Resolving differences in mass tables in predictions for the production of elements 119 and 120

C.D. Pritchard[1,2] and C.M. Folden III[1,3]
[1]*Cyclotron Institute, Texas A&M University, College Station, Texas 77843*
[2]*Department of Chemistry, Jacksonville University, Jacksonville, Florida 32211*
[3]*Department of Chemistry, Texas A&M University, College Station, Texas77843*

There are significant discrepancies in theoretical predictions of the excitation functions for the synthesis of elements 119 and 120. Many of the predictions use different mass tables, and this has led to questions about the optimum excitation energy and optimum projectile energy for producing them. To understand this effect, we have corrected published excitation functions to use the same mass model. In this work, data from published predictions were shifted to consistently use the mass model by Möller *et al.* [1]. Changes in cross sections caused by the changes in excitation energy were outside the scope of this work.

Literature was reviewed to find excitation functions for the production of elements 119 and 120. The data were digitized using Graph Grabber 2.0 [5] and each exit channel was analyzed. The projectile energy was determined using the mass table listed in the reference and then the corresponding excitation energy was calculated using the Möller *et al.* mass table. In some cases, there was a clear distinction between the literature data and the revised data. For example, the Kowal *et al.* mass table [3] had a 3.58 MeV difference from Möller *et al.*'s [1] predicted mass of element 120 for the $^{54}Cr + ^{248}Cm$ reaction, which caused a change in the Q-value for compound nucleus formation and led to a difference in excitation energy. In other cases, the difference was not as large, mainly due to many of the sources using Möller *et al.*'s 1995 mass model [2], which had only slight adjustments compared to their 2012 mass model.

There were a total of nine element 119 and eleven element 120 reactions analyzed and preliminary results are reported here. Figs. 1-16 show the initial excitation functions and their corresponding adjustments for the 2n-5n exit channels of both the element 119 and element 120 reactions. The adjustment of mass tables generally caused the predictions to be in better agreement, showing that the differences are generally due to variations in the mass model used. More accurate predictions for the production of elements 119 and 120 could possibly be made if the same mass table were used. This procedure could potentially be repeated for even heavier elements, which would allow for better planning of future new element searches.

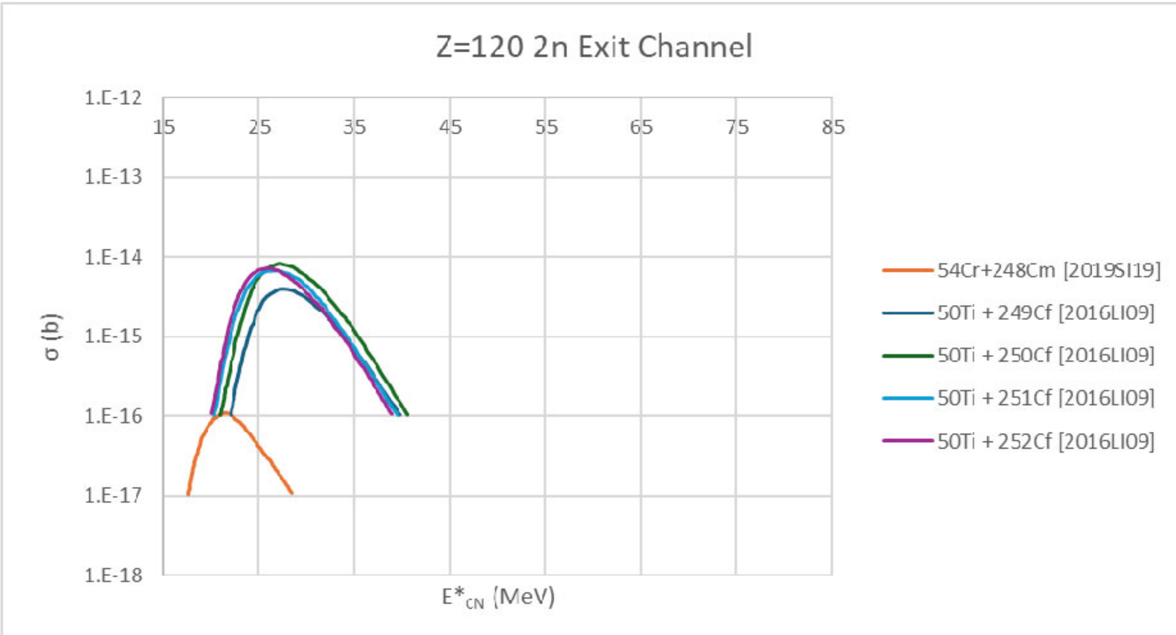

Fig. 1. Element 120 2n predictions before correction.

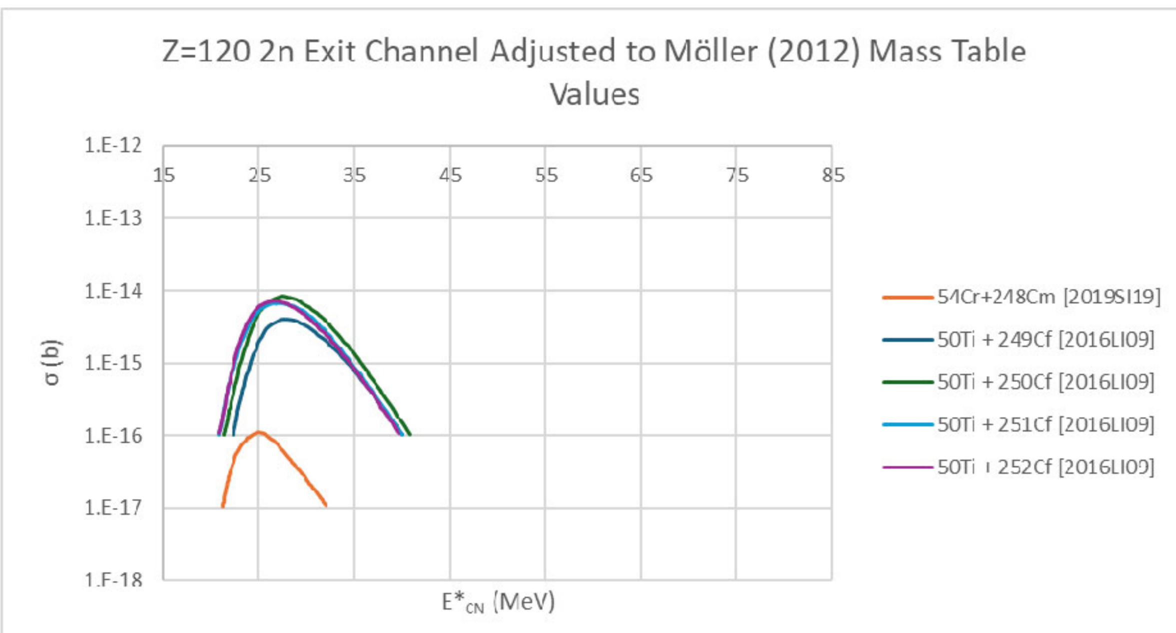

Fig. 2. Element 120 2n predictions after correction.

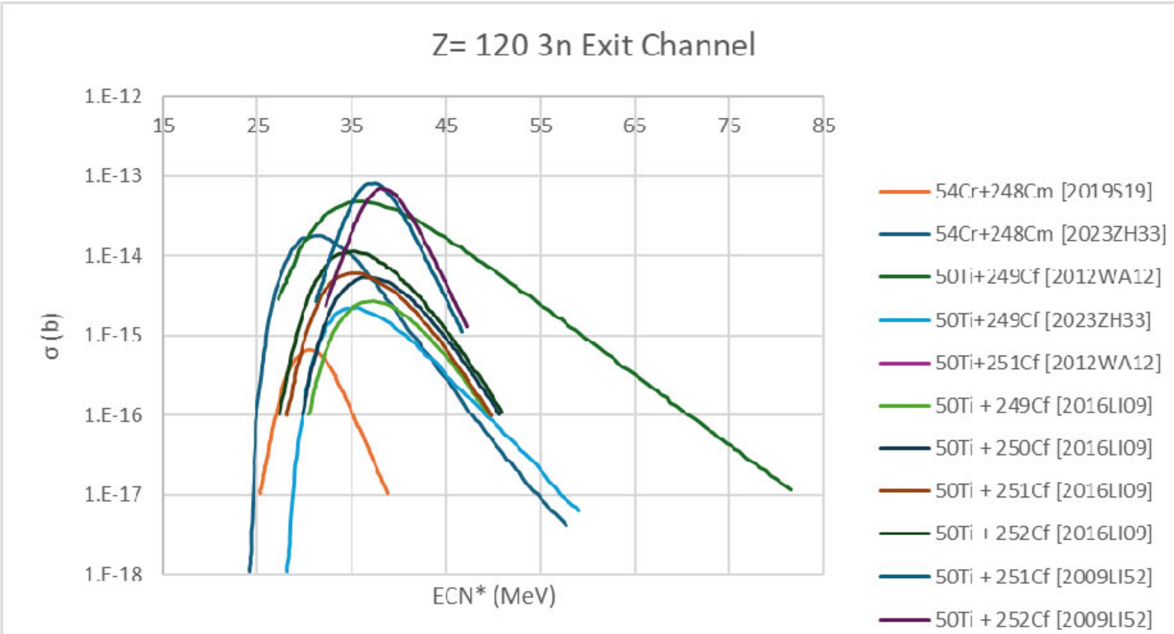

Fig. 3. Element 120 3n predictions before correction..

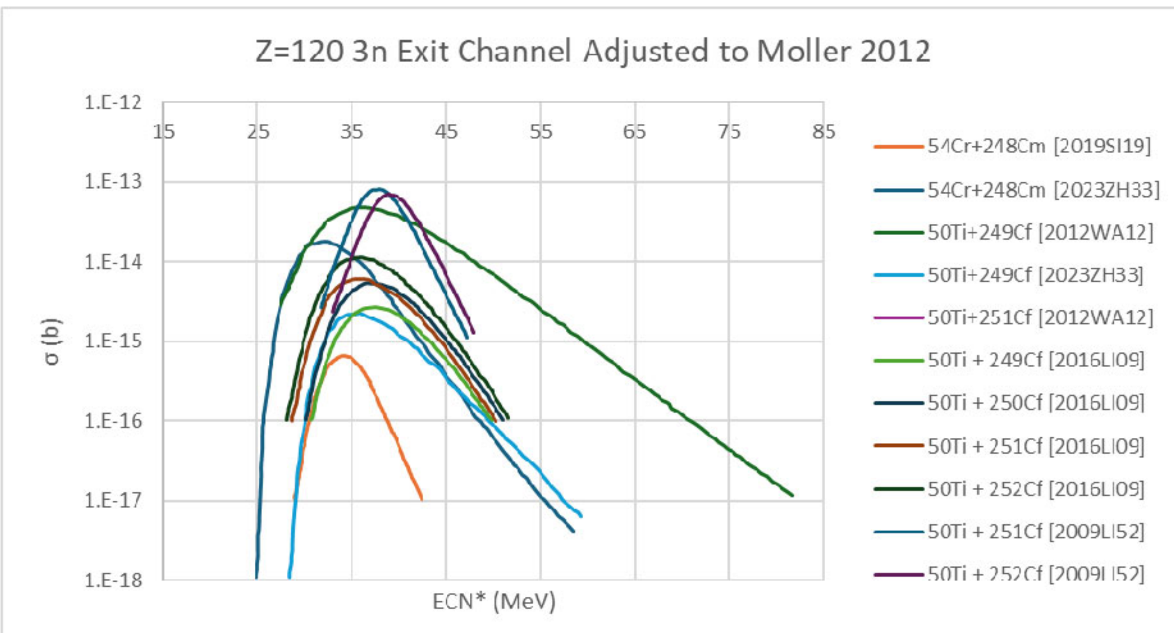

Fig. 4. Element 120 3n predictions after correction.

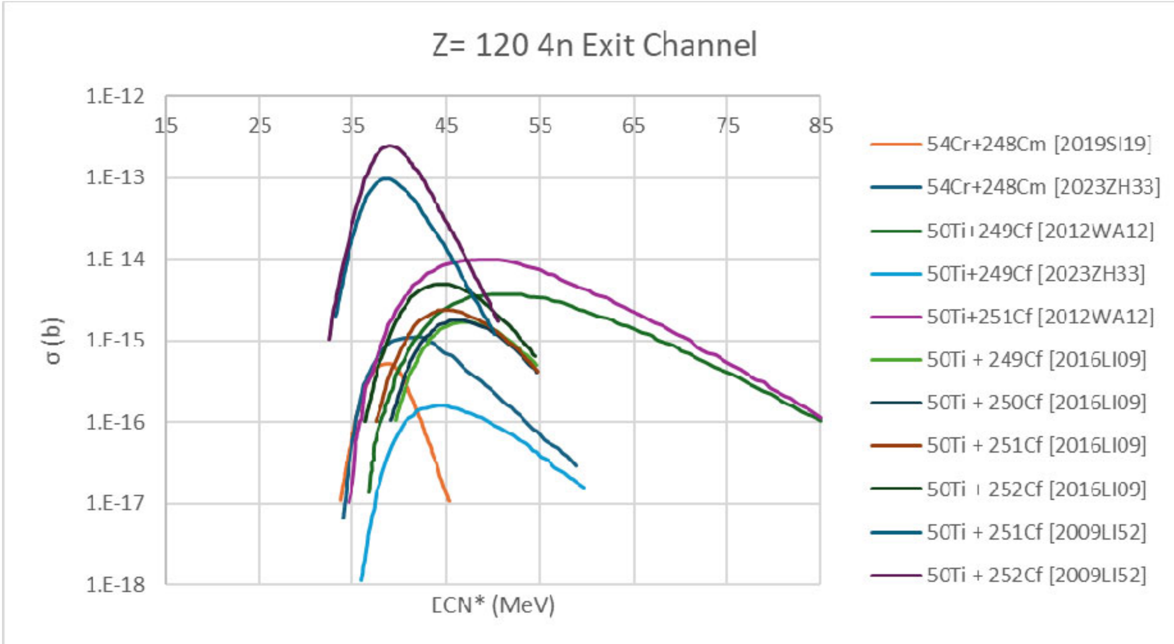

Fig. 5. Element 120 4n predictions before correction.

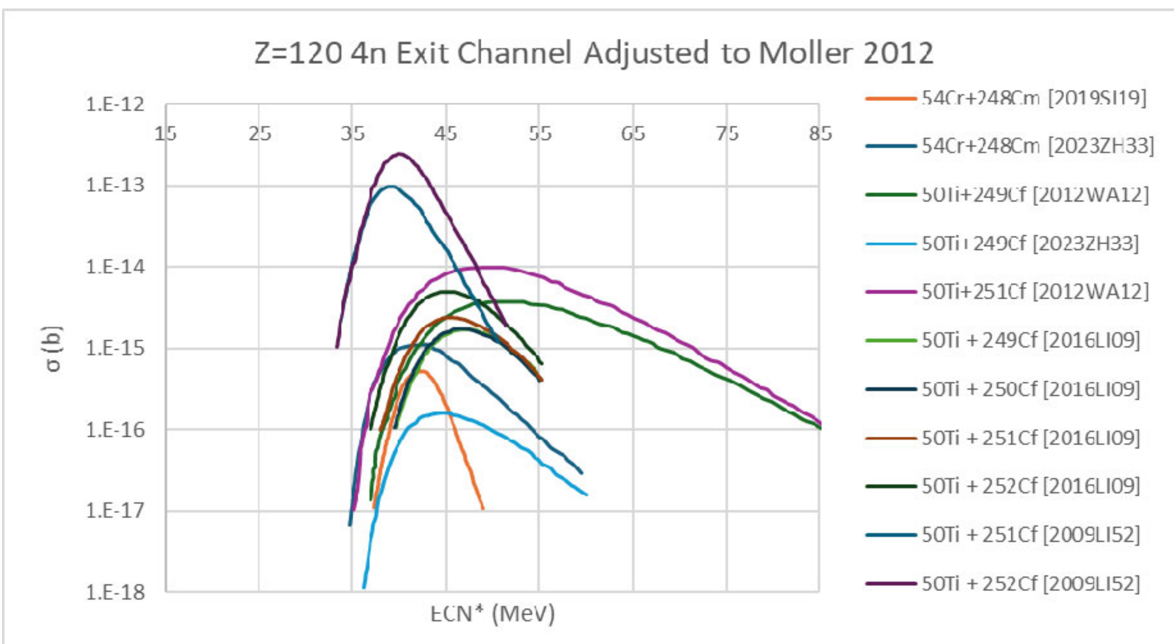

Fig. 6. Element 120 4n predictions after correction..

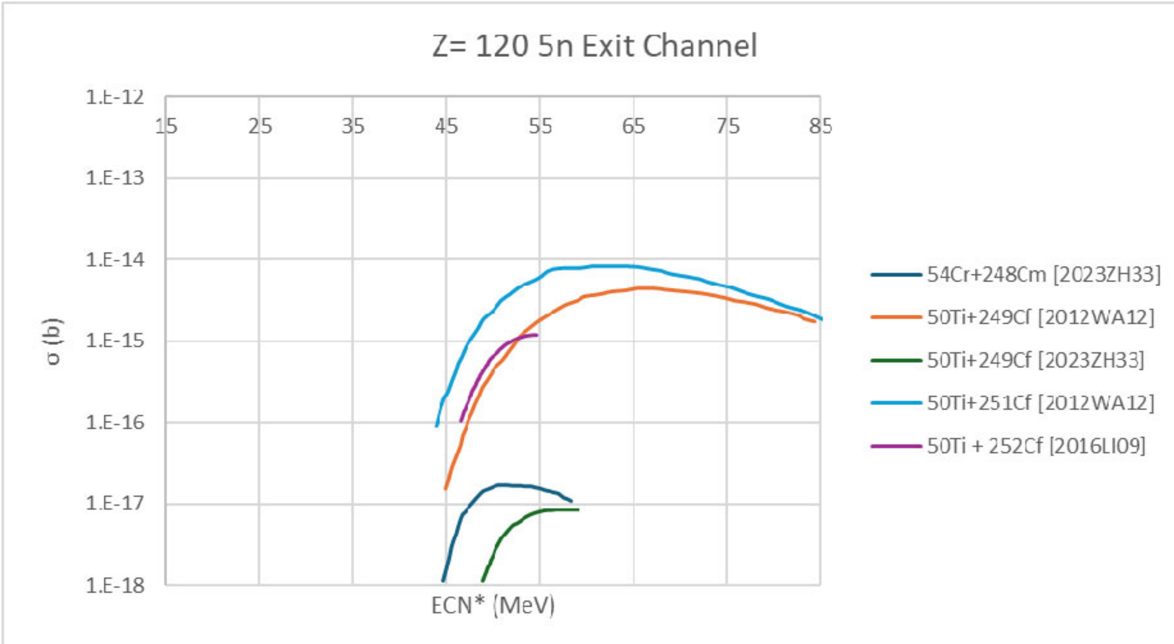

Fig. 7. Element 120 5n predictions before correction.

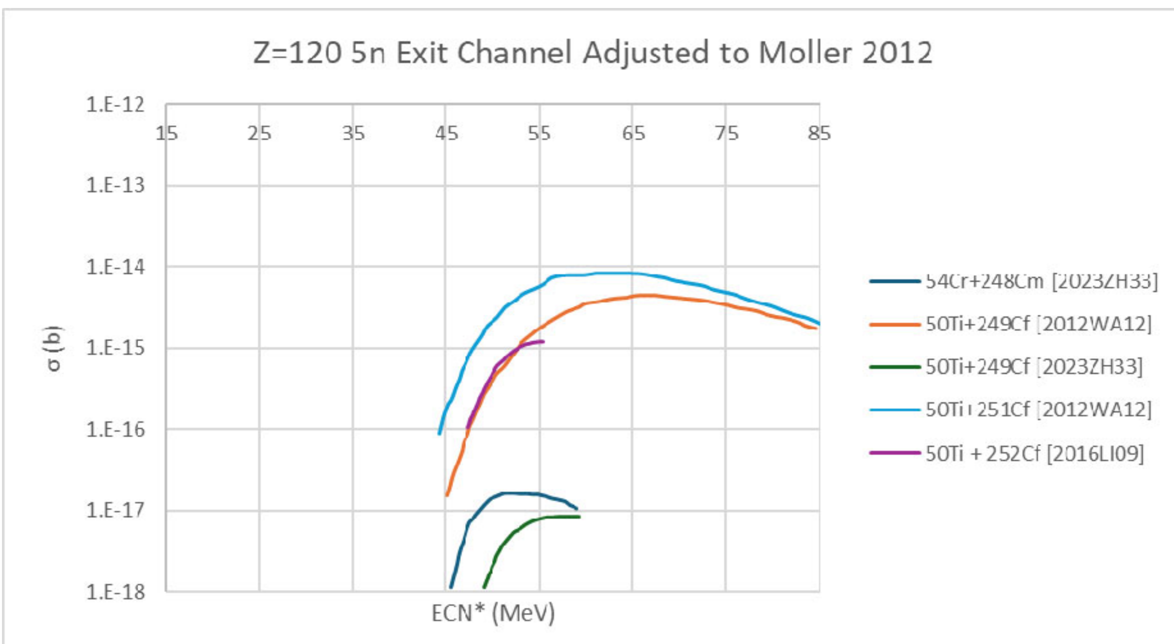

Fig. 8. Element 120 5n predictions after correction.

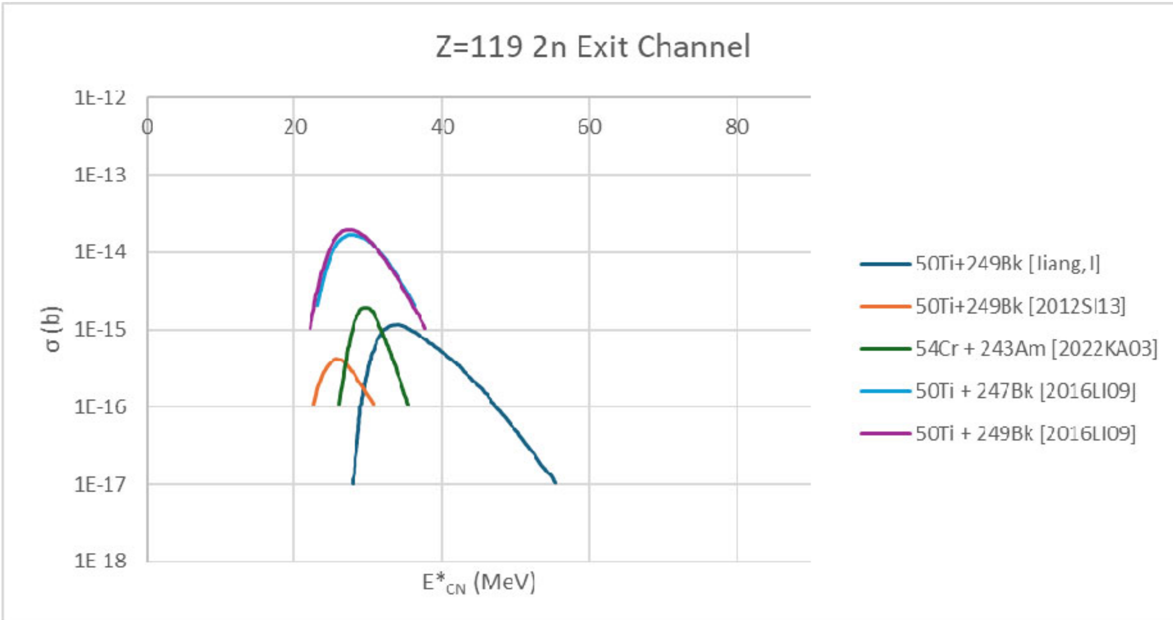

Fig. 9. Element 119 2n predictions before correction.

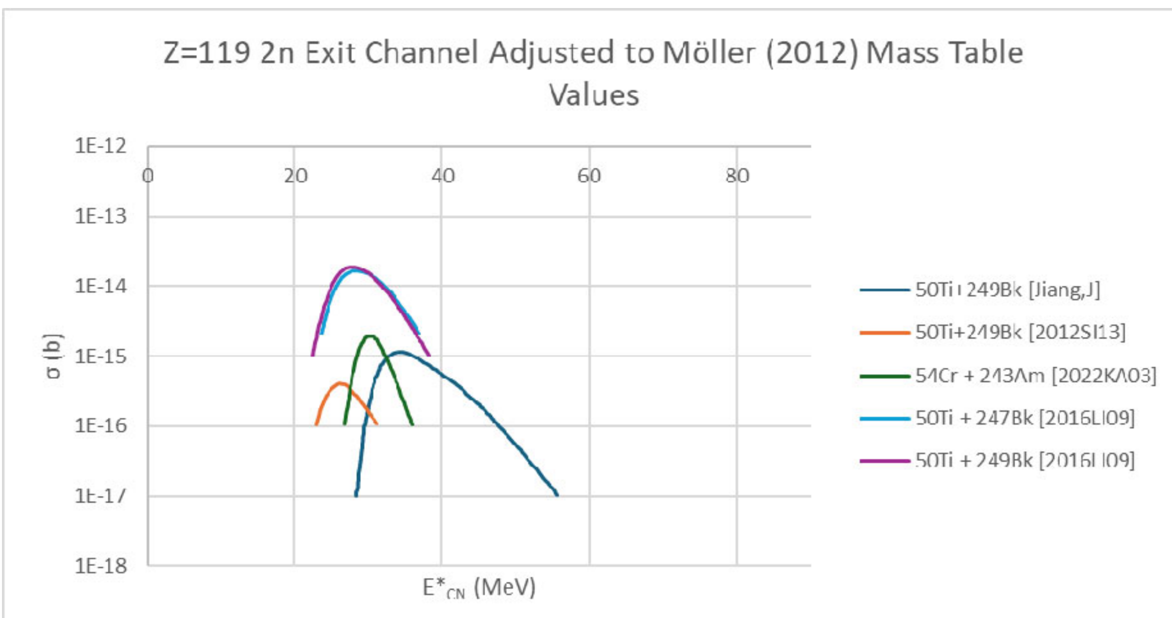

Fig. 10. Element 119 2n predictions after correction.

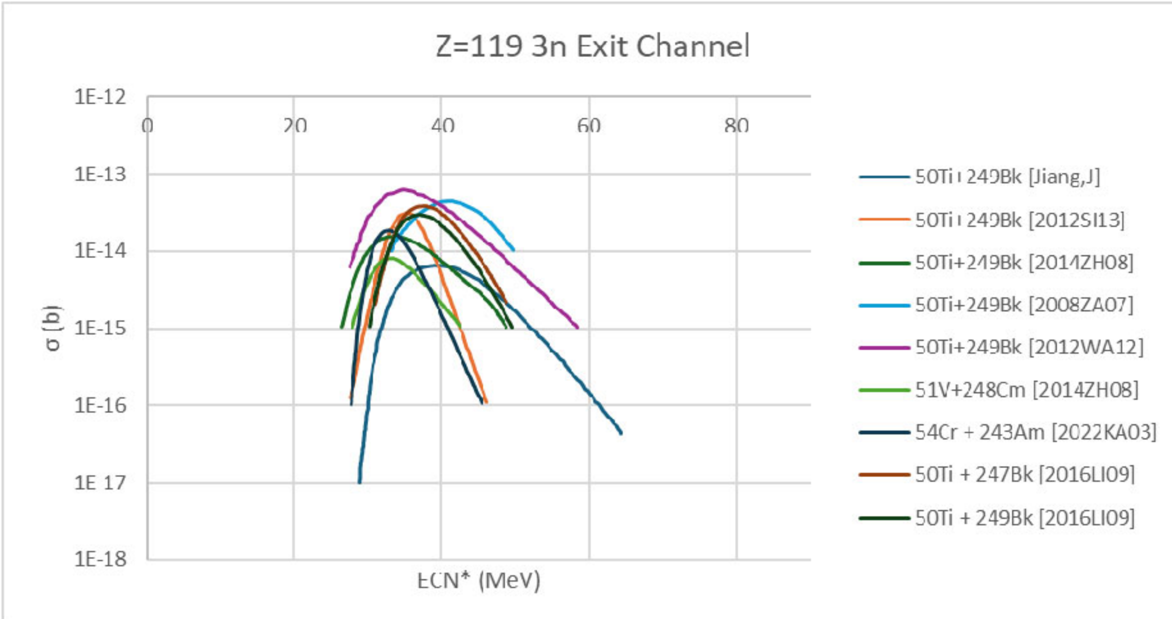

Fig. 11. Element 119 3n predictions before correction.

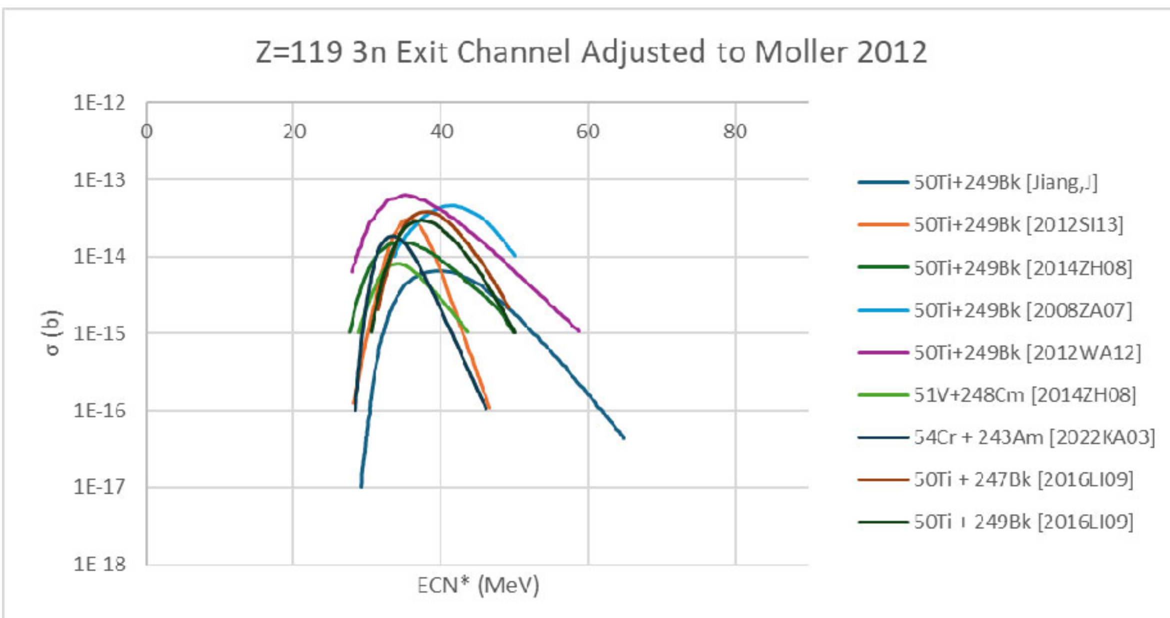

Fig. 12. Element 119 3n predictions after correction.

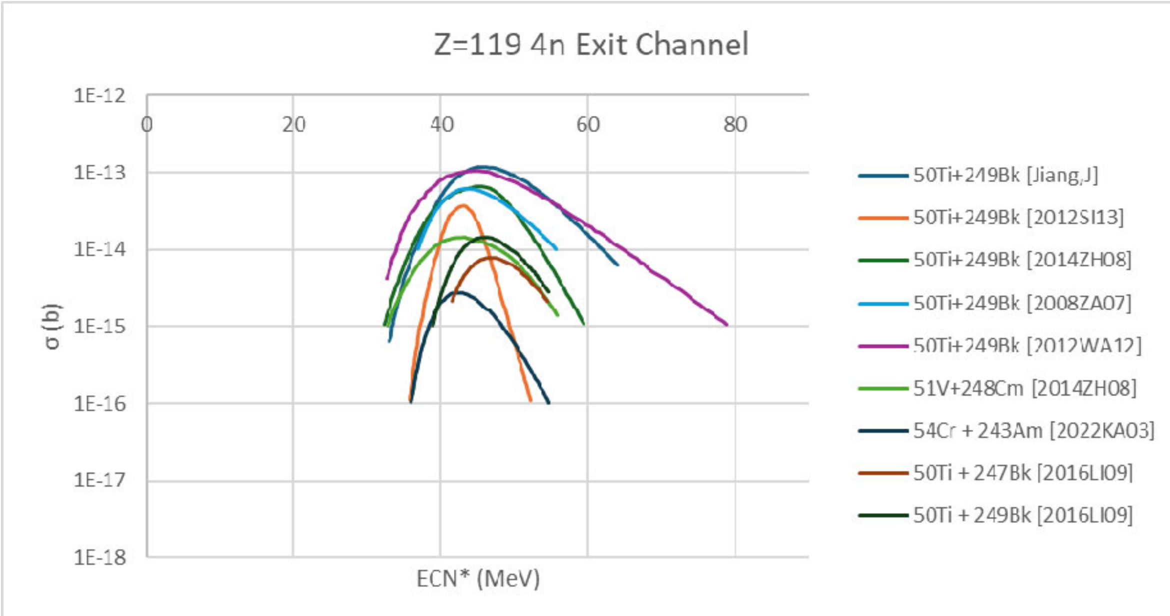

Fig. 13. Element 119 4n predictions before correction.

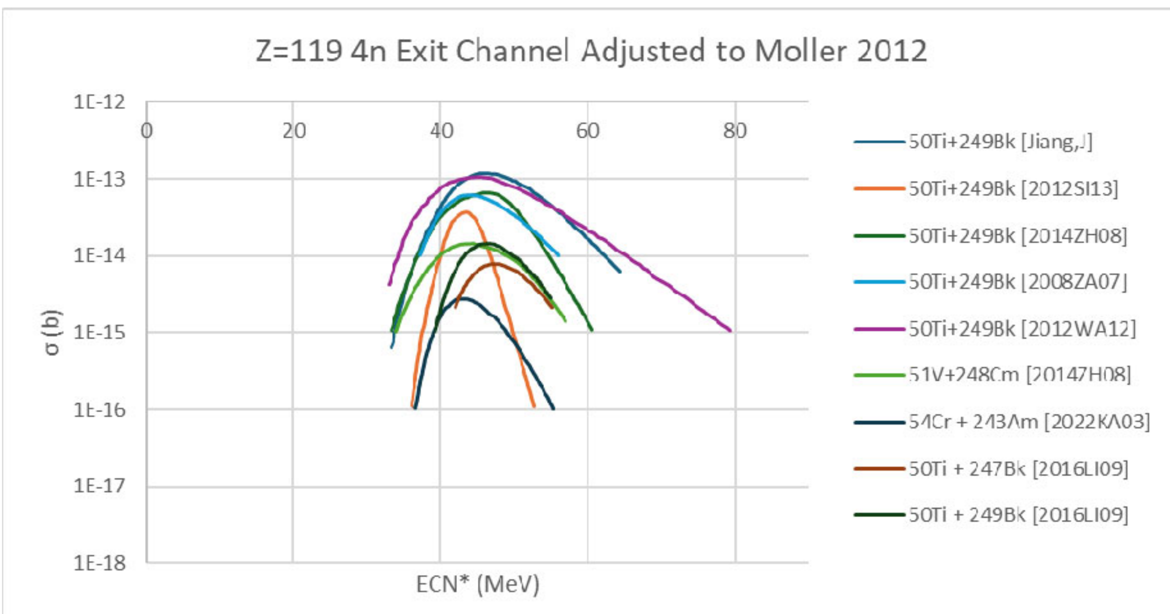

Fig. 14. Element 119 4n predictions after correction.

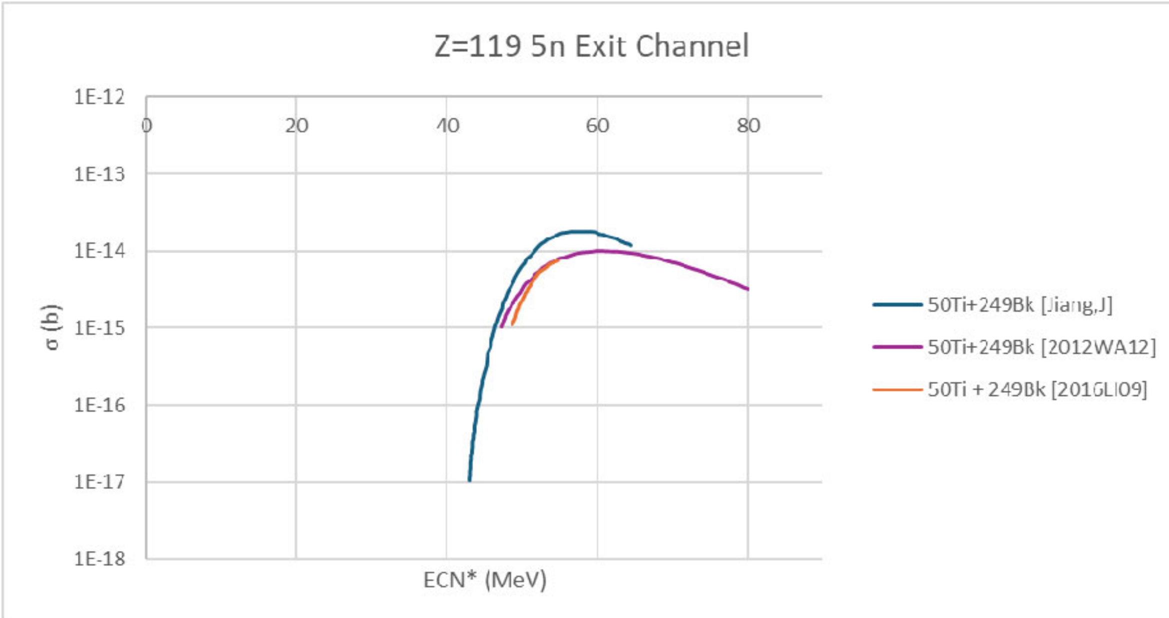

Fig. 15. Element 119 5n predictions before correction.

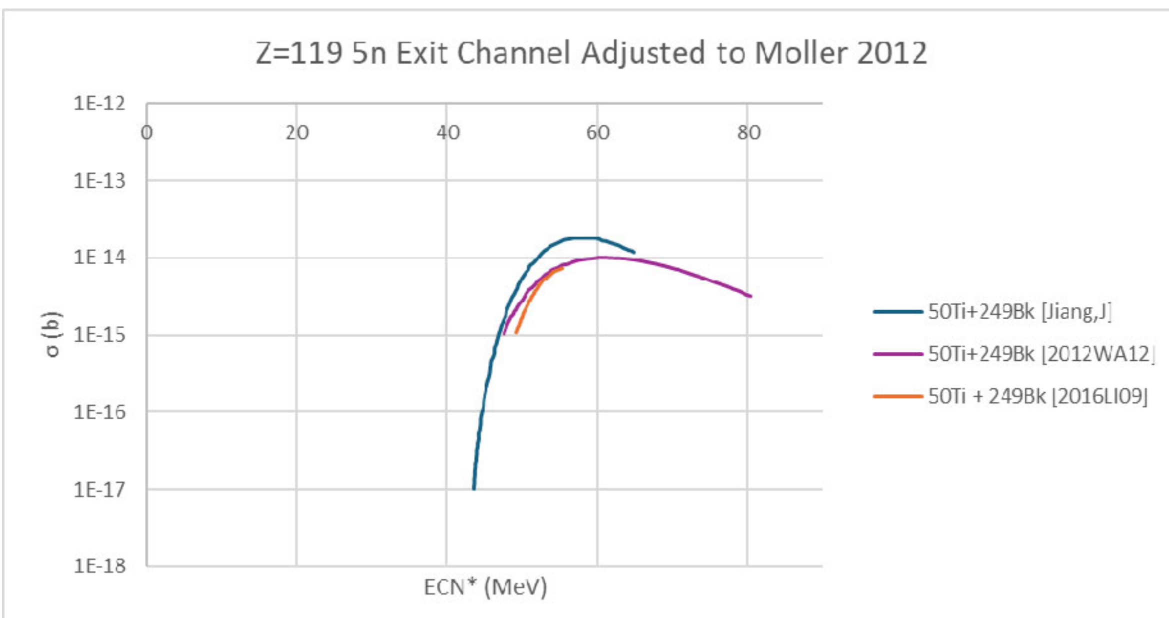

Fig. 16. Element 119 5n predictions after correction.

References

[1] P. Möller *et al.*, Nuclear Ground-State Masses and Deformations: FRDM (2012). At. Data Nucl. Data Tables **109**, 1 (2016); DOI: 10.1016/j.adt.2015.10.002

[2] P. Möller *et al*., Nuclear Ground-State Masses and Deformations. At. Data Nucl. Data Tables **59**, 2 (1995); DOI: 10.1006/adnd.1995.1002
[3] M. Kowal *et al.*, Ground State and Saddle Point: masses and deformations for even-even superheavy nuclei with 98 < Z < 126 and 134< N < 192. arXiv:1203.5013; DOI: 10.48550/arXiv.1203.5013
[4] S. Goriely *et al.*, A Hartree-Fock Nuclear Mass Table. At. Data. Nucl. Data Tables **77**, 2 (2001); DOI: 10.1006/adnd.2000.0857
[5] S. Benbow, Graph Grabber 2.0.2 Quintessa Labs. (Accessed February 2023); https://www.quintessa.org/software/downloads-and-demos/graph-grabber-2.0.
[6] J. Jiang *et al.*, Nucl. Phys. Rev. **30**, 4, 391 (2013); DOI: 10.11804/NuclPhysRev.30.04.391
[7] K. Siwek-Wilczyńska *et al.*, Phys. Rev. C **84**, 1 (2012); DOI: 10.1103/PhysRevC.86.014611
[8] K. Siwek-Wilczyńska *et al.*, Phys. Rev. C **99**, 1 (2019); DOI: 10.1103/PhysRevC.99.054603
[9] V. Zagrebaev and W. Greiner, Phys. Rev. C. **78**, 1 (2008);DOI:10.1103/PhysRevC.78.034610
[10] L. Zhou *et al.*, Phys. Rev. C **89**, 1 (2014); DOI: 10.1103/PhysRevC.89.024615
[11] N. Wang *et al.*, Phys. Rev. C. **85**, 041601(R)(2012); DOI: 10.1103/PhysRevC.85.041601
[12] B. M. Kayumov *et al.*, Phys. Rev. C. **105**, 014618 (2022); DOI: 10.1103/PhysRevC.105.014618
[13] Ling Liu *et al.*, Eur. Phys. J. A 52, 35 (2016) 52: 35 DOI: 10.1140/epja/i2016-16035-0
[14] S. H. Zhu *et al.*, Phys. Rev. C. **108**, 014604 (2023); DOI: 10.1103/PhysRevC.108.014604
[15] Z. H. Liu *et al.*, Phys. Rev. C. **80**, 054608 (2009); DOI: 10.1103/PhysRevC.80.054608