

Zwischenbericht (Sachbericht)

Förderinstrument:	Postdoktorandenprogramm
Impulsfonds-Förderkennzeichen:	PD-004
Projekttitle:	Temporal Characterization of Femtosecond X-ray Pulses and Beam-driven Wakefield Acceleration Experiments
Postdoktorand/in:	Dr. Christopher Behrens
Helmholtz-Zentrum:	DESY
Berichtszeitraum (=Kalenderjahr!):	01/2014-12/2014

1) Arbeitsfortschritt / Meilensteine

Welche Fortschritte wurden im geplanten Arbeitsprogramm gemacht. Nehmen Sie explizit Bezug auf das im Antrag beschriebene Programm und die dort aufgeführten Meilensteine. Waren Abweichungen vom Programm notwendig?

The already completed subproject “**Simultaneous temporal diagnosis of electron and x-ray pulses by using a transverse deflecting r.f. structure**” on **Temporal Characterization of Femtosecond X-ray Pulses** has been further expanded by several new scientific results and advances in free-electron laser (FEL) technology. The successfully commissioned x-band transverse deflecting structure has been a critical component in demonstrating a two-beam two-color FEL with adjustable color and time separation. Moreover it has been used to establish self-seeding in the soft X-ray range, and first time-resolved studies of microbunching instabilities in FELs with superior resolution and measurement quality have been performed. These advances are documented in high-impact journals (see below). This project has been carried out within the one-year stay at SLAC-Stanford in CA, USA.

Within the subproject “**THz streaking technique for simultaneous x-ray temporal and arrival time information**” of the same first main topic as above, an all-optical synchronization system demonstrating overall performance at the femtosecond level at FLASH has been established and published in a high-impact journal. Furthermore a first physics experiment (Time-resolved Auger spectroscopy) has been carried out recently at the Linac Coherent Light Source at SLAC utilizing the unique capabilities of THz streaking. The experimental data is very promising and may lead to new findings in multi-electron dynamics. This work is based on a collaboration with the Max Planck Institute for the Structure and Dynamics of Matter at CFEL.

The second main topic **Beam-driven wakefield acceleration experiments** is currently picking up speed. The design phase for the beam-driven wakefield accelerator FLASHForward at DESY is almost completed and the project finally became official. The first installations will occur in May 2015. A beam time proposal by a PhD student, who was hired within this Fellowship, for a beam-driven plasma wakefield experiment at FACET at SLAC-Stanford has been ranked very good. Beam time allocation is in discussion and carrying out the experiment is foreseen for 2015. We are part of the Helmholtz Virtual Institute on plasma wakefield acceleration at FLASHForward and coordinate one of the four working groups (VI-photons).

In summary, all the proposed projects are evolving well and within the planned budget and time schedule. Beside the publications listed below, several more are in preparation.

2) Finanz-/Zeitplan

Können Sie Finanz- und Zeitplan einhalten oder sind Anpassungen notwendig?

The budget and time schedule meet the original planning. Adaption is not required.

3) Publikationen / Preise

Journal papers:

- D. Ratner, C. Behrens, Y. Ding, Z. Huang, A. Marinelli, T. Maxwell, and F. Zhou, *Time Resolved Imaging of the Microbunching Instability and Energy Spread at the Linac Coherent Light Source*, Phys. Rev. ST Accel. Beams 18, 030704 (2015). □

- A. Marinelli, D. Ratner, A.A. Lutman, J. Turner, J. Welch, F.-J. Decker, H. Loos, C. Behrens, S. Gilevich, A.A. Miahnahri, S. Vetter, T. Maxwell, Y. Ding, R. Coffee, S. Wakatsuki, and Z. Huang, *High-intensity double-pulse X-ray free-electron laser*, Nature Communications 6 6369 (2015). □

- D. Ratner, R. Abela, J. Amann, C. Behrens, D. Bohler, G. Bouchard, C. Bostedt, M. Boyes, K. Chow, D. Cocco, F.J. Decker, Y. Ding, C. Eckman, P. Emma, D. Fairley, Y. Feng, C. Field, U. Flechsig, G. Gassner, J. Hastings, P. Heimann, Z. Huang, N. Kelez, J. Krzywinski, H. Loos, A. Lutman, A. Marinelli, G. Marcus, T. Maxwell, P. Montanez, S. Moeller, D. Morton, H.D. Nuhn, N. Rodes, W. Schlotter, S. Serkez, T. Stevens, J. Turner, D. Walz, J. Welch, and J. Wu, *Experimental Demonstration of a Soft X-Ray Self-Seeded Free-Electron Laser*, Phys. Rev. Lett. 114, 054801 (2015). □

- S. Schulz, I. Grguraš, C. Behrens, H. Bromberger, J.T. Costello, M.K. Czwalinna, M. Felber, M.C. Hoffmann, M. Ilchen, H.Y. Liu, T. Mazza, M. Meyer, S. Pfeiffer, P. Predki, S. Schefer, C. Schmidt, U. Wegner, H. Schlarb, and A.L. Cavalieri, *Femtosecond all-optical synchronization of an X-ray free-electron laser*, Nature Communications 6 5938 (2015). □

- S. Düsterer, M. Rehders, A. Al-Shemmary, C. Behrens, G. Brenner, O. Brovko, M. DellAngela, M. Drescher, B. Faatz, J. Feldhaus, U. Frühling, N. Gerasimova, N. Gerken, C. Gerth, T. Golz, A. Grebentsov, E. Hass, K. Honkavaara, V. Kocharian, M. Kurka, Th. Limberg, R. Mitzner, R. Moshhammer, E. Plönjes, M. Richter, J. Rönsch-Schulenburg, A. Rudenko, H. Schlarb, B. Schmidt, A. Senftleben, E.A. Schneidmiller, B. Siemer, F. Sorgenfrei, A. A. Sorokin, N. Stojanovic, K. Tiedtke, R. Treusch, M. Vogt, M. Wieland, W. Wurth, S. Wesch, M. Yan, M. V. Yurkov, H. Zacharias, and S. Schreiber, *Development of experimental techniques for the characterization of ultrashort photon pulses of extreme ultraviolet free-electron lasers*, Phys. Rev. ST Accel. Beams 17, 120702 (2014). □

- C. Behrens, F.-J. Decker, Y. Ding, V. A. Dolgashev, J. Frisch, Z. Huang, P. Krejcik, H. Loos, A. Lutman, T. J. Maxwell, J. Turner, J. Wang, M.-H. Wang, J. Welch, and J. Wu, *Few-femtosecond time-resolved measurements of X-ray free-electron lasers*, Nature Communications 5 3762 (2014). □

Books:

- P. Schmüser, M. Dohlus, J. Rossbach, and C. Behrens, *Free-Electron Lasers in the Ultraviolet and X-Ray Regime: Physical Principles, Experimental Results*, Technical Realization, 2nd edition, Springer-Verlag, Berlin (2014).

Conference papers:

- T.J. Maxwell, C. Behrens, Y. Ding, Z. Huang, P. Krejcik, A. Marinelli, L. Piccoli and D.

Ratner, *Femtosecond-scale x-ray FEL diagnostics with the LCLS X-band transverse deflector*, Proc. SPIE 9210, Advances in X-ray Free-Electron Lasers: Radiation Schemes, X-ray Optics, and Instrumentation, San Diego, USA (2014). □

- Y. Ding, F.-J. Decker, V. A. Dolgashev, J. Frisch, Z. Huang, P. Krejcik, H. Loos, A. Lutman, A. Marinelli, T. J. Maxwell, D. Ratner, J. Turner, J. Wang, M.-H. Wang, J. Welch, J. Wu, and C. Behrens, *Results from the LCLS X-band Transverse Deflector With Femtosecond Temporal Resolution*, Proceedings of the 27th Linear Accelerator Conference, Geneva, Switzerland, 2014, THIOB03.

- R. Assmann, C. Behrens, R. Brinkmann, U. Dorda, K. Flo'ttmann, B. Foster, J. Grebenyuk, M. Gross, I. Hartl, M. Hu'ning, F. Ka'rtner, B. Marchetti, Y. Nie, J. Osterho□, A. Ruhl, H. Schlarb, B. Schmidt, F. Stephan, A.S. Mu'ller, M. Schuh, F. Gru'ner, B. Hidding, A. R. Maier, and B. Zeitler, *SINBAD - a Proposal for a Dedicated Accelerator Research Facility at DESY*, Proceedings of the 5th International Particle Accelerator Conference, Dresden, Germany, 2014, TUPME047. □

Invited talks:

- Plenary talk at the German Conference for Research with Synchrotron Radiation, Neutrons and Ion Beams at Large Facilities 2014, *Temporal characterization of femtosecond x-ray pulses at free-electron lasers*, Bonn, Germany (2014). □

- Workshop on Advanced X-Ray FEL Development, *Few-femtosecond time-resolved measurements of X-ray free-electron lasers*, Hamburg, Germany (2014). □