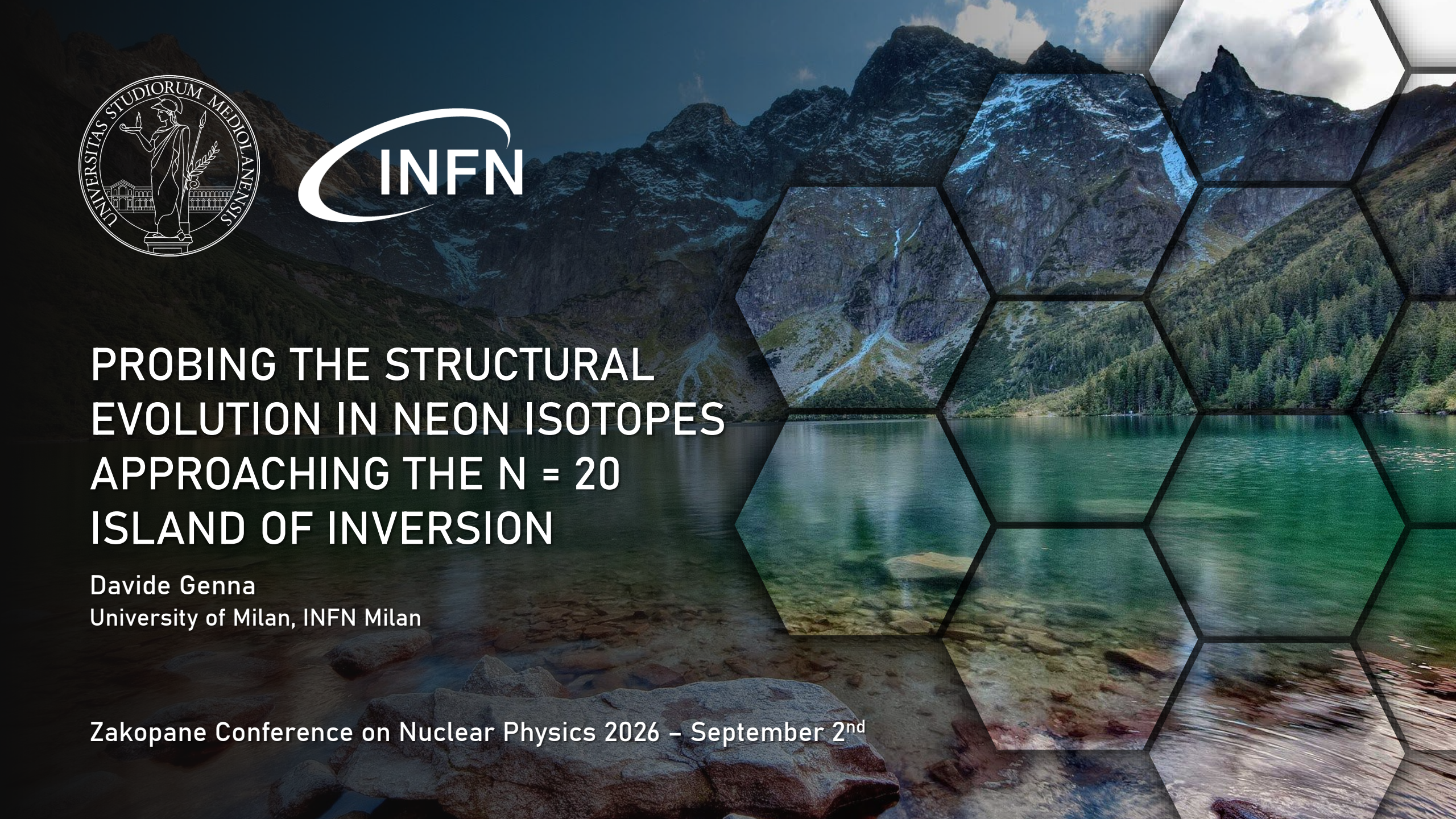

PROBING THE STRUCTURAL EVOLUTION IN NEON ISOTOPES APPROACHING THE N = 20 ISLAND OF INVERSION

Davide Genna
University of Milan, INFN Milan

Zakopane Conference on Nuclear Physics 2026 – September 2nd

D. Genna[1,2], F. Drent[3], K. Wimmer[3] , S. Bottoni[1,2], P. Aguilera[4], G. Benzoni[2], F. Recchia[5,6], G. Andreetta[5,6], F. Angelini[3], M. Balogh[7], J. Bardak[3,8], J. Benito[9], B. Bles[3,8], A. Bracco[1,2], D. Brugnara[9], S. Carollo[5,6], Z. Chen[3], F. Conca[1,2], L. Corradi[9], G. Corbari[1,2], F. C. L. Crespi[1,2], M. del Fabbro[10], A. Ertoprak[5,6], E. Fioretto[9], F. Galtarossa[5], A. Giaz[2], A. Goasduff[9], B. Gongora Servin[9], A. Gottardo[9], Gozzelino[9], B. Greaves[9], A. Jungclaus[11], T. Kröll[7], G. Kosir[12], S. Leoni[1,2], M. Luciani[1,2], R. Menegazzo[6], D. Mengoni[5,6], B. Million[2], G. Montagnoli[6], R. Nicolás del Álamo[5,6], J. Pellumaj[5,6], R. Pérez-Vidal[13], S. Pigliapoco[14], E. Pilotto[9], W. Poklepa[3], M. Polettini[3,15], K. Rezynkina[5,6], M. Rocchini[16], E. Ronning[9], M. Sedlak[7], F. Simioni[5,6], A. Stefanini[6], A. Togni[5,6], J. J. Valiente-Dobón[13], J. Vesic[12], L. Zago[17], I. Zanon[18].

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[2] INFN Sezione di Milano, Italy
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[4] Comisión Chilena de Energía Nuclear (CCHEN), Chile
[5] Dipartimento di Fisica, Università degli Studi di Padova, Italy
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[7] Institute of Physics of the Slovak Academy of Sciences, Slovakia
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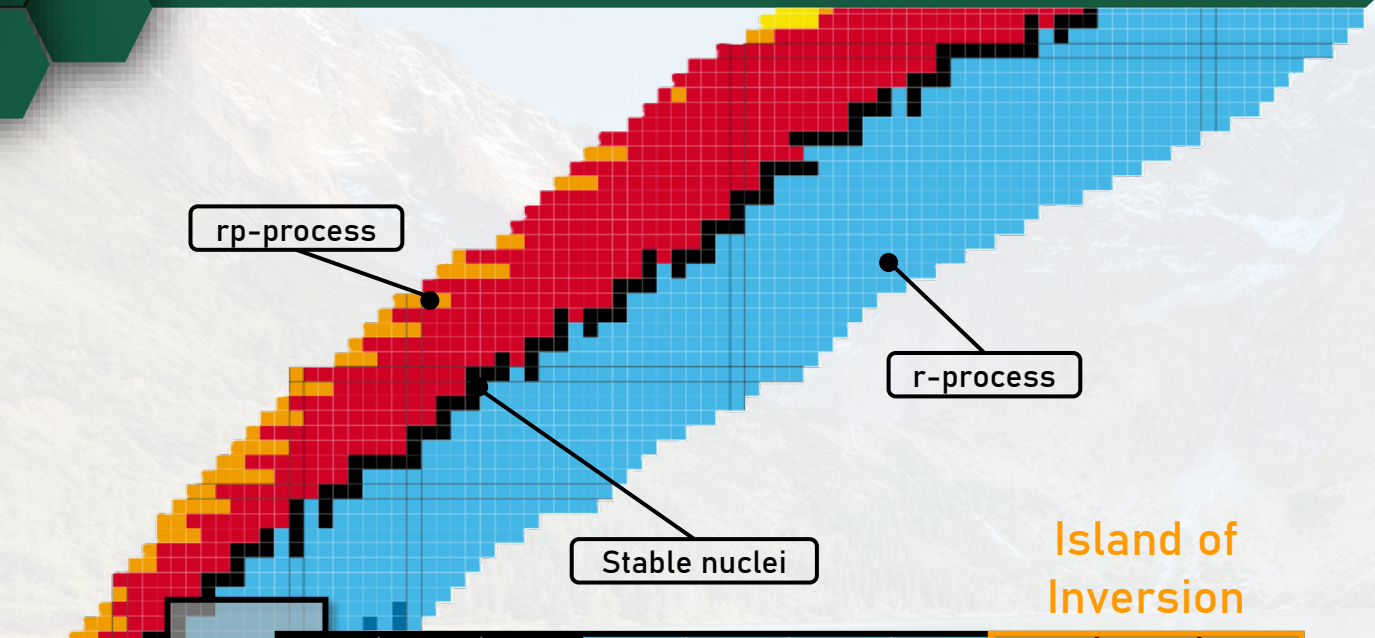
[10] Ruđer Bošković Institute, Croatia
[11] CSIC Madrid, Spain
[12] Jožef Stefan Institute, Slovenia
[13] IFIC Universitat de València, Spain
[14] Grand Accélérateur National d'Ions Lourds, France
[15] Facility for Antiproton and Ion Research in Europe GmbH (FAIR GmbH), Germany
[16] INFN Sezione di Firenze, Italy
[17] Institut de Physique des Deux Infinis de Lyon, France
[18] KTH Royal Institute of Technology, Sweden

Zakopane Conference on Nuclear Physics 2026 – September 2nd

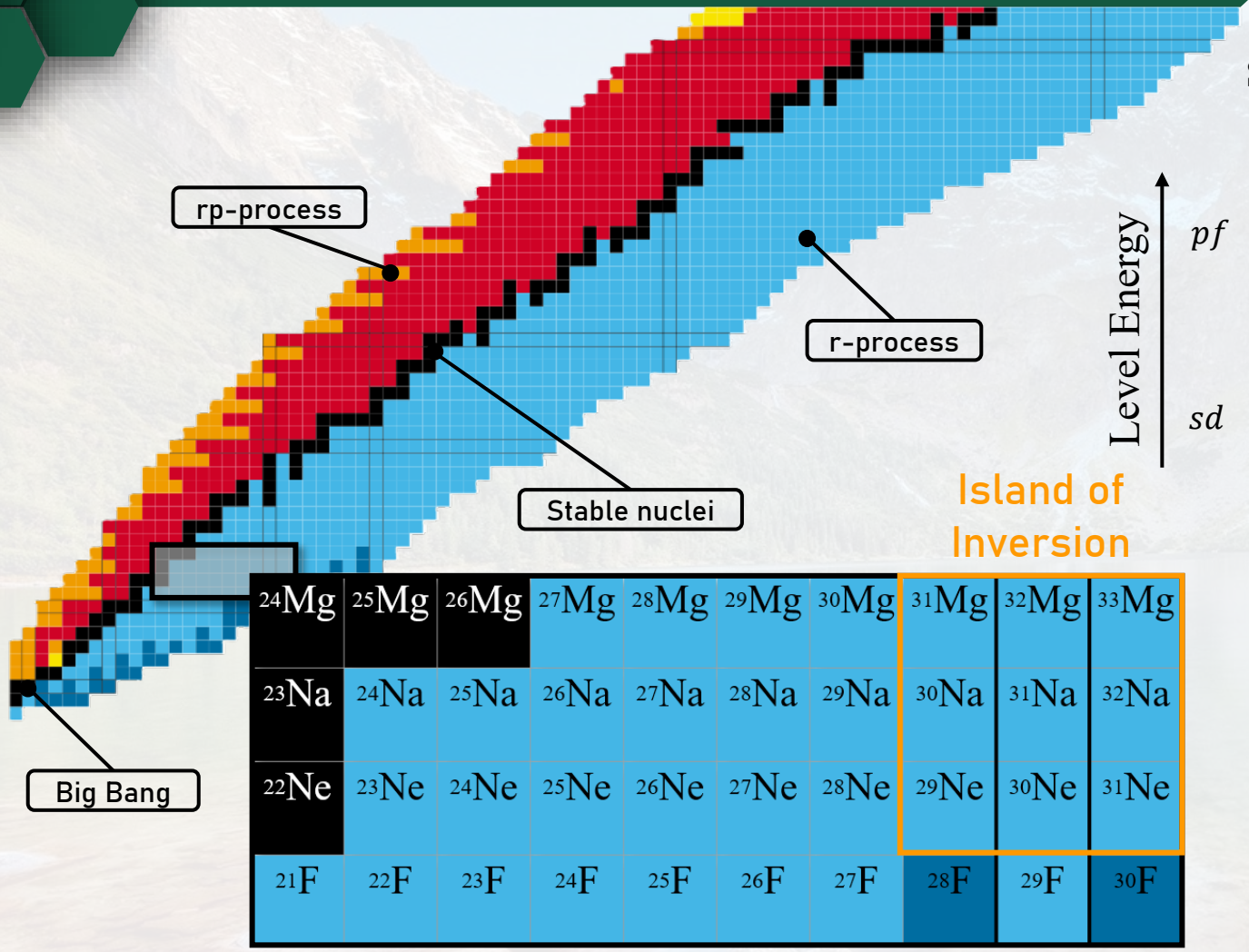
The N = 20 Island of Inversion



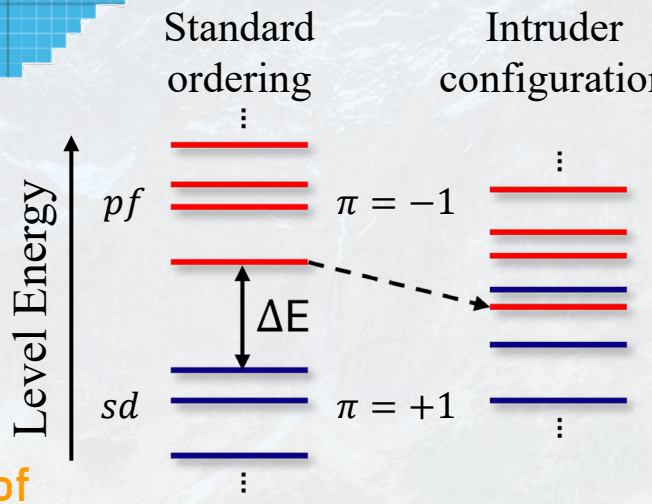
Island of Inversion

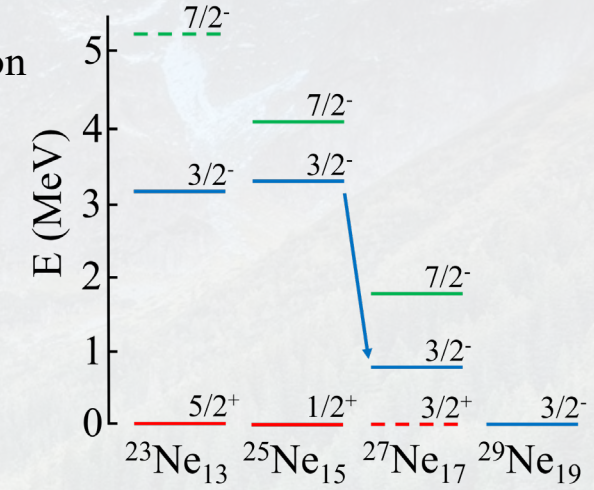
^{24}Mg	^{25}Mg	^{26}Mg	^{27}Mg	^{28}Mg	^{29}Mg	^{30}Mg	^{31}Mg	^{32}Mg	^{33}Mg
^{23}Na	^{24}Na	^{25}Na	^{26}Na	^{27}Na	^{28}Na	^{29}Na	^{30}Na	^{31}Na	^{32}Na
^{22}Ne	^{23}Ne	^{24}Ne	^{25}Ne	^{26}Ne	^{27}Ne	^{28}Ne	^{29}Ne	^{30}Ne	^{31}Ne
^{21}F	^{22}F	^{23}F	^{24}F	^{25}F	^{26}F	^{27}F	^{28}F	^{29}F	^{30}F

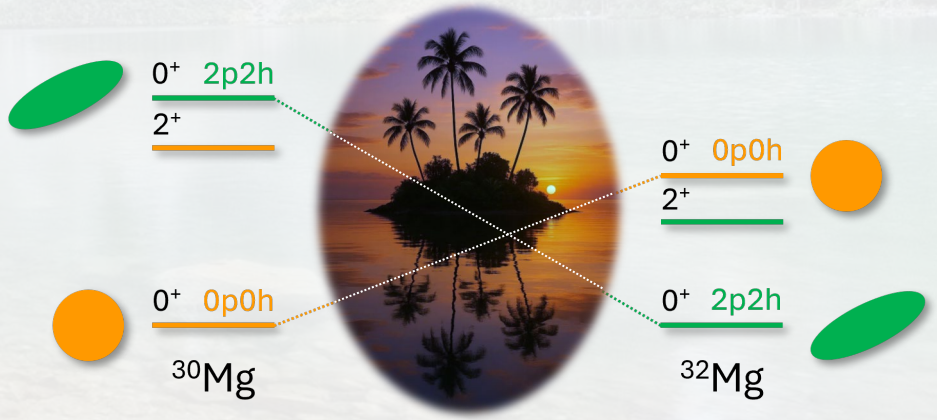
The N = 20 Island of Inversion



^{24}Mg	^{25}Mg	^{26}Mg	^{27}Mg	^{28}Mg	^{29}Mg	^{30}Mg	^{31}Mg	^{32}Mg	^{33}Mg
^{23}Na	^{24}Na	^{25}Na	^{26}Na	^{27}Na	^{28}Na	^{29}Na	^{30}Na	^{31}Na	^{32}Na
^{22}Ne	^{23}Ne	^{24}Ne	^{25}Ne	^{26}Ne	^{27}Ne	^{28}Ne	^{29}Ne	^{30}Ne	^{31}Ne
^{21}F	^{22}F	^{23}F	^{24}F	^{25}F	^{26}F	^{27}F	^{28}F	^{29}F	^{30}F

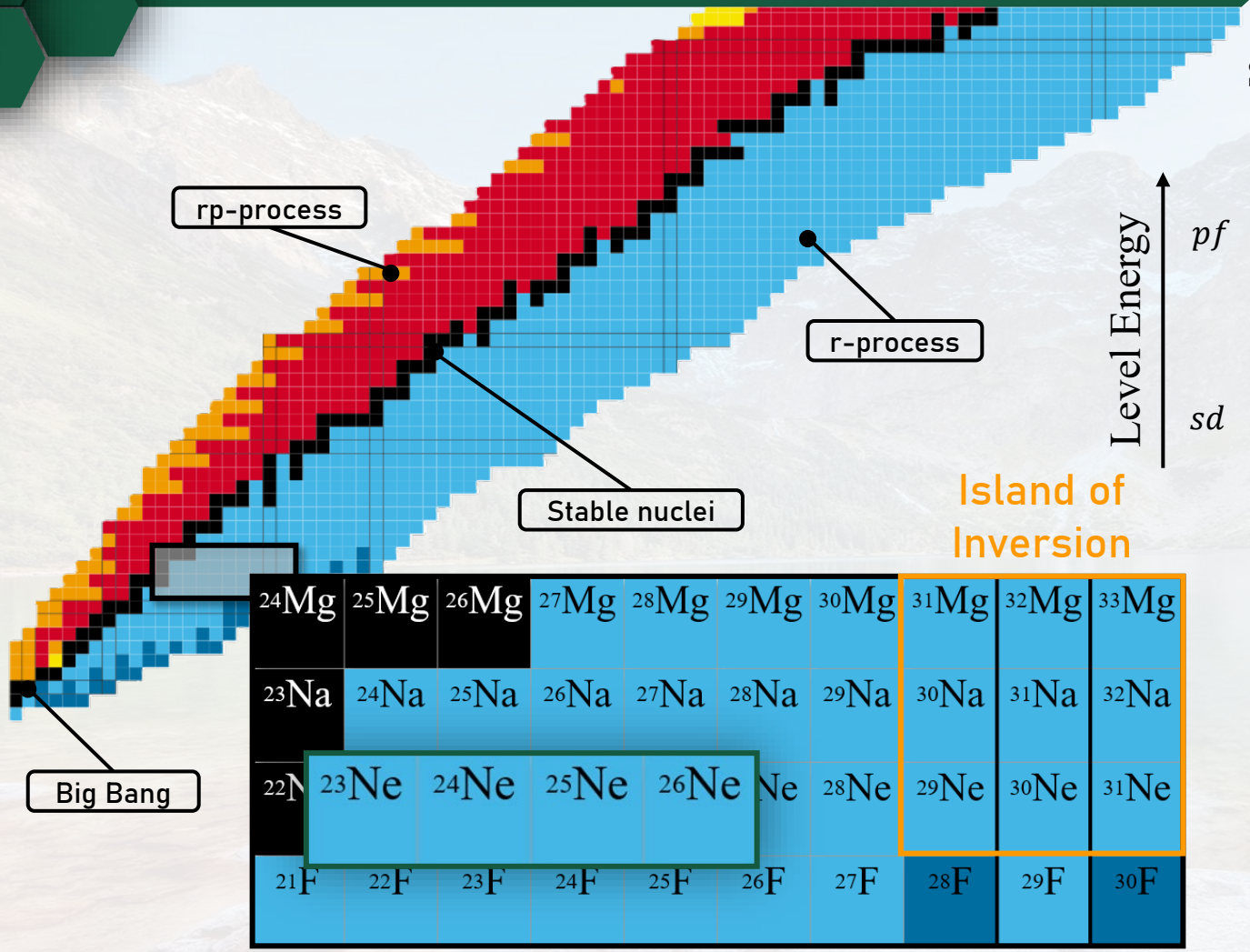


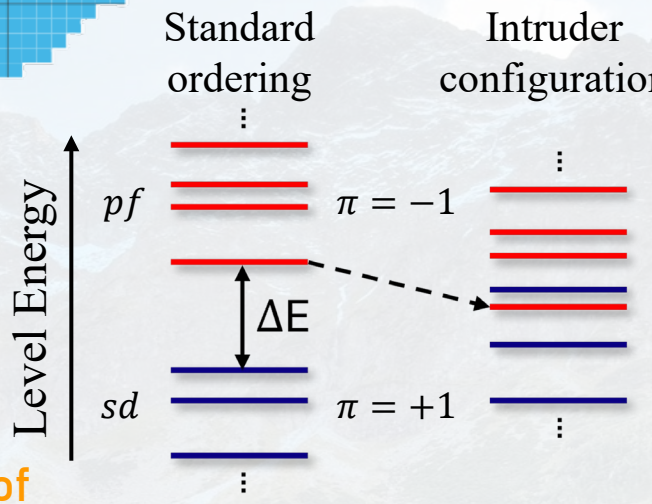


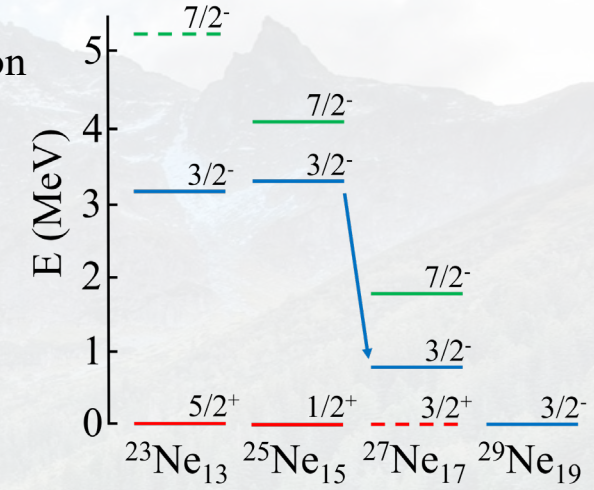


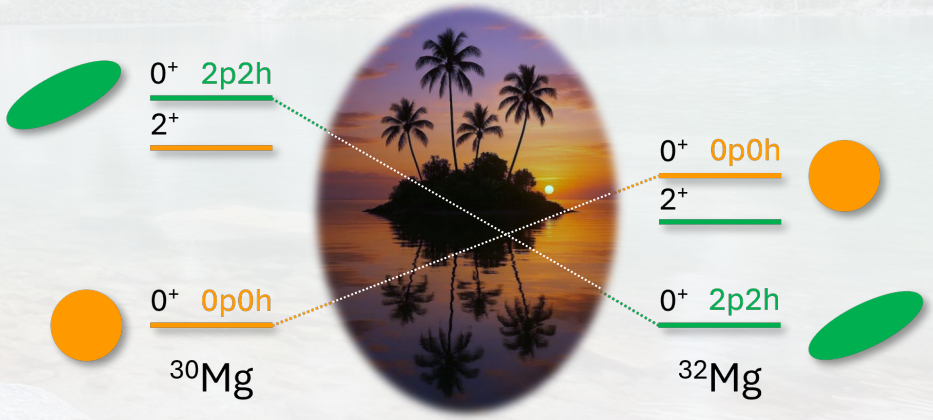
Adapted from K. Wimmer et al., Phys. Rev. Lett. 105 252501 2010

The N = 20 Island of Inversion









Adapted from K. Wimmer et al., Phys. Rev. Lett. 105 252501 2010

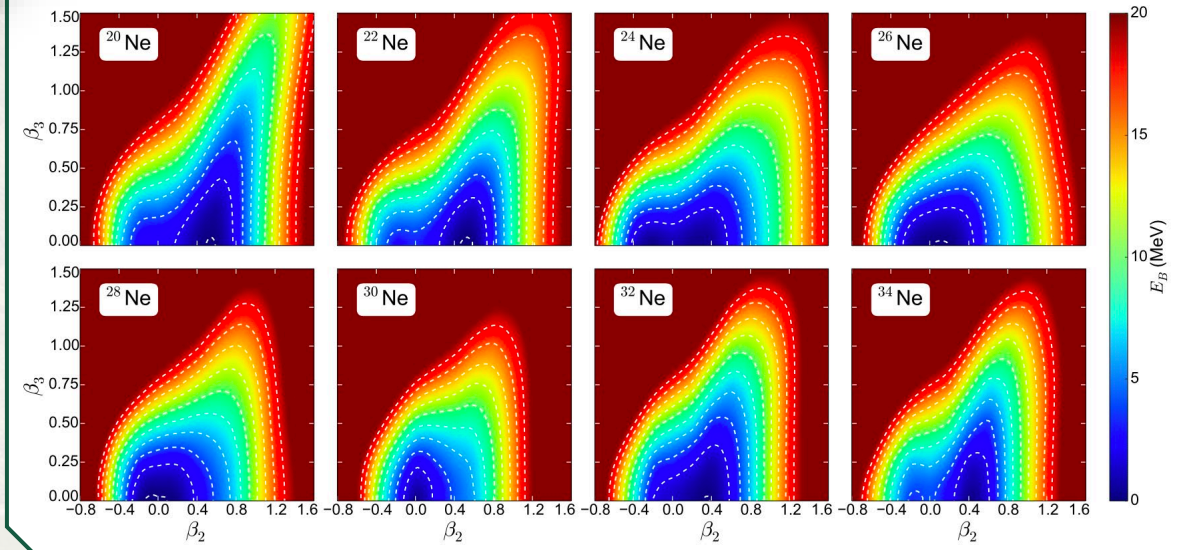
Spectroscopy and lifetime measurements for n-rich Ne isotopes

Validation for different theoretical models

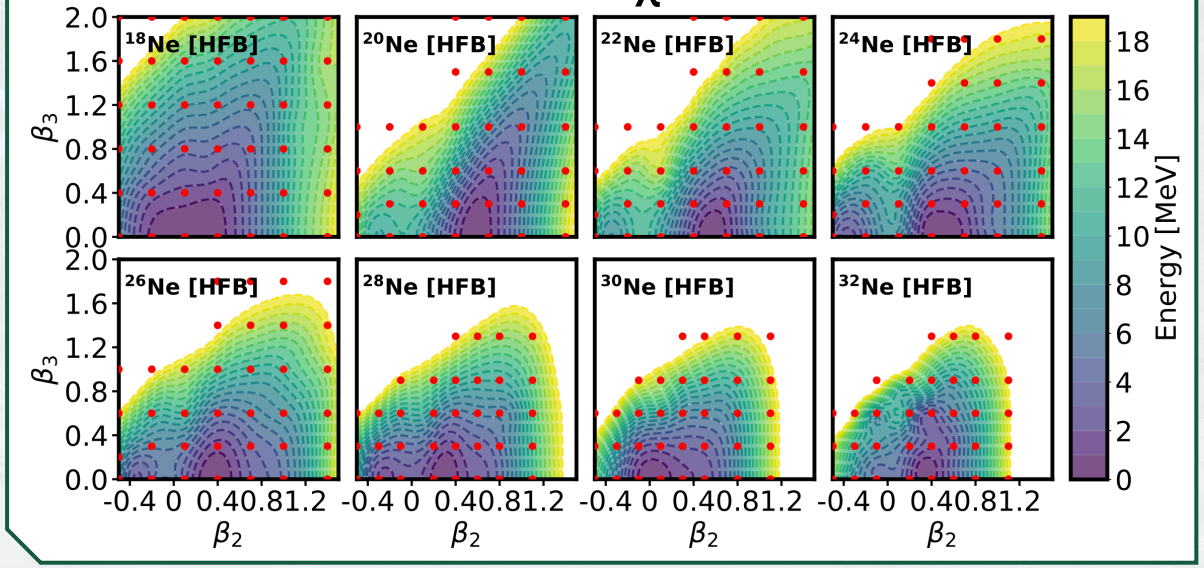
DFT and ab initio calculations

RHB: Physical Review C 97 024334 2018
PGCM, IN-NCSM: The European Physical Journal A 58:63 2022

Relativistic HFB



PGCM & IN-NCSM on χEFT Hamiltonians



DFT and ab initio calculations

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CC: Physical Review C 111 044304 2025
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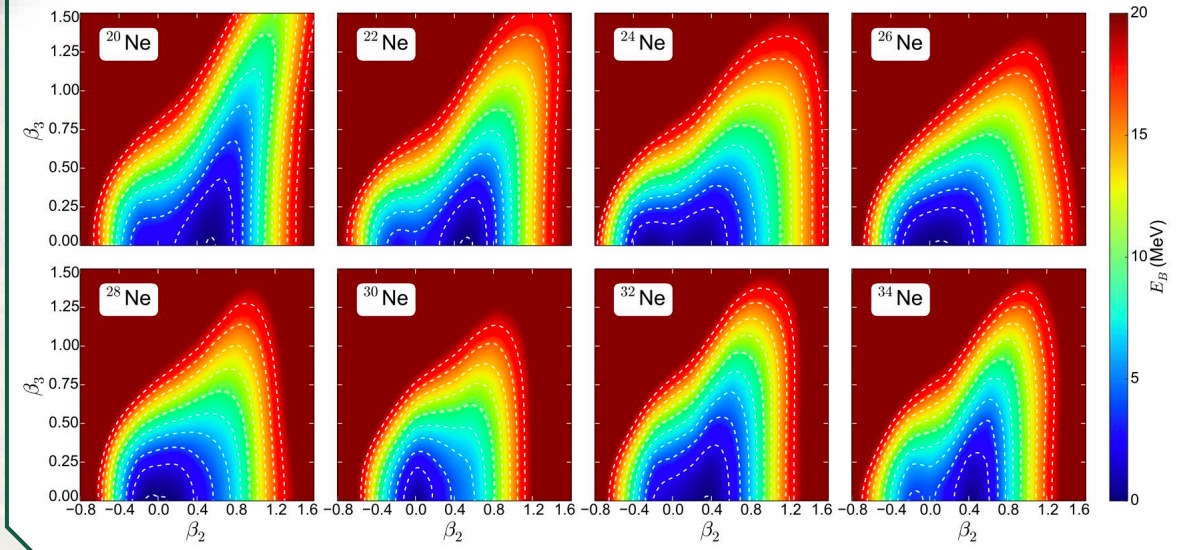
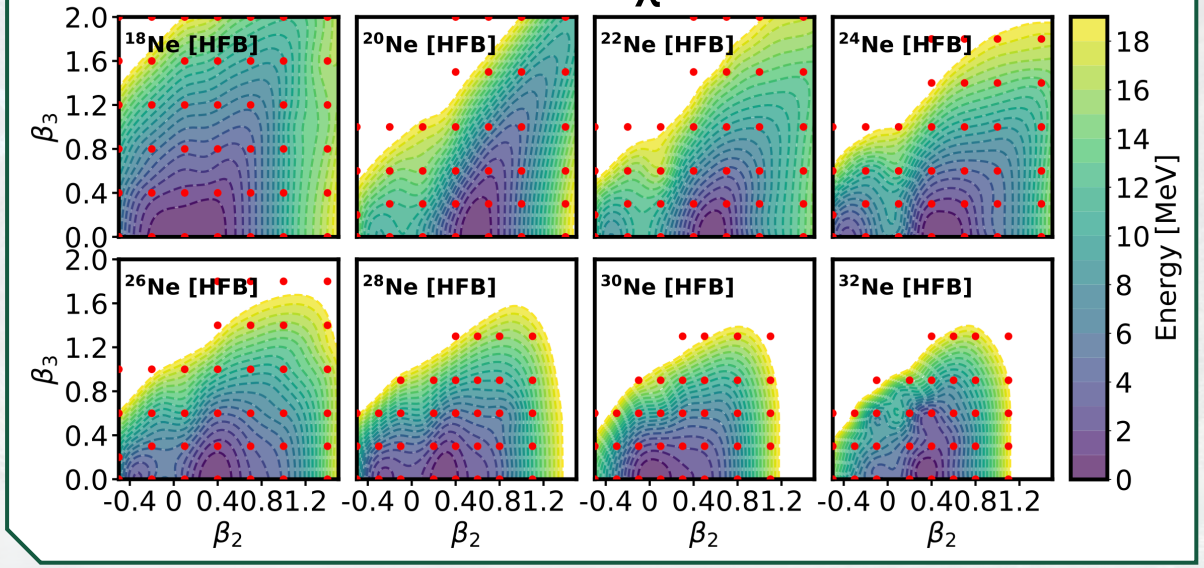
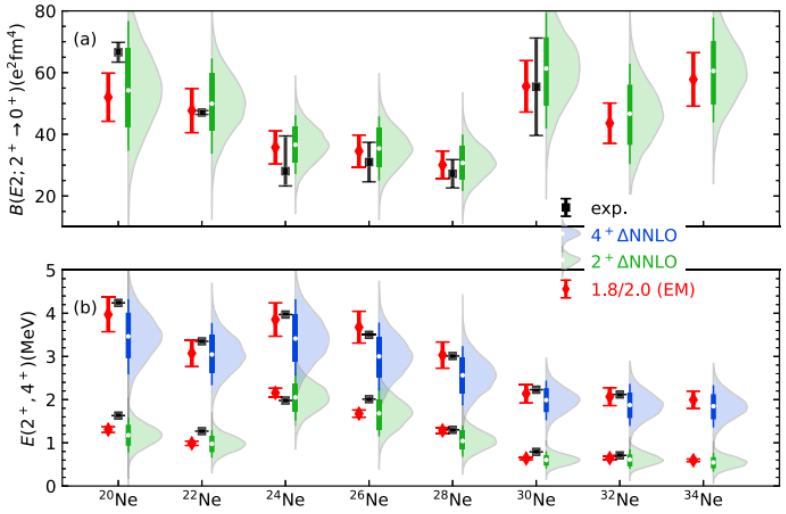
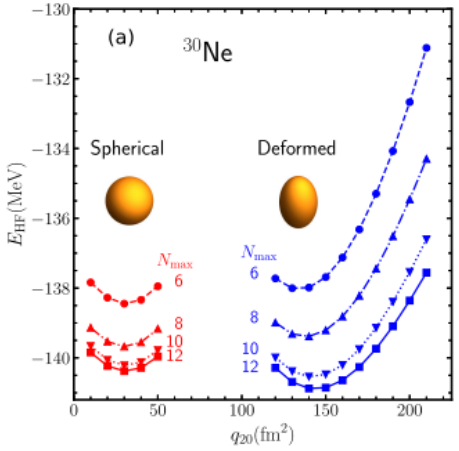


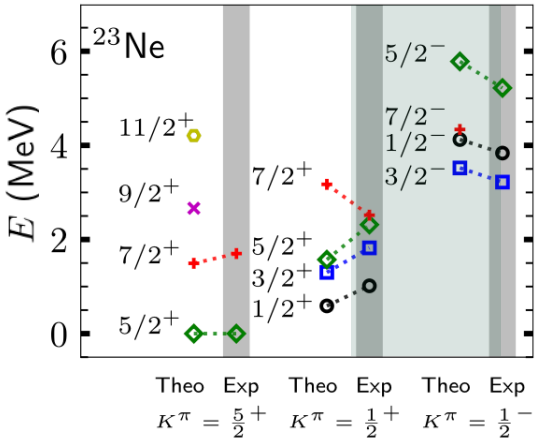
PGCM & IN-NCSM on χEFT Hamiltonians

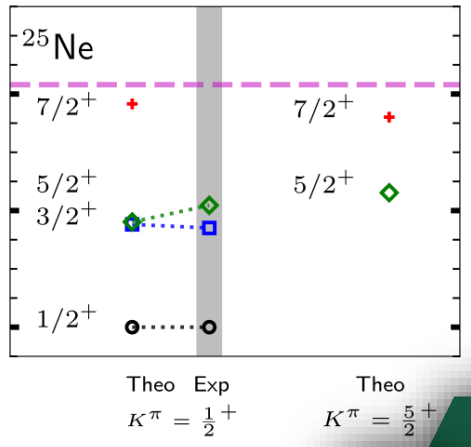


Coupled Cluster









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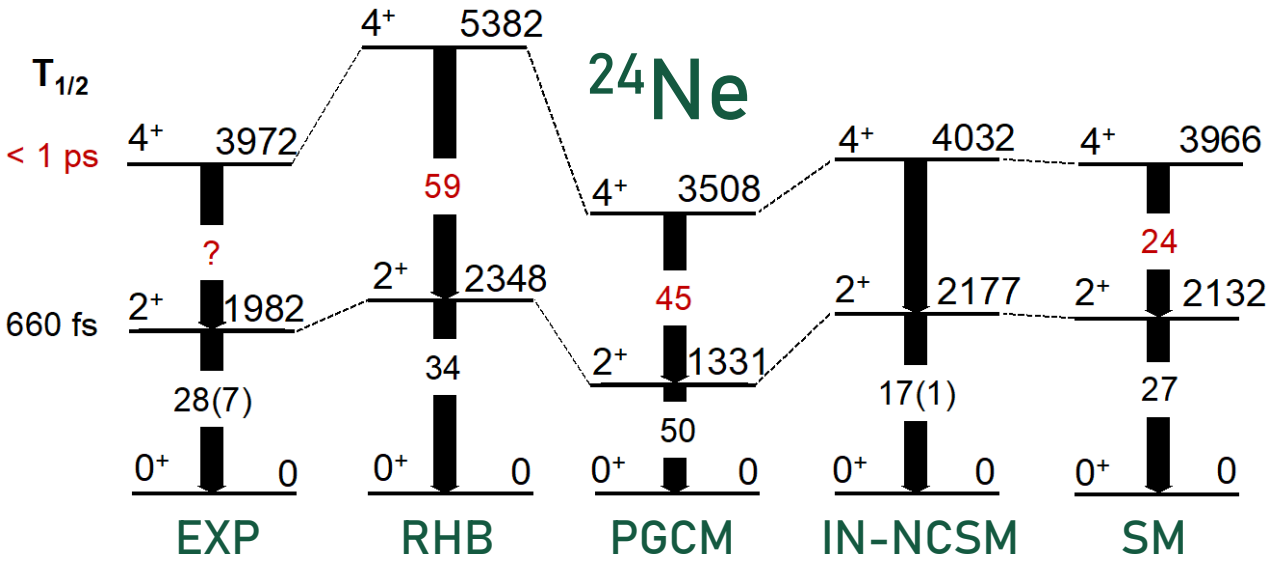
Data-models discrepancies even in less exotic nuclei

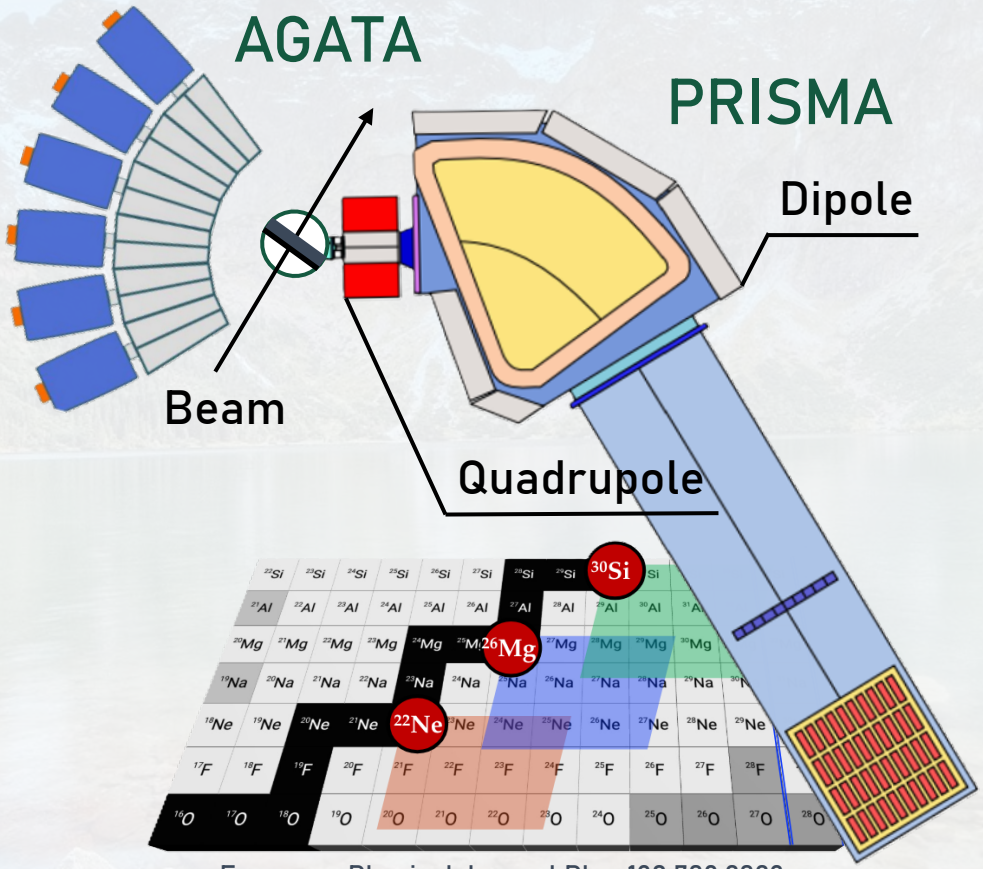
Limited experimental information



The experimental campaign

Multi-nucleon transfer reactions @LNL

AGATA-PRISMA with ^{238}U target



European Physical Journal Plus 138:709 2023

Spectroscopy and lifetimes based on clean ion-γ coincidences

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Multi-nucleon transfer reactions @LNL

AGATA-PRISMA with ^{238}U target

April 2023: ^{22}Ne + ^{238}U

Spectroscopy

^{22}Ne, 160 MeV → ^{238}U 1mg/cm^2, 54°

June 2024: ^{26}Mg + ^{238}U

Lifetime Measurements

^{26}Mg, 200 MeV → ^{238}U 1mg/cm^2 + ^{93}Nb 5mg/cm^2, 50° DSAM

May 2026: ^{22}Ne + ^{238}U

Lifetime Measurements

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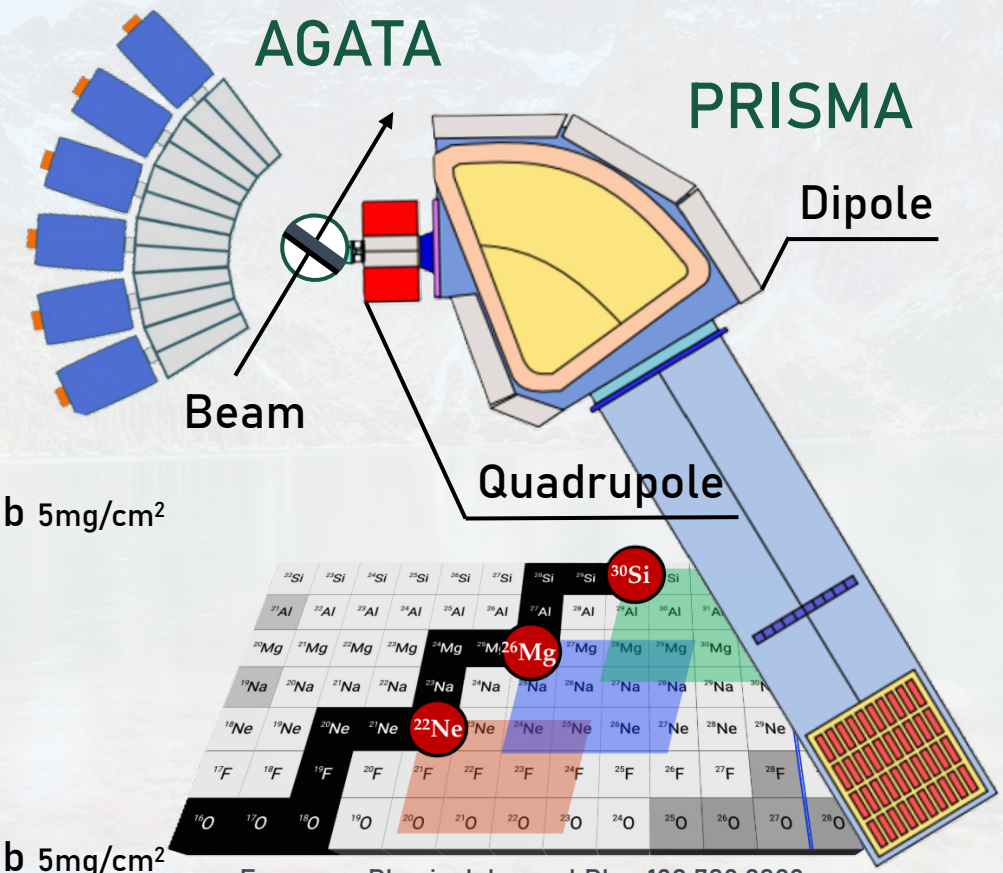

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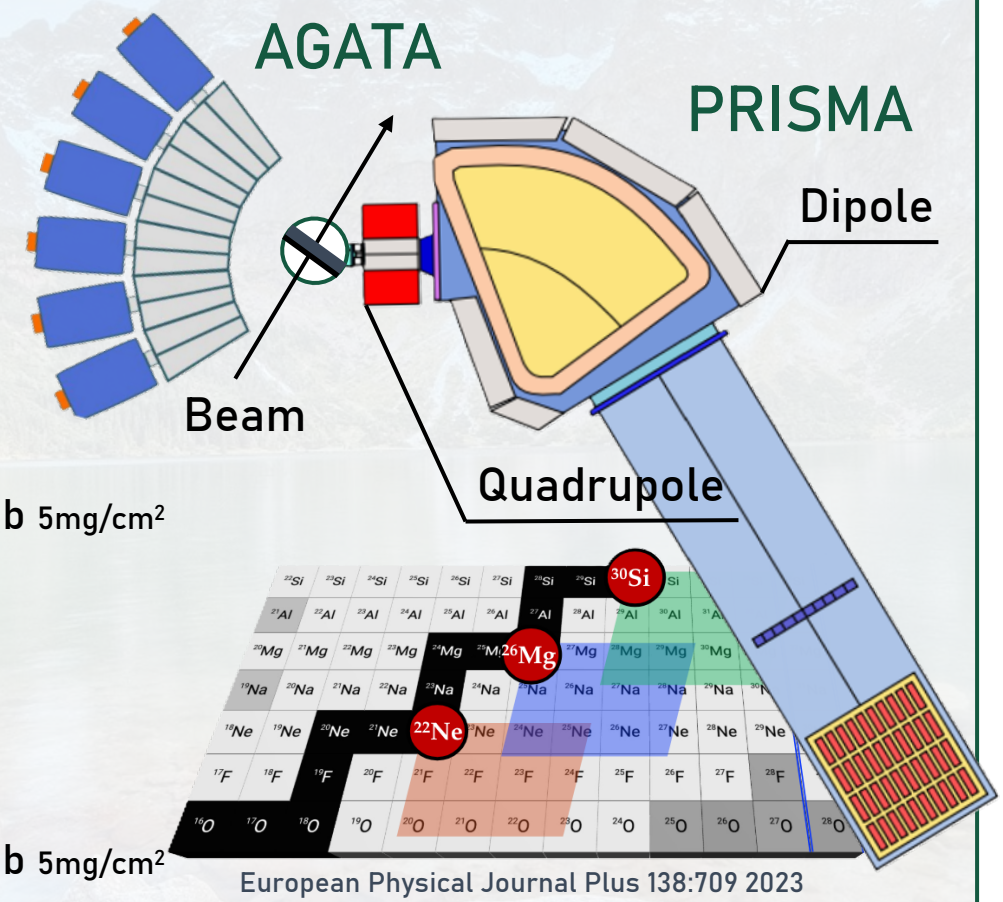

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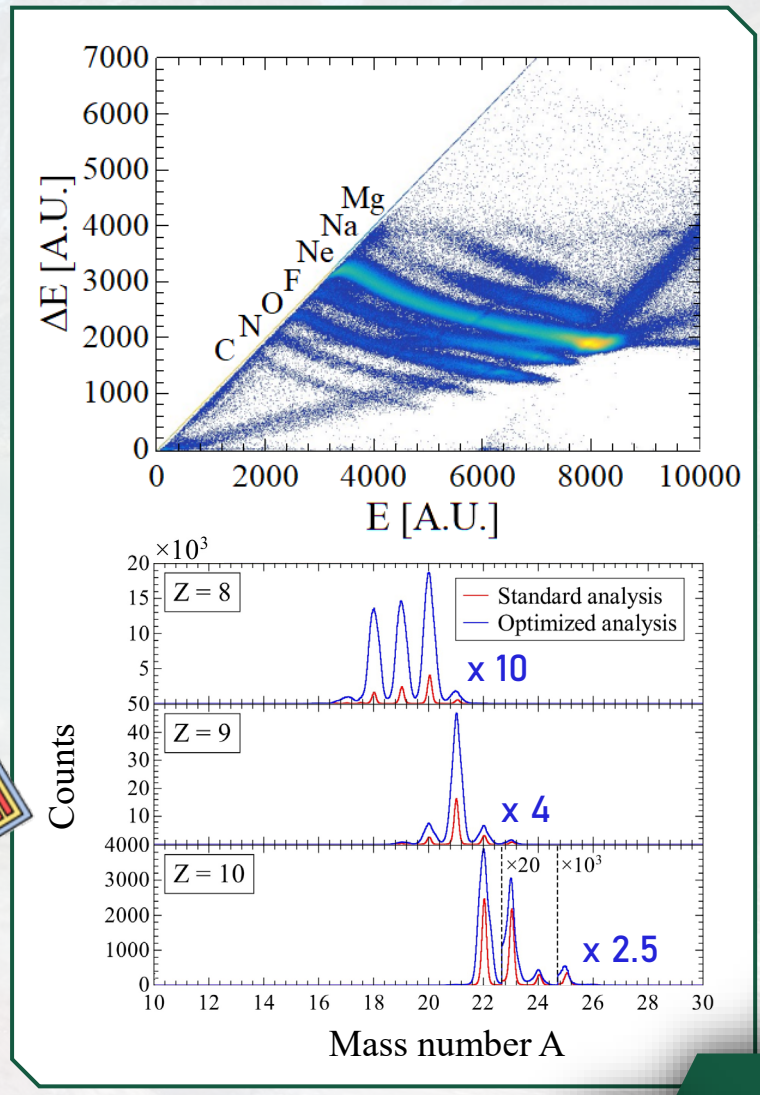
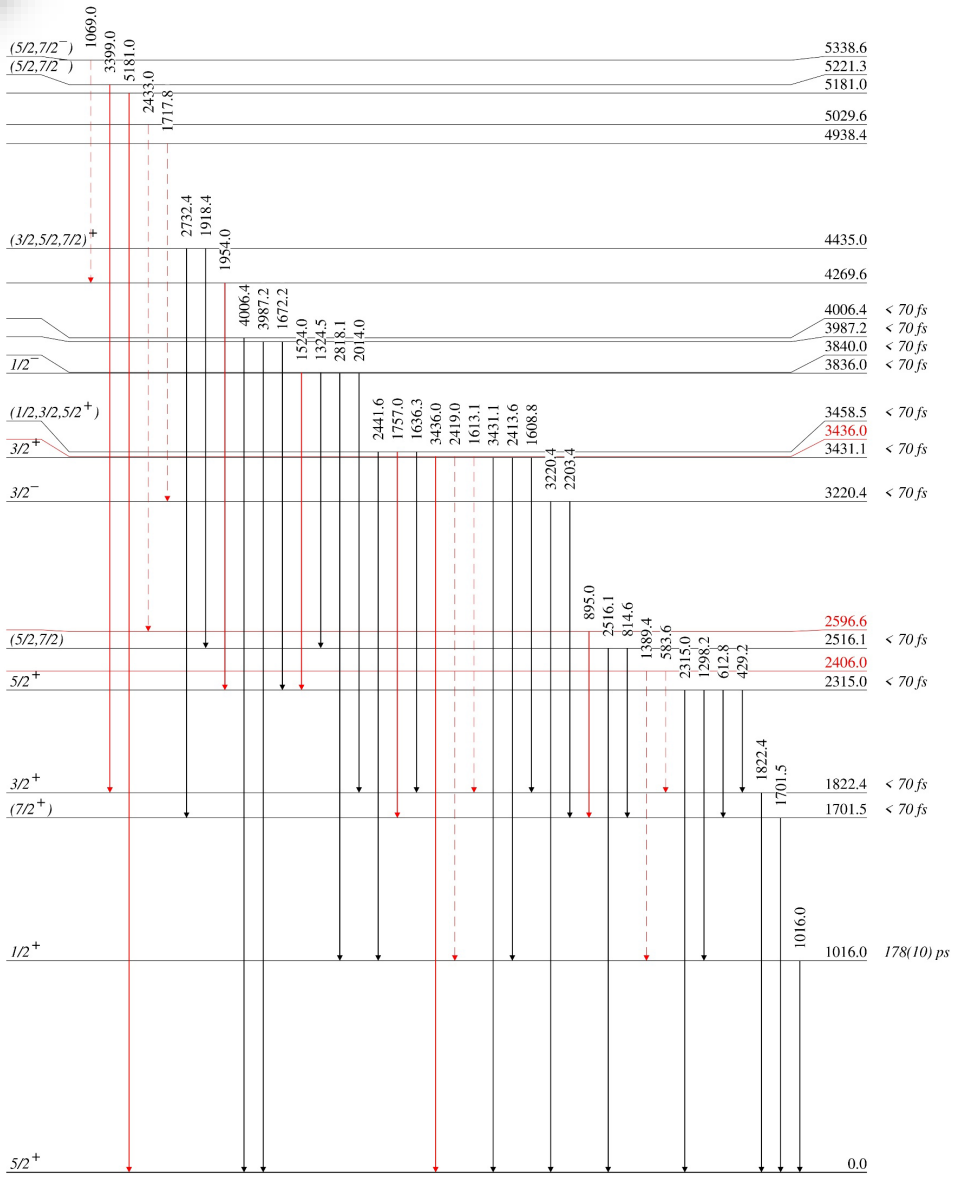
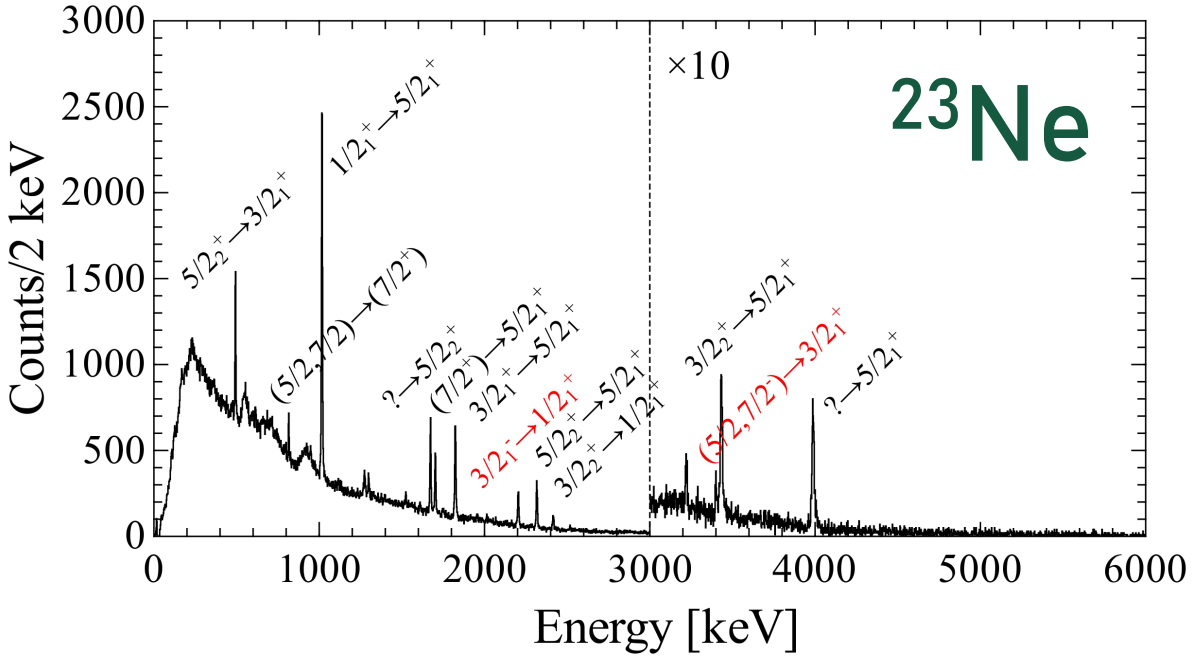


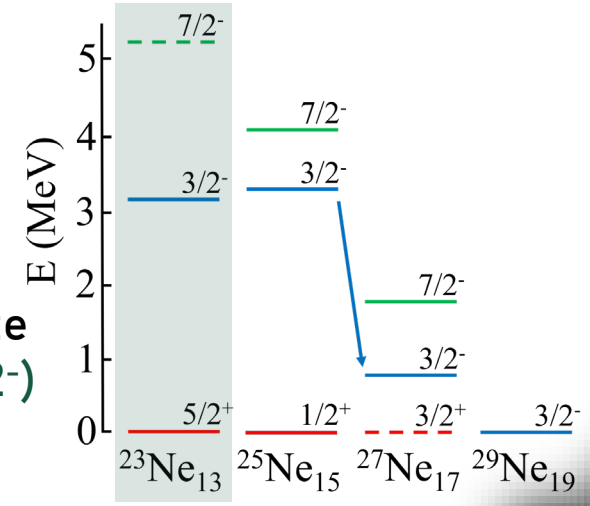
Results: Ne level schemes

Spectroscopy

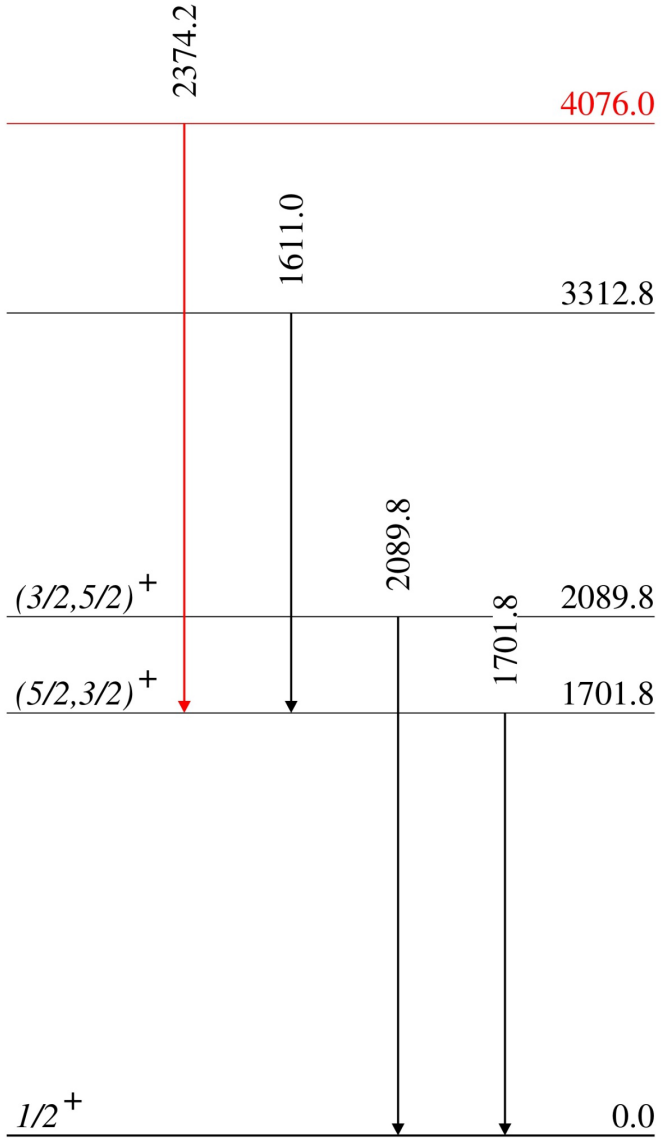


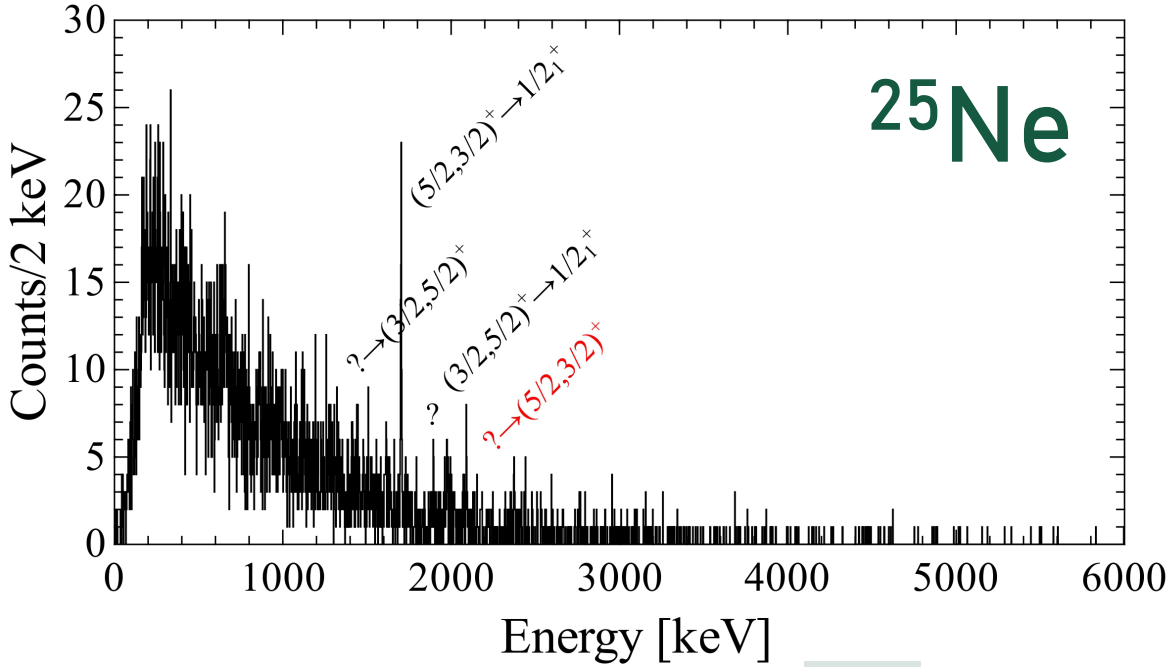


- 3 new levels added
- 7 (+6 uncertain) new observed transitions
- First transition candidate originating from (5/2,7/2⁻) state



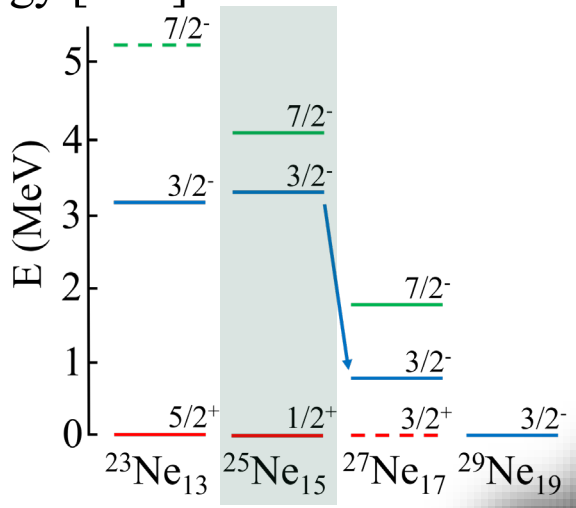
Results: Ne level schemes



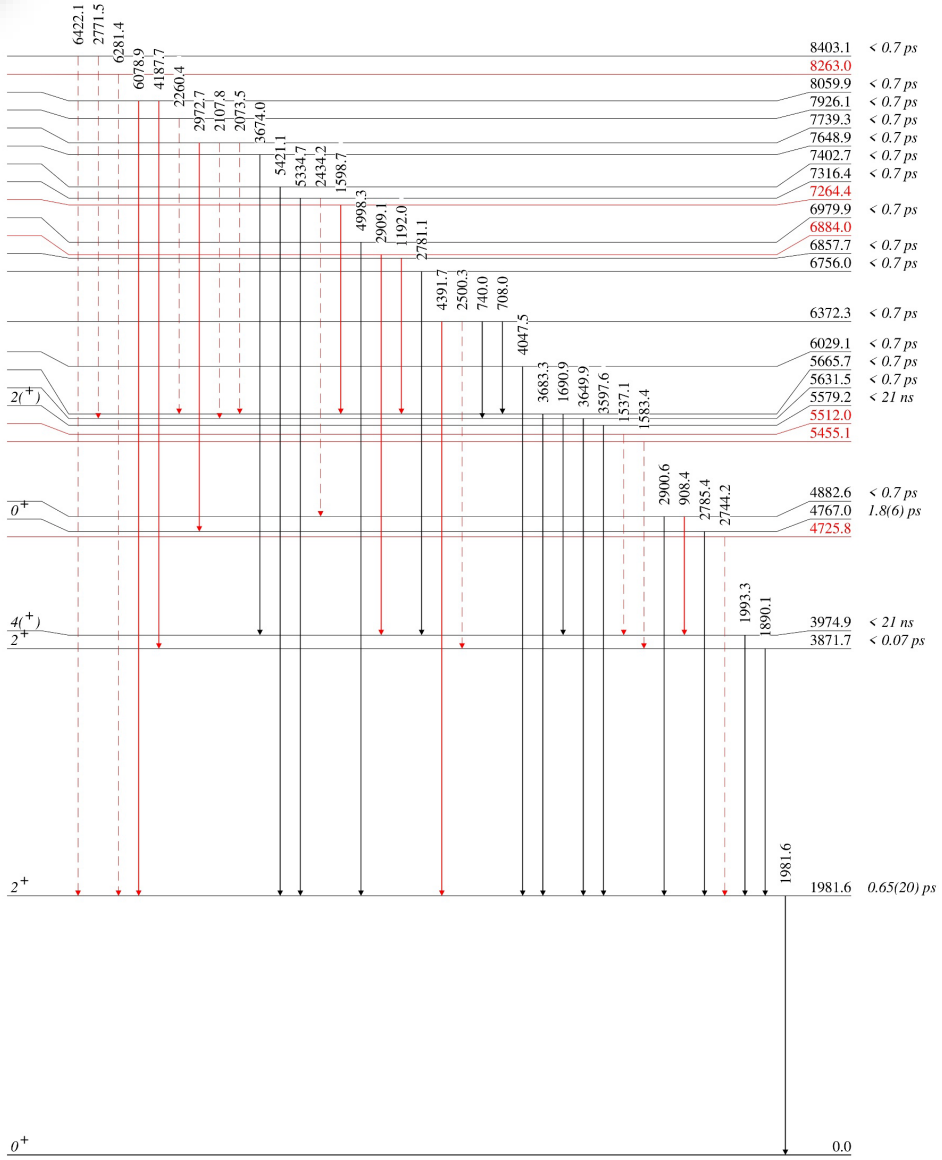


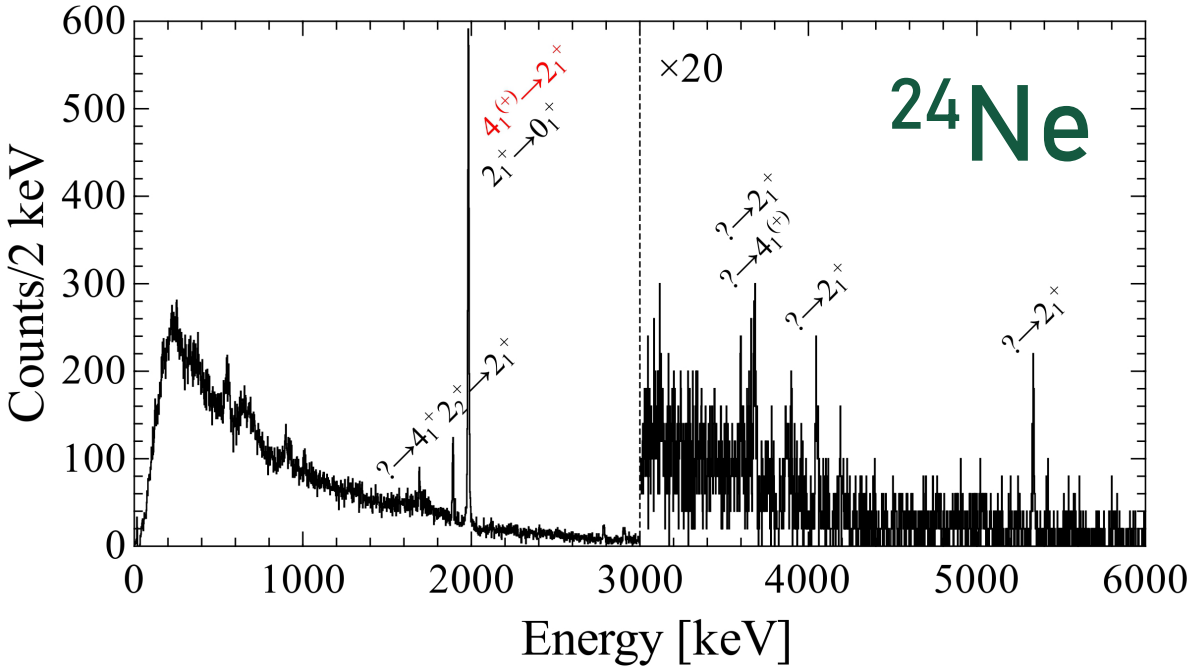
- New energy value for (7/2⁻) state
- Possible candidate originating from (7/2⁻) state

Phys. Rev. Lett. 104 192501 2010

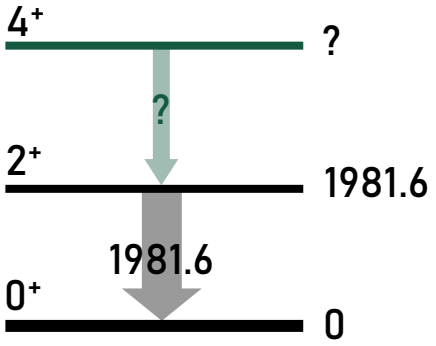


Results: Ne level schemes



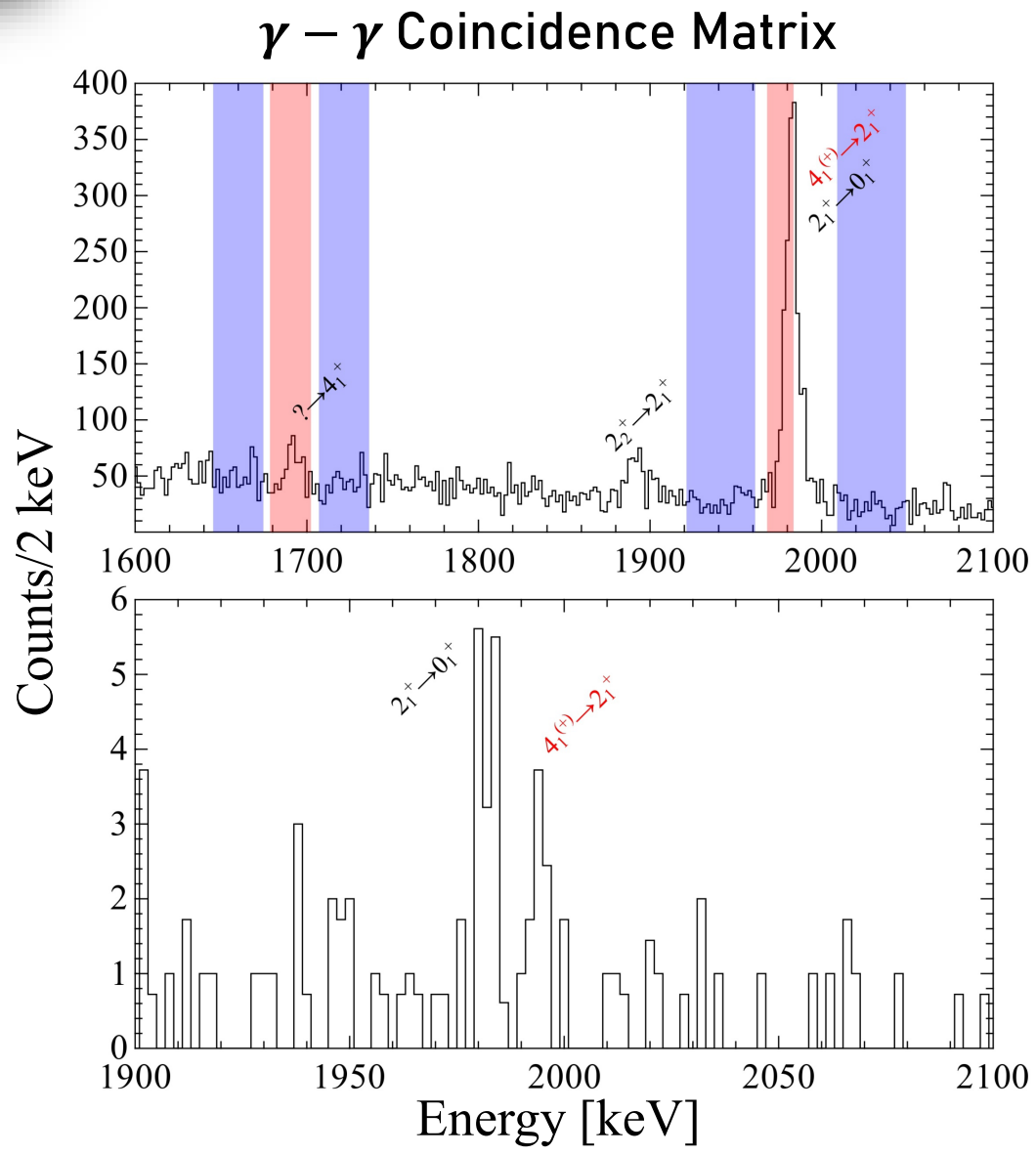


- 6 new levels added
- 8 (+11 uncertain) new observed transitions
- Focus on low energy doublet structure: 2_1^+ and 4_1^+ states



Results: ^{24}Ne energy doublet

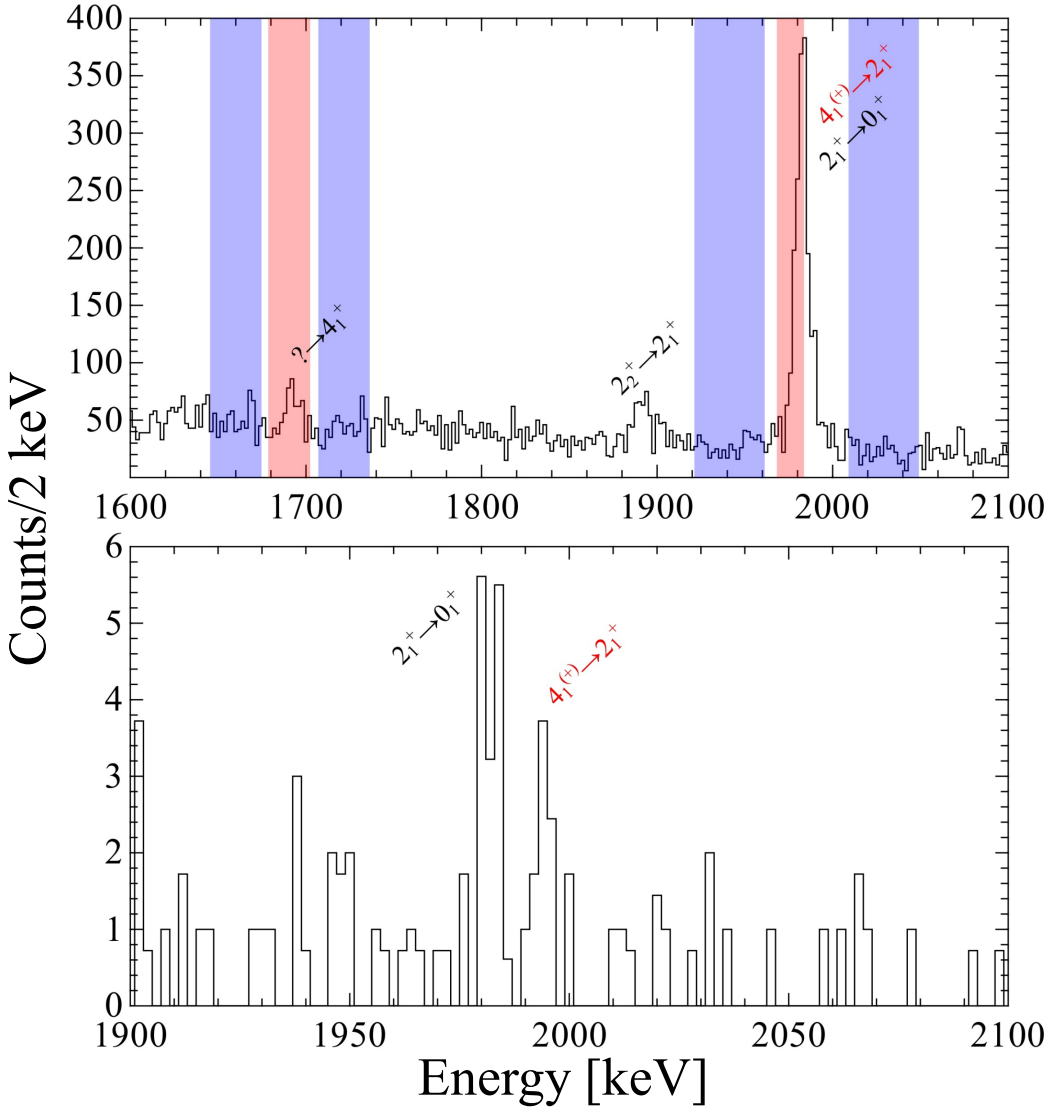
Spectroscopy



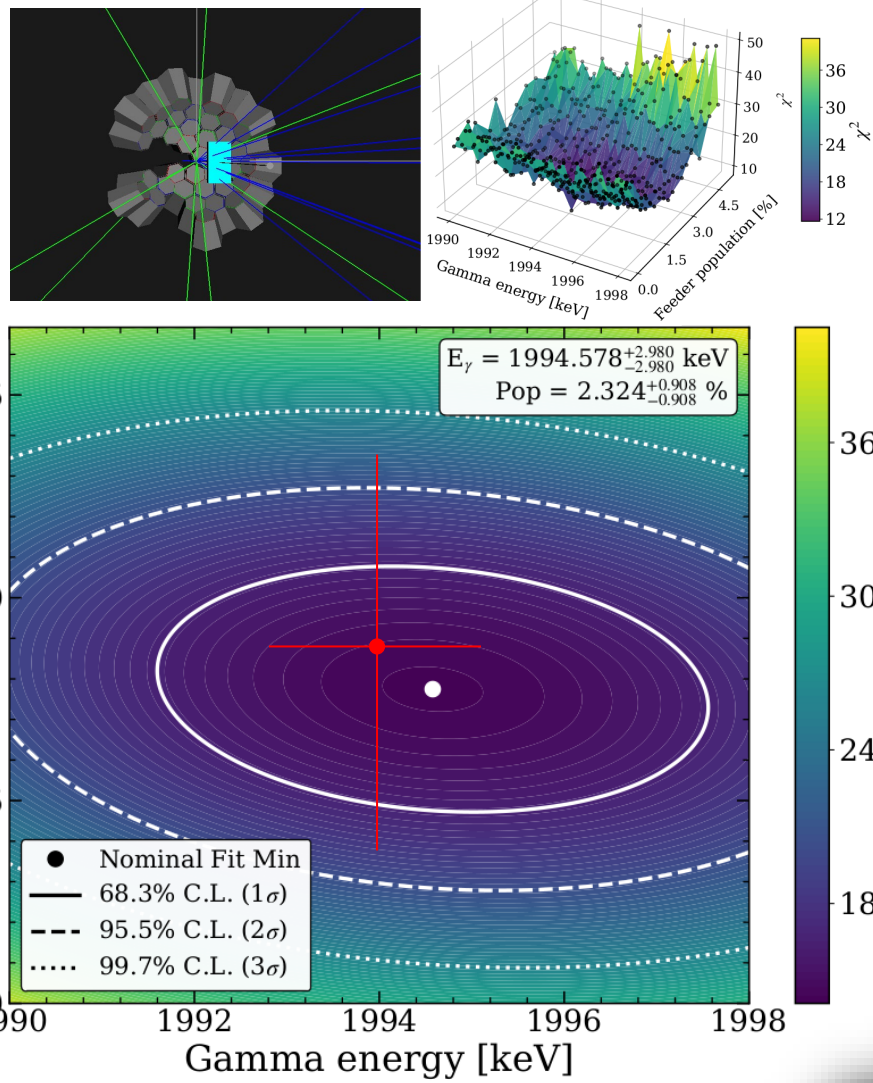
Results: ^{24}Ne energy doublet

Spectroscopy

$\gamma - \gamma$ Coincidence Matrix

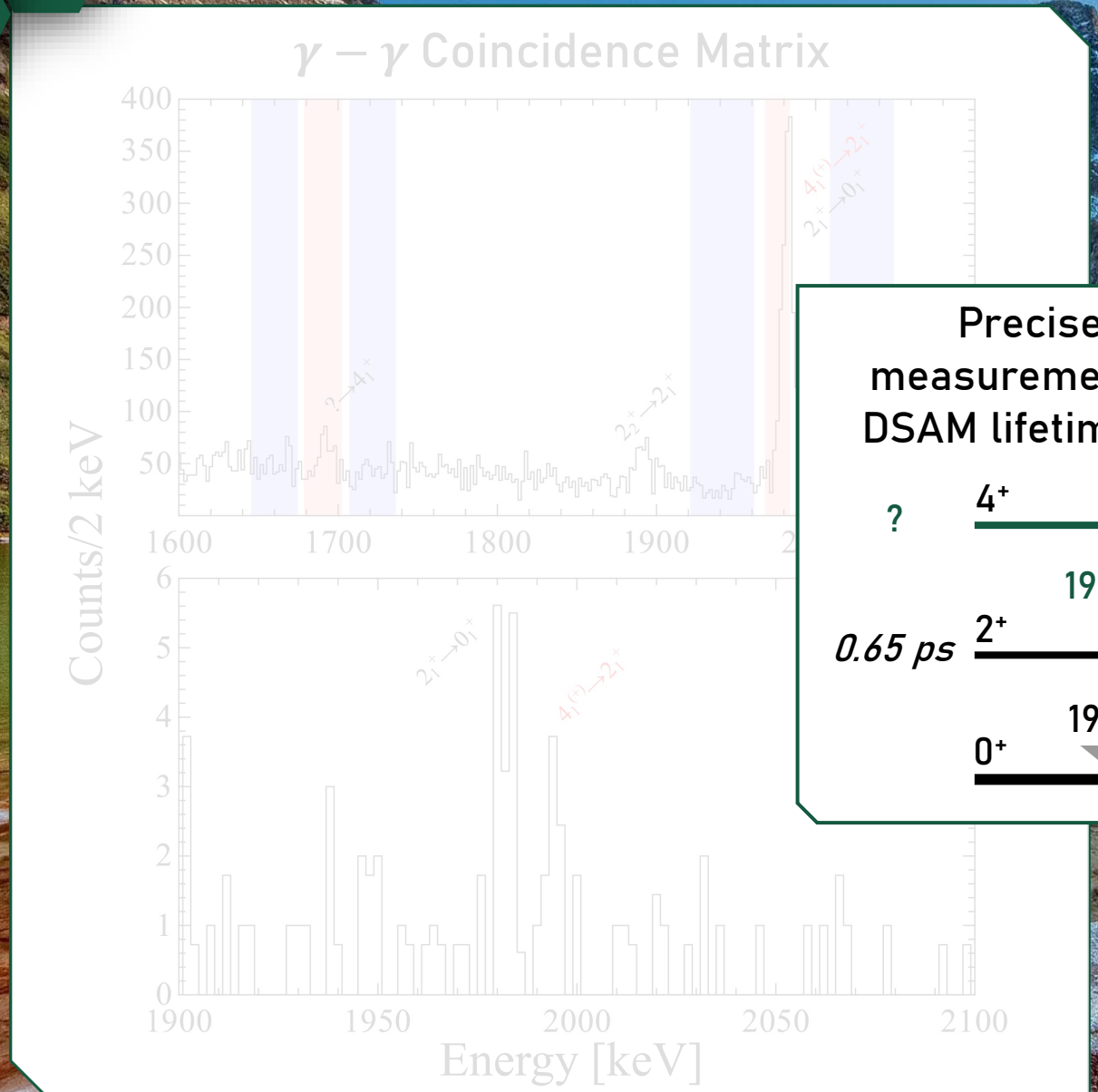


AGATA Simulations (Geant4)

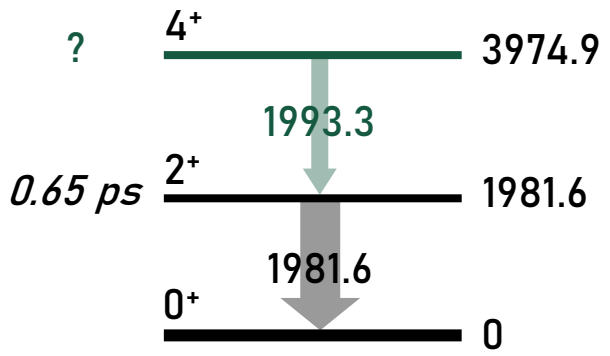


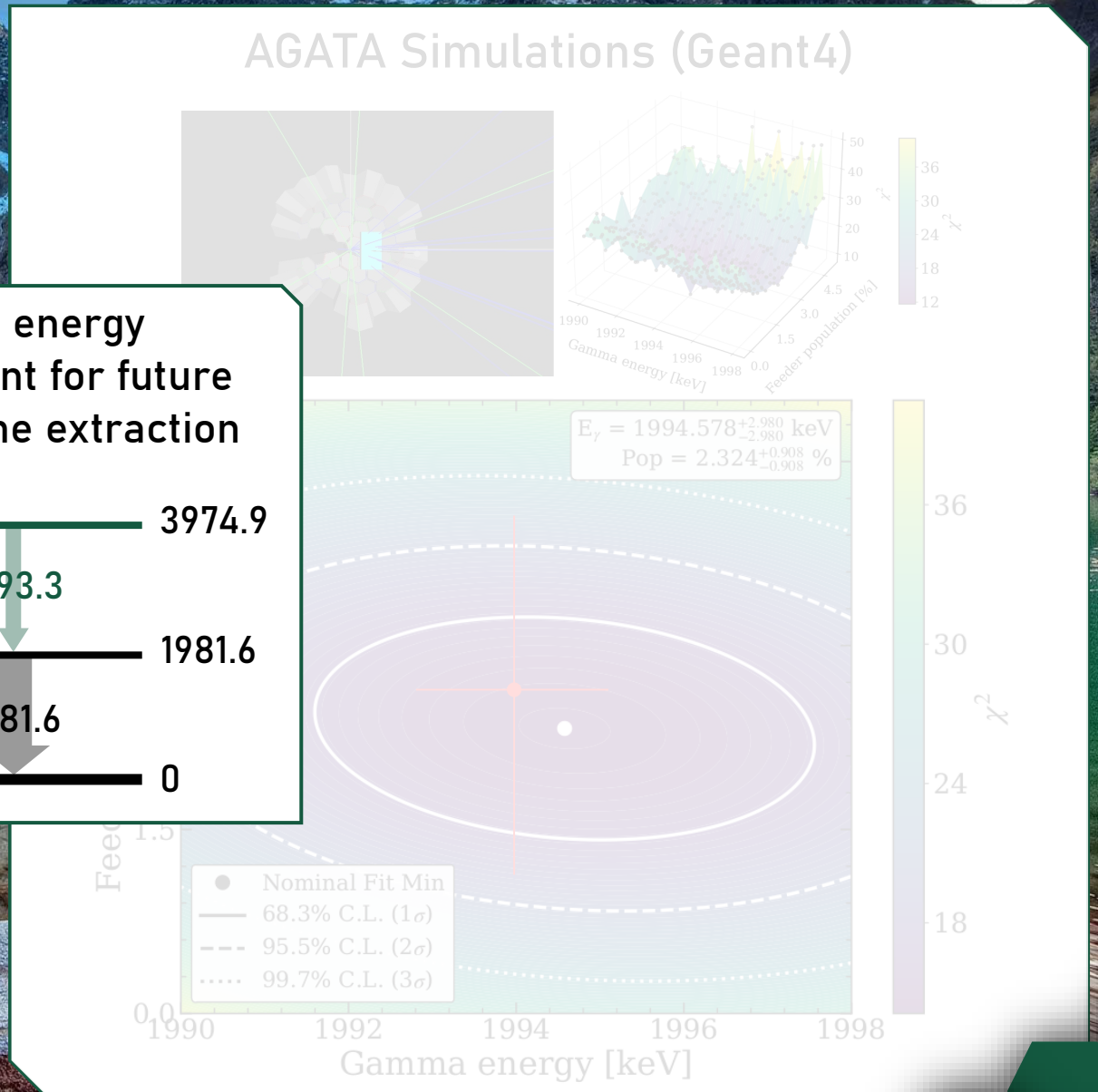
Results: ^{24}Ne energy doublet

Spectroscopy



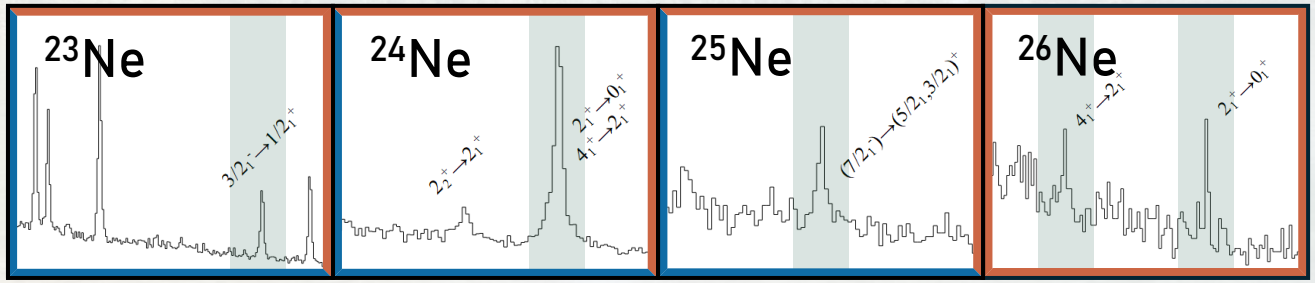
Precise energy measurement for future DSAM lifetime extraction





Outlook and perspectives

- Rotational band collectivity in ^{24,26}Ne
- Intruder states in ^{23,25}Ne



April 2023: ^{22}Ne + ^{238}U

June 2024: ^{26}Mg + ^{238}U

Pre-analysis by F. Drent (GSI)

May 2026: ^{22}Ne + ^{238}U

Outlook and perspectives

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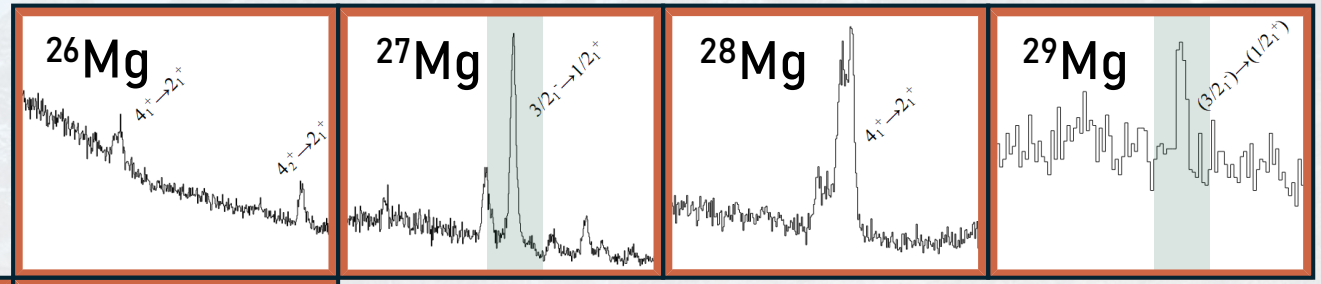

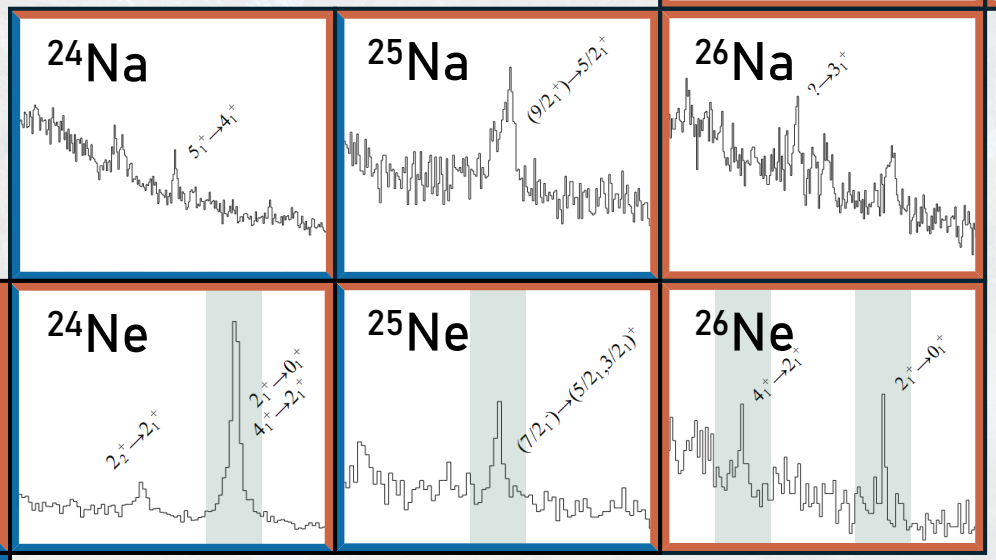

Z

N

- Proton contribution to deformation along N = 14

- Exotic Mg isotopes toward the Island of Inversion

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June 2024: ^{26}Mg + ^{238}U

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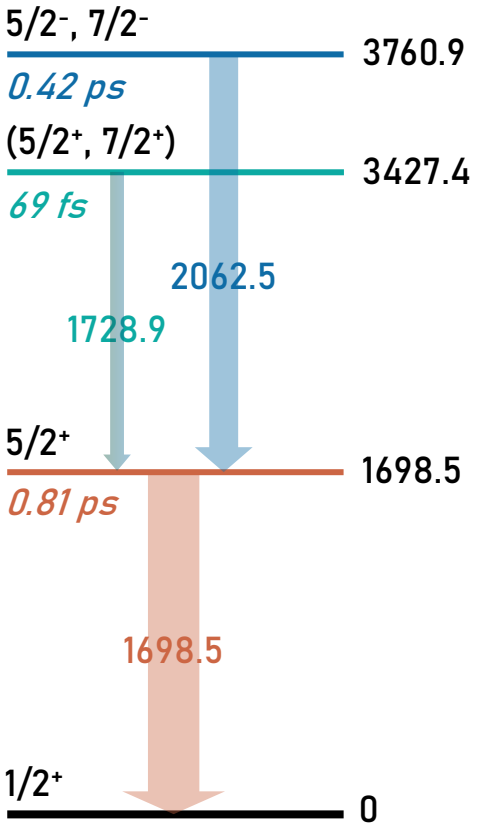
DSAM Benchmarks on ^{27,28}Mg

Lifetimes

^{27}Mg

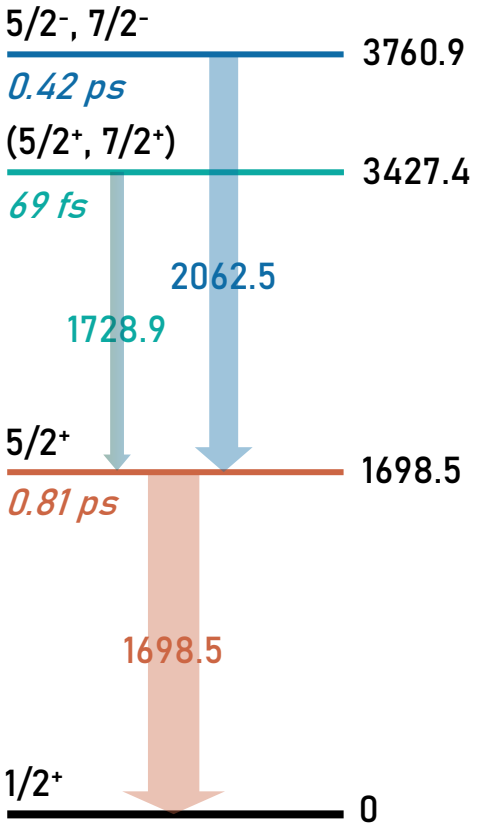
State: 1698.5 keV

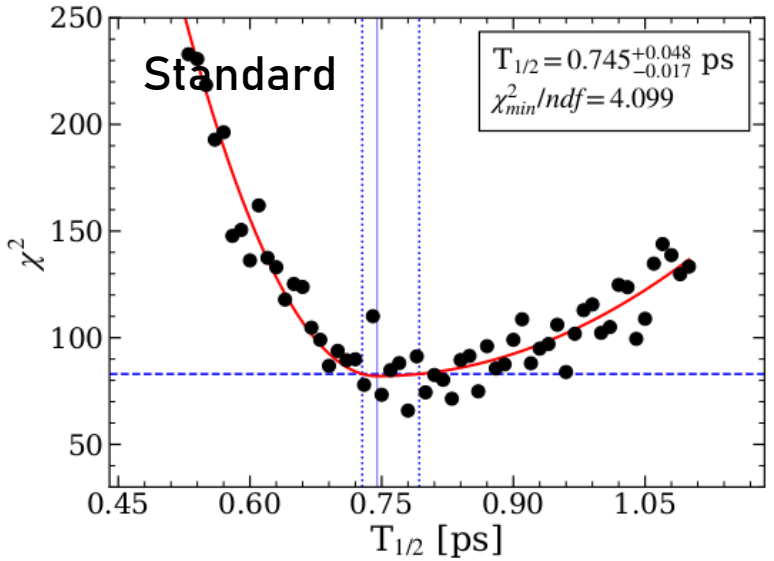


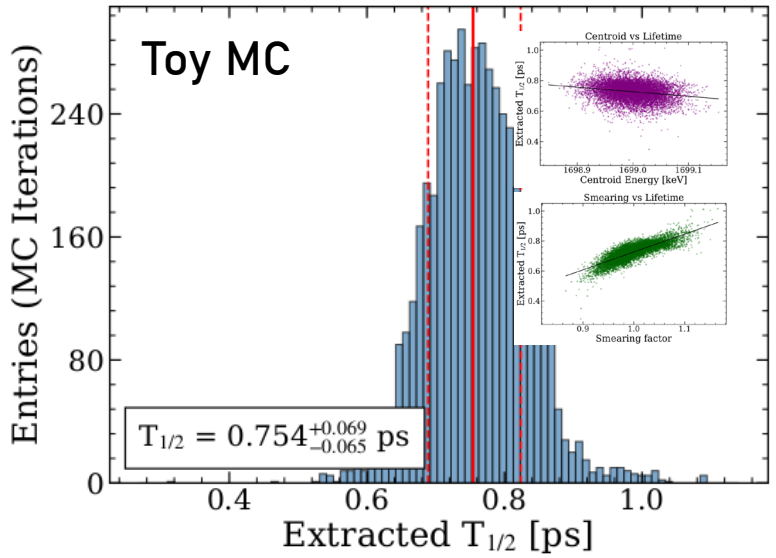
DSAM Benchmarks on ^{27,28}Mg Lifetimes

^{27}Mg

State: 1698.5 keV



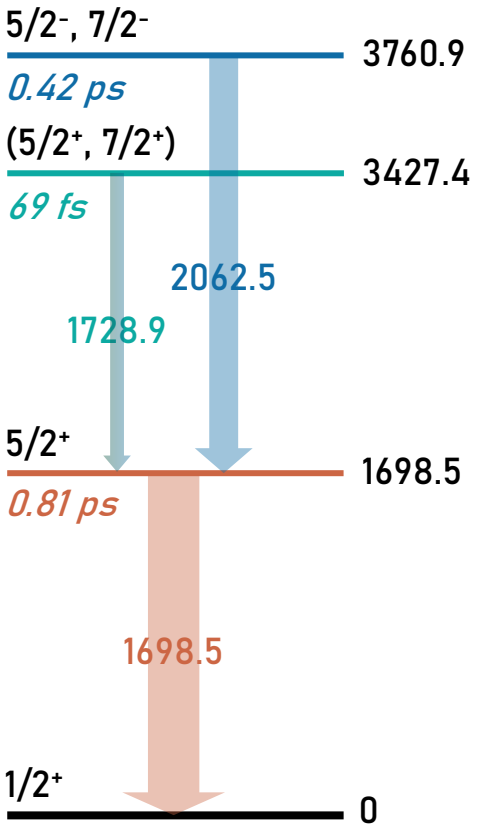


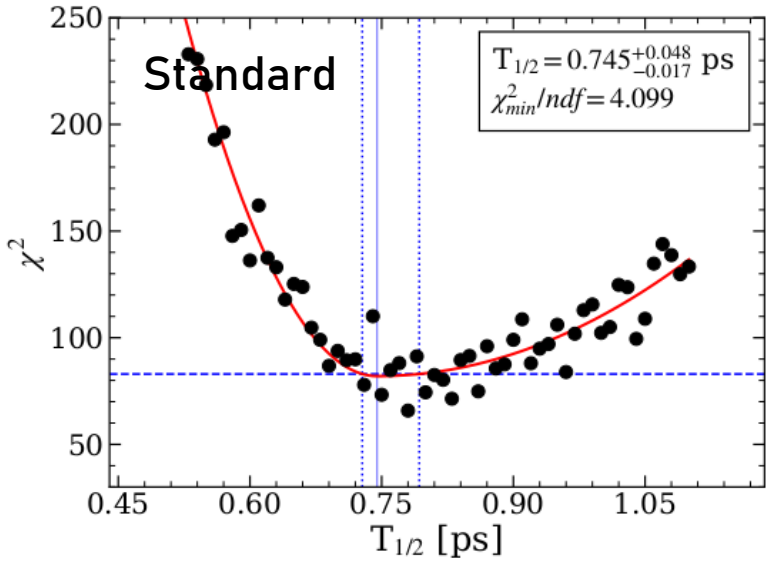


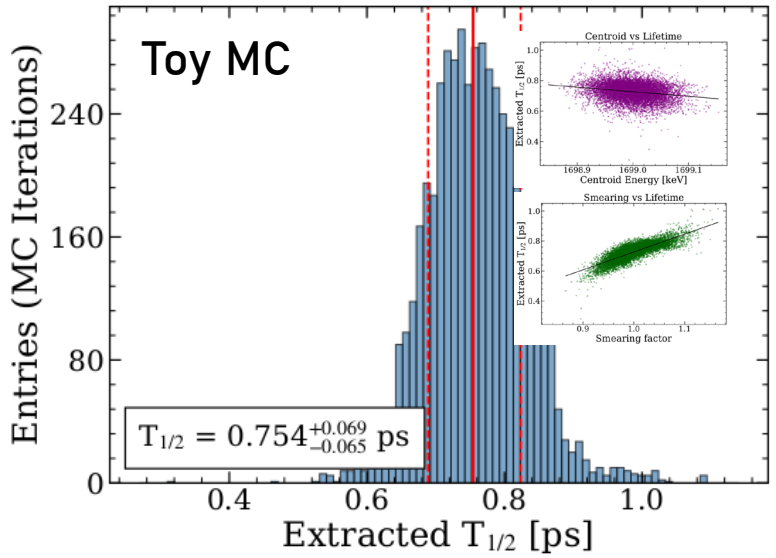
DSAM Benchmarks on ^{27,28}Mg — Lifetimes

^{27}Mg

State: 1698.5 keV

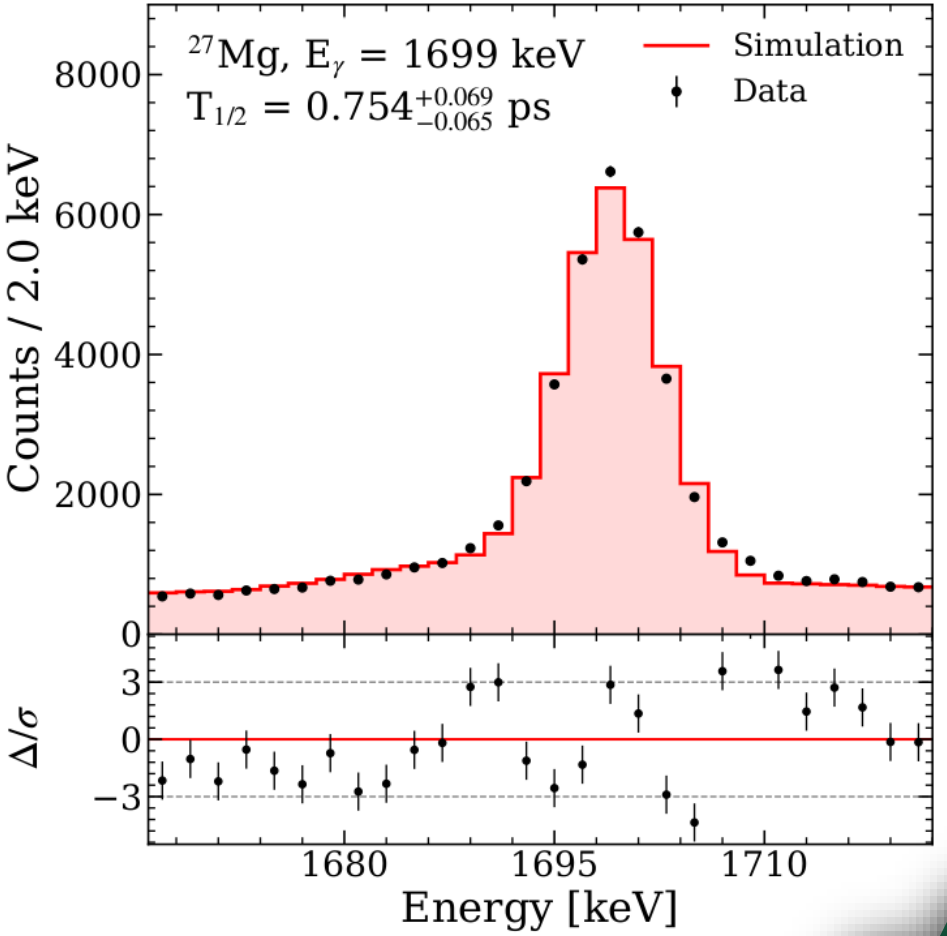






$$T_{1/2} = 0.754^{+0.069}_{-0.065}\ \text{ps}$$

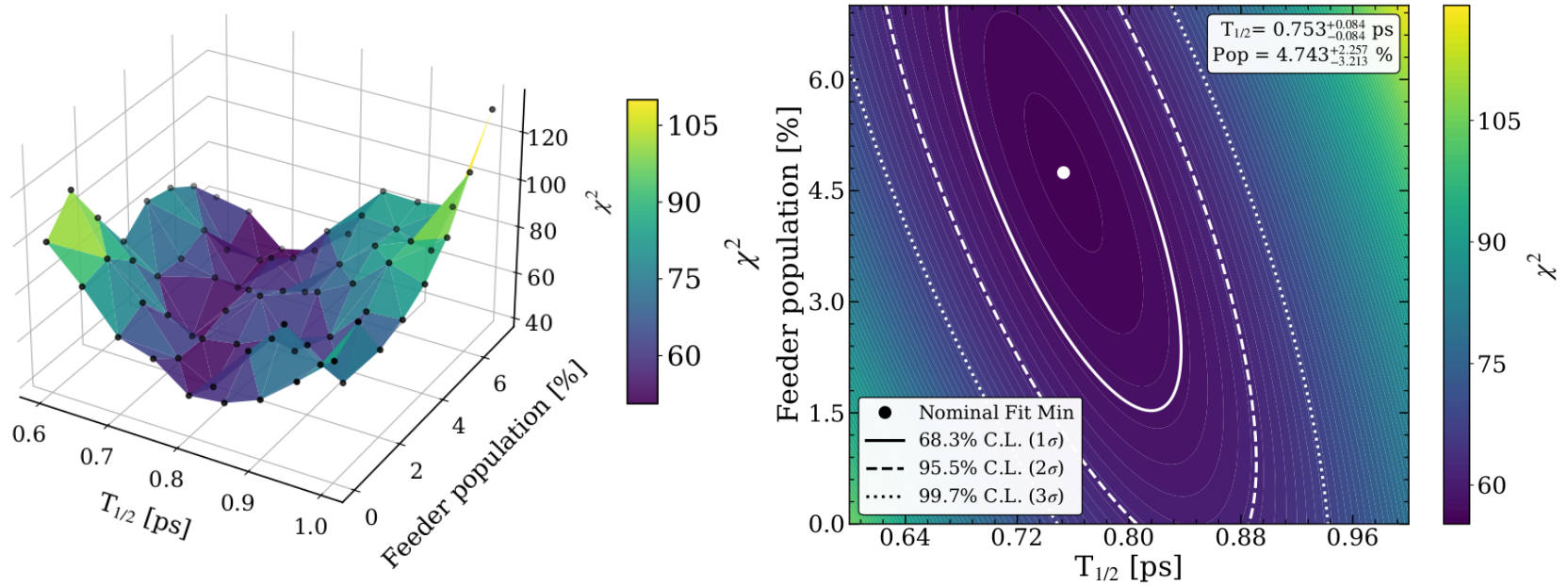
NNDC: $T_{1/2} = 0.81(17)$ ps



DSAM Benchmarks on ^{27,28}Mg

Lifetimes

Almost same cascade structure as 24Ne!
Optimal 2D Benchmark

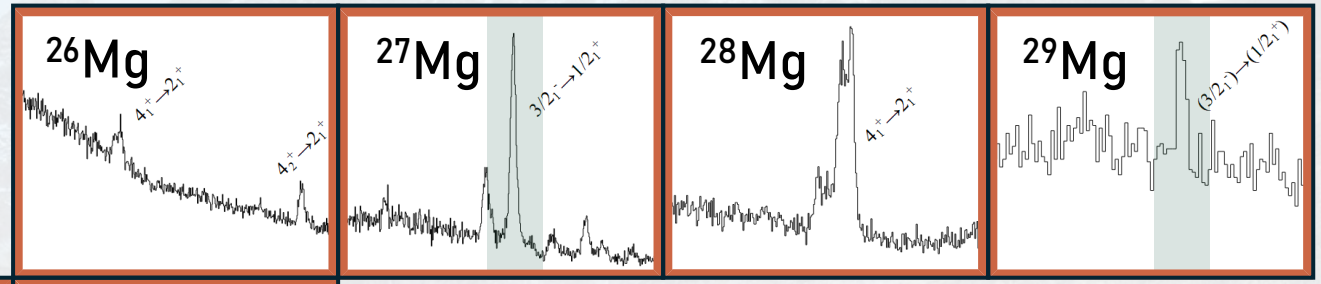


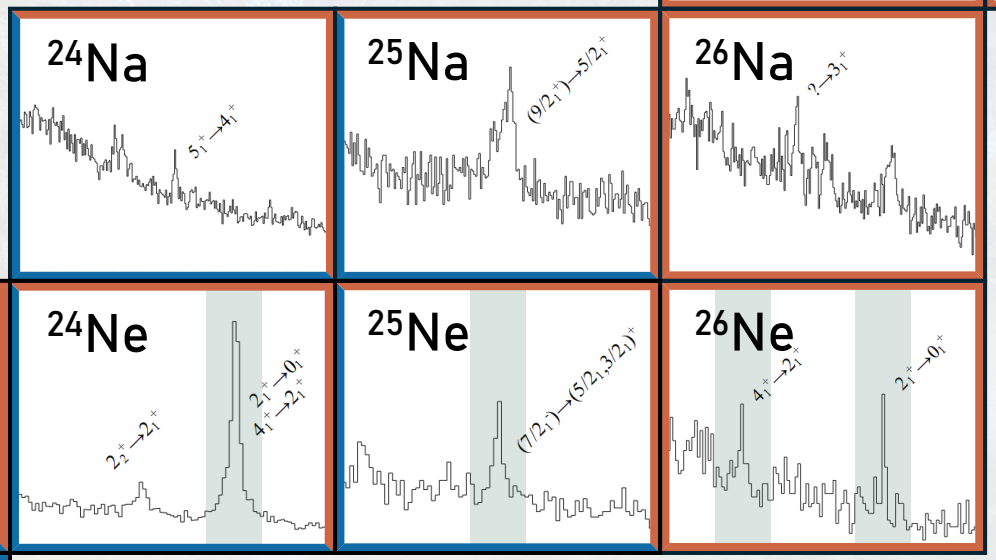
$$T_{1/2} = 0.753^{+0.084}_{-0.084}\ \text{ps}$$

NNDC: $T_{1/2} = 0.81(17)$ ps

Outlook and perspectives

- Rotational band collectivity in ^{24,26}Ne
- Intruder states in ^{23,25}Ne





Z

N

- Proton contribution to deformation along N = 14

- Exotic Mg isotopes toward the Island of Inversion

April 2023: ^{22}Ne + ^{238}U

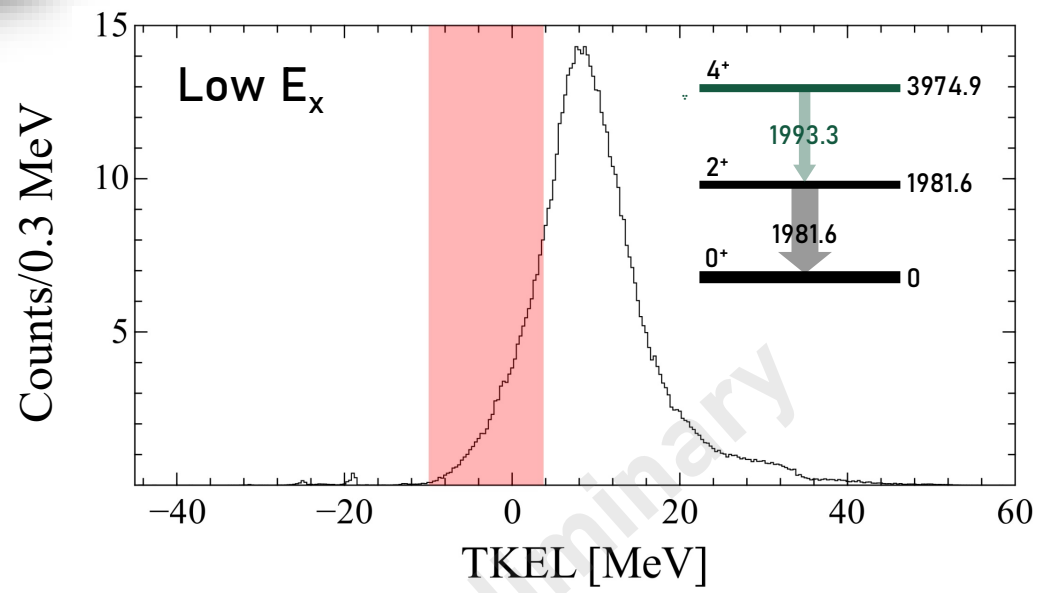
June 2024: ^{26}Mg + ^{238}U

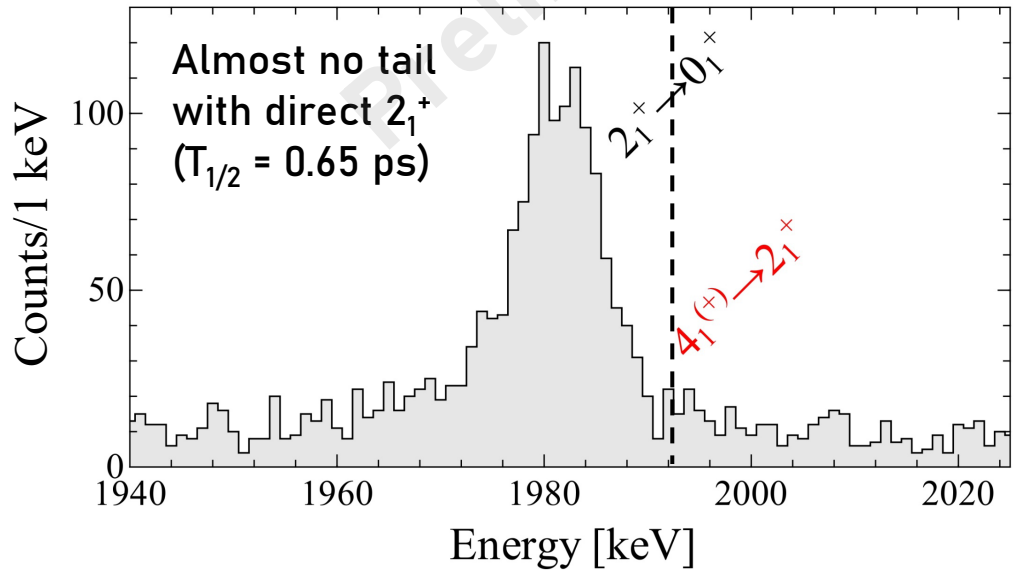
Pre-analysis by F. Drent (GSI)

May 2026: ^{22}Ne + ^{238}U

^{24}Ne energy doublet sensitivity

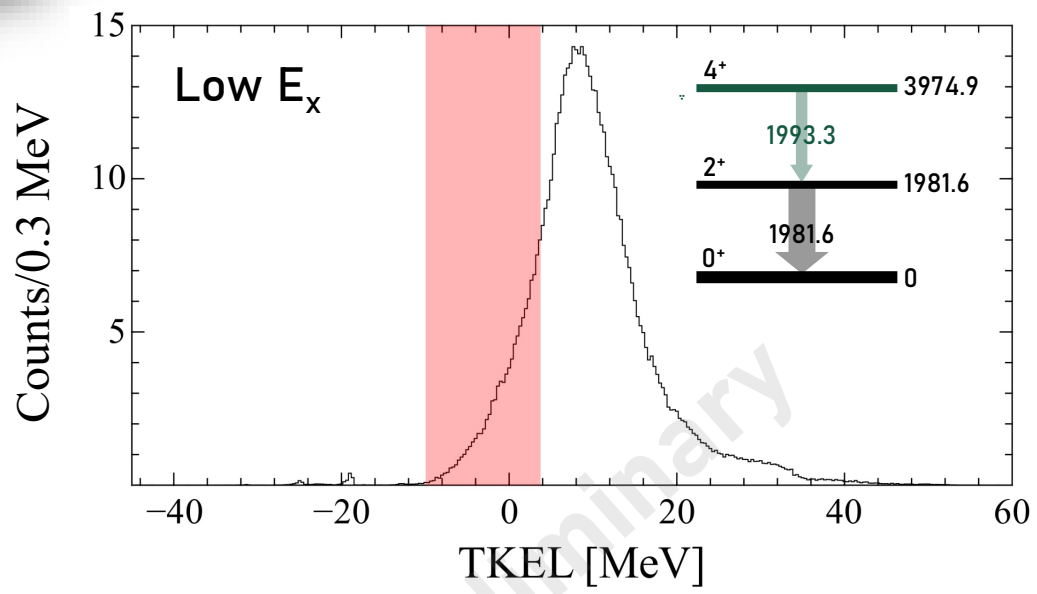
Lifetimes

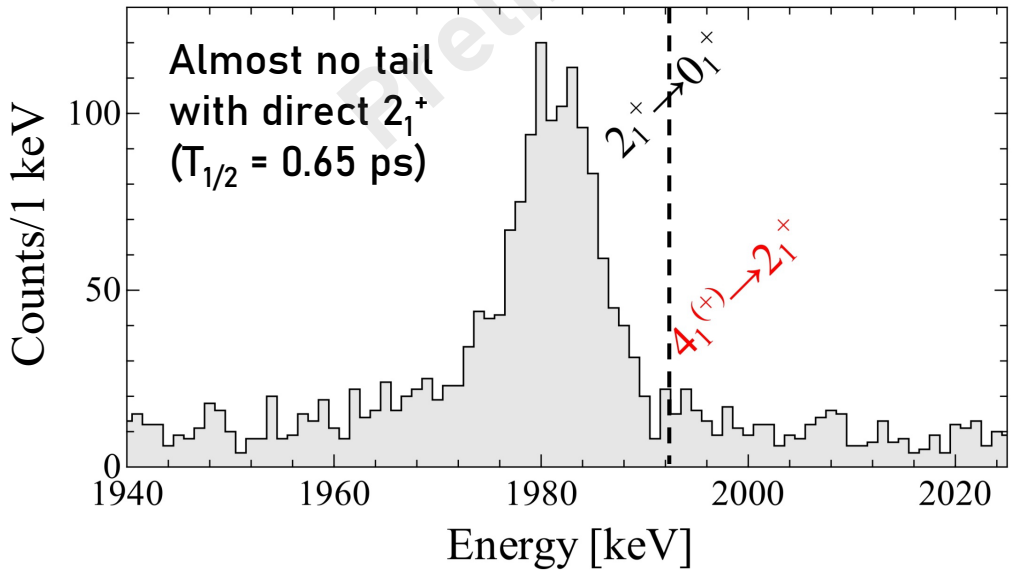


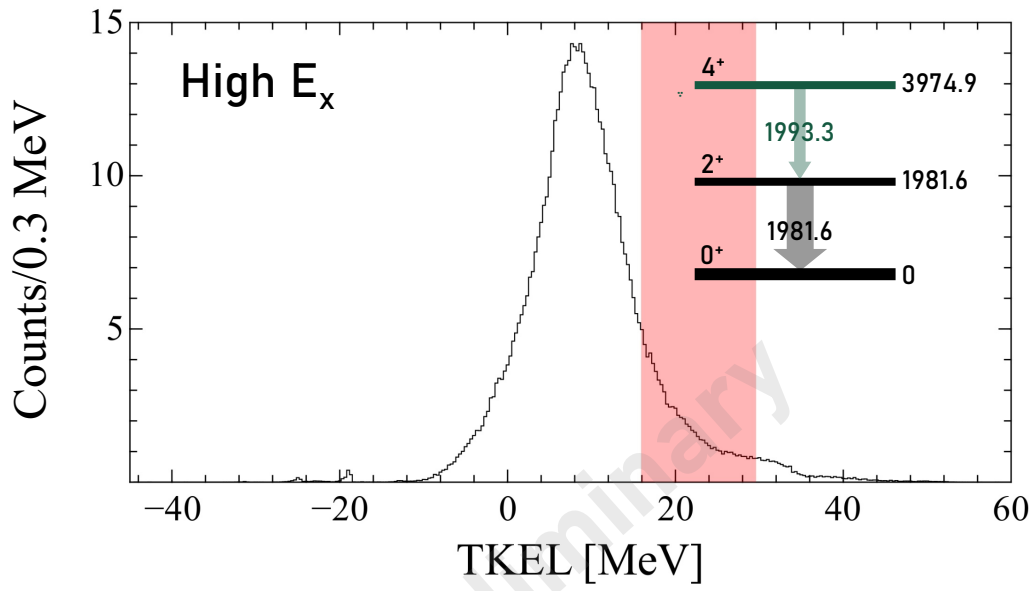


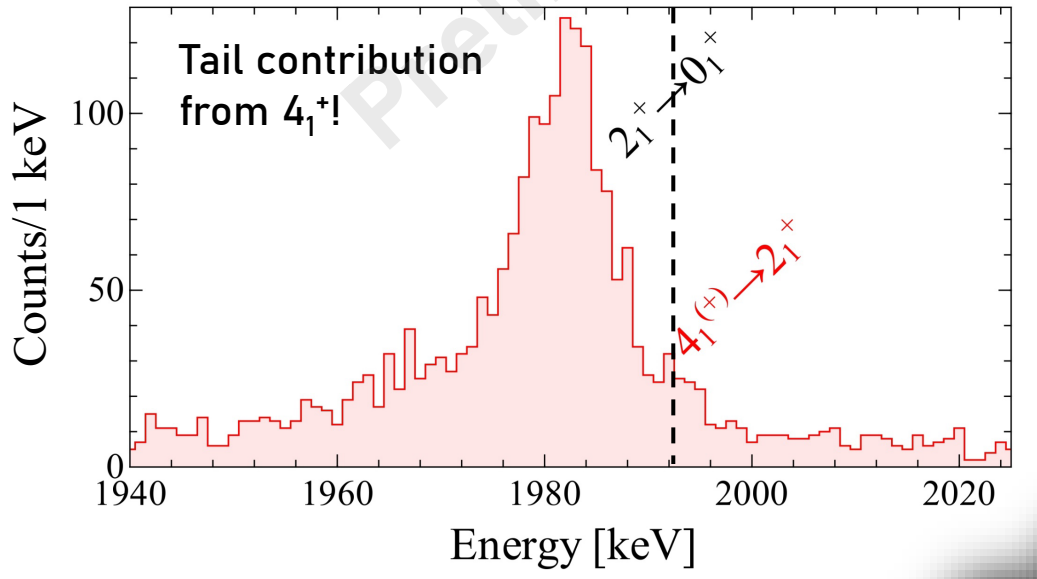
^{24}Ne energy doublet sensitivity

Lifetimes









- The AGATA-PRISMA campaign targeting Ne and Mg nuclei toward the Island of Inversion is now completed.
- Decay level scheme were extracted for ^{23,24,25}Ne, including the low energy doublet in ^{24}Ne.
- Simulation-based DSAM was successfully benchmarked; lifetimes extraction in progress.
- The analysis on ion-γ angular distributions with AGATA is nearing completion.

Zakopane Conference on Nuclear Physics 2026 – September 2nd

D. Genna[1,2], F. Drent[3], K. Wimmer[3] , S. Bottoni[1,2], P. Aguilera[4], G. Benzoni[2], F. Recchia[5,6], G. Andreetta[5,6], F. Angelini[3], M. Balogh[7], J. Bardak[3,8], J. Benito[9], B. Bles[3,8], A. Bracco[1,2], D. Brugnara[9], S. Carollo[5,6], Z. Chen[3], F. Conca[1,2], L. Corradi[9], G. Corbari[1,2], F. C. L. Crespi[1,2], M. del Fabbro[10], A. Ertoprak[5,6], E. Fioretto[9], F. Galtarossa[5], A. Giaz[2], A. Goasduff[9], B. Gongora Servin[9], A. Gottardo[9], Gozzelino[9], B. Greaves[9], A. Jungclaus[11], T. Kröll[7], G. Kosir[12], S. Leoni[1,2], M. Luciani[1,2], R. Menegazzo[6], D. Mengoni[5,6], B. Million[2], G. Montagnoli[6], R. Nicolás del Álamo[5,6], J. Pellumaj[5,6], R. Pérez-Vidal[13], S. Pigliapoco[14], E. Pilotto[9], W. Poklepa[3], M. Polettini[3,15], K. Rezynkina[5,6], M. Rocchini[16], E. Ronning[9], M. Sedlak[7], F. Simioni[5,6], A. Stefanini[6], A. Togni[5,6], J. J. Valiente-Dobón[13], J. Vesic[12], L. Zago[17], I. Zanon[18].

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[2] INFN Sezione di Milano, Italy
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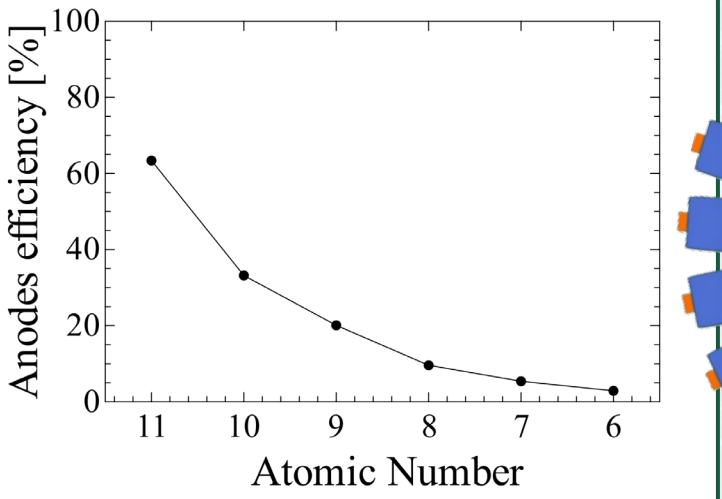
[6] INFN Sezione di Padova, Italy
[7] Institute of Physics of the Slovak Academy of Sciences, Slovakia
[8] University of Novi Sad, Serbia
[9] Istituto Nazionale di Fisica Nucleare LNL, Legnaro, Italy
[10] Ruđer Bošković Institute, Croatia
[11] CSIC Madrid, Spain
[12] Jožef Stefan Institute, Slovenia
[13] IFIC Universitat de València, Spain
[14] Grand Accélérateur National d'Ions Lourds, France
[15] Facility for Antiproton and Ion Research in Europe GmbH (FAIR GmbH), Germany
[16] INFN Sezione di Firenze, Italy
[17] Institut de Physique des Deux Infinis de Lyon, France
[18] KTH Royal Institute of Technology, Sweden

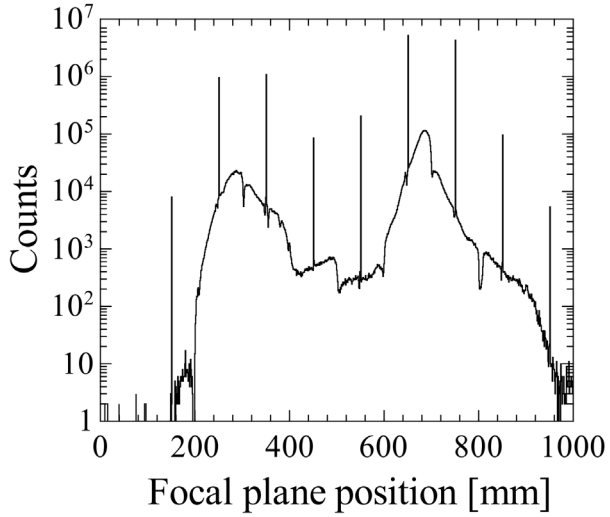
Zakopane Conference on Nuclear Physics 2026 – September 2nd

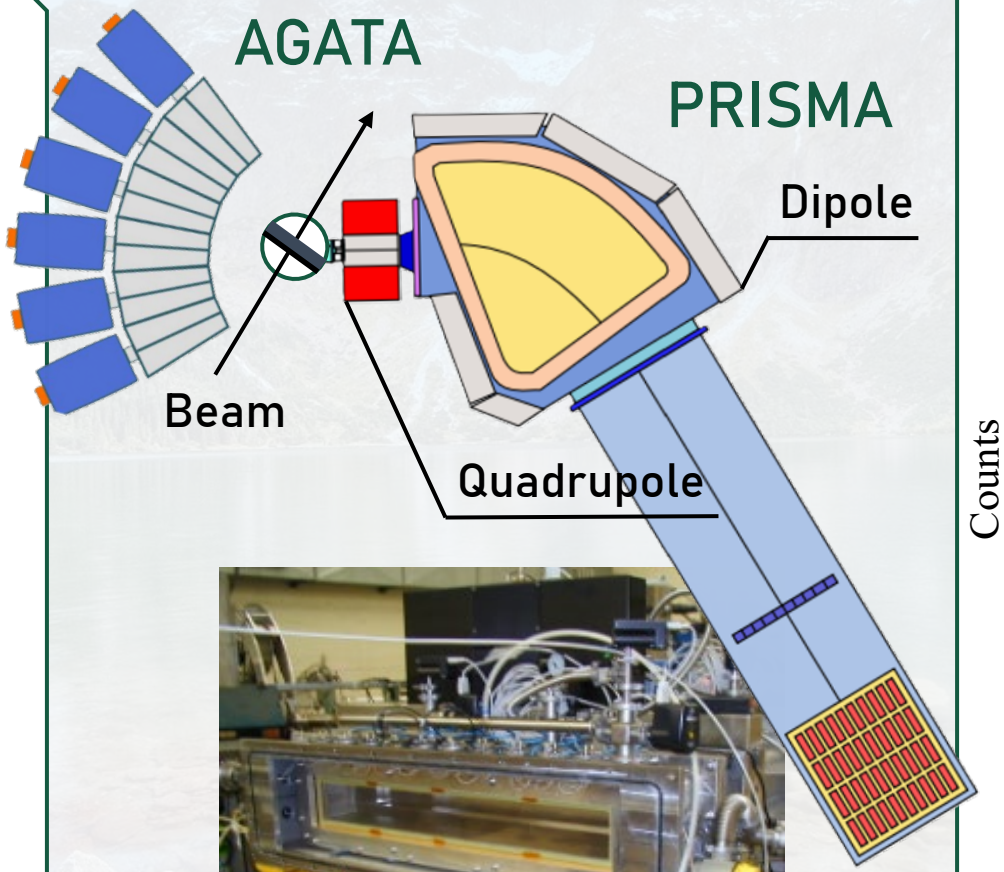
Optimized PRISMA analysis

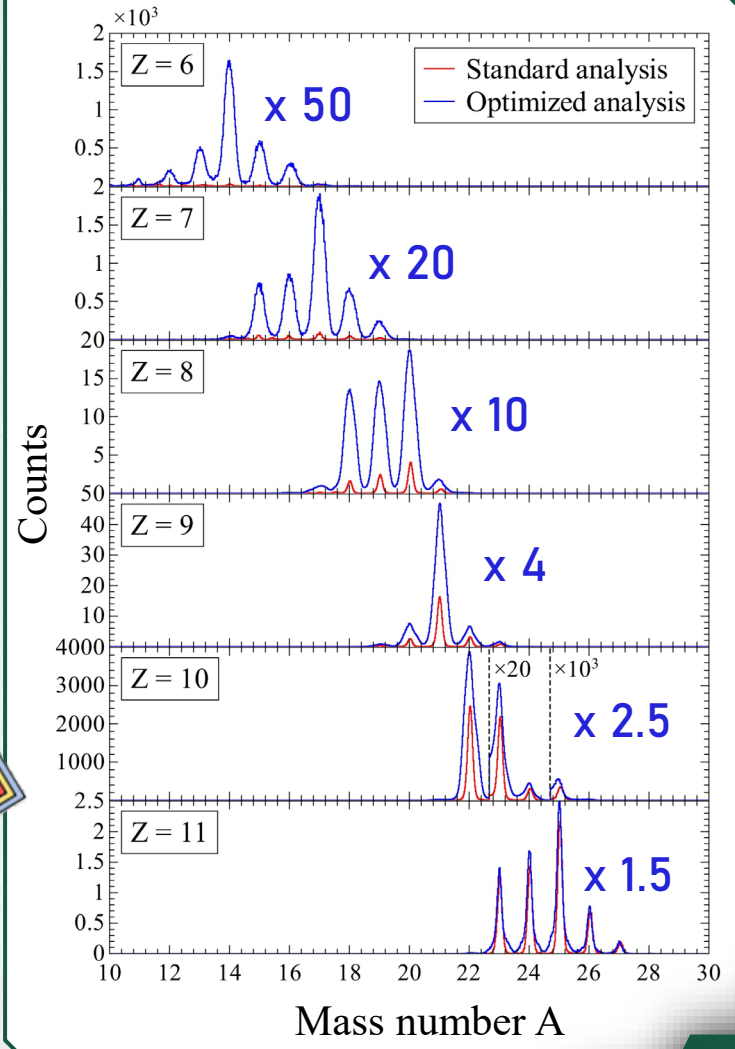
Recovery of only PPAC cathodes events

Suited for light ions





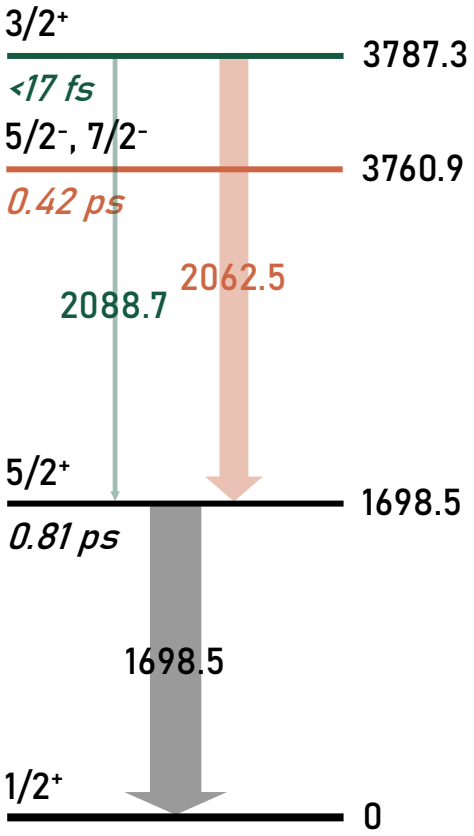


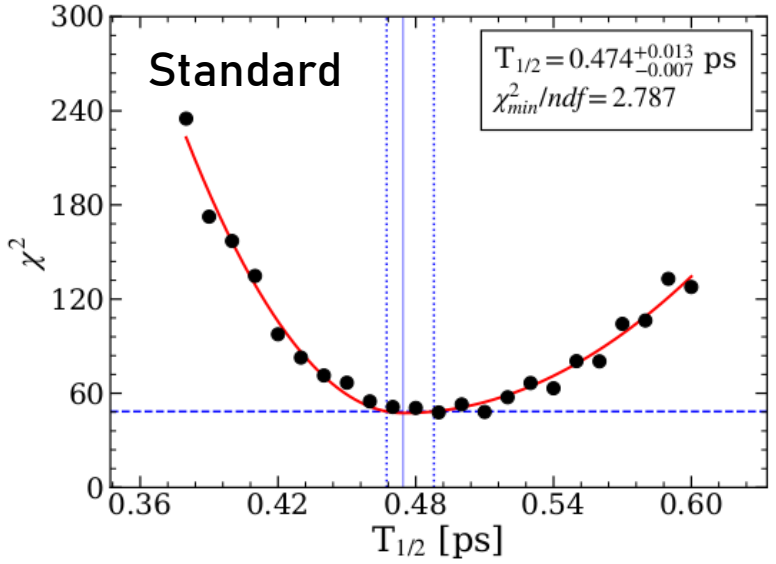


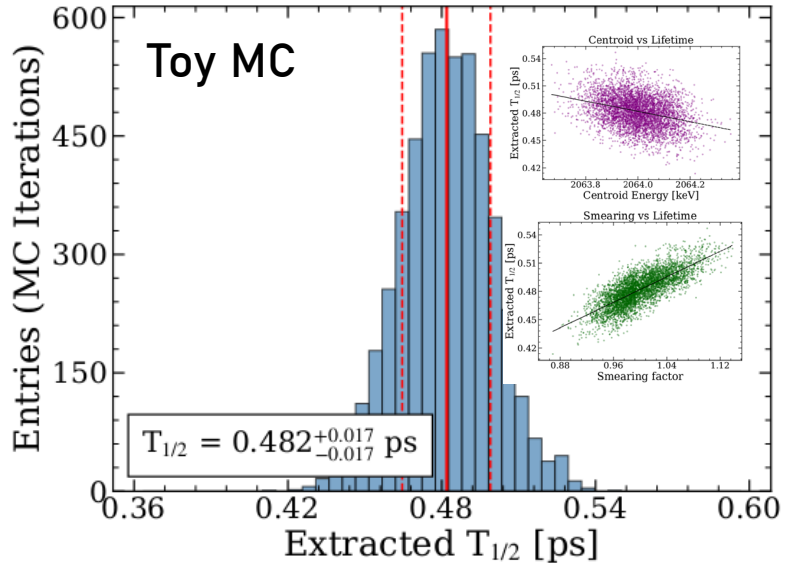
DSAM Benchmarks on ^{27,28}Mg — Lifetimes

^{27}Mg

State: 3760.9 keV

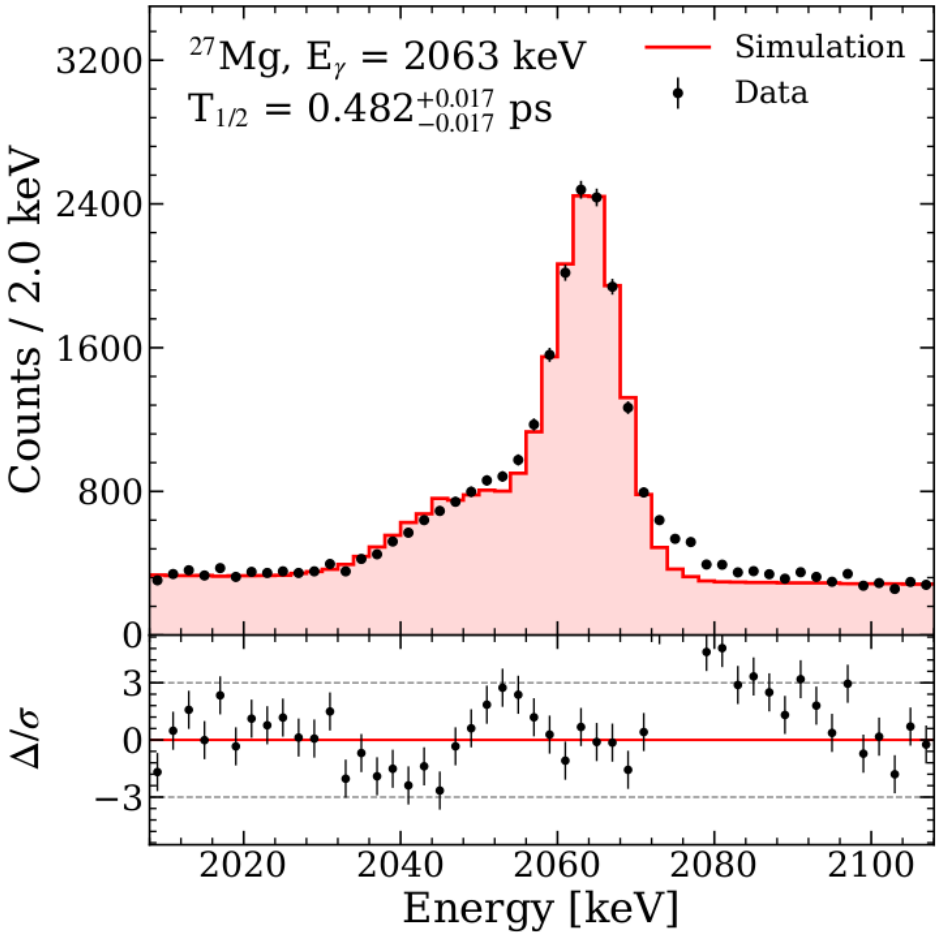






$T_{1/2} = 0.482^{+0.017}_{-0.017}$ ps

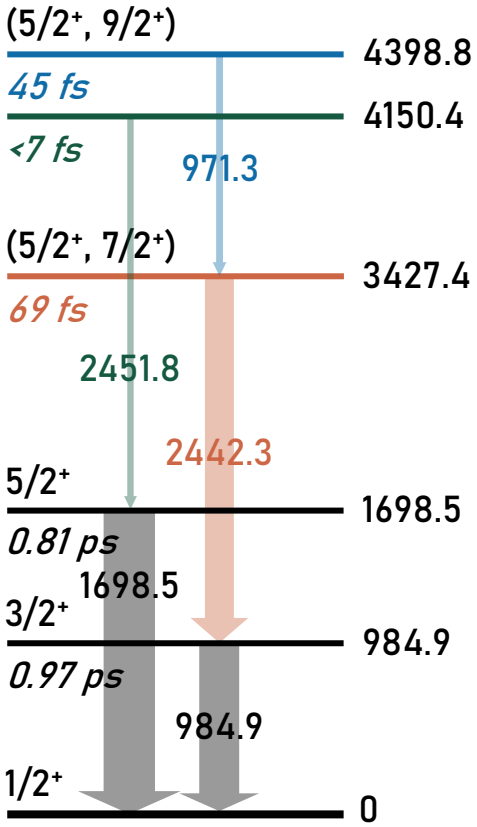
NNDC: $T_{1/2} = 0.42(9)$ ps

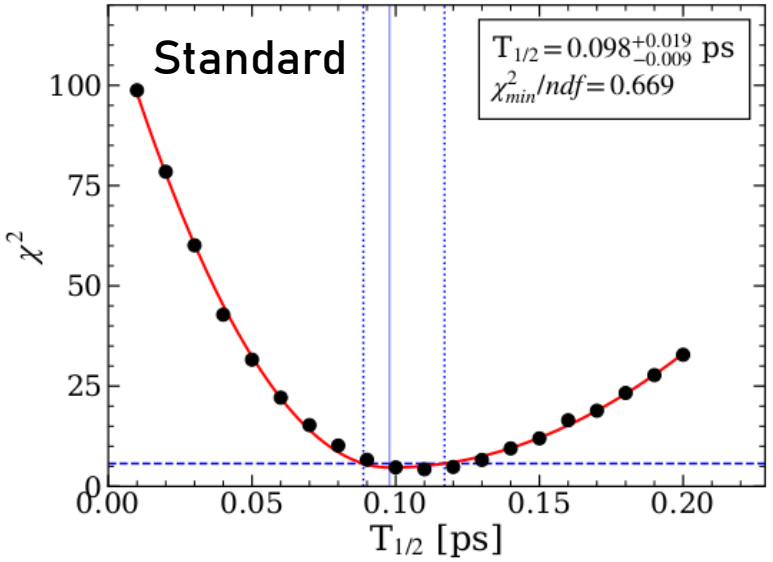


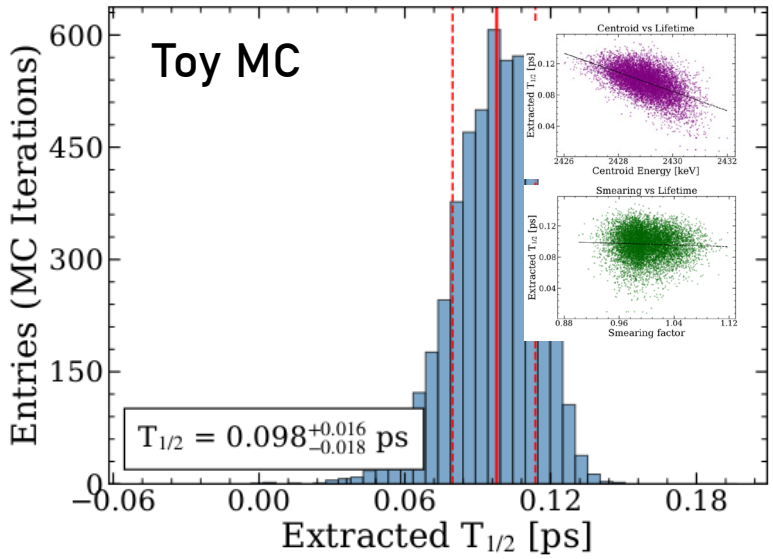
DSAM Benchmarks on ^{27,28}Mg — Lifetimes

^{27}Mg

State: 3427.4 keV

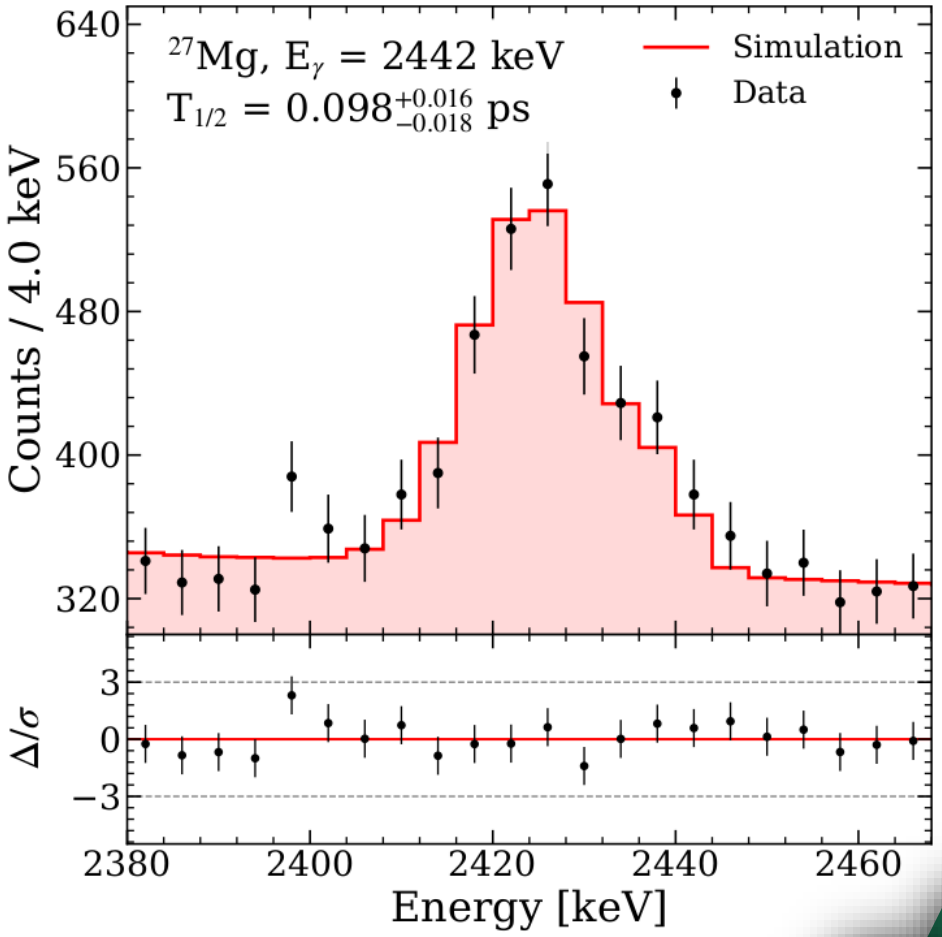






$T_{1/2} = 98^{+16}_{-18}$ fs

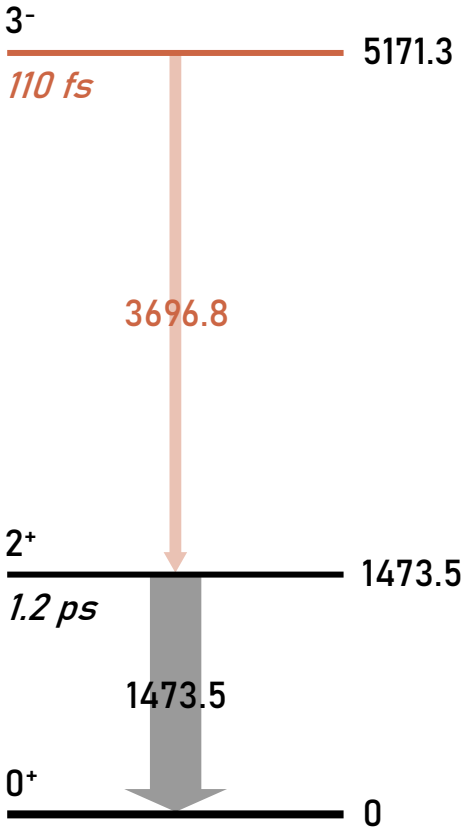
NNDC: $T_{1/2} = 69(34)$ fs

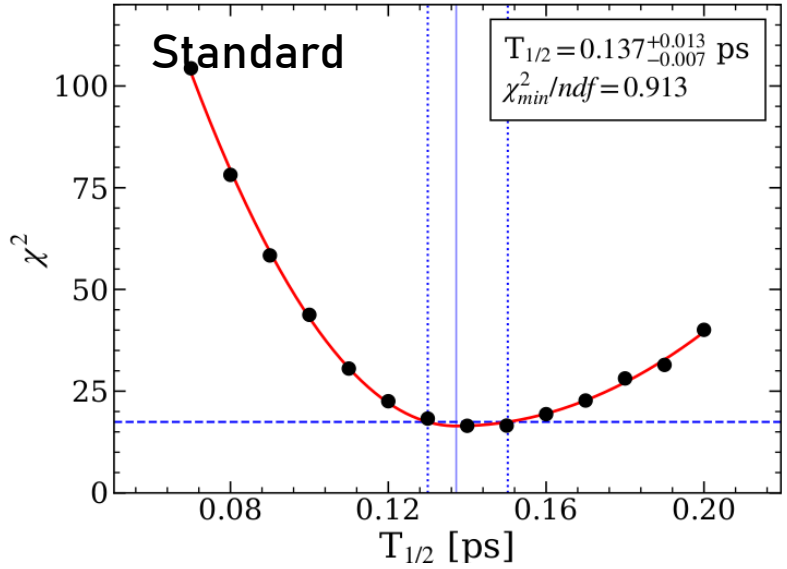


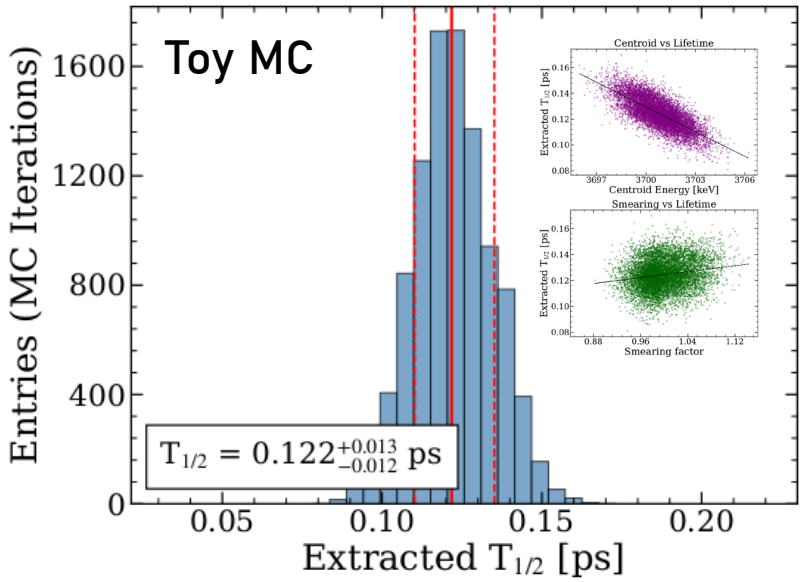
DSAM Benchmarks on ^{27,28}Mg — Lifetimes

^{28}Mg

State: 5171.3 keV

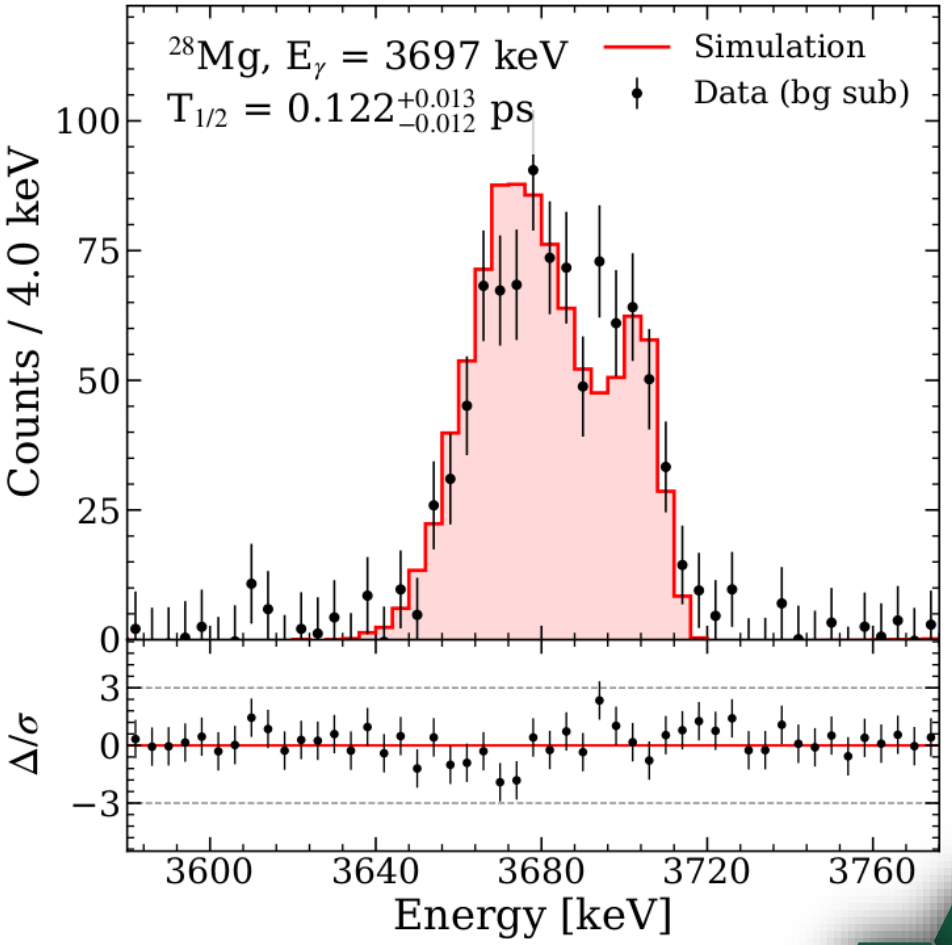






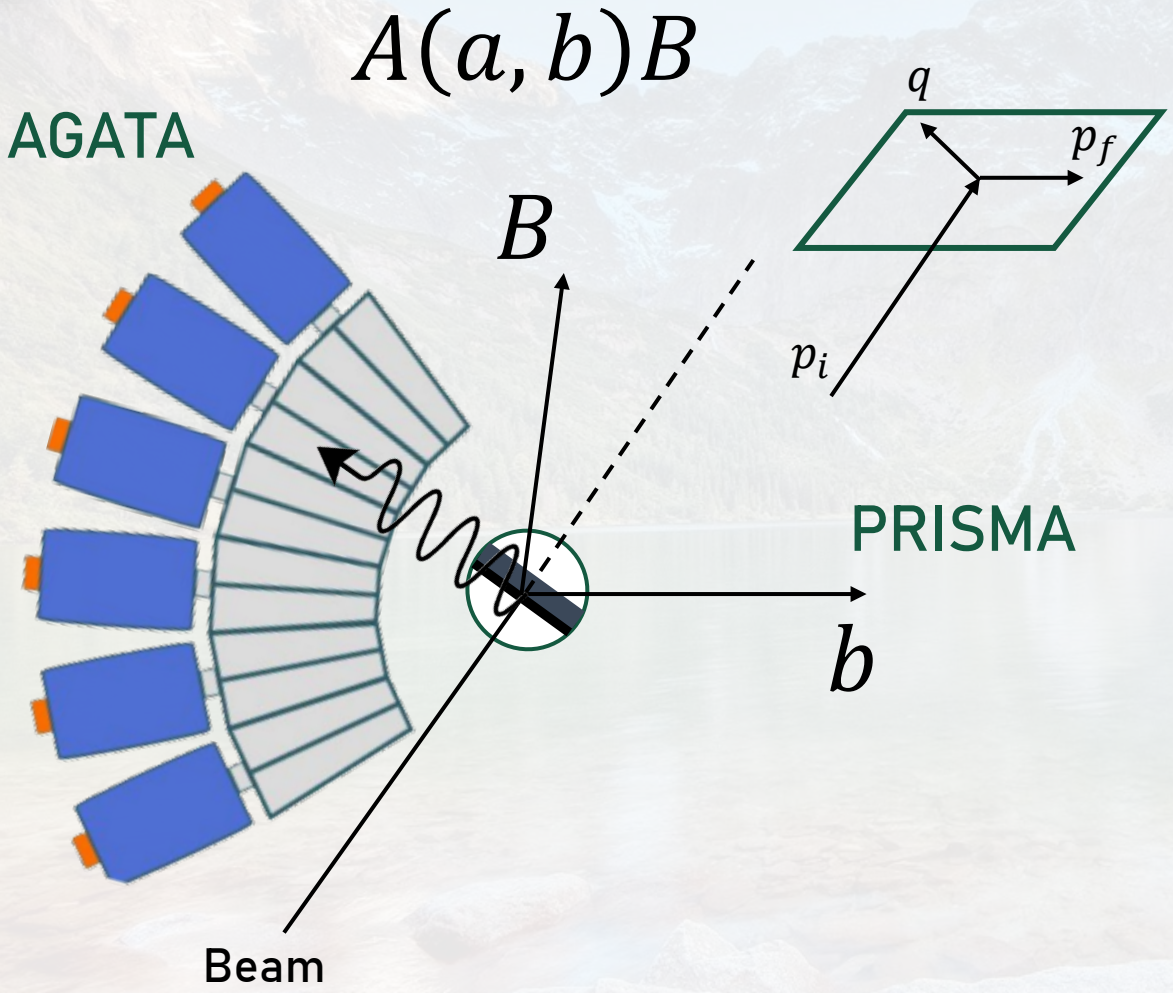
$T_{1/2} = 122^{+13}_{-12}$ fs

NNDC: $T_{1/2} = 110\ (90)$ fs



Ion-γ angular distributions

Spectroscopy



Observed states are prepared once the emitter beam-like fragment is detected in PRISMA

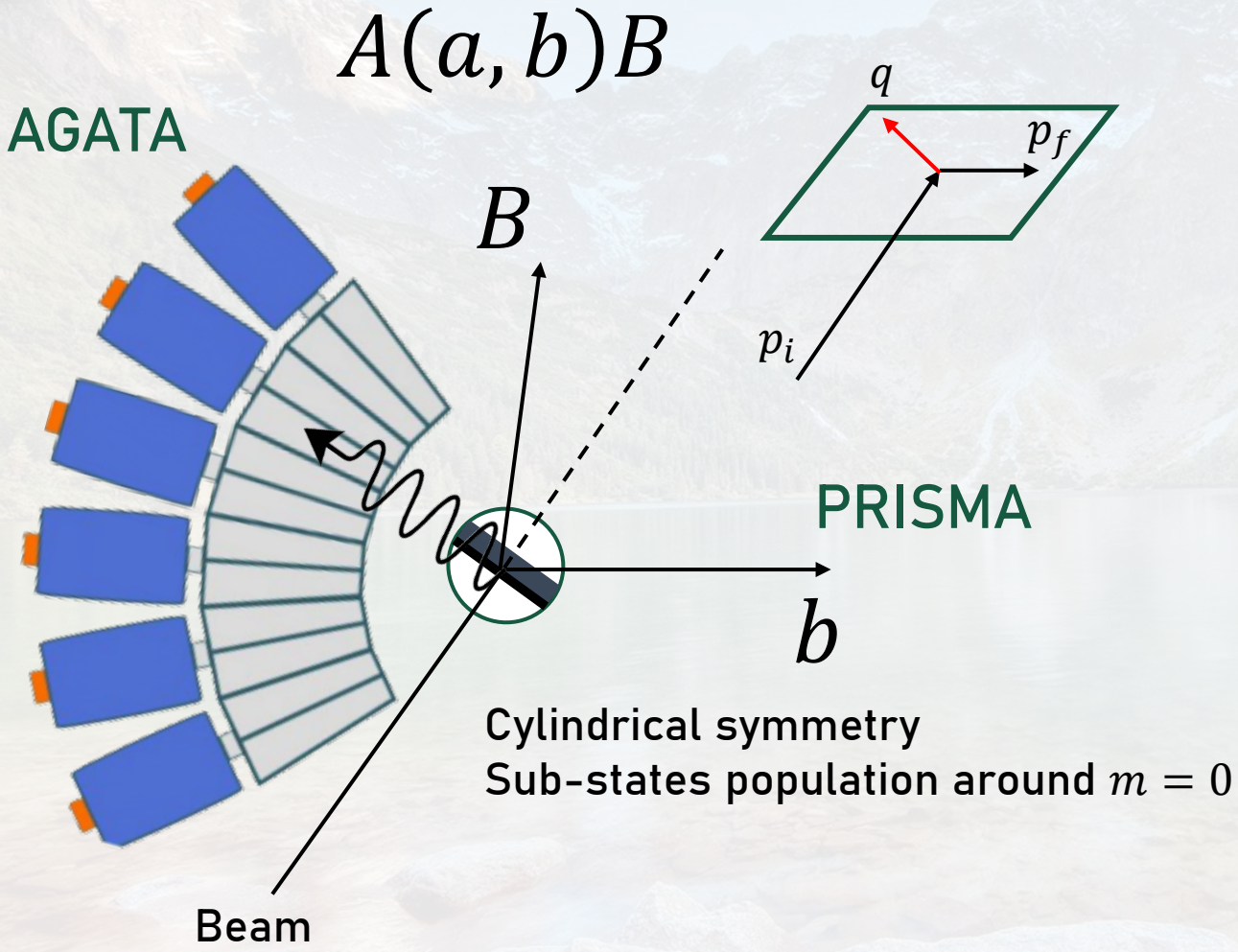
φ selection

Quantization axis	Cylindrical symmetry
Beam	✗
Beam-like (b)	✗
Recoil-like (B)	✓
Normal to reaction plane	✗ (but...)

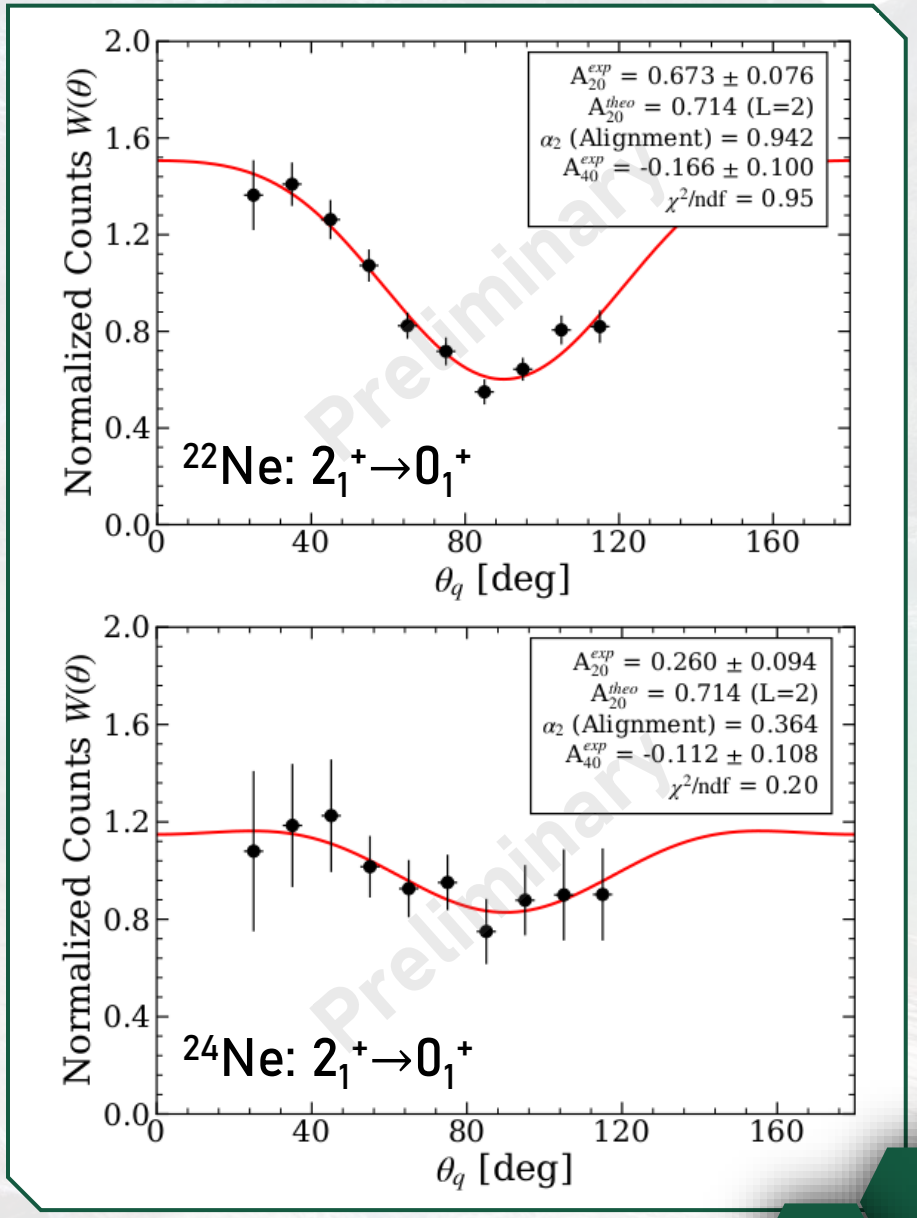
Reaction plane reconstructed event-by-event

Ion-γ angular distributions

Spectroscopy

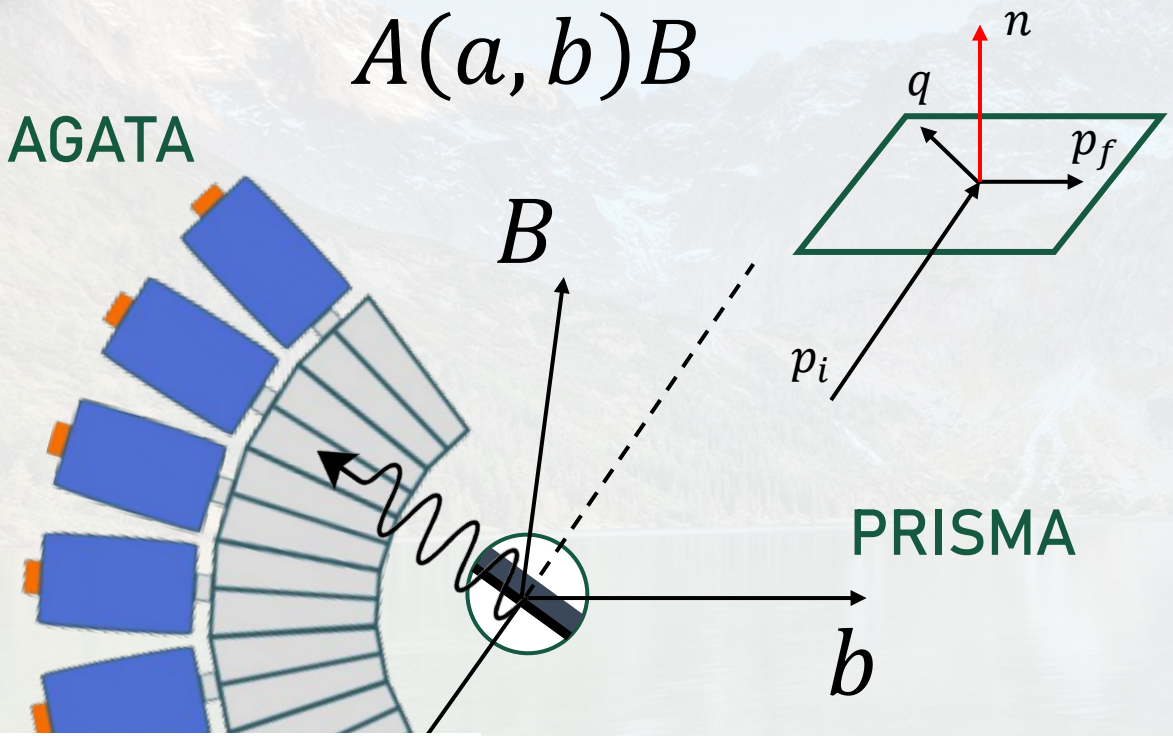


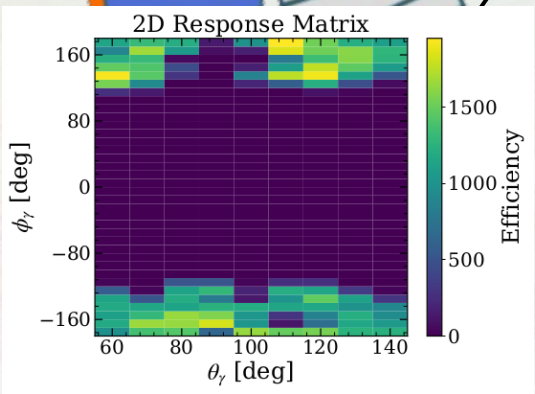
Cylindrical symmetry
Sub-states population around $m = 0$



Ion-γ angular distributions

Spectroscopy





Cylindrical symmetry
Sub-states population around $m = \pm 2$

Need complete $W(\theta, \varphi)$ with mixed parameters: A_{22}, ϕ_{22}

More statistics is needed when adding mixed parameters…