



Theory Alliance
FACILITY FOR RARE ISOTOPE BEAMS

FRIB-TA Topical Program: Statistical Nuclear Properties in the AI/ML Era: Advances, Challenges, and Synergies for FRIB Science

June 29, 2026 to July 10, 2026
Facility for Rare Isotope Beams
America/New_York timezone

Overview

Registration

Timetable

Participant List

Meeting Venue and Area
Information

Airports

... Maps

Parking

U.S. Visa and Health
Insurance Information

FRIB Theory Alliance
Code of Conduct

Past FRIB Theory Alliance
Topical Programs

Contact

✉ ta-programs@frib.msu.edu

Statistical nuclear properties from the shell model and reduced-order fitting schemes



📅 Jul 7, 2026, 10:30 AM

🕒 1h

📍 1221A/B (Facility for Rare Isotope Beams)

Speaker

👤 Oliver Gorton (Lawrence Livermore National Laboratory)

📎 Presentation materials

There are no materials yet.

Statistical properties from the shell model and reduced-order fitting schemes

Oliver Gorton, postdoc | Lawrence Livermore National Laboratory, California, USA

Reaction Theory for R-process Observables (RETRO) Collaboration:

Jutta Escher¹ (PI), Jeffrey M. Berryman¹, Jonathan Cabrera Garcia²,
Erika M. Holmbeck¹, Atul Kedia³, Kostas Kravvaris¹, Gail C. McLaughlin³,
Cole D. Pruitt¹, Andre Sieverding¹, and Rebecca Surman²

¹LLNL, ²U. Notre Dame, ³North Carolina State University

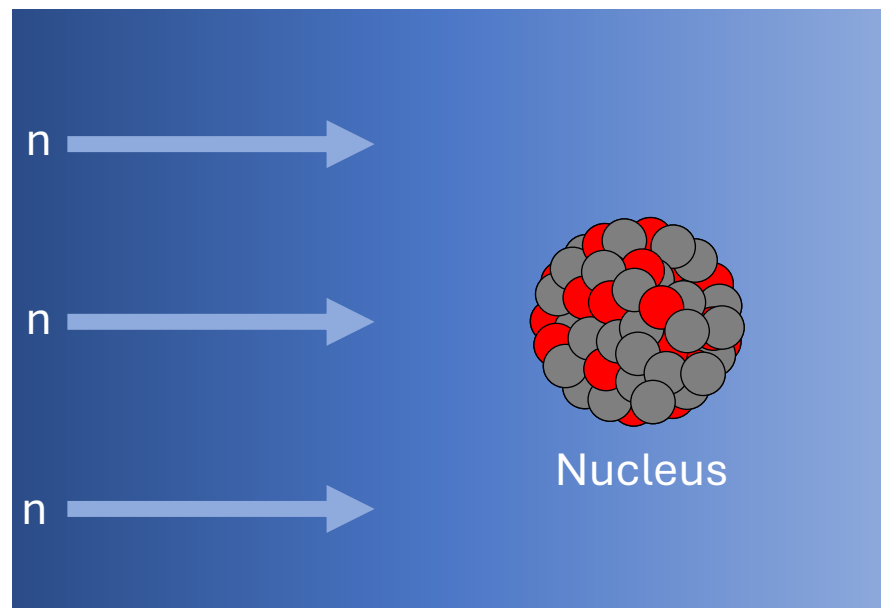


How and where are heavy elements formed?

Answer “Extreme radiation environments with ultra-high neutron fluxes”



Neutron star merger



Flux $> 10^{37}/\text{cm}^2/\text{s}$
(Neutron density $> 10^{29}/\text{cm}^3$ @ 1GK)

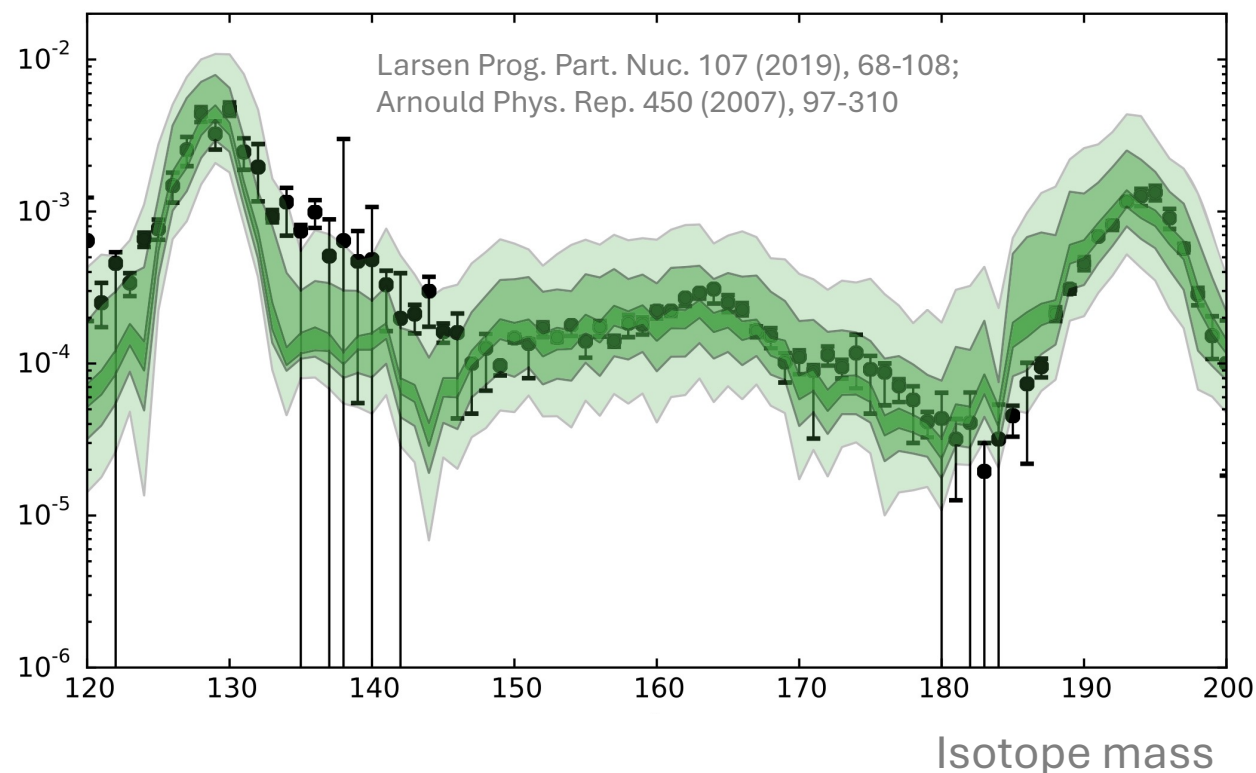
Isotopic “fallout” from extreme events

The task

Given **radiochemical evidence**,
determine the **event** (neutron source) that produced it

Number of
each isotope

x2
x10
x100



Hydrodynamics versus nuclear physics uncertainty

Task Given **radiochemical evidence**, determine the **event** that produced it

3 hydro simulations (2 NS mergers, 1 supernova) + 1 source of nuclear uncertainties*

Amount of
isotope produced

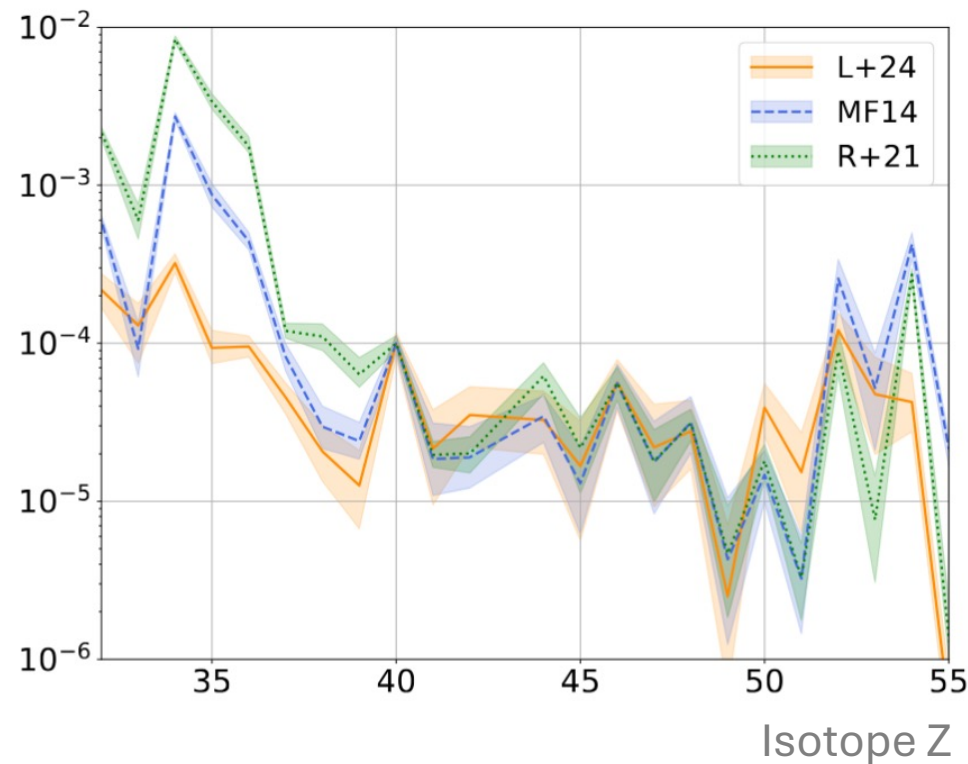
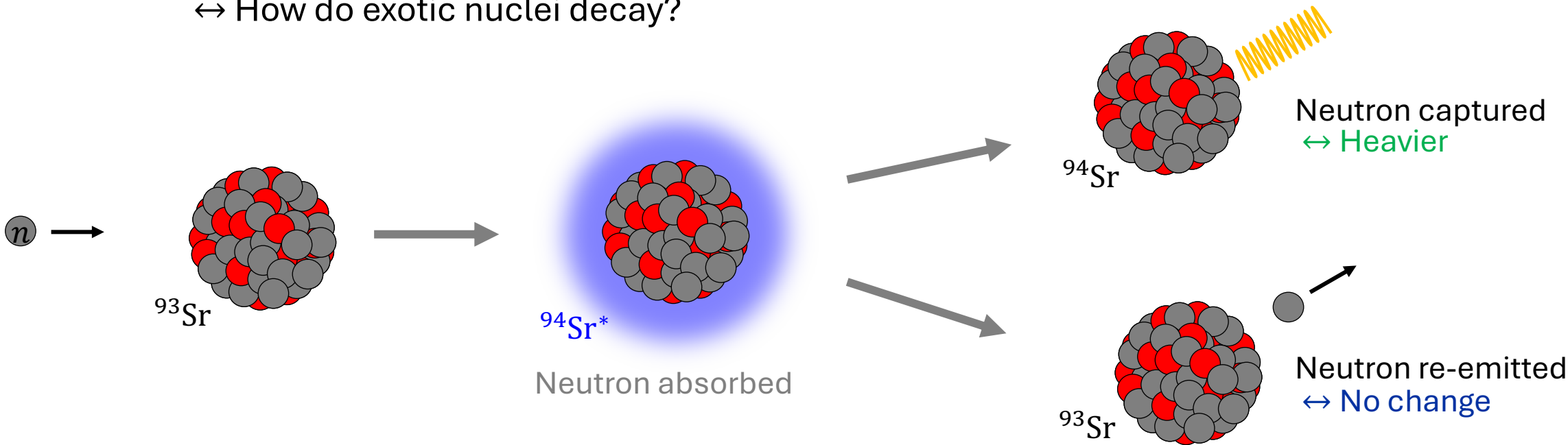


Figure from Atul Kedia (NCSU) arXiv:2602.12428 (under review for PRC)

*neutron optical model

Nuclear physics needs

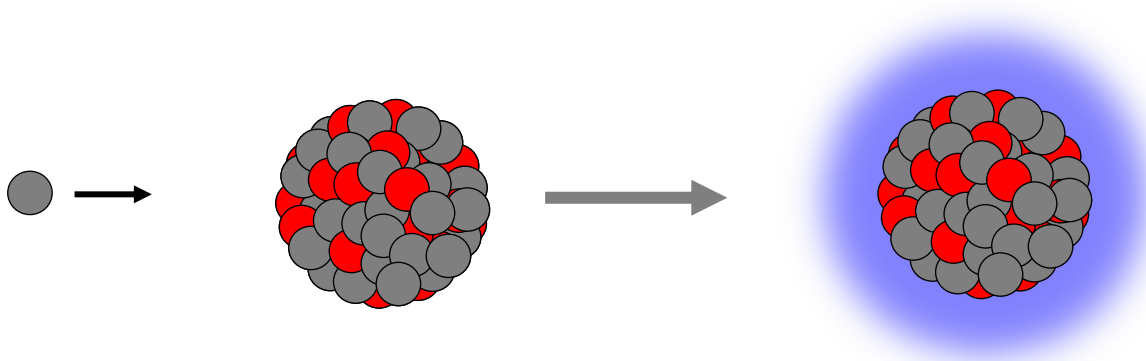
Need to know: How do exotic nuclei get heavier?
 $\leftrightarrow$ How do exotic nuclei decay?



Optical model

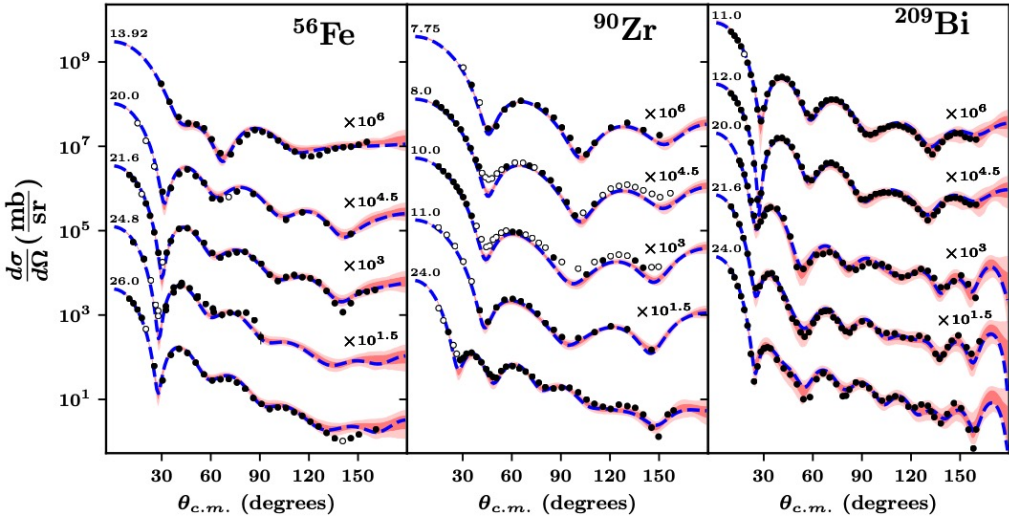
Radiative strength functions,
 Level densities,
 Optical model

Optical potentials with uncertainties have led the way for physics-informed UQ in reactions



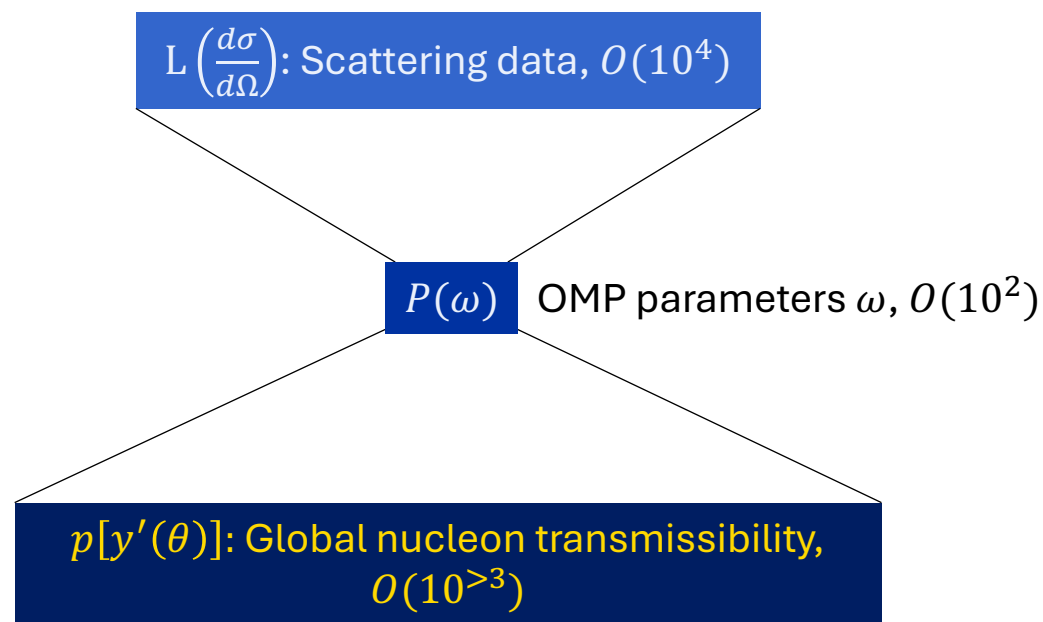
Optical model

KDUQ global optical potential



From Pruitt, Escher, Rahman PRC 107 014602 (2023)

Physics-informed UQ in reactions: learn physical parameters, predict observables



Optical model

Astrophysics applications with 500+ cross sections from physics-informed uncertainties

Neutron-capture rates with UQ from the KDUQ potential*

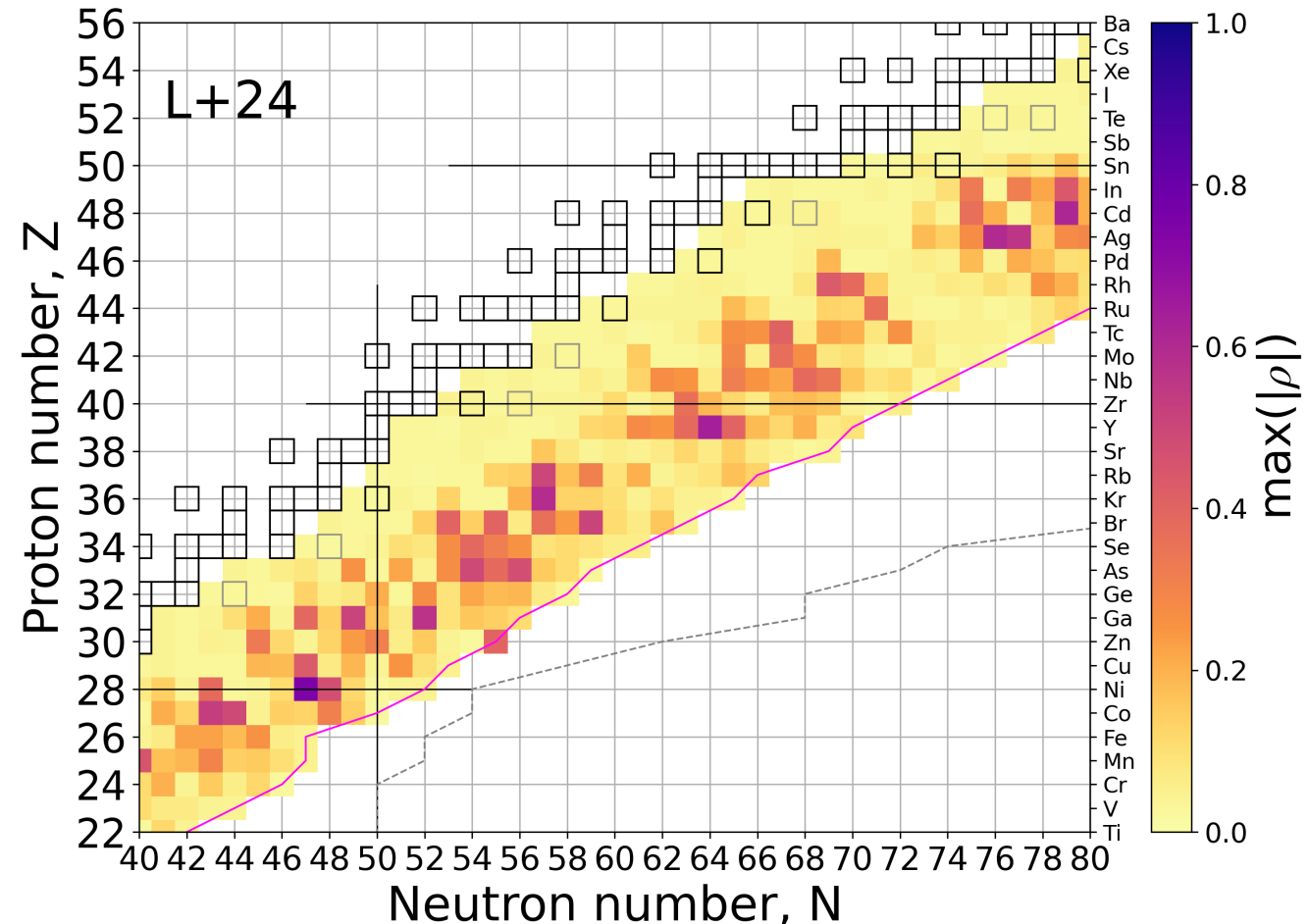
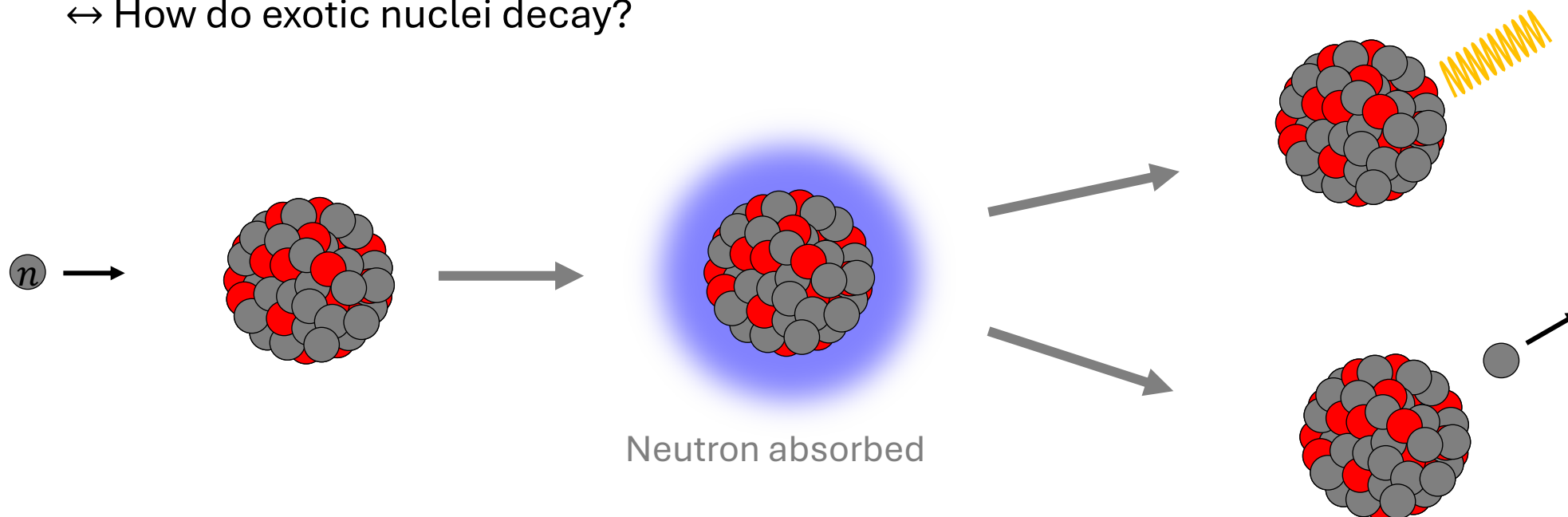


Figure from Atul Kedia (NCSU)
arXiv:2602.12428
(under review for PRC)

*neutron optical model

The other inputs for nuclear reactions

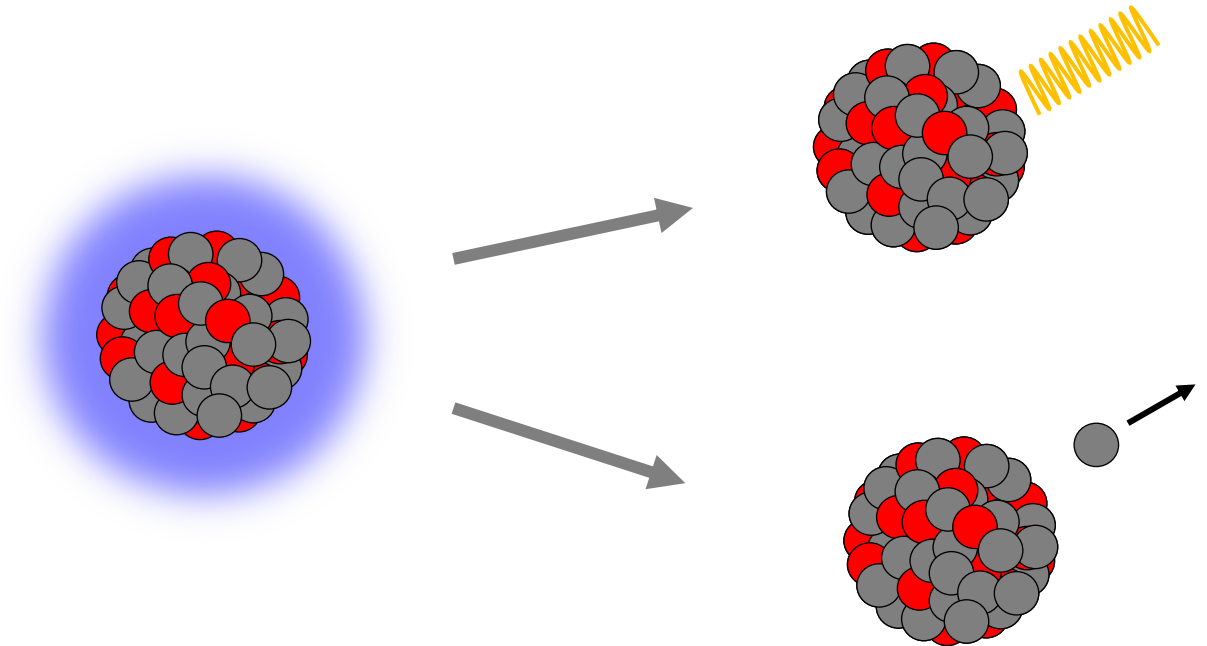
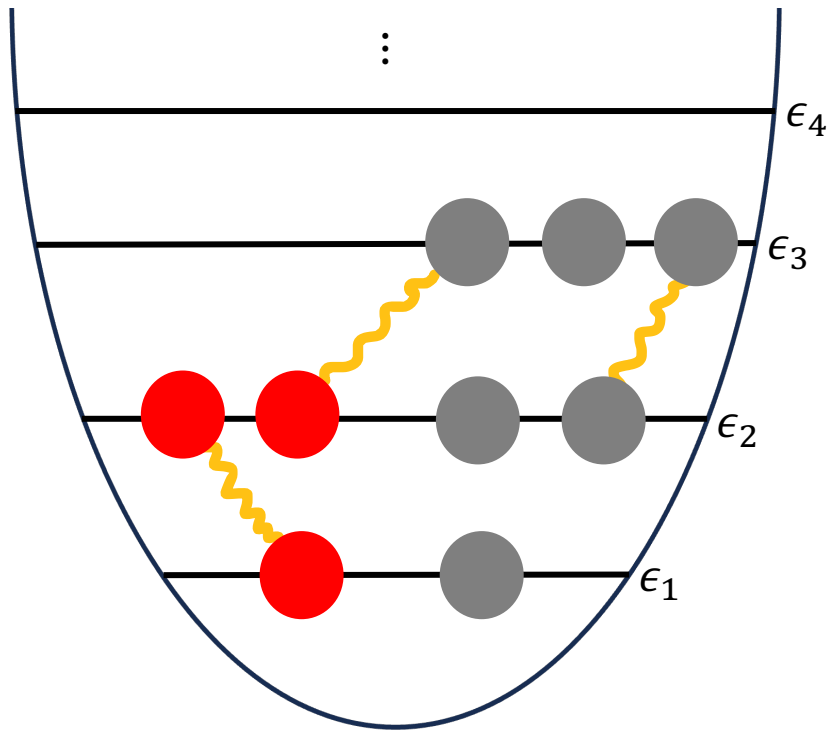
Need to know: How do exotic nuclei get heavier?
 $\leftrightarrow$ How do exotic nuclei decay?



Optical model

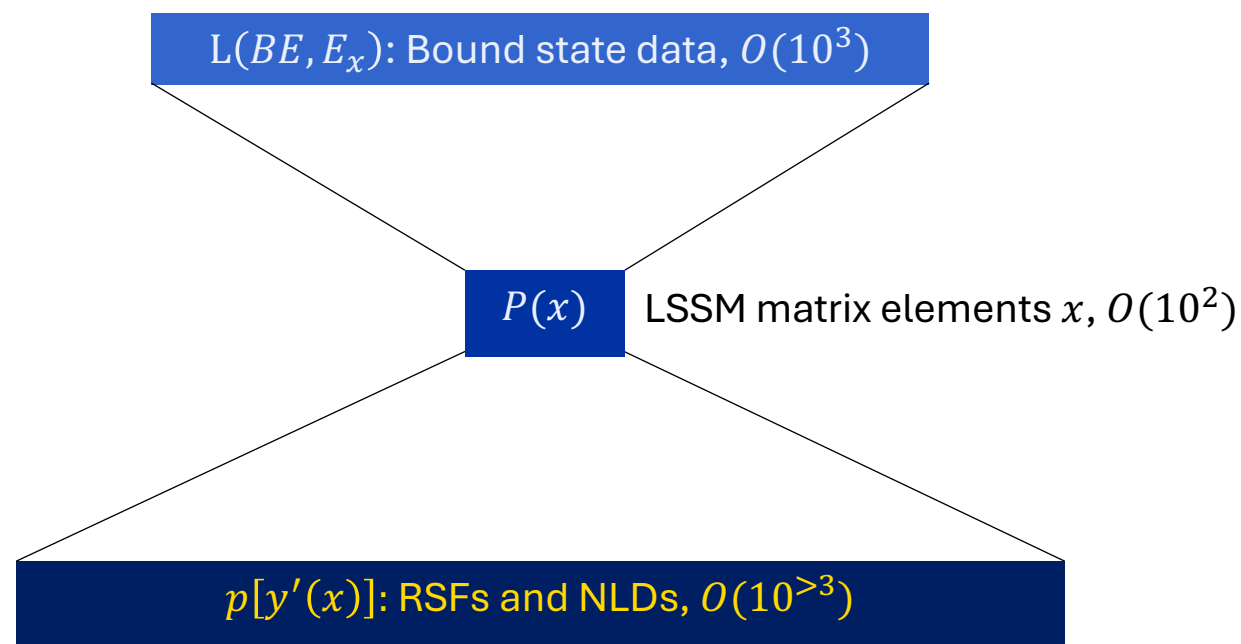
Radiative strength functions,
 Level densities,
 Optical model

Large-scale nuclear shell model (LSSM) can provide these inputs



Radiative strength functions,
Level densities,
Optical model

Physics-informed UQ from shell model: learn physical parameters, predict observables

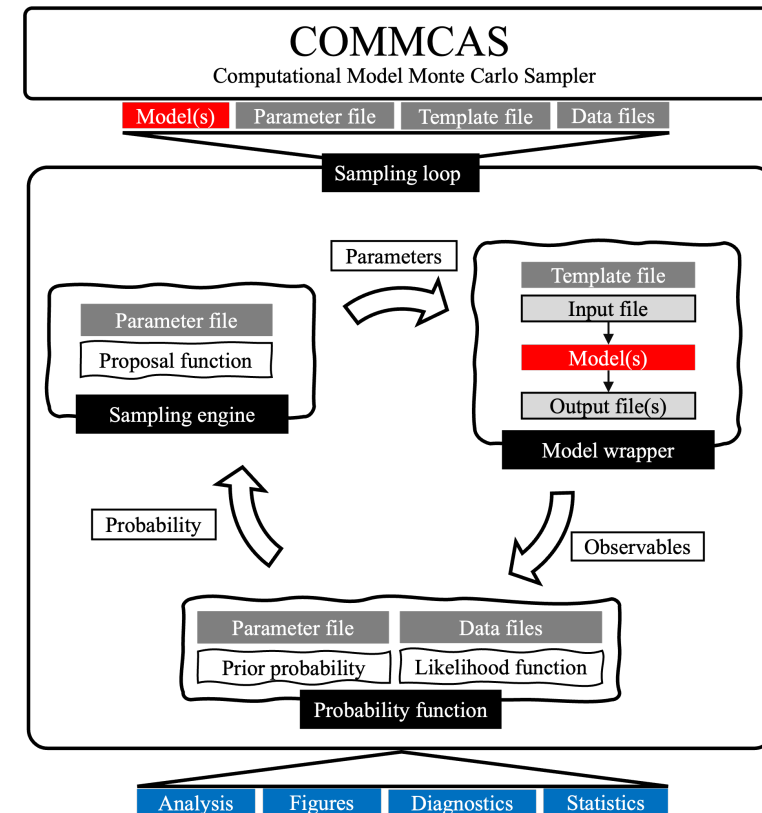
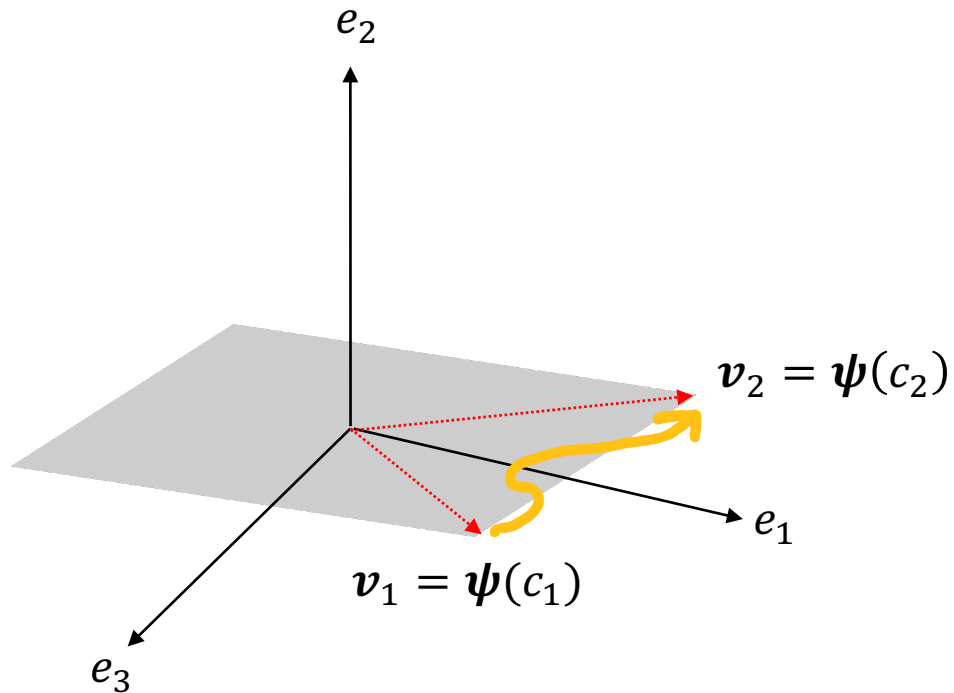


Reduced-order models (eigenvector continuation) accelerate MCMC parameter inference

Shell model emulator

+

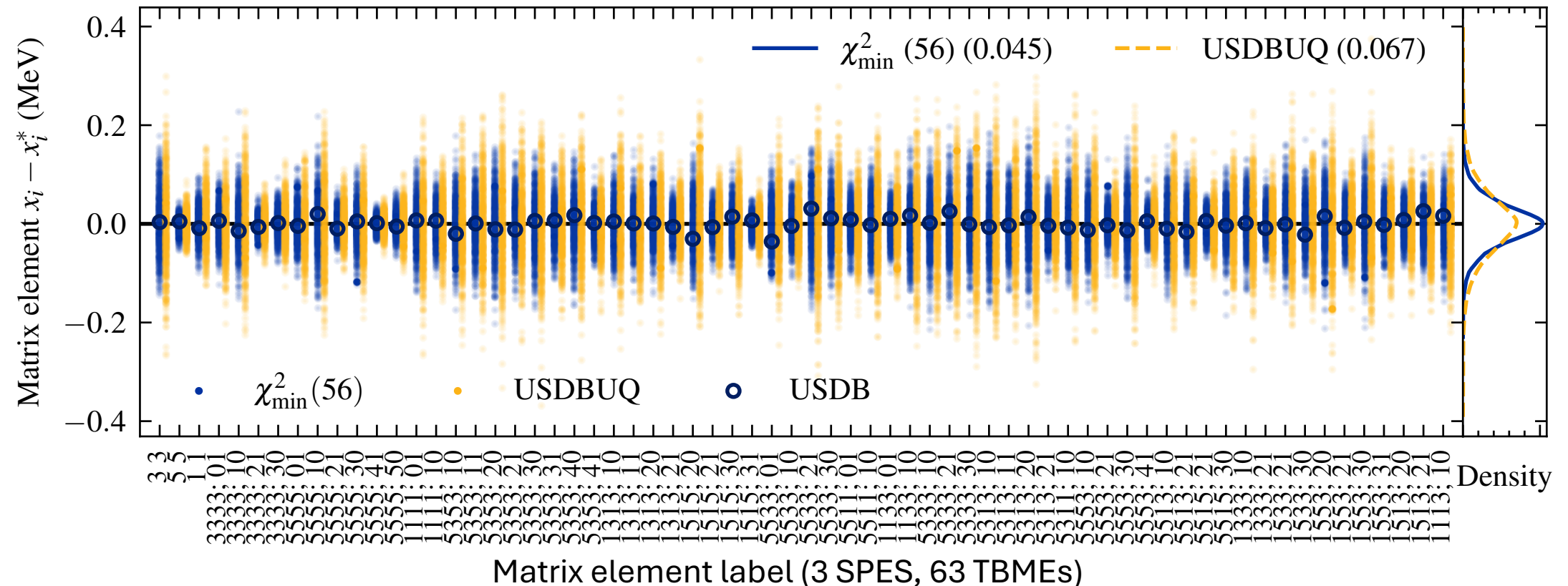
MCMC parameter inference



Gorton, Kravvaris PRC 112, 014302 (2025)

We published the first shell model interaction with uncertainties

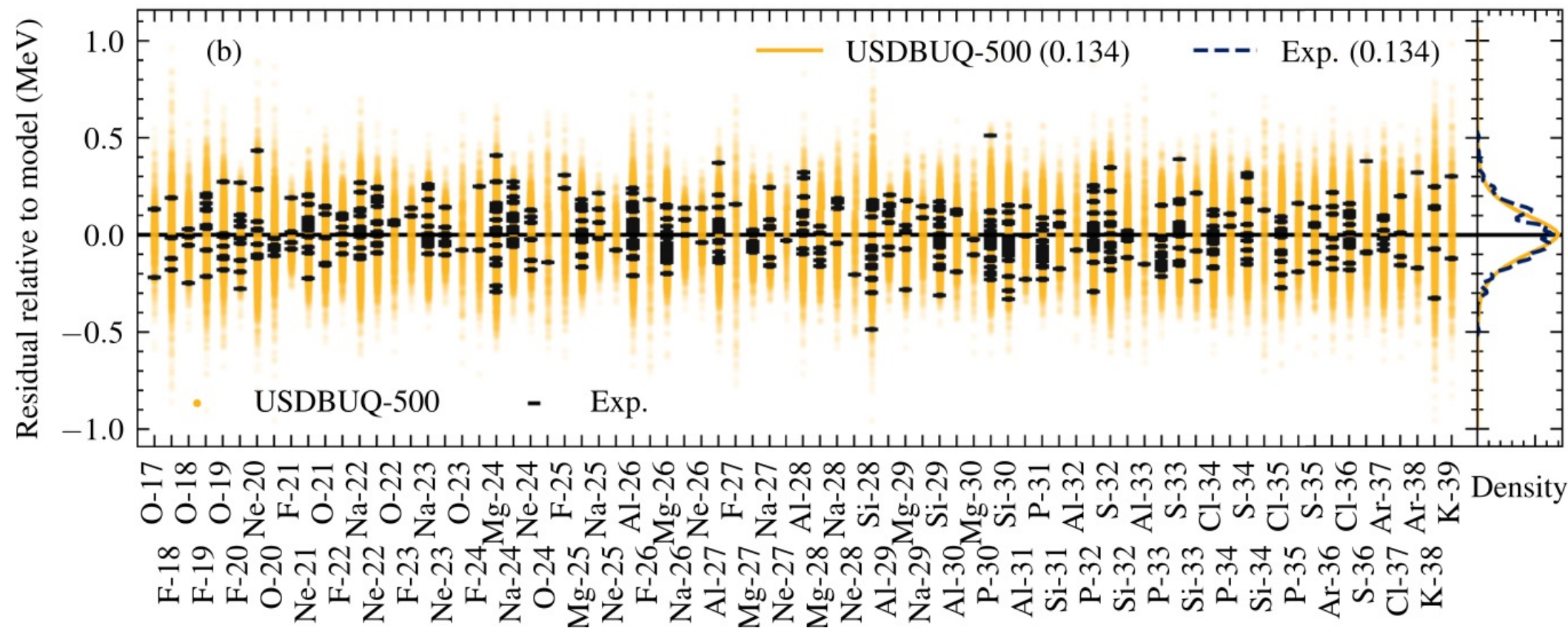
Distribution of effective-interaction matrix elements



Gorton, Kravvaris PRC 112, 014302 (2025)

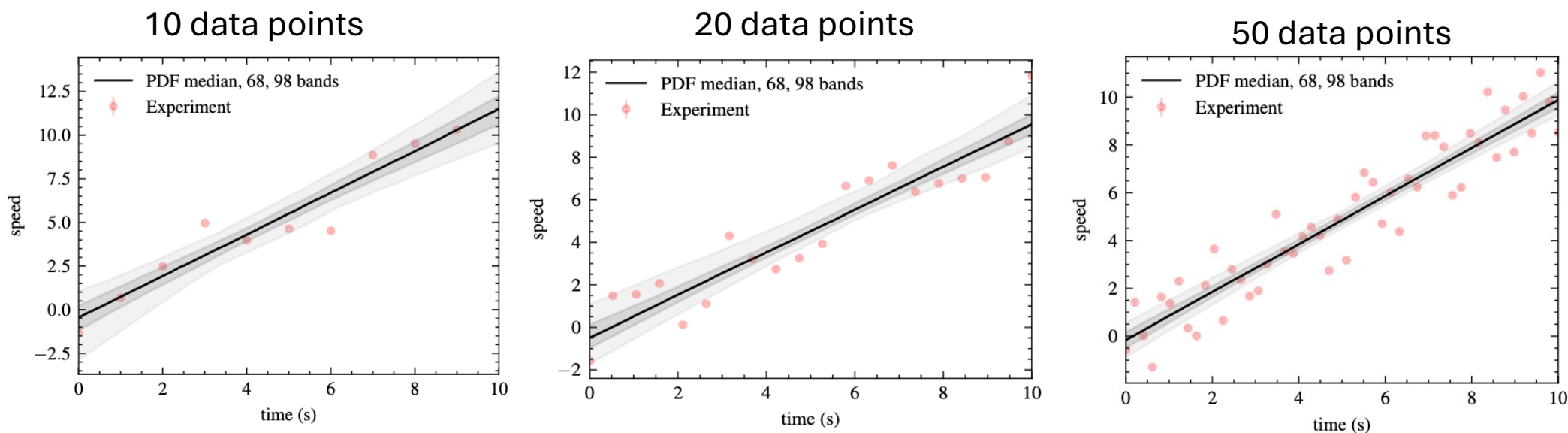
We published the first shell model interaction with uncertainties

Distribution of energy-level predictions



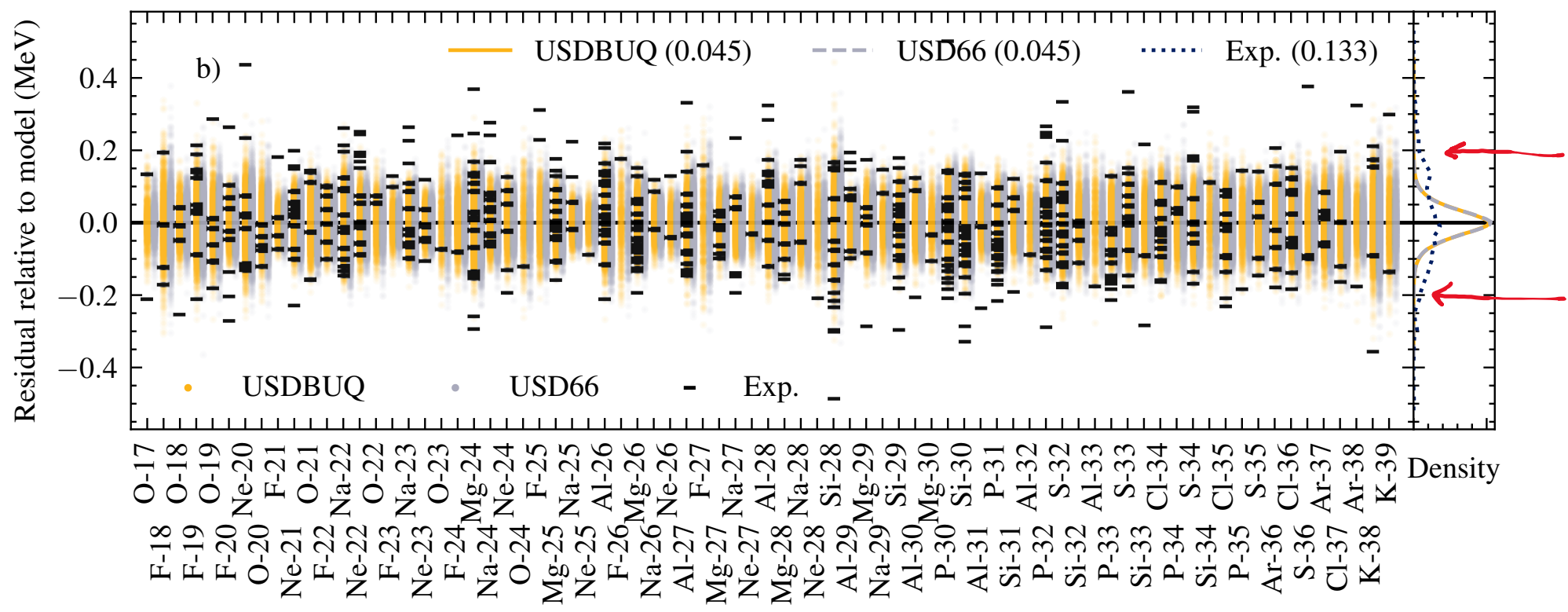
Gorton, Kravvaris PRC 112, 014302 (2025)

With uncorrelated noisy measurements, **confidence intervals shrink** with number of data



“Noise from flawed measurements are washed out”

Residual is dominated by *systematic* and *correlated* model defect, NOT noisy measurement!



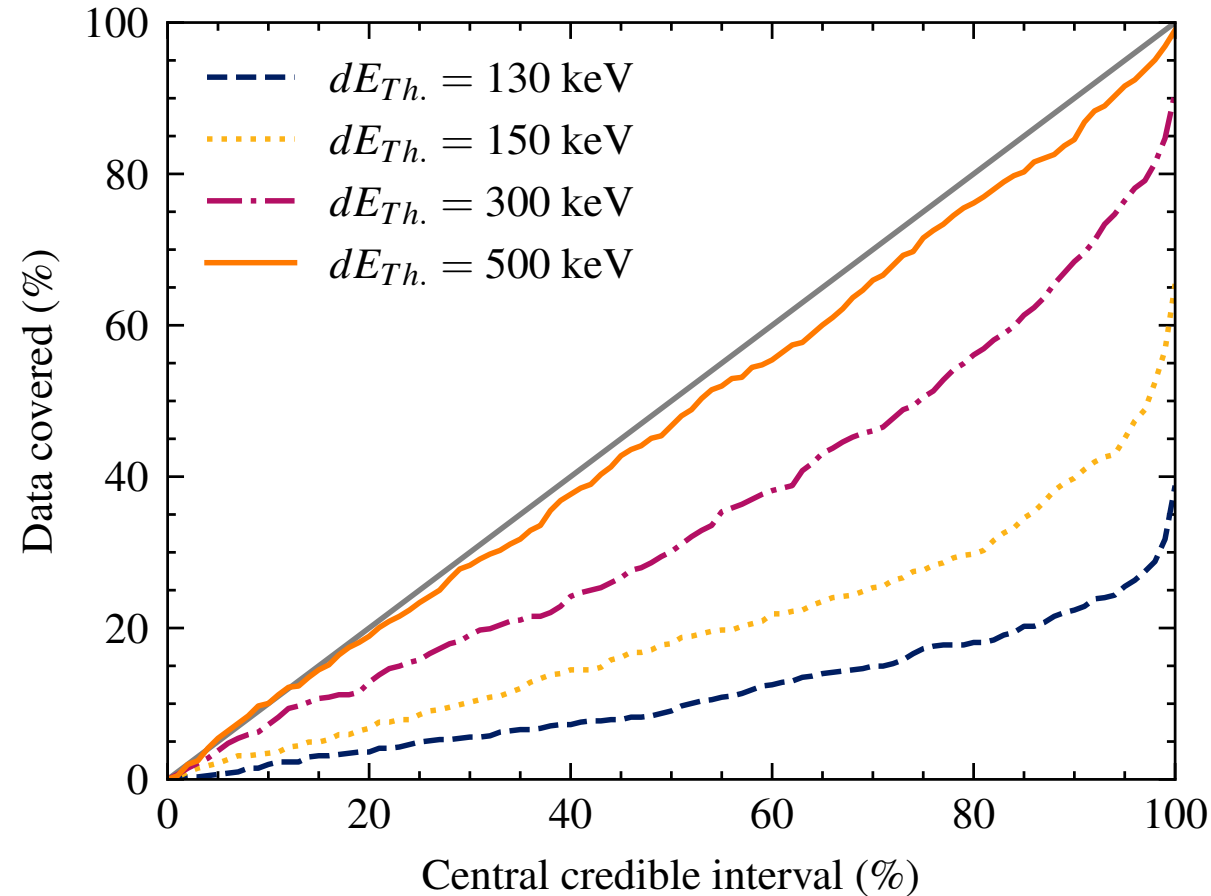
$$\sigma_i^2 = \cancel{\sigma_i^2(\text{Experiment})} + \sigma_i^2(\text{Theory})$$

a few keV << 130 keV

We do NOT want **confidence intervals** to decrease with # of data

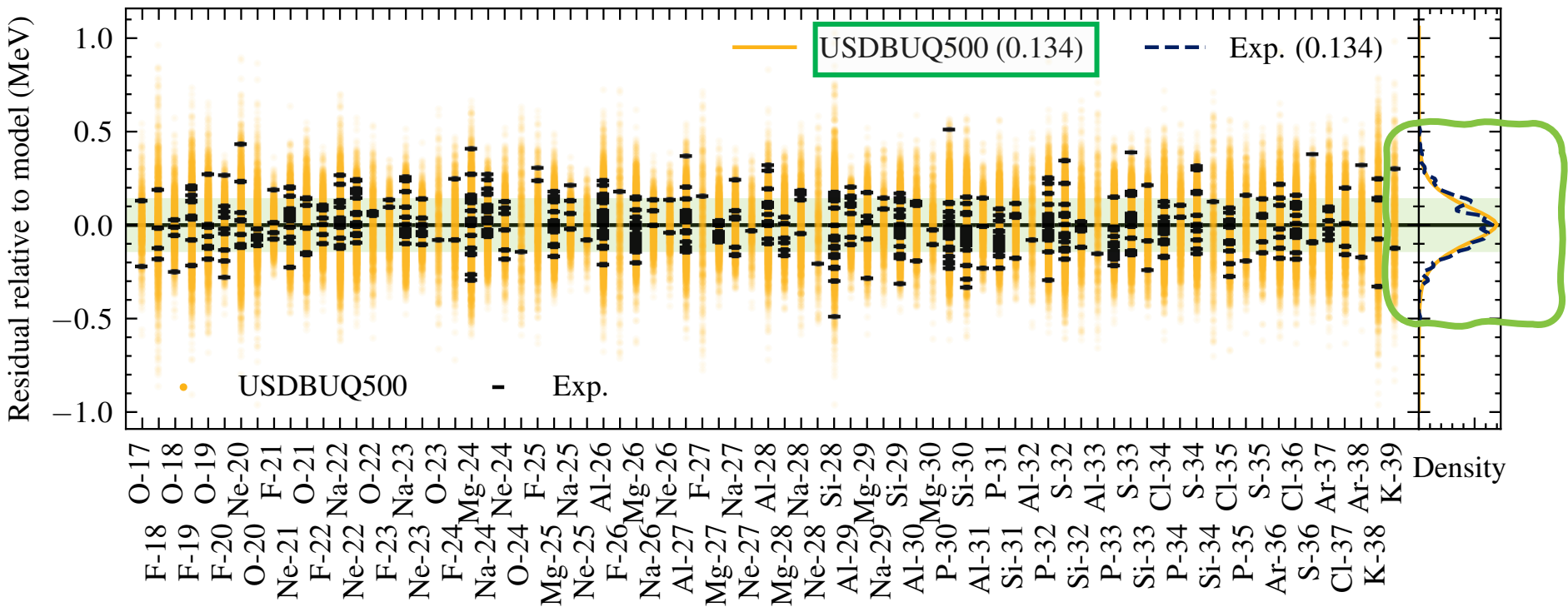
This sets the size of error bars

Working solution: empirical data coverage test



Does this mean the Shell model uncertainty is 500 keV instead of 130 keV?

Takeaway: be careful when applying “textbook” statistics to real problems



500 keV is not actual uncertainty

USDBUQ500 stat sheet

Standard error of **random prediction**:

- 190 keV (USDB is 130 keV)

Standard error of **averaged prediction**:

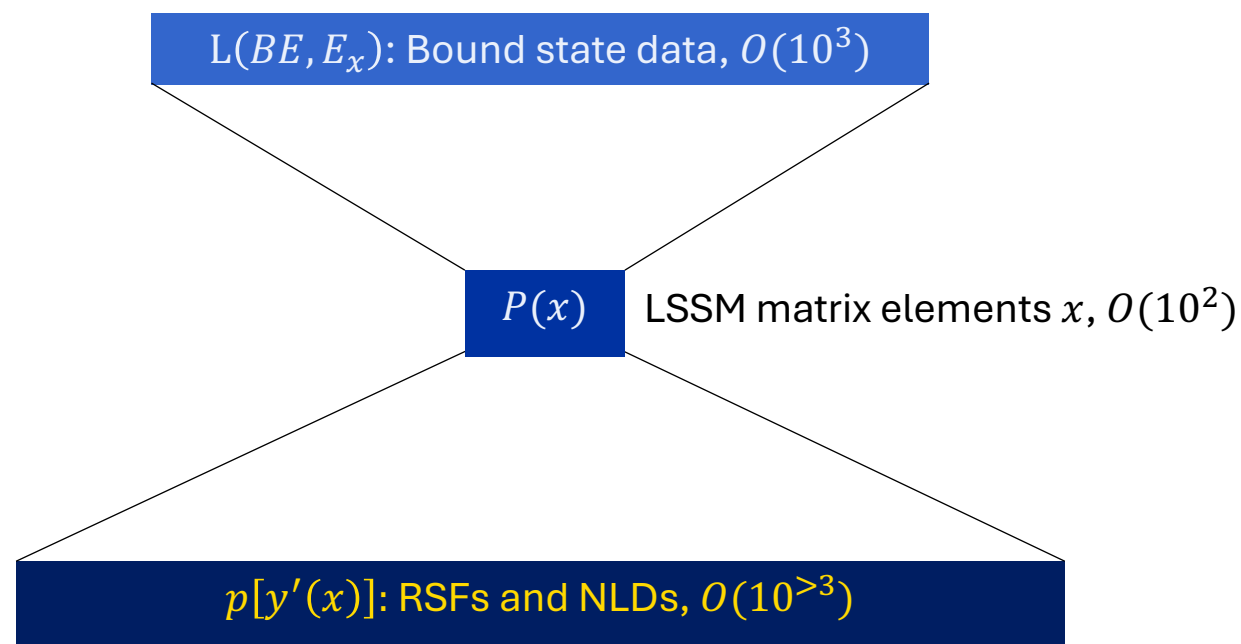
- 134 keV

Average half-width of **error bar**:

- 134 keV



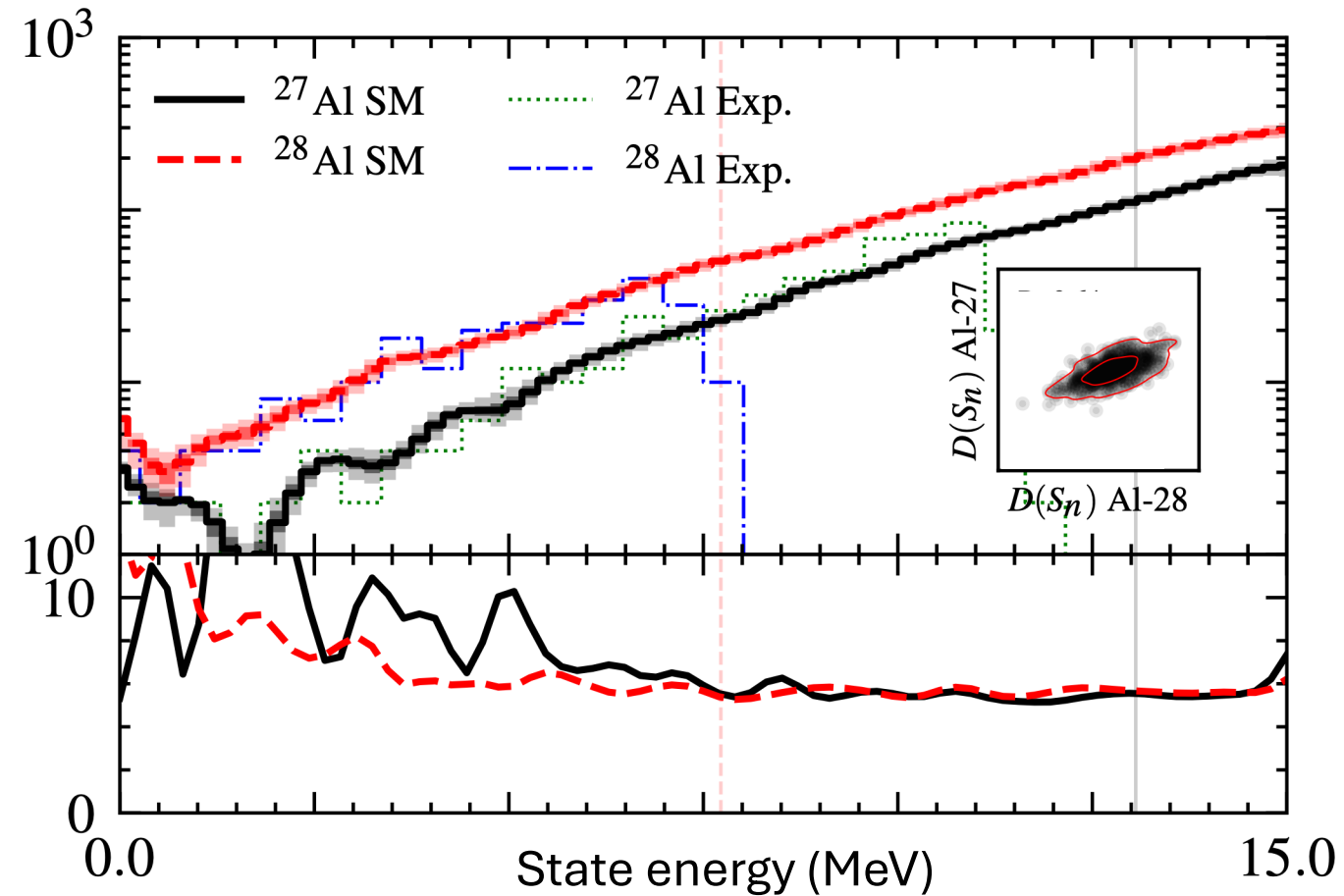
Physics-informed UQ from shell model: learn physical parameters, predict observables



Now we compute structure inputs for reactions: **Nuclear Level Densities (NLDs)**

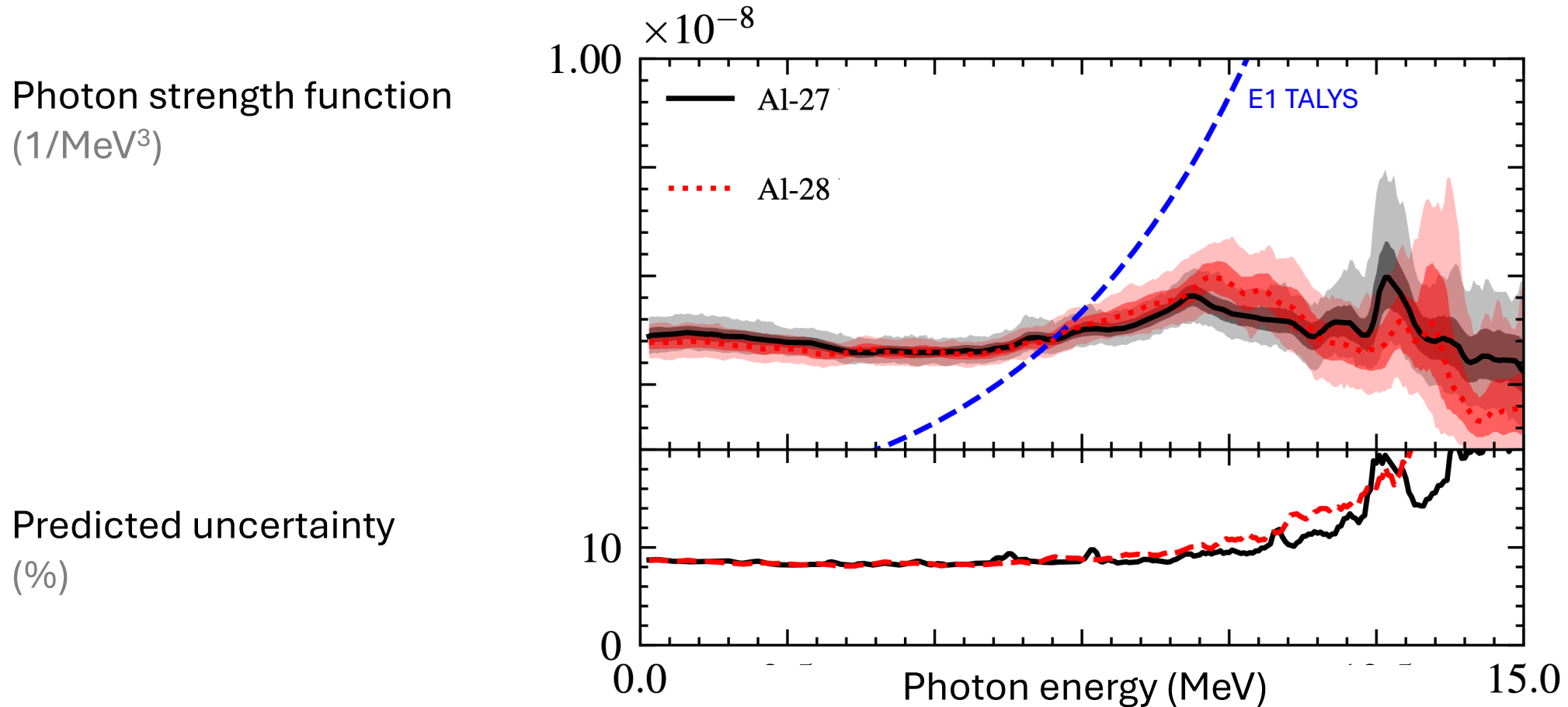
Density of states
(1/MeV)

Predicted uncertainty
(%)



Gorton and Kravvaris (2026) arXiv:2604:09935

Now we compute structure inputs for reactions: **Radiative Strength Functions (RSFs)**



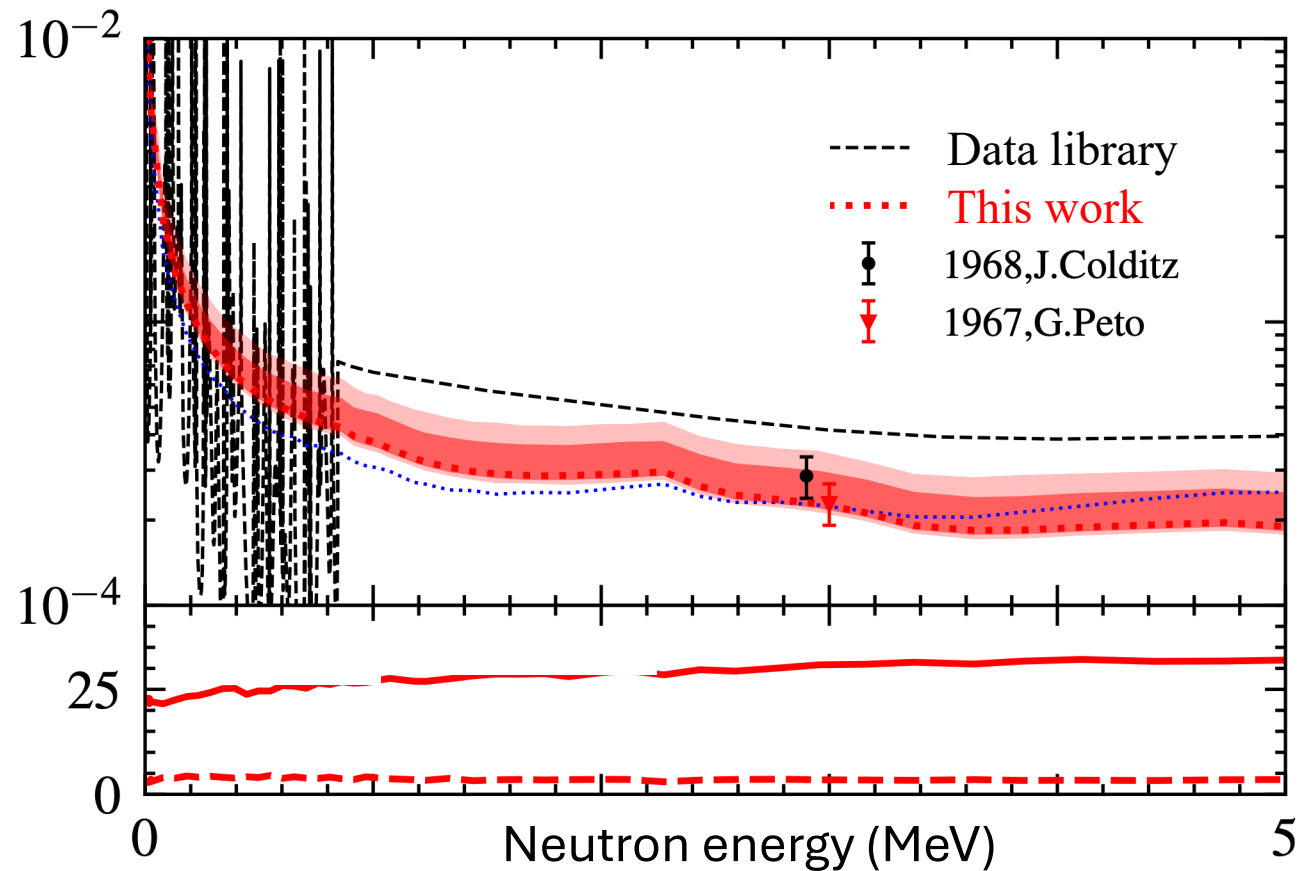
Gorton and Kravvaris (2026) arXiv:2604:09935

Developing workflows to propagate uncertainty from microscopic theory to applications

Capture cross section
(10^{-24} cm^2)

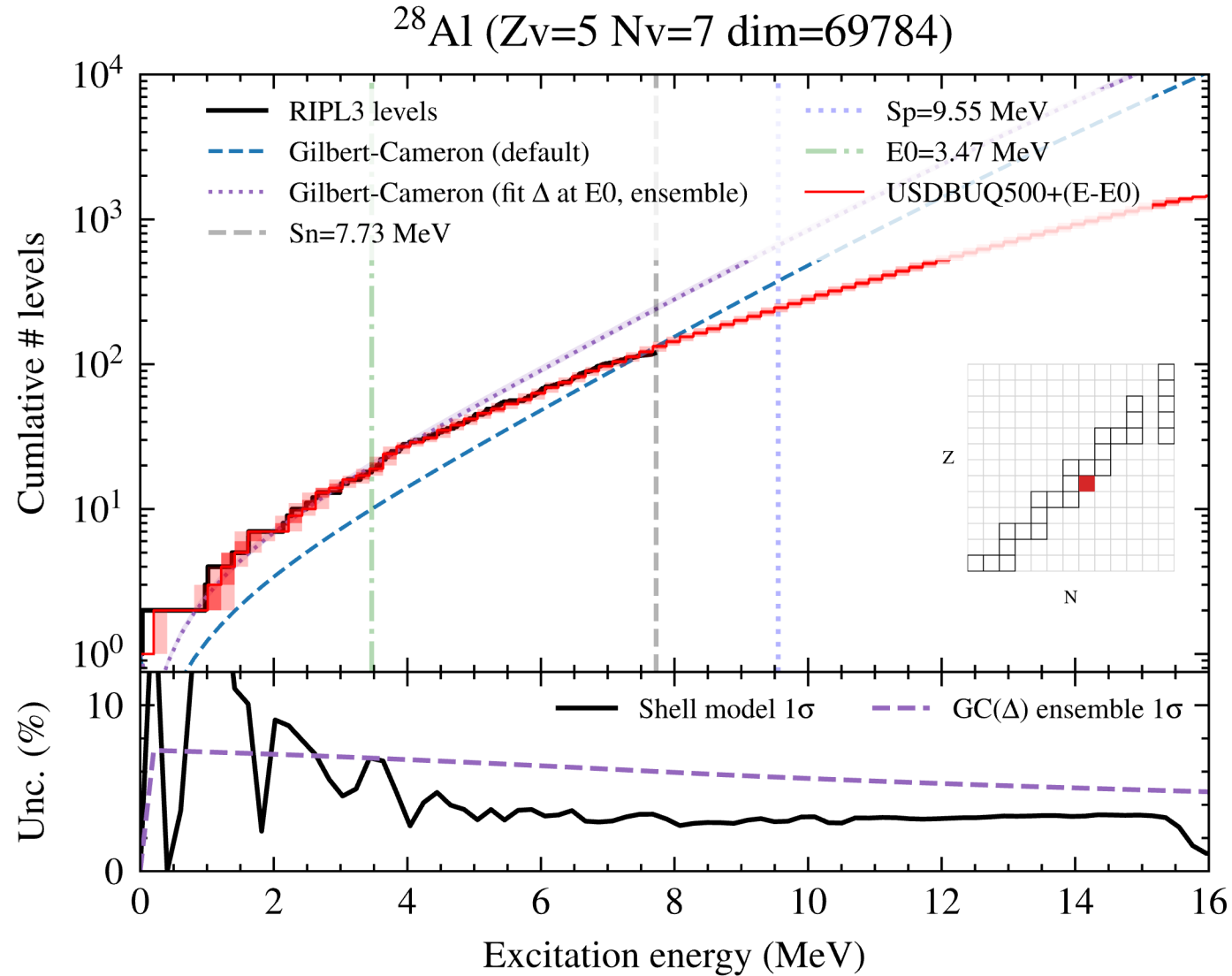
Modern
statistical methods
enhance credibility

Predicted uncertainty
(%)



Gorton and Kravvaris (2026) arXiv:2604:09935

Hybrid approach to level densities

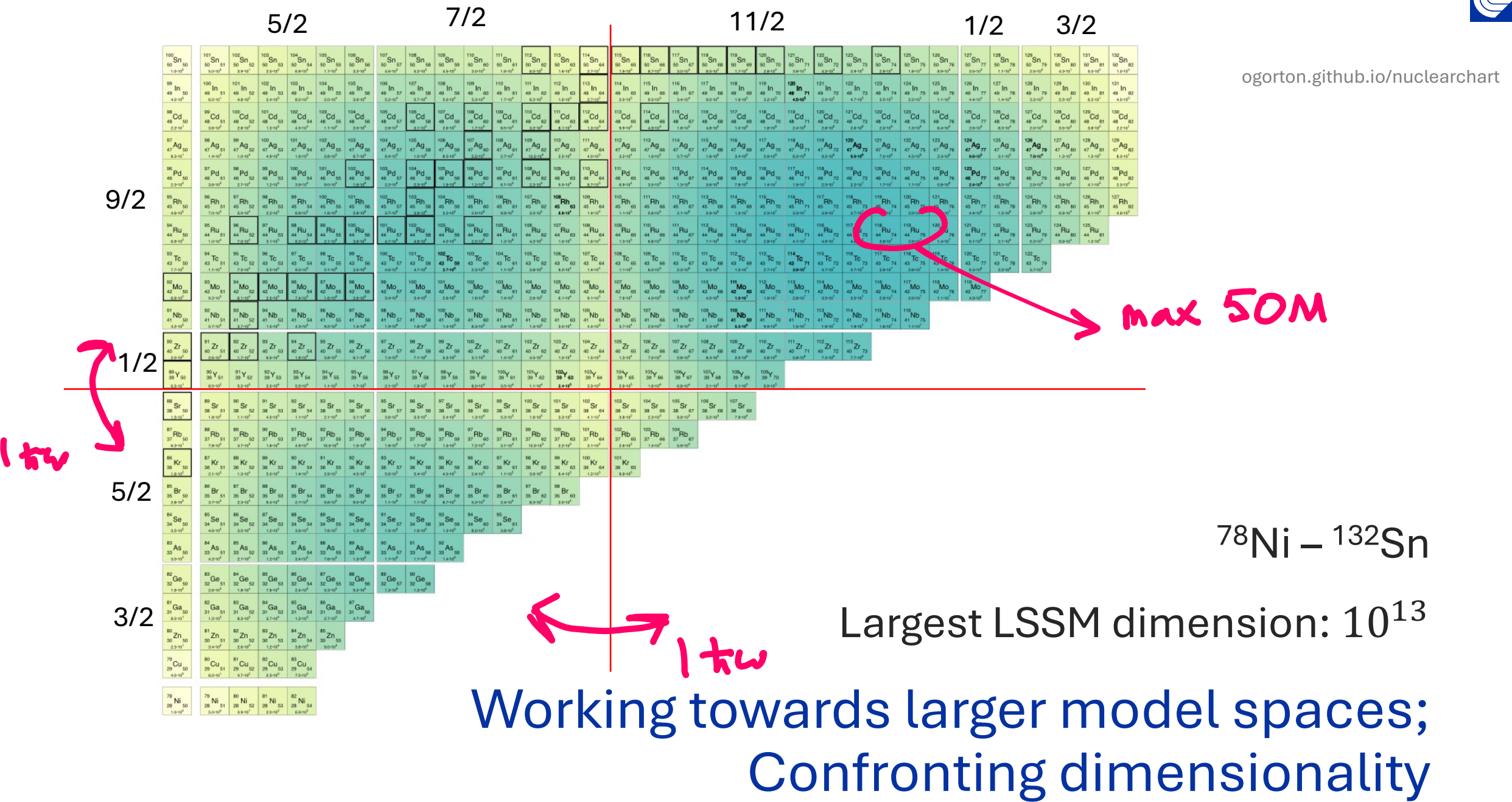


sd shell

[illegible]

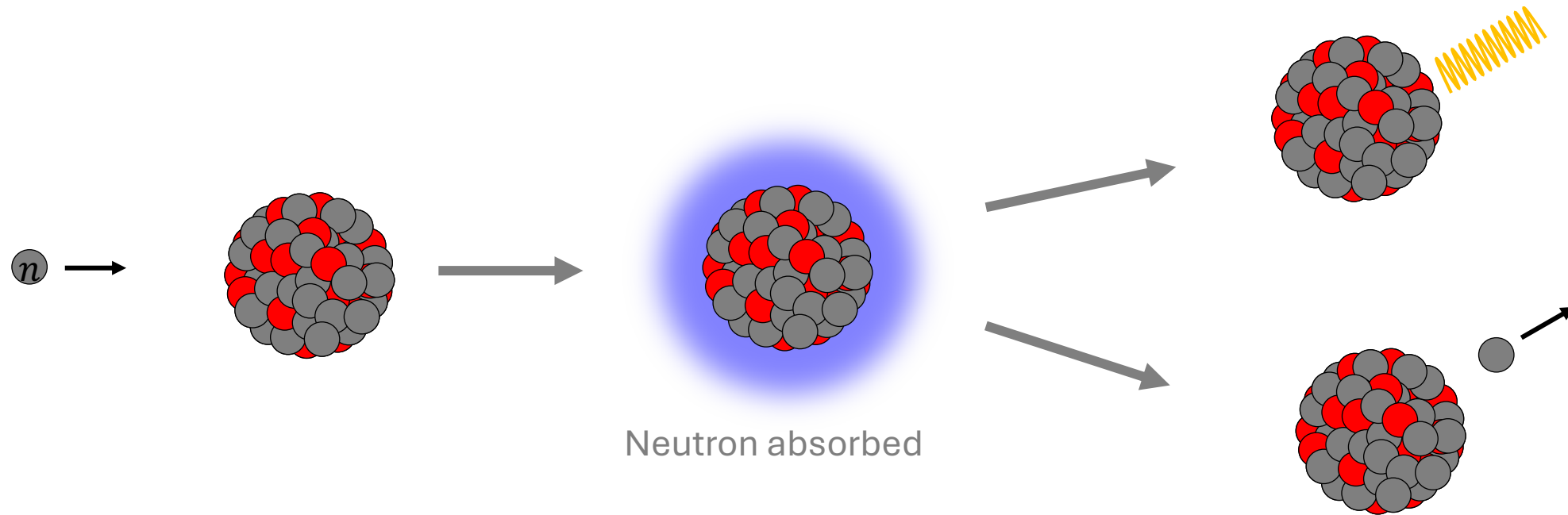


100 Sn 50 1.0 ⁻¹⁰	101 Sn 50 5.0 ⁻¹⁰	102 Sn 50 5.9 ⁻¹⁰	103 Sn 50 4.9 ⁻¹⁰	104 Sn 50 2.9 ⁻¹⁰	105 Sn 50 1.5 ⁻¹⁰	106 Sn 50 6.2 ⁻¹⁰	107 Sn 50 2.2 ⁻¹⁰	108 Sn 50 6.9 ⁻¹⁰	109 Sn 50 1.7 ⁻¹⁰	110 Sn 50 3.7 ⁻¹⁰	111 Sn 50 7.2 ⁻¹⁰	112 Sn 50 1.2 ⁻¹⁰	113 Sn 50 1.9 ⁻¹⁰	114 Sn 50 2.5 ⁻¹⁰	115 Sn 50 3.9 ⁻¹⁰	116 Sn 50 2.2 ⁻¹⁰	117 Sn 50 3.0 ⁻¹⁰	118 Sn 50 2.5 ⁻¹⁰	119 Sn 50 1.9 ⁻¹⁰	120 Sn 50 1.2 ⁻¹⁰	121 Sn 50 7.2 ⁻¹⁰	122 Sn 50 3.2 ⁻¹⁰	123 Sn 50 1.7 ⁻¹⁰	124 Sn 50 5.5 ⁻¹⁰	125 Sn 50 2.2 ⁻¹⁰	126 Sn 50 6.2 ⁻¹⁰	127 Sn 50 1.5 ⁻¹⁰	128 Sn 50 2.9 ⁻¹⁰	129 Sn 50 4.5 ⁻¹⁰	130 Sn 50 5.6 ⁻¹⁰	131 Sn 50 5.0 ⁻¹⁰	132 Sn 50 1.0 ⁻¹⁰										
99 In 49 4.0 ⁻¹⁰	100 In 49 1.0 ⁻¹⁰	101 In 49 1.0 ⁻¹⁰	102 In 49 8.9 ⁻¹⁰	103 In 49 3.0 ⁻¹⁰	104 In 49 3.0 ⁻¹⁰	105 In 49 1.3 ⁻¹⁰	106 In 49 4.5 ⁻¹⁰	107 In 49 1.3 ⁻¹⁰	108 In 49 3.5 ⁻¹⁰	109 In 49 7.8 ⁻¹⁰	110 In 49 1.5 ⁻¹⁰	111 In 49 1.5 ⁻¹⁰	112 In 49 6.4 ⁻¹⁰	113 In 49 6.4 ⁻¹⁰	114 In 49 6.4 ⁻¹⁰	115 In 49 6.4 ⁻¹⁰	116 In 49 6.4 ⁻¹⁰	117 In 49 6.4 ⁻¹⁰	118 In 49 6.4 ⁻¹⁰	119 In 49 6.4 ⁻¹⁰	120 In 49 6.4 ⁻¹⁰	121 In 49 6.4 ⁻¹⁰	122 In 49 6.4 ⁻¹⁰	123 In 49 6.4 ⁻¹⁰	124 In 49 6.4 ⁻¹⁰	125 In 49 6.4 ⁻¹⁰	126 In 49 6.4 ⁻¹⁰	127 In 49 6.4 ⁻¹⁰	128 In 49 6.4 ⁻¹⁰	129 In 49 6.4 ⁻¹⁰	130 In 49 6.4 ⁻¹⁰	131 In 49 6.4 ⁻¹⁰	132 In 49 6.4 ⁻¹⁰									
98 Cd 48 3.1 ⁻¹⁰	99 Cd 48 7.3 ⁻¹⁰	100 Cd 48 9.7 ⁻¹⁰	101 Cd 48 8.8 ⁻¹⁰	102 Cd 48 5.7 ⁻¹⁰	103 Cd 48 3.0 ⁻¹⁰	104 Cd 48 1.3 ⁻¹⁰	105 Cd 48 4.5 ⁻¹⁰	106 Cd 48 1.4 ⁻¹⁰	107 Cd 48 3.5 ⁻¹⁰	108 Cd 48 7.9 ⁻¹⁰	109 Cd 48 8.1 ⁻¹⁰	110 Cd 48 2.3 ⁻¹⁰	111 Cd 48 6.0 ⁻¹⁰	112 Cd 48 5.3 ⁻¹⁰	113 Cd 48 5.4 ⁻¹⁰	114 Cd 48 5.5 ⁻¹⁰	115 Cd 48 5.5 ⁻¹⁰	116 Cd 48 5.5 ⁻¹⁰	117 Cd 48 5.5 ⁻¹⁰	118 Cd 48 5.5 ⁻¹⁰	119 Cd 48 5.5 ⁻¹⁰	120 Cd 48 5.5 ⁻¹⁰	121 Cd 48 5.5 ⁻¹⁰	122 Cd 48 5.5 ⁻¹⁰	123 Cd 48 5.5 ⁻¹⁰	124 Cd 48 5.5 ⁻¹⁰	125 Cd 48 5.5 ⁻¹⁰	126 Cd 48 5.5 ⁻¹⁰	127 Cd 48 5.5 ⁻¹⁰	128 Cd 48 5.5 ⁻¹⁰	129 Cd 48 5.5 ⁻¹⁰	130 Cd 48 5.5 ⁻¹⁰	131 Cd 48 5.5 ⁻¹⁰	132 Cd 48 5.5 ⁻¹⁰								
97 Ag 47 1.6 ⁻¹⁰	98 Ag 47 4.4 ⁻¹⁰	99 Ag 47 5.9 ⁻¹⁰	100 Ag 47 5.4 ⁻¹⁰	101 Ag 47 3.6 ⁻¹⁰	102 Ag 47 1.9 ⁻¹⁰	103 Ag 47 8.1 ⁻¹⁰	104 Ag 47 2.9 ⁻¹⁰	105 Ag 47 6.7 ⁻¹⁰	106 Ag 47 2.3 ⁻¹⁰	107 Ag 47 5.1 ⁻¹⁰	108 Ag 47 10.0 ⁻¹⁰	109 Ag 47 1.2 ⁻¹⁰	110 Ag 47 2.6 ⁻¹⁰	111 Ag 47 2.5 ⁻¹⁰	112 Ag 47 4.2 ⁻¹⁰	113 Ag 47 4.4 ⁻¹⁰	114 Ag 47 4.2 ⁻¹⁰	115 Ag 47 4.2 ⁻¹⁰	116 Ag 47 4.2 ⁻¹⁰	117 Ag 47 4.2 ⁻¹⁰	118 Ag 47 4.2 ⁻¹⁰	119 Ag 47 4.2 ⁻¹⁰	120 Ag 47 4.2 ⁻¹⁰	121 Ag 47 4.2 ⁻¹⁰	122 Ag 47 4.2 ⁻¹⁰	123 Ag 47 4.2 ⁻¹⁰	124 Ag 47 4.2 ⁻¹⁰	125 Ag 47 4.2 ⁻¹⁰	126 Ag 47 4.2 ⁻¹⁰	127 Ag 47 4.2 ⁻¹⁰	128 Ag 47 4.2 ⁻¹⁰	129 Ag 47 4.2 ⁻¹⁰	130 Ag 47 4.2 ⁻¹⁰	131 Ag 47 4.2 ⁻¹⁰	132 Ag 47 4.2 ⁻¹⁰							
96 Pd 46 7.0 ⁻¹⁰	97 Pd 46 1.9 ⁻¹⁰	98 Pd 46 2.6 ⁻¹⁰	99 Pd 46 2.4 ⁻¹⁰	100 Pd 46 1.6 ⁻¹⁰	101 Pd 46 8.6 ⁻¹⁰	102 Pd 46 3.7 ⁻¹⁰	103 Pd 46 1.3 ⁻¹⁰	104 Pd 46 4.0 ⁻¹⁰	105 Pd 46 1.0 ⁻¹⁰	106 Pd 46 2.3 ⁻¹⁰	107 Pd 46 4.8 ⁻¹⁰	108 Pd 46 7.3 ⁻¹⁰	109 Pd 46 1.2 ⁻¹⁰	110 Pd 46 1.2 ⁻¹⁰	111 Pd 46 1.9 ⁻¹⁰	112 Pd 46 2.1 ⁻¹⁰	113 Pd 46 1.9 ⁻¹⁰	114 Pd 46 1.9 ⁻¹⁰	115 Pd 46 1.9 ⁻¹⁰	116 Pd 46 1.9 ⁻¹⁰	117 Pd 46 1.9 ⁻¹⁰	118 Pd 46 1.9 ⁻¹⁰	119 Pd 46 1.9 ⁻¹⁰	120 Pd 46 1.9 ⁻¹⁰	121 Pd 46 1.9 ⁻¹⁰	122 Pd 46 1.9 ⁻¹⁰	123 Pd 46 1.9 ⁻¹⁰	124 Pd 46 1.9 ⁻¹⁰	125 Pd 46 1.9 ⁻¹⁰	126 Pd 46 1.9 ⁻¹⁰	127 Pd 46 1.9 ⁻¹⁰	128 Pd 46 1.9 ⁻¹⁰	129 Pd 46 1.9 ⁻¹⁰	130 Pd 46 1.9 ⁻¹⁰	131 Pd 46 1.9 ⁻¹⁰	132 Pd 46 1.9 ⁻¹⁰						
95 Rh 45 2.3 ⁻¹⁰	96 Rh 45 6.5 ⁻¹⁰	97 Rh 45 9.0 ⁻¹⁰	98 Rh 45 8.4 ⁻¹⁰	99 Rh 45 5.7 ⁻¹⁰	100 Rh 45 3.9 ⁻¹⁰	101 Rh 45 1.3 ⁻¹⁰	102 Rh 45 4.7 ⁻¹⁰	103 Rh 45 1.0 ⁻¹⁰	104 Rh 45 3.7 ⁻¹⁰	105 Rh 45 8.2 ⁻¹⁰	106 Rh 45 1.8 ⁻¹⁰	107 Rh 45 2.8 ⁻¹⁰	108 Rh 45 4.3 ⁻¹⁰	109 Rh 45 5.7 ⁻¹⁰	110 Rh 45 6.8 ⁻¹⁰	111 Rh 45 7.3 ⁻¹⁰	112 Rh 45 6.9 ⁻¹⁰	113 Rh 45 6.9 ⁻¹⁰	114 Rh 45 6.9 ⁻¹⁰	115 Rh 45 6.9 ⁻¹⁰	116 Rh 45 6.9 ⁻¹⁰	117 Rh 45 6.9 ⁻¹⁰	118 Rh 45 6.9 ⁻¹⁰	119 Rh 45 6.9 ⁻¹⁰	120 Rh 45 6.9 ⁻¹⁰	121 Rh 45 6.9 ⁻¹⁰	122 Rh 45 6.9 ⁻¹⁰	123 Rh 45 6.9 ⁻¹⁰	124 Rh 45 6.9 ⁻¹⁰	125 Rh 45 6.9 ⁻¹⁰	126 Rh 45 6.9 ⁻¹⁰	127 Rh 45 6.9 ⁻¹⁰	128 Rh 45 6.9 ⁻¹⁰	129 Rh 45 6.9 ⁻¹⁰	130 Rh 45 6.9 ⁻¹⁰	131 Rh 45 6.9 ⁻¹⁰	132 Rh 45 6.9 ⁻¹⁰					
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93 Tc 43 1.3 ⁻¹⁰	94 Tc 43 3.9 ⁻¹⁰	95 Tc 43 5.5 ⁻¹⁰	96 Tc 43 5.1 ⁻¹⁰	97 Tc 43 8.1 ⁻¹⁰	98 Tc 43 8.1 ⁻¹⁰	99 Tc 43 8.1 ⁻¹⁰	100 Tc 43 2.9 ⁻¹⁰	101 Tc 43 2.9 ⁻¹⁰	102 Tc 43 2.9 ⁻¹⁰	103 Tc 43 2.9 ⁻¹⁰	104 Tc 43 2.9 ⁻¹⁰	105 Tc 43 2.9 ⁻¹⁰	106 Tc 43 2.9 ⁻¹⁰	107 Tc 43 2.9 ⁻¹⁰	108 Tc 43 2.9 ⁻¹⁰	109 Tc 43 2.9 ⁻¹⁰	110 Tc 43 2.9 ⁻¹⁰	111 Tc 43 2.9 ⁻¹⁰	112 Tc 43 2.9 ⁻¹⁰	113 Tc 43 2.9 ⁻¹⁰	114 Tc 43 2.9 ⁻¹⁰	115 Tc 43 2.9 ⁻¹⁰	116 Tc 43 2.9 ⁻¹⁰	117 Tc 43 2.9 ⁻¹⁰	118 Tc 43 2.9 ⁻¹⁰	119 Tc 43 2.9 ⁻¹⁰	120 Tc 43 2.9 ⁻¹⁰	121 Tc 43 2.9 ⁻¹⁰	122 Tc 43 2.9 ⁻¹⁰	123 Tc 43 2.9 ⁻¹⁰	124 Tc 43 2.9 ⁻¹⁰	125 Tc 43 2.9 ⁻¹⁰	126 Tc 43 2.9 ⁻¹⁰	127 Tc 43 2.9 ⁻¹⁰	128 Tc 43 2.9 ⁻¹⁰	129 Tc 43 2.9 ⁻¹⁰	130 Tc 43 2.9 ⁻¹⁰	131 Tc 43 2.9 ⁻¹⁰	132 Tc 43 2.9 ⁻¹⁰			
92 Mo 42 2.4 ⁻¹⁰	93 Mo 42 7.0 ⁻¹⁰	94 Mo 42 1.0 ⁻¹⁰	95 Mo 42 9.4 ⁻¹⁰	96 Mo 42 6.5 ⁻¹⁰	97 Mo 42 3.6 ⁻¹⁰	98 Mo 42 1.6 ⁻¹⁰	99 Mo 42 4.2 ⁻¹⁰	100 Mo 42 1.6 ⁻¹⁰	101 Mo 42 4.2 ⁻¹⁰	102 Mo 42 9.6 ⁻¹⁰	103 Mo 42 1.9 ⁻¹⁰	104 Mo 42 5.0 ⁻¹⁰	105 Mo 42 6.7 ⁻¹⁰	106 Mo 42 6.7 ⁻¹⁰	107 Mo 42 6.7 ⁻¹⁰	108 Mo 42 6.7 ⁻¹⁰	109 Mo 42 6.7 ⁻¹⁰	110 Mo 42 6.7 ⁻¹⁰	111 Mo 42 6.7 ⁻¹⁰	112 Mo 42 6.7 ⁻¹⁰	113 Mo 42 6.7 ⁻¹⁰	114 Mo 42 6.7 ⁻¹⁰	115 Mo 42 6.7 ⁻¹⁰	116 Mo 42 6.7 ⁻¹⁰	117 Mo 42 6.7 ⁻¹⁰	118 Mo 42 6.7 ⁻¹⁰	119 Mo 42 6.7 ⁻¹⁰	120 Mo 42 6.7 ⁻¹⁰	121 Mo 42 6.7 ⁻¹⁰	122 Mo 42 6.7 ⁻¹⁰	123 Mo 42 6.7 ⁻¹⁰	124 Mo 42 6.7 ⁻¹⁰	125 Mo 42 6.7 ⁻¹⁰	126 Mo 42 6.7 ⁻¹⁰	127 Mo 42 6.7 ⁻¹⁰	128 Mo 42 6.7 ⁻¹⁰	129 Mo 42 6.7 ⁻¹⁰	130 Mo 42 6.7 ⁻¹⁰	131 Mo 42 6.7 ⁻¹⁰	132 Mo 42 6.7 ⁻¹⁰		
91 Nb 41 3.7 ⁻¹⁰	92 Nb 41 1.1 ⁻¹⁰	93 Nb 41 1.2 ⁻¹⁰	94 Nb 41 1.4 ⁻¹⁰	95 Nb 41 8.9 ⁻¹⁰	96 Nb 41 8.3 ⁻¹⁰	97 Nb 41 2.8 ⁻¹⁰	98 Nb 41 8.8 ⁻¹⁰	99 Nb 41 2.8 ⁻¹⁰	100 Nb 41 8.8 ⁻¹⁰	101 Nb 41 8.8 ⁻¹⁰	102 Nb 41 8.8 ⁻¹⁰	103 Nb 41 8.8 ⁻¹⁰	104 Nb 41 8.8 ⁻¹⁰	105 Nb 41 8.8 ⁻¹⁰	106 Nb 41 8.8 ⁻¹⁰	107 Nb 41 8.8 ⁻¹⁰	108 Nb 41 8.8 ⁻¹⁰	109 Nb 41 8.8 ⁻¹⁰	110 Nb 41 8.8 ⁻¹⁰	111 Nb 41 8.8 ⁻¹⁰	112 Nb 41 8.8 ⁻¹⁰	113 Nb 41 8.8 ⁻¹⁰	114 Nb 41 8.8 ⁻¹⁰	115 Nb 41 8.8 ⁻¹⁰	116 Nb 41 8.8 ⁻¹⁰	117 Nb 41 8.8 ⁻¹⁰	118 Nb 41 8.8 ⁻¹⁰	119 Nb 41 8.8 ⁻¹⁰	120 Nb 41 8.8 ⁻¹⁰	121 Nb 41 8.8 ⁻¹⁰	122 Nb 41 8.8 ⁻¹⁰	123 Nb 41 8.8 ⁻¹⁰	124 Nb 41 8.8 ⁻¹⁰	125 Nb 41 8.8 ⁻¹⁰	126 Nb 41 8.8 ⁻¹⁰	127 Nb 41 8.8 ⁻¹⁰	128 Nb 41 8.8 ⁻¹⁰	129 Nb 41 8.8 ⁻¹⁰	130 Nb 41 8.8 ⁻¹⁰	131 Nb 41 8.8 ⁻¹⁰	132 Nb 41 8.8 ⁻¹⁰	
90 Zr 40 4.6 ⁻¹⁰	91 Zr 40 1.4 ⁻¹⁰	92 Zr 40 2.0 ⁻¹⁰	93 Zr 40 1.9 ⁻¹⁰	94 Zr 40 1.3 ⁻¹⁰	95 Zr 40 6.8 ⁻¹⁰	96 Zr 40 3.0 ⁻¹⁰	97 Zr 40 1.1 ⁻¹⁰	98 Zr 40 3.3 ⁻¹⁰	99 Zr 40 6.5 ⁻¹⁰	100 Zr 40 1.9 ⁻¹⁰	101 Zr 40 3.8 ⁻¹⁰	102 Zr 40 6.0 ⁻¹⁰	103 Zr 40 9.0 ⁻¹⁰	104 Zr 40 1.3 ⁻¹⁰	105 Zr 40 1.9 ⁻¹⁰	106 Zr 40 1.9 ⁻¹⁰	107 Zr 40 1.9 ⁻¹⁰	108 Zr 40 1.9 ⁻¹⁰	109 Zr 40 1.9 ⁻¹⁰	110 Zr 40 1.9 ⁻¹⁰	111 Zr 40 1.9 ⁻¹⁰	112 Zr 40 1.9 ⁻¹⁰	113 Zr 40 1.9 ⁻¹⁰	114 Zr 40 1.9 ⁻¹⁰	115 Zr 40 1.9 ⁻¹⁰	116 Zr 40 1.9 ⁻¹⁰	117 Zr 40 1.9 ⁻¹⁰	118 Zr 40 1.9 ⁻¹⁰	119 Zr 40 1.9 ⁻¹⁰	120 Zr 40 1.9 ⁻¹⁰	121 Zr 40 1.9 ⁻¹⁰	122 Zr 40 1.9 ⁻¹⁰	123 Zr 40 1.9 ⁻¹⁰	124 Zr 40 1.9 ⁻¹⁰	125 Zr 40 1.9 ⁻¹⁰	126 Zr 40 1.9 ⁻¹⁰	127 Zr 40 1.9 ⁻¹⁰	128 Zr 40 1.9 ⁻¹⁰	129 Zr 40 1.9 ⁻¹⁰	130 Zr 40 1.9 ⁻¹⁰	131 Zr 40 1.9 ⁻¹⁰	132 Zr 40 1.9 ⁻¹⁰
89 Y 39 6.2 ⁻¹⁰	90 Y 39 1.5 ⁻¹⁰	91 Y 39 2.2 ⁻¹⁰	92 Y 39 2.0 ⁻¹⁰	93 Y 39 1.4 ⁻¹⁰	94 Y 39 7.8 ⁻¹⁰	95 Y 39 3.2 ⁻¹⁰	96 Y 39 1.2 ⁻¹⁰	97 Y 39 3.5 ⁻¹⁰	98 Y 39 9.2 ⁻¹⁰	99 Y 39 2.1 ⁻¹⁰	100 Y 39 4.1 ⁻¹⁰	101 Y 39 7.1 ⁻¹⁰	102 Y 39 1.1 ⁻¹⁰	103 Y 39 1.9 ⁻¹⁰	104 Y 39 1.9 ⁻¹⁰	105 Y 39 1.9 ⁻¹⁰	106 Y 39 1.9 ⁻¹⁰	107 Y 39 1.9 ⁻¹⁰	108 Y 39 1.9 ⁻¹⁰	109 Y 39 1.9 ⁻¹⁰	110 Y 39 1.9 ⁻¹⁰	111 Y 39 1.9 ⁻¹⁰	112 Y 39 1.9 ⁻¹⁰	113 Y 39 1.9 ⁻¹⁰	114 Y 39 1.9 ⁻¹⁰	115 Y 39 1.9 ⁻¹⁰	116 Y 39 1.9 ⁻¹⁰	117 Y 39 1.9 ⁻¹⁰	118 Y 39 1.9 ⁻¹⁰	119 Y 39 1.9 ⁻¹⁰	120 Y 39 1.9 ⁻¹⁰	121 Y 39 1.9 ⁻¹⁰	122 Y 39 1.9 ⁻¹⁰	123 Y 39 1.9 ⁻¹⁰	124 Y 39 1.9 ⁻¹⁰							



ogorton.github.io/nuclearchart

How to compute Radiative Strength Functions with the LSSM



Optical model

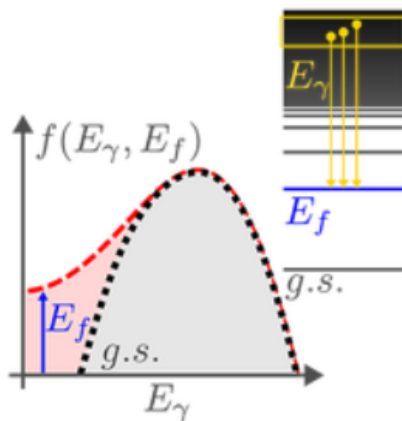
Radiative strength functions,
Level densities,
Optical model

EDITORS' SUGGESTION

Radiative strength functions from the energy-localized Brink-Axel hypothesis

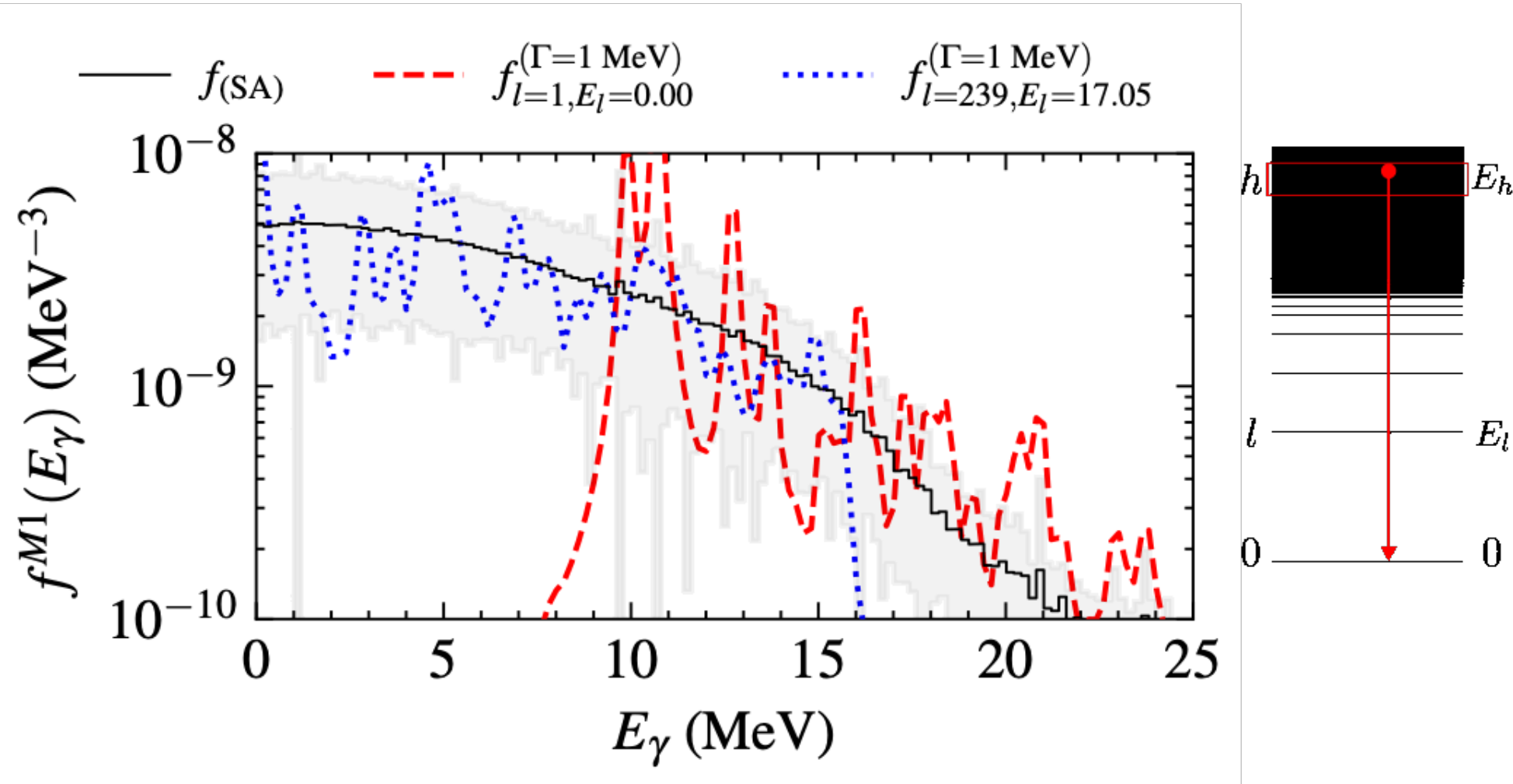
Oliver C. Gorton, Konstantinos Kravvaris, Jutta E. Escher, and Calvin W. Johnson

Phys. Rev. C **113**, 044327 (2026) - Published 29 April, 2026



Radiative strength functions (RSFs) are crucial inputs for statistical nuclear reaction codes but are difficult to calculate because they require wave functions of highly excited states. The authors used large-scale shell model calculations to identify a key result of the energy-localized Brink-Axel hypothesis: the shape of the RSF evolves smoothly with wave-function energy. Combined with an efficient Lanczos strength-function method, this insight leads to a practical new approach for computing RSFs which was validated for ^{24}Mg and provided novel results for ^{56}Fe . The method is expected to simplify RSF calculations while motivating the use of energy-dependent RSFs in modern reaction codes.

Radiative strength function depends on energy of residual state



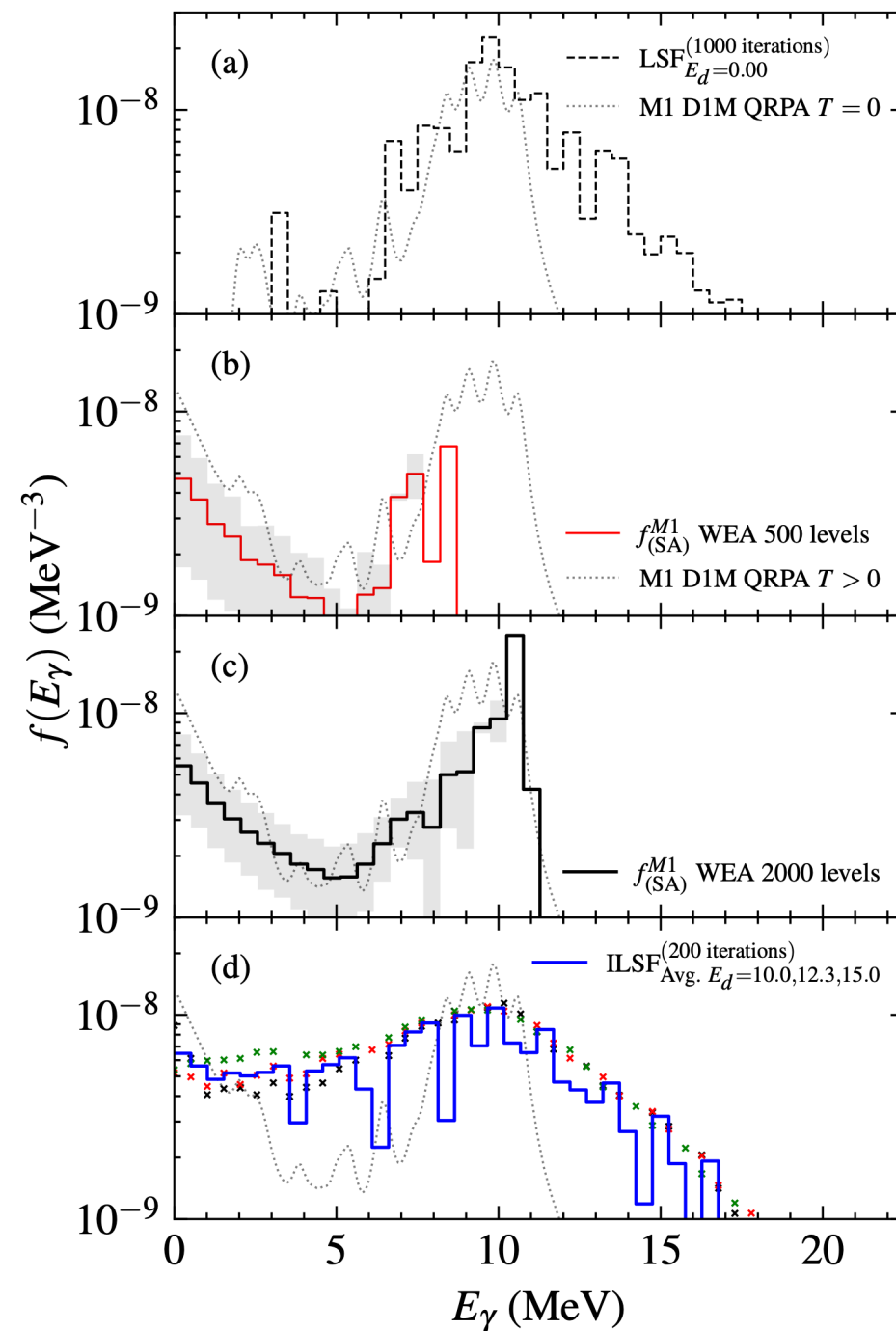
^{56}Fe M1 shape evolution?

To ground state

Average over
first 500 levels

Average over
first 2000 levels

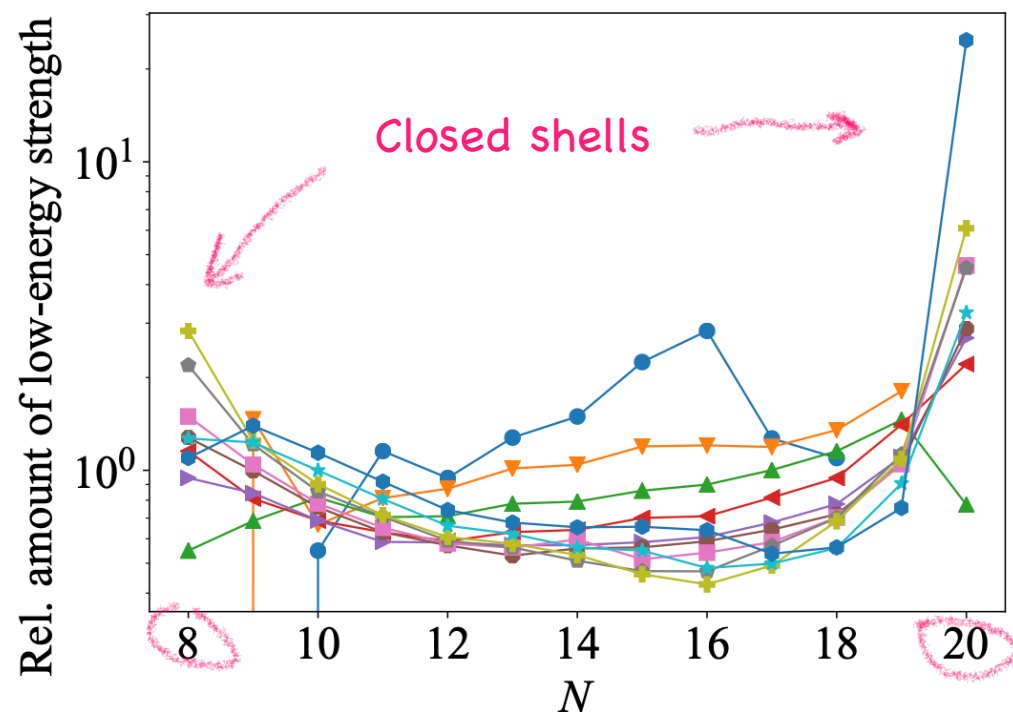
Average over
3 high-energy
levels



Evolution of low-energy M1 strength:

(1) nearness to closed shell

(2) restricted valence space



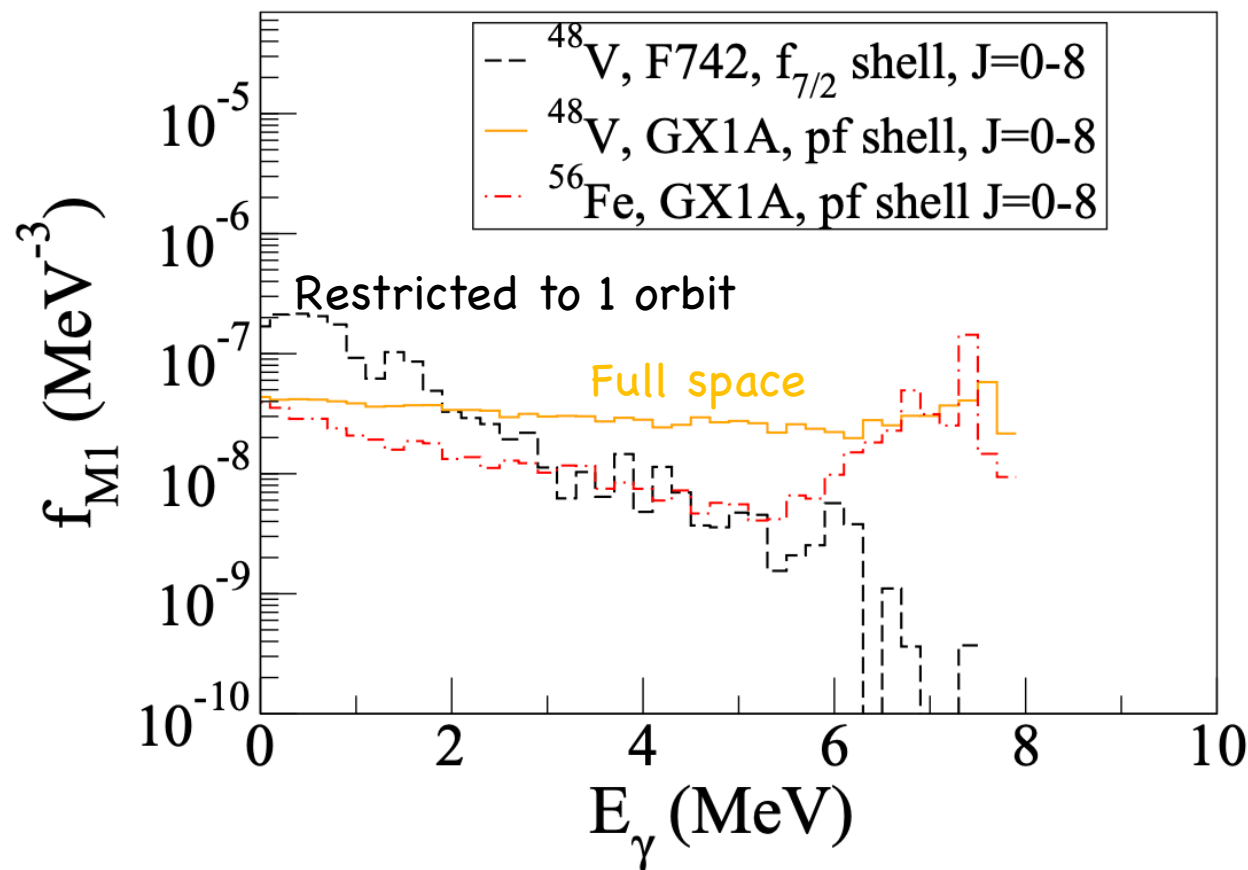
Midtbø, Larsen, et al. (2018)
PRC 98, 064321

sd-shell: biggest M1 upturn
near closed shells

Evolution of low-energy M1 strength:

(1) nearness to closed shell

(2) restricted valence space



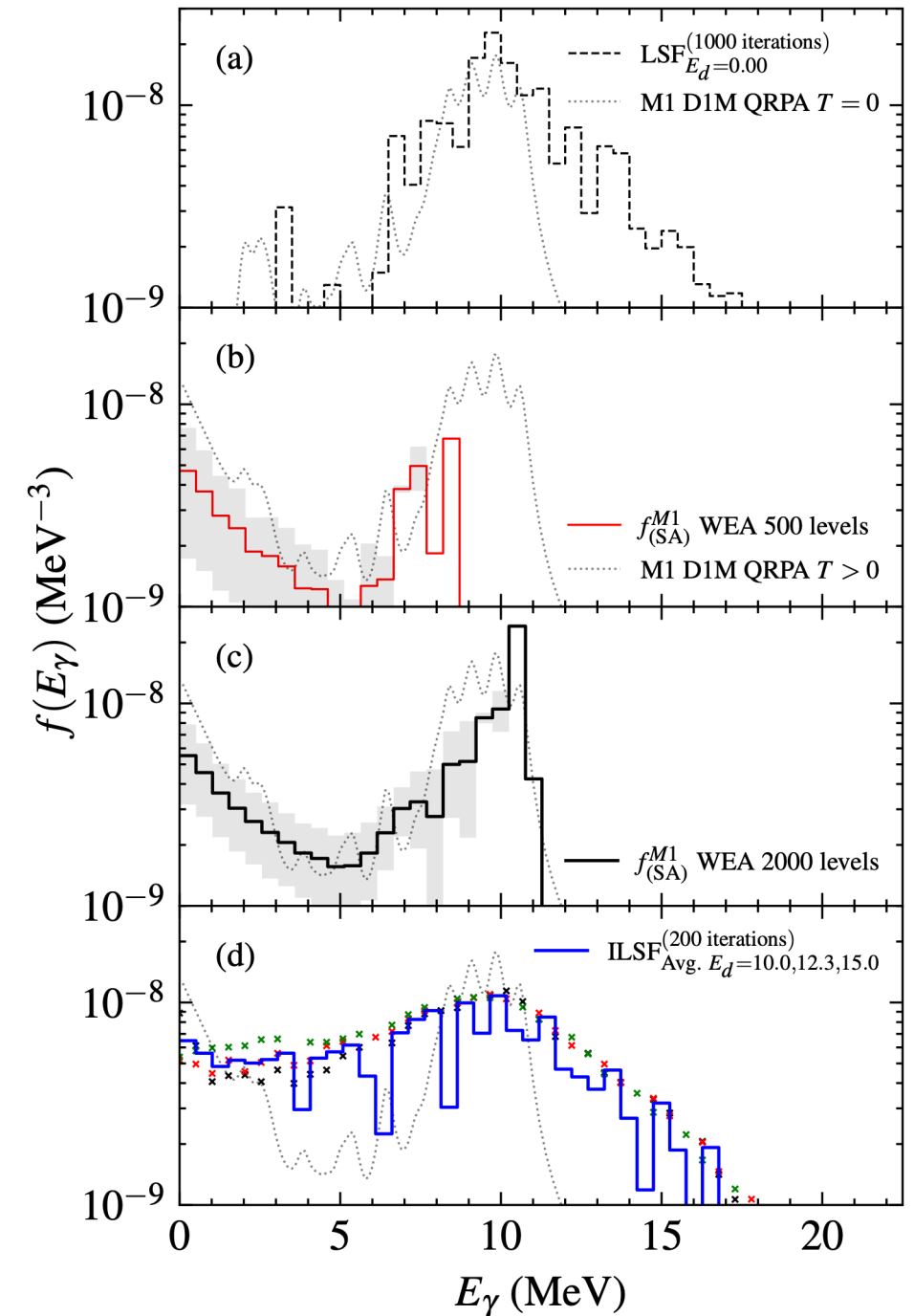
Karampagia, Brown, Zelevinsky (2017)
PRC 95, 024322

pf-shell: exponential shape damped
by orbital mixing

M1 shape flattens with energy
because single-particle orbits
become entangled

^{56}Fe

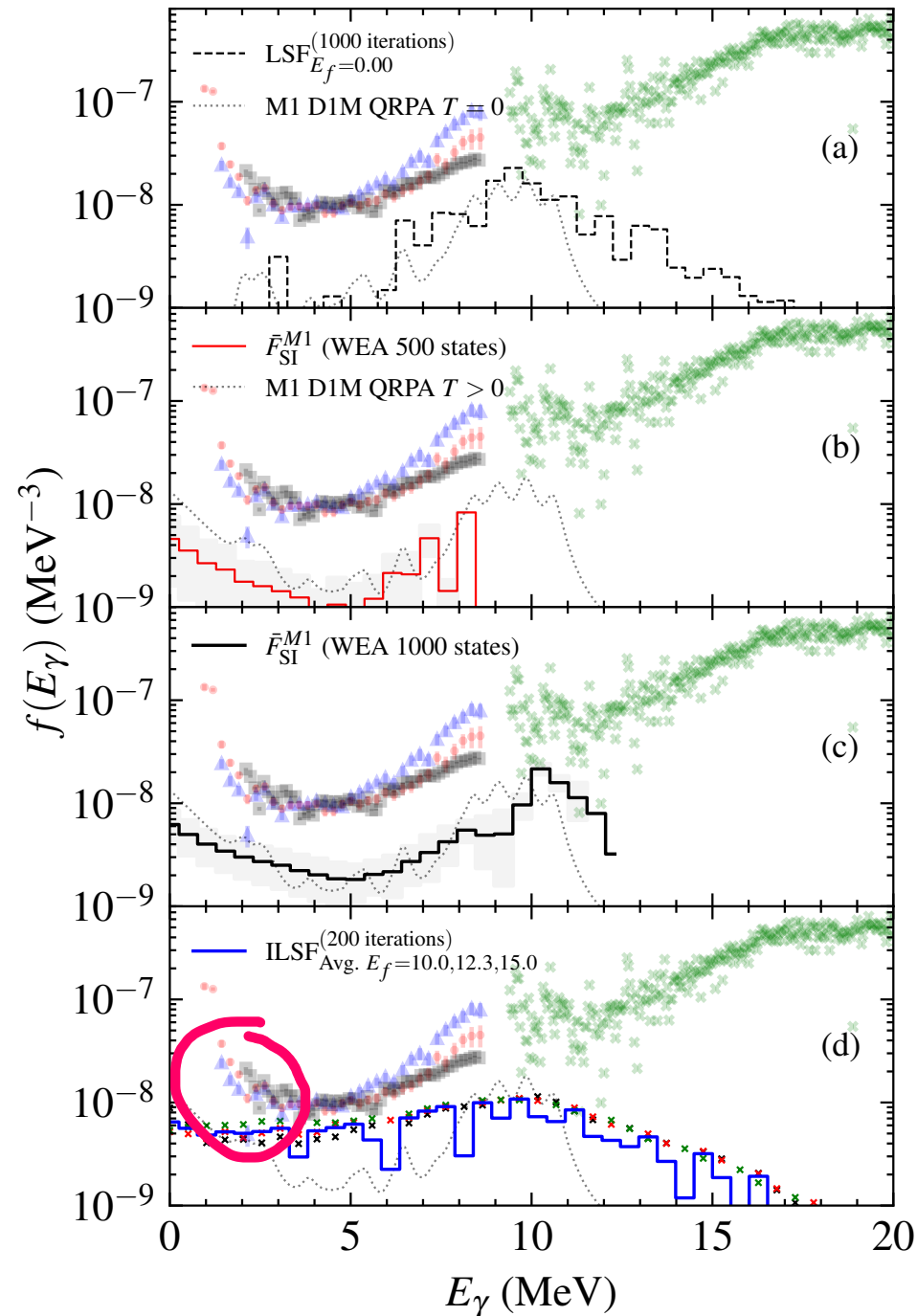
Strength flattens
when decaying to excited states



What about the Oslo-type data?

^{56}Fe

M1 cannot explain
observed up-turn
according to LSSM



E1 RSF to excited states now possible with LSSM

Fe-56

No adjustment

No folding

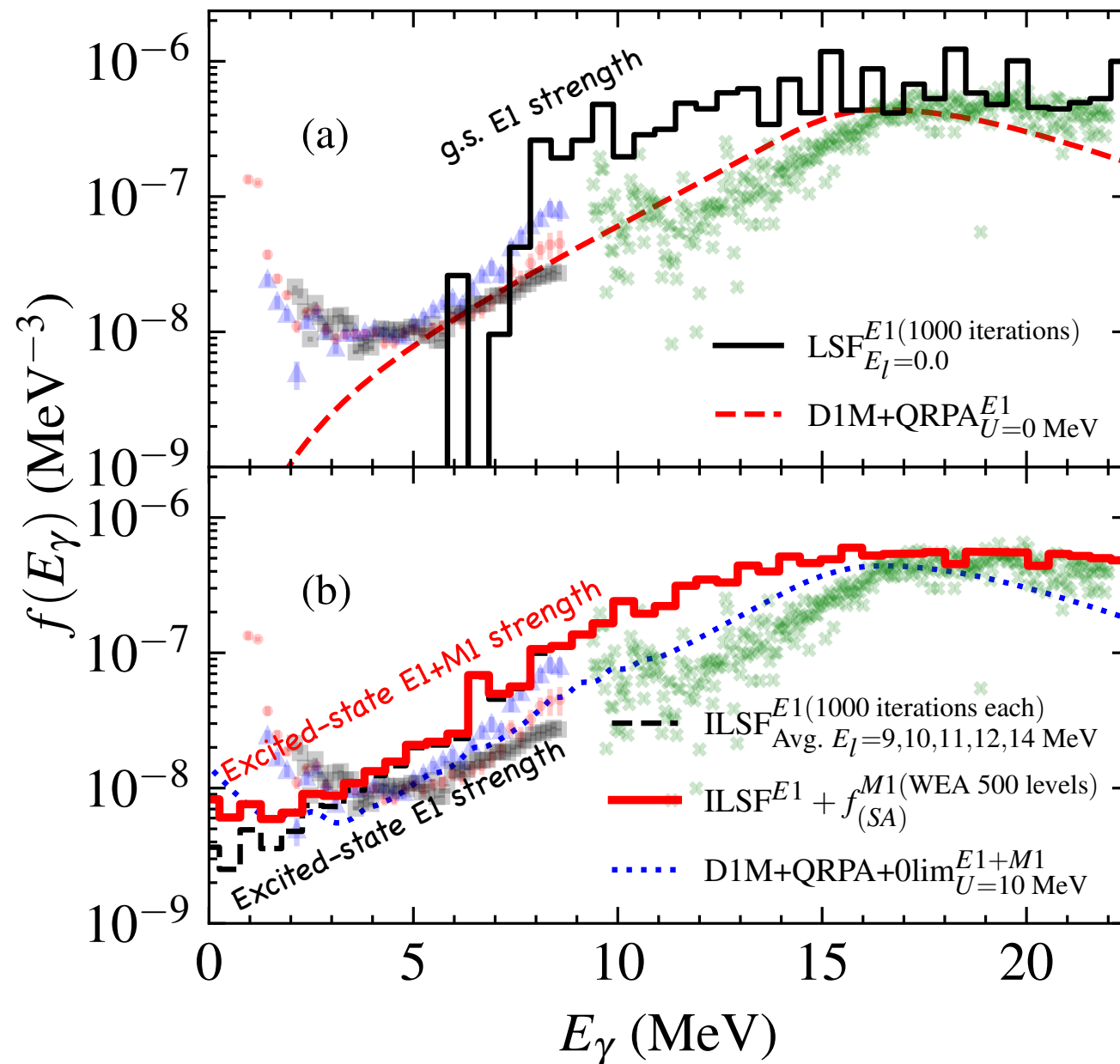
sdpf model space (dimension 10^{15})

+ Energy-based configuration truncation (500 M)

+ ILSF method (5 semi-converged wave functions)

For your consideration:

- Interaction (sdpfmu-db) not tuned for pf nuclei
- Missing g9/2 orbit:
 - May shift E1 mean-energy up
 - Should not affect low-energy
- What could generate observed strength?
 - Would need to modify total M1



Radiative strength functions and ELBA hypothesis

Takeaways:

1. Radiative strength (E1 and M1) increases at low E_γ , relative to photo-absorption (see Kopecky-Uhl model)
2. Exponential shape (M1) related to single-shell transitions; changed by orbital **entanglement**:
 - Open shells (see Midtbø 2018, Karampagia 2017)
 - **Level energy E_f** (this work)
3. The **energy** of the level E_f matters, not the number of levels; use **Lanczos**!

