Karlsruhe Institute of Technology

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A versatile linac-based THz source with high bunch charge: FLUTE

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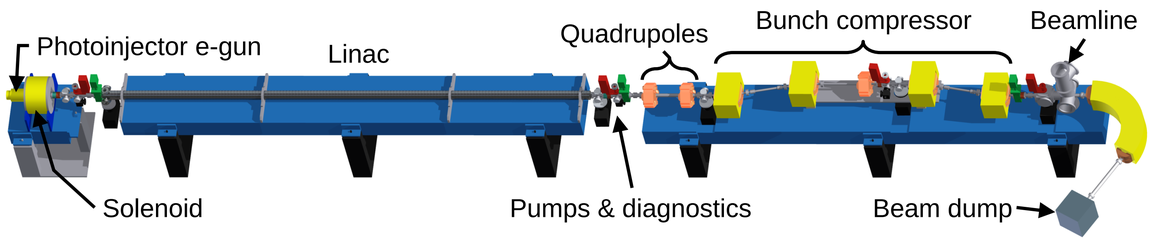
FLUTE

The Karlsruhe Institute of Technology (KIT) is realising a new versatile **linac-based THz source** named FLUTE ("Ferninfrarot Linac- Und Test-Experiment"). The presented design study is carried out in close collaboration with the Paul Scherrer Institute (PSI) in Switzerland. FLUTE has the **dual purpose** of providing **high-field THz pulses** for various scientific applications and to serve as a **test facility** for the study of important open questions in **accelerator physics**. This is of particular importance in view of the planned **ultra-broadband THz–mid infrared user facility TBONE**. For FLUTE, special emphasis is put on studies of bunch compression and beam stability as a function of bunch charge and of different generation mechanisms of coherent radiation.

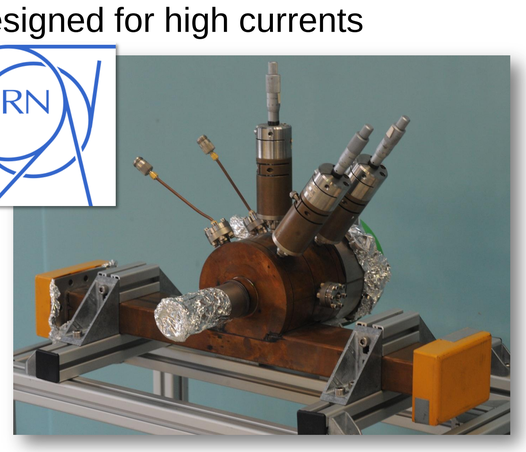
Final electron energy	42	MeV
Electron bunch charge	0.1-3	nC
Electron bunch length	50-400	fs
Spectral bandwidth	0.05-8	THz
Pulse repetition rate	10	Hz

Table 1: FLUTE key parameters



Laser photoinjector gun:

- CERN CTF (CLIC Test Facility) gun
- Designed for high currents

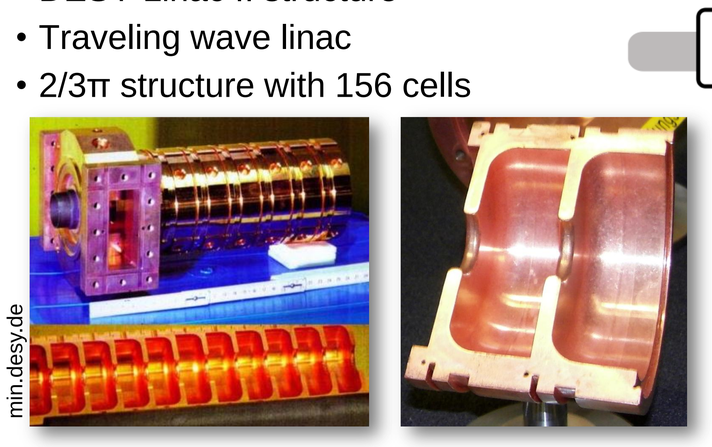


Frequency	2.998	GHz
Cells	2.5	
Acc. gradient	~100	MV/m
Peak power	~20	MW
Output energy	7	MeV
Bunch charge	≤3	nC

Table 2: CTF gun parameters

Linac:

- DESY Linac II structure
- Traveling wave linac
- 2/3π structure with 156 cells



Frequency	2.998	GHz
Length	5.2	m
Acc. gradient	~10	MV/m
Peak power	~20	MW
Output energy	~42	MeV

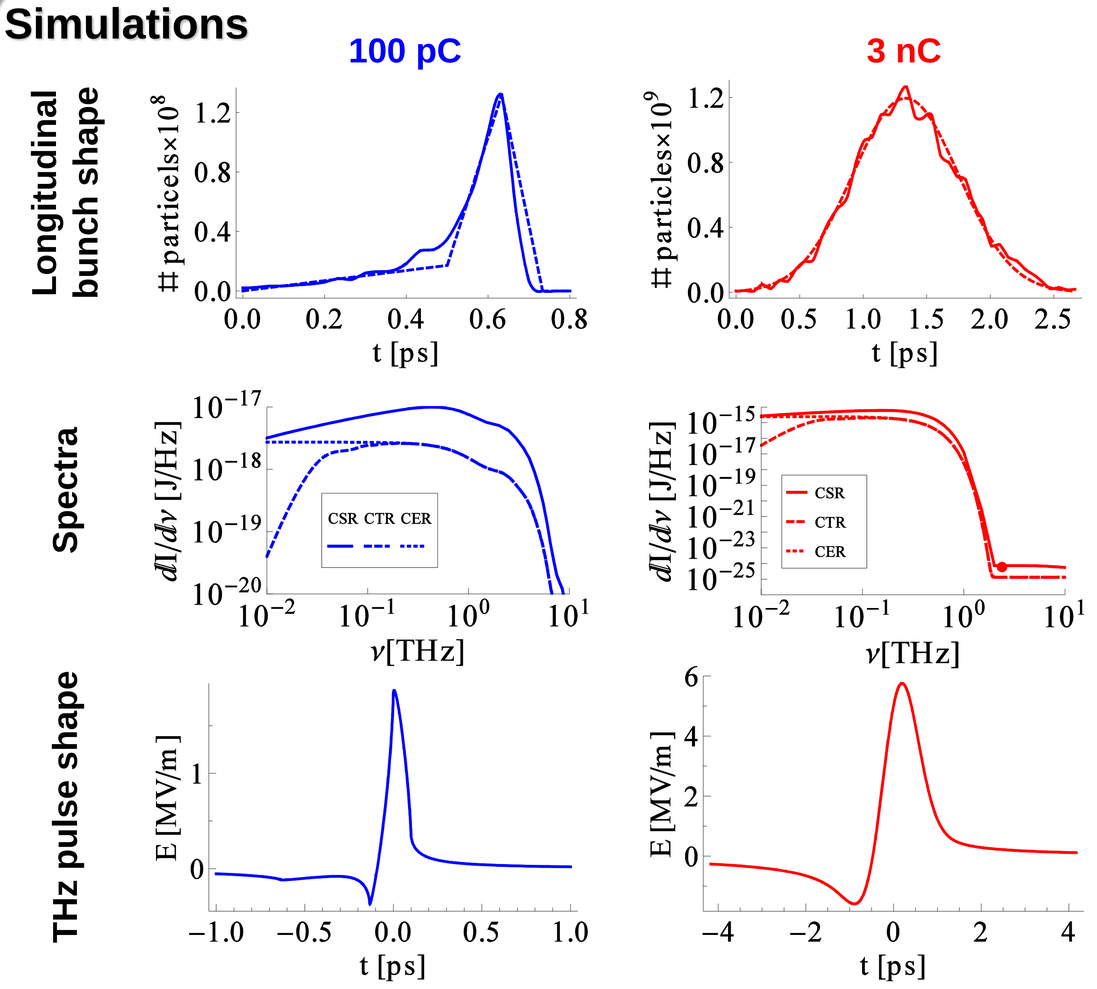
Table 3: Linac parameters

Accelerator physics tests

FLUTE will allow systematic testing and optimisation of several machine parameters necessary to enhance the peak electric field/power and beam stability, both for FLUTE and later for the TBONE:

- Bunch length with high charge (single-cycle electric field)
- Bunch compression schemes
- Coherent synchrotron radiation (edge vs. dipole radiation)
- Coherent transition radiation
- THz transport line (impedance), etc.

Simulations

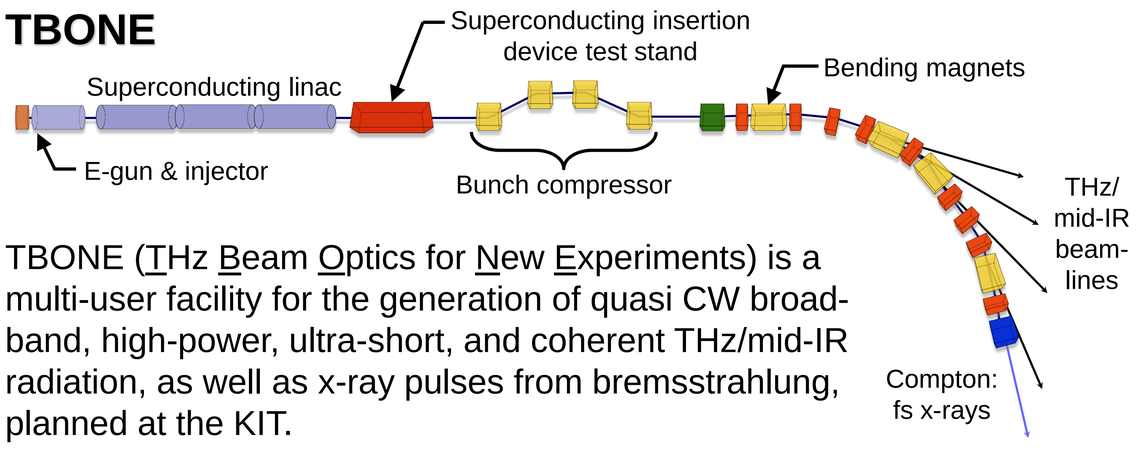


Calculated FLUTE output after compressor:

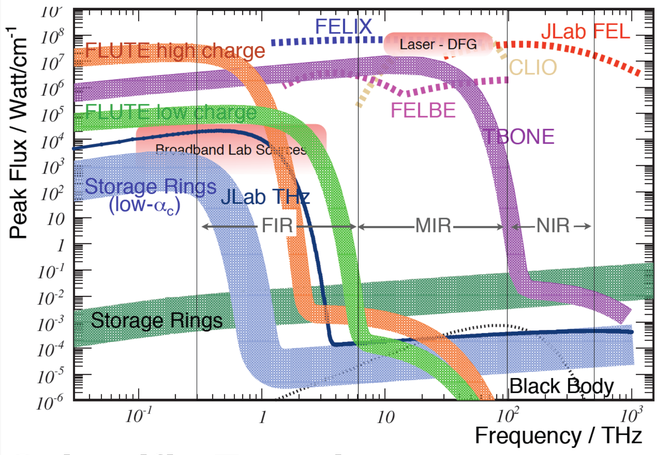
Simulation tools: ASTRA (gun→linac), CSRtrack (compressor)

- CSR: Coherent Synchrotron Radiation
- CTR: Coherent Transition Radiation
- CER: Coherent Edge Radiation

TBONE



TBONE (THz Beam Optics for New Experiments) is a multi-user facility for the generation of quasi CW broadband, high-power, ultra-short, and coherent THz/mid-IR radiation, as well as x-ray pulses from bremsstrahlung, planned at the KIT.



Final electron energy	60-100	MeV
Electron bunch charge	10-100	pC
Electron bunch length	5	fs
Spectral bandwidth	0.1-150	THz
Pulse repetition rate	10	MHz

Table 4: TBONE key parameters

Scientific Experiments

The intense THz pulses generated by FLUTE and especially in the future by TBONE are very interesting for many scientific applications, such as 2D Spectroscopy and **pump-probe** experiments. Here, in contrast to many conventional setups, the strong THz radiation is used as the pump pulse. These pulses couple to vibrational modes extending across large domains of a crystal lattice and allow studying **interactions between molecules** non-destructively, **without heat-transfer**.