INTRODUCTION

In 2014, the activity of the diagnostics laboratory was devoted to the construction and test of a Fast Faraday Cup (FFC), designed for the LIPAc (Linear IFMIF Prototype Accelerator) [1] and to the test of the prototype of beam profile monitor developed for the SPES project.

FAST FARADAY CUP FOR HIGH INTENSITY BEAM

The IFMIF project is described elsewhere and the LNL diagnostics group is in charge of a bunch length monitor design. The goal is to measure bunches of about 300 ps with a frequency of 175 MHz. Due to the very high intensity beam, a not interceptive device was designed and described in a previous LNL Annual Report [3].

Besides that, a “spare” bunch length monitor based on a Fast Faraday Cup was designed. It is a FFC in planar configuration as shown in figure 1 (detector is in the foreground connected to sampling oscilloscope input for the off-line test). A 1 mm diameter hole, visible on figure 1, was in the ground plane center for the beam to pass through.

The ground plane is 10 mm thick because eventually it will be water cooled, so some holes will be drilled to flux water on it. The ground plane will face the beam and the “strip” (a tungsten cylinder, 1 mm diameter) will stand behind it. 50 Ω characteristic impedance is obtained with the correct distance between the cylinder and the ground plane.

In figure 2 there are the results with the Time Domain Transmission (TDT) method. The rise time without the device is about 50 ps, whereas with the device (result shown in figure 2) it is about 60 ps, hence the estimated bandwidth of the device alone is about 10 GHz (from the usual relationship between rise time and bandwidth, tr*BW = 0.35). In this way, it is possible to measure down to 100 ps FWHM, if the whole electronic chain impedance is well matched. The device was tested with an 81 MeV ³²S beam, from XTU-Tandem, bunched using a pre-Tandem chopper and 5 MHz buncher, and re-bunched with a high energy buncher about 10 meter upstream the device.

The detector was connected by a 10 meters broadband cable (to exit from the accelerator vault) to a 10 GHz oscilloscope: less than 300 ps FWHM.
bandwidth 30 dB broadband amplifier from MITEQ company and the amplifier output was connected to the sampling oscilloscope. A signal from the detector, produced by 100 e-nA average beam current, is shown in figure 3.

Some preliminary simulation to study the water cooling capability of the detector were begun and the work is still in progress.

TEST ON THE BEAM PROFILE MONITOR WITH MICROCHANNEL PLATE

In the SPES Project, in order to monitor the position and profile of the radioactive ion beam after the target, some new detectors must be designed, due to very low intensity current foreseen. The diagnostics laboratory of the LNL designed and tested new detectors as beam position and profile monitors, based essentially on microchannel plate (MCP) as beam intensifier. The very simple idea was to put a MCP directly on the beam. Electrons produced on it and collected, after multiplication, on a position sensitive anode give the beam impact position.

During 2014, a prototype for this SPES beam profile monitor (BPM) was carried out. Few tests were made on this BPM using an electron beam produced by thermoelectric effect.

In front of the MCP, a screen with two holes was placed. These 2 holes are 0.5 mm diameter each and are separated by 2 mm from centre to centre, but the holes are on the diagonal of the square limited by the 40 wires in horizontal and vertical directions. So the hole distances on the two plans are about 1.4 mm. In figure 4 the result obtained.

In figure 4, each step is 0.25 mm, so the two peaks distance is 1.25 mm (5 steps) and the FWHM peak thickness is about 2-3 steps. Also the space resolution is more or less maintained.

The electron beam was produced by heating a tungsten wire, 100 microns diameter, inside vacuum, kept at -3300 V. The current on the wire was 0.9 A and the electron current about 500 nA. Obviously these 500 nA are the electron cloud emitted by the heated wire. On each MCP the voltage was 520 V and from the last MCP side to the collecting position sensitive anode the voltage difference was 260 V. Collecting anode was at ground potential, MCP side in front of the beam was -1300 V. Vacuum was 1.2 x 10^-6 mbar.

The peak electron current through the holes could be estimated the following: peak signals are about 300 mV. Conversion gain is 1nA/V, so peak current is 300 pA. At about 1 kV for two MCPs stage, the amplification is about 2*10^4 (from Hamamatsu MCP selection guide), so in the peak about 15-20 fA of electron can be estimated (not so easy to give the right number, also because the electron beam produced in this way is not very sharp).

CONCLUSIONS

Both detectors, for IFMIF and for SPES, gave encouraging results. The IFMIF Fast Faraday Cup has to be tested from the point of view of the cooling capability, essentially it will be important to do simulations with an appropriate code.

The SPES beam profile monitor prototype was installed on the beam line in ALPI. It will be very important to test whether the electrons produced by the cavities may decrease the signal to noise ratio and in doing so, to increase the lower limit of the visible signal. If so, a different concept of beam profile monitor systems for SPES project shall have to be investigated.

REFERENCES