Requirement Specification
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Faraday cup design specifications for the ESS DTL

1. INTRODUCTION

In the DTL, two FCs shall be installed in order to avoid beam losses in the downstream part of the ESS warm linac during tune up of the first DTL. The layout of the beam instrumentation in the DTL section is shown in Fig.1.

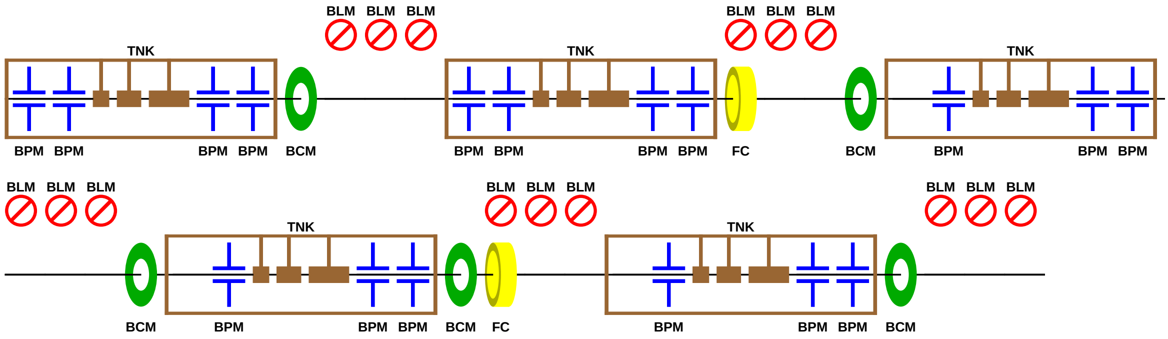

Figure 1 ESS DTL beam instrumentation layout

The FCs shall be installed in the intertank area, in this document the FC positioned after the second DTL tank is named FC2, the one after the fourth DTL tank is named FC4.

2. SPECIFICATIONS

2.1 Beam power

The FC2 and FC4 shall be design to absorb a beam energy range from 21 MeV to 39 MeV and 39 MeV to 74 MeV respectively. From these values, the maximum peak power absorbed by each FCs can be calculated. Assuming a beam current equal to 62.5 mA, the peak power absorbed by the FC2 and FC4 shall be 2.43 MW and 4.62 MW respectively.

The FCs shall be primary used during the RF tuning of the upstream tank(s) with a reduced beam duty cycle. For this particular studies it is foreseen to use a 5 µs pulse length at a repetition rate of 14 Hz. In this case the maximum average beam power absorbed by the FCs shall be 170 Watt for the FC2 and 324 Watt for the FC4.

In addition, the two FCs shall be able to absorb a 50 µs pulse length at a repetition rate of 1 Hz, at this duty cycle, the maximum average beam power shall be 122 Watt for the FC2 and 231 Watt for the FC4. It has to be noted that due to mechanical stresses this specification might not be satisfied, thermo mechanical analysis are mandatory to estimate the maximum power which can be absorbed by the FCs[1] and define the beam modes/duty cycle which allow a safe operations of the FCs.

[1] Conceptual design of the ESS DTL Faraday cup, B. Cheymol and E. Lundh MOPP037, LINAC14 proceedings

At the FCs locations, assuming Gaussian distribution of the beam, the minimal beam sizes are 1.24 mm by 1.16 mm (1 rms) at the FC2 location and 1.35 mm by 1.32 mm (1 rms) at the FC4 location. In both case, the beam sizes are minimal at the lowest beam energy

2.2 Mechanical design

The DTL FCs shall be able to measure the full beam current without limitation on the beam position; the aperture of the FC shall be at least equal to 30 mm. The envelope of the FC shall fit in a square aperture with a minimum dimension equal to 110x36 mm^2 defined by the limited space in the intertank area. Analytical estimation of the thermal load on both FCs have been performed to get a preliminary design (see Fig. 2 and Fig. 3).

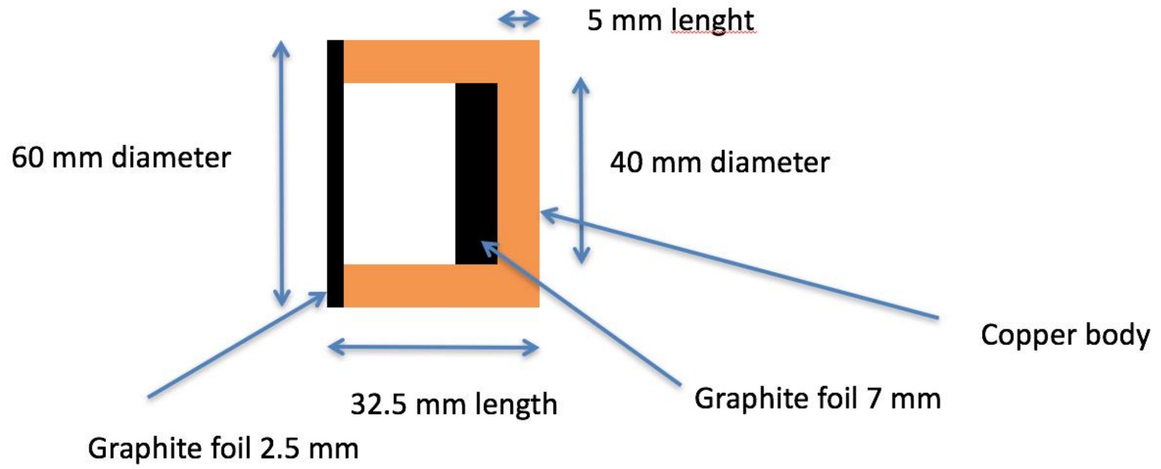

Figure 2 Preliminary design of the Faraday to be installed after the second DTL tank

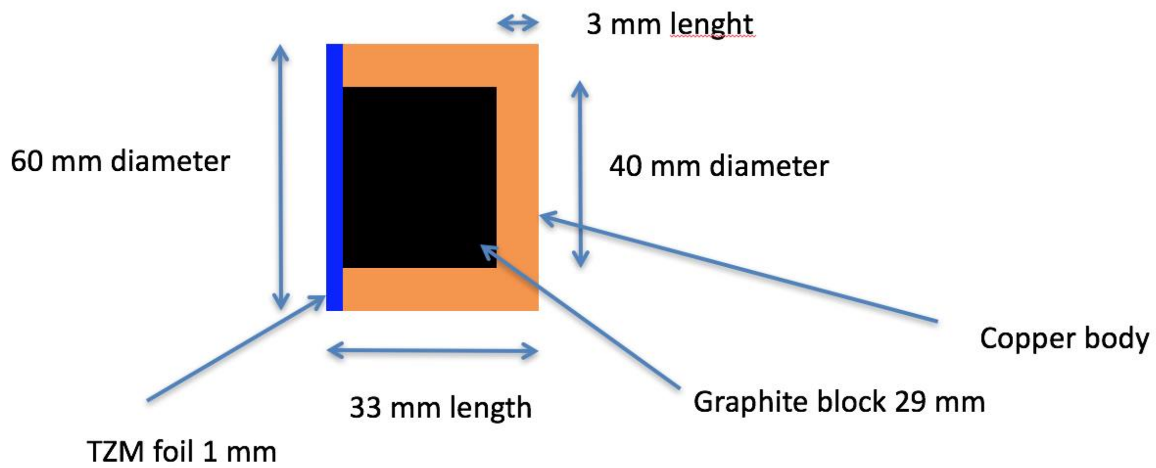

Figure 3 Preliminary design of the Faraday to be installed after the fourth DTL tank

FEA are on-going to finalize the design.

2.3 Current readout-Acquisition

Due to the relatively high energy of the beam and the compactness of the FC, the capture of the total charge of the beam is difficult, previous simulations show that the charge collection efficiency can go down to 90 % for a 74 MeV beam. Thus, the specifications of the current readout acquisition channel are relaxed compare to lower energy FCs (i.e in the LEBT and the MEBT), in particular the efficiency of the secondary electrons capture with a repeller electrode can be less than 100%.

The DTL FCs shall be able to measure the beam current with accuracy better than 10% and a resolution better than 1%, for all beam intensity foreseen in the ESS linac (6.3 to 62.5 mA), note that these numbers are including the efficiency of the beam charge collection, the collection of secondary electron and the noise of the electronic readout. The signal shall be sample at a frequency at least equal to 2 MHz, the digitizer card shall be compliant with the ESS standards defined by the Integrated Control System (ICS) division.

Due to the design of the FCs, only the one installed ate the DTL tank 2 will be equipped with a repeller electrode, which shall be biased with a negative voltage. The power supply shall be able to provide a voltage at least equal to 1000 Volts (in absolute value) and be remotely controlled. This power supply shall be compliant with the ESS standards, preferably the same model as the other FCs shall be used.

2.4 Actuation

The LEDP FC shall be moved in and out with a pneumatic actuator. It is mandatory to install 2 limit switches at both ends position, one will be use for motion control purposes, and the other one will be connected directly to the Machine Protection System (MPS). “Dry contact” end switches are preferred.

All the components shall be compliant with the ESS standards, a list of standard solutions for motion control component, in particular the limit switches, are summarized in the ESS document “Motion control components standard for ESS applications” ESS-0037290.

2.5 Water cooling

Water cooling systems shall be compliant with the standard defined by the water cooling work package (WP16).

2.6 Vacuum

All material used for the Faraday cup fabrication shall be compliant with the ESS vacuum group specifications [2].

In particular, the ESS vacuum group shall approve all the material used for the FC manufacturing. A list of approved material can be found in the ESS Vacuum handbook "General Requirements for the ESS Technical Vacuum System" (ESS-0012894). All materials not approved for use in vacuum per ESS Vacuum Handbook are to be submitted to the ESS Vacuum Team for approval. No non-metallic materials are not to be used unless tested and approved by the ESS Vacuum Team. Materials used shall be non-particle generating.

ISO bakable knife-edge flanges (Conflat style - CF) are the preferred type for high vacuum and UHV applications. Metal seals shall be OHFC copper.

All parts have to be cleaned and prepared in accordance with the requirements of the ESS Vacuum Handbook. Packaging for shipment should reflect this requirement.

[2] "ESS Vacuum Handbook", Part 1-4, ESS-0012894, ESS-0012895, ESS-0012896, ESS-0012897