Reaction cross sections of carbon isotopes Incident on proton and ^{12}C target

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C+C: Phys. Rev. C 75, 044607 (2007).
C+p: to be submitted.

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- Formulation
- Proton-nucleus reaction
- Nucleus-nucleus reaction
- Summary

Motivation:

Measurements of p-22C (Next talk by Tanaka-san)

Reaction mechanism

Descript. of *p-A* reactions

- Glauber approxi.

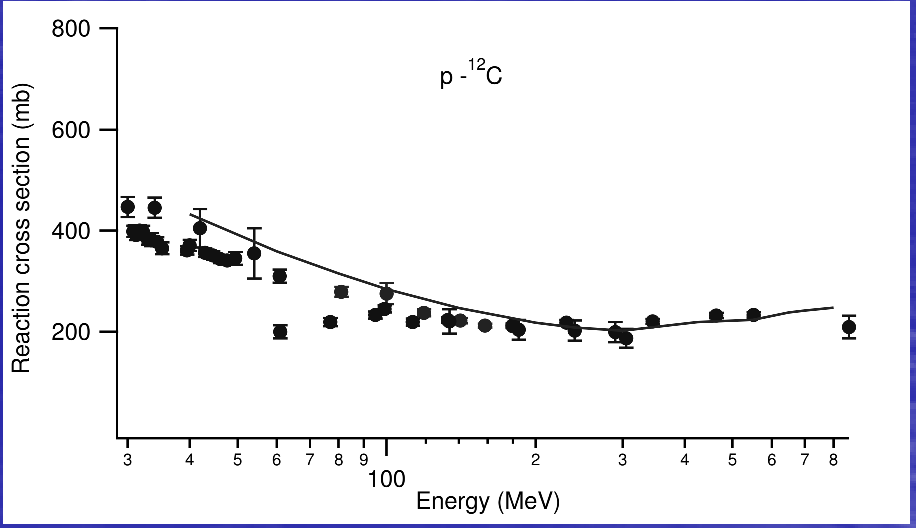
$$\sigma_R = \int db \left(1 - \left| e^{i\chi(b)} \right|^2 \right)$$

$$e^{i\chi(b)} = \left\langle \Psi_0 \left| \prod_{i \in P} \left(1 - \Gamma_{pi}(b + s_i)\right) \right| \Psi_0 \right\rangle$$

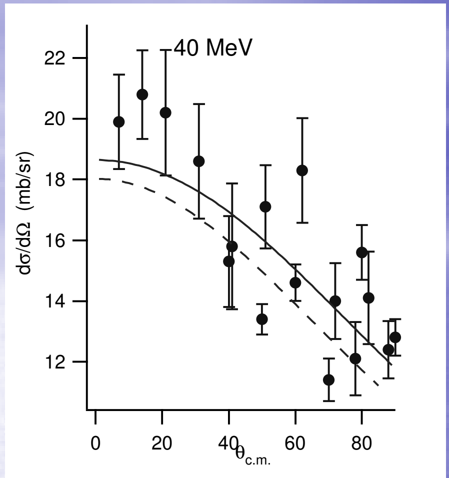
$$e^{i\chi_{OLA}(b)} = e^{i\chi_n(b) + i\chi_p(b)}$$
$$= e^{-\int dr \left[\rho_n(r)\Gamma_{pn}(b+s) + \rho_p(r)\Gamma_{pp}(b+s)\right]}$$

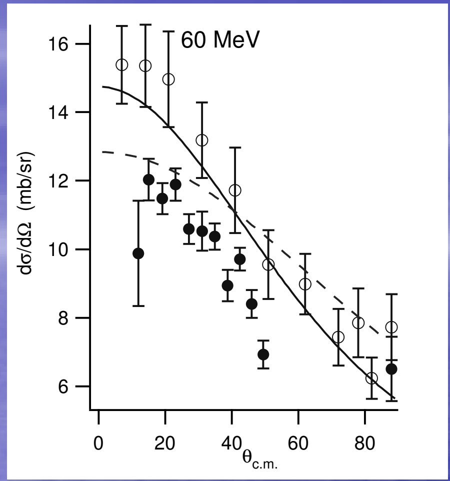
$$\Gamma_{pi}(b) = \frac{1 - i\alpha_{pi}}{4\pi\beta_{pi}} \sigma_{pi}^{tot} \exp\left(\frac{b^2}{2\beta_{pi}} \right)$$

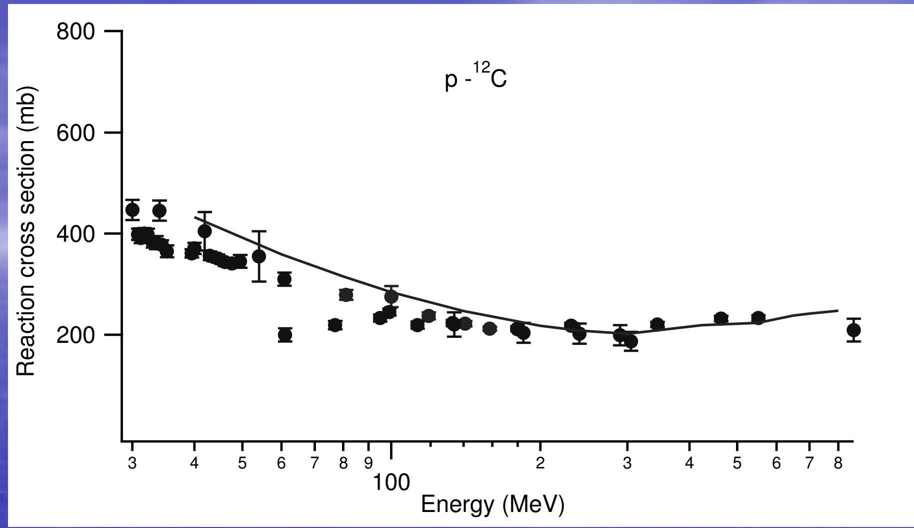
- σ_R of p-12C

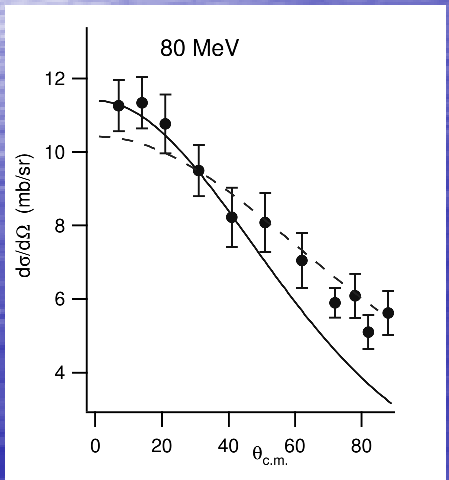


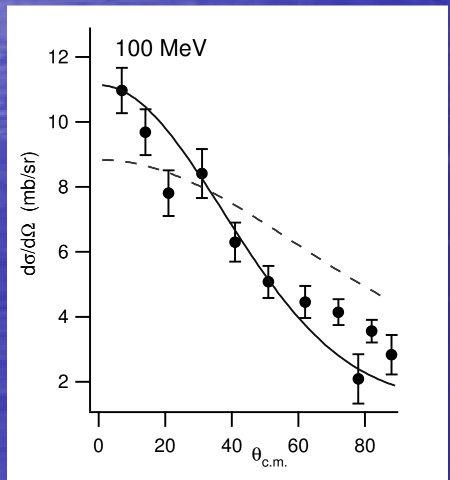
pn-scattering









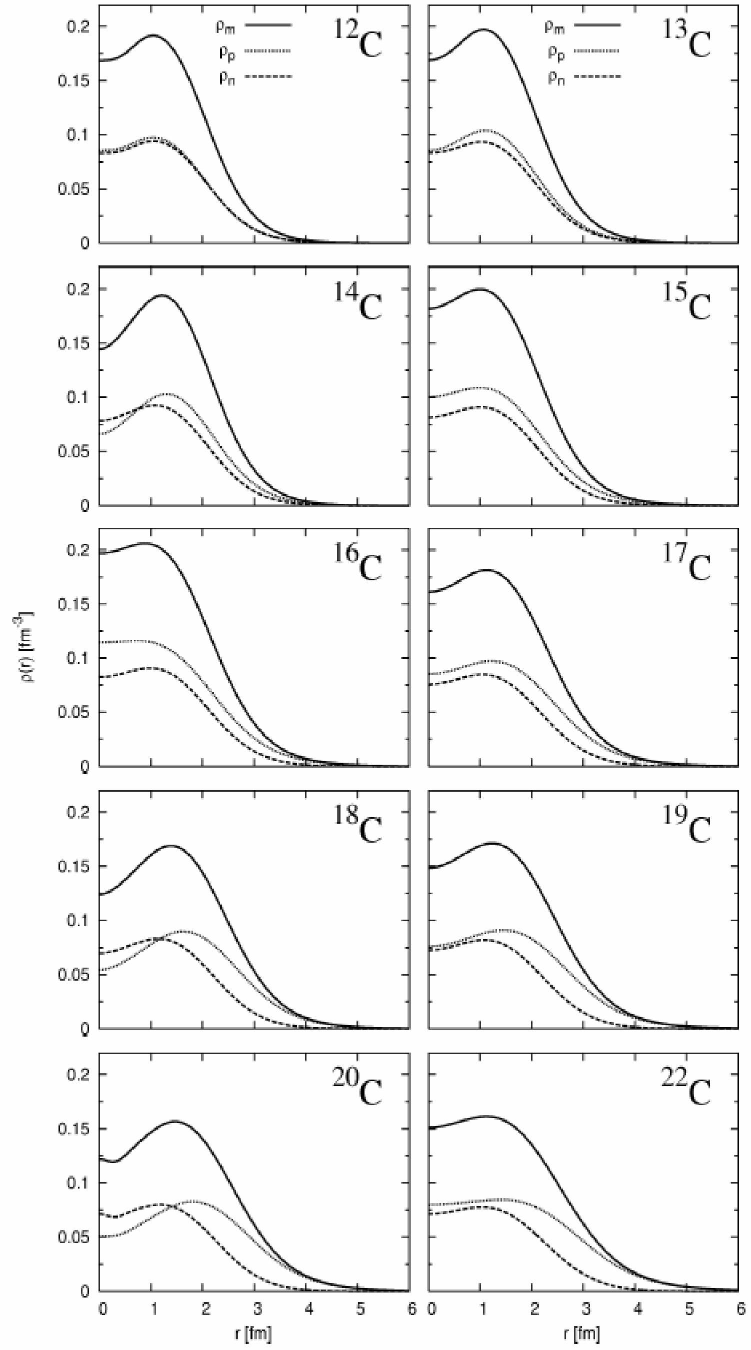


σ^{tot}(p-12C) mb

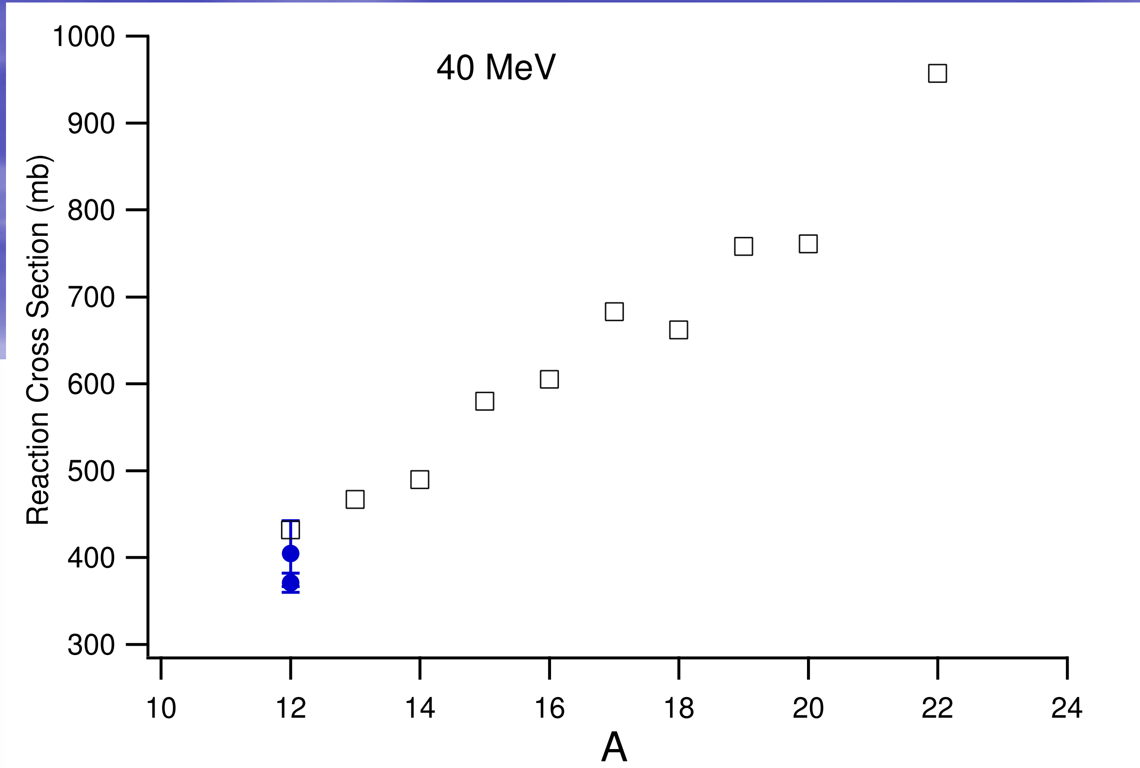
E(MeV)	dashed	solid
40	432	416
60	359	387
80	314	320
100	284	275

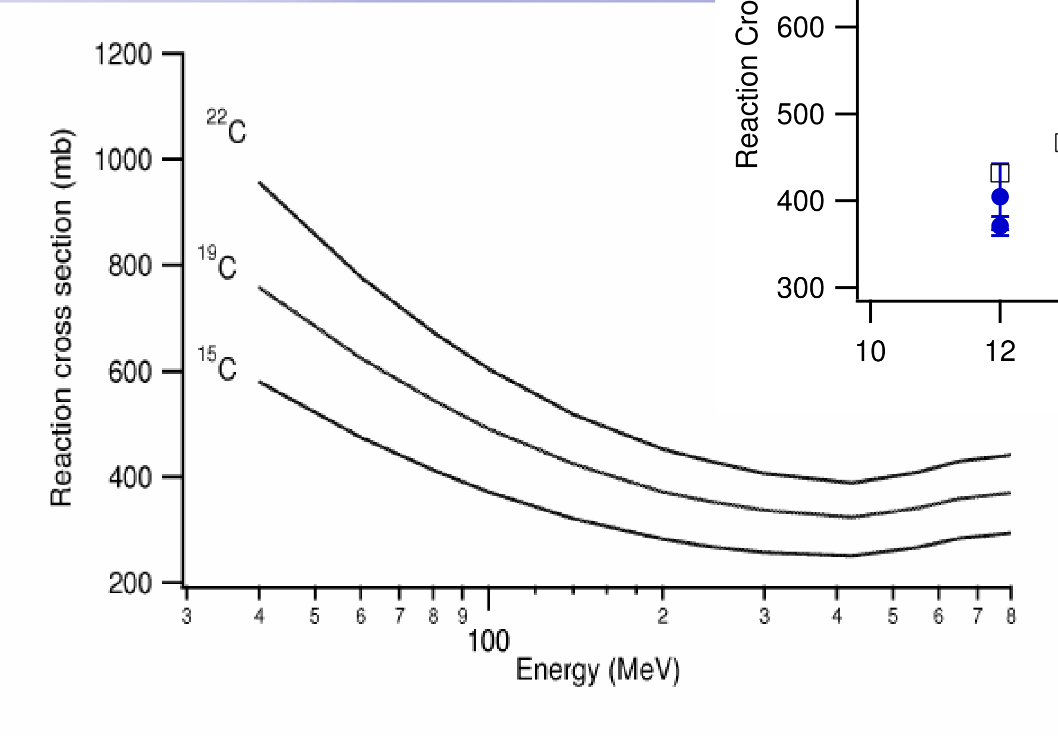
Density distr. of carbon isotopes

- A Slater determinant-type w.f.
- Dynamical model
  - Core+n: odd-A
  - Core+2n: 16C, 22C
- The param. of cen. poten. to reproduce 1*n* (2*n*)-sep. energy.
- c.m. motion is removed.
  - W. Horiuchi et al., PRC75 (2007).



Numerical Results



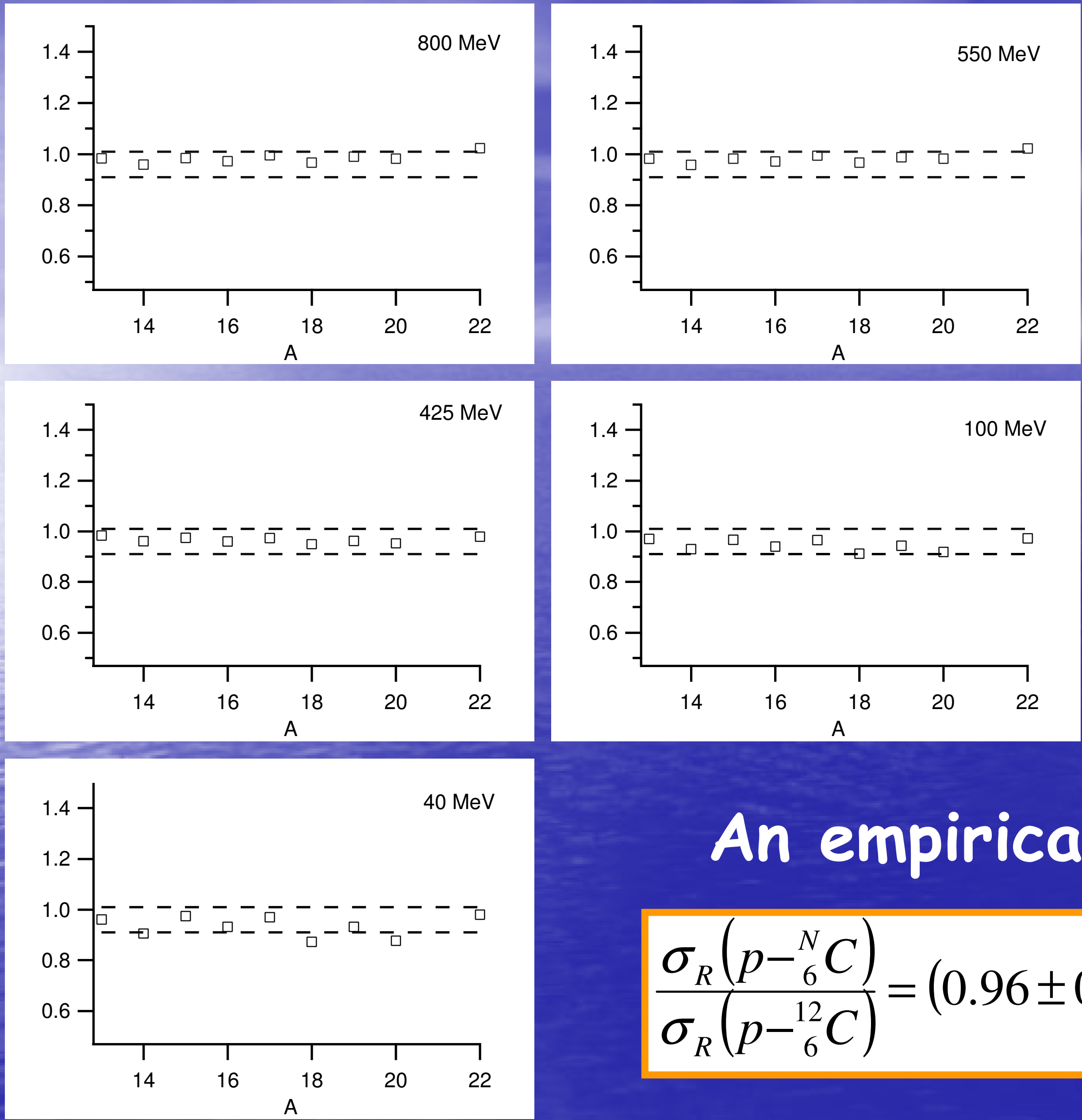


For 22C, the last two neutrons are in s1/2 orbit.

S_{2n} = 0.489 MeV   rms=3.6 fm rcs=957 mb

S_{2n} = 0.122 MeV   rms=4.1 fm rms=1005 mb ⇦

For this case, the breakup effect is expected to increase the cross section, but we estimated it to be less than one %.



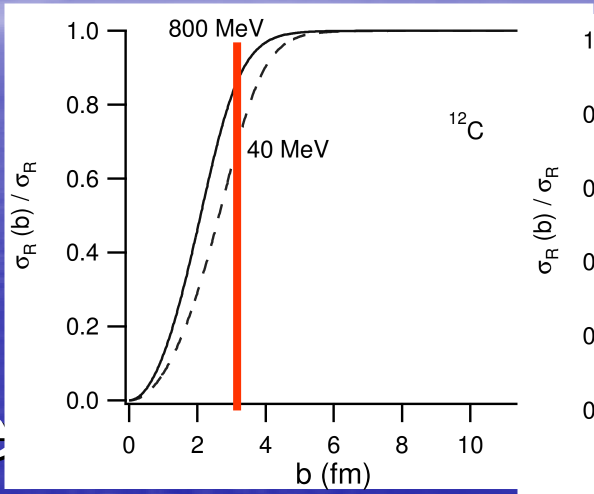
An empirical formula

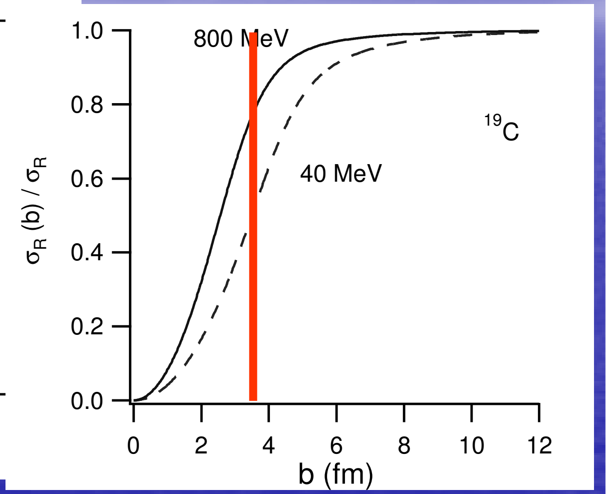
$$\frac{\sigma_R\left(p-{}^{N}_{6}C\right)}{\sigma_R\left(p-{}^{12}_{6}C\right)} = (0.96 \pm 0.05)\frac{6\sigma_{pp} + N\sigma_{pn}}{6\sigma_{pp} + 6\sigma_{pn}}$$

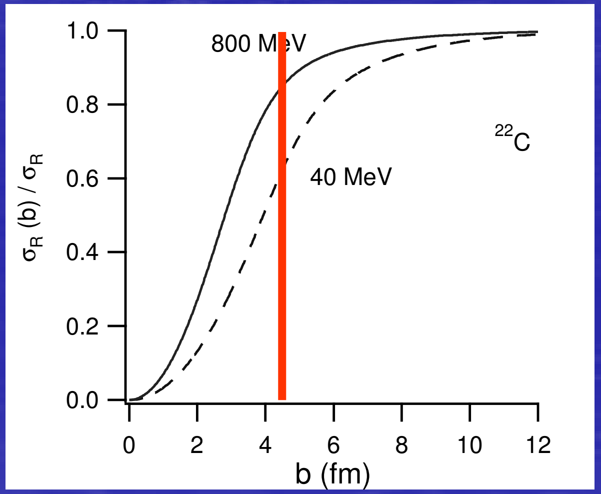
Once we know σ_R of a stable isotope, …

The major contribution to σ_R?

- If we determine a scale, a, from $\sigma_R = \pi a^2$ at 800 MeV, about 80% of σ_R is filled within this scale for all the cases.
- Surface contributions are more or less the same at high E.







$\sigma_R(b)/\sigma_R$

$\sigma_R = \sigma_R(b=\infty)$.

Neutron contributions to the reaction cross sections

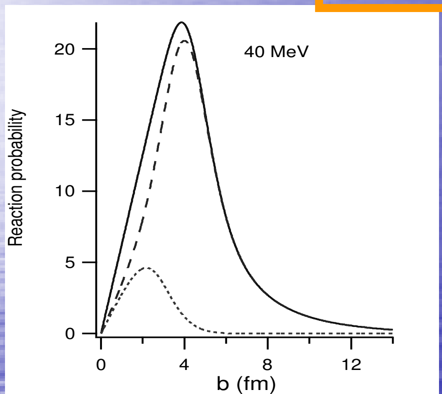
$$\sigma_R = 2\pi \int_0^\infty b\,db\,\left(P_p(b) + P_n(b)\right).$$

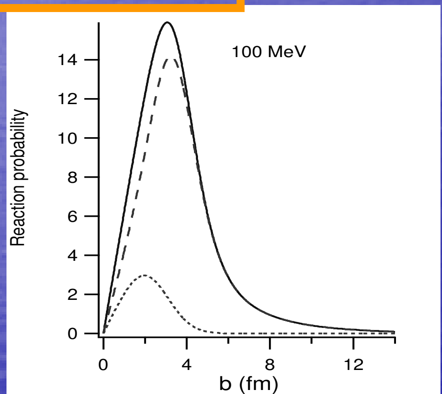
$$P_n(b) = \left|e^{i\chi_p(b)}\right|^2 \left(1 - \left|e^{i\chi_n(b)}\right|^2\right) + c\left(1 - \left|e^{i\chi_n(b)}\right|^2\right)\left(1 - \left|e^{i\chi_p(b)}\right|^2\right)$$

$c + d = 1.$

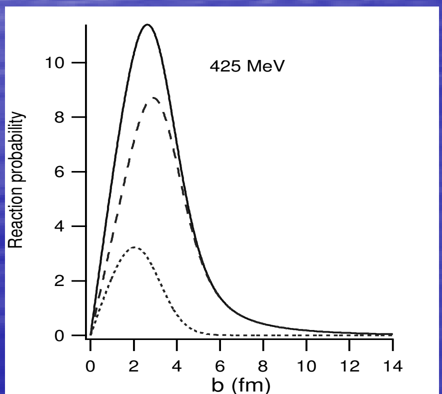
$$P_p(b) = \left|e^{i\chi_n(b)}\right|^2 \left(1 - \left|e^{i\chi_p(b)}\right|^2\right) + d\left(1 - \left|e^{i\chi_n(b)}\right|^2\right)\left(1 - \left|e^{i\chi_p(b)}\right|^2\right)$$

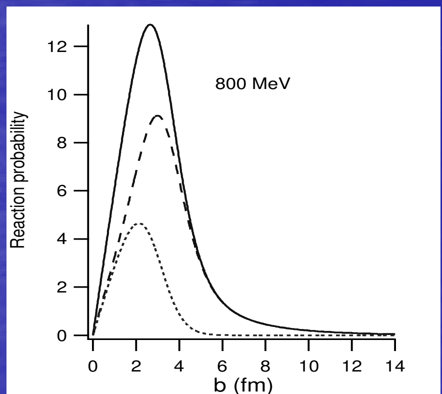
2πb P(b)

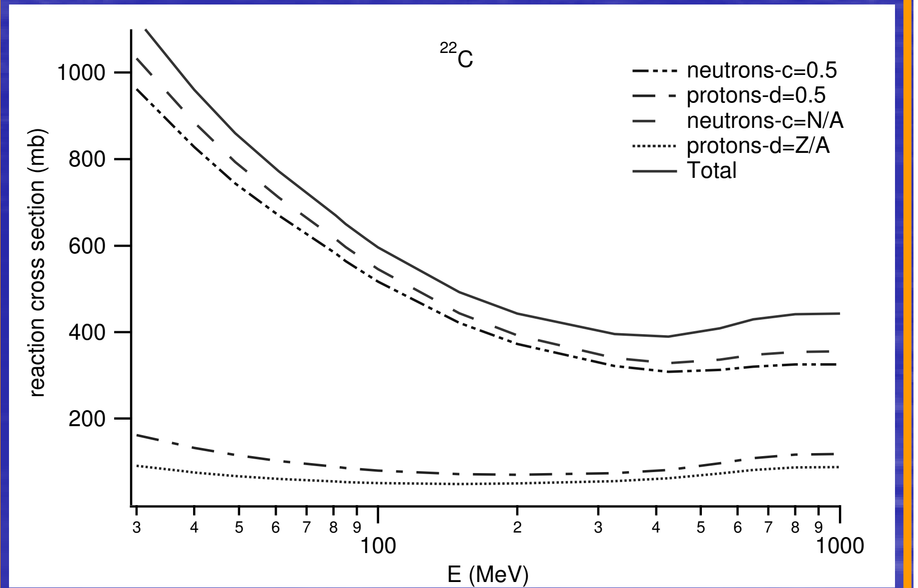




p-22C





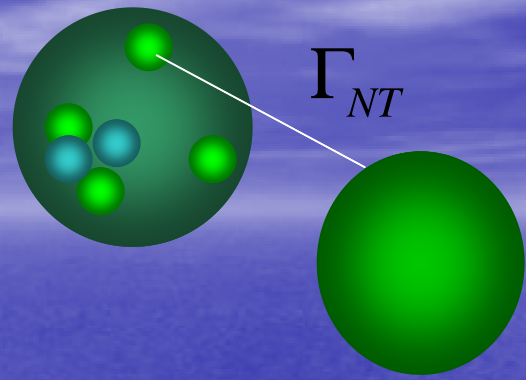


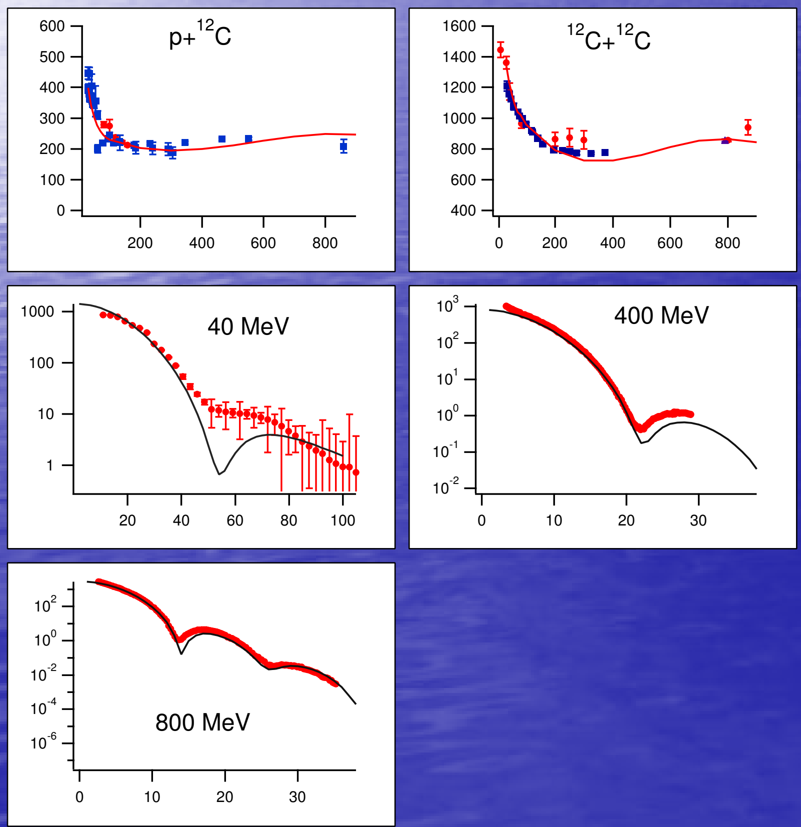
Nucleus-Nucleus Reaction

$$e^{i\chi(b)} = \left\langle \Psi_0 \middle| \prod_{i \in P} \left(1 - \Gamma_{NT}(r_i + b)\right) \middle| \Psi_0 \right\rangle$$

$$i\chi_{OLA}^{NT}(b) = -\int dr \rho_P(r) \Gamma_{NT}(r+b)$$

$$\Gamma_{NT}(b) = 1 - \exp\left(-\frac{i}{\hbar v} \int_{-\infty}^{\infty} U_{NT}(b+z)dz\right)$$

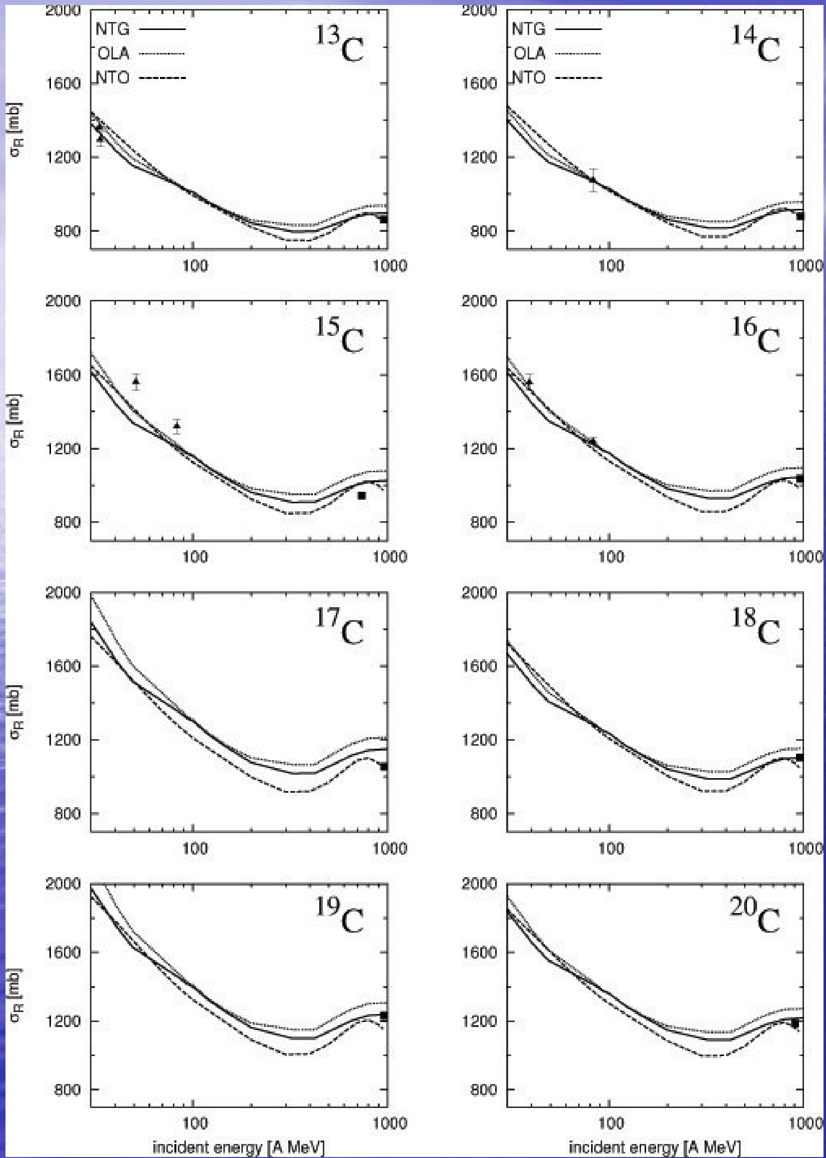


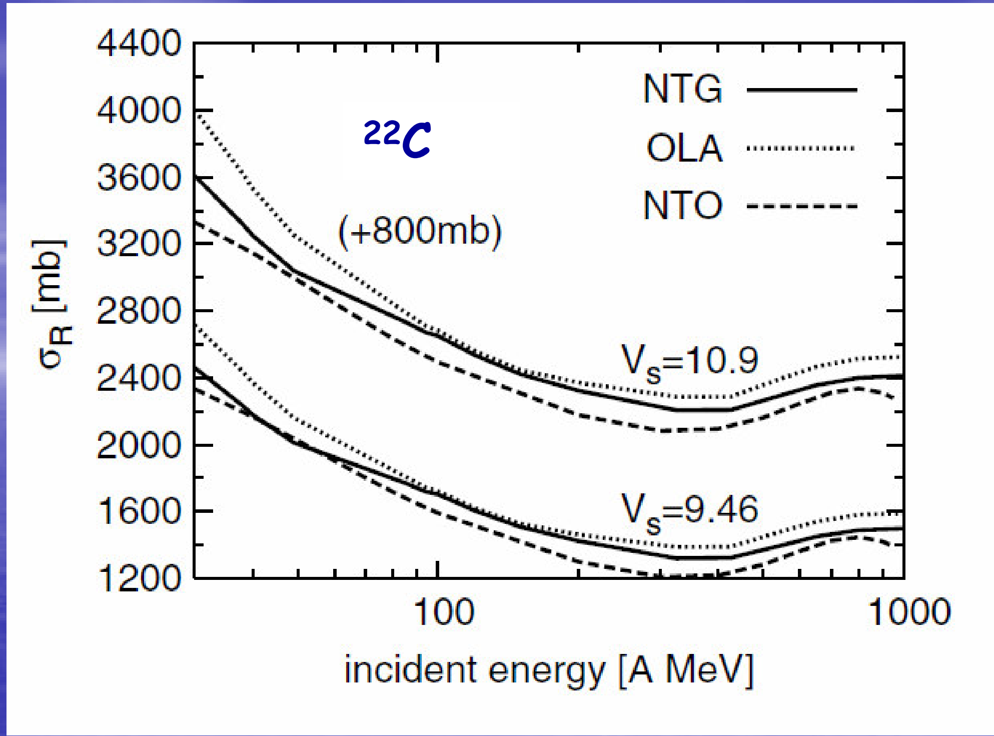


Using N-T interaction means various in-medium effects has been taken into account

1- L.N. Blumberg et al PR 147(1966)812.
2- G.S. Blanpied et al PRL 39(1977)1447.
3- K.W. Jones et al PRC 33 (1986)17.
4- H.O. Meyer et al PRC 23 (1981) 616.
5- M. Takechi et al., Eur. Phys. J. A 25, s01, 217 (2005).
6- S. Kox et al., Phys. Rev. C 35, 1678 (1987).

Numerical Results





Vs for poten. of n-20C.

16C, 22C: core+2n model.

Exp.data:
NPA 693, 32 (2001).
PRC 69, 034613 (2004).
NPA 709, 103 (2002).
PRC 61, 064311 (2000).

Summary

1. We have predicted the reaction cross sections of carbon isotopes incident on a proton target on the energy range from 40 MeV to 800 MeV.

2. A new set of NN-parameters values has been obtained.

3. We have proposed a relation that separates the neutrons and protons contributions to the reaction cross section. The neutron and proton contributions to the reaction cross section have been studied.

4. The reaction cross sections for carbon isotopes incident on 12C have been studied. Our calculations reproduced the available experimental data, except for 15C.

5. The reaction cross section of 22C+12C has been predicted at different energies.