

Recent seeding activities and future plans at FLASH

The Xseed-group and the FLASH2020+ project

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Hamburg, November 4th, 2021

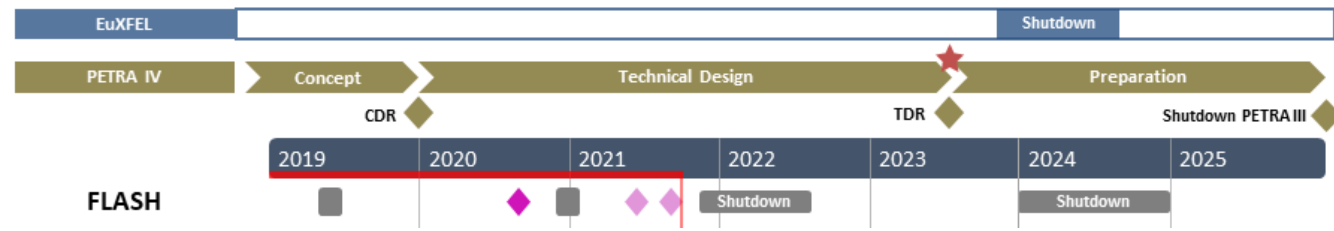
Scientific user demand

Results on a survey on user's dream machine for soft-X-ray FELs

Request	Science case	FLASH2020+ plan	FEL line
Extended wavelength range	Oxygen and Nitrogen K-edges and 3d-metal L-edges	Increased accelerator energy Advanced undulator schemes	FLASH2
Variable polarisation	Circular dichroism for magnetism and chirality	APPLE-II undulators and afterburner	FLASH1 / FLASH2
Flexible pump-probe schemes	Resonant excitations	Flexible schemes using optical laser and multi-color FEL pump-probe experiments	FLASH1 / FLASH2
Fourier-limited pulses	Stable, small bandwidth spectroscopy and coherence applications	External seeding at 1 MHz (HG/HG/EEHG)	FLASH1
Ultrashort pulses (1 fs and shorter)	Ultimate temporal resolution at highest power	New undulator combinations	FLASH2

Four phases of FLASH2020+

Phases composed of individual sub-projects



Phase 0

- Injector Laser
- Energy upgrade
- 3rd BC (FLASH2)
- Afterburner FLASH2
- TDS (FLASH2)

Phase 1

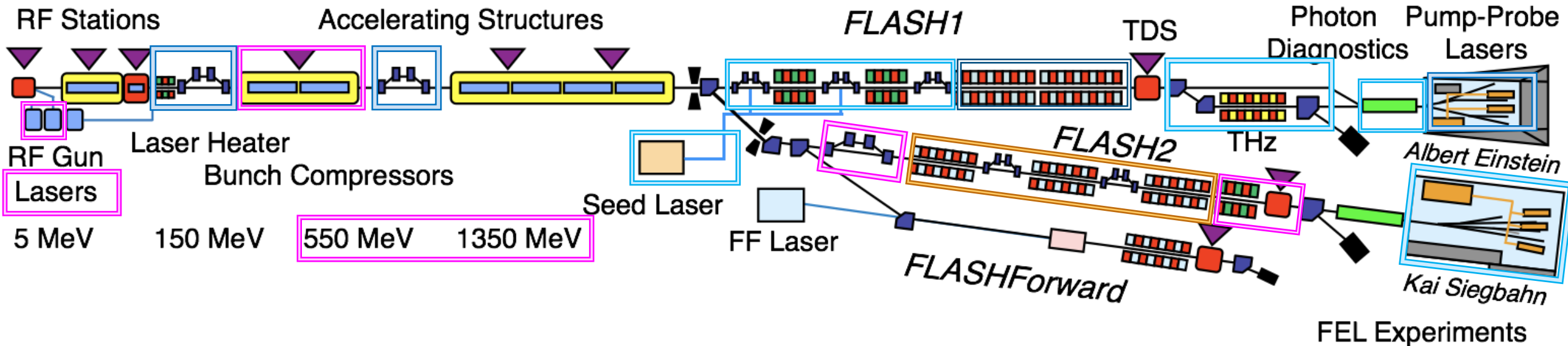
- Laser heater in 1st BC
- New 2nd bunch compressor (BC)
- Variable gap undulators (FLASH1)
- Pump-probe laser (FLASH1)

Phase 1+

- High rep.rate seeding (FLASH1)
- Photon diagnostics (FLASH1)
- Flexible pump-probe
- New beamlines

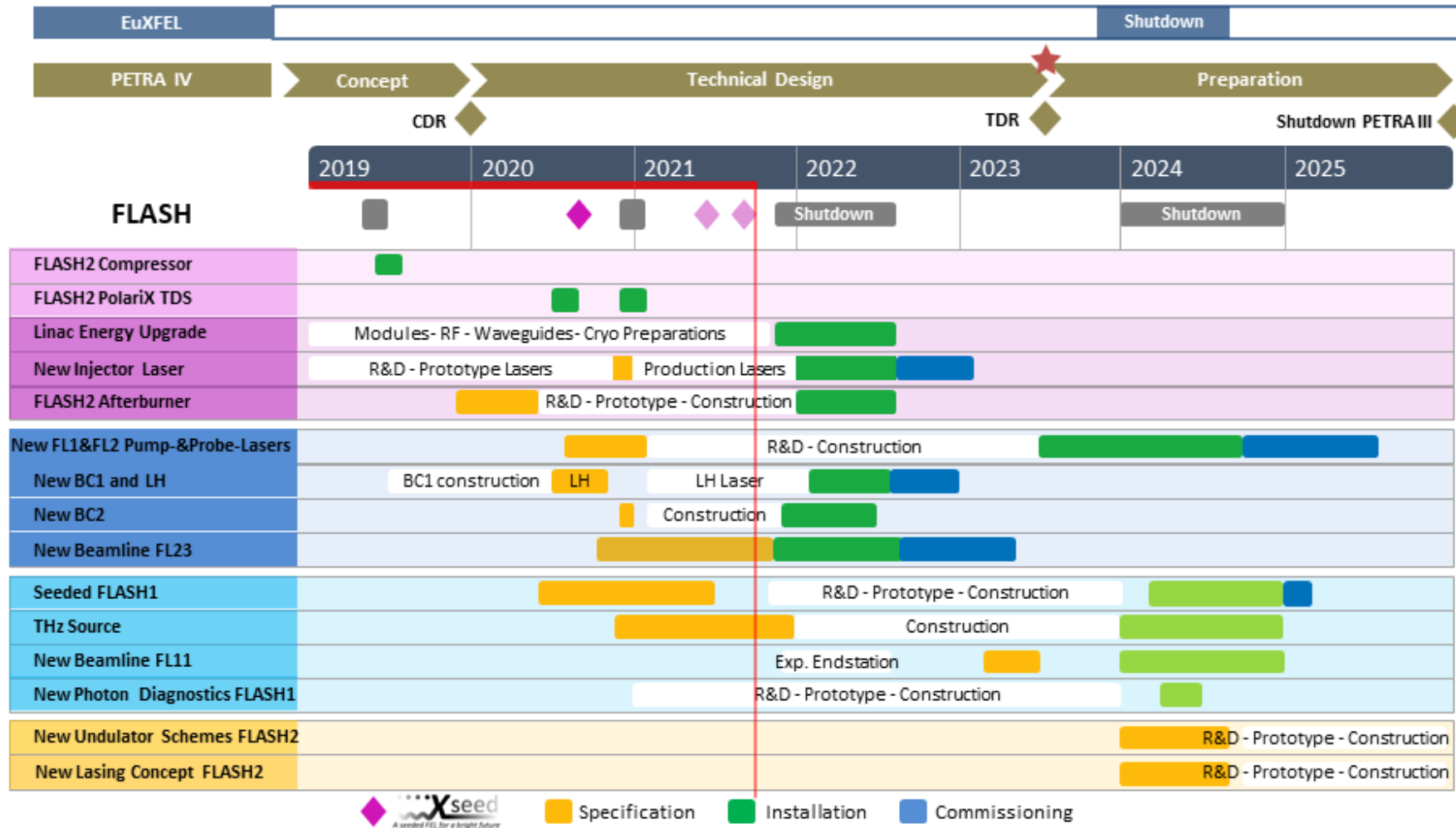
Phase 2 (no funding yet)

- New variable gap undulators
- Chicanes for new lasing concepts (FLASH2)



Project timeline

Where we are today



Shutdown work

2021/22

- Energy upgrade
 - Exchange of ACC2/ACC3
 - Waveguides ACC2/3, ACC4/5
- Injector upgrade
 - Bunch compressor 1 + Laser heater
 - New bunch compressor 2
- FLASH2 Afterburner
 - Prototype for FLASH2020+ radiator design

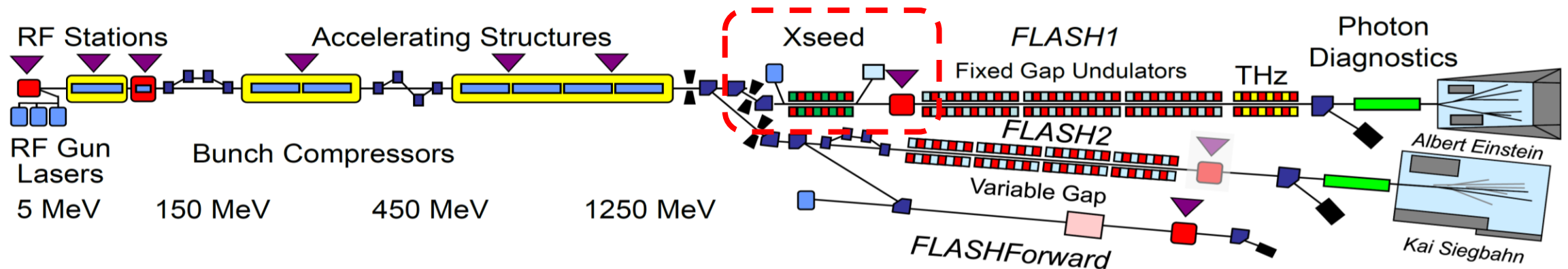
Preparation of 2024

- Beam line design almost finished
- Parameters for seed lasers, chicanes, modulator undulators finished

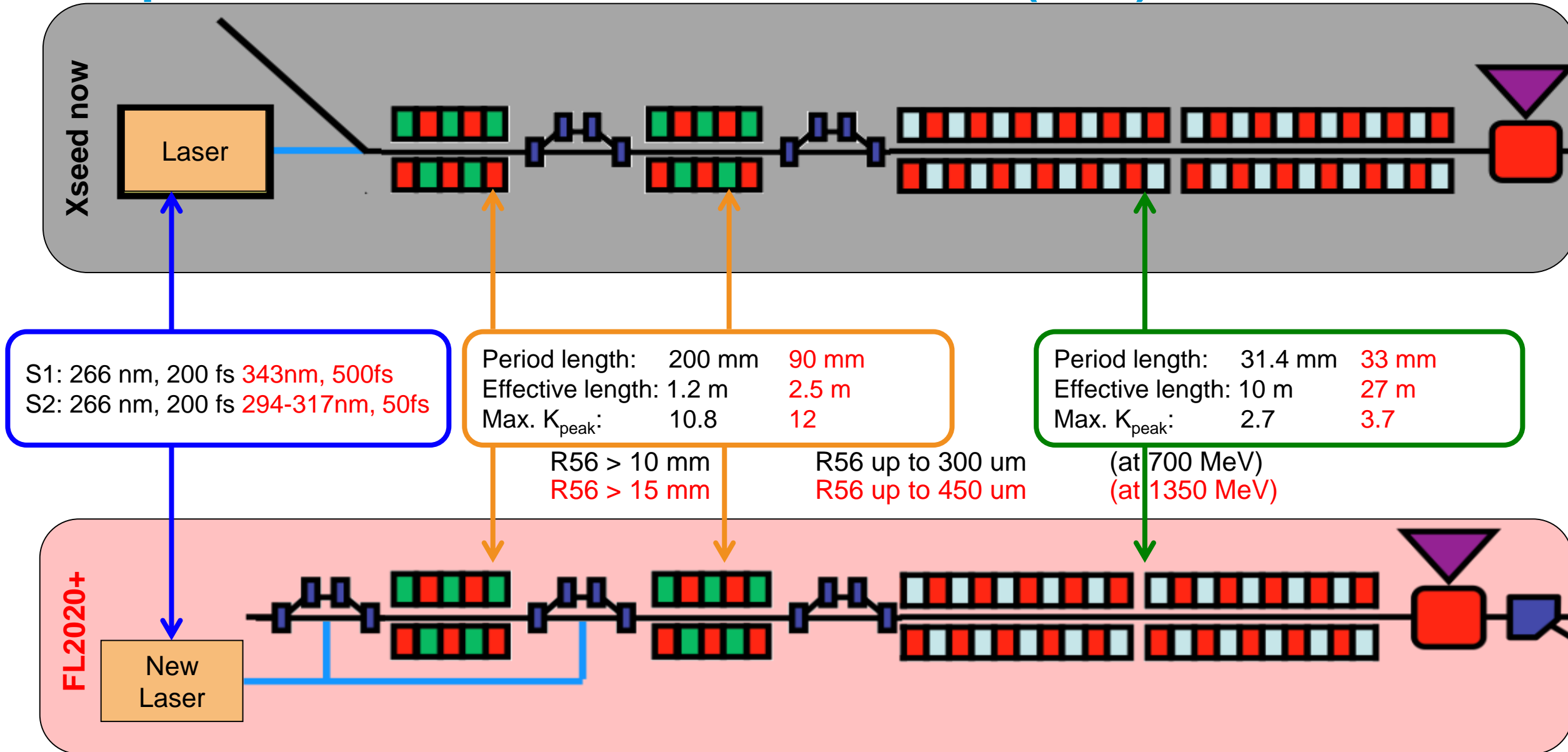
Xseed: eXternal seeding at FLASH

Sections used by Xseed

- Seed laser laboratory
- Laser transport and incoupling beam line
- Modulation and dispersion section
- Radiator section
- Outcoupling and diagnostics section
- Transport line to diagnostic laser laboratory
- Components inherited from “sFLASH”
- Used to demonstrate direct seeding below 40 nm (2012, still world record)
- Many changes were taken to enable HGHG/EEHG seeding
- It allows to study external seeding with almost the same components foreseen for FLASH2020+!



Comparison between Xseed and FLASH1 (new)

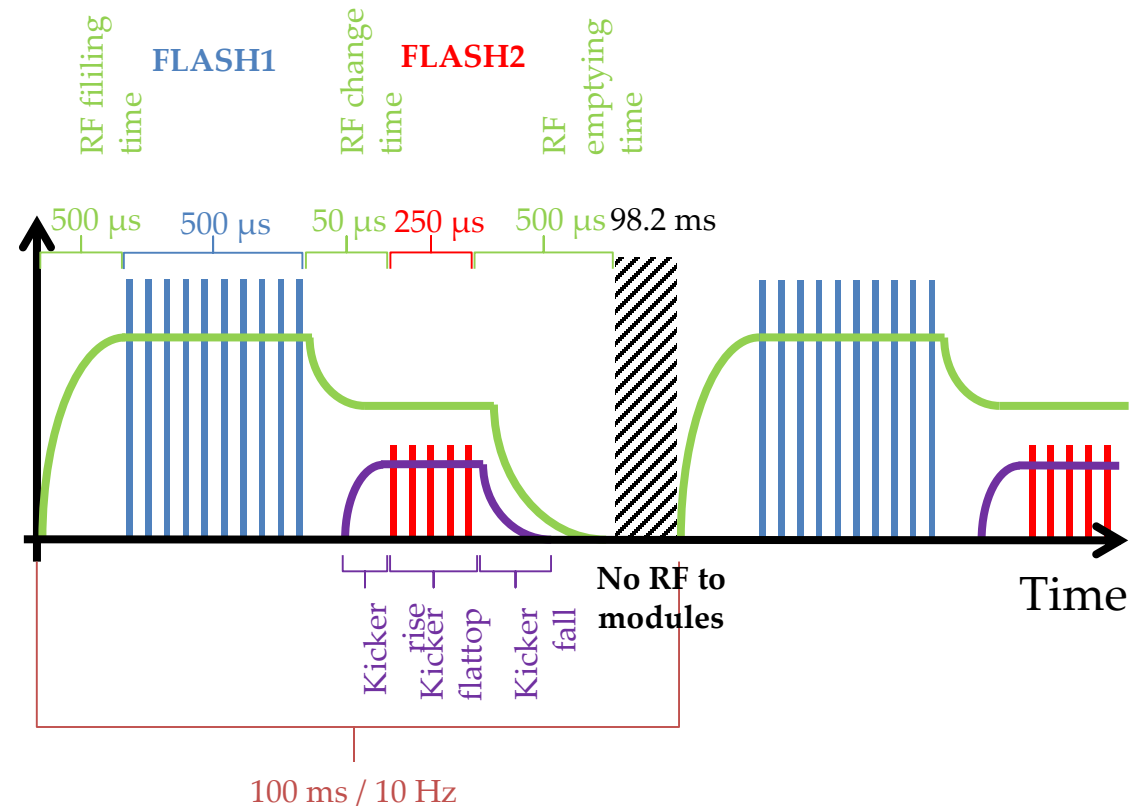


FEL multiplexing

and seeding

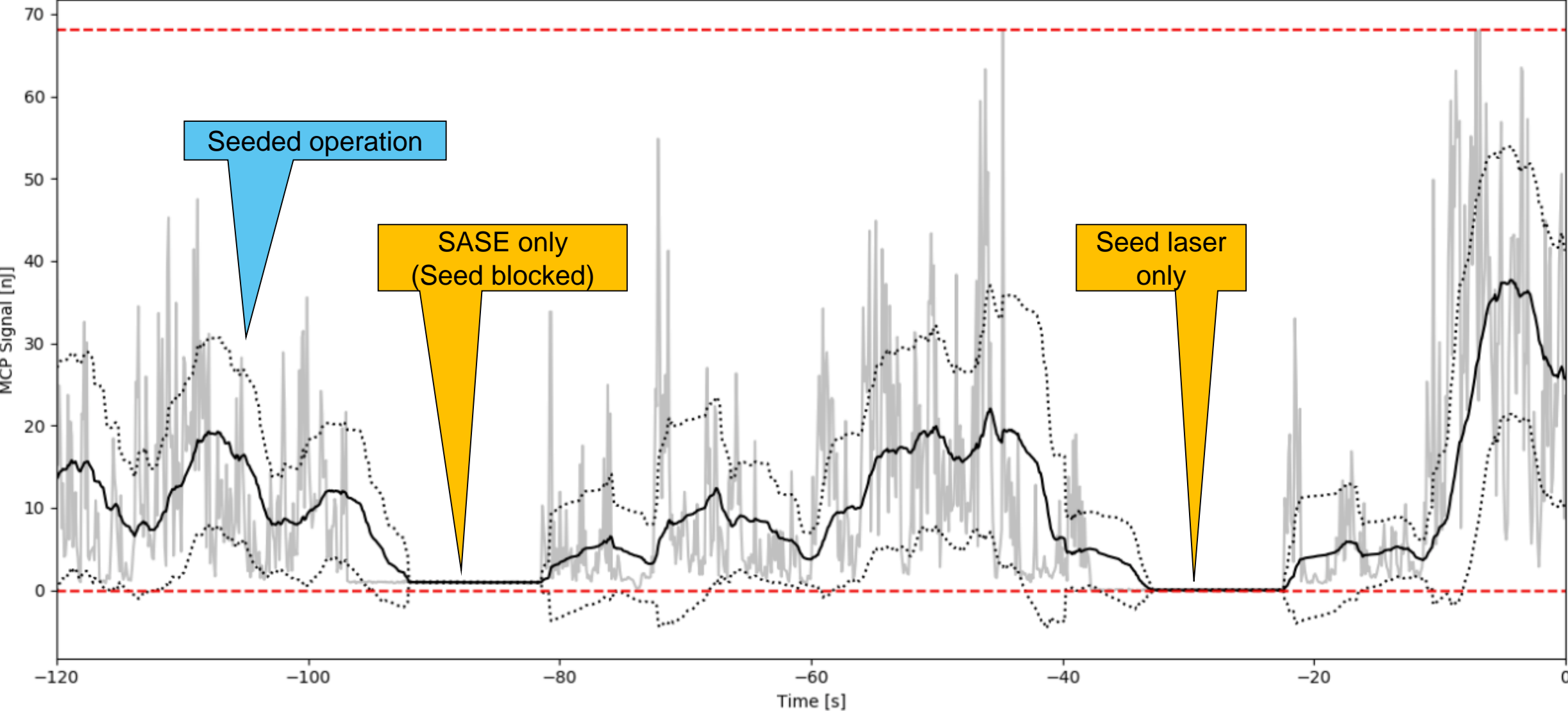
- Since 2015, the FLASH2 user beam line is given to photon science users
- The parallel operation allows for radiation delivery on two photon beam lines
- Requirements for seeded and SASE operation are different
- For SASE, a strong chirp to compress to sufficient peak current
- For Seeding, the interaction with the external seed defines the pulse properties → bunch properties should be flat for seed laser duration
- RF transition time is limiting the number of pulses

→ Can FLASH1 deliver seeded radiation while FLASH2 operates in SASE mode simultaneously?



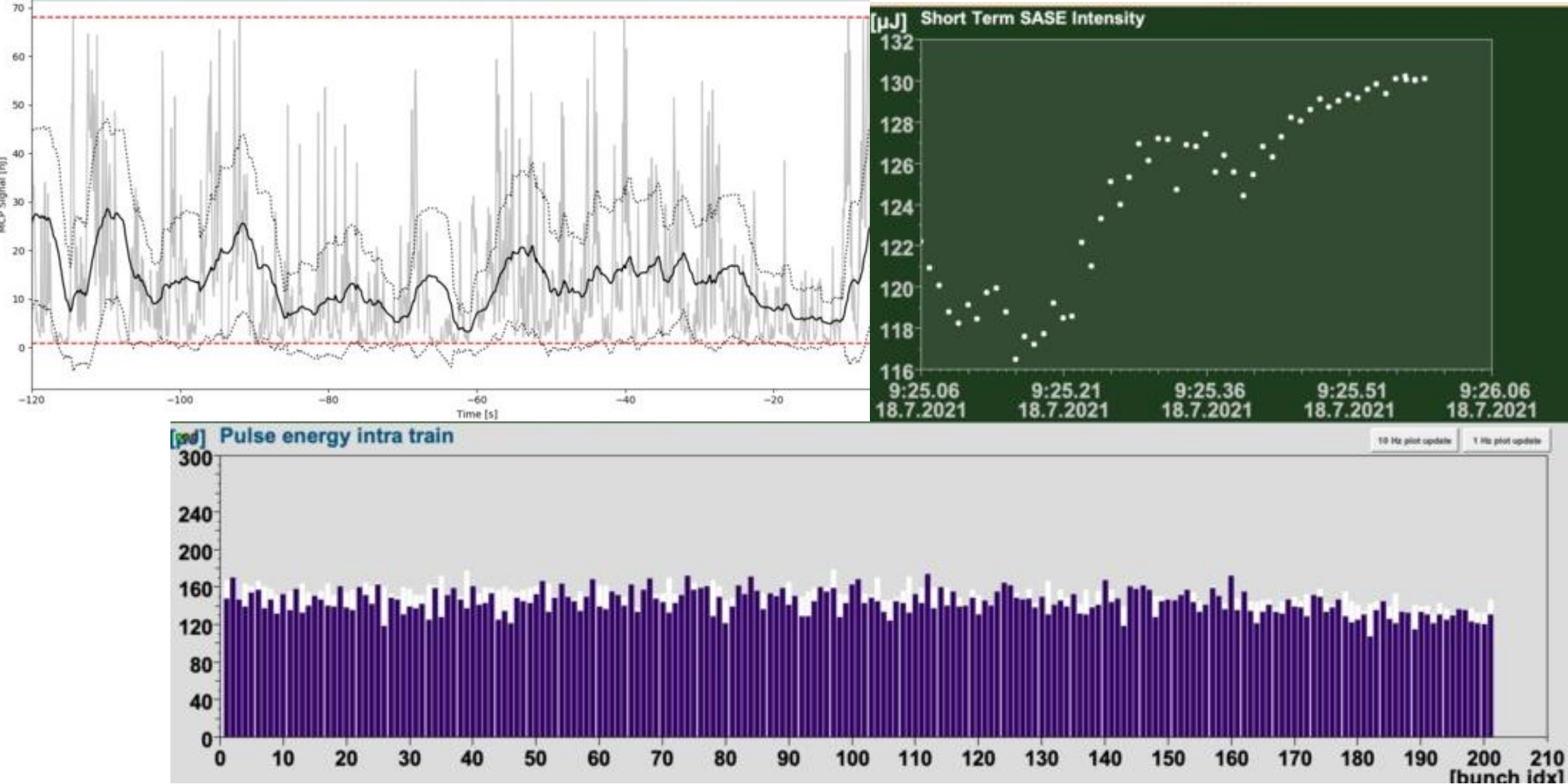
First demonstration of HGHG seeding parallel to SASE

18.07.2021



First demonstration of HGHG seeding parallel to SASE

18.07.2021



Demonstration of EEHG seeding

Situation

- Before 2021 the overbunching chicane („EEHG chicane“) was too weak to allow EEHG operation
- In the shutdown, a new chicane fitting the restrictive space requirements was installed
- Laser diagnostic upgrades:
 - Power meter in the tunnel allows transmission measurements without ZZ
 - A virtual beam line for offline laser beam analysis in the laser lab
 - Camera looking directly at the laser focus
- **Next attempt for EEHG: 09.11.2021-11.11.2021**



Future upgrades and plans

of Xseed

- During the next shutdown, various upgrades are planned
- Electron beam line components
 - Installation and improvement of new and existing diagnostics
 - Installation of new diagnostic chamber
 - Quadrupole movers
- Laser beam transport
 - Enhancing laser beam line capabilities
 - Mode quality of laser in focus by implementing a deformable mirror into the beam line
- Diagnostics
 - Installation of virtual undulator focus diagnostics for the seed lasers (allow parasitic observation and feedback on seed laser position)
 - Change camera setup:
 - All Ethernet-based, no more EM-CCD, FireWire, USB, ...
 - Move sensitive electronics out of the tunnel
 - Improve network infrastructure

Future plans

- Plans and tasks for next period
 - Demonstrate EEHG seeding, in parallel with FLASH2 operation
 - Seeding development for FLASH2020+
 - Benchmark simulation codes against our setup
 - Simulate and test laser heater
 - Exploiting flexibility of the setup to explore advance seeding schemes

Team effort

- Building large scale FEL facilities is a team effort
- I would like to thank everyone working for Xseed and the FLASH2020+ project

Thank you!

谢谢!

CHILFEL

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