Budker Institute of Nuclear Physics SB RAS

Current status of VEPP-5 Injection Complex

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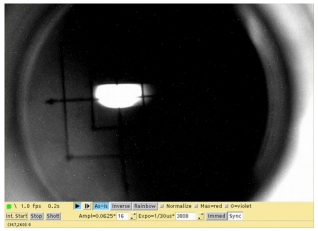
On behalf of Injection Complex team

Outline

- VEPP-5 Injection Complex:
  - main goal, parameters, operation modes
- Performance in 2020/2021:
  - achievements and challenges
- Performance improvements:
  - beam diagnostics, control system etc.
- Summary

BINP Colliders Layout



Beam @ BEP

Beam @
VEPP-3

2015 – main injector for VEPP-2000

2016 – main injector for VEPP-4M, and routine operation for both colliders simultaneously

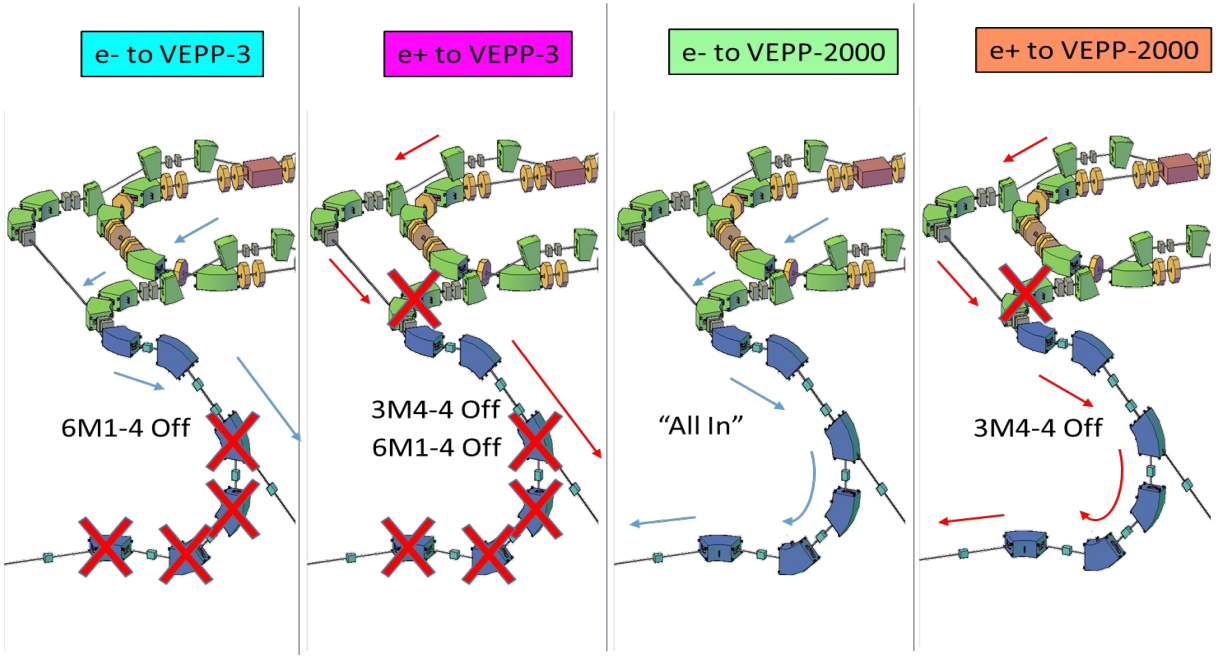
VEPP-5 Injection Complex

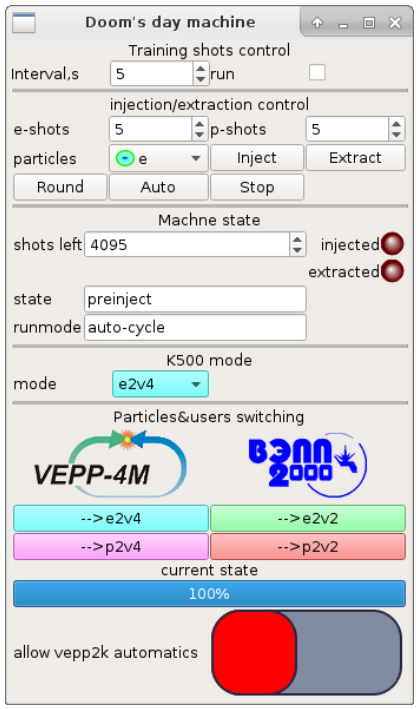
Linacs	Max. Energy	280/430 MeV
	RF frequency	2855.5 MHz
	Max. Number of e- in beam	10^{11}
	Max. Number of e+ in beam	$6.3 \cdot 10^{9}$
	Max. Repetition rate	12.5 Hz
	Energy spread e+/e-	3%, 1%
Damping Ring	Max. Energy	510 MeV
	Circumference	27.4 m
	RF harmonic number	1 (64 before 2017)
	Design beam current	30 mA
	Damping times, h/v/l	11/18/12 ms
	Hor./vert. emittance	$2.3/0.5 \cdot 10^{-6}$ rad·cm

Two Collider Operation

– 4 modes of K-500

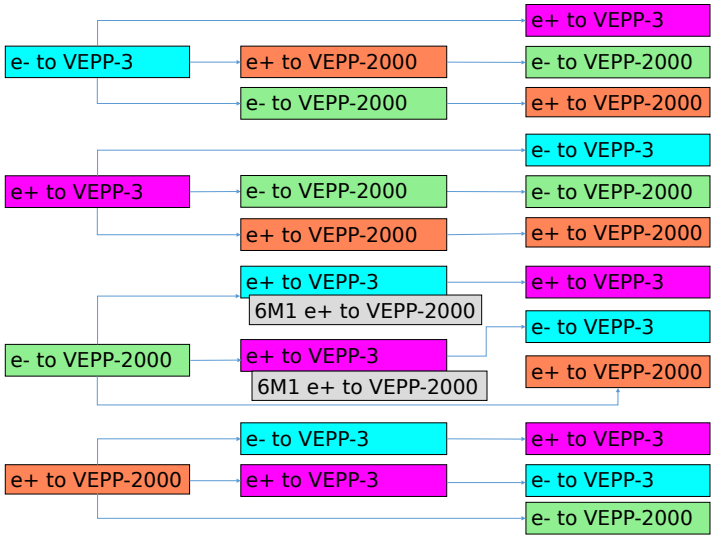
– 12 transitions between user/particle type





– Fully automatic operation with VEPP-2000

– Switching to VEPP-4 by operator request



30 seconds per "arrow"

Performance 2020/2021

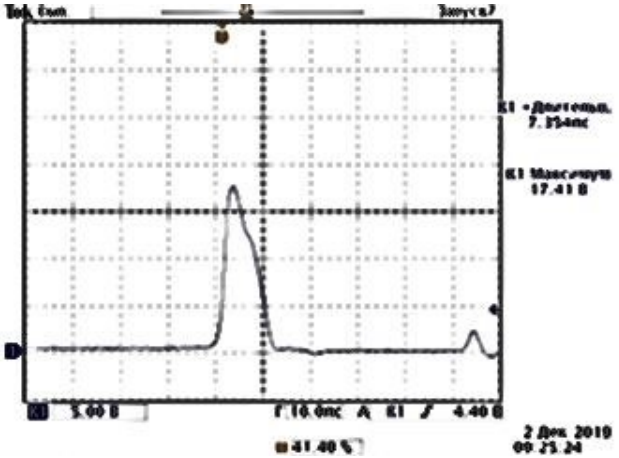
- Operation over 7000 hours, (50/50% - VEPP-4 / VEPP-2000)
- Maintenance work – 10 % of the operation time,
- System failures mostly are due to outdated electronics of klystron modulators,
- Less failures due to magnetic system power supplies, since: 9 of 500 A and 8 of 1000 A power supplies have been replaced in 2019/2020,
- Energy increase to 430 MeV due to more accurate linac tuning,
- Decrease of e+ storage rate due to positron solenoid malfunction, by the factor of 2.

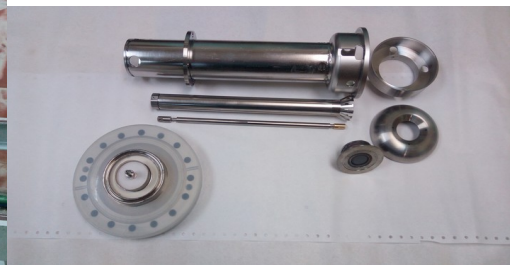
Parameter	Value
Energy, MeV	**430 (previous 390)**
Extraction freq, Hz	≤ 2
Injection frequency, Hz	Up to 12.5
Max. e+ storage rate, e+/sec	**$0.9 \cdot 10^{10}$ (previous $1.7 \cdot 10^{10}$)**
Max. e- storage rate, e-/sec	$1.4 \cdot 10^{11}$
Single injection, e+	$0.7 \cdot 10^{9}$
Single injection, e-	$1.3 \cdot 10^{10}$

Operation with New Cathode

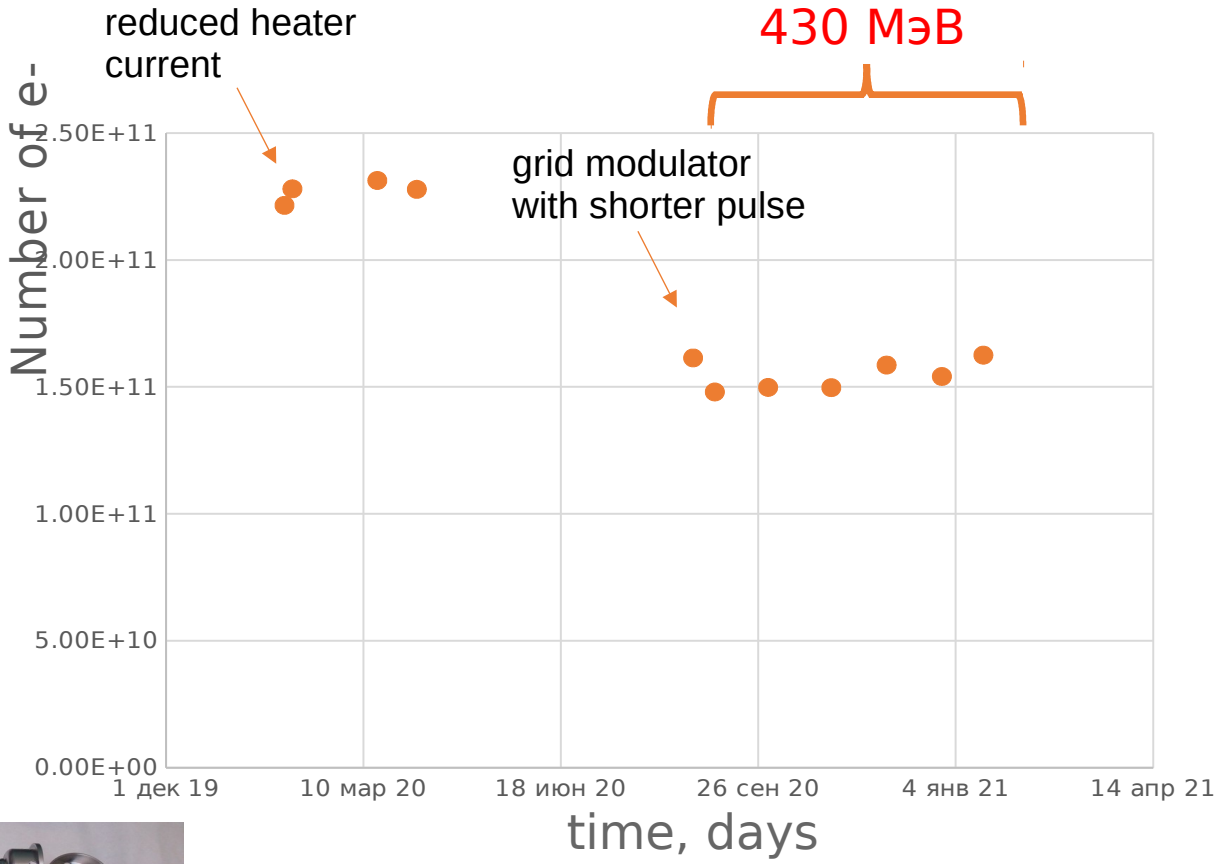
New electron gun cathode assembly of up to 10 A, 8 ns.

Current: 7.25 A
Pulse width: 7.3 ns
Number of electrons: $3.3 * 10^{11}$





Operation at VEPP-4M with electron beams
430 МэВ



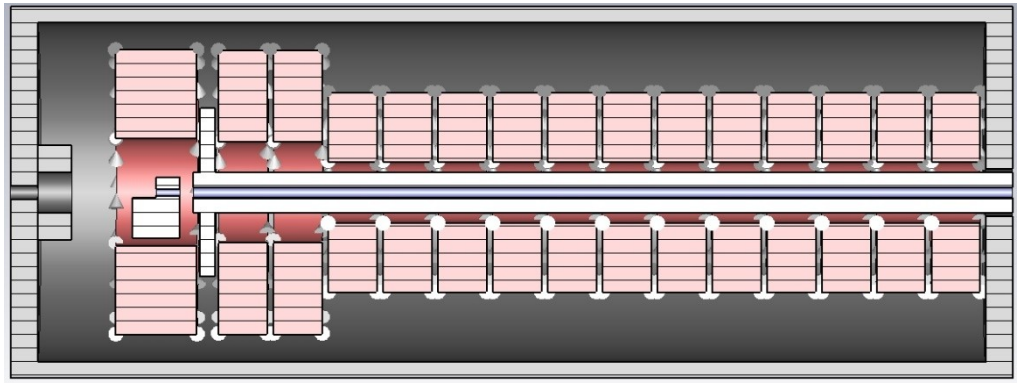
Positron Solenoid

12.10.2019 – positron solenoid accidental damage.

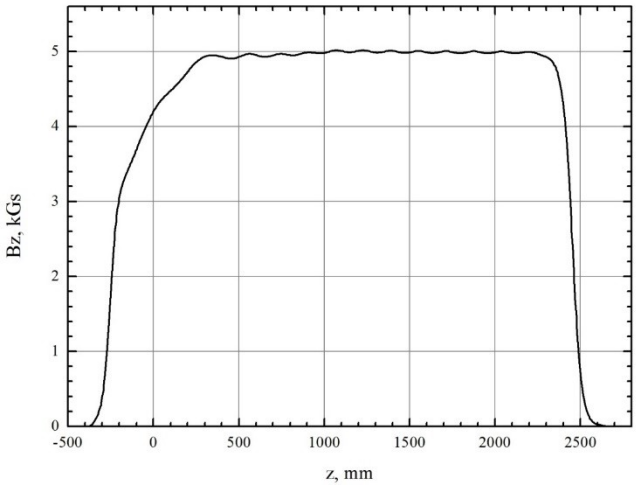
New positron solenoid

- Damage to positron solenoid resulted in significant reduction of e+ production rate: from $1.7 \cdot 10^{10}$ to $0.9 \cdot 10^{10}$ e+/sec,
- It only can be replaced as a whole unit including conversion system and 1st positron accelerating structure.
- Estimated replacement period – 2021/2022.

Project of a new solenoid



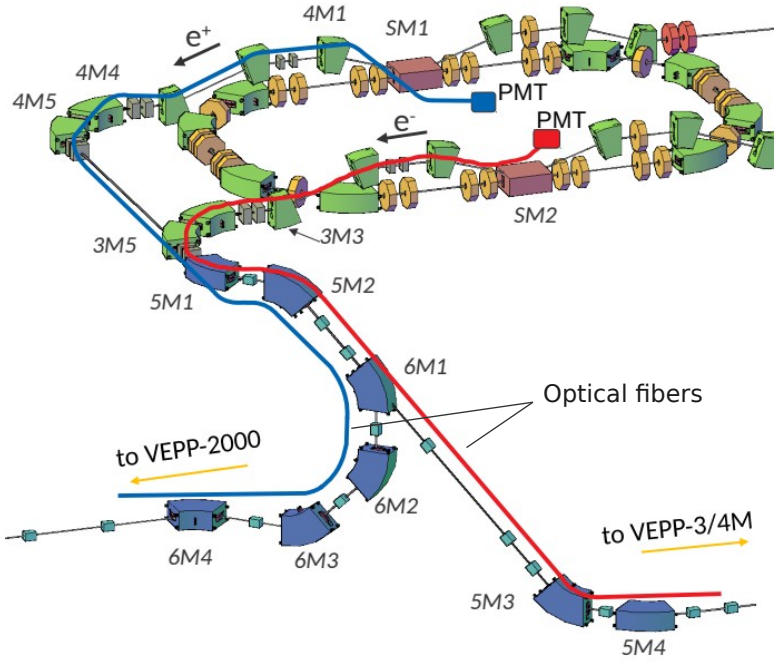
Expected magnetic field

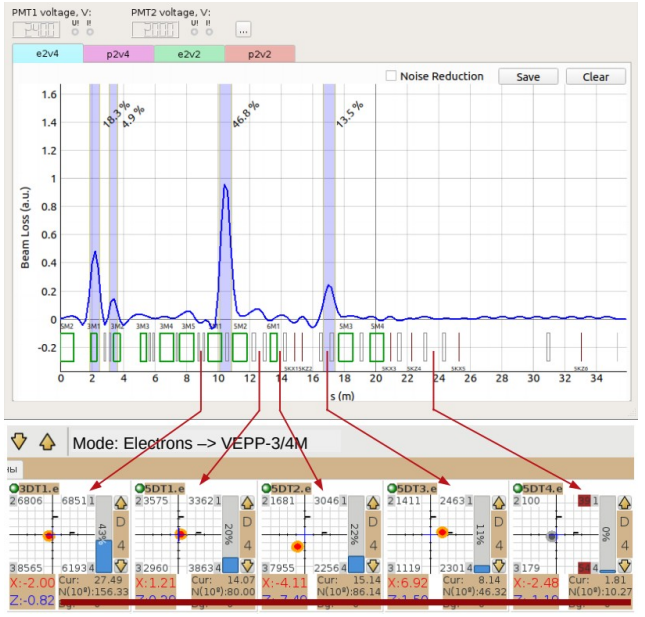


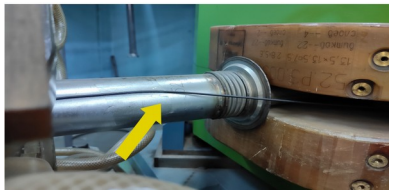
Performance Improvement

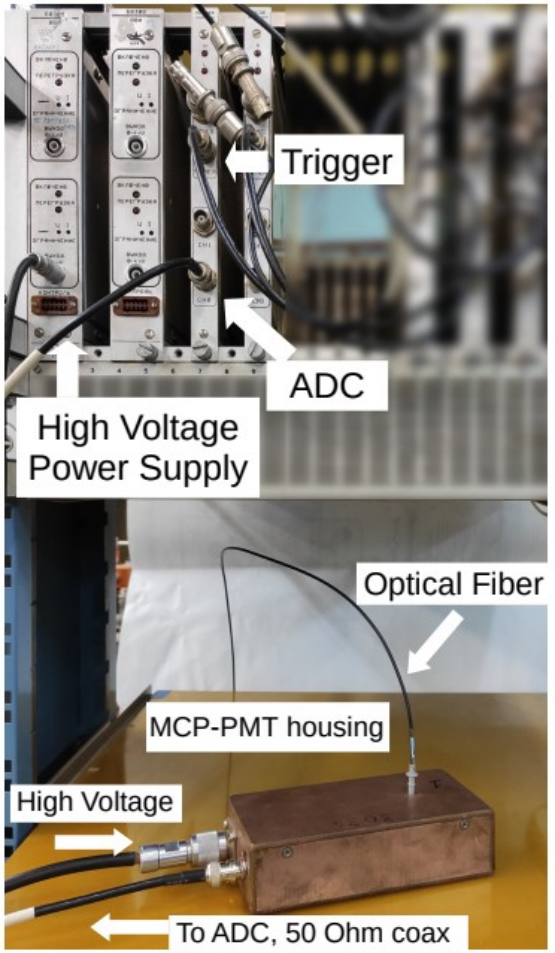
Beam Loss Monitors

Fiber-based beam loss monitors were installed at the extraction channels in both collider directions. They allow on-line monitoring of beam loss distributions along the transfer lines.
Currently devices are integrated in the Complex control system and used in routine operation.







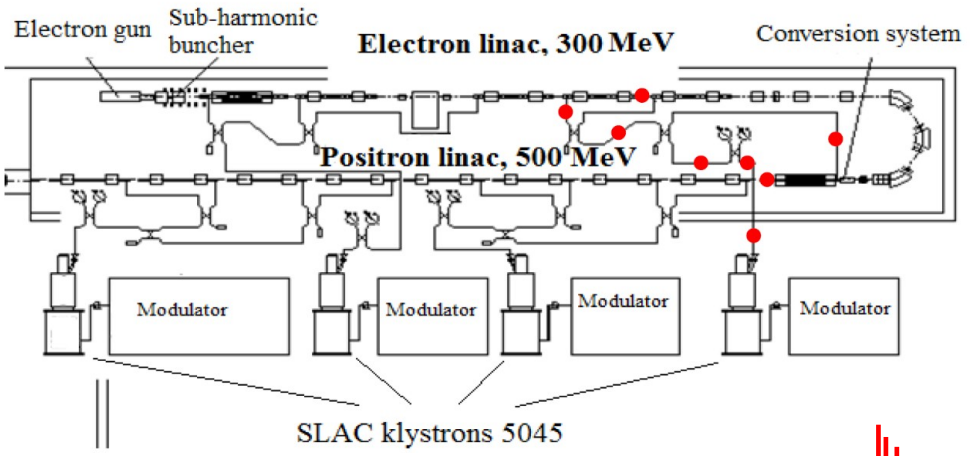


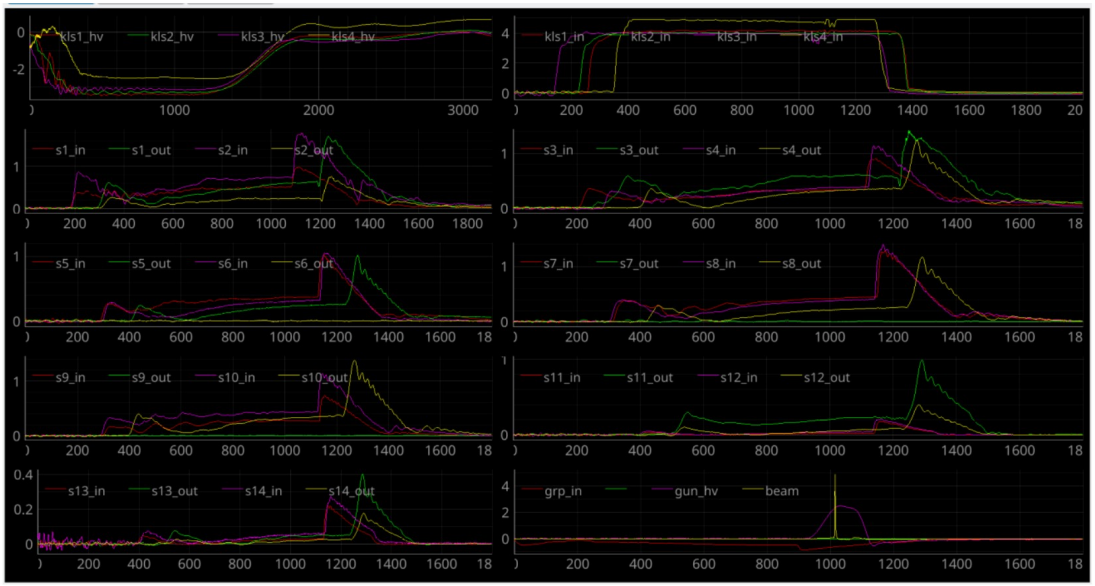
More detailed information at Poster session C (Yu.Maltseva, WEPSC44)

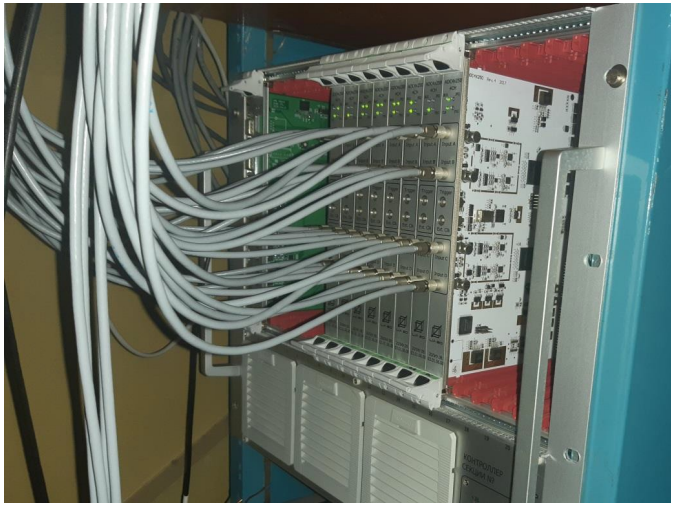
Linac RF System Monitoring

- BINP developed VME ADC250x4 are deployed in order to measure all signals simultaneously.
- Common ADC clock connected to injection complex master generator allows to measure time between any signals.
- Integrated into injection complex software, automatic detection of usual signal changes under development.

Linac RF measurement points







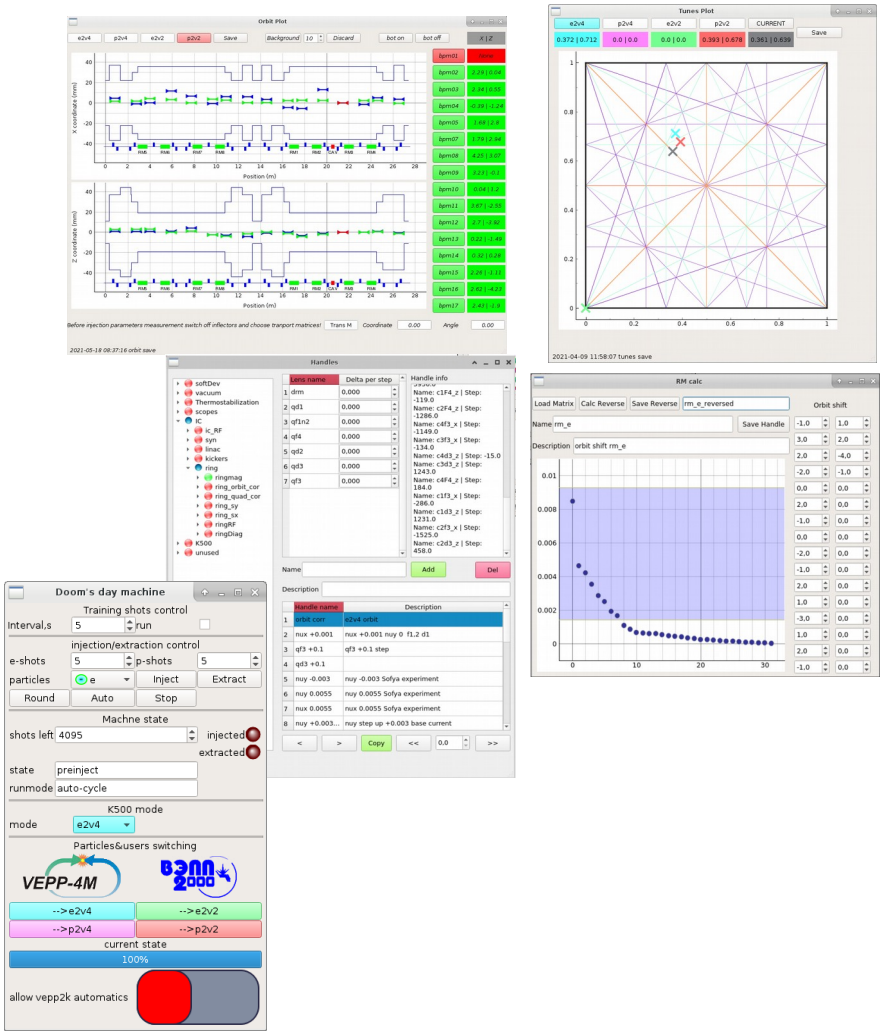
8*4 channels
250 MHz ADC

Control Software

Injection complex software based on CXv4 framework. We are constantly improving our software set. There are our latest steps in this direction:

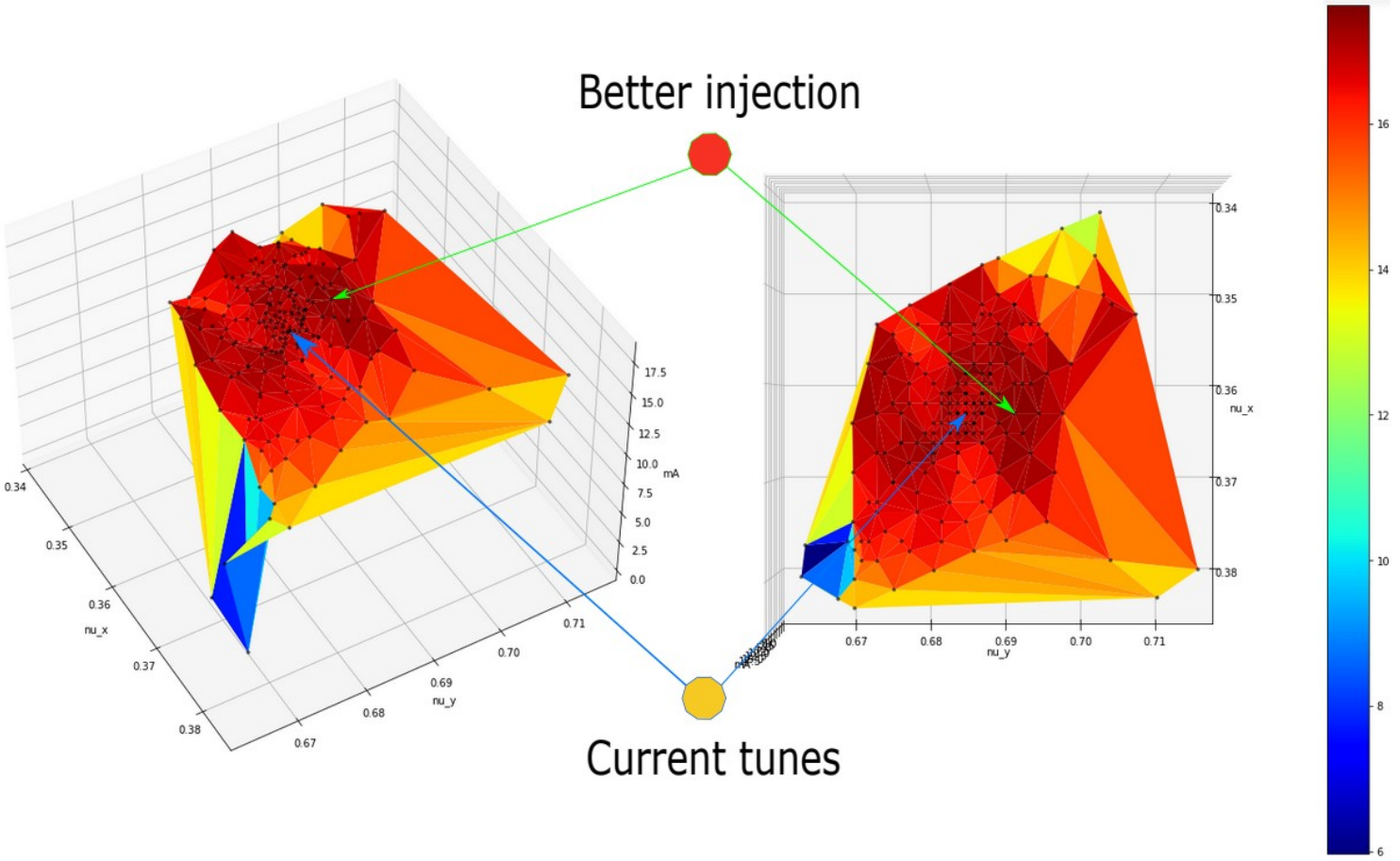
- Many base framework improvements
- Server-side bridging, used to easily interface beam user control systems.
- EPICS and TANGO client modules for CX
- Improved python bindings for CX client libraries
- Improved CX-connected Qt widgets set
- Improved Database tools for machine configuration, configuration files generation and operation data archieving.
- Improved automatic and data preprocessing software
- Developed a software set for damping ring optic measurement and studies
- Developed few new operator’s screens

Frontend clients for damping ring optic studies



Injection Efficiency

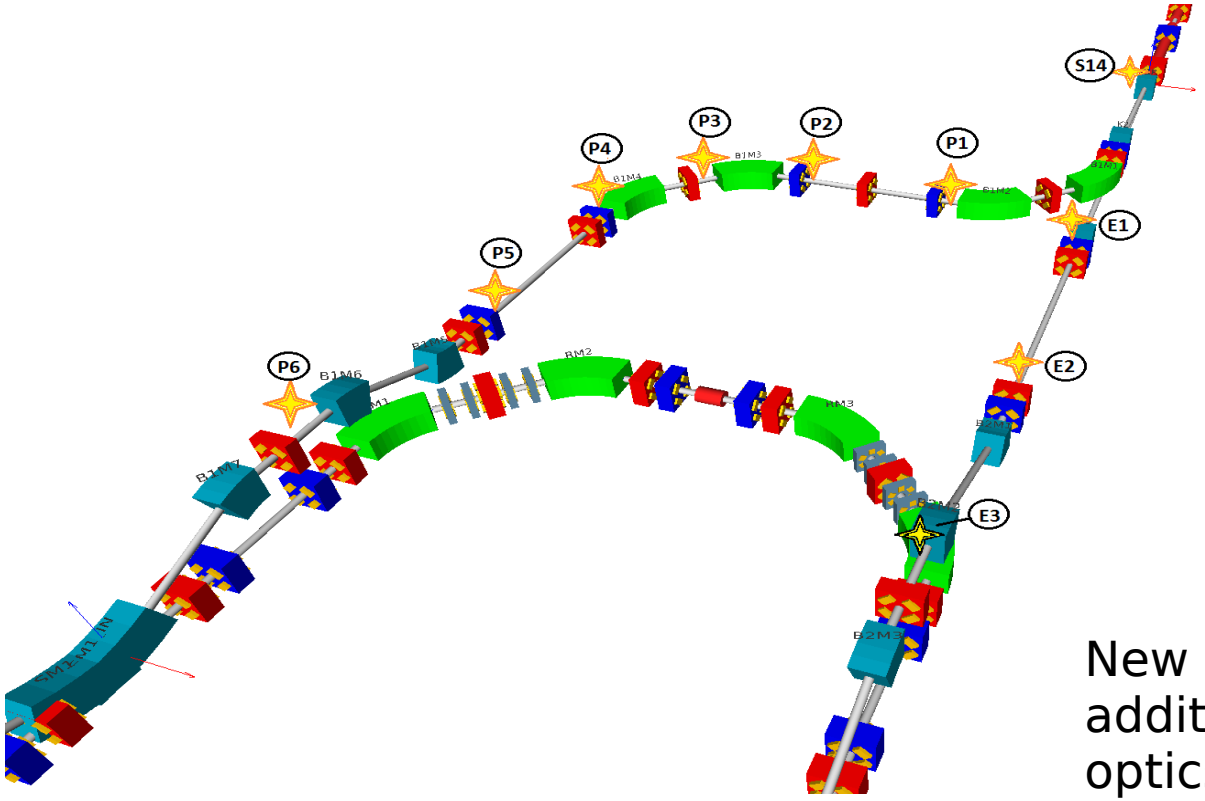
Amount of captured positrons in the damping ring vs. tunes



V. Balakin, WEPSC56, Poster session C

Beam Diagnostics for Injection Channels

Layout of proposed BPMs for injection channels



New set of BPMs should prevent additional losses related to trajectory or optics inaccuracies.

And as a result, better productivity and operation stability of the Injection Complex.

Summary

- Since 2016 VEPP-5 IC routinely supplies both BINP colliders with high energy electron and positron beams.
- Sufficient charge production rates and minimal switching times between the operating modes for colliders to achieve their desired luminosity, are obtained.
- 10 A electron gun for better production rate is installed.
- Fiber-based beam loss monitor system for reliable operation is installed.
- Software improvements were performed.
- Measurements for injection efficiency are performed.
- Further IC performance and operation stability improvements are still required and under consideration.

Thank you
for your attention

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