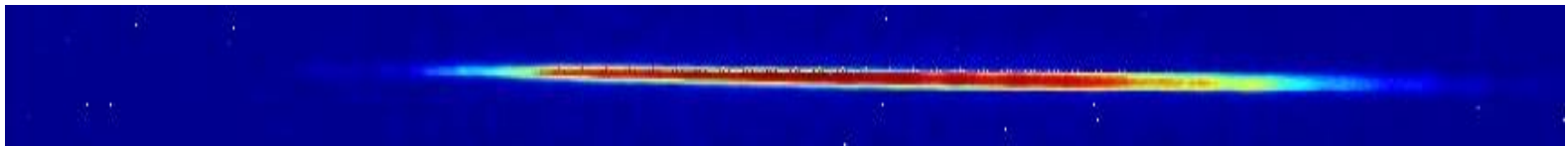
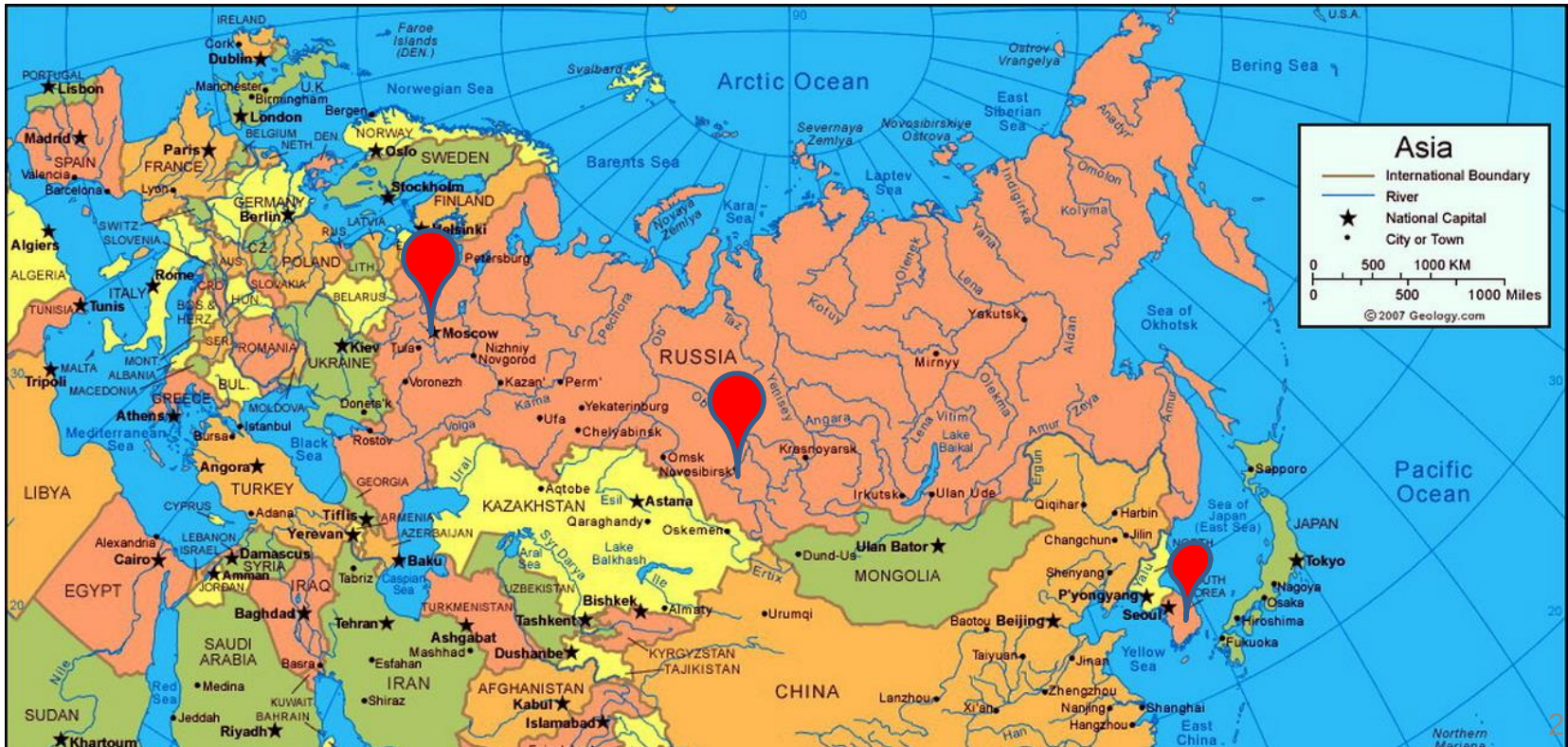
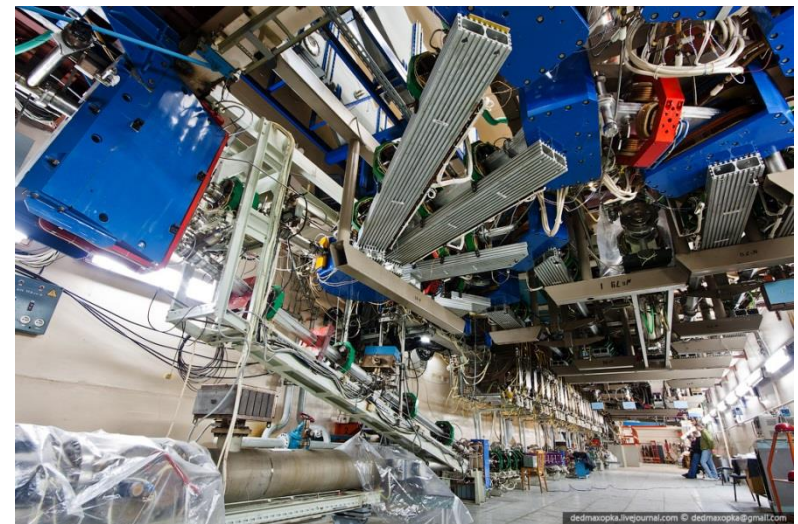


O. Meshkov

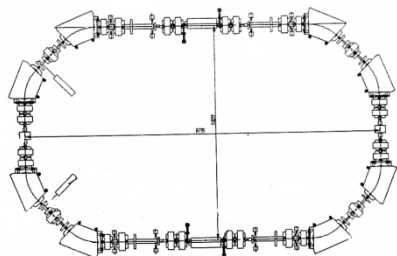
***Study of the BINP damping ring
performance with the streak camera***

Budker Institute of Nuclear Physics SB RAS, Novsibirsk, Russia

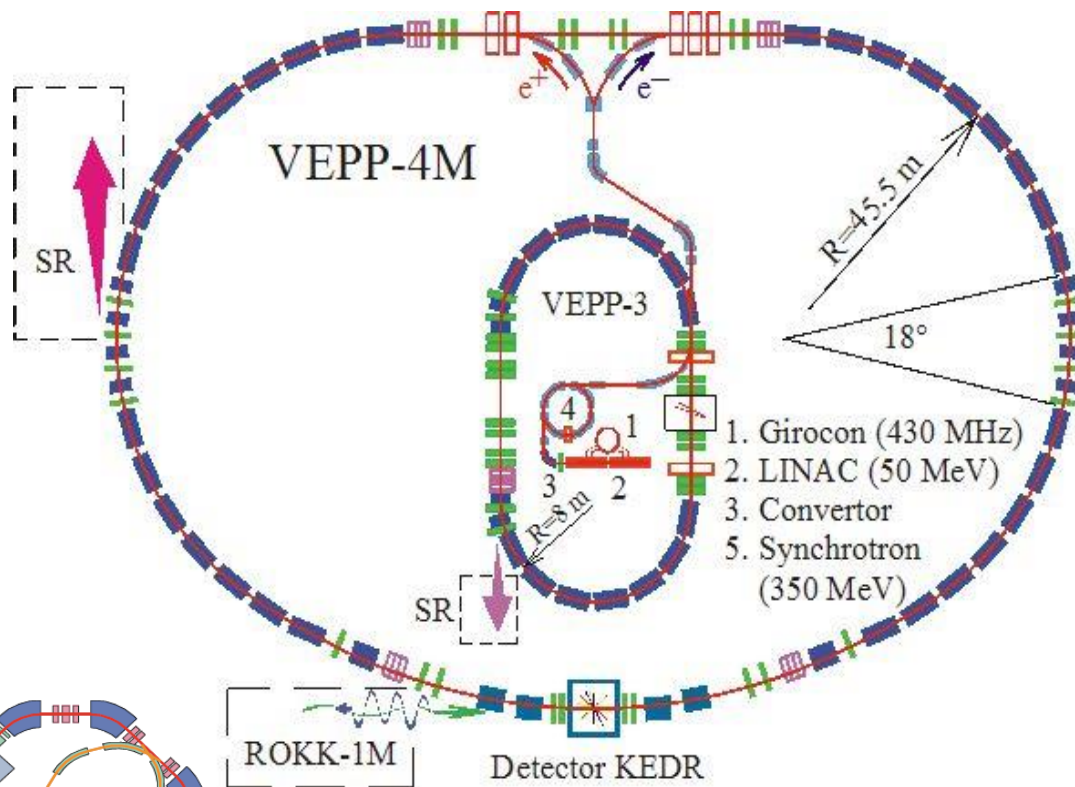
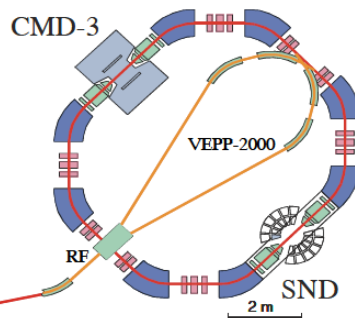
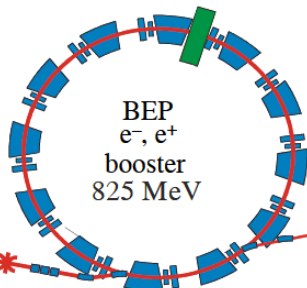
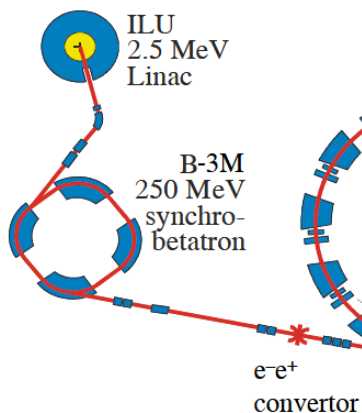




BINP cyclic Accelerators



**Damping Ring, $E = 450$ MeV,
 $C = 28$ m, $\nu_{RF} = 700$ MHz**



**VEPP-4M, $E = 2 \times 4500$ MeV,
 $C = 366$ m, $\nu_{RF} = 181$ MHz**

VEPP-2000, $E = 2 \times 1000$ MeV, $C = 25$ m, $\nu_{RF} = 170$ MHz

Injection Complex VEPP-5 providing both BINP colliders VEPP4M and VEPP-2000 with the electron and positron beams

Parameters (2016): Energy: **395 MeV**

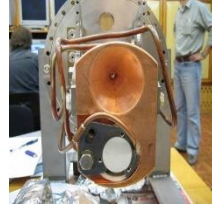
Storage rate e^- @ 12.5 Hz: **$4.0 \cdot 10^{10}/s$** (70 mA/s)

Storage rate e^+ @ 12.5 Hz: **$4.0 \cdot 10^9/s$** (7 mA/s)

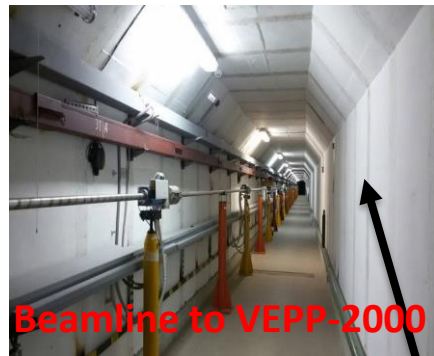
Max. beam current e^- : **100 mA, $4.2 \cdot 10^{10}$ particles**

Max. beam current e^+ : **70 mA, $2.9 \cdot 10^{10}$ particles**

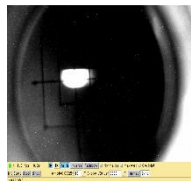
beams



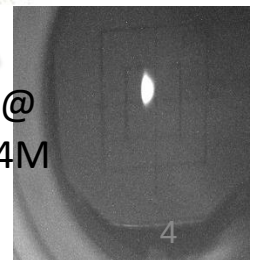
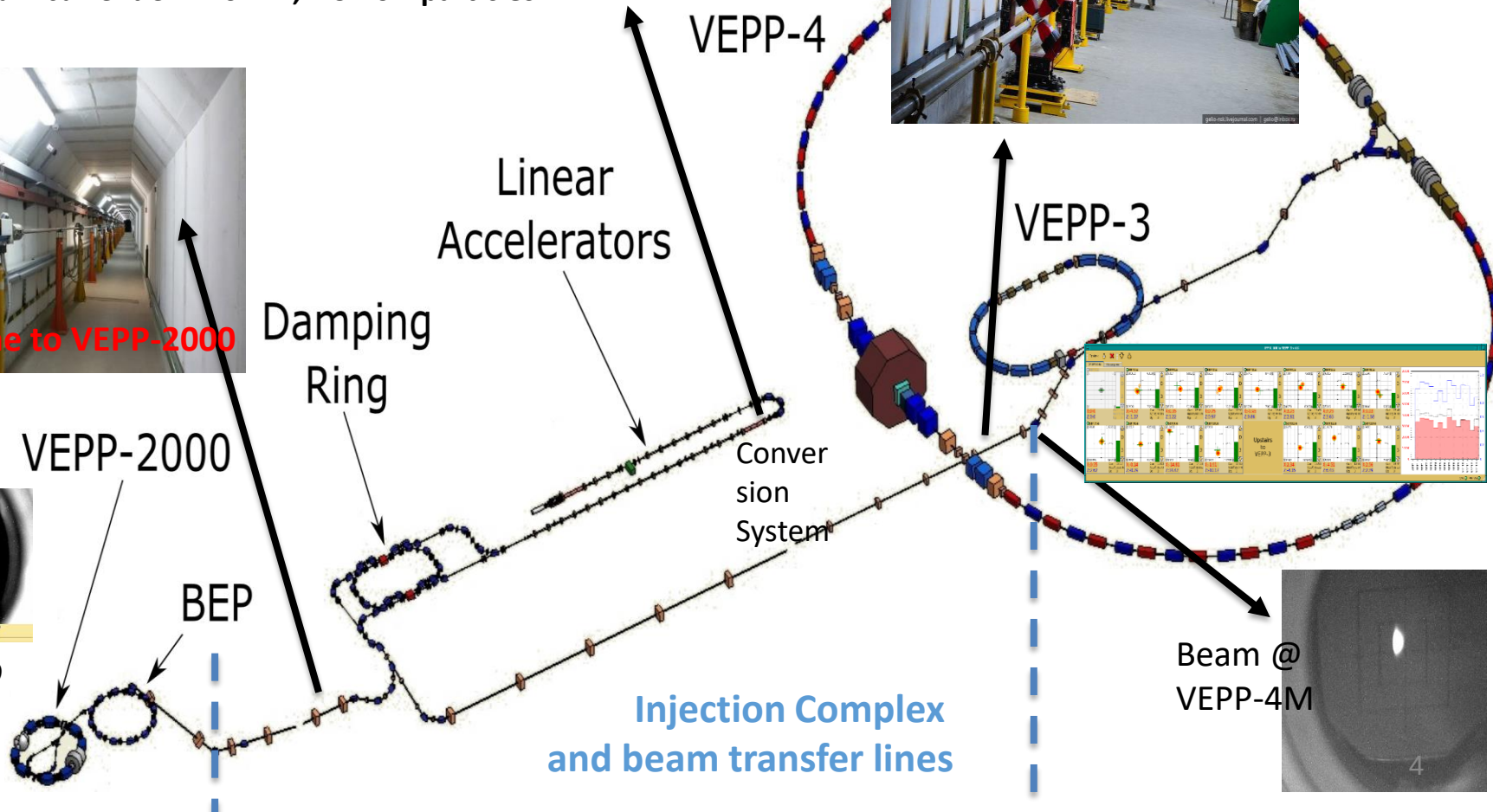
Beamline to VEPP-4M



Beamline to VEPP-2000



Beam @
BEP



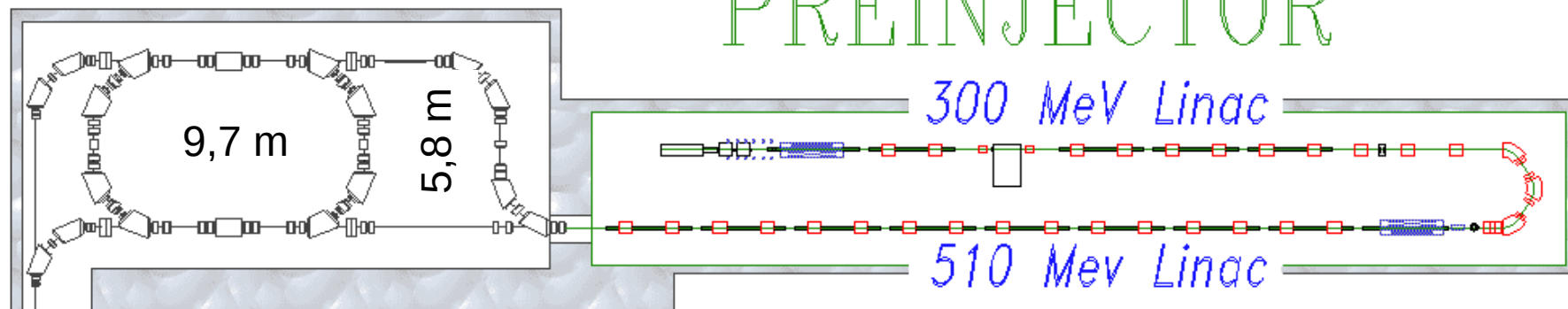
Beam @
VEPP-4M

Injection Complex
and beam transfer lines

Streak camera for BINP Damping Ring tuning

DAMPING RING

PREINJECTOR



Beam from VEPP-5 injection complex

energy, W_0	510 MeV
number of particles in bunch	$(2 \div 5) \cdot 10^{10}$
rms bunch length, σ_z	4 mm
transverse rms size, $\sigma_x \times \sigma_y$	1.5×0.03 mm
x -emittance	$2.3 \cdot 10^{-3}$ mrad · cm
y -emittance	$0.5 \cdot 10^{-3}$ mrad · cm
energy spread, $\delta W/W_0$	0.05%

e+, e- to VEPP-2000, VEPP-4M

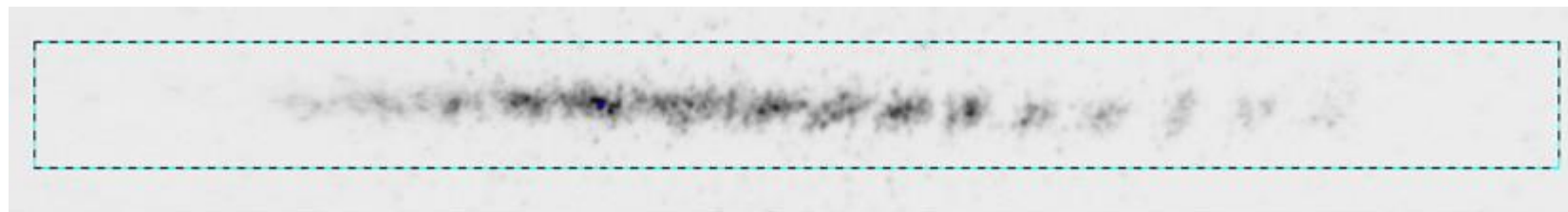




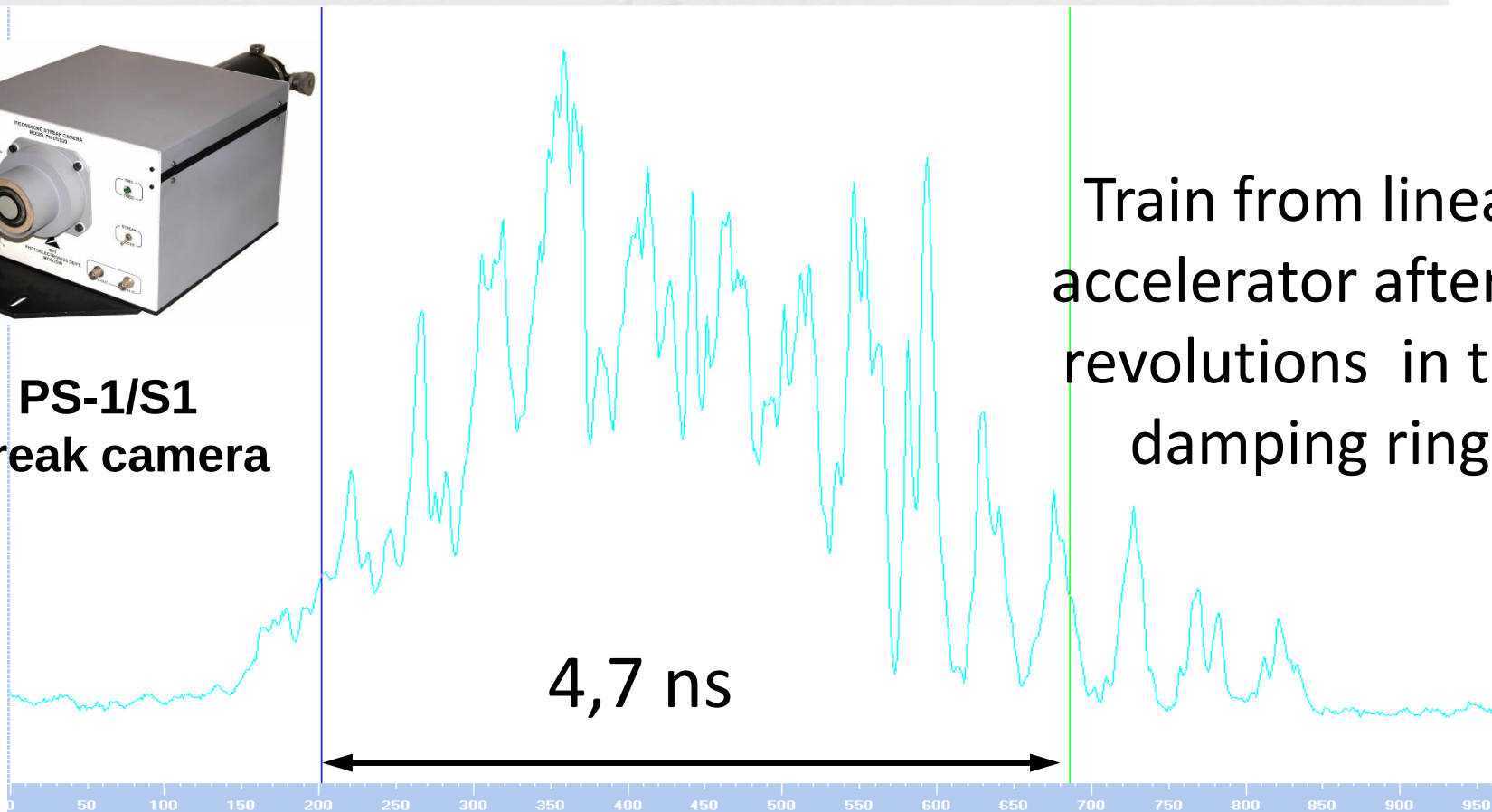
SR

BINP Damping Ring

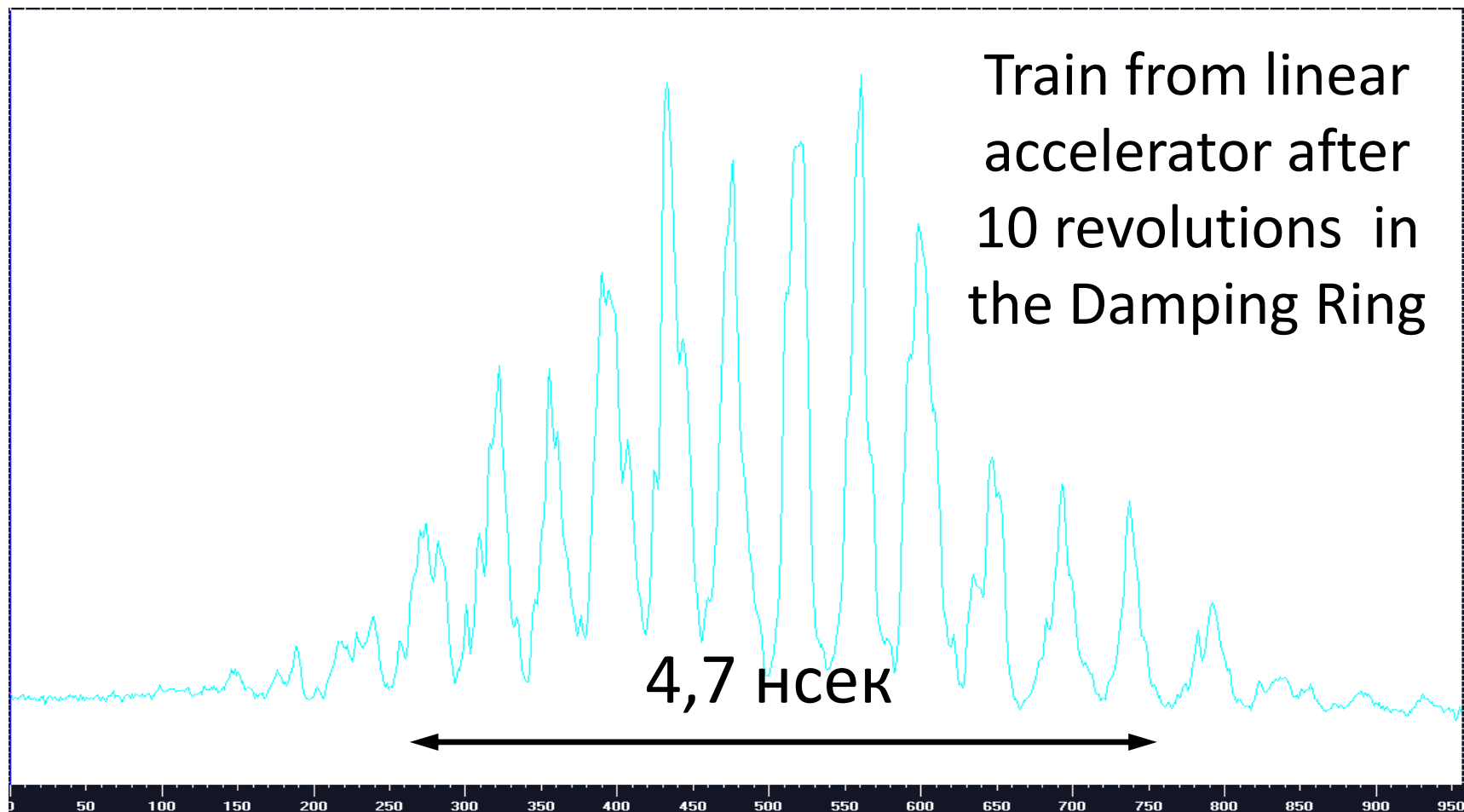
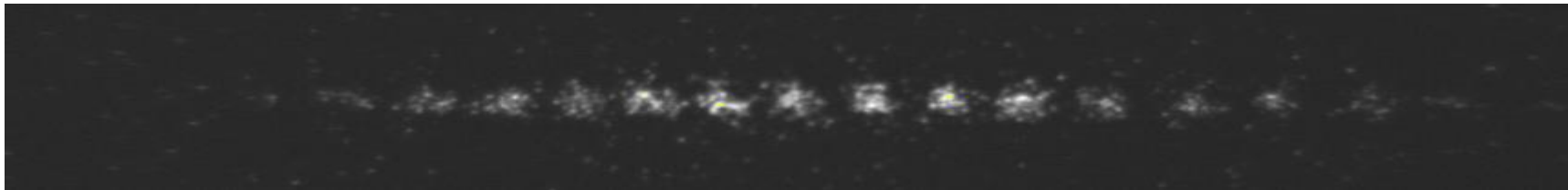
Streak camera for accelerator tuning



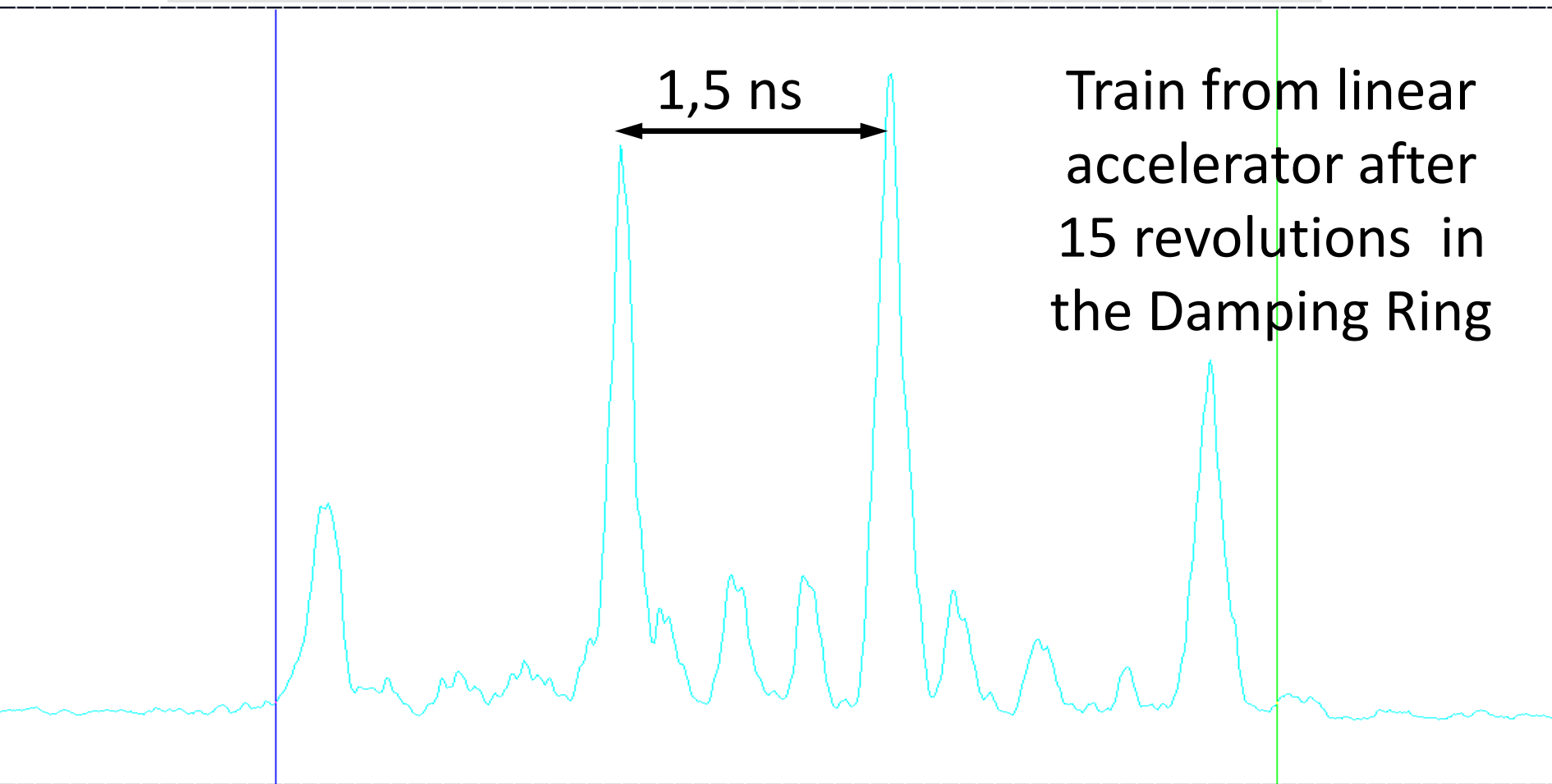
**PS-1/S1
streak camera**



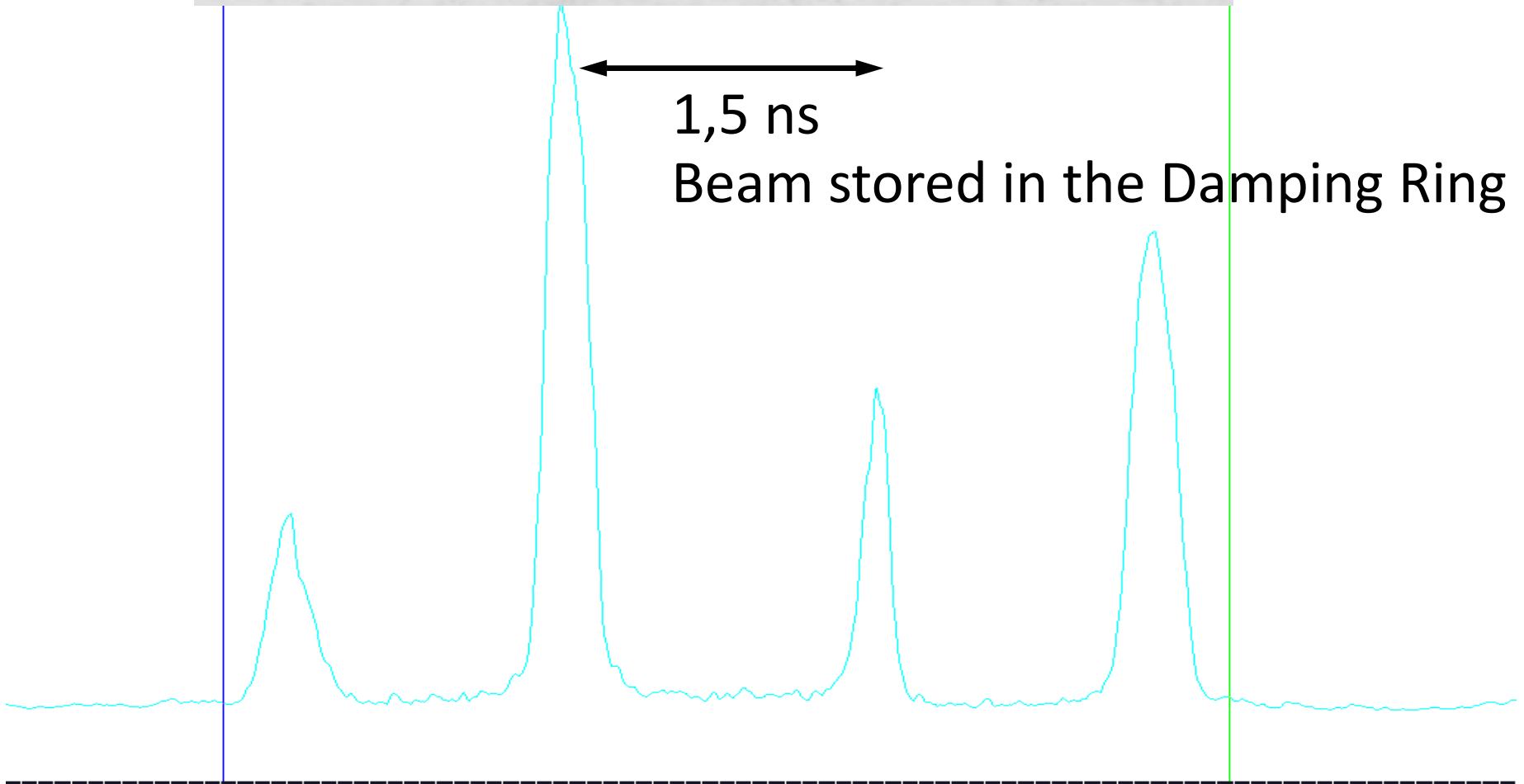
Train from linear
accelerator after 5
revolutions in the
damping ring



Streak camera for accelerator tuning



Streak camera for accelerator tuning

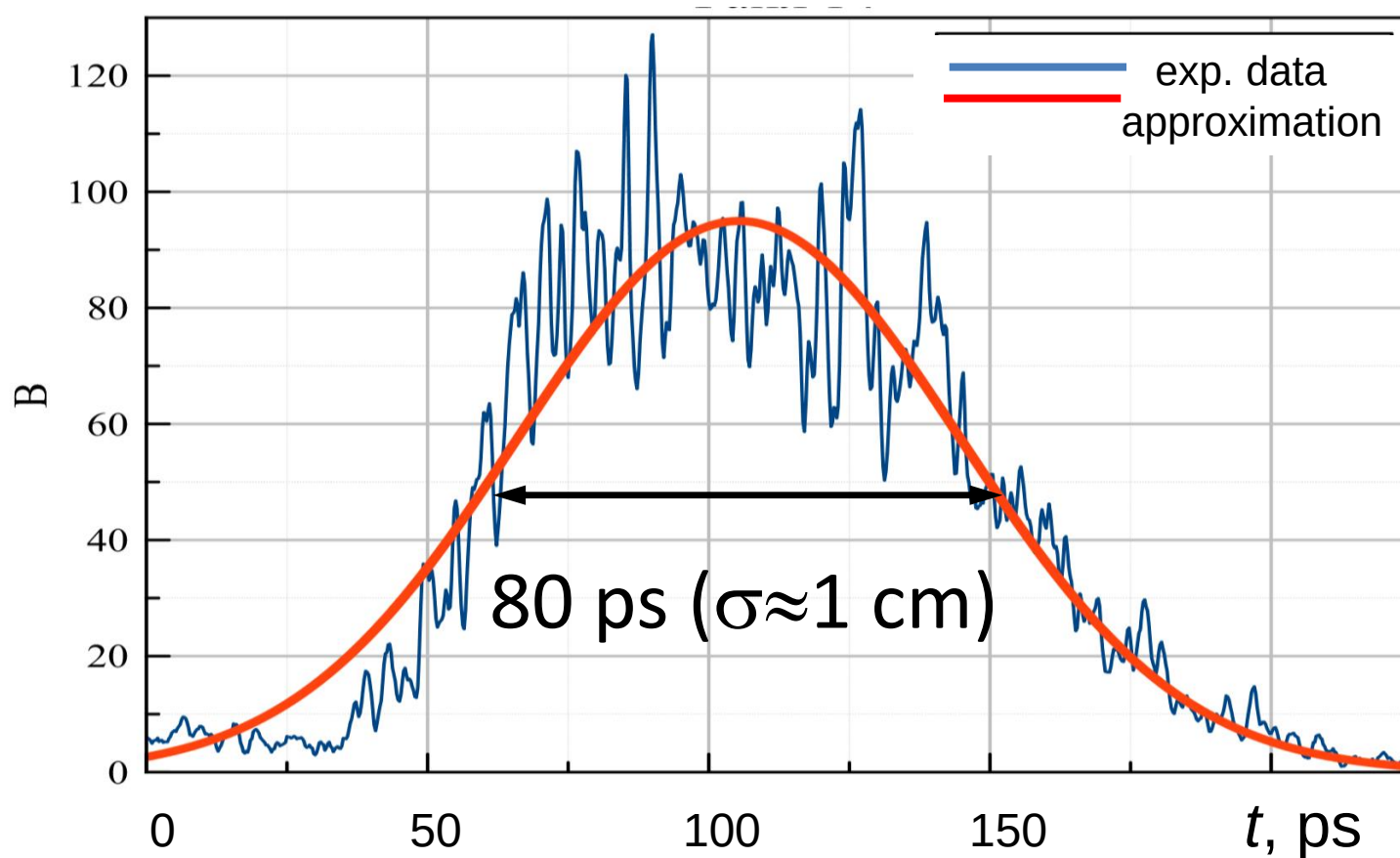


$1,5 \text{ ns} = 1/\nu_{\text{RF}} ; \nu_{\text{RF}} \approx 700 \text{ MHz}$ – a frequency of accelerating voltage

Streak camera for accelerator tuning



Structure of a single bunch stored in the damping ring



The efficiency of particle capture from linac into the DR separatrix

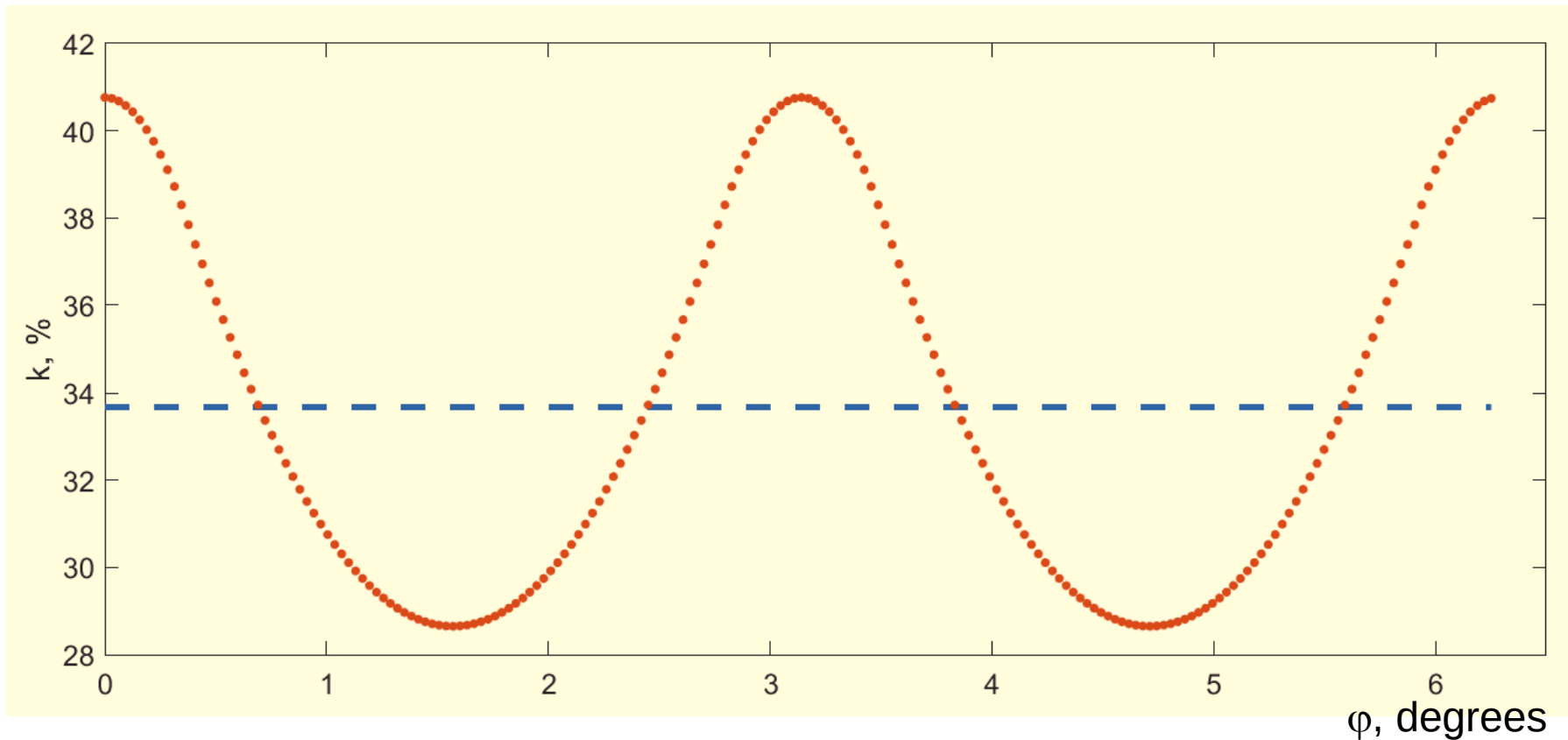
$$k(\varphi) = \frac{\int \rho(z, \delta) |\cos(\pi z / \sigma_{\text{RF}} + \varphi)| dz d\delta}{\int \rho(z, \delta) dz d\delta}$$

φ - the RF phase at the center of the injected beam;

$\rho(z, \delta)$ - the injected beam distribution along the longitudinal coordinates.

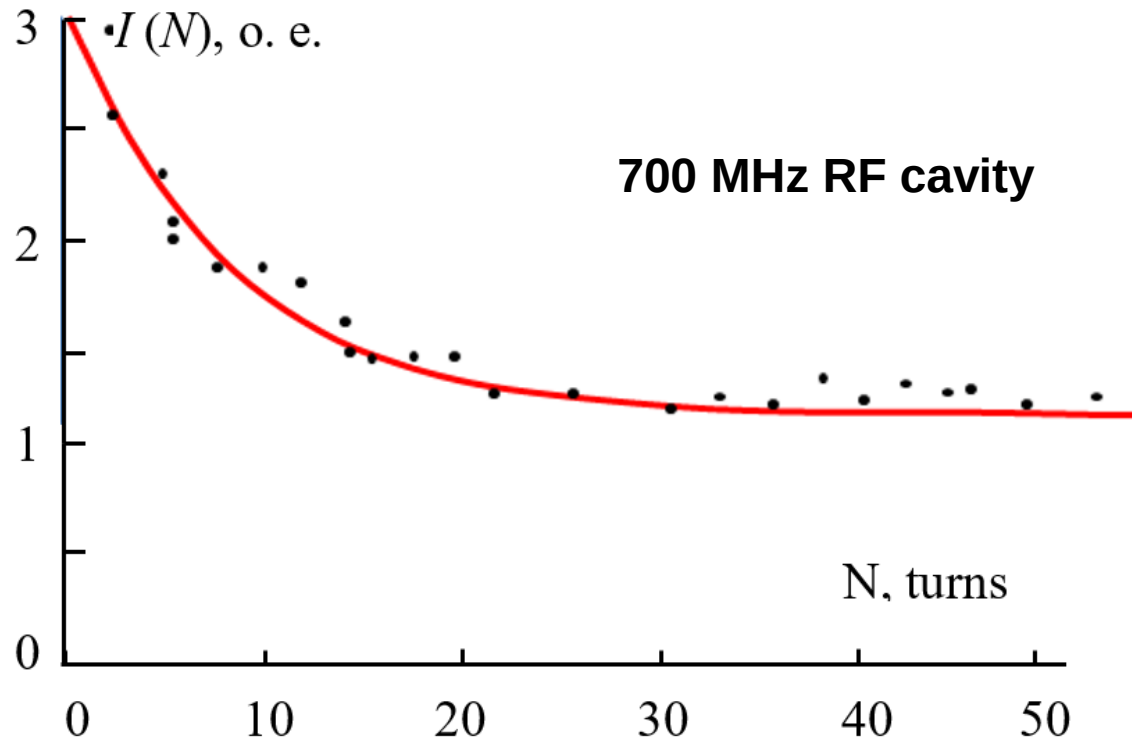
The RF separatrix parameters in the
DR are $\sigma_{\text{RF}} = 0.82\%$, $L_{\text{RF}} = 0.428\text{m}$ at $U_{\text{RF}} = 120\text{ kV}$

The efficiency of particle capture from linac into a DR separatrix



The efficiency of the injection into the DR from linac depending on the phase φ of voltage on the RF cavity at $f_{\text{RF}} = 700$ MHz.

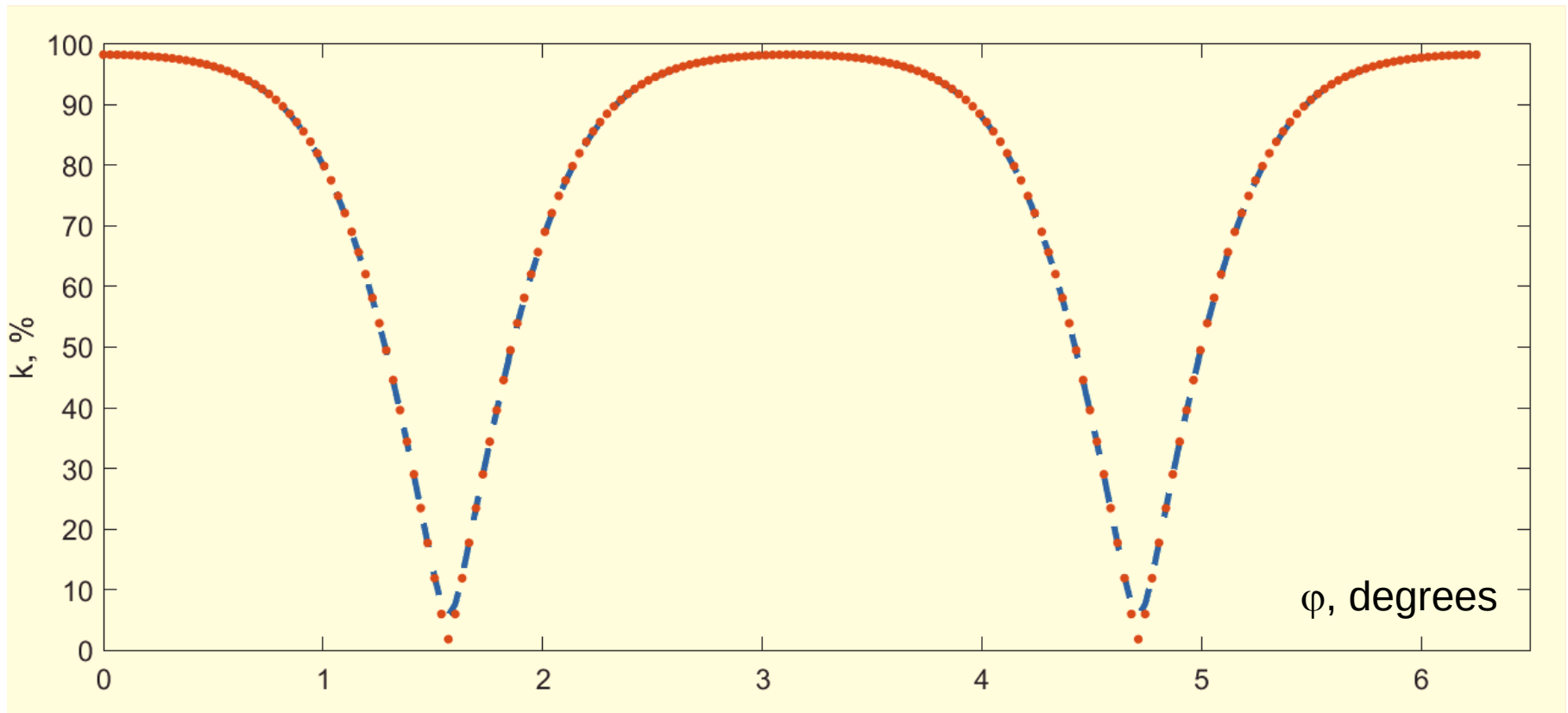
The efficiency of particle capture from linac into a DR separatrix



Beam losses after its injection from the linear accelerator into the DR.

Dots: amplitude of the signal from photomultiplier that records the intensity of synchrotron radiation (SR); the data are fitted by the exponential curve. Every second turn of the beam in the DR is shown.

How to improve the efficiency of the injection?



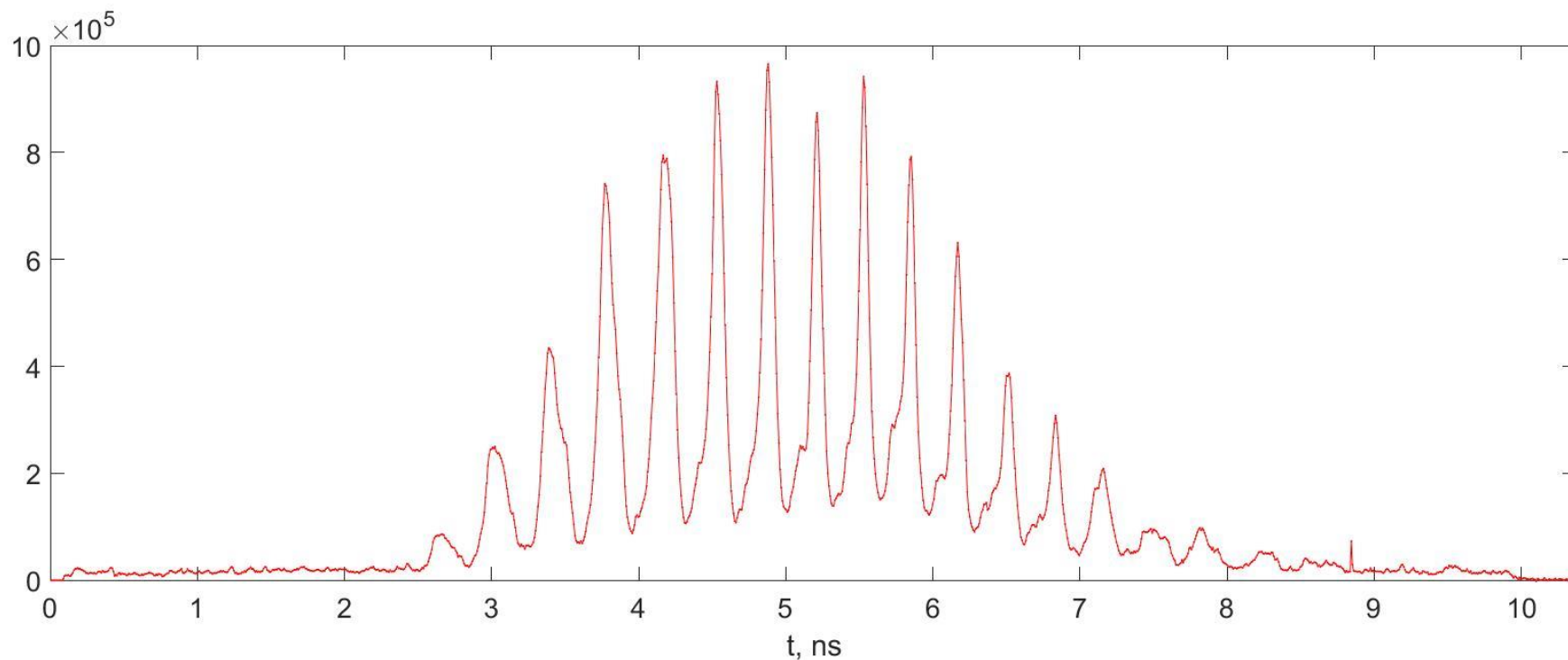
Efficiency of the injection from the linac into the DR depending on the phase of voltage on the HF resonator at $f_{RF} = 11$ MHz and $U_{RF} = 10$ kV.

Dark blue dots mark the rectangular longitudinal distribution of particles in the beam; red points correspond to the Gaussian distribution

At the beginning of the 2017 the new RF system of the Damping Ring was commissioned and the measurements with a streak camera were repeated.

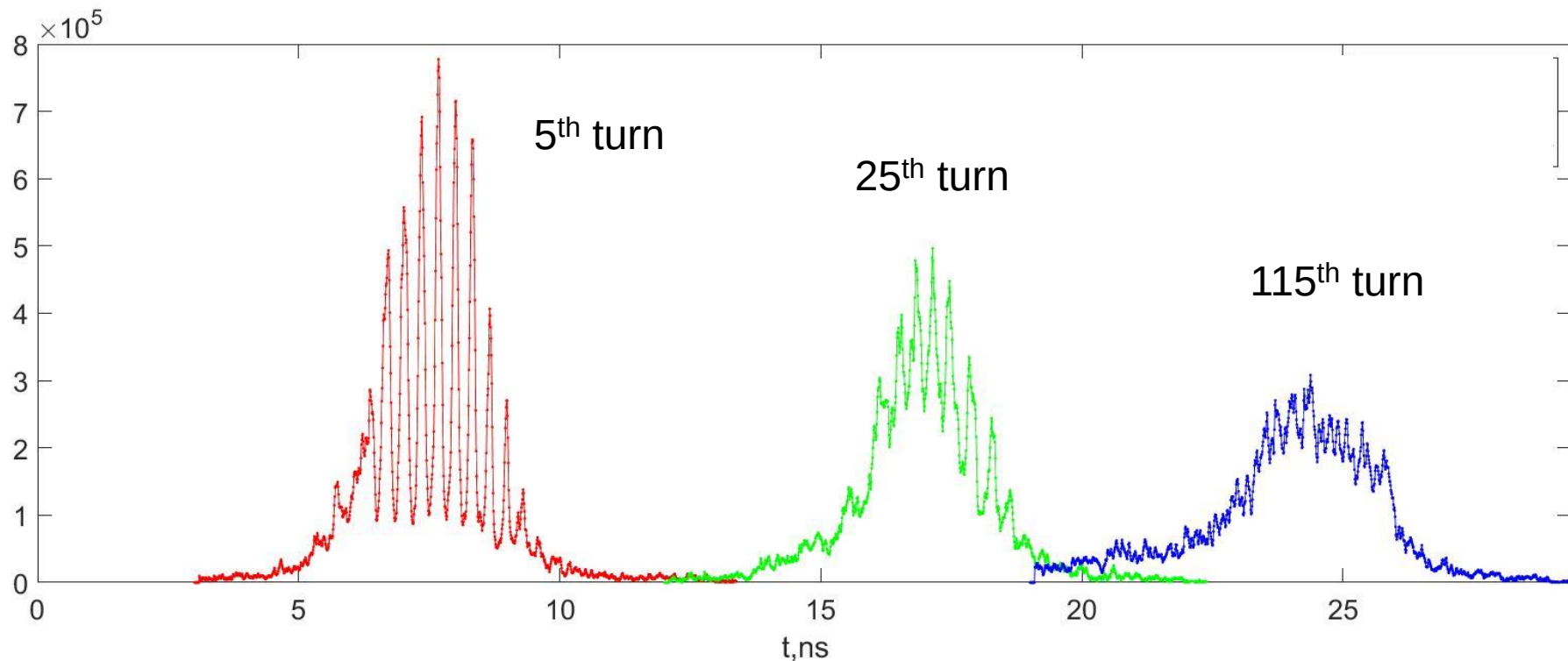


The turn-to turn behavior of the longitudinal beam profile, $f_{RF} = 11$ MHz



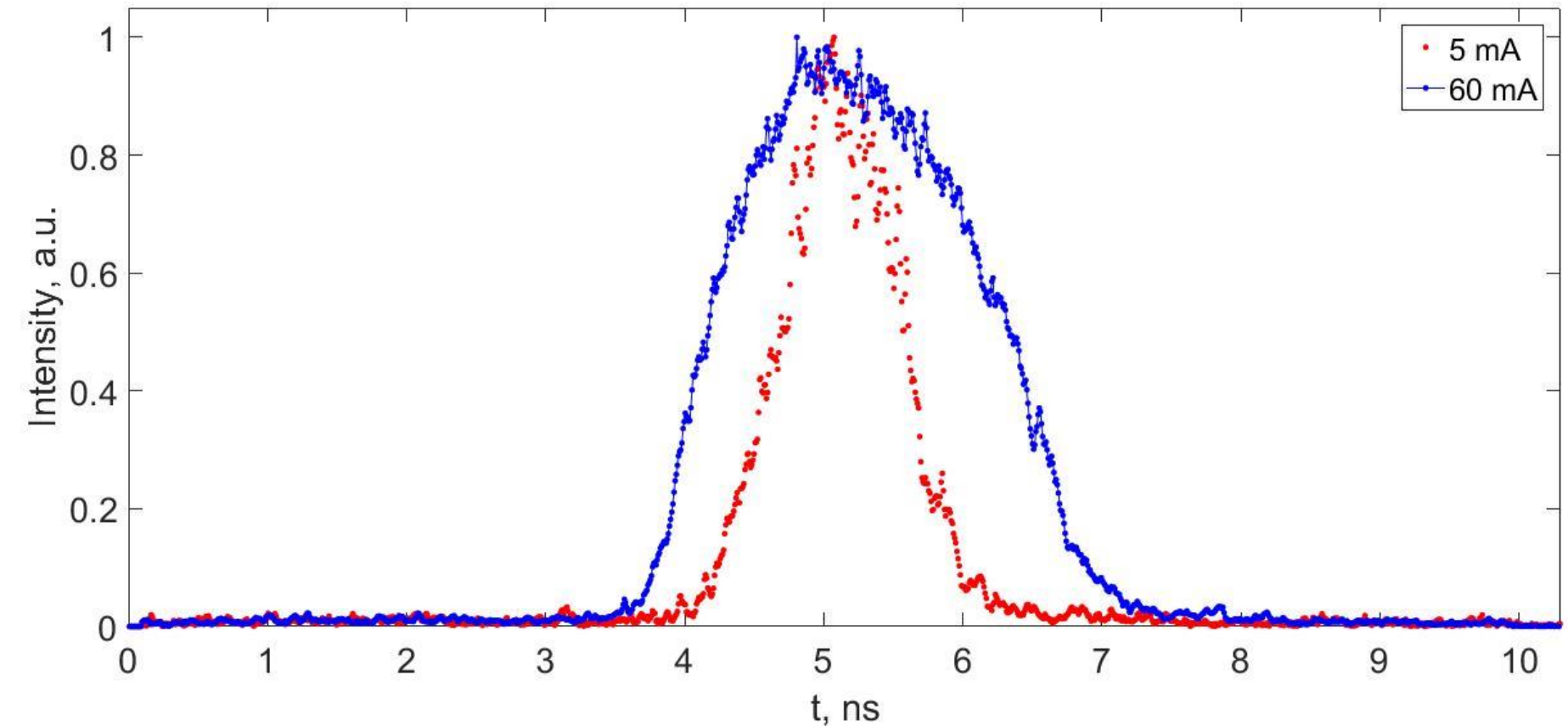
Train from linear accelerator at the first revolution after injection into the Damping Ring

The turn-to turn behavior of the longitudinal beam profile, $f_{RF} = 11$ MHz

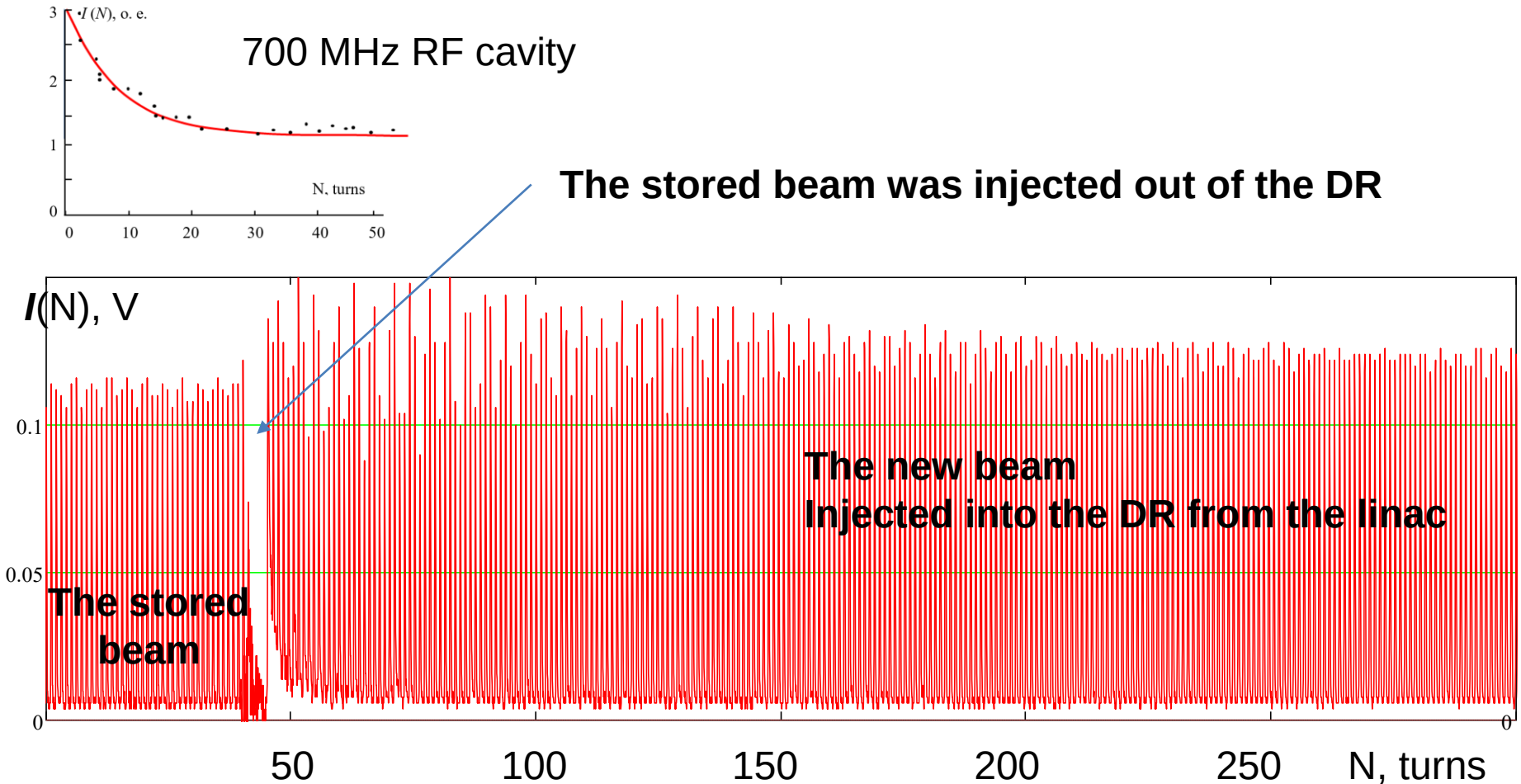


The bunches “shrink” into single beam after about 100 turns in the Damping Ring

The longitudinal profile of the stored beam, $f_{\text{RF}} = 11$ MHz



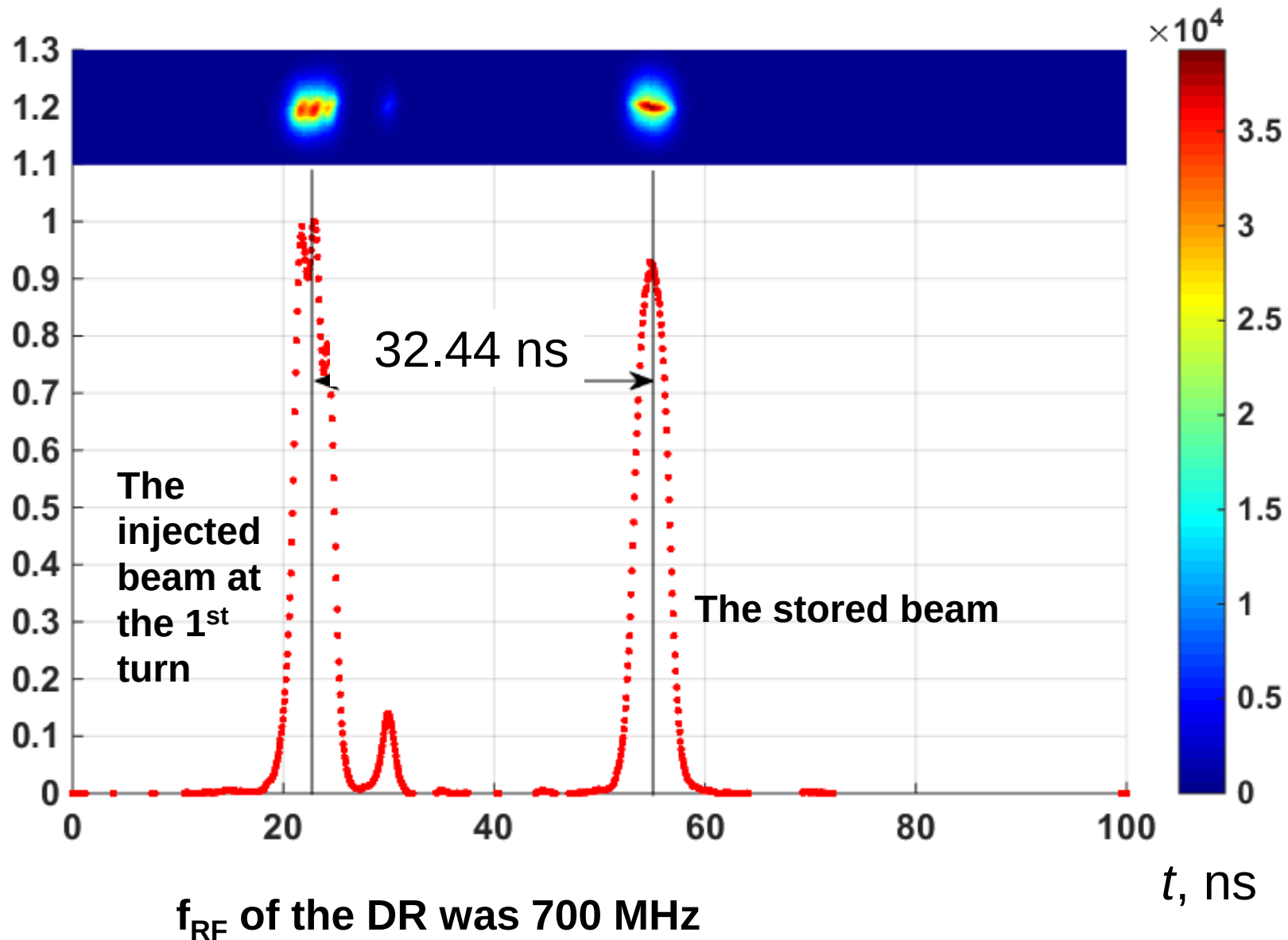
The efficiency of particle capture from linac into a DR separatrix



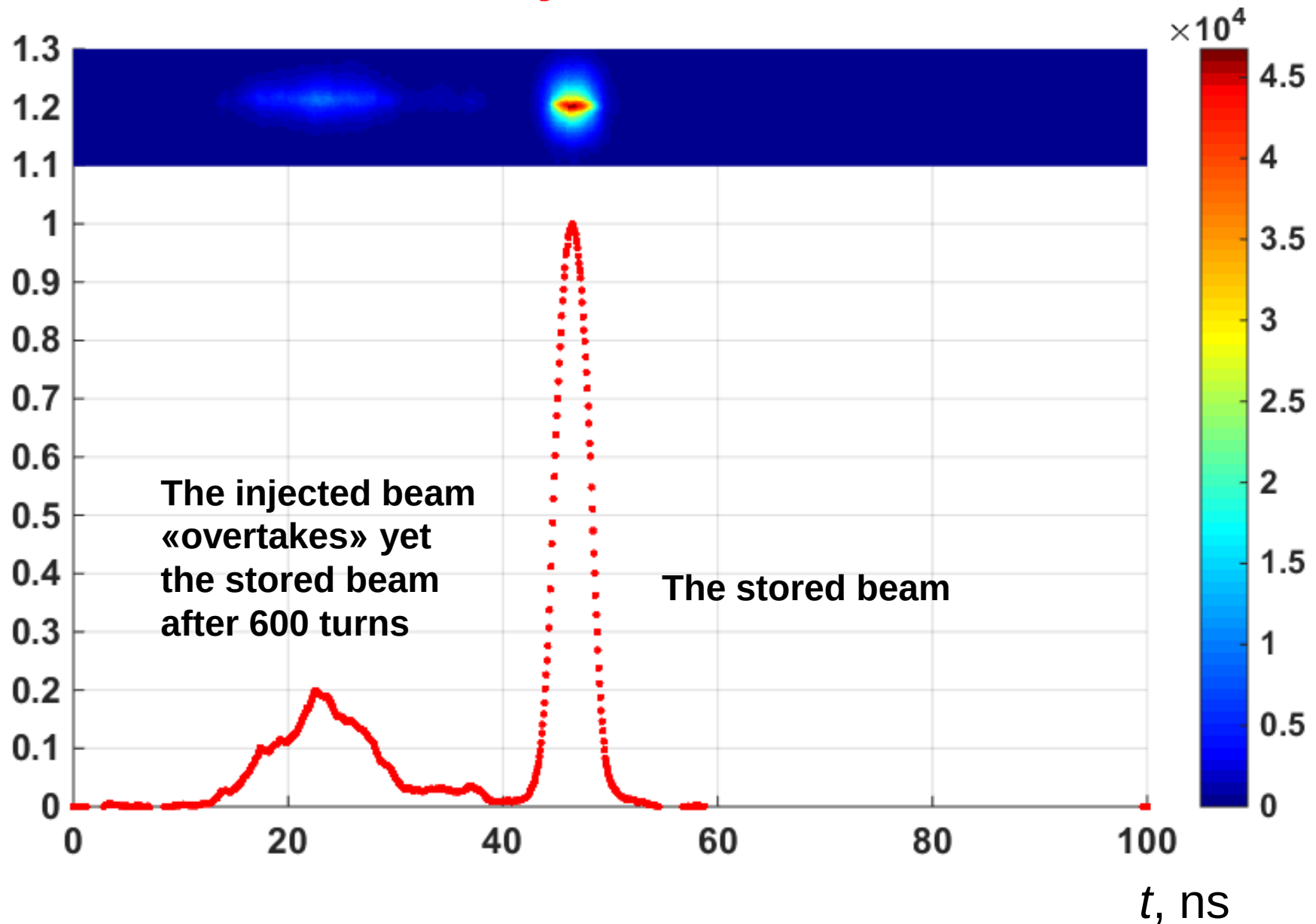
Amplitude of the signal from photomultiplier that records the intensity of synchrotron radiation (SR) is presentd, $f_{\text{RF}} = 11 \text{ MHz}$.

The efficiency of the beam trapping two fold improved with the new RF system.

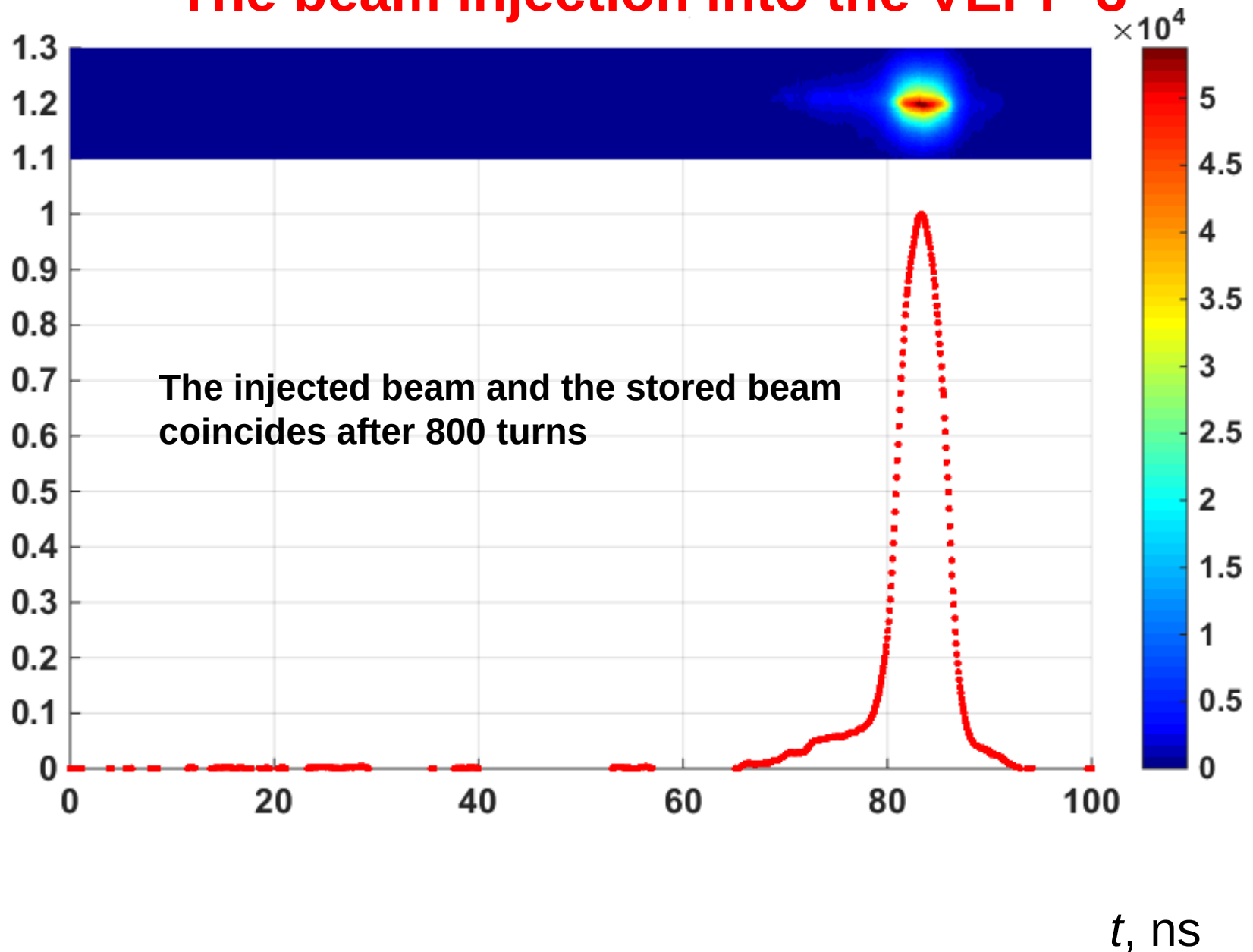
The beam injection into the VEPP-3



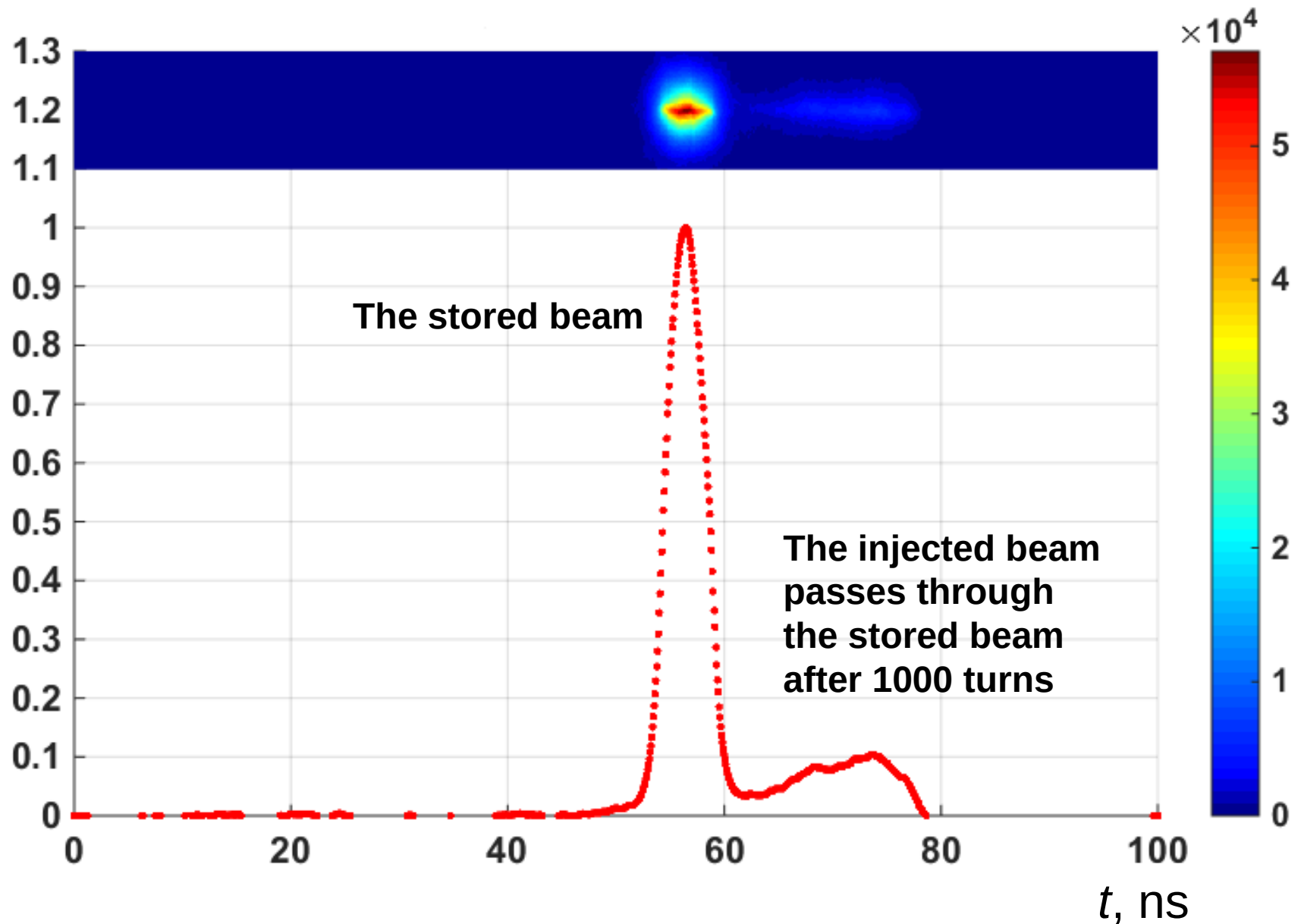
The beam injection into the VEPP-3



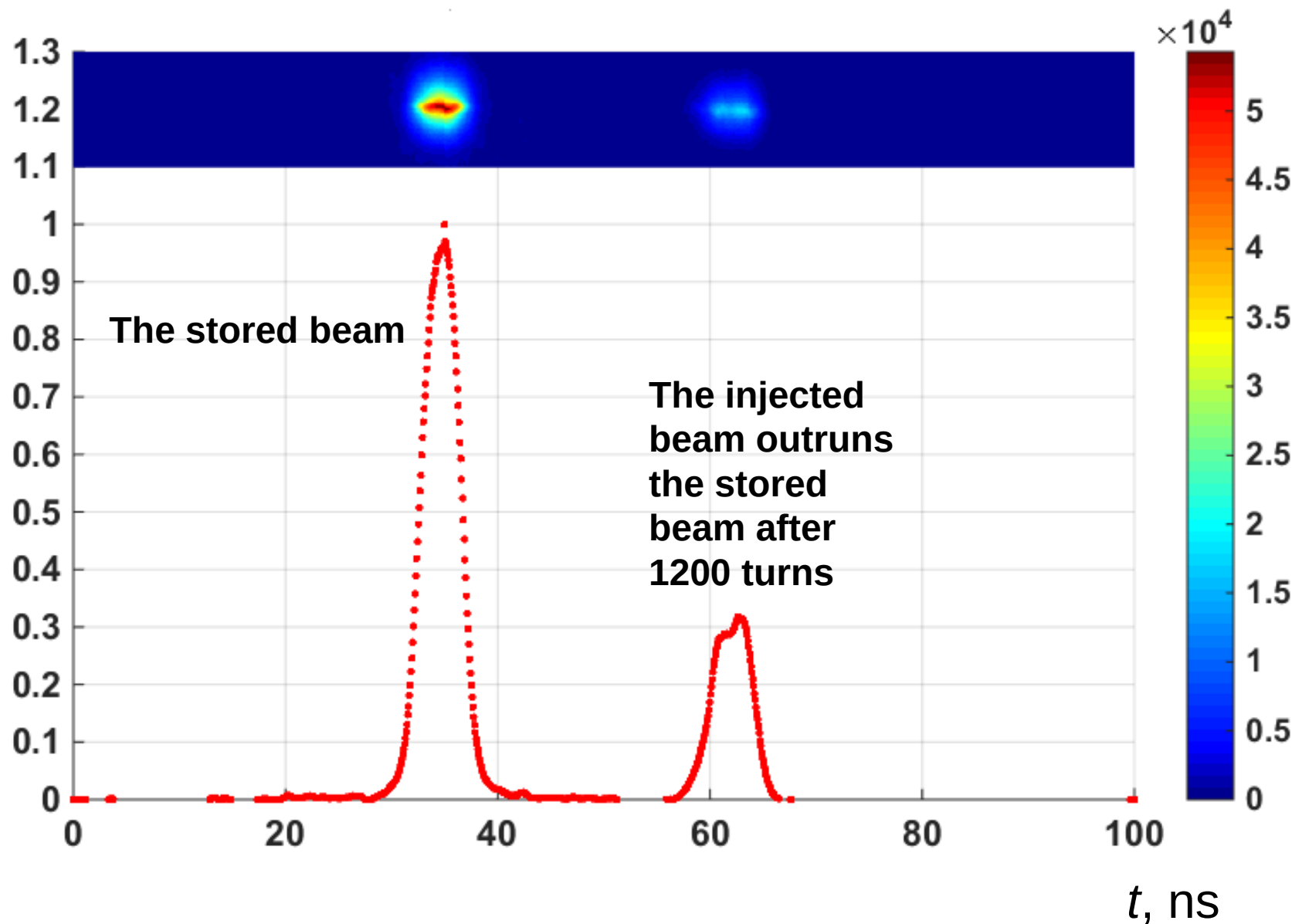
The beam injection into the VEPP-3



The beam injection into the VEPP-3



The beam injection into the VEPP-3



Conclusion

- Streak camera was successfully applied for measurements of the longitudinal beam dynamic in the Damping Ring of the BINP.
- The data acquired by the streak camera promoted to make up a decision about upgrade of the RF system of the installation.
- The efficiency of the Injection Complex significantly improved after the upgrade of the RF system of the Damping Ring

Thank you for your attention!