

User Operation at FLASH: First Experiences

Rolf Treusch
DESY FS

Deutsches Elektronen-Synchrotron
Photon Science



FLASH, the first free-electron laser built for the vacuum-ultra-violet and soft X-ray region, has started user operation at DESY. Currently the FEL is covering a wavelength range from 13 nm to 50 nm providing typically 150 pulses per second with GW peak power and a pulse duration between 20 and 50 fs. Within the next two years the facility will provide beams for users with wavelengths from approx. 6.5 to 60 nm with several thousand pulses per second.

Call for Proposals for Experiments at FLASH

Interested researchers and groups are invited to submit proposals for experiments at FLASH starting in summer 2007. They must reach us before October 1, 2006. The evaluation will be based on scientific merit and feasibility at the FLASH user facility. Access is provided free of charge for all non-proprietary research. Detailed information can be found at www-hasylab.desy.de/facility/fel/main.htm. New users may contact Dr. Josef Feldhaus (phone: +49 40 8998-3901, josef.feldhaus@desy.de) for additional information before preparing a proposal.

Hamburger Synchrotronstrahlungslabor HASYLAB at
 Deutsches Elektronen-Synchrotron DESY
 Notkestrasse 85 • D-22603 Hamburg • Germany
 Phone: +49 40/8998-2305 or -1803 • Fax: -4475
www-hasylab.desy.de • E-mail: hasylab@desy.de

Review on December 4-5, 2006 :

45 proposals from 9 countries*

- *atoms, ions, molecules and clusters*
- *plasma states, warm dense matter*
- *imaging, diffraction*
- *strong field processes*
- *spectroscopy of bulk solids and surfaces*
- *surface reactions*
- *spin dynamics*
- *diagnostics*
- *methods development*

<i>D</i>	<i>DK</i>	<i>Est</i>	<i>F</i>	<i>NL</i>	<i>P</i>	<i>S</i>	<i>UK</i>	<i>USA</i>
31	1	1	1	1	1	3	3	3

***: Counted are project leader affiliations**

total of 45 proposals, 13 rejected

**~404 twelve hour user shifts available in 20 months,
316 +14 shifts allocated + $\geq 20\%$ (management) contingency**

<i>Research fields</i>	<i>Number of 12 hour shifts</i>		<i>Percentage</i>
	<i>Requested (all 45 prop.)</i>	<i>Allocated</i>	
<i>Atoms, Molecules, Ions</i>	247	61	25
<i>Clusters</i>	71	36	50
<i>Imaging, Diffraction</i>	90	53	59
<i>Plasma physics / Warm dense matter</i>	194	56	29
<i>Solids, Surfaces</i>	214	46	21
<i>Methods/ Technology</i>	157	64	41

General recommendation of the panel:

*In view of the large over-booking by roughly a factor three, and in order to make best usage of the allocated beamtime, management was encouraged to stimulate the **formation of larger collaborations** pursuing related scientific goals and using similar technical equipment.*

*Each collaboration should determine a **Speaker** and identify **Principle Investigators** who are deeply involved in the execution of the experiments and well informed about the technicalities.*

45 proposals submitted in 2006, 32 proposals approved in Dec. 2006

Beamtime: Jul.(Nov.) 2007 - Mar. 2009, 404 shifts total (~36%)

Collaboration

Collaboration

Collaboration

Proposal no	Proposer, Project Leader	Title
I-20060122	Jose Ramon Crespo Lopez-Umaria	Resonant single- and multi-photon excitation and photoionization of highly charged ions by FEL radiation
I-20060250	Robert Moshhammer	Few Photon Multiple Ionization of Atoms and Molecules using a Reaction Microscope
I-20060251	Robert Moshhammer	Coulomb-Explosion Imaging of Small Molecules and Pump-Probe Experiments
I-20060259	Reinhard Dörner	Multiple Fragmentation Processes of Molecules and Clusters Probed by Momentum Imaging Spectroscopy
I-20060262	Alexander Dorn	A Lithium Magneto-Optical Trap in a Reaction Microscope at FLASH: Complete Photo-Fragmentation of Lithium Atoms Dynamics of a Strongly Coupled Ultra-Cold Plasma
I-20060263	Uwe Hergenroth	Intermolecular Coulombic Decay in doped water clusters
I-20060278 EC	Marc Vrakking	Velocity map imaging of strong field processes
I-20060280 EC	Michael Meyer, John Costello	Two-color photoionization of atoms and molecules
I-20060293	Axel Reinkensperger, Uwe Becker	Study of multiphoton-ionization processes of free atoms and molecules
I-20060277	Karl-Heinz Meiwes-Broer	Electron Structure and Dynamics in Clusters
I-20060286	Thomas Möller	Ultrafast processes and imaging of clusters
I-20060257	Ivan Vartanants, Christian Gult	Characterization and Coherent Scattering Applications of the Femtosecond Pulses at the FLASH Facility
I-20060269	Axel Rosenhahn	Single pulse digital in-line holography with VUV radiation and soft X-rays at FLASH
I-20060264	Stefan Eisebitt	Time Resolved Imaging and Scattering for the Study of Sub-Picosecond Correlations on Nanometer Lengthscales
I-20060270	Henry Chapman	Flash Diffraction Imaging of Biological Samples
I-20060296	Simone Techert	Probing the molecular dynamics of supramolecular assemblies by time-resolved x-ray diffraction in the few Å regime
I-20060253	Klaus Sokolowski-Tinten	Transient response of solids to high intensity femtosecond XUV-excitation
I-20060267 II C	David Riley	Probing plasma dynamics using time-resolved spectroscopy
I-20060271	Art Nelson	Creation and characterization of WDM using high intensity XUV radiation
I-20060279 EC	Arne Höl, Gianluca Gregori	Thomson scattering measurements of plasma dynamics
I-20060283 EC	János Hajdu, N. Timneanu	X-ray induced Coulomb explosions and nuclear fusion
I-20060254 EC	Andreas Cavalleri	Resonant Soft X-ray Scattering in Complex Codes with near-2-nm Free Electron Laser Pulses
I-20060258	Kai Rossnagel	Femtosecond Dynamics of Photoinduced Insulator-to-Metal Transitions in Layered Transition-Metal Compounds Probed by Time- and Momentum-Resolved Photoemission
I-20060269	Marco Rutkowski, Helmut Zacharias	Investigation of highly excited surface reactions
I-20060276	Alexander Föhlisch	Non-equilibrium dynamics and low energy excitations in complex systems
I-20060285	Hermann Dürr	Femtosecond electron and spin dynamics in functional materials
I-20060108	Michael Martins	Multi-photon processes in soft X-ray regime
I-20060292	Mathias Richter	Quantitative gas-phase experiments for FEL photon diagnostics at high photon energies and small spot size
I-20060261	Lutz Kipp	VUV-FEL Nanospectroscopy
I-20060266	Marco Rutkowski, Helmut Zacharias	Evaluation of FEL pulse duration by non-linear autocorrelation in atoms and molecules
I-20060268	Michael Rübhausen	Light Scattering at the FEL
I-20060272	Markus Drescher	Pump-probe experiments exploiting FLASH's intrinsic temporal resolution

Atoms, Molecules, Ions

Clusters

Imaging, Diffraction

Plasma/Warm dense matter

Solids, Surfaces

Methods/Technology

Proposal no	Proposer, Project Leader	Title
II-20060122	Jose Ramon Crespo Lopez-Urrutia	Resonant single- and multi-photon excitation and photoionization of highly charged ions by FEL radiation
II-20060250	Robert Moshhammer	Few Photon Multiple Ionization of Atoms and Molecules using a Reaction Microscope
II-20060251	Robert Moshhammer	Coulomb-Explosion Imaging of Small Molecules and Pump-Probe Experiments
II-20060259	Reinhard Dörner	Multiple Fragmentation Processes of Molecules and Clusters Probed by Momentum Imaging Spectroscopy
II-20060262	Alexander Dorn	A Lithium Magneto Optical Trap in a Reaction Microscope at FLASH: I. Complete Photo-Fragmentation of Lithium Atoms II. Dynamics of a Strongly Coupled Ultra Cold Plasma
I-20060263	Uwe Hergenhahn	Intermolecular Coulombic decay in doped water clusters
II-20060278 EC	Marc Vrakking	Velocity map imaging of strong field processes
I-20060280 EC	Michael Meyer, John Costello	Two-color photoionization of atoms and molecules
I-20060293	Axel Reinköster, Uwe Becker	Study of multiphoton-ionization processes of free atoms and molecules
II-20060277	Karl-Heinz Meiwes-Broer	Electron Structure and Dynamics in Clusters
II-20060286	Thomas Möller	Ultrafast processes and imaging of clusters
II-20060257	Ivan Vartaniants, Christian Gutt	Characterization and Coherent Scattering Applications of the Femtosecond Pulses at the FLASH Facility
II-20060289	Axel Rosenhahn	Single pulse digital in-line holography with VUV radiation and soft X-rays at FLASH
II-20060264	Stefan Eisebitt	Time Resolved Imaging and Scattering for the Study of Sub-Picosecond Correlations on Nanometer Lengthscales
II-20060270	Henry Chapman	Flash Diffraction Imaging of Biological Samples
II-20060296	Simone Techert	Probing the molecular dynamics of supramolecular assemblies by time-resolved x-ray diffraction in the low q regime

Atoms, Molecules, Ions

Clusters

Imaging, Diffraction

II-20060253	Klaus Sokolowski-Tinten	Transient response of solids to high intensity femtosecond XUV-excitation	Plasma / Warm dense matter
II-20060267 EC	David Riley	Probing plasma dynamics using time-resolved spectroscopy	
II-20060271	Art Nelson	Creation and characterization of WDM using high intensity XUV radiation	
II-20060279 EC	Arne Höll, Gianluca Gregori	Thomson scattering measurements of plasma dynamics	
II-20060283 EC	Janos Hajdu, N. Timneanu	X-ray induced Coulomb explosions and nuclear fusion	
I-20060254 EC	Andrea Cavalleri	Resonant Soft X-ray Scattering in Complex Oxides with near-2-nm Free Electron Laser Pulses	Solids, Surfaces
II-20060258	Kai Rossnagel	Femtosecond Dynamics of Photoinduced Insulator-to-Metal Transitions in Layered Transition-Metal Compounds Probed by Time- and Momentum-Resolved Photoemission	
I-20060269	Marco Rutkowski, Helmut Zacharias	Investigation of highly excited surface reactions	
II-20060276	Alexander Föhlisch	Non-equilibrium dynamics and low energy excitations in complex systems	
II-20060285	Hermann Dürr	Femtosecond electron and spin dynamics in functional materials	
II-20060108	Michael Martins	Multi-photon processes in soft X-ray regime	Methods / Technology
II-20060292	Mathias Richter	Quantitative gas-phase experiments for FEL photon diagnostics at high photon energies and small spot size	
II-20060261	Lutz Kipp	VUV-FEL Nanospectroscopy	
I-20060266	Marco Rutkowski, Helmut Zacharias	Evaluation of FEL pulse duration by non-linear autocorrelation in atoms and molecules	
II-20060268	Michael Rübhausen	Light Scattering at the FEL	
II-20060272	Markus Drescher	Pump-probe experiments exploiting FLASH's intrinsic temporal resolution	

***2/3 of proposers performed already experiments at FLASH
1/3 are newcomers (mostly in collaborations)***

User Workshops are indispensable!



“The FLASH user workshops are intended to keep the users up to date regarding the **status of FLASH** and to inform them about the **facility infrastructure** and the **requirements to be able to perform an experiment**. Users briefly present their recent results and discuss their **demands and expectations** regarding the next experiments. The users' feedback is collected and evaluated and **goes into strategies for technical developments/improvements** and future operation modes of FLASH.”

from FLASH webpages

Example: User Workshop 2004

Scope:









The "VUV-FEL Users Workshop on technical issues of first experiments" was held at DESY on August 23-24, 2004. It was well received with a total of 96 participants. Topics which are of interest to all groups planning experiments at the new FLASH User Facility were covered, such as

- FLASH parameters and time line
- Experience of user experiments from phase 1
- Scheduling of beamtime for experiments
- Efficient set up and alignment of experimental stations
- Vacuum interface
- Optical laser system available for pump-probe experiments and synchronization of laser systems
- Data acquisition systems





The idea was to discuss open questions before user experiments start in 2005 in order to make the most of the limited available beamtime.

Talks:

-  **Machine status and expected FEL parameters (978KB)**
Speaker: Pedro Castro
-  **Layout of the user facility (5.7 MB)**
Speaker: Kai Tiedtke
-  **Online photon diagnostics (1.5 MB)**
Speaker: Rolf Treusch
-  **Optical laser facility (4.5 MB)**
Speaker: Ingo Will (MBI)
-  **Synchronisation and pump-probe experiments (1.9 MB)**
Speaker: Stefan Düsterer
-  **Vacuum requirements and beamline interface (1.8 MB)**
Speaker: Mathias Hesse
-  **Alignment of experimental chambers at beamline stations (2.6 MB)**
Speaker: Elke Plönjes
-  **Data acquisition (709KB)**
Speaker: Teresa Nunez

Important issues

- **FEL capabilities** (wavelength, intensity, pulse patterns, repetition rate, diagnostics,...)
- **Users demands** (see beamtime application form next slide)
- **Technical boundary conditions** (vacuum, experiment size, etc.)
- **Facility Infrastructure** (vacuum connection, gases, water electricity, computing, lab. space lasers, shutters, DAQ, ...)
- **Safety aspects** (lasers, chemical, radioactive sources)
- **Logistics** (transport, (un)loading, setup and storage)


DOOR DESY ONLINE OFFICE FOR RESEARCH WITH PHOTONS
 

HASYLAB | DORIS III | FLASH | DESY

DOOR Home
 • Contact
 • Function Selection

DESY Research
 • Declaration of Substances
 • Use of Chemistry Laboratory
 • Register your Publications
 • Logout

Application for Beamtime

General information
 Applicant Dr. Rolf Treusch
 Project Number H-20000024

Beamline information
 Requested beamline (*) - Select one -
 Number of shifts (12h) required (*)
 Safety precautions for the experiment necessary? (*) - Select one -
 Use of chemistry laboratory? (*) - Select one -

Machine parameters
 Wavelength(s) (*)
 (for further information please read the [help page](#))

Wavelength [nm]	Required accuracy (+/-) [nm]	No. of shifts

 Pulse energy requirements [μJ] (*) $0.10 \leq \text{ } \leq 100.00$
 Number of pulses per train (*)
 Pulse repetition rate(s) (*) ☐ 100kHz ☐ 250kHz ☐ 1MHz
 Use of gas filled attenuator? (*) - Select one -
 Fast shutter needed? (*) - Select one -

Example of a shift schedule

November / December 2007		Final (30.11.2007), incl. assignment of most contingency shifts	
		day shift (7:00-19:00)	night shift (19:00 - 7:00)
26.11.07	Mo	Meyer (BL2, 13.7 +/- 0.2 nm, single bunch, 200kHz o.k.)	Wolf (PG2, ~13.7nm, like Meyer, 200kHz, 20 bunches, >= 10 microJ)
27.11.07	Tu	Maintenance	Wolf (PG2, ~13.7nm, like Meyer, 200kHz, 20 bunches, >= 10 microJ)
28.11.07	We	Meyer (BL2, 13.7 +/- 0.2 nm, single bunch, 200kHz o.k.)	Wolf (PG2, ~13.7nm, like Meyer, 200kHz, 20 bunches, >= 10 microJ)
29.11.07	Th	Meyer (BL2, 13.7 +/- 0.2 nm, single bunch, 200kHz o.k.)	extra for Meyer (Richter) / Contingency
30.11.07	Fr	Meyer (BL2, 13.7 +/- 0.2 nm, single bunch, 200kHz o.k.)	SLAC (PG2, 12.7 +/- 0.1nm, single bunch) incl. wavelength change
1.12.07	Sa	Meyer (BL2, 13.7 +/- 0.2 nm, single bunch, 200kHz o.k.)	SLAC (PG2, 12.7 +/- 0.1nm, single bunch) incl. wavelength change
2.12.07	Su	Düsterer et al.: multibunch (500kHz) intra-pulse train-timing studies (12.7/13.7nm tbd?)	extra for SLAC / Contingency
3.12.07	Mo	Mitner-Zacharias (BL3, 13.7 nm, single bunch)	SLAC (PG2, 17 +/- 0.1 nm, Al 2p resonance, single bunch) incl. wavelength change
4.12.07	Tu	Maintenance	SLAC (PG2, 17 +/- 0.1 nm, Al 2p resonance, single bunch) incl. wavelength change
5.12.07	We	Vartanians, Gutt (PG2, 13.7nm)	Mitner-Zacharias (BL3, 13.7 nm, single bunch)
6.12.07	Th	Drescher (BL1, 13.4 nm, mainly single bunch)	Becker (BL2, 13.4nm, probably multi-bunch 1MHz or 200kHz tbd)
7.12.07	Fr	Drescher (BL1, 13.4 nm, mainly single bunch)	Becker (BL2, 13.4nm, probably multi-bunch 1MHz or 200kHz tbd)
8.12.07	Sa	extra for Drescher / Contingency (wavelength)	change wavelength to 24 nm
9.12.07	Su	Mitner-Zacharias (BL3, 24 +/- 0.2nm, single bunch)	extra for Mitner, Zacharias / Contingency
10.12.07	Mo	Mitner-Zacharias (BL3, 24 +/- 0.2nm, single bunch)	Contingency
11.12.07	Tu	Maintenance	Mitner-Zacharias (BL3, 24 +/- 0.2nm, single bunch)
12.12.07	We	Mitner-Zacharias (BL3, 24 +/- 0.2nm, single bunch)	change to 28 nm
13.12.07	Th	Drescher (BL1, 28nm / can be 27.6nm, single bunch)	Becker (BL2, 26.1 +/- 0.1nm, probably multi-bunch 1MHz/200kHz tbd)
14.12.07	Fr	Drescher (BL1, 28nm / can be 27.6nm, single bunch)	Becker (BL2, 26.1 +/- 0.1nm, probably multi-bunch 1MHz/200kHz tbd)
15.12.07	Sa	Drescher (BL1, 28nm / can be 27.6nm, single bunch)	Becker (BL2, 26.1 +/- 0.1nm, probably multi-bunch 1MHz/200kHz tbd)
16.12.07	Su	Drescher (BL1, 28nm / can be 27.6nm, single bunch)	extra for Becker / Contingency
17.12.07	Mo	change to 8 nm (if not, tbd by Vartanians, Gutt et al.)	Vartanians, Gutt (PG2, 8nm)
18.12.07	Tu	Maintenance	Contingency
19.12.07	We	Vartanians, Gutt (PG2, 8nm)	improvement 8nm performance or SLAC (PG2, 8nm) ?
20.12.07	Th	Vartanians, Gutt (PG2, 8nm)	extra for Vartanians, Gutt / Contingency

- *single user machine, frequent parameter changes*
→ *quite different from storage ring, particularly tough for operators*
- *scheduling needs a lot of input due to many boundary conditions*
- *changes for one experiment might affect others*
→ *coordinators (machine and experiment side) required*

Experimenters use

- *explosive and toxic **chemicals**, mostly gases
(hydrogen, bromine, benzene, ammonia, CO, ...)
→ extremely elaborate gas supply system with distributed gas
cabinets, alarm sensors, exhaust ventilation, ...*
- ***high voltage** power supplies (several 10 kV)*
- *strong **magnetic fields** (up to 6T) for magnetic traps*
- *lots of own **class 4 lasers**
(use of facility provided μ J and mJ Lasers grew from
20% of all experiments to 50% of them in second campaign)
→ careful instructions and safety checks needed*

Some typical numbers ...

- *experimental setup fills a small truck (7.5 tons)*
- *time needed for setup, alignment (< 1mm), vacuum connection and bakeout, DAQ connection, ... about 1.5-2 weeks*
- *then 5-10 shifts (12h each) within the next 1-2 weeks*
- *1-3 days for disassembly and removal from beamline*

*Prior to beamtime **local contact** spends about **1 week** (overall) for **coaching**, i.e. technical issues, safety issues, etc., at beamline 2-3h/day, first 1-2 shifts full 12h and more if fully involved in experiment*

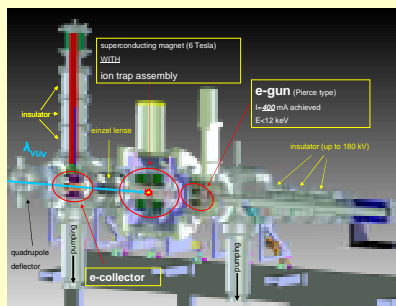
Single user machine

- ➔ *4 operators/shift (about 60 operators total, 50% FLASH specific)*
- 24/7 on call duty for all subsystems*
- 1 machine run coordinator*
- 1 photon run coordinator*

For comparison take DORIS III



- *multi-user machine*
- *typical experiment gets 3-7 days of beamtime (except bio-experiments at EMBL beamlines)*
- *mostly only samples or small sample environments for use at dedicated instruments are brought*
- *beamline scientist spends ≈ 1 day to align beamline and get experiment started (experienced users)*
- *only shift technicians on call after working hours*
→ *problems during night mostly have to wait until next morning*



About 30 publications on new and exciting science in two years of operation, among them

- ***1 Optics Letter***
- ***5 Applied Physics Letters***
- ***4 Physical Review A***
- ***6 Physical Review Letters***
- ***1 Nature Physics***
- ***2 Nature Photonics***
- ***1 Nature***

... and many more in queue

