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U.S. DEPARTMENT OF ENERGY
Office of Science

Update on the NSAC Nuclear Data Charge Subcommittee

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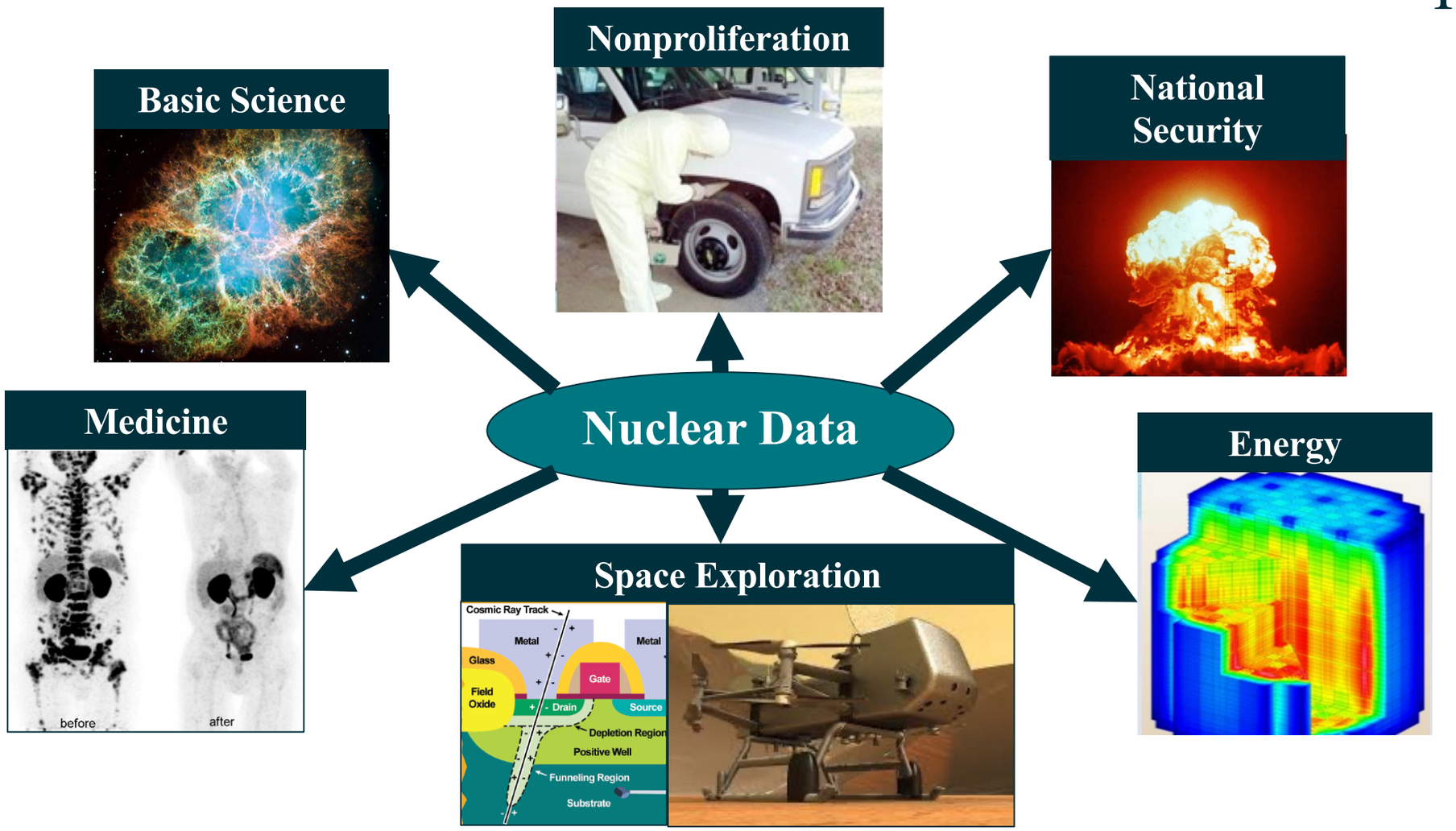
Briefing to NSAC
March 7, 2023

A host of meetings held over the last 8 years have raised awareness about the role of nuclear data for applications



It should come as no surprise that DOE-NP would seek out guidance from NSAC on how to address these nuclear data needs

The First Part of the Charge (due 9/15/22)

1. Assess USNDP Status, which would include the following actions:

   a) Assess and document ***recent achievements*** in nuclear data and their impact.

Input from USNDP staff

   b) Survey current and future federal and non-federal ***needs*** for reliable, accurate, secure, accessible nuclear data.

Input from the NSAC Nuclear Data Charge Subcommittee (NSAC-ND)

   c) Assess the role, competitiveness, and importance of the USNDP in an ***international context***.

Input from USNDP and IAEA staff

The NSAC Nuclear Data (NSAC-ND) Charge Subcommittee

Person	Org	Person	Org
Friederike Bostelmann	ORNL	Arjan Koning	IAEA/Petten
Mike Carpenter	ANL/Atlas	Ken LaBel & Tom Turflinger	NASA & Aerospace
Mark Chadwick	LANL	Caroline Nesaraja	ORNL
Max Fratoni	UCB	Syed Qaim	Jülich
Ayman Hawari	NC State	Catherine Romano	Aerospace
Lawrence Heilbronn	UTK	Sunniva Siem	Univ. of Oslo
Calvin Howell	TUNL	Artemis Spyrou	MSU
Jo Ressler	LLNL	Etienne Vermeulen	LANL
Thia Keppel	J-lab	Ramona Vogt	LLNL

All of these people were chosen based on their experience in nuclear data and some of the applications that rely on it

The first report by the numbers…

– Totals: 88 pages, 6 Chapters, 30 figures, 7 tables, 293 references

1. USNDP since 2018-now Accomplishments: 25 items; 23 pages
2. International efforts/collaborations: 4 pages
3. Nuclear Data needs (50 pages): Basic Science (8); Energy (9), including 4 detailed tables); Medical (8); National Security (3); Nonproliferation (8); Space (10).
4. Crosscutting Needs: Workforce Development; Ongoing Fission Evaluation; Accelerated Decay Data Evaluation; Statistical Structure Evaluation; (n,x) data & High energy data (5 pages).

Some information was moved to the second report and a final version released on January 22, 2023

It also produced a new view of the connections between nuclear data and applications

Old Picture

Facilities/Capabilities

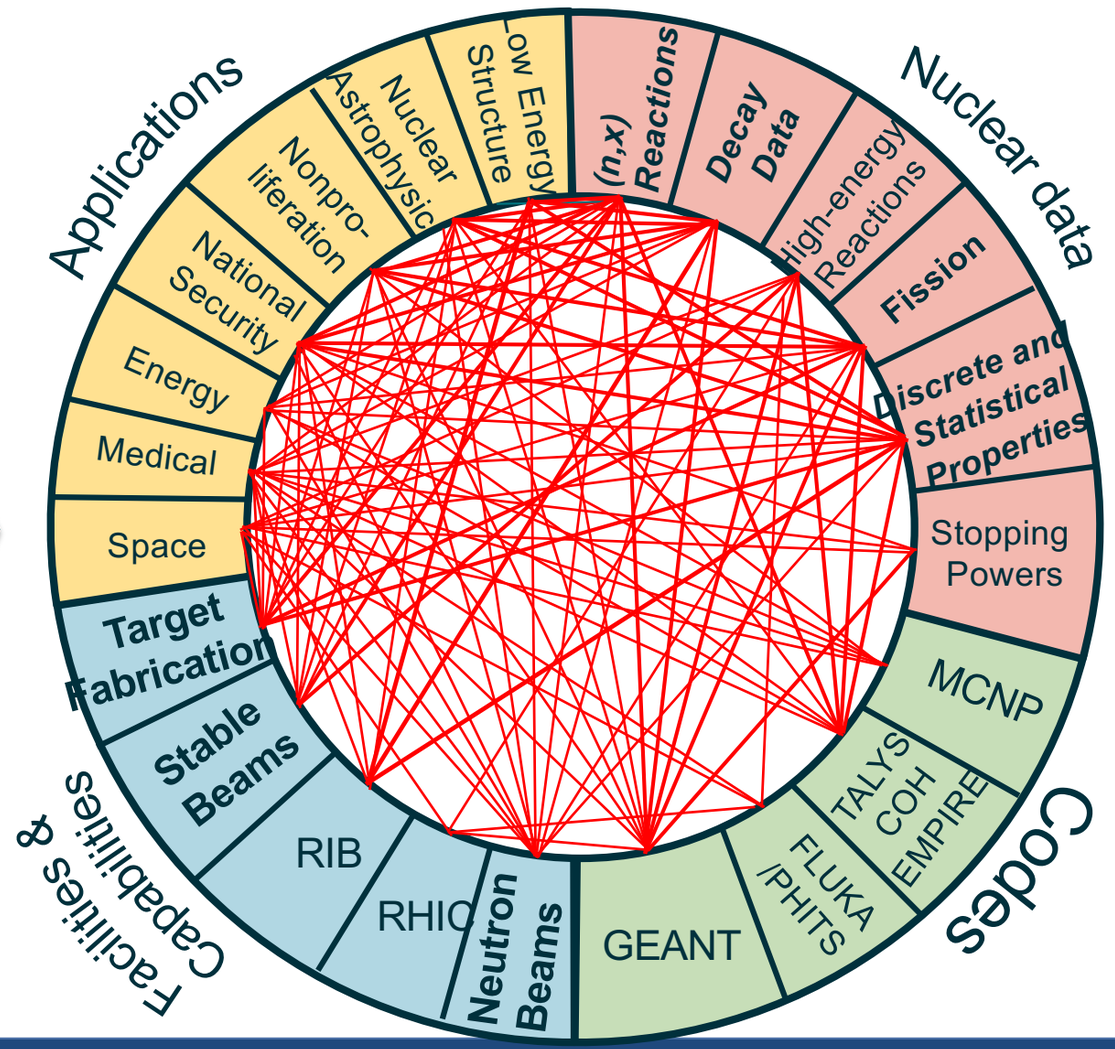
Nuclear Data

Codes

Applications

The real picture is far more complex

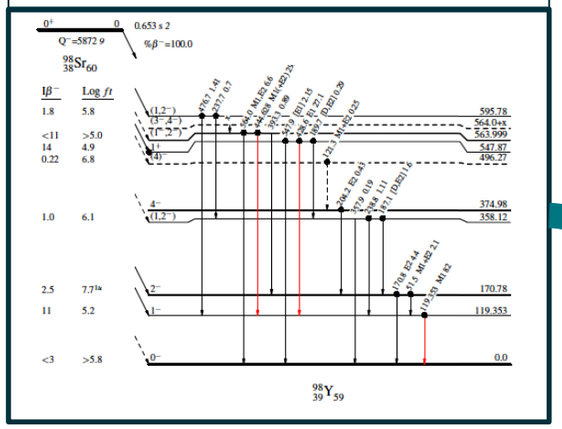
This step is often *well-hidden!*



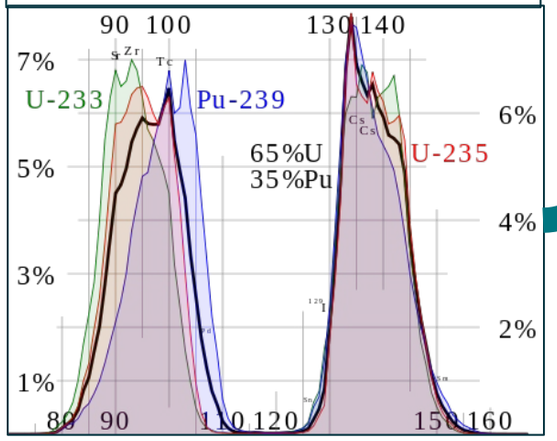
Thanks to Artemis Spyrou!

Here are three examples of "hidden" nuclear data

Decay Data



Fission Product Yield Distribution Data



FLUKA

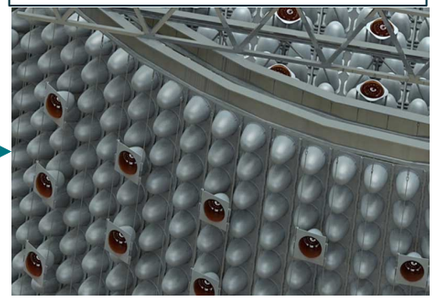
GEANT4
A SIMULATION TOOLKIT

Model

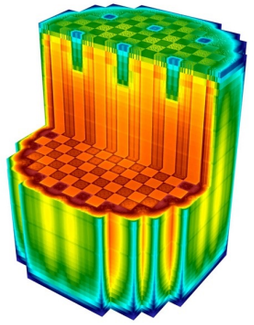
scale
Nuclear Systems Modeling & Simulation

MCNP6

Non-proliferation using $\bar{\nu}_e$ monitors



Decay Heat calculations

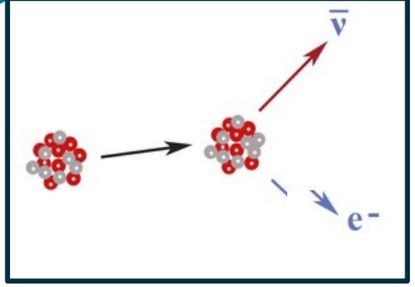


NNSA
National Nuclear Security Administration

U.S. Department of Homeland Security

Defense Threat Reduction Agency
United States of America

Physics beyond the standard model



U.S. Department of Energy
Office of Nuclear Energy

The codes often hide shortcomings in the underlying nuclear data

Several cross-cutting nuclear data needs emerged from the First Report

- Workforce development

All areas need this!

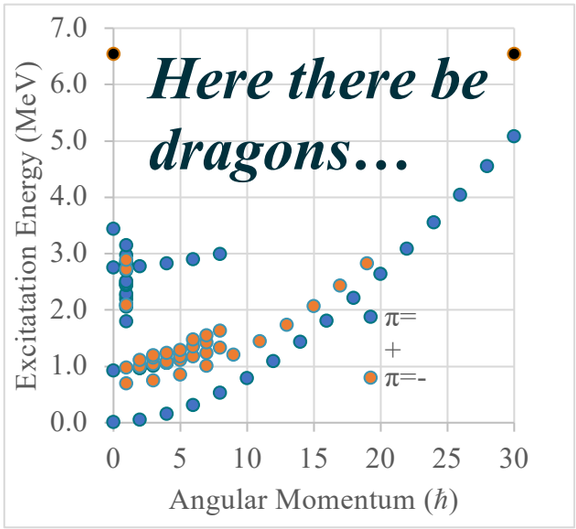
- Ongoing Fission Evaluations

Not just fission yields once/30 years

- Accelerated Decay Data Evaluations for key nuclides

Not all data are created equal

- Improved Reaction Modeling via Extended Nuclear Structure Data Evaluation
- Consistent structure and reaction data for (n,x) reaction from thermal to 20 MeV



Neutrons are special

- High Energy reactions and stopping powers

Moving beyond 20 MeV neutrons

The Second Part of the Charge (due 1/30/23)

2. Based on the USNDP Status Report (from part 1), provide recommendations for maintaining effective stewardship of nuclear data, which includes the following actions:
   a) Identify challenges for nuclear data stewardship in the future, including identifying and prioritizing the most compelling opportunities to enhance and advance NP stewardship of nuclear data and the impact if those opportunities can be realized.
   b) Describe possible ways the Nuclear Data (ND) community can work to train and retain a diverse, equitable, and inclusive workforce capable of sustaining the U.S. ND enterprise.
   c) Identify access needs for facilities and instrumentation, crosscutting opportunities with other federal programs, and potentially mutually beneficial interactions with other domestic and international stakeholders.

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   c) Identify ***access needs for facilities and instrumentation, crosscutting opportunities with other federal programs, and potentially mutually beneficial interactions with other domestic and international stakeholders.***

The first report and input from the USNDP was used

The second report by the numbers…

- Main Body: 41 pages, 4 Chapters, 9 figures/tables, 123 references
  1. Executive Summary (2 pages)
  2. Challenges and Opportunities for Nuclear Data (28 pages)
  3. Diverse, Equitable & Inclusive Workforce Development (3 pages)
  4. Facilities and Instrumentation Access Needs (8 pages)
- Appendix: Domestic Nuclear Data Generating Facilities
  - 21 Facilities @ 17 National Labs and Universities
  - Updated & Expanded from the 2015 NDNCA Whitepaper Appendix D.

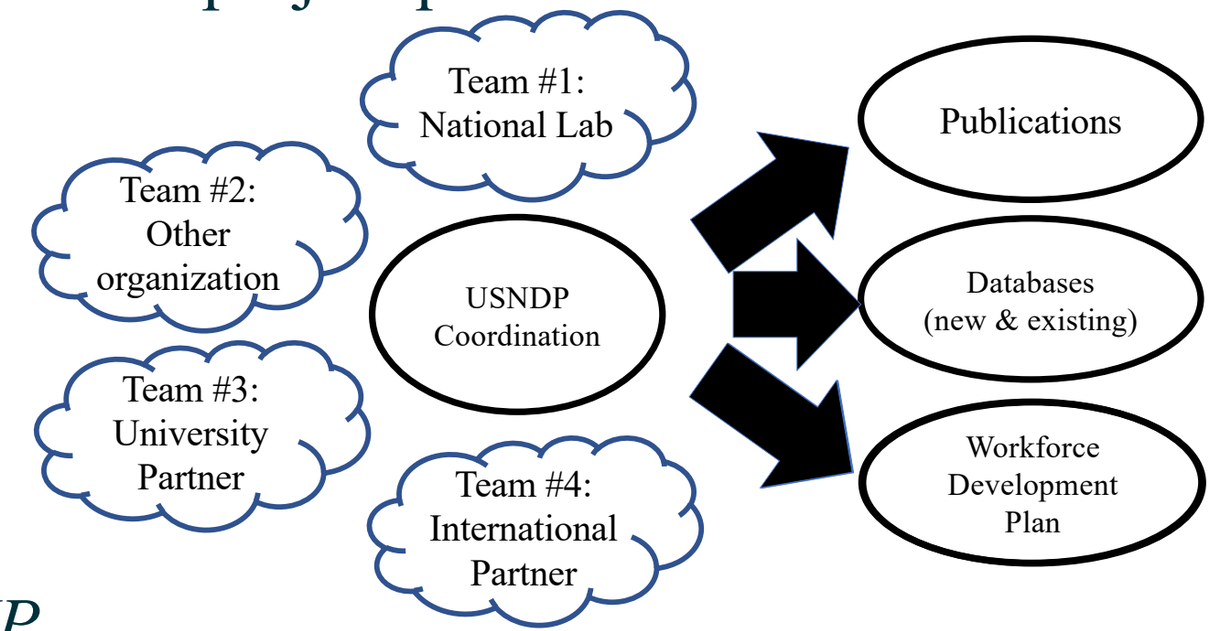
Three critical "Take Aways" from the Second Report

1. Continued support is necessary for the existing nuclear reaction (ENDF), structure (ENSDF) and mass (AME) evaluation efforts.
2. A number of ***new initiatives*** are required to address societies evolving nuclear data needs. These initiatives will require a concerted recruitment effort and support over time to build.
3. These new evaluators should be a part of any experimental activities to ensure expedite data incorporation and ensure a good understanding of the nominal values and uncertainties of the data being measured.

Collaboration is Essential

A key finding is that USNDP members should be part of *Topical Nuclear Data Collaborations (TNDC)*

1. The TNDC brings together application and data subject matter experts and includes workforce development in its project plan.
2. Data would be published in appropriate peer-reviewed journals as well as being incorporated into new or existing databases.



This paradigm is already used by NP (e.g., FIRE) and by NA-22 (e.g., ventures)

Think of these people as *embedded evaluators*

Fourteen Nuclear Data Thrust Areas were presented including eleven new initiatives

1. Supporting Structure Evaluation Capabilities
2. Enhance Reaction Evaluation Capabilities
3. Maintain Atomic Mass and Nuclear Property Evaluation

} Existing Efforts ✓

✓ - Covered at a WANDA

4. Nuclear Astrophysics Evaluation
5. Develop Statistical Nuclear Structure Data Evaluation and Databases ✓
6. Establish Methods for Continuous Fission Evaluation ✓
7. Targeted Accelerated Decay Data Evaluations ✓
8. Provide Comprehensive, Consistent Neutron Reaction and Structure Data ✓
9. Charged-particle stopping powers measurement and evaluation ✓
10. Comprehensive reaction measurement and evaluation to E/A≤10 GeV/amu) ✓

} Topical Initiatives

11. Provide Nuclear Data for Fusion Energy

A workshop is being planned for April 2023

12. Continue Development of Modern Data Formats ✓
13. AI/ML for Modern Nuclear Data Compilation, Evaluation, and Dissemination ✓
14. Create an Infrastructure for Data Preservation and Open Data ✓

} Enabling Initiatives

These 14 crosscutting nuclear data topics map onto all of the topic areas presented in the first report

Nuclear Data Initiative	Basic Science	Energy	Medical Applications	Nat'l Security & Nonproliferation	Space Applications
Structure Data	■	■	■	▒	▒
Reaction Data	▒	■	■	■	■
Mass Data	■	■	▒	■	▒
Astrophysics	■	□	□	▒	□
Statistical Data	■	■	■	■	▒
Fission	■	■	■	■	■
Decay Data	■	■	■	■	▒
(n,x) data	▒	■	■	■	■
Stopping	□	□	■	■	■
High Energy Data	▒	□	■	□	■
Fusion	□	■	□	■	■
Data Formats	■	■	■	■	■
AI/ML Tools	■	■	■	■	■
Data Preservation	■	■	■	■	■

Existing USNDP Efforts

New USNDP Initiatives

Enabling USNDP initiatives

Each nuclear data initiative is presented in 4 parts

1. **Issue**: Identification of a crosscutting nuclear data need;
2. **Background**: A discussion of how the initiative is related to the need;
3. **Recommendation**: A recommendation of how to carry out the initiative, including an estimate of the additional workforce needs and a recruitment/training timeline;
4. **Impact**: The societal benefits that would result from carrying it out.

The initiatives are targeted towards intelligent non-experts

The First Three Topics Support Existing Core Programs

1. Support the nuclear structure evaluation workforce to improve the currency, consistency, and accessibility of the Evaluated Nuclear Structure Data File (ENSDF);
2. Enhance nuclear reaction evaluation within the USNDP in support of the Evaluated Nuclear Data File (ENDF) through expansion of the workforce and integration of high-performance computing, automation, and machine learning;
3. Continue atomic mass evaluation in support AME and NUBASE databases.

Continued support for these foundational activities is essential

These are followed by 8 new initiatives

4. Establish a coordinated effort to improve evaluation and modeling in nuclear astrophysics for stellar dynamics, multi-messenger astronomy and nucleosynthesis;
5. Initiate and maintain an effort to develop and maintain nuclear structure evaluation beyond discrete states, including nuclear level densities, photon strength functions and photonuclear data for improved reaction modeling, and exploring nuclear structure at finite temperature;
6. Maintain an ongoing effort for correlated fission data evaluation, including cross sections, fragment yields, $\nu(A)$, $\nu(E_\nu)$ for nuclear energy, national security, nonproliferation and basic science;

These are followed by 8 new initiatives (cont.)

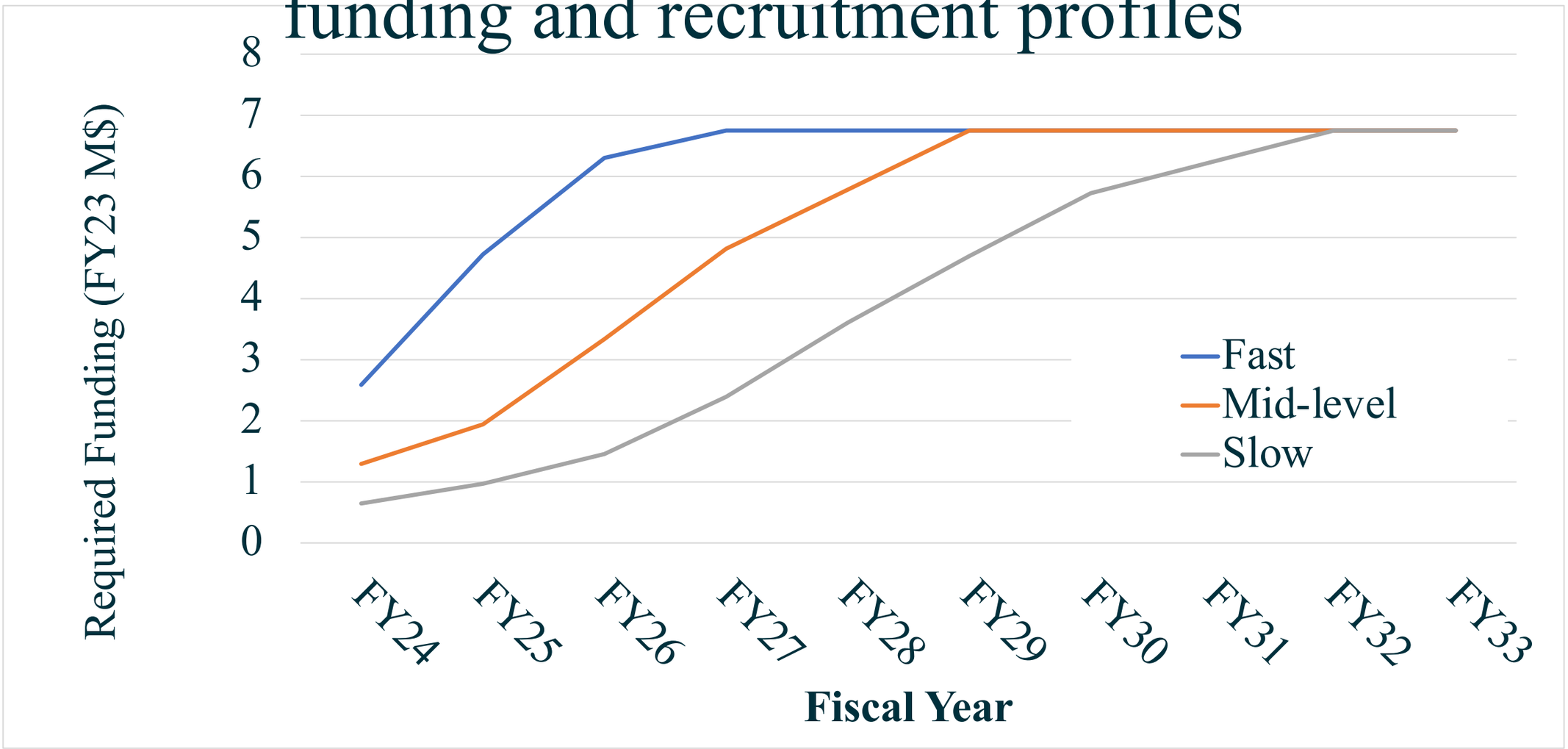
7. Form a panel of experts to annually update key evaluated decay data for targeted high-value nuclides for national security, nonproliferation and medical applications;
8. Maintain comprehensive, consistent (n,x) structure and reaction data for energy, national security, nonproliferation & planetary nuclear spectroscopy;
9. Develop and maintain evaluated charged-particle stopping power data for detector design, space effects, isotope production and ion beam therapy;
10. Extend reaction evaluation to higher energies for space exploration and medical nuclide production.
11. Address Nuclear Data for fusion energy systems including tritium production and materials damage cross section.

The last three initiatives build a robust nuclear data infrastructure for the 21st century

12. The continued development of new data formats to accommodate all nuclear data types and improve access by modern software systems.
13. The design and incorporation of artificial intelligence and machine learning tools to improve the nuclear data evaluation process.
14. The creation of an infrastructure for open data and data preservation for use by the entire nuclear physics community.

Each new initiative requires 1-2 FTE in an ongoing basis

The time scale of this expansion can be adjusted to fit funding and recruitment profiles



Conclusions

- A few typos have been corrected since the 2/13/23 release. Please report others as you find them!
- Input from the report will be used for portions of the Long Range Plan (e.g., applications, low-energy program etc.)

Special Thanks

Ramona Vogt, Cathy Romano, Bethany Goldblum, Jo Ressler and many of my colleagues in the USNDP