X-ray photon diagnostics

X-Ray photon diagnostics

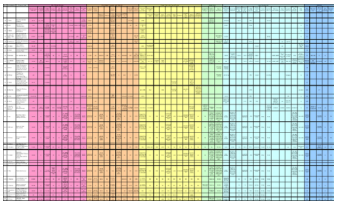
is mandatory for

- tuning the FEL
- characterizing and understanding the FEL
- providing user experiments with required beam parameters

and will be realized via

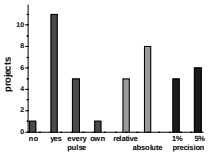
- developing pulse-resolved diagnostics based on well-known techniques (from synchr. rad. and lasers)
- learning from the VUV FEL experience

Example for user requirements: VUV-FEL Questionnaire

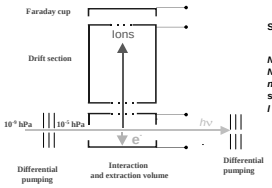


FEL Pulse Intensity

User requirements:
FEL Intensity Monitoring



Gas ionization detector for the VUV-FEL and XFEL (collaboration: PTB, Ioffe Institute)



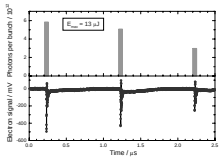
Single photoionisation:
$N = N_{ph} \times n \times s \times l$

N = number of electrons or ions
N_{ph} = number of photons
n = target density
s = photoionisation cross section
l = length of interaction volume

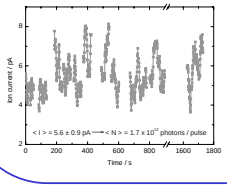
Online monitor of single-pulse FEL intensity

- transparent
- wide dynamic range (spont. to sat.)
- independent of beam position
- can measure beam position
- no saturation effects
- < 93 nm
- absolute calibration

TTF1 results:



Bottom: Electron-pulse signal of the gas monitor detector generated by a FEL bunch train filled with 3 bunches. The measurement was taken with Xe at 87nm.
Top: Evaluated photon numbers per bunch (uncertainty ~15%).

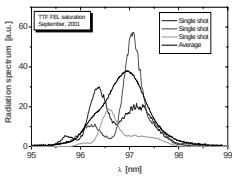


Ion signal of the gas-monitor detector integrated over several bunch trains.

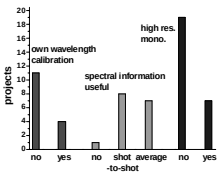
responsible author:
Kai Tiedtke, Elke Plönjes, DESY
kai.tiedtke@desy.de, elke.ploenjes@desy.de, Oct 2003

Wavelength Calibration and Spectral Distribution

TTF1 results:
Spectra of single FEL pulses

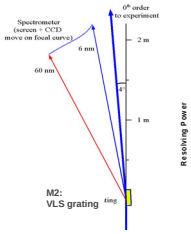


User requirements:



VUV FEL

1. Online spectrometer for single pulses (collaboration: SAS, CLRC Daresbury)
with high transmission of 0. order to experimental stations



resolving power, 1200 lines/mm

2. High resolution monochromator beamline (collaboration: Universtät Hamburg)

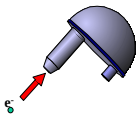
- wavelength range 60 – 2 nm
- resolving power E/ΔE up to 6*10⁴ using 1200 lines/mm grating
- beamline transmission up to 0.3 using 300 lines/mm grating

3. Seeding, see separate poster

XFEL

1. Wavelength calibration:

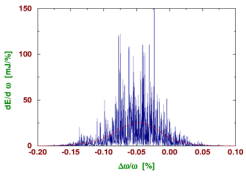
- **crystal spectrometer**
- **photoelectron spectrometer**



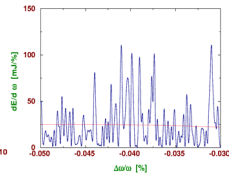
2. Characterization of the spectral distribution

- **Dispersive bend crystal monochromator**

3. Online spectrometer for single pulses
is not necessary due to multitude of peaks in spectral structure



Spectral structure of radiation pulse from SASE 1 FEL at 1 Å

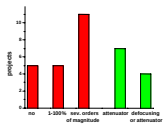


Enlarged section of central part of pulse

4. Seeding schemes are developed and tested on VUV FEL, see separate poster

Adjustment of FEL Intensity

User requirements:

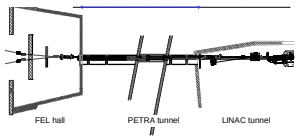


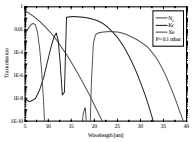
Gas filled attenuator in combination with differential pumping units

- Controlled attenuation of FEL beam
- Attenuation of 10^{-6} (depends on pressure and gas)
- Preserves beam attributes (coherence, statistics, spectrum, etc.) - not possible by changing LINAC settings

VUV FEL

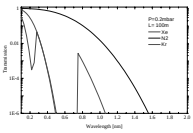
gas filled attenuator
(length: 15 m, Ø: 35 mm)





Calculated transmission of gas filled attenuator (length: 15m, P: 0.1 mbar)

XFEL



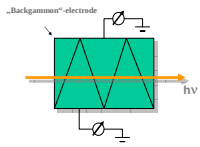
Calculated transmission of gas filled attenuator (length: 100 m, P: 0.2 mbar)

- To minimize the gas consumption of the absorber, a recirculation scheme will be used.

Beam position monitor

Two beam position monitors based on the gas ionization detector equipped with split electrodes can be installed at the entrance and at the end of the gas cell.

- 10 µm transversal resolution
- 0.1 µrad angular resolution

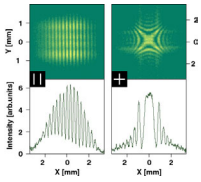


Transverse coherence

TTF1 results:

Diffraction pattern at 95nm observed on a Ce:YAG crystal 3m behind the slits (near zone)

parallel slits:
2mm long
200µm wide
separation 1mm



crossed slits:
100µm wide
4mm long