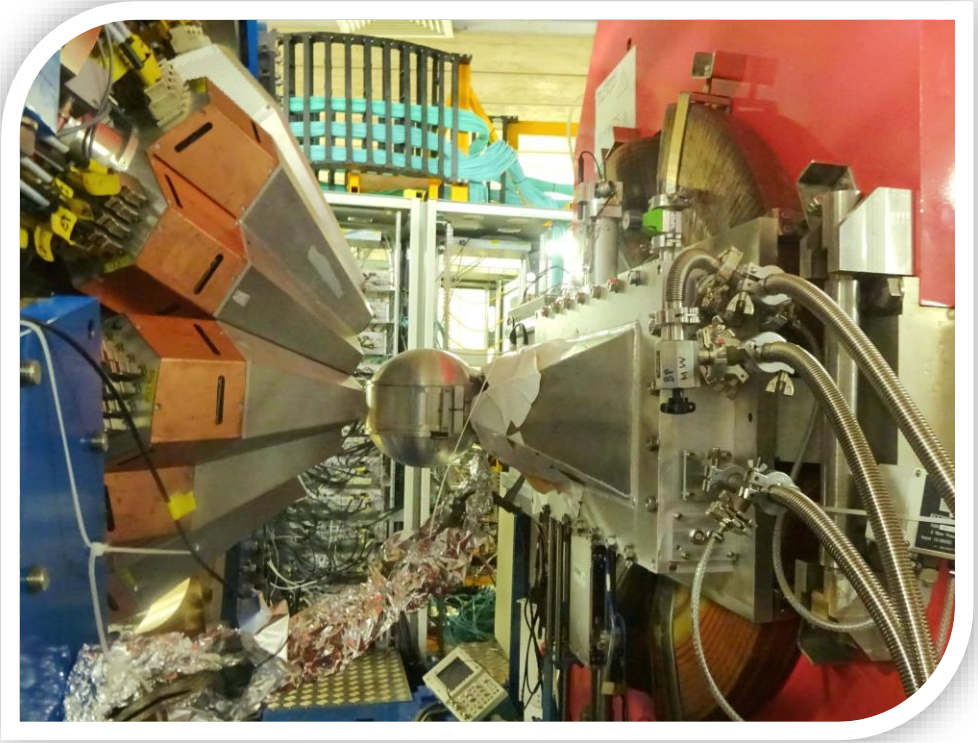
G. Pollarolo (private comm 2015) Program GRAZING, http://www.to.infn.it/~nanni/grazing/ (unpublished).

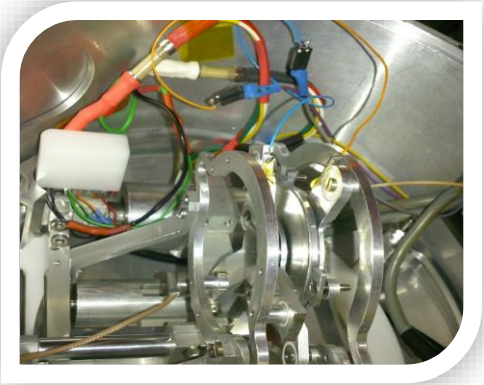




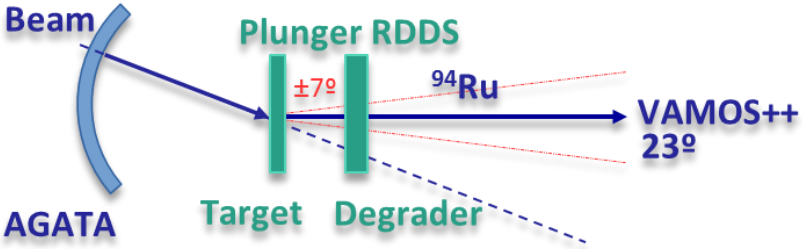
Experimental Setup

GANIL





Cologne differential plunger setup for RDDS measurements in grazing reactions. A.Dewald, Th. Pissulla, J. Jolie IKP-Uni. Köln.

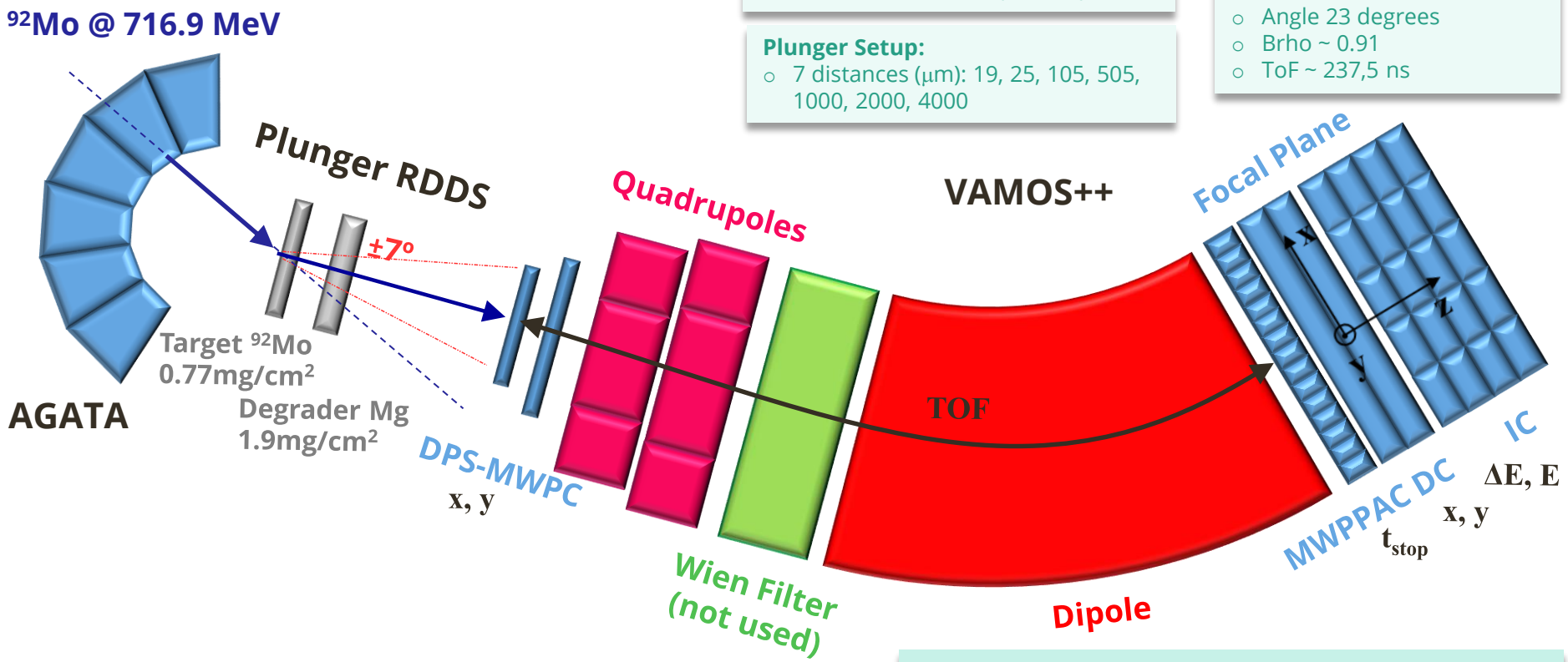


Experimental Setup

Agata Setup:
- 23 Crystals
- Counting rate per crystal : 50 kHz
- Shapping 2.5 us
- Position: Nominal (23.5cm)

Plunger Setup:
- 7 distances (μm): 19, 25, 105, 505, 1000, 2000, 4000

VAMOS++ Setup:
- Horizontal Acceptance: ±7º
- Vertical Acceptance: ±10º
- DM/M~1/220
- DZ/Z~1/66
- Angle 23 degrees
- Brho ~ 0.91
- ToF ~ 237,5 ns



Trigger MWPPAC & MWFP & OrGAMMA

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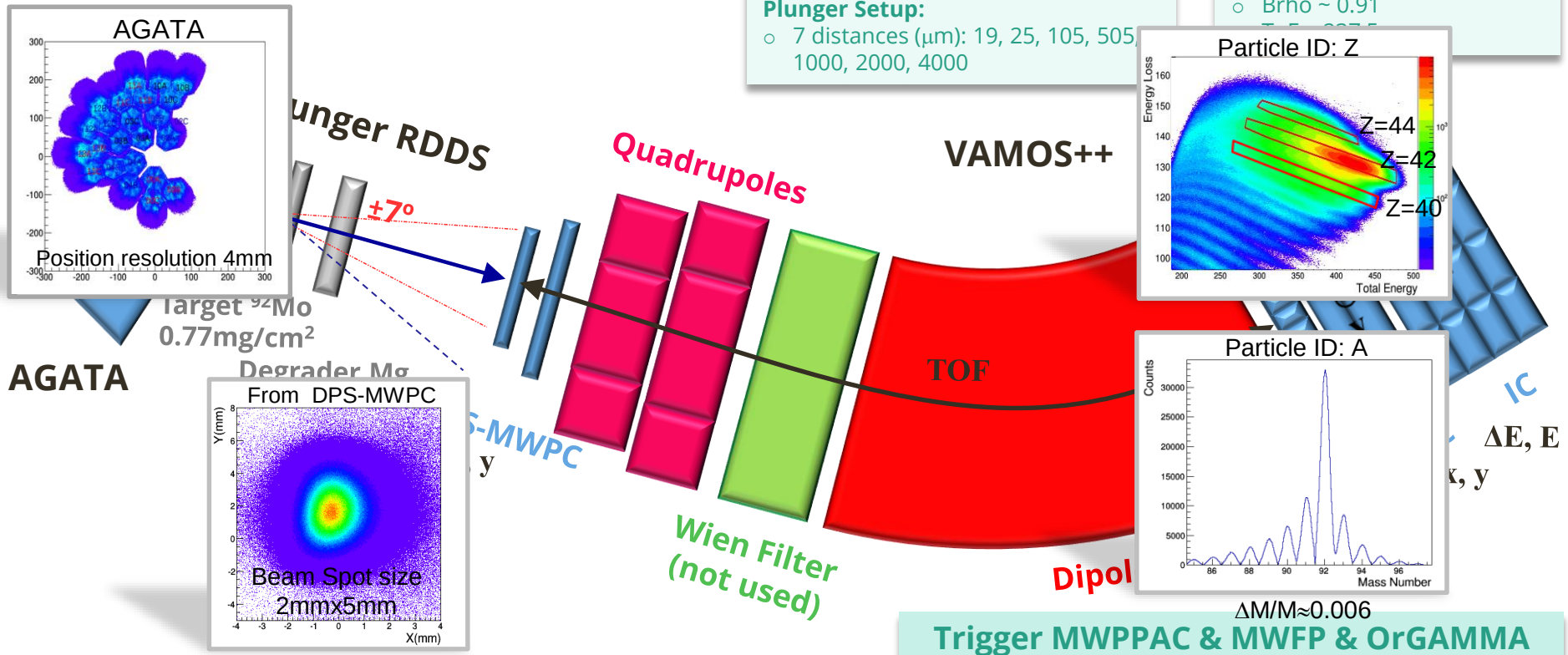
^{92}Mo @ 716.9 MeV

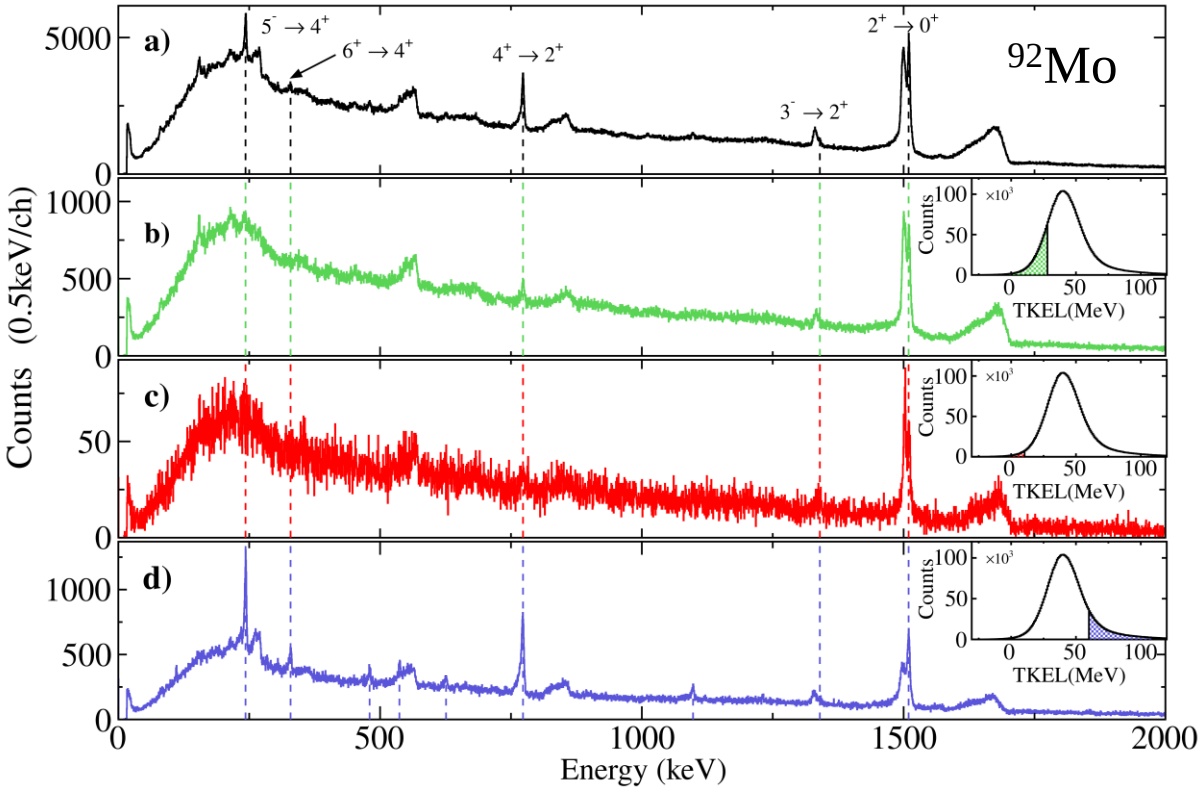


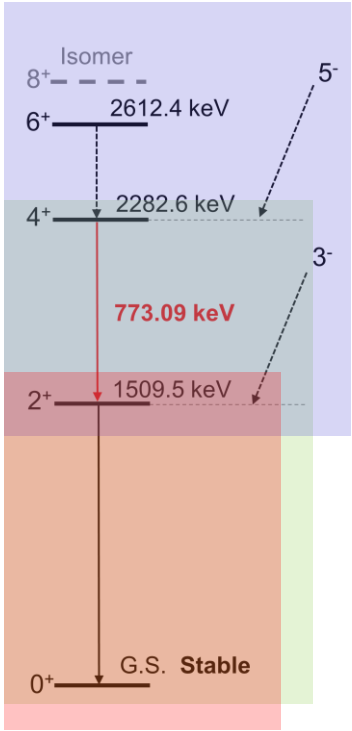
Trigger MWPPAC & MWFP & OrGAMMA

Analysis

Total Kinetic Energy Loss (TKEL)

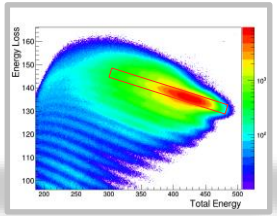
TKEL ↓↓ population of lower excited states
TKEL ↑↑ population of higher excited states



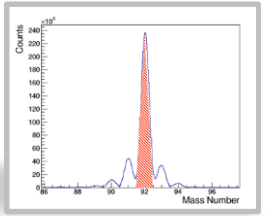


Analysis

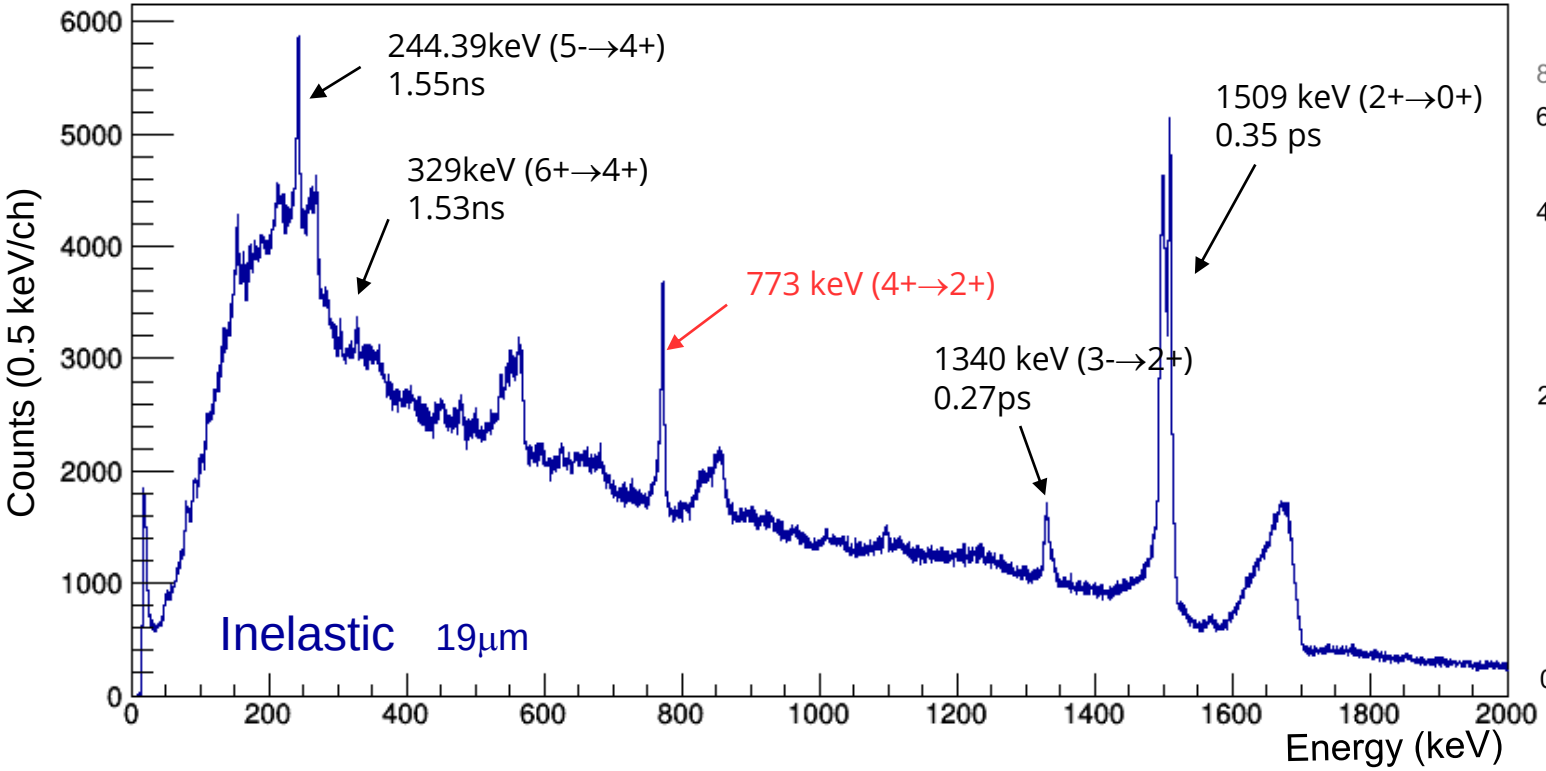
^{92}Mo Gamma Tracked Spectrum

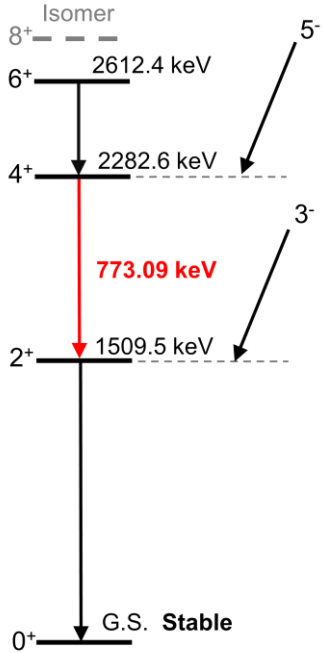


Z=42



A=92

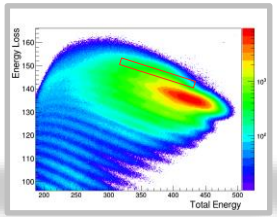




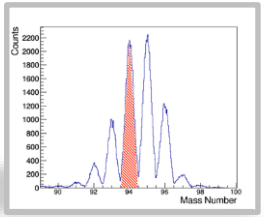
$^{92}_{42}Mo_{50}$

Analysis

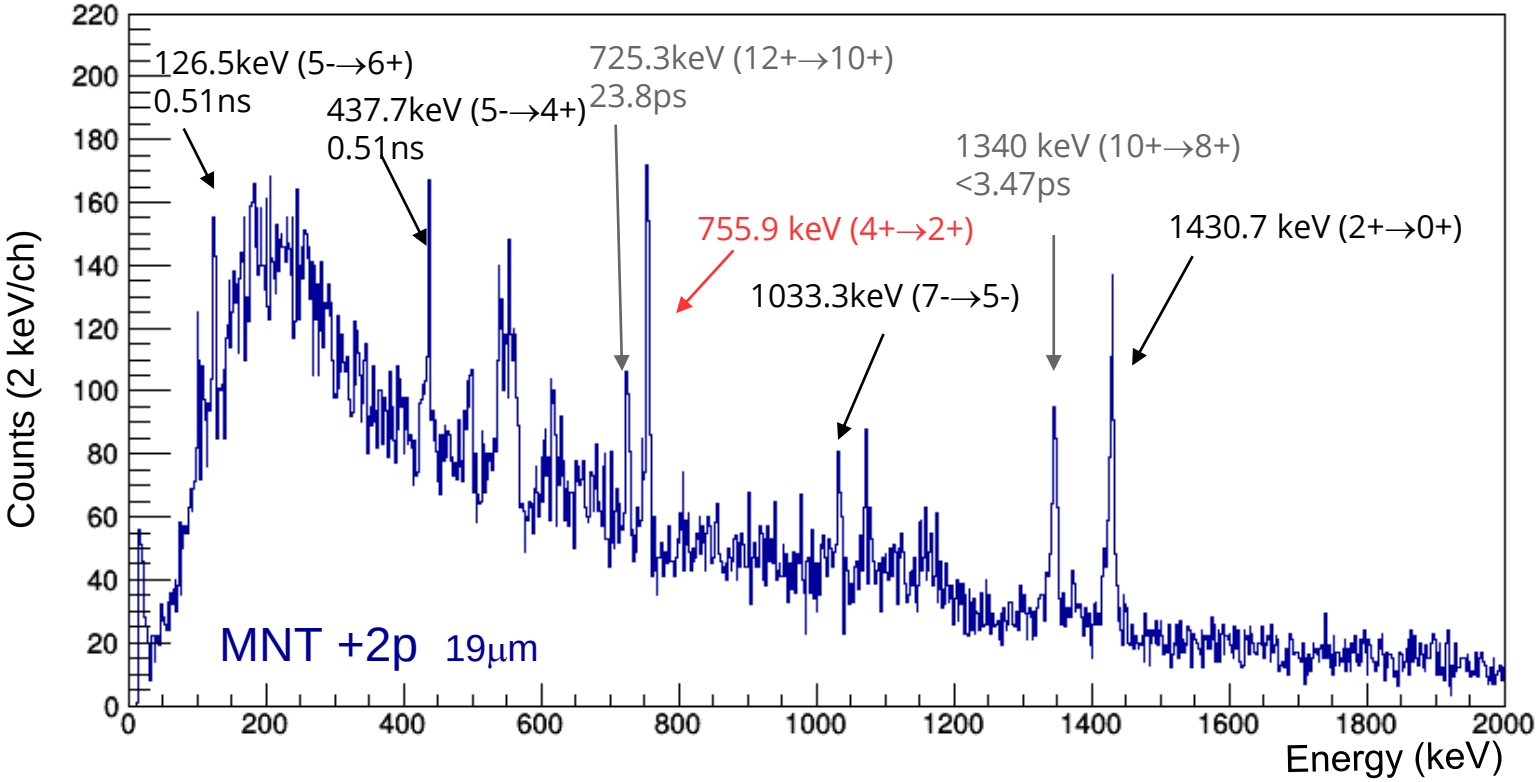
^{94}Ru Gamma Tracked Spectrum

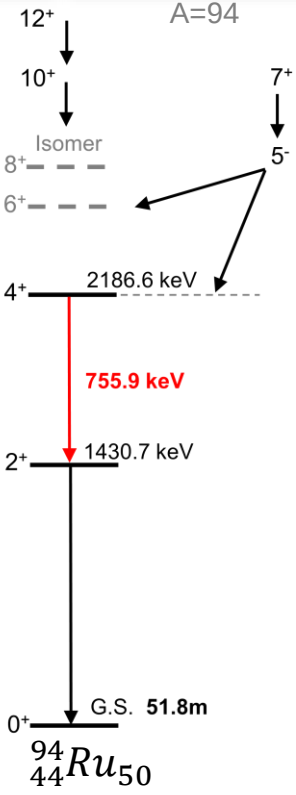


Z=44



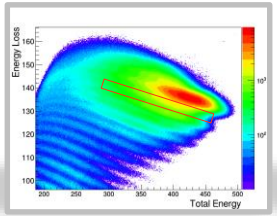
A=94



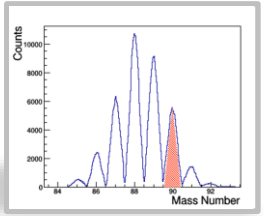


Analysis

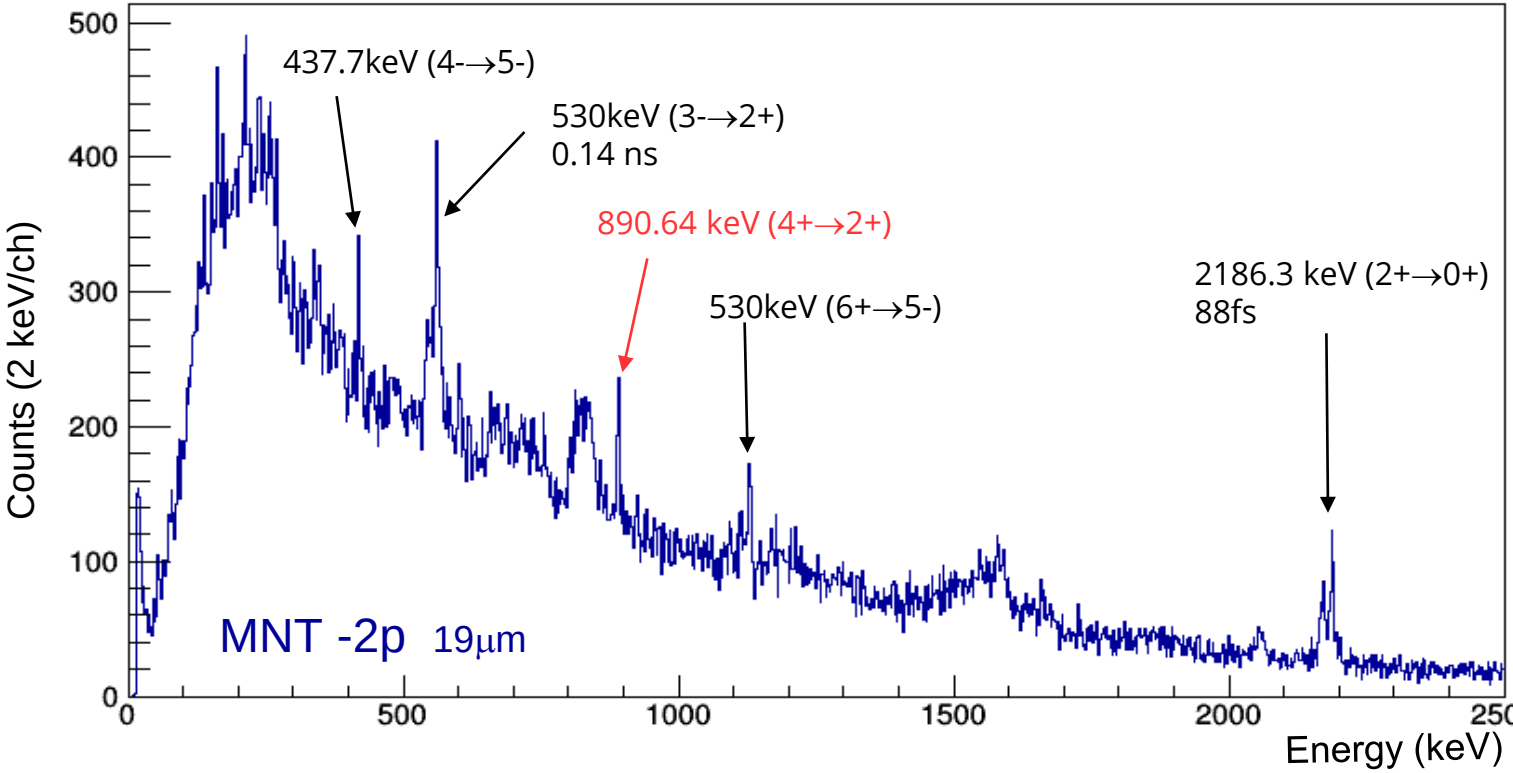
^{90}Zr Gamma Tracked Spectrum

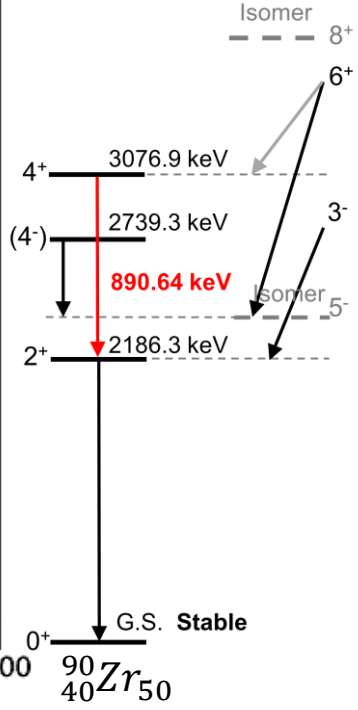


Z=40



A=90

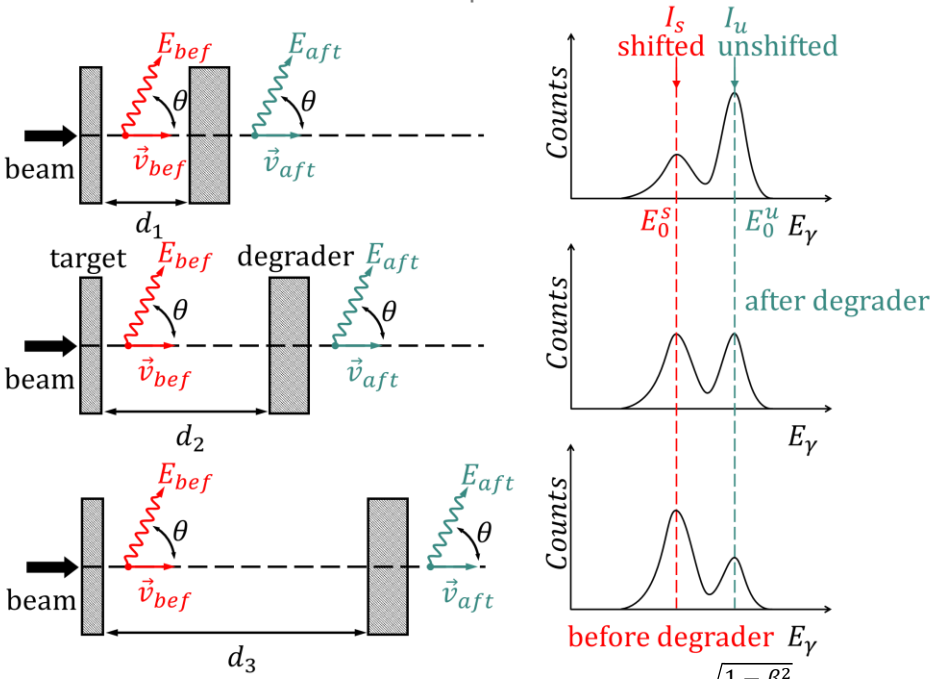




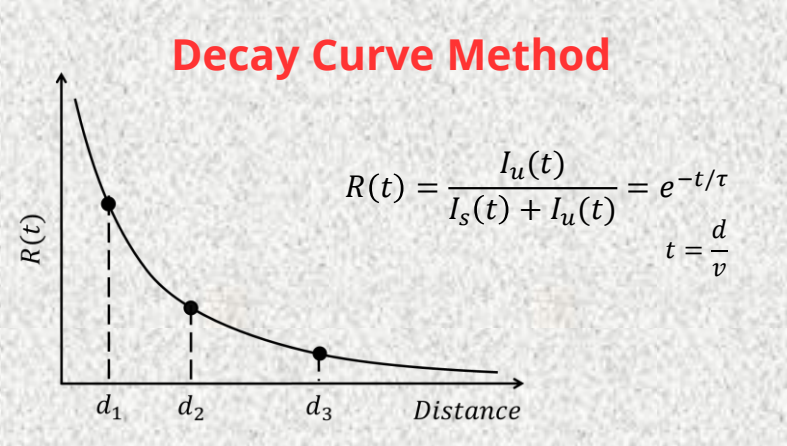
Analysis

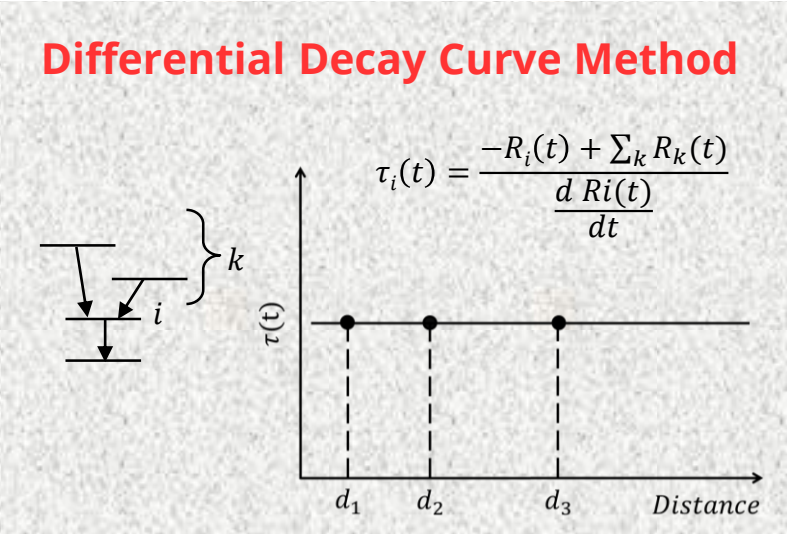
RDDS technique
(Recoil Distance Doppler-Shift)

Lifetimes: ~1 to ~500 ps at v/c ≈ 10%



$$E = E_0 \frac{\sqrt{1-\beta^2}}{1-\beta\cos\theta}$$



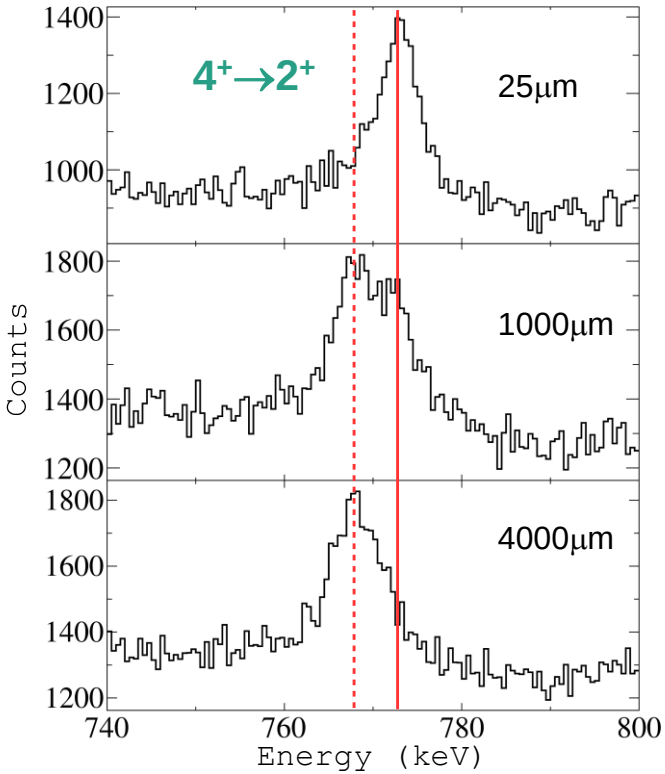


A. Dewald et al. Prog. Part. Nucl. Phys. 63 (3)2012

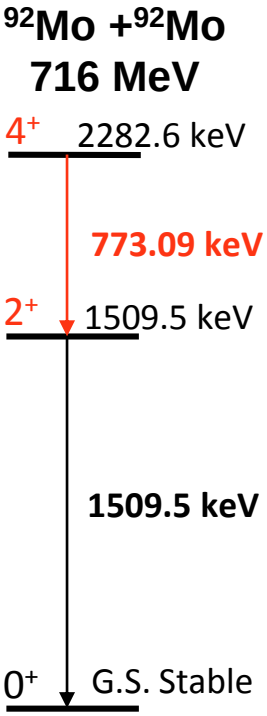
Results

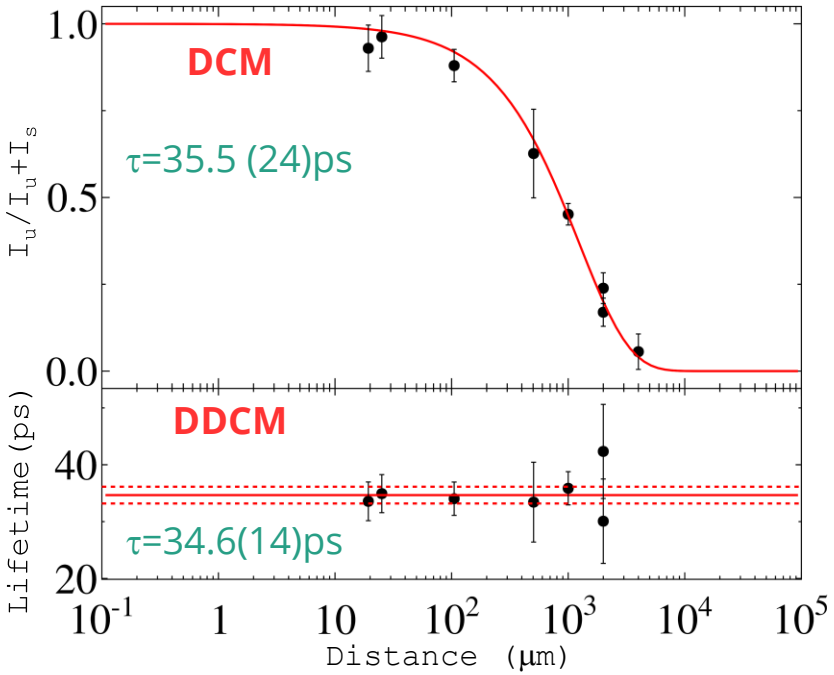
^{92}Mo $4^+ \rightarrow 2^+$ lifetime

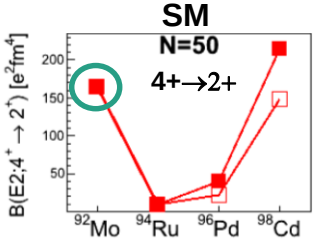
Q value to avoid 5^- & 6^+ feeding



Small feeding from 5^- taken into account

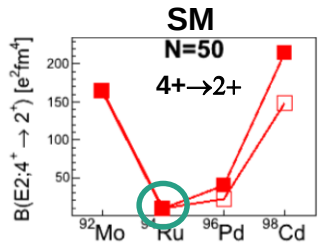


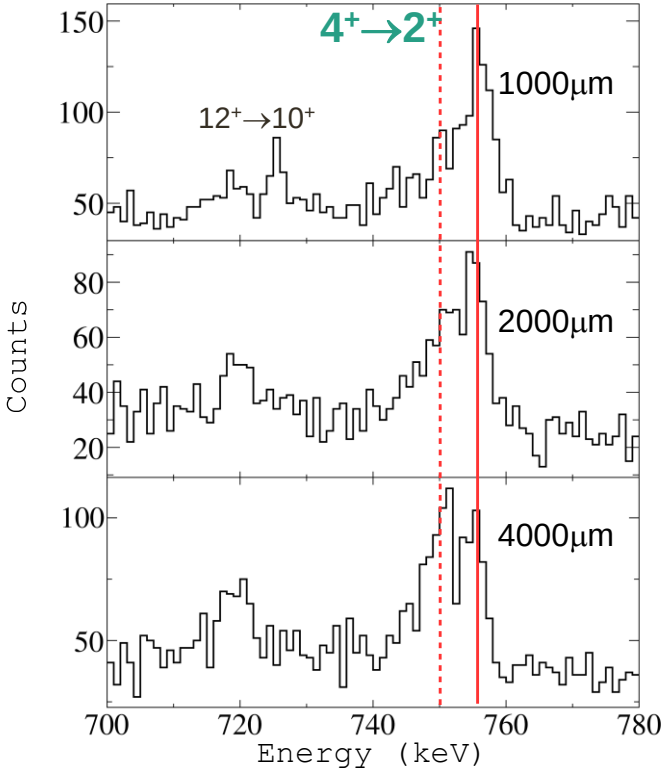




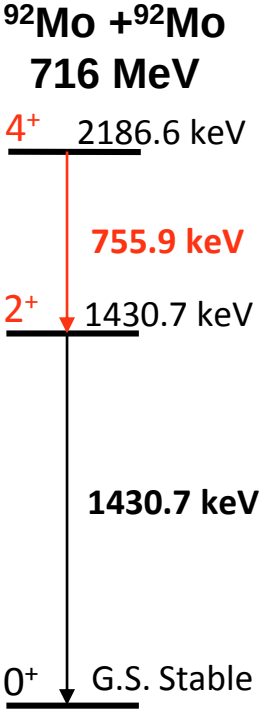
Results

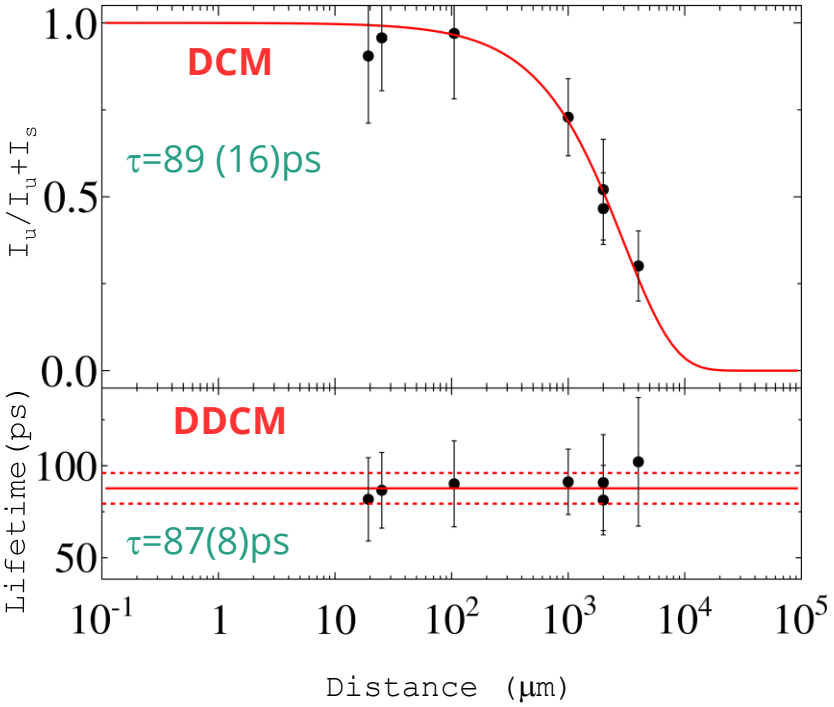
^{94}Ru $4^+ \rightarrow 2^+$ lifetime





Feeding from 5^- taken into account

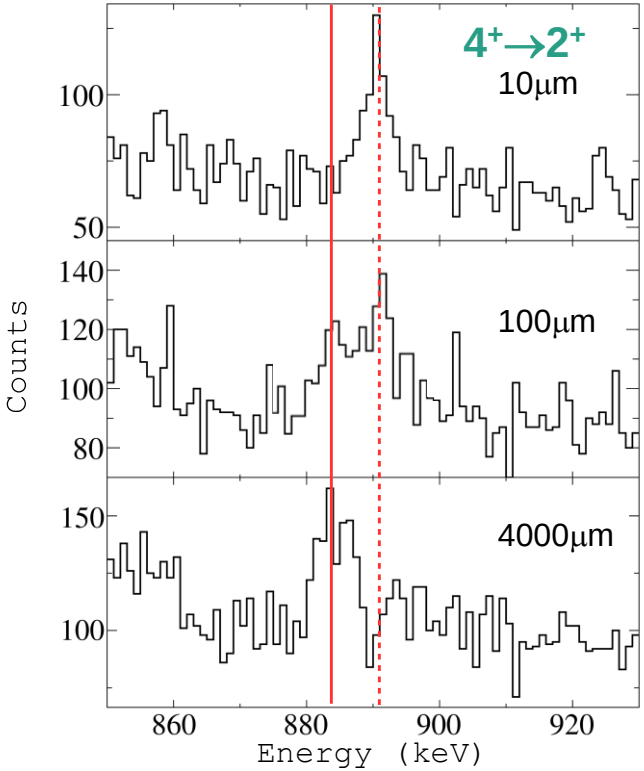


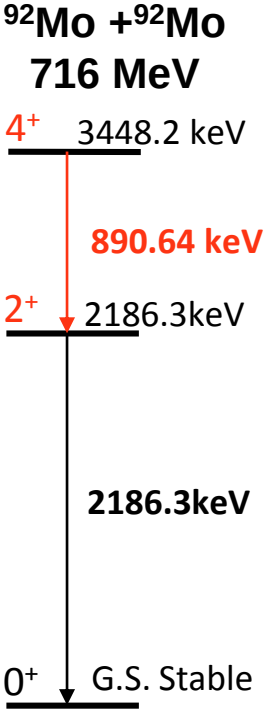


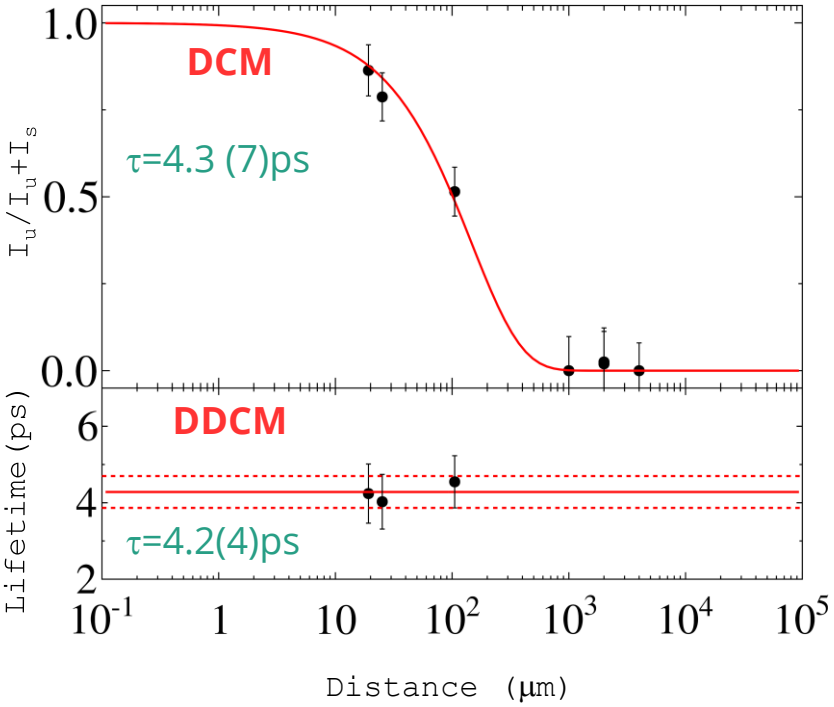
Results

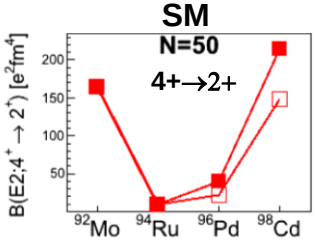
^{90}Zr $4^+ \rightarrow 2^+$ preliminary lifetime

Q value to avoid 6^+ feeding









Results

[1] A.F. Lisetskiy et al. PRC 2004
[2] H. Mach et al. PRC 2017
[3] A. Gargano Private communication
[4]http://www.nndc.bnl.gov/nndc/ensdf/

B(E2)

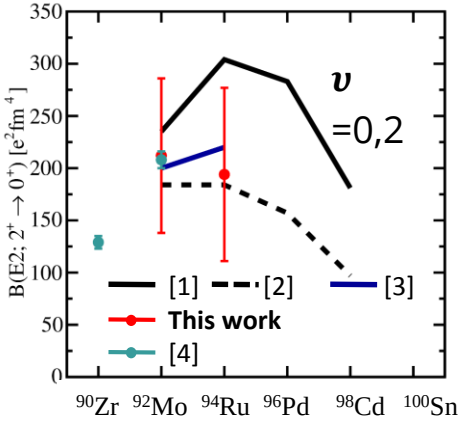
Nucleus	State	τ (ps)	B(E2) (e^2fm^4)
^{92}Mo	4+→2+	35.3(6)	84.4 (14)
^{94}Ru	4+→2+	87 (8)	38(3)
^{90}Zr	4+→2+	4.2(4)	300 (30)

Shell model theory in the proton valence space
$f_{5/2}, p_{3/2}, p_{1/2}, g_{9/2}$

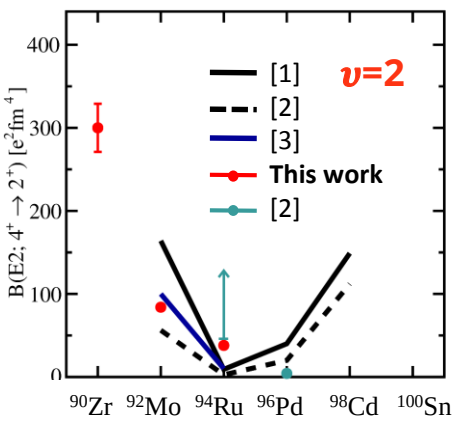
A. F. Lisetskiy et al. PRC 2004
- Bonn-C
- e_p=2

A. Gargano (private comm 2019)
- Bonn-A
- e_p=1.55

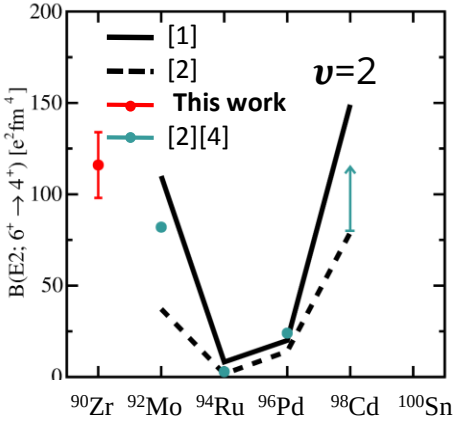
$2^+ \rightarrow 0^+$



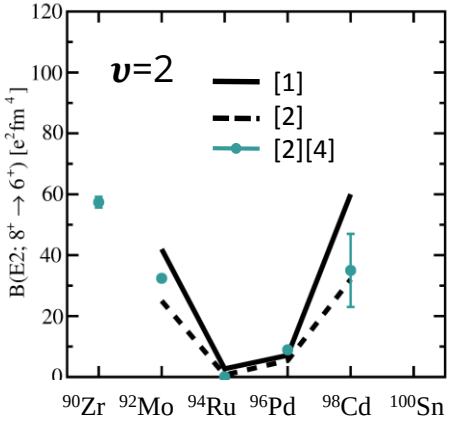
$4^+ \rightarrow 2^+$



$6^+ \rightarrow 4^+$



$8^+ \rightarrow 6^+$



Summary and Outlook

- Experimental study of the seniority along the N=50 isotones in the vicinity of ^{100}Sn
- Successful lifetime measurement of the $4^+ \rightarrow 2^+$ yrast transition in ^{90}Zr, ^{92}Mo and ^{94}Ru at GANIL using **AGATA + PLUNGER + VAMOS++** for 7 target-degrader distances (19,25,105,505,1000,2000,4000 μm)
- The results are being interpreted on the basis of Shell Model predictions for the comparison of the nuclear structure trends between the valence mirror symmetry partners $^{56\text{-}78}$Ni Z=28 isotopes and ^{78}Ni- ^{100}Sn N=50 isotones
- **Lifetimes and B(E2) for the $4^+ \rightarrow 2^+$ ^{90}Zr, ^{92}Mo and ^{94}Ru allow to eventually confirm the conservation of seniority predicted by the Shell Model calculations**

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Thank you to the AGATA, VAMOS++ and the IKP Plunger collaborations and all the e682 collaborators

Seniority conservation along N=50: The neutron-magic ^{90}Zr, ^{92}Mo and ^{94}Ru

R.M. Pérez-Vidal
for the AGATA, VAMOS++ and IKP Plunger Collaboration

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