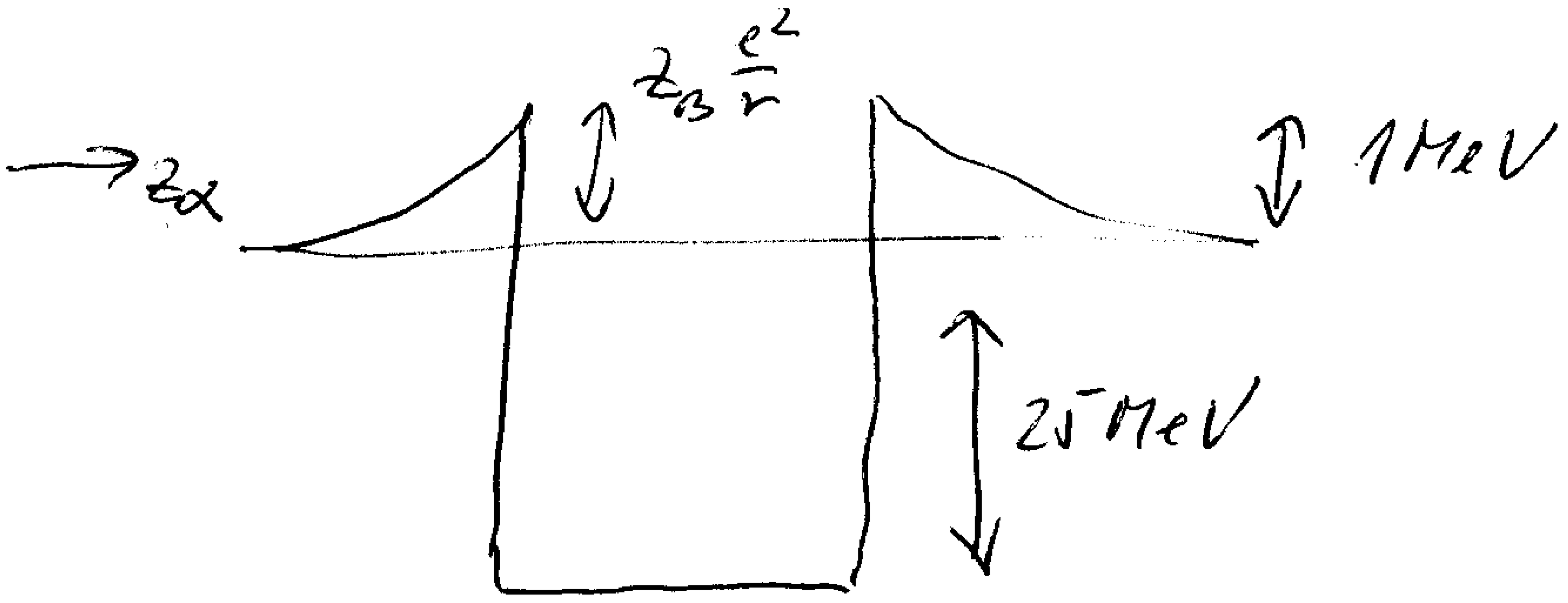
Gamowův pík

reakce pomalé, protože ⊕ + ⊕



p+p bariéra 1 MeV
střední energie ~1 keV

tempo reakcí v jedn. hmotnosti

$$r_{\alpha\beta} \sim n_\alpha n_\beta \langle \sigma v \rangle$$

→ rel. rychlost
→ účinný průřez

$$\langle \sigma v \rangle = \int \sigma v \, f(v)\, dv$$

$$f(v)\,dv \sim v^2 \exp\left(-\frac{m v^2}{2kT}\right) \quad \text{Maxwell-Boltzmann}$$

$$\text{pro } E = \frac{m v^2}{2} \qquad dE \sim v\, dv$$

$$\Rightarrow f(v)\,dv \sim v^2 \exp\left(-\frac{m v^2}{2kT}\right) \sim E \exp\left(-\frac{E}{kT}\right) \frac{dE}{v}$$

$$\Rightarrow \langle \sigma v \rangle = \int \sigma \cancel{v}\, E \exp\left(-\frac{E}{kT}\right) \frac{dE}{\cancel{v}}$$

tedy

$$r_{\alpha\beta} \sim \int \exp\left(-\frac{E}{kT}\right) \sigma(E)\, E\, dE$$

účinný průřez: interakce na de Broglieho vlnové délce s korekčním faktorem tunelového jevu

$$\sigma \sim \lambda_p^2 \exp\left(-\frac{E_e}{E}\right), \quad E_e = \frac{Z_\alpha Z_B e^2}{\lambda_p}$$

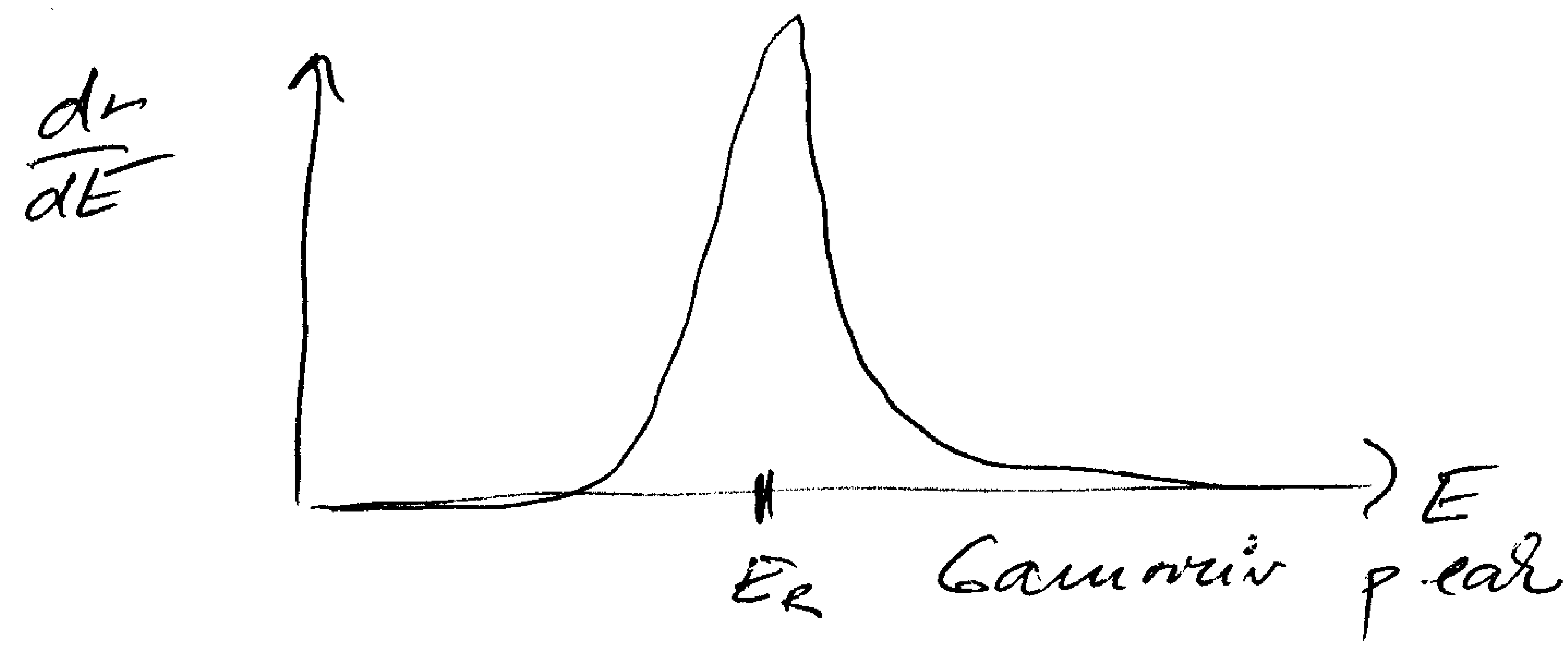
$$\Rightarrow \sigma \sim \lambda_p^2 \exp\left(-\frac{Z_\alpha Z_B e^2}{E \lambda_p}\right) \sim \frac{h^2}{2mE} \exp\left(-\frac{Z_\alpha Z_B e^2}{h} \frac{\sqrt{2mE}}{E}\right) \sim$$

$$\sim \frac{1}{E} \exp\left(-\frac{b}{\sqrt{E}}\right)$$

celkově

$$r_{\alpha\beta} \sim \int e^{-E/kT}\, E\, \frac{1}{E} \exp\left(-\frac{b}{\sqrt{E}}\right) dE \sim \int e^{\left(-\frac{E}{kT} - \frac{b}{\sqrt{E}}\right)} dE$$

max: $E \sim (bkT)^{2/3}$



Odhady z rovnic vnitřní struktury

teplota: hydrostatická rovnováha + stavová rce

$$\langle\rho\rangle \sim M/R^3$$

$$\frac{dP}{dr} \sim \frac{0-P_c}{R_\odot - 0} \sim -\frac{GM\langle\rho\rangle}{(R_\odot - 0)^2} \sim -\frac{GM^2}{R^5}$$

$$\to P_c \sim \frac{\mathcal{R}\langle\rho\rangle T_c}{\mu} \sim \frac{\mathcal{R} M T_c}{\mu R^3}$$

$$\Rightarrow T_c = \frac{P_c \mu R^3}{\mathcal{R} M} = \frac{GM^2}{R^4}\frac{\mu R^3}{\mathcal{R} M} \sim \frac{GM\mu}{R\mathcal{R}} \sim 1{,}4\times 10^7\,\mathrm{K}$$

$\mu \sim 0{,}6$