Cyclotron institute evaluation center report: US nuclear structure data program

N. Nica and J.C. Hardy

Nuclear data evaluation is the main activity designed to capitalize the results of nuclear science research. From its beginnings more than a century ago, it became evident that nuclear science evolves over the years in such a way that establishing the "best" parameters at any given time is an important and challenging task. Thus, very early in its development the scientific community became aware, as Marie Curie wrote [1], that "*the need has arisen for the publication of special Tables of the Radioactive Constants*", which she, together with a prestigious group of contemporary scientists, co-authored the first major international nuclear data evaluation paper, titled "*The Radioactive Constants as of 1930*". Moreover, as she continues, "*This responsibility has been assumed by the International Radium Standards Commission chosen in Brussels in 1910 (...)*", which means that, due to its practical importance, this type of activity got institutionalized from its beginnings. Therefore, the origins of what today is known as *nuclear data evaluation* dates to the dawn of nuclear science itself.

In more recent times, it was recognized that the diversity of published data, not to mention their occasional inconsistencies, demanded that all published results should be assembled and reconciled by a specialized group of experienced scientists. Even collecting the relevant information from all the world's publications, was a nontrivial task, but documented databases were gradually established. This culminated with today's *Nuclear Science Reference* (NSR) database, which is maintained at the National Nuclear Data Center (https://www.nndc.bnl.gov/nsr/). Gradually after several cycles of systematic data analyses the community arrived at "practical standards" of data, which are then revisited periodically to include the continuous updates of newly published data. In this way, nuclear data evaluation has become a new research domain with its own specificity.

A new turning point emerged after the Second World War when the United States got the leading position in the nuclear research field, and consequently the transatlantic nuclear data evaluation changed shores, with the US becoming its main contributor. The United States Nuclear Structure Data Program (USNDP) was started (with its two main subcomponents, one for nuclear reactions and one for nuclear structure), being designed to maintain the so-called Evaluated Nuclear Structure Data File (ENSDF) database, the most extensive nuclear structure data repository in the world. This effort was shared initially among several national institutes and was extended to gradually include a few universities, of which Texas A&M Cyclotron Institute has been one since 2005. It was first funded by a contract with Brookhaven National Laboratory, but in 2017 we started to receive direct funding through the DOE Grant DE-FG02-93ER40773, "Cyclotron-based Nuclear Science". At that time, we became the Texas A&M Cyclotron Institute independent ENSDF Data Evaluation Center, one of the important contributors to the USNDP, as well as to the Nuclear Structure and Decay Data international network hosted by the IAEA Vienna.

Between 2005 and 2020, we completed and published the following full mass-chain evaluations: the superheavy A=252 mass chain [2]; the very data-rich mid-mass chains, A=140 [3], A=141 [4], A=147 [5] and A=148 [6]; and the relatively lighter chains, A=97 [7] and A=84 [8], the latter in a large international collaboration. In collaboration with B. Singh and a group of authors from McMaster

University, Canada, we also published the A=77 [9], A=37 [10], A=36 [11], and A=34 [12] mass chains. At the beginning of 2016, we published another large mass chain, A=157, in Nuclear Data Sheets [13], followed by A=158 in 2017 [14], the renewed full evaluation of A=140 in 2018 [15], A=155 in 2019 [16], A=153 in 2020 [17] and A=160 in 2021 [18].

As mentioned in our previous reports, our community has been passing through two crises: a critical shortage of evaluators, followed by a similar shortage of reviewers, due mainly to the retirement of several experienced evaluators. Moreover, the publication pipeline became more demanding, with a prereview process, followed by the main technical review with a couple of iterations, and finally by an editorial review, which together propagated substantial delays of 2-3 years to the currency of the ENSDF database.

In the interval of this report, Apr 1, 2022 – March 31, 2023, between April-September we continued the full evaluation work on the A=154 mass chain, covering a period of more than 14 years since the publication of its last evaluation. This mass chain was successfully submitted to NNDC before Oct 1, 2022, when it was due.

In parallel with the mainstream work, we also completed a technical review of the A=200 mass chain as assigned by NNDC. Although it was 300 pages long, we succeeded in returning the reviewed manuscript at the end of Feb 2023, less than five months after receiving it. The review itself had taken two months of dedicated effort.

After addressing the most substantial part of the after-review and editorial work on the A=147 mass chain during the Fall of 2021 (our second full evaluation of A=147 after that in 2009), this mass chain finally was published in the March-April 2022 issue of Nuclear Data Sheets [19]. This mass chain was published in collaboration with B. Singh who evaluated ^{147}Pm (including the half-life of its β^- decay parent, ^{147}Nd).

During about two months in the Summer of 2022, we also completed the after-review work for the A=141 mass chain, followed by the editorial review and preparations for publication during the Fall of that year. We finally published the A=141 mass chain in Nuclear Data Sheets in early 2023 [20].

Together with our previously published full evaluation of the A=147 mass chain (available on-line on Apr. 12, 2022), we succeeded to publish the two A=147 and A=141 mass chains in the 12 months interval now under review, Apr.1, 2022 – Mar 31, 2023. This is notable since we customarily manage to publish only one mass chain per 12 months interval.
In April 2023 we also started the post-review work on the large A=162 mass chain. The manuscript is more than 500 pages long.

After Oct 2022 we did a substantial part of the work on this fiscal year's principal commitment, the A=148 full mass-chain evaluation, which we evaluated previously in 2014 [6]. This mass chain involves more than 1200 experimental publications, of which more than 116 have been added since our last evaluation. This work is currently in progress and is to be submitted to NNDC by Sept 30, 2023.

[1] M. Curie, A. Debierne, A.S. Eve, H. Geiger, O. Hahn, S.C. Lind, S. Meyer, E. Rutherford, E. Schweidler, Rev. Mod. Phys. **3**, 427 (1931).
[2] N. Nica, Nucl. Data Sheets **106**, 813 (2005).
[3] N. Nica, Nucl. Data Sheets **108**, 1287 (2007).

[4] N. Nica, Nucl.Data Sheets **122**, 1 (2014).
[5] N. Nica, Nucl. Data Sheets **110**, 749 (2009).
[6] N. Nica, Nucl. Data Sheets **117**, 1 (2014).
[7] N. Nica, Nucl. Data Sheets **111**, 525 (2010).
[8] D. Abriola *et al.*, Nucl. Data Sheets **110**, 2815 (2009).
[9] B. Singh and N. Nica, Nucl. Data Sheets **113**, 1115 (2012).
[11] N. Nica, J. Cameron, and B. Singh, Nucl. Data Sheets **113**, 1 (2012).
[12] N. Nica and B. Singh, Nucl. Data Sheets **113**, 1563 (2012).
[13] N. Nica, Nucl.Data Sheets **132**, 1 (2016).
[14] N. Nica, Nucl.Data Sheets **142**, 1 (2017).
[15] N. Nica, Nucl.Data Sheets **154**, 1 (2018).
[16] N. Nica, Nucl.Data Sheets **160**, 1 (2019).
[17] N. Nica, Nucl.Data Sheets **170**, 1 (2020).
[18] N. Nica, Nucl.Data Sheets **176**, 1 (2021).
[19] N. Nica, B. Singh, Nucl.Data Sheets **181**, 1 (2022).
[20] N. Nica, Nucl.Data Sheets **187**, 1 (2023).