Argonne NATIONAL LABORATORY

Member of the US Nuclear Data Program

Update on AME & NUBASE

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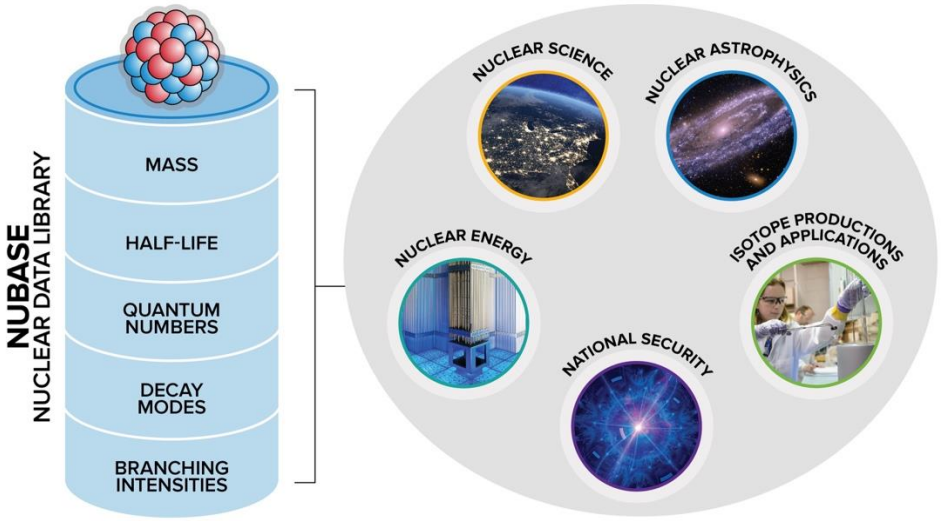
U.S. DEPARTMENT OF ENERGY | Office of Science

Nuclear Physics

U.S. DEPARTMENT OF ENERGY

AME & NUBASE



⇒ **AME:** provide the recommended values for atomic masses (decay and reaction Q values) for all nuclei in their ground state

⇒ **NUBASE:** provide the recommended values for the atomic masses for all isomers ($T_{1/2}$ >100 ns) & other basic nuclear properties ($T_{1/2}$, Jπ, decay modes and BR) for all known nuclei in their ground and isomeric states

- impact on the fundamental sciences (not only NP!) and applied programs
- ones of the most cited articles in LE Nuclear Physics

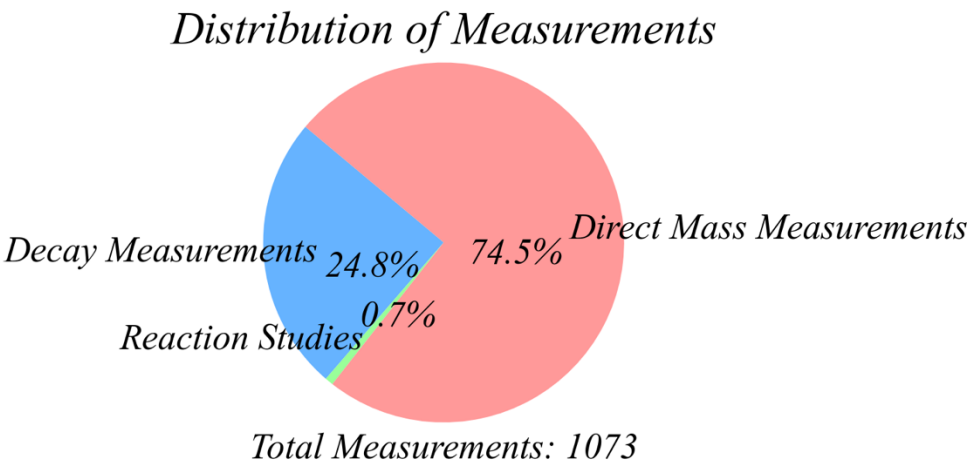
⇒ Contributions to AME & NUBASE are collaborative effort

⇒ ANL-NDP contributes since **2005** – involved in the **2012, 2016** & **2020** editions

⇒ latest libraries were published in **March 2021**: **AME2020 & NUBASE2020**

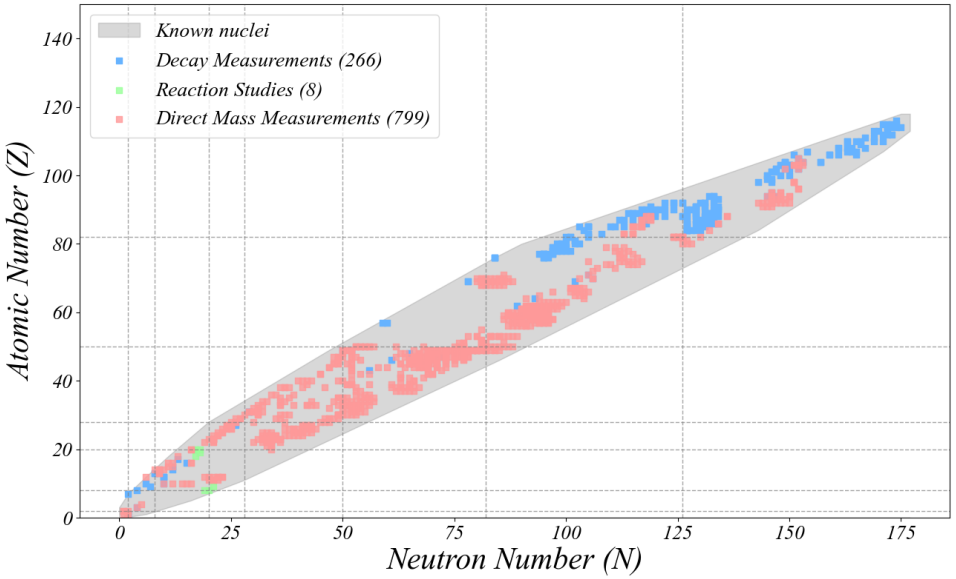
- coordinated by M. Wang (IMP) & F.G. Kondev (ANL)
- recommended data for **3558** ground states and **1983** isomers

AME & NUBASE - updates



AME & NUBASE Updates

- significant amount of new data has been incorporated since the last AME & NUBASE publications
  ⇒ references included 4610 (AME) & 5138 (NUBASE)
- improved precision in the masses of over 1000 isotopes compared to AME2020



Ongoing Effort

- integrate all relevant data into the databases
- identify and resolve discrepancies
- modernizing legacy codes

AME evaluation - Example: MR-TOF

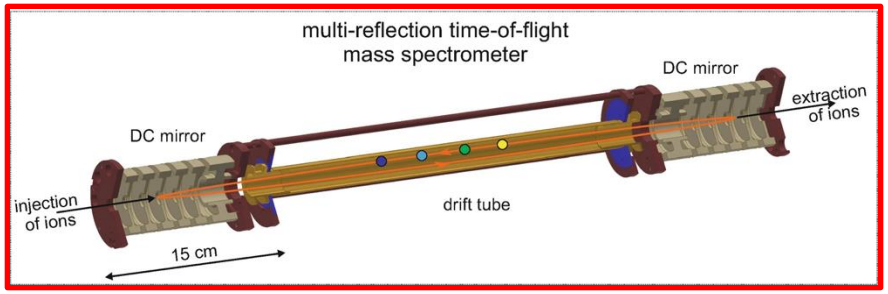


Figure from: Blaum, K., Eliseev, S., Goriely, S. (2023). Masses of Exotic Nuclei. In: Tanihata, I., Toki, H., Kajino, T. (eds) Handbook of Nuclear Physics . Springer, Singapore

MR-TOF

⇒ relatively fast measurements

⇒ improved precision

$$E_{KE} = \frac{1}{2}Mv^2 = qU$$

$$\frac{M}{q} = \frac{2U}{v^2} = \frac{2Ut^2}{l^2} = \frac{2U(t_{exp} - t_0)^2}{l^2}$$

$$M = \frac{q}{q_r}M_r\left(\frac{t - t_0}{t_r - t_0}\right)^2 = \frac{q}{q_r}M_r\rho^2$$

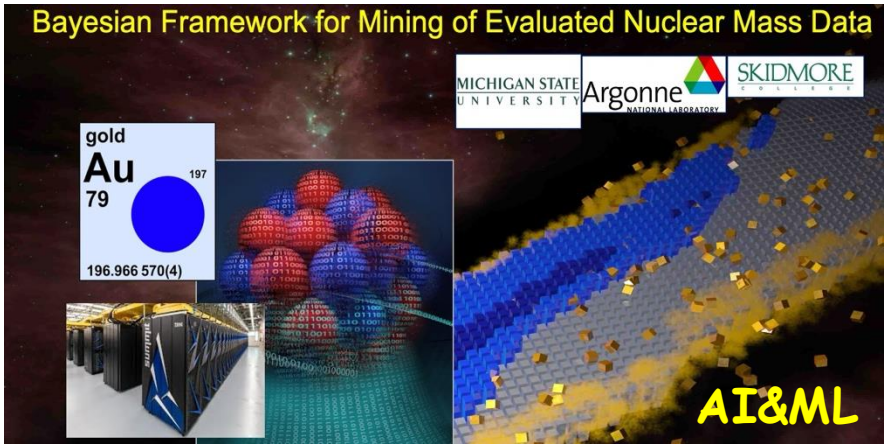
PHYSICAL REVIEW C **110**, 045810 (2024)

Comprehensive mass measurement study of ^{252}Cf fission fragments with MRTOF-MS and detailed study of masses of neutron-rich Ce isotopes

Species	Ref	ρ^2	Rep. ME (keV)	Cal. ME (keV)	Δ (Rep. - Cal.)
^{111}Pd ^{40}Ar^{2+}	^{151}Pr^{2+}	0.99961500 (13)	-120906 (30)	-120906 (22)	0.31
^{111}Rh ^{40}Ar^{2+}	^{151}Pr^{2+}	0.999640390 (47)	-117336 (24)	-117337 (14)	0.78
^{111}Ru ^{40}Ar^{2+}	^{151}Pr^{2+}	0.999679667 (46)	-111815 (24)	-111815 (14)	-0.09
^{151}Pm^{2+}	^{151}Pr^{2+}	0.999953012 (47)	-73386 (24)	-73386 (14)	-0.06
^{151}Nd^{2+}	^{151}Pr^{2+}	0.999970367 (18)	-70946 (23)	-70946 (12)	0.04
^{151}Ce^{2+}	^{151}Pr^{2+}	1.000039526 (19)	-61223 (24)	-61223 (12)	0.13
^{150}Ce ^{1}H^{2+}	^{151}Pr^{2+}	1.000065422 (20)	-57582 (24)	-57582 (12)	0.46
^{151}La^{2+}	^{151}Pr^{2+}	1.000094199 (89)	-53537 (26)	-53537 (17)	-0.23
^{150}La ^{1}H^{2+}	^{151}Pr^{2+}	1.000126206 (35)	-49037 (24)	-49037 (13)	-0.02
^{112}Rh ^{40}Ar^{2+}	^{152}Pr $^{2+}$	0.999640920 (55)	-114600 (21)	-114600 (13)	0.03
^{112}Ru ^{40}Ar	^{152}Pr^{2+}	0.999668761 (51)	-110660 (21)	-110660 (12)	-0.10
^{12}C ^{32}S$_2$$^{1+}$	^{152}Pr^{2+}	0.999715477 (32)	-52024 (10)	-52024.3 (5.4)	0.27
^{58}Ni ^{16}O ^{1}H$_2$$^{1+}$	^{152}Pr $^{2+}$	0.999738692 (29)	-50382 (10)	-50381.6 (5.3)	-0.45
^{148}Ce ^{40}Ar$_2$$^{3+}$	^{152}Pr^{2+}	0.99978904 (12)	-140456 (39)	-140457 (29)	0.62
^{152}Pm^{2+}	^{152}Pr^{2+}	0.999947464 (25)	-71217 (20)	-71217 (10)	0.22
^{152}Nd^{2+}	^{152}Pr^{2+}	0.999955016 (17)	-70148 (20)	-70148 (10)	0.44
^{152}Ce^{2+}	^{152}Pr^{2+}	1.000034560 (18)	-58891 (20)	-58891 (10)	0.19
^{151}Ce ^{1}H^{2+}	^{152}Pr^{2+}	1.000069506 (20)	-53945 (20)	-53946 (10)	0.55
^{151}La ^{1}H^{2+}	^{152}Pr^{2+}	1.000123838 (62)	-46256 (22)	-46256 (13)	0.36
^{113}Pd ^{40}Ar^{2+}	^{153}Nd^{2+}	0.99963982 (15)	-118639 (39)	-118638 (22)	-0.87
^{113}Rh ^{40}Ar^{2+}	^{153}Nd^{2+}	0.999673917 (48)	-113781 (34)	-113781.0 (7.4)	0.00
^{113}Ru^{40}Ar^{2+}	^{153}Nd^{2+}	0.99972269 (20)	-106833 (44)	-106833 (29)	0.28
^{125m}Sn ^{14}N$_2$$^{2+}$	^{153}Nd^{2+}	0.99991043 (16)	-80089 (40)	-80090 (23)	0.67
^{125}In ^{14}N$_2$$^{2+}$	^{153}Nd^{2+}	0.99994834 (18)	-74690 (42)	-74689 (30)	-0.62
^{153}Sm^{2+}	^{153}Nd^{2+}	0.999963232 (36)	-72568 (33)	-72568 (17)	0.01
^{153}Pm^{2+}	^{153}Nd^{2+}	0.999976473 (18)	-70682 (33)	-70682 (16)	-0.17
^{153}Pr^{2+}	^{153}Nd^{2+}	1.000040537 (15)	-61556 (33)	-61556 (16)	-0.11
^{152}Pr ^{1}H^{2+}	^{153}Nd^{2+}	1.00007585 (15)	-56526 (39)	-56526 (27)	-0.45
^{153}Ce^{2+}	^{153}Nd^{2+}	1.000088541 (34)	-54718 (33)	-54718 (17)	-0.29
^{152}Ce ^{1}H^{2+}	^{153}Nd^{2+}	1.000110410 (36)	-51602 (33)	-51602 (17)	0.47

- we don't accept the authors *ME* values automatically
  ⇒ frequently communicate with the authors – when erroneous values are observed corrections via private communications or published errata

AME & AI/ML



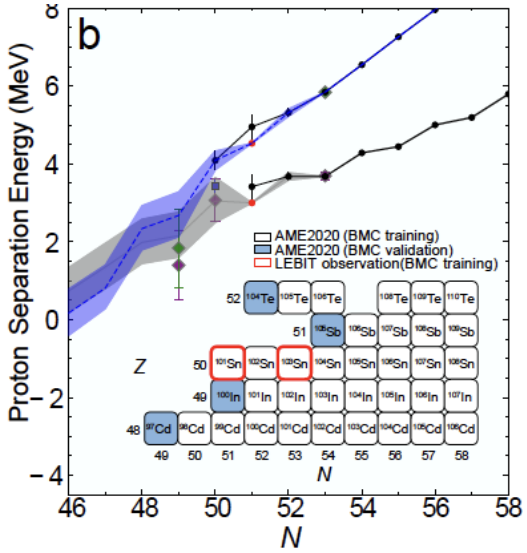
- **Collaborative DOE/SC/NP FOA funded project between MSU/FRIB & ANL**

  ⇒ quantify nuclear binding in regions where no experimental data are available by employing **global nuclear models, current Nuclear Data and Bayesian ML** – implications for nuclear astrophysics

experts in nuclear theory, nuclear astrophysics & nuclear data

- collaboration meeting in March 2025@MSU

  ⇒ provided interim mass table to "train" theoretical models



arXiv:2510.11815v1 [nucl-ex] 13 Oct 2025

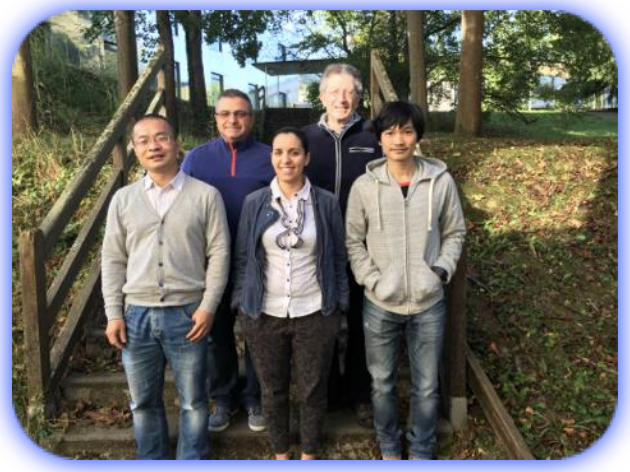
The mass of ^{101}Sn and Bayesian extrapolations to the proton drip line

C. M. Ireland, G. Bollen, S. E. Campbell, X. Chen, H. Erington, N. D. Gamage, K. Godbey, A. M. Houff, C. Izzo, B. Knight, S. Lalit, E. Leistenschneider, E. M. Lykiardopoulou, F. M. Maier, W. Nazarewicz, R. Orford, W. S. Porter, C. Quick, A. Ravlić, M. Redshaw, P.-G. Reinhard, R. Ringle, S. Schwarz, C. S. Sumithrarachchi, A. A. Valverde and A. C. C. Villari

Obs.	^{96}Sn	^{97}Sn	^{98}Sn	^{99}Sn
BE	761.11(77)	777.02(78)	794.16(78)	809.26(78)
ME	−25 380(770)	−33 220(780)	−42 280(780)	−49 320(780)
S_{1n}	-	15.94(56)	17.40(58)	15.09(58)
S_{2n}	-	-	33.22(65)	32.62(64)
S_{1p}	0.74(58)	1.35(59)	1.98(57)	2.16(59)
S_{2p}	0.17(60)	0.81(56)	2.34(57)	2.68(58)

Next AME & NUBASE Libraries

- ~3.5 FTE total
  ⇒ 0.4 ANL
  2016



Collaboration

- ~2.4 FTE total
  ⇒ 1.4 ANL

2024

2023

- **initially** planed for 2024 -> currently aiming for 2026
  ⇒ limited workforce – positive development Rikel Chakma (PD-ANL)
  ⇒ collaboration is more challenging – mostly via ZOOM -> managing different time zones …