Quasi-continuum Nuclear Data Evaluator Training

Mathis Wiedeking
Nuclear Science Division
mwiedeking@lbl.gov
https://nuclearscience.lbl.gov/

Supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contracts No. DE-AC02-05CH11231 and the US Nuclear Data Program.

Overview

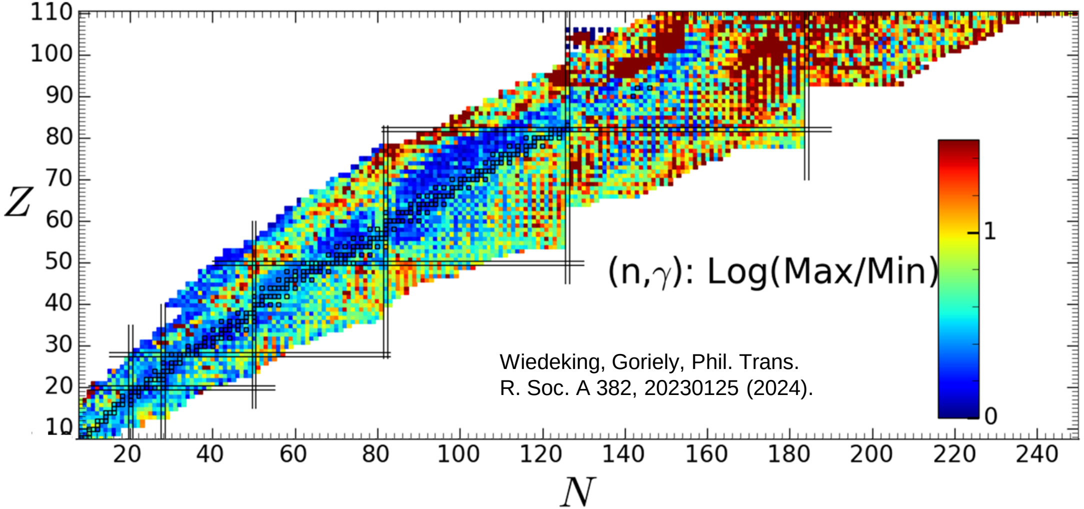
PSF Database → Annual Updates, Quality Indicators, Outliers

NLD Database → Started 2025

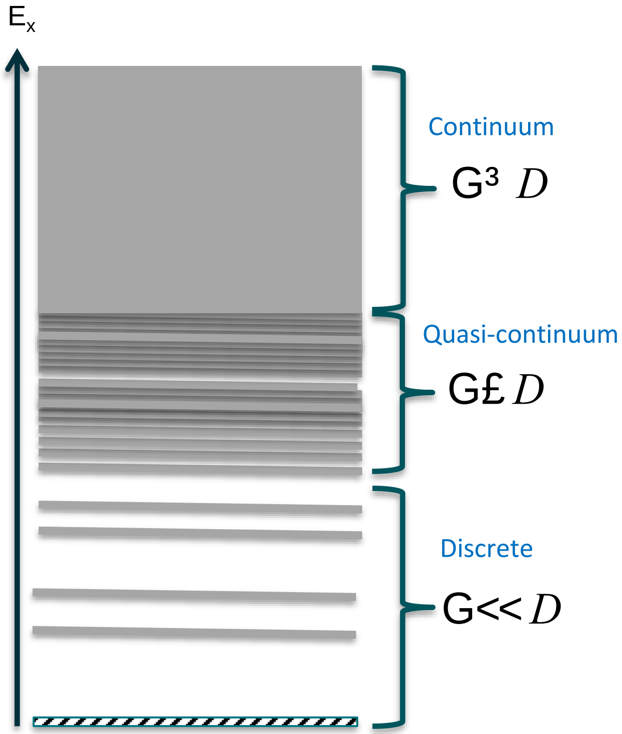
(n,γ) cross sections → HF Model Constraints

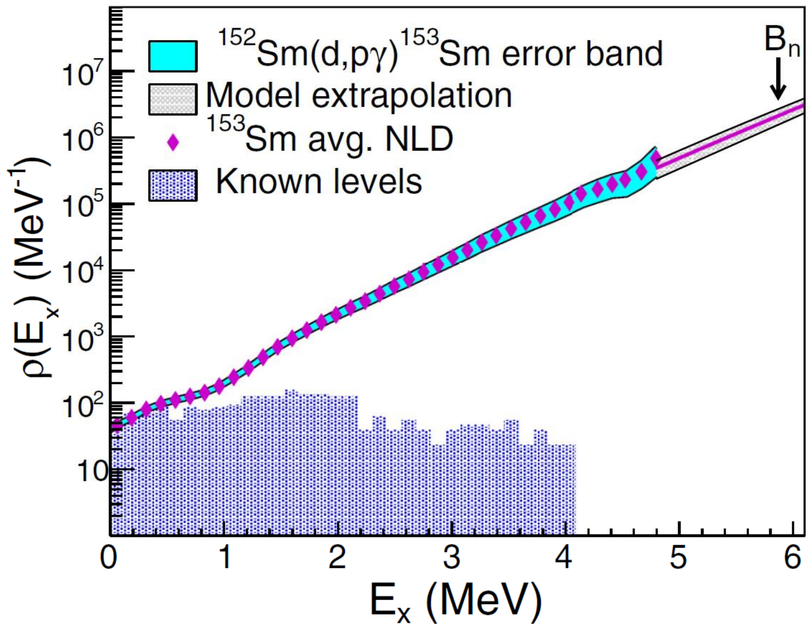
Basic Science → Nucl. Structure, Nucl. Reactions, Nucl. Astrophysics

Applications → Nuclear-Plasma Interactions, Gen IV reactors, Advanced Nuclear Fuel Cycles, Waste transmutation, Radioisotope Production, Security, Non-proliferation



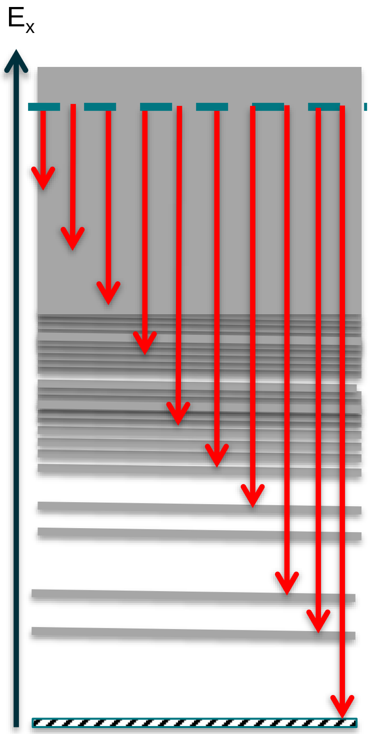
Nuclear Level Density

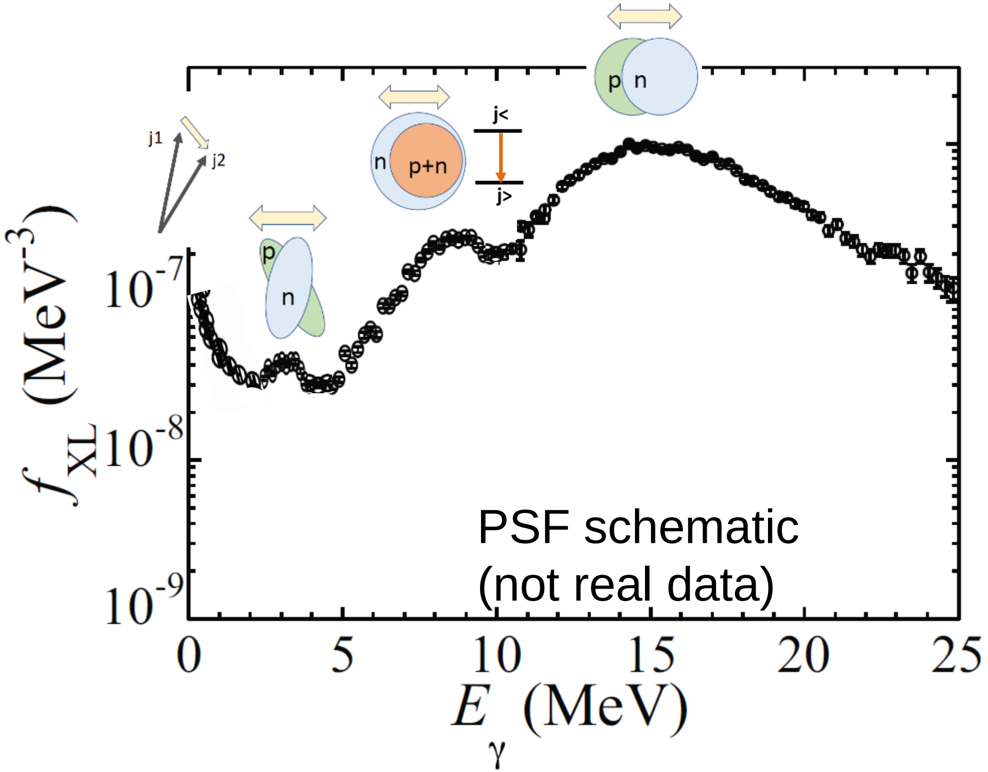




KL Malatji *et al*., Phys. Rev. C 103, 014309 (2021).

Photon Strength Function





Trainees

MSc: Statistical properties of the well deformed ^{153,155}Sm nuclei and the scissors resonance
PhD: Re-estimation of ^{180}Ta nucleosynthesis in light of newly constrained reaction rates

In parallel to traineeship: Analysis of PSF data from (p,γ) reaction with GRETINA at ANL – supported by LLNL (Bleuel).

PhD: Properties of ^{243}Pu, and ^{242}Pu(n,γ) cross section calculation.

In parallel to traineeship: Scintillator Library Manager, LBNL's GENESIS neutron scattering experiments, CLYC-based neutron spectrometer development – supported by NA-22

Photon Strength Function Database

2013: Consultant’s meeting at IAEA with recommendation on PSF database.
2016-2019: IAEA Coordinated Research Project
Photonuclear Data and Photon Strength Functions F41032.

https://www-nds.iaea.org/PSFdatabase/

Eur. Phys. J. A (2019) **55**: 172
DOI 10.1140/epja/i2019-12840-1

THE EUROPEAN PHYSICAL JOURNAL A

Review

Reference database for photon strength functions

S. Goriely[1], P. Dimitriou[2,a], M. Wiedeking[3], T. Belgya[4], R. Firestone[5], J. Kopecky[6], M. Krtička[7], V. Plujko[8], R. Schwengner[9], S. Siem[10], H. Utsunomiya[11], S. Hilaire[12], S. Péru[12], Y.S. Cho[13], D.M. Filipescu[14], N. Iwamoto[15], T. Kawano[16], V. Varlamov[17], and R. Xu[18]

Since 2024 update annually

Data in the PSF database updated 2025

Experimental
338 unique nuclides (1123 datafiles) for all experimental methods

58 nuclides (137 files)	Thermal neutron capture
13 nuclides (34 files)	Ratio and Shape Method
113 nuclides (222 files)	Oslo Methods
9 nuclides (55 files)	Proton scattering
29 nuclides (47 files)	Nuclear Resonance Fluorescence
54 nuclides (123 files)	Average Resonance Capture
52 nuclides (99 files)	Discrete Resonance Capture
154 nuclides (337 files)	Photonuclear
63 nuclides (115 files)	Absolute Photonuclear
22 nuclides (37 files)	Proton capture

Theoretical
Two models validated and recommended to perform global calculations of E1 and M1 PSFs for all nuclides across the nuclear chart: D1M-QRPA and SMLO.

PSF database 2025 Update

Added assessed data for 34 nuclei:

^{51}Ti: bOM, OM
^{56,57,58,60}Fe: bOM, OM, SM
^{59}Co: NRF
^{67}Ni: iOM
^{66}Zn: NRF
^{76}Ge: SM
^{88}Kr: bOM, SM
^{111,112,113,114,116,117,118,119,120,122,124}Sn: OM
^{128,130}Te: OM, NRF
^{140}Ba: bOM
^{147,149}Sm: OM
^{161,162,163,164}Dy: OM
^{186}W: OM
^{195}Pt: OM
^{198}Au: OM
^{239}U: OM

Additional new isotopes to each method

5 nuclides	OM
4 nuclides	bOM
3 nuclides	SM
1 nuclides	iOM
1 nuclides	NRF

- 53 new data files.
- 53 new readme files.
- Implementation of unified procedure for asymmetric and total uncertainties.
- Corrected 20 previously published files.
- New file labeling scheme → 528 files.

Quality Indicators

For Oslo-type data have large number of nuclei and define quality based on:

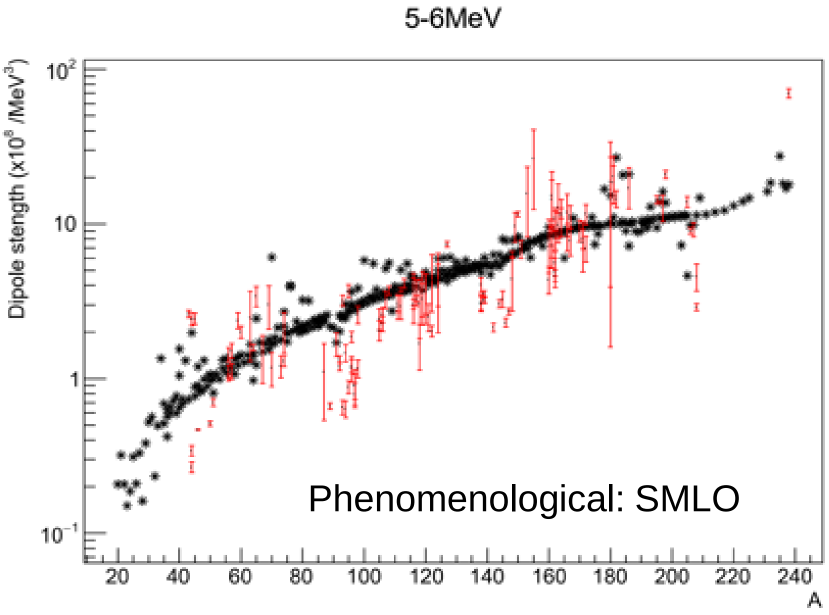
- Full experimental uncertainty budget
- Full model uncertainties such as using different NLD models
- NLD at S_n: Availability of external data from neutron resonance spacing (D_0).
- PSF: Availability of average radiative width (Γ_γ) from neutron resonance data.
- Application of the Shape method to constrain slope of PSF.
- Oslo Method analysis code version used.

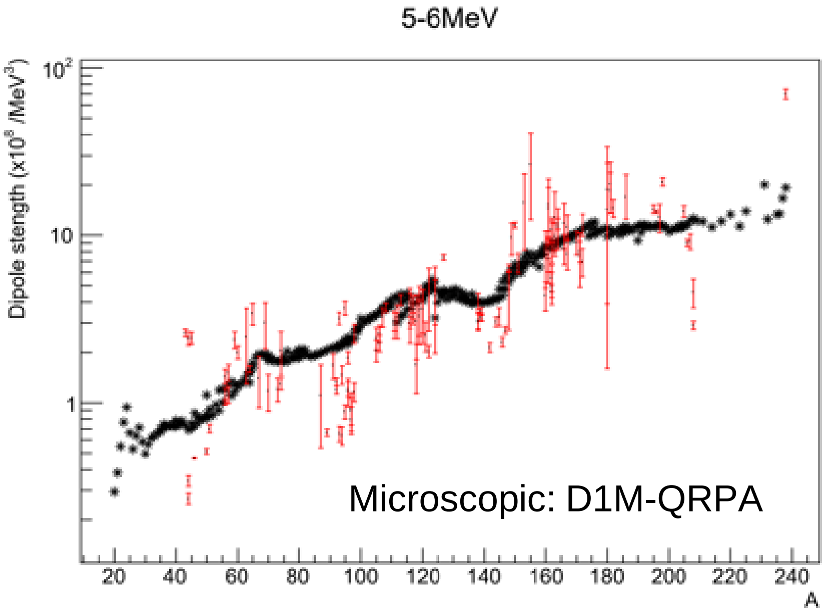
A Residual	Z Residual	Residual Element	A_Target	Z_Target	Target Element	Projectile	Ejectile	Ebeam	Reference	Full experimental including Gg and D0	Full model uncertainties	D0	Gg	Shape Method	After March 2014	Quality indicator 1 to 5
106	48	Cd	106	48	Cd	3he	3he	38.0	A. C. Larsen e	no	Yes	no	no	no	no	2
111	48	Cd	112	48	Cd	3he	a	38.0	A. C. Larsen e	yes	Yes	yes	yes	no	no	2
112	48	Cd	112	48	cd	3he	3he	38.0	A. C. Larsen e	yes	Yes	yes	yes	no	no	2
111	50	Sn	110	50	Sn	p	d	25.0	Markova et a	Yes	No	No	No	No	Yes	2
112	50	Sn	112	50	Sn	p	p	12.7	P.-A. Söderstı	Yes	No	No	No	No	Yes	2
112	50	Sn	112	50	Sn	p	p	16.0	Markova et a	Yes	No	No	No	No	Yes	2
113	50	Sn	114	50	Sn	d	p	11.5	Markova et a	Yes	No	Yes	Yes	No	Yes	3
114	50	Sn	115	50	Sn	d	p	12.7	P.-A. Söderstı	Yes	No	Yes	Yes	No	Yes	3
116	50	Sn	117	50	Sn	3he	a	38.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
116	50	Sn	117	50	Sn	3he	a	38.0	H. K. Toft et a	no	no	Yes	yes	no	no	1
116	50	Sn	117	50	Sn	3he	a	38.0	M. Markova,	yes	Yes	Yes	yes	Yes	yes	5
117	50	Sn	117	50	Sn	3he	3he	38.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
117	50	Sn	117	50	Sn	p	p	16.0	Markova et	Yes	No	Yes	Yes	No	Yes	3
117	50	Sn	117	50	Sn	3he	3he	38.0	H. K. Toft et a	no	no	Yes	yes	no	no	1
118	50	Sn	119	50	Sn	3he	a	38.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
118	50	Sn	119	50	Sn	3he	a	38.0	H. K. Toft et a	no	no	Yes	yes	no	no	1
119	50	Sn	119	50	Sn	3he	3he	38.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
119	50	Sn	119	50	Sn	3he	3he	38.0	H. K. Toft et a	no	no	Yes	yes	no	no	1
120	50	Sn	120	50	Sn	p	p	16.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
120	50	Sn	120	50	Sn	p	p	16.0	M. Markova,	yes	Yes	Yes	yes	Yes	yes	5
121	50	Sn	122	50	Sn	3he	a	38.0	Markova et a	Yes	No	Yes	Yes	yes	Yes	4
121	50	Sn	122	50	Sn	3he	a	38.0	H. K. Toft et a	no	no	Yes	yes	no	no	1
122	50	Sn	122	50	Sn	3he	3he	38.0	Markova et a	Yes	No	Yes	Yes	No	Yes	3
122	50	Sn	122	50	Sn	3he	3he	38.0	H. K. Toft et a	no	no	no	no	no	no	1

Scale:
1 (lowest) to
5 (highest) quality
indicator

Indicates reliability of experimental data.

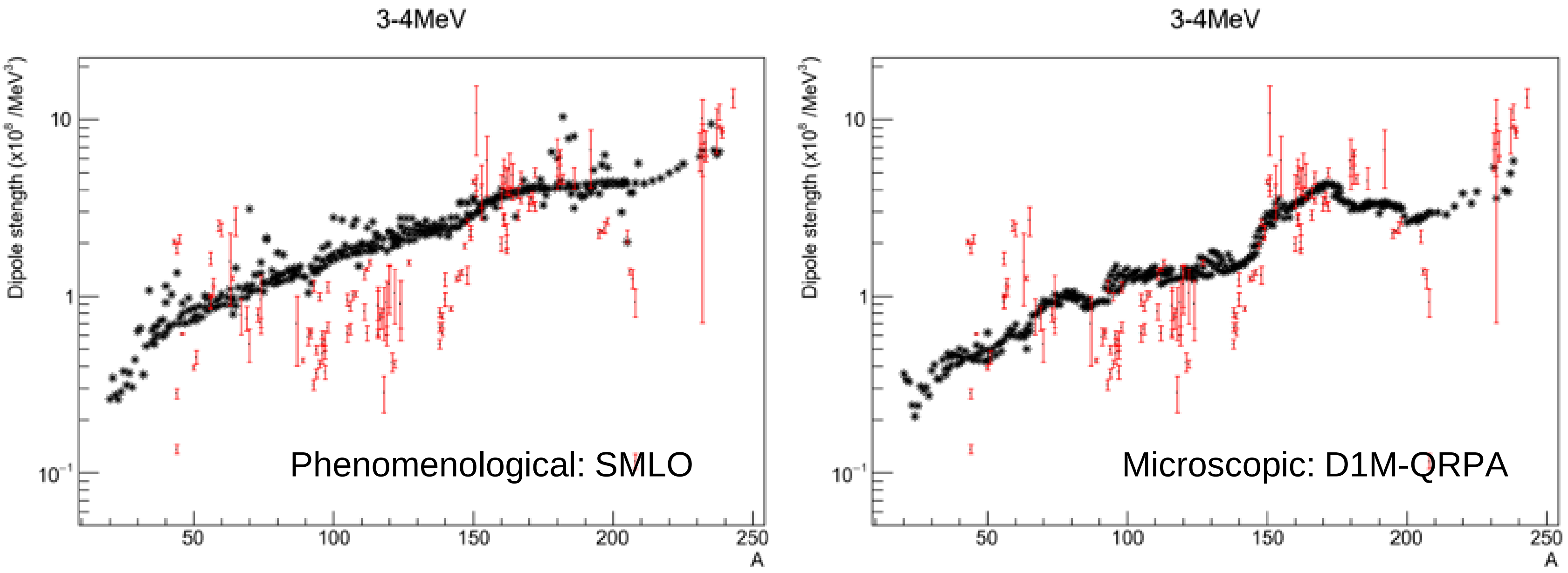
PSF Outliers: Guide where to focus attention





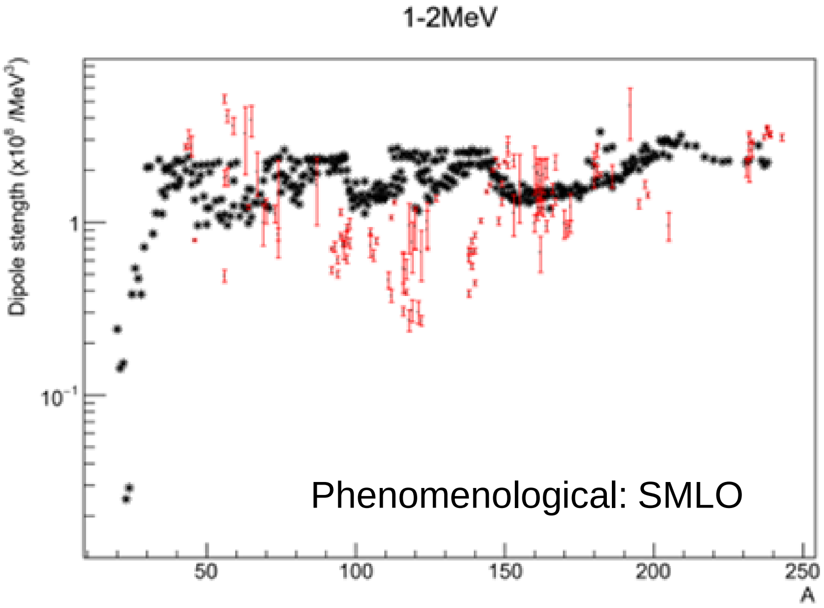
Individual data point outliers: focus on experiment or data analysis, e.g. A~44, A=240
Cluster of outliers: focus on model/theory: e.g. A~90, A=240

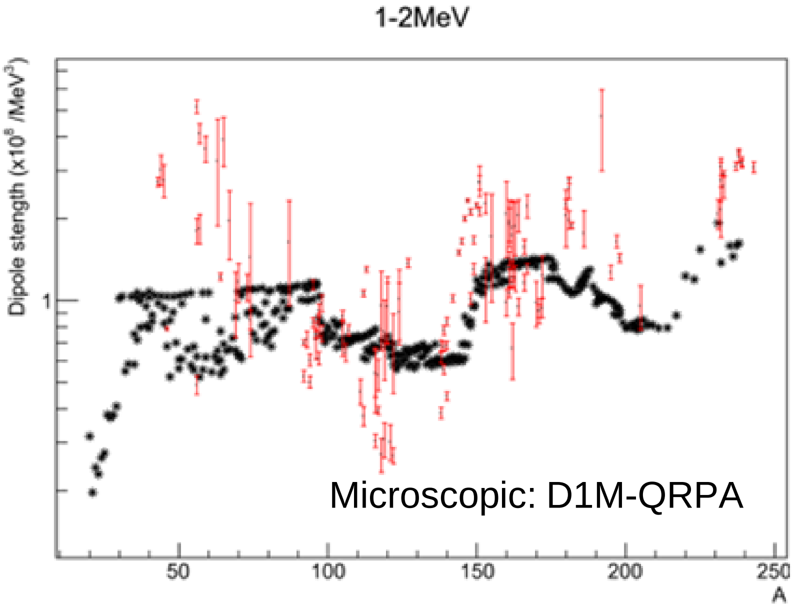
PSF Outliers: Guide where to focus attention



Individual data point outliers: focus on experiment or data analysis, e.g. A~44, A=240
Cluster of outliers: focus on model/theory: e.g. A~90, A~ 50 – 70, A~80 – 150,

PSF Outliers: Guide where to focus attention





Individual data point outliers: focus on experiment or data analysis, e.g. A~44, A=240, A=181
Cluster of outliers: focus on model/theory: e.g. A~90, A~ 50 – 70, A~80 – 150

Planned publication on outlier analysis.

Updating/Improving Nuclear Level Densities for Applications

- Since 2008: important developments and new information available
- Wealth of new experimental information obtained also with new methods
- New advanced modelling capabilities for global calculations
- Improved fundamental theories to guide the models
- New measurements to validate the models
- Enhanced dissemination tools: interactive retrieval interfaces, web-based APIs
- IAEA CRP started 2025.
- Estimated publication of database 2028.

1st RCM on Nuclear Level Densities for Applications

- Held at IAEA 24-28 March 2025
- Total of 45 Actions:
  - Malatji leading 4 teams. Laplace leading 2 teams.
  - Malatji part of 5 teams, Laplace part of 7 teams (not led by them)
- Provides trainees with skills to manage/work with teams to accomplish actions.
- NLD compilation ~90% complete.
- Transitioning to NLD assessment.

10	Compilation of Oslo-type experimental NLD	Ingeberg, Laplace, Malatji, Wiedeking	July 2025
11	Compile all the shape-method NLD	Wiedeking, Laplace, Malatji, Ingeberg	July 2025
19	Compile list of anticipated nuclei	Wiedeking, Voinov, Banerjee, Roy, Laplace, Malatji, Soderstrom, von Neumann-Cosel, Ingeberg, Krticka	July 2025
20	Assessment of experimental data and quality indicator for experimentally derived NLDs	Banerjee, Roy, Laplace, Voinov, Malatji, Ingeberg, von Neumann-Cosel, Soderstrom, Wiedeking	March 2026
21	Comparison of assessed data and identify outliers	Laplace, Malatji, Wiedeking	June 2026
36	Comparison of optimized model calculations to experimentally derived NLD data	Ingeberg, Voinov, Laplace, Malatji, Banerjee, Roy, Soderstrom, Wiedeking, von Neumann-Cosel	November 2026
39	Spin distribution from Shape, (p,p') and evaporation techniques and testing models.	Ingeberg, Voinov, Laplace, Malatji, von Neumann-Cosel, Banerjee, Roy, Soderstrom, Wiedeking	June 2027
40	Investigate the use of a standardized yml format for all experimental data in addition to current file format.	Ingeberg, Voinov, Laplace, Malatji, von Neumann-Cosel, Banerjee, Roy, Soderstrom, Wiedeking	December 2025
41	Develop guidelines for all experimental information that should be published with NLD/PSF data to be incorporated in database	Ingeberg, Voinov, Laplace, Malatji, von Neumann-Cosel, Banjeree, Roy, Soderstrom, Wiedeking	November 2026

Thank you!

Mathis Wiedeking
Nuclear Science Division
mwiedeking@lbl.gov
https://nuclearscience.lbl.gov/

Supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under Contracts No. DE-AC02-05CH11231 and the US Nuclear Data Program.