# Laser-plasma accelerator driven X-ray sources and advanced concepts at ELI Beamlines

M. Lamac[1,2], U. Chaulagain[1], M. Raclavský[1,3], K. H. Rao[1], S. V. Bulanov and J. Nejdl[1,3]
[1]*ELI Beamlines Centre, FZU ASCR, v.v.i. Za Radnicí 835, 252 41, Dolní Břežany, Czechia*
[2]*Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, Prague 2, 12116, Czechia*
[3]*Czech Technical University in Prague, FNSPE, Břehová 7, 115 19 Prague 1, Czechia*
Marcel.Lamac@eli-beams.eu

We report on the development progress of the user-oriented Gammatron beamline designed to deliver ultrashort X-ray pulses in the 1 – 100's keV range in either betatron X-ray generation or Thomson backscattering scheme for a broad range of applications [1, 2].

We also review our work on advanced concepts, in one of which we show that the presence of second and third harmonic of the fundamental laser frequency co-propagating with the relativistic laser wakefield accelerated electrons enhances photon flux of betatron X-ray radiation by more than an order of magnitude (Fig. 1). This enhancement originates from nonlinear resonances in betatron oscillations induced by two laser pulses with different frequencies interacting with the electrons. This resonance results in a boost of the transverse momentum. Betatron oscillation resonance is achieved when either of the shifted frequencies seen by the electron matches its betatron frequency. Such resonance results in significant transverse momentum enhancement [3].

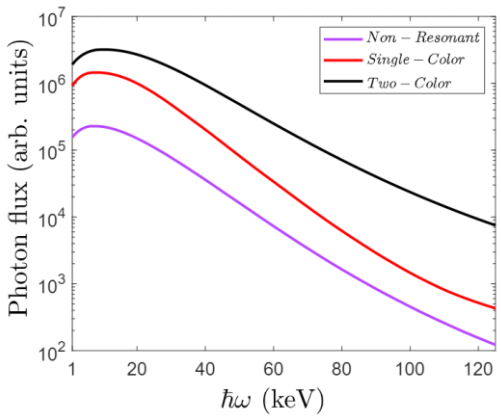


Figure 1: Enhanced X-ray photon flux resulting from the nonlinear oscillations of laser wakefield accelerated electrons with two-color laser field.

**Acknowledgments**

This work was supported by the project ADONIS (CZ.02.1.01/0.0/0.0/16 019/0000789) and by the project HiFi (CZ.02.1.01/0.0/0.0/15 003/0000449) from European Regional Development Fund and the project LM2015065 as part of targeted support of Large infrastructures of the Ministry of Education, Youth and Sports of the Czech Republic.

## References

[1] U. Chaulagain, et al. "ELI Gammatron Beamline: A Dawn of Ultrafast Hard X-ray Science." *Photonics* 9 (11), 853 (2022)
[2] J. Nejdl, et al. "Update on laser-driven X-ray sources at ELI Beamlines.", Compact EUV & X-ray Light Source, Eth5A. 6 (2022)
[3] M. Lamač, et al. "Two-color nonlinear resonances in betatron oscillations of laser accelerated relativistic electrons." *Physical Review Research* 3.3 (2021): 033088.