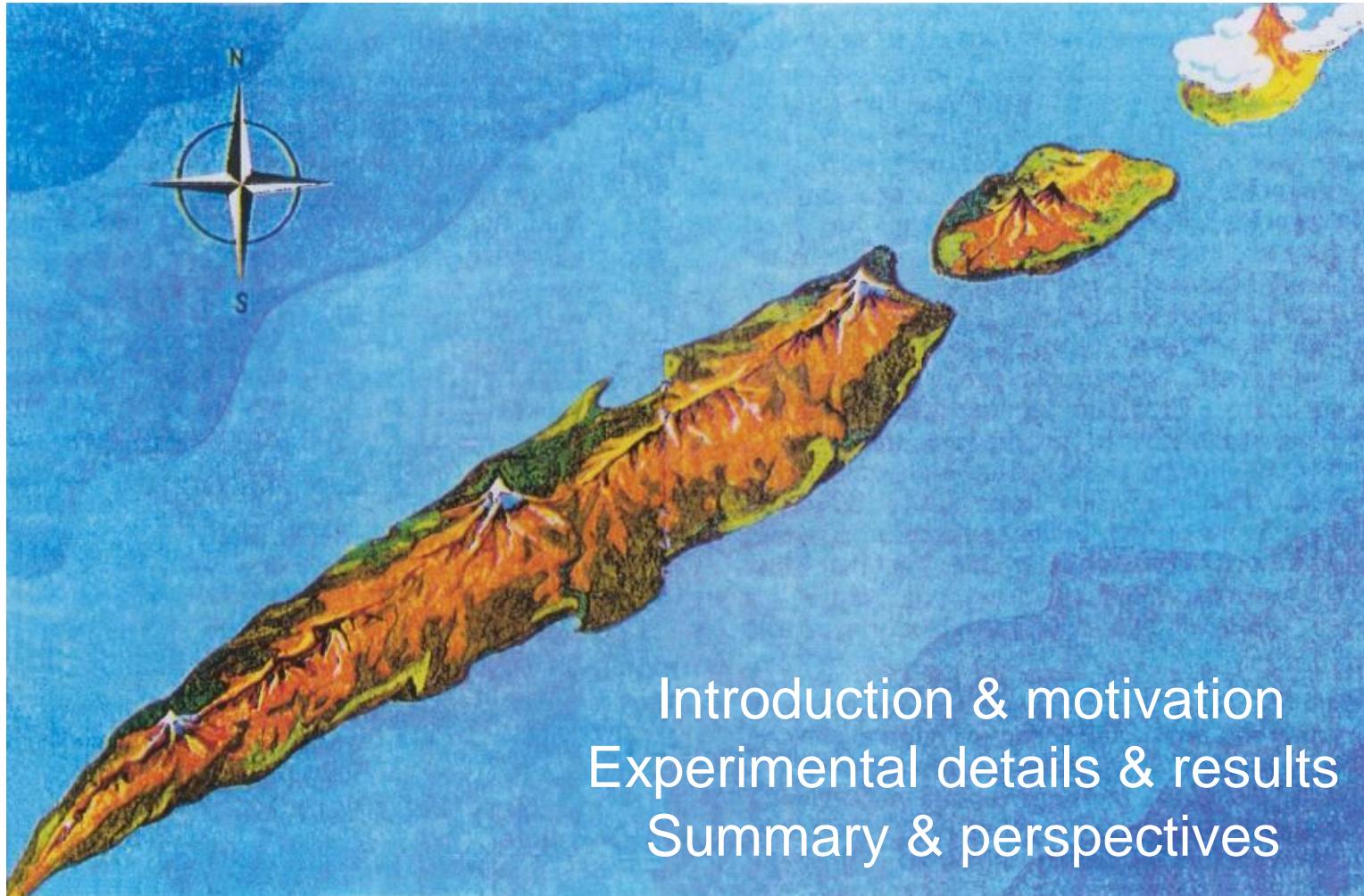




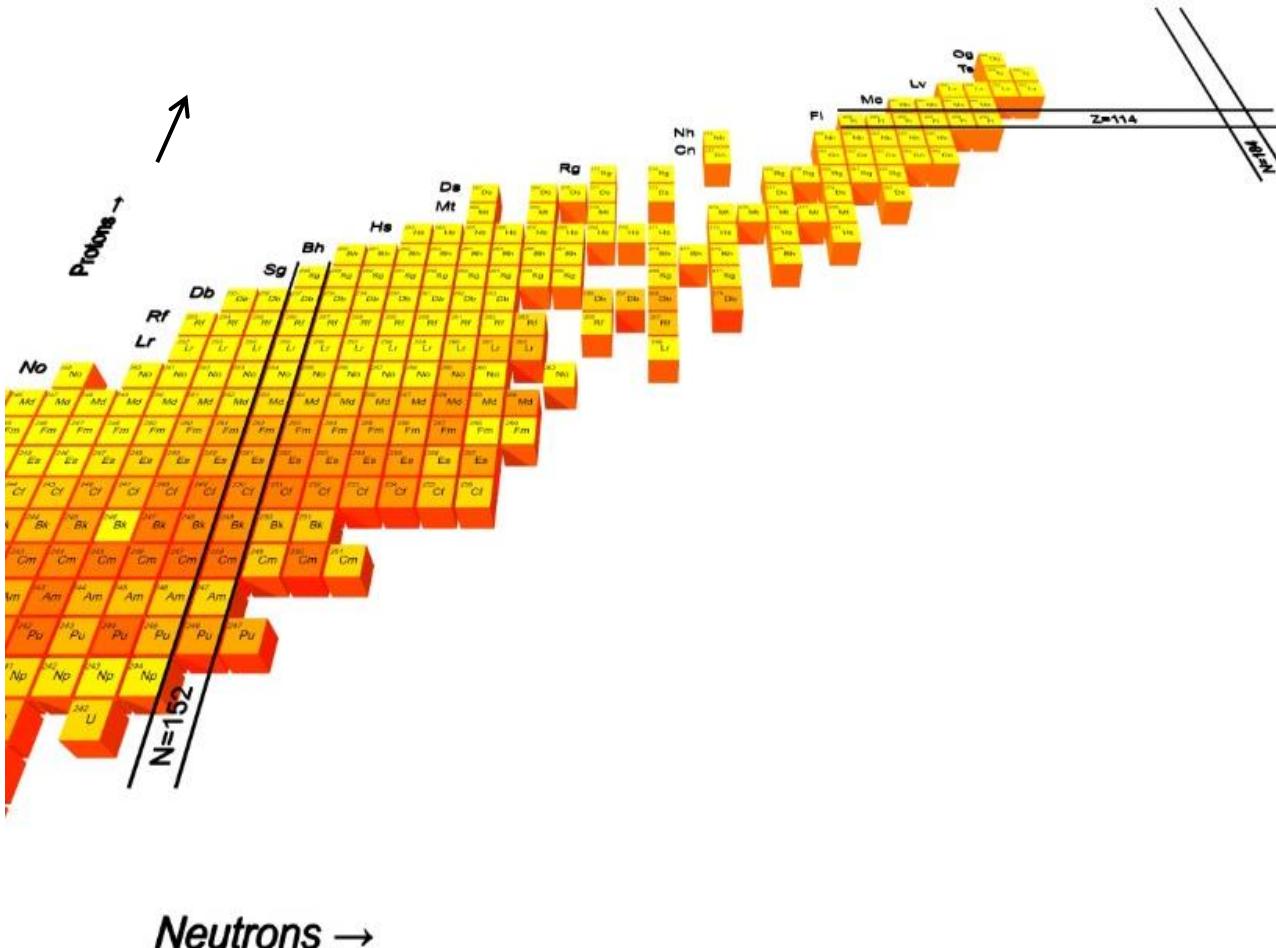
Fission Hindrances in transfermium nuclei



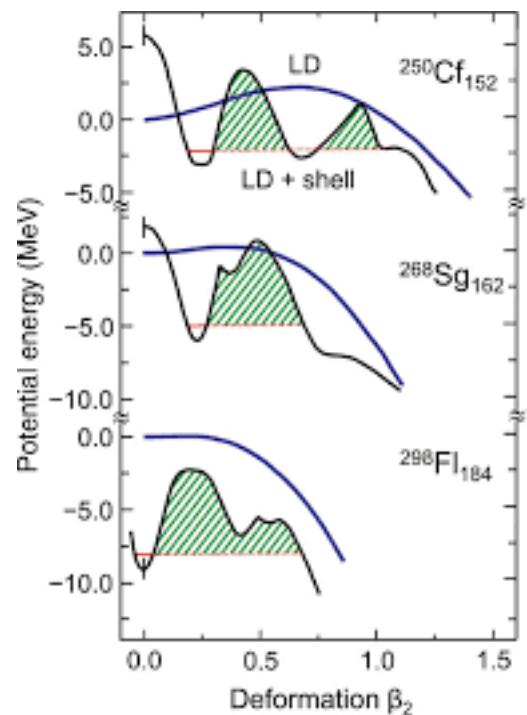
Introduction & motivation
Experimental details & results
Summary & perspectives



Super Heavy Nuclei

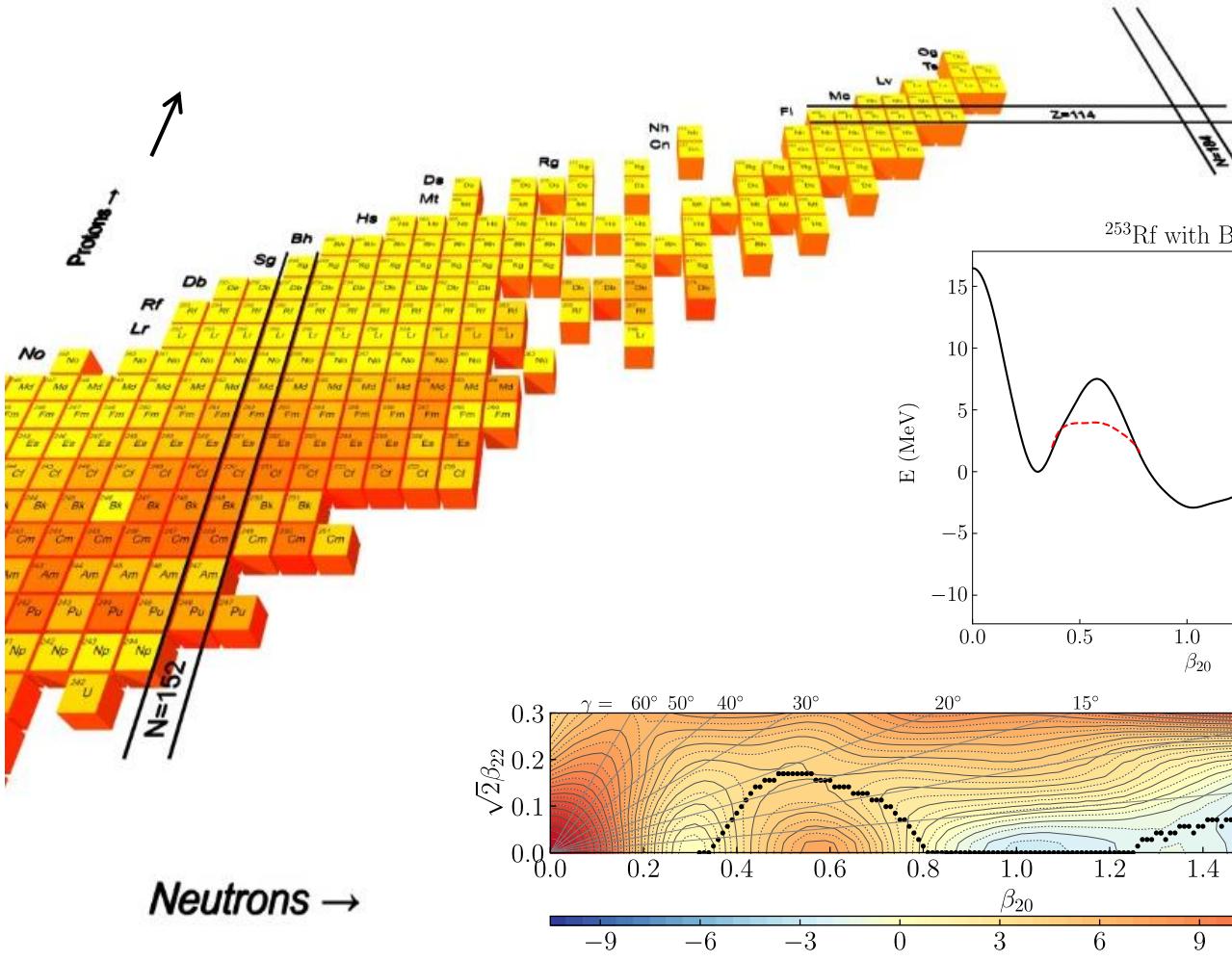


S. Hofmann, Radiochimica Acta 107 (2019) 879



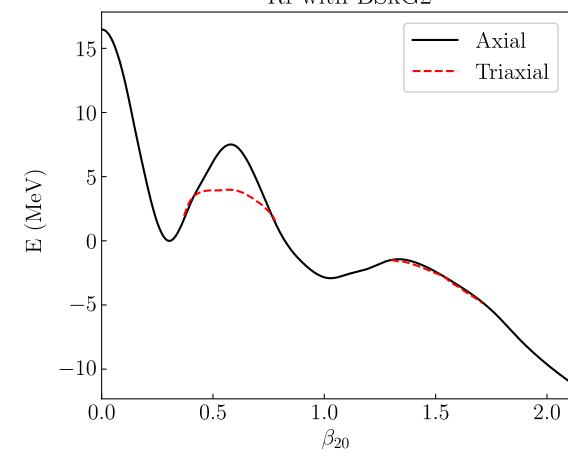


Super Heavy Nuclei

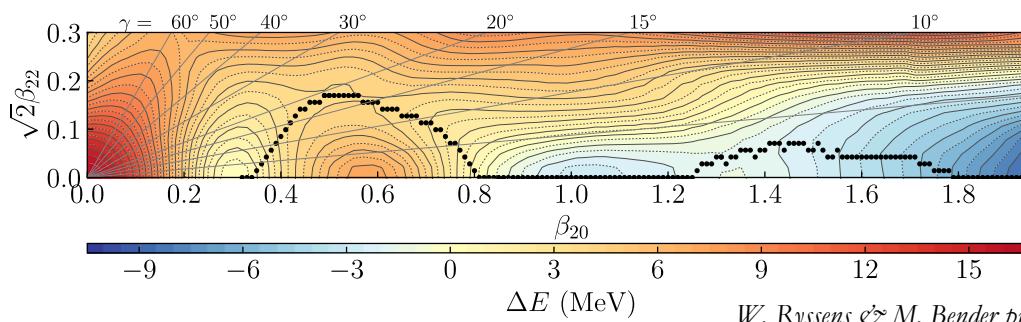


$Z=114$

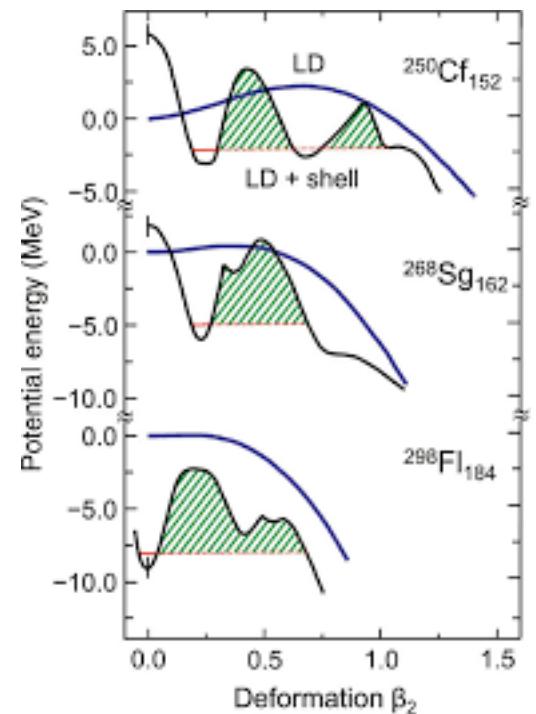
^{253}Rf with BSkG2



$\sqrt{2}\beta_{22}$



S. Hofmann, Radiochimica Acta 107 (2019) 879



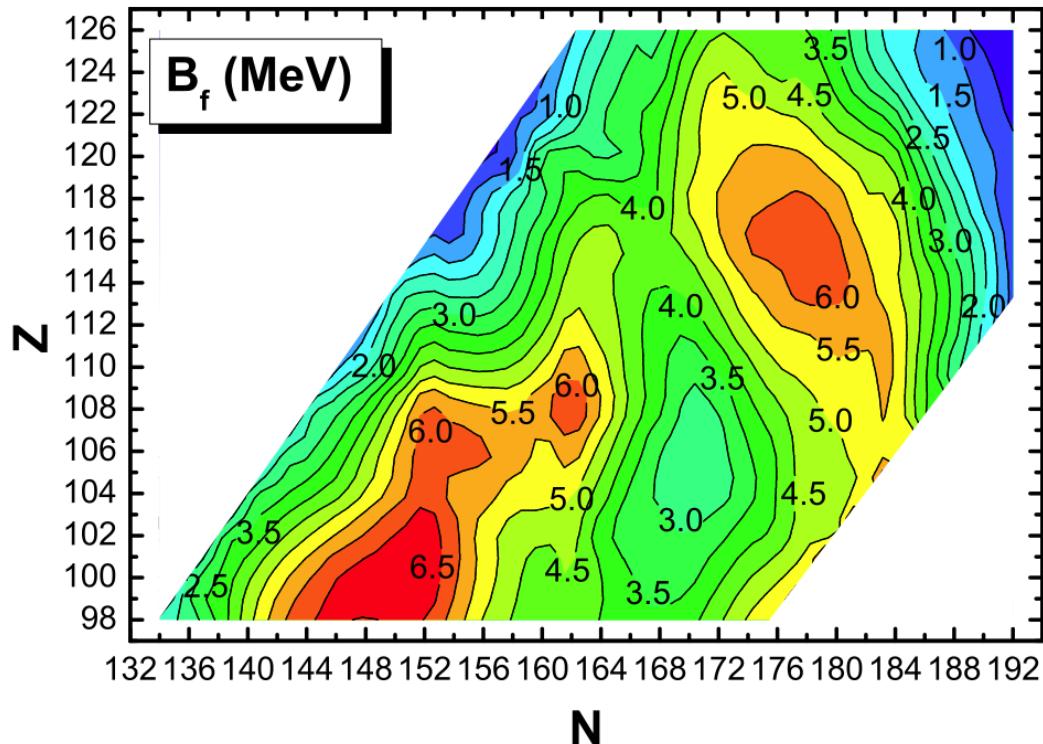
W. Ryssens & M. Bender private comm.



Systematics of Fission half-lives

Mic-Mac model calculations

A. Baran *et al.*, Nucl. Phys. A. 944 (2015) 442

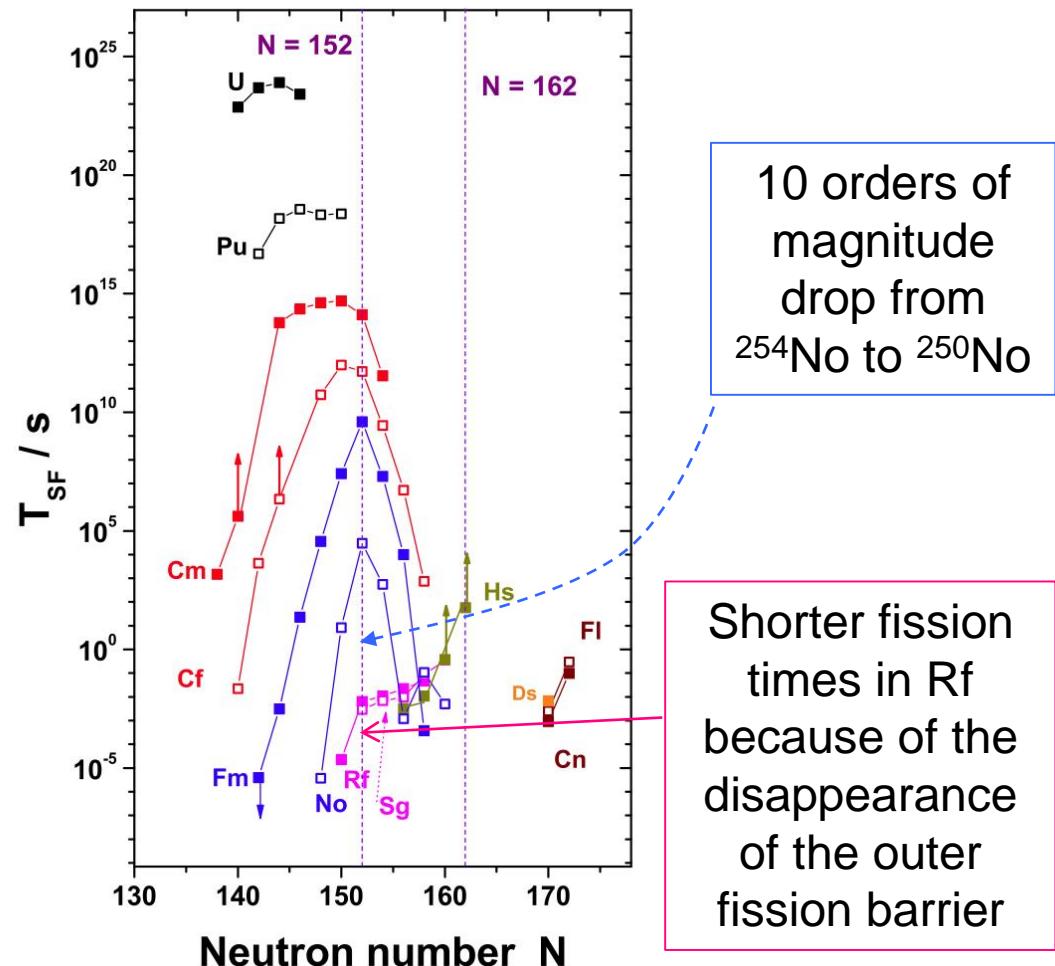
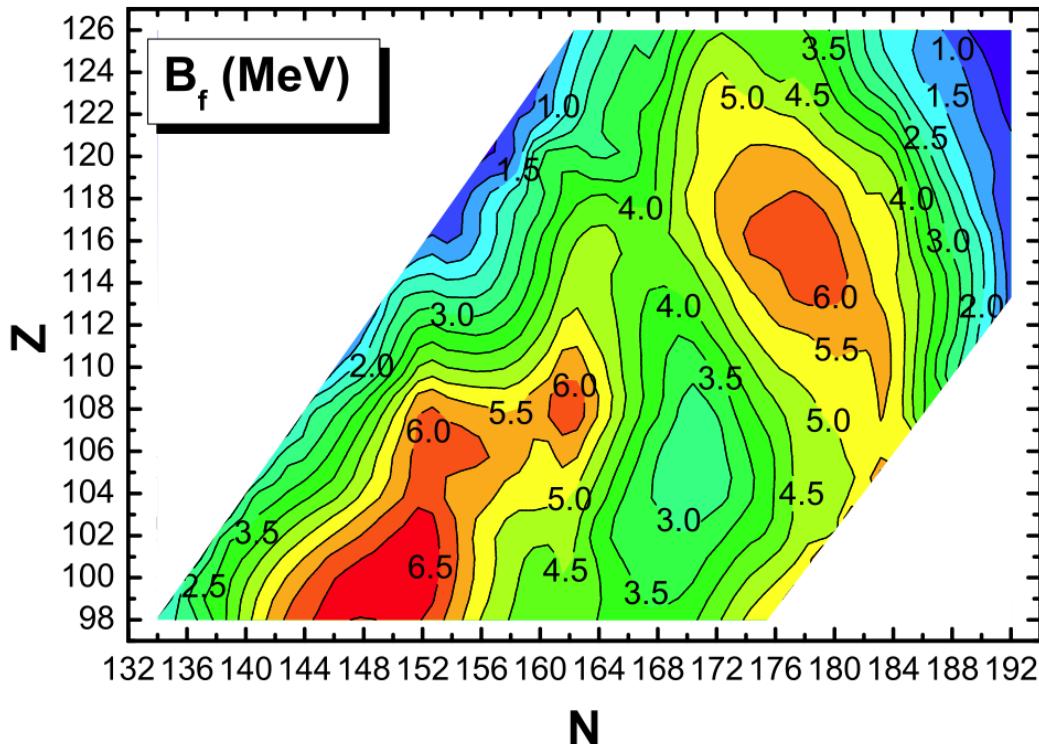




Systematics of Fission half-lives

Mic-Mac model calculations

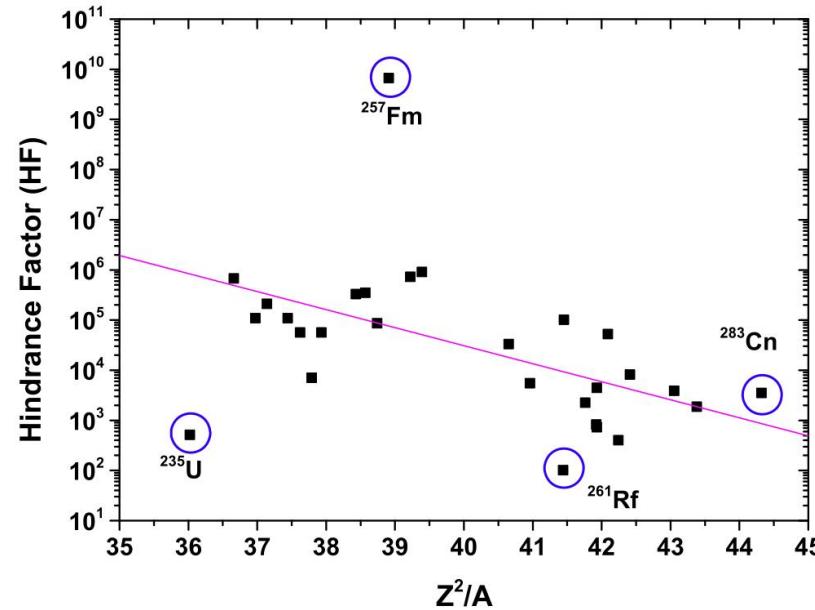
A. Baran *et al.*, Nucl. Phys. A. 944 (2015) 442



F.P. Hessberger, Eur. Phys. J. A (2017) 53: 75



Fission hindrance

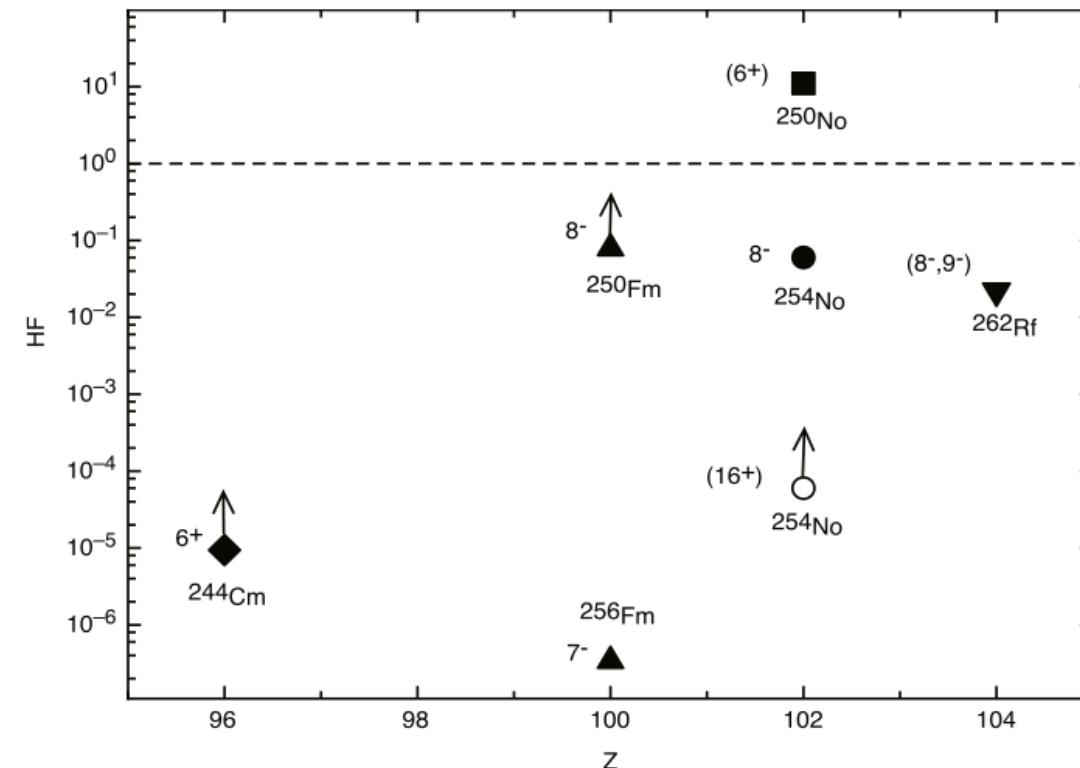


$$\text{HF}(Z,N) = T_{oe}(Z,N)/T_{ee}(Z,N)$$

$$T_{ee} = (T(Z,N+1) \times T(Z,N-1))^{1/2}$$

$$T_{ee} = (T(Z+1,N) \times T(Z-1,N))^{1/2}$$

F. Konder, G. Draouli and T. Kibedi, At. Dat. And Nucl. Dat. Tables 103-104 (2015) 50



$$\text{HF}(Z,N) = T_{iso}(Z,N)/T_{gs}(Z,N)$$

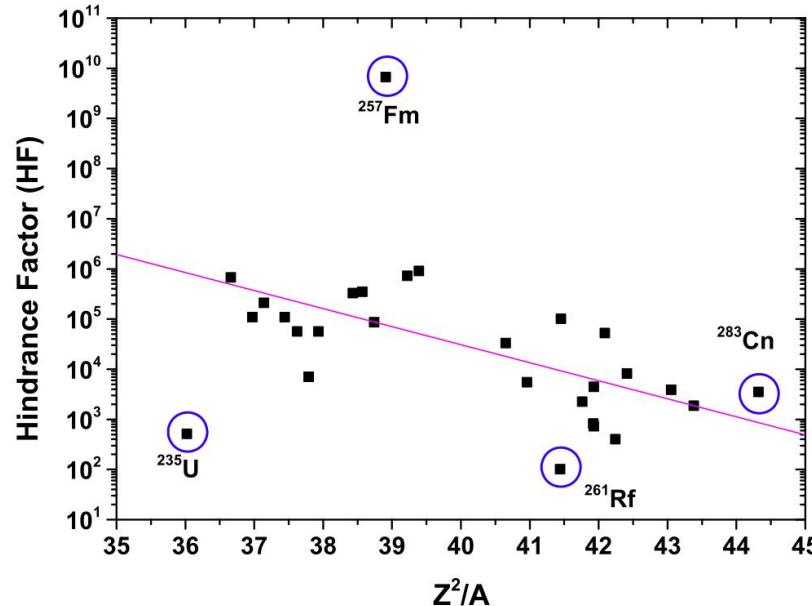


Fission hindrance

J. Khuyagbaatar et al., Phys. Rev. C106 (2022) 024309 : HF(^{250}No) > 286

H. David et al., Phys. Rev. Lett. 115 (2015) 132502

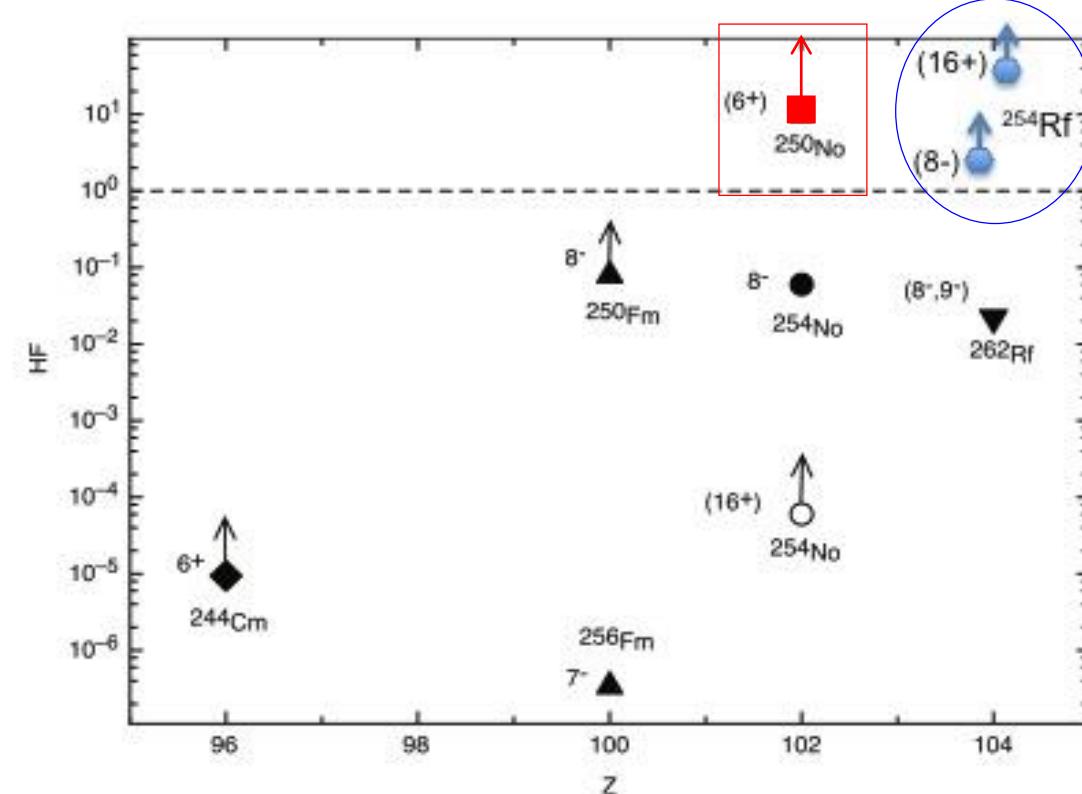
J. Kallunkkathariyil et al. Phys. Rev. C 101 (2020) 011301(R)



$$\text{HF}(Z, N) = T_{oe}(Z, N) / T_{ee}(Z, N)$$

$$T_{ee} = (T(Z, N+1) \times T(Z, N-1))^{1/2}$$

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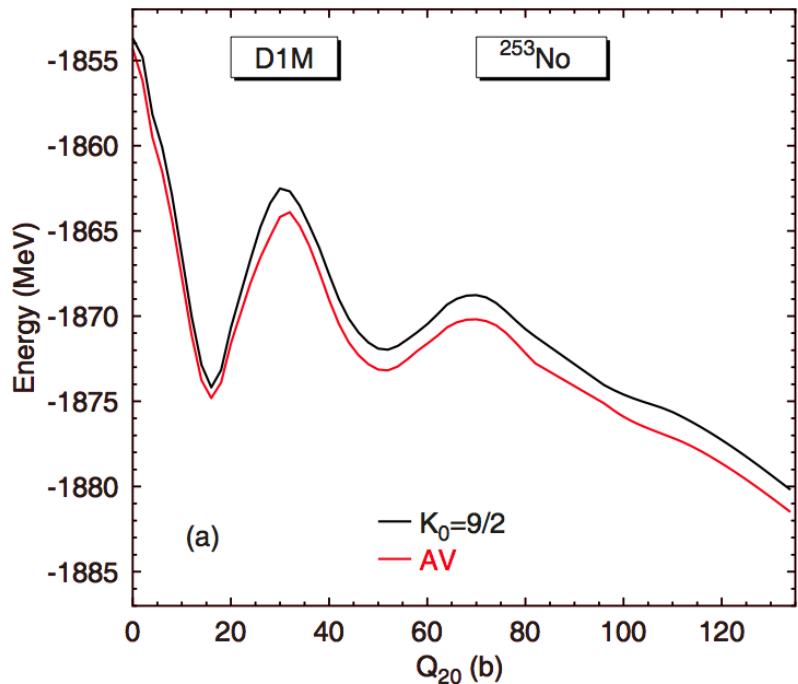


$$\text{HF}(Z, N) = T_{iso}(Z, N) / T_{gs}(Z, N)$$

Qualitative theoretical understanding

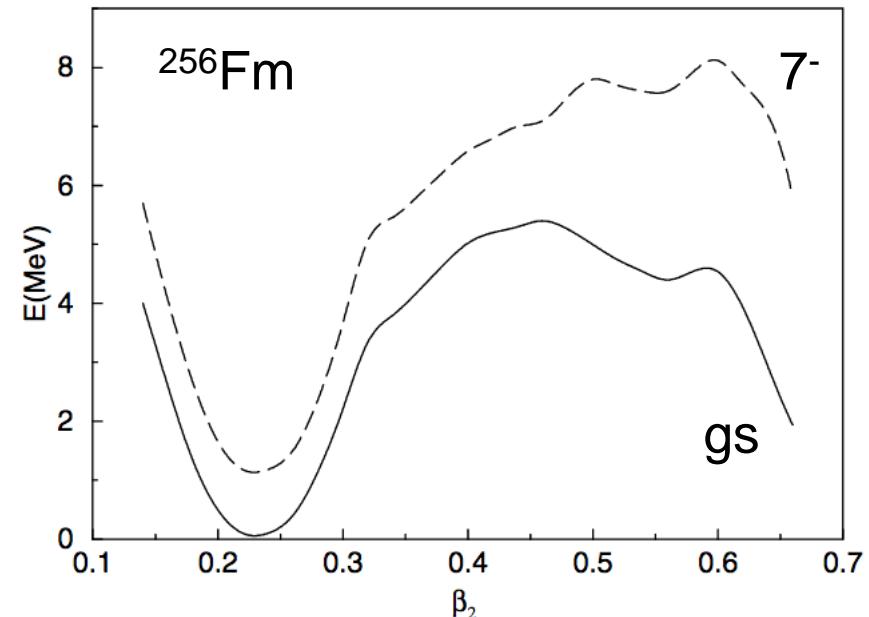
Configuration-constrained PES calculation

F.R. Xu et al., Phys. Rev. Lett. 92 (2004) 252501



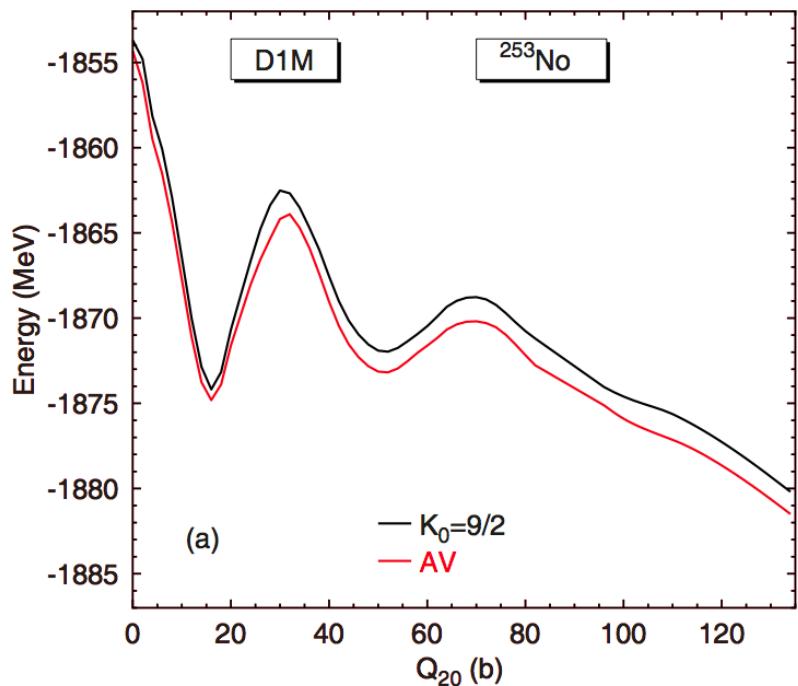
HFB + blocking with D1M

R. Rodriguez-Guzman and L.M. Robledo, Eur. Phys. J. A 52 (2016) 348





Qualitative theoretical understanding

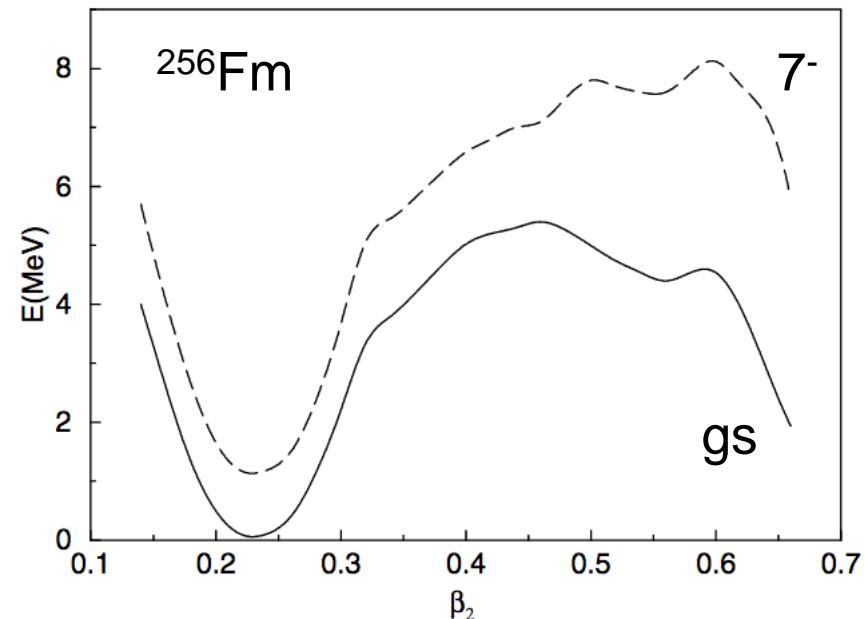


HFB + blocking with D1M

R. Rodriguez-Guzman and L.M. Robledo, Eur. Phys. J. A 52 (2016) 348

Configuration-constrained PES calculation

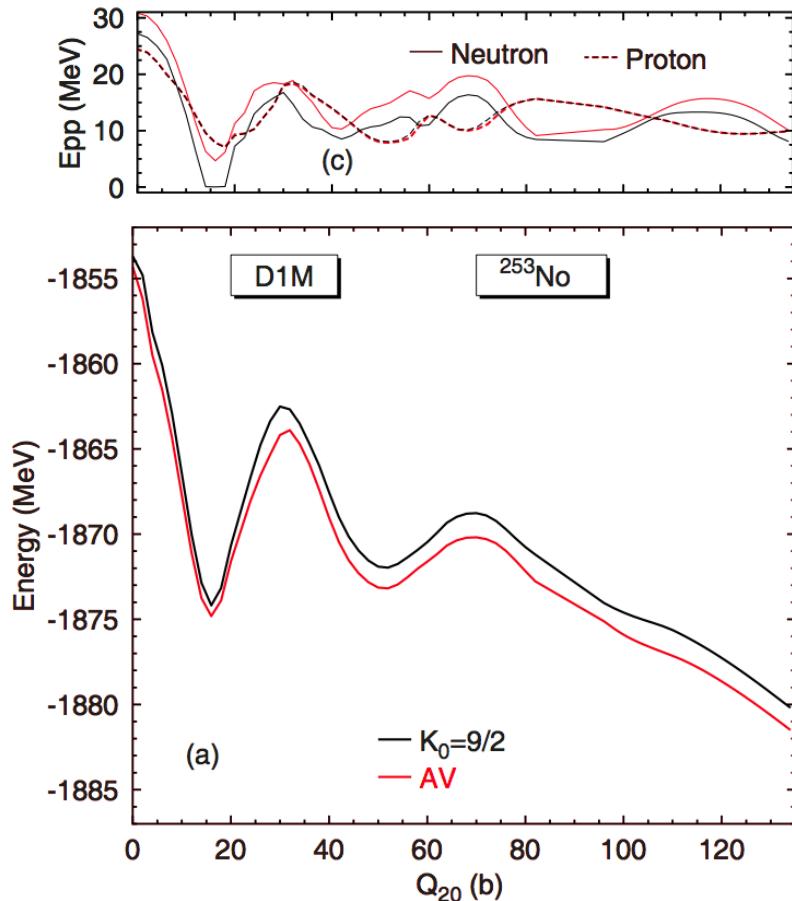
F.R. Xu et al., Phys. Rev. Lett. 92 (2004) 252501



Specialization energy



Qualitative theoretical understanding

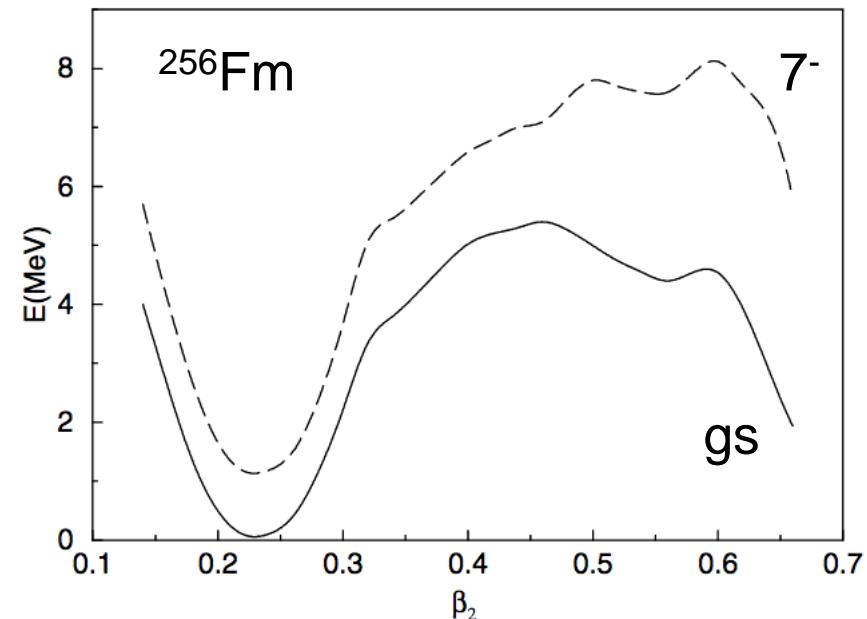


HFB + blocking with D1M

R. Rodriguez-Guzman and L.M. Robledo , Eur. Phys. J. A 52 (2016) 348

Configuration-constrained PES calculation

F.R. Xu et al., Phys. Rev. Lett. 92 (2004) 252501



Specialization energy

Reduced pairing



Questions

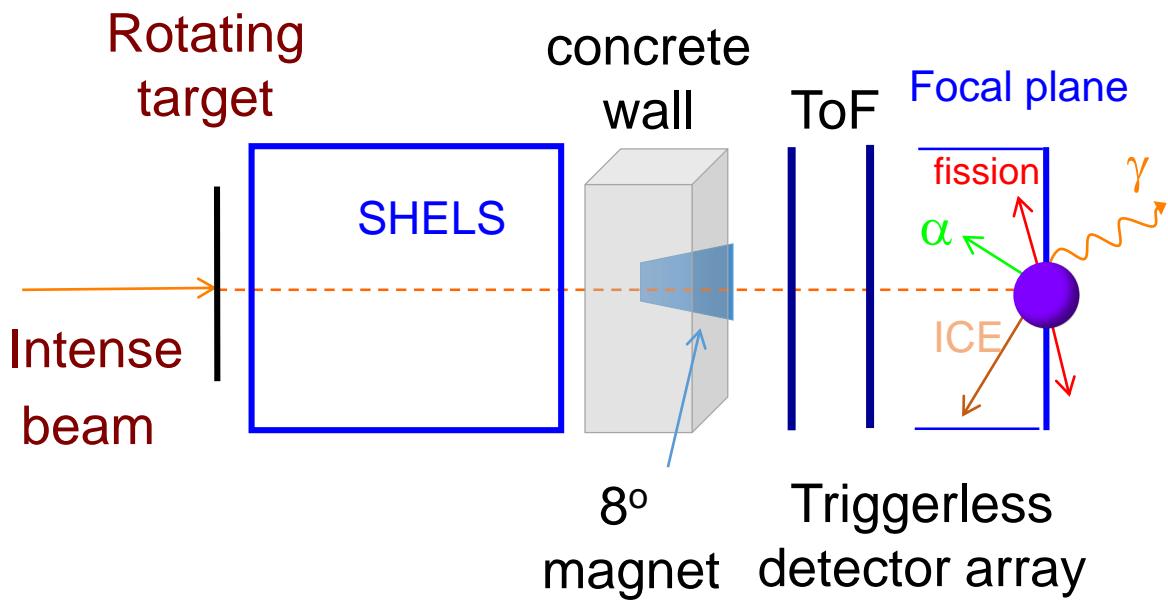
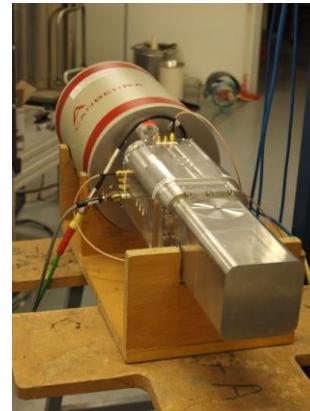
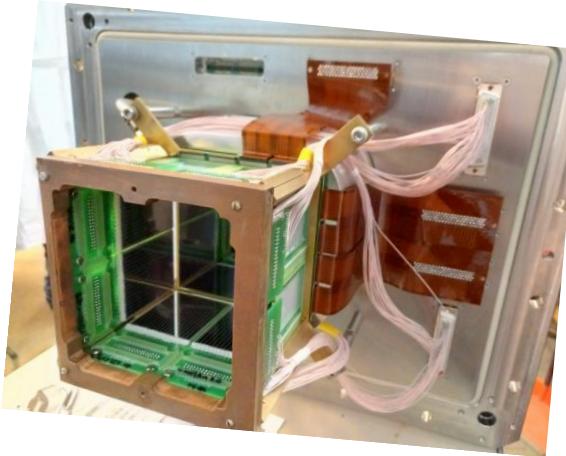
- Limits of the nuclear chart for neutron deficient Rf isotopes ?
- Fission hindrance of the 8⁻ isomer in ^{254}No ?



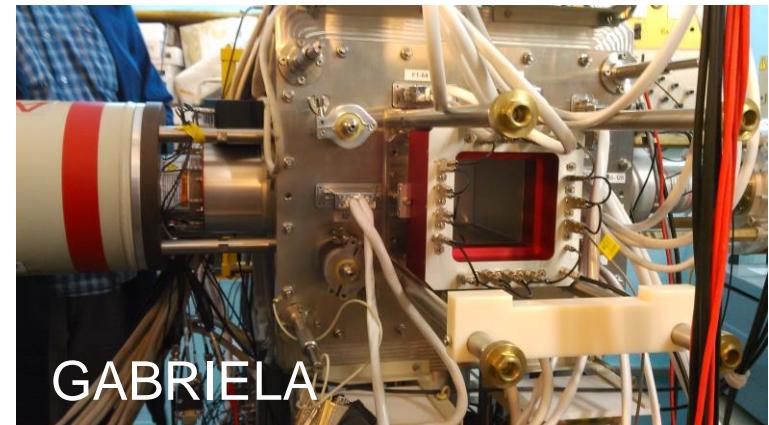
GABRIELA @ SHELS



SHELS

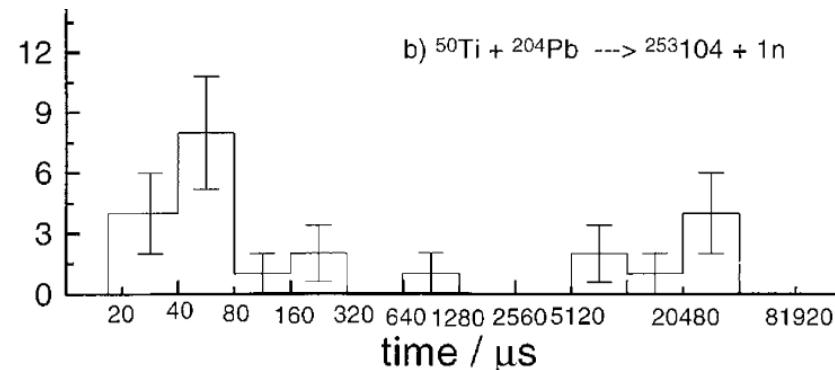


R. Chakma et al., Eur. Phys. J. A 56 (2020) 245



GABRIELA

Most neutron-deficient known Rf: ^{253}Rf



One 48 μs (and possibly another 11 ms ?) fission activity was identified

F.P. Hessberger *et al.*, Z. Phys. A 359 (1997) 415

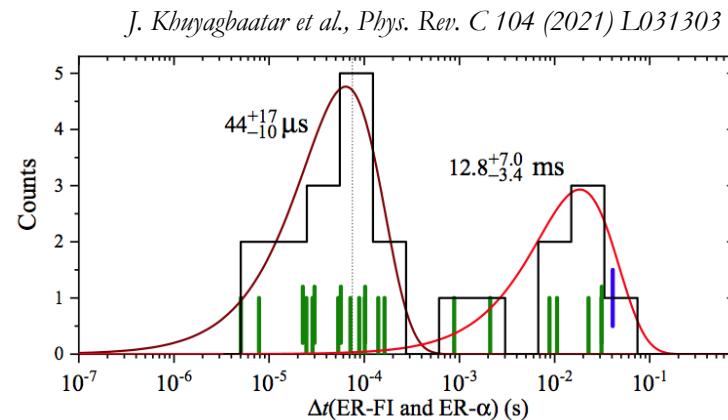


Most neutron-deficient known Rf: ^{253}Rf

21 fission events

1 alpha decay

1 candidate for a fast isomeric decay





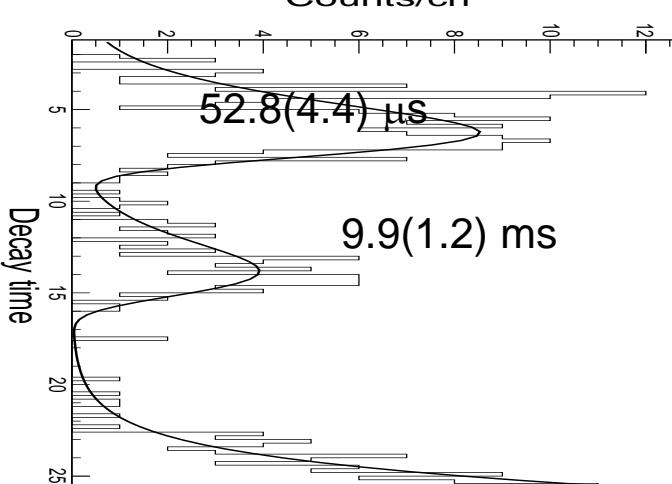
Most neutron-deficient known Rf: ^{253}Rf

21 fission events

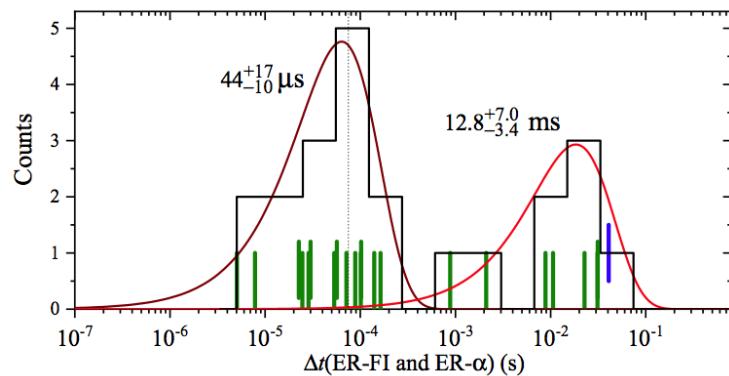
1 alpha decay

1 candidate for a fast isomeric decay

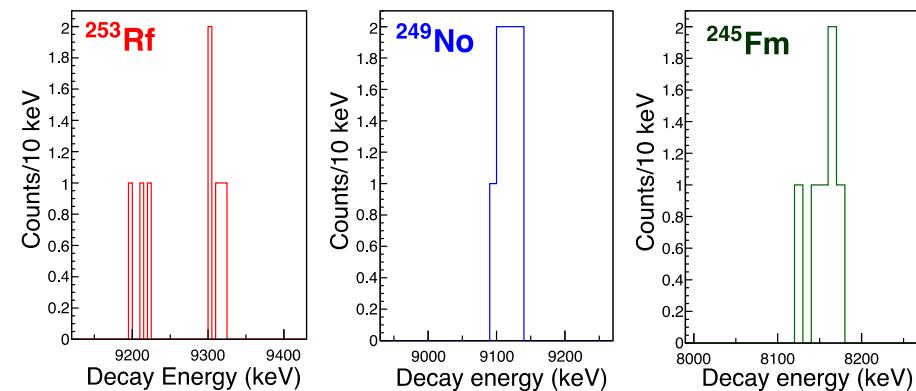
240 fission events



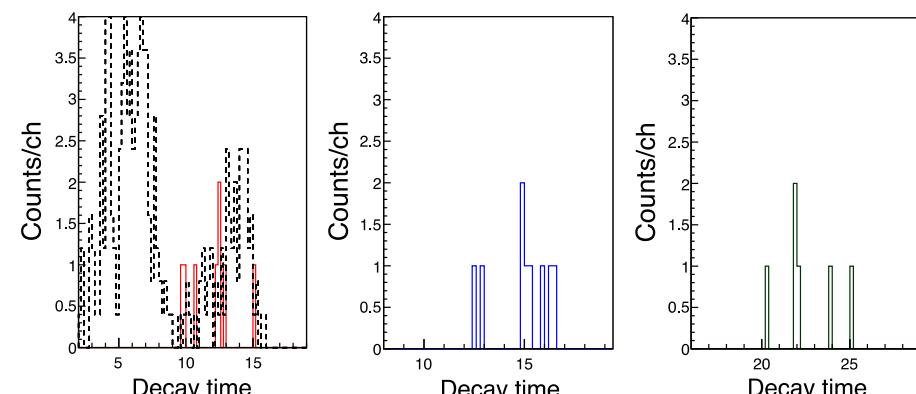
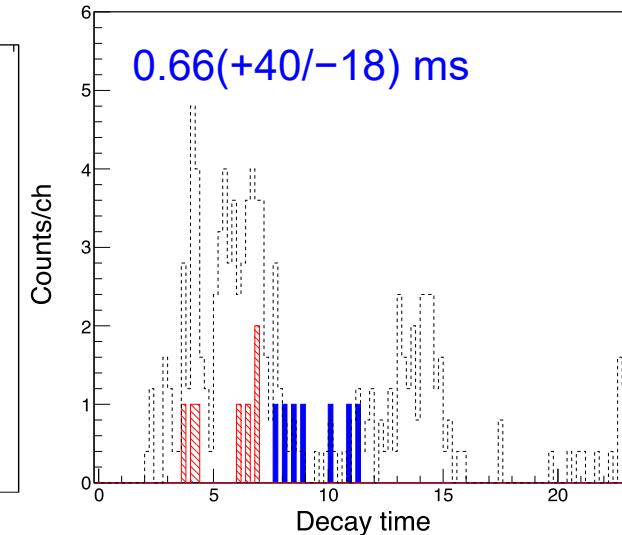
J. Khuyagbaatar et al., Phys. Rev. C 104 (2021) L031303



8 full-energy alpha decays

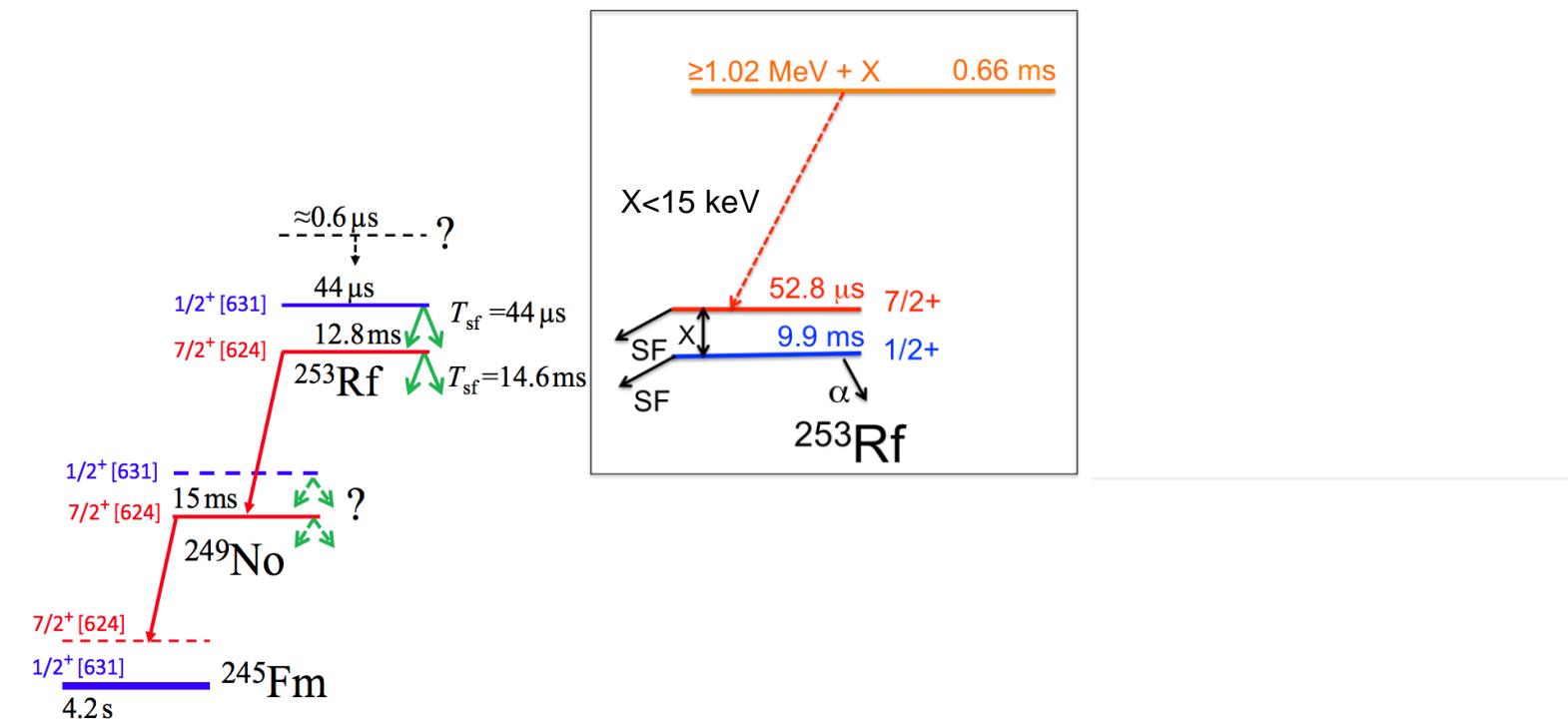


7 isomeric decays



^{253}Rf – Decay scheme

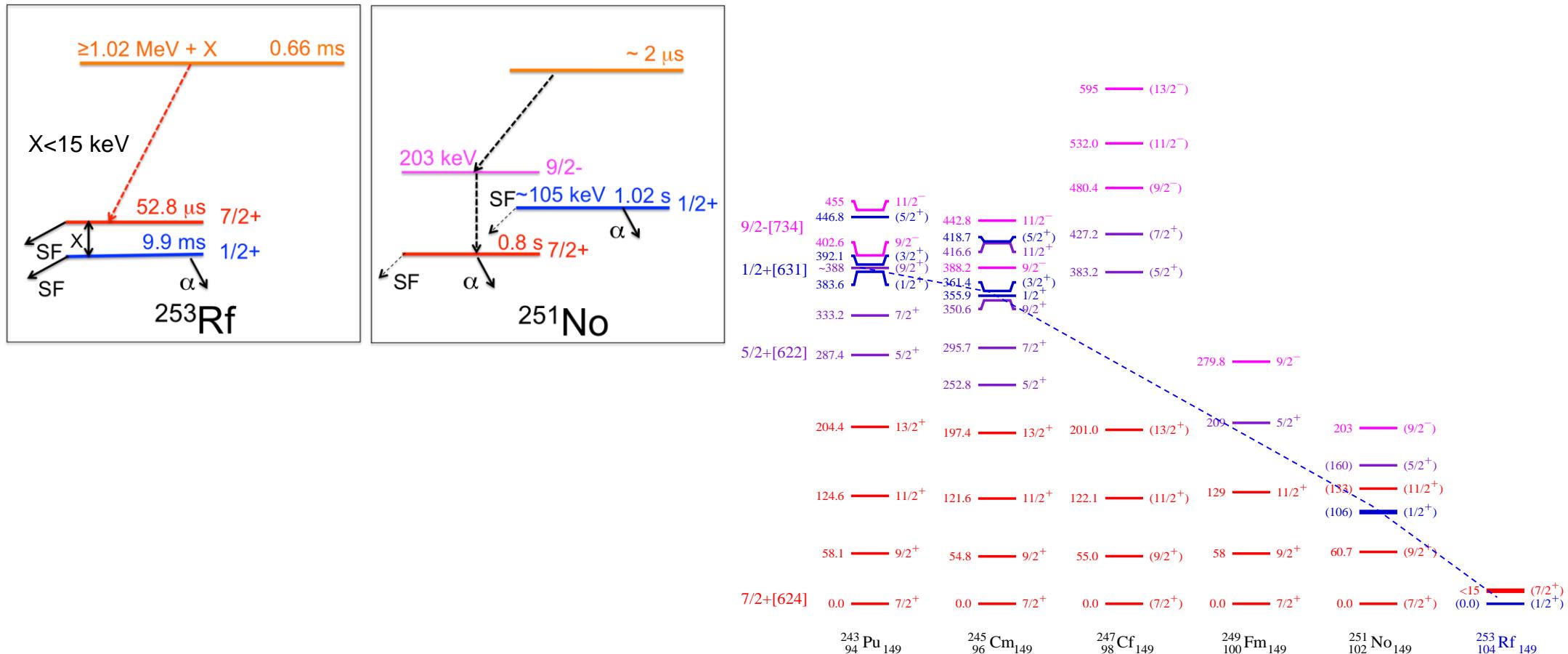
A. Lopez-Martens et al., Phys. Rev. C 105, L021306 (2022)



J. Khuyagbaatar et al., Phys. Rev. C 104 (2021) L031303

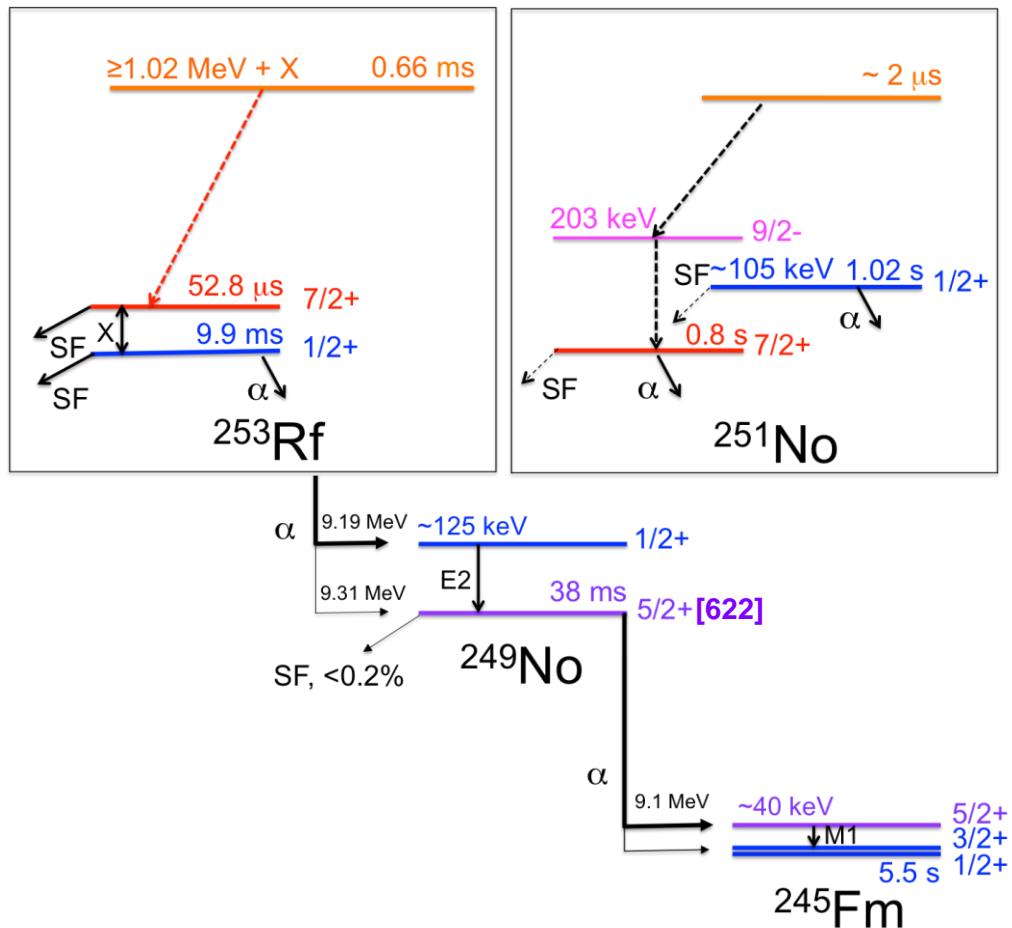
^{253}Rf – Decay scheme

A. Lopez-Martens et al., Phys. Rev. C 105, L021306 (2022)

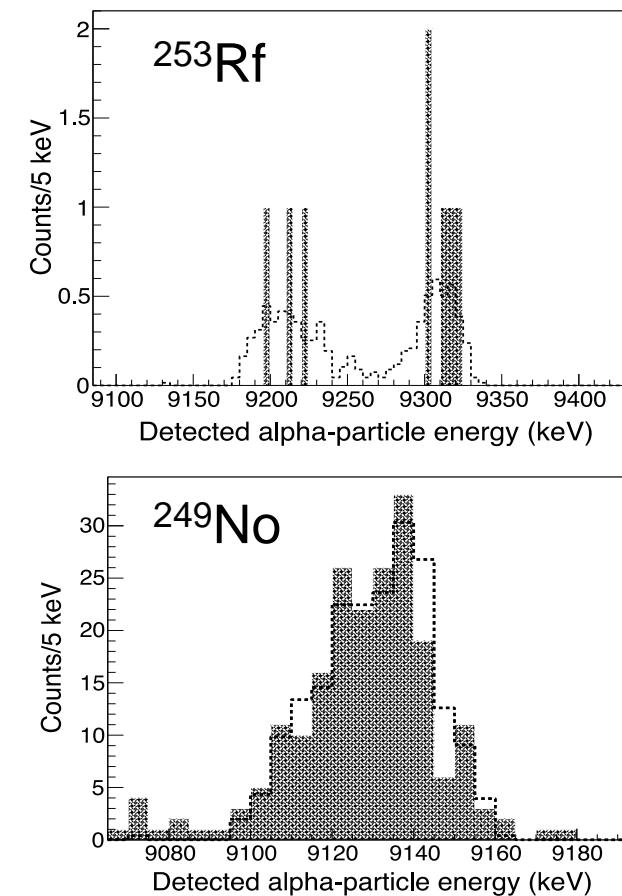




^{253}Rf – Decay scheme



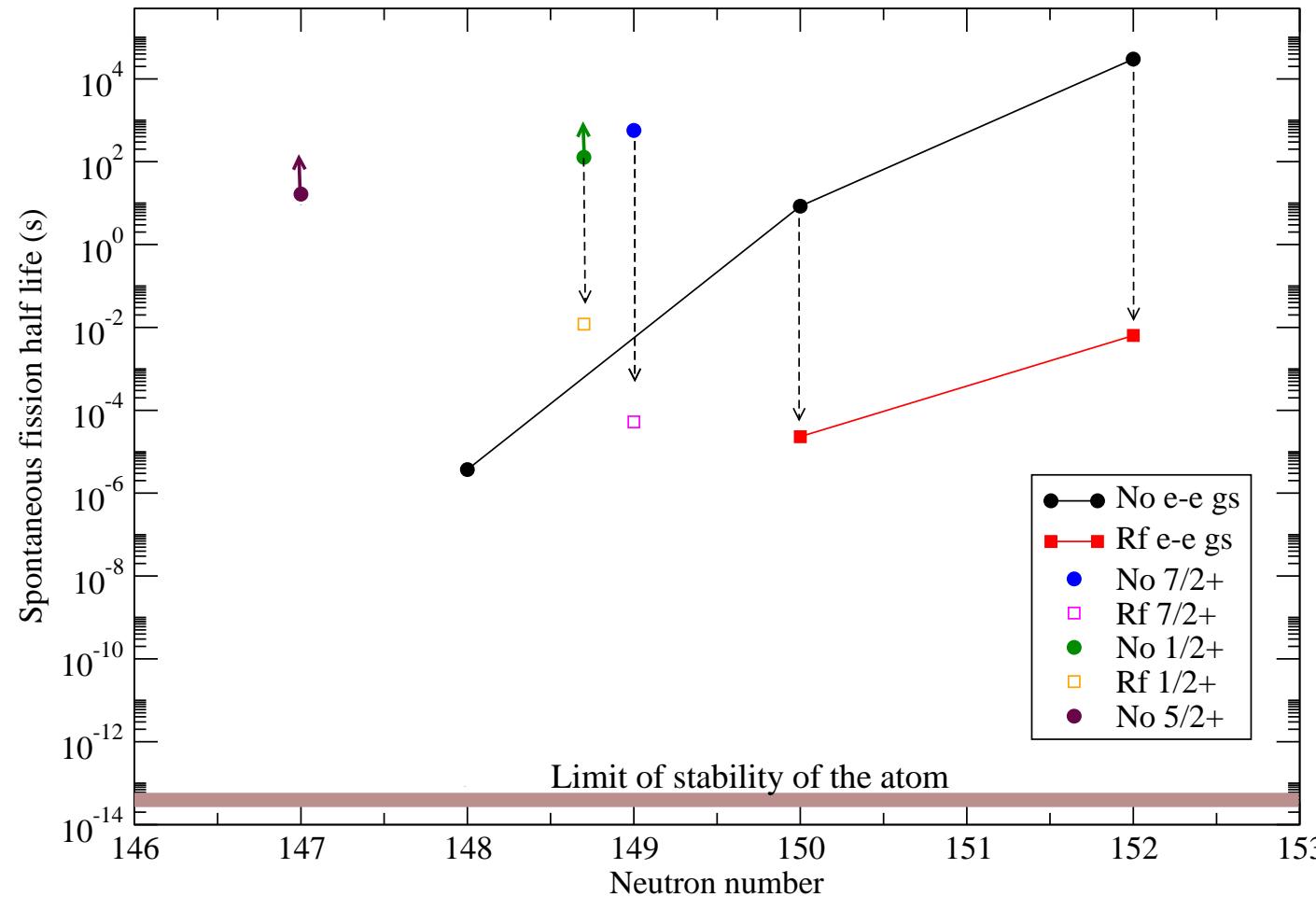
Geant4-assisted analysis



M. S. Tezekbayeva, Eur. Phys. J. A 58 (2022) 52

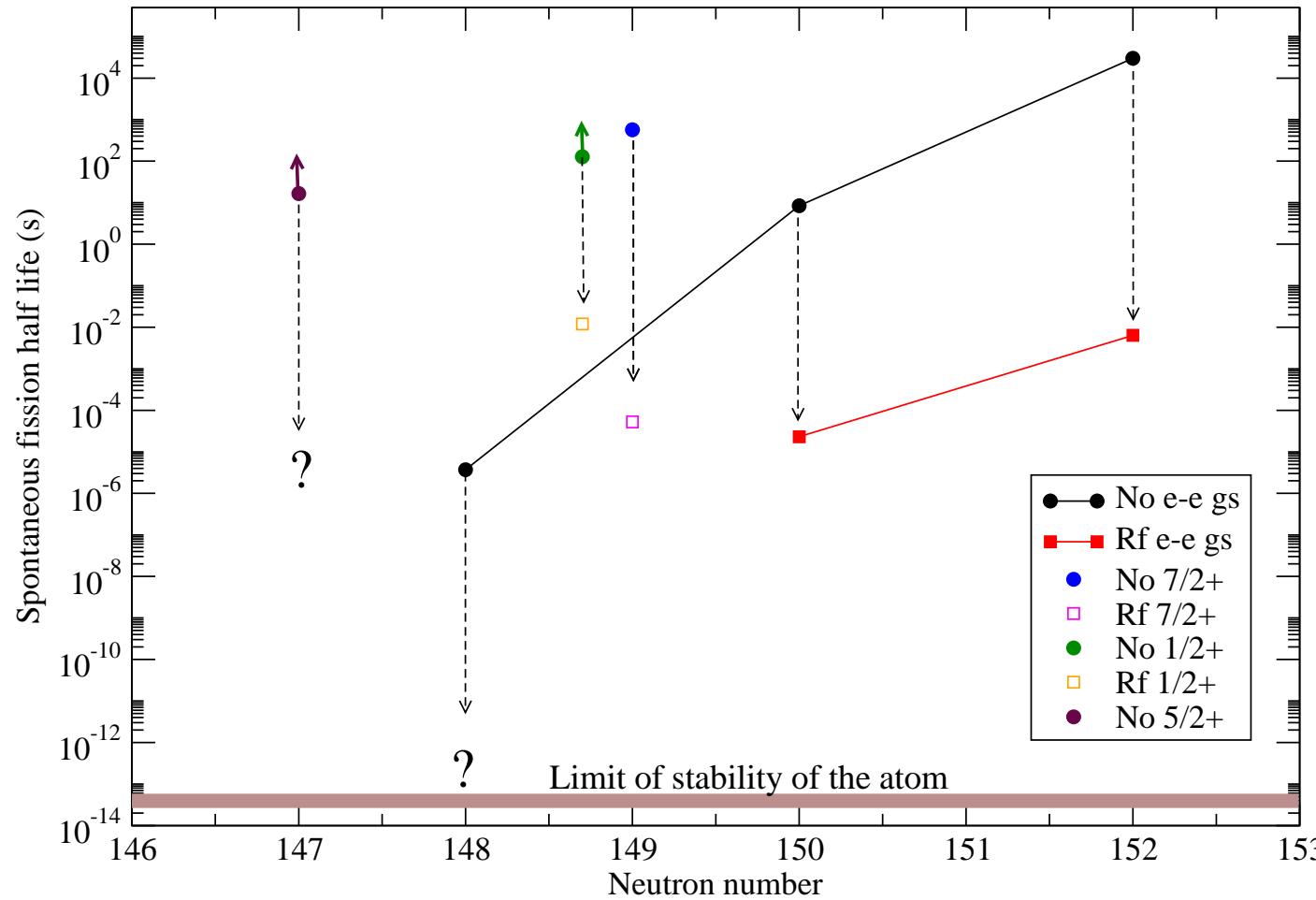


Stability against fission of Rf isotopes



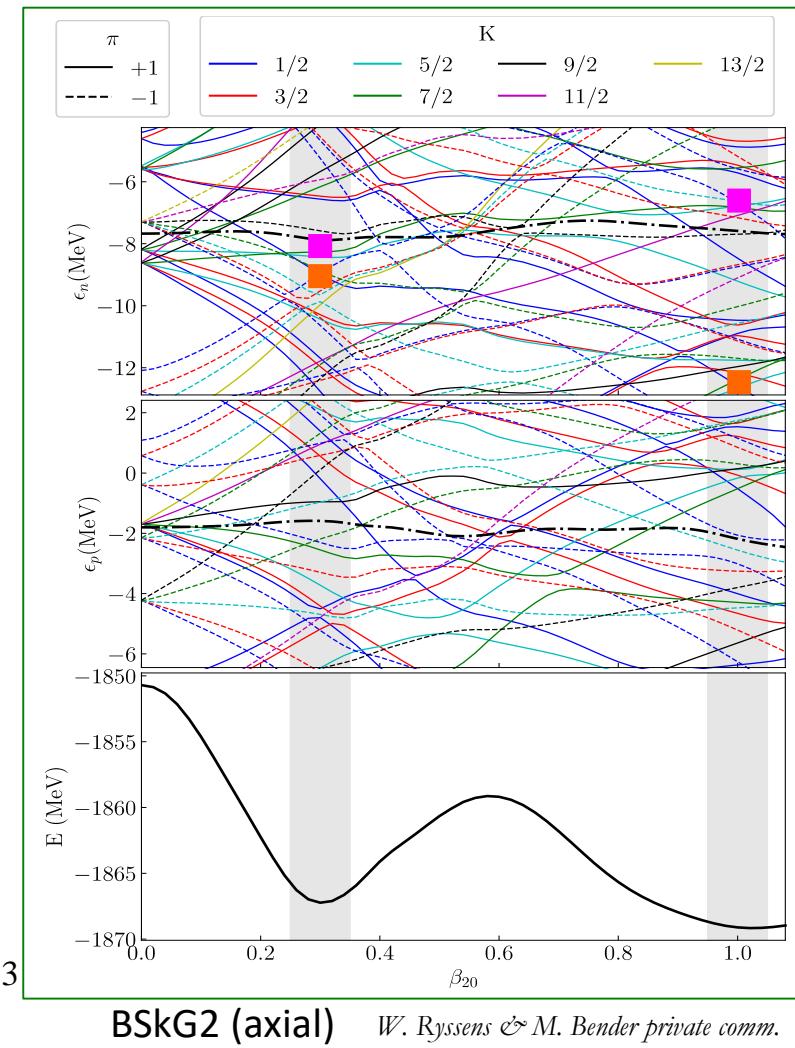
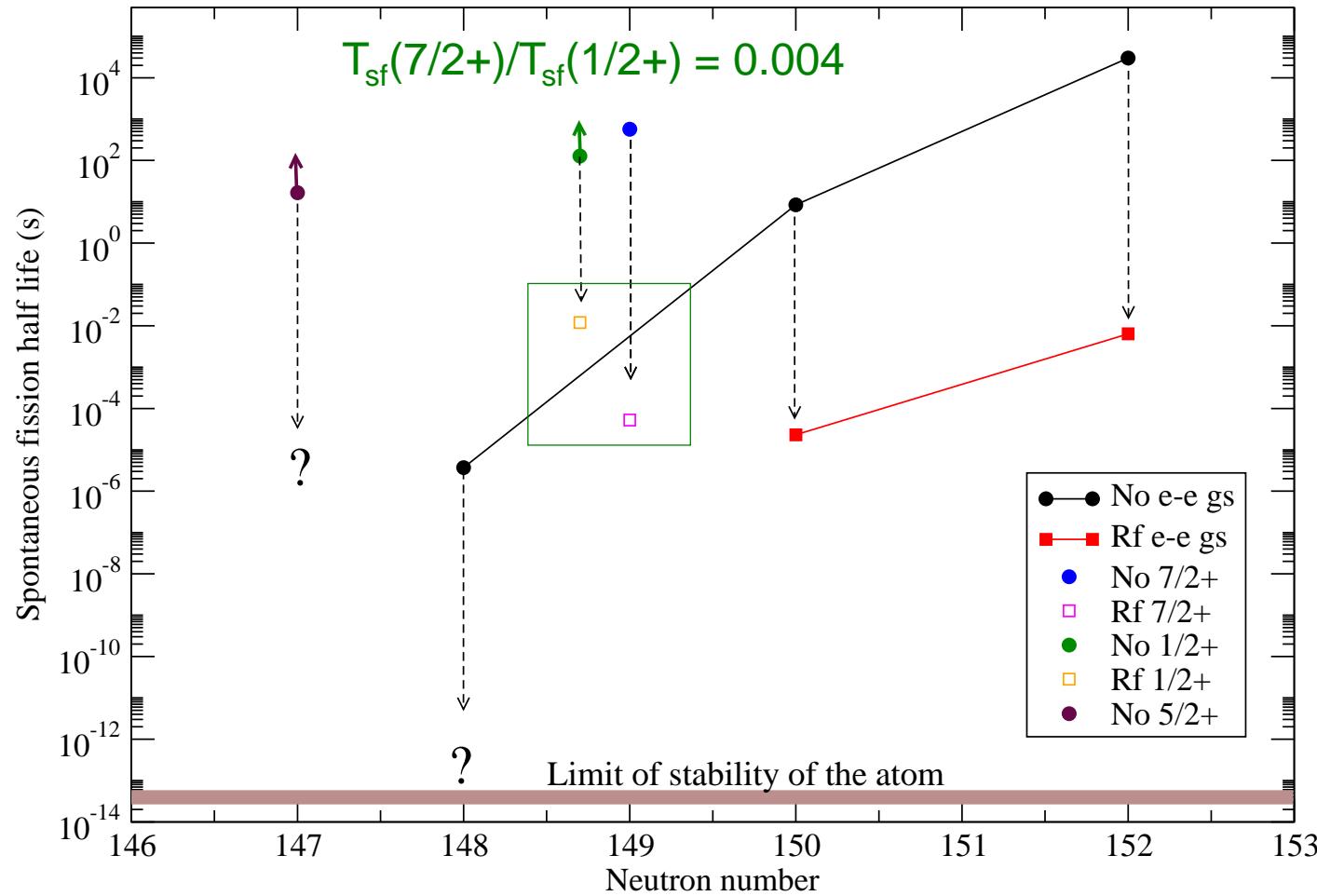


Stability against fission of Rf isotopes





Stability against fission of Rf isotopes

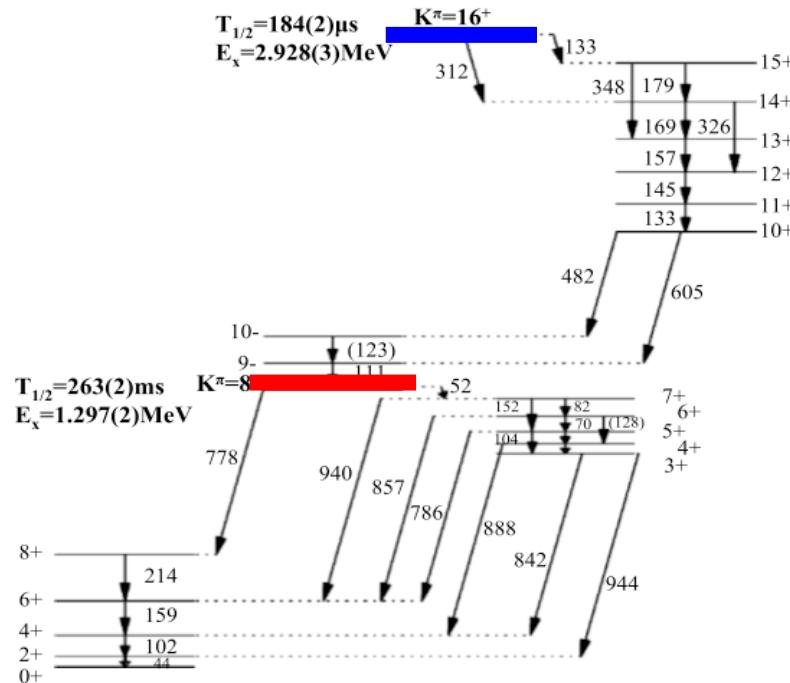




$K^\pi=8^-$ isomer in ^{254}No

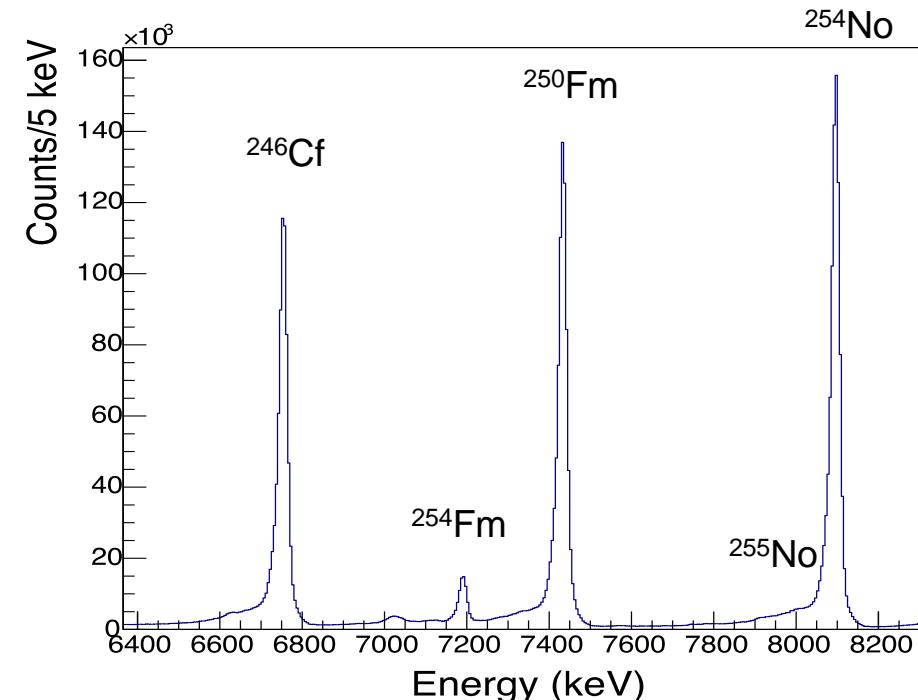
$b_{SF}(8^-) = (2.0 \pm 1.2) \cdot 10^{-4}$, “corrected for the expected contributions of $^{252,254g}\text{No}$ ”
 $b_{SF}(16^+?) < 1.3 \cdot 10^{-4}$

F.P. Hessberger et al., Eur. Phys. J. A 43, 55–66 (2010)



R. Clark et al., Phys. Lett. B 690, 19 (2010)

$^{208}\text{Pb}(^{48}\text{Ca}, 2n)^{254}\text{No}$
~1 million $^{254,255}\text{No}$ alphas detected

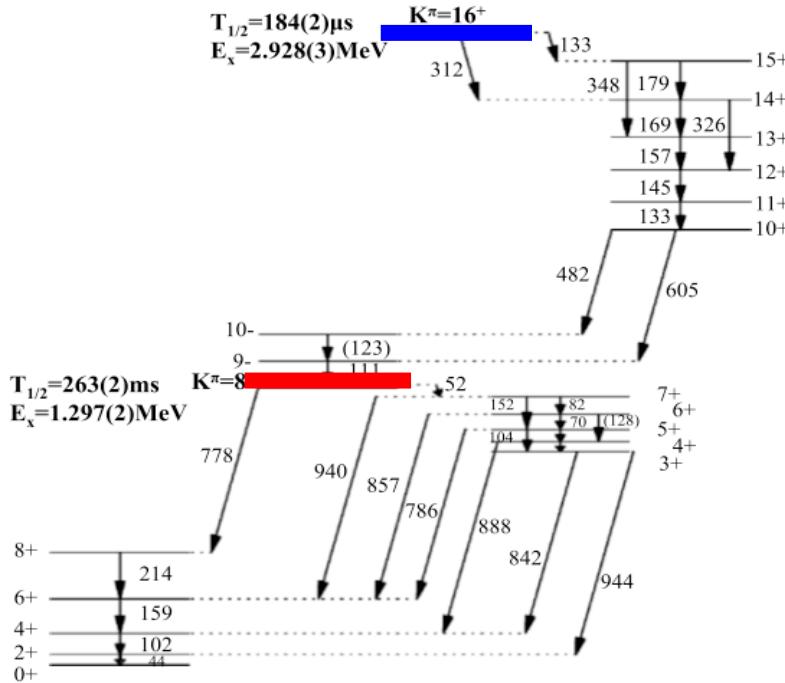




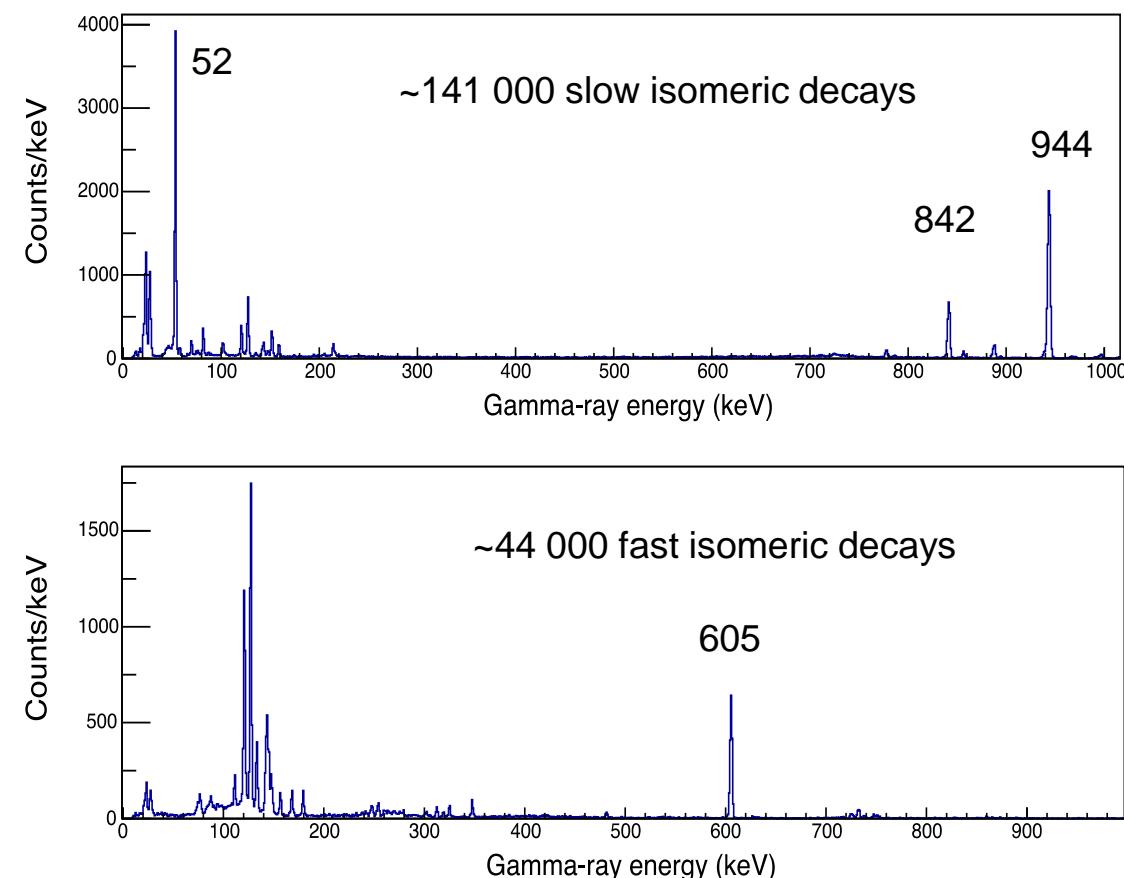
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F.P. Hessberger *et al.*, Eur. Phys. J. A 43, 55–66 (2010)

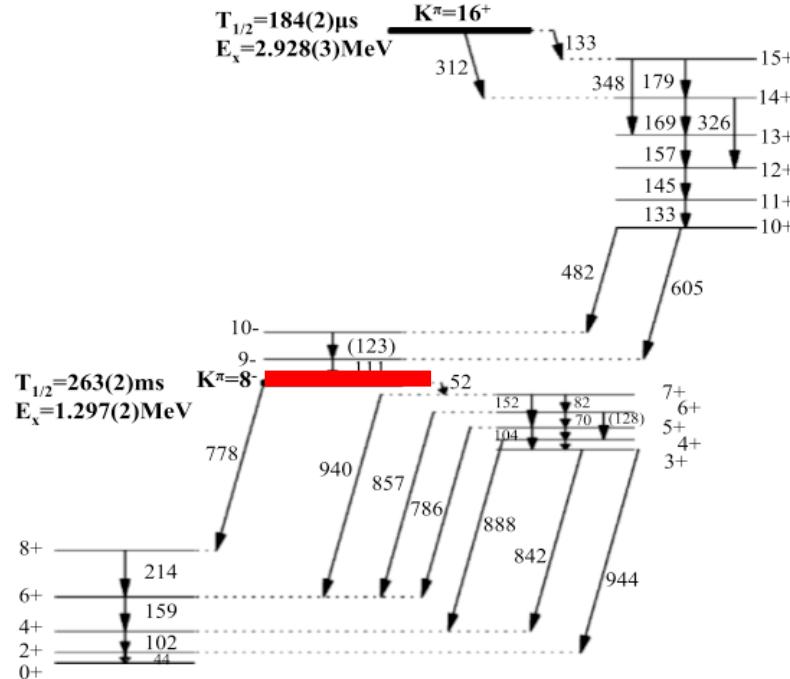


R. Clark *et al.*, Phys. Lett. B 690, 19 (2010)

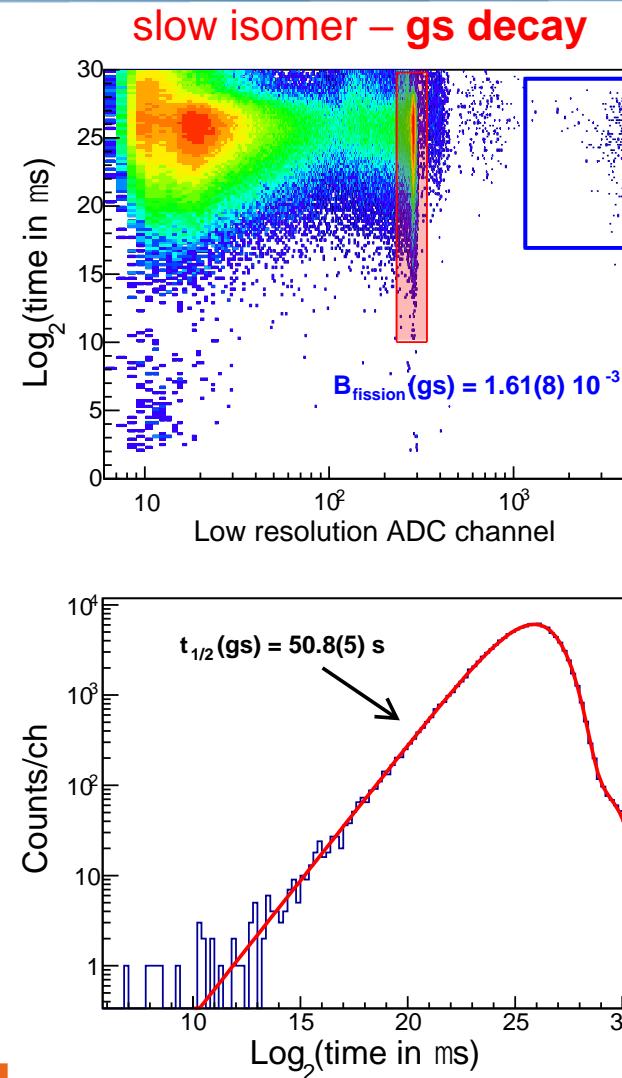




Clean selection of the fission events of interest

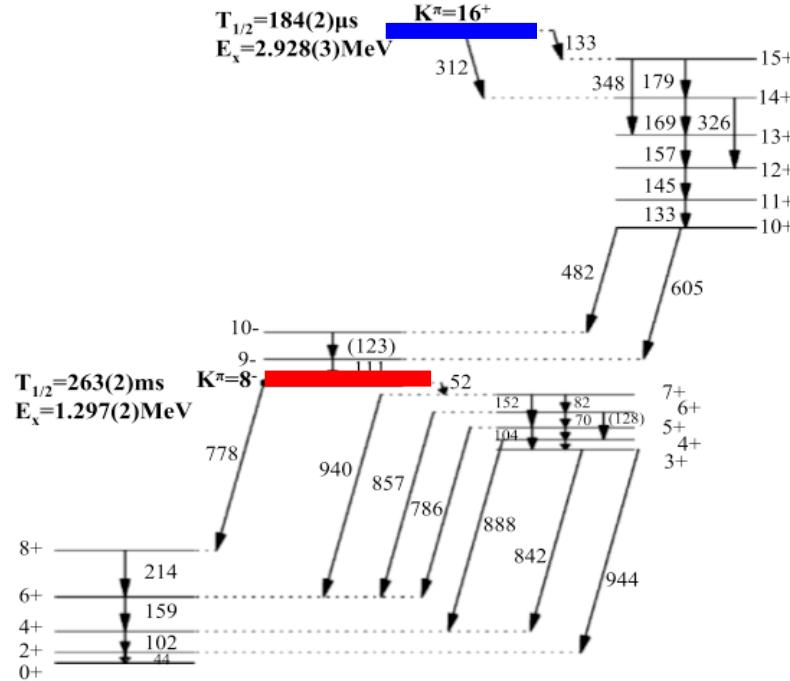


R. Clark et al., Phys. Lett. B 690, 19 (2010)

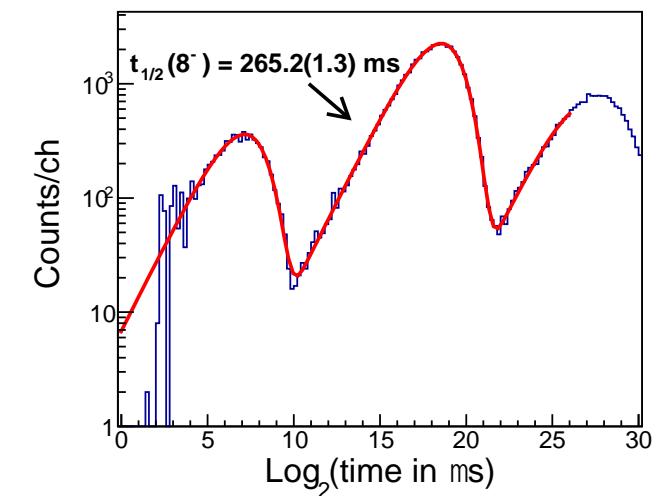
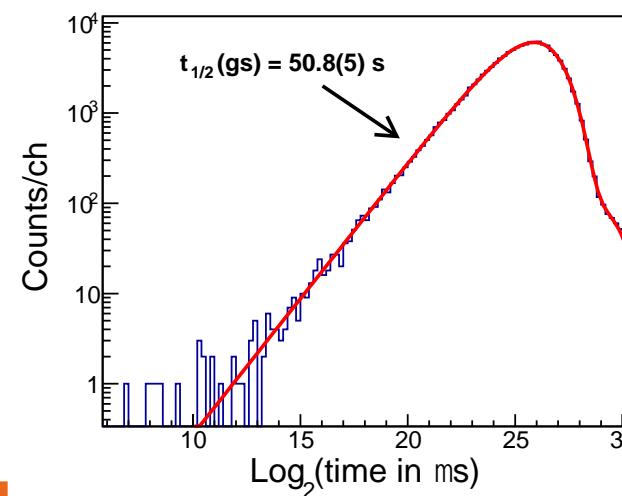
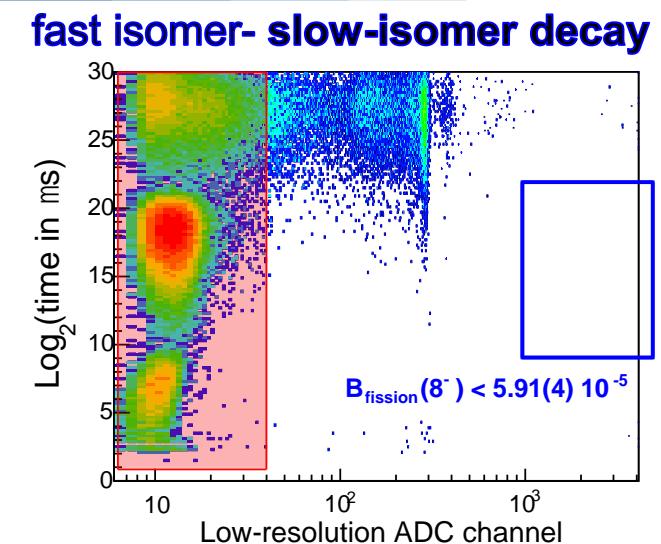
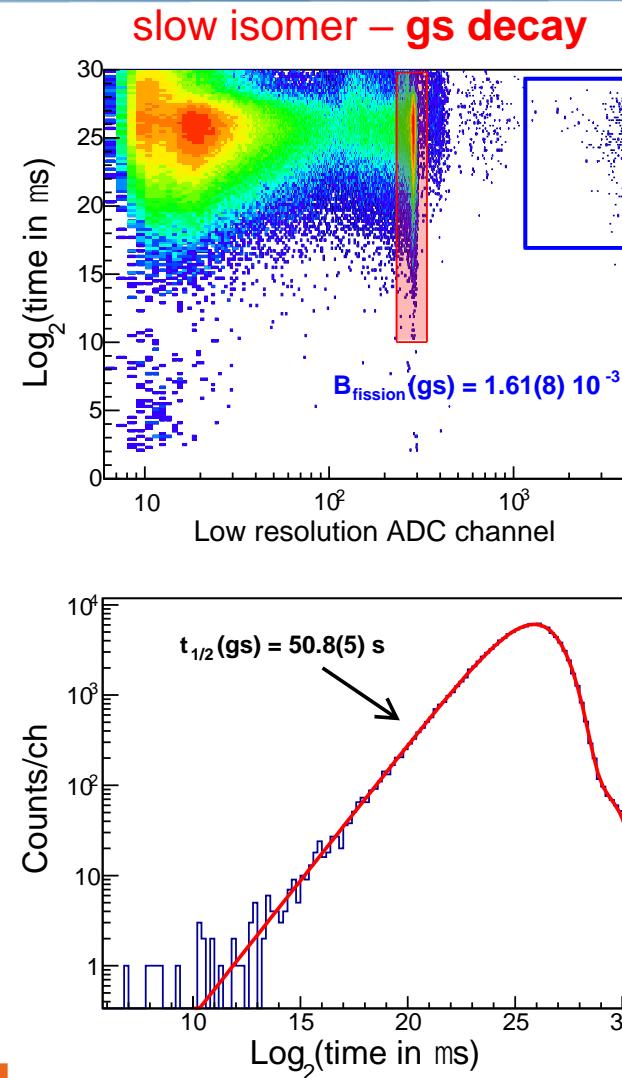




Clean selection of the fission events of interest

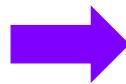


R. Clark et al., Phys. Lett. B 690, 19 (2010)

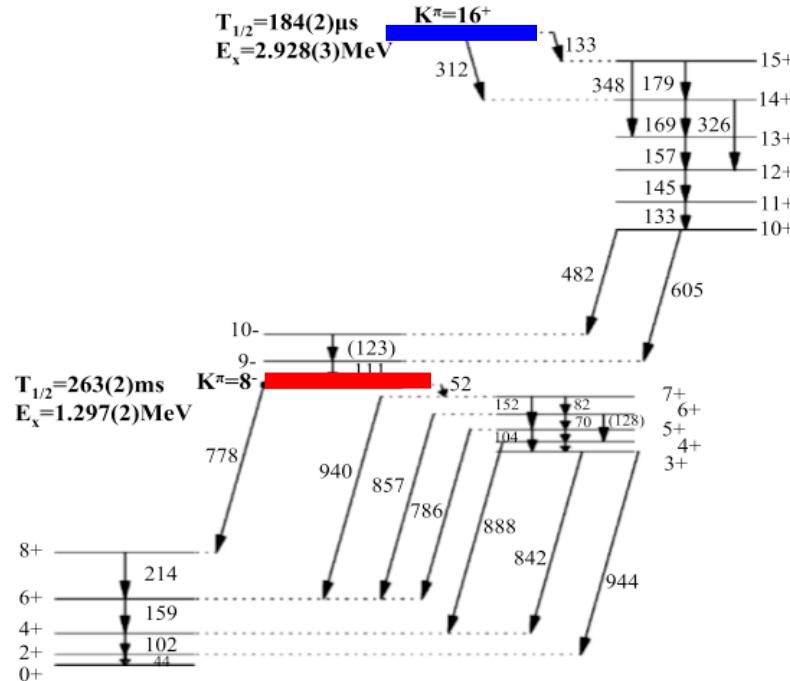




Clean selection of the fission events of interest

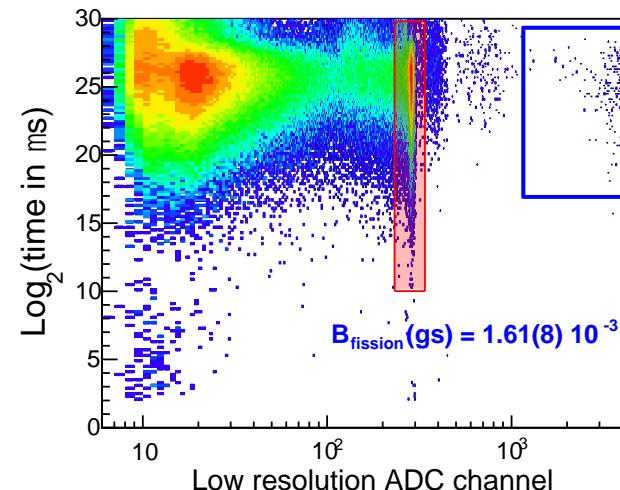


HF (8^-) > 0.37

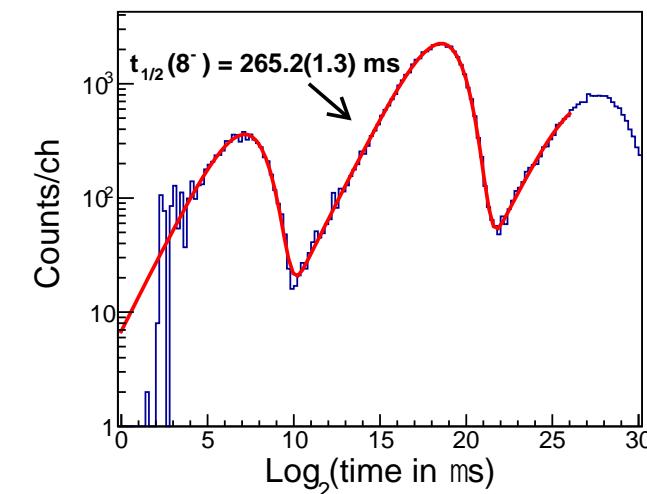
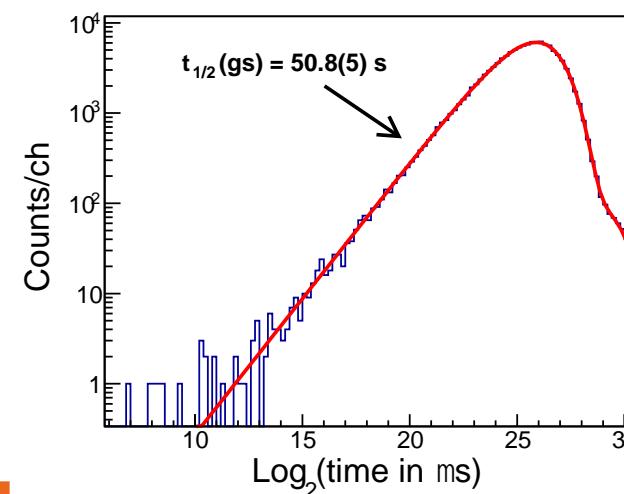
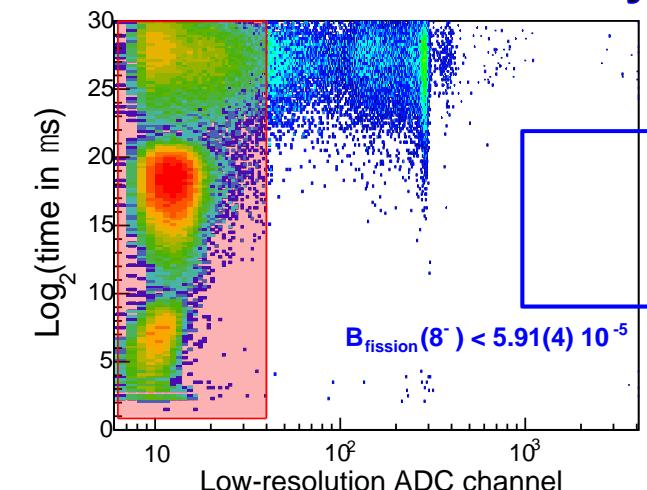


R. Clark et al., Phys. Lett. B 690, 19 (2010)

slow isomer – gs decay



fast isomer- slow-isomer decay





Conclusions & perspectives

The HF of the 8⁻ isomer of ²⁵⁴No has been revised: it is now a lower limit (~8 times higher than the previously established value)

It would seem all the HFs of high-K isomers are moving upwards when remeasured: this gives hope to extend the nuclear chart beyond the « fission dripline »

Neutron deficient transfermium nuclei are a unique laboratory to study the fission properties of different nucleonic configurations (in the same nucleus)

The gs of the next even-even Rf isotope (²⁵²Rf) will probably be at the limit of stability of an atom

There may be hope to observe ²⁵¹Rf

Need for « proper » microscopic modelling of the fission from odd Z/odd N nuclei and high K states



Gabriela Collaboration

France

A. Lopez-Martens, K. Hauschild

Z. Asfari, O. Dorvaux, M. Forge, B. Gall, K. Kessaci

D. Ackermann, R. Chakma, J. Piot

Russia

A.I. Svirikhin, M.L. Chelnokov , V.I. Chepigin, A.V. Isaev, I.N. Izosimov, A.A. Kuznetsova, O.N. Malyshev, R.S Mukhin, A.G. Popeko, Yu.A. Popov, B. Sailaubekov, E.A. Sokol, M.S. Tezekbayeva and A.V. Yeremin

Slovakia

P. Mosat, B. Andel

China

B. Ding, Z. Liu, F. Zhang



N=147 isotopes

