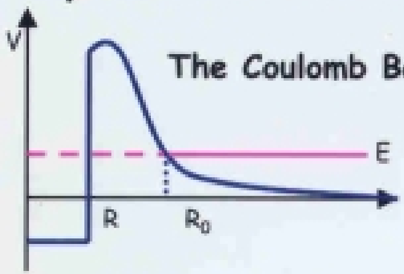
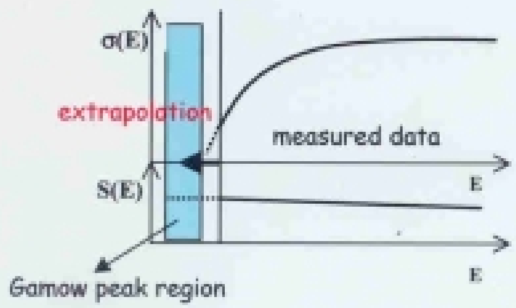
Determination of Nuclear Cross Section at Astrophysical Energies

We have to face several problems

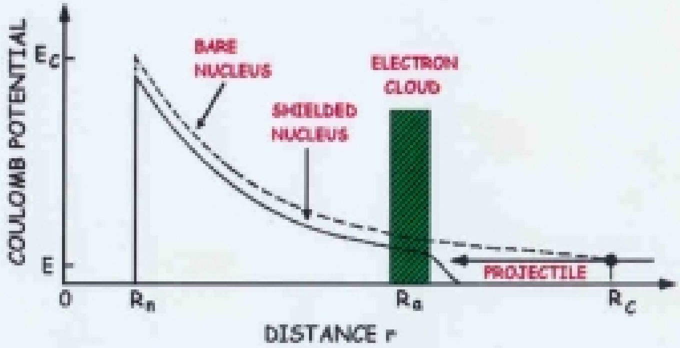
Very low Cross Section





$$\sigma(E) = \pi\lambda^2 \cdot P \cdot S(E)$$

Presence of the Electron Screening Effect



Result: Enhancement of the *Astrophysical Factor*

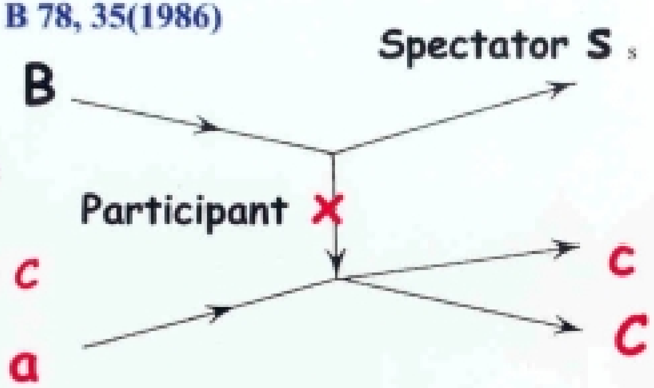
$$f(E) \approx \frac{S_s(E)}{S_b(E)} \approx \exp\left(\pi\eta \frac{U_e}{E}\right)$$

The Trojan-Horse Method

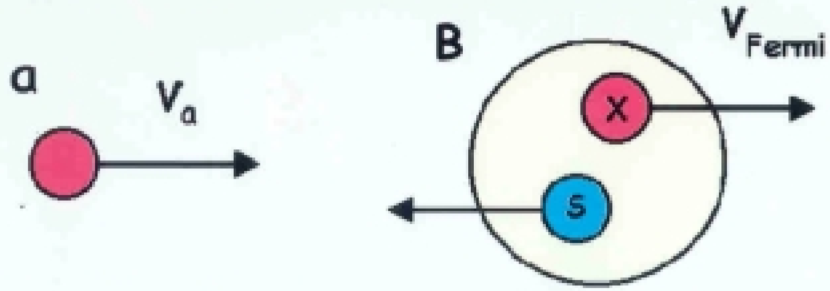
G. Baur Phy. Lett. B 78, 35(1986)

- **Quasi-free mechanism**

three-body reaction $a + B \rightarrow c + C + s$
(with B composed by two clusters $x \oplus s$)
in order to study the 2-body $a + x \rightarrow c + C$
reaction at the astrophysical energies



- If $E_a > E_{Coul} \Rightarrow$ we can neglet Coulomb Effects...
(Coulomb Barrier and Electron Screening)



- but we can have $E_{ax} \approx 0 \Rightarrow$ due to the internal Fermi Motion

The Link between the two-body and the three-body (TH) reaction

Calculated

$$\frac{d^3\sigma}{d\Omega_c\, d\Omega_C\, dE_c} \propto (KF)\cdot\left|G(\vec{P}_s)\right|^2 \cdot \left(\frac{d\sigma}{d\Omega}\right)_{x(a,c)C}$$

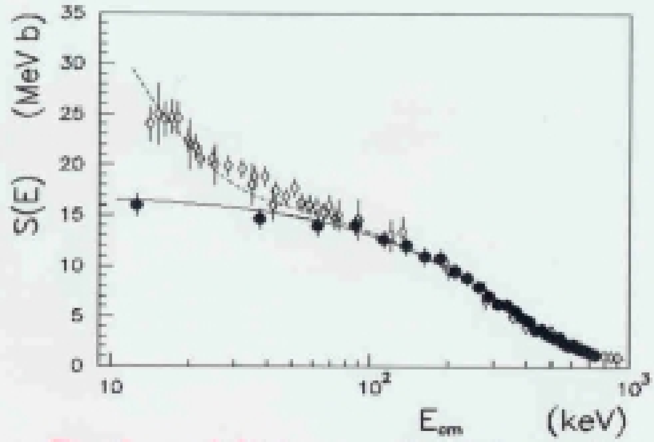
Measured

The two-body relevant Cross-Section

KF= Kinematic Factor

$|G(P_s)|^2$= Momentum Distribution of **s** inside **B**

$^{6}Li(d,\alpha)^{4}He \Leftarrow {}^{6}Li(^{6}Li,\alpha\,\alpha)^{4}He$



$^{6}Li = d \oplus \alpha$

U_e=320±51 eV

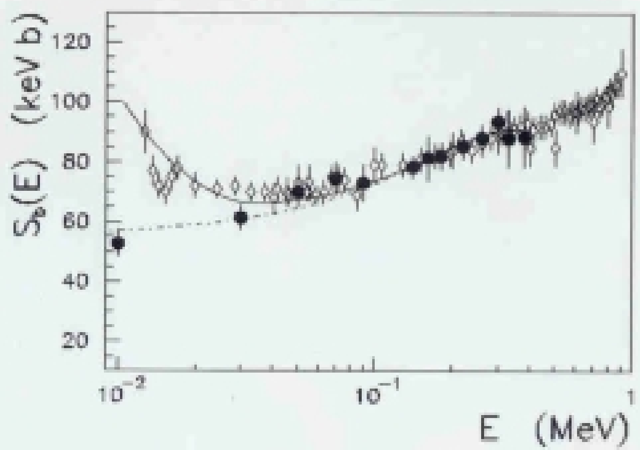
U_{theo}=186 eV

S(0)=16.9±0.5 MeV·b

◊ (Engstler S. et al.: 1992, Z. Phys., A342, 471)

• (C. Spitaleri et al.: 2001, new results)

$^{7}Li(p,\alpha)^{4}He \Leftarrow {}^{7}Li(d,\alpha\,\alpha)n$



$d = p \oplus n$

U_e=330 ±40 eV

U_{theo}=186 eV

S_0=55 ± 3 keV·b

◊ (Engstler S. et al.: 1992, Z. Phys., A342, 471)

• (Aliotta M.. et al.: 2000, Eur.Ph.J. 9, 435)

Summary

U_e (theo) (ad. Limit).	U_e ^{6}Li+d (THM)	U_e ^{6}Li+d (DIRECT)	S(0) ^{6}Li+d (THM)	S(0) ^{6}Li+d (DIRECT)
186 eV	320 ± 50 eV	380±250 eV	16.9 ± 0.5 MeV b	17.4 MeV b

- We confirm the extrapolation trend for S(E);
- We find a good agreement between $U_{e(THM)}$ and $U_{e(DIRECT)}$ previously measured (but with a smaller error bar for $U_{e(THM)}$);
- We find again discrepancies between experimental e theoretical determinations of U_e (troubles with the atomic models ???);
- we find again no isotopic depence of the Screening Effect.

Conclusions

- Reduced Coulomb barrier effects
- Improved information on Electron Screening

- Normalization to Direct Data
- Discrimination from "Background" Reactions

Perspectives...

The reaction $^{6}Li(p,\alpha)^{3}He$ (depletion ^{6}Li e screening);

The reaction $^{3}He(d,p)^{4}He$ (screening).