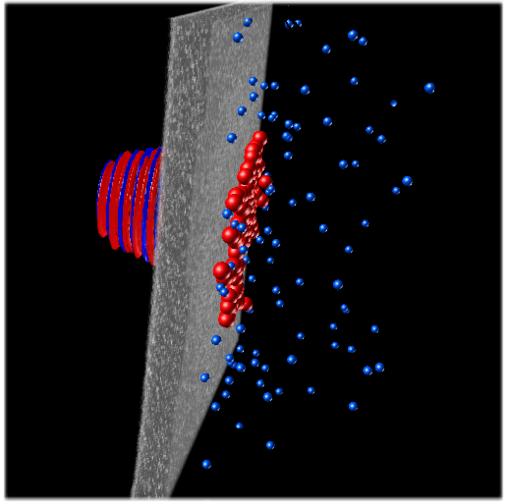
What can we expect from TNSA for SCAPA-like conditions?

Elisabetta Boella

Physics Department, Lancaster University
and
Cockcroft Institute, Daresbury Laboratory

e.boella@lancaster.ac.uk

https://www.lancaster.ac.uk/staff/boella/



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Modelling expected SCAPA conditions using 3D Particle-In-Cell simulations

$I = 9 * 10^{20}$ W/cm^2

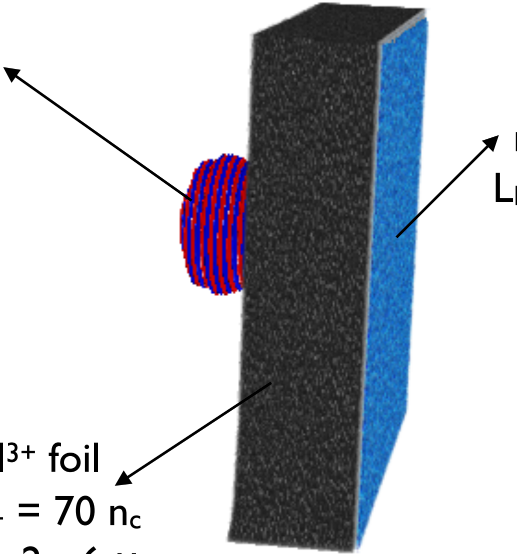
$\lambda_0 = 800$ nm

$a_0 = 20.52$

$\tau_{FWHM} = 25$ fs

$w_0 = 1.5$ µm

p - polarised



H^+ layer

$n_{H+} = 1.15\ n_c$

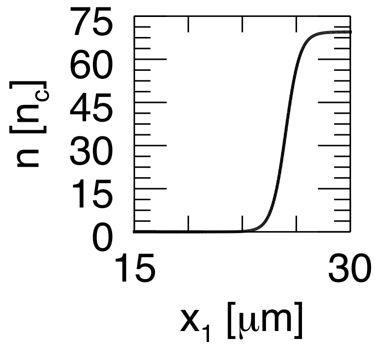
$L_{H+} = 31.83$ nm

Al^{3+} foil

$n_{Al3+} = 70\ n_c$

$L_{Al3+} = 2 - 6$ µm

Initial density profile detail



$$n_{Al^{3+}} = 70\frac{n_c}{2}\left[\tanh\left(\frac{x_1 - x_{1,0}}{L_g}\right) + 1\right]$$

$x_{1,0} = 25.5$ µm

$L_g = 0.08 - 1$ µm

58920 time steps (~ 1.8 ps)

12288 CPUs x ~ 30 h

~ 370,000 CPUhours ~ £ 10,000

Bulk target ions and contaminants are accelerated by the charge separation field triggered by the escaping hot electrons

2 μm thick target, L_g = 0.08 μm

Electron longitudinal phase space

H^+ longitudinal phase space

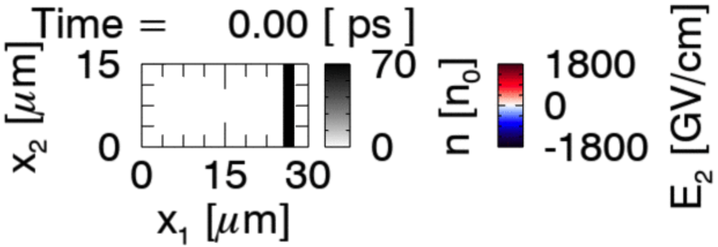
Laser electric field and plasma density

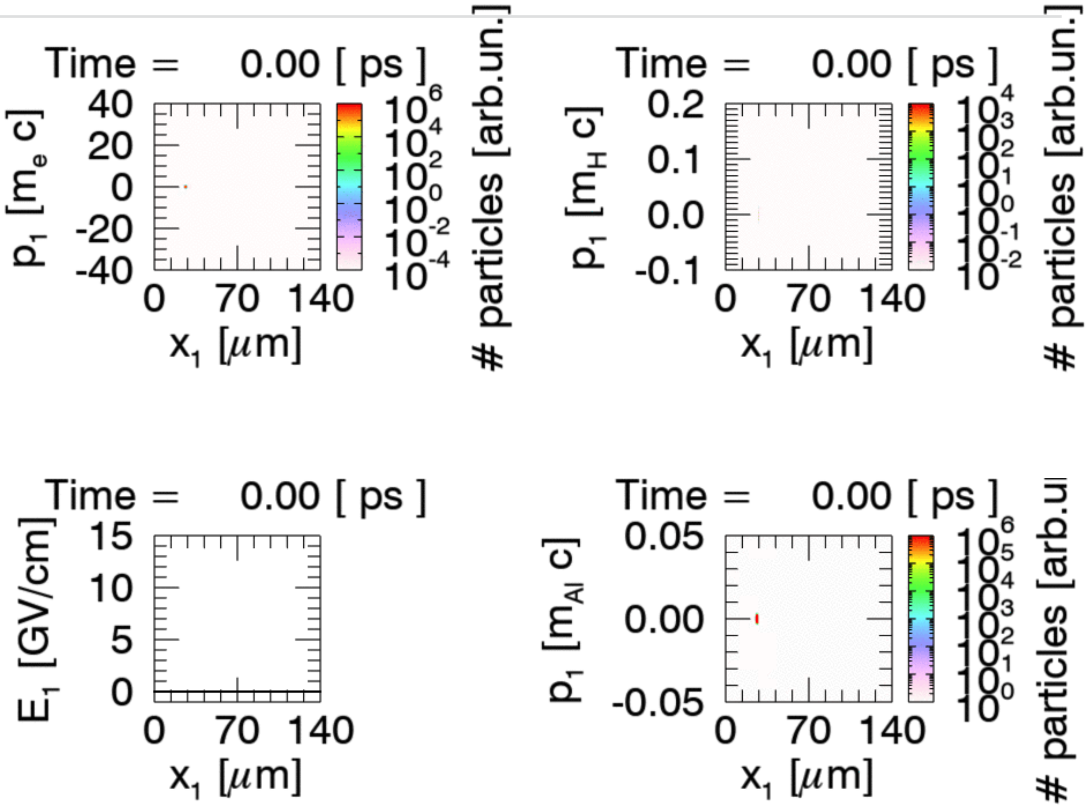
Longitudinal electric field

Al^{3+} longitudinal phase space

Bulk target ions and contaminants are accelerated by the charge separation field triggered by the escaping hot electrons

2 µm thick target, L_g = 0.08 µm

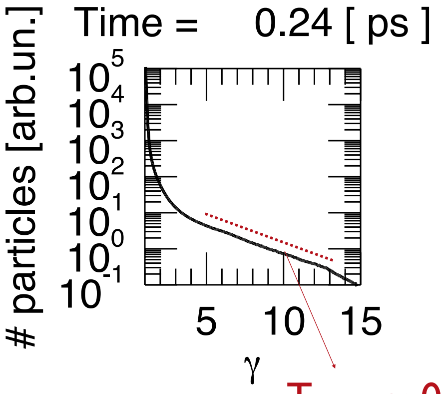




Selected protons are collimated

2 μm thick target, L_g = 0.08 μm

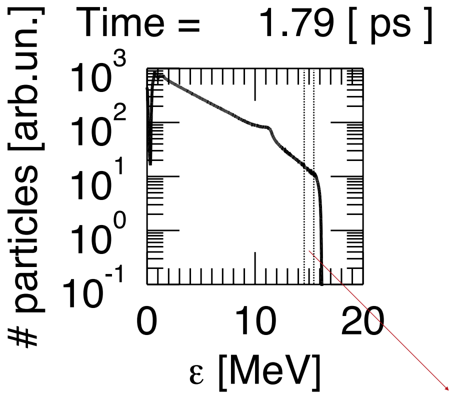
Electron distribution function



$T_{e,hot}$ ~ 0.88 MeV

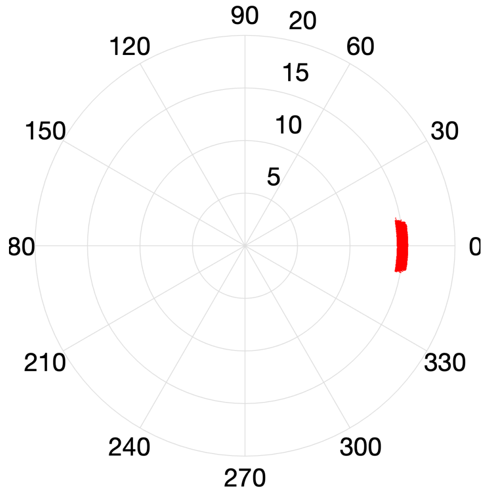
$T_{e,pond}$ = 6.93 MeV

Proton spectrum



8.7 pC

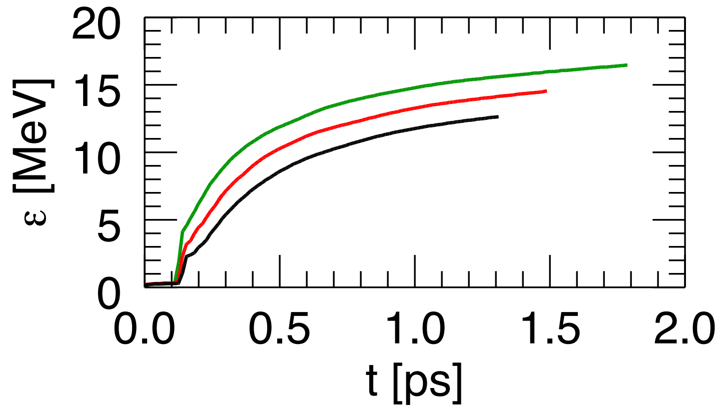
Divergence of proton with $14.5\ \text{MeV} \leq \varepsilon \leq 15.5\ \text{MeV}$



θ_{rms} ~ 4°

In the case of almost abrupt plasma-to-vacuum transition, only the 2 μm Aluminium target allows for achieving LhARA target goals

Proton cutoff energy vs time



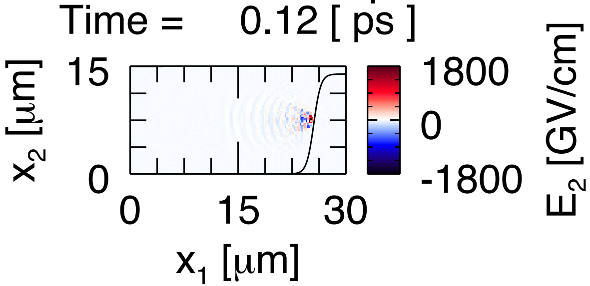
— 6 μm — 4 μm — 2 μm

A short scale-length pre-plasma leads to proton energies higher than 15 MeV using thicker targets

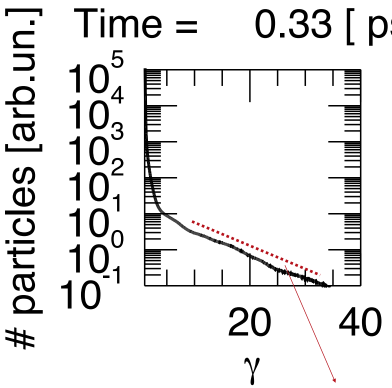
6 μm thick target

L_g = 1 μm

Laser electric field and plasma density

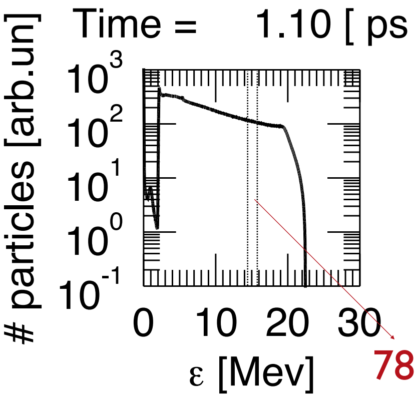


Electron distribution function



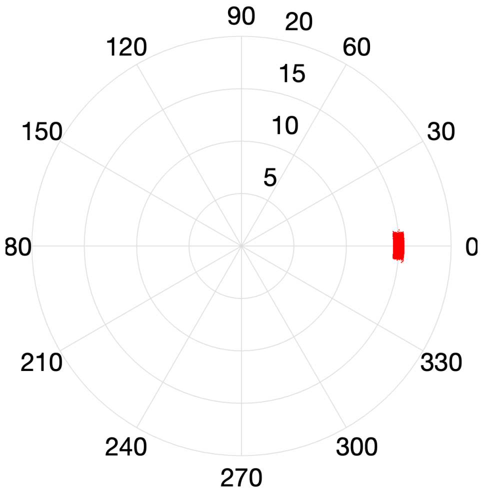
$T_{e,hot}$ ~ 1.85 MeV

Proton spectrum



78 pC

Divergence of proton with $14.5\,\mathrm{MeV} \leq \varepsilon \leq 15.5\,\mathrm{MeV}$



θ_{rms} ~ 1.14°

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Summary

- We explored via 3D Particle-In-Cell simulations the interaction of the SCAPA laser with Aluminium foils of different thicknesses.
- We also investigated the effect of the presence of a pre-plasma in front of the target.
- In the case of almost abrupt plasma-vacuum transition, very thin Aluminium targets (~2 μm) will be necessary to exceed proton energies of 15 MeV.
- The presence of a pre-plasma allows for accelerating protons to energies >> 15 MeV with thicker targets. Protons appear to be better collimated.