



# Working group summary slides

## Defining the HED instrument

International Workshop on the High Energy Density Science  
Endstation and Associated Instrumentation at the European XFEL  
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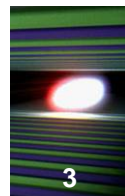
## I. X-ray instrumentation

- define various types of applications using x-rays to generate or to probe HED samples → classification possible ?
- requirements
  - **x-ray parameters**
  - **required instrumentation**
  - **detectors**
- where is R&D required

## II. Optical laser instrumentation

- define various types of applications using optical lasers to probe or to generate HED samples → classification possible ?
- requirements
  - **optical laser parameters**
  - **used techniques**
- where is R&D needed

**Bring together in discussing experiments combining both techniques**

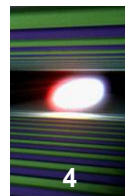


## Experimental requirements might be best discussed if following the following classification of types of experiments

1. Use FEL beam to excite matter. Probe the excited state using optical laser methods and opt./XUV/x-ray emission spectroscopy.
2. Use FEL to probe excited matter. Employ various diagnostics methods to probe matter excited by optical lasers or other means. Additional optical laser diagnostics might be required.
3. Use FEL-pump/FEL-probe configurations to study combinations of the above.

**Still further definition of requirements is needed to enable real designs. This might best be done by defining a few experiments more precisely. Here a suggestion (increasing complexity) :**

- X-ray heating/transmission experiments using emission spectroscopy (parameters for initial experiment: see next slide)
- X-ray scattering probe of FEL excited samples (pump/probe; 3<sup>rd</sup> harm.)
  - **secondary optical diagnostics of expansion**
- X-ray diffraction from shocks and excited solids
  - **VISAR of shock as secondary diagnostic**



## Characterization of XFEL interaction with matter

- X-ray parameters:
  - photon energy : ~6 keV
  - flux : max. peak flux (rep. rate ~10 Hz, if sample permits)
  - spot size : 1 (without laser probing) – 3 (w. laser)  $\mu\text{m}$ ; uniform dist. (e.g. Gaussian)
  - bandwidth : natural  $\sim 10^{-3}$
- samples
  - solid foil; V, C (these have K-edges near/far 6 keV; others are easy)
  - fast/automatized sample replacement and positioning verification
- diagnostics/probing excited state
  - transmission measurement  $I_{\text{out}}(I_{\text{in}}, \lambda, \dots)$
  - spectrometry: vis./XUV/X/particles
    - x-ray crystal spectrometer (around 6 keV,  $\Delta E/E < 10^{-4}$ , adjustable angle, forward and backward scattering)
    - soft x-ray crystal spectrometer (0.5 – 2.5 nm,  $\Delta E/E < 10^{-3}$ , fixed angle)
    - XUV spectrometer (2.5 - 25 nm,  $E/\Delta E > 10^3$ , forward & backward)
    - The soft x-ray and XUV spectrometers should have the capability to use streak cameras enabling ps time resolution.
    - others: visible, particles/electrons (scope & space charge effect to be investigated)
  - FDI setup

## Two classes of laser systems will be required for different types of experiments.

1. Laser as a probe for plasma produced by XFEL
    - 100 mJ, 30fs, 10Hz (if possible match the intra-bunchtrain pattern).
    - Furthermore the benefits of an x-ray backlighter (or similar diagnostics) requiring an higher laser energy should be analysed. Such a system requires >1J, 30fs, 10Hz. One should investigate if it is possible to use a part of the FEL beam to create the backlighter.
    - These systems require a very high pulse contrast :  $10^7 - 10^8$
  2. Laser to produce plasma
    - The scientific driver are investigations of shocked matter. Isentropic compression to reach pressures >10Mbar is targeted. Such a system requires >100 J, 1-10 ns,. Pulse energies up to 1 kJ will increase capability at the high pressure boundary.
    - A 2nd priority are lasers enabling to generate fast ignitor like plasmas. Such a system requires 10 ps, >10 J, 10 ps.
    - These systems require a capability of pulse shaping and VISAR diagnostics. The possibility of 10 Hz systems (e.g. DPSSL) requires further investigation.
- Primary laser characteristics
- Focal spot small ( calculation to be done), Smooth beam, Alignment capability, Synchronisation (Laser vs. XFEL) live with the jitter measured post mortem

Several types of experimental techniques or instrumentation items have been considered part of the HED instrument, but require further definition and work. An assessment of conditions (motivation – feasibility – requirements – realisation) is needed. Where appropriate it should include scaling output vs. effort. These assessments will become part of the workshop report.

### Experimental techniques

- x-ray scattering (elastic, inelastic, small-angle) → G. Gregori
- plasma spectroscopy (XFEL pump → x-ray emission) → F. Rosmej
- WDM generation/Transmission → B. Nagler
- (2-color) FEL/FEL pump-probe experiments → H. Sinn
- studying strongly driven matter → K. Sokolowski-Tinten

### Laser issues

- Lasers for shock generation → J. Wark
- Lasers for driving matter to excited states → P. Audebert, K. Sokolowski-Tinten

### Instrumentation

- Soft x-ray spectroscopy → D. Riley
- Hard x-ray spectroscopy → E. Förster, F. Rosmej
- Visible light & charged particle spectroscopy → L. Juha
- Coherent diffraction imaging → D. Higgs (?, LLNL), NN
- Bragg/Powder diffraction → A. Jephcoat, J. Wark
- Visible light diagnostics (Visar, FDI, tr optical probing) → NN

1. **We need to narrow down parameters and configurations**
  - started already during the session
  - continue during next weeks with collecting assessments for various types of experiments and instrumentation to be used at the HED instrumentation
2. **Workshop report**
  - including detailed considerations about various areas of HED science to be investigated at this instrument
  - this will be condensed by the main organizers and the WG chairs following reception of feedback on the several areas of instrumentation
3. **A few general questions have *only* been scratched**
  - The scope of experiments at repetition rates above 10 Hz. Due to the time pattern of the European XFEL this means 10 – 1000 kHz.
    - **Use of solid samples at these rates seemed unrealistic -> liquid droplets or gases. The biggest concern was sample delivery and debris.**
    - **Deemed nevertheless of interest if feasible → small effects, high accuracy, ...**
  - The needs for detectors.
    - **details depend on various assessments of experimental techniques**
    - **Need for high rep. framing rate depends on experiments feasibility**

**We would like to develop an open community for this instrument. This community might develop as the future user group for the HED instrument. The participants list of this and other, previous workshops might serve as an initial interest list, but we would like to ask you to subscribe to the following email list**

- <http://www.xfel.eu/en/experiment-stations/hed/>

**The following spokespeople were nominated for cases of particular requests by the project or for reviewing:**

**Justin Wark (Oxford, STFC)**

- Shock experiments, diffraction, excited condensed-matter

**Gianluca Gregori (Oxford & RAL)**

- WDM probing using x-ray scattering & diffraction

**Frank Rosmej (Universite Paris VI)**

- Spectroscopy, plasma dynamics

**P. Audebert (LULI)**

- Lasers, WDM generation and probing

**K. Sokolowski-Tinten (U Duisburg-Essen)**

- Creation & probing of strongly driven solids

**Martin Tolley (RAL)**

- Sample delivery issues