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Experiment towards the Gamma Flare regime

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Gamma-Flare, which is an efficient regime of MeV to GeV hard x-ray generation, is one of the most promising and expected applications of high-power lasers [1,2]. The generation mechanism is the nonlinear Thomson/inverse Compton scattering, and the efficiency can be as high as 30-40% when a relatively large optimized preplasma is used [3]. Another mechanism acting nearly simultaneously and producing similar photon energies is Bremsstrahlung by the electrons going through the target [4-6], which includes refluxing [5,7]. According to the theoretical predictions and simulations, the Gamma Flare regime dominates at high intensities, while at presently attainable intensities Bremsstrahlung dominates. Thus, the Gamma Flare mechanism has not yet been demonstrated experimentally.

Here we present results of our experiment performed with the J-KAREN-P laser [8-10] at the intensity approaching 10^{22} W/cm^2, including 20 keV-10 MeV hard x-rays measured with spectrographs comprising scintillator stack [11]. The x-ray spectra were reconstructed with a method [12]. We also discuss a range of additional diagnostics used for fine positioning of the target into the best focus and to understand the interaction physics.

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References

1. T. Nakamura, *et al.*, "High-Power γ-Ray Flash Generation in Ultraintense Laser-Plasma Interactions," *Phys. Rev. Lett.* **108**, 195001 (2012).
2. C. P. Ridgers, *et al.*, "Dense Electron-Positron Plasmas and Ultraintense γ rays from Laser-Irradiated Solids," *Phys. Rev. Lett.* **108**, 165006 (2012).
3. K. V. Lezhnin, P. V. Sasorov, G. Korn, and S. V. Bulanov, "High power gamma flare generation in multi-petawatt laser interaction with tailored targets," *Phys. Plasmas* **25**, 123105 (2018).
4. D. Wu, *et al.*, "Characteristics of X/γ-ray radiations by intense laser interactions with high-Z solids: The role of bremsstrahlung and radiation reactions," *Matter Rad. Extremes* **3**, 293-299 (2018).
5. J. Vyskočil, O. Klimo, S. Weber, "Simulations of bremsstrahlung emission in ultra-intense laser interactions with foil targets," *Plasma Phys. Control. Fusion* **60**, 054013 (2018).
6. S. Singh, *et al*., "Bremsstrahlung emission and plasma characterization driven by moderately relativistic laser-plasma interactions," *Plasma Phys. Control. Fusion* **63**, 035004 (2021).
7. D. R. Rusby, *et al.*, "Effect of rear surface fields on hot, refluxing and escaping electron populations via numerical simulations," *High Pow. Las. Sci. Eng*. **7**, e45 (2019).
8. A. S. Pirozhkov *et al.,* "Approaching the diffraction-limited, bandwidth-limited Petawatt," *Opt. Expr.* **25**, 20486 (2017).
9. H. Kiriyama, *et al.*, "High-contrast high-intensity repetitive petawatt laser," *Opt. Lett.* **43**, 2595 (2018).
10. H. Kiriyama, *et al.*, "Experimental investigation on temporal contrast of pre-pulses by post-pulses in a petawatt laser facility," *Opt. Lett.* **45**, 1100 (2020).
11. D. R. Rusby, *et al.*, "Novel scintillator-based x-ray spectrometer for use on high repetition laser plasma interaction experiments," *Rev. Sci. Instr.* **89**, 073502 (2018).
12. C. D. Armstrong *et al*., "Deconvolution of X-ray Spectra from Linear Absorption Spectrometer via Parameter Reduction and Cost-Function Minimisation Routine," submitted.