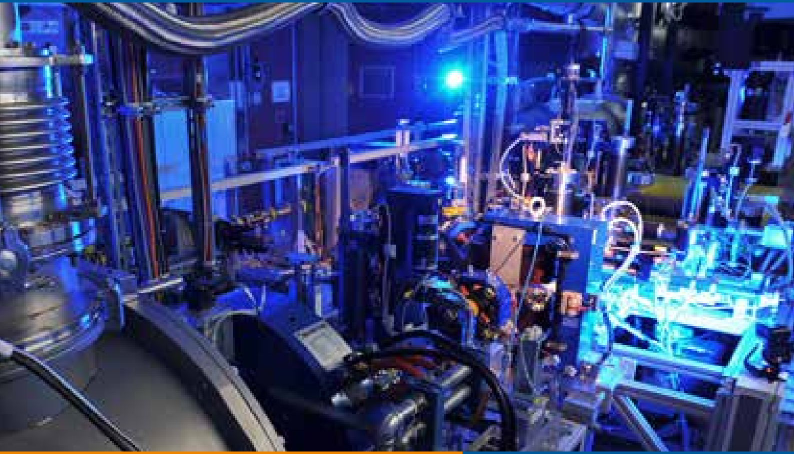
ELBE.

Center for High-Power Radiation Sources



HZDR

HELMHOLTZ
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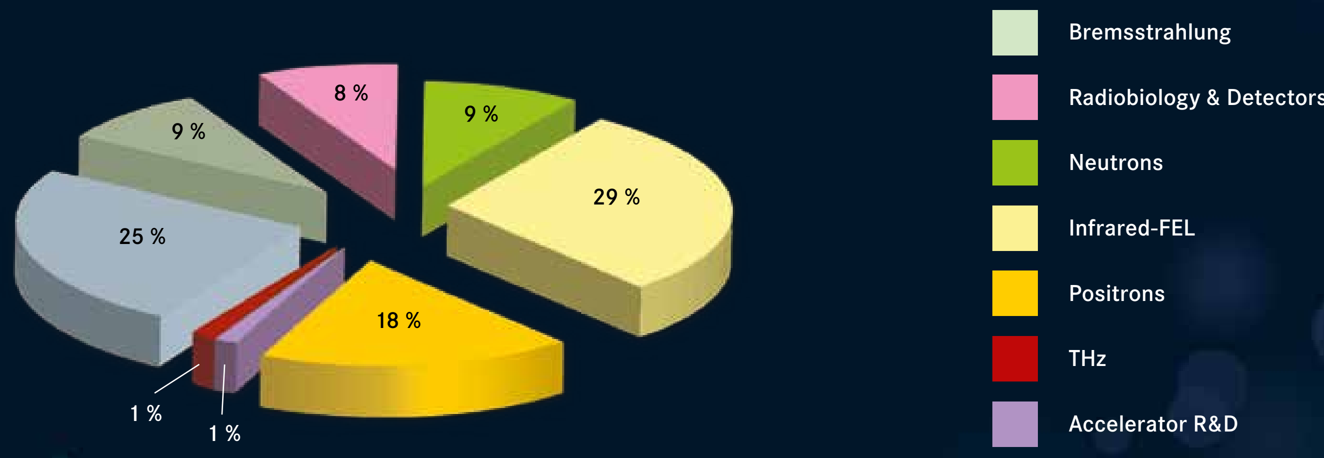
ELBE.

Center for High-Power Radiation Sources

In the ELBE Center for High-Power Radiation Sources two free-electron lasers, sources for coherent THz radiation, mono-energetic positrons, electrons, γ-rays, a neutron time-of-flight system as well as two synchronized ultra-short pulsed Petawatt laser systems are collocated. The characteristics of these beams make ELBE a unique research instrument for external users as well as scientists of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR).

Every year up to 30 user groups from all over the world carry out experiments at one of the various radiation sources. This number is increasing and already now more than 50% of the total user beamtime is provided to external users.



Beamtime per year ≈ 6,000 h
Reliability ≥ 90%
Breakdown of beamtime shown here above: Example from 2013

USER ACCESS

ELBE is a research infrastructure providing more than 50% of the available beamtime to external users. Access is free-of-charge for non-proprietary research.

Two calls for proposals are published per year. Proposals are submitted through **GATE** (https://www.hzdr.de/gate), the electronic portal for user access to ELBE and to the Ion Beam Center at HZDR. Proposals are evaluated by independent reviewers from the international Scientific Advisory Committee for the ELBE Center for High-Power Radiation Sources.

Access to FELBE is also possible through wayforlight (http://www.wayforlight.eu), the unified access portal for all synchrotrons and FELs in Europe.

GATE

wayforlight

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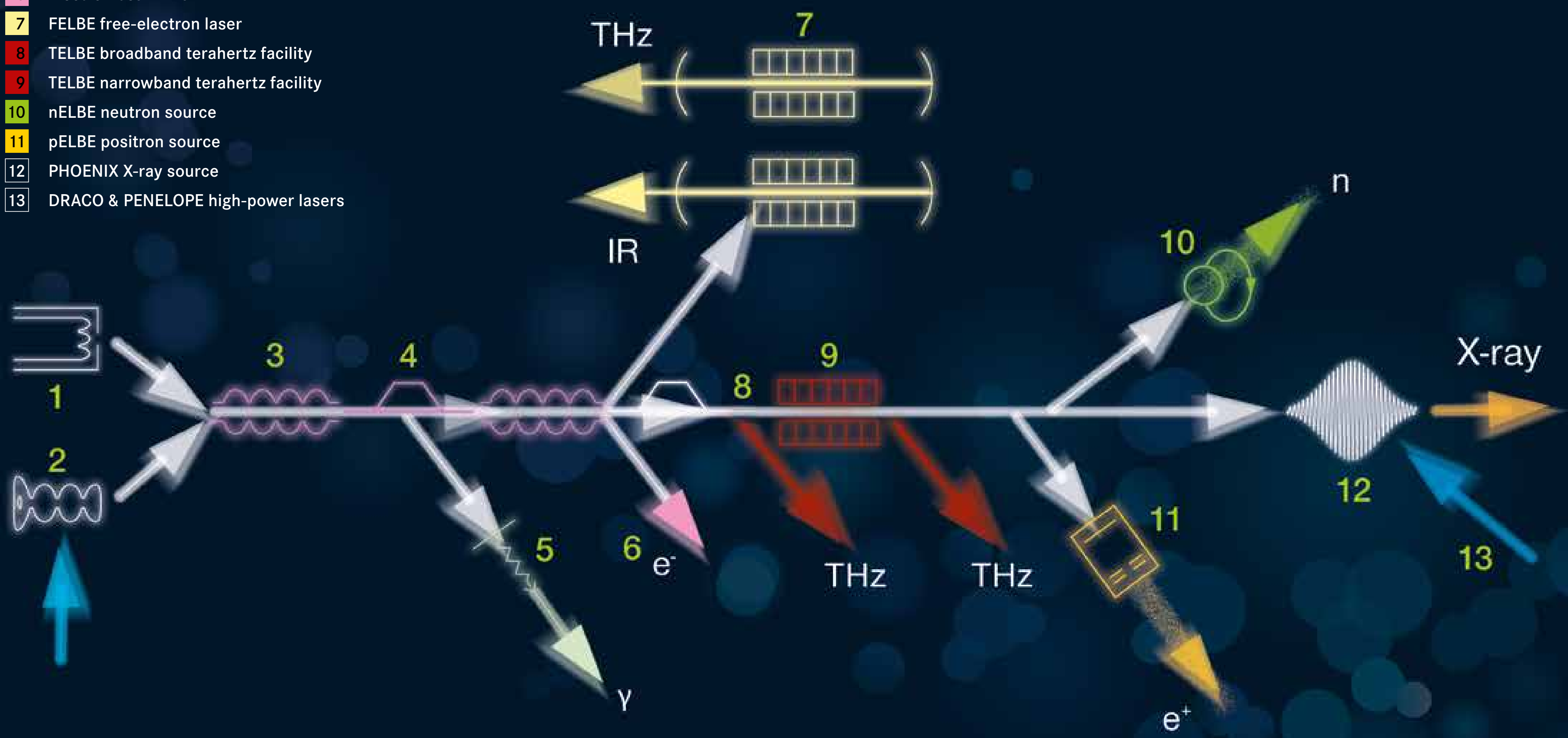
Detailed information is available from the ELBE user-site
http://www.hzdr.de/elbe-user

ELBE user site

1 Thermionic electron gun
2 Superconducting high-frequency electron gun
3 Main accelerator
4 Bunch compressor
5 γELBE bremsstrahlung facility
6 Electron beam in air
7 FELBE free-electron laser
8 TELBE broadband terahertz facility
9 TELBE narrowband terahertz facility
10 nELBE neutron source
11 pELBE positron source
12 PHOENIX X-ray source
13 DRACO & PENELOPE high-power lasers



Mono-Energetic Positron Source pELBE

Positron beams of variable kinetic energy and with adjustable repetition rate are used for positron annihilation lifetime studies (PALS) and Doppler-broadening spectroscopy (DBS). Both techniques allow for depth-dependent defect characterization studies in thin films, porosimetry, and basic research on positron and positronium annihilation.

Bunched positron beams are generated by means of pair production from high-energy electron bremsstrahlung (max. 36 MeV) produced inside a converter from the superconducting LINAC. Positrons are injected into a tungsten moderator, then thermalized and extracted at a fixed kinetic energy of 2 keV and transported by magnetic guiding fields to the measurement area. Before reaching the sample under study, the positron beam is re-bunched and post-accelerated to the desired energies. The repetition rate can be adjusted in order to cope with various annihilation lifetimes of up to about 150 ns. With variable positron kinetic energies samples can be investigated from the surface to a depth of about 2 µm.

pELBE SPECIFICATIONS

Energy	0.5 - 20 keV
Repetition rate	1.625, 6.5, 13 MHz
Intensity	$5 \cdot 10^5$ / s

EXEMPLARY EXPERIMENTS

// Pore size distributions in micro-porous gas-separation membranes
// Porous structure of ultralow-k dielectrics for semiconductor applications
// Structural and thermal vacancies in metal alloys
// Defect-induced ferromagnetism in diluted magnetic oxides

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Positron source
pELBE

Bremsstrahlung Facility γELBE

Electron energy range	6 - 16 MeV
Flux on niobium foil target (Ø 2 cm) for production of γ-rays	10^9 s^{-1} (max. average current 0.7 mA)
Collimator	2.60 m long high-purity Al tube
Detectors	4 HPGe detectors surrounded by BGO escape suppression shields
Detector geometry (relative to the incident beam)	2 detectors at 127°, 2 detectors movable between 90° and 127°
Mounting of other detectors	LaBr, BaF possible

γELBE is particularly suitable for:
// Photon scattering and photodissociation experiments
// Gamma-induced positron spectroscopy (GiPS) using positron annihilation lifetime studies (PALS)
// Tests of photon detectors at high energies

REFERENCES

R. Massarczyk et al., Phys. Rev. Lett. 112 (2014), 072501
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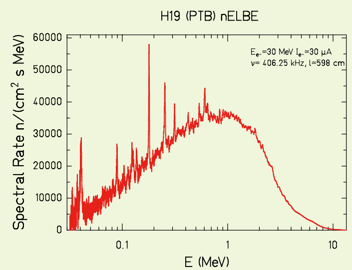
Neutron Time-of-Flight Facility nELBE

HZDR operates the world's only photoneutron source at a superconducting electron accelerator. Intense beams of fast neutrons with a repetition rate of more than 100 kHz are produced for high-resolution time-of-flight measurements with a background-free flight path in the range of 4-11 m.

Experimental setups include:
// Elastic and inelastic neutron scattering
// Neutron-induced fission
// Transmission measurements of the total neutron cross section



Photoneutron spectrum

Bremsstrahlung facility

REFERENCES

R. Beyer et al., Nucl. Phys. A 927 (2014), 41
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Neutron time-of-flight system

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Direct Electron Beam in Air

The direct electron beam may exit the vacuum chamber through a thin beryllium window. As the beam can be used in air, dedicated detector tests are possible as well as irradiation of living cells, thus enabling radiobiological experiments. A biological cell laboratory located close-by can be made available to users.

SPECIFICATIONS OF THE ELECTRON BEAM

Beam property	Operation mode	Value
Number of bunches/ s	CW	$13 \cdot 10^6 / 2^n$; n=0,1, 2, …6
	single-pulse mode	1 - $1.3 \cdot 10^7$
	single electrons	1 - 10^5
Charge/ bunch	CW	≤ 7.77pC
	single-pulse mode	~1 fC - ~100 pC
	single electrons	1 - 20 elementary charges
Jitter of reference clock	all	≈35 ps

Exemplary Experiments:
// Detector time resolution in the picosecond range
// Rate characterization capability of detectors up to MHz/cm²
// Recombination loss in gas- and liquid-filled ionization chambers
// Cell culture response to electron pulses of ultra-high pulse dose rate

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L. Laschinsky et al., J. Radiat. Res. 53 (2013), 395

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Detector tests with the electron beam

Superconducting Electron Linear Accelerator

The Radiation Source ELBE is based on a superconducting linear accelerator that can be operated in high average-power mode (quasi continuous wave mode, CW). Electrons are pre-accelerated in a 250 keV-thermionic DC electron gun and are pre-bunched in a two-stage RF-buncher section. The main accelerator consists of two 20 MeV superconducting linear accelerator modules operating at 1.3 GHz which are cooled with liquid helium. The RF power is generated by transistor amplifiers, controlled by the low level RF system.

With an electromagnetic chicane between the modules, the micro-pulse duration and energy spread of the beam can be optimized. The accelerator is mainly controlled by the control system, and the electron beam parameters can be measured by multiple diagnostic tools.

SPECIFICATIONS OF THE ELBE LINAC // DESIGN

Max. energy	36 MeV
Max. current	1.6 mA
Micro-pulse repetition rate	13 MHz/2^n up to single pulse
Micro-pulse length	1 - 10 ps
Macro-pulse repetition rate	1 - 25 MHz or CW
Macro-pulse duration	0.1 - 40 ms
Max. bunch charge thermionic gun	100 pC
Max. bunch charge SRF gun	1 nC (goal)

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J. Teichert et al., NIM A, 743 (2014), 114 - 120
P. Michel et al., Nuclear Science Symposium Conference Record, 2008. NSS#08 IEEE, 3078
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Accelerator

Free-Electron Laser FELBE

The free-electron-laser facility, FELBE, provides picosecond infrared pulses. Two free-electron lasers cover the mid- and far-infrared spectral range from 4 - 250 µm.

FELBE SPECIFICATIONS

Photon energy	5 - 300 meV
Wavelength	4 - 250 µm
Polarization	Linear; circular possible for some wavelengths
Estimated pulse length	1 - 25 ps
Repetition rate	13 MHz, 1 kHz; macrobunch: bunch length > 100 µs, repetition rate <25 Hz
Pulse energy	0.1 - 2 µJ
Peak power	up to 1 MW
Average power	up to 20 W
FEL mode	TEM_00
FEL bandwidth	0.3 - 1.5 % (FWHM)

The FELBE user labs are equipped mainly for time-resolved spectroscopy. The following additional equipment is available for users:
// Various table-top NIR and THz sources that can be synchronized to FELBE
// Setups for single-colour and two-colour pump-probe experiments
// Time-resolved photoluminescence measurements
// Near-field spectroscopy and Fourier-transform infrared spectroscopy
// 8 T split-coil magnet with optical access
// Pulsed magnetic fields up to 70 T (150 ms magnetic pulse duration) due to an optical transfer line to the adjacent Dresden High Magnetic Field Laboratory

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FELBE

High-Field High-Repetition-Rate THz Facility TELBE

A new facility for the generation of low-frequency, high-field THz pulses, covering the lower THz range between 0.1 and 3 THz, is currently being commissioned. The fundamental generation principle is based on superradiance from electron bunches that are appropriately shorter than the inverse frequency of the desired THz pulse.

Pulses from TELBE will be carrier-envelope-phase stable and can be provided at flexible repetition rates between a few tens of Hz to 13 MHz.
The accelerator will be operated in a new high-charge mode, providing bunch charges up to 1000 pC and pulse energies up to 100 µJ.

TELBE SPECIFICATIONS // DESIGN

Radiator type	Electron charge/ pC	Repetition rate/ kHz	Pulse energy/ µJ	Band-width/ %	No. of field cycles
Undulator	< 100	$\le 1.3 \times 10^4$	1	~20	8
	< 1000	≤ 500	100	~20	8
Diffraction radiator	< 100	$\le 1.3 \times 10^4$	0.25	100	1
	< 1000	≤ 500	25	100	1

The TELBE laboratory is equipped for time-resolved spectroscopy:
// Two femtosecond laser systems
// THz spectrometers
// High-field THz source based on optical rectification
// Different end stations for time-resolved THz pump-probe experiments
// 10 T split-coil magnet with optical access

User operation with preliminary parameters is envisaged to start in 2016.

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Super-radiant THz radiation

Helmholtz-Zentrum Dresden-Rossendorf

The long-term goal of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) is to conduct cutting-edge research in the areas of energy, health, and matter. Strategic collaborations with both national and international partners allow scientists to address some of the pressing challenges faced by modern-day industrialized society:

// How can energy and resources be utilized in an efficient, safe, and sustainable way?
// How can malignant tumors be more precisely visualized, characterized, and more effectively treated?
// How do matter and materials behave under the influence of strong fields and in smallest dimensions?

To answer these scientific questions, several large-scale research facilities provide unique research opportunities. The HZDR is member of the Helmholtz Association, has four locations (Dresden, Leipzig, Freiberg and Grenoble), and employs about 1,000 people – approximately 500 of whom are scientists.

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Directions

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