STATUS ON AIRIX RESTART

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Abstract

The Airix accelerator has been moved from Moronvilliers to Valduc to be part of the EPURE facility. Airix has been refurbished and restarted. This paper presents the first results and quantification of performances at its new location.

AIRIX MOVE

Airix is a linear induction accelerator with a 4 MeV beam injector and 64 induction cells. A more complete description is available in [1, 2]. It is used for hydrodynamics experiments.

Following the creation of the French-British shared experimental facility EPURE at Valduc, France, the Airix machine has been moved from its previous location in Moronvilliers, France to this new facility, where it will provide a 1st radiographic axis.

AIRIX REFURBISHMENT

Main Systems

This move has been used to address and upgrade a number of technological issues:

- replacement of sulfur hexafluoride by pressurized dry air gaseous medium for the main switches of accelerating cells drivers [3],
- replacement of high voltage rubber-based cables and high voltage connections between the drivers and the cells [3],
- oil change in accelerating cells
- replacement of thyratron switches
- redesign of the drifting and focusing space at the end of the accelerator to accommodate for the new building characteristics and norms.

Ancillary Systems

This move has also been the occasion to improve upon the performances of ancillary systems:

- upgrade of the vacuum system, with faster pumping times and locally improved levels of secondary vacuum or some measurements systems,
- alignment and beam position monitors, with positioning and testing systems with higher precision. Those systems have kept their original designs [4].
- refurbishment of the command-control system and data acquisition system
- modernization of the imaging systems,
- installation of a high performance safety system

The machine has also been hardened against the effect of a seismic event in accordance with building regulations for this experimental facility.

AIRIX RESTART

Initial Testing

In accordance with the plan, systems have been transferred and individually tested for a year before being run together. On schedule, Airix has been completely restarted on April 1st 2014.

Production

Since then, the machine has delivered more than 1000 electron beams for adjustment and optimization of parameters. Up to 20 X-ray beams per day have been produced reliably by conversion of the electron beams.

AIRIX PERFORMANCES

On a usual day of operations, Airix will display very stable characteristics.

Electrical Performances

The beam injector has been fitted with a 50 mm cathode (2 mm recess) [5]. The beam current, for an amplitude range of 800 A to 2 kA, will present a peak to peak amplitude jitter of 10 A and for pulse duration of 100 ns (at 10% of the maximum voltage) a rms timing jitter (1σ) of 1 ns. Since the objective is to obtain a flat top, we also gauge the stability of the 60 ns pulse plateau at less than 1% (cf. Figure 1).

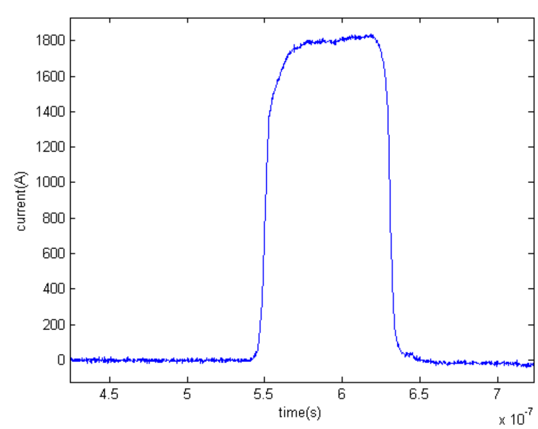

Figure 1: beam current input pulse shape

The voltage sensors of the emission diode have been calibrated by a parallel time-resolved electron spectrometry measurement. Energy spread remains very

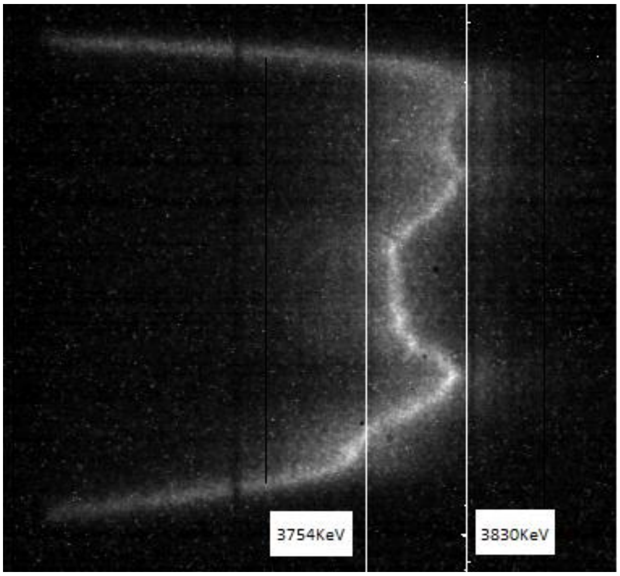

Figure 2: time-resolved spectrum of the electron beam at accelerator input

low (less than 1%) over the full plateau length (cf Figure 2).

The successive accelerating voltage pulses, for a range of 130 kV to 260 kV, present a peak to peak amplitude jitter of 2.5 kV and for a pulse duration of 110 ns (at 10% of the maximum voltage), and a rms timing jitter (1σ) of 1 ns (cf. Figure 3). This is slightly better than in its previous configuration at Moronvilliers. Including the effect of beam-loading on the shape of the accelerating pulses, we gauge the stability of a pulse plateau at less than 4%.

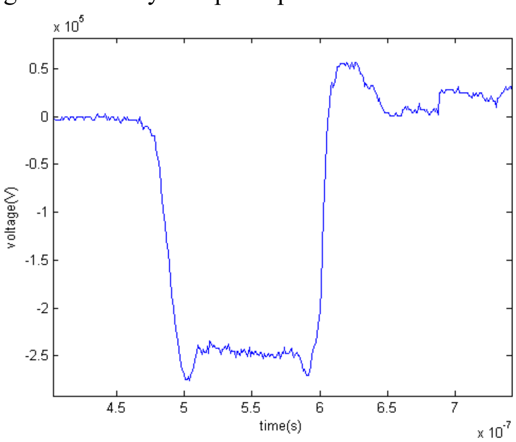

Figure 3: voltage pulse shape at an accelerating cell

Globally, the electron beam delivered to the heavy material conversion target has a peak to peak current amplitude jitter less than 0.5%, a peak to peak voltage amplitude jitter less than 1%, a timing rms jitter less than 1ns and a pulse voltage stability less than 1% (cf. Figure 4).

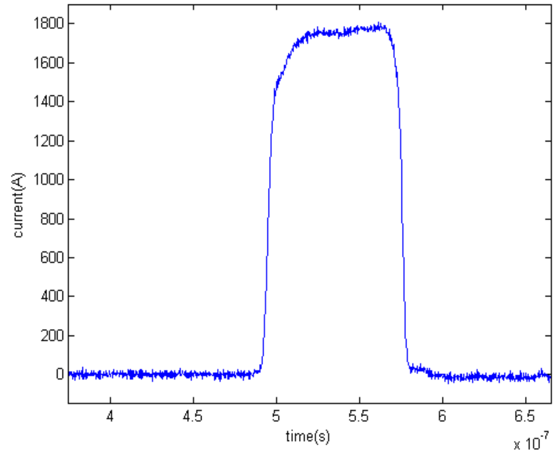

Figure 4: beam current output pulse shape

E-BEAM IMAGING

The imaging systems we have at our disposal show the e-beam either on the conversion target, either at an intermediate position (cf. Figure 5). It enables us to determine position, divergence and emittance parameters at the location of measurements through a gradient method (described in ref [5]) and to estimate the size of the interaction area on the conversion target (typically less than 1mm).

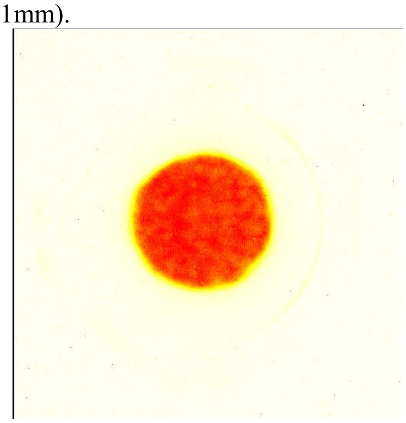

Figure 5: Beam imaging at the accelerator input

Time resolved imaging is under way to estimate the parameters variations along the pulse.

X-RAY PRODUCTION

X-rays have been produced with regularity. A lot have been used to establish the safety of the experimental facility to ensure a minimum area of effect and a large possibility of parallelized operations.

The X-ray dose delivered along the beam axis at 1m after the conversion target has been measured in air at 4 Gy (+/- 7%). Measurements have been made with FLi dosimeters calibrated with a Co^{60} source.

TECHNICAL ISSUES

Some materials problems have been occasional nuisances for the system : pollution of the air switches by

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grease/oil, depending on the quality of the assembly and/or the air supply system, slow but constant degradation of laser optics under the energy strain (notably beam separating crystals), variations of values of resistors in oil (either carbon or liquid). Those issues have been tackled by thorough and regular maintenance operations.

One HV cable has failed. This occurrence remains unique and is probably due to an isolated defect in the insulating material. We aim to achieve a system as reliable or more as the one which was previously operated in Moronvilliers [2].

CONCLUSION

Airix accelerator has been successfully moved to Valduc EPURE facility to serve as a 1st radiographic axis for hydrodynamics experiments. Its performance, as characterized today, is as good as and even slightly better than in its last configuration at Moronvilliers. It will benefit from refurbished ancillary systems within a modern facility. New studies are on their way to deepen our comprehension of the accelerator behavior and to monitor its performances and reliability. It seems that these last characteristics will remain as least as good as they were in Moronvilliers.

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