Recent results of HHG-seeding experiment at FLASH

Seeding and Self-seeding at New FEL Sources

Trieste

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on behalf of the sFLASH group

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•DFG GrK 1355
•Joachim Herz Stiftung
FLASH layout

Running for users down since 2005
Wavelengths down to 4.1 nm

- Normal conducting 1.3 GHz RF gun
- Ce$_2$Te cathode
- Nd:YLF based ps photocathode laser

RF Gun THz

Bunch Compressor 150 MeV

Bunch Compressor 450 MeV

1250 MeV

LOLA

Undulators

Bypass

5 MeV

150 MeV

315 m

Diagnostics and matching

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3rd harmonic cavity 3.9 GHz

TESLA type superconducting accelerating modules

Fixed gap undulator

length ~ 27 m

FEL Experimental Hall

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FEL Experimental Hall

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sFLASH building blocks
Linac set up

- setup accelerator for 700 MeV
  - bunch charge 0.5 nC
  - feedback systems for compression and energy
- establish high FEL gain at correct wavelength
  - tuning sFLASH to SASE
  - spectral overlap of 21st harmonic ($\lambda = 38.1$ nm) and sFLASH SASE
- transverse overlap (tolerances 50 μm, 50 μrad)

Example for **longitudinal current profile** of the electron bunches used for the seeding experiment. **Single-shot measurement** using a coherent radiation intensity spectrometer.
Transverse overlap

Superimposed beam profiles measured on Ce:YAG screen

$\Delta X, \Delta Y < 50 \mu m$

$\theta < 50 \mu rad$, 

V. Miltchev, SSSFEL’12, 10-12/12/2012
Temporal overlap

- temporal overlap
  - down to 1 ns: photomultiplier + oscilloscope
  - down to 10 ps: streak camera
  - finally: time scan (100 fs steps)

 durations (FWHM):
 electron bunch 300-400 fs
 HHG seed pulse 20 fs
 Tolerance 100 fs
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With the LOLA transverse deflecting structure (TDS) one can measure the longitudinal phase space after sFLASH undulators ...

![Graph showing longitudinal phase-space characterisation](image)
Summary and outlook

• HHG seeding at $\lambda = 38\text{nm}$ demonstrated

• Energy contrast in the order of 10 possible.
• Power contrast $\sim 100$ possible; should be OK for (some) users.
• HHG relies on perfect control and stability.

Outlook
• Establish seeding quicker & reliably (use ORS-timing, online spectrometer, optimized bunch length, intrabunch RF feedback)
• Parallel operation with FLASH SASE
• Pilot pump-probe experiment
• THz streaking for photon pulse length measurement
• Tests of HGHG and EEHG at FLASH -> decision on FLASH II later
On behalf of the sFLASH team