Addressing open riddles surrounding the proton-emitting isomer(s) in ^{94}Ag

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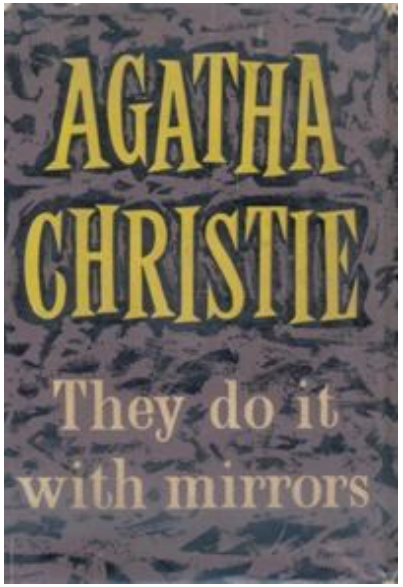
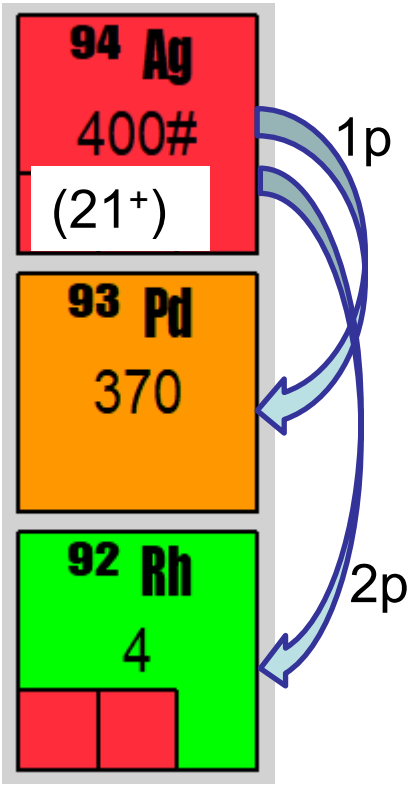


^{94}Ag (21^+) isomer

A (21^+) isomer in ^{94}Ag has been reported to have unique properties:

- β-decay C. Plettner et al., Nucl. Phys. A 733, 20 (2004)
- β-delayed proton emission I. Mukha et al., Phys. Rev. C 70, 044311 (2004)
- direct 1p-decay I. Mukha et al., Phys. Rev. Lett. 95 (2005) 022501
- direct 2p-decay I. Mukha et al., Nature 439 (2006) 298



- It has a measured β-decay half-life of 400(40) ms.
- It has an excitation energy of more than 6 MeV.

Intense scientific discussions

- O. L. Pechenaya et al., Phys. Rev. C 76, 011304 (2007)
- K. Kaneko et al., Phys. Rev. C 77, 064304 (2008)
- D. G. Jenkins et al., Phys. Rev. C 80, 054303 (2009)
- J. Cerny et al., Phys. Rev. Lett. 103, 152502 (2009)
- A. Kankainen et al., Phys. Rev. Lett. 101 (2008) 142503
- **. . . And many more . . .**

Riddle

1p and 2p-decay of ^{94}Ag are unique and puzzling

Riddle #3.1: 2p emission could not be confirmed in Berkeley?!

J. Cerny et al., Phys. Rev. Lett. 103, 152502 (2009)

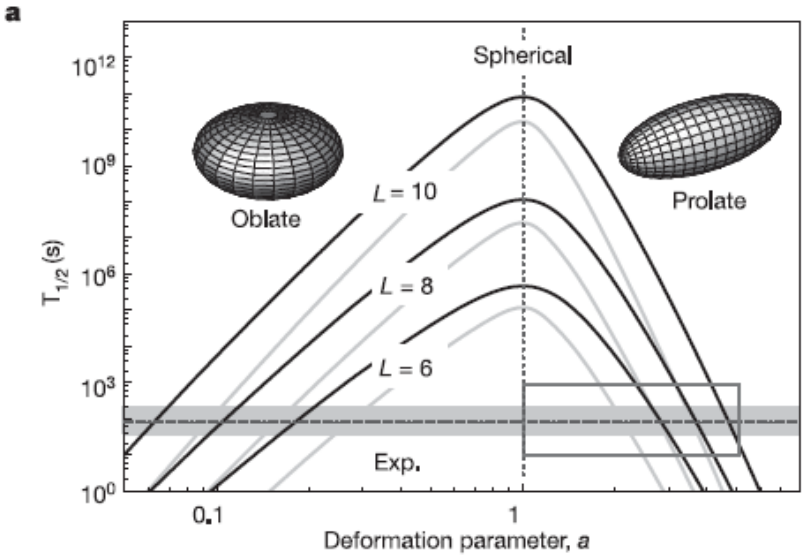
Riddle #3.2: Why simultaneous 2p emission, why not sequential 2p?!

I. Mukha et al., Nature 439 (2006) 298

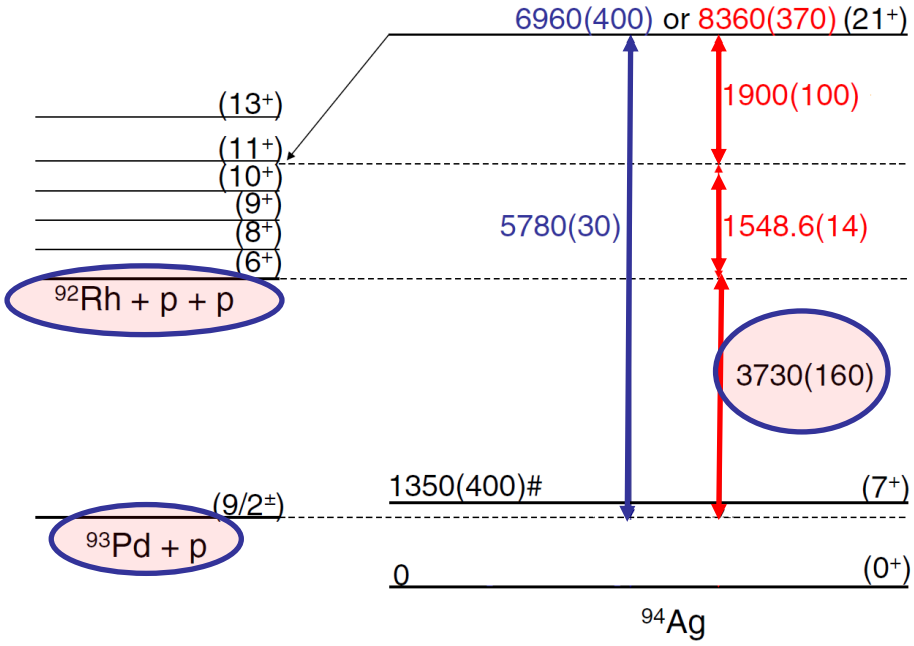
Riddle #3.3: Strongly deformed?!

K. Kaneko et al., Phys. Rev. C 77, 064304 (2008)

I. Mukha et al., Nature 439 (2006) 298



Riddle #3.4: Energy mismatch?!



Based on extrapolation

A. Kankainen et al., Phys. Rev. Lett. 101 (2008) 142503

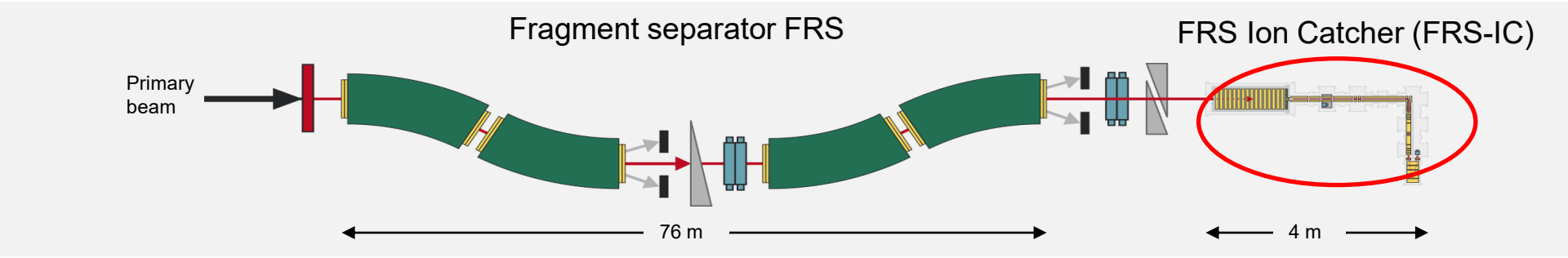
UNIVERSITY OF JYVÄSKYLÄ

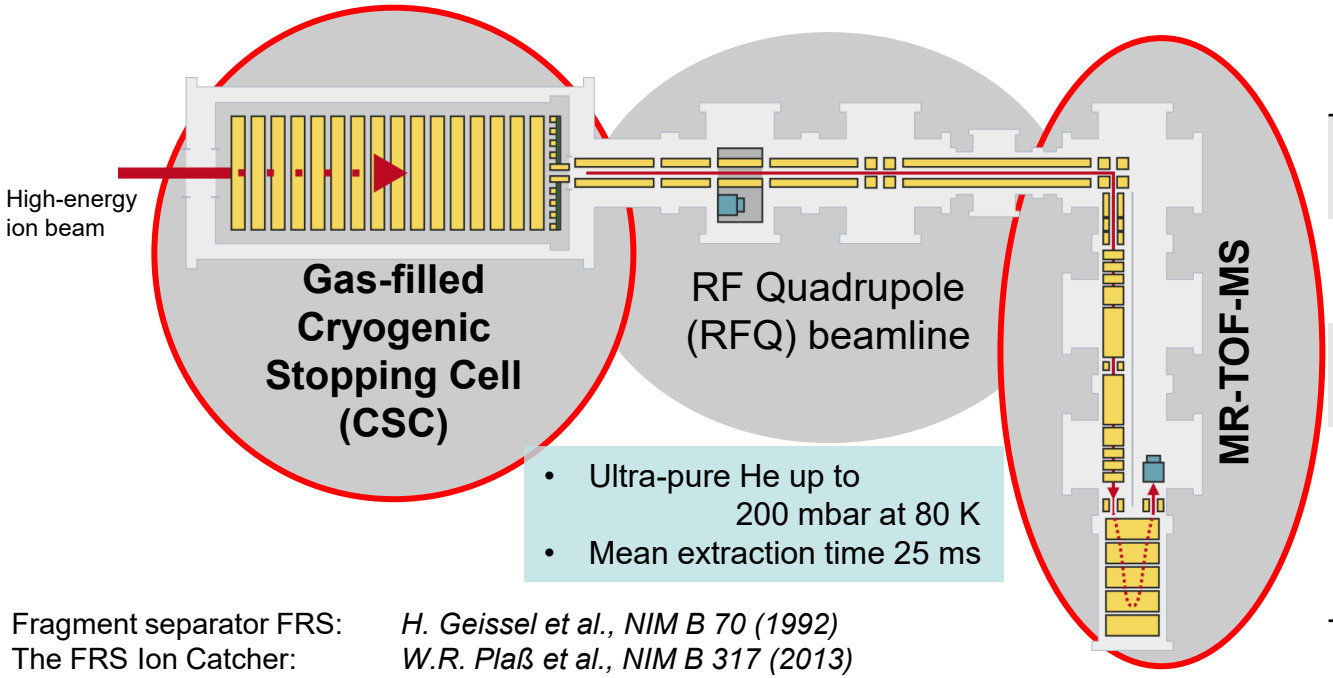
Dedicated hot cavity catcher for measuring ^{94}Ag

M. Reponen et al., Rev. Sci. Instrum. 123501 (2015)

The FRS Ion Catcher at GSI

- **FRS: In-flight** isotope production and separation
- High-resolution **mass spectrometer/separator** for the projectile fragmentation/fission products
- **FRS Ion Catcher:** High-precision studies on thermalized ions

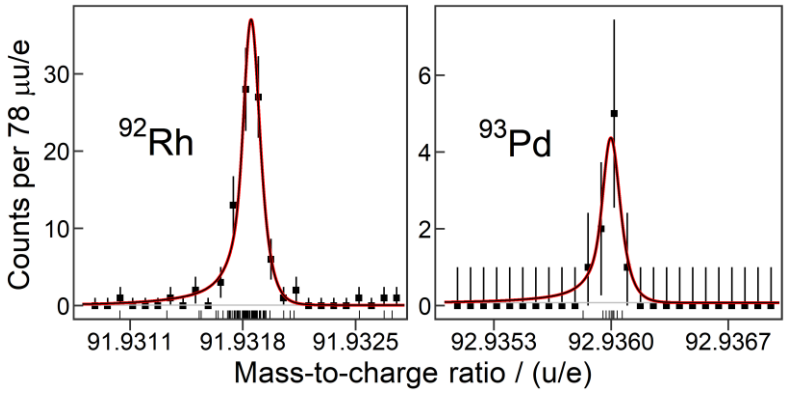




Thick CSC	Stopping of relativistic nuclei
Clean and sensitive	low production cross section
Fast	short-lived ions with $T_{1/2}$ ~ms
Broadband & non-scanning MR-TOF-MS	Efficient way of collecting data

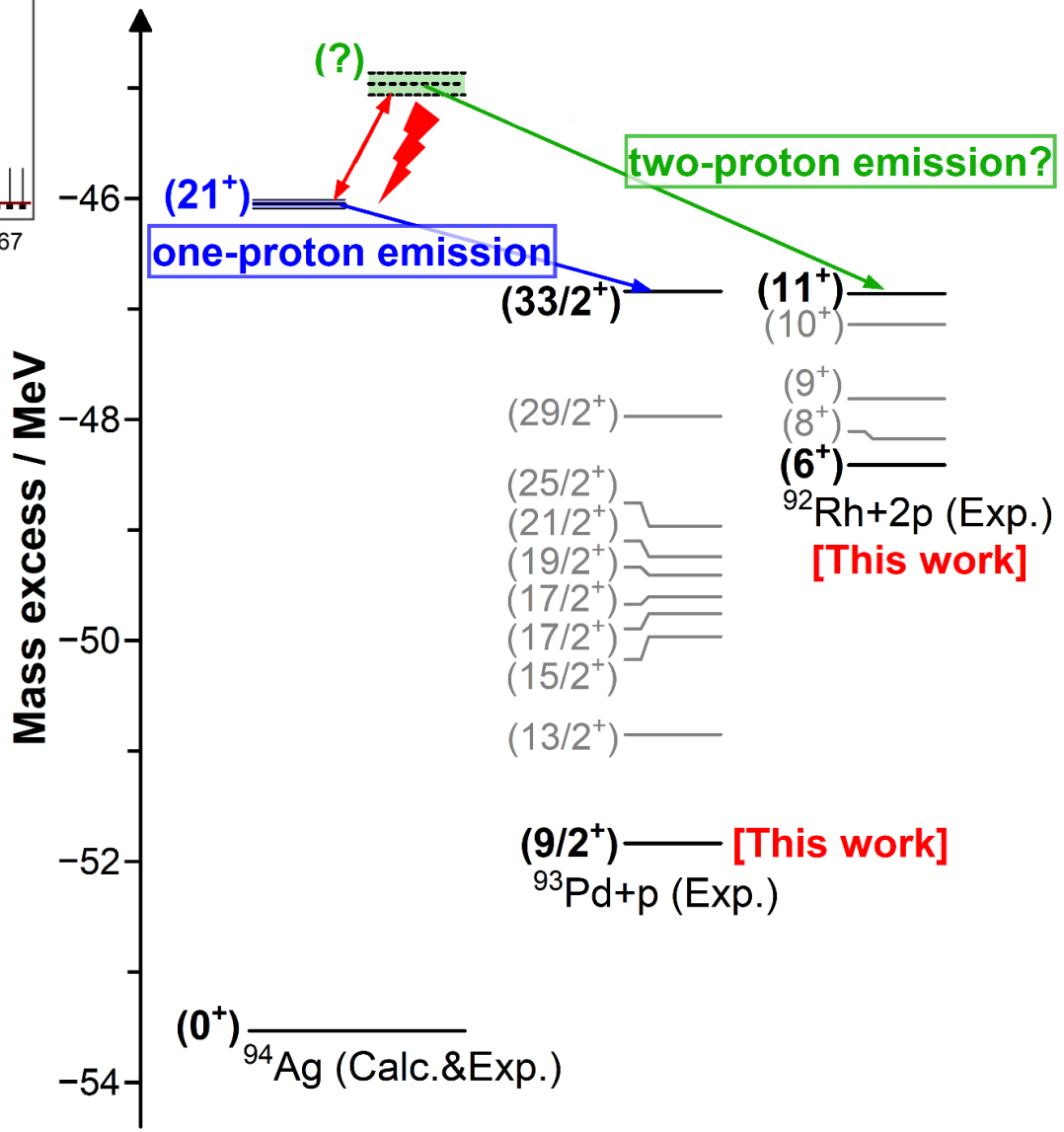
Fragment separator FRS: *H. Geissel et al., NIM B 70 (1992)*
The FRS Ion Catcher: *W.R. Plaß et al., NIM B 317 (2013)*
Coupling of FRS and FRS IC: *T. Dickel et al., Atoms (2024), 12, 52*

The 1p/2p-decay of ^{94}Ag (21^+) isomer

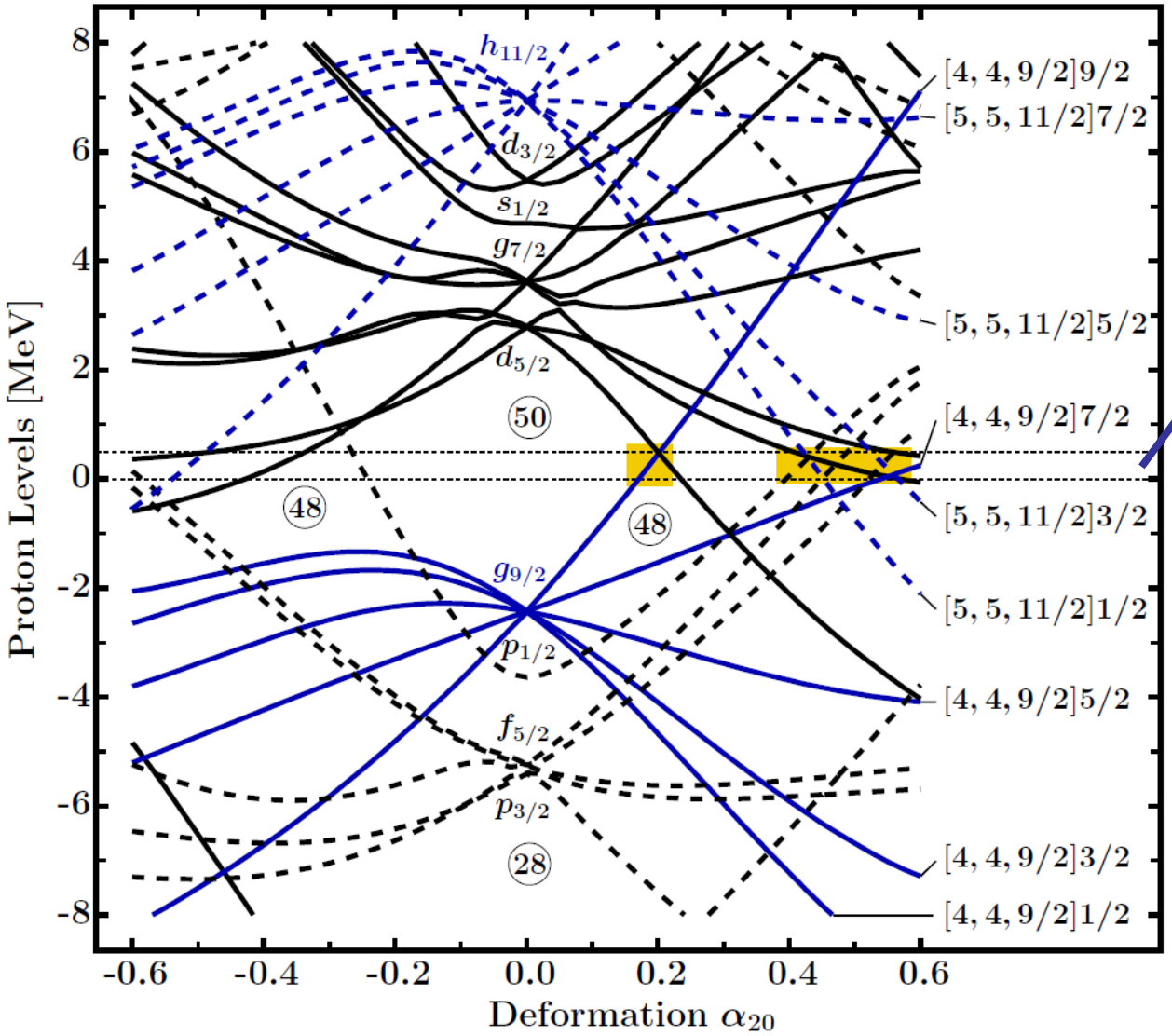


Measurement yields a ~10σ mismatch between ME of 21+, when obtaining it from 1p/2p-decay branches.

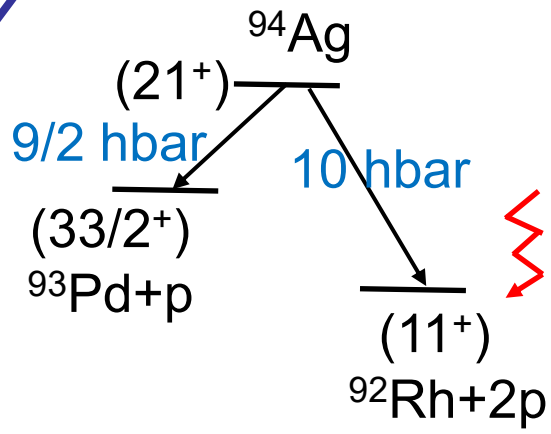
G. Kripkó-Koncz *et al.*, Phys. Rev. Research 7, L042022 (2025)



Mean-field calculations



Proton-emitting orbital with $T_{1/2} > 30$ ms



Mean-field calculations indicate that 1p and 2p decay should occur from two different isomers

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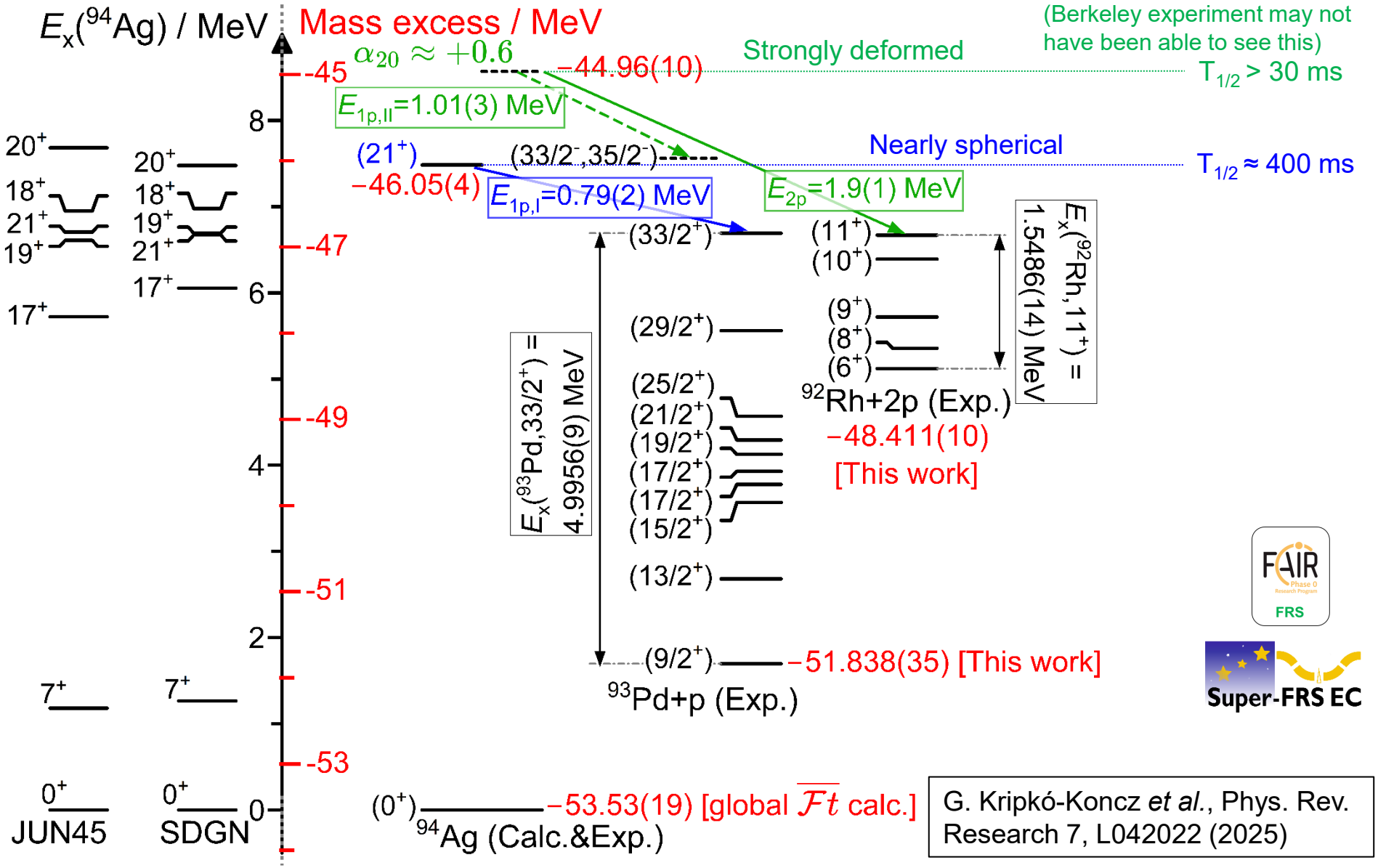
One possible scenario, which is “consistent with all”



G. Kripkó-Koncz *et al.*, Phys. Rev. Research 7, L042022 (2025)

Acknowledgements

Super-FRS Experiment Collaboration

FRS Ion Catcher

D. Amanbayev, O. Aviv, S. Ayet San Andrés, J. Äystö, S. Bagchi, D.L. Balabanski, S. Beck, O. Beliuskina, J. Bergmann, A. Blazhev, K. Botsiou, Z. Brencic, S. Cannarozzo, V. Charviakova, P. Constantin, D. Curien, I. Dedes, T. Dickel, F. Didierjean, G. Duchene, J. Dudek, T. Eronen, T. Fowler-Davis, M. Friedman, Z. Ge, H. Geissel, S. Glöckner, M. Górska, T. Grahn, F. Greiner, L. Gröf, M. Gupta, E. Haettner, M. Harakeh, J. Harkin, C. Hornung, W. Huang, Y. Ito, A. Jaries, A. Jokinen, N. Kalantar-Nayestanaki, A. Kankainen, D. Kar, A. Karpov, N. Keeppalli, Y. Kehat, K. Khokhar, D. Kostyleva, G. Kripkó-Koncz, D. Kumar, B. Lehnert, K. Mahajan, I. Mardor, A.A. Mehmandoost-Khajeh-Dad, N. Minkov, A. Mollaebrahimi, D. Morrissey, I. Mukha, M. Narang, Z. Patyk, H. Penttilä, A. Perry, S. Pietri, A. Pikhtelev, W.R. Plaß, I. Pohjalainen, S. Pomp, R.K.Prajapat, S. Purushothaman, M.P. Reiter, M. Reponen, H. Rösch, A. Rotaru, J. Ruotsalainen, C. Scheidenberger, P. Schury, A. Shrayer, M. Simonov, S.K. Singh, A. Solders, A. Spataru, A. State, N. Steinbrenner, Y. Tanaka, P. Thirolf, Y. Tian, N. Tortorelli, F. Uhlemann, L. Varga, M. Vencelj, V. Virtanen, M. Wada, H. Weick, L. Welde, M. Will, H. Wilsenach, M.I. Yavor, J. Yu, A. Zadvornaya, J. Zhao, K. Zuber

FAIR Phase 0 Research Program

FRS

The results presented here are based on the experiment S474, which was performed at the FRS at the GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany) in the context of FAIR Phase-0

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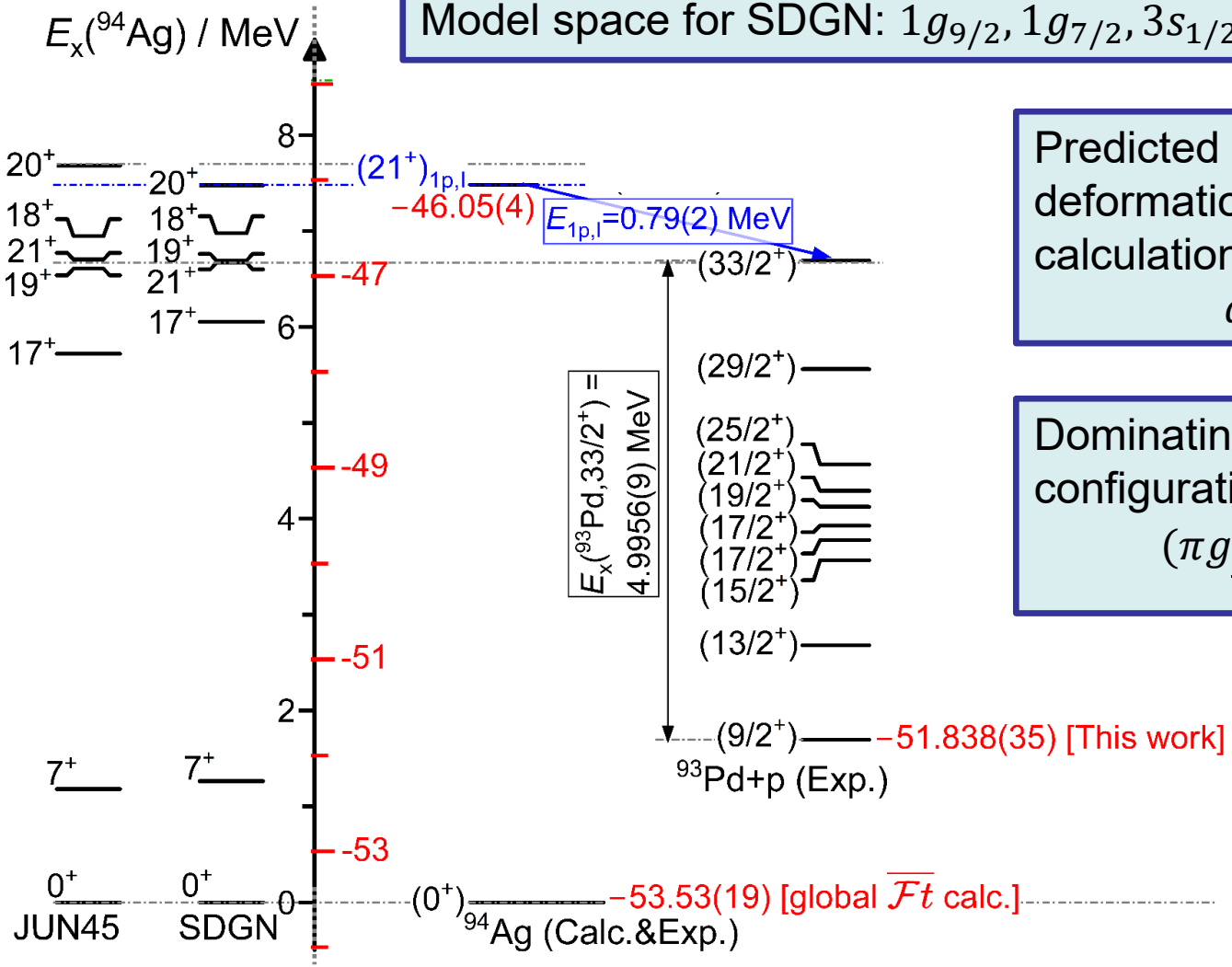
Backup slides

Shell-model calculations

Model space for JUN45: $2p_{3/2}, 1f_{5/2}, 2p_{1/2}, 1g_{9/2}$
Model space for SDGN: $1g_{9/2}, 1g_{7/2}, 3s_{1/2}, 2d_{5/2}, 2d_{3/2}$



Predicted small prolate deformation using DNO-SM calculations:

$$\alpha_{20} < 0.1$$

Dominating single-particle configuration for 21_1^+:

$$(\pi g_{\frac{9}{2}}^{-3}\ \nu g_{\frac{9}{2}}^{-3})_{21}$$

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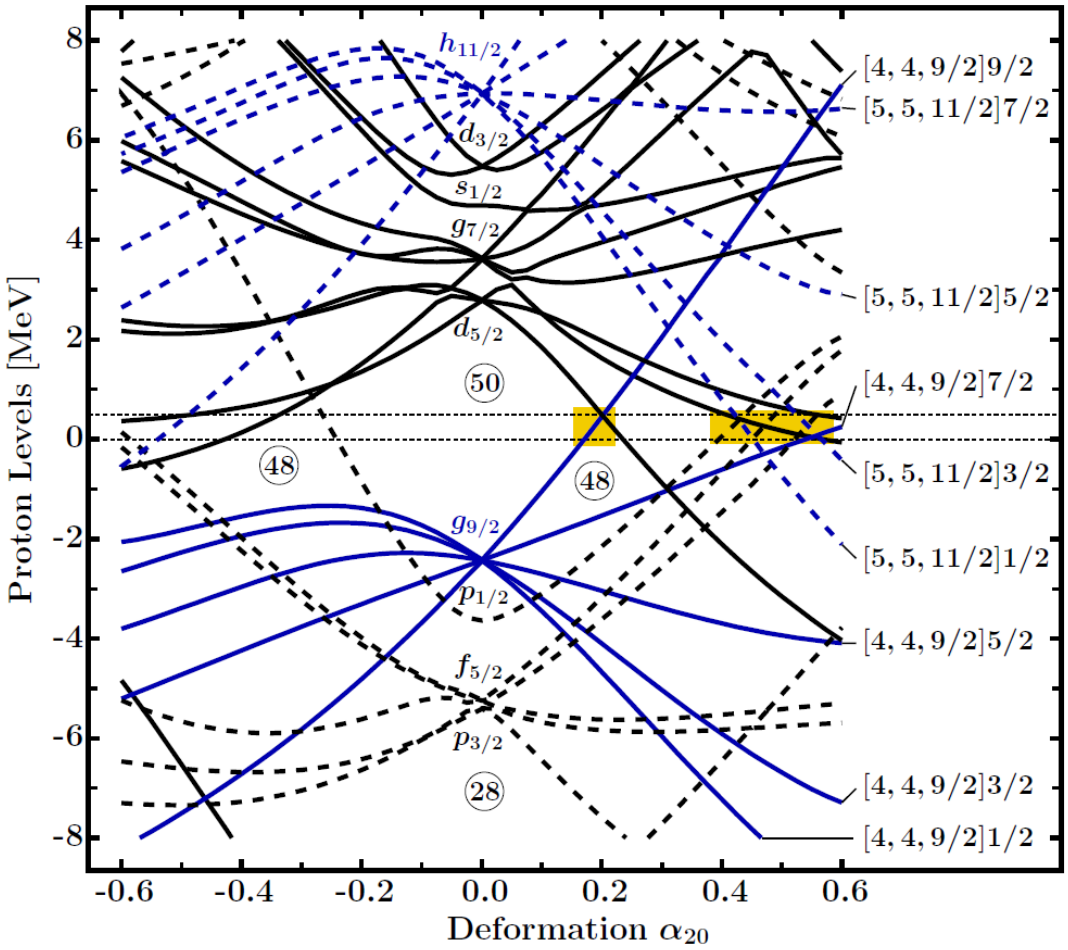
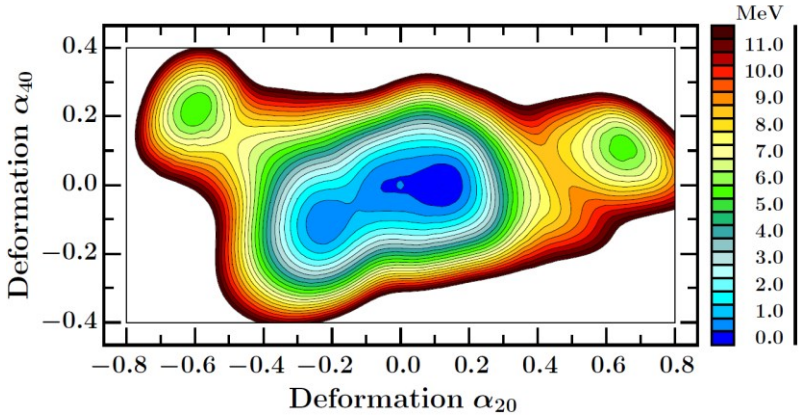


Concerning the normal-deformed states: a 21^+ state is predicted as a spin-trap isomer with dominating single-particle configuration of $(\pi g_{\frac{9}{2}}^{-3}\ \nu g_{\frac{9}{2}}^{-3})_{21}$



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