Quarterly Newsletter of the FLASHForward Project - October 2016

General information on project progress

Efforts in FLASHForward have concentrated on preparing the installation of the main part of the laser beamlines and ~40% of the planned electron-beam vacuum lines, which will take place during the FLASH shutdown from November 22 until the end of 2016. A plan has also been devised to add an X-band transverse deflector with a temporal resolution of ~1 fs 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.
In addition, great progress has been made in the FLASHForward test and preparation laboratory. The experimental setups of the laser-wakefield experiment and the ionization test line have been finalised. First experimental results are expected in the near future.
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 subject to agreement on a MoU. Presentations made at the meeting can be found on the Virtual Institute Web pages at the following address: https://vi-pwfa.desy.de/e160195/e225106/. It was also agreed that the next Annual Meeting would be held in conjunction with the next EAAC meeting, probably on September 23rd, 2017, on Elba.
Finally, we welcome three new members of the FLASHForward core team, all of them PhD students: Sarah Schröder and Paul Winkler did their first degrees at Hamburg University, while Bridget Sheeran comes from the University of Manchester. Meanwhile, Charlotte Palmer, Matthew Streeter, Gregor Indorf and Jan-Niclas Gruse (after finishing his Masters) have left the team. We wish them all the best!

Reports from Working Groups

WG1: Plasma simulations

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

A new theoretical model for the description of beam hosing has been developed by T. Mehrling *et al.*, and is currently under review. This work demonstrates that self-consistent effects occurring during excitation of the plasma wave and particular initial beam properties (i.e. energy spread) can suppress the hose instability. In addition, this work proposes a new method for the reduction of the hosing seed by tapering the plasma entrance.
Start-to-end simulations for the optimisation of the FLASHForward beams with respect to beam hosing have been carried out (ELEGANT + OSIRIS simulations). Optimisation of the beam longitudinal profile and beam emittance has led to a

reduction of longitudinally varying transverse beam-centroid deviations. Work on a further reduction of the hosing seed is ongoing.
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 is set up and has been optimised by the collaboration. Simulations utilising realistic density profiles and realistic start-to-end beams are foreseen to be conducted as a next step.

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

Efforts within WG2 are mainly focused on preparations for a partial installation of FLASHForward during the FLASH shutdown of November-December 2016. This includes finalizing the vacuum design for the beam-line sections to be installed, which are the matching and final-focus section (FLF-MAFF) and a downstream part of the dispersive section (FLF-COMP), as well as procurement of the corresponding components.
Beam pipes were specified (diameters, lengths, flange types, material, coating) and ordered, along with additional components, such as the vacuum valves or the mounts for the standard diagnostics. Final checks are being performed at the moment, including the influence of geometric wakefields on the beam in the vicinity of the newly designed vacuum chamber for the final bending magnets ("X-chamber").
The conceptual design for the post-plasma extension was amended to include a transverse-deflecting structure (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).

Currently, contract negotiations are ongoing between CERN, PSI and DESY to procure many of the TDS components; a meeting was held 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. Fig. 1 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.

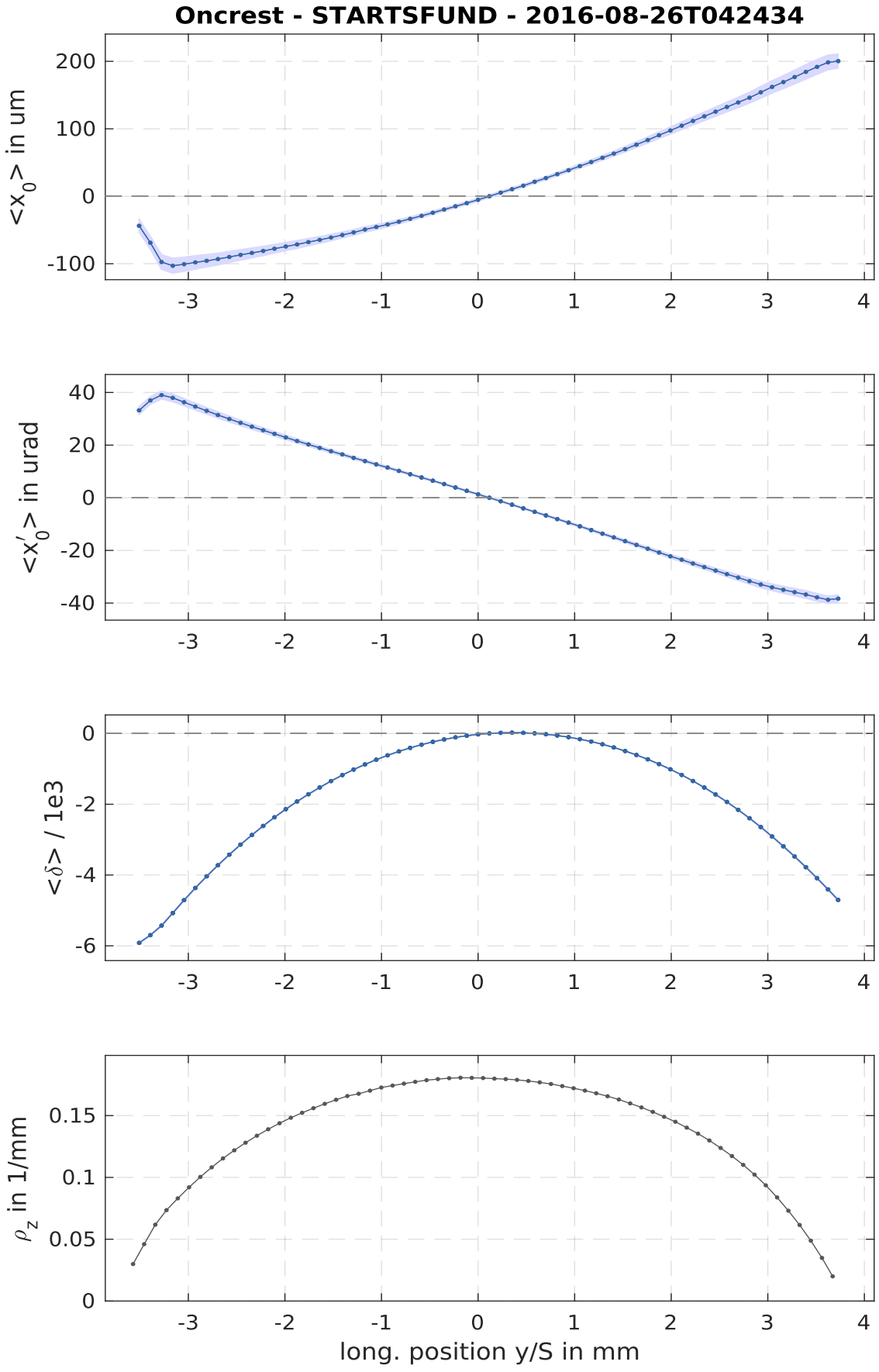

Figure 1: Results of a first FLASHForward centroid-offset detection campaign at FLASH.

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, see Fig. 2. Another shift took place on September 26, 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.

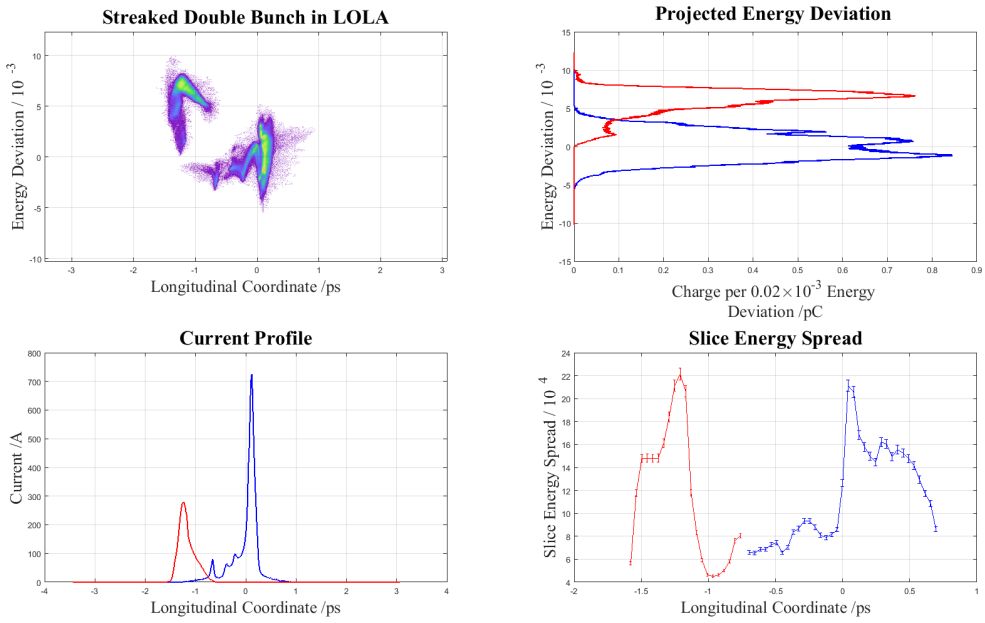

Figure 2: Results of a double-bunch campaign at FLASH for driver (blue line) and witness (red line) generation.

WG3: Plasma sources

Coordinators: Lucas Schaper (DESY), Patric Muggli (MPP)

Progress in WG3 during the past few month was slowed by various time-consuming problems that prevented the generation of a stable plasma in the ionisation test chamber with the 25TW laser. The problems encountered have either been solved or possible solutions have been identified and are being worked on. This should allow first plasma generation under controlled conditions to be achieved during October.
In addition, a new laser beam line is in the process of being set up to allow for additional diagnostics on the generated plasmas.

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.

WG4: Photon sources
Coordinators: t.b.d. (DESY), Carl Schroeder (LBNL)

There is no progress to report in WG4 due to the departure of Matthew Streeter, the former co-coordinator of this WG, to the University of Lancaster. We wish Matthew all the best for his future professional career. A new WG4 coordinator from the Hamburg groups will be appointed by the end of 2016.