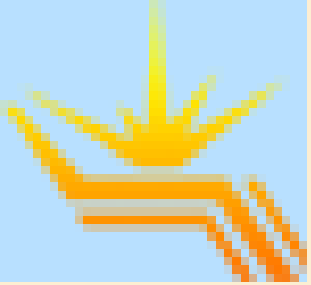


# STATUS OF INJECTION COMPLEX VEPP-5

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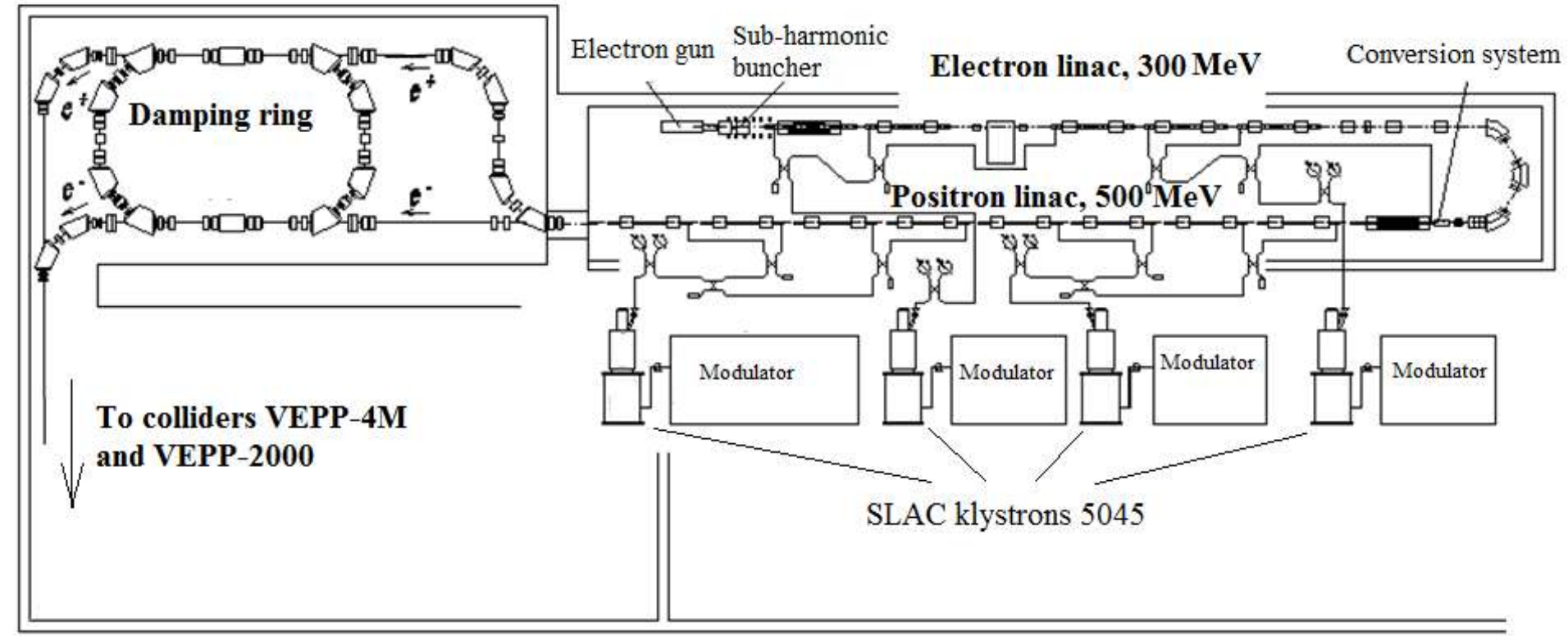
BINP, Novosibirsk

# Outline

- ❑ General Description and layout
- ❑ Design of Linacs
  - Electron gun
  - Acceleration structures
- ❑ Results of linac's commissioning
- ❑ Design of Damping Ring
- ❑ Results of damping ring commissioning
  - Injection angle measurement
  - Closed orbit correction
  - Lattice correction
- ❑ Summary

# General Description and layout


Damping ring
e+
e+
e-
e-
Electron gun
Sub-harmonic buncher
Electron linac, 300 MeV
Conversion system
Positron linac, 500 MeV
Modulator
Modulator
Modulator
Modulator
To colliders VEPP-4M and VEPP-2000
SLAC klystrons 5045

Klystron Gallery

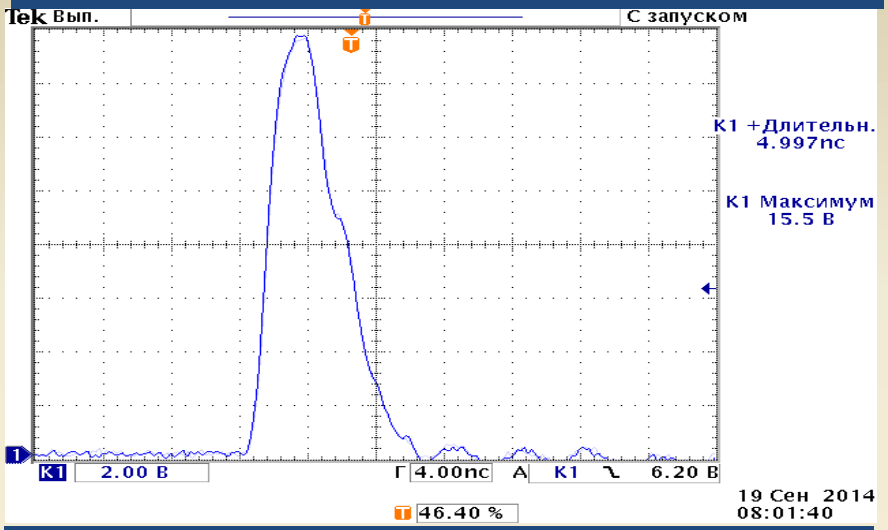
Transfer line to VEPP-4M

Transfer line to VEPP-2000

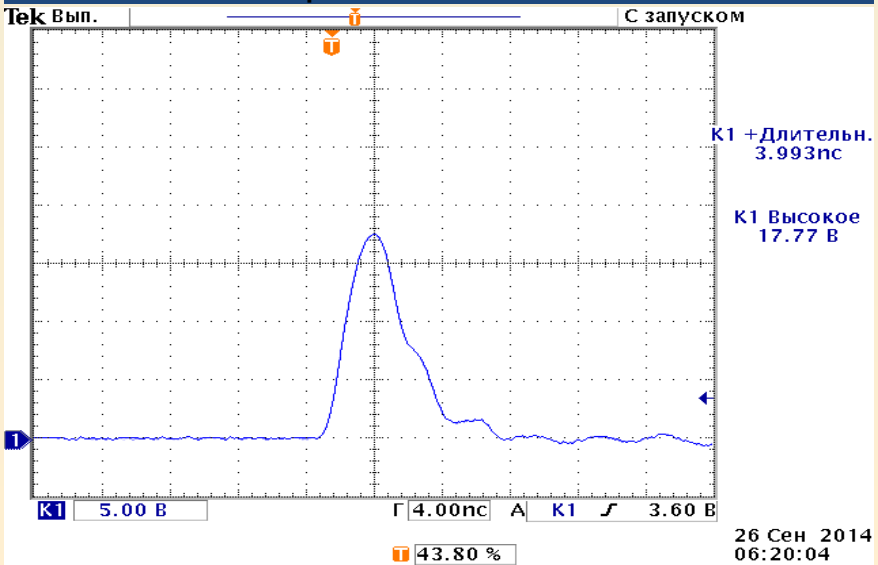

# Design of Linacs base parts

# 200kV Electron gun

$I_{max}$=6,4A Ne= $2*10^{11}$ **(e-)**
(September.19.2014)



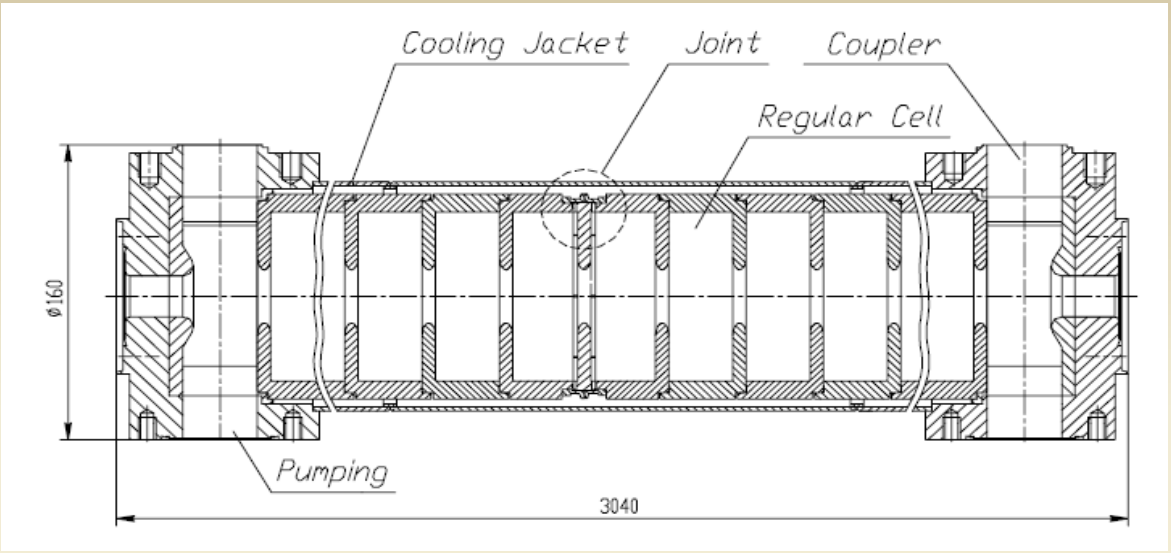

$I_{max}$=7,4A Ne= $2,2*10^{11}$ **(e-)**
September.26.2014




Electron gun

13 mm oxide cathode

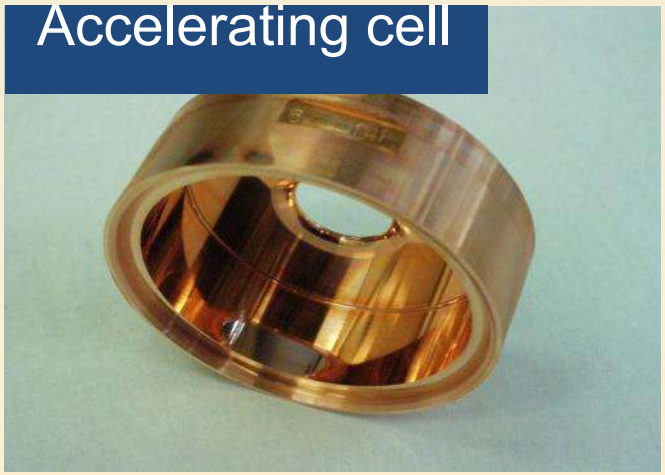
# Disk-loaded travelling wave accelerating structure



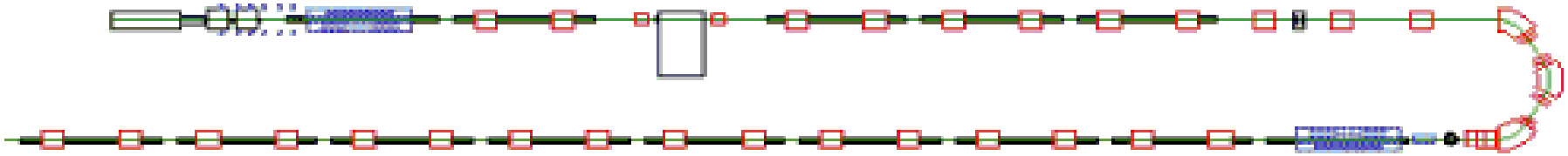

| | |
|---|---|
| Operational frequency | 2855.5 MHz |
| Internal cell diameter $2b$ | 83.75 mm |
| Iris diameter $2a$ | 25.9 mm |
| Iris thickness $t$ | 6 mm |
| Period $D$ | 34.99 mm |
| Operational mode of oscillation $\theta$ | $2\pi/3$ |
| Relative phase velocity $\beta_p$ | 1 |
| Relative group velocity $\beta_g$ | 0.021 |
| Section length $L$ | 2.93 m |
| Total number of cells (incl. 2 WTT) | 85 |
| Unloaded quality factor $Q_0$ | 13200 |
| Shunt impedance $R_{sh}$ | 51 MOhm/m |
| Time constant $\tau_{0a}=2Q_0/\omega_0$ | 1.471 μs |
| Attenuation (by field) $\alpha=1/(\tau_{0a}v_{gr})$ | 0.108 $m^{-1}$ |
| Filling time $T_f=L/v_{gr}$ | 0.465 μs |

Accelerating structure

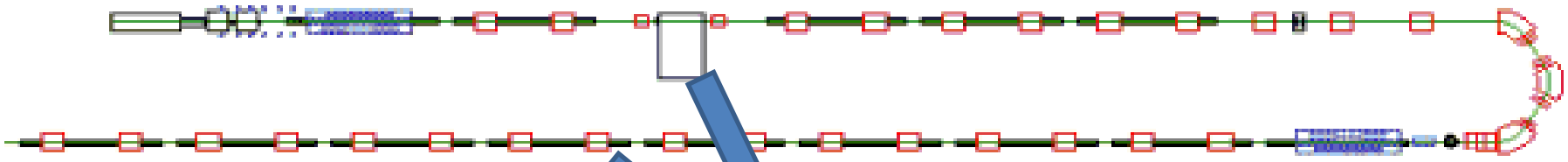
Accelerating cell



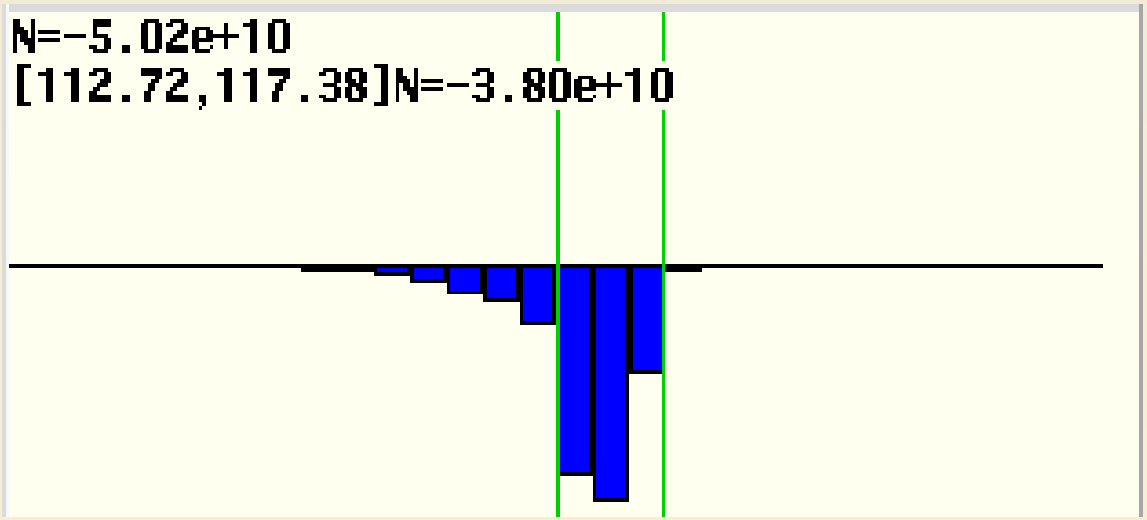
# Results of linacs commissioning



- Number of e- on conversion target - $1.5 \cdot 10^{10}$ /pulse
- Energy of e- on conversion target – 275MeV
- Energy of e+ at the end of linac - 420 MeV
- Number of e+ at the end of linac - $6 \cdot 10^{8}$ /pulse
- Position conversion coefficient - 0.14 / GeV



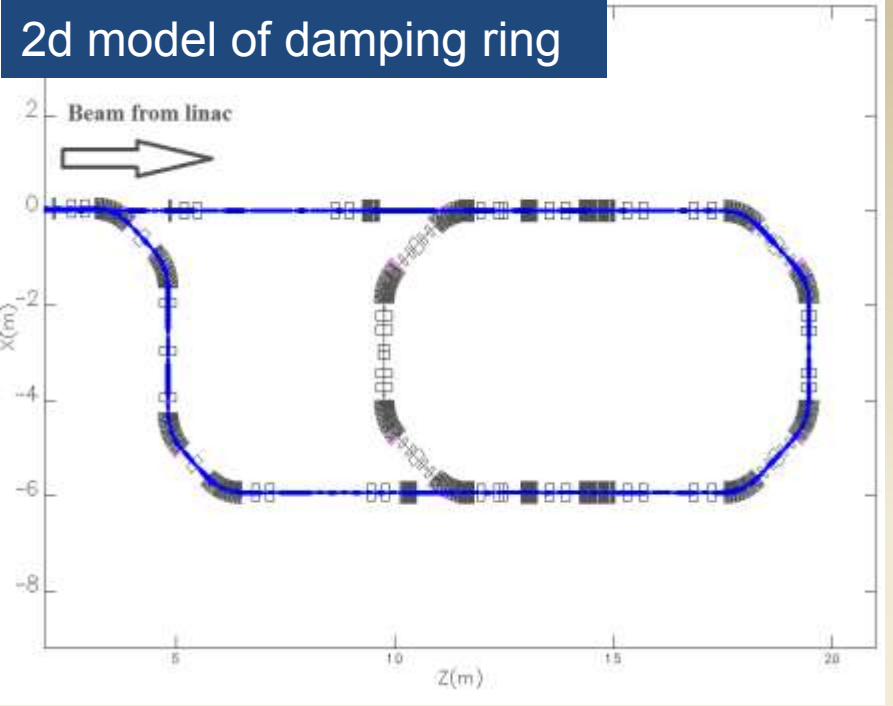
Electron beam on phosphor screen after the tenth acceleration section




Energy spectrum and number of electrons on spectrometer after second acceleration section

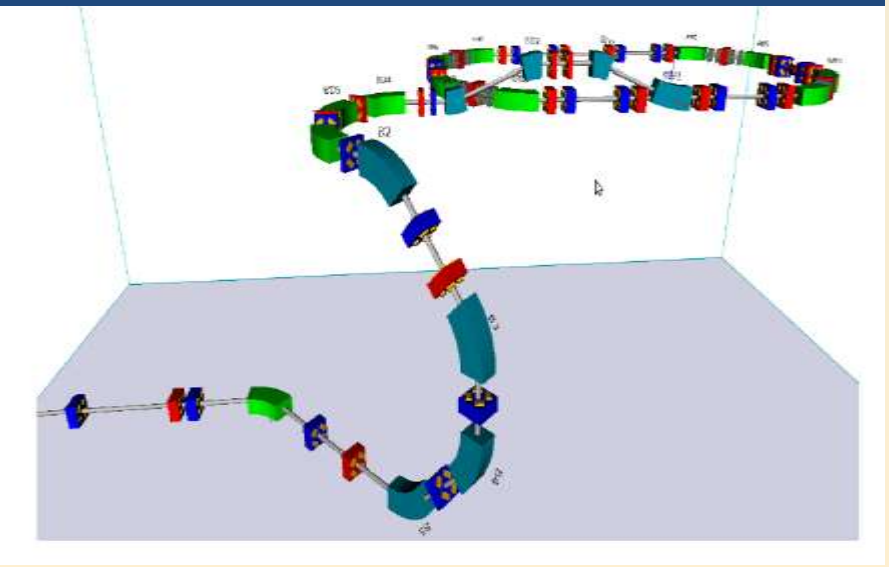
# Design of Damping ring

## 2d model of damping ring

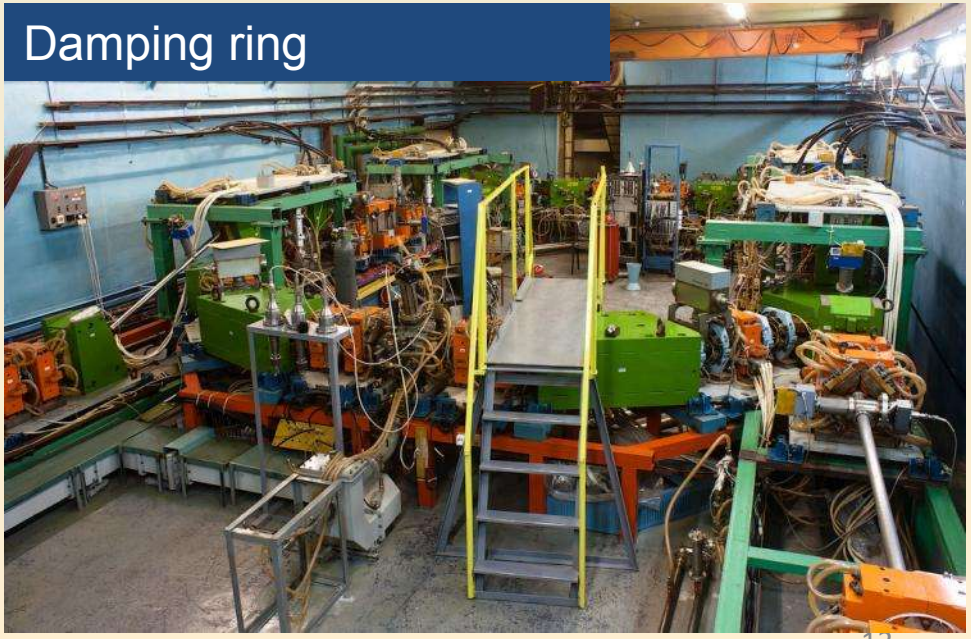



| | |
|---|---|
| Beam energy | 510 MeV |
| Perimeter | 2740 cm |
| RF Frequency | 700 MHz |
| Damping time | 18 msec |
| Horizontal emittance | $2.3 \cdot 10^{-6}$ rad·cm |
| Vertical emittance | $0.5 \cdot 10^{-6}$ rad·cm |

## 3d model of damping ring and extraction line

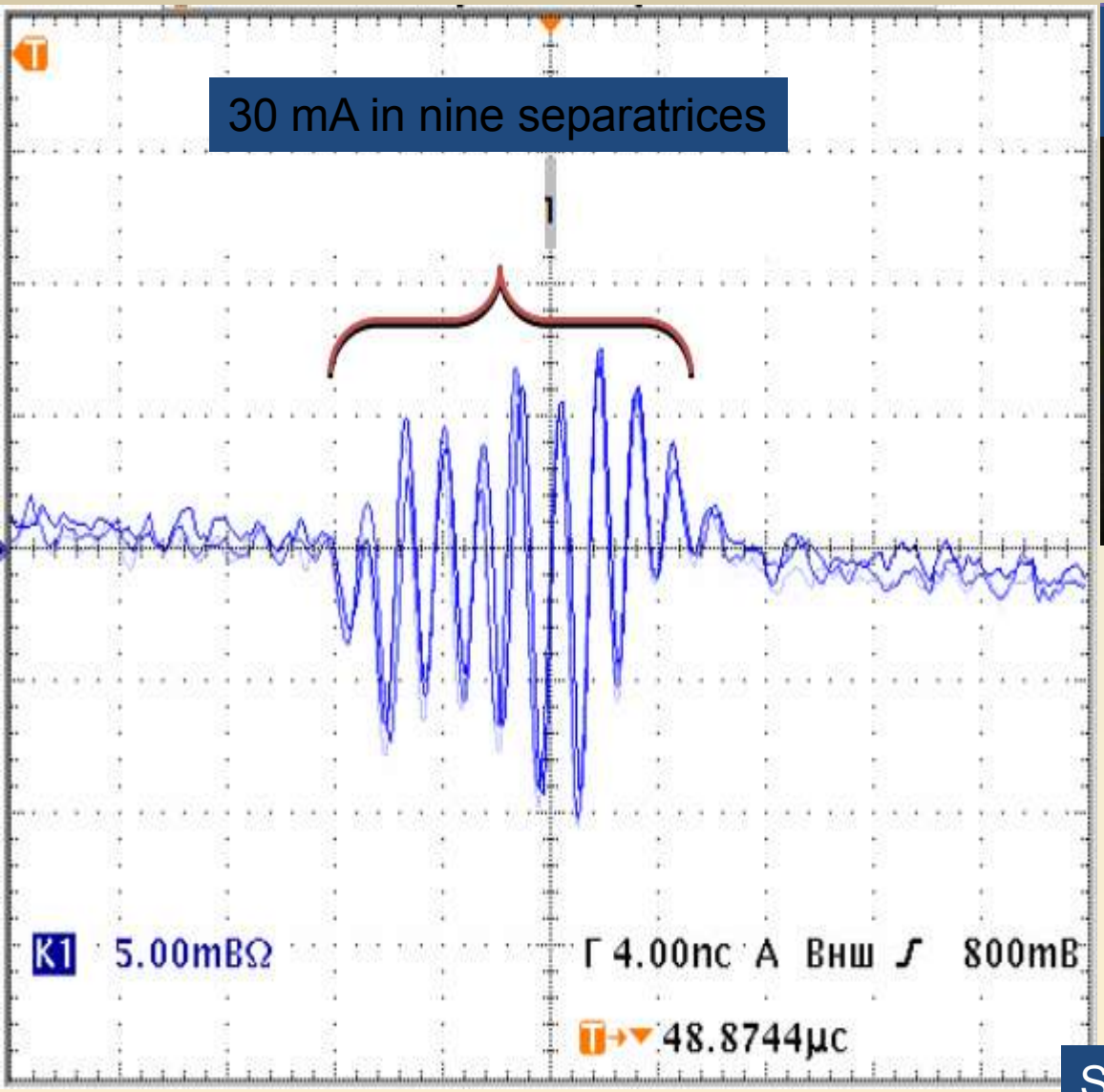


## Damping ring

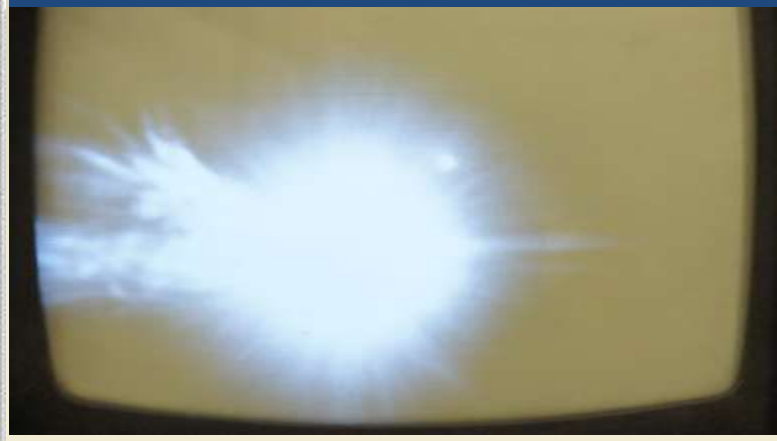


# Results of damping ring commissioning

| Damping ring and positrons | |
|---|---|
| Maximum current e+ | 70mA ($4\cdot 10^{10}$) |
| Storage rate | $2.5\cdot 10^{8}$/c |
| Injection rate | 12.5 Hz |
| Energy of e+ | 420 MeV |
| Damping ring and electrons | |
| Maximum current e- | 160mA ($9\cdot 10^{10}$) |
| Energy of e- | 360 MeV |
| Storage rate | $1.8\cdot 10^{9}$/c |

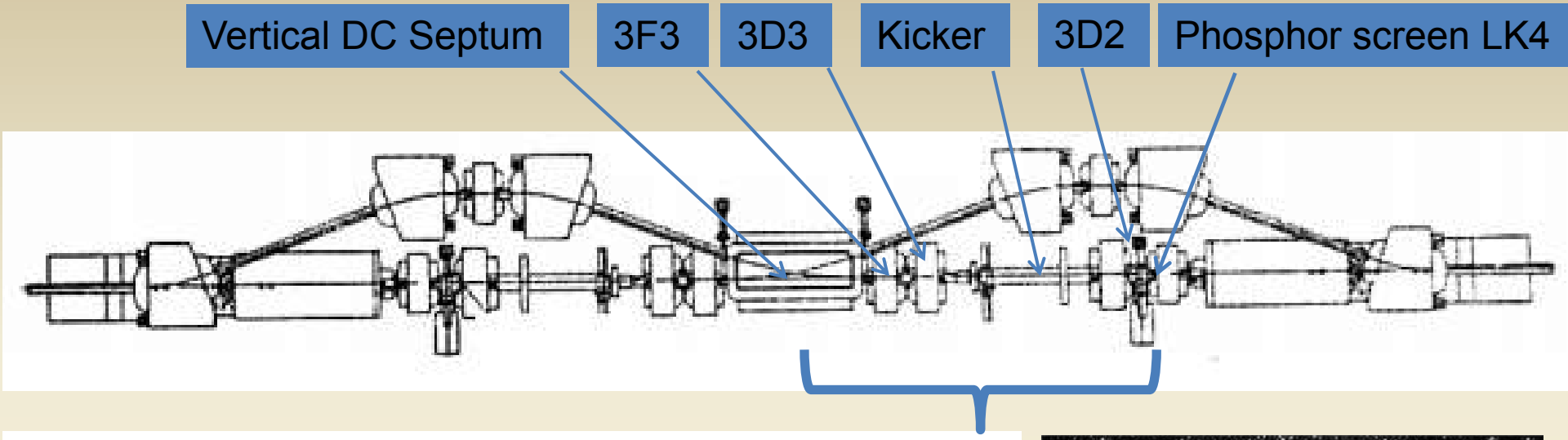


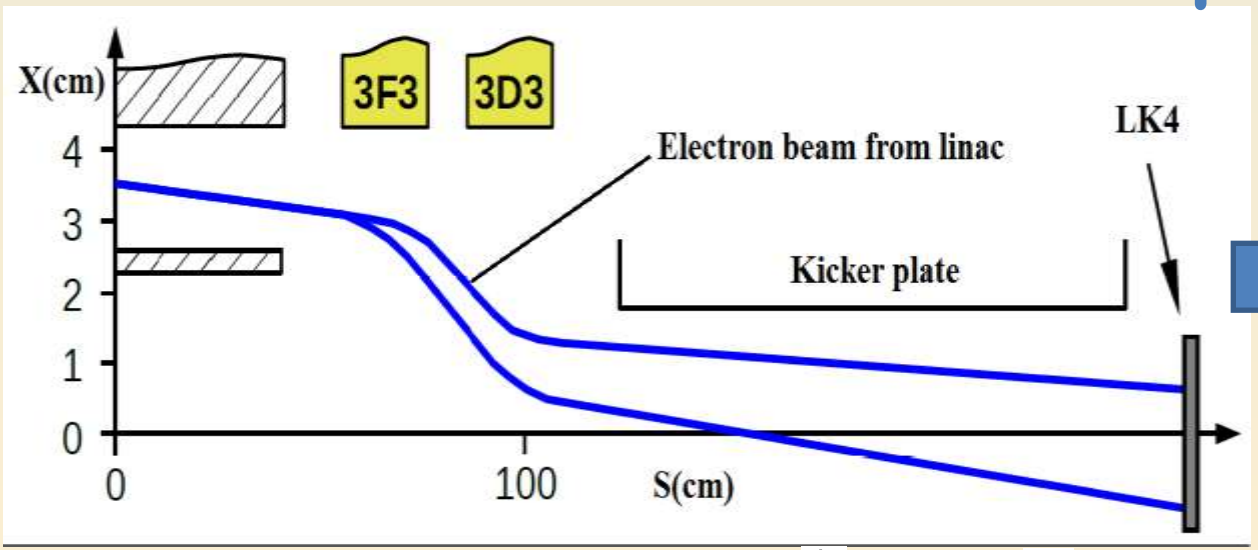

Synchrotron radiation in damping ring

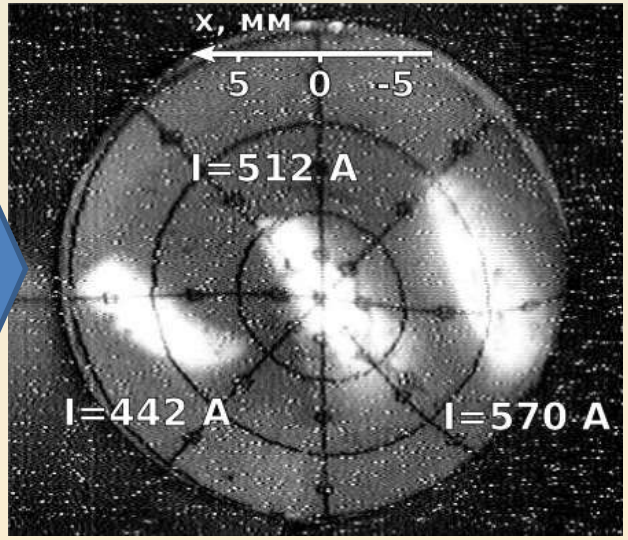


Synchrotron radiation in damping ring after detuning of sextupole lens

# Injection angle measurement



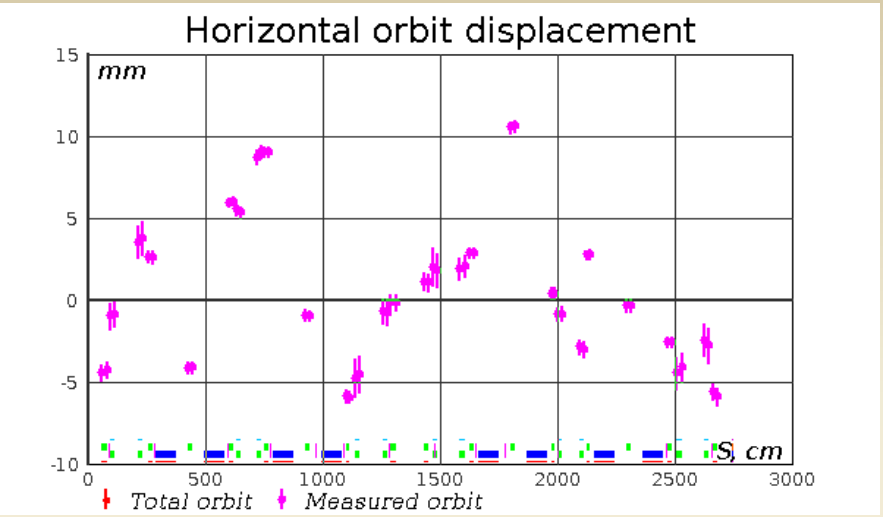

$$\begin{pmatrix} x \\ x' \end{pmatrix} = \begin{pmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{pmatrix} \begin{pmatrix} x_0 \\ x_0' \end{pmatrix}$$

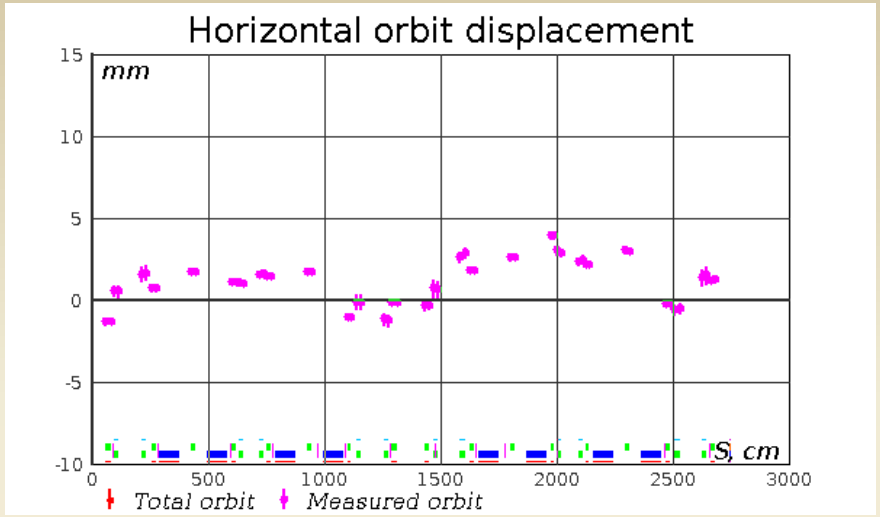
$$\begin{cases} R11(I1)x_0 + R12(I1)x_0' = x1 \\ R11(I2)x_0 + R12(I2)x_0' = x2 \end{cases}$$

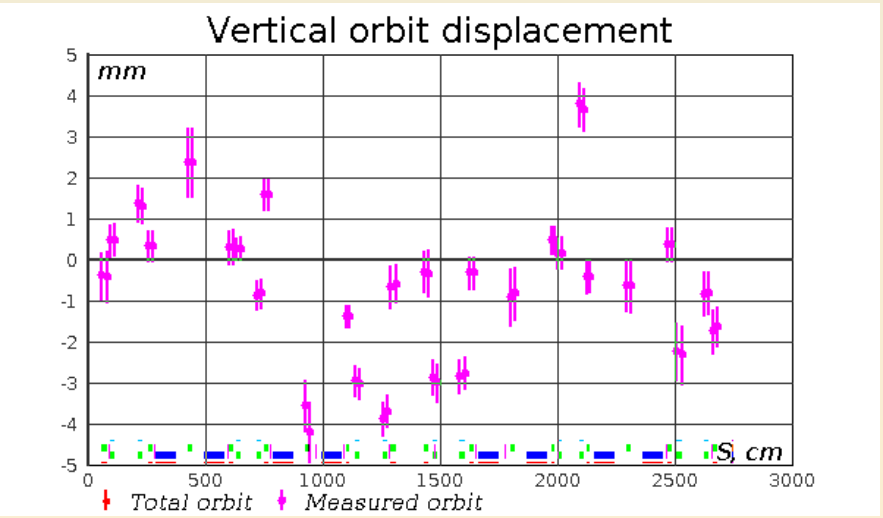
[redacted]

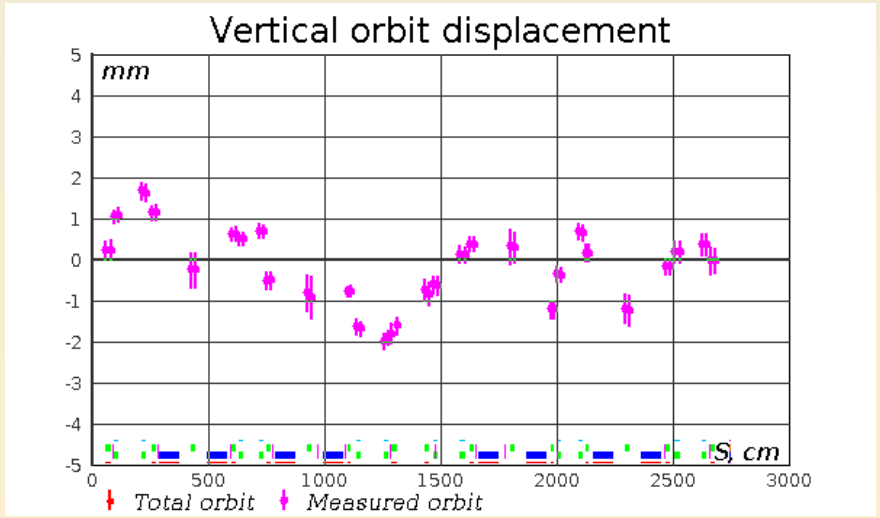
Change 3F3 current (two iterations) and calculate transport matrix(Septum to luminophore LK4)

# Closed orbit correction



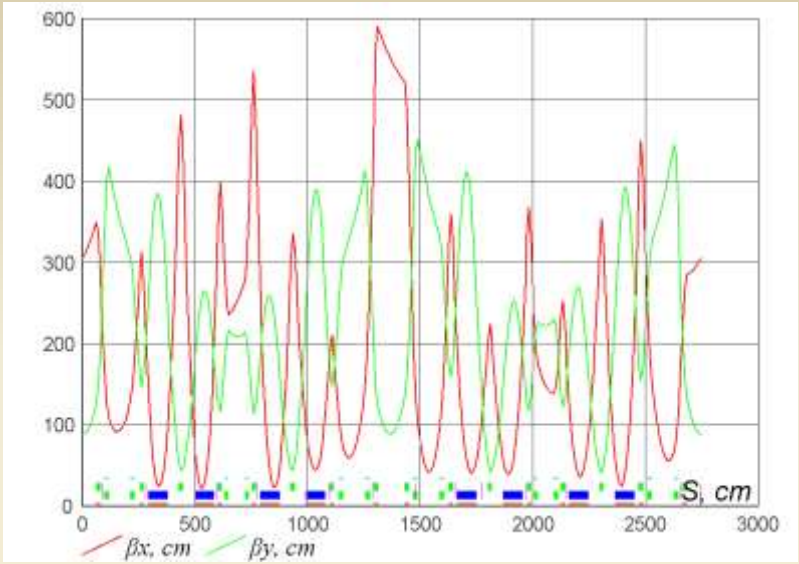



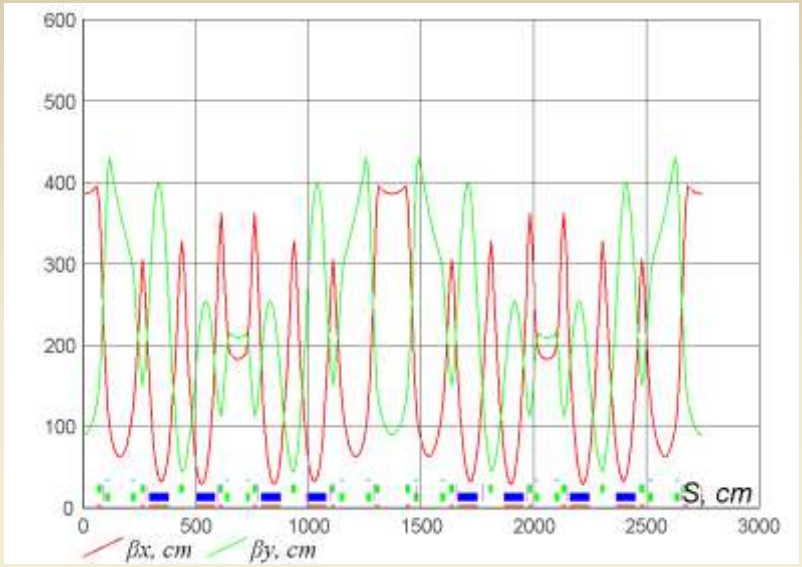

Closed orbit correction was done with respect to the quadrupole magnetic centers. To do so closed orbit responses to the gradient variations of the individual quadrupoles.

# Lattice correction

Uncorrected beta functions in VEPP 5 Damping ring

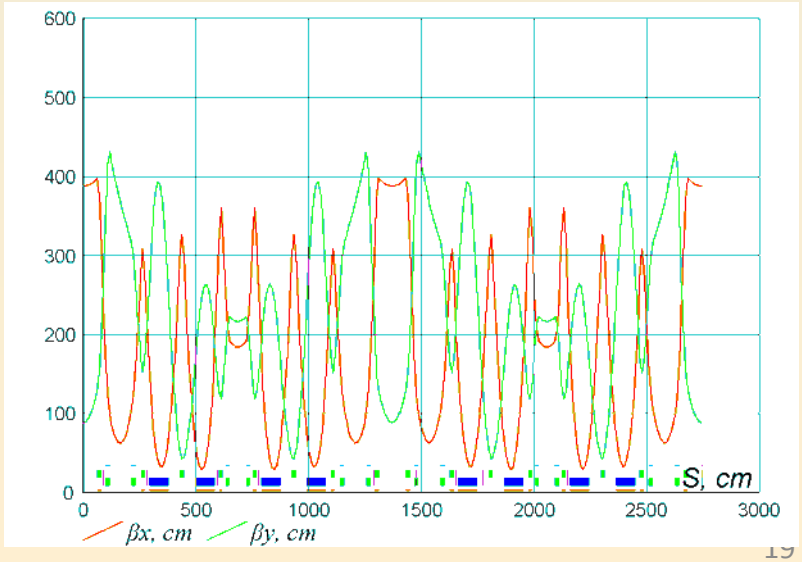



Corrected beta functions in VEPP 5 Damping ring (after four iterations)



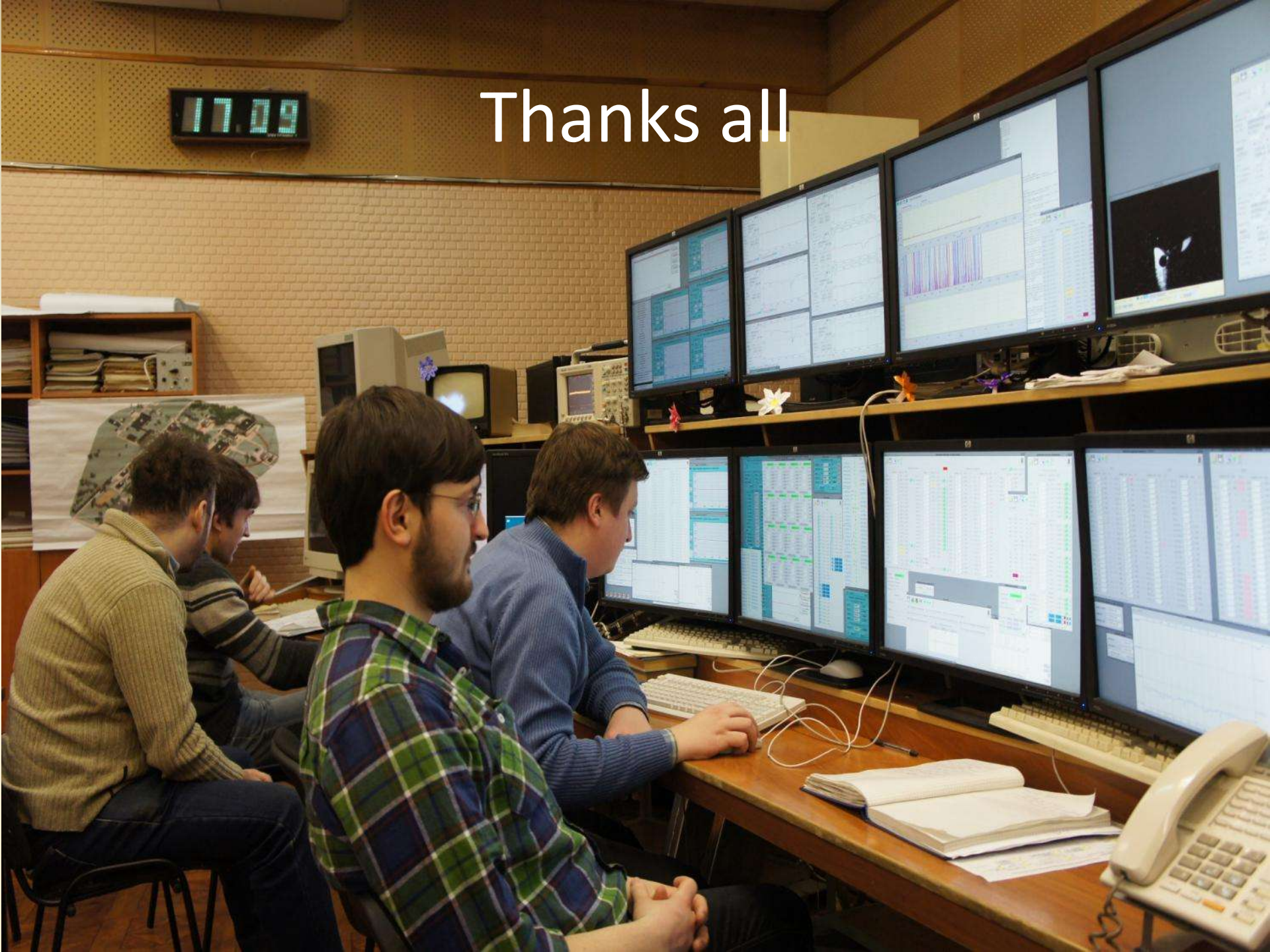

First betatron tunes were set to the project values. After that software "sixdsimulation" developed for VEPP-2000, was applied to correct linear lattice . It took 4 iterations to correct linear lattice by fitting the model to the experimental data composed of closed orbit responses to the all dipole correctors, dispersion, and betatron tunes. **After last iteration the fitted model didn't show significant variation from the ideal configuration.**

Project beta functions in VEPP 5 Damping ring



# Summary

The VEPP-5 Injection Complex should be running with project parameters in the near future. Damping ring of the Complex stores the electron beams of 350 MeV today. Storage rate is $3 \bullet 10^9$ electrons per pulse and maximum store current is 160 mA, which exceeds design parameters. Beam transfer line to the BINP colliders is completely assembled and ready for beam accepting. The Damping ring optics were tuned to improve the Complex stability.


Thanks all