Combined method to extract spectroscopic factors from transfer reactions.

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We need spectroscopic factors to predict A(n,γ)A+1

Spectroscopic factors are expected to be extracted from transfer reaction A(d,p)A+1

$$S_{\exp} = \frac{experimental\ cross\ section}{theoretical\ cross\ section\ (S_{theor} = 1)} = \frac{\sigma_{\exp}}{\sigma_{th}}$$

To calculate σ_{th} we need

- Optical potentials to describe *A+d* and *p*+(*A*+1) scattering
- Potential well for describe bound state for *n+A*

Usually, for bound states r_0*=1.25 fm* and a *= 0.65 fm* are used. The depth V_0 is adjusted to reproduce the *n+A* binding energy.

Is it possible to determine r_0 and a in a model-independent way?

Original idea of how to extract spectroscopic factors in a “model-independent way” from (d,p) reactions was proposed in

S.A.Goncharov, Ya.Dobesh, E.I.Dolinsky, A.M.Mukhamedzhanov, Ya.Tseipek, *Nuclear Vertex Constants, Spectroscopic Factors and the Distorted-Wave Born Approximation,* Yad.Fiz. 35, 662 (1982)

The reaction amplitude is

$$T = T_{int} + T_{ext}$$

T_{int} probes the wave functions in the nuclear interior, therefore the spectroscopic factor *S* can be determined from T_{int}

T_{ext} probes the tail of the overlap integral, the magnitude of which is given by the Asymptotic Normalization Coefficients (ANC).

The idea is to fix T_{ext} using measures ANCs.

$$\sigma(\theta) \propto \left|T_{\text{int}} + T_{ext}\right|^2 = \left|\sqrt{S}\tilde{T}_{\text{int}}(b) + \sqrt{S}b\tilde{T}_{ext}\right|^2$$

$\tilde{T}_{\text{int}}(b)$: does not depends on S

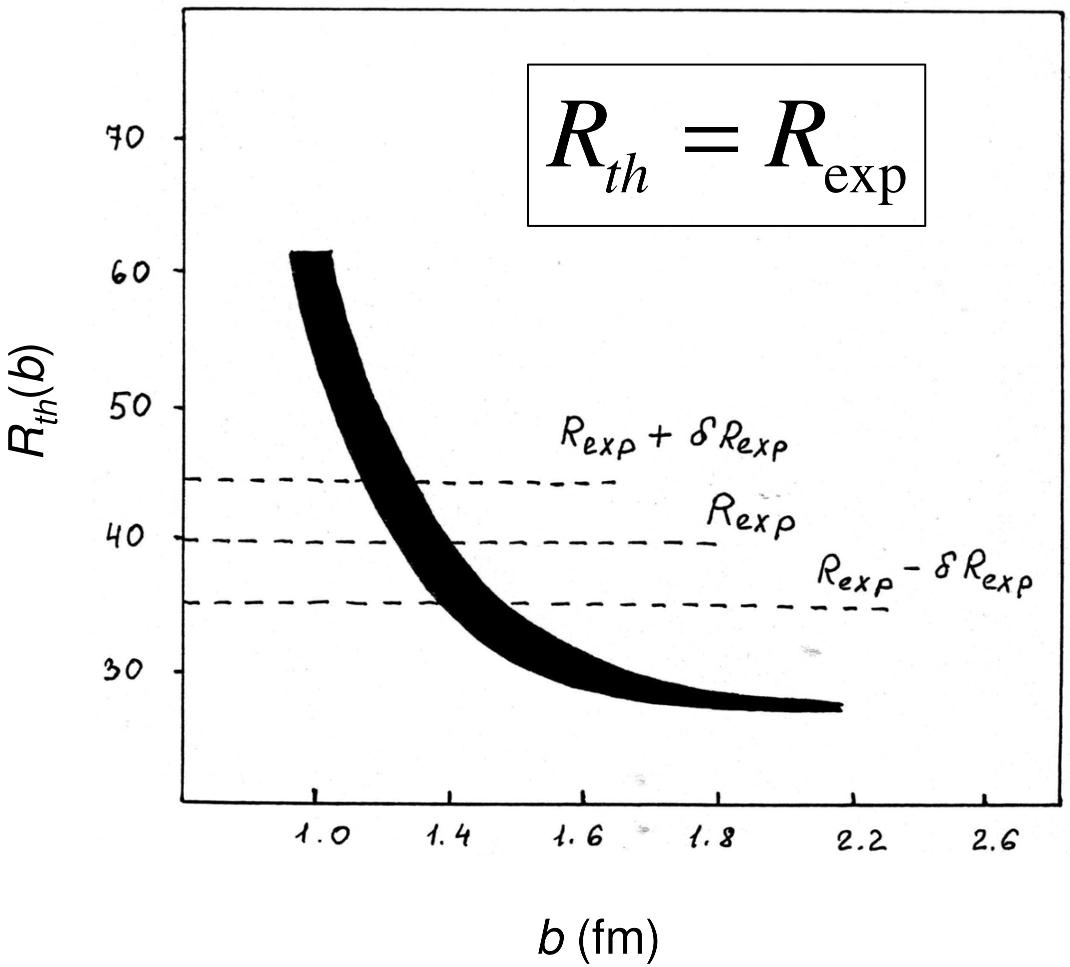
$\tilde{T}_{ext}$: does not depens on b

$$\sigma(\theta) \propto Sb^2 \left|\frac{\tilde{T}_{\text{int}}(b)}{b} + \tilde{T}_{ext}\right|^2 \quad \Rightarrow \quad \frac{\sigma(\theta)}{Sb^2} \propto \left|\frac{\tilde{T}_{\text{int}}(b)}{b} + \tilde{T}_{ext}\right|^2$$

$$\boxed{R_{th}(b) \equiv \frac{\sigma_{th}(\theta)}{S_{th}b_{th}^2} = \frac{\sigma_{\exp}(\theta)}{C_{\exp}^2} \equiv R_{\exp}}$$

$^{13}C(p,d)^{12}C$ $E_p = 18.6$ MeV

(taken from my PhD Thesis)



$b_{exp} = 1.3\,^{-0.17}_{+0.26}$ fm$^{-1/2}$

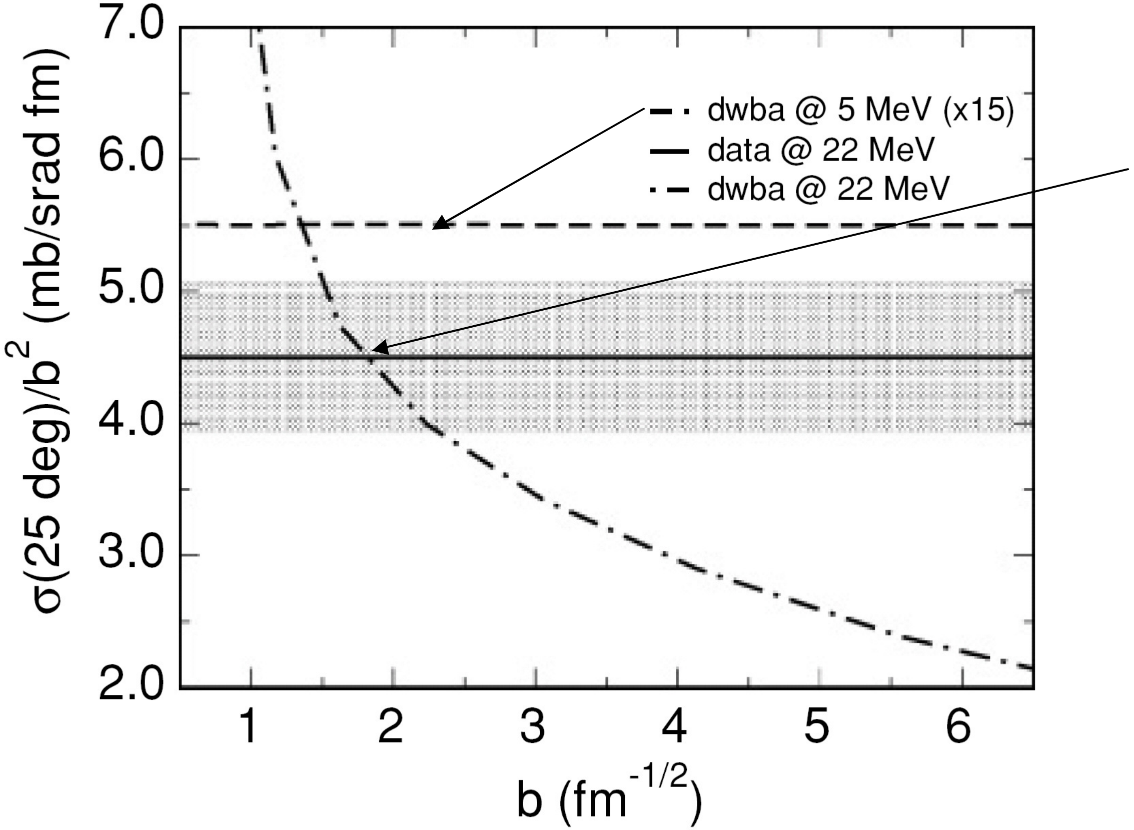
$S_{exp} = 1.19^{+0.08}_{-0.21}$

$r_0 = 1.0$ fm, $a = 0.49$ fm

$S_{SM} = 0.68$

$^{208}Pb(d,p)^{209}Pb$

*A.M. Mukhamedzhanov and F.Nunes, Phys. Rev. C **72**, 017602 (2005)*

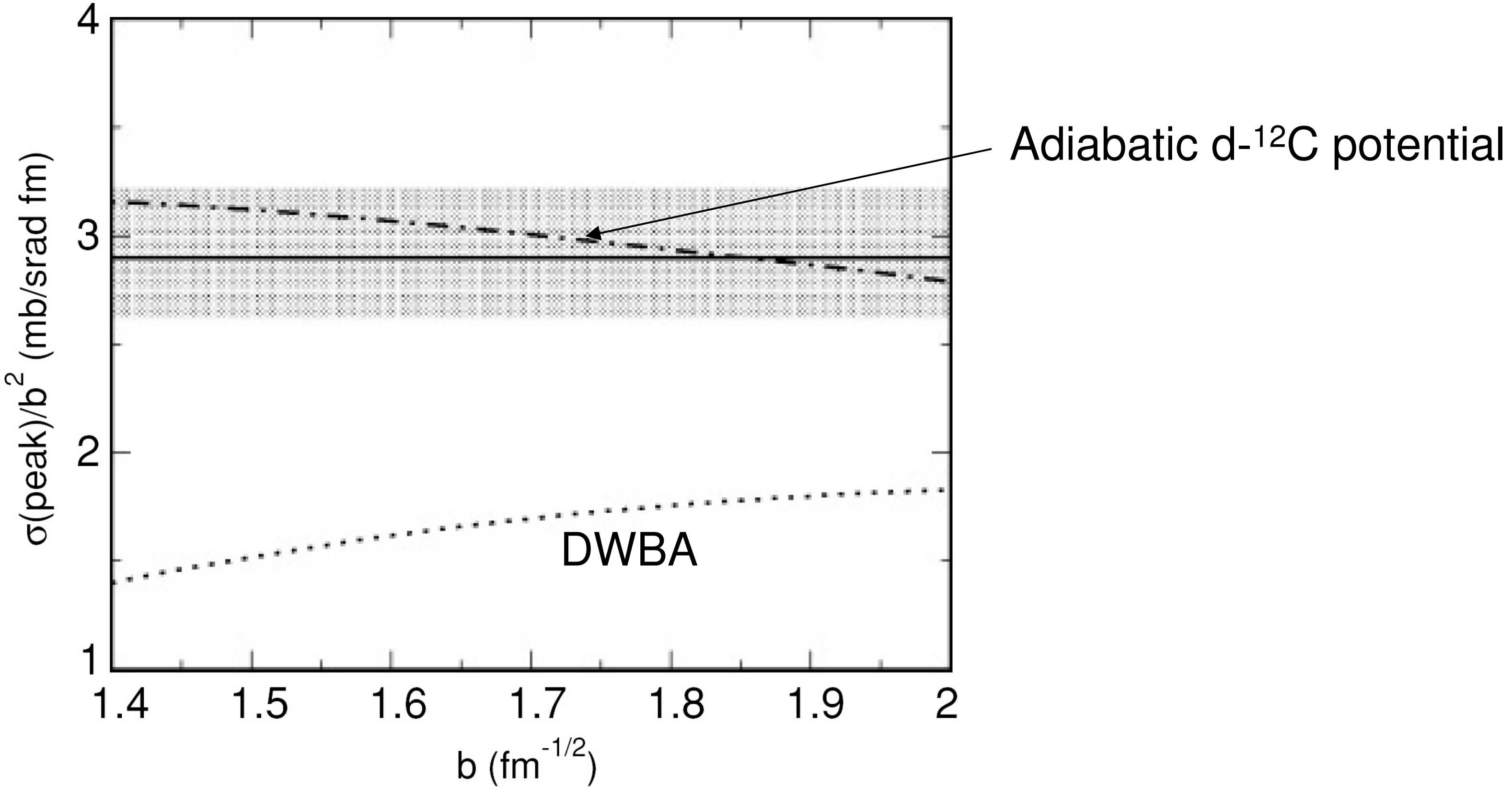


$b = 1.82\ fm^{-1/2}$

$S = 0.74$

$^{12}C(d,p)^{13}C$ at $E_d = 51$ MeV

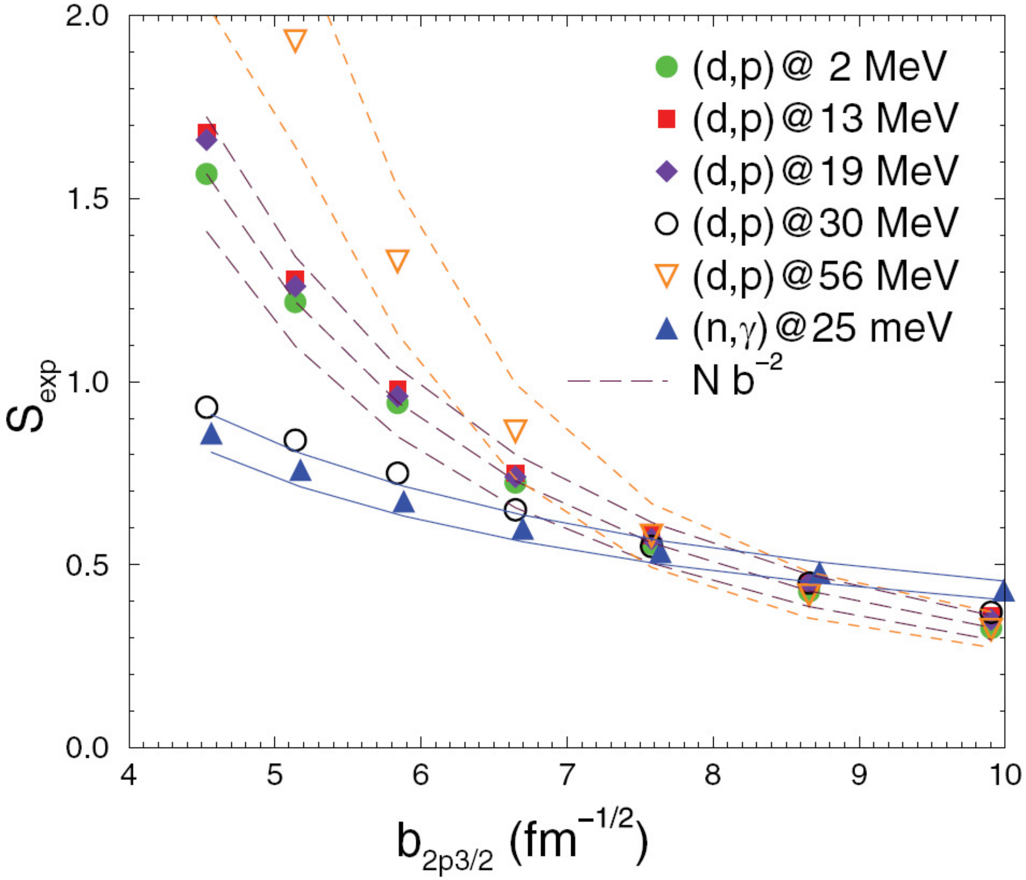
*A.M. Mukhamedzhanov and F.Nunes, Phys. Rev. C **72**, 017602 (2005)*

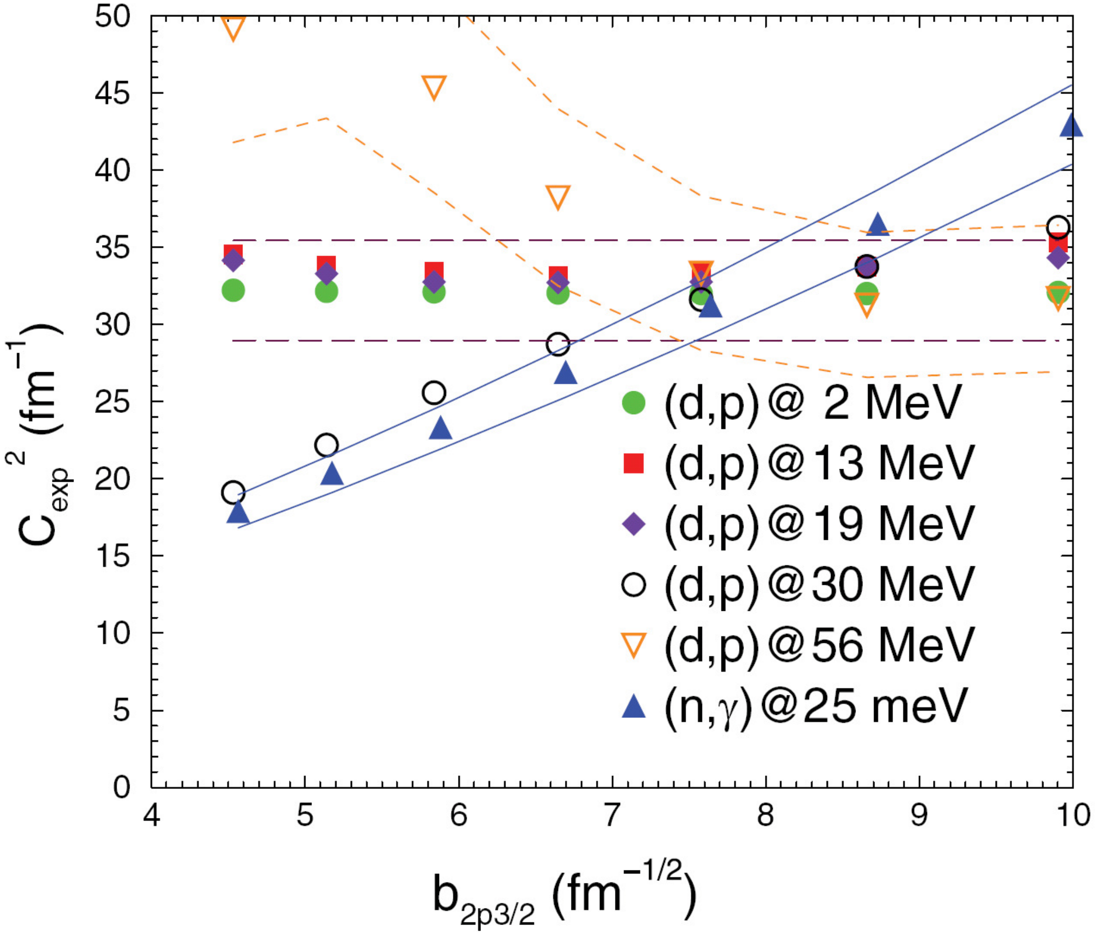


It is not possible to determine *b* (and therefore *S*) from this graph.

$^{48}Ca(d,p)^{49}Ca$

*A.M. Mukhamedzhanov and F.Nunes, Phys. Rev. C **77**, 051601(R) (2008)*





^{49}Ca(g.s.)

b_{exp}=7.8 ±1.2 fm$^{-1/2}$

S_{exp}= 0.53 ± 0.11

r_0 = 1.45 fm, a = 0.65 fm

^{49}Ca(1st ex.st.)

b_{exp}=3.63 ± 0.56 fm$^{-1/2}$

S_{exp}= 0.71$^{+0.20}_{-0.12}$

r_0 = 1.45 fm, a = 0.65 fm

Conclusion

- External contributions to the (*d,p*) reaction amplitude can be fixed by using measured ANCs.

- When the (*d,p*) reaction is peripheral it is not possible to determine b, r_0 and a in a model-independent way. Therefore, some model assumptions should be made about them to determine spectroscopic factor.

- When internal region contributes to the (*d,p*) amplitude it is possible to determine experimental limits for b, r_0, a and S. This can be done by graphically solving the equation $R(b)=\mathrm{R}_{\mathrm{exp}}$