Status TTF / VUV-FEL Linac

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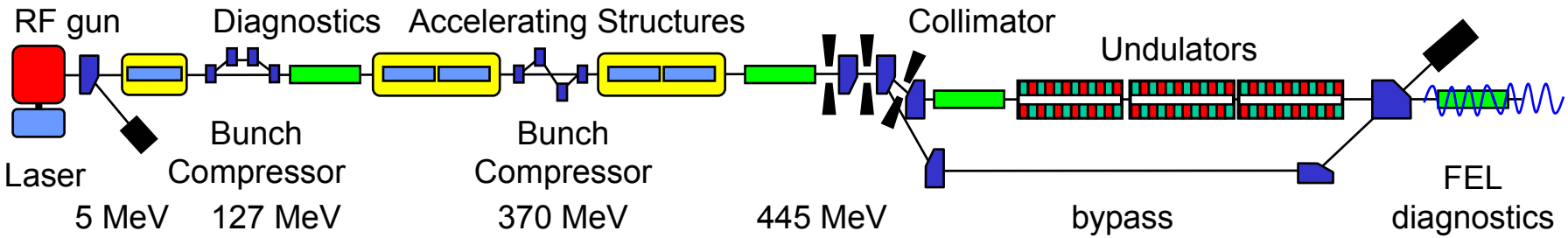
for the TTF/ VUV-FEL Group

and for Siegfried Schreiber

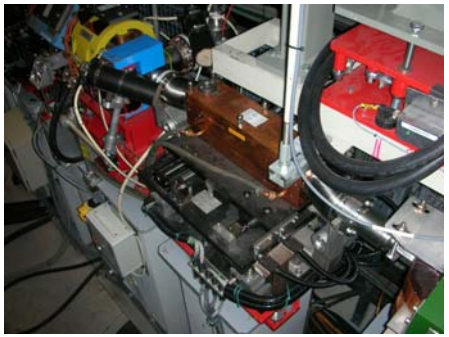
TESLA Technology Collaboration Meeting
Frascati, December 5th - 7th, 2005

Present Layout of the VUV-FEL








250 m

Accelerator Modules in Operation

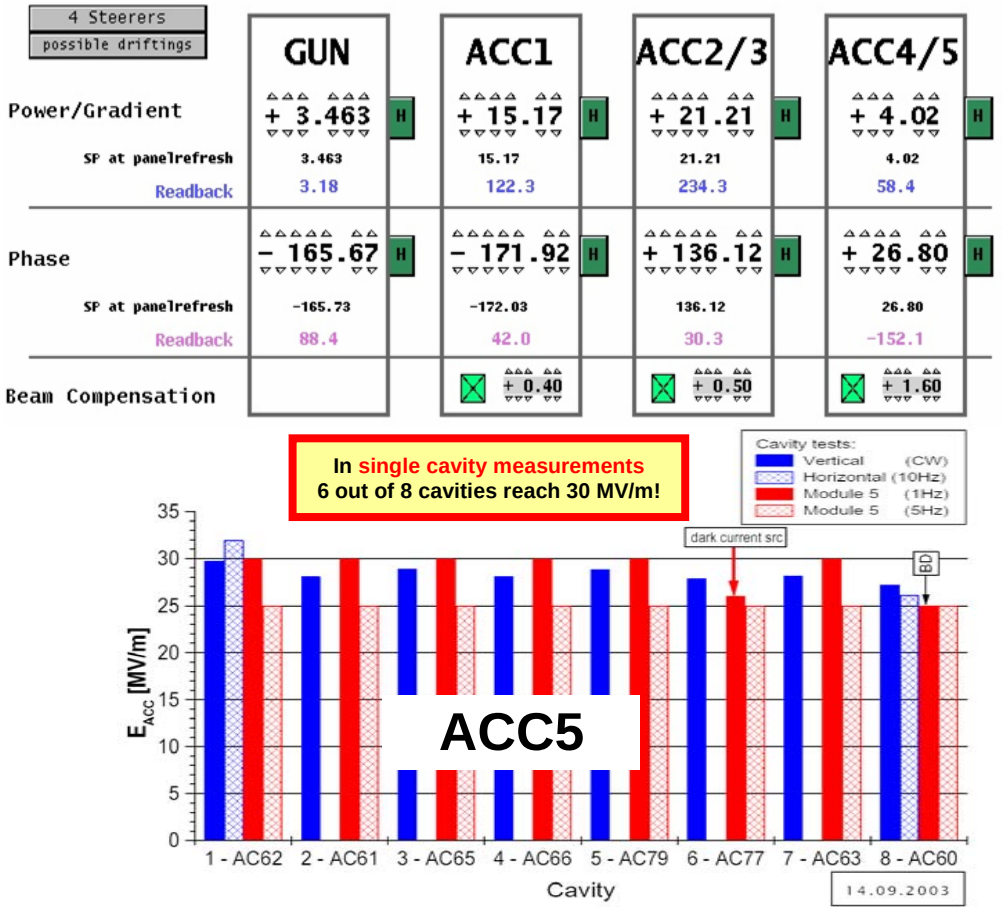
At present we are operating modules

2*	ACC1	Febr 04
1*	ACC2	June 02
3*	ACC3	April 03
4	ACC4	April 03
5	ACC5	April 03

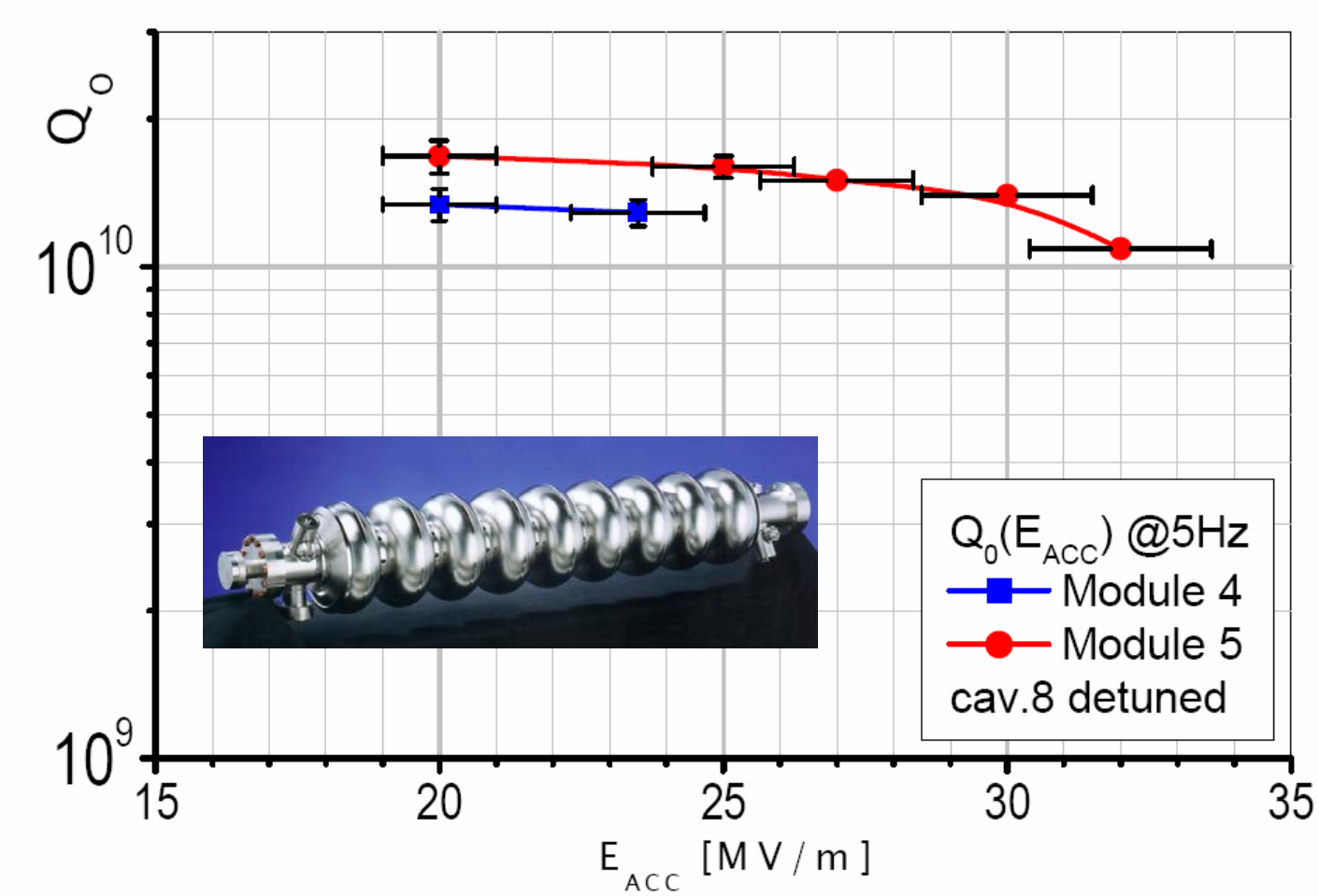
The standard operation for the VUV-FEL lasing at 32 nm requires an ACC4 / ACC5 set-point of about 4 MV/m.

In July a two weeks period was used to verify the high gradients in ACC5 by accelerating the beam. Previously measured RF gradients were confirmed.

RF conditioning was not needed, i.e. the input power increase was set by the software procedure.



Accelerator Module ACC5

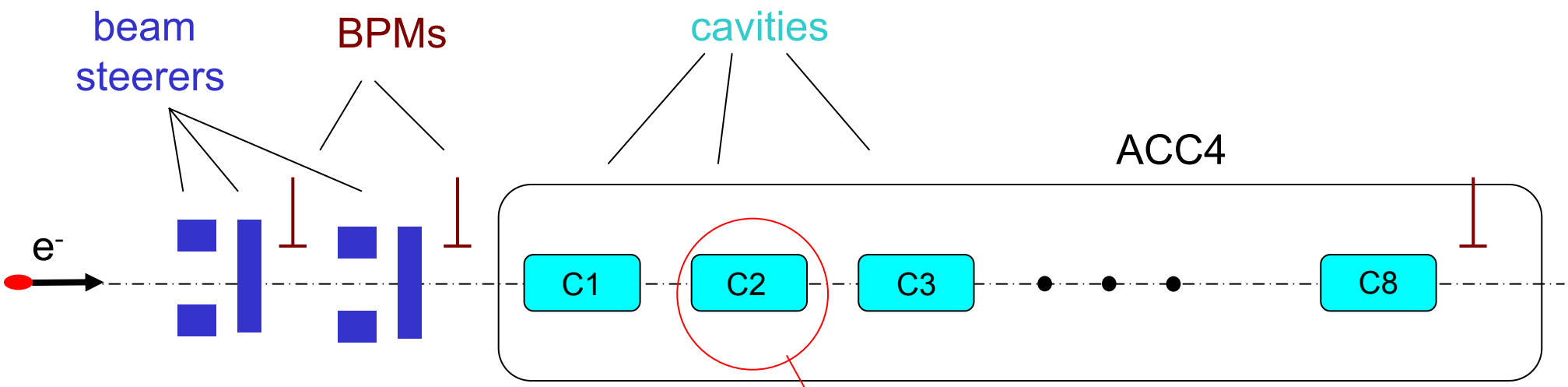


The cryogenic load was measured with 800 µs flat top, 5 Hz.

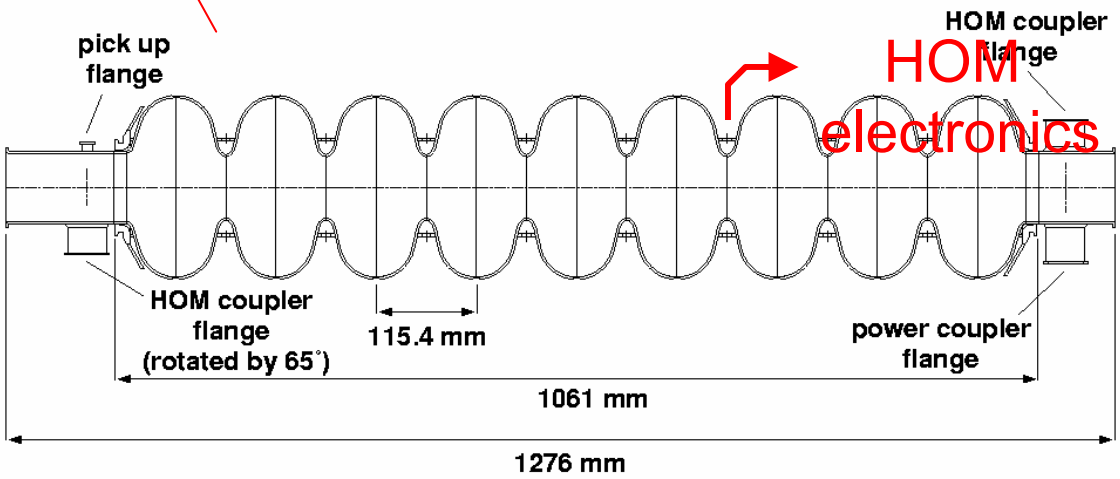
ACC5 reached 25 MV/m with all cavities and 32 MV/m with cav.8 detuned.

Cryogenic load at 40/80 K was within specifications.

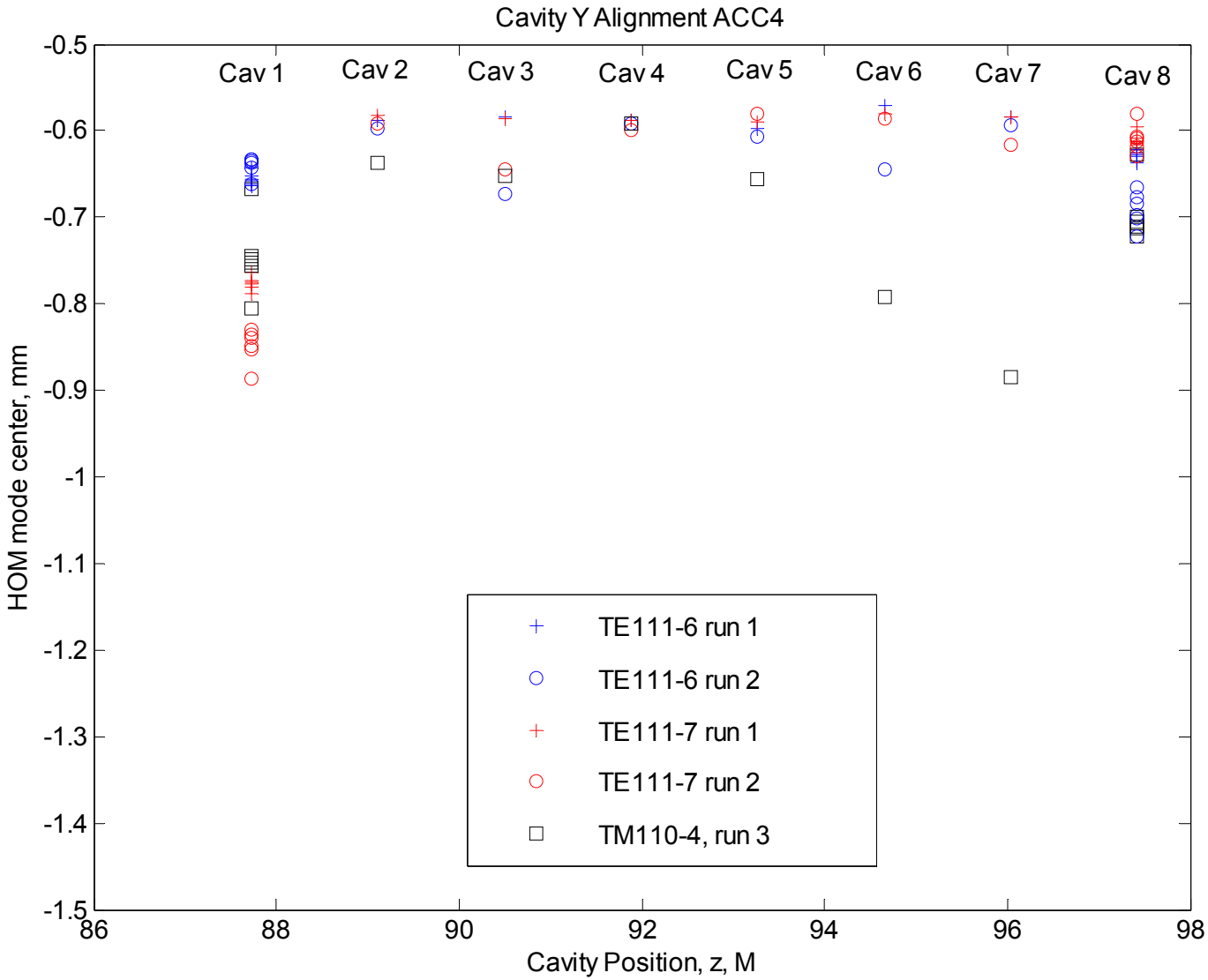
HOM Measurements (SLAC / CEA / DESY)



HOM electronics

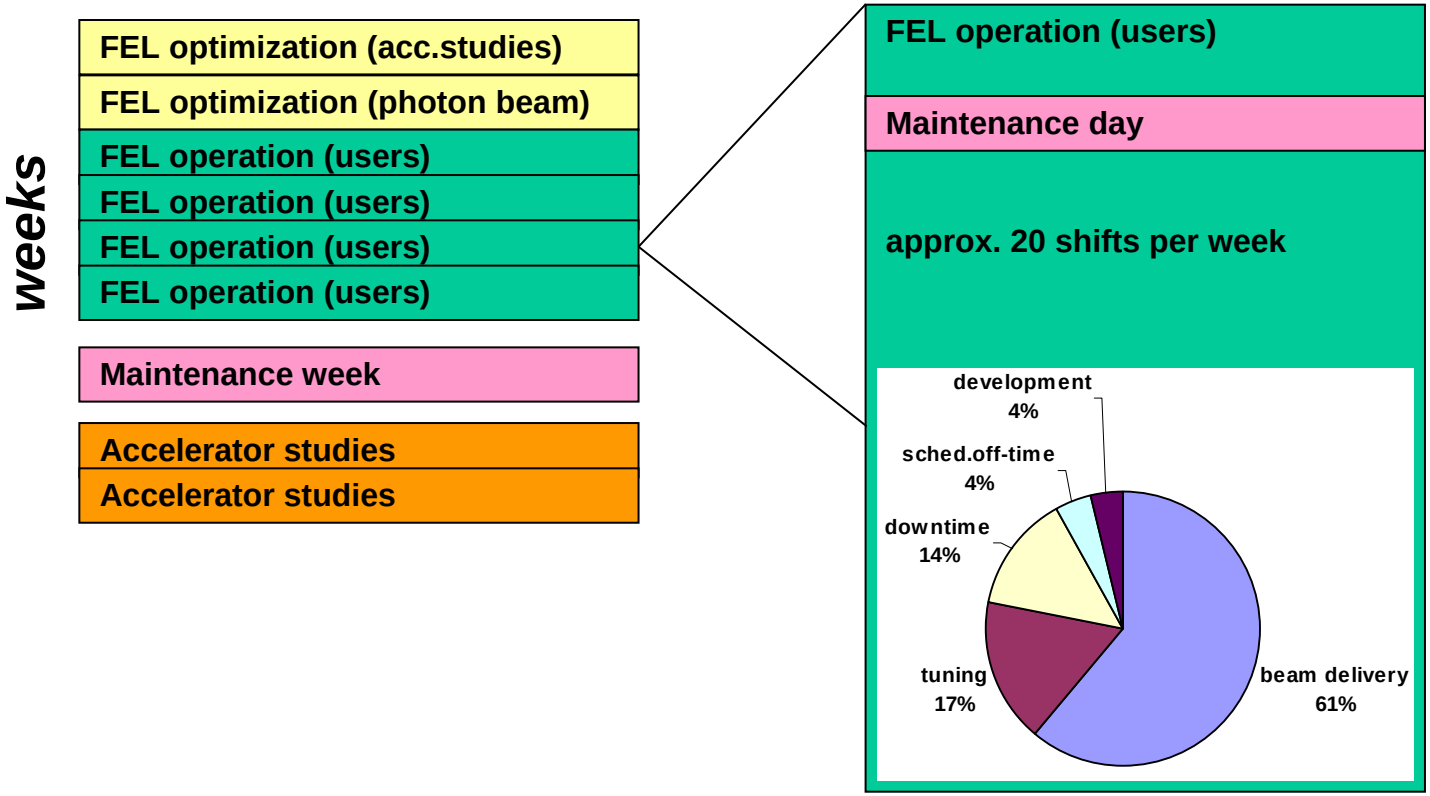


HOM Measurements some preliminary results



preliminary result

The VUV-FEL schedule in 2005



At present we can expect typically 20 weeks of photon beam user operation per year. This time includes *Tuning* shifts.

In August we decided to group all accelerator studies and schedule them for a longer (six weeks) period early 2007.

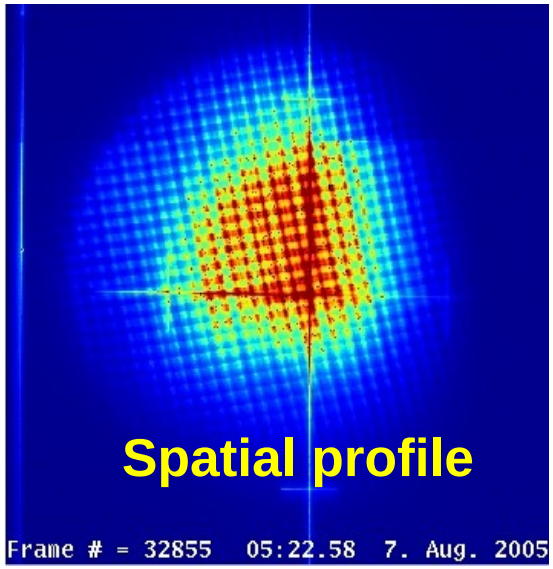
Additional time was needed to stabilize the TTF / VUV-FEL operation.

The VUV-FEL schedule in 2005

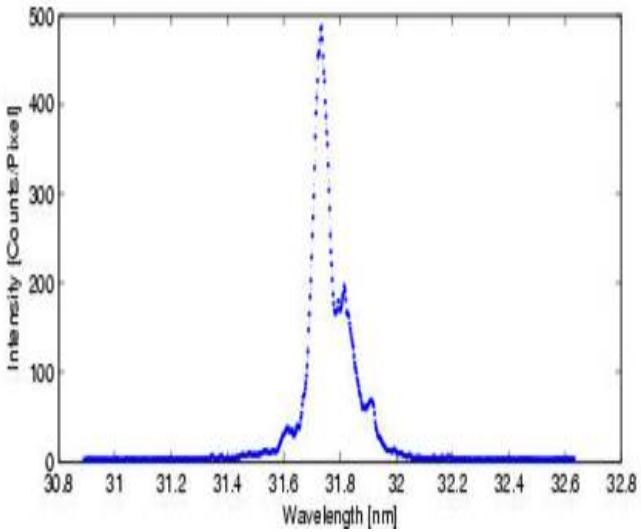
Experiments/Photon BL com. | FEL studies | Accelerator studies | Maintenance

June	22	30.05. - 05.06.	
	23	06.06. - 12.06.	Maintenance incl. MBK + addl. Klystron/Modulator (Choroba)
	24	13.06. - 19.06.	
	25	20.06. - 26.06.	Commissioning of BL2 and monochromator beamline and photondiagnostics
	26	27.06. - 03.07.	
July	27	04.07. - 10.07.	High gradient studies incl. Cryo and LLRF
	28	11.07. - 17.07.	
	29	18.07. - 24.07.	FEL studies
	30	25.07. - 31.07.	II-02-052 FEL, W. Wurth
August	31	01.08. - 07.08.	II-02-048 FEL, M. Richter and P. Zeitoun: I3-JRA2
	32	08.08. - 14.08.	Accelerator Studies (e.g. HOM studies cav. alignment) or FEL studies
	33	15.08. - 21.08.	Beamline commissioning BL and PG2 (Martins)
	34	22.08. - 28.08.	II-02-037 FEL (BL2), II-02-042 FEL (BL2), II-02-047 FEL (BL1)
September	35	29.08. - 04.09.	II-02-037 FEL (BL2), II-02-042 FEL (BL2), II-02-052 FEL (PG2)
	36	05.09. - 11.09.	Maintenance: modulators/10 MW klystron installation modulator 4
	37	12.09. - 18.09.	
	38	19.09. - 25.09.	LLRF Studies/continue 10 MW klystron installation
	39	26.09. - 02.10.	LLRF Studies
October	40	03.10. - 09.10.	FEL studies and preparation for user experiments
	41	10.10. - 16.10.	
	42	17.10. - 23.10.	II-02-054 FEL (PG2), II-02-050 FEL (PG2 in parallel), II-02-049 FEL R. Lee, P. Zeitoun (BL2)
	43	24.10. - 30.10.	II-02-047 FEL (BL1), II-02-049 FEL R. Lee, P. Zeitoun (BL2)
November	44	31.10. - 06.11.	II-02-049 FEL R. Lee, K. Sokolowski-Tinten (BL2)
	45	07.11. - 13.11.	II-02-044 FEL (PG2), II-02-050 FEL (PG2 in parallel), II-02-049 FEL R. Lee, K. Sokolowski-Tinten (
	46	14.11. - 20.11.	FEL studies and preparation for user experiments
	47	21.11. - 27.11.	
December	48	28.11. - 04.12.	II-02-041 FEL (BL1), II-02-046 FEL (BL2)
	49	05.12. - 11.12.	II-02-041 FEL (BL1), II-02-046 FEL (BL2), II-02-045 FEL (PG2), II-02-050 FEL (PG2 in parallel)
	50	12.12. - 18.12.	II-02-045 FEL (PG2), II-02-050 FEL (PG2 in parallel), II-02-043 FEL (BL1)
	51	19.12. - 25.12.	II-02-045 FEL (PG2), II-02-050 FEL (PG2 in parallel),II-02-043 FEL (BL1), II-02-053 FEL (BL2)
	52	26.12. - 01.01.	Maintenance incl. kryo studies

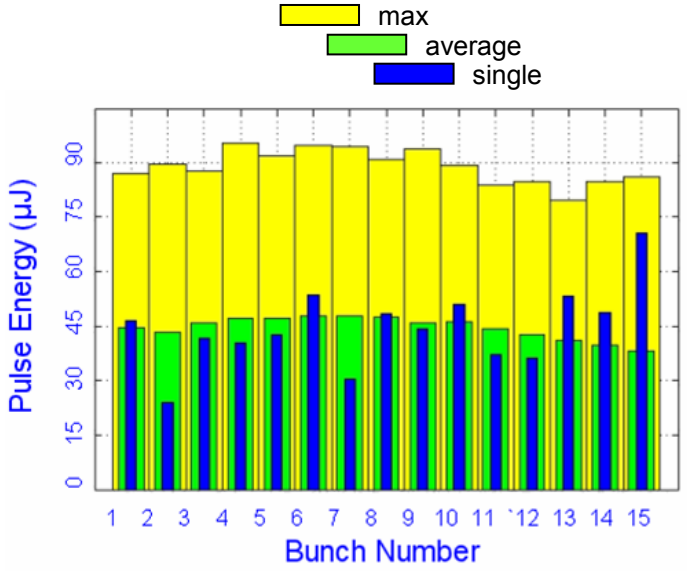
VUV-FEL performance



Spectral distribution

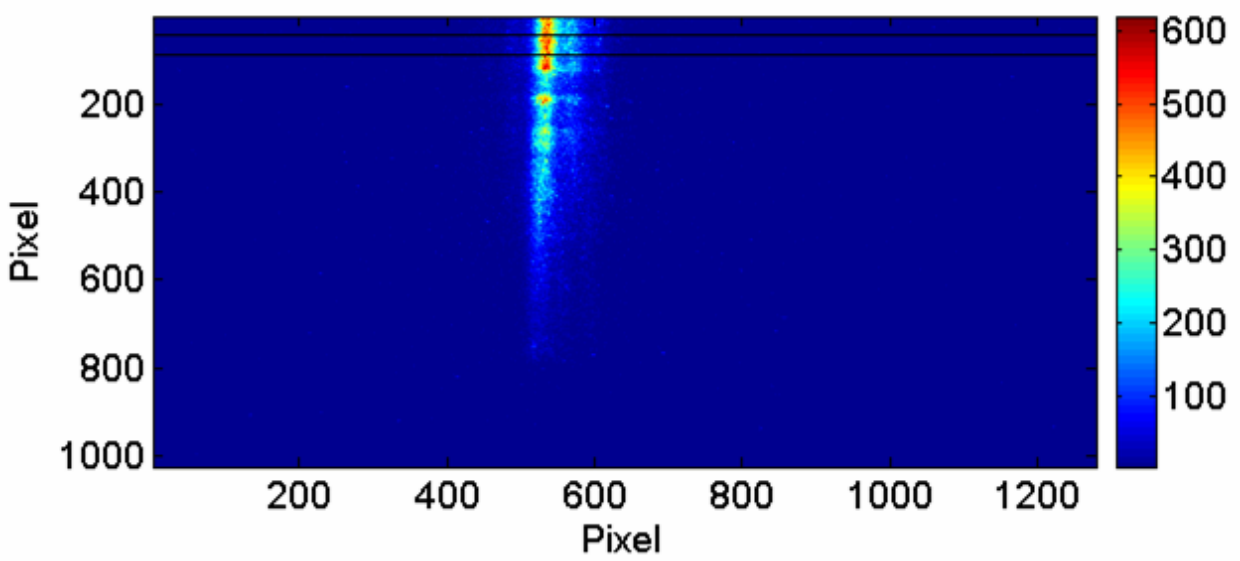


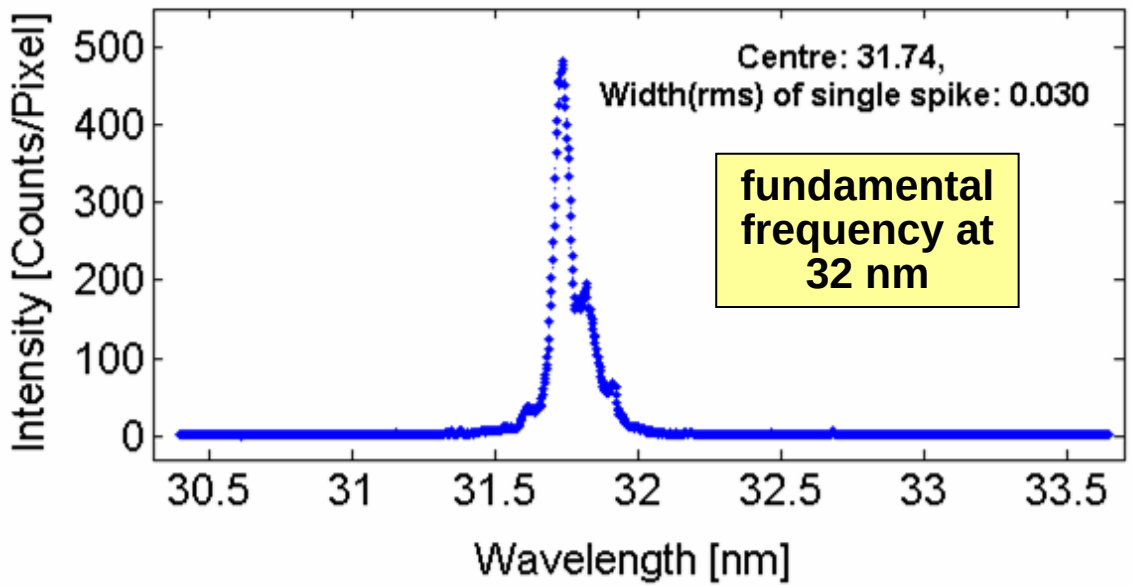
Multibunch SASE signal (µJ)
recorded with MCP Detector



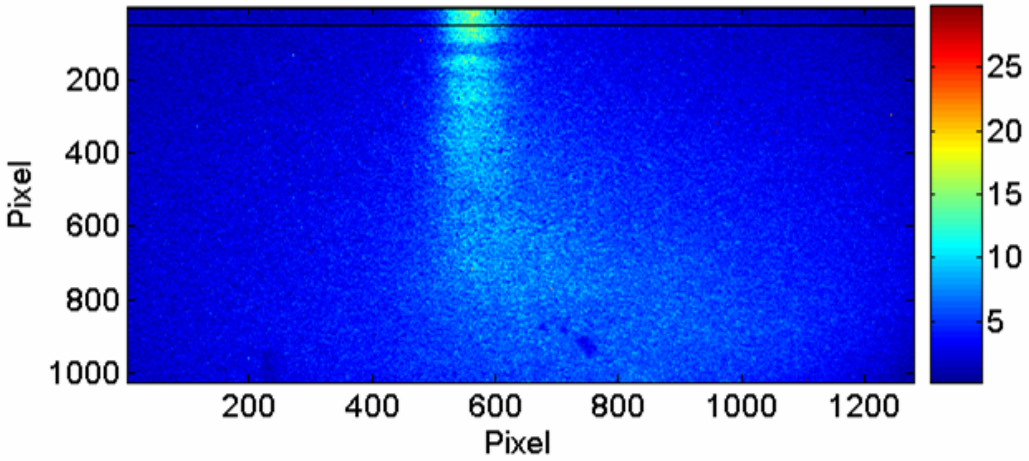
parameter	expected	measured
Wavelength	30 nm	32 nm
Pulse duration	15-50 fs	20-40 fs
Pulse energy	50-150 µJ at saturation	up to 130 µJ (mostly 5-10 µJ) onset of nonlinear regime
Bandwidth	0.8%	0.5-1.0%
Divergence	70-80 µrad	< 150 µrad

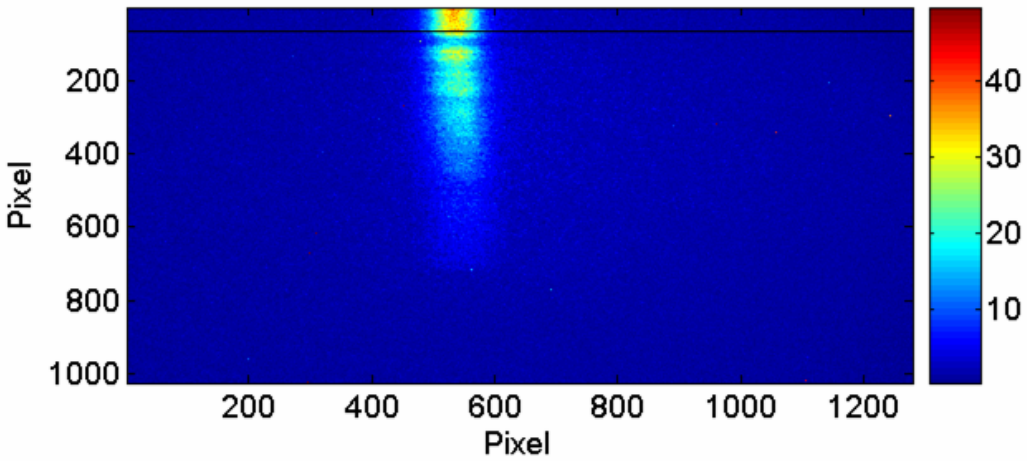
VUV-FEL Single shot spectrum

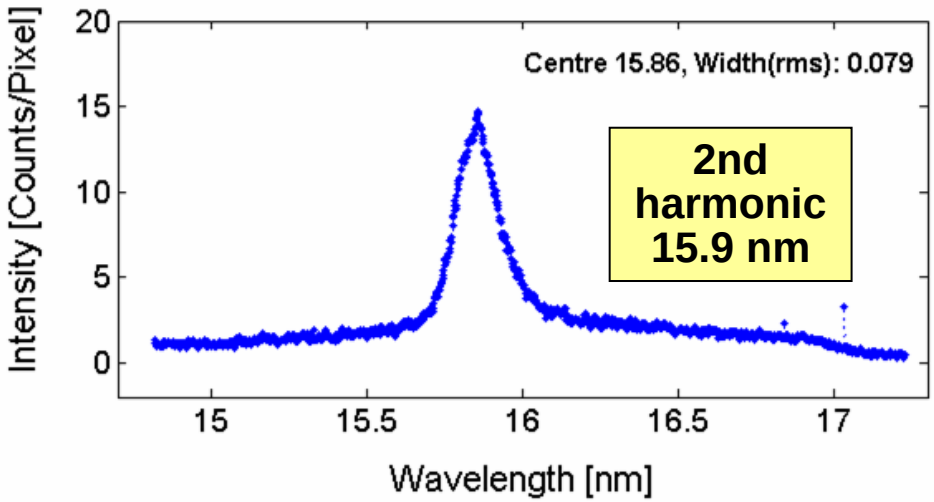


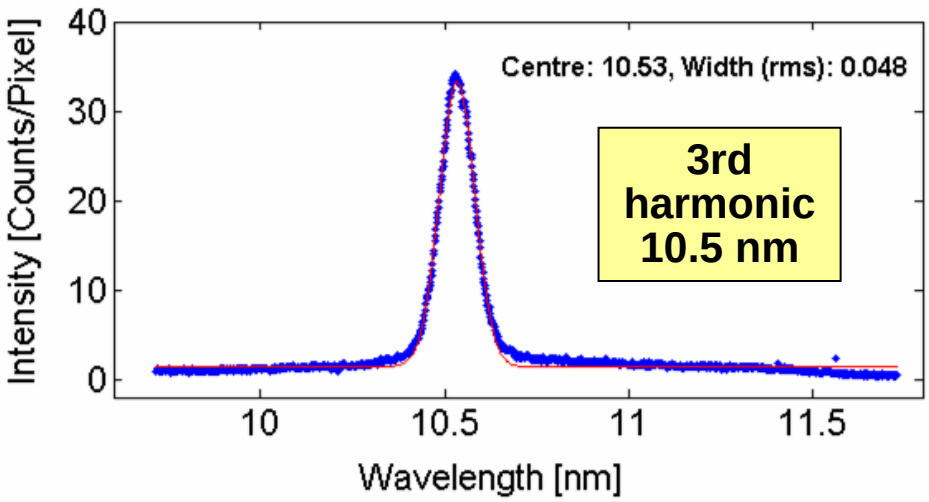


VUV-FEL 2nd and 3rd harmonic









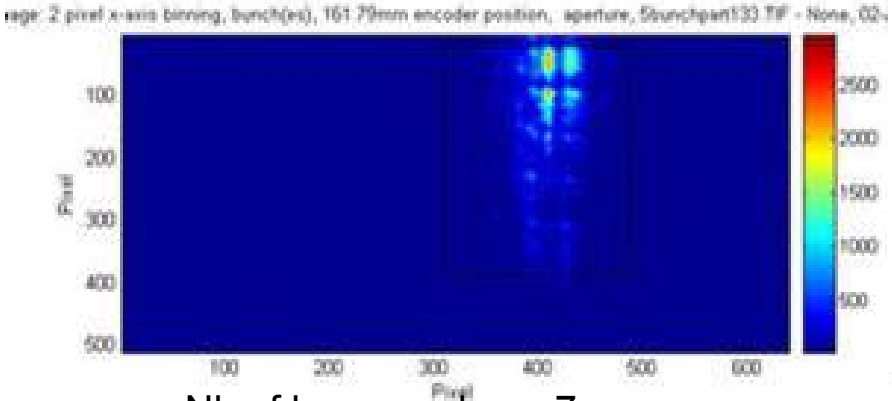
in both cases average over 4000 photon pulses

Saturation Reached

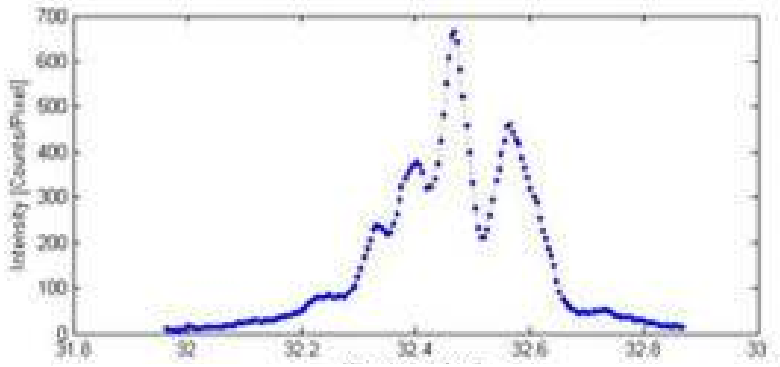
In the statistical model, the fluctuation of the energy decreases when the lasing leaves the exponential regime and approaches saturation

Energies of up to 130 µJ have been seen, energy fluctuations below 30 % at high energy levels have frequently been observed

Second and third harmonics have been observed and seen in user experiments.

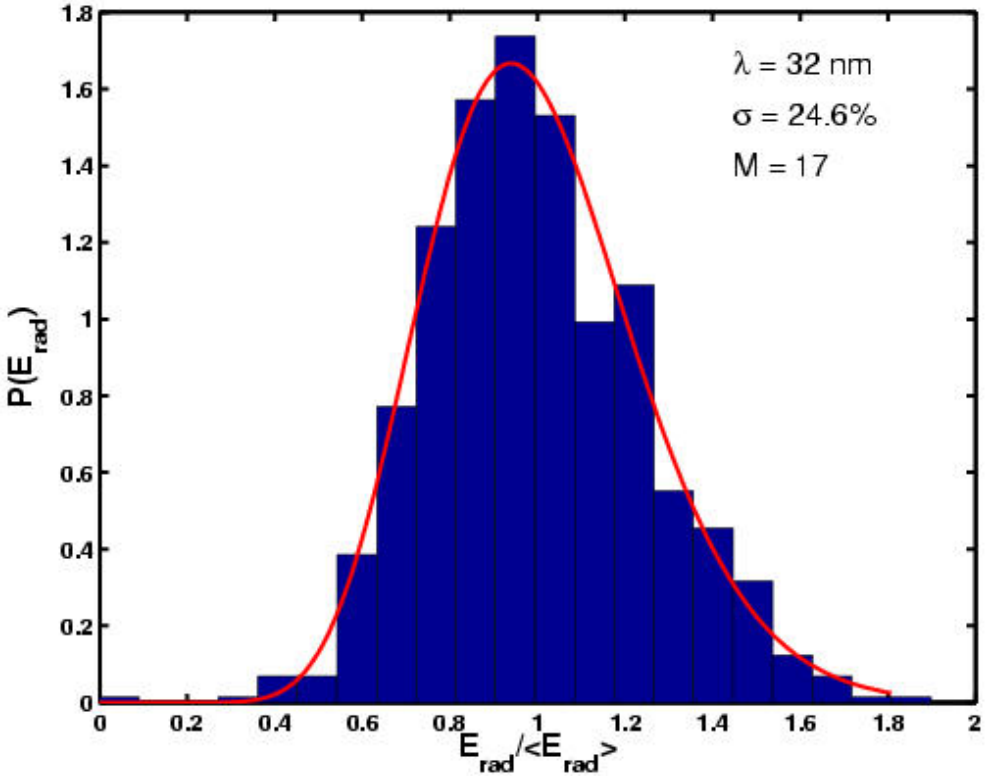


Nb of long. modes ~ 7 or more



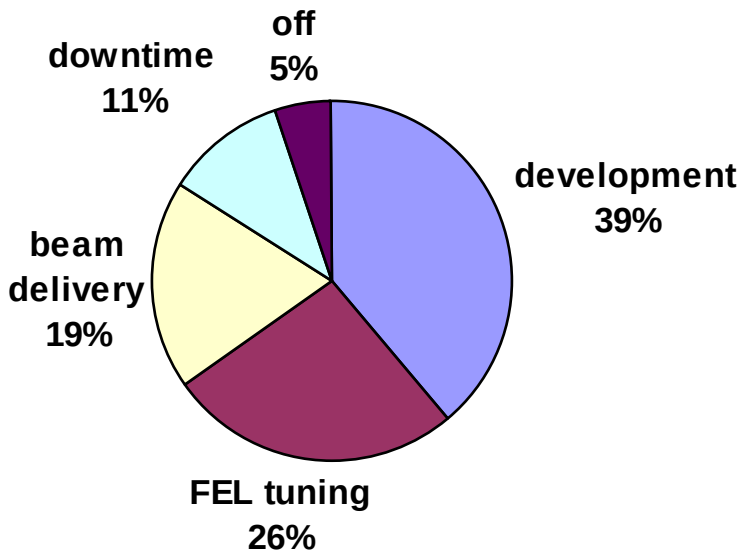
Wavelength (nm)

Energy 90 µJ and rms δE/<E> < 30 %

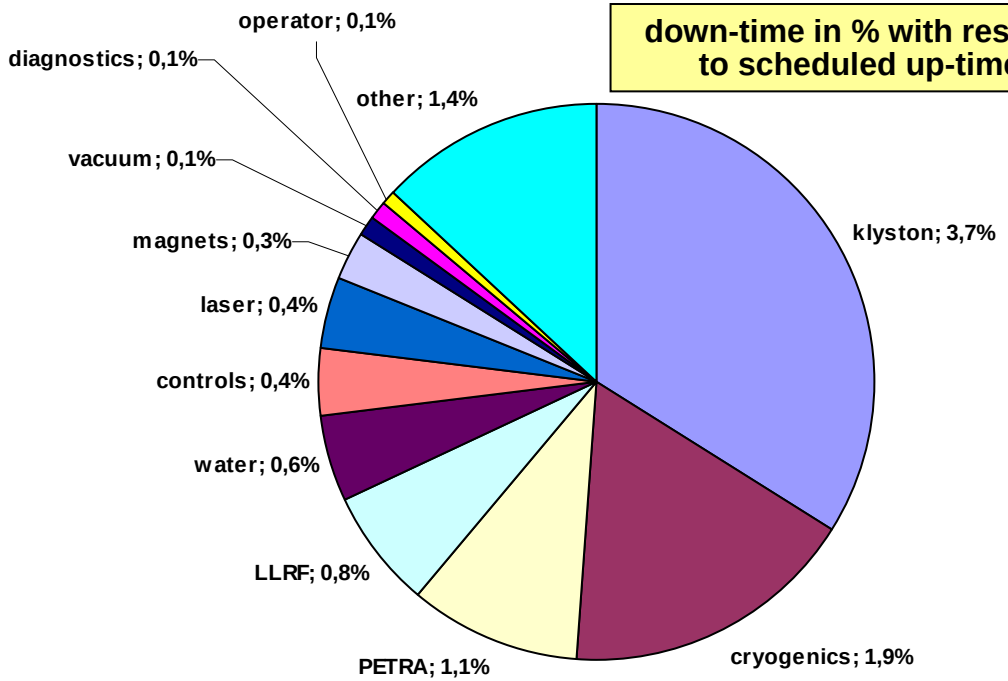


2005 Downtime statistics

TTF/VUV-FEL operation between January 6th and November 1st, 2005



down-time in % with respect to scheduled up-time



The TTF/VUV-FEL downtime over 10 months was approx. 11%.

During this period we had

. user operation

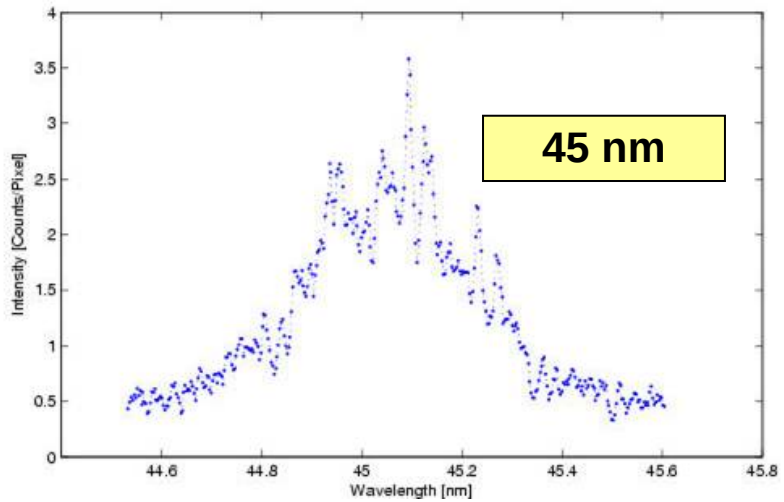
. accel.studies

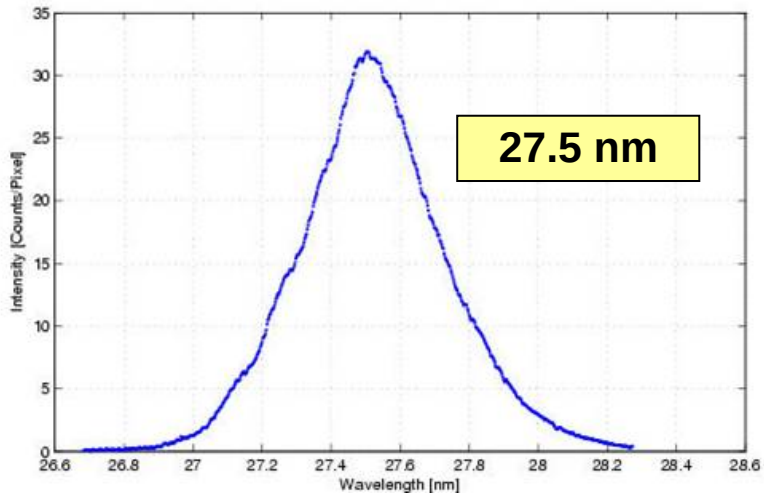
. system R&D.

3.7% klystron	**mostly problems with the prototype MBK**
1.9% cryogenics	**clearly dominated by one event connected with the use of the small/local refrigerator**
1.1% PETRA	**PETRA ramping disturbs the TTF/VUV-FEL operation**
0.8% LLRF	**clearly driven by system ‚improvements' since failures often shortly after R&D efforts**

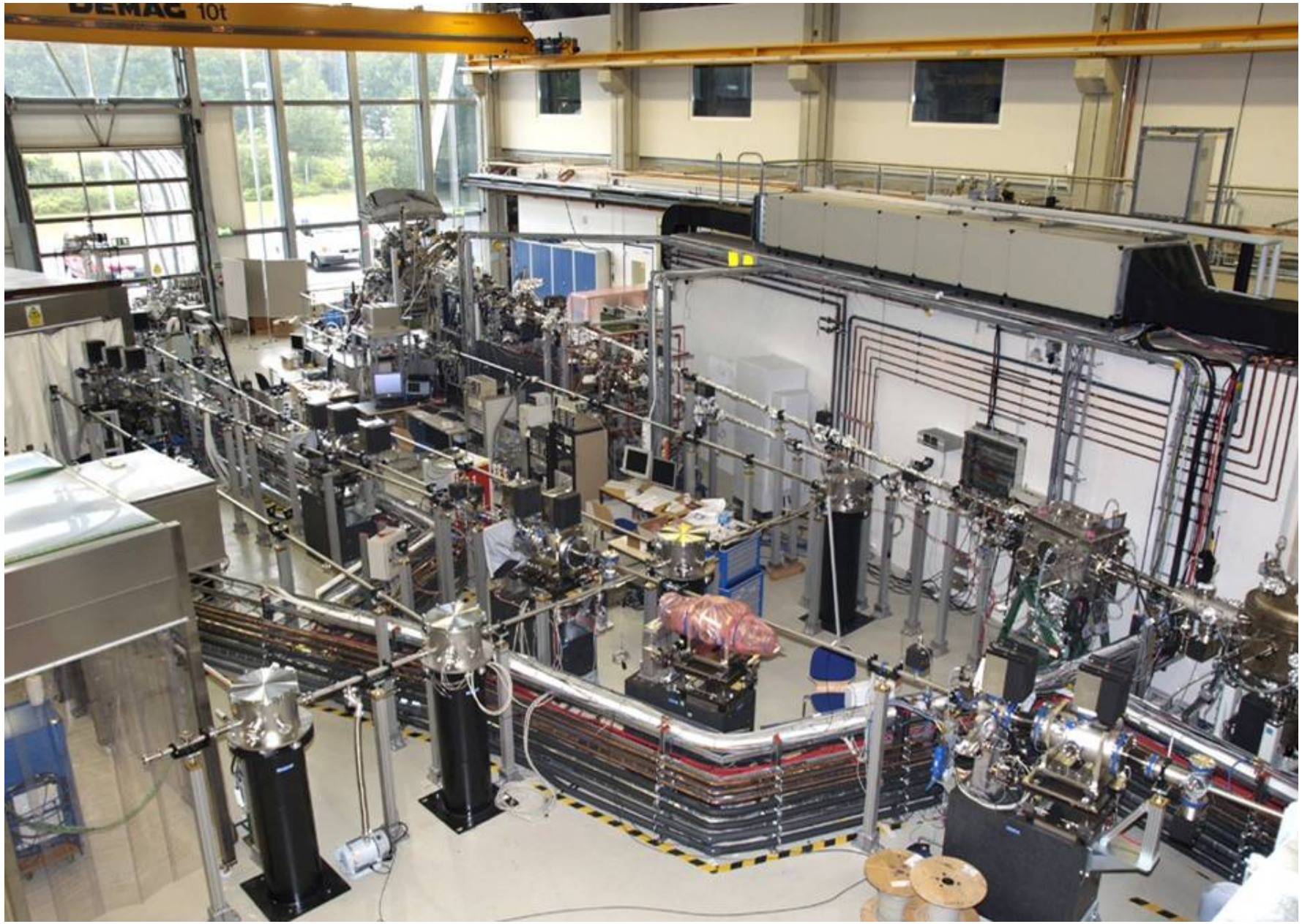
Needed improvements

- better SASE stability, in particular position and intensity (not necessarily at saturation level)
- improve stability of single bunch operation
- more bunches / longer bunch trains / more inter-bunch-spacing
- wavelength tunability
- need for online diagnostics, in particular pulse intensity at all experiments, and beam position feedback for machine (both is in commissioning phase)

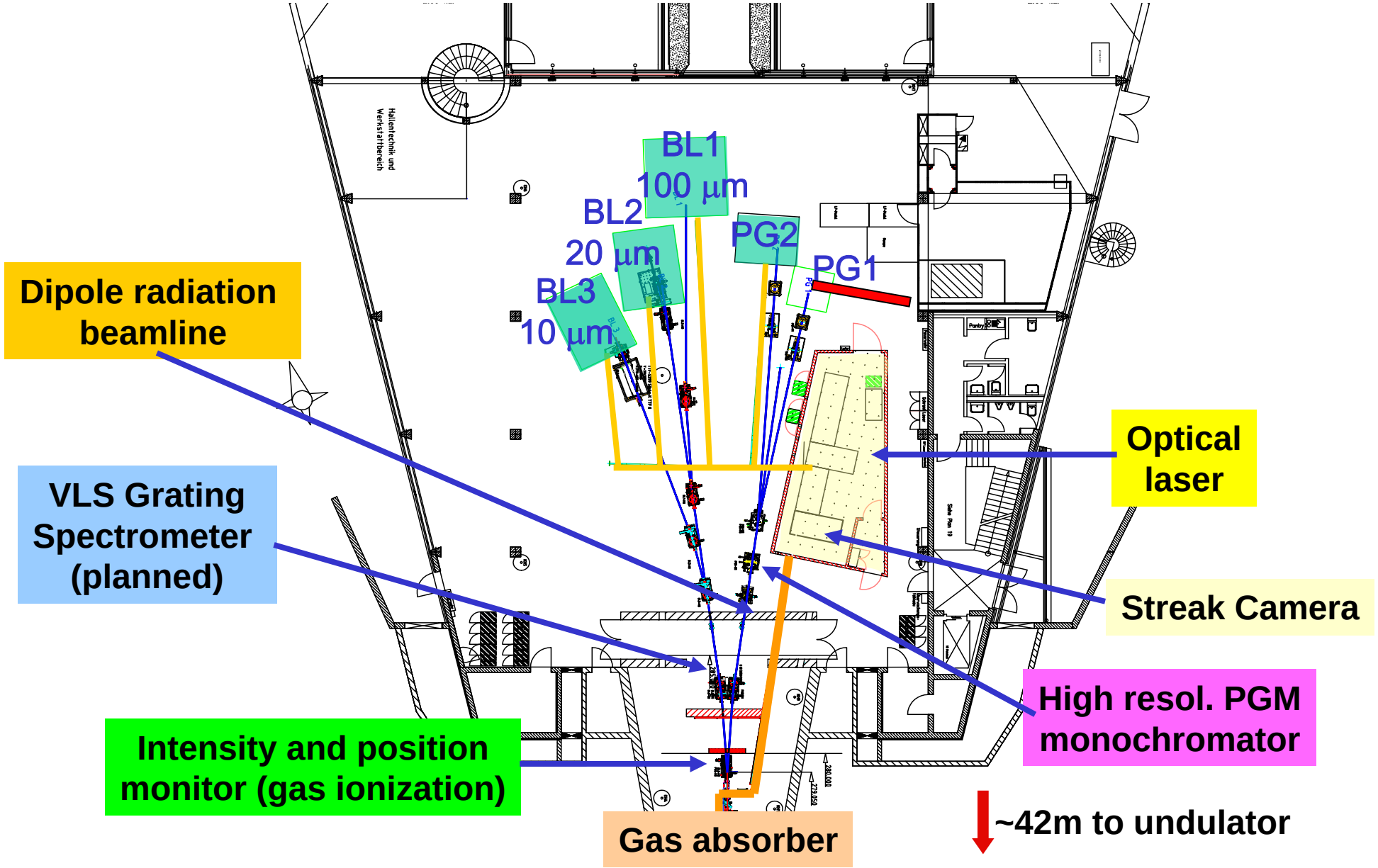




VUV-FEL user experiments



Beamlines and Diagnostics



Operations Coordination and Beam Time Allocation

Beam Time Allocation Committee (BAC)

Hans Weise	Chair
Siegfried Schreiber	Operation Acc.
Josef Feldhaus	Operation Exp.
Joerg Rossbach	Proj.Leader: Further Developm. VUV-FEL
Joachim Ullrich	FEL User
Reinhard Brinkmann	XFEL issues
Helen Edwards	TTC / ILC issues

Identify and evaluate beam time requests from

- Photon Beam Users
- FEL Physicists
- XFEL Study/Prep. Group
- TTC / ILC Study Group

Discuss and assemble an overall schedule in order to support the DESY Directorate concerning the TTF/VUV-FEL planning.

Shutdown in 2006 / 2007

Beside short maintenance periods (about 1 week per 3 months) we were and are planning a long shutdown for 2006.

Installation of accelerator module ACC6 (available in Sept.06)

Repair of the stepping motors in ACC5.

Exchange of accelerator module ACC3 (available in Sept.06)

Installation of the 3.9 GHz acceleration section (n/a in 2006!!!)

The optimistic schedule for the 3.9 GHz section gives 2/2007 for the installation. The realistic schedule depends on the cavity results in spring 2006.

A possible scenario:

to be discussed

until mid 2/2006	continue user operation
mid 2/06 – 3/06	accelerator studies
4/06 – 9/06	6 months operation
10/06 – 12/06	Shutdown ACC3, ACC5, ACC6
01/07 – 04/07	4 months operation
05/07 – 06/07	shutdown 3.9 GHz

Summary

- The VUV-FEL is a unique machine in the world providing laser like radiation in the VUV range:

  regular around 15 µJ, peak 120 µJ or up to 1.6 GW, length 25 to 50 fs, 1 to 30 bunches with 2 Hz, 32 nm, now also 25 and 44 nm

- User experiments have started, already with promising results.

- There has been very important interaction between users and machine!

- Important improvements:

  Stability of beam energy and pointing stability are the most important issues.

  Machine is very sensitive to external noise.

  Improvement of beam orbit and optics in injector, collimator, and undulator section (non-linear beam dynamics) is needed.

  Improve operation procedures.

- Further steps:

  shorter wavelengths, longer pulse trains, higher repetition rate

  repair modules (ACC3 new, ACC5 tuners), install module ACC6 to reach 1 GeV, install 3rd harmonic cavity to improve longitudinal phase space