# A big step towards the study of super-heavy calcium isotopes

O.B. Tarasov

*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, 48824, USA*

Measurements at NSCL [1,2] have demonstrated that the fragmentation of $^{76}$Ge and $^{82}$Se beams using a two-stage separator can be used to produce new neutron-rich isotopes in the calcium region. This work was continued at the RIKEN RIBF facility, using a higher beam energy and intensity, and so accessing the one-order-of-magnitude lower production cross sections needed to explore the stability of $^{59;60}$Ca.

The discovery of $^{60}_{20}Ca_{40}$ and seven other neutron-rich nuclei near the limits of stability is reported [3] from the projectile fragmentation of a 345 MeV/u primary $^{70}$Zn beam on Be targets at the RI Beam Factory. During a 99.5 hour measurement, $^{47}$P, $^{49}$S, $^{52}$Cl, $^{54}$Ar, $^{57}$K, $^{59,60}$Ca, and $^{62}$Sc, the most neutron-rich isotopes of the respective elements, were observed for the first time. In addition, one event consistent with $^{59}$K was observed. The results are compared with the drip-line predictions of a wide variety of mass models. The two isotopes $^{49}$S and $^{52}$Cl, discovered in this work, emerge as key discriminators between different models. The energy density functionals in best agreement with the limits of existence in the explored region, HFB-22 [4] and UNEDF0 [5], predict the even-mass Ca isotopes to be bound out to at least $^{70}$Ca, at odds with ab-initio models that predict the neutron drip line in Ca to be closer to $^{60}$Ca with $^{59}$Ca unbound.

After benchmarking against experimental limits obtained in this work the recent ab-initio and EDF calculations [6,7] provide drip line predictions in the neutron-rich region to guide ongoing and future efforts at rare-isotope beam facilities.

The potential for the synthesis of such super neutron-rich calcium isotopes at Facility for Rare Isotope Beams (FRIB) / MSU will be discussed.

1. O.B. Tarasov *et al.,* Phys. Rev. Lett. 102, 142501 (2009).
2. O.B. Tarasov *et al.*, Phys. Rev. C 87, 054612 (2013).
3. O.B. Tarasov *et al*., Phys. Rev. Lett. 121, 022501 (2018).
4. S. Goriely *et al.,* Phys. Rev. C 88, 024308 (2013).
5. M. Kortelainen *et al*., Phys. Rev. C 82, 024313 (2010).
6. J.D. Holt *et al*., arXiv: 1905.10475v1 [nucl-th] 24 May 2019.
7. L. Neufcourt, *et al*., Phys. Rev. Lett. 122, 062502 (2019).