

Short Pulse Generation at SASE2

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DESY

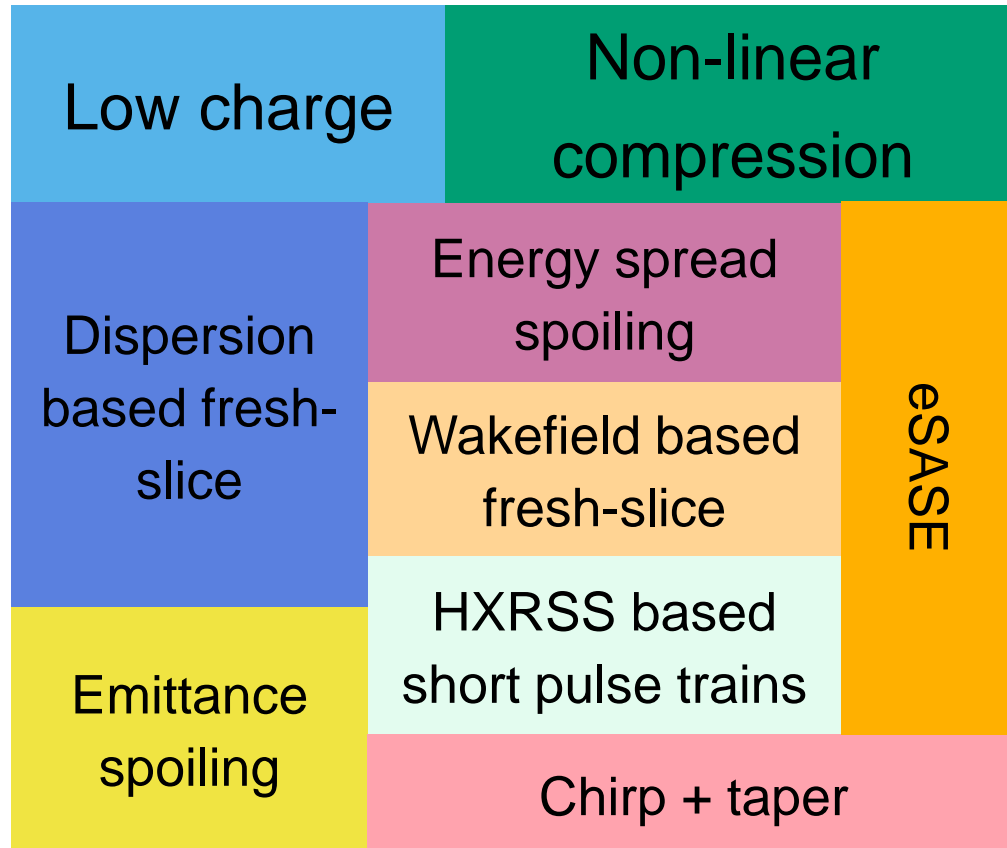
on behalf of the FEL R&D team

MID workshop:
User research and new developments

24 Jan. 2022



Short pulse techniques



Capability:

- duration: < 1fs, 1-5fs, 5-10fs, >10fs
- intensity: GW - TW
- multicolor compatible
- isolated pulse or pulse train
- etc...

Feasibility: wavelength range, XFEL real life

- Availability and timeline: hardware (cost), installation time, development stage, etc...

Short pulse techniques for SASE2

Technique	duration	hardware	dev. stage	op. influence
low charge	~10fs (50pC)	None	in development	gun separate flattop
non-linear compression	<10 fs	None	tested	on separate flattop
dispersion based fresh-slice	a few fs	None	in development	
wakefield based fresh- slice	a few fs	dechirper	in development for SA1/SA3	
chirp + taper /eSASE	sub-fs	laser + chicane	in development for SA1/SA3	
energy spread /emittance spoiler	a few fs	laser shaping / slotted foil	considered as an option	affect all beamlines

<https://confluence.desy.de/display/FELRD/Short+Pulse+Table>

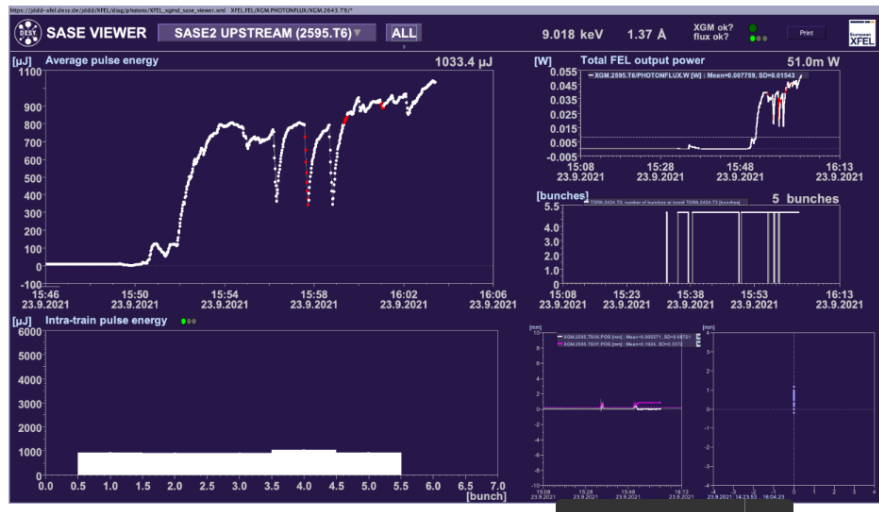
low charge operation (100pC)



- Gun settings for minimized mismatch
- No magnets in common parts touched
- Only compression, launch, tapering

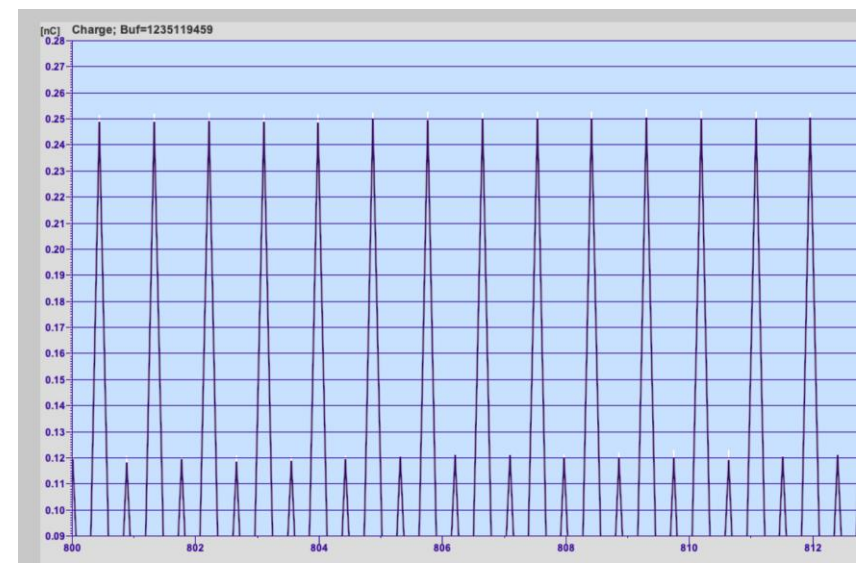
slide from B. Beutner

- FD shifts on 23.09.2021, 30.11.2021
- normal charge (250pC) to low charge transition without touching magnets in the common part
- mismatch for the low charge beam compensated by gun gradient and phase
- interleaved bunches with different charges tested, FD30.11.2021

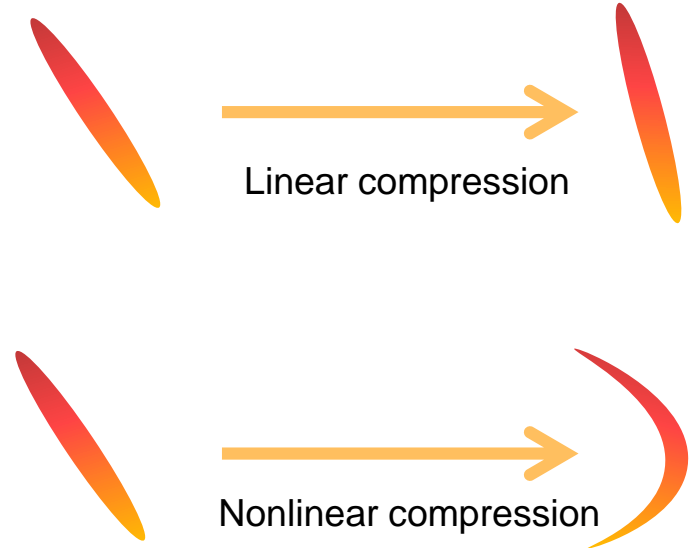
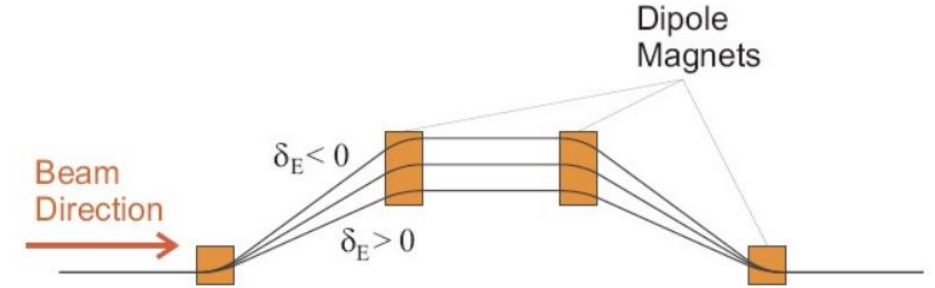
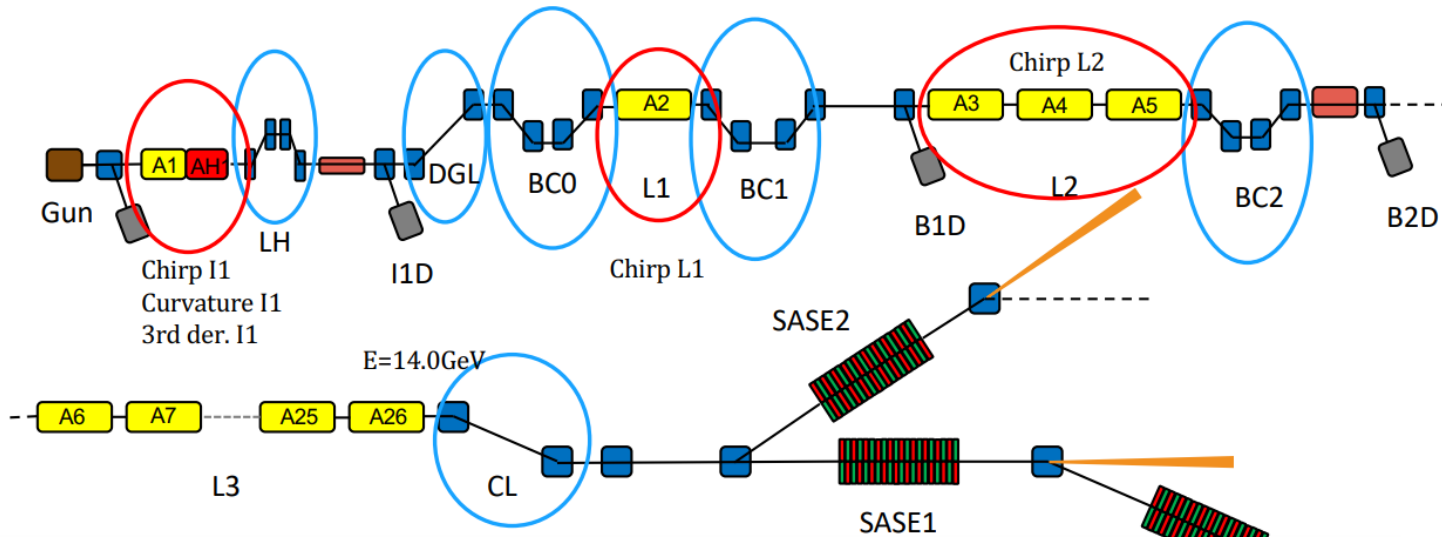


SASE2
9 keV
1 mJ

lower charge under development



Linear compression and Non-linear compression



- RF components to introduce chirp and curvature etc in electron beam phase space
- dispersive elements with R56, T566, U5666 to compress the bunch

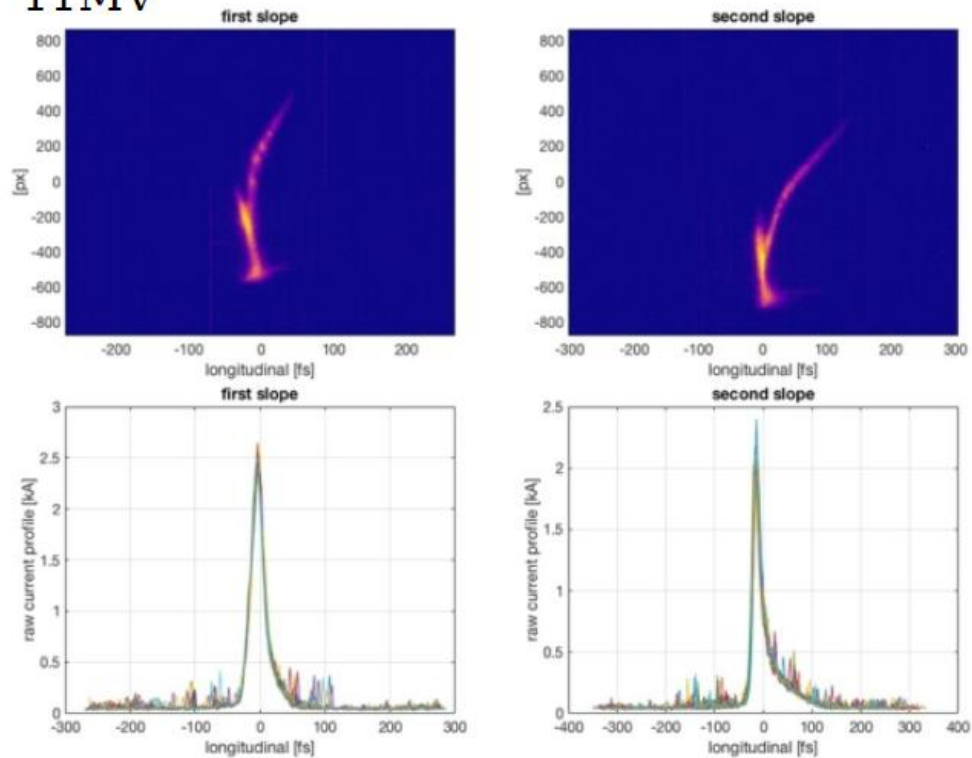
mostly change AH1 (curvature)

Non-linear compression (100pC, 250pC)

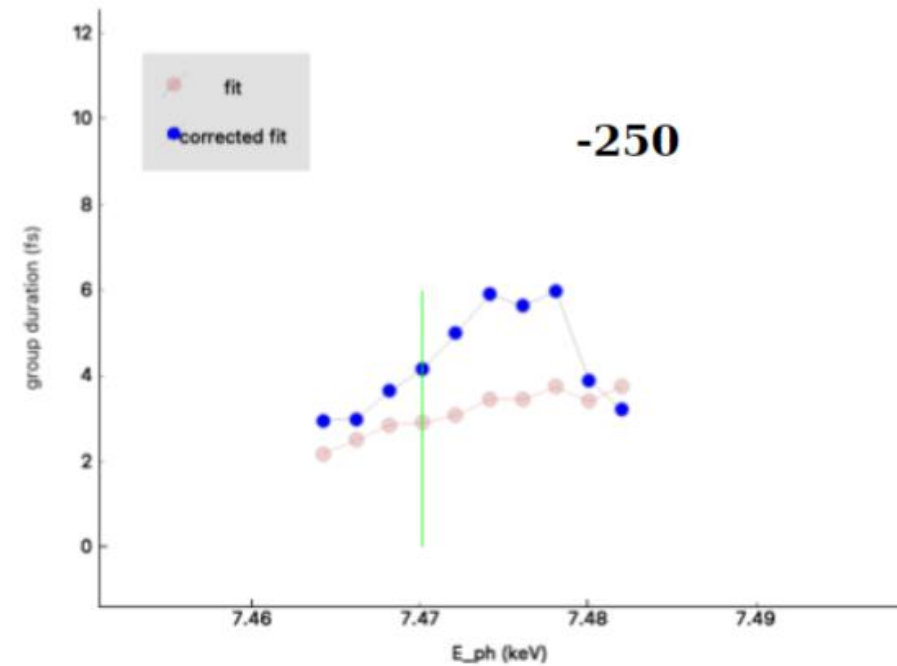
Curvature: -230

AH1 voltage:

11MV

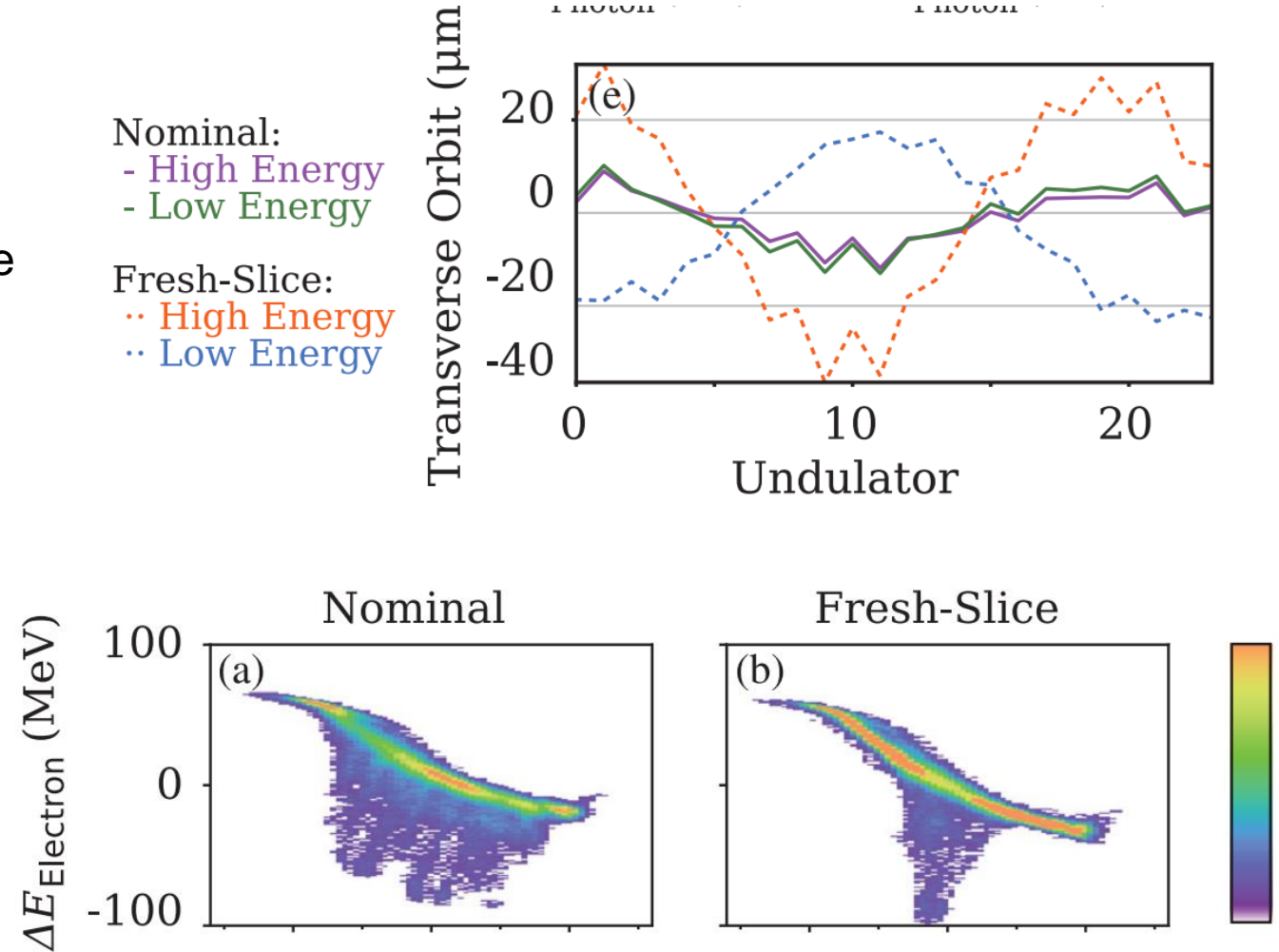


- FD in 10.2020, 03.2021
- user assisted commissioning with MID in 08.2021
- a few hundred uJ
- group duration estimated from spectra: < 10fs
- No direct duration measurement yet



Dispersion based pulse shortening

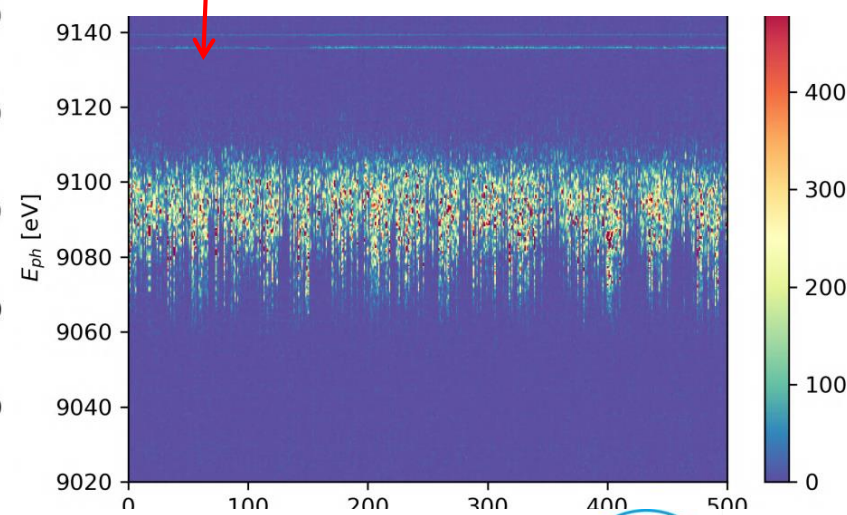
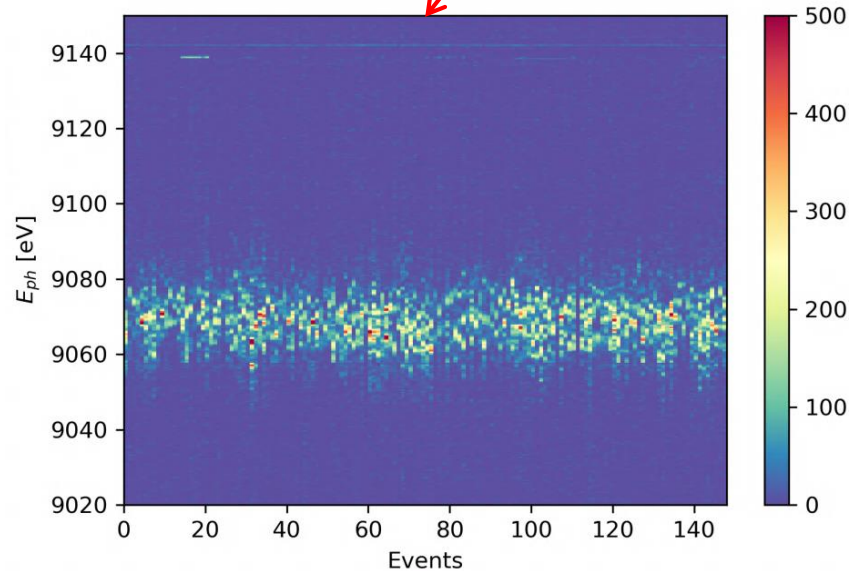
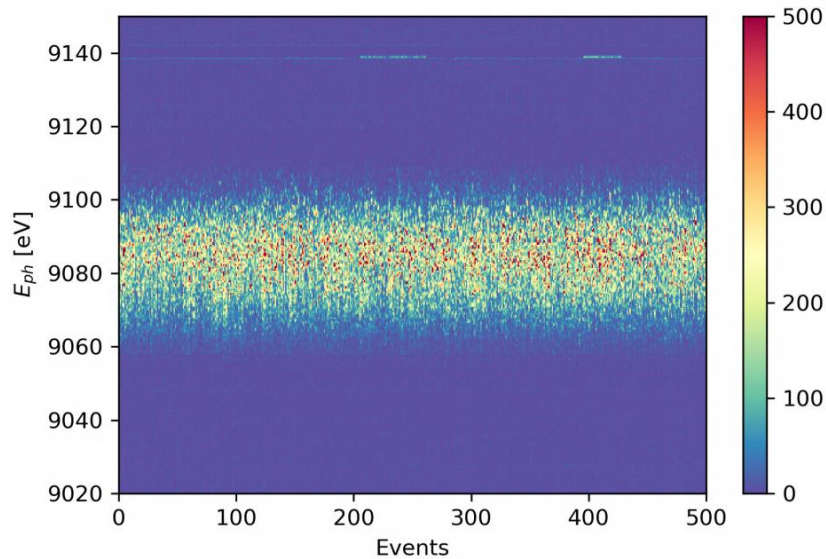
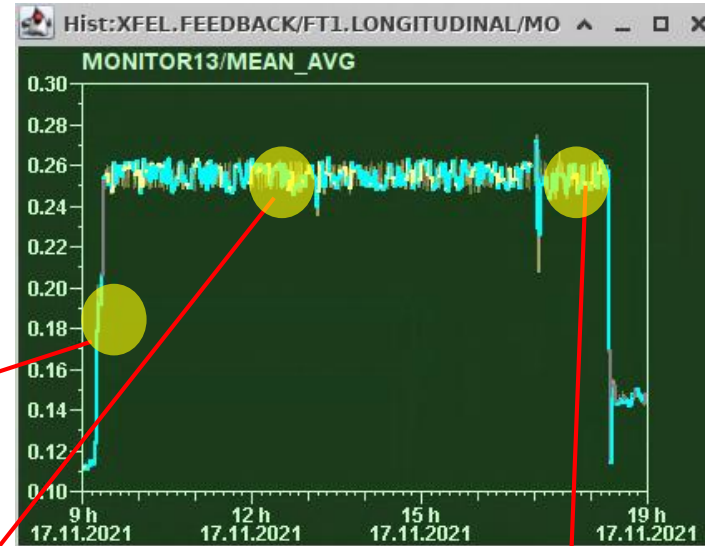
- Chirp in the electron beam + dispersion in the undulator
- electrons with high and low energy deviate from lasing orbit and emission is suppressed
- FEL pulse duration is shortened down to a few fs
- two color or high power mode available



M. W. Guetg et al., PRL 120, 264802 (2018)

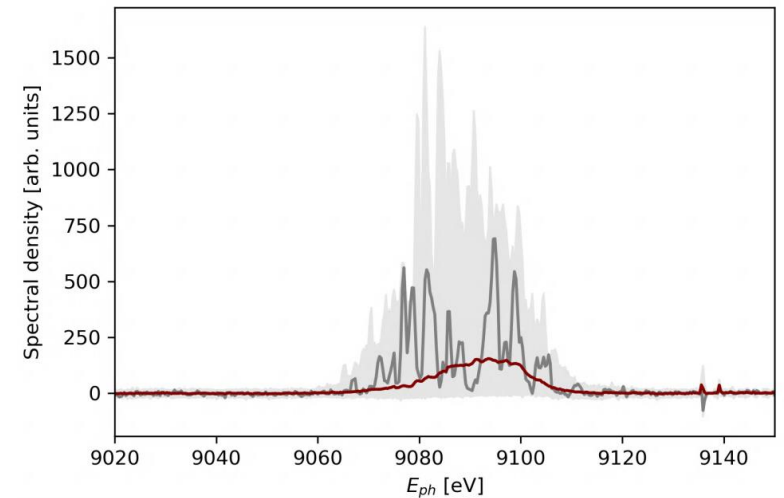
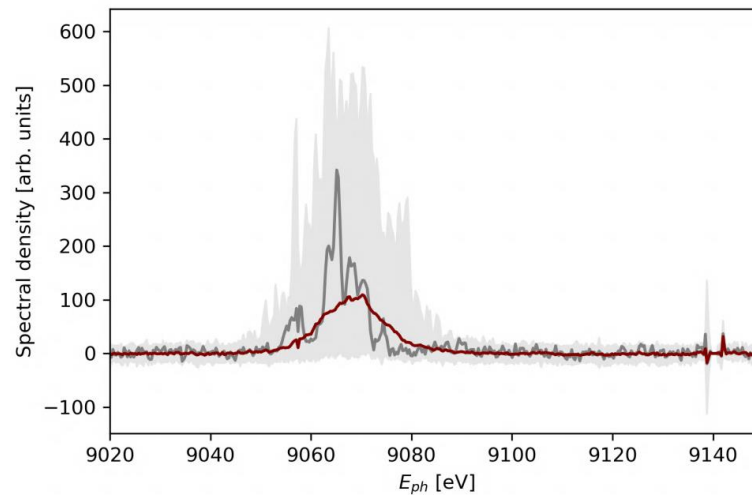
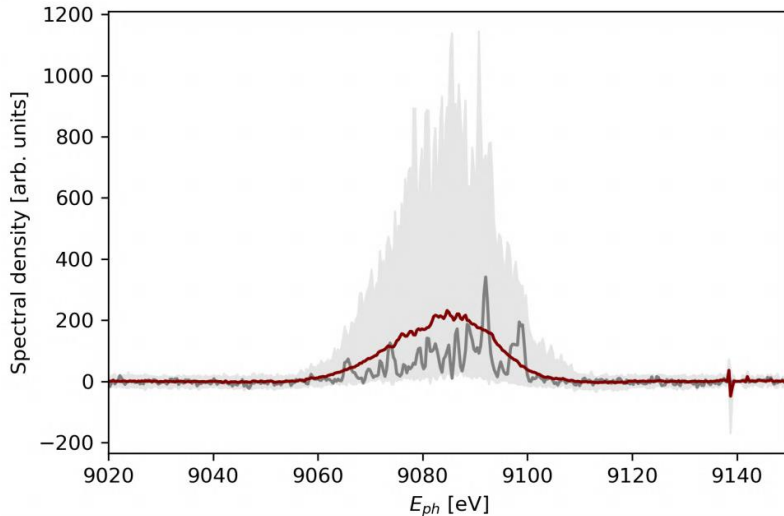
Dispersion based pulse shortening

- FD 17.11.2021 with MID
- Tweaking L1 chirp to go to high linear compression
- Spectral narrowing observed (shorter lasing window)
- jittered shots in the end



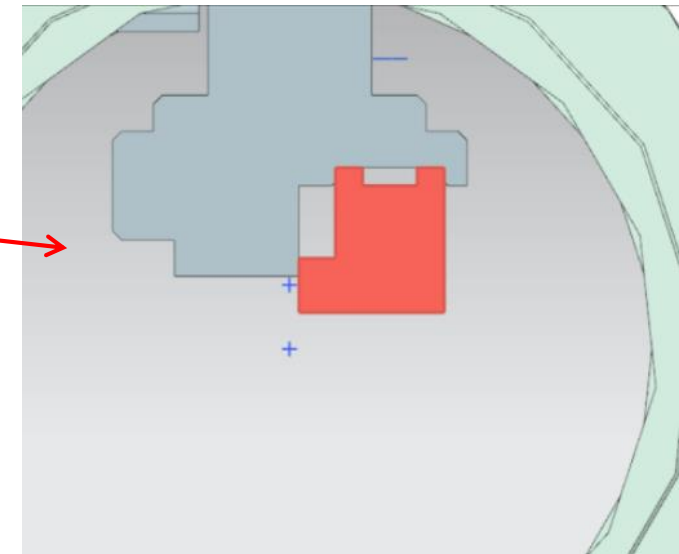
Dispersion based pulse shortening

- narrower bandwidth and less spikes for high linear compression
- < 10 fs from spectral analysis



Plans in 2022

- Nonlinear compression procedure to operators/RCs
- Further investigation of dispersion based short pulses
- Further investigation of lower charge mode
- A diagnostic dechirper after SA2 undulator
- A dechirper before undulator to be installed in summer shutdown for SA1/3
- Toward a CDR for chirp/taper scheme (<1fs)
- Other ideas emerging...



Thanks for your attention!