Narrow bandwidth Thomson photon source using laser-plasma accelerators

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Abstract: *Compact, high-quality photon sources at MeV energies are being developed based on Laser-Plasma Accelerators (LPAs). Simulations are presented on production of controllable, narrow bandwidth sources using LPAs. Appropriate pulse shaping and laser guiding of an independent scattering laser are required to realize high photon yield. Plasma optics are considered to tailor the beam divergence in cm-scale distances, reducing photon source bandwidth. Plasma-based methods to decelerate the electron beam after photon production are considered to reduce shielding requirements. Design of experiments combining these elements towards a compact photon source system will be presented.*

Near-monoenergetic photon sources at 1–10 MeV energies offer improved sensitivity at greatly reduced dose for detection and characterization of nuclear materials, contraband, and for other applications including industrial and medical radiography. Many of the issues with current broad-bandwidth photon sources, including unnecessary dose and restricted operations, can be resolved using near-monoenrgetic sources with the ability to select photon energy, energy spread, flux, and pulse structure. Many applications of near-monoenergetic photon sources have been limited by the size of the required electron accelerator, scattering laser, and electron beam dump.

To enable new applications outside of fixed facilities, compact tunable near-monoenergetic photon sources are desired with narrow divergence to allow high spatial resolution and dose control, and to reduce need for collimation. Thomson scattering of a laser from an electron beam is a well-established, tunable, and narrow divergence source (also referred to as Compton Scattering or Inverse Compton Scattering) whose application is currently limited by the need for high-energy electron linacs, which are large fixed facilities using conventional technology. More compact accelerators producing electron beams with hundreds of MeV energies, suitable for application needs of 1–10 MeV photons, are now possible using cm-scale laser-plasma accelerators (LPAs).

Heavy shielding is conventionally required due to the high electron beam energy in Thomson sources. The low photon production cross section of Thomson scattering has also required either high electron current (and thus heavier shielding) or large scattering lasers. Therefore it is critical to also develop techniques to reduce shielding needs and scattering laser size, which can dominate overall system size and weight, as the electron accelerator is made more compact.

In this talk, we show how a compact high-flux Thomson scattering source can be achieved by integrating a high-quality LPA with techniques for efficient scattering. In addition, it is shown how plasma-based techniques can be employed to decelerate the electron beam to low energy after photon production, greatly reducing shielding requirements.