MCP-Based Detectors for Diagnostics of Circulating Beams in the NICA Accelerating Complex

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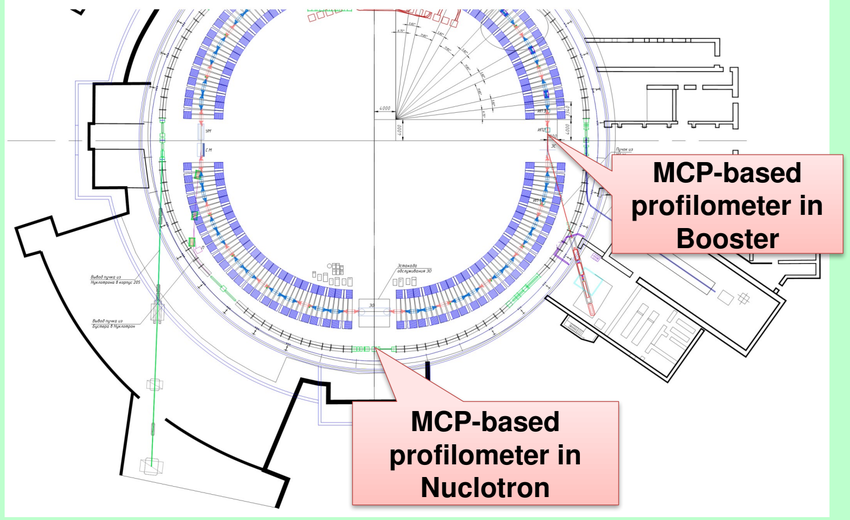
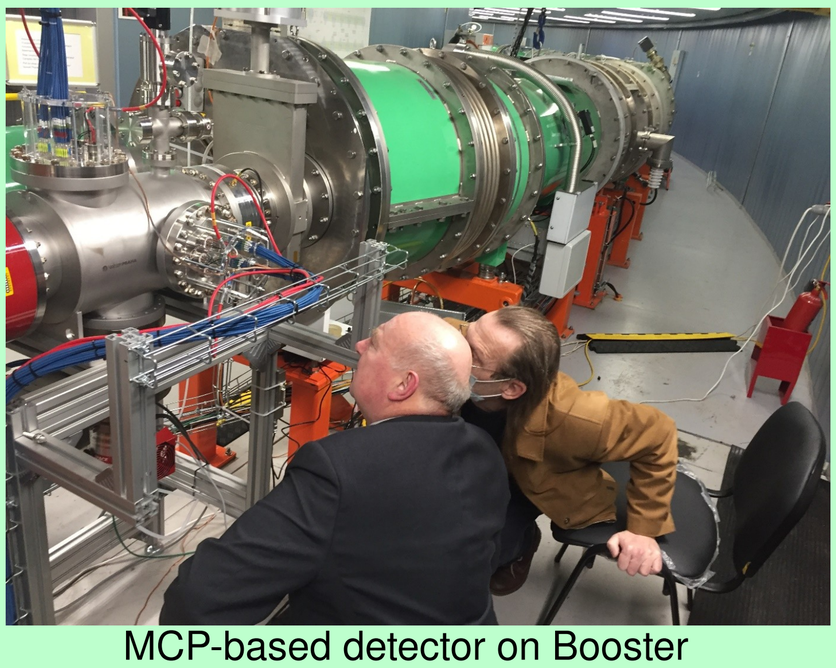
All of accelerators need to nondestuctive diagnostic. At the NICA accelerator complex, two profilometer for nondestructive diagnostic based on microchannel plates (MCP) are installed. One profilometer is installed at the Nuclotron ring, and the second profilometer is installed at the Booster ring. The profilometer consists of two MCP for two axes. The MCP plate consists of small-sized channels.The MCP operates on the principle of electron multiplication, generated during the interaction of residual gas ions with the MCP channels. The signals from the MCP are obtained using the TIC64 data acquisition system. With the help of these detectors, the accelerator team adjusts the configuration of accelerators, especially at low intensities, conducts tests of systems, etc.

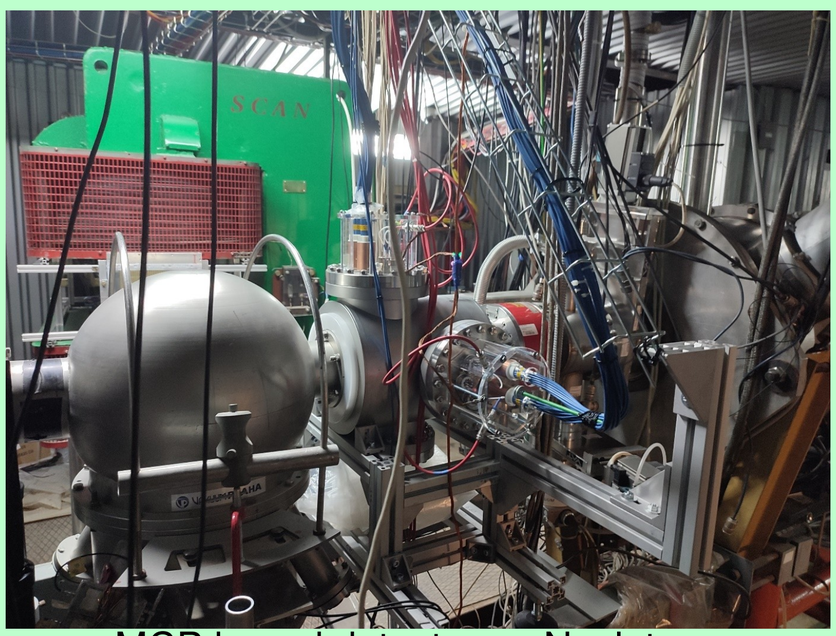
Diagnostic stations



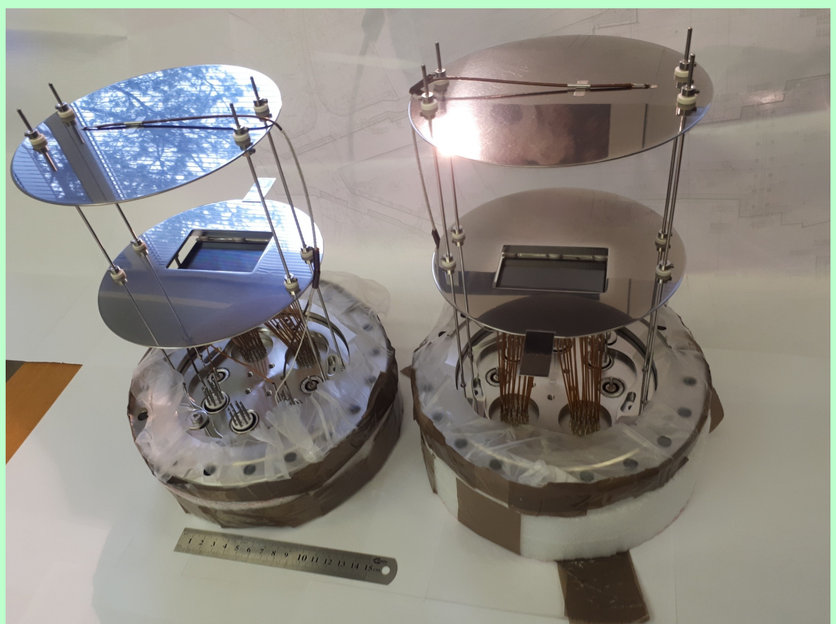
Detector installation location



MCP-based detector on Booster



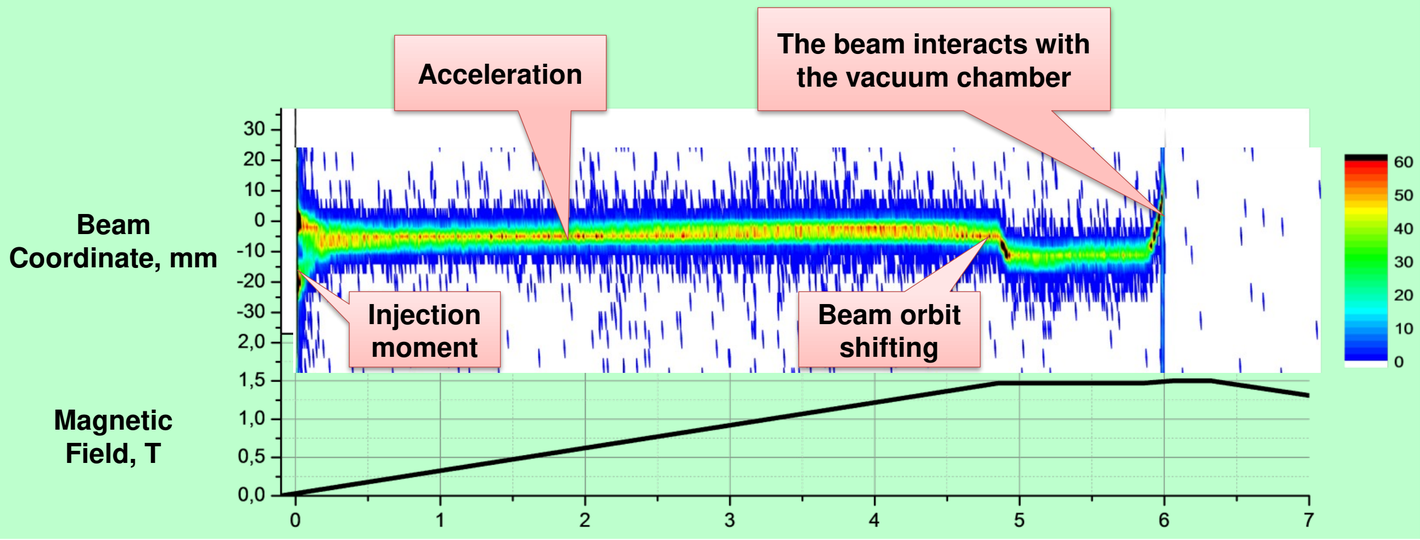
MCP-based detector on Nuclotron



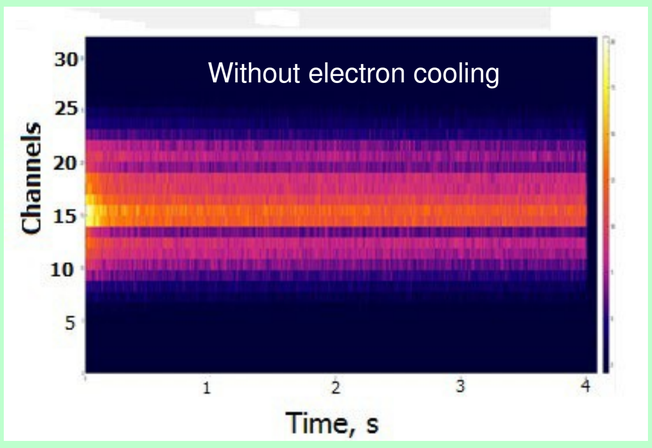
Disassembled MCP-based detector

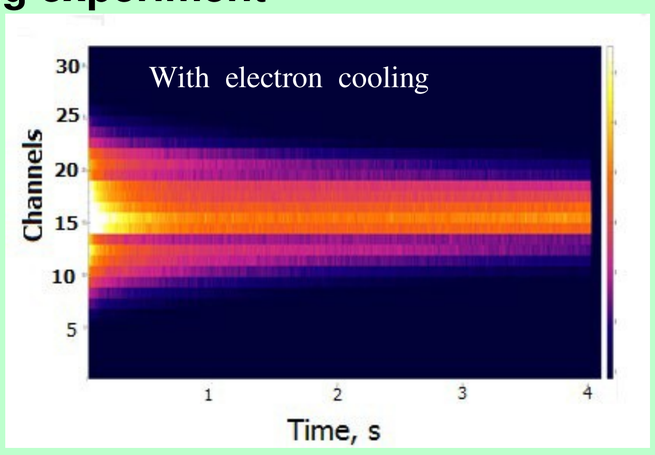
Diagnostics of circulating beam (deuterons 4 GeV/n)

We will look at the data of profilometer of nuclotron. We can see four step of one acceleration cycle on the top heatmap. Injection moment, acceleration,beam orbit shifting for extracting to the experement, and at the end the remnants of beam interacts with the vacuum chamber. Additionally, we can compare this time structure of the profile of the beam with magnetic field on the graph below the heatmap.

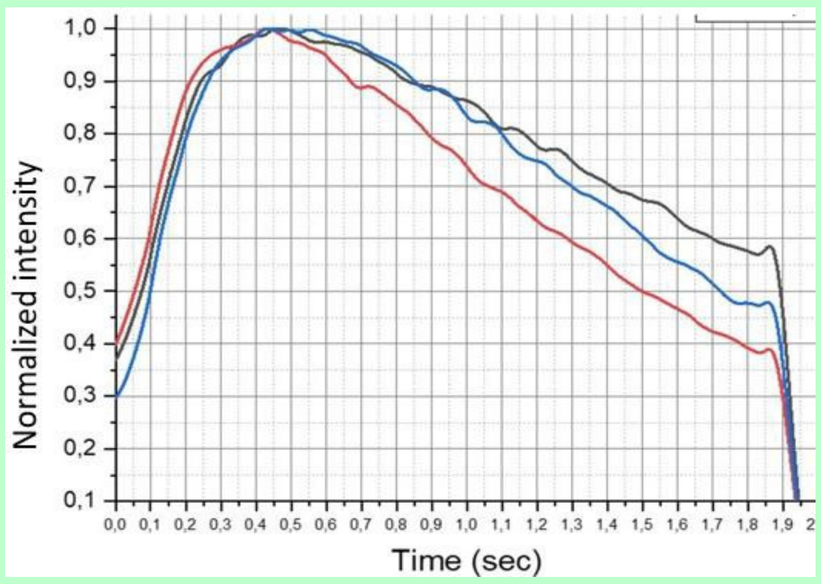


Electron cooling experiment





During the first Booster session in December 2020, an experiment was conducted to commission the ECS with a circulating helium ion beam with an energy of 3.2 MeV/u (injection energy into the Booster). In this experiment the only diagnostic devices that allowed observing the cooling effect were used: a parametric current transformer (PCT) measuring ion beam current and ionization profilometer, that was operated in summing mode the counting rate of all the MCP channels registering the vertical distribution of the beam density, and the time dependence RC(t) was measured. Then the results were summed over several injection cycles RC(t). Figure on the right showcases normalized intensity for different electron energy. Black curve – 1.82 keV, blue curve – 1.72 keV, red curve – 1.76 keV. As can be seen, the strong decrease in the lifetime of the ion beam occurs at the energy 1.76 keV, which is in good agreement with the theoretical value. The optimal (theoretical) value of the electron energy is equal to 1.754 keV, what is different from 1.76 keV by the 5.7 V, or 0.3%.



Conclusion

The results of reliable continuous operation of MCP-based profilometers at the NICA accelerator complex have been provided during the last four-month session B4 of the 2022-2023 period. Additionally, these profilometers have proven valuable during the setup of the booster's electronic cooling system. The MCP-based detector was utilized in the applied research channel of the SOCHI experimental facility within the NICA accelerator complex for monitoring sample irradiation. Practical usage of MCP-based detectors revealed limitations in their loading characteristics. Depending on the type of plates used and operating modes, laboratory research was conducted on the temporal loading characteristics of MCP-based detectors. Based on the obtained data, a new upgraded design for the MCP-based diagnostic system was developed, allowing for an order of magnitude increase in the loading capabilities of this type of detector.

References

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