



Status of AME & NUBASE

F.G. Kondev
Physics Division, Argonne National Laboratory



Nuclear Physics

Atomic Masses & Nuclear Physics

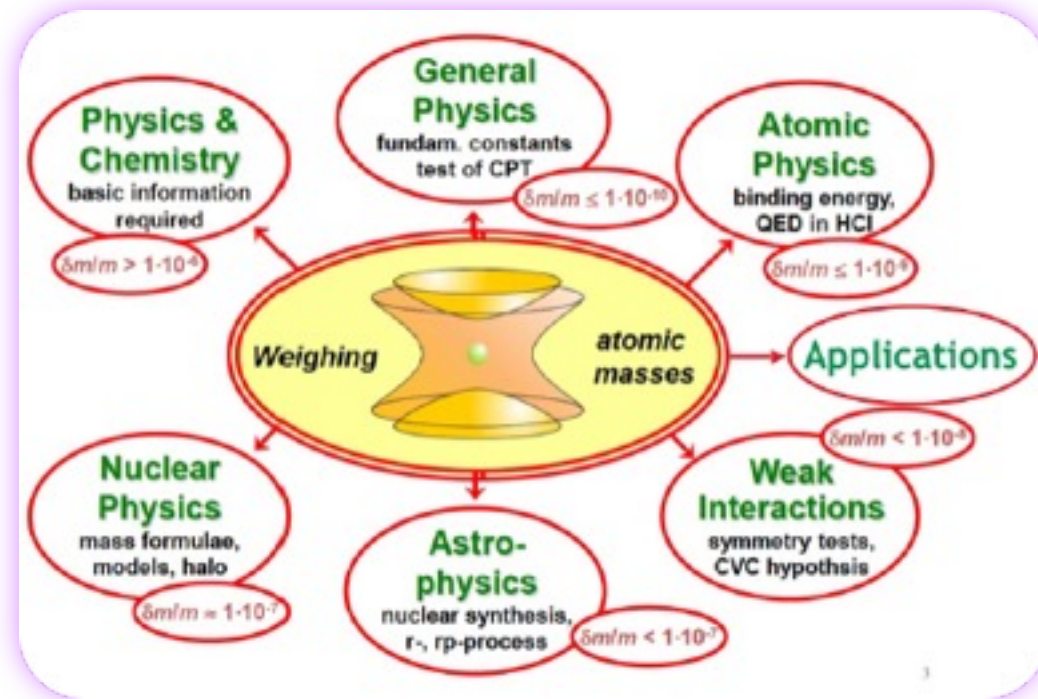
- ⇒ Binding energy
 - mass models
 - shell structure

- ⇒ Correlations
 - pairing
 - p-n

- ⇒ The limits of existence
 - drip lines

- ⇒ Nuclear astrophysics
 - nucleosynthesis pathways & scenarios

- essential to Nuclear Structure research & widely used in other areas of physics, chemistry, metrology and applications ...



AME & NUBASE

- AME & NUBASE provide the recommended values for atomic masses, various decay and reaction Q values & other basic properties for all known nuclei



- historically contributed by A. Wapstra & G. Audi
- since 2008 - collaboration between experts from Europe, China & US

- ⇒ input to ENSDF, ENDF, RIPL ...
- ⇒ applications of nuclear science
MCNP, GEANT4, OpenMC ...

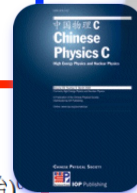
latest tables were published in March 2021
*** AME2020 & NUBASE2020 ***
coordinated by **M. Wang** & **F.G. Kondev**



The AME2020 atomic mass evaluation **

The NUBASE2020 evaluation of nuclear physics properties**

F.G. Kondev^{1,*}, M. Wang (王猛)^{2,3,*}, W.J. Huang (黄文嘉)^{2,4,5,6}, S. Naimi⁷, G. Audi (欧乔治)



IOP
science

since March 5, 2021

49160 downloads

- more than **6780** citations since 2012

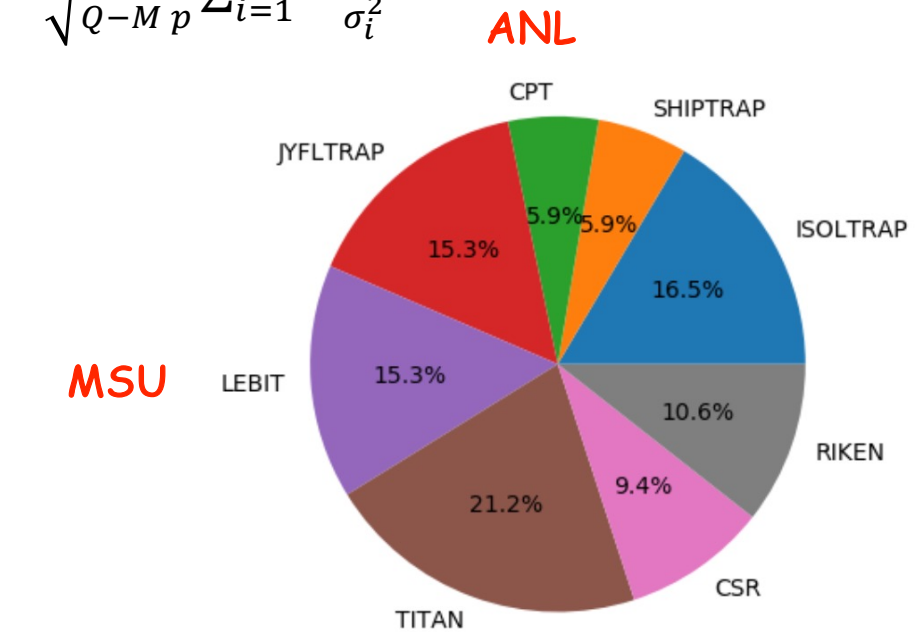
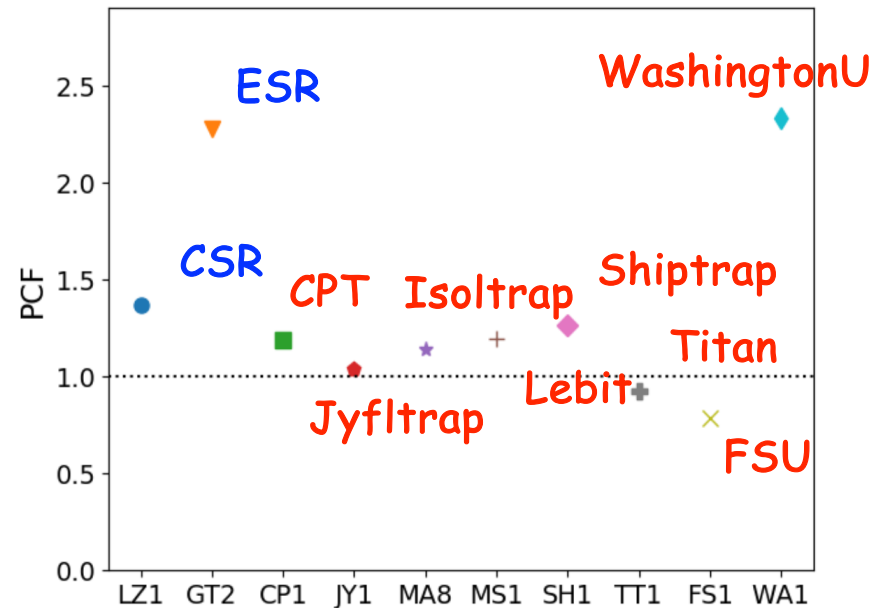
Which Data Are Considered

⇒ Direct (mass spectrometry) and Indirect (reactions and decays) Data produced worldwide

- TOF & MR-TOF, Storage Rings & Penning Traps
- Decay Energies in β^- , β^+ , α and p decays - far from stability

⇒ critically evaluate all experimental data & combine the accepted values using the least-squares fit approach → mass values & covariances for all known nuclei

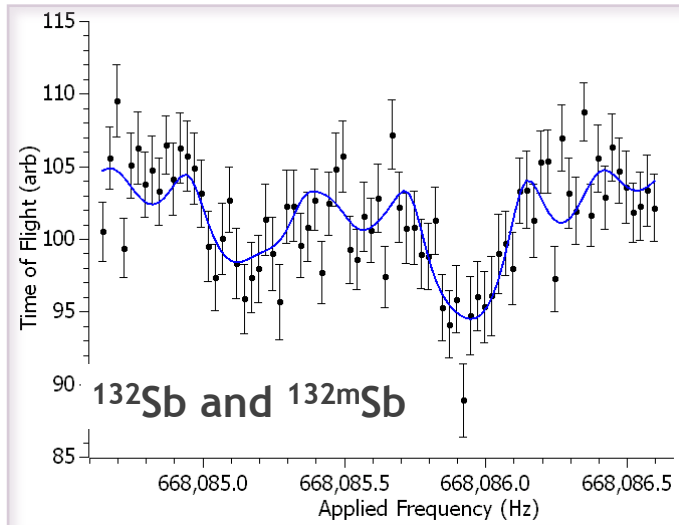
Partial Consistency Factor (PCF): $\chi^p = \sqrt{\frac{Q}{Q-M} \frac{1}{p} \sum_{i=1}^p \frac{(q_i - \bar{q})^2}{\sigma_i^2}}$



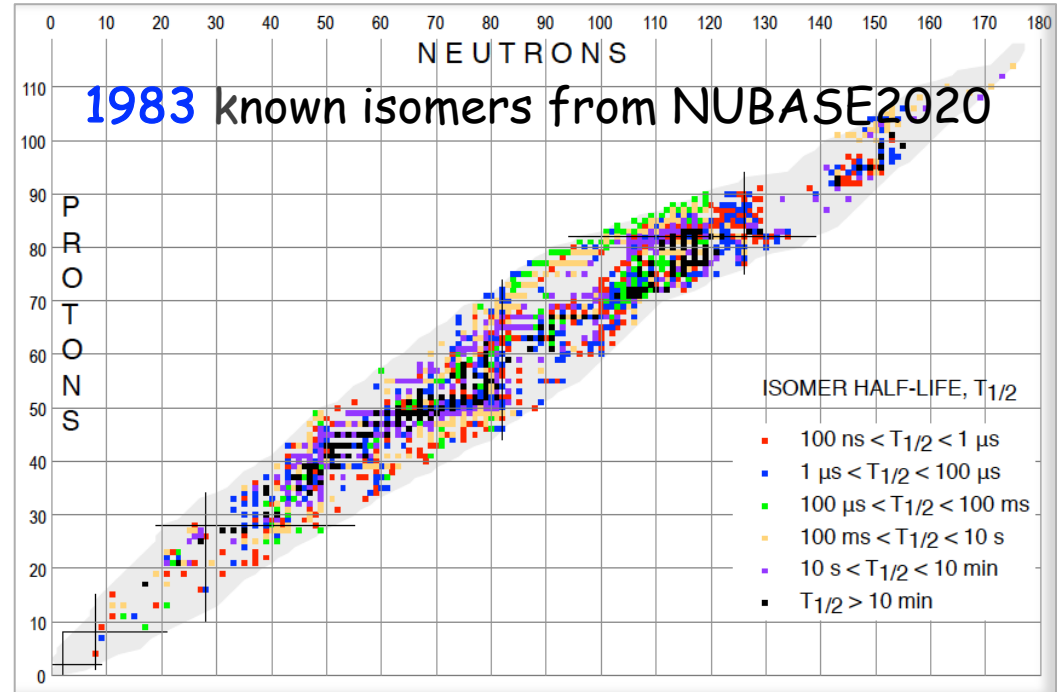
published direct mass data since AME2016

Connection to Nuclear Structure

- Beware of isomers - do we have the right relations?



J. Van Schelt et al., PRL111 (2013) 061102



F.G. Kondev et al., CPC 45 (2021) 030001

NUBASE evaluation of basic nuclear properties

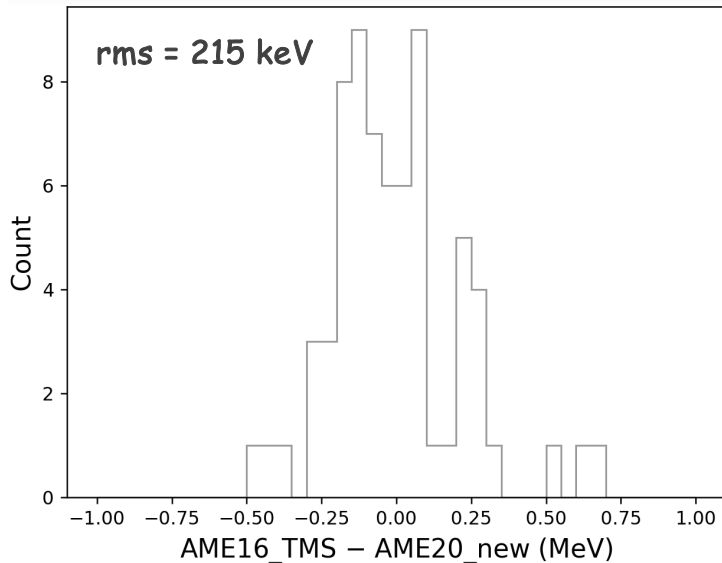
- ⇒ masses (E_x) for isomers and their method of deduction - integral part of AME
- ⇒ $T_{1/2}$, $J\pi$, decay modes and BR for both ground states (3558) and isomers (1983)
- ⇒ properties of 205 Isobar Analog States

- AME & NUBASE cover majority of nuclear properties needed in astrophysics simulations -> widely used in all Astro libraries REACLIB, LANL, UND, STARLIB ...

AME extrapolations

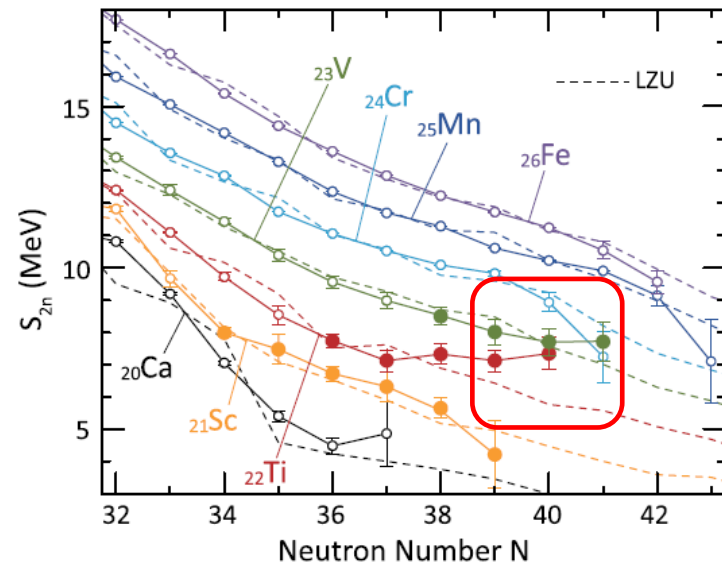
- ⇒ using an empirical approach by assuming that the Trend of the Mass Surface (TMS) is smooth
- TMS extrapolated mass values for a limited number of unknown nuclei
 - replace "irregular" experimental masses by TMS extrapolated values - 77 cases in AME2020

accuracy of the AME extrapolation



not always justified ... new physics?

S. Michimasa et al., PRL125 (2020) 122501



TMS in AME2016, BUT exp in AME2020

build up of deformation around N=40

AME extrapolations - cont.

Bayesian Framework for Mining of Evaluated Nuclear Mass Data

MICHIGAN STATE UNIVERSITY | Argonne NATIONAL LABORATORY | SKIDMORE COLLEGE

gold
Au
79
197
196.966 570(4)

Collaborative DOE/SC/NP FOA funded project between MSU, ANL and SKIDMORE

⇒ 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 data, nuclear astrophysics & statistics



Witek Nazarewicz (PI)



Filip Kondev



fully-funded post-doc



Vojtech Kejzlar

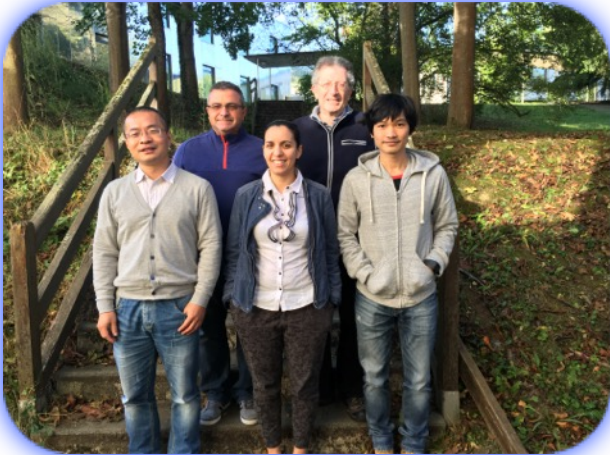


Hendrik Schatz

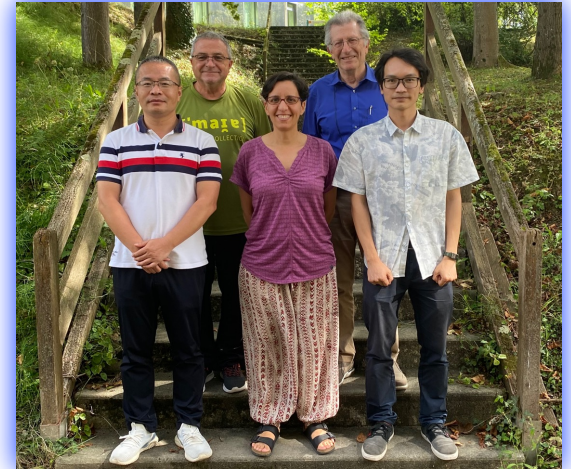


Next AME & NUBASE Tables

2016



2023



- AME & NUBASE collaboration meeting - Sept. 2023, Orsay
- next tables were planned for 2024 but will be delayed -> aiming at 2026
⇒ adding a full-time post-doc through the DOE/SC/NP FOA project would help, but full-time USNDP support to the ANL/USNDP staff is needed (essential)