Nuclear Data Activities at ORNL

Michael Smith
Caroline Nesaraja
Murray Martin

ORNL is managed by UT-Battelle for the US Department of Energy
Activities and Capabilities

• Nuclear Structure (Nesaraja, Martin, C. Smith)
  – A-Chain Evaluations for ENSDF (A=241 – 249)
  – Compilations for XUNDL
  – Technique refinement / student training

• Nuclear Astrophysics (M. Smith, C. Smith, S. Zhang)
  – Assessing reaction and structure info critical for stellar explosion studies
  – Determining rates from USNDP and other data sets
  – Calculating rates with theoretical models

• Online Software Systems (M. Smith, E. Lingerfelt, C. Smith)
  – Updating / improving input
  – Maintaining codes and systems
  – Developing new user-requested features
In recognition of her work as a nuclear data evaluator, Caroline Nesaraja was named the **June 2016 Woman Physicist of the Month** by the American Physical Society’s Committee on the Status of Women in Physics.
Evaluation Technique Refinement

- **ENSDF Evaluation Guidelines**
  - Initial version written in 1988, updated in 2015
  - Used as lectures in Specialized Workshop on NSDD Evaluations in 2015 at IAEA
  - Draft version online, revisions still in progress
  - Author Murray Martin currently collecting feedback

- **Discussed special issues encountered during evaluations with LBNL/UCB evaluators**
  - Currently collecting information on a Google Drive for later distribution

- **For A=244 evaluation, learned**
  - K-forbidden beta transitions from “Theory of Complex Nuclei” (V.G. Soloviev 1976) and articles by Kondev and Dracoulis …
  - Gallagher-Moszkowski Rules and Newby shifts
  - Utility of Br1ccMixing code to calculate δ (mixing ratios)
  - Alaga rules – wrote out detailed description
• **Alaga Rules**
  
  - Determine ratio of gamma transition probabilities involving C-G coefficients
  - Need to verify additional documentation in previous A=244 evaluation
  - Some previous descriptions incomplete or incorrect
  - Worked with young ORNL postdoc James Matta using online software code to correctly calculate
Related Activities

- Collaborated with K. Rykaczewski et al. on total absorption spectroscopy measurements relevant for reactor neutrino spectrum (measurement supported by Data Program)

- Visited LBNL for a month and participated in beamline calibration run at the 88” cyclotron to benchmark its use to measure isotope production

- Saving legacy reports and private communications
  - Extensive documentation at ORNL of critical private communication, reports, theses …
  - Worked with J. Totans to sort, pack, and ship to BNL for inclusion in NNDC library
**Astrophysics Reactions**

- Processing data sets for use in astrophysical models
  - required several improvements for fitting code
  - without this processing, published rates cannot be used in most popular nucleosynthesis codes
  - paper in preparation on fits to 96 rates
Astrophysics Reactions

- Processing data sets for use in astrophysical models
  - required several improvements for fitting code
  - without this processing, published rates cannot be used in most popular nucleosynthesis codes
  - paper in preparation on fits to 96 rates
Astrophysics Reactions

Assessing structure and reaction information for crucial reactions

- Relevant for explosive burning in the rp-process $[^{20}\text{Ne}(p,d) \text{ for } ^{18}\text{F}(p,\alpha)]$

- Relevant for neutron captures on exotic Sn nuclei in supernovae
  
  $[^{124,126,128,130,132}\text{Sn}(d,p) \text{ for } ^{124,126,128,130,132}\text{Sn}(n,\gamma)]$

---

Table 2: The resonance parameters used in the calculation of the $[^{18}\text{F}(p,\alpha)\gamma]$ rate and its associated uncertainties. The ANK is given for the subthreshold resonance while other resonances are tabulated with their width. Quantities come from measurements unless where explicitly noted in the footnotes.

<table>
<thead>
<tr>
<th>Resonance</th>
<th>$E_{\text{R}}$ (MeV)</th>
<th>$\Gamma_{\text{R}}$ (MeV)</th>
<th>$E_{\text{L}}$ (MeV)</th>
<th>ANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$J^P$ (X)</td>
<td>3</td>
<td>5.4</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>$J^P$ (Y)</td>
<td>3</td>
<td>5.4</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>$J^P$ (Z)</td>
<td>3</td>
<td>5.4</td>
<td>1.5</td>
<td>3</td>
</tr>
</tbody>
</table>

* Adapted from mirror level.

* Based on assumed reduced proton width.
Online Software Systems

Computational Infrastructure for Nuclear Astrophysics
- CINA streamlines the incorporation of the latest NUCLEAR DATA into astro simulations
- Accessible via an easy-to-use, web-deliverable, cross-platform Java application
- Used by researchers in 160 institutions in 35 countries
- Enables uploading, modification, processing, storage, management, visualization, sharing of nuclear information for astrophysics studies
- Users request new features and tools
- Simulation results routinely used in beam time proposals by experimentalists
• Nuclear Mass Toolkit
  – Enables quick comparison of measured, compiled, evaluated, & theoretical masses
  – Users can quickly share mass data sets
  – Custom 1D and 2D visualizations with a few mouse clicks

• New Atomic Mass Evaluation effort (IMP Lanzhou) has requested special tools
  – creation of new data space to enable AME collaborators to share files
  – new visualization tools for AME collaborators
  – enable mass values to be tagged with comments by AME collaborators
  – pop-up graphs of previous mass values of any chosen nuclide
  – upload additional theory mass tables
  – upload additional nuclear mass references
Budget Situation

• Recent cut in ORNL Data Program funding

• Can no longer support
  – Chris Smith (Postmasters) – XUNDL 0.2 FTE, Astro Reactions 0.8 FTE
  – Eric Lingerfelt (Staff) – Software (0.3 FTE)
  – Shisheng Zhang (Visiting Faculty Subcontractor) – Astro Reactions 0.4 FTE

• Astro and Software activities significantly reduced or nearly terminated …
  – Assessing reaction and structure info critical for stellar explosion studies
  – Determining rates from USNDP and other data sets
  – Calculating rates with theoretical models
  – Updating / improving online software systems input
  – Maintaining codes and systems
  – Developing new user-requested features

• Requested funds to partially gain back these capabilities