Status and Progress VEPP-2000

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BINP,Novosibirsk

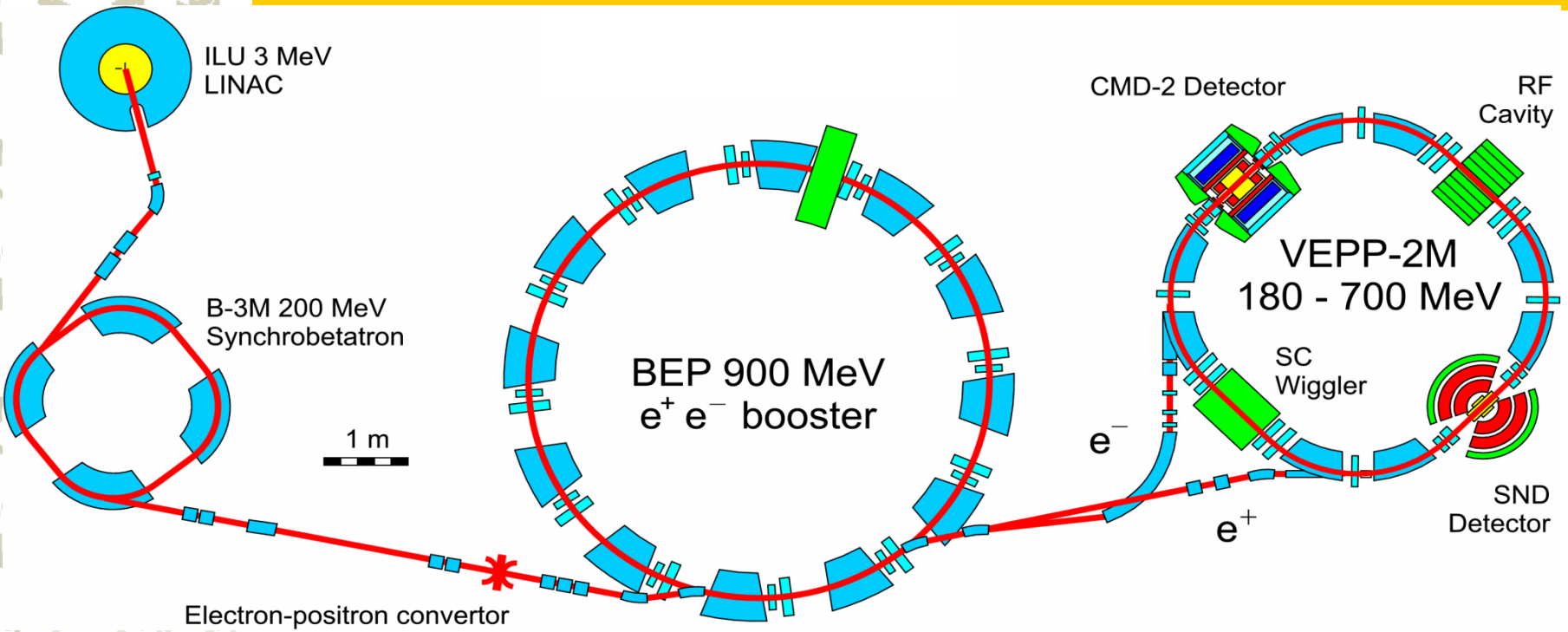
RUPAC-08, Zvenigorod. 28.09.08 – 3.10.08

OUTLINE

- VEPP-2M → VEPP-2000
- Round beams - a way to increase luminosity.
- How to make beams round
- VEPP-2000 systems: magnets, RF, vacuum, control and diagnostics
- First beam
- Round beam
- Beam-beam study
- Detectors CMD-3 and SND
- Physics at VEPP-2000
- Conclusion

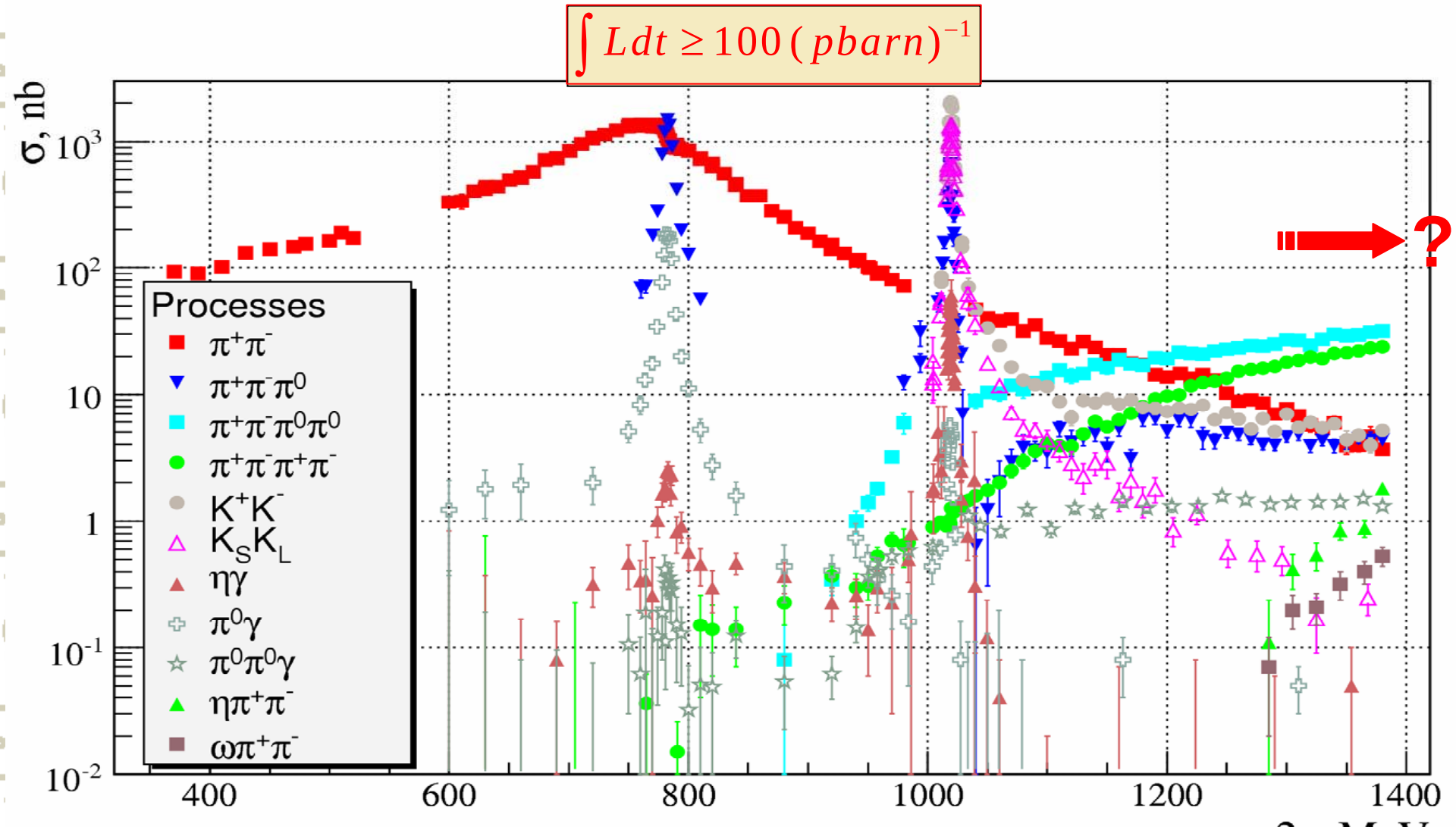
VEPP-2M collider complex

(1974-2000)



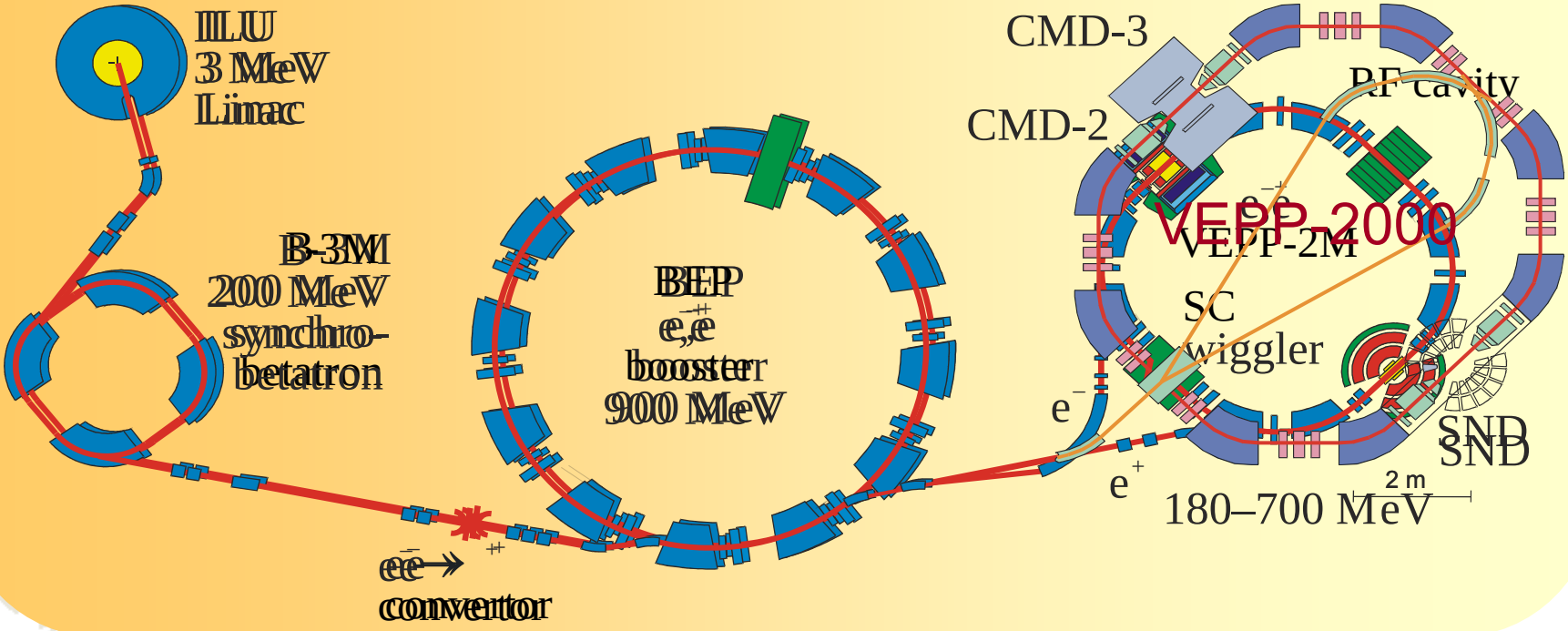
- High luminosity: $L=5\times10^{30}cm^{-2}s^{-1}$:
- Radiative polarization
- Spin precession frequency measurements
- $\rho, \omega, \varphi, K^{\pm}, K^{0}$ mass measurements
- e^+e^- anomalous magnetic moment comparison (10^{-11})

Overview of VEPP-2M results



VEPP-2M → VEPP-2000

(2000-2007)



- E ≈ 1 GeV (per beam)
- L ≈ 1×10^{32} cm^{-2} sec^{-1} (1×1 bunch)

Increasing of Luminosity

- Number of bunches (i.e. collision frequency)
- Bunch-by-bunch luminosity

$$L = \frac{\pi \gamma^2 \xi_x \xi_y \varepsilon_x f}{r_e^2 \beta_y^*} \left(1 + \frac{\sigma_y}{\sigma_x}\right)^2$$

Round Beams:

$$L = \frac{4\pi \gamma^2 \xi^2 \varepsilon f}{r_e^2 \beta^*}$$

✓Geometric factor (gain=4)

✓Beam-beam limit enhancement

$$\xi_{x,y} \geq 0.1$$

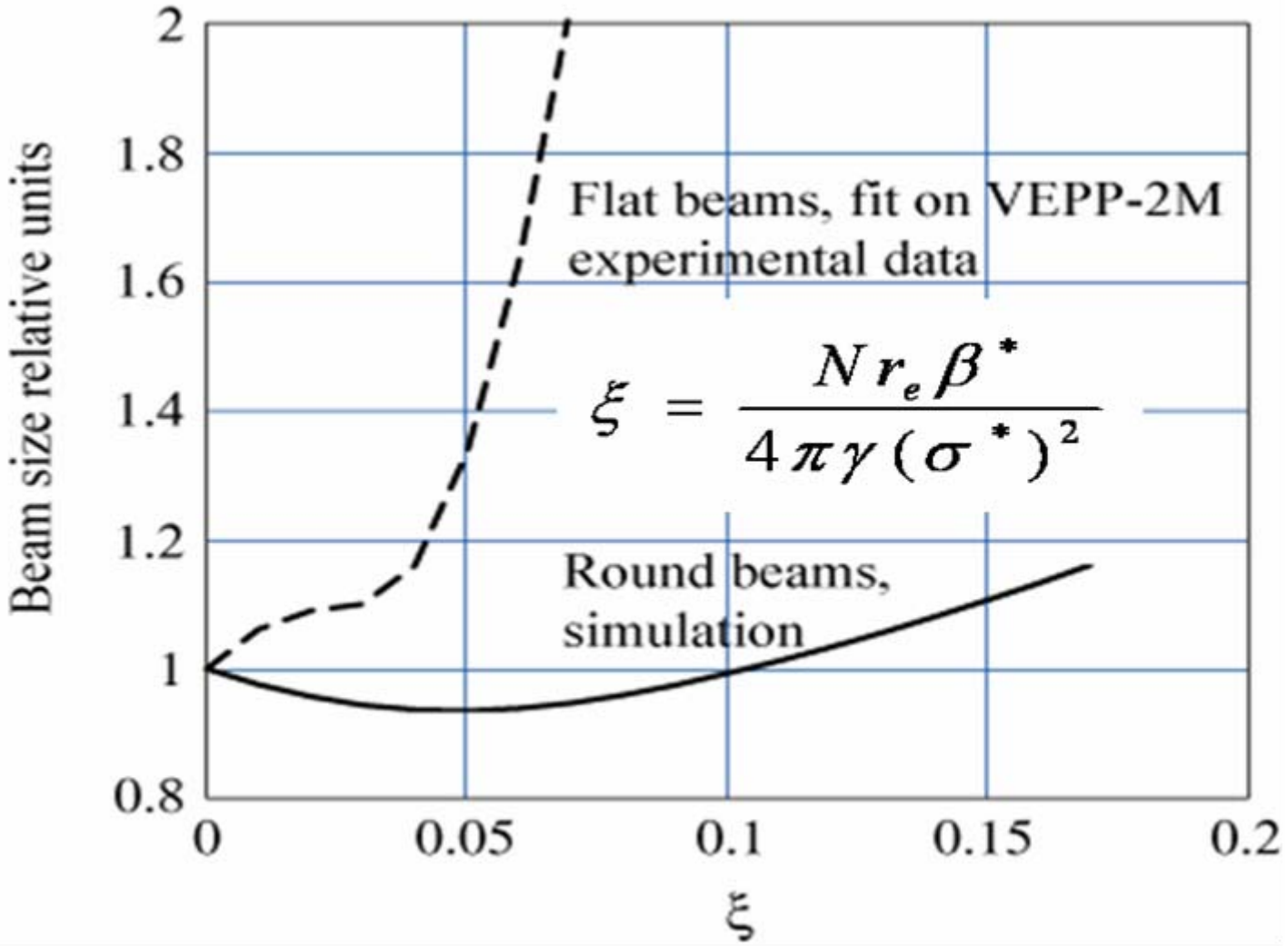
The Concept of Round Colliding Beams

- Angular momentum conservation! $M_z = x'y - xy'$
- Small and equal β-functions at IP: $\beta_x = \beta_y$
- Equal beam emittances: $\varepsilon_x = \varepsilon_y$
- Equal betatron tunes: $\nu_x = \nu_y$
- Small and positive fractional tunes

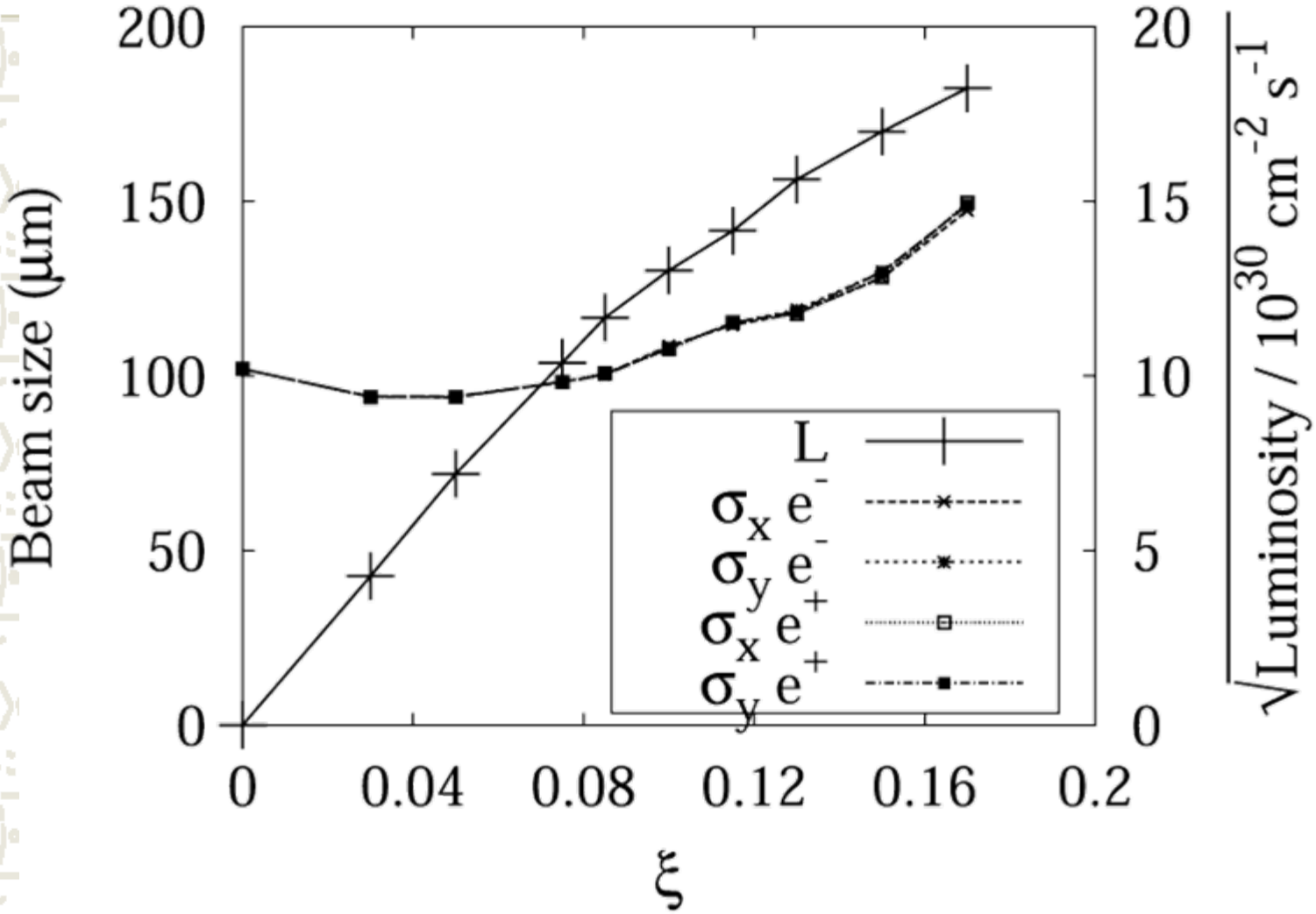
(V.V.Danilov et al., EPAC'96, Barcelona, p.1149, (1996))

Vertical size dependence on beam- beam parameter ξ

"Weak-Strong" Beam-Beam Simulations



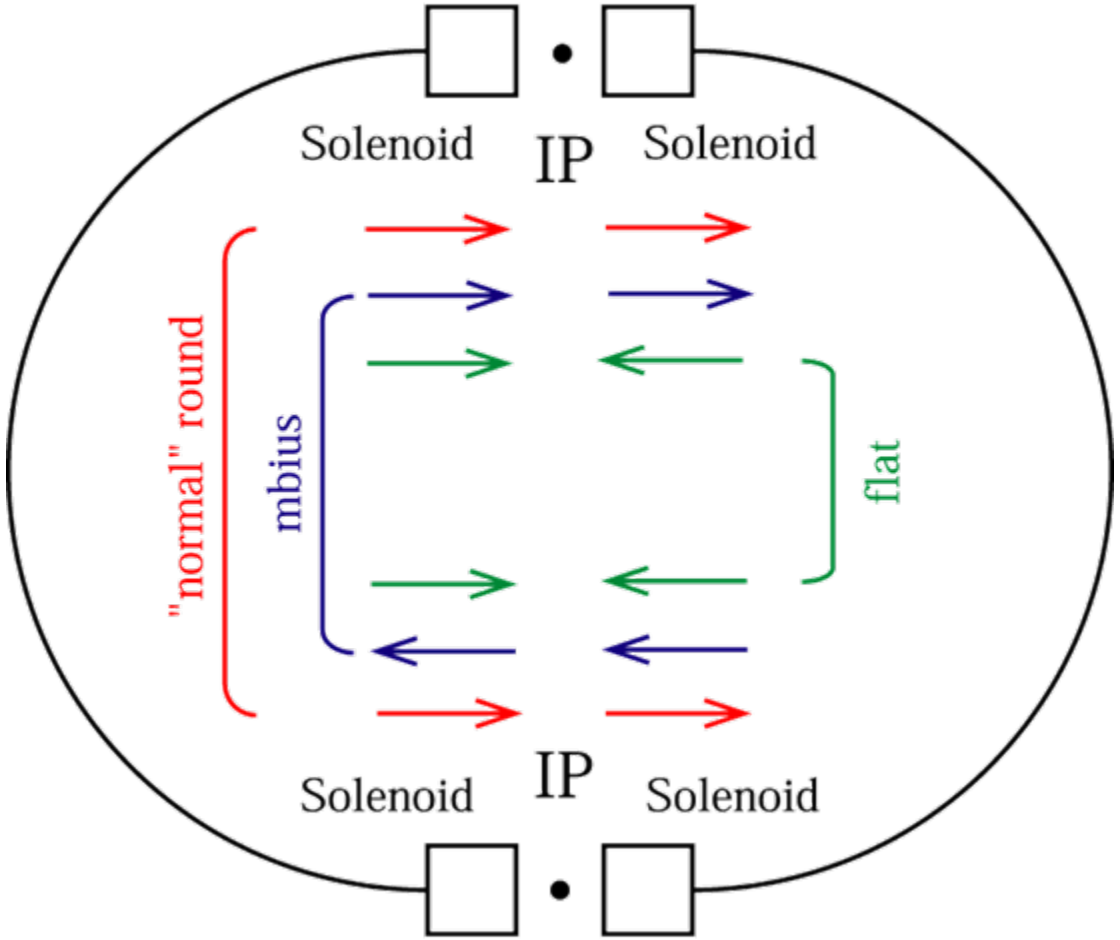
“Strong-Strong” Beam-Beam Simulations



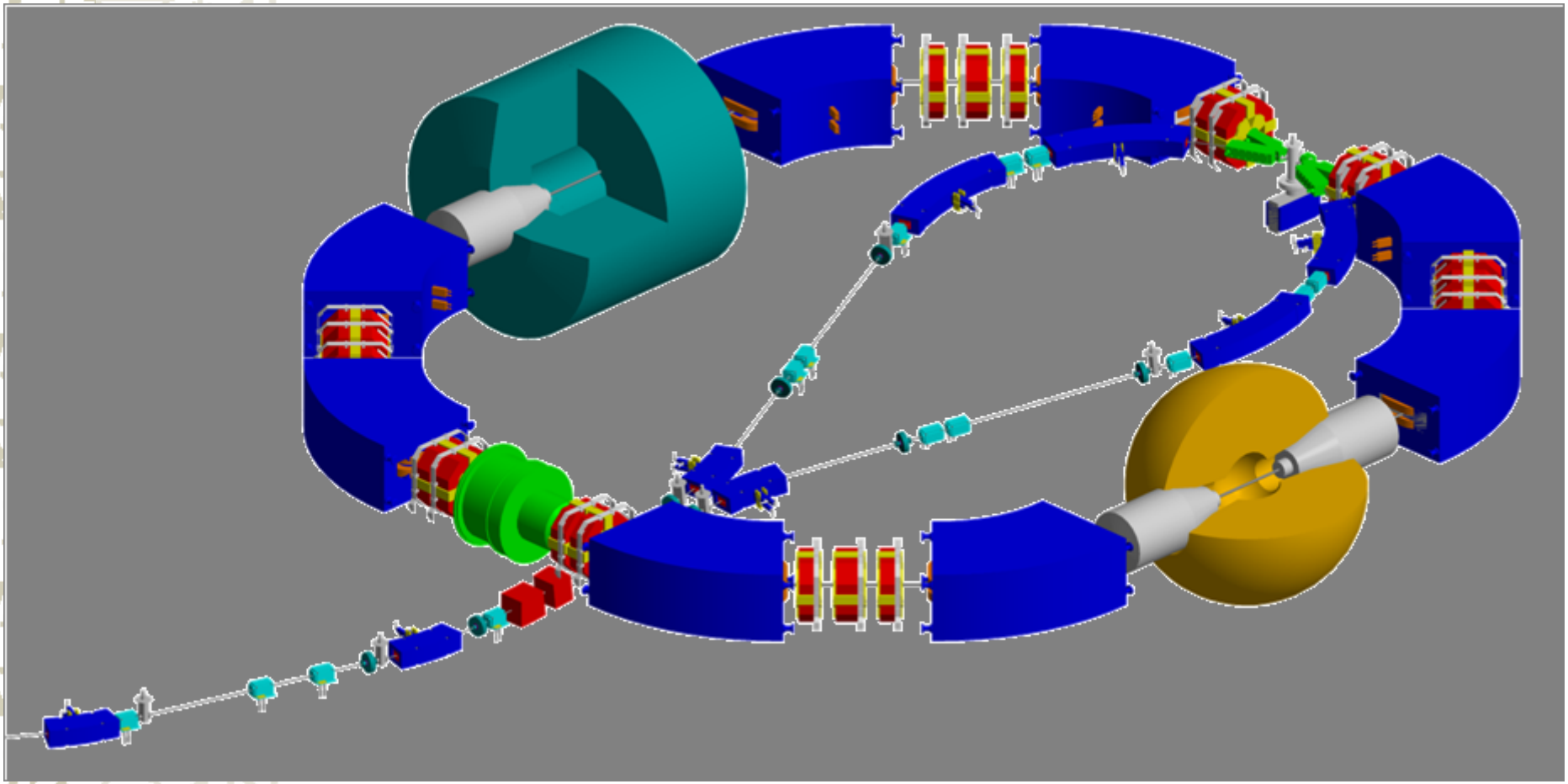
Main Parameters of VEPP-2000

Circumference	**24.38 m**
RF frequency	**172 MHz**
RF voltage	**100 kV**
RF harmonic number	**14**
Momentum compaction	**0.036**
Synchrotron tune	**0.0035**
Energy spread	**6.4×10^{-4}**
Beam emittances (in the round mode)	**1.29×10^{-7} m rad**
Dimensionless damping decrements (x,y,s)	**2.19×10^{-5}, 2.19×10^{-5}, 4.83×10^{-5}**
Betatron tunes	**4.05, 2.05**
Betatron functions at IP	**10 cm**
Number of bunches per beam	**1**
Number of particles per bunch	**1×10^{11}**
Beam-beam parameter (x,y)	**0.075, 0.075**
Luminosity per IP (at 1 GeV)	**1×10^{32} $cm^{-2}s^{-1}$**

Practical Realization of Round Beams: Options for VEPP-2000

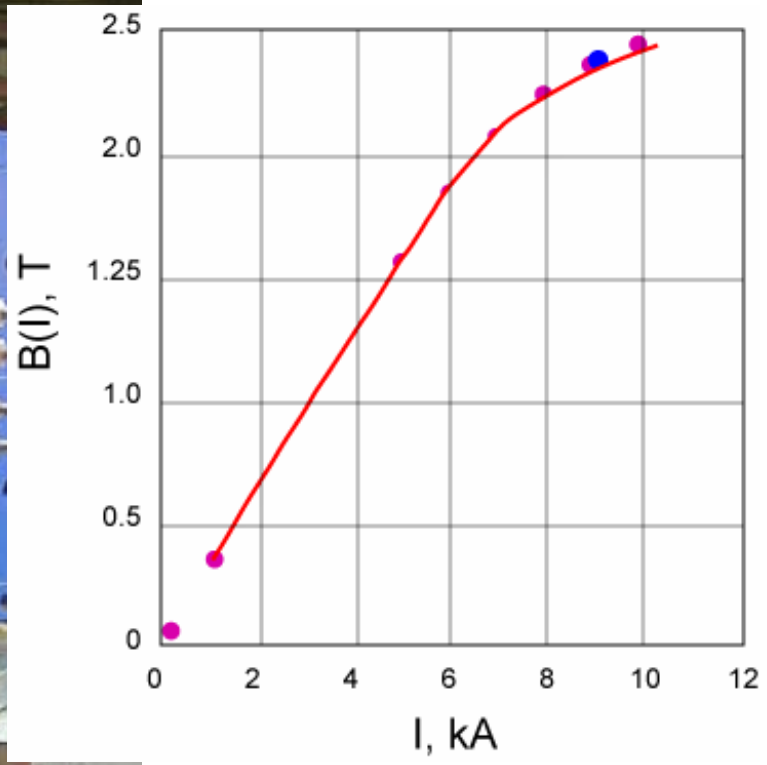


Cartoon of VEPP-2000 Collider



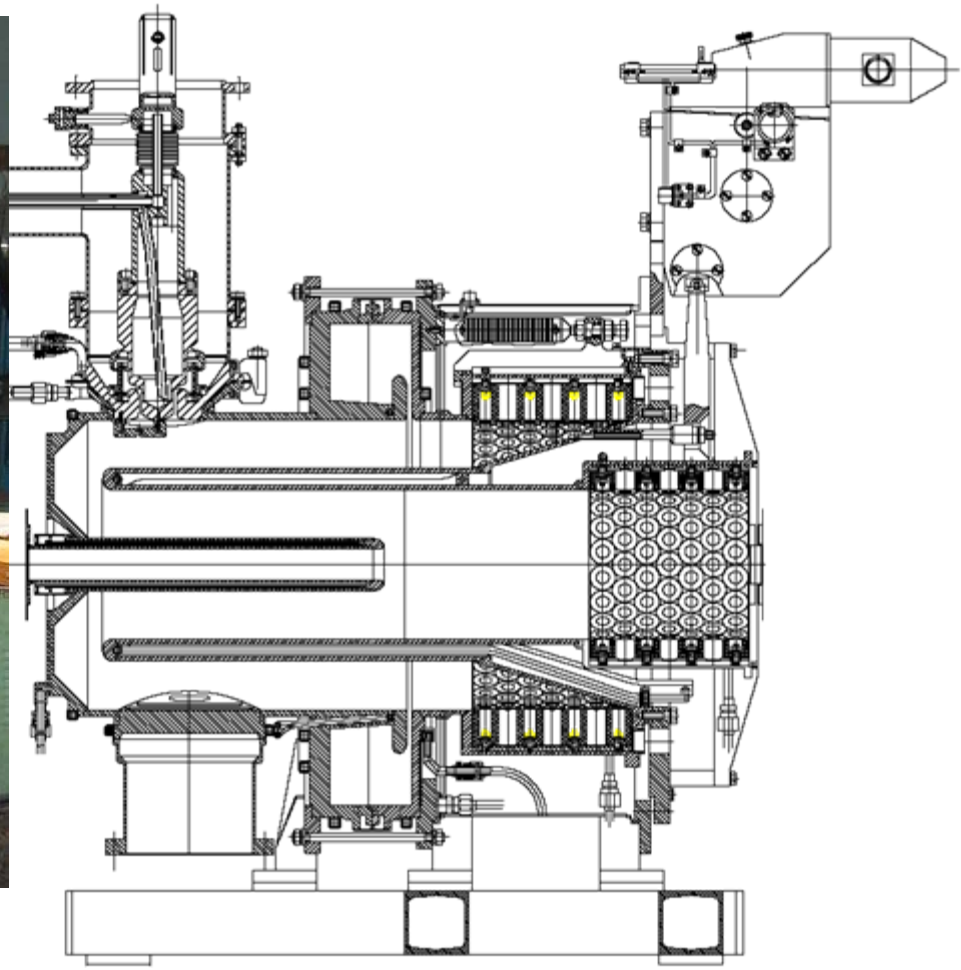
First “mile stones” of VEPP-2000
(14.05.2001)

Dipole Magnet (2.4 T)



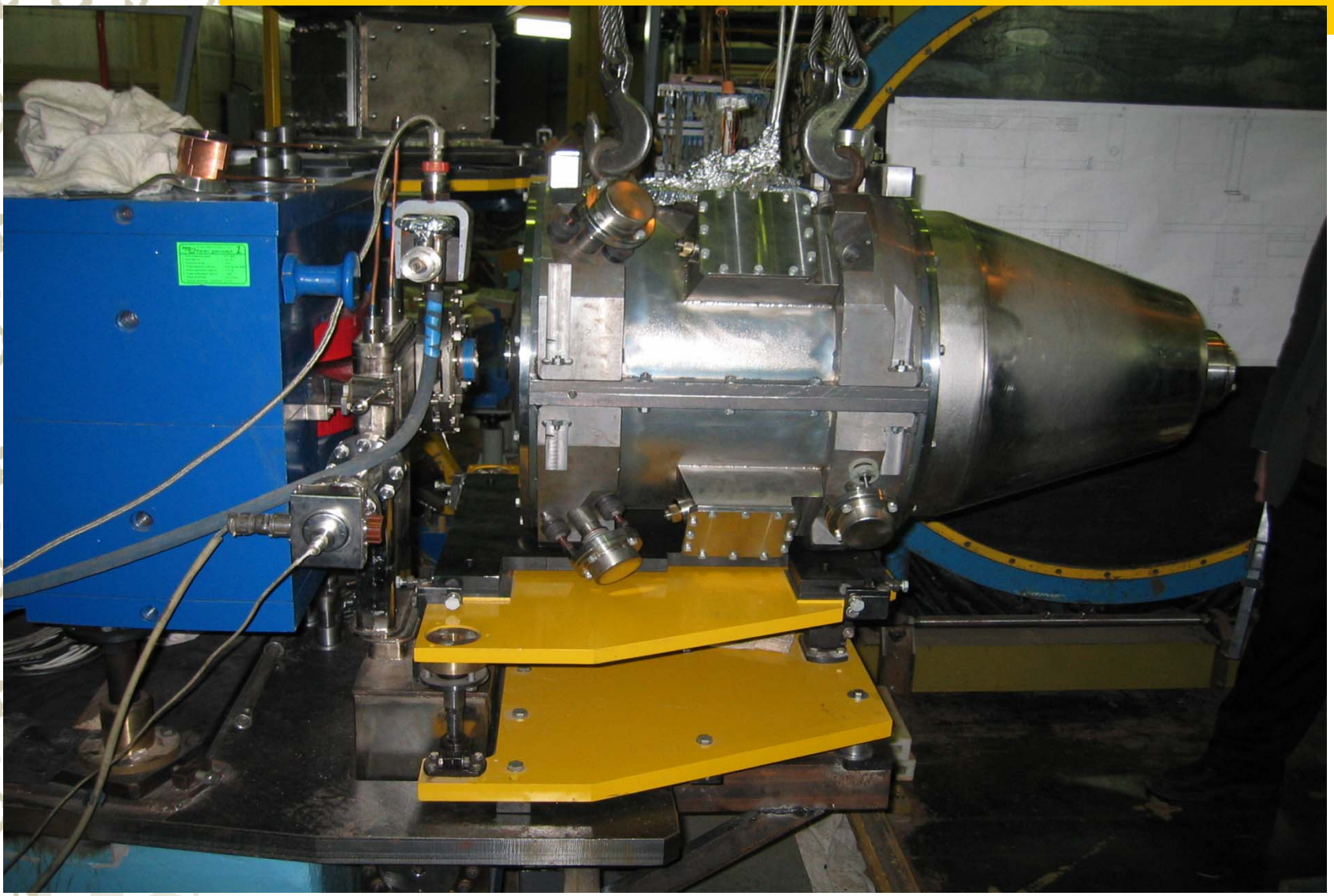
Vacuum chamber and mirror

Single-Mode RF Cavity (172 MHz)

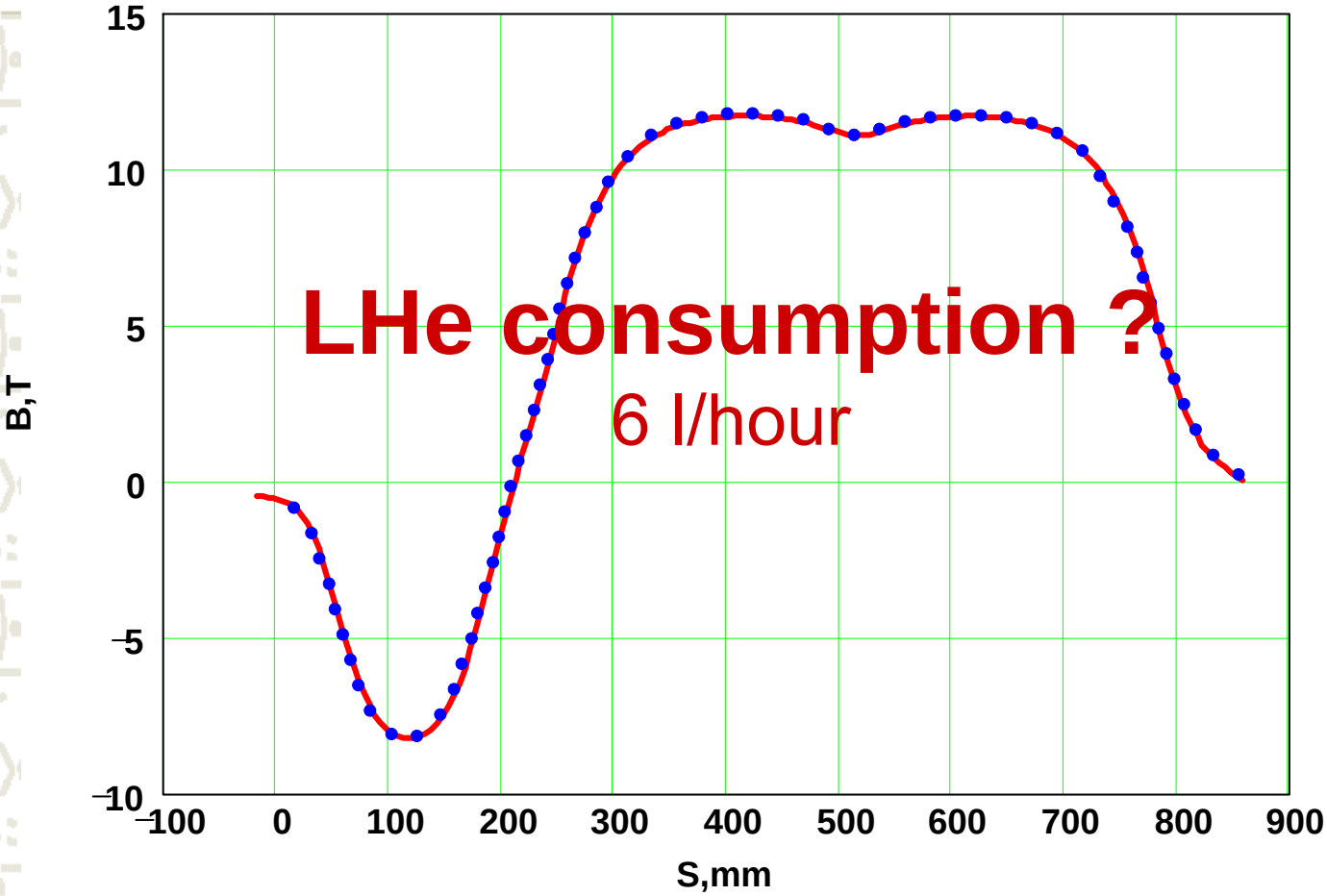


Solenoid 13.0 T

Solenoid 13.0 T at VEPP-2000

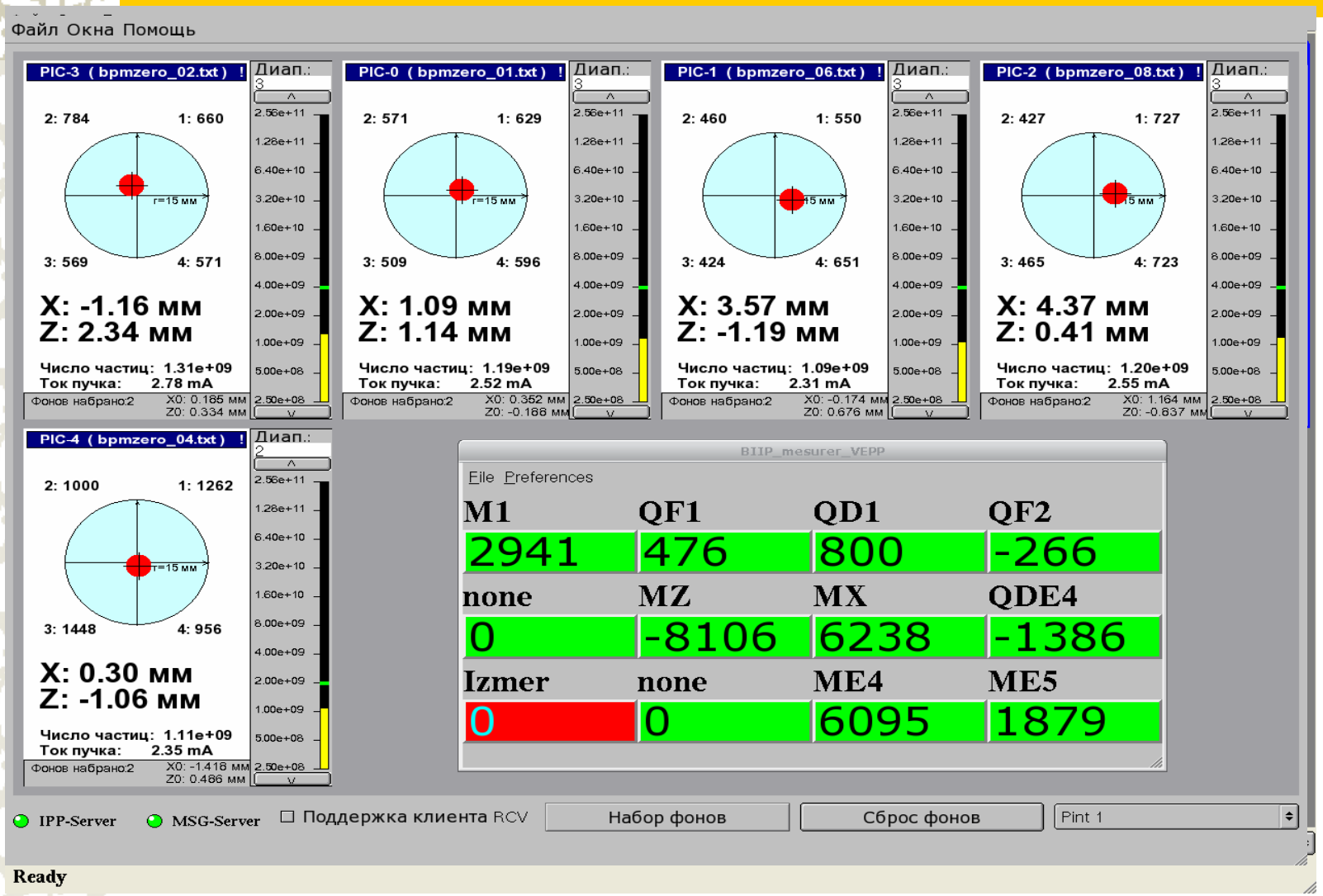


Solenoid Test

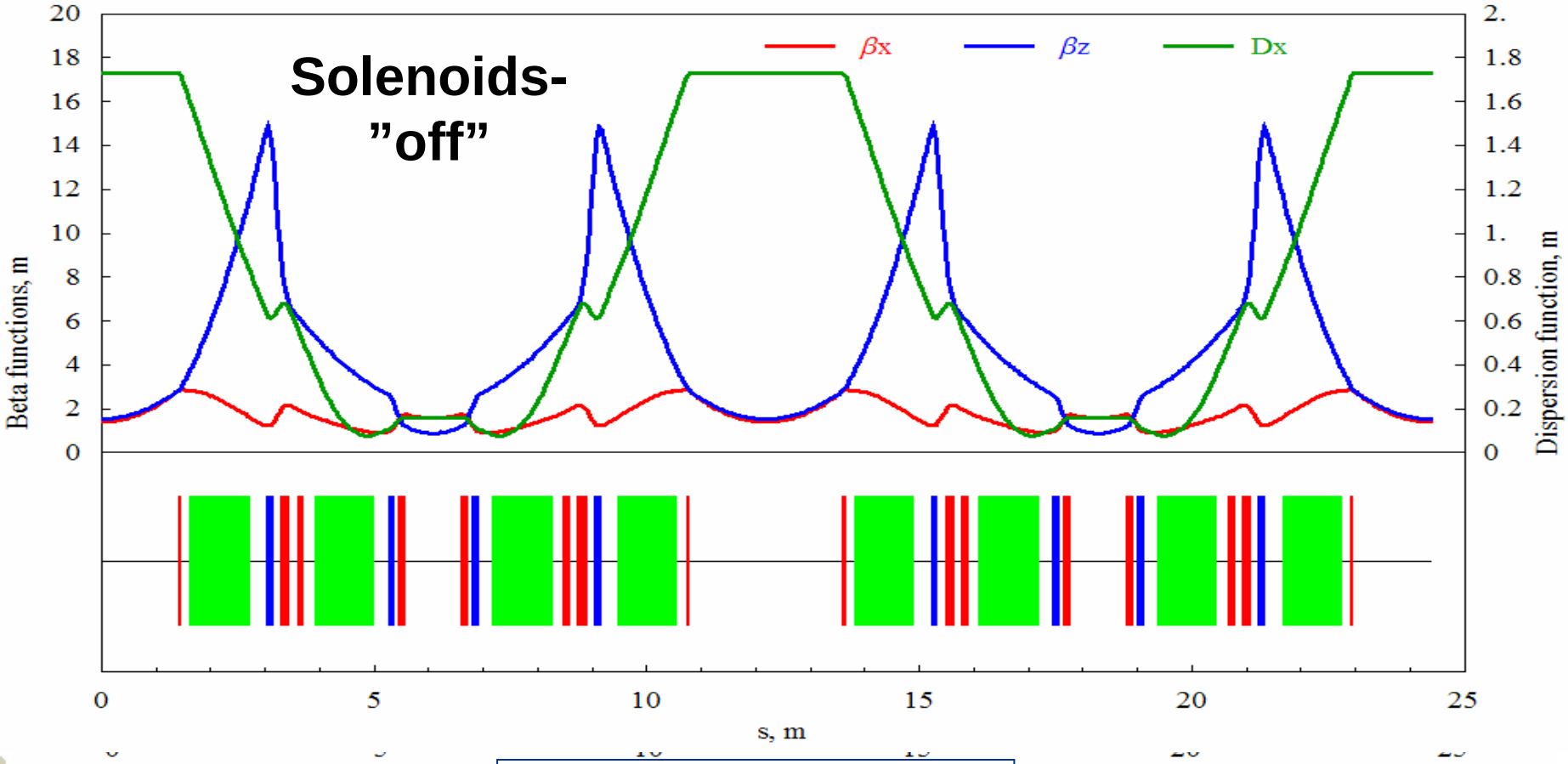


VEPP-2000
(10.01.07)

Beam in Transfer Line

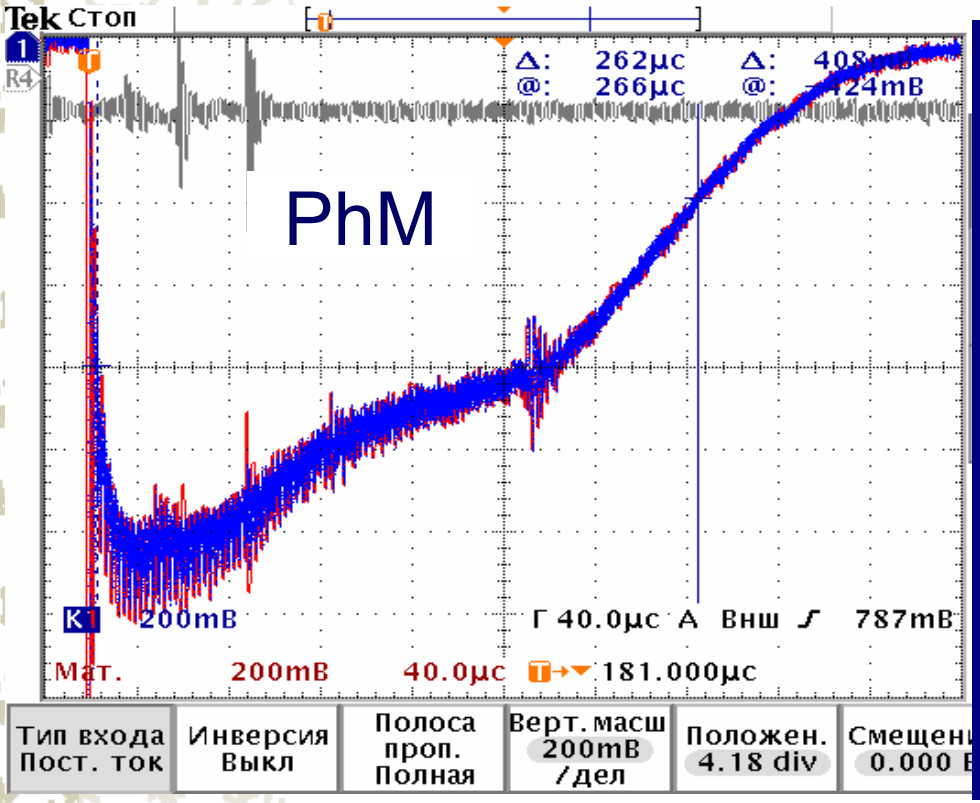


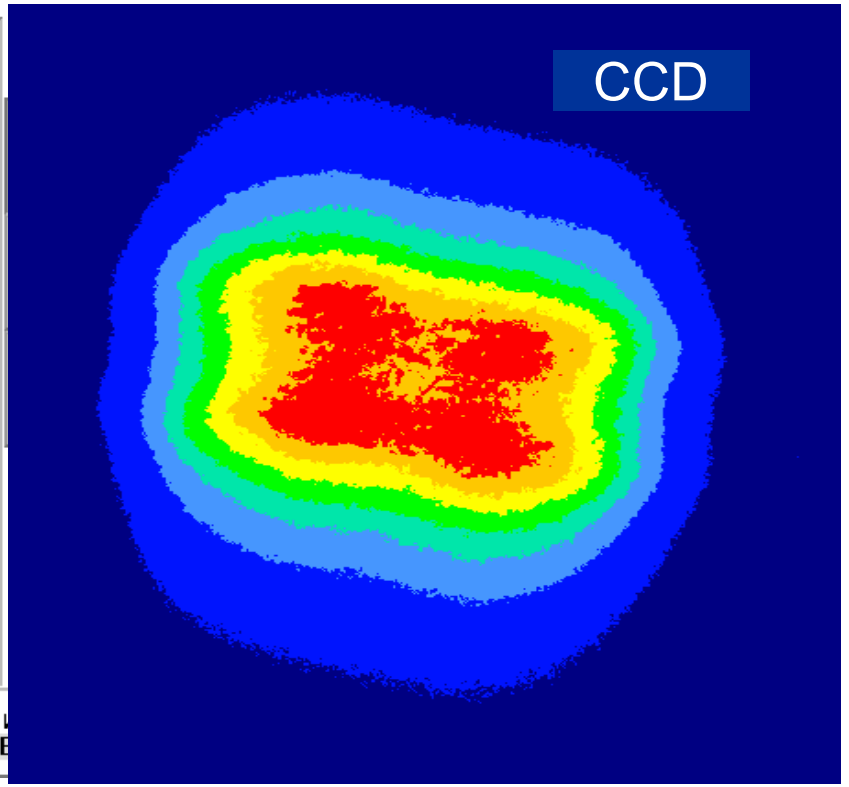
VEPP-2000 Lattice



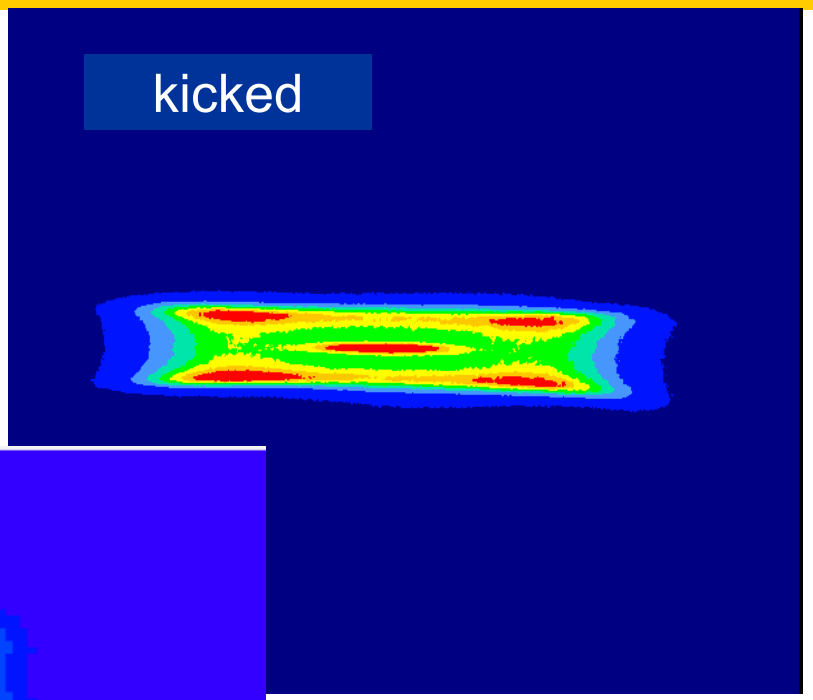
$$\nu_z = 1.38; \quad \nu_x = 2.44$$

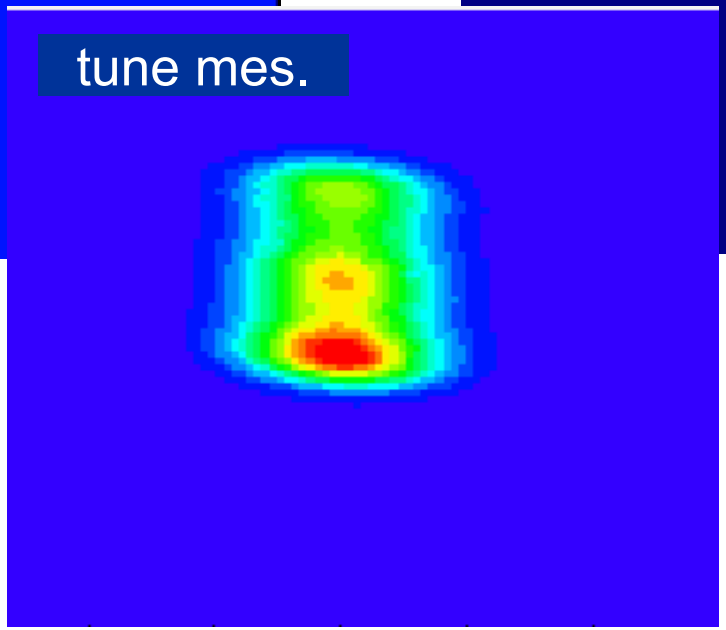
First injection (RF “off”)



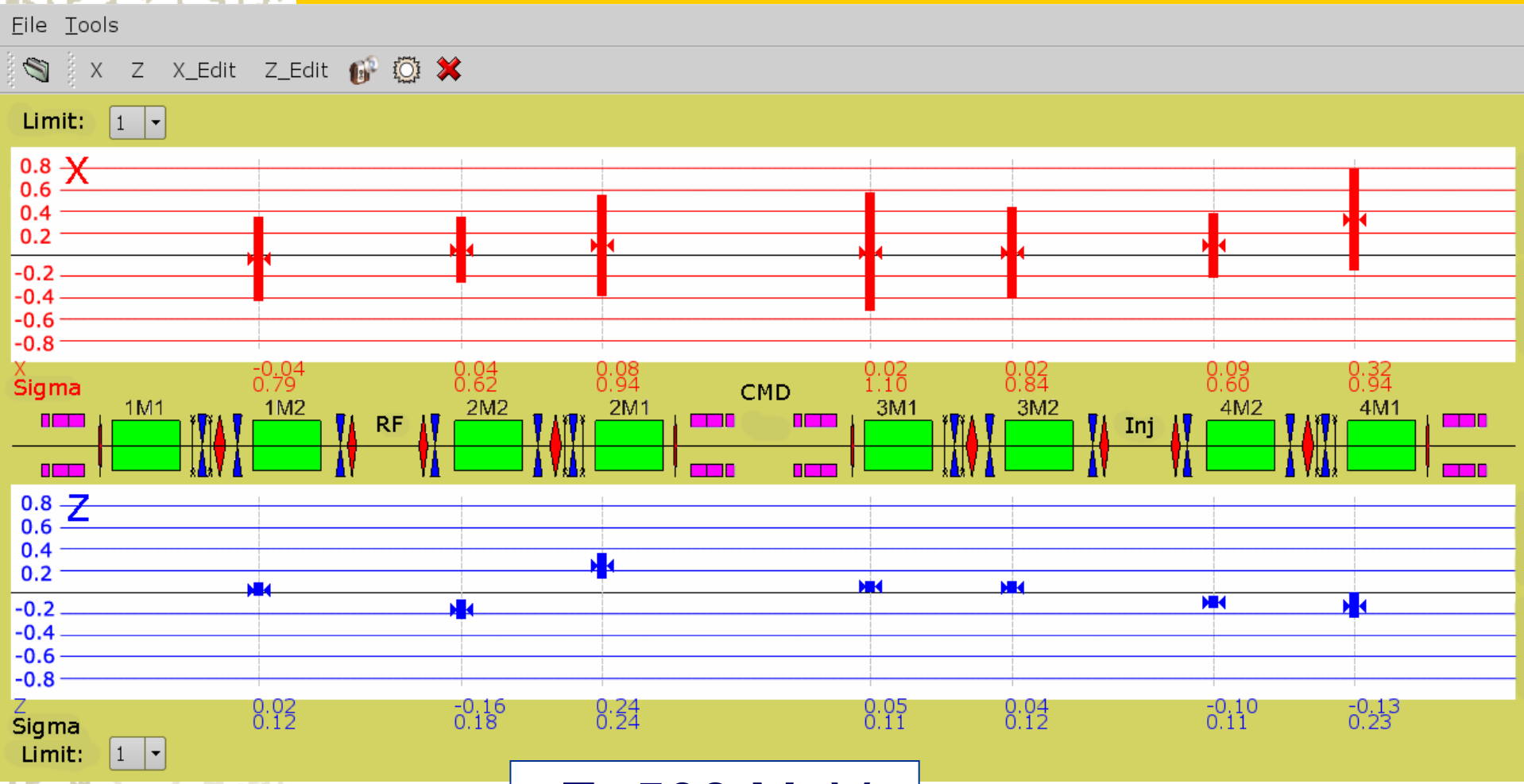


Beam's CCD pictures (RF "on")



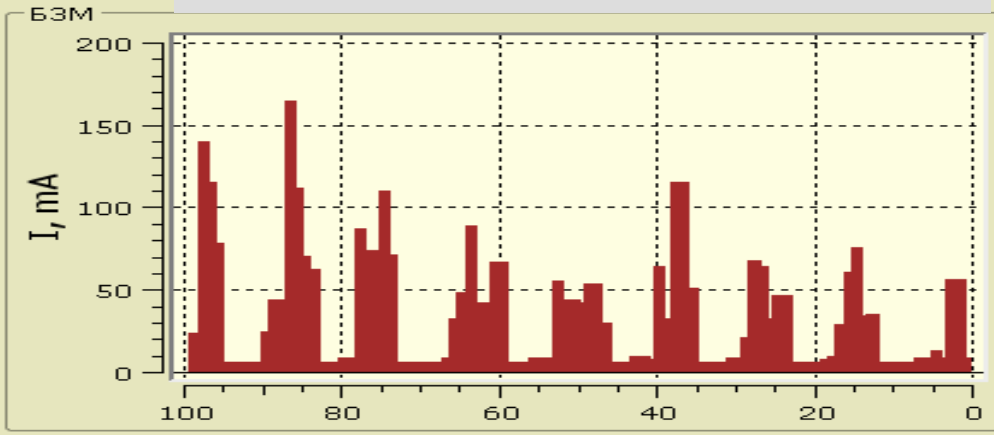


CO and Beam Sizes (weak focusing)

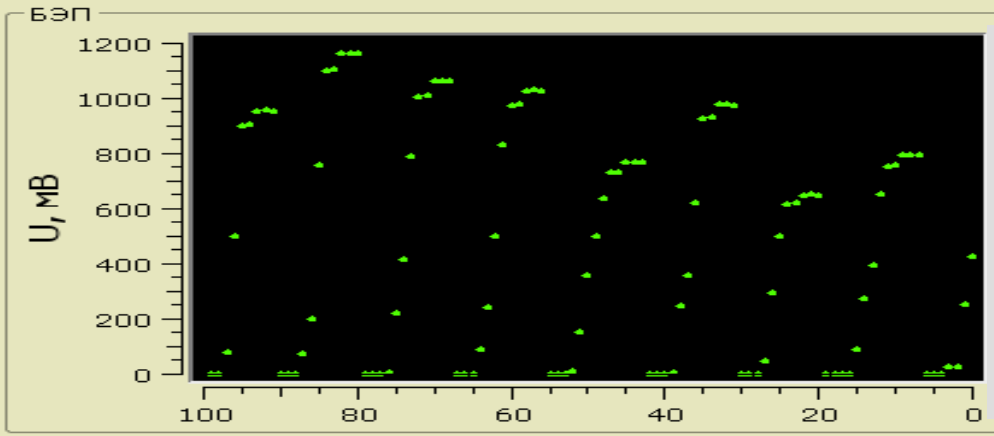


E=508 MeV

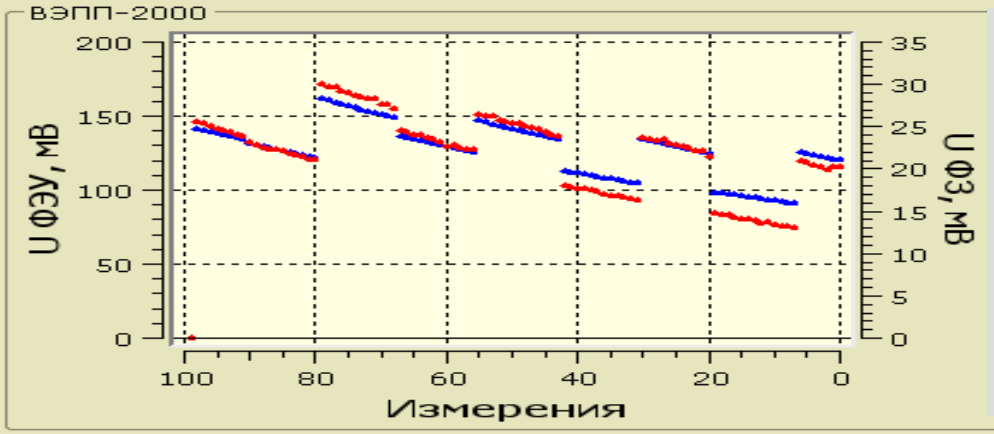
Beam currents



Synchrotron B-3M



Booster BEP



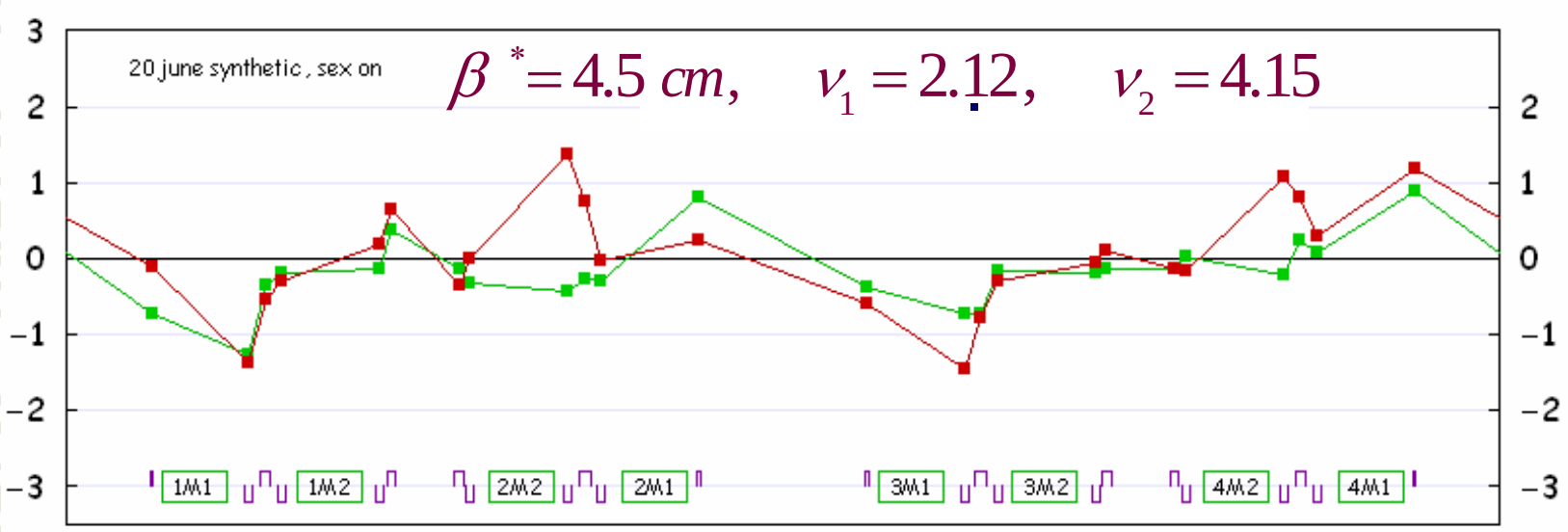
VEPP-2000

$$\tau(150\,mA) \approx 500\,\text{sec}$$

$$\tau(1\,mA) \geq 10\,hours$$

Round beam operation

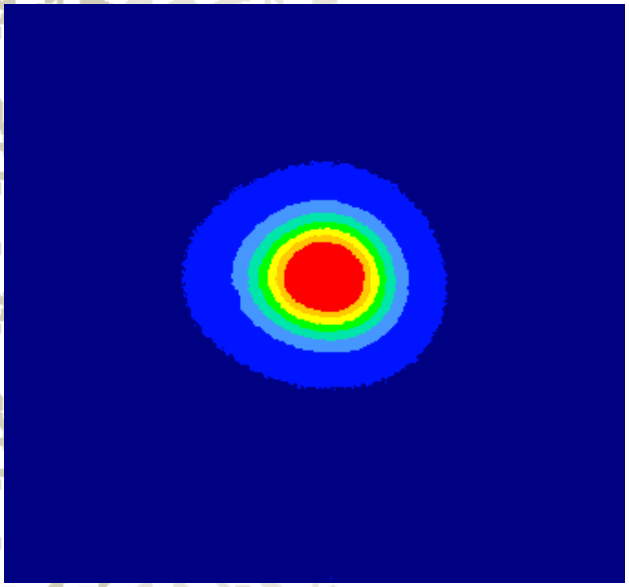
- E = 508 MeV

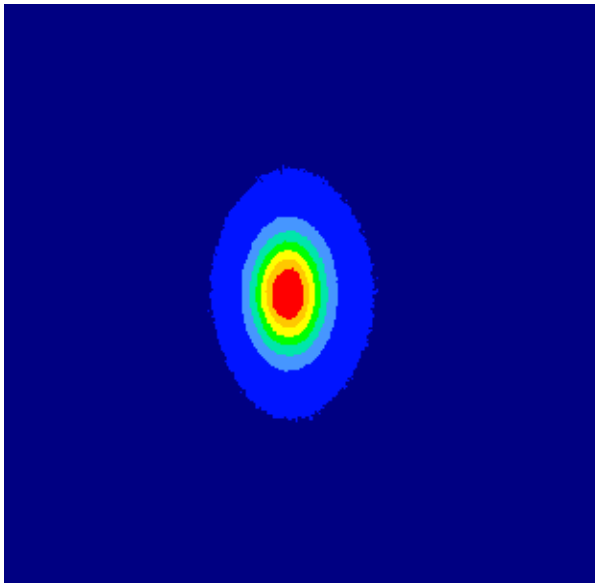


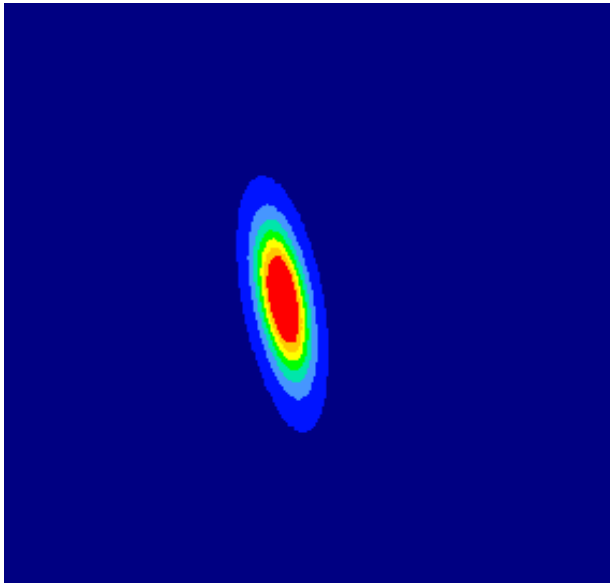
- Orbit response matrices on dipole and quadrupole corrections + Singular values decomposition

Round beams (solenoid field 10 T)

positron beam





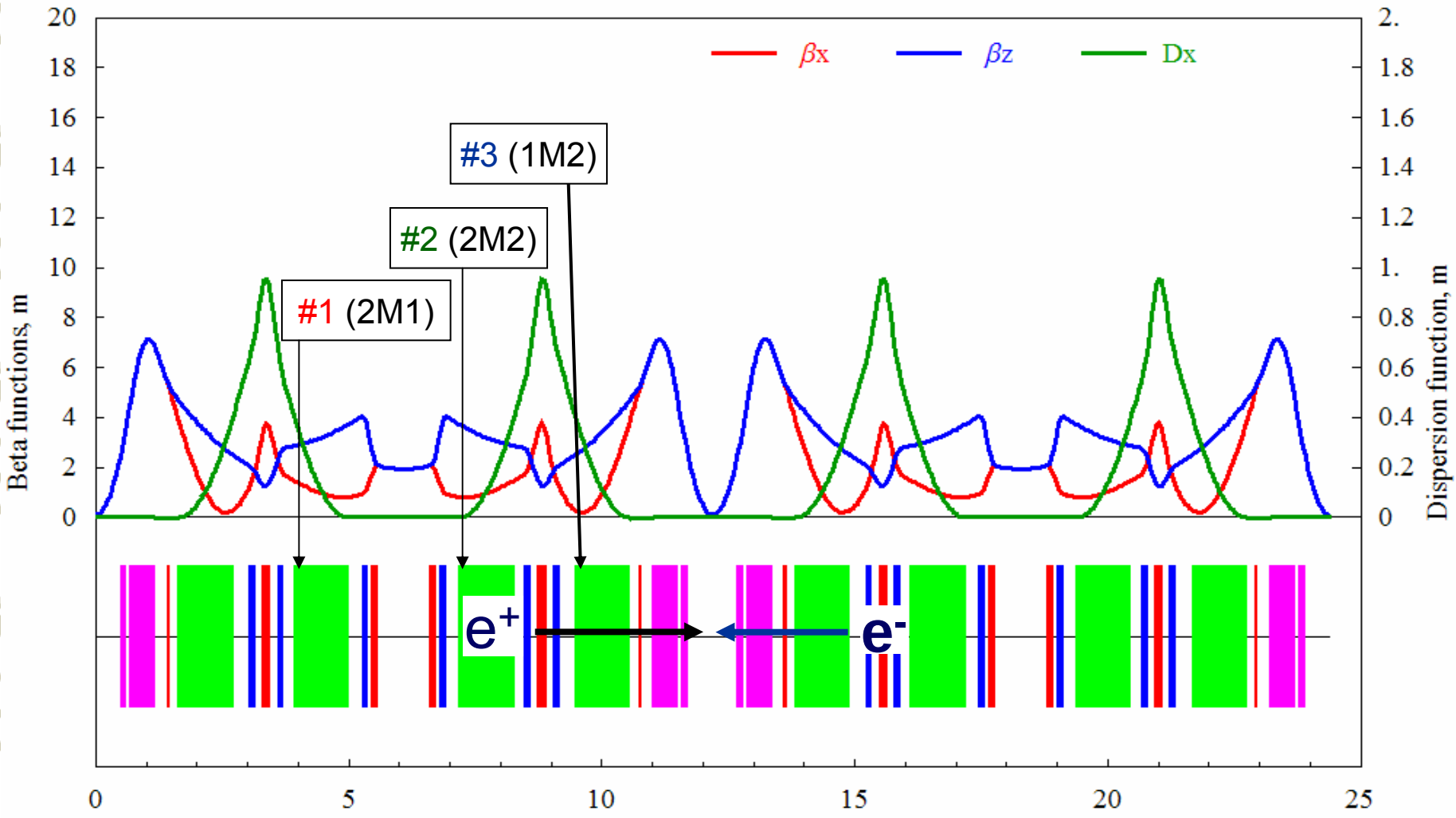


#1 (1M2)

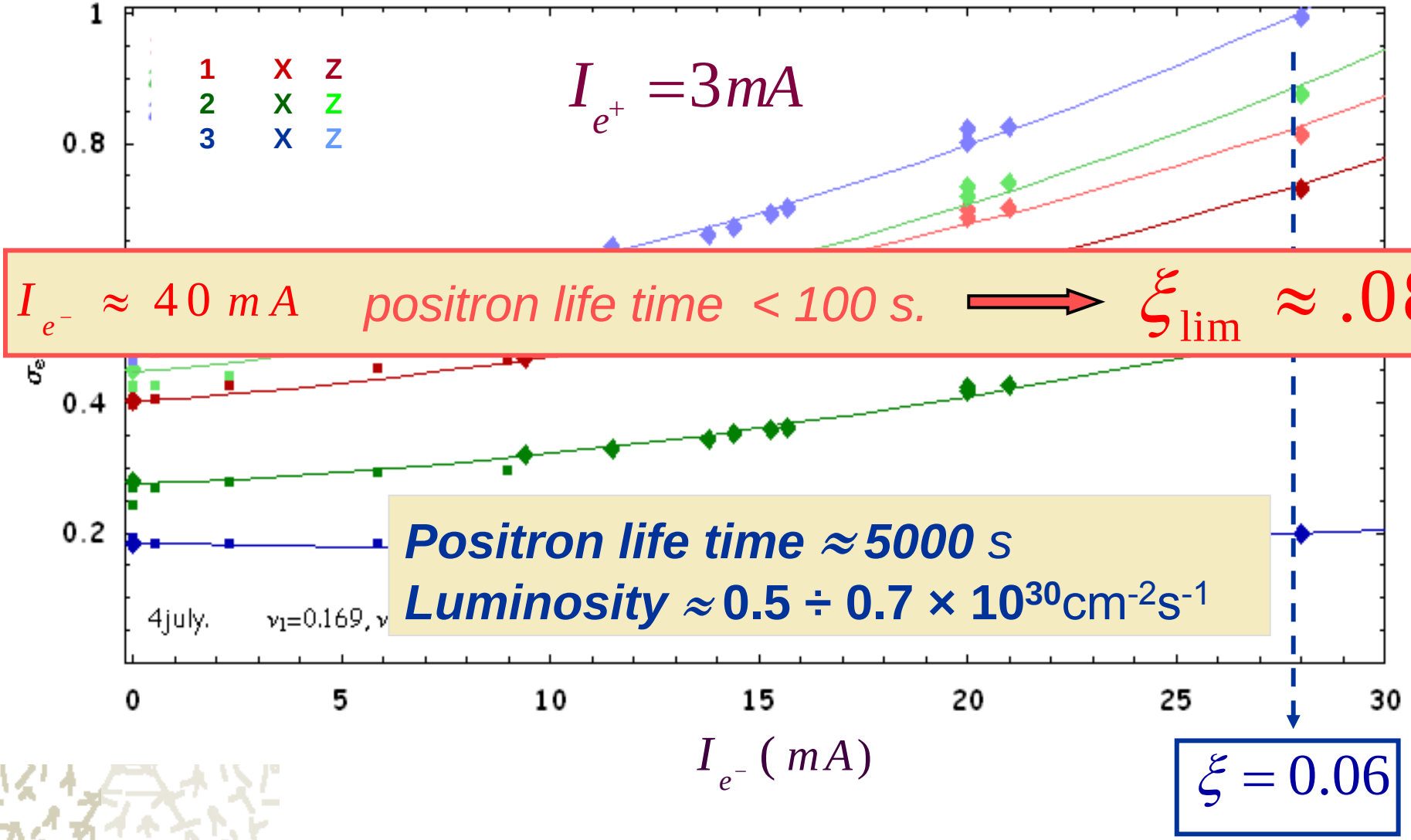
#2 (2M2)

#3 (2M1)

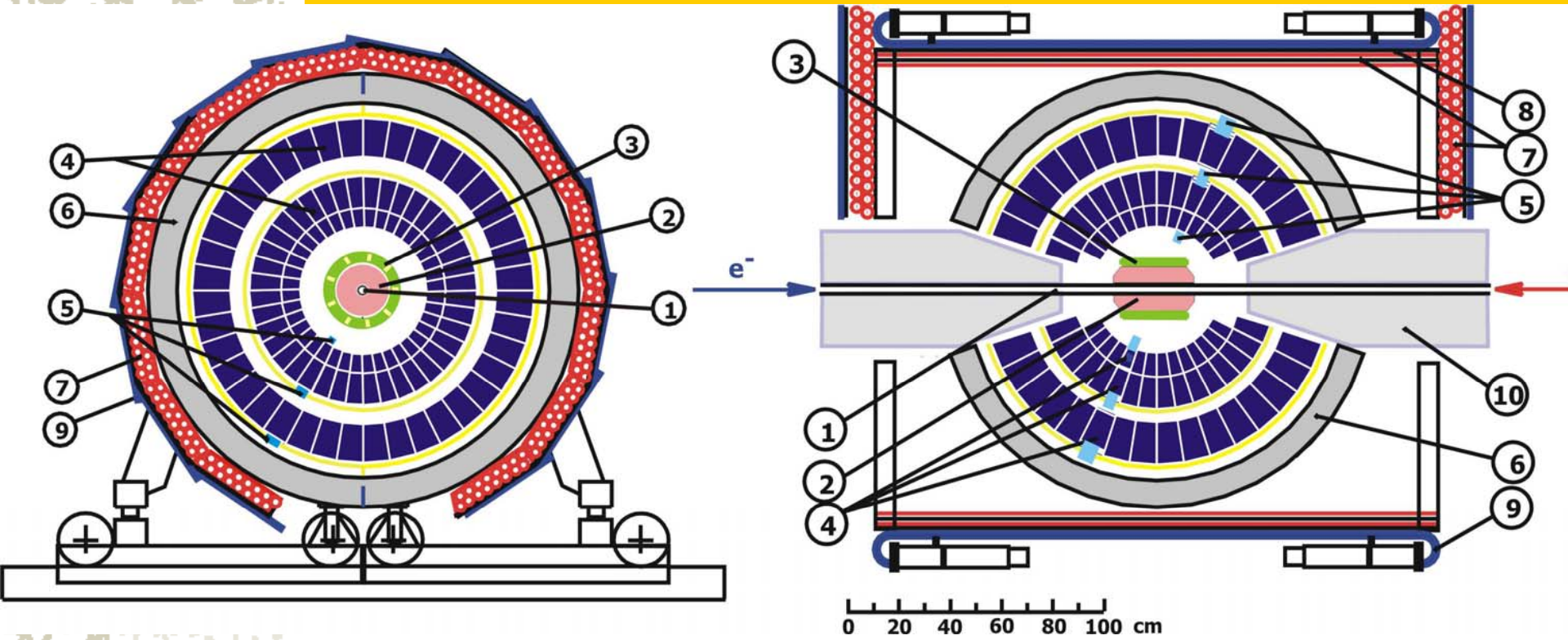
Round beam lattice



“Weak-strong” beam-beam study



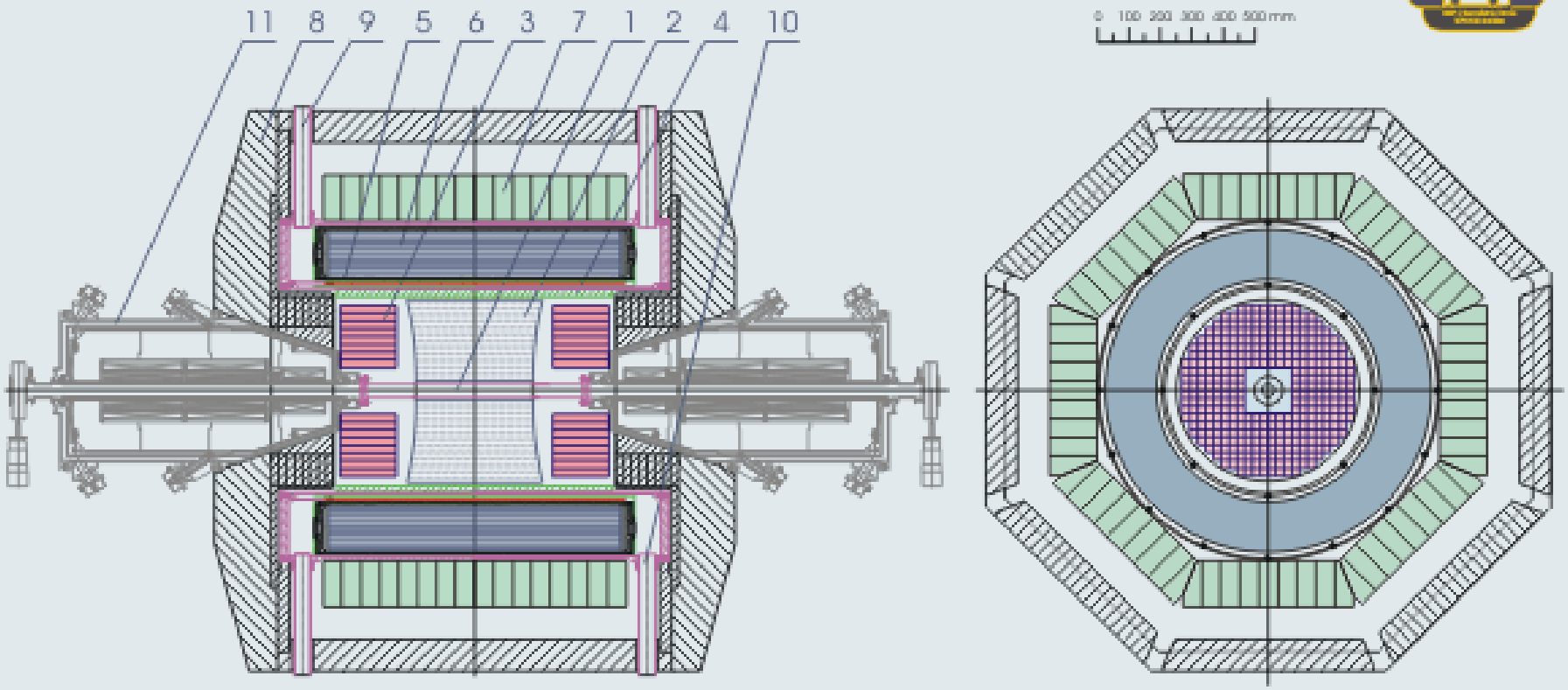
SND detector



1 – VEPP-2000 beam pipe, 2 – tracking system, 3 – aerogel cherenkov counter, 4 – NaI(Tl) counters, 5 – vacuum phototriodes, 6 – absorber, 7-9 – muon system, 10 – VEPP-2000 s.c focusing solenoids.

CMD-3 DETECTOR

HTTP://CMD.INP.NSK.SU



1 - Vacuum pipe
2 - Drift chamber
3 - BGO endcap calorimeter
4 - Z-chamber
5 - Superconducting solenoid
6 - LXe calorimeter
7 - CsI barrel calorimeter
8 - Yoke
9 - LHe supply
10 - Vacuum pumpdown
11 - VEPP2000 superconducting magnetic lenses

Physical program at VEPP-2000

- Precise measurement of the quantity
  R=σ(e+e-- > hadrons)/ σ(e+e-->μ+μ--)
- Study of hadronic channels: e+e- > 2-3-4…(π,K,η).
- Study of 'excited' vector mesons: ρ', ρ'', ω', φ',..
- CVC tests: comparison of e+e-- > hadr. (T=1) cross section with τ-decay spectra
- Study of nucleon-antinucleon pair production – nucleon electromagnetic formfactors, search for NNbar resonances, ..
- Hadron production in 'radiative return' (ISR) processes
- Two photon physics
- Test of the QED high order processes 2->4,5

Conclusion

- Beam parameters of VEPP-2000 correspond to the project
- All systems of VEPP-2000 are working
- Vacuum life time exceeds 10 hours (I=1 mA)
- Round beam option was realized.
- First beam-beam study is done: $\xi_{\mathrm{lim}} \approx .08$ is achieved
- Further beam-beam study will continue soon
- Detectors CMD-3 and SND are near to completion
- Experiments start in 2008
- Interesting physics can be done at VEPP-2000