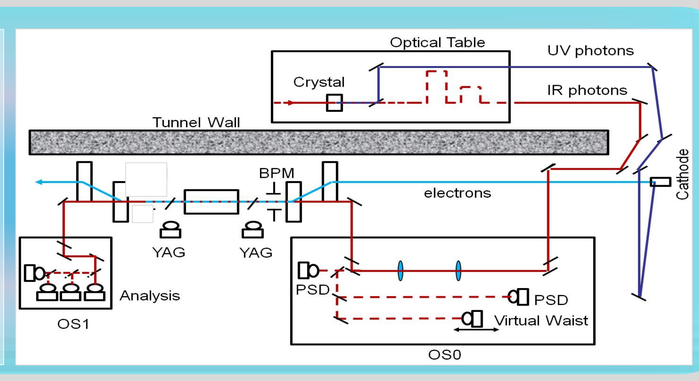
FIRST HEATING WITH THE EUROPEAN XFEL LASER HEATER

Mathias Hamberg Uppsala University Sweden **Frank Brinker & Matthias Scholz** DESY Germany

INTRODUCTION

•The 3.4 km long European X-ray Free-Electron Laser (EUXFEL) will deliver radiation in the wavelength interval 0.05 - 4.7 nm.
•Longitudinal micro bunching instabilities may affect the overall stability of the brightness of EUXFEL. A proven way to overcome this is to use a laser heater [1-2]
•It's interaction region is located in a chicane and consists of a 0.7 m permanent magnet undulator in which IR-laser pulses are overlapping electron bunches during the passage. The induced phase space modulation is smeared out and leave a net "heating effect" when the electron bunches leave the chicane.
•The EUXFEL Laser Heater is a Swedish in kind contribution and has earlier been described in detail



Acknowledgements

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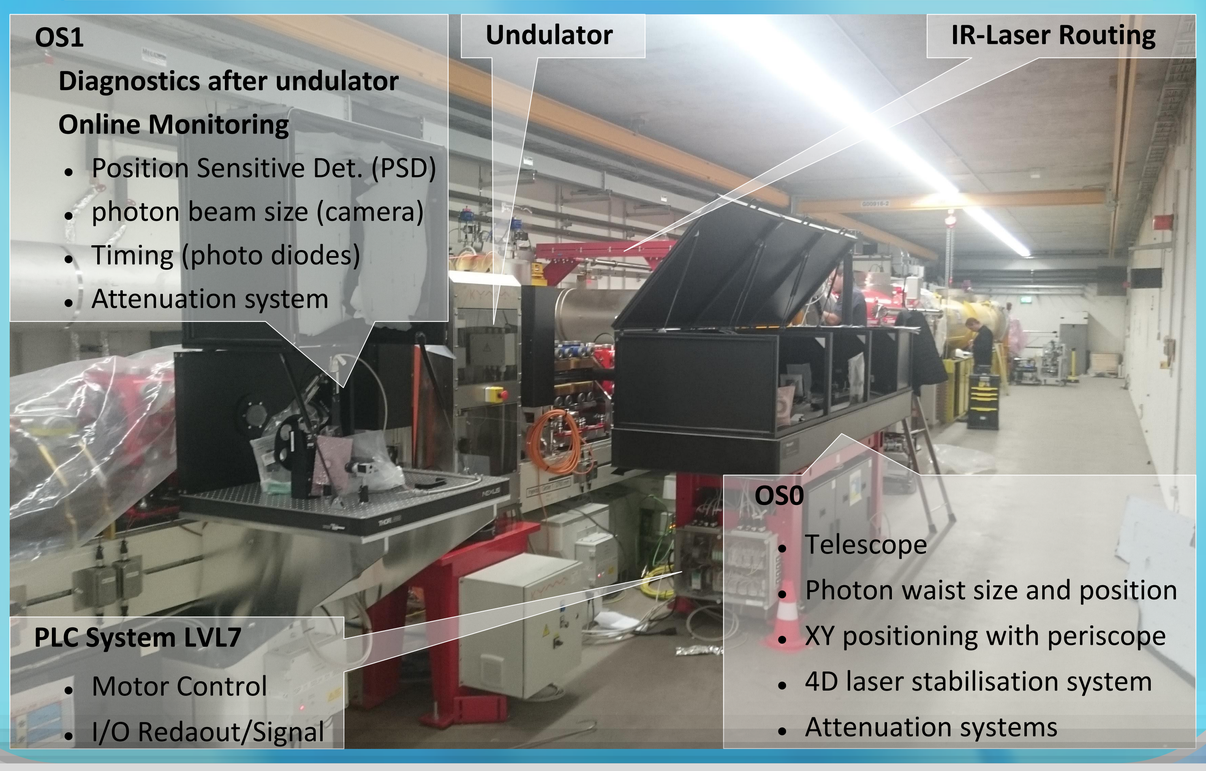
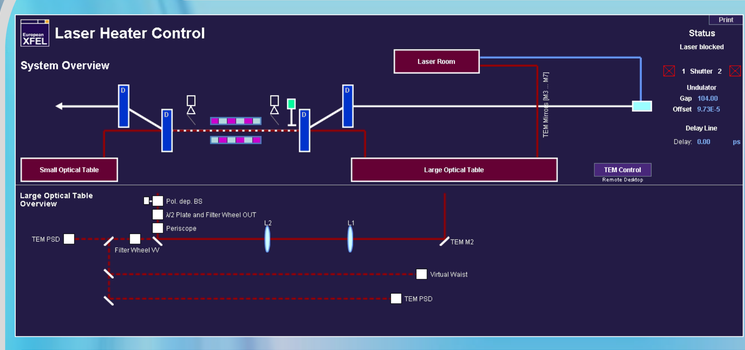
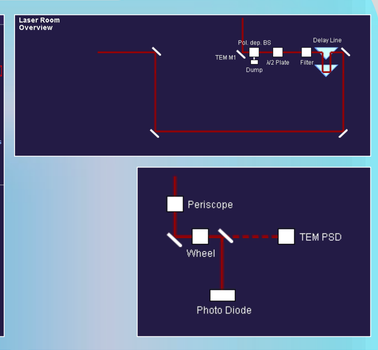
OVERVIEW OPTICAL STATIONS & UNDULATOR



CONTROL SYSTEM & GUI



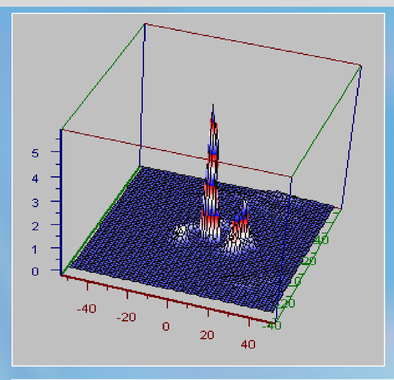


DOOCS Control GUI: A graphical user interface (GUI) for the Laser Heater is implemented in the control system such that EUXFEL operators easily can tune the setup. The main layout of this is ready and the ~40 motors can now be controlled through the GUI.

DOOCS Control GUI:
TopLeft: Layout & OS0
Top: LVL5 setup
Just above: OS1 setup

4D LASER STABILISATION & ROUTING SYSTEM

•Laser signal is recorded by a photo-diode behind mirrors along the way
•Scanning a mirror angle upstreams in X&Y direction for laser intensity gives a diagram
•No movement of mirrors during pumpdown observed
•Full detailed routing from start to end ➔ <2 h



•Need <±30µm laser fluctuation at interaction region 50m after source
•Stabilized value show ~5µm shot to shot fluctuations ➔ Well below limits

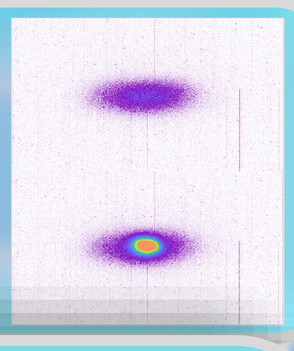
Left: Stabilisation system off and subsequently turned on. Red and green lines are the angle and position value respectively (arbitrary units on y-axis)

Left: Scan result from one mirror (not to scale). Ring structure from pipe reflection and edge scatter

System setup mentioned as the worlds most advanced laser routing and stabilisation system

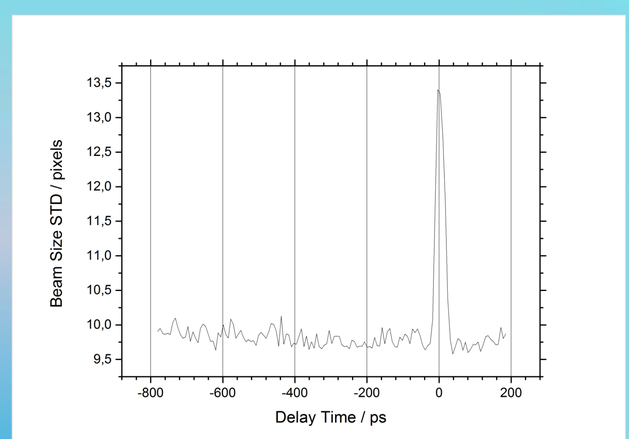
TRANSVERSE OVERLAP

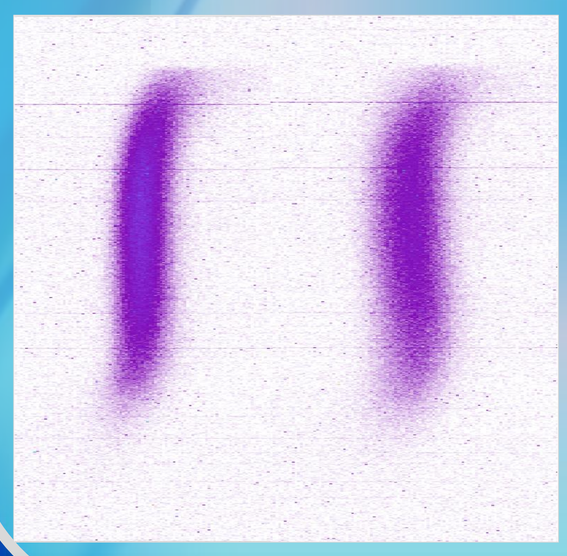
Cromox screens were used to display both laser and electron bunch position simultaneously
Top: laser position on the screen
Bottom: Electrons and laser beam



TEMPORAL OVERLAP & FIRST HEATING

Temporal overlap was first **coarsely** set by reading out photo diode signal radiated by laser and synchrotron light. When that overlap was found a fine (µm resolution) motorized delay line was scanned while reading out the standard deviation width of the beam at the dispersive section before the dump of the injector



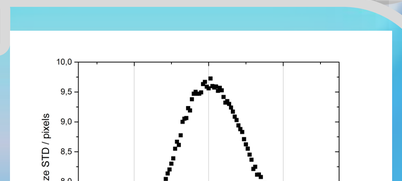


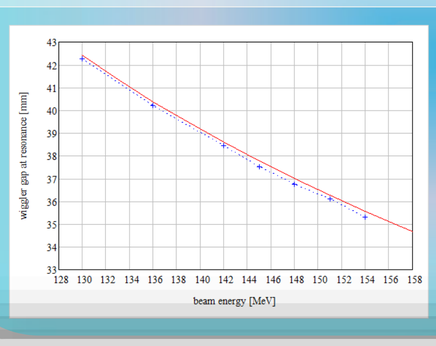
Top: The first scan resulted in this spectrum. The extra energy from the heating creates the net broadening effect which was discovered at the preset 0 position. Each pixel corresponds to ~1.4 keV energy spread. The increase from 14 keV to 18 keV is in agreement with the low laser power

The transverse deflecting structure (TDS) trace observed in the dispersive section is displayed when **far left:** the IR laser is blocked **left:** the laser is un-blocked. It is clear that the trace is becoming fuzzier during laser overlap i.e. is heated

UNDULATOR GAP SCAN

Initial undulator setting was chosen to match the 130 MeV e-beam energy and the undulator gap set to 42.4 mm.
Rigth: Gap scans results

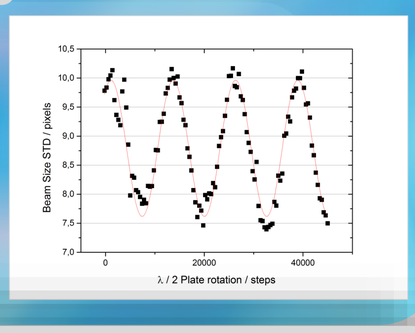




Bottom: For energies between 130-154 MeV the optimal undulator gap is compared with theoretical values

ATTENUATOR SCAN

The limited laser energy of ~4 µJ inside of the undulator was scanned for using a stepper motor rotated λ/2 plate with a subsequent polarization dependent beam splitter cube



OUTLOOK

- Injector commissioning remade with amplifier implemented ➔ >200 µJ/pulse
- Laser attenuator system implemented to protect PSD's
- Simplified "one knob" beam width adjustment
- Pipes around laser beam close to source will further reduce acoustic wave fluctuations in air
- UHV metal mirrors ➔ Recoated with amorphous coating
- Fast scale delay line using the 4D system and a cross correlator for overlap fixation
- 2017 optimization of EUXFEL laser heater impact

REFERENCES

[1] Z. Huang et al., Phys. Rev. ST Accel. Beams 13 (2013) 020703
[2] S. Spampanati et. al, Phys. Rev. ST Accel. Beams 17 (2014) 120705.