



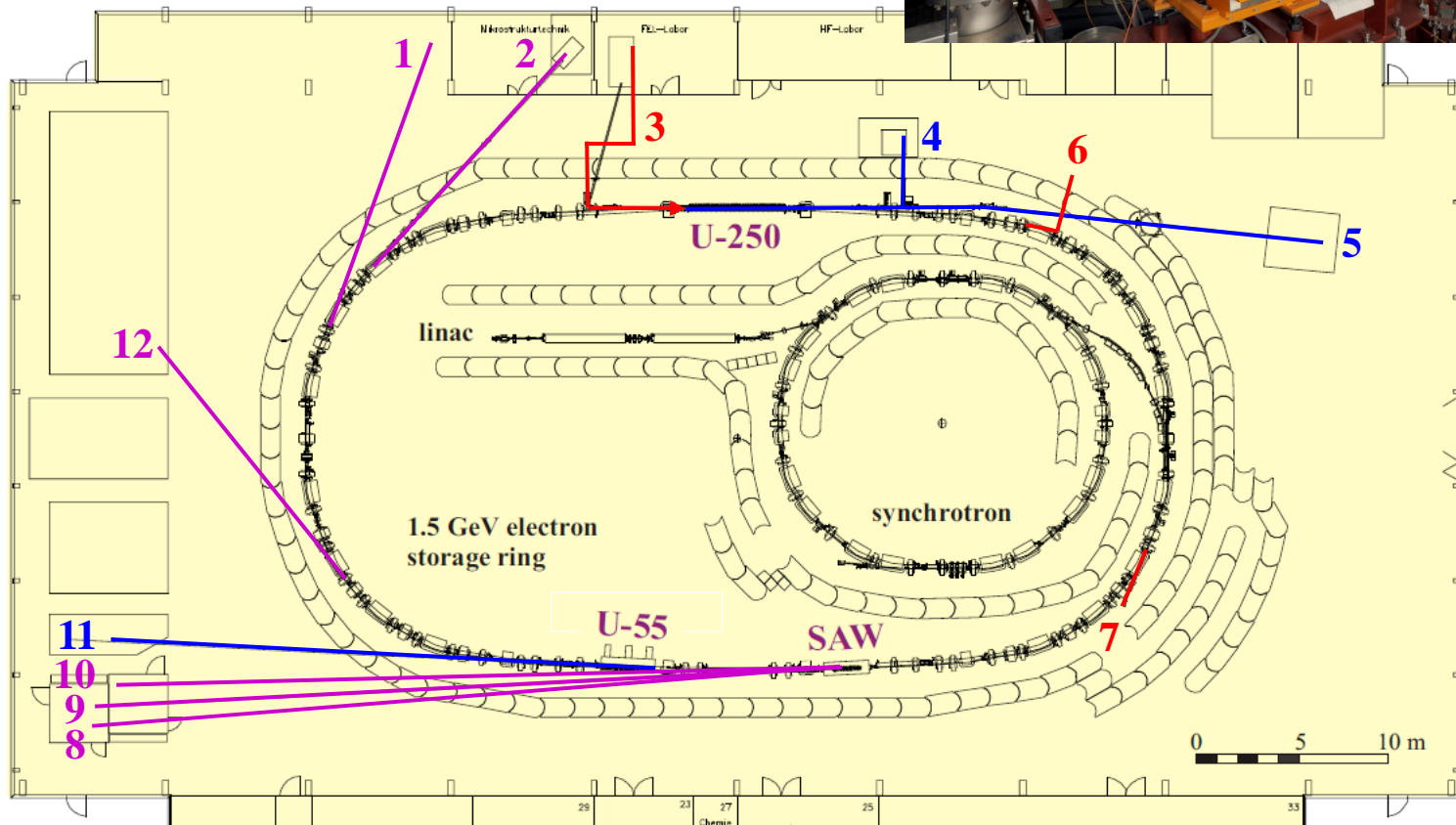
New Projects at DELTA

**Shaukat Khan
Center for Synchrotron Radiation - DELTA
(central scientific institution of TU Dortmund)**



DELTA Operation

beam energy	1.5 GeV
max. current	130 mA, 3 injections/day
lifetime@130 mA	9-11 hrs
user operation	2000 hrs, 20 weeks Mo-Fr
machine shifts	1000 hrs, 10 weeks Mo-Fr
availability	90%



Typical shift schedue

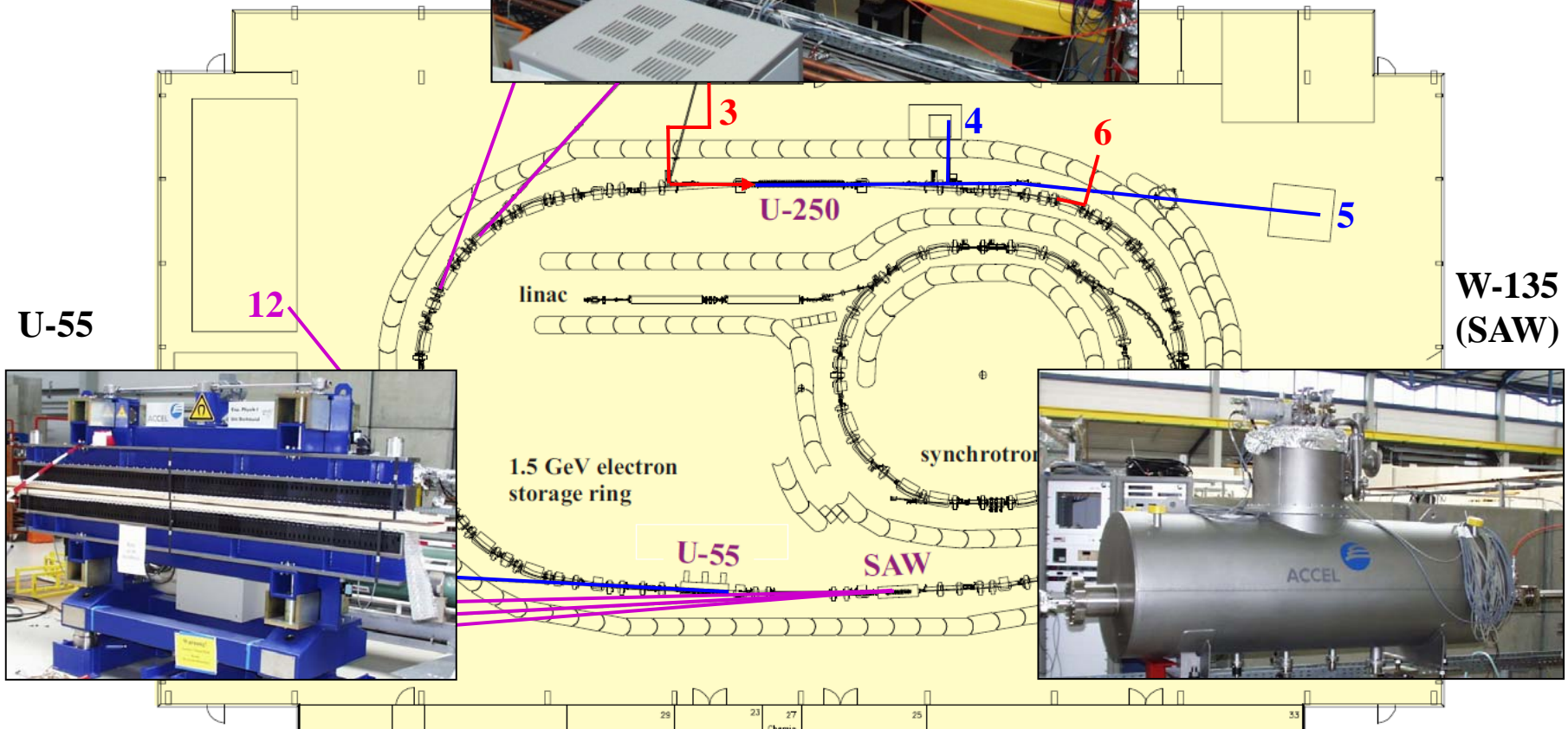
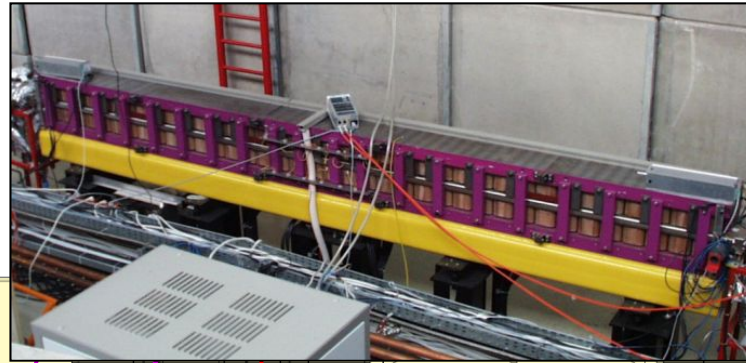
Betriebswochen 1.HJ 2011 1c.Version 16.11.2010

Januar	Februar / März	März / April	April / Mai	Mai / Juni	Juni / Juli									
27.12.2010	Betriebsferien	31.01.2011	Syli S+N	07.03.2011	Syli S+N	Rosenm.	11.04.2011	Shutdown	16.05.2011	Syli S+N	20.06.2011	Shutdown		
28.12.2010	Betriebsferien	01.02.2011	Syli T+S+N	08.03.2011	Syli T+S+N		12.04.2011	Shutdown	17.05.2011	Syli T+S+N	21.06.2011	Shutdown		
29.12.2010	Betriebsferien	02.02.2011	Syli T+S+N	09.03.2011	Syli T+S+N		13.04.2011	Shutdown	18.05.2011	Syli T+S+N	22.06.2011	Shutdown		
30.12.2010	Betriebsferien	03.02.2011	Syli T+S+N	10.03.2011	Syli T+S+N		14.04.2011	Shutdown	19.05.2011	Syli T+S+N	23.06.2011	Feiertag	Frontl.	
31.12.2010	Silvester	04.02.2011	Syli T	11.03.2011	Syli T		15.04.2011	Shutdown	20.05.2011	Syli T	24.06.2011	Shutdown		
01.01.2011	Neujahr	05.02.2011		12.03.2011			16.04.2011		21.05.2011		25.06.2011			
02.01.2011		06.02.2011		13.03.2011			17.04.2011		22.05.2011		26.06.2011			
03.01.2011	Shutdown	07.02.2011	Syli S+N	14.03.2011	Shutdown	DPG User	18.04.2011	Shutdown	23.05.2011	Syli S+N	27.06.2011	BP/IMG		
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23.01.2011		27.02.2011		03.04.2011			08.05.2011		12.06.2011		17.07.2011			
24.01.2011	BP/IMG	28.02.2011	Syli S+N	04.04.2011	Syli S+N	Am. SS	09.05.2011	Syli S+N	Messzeit v.	13.06.2011	Feiertag	Pfingst.	18.07.2011	Syli S+N
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DELTA Operation

U-250 (FEL)



U-55

12

U-250

3

4

6

5

W-135 (SAW)

1.5 GeV electron storage ring

synchrotron

U-55

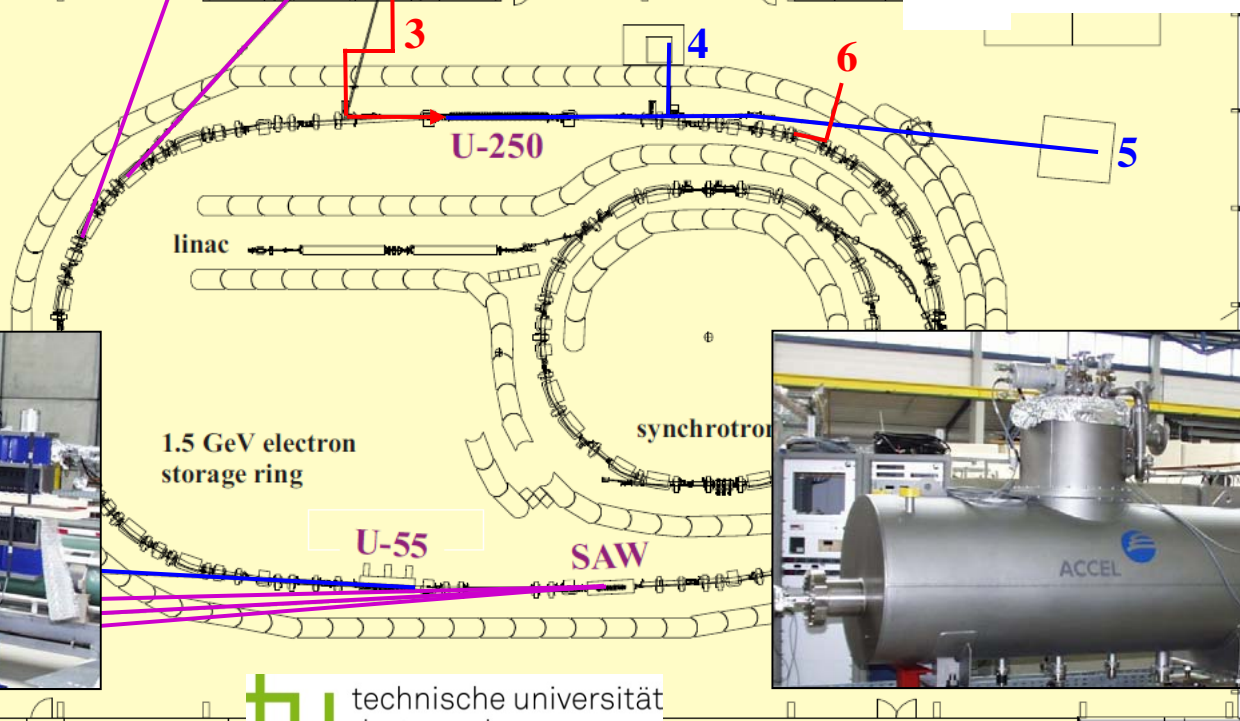
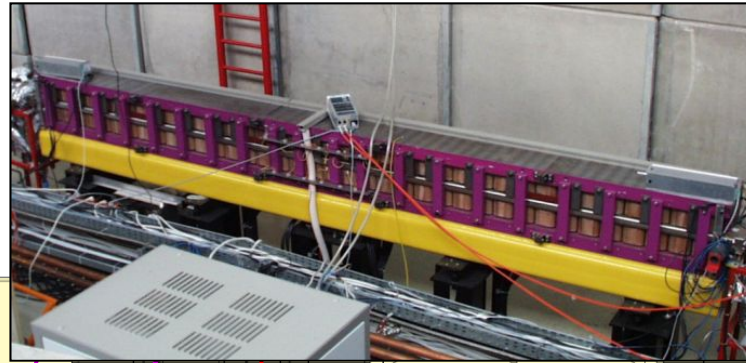
SAW

ACCEL

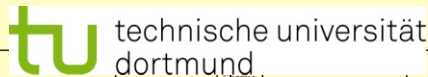


DELTA Operation

U-250 (FEL)



U-55



Improvements

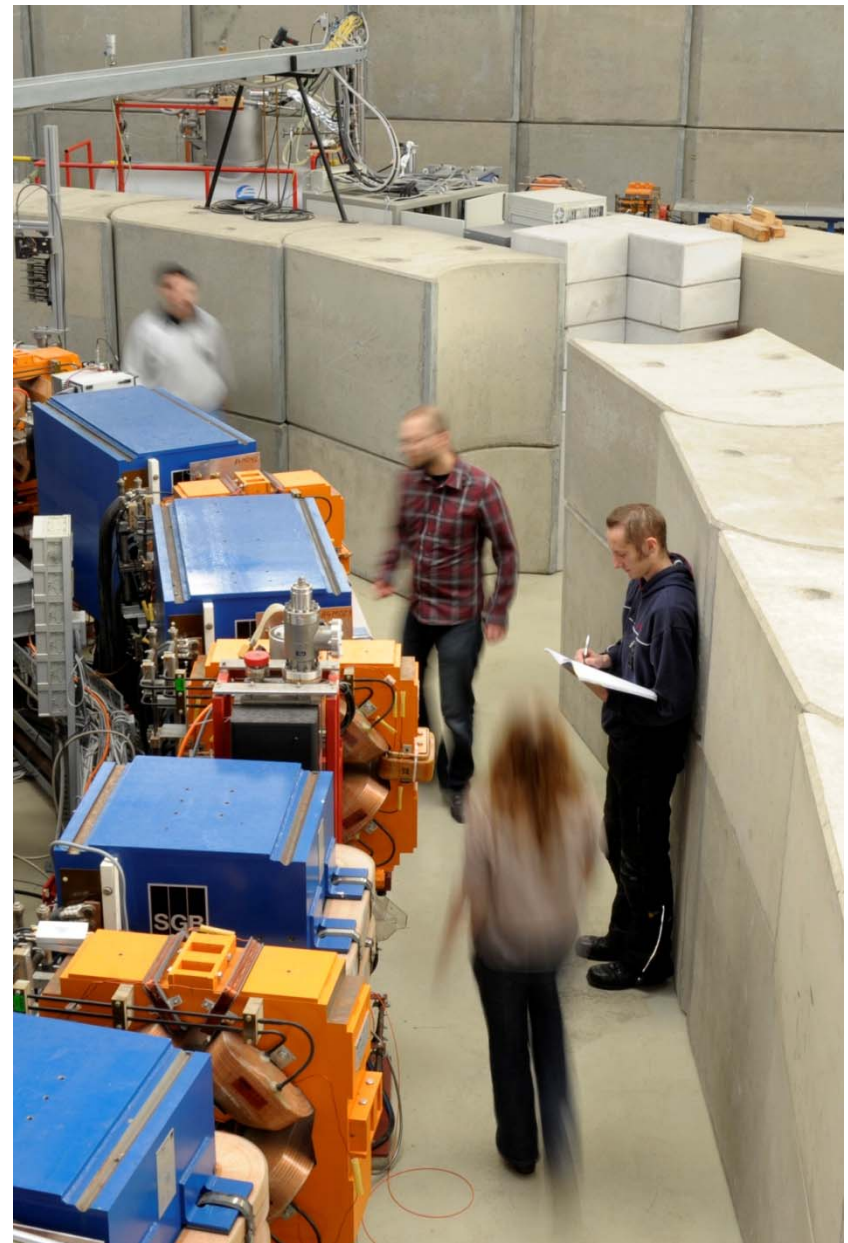
- all storage ring dipoles refurbished
- replace sextupole coils by better design
- magnet and vacuum chamber alignment
- new kicker pulsers underway
- storage ring optics under study
- new concept of timing system
- improvement of control system
- rf phase modulation to improve lifetime

Upgrade program

- new electron gun for hybrid fill patterns
- fast orbit correction system
- bunch-by-bunch feedback systems

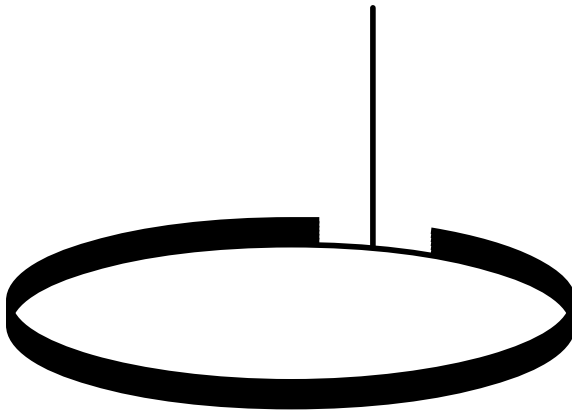
Mayor project

- ultrashort VUV and THz radiation pulses

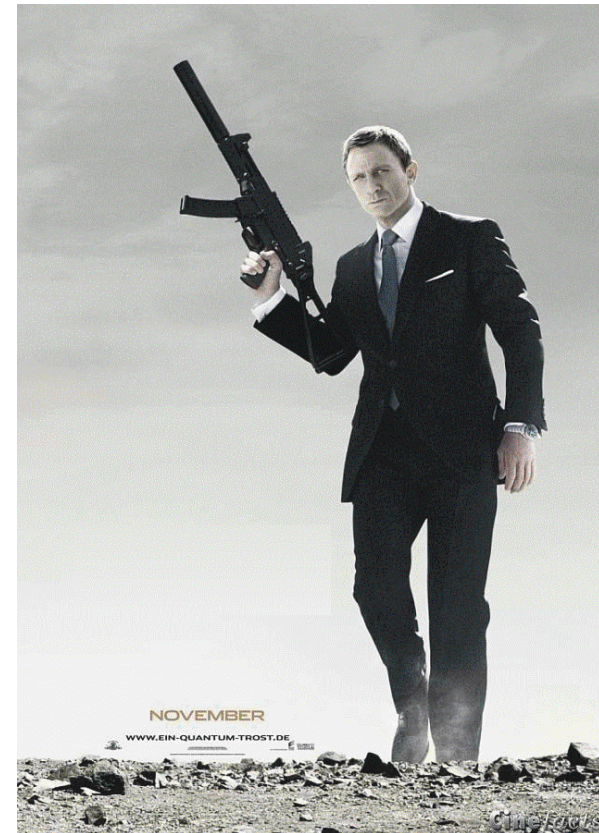


Upgrade projects

- **new electron gun** (*P. Hartmann, J. Friedl, W. Brembt*)
- **fast orbit correction** (*G. Schünemann, P. Towalski, P. Grete, P. Hartmann, T. Weis*)
- **bunch-by-bunch feedback system** (*D. Teytelman, S. Khan, B. Hippert*)

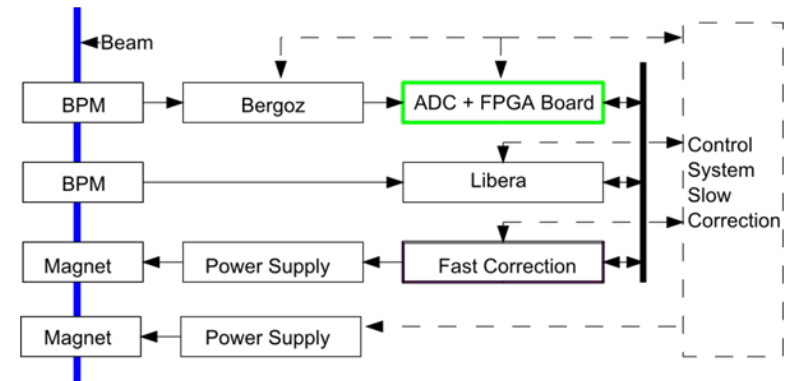
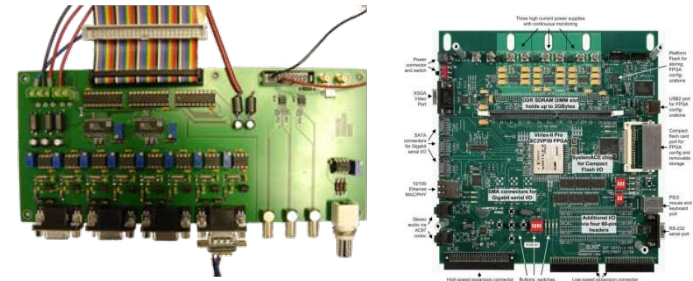
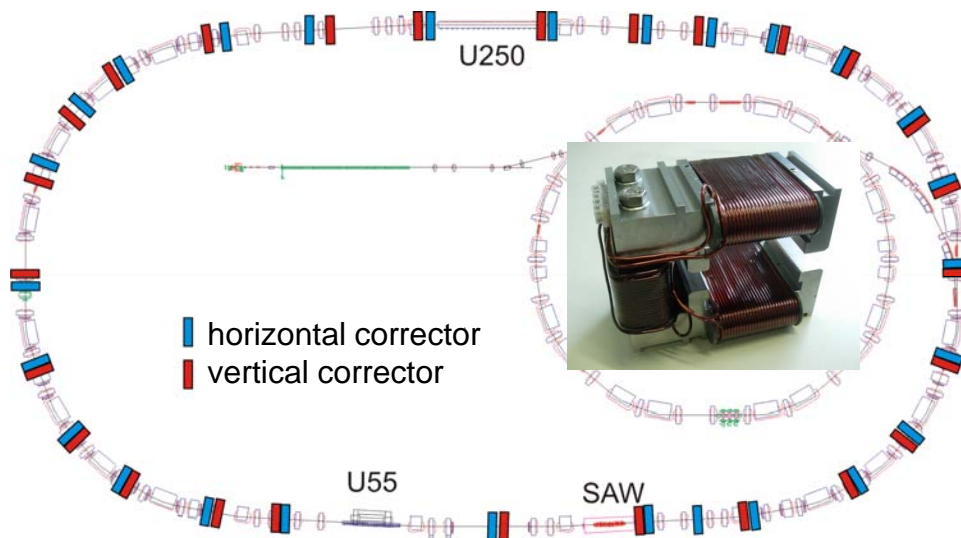


**switching between single- and multi-bunch
allows hybrid fill patterns**



Upgrade projects (adding new qualities)

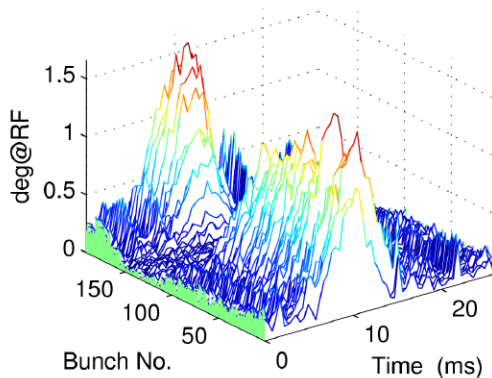
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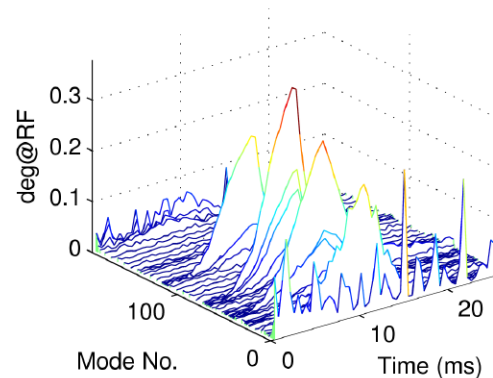
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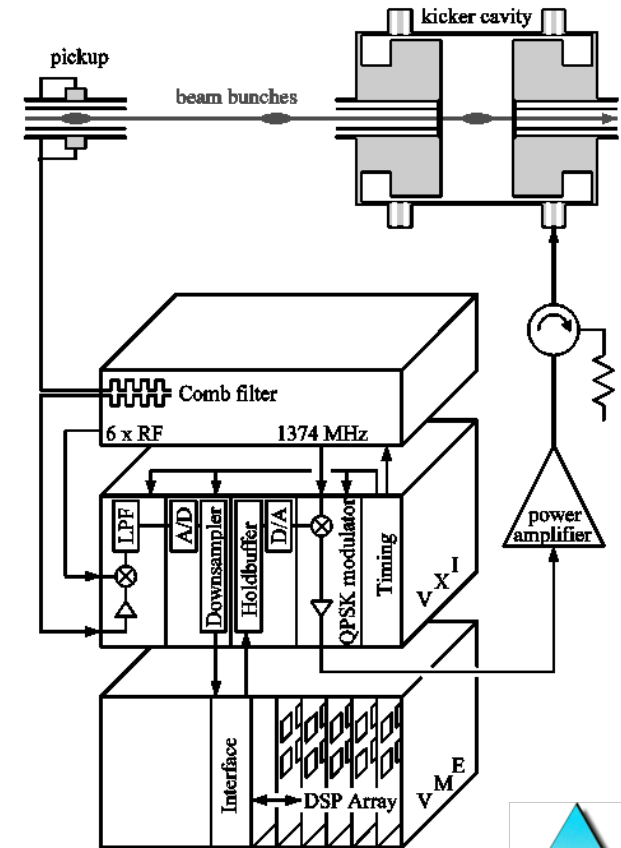
a) Osc. Envelopes in Time Domain



b) Evolution of Modes



test at DELTA in Nov 2009



Source for ultrashort radiation pulses in the vacuum-UV and THz regime (ultrashort = 50-100 fs)

- using unique features of DELTA (storage-ring FEL)
- opening up new regimes for users (100-fs timescale, THz)



electron bunch ~ 100 ps (FWHM)

laser pulse ~ 50 fs



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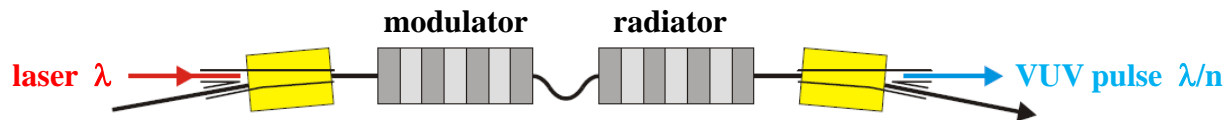
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Source for ultrashort radiation pulses in the vacuum-UV and THz regime

(a) Coherent harmonic generation (CHG)

- proof-of-principle demonstrated (ELETTRA, UVSOR-II)
- funded (DFG major instrumentation program Art. 91 GG)



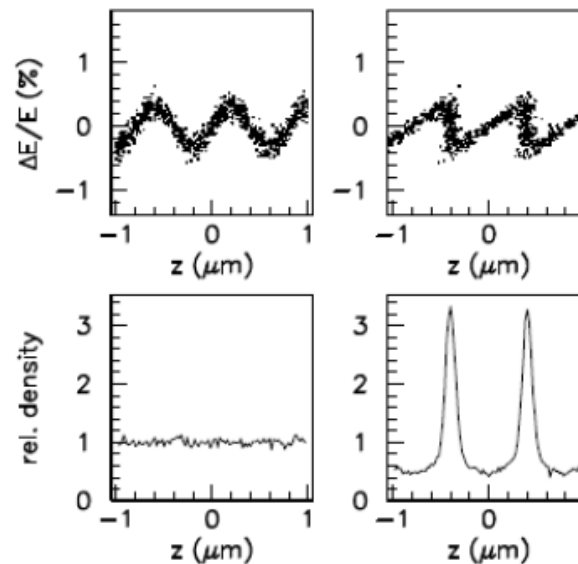
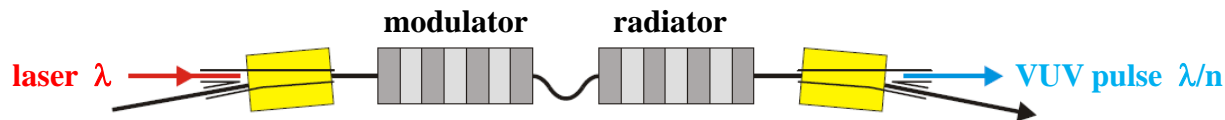
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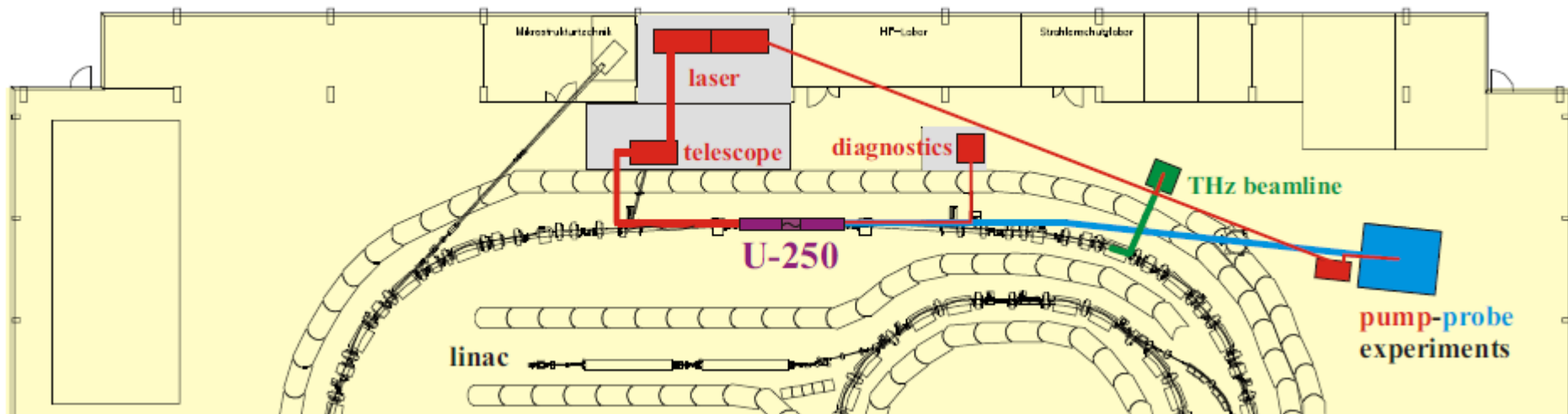
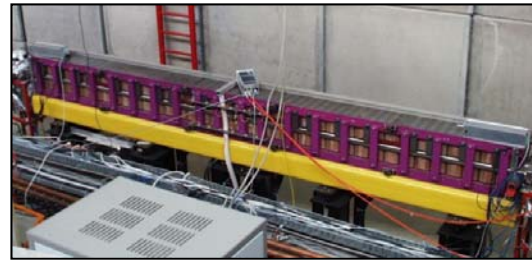
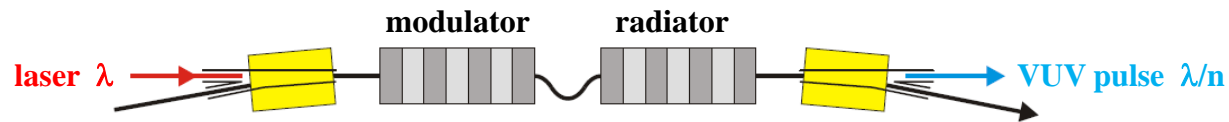


- wavelength conversion ($n \sim 5$)
- high intensity
- ultrashort pulses
- high transverse coherence
- laser-synchronized
- FEL seeding scheme (HGHG)

Source for ultrashort radiation pulses in the vacuum-UV and THz regime

(a) Coherent harmonic generation (CHG)

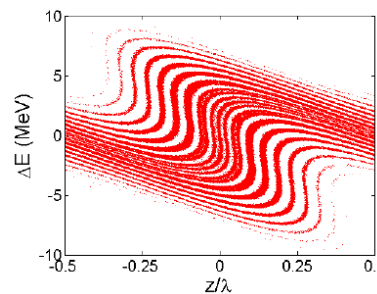
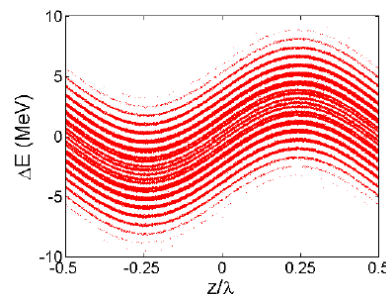
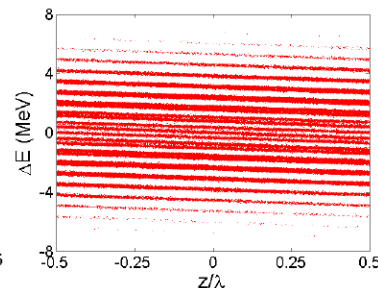
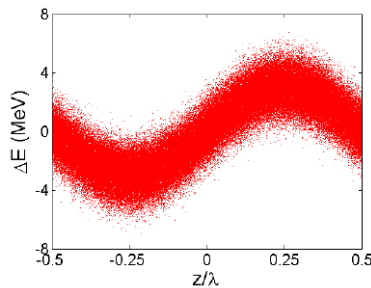
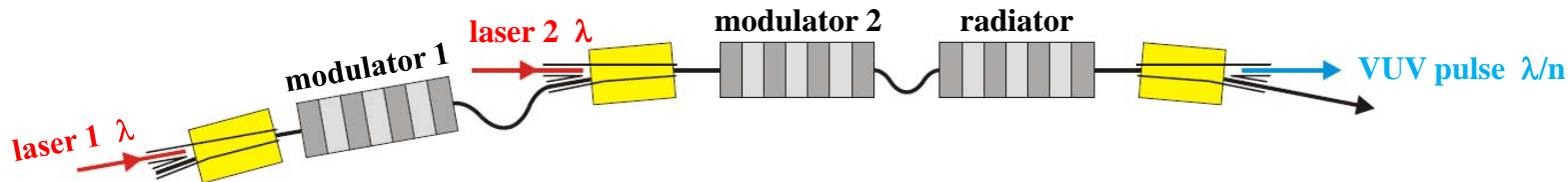
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- funded (DFG major instrumentation program Art. 91 GG)



Source for ultrashort radiation pulses in the vacuum-UV and THz regime

(b) Echo-enabled harmonic generation (EEHG)

- recently proposed [G. Stupakov, PRL 102 (2009), 074801]
- under study at linacs [D. Xiang et al., PRL 105 (2010), 114801]
- requires addition funding (undulator, vacuum chamber, ...)



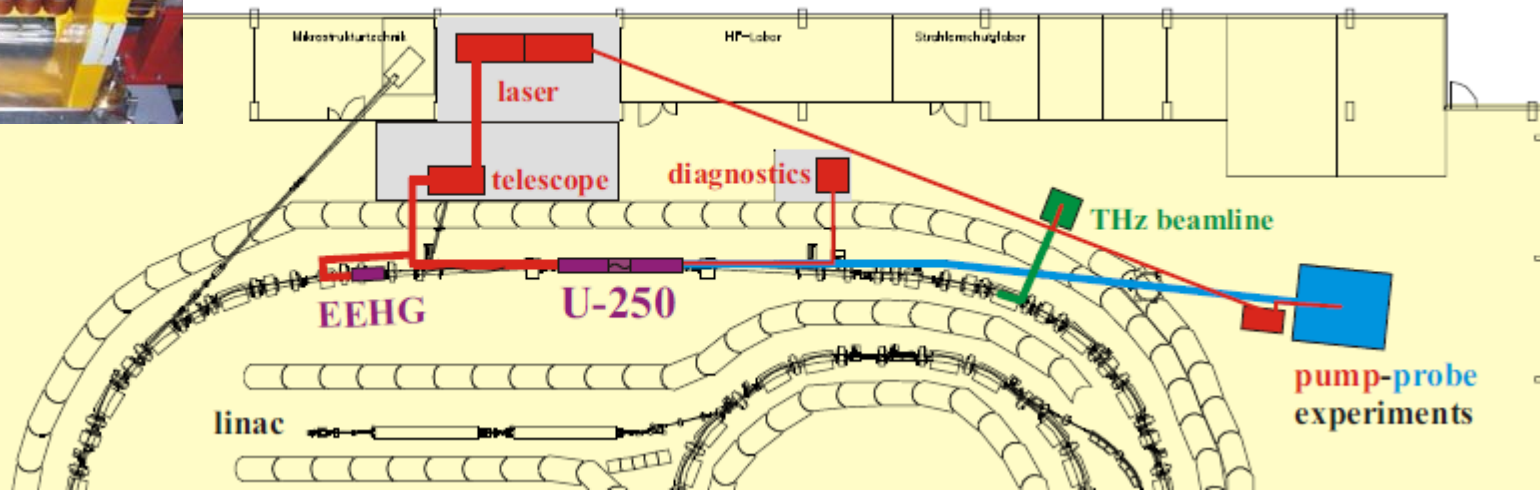
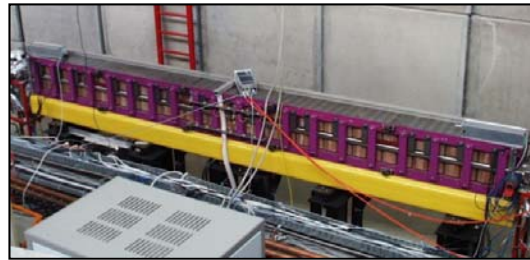
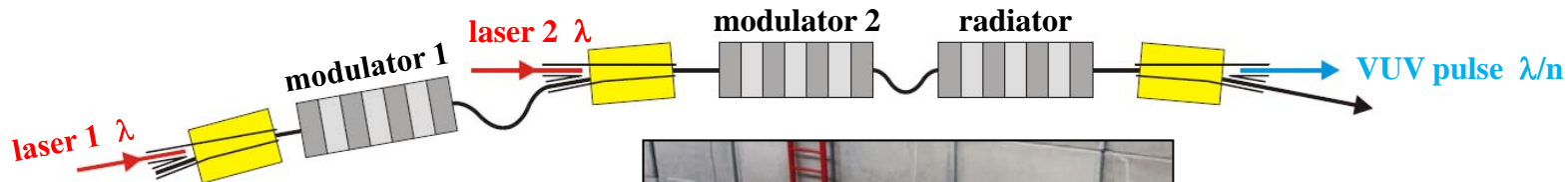
- wavelength conversion ($n \sim 30$)
- high intensity
- ultrashort pulses
- high transverse coherence
- laser-synchronized
- new FEL seeding scheme

simulations
by D. Xiang and
G. Stupakov (2009)

Source for ultrashort radiation pulses in the vacuum-UV and THz regime

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Source for ultrashort radiation pulses in the vacuum-UV and THz regime

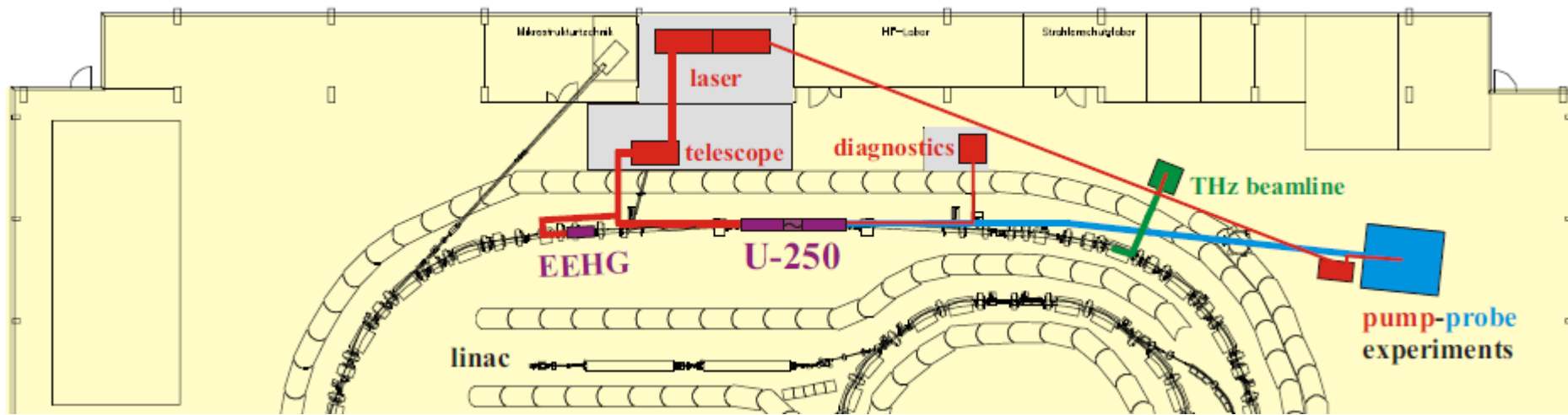
(c) Coherent radiation in the Terahertz regime

- routinely used (BESSY, ALS, SLS)
- diagnostics for laser-electron overlap
- time-resolved far-IR studies
- funded (DFG Art. 91 GG + BMBF)

electron bunch ~ 100 ps (FWHM)

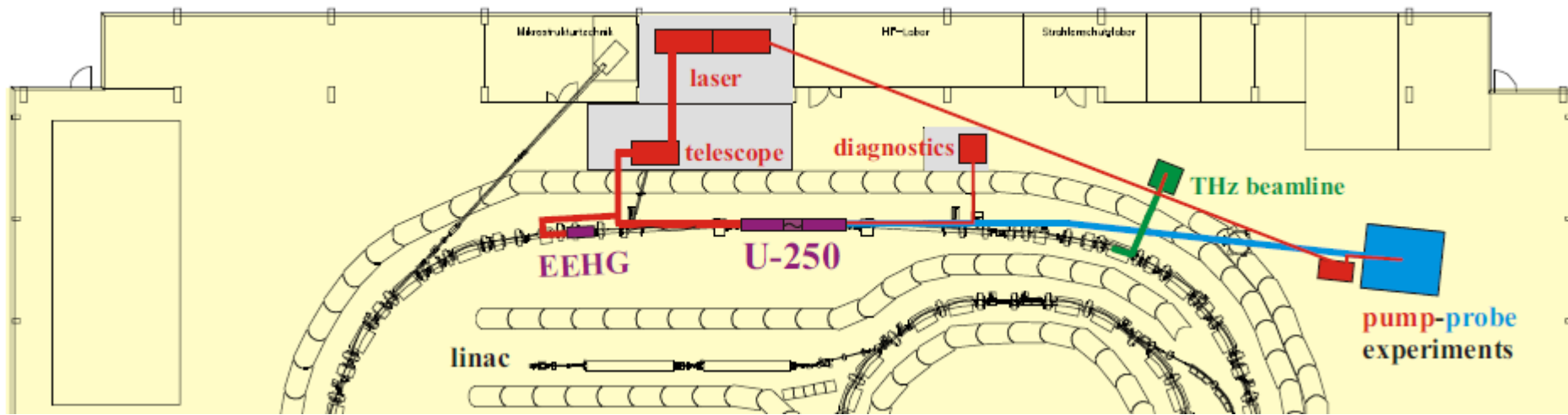
gap ~ 300 fs

- broad spectrum
- high intensity
- short pulses < 1 ps
- laser-synchronized
- FEL bunch diagnostics



Source for ultrashort radiation pulses in the vacuum-UV and THz regime

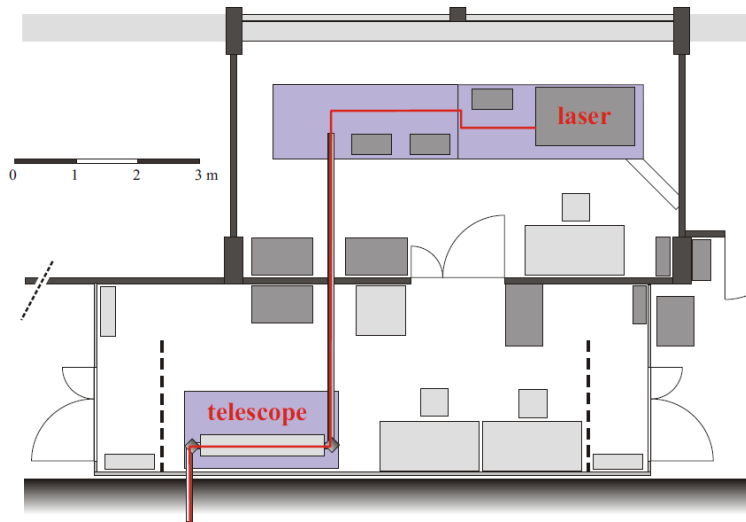
- **undulator upgrade to 800 nm wavelength**
(*G. Dahlmann, H.-P. Ruhl*)
- **laboratory with electricity, air-condition, cooling water etc.**
(*H. Huck, J. Friedl, A. Schick, P. Kortmann, H.-P. Ruhl, G. Dahlmann, Department 6, BLB*)
- **laser system, frequency conversion, OPA**
(*A. Schick*)
- **laser manipulation, diagnostics**
(*H. Huck, A. Schick*)
- **telescope and evacuated laser beamlines**
(*H. Huck, D. Schirmer, A. Schick, M. Zeinalzadeh, B. Hippert, S. Cramm/FZJ*)
- **THz beamline, detection, spectrometer**
(*M. Höner, P. Ungelenk, B. Hippert*)
- **simulations, EEHG upgrade**
(*M. Höner, R. Molo, P. Ungelenk, B. Hippert*)



Source for ultrashort radiation pulses in the vacuum-UV and THz regime

Titanium:sapphire laser system

mode-locked oscillator + 5 W Nd:YVO4 pump
 regenerative CPA amplifier + 45 W Nd:YLF pump
 upgradable to CEP stabilization
 wavelength 790 nm
 pulse energy 2-8 mJ
 repetition rate 1-5 kHz
 pulse duration 25-35 fs



"laser lab" and "telescope lab"
 55 square meter, air-conditioned

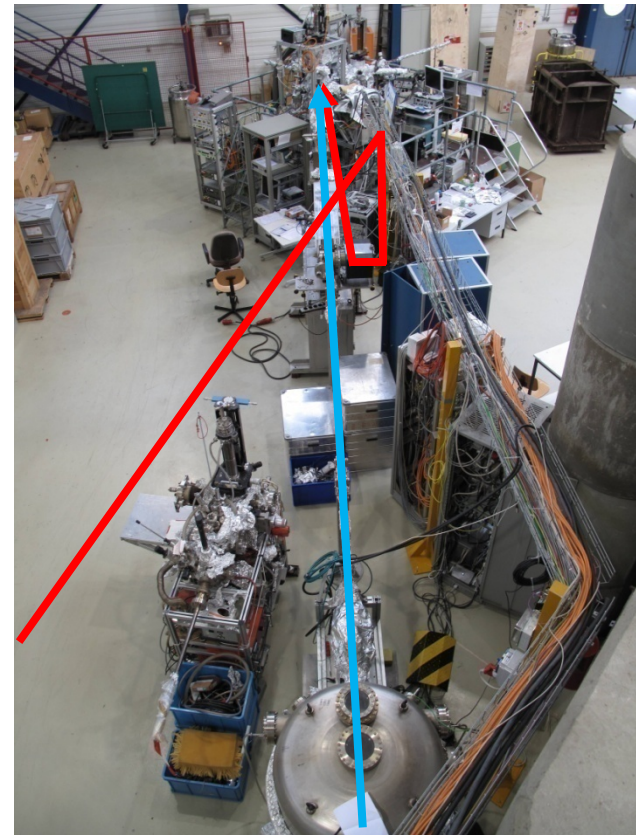


Source for ultrashort radiation pulses in the vacuum-UV and THz regime

New laser/telescope lab and U-250



beamline BL-5



Long-term program with storage ring & laser infrastructure

■ laser-electron interaction

- ultrashort pulses for users (short wavelength, shorter pulse length)
- femtoslicing (far future)
- study FEL seeding schemes
- study Inverse FEL process
- gamma pulses by Compton scattering
- optical stochastic cooling
- timing and synchronization
- innovative beam diagnostics (ORS, EOS, laser wire, etc)

■ Terahertz detection and spectroscopy

- short pulses for users
- electron bunch diagnostics
- study THz bursts, beam dynamics, instabilities

■ additional laser experiments

- laser spectroscopy
- few-cycle pulses, CEP stabilization, attosecond physics
- laser-based acceleration (far future)



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Interdisciplinary education and training

- accelerator physics
- femtosecond laser physics
- synchrotron radiation research



Summary and conclusions

- smooth user operation
- improvements and upgrades underway
- unique source for ultrafast radiation pulses under construction
- collaborations (GSI, FZJ, HZB, DESY, KIT)

DELTA accelerator crew

Wolfgang Brembt, Günther Dahlmann, Thomas Dybiona, Alessandro Ferrarotto, Jonathan Fürsch, Andreas Erpelding, Jochem Friedl, Patrick Grete, Kirsten Hacker, Peter Hartmann, Bernhard Hippert, Markus Höner, Shaukat Khan, Vadim Kniss, Peter Kortmann, Robert Molo, André Nowaczyk, Helge Rast, Bernhard Riemann, Hans-Peter Ruhl, Detlev Schirmer, Gerald Schmidt, Gerrit Schönemann, Patrick Towalski, Thomas Weis, Klaus Wille, Peter Ungelenk

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- DESY and University of Hamburg
- and many colleagues elsewhere



