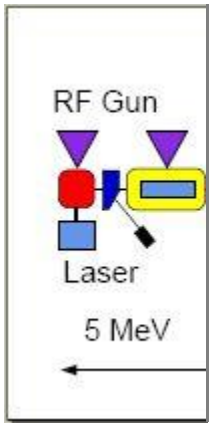
FLASH Operation at DESY

From a Test Accelerator to a User Facility



Michael Bieler
FLASH Operation at DESY
WAO2012, SLAC, Aug. 8, 2012

HELMHOLTZ ASSOCIATION

DESY

Vocabulary

DESY: **D**eutsches **E**lektronen-**Sy**nchrotron, Hamburg, Germany

TTF: **T**ESLA **T**est **F**acility

TESLA: **T**eV **E**nergy **S**uperconducting **L**inear **A**ccelerator

FLASH: **F**ree Electron **Las**er in **H**amburg

Content

The History of FLASH

1994: The **TESLA** project requires superconducting rf cavities for a TeV-scale linear collider.
TESLA **T**est **F**acility: A 500 MeV testbed for TESLA.

1997: **TTF** reaches 16.7 MeV/m with superconducting cavities

1998: **TTF** tunnel extended, first undulators in the tunnel

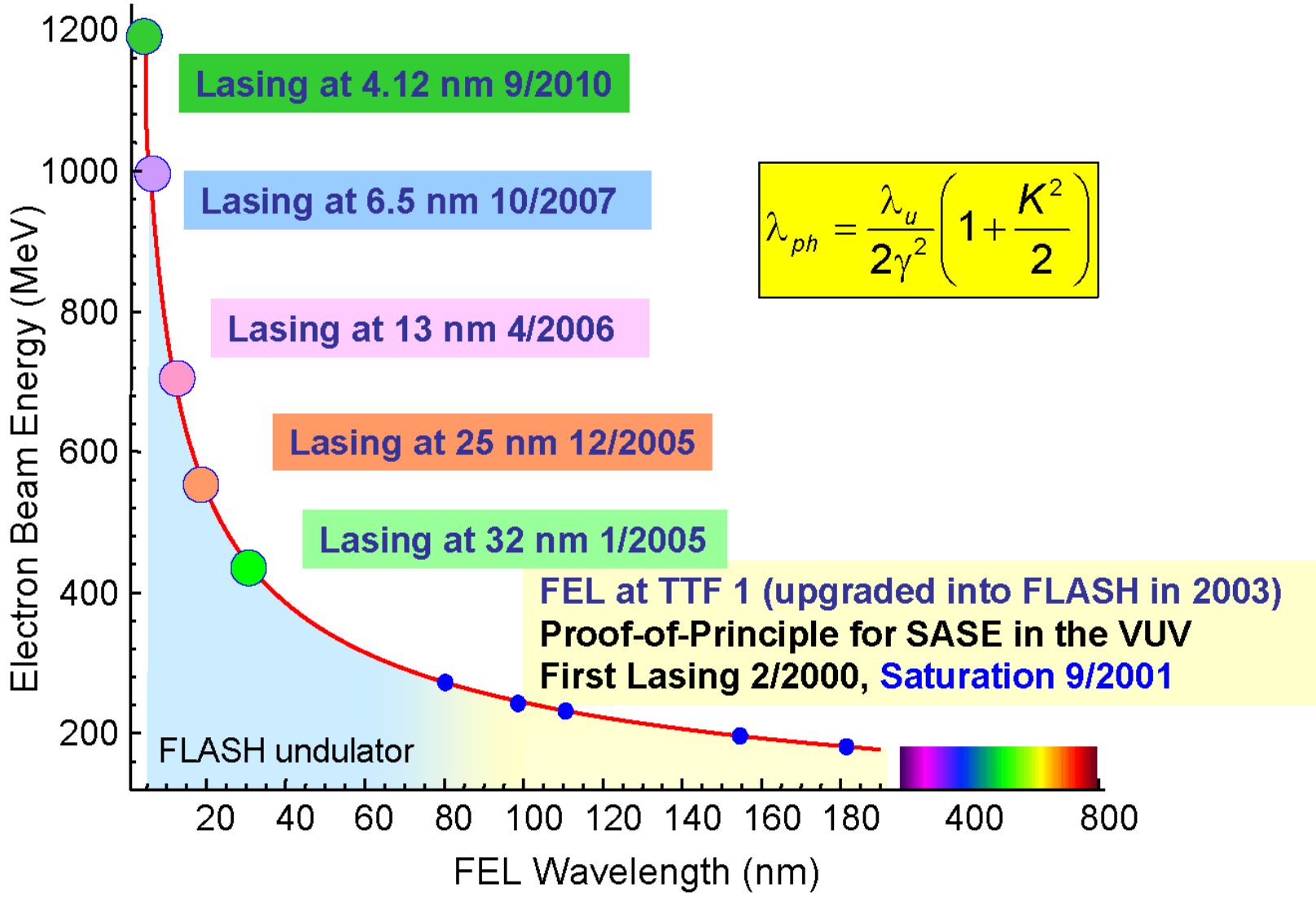
2000: First lasing @110 nm

2003: Extension from 100 m to 260 m, TTF becomes **FLASH**

2005: **FLASH** becomes a user facility, lasing at 25 nm

A test facility becomes a user facility.

The History of FLASH

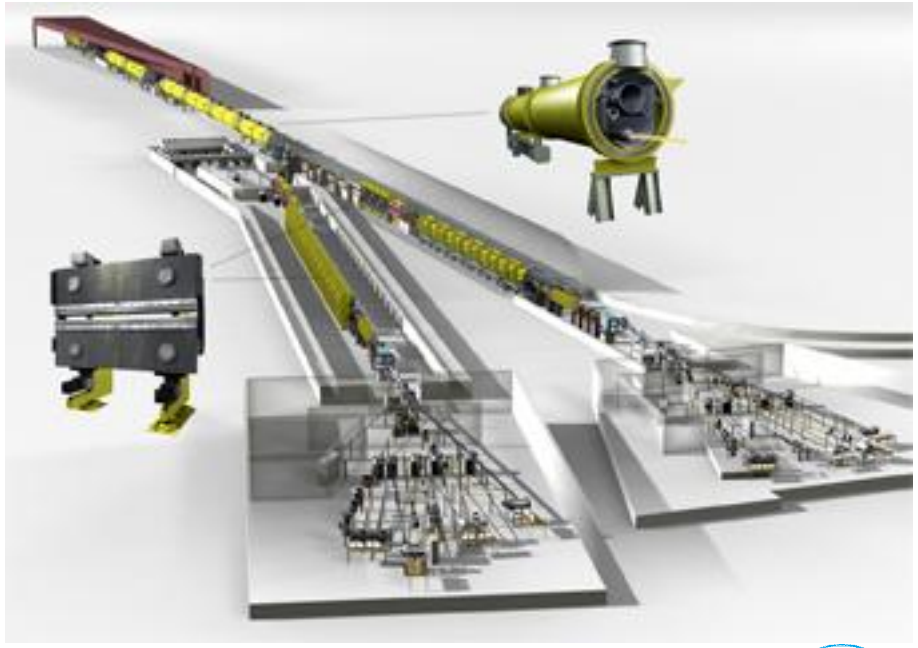


$$\lambda_{ph} = \frac{\lambda_u}{2\gamma^2}\left(1+\frac{K^2}{2}\right)$$

The Future of FLASH

2012: FLASH running as
- a user facility, 4.1 – 50 nm
- a testbed for XFEL (component tests, diagnostics, control system, etc.)
- as a testbed for machine studies (Seeding, …)

2013: FLASH will be upgraded to FLASH II



TTF as a linear collider testbed

TESLA **T**est **F**acility was a test facility:

- Components running at their limits
- Components from different vendors or collaborators
- Different kinds of the same component
  (BPMs, current monitors, klystrons, modulators,…)
- Only the backbone of a control system
- Different integration of components into the control system
- Different levels of application software
- Different levels of documentation

TTF operation

Goals of TTF operation:

- High accelerating gradients
- Component tests for a linear collider

Mode of TTF operation:

- Separate control room
- Separate control system
- Separate operators (scientists and students)

TTF becomes FLASH

TTF was an ideal testbed for the SASE mechanism

- 200 MeV beam energy
- high current, pulsed, laser driven gun

1998: Conversion into a SASE FEL

- Chicanes for bunch compression (no 3rd harmonic cavity)
- More beam energy
- Better diagnostics
- Undulators
- Lots of Research and Development

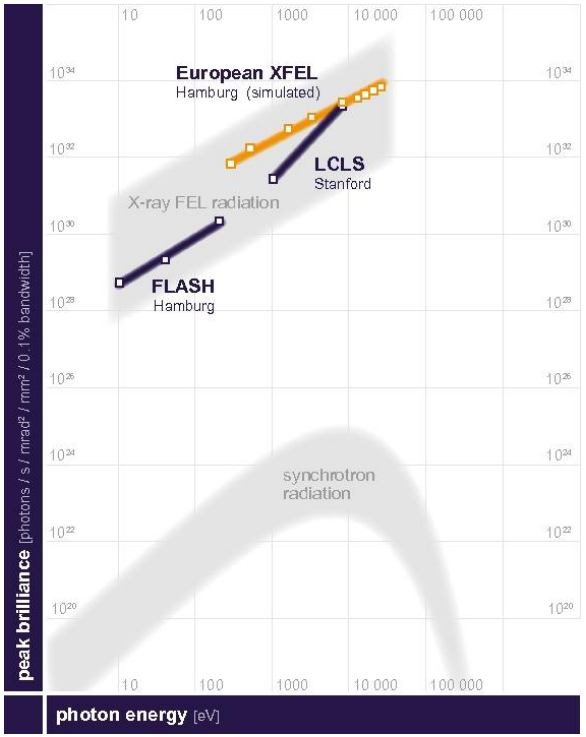
The TTF VUV SASE FEL was born
(But it took years to get it running)

2000: First lasing @110 nm

TTF becomes FLASH

2003: Extension from 100 m to 260 m, TTF becomes FLASH

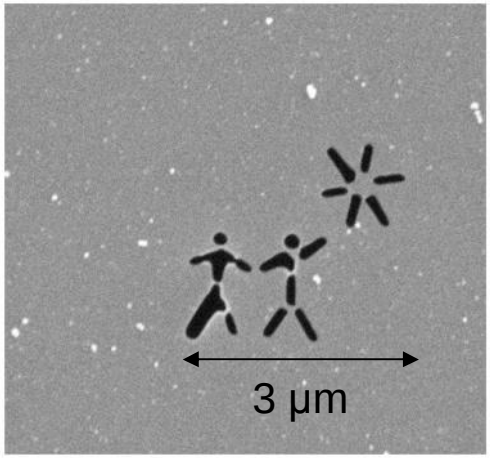
- longer tunnel, space for more accelerating modules
- energy upgrade over the years, 3rd harmonic cavity
- 1200 MeV reached in 2010



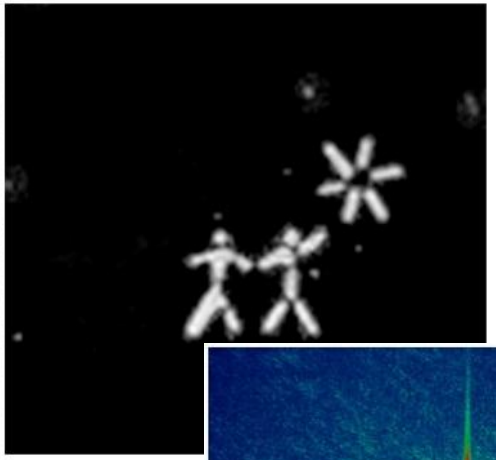
FLASH user operation

2010: 4.12 nm wavelength (well within the 'water window')

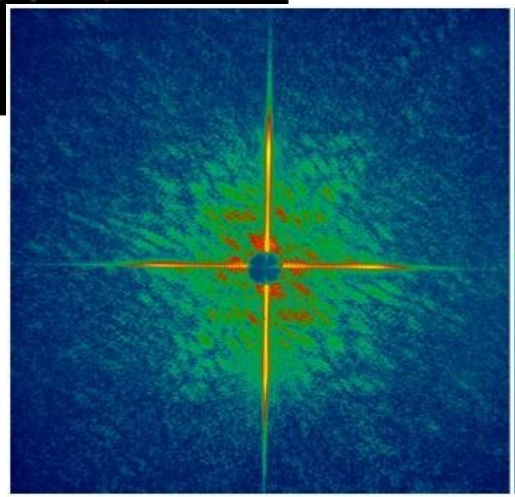
- FLASH is used for fundamental research



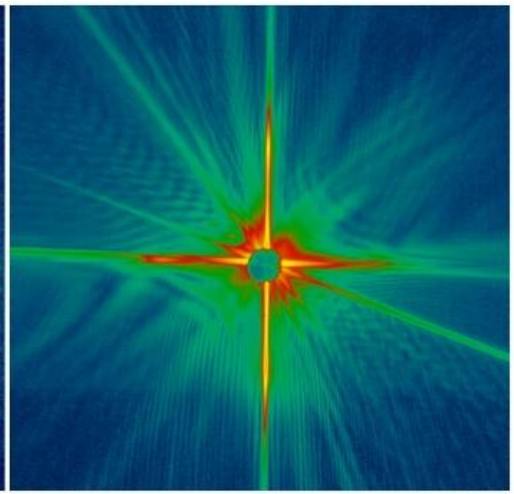
Original Foil



Reconstruction from the diffraction pattern of one shot



Diffraction pattern of the first shot



Diffraction pattern of the second shot

FLASH user operation

FLASH schedule:

User runs (3 – 5 weeks)

interleaved with

Accelerator studies
and FEL studies
(2 – 7 weeks)

FLASH
Schedule 2012-2013

	week	date	schedule	goal
	52	26.Dec - 1.Jan		
2012	1	2.Jan - 8.Jan	FLASH commissioning	
	2	9.Jan - 15.Jan		
	3	16.Jan - 22.Jan		
	4	23.Jan - 29.Jan		
	5	30.Jan - 5.Feb	Accelerator studies	
	6	6.Feb - 12.Feb		
	7	13.Feb - 19.Feb		
	8	20.Feb - 26.Feb	FEL studies	
	9	27.Feb - 4.Mar		
	10	5.Mar - 11.Mar		
	11	12.Mar - 18.Mar		preparation user run
	12	19.Mar - 25.Mar	User Run	
	13	26.Mar - 1.Apr	Block 1	
	14	2.Apr - 8.Apr		
	15	9.Apr - 15.Apr	FEL studies	Survey
	16	16.Apr - 22.Apr		
	17	23.Apr - 29.Apr		preparation user run
	18	30.Apr - 6.May		
	19	7.May - 13.May	User Run	
	20	14.May - 20.May	Block 2	
	21	21.May - 27.May		
	22	28.May - 3.Jun		
	23	4.Jun - 10.Jun		
	24	11.Jun - 17.Jun	Maintenance	rf gun exchange G4.2 -> G4.1
	25	18.Jun - 24.Jun		vacuum work, dismount bypass
	26	25.Jun - 1.Jul		
	27	2.Jul - 8.Jul		
	28	9.Jul - 15.Jul		
	29	16.Jul - 22.Jul	Maintenance	vacuum work, survey
	30	23.Jul - 29.Jul	FEL studies	
	31	30.Jul - 5.Aug		
	32	6.Aug - 12.Aug		preparation user run
	33	13.Aug - 19.Aug	User Run	
	34	20.Aug - 26.Aug	Block 4	
	35	27.Aug - 2.Sep		
	36	3.Sep - 9.Sep		
	37	10.Sep - 16.Sep	FEL studies	
	38	17.Sep - 23.Sep	Accelerator studies	
	39	24.Sep - 30.Sep		
	40	1.Oct - 7.Oct		preparation user run
	41	8.Oct - 14.Oct	User Run	
	42	15.Oct - 21.Oct	Block 5	
	43	22.Oct - 28.Oct		
	44	29.Oct - 4.Nov		
	45	5.Nov - 11.Nov	FEL studies	
	46	12.Nov - 18.Nov		preparation user run
	47	19.Nov - 25.Nov	User Run	
	48	26.Nov - 2.Dec	Block 6	
	49	3.Dec - 9.Dec		
	50	10.Dec - 16.Dec		
	51	17.Dec - 23.Dec		
	52	24.Dec - 30.Dec	Maintenance	

FLASH user operation

FLASH accelerator studies and FEL studies:

Performed by experts with a little help from some experienced operators.

FLASH user runs:

Performed by operators with a little help from some experts.

Difficulties for Operators

Questions of a storage ring operator on his first day at an FEL:

First turn steering all day long?
Closed orbit? Closed bumps?

Betatron Tunes?
Where are the resonances?

Beam Energy, RF-Phases?
Not constant? Not known everywhere?

Dark Current?
What's that?

Bunch length?
Who cares?

Difficulties for Operators

Problems of a storage ring operator at an FEL:

Every slight change at the injector spoils the beam in the undulator section.

Every change in the energy distribution changes the beam optics.

Every change of RF-phases spoils the bunch length.

Dark current from the gun must not reach the undulator section.

Feedbacks, feedbacks, feedbacks….
Orbit, energy, peak current

Difficulties for Operators

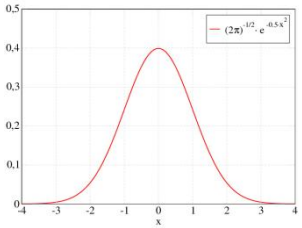
Problems of a storage ring operator at an FEL:

Which tuning strategy works today?

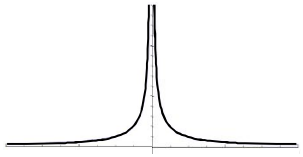
Many tuning parameters (like luminosity tuning)**,**
but some can totally destroy SASE.

The SASE effect is less robust than luminosity.

Most lumi parameters have
a Gaussian distribution,



many SASE parameters
are steep peaks.



Conclusion

FLASH had (and in parts still has) **a lot of childhood diseases.**

Parts of FLASH were never meant to be a user facility.

FLASH was (and in parts still is) **a testbed.**

The level of automation and feedbacks is not optimal.

Operators were not part of the FLASH crew from the beginning.

(Some) **Storage ring operators have a hard time with an FEL.**

Operators are performing routine user operation now
(but still need help for e.g. wavelength changes)**.**

Conclusion

“FLASH performance is too much operator dependent”
(from our funding agency)

Operator Training!

Automation of Procedures!

Feedbacks!
(LCLS has 16 feedbacks running)