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EURO-LABS

EUROpean Laboratories for Accelerator Based Science

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MILESTONE REPORT

DESIGN AND COMMISSIONING OF THE BEAM LINE (VACUUM AND TEST CHAMBER)

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Abstract:

Within the scope of work-package 4.4, subtask 4.4.9 aims to construct a new vacuum chamber where irradiations, with heavy ions, of electronic components can be made in the new HIF line constructed at UCLouvain-CRC. In this document are described the activities to get this service improvement ready.

For more information on EURO-LABS, its partners and contributors please see https://web.infn.it/EURO-LABS/

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Executive summary

CRC (Cyclotron Research Center) operates two cyclotrons and offers several beam lines for irradiation studies. During last years the Center has specialised irradiation of electronic equipment used in space, scientific and industrial applications with Heavy Ions, Protons and Neutrons.

A new beam line has been recently available to improve the Heavy Ion irradiation Facility (HIF). In this document we report the advancement towards a new vacuum vessel for this line.

1. INTRODUCTION

Cyclotron Research Centre (CRC) is a research unit attached to the Institut de Recherche en Mathematique et Physique (IRMP) department at UCLouvain. The facility operates one cyclotron, called CYCLONE110, able to accelerate charged ions to kinetic energies up to 110 x Q^2/M (in MeV). Main activities of the centre are: experiments for research in Nuclear (Astro) Physics, industrial applications (membrane production), irradiation of electronic components and detectors and radiobiological experiments. In total, around 2,500 effective hours of beam are delivered to users during 35 weeks of operations.

Most relevant activities are electronics irradiation (ESA, CNES, THALES,...) membrane fabrication (IT4P, ...). Around10% of access is devoted to scientific applications, mainly nuclear physics experiments, detector irradiations, rad-hard electronic devices and biomedical.

CRC offers 3 irradiation facilities based on the CYCLONE110 operation

- Neutron Irradiation Facility (NIF). Neutrons obtained impinging a 50 MeV deuteron beam on a Be target giving a continuous neutron spectrum up to 50 MeV with a mean energy of 20 MeV. The intensity of the beam can reach a flux of 7.3×10^{10} n s^{-1} cm^{-2}, providing a beam diameter ~4 cm. Irradiation area can be maintained at constant temperature down to -20°C during irradiation.
- Light Ion Irradiation Facility (LIF). Mono-energetic protons with energies between 10 and 62 MeV. Beam size of ~8 cm diameter and maximum flux of 5×10^8 p s^{-1} cm^{-2}.
- Heavy Ion Irradiation Facility (HIF). This facility provides a beam of up to 10^4 ions s^{-1} cm^{-2} monoenergetic heavy ions with well-known ranges and LET. Irradiation area is ~25 mm diameter with 10% homogeneity. Various "ion cocktails" can be accelerated allowing an easy and efficient way to change LET. The available cocktails, LET and ranges are described in the facility webpage. This facility is especially devoted to irradiate electronics. DUT are in vacuum and should not be encapsulated.

2. NEW TEST CHAMBER FOR THE HEAVY ION IRRADIATION FACILITY

The CRC is one of the reference centers for ESA radiation hardness tests and as such one of the reference centers in Europe for the radiation hardness for readout electronics. The actual heavy ions test chamber has been designed and build between 2000 and 2005.

After the decommissioning of the LISOL (Leuvevn Isotope Separator On Line) facility, a new beam line, with a shorter beam transport, is available and a new beam line for HIF is in construction. Besides the beam transport, a new test chamber has been designed and manufactured with the following advantages:

- The shorter beam transport line will allow us to increase the beam quality and the transport efficiency.
- The pumping time in the chamber will be reduced.
- The positioning system of the components will be automated, in order to have more precision.
- The chamber has been designed for larger boards.

- The ergonomics and accessibility around the chamber will be improved.
- More space will be available for the users around the chamber and for the preparation of the setup.

2.1. ADVANCEMENT OF THE INSTALLATION

Beam transport line

The beam transport line has been refurbished and fully installed, including the vacuum system, quartz and Faraday cup to tune the beam transport.

Mechanical Design

In the first phase, the mechanical design of the test chamber and the DUT (Device Under Test) positioning (X-Y-Z and tilt) system were developed. The chamber and the components are now installed (see Figure 1). A new electrical system has been installed (see Figure 2)

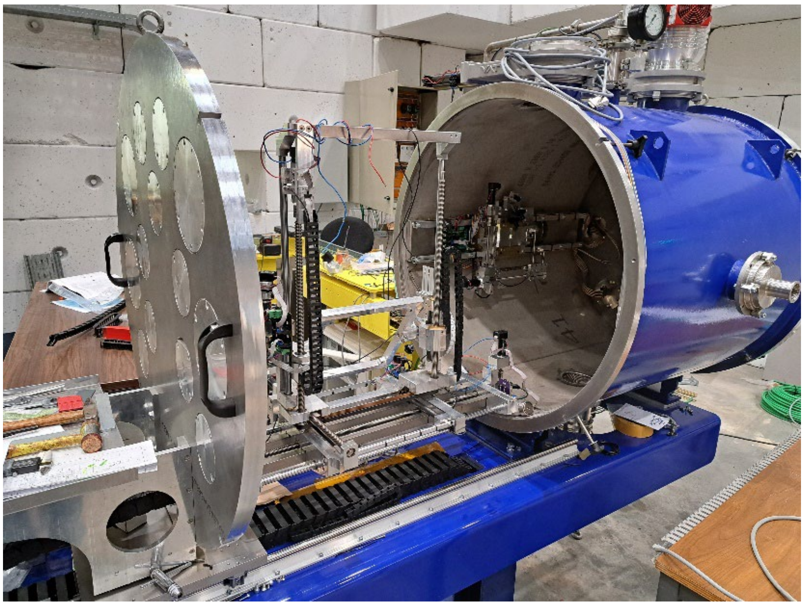

Figure 1: New HIF chamber as in August 2023

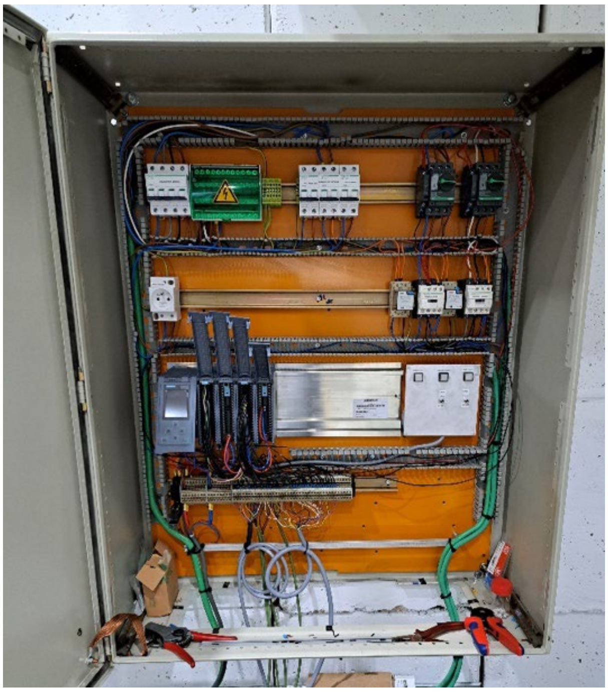

Figure 2: Electrical cabinet

Control system

A completely new and up-to-date control system, using National Instruments components has been developed.

We bought a new PXI chassis, a CPU and CAN communication boards. We will use LabVIEW software to control the different equipment of the test chamber. We have already developed the two main parts: the communication with the Siemens PLC for the vacuum control and the CAN communication with the Maxon drives for the DUT positioning. We will reuse the existing board for beam control and monitoring.

Vacuum system

A new vacuum system has been installed. This system includes new vacuum chambers and a PLC for control.

- We bought a new rotary vane pump from Pfeiffer Vacuum. This DUO 65 is used to obtain the pre-vacuum in the chamber before pumping with the turbomolecular pump. After a delay of 9 months, we received and installed this pump in May 2023
- We also installed a new vacuum gauge controller TPG 500 and special cables but we reuse existing Pirani and Penning gauges from another beam line.
- The vacuum system (gauges, pumps, valves) is controlled by a Siemens S7-1500 PLC that we purchased in the frame of this project. All this equipment is now installed, cabled and the PLC is programmed to automatize security and the vacuum generation sequence.

Feedthrougs:

New SUB-D 25 feedthroughs for the positioning system signals (motor control, limit switch, coder signal, camera, …) have been installed.

Several user feedthroughs, with a large variety of connectors are available from the previous HIF vacuum chamber and new flanges to host new connectors can be designed and machined in our workshop when required.

Beam dosimetry:

We still have to develop the beam monitoring but for the calibration of the dosimetry we will use PIPS diode from Mirion. We bought these detectors and they have been already installed in the chamber. The first one will be used for the beam energy measurement and the second is mounted on a X-Y scanning system and will be used to measure the beam profile.

We are studying a beam monitoring system using scintillators. The first detector was ordered in April and should have been delivered before the summer. The new delivery date is now not expected before October.

3. ONGOING DEVELOPMENTS, OUTLOOK & CONCLUSIONS

With the equipment already installed we can now develop the software for the control system and mainly the positioning system. The cabling for this is almost finished and the first tests were conclusive.

The main remaining challenge is the development of the beam monitoring. The first scintillator was ordered but the expected delivery date was postponed. As soon as we will receive the detector, we will conduct tests with beam in the existing test chamber.

According to the results of the tests, we will define the design of the monitoring system and order the electronics needed.

In parallel we will continue with the technical installation around the chamber (network, operator desk, beam control, electrical sockets, …).