Parameters for early user experiments

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Schenefeld, 23.01.2018
European XFEL: HED at SASE2

- Accelerator and SASE1 X-ray commissioning (from April 2017)
- First user experiments at SASE1 SPB/SFX and FXE instruments (September – December 2017)
### XFEL properties at the HED instrument

<table>
<thead>
<tr>
<th>Property</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Fully tunable between</strong></td>
<td>3 – 25 keV (3 – 5 keV with limited performance)</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>2 – 100 fs</td>
</tr>
<tr>
<td>Photons per pulse</td>
<td>(\sim 10^{11}) (25 keV), (\sim 10^{12}) (5 keV)</td>
</tr>
<tr>
<td>Spot size on sample</td>
<td>sub-(\mu) m (HIBEF), few (\mu) m, 20 – 30 (\mu) m, 200 – 300 (\mu) m, few mm</td>
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<tr>
<td>Seeded beam</td>
<td>available in early phase</td>
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<tr>
<td>Repetition rate</td>
<td>shot on demand, 10 Hz – 27000 pulses/s</td>
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</table>

10 Hz burst

0-2700 pulses/bunch

\[ \implies 4.5 \, \text{MHz} \]
First beam in SASE1

- One of the first SASE beam (May 2017) as comes out of the undulators
First beam in SASE1

- One of the first SASE beam (May 2017) as comes out of the undulators
- Beam diagnostics – shot-to-shot intensity (XGM), X-ray spectrum (HIREX)

$\Delta E/E = 10^{-3}$: SASE

Naresh Kujala, HIREX

X-ray Optics & Beam Transport Group
X-ray Photon Diagnostics Group
First beam in SASE1

- One of the first SASE beam (May 2017) as comes out of the undulators

- Beam diagnostics – shot-to-shot intensity (XGM), X-ray spectrum (HIREX)

- Beam delivery all the way up to the experimental hall
Mirrors at HED: offset and distribution

- **Offset mirrors**: 1.1 – 3.6 mrad, B\textsubscript{4}C coating
- **Distribution mirror**: 1.3 mrad;
  - B\textsubscript{4}C (21.4 keV);
  - Si (23.8 keV);
  - Pt (60.7 keV)

- **All mirrors** have a useable length > 80 cm
Focussing with Be Compound Refractive Lenses (CRL)

- 4 CRL systems placed at various distances from the source
- Foci ranging from ~1 mm down to sub-micron
  (using nanofocus setup - framework HIBEF DESY, A. Schropp)
- Energy range 5 - 25 keV
- Chromatic (different set of lenses for different X-ray energies)
- Optimized for transmission (>95%)
Split and Delay Line (BMBF, University of Münster)

- Multi-layer mirrors
- Variable delay up to ~23 ps (5 keV), ~4 ps (15 keV), 2 ps (20 keV)

Inside of the SDL in Münster

Vacuum vessel in the tunnel

BMBF project 05K10PM2
University of Münster
Monochromator

- 4-bounce, Si$_{111}$ crystals
- Beam size: $6\sigma$
- Energy range: 5 - 25 keV ($24.5^\circ$ - $4.5^\circ$)
- Cryogenically cooled
- $\Delta E/E = 10^{-4}$

Status: delivered, ready to be mounted
High Resolution Monochromator

- First 2 crystal of standard mono + Si_{533} crystals in backscatter geometry
- Design being finalized by FMB Oxford

Four different bandwidths:
- $\Delta E/E = 10^{-3}$: SASE
- $\Delta E/E = 10^{-4}$: $\text{Si}_{111}$ monochromator
- $\Delta E/E = 10^{-4} - 10^{-5}$: seeded (NOT day 1)
- $\Delta E/E = 10^{-6}$: Si_{533} $\Rightarrow$ 7.494 keV
Optics hutch

- Power slits
- BIU
- Grating holder
- CRL3
- Solid Foils Attenuator
- General purpose post (QWP)
- Spectrometer
- I0 monitor
- Shutter
- BIU 1st order
- PAM
Photon Arrival Monitor (PAM)

- Shot-to-shot measurement of timing between X-rays and PP laser (800 nm, 15 fs)
- Spatial AND spectral encoding simultaneously

- Ready to be shipped from Japan

For more information, please contact Motoaki
Single Shot Spectrometer

- Contribution by CAEP, China
- Crystals: 4x Si 10 μm
- 3~15 keV with grating, 5~25 keV crystal only

Energy resolution: ~$1 \times 10^{-4}$

Detector:
- Gotthard-I detector (1D)
- Optical CCD (2D)

Detector arm rotation 60° (30° - 90°)
Beam Imaging Unit + grating holder

- Basler camera
- Grating holder
- YAG screens

- Power slits – installed and tested in the optics hutch
- BIU, grating holder – installed in optics hutch
**I0 monitor**

- Mount for diamond windows
- Mount for diodes

- **I0** – to be installed (20-400 um diamonds, <10% attenuation)
Experimental hutch

- Laser shutter
- Alignment laser
- Differential pumping system
- Diamond gate valve
- I0 monitor
- 2x 2pairs of clean-up slits

Optics hutch

Experimental hutch

European XFEL
X-ray beam transport: Focusing schemes

(a) $f = 229$
(b) $f = 175$
(c) $f > 175$
(d) $f > 132$
(e) $f = 132$
(f) $f = 141$

5 – 25 keV
970 – 290 μm
260 – 160 μm
low flux
> 50 μm
high flux
40 – 24 μm
2.6 – 1.1 μm
SASE 2 X-ray beam properties

Zuzana Konôpková, HED Instrument Scientist, 23.01.2018
I0 monitor, Beam Imaging Units, Power and Clean up slits, Diamond Window

- Power slits – installed and tested in the optics hutch
- BIU, grating holder – installed in optics hutch
- PAM – being shipped
- Solid foils attenuators – foils to be mounted in the lab
- CRL – granite installed, need to be equipped with lenses
- 1st order BIU – in design
- Spectrometer – awaits for FAT (in china)
- I0 – to be installed (20-400 um diamonds, <10% attenuation)
- X-ray shutter – installed
- Laser beam shutter – installed
- Alignment laser – partly installed
- DPS – granite there, vacuum system to be built
- 2 pairs of slits (JJ) – bought, to be installed
- I0 – no movable diodes, screen to remove for exps, design nearly ready
- Diamond Gate valve – diamonds and gate valve purchased
- Beam stops
Pulse Picker

- 0.5 mm B$_4$C (facing beam) + 0.5 mm Ta? (downstream)
- 10 Hz → shot on demand