Exploring shape coexistence across N=60 in $^{100}Sr_{62}$ using IDS

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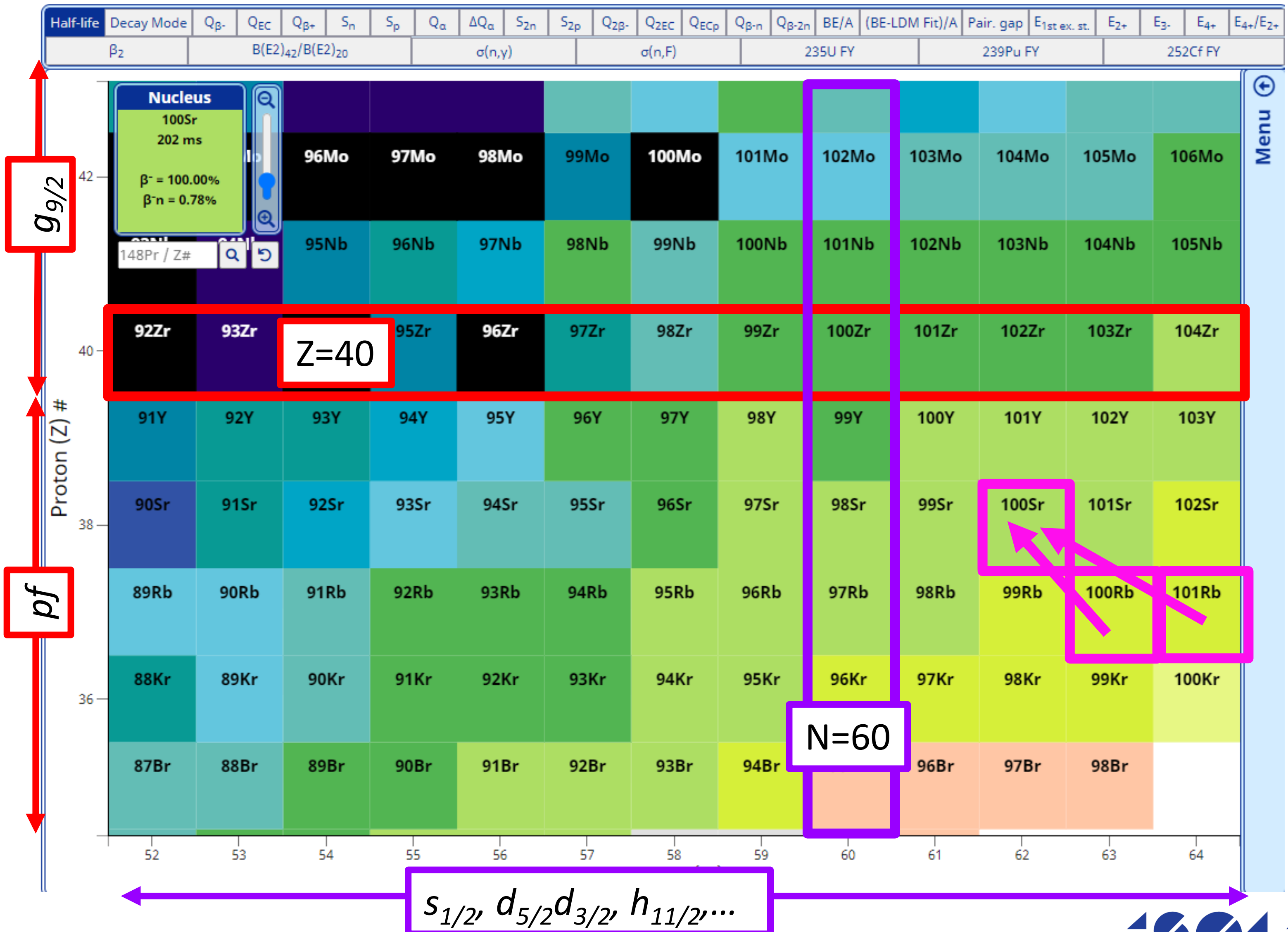
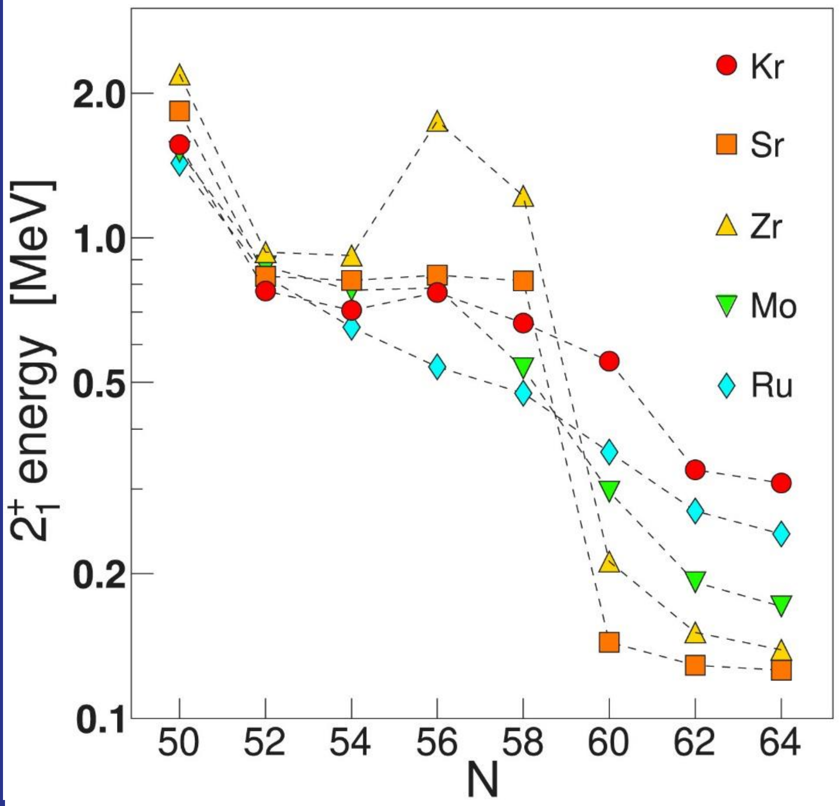
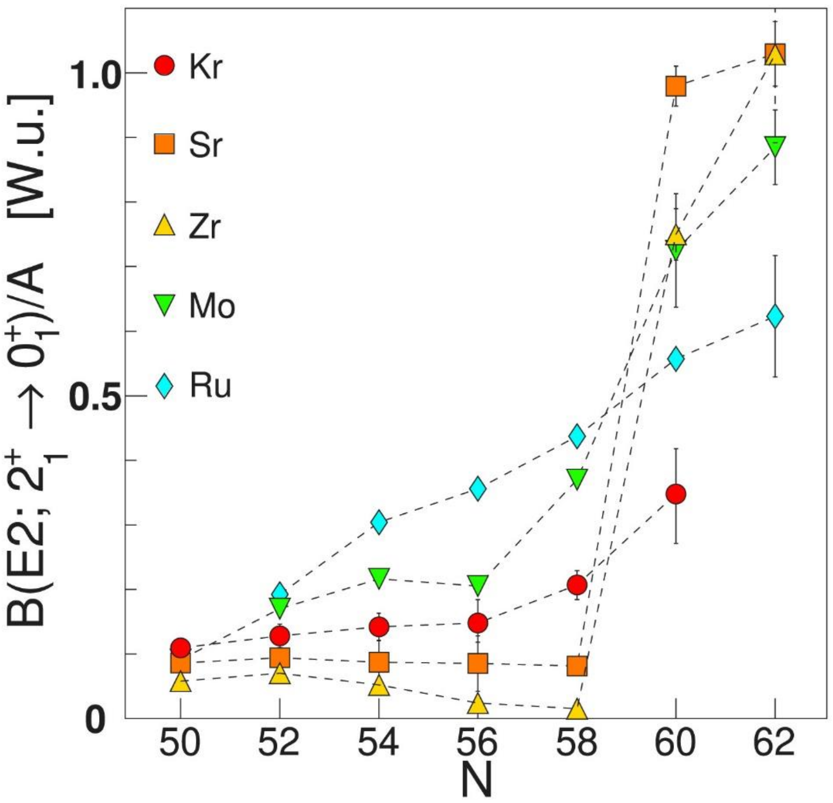
Region of interest



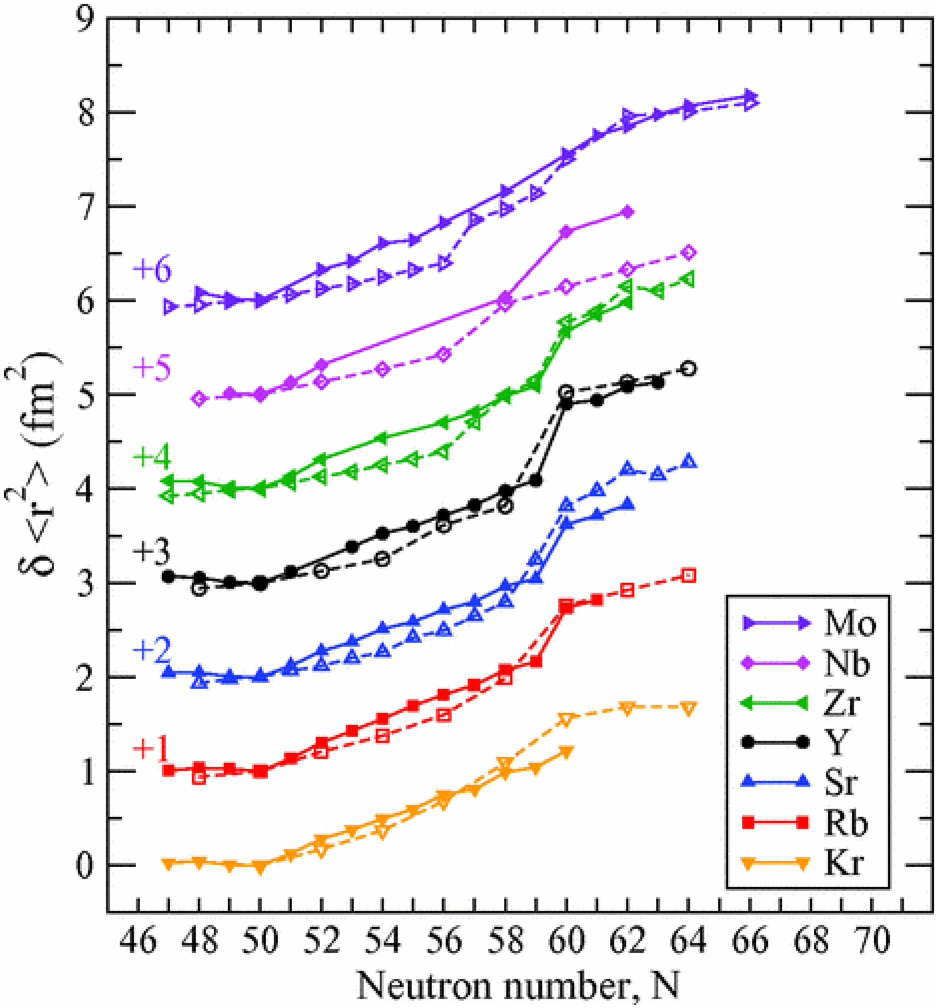
2^+ state systematics





P. E. Garrett, M. Zieli´nska, and E. Cl´ement, Prog. Part. Nuc. Phys. 163, 103931 (2021)

Isotope shift

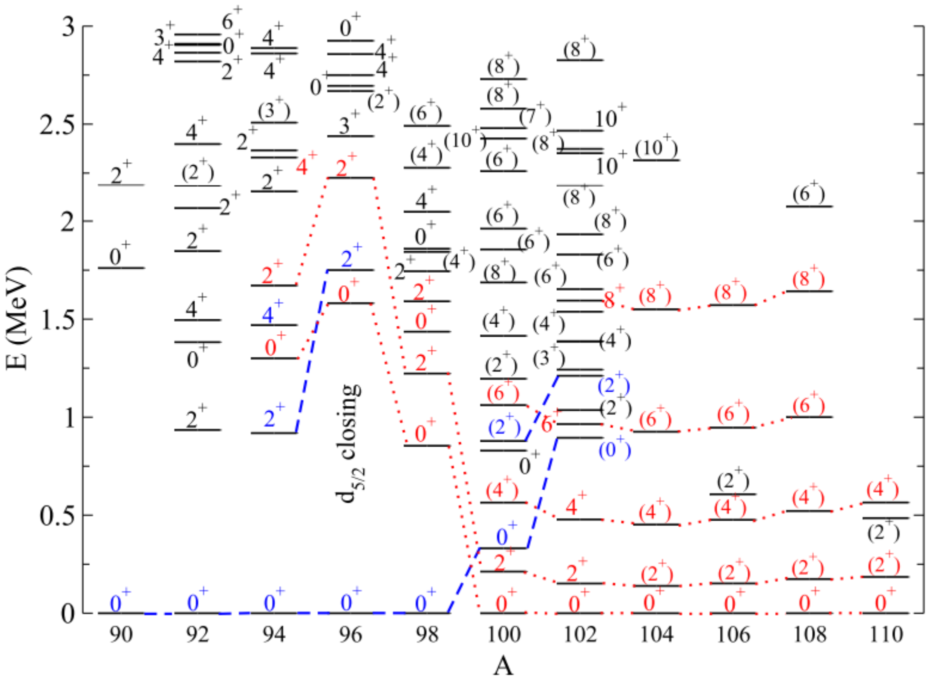


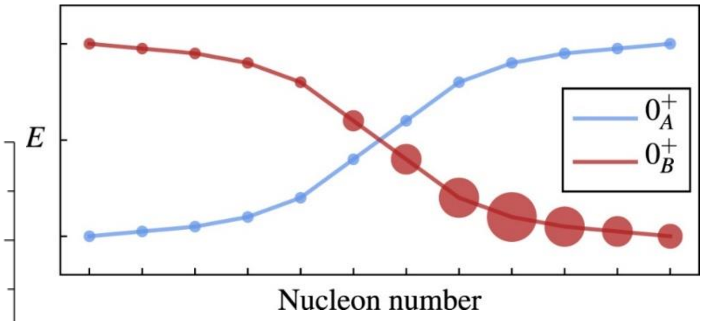
R. Rodriguez-Guzman, P. Sarriguren, and L. M. Robledo. Shape evolution in yttrium and niobium neutron-rich isotopes. Phys. Rev. C, 83:044307, Apr 2011.

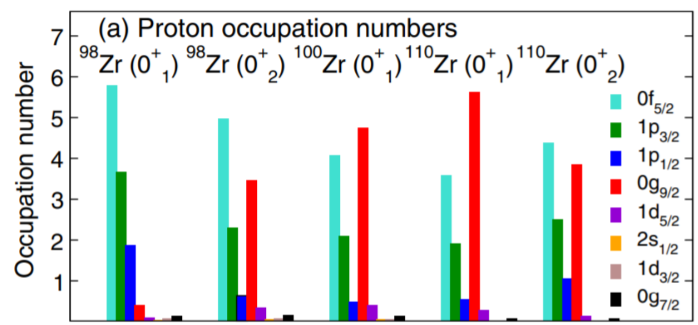
- Large change in charge radii when crossing N=60
- Large for Zr
- Larger for Sr
- Largest for Y
- Comparison to Gogny-D1S-HFB calculations
- Clear indication of shape transition

Quantum phase transition

Zr isotopes







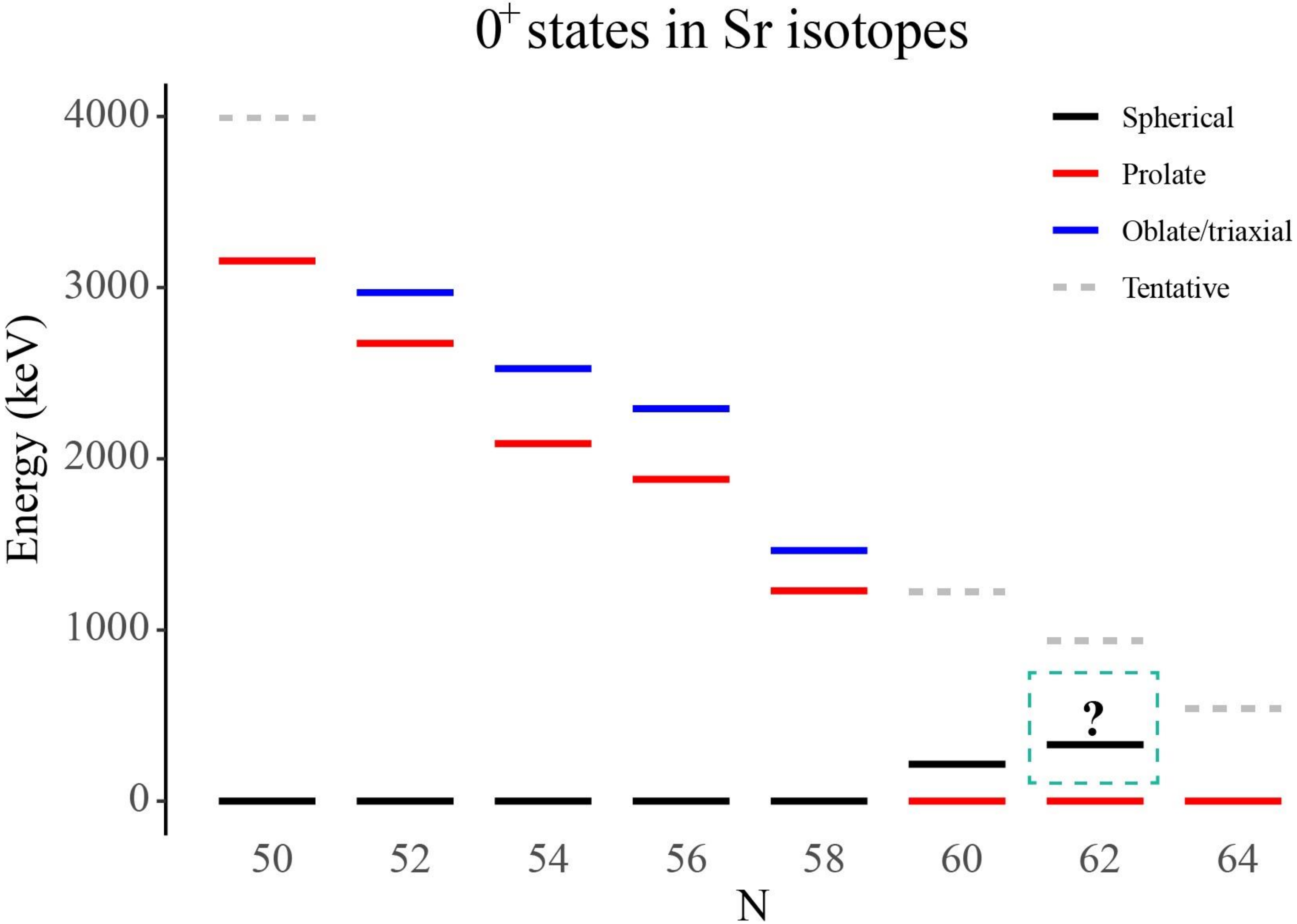
Pavel Cejnar, Jan Jolie, and Richard F. Casten Rev. Mod. Phys. 82, 2155 (2010)

N Gavrielov et al 2020 Phys. Scr. 95 024001

J. E. García-Ramos and K. Heyde Phys. Rev. C 102, 054333

Togashi et al Phys. Rev. Lett. 117, 172502 (2016)

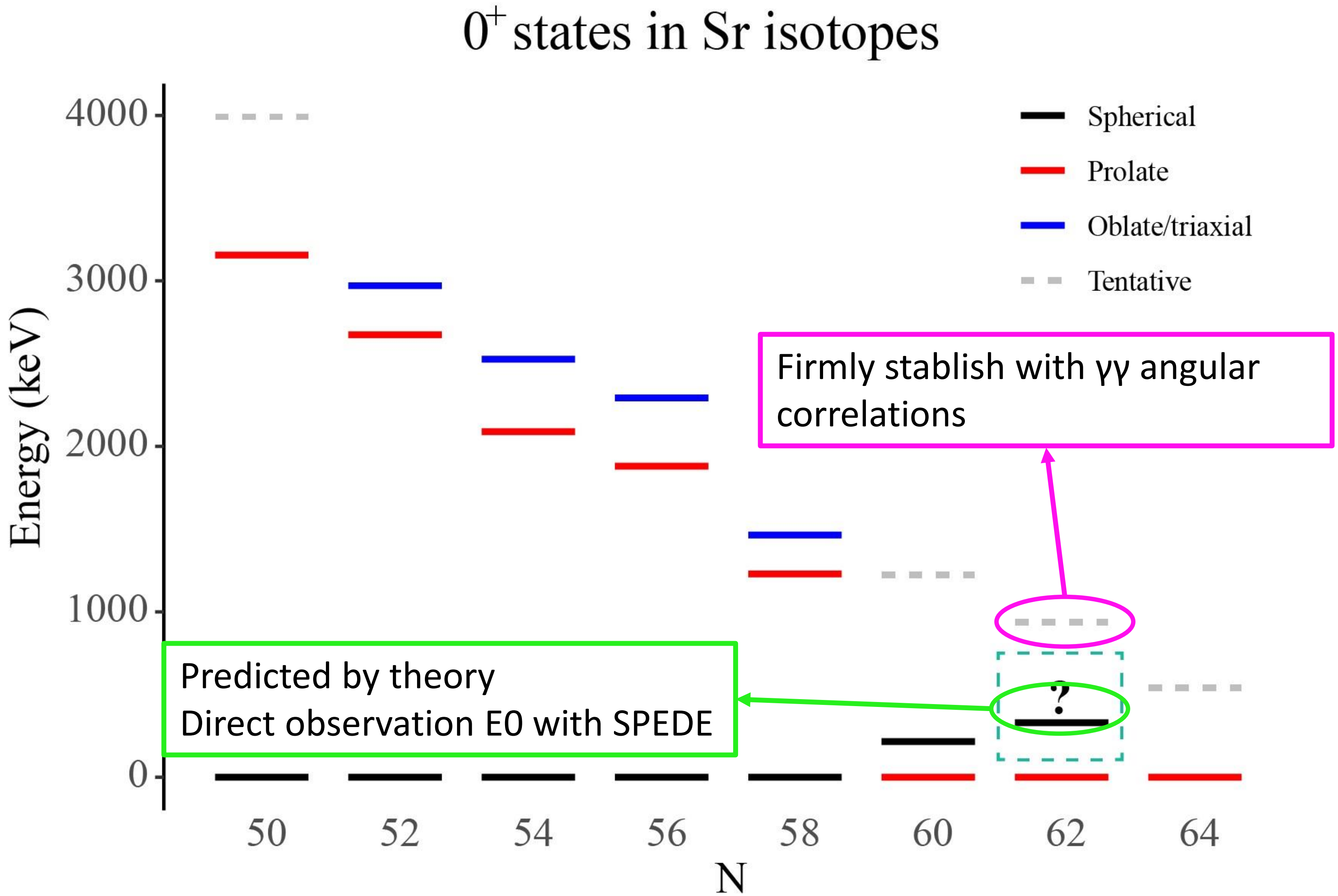
Sr 0^+ systematics



NNDC

H. Mei et al.Phys. Rev. C, 85:034321, 2012

Goal of the experiment

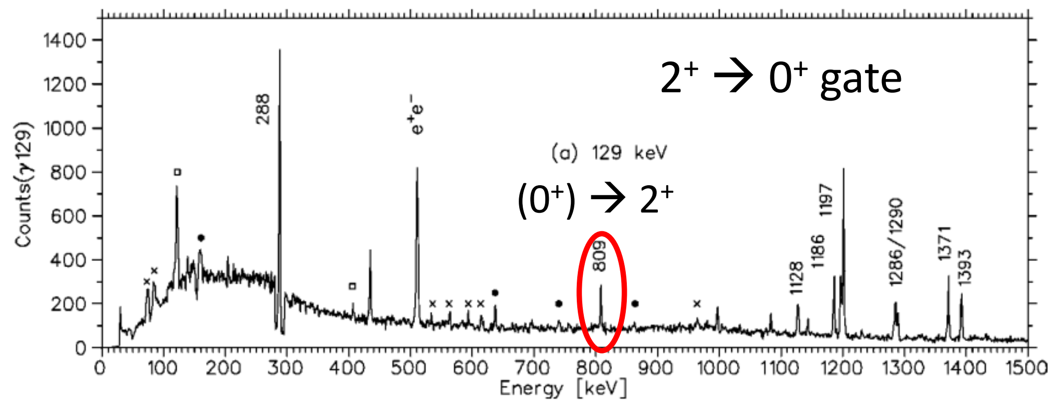


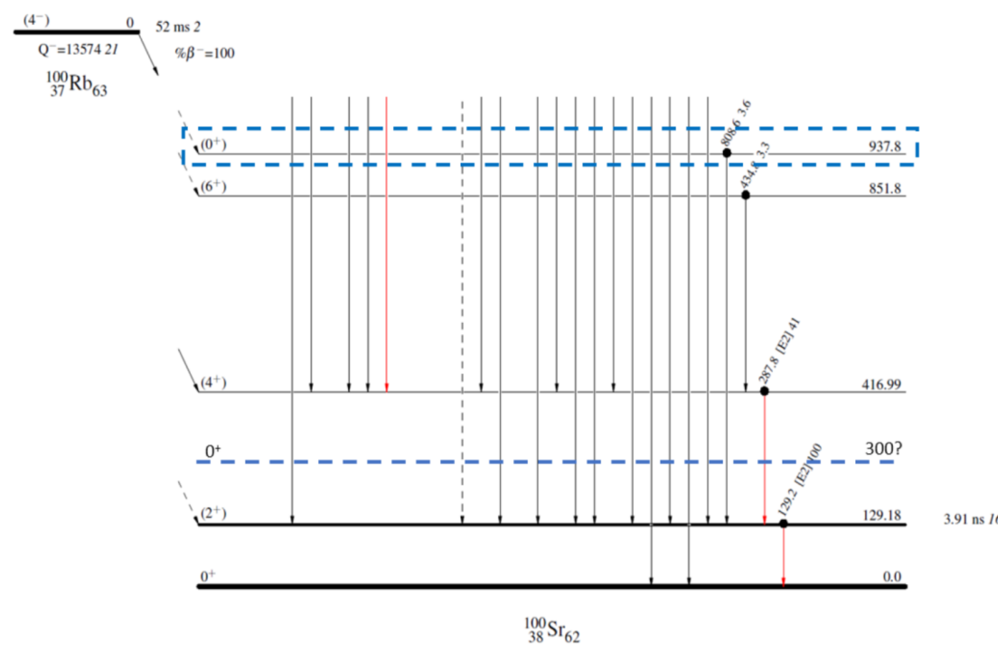
NNDC

H. Mei et al.Phys. Rev. C, 85:034321, 2012

Previous work

- Performed at ISOLDE
- Medium statistics β decay experiment
- **Only two Ge detectors**
- Tentative 0^+ state only based on systematics
- **All J^π above g.s. are tentative!!!**
- ENDSF evaluators noted: *"The decay scheme is not normalized as it is considered incomplete in several ways"*
- ^{101}Rb decay experiments only reported P_n

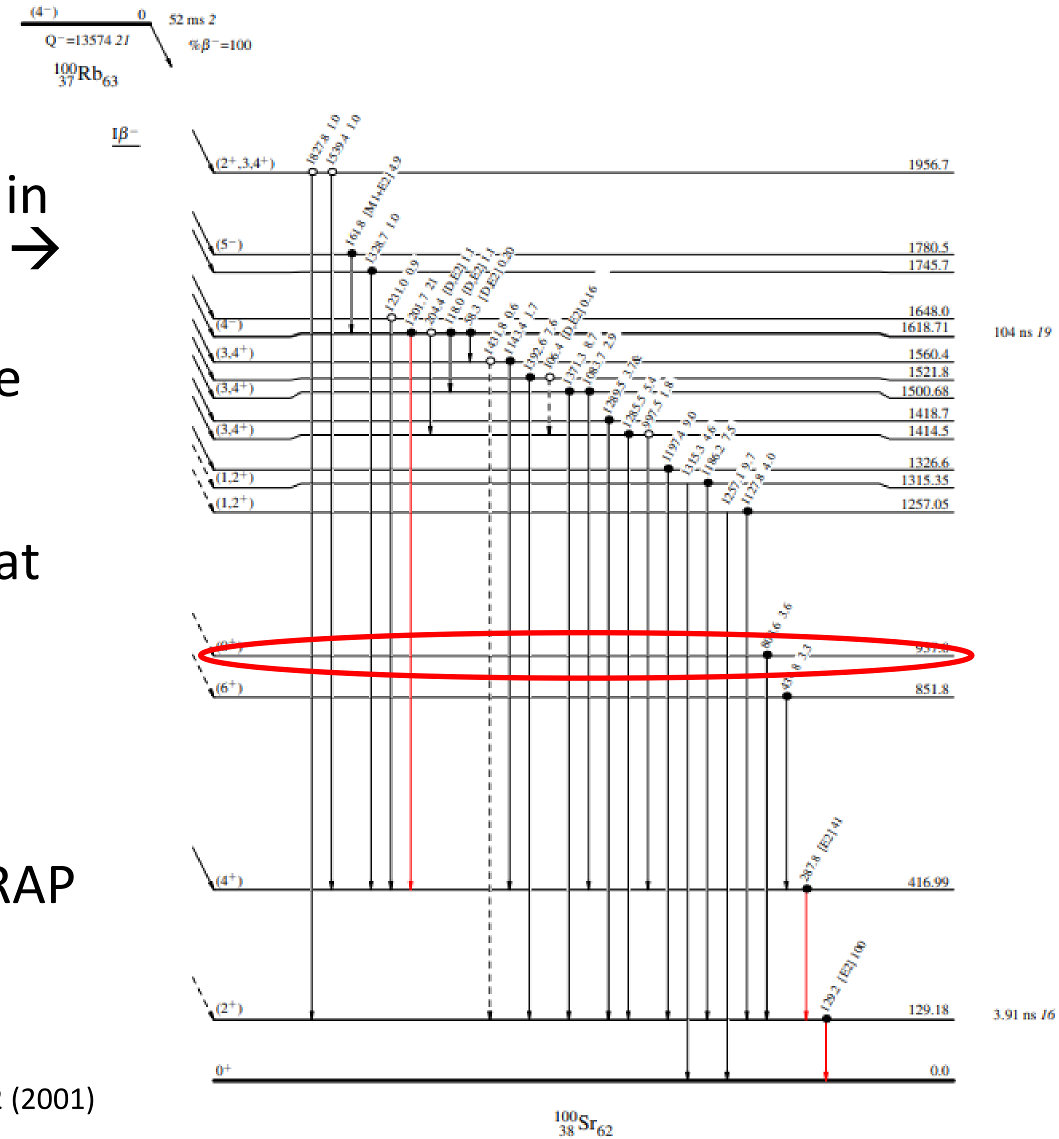




G. Lhersonneau, et al. Phys. Rev. C 63, 054302 (2001)

Partial level scheme

- ^{100}Rb g.s. is (4$^-$)
- Intensity concentrates in the (4$^-$) → (4$^+$) → (2$^+$) → 0$^+$ cascade
- Several J<3 states have significant direct β population
- I_β=2.1(3)% for the (0$^+$) at 938 keV
- Unphysical scenario
- (1$^-$) β-decaying isomer hypothesized in ^{100}Rb
- No observed by ISOLTRAP or TITAN



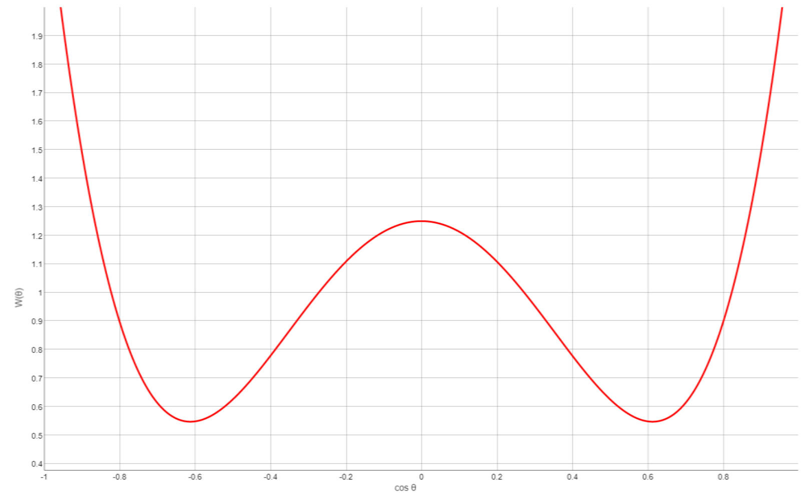
G. Lhersonneau, et al. Phys. Rev. C 63, 054302 (2001)

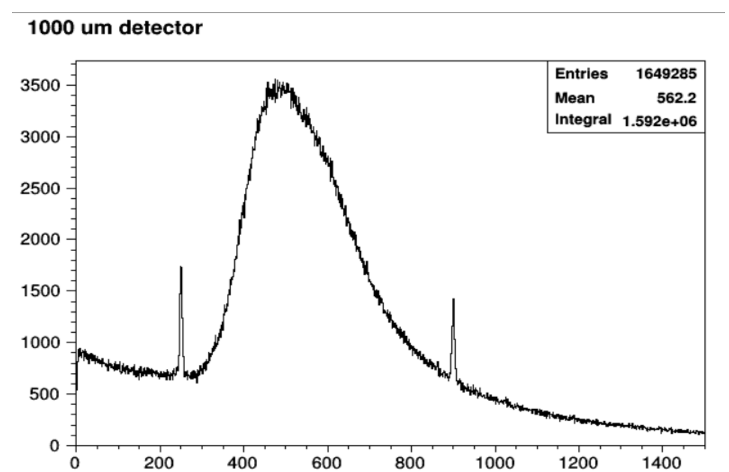
NNDC

This experiment

Two independent approaches:

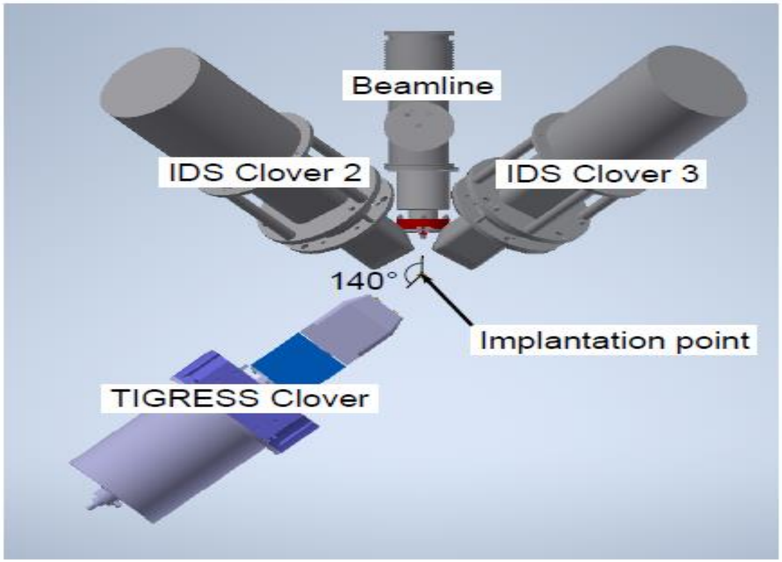
- ^{100}Rb beam: Angular correlations
  - Firmly establish the (0^+_3) state at 938 keV
- ^{101}Rb beam: Conversion electrons
  - Locate predicted ~300-keV (0^+_2) with SPEDE via E0

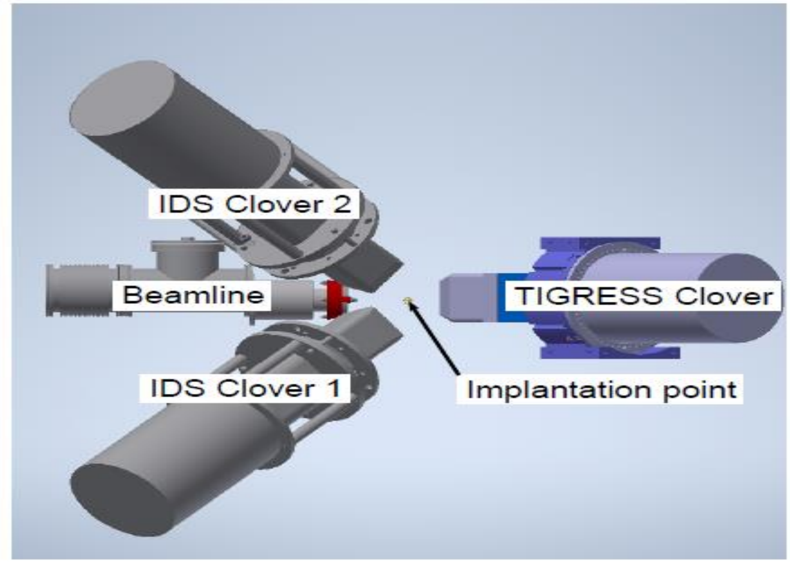




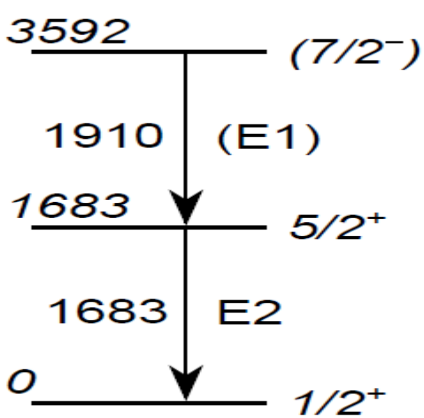
ISOLDE

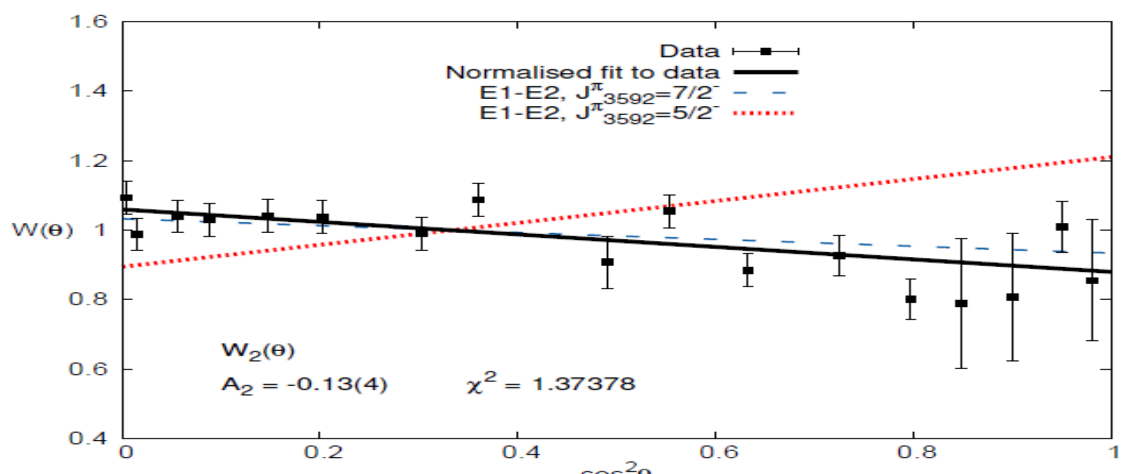
Angular correlations with IDS





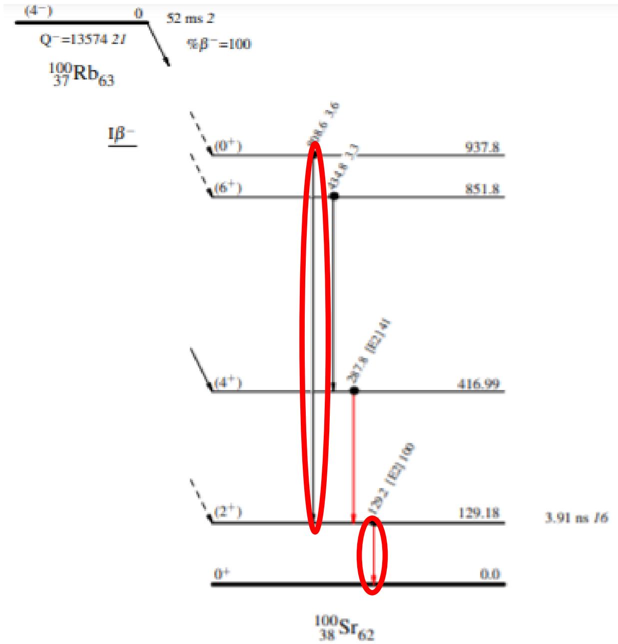
1910 − 1683 keV correlation

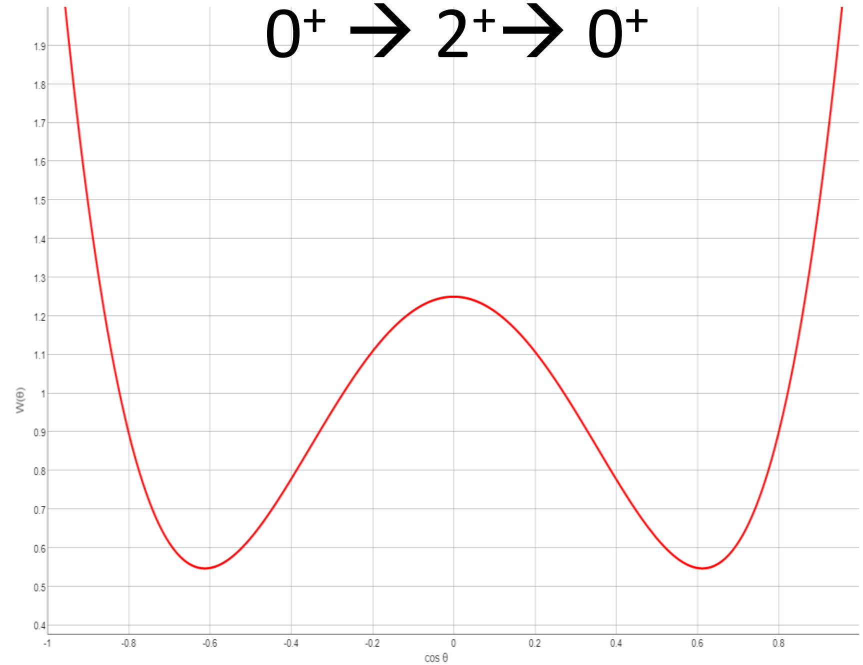




T. Berry PhD thesis UoSurrey (2019)

$0^+ \rightarrow 2^+ \rightarrow 0^+$



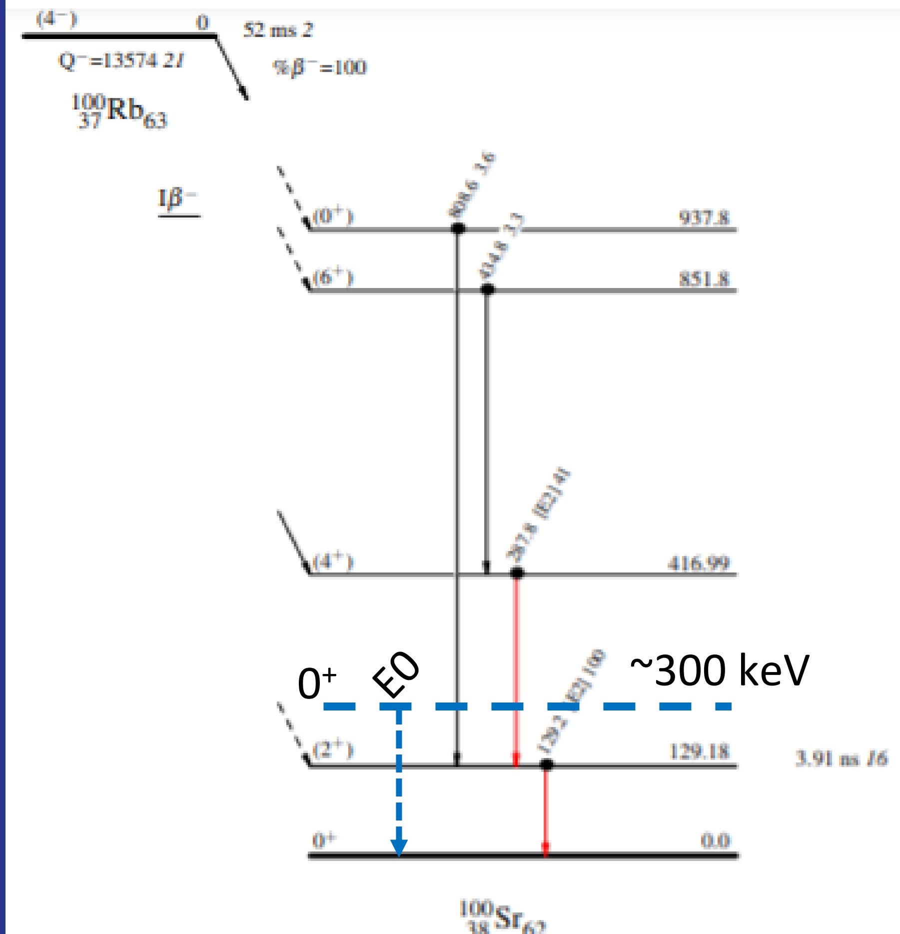


- $(0^+) \rightarrow (2^+) \rightarrow 0^+$ cascade
- 160 crystal pairs
- 100 counts per pair
- 16k in 6 shifts

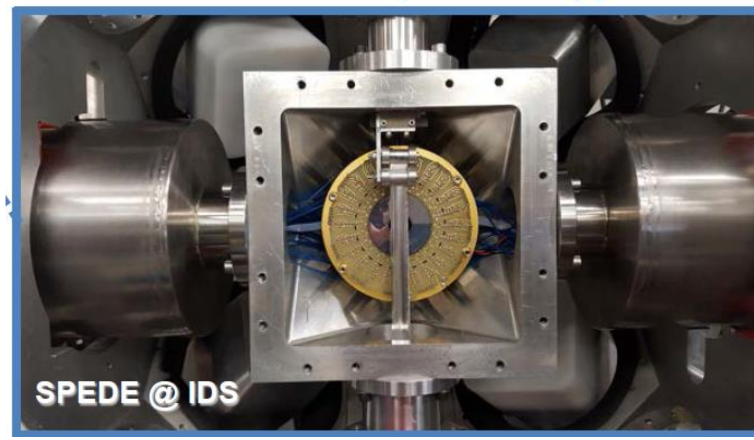
TABLE I. Number of crystal-crystal pairs per 5° angular bin for the asymmetric five-clover detector configuration at IDS, used here for angular correlation measurements. Angles are symmetric around 90°, so, e.g., 0°–5° also includes 175°–180°.

Angle	0°–5°	5°–10°	10°–15°	15°–20°	20°–25°	25°–30°
Pairs	0	1	2	1	1	3
	30°–35°	35°–40°	40°–45°	45°–50°	50°–55°	55°–60°
	3	7	10	2	14	12
	60°–65°	65°–70°	70°–75°	75°–80°	80°–85°	85°–90°
	15	8	19	24	18	20

Conversion electrons

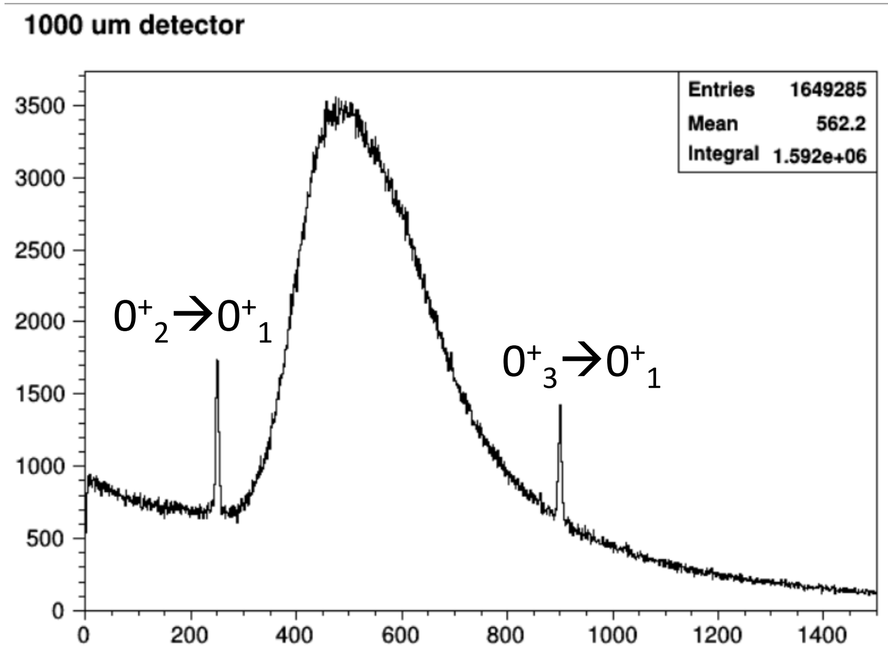


Conversion Electron Spectroscopy

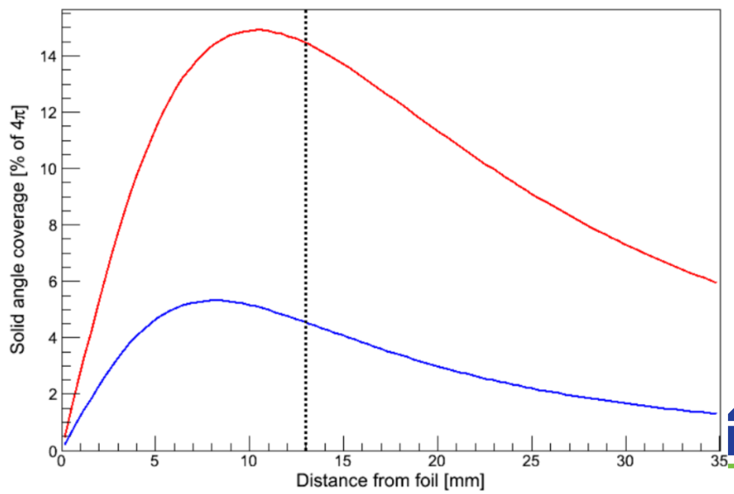


0^+_2 direct observation

- Low-lying 0^+_2 states populated in βn for $^{96,98}Sr$
- We assume similar branching ratios for ^{100}Sr
- 200 counts in 5 shifts
- Simulations performed by J. Cubiss - UoYork
- 1% branching ratios
- NO β-tagging
- Imposing β coincidences greatly reduces β background



Solid angle coverage of SPEDE



Secondary goals

- Expand ^{100}Sr level scheme
- Perform angular correlations in many more states
- Clarify the presence (or not) of the (1^-) state in ^{100}Rb
  - Detailed level scheme
  - Different mother nucleus lifetimes
- Measure state lifetimes via fast timing:
  - 5σ discrepancy for $\tau(2^+)$
  - First measurement of $\tau(4^+)$

List of collaborators

- B. Olaizola1, S. S. Bhattacharjee2, R. Kanungo3, A. Algora4, A. Andreyev5, Y. Ayyad6,M.J. Borge7, J.A. Briz8, F. Browne1, R. Caballero-Folch3, C. Costache9, J. Cubiss5,S. J. Freeman1, L.P. Gaffney10, A. Illana11, P. Jones12U. Koester13, R. Licˇa1,9,N. Marginean9, C. Mihai9, R. E. Mihai9, C. Page5, J. Pakarinen11, S. Pascu9,V. Petousis2, Z. Podolyak14, M. Stryjczyk11, A. Turturica9, M. Veselsky2, N. Warr15,K. Wimmer16, Z. Yue5

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Rb yields at ISOLTRAP

A	Sr [1/s]	Rb [1/s]
95	1.18E+06	6.22E+05
100	1.59E+03	8.93E+02
101	3.65E+02	4.00E+01
102	1.42E+02	3.00E+00