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STRIPLINE DESIGN OF A FAST FARADAY CUP FOR THE BUNCH LENGTH MEASUREMENT AT ISOLDE-ISRS

S. Varnasseri, I. Bustinduy, J.L. Muñoz, P. González, R. Miracoli, ESS-Bilbao, Zamudio, Spain

INTRODUCTION

In order to measure the bunch length of the beam after Multi Harmonic Buncher (MHB) of ISOLDE Superconducting Recoil Separator (ISRS) and characterize the longitudinal structure of bunches of MHB, installation of a Fast Faraday Cup (FFC) is foreseen. Several possible structures of the fast faraday cup are studied and due to timing characteristics of the beam, a microstrip design is selected as the first option. The beam is collected on the biased collector of the microstrip with a matched impedance and transferred to the RF wideband amplification system. The amplified signal then can be analysed on the wideband oscilloscope or acquisition system to extract the bunch length and bunch timing structure with precision. The design of the microstrip FFC and primary RF measurement of the prototype are discussed.

ESS-Bilbao is designing a Multi Harmonic Buncher (MBH) for the ISOLDE-ISRS. In order to measure the functionality and characteristics of the MBH bunches, some diagnostics have been foreseen. They include ACCT current measurement, energy measurement, and a Fast Faraday Cup (FFC) for bunch length measurement. Prior to delivery of MHB to its final location at ISOLDE-ISRS, it will be tested with ion source beam at ESS-Bilbao with a β equal to 0.00328. The operational RF frequency of MHB is 10.126 MHz. The maximum proton energy is 50 keV, the beam current could reach up to 40 mA and the maximum pulse width is 3 ms. The beam repetition rate varies from 1 to 30 Hz. It should be mentioned the beam species, energy and current at ISOLDE-ISRS are different than ESS-Bilbao injector.

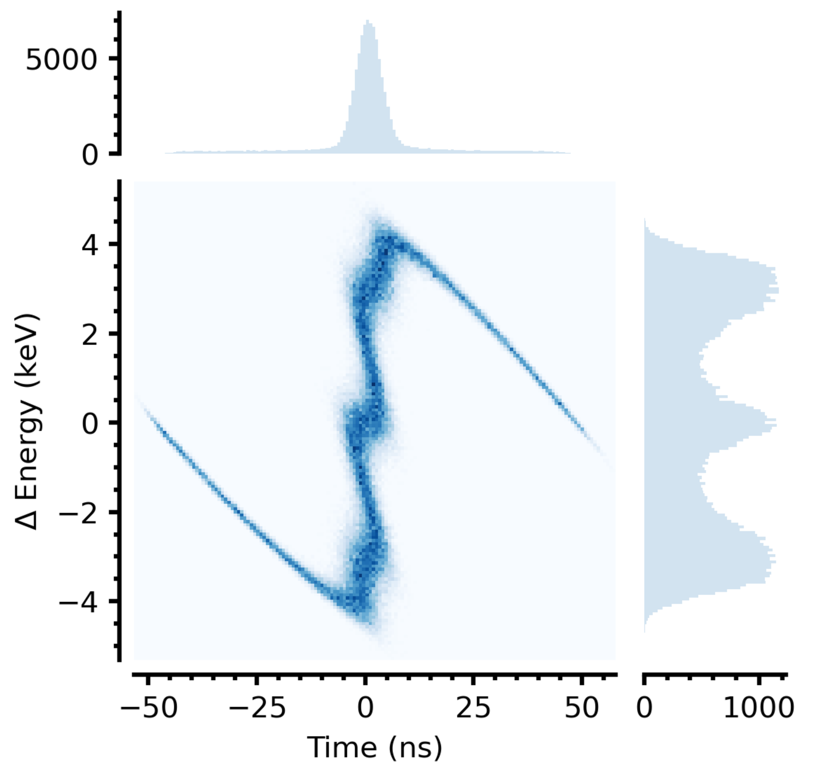

Figure 1: Bunch formation development at a distance of 1m from MHB. Horizontal axis corresponds to time (ns) and vertical axis to Δ energy (keV).

FFC GEOMETRY AND ANALYSIS

Striplines FFC provide a direct way to capture the charge distribution within a bunch by measuring the transient electric field induced by passing particles. In order to transmit accurately the induced signal, the RF structure of FFC should be matched to the adjacent structures such as connector, coaxial cable and the low noise amplifier.

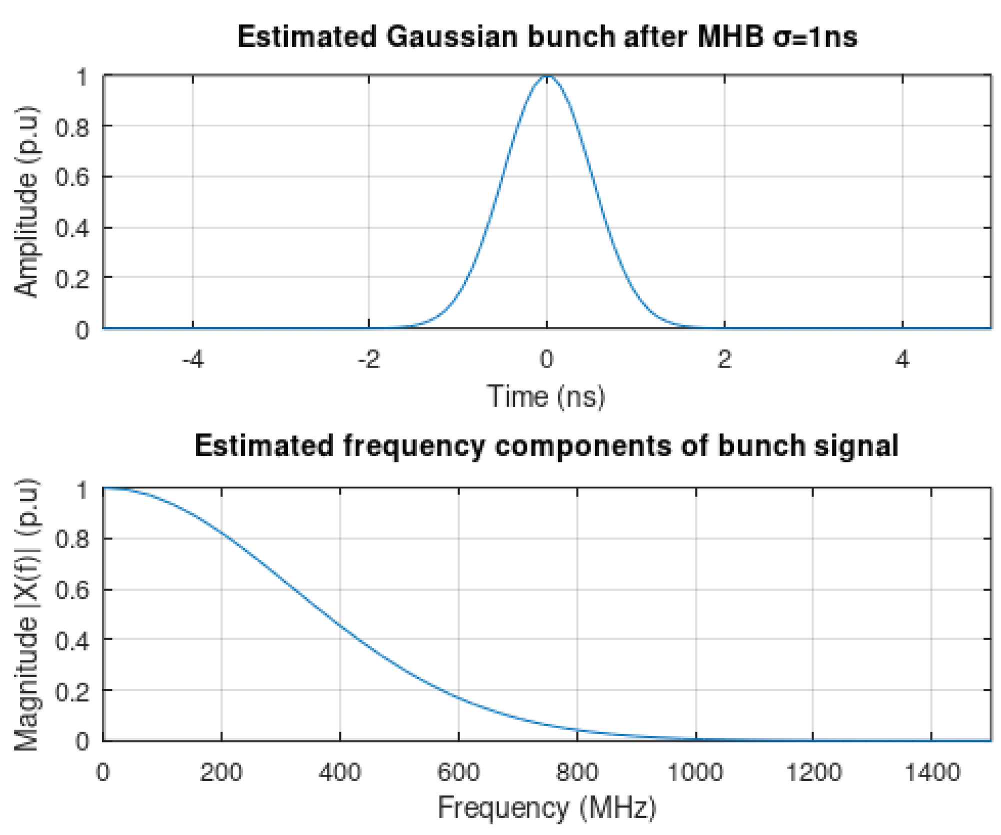

Figure 2: Expected shortest bunch temporal distribution and frequency spectrum after MHB in the FFC location.

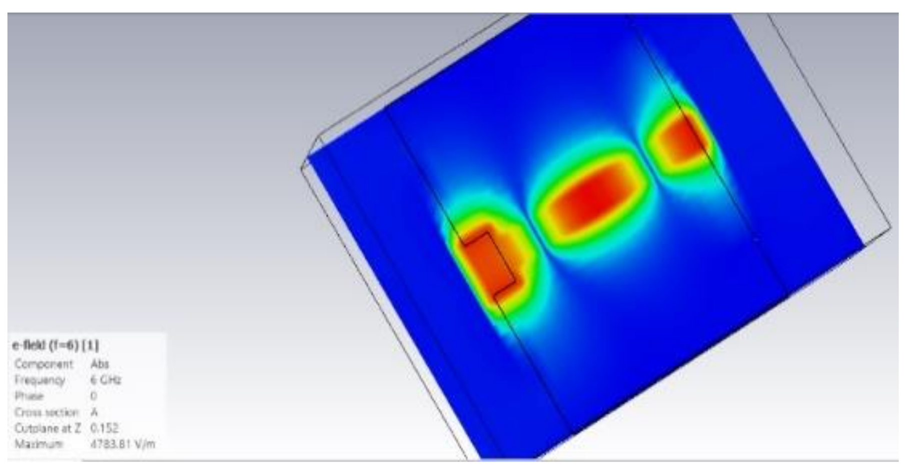

Figure 3: Screenshot of the 6GHz signal component propagation in the FFC mid-plane.

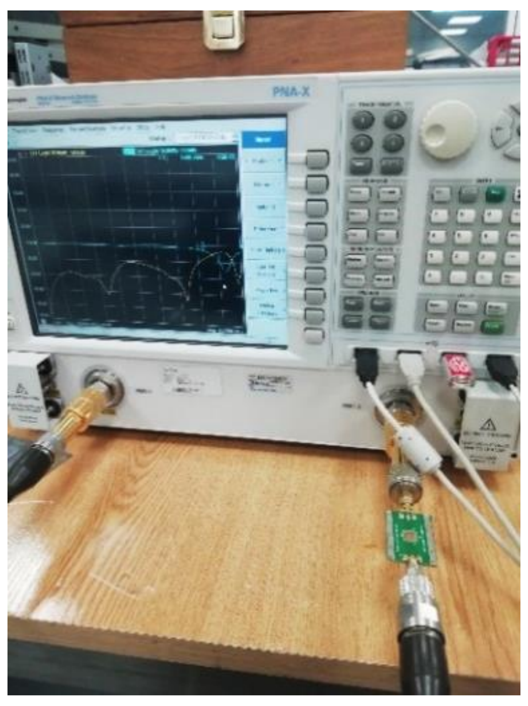

Figure 4: FFC microstrip PCB without collector during measurements of scattering parameters.

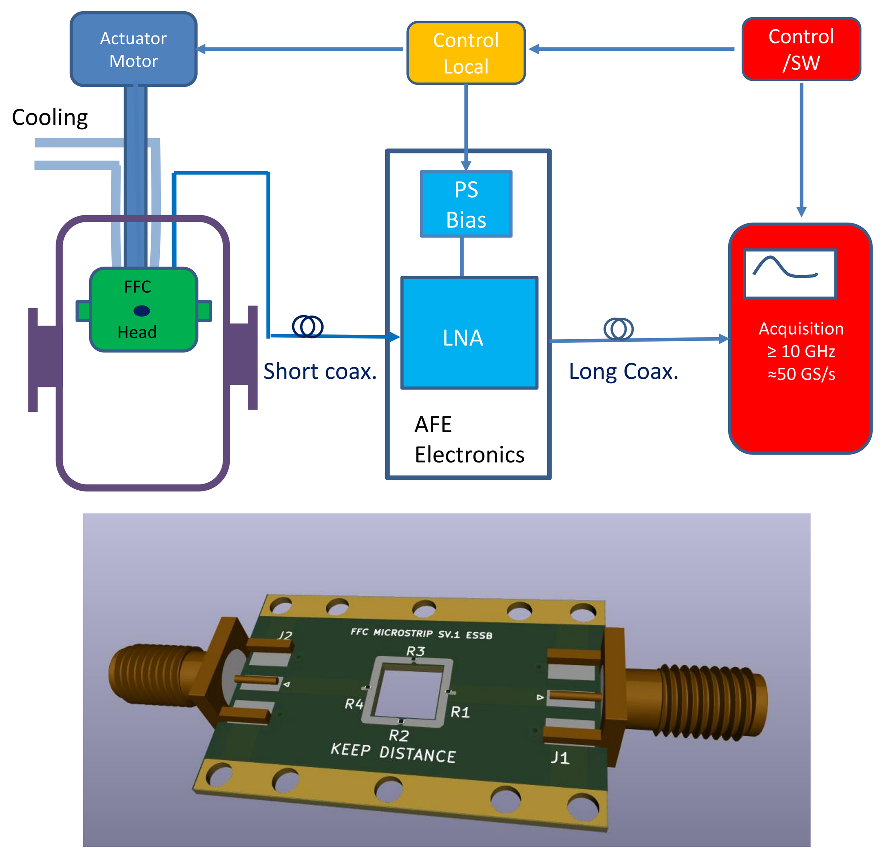

Figure 5: Overall system and a 3D image of the FFC Head without the collector and collimator

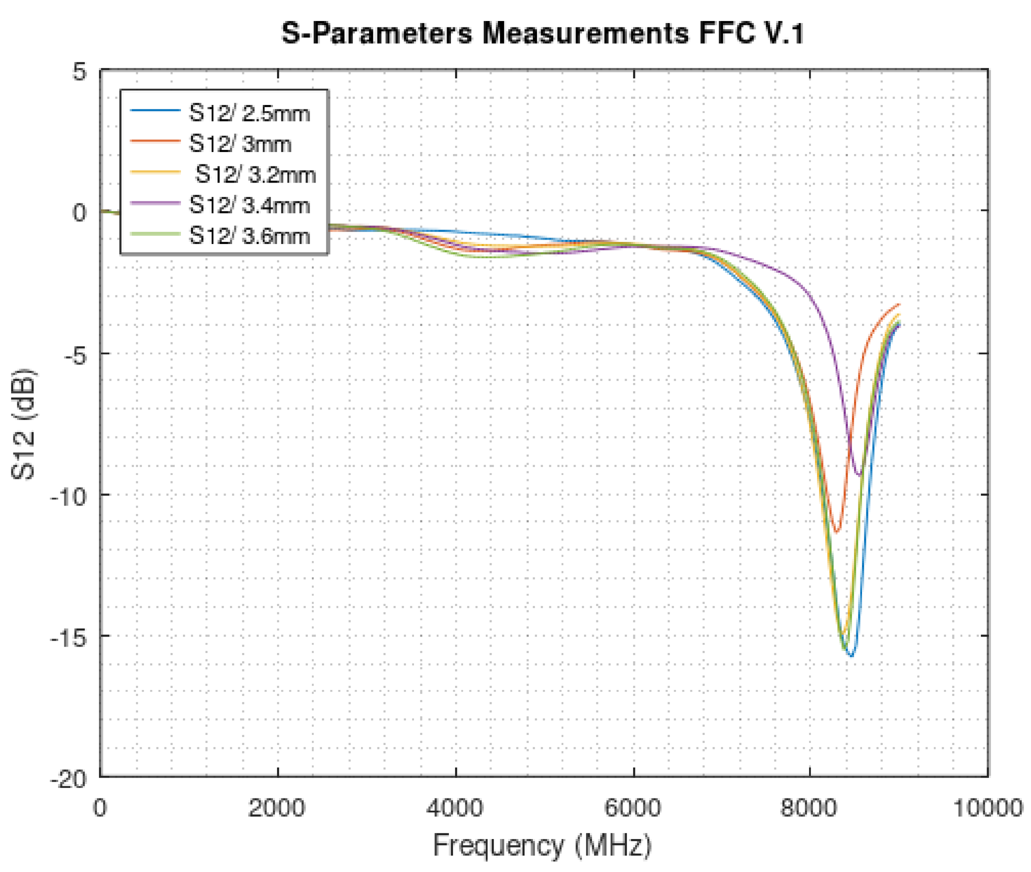

Figure 6: Measured S_{12} parameters for different trace thickness of microstrips.

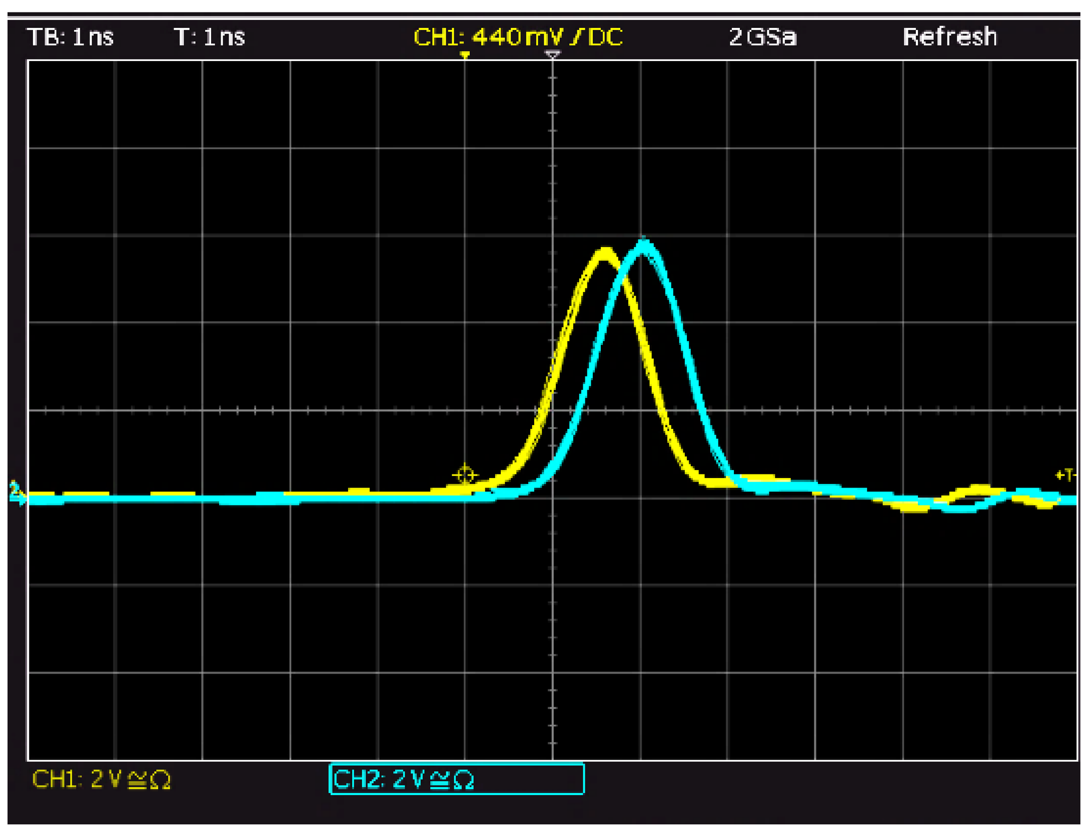

Figure 7: The incident 1ns rise time pulse (yellow) and after passing through the FFC (blue). Ver: 2 V/div, Hor.: 1 ns/div.

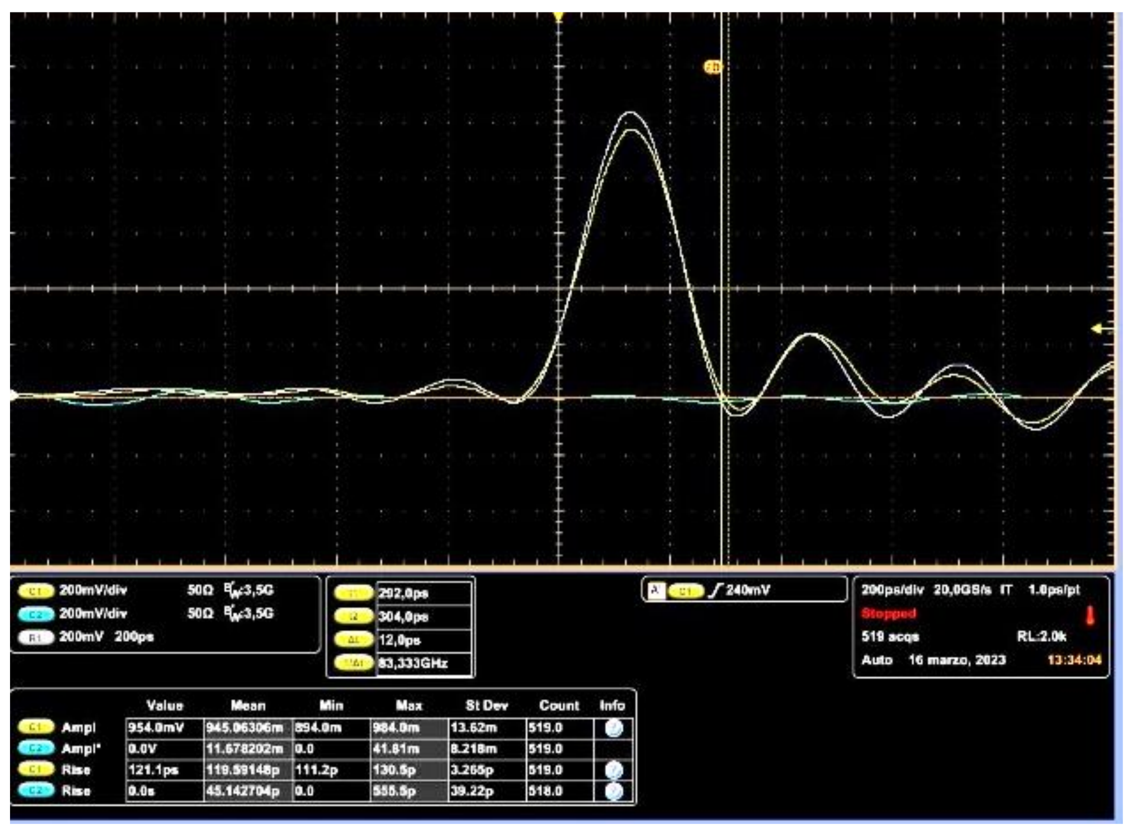

Figure 8: The incident 115ps fast rise time pulse variation before and after passing through the FFC microstrip.

ELECTRONICS AND DATA AQUISITION

In order to reduce the thermal heat on the FFC microstrip, the portion of beam which is collected on the FFC collector is reduced by a collimator in front of the FFC. The collimator opening aperture diameter is 0.8 mm and the stop range of hydrogen and nitrogen ions in the collector is less than a few μm. In this configuration, the signal amplitude at the signal port of the FFC is very weak with a power of less than -35 dBm. For that reason, we will use a broadband low noise amplifier (LNA) to amplify the signal before transmitting it via coaxial cable to the acquisition system. In addition, a DC bias voltage is placed on the signal port in order to supress the secondary electrons emission.