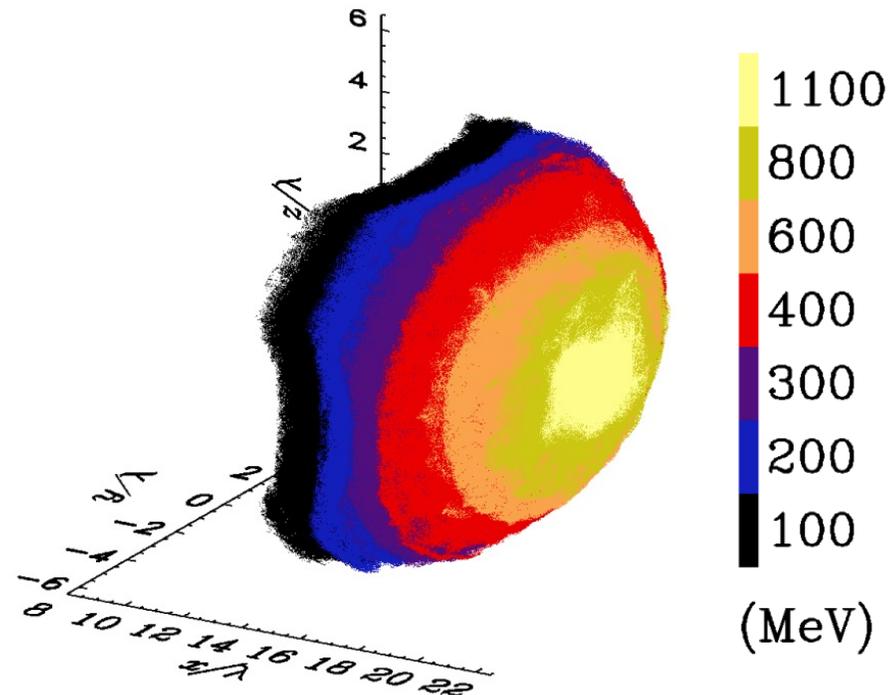


Ion acceleration from intense laser-plasma interactions

João André Matias (I03572)

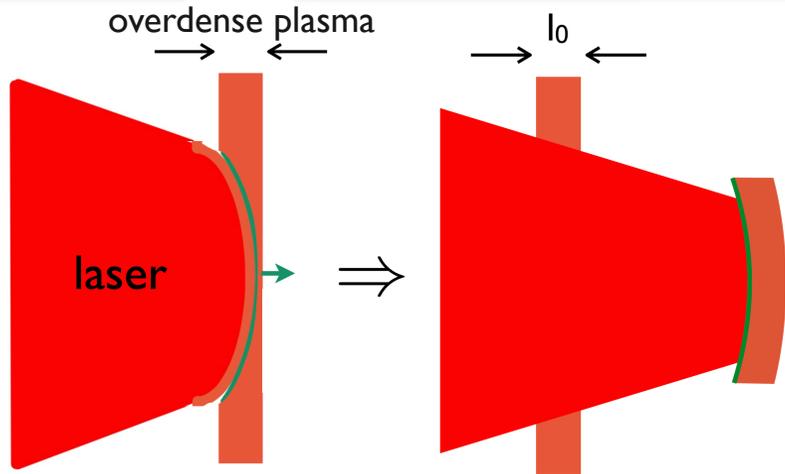
Supervisor: Prof. Frederico Fiúza

GAP / Instituto de Plasmas e Fusão Nuclear
Instituto Superior Técnico, Lisbon, Portugal



Credit: M. Tamburini et al. "Radiation-pressure-dominant acceleration: Polarization and radiation reaction effects and energy increase in three-dimensional simulations"

Light sail (LS) regime



- l_0 = target (foil) thickness
- n_0 = target density
- n_c = critical density
- a_0 = peak normalized laser vector potential
- τ_0 = laser duration

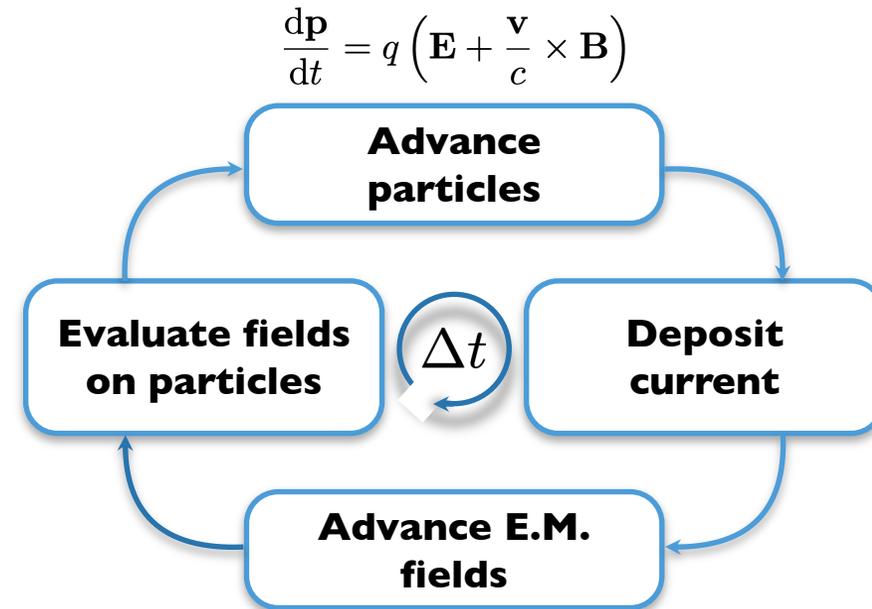
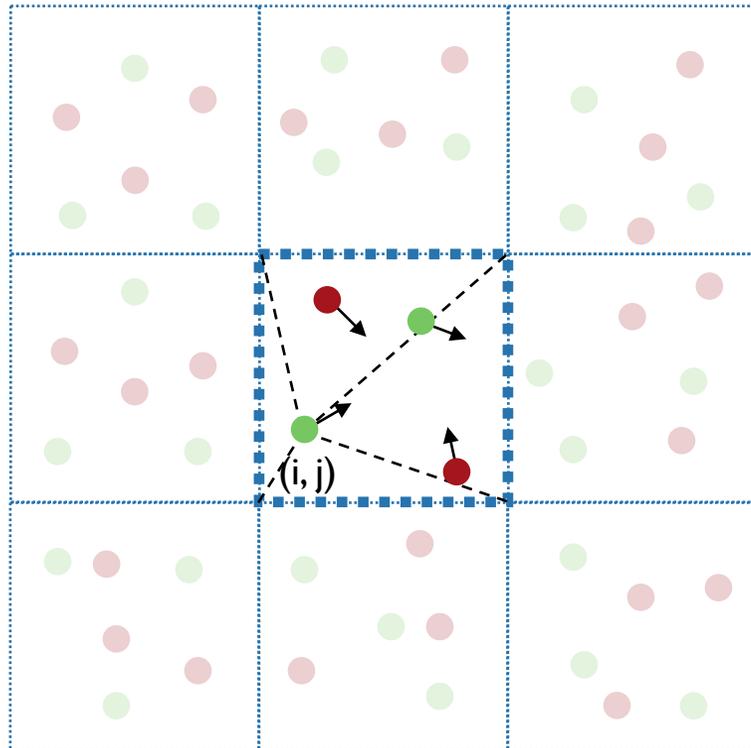
Predicted scalings from the model

Final foil velocity	Peak energy per nucleon	Energy conversion eff.
$\beta_f = \frac{[1 + \mathcal{E}]^2 - 1}{[1 + \mathcal{E}]^2 + 1}$	$\epsilon_0 = m_p c^2 \frac{\mathcal{E}^2}{2(\mathcal{E} + 1)}$	$\eta = 1 - \frac{1}{[\mathcal{E} + 1]^2}$

with $\mathcal{E} \propto \frac{n_c a_0^2 \tau_0}{n_0 l_0}$ \rightarrow Attractive scalings with laser intensity (a_0)

Improved spectral quality (including quasi-monoenergetic ion features) has been **very challenging to observe experimentally**

Particle-in-cell (PIC) simulations were used to study RPA

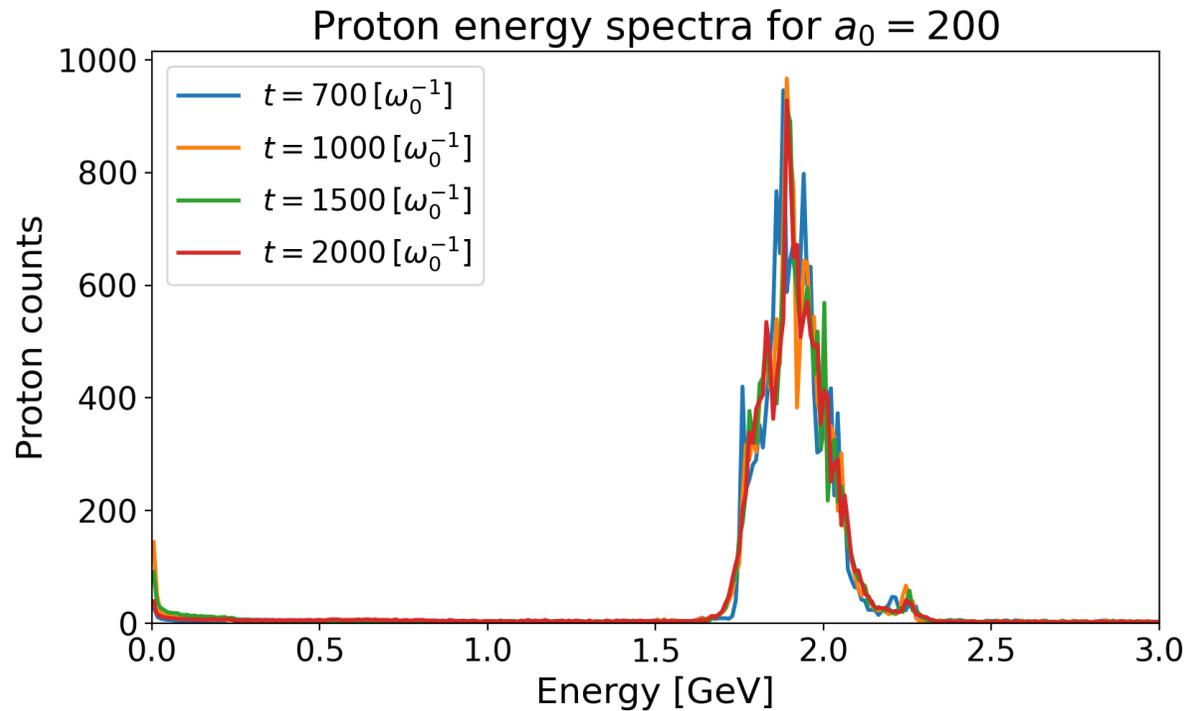


$$\frac{\partial \mathbf{E}}{\partial t} = c \nabla \times \mathbf{B} - 4\pi \mathbf{j}$$
$$\frac{\partial \mathbf{B}}{\partial t} = -c \nabla \times \mathbf{E}$$



Measured acceleration gradients of the order of 10 TV/m!

Ion beam energy spectra from 1D PIC simulations



Peak energy stays well localized around 2 GeV after the acceleration ceases ($t \approx 625 \omega_0^{-1}$)

Acceleration gradient ~ 10 TV/m



5 orders of magnitude higher than in conventional RF accelerators