X-ray radiation source preliminary characterization within the EuAPS project

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Plasma-based accelerators are capable of intrinsically generating betatron radiation emitted by accelerated electrons.
This radiation is ultra-short (fs-range), spatially coherent, and its emission spectrum ranges from soft/hard X-rays up to gamma rays.

Introduction

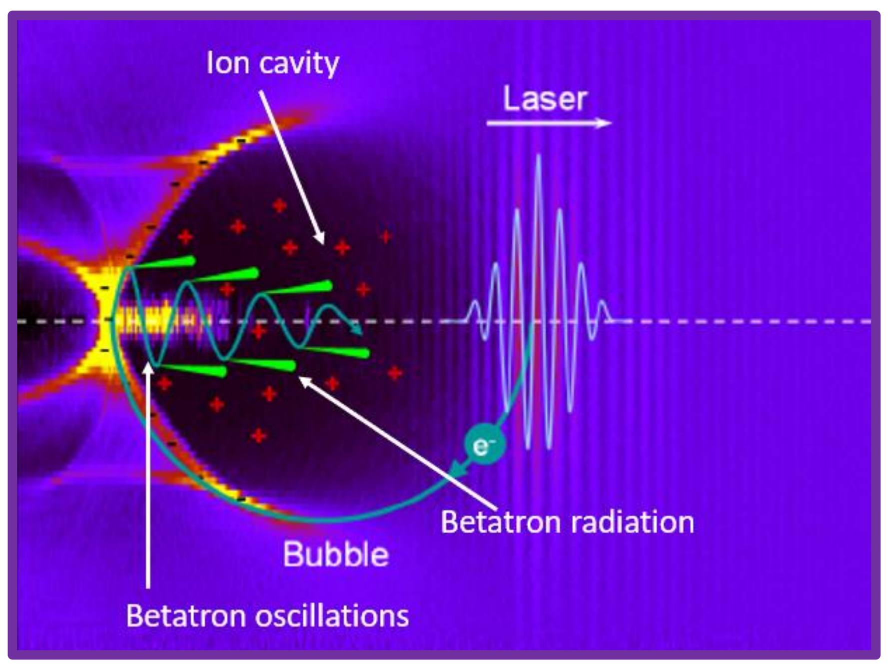


Fig: Simple sketch of the LWFA process [1].

High-intensity laser pulse - plasma interaction results in the generation of energetic electron bunches and X-ray radiation emission.
The radiation is emitted from electrons undergoing transverse oscillations around the reference orbit while accelerating under the action of a longitudinal field.

Experimental setup at CLPU

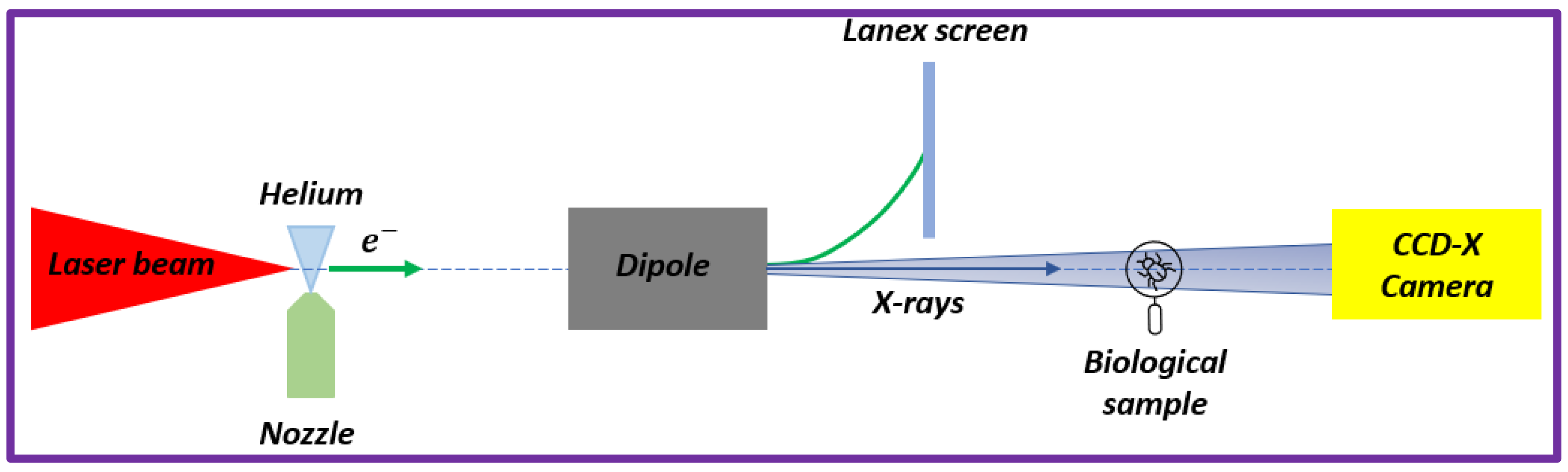


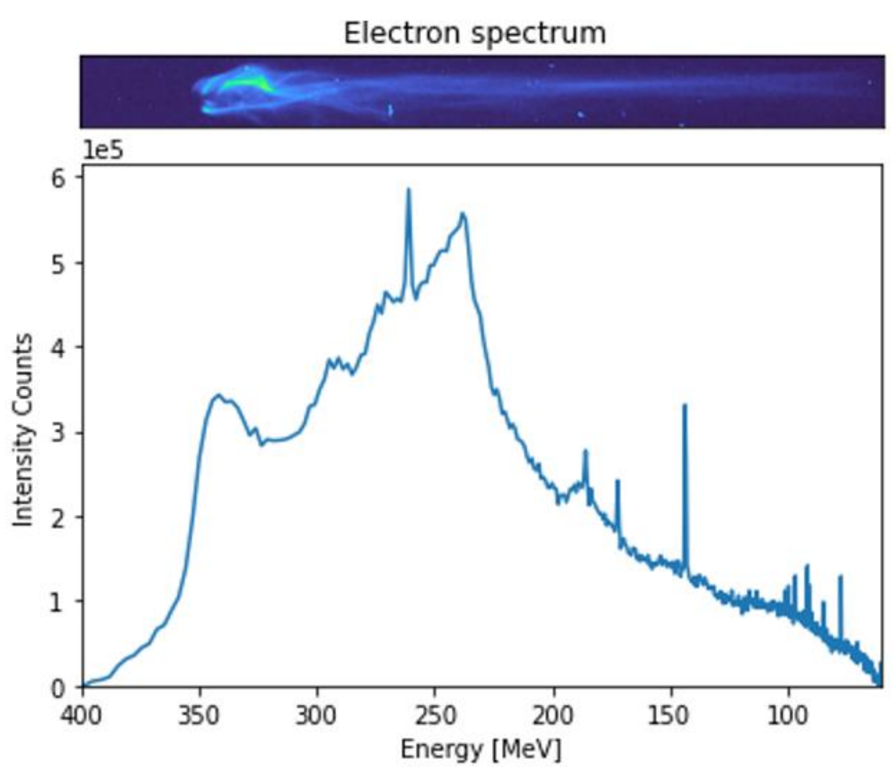
Fig: Sketch of the experimental setup set at CLPU (Salamanca, Spain).

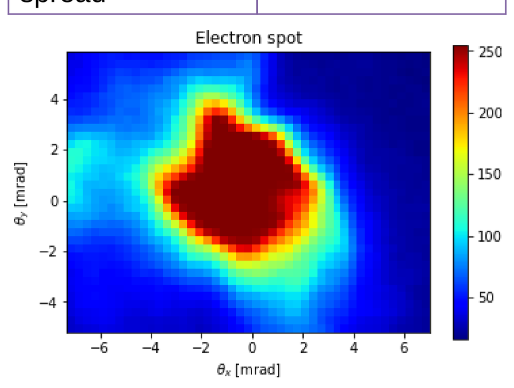
The 200 TW **Ti:Sa VEGA2 laser system** [2] delivers 30 fs (FWHM) pulses with energy up to ~4 J on target at 800 nm central wavelength and 10 Hz repetition rate.
Reaching a spot size of 20 um (FWHM).
A peak intensity $\sim 2 \cdot 10^{19}\ W/cm^2$ is achieved on the target.

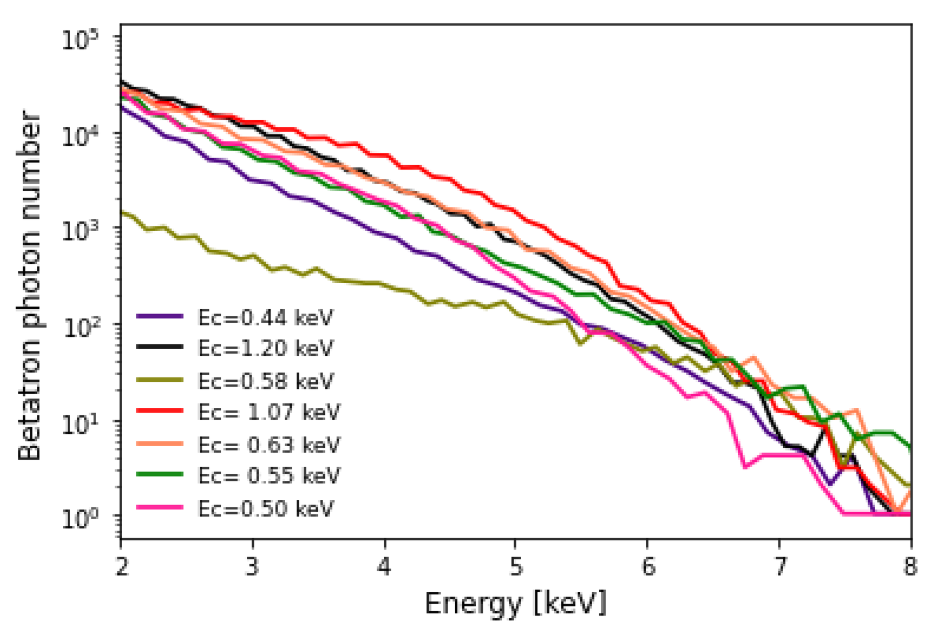
Experimental results

- 100 % He
- 35 bar
- 5 mm nozzle
- ~ 4 J on target

Divergence	4 mrad
Charge	280 pC
Mean / Max energy	250 / 400 MeV
Relative energy spread	28 %







- $\overline{N_\gamma} = (3.5 \pm 2) \times 10^5$ for $E > 2\ keV$
- $E_c = (0.7 \pm 0.3\ )\ keV$

X-ray Phase Contrast Image

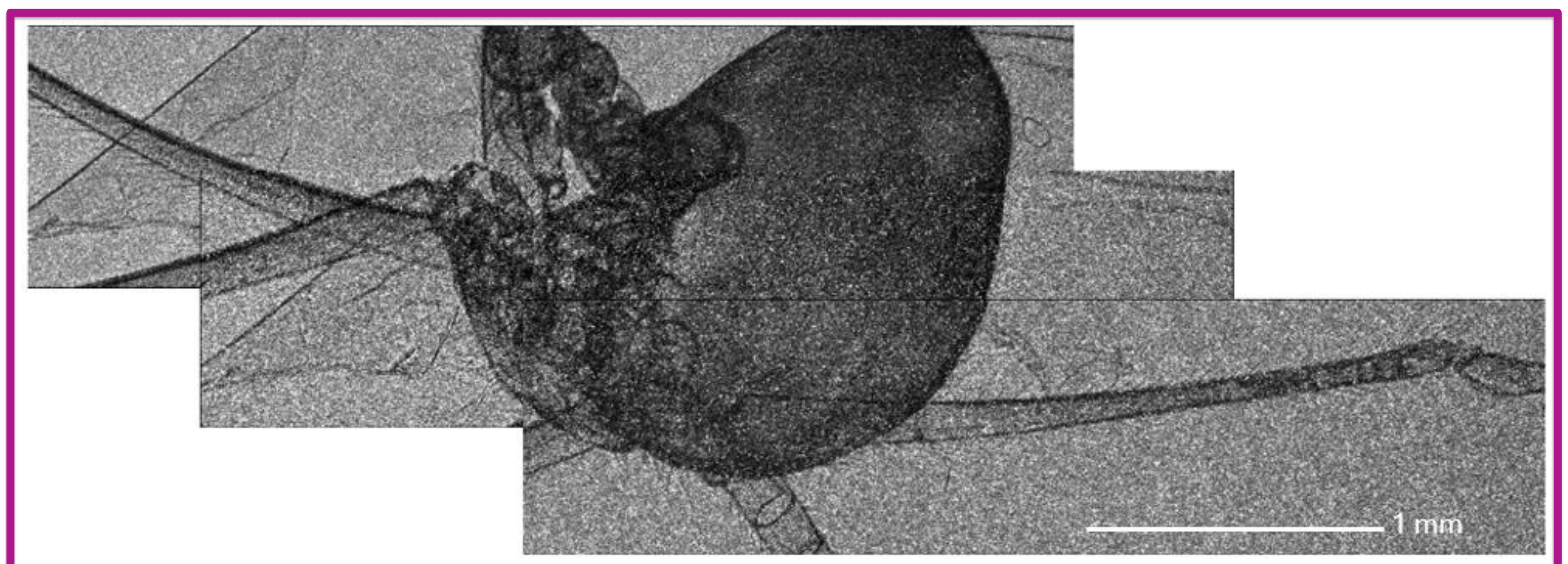
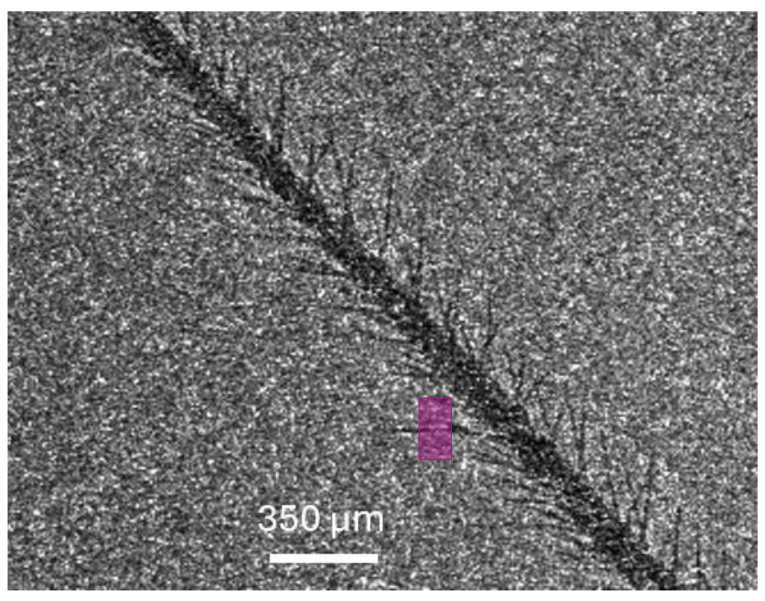


Fig: Single shot X-ray phase contrast image of a spider



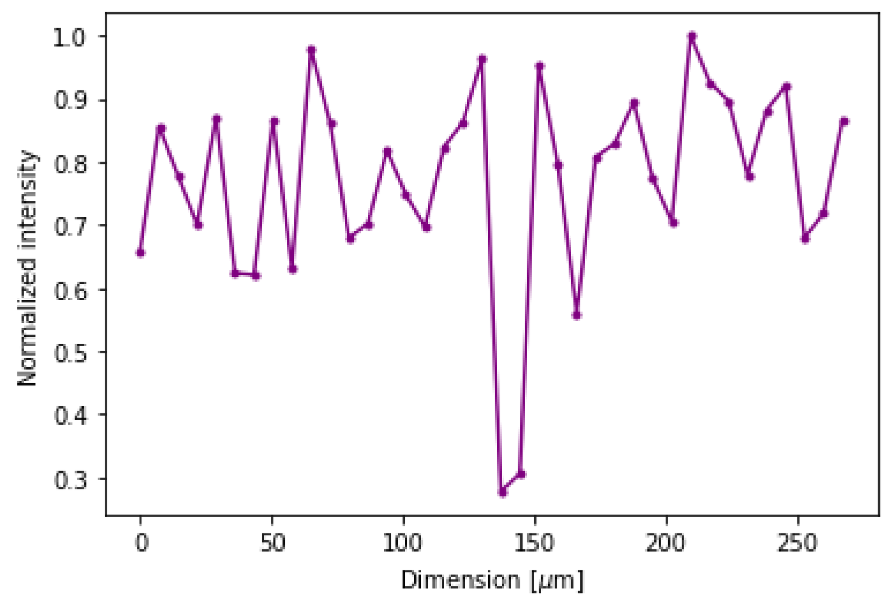


Fig. Details of the leg with hairs and intensity lineout of the purple box.

EuAPS project at SPARC_LAB

EuPRAXIA Advanced Photon Sources (EuAPS) project: laser-driven «betatron» X-ray user facility at the SPARC_LAB laboratory [3].

The high-power laser system FLAME [4] is the driver of the plasma-based acceleration process.

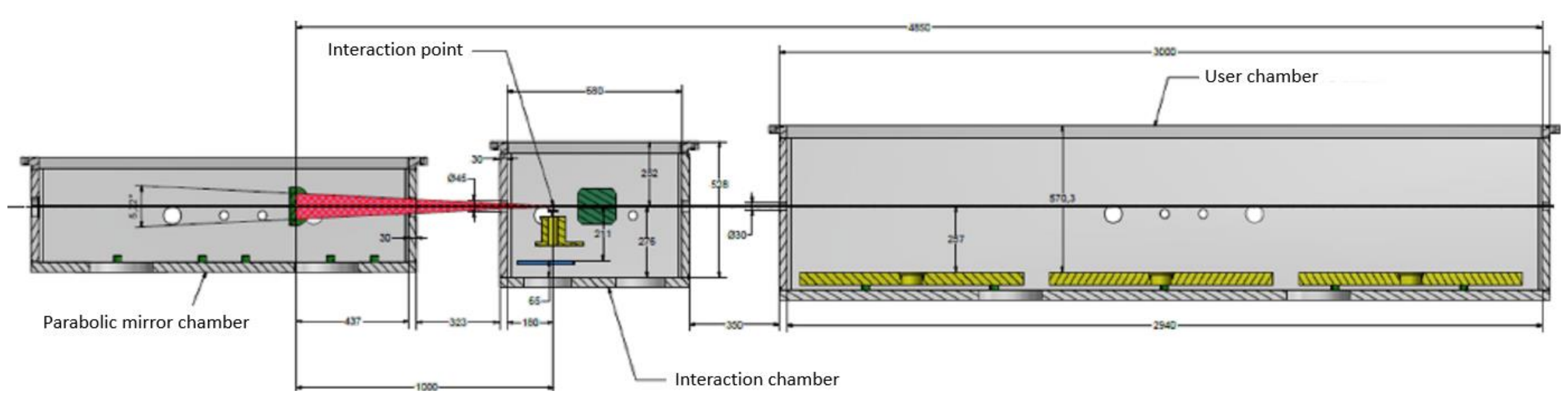


Fig. EuAPS layout: interaction and user chamber in SPARC bunker

Expected parameters

Intensity $[W \cdot cm^{-2}]$	$\sim 2 \times 10^{19}$
$n_e\ [cm^{-3}\ ]$	$10^{18} - 10^{19}$
Repetition rate [Hz]	1 - 5
Electron energy [MeV]	100 - 500
Photon E_c [keV]	1 - 10
N_γ per pulse	$10^6 - 10^9$

[1] J. Ju, PhD thesis, Université Paris-Sud, 06 2013.
[2] L. Volpe, et al., High Power Laser Sci. Eng. 7, E25 (2018).
[3] M. Ferrario, et al., NIMB, 309, 183 (2013).
[4] F. Bisesto, et al., NIMA, 909, 452 (2018).

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