

# Status of DELTA: Light Source and Short-Pulse Facility

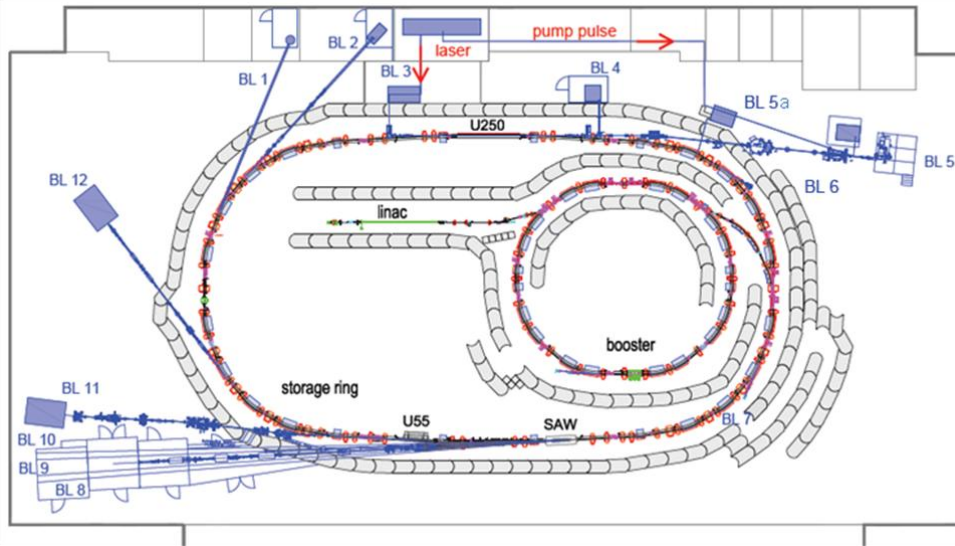
1

Shaukat Khan, Zentrum für Synchrotronstrahlung

Lund November 29th 2016

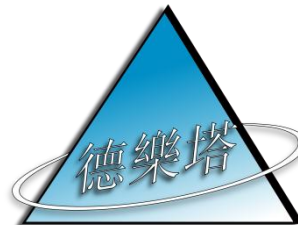


# Parameters and availability

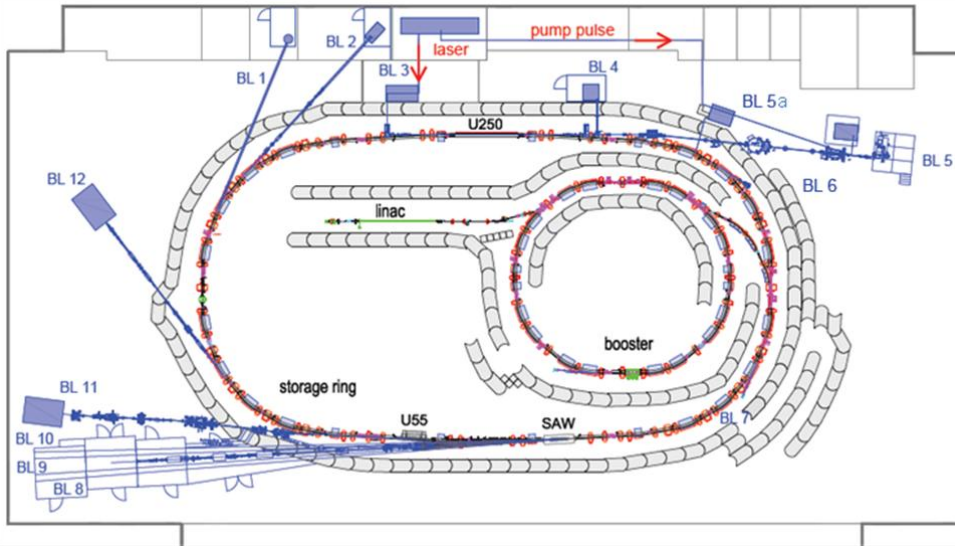


## Parameters

circumference	115.2 m
beam energy	1.5 GeV
beam current	130 mA multi-bunch
beam current	20 mA single bunch
beam lifetime	~16 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)

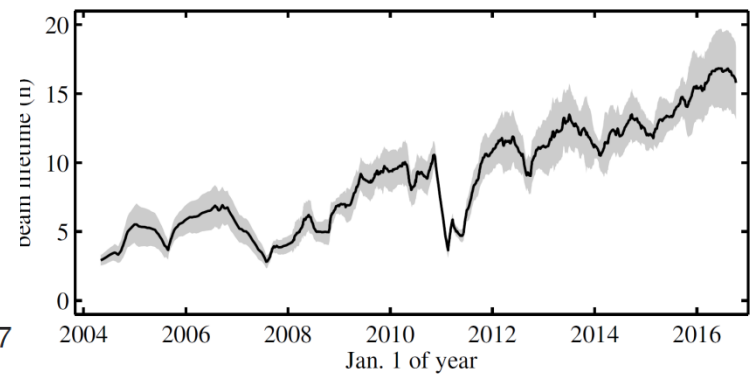
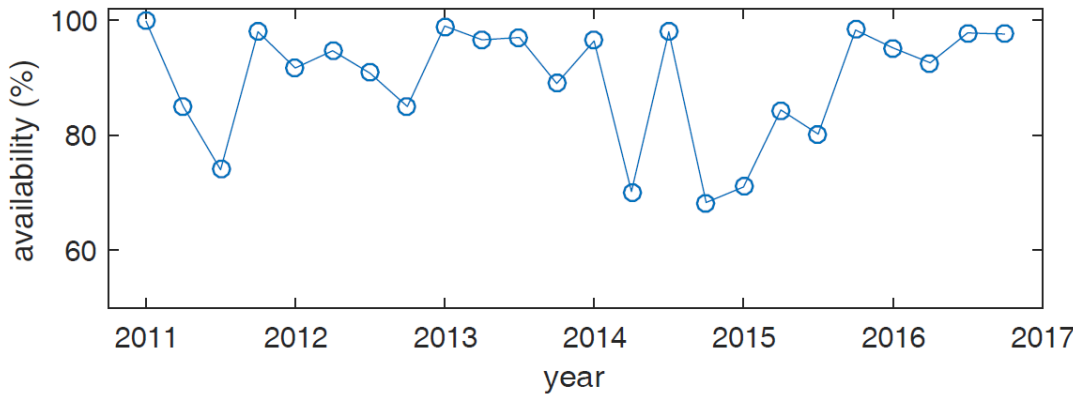


# Parameters and availability



## Parameters

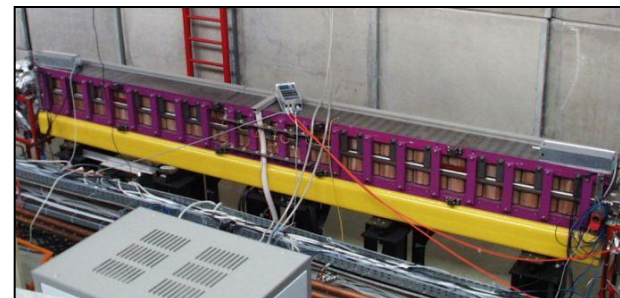
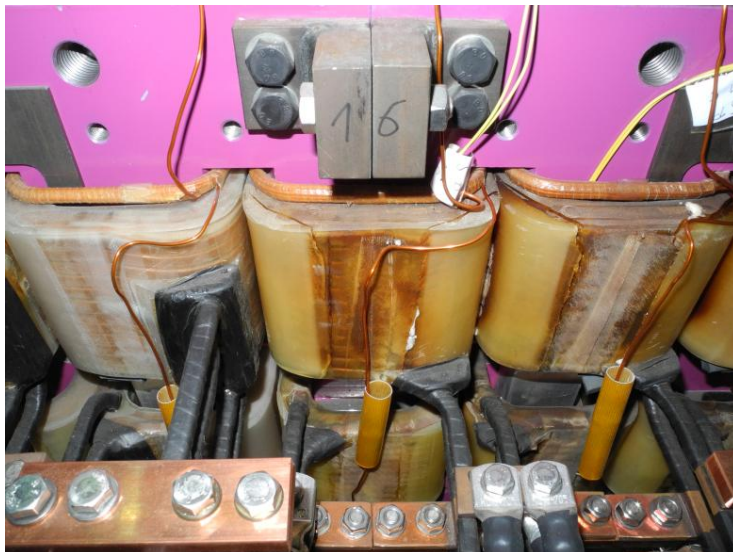
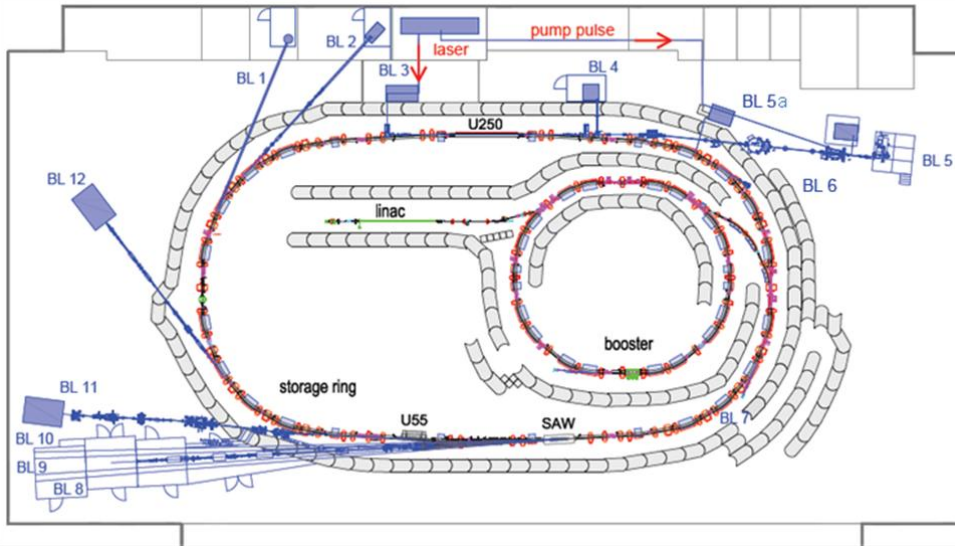
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(J. Friedl, G. Schmidt, P. Ungelenk)

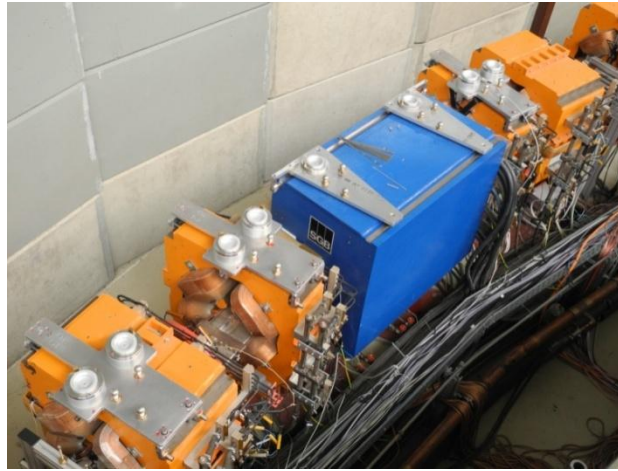


# Insertion devices



# 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)



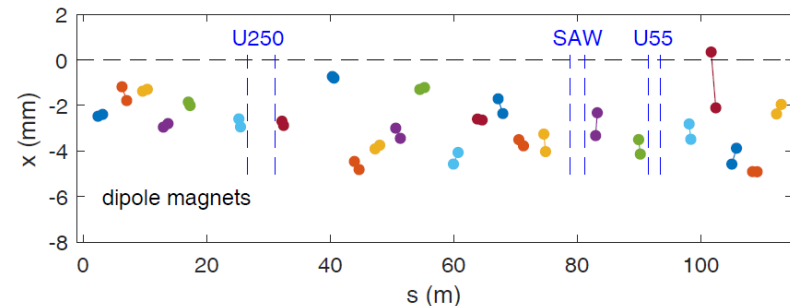
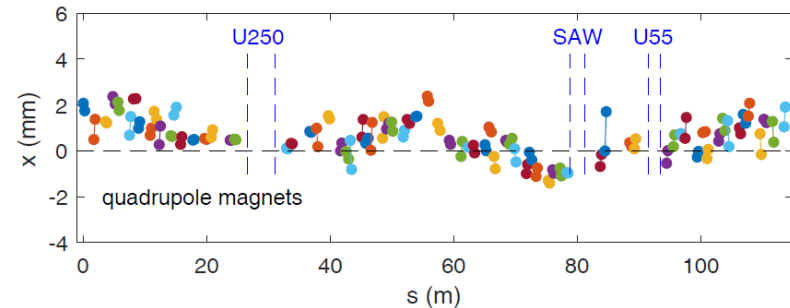
## Vertical alignment completed in 2013

- improved stability, radiation level, lifetime ...

## Horizontal alignment underway

- 180 reference panels for Taylor-Hobson spheres

- laser tracker



# Superconducting wiggler

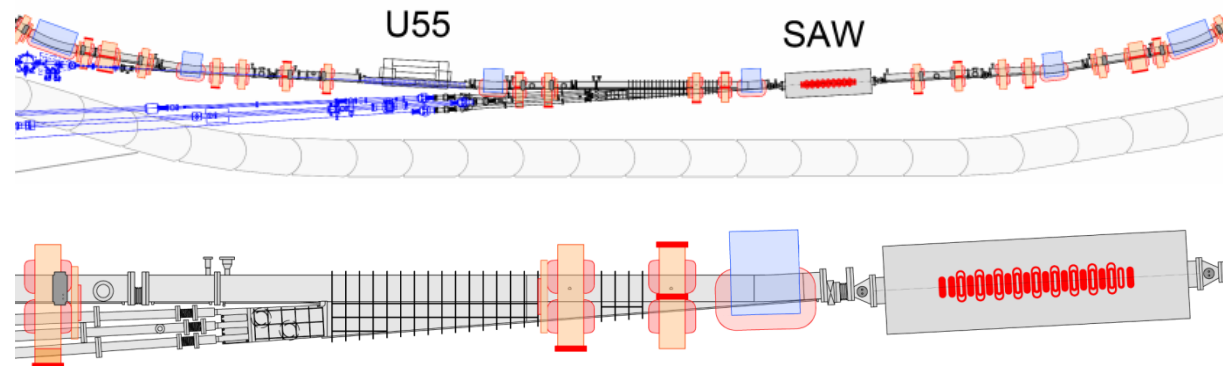
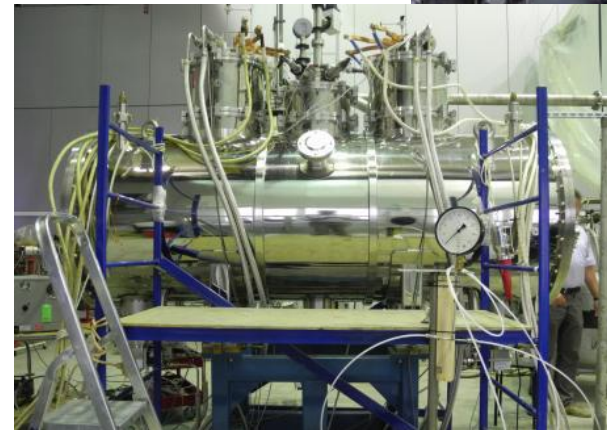
(W. Brembt, P. Hartmann, B. Hippert, S. Khan, V. Kniss, P. Kortmann, R. Molo, M. Paulus, D. Schirmer, G. Schmidt, C. Sternemann, M. Tolan)

## Superconducting asymmetric wiggler

- is ageing, no support from manufacturer
- new device funded and ordered (end of 2018)**
- no asymmetry option
- higher field (5.3 T  $\rightarrow$  7 T)
- more periods (5  $\rightarrow$  10)
- less He consumption (130 l/week  $\rightarrow$  none)

## Additional issues

- second RF cavity and solid-state RF amplifier
- modified storage ring lattice
- new vacuum chamber and absorber
- integration into control system
- radiation safety

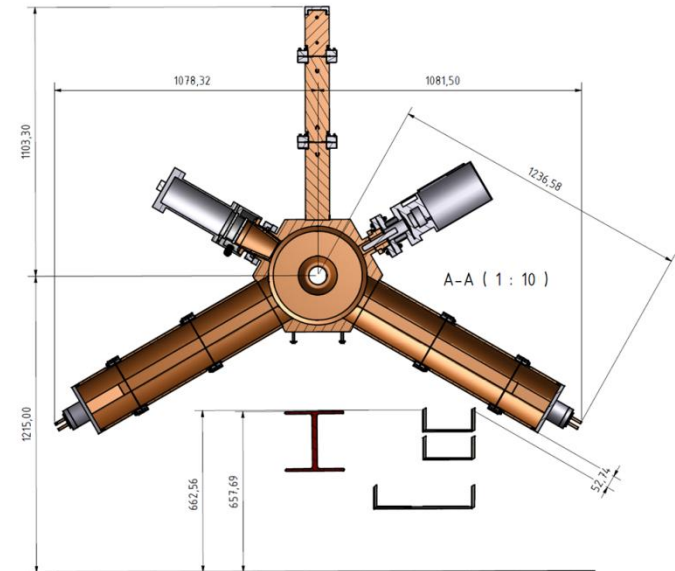


# RF upgrade

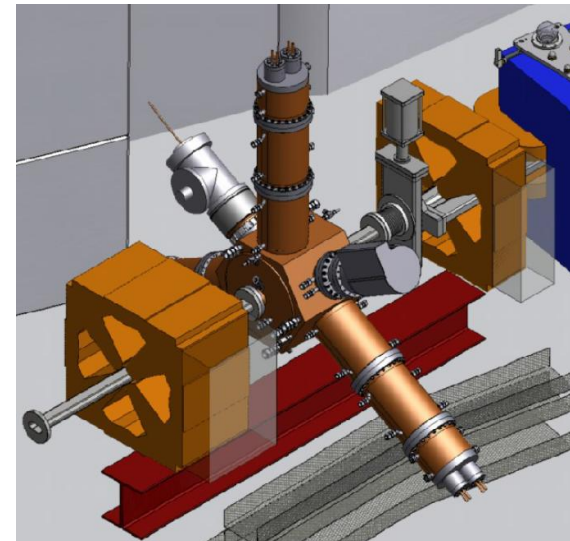
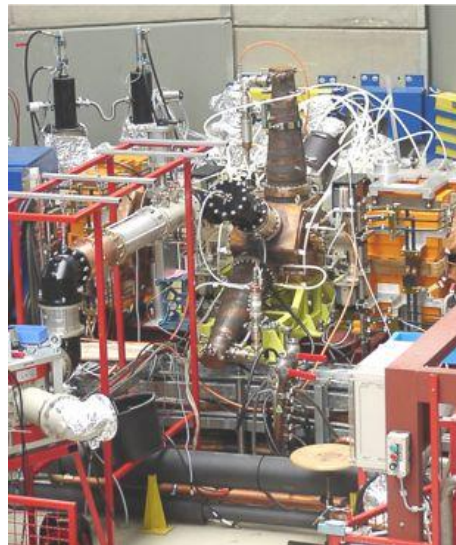
(W. Brembt, P. Hartmann, V. Kniss, T. Weis)

**500 MHz European HOM-damped cavity**  
**funded and ordered (beginning of 2018)**

**500 MHz Solid-state amplifier**  
**funded and ordered (February 2017)**  
 - 75 kW for the storage ring  
 - 20 kW for the booster synchrotron



(Courtesy Research Instruments GmbH)



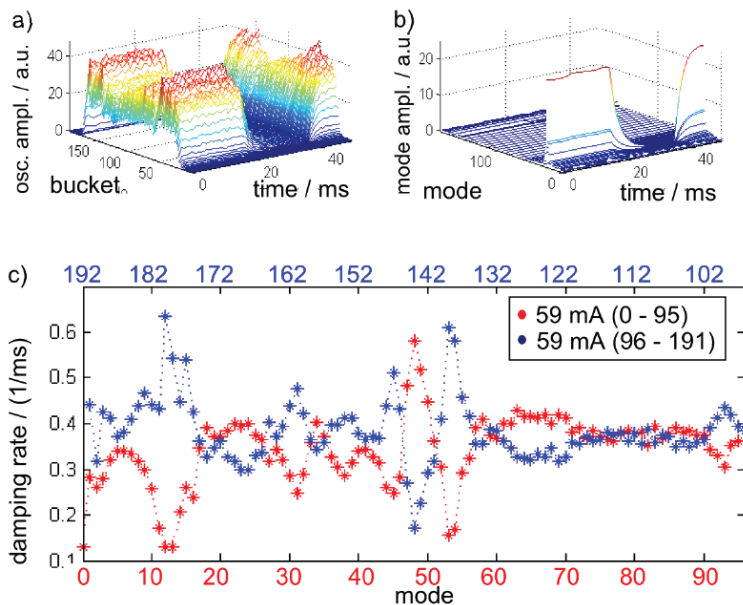
# Stability, lifetime and all that

(M. Höner, S. Khan, M. Sommer)

## Bunch-by-bunch feedback systems (installed 2011)

- damp longitudinal and transverse oscillations,  
used for accelerator studies and diagnostics

**example: longitudinal damping rates**



M. Sommer, M. Höner et al., IPAC 2015, Richmond, USA, p. 179



# Stability, lifetime and all that

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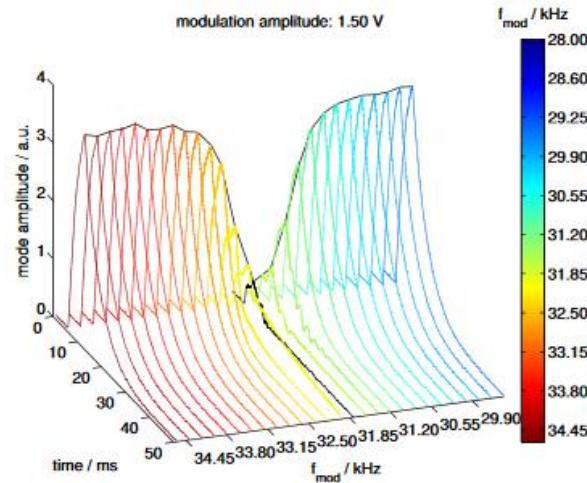
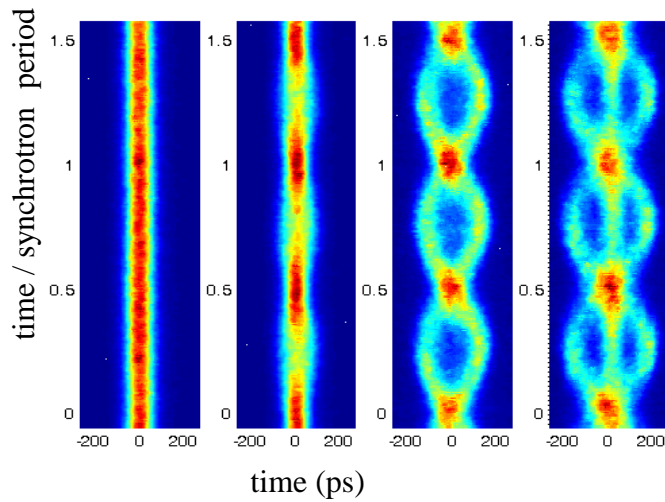


## Bunch-by-bunch feedback systems (installed 2011)

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### example: RF phase modulation



M. Sommer, M. Höner et al., IPAC 2015, Richmond, USA, p. 179



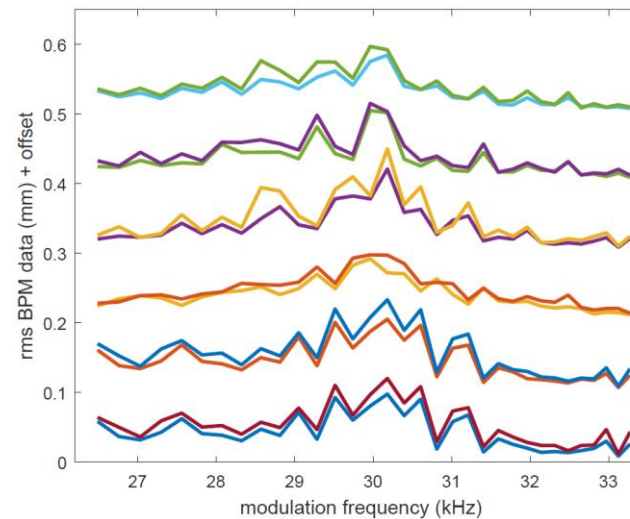
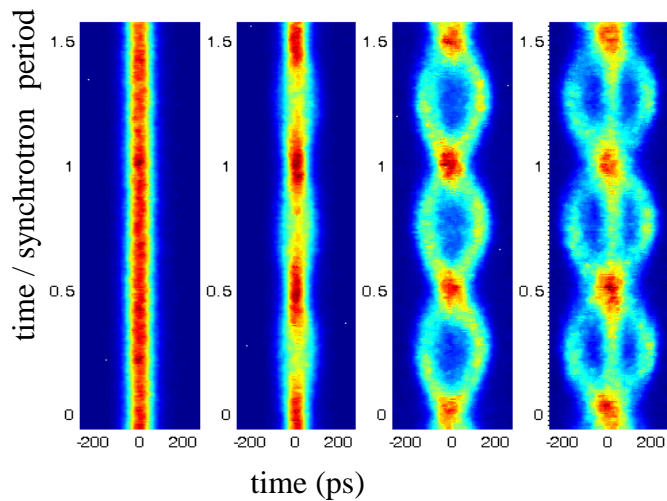
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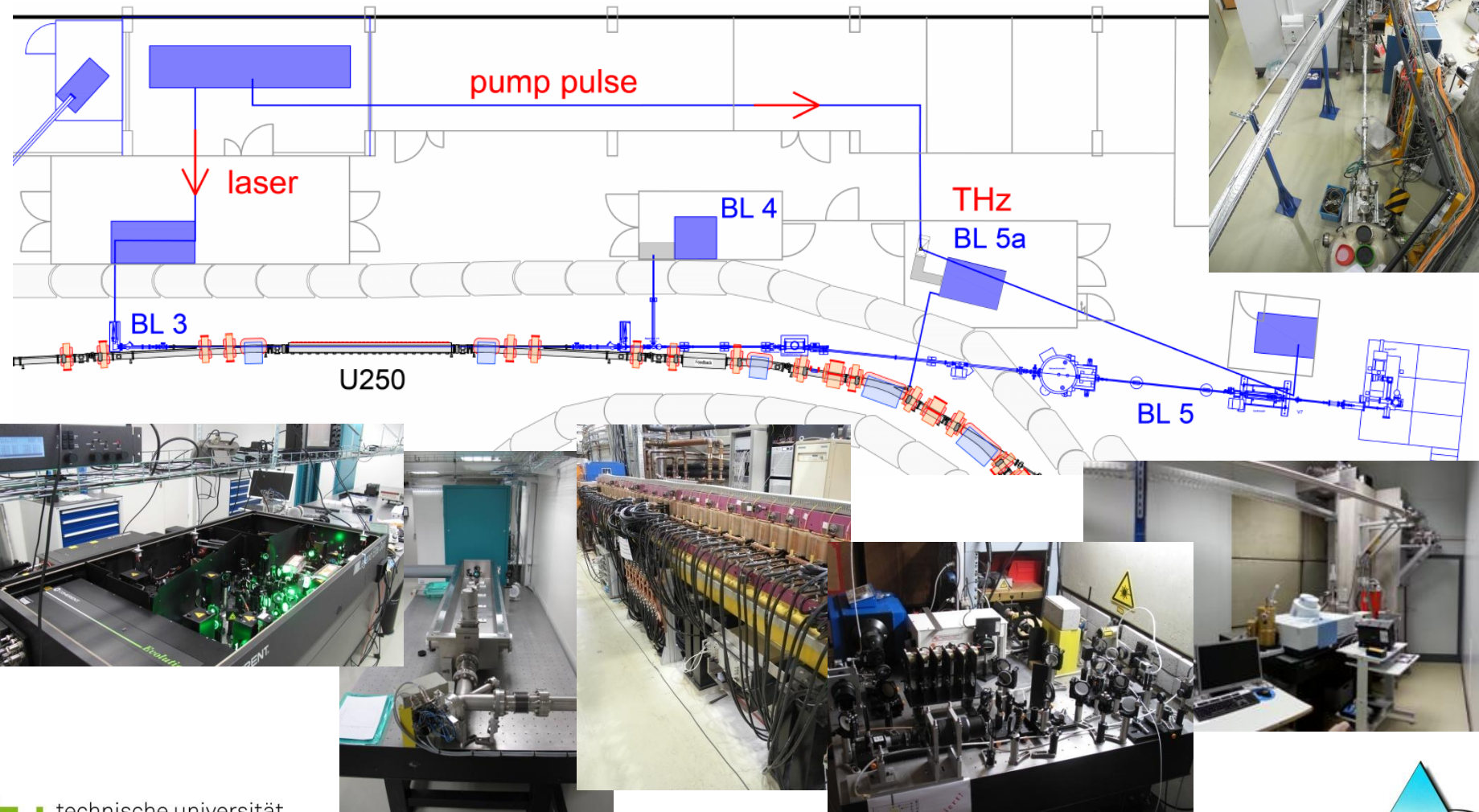
**example: RF phase modulation**



RF phase modulation influences BPM data

# Facility for ultrashort VUV and THz pulses

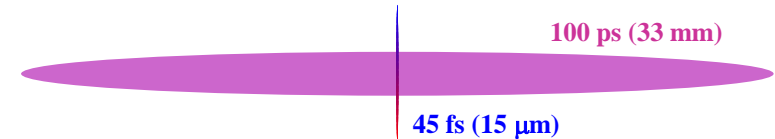
(F. Bahnsen, F. Götz, M. Höner, S. Hilbrich, N. Lockmann, S. Khan, C. Mai, A. Meyer auf der Heide, R. Niemczyk, B. Riemann, G. Shayeganrad, P. Ungelenk [TU Dortmund] S. Cramm, S. Döring, M. Plötzing, L. Plucinski, C. Schneider [FZ Jülich and U Duisburg-Essen])



# Facility for ultrashort VUV and THz pulses

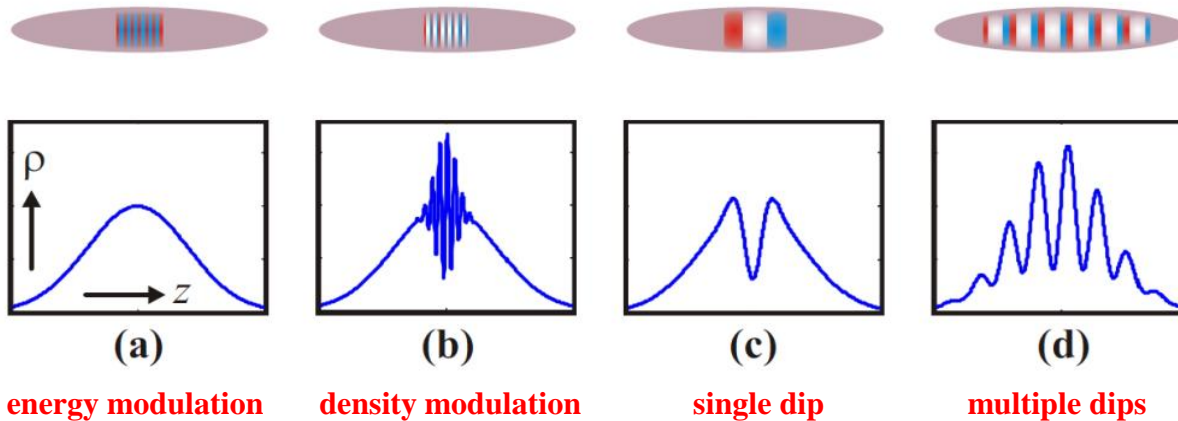
## Coherent harmonic generation (CHG)

- 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

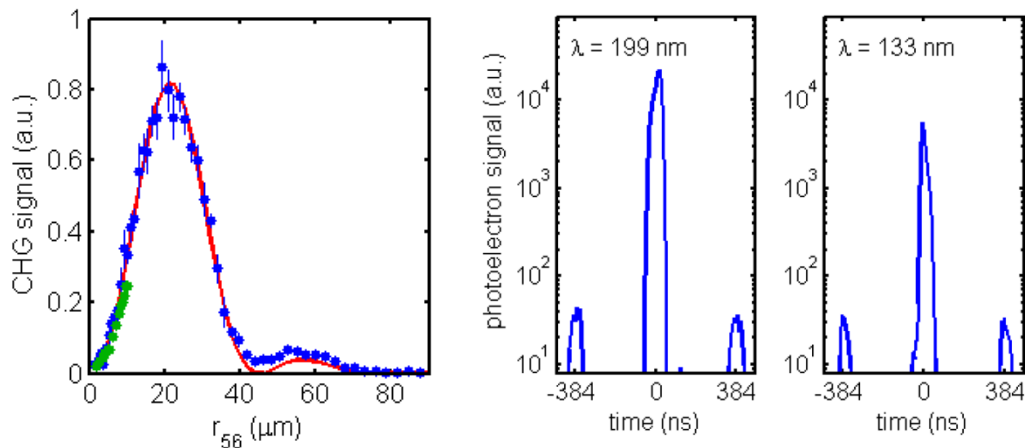
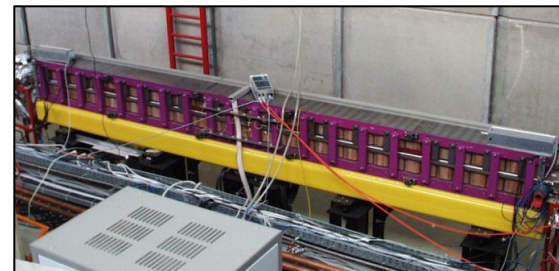
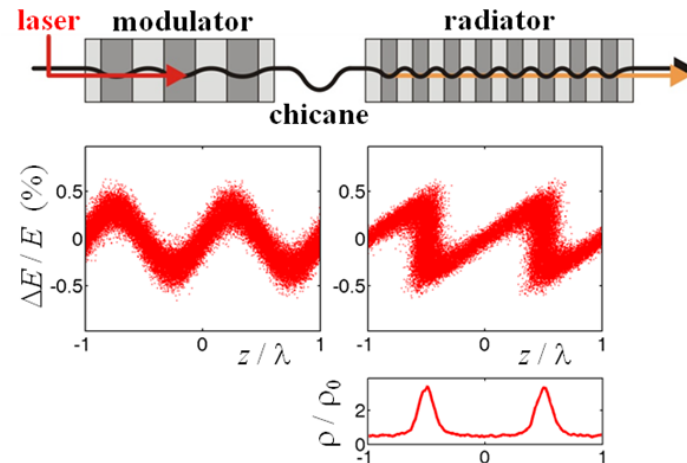
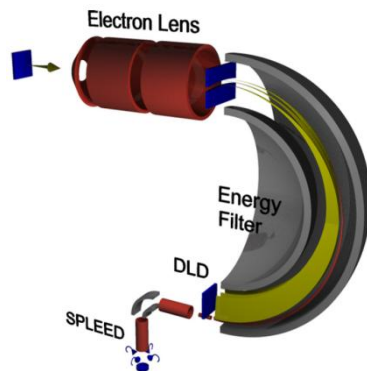
- short "dip" due to energy-dependent path length
- broadband coherent THz radiation
- narrowband coherent THz radiation from multiple dips



# Facility for ultrashort VUV and THz pulses

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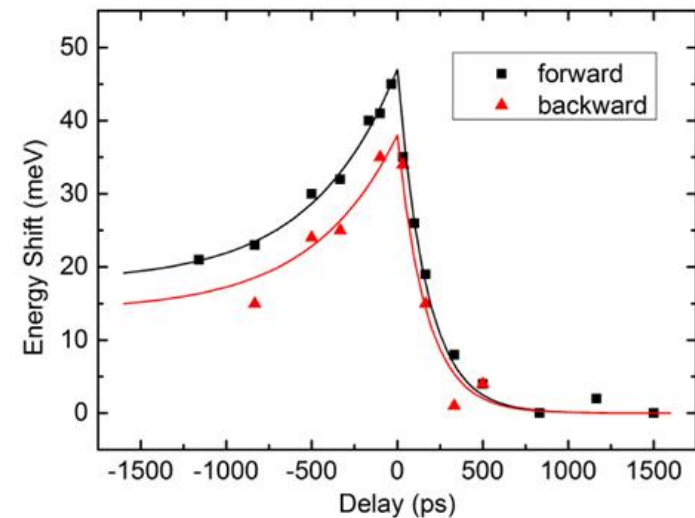
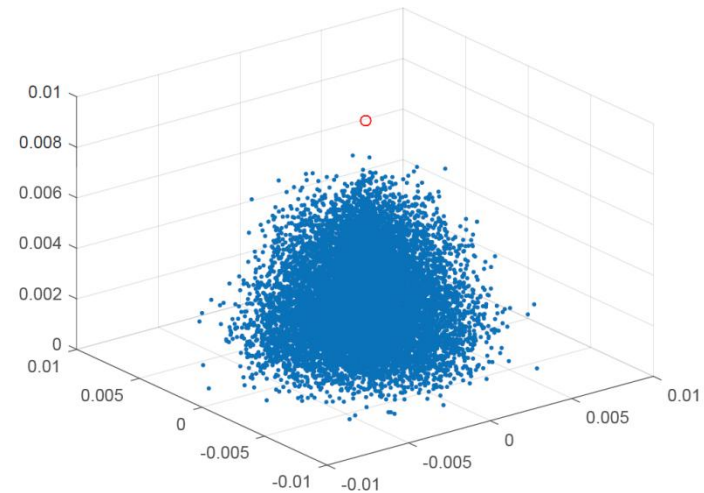
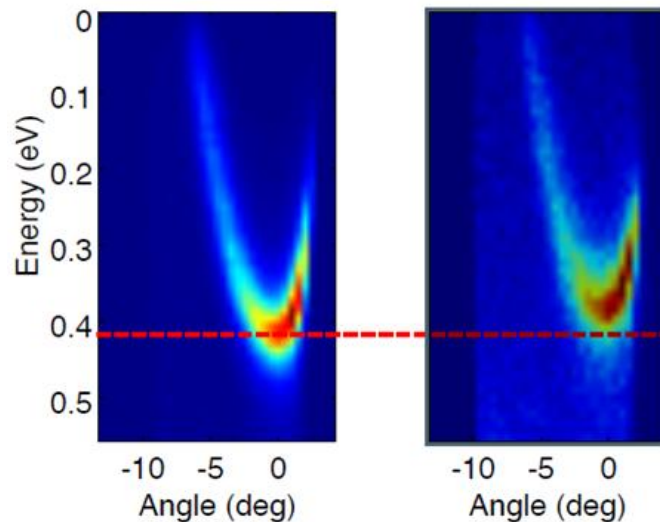
S. Khan et al., Sync. Rad. News 26:3, 25 (2013)

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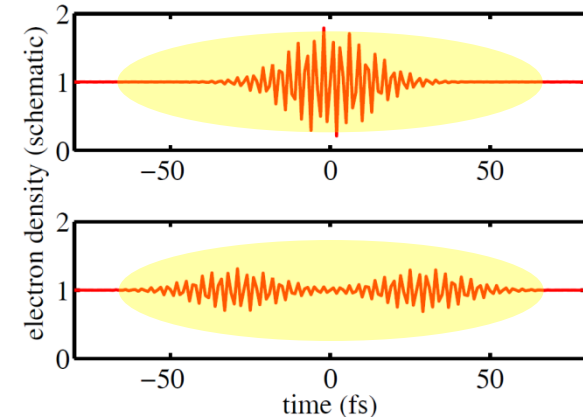
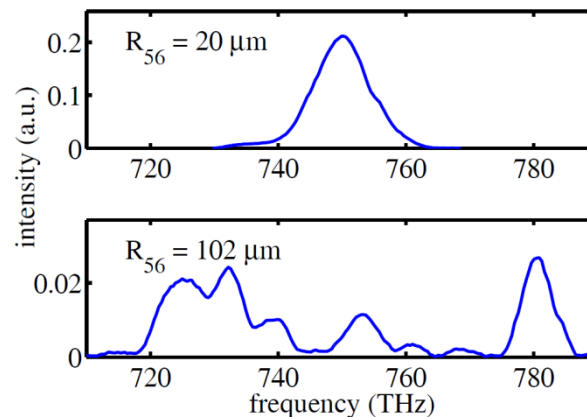
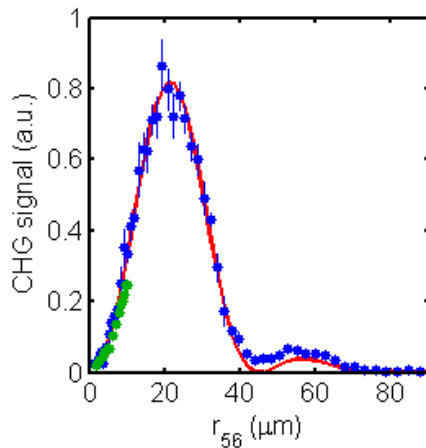
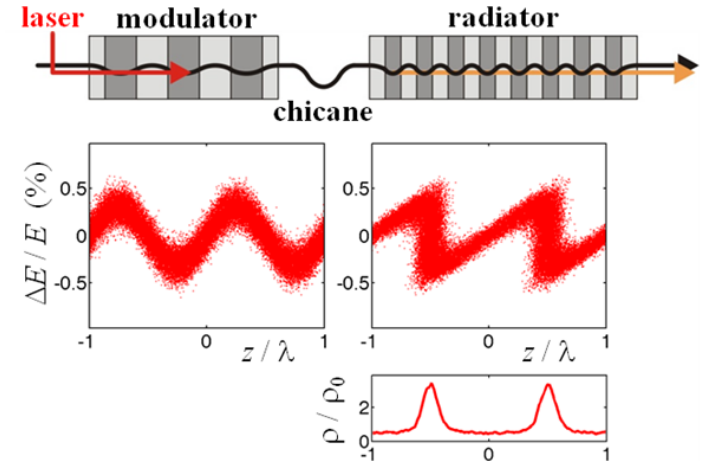
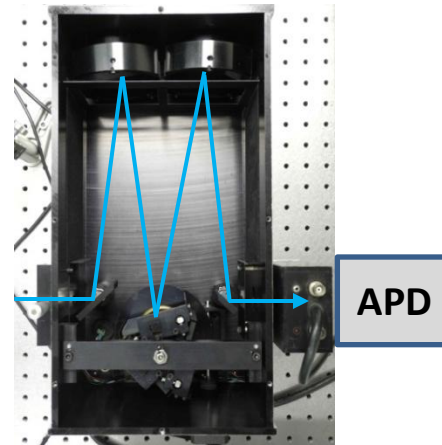
**recently: first pump-probe result**  
**shift of photoelectron kinetic energy due to space charge**



# Facility for ultrashort VUV and THz pulses

## Coherent harmonic generation (CHG)

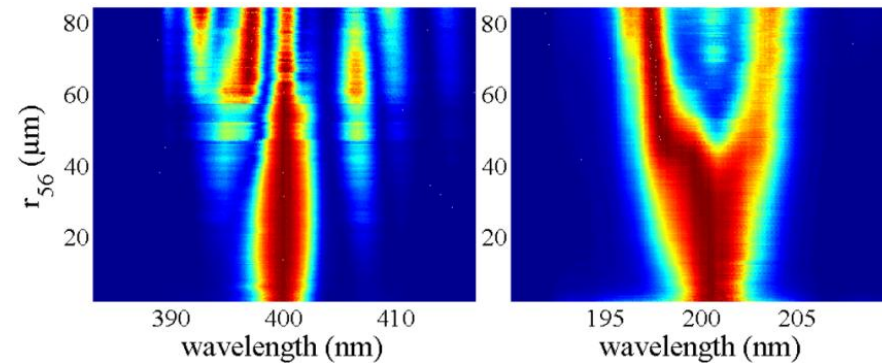
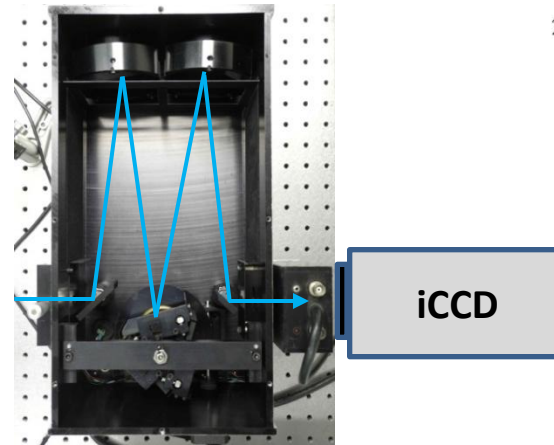
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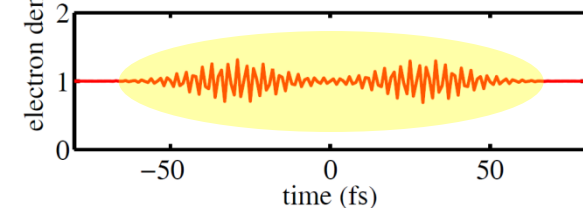
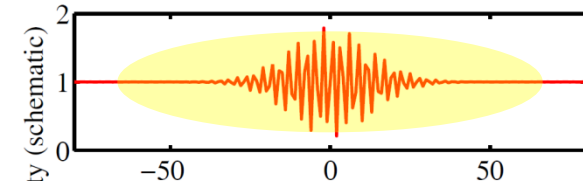
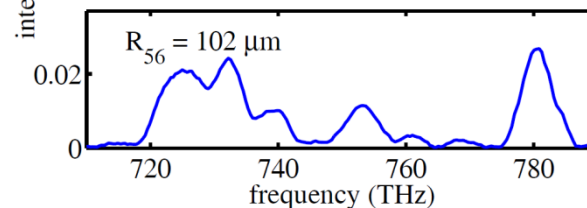
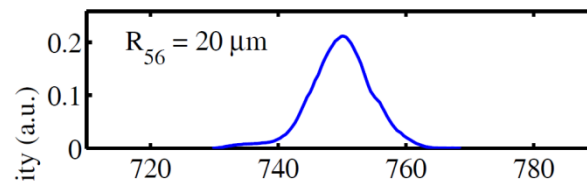
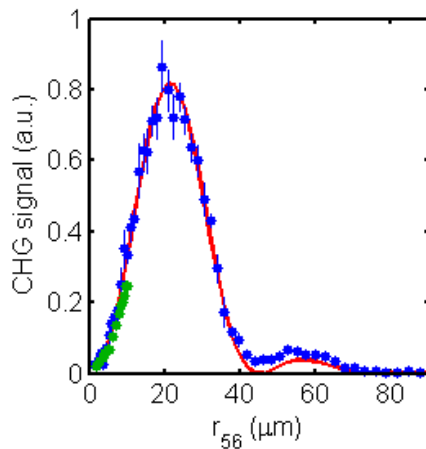
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S.Khan et al., IPAC 2016, Busan, Korea, p. 2851

compare with:

D. Gauthier et al., PRL 115, 114801 (2015)

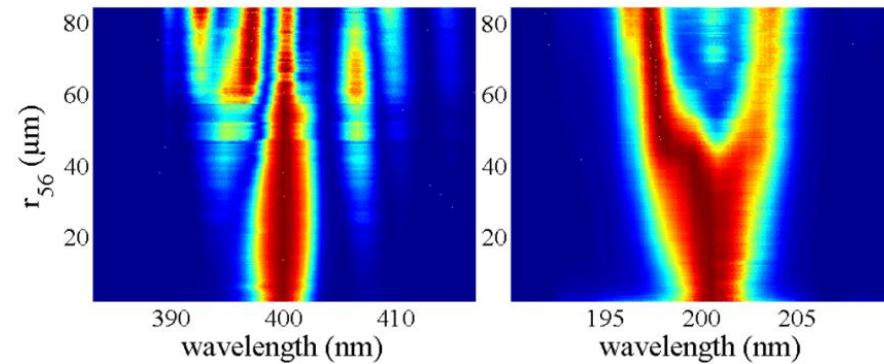




# Facility for ultrashort VUV and THz pulses

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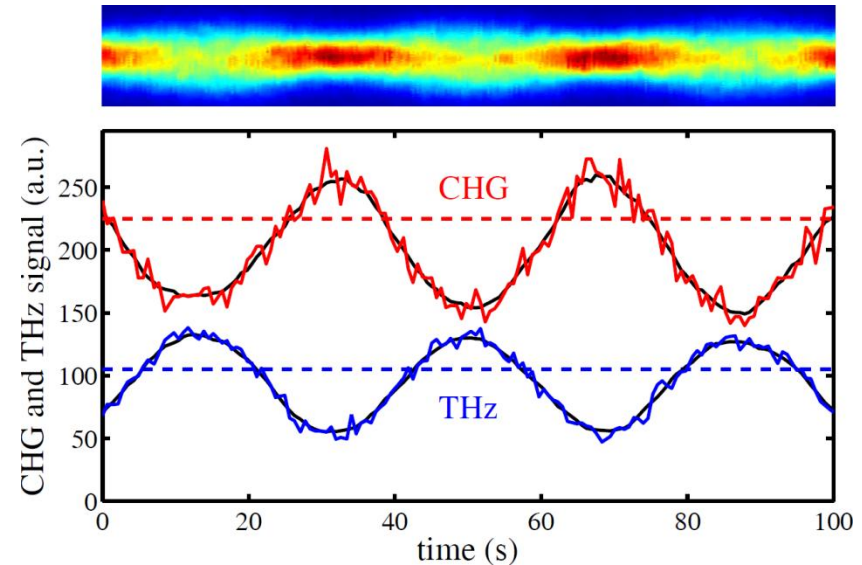
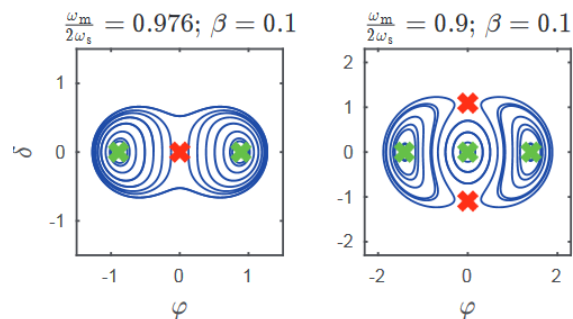
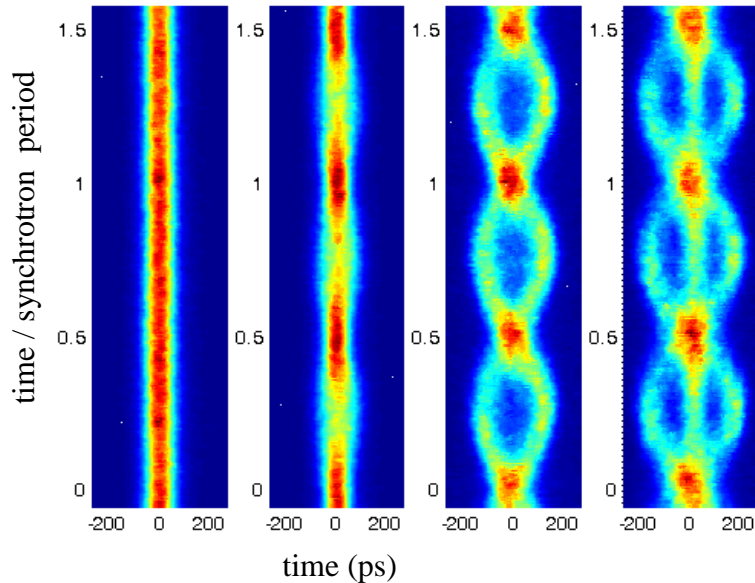
S. Khan et al., IPAC 2016, Busan, Korea, p. 2851

D. Gauthier et al., PRL 115, 114801 (2015)

# Facility for ultrashort VUV and THz pulses

## RF-phase modulation

- suppresses coupled-bunch instabilities
- improves the beam lifetime



## RF-phase modulation and CHG

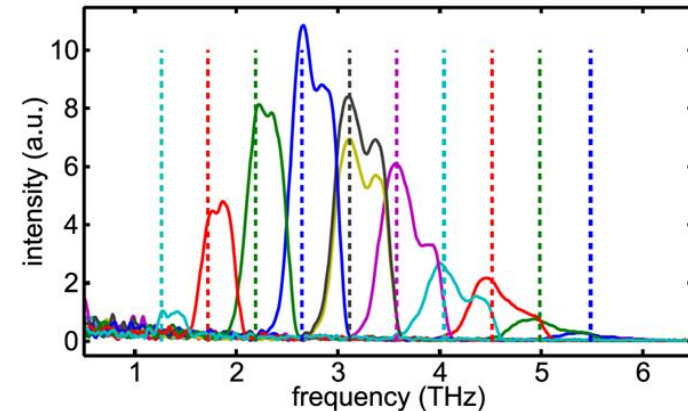
- synchronize modulation with laser pulses
- phase scans (i) electronic delay  
(ii) frequency mismatch (beating)
- CHG and THz signal enhanced, out of phase

M. Jebramcik et al., IPAC 2016, Busan, Korea, p. 2847

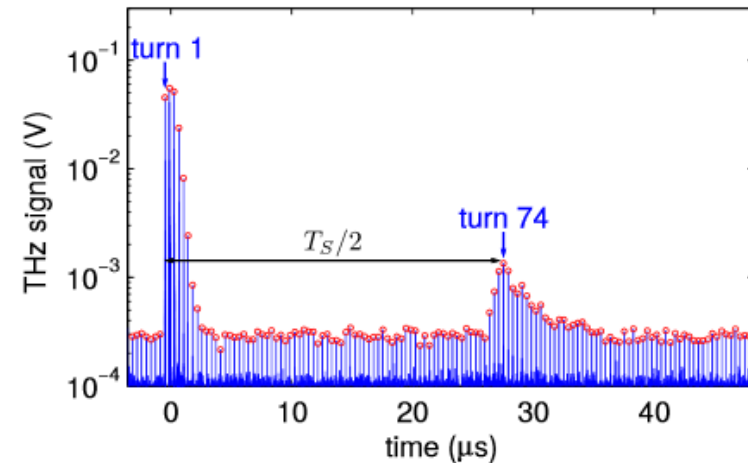
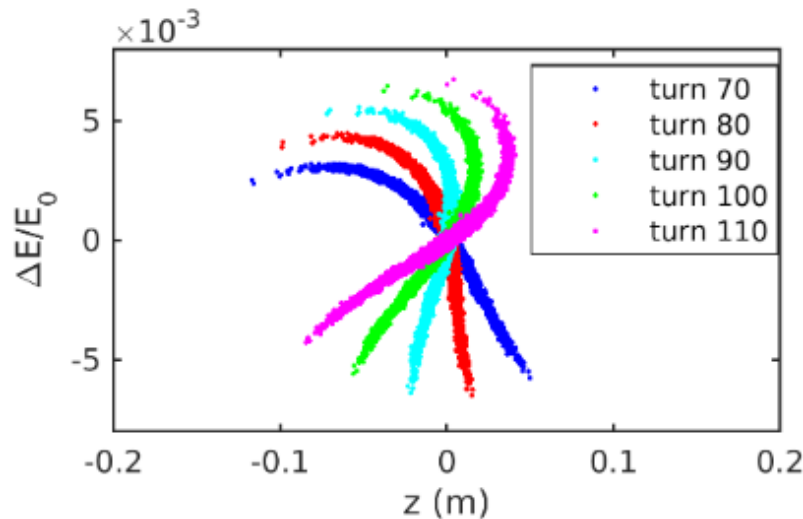
# Facility for ultrashort VUV and THz pulses

## 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
- construction a sub-THz spectrometer
- electro-optical sampling



P. Ungelenk et al., IPAC 2014, Dresden, Germany, p. 1936  
C. Mai et al., IPAC 2015, Richmond, USA, p. 823



# Echo-enabled harmonic generation at DELTA

Supported by Helmholtz ARD initiative (FZ Jülich)

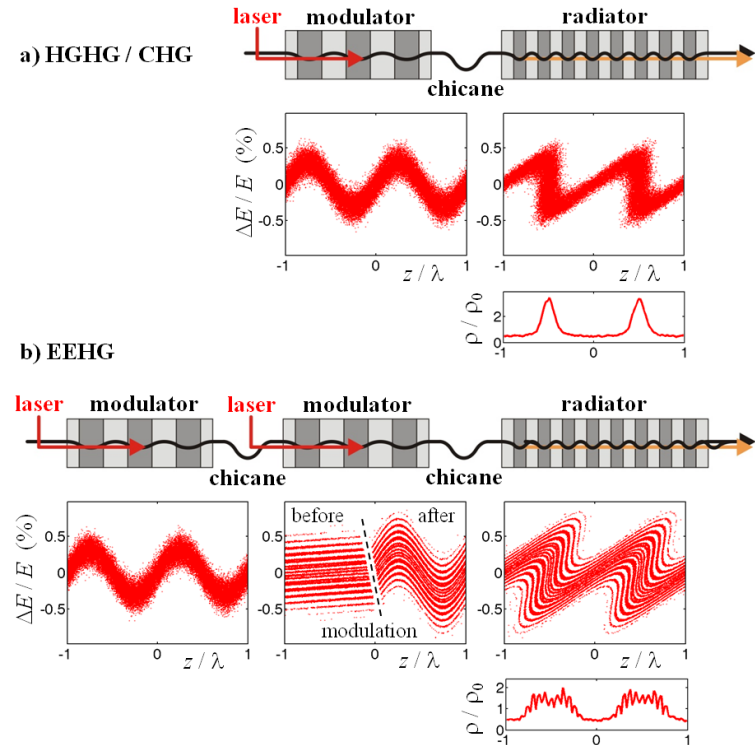
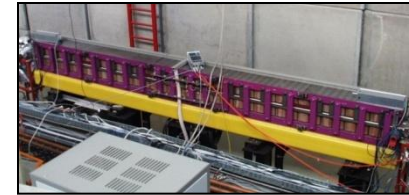
- modulators: 2 short undulators
- radiator: present U250 undulator
- requires longer straight section
- modified storage ring optics
- additional undulator for "slicing"

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)



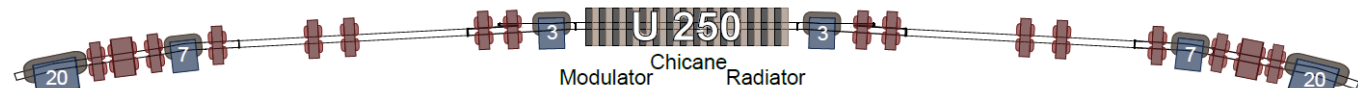
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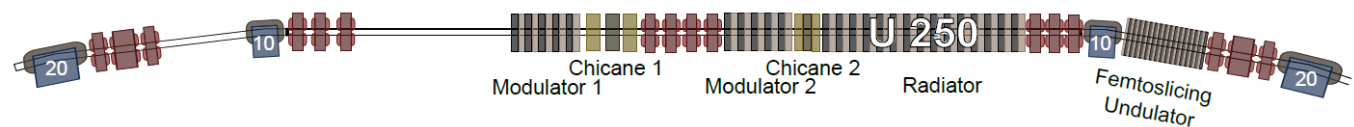
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- two undulators + power supplies delivered
- undulator chambers ordered



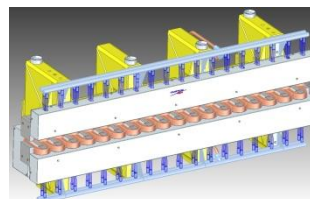
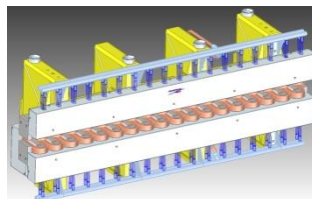
D. Zimmermann, master's thesis, TU Dortmund 2016



S. Hilbrich et al., FEL 2014, Basel, 255



Courtesy Scanditronix AB



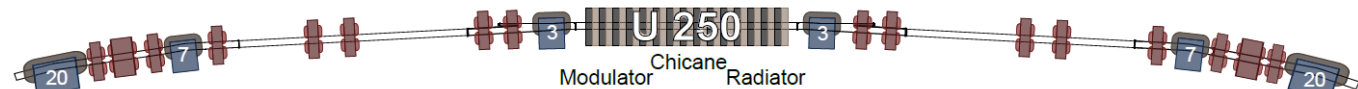
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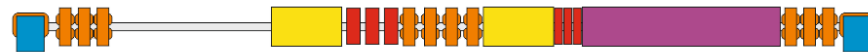
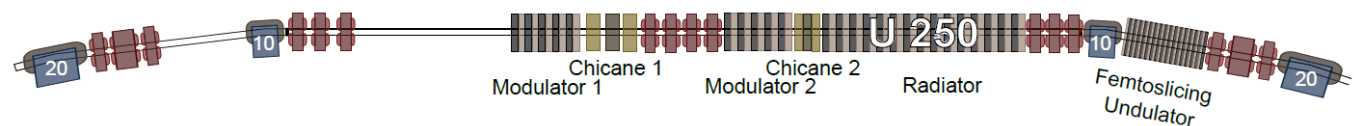
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D. Zimmermann, master's thesis, TU Dortmund 2016



S. Hilbrich et al., FEL 2014, Basel, 255



# Accelerator physics in the bachelor and master curriculum

**Bachelor, master, PhD 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...)



# The Future of DELTA

**Workshop on July 15, 2016**

**The next 10 years**

- **consolidation and improvement**
- **7-T wiggler and RF upgrade**
- **EEHG short-pulse source**





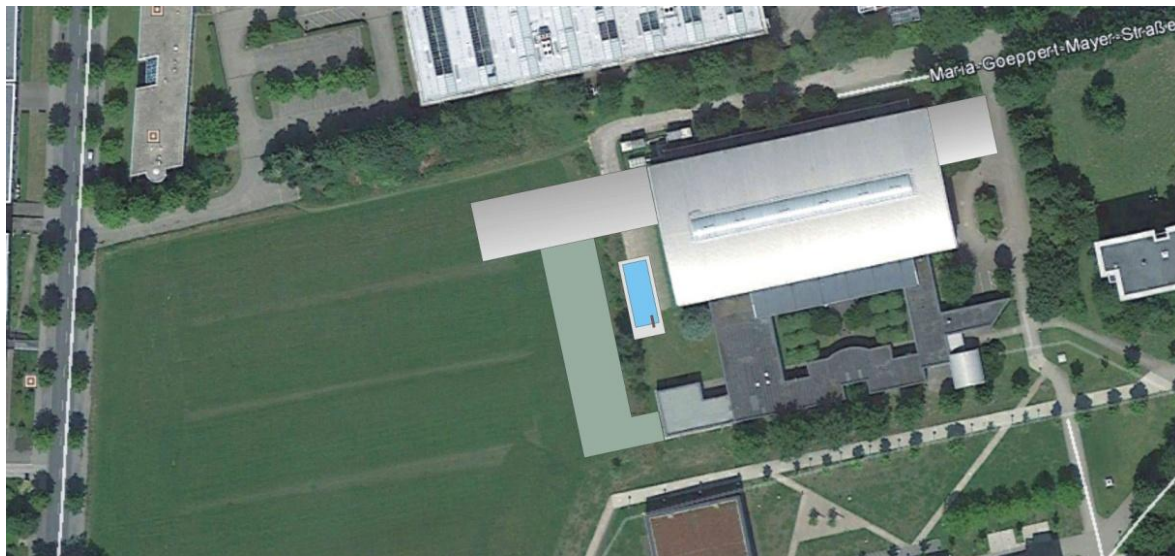
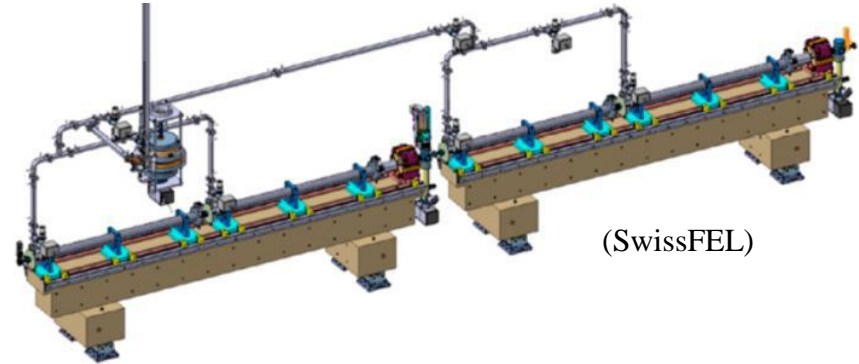
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and beyond ...



# Tack så mycket !

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

