Wave Front Observations at FLASH

Characterisation of a FEL beam
by a Hartmann-Plate setup
under user-run conditions.

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Intention

1. Beamline commissioning

   The first implementation and long-term observations of diagnostic tools and optics can be facilitate.

2. FEL characteristics

   The FEL source can be analysed in position, shape and size. The beam position and its stability can be documented in addition to other tools.

3. Part of user experiments

   The focus size and position can be determine in online mode for single shots, if the direct beam path is not blocked by the main experiment.

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Unique Conditions

EUV and soft x-ray regime

The FEL operates between 60nm and 13nm.
Higher harmonics up to the 7th were measured.
The facility requires particle-free vacuum conditions.

Shot to shot characteristic

All FEL features differ from shot to shot, depending on the degree of saturation.

Pulse duration of 10 fs to 50 fs

The short pulse length depends on the modes of the FEL and is a challenge for any synchronization requirements.

High intensity level

At a high level of ~10μJ the FEL can operate in an intensity regime of two orders of magnitude.

Variable time structures

With 2 or 5Hz a single bunch or up to 30 bunches are generated in on pulse.
(1-300 bunches with 10Hz in the near future)

User facility since August 05

The beam time is limited and beam lines are overbooked. The commission week assists the following user-runs.

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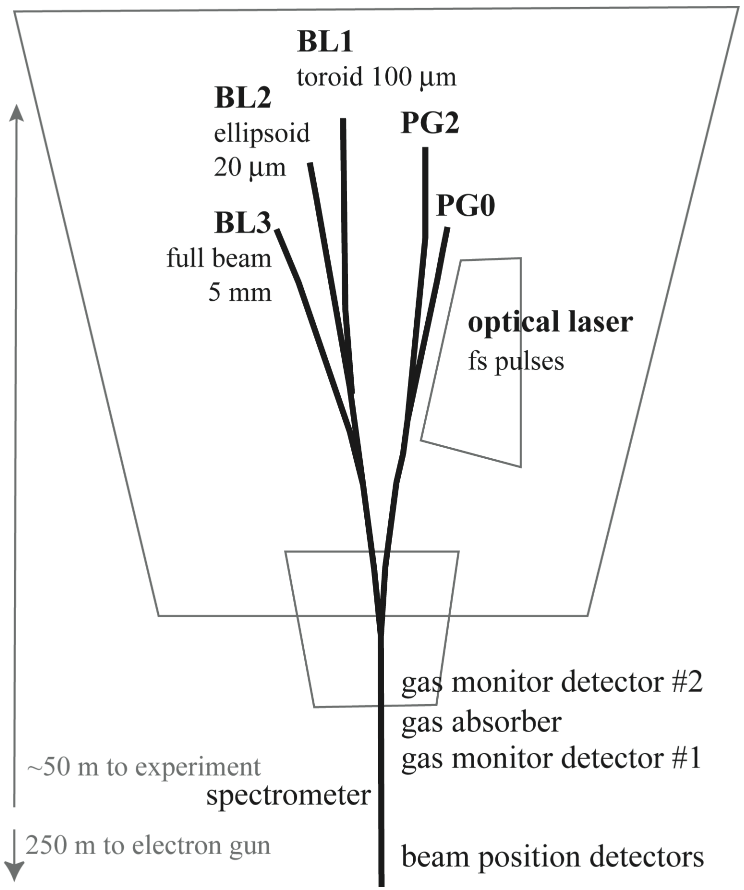
FLASH Experiment Hall



- More than 10 switching and focusing mirrors are in use.
- Only one beam line can make use of the FEL beam at a time.
- All mirrors are operating under an angle of incidence of 2 to 4 degree.
- All mirrors are carbon coated (GKSS) or have an additional Ni coating.
- At each beam line an optical laser is available for pump-probe experiments.
- A gas monitor system documents the intensity of the FEL (K. Tiedtke).

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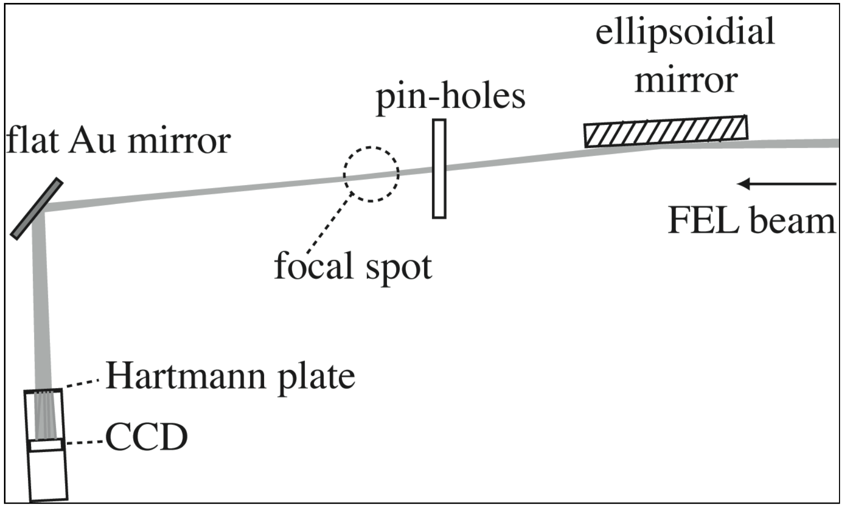
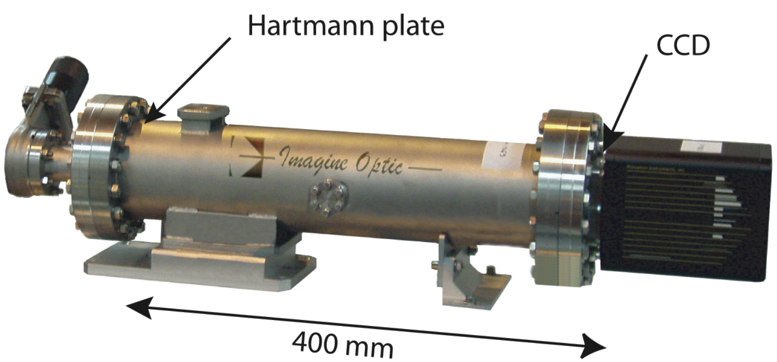
Setup at BL2

Ellipsoidal mirror
2 m focal length
73 m behind theoretical source
20 µm fwhm designed spot size

Wave-front setup
pinholes of 2 or 5 µm close to focal spot
flat mirror in 45 degree (Au,Ag,Al)
sensor position 3.5 m behind the focal spot





Sensor
Field of view = 19.5 mm x 19.5 mm
Hartmann plate => 51 x 51 holes
CCD => 1340 x 1300 pixels

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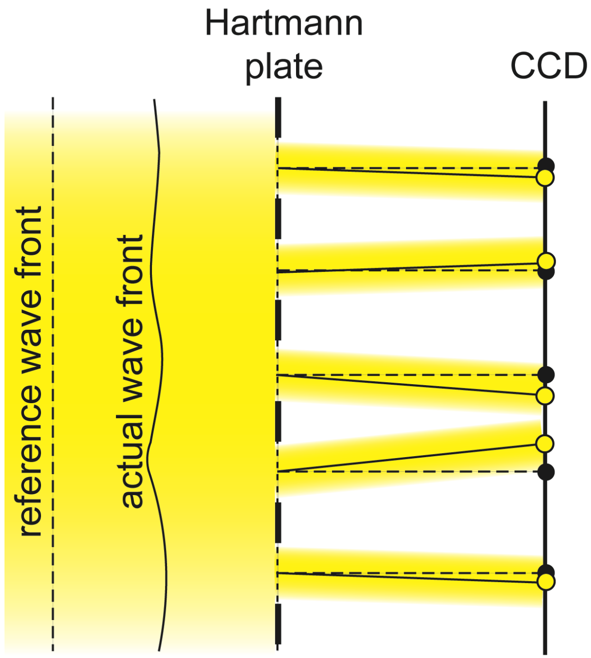
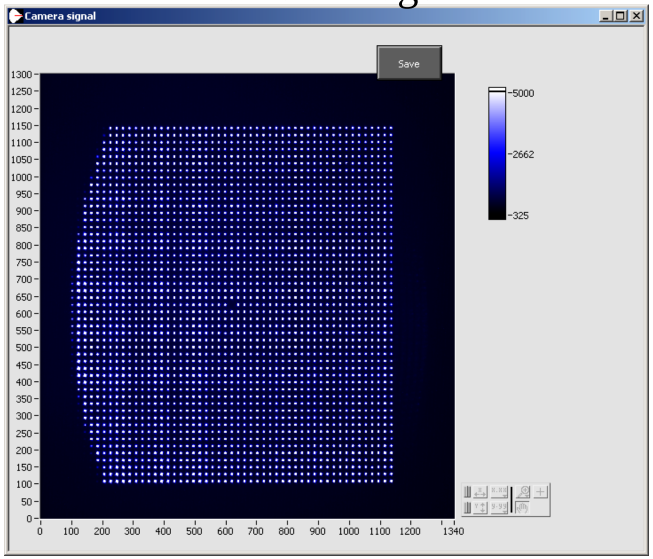
The Sensor



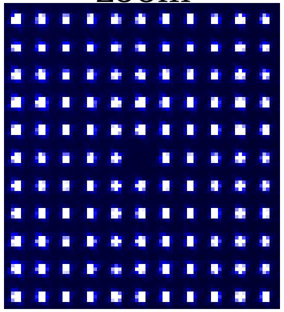
• A perfect spherical wave is compared with the actual beam.

• The Hartmann plate consists of 51 x 51 quadratic holes tilted by 25° to prevent interference of adjacent holes.

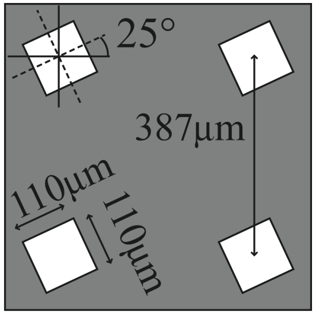
camera image



camera image zoom



sketches and sensor development by **Pascal Mercère** SOLEIL



soft- and hardware are provided by **Imagine Optic**

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This work was supported by the **European Community Research Infrastructure** Action under the FP6 “Structuring the European Research Area” Programme through the Integrated Infrastructure Initiative **“Integrating Activity on Synchrotron and Free Electron Laser Science”**, contract number RII3-CT-2004-506008.

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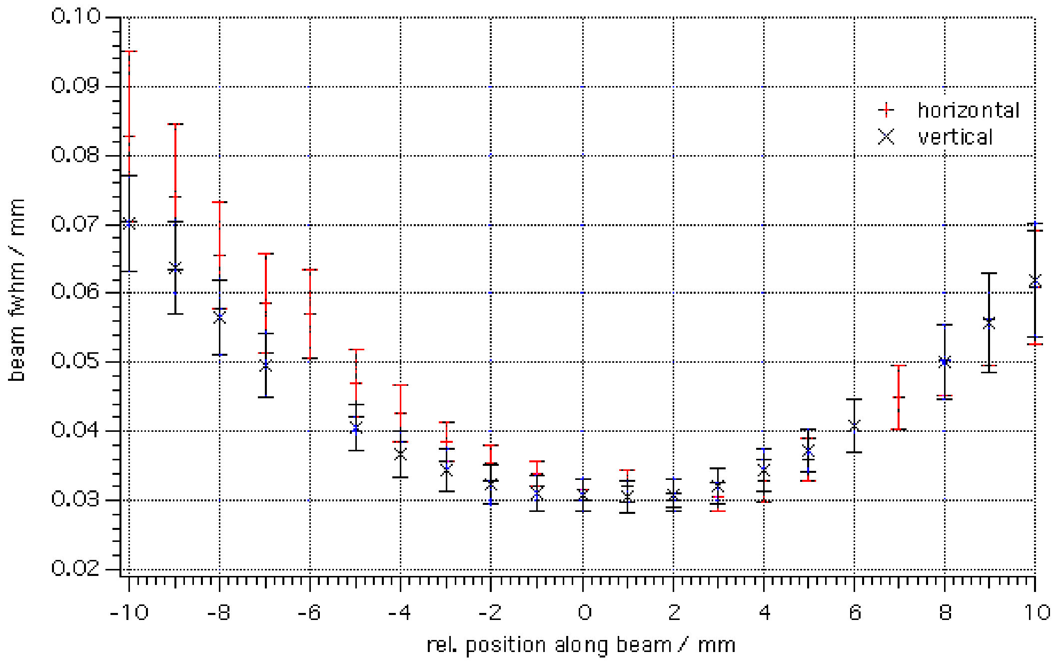
Focused Beam at BL2



Results

focal length 2 m
focal size 31 µm x 31 µm

fit error of spot size 2 µm
deviation of spot size 4.5 µm
(October 05, unstable beam)

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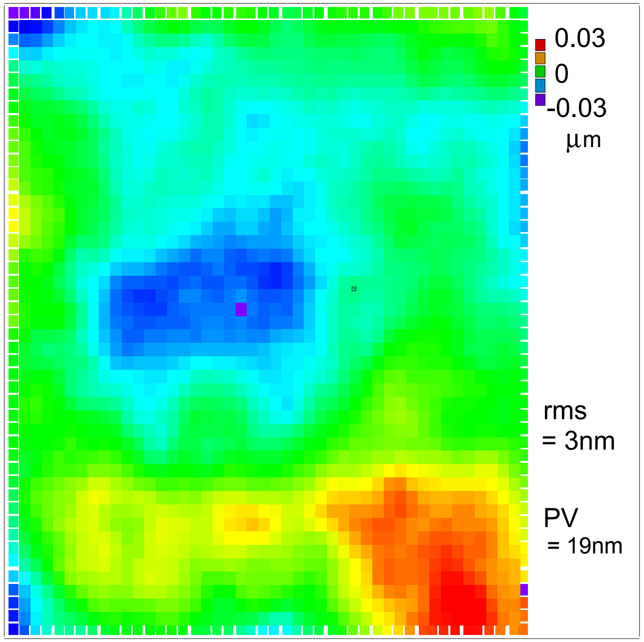
Focused Beam at BL2



51 x 51 pixels = full field of view

Evaluation of the wave front by its root-mean-square rms distribution and the maximal peak-valley PV difference.

Actual sensor calibration:
rms = 0.64nm, PV = 4nm

Shot to shot variation of the FEL beam:
rms ~2nm (under stable beam conditions)

Wave front quality is close to the actual sensor resolution!

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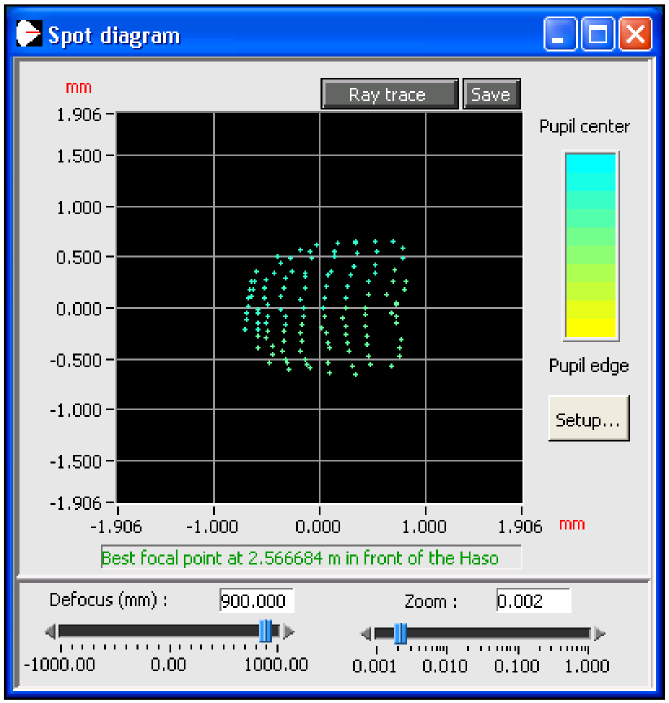
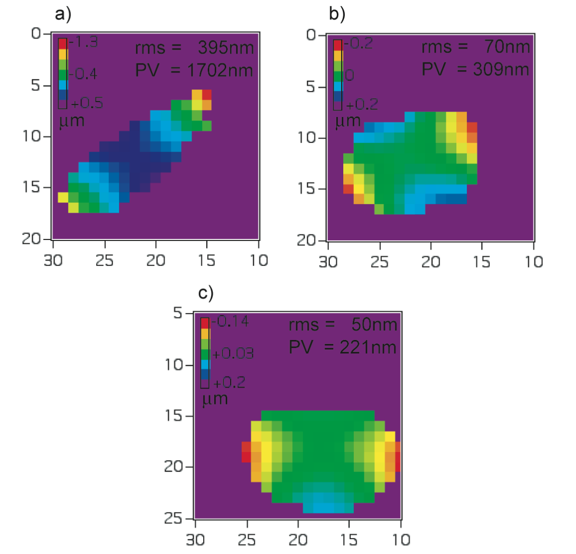
Commissioning at BL1

Beamline

Toroidal mirror with a focal length of 10 m and a designed focal size of ~100 µm.



Critical adjustment of the mirror in yaw direction over 10 mrad.



73 % astigmatism => yaw angle

12 % coma => roll angle

Improvements of the field of view are in preparation.

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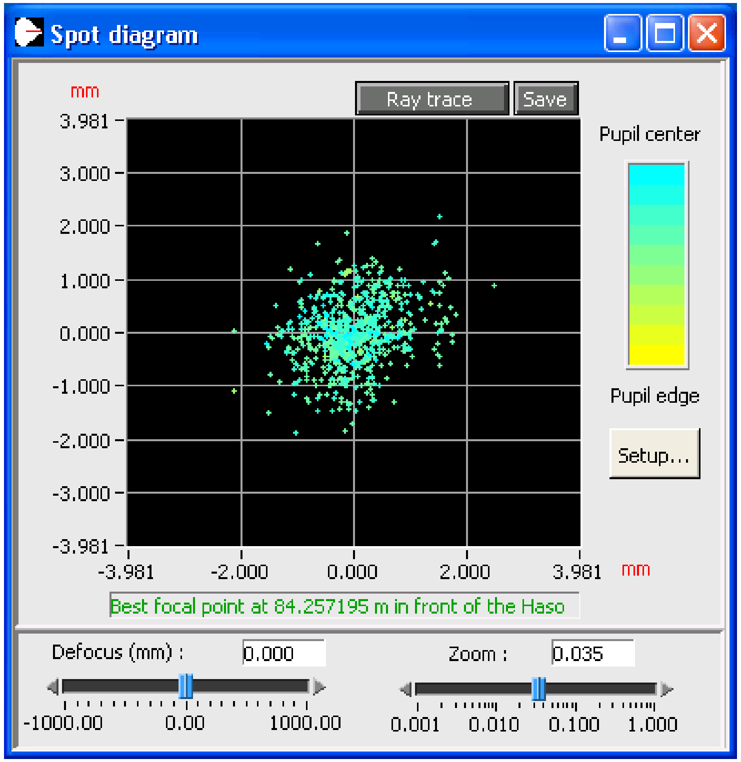
Flat Beam at BL3



Measurements
beam size = 10 mm fwhm
beam movement in x-direction 1.3 mm
in y-direction 2.3 mm
[correspond to a beam close to saturation]
(Data from Feb. 06 with 32 nm)

Calculations of the source in position and size suffer from the long distance to the source of > 80 m.

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Filter Performance

higher harmonics

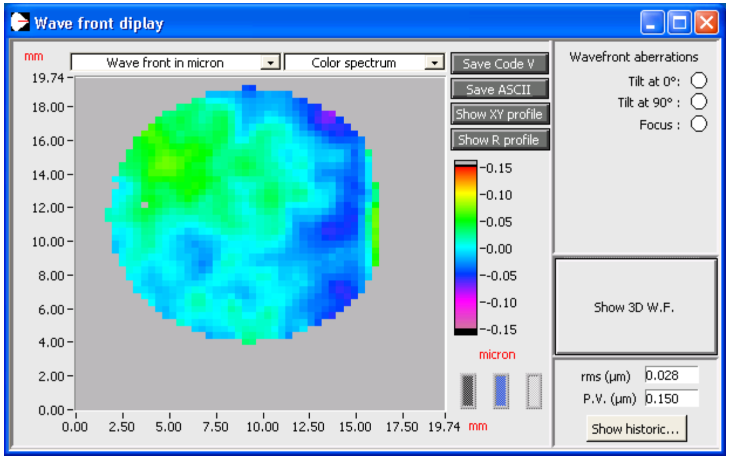
The FEL generate higher harmonics. Measurements up to the 7th harmonic were recorded up to now. Maximal 1% of the fundamental can be origin in the most intensive first harmonic. Filters are required to make use of these wavelengths or to eliminate any ill effects.

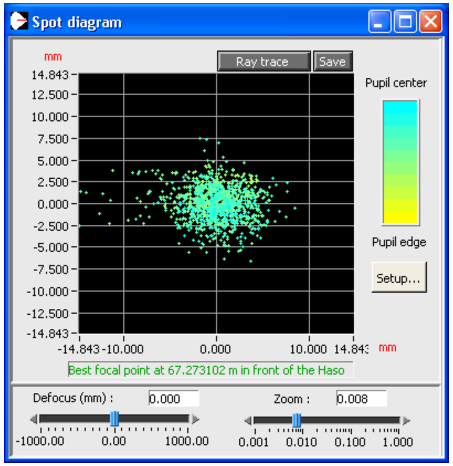
gas absorber

A standard gas absorber can be used, N_2, Ne and Xe are implemented. At 32 nm an absorption of 99.9% by N_2 **do <u>not</u> change the wave front**. Further measurements are planned.
(Gas diagnostics by **K. Tiedtke** et al.)

solid filters

An Al foil with 2 µm thickness changes the wave front slightly.
Of greater consequence, a secondary source is created.





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Conclusion

The wave-front sensor proved to be a valuable diagnostic tool during the beam line commissioning at FLASH.

The high sensitivity of the wave-front sensor is required for the high beam quality of the FEL.

First order aberrations were recorded and weighted by their origin.

In the near future:

- **an optimal calibration is required**
- **development of an online implementation**
- **the use for focal spots below 1 µm must be evaluated**

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Thank you!

FLASH

experiments and photon diagnostics

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DESY and FLASH

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