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R&Ds of Compact, hybrid-type sub-THz Wakefield Accelerator

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A compact sub-THz wakefield Accelerator, comprised of a two-beam acceleration (TBA) scheme of structure-based wakefield accelerators and a laser-plasma injector of laser wakefield accelerators, are under development in collaboration with Korea University, PAL, ANL and so on. In a two-beam acceleration (TBA) scheme, two-type of structures, one for a high-power extractor and the other for high-gradient accelerator, are required. In the sub-THz structure, the fabrication and assembly of structures is critical to achieve its feasibility. For a high power generation, highly charged, multi-bunch train as a drive beam can be attainable from a high power RF linac with a photocathode gun. For a witness beam, a compact electron gun can provide high quality beam with low emittance and reasonable bunch charge. The overall layout is illustrated in Fig.1.

After successful demonstration of high power generation using 0.2 GHz corrugated structure [1], the structure at 0.4 THz designed for high power extraction was fabricated using X-ray lithography method and assembled using specially design tool. A 5-cm long corrugated structure with through-hole of < 1 mm diameter was installed at AWA facility in ANL for high-power test in 2024. The first test result showed the possibility of high power extraction despite of the problem of RF Klystron. In the next experiment on August, 2025, it is expected to extract high power THz pulse of ~ GW from the PET (Power Extraction Tube). Two off-axis parabolic mirrors for extraction and a bolometer for detection will be installed for the power measurement from the PET in this demonstration. The coupler and transport waveguide for THz extraction from the PET and injection to the accelerating structure will be designed and fabricated for the realization of TBA scheme.

For a laser electron injector, the plasma target using two different gases and/or two different metallic plasma is under development. Two different elements, having different ionization energy levels, can be allocated for different roles in laser wakefield acceleration mechanism. One is for an electron bunch generation while the other is for a wakefield accelerator. The strong ionization diffraction allows the dephasing-free condition keeping the energy spread constant through the plasma along the electron extraction. In the dephasing-free region, the electron beam is diverged transversely due to no accelerating field, so a focusing system is required for beam injection to THz-accelerating structure. The focusing system using permanent quadrupole magnets or a plasma lens is considered. The undulator may be designed using a permanent magnet or a Dielectric Laser Undulator (DLU) for a compact light source.

The low emittance, narrow energy spread, and short pulse length of electron beams is essential for injecting to sub-THz scaled structure-based accelerator and generating SASE FELs.

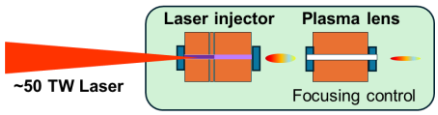

Figure 2. Schematic of Laser injector

We will present the status and issues on developing a compact, hybrid-type sub-THz wakefield accelerator.

References

[1] H. Kong *et. al.*, Scientific Reports 13:3207 (2023)

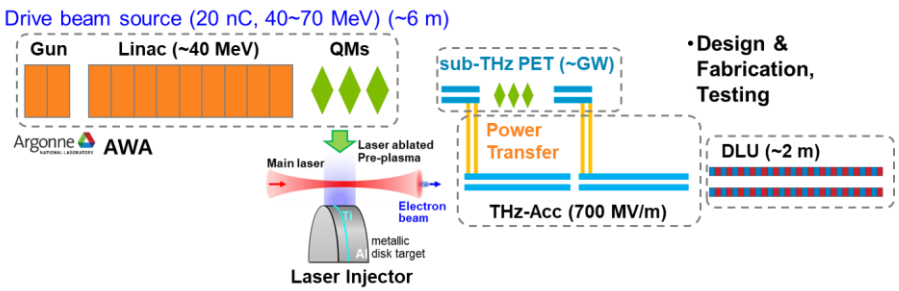

Figure 1. Schematic of compact, hybrid-type sub-THz Wakefield Accelerator