

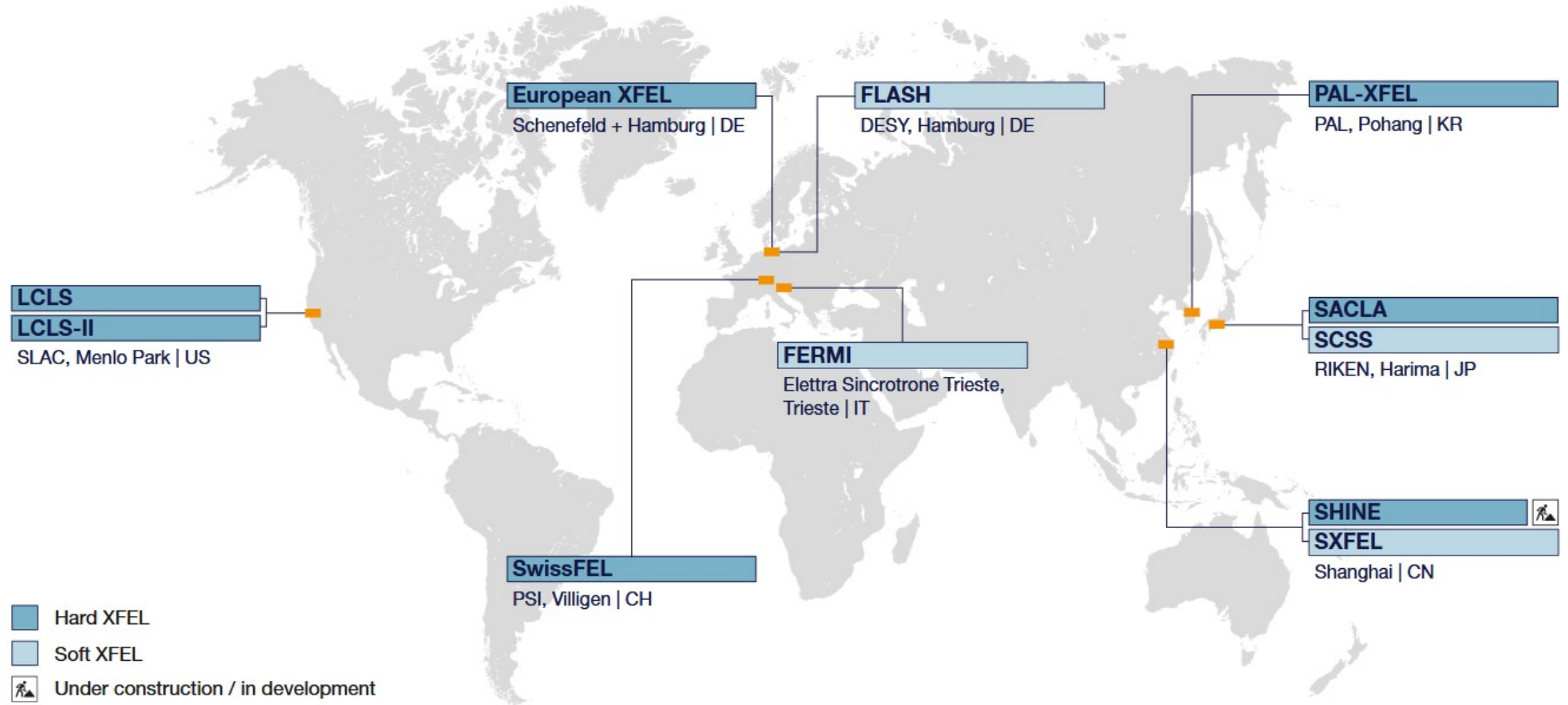
Measuring Pulsed Photon and Neutron Dose Rates at the European XFEL facility

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Deutsches Elektronen-Synchrotron

Hamburg, May 11th, 2026



European XFEL



Location, type, and current status (as of February 2023) of the world's free-electron lasers

European XFEL

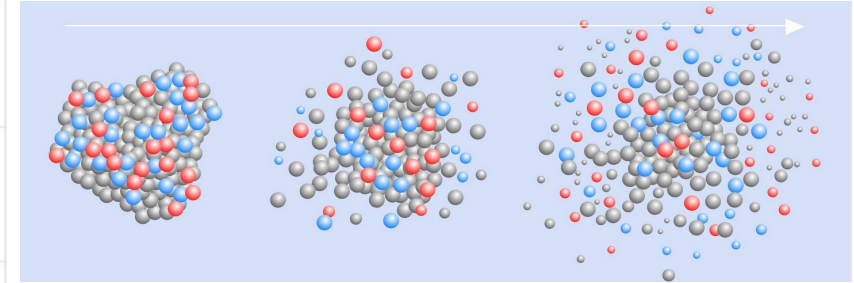
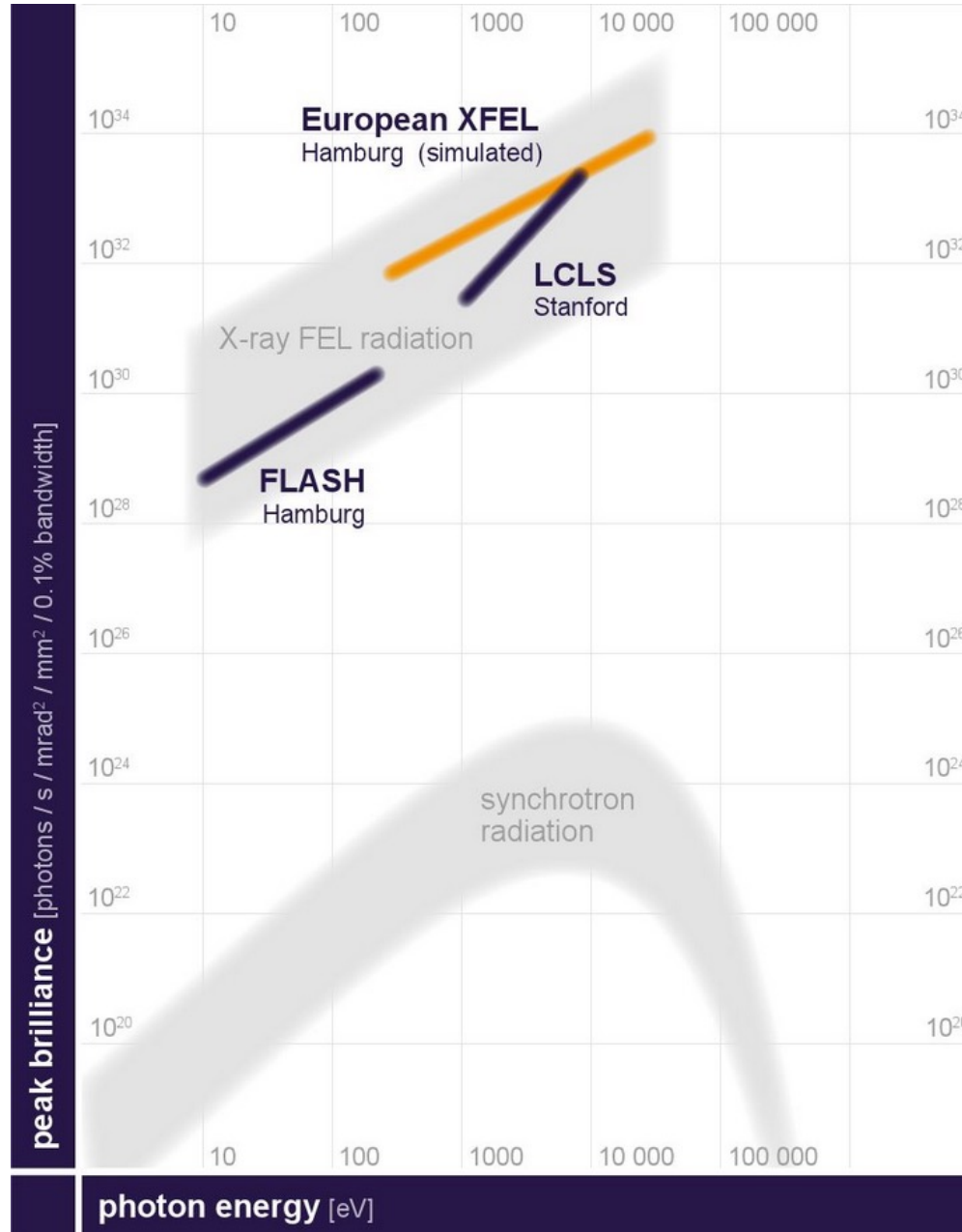


The European XFEL X-ray laser is a 3.4-km-long facility which runs essentially underground. The three sites (framed in orange) are located in Hamburg (DESY-Bahrenfeld and Osdorfer Born) as well as in the south of the city of Schenefeld (Pinneberg district, Schleswig-Holstein)

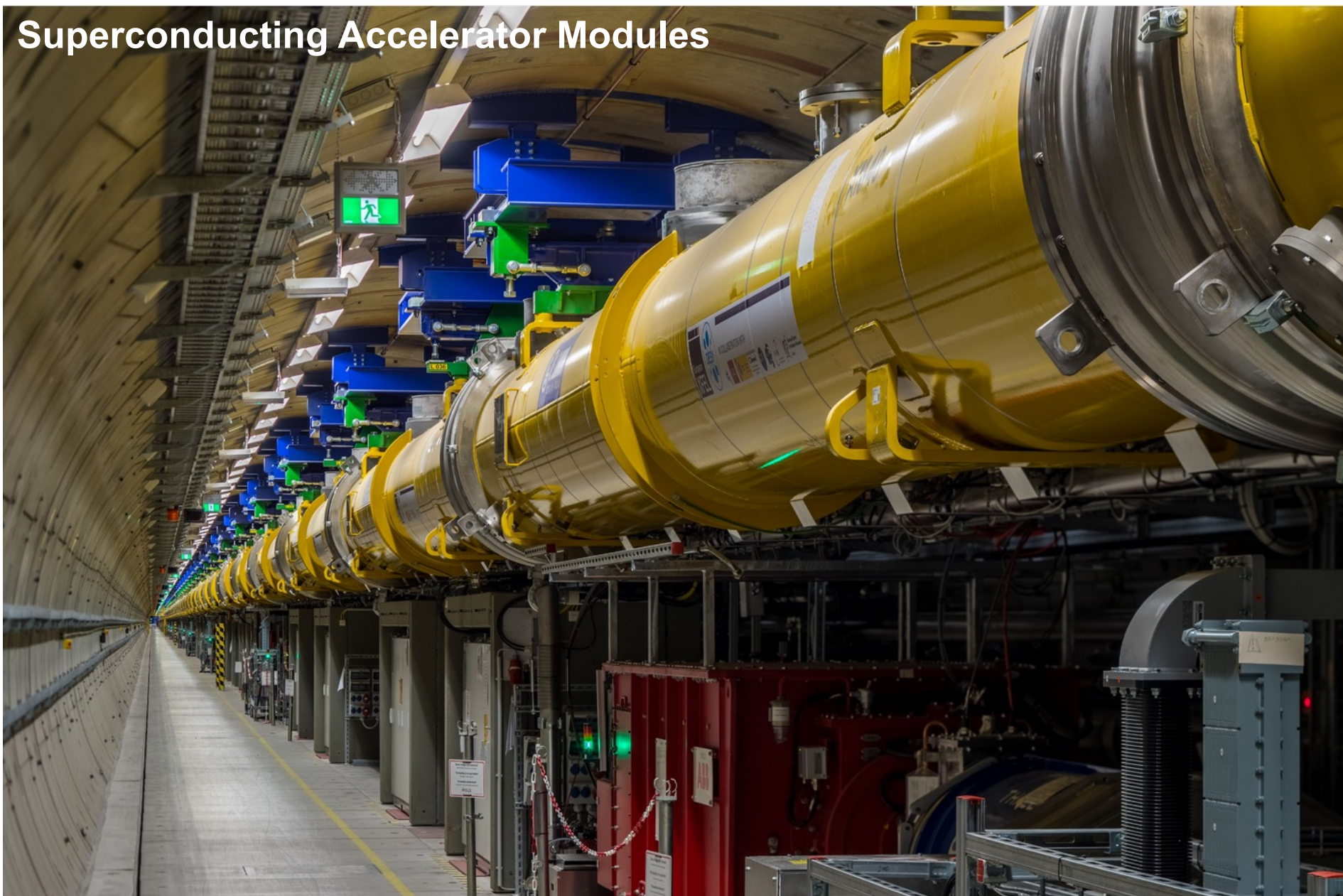
Peak brilliance

The peak brilliance of free-electron lasers exceeds that of the most modern synchrotron radiation sources by several orders of magnitude.

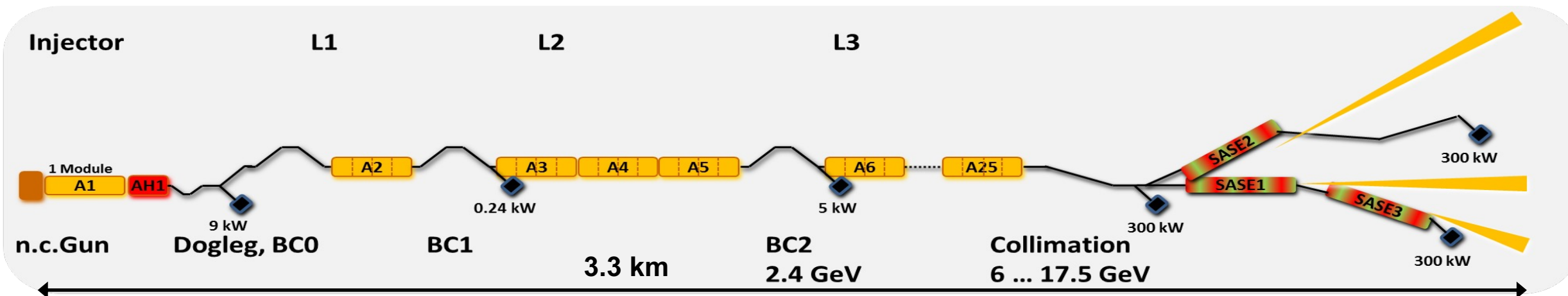
In this graphic, the DESY facility FLASH, the European XFEL and the LCLS (USA) are compared with third-generation synchrotron radiation sources.



Superconducting Accelerator Modules



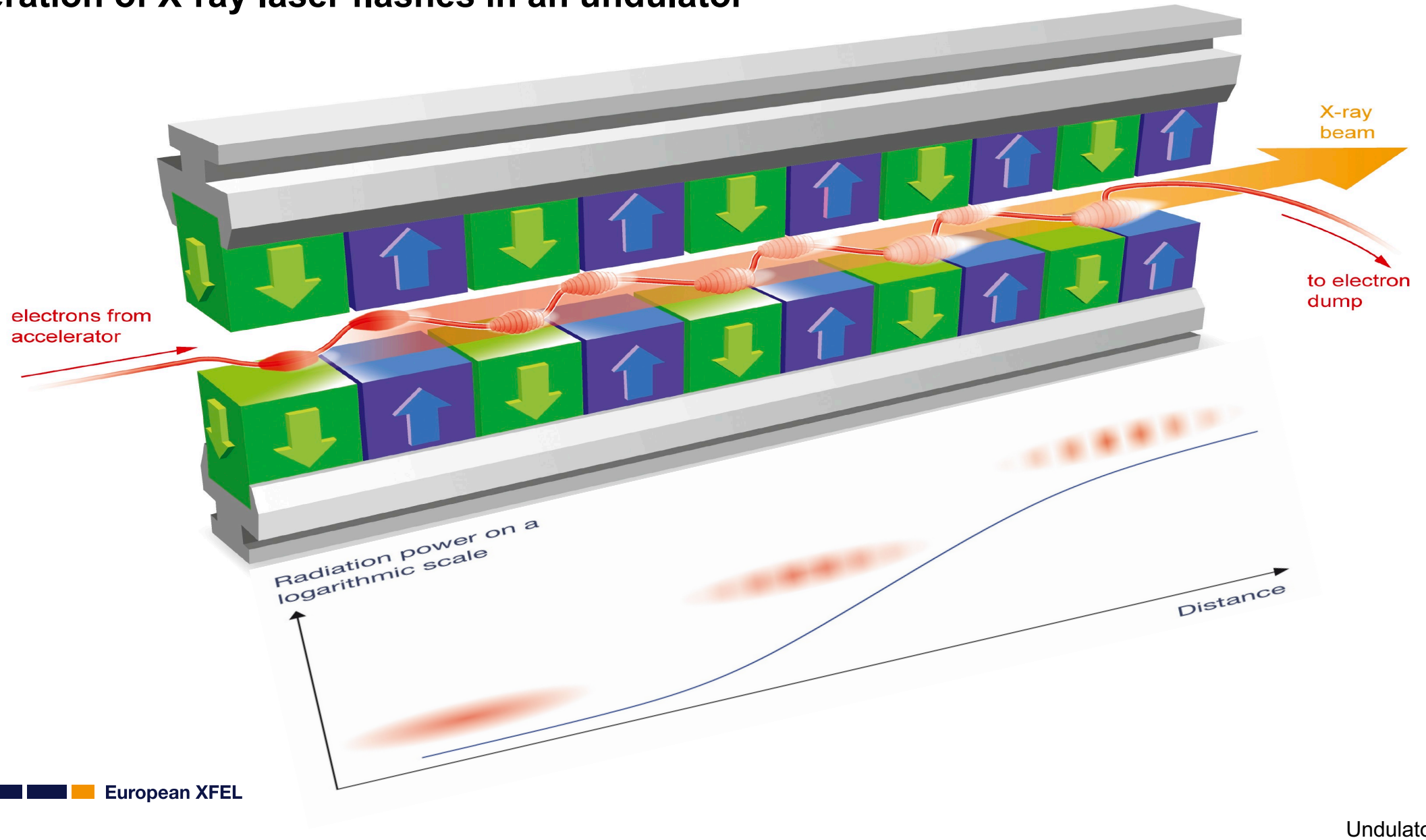
Superconducting Accelerators Offer Flexible Operation Parameters



- In operation since 2017
- Operating about 42 weeks per year with 32 weeks for scheduled X-ray program
- Excellent overall availability of > 95 %

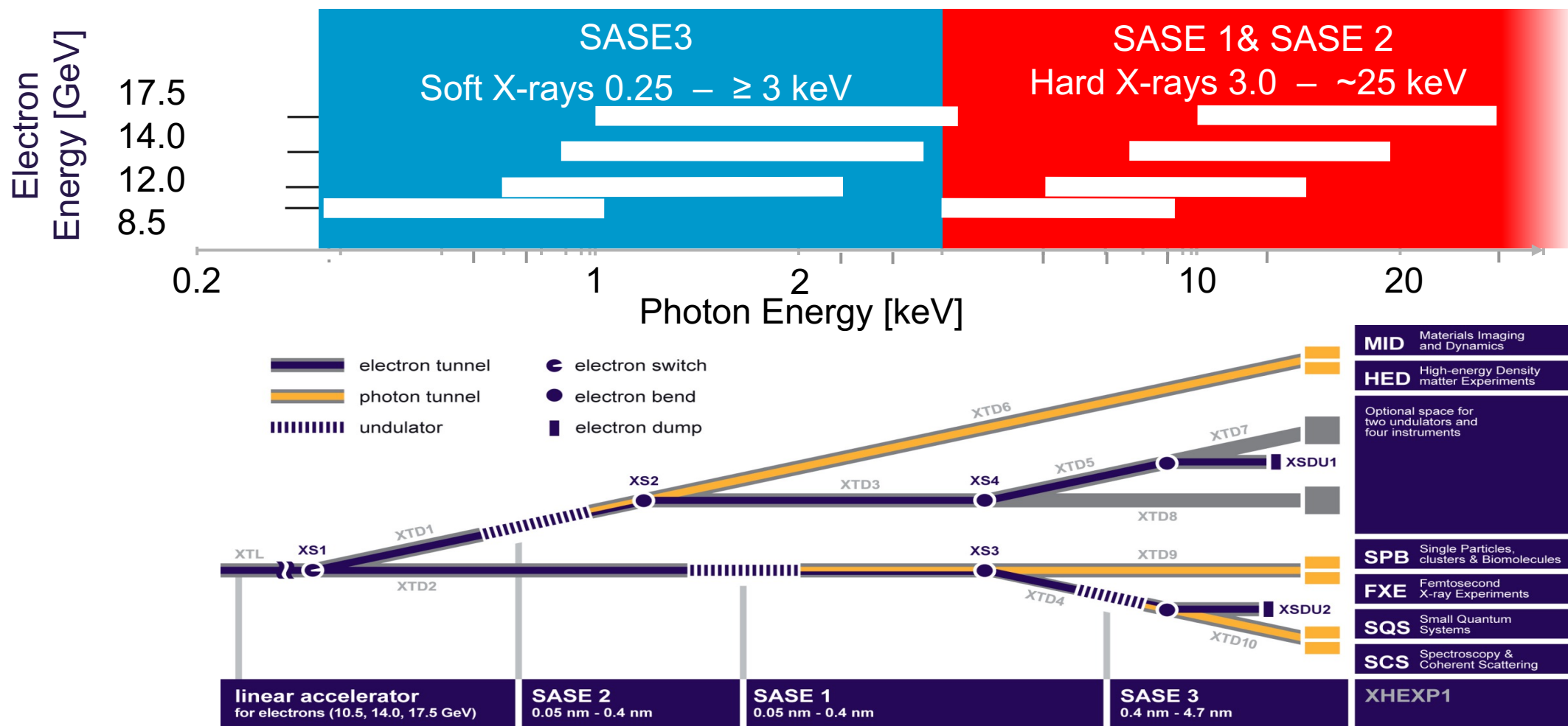
electron beam energy	8 - 17.5 GeV
macro pulse repetition rate	10 Hz
RF pulse length (flat top)	600 μ s (800 μ s from 2026)
# of bunches/second	27,000 (40.000 from 2026)
Typical e-beam parameters	250 pC, 40 fs FWHM bunch length, 0.4 mm mrad slice emittance
simultaneously operation of three SASE undulators	

Generation of X-ray laser flashes in an undulator

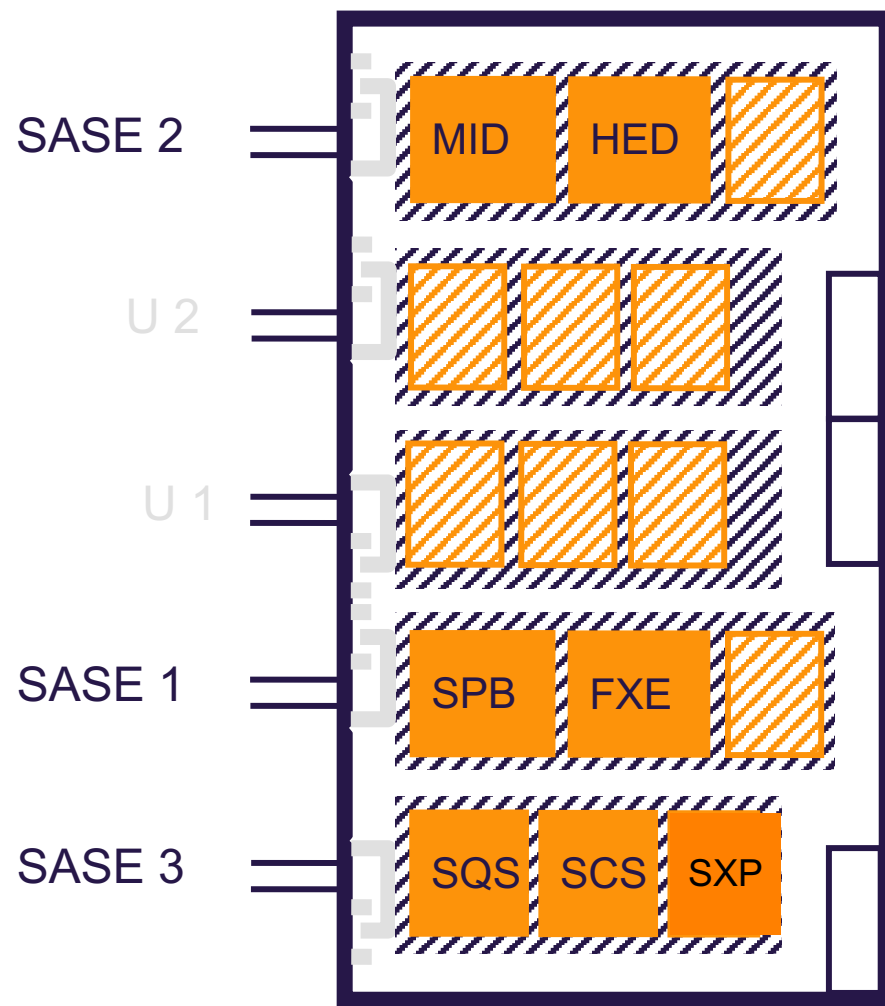


Three Undulators cover photon energies from 0.25 keV to 30 keV

Three variable gap undulators for hard and soft X-rays operated in parallel



More about experiments: <http://www.xfel.eu>



MID Materials Imaging & Dynamics

HED High Energy Density Science

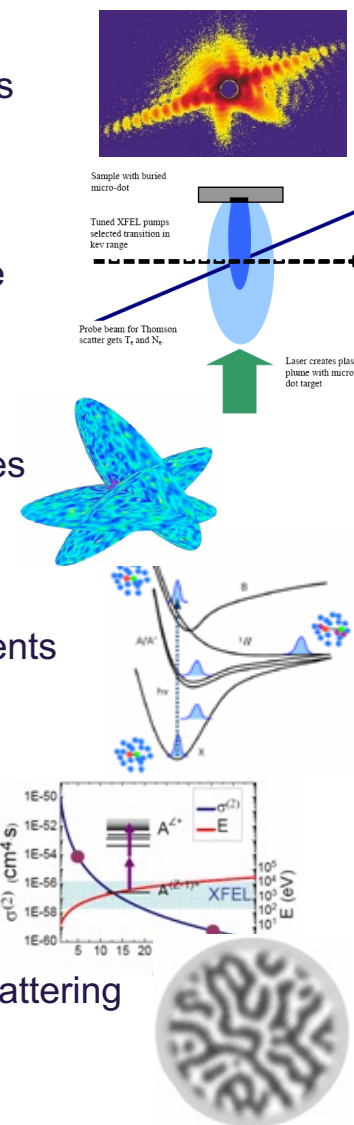
SPB Single Particle & Biomolecules

FXE Femtosecond X-ray Experiments

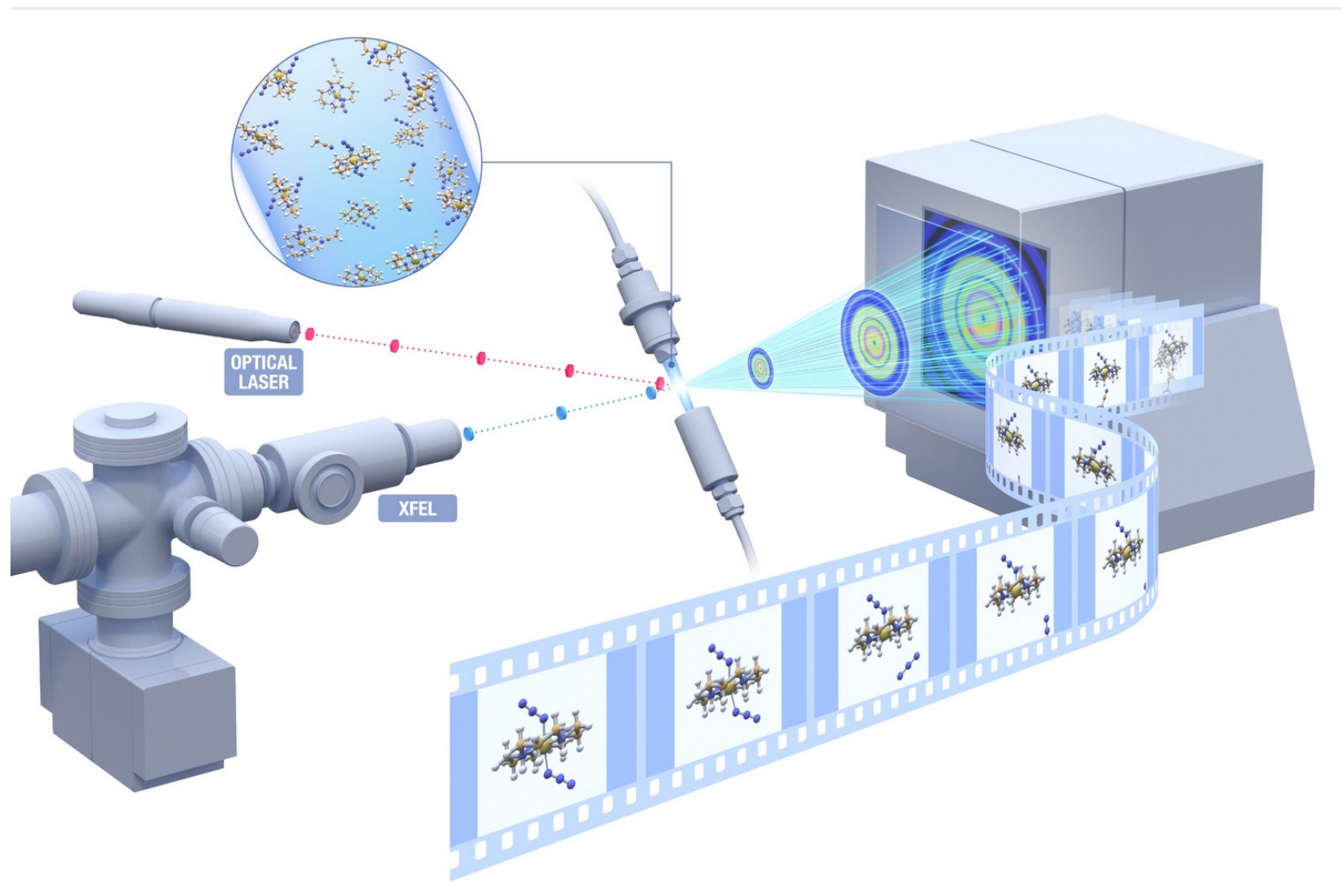
SQS Small Quantum Systems

SCS Spectroscopy & Coherent Scattering

SXP Soft X-ray port



Femtochemistry experiments at the FXE station



The ultrashort, ultrahigh-intensity X-ray laser pulses of the European XFEL enable studies of ultrafast processes in chemistry.

Synchronized optical laser pulses (red) activate a sample, here shown dissolved in a liquid jet, initiating a chemical reaction. X-ray laser pulses (blue) immediately follow the optical laser, with the resulting scatter recorded by a detector (right). Several of these pulses image different stages of the chemical reaction as it happens, and the data can be arranged sequentially to form a super slow-motion "molecular movie" of the reaction.

LB 6419: an Active Dose rate Meter

Detector Design

Photon detection:

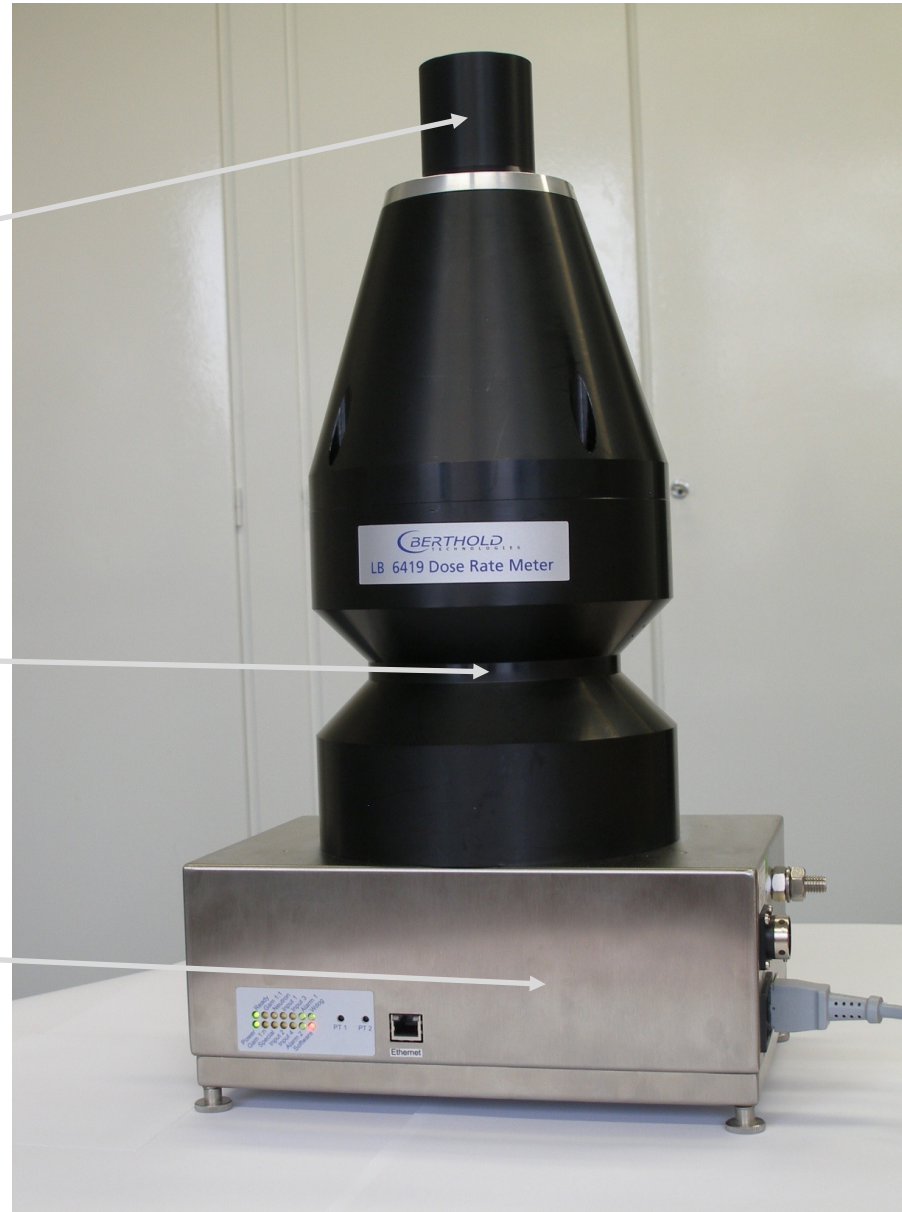
Plastik – Scintillator
Ø4cm × 4cm thick
in a 1 cm PE cover

Neutron detection:

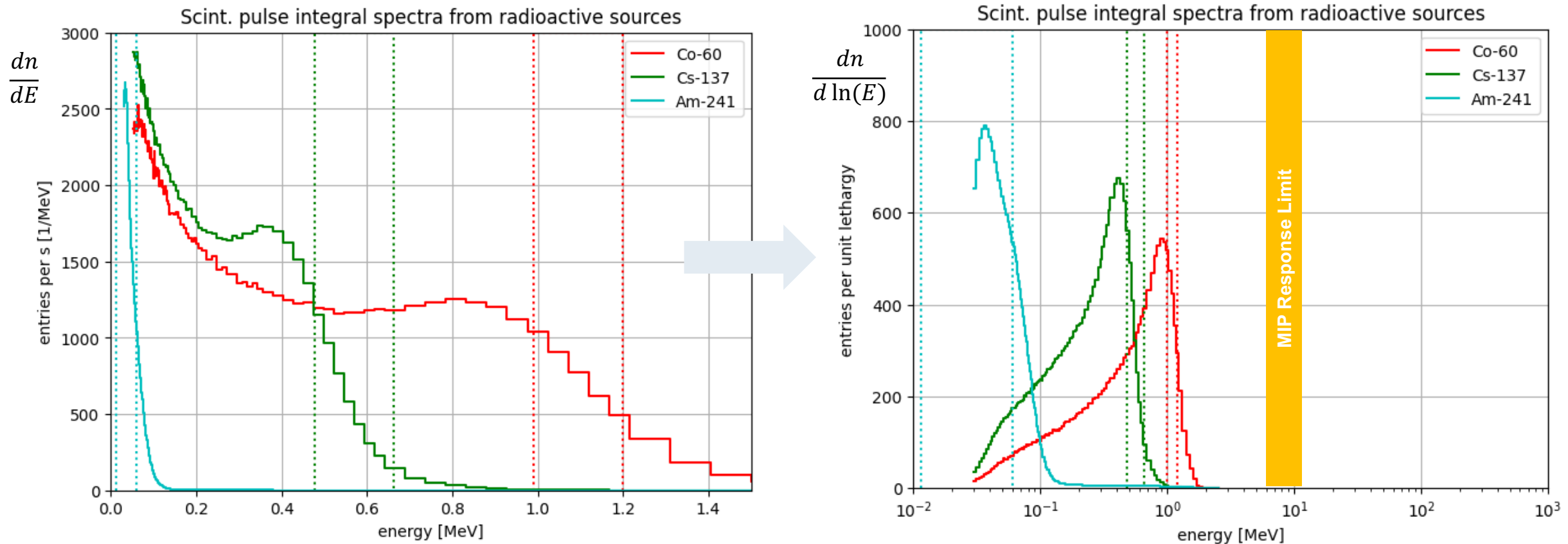
^3He – Counter
In PE moderator
rem – counter type

Electronics- Box
Power supplies
FADCRMON board (SIS)

Example Of PileUp



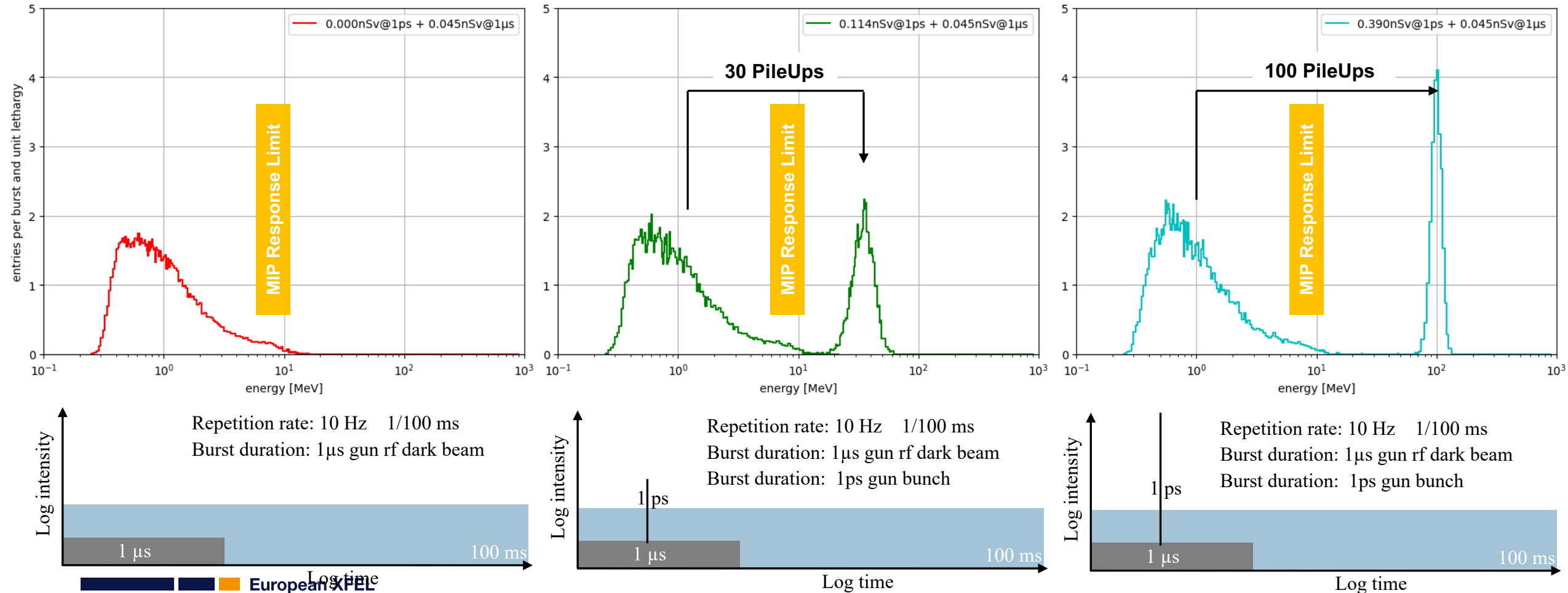
Scintillators Photon Energy Spectra: Radioactive Sources



Pulse integral spectra of 3 different radioactive sources are shown here with their corresponding photon energies and Compton edges (dotted lines) in a linlin representation (left) and a loglin lethargy representation (right). The latter allows us a spectral view over many orders of magnitude as common in neutron spectroscopy. The plastic scintillator is Ø4cm × 4cm thick. Minimum ionizing particles like $e^\pm$, $\mu^\pm$ and γ can deposit an energy of $4\text{cm} \times 2\text{MeV/g/cm}^2 \times 1\text{g/cm}^3 = 8\text{ MeV}$ in it at maximum.

Scintillators Photon Energy Spectra: Pulsed Radiation

The scintillation detector delivers electrical pulses with a width of about 20 ns. So it has a response duration of 20 ns. For example, the photons with an burst duration of 1 μ s are registered individually (left image), while those with a burst duration of 1 ps are mapped as pile-ups in a single pulse (center and right).



Detector Design

Photon detection:

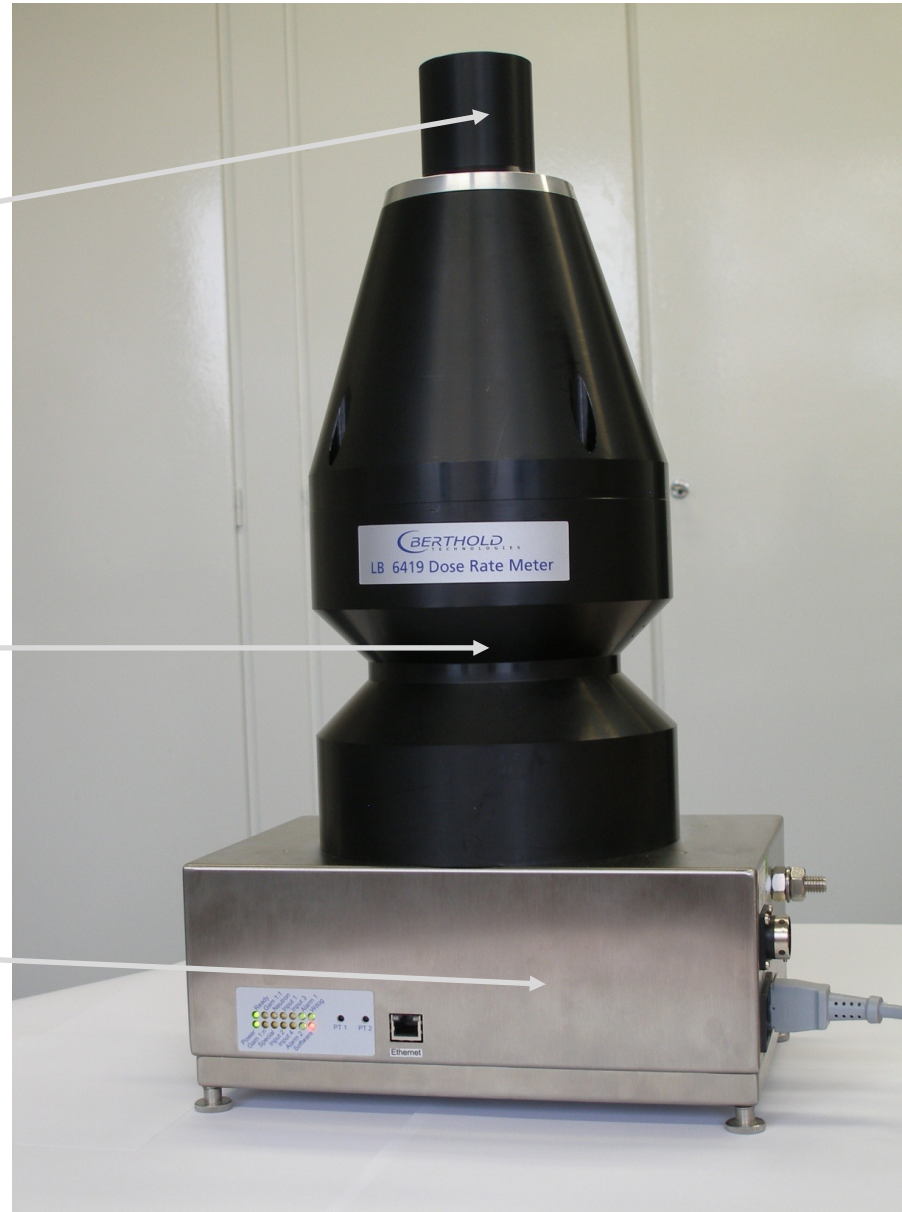
Plastik – Scintillator
Ø4cm × 4cm thick
in a 1 cm PE cover
Response duration: 20 ns

Neutron detection:

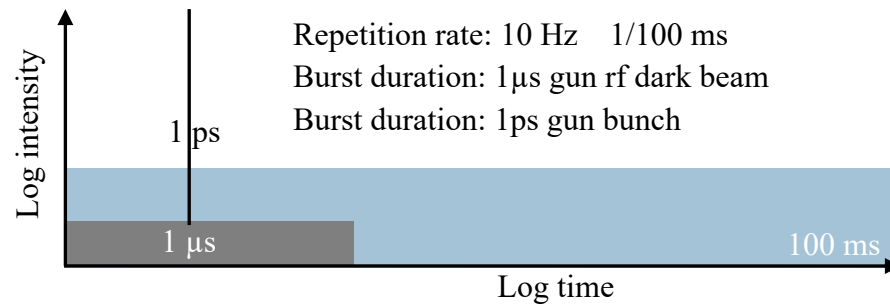
³He – Counter
In PE moderator
rem – counter type
Response duration: 1 µs

Electronics- Box
Power supplies
FADCRMON board (SIS)

Example Of Time Spectra



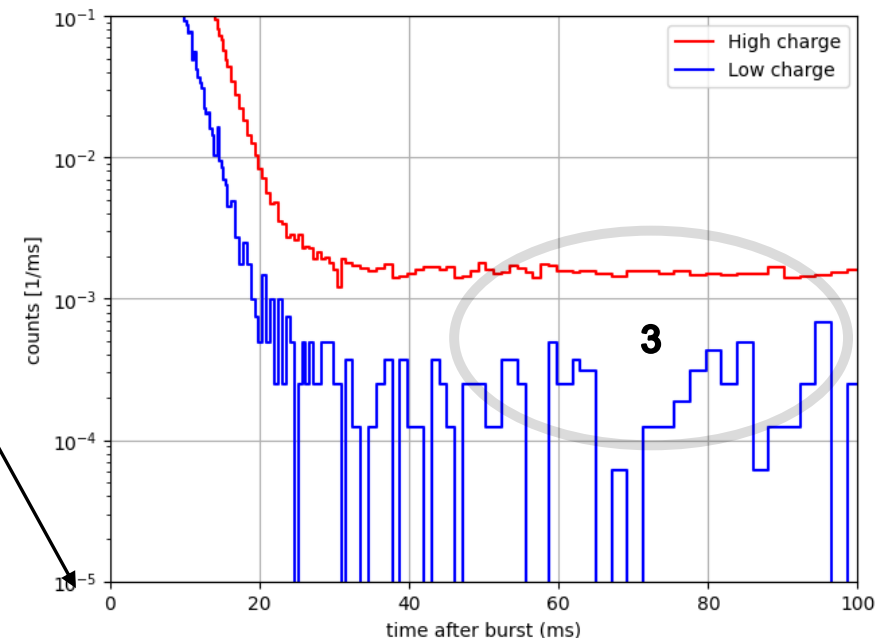
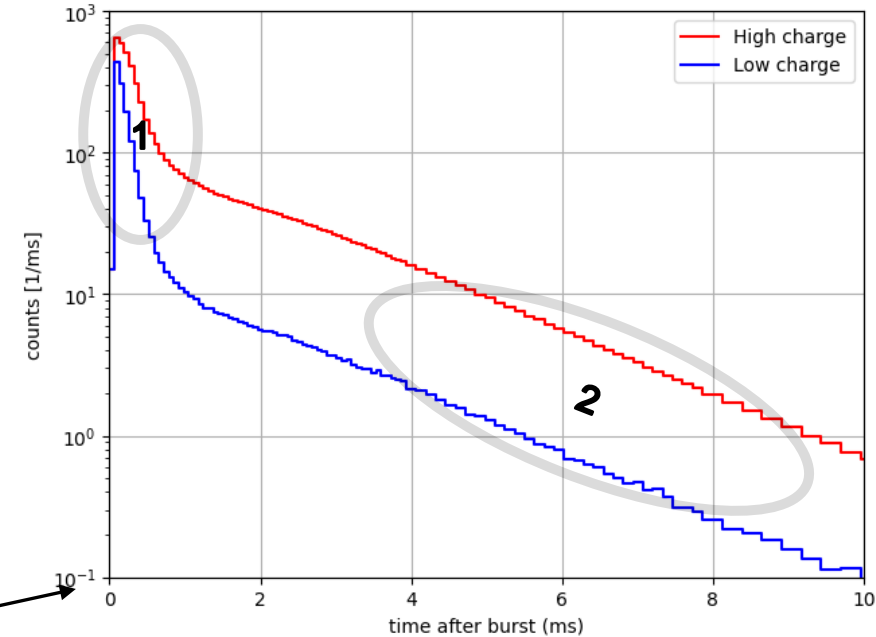
³He Counter Time Spectra: A Rough Neutron Energy Spectroscopy



The detector's time-resolved response is scanned for a **burst trigger** signature that marks time 0. The following counts are binned according to their arrival time. The next trigger stops this sequence and starts a new one.

These time spectra reveal 3 signatures:

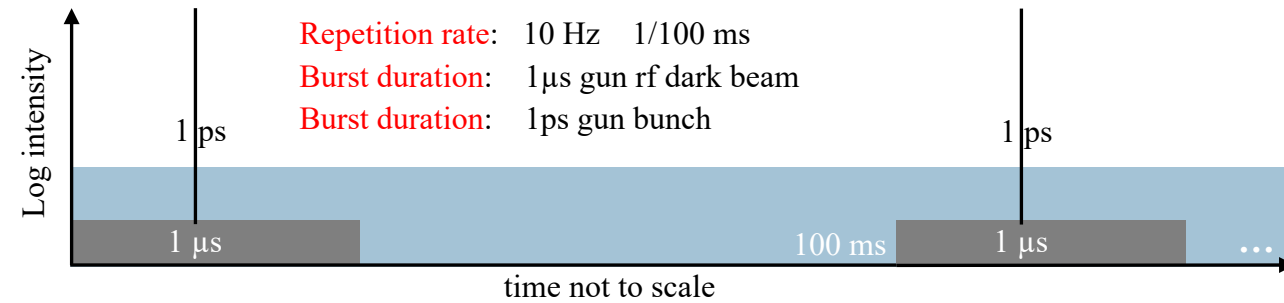
1. Integral Response: Neutron Diffusion in the Detector
Moderator: $\tau = 0.12$ ms / 0.26 m
2. Thermal neutrons: neutron diffusion in the vicinity of the detector (floor, ceiling, walls): $\tau \approx 2$ ms / 4.4 m
3. High-energy neutrons: delayed neutrons from the decay of long-lived nuclides: > 50 ms



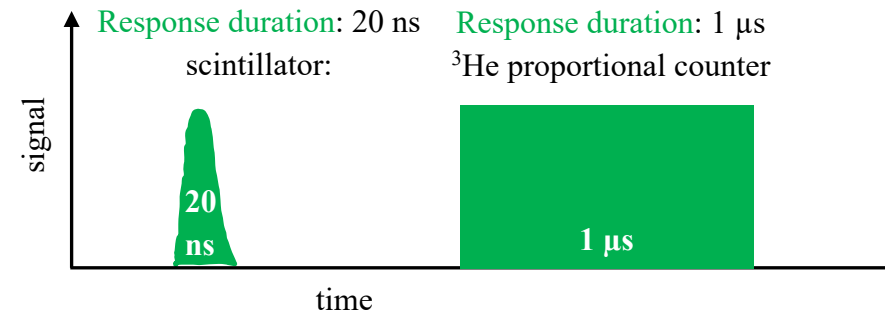
Natural
Background:
 2×10^{-6} counts/ms

Summary

The **time constants of the production of the pulsed radiation** are determined by the accelerator.



The **detector properties** describe how pulsed radiation is reflected in its response.

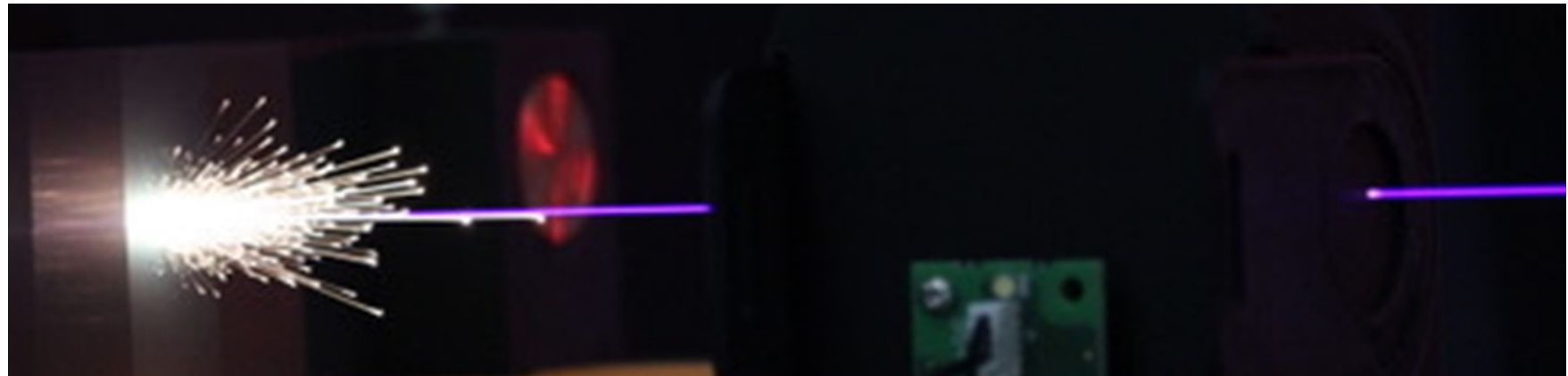


IF (**Burst duration** $\ll$ **Response duration**): **Pile-Up**

Saturation

The **half-response dose** indicates which response can be expected to underestimate the dose by 50%.

Thanks for your attention



The EuXFEL laser sword pierces a copper block like a piece of butter !