DACTOMUS STATUS REPORT

1. Project goals

Laser plasma accelerators have demonstrated their ability to produce ultra-high accelerating fields. The next challenge is to demonstrate the control of the electron acceleration process in a scheme scalable to ultra-relativistic energies. This project brings together three research teams from P2IO to perform joint experiments, in collaboration with local laser and plasma physics teams, to demonstrate the feasibility of electron transport in the perspective of a multi-stages laser-plasma accelerator. The aim is to design and implement a compact beam transport, and the associated diagnostics, to focus an electron beam generated by a laser plasma source to the volume required at the entrance of a laser plasma accelerator stage. The expertise and knowledge of the teams will allow them to deliver the beam transport and diagnostic implementation required to achieve the ultra strong focus needed by this collaboration.

2. Description of work achieved

The measurement that we intend to do as part of this project have two prerequisite which are the design of a transport line to focus the electron at the place where the measurements are expected to take place and the availability of a laser-driven plasma accelerator capable of delivering a beam with the specified parameters.

At the moment the work in the collaboration is focussed on these two prerequisites.

2.1. **Design of the transport line.** Transport lines are a common component at particle accelerators, however matching them to laser-driven plasma accelerators is not that easy and specific constraints have to be dealt with. For example plasma-accelerator beams have a much larger energy spread than usual beams. All these constraints have been taken into account and a design for the transport line has been produced. A full report about this design has been produced and discussed within the collaboration. Views of this line are shown in figure 1.

This transport line is based on a triplet of quadrupoles (to refocus the beam) and a dipole (to measure the beam energy). Given that all these magnets will be placed in vacuum and with very limited space available it has been decided to use permanent magnets rather than electromagnets.

After approval from the collaboration these magnets have been ordered and we expect their delivery in December. The next step will be to measure their field map. Discussions are in progress within the collaboration to decide how this will be done. This field map will allow us to predict with great accuracy how the particles will propagate on the magnets.

2.2. **Preparation of the laser-driven plasma accelerator.** The other important preliminary task is the preparation of the accelerator itself. Our project uses the laser UHI100 installed at Iramis/LIDyL. The LIDyL team working with colleagues from LPGP has started the commissioning of the experiment last June they have made steady progress in producing electrons and they hope to be ready to deliver the beam for us early in 2015.

At the same time the LIDyL and LPGP teams have had a campaign of data taking in Sweden at Lund where they tried some of the components that will be used on UHI100 later and they have

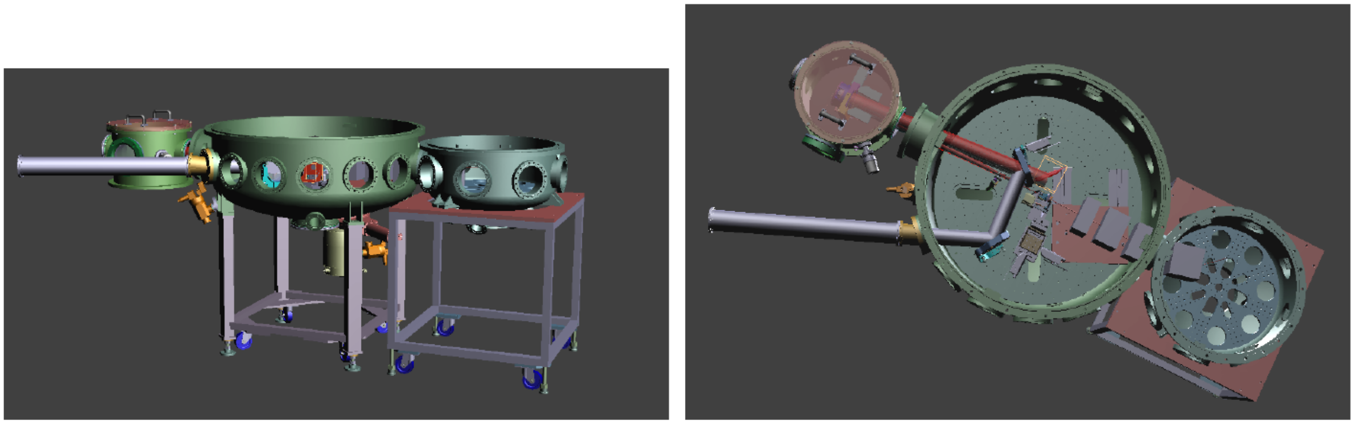

Figure 1. The plasma accelerator and the transport line for the electrons. Top view (left) and side view (right). The electrons are produced in the center of the main (large) chamber. They travel towards the bottom right corner of the right image. The four rectangles represent the four magnets that will be used to refocus the electron beam.

shown that they could get a very reproducible beam. We also purchased some diagnostics to help them with these tests.

2.3. **Outlook.** The magnets should be delivered in December 2014 and then two months will be necessary to do the field maps measurements. At the same time our colleagues from LIDyL and LPGP will have two more periods with access to the high power laser. By February 2015 we expect to have everything in place and we will then be able to start the actual tests to demonstrate our ability to refocus the beam.

Such demonstration is a key step for the future Apollon project which will use a much more powerful laser and attempt to accelerate the electrons in several steps.

3. Publications

So far, as the project is still in its construction phase, we have only one publication:

Transport line for a multi-staged laser-plasma acceleration: DACTOMUS Chancé et al., NIM A, Volume 740, 11 March 2014, Pages 158-164, `http://dx.doi.org/10.1016/j.nima.2013.10.036`

4. Relevance of the project within P2IO and specific added value for P2IO

This project has had a key impact on structuring groups working separately on the same topic in the P2IO area. Thanks to the funding received from P2IO these groups are now working together on a common project (which was not the case before). We hope that this will help P2IO to be a key player once the Apollon laser comes online.

5. Possible valorization of the project

The project can not be directly valorized however it is a key steps towards multi-stages plasma acceleration at Apollon and if multi-stages acceleration is demonstrated at Apollon (or in a second phase of DACTOMUS) it will open the way to building high energy particle accelerators based on laser-driven plasma accelerators and could therefore have tremendous applications in the field.

6. Expenses

We have spent about half of the funding allocated to us by P2IO. The magnets have been our biggest expenditure so far: 24kEuros. We have also purchased a screen for 600 Euros. The remainder of the money will be spent on the equipment needed to do the field map and on diagnostics for the accelerator.