Cross-section Ratio Predictions for Boron Isotopes

Abhyuday Sharda

Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee

This document uses a model detailed in [3]. The details of the models can be found in supplemental material of the paper[1].

From the SRC Model:

$$\frac{\sigma_{A1}/A_1}{\sigma_{A2}/A_2} = \frac{A_2^2}{A_1^2} \cdot \frac{\alpha_1 \cdot R + \beta_1}{\alpha_2 \cdot R + \beta_2} \tag{1}$$

where

$$r = \frac{\sigma_{ep}}{\sigma_{en}} \tag{2}$$

$$\alpha = N \cdot Z \cdot (1 + r) \tag{3}$$

$$\beta = Z \cdot (Z - 1) \cdot r + N \cdot (N - 1) \tag{4}$$

R is the probability that the NN interaction generates a high-momentum pair

$$R = \frac{p_{np}}{p_{pp}} \tag{5}$$

Calculating per-nucleon cross-section ratio for Calcium isotopes to see if I'm understanding the model correctly:
Assuming isospin independence, R = 1

$A_1 = 48$
$A_2 = 40$

$$\frac{\sigma_{Ca48}/48}{\sigma_{Ca40}/40} = \frac{40^2}{48^2} \frac{\alpha_1 + \beta_1}{\alpha_2 + \beta_2} \tag{6}$$

$$\frac{\sigma_{Ca48}/48}{\sigma_{Ca40}/40} = 0.694 \times \frac{\alpha_1 + \beta_1}{\alpha_2 + \beta_2} \tag{7}$$

$$\alpha_1 = 28 \times 20 \times (1 + 2.6) = 2016 \tag{8}$$

$$\beta_1 = 20 \times 19 \times 2.6 + 28 \times 27 = 1744 \tag{9}$$

$$\alpha_2 = 20 \times 20 \times (1 + 2.6) = 1440 \tag{10}$$

$$\beta_2 = 20 \times 19 \times 2.6 + 20 \times 19 = 1368 \tag{11}$$

$$\frac{\sigma_{Ca48}/48}{\sigma_{Ca40}/40} = 0.694 \times \frac{3760}{2808} = 0.929 \tag{12}$$

Agrees with the value given in the paper.
For isospin dependence,

$$\alpha \cdot R >> \beta \tag{13}$$

Therefore:

$$\frac{\sigma_{Ca48}/48}{\sigma_{Ca40}/40} = 0.694 \times \frac{\alpha_1}{\alpha_2} = 0.972 \tag{14}$$

Agrees with the value given in the paper.

Calculation for Boron isotopes

Now performing the calculation for the Boron targets. For the kinematics of this experiment, r is taken to be 2.6 according to [4]:

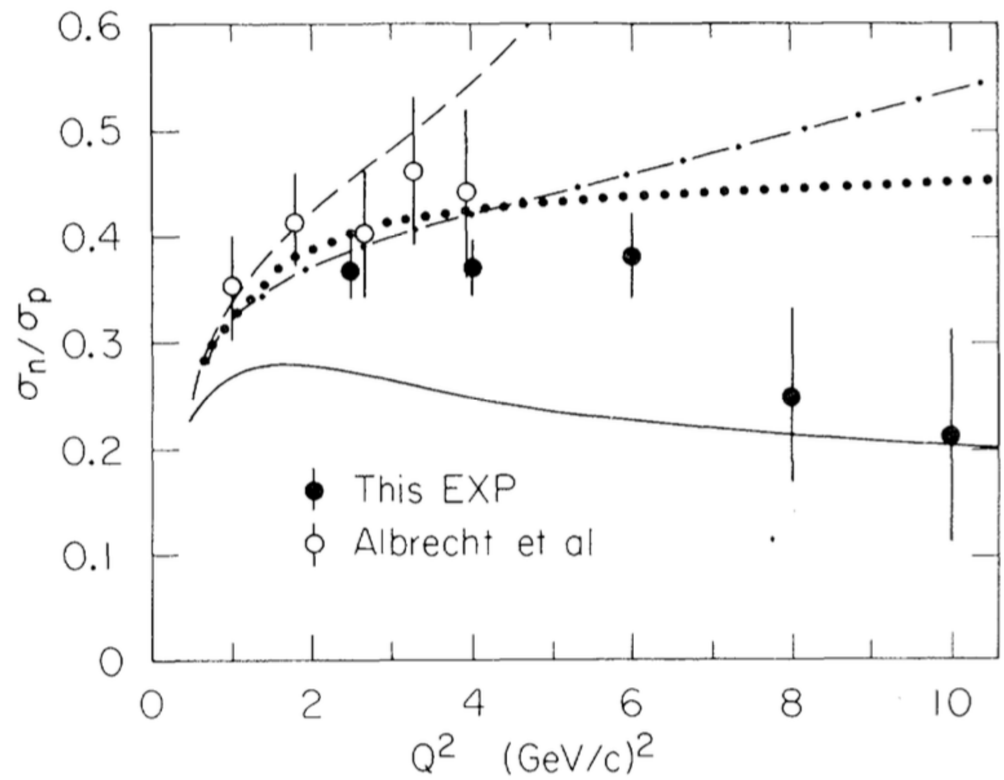


FIG. 2. The ratio σ_n/σ_p as a function of Q^2. Previous data from Albrecht *et al.* (Ref. 6) have been extrapolated to 10°. The dashed and solid curves are the vector-dominance models of Höhler *et al.* and Blatnik and Zovko (Ref. 2), respectively. The dotted curve is form-factor scaling: $G_{Mn}/\mu_n = G_{Mp}/\mu_p = G_{Ep}$ and $G_{En} = 0$. The dash-dotted curve is the dipole law for G_{Mn} with $G_{En} = 0$ and σ_p from our experimental results.

Assuming isospin independence:

$$\frac{\sigma_{B10}/10}{\sigma_{B11}/11} = \frac{11^2}{10^2} \cdot \frac{\alpha_1 + \beta_1}{\alpha_2 + \beta_2} \tag{15}$$

$$\alpha_1 = 5 \times 5 \times (1 + 2.6) = 90 \tag{16}$$

$$\beta_1 = 5 \times 4 \times 2.6 + 5 \times 4 = 72 \tag{17}$$

$$\alpha_2 = 6 \times 5 \times (1 + 2.6) = 108 \tag{18}$$

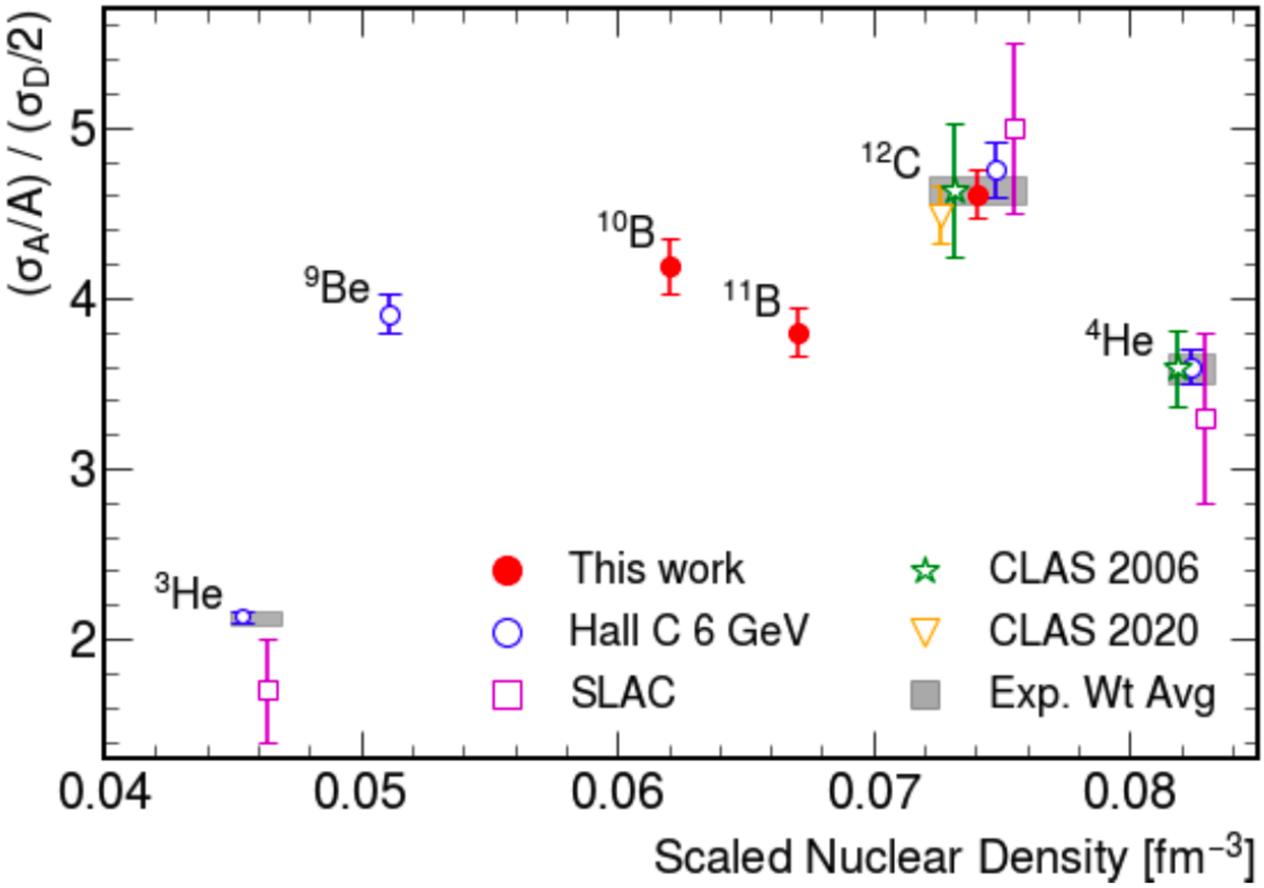
$$\beta_2 = 5 \times 4 \times 2.6 + 6 \times 5 = 82 \tag{19}$$

$$\frac{\sigma_{B10}/10}{\sigma_{B11}/11} = 1.21 \times \frac{90 + 72}{108 + 82} = 1.03 \tag{20}$$

Assuming complete np dominance:

$$\frac{\sigma_{B10}/10}{\sigma_{B11}/11} = 1.21 \times \frac{90}{108} = 1.008 \tag{21}$$

Therefore, this model predicts a higher a_2 for Boron-10 either way. Looking at Casey's preliminary results[2], it looks like this ratio is ~ 1.05 but a closer look at exact values might be beneficial.



References

[1] `https://journals.aps.org/prc/supplemental/10.1103/PhysRevC.102.064004`.

[2] Casey Morean. "Short Range Correlation measurements in the quasielastic region with an 11 GeV beam". PhD thesis. University of Tennessee, 2023. URL: `https://trace.tennessee.edu/utk_graddiss/9081/`.

[3] D. Nguyen et al. "Novel observation of isospin structure of short-range correlations in calcium isotopes". In: *Phys. Rev. C* 102 (6 Dec. 2020), p. 064004. DOI: `10.1103/PhysRevC.102.064004`. URL: `https://link.aps.org/doi/10.1103/PhysRevC.102.064004`.

[4] S. Rock et al. "Measurement of Elastic Electron-Neutron Cross Sections up to $Q^2 = 10$ $(\mathrm{GeV}/c)^2$". In: *Phys. Rev. Lett.* 49 (16 Oct. 1982), pp. 1139–1142. DOI: `10.1103/PhysRevLett.49.1139`. URL: `https://link.aps.org/doi/10.1103/PhysRevLett.49.1139`.