DIAGNOSTIC TOOL AND INSTRUMENTATION FOR HANDLING 50 KW BEAM POWER

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Abstract

The SPES facility entered the commissioning phase and the 70 MeV cyclotron is delivering the proton beams at the maximum power permitted. The INFN team has developed additional beam instrumentation in order to stop the particles at different power allowing the tuning of the beamline and to check the particles losses during the transport. In particular, a beam dumper able to stop up to 55 kW beam power has been constructed and tested as well as the beam loss monitor system by INFN team. Here we present the status of the beam instrumentations supplied by INFN and the results achieved during the test with the beam.

INTRODUCTION

For the SPES facility at Laboratori Nazionali Legnaro of INFN in Italy a 70 MeV proton cyclotron has been installed and is being commissioned. To safely verify the capability of the machine, and correctly tune both cyclotron and beam line, several diagnostic have been developed and installed. Among them most relevant are Faraday cups (FC) for low power (up to 1 kW) beam, a more powerful beam dumper (BD) to stop the full power (700 µA, 70 MeV, i. e. 49 kW) beam and ionization chambers beam loss monitors, divided into four sectors to be able to highlight misalignment of the beam on the beam line. The general layout of the cyclotron vault is shown in Fig. 1.

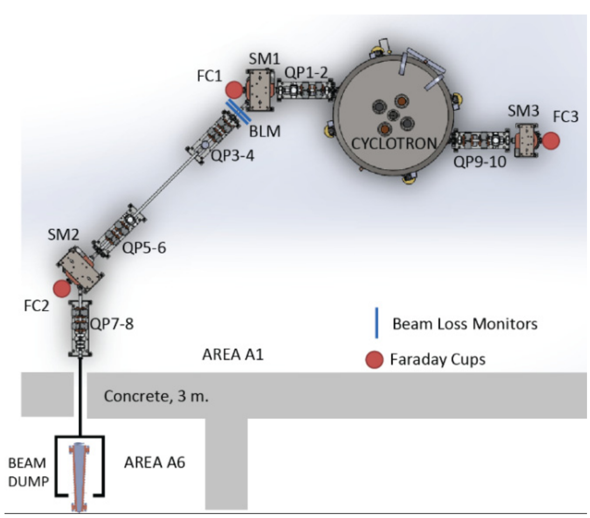

Figure 1: General layout of the cyclotron vault, showing the cyclotron, the main diagnostics and the focusing quadrupoles (QP).

LOW POWER FARADAY CUPS

Two low power water-cooled (closed-circuit) Faraday cups (FC) have been installed. They are able to withstand and measure up to 1kW:

- 14 µA, 70 MeV
- 28 µA, 35 MeV

The temperature of the FCs are measured with Pt1K sensors, current is measured directly through a current amplifier, and 50 mm Pb shielding wrap the FCs to allow access to the cyclotron vault. The FCs are made of oxygen-free high conductivity (OFHC) copper. The thickness of the copper at the impact walls span from a minimum of 8 mm, were the cooling water flows, to a maximum of 24 mm. The FCs were simulated using Comsol software, using as a cooling medium water, 3 litres/min, at 20 °C inlet temperature. The thermal power simulated is a cylinder with depth of 7.09 mm, with Gaussian power distribution (with σ = 5mm) with cylindrical symmetry, as shown in Fig. 2.

The simulated temperature profile on the symmetry axis is at 500 W incident power is shown in Fig. 3. The beam is arriving from the right side. The curves refer to different elapsed times since start of the beam.

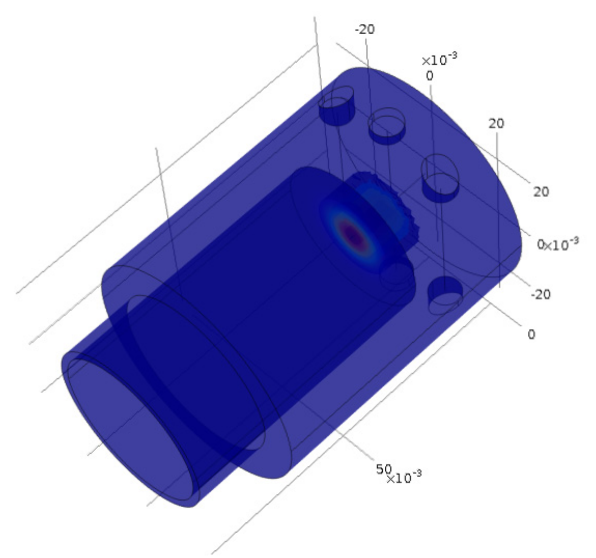

Figure 2: In blue the simulated FC volume, in red at its centre the thermal load of gaussian profile.

ISBN 978-3-95450-167-0

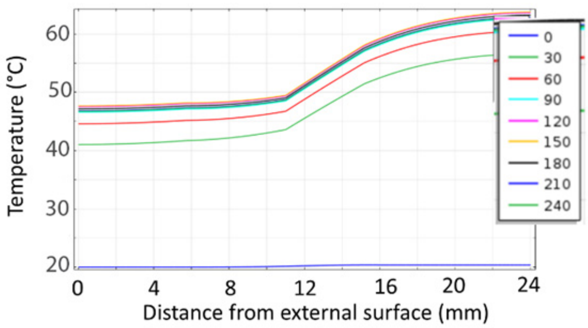

Figure 3: Results from the numberical simulations of the temperature along the symmetry axis, with 500 W input power (70 MeV; 6 µA).

The graph shows that after 240 the regime temperature of the hottest point of the Faraday Cup is at less than 70 °C.

During operations the FCs were not operated up to regime temperature. The measured temperatures on the external side of the FCs (see Fig. 4 to locate the temperature sensors, Pt1k) never exceeded 35 °C. The FCs were insulated from the cyclotron using viton o-rings and plastic clamping rings.

The two FCs were eventually shielded with 50 mm of lead to allow maintenance in the cyclotron vault.

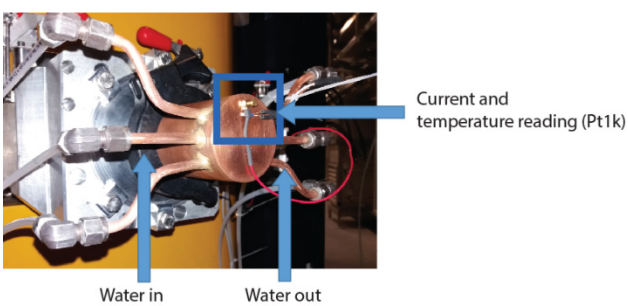

Figure 4: The blue square indicates the positions of the temperature sensor and of the current pick-up of the low-power Faraday Cup.

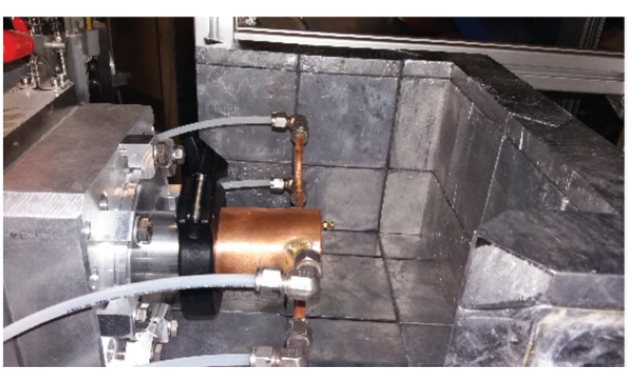

Figure 5: The FCs are shielded with 50 mm Pb bricks, to allow maintenance. Here only partial shielding is shown.

HIGH POWER BEAM DUMPER

To demonstrate the full power (700 µA, 70 MeV) capability of the cyclotron, a beam dumper (BD) has been developed. It is cooled by a separate circuit, to avoid mixing of activated water with the water used for other purposes. Pressure level near the BD, and 12 thermocouple temperature sensors serve as diagnostics to monitor the condition of the BD. The positions of the temperature sensors relative to the BD are shown in Fig. 6.

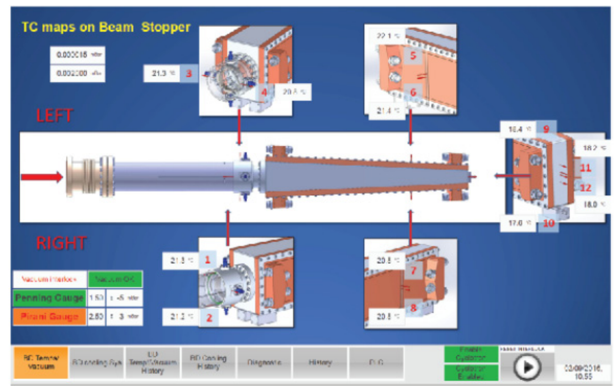

Figure 6: Screen shot of the diagnostic system of the BD.

Monitoring of the power dissipated by the cooling system provides a rough but reliable indication of the total power of the beam.

BEAM LOSS MONITORS

Two beam loss monitors, based on ionization chambers are used to verify both losses on the beam lines and misalignment between beam and line. They are made of two faces, separated by 20 mm air gap, biased by 500 V. The current of each sector is read by a current/voltage amplifier and acquired through a multiplexer. The currents can be read directly on an oscilloscope and through a LabView code the alignment of the beam is directly seen.

The monitors proved useful to set beam line parameters.

ACKNOWLEDGEMENT

The authors would like to acknowledge the prompt and valuable help of all the staff at LNL-INFN. Best Theratronics team also has been very helpful during the installation of the diagnostics.

ISBN 978-3-95450-167-0