Progress of the L3IA ion beamline at ILIL-PW

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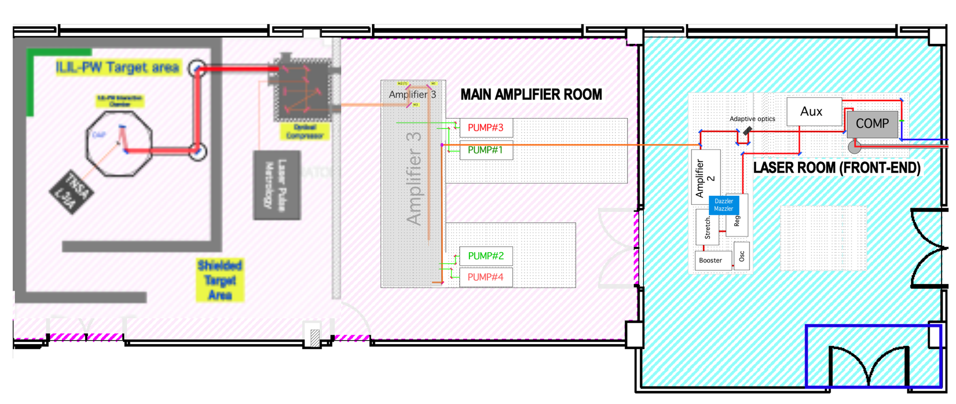
Abstract

We report on the recent experimental results obtained at the Laser Light Ion beam-Line using both flat and nanostructured thin foil targets, where accelerated ions were characterized using a wide range of detection techniques, optimized for the severe conditions typical of a laser-plasma acceleration environment. Advanced targets are also being explored with special attention to nanostructured targets, including nano-pillars and porous materials that are used for their role in modifying the electron distribution function of fast electrons. Preliminary results and numerical simulations show that a key role is played in these measurements by the level of plasma filling gaps and cavities in the target, before the ultrashort laser pulse hits the target. In view of the applications, we also focus on the shot by shot fluctuations of the ion source, investigating the possible role of target imperfections, laser-beam energy, focal spot intensity, pulse duration and pointing stability.

The ILIL-PW facility

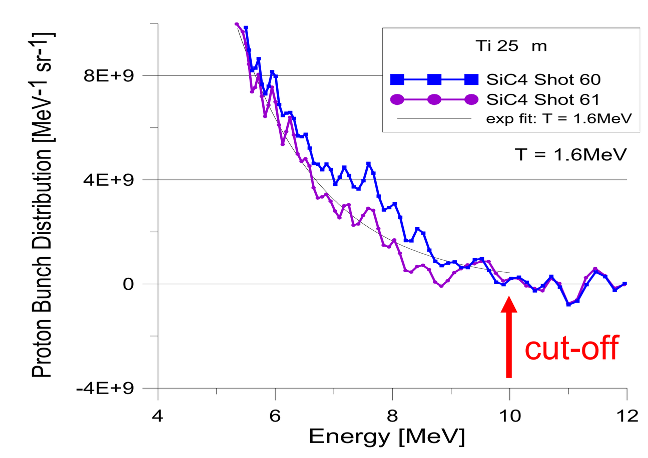
Phase 1: operational since July 2017 – Phase 2 being commissioned

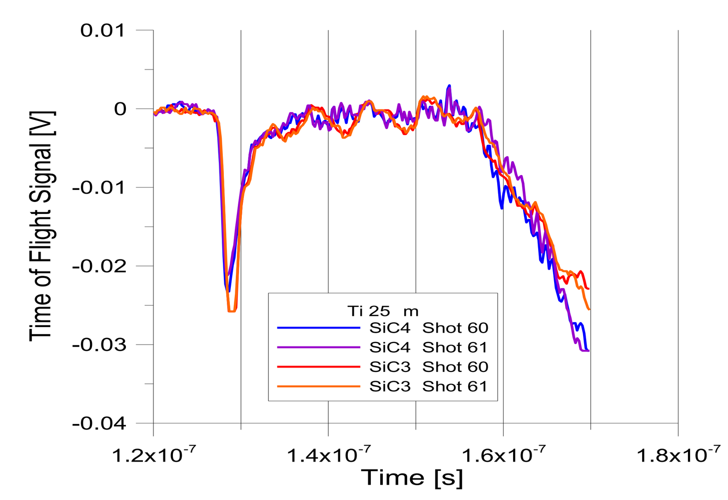
MAIN BEAM	0th Phase	1st Phase	2nd Phase	Final
Wavelength (nm)	800	800	800	800
Pump Energy (J)	1.8	10	15	20
Pulse Duration (fs)	40	30	30	25
Energy Before Compression (J)	0.6	4	6	7.5
Energy After Compression (J)	0.4	3	4.5	5.6
Rep. Rate (Hz)	10	1	1	2
Max intensity on target (W/cm^2)	2x10^{19}	2x10^{20}	2.5x10^{20}	>3x10^{20}
Contrast@100ps	>10^9	>10^9	>10^9	>10^{10}
Beam Diameter (mm)	36	100	100	100

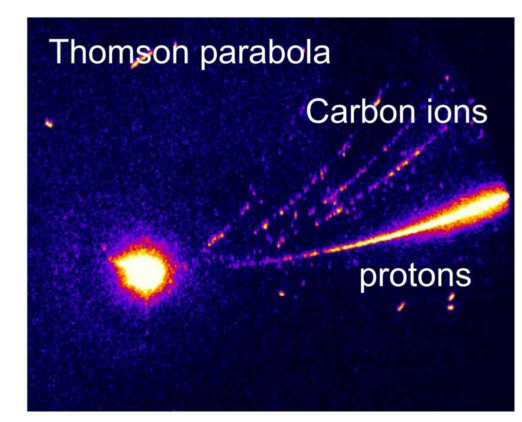


Ion measurements

In TOF detection scheme due to the high particle fluxes, it is not possible to distinguish between individual particles. A deconvolution approach that provides valuable information about proton bunch distribution vs. proton energies has been developed and a preliminary result is shown in figure.

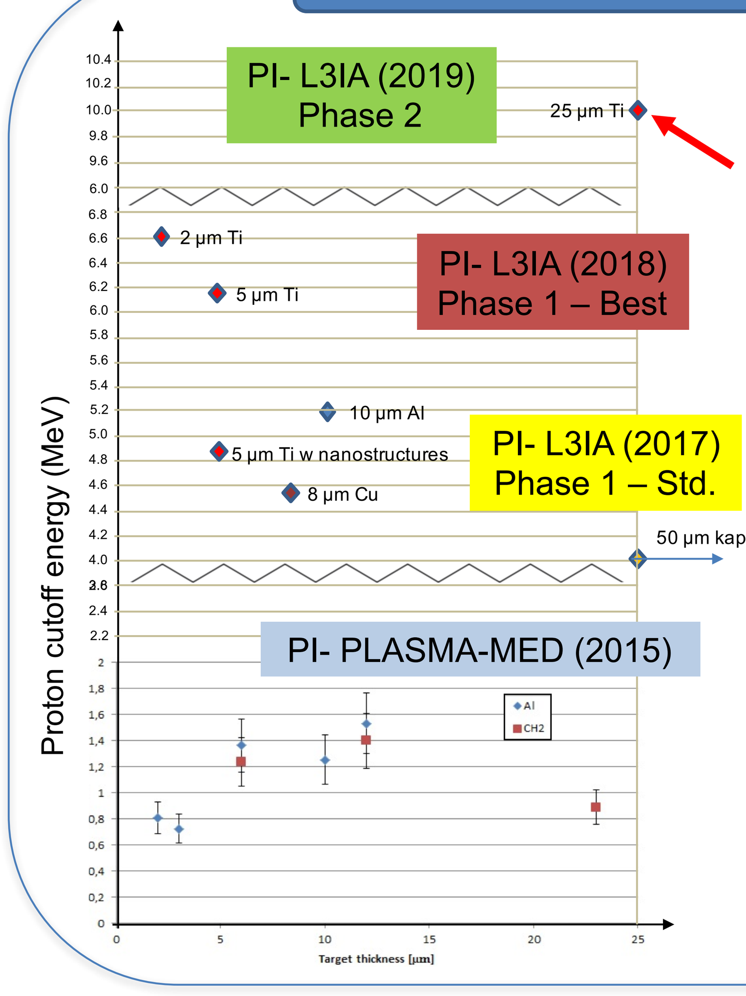


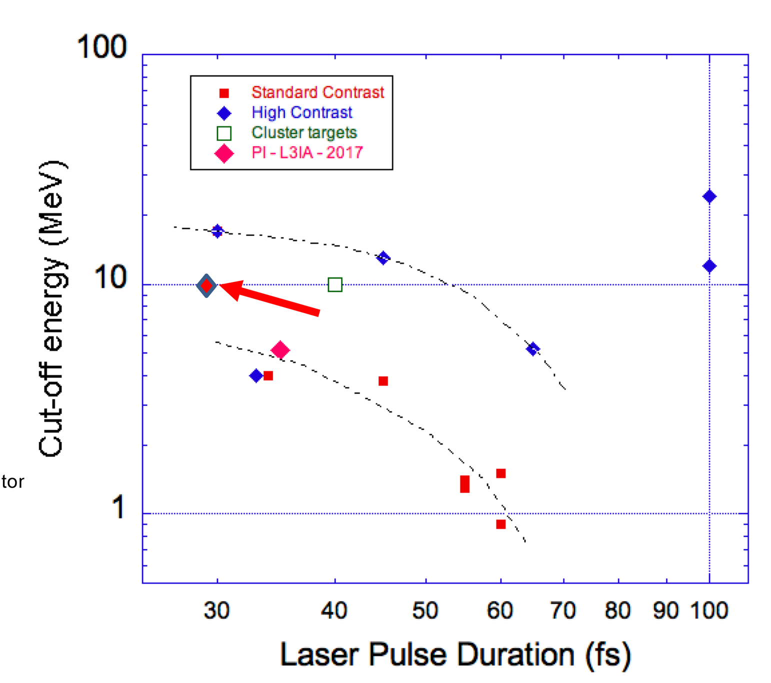




Advanced, high quality ion measurements

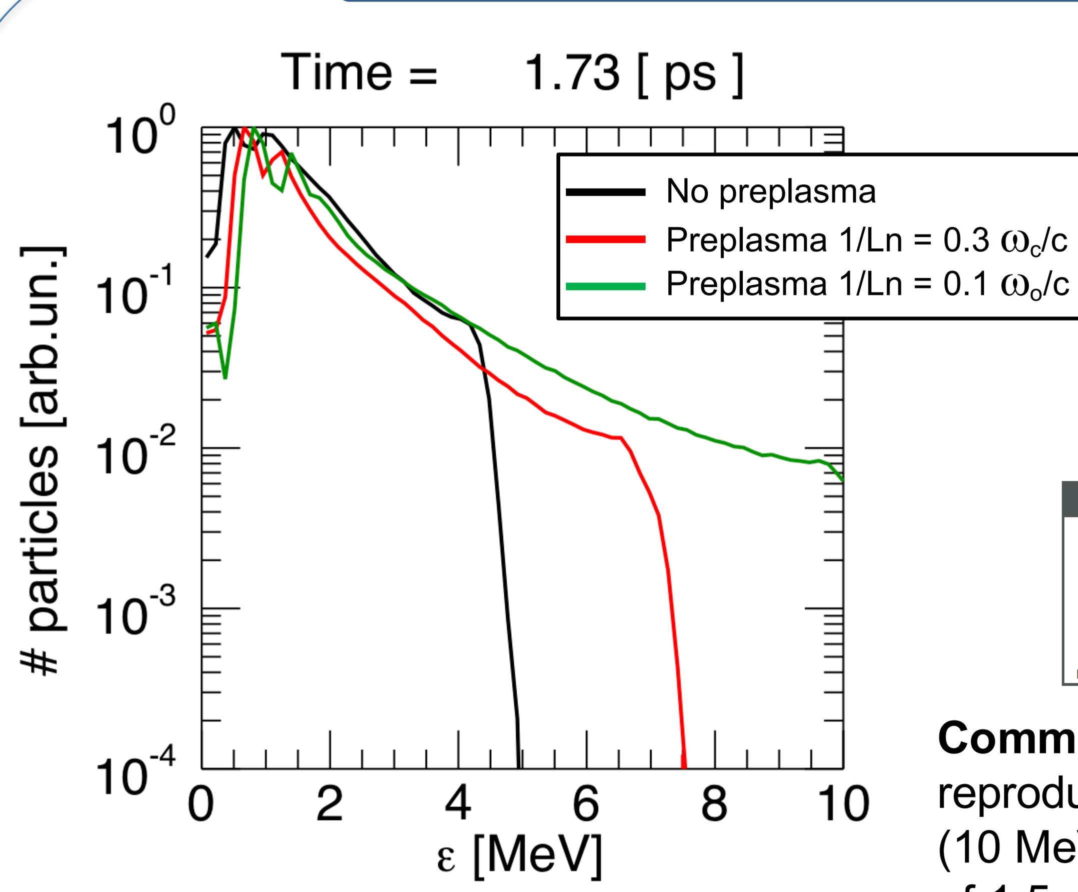
Main results [2] with flat targets

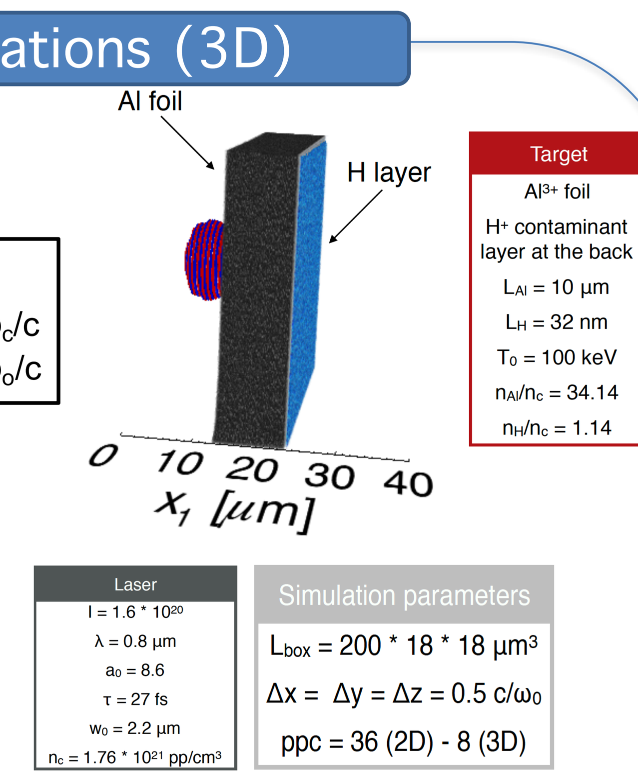




Comment: Main (best) experimental results with standard flat foils – Phase 1 of Laser configuration (see table above) show cut-off energy exceeding typical (published[3]) values without plasma mirror.

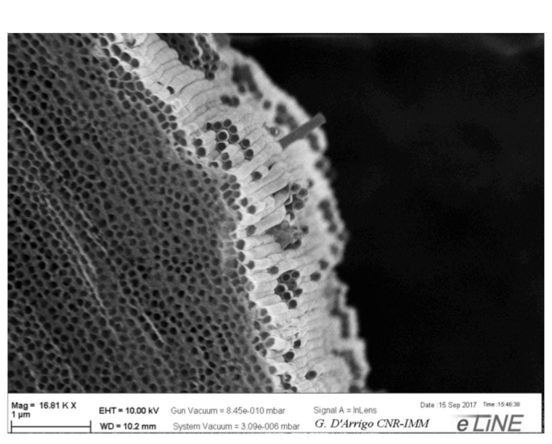
OSIRIS Numerical simulations (3D)



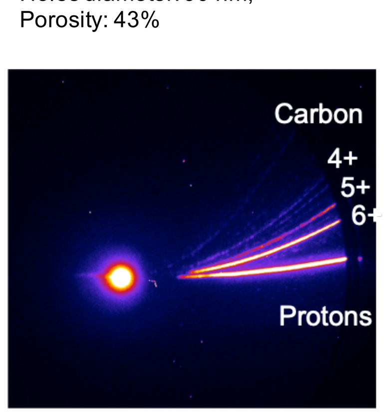


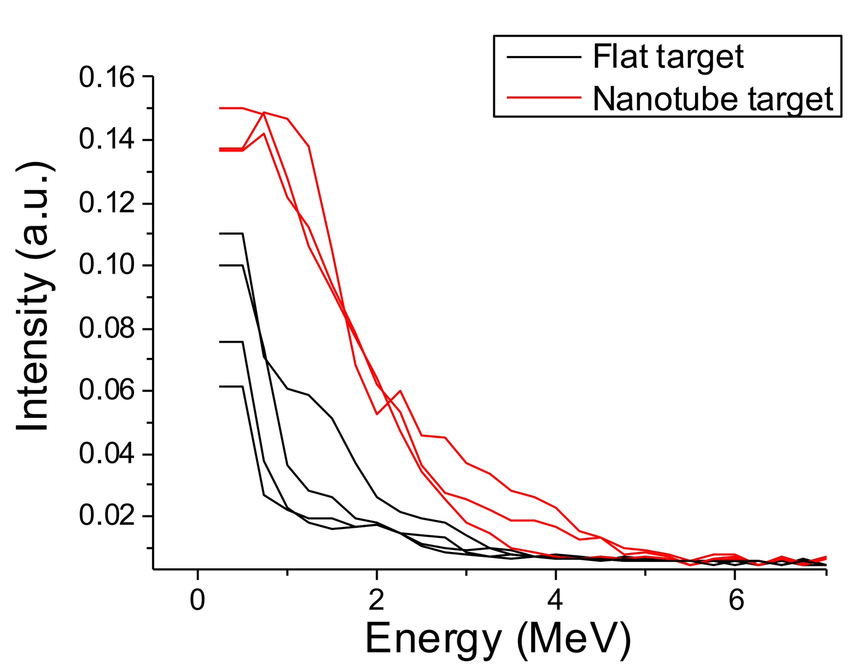
Comment: 3D numerical simulations reproduce the protons cut-off energy (10 MeV) for a pre-plasma scalelength of 1.5 μm (with 10 μm thickness Al.)

Main results with nanostructured targets



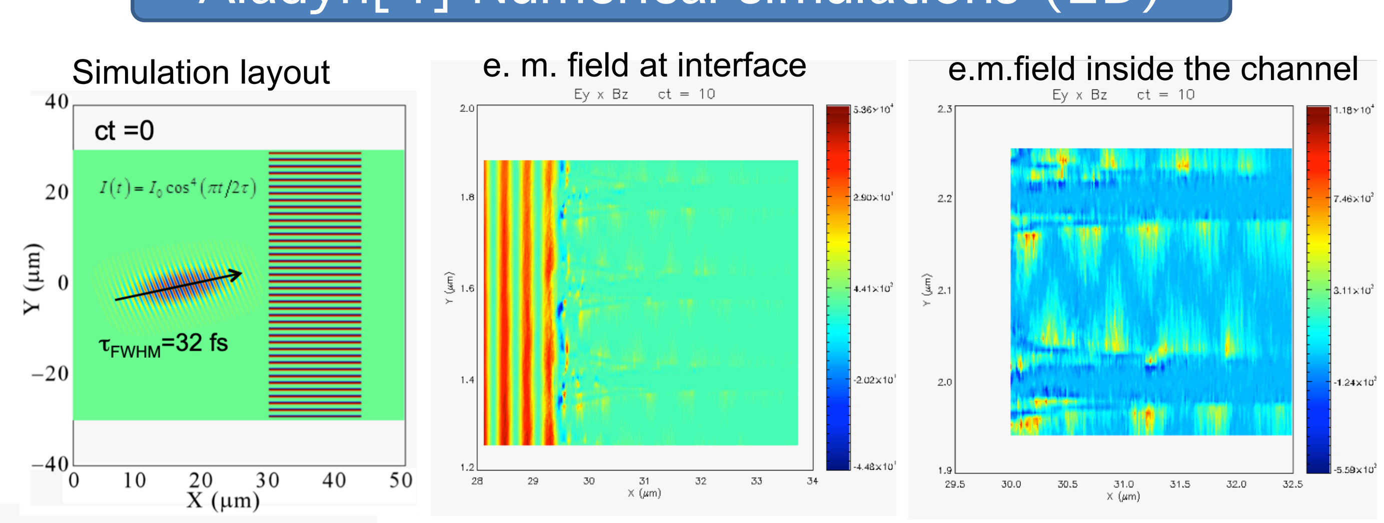
Target: 14 micron whole thickness
Holes diameter: 90 nm,
Porosity: 43%

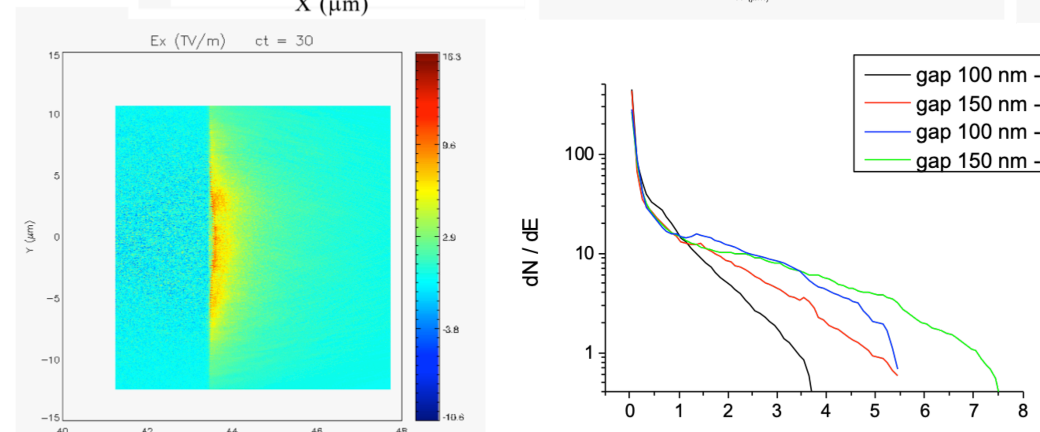




Comment: proton spectra from irradiation of porous targets show higher proton flux with enhanced cut-off energy compared to flat targets.

Aladyn[4] Numerical simulations (2D)





Comment: the enhancement of cut-off energy in porous targets found experimentally, is observed also in simulations. Electrons are predominantly accelerated at the edges of the hole, where the e.m. field propagates. The proton cut-off energy increases with the hole diameter.

Acknowledgements

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References

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