Present status of VEPP-2000

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BINP,Novosibirsk

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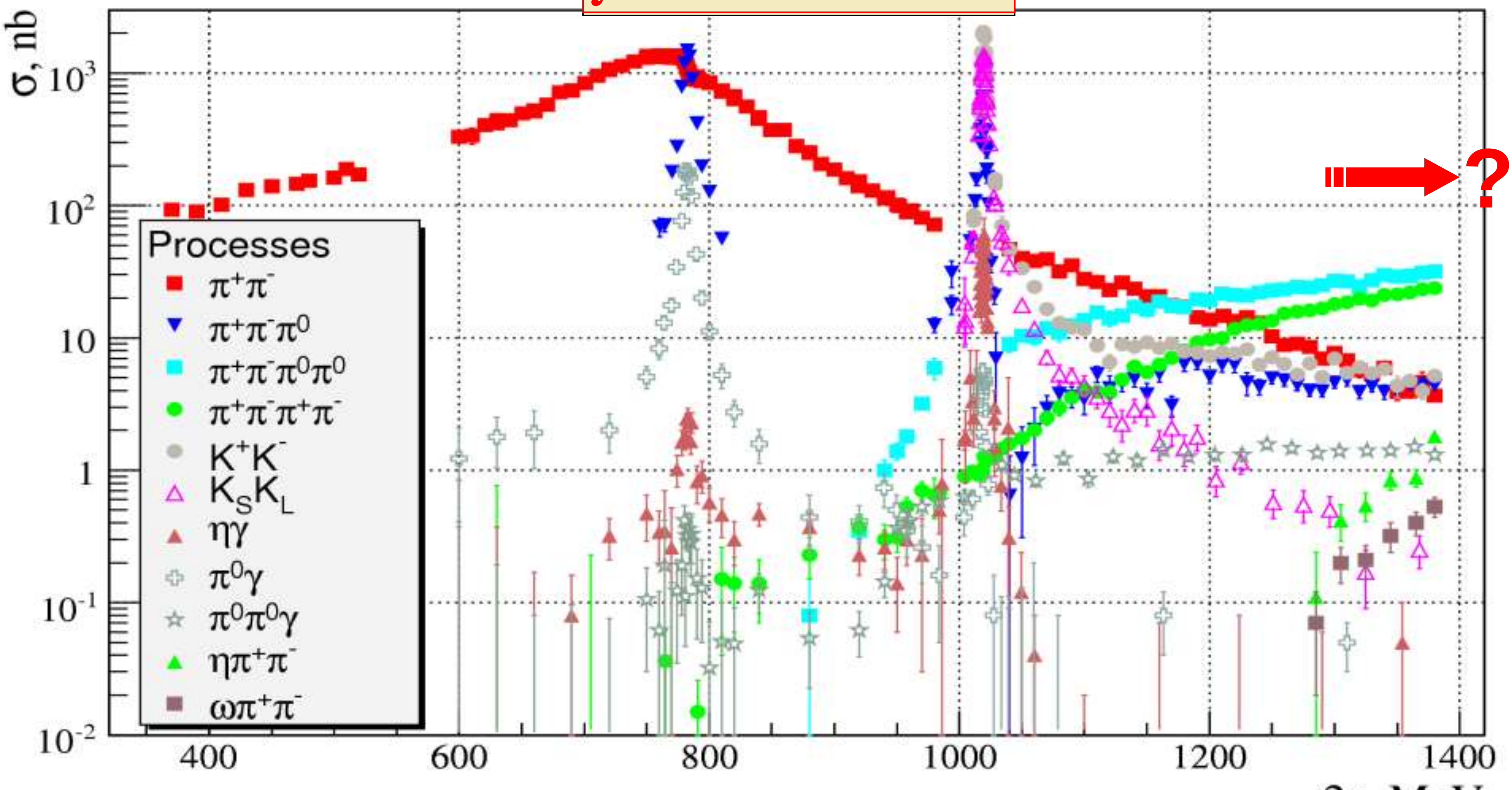
Outline

- VEPP-2M $\rightarrow$ VEPP-2000
- Round beams concept
- VEPP-2000 overview
- Lattice options
- Beam-beam study
- Luminosity & data collection
- Dynamic aperture
- Energy calibration
- Conclusion

Overview of VEPP-2M results

$$\int Ldt \geq 100(pbarn)^{-1}$$

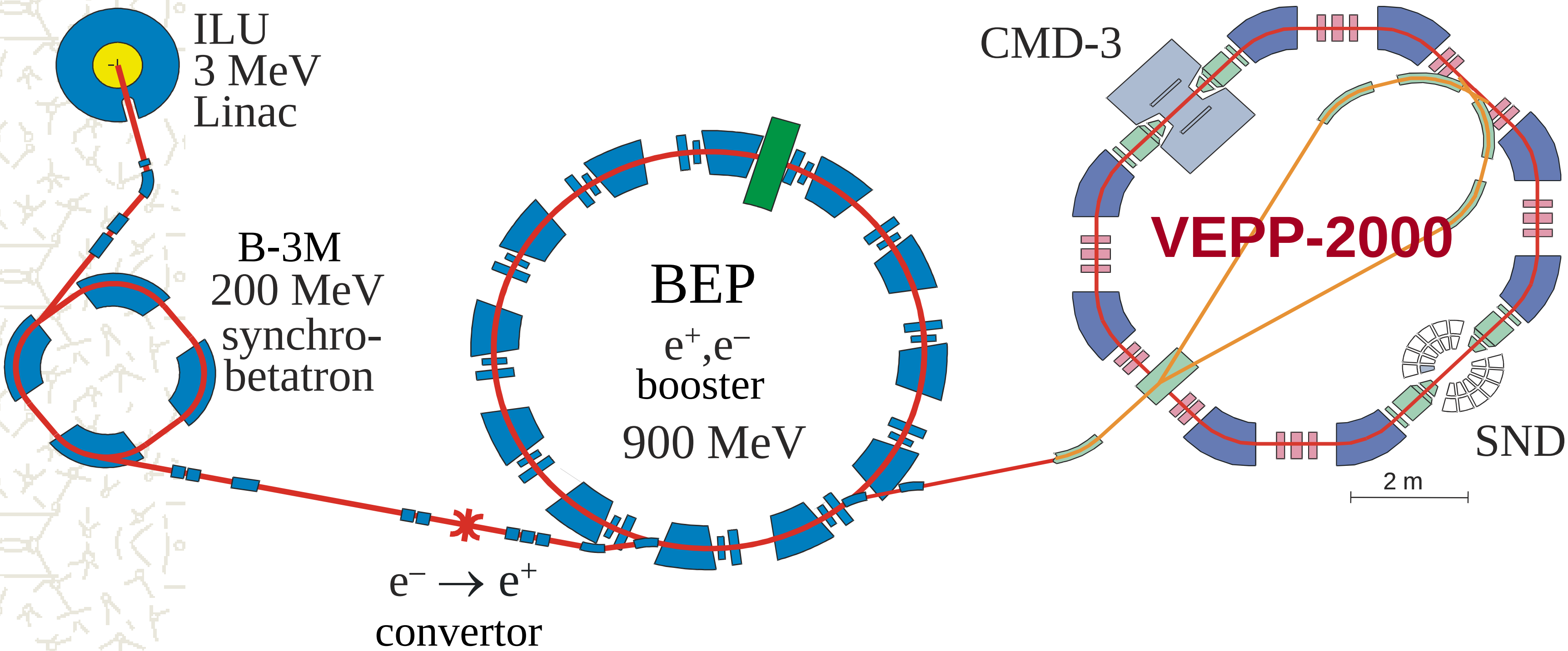


Physics at VEPP-2000 at beam energy 0.2 – 1 GeV

1. Precise measurement of the quantity
   $R=\sigma(e^+e^- \to \text{hadrons})/\sigma(e^+e^- \to \mu^+\mu^-)$
2. Study of hadronic channels:
   $e^+e^- \to 2h, 3h, 4h \ldots$, h= π, K, η
3. Study of 'excited' vector mesons: $\rho', \rho'', \omega', \varphi'$,..
4. CVC tests: comparison of $e^+e^- \to$ hadr. (T=1) cross section with τ-decay spectra
5. Study of nucleon-antinucleon pair production – nucleon electromagnetic form factors, search for NNbar resonances, ..
6. Hadron production in 'radiative return' (ISR) processes
7. Two photon physics
8. Test of the QED high order processes 2-> 4,5

VEPP-2M → VEPP-2000

(2001-2007)



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

Luminosity approach

- Number of bunches (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 = 2)

✓Beam-beam limit enhancement

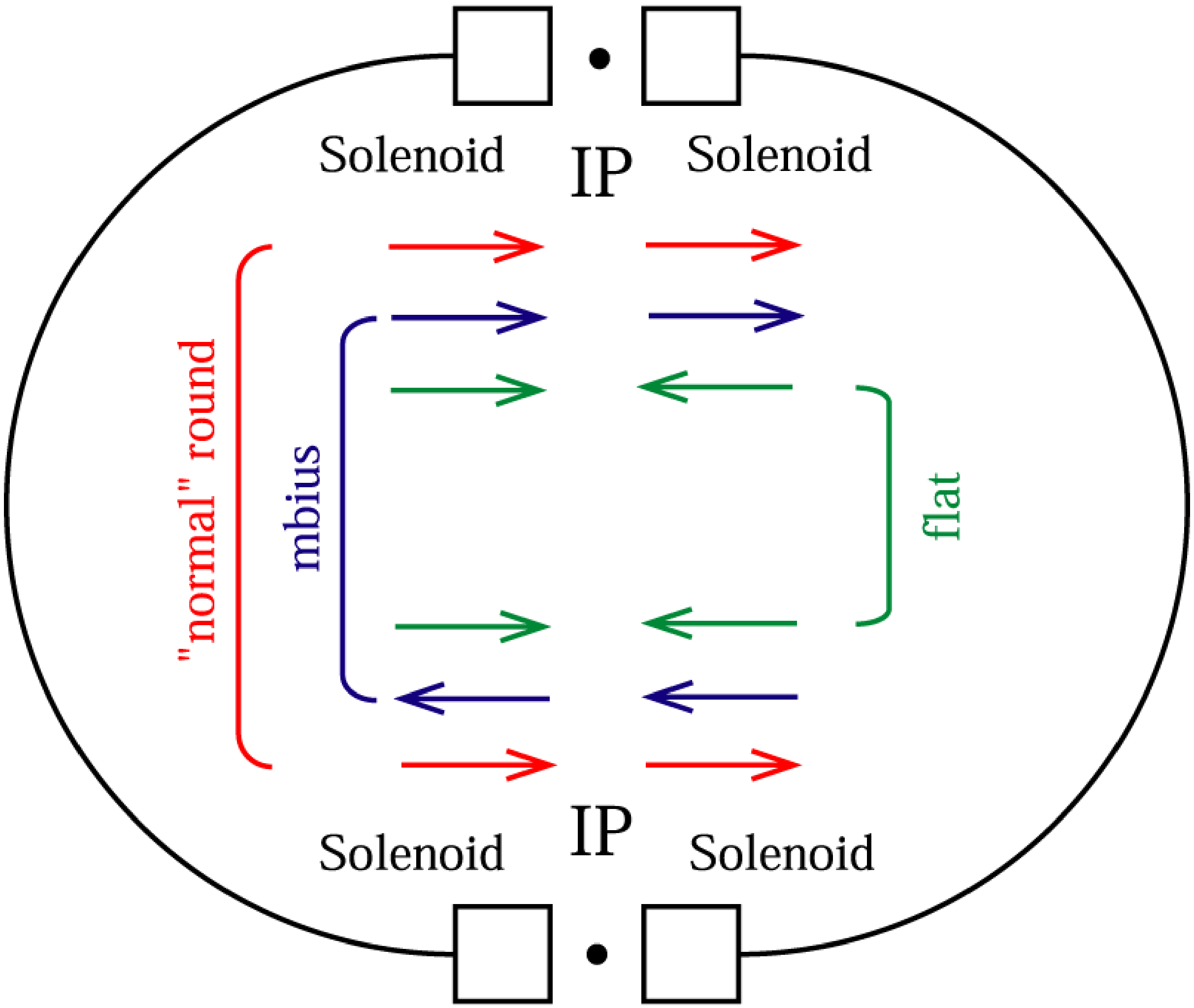
$$\xi = \frac{N^- r_e}{4\pi \cdot \varepsilon \cdot \gamma} \geq 0.1$$

The Concept of Round Colliding Beams

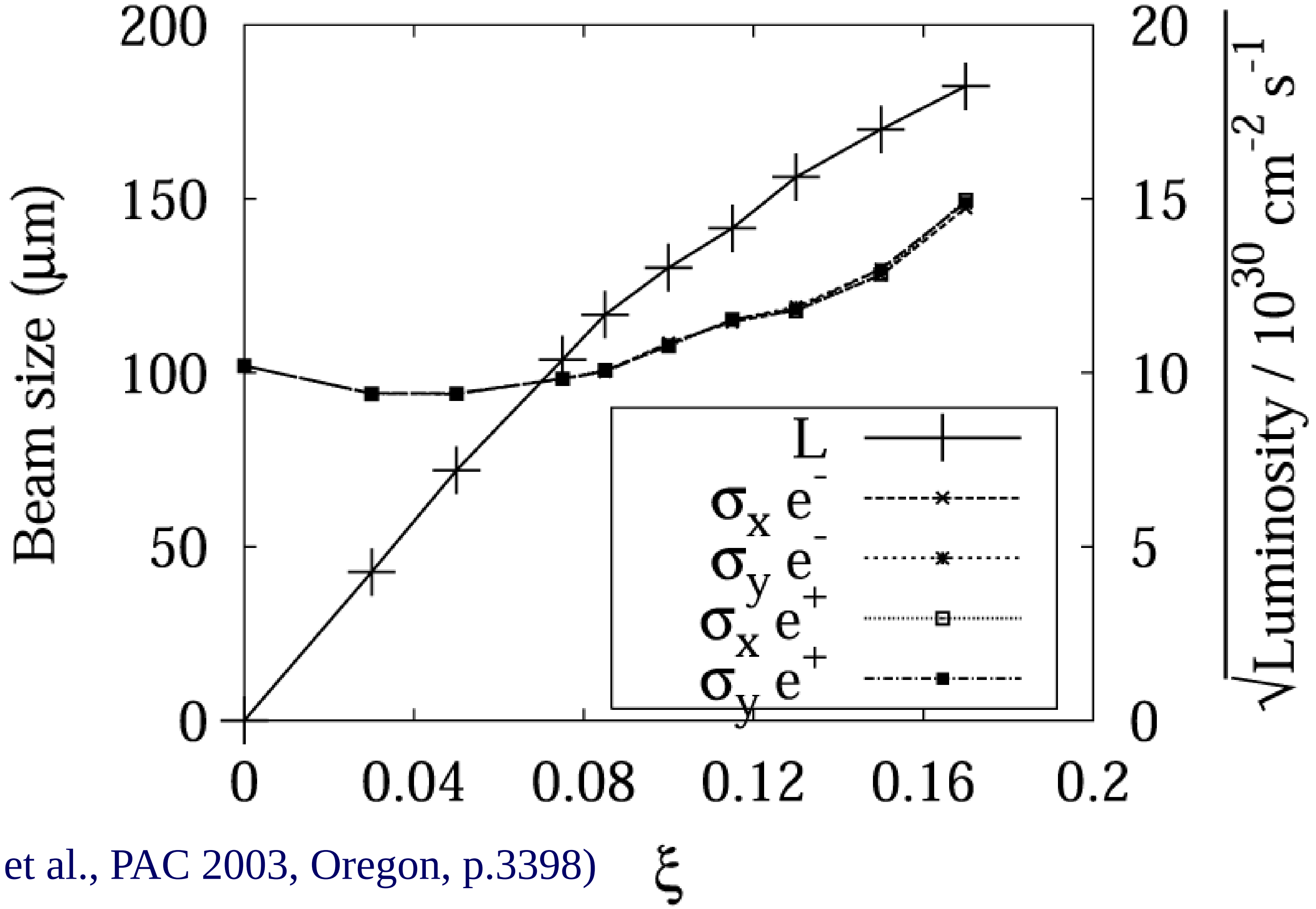
- Angular momentum conservation: $M_z = x'y - xy'$
- Small and equal β-functions at IP: $\beta_x = \beta_y$
- Equal beam emittances: $\varepsilon_x = \varepsilon_y$
- Equal betatron tunes: $\nu_x = \nu_y$
- Small and positive fractional tunes

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

Realization of Round Beams



“Strong-Strong” Beam-Beam Simulations

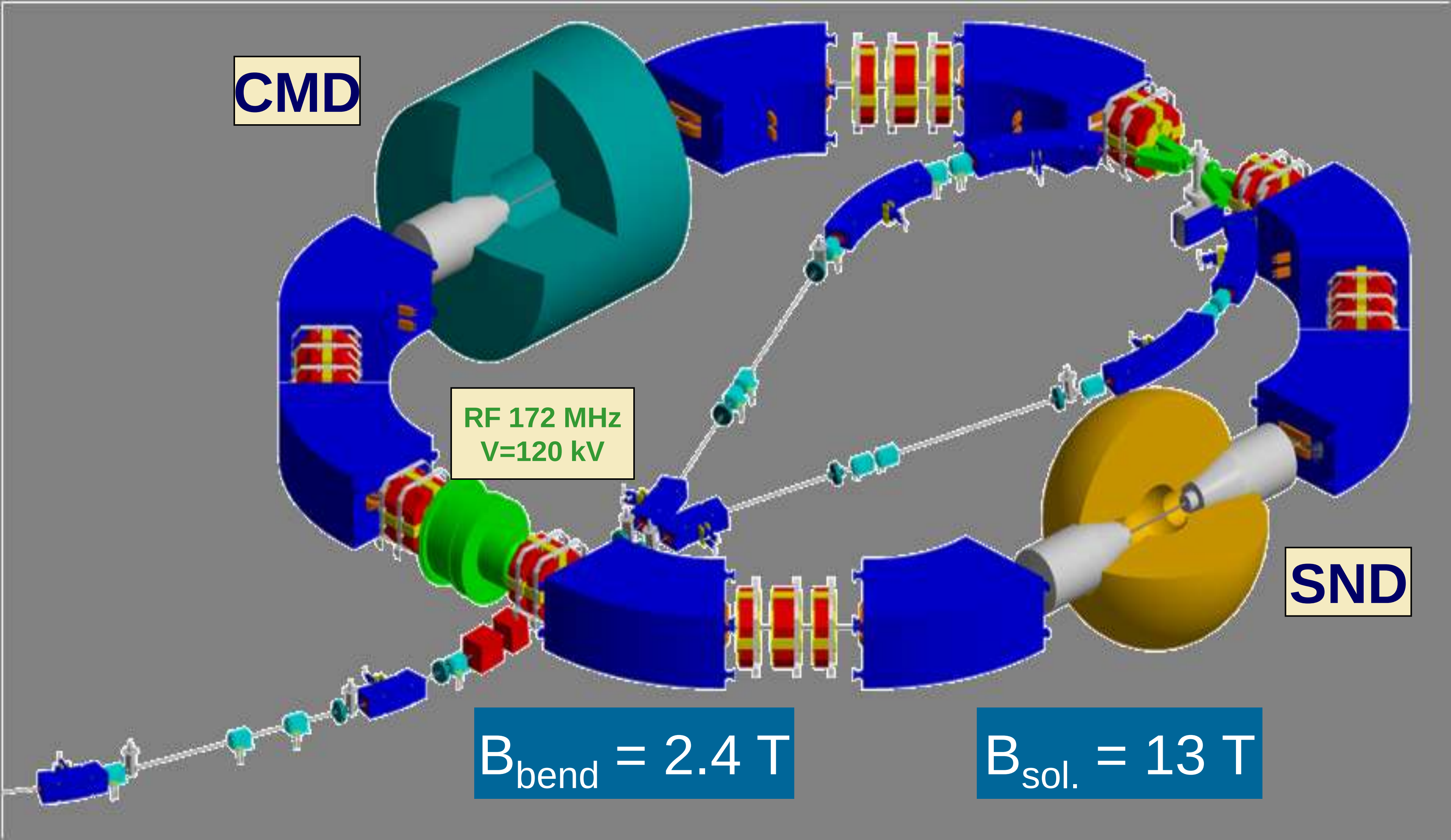


(A.A.Valishev et al., PAC 2003, Oregon, p.3398)

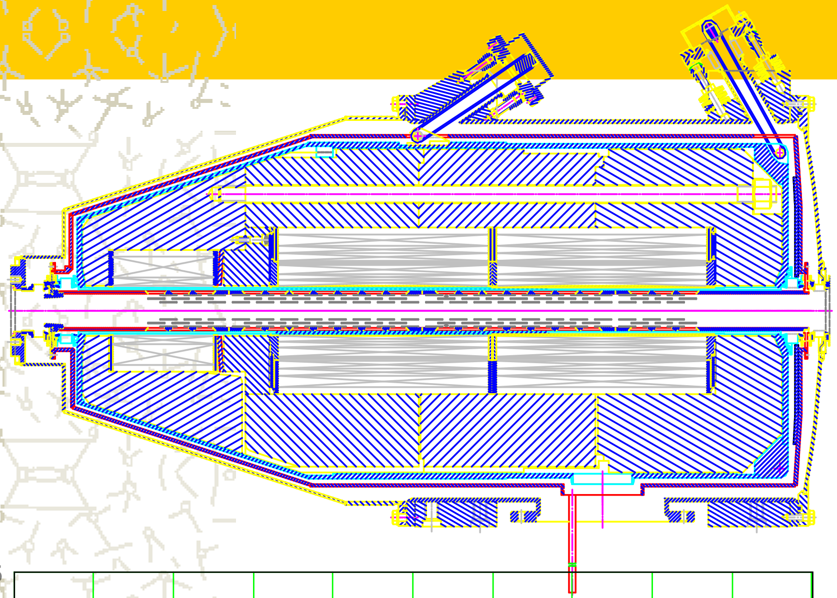
Main Parameters of VEPP-2000

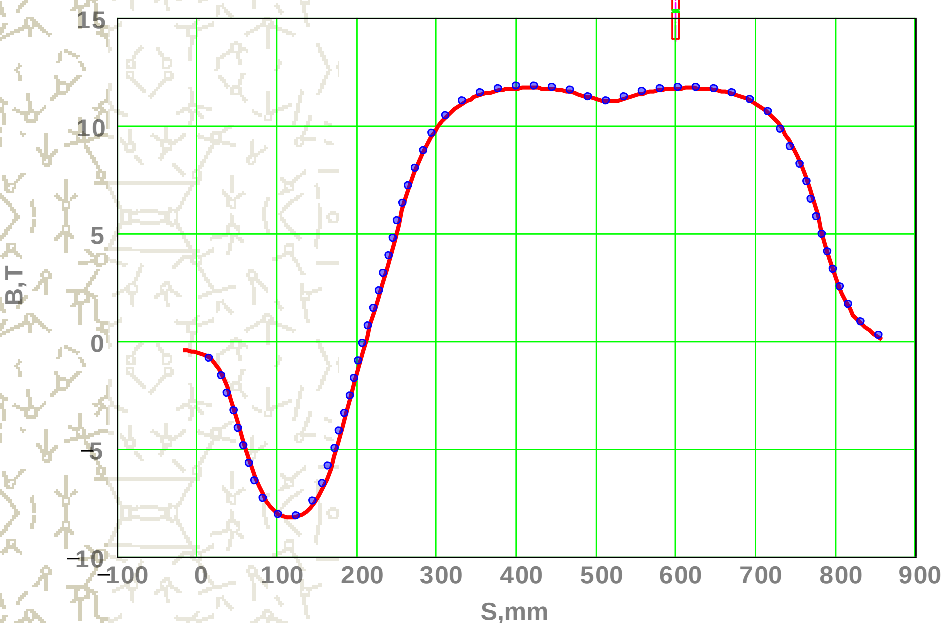
Circumference, Π	24.39 m
Betatron functions at IP, $\beta^*_{x,z}$	10 cm
Betatron tunes, $\nu_{x,z}$	4.1, 2.1
Beam emittance, $\varepsilon_{x,z}$	1.4×10^{-7} m rad
Momentum compaction, α	0.036
Synchrotron tune, ν_s	0.0035
Energy spread, $\sigma_{\Delta E/E}$	6.4×10^{-4}
RF frequency	172 MHz
RF harmonic number, q	14
RF voltage	120 kV
Number of particles per bunch, N	10^{11}
Beam-beam parameters, $\xi_{x,z}$	0.075
Luminosity, L	10^{32} cm^{-2}s^{-1}

VEPP-2000 scheme

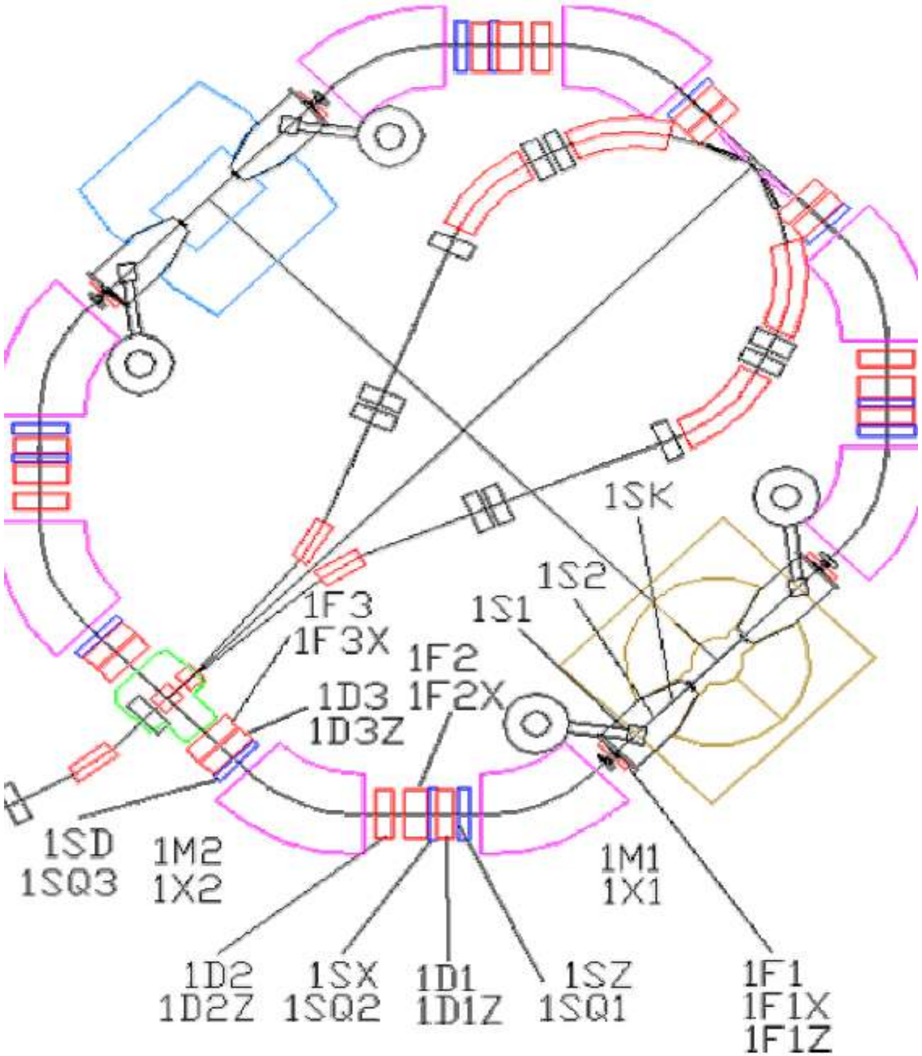


13 T Solenoid

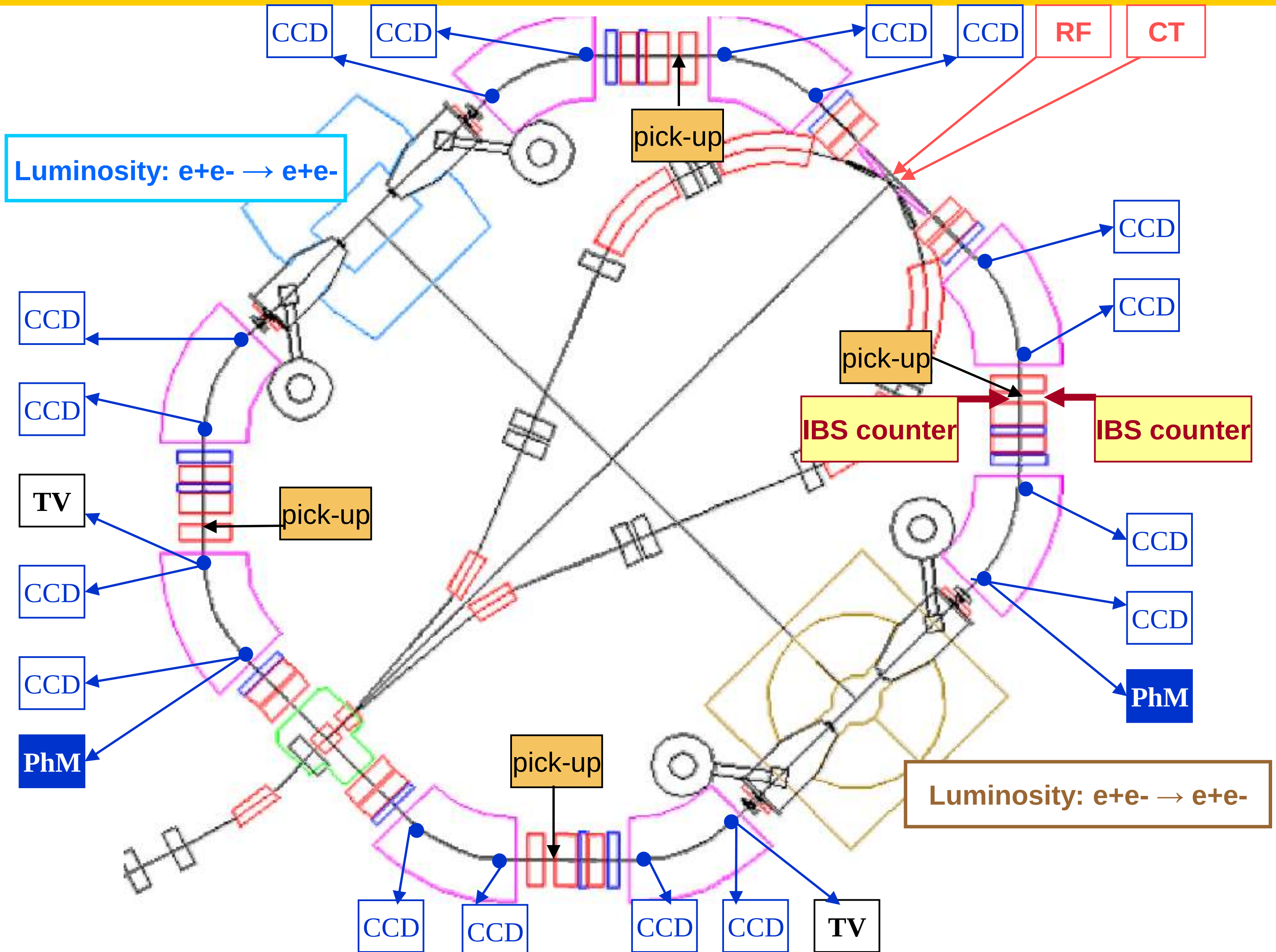




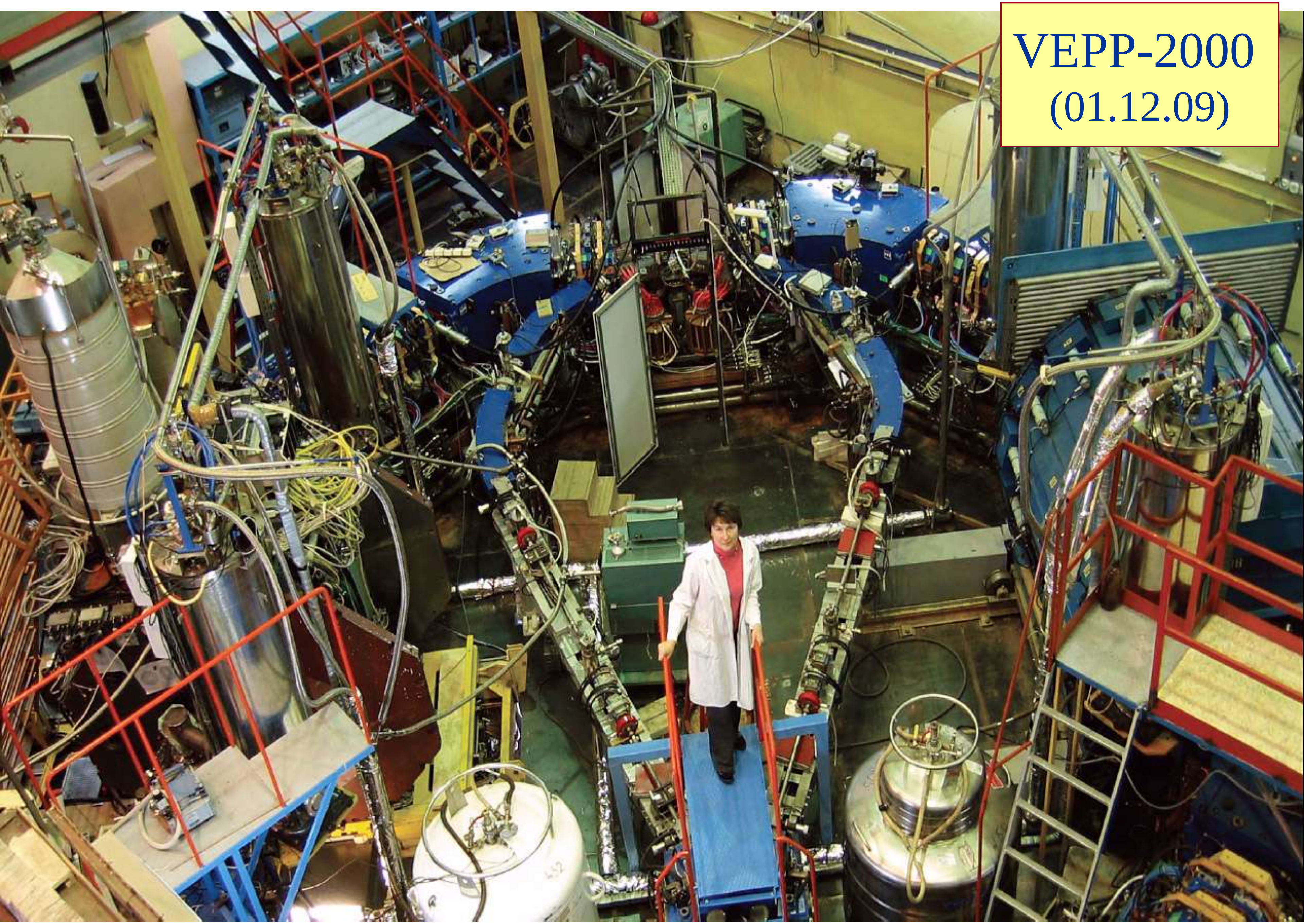
Quads, skew quads, sextupoles, steering coils



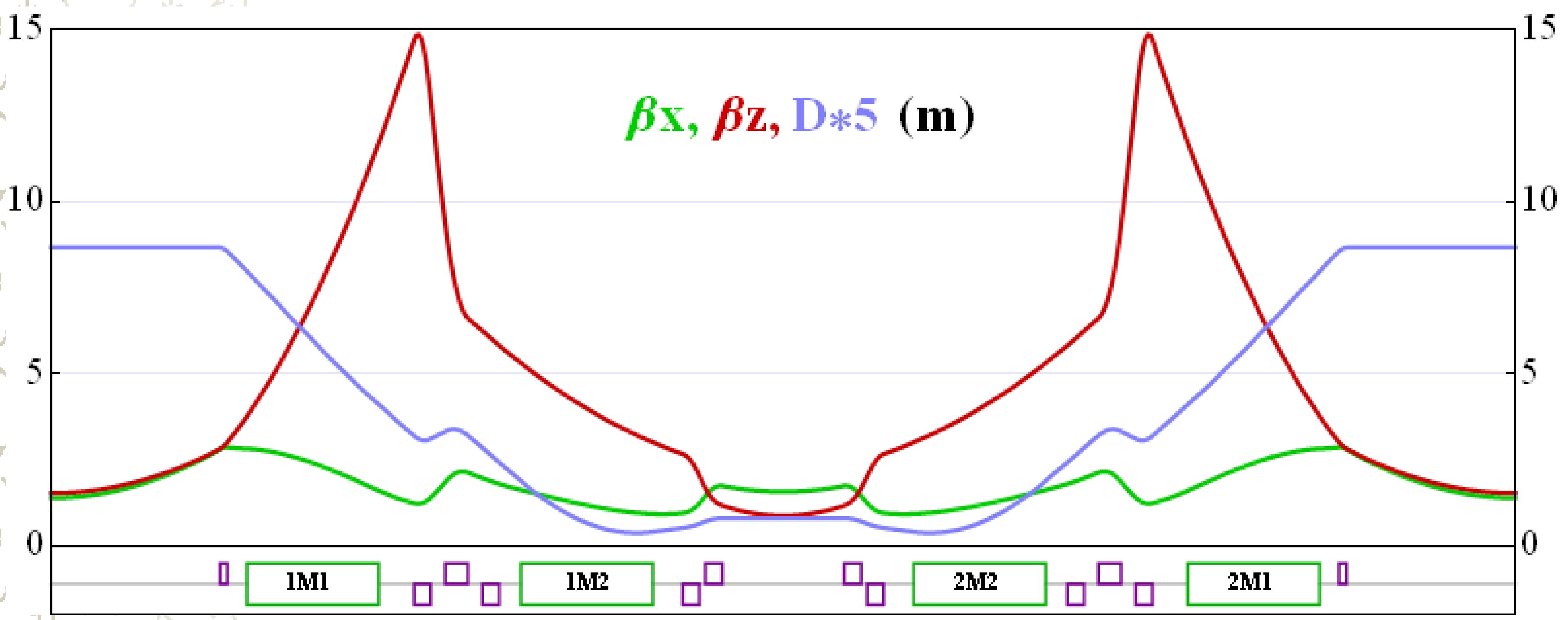
Beam diagnostics




VEPP-2000
(10.01.07)


VEPP-2000
(01.12.09)

Lattice options: solenoids off

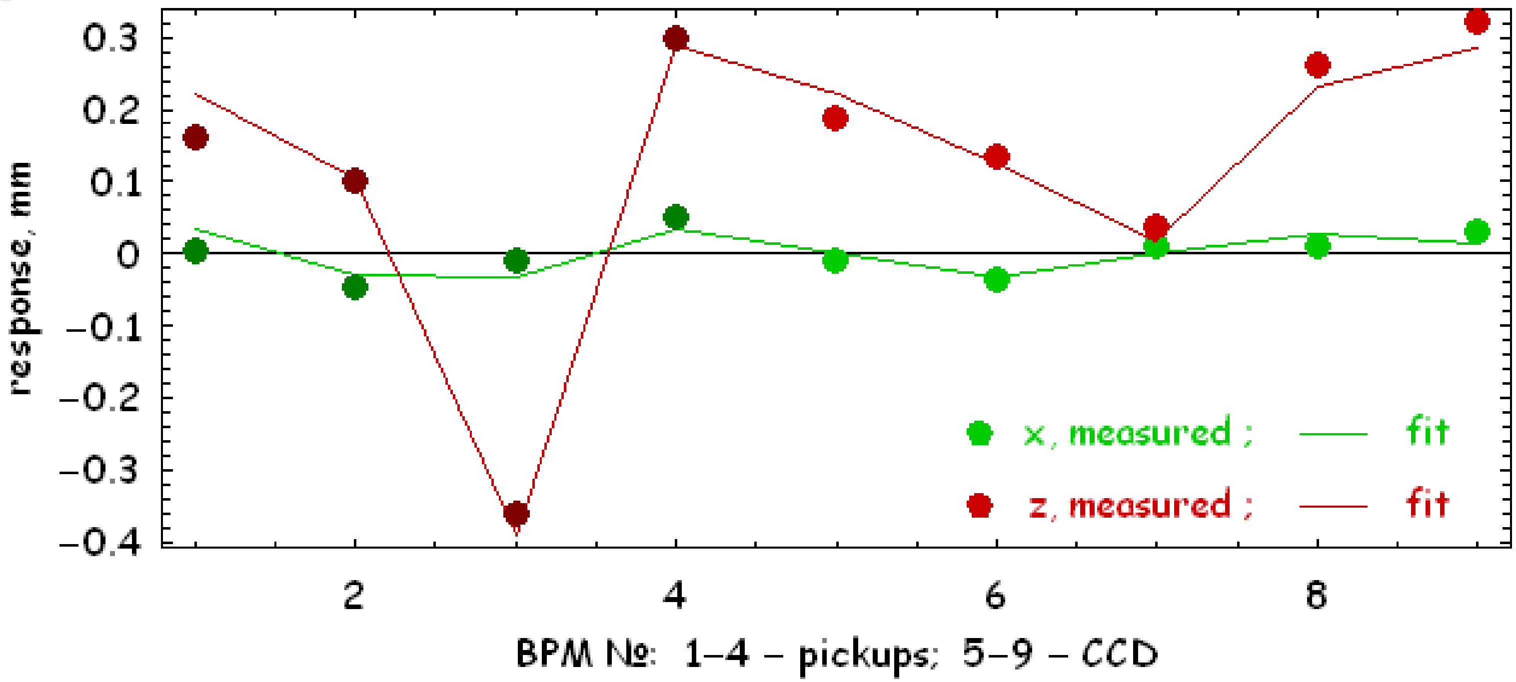


$(\nu_x = 2.4;\ \nu_z = 1.4)$

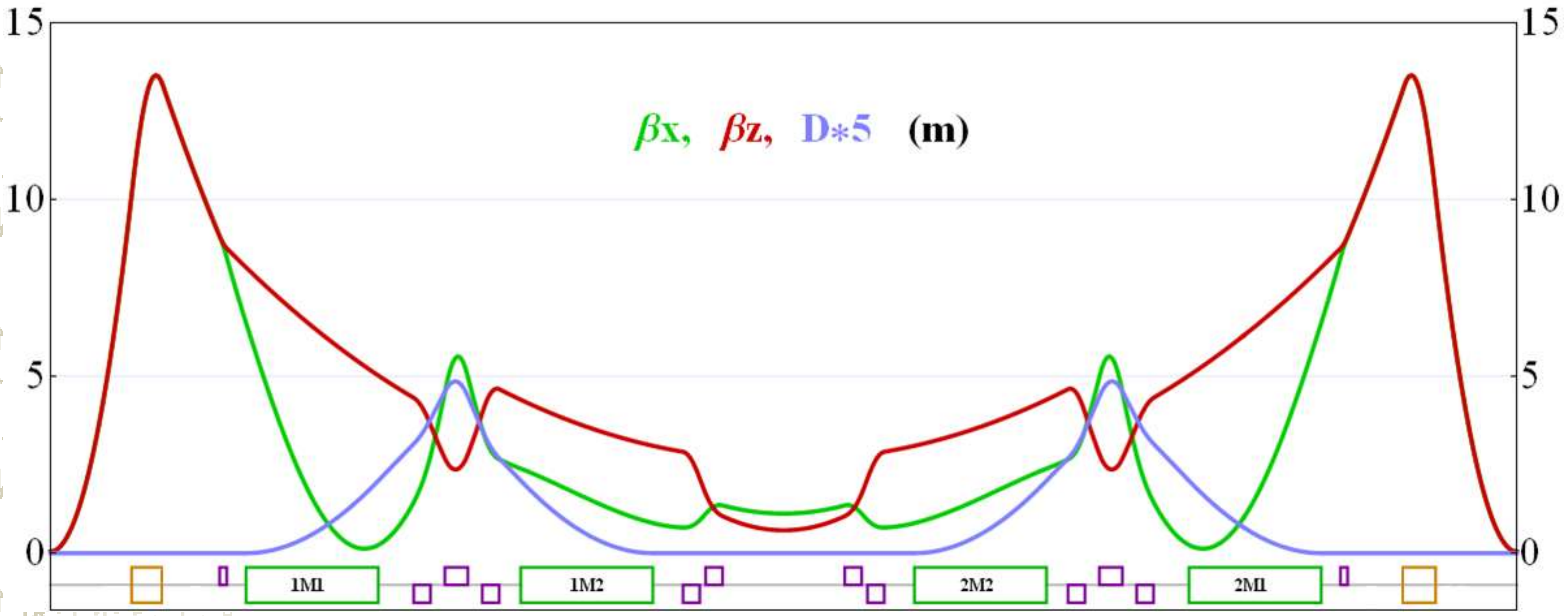
$E \lesssim 600$ MeV

Lattice options: solenoids off

- Beam injection
- Vacuum chamber treatment by SR
- Solenoids alignment:



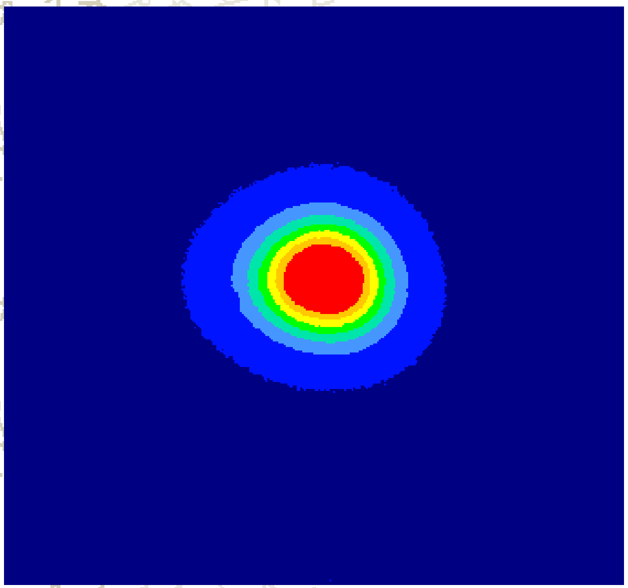
Lattice options: low-beta (short solenoids)



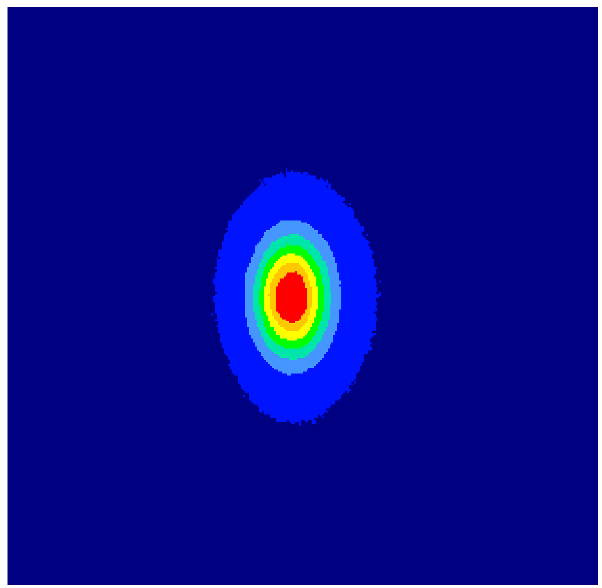
$(\nu_x = 4.128;\ \nu_z = 2.128,\quad \beta^* = 4.5\ cm)\quad E \lesssim 600\ \mathrm{MeV}$

Round beam at CCDs

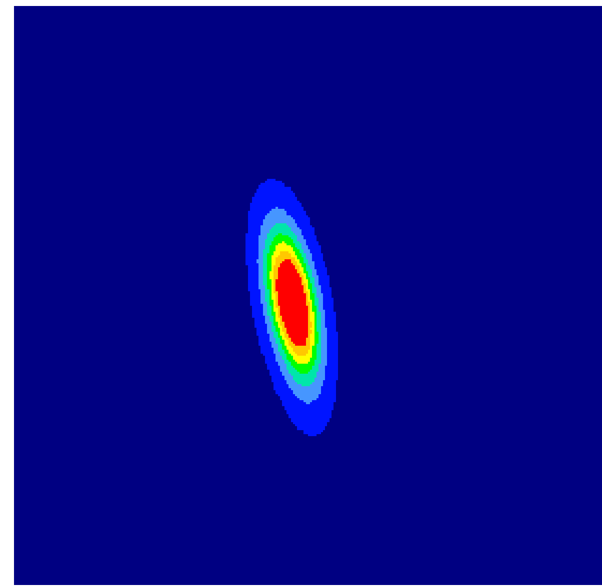
positron beam



#1 (1M2)

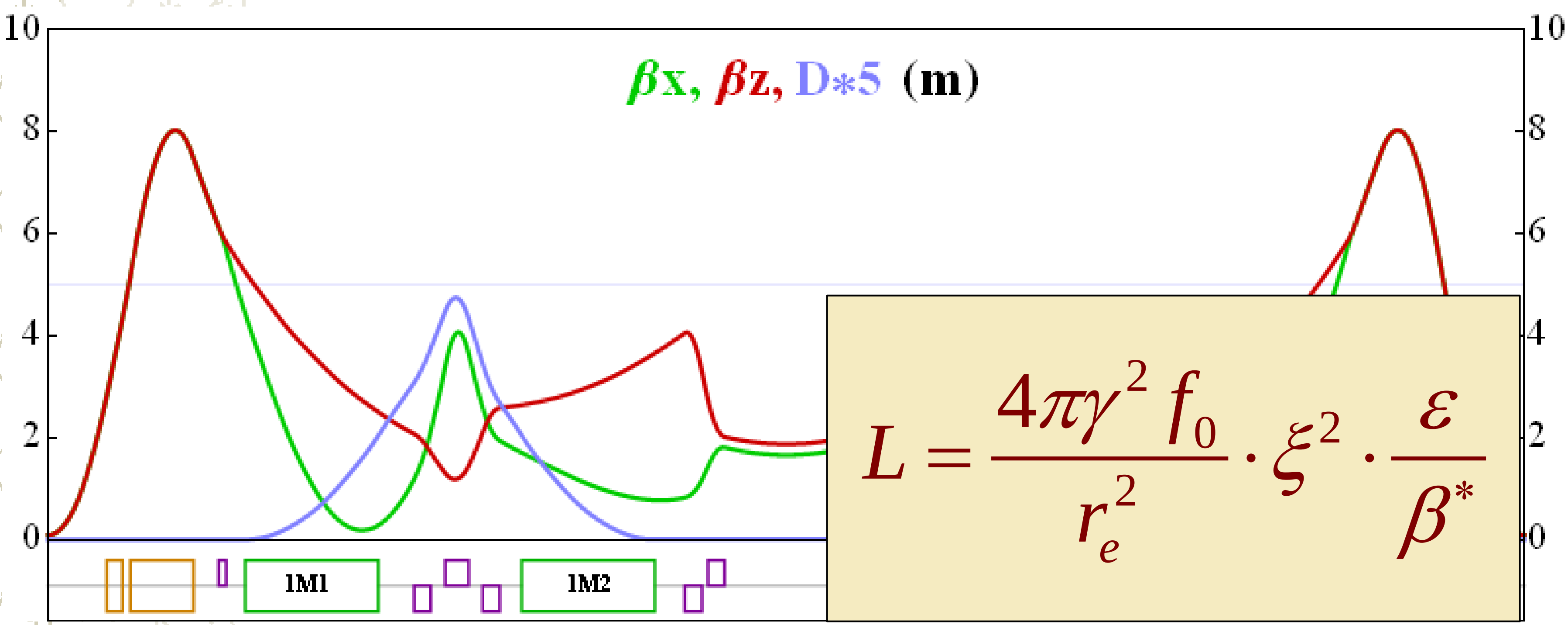


#2 (2M2)



#3 (2M1)

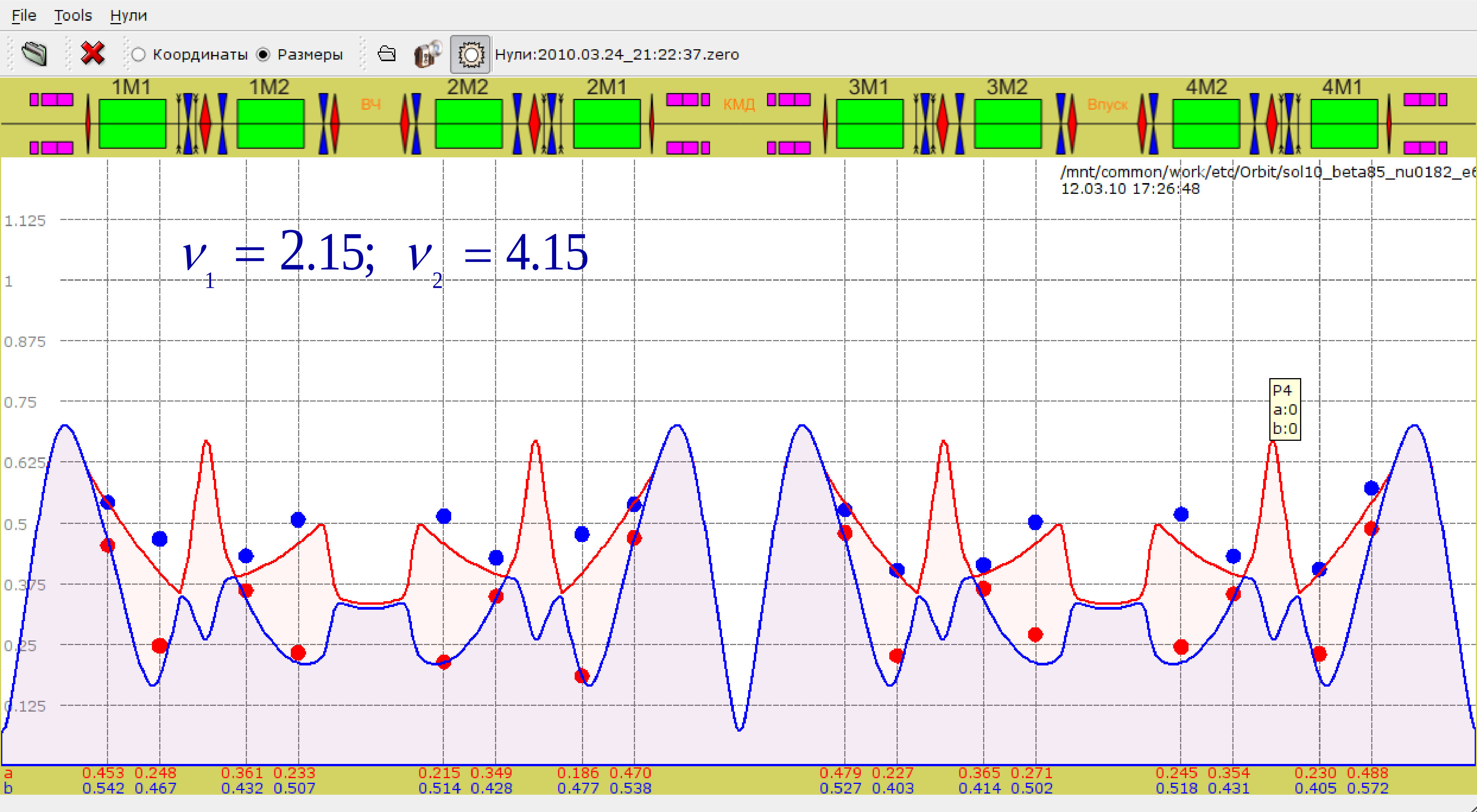
Lattice options: regular round (long solenoids)



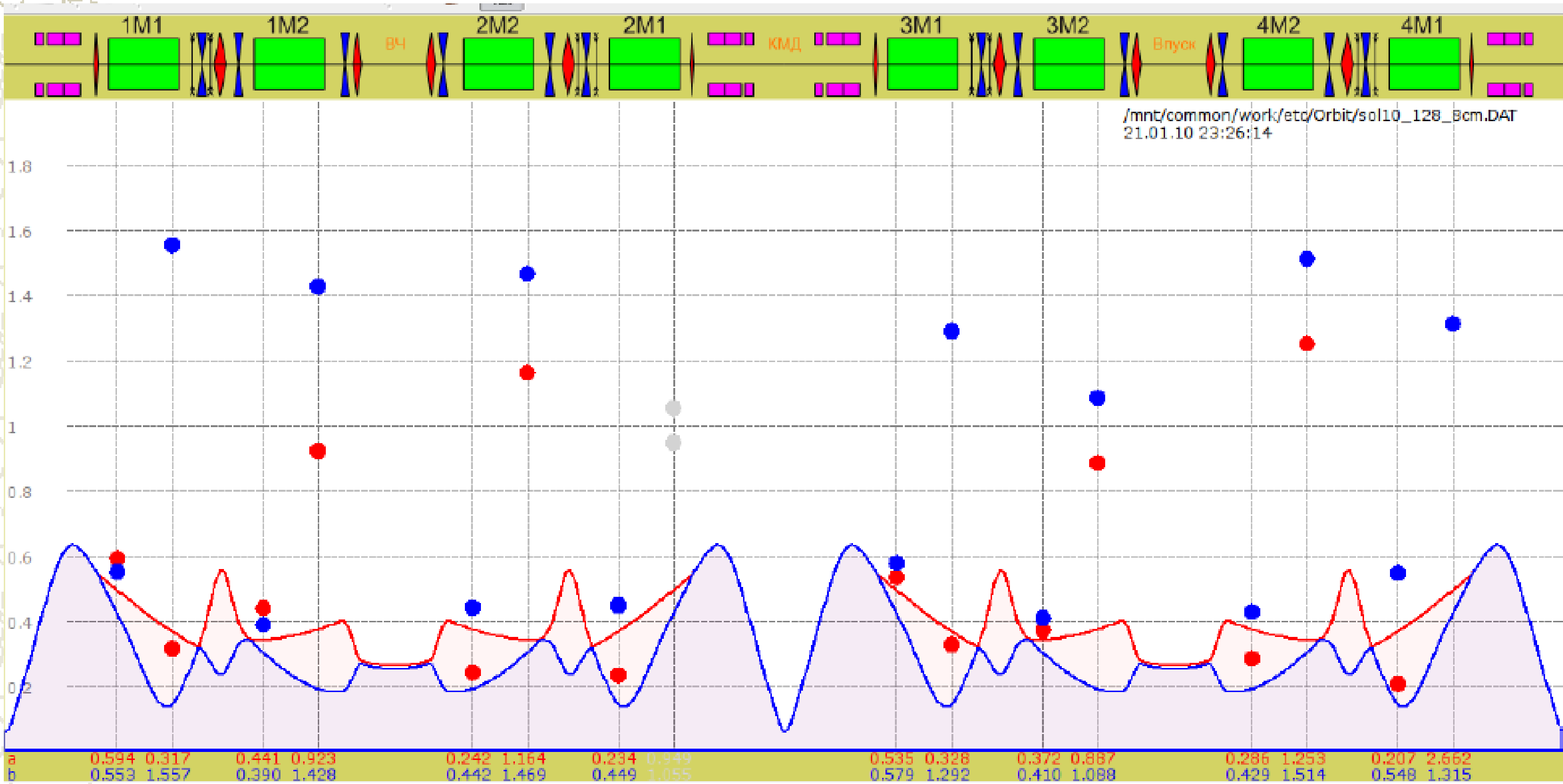
$$L = \frac{4\pi\gamma^2 f_0}{r_e^2} \cdot \xi^2 \cdot \frac{\varepsilon}{\beta^*}$$

$(\nu_x = 4.128;\ \nu_z = 2.128,\quad \beta^* = 8.5\ cm)$

VEPP-2000 lattice and beam sizes



“Weak-strong” beam-beam study

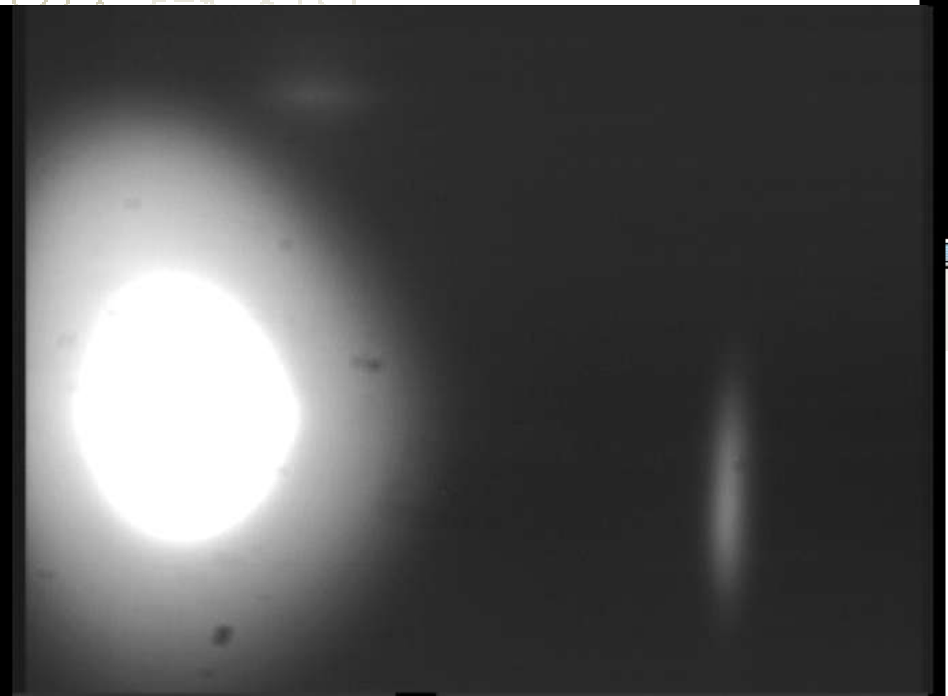


$I^+=3$ mA; $I^-=45$ mA; $\xi^+=0.1$

"Weak-strong" beam-beam

E = 500 MeV

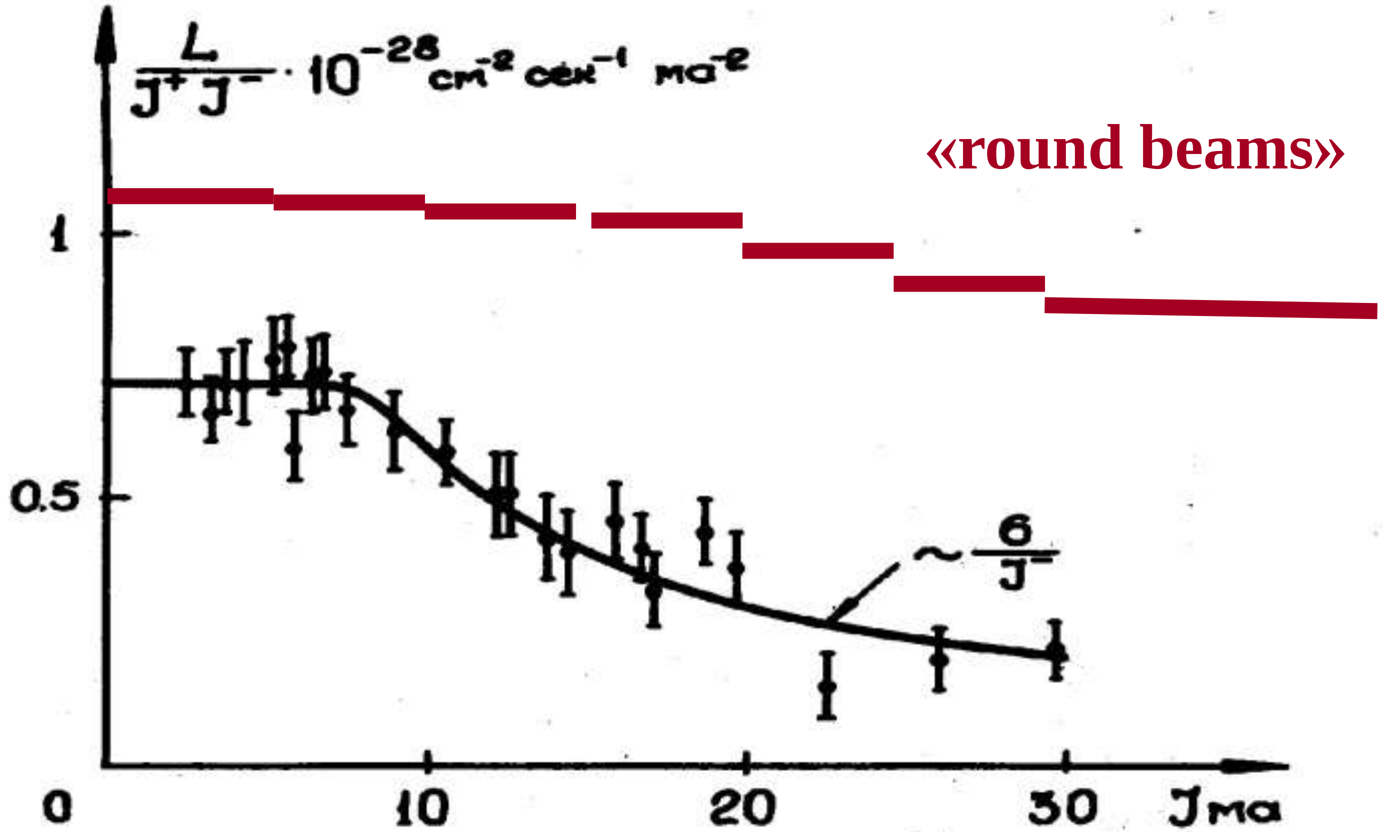
Low-beta mode (β^*=4.5cm)



I^+=2 mA; I^-=80 mA;

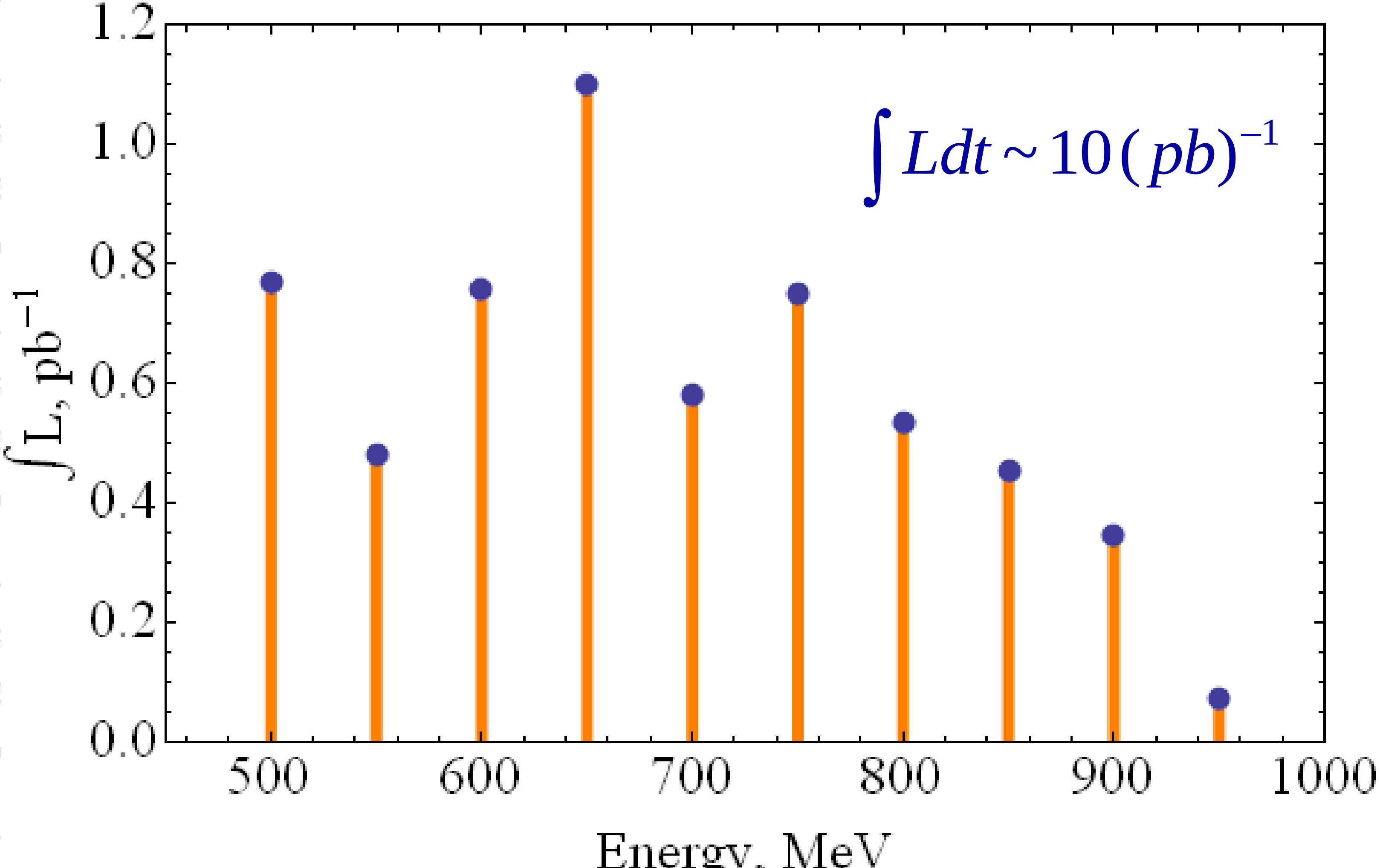
$\xi^+ = 0.18$

Test «flat» - «round»

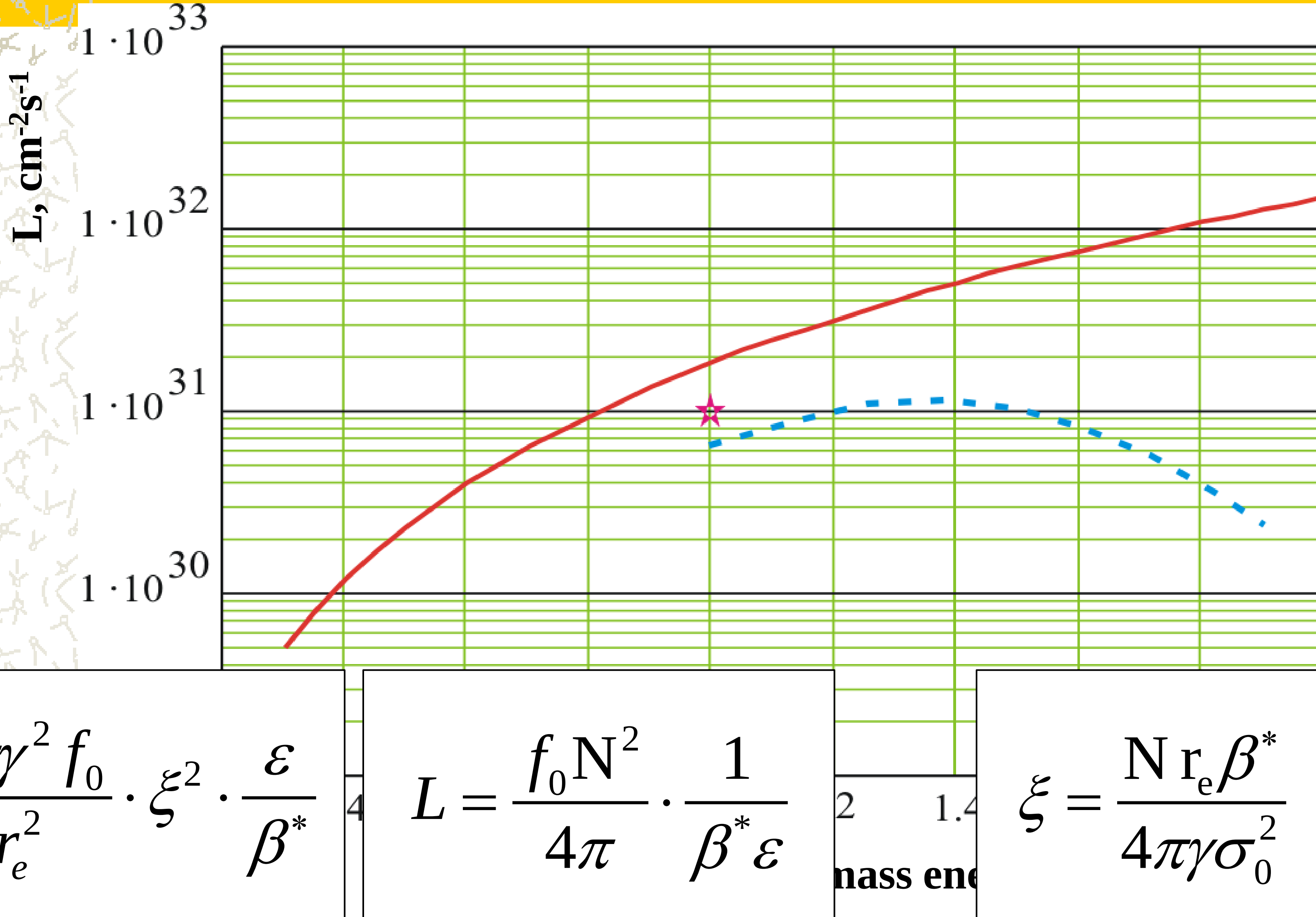


Specific luminosity versus electron beam current

Run 2009-2010 (SND data)



VEPP-2000 Luminosity



$$L = \frac{4\pi\gamma^2 f_0}{r_e^2} \cdot \xi^2 \cdot \frac{\varepsilon}{\beta^*}$$

$$L = \frac{f_0 N^2}{4\pi} \cdot \frac{1}{\beta^* \varepsilon}$$

$$\xi = \frac{N\, r_e \beta^*}{4\pi\gamma\sigma_0^2}$$

Luminosity restrictions

- Insufficient positrons production (> 600 MeV)

$\rightarrow$ New injection complex VEPP-5

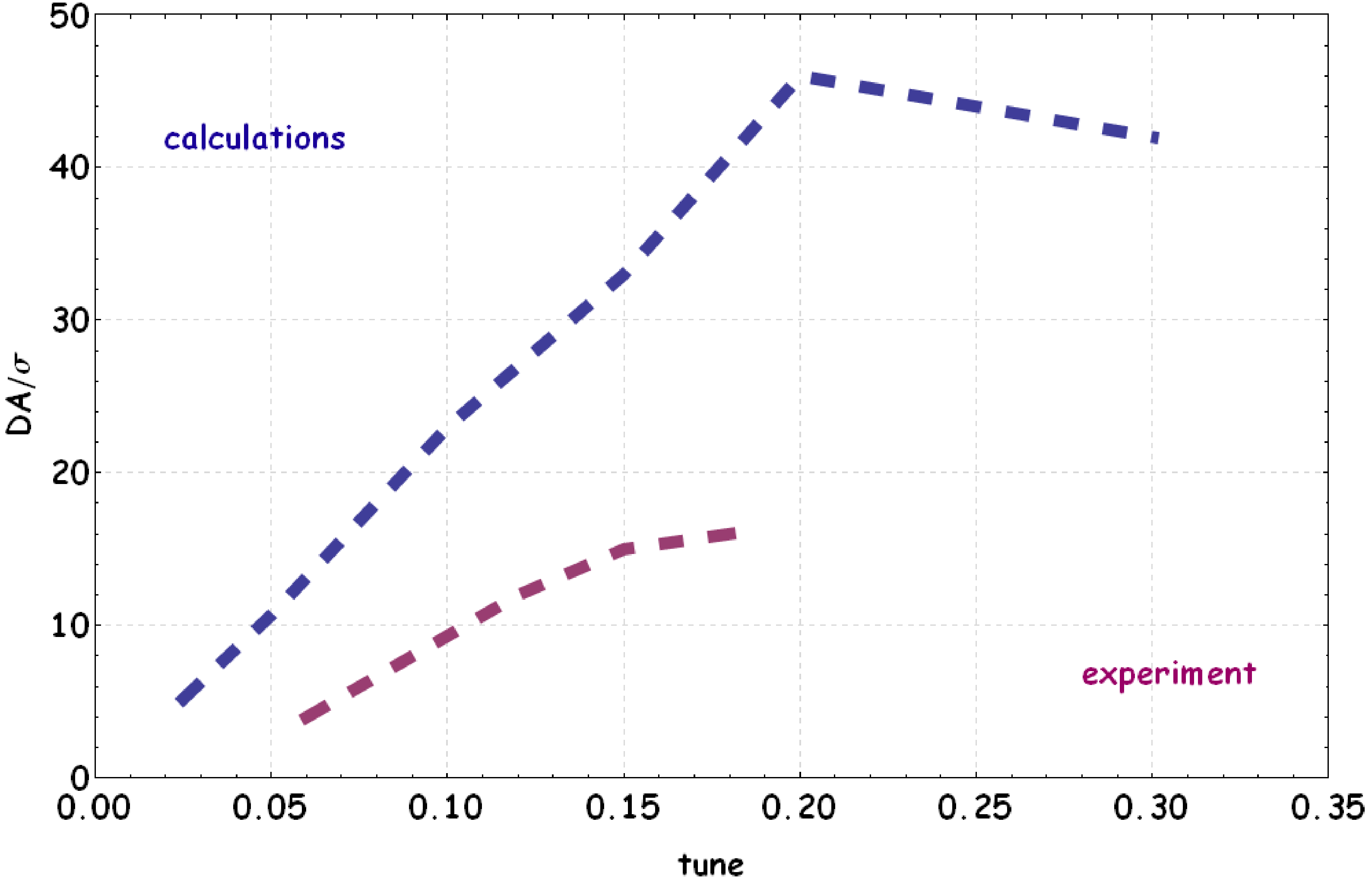
$$\xi = \frac{Nr_e}{4\pi \cdot \varepsilon \cdot \gamma}$$

- Energy ramping (> 800 $\rightarrow$ 900 MeV)
  - Dead time
  - Beam-beam limit at lowest energy

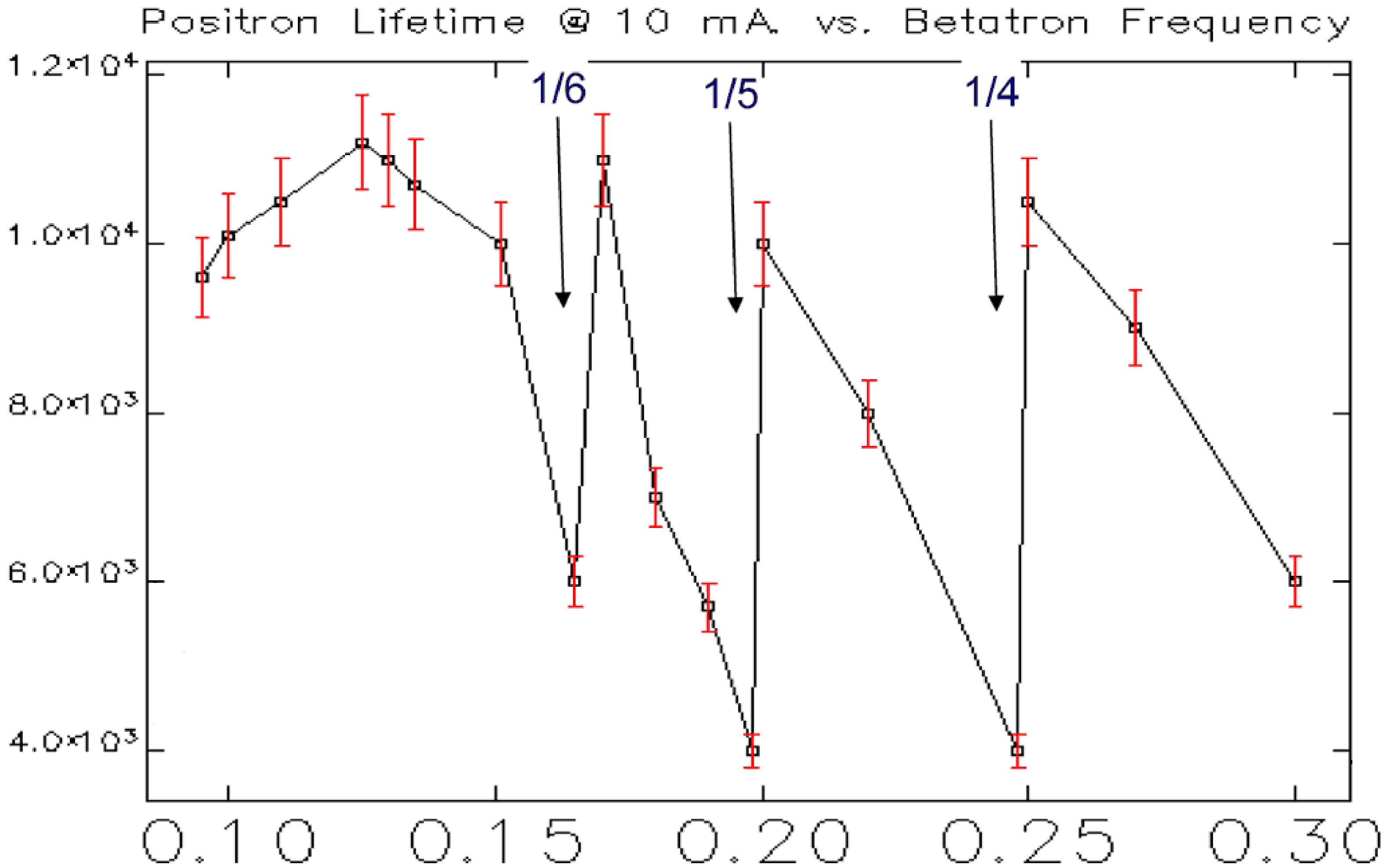
$\rightarrow$ BEP upgrade up to 1 GeV

- Dynamic aperture
  - Injection
  - Beam-beam (lifetime)
  - Beam-beam during ramping (working point drift)

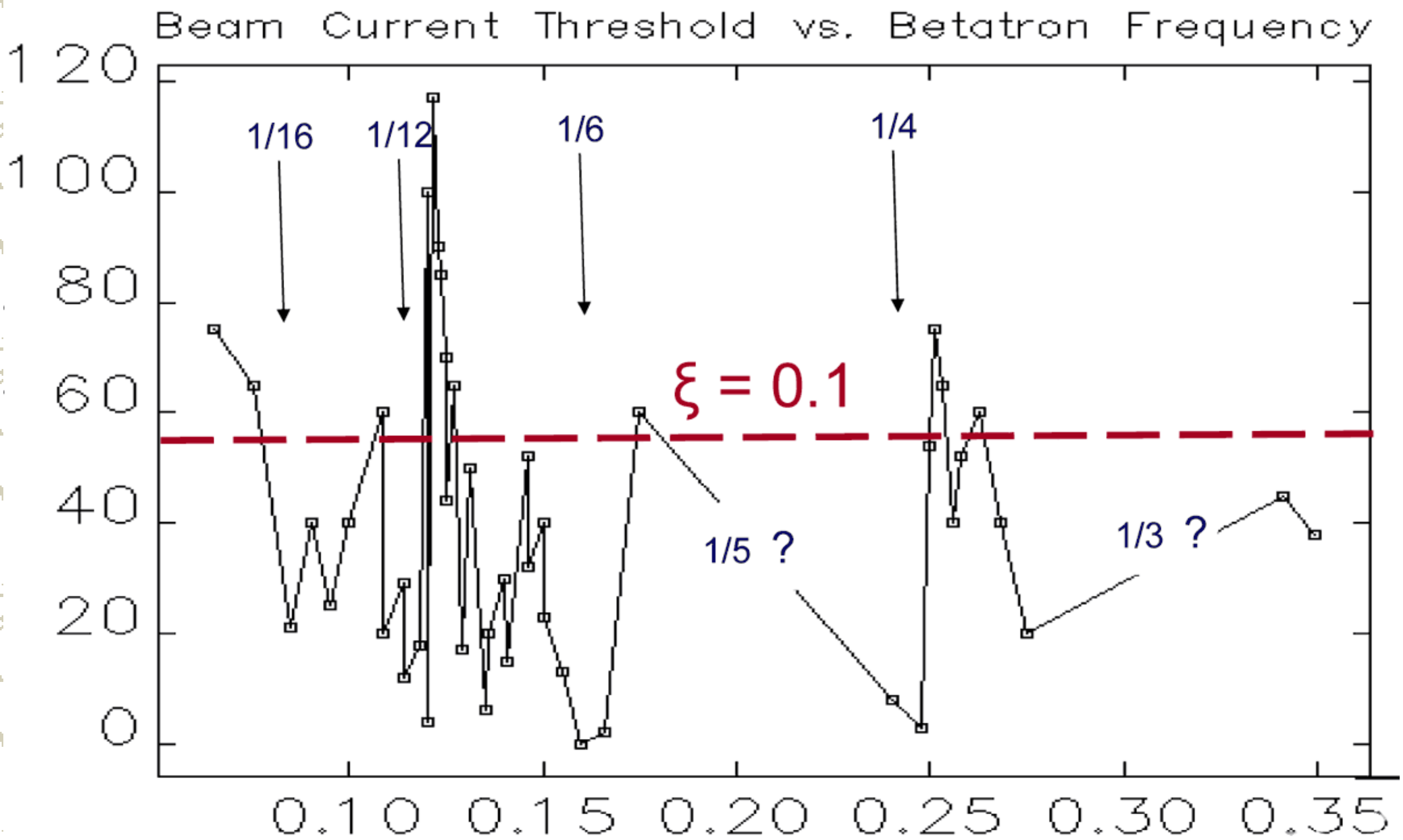
Dynamic aperture



Beam lifetime & nonlinear resonanses



“Weak-strong” threshold

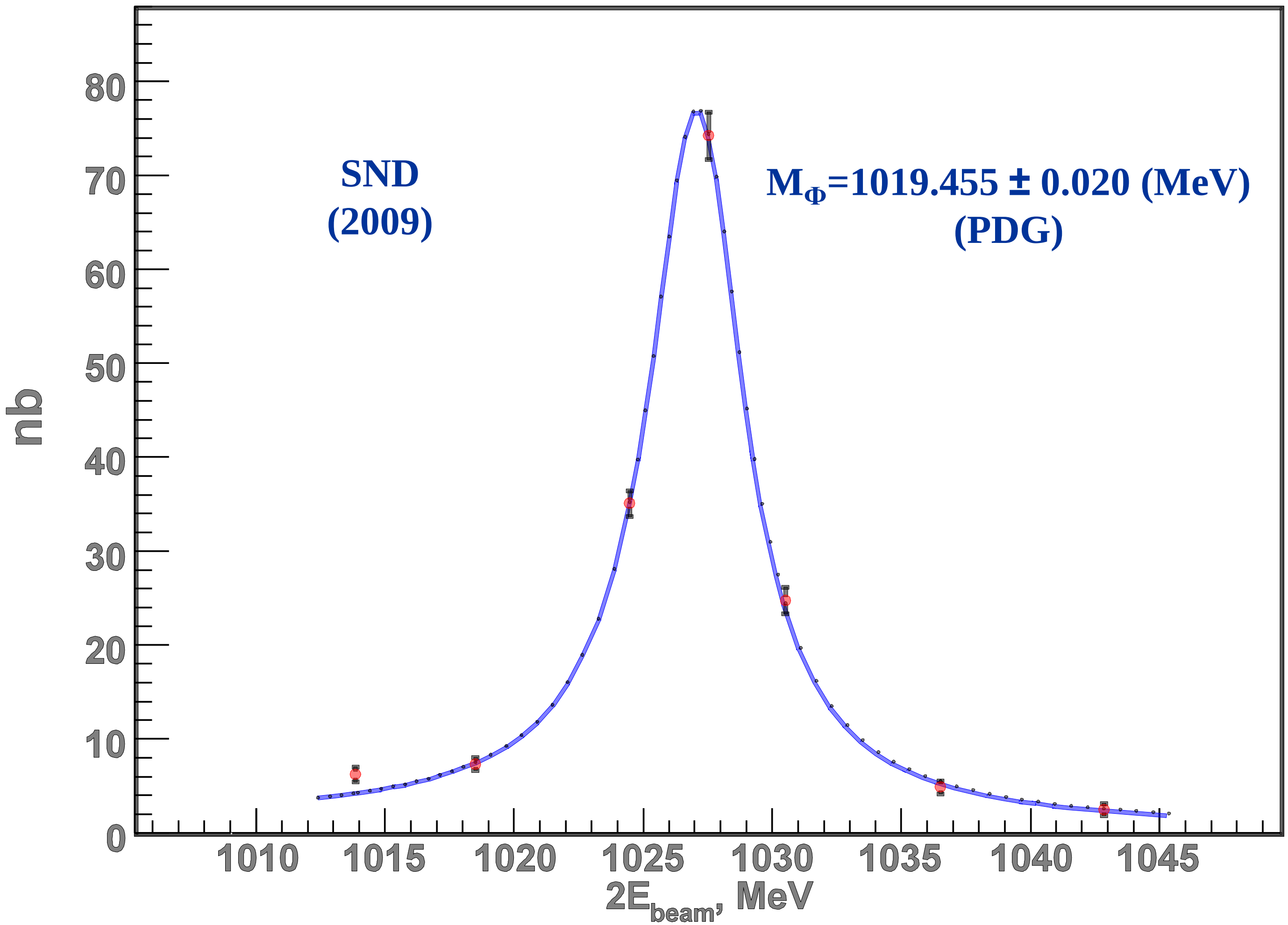


Beam energy calibration

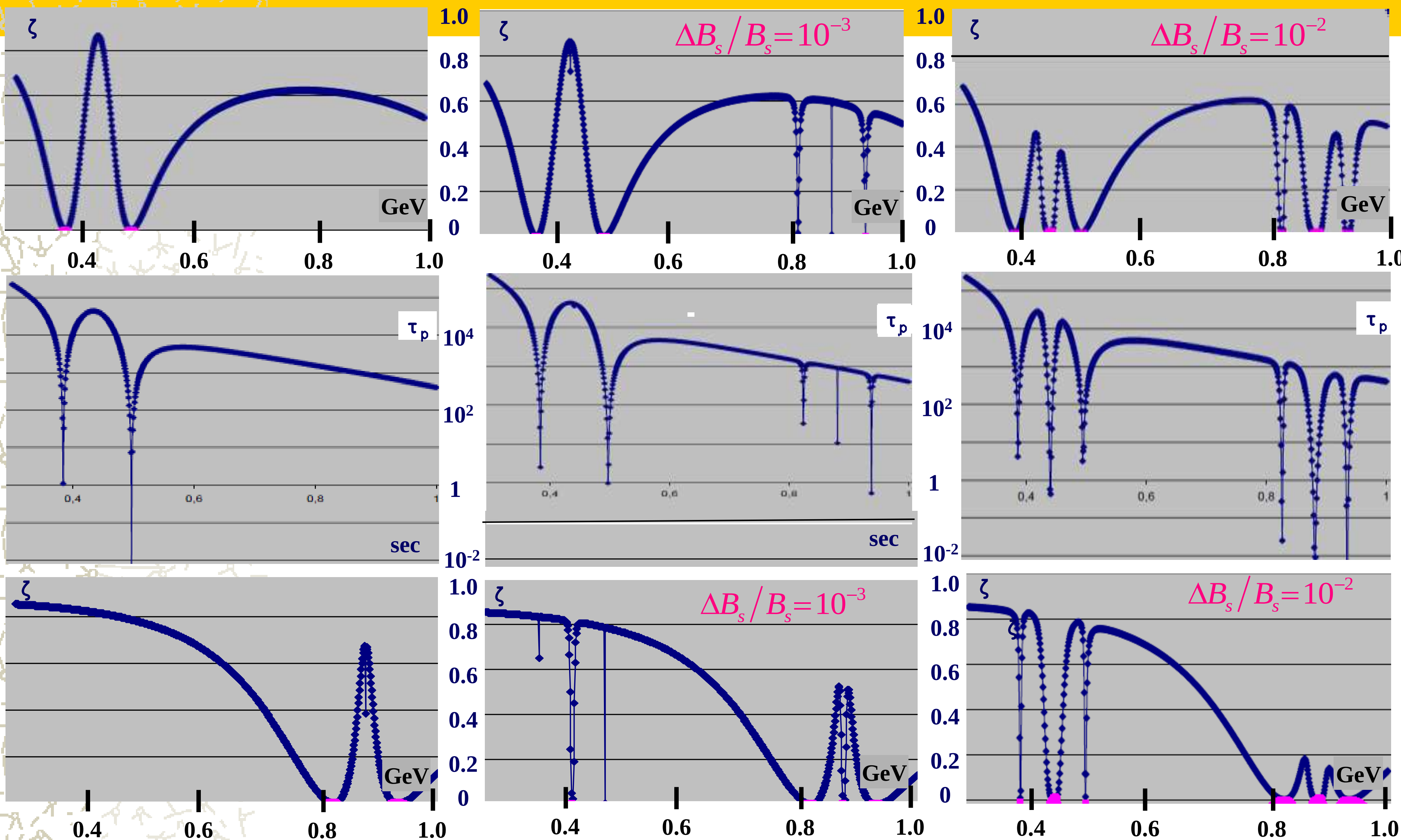
- **Requirement: $\Delta E/E \leq 10^{-4}$**
- **Magnetic field measurements:**
  - **16 NMR probes in dipoles**
- **Phi meson mass**
- **Radiative polarization:**
  - **IBS polarimeter**
  - **Resonant depolarization by RF- field**
- **Back Compton scattering**

Beam energy calibration

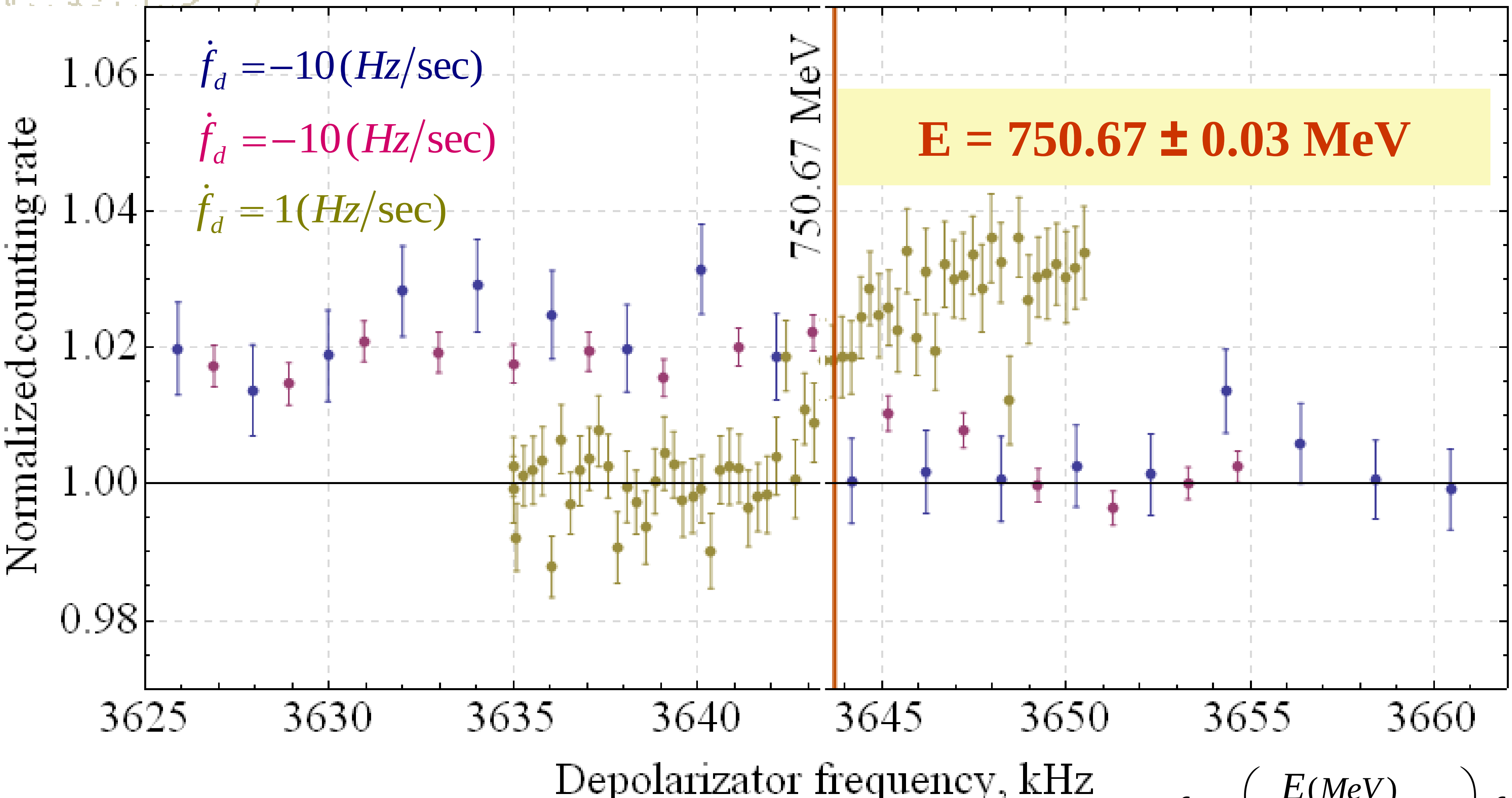
e+e- -> 3pi visible cross section



Radiative polarization at VEPP-2000



Resonant depolarization



$$f_d = \left(\frac{E(MeV)}{440.6484} - 1 \right) f_0$$

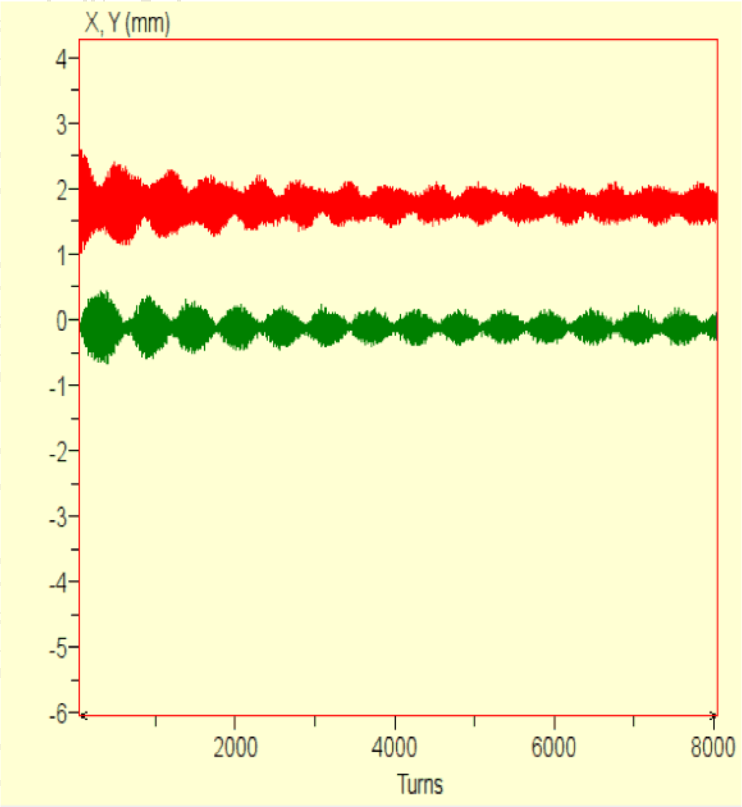
Conclusion

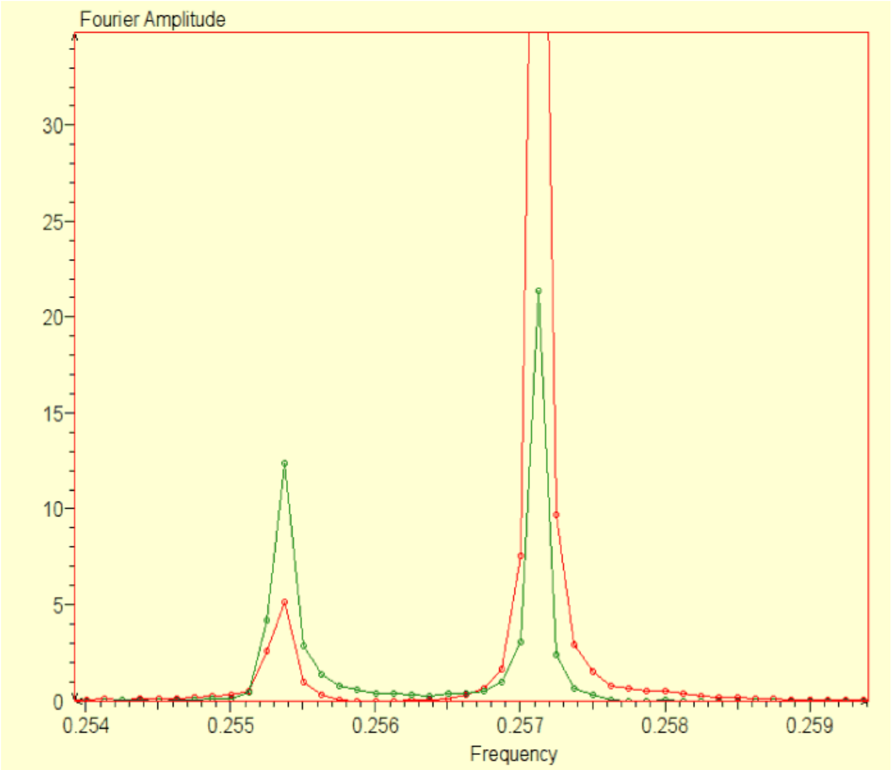
- **VEPP-2000 started-up for data taking.**
- **«Round beams» give luminosity enhancement.**
- **Luminosity 1×10^{31} cm^{-2}s^{-1} achieved at phi - meson energy.**
- **Potentially 2×10^{31} cm^{-2}s^{-1} is possible at φ**

  and 1.6×10^{32} cm^{-2}s^{-1} at 2 GeV.
- **To reach the target luminosity, more positrons are required booster BEP upgrade is needed.**
- **Beam energy calibration in progress.**

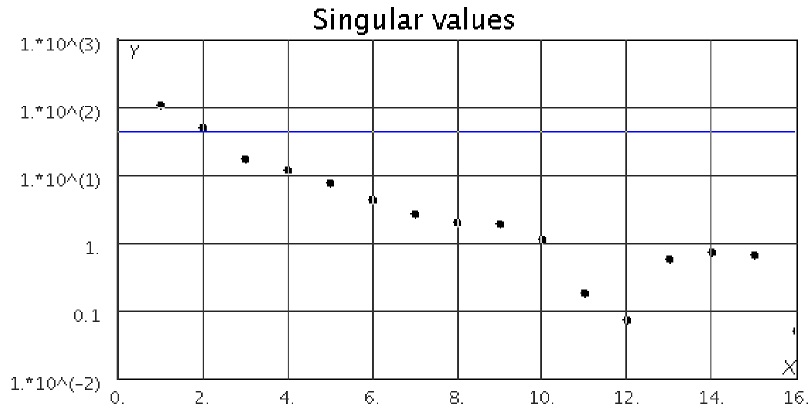
Thanks for attention!

Betatron tunes measurement (FFT)



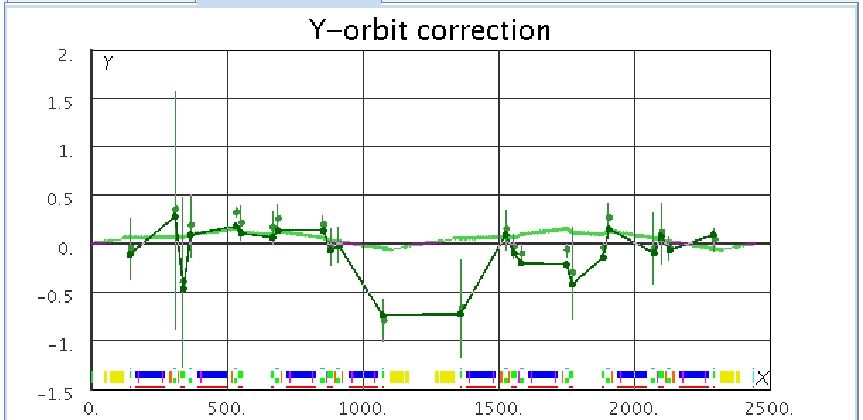


Orbit correction via ORM SVD



Singular values edge (by minimum value): 4.42*10^(1) Scale factor: 1.0

X-orbit correction | Y-orbit correction

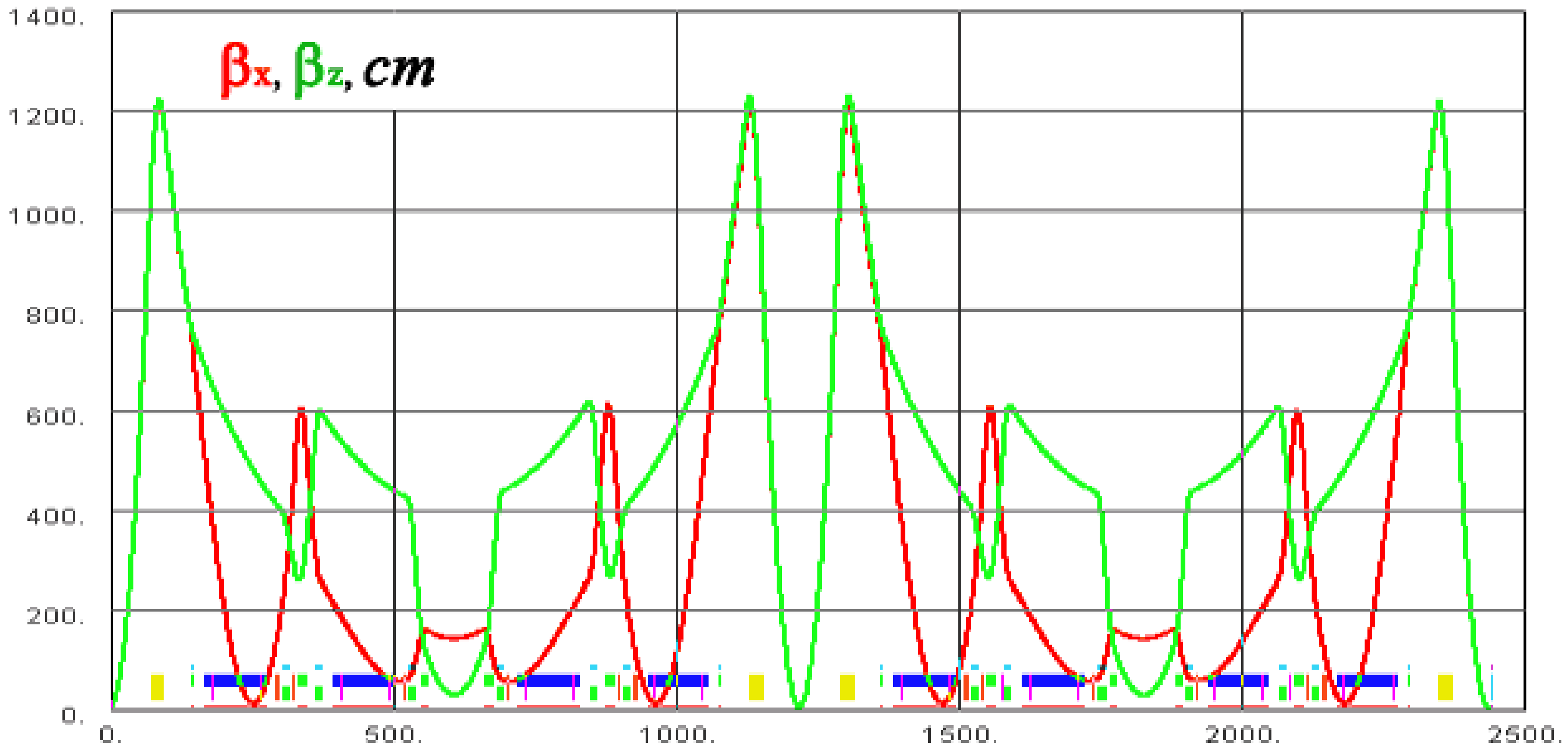


Correctors values:

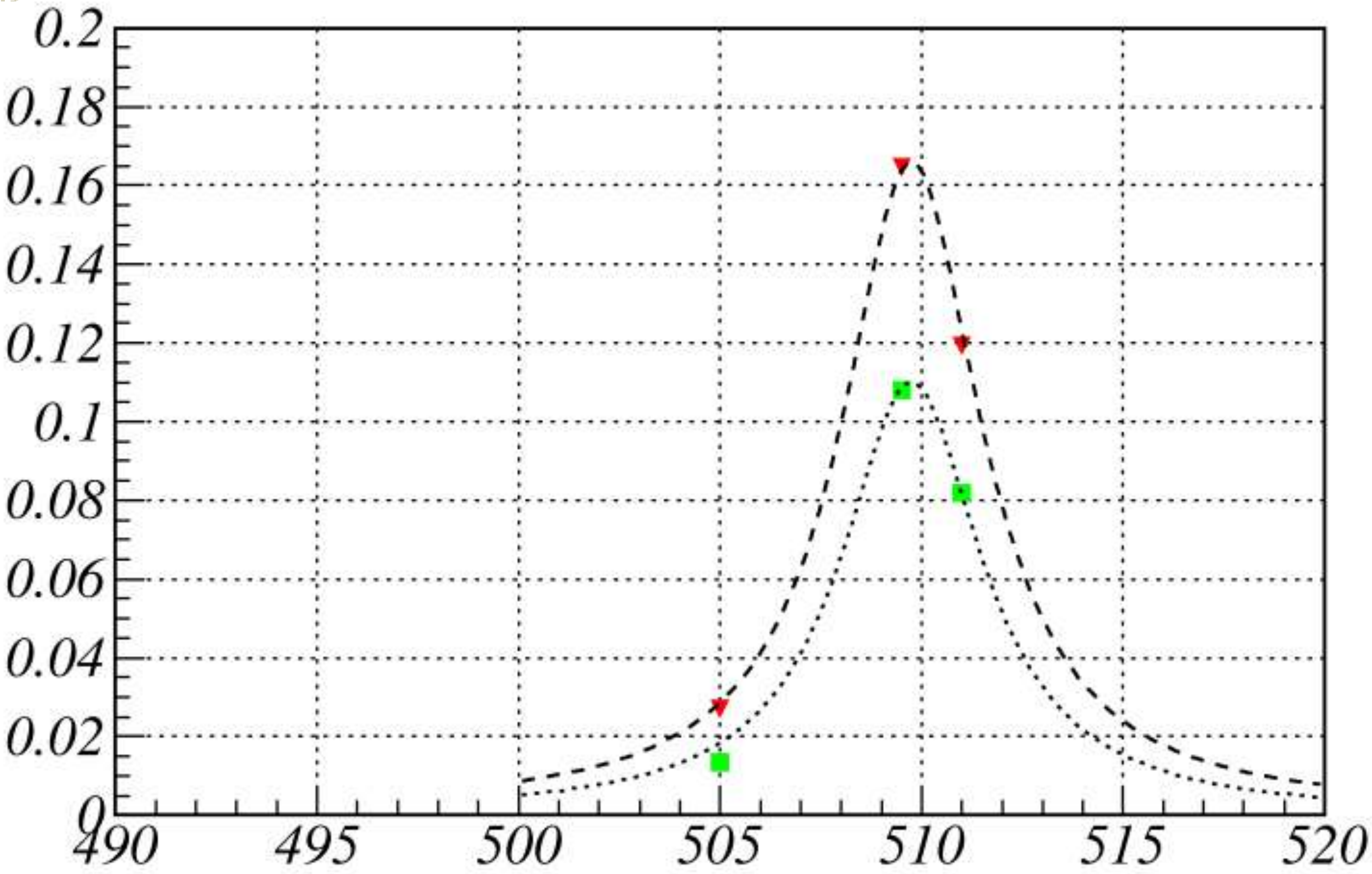
ID	Δ	ID	Δ	ID	Δ	ID	Δ	ID	Δ
1F1Z	0.002	1D1Z	0.004	1D2Z	0.006	1D3Z	0.008	2D3Z	0.006
2D2Z	0.001	2D1Z	-0.	2F1Z	-0.002	3F1Z	0.002	3D1Z	0.004
3D2Z	0.006	3D3Z	0.007	4D3Z	0.005	4D2Z	0.001	4D1Z	-0.
4F1Z	-0.002								

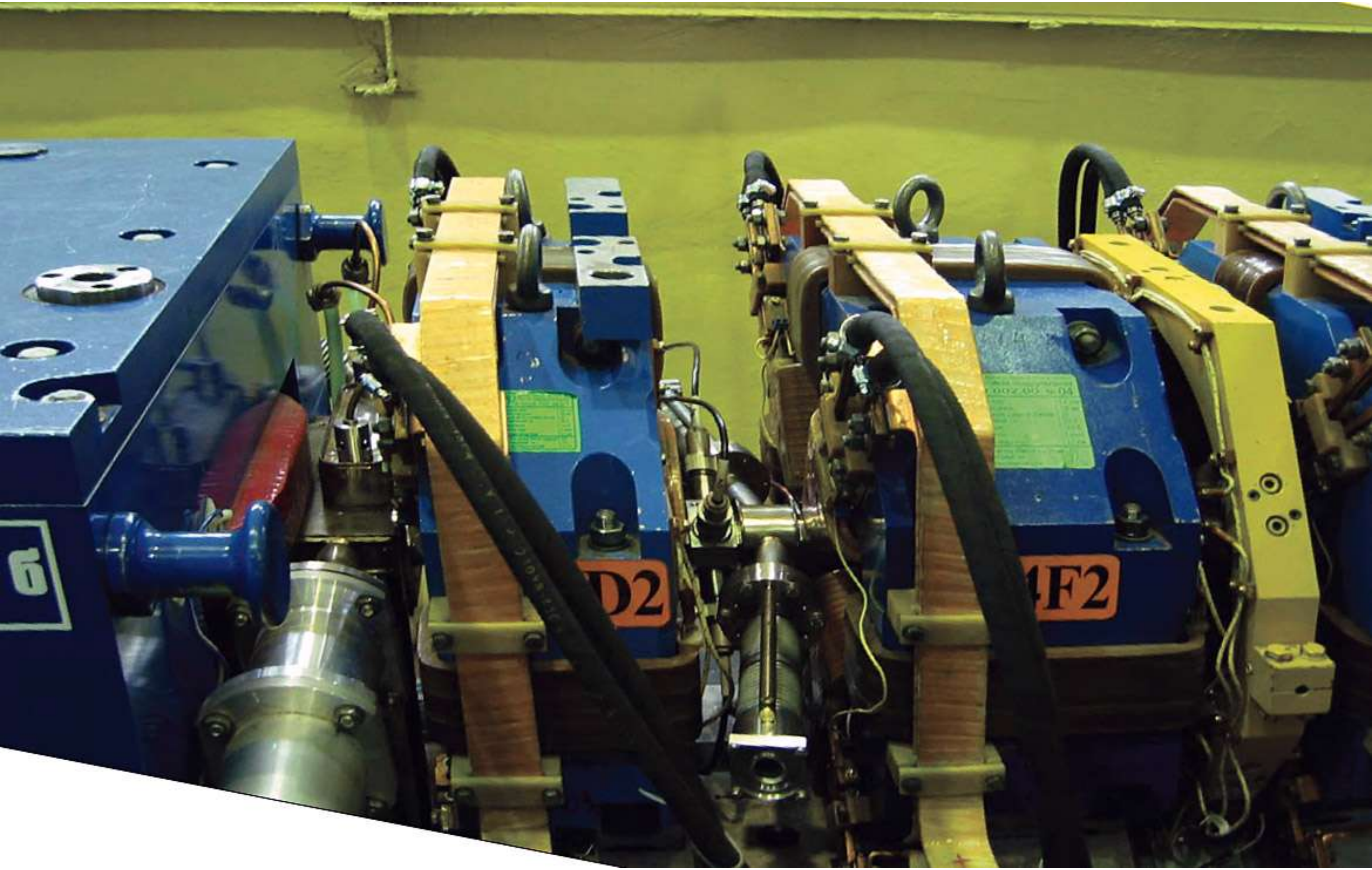
Back | Finish | Save RM in quads | Apply

Lattice correction via ORM SVD



Beam energy calibration




6
D2
4F2