# Recent Advances in Electron Acceleration and Gamma-Ray Generation with 4 PW laser at CoReLS

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Recent advances in petawatt (PW) and multi-petawatt (multi-PW) laser technologies [1,2] have significantly accelerated developments in particle acceleration and radiation generation, providing unprecedented opportunities for fundamental research and diverse practical applications. Noteworthy breakthroughs include electron acceleration approaching energies of 10 GeV [3], the production of intense X-ray radiation through betatron emission processes [4], and extensive investigations into nonlinear Compton scattering phenomena [5].

These advancements are facilitating the development of compact, versatile, and high-energy electron and radiation sources, holding considerable potential across numerous scientific and industrial fields. In materials science, precisely controlled, high-energy radiation beams enable sophisticated characterization methods; in bioscience, they significantly enhance high-resolution imaging and targeted radiation therapies; and in nuclear physics, they offer novel pathways to investigate high-energy particle interactions and nuclear phenomena.

Our research group has continuously pursued these advancements. We successfully developed a state-of-the-art 4 PW laser system, representing a significant milestone in ultra-high-intensity laser technology [6]. Utilizing multi-PW laser pulses, we have achieved substantial progress, notably generating high-quality electron beams with energies of up to 4.5 GeV. This advancement was enabled through strategically doping helium gas cells with 1% neon, optimizing the electron injection and acceleration processes within the laser wakefield acceleration (LWFA) mechanism.

Additionally, our recent research has demonstrated the successful generation of gamma-ray emissions with exceptional brightness and flux using a novel hybrid betatron method [7]. This innovative approach effectively separates radiation generation from the electron acceleration stage, significantly improving control over gamma-ray characteristics. Consequently, this technique has yielded gamma-ray beams with superior brightness and flux, making them particularly suitable for high-resolution imaging and precision spectroscopy applications.

In this presentation, we will discuss these recent technological breakthroughs, emphasizing our advancements in LWFA utilizing multi-PW laser pulses and the innovative hybrid betatron-based gamma-ray source. By elucidating the capabilities and broad applicability of these advanced, compact, and tunable high-energy electron and gamma-ray sources, we aim to promote further innovation and facilitate collaborative exploration within the communities of materials science, bioscience, and nuclear physics.

References

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