First results of ELEGANT simulations for the laser heater

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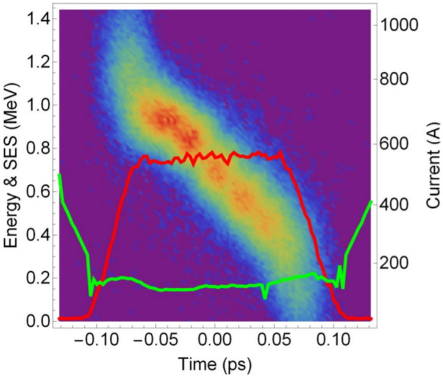
Overview

> Concept of the Laser Heater
> Simulation details
> First results
> Application of the results

Concept: Motivation

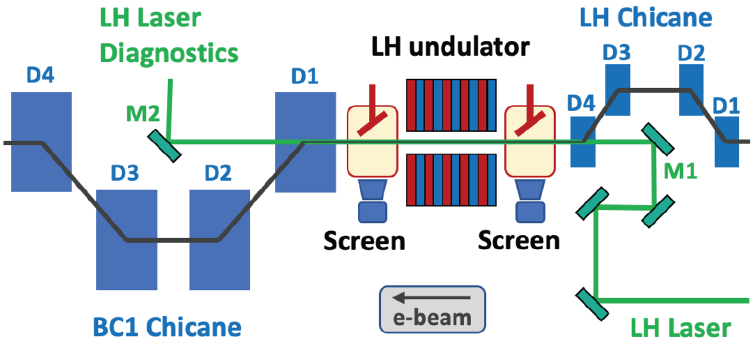


Resolution:
10 fs and 70 keV

Ref: Brynes, A.D., Akkermans, I., Allaria, E. et al. Characterisation of microbunching instability with 2D Fourier analysis. Sci Rep 10, 5059 (2020).

https://doi.org/10.1038/s41598-020-61764-y

Concept: Layout



Ref: C. Gerth et al., “Layout of the Laser Heater for FLASH2020+”, in Proc. 12th Int. Particle Accelerator Conf. (IPAC’21), Campinas, Brazil, May 2021, pp. 1647-1650.

Simulations: parameters

Gaussian bunch (1mm rms, 0.4nC) is generated by ELEGANT, propagated through ACC1 and ACC39

Central energy	Slice Energy Spread	Beam size rms
146 MeV	3 keV	316 µm

UND period	# of periods	B (K)
43 mm	11	0.356 T (1.43)

Laser wavelength	Max peak power	Waist size	Pulse length rms
532 nm	2 MW	316 µm	3.3 ps*

Concept: Working point

- To suppress µB: 10-20 keV induced energy spread by the LH
- Total energy spread grows especially in bunch compressors ($\times$4 in each)
- For FEL operation: below 150 keV after linac

Example: total energy spread σ_E after the LH consist of total energy spread before it σ_{init} and induced modulation $\Delta\gamma \approx$ 10-20keV:

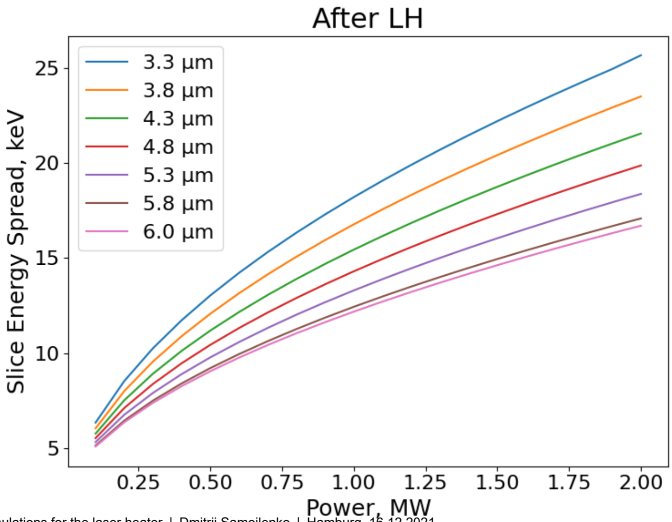
$$\sigma_E = \sqrt{\sigma_{init}^2 + \frac{\Delta\gamma^2}{2}}\,.$$

To have $\sigma_E = 150$ keV after BC2, we should have $\sigma_E = \frac{150\text{keV}}{16} \approx 9.5\text{keV}$ after LH.

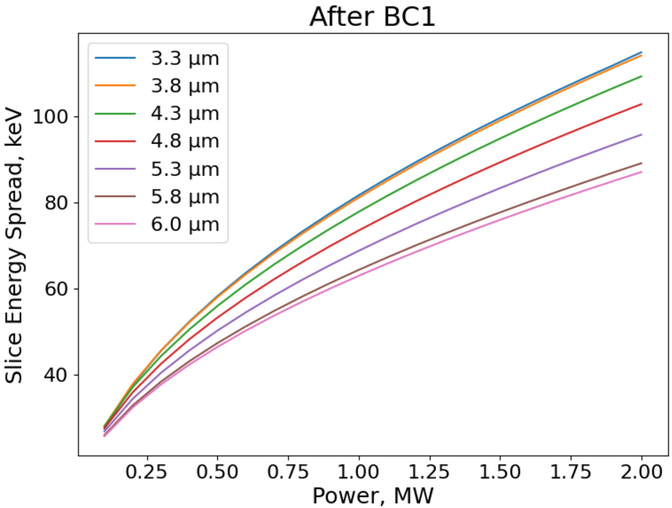
Then,

$$9.5\text{keV} = \sqrt{(3\text{keV})^2 + \frac{\Delta\gamma^2}{2}},\ \Delta\gamma = 12.6\text{keV}$$

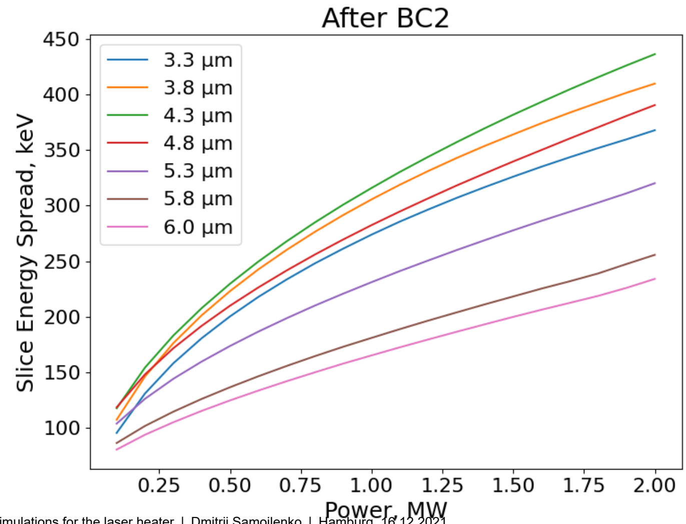
Simulation: Results



Simulation: Results



Simulation: Results



Conclusion

Calibration curves are helpful because:

- no device to measure energy spread right after the LH $\rightarrow$ we need to know how energy spread evolves
- Will the TDS have enough resolution for a good measurement? $\rightarrow$ If not, measurements may have to be made with total energy spread higher than operation mode

Once the working point is chosen we can include LH in S2E simulation

Thank you!

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