The Galileo Galilei Institute for Theoretical Physics

Istituto Nazionale di Fisica Nucleare

Systematics of reaction cross sections and geometrical parameters from double folding and single folding optical potentials

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University of Santiago de Compostela-Spain
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Imane MOUMENE

Work Plan

- Motivation
- Basic equations of eikonal formulae
- Numerical results
- Conclusion

Motivation

- Breakup reaction is one of the main tools for the study of exotic nuclei.
- The optical potential model can be obtained microscopically through a folding model approach : single folding and double folding.
- The single-folded optical potential is more accurate than the double-folded optical potential.

In this work

- A systematic comparison of calculated reaction cross sections on a ^{9}Be target via a single folding versus a double folding optical potential.

- Comparison of the strong absorption radius parameter extracted from the S matrices for single folding and double folding results.

Basic equations of eikonal formalism

- The eikonal reaction cross section:

$$\sigma_R = 2\pi \int_0^{\infty} bdb \left(1 - \left|S_{PT}(\mathbf{b})\right|^2\right) \qquad \textbf{(1)}$$

Where

$$\left|S_{PT}(\mathbf{b})\right|^2 = e^{2\chi_I(b)} \qquad \textbf{(2)}$$

- The imaginary part of the eikonal phase shift:

$$\chi_I(\mathbf{b}) = \frac{1}{\hbar v} \int dz W^{PT}(\mathbf{b}, z) \qquad \textbf{(3)}$$

Basic equations of eikonal formalism

Single folding potential:

$$W^{PT}_{s.f.}(\mathbf{r}) = \int d\mathbf{b_1} W^{nT}\left(\mathbf{b_1}-\mathbf{b}, z\right) \int dz_1 \rho_P\left(\mathbf{b_1}, z_1\right) \quad \textbf{(4)}$$

n+^{9}Be phenomenological nucleon-target potential (AB)

- A. Bonaccorso, R.J. Charity, Phys. Rev. C 89 (2014) 024619.

Double folding potential:

$$W^{PT}_{d.f.}(\mathbf{r}) = -\frac{1}{2}\hbar v \sigma_{nn} \int d\mathbf{b}_1 \rho_T\left(\mathbf{b}_1-\mathbf{b}, z\right) \int dz_1 \rho_P\left(\mathbf{b}_1, z_1\right) \qquad \textbf{(5)}$$

Energy-dependent nucleon-nucleon (nn) cross section

Densities: HFB code

- C.A. Bertulani, C. De Conti, Phys. Rev. C 81 (2010) 064603.

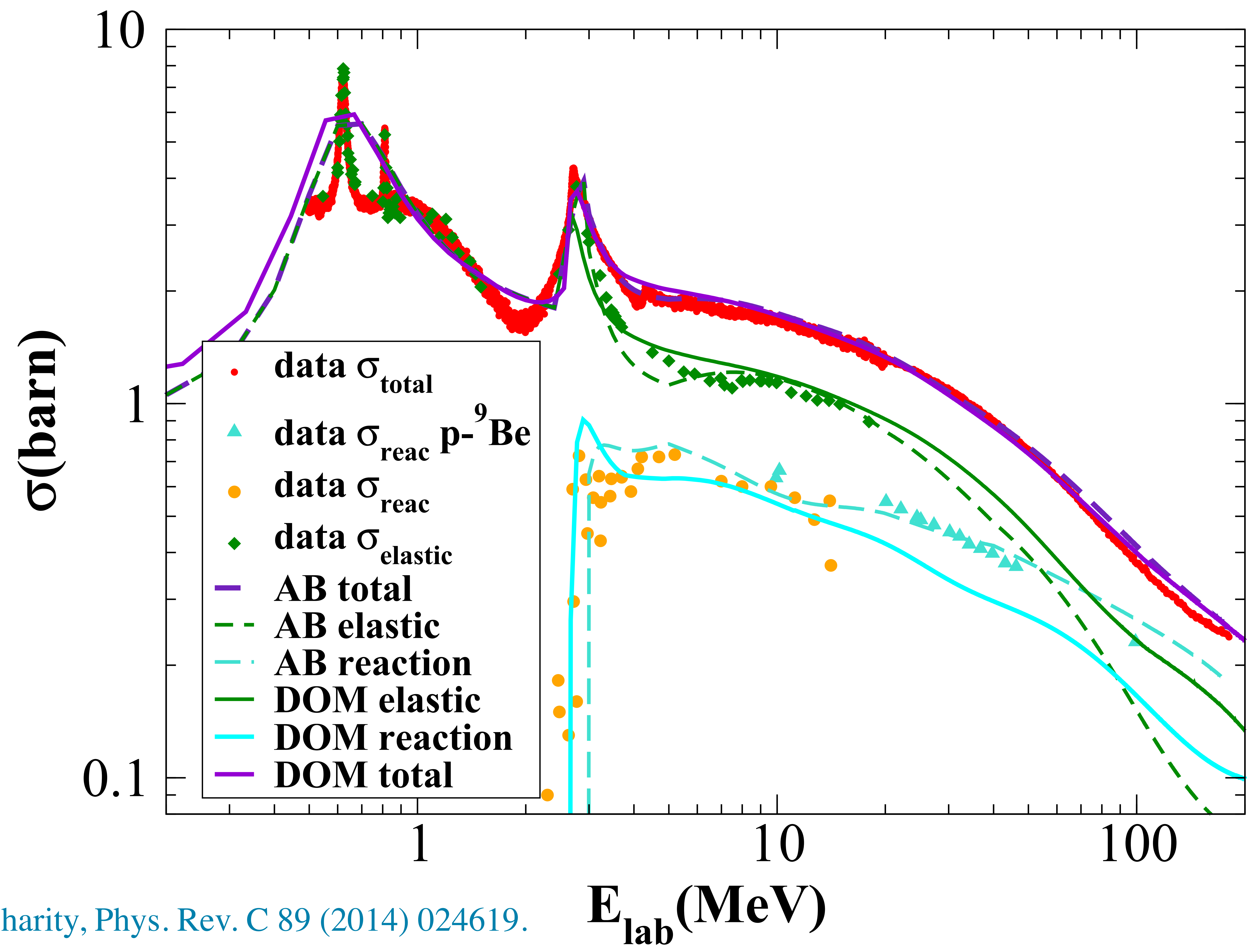
➡ Eq. (5) can be given the same structure as Eq. (4) by defining

$$W^{nT}(\mathbf{r}) = -\frac{1}{2}\hbar v \sigma_{nn} \rho_T(\mathbf{r}) \qquad \textbf{(6)}$$

Justification

Reminder:

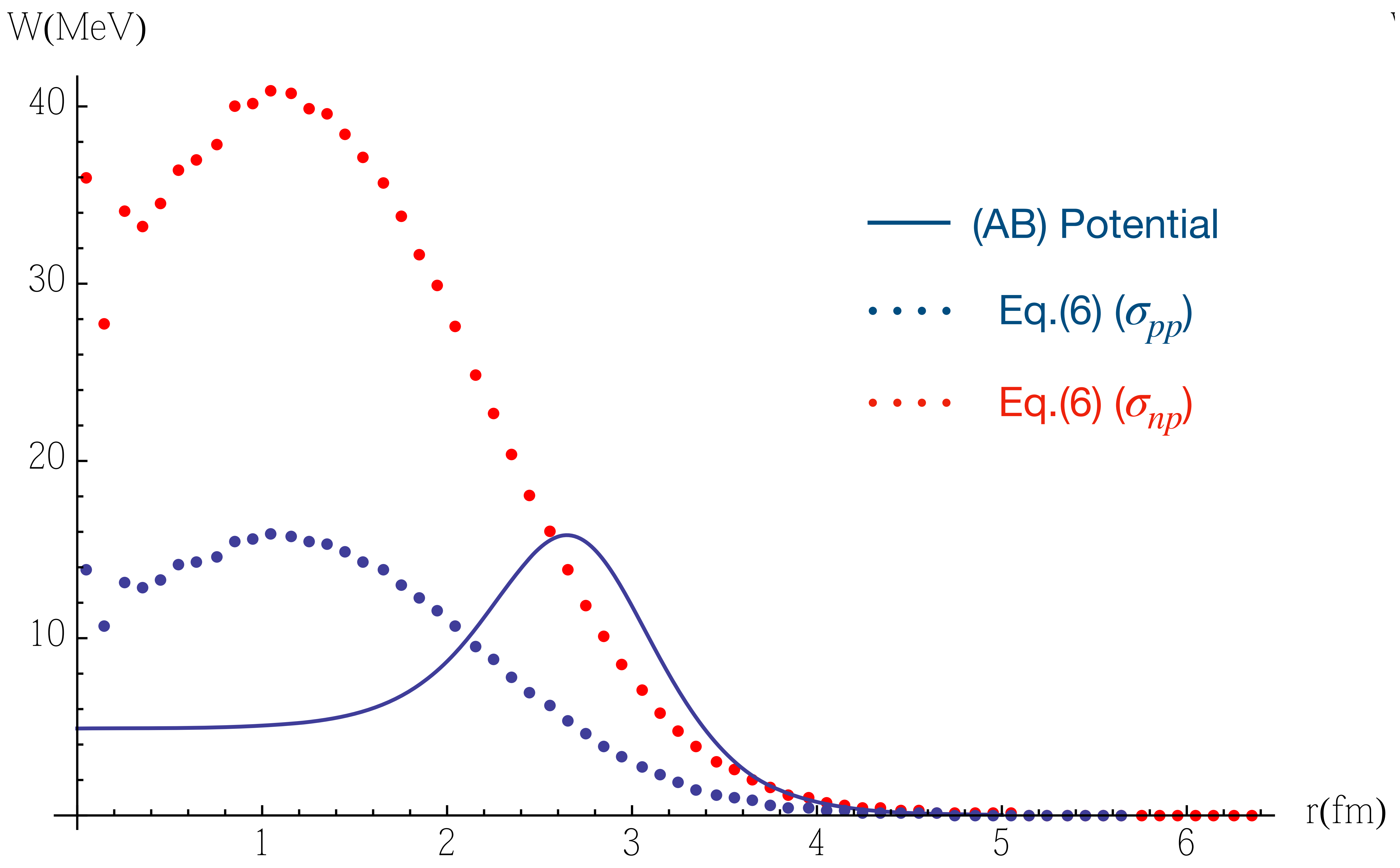
$$W^{PT}_{s.f.}(\mathbf{r}) = \int d\mathbf{b_1} W^{nT}\left(\mathbf{b_1} - \mathbf{b}, z\right) \int dz_1 \rho_P\left(\mathbf{b_1}, z_1\right) \quad \textbf{(4)}$$



- A. Bonaccorso, R.J. Charity, Phys. Rev. C 89 (2014) 024619.

Justification

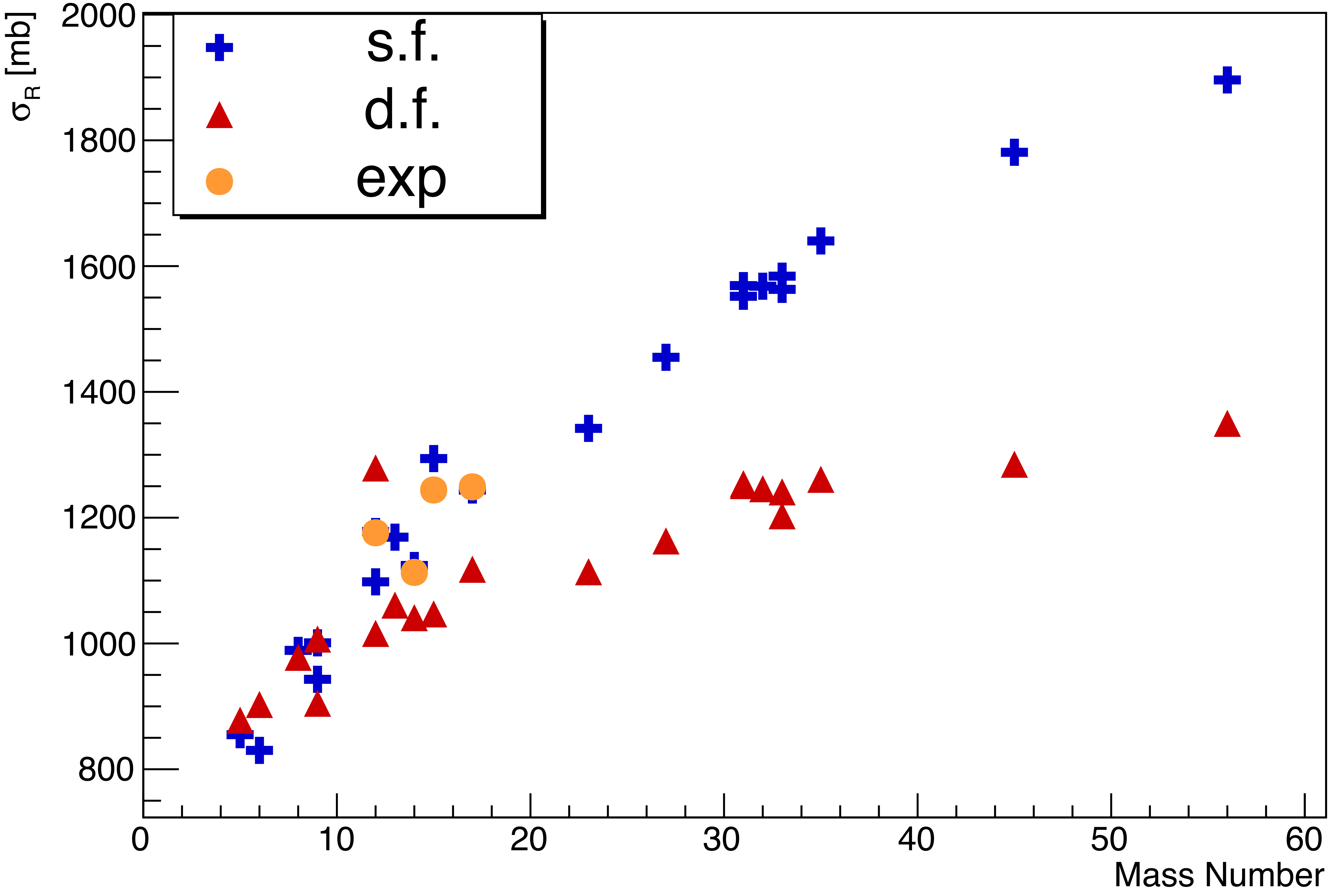
E=100 MeV



$$W^{nT}(\mathbf{r}) = -\frac{1}{2}\hbar v \sigma_{nn} \rho_T(\mathbf{r}) \qquad \textbf{(6)}$$

- A. Bonaccorso, et al. Few-Body Syst (2016) 57 :331-226.

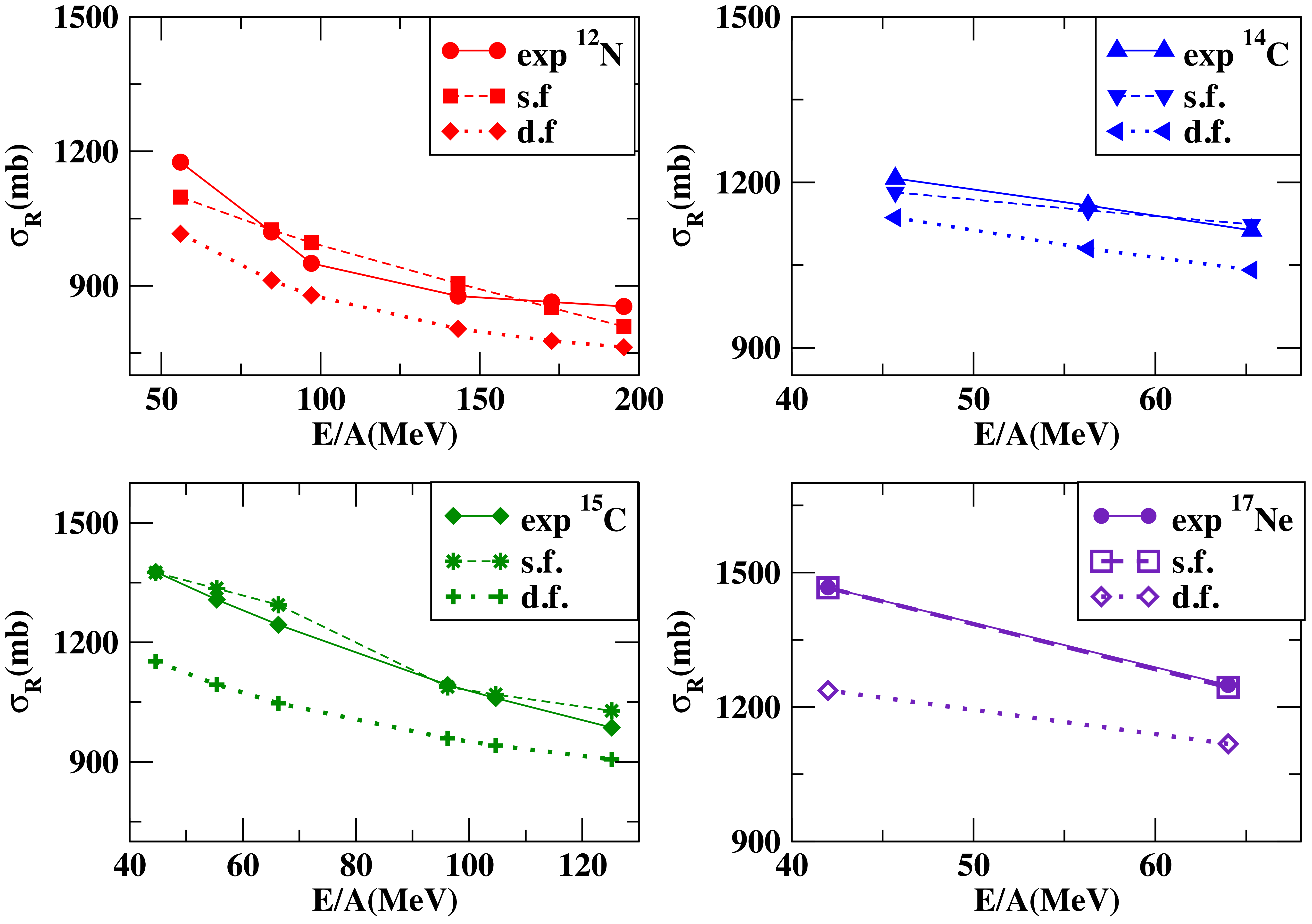
Results : Reaction cross section



E=60 A.MeV

I. Moumene and A. Bonaccorso, Nucl. Phys. A 1006 (2021)

Results : Reaction cross section



I. Moumene and A. Bonaccorso, Nucl. Phys. A 1006 (2021)

^{12}N : M. Fukuda, Y. Morita et al., JPS Conf. Proc. 6, 030103 (2015).

^{15}C : H. Du, M. Fukuda et al., Acta Physica Polonica B 48, 473 (2017). J. A 25 (s01) (2005) 221.

^{17}Ne : K. Tanaka, M. Fukuda, et al., Eur. Phys. J. A 25 (s01) (2005) 221.

^{14}C : M. Fukuda, private communication.

Strong absorption radius

Reminder:

$$\sigma_R = 2\pi \int_0^\infty bdb \left(1 - \left|S_{PT}(\mathbf{b})\right|^2\right)$$

$$\left|S_{PT}(\mathbf{b})\right|^2 = e^{2\chi_I(b)}$$

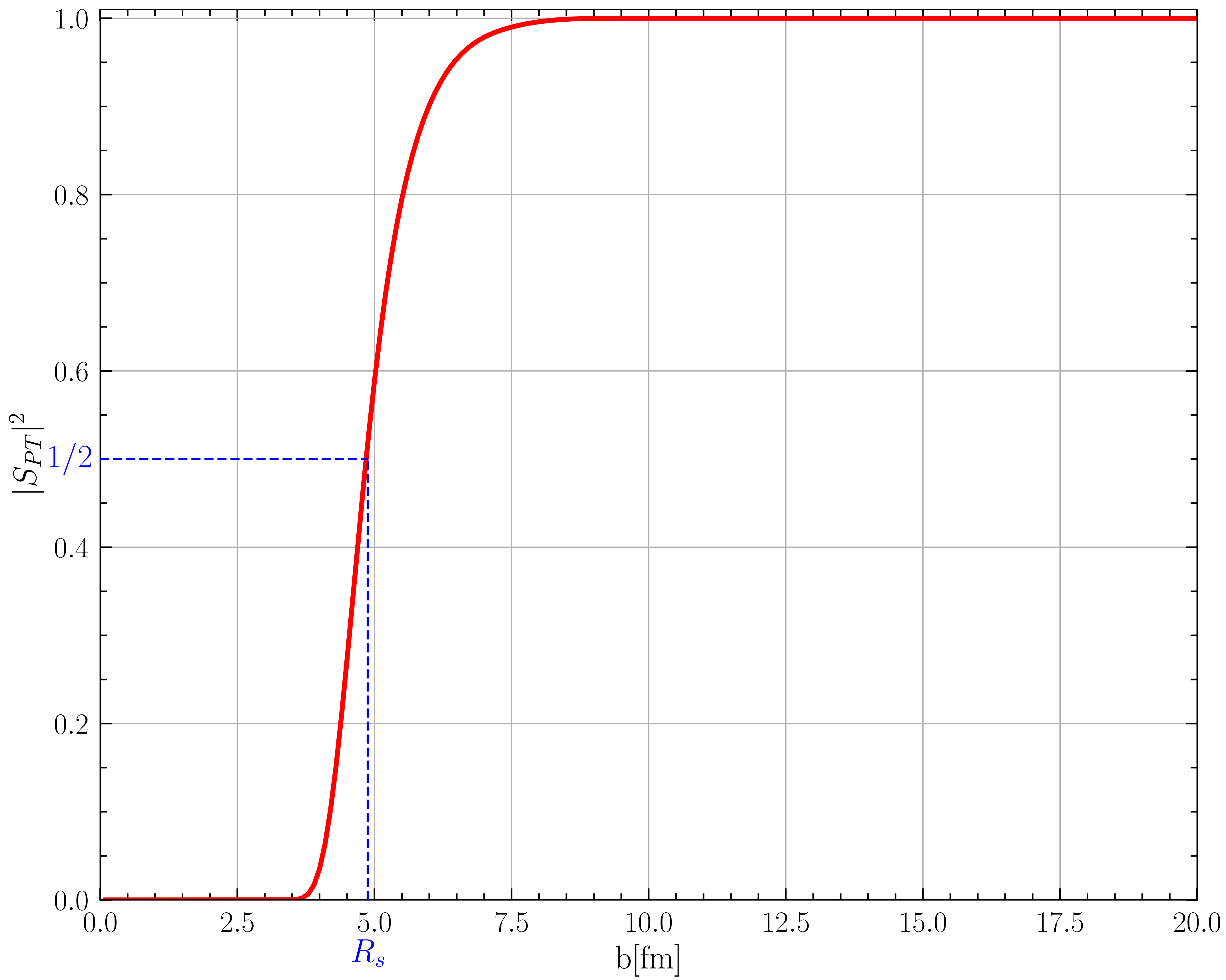
The strong absorption radius:

$$|\, S_{PT}\left(R_S\right) |^2 = \frac{1}{2} \qquad \textbf{(7)}$$

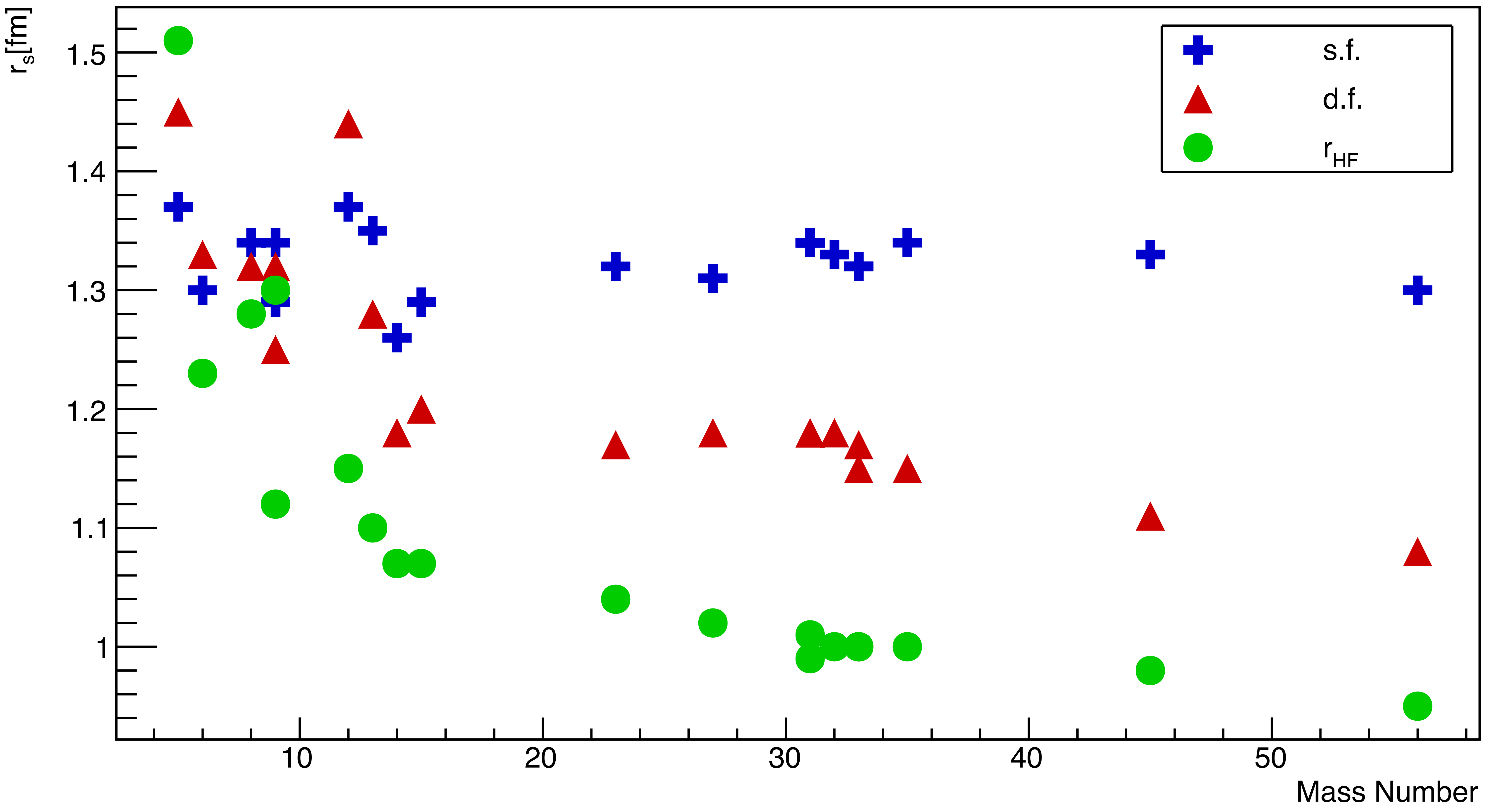
With

$$R_s = r_s\left(E_{inc}\right)\left(A_P^{1/3} + A_T^{1/3}\right) \qquad \textbf{(8)}$$

r_s : Determine the range of impact parameters for which surface reacti
dominate the core-target interaction from regions in which the stro
absorption regime applies.

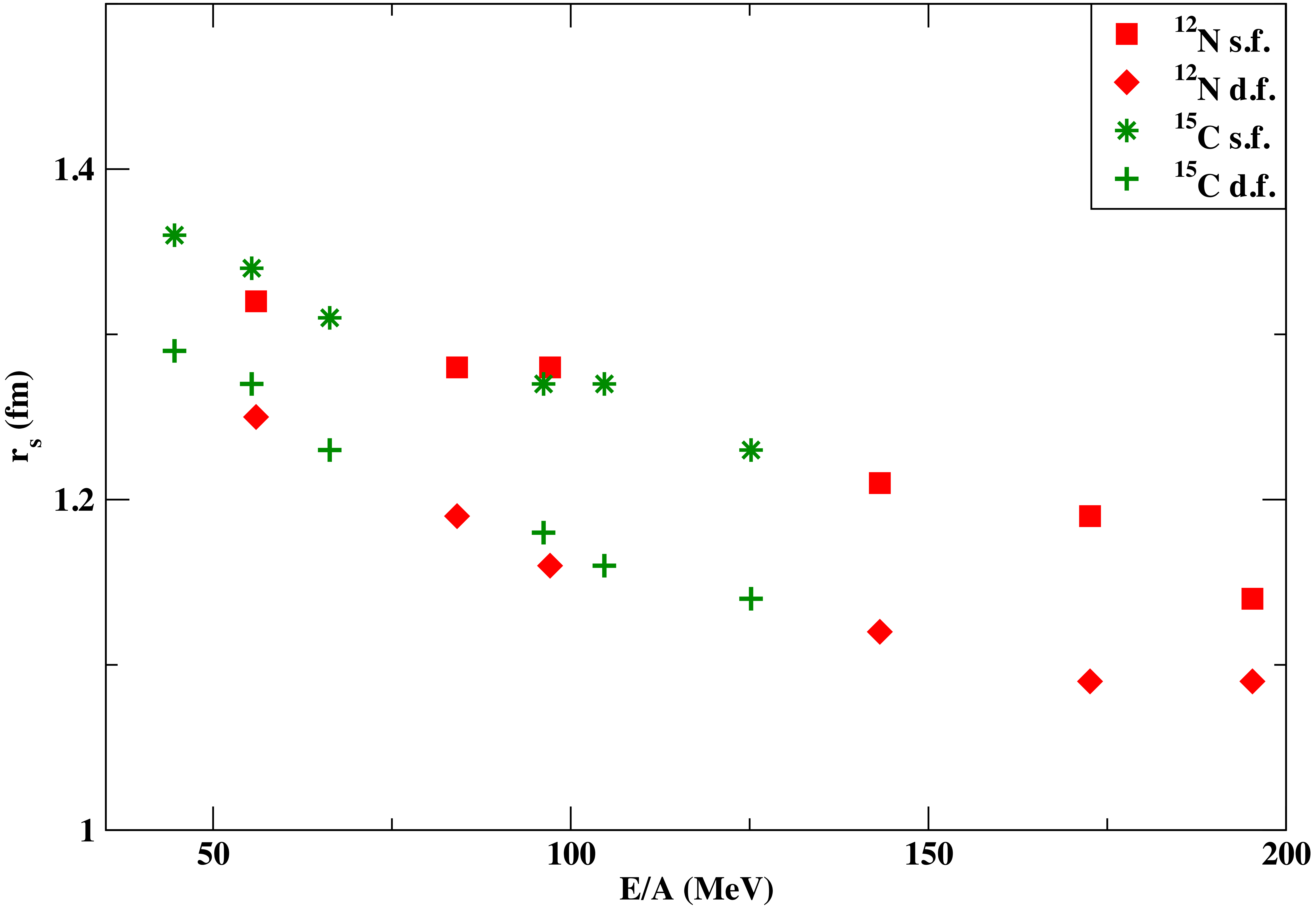


Results: Strong absorption radius



I. Moumene and A. Bonaccorso, Nucl. Phys. A 1006 (2021)

Results : Strong absorption radius



I. Moumene and A. Bonaccorso, Nucl. Phys. A 1006 (2021)

Conclusion

- The single folding model is more reliable than the double folding model in describing the total reaction cross sections for several nuclei.
- The d.f. gives smaller reaction cross sections and in turn it is expected to produce larger breakup cross sections.
- The fact that the single folding model has provided very stable values of the strong absorption radius parameter, r_s=1.3-1.4 fm, confirms the validity and potentiality of our s.f. approach for future studies with breakup and knockout reactions.
- Study the reaction cross section using densities from coupled cluster model (In progress)

Thank you for your attention