# nuclear reactions inside an LHC bunch?

$$\langle p_\perp \rangle_{rms} \approx \sqrt{\frac{\varepsilon}{\beta}} p_0 \approx 0.02\,\mathrm{GeV/c}$$

invariant scattering amplitudes:

$$M_{em} = \frac{4\pi\alpha}{q^2}$$

electro-magnetic

$$M_{nucl} = \frac{4\pi\alpha_s}{q^2 + m^2c^2}$$

nuclear (Yukawa force)

$$\alpha_s \approx 1, \quad \alpha \approx 1/137$$

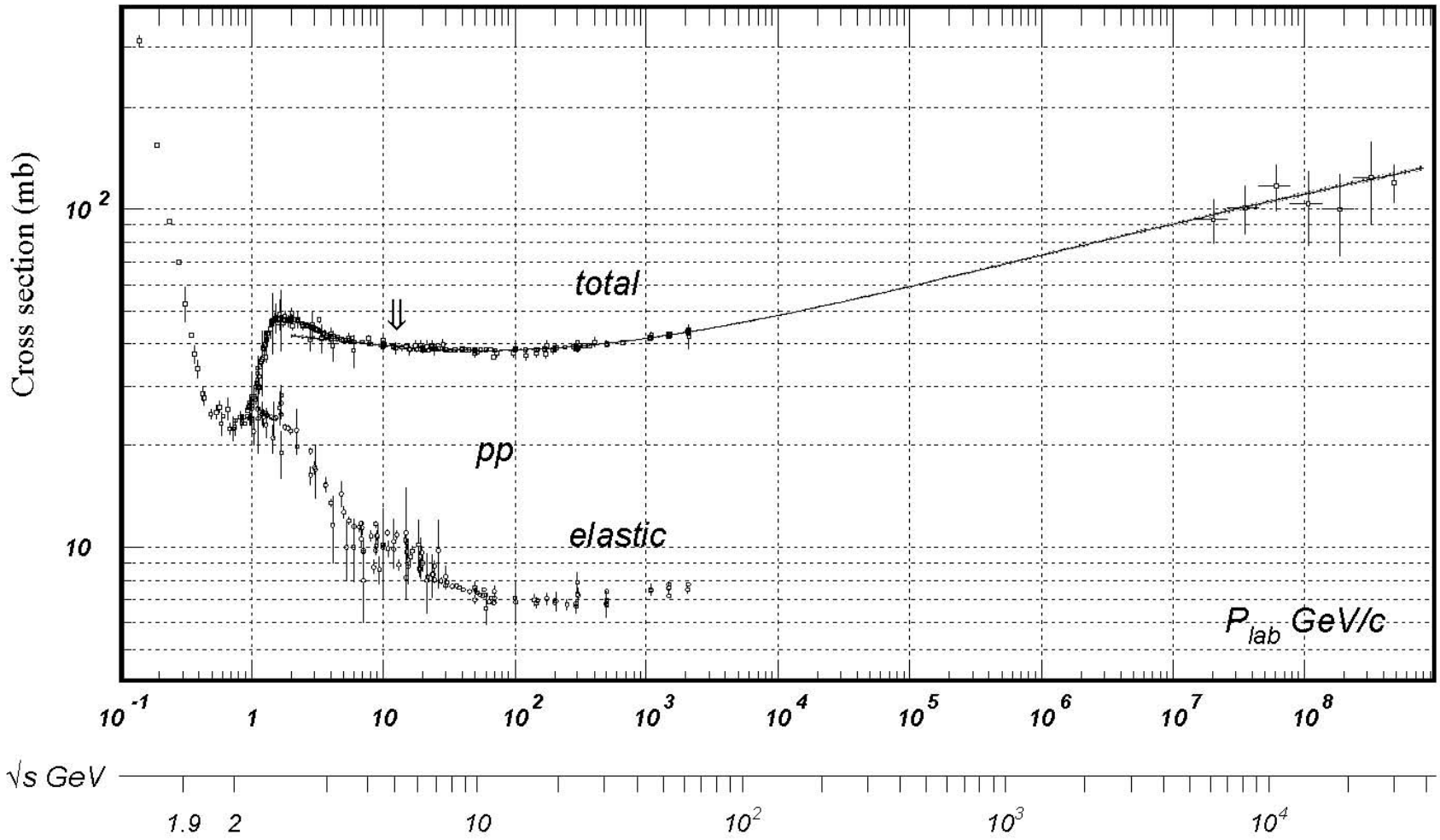
$$\mathrm{mc}^2 \approx 100\,\mathrm{MeV}$$

$$M_{nucl} \approx \frac{q^2}{m^2c^2}\frac{\alpha_s}{\alpha} M_{em} \approx 5.5 M_{em}$$

$$\sigma_{nucl} \propto \left|M_{nucl}^2\right| \approx 30\left|M_{em}^2\right|$$

$$\sigma_{nucl} \approx 30\sigma_{em}$$

from: Review of Particle Properties – the Particle Data Group




$$\sigma \approx 300\,\text{mbarn}$$

$$\frac{1}{\tau} \approx \frac{c\sigma}{\gamma^2} \frac{\sqrt{2} N_b}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \approx 2.5 \times 10^{-6} \frac{1}{s}$$

or 100 h beam lifetime

for comparison

$$\left.\frac{1}{\tau}\right|_{Touschek} \approx 2 \times 10^{-8} \frac{1}{s}$$

ratio roughly consistent with the scaling of the cross section