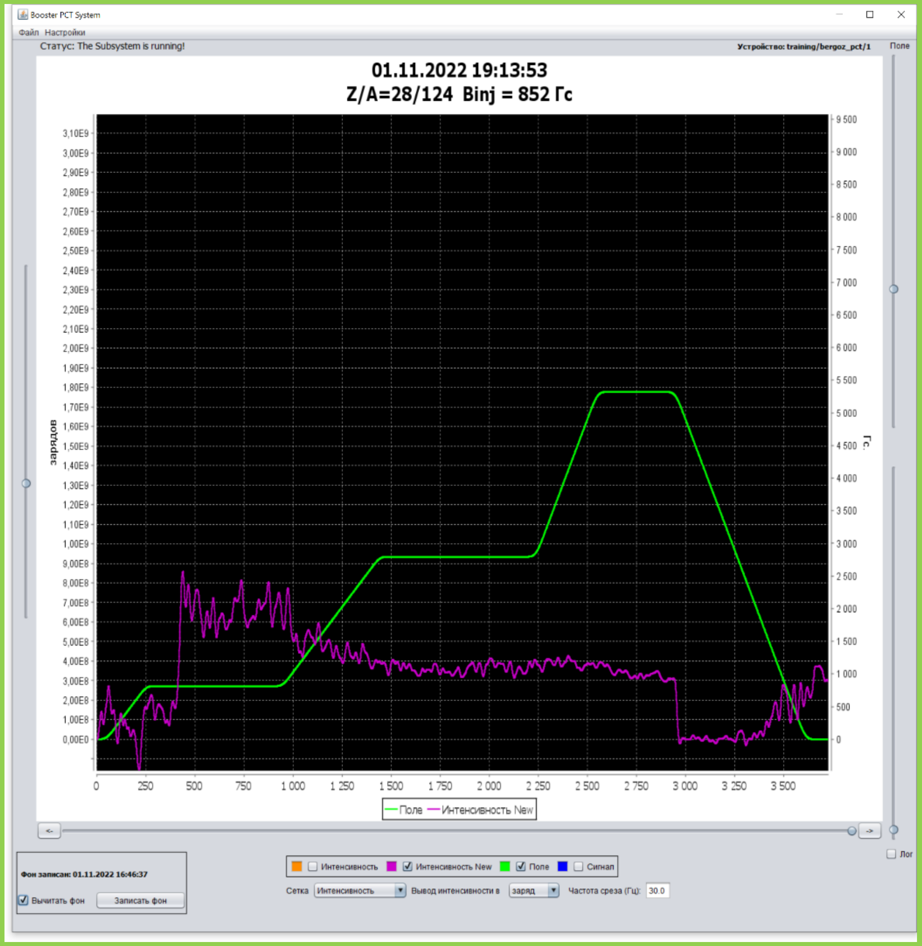
Construction and commissioning of the NICA complex



A.Sidorin, on behalf of the AD

X Collaboration Meeting of the MPD Experiment at the NICA Facility

JINR, Dubna, November 08-10, 2022

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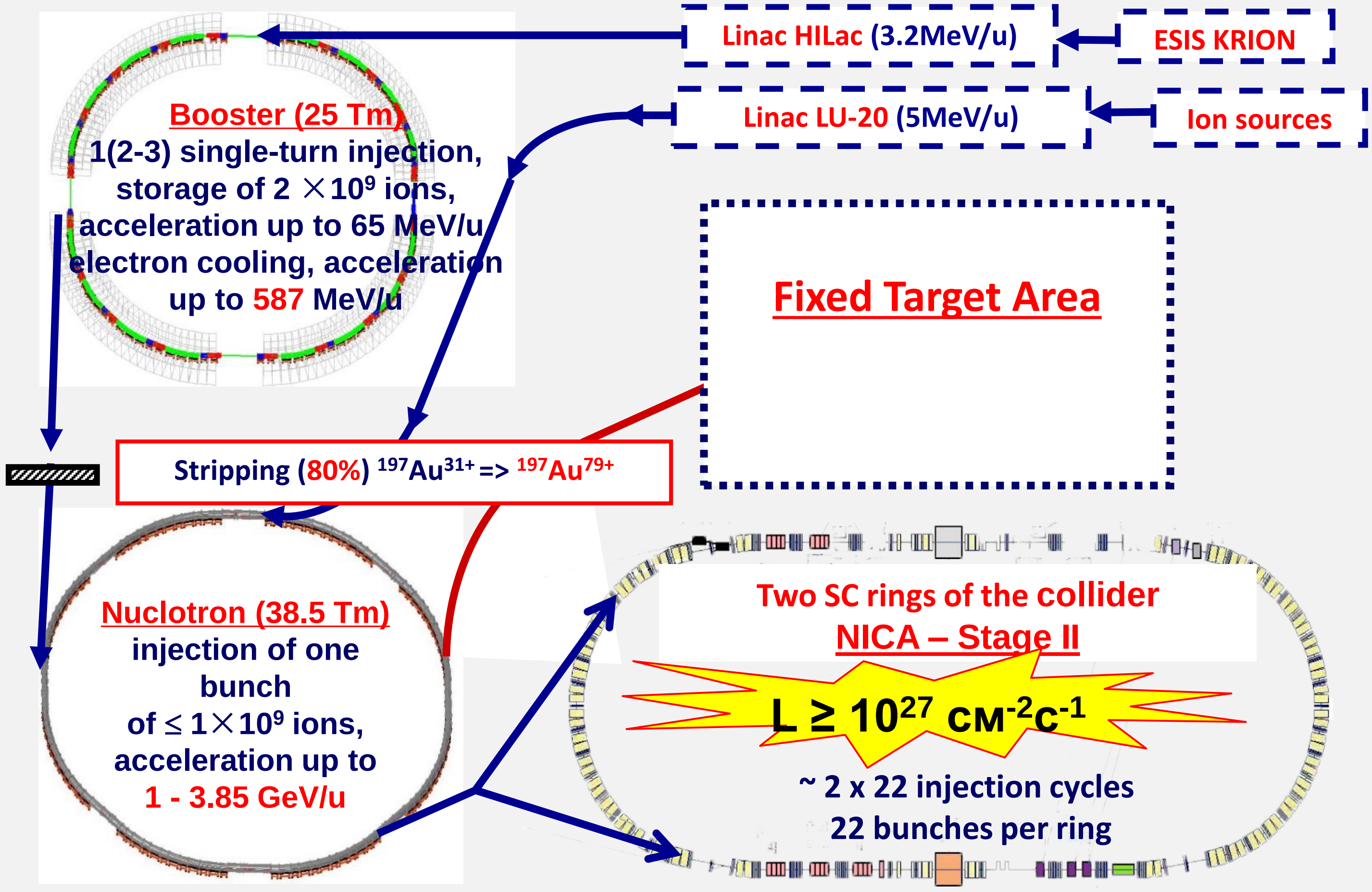
NICA accelerator complex



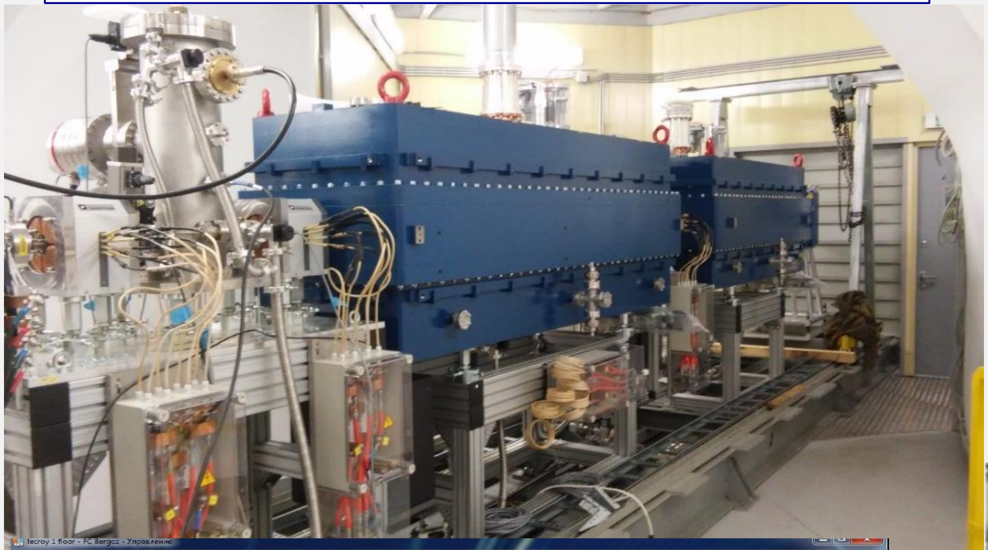
Heavy ions: ESIS + HILac + Booster + Nuclotron

Stages of the accelerator complex commissioning

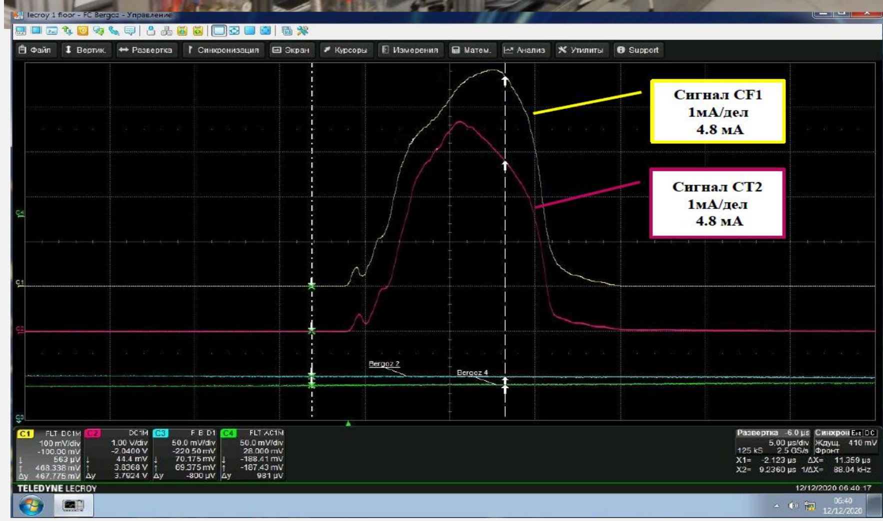
- HILAC + transfer line to Booster
- HILAC + Booster
- HILAC + Booster + transfer line to Nuclotron
- HILAC + Booster + Nuclotron + transfer line to BM@N
- ESIS + HILAC + Booster + modified Nuclotron + transfer line to BM@N

HILAC + transfer line to Booster

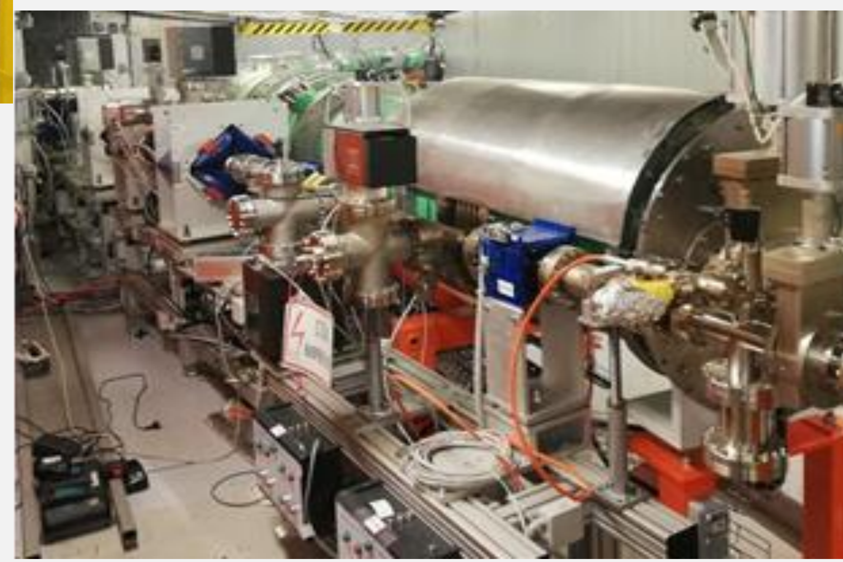
First beam: Oct. 16



Acceleration of $_{12}C^{2+}$ ions with A/Z=6.
Maximal ion $_{4}He^{1+}$ beam current at HILAC entrance corresponds to project value 10 mA, efficiency of beam transportation through second and third IH sections 78.5%.



$_{4}He^{1+}$ ion beam at HILAC exit measured by current transformer and Faraday Cup



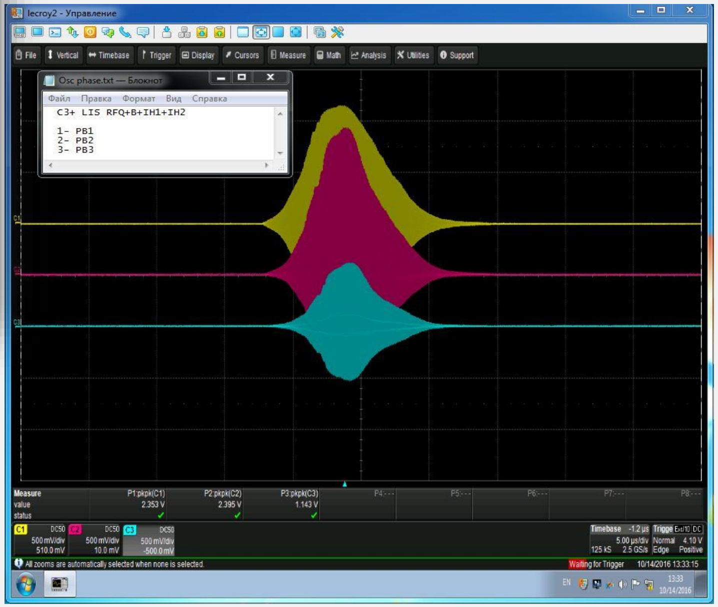
Transfer line HILAC-Booster.
Efficiency of beam transportation -90%.

Stable and safe operation during complex commissioning with He^{1+} Fe^{14+} C^{4+} Ar^{14+} Xe^{28+} beams

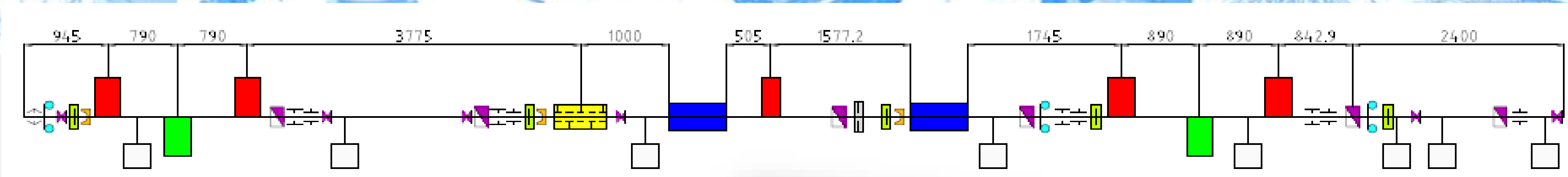
A/q (Target Ion Au^{31+})	*6.25*
Beam current	*< 10 emA*
Repetition rate	*< 10 Hz*
Output energy	*3.2 MeV/u*

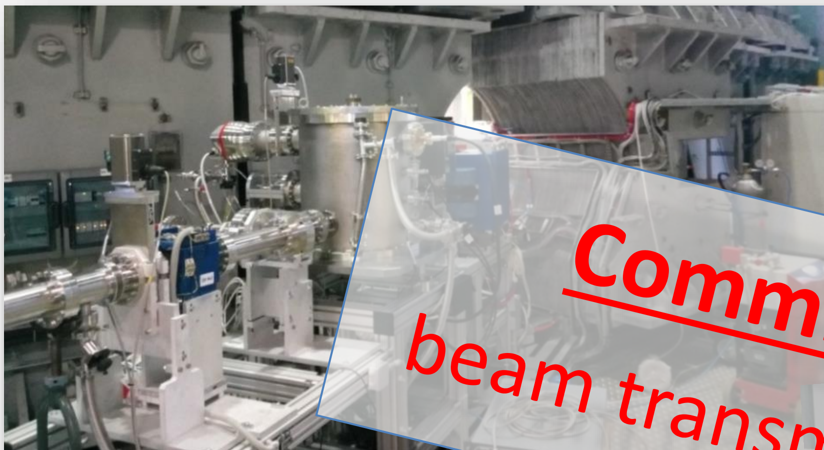
Transmission of carbon ions about 70% from RFQ to the exit of linac, 3.2 MeV/u

Phase probe's signals
RFQ (red), IH1 (yellow), IH2 (blue)



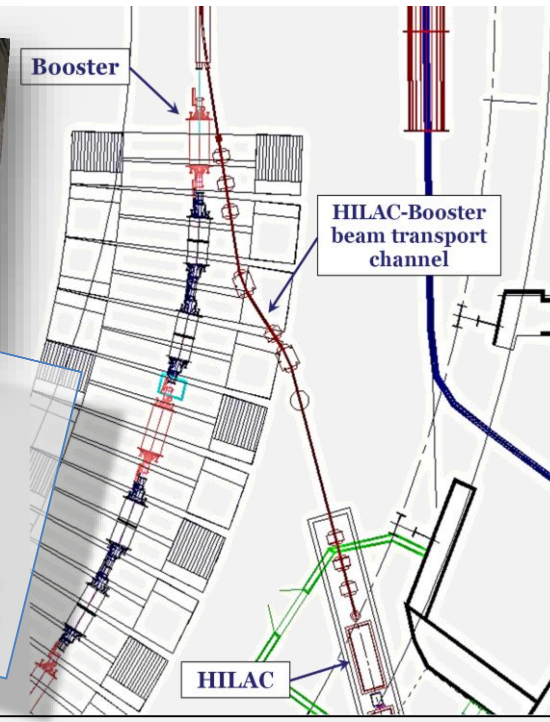
Booster injection beam line





Commissioned

beam transmission ~75%



- ✓Debunching
- ✓Matching
- ✓Separation and adsorption of neighbor charge states of ions.
- ✓Provide different schemes of the beam injection into the Booster.

HILAC + Booster

First commissioning run 12.11 – 30.12. 2020, He^{1+} beam :

- assembly and test of vacuum system

- cooling, thermometry commissioning

- commissioning of quench protection system, tuning of power supply,

- tuning of the HILAC – Booster transfer line

- tuning He^{1+} beam circulating

- test of beam diagnostics, beam acceleration, test of electron cooling

- test of power supply, magnetic and cryogenic systems at design field

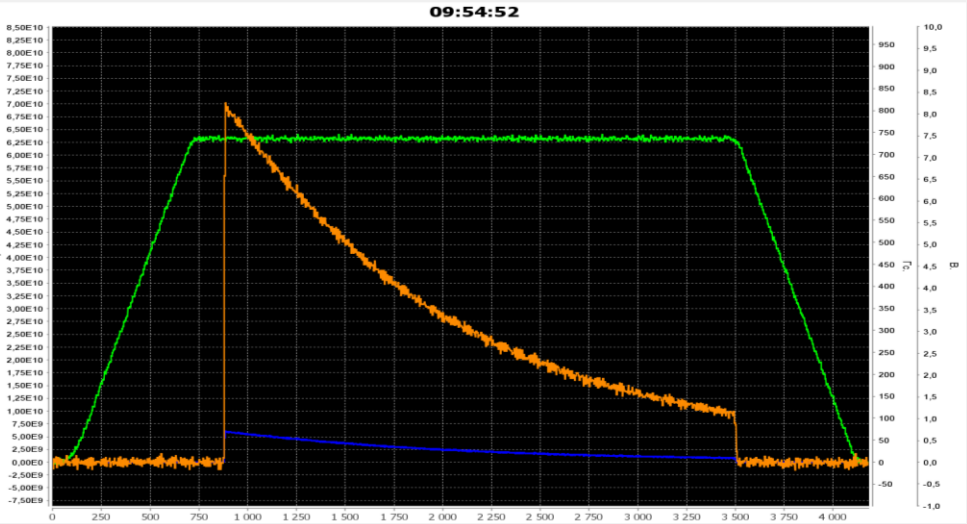
HILAC + Booster + transfer line to Nuclotron

Second commissioning run 06.10 – 24.10 2021, He^{1+}, Fe^{16+} Ions:

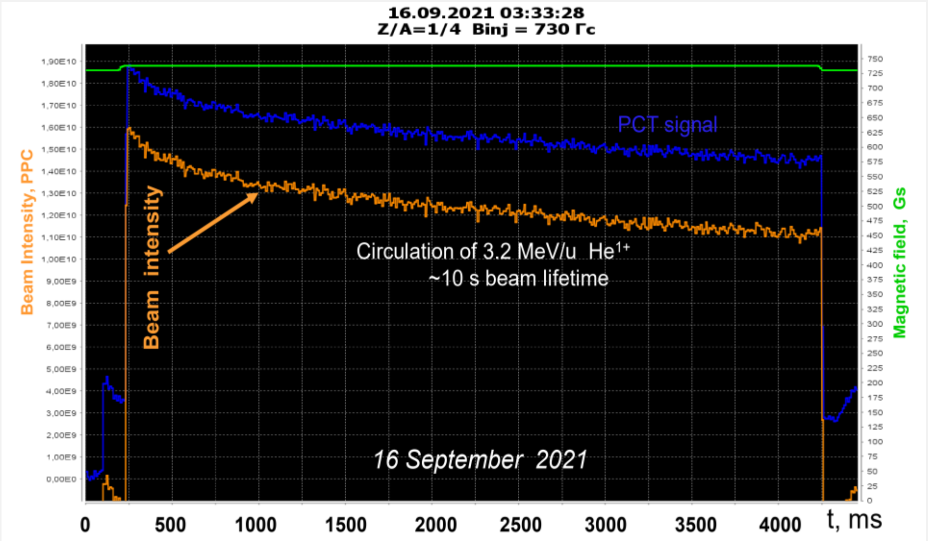
- Improvement of the vacuum conditions
- Optimization of the beam dynamics,
- Test of the Booster Electron Cooler
- **Test of the BNTL**

Improvement of the vacuum conditions

First run (December 2020)

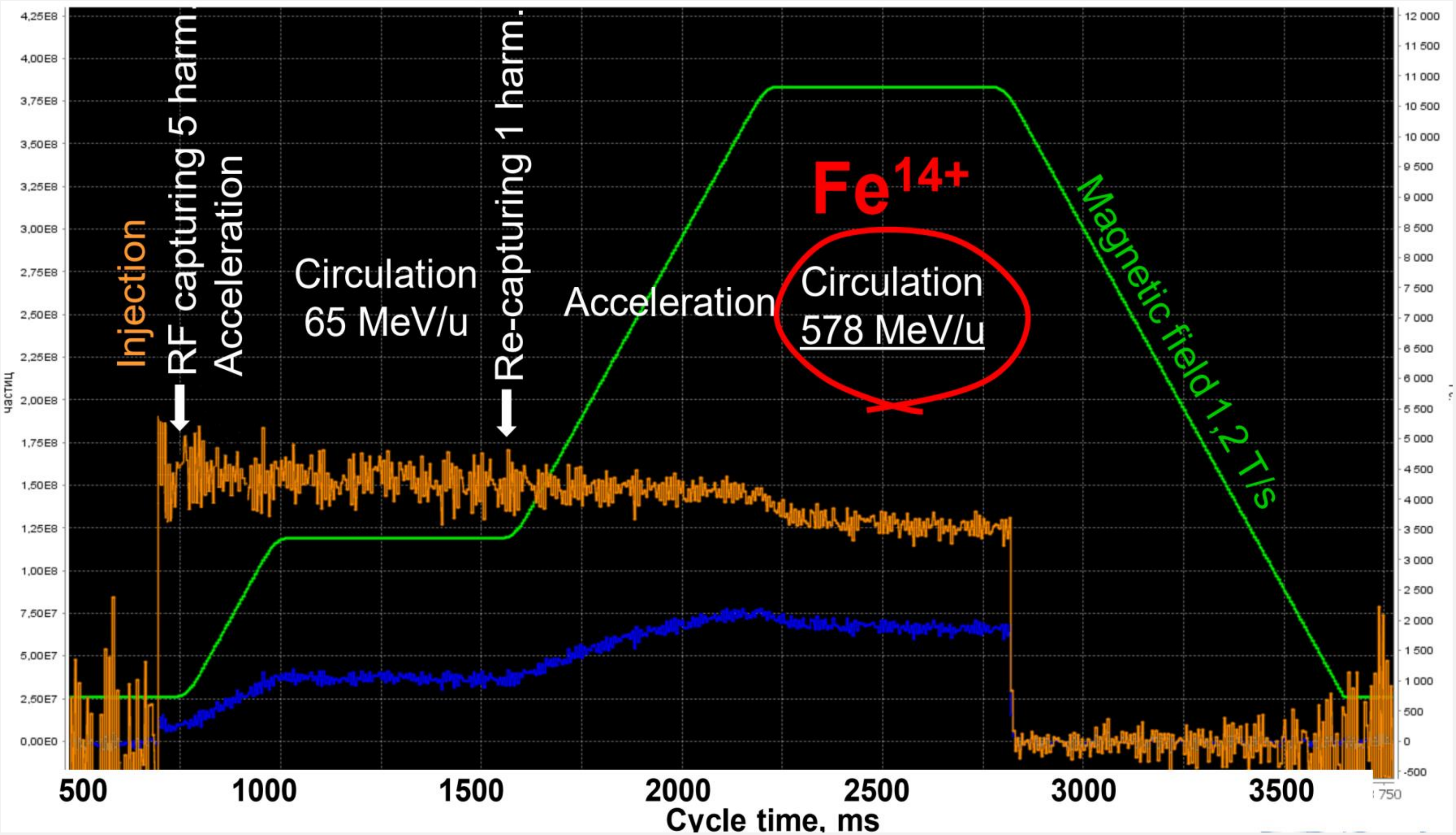


Second run (September 2021)



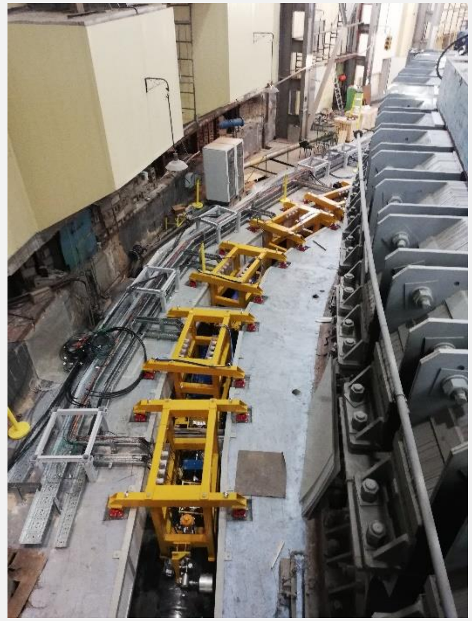
Residual gas pressure inside the beam pipe was sufficiently reduced down to the value required for heavy ion acceleration

Tuning of the RF system



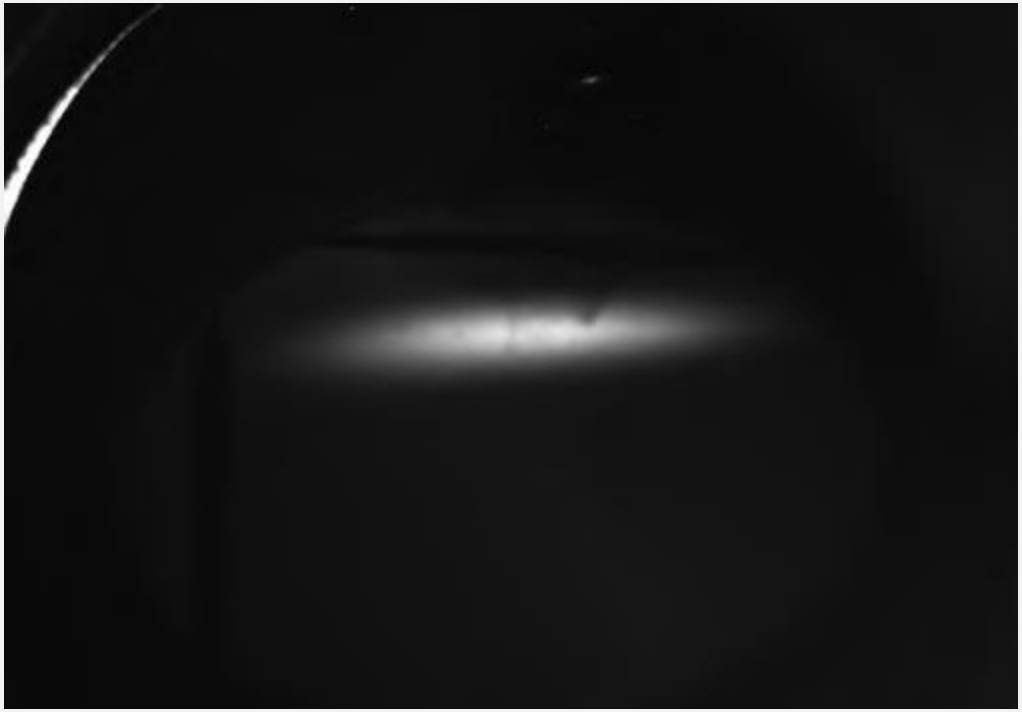
Adiabatic capture of the beam into acceleration was fulfilled
at 5-th harmonics of the acceleration field,
The beam was recaptured into 1-st harmonics at 65 MeV/n energy,
The iron ion beam was accelerated up to design energy of 578 MeV/u

Assembly BNTL after the first run



Beam transport from Booster to Nuclotron

The orbit bump system was tuned at the beam extraction,
The systems for the beam extraction from the Booster and transport line to the Nuclotron were put into operation and tuned,
Helium beam and then the iron $^{56}Fe^{14+}$ beam were transported through the beam transfer line.



Beam of Fe ions on the phosphor screen
at the end section of the Booster-Nuclotron transport line

HILAC + Booster + Nuclotron + transfer line to BM@N

Third commissioning run 2.01.2022 – 01.04.2022, C ions:

- Tuning of the Booster cycle:
- adiabatic capture at injection (5 harmonics),
- recapture at 65 MeV/u (1 harmonics),
- Single-turn extraction

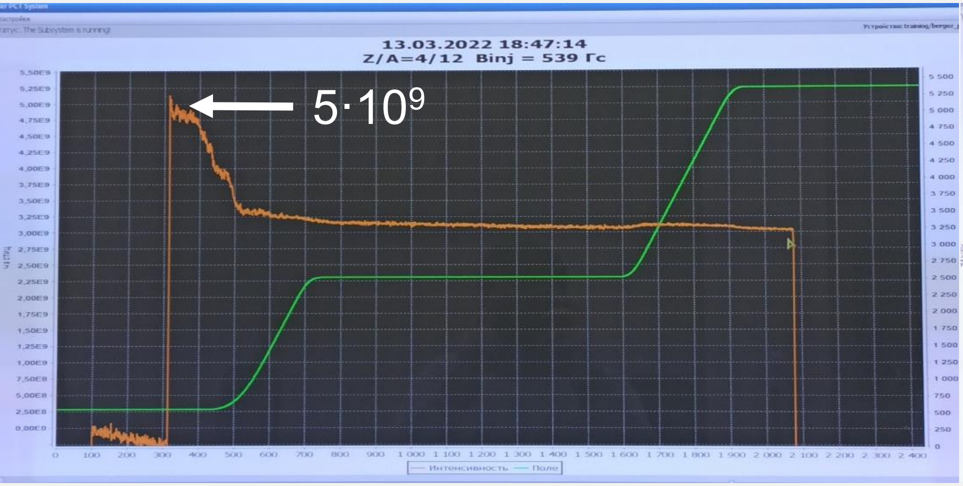
Transport Booster – Nuclotron:
- Stripping C^{4+} - C^{6+}

Nuclotron:
- Injection from Booster (new kicker and Lambertson magnet),
- adiabatic capture at 5th harmonics,
- acceleration to 3 Gev/u,
- Slow extraction during 6 sec.

Beam transport to BM@N area:
- Test of new power supply, diagnostic and control systems,
- Stable operation during 24 days

Tuning of the beam acceleration

Booster



Nuclotron

Average efficiency ~ 30%:

- pulse-to-pulse variation of the injected beam parameters
- non-optimum stripping target thickness

SRC collaboration registered 185 MEvents of carbon interaction with hydrogen target

ESIS + HILAC + Booster + modified Nuclotron + transfer line to BM@N

- ESIS Krion-6T installed and tuned at HILAC

- Nuclotron structure was modified for installation of fast extraction

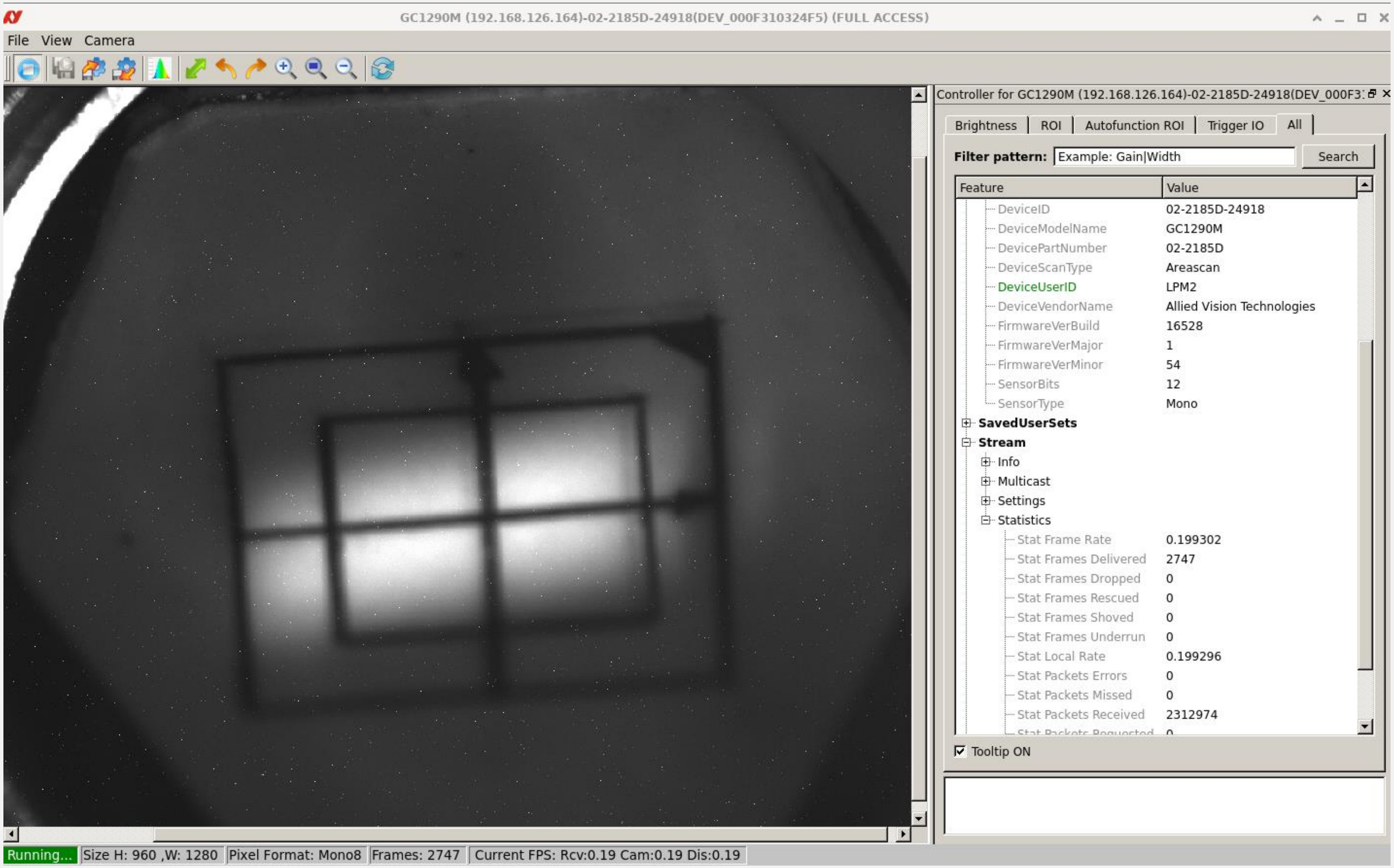
Forth commissioning run: started 20.09.2022, Ar, Xe ions

- Acceleration of Ar ions in the Booster

- Tuning of Xe acceleration

For the moment:

1-2·10^7 Xe^{28+} ions are accelerated in the Booster



Beam of Xe ions on the phosphor screen
at the end section of the Booster-Nuclotron transport line

Plans of the collider commissioning

August – September 2023: technological run

Main limitation –
completion of engineering infrastructure bld. 17

End of 2023: first beam run

- Fast extraction from the Nuclotron
- Assembly of the Nuclotron-Collider beam line (negotiations with contractor)
- Injection into Collider
- Synchronization

All arc dipole magnets are installed in the tunnel

Preliminary program of first technological collider run (middle of 2023?)

- Insulating volume and beam pipe vacuum tests
- Test of cryogenic system
- Start of the collider control system
- Test of the main power supply and cycle control system on equivalent load
- Commissioning of thermometry system
- Cooling of the rings
- Commissioning of quench detection system
- Commissioning of energy evacuation system
- Test of the main power supply on superconducting load

Thank you for attention