

DELTA: Status and New Developments

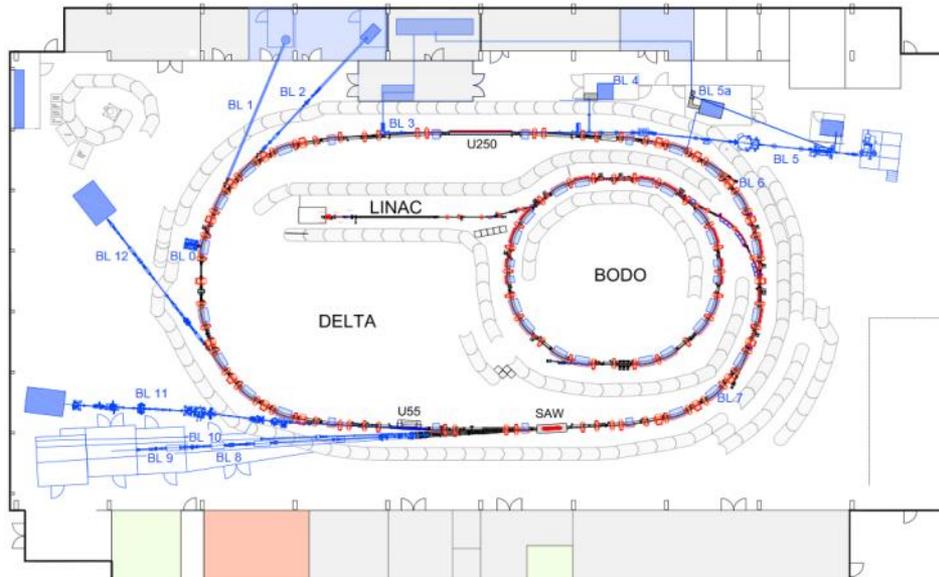
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Shaukat Khan, Zentrum für Synchrotronstrahlung

Dortmund, Nov 27, 2018

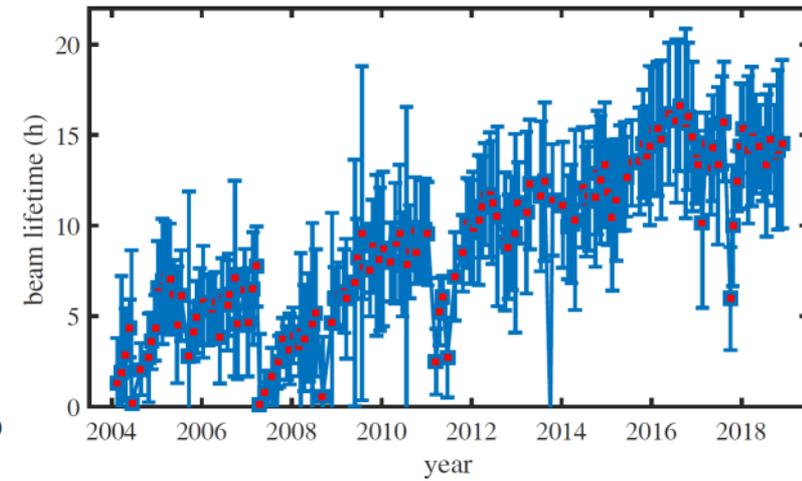
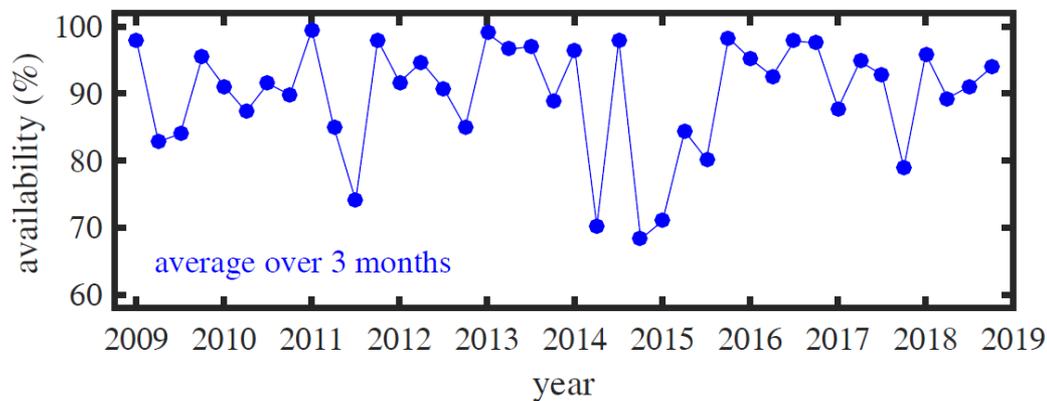


Parameters and availability



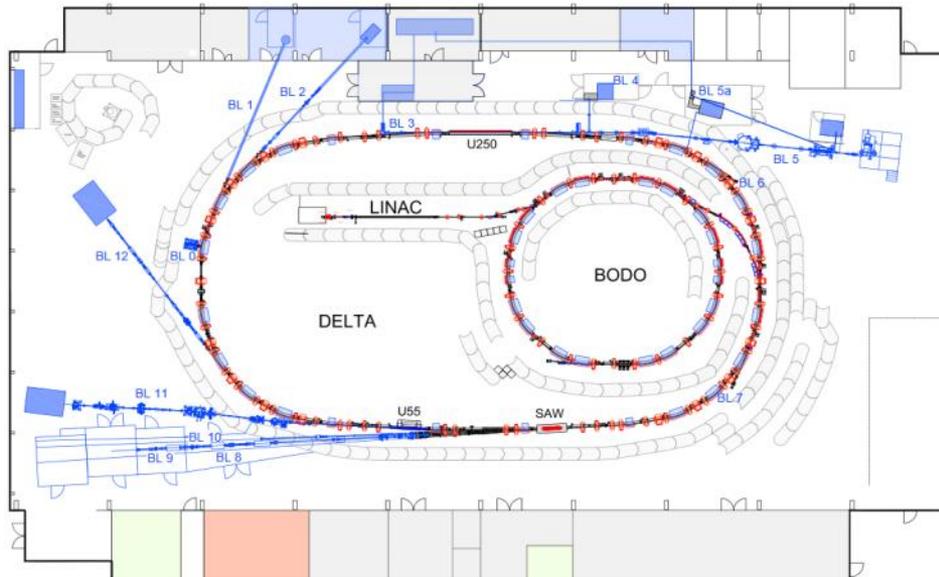
Parameters

circumference	115.2 m
beam energy	1.5 GeV
beam current	130 mA multi-bunch
beam current	20 mA single bunch
beam lifetime	~14 h at 100 mA
hor. emittance	~16 nm rad
bunch length	40 ps rms
user operation	2000 h/y (20 weeks/y)
machine studies	1000 h/y (10 weeks/y)



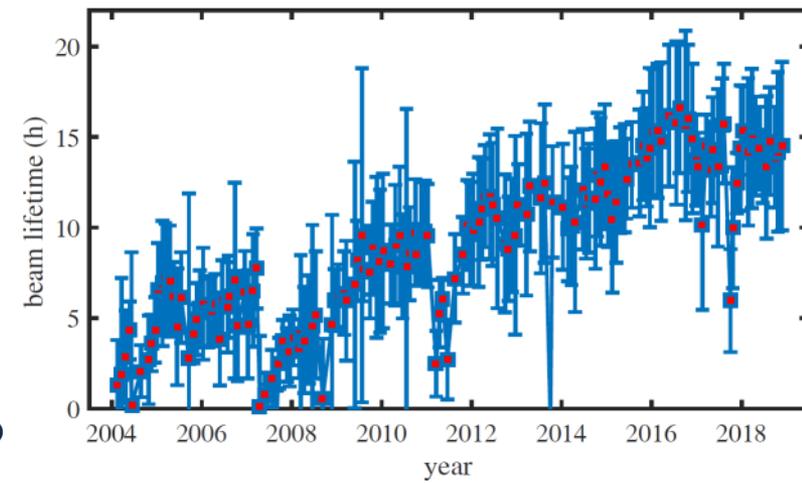
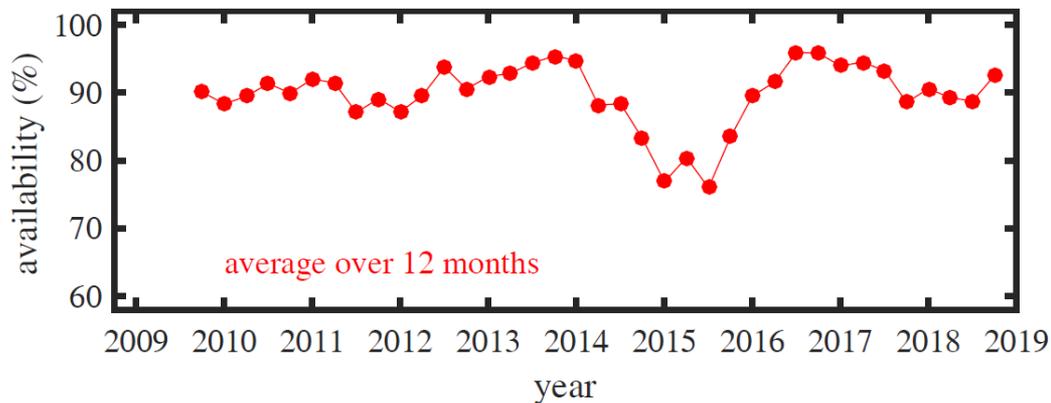
(J. Friedl, G. Schmidt)

Parameters and availability



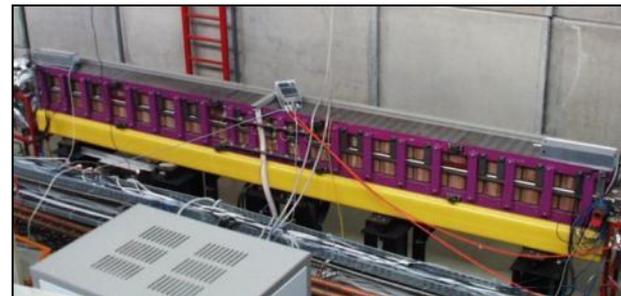
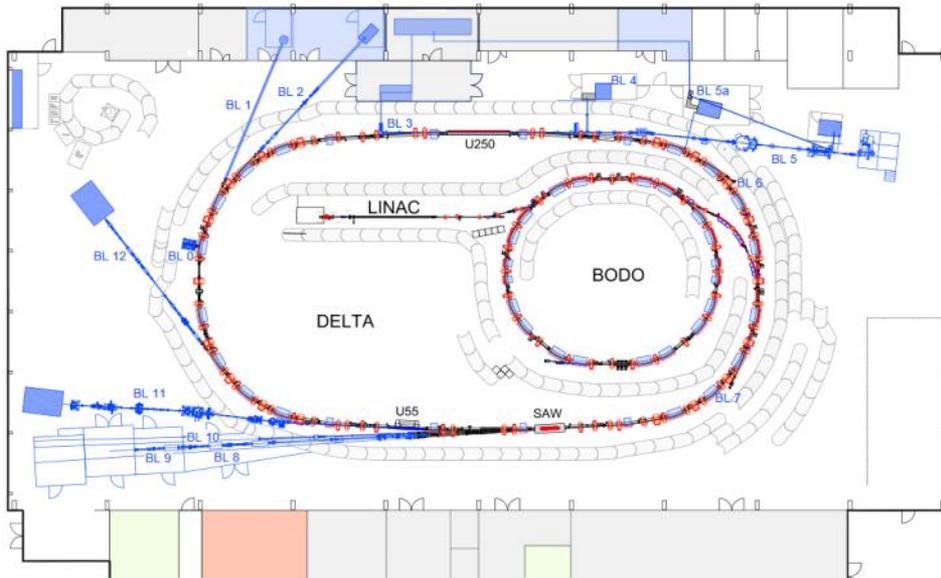
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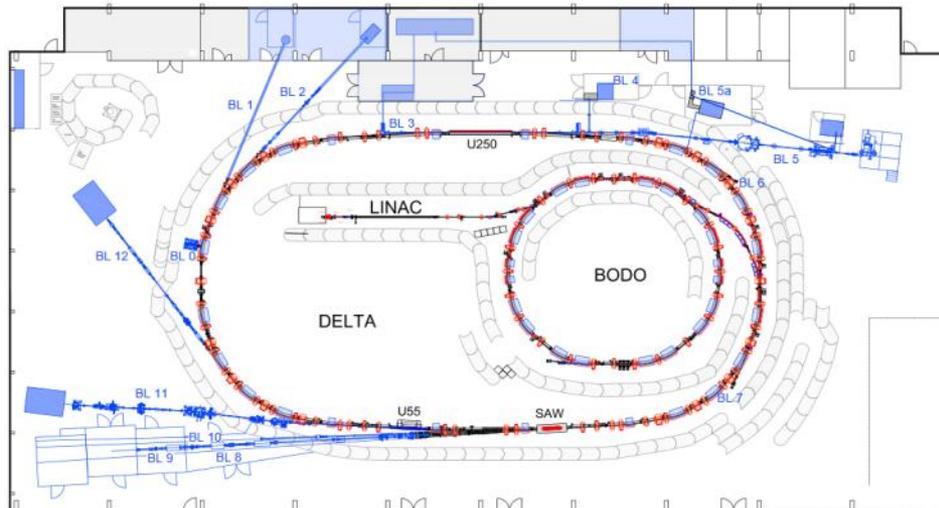


(J. Friedl, G. Schmidt)

Insertion devices



Insertion devices



New superconducting wiggler delivered in July 2018

configuration:
asymmetric → symmetric

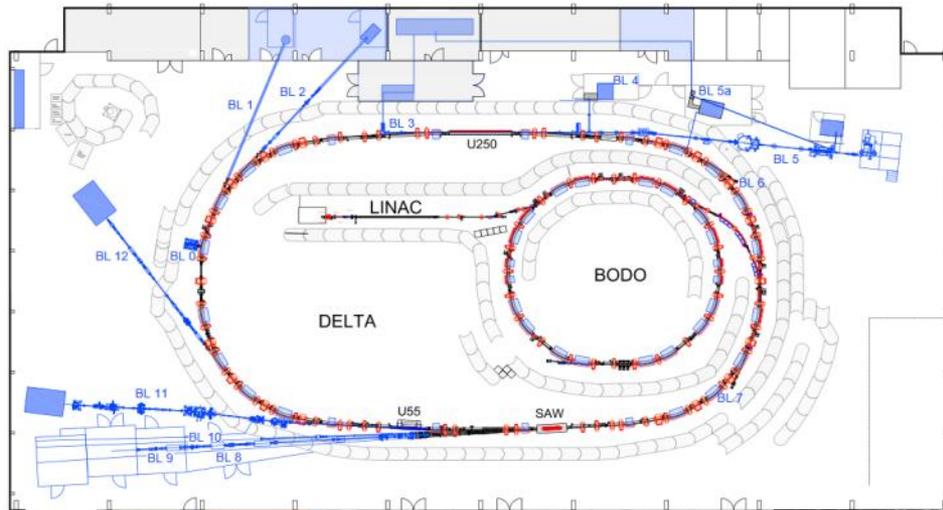
magnetic field
5.3 T → 7 T

periods
5 → 9

He consumption
130 l/week → none

(B. Beyer, W. Brembt, P. Hartmann, B. Hippert, S. Khan, V. Kniss, P. Kortmann, M. Paulus, D. Schirmer, G. Schmidt, C. Sternemann, M. Tolan + BINP team)

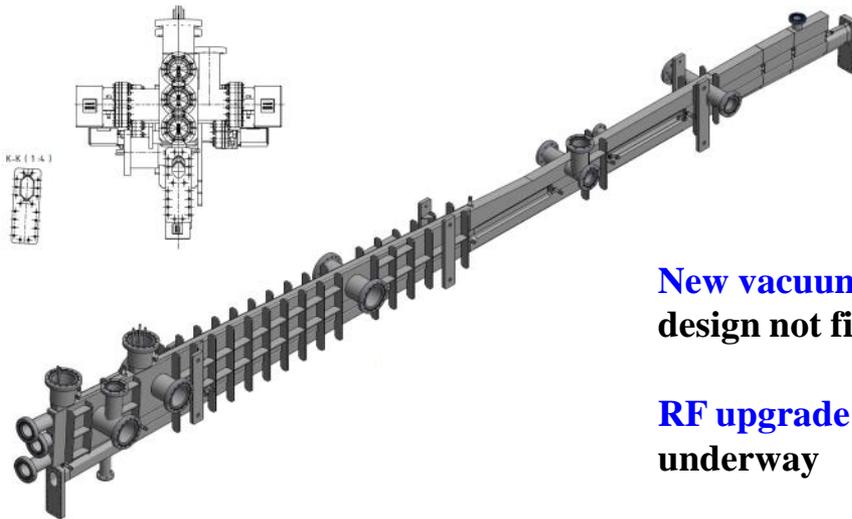
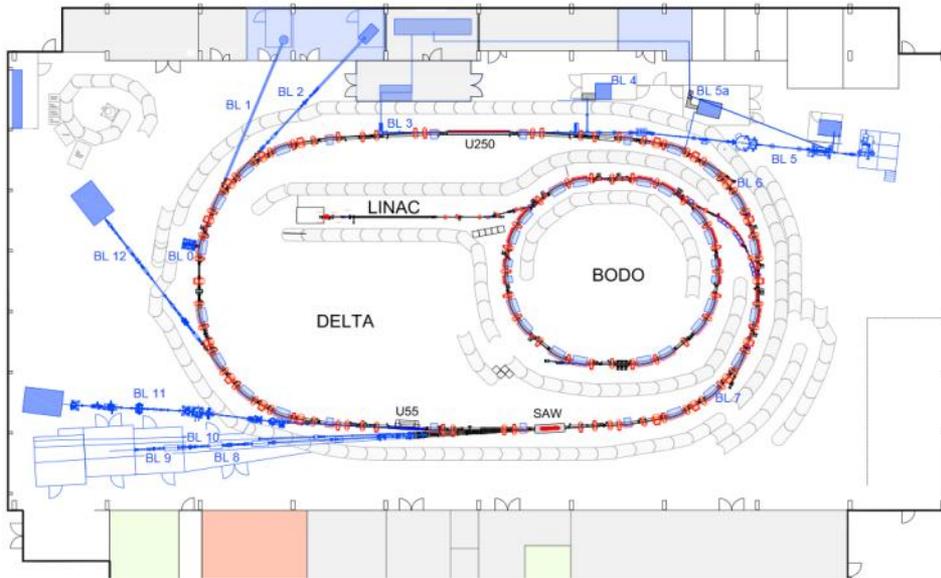
Insertion devices: Superconducting wiggler



(B. Beyer, W. Brembt, P. Hartmann, B. Hippert, S. Khan, V. Kniss, P. Kortmann, M. Paulus, D. Schirmer, G. Schmidt, C. Sternemann, M. Tolan + BINP team)



Insertion devices: Superconducting wiggler



New vacuum chambers design not finalized

RF upgrade underway

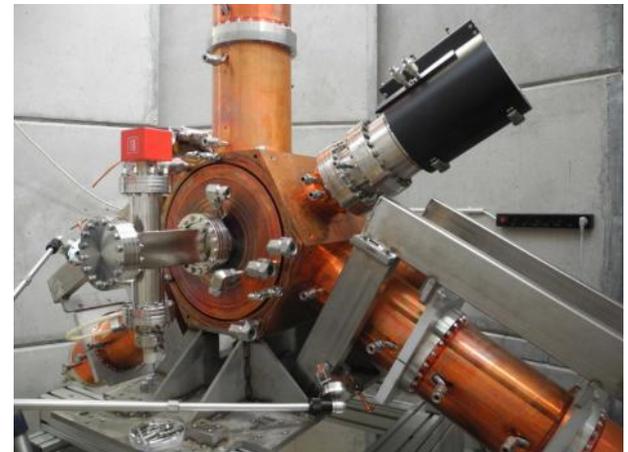
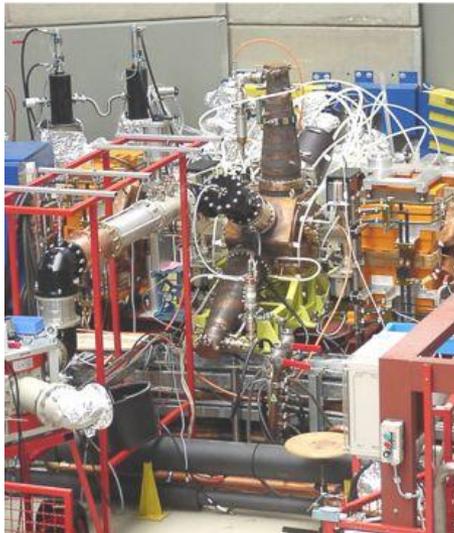
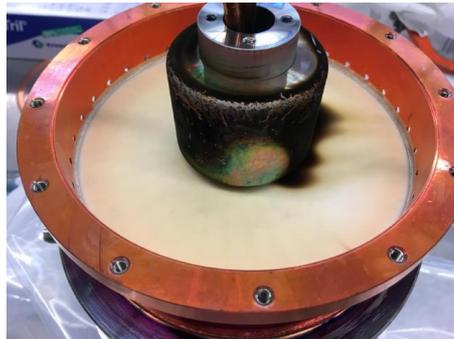
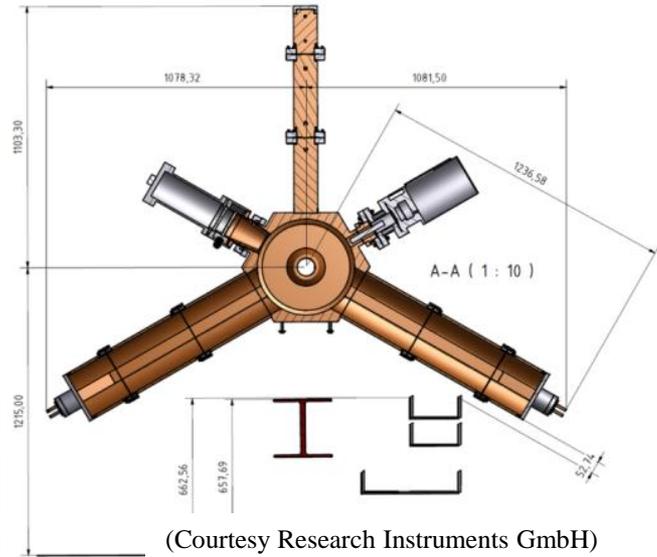


RF upgrade

(W. Brembt, P. Hartmann, V. Kniss, T. Weis)

500 MHz European HOM-damped cavity
delivered and conditioned in 2018
problem with coupler
(but help from BESSY!)

500 MHz solid-state amplifiers
installed in 2017
- 75 kW for the storage ring
- 20 kW for the booster



EU cavity prototype tested at DELTA > 10 years ago

Alignment of the storage ring

(U. Berges, G. Dahlmann, T. Dybiona, B. Isbarn, B. Hippert, P. Kortmann, G. Pike**,
H. Rast, G. Schmidt, T. Schulte-Eickhoff; **Faculty of Physics, TU Dortmund)

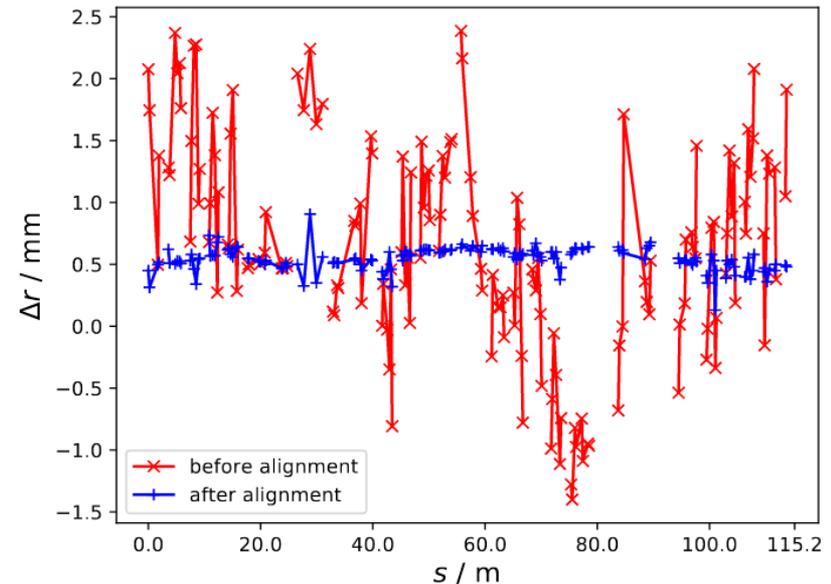


Vertical alignment completed in 2013

- improved stability, radiation level, lifetime ...

Horizontal alignment completed in 2018

- 180 reference panels for Taylor-Hobson spheres
- laser tracker



Orbit stability

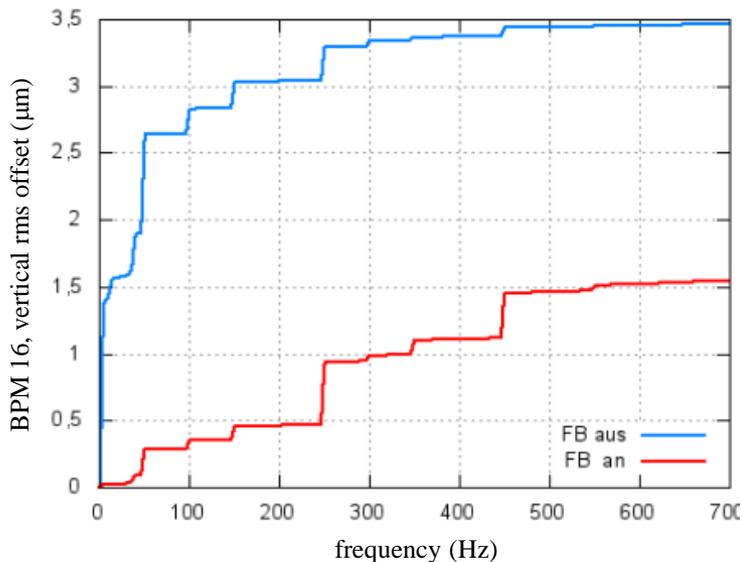
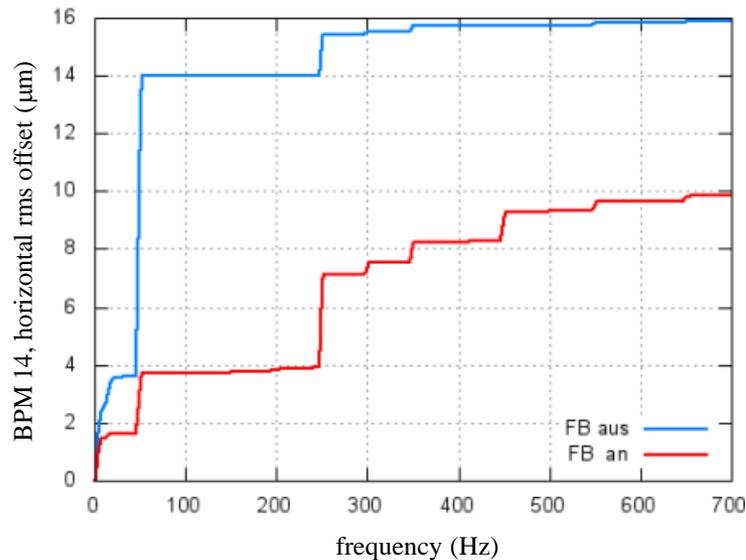
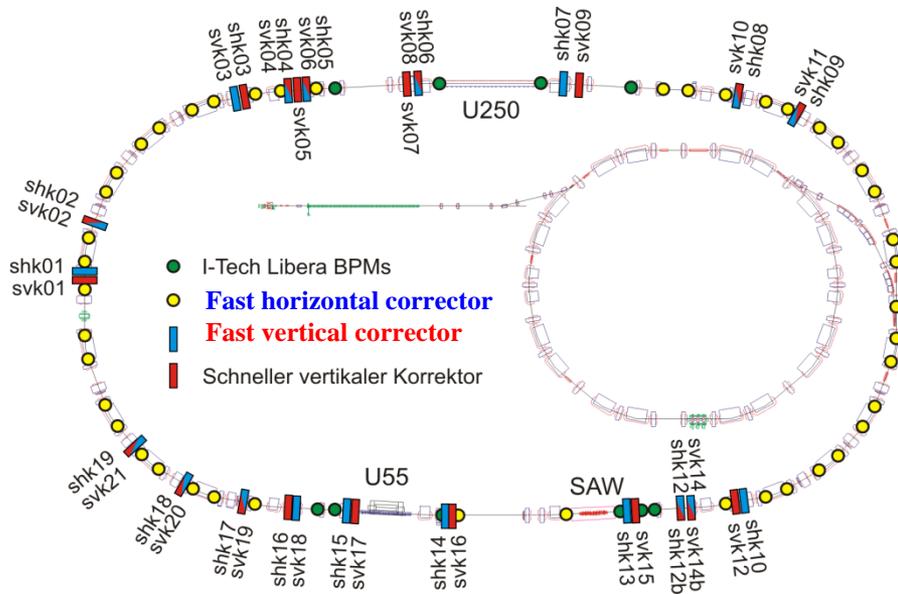
(P. Hartmann, S. Kötter, D. Rohde, G. Schünemann, P. Towalski, T. Weis)

Slow orbit feedback

- new software underway
- (talk by S. Kötter)

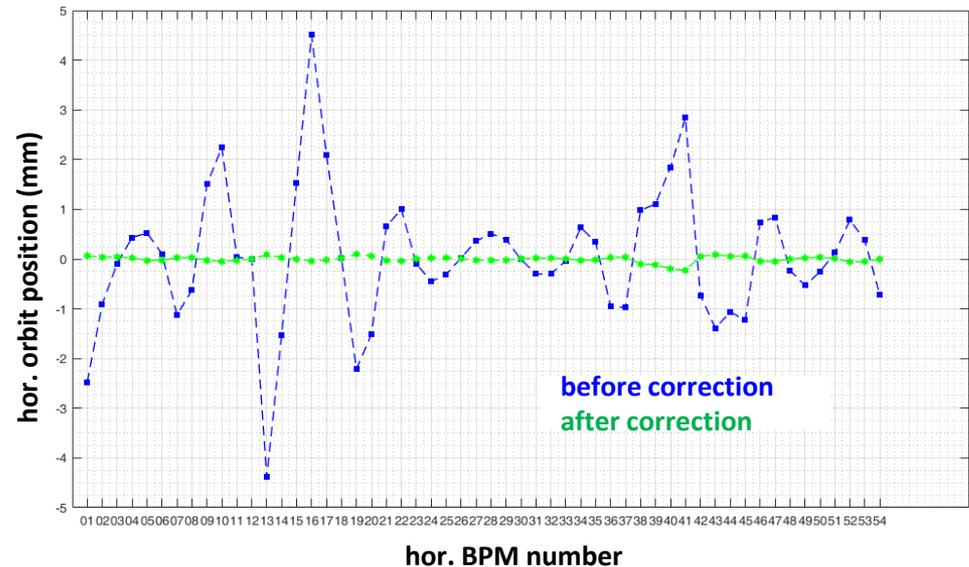
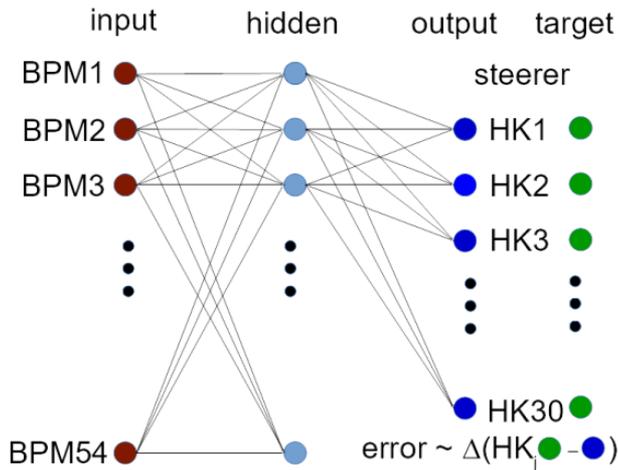
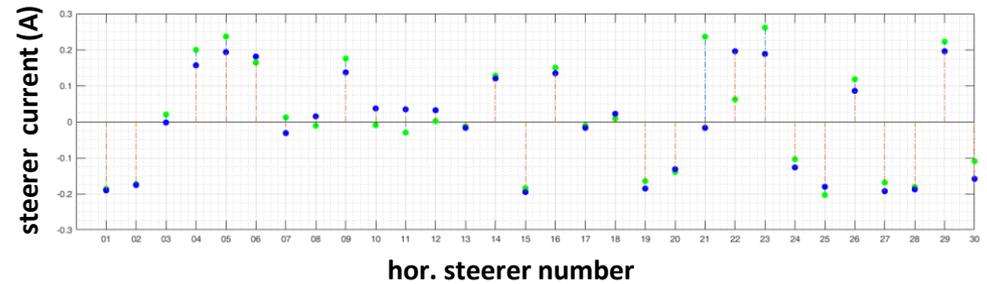
Fast orbit feedback

- completed
- under test



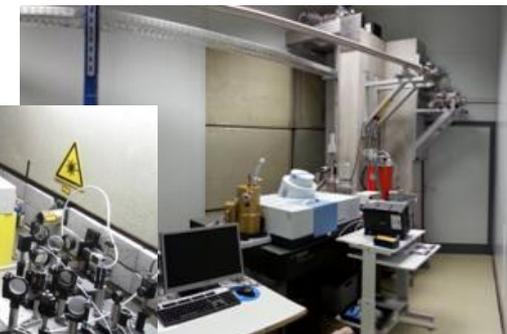
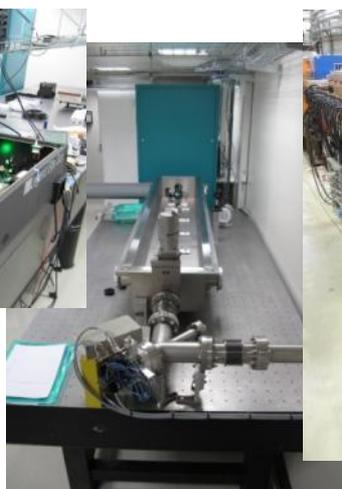
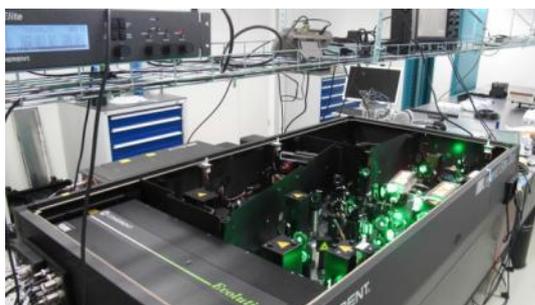
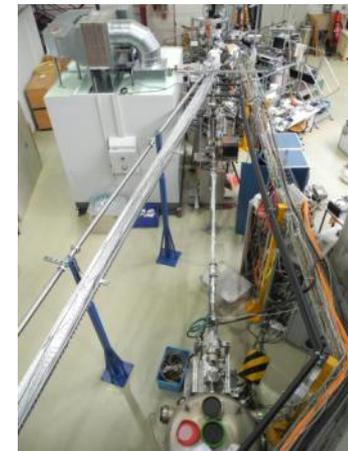
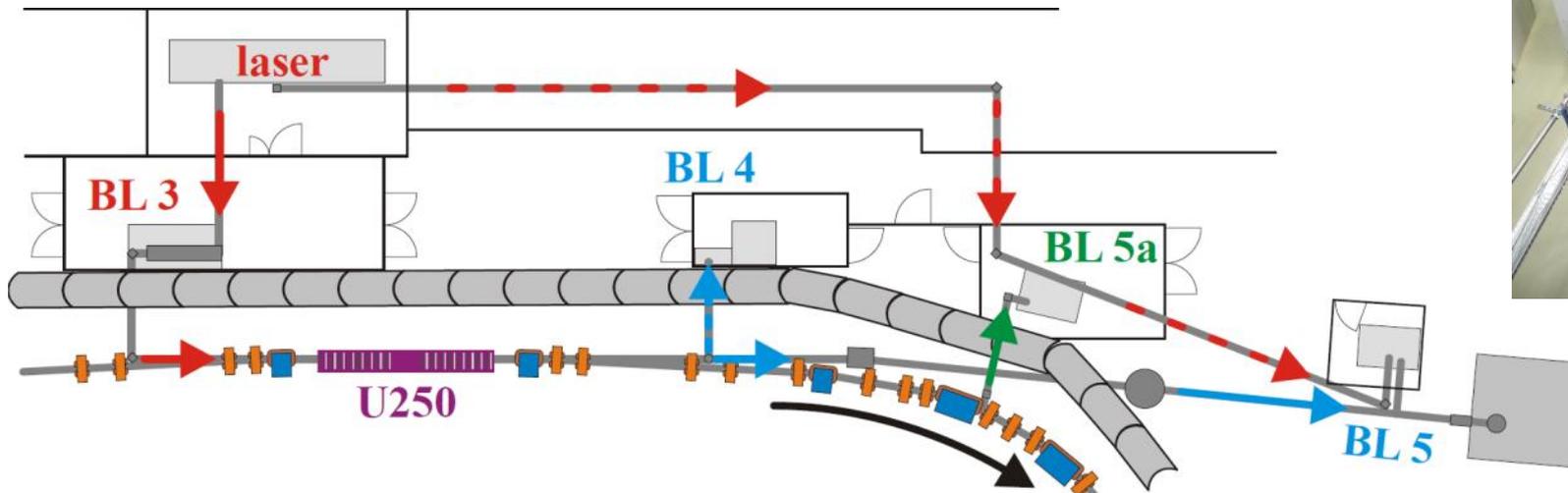
(D. Schirmer)

Successful application of feedforward neural net (FFNN)
trained with ~ 1500 random steerer settings (1 shift)
orbit correction similar to SVD results



Facility for ultrashort VUV and THz pulses

B. Büsing, N. Lockmann, S. Khan, D. Krieg, C. Mai, A. Meyer auf der Heide, B. Riemann, B. Sawadski, M. Schmutzler, F. Teutenberg [TU Dortmund]
 S. Cramm, L. Plucinski, C. Schneider [FZ Jülich and U Duisburg-Essen]
 M. Cinchetti, S. Ponzoni [TU Dortmund]



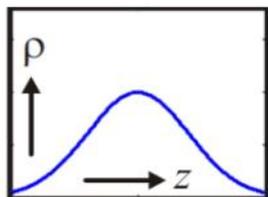
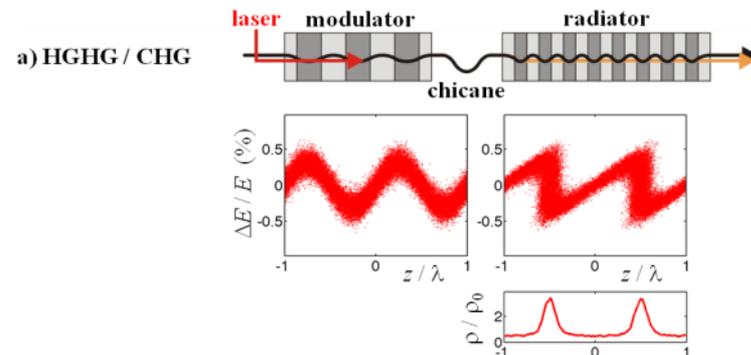
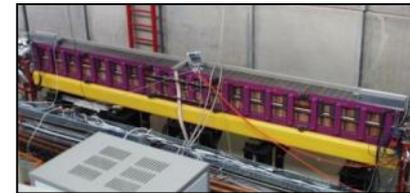
Facility for ultrashort VUV and THz pulses

Coherent harmonic generation (CHG)

- laser-induced energy modulation within a bunch "slice"
- density modulation in a magnetic chicane
- coherent radiation at harmonics of the laser wavelength (so far 80 nm, goal 53 nm)

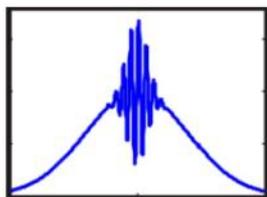
Coherent terahertz (THz) radiation

- short "dip" due to energy-dependent path length
- broadband coherent THz radiation
- narrowband coherent THz radiation from multiple dips



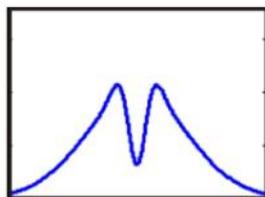
(a)

energy modulation



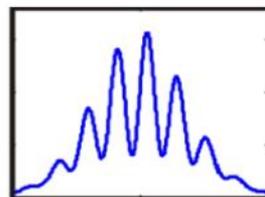
(b)

density modulation



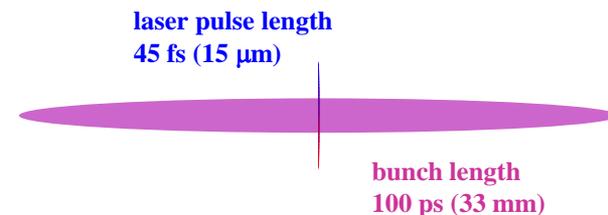
(c)

single dip



(d)

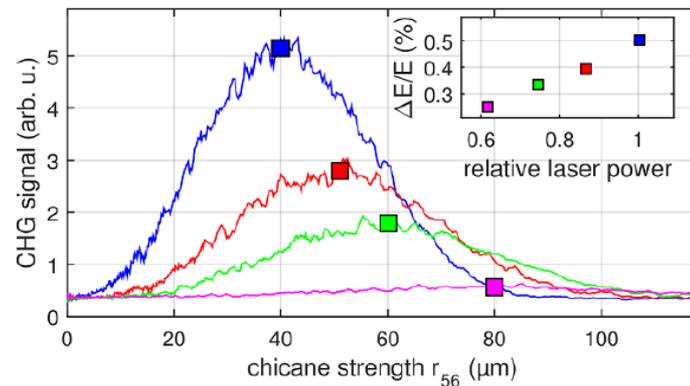
multiple dips



CHG under variation of laser power

r_{56} for optimum CHG measures energy modulation

$$\Delta z = r_{56} \cdot \frac{\Delta E}{E} \quad \Delta z \approx \frac{\lambda}{4}$$



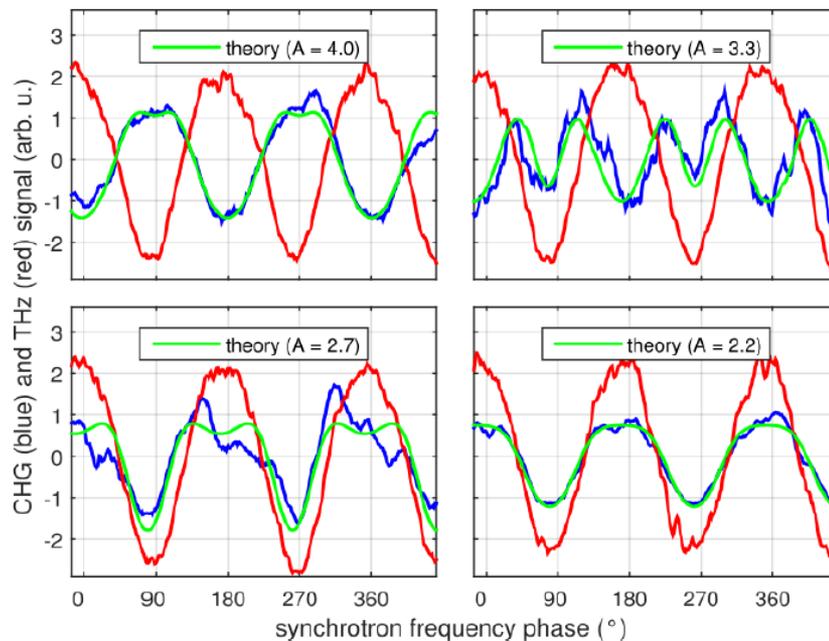
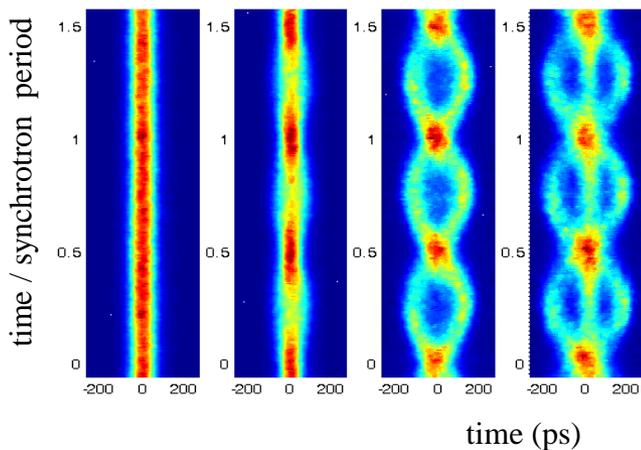
CHG with RF phase modulation

Large energy modulation:
CHG and THz signals out of phase

$$A \equiv \frac{\Delta E / E}{\sigma_E / E}$$

Small energy modulation:
CHG and THz signals in phase

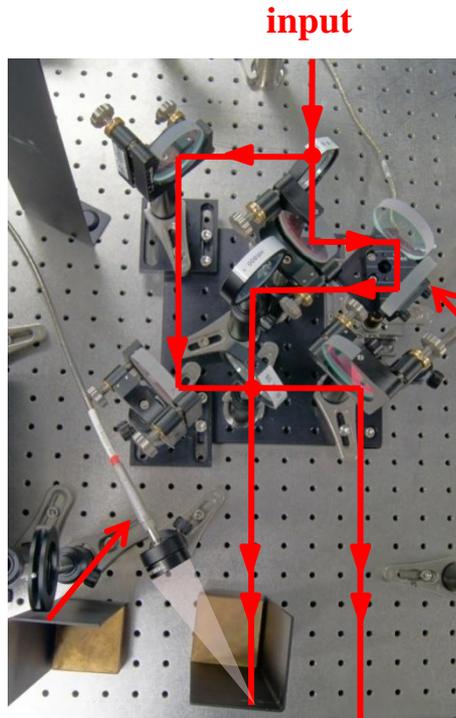
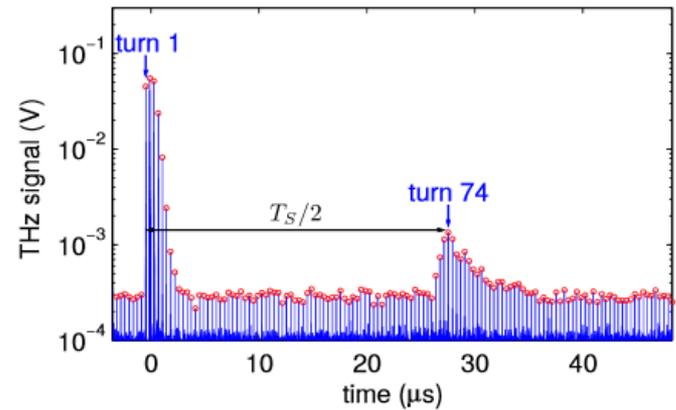
allows to determine the energy spread σ_E



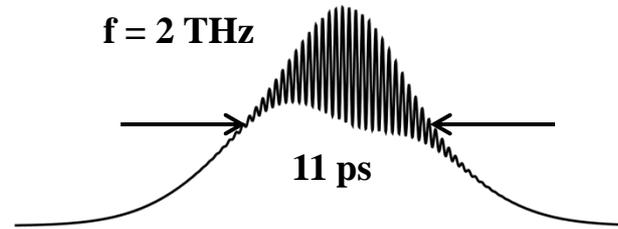
Facility for ultrashort VUV and THz pulses

Coherent emission of Terahertz radiation

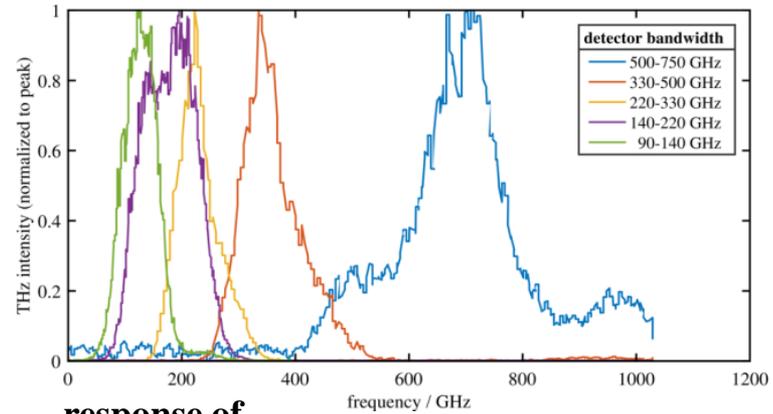
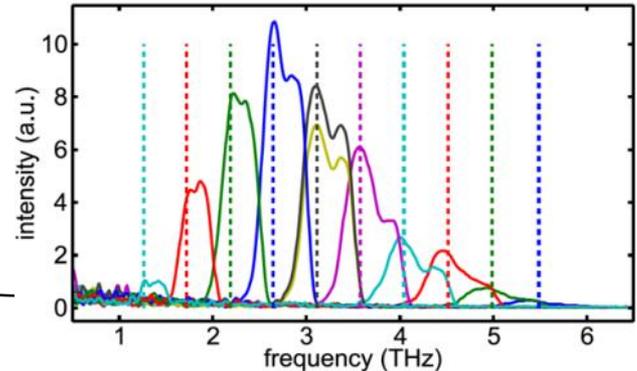
- diagnostics of laser-electron interaction
- short laser pulse: broadband THz radiation
- long modulated pulse: narrowband THz radiation
- sub-THz signal after 1/2 synchrotron period



interferometric delay measurement



motorized delay

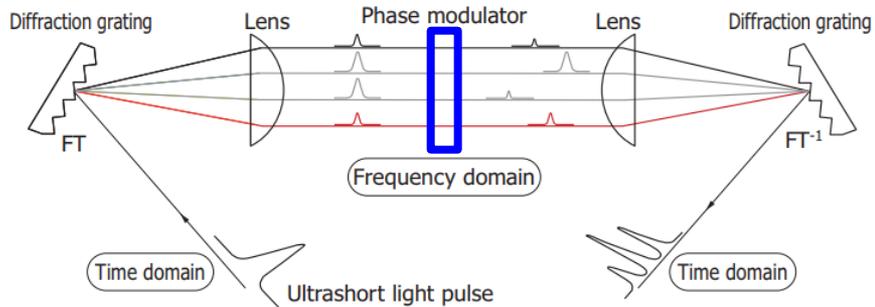
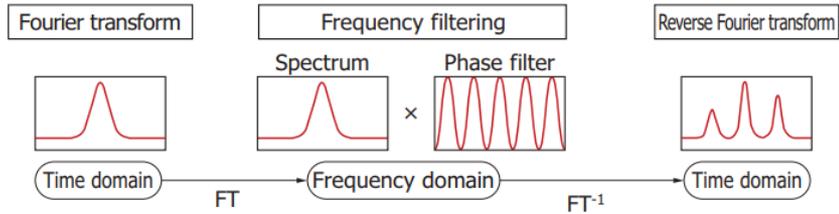


response of narrowband detectors from TU Dresden

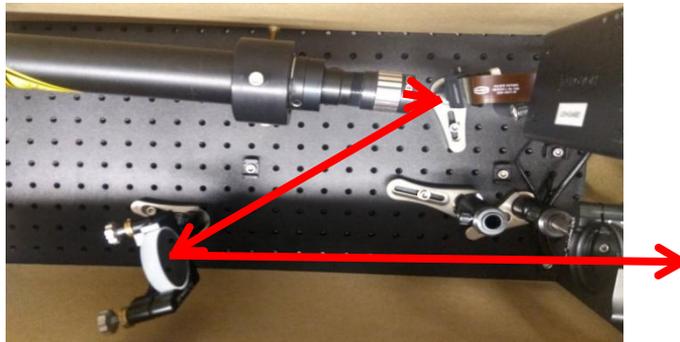


Shaping THz (and CHG) pulses

using spatial light modulators



**First test (C. Mai):
2d Fourier transform
of DELTA logo on
spatial modulator**



Echo-enabled harmonic generation at DELTA

Supported by Helmholtz ARD initiative (FZ Jülich)

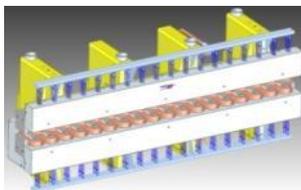
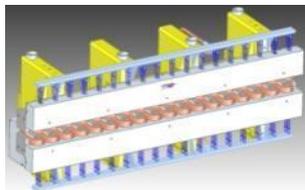
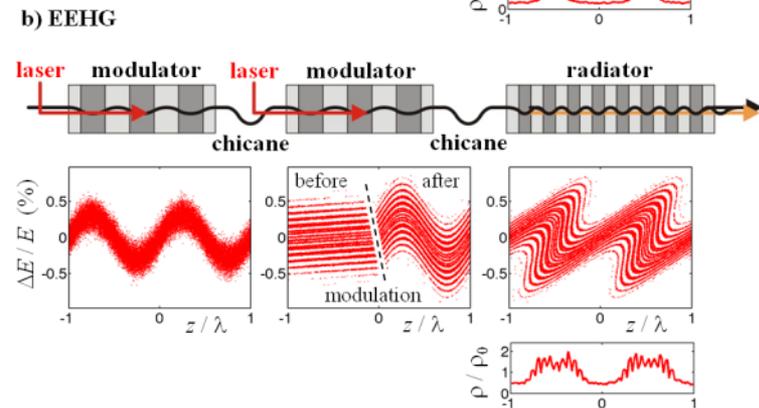
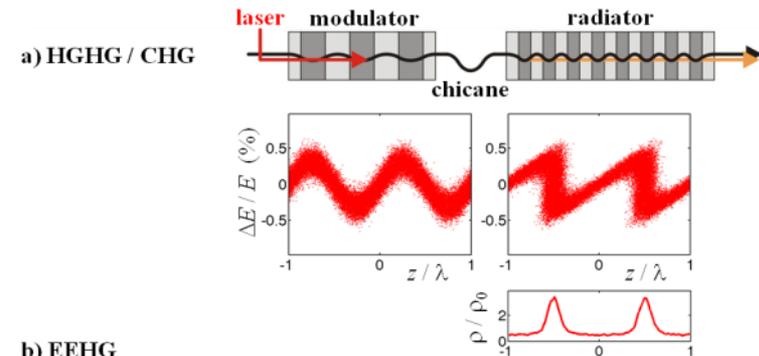
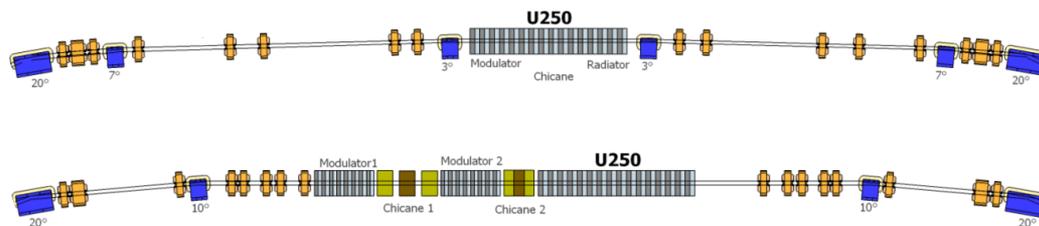
- modulators: 2 short undulators
- radiator: present U250 undulator
- requires longer straight section
- modified storage ring optics
- additional undulator for "slicing"

G. Stupakov, Phys. Rev. Lett. 102, 074801 (2009)

D. Xiang et al., Phys. Rev. Lett. 105, 114801 (2010)

Z.T. Zhao et al., Nature Photonics 6, 360 (2012)

E. Hemsing et al., Nature Photonics 10, 512 (2016)



Courtesy Scanditronix AB

Accelerator physics in the bachelor and master curriculum

Bachelor, master, doctoral theses

One-semester course on instruments

- 2 hrs lecture
- 1 hr exercises

Two-semester accelerator course

- 2 hrs lecture
- 1 hr exercises
- 1 hr seminar
- field trips
(Berlin, Hamburg, Mainz...)

Recent visit from Bad Honnef FEL School

- real-life demonstration of seeding



The Future of DELTA

1. workshop on July 15, 2016
2. workshop on February 20, 2018

- the next 10 years
- and beyond ...



A brief history of DELTA

- 1992 building completed**
- 1994 first linac beam**
- 1995 first beam in BoDo**
- 1996 beam in storage ring**
- 1998 SAW and U55 installed**
- 1999 U250, first FEL lasing**
- 2011 start-pulse facility**



Klaus Wille

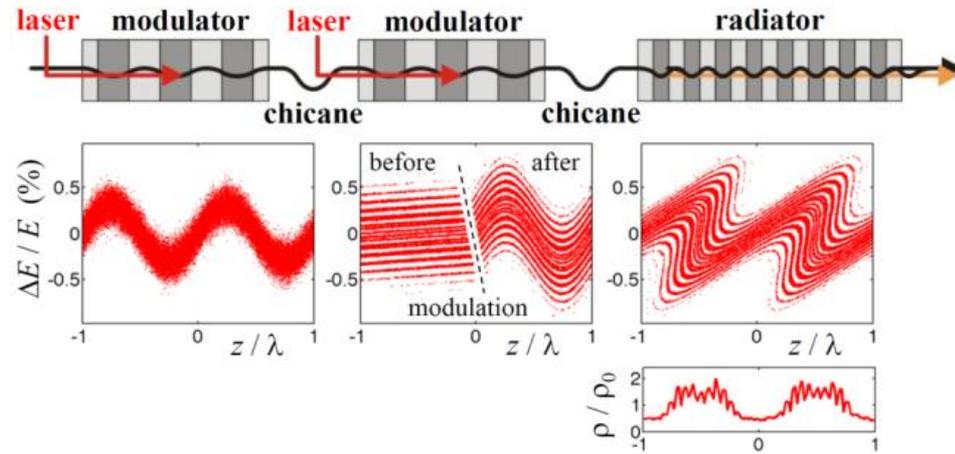
Near-future projects

New superconducting wiggler

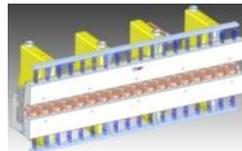
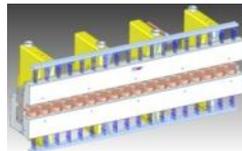
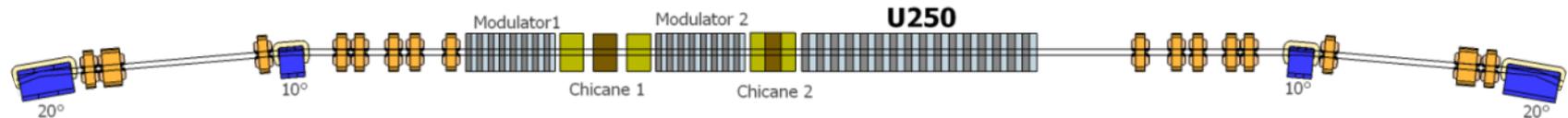
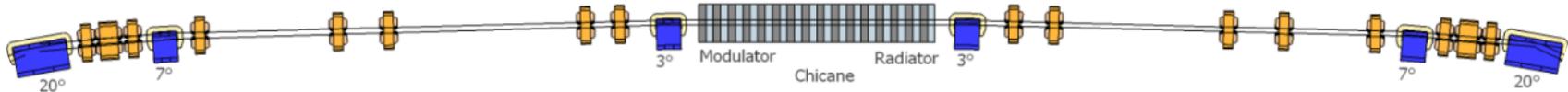
- including RF upgrade

Echo-enabled harmonic generation

- FEL seeding scheme (G. Stupakov 2009)
- access to higher harmonics
- unique at storage rings
- two undulators U200 in house



U250

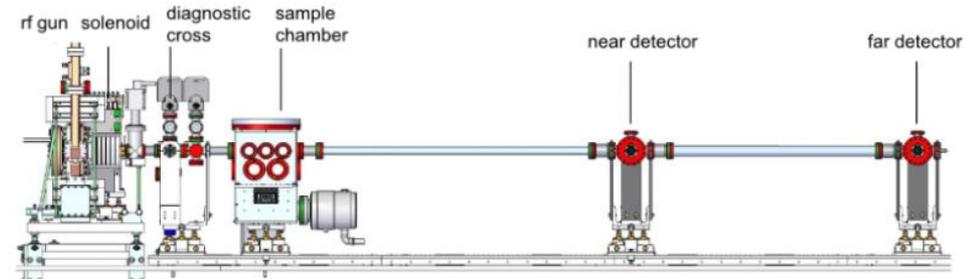
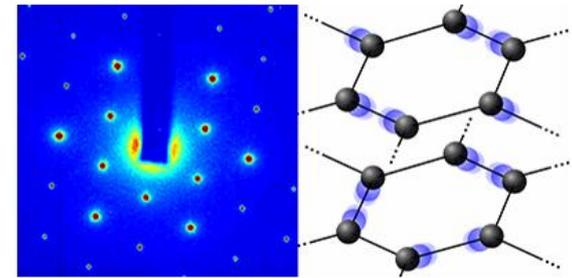


Not-so-near-future project

(S. Khan, D. Krieg, K. N.N., Sokolowski-Tinten, TU Dortmund and U Duisburg-Essen)

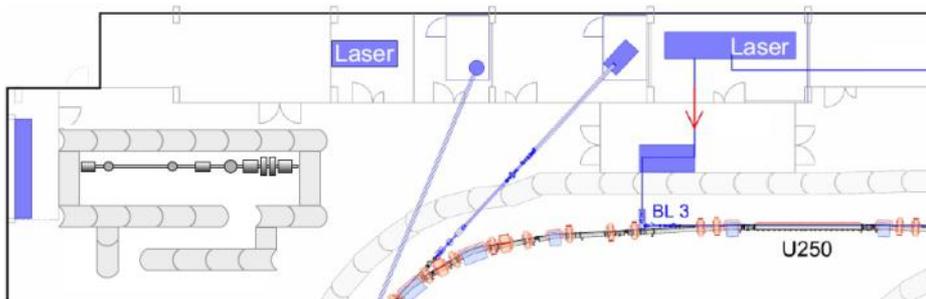
Ultrafast electron diffraction

- 5-MeV source of ultrashort bunches (like UED@ASTA, REGAE)
- pump-probe experiments



Design study

- two doctorate positions funded by MERCUR
- space and infrastructure available





Thank you

Ministerium für Innovation,
Wissenschaft und Forschung
des Landes Nordrhein-Westfalen



DFG Deutsche
Forschungsgemeinschaft

 **Mercator Research Center Ruhr**
Eine Initiative der Stiftung Mercator
und der Universitätsallianz Ruhr



Bundesministerium
für Bildung
und Forschung

