Design of the ESS MEBT FC

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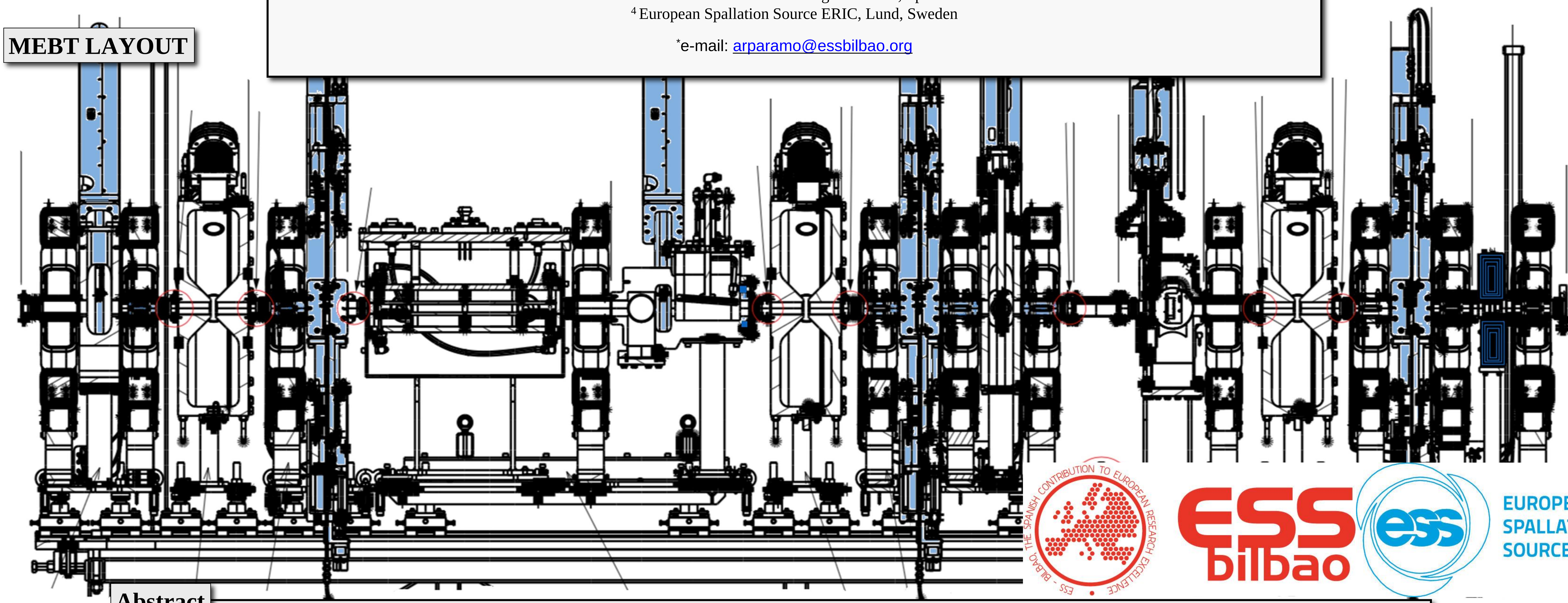
MEBT LAYOUT



Abstract

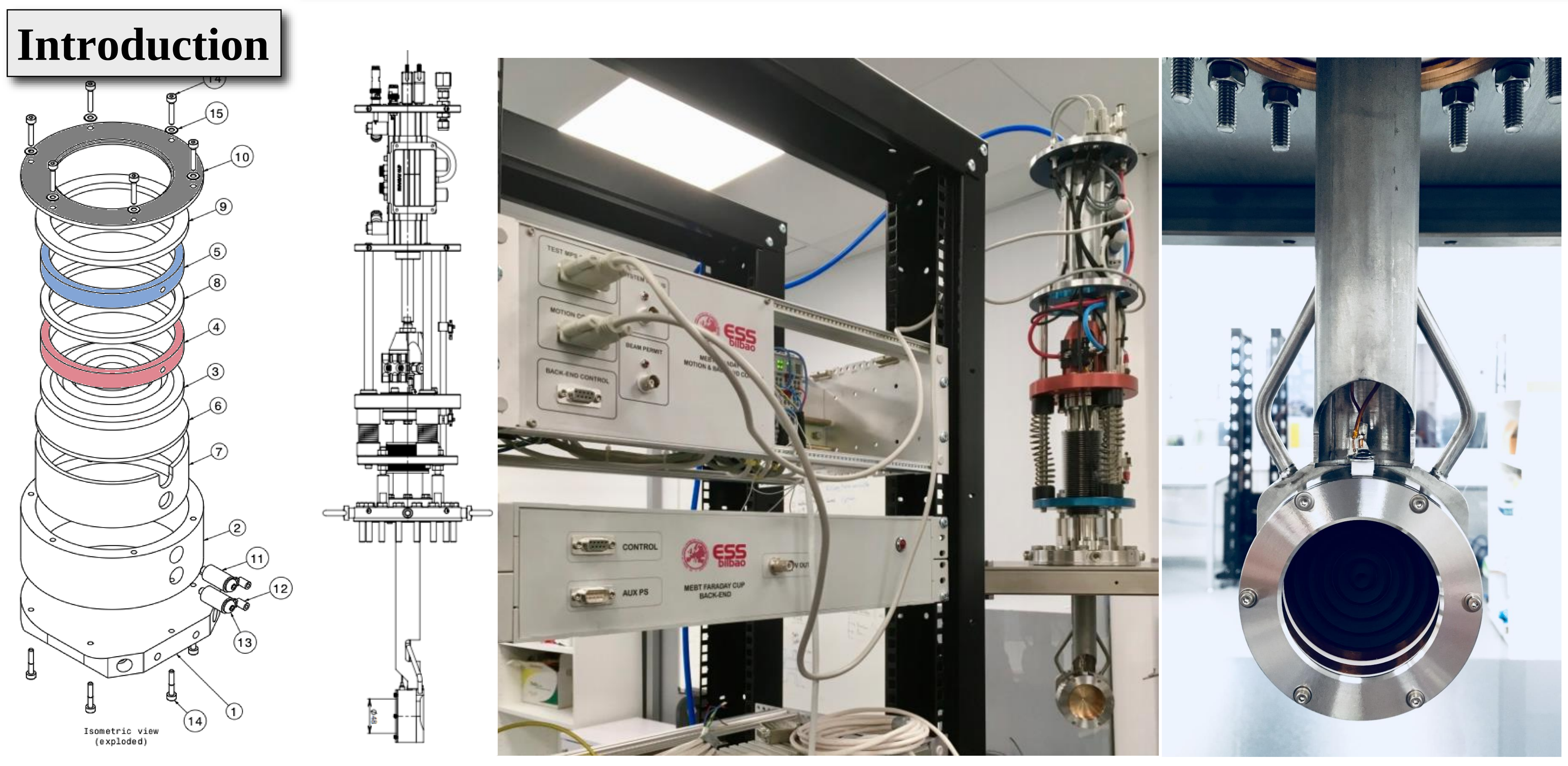
The European Spallation Source (ESS) [1,2] is currently under construction and the Medium Energy Beam Transfer (MEBT) is developed by ESS-Bilbao as an in-kind contribution.

In the MEBT a set of diagnostics is included for beam characterization, among them the MEBT Faraday Cup is used to measure beam current and as a beam stopper for the commissioning modes. The main challenges for the design and manufacturing of the Faraday Cup are the high irradiation loads and the necessity of a compact design due to the space constraints in the MEBT.

We describe the design of the FC, characterized by a graphite collector, required to withstand irradiation, and a repeller for suppression of secondary electrons. For the operation of the Faraday Cup acquisition electronics and control system are developed, all systems have been integrated in the ESS-Bilbao ECR ion source to test operation under beam conditions.

In this work, we discuss the design of the Faraday Cup, the results of the tests and how they agree with the expected performance of the Faraday Cup.

Introduction

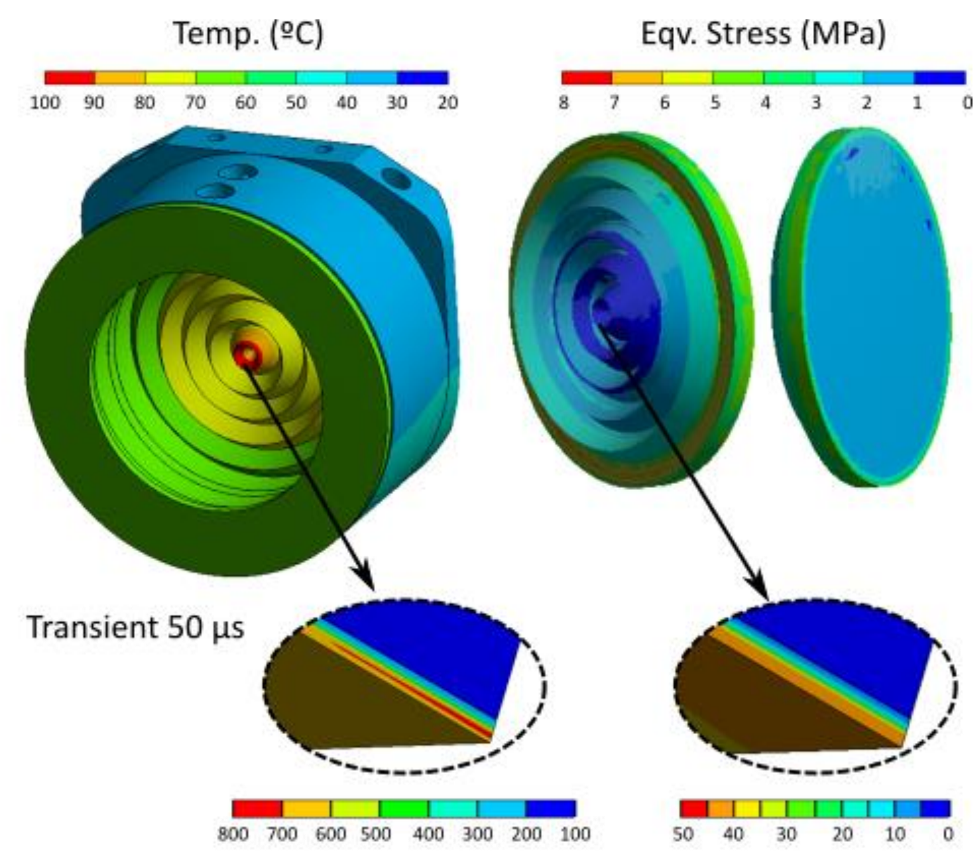


The FC is designed for current measurement and as a beam stopper for MEBT commissioning modes.

The FC has been manufactured with a 1 kV repeller for secondary electron suppression and with a graphite collector to withstanding the high intensity beam.

For the operation of the FC, integration with the electronics and control system is required. The different systems have been integrated and tested in the Bilbao ECR ion source and we analyse the results and its agreement with the expected performance of the FC.

Irradiation

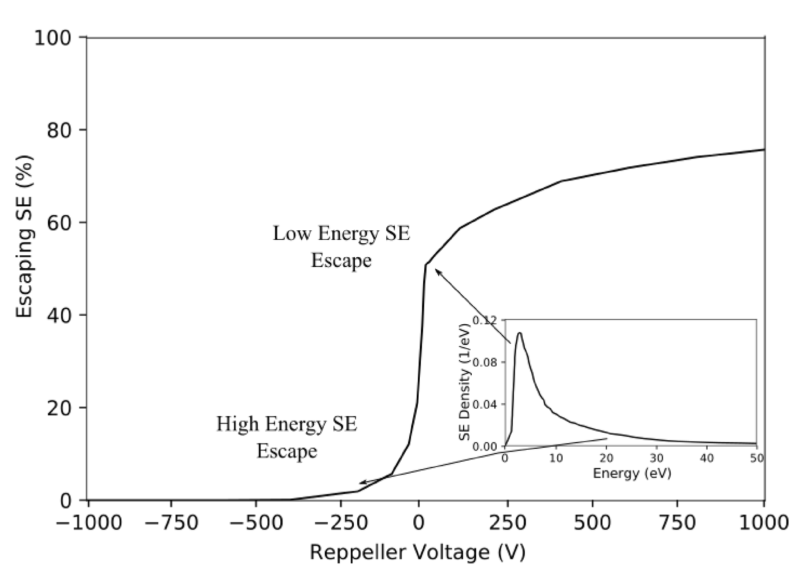


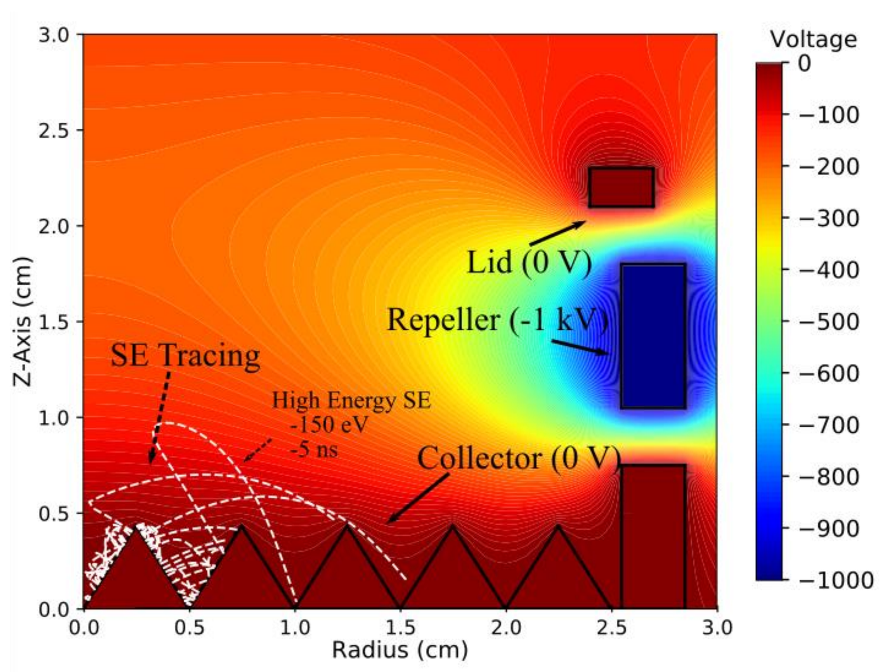
Due to the high power beam (3.63 MeV, 62.5 mA) and reduced beam size (σ_x~σ_y~2.5 mm), high temperature and stresses will appear in the graphite collector during irradiation.

We study the thermomechanical effects using MCNPX and Ansys, estimating operation below the graphite strength limit.

The modular design of the Faraday Cup is specially intended for collector replacement in case long term irradiation affects the integrity of the graphite.

SE Supresion





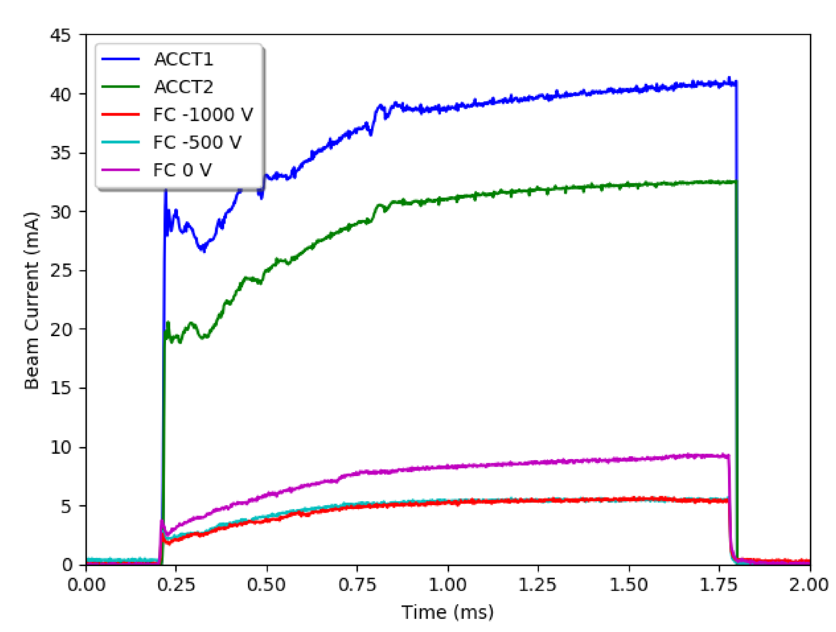
The Faraday Cup includes a copper repeller that operates at a nominal voltage of -1 kV for effective secondary electrons (SE).

We use the SE spectra from reported values of 1 MeV proton irradiation on carbon foils[3]. Then estimate the electrostatic field of the FC using Ansys APDL and perform and the tracing of secondary electrons using GPT.

From the analysis of SE suppression, we offer an estimation of the performance of the MEBT FC. Studying the secondary electron recapture time and the effect of the geometry or the repeller voltage.

We characterize the FC performance and obtain full suppression secondary electrons for voltages below -500 V.

Integration Test



The Faraday Cup along with the control and electronics were integrated in the ESS-Bilbao Injector[4] to check operation under beam conditions.

The ESS-Bilbao Injector is composed by the Ion Source Hydrogen Positive (ISHP) and the Low Energy Beam Transport (LEBT), and the FC was is installed in an additional diagnostic box downstream the LEBT.

The test were done with beam energies of 45 kV, intensities of ~40 mA, pulse duration of 1.6 ms at 1 Hz. The large beam size downstream the LEBT and the small aperture decrease the size of the beam collected in the FC signal compared to the ACCTs, down to ~5 mA.

Analysing the FC signal for different repeller voltages we observed saturation for values over -500 V, which agrees with the expected secondary electron suppression in the FC.

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[2] T. Shea et al., "Overview and Status of Diagnostics for the ESS Project," IBIC 2017, MO2AB2.
[3] C. Drexler and R. DuBois, "Energy-and angle-differential yields of electron emission…" Phys. Rev. A, 53-3 1630, 1996.
[4] Z. Izaola et al., "Advances in the Development of the ESS-Bilbao Proton Injector," HB2016 Malmö Swed.