Quarterly Newsletter of the FLASHForward Project - March 2016

General information on project progress

Activities in the FLASHForward project are centered around two near-term goals: installation of the magnets in the pre-plasma beamline during the upcoming June FLASH shutdown (June 15 to 26) and finalisation of installations in the preparation and test laboratory. The final piece of equipment necessary for operation of the test laboratory will be the radiation protection system, which is foreseen to be completed this month. We expect to begin preliminary experiments soon thereafter.

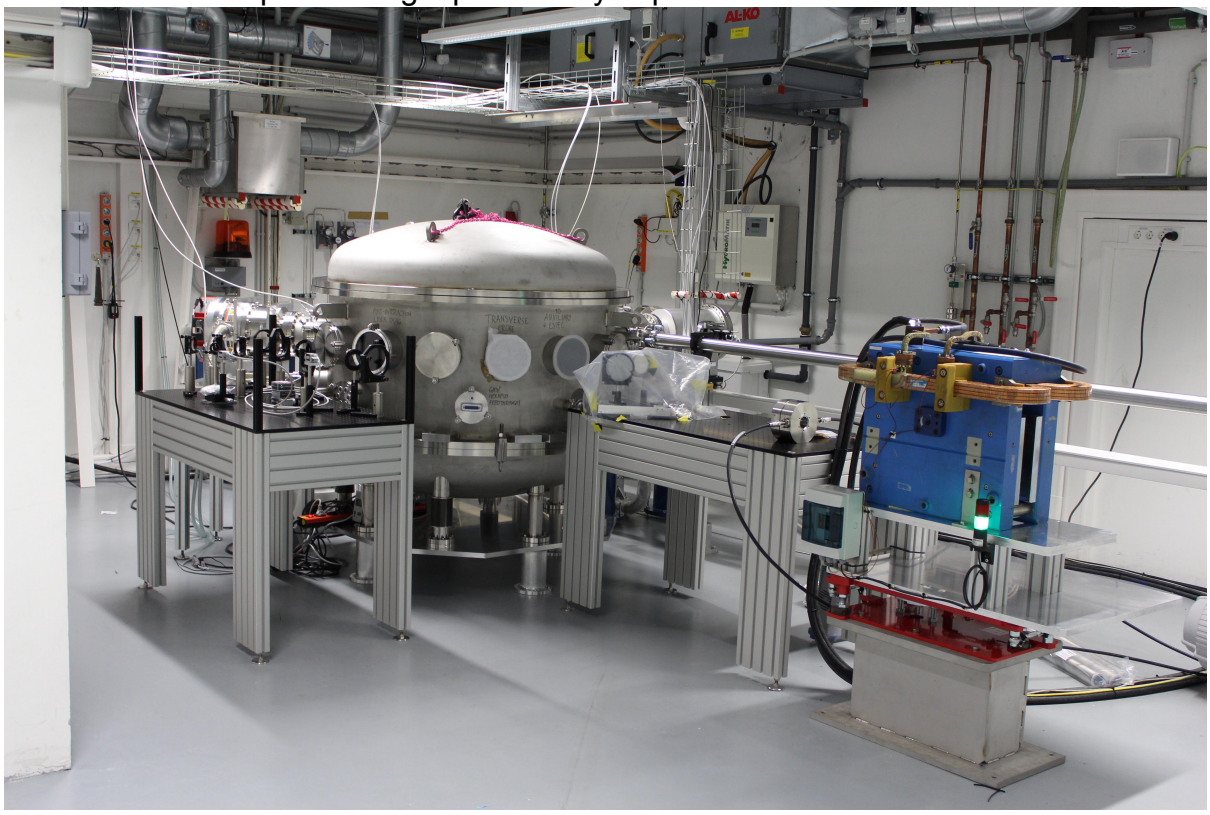

Fig 1. FLASHForward laser-wakefield acceleration setup for component tests.

Fig 2. Long focal length ionisation test chamber for FLASHForward plasma target development.

In April we are looking forward to an international workshop organised by Alberto Martinez de la Ossa on possible injection schemes for FLASHForward. The workshop will take place on April 5th and 6th. Further details are given below.

We are glad to welcome new members in the FLASHForward team: Martin Quast decided to complete his Masters at the University of Hamburg within our project. Stefan Wesch was awarded a DESY fellowship and joins FLASHForward. He returns to DESY after an extended period as a postdoc at Helmholtz-Zentrum Berlin. We are

always pleased to welcome candidates interested in applying for DESY Fellowships on FLASHForward – the next deadline is 31st March – see http://www.desy.de/about_desy/career/academic_careers/fellowships/index_eng.html. In addition, we are currently looking for a technician with a focus on laser technologies. The job advert can be accessed here: http://www.desy.de/v2/docs/1454583471.pdf

Reports from Working Groups

WG1: Plasma simulations

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

The simulation group is concentrating on preparing the "FLASHForward Injection Shoot-out and Hosing Workshop" on April 5th and 6th. The goal of this two-day workshop is twofold. On day one priorities will be discussed and set for theoretical and experimental studies at FLASHForward with respect to the various electron-injection methods that have been explored so far. Day two will focus on a discussion of the hosing instability at FLASHForward, which may be triggered by head-to-tail shifts in transverse beam centroid position that can be created by CSR effects in bunch compressors. The goal of this day is to devise a plan for centroid-shift mitigation on the accelerator side as well as plasma-based hosing mitigation strategies.

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.

Furthermore, a proposal for 17.7 MCPUh has been submitted within this WG to the Jülich Supercomputing Centre through the JuQUEEN national call for proposals at the end of February. The proposal 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 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 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. Currently, a high-transmission X-ray vacuum window and a 10 Hz direct-detection X-ray CCD are being ordered. First tests are planned to be performed in April when Elias is visiting DESY.

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.

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

The FLASHForward plasma-cell prototype for initial experiments on ionizing hydrogen is currently in manufacturing and expected to be finished in March. Once installed in the corresponding test chamber, the focusing geometry for ionization can be tested and the dimensions of the resulting plasma can be investigated experimentally and compared to simulations. Also, experiments for benchmarking of simulations on fast dissociation and ionization dynamics as well as cross-calibration of the Stark-broadening-based plasma-density diagnostics will be performed in the FLASHForward preparation laboratory once it is fully operational.

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

The decision has been taken to use the TTF undulators for Phase II of the FLASHForward project. This has narrowed the approach of the simulation and theory groups to assessing the quality of accelerated electron beams. Recently 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 undulator-slippage lengths. Work is currently underway to assess potential FEL gain with these beams using an analytical model.

The FLASHForward test and preparation laboratory is nearing readiness to perform the first acceleration and ionization experiments. This will allow us to start generating energetic photon beams via betatron radiation and Thomson scattering. 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 Oxford University, as well as a scintillator-based diagnostic for detecting MeV photons.