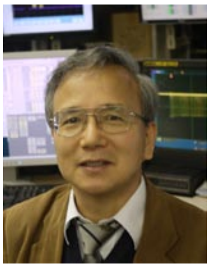

# Title of Project : Ultra-Compact Short Pulse and Coherent Teraherts (THz) Light Source Using Super-radiance

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Research Area : Accelerator Physics, Applied Physics and Engineering Fundamentals
Keyword : RF Gun, Femtosecond(fs) Laser, Photo-Cathode, High Gradient Acceleration, FEL

**【Purpose and Background of the Research】**

The short pulse high-brightness coherent THz light source of ~0.3 to 10THz in the intermediate zone between radio and light waves gives a breakthrough in the rapidly expanding field of THz photon science. A photocathode is irradiated with a fs laser pulse train of ~10 pulses, and a fs electron bunch train (Comb beam) is accelerated by a radio-frequency(RF) accelerating field more than ~50MV/m. In this way, Comb beam is carried on a single RF accelerating field, enabling it to be accelerated to 5MeV in a 7.5cm RF gun. When the Comb beam is passed through a small wiggler (30cm), super-radiance in the THz region arises. The objective is to develop and apply an ultra compact high-brightness coherent THz light source, with short pulses of ~10MW, variable between 0.3 to 10THz, with radiation of ~10μJ/pulse.

Peak power of ~10MW is about 100 times that of earlier THz light sources, comparable to the intensity of THz light generated by 10m facility using advanced accelerator technologies, which are being developed around the world. With this light source, it is possible to substantially reduce THz time-domain spectroscopy (THz-TDS) measurement time, and greatly improve the accuracy of measurement. In addition, it enables fs timescale and multi-photon absorption nonlinear science phenomena to be captured with high precision. Applied experiments using the device developed(see the figure) will be carried out from 2014.

**【Research Methods】**

In order to maintain the time structure of the photoelectrons generated in the RF gun, it is necessary to engage them with the RF phase that overcomes Coulomb repulsion and in which bunch compression arises dynamically. The cathode end plate of the RF gun is fixed in the position where the high electric field of the cavity arises. If the accelerating field is an increasing phase(20 degrees) and the cathode is irradiated with 100 fs micro-pulses, the S-band(2856MHz) RF accelerating field (130MV/m) is changed from 44.46 to 44.68MV/m. The subsequent photoelectrons gain slightly larger acceleration and dynamic bunch compression while at the same time receiving rapid acceleration. By coming close to relativistic energy, Coulomb repulsion and Lorentz force reach equilibrium. The time difference between the beginning and end of the Comb beam is about 8ps. The accelerating field increases to 61.03 MV/m, therefore the 8ps bunch receives about 30% bunch compression at the RF gun exit. The electron micro-bunch structure predicted in the simulation is confirmed with CDR measurement.

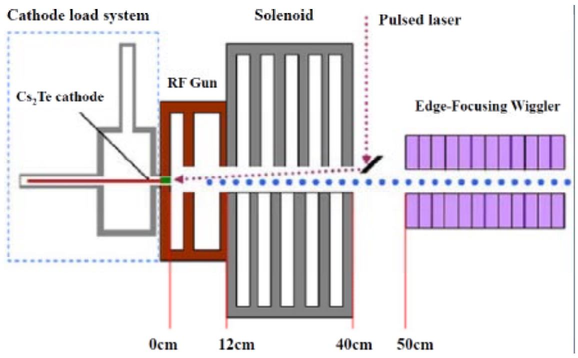


**Table-Top Short Pulse and Coherent THz Light Source**

**【Expected Research Achievements and Scientific Significance】**

By tuning the micro-bunch spacing to the THz wavelength, it is possible to generate a narrowband coherent THz wave. Depending on whether an ideal Comb beam can be formed in the RF gun by high gradient acceleration, super-radiance peak power from the small wiggler (30cm) reaches ~100MW. Innovative THz light source applications can be developed.

**【Publications Relevant to the Project】**

"Femtosecond pulse radiolysis and femtosecond electron diffraction", Jinfeng Yang et al., NIM, **A 637**, pp. S24-S27, 2011
"Experimental results of an rf gun and the generation of a multibunch beam", Abhay Deshpande et al., Phys. Rev. ST Accel. Beams, **14**, 063501-1-9, 2011
"Improvement of an S-band RF gun with a $Cs_2Te$ photocathode for the KEK-ATF", N. Terunuma et al., Nuclear Instruments and Methods in Physics Research **A**, **613**, 1–8, 2010

**【Term of Project】** FY2011-2015

**【Budget Allocation】** 154,700 Thousand Yen

**【Homepage Address and Other Contact Information】**

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