Supervising the PhD of Marc Bizot with the CEA (Atomic energy commission)

Partner: CEA CESTA (Atomic energy commission - Center for scientific and technical studies of Aquitaine)

Project name: supervising the PhD of Marc Bizot with the CEA (Atomic energy commission)

Subject: contribution to the study and design of a very high current induction injector

Start date: February 9, 2017

End date: February 9, 2020

Partner: CEA CESTA (Atomic energy commission - Center for scientific and technical studies of Aquitaine)

Scientific manager: Laurent PECASTAING

Type of contract: cooperation agreement

Project description

Installations for hydrodynamic studies coupled with pyrotechnical experiments include pulsed X-ray units. They give access to the shapes and volumes of the components of the object studied throughout its dimensional evolution. Most of these X-ray machines are single-pulse and therefore deliver only one image at a given time, such as the unit of the CEA (AIRIX, which stands for induction accelerator for radiography and X-ray imaging).

Today, the request has been made to study the feasibility of developing an induction accelerator that could deliver two X-ray pulses at very short intervals (a few hundred ns).

In terms of high pulsed power, this consists of designing, and especially operating, systems at pulse repetition frequencies in the range of MHz without jeopardizing reliability, essential with regard to the application.

In a first approach, a power generator was developed that delivers two 250-kV pulses. This generator powers induction cells, which accelerate electrons. Upstream of this accelerator section, it will be necessary to install an injector capable of producing two intense electron beams, in the range of a few MeV for energy, and of delivering high currents. The energy of the electrons must be constant over the pulse duration so that they can be transported to the conversion target. So, as for the generators mentioned, the voltages applied must be stable at a few percent.

Induction injectors are currently the only technology identified.

Designing such a machine is very complex and will require implementing two IVAs (Inductive Voltage Adders). In these cells, analyzing the behavior of the magnetic material used is crucial to guarantee the electrical quality of the high-voltage pulses delivered. In addition, the two IVAs produce a certain number of parasitic elements (transmission lines, inductance, capacities) that also need to be managed. Finally, these pulses must be applied to a diode under vacuum (emissive cathode and anode) to generate the electron beams. Definition of this part and its connection is a critical aspect too.

In these sub-systems, the presence of very high voltages and their fast pulse shapes in the 10 to 100 ns range severely constrain the design, meaning compromises must be found.

These studies draw on modeling work based on circuit codes and EM 3D codes as well as on experimental schemes that help identify the risks posed by the sub-systems.