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L. Zago
UniMi Statale and INFN-LNL

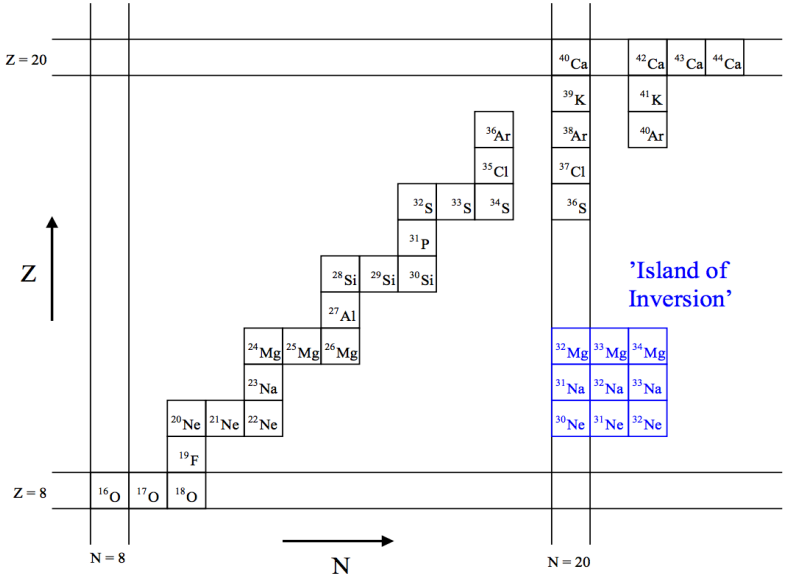
Mixing between single-particle and intruder states towards the N=20 island of inversion: lifetimes in ^{37}S

UNIVERSITÀ DEGLI STUDI DI MILANO

UNIVERSITÀ DEGLI STUDI DI PADOVA

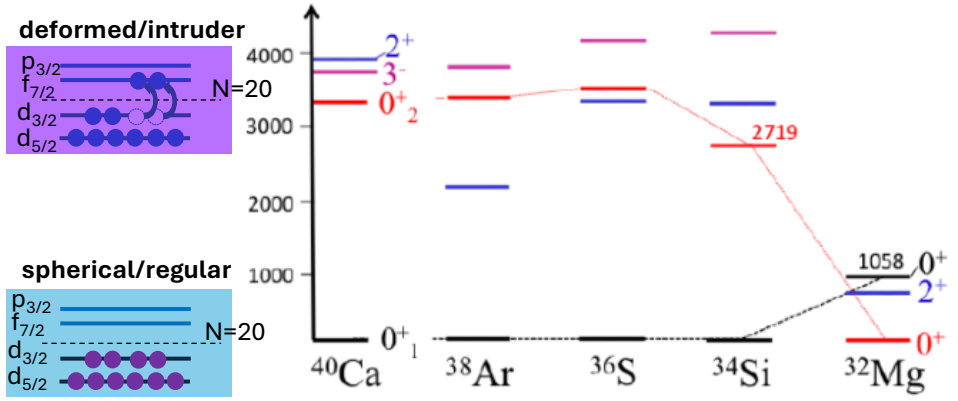
INFN LNL

The N=20 Island of Inversion

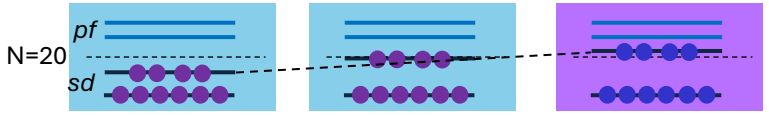


Erosion of the N=20 shell gap and increase of correlations with decreasing Z

Image from O. Sorlin, EPJ Web Conf. **66** (2014)



Described in shell-model framework with the *sdpf-u-mix* interaction



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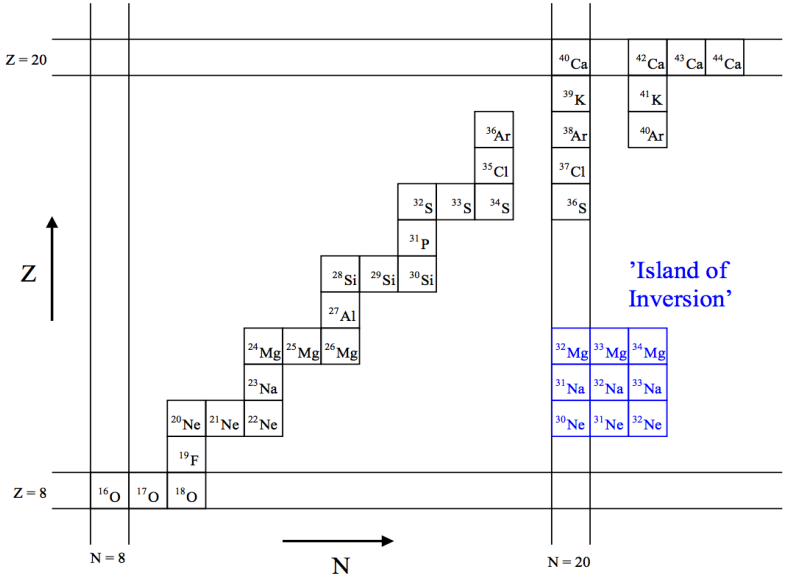

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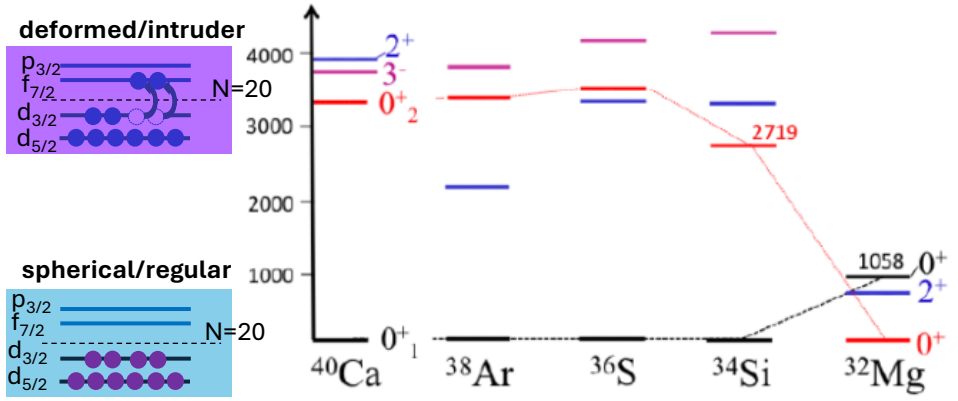

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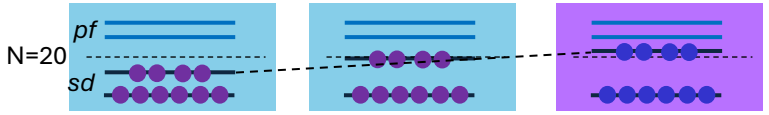
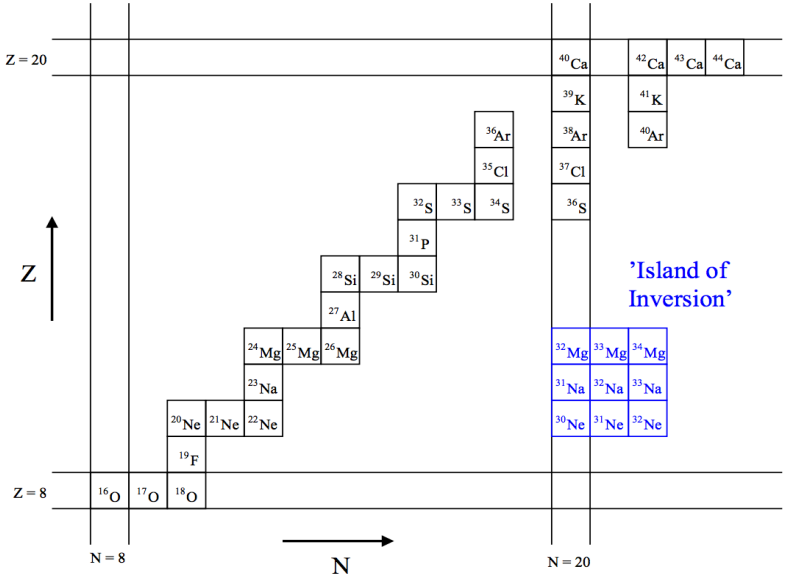


Test the predictions of the *sdpf-u-mix* interaction in describing structural evolution towards the N=20 Island of Inversion

The N=20 Island of Inversion



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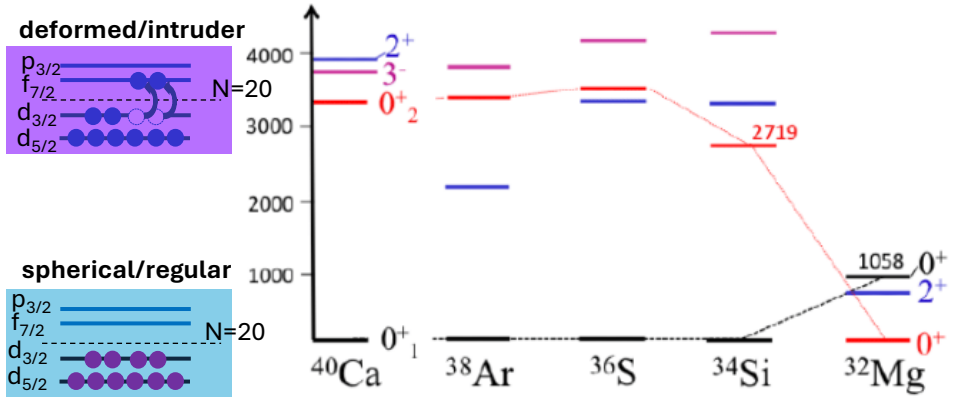

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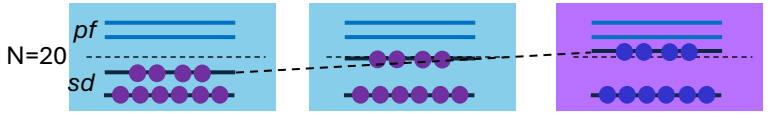


Test the predictions of the *sdpf-u-mix* interaction in describing structural evolution towards the N=20 Island of Inversion

Precision measurements near stability

The N=21 chain

Need to test the neutron component of the wavefunction towards the IoI

→ odd N=21 chain

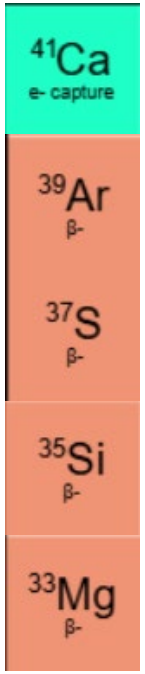
Z=20

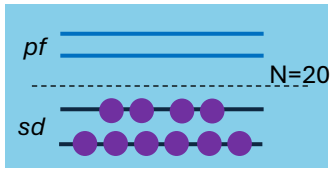
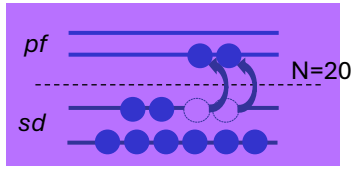
Z=18

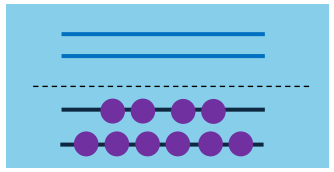
Z=16

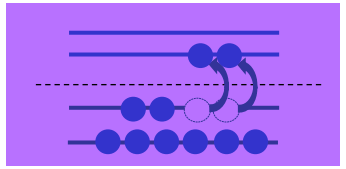
Z=14

Z=12



$$|\Psi\rangle = ($$  $+$  $) \otimes \nu$

 $\otimes \nu$ = single-particle state

 $\otimes \nu$ = intruder configuration

Relative positions of the single-particle orbitals

Mixing between intruder and normal configurations

The N=21 chain

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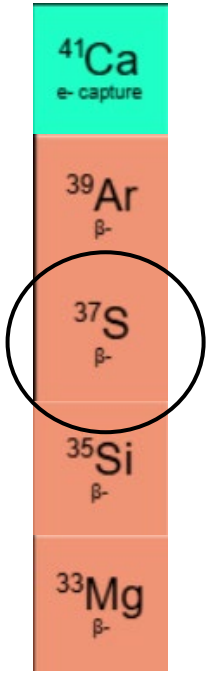
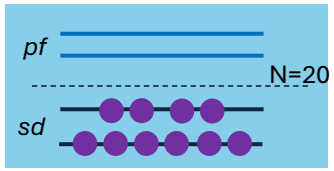
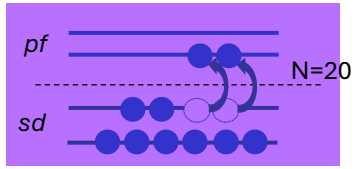
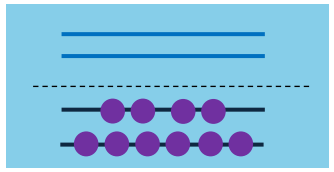
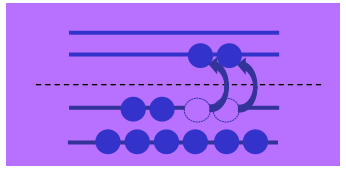


$$|\Psi\rangle = ($$  $+$  $) \otimes \nu$

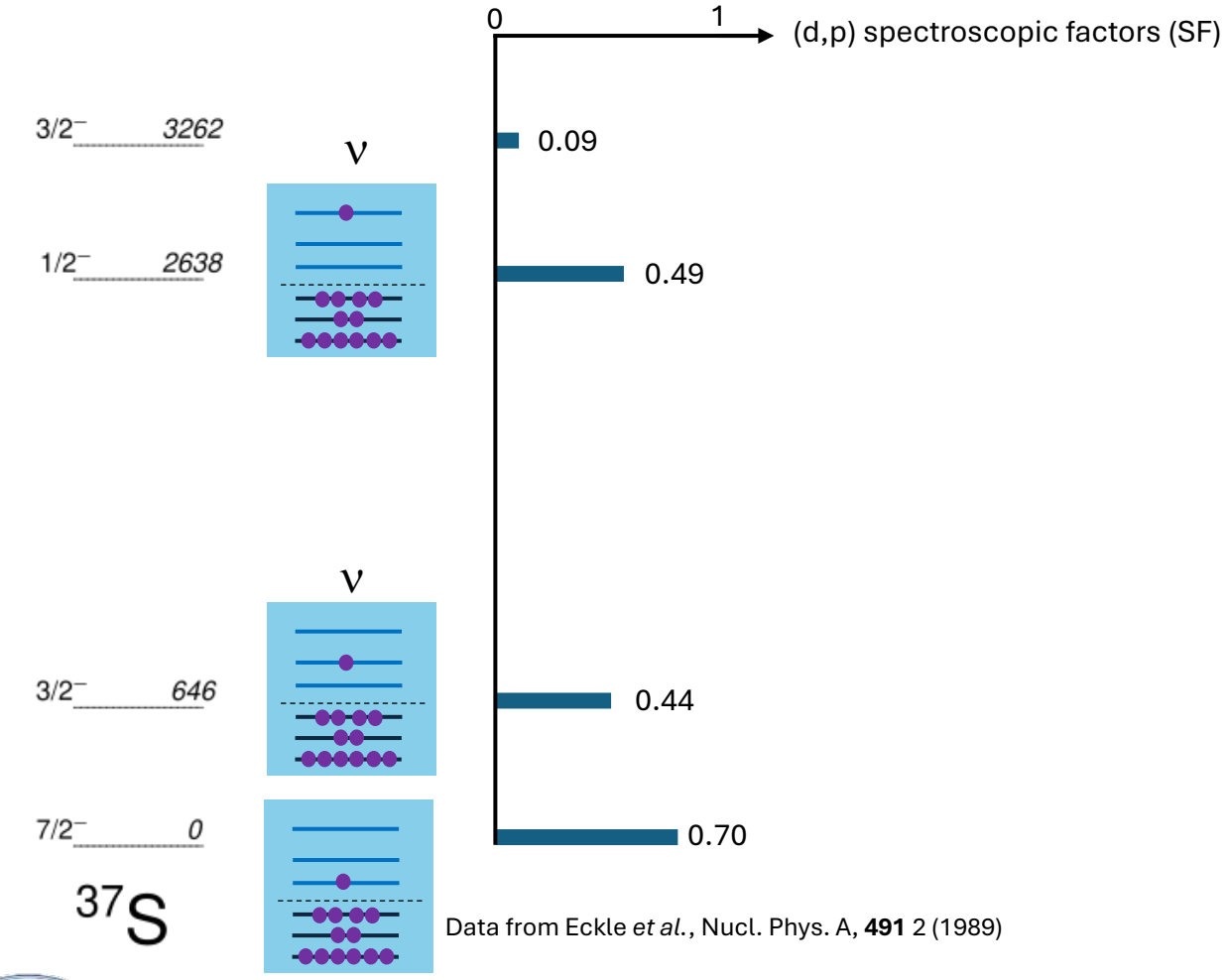
 $\otimes \nu$ = single-particle state

 $\otimes \nu$ = intruder configuration

Relative positions of the single-particle orbitals

Mixing between intruder and normal configurations

Low-lying states in ^{37}S



Data from Eckle *et al.*, Nucl. Phys. A, **491** 2 (1989)

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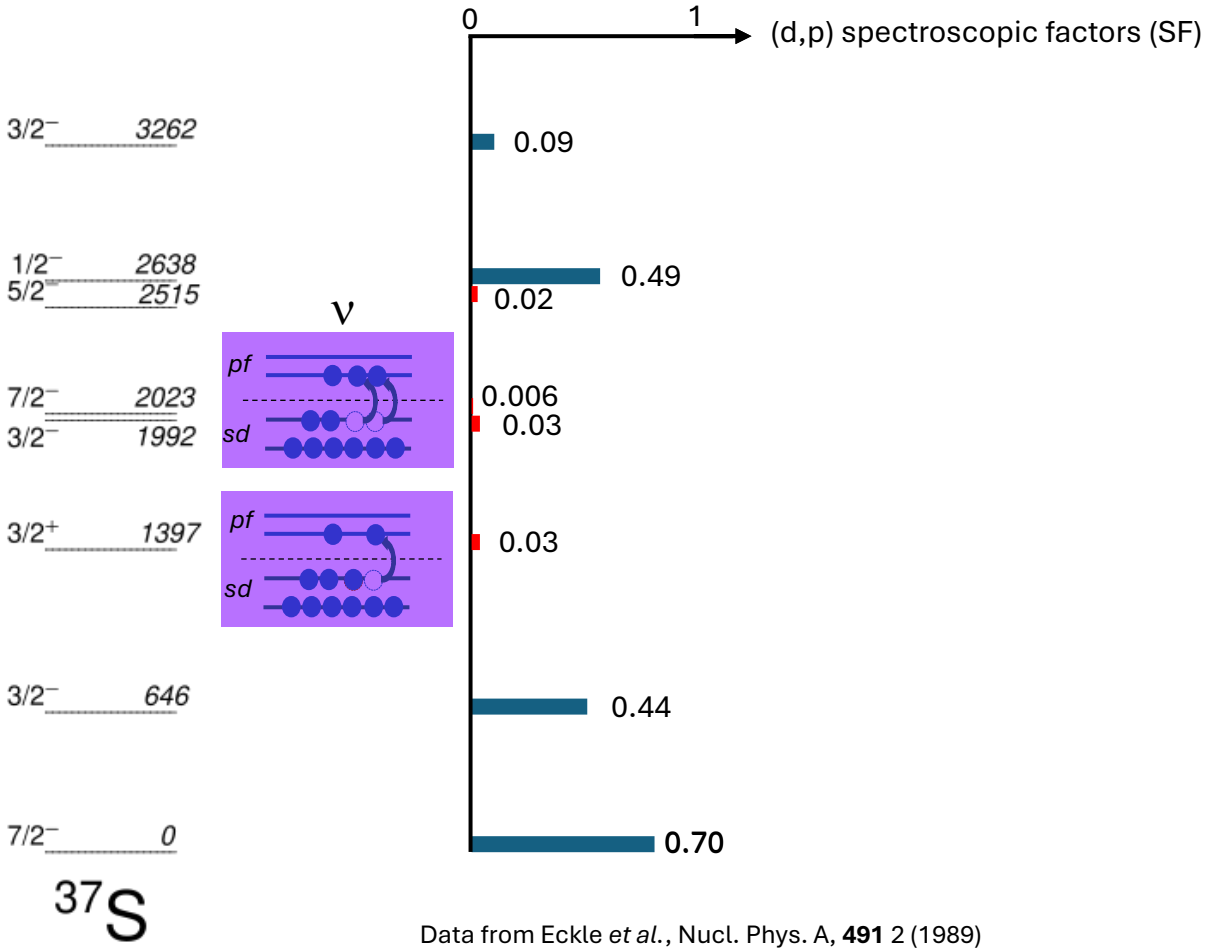

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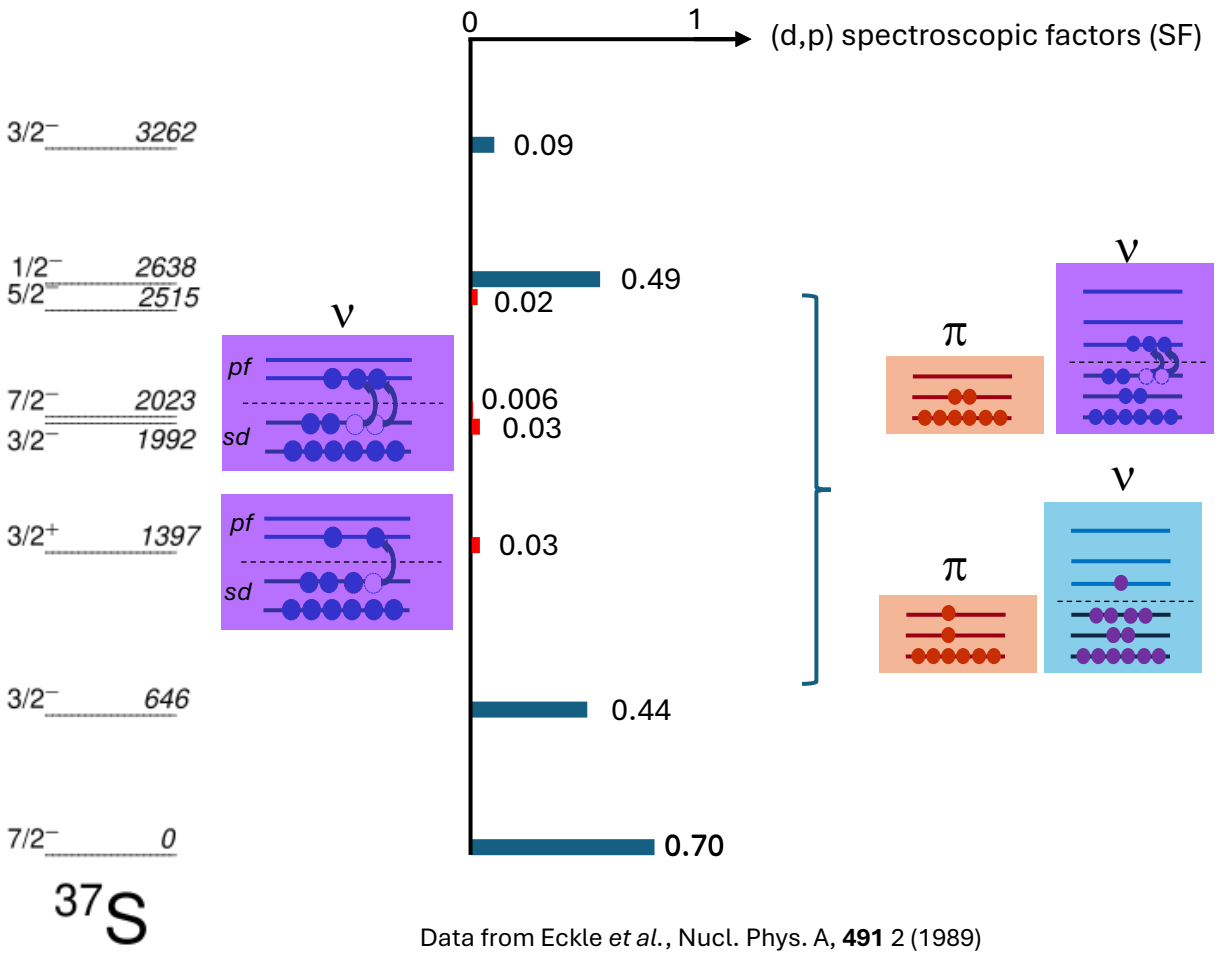

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intruder states

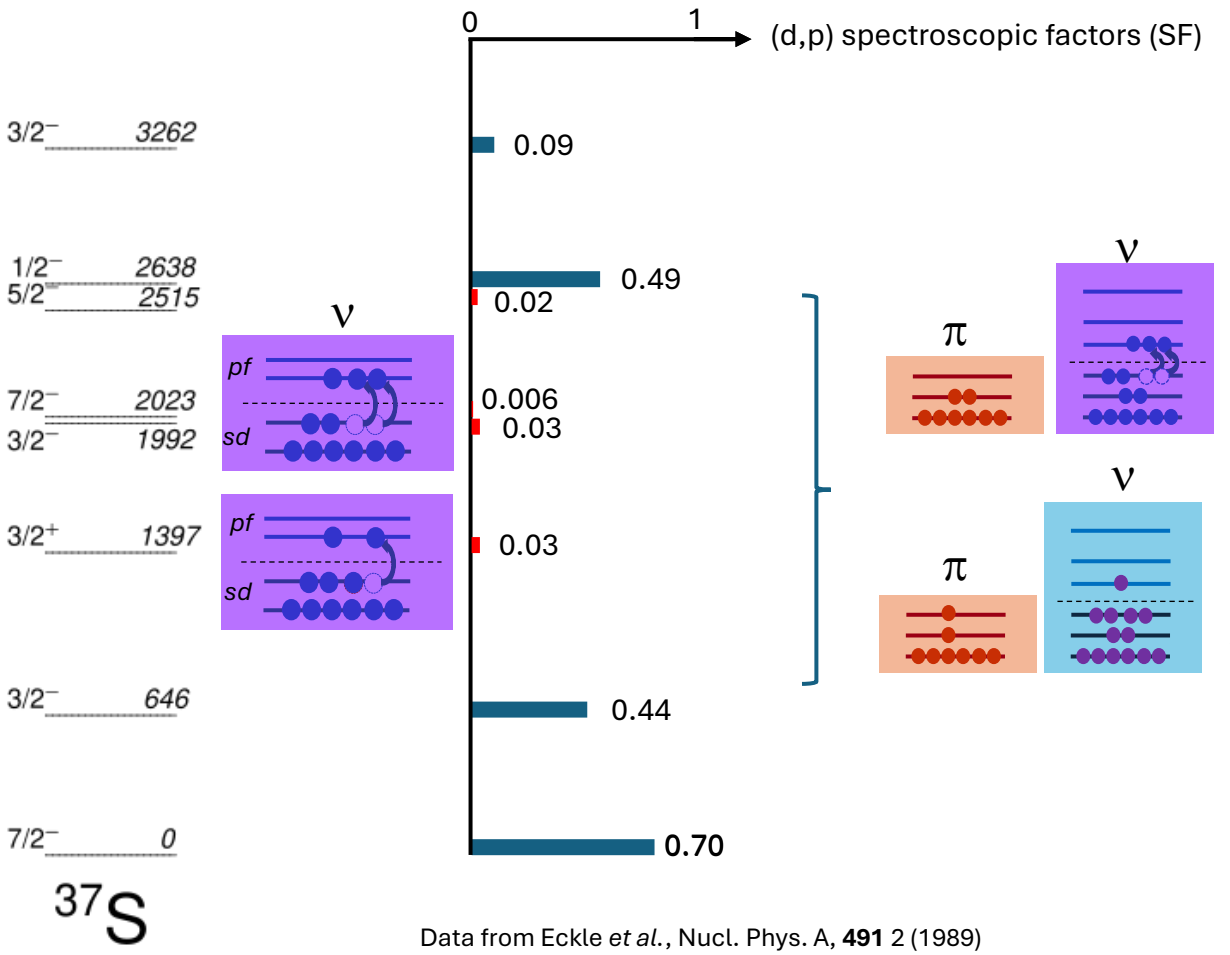
or

Single-particle on π excitations

How much do single-particle states mix with intruder configurations?

What is the nature of the states with small spectroscopic factor?

Low-lying states in ^{37}S



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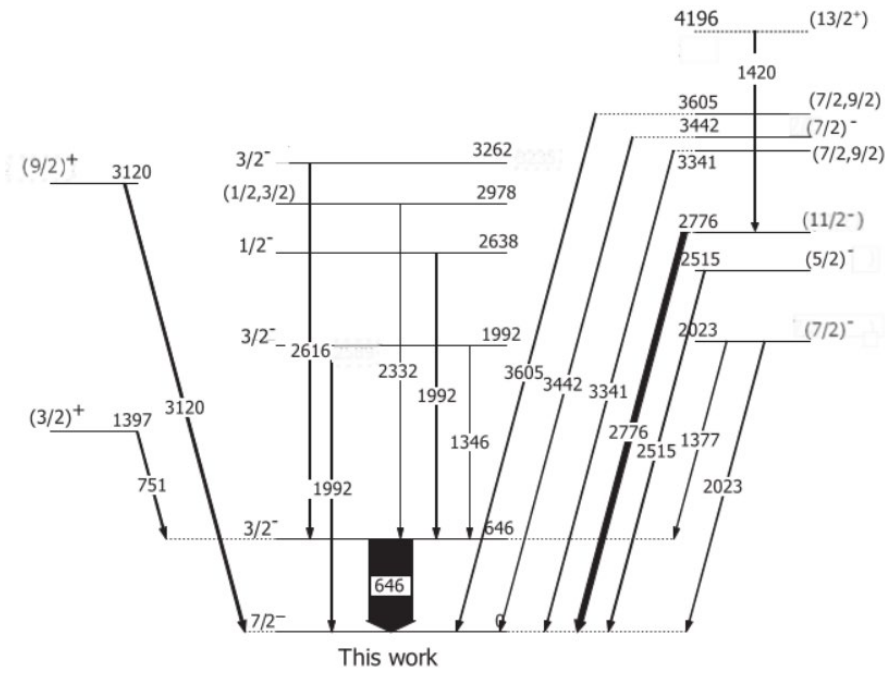
Need access to the nuclear wavefunction:
Nuclear lifetime measurements

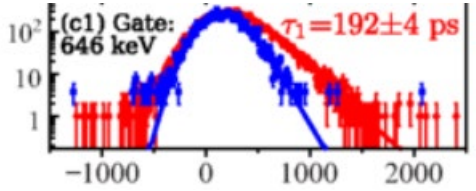
What is the nature of the states with small spectroscopic factor?

Lifetimes in ^{37}S: a new measurement

previous results



Chapman *et al.*, Phys. Rev. C, **93** 044318 (2016)



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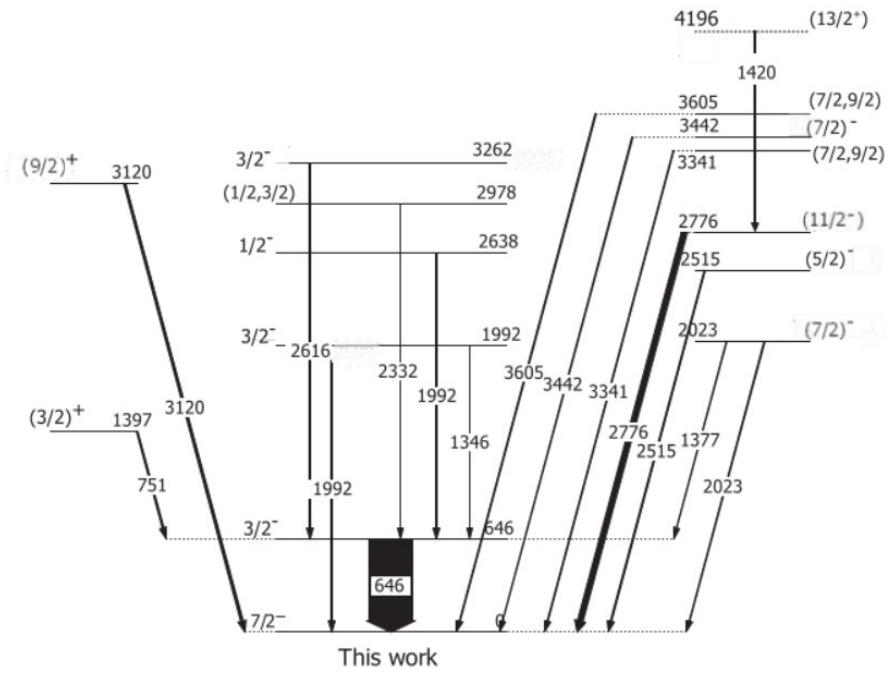

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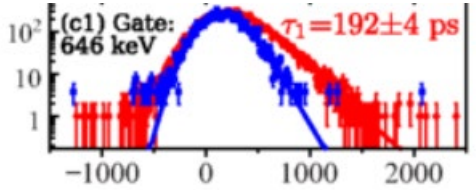

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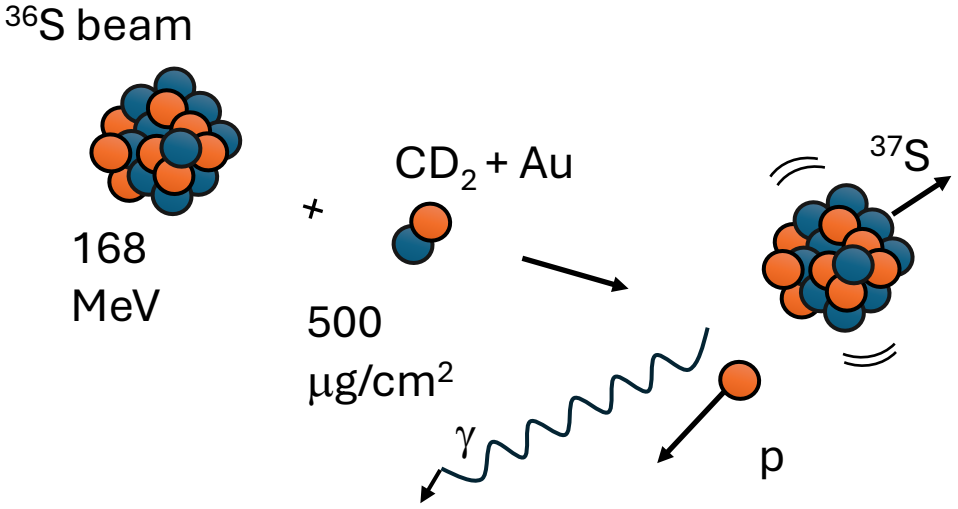

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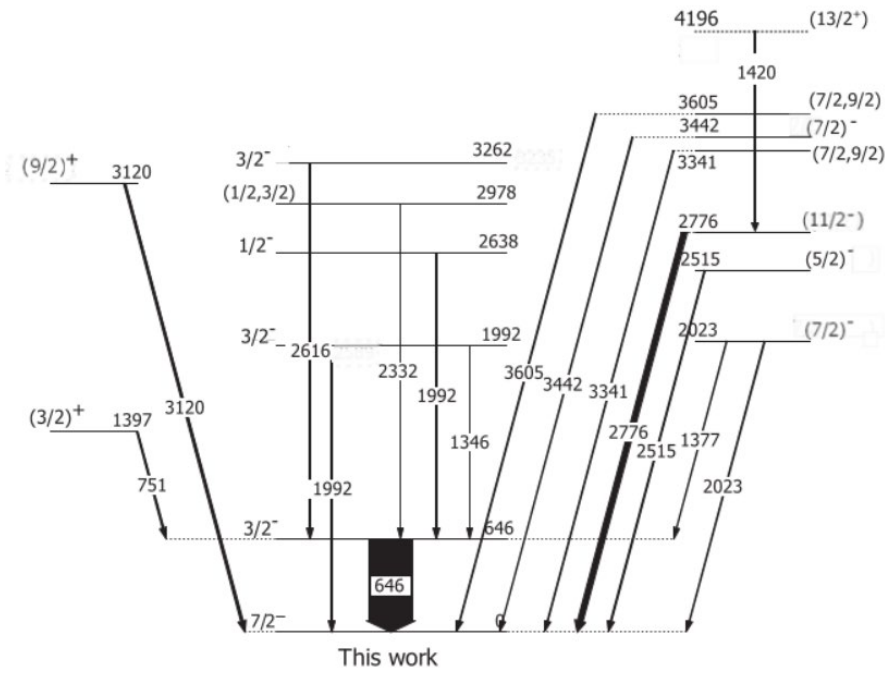

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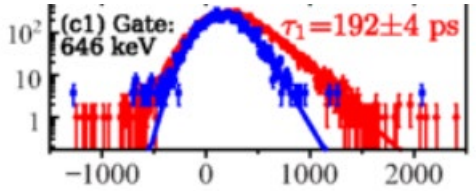

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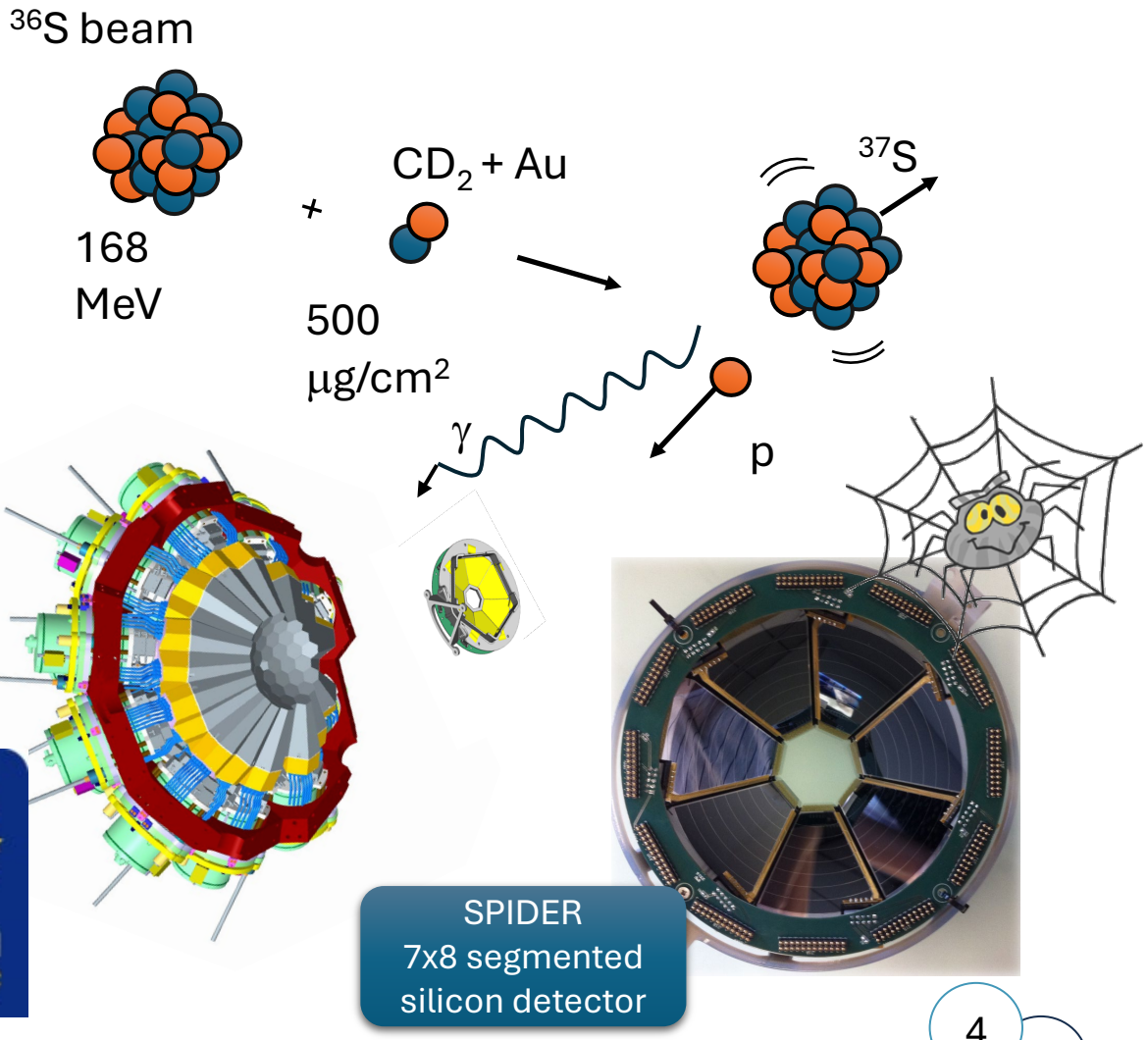
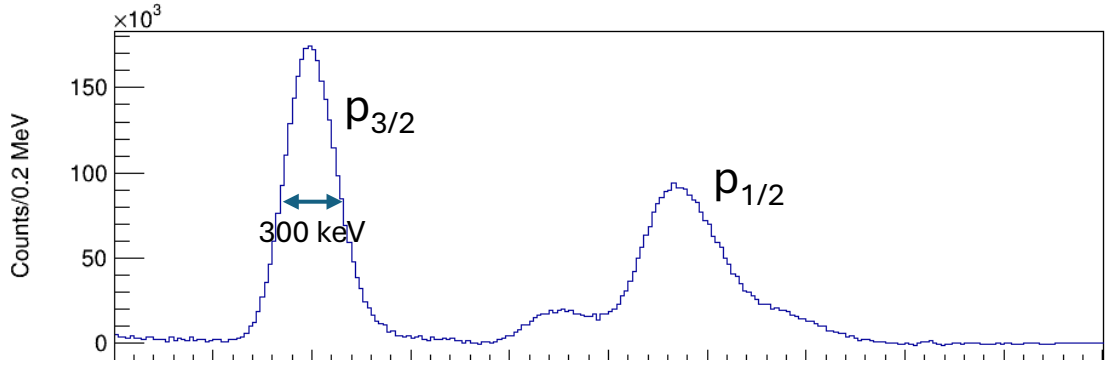
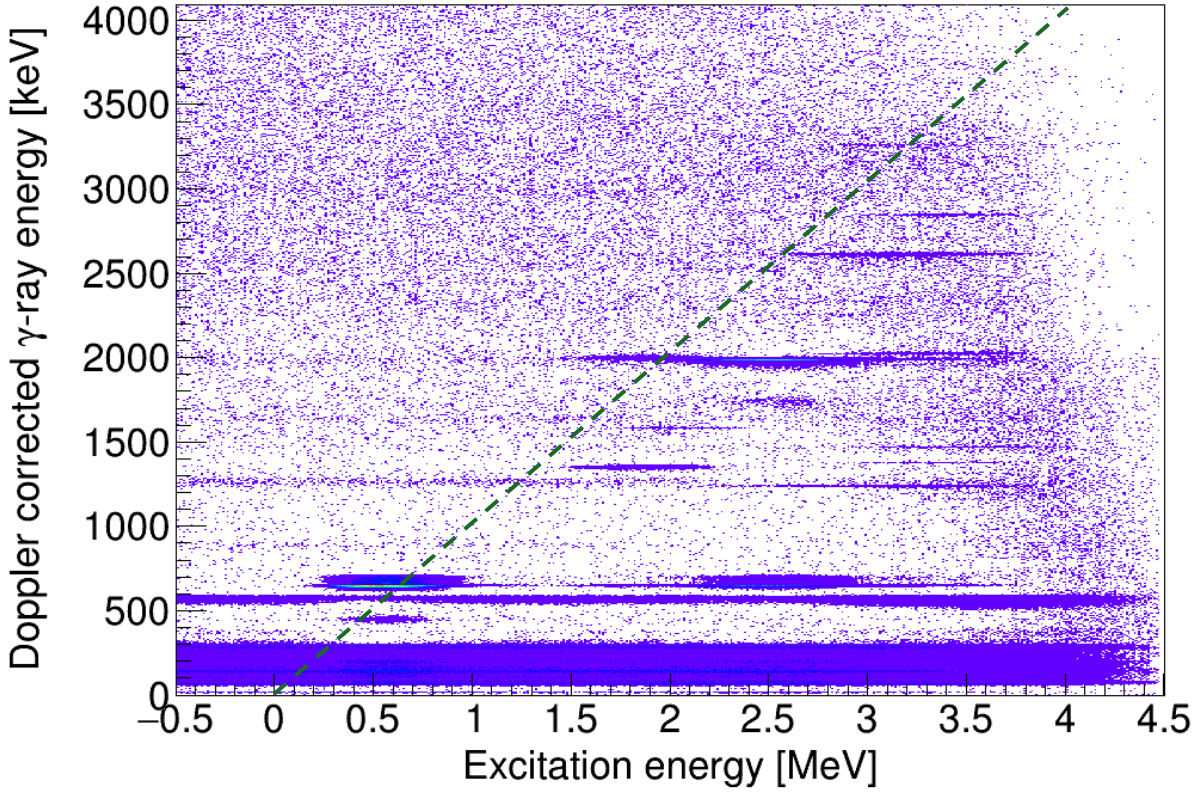


Particle-gamma matrix





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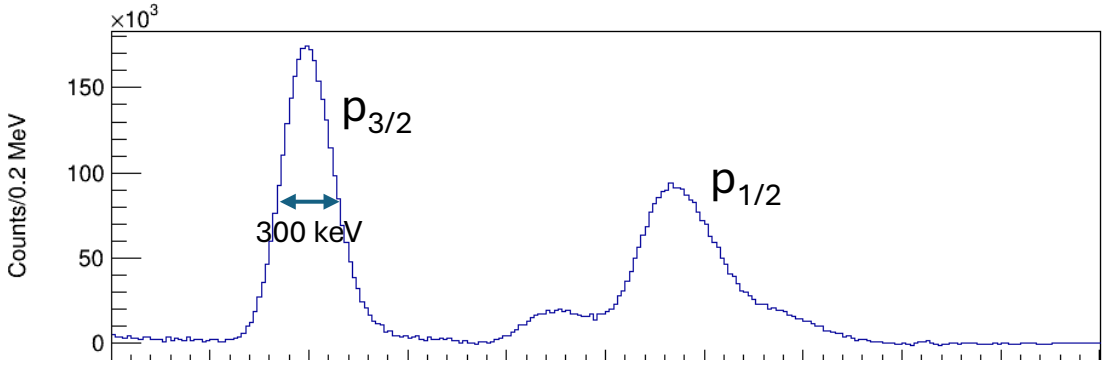

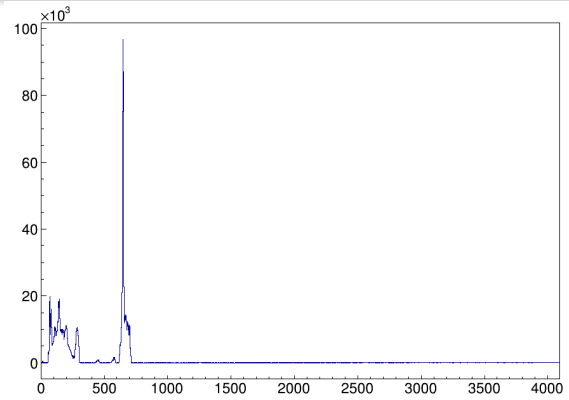

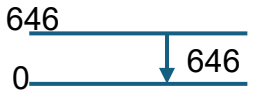

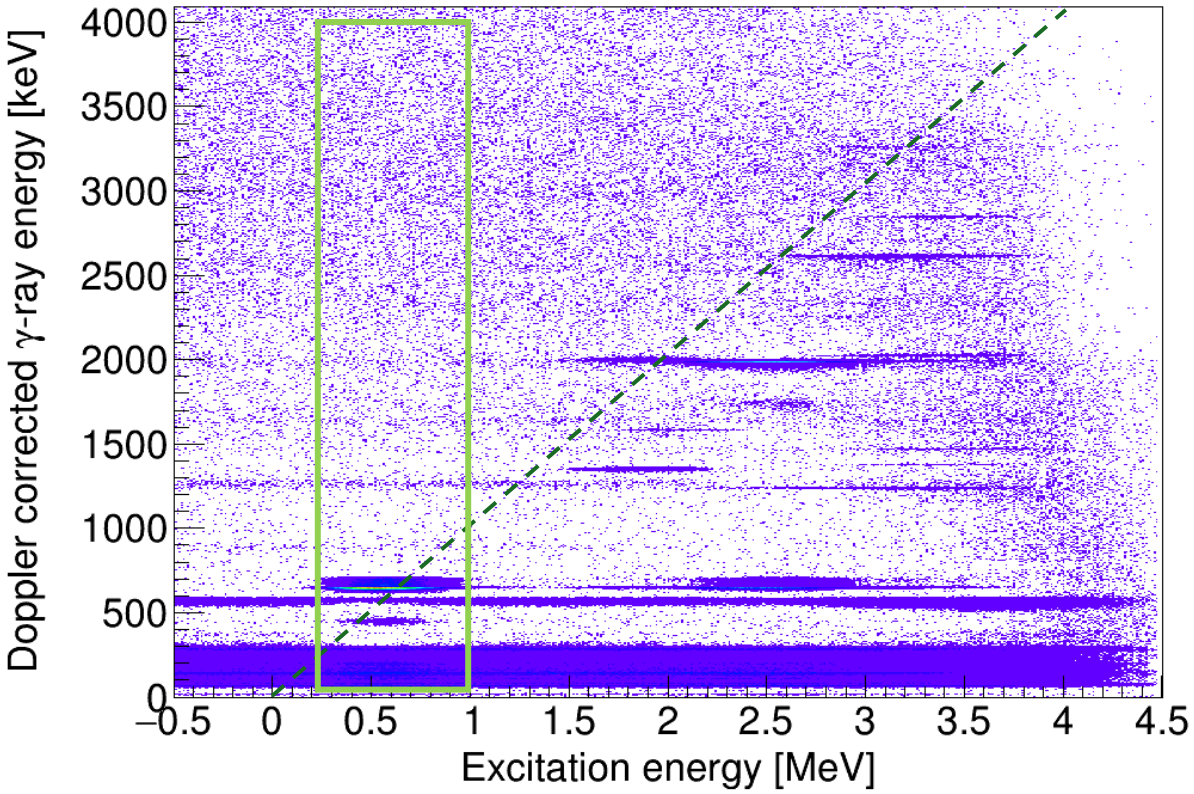

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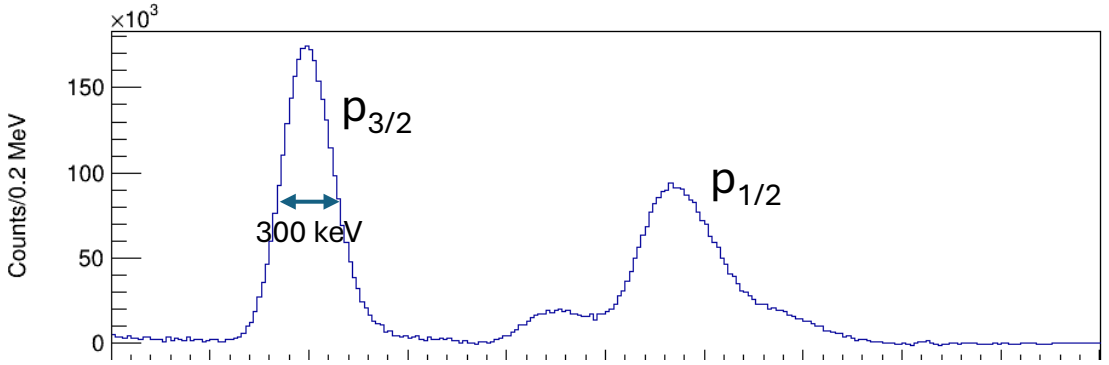

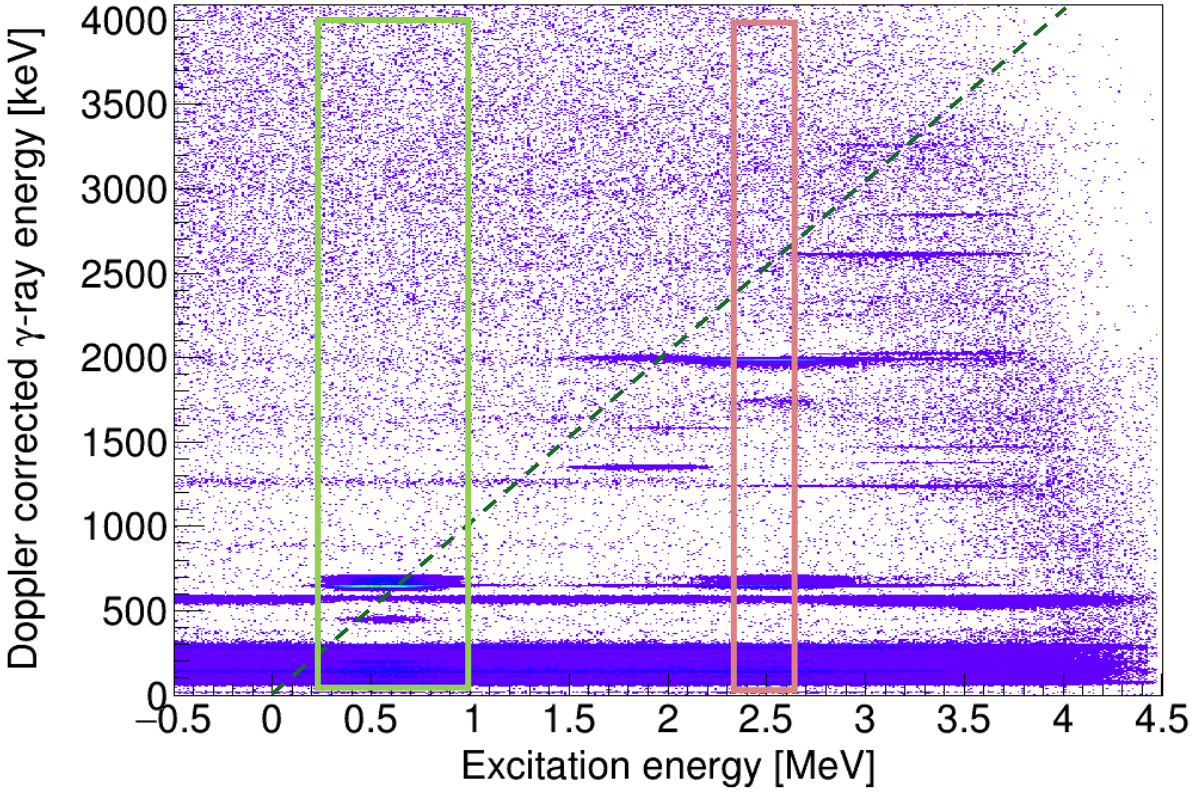

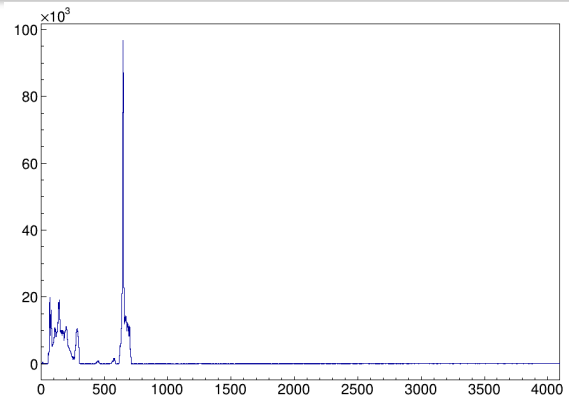

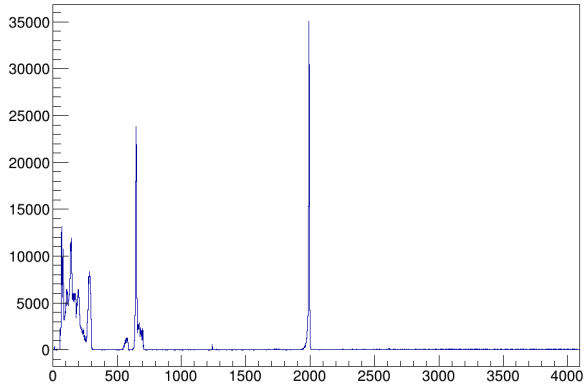

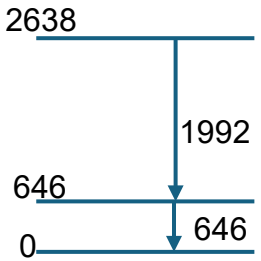

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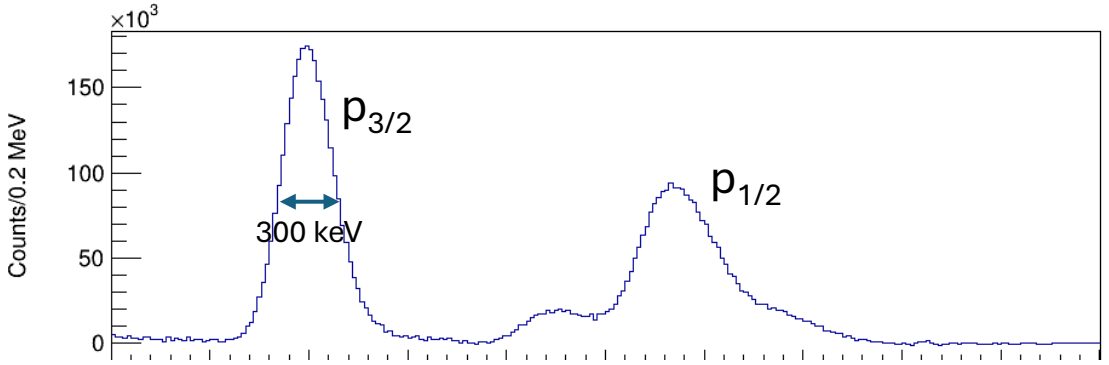
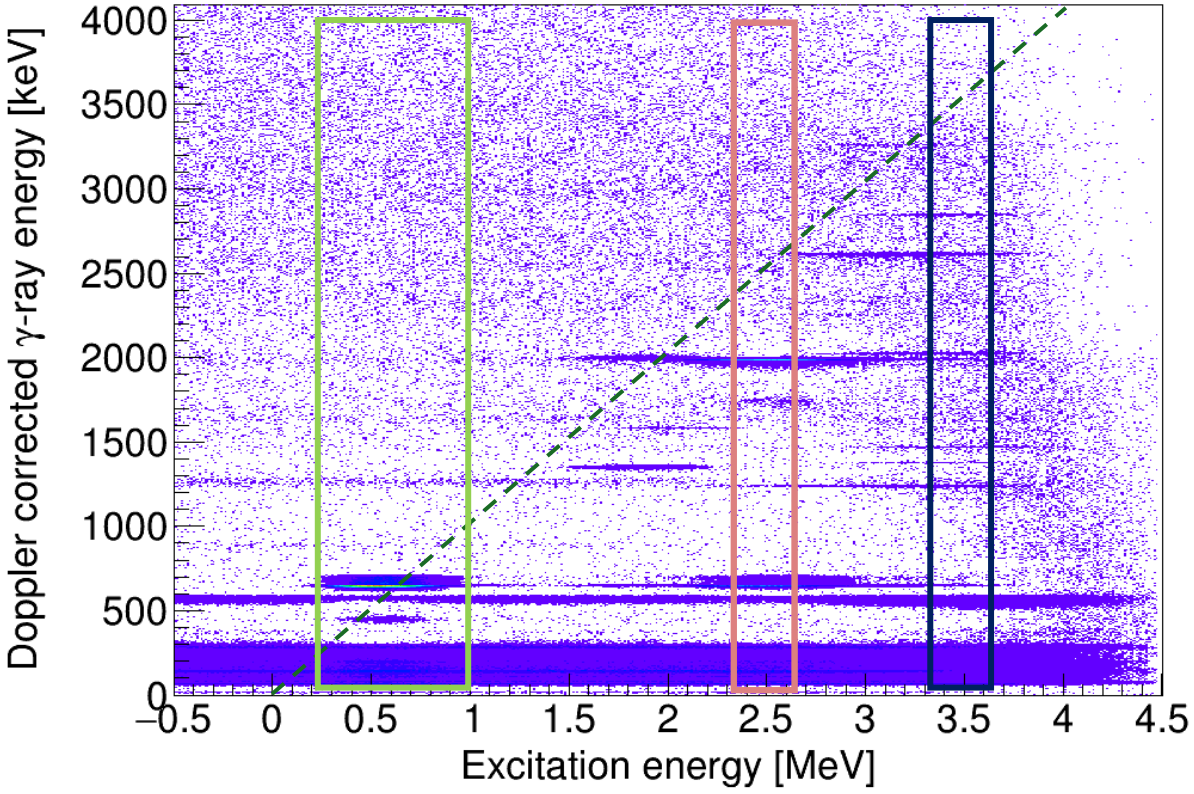
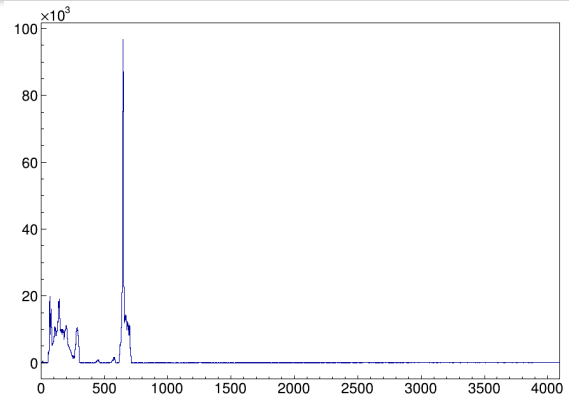
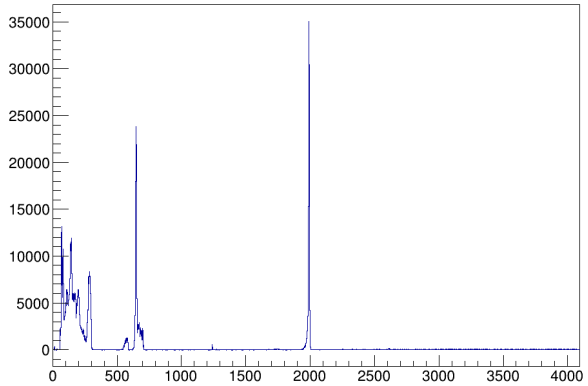
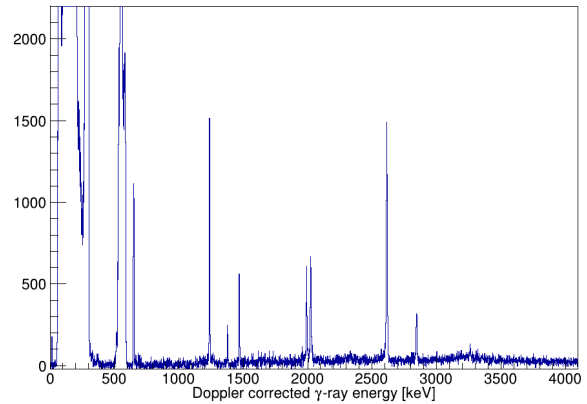
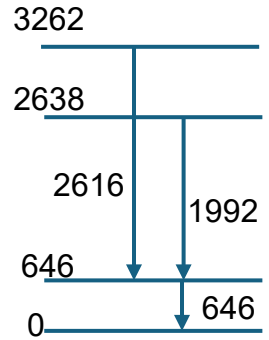












p-γ coincidences

Level scheme

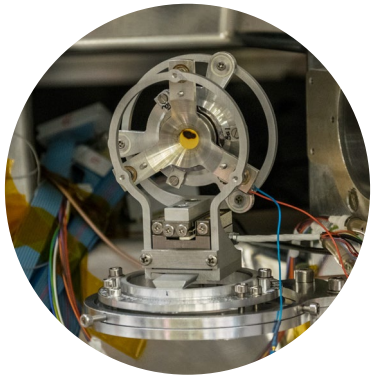
Feeder control

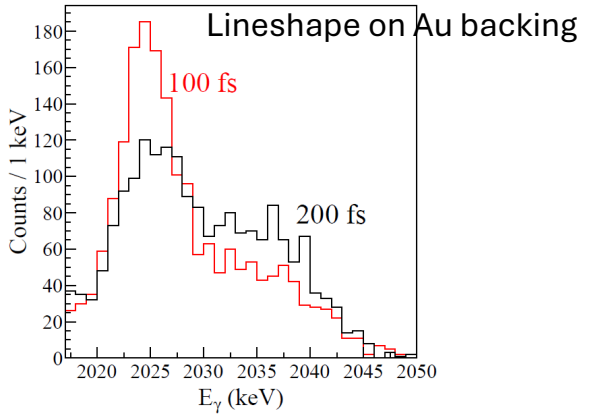
All spectroscopic results agree with previously published measurements

Lifetimes in ^{37}S

Based on SM calculations and ^{39}Ar (Z=18) results, lifetimes span from fs to 100 ps

Combined RDDS+DSAM measurement





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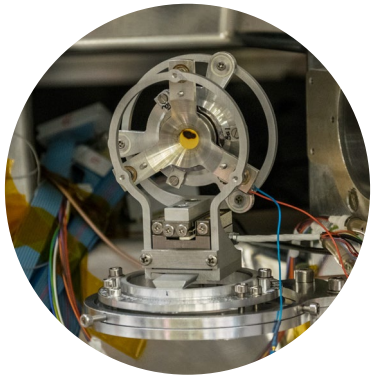
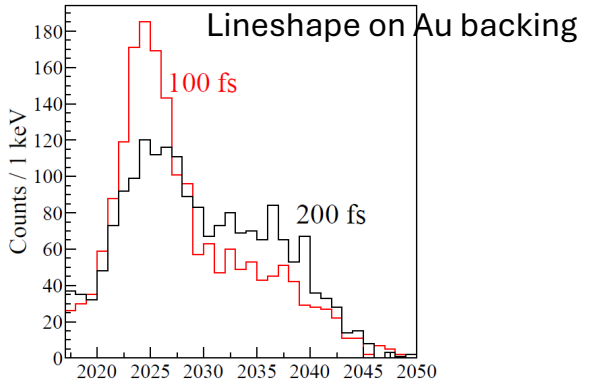
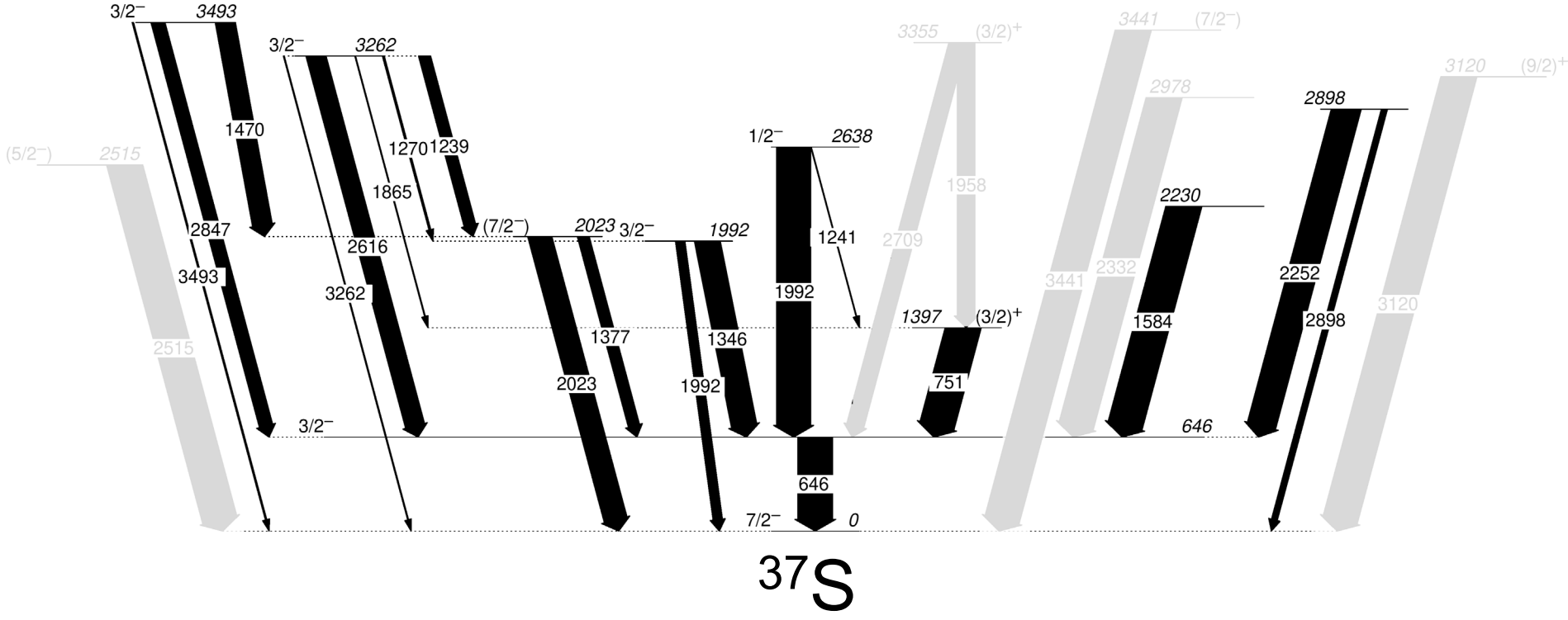
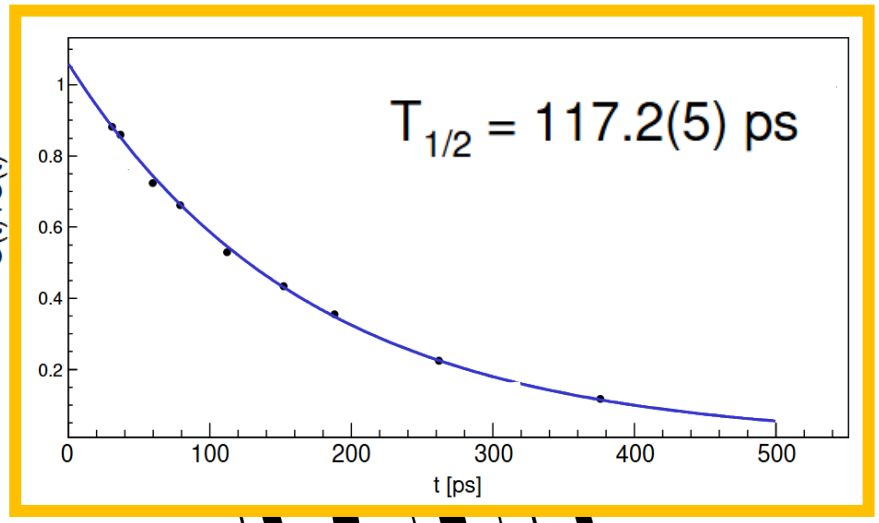
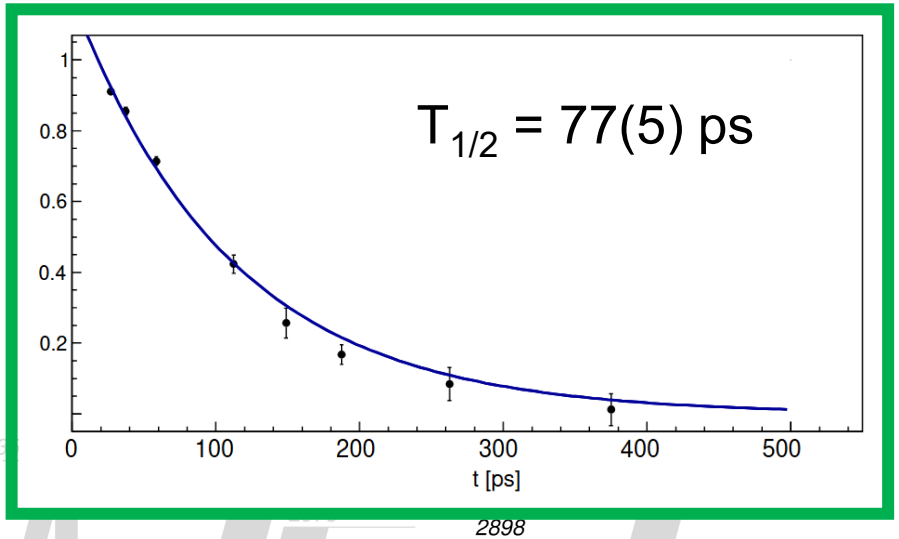


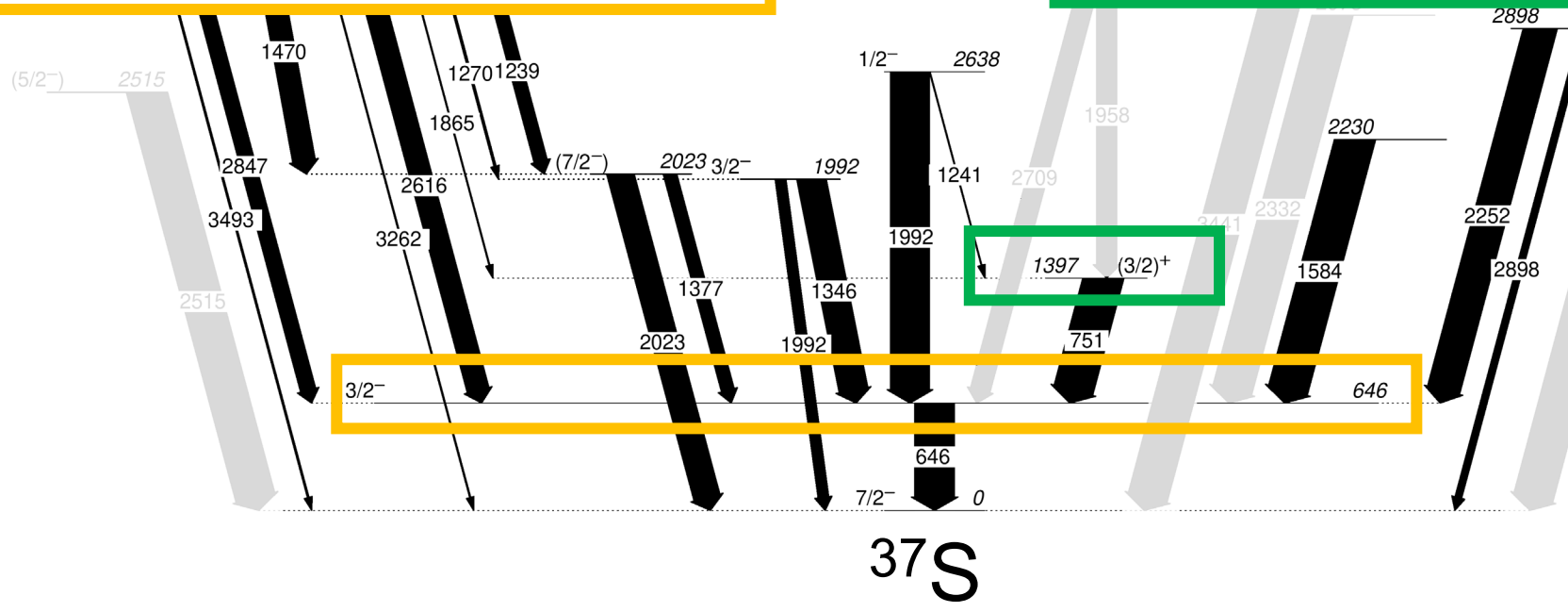




RDDS results

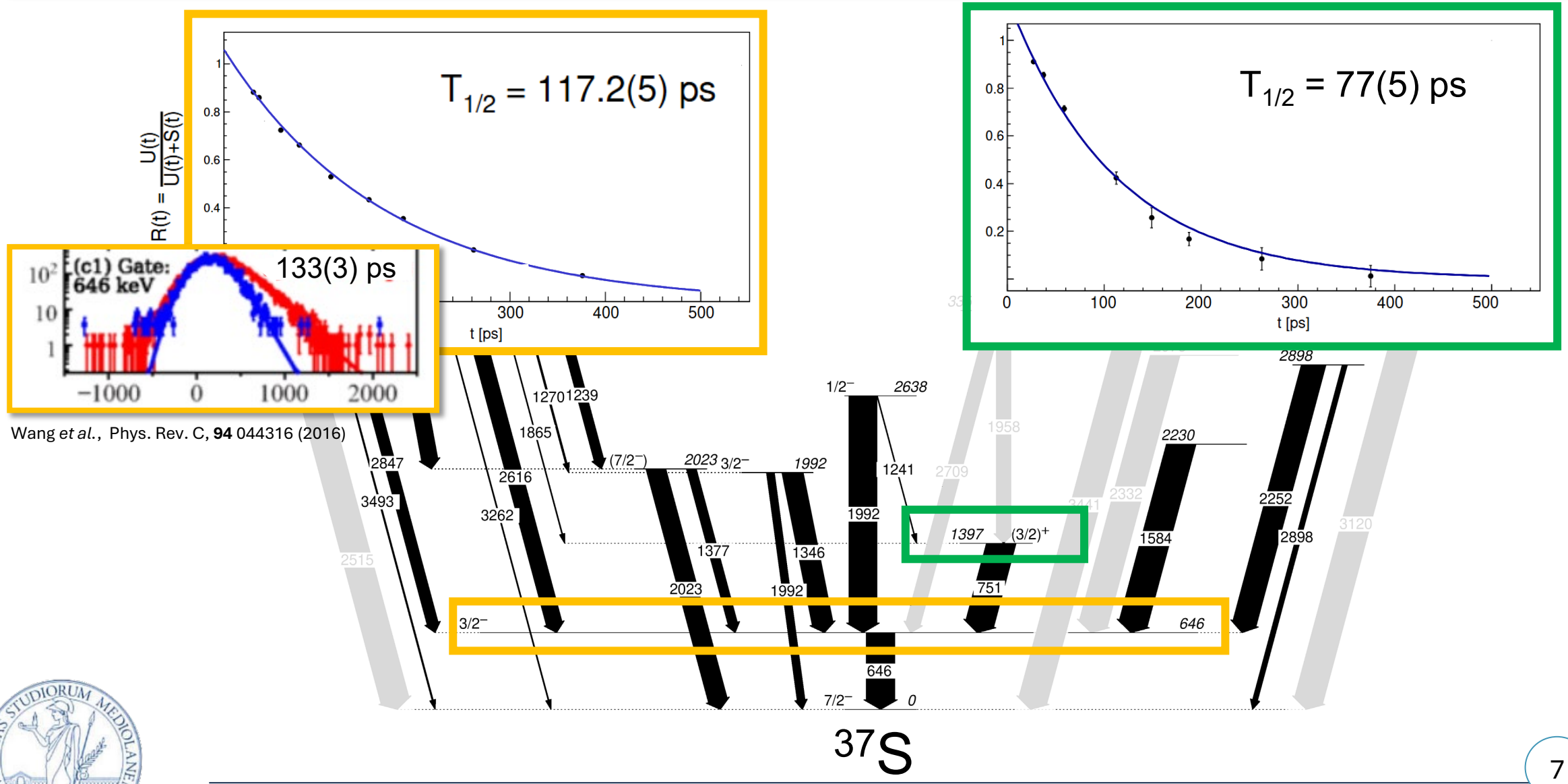






^{37}S

RDDS results



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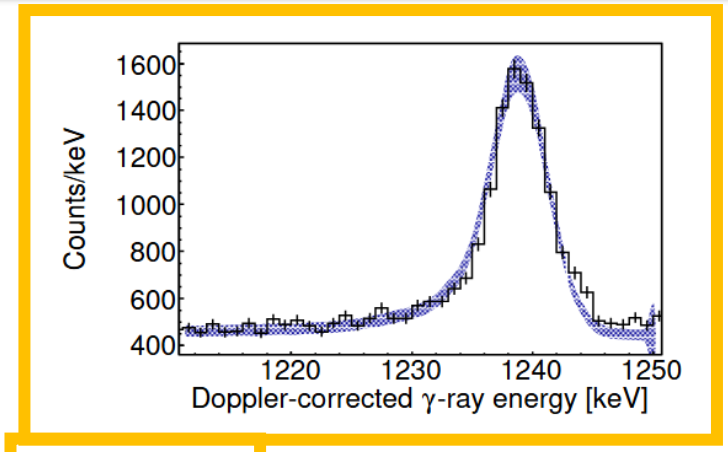
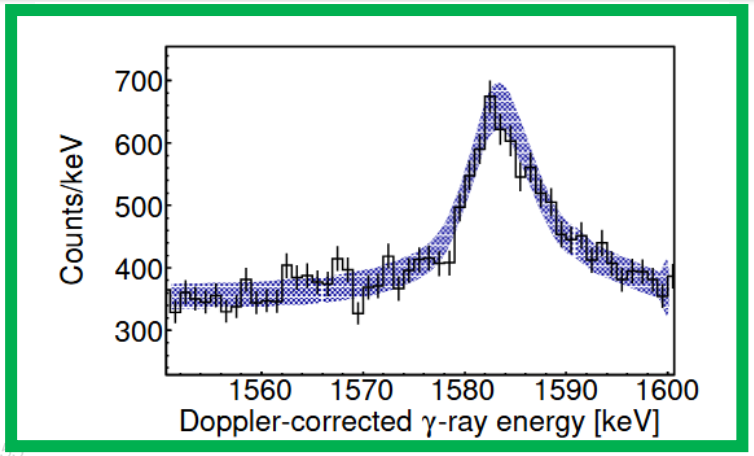
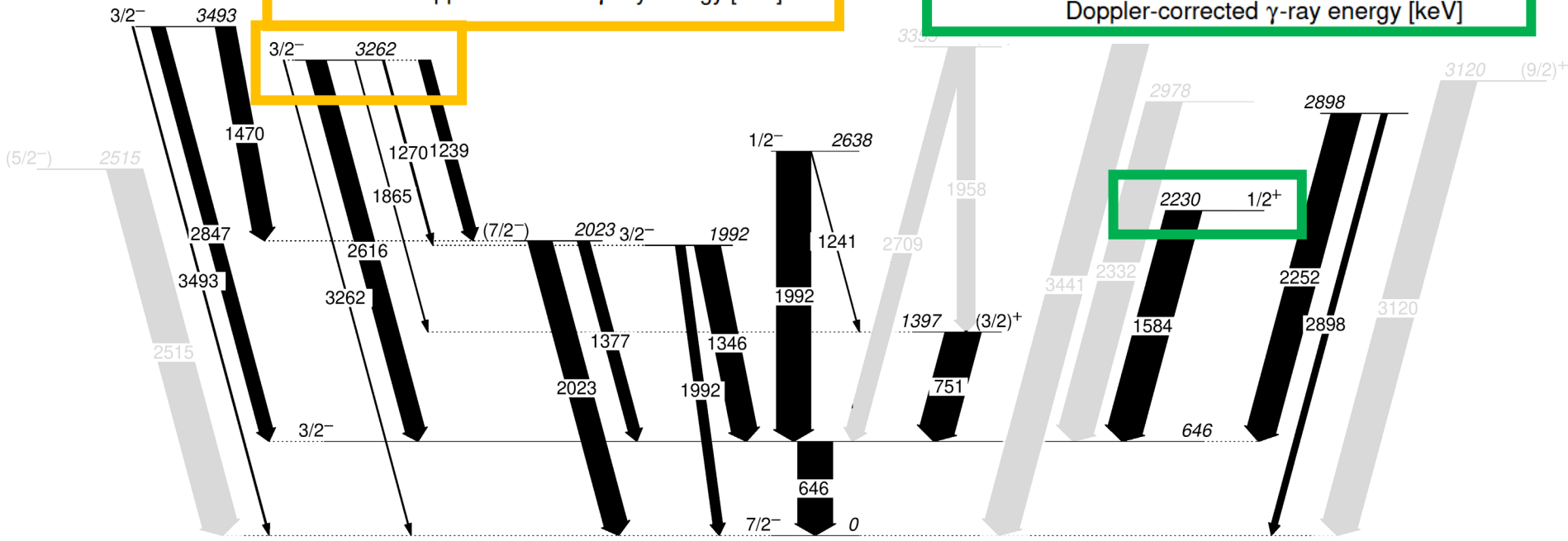
DSAM results

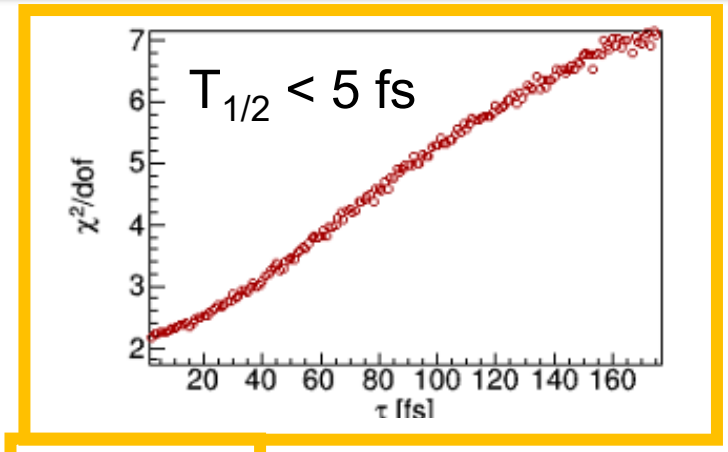


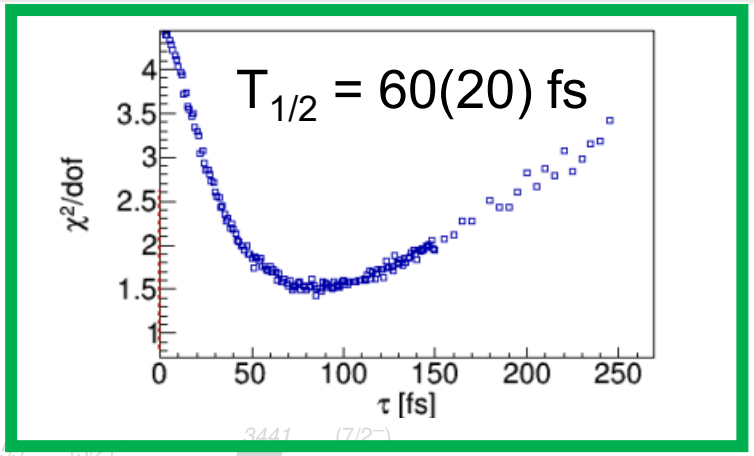


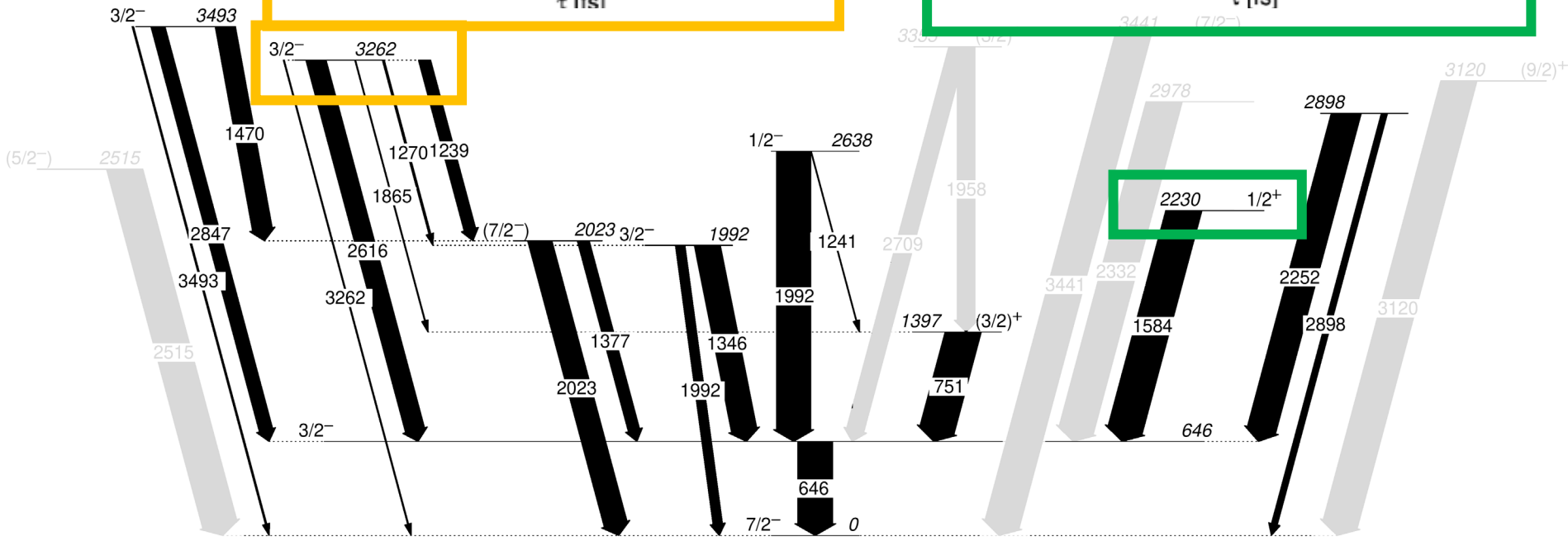


^{37}S

DSAM results

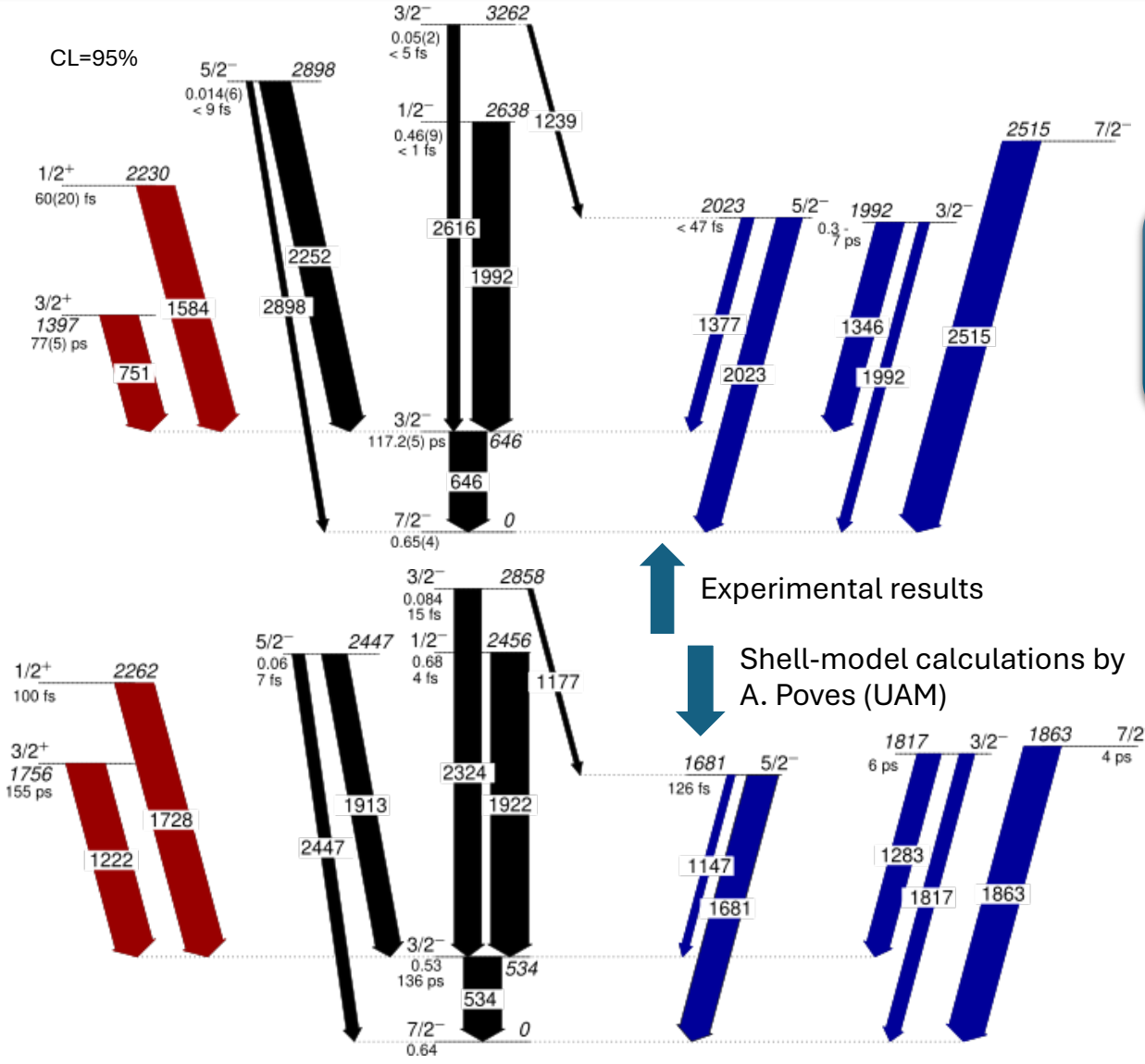






^{37}S

Comparison with *spdf-u-mix*



Experimental results

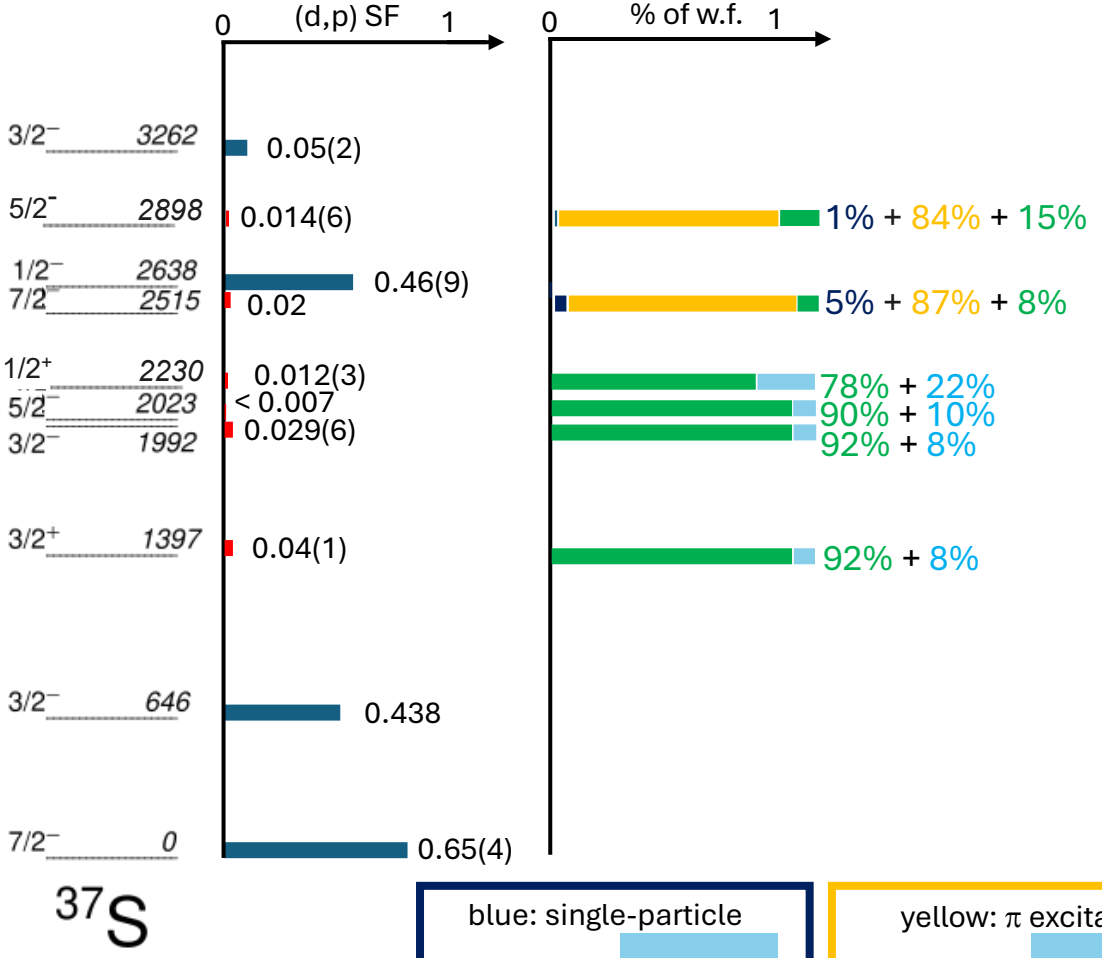
Shell-model calculations by A. Poves (UAM)

All observables are reproduced by SM calculations with the *sdpf-u-mixing* interaction below 3.5 MeV

comparison above 3.5 MeV becomes hard due to the high density of states

microscopic configuration of excited states in ^{37}S

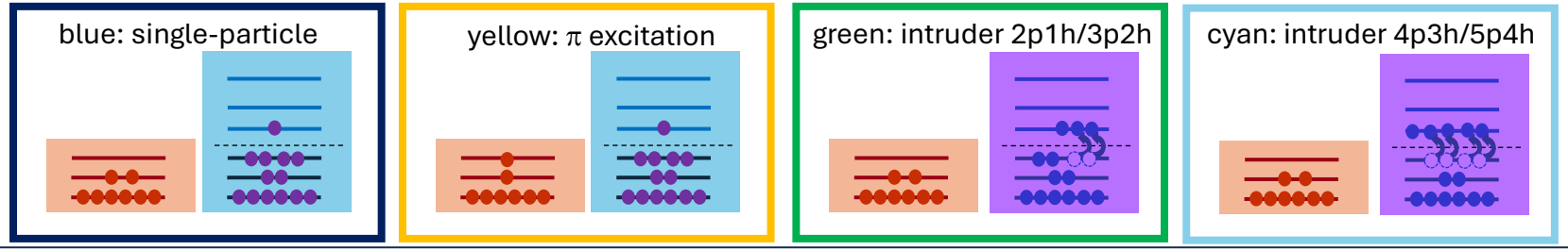
Small SF states



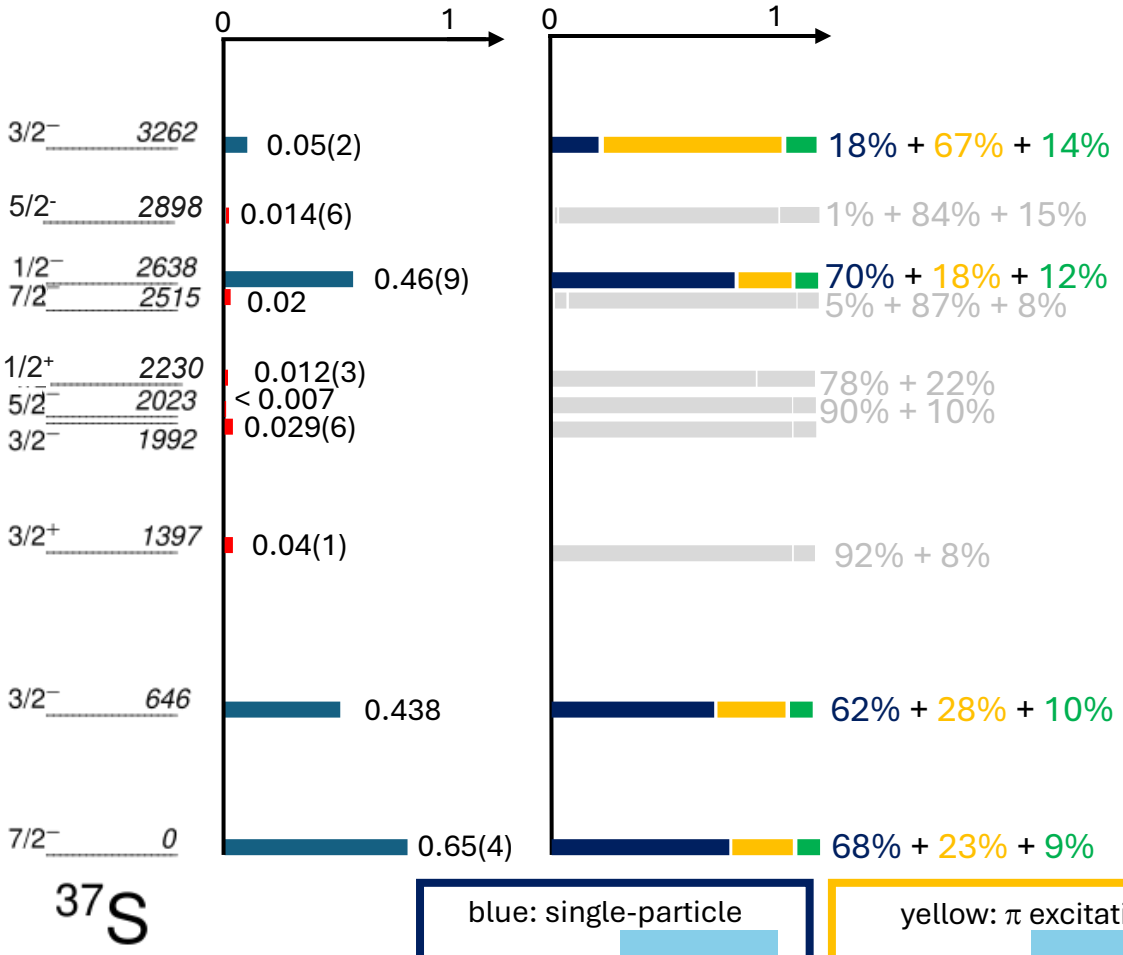
What is the nature of the states with low spectroscopic factor?

Single-particle states built on π excitations with small intruder components

Low-energy intruder states, with small higher-order excitations

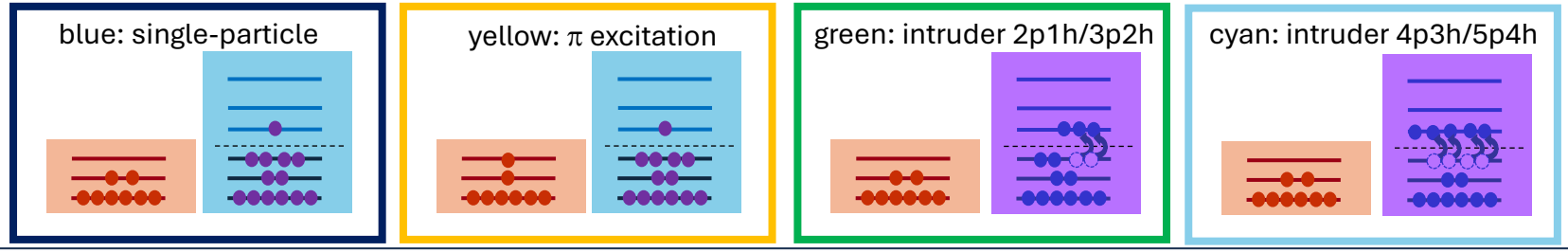


Large SF states



How much do single-particle states mix with intruder configurations?

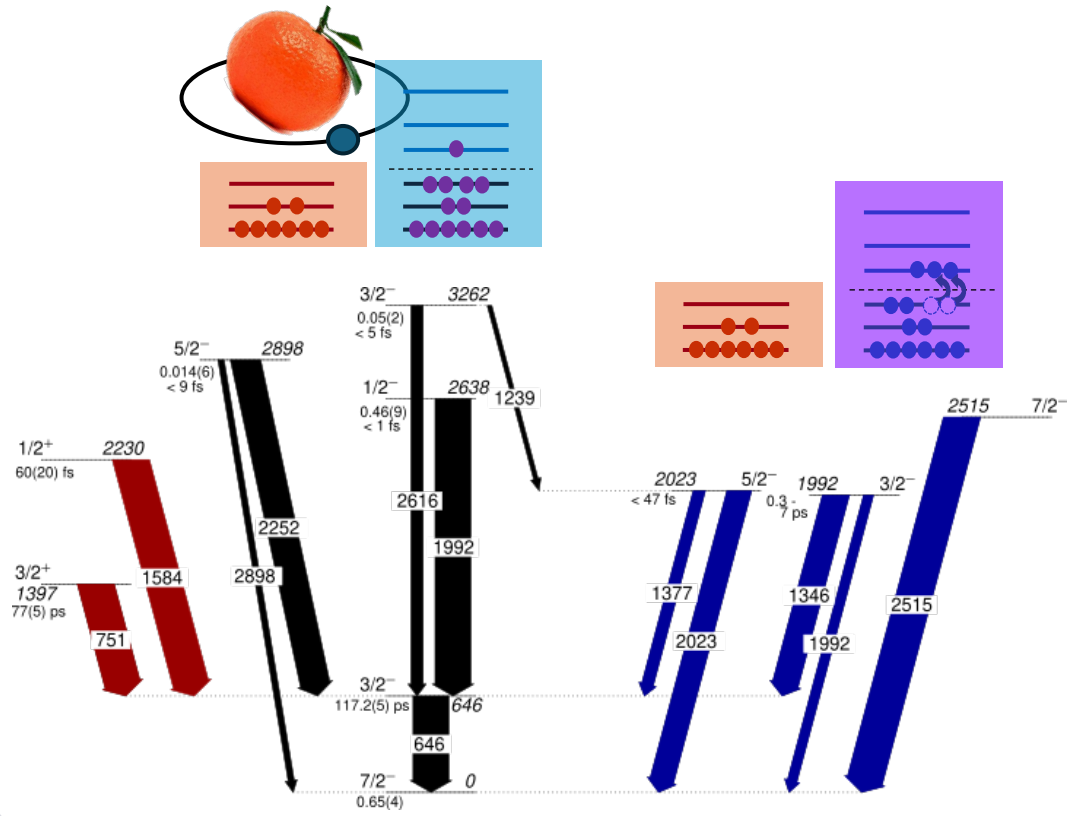
Small intruder components are already present in the ground-state, which seem to increase with excitation energy



Conclusions

Bulk of single-particle structure built on modestly oblate configuration (^{38}S), small mixing (10%) already at ground state

Above 2.5 MeV, higher-order excitations and proton excitations become the leading components of the wavefunction



Precise measurements near stability provide the opportunity to perform stringent tests on nuclear interaction

Need for multiple complementary observables to understand nuclear structure

Direct reactions + lifetime measurements have proved to be a very successful tool to probe the nuclear wavefunction

High-efficiency highly-segmented detectors are key to perform spectroscopic studies both near and far the valley of stability

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27th May 2025
29th International Nuclear Physics Conference
DCC, Daejeon, Korea

L. Zago
UniMi Statale and INFN-LNL

Mixing between single-particle and intruder states
towards the N=20 island of inversion: lifetimes in 37S

Thank you for your attention