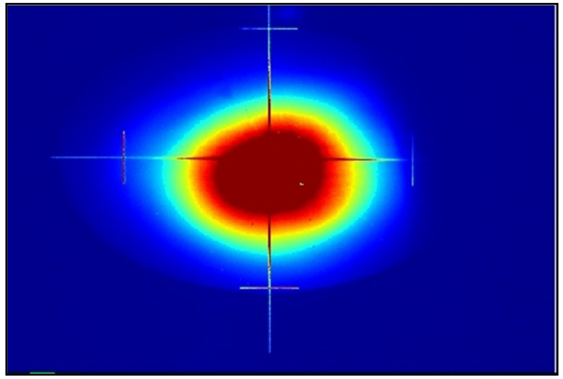
Status of FLASH

FLASH.
Free-Electron Laser in Hamburg

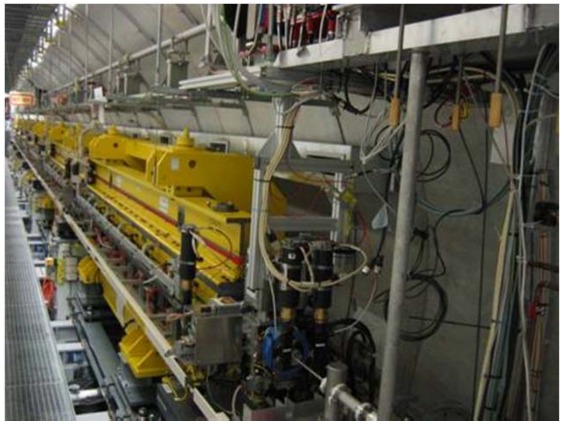
FLASH. free-electron laser user facility at DESY

Siegfried Schreiber
DESY



Workshop
New Science
Opportunities at FLASH

DESY
Oct 12-14, 2011



HELMHOLTZ
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DESY

FLASH at DESY in Hamburg

FLASH. Free-Electron Laser in Hamburg

FLASH at DESY in Hamburg

FLASH. Free-Electron Laser in Hamburg

> Single-pass high-gain SASE FEL
  - **SASE = self-amplified spontaneous emission**
> Photon wavelength range from vacuum ultraviolet to soft x-rays
> Free-electron laser user facility since summer 2005
  - 1st period: Jun 2005 – Mar 2007
  - 2nd period: Nov 2007 – Aug 2009
  - 3rd period: Sep 2010 – Sep 2011
  - 4th period: Mar 2012 – Dec 2012
> FLASH2, a second undulator beam line in preparation
> FLASH is also a test bed for the European XFEL and the International Linear Collider (ILC)

DESY

FLASH Accelerator Workshop

FLASH.
Free-Electron Laser in Hamburg

FLASH Accelerator Workshop

04 October 2011 *DESY*
Europe/Berlin timezone

https://indico.desy.de/conferenceDisplay.py?confId=4736

> Impressive proposals for many accelerator studies at FLASH
> Subjects are Plasma Acceleration, ILC related, seeding schemes, undulator options, XFEL related studies
> Accelerator studies and FEL related machine studies have always been overbooked by a factor of 2 to 3
> As in the past, a substantial amount of beamtime will be allocated for these proposals
> In order to be able to increase user beam time (goal: > 4000 h/y), a 3rd beamline FLASH3 is a perfect option for many of these proposals

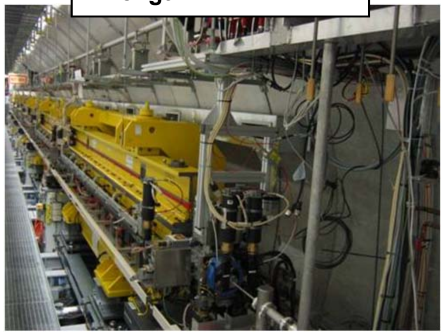
FLASH layout

FLASH.
Free-Electron Laser in Hamburg

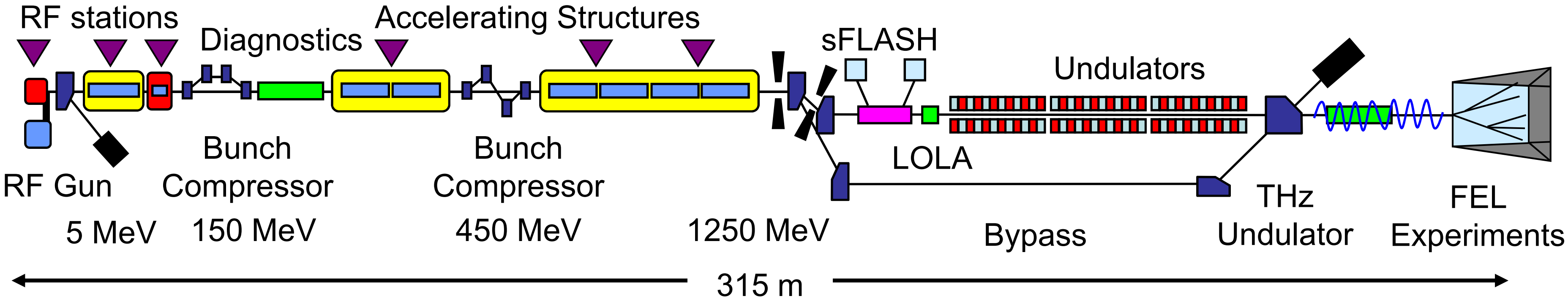
> 3rd harmonic cavity 3.9 GHz

> TESLA type superconducting accelerating modules

> Fixed gap undulator
> length ~ 27 m



> FEL Experimental Hall



> FEL Experimental Hall

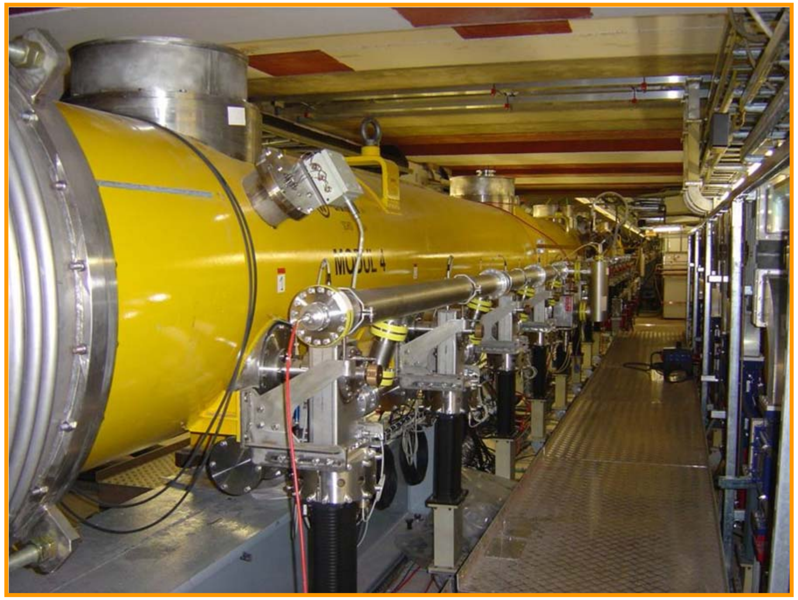
> Normal conducting 1.3 GHz RF gun
> Ce_2Te cathode
> Nd:YLF based ps photocathode laser

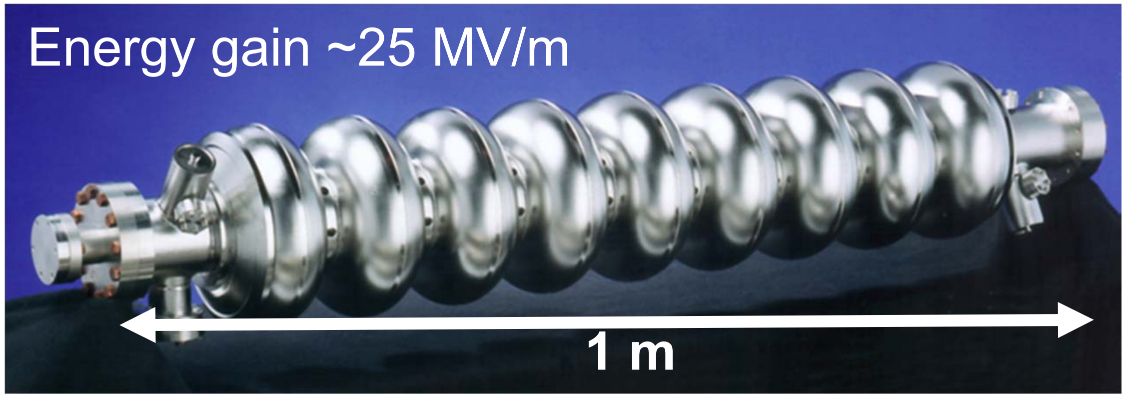
> Diagnostics and matching

> sFLASH undulators

FLASH Accelerator

- FLASH uses TESLA technology
- Seven accelerating modules:
  each with eight 9-cell superconducting cavities operated at 1.3 GHz
- Burst mode:
  acceleration for 800 μs at 10 Hz
- Efficient acceleration due to high $Q \sim 10^{10}$
  (loaded $Q = 2 \times 10^{6}$)

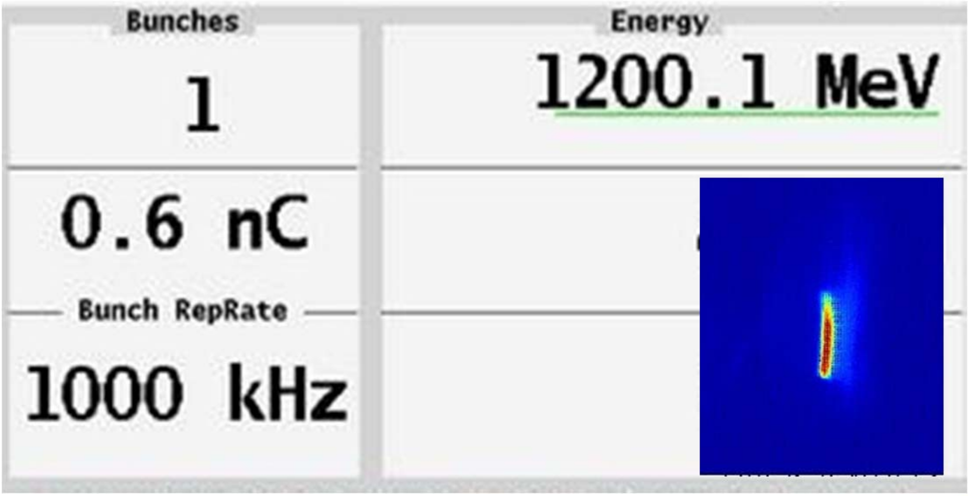




Energy upgrade

- Originally designed for 1 GeV and a wavelength of 6.4 nm
- Upgrade 2009/10:
- Installation of a 7th superconducting accelerating module
  - Prototype module for the European XFEL
  - Cryostat from China
  - Energy reach 240 MeV

1.2 GeV demonstrated with beam in May 2010



3.9 GHz (3rd harmonic) Module and Module 1

FLASH.
Free-Electron Laser in Hamburg

- New 1st accelerating module with improved cavities and Piezo tuners
- 3rd harmonic module with four nine-cell superconducting cavities operated at 3.9 GHz
  - with RF system and LLRF regulation
  - built at FNAL (Fermilab) in a collaboration with DESY

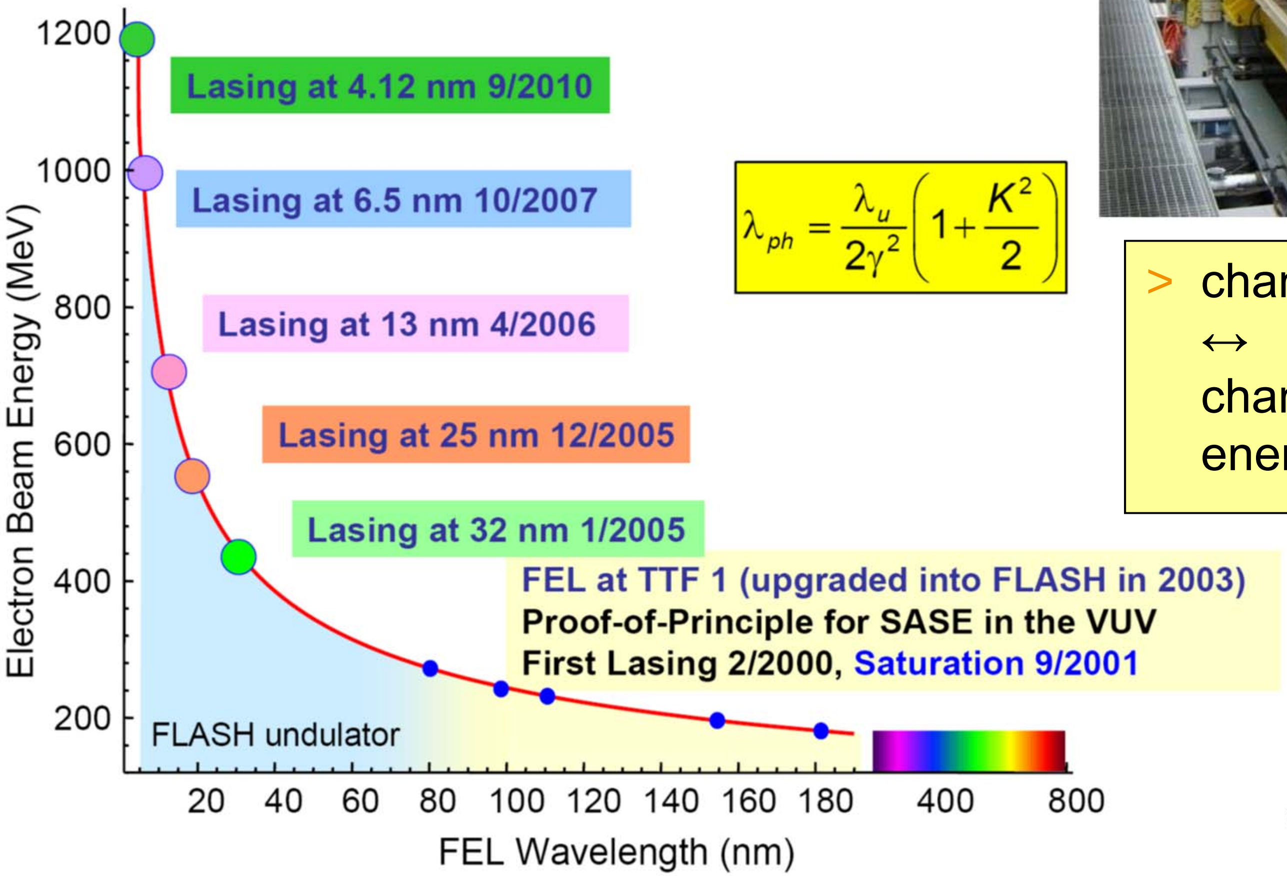
Fermilab DESY

First Lasing in the Water Window

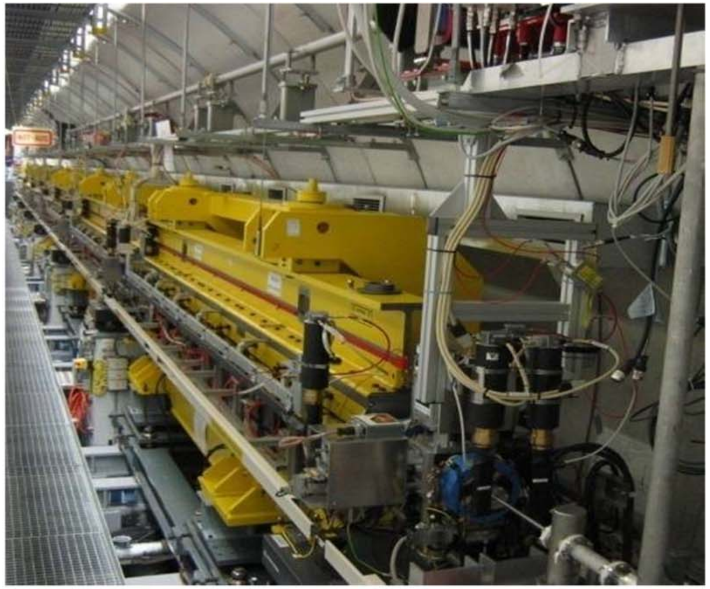
FLASH Undulators

FLASH. Free-Electron Laser in Hamburg

- 6 undulator modules, total length 27 m
- Fixed gap of 12 mm
  - permanent NdFeB magnets
  - peak B = 0.48 T, K = 1.23, period of 27.3 mm



$$\lambda_{ph} = \frac{\lambda_u}{2\gamma^2}\left(1+\frac{K^2}{2}\right)$$



- change of wavelength ↔ change of electron beam energy

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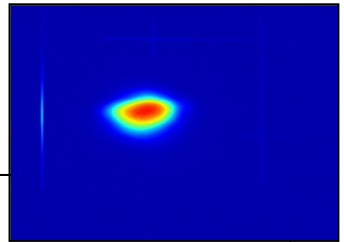
FLASH reaches the water window

FLASH. Free-Electron Laser in Hamburg

- On 25-Sep-2010 we have been able to increase the beam energy to 1250 MeV
- First lasing at a wavelength of 4.12 nm in the fundamental



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Deutsches Elektronen-Synchrotron
Ein Forschungszentrum der Helmholtz-Gemeinschaft

WASSERFENSTER.

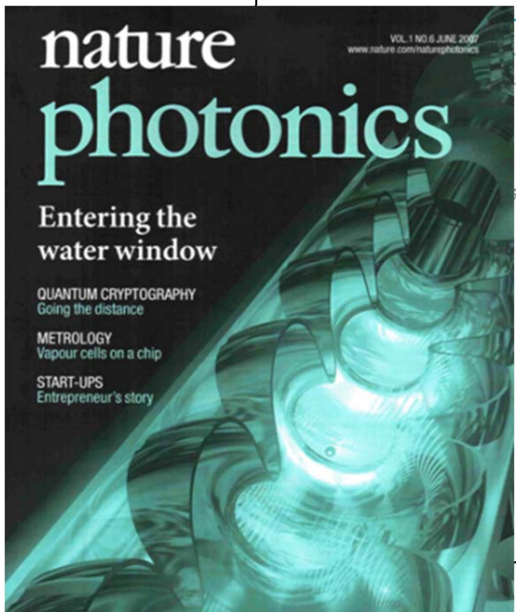
Home / Aktuelles / DESY News / 2010 / Wasserfenster

Hamburg 28.09.2010

FLASH eröffnet den Blick durchs Wasserfenster

Der Freie-Elektronen-Laser FLASH (Free-Electron Laser in Hamburg) hat einen neuen Rekord aufgestellt: Am Wochenende hat die FLASH-Beschleunigermannschaft den FEL mit einer Elektronenenergie von 1,25 Giga-Elektronenvolt betrieben und so eine Wellenlänge von 4,12 Nanometern erzielt. Damit hat FLASH zum ersten Mal in seiner Grundwellenlänge Laserlicht im so genannten Wasserfenster erzeugt – bisher war dies nur mit Oberschwingungen des Lasers erreicht worden. Die kurzwelligen Lichtblitze hatten eine durchschnittliche Energie von 70 und eine Spitzenenergie von 130 Mikrojoule.

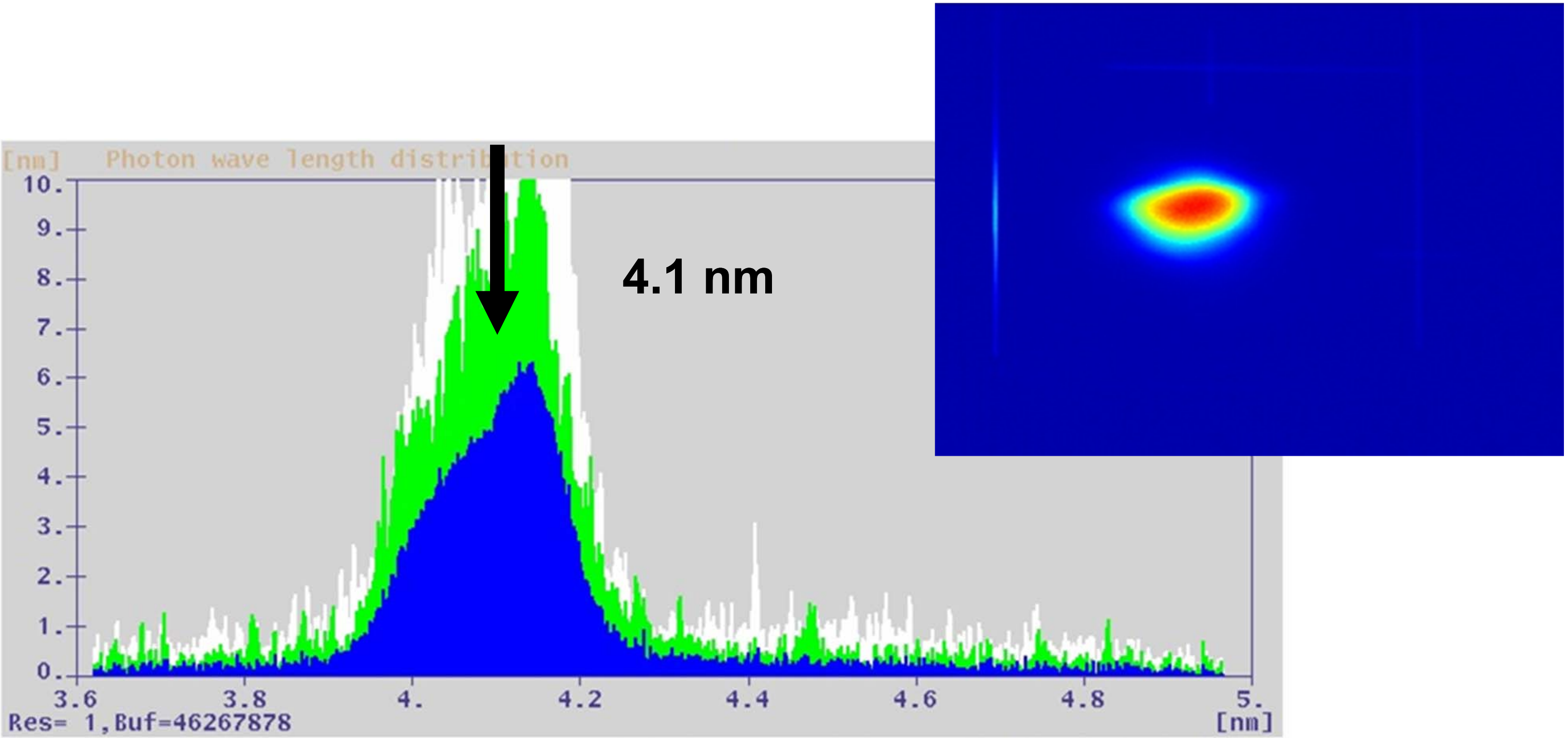
Der Plot für Experten: Das Spektrum eines FLASH-Blitzes bei 4,12 Nanometern Wellenlänge.



Nature photonics **1** (2007) 336

First Spectrum in the water window

> Wavelength 4.12 nm (fundamental)
> Single pulse energy ~130 µJ (max), ~70 µJ (av)



First Water Window Experiment

FLASH. Free-Electron Laser in Hamburg

- First proof of principle experiment in the water window at 4.3 nm
- In-house experiment (FLASH Crew with K. Tiedtke et al. and external partners (PTB, M Richter et al.)
- Direct double photo-ionization in the focused FEL beam (3-5 µm) at CO_2, ZrO_2 und O_2
- Ion-ToF Spectra and fluorescence detection
- Especially the decay channel of the fluorescence signal is interesting
- We showed, that we can transport the radiation to one beamline (BL2) (impossible with standard carbon coated mirrors)
- Good transmission ~45 % with two Ni-coated plane mirrors and a spherical multilayer mirror to focus the beam
- We saw nice ion- and fluorescence spectra at different targets, like 1s-oxygen (gas phase) and Al-oxide (solid)

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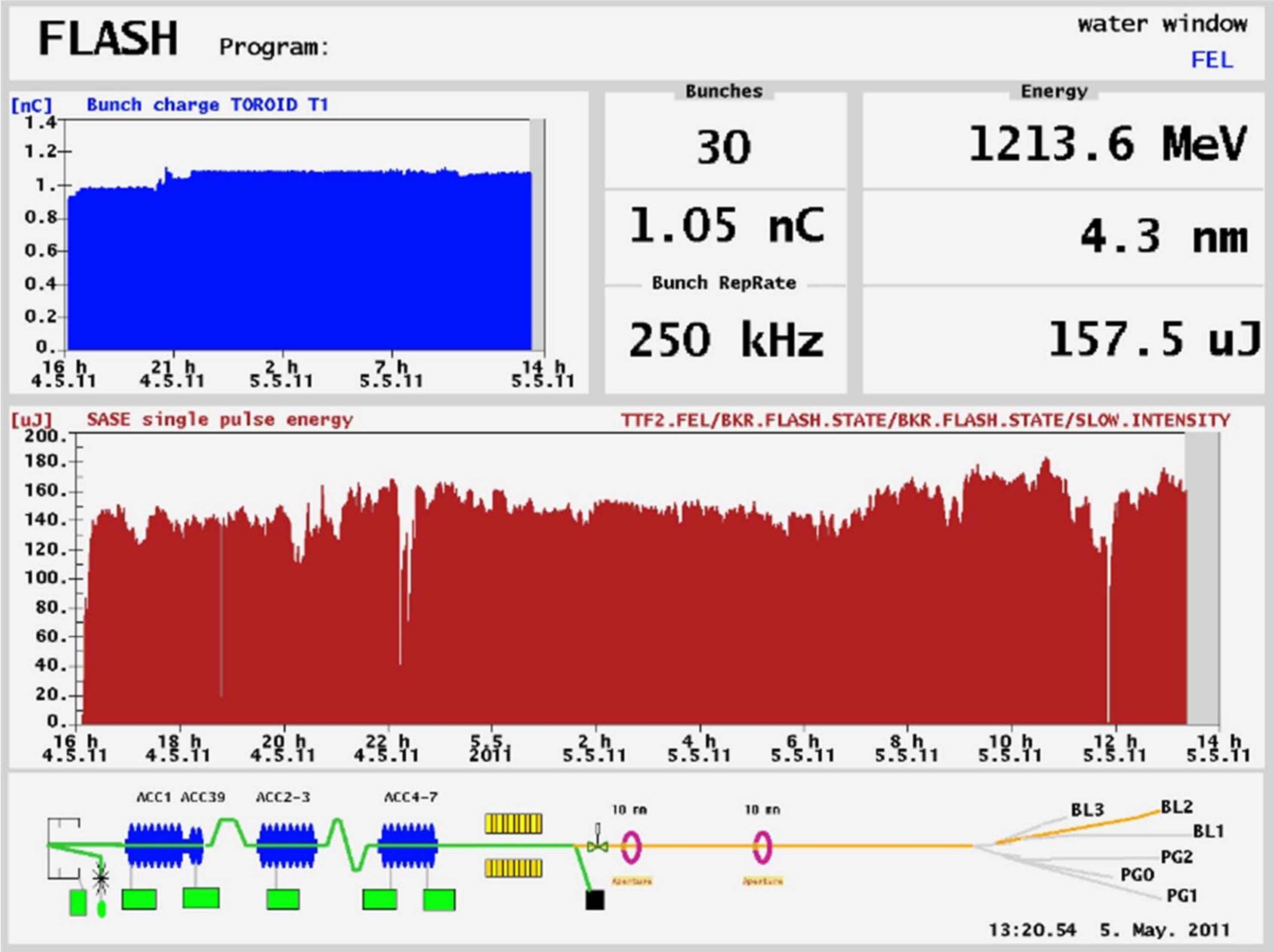
Performance during the WW Experiment

FLASH. Free-Electron Laser in Hamburg



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SASE Parameters for 4.3 nm

FLASH. Free-Electron Laser in Hamburg

Preliminary data for 4.3 nm:

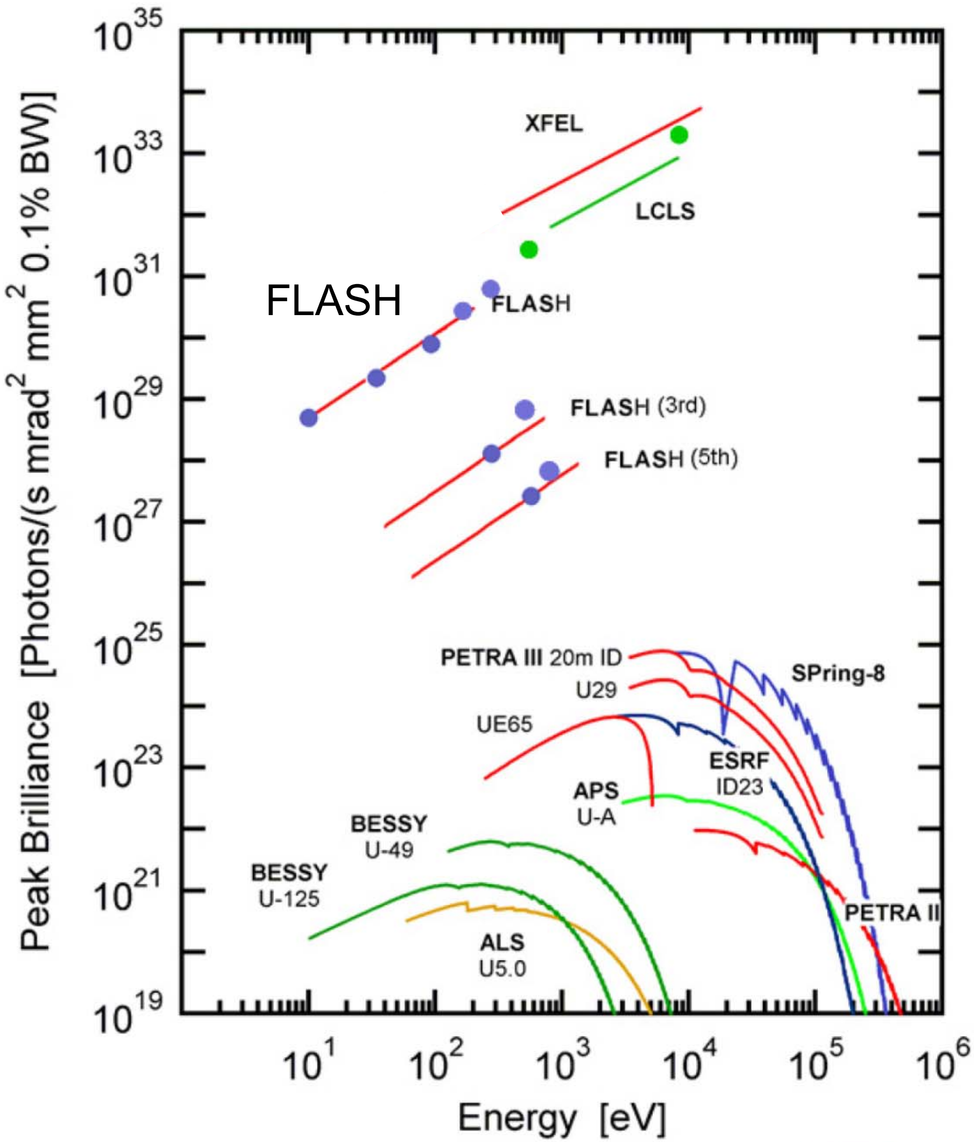
> Energy 160 µJ (av.)

> Peak power ~ 2 GW (estimate)

> bandwidth ~1 % fwhm

> Peak Brilliance

B ~ 10^{30} - 10^{31} photons/s/mrad²/mm²/0.1%bw



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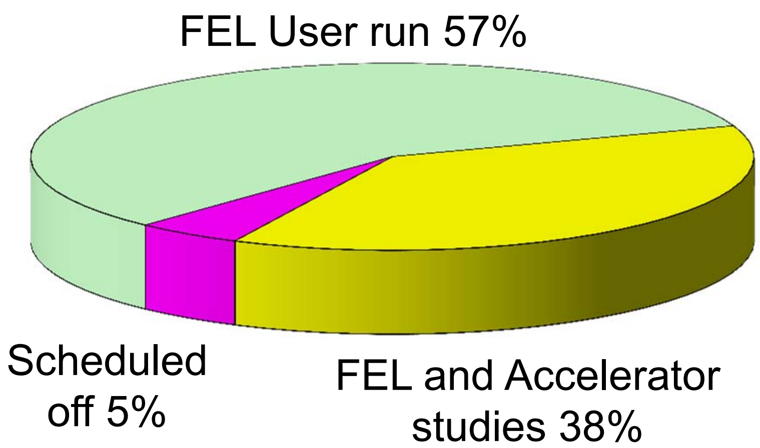
Lasing Performance 3rd User Period

Sep 2010 – Sep 2011

3rd User period

- Sep-2, 2010 – Sep-12, 2011
- 75 proposals reviewed, 29 proposals accepted
- 333 x 12 h-shifts are scheduled plus ~10 % for in-house experiments and contingency
  - 8 user blocks of ~ 4 weeks each



Requested Pulse Pattern	
Single bunch	47 %
multi-bunch with different bunch spacing	53 %

Requested FEL pulse duration		
	< 50 fs fwhh	28 %(*)
	50 -100 fs	54 %
	not critical, but high intensity	18 % (**)

(*) 72 % multi-bunch (**) mostly multi-bunch

	37	13.Sep - 19.Sep	1		
	38	20.Sep - 26.Sep	2	FEL studies	
	39	27.Sep - 3.Oct	3		preparation user run
	40	4.Oct - 10.Oct	1	User Run	
	41	11.Oct - 17.Oct	1		
	42	18.Oct - 24.Oct	1		
	43	25.Oct - 31.Oct	1		
	44	1.Nov - 7.Nov	2	FEL studies	
	45	8.Nov - 14.Nov	2		
	46	15.Nov - 21.Nov	3		preparation user run
	47	22.Nov - 28.Nov	1	User Run	
	48	29.Nov - 5.Dec	1		
	49	6.Dec - 12.Dec	1		
	50	13.Dec - 19.Dec	1		
	51	20.Dec - 26.Dec	5	Maintenance	
January	52	27.Dec - 2.Jan	5		
2011	1	3.Jan - 9.Jan	4		preparation accelerator studies
	2	10.Jan - 16.Jan	4	Accelerator studies	
	3	17.Jan - 23.Jan	4		
	4	24.Jan - 30.Jan	2	FEL studies	
	5	31.Jan - 6.Feb	2		
	6	7.Feb - 13.Feb	3		preparation user run
	7	14.Feb - 20.Feb	1	User Run	
	8	21.Feb - 27.Feb	1		
	9	28.Feb - 6.Mar	1		
	10	7.Mar - 13.Mar	1		
	11	14.Mar - 20.Mar	2	FEL studies	test personnel interlock
	12	21.Mar - 27.Mar	3		preparation user run
	13	28.Mar - 3.Apr	1	User Run	
	14	4.Apr - 10.Apr	1		
	15	11.Apr - 17.Apr	1		
	16	18.Apr - 24.Apr	1		
	17	25.Apr - 1.May	2	FEL studies	
	18	2.May - 8.May	2		
	19	9.May - 15.May	3		preparation user run
	20	16.May - 22.May	1	User Run	
	21	23.May - 29.May	1		
	22	30.May - 5.Jun	1		
	23	6.Jun - 12.Jun	1		
	24	13.Jun - 19.Jun	2	FEL studies	
	25	20.Jun - 26.Jun	3		preparation user run
	26	27.Jun - 3.Jul	1	User Run	
	27	4.Jul - 10.Jul	1		
	28	11.Jul - 17.Jul	1		
	29	18.Jul - 24.Jul	1		
	30	25.Jul - 31.Jul	2	FEL studies	
	31	1.Aug - 7.Aug	3		preparation user run
	32	8.Aug - 14.Aug	1	User Run	
	33	15.Aug - 21.Aug	1		
	34	22.Aug - 28.Aug	1		
	35	29.Aug - 4.Sep	1		
	36	5.Sep - 11.Sep	1		
	37	12.Sep - 18.Sep	6	FLASH II construction	shutdown starts 15-Sep

Other requested FEL parameters

FLASH. Free-Electron Laser in Hamburg

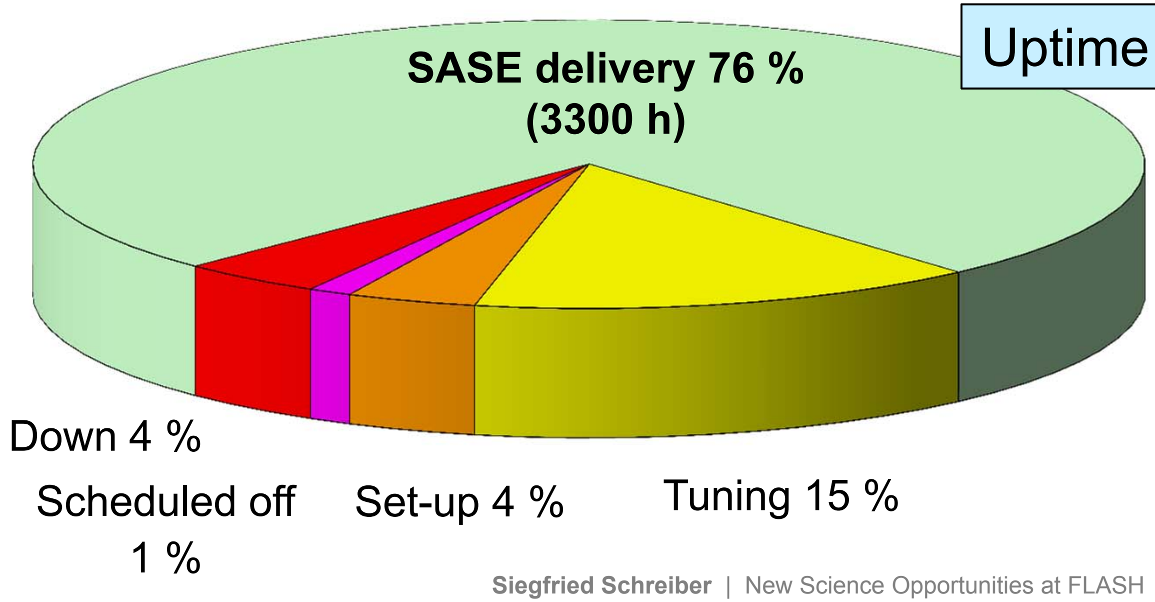
- More than 30 different wavelengths between 4.7 nm and 45 nm
  - Call did not include the water window
  - ~ 1/3 of accepted experiments requested < 10 nm
  - ~ 1/3 around 13.5 nm
  - ~ 1/3 > 20 nm
- Different train patterns (all 10 Hz)
  - single bunch
  - up to 100 bunches (50 kHz / 100 kHz / 200kHz / 250 kHz / 500 kHz/ 1 MHz)
  - 150 to 300 bunches (1 MHz)
- Small bandwidth < 1%
- Exact wavelength within the bandwidth
- With pump-probe laser (single pulse laser/multi-pulse laser)
- Split and delay unit, THz radiation
- …

Blocks 1 – 7 Sep 2010 – July 2011

FLASH.
Free-Electron Laser in Hamburg

- 3300 hours of SASE radiation delivered to experiments
  - 101 % of time when compared with originally scheduled beam time for users
  - Thus, we could manage to compensate tuning time, downtime using contingency, and partially in-house research time
- Usually, 2 experiments run in parallel at different beamlines
- Experiments and beam parameters are often changed once or twice per day, some users run extended blocks of several shifts

Uptime accelerator 96%



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Example of a user block schedule

FLASH. Free-Electron Laser in Hamburg

> Colors indicate different experiments

> The schedule is a delicate balance between beamline availability, pump-probe lasers, set-up time, probe changes, and many other constraints

May-June 2011 / Beamblock 6

last update: 25./26.5.'11 (parameter change Wernet, Moshammer & Wurth, distribution of Cont. and Inhouse res.)

L = optical pump-probe laser SD= Split and delay

Date	Day	*day shift (7:00-19:00)*	Wavelength	Parameters	BL	L	SD	*night shift (19:00 -7:00)*	Wavelength	Parameters	BL	L	SD
16.5.11	Mo	machine setup for users		13.7nm				inh. research - Düsterer	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L	
17.5.11	Tu	inh. research - Düsterer	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L		machine setup for users		change to 4.7 nm			
18.5.11	We	Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1			Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1		
19.5.11	Th	Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)		Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)	
20.5.11	Fr	Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1			Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1		
21.5.11	Sa	Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)		timeslot for inhouse research					
22.5.11	Su	Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)		Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)	
23.5.11	Mo	Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1			Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1		
24.5.11	Tu	Maintenance + machine startup						Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)	
25.5.11	We	Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)		Johnsson	13.7 nm ± 0.1 nm	30 bunches, 100kHz, <50fs	BL2	L/(THz)	
26.5.11	Th	machine setup for users		change to 4.7 nm				Senz / Meiwes-Broer	4.7 nm ± 0.1 nm	800b,1MHz,high int.,small bandw.	BL1		
27.5.11	Fr	Wernet	10.1 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L		Contingency (8h Wernet, 4h setup 8 nm)					
28.5.11	Sa	Vartaniants	8 nm ± 0.2 nm	single bunch, ~100fs	BL3			Vartaniants	8 nm ± 0.2 nm	single bunch, ~100fs	BL3		
29.5.11	Su	Wernet	10.1 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L		Wernet	10.1 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L	
30.5.11	Mo	Wernet	10.1 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L		Contingency (Wernet)					
31.5.11	Tu	Contingency						Wernet	21.9 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L	
1.6.11	We	Wernet	21.9 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L		machine setup for users (from 3p.m.!)		change to 44nm ± 1nm, 200b., 500 kHz, <50fs			
2.6.11	Th	Moshammer	44 nm ± 1 nm	100b., 250 kHz, <50fs	BL2		SD	Moshammer	44 nm ± 1 nm	100b., 250 kHz, <50fs	BL2		SD
3.6.11	Fr	Wernet	21.9 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L		Wernet	21.9 nm ± 0.2 nm	2 bunches, 100kHz, <=100fs	PG2	L	
4.6.11	Sa	Moshammer	44 nm ± 1 nm	100b., 250 kHz, <50fs	BL2		SD	Moshammer	44 nm ± 1 nm	100b., 250 kHz, <50fs	BL2		SD
5.6.11	Su	machine setup for users		change to 6nm ± 0.5nm, 200b., 500 kHz, <50fs				Moshammer (former timeslot for inhouse research)					
6.6.11	Mo	Moshammer	6 nm ± 0.5 nm	50b., 200 kHz, <50fs	BL2		SD	Moshammer	6 nm ± 0.5 nm	50b., 200 kHz, <50fs	BL2		SD
7.6.11	Tu	Contingency (setup for Vartaniants)						Vartaniants	8 nm ± 0.2 nm	single bunch, ~100fs	BL3	L	
8.6.11	We	Vartaniants	8 nm ± 0.2 nm	single bunch, ~100fs	BL3	L		Vartaniants	8 nm ± 0.2 nm	single bunch, ~100fs	BL3	L	
9.6.11	Th	machine setup for users		change to 6nm ± 0.5nm, >=40b., 100 kHz, <50fs				Moshammer	6 nm ± 0.5 nm	>=40b., 100 kHz, <50fs	BL2		SD
10.6.11	Fr	Moshammer	6 nm ± 0.5 nm	>=40b., 100 kHz, <50fs	BL2		SD	Contingency (Moshammer)					
11.6.11	Sa	Moshammer	6 nm ± 0.5 nm	>=40b., 100 kHz, <50fs	BL2		SD	Moshammer	6 nm ± 0.5 nm	>=40b., 100 kHz, <50fs	BL2		SD
12.6.11	Su	machine setup for users		change to 6.5 nm ± 0.1nm, 30 b., 500kHz, <50fs				Wurth	6.5 nm ± 0.1 nm	30b., 500 kHz, <50fs	PG2	L	
13.6.11	Mo	Wurth	6.5 nm ± 0.1 nm	30b., 500 kHz, <50fs	PG2	L		Wurth	6.5 nm ± 0.1 nm	30b., 500 kHz, <50fs	PG2	L	

…. you are not supposed to read the details

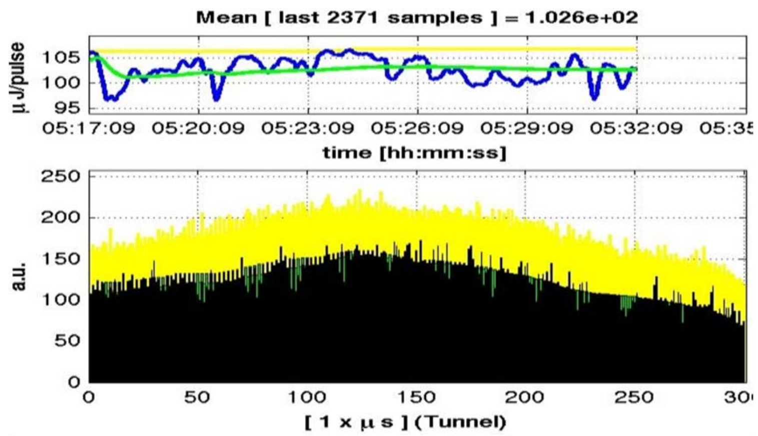
DESY

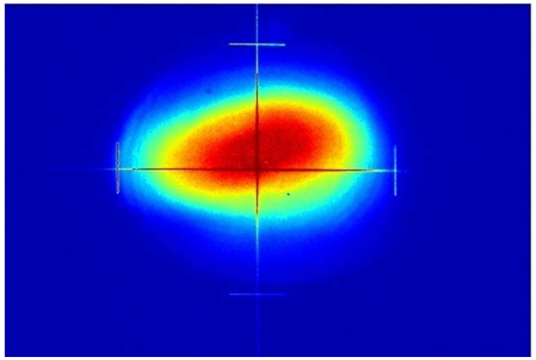
FLASH Parameters 2011

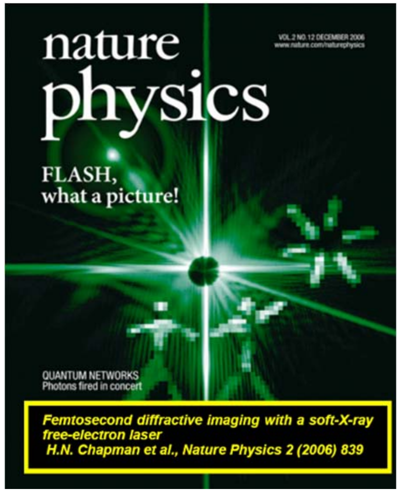
FLASH. Free-Electron Laser in Hamburg

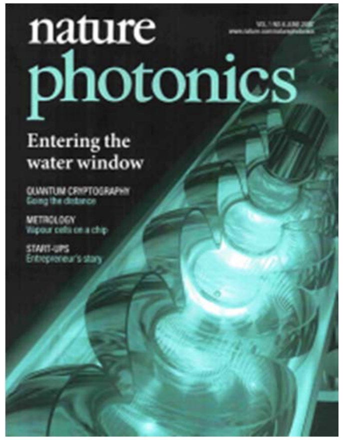
FEL Radiation Parameters 2011	
Wavelength range (fundamental)	4.1 – 45 nm
Average single pulse energy	10 – 400 µJ
Pulse duration (FWHM)	50 – 200 fs
Peak power (from av.)	1 – 3 GW
Average power (example for 3000 pulses/sec)	~ 300 mW
Spectral width (FWHM)	~ 0.7 - 2 %
Average Brilliance	$10^{17} – 10^{21}$ *
Peak Brilliance	$10^{29} – 10^{31}$ *

* photons/s/mrad^2/mm^2/0.1%bw







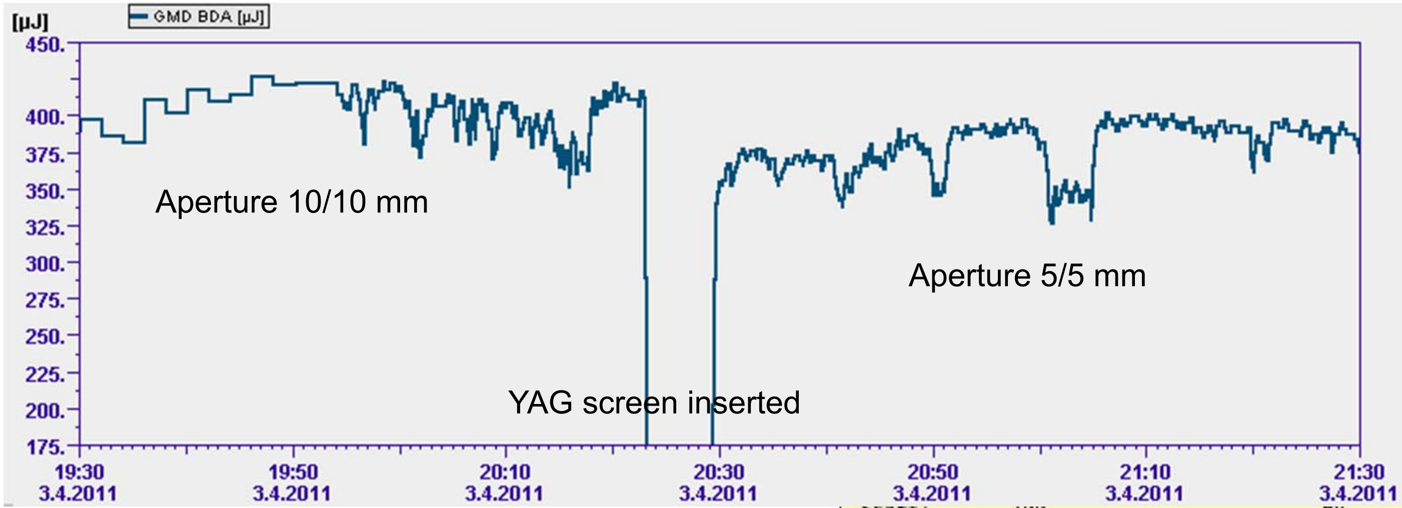


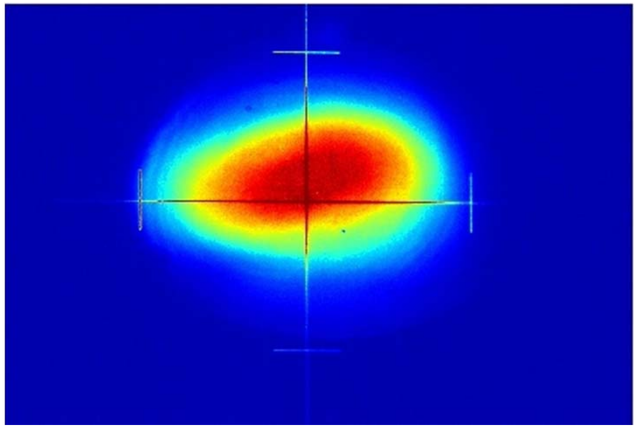
> 150 publications on photon science at FLASH, many in high impact journals

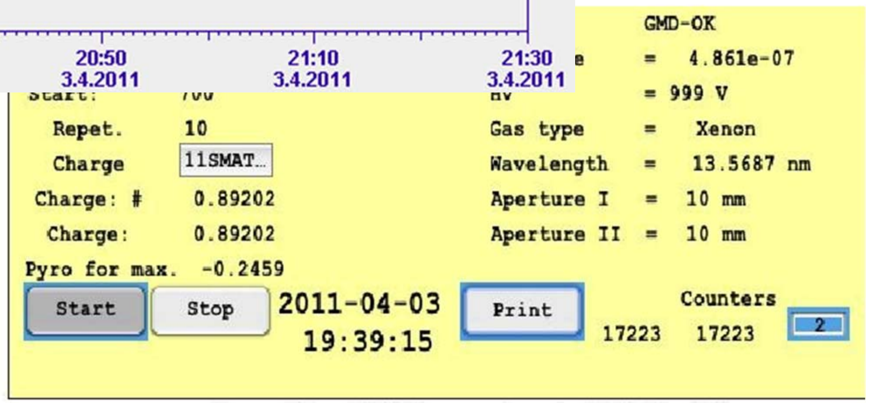
- http://hasylab.desy.de/facilities/flash/publications/selected_publications

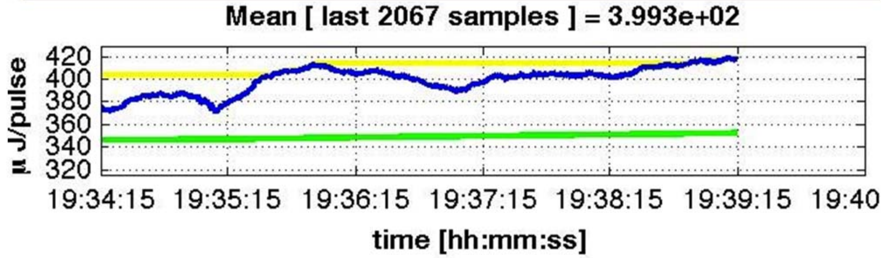
> 400 µJ, single bunch 13.5 nm, ~ 0.9 nC

FLASH.
Free-Electron Laser in Hamburg



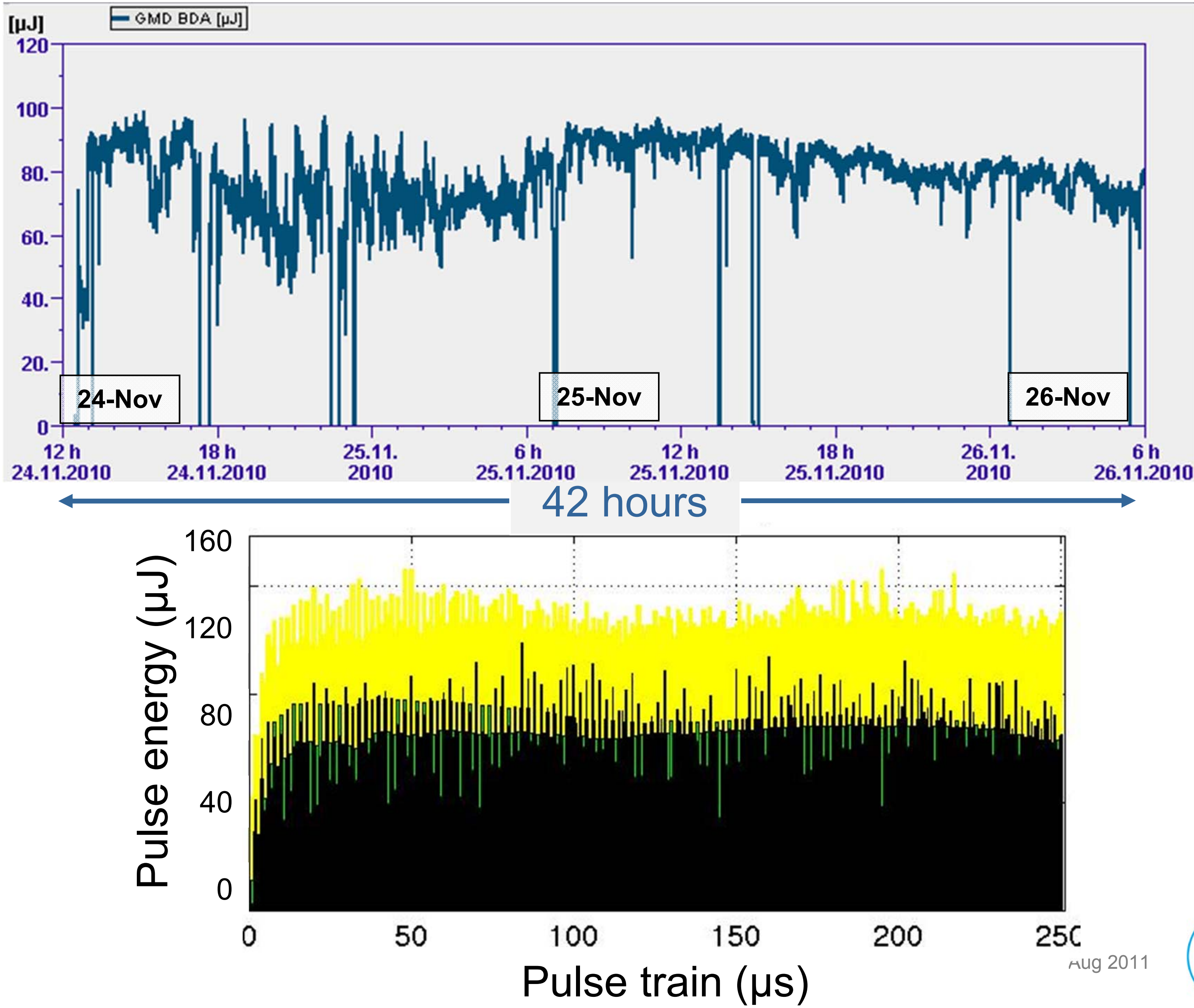






4.8 nm, 250 pulses/train, 1 MHz

FLASH.
Free-Electron Laser in Hamburg



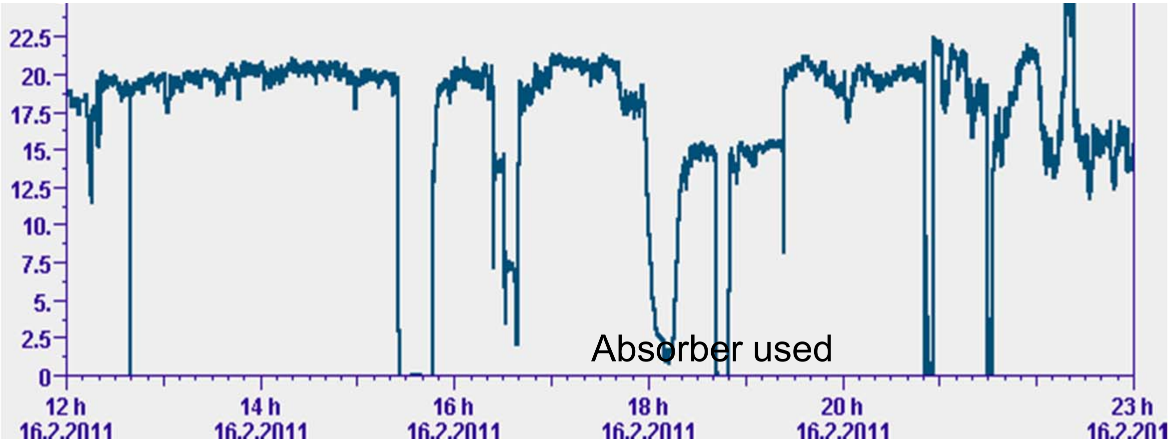
DESY

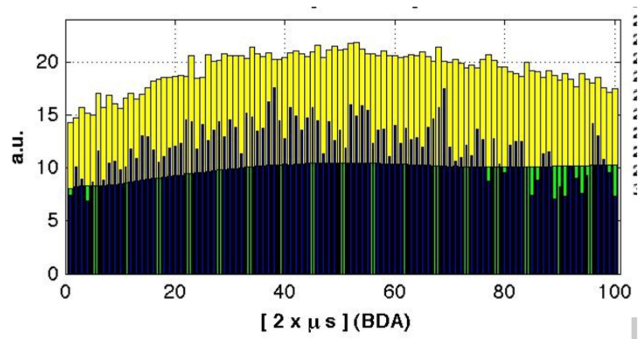
Very small charge / multi-bunch examples

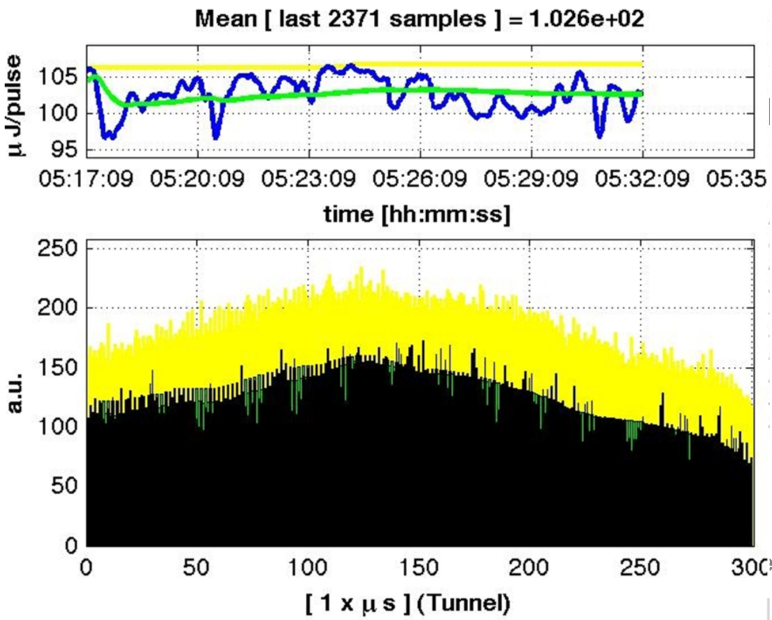
FLASH.
Free-Electron Laser in Hamburg

> SASE with small charge 120 pC for short pulses

> 20.3 nm, 100 bunches / 500 kHz







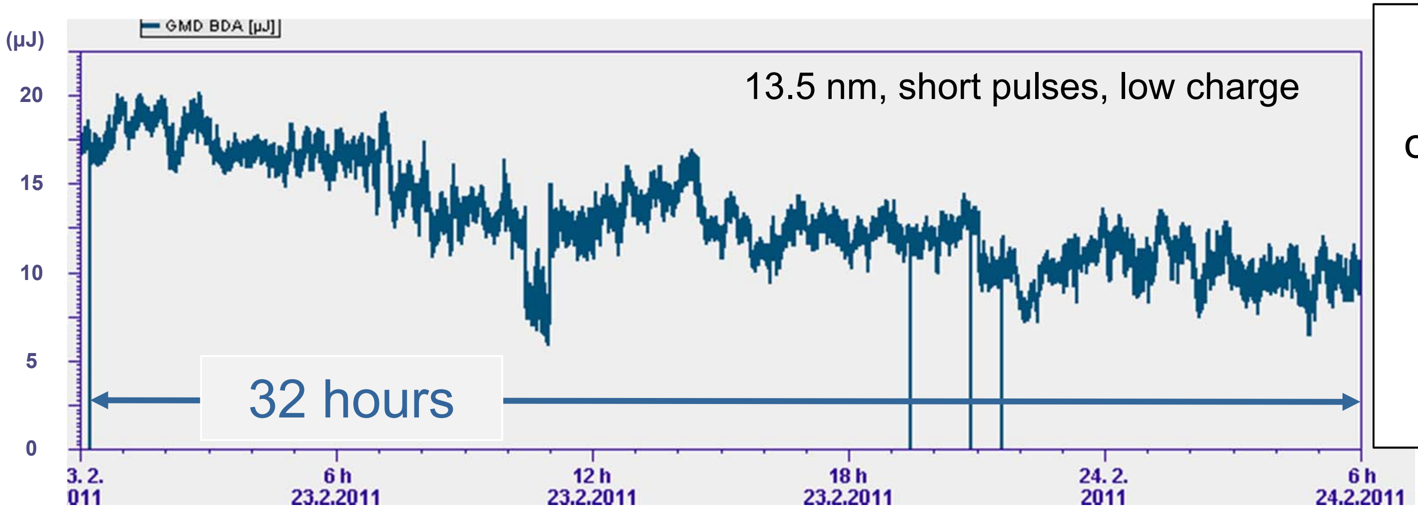
> 6.9 nm, 300 bunches, 1 MHz

New record for FLASH:

Average power exceeds 300 mW

Pump-probe experiment + arrival time stabilization

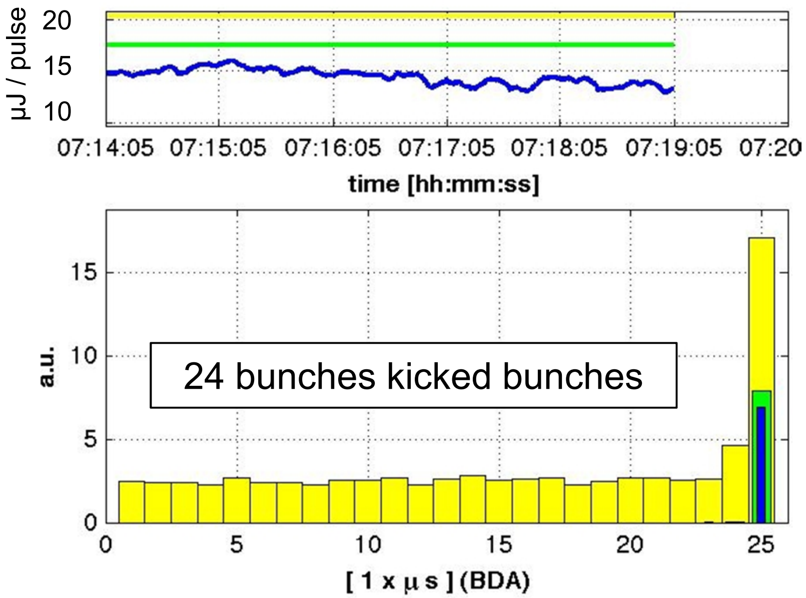
FLASH. Free-Electron Laser in Hamburg

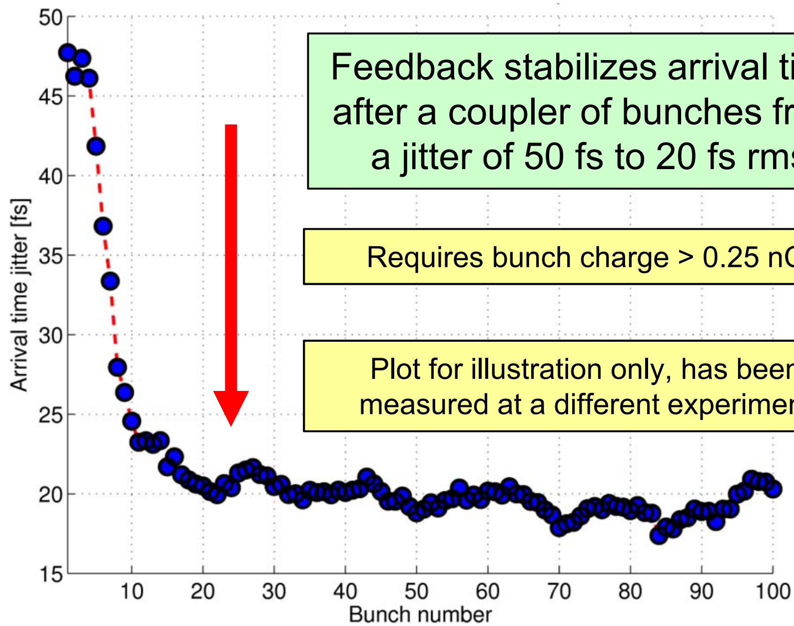


Orbit of 24 bunches kicked,
only 25th lasing lasing,
quick set-up time

arrival time feedback running

Stable over days





Feedback stabilizes arrival time after a coupler of bunches from a jitter of 50 fs to 20 fs rms

Requires bunch charge > 0.25 nC

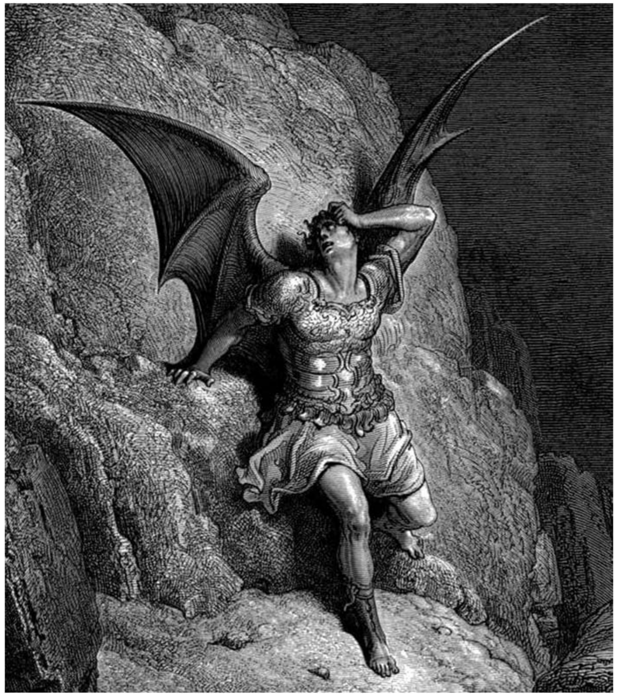
Plot for illustration only, has been measured at a different experiment

Summary Blocks 1 – 7 Sep 2010 – July 2011

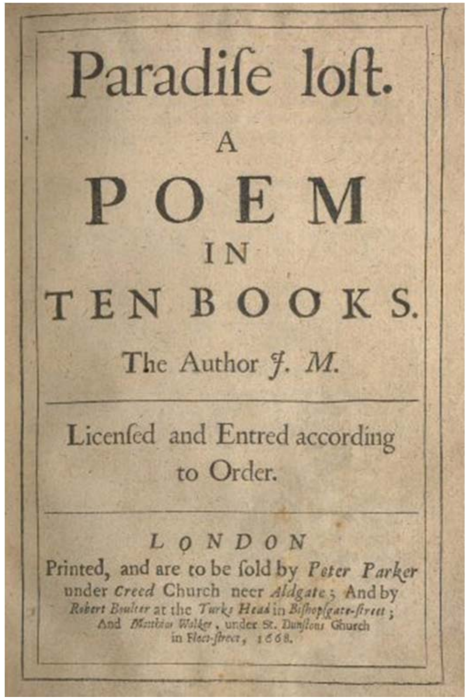
FLASH.
Free-Electron Laser in Hamburg

- Block 1 - 7 was a great success and shows, that FLASH is able to deliver with high reliability (uptime 96 %) SASE radiation in the EUV and soft X-ray reaching the water window
- This is thanks to the enormous effort of the DESY machine division keeping FLASH alive 24/7 and the FS group taking care of the successful experimental runs
- The down time reduction to a low 4 % is due to regular maintenance and also due to the ongoing R&D efforts of key technologies keeping the FLASH hardware up to date – like RF-stations, LLRF, and others
- Not everything is perfect though, many issue still need to be addressed and are being developed – many of them together with users
- One example is the need for a reliable operation with very short pulses (<50 fs fwhh) together with many pulse per trains and at the same time synchronization to the pulse length level

Block 8



Satan, as drawn by Gustave Doré, in John Milton's Paradise Lost.



Paradise loſt.
A
POEM
IN
TEN BOOKS.
The Author J. M.

Licenſed and Entred according to Order.

LONDON
Printed, and are to be ſold by Peter Parker under Creed Church neer Aldgate; And by Robert Boulter at the Turks Head in Biſhopſgate-ſtreet; And Matthias Walker, under St. Dunſtons Church in Fleet-ſtreet, 1668.

Paradise Lost is an epic poem by the 17th-century English poet John Milton.

Block 8 (8 Aug 2011 – 12 Sep 2011)

FLASH.
Free-Electron Laser in Hamburg

- The first 11 days of 36 w/o any problem
  - SASE 83%, down 2 %
- Problems started with week 33 and continued worse in 34 and 35
  - Tuning issues (not understood): 30 h lost
  - Pressured air leak: 3 h lost
  - Oil-leak RF-3: 3 h lost
  - Cryogenics down (network): 10 h lost
  - External work forced cooling water loss: 2 h lost
  - Modulator RF-4: 2 h lost
  - Hot and humid air condition in annex RF-building: 4.5 h lost
  - External work forced interlock cables:14 h lost
  - Flow sensor RF gun: 4 h lost
  - Broken RF/window RF-gun (2-Sep 22:00 h): operation stopped
- In total 122.5 h lost in 3 weeks! This is 24 % downtime!

DESY

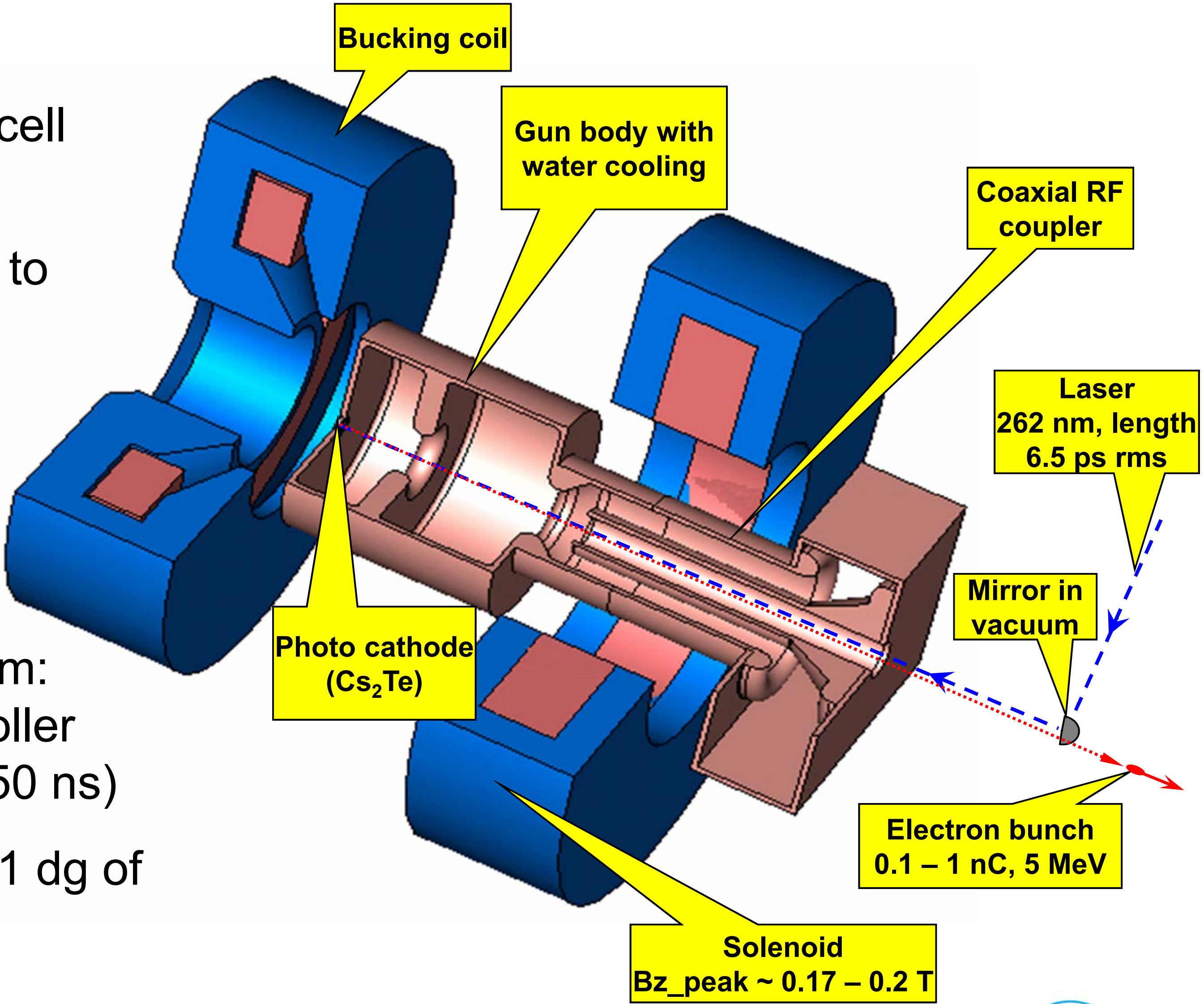
Block 8 lost beamtime will be compensatd

FLASH. Free-Electron Laser in Hamburg

- > Operating a broken RF window at the RF-gun is an unacceptable risk for the superconducting accelerator
- > Therefore, I had to cancel the remaining block Mo 5-Sep-2011
- > Substantial amount of beam time has been lost
- > Lost beam time will be compensated spring 2012

RF Gun

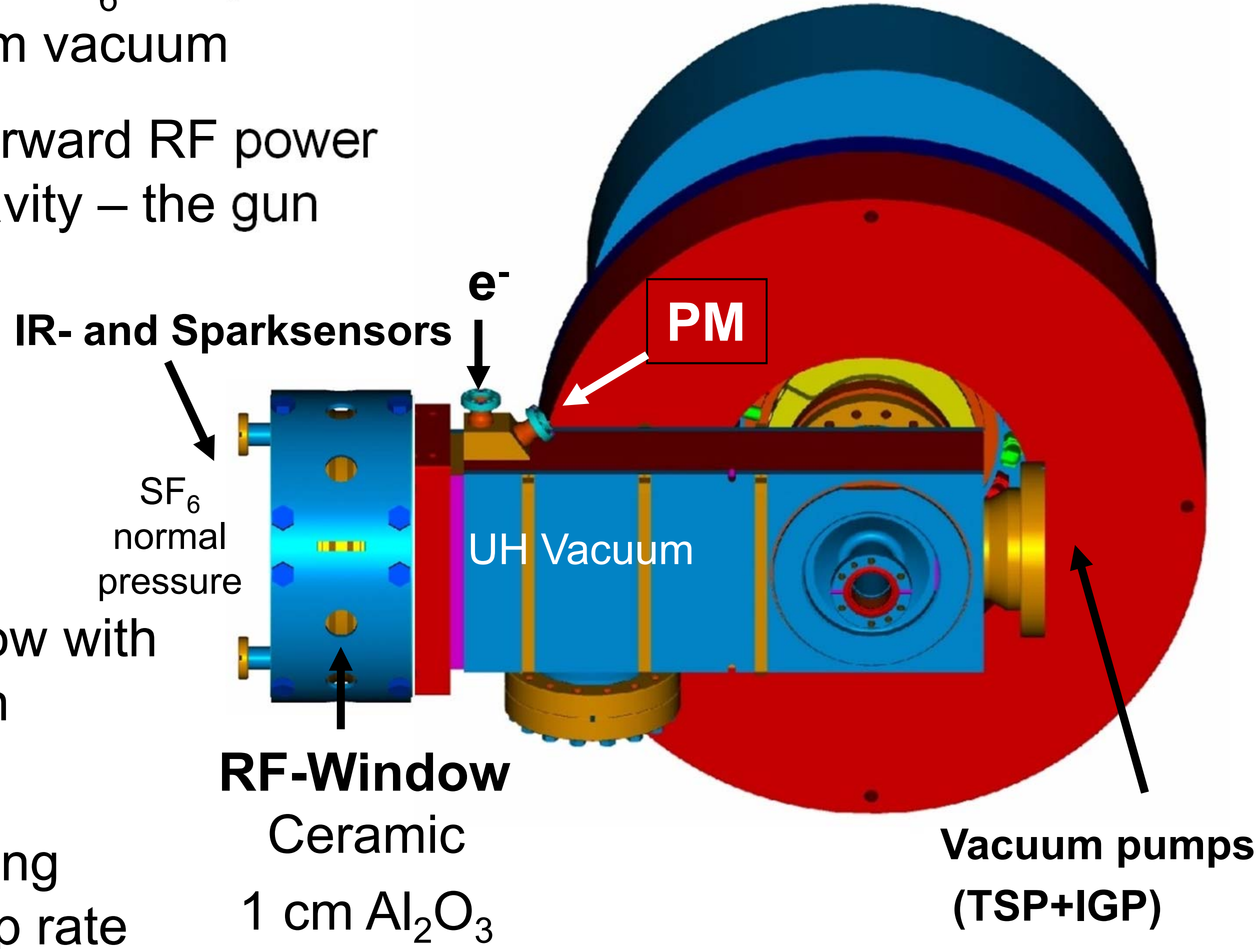
- RF gun: 1.3 GHz copper cavity, 1 ½ cell
- RF power 4 MW, RF pulse length up to 850 μs, 10 Hz
- Gun tested and commissioned at PITZ (DESY-Zeuthen)
- Low level RF system: FPGA based controller with low latency (150 ns)
- Phase stability < 0.1 dg of 1.3 GHz



RF-Gun Coupler Design

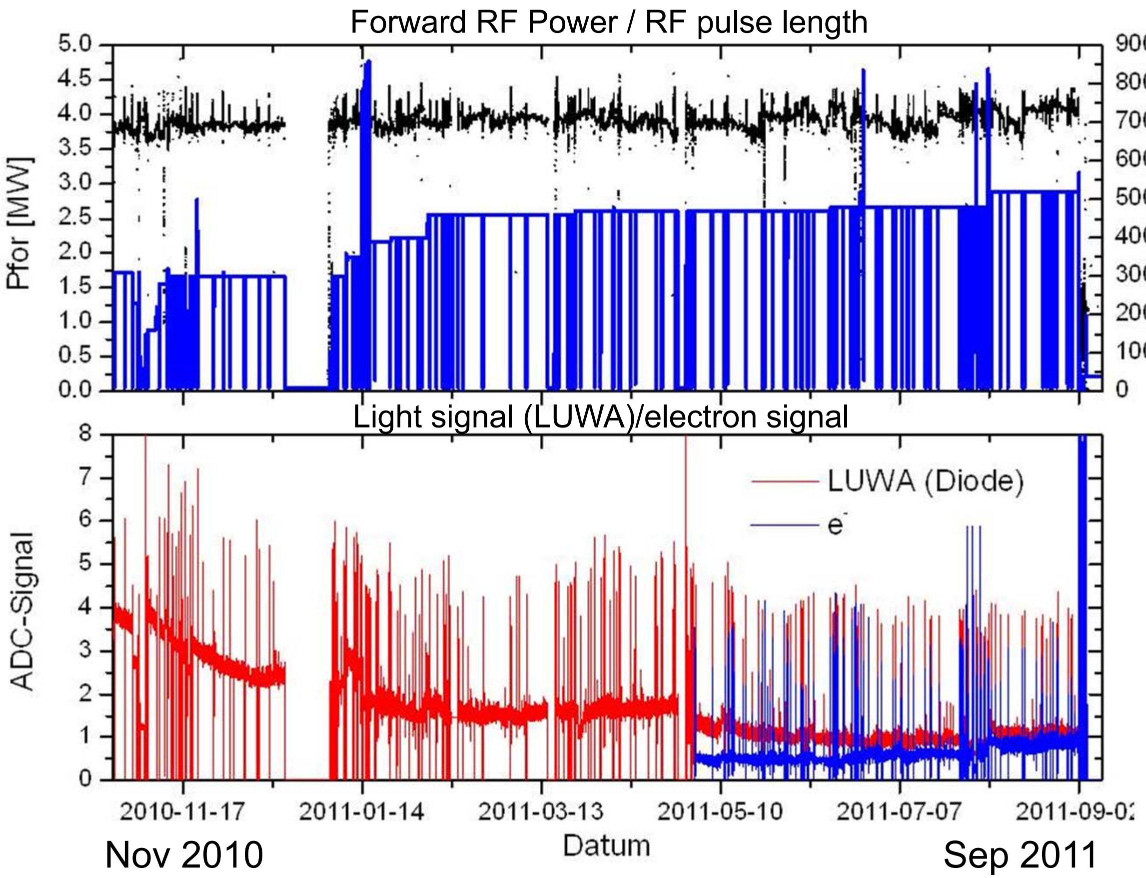
- RF-Window separates SF_6 filled waveguides with beam vacuum
- Has to stand 4 MW forward RF power to a standing wave cavity – the gun
- After installation in 2010 unacceptable high trip rate from RF window
- June 2010: New window with large light and electron signals at ceramics
- But: RF-gun was running stable with very low trip rate
- RF pulse length 500 µs reached slowly

RF-Gun with solenoids



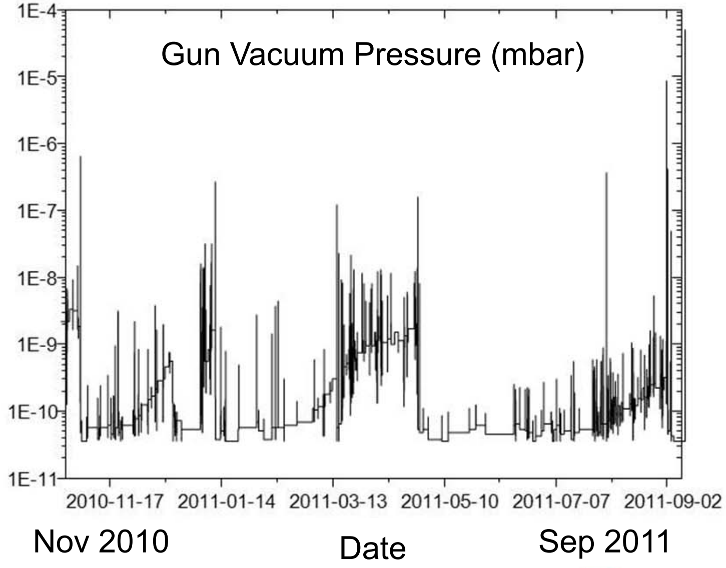
The window seamed to improve over the year

FLASH.
Free-Electron Laser in Hamburg



> RF pulse length increased slowly to 500 µs

> Vacuum pressure finally very good $< 10^{-10}$ mbar



> Slow but steady decrease of light measured at the window

> Slight increase of electron signals

DESY

Reduction of multipactoring

FLASH.
Free-Electron Laser in Hamburg

> TiN coating on Al_2O_3 ceramics reduces the secondary electron emission yield
> Thick coating gives effective suppression
> But also is a risk of break down due to RF losses

Failure of window most likely due to issues with the coating

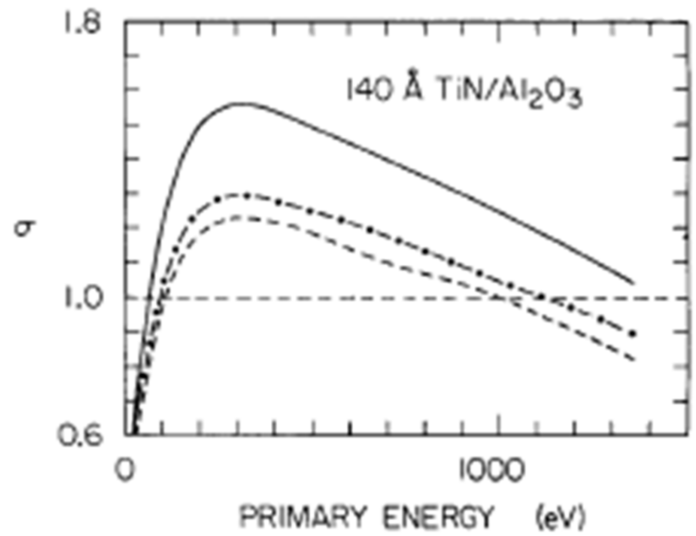


FIG. 1. Total SEE yield, 140 Å TiN on alumina: (---) after deposition, air exposure, and bake at 550° *in vacuo* for 10 h; (—) subsequently exposed to ambient atmosphere for 1 h; (–··–) followed by electron bombardment of 3×10^{17} electrons/cm^2.

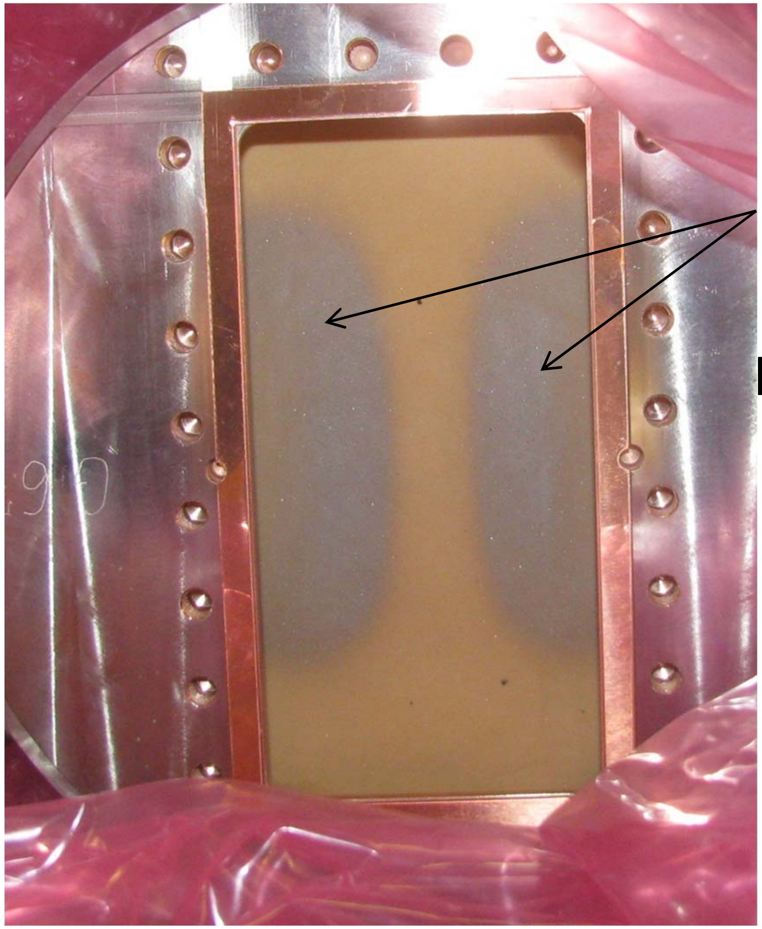
A. R. Nyaiesh, E. L. Garwin, F. K. King, and R. E. Kirby, J. Vac. Sci. Technol. A **4** (5), 1986

DESY

RF-Window after dismounting

FLASH.
Free-Electron Laser in Hamburg

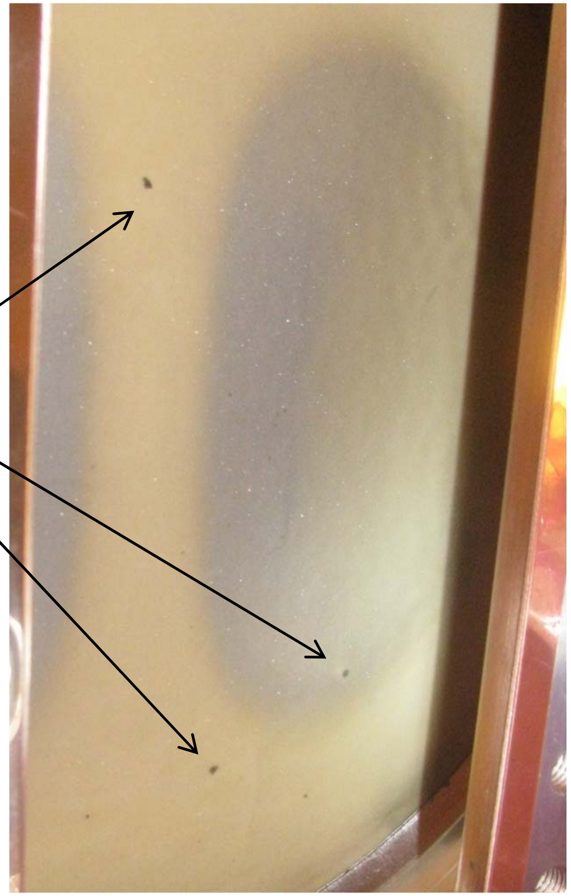
Vacuum side



Pattern which indicates the high field region (dipole field)

Many particles/dark spots visible

Dark area most likley metallization which is a definite risk of operation



DESY

Window replaced

FLASH.
Free-Electron Laser in Hamburg

> New window installed within a week – fast enough to preform initial RF tests before shutdown

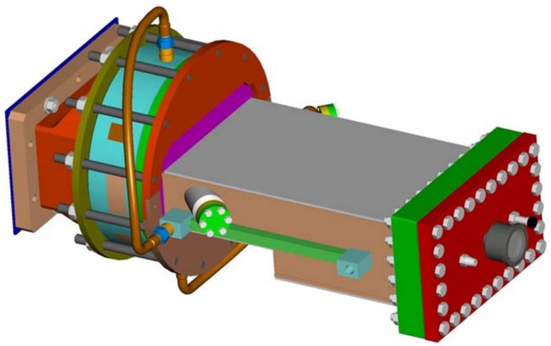
> Very good impression during conditioning – normal behaviour

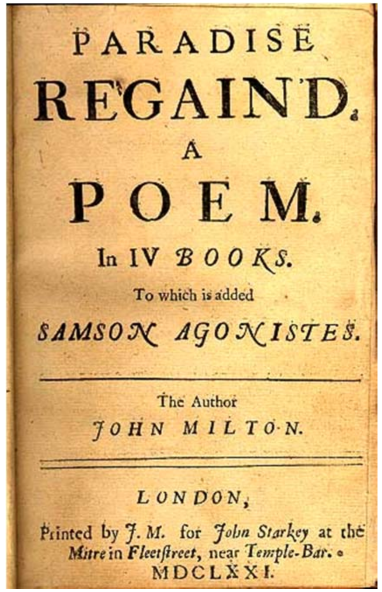
> 4 MW reached with short 30 µs RF pulses after 3 hours only (10 Hz)

> 4 MW with 200 µs without problems – until we had to stop

> We foresee still some conditioning time in January, but we expect to have 800 µs back for users

> In parallel (since last year): RF-window development with Thales Electron Devices S.A. with the aim to achieve of 8 MW of RF power (75 kW av.) avoiding SF_6





PARADISE
REGAIN'D.
A
POEM.
In IV BOOKS.
To which is added
SAMSON AGONISTES.

The Author
JOHN MILTON.

LONDON,
Printed by J. M. for John Starkey at the Mitre in Fleetstreet, near Temple-Bar.
MDCLXXI.

DESY

Schedule 2012/13

Time Schedule 2012

FLASH. Free-Electron Laser in Hamburg

- > Shutdown autumn 2011 due to work on FLASH2 buildings close to the FLASH tunnel which requires removal of radiation shielding
- > Restart 2-Jan-2012 with commissioning and accelerator studies
- > Compensation of lost beamtime 3rd period, tentative start: 19-Mar-2012
- > 4th user period with 3000 hours of user beam time scheduled (250 12-h shifts)
- > Start (tentative): 7-May-2012
  - Users: 63%
  - FEL related machine studies: 19%
  - User experiment preparation: 13%
  - General accelerator Studies: 6%

Tentative Schedule 2012

FLASH.
Free-Electron Laser in Hamburg

January	52	26.Dec - 1.Jan	6				expert assessment shielding	
2012	1	2.Jan - 8.Jan	7	FLASH commissioning			Survey/Magnet Tests/Gun conditioning	
	2	9.Jan - 15.Jan	7				Gun RF window conditioning	
	3	16.Jan - 22.Jan	7					
	4	23.Jan - 29.Jan	7					
	5	30.Jan - 5.Feb	4	Accelerator studies				
	6	6.Feb - 12.Feb	4					
	7	13.Feb - 19.Feb	4					
	8	20.Feb - 26.Feb	2	FEL studies				
	9	27.Feb - 4.Mar	2					
	10	5.Mar - 11.Mar	2					sum user shifts
	11	12.Mar - 18.Mar	3		preparation user run		Interlock test latest 17-Mar-2011	0
	12	19.Mar - 25.Mar	1	User Run			Reload 3rd period	13
	13	26.Mar - 1.Apr	1					26
	14	2.Apr - 8.Apr	1					39
	15	9.Apr - 15.Apr	2	FEL studies				
	16	16.Apr - 22.Apr	2					
	17	23.Apr - 29.Apr	3		preparation user run			sum user shifts
	18	30.Apr - 6.May	3					0
	19	7.May - 13.May	1	User Run			Start 4th User Period	13
	20	14.May - 20.May	1					25
	21	21.May - 27.May	1			IPAC New Orleans		38
	22	28.May - 3.Jun	1					50
	23	4.Jun - 10.Jun	2	FEL studies				50
	24	11.Jun - 17.Jun	3		preparation user run			50
	25	18.Jun - 24.Jun	1	User Run		school holidays HH		63
	26	25.Jun - 1.Jul	1			school holidays HH/SH		75
	27	2.Jul - 8.Jul	1			school holidays HH/SH		88
	28	9.Jul - 15.Jul	1			school holidays HH/SH		100
	29	16.Jul - 22.Jul	2	FEL studies		school holidays HH/SH		100
	30	23.Jul - 29.Jul	2			school holidays HH/SH		100
	31	30.Jul - 5.Aug	2			school holidays HH/SH		100
	32	6.Aug - 12.Aug	3		preparation user run			100
	33	13.Aug - 19.Aug	1	User Run				113
	34	20.Aug - 26.Aug	1					125
	35	27.Aug - 2.Sep	1			FEL Nara		138
	36	3.Sep - 9.Sep	1					150
	37	10.Sep - 16.Sep	4	Accelerator studies				150
	38	17.Sep - 23.Sep	4					150
	39	24.Sep - 30.Sep	2	FEL studies				150
	40	1.Oct - 7.Oct	3		preparation user run			150
	41	8.Oct - 14.Oct	1	User Run				163
	42	15.Oct - 21.Oct	1					175
	43	22.Oct - 28.Oct	1					188
	44	29.Oct - 4.Nov	1					200
	45	5.Nov - 11.Nov	2	FEL studies				200
	46	12.Nov - 18.Nov	3		preparation user run			200
	47	19.Nov - 25.Nov	1	User Run				213
	48	26.Nov - 2.Dec	1					225
	49	3.Dec - 9.Dec	1					238
	50	10.Dec - 16.Dec	1				End 4th User Period	250
	51	17.Dec - 23.Dec	6	Start Shudown 20-Dec-2012				250
	52	24.Dec - 30.Dec	6					250
January	1	31.Dec - 6.Jan	6					250

Time Schedule 2013

FLASH.
Free-Electron Laser in Hamburg

- Next Shutdown: Jan to Mar 2013 to connect FLASH with FLASH2 beamline
- May – Dec 2013:
  Tentative 5th user period with another 3000 hours of user beam time, this time in parallel to FLASH 2 commissioning
- Schedule risk:
  - Construction work progress of FLASH II project

DESY

Tentative Schedule 2013

FLASH.
Free-Electron Laser in Hamburg

January	1	31.Dec - 6.Jan	6					250
2013	2	7.Jan - 13.Jan	6					250
	3	14.Jan - 20.Jan	6					250
	4	21.Jan - 27.Jan	6	Connection to FLASH II				250
	5	28.Jan - 3.Feb	6					250
	6	4.Feb - 10.Feb	6					250
	7	11.Feb - 17.Feb	6					250
	8	18.Feb - 24.Feb	6					250
	9	25.Feb - 3.Mar	6					250
	10	4.Mar - 10.Mar	6					250
	11	11.Mar - 17.Mar	6					250
	12	18.Mar - 24.Mar	6					250
	13	25.Mar - 31.Mar	6					250
	14	1.Apr - 7.Apr	7	Commissioning			F2 commissioning starts	250
	15	8.Apr - 14.Apr	7					250
	16	15.Apr - 21.Apr	7					250
	17	22.Apr - 28.Apr	7					250
	18	29.Apr - 5.May	2	FEL studies			Start 5th User Period	sum user shifts
	19	6.May - 12.May	3		preparation user run			0
	20	13.May - 19.May	1	User Run				13
	21	20.May - 26.May	1					25
	22	27.May - 2.Jun	1					38
	23	3.Jun - 9.Jun	1					50
	24	10.Jun - 16.Jun	4	Accelerator studies				50
	25	17.Jun - 23.Jun	4					50
	26	24.Jun - 30.Jun	2	FEL studies		school holidays HH/SW		50
	27	1.Jul - 7.Jul	3		preparation user run	school holidays HH/SW		50
	28	8.Jul - 14.Jul	1	User Run		school holidays HH/SW		63
	29	15.Jul - 21.Jul	1			school holidays HH/SW		75
	30	22.Jul - 28.Jul	1			school holidays HH/SW		88
	31	29.Jul - 4.Aug	1			school holidays HH/SW		100
	32	5.Aug - 11.Aug	2	FEL studies				100
	33	12.Aug - 18.Aug	3		preparation user run			100
	34	19.Aug - 25.Aug	1	User Run				113
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	48	25.Nov - 1.Dec	1	User Run				213
	49	2.Dec - 8.Dec	1					225
	50	9.Dec - 15.Dec	1					238
	51	16.Dec - 22.Dec	1				End 5th User Period	250
	52	23.Dec - 29.Dec	5	Maintenance				250

Short FEL pulses

FLASH. Free-Electron Laser in Hamburg

- To reliably provide very short (<50 fs fwhh) FEL pulses for experiments we need to measure and monitor the photon pulse length with an appropriate resolution
- Experiments to compare different techniques have been and will be performed
- The electron bunch length is measured with LOLA and is also estimated using coherent radiation from electron bunches
- Many methods to measure FEL pulse duration is being used and tested

Details next talk by Torsten Limberg

- Proposed by the Beam Time Allocation Committee
  Friday 14-Oct-2011
  15:30 h 25f/456
  Satellite meeting "FEL pulse duration"

Summary and Outlook

FLASH. Free-Electron Laser in Hamburg

- Energy upgrade to 1.25 GeV
- First lasing in the water window with the fundamental
  - 25-Sep-2010: wavelength 4.12 nm, ~130 µJ (max), ~70 µJ (av)
- 3rd user period
  Sep. 2010 – Sep. 2011 with a scheduled 4992 hours (416 shifts) of beamtime
- Excellent SASE performance
  - Single photon pulse energies of up to 400 µJ
  - Phase space linearization with 3rd harmonic works excellent
- Providing reliable very short pulses an issue
- Block 8 (after day 11) a failure, beam time will be compensated
  - RF gun window replaced, promising conditioning towards nominal performance
- FLASH II construction has started
- 4th user period with 3000 h of beamtime scheduled for 2012
  - 5th user period expected with another 3000 hours in 2013

DESY