Annual report

Funding Programme:	**Virtual Institutes**
Project ID No.:	VH-VI-503
Project title:	Plasma wakefield acceleration of highly relativistic electrons with FLASH
Project spokesperson	Prof. Dr. Brian Foster
Report period:	01.01.2016 – 31.12.2016

Activity report

a) Progress within the work plan delineated in the application

The activities within the Virtual Institute in the reporting year have concentrated on the installation of the FLASHForward beamline and its ancillary laboratories and equipment. The test laboratory became operational in April after the completion of the radiation protection system. The experimental setups of the laser-wakefield experiment and the ionization test line have been finalized (cf. Figs. 1 and 2). This was made possible by the granting of the operation license for our laser-wakefield accelerator by the city of Hamburg.

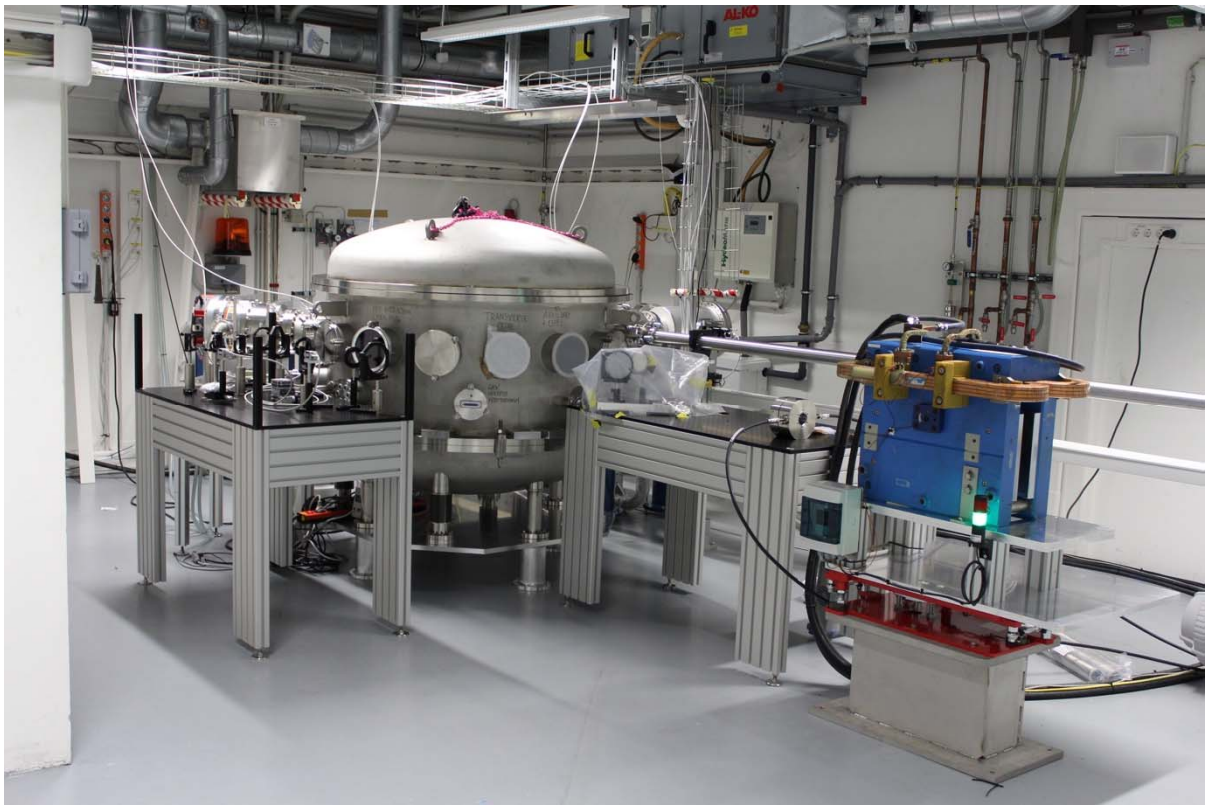


Figure 1. FLASHForward laser-wakefield acceleration setup for component tests.

Figure 2. Long focal-length ionisation test line for FLASHForward target development.

During a short FLASH shutdown window in June, the installation of magnet supports and all quadrupole magnets in the preplasma beamline was completed (see Figure 3).

Figure 3. The first magnet installation for the FLASHForward beamline.

A X-band transverse deflector with a temporal resolution of ~1 fs is now planned to be added to the post-plasma diagnostics beamline of FLASHForward in 2018. This would give FLASHForward the best resolution on the longitudinal beam phase-space of any plasma-wakefield experiment. Funding for this upgrade has now been secured.

The beamline installation inside the FLASH 2 tunnel continued during the shutdown of the FLASH machine in November and December of 2016. Various support components have been installed by the FLASHForward team, including all beam-line-related mounts and supports, cabling for all standard diagnostics and magnets, cooling water, a new clean-room rail system (needed for the vacuum beam-line installation), most magnets, and the majority of the laser beam line. It is foreseen that installation will be concluded in time to allow technical commissioning to commence in August 2017.

In terms of VI meetings, an international workshop on possible injection schemes for FLASHForward was organized in Hamburg on April 5th and 6th; its results are reported in the working group reports below. In addition to this excellent technical progress, there have also been developments within the collaboration itself and its governance. New collaboration partners from the German university landscape could be added to the project. Groups from the Universities of Jena, Düsseldorf, and Hamburg have formed two collaborations funded through the BMBF Verbundforschung scheme to implement Trojan Horse injection and transverse plasma probing at FLASHForward over the next few years. Prof. Georg Pretzler from Düsseldorf and Prof. Malte Kaluza from Jena are acting as the chairs, respectively. The collaboration kick-off workshops were hosted in Jena on August 18 and at DESY on December 15.

Our recent success in the realisation and implementation of active plasma lenses has been funded by the President of the Helmholtz Foundation within the HGF IuVF Zukunftsprojekte scheme with ~600 kEuro over the next three years to further develop this technology. Such plasma lenses may prove to be of paramount importance not just for FLASHForward but for the application of many plasma-wakefield acceleration techniques.

The second meeting of the VI Scientific Advisory Committee took place at DESY on 19th and 20th April. The committee is chaired by Ilan Ben-Zvi and consists of Mitsuhiro Yoshida, Brigitte Cros, Philippe Piot and Stefan Karsch. The conclusions were generally highly positive, e.g. “The HVI presentations again exhibited high quality and inspire confidence in the ability of the HVI to deliver on its mission.” And “The SAC was impressed by the progress made in the various areas of the HVI and the clear growth in the FLASHForward project.” A detailed list of suggestions and comments was produced which have been addressed as the project has progressed.

FLASHForward was evaluated by the DESY machine advisory committee (MAC) in November. Their evaluation was very positive with constructive suggestions to investigate additional schemes for the mitigation of hosing induced by coherent synchrotron radiation and for tests of the simultaneous operation of FLASHForward with the FLASH FEL user beam lines.

The Annual Meeting of the Helmholtz Virtual Institute took place in conjunction with the Advanced Accelerator Conference in the Gaylord National Convention Centre, near Washington D.C. There was an excellent attendance, with fourteen members of the VI taking part, including representatives from DESY, INFN Frascati, Hamburg University, JAI, LBL, SLAC and UCLA. The status of the project and activities in the partner institutions were presented and discussed. At the meeting of the Collaboration Council that followed the main meeting, it was agreed that Prof. Bernhard Hidding’s group at Strathcylde would be admitted to the VI as an associate member, subject to agreement on a MoU. It was also agreed that the next Annual Meeting would be held in conjunction with the next EAAC meeting on September 24th, 2017, on Elba. In addition, FLASHForward now has its own Twitter feed: @FForwardDESY.

There have been a number of personnel changes within the core Hamburg team of the Virtual Institute. Stefan Wesch has joined as a DESY Fellow. He returns to DESY after an

extended period as a postdoc at Helmholtz-Zentrum Berlin. Pardis Niknejadi has also joined as a DESY fellow from the University of Hawaii in December. Maik Dinter has accepted the position of FLASHForward laser technician. Our master students Gabriele Tauscher and Simon Bohlen have successfully completed their Master of Science degrees. Both of them continue their research as PhD students. Other new PhD students include Sarah Schröder and Paul Winkler, who did their first degrees at Hamburg University, while Bridget Sheeran comes from the University of Manchester. Jelto Thesinga and Paul Pourmoussavi have joined the team as student assistants. Meanwhile, Charlotte Palmer, Matthew Streeter, Gregor Indorf and Jan-Niclas Gruse have left the team.

Reports from Working Groups

The scientific work and preparation of the Virtual Institute is organized into four working groups.

WG1: Plasma simulations
Coordinators: Alberto Martinez de la Ossa (UHH), Jorge Vieira (IST)

The simulation group organised the “FLASHForward Injection Shoot-out and Hosing Workshop” at DESY on April 5th and 6th. On the first day, a committee of international experts in the field from within the VI helped us to rank and prioritize the different proposed injection techniques for generation of witness beams. The ranking was based on the quality of the expected bunch parameters, expected jitter sensitivity, and the complexity of implementation under realistic experimental conditions at FLASHForward. As a result, density down-ramp injection methods will receive highest priority. On day 2, the problem of beam hosing was discussed in detail. A new theoretical model for the beam hosing instability in the blowout regime was presented by Timon Mehrling. This work demonstrates that self-consistent effects occurring in the excitation of the plasma-wave in realistic density profiles and the energy spread of the beam may effectively suppress the hose instability. In addition, a new method for the reduction of the hose seed by shaping of the plasma target has been proposed. The agreement between the theoretical prediction and full 3D PIC simulations was found to be excellent. Still, full start-to-end simulations are required to diagnose and study the performance of realistic beams that do not completely match the assumptions in the model. A paper on this subject has just been accepted for publication in Physical Review Letters. In this context, a new field solver and particle pusher have been implemented into our quasi-static particle-in-cell (PIC) code HiPACE, which is now capable of dealing with hosing dynamics with high physical fidelity at numerical noise levels significantly below those of typical finite-difference-time-domain codes, whose artificial numerical fluctuations may seed beam hosing and alter its growth dynamics, in particular for long propagation distances in the plasma.

In preparatory studies, PIC simulations with realistic FLASH beams have shown that increasing the emittance and the spot size of the FLASHForward drive beams at the plasma entrance can lead to substantial hosing mitigation. Theoretical models predict that hosing can in addition be mitigated by deploying beams with a significant energy spread and/or strong energy chirps. The goal of these studies is to define an experimental setup in which beam hosing is largely suppressed for the stable high-current operation of the FLASHForward plasma accelerator

In addition, WG1 is exploring a new injection concept that involves a laser-driven wakefield stage for the generation of witness beams to be injected into the FLASHForward beam-driven stage. The setup involves a two-compartment plasma cell with two gas components, helium and hydrogen. The relatively low-intensity hydrogen-ionization laser and the FLASHForward beam are not capable of ionizing helium. The helium is only ionized by an intense laser pulse trailing the FLASH beam. By tuning the helium density profile, and the

intensity and the focal position of the high-intensity laser, it is possible to create a high-quality beam from the laser-driven helium stage. Subsequently, this beam is injected as a witness into the FLASHForward beam-driven hydrogen wakefield by appropriately delaying the laser (and thus the witness bunch) with respect to the drive beam. Current simulations show promising results. The main advantages of this scheme over traditional laser-triggered ionization injection (aka Trojan Horse) are its strongly reduced peak current requirements for the drive beam and the possibility to generate longer beams that do not suffer from gain-suppression effects in FELs due to beam slippage.

Another major focus of current simulation work is the analysis of the density down-ramp injection method for FLASHForward-type beams and plasma targets. The theoretical framework has been set up and optimised by the collaboration. Simulations utilising realistic density profiles and realistic start-to-end beams are foreseen to be conducted as a next step. The observed effect that steeper ramps lead to beams that are longer, have higher current, lower energy spread and lower emittance is explained. We highlight a case for FLASHForward consisting of a Gaussian-shaped density spike with a top (bottom) density value of $4x10^{17}$ ($4x10^{16}$) cm^{-3} and a total length of ~100 µm. The injected bunch has 130 pC of charge, 130 fs duration, GeV energy with ~0.3% un-correlated relative energy spread and 0.3 µm sliced normalised emittance.

Our proposal for 17.7 MCPUh on the supercomputer JUQUEEN, Jülich, Germany, to be dedicated to studies directly related to the activities of this VI WG has been approved. Furthermore, the project received the excellence award of the John von Neumann-Institute for Computing, recognizing it as the best scientific proposal of the JUQUEEN computing cycle from May 2016 to April 2017. The project supports large-scale FLASHForward plasma simulations for refined start-to-end studies of injection techniques and beam quality preservation.

WG2: Beam dynamics and instrumentation
Coordinators: Vladyslav Libov (UHH), Ivan Konoplev (JAI)

The goal of Working Group 2 is to develop, install, commission and operate a beam line suitable for transport and diagnostics of plasma-accelerated electron beams at FLASHForward. The technical design of this post-plasma beam line is in progress. Technical drawings are being produced by the DESY construction and engineering department and will be interfaced with the existing drawings of the pre-plasma beam line.

Several additional extensions to the FLASHForward beamline have been simulated and included in its technical design. Its compatibility with an active plasma lens setup has been studied. The current lattice supports the inclusion of a high-field gradient (in excess of 1000 T/m) plasma lens close to the plasma cell. Such a lens, pioneered in the LBNL group of Wim Leemans, reduces chromatic emittance growth at FLASHForward by an order of magnitude compared to conventional focusing elements. Combined with the controlled beam release from plasma to vacuum (plasma-density tailoring), emittance can be conserved.

Detailed studies for beam orbit control have been performed. The current design, containing four cavity beam-position monitors, allows measurements of position, pointing and charge of the beams exiting the plasma. Additionally, the quadrupoles after the plasma cell can be transversely aligned by external movers with an accuracy of a few micrometers.

The design of the betatron diagnostics is in progress. A new student from Imperial College London/JAI, Elias Gerstmayr, has joined WG 2 and is supporting our efforts on betatron-radiation detection. A high-transmission X-ray vacuum window and a 10 Hz direct-detection X-ray CCD were ordered.

Discussions are ongoing to finalise modifications to our existing screen chambers to facilitate their use for both emittance measurements and transition-radiation generation. Planning of the geometry for the imaging optics continues.

In addition, two beam-time proposals for FLASH accelerator research and development have been submitted. Proposal 1 suggests that head-to-tail centroid shifts induced in the FLASH bunch compressors should be quantified and that test mitigation strategies should be tested. Proposal 2 is a continuation of our efforts to test driver-witness beam generation by two independently timed laser pulses onto the FLASH photo gun.

Several issues in the design of the vacuum system of the pre-plasma section of the beamline have been identified and solved, such as beam-pipe diameter steps in the vicinity of beam-position monitors (which might deteriorate their performance), and collision conflicts between the laser in-coupling beam pipes and various diagnostic components. First technical drawings of the post-plasma line by the engineering group at DESY are ready.

A transverse-deflecting structure (TDS) will be included in the FLASHForward beamline in order to allow longitudinal phase-space and slice emittance measurements. This requires extension of the post-plasma section, adding some space for the TDS and additional quadrupoles to meet the beam-optics requirements.

A meeting of Working Group 2 held at DESY included group members from JAI. Progress in WG2 was reviewed and various ideas for further improvements were discussed. The team from JAI presented a maturing design of a non-invasive, single-shot longitudinal electron-beam diagnostic device based on Smith-Purcell (SP) radiation. This device needs to be adapted to specific FLASHForward beam properties, requiring careful study before implementation can be considered.

The technical design of the transition radiation (TR) diagnostic continues. A diamond window for separating the ultra-high-quality FLASH vacuum from the secondary vacuum of the TR beam line is already at DESY and is being characterised. Investigation of the various types of beam splitters (to distribute the TR between the available THz-to-visible spectrometers) has been started. We have shown the feasibility of Inverse Compton Scattering as a diagnostic for electron beam divergence, and investigated the spectrum, longitudinal phase-space and requirements on the photon detectors. Within this context, a scintillator array to measure the photon angular distribution has been built and is ready to be tested with LWFA electrons in the test lab of FLASHForward. Options to mitigate the driver beam deterioration from coherent synchrotron radiation (CSR) are being studied. In particular, preparations are ongoing for beam time at FLASH which is dedicated to a measurement of centroid shift offsets caused by CSR in the bunch compressors using a TDS.

First results from the active plasma lens experiments at the MaMi Microtron (Mainz, Germany) support the feasibility of stable operation of these devices with gradients of ≥ 500 T/m, as well as the linearity of their fields. These features should allow for preservation of the emittance of divergent beams from plasma accelerators. The next measurement campaign at MaMi, now in collaboration with Lawrence Berkeley Laboratory (LBNL), is confirmed for November 2016.

The conceptual design for the post-plasma extension was amended to include a TDS for a fs-level longitudinal diagnosis of the drive and the witness beams. The beamline concept, including the cavity and RF source specifications, was presented at the International Beam Instrumentation Conference (IBIC 2016). A collaboration with CERN, PSI and DESY to procure many of the TDS components has been organized and held a meeting on September 21 to discuss the details of this collaboration.

Strategies to mitigate coherent-synchrotron radiation (CSR) effects are being investigated. Three measurement shifts were performed at FLASH in August 2016. The main goal was to test the procedures for centroid-offset measurements using the transverse-deflecting cavity of FLASH (LOLA). Special optics for the LOLA section were devised for this and tested during the shifts; the data is being analysed. Figure 4 shows preliminary results on the centroid offsets in the horizontal plane (the plane where the largest offsets are expected owing to the bunch compressors) for on-crest phases (minimum compression). The two topmost plots show the slice centroid and slice pointing of the beam as a function of the longitudinal coordinate. Indeed, in this uncompressed state the beams show head-to-tail correlations of the horizontal centroid; such effects from CSR are expected only for high currents, therefore the observed correlations are presumably due to various effects in the gun, coupler kicks induced by accelerating modules, wakefields etc. Some of these offsets are expected to be minimized by applying bunch compression, since their severity scales with bunch length.

Studies are underway to minimize centroid shifts from CSR while maintaining the high peak current by choosing an appropriate compression scheme and/or using an emittance spoiler (thin foil). Initial simulation results are promising; centroid offsets are mitigated at the expense of emittance growth. In contrast to the unoptimised case, these beams show no significant hosing inside plasma in particle-in-cell simulations.

Another shift on double-bunch generation with a double-laser-pulse method (one of two schemes to allow for external injection experiments at FLASHForward) was conducted on August 18, 2016. Good transmission of both the drive and witness bunches from the RF gun to the LOLA was achieved. A working point was found where the drive bunch was compressed to around 700A and separated by around 1 ps from the witness, as shown in Fig. 5. Another shift took place on September 26th, with the goal of further optimising the compression scheme and generating high currents in both bunches. Results will be published soon.

Alternatively, double-bunches can be produced with a mask in the dispersive section of FLASHForward. Preliminary investigations indicate that it is possible to obtain double bunches appropriate for external injection with this technique.

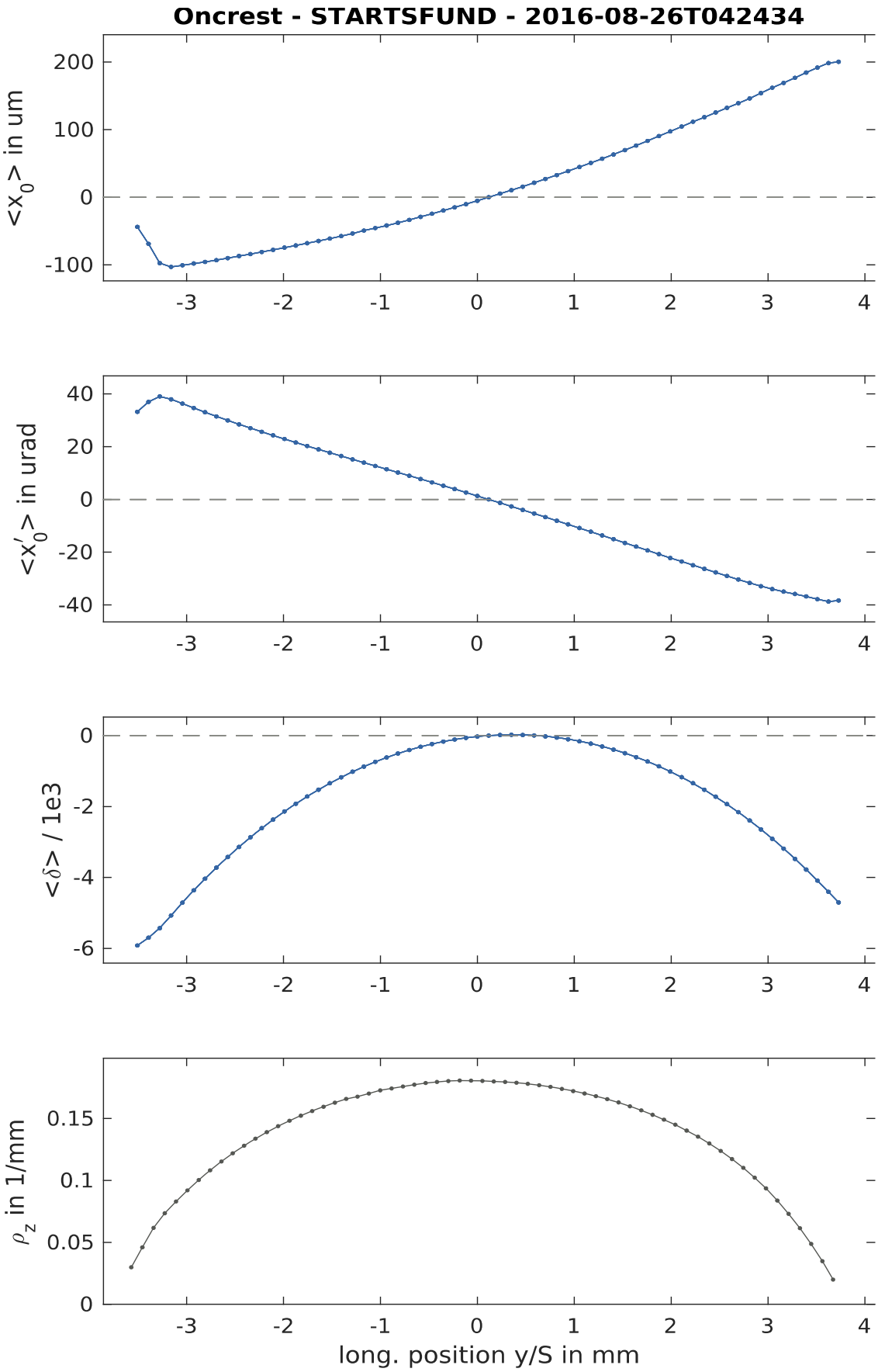


Figure 4. Results of FLASHForward centroid-offset detection campaign at FLASH.

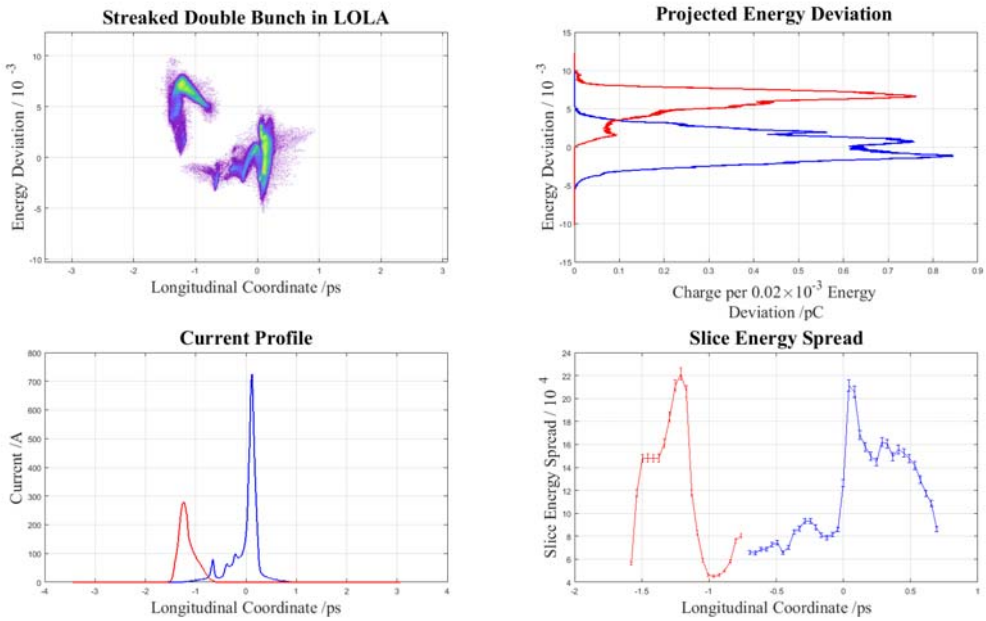


Figure 5. Results of a double-bunch campaign at FLASH for driver (blue line) and witness (red line) generation.

In-situ tests of the pulsed dipoles (of type TDG) that will be used to extract beams from FLASH2 into the FLASHForward beamline have been performed. One of the two magnets has been temporarily installed into a position in close proximity to its final location in the FLASH extraction area, and connected to its half-sine pulser to check for the influence of electromagnetic noise on existing FLASH electronics. A small perturbation on some sensitive FLASH diagnostic components was observed when the magnet is in operation. This is being investigated and is expected to be improved with advanced shielding. In addition, the heat load generated by Eddy currents in the TDG magnets, in particular caused by fringe fields at the edges of the entrance and exit openings, are being examined both in simulations and experimentally.

The preparations for the 2017 summer shutdown of FLASH are well underway. The technical design of the vacuum system for the pre-plasma beam line has been. The focus is now on the final design of the initial post-plasma section of FLASHForward, including the capturing section and the beam energy spectrometer. This work is done in collaboration with WG1 - double-bunch beams obtained from start-to-end simulations including the scraper are used in particle-in-cell codes to assess the suitability of the generated beam distributions.

Studies on characterisation and minimisation of the impact of CSR effects are advancing. Two measurement shifts of 12 hours each were performed on November 26 and 27 with the goal of refining the measurement of the beam slice properties at FLASH. In particular, a multi-quadrupole scan was performed to determine slice-resolved emittance and centroid offsets for the minimum-energy-spread setting and for a compressed beam of ~200 fs duration. In addition, several measurements were taken with the CRISP transition radiation spectrometer in order to cross-check the results from the LOLA transverse-deflecting cavity. Finally, a compression scan was performed with the goal of assessing the quality of FLASH start-to-end simulations. The data is being analysed.

WG3: Plasma sources
Coordinators: Lucas Schaper (DESY), Patric Muggli (MPP)

The FLASHForward plasma-cell prototype for initial experiments on ionizing hydrogen has been manufactured and installed in the corresponding test chamber, allowing the focusing geometry for ionization to be tested and the dimensions of the resulting plasma to be investigated experimentally and compared to simulations. The beam lines and chambers for ionisation and target testing in the FLASHForward test lab have been completely installed. The first experiments are investigating the plasma generation and resulting electron densities from different peak intensities and pulse durations of a two-lens laser focusing system with about 17m focal length. The corresponding lens system has been set up and the focus has been studied at atmospheric pressure conditions. After first ionization studies the FLASHForward target prototype will be characterized. Progress has been slowed by various time-consuming problems that prevented the generation of a stable plasma in the ionisation test chamber with the 25TW laser. These problems have now been solved.

The modified requirements imposed on FLASHForward components in contact with the accelerator vacuum resulted in new options for the gas-supply infrastructure. Currently, a more convenient and cost-effective solution for the gas-control system is being investigated. In addition, studies on the fragmentation and ionisation dynamics of molecular hydrogen interacting with ultrashort laser pulses were presented at the 2016 AAC conference and received significant interest from the community.

The experimental setup for FLASHForward plasma-target tests, for the cross-calibration of the electron density measurement via Stark broadening, and for benchmark experiments for the developed code on fragmentation dynamics of molecular gases has been refined. Data taking for all of these experiments is imminent.

A plasma lens characterisation campaign was executed at the MaMi microtron accelerator in Mainz in November 2016 using an electron beam of 855 MeV. One of the goals was to evaluate the magnetic field quality of active plasma lenses, important for beam quality preservation. For this purpose, beam emittance was measured as a function of the discharge current and without the plasma lens in operation. Additionally, a transverse offset scan was performed as a direct measurement of the field gradient. The data analysis is ongoing.

At the end of 2016, first acceleration of electrons via laser wakefield acceleration (LWFA) was achieved using the 25TW FLASHForward system. The generated electron beams originated from wave breaking and showed the expected properties. The purpose of this LWFA setup is the reliable creation of electron beams for the development of components for FLASHForward, such as the transition-radiation spectrometer.

WG4: Photon sources
Coordinators: originally Matthew Streeter (DESY), now Pardis Niknejadi (DESY), *Carl Schroeder (LBNL)*

The decision has been taken to utilize the TTF undulators as the baseline design for Phase II of the FLASHForward project. This has resulted in concentrating the approach of the simulation and theory groups on assessing and optimising the quality of accelerated electron beams. Several cases have been demonstrated that have attractive properties for FEL gain, i.e. low energy spread and emittance, plus a high beam current extending over many slippage lengths. Work is currently underway to assess potential FEL gain with these beams using an analytical model.

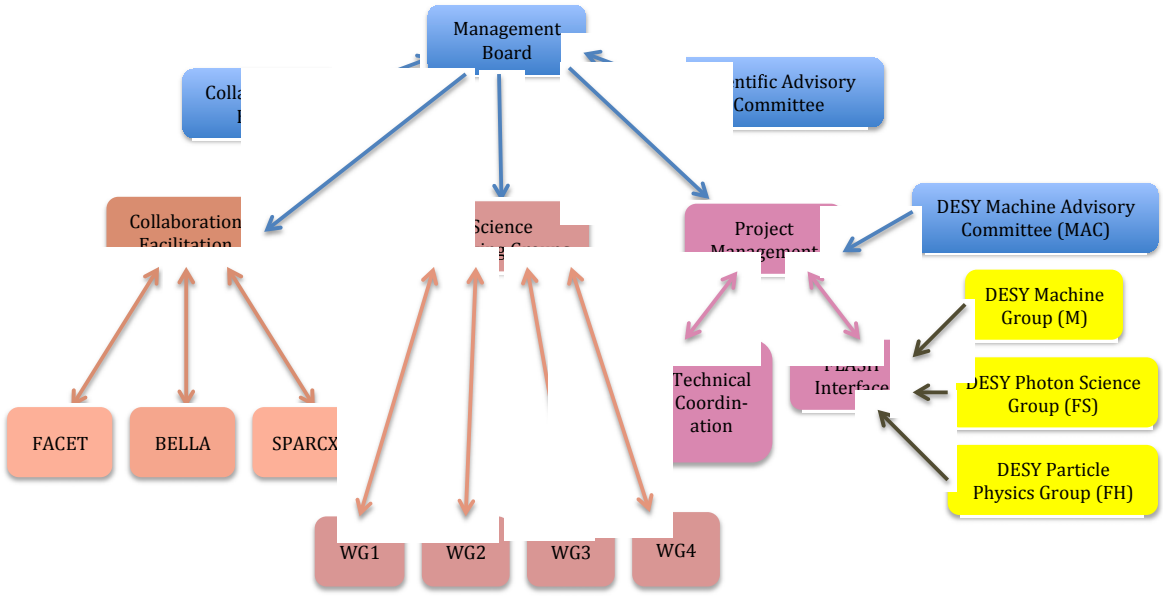
Energetic photon beams can now be generated via betatron radiation and Thomson scattering in the FLASHForward test and preparation laboratory. This photon source will be the first produced by the FLASHForward collaboration so it is an ideal opportunity to start testing experiments and diagnostics. We are currently planning a test of an X-ray powder diffraction diagnostic with the group from JAI, as well as a scintillator-based diagnostic.

Following on from the preliminary work carried out on evaluating the performance of some particle distributions from plasma PIC simulations with the available TTF undulators, the following future work plan has been specified:

- Establish the capability to model the transport of beams from the plasma section to the undulator with the final FLASHForward beamline design by simulation with Elegant. This simulation setup will be modified as and when the diagnostic beamline optics change - or to evaluate beam transport options.
- We will start with a basic FODO setup for the undulator section.
- Provide a code based on Ming Xie for a quick evaluation of beams. This could be used as a rapid way to quantify the results of PIC simulations.
- Develop Genesis 1.3 and Puffin simulations for a full evaluation of the simulated beams. Use code in 1D for relatively quick checks of promising beams. Use code in 3D for more rigorous checks of still promising beams - This will require the beam distributions to be modified so that they are matched to the undulator section.
- Include nonlinear beam transport effects into 3D simulations for beams that are particularly interesting.

VI organisation and collaboration structure

The VI structure is displayed in the following diagram



The Collaboration board in chaired by Professor Andrei Seryi, JAI, and meets annually in conjunction with the Annual Meeting of the VI. This is normally held at the Advanced Accelerator Concepts meetings which alternate between the US and Europe. The next VI Annual Meeting will be held on September 24th, 2017, on Elba in advance of the EAAC meeting.

b) Milestones achieved

The major milestone of the VI is the installation and commissioning of the FLASHForward beamline. After significant delays prior to 2016 relating to the delay in completion of the European XFEL, which absorbed the specialist staff at DESY required for FLASHForward engineering and installation, the project is now on schedule for completion of the installation and beginning of commissioning in the summer of 2017. The work required to complete the various reports specified in the original VI proposal has also been delayed because of the overall delay to FLASHForward and it has therefore been decided to incorporate all these reports into the final report of the VI which will be prepared in 2018.

c) Compliance with financial plan and schedule

No further delays have occurred in the year 2016, such that the installation of the major infrastructure of this VI, the FLASHForward beamline, is on track for commissioning starting in August 2017 (also cf. Fig. 6). This progress has accordingly led to compliance with the financial plan in terms of expenses for infrastructure, material and consumables. The planned spending on personnel has been running a little slow up until the end of 2016 owing to the departure of two postdoctoral researchers. Their positions will be filled again in 2017. Two suitable candiates, Kristjan Poder (from JAI) and Alexander Knetsch (from UHH), have been identified and their hiring at DESY has been initiated at the beginning of this year. It is expected that all funds will be spend as foreseen by the end of the runtime of the Virtual Institute.

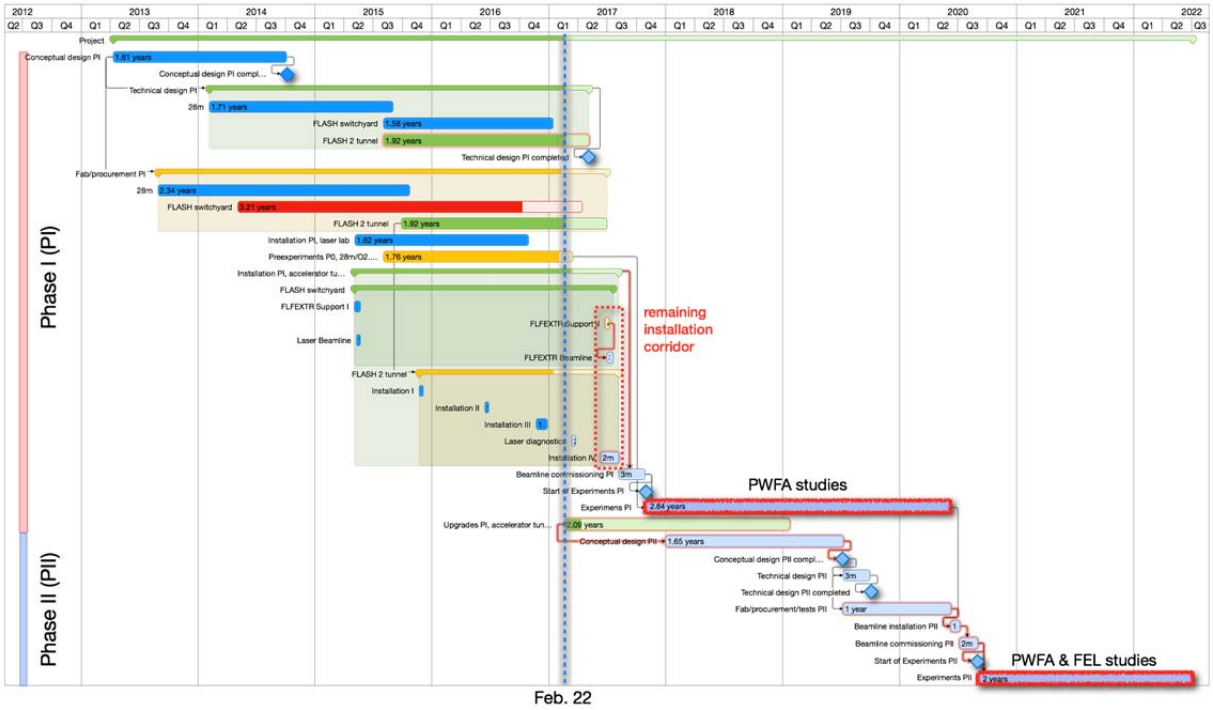


Figure 6: WBS of the FLASHForward Installation as of Feb. 22, 2017

d) Publications, talks, prizes, etc.

Peer-reviewed publications:

- Caldwell, A. ; Adli, E. ; Amorim, L. ; Apsimon, R. ; Argyropoulos, T. ; Assmann, R. ; Bachmann, A.-M. ; Batsch, F. ; Bauche, J.; Berglyd Olsen, V. K. ; Bernardini, M. ; Bingham, R. ; Biskup, B. ; Bohl, T. ; Bracco, C. ; Burrows, P. N. ; Burt, G. ;Buttenschön, B. ; Butterworth, A. ; Cascella, M. ; Chattopadhyay, S. ; Chevallay, E. ; Cipiccia, S. ; Damerau, H. ; Deacon, L. ;Dirksen, P. ; Doebert, S. ; Dorda, U. ; Elsen, E. ; Farmer, J. ; Fartoukh, S. ; Fedosseev, V. ; Feldbaumer, E. ; Fiorito, R. ;Fonseca, R. ; Friebel, F. ; Geschonke, G. ; Goddard, B. ; Gorn, A. A. ; Grulke, O. ; Gschwendtner, E. ; Hansen, J. ; Hessler, C. ; Hillenbrand, S. ; Hofle, W. ; Holloway, J. ; Huang, C. ; Hüther, M. ; Jaroszynski, D. ; Jensen, L. ; *et al.*, **Path to AWAKE: Evolution of the concept**, Nuclear instruments & methods in physics research / A 829, 3 - 16 (2016) [10.1016/j.nima.2015.12.050]
- Dorda, U. ; Assmann, R. ; Brinkmann, R. ; Flöttmann, K. ; Hartl, I. ; Hüning, M. ; Kärtner, F. ; Fallahi, A. ; Marchetti, B. ; Nie, Y. ; Osterhoff, J. ; Schlarb, H. ; Zhu, J. ; Maier, A. R. **SINBAD—The accelerator R&D facility under construction at DESY**, Nuclear instruments & methods in physics research / A 829, 233-236 (2016) [10.1016/j.nima.2016.01.067]
- Kononenko, O. ; Lopes, N. C. ; Cole, J. M. ; Kamperidis, C. ; Mangles, S. P. ; Najmudin, Z. ;Osterhoff, J. ; Palmer, C. A. J. ; Poder, K. ; Rusby, D. ; Symes, D. R. ; Warwick, J. ; Wood, J. C. **2D hydrodynamic simulations of a variable length gas target for density down-ramp injection of electrons into a laser wakefield accelerator**, Nuclear instruments & methods in physics research / A 829, (2016) [10.1016/j.nima.2016.03.104]
- Lishilin, O. ; Gross, M. ; Brinkmann, R. ; Engel, J. ; Gruener, F. ; Koss, G. ; Krasilnikov, M. ; Martinez de la Ossa, A. ; Mehrling, T. ; Osterhoff, J. ; Pathak, G. ; Philipp, S. ; Renier, Y. ; Richter, D. ; Schroeder, C. ; Schütze, R. ;Stephan, F., **First Results of the Plasma Wakefield Acceleration Experiment at PITZ**, Nuclear instruments & methods in physics research / A 829, (2016) [10.1016/j.nima.2016.01.005]
- Mehrling, T. J. ; Robson, R. E. ; Erbe, J.-H. ; Osterhoff, J., **Efficient numerical modelling of the emittance evolution of beams with finite energy spread in plasma wakefield accelerators**, Nuclear instruments & methods in physics research / A 829, 367-371 (2016) [10.1016/j.nima.2016.01.091]

Invited conference proceedings:

- Osterhoff, J. ; Najmudin, Z. ; Faure, J., **Case Studies on Plasma Wakefield Accelerator Desig**, CAS-CERN Accelerator School: Plasma Wake Acceleration, Geneva, Switzerland, 23 Nov 2014 - 29 Nov 2014 CERN Accelerator School Yellow Report CERN-2016-001, 301-308 (2016) [http://dx.doi.org/10.5170/CERN-2016-001.301]

Invited presentations:

- Osterhoff, J., **The Wave of the Future - Plasma wakefield acceleration at DESY, in the Helmholtz Association, and in Germany**, IAEA Technical Meeting on Advanced Accelerator Technology, Athen, Greece, 13 Jun 2016 - 17 Jun 2016
- Osterhoff, J., **Beam Diagnostics Challenges in Plasma Wakefield Acceleration**, International Beam Instrumentation Conference, Barcelona, Spain, 11 Sep 2016 - 15 Sep 2016
- Osterhoff, J., **Novel Acceleration Technologies - Miniature machines for the future of photon science and particle physics**, Helmholtz Alliance “Physics at the Terascale” 10th Annual Meeting, Hamburg, Germany, 21 Nov 2016 - 23 Nov 2016
- Osterhoff, J., **FLASHForward into the Future - Challenges and Prospects for Beam-Driven Plasma-Wave Acceleratio**, Seminar, Universiteit Gent, Gent, Belgium, 21 Mar 2016 - 21 Mar 2016
- Osterhoff, J., **The Wave of the Future - Prospects for Plasma-Wave Acceleration in Particle Physics and Photon Science**, Seminar for the Vereniging Voor Natuurkunde, Gent, Belgium, 21 Mar 2016 - 21 Mar 2016
- Osterhoff, J., **Plasma Wakefield Acceleration - An introduction to laser- and beam-driven concepts**, The 7th Asian Summer School and Symposium on Laser-Plasma Acceleration and Radiation, Shanghai, China, 17 Jul 2016 - 23 Jul 2016

Contributed conference presentations:

- Aschikhin, A. ; Ossa, A. M. d. l. ; Mehrling, T. ; Osterhoff, J., **Emittance conservation through tailored plasma ramps in PWFA scenarios**, DPG-Frühjahrstagung: Arbeitskreis Beschleunigerphysik, Darmstadt, Germany, 14 Mar 2016 - 18 Mar 2016

- Bohlen, S. ; Corvan, D. ; Osterhoff, J. ; Schmidt, B. ; Schwinkendorf, J.-P. ; Streeter, M., **Detection of Inverse Compton Scattering in Plasma Wakefield Experiments**, DPG-Frühjahrstagung: Arbeitskreis Beschleunigerphysik, Darmstadt, Germany, 14 Mar 2016 - 18 Mar 2016
- Goldberg, L. ; Schaper, L. ; Schwinkendorf, J.-P. ; Tauscher, G. ; Osterhoff, J., **Electron density determination via broadening and shift of spectral lines**,17th Advanced Accelerator Concepts Workshop, AAC 2016, National Harbor, Maryland, USA, 31 Jul 2016 - 5 Aug 2016
- Kononenko, O. ; Bohlen, S. ; Dale, J. ; Darcy, R. ; Dinter, M. ; Erbe, J.-H. ; Horbatiuk, T. ; Indorf, G. ;Di Lucchio, L. ; Goldberg, L. ; Gruse, J.-N. ; Karstensen, S. ; Libov, V. ; Ludwig, K. ; Martinez de la Ossa, A. ; Marutzky, F. ;Niroula, A. ; Osterhoff, J. ; Quast, M. ; Schaper, L. ; Schwinkendorf, J.-P. ; Streeter, M. ; Tauscher, G. ; Weichert, S. ; Palmer, C., **Investigation of advanced electron bunch generation and diagnostics in the BOND laboratory at DESY**, 58th Annual Meeting of the APS Division of Plasma Physics, San Jose, USA, 31 Oct 2016 - 4 Nov 2016
- Kövener, T. ; Wunderlich, S. ; Peier, P. ; Hass, E. ; Schmidt, B., **THz Spectrometer Calibration at FELIX**, DPG-Frühjahrstagung: Arbeitskreis Beschleunigerphysik, Darmstadt, Germany, 14 Mar 2016 - 18 Mar 2016
- Mehrling, T. ; Martinez de la Ossa, A. ; Fonseca, R. ; Vieira, J., **Mitigation of the hose instability in plasma-wakefield accelerators**, 17th Advanced Accelerator Concepts Workshop, AAC 2016, National Harbor, Maryland, USA, 31 Jul 2016 - 5 Aug 2016
- Osterhoff, J., **FLASHForward – Status and Plans**, BMBF Verbund Kick-Off Workshop "Trojan Horse at FLASHForward", Hamburg, Germany, 15 Dec 2016 - 15 Dec 2016
- Osterhoff, J., **Considerations for a Beam-Driven EuPRAXIA Accelerator of High Average Power**, EuPRAXIA WP 9 Meeting, Frascati, Italy, 3 Oct 2016 - 4 Oct 2016
- Schaper, L. ; Tauscher, G. ; Goldberg, L. ; Schwinkendorf, J.-P. ; Martinez de la Ossa, A. ; Osterhoff, J., **Fragmentation Dynamics of Gases and their Impact on Plasma Wakefield Acceleration**, 17th Advanced Accelerator Concepts Workshop, AAC 2016, National Harbor, USA, 31 Jul 2016 - 5 Aug 2016
- Schwinkendorf, J.-P. ; Aschikhin, A. ; Behrens, C. ; Bohlen, S. ; Dale, J. ; di Lucchio, L. ; Erbe, J.-H. ;Felber, M. ; Foster, B. ; Goldberg, L. ; Gruse, J.-N. ; Hidding, B. ; Hu, Z. ; Knetsch, A. ; Kononenko, O. ; Libov, V. ; Martinez de la Ossa, A. ; Mehrling, T. ; Palmer, C. A. J. ; Schaper, L. ; Schlarb, H. ; Schmidt, B. ; Streeter, M. ; Tauscher, G. ; Wacker, V. ; Weichert, S. ; Wunderlich, S. ; Zemella, J. ; Osterhoff, J., **FLASHForward - Beam-driven plasma wakefield acceleration at DESY**, 17th Advanced Accelerator Concepts Workshop, AAC 2016, National Harbor, Maryland, USA, 31 Jul 2016 - 5 Aug 2016
- Tauscher, G. ; Schaper, L. ; Aschikhin, A. ; Bohlen, S. ; Dale, J. ; Erbe, J.-H. ; Goldberg, L. ; Mehrling, T. ; Palmer, C. ; Streeter, M. ; Schwinkendorf, J.-P. ; Wesch, S. ; Ossa, A. M. d. l. ; Osterhoff, J., **Theoretical and Experimental Studies on Ionisation Properties for Plasma Accelerators**, DPG-Frühjahrstagung: Arbeitskreis Beschleunigerphysik, Darmstadt, Germany, 14 Mar 2016 - 18 Mar 2016

Conference posters:

- Bohlen, S. ; Streeter, M. ; Aschikhin, A. ; Hu, Z. ; Di Lucchio, L. ; Martinez de la Ossa, A. ; Schmidt, B. ; Osterhoff, J., **Simulations of Inverse Compton Scattering as a Diagnostic for Plasma Wakefield Electrons at FLASHForward**, Nuclear Photonics 2016, NP2016, Monterey, California, USA, 16 Oct 2016 - 21 Oct 2016
- Libov, V. ; Aschikhin, A. ; Behrens, C. ; Bohlen, S. ; Dale, J. ; Darcy, R. ; Delbos, N. ; Lucchio ; Erbe, J.-H. ; Felber, M. ; Foster, B. ; Goldberg, L. ; Gruse, J.-N. ; Hidding, B. ; Karstensen, S. ; Knetsch, A. ; Kononenko, O. ;Ludwig, K. ; Maier, A. ; delaossa ; Marutzky, F. ; Mehrling, T. ; Palmer, C. ; Pannek, F. ; Schaffran, J. ; Schaper, L. ; Schlarb, H. ; Schmidt, B. ; Schreiber, S. ; Schwinkendorf, J.-P. ; Streeter, M. ; Tauscher, G. ; Wacker, V. ; Weichert, S. ; Wesch, S. ;Wunderlich, S. ; Zemella, J. ; Osterhoff, J., **Future-oriented wakefield-accelerator research and development at FLASH**, International Beam Instrumentation Conference, IBIC2016, Barcelona, Spain, 11 Sep 2016 - 15 Sep 2016

Theses:

- Bohlen, S., **Detection of Inverse Compton Scattering in Plasma Wakefield Experiments**, DESY-THESIS 112 pp., (2016) [10.3204/PUBDB-2016-05732]
- Borissenko, D., **Designing and Commissioning of a Setup for Timing-Jitter Measurements Using Electro-Optic Temporal Decoding**, DESY-THESIS 87 pp., (2016) [10.3204/PUBDB-2016-05592]
- Gruse, J.-N., **Calibration of laser diagnostics for laser plasma-wakefield acceleration**, ca. 90 (2016)
- Koevener, T., **THz spectrometer calibration at FELIX** 1-83 (2016) [10.3204/PUBDB-2016-06662]
- Wunderlich, S., **Development and Commissioning of a Double-Prism Spectrometer for the Diagnosis of Femtosecond Electron Bunches**, DESY-THESIS 201 pp., (2016) [10.3204/PUBDB-2016-05734]

Prizes:

- Excellence award of the John von Neumann-Institute for Computing, Helmholtz Centre Jülich, recognizing the core high-performance computing project of this Virtual Institute as the best scientific proposal of the JUQUEEN computing cycle from May 2016 to April 2017. P.I.: Alberto Martinez de la Ossa, Hamburg University.