Unbound exotic nuclei studied by projectile fragmentation.

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Outline.

- Reactions to study ^{13}Be .

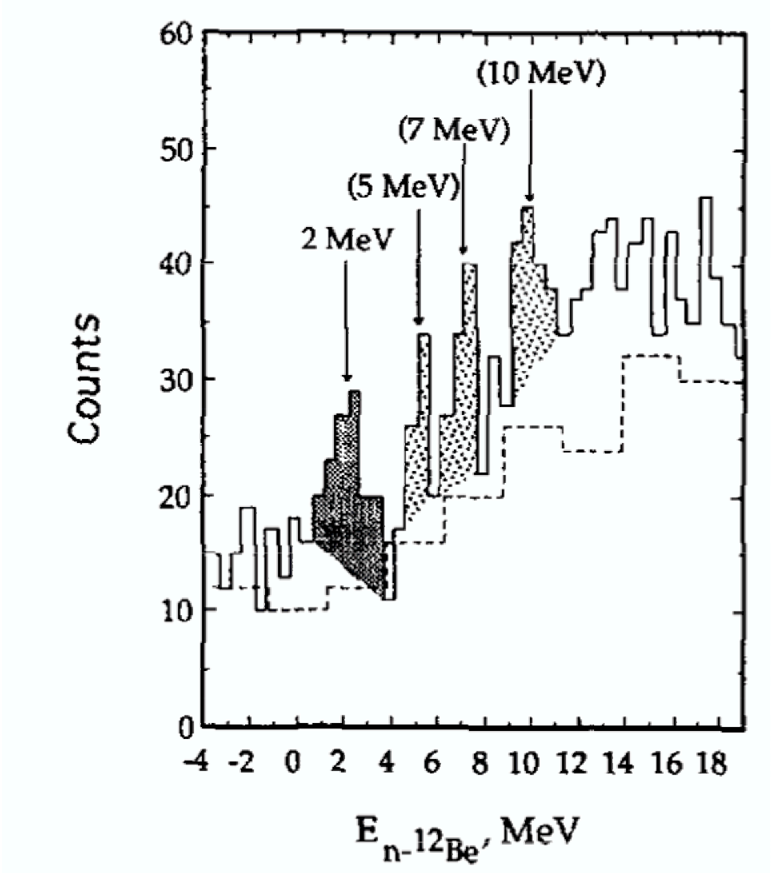
- Simple time dependent model for the excitation of a nucleon from a bound state to a continuum resonant state.

- Conclusion and Outlooks.

Reactions to study halo nuclei.

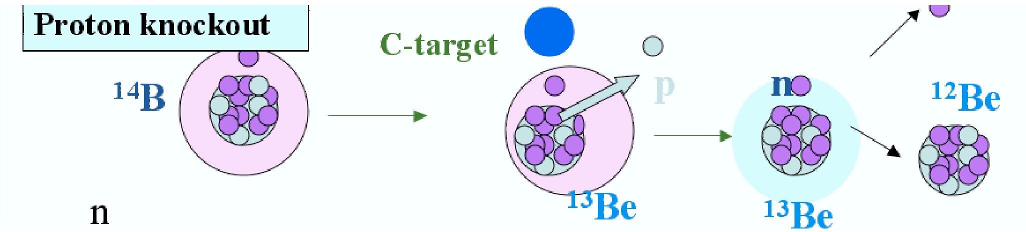
- Transfer to the continuum reaction.
- Fragmentation reaction.

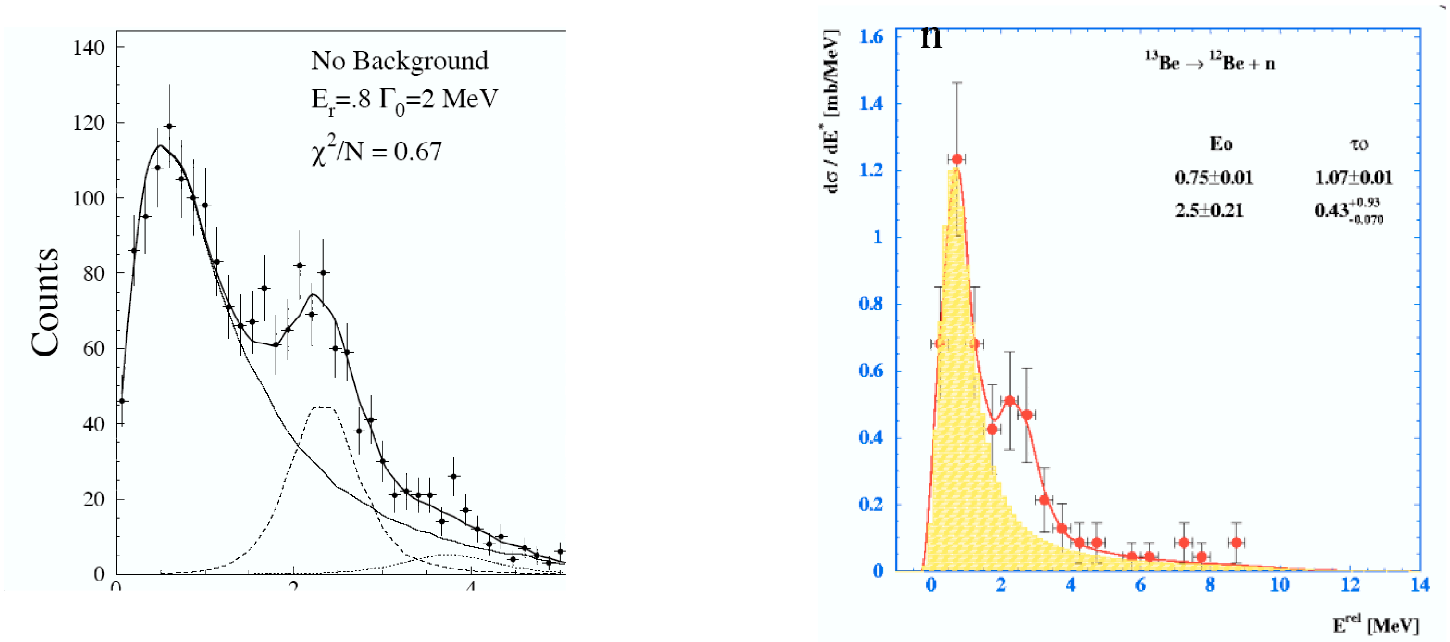
^{13}Be obtained by transfer reaction



^{12}Be (d,p) RIKEN (Korsheninnikov) (1995)

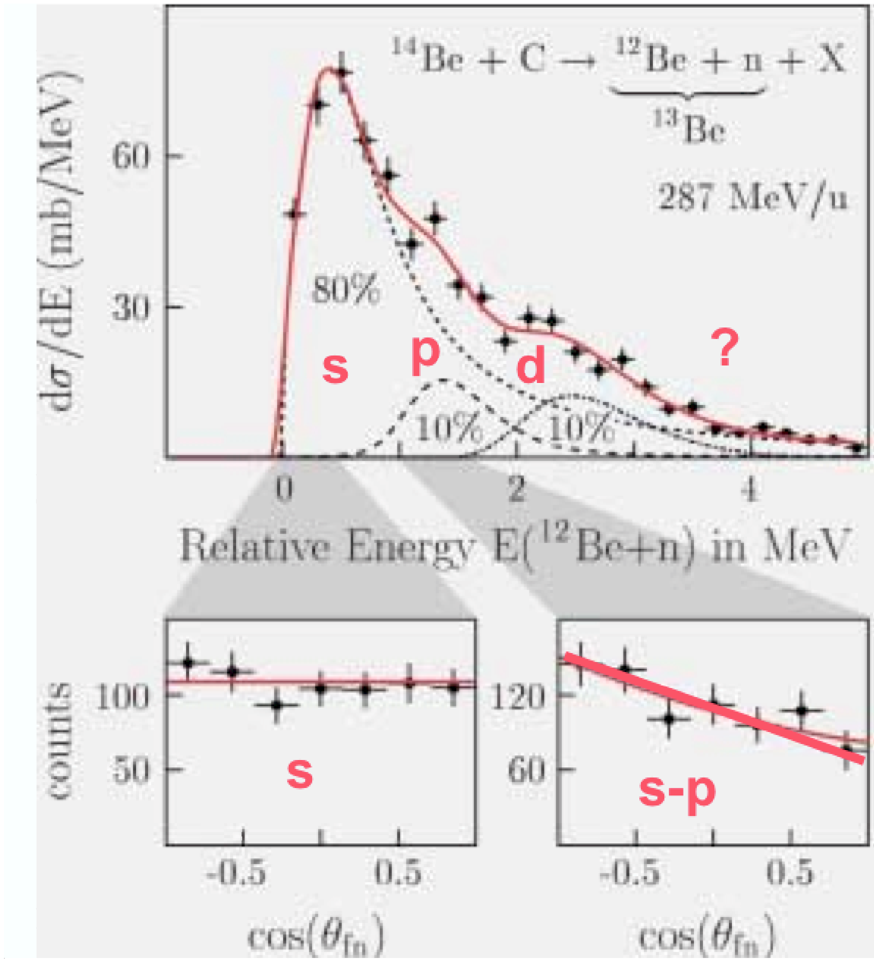
^{13}Be obtained by proton knockout on ^{14}B

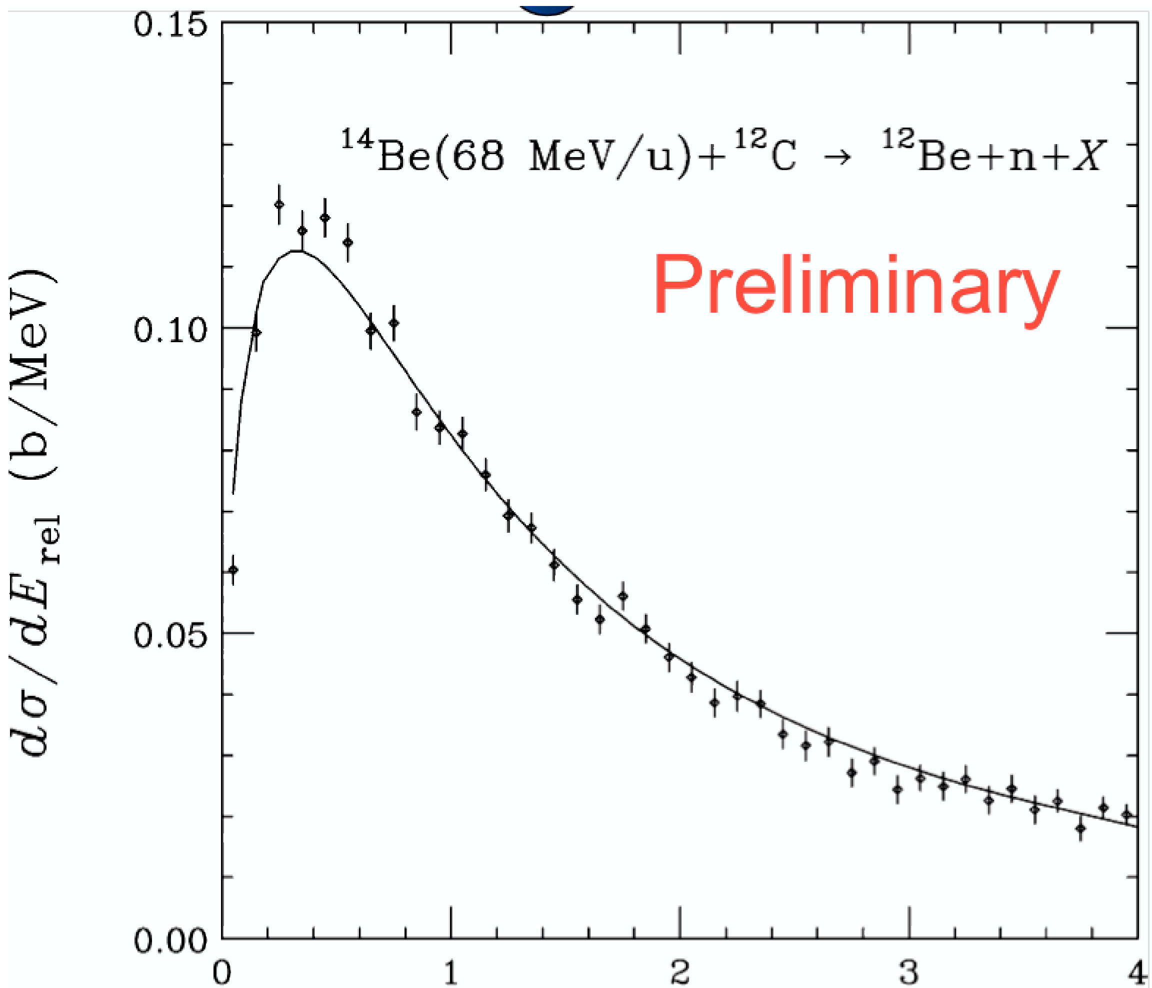




(a) LPC GANIL (Lecouey, Orr) (2002). (b) GSI (U Datta Pramanik) (Surrey conference Jan.2005).

^{13}Be obtained by neutron knockout from ^{14}Be





(a) GSI (Simon Nucl. Phys. A734 (2004) 323-326,(b) RIKEN (Nakamura)(ECT* 2004)unpublished

Inelastic excitation.

Inelastic-like excitations can be described by the first order time dependent perturbation theory amplitude:

$$A_{fi} = \frac{1}{i\hbar} \int_{-\infty}^{\infty} dt \langle \psi_f(t) | V_2(\mathbf{r}) | \psi_i(t) \rangle$$

In order to obtain a simple analytical formula we consider the special case in which $V_2(r) = v_2 \delta(x)\delta(y)\delta(z)$.

$$A_{fi} = \frac{v_2}{i\hbar v} \int_{-\infty}^{\infty} dz \;\; \psi_f^*(b_c, 0, z) \psi_i(b_c, 0, z) e^{iqz}$$

General wave functions (asymptotic form)

For the initial state:

$$\psi_i(b_c, 0, z) = -C_i i^l \gamma h_{l_i}^{(1)}(i\gamma r) P_{l_i}(z/r).$$

For the final continuum state:

$$\psi_f(b_c, 0, z) = C_f k \frac{i}{2}(h_{l_f}^{(+)}(kr) - S_{l_f} h_{l_f}^{(-)}(kr)) P_{l_f}(z/r).$$

Simple time dependent modele.

$$A_{fi} = \frac{v_2}{i\hbar v} \int_{-\infty}^{\infty} dz \ \psi_f^*(b_c, 0, z)\psi_i(b_c, 0, z)e^{iqz}$$

$$I(k, q) = I_R + iI_I = |I|e^{i\alpha}$$

$$\bar{S} = Se^{2i\alpha} = e^{2i(\delta+\alpha)}$$

$$|A_{fi}|^2 = C^2|I|^2|1 - \bar{S}|^2.$$

Comparison to the transfer to the continuum.

Fragmentation:

$$\frac{dP_{in}}{d\varepsilon_f} = \frac{2}{\pi}\frac{v_2^2}{\hbar^2 v^2}C_i^2\frac{m}{\hbar^2 k}\Sigma_{l_f}(2l_f+1)|1-\bar{S}_{l_f}|^2|I_{l_f}|^2.$$

Transfer:

$$\frac{dP_t(b_c)}{d\varepsilon_f} \approx \frac{4\pi}{k^2}\Sigma_{l_f}(2l_f+1)|1-S_{l_f}|^2 B_{l_f,l_i}$$

(*G. Blanchon, A. Bonaccorso and N. Vinh Mau, Nucl. Phys. A739 (2004) 259.*)

Cross section.

$$\frac{d\sigma}{d\varepsilon_f} = C^2 S \int_0^{\infty} d\mathbf{b_c} \frac{dP_{in}(b_c)}{d\varepsilon_f} P_{ct}(b_c),$$

The core survival probability:

$$P_{ct}(b_c) = |S_{ct}|^2$$

$$P_{ct}(b_c) = e^{(-\ln 2 exp[(R_s - b_c)/a])}$$

Determination of the S-matrix.

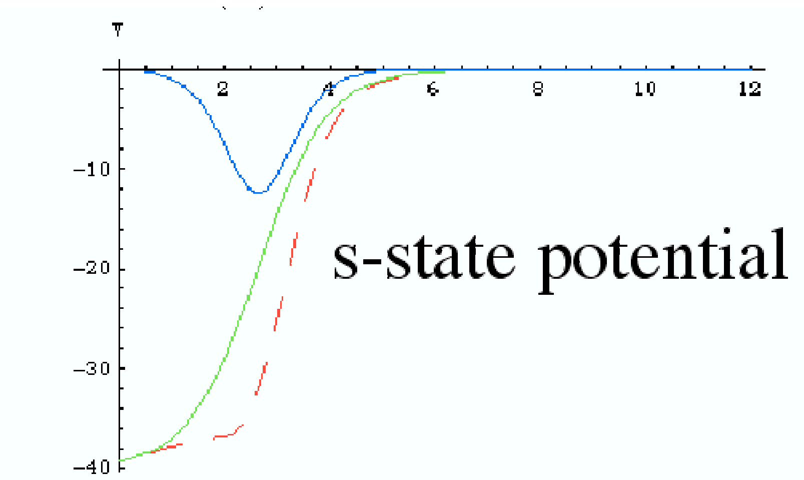
$$
\begin{aligned}
h &= t + U. \\
U(r) &= V_{WS} + \delta V. \\
\delta V(r) &= 16\alpha e^{2(r-R)/a}/(1+e^{(r-R)/a})^4.
\end{aligned}
$$

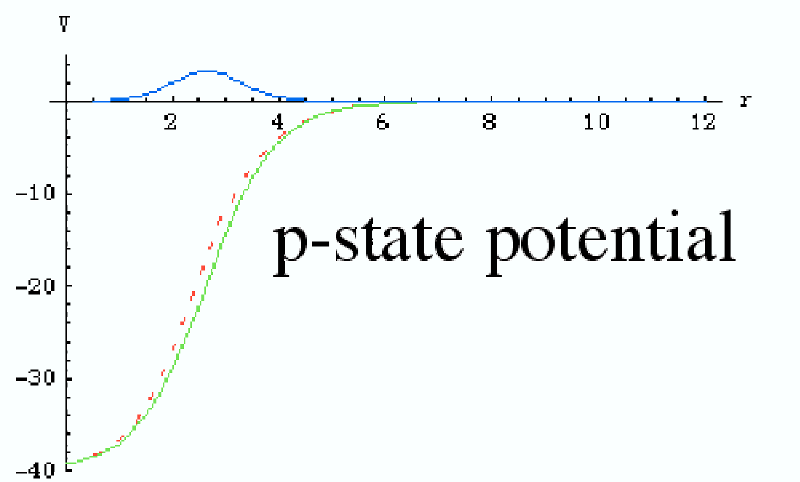
V_{WS} = Woods-Saxon potential plus spin-orbit.

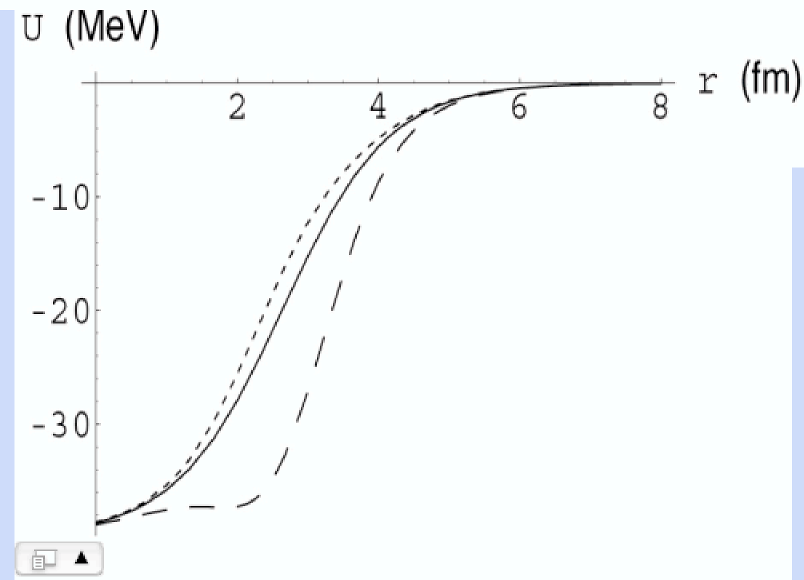
δV = correction which originates from particle-vibration couplings.

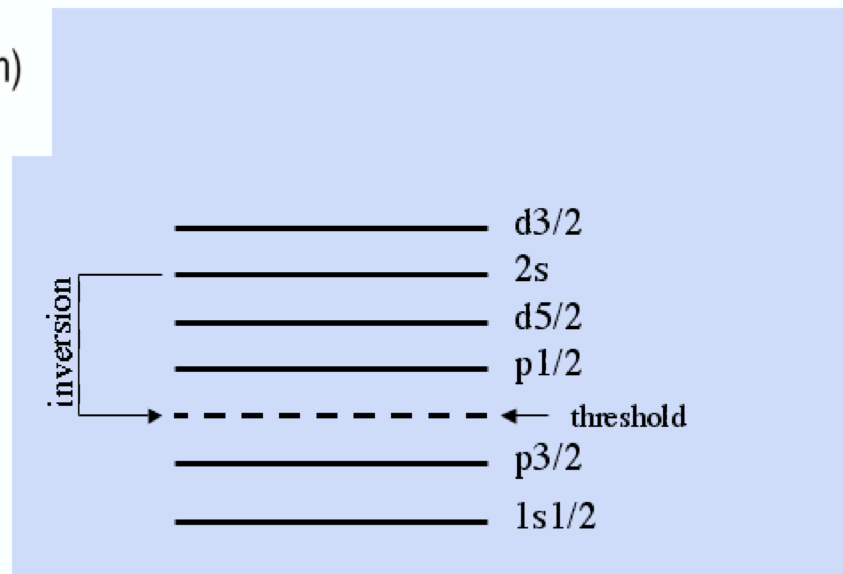
(N. Vinh Mau and J. C. Pacheco, Nucl. Phys. A607 (1996) 163.)

Potential correction.

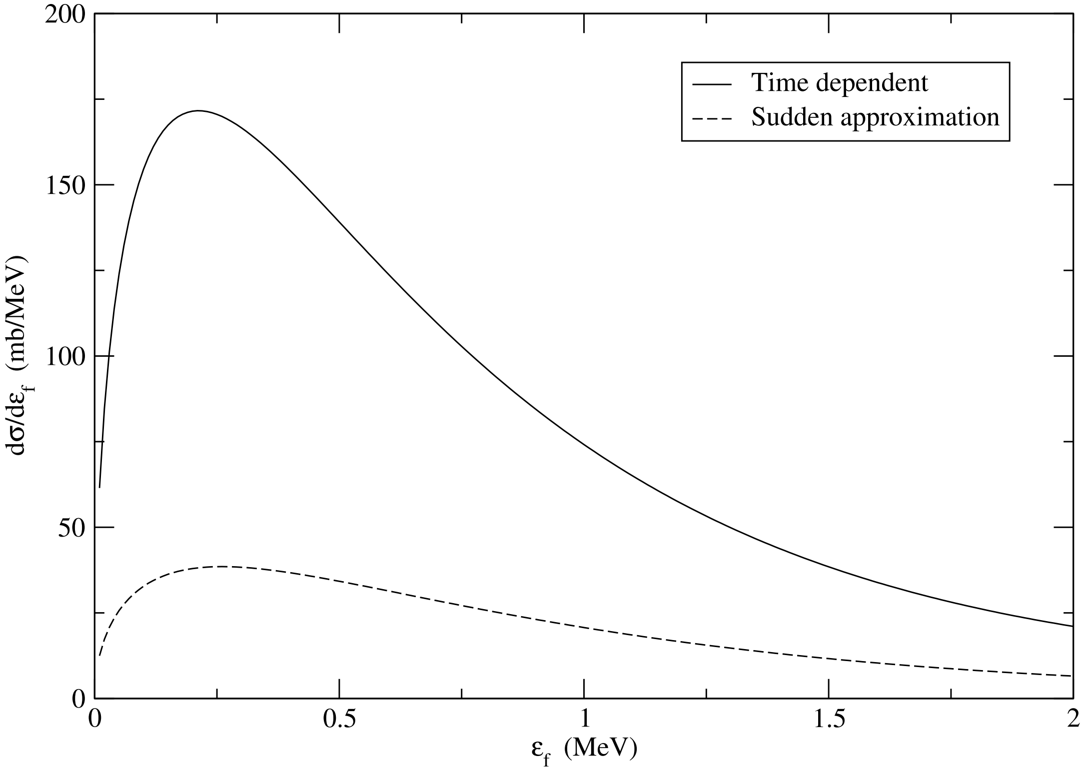




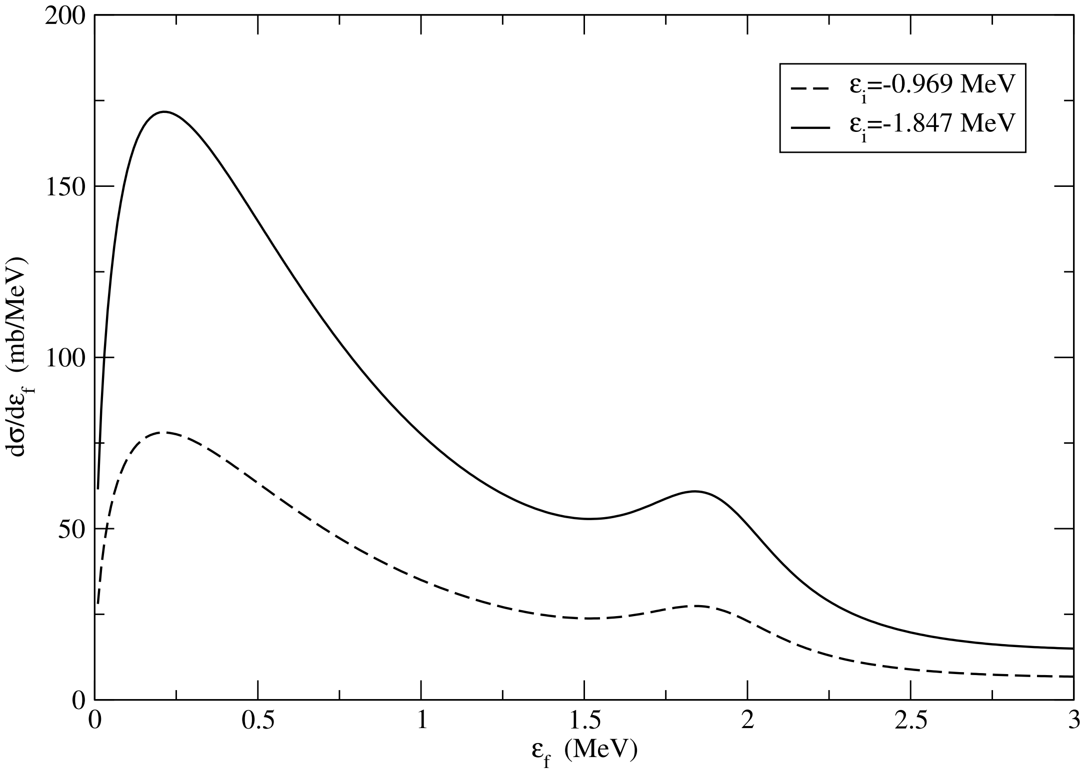




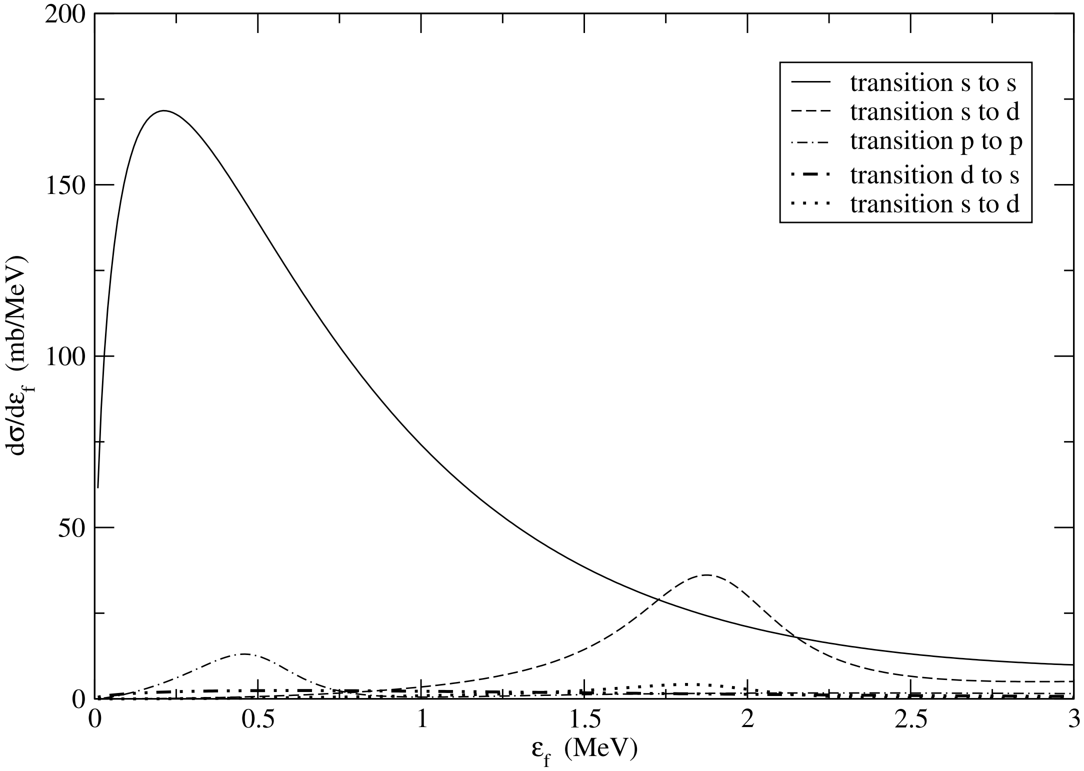
Comparison between time dependent and sudden approximation.



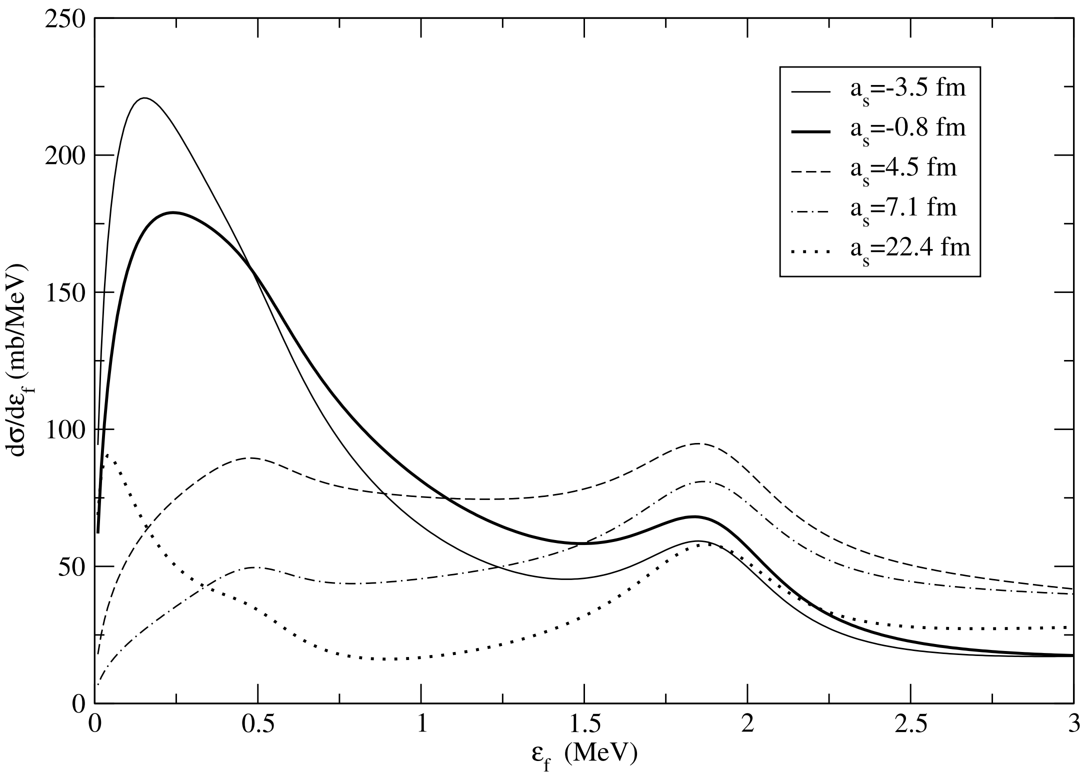
Dependence on the binding energy of the initial state.



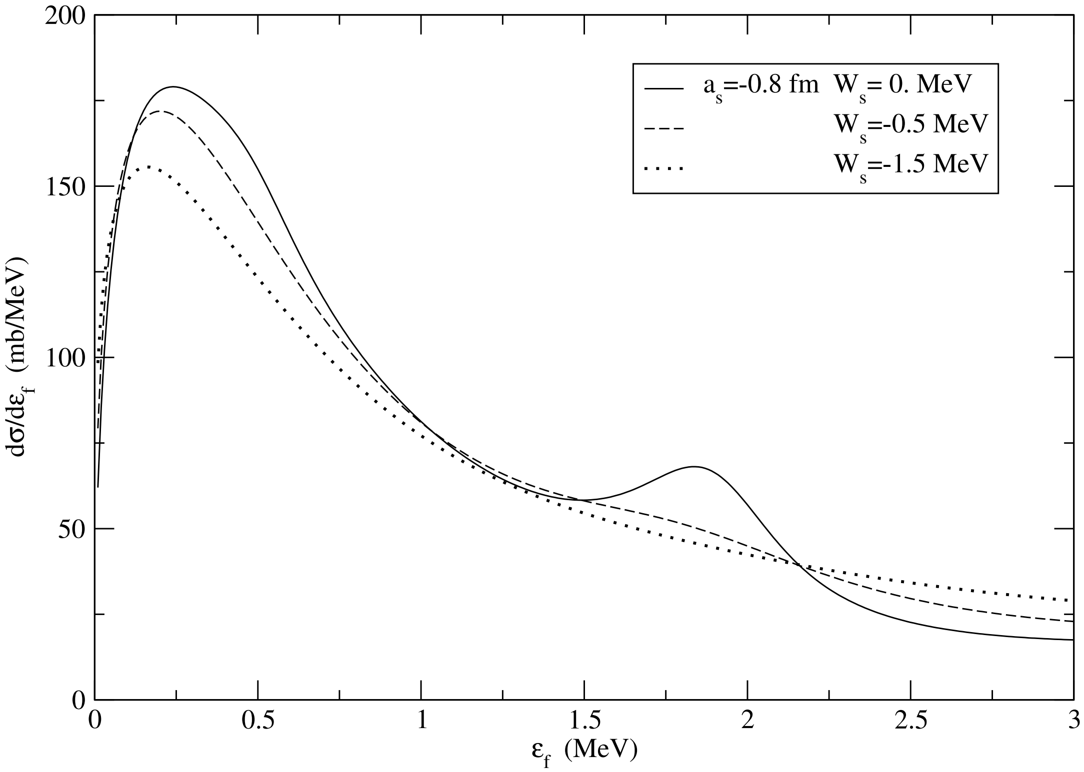
Strength of every transition.



Dependence on the scattering length of the final s-state.



Add of a complex part to the potential.



Conclusions and outlooks

- ^{13}Be is a signature of the halo state of the neutron.

- Possibility to use s resonances.

- One or two steps calculation.