Nondestructive Diagnostics of Accelerated Ion Beams with MCP-Based Detectors at the Accelerator Complex NICA. Experimental Results and Prospects

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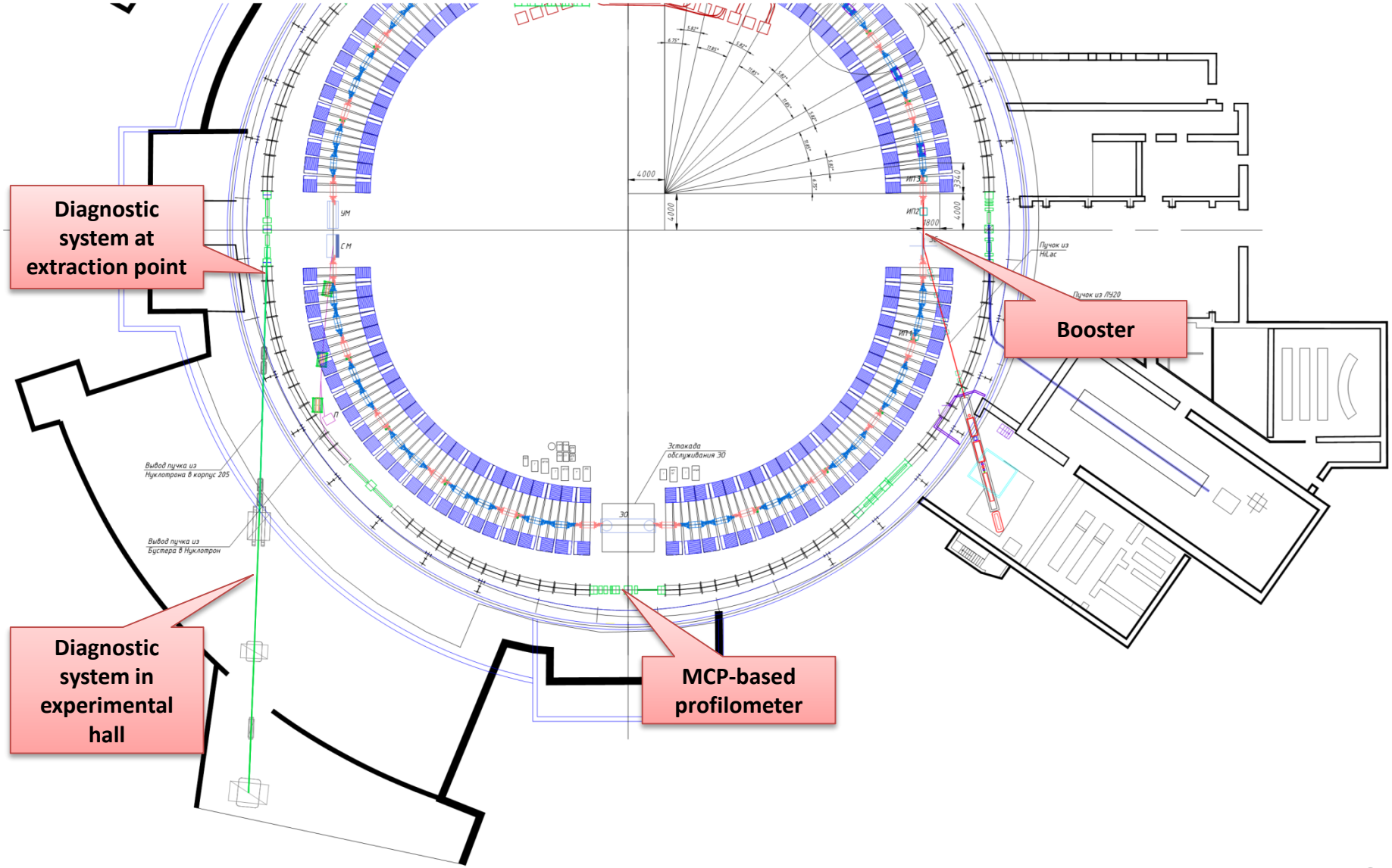
29.09.2021 Alushta

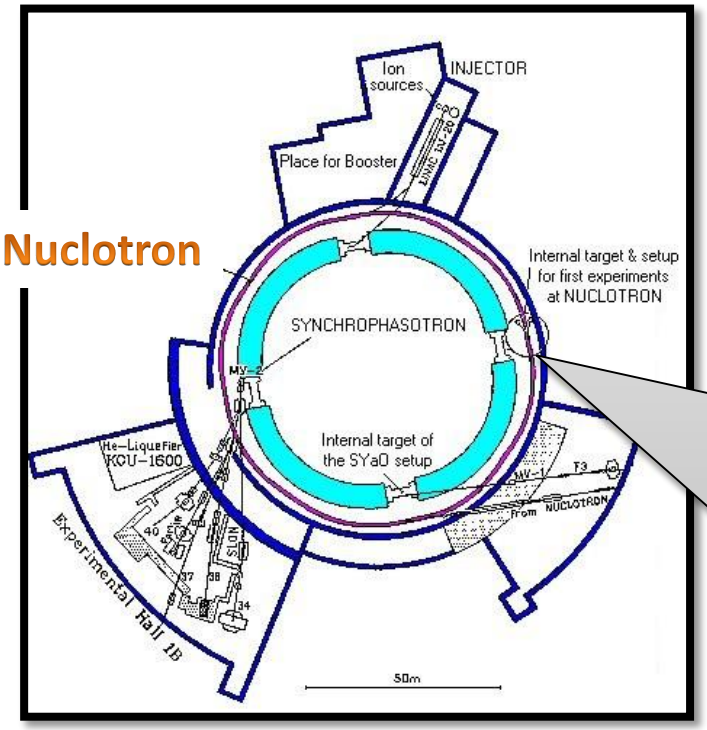
Diagnostic systems at the acceleration complex

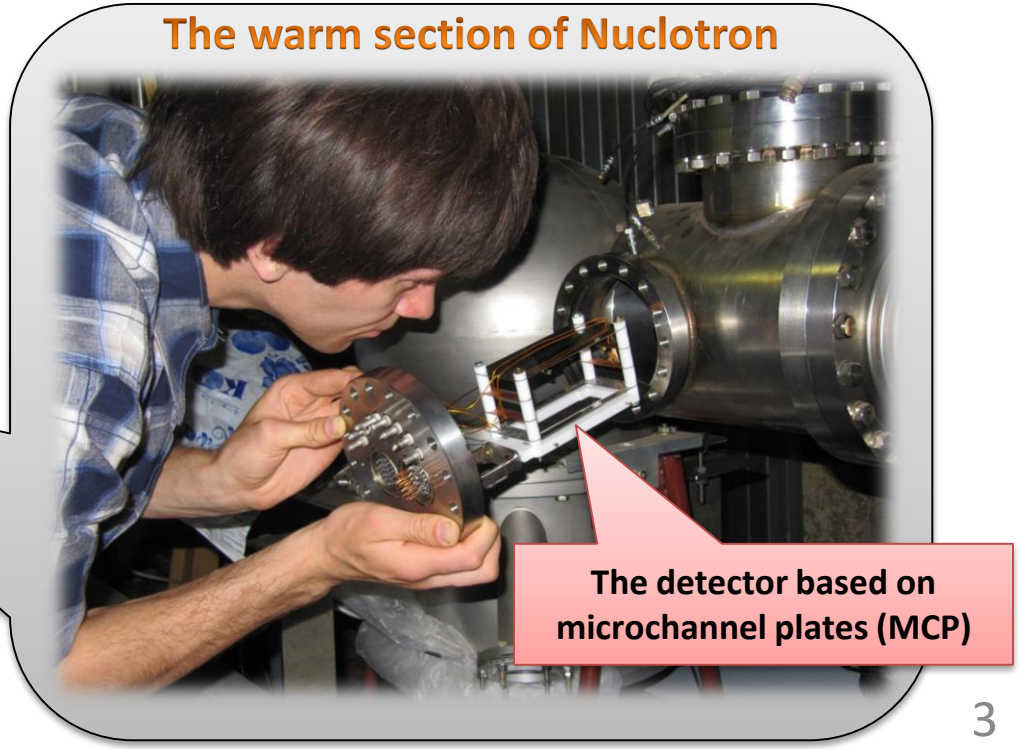


Diagnostics of circulating beam

Creation of modern nondestructive control systems of space-time characteristics of the beam during acceleration and extraction is the one of the most important tasks for exploitation of the Nuclotron accelerator complex (JINR LHEP).

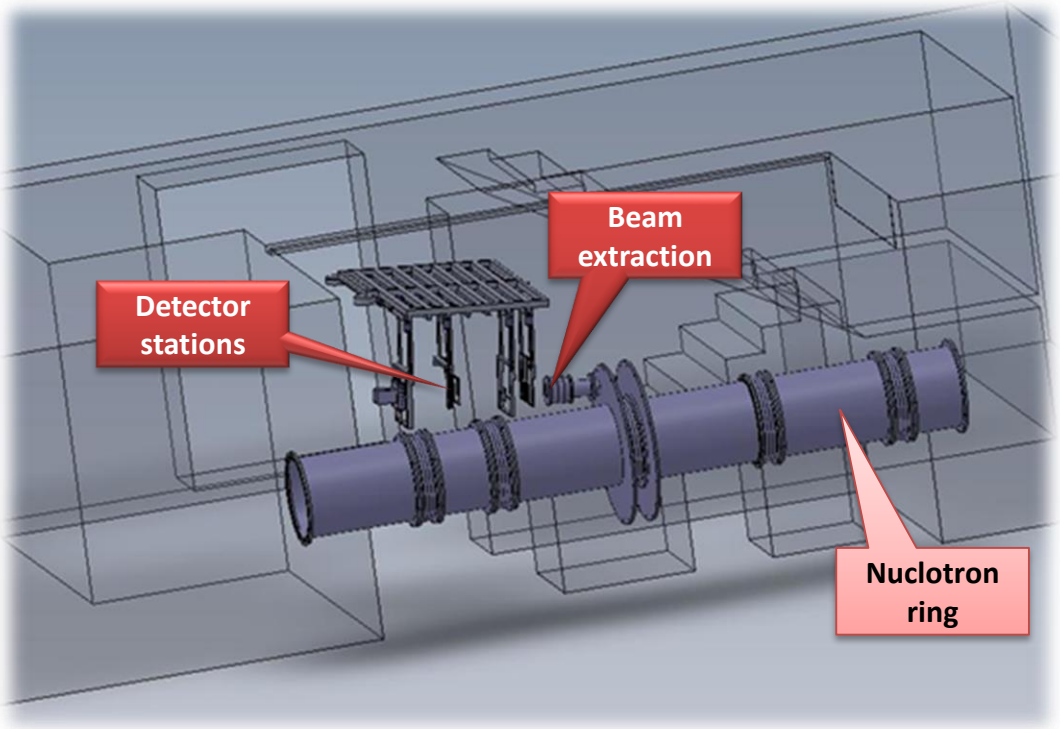
The detector was developed for registration of the space-time characteristics of the radial beam component. The system provides measurements in the intensity range of 10^6 – 10^8 for singly charged ions which is not covered by existing measuring devices.



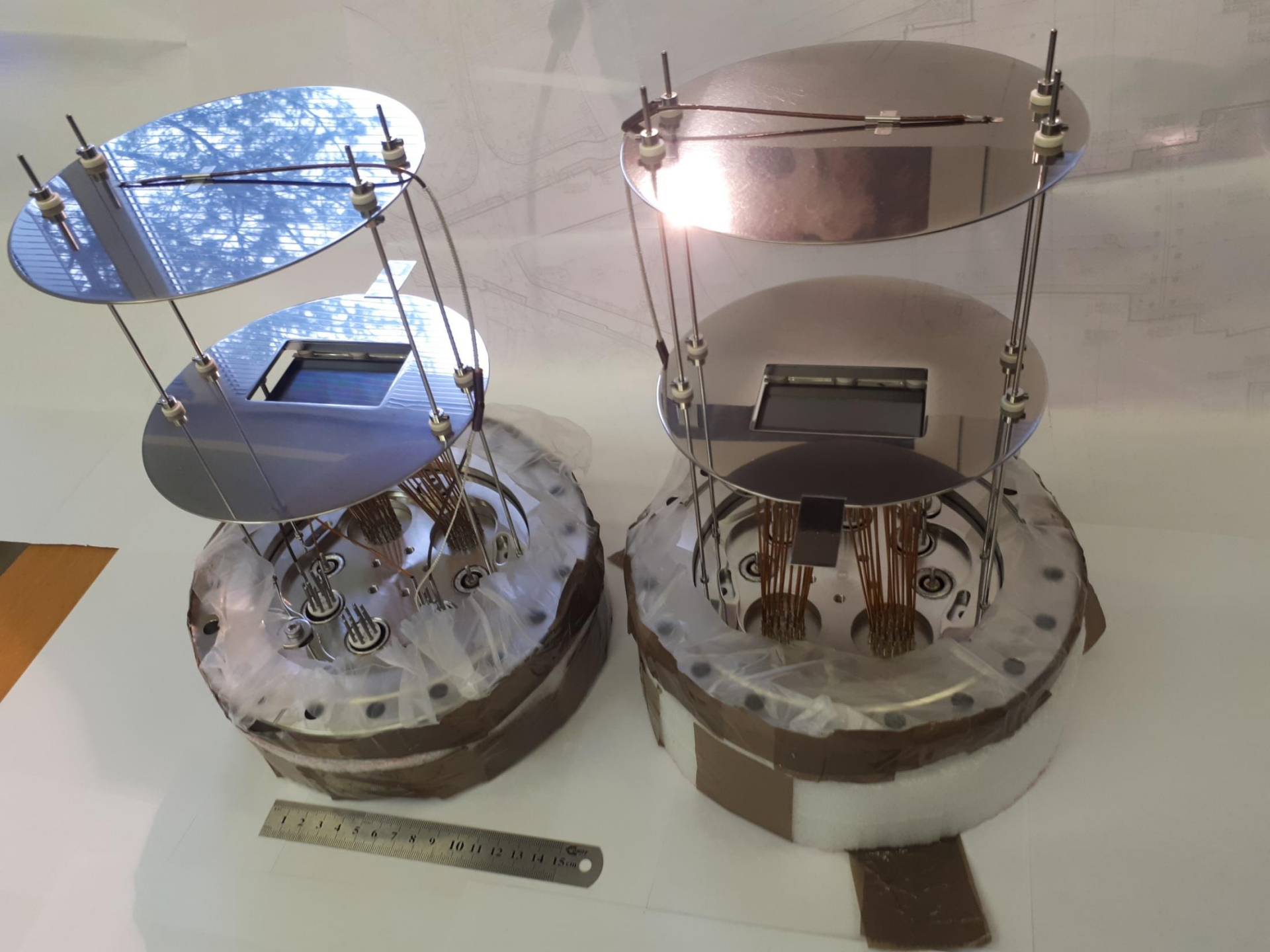


Диагностика пучка в зоне вывода из Нуклотрона.

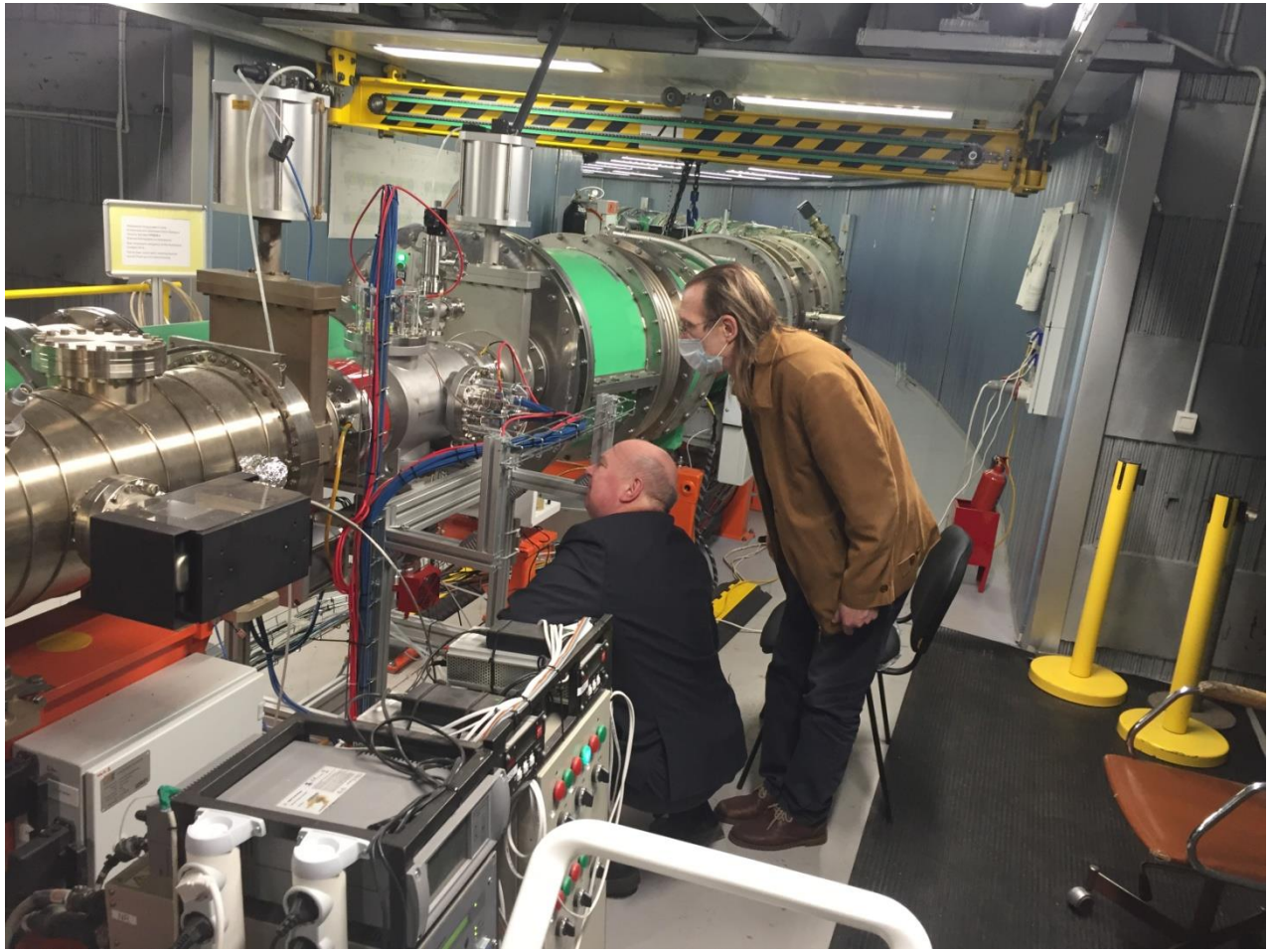
1. Nuclear photoemulsions
   Ionization chamber
2. Thin scintillation counter
3. Scintillation profilometer



Beam extraction region

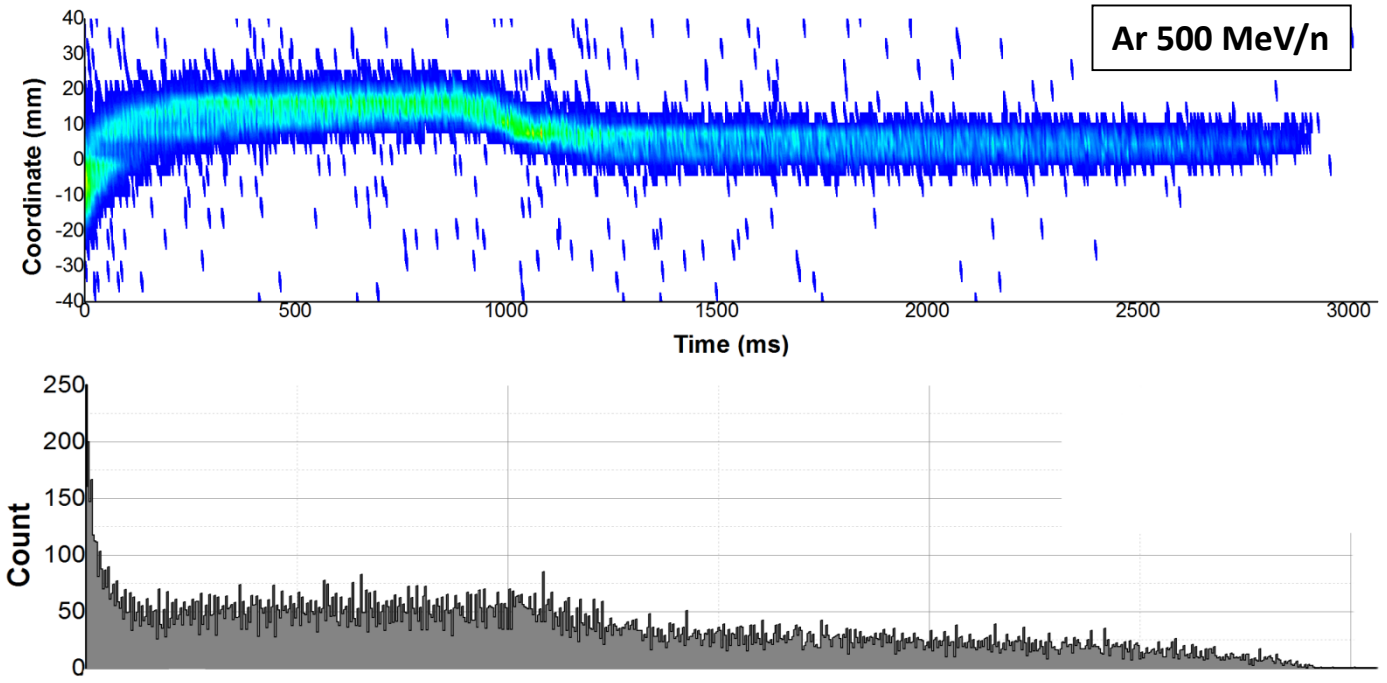


Booster



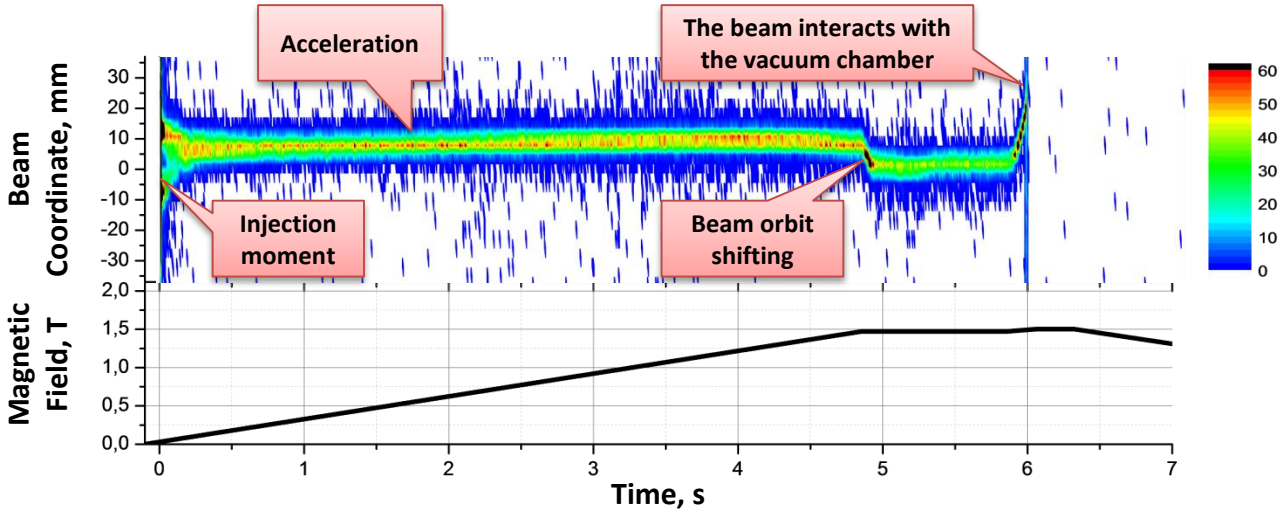
Multichannel counter with buffer memory TIC-64

2014.06 – circulating Ar^{+16} beam

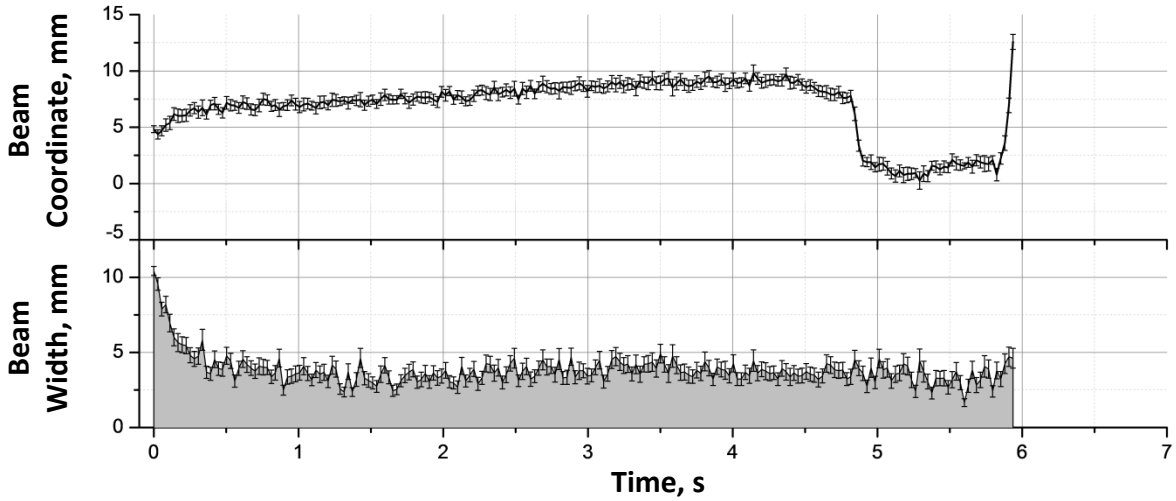


Dynamic profile of circulating 500 MeV/nucleon Ar^{+16} beam

Diagnostics of circulating beam. Deuteron 4 GeV/n



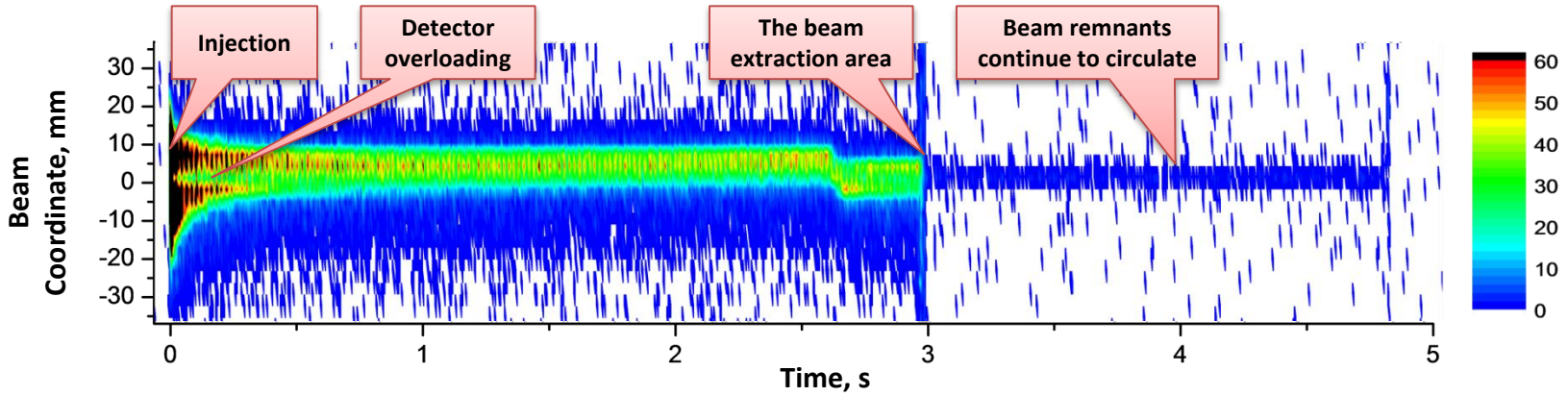
Radial beam profile (top graph) and magnetic accelerator field (bottom graph).



Radial beam coordinate (top graph) and beam width (bottom graph).

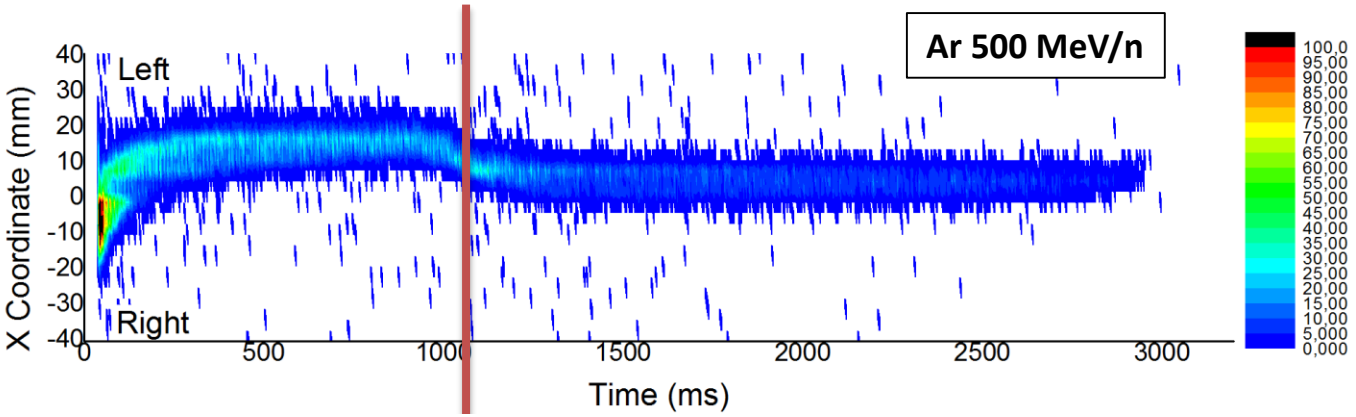
Diagnostics of circulating beam. Deuteron 2 GeV/n.

The graph of an accelerator cycle with fast beam extraction (50 ms) at an intensity corresponding to the upper limit of the detector operating range (10^8 single charged ions). At the beginning of the acceleration (the first 0.5 seconds from the time of injection) the detector is overloaded. After transition to the constant magnetic field the beam extraction is produced (3 seconds after injection moment) and than the circulating beam remnants is registered.

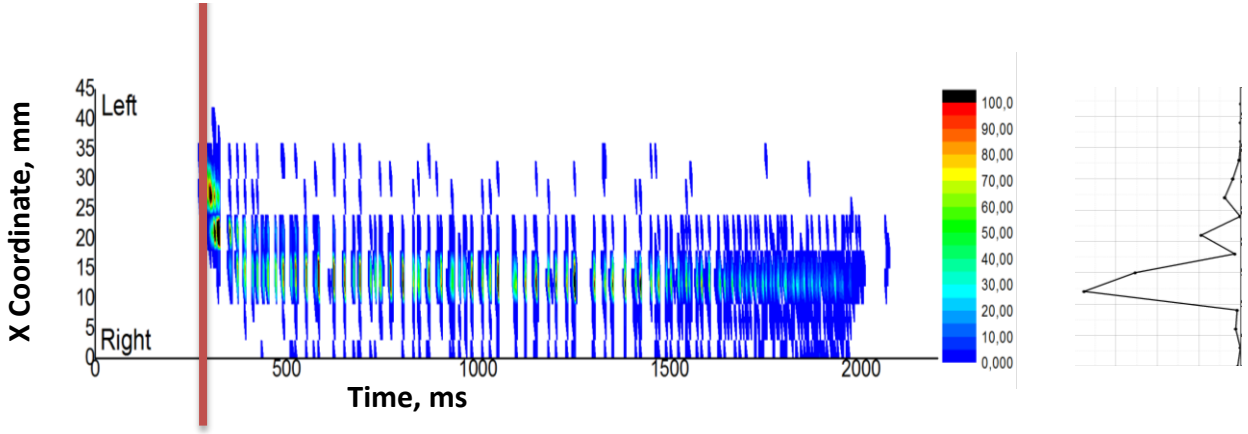


Radial beam profile.

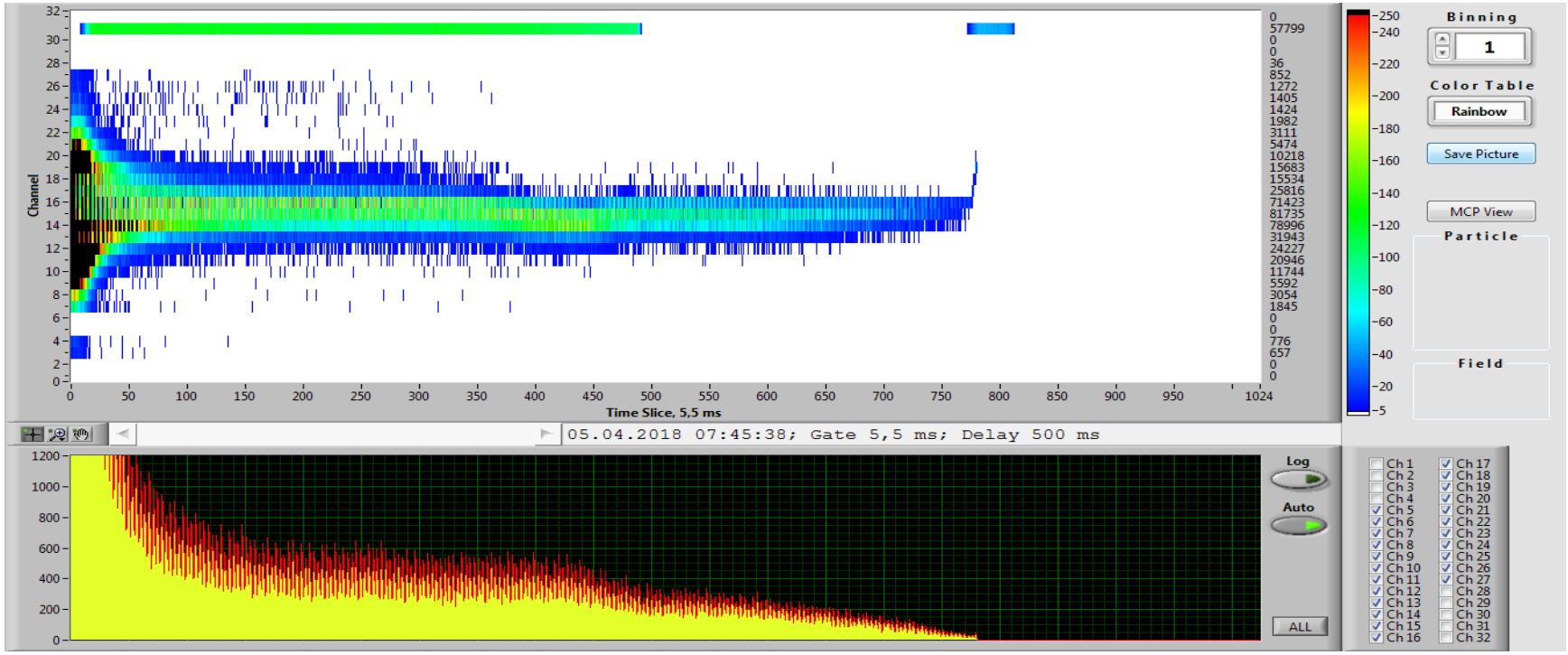
Run 50. Diagnostics of the extracted beam. The beam orbit shifting.

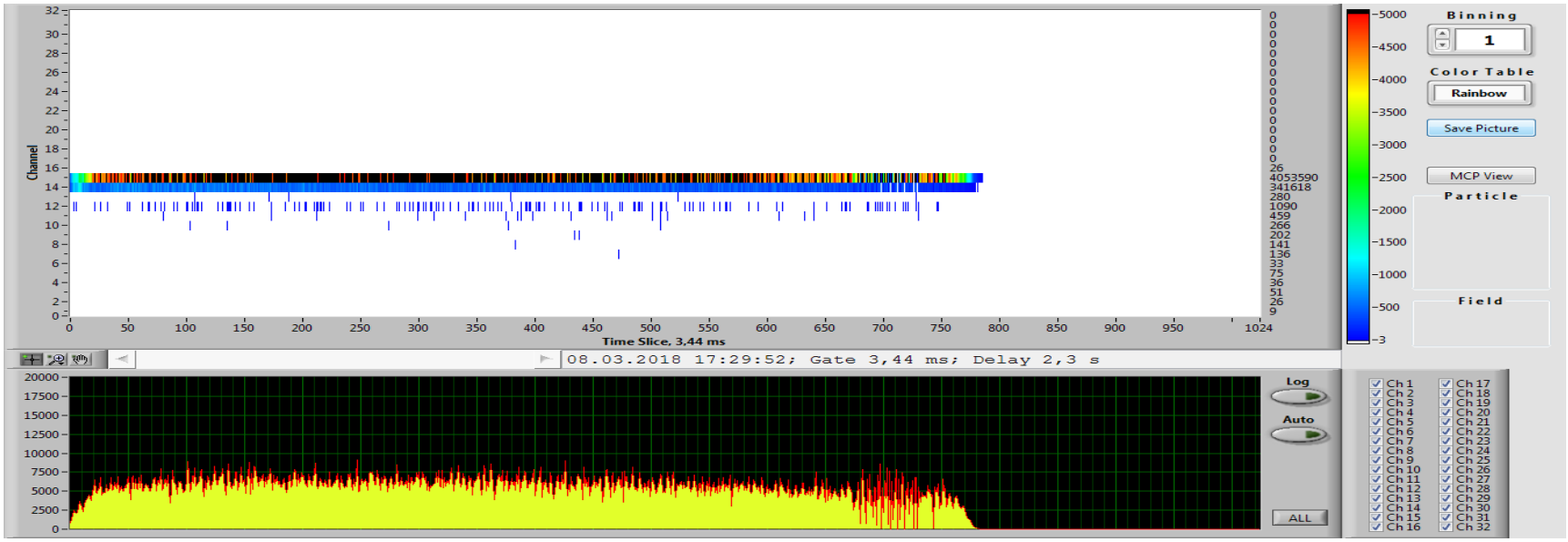


Dynamic profile of the circulating beam registered by the MCP detector.



Horizontal dynamic profile of the extracted beam of Ar^{+18} 500 MeV/n.


Channel
Time Slice, 5,5 ms
05.04.2018 07:45:38; Gate 5,5 ms; Delay 500 ms
Binning
1
Color Table
Rainbow
Save Picture
MCP View
Particle
Field
Log
Auto
ALL
Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6 Ch 7 Ch 8 Ch 9 Ch 10 Ch 11 Ch 12 Ch 13 Ch 14 Ch 15 Ch 16
Ch 17 Ch 18 Ch 19 Ch 20 Ch 21 Ch 22 Ch 23 Ch 24 Ch 25 Ch 26 Ch 27 Ch 28 Ch 29 Ch 30 Ch 31 Ch 32


Channel
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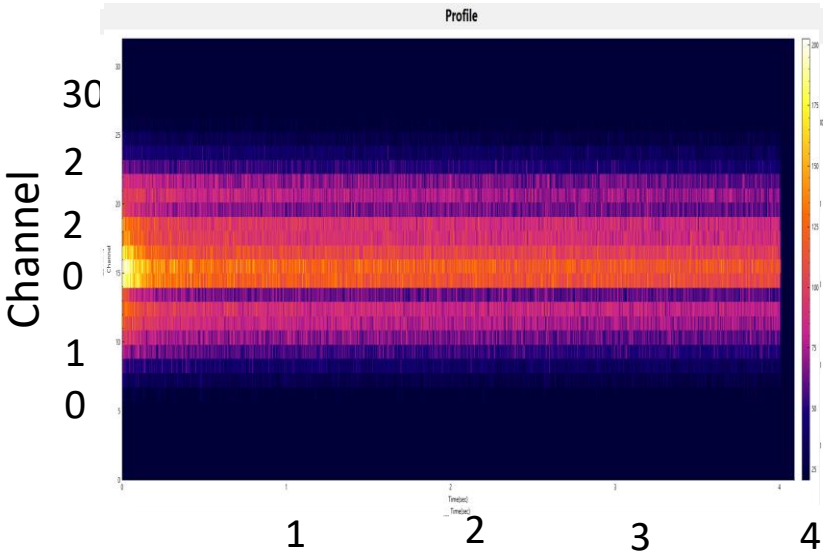
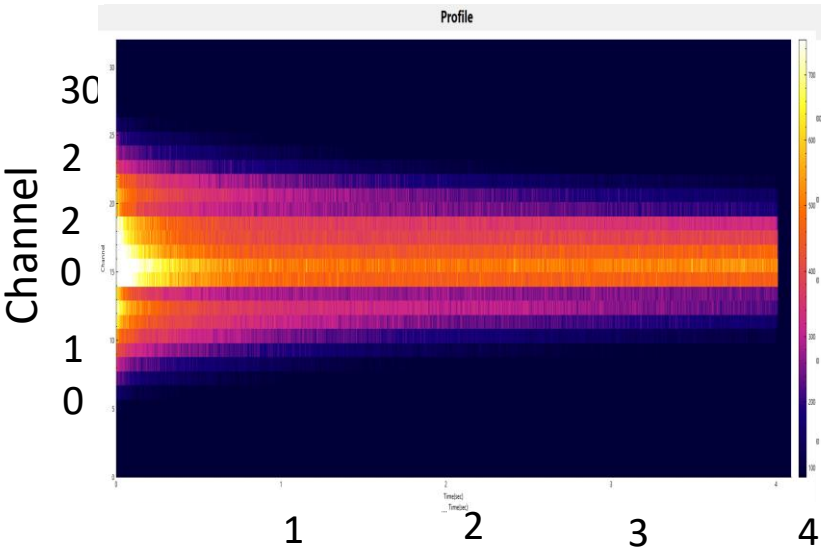
08.03.2018 17:29:52; Gate 3,44 ms; Delay 2,3 s
Binning
1
Color Table
Rainbow
Save Picture
MCP View
Particle
Field
Log
Auto
ALL
Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6 Ch 7 Ch 8 Ch 9 Ch 10 Ch 11 Ch 12 Ch 13 Ch 14 Ch 15 Ch 16
Ch 17 Ch 18 Ch 19 Ch 20 Ch 21 Ch 22 Ch 23 Ch 24 Ch 25 Ch 26 Ch 27 Ch 28 Ch 29 Ch 30 Ch 31 Ch 32

Booster, September 23, 2021
Voltage switched off - Voltage 1.83 kV, current 46 mA





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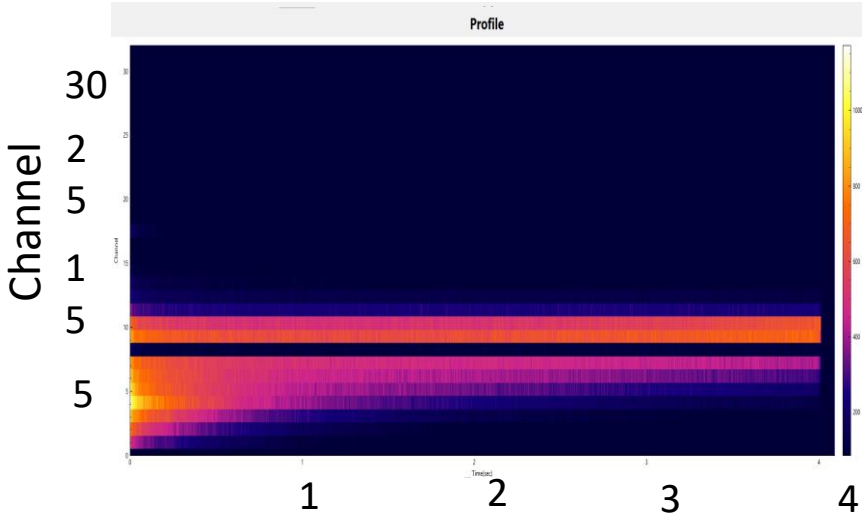
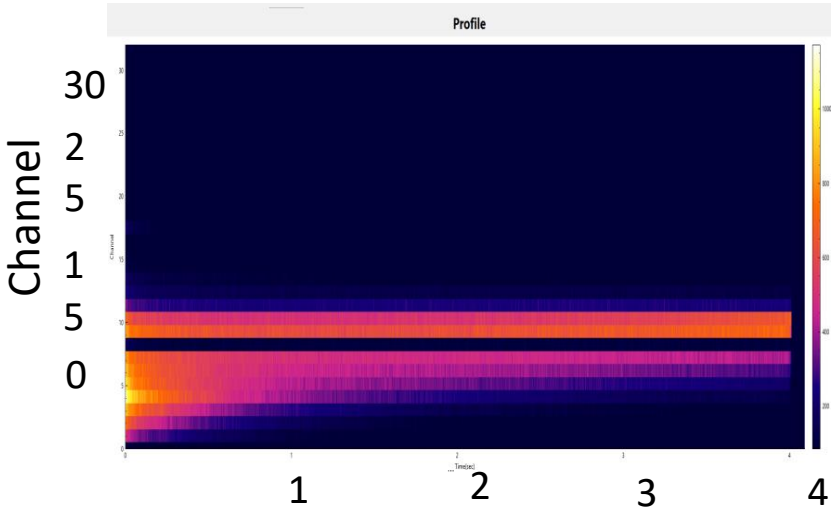
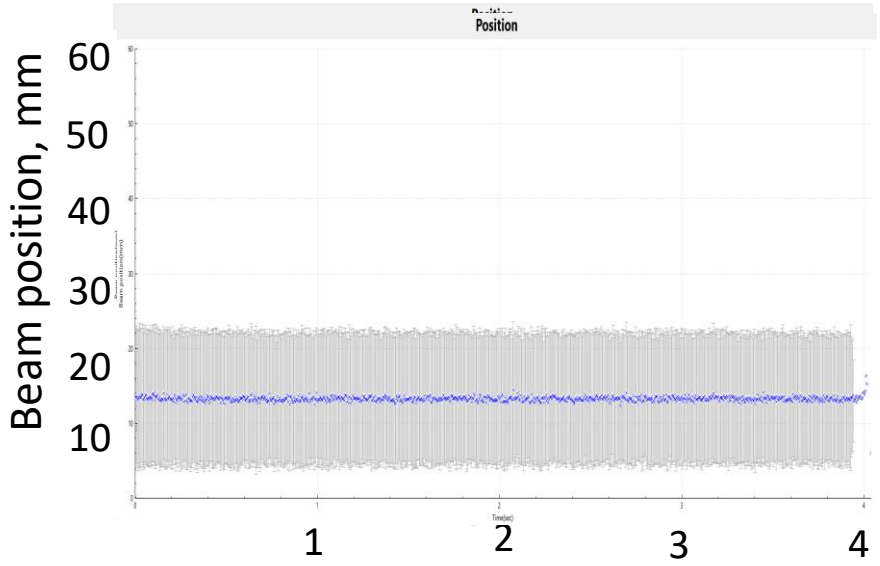
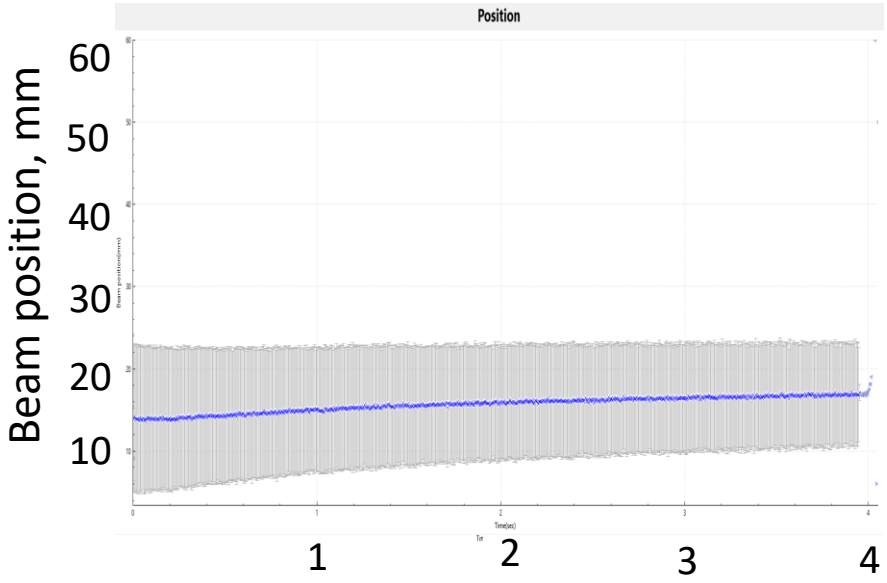




Booster, September 23, 2021
Voltage switched off - Voltage 1.83 kV, current 46 mA

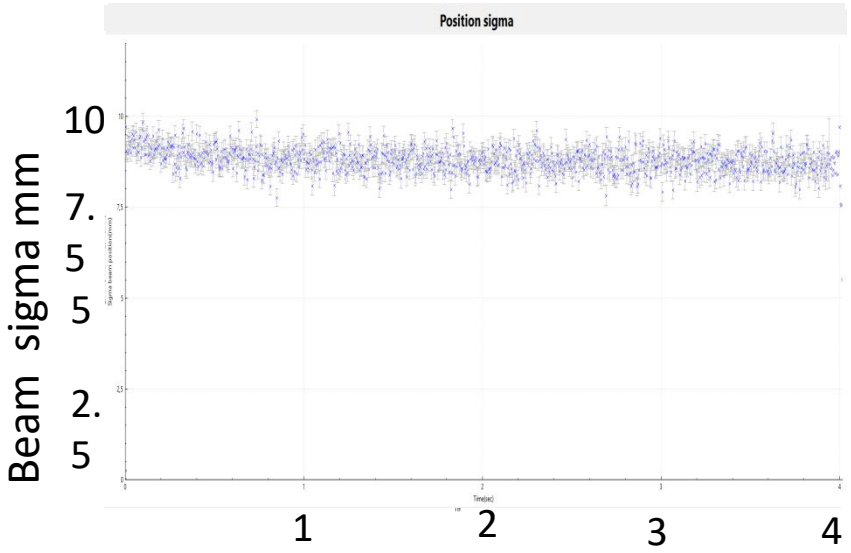


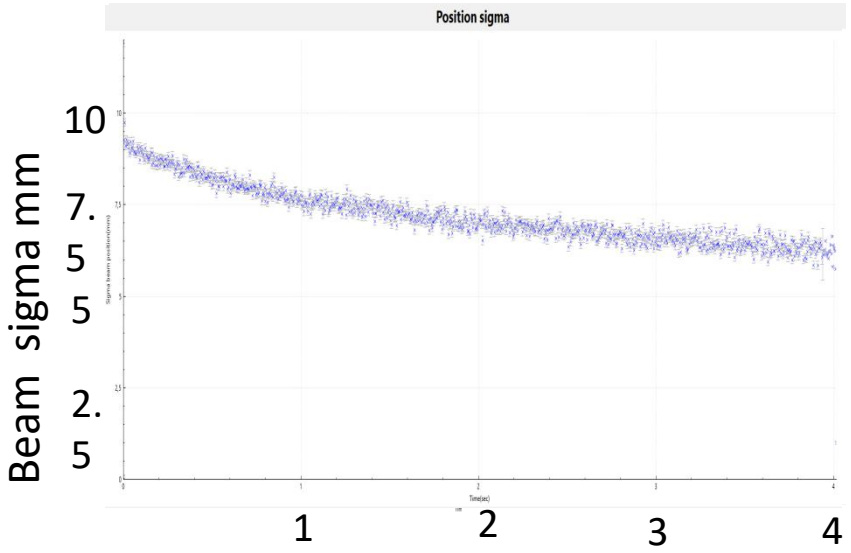
Axis X



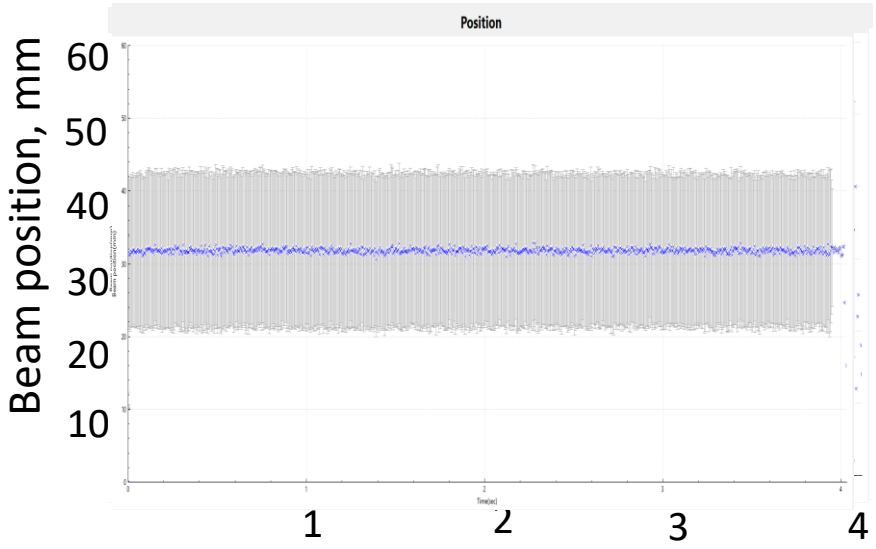
Axis X

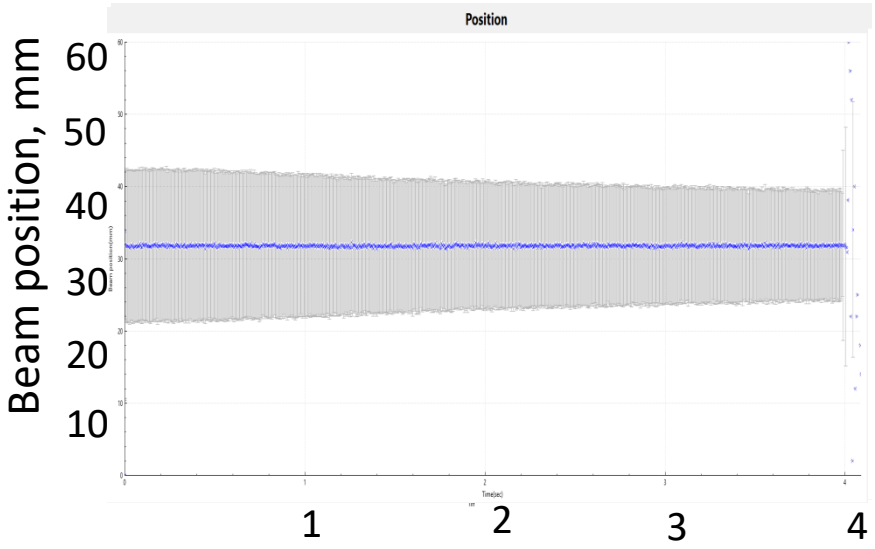
Booster, September 23, 2021
Voltage switched off - Voltage 1.83 kV, current 46 mAA





Booster, September 23, 2021
Voltage switched off - Voltage 1.83 kV, current 46 mA





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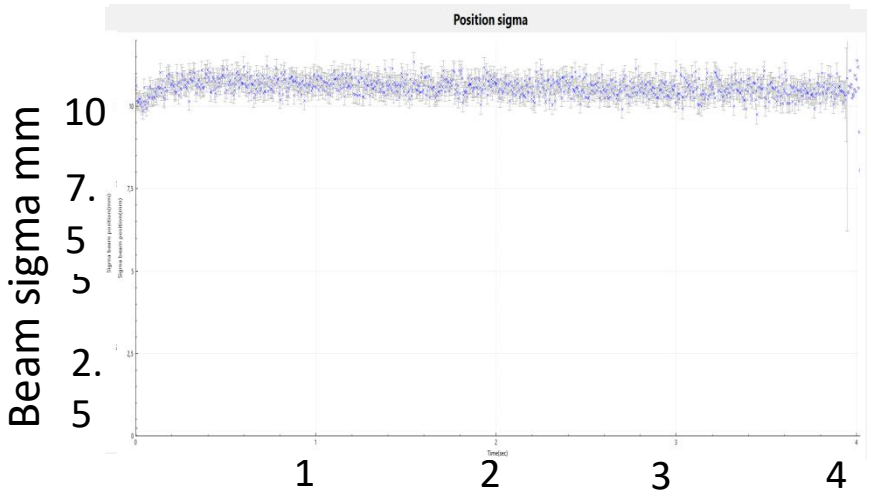
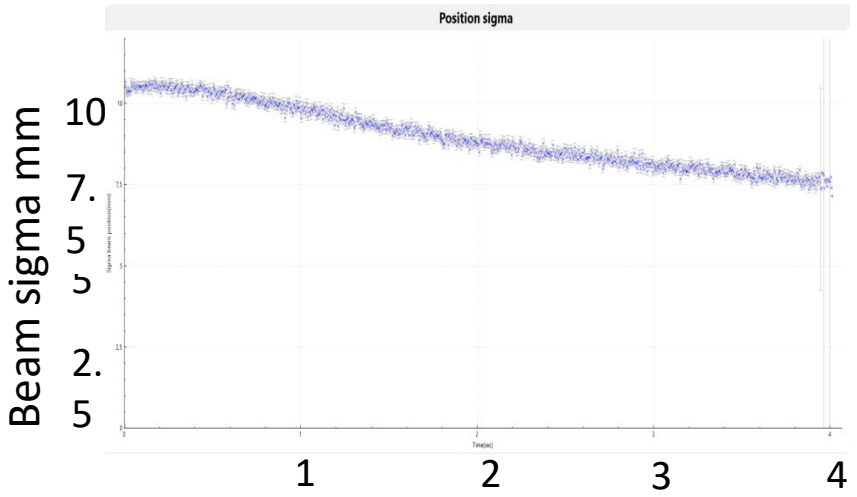
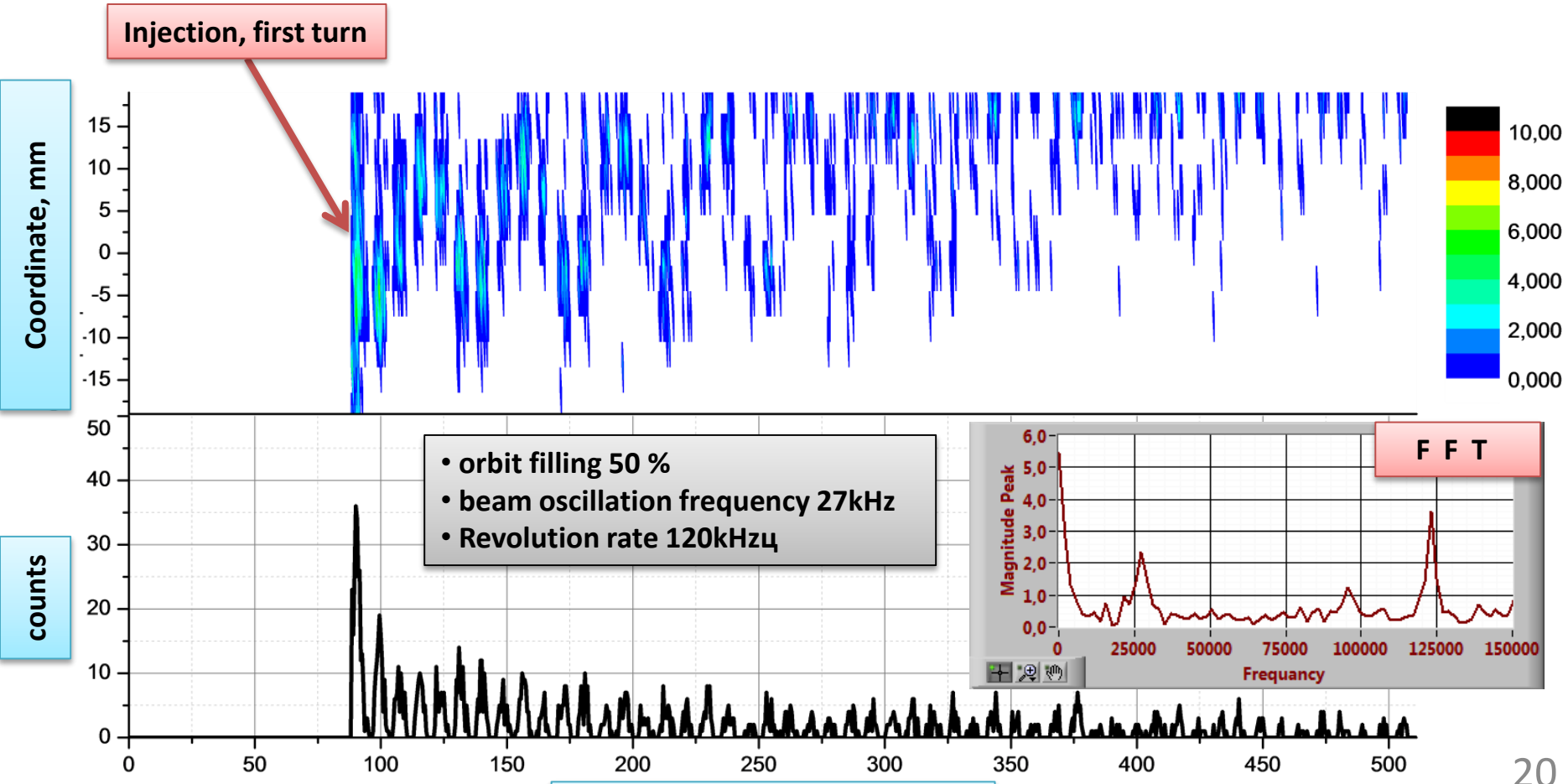


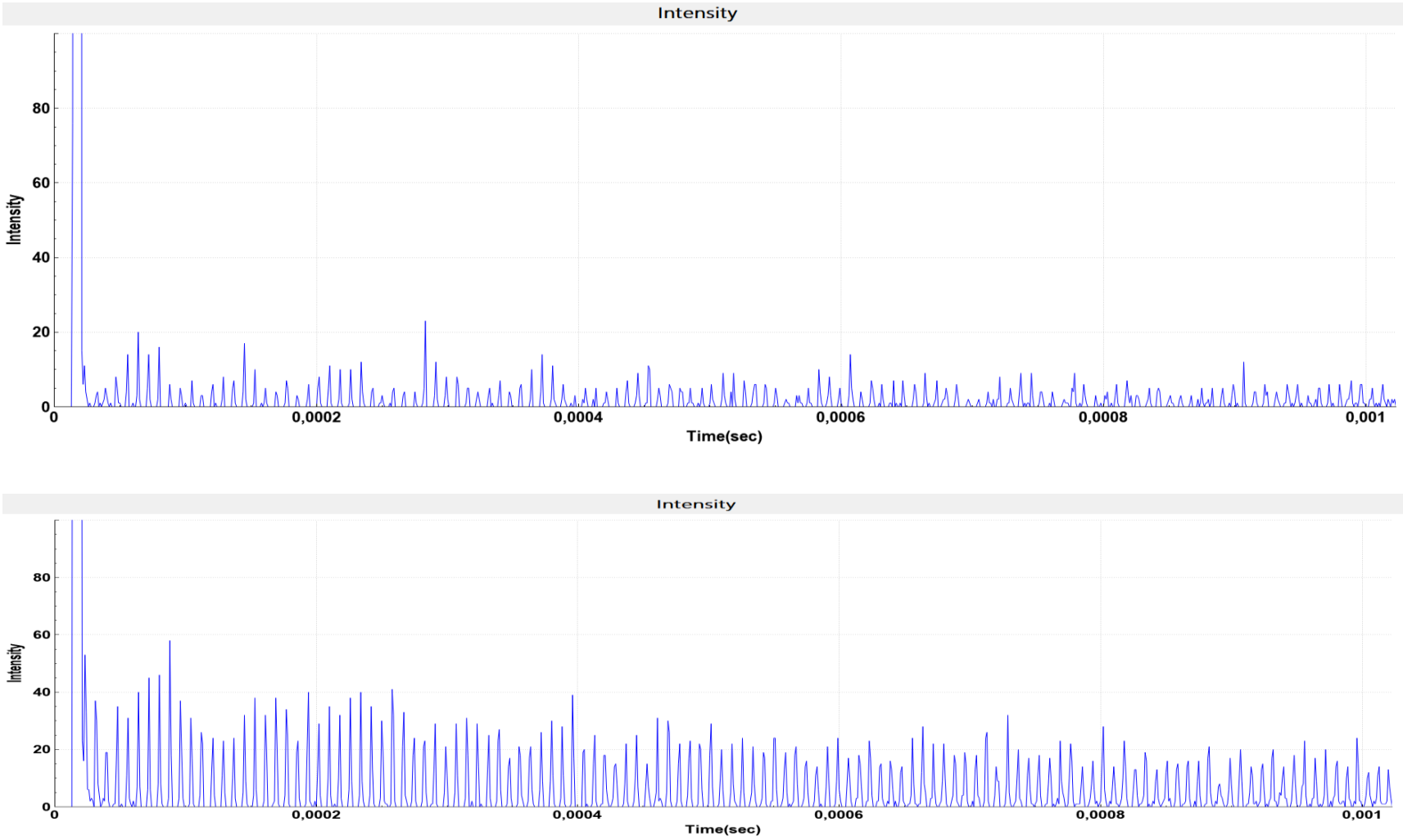


Registration of first beam turns after injection (2013r., α-particles)

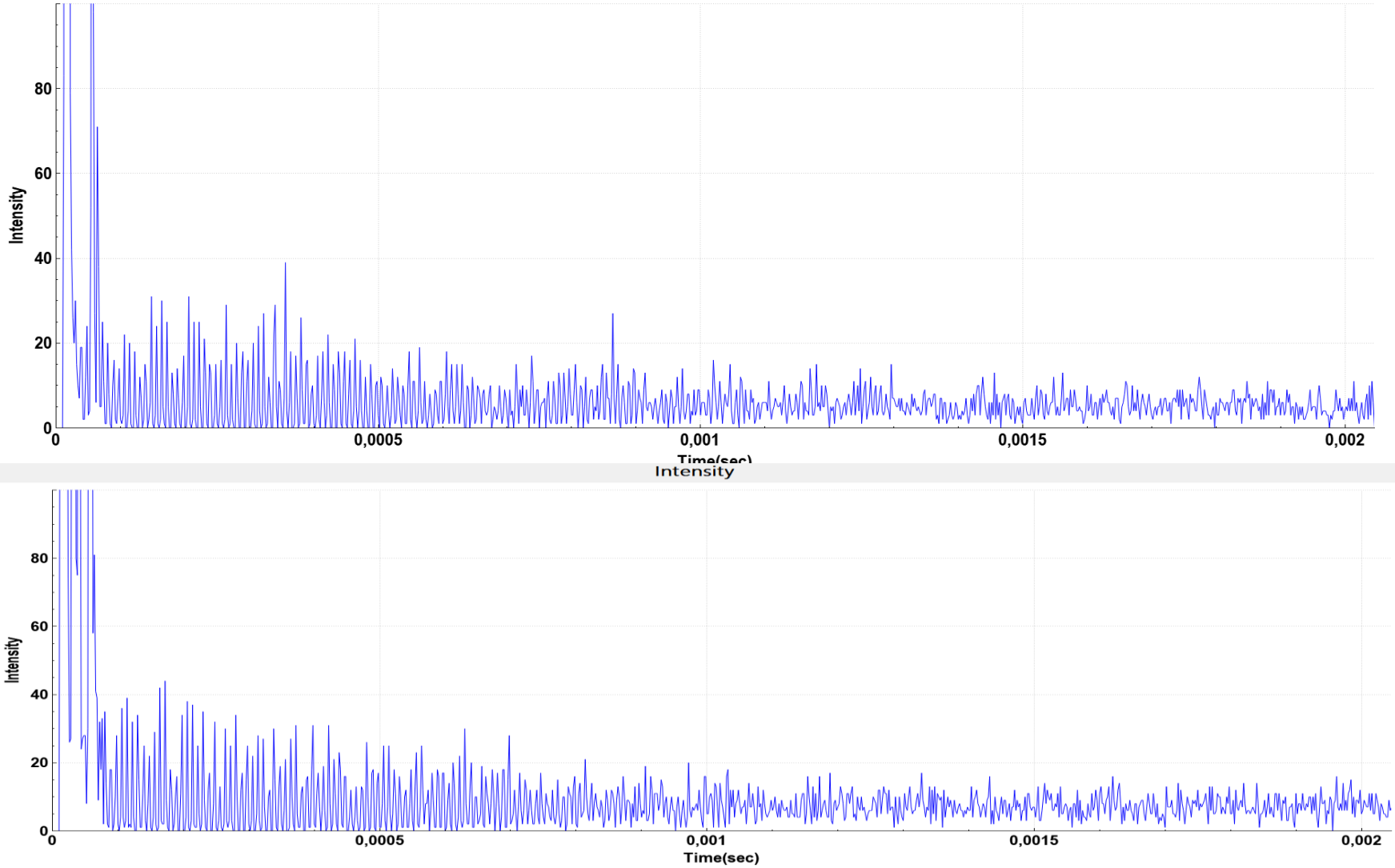
- ❑ The detector is used for adjustment of acceleration for the low-intensity injected beam.
- ❑ One of the most important tasks is minimization of injection losses. The fraction of losses during first beam turns in the Nuclotron ring reaches **50 %**.
- ❑ Fourier analysis yields typical oscillation frequencies for the spatial beam position.



Booster, September 2021. First beam turns after injection. TimeSlice 1 mksec



Booster, September 2021. First beam turns after injection. TimeSlice 2 mksec



Estimates of registration range for dynamic profile and time structure of the beam

Circulating beam

- MCP-based detector
- Vacuum 2×10^{-6} Pa
- d beam intensity from 10^{6}
- Ar^{+16} beam intensity from 10^{4}
- Au^{+65} beam intensity from 5×10^{3}

Extracted beam

- MCP-based detector
- Vacuum 1×10^{-3} Pa
- d beam intensity from 10^{8}
- Ar^{+18} beam intensity from 10^{6}
- Au^{+79} beam intensity from 3×10^{5}

Thanks for your attention!

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