Group Meeting 9.20

Reading Phys. Lett. B 811 (2020) 135962

Systematic reduction of the proton-removal cross section in neutron-rich medium-mass nuclei

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Overview

How to describe the difference between single-neutron removal cross-section and single-proton removal.

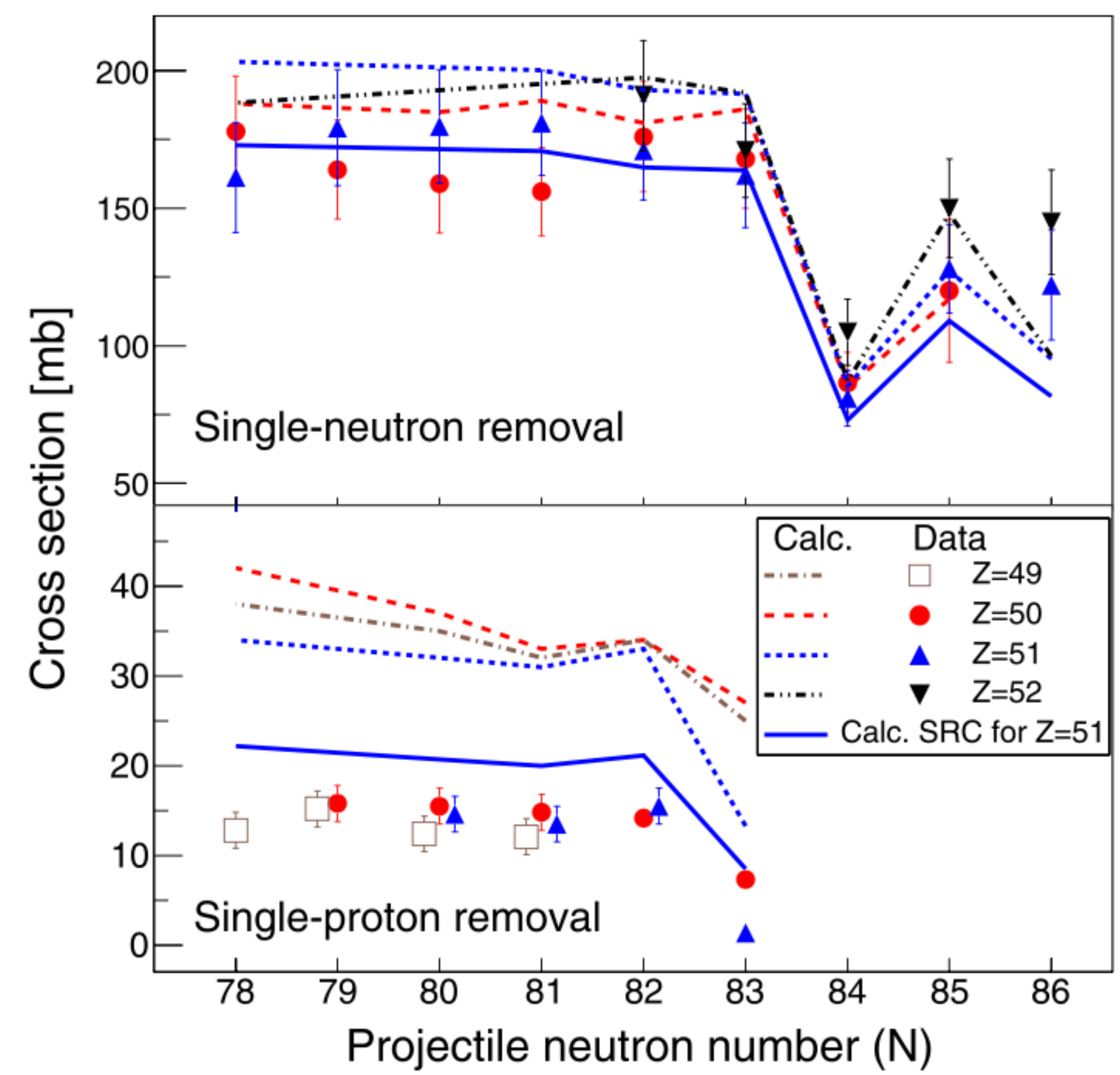


FIG 1: Single-neutron and single-proton removal cross-section of different isotopes of indium, tin, antimony, and tellurium.

Overview

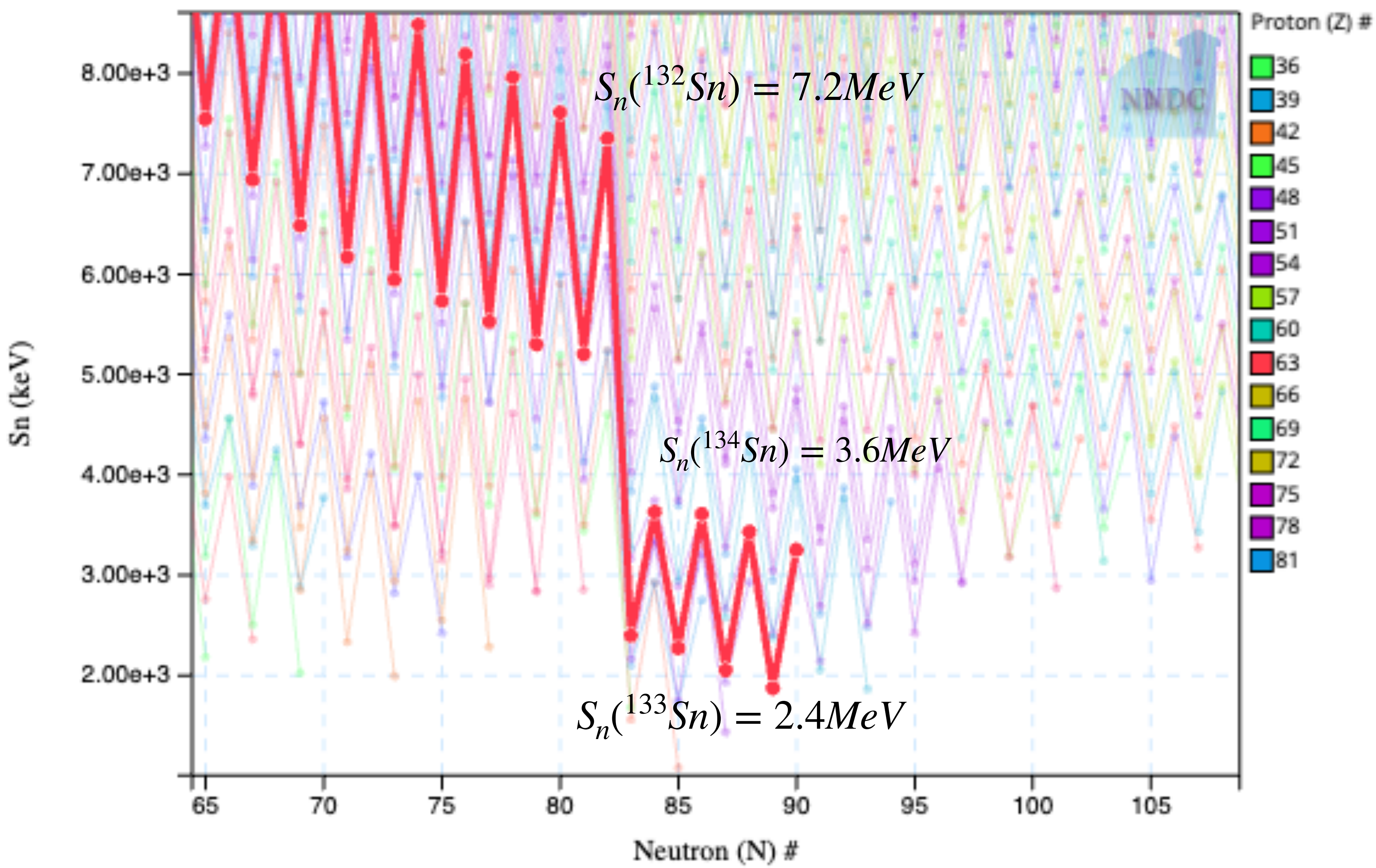


FIG 2: Neutron separate energy of tin's isotopes near N=82. [1]

[1]. NuDat 3.0, NNDC. https://www.nndc.bnl.gov/nudat3/

Overview

For N=83 residues, there is a hole state in 0h11/2 or 1d3/2 orbital, and a neutron occupying the 1f7/2 orbital.
The excitation energy is about 3.7MeV.

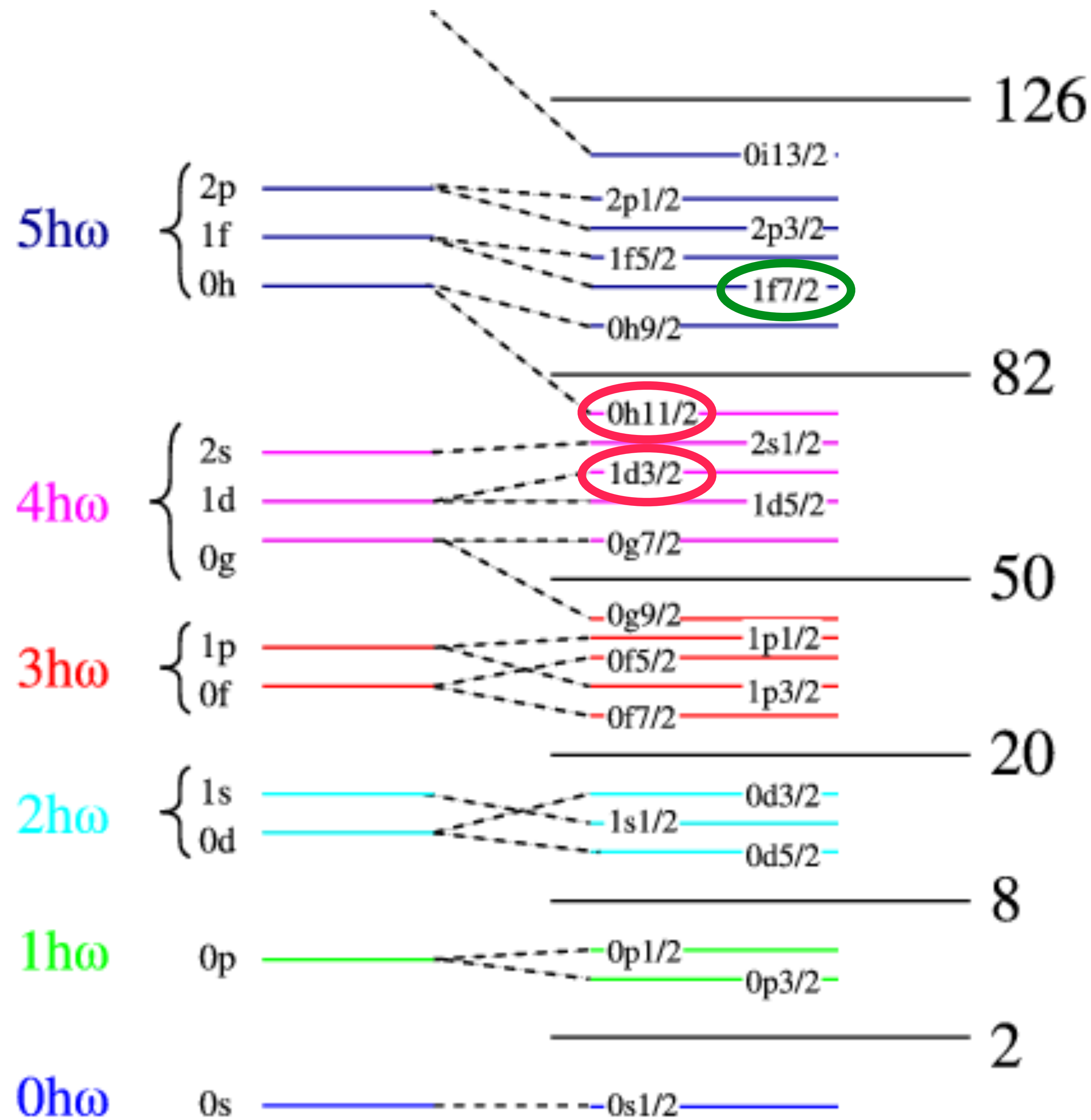


FIG 3: Shell model energy level

Model

1). Using a $^{88}_{38}Sr_{50}$ core with the orbitals 1p1/2, 0g9/2, 0g7/2, and 1d5/2 as model space for protons, and 0g7/2, 1d5/2, 1d3/2, 2s1/2, and 0h11/2 for neutrons [2].

2). Liege intra-nuclear cascade (INCL) model provides an accurate description of the knock-out processes, including realistic radial profiles for protons and neutrons[3].

[2]. L. Coraggio, A. Gargano, N. Itaco, Phys. Rev. C 93 (2016) 064328.

[3]. J.L. RodrÃguez-SÃ¡nchez, et al. Phys. Rev. C 96 (2017) 054602,

Model

Short Range Correlations(SRC) are brief fluctuations of two nucleons with high and opposite momenta, where each of them is higher than the Fermi momentum for the given nucleus, and the center of mass momentum is lower than the Fermi momentum.[4]

The nucleons, which had high momentum before the interaction, presumably belong to SRC pairs.[4]

[4] Patsyuk, M. , Hen, O. , & Piasetzky, E. (2019).The European Physical Journal Conferences, 204, 01016.

Model

a)

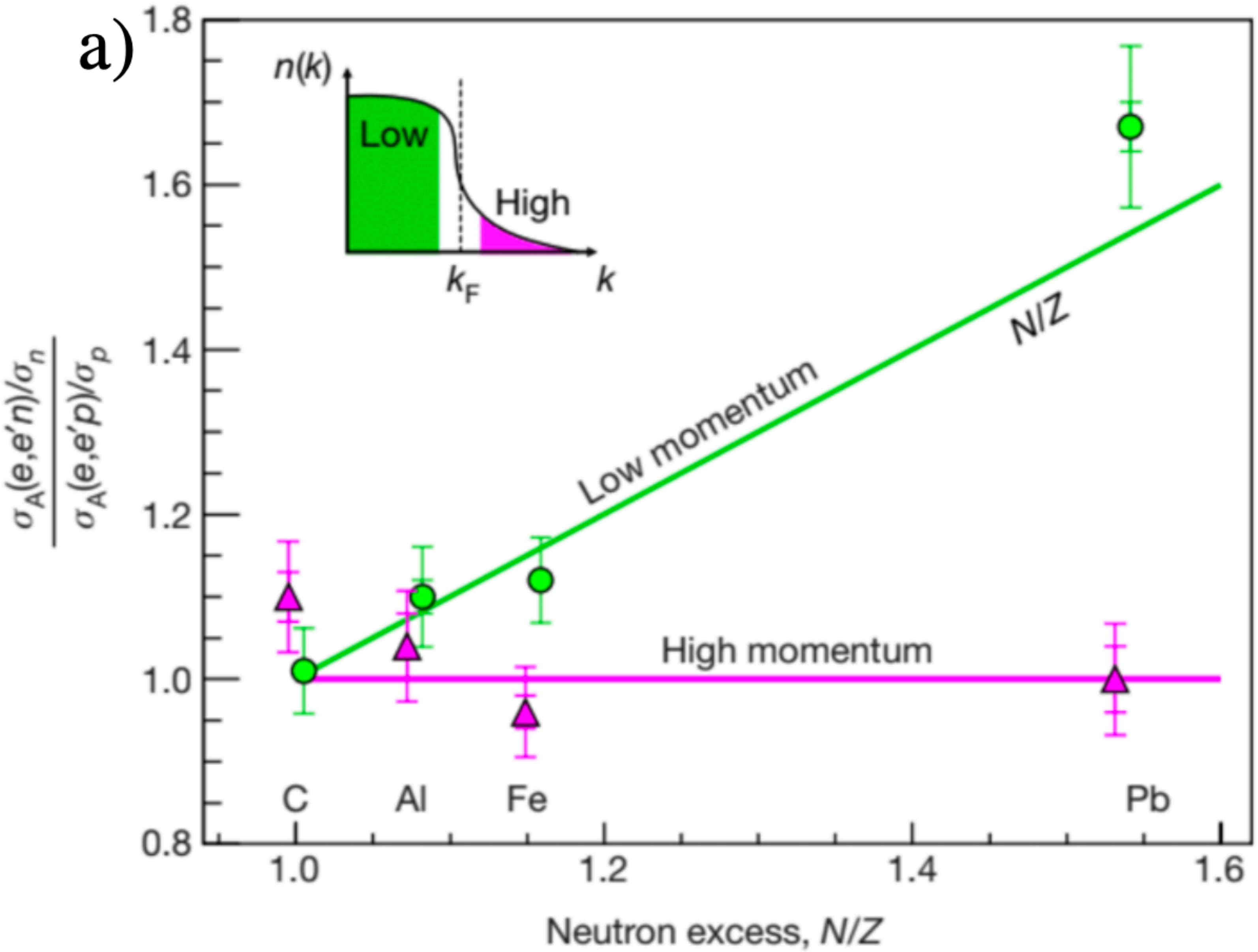


FIG 4: The ratios between neutrons and protons with high and low momenta for different nuclei are shown as reduced cross-section ratios.[4]

[4] Patsyuk, M. , Hen, O. , & Piasetzky, E. (2019).The European Physical Journal Conferences, 204, 01016.

Model

The modern state of the SRC studies can be summarized as[4]:

- **SRC exist in nuclei and account for about 20% of nucleons and almost all high momentum ($p_{miss} > k_F$) nucleons;**
- **Nucleons within the pair have high momentum ($p_{miss} > k_F$), and the c.m. momentum of the pair is low ($p_{c.m.} < k_F$);**
- **np-pairs are about 10 times more likely than pp- or nn-pairs;**
- **Tensor, spin-dependent interaction within SRC pair.**

[4] Patsyuk, M. , Hen, O. , & Piasetzky, E. (2019).The European Physical Journal Conferences, 204, 01016.

Model

The knock-out of SRC protons induces the emission of the neutron partner, because of their large relative momentum, depopulating the 1p0n channel in favor of the 1p1n.

Moreover, in neutron-rich systems, the relative fraction of protons in SRC pairs is rather large (i.e. in 132Sn 13 protons and 13 neutrons belong to SRC pairs, representing 26% or the protons and 16% of the neutrons).

We assume that 20% of nucleons belong to SRC np pairs, and we can get the probability of knocking out a proton or a neutron from SRC pairs.

Result

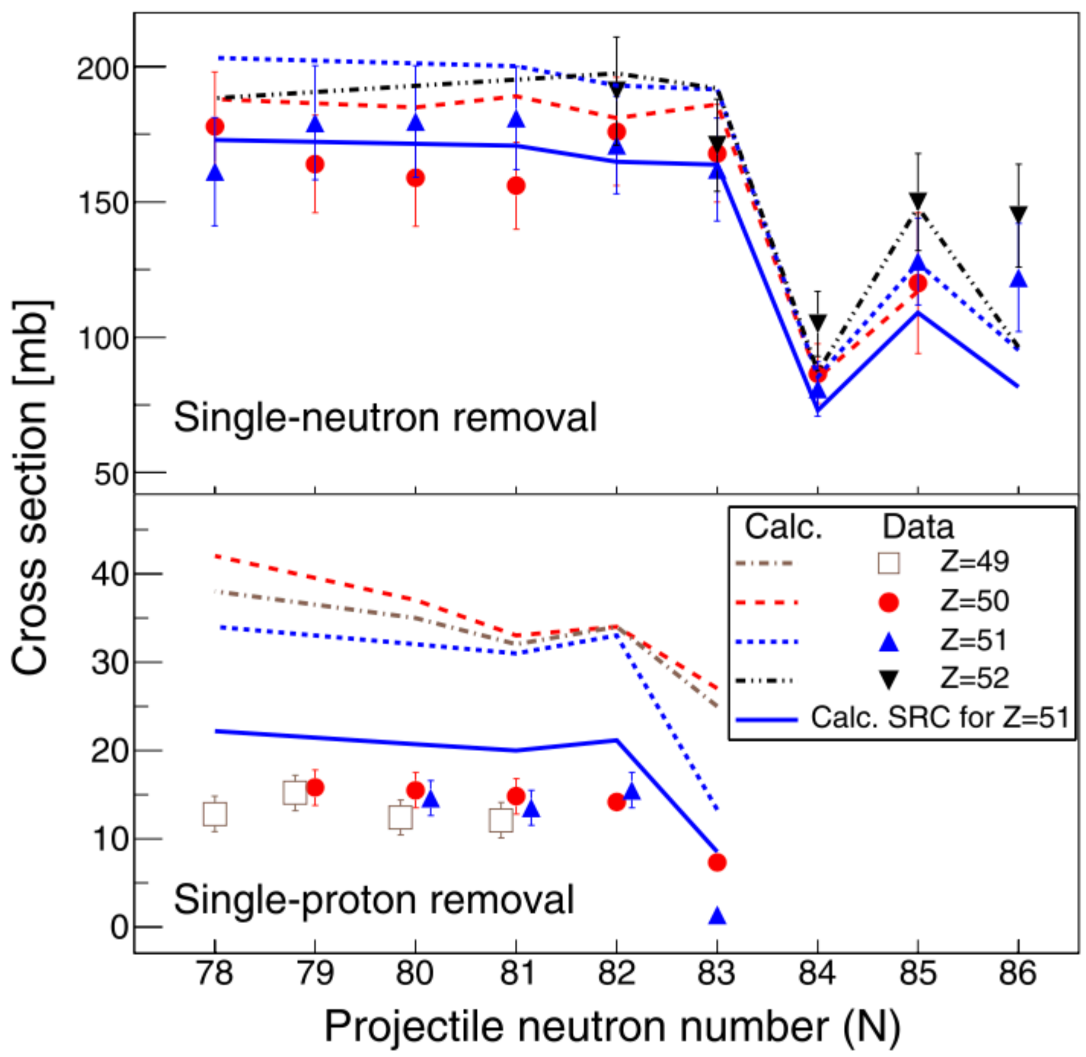


FIG 5: Single-neutron and single-proton removal cross-section of different isotopes of indium, tin, antimony, and tellurium.

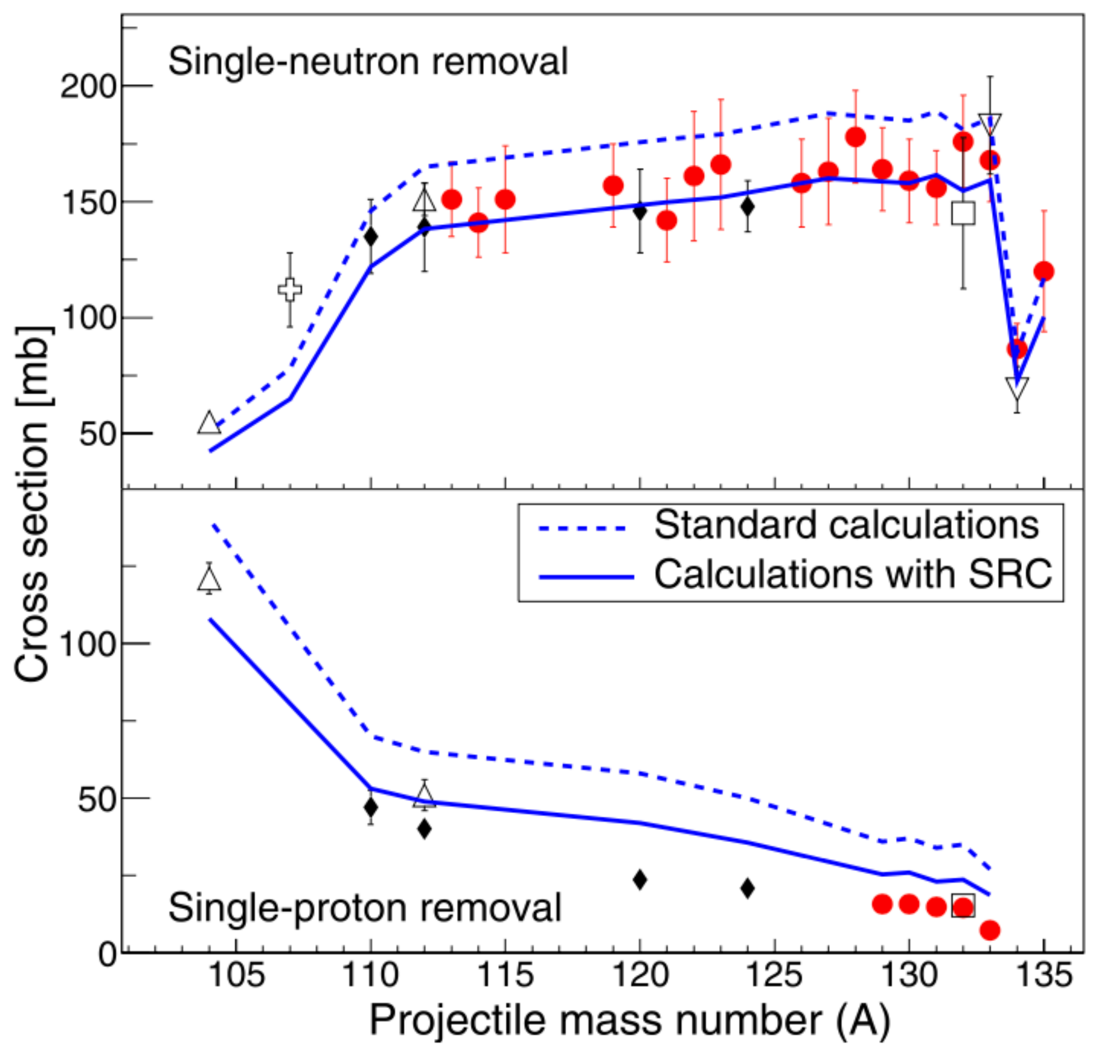


FIG 6: Single-neutron and single-proton removal cross sections for different tin isotopes measured.

Result

We can find depopulating the 1p0n channel in favor of the 1pXn in calculations with SRC. The removal of a SRC proton mostly populates the 1pXn channels rather than the 1p0n.

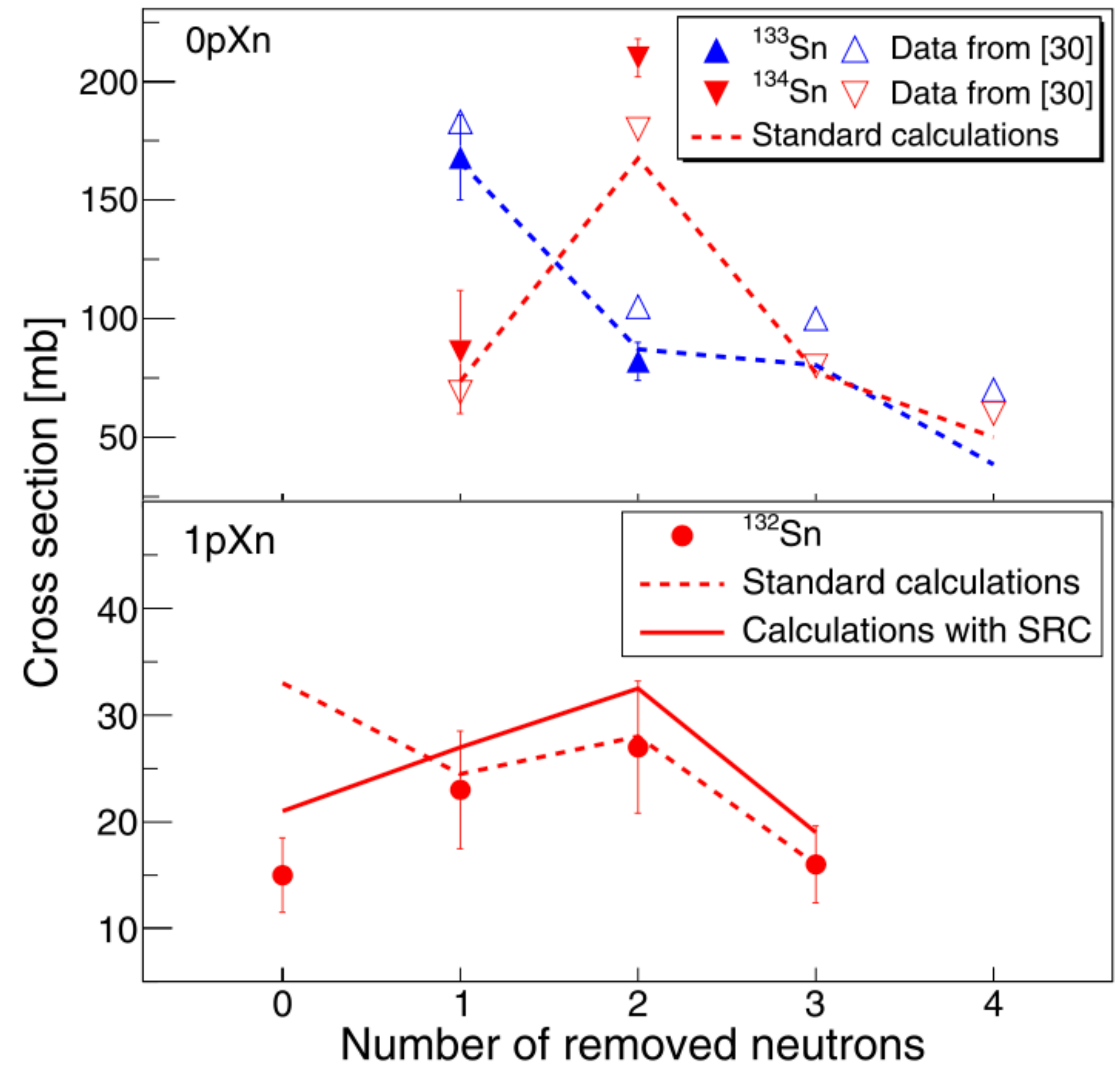


FIG 7: 0*pXn* removal cross sections for ^{133}Sn and ^{134}Sn compared to previous measurements; 1pXn removal cross section for ^{132}Sn.

Result

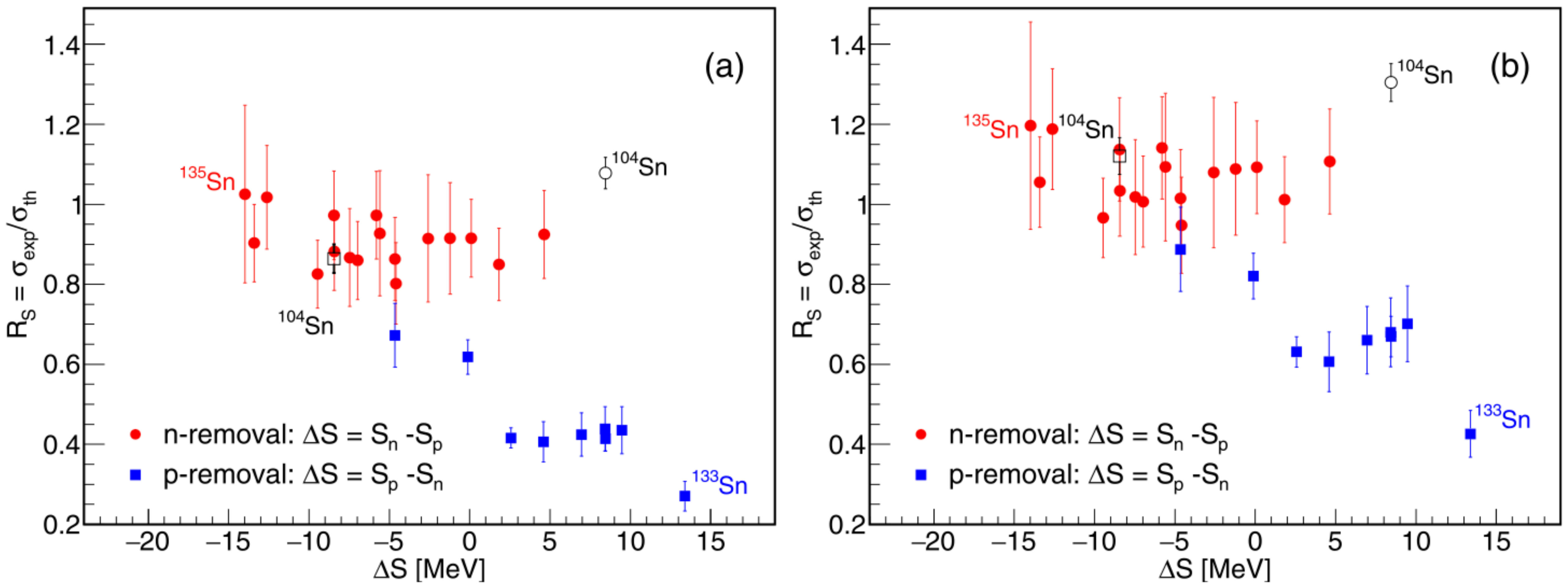
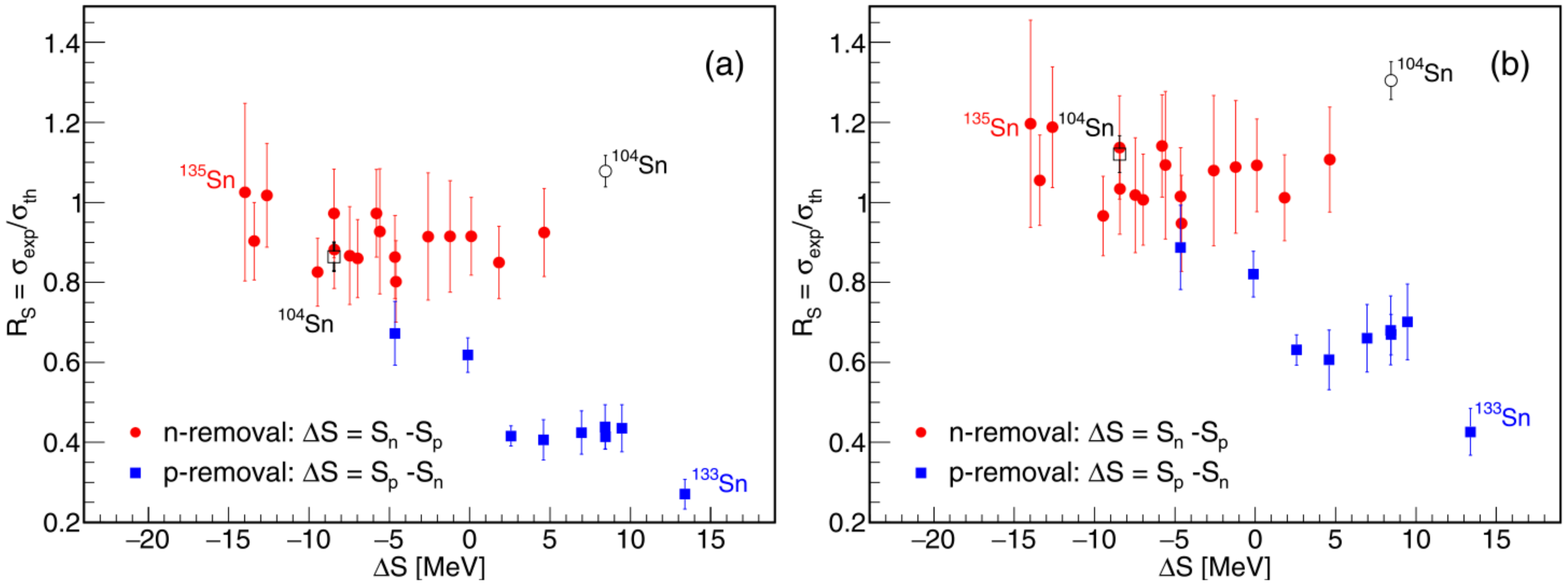


FIG 8: Ratios of the experimental and calculated inclusive single-nucleon removal cross sections R_S, for a long chain of tin isotopes, as a function of the asymmetry energy ΔS. The left is standard calculation. And the right is calculations with SRC

Result



- Single-neutron removal doesn't show any clear dependence with ΔS.
- In single-proton removal, the Rs decrease with ΔS. However, this strong dependence of the ratio with the asymmetry energy clearly reduces when SRC nucleon pairs are considered in the calculations.