Quarterly Newsletter of the FLASHForward Project - July 2016

General information on project progress

FLASHForward activities at the moment focus on the preparation of the upcoming end-of-year installation for the final part of the laser beamline and the compression and final focus sections of the electron beamline. In addition, the integration of an X-band transverse deflector for longitudinal phase-space analysis of driver and witness beams has gained traction during the last months. Vendor options are currently being explored.
These activities follow a successful short FLASH shutdown window in June, which has resulted in the installation of magnet supports and all quadrupole magnets in the preplasma beamline (see Figure 1).

Figure 1: First magnet installation window for the FLASHForward beamline has been completed.

In the meantime, the FLASHForward preparation and test laboratory has been finished and is ready for first experiments, which will start after the operation license for our laser-wakefield accelerator has been received from the city of Hamburg. This is expected any day.

The second meeting of the VI Scientific Advisory Committee took place at DESY on 19th and 20th April. The members of the committee, chaired by Ilan Ben-Zvi and consisting of Mitsuhiro Yoshida, Brigitte Cros, Philippe Piot and Stefan Karsch connected by video, except for Mitsuhiro, who came to DESY to join the meeting and to have discussions with several people at DESY. 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 and will be addressed by the project in the coming months.

The 2016 Annual Meeting of the VI will be held at the Gaylord National Convention Centre in Maryland on July 31st. This is just before the AAC meeting at the same venue. VI members who wish to attend and who have not already contacted Brian Foster should do so by 15th July at the latest.

Other developments over the past three months:

- We welcome the addition of new project members. 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 within our project. Both of them will stay onboard and continue their research as PhD students. Additionally, Jelto Thesinga and Paul Pourmoussavi have joined the team as student assistants.
- FLASHForward now has its own Twitter feed: @FForwardDESY. Please join, if you are interested.

Reports from Working Groups

WG1: Plasma simulations

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

On day 1 of the "FLASHForward Injection Shoot-out and Hosing Workshop" held on April 5th and 6th at DESY, a committee of international experts in the field from within the HGF 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 is proposed. The agreement between the theoretical prediction and full 3D PIC simulations is 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.

We are also pleased that 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 (DESY), Ivan Konoplev (JAI)

The design of the vacuum system of the pre-plasma section of the beamline is well underway. Several issues in this beamline part have recently 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 certain diagnostic components. First technical drawings of the post-plasma line by the engineering group at DESY are ready.
Discussions are ongoing to incorporate a transverse-deflecting structure (TDS) in order to allow longitudinal phase-space and slice emittance measurements. This requires extension of the post-plasma section of the beam line, adding some space for the TDS and additional quadrupoles to meet the beam-optics requirements.
An in-person meeting of Working Group 2 was recently held at DESY, joined by 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. Currently both the manpower and funds for the SP-monitor are lacking.
- 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 characterized. Investigation of the various types of beam splitters (to distribute the TR between the available THz to visible spectrometers) has been started.
- Simon Bohlen has submitted his Masters thesis on Inverse Compton Scattering as a beam diagnostic for plasma wakefield accelerators. Detailed simulations have been performed within the thesis; they show the feasibility of ICS as a diagnostic for electron beam divergence, spectrum, longitudinal phase-space as well as the 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.
- Preparations for beam time dedicated to double-bunch generation at FLASH (using the double-laser-pulse method) are also ongoing. As understanding of technical aspects (laser pulse stacker alignment and stabilization, setting up the machine for the double bunch mode) is improved, the focus is shifting to the determination of proper RF settings for optimal compression of both bunches while maintaining the desired separation between them.
- 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.

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

The beam lines and chambers for ionisation and target testing in the FLASHForward test lab are completely installed and experiments are expected to commence within the next few weeks. The first experiments will look at 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, which now has been manufactured, will be characterized.

WG4: Photon sources
Coordinators: Matthew Streeter (DESY), Carl Schroeder (LBNL)

Following on from preliminary work on evaluating the performance of some particle distributions from plasma PIC simulations with the available TTF undulators, we now have the following work plan for the short/medium term:

- Establish the capability to model the transport of beams from the plasma section to the undulator with the final FLASHForward beamline design. Slava Libov will help to set up a simulation environment in Elegant to do this. 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 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 modifying the beam distributions so that they are matched to the undulator section.
- Include nonlinear beam transport effects into 3D simulations for beams that are particularly interesting.