FLUTE: A versatile linac-based THz source generating ultra-short pulses

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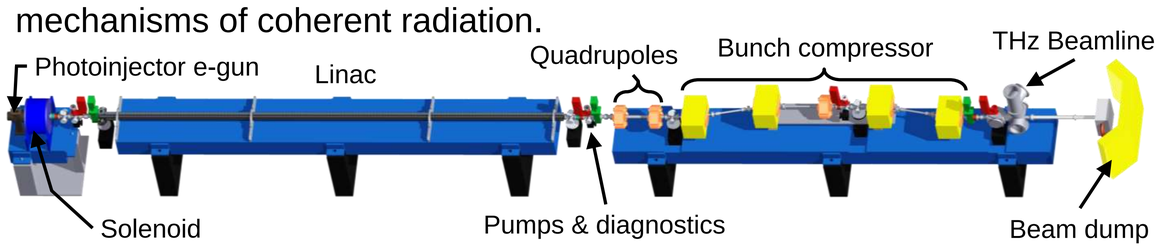
FLUTE

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 is carried out in collaboration with the Paul Scherrer Institute (PSI) and the Deutsches Elektronen-Synchrotron (DESY). FLUTE has the **dual purpose** of providing **short 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 future **ultra-broadband THz–mid infrared user facilities such as 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.

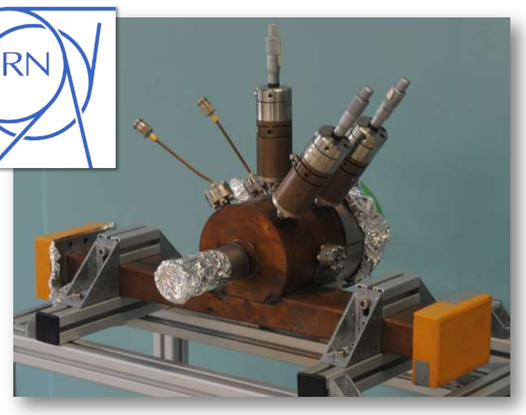
Final electron energy	~41	MeV
Electron bunch charge	0.001–3	nC
Electron bunch length	13–270	fs
Spectral bandwidth	~4–33	THz
Pulse repetition rate	10	Hz
-R_{56} range	~28–36	mm

Table 1: FLUTE key parameters



Laser photoinjector gun:

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

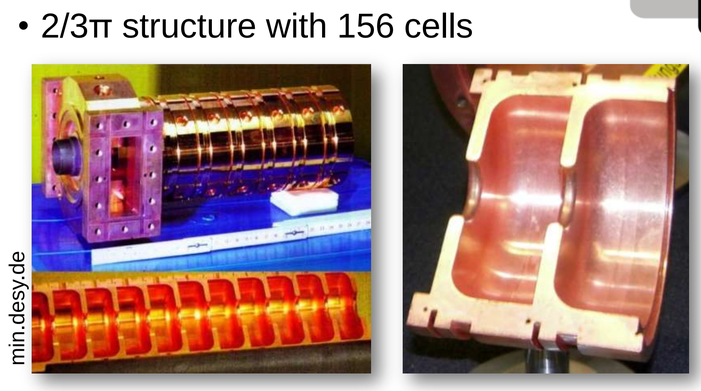


Frequency	2.998	GHz
Cells	2.5	
Peak E-field	~120	MV/m
Peak power	~20	MW
Output energy	7	MeV
Bunch charge	≤3	nC

Table 2: 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	~16	MW
Output energy	~41	MeV

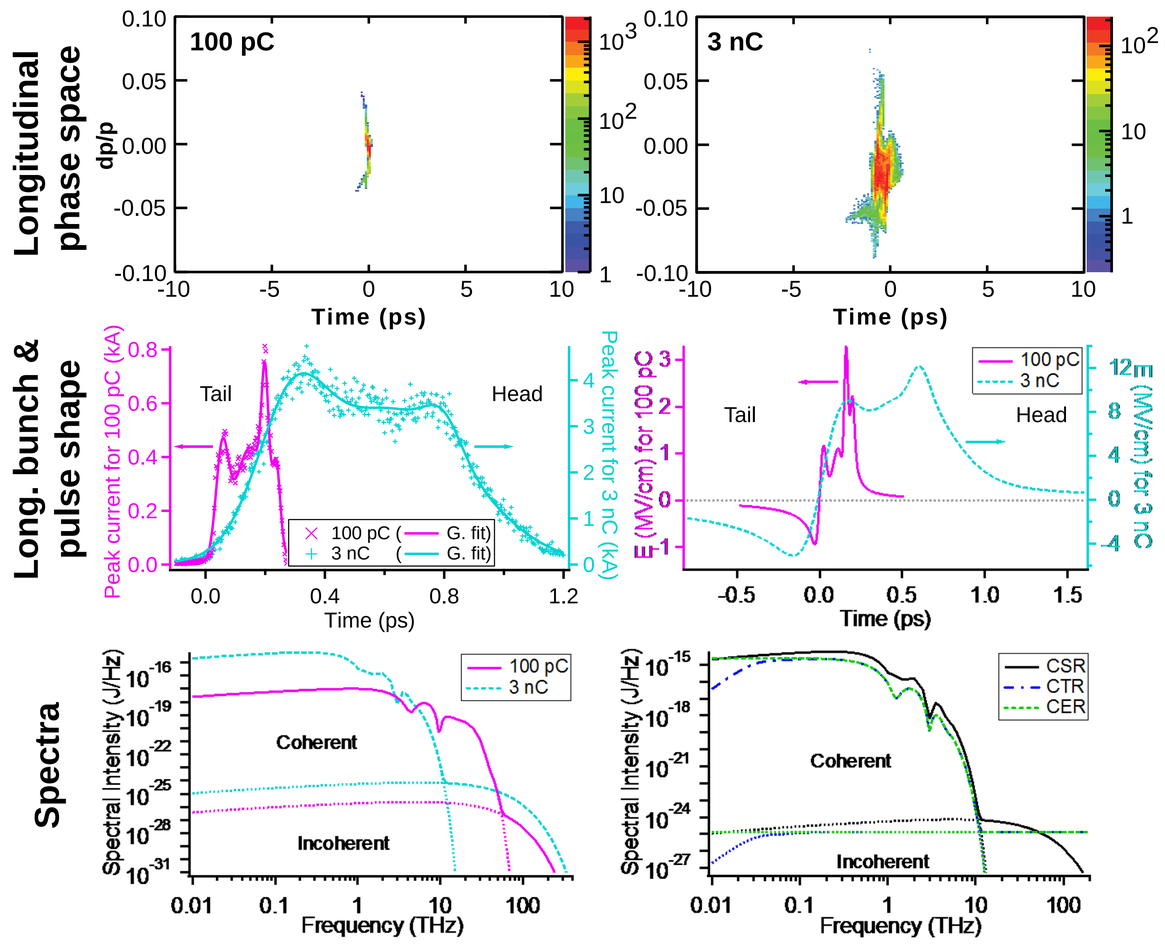
Table 3: Linac parameters

Accelerator physics tests

FLUTE will allow systematic testing and optimisation of several machine parameters necessary to enhance the peak electric field/power, pulse length, and beam stability, for FLUTE & future short-pulse user-facilities:

- Bunch length with low & high charge (single-cycle electric field)
- Bunch compression schemes
- Comparison (simulation vs. experiment) of coherent synchrotron, transition & edge radiation (CSR, CTR, CER)
- THz transport line (impedance), etc.

Simulations

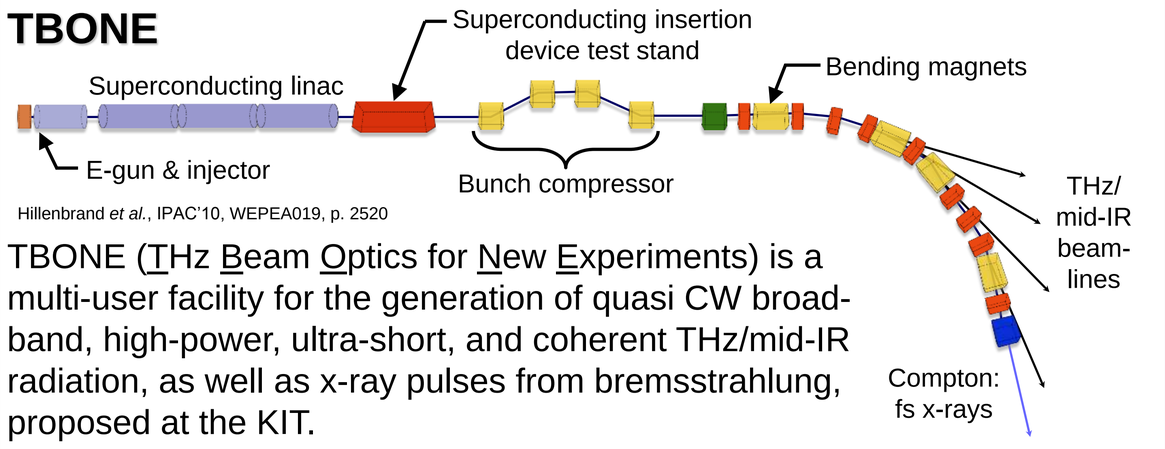


Nasse *et al.*, Rev. Sci. Instrum. **84**, 022705 (2013)

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



Hillenbrand *et al.*, IPAC'10, WEPEA019, p. 2520

TBONE (THz Beam Optics for New Experiments) is a multi-user facility for the generation of quasi CW broad-band, high-power, ultra-short, and coherent THz/mid-IR radiation, as well as x-ray pulses from bremsstrahlung, proposed 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 short intense THz pulses generated by FLUTE and future user-facilities such as TBONE are very interesting for many scientific applications like 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**.