

Figure 1: The new FLASHForward polarisable X-band transverse deflection structure — to be utilised for world-first fs-level diagnostics of PWFA bunches later in 2019 — undergoing high-power conditioning at the XBOX facility at CERN (2019-07-12).

General Information and Project News

Firstly, we would like to apologise for the lengthy delay since the last newsletter. The commissioning and running of FLASHForward, the ending of the Helmholtz Virtual Institute and the concomitant paperwork, and the formation of the new FLASHForward International Partnership for Science (FIPS) has left little time for important but postponable items such as the Newsletter. The FLASHForward facility is now fully commissioned and being used to produce first-class science. Highlights can be found in the section given below.

The first Annual Meeting of the FIPS Collaboration was held from 4th—6th December in DESY. There were more than fifty participants from all over the world. Tours of the FLASHForward facility began proceedings, followed by two days of talks, reports and discussion. The FIPS Scientific Advisory Committee (SAC) attended the entire proceedings and finished off the meeting by reporting on their impressions of progress over the previous year. They were also asked to evaluate the various proposals for time at the facility, which they did in a subsequent written report. This was in general highly complimentary of the quality of the experimental programme proposed. Various clarifications — were requested and the resulting prioritised list has been extremely useful to the FLASHForward management in planning the allocation of beam time for 2019. In particular the elevation of the scientific profile of high average-power research and the necessary search for funding in order to secure its realisation were highlighted by the SAC. Material from the FIPS Collaboration Meeting is available on <https://indico.desy.de/indico/event/21556/overview>. **The second FIPS Meeting will take place at DESY on November 26th - 28th 2019. Further information will be provided nearer the time.**

In addition to the valuable feedback on internal FLASHForward research, the SAC provided scientific oversight of the first round of experimental proposals from potential external collaborators. FLASHForward received ten proposals in total from institutes across Europe, with every proposal representing an exciting avenue of exploration for the unique infrastructure available at DESY. Many of these proposals have already been integrated into the FLASHForward 'X-number' system with the hope for beam time at FLASHForward in the near future.

Members of the FLASHForward group have played a full part in recent meetings, including the ALEGRO workshop at CERN in March, looking at the specification of a future particle-physics collider as an input into the CERN Strategy discussions. Group members attended the Open Symposium on the CERN Strategy in Granada in May, in which the possibilities of a future plasma-based high-energy particle colliders were discussed. In the same month, group members also attended the LPAW2019 conference in Split. The major accelerator conference of the year, IPAC 2019, was held in Melbourne in May. Again the group was represented, although the cost and distance involved did reduce numbers somewhat. Plasma acceleration was well represented.

A large number of papers have been published by group members since the last Newsletter:

R. D'Arcy et al., "*FLASHForward: plasma wakefield accelerator science for high-average-power applications*", Phil. Trans. R. Soc. A **377**: 20180392 (2019)

R. D'Arcy et al., "*Tunable Plasma-Based Energy Dechirper*", Phys. Rev. Lett. **122**(3), 034801 (2019)

C. Lindstrøm et al., "*Emittance Preservation in an Aberration-Free Active Plasma Lens*", Phys. Rev. Lett. **122**, 129901 (2019)

T. Kurz et al., "*Calibration and cross-laboratory implementation of scintillating screens for electron bunch charge determination*", Review of Scientific Instruments **89**, 093303 (2018)

M. J. V. Streeter et al., "*Temporal feedback control of high-intensity laser pulses to optimize ultrafast heating of atomic clusters*" Appl. Phys. Lett. **112**, 244101 (2018)

T. Mehrling et al., "*Accurate modelling of the hose instability in plasma wakefield accelerators*", Physics of Plasmas **25**(7), 079902 (2018)

J.H. Röckemann et al., "*Direct measurement of focusing fields in active plasma lenses*", Phys. Rev. Accel. Beams **21**(12), 122801 (2018)

A. Martinez de la Ossa et al., "*Intrinsic Stabilisation of the Drive Beam in Plasma Wakefield Accelerators*", Phys. Rev. Lett. **121**(6), 064803 (2018)

A. Aschikhin et al., "*Analytical model for the uncorrelated emittance evolution of externally injected beams in plasma based accelerators*", Nuclear Instruments & Methods A **909**, 414-418 (2018)

P. Niknejadi et al., “*Status of the Transverse Diagnostics at FLASHForward*”, Journal of Physics Conference Series **1067**, 042010 (2018)

In terms of personnel changes, the biggest news is the arrival of Wim Leemans to succeed Reinhard Brinkmann as Director of Accelerators at DESY. He has already shown great interest in the facility and our future plans and we look forward to working with him closely in the future.

Congratulations to Lars Goldberg, who defended his PhD thesis, “Spectroscopic Electron Density Determination of Plasma Targets for Plasma Wakefield Acceleration” on August 8th 2018. Congratulations are also due to Jan-Patrick Schwinkendorf, who successfully defended his PhD thesis “Electron-beam diagnostics for a laser-driven plasma wakefield accelerator on the framework of FLASHForward” on August 30th, 2018. Congratulations to Alexander Aschikhin, who defended his PhD thesis “Numerical beam stability studies in external injection plasma-wakefield acceleration regimes” on March 18th, 2019. Severin Diederichs was awarded an M.Sc. degree in May 2019, in part for his thesis “Positron Acceleration with Beam-Driven Plasma Accelerators”. He is now continuing to work in the group as a PhD student.

A heartfelt goodbye was said to Slava Libov, who left the group earlier this year for exciting pastures new outside of research. Thank you for all the amazing contributions made to FLASHForward over the years! However, in his stead we are pleased to welcome Carl Andreas Lindstrøm to the group. He has joined us from the University of Oslo/CERN/SLAC and has taken over coordination of the external injection experiment, X-2, from Slava. In addition to Severin we would also like to welcome a number of students to the group: Lewis Boulton, James Chappell, Jan Lukas Dresselhaus, Artemis Kontogoula, Yannick Ruske, and Jonathan Targaczewski.

Overview of Scientific Progress

Since experimentation began in Summer 2018, FLASHForward’s experimental development has progressed at pace. The milestones reached during this time were made possible due to the support of the FLASH directorate, with 1,738 hrs of beam time allocated for FLASHForward experimentation over the last 12 months — a truly impressive quantity, demonstrating recognition of the outstanding scientific potential of the facility.

In the first few hours of this beam time, field strengths in the plasma of greater than 10 GV/m were observed. After this excellent start, the first experiment was performed in July 2018, in which a linear negative chirp was artificially created in the linac and measured with LOLA, the longitudinal phase space diagnostic tool in the FLASH1 beamline. This beam, of ~200 fs rms in length and with an energy spread of 1.3% FWHM, was then transported to the FLASHForward plasma cell and focussed down to a 20 x 60 μm spot size. By varying the arrival time of the electron beam relative to the plasma-generating high-voltage discharge, a plasma density corresponding to a dechirping strength of 1.8 GeV/mm/m was found, significantly exceeding those demonstrated by competing state-of-the-art techniques (see Fig. 2). This proof-of-principle development may prove key to future plasma-wakefield-based free-electron lasers and high-energy physics facilities, where large intrinsic chirps need to be removed. These results were published in *Phys. Rev. Lett.* in Jan 2019.

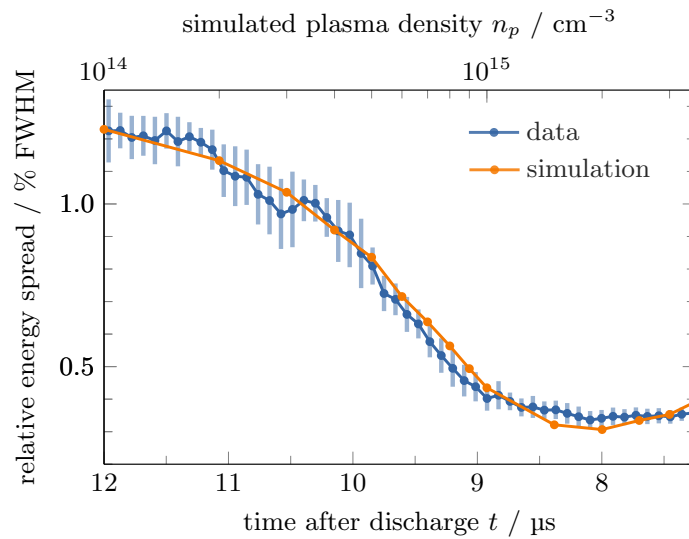


Figure 2: The FWHM of the chirped bunch energy as a function of discharge time relative to the arrival time of the electron bunch. The standard deviation, representing the shot-to-shot fluctuations per delay step, is plotted. Simulated FWHM of the chirped bunch energy spectra as a function of electron plasma density over the identical range are shown for comparison.

This first experiment provided the basis for understanding and benchmarking the interaction between the FLASH electron beam and the FF» plasma infrastructure. As such, the studies formed an experimental springboard for the core scientific experiments, denoted by the idiosyncratic FF» nomenclature of ‘X-numbers’ — about which you can here much more over the coming months at various international conferences as well as the 2nd FLASHForward FIPS Collaboration Meeting.

Follow the group on Twitter at [@FFForwardDESY](https://twitter.com/FFForwardDESY) or visit us online at forward.desy.de