

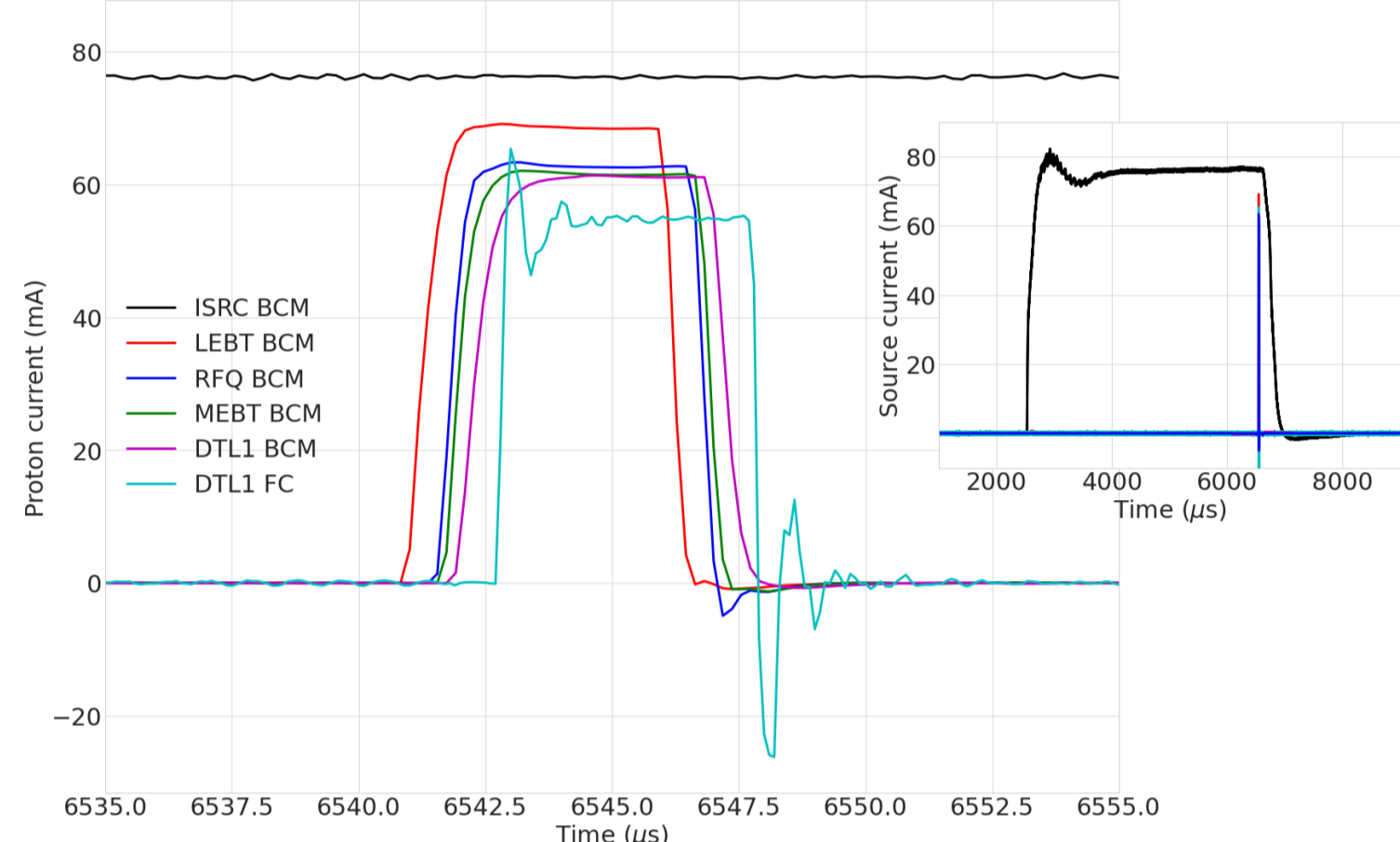
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In late 2021 through mid-2022, the first protons were accelerated and transported through the European Spallation Source's RFQ and MEBT at 3.6 MeV, and finally through the first DTL tank at 21 MeV. To enable these achievements, the following beam instrumentation systems were deployed: Ion Source power supply monitors, a beam chopping system, Faraday Cups, Beam Current Monitors and Beam Position Monitors that also measured phase. Additional systems were deployed for dedicated studies, including Wire Scanners, a slit and grid emittance measurement unit, neutron Beam Loss Monitors, and fast Beam Current and Position Monitor systems. The instrumentation deployment is the culmination of efforts by a partnership of the ESS beam diagnostics section, multiple ESS groups and institutes across the globe. This paper summarizes the beam tests that characterized the performance of the instrumentation systems and verified the achievement of commissioning goals.



75 keV	3.6 MeV		21.3 MeV	
Ion Source	2.5 m LEBT	4.6 m RFQ	4 m MEBT	7.6 m DTL 1
2 BCM	1 FC 1 Chopper 1 BCM	1 BCM	1 FC 1 Chopper 3 BCM 1 FBCM 8 BPM 2 FBPM 3 WS 1 EMU	1 FC 1 BCM 6 BPM

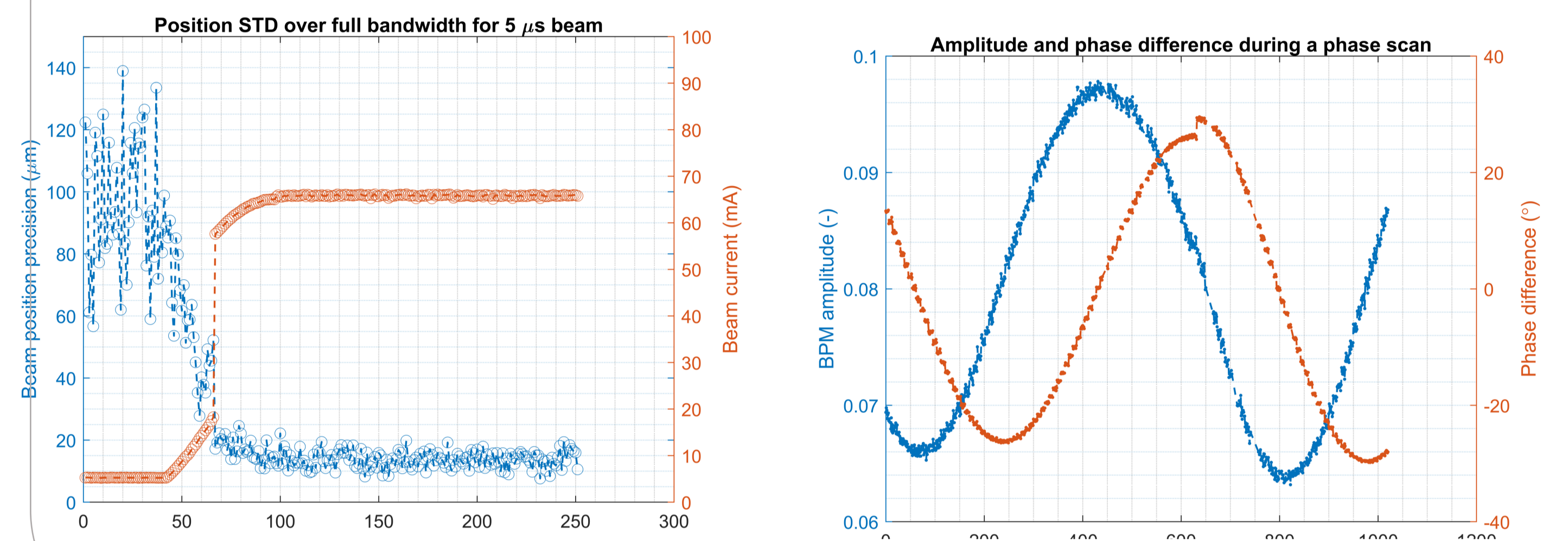
## Current



- Inner plot: pulse produced by the ESS proton source
- July, 1<sup>st</sup> 2022: current ramped up to the maximum (62.5 mA)

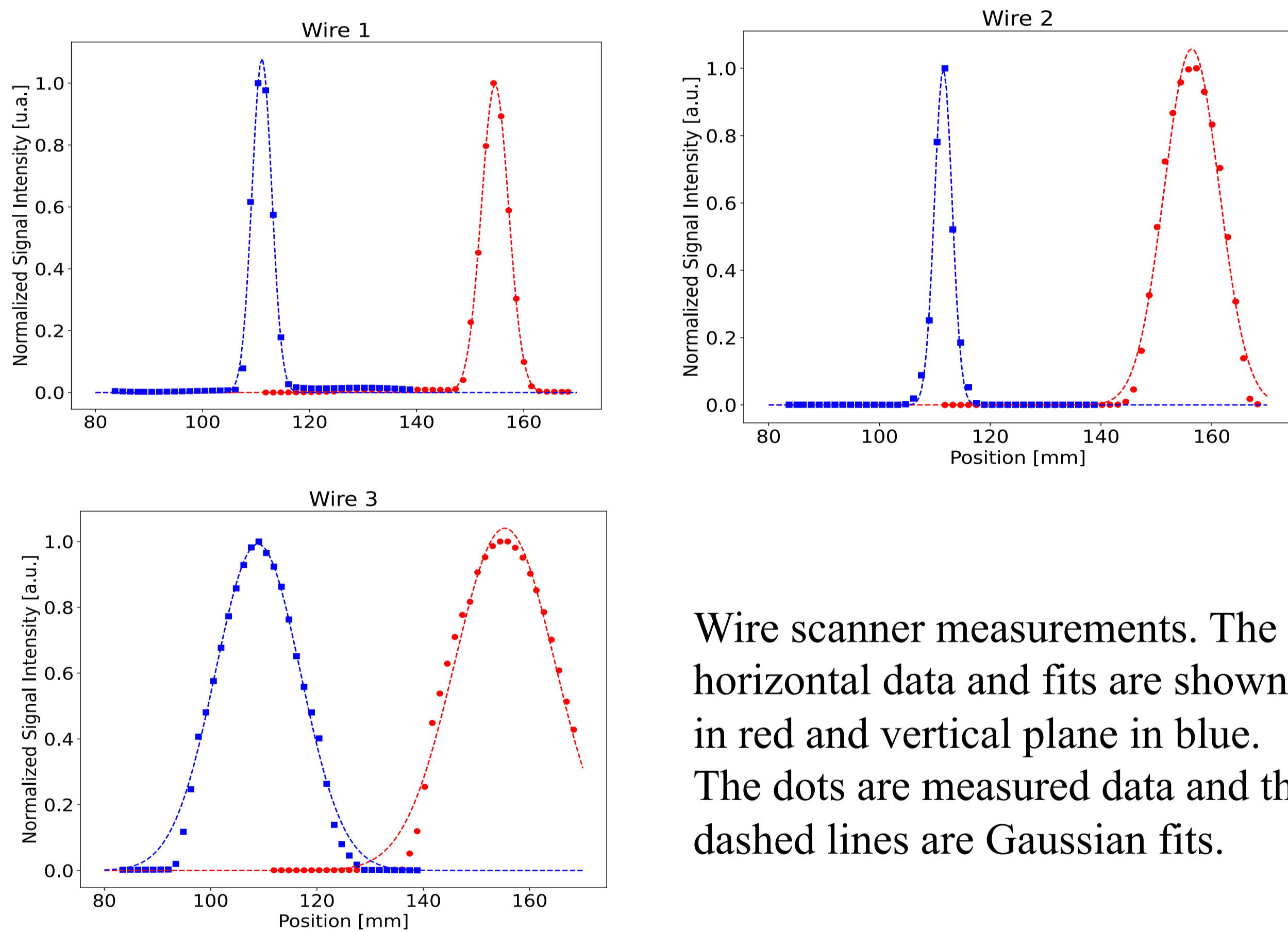
Proton pulses measured by five Beam Current Monitors and by the DTL1 Faraday cup

## Position and phase



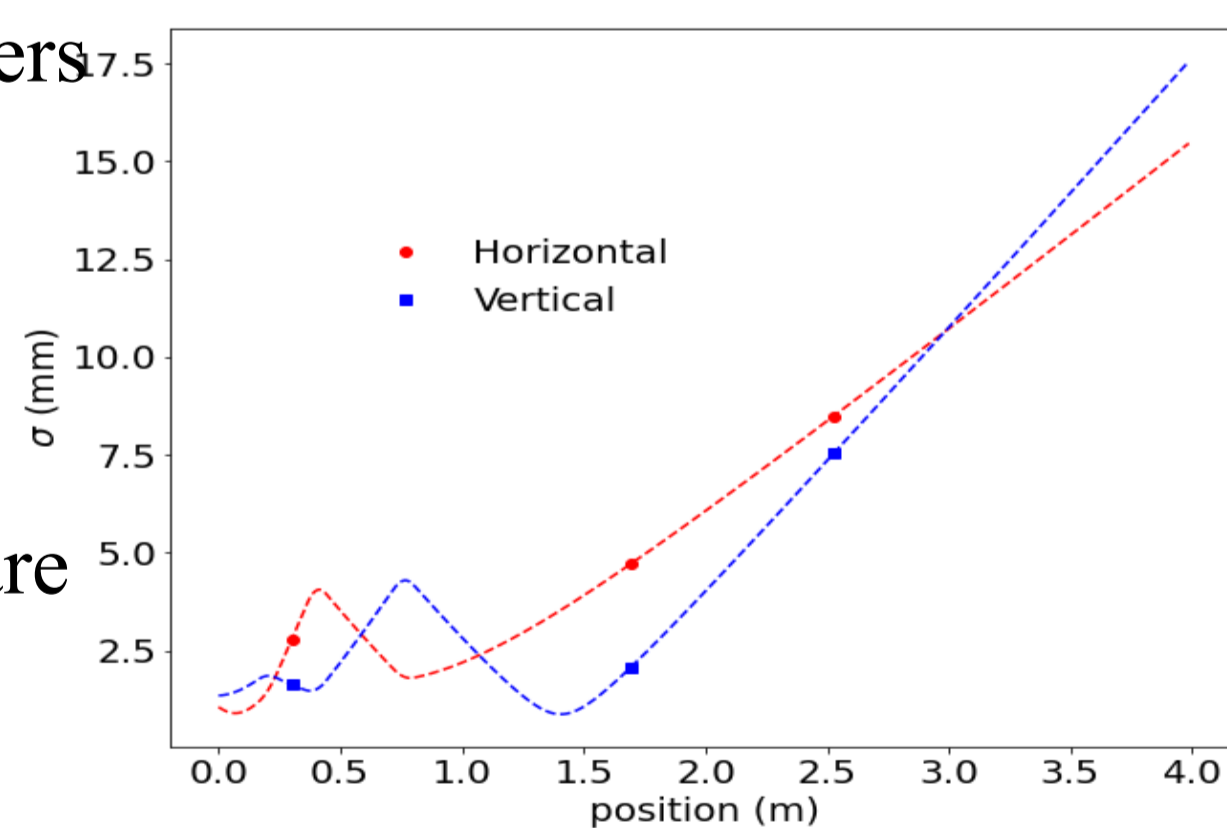
Beam position measurements vs beam current and typical phase scan plots.

## Wire Scans

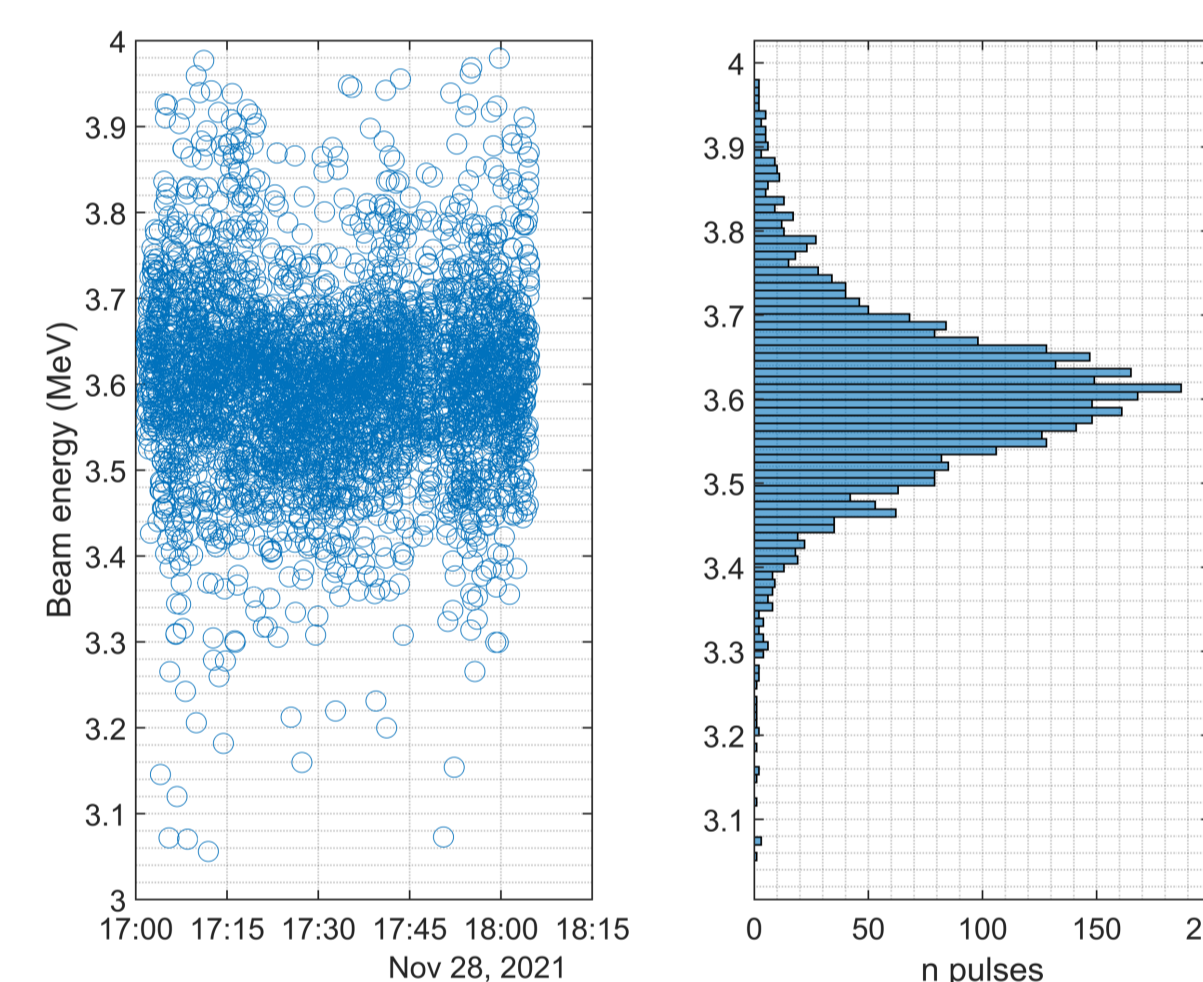


Wire scanner measurements. The horizontal data and fits are shown in red and vertical plane in blue. The dots are measured data and the dashed lines are Gaussian fits.

Measurement using all wire scanners in the MEBT. Bunchers are not powered and only the first 3 quads are turned on. This was a special optics setup to protect the MEBT Faraday Cup. The measurements are for a beam current of 57 mA.

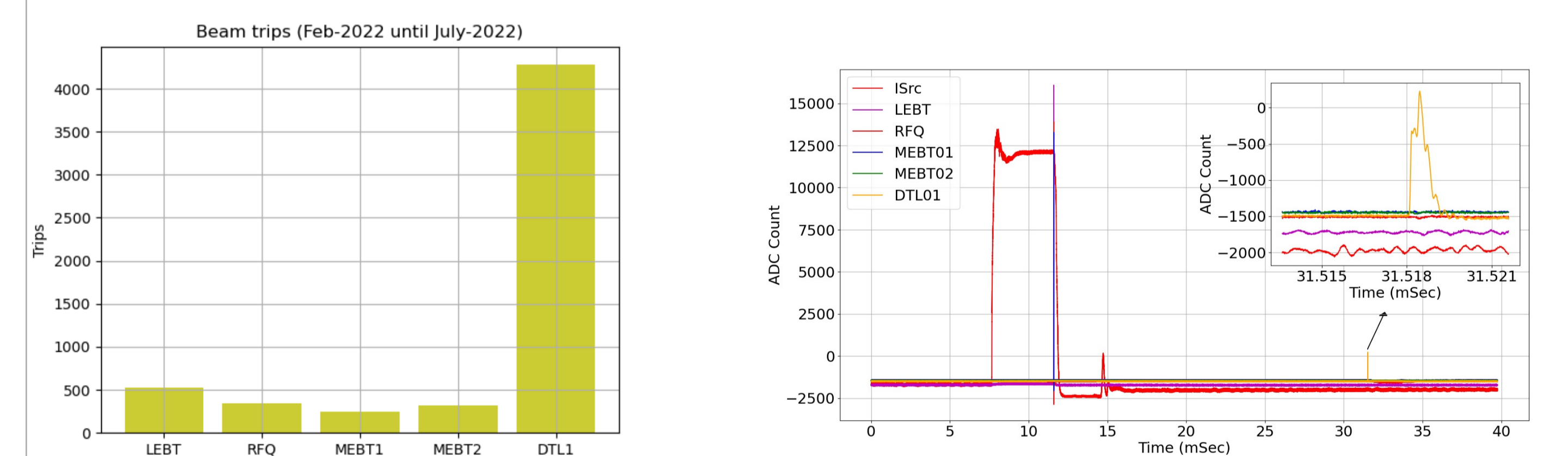


## Energy measurements



Energy distribution measurements over approximately one hour of machine operation as measured by the fast BPM. The measurements are obtained with a high bandwidth high sampling rate acquisition.

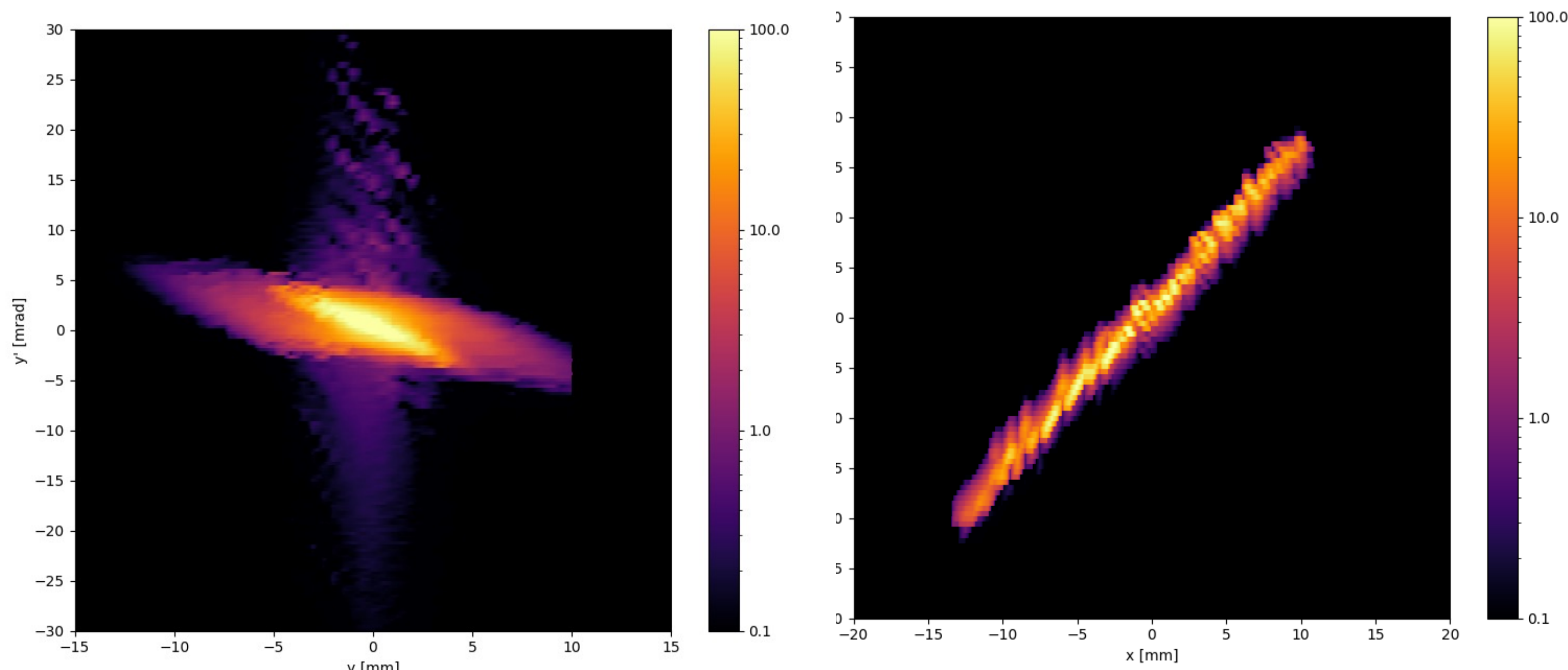
## Protection Functions



Trip statistics

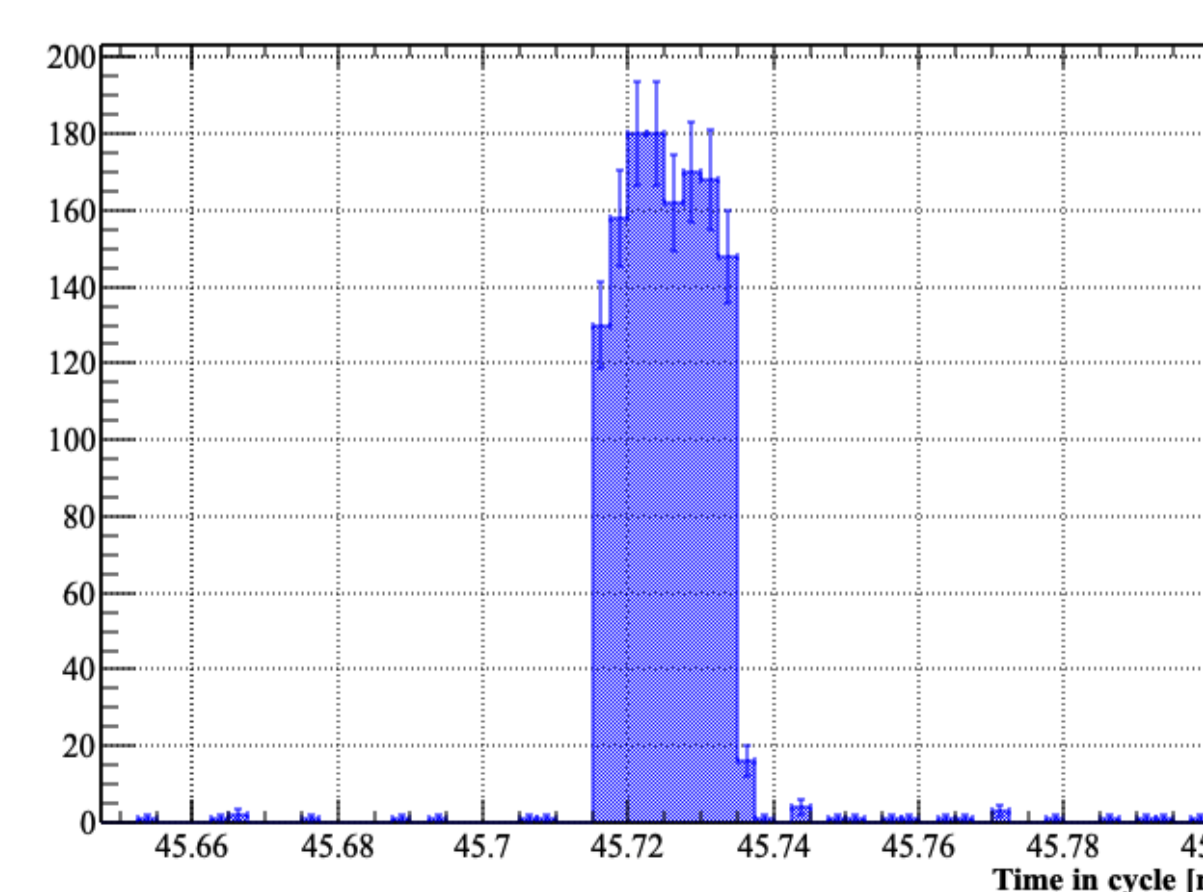
Example waveform leading to a trip caused by signal other than proton beam current

## Emittance



Reconstructed horizontal (top) and vertical (bottom) emittance for the MEBT EMU at nominal current, 62 mA.

## Neutron Measurements



- Neutrons measured for the first time during intentional beam loss on TzM chopper dump
- 3.6 MeV protons
- Fast nBLM detector

## Outlook

All system required for commissioning were verified and available for first protons. High level performance requirements were met and with some limitations, all were declared operational. In addition, several systems were prepared for studies and acquired beam data for the first time. Next commissioning run scheduled for Q1/Q2 of 2023 will take beam through the first 4 of 5 DTL tanks to about 70 MeV.