SYSTEM OVERVIEW AND PRELIMINARY TEST RESULTS OF THE ESS BEAM CURRENT MONITOR SYSTEM

EUROPEAN SPALLATION SOURCE

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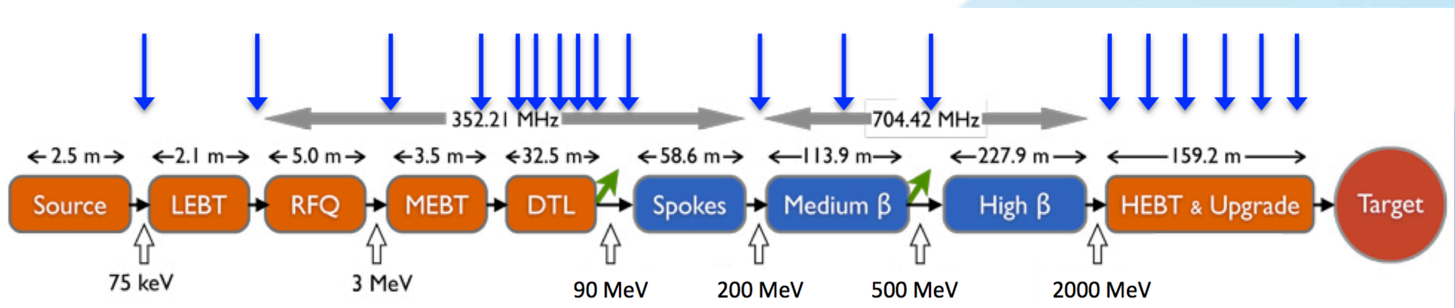
BCM System Overview

The BCM (Beam Current Monitor) system of the ESS will be mainly based on ACCTs (AC Current Transformers). However, a few FCTs (Fast Current Transformers) may also be used wherever a faster response is required. The BCM system will be primarily used for monitoring the beam current and charge, but it will also provide input to the MIS (Machine Interlock System) in case the absolute or the differential current exceeds user-defined thresholds. The differential current measurement is particularly important in the low energy part of the Linac where BLMs (Beam Loss Monitors) cannot reliably measure beam losses. A BCM prototype based on a commercial ACCT and MTCA.4 electronics has been procured and integrated into the ESS EPICS control system and tested with promising results. The system will be improved by programming the on-board FPGA of the digitizer card to perform the required digital signal processing including differential current measurement and post-mortem data capture, as well as providing a fast input to the MIS.

Distribution of the Current Monitors



Main Parameters

ESS beam parameters and BCM requirements (draft)

Parameter	Value	Unit
Particle type	Protons	
Max. beam energy	2	GeV
Average beam power	5	MW
Pulse repetition rate	14	Hz
Pulse duration	2.86	ms
Max. beam current (nominal beam)	62.5	mA
Min. beam current	6.25	mA
RF frequency	352, 704	MHz
BCM accuracy (nominal beam)	+/−1	%
BCM resolution (nominal beam)	< 1	%
BCM response time	< 1	µs
Beam pipe diameter	60, 100	mm

Specifications of the Bergoz ACCT

Parameter	Value	Unit
Input current	+/− 100	mA
Output voltage (full scale)	+/− 5	V
Lower −3 dB cutoff frequency	3	Hz
Upper −3 dB cutoff frequency	1	MHz
Droop	< 2	%/ms
Slew rate	2	V/µs
Output offset (max)	0.5	mV
Noise at 100 mA (full scale)	< 20	µA (rms)
Power supply	+/− 5, 100	V, mA
Connectors	Sensor: BNO Elect. In: BNO Elect. Out: BNC	

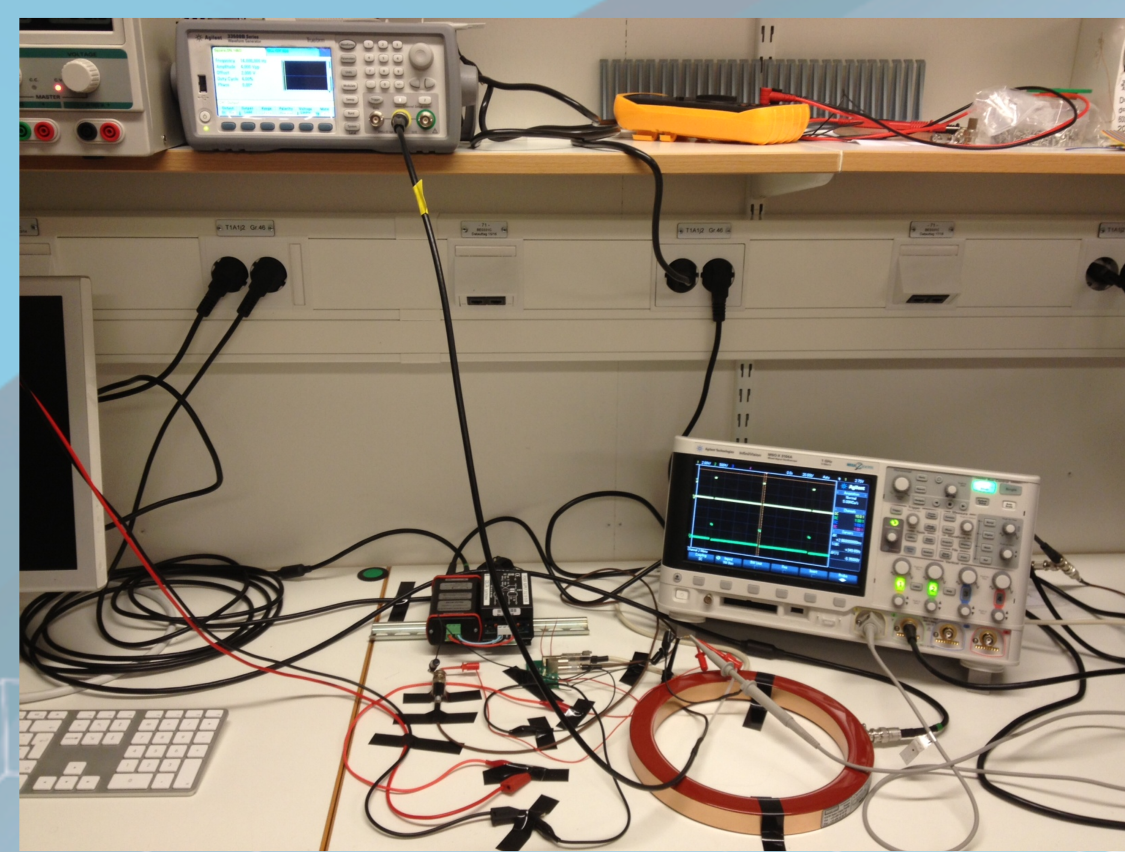
Future Works and Improvements

In the current version of the ACCT system, the entire digital signal processing after the A-D conversion is done by the computer running the GUI. It is planned to transfer part of the digital processing such as droop compensation, synchronization to the trigger input, DC level correction and filtering to the FPGA of the digitizer card.

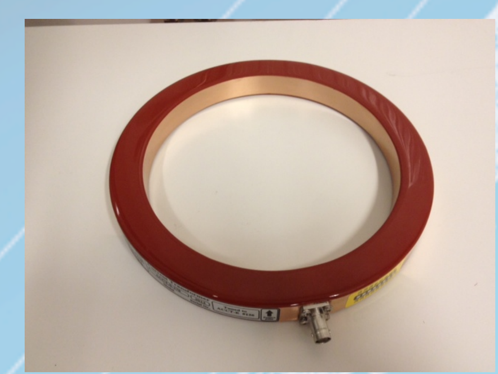
Differential current measurement and providing a fast input to the BIS will be one of the first ACCT functionalities needed for the commissioning of the low energy part of the Linac. For that purpose, it is planed to use two inputs of the digitizer card to measure the beam current at two BCM locations. The FPGA will be programmed to compare the two current levels, and in case the difference exceeds a user-defined threshold, send a pulse to the BIS for a fast beam abort.

A post-mortem data capture mechanism is planned to be implemented at a later stage. In that case, the most recent ACCT data will be stored in a buffer implemented on the local AMC memory. The data can then be retrieved and examined upon a user request or machine failure.

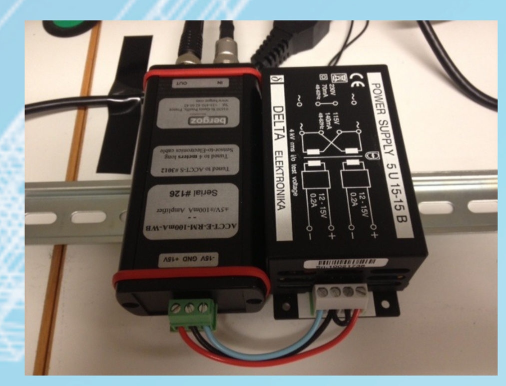
ACCT Test Setup



ACCT test setup (ESS electronics lab.)

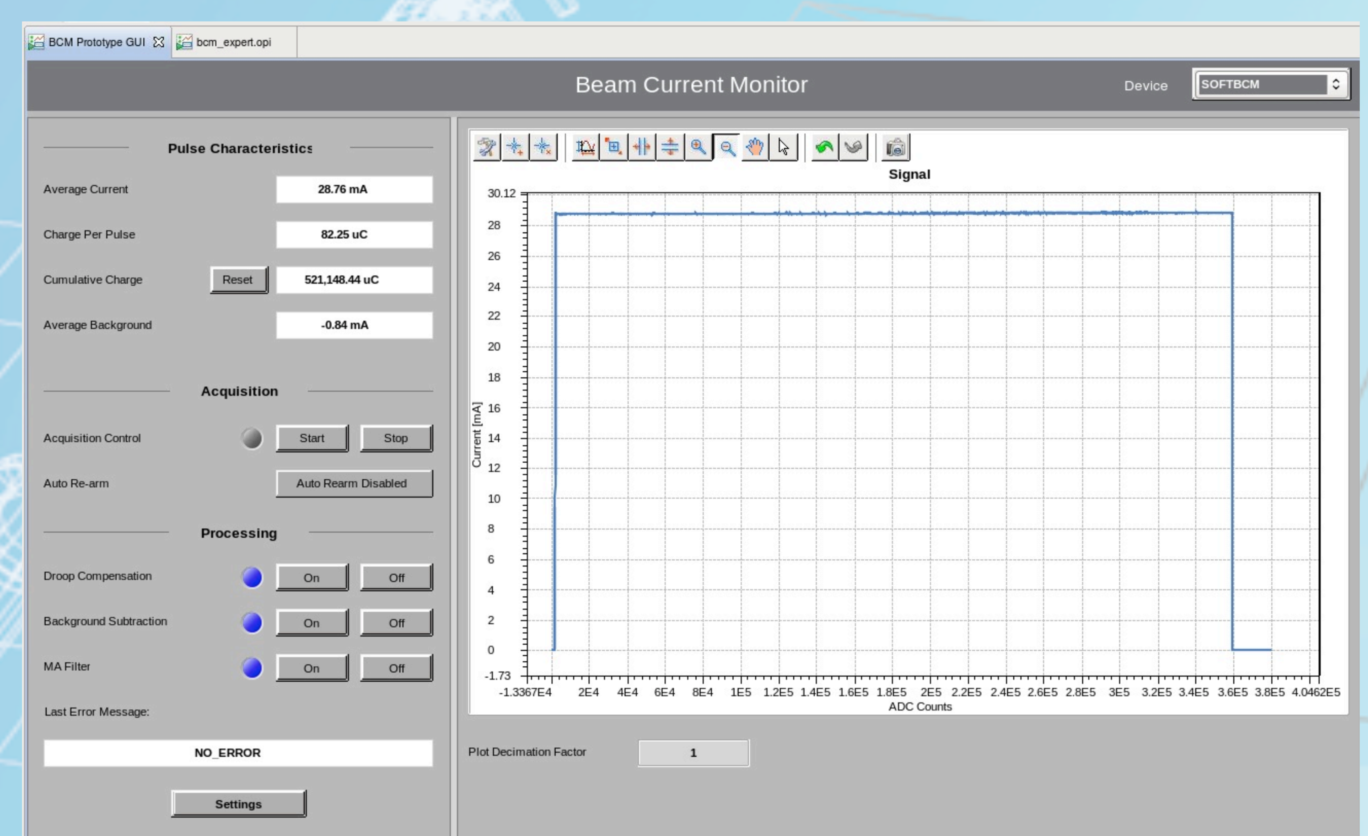


Bergoz ACCT toroid



ACCT electronics and power supply

MTCA.4 electronics including a Struck SIS8300



EPICS-integrated ACCT GUI

MRF timing system

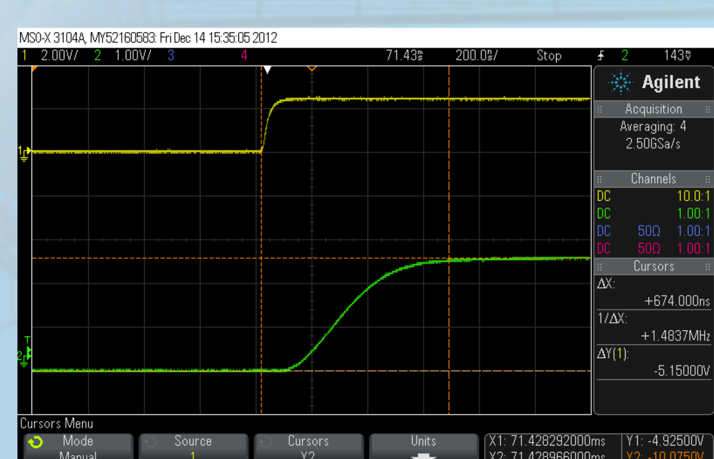
MTCA.4 system:

- 019 chassis from Schroff
- Telkoor power module
- NAT MCH
- Gen. 2 CPU unit from Concurrent Tech.
- SIS8300 AMC from Struck
- SIS8900 RTM from Struck

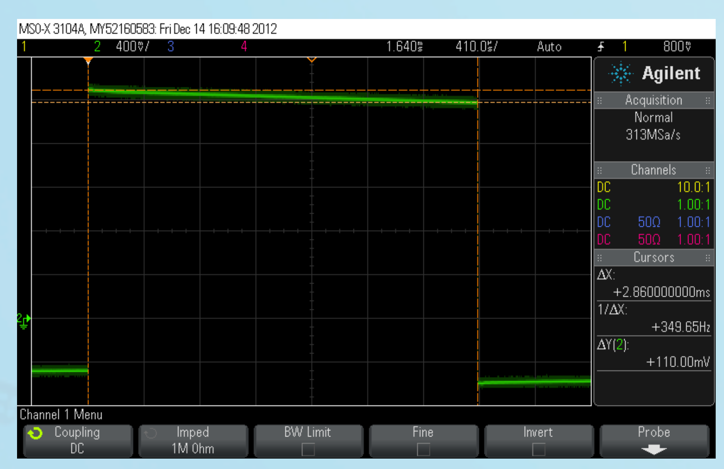
Software:

- SIS8300 kernel (Struck)
- User-space driver (Cosylab)
- EPICS application (Cosylab)
- GUI (Cosylab)

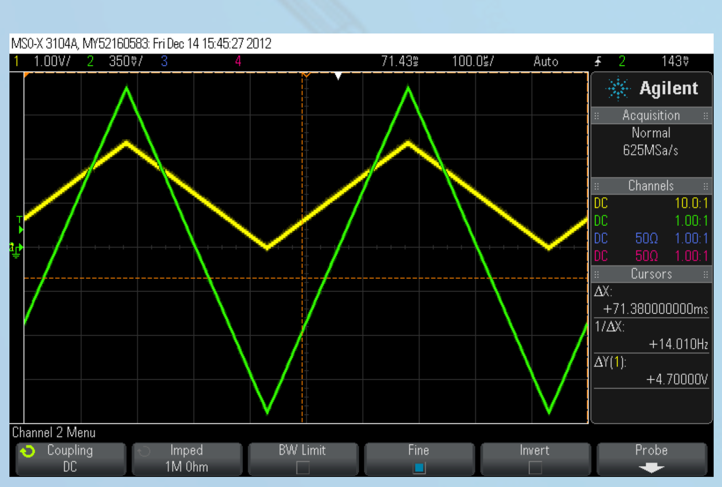
Test Results



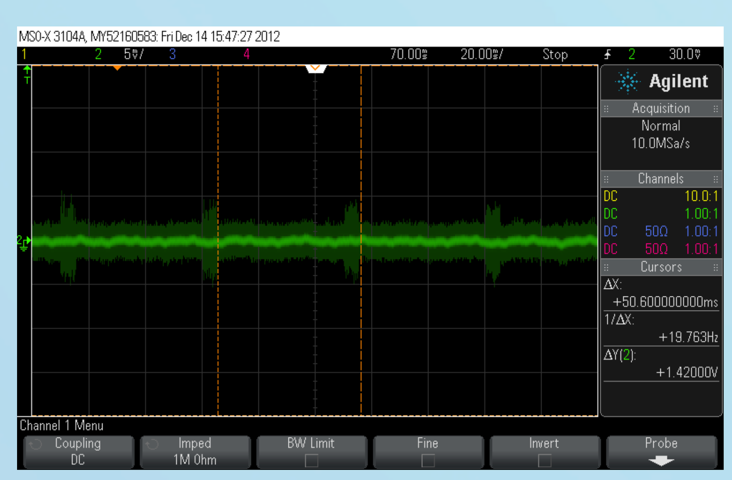
ACCT response time (< 1 μs)



Droop (4.2% for a 2.86 ms pulse)



Linearity (almost 100%)



Noise