ID #546

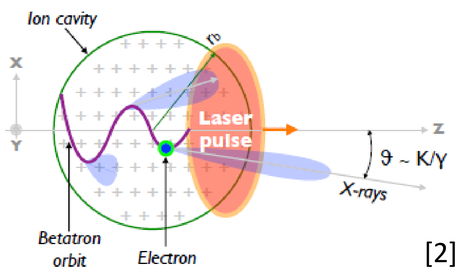
Characterization of Secondary Radiation from LWFA in the EuAPS Project

F. Stocchi[1*,2], M.P. Anania[1], A. Cianchi[2], G. Costa[1], A. Curcio[3], M. Del Giorno[1], V. Dompè[1], D. Francescone[3], M. Galletti[1], G. Gatti[4], A. Ghigo[1], J.A. Pérez-Hernandez[4], C. Salgado-López[4], F. Villa[1], M. Ferrario[1]

[1] INFN-LNF, Frascati, Italy, [2] Università degli studi di Roma " Tor Vergata ", Rome, Italy,
[3]Università degli studi di Roma "Sapienza", Rome, Italy, [4]CLPU, Villamayor, Salamanca, Spain

***federica.stocchi@lnf.infn.it**

Laser WakeField Acceleration process [1] is a mechanism for accelerating electrons using large electric fields, sustained by plasma waves. The ponderomotive force of an **ultra-short, high-intensity laser pulse**, propagating through a plasma, drives a **plasma wave** by displacing plasma electrons and creating regions of charge separation with a bubble-like structure in the strongly non-linear regime. Electrons can be self-injected into the rear of this bubble and are accelerated by the strong longitudinal electric field within the wake. The radial electric field component forces electrons to undergo betatron oscillations within the bubble, emitting synchrotron-like radiation, known as **betatron radiation** [2]. The relativistic electron bunches can also be a **THz radiation source**. They emit coherent transition radiation (CTR) exiting a plasma-vacuum boundary. [3]

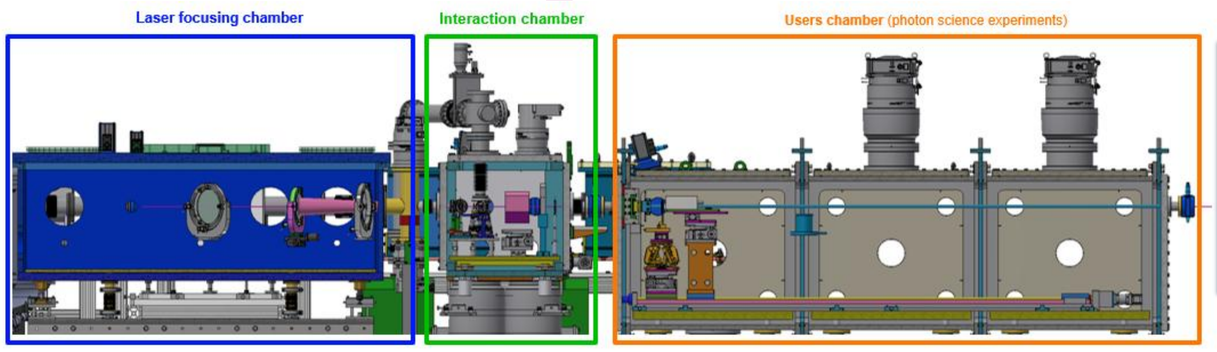


[2]

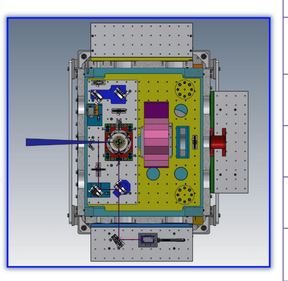
EuPRAXIA Advanced Photon Source at SPARC_LAB

The EuAPS main goal is the realization of the laser-driven **«betatron» X-ray user facility** at the SPARC_LAB laboratory [4].

EuAPS layout and interaction chamber's overview



(courtesy of S. Lauciani)



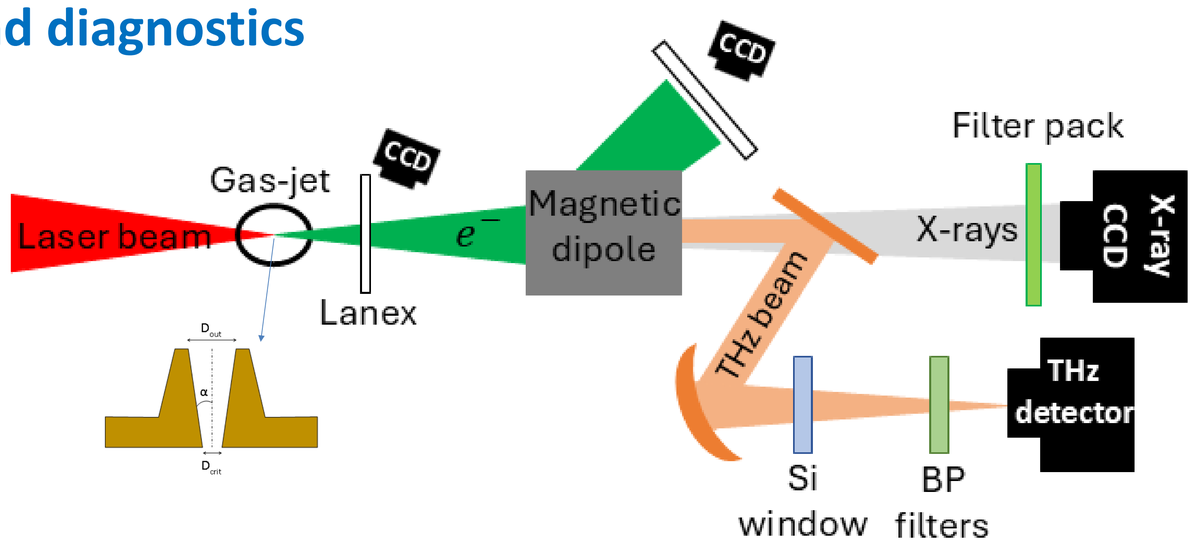
Expected parameters

I $[W \cdot cm^{-2}]$	$\sim 2 \times 10^{19}$
n_e $[cm^{-3}]$	10^{18-19}
R.R [Hz]	1
E_e [MeV]	100 - 500
Photon E_c [keV]	1 - 10
N_γ per pulse	$10^6 - 10^9$
τ_γ	tens of fs

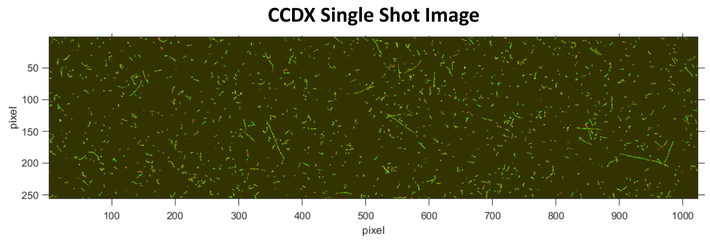
The high-power laser system FLAME will be the driver of the plasma-based acceleration process and betatron radiation emission.

Experimental setup and diagnostics

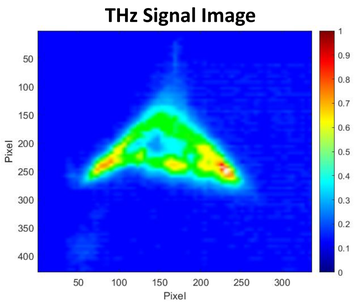
The 200 TW **Ti:Sa laser systems** (FLAME and VEGA2) [5,6] deliver 30 fs (FWHM) pulses with a maximum energy of 6 J, at 800 nm and 10 Hz repetition rate. The pulse is focused on the gas jet (100%He or 90%He and 10% N_2) from a 3mm nozzle at 30 bar.



CCDX Single Shot Image

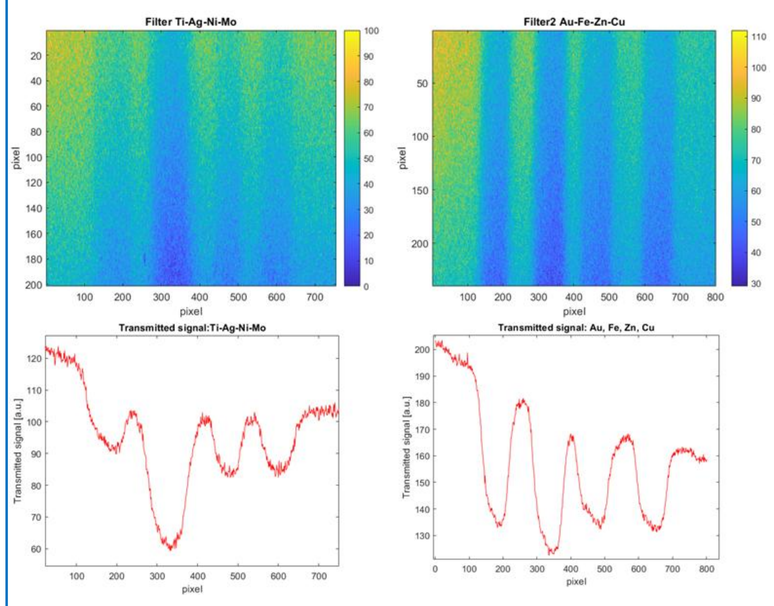


THz Signal Image



X-ray Betatron Radiation @FLAME

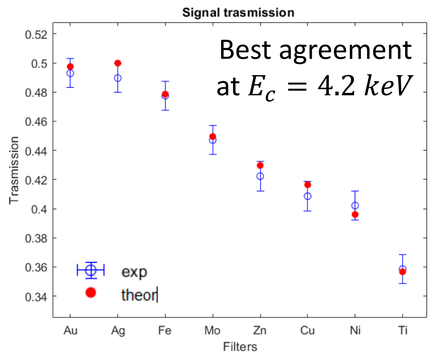
- **Ross Filter technique**



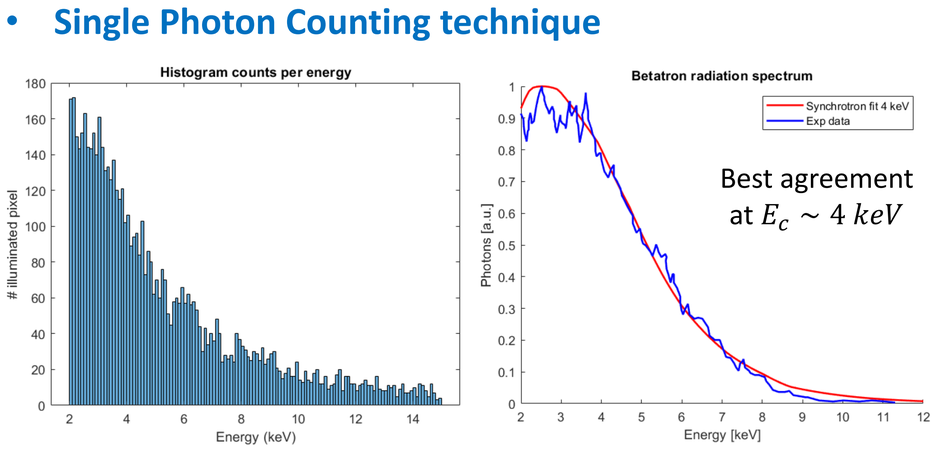
On-axis synchrotron-like spectrum [1] and theoretical signal counts

$$S(E) = \frac{d^2 I}{dE d\Omega}\Big|_{\theta=0} \propto \left(\frac{E}{E_c}\right)^2 K_{\frac{2}{3}}^2\left(\frac{E}{E_c}\right)$$

$$T_{th} = A \int_{E_{\min}}^{E_{\max}} S(E) Q(E) T_{f_i}(E) dE$$

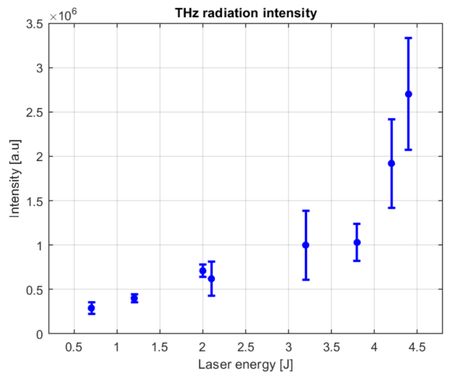


- **Single Photon Counting technique**



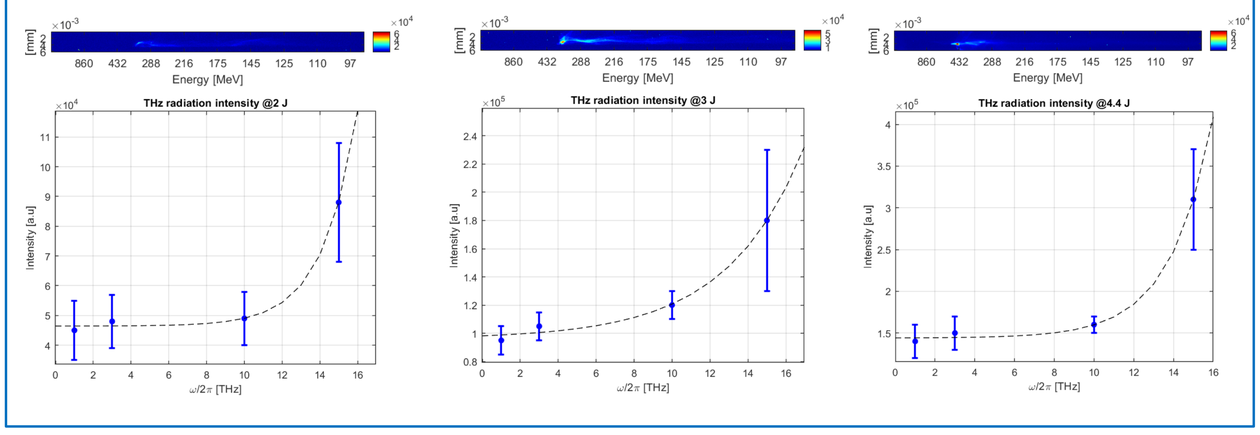
Best agreement at $E_c \sim 4\ keV$

THz pulses @VEGA2

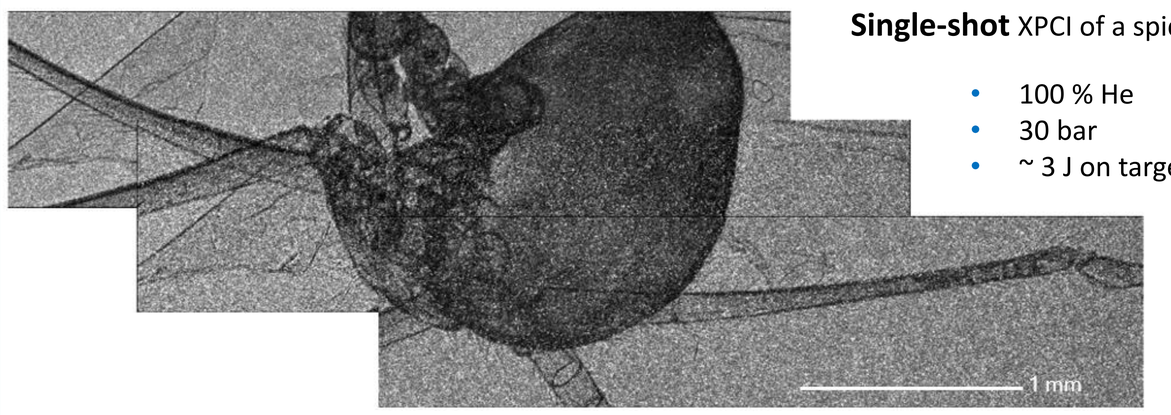


- He gas jet
- Radiation is focused outside the vacuum chamber by a gold-coated spherical mirror (f=50 cm)
- Laser energy scan: (0.7-4.4) J
- Band-pass filters: 1-15 THz

- Different laser energies and different band-pass filters: $I_{THz} \propto e^{\alpha\omega}$



X-ray Phase Contrast Imaging



Single-shot XPCI of a spider

- 100 % He
- 30 bar
- ~ 3 J on target

System magnification: 2.7 Maximum resolution: 19 μm Contrast value of 0.55

References

[1] T. Tajima, J. M. Dawson, *Phys. Rev. Lett.*, 43, (1979).
[2] S. Corde, et al., *Rev. Mod. Phys.,* 85, 1, (2013).
[3] W. P. Leemans, et al., *Phys. Rev. Lett.,* 91,7 (2003)
[4] M. Ferrario, et al., *NIMB*, 309, 183 (2013).
[5] M. Galletti, F. Stocchi, et al., *Appl. Sci.*, *14*, 8619 (2024).
[6] https://www.clpu.es/en/laser-vega-pw/.
[7] A. Curcio, et al., *Appl. Sci.*, 12, 12471, (2022).

ACKNOWLEDGEMENT - This poster presentation has received support from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 101004730, '*I.FAST* '.