

KALDERA DESY.

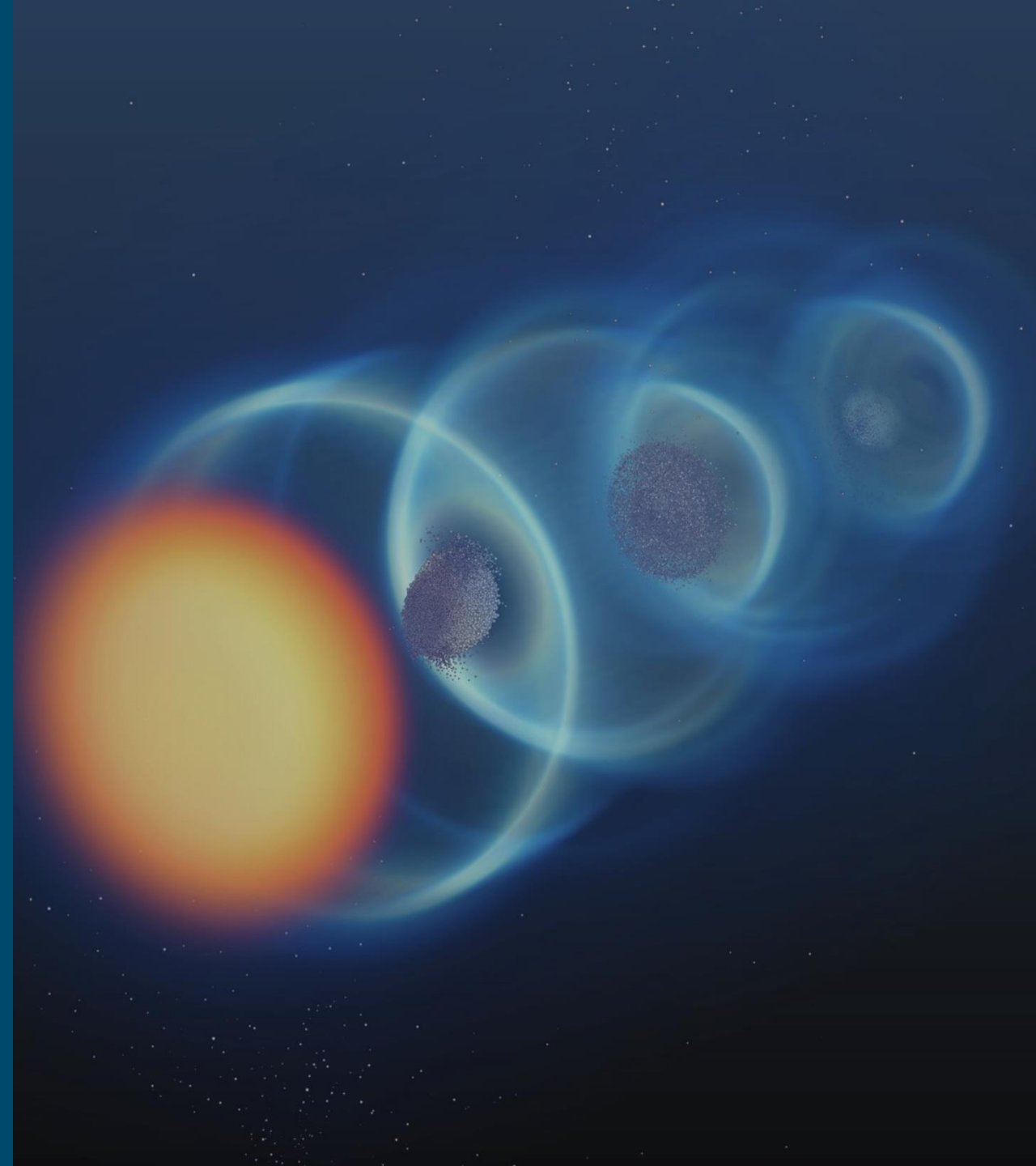
Radiation Protection
for a Laser-Plasma Facility

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T. Liang, E. Panofski, S. Bohlen, A. Leuschner

RadSynch 2025, Brazil

25.06.2025

HELMHOLTZ



Overview DESY



XFEL:

FEL with superconducting LINAC

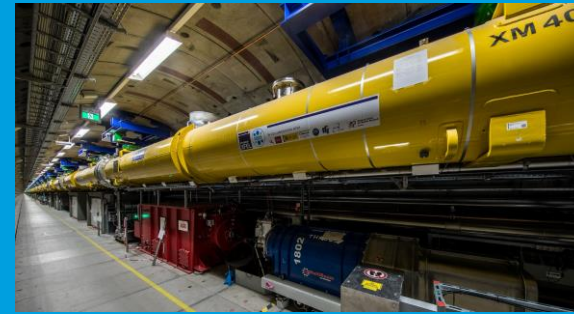
Up to 17,5 GeV

3,4 km (1,7 km accelerator)

photon energy 0,26 – 25 keV

1 Experimental Hall, 8 Beamlines

Status: Shutdown starts this week



PETRA III:

3. Generation Synchrotron

6 GeV, max. 200 mA

Circumferences: 2,3 km

3 Experimental halls

25 Beamlines

Status: running, running, running



FLASH:

FEL with superconducting LINAC

Up to 1,6 GeV

315 m

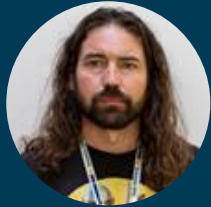
XUV and soft X-ray photon beams

2 experimental halls, 5 Beamlines

Status: FLASH 2020+ Shutdown



**European XFEL
Schenefeld / Schleswig-Holstein**



Eric Boyd:
Integrating High-Power Lasers
into a Free Electron Laser
Environment, ReLaX Laser
27.06.2025, 10:05

European XFEL

**DESY
Hamburg**

FLASH 1

FLASH 2

PETRA III



Ted Liang:
Radiation Protection of
FLASH2020+ at DESY
26.06.2025, 12:25



Eva Panofski:
Personnel Safety Systems at
DESY and XFEL in Transition
25.06.2025, 17:15



Andreas Rathjen:
Personnel Interlock Systems:
Implementation of risk
assessment requirements (SIL 3)
25.06.2025, 17:50

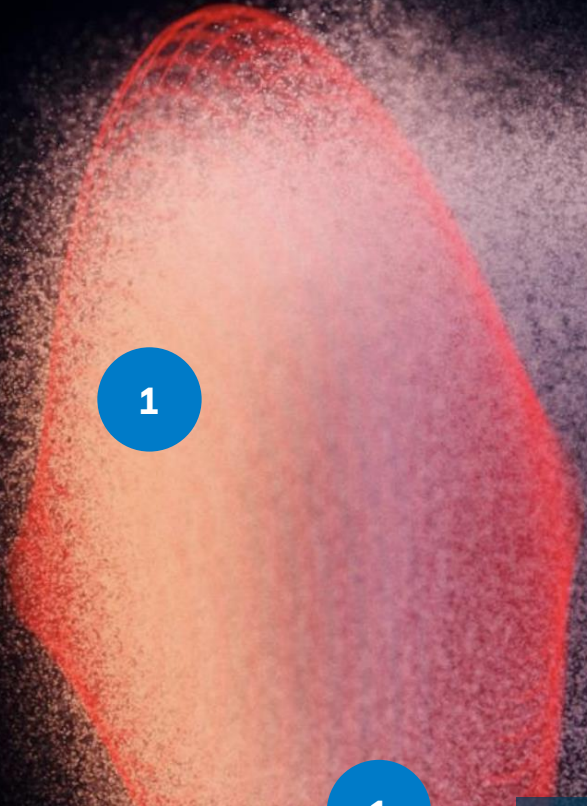


Anne Wefer:
Design and Shielding
Calculations for a New White
Beam Beamline at DESY
26.06.2025, 10:05

Laser-Plasma-Accelerators

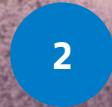
Development@ DESY

Laser-Plasma Acceleration



Intense Laserpulses

High intensity laser pulses with strong electro-magnetic fields are needed



Inonized gas

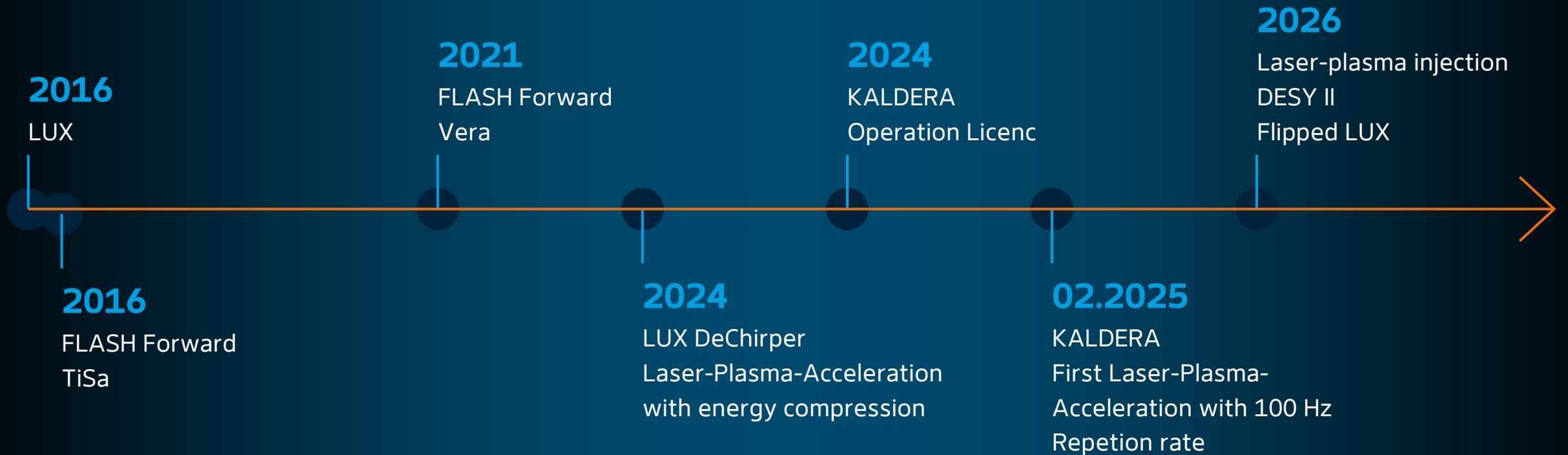
Laser pulses generate bubble-shaped plasma waves consisting of electrons by propagating through ionized gas



Electron bunch

Electric fields of the plasma wave can be used to accelerate electron bunches (high electric field gradients)

Laser-Plasma Development@DESY



KALDERA

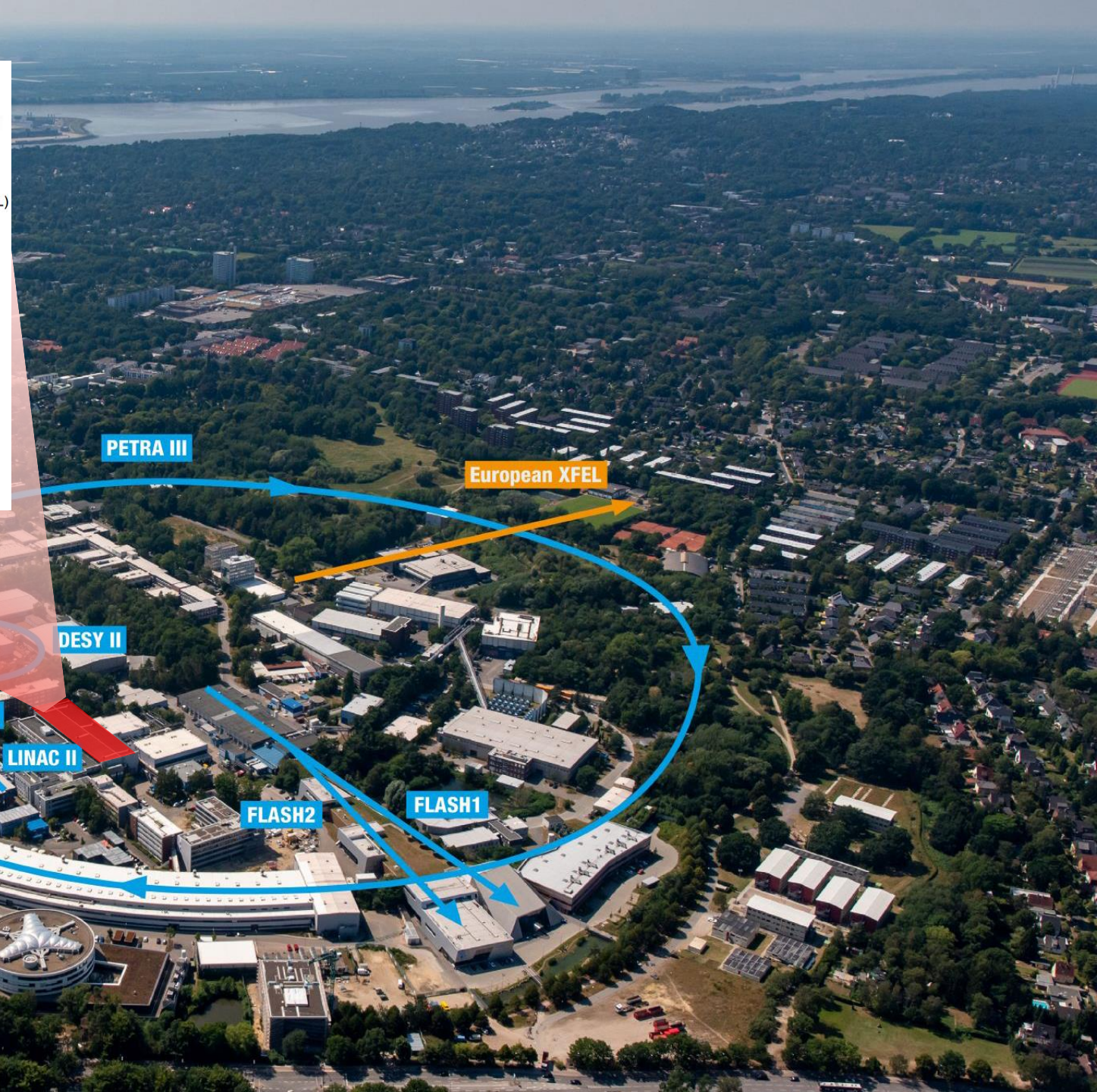
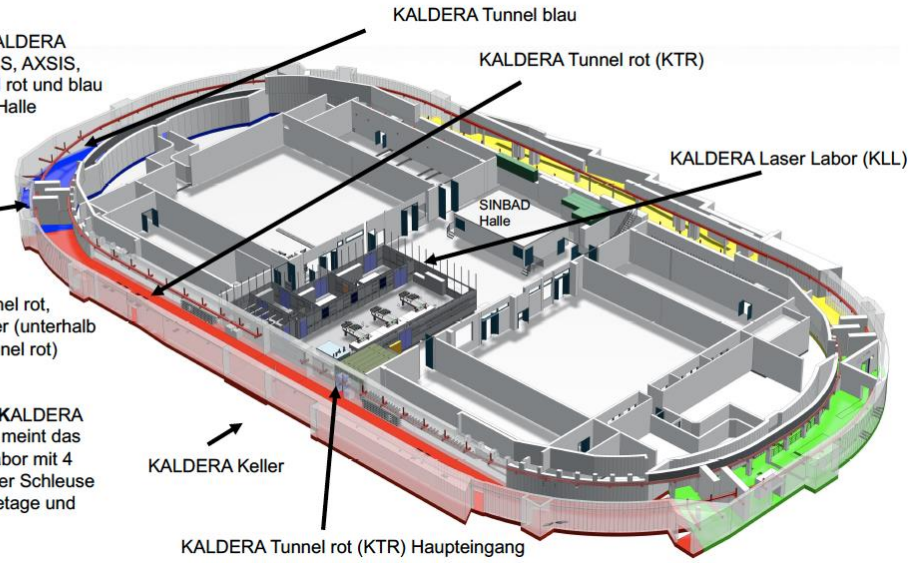
radiation protection concept

"SINBAD" =
Anlage welche KALDERA
Laser Labor, ARES, AXIS,
KALDERA Tunnel rot und blau
und die SINBAD Halle
beinhaltet.

Labyrinth

"KALDERA" =
Laser Labor, Tunnel rot,
Tunnel blau, Keller (unterhalb
des Labors & Tunnel rot)

"KLL" = steht für KALDERA
Laser Labor, und meint das
gesamtes Laserlabor mit 4
Laserlaboren, einer Schleuse
und der Lüftungsetage und
dem Dach.



PETRA III

European XFEL

DESY II

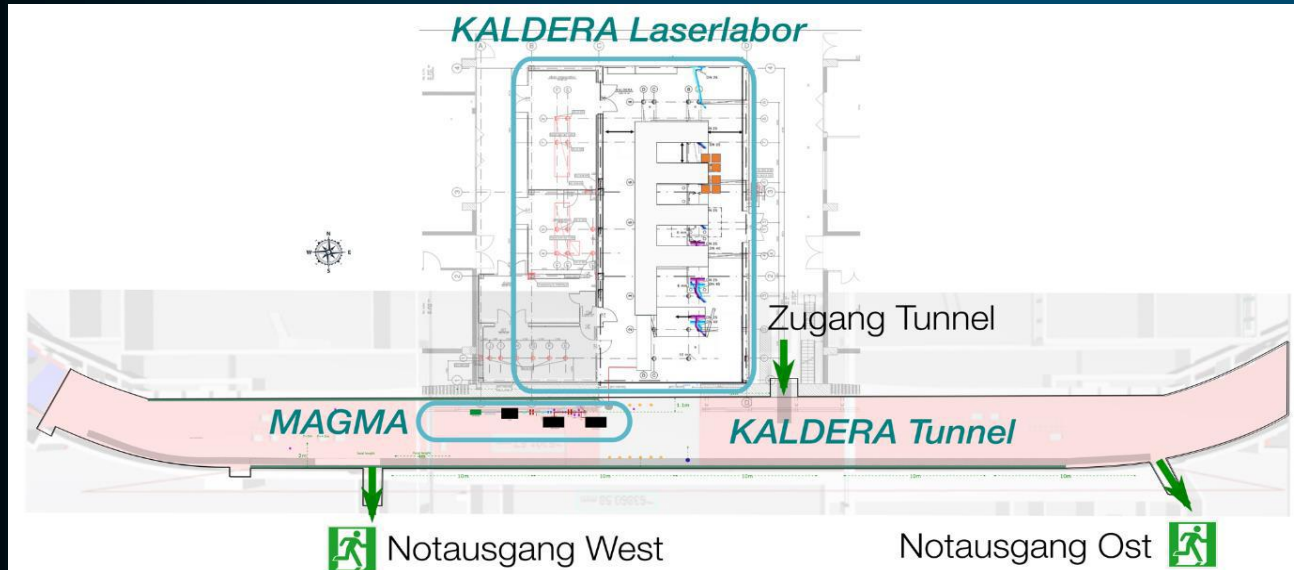
PIA

LINAC II

FLASH2

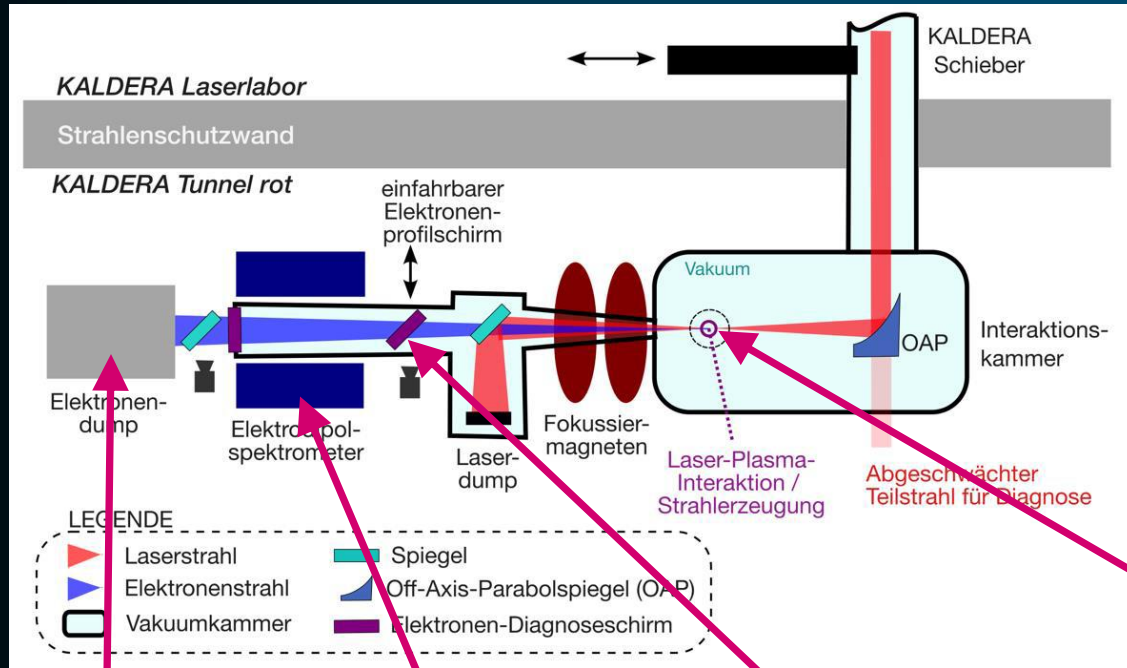
FLASH1

KALDERA – radiation protection areas



- laser-lab:
 - no radiation protection restrictions
- KALDERA-Tunnel (Area protected by PPS):
 - operation: restricted area
 - Maintenance: supervised area
- KALDERA – cellar:
 - Supervised area

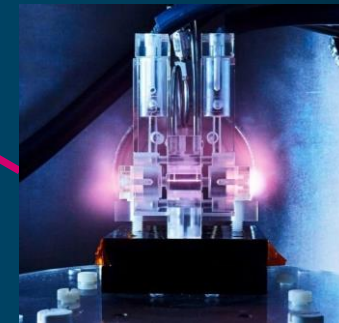
KALDERA – tunnel setup



dump

spectrometer

measurement of the electrons



plasma cell

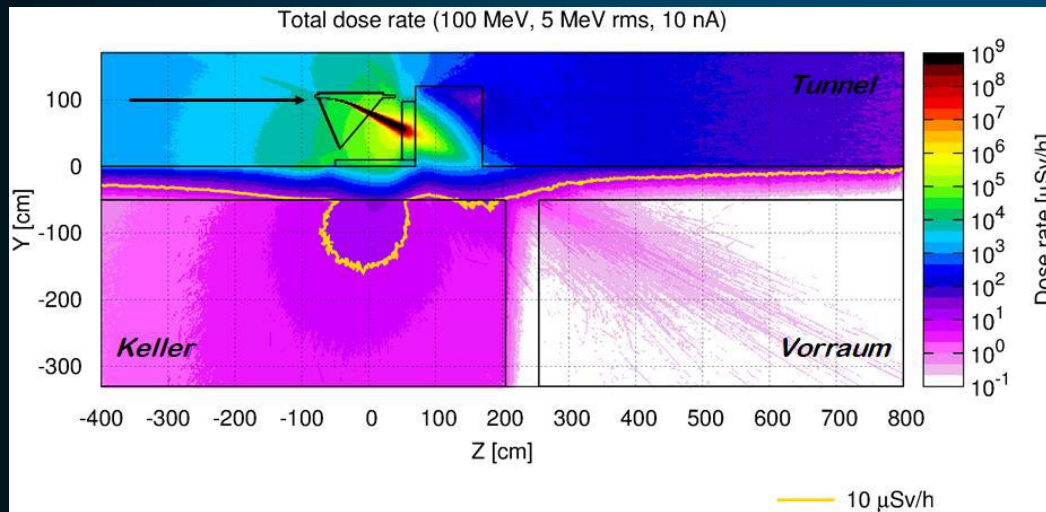
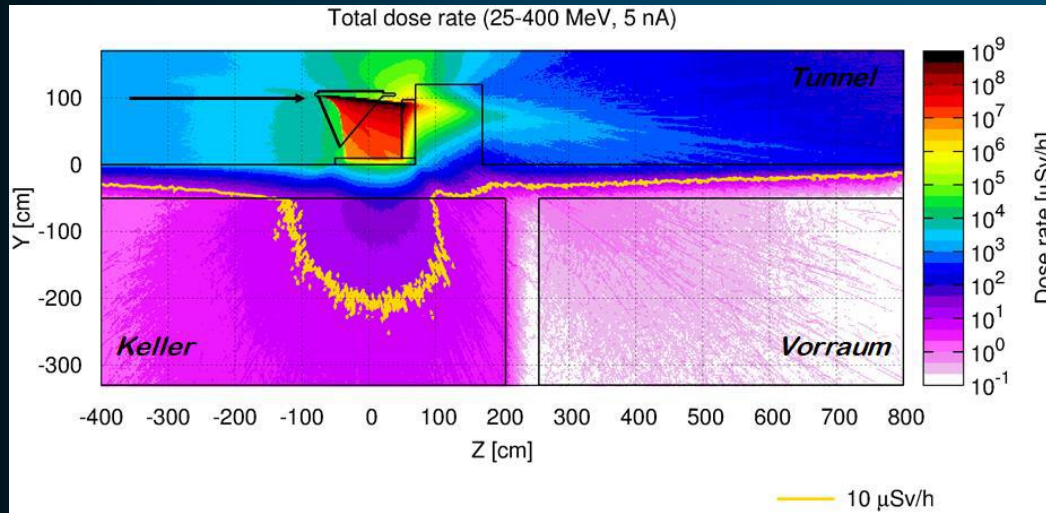
KALDERA – radiation simulations (FLUKA)

Starting point

- 2 main operation scenarios defining start parameters of the simulations and the boundary conditions of the operation license
- Main operation license parameters:
400 MeV and 1 Watt

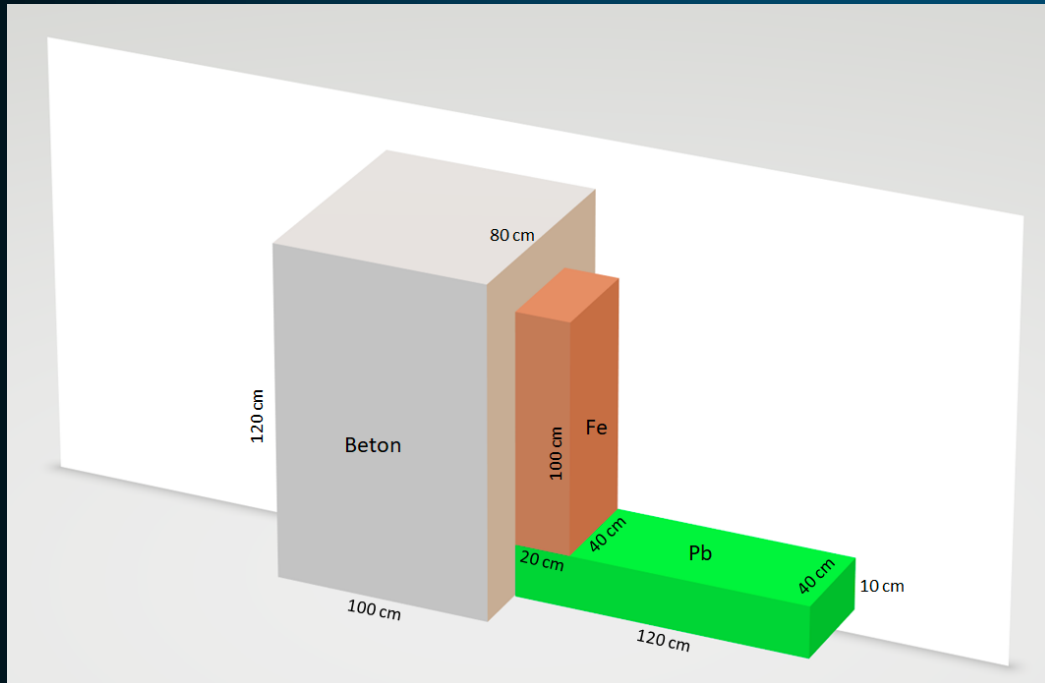
Operation mode	Max. beam energy	Max. bunch charge	Energy spread	Rep. rate
Case 1	100 MeV	100 pC	5 MeV	100 Hz
Case 2	400 MeV	10 pC	10 MeV	100 Hz

KALDERA –cellar



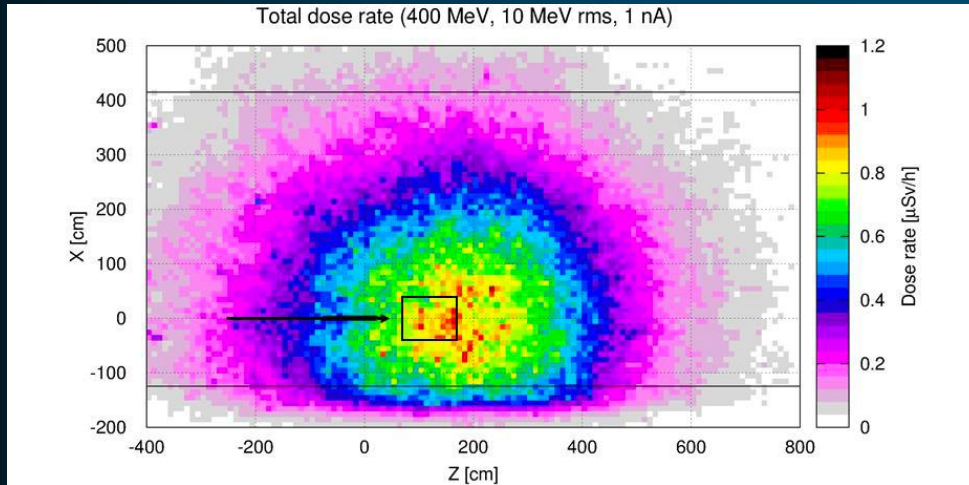
- high energy part goes straight through spectrometer dipole and stays in the tunnel
- strong downwards bending of the low energy part
- For the dose rate level the lower energies are important
- Strong wish to have no controlled area in the cellar
- Active monitoring of this area (?)

KALDERA – Dumpdesign



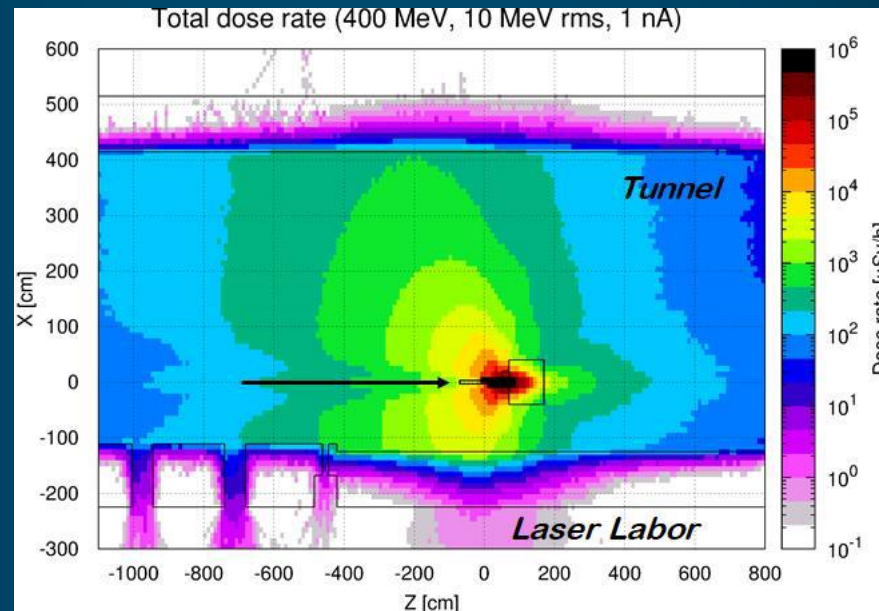
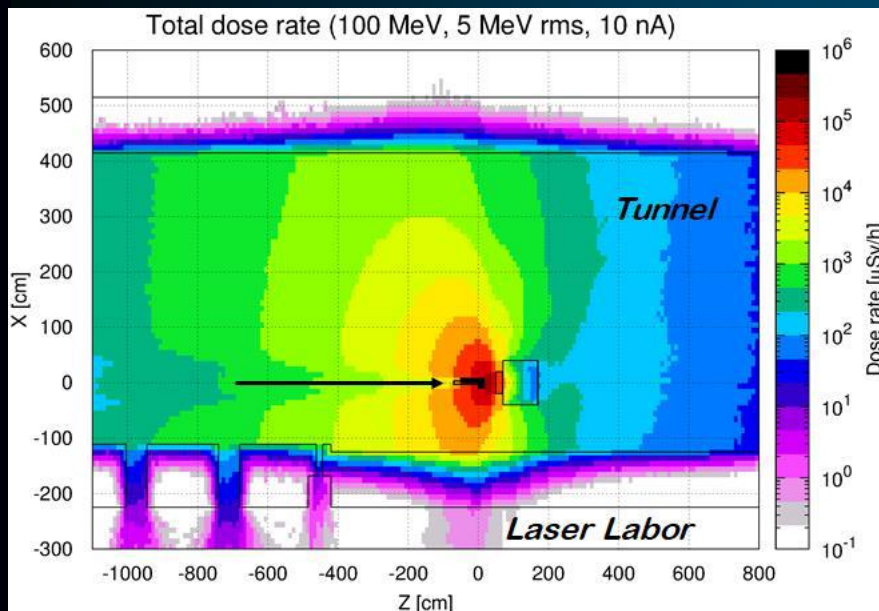
- Strong limitations by the load capacity of the floor
- **Forward direction (50 - 400 MeV):**
 - 20 cm Iron
(Energy reduction of high energy Neutrons)
 - 80 cm concrete:
(absorption of neutrons)
- **Downward direction (<50 MeV):**
 - 10 cm lead:
(photon absorption, thermal Neutrons)

KALDERA – roof and sidewalls



Roof:

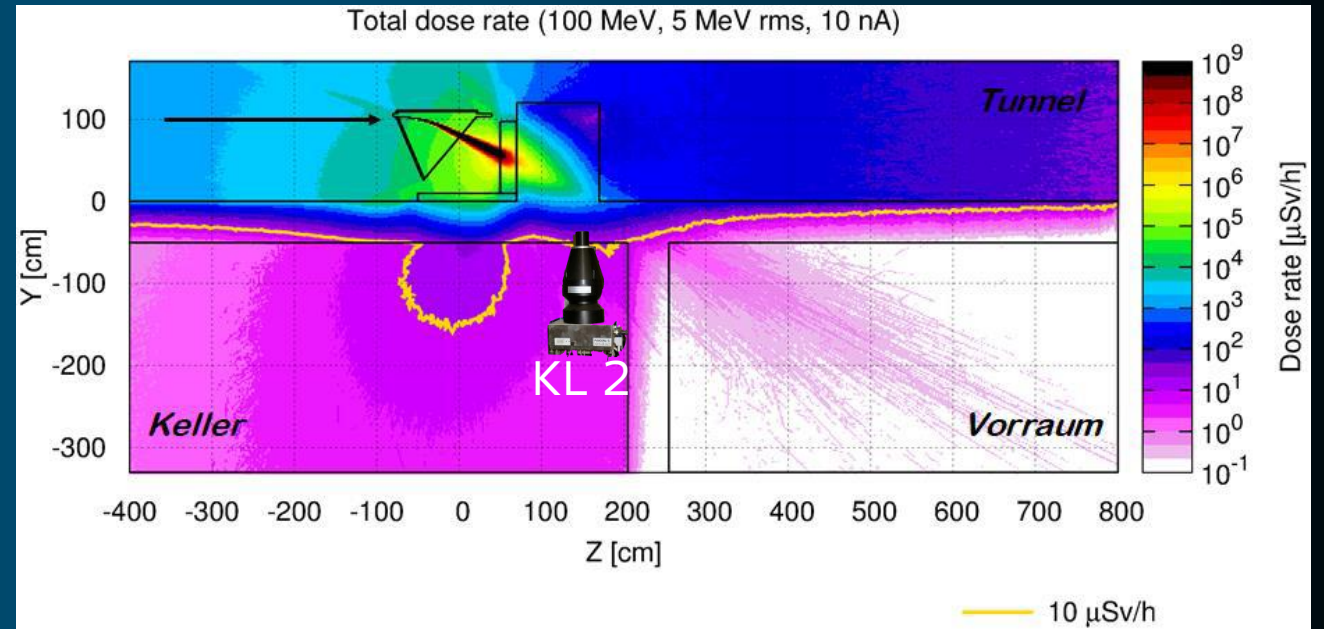
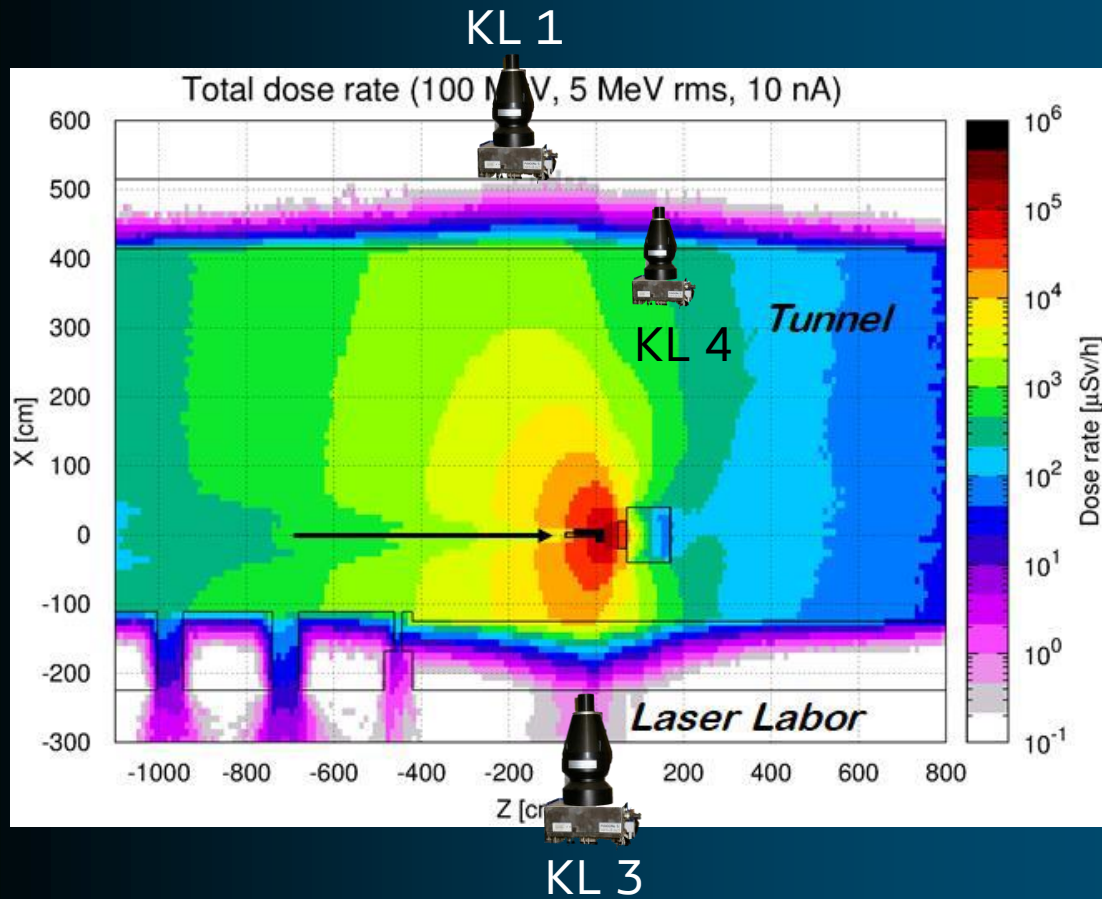
- 1 meter of concrete
- Dominant scenario: 400 MeV
- Dose rate $< 1\mu\text{Sv/h}$



walls:

- 1 meter of concrete
- Comparable dose rates for both scenarios outside of the walls
- Outside of the Tunnel: up to $1\mu\text{Sv/h}$
- Laser lab: ca. $2\text{-}3\mu\text{Sv/h}$

KALDERA – positions for active monitoring



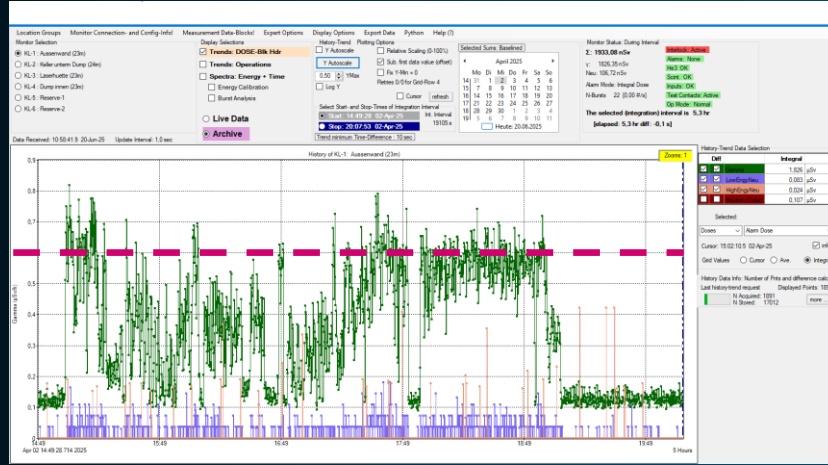
KALDERA

Commissioning

KALDERA – first operation @ 100 MeV, 0.5-0.7 Watt

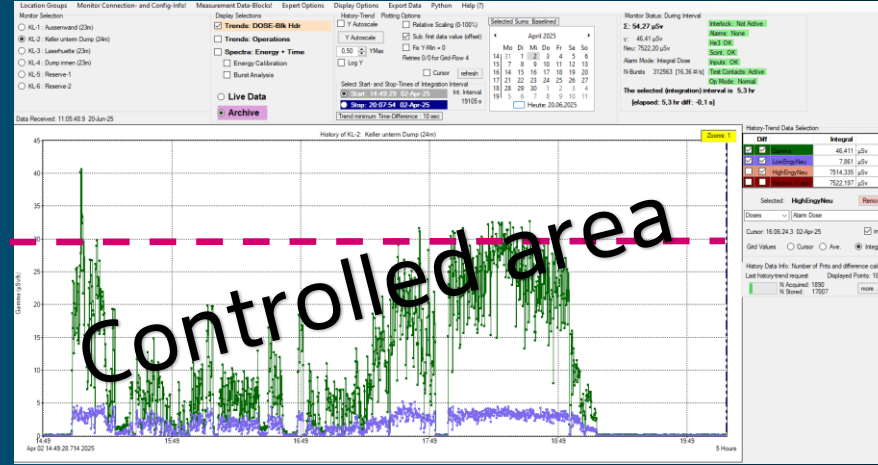
KL 1: (FLUKA: ca 1 $\mu\text{Sv/h}$)

KL 2: (FLUKA: ca 5 $\mu\text{Sv/h}$)



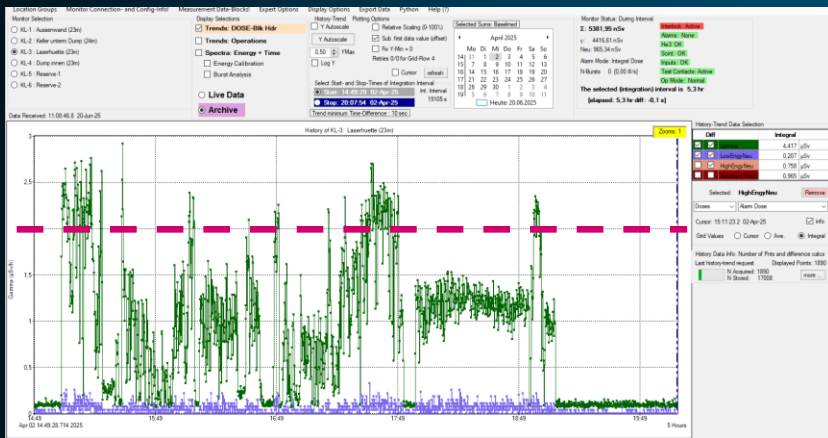
0,6 $\mu\text{Sv/h}$

30 $\mu\text{Sv/h}$



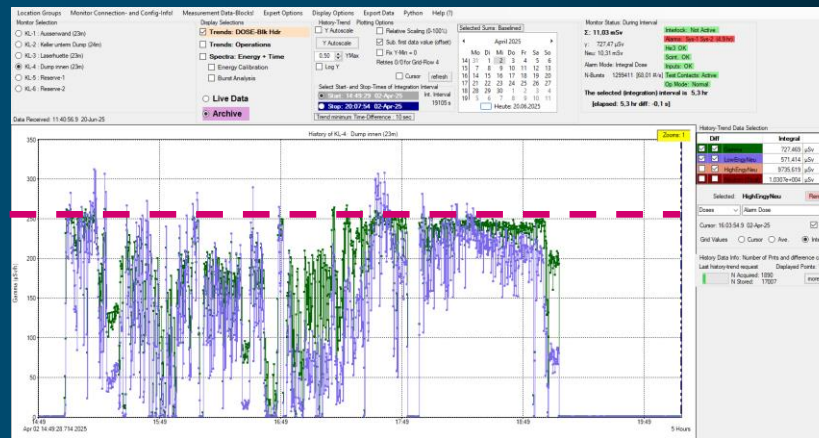
KL 3: (FLUKA: ca 3 $\mu\text{Sv/h}$)

KL 4: (FLUKA: 300-400 $\mu\text{Sv/h}$)

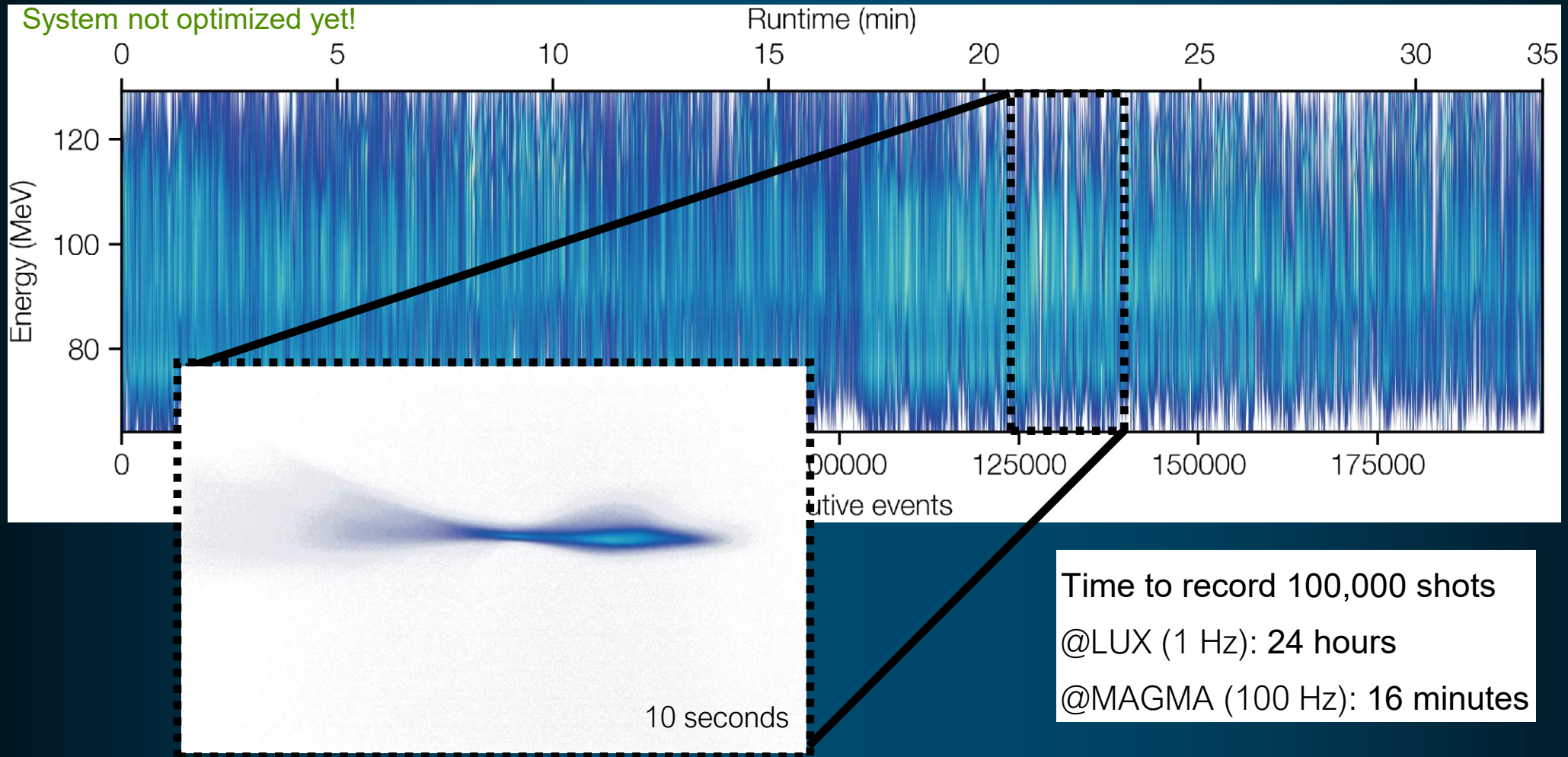


2 $\mu\text{Sv/h}$

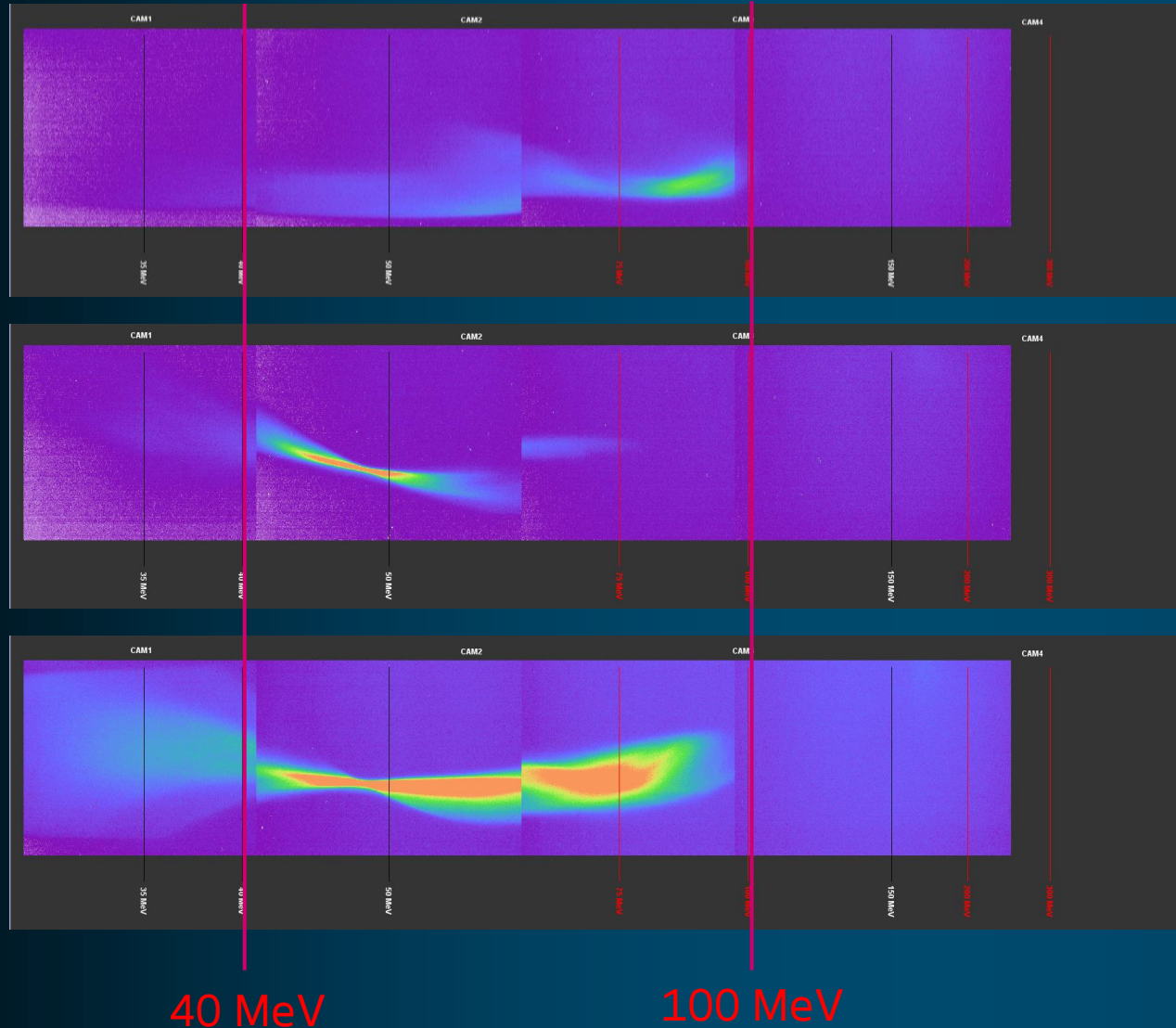
250 $\mu\text{Sv/h}$



KALDERA – commissioning phase



KALDERA – commissioning phase



- Fluctuating energy spectrum due to adjustments during commissioning
- energy fluctuation correlates to fluctuation in dose rates in the cellar
- Low energy part contributes strongly to the dose rate

KALDERA – commissioning phase, lessons learned

Energy transportation (theory):



- Laser-Plasma-Simulations typically have a cut off between 10 and 25 MeV
- Low energy electrons are not interesting for Laser-Plasma acceleration but for radiation protection!
- A complete start-to-end simulation is complicated...but the solution

KALDERA – commissioning phase, lessons learned

Energy transportation (experience):



experiment	laser power	electron power	efficiency
TiSa	6,25 W	1 W	16 %
VERA	75 W	5 W	6,5 %
KALDERA	50 W	1 W	2 %

KALDERA – summary

- It is a challenge to build new accelerators in old buildings
- Results of the FLUKA-simulations matches well with the measurements
- Commissioning of KALDERA is connected with a broad energy spectrum and fluctuation of the electrons
- Rule of thumb: 5% of the Laser power is a solid value for the electron-power

Outlook

- KALDERA operation will be optimized
- Next KALDERA upgrade (Beetle)
- Laser-Plasma-Injection @ DESY II (300 MeV)
- Laser-Plasma-Injector-Development (6 GeV)
- Laser-Plasma-Injector@ PETRA IV

Thank you!

contact

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