INFN
Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DEGLI STUDI DI MILANO

Fabio Conca

Università degli Studi di Milano and INFN

Gamma Science, April 9th–11th 2026, Milano

SHAPE COEXISTENCE STUDIES AT Z=28 AND N=50 WITH ROSPHERE

OUTLINE

- Shape coexistence at Z=28: the Ni case
- Shape coexistence at N=50: first evidence in ^{84}Se

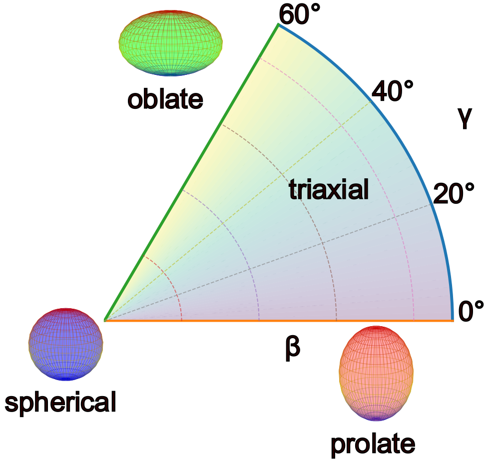
- ROSPHERE setup
- The ^{89}Y(^{11}B,^{12}C)^{88}Sr reaction: lifetimes of the 0_2^+ and 0_3^+ excited states
- The ^{64}Ni(^{13}C,^{12}C)^{65}Ni reaction: new results and comparison with MCSM calculations

- Summary

SHAPE COEXISTENCE AT Z=28

Shape coexistence: the appearance of different nuclear shapes at similar excitation energies

K. Heyde et al., Rev. Mod. Phys. **83** (2011)
P.E. Garret et al., Prog. Part. Nucl. Phys. **124** (2022)
S. Leoni et al., Prog. Part. Nucl. Phys. **139** (2024)



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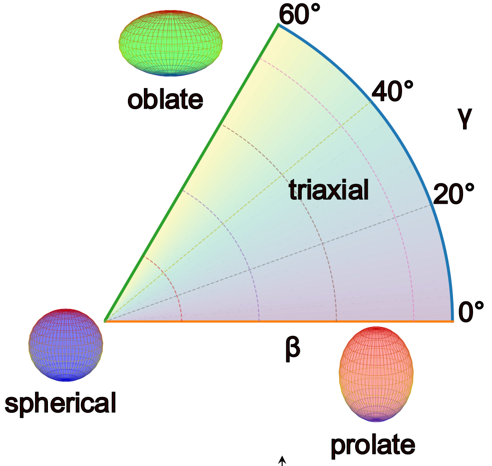

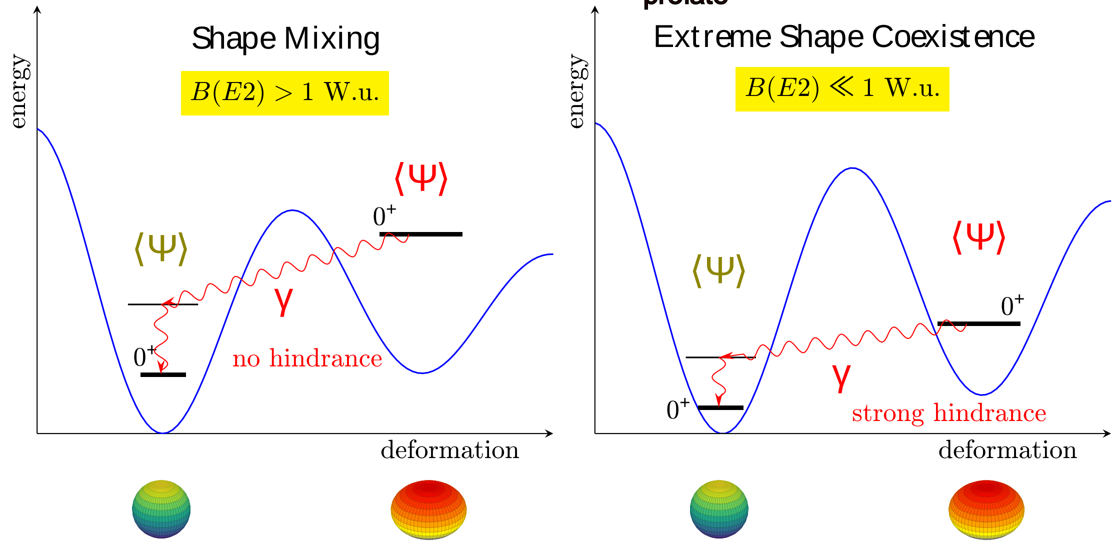

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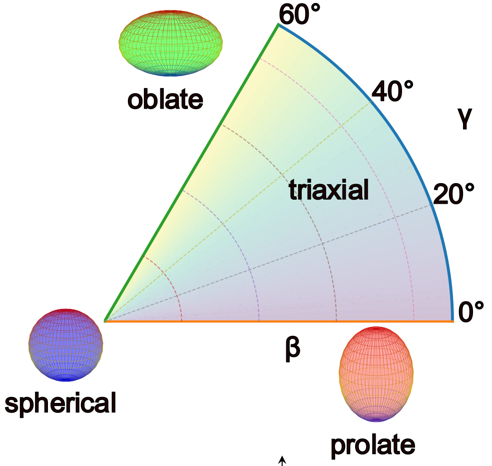
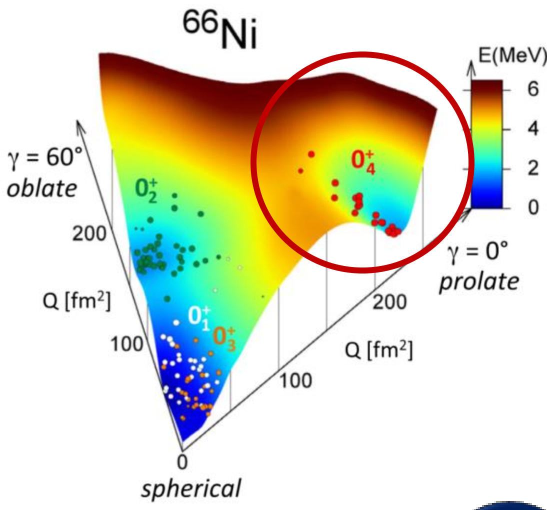
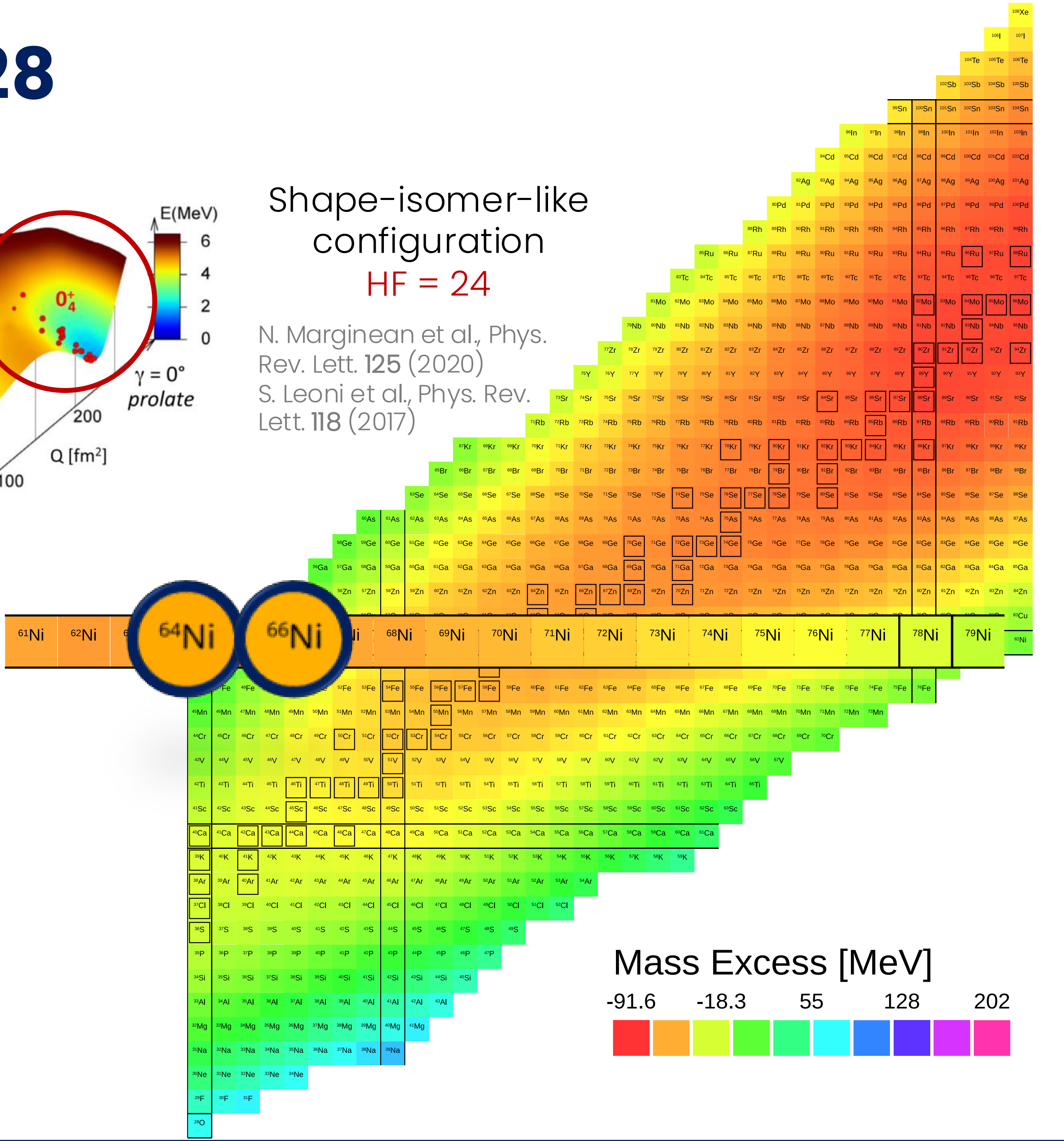




Shape-isomer-like configuration
HF = 24

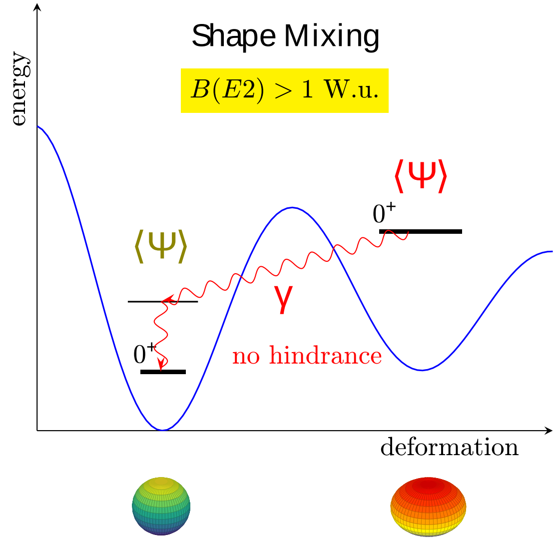
N. Marginean et al., Phys. Rev. Lett. **125** (2020)
S. Leoni et al., Phys. Rev. Lett. **118** (2017)

Z=28



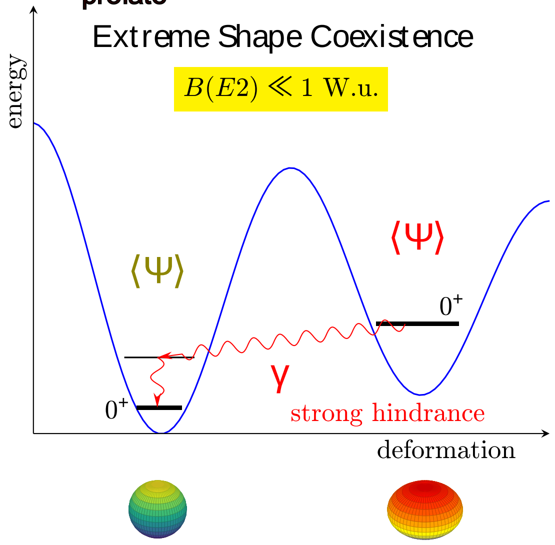
Shape Mixing

$B(E2) > 1$ W.u.



Extreme Shape Coexistence

$B(E2) \ll 1$ W.u.



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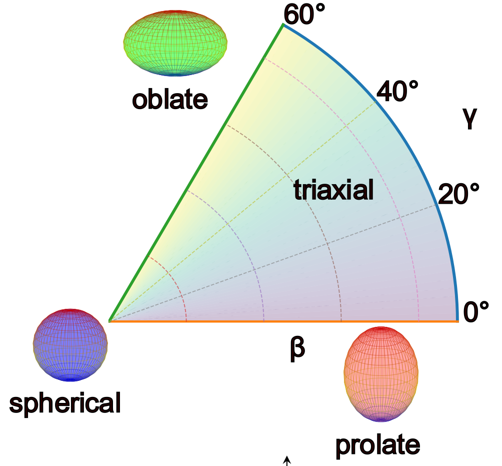

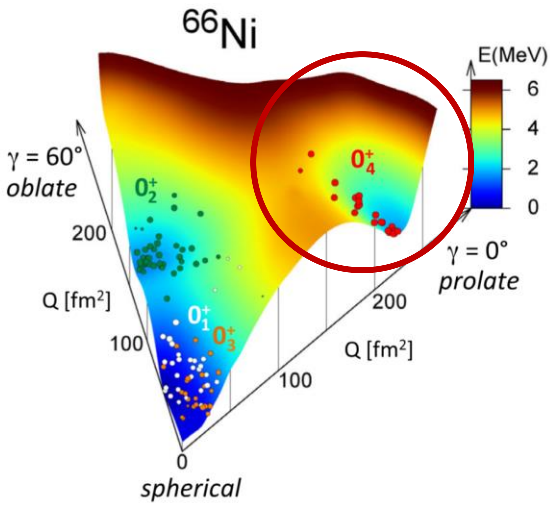

Z=28

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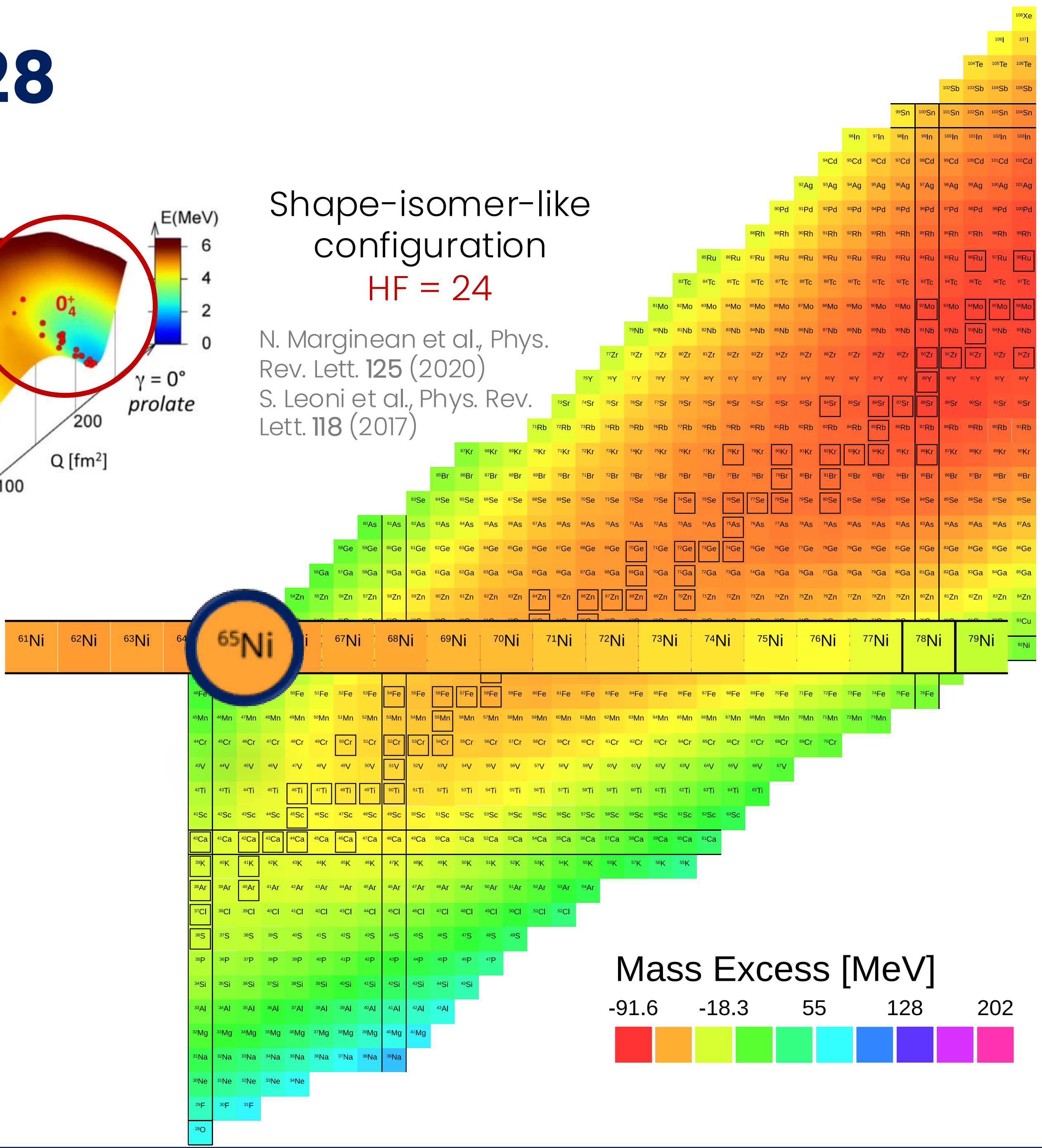

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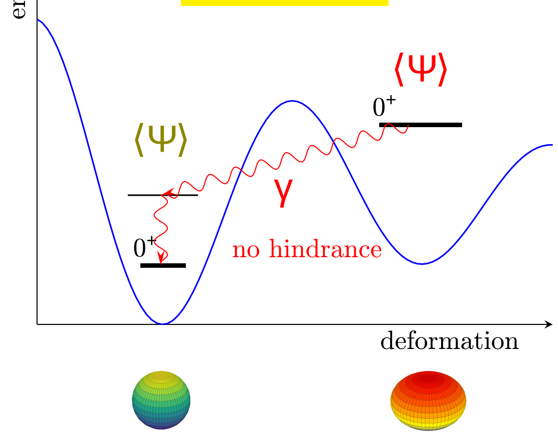

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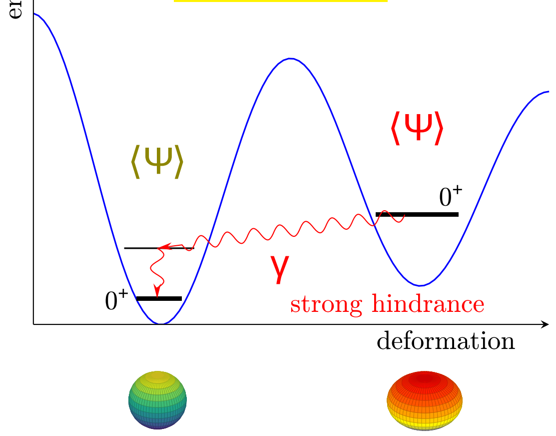

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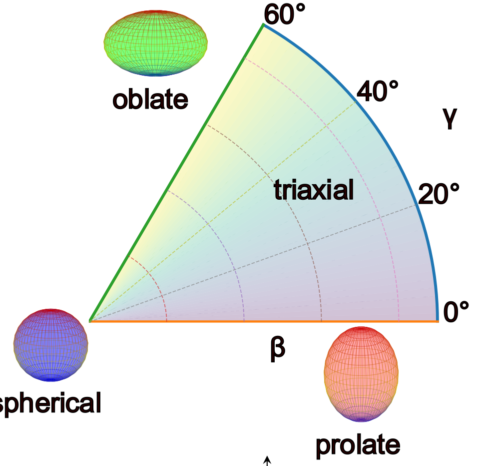

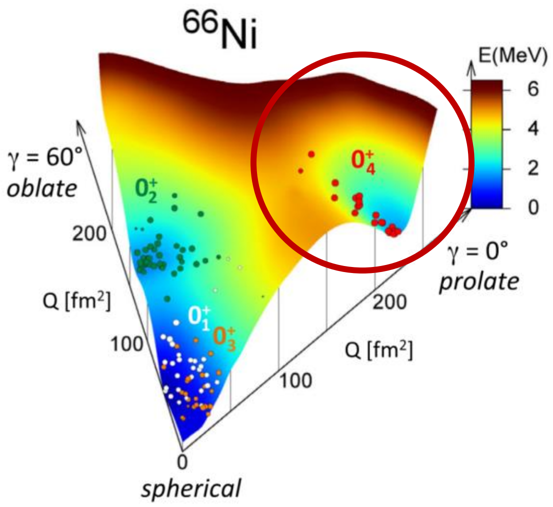

Z=28

Shape-isomer-like configuration

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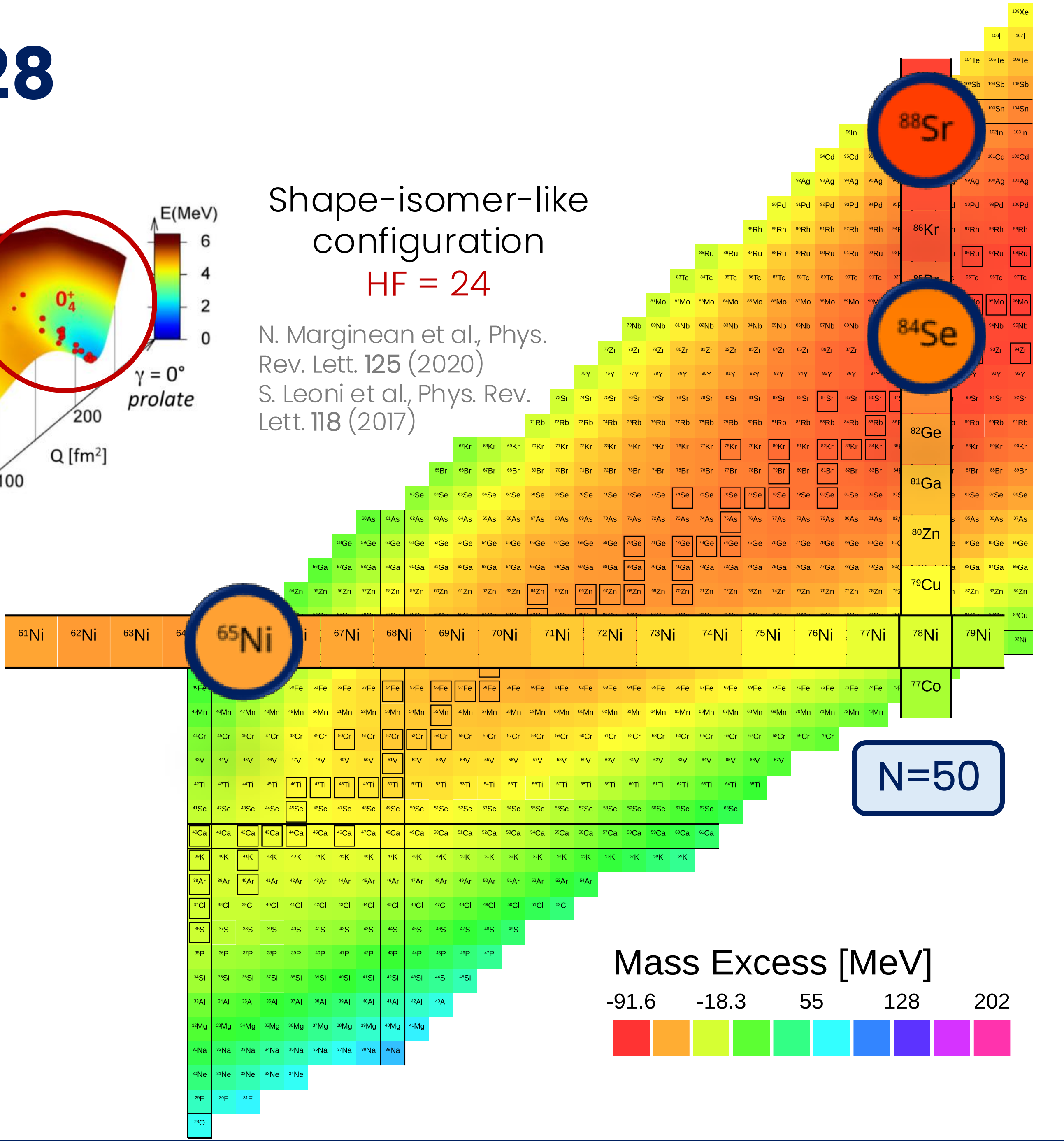
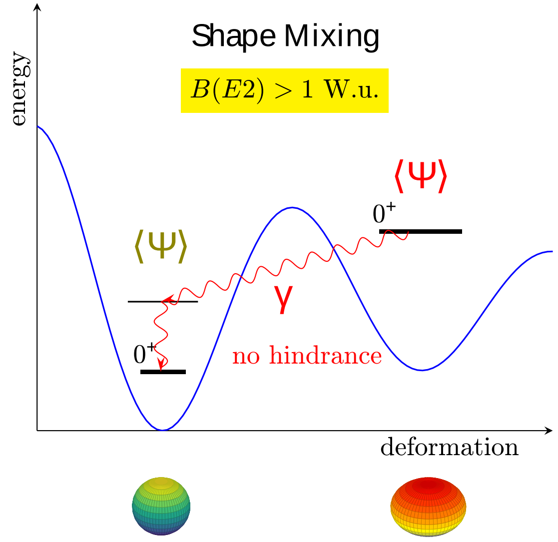
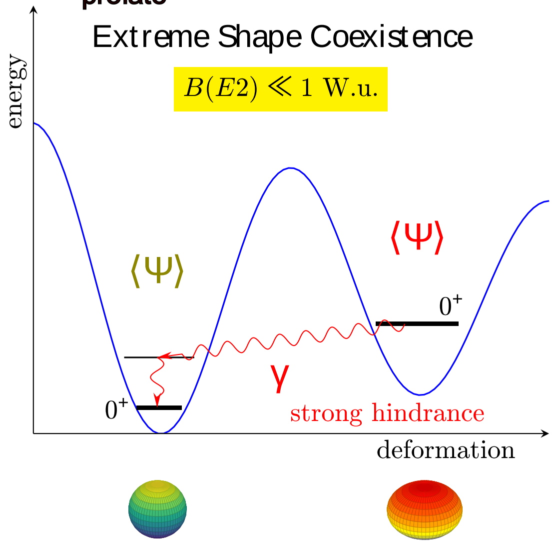
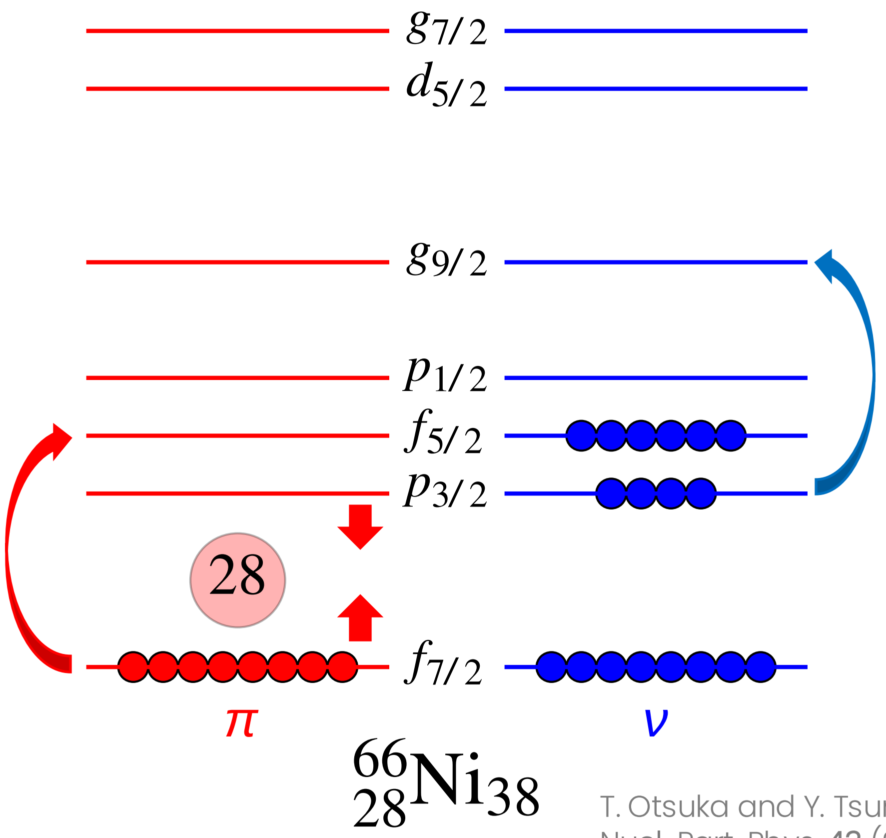






MICROSCOPIC PICTURE

Neutron excitations reduce the proton shell gap

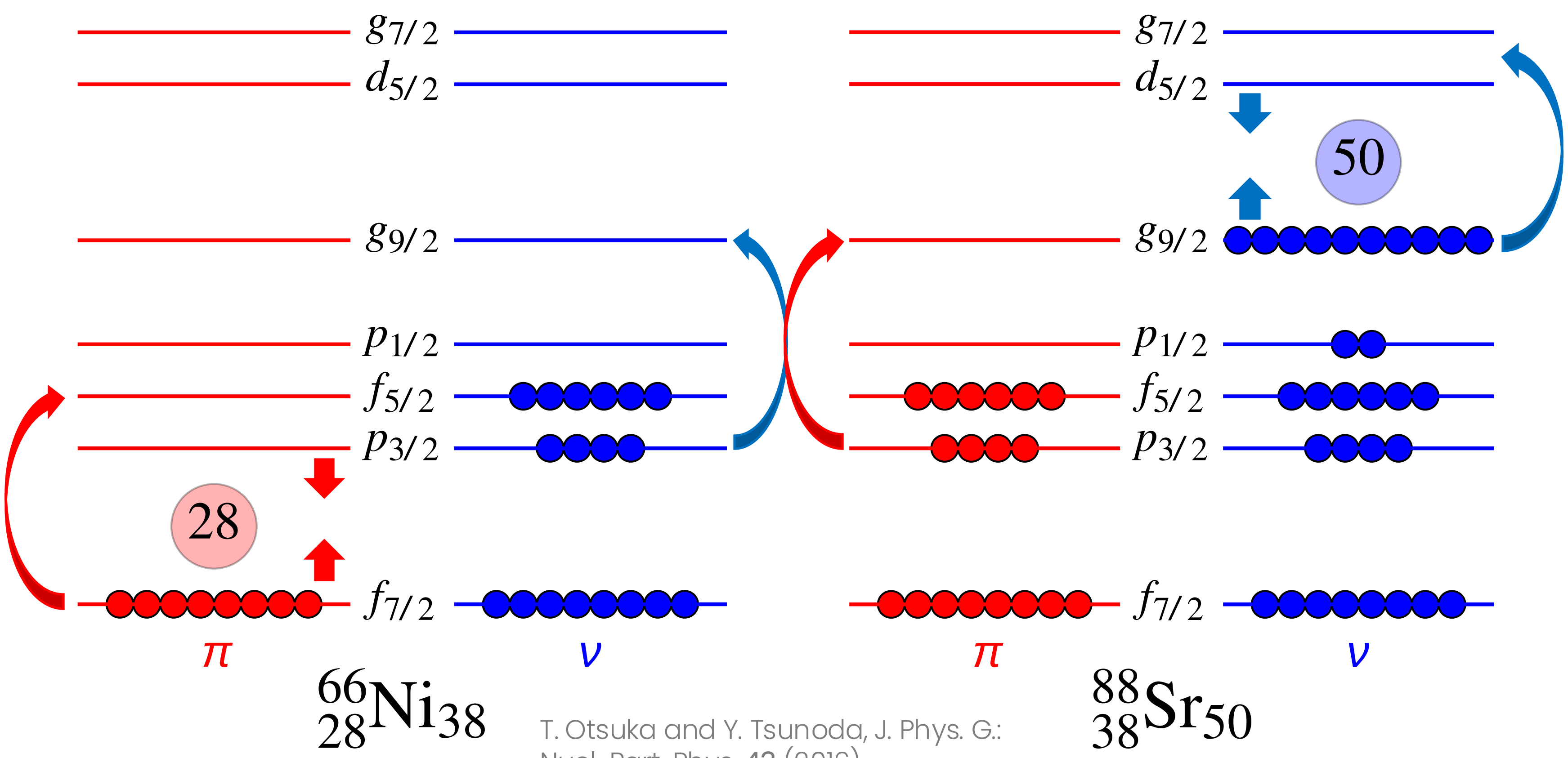


T. Otsuka and Y. Tsunoda, J. Phys. G.: Nucl. Part. Phys. **43** (2016)
Y. Tsunoda et al. Phys. Rev. C **89** (2014)

MICROSCOPIC PICTURE

Neutron excitations reduce the proton shell gap

Proton excitations reduce the neutron shell gap



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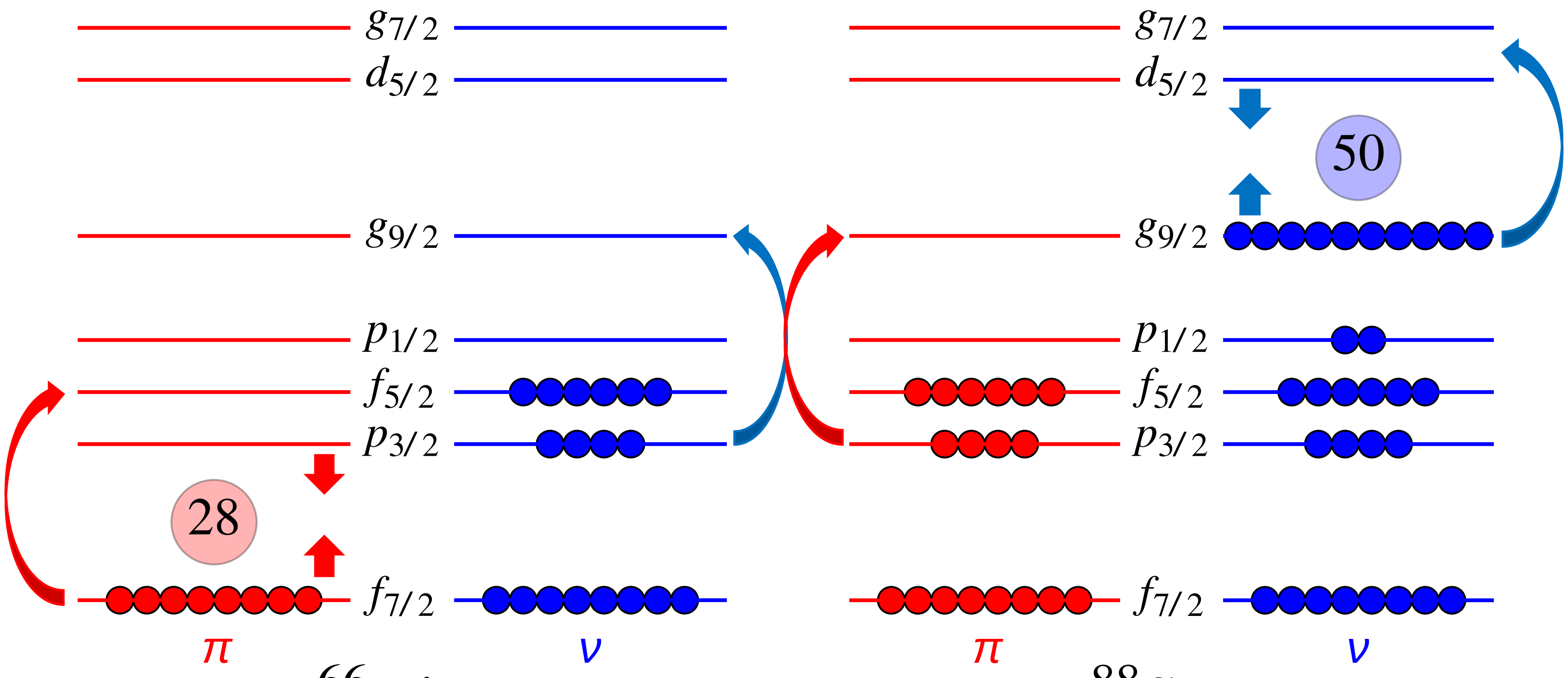


$^{66}_{28}Ni_{38}$ $^{88}_{38}Sr_{50}$

Similar behavior expected

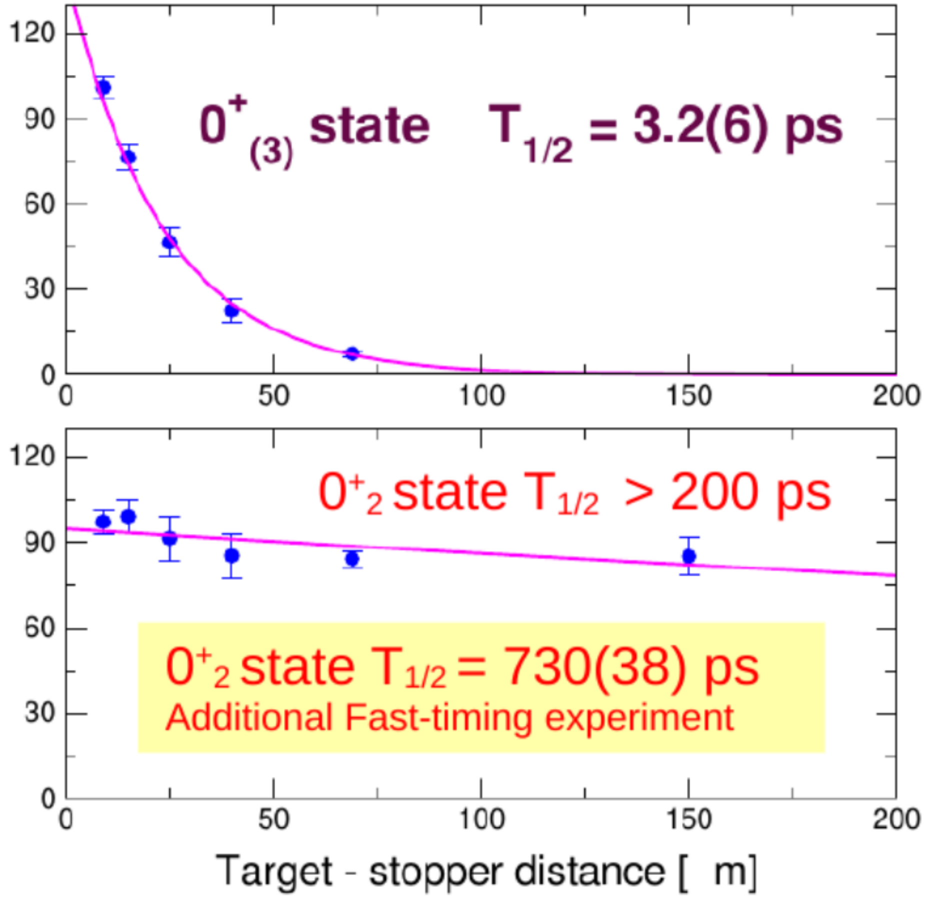
↓

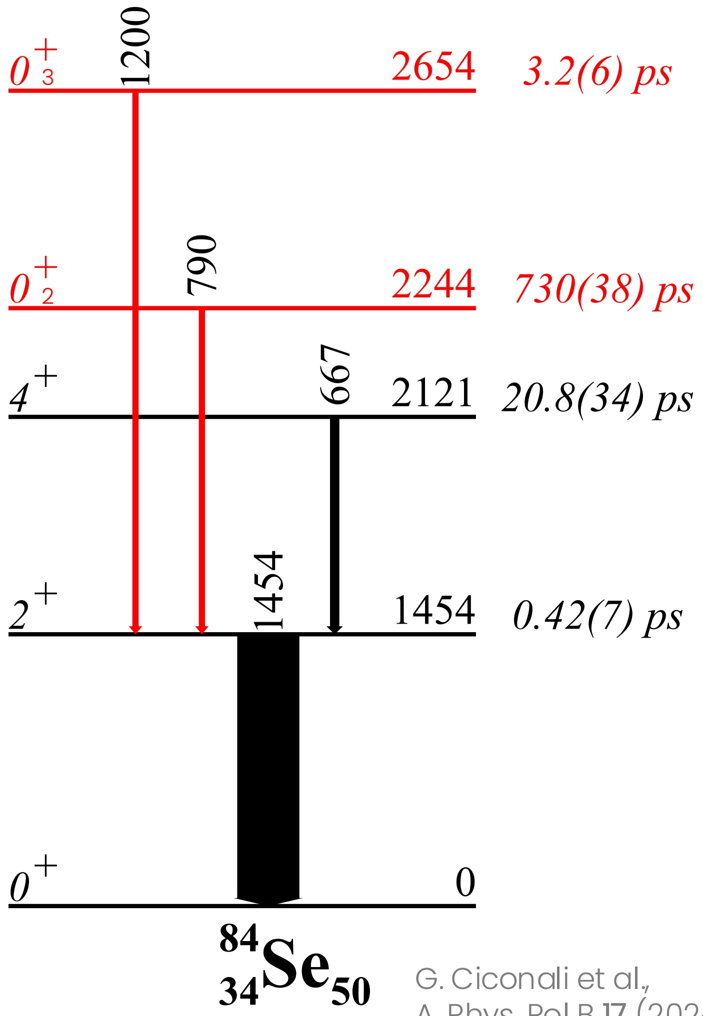
Appearance of deformed configurations at N=50?

T. Otsuka and Y. Tsunoda, J. Phys. G.: Nucl. Part. Phys. **43** (2016)
Y. Tsunoda et al. Phys. Rev. C **89** (2014)

SHAPE COEXISTENCE AT N=50: ^{84}SE

$^{82}Se(^{18}O,^{16}O)$ 2n-transfer reaction at sub-barrier energy





G. Ciconali et al., A. Phys. Pol B 17 (2024)

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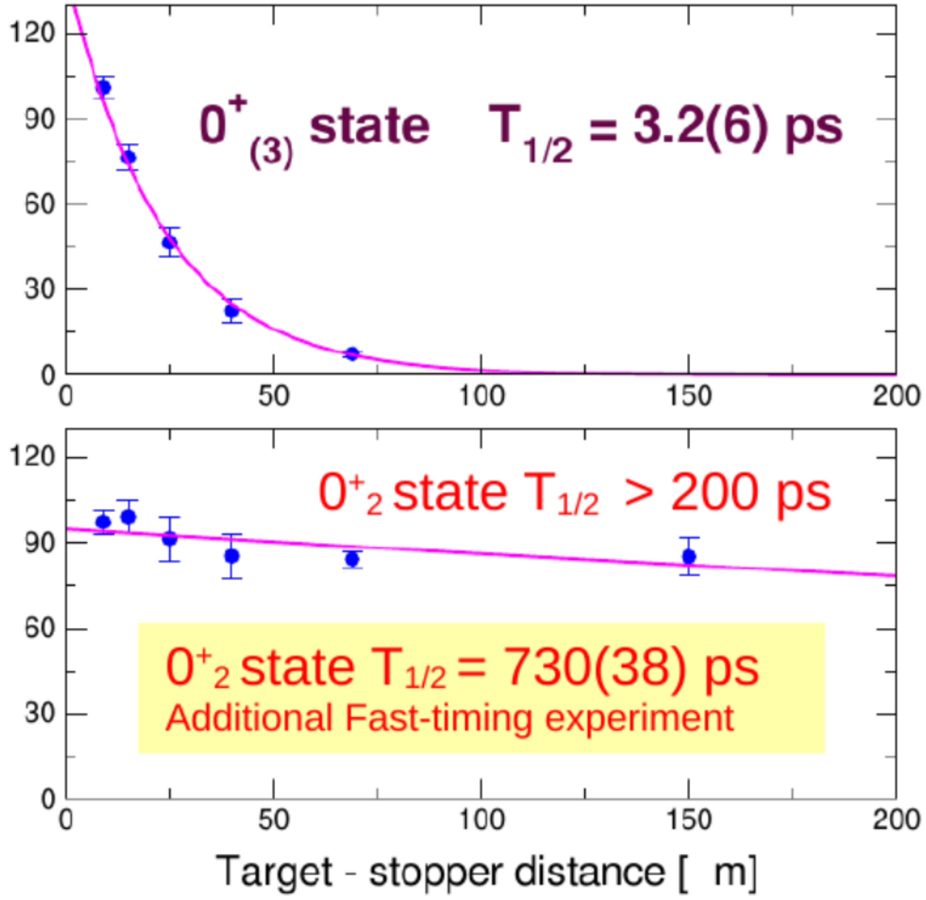

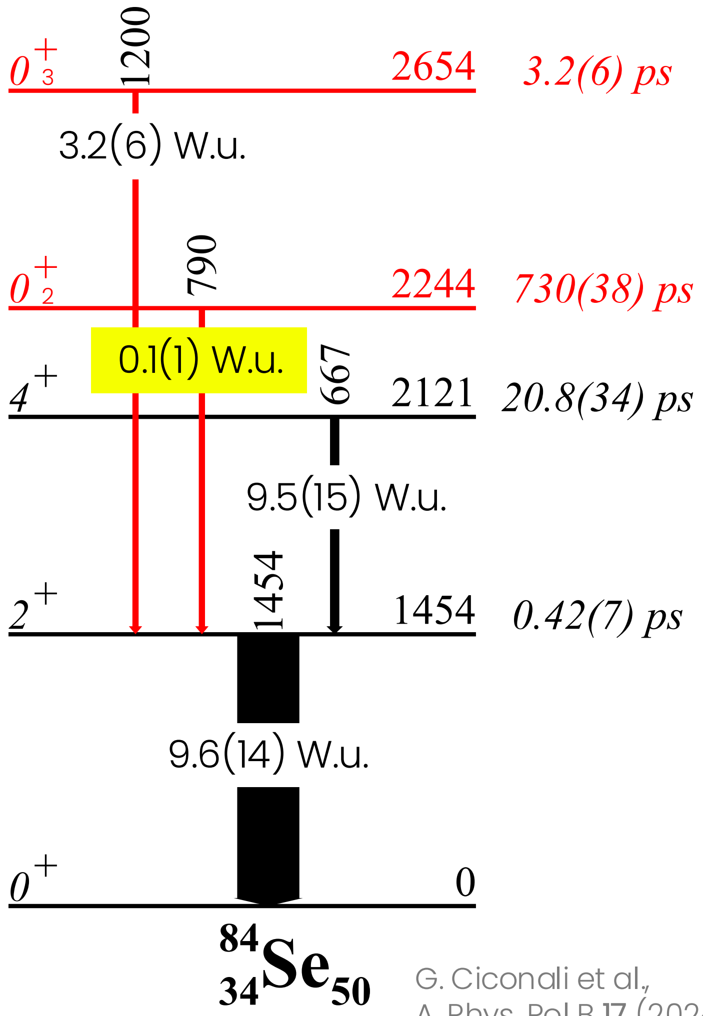

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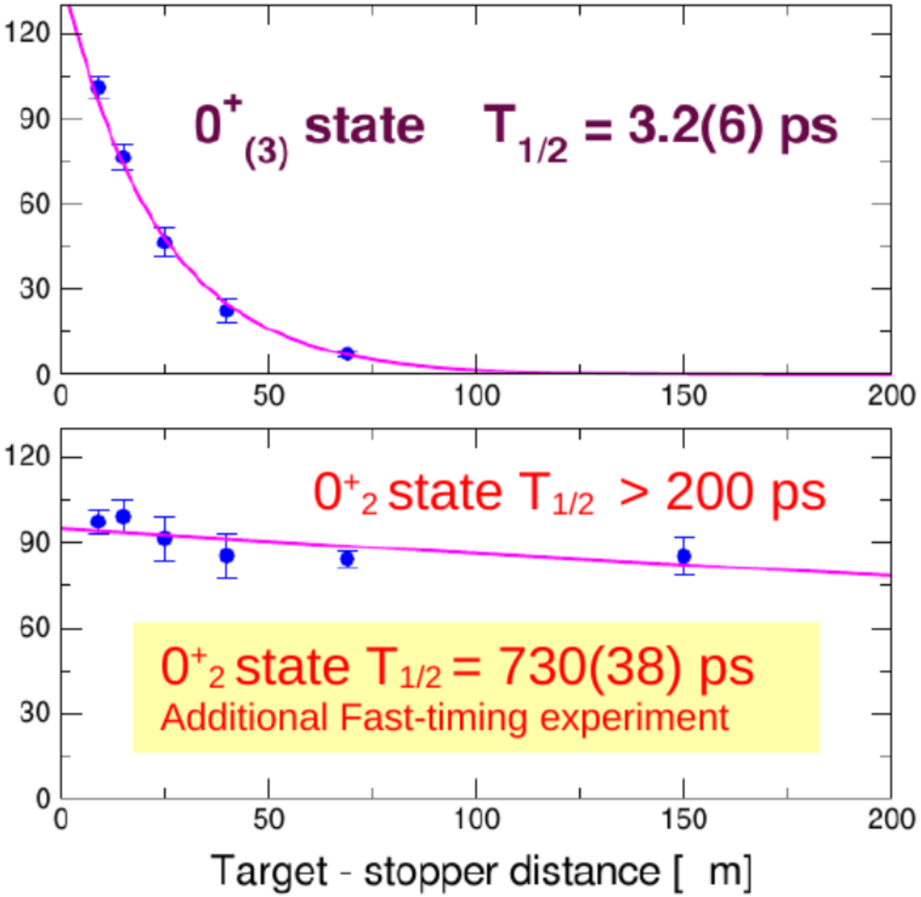
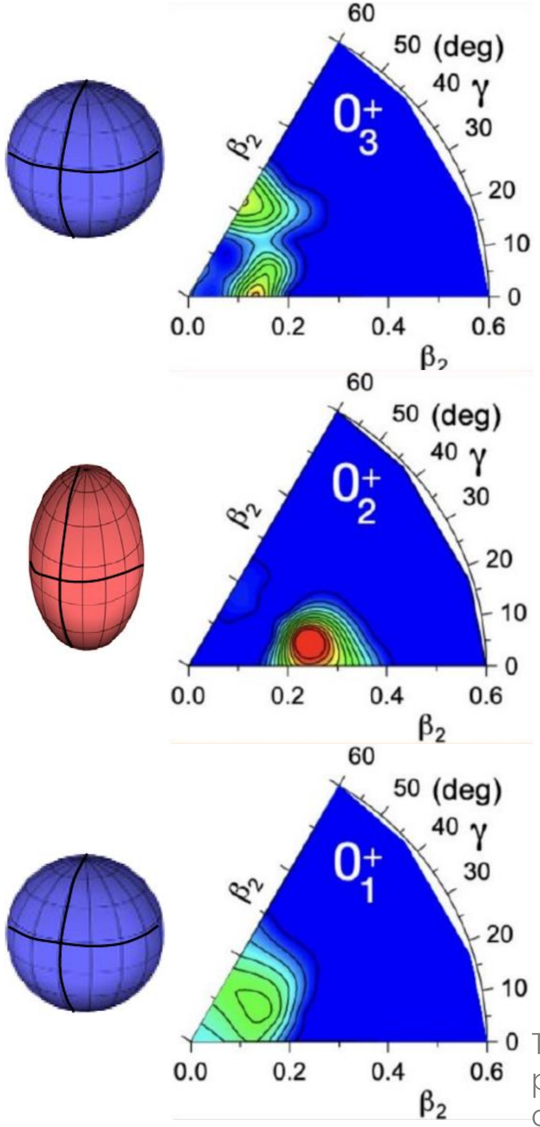
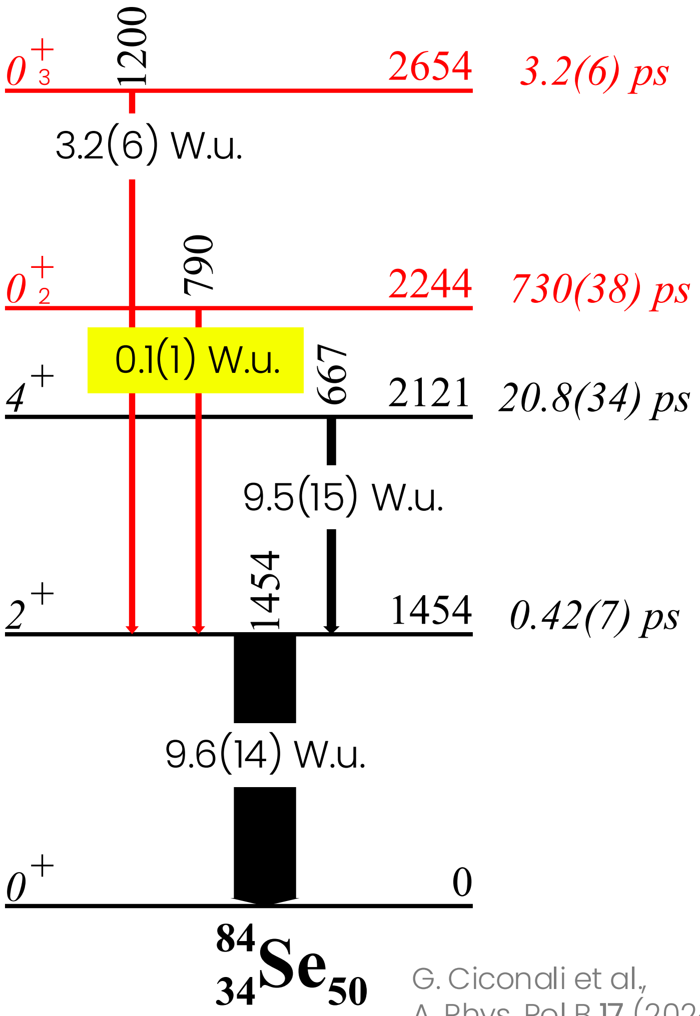




T.R. Rodríguez, private communication



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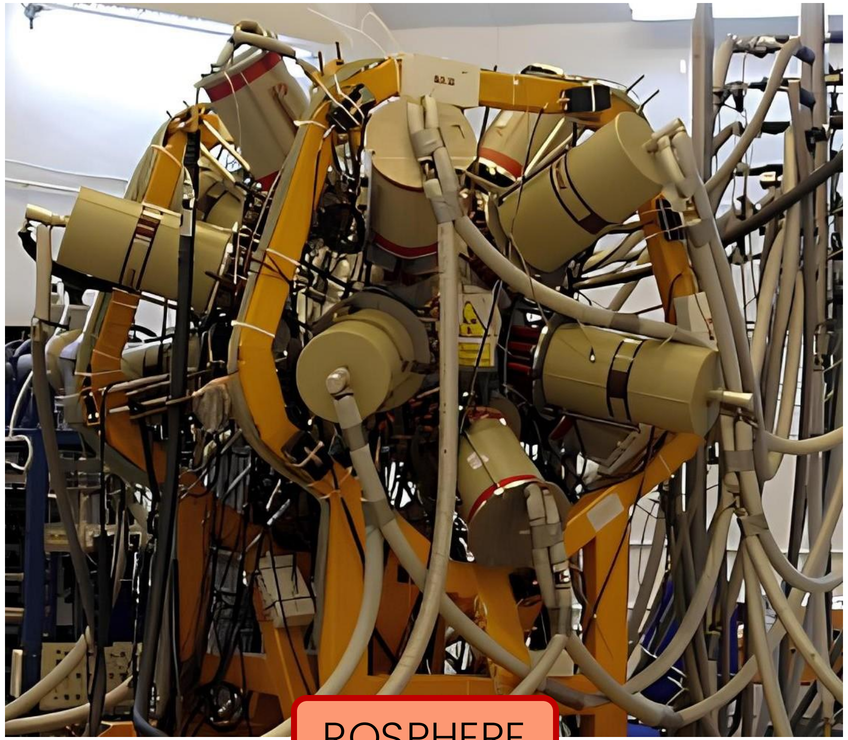
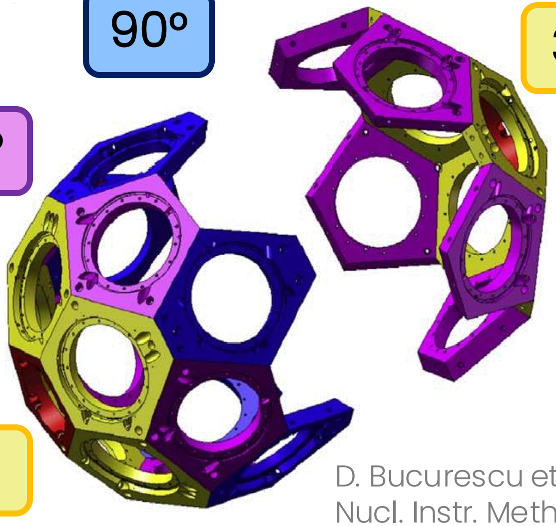
ROSPHERE SETUP



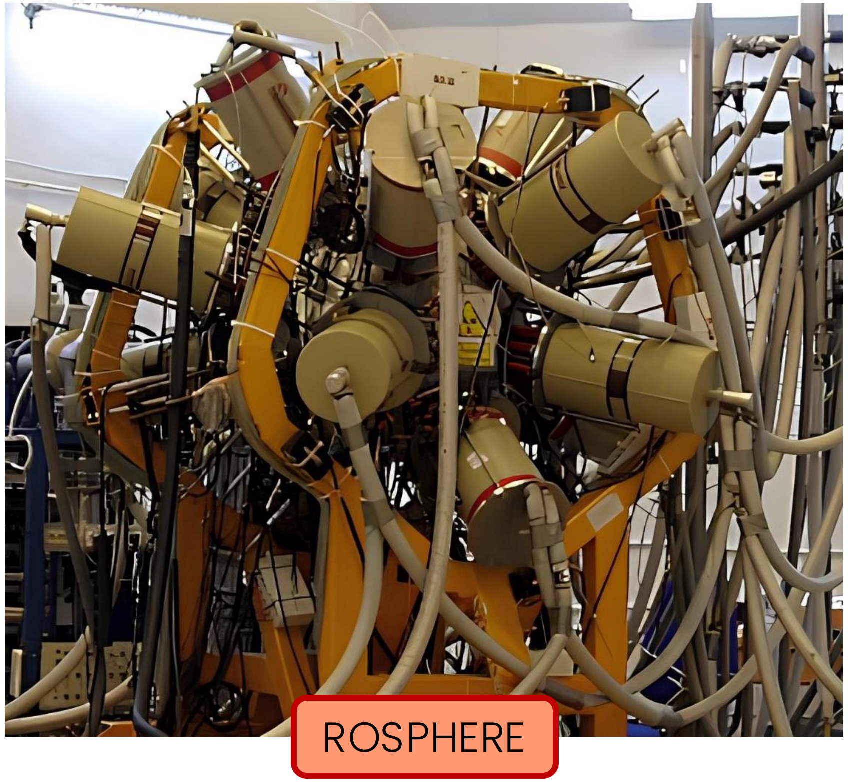
25 detectors
Compton-suppressed HPGe
Large-volume $LaBr_3$



D. Bucurescu et al., Nucl. Instr. Meth. A **837** (2016)

- DSAM
- RDDS plunger
- Fast timing

ROSPHERE SETUP



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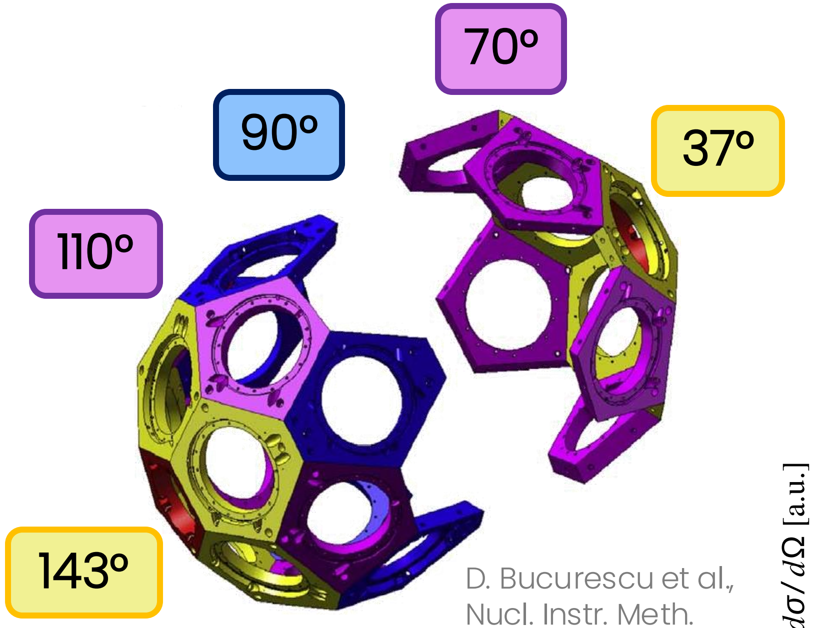

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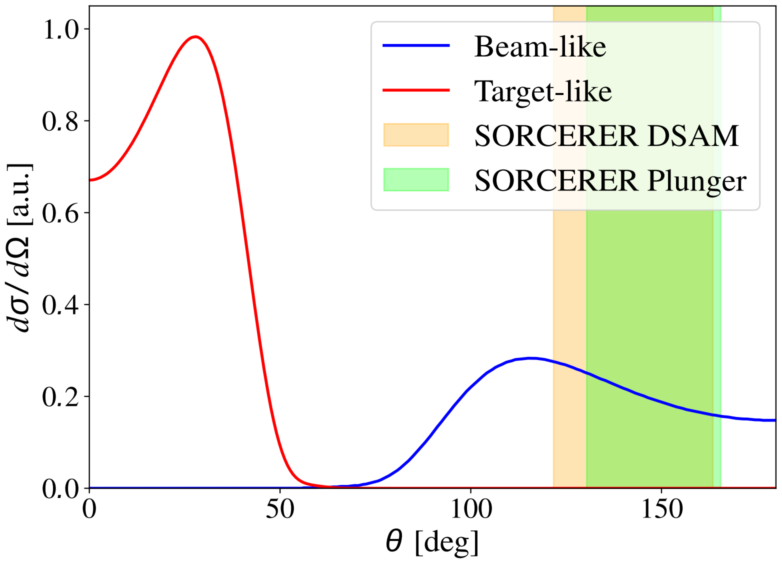
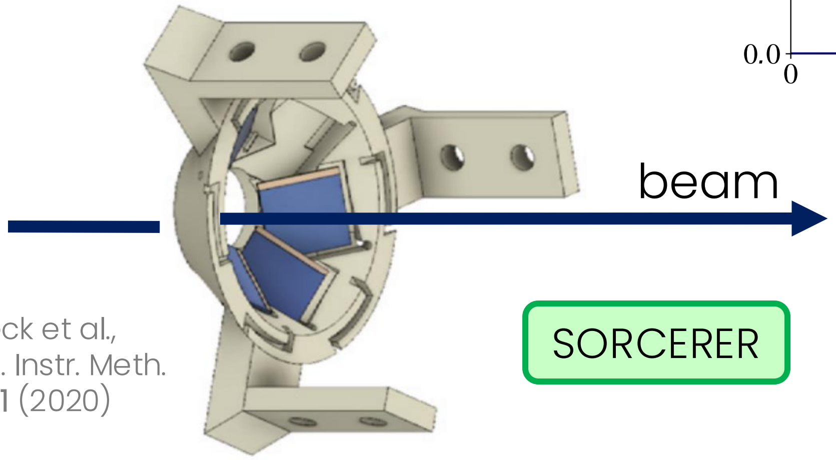


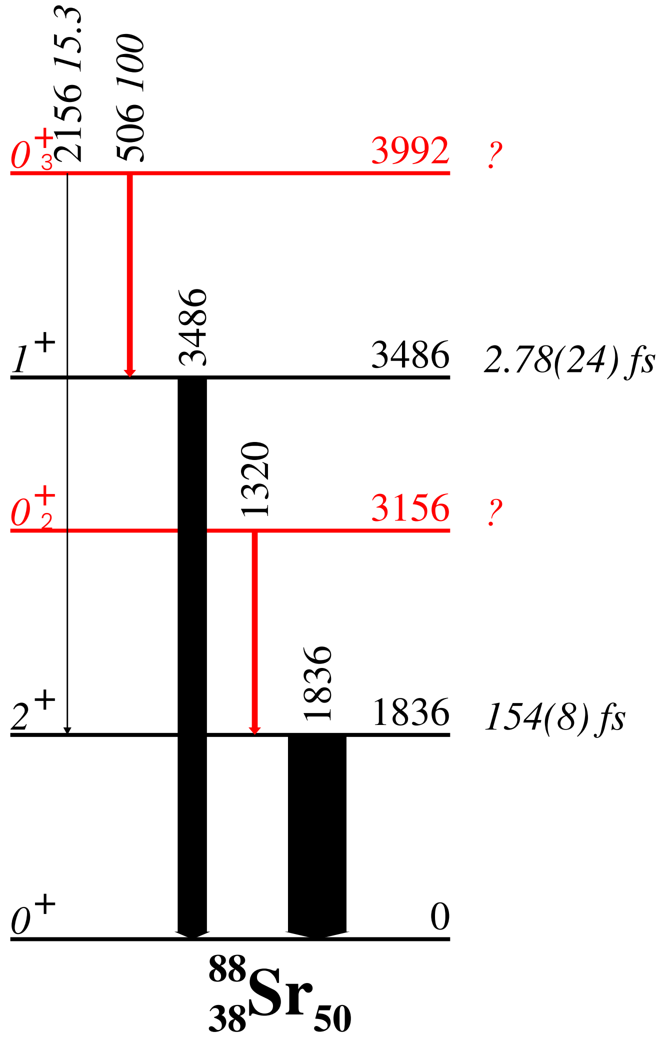


T. Beck et al., Nucl. Instr. Meth. A **951** (2020)

6 photodiodes
Si detectors

SHAPE COEXISTENCE AT N=50: ^{88}SR

$^{89}Y(^{11}B,^{12}C)$ 1p-transfer reaction at sub-barrier energy



SHAPE COEXISTENCE AT N=50: ^{88}SR

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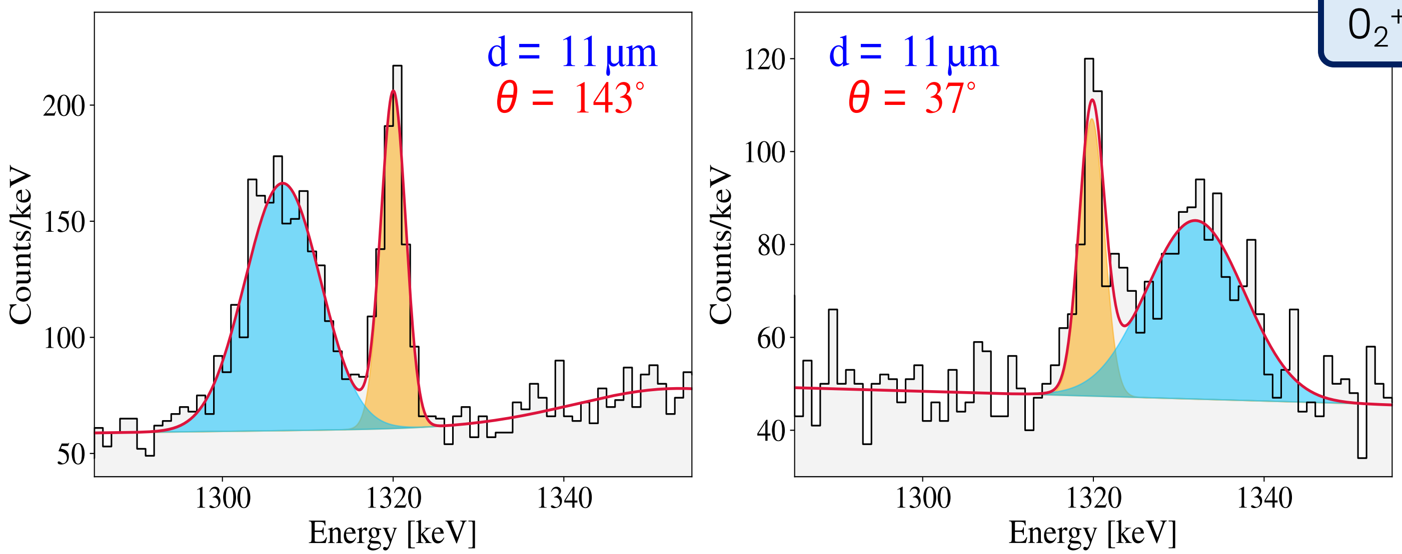
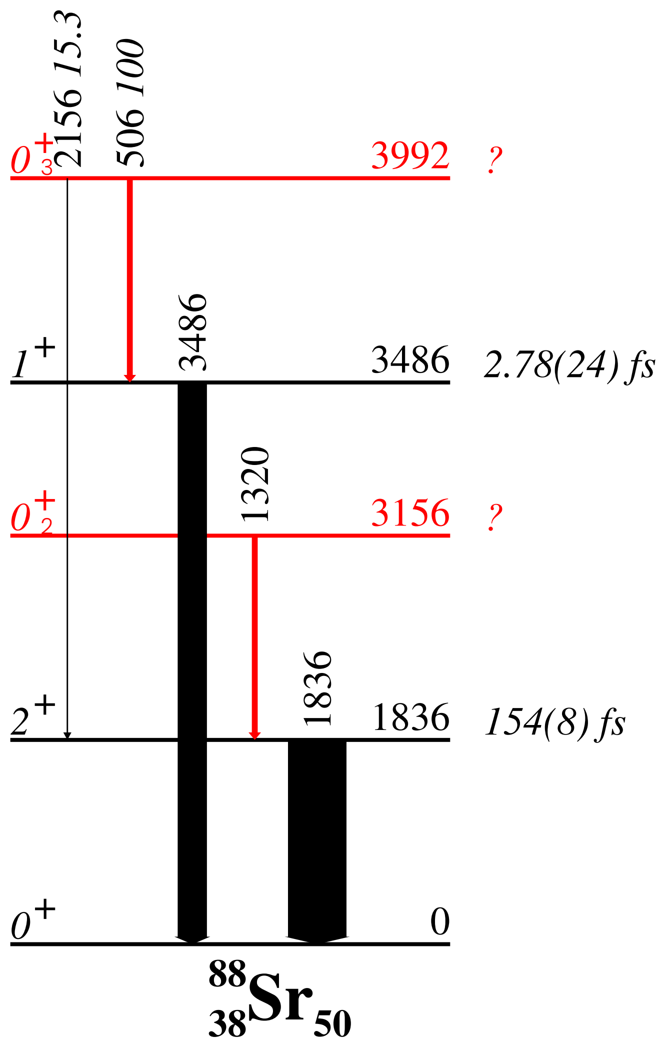
0_2^+



Plunger
1 mg/cm²
target



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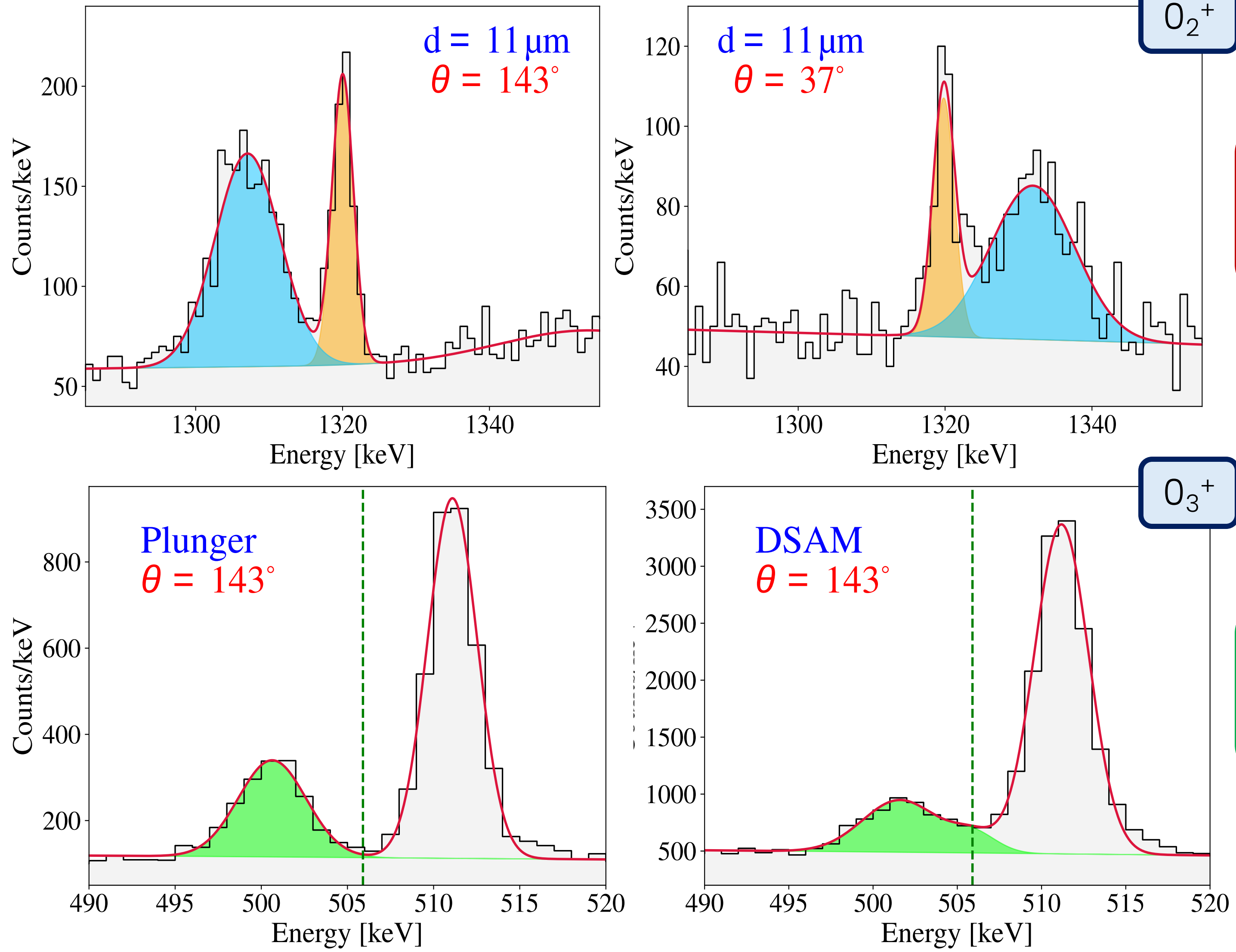
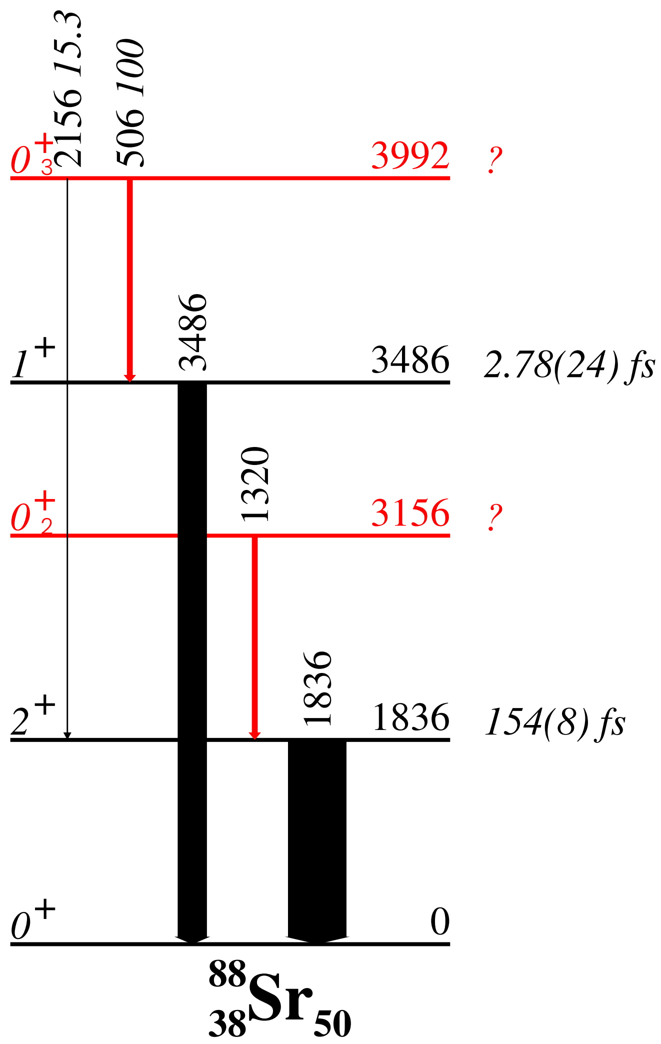


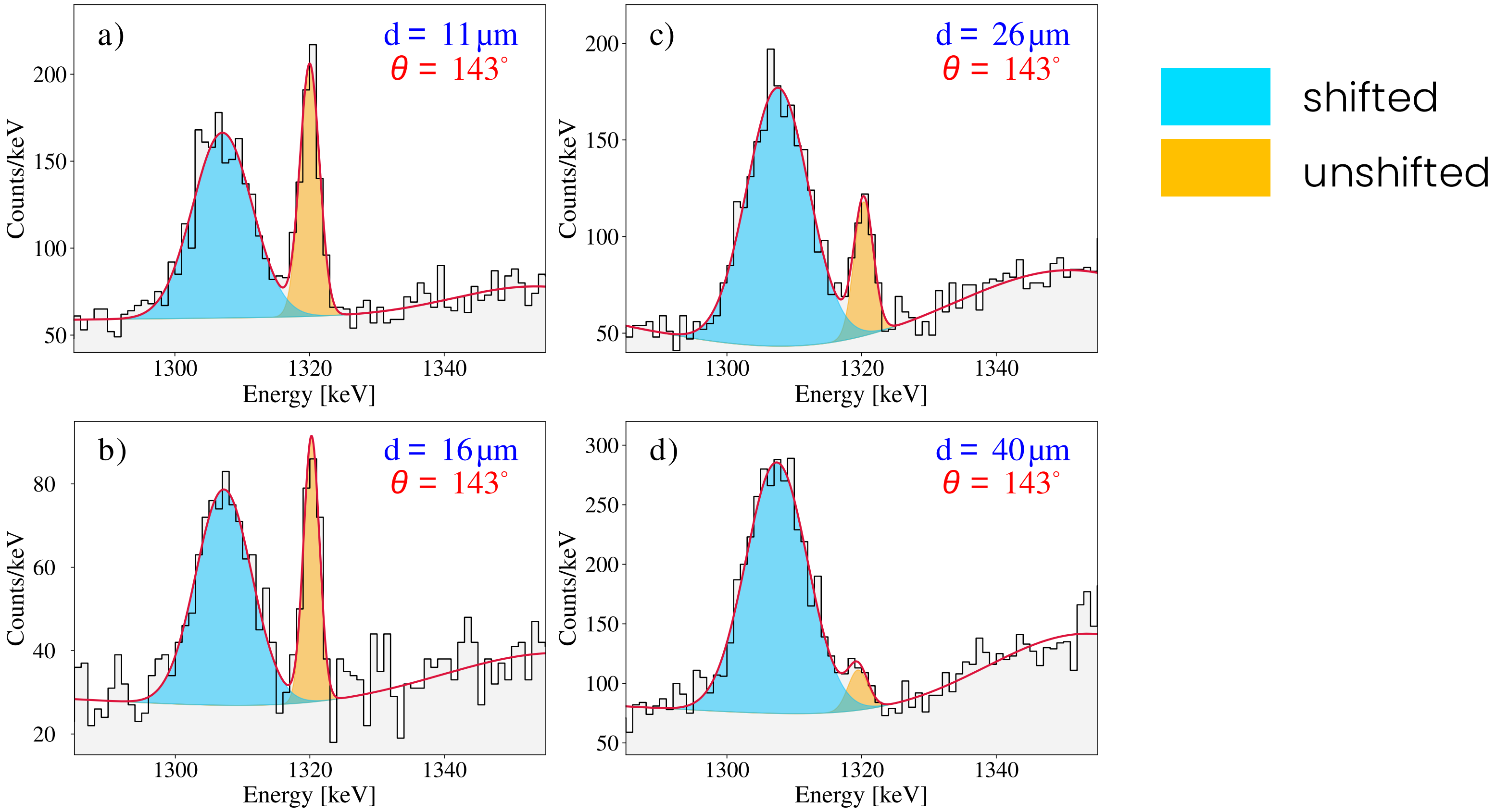
0_3^+

Plunger
1 mg/cm²
target

DSAM
6mg/cm²
target

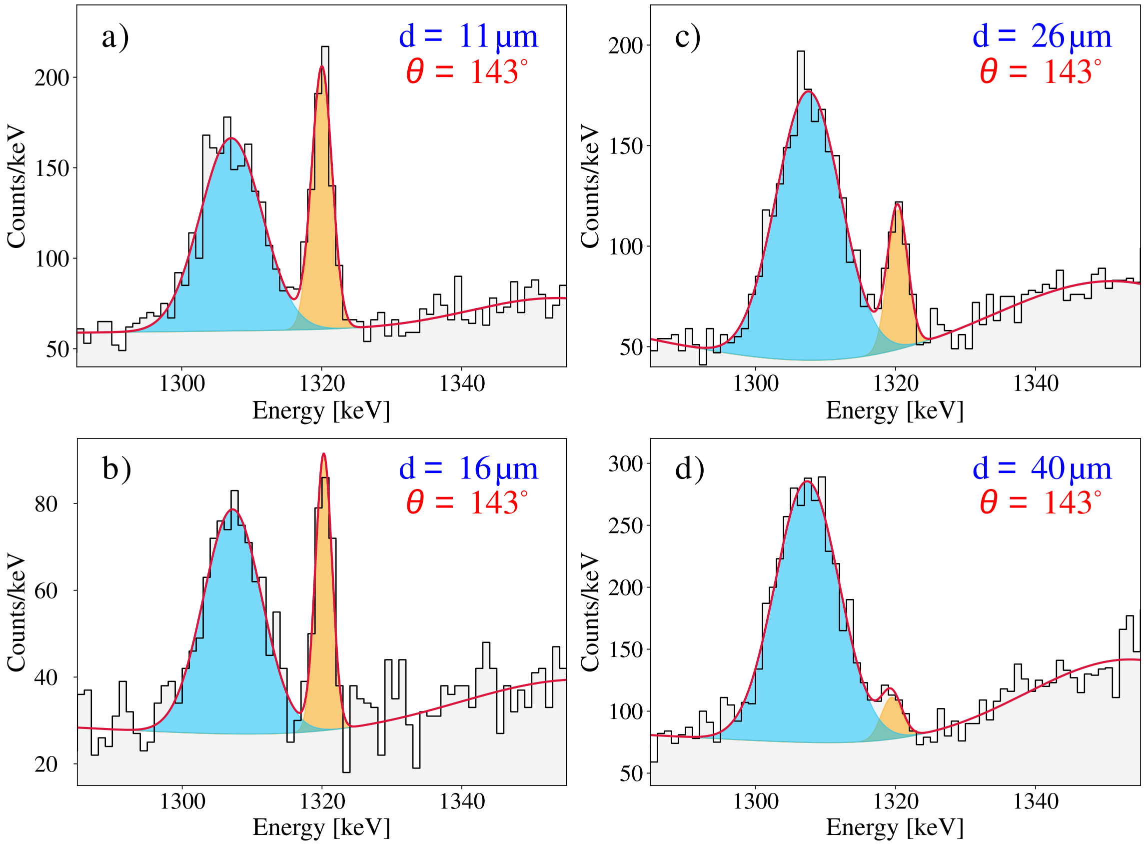


LIFETIME OF THE 0_2^+ STATE: PLUNGER

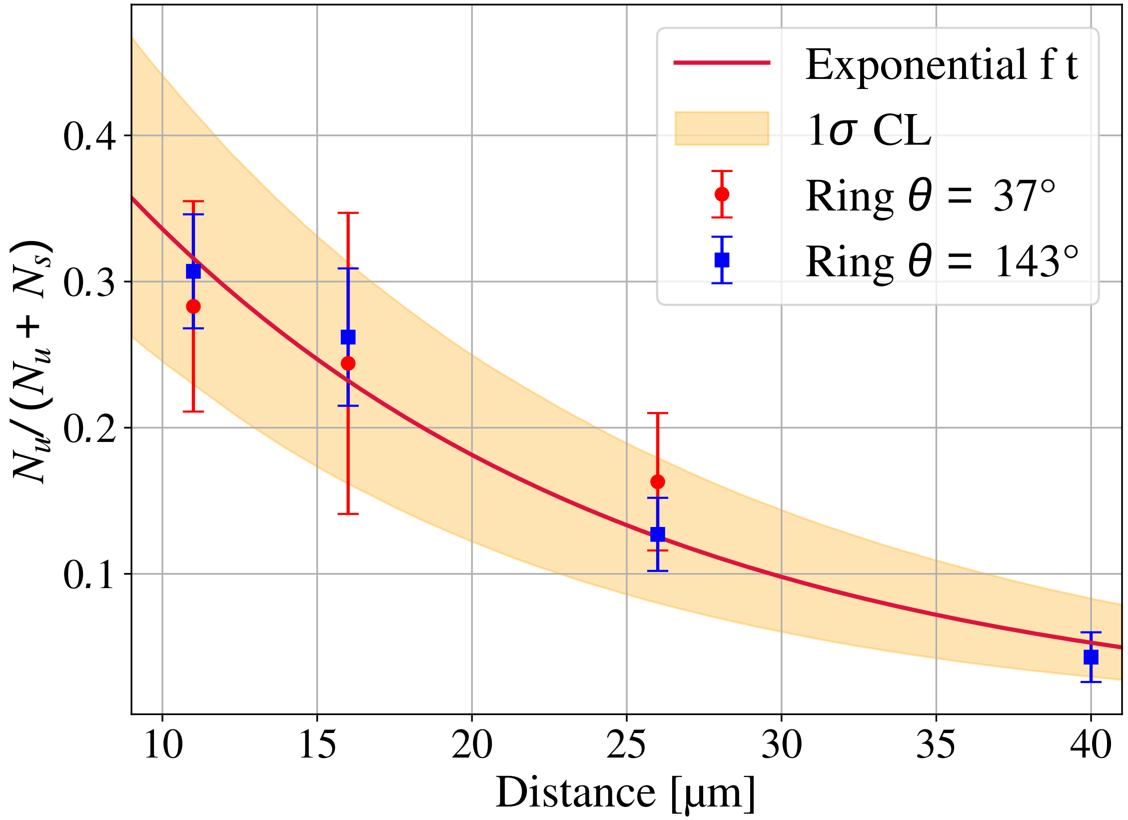


$$R(x) \equiv \frac{N_u(x)}{N_u(x) + N_s(x)} = \exp\left(-\frac{x+c}{v\tau}\right)$$

LIFETIME OF THE 0_2^+ STATE: PLUNGER



$T_{1/2}$ = 3.02(45) ps
B(E2) = 2.01(31) W.u.



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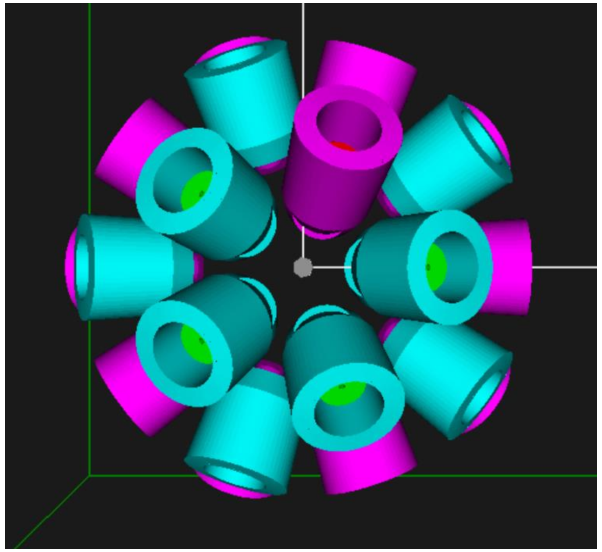
LIFETIME OF THE 0_3^+ STATE: DSAM

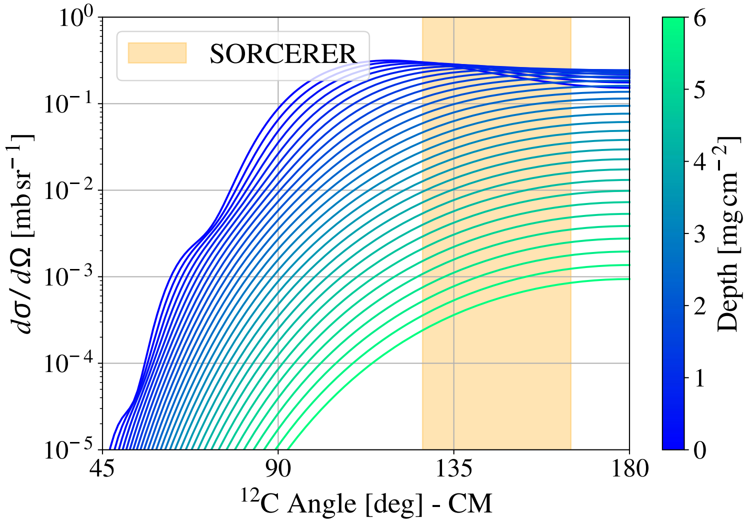
M. Labiche et al., Eur. Phys. J. A **59** (2023)

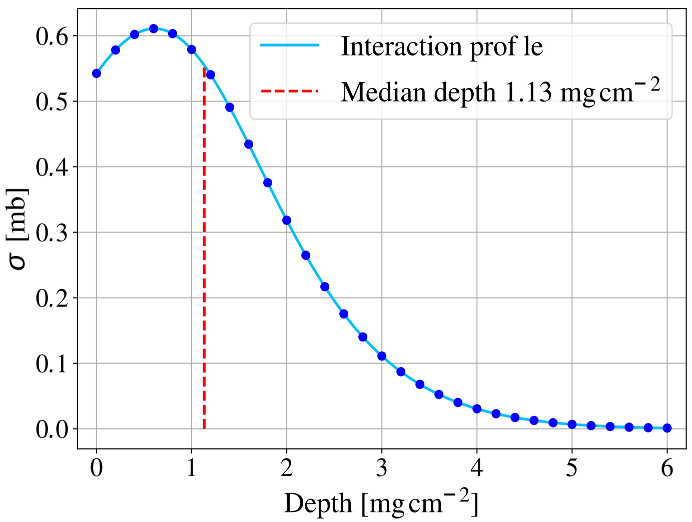
ROSPHERE geometry implemented in AGATA simulation code



LIFETIME OF THE 0_3^+ STATE: DSAM

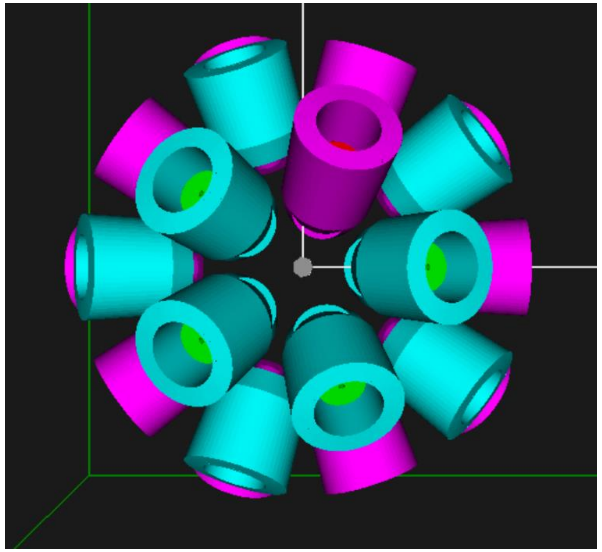
M. Labiche et al., Eur. Phys. J. A **59** (2023)





Angular distributions of reaction products + interaction profile within the target

ROSPHERE geometry implemented in AGATA simulation code



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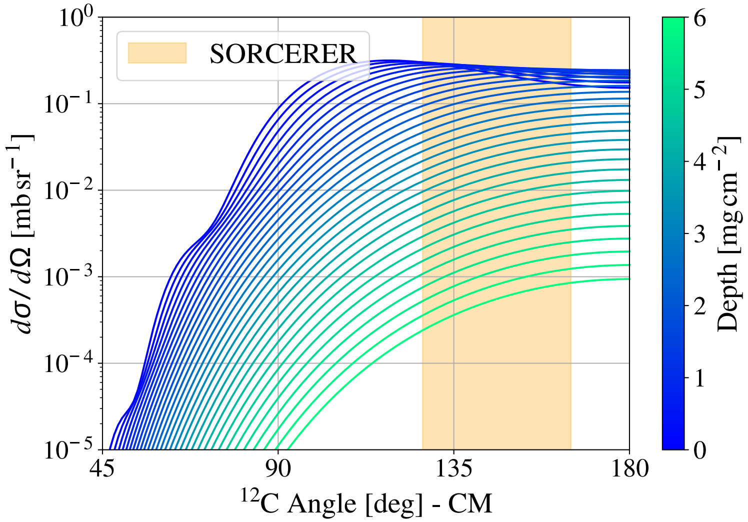

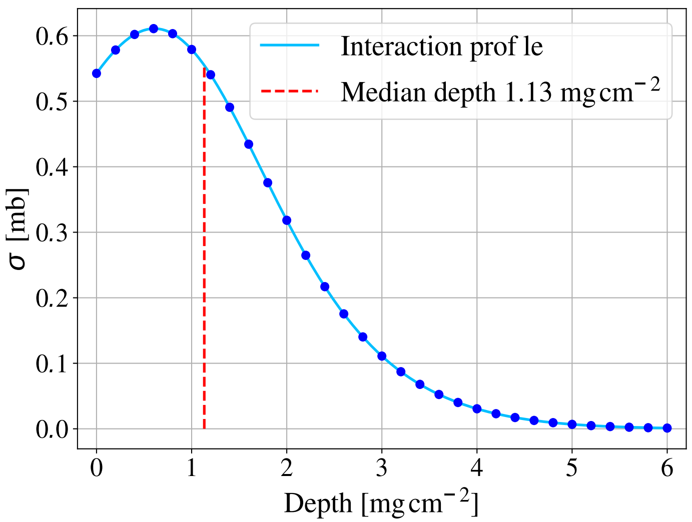

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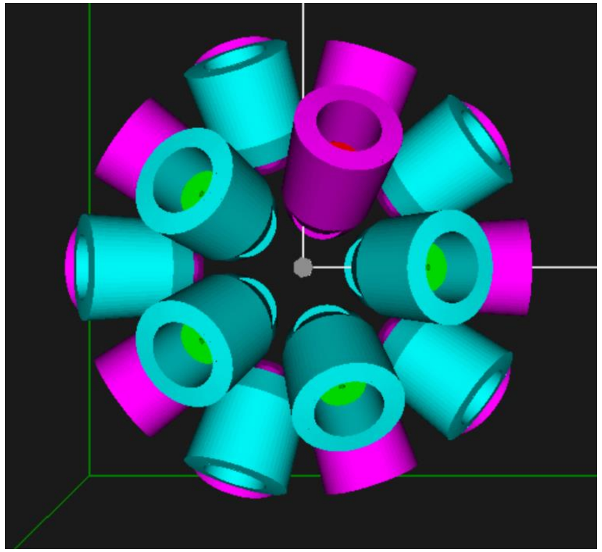
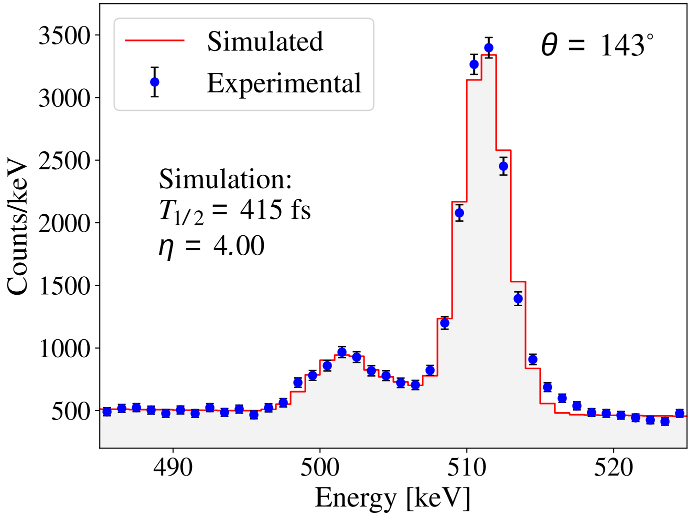
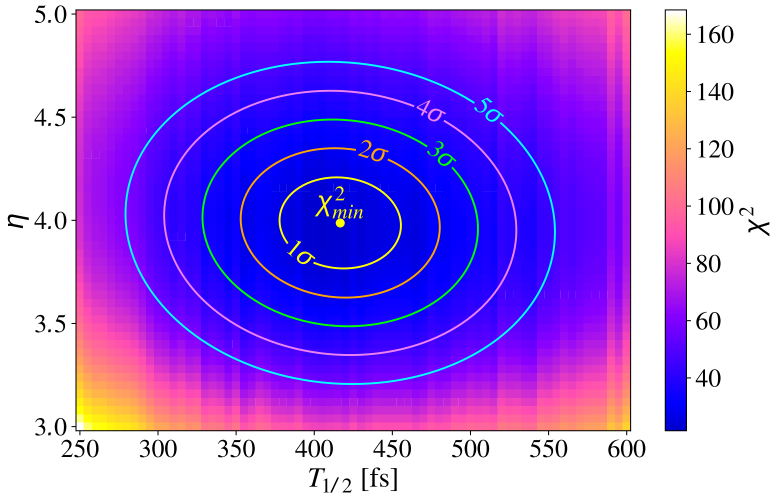


511-keV annihilation peak included with proportionality constant η

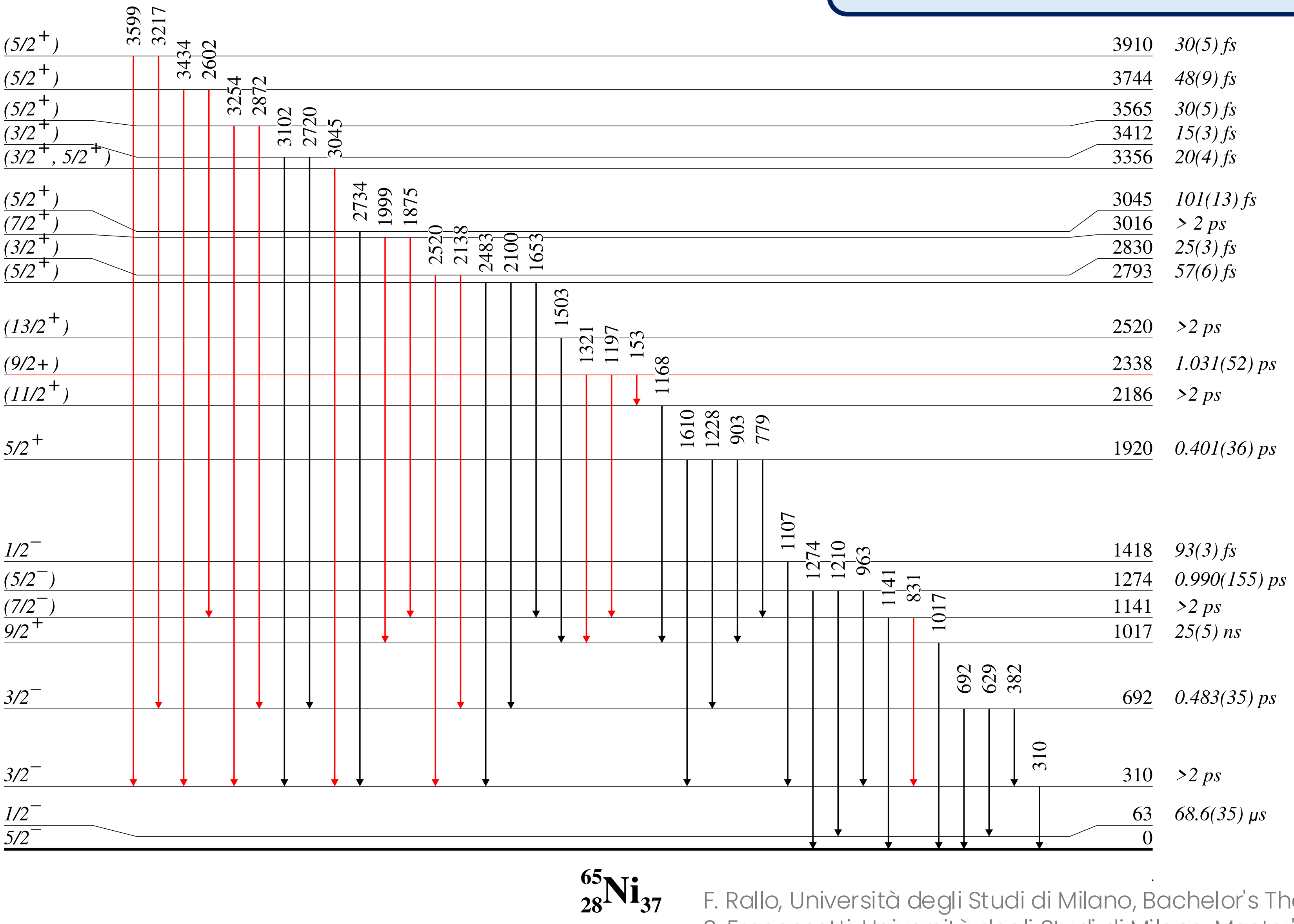




$T_{1/2}$ = 417(39) fs
B(E2) = 0.17(2) W.u.

RECENT RESULTS IN ^{65}NI

^{64}Ni(^{13}C,^{12}C) 1n-transfer reaction at sub-barrier energy



F. Rallo, Università degli Studi di Milano, Bachelor's Thesis
S. Fracassetti, Università degli Studi di Milano, Master's Thesis

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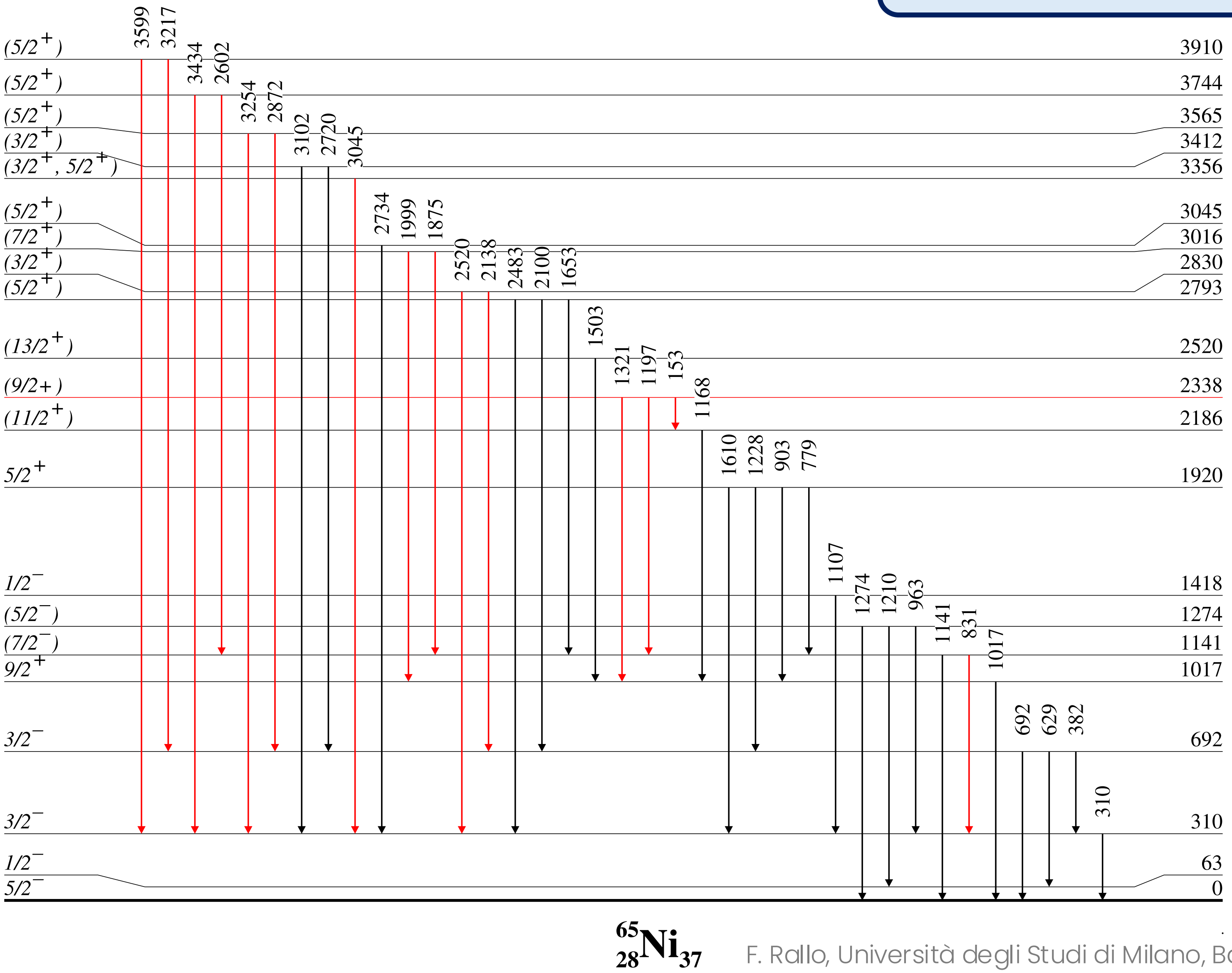
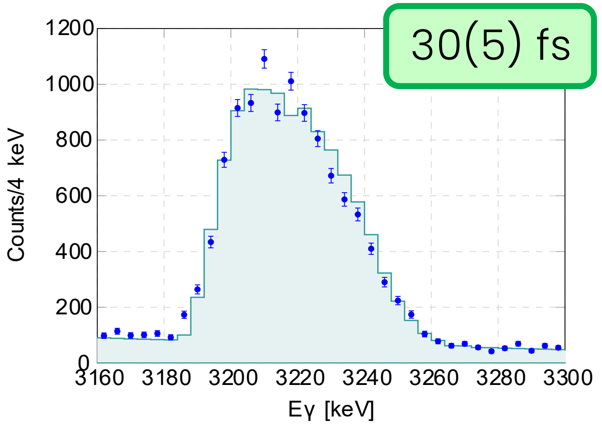
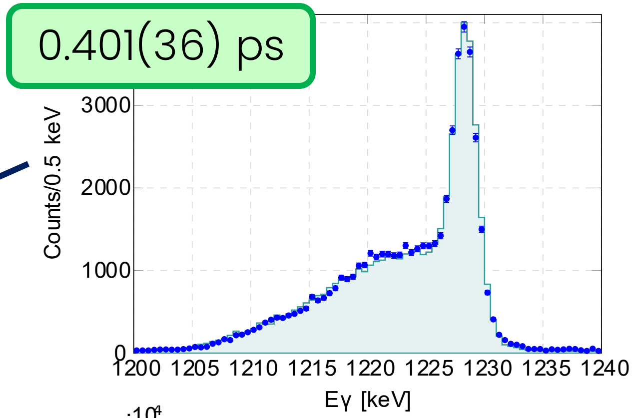
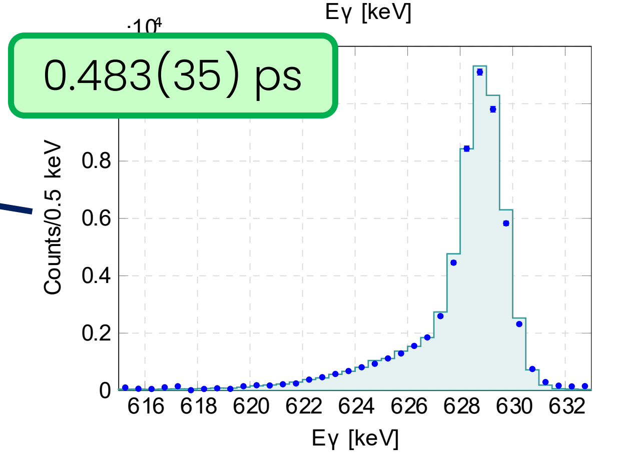




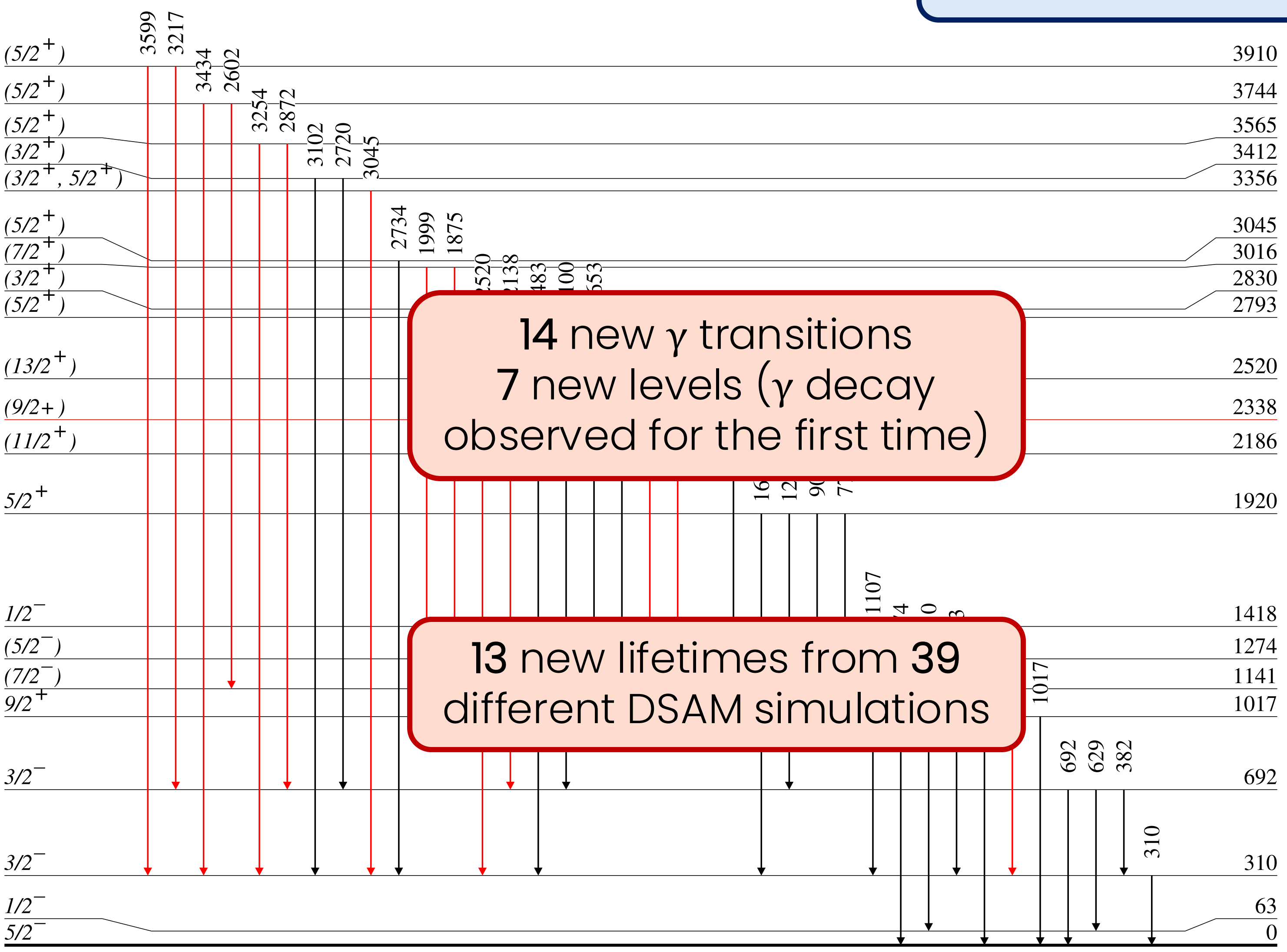




F. Rallo, Università degli Studi di Milano, Bachelor's Thesis
S. Fracassetti, Università degli Studi di Milano, Master's Thesis

RECENT RESULTS IN ^{65}NI

$^{64}Ni(^{13}C,^{12}C)$ 1n-transfer reaction at sub-barrier energy

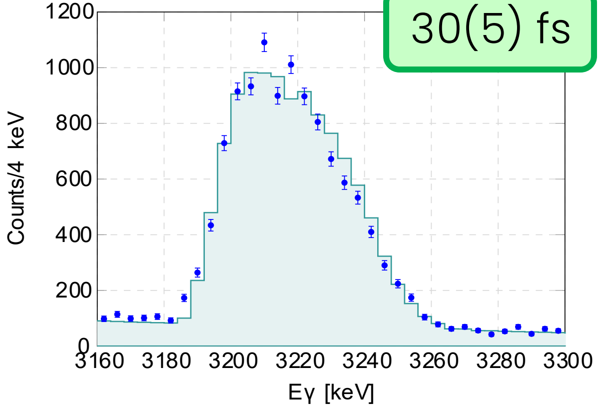


$^{65}_{28}Ni_{37}$

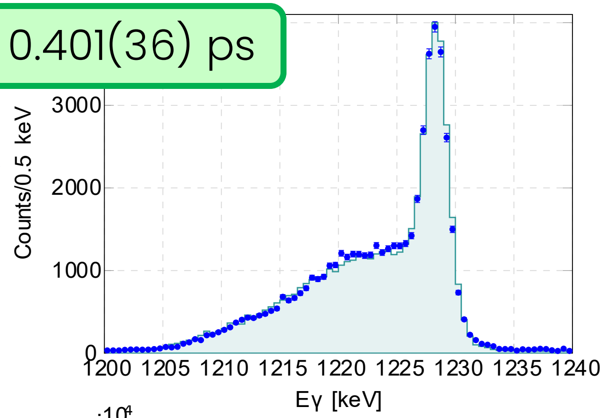
14 new γ transitions
7 new levels (γ decay observed for the first time)

13 new lifetimes from **39** different DSAM simulations

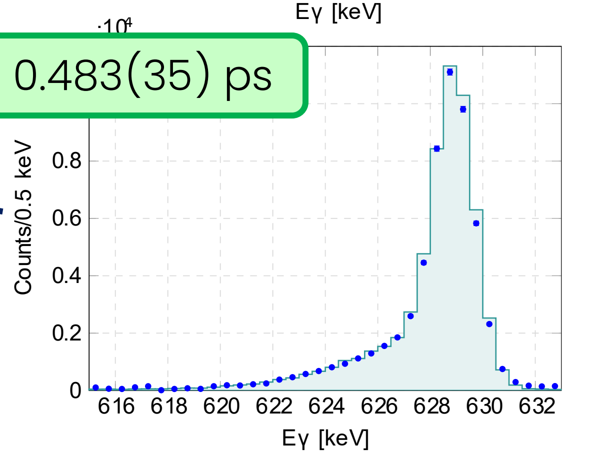
30(5) fs



0.401(36) ps



0.483(35) ps



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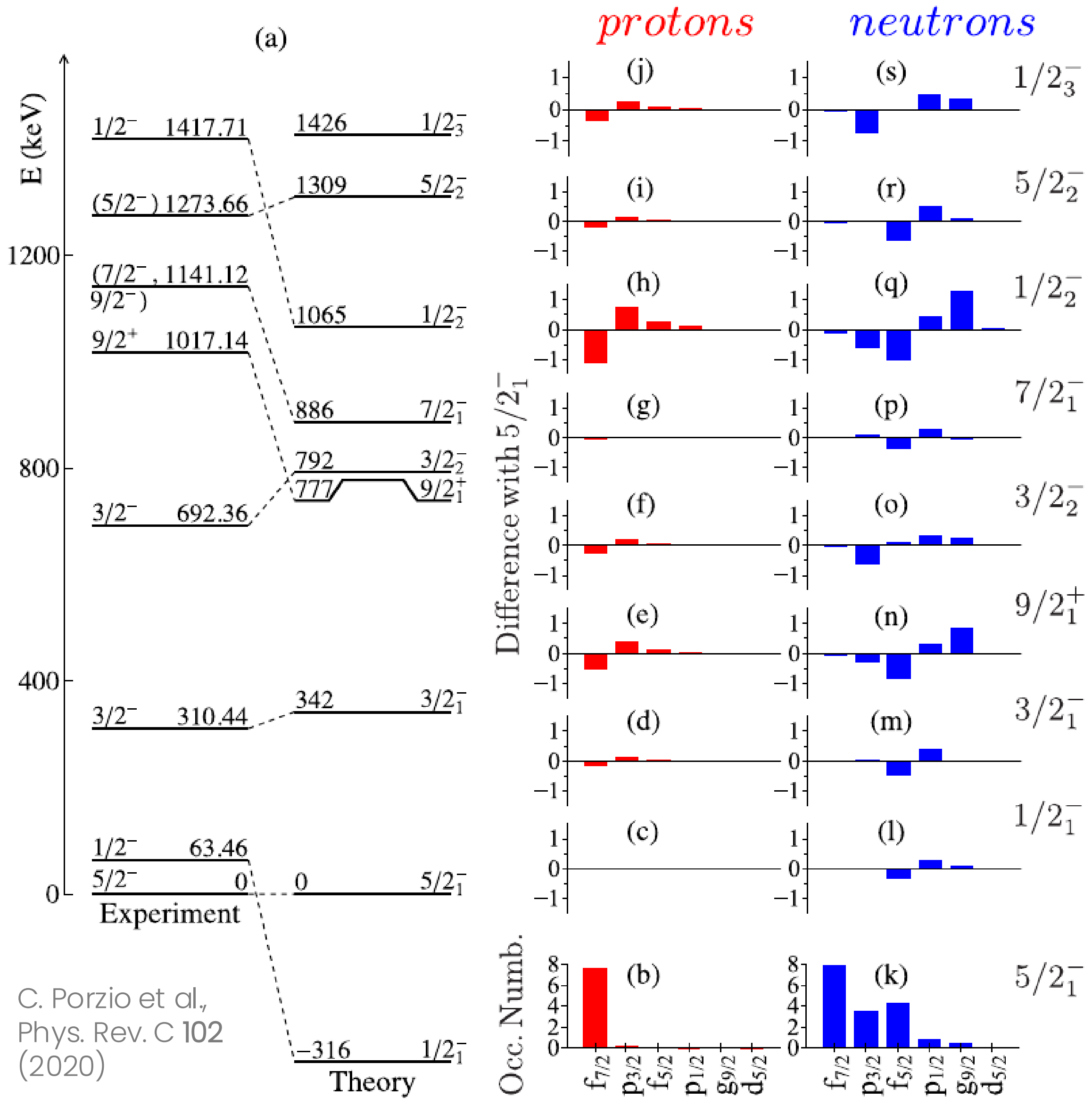
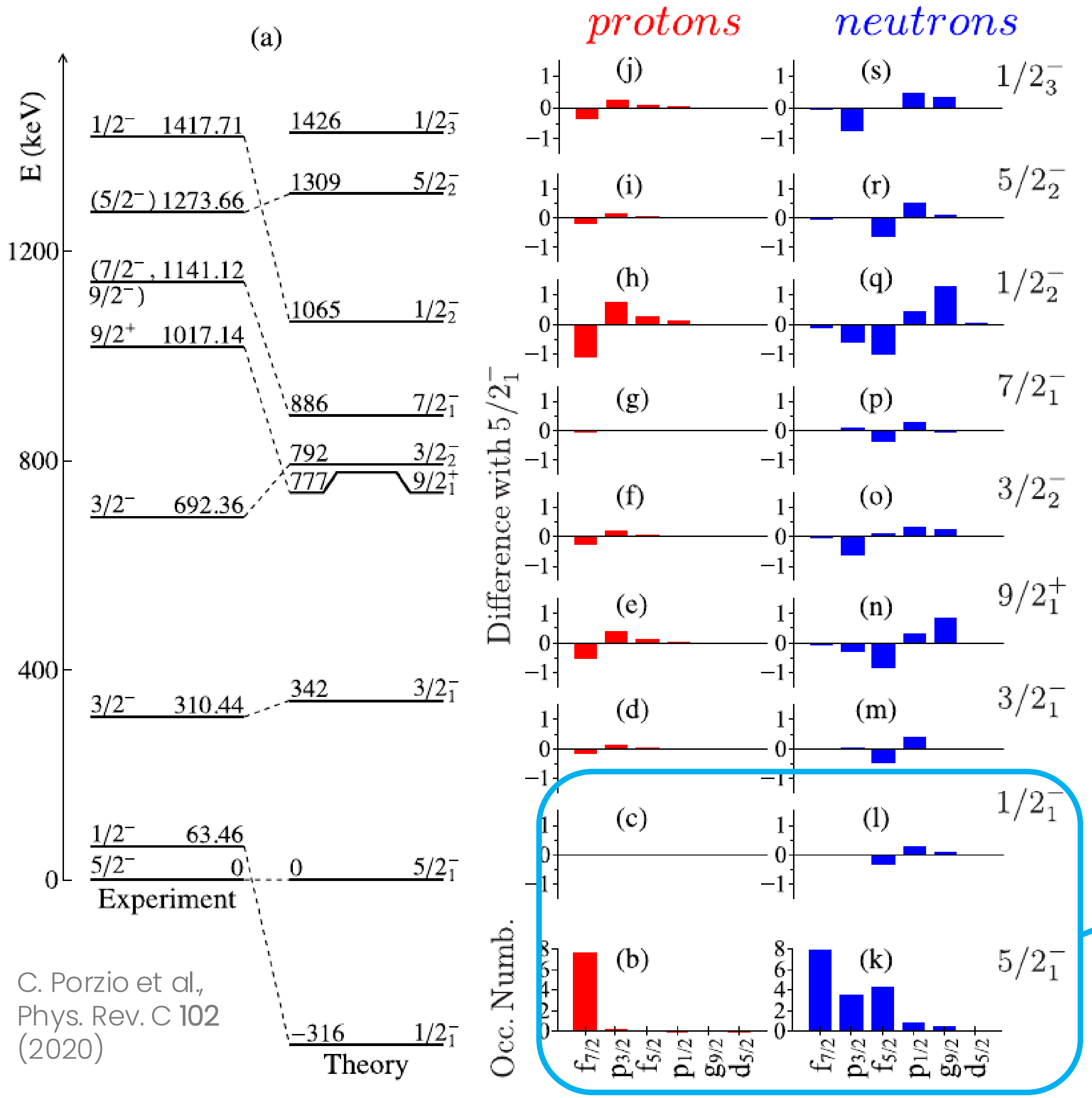
MCSM CALCULATIONS



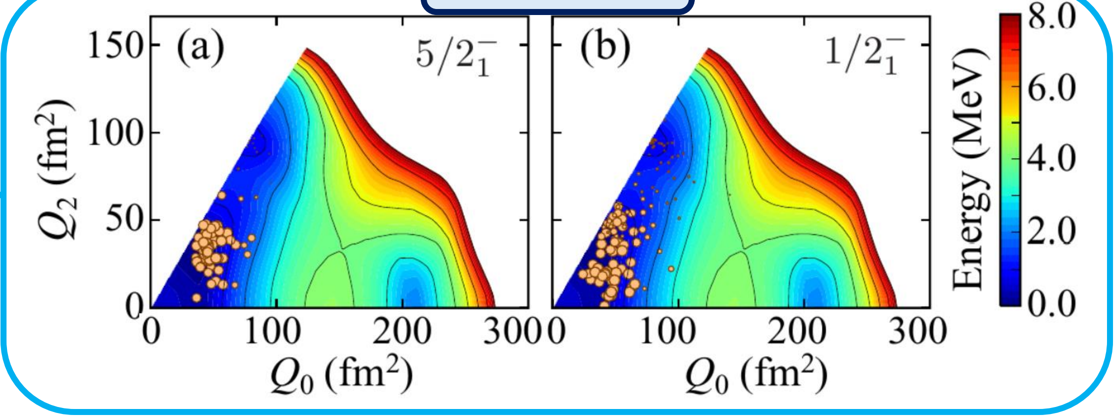
C. Porzio et al., Phys. Rev. C **102** (2020)

MCSM CALCULATIONS

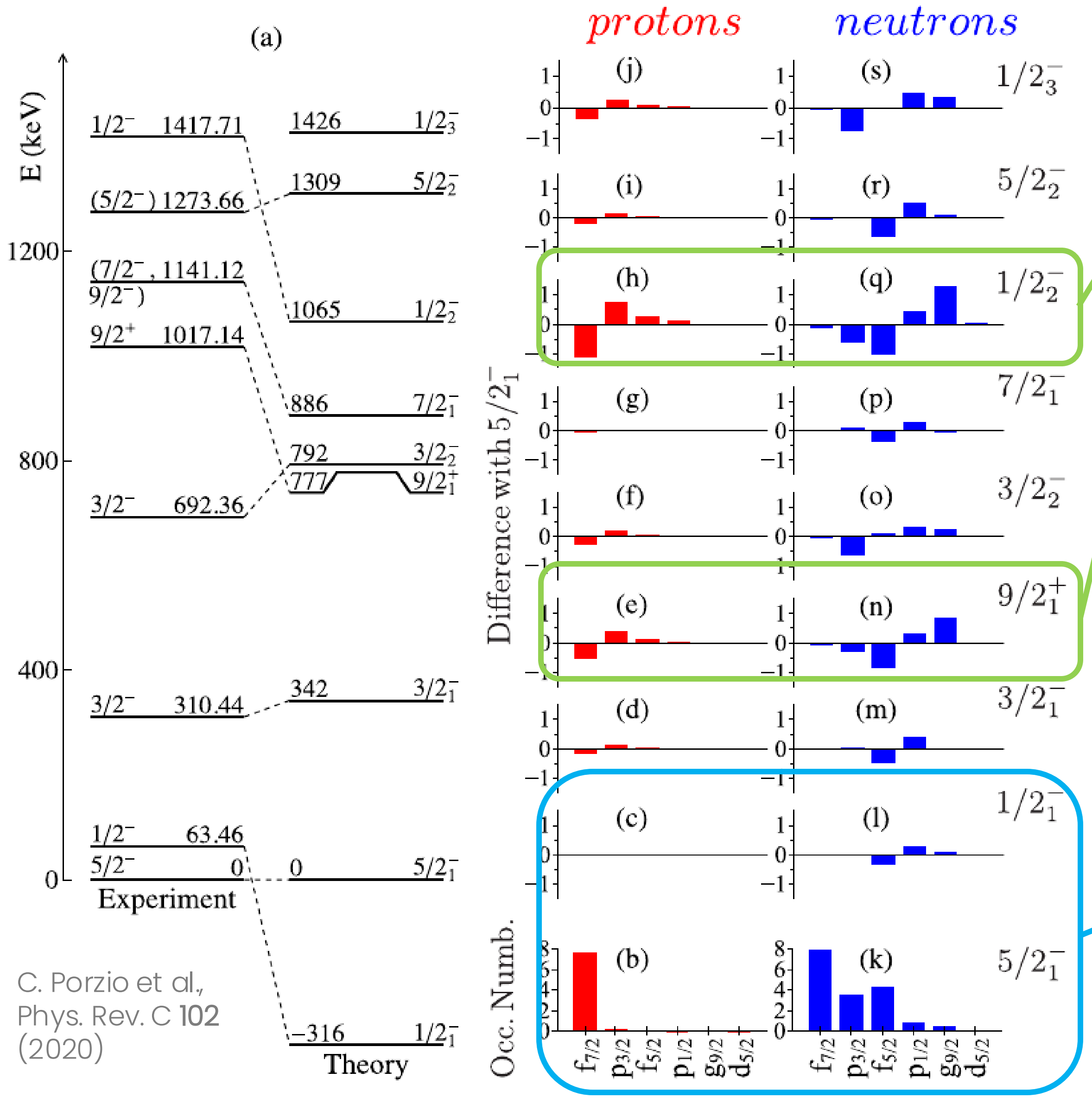


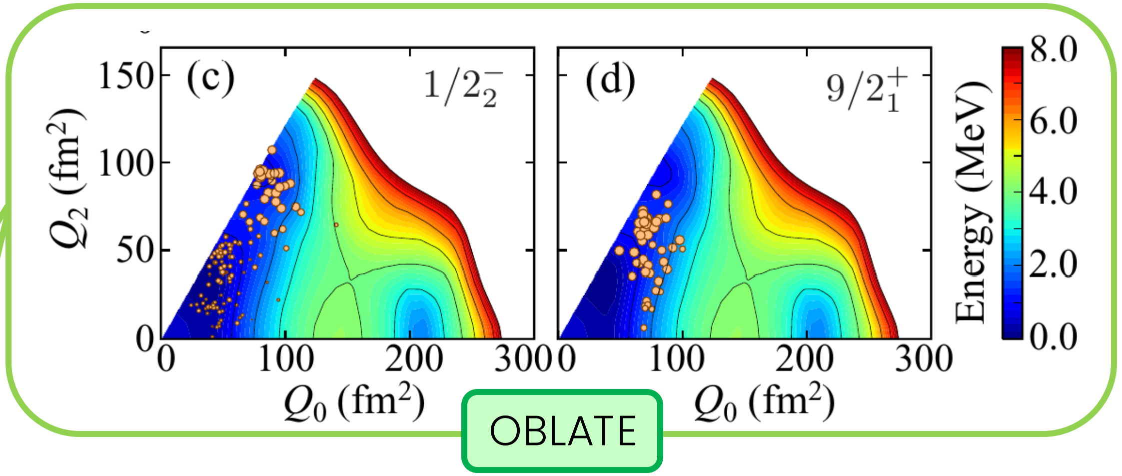
C. Porzio et al., Phys. Rev. C 102 (2020)

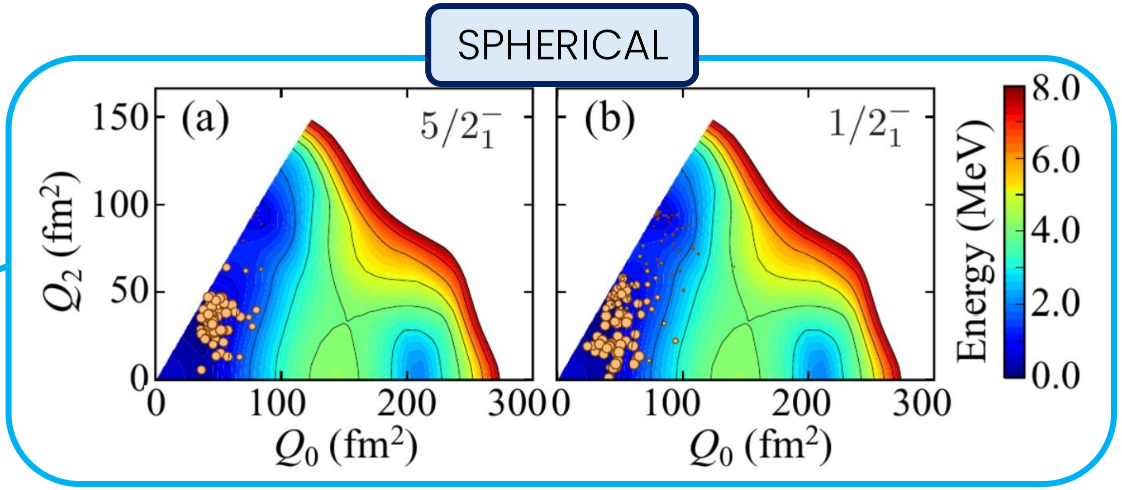
SPHERICAL



MCSM CALCULATIONS







C. Porzio et al., Phys. Rev. C 102 (2020)

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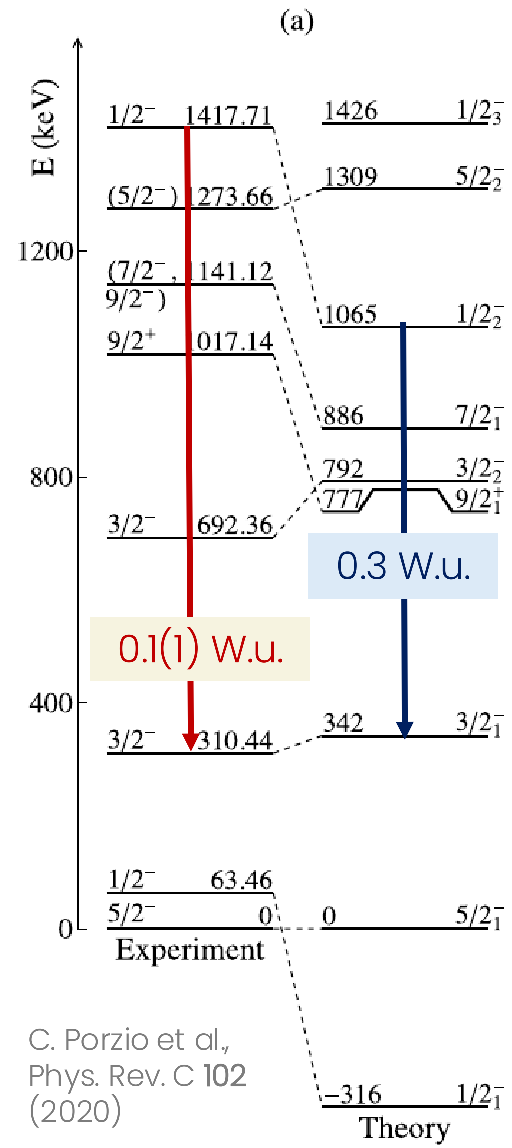
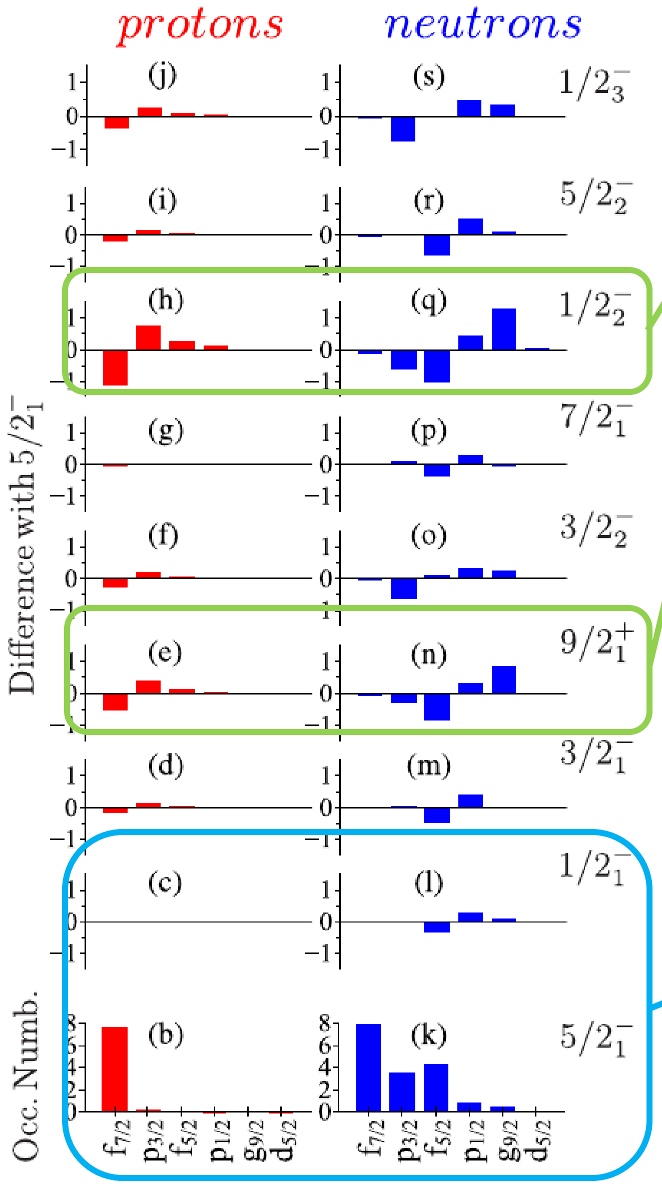
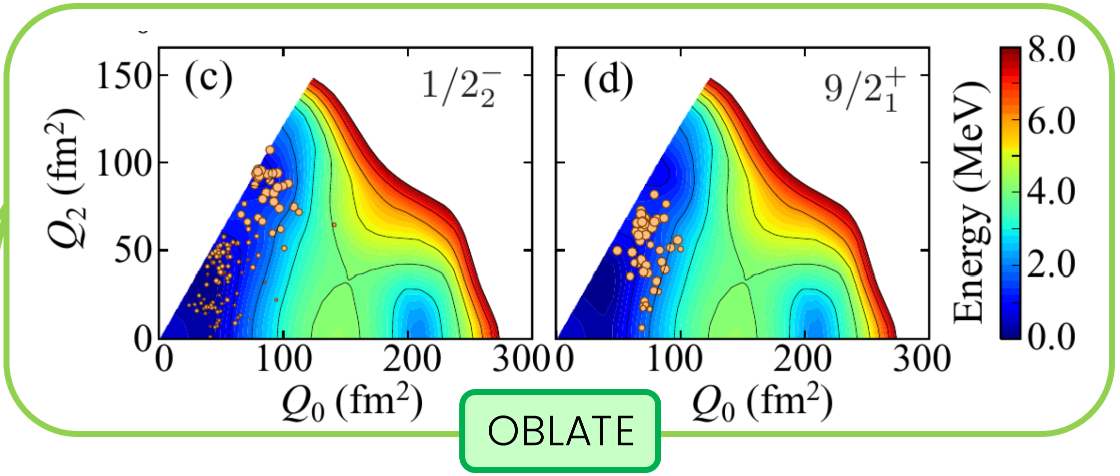
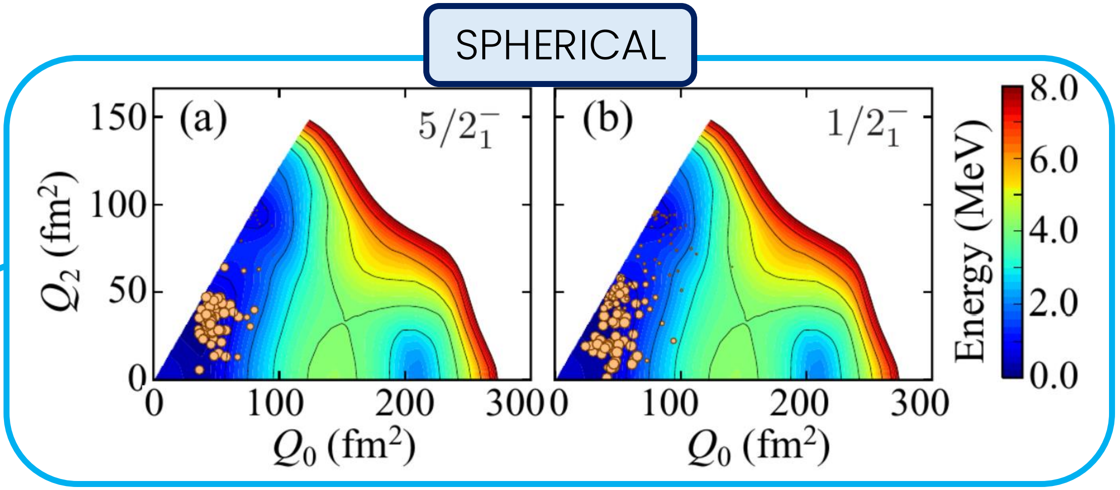


C. Porzio et al., Phys. Rev. C 102 (2020)





B(E2; 1/2$_2^-$→3/2$_1^-$)$_{exp}$ = **0.1(1) W.u.**
B(E2; 1/2$_2^-$→3/2$_1^-$)$_{th}$ = **0.3 W.u.**



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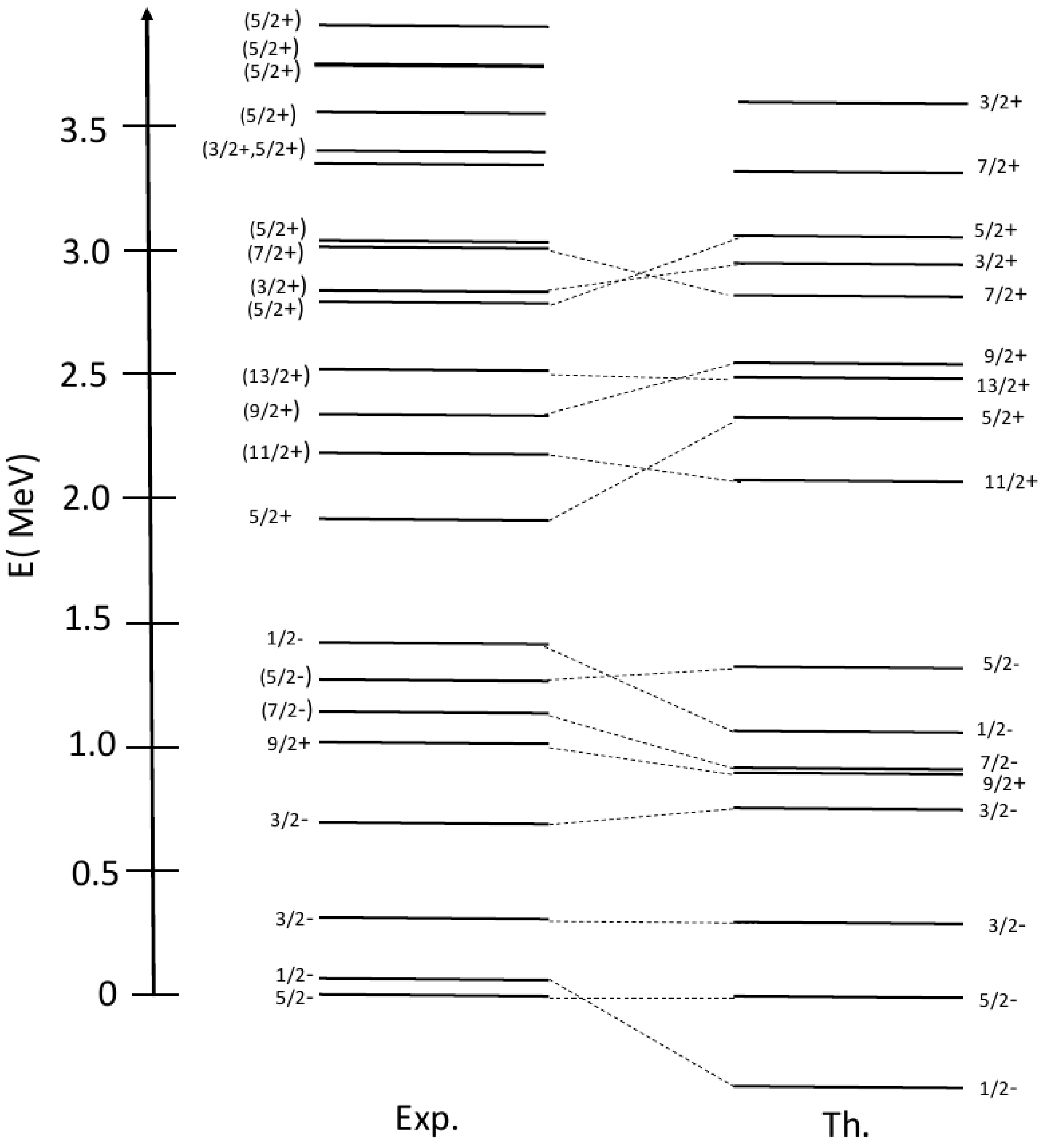
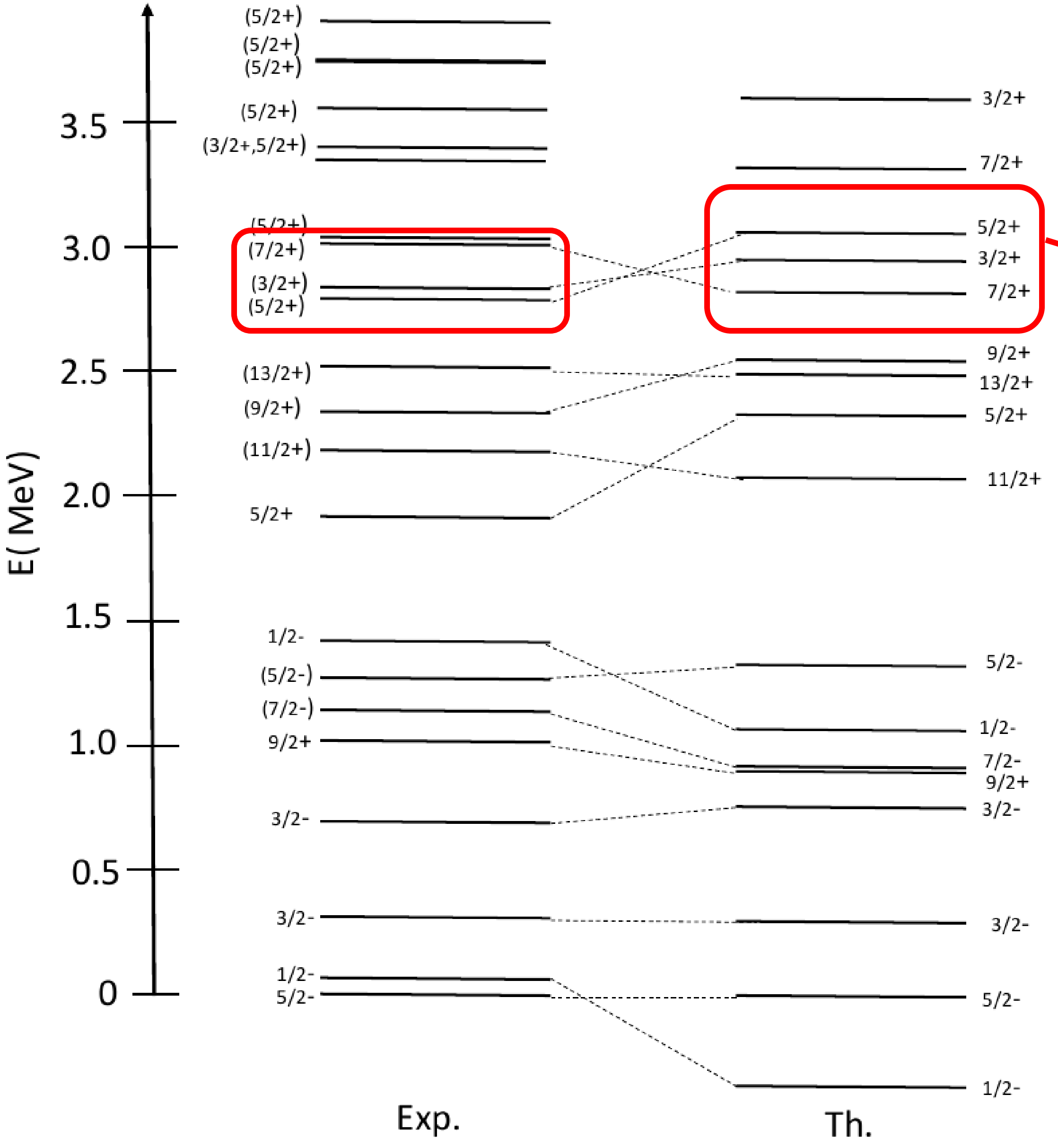
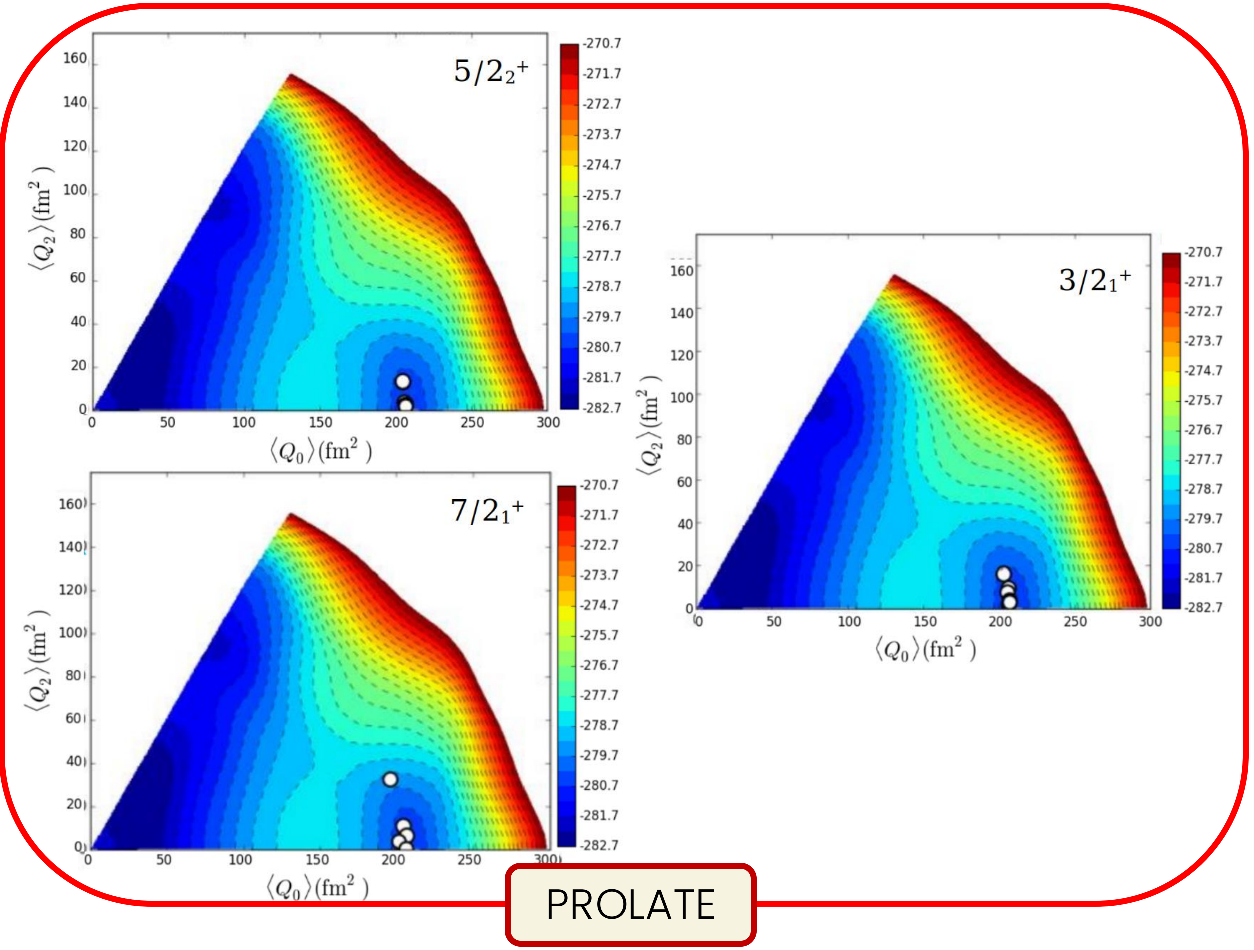


T. Otsuka, private communication

MCSM CALCULATIONS





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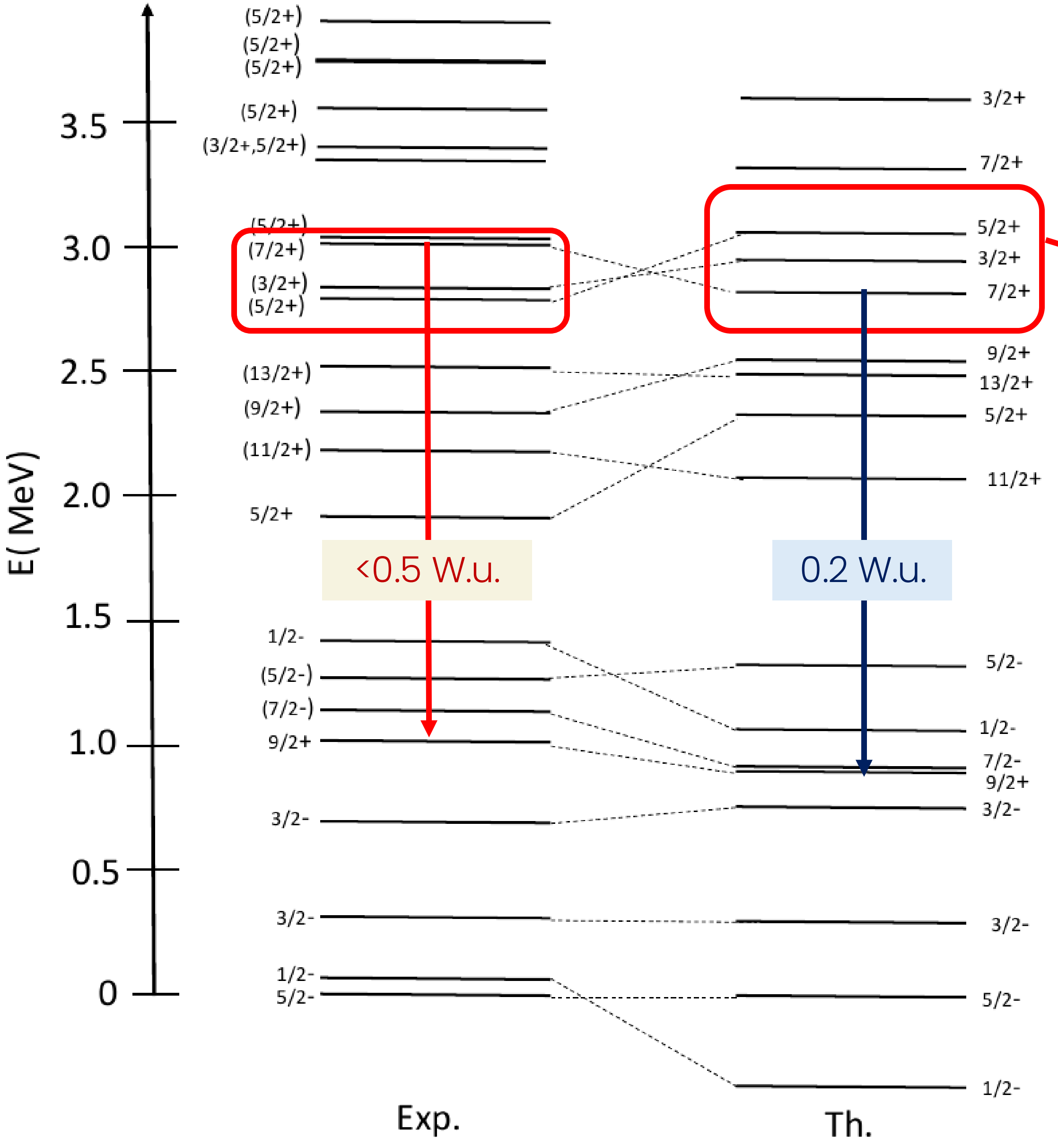
MCSM CALCULATIONS



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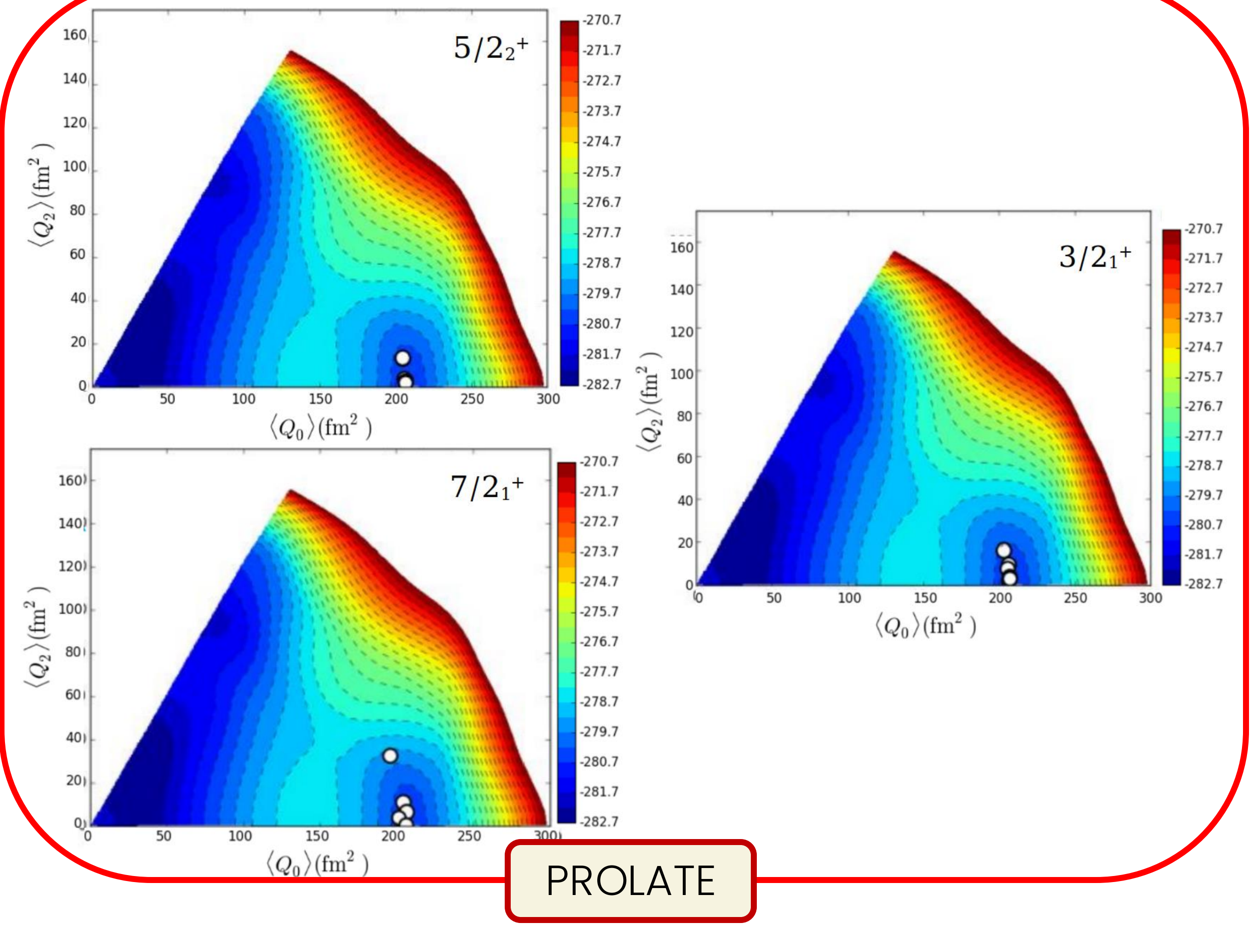

For the $7/2_1^+$ level at 3015 keV:

Assuming $T_{1/2}$**>2 ps**, pure E2 character:
$B(E2; 7/2_1^+ \rightarrow 9/2_1^+)_{exp}$ < **0.5 W.u.**
$B(E2; 7/2_1^+ \rightarrow 9/2_1^+)_{th}$ = **0.2 W.u.**

SUMMARY

- Nuclei at **Z=28** and **N=50** were populated by sub-barrier transfer reactions at IFIN-HH with ROSPHERE

- The 0_2^+ and 0_3^+ excited states were populated in ^{84}**Se** and ^{88}**Sr**, and their lifetimes were measured
- The small $B(E2; 0_2^+ \rightarrow 2_1^+)$ and $B(E2; 0_3^+ \rightarrow 2_1^+)$ strengths in ^{84}Se and ^{88}Sr, respectively, indicate **hindered transitions**, suggesting **shape-isomer-like** configurations
- Theoretical calculations for ^{88}Sr will be soon available

- A detailed investigation of the structure of ^{65}**Ni** was carried out:
  - The level scheme was expanded
  - Spin-parity assignments were determined from **γ-ray angular distributions**
  - Lifetimes were measured using the **DSAM** technique
- Comparison with MCSM calculations is currently ongoing

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Thank you!