



Electron-positron collider VEPP-2000 commissioning

Yu.Shatunov
on behalf of VEPP-2000 team,

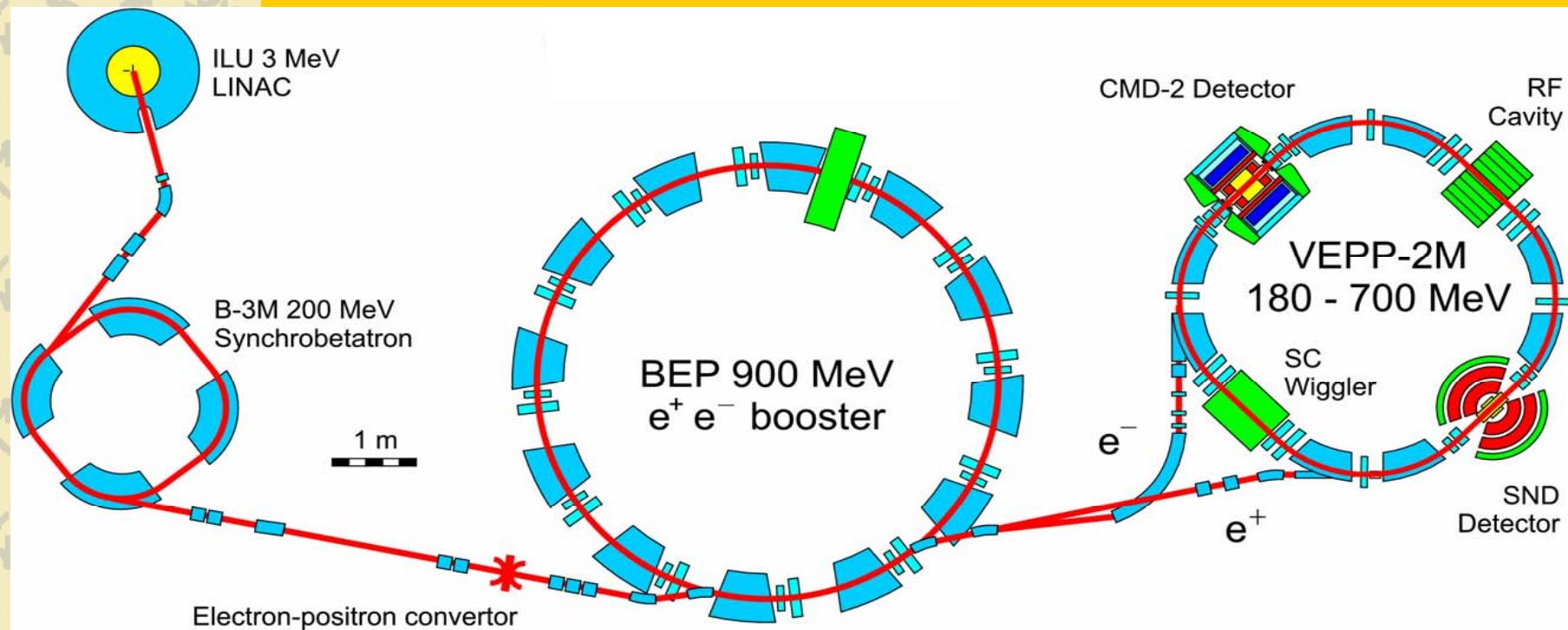
**ABDW
April 14-16, 2008
Novosibirsk**



OUTLINE

- ✖ VEPP-2M → VEPP-2000
- ✖ Physics at VEPP-2000
- ✖ Round beams - a way to increase luminosity.
- ✖ VEPP-2000 systems
- ✖ First beam
- ✖ Round beam
- ✖ Beam-beam study
- ✖ Conclusion

VEPP-2M collider complex (1974-2000)

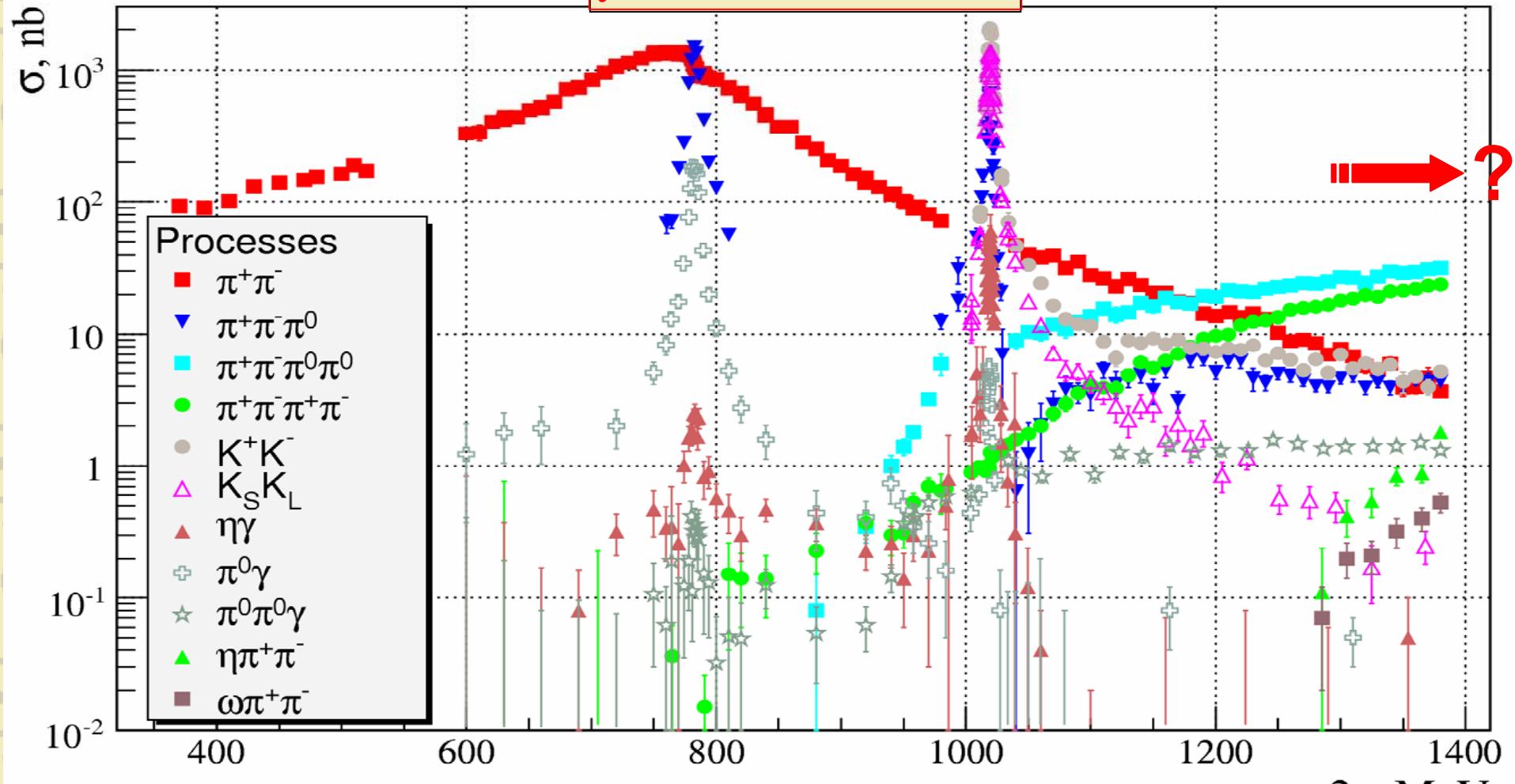


Electron-positron convertor

- Luminosity: $L=5\times10^{30} \text{ cm}^{-2}\text{s}^{-1}$:
- 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

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



Physical program at VEPP-2000

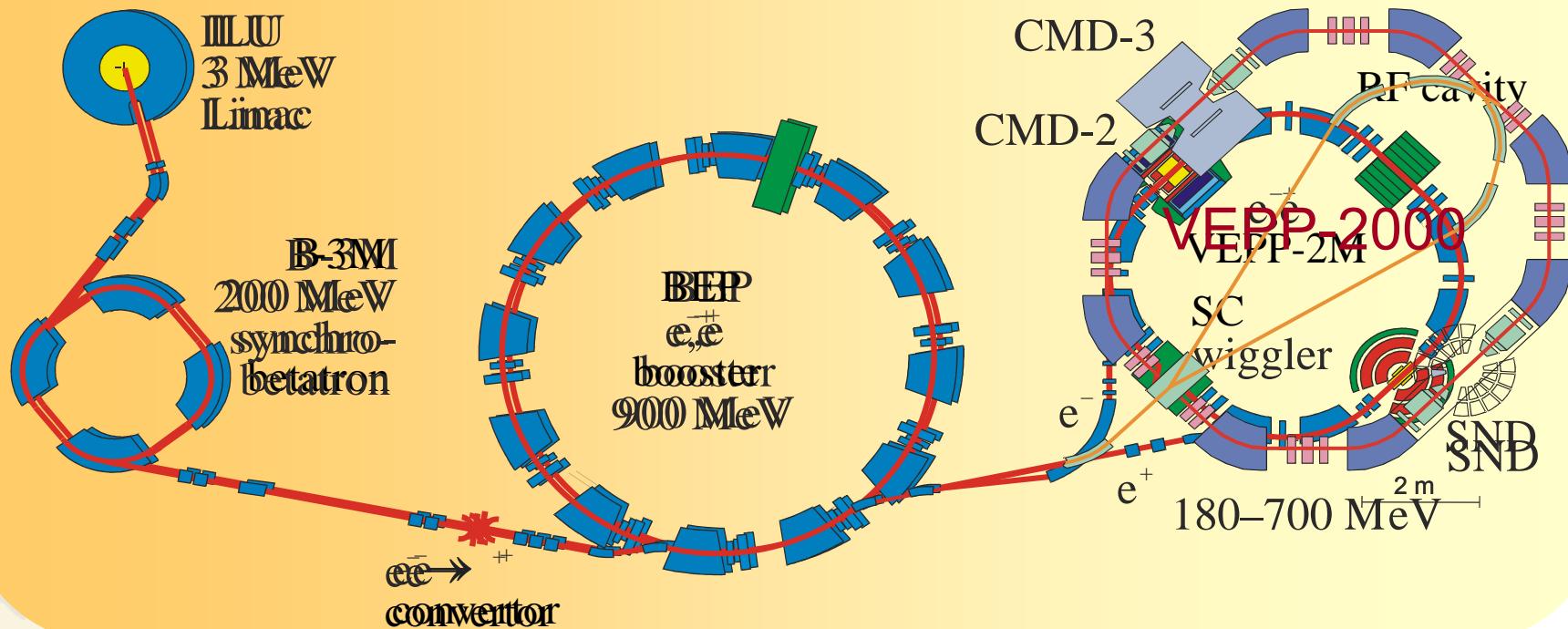
1. Precise measurement of the quantity
 $R = \sigma(e^+e^- \rightarrow \text{hadrons}) / \sigma(e^+e^- \rightarrow \mu^+\mu^-)$
2. Study of hadronic channels:
 $e^+e^- \rightarrow 2h, 3h, 4h \dots, h = \pi, K, \eta$
3. Study of 'excited' vector mesons: $\rho', \rho'', \omega', \varphi', \dots$
4. CVC tests: comparison of $e^+e^- \rightarrow \text{hadr.}$ ($T=1$)
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

(2000-2007)

VEPP-2000



$E \approx 1 \text{ GeV}$

(per beam)

$L \approx 1 \times 10^{32} \text{ cm}^{-2} \text{ sec}^{-1}$

(1x1 bunch)

Increasing of Luminosity

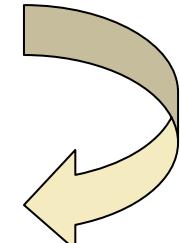
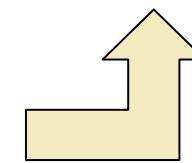
- ❑ Number of bunches (i.e. collision frequency)
- ❑ Bunch-by-bunch luminosity

$$L = \frac{\pi \gamma^2 \xi_x \xi_y \epsilon_x f}{r_e^2 \beta_y^*} \left(1 + \frac{\sigma_y}{\sigma_x} \right)^2 \quad \Rightarrow \quad \text{Round Beams:}$$

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

- ✓ Geometric factor (gain=4)
- ✓ Beam-beam limit enhancement
- ✓ IBS for low energy? worth life time!

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





Round Colliding Beams Concept

💡 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:

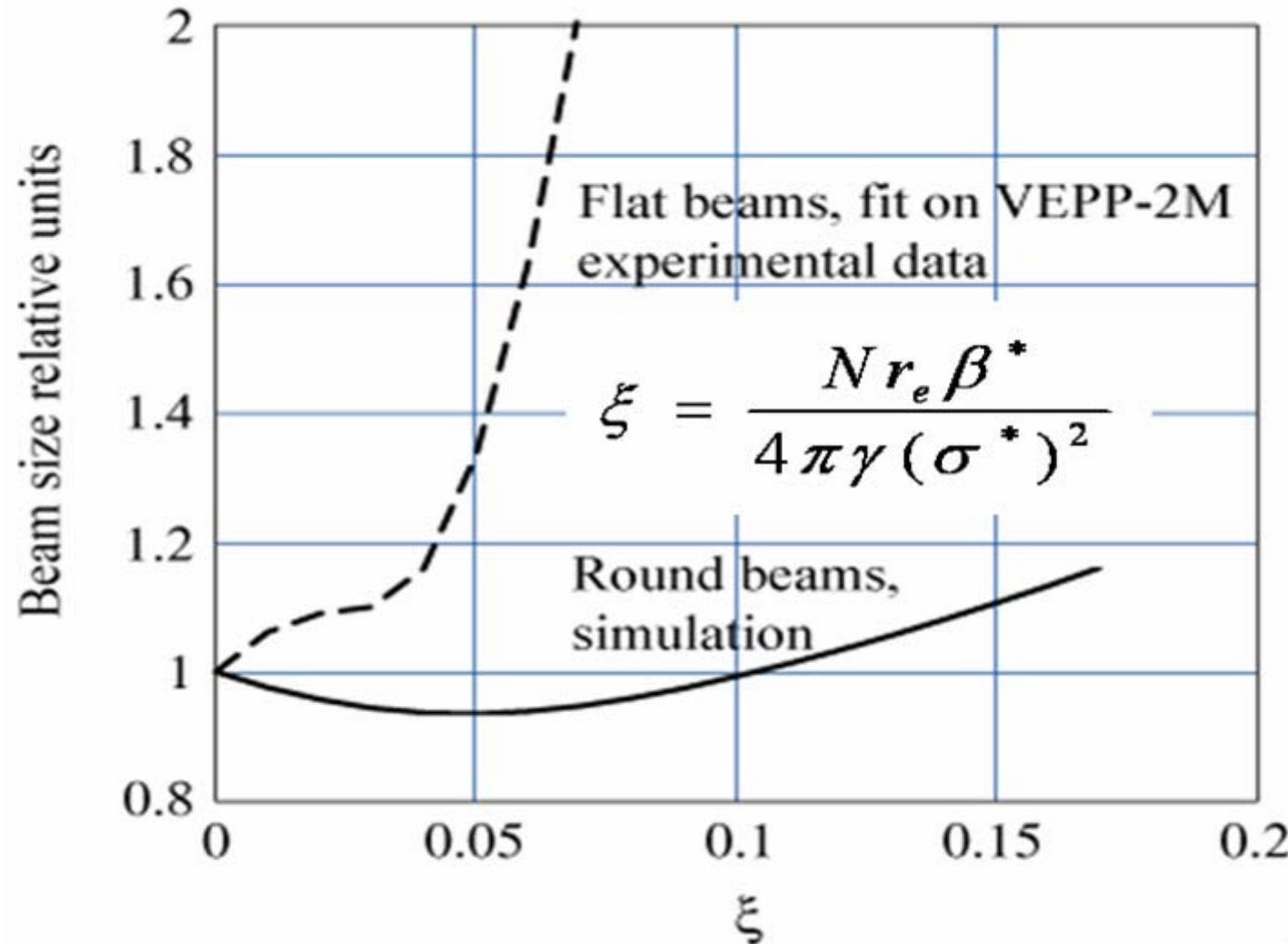
$$\nu_x = \nu_y$$

💡 Small and positive fractional tunes

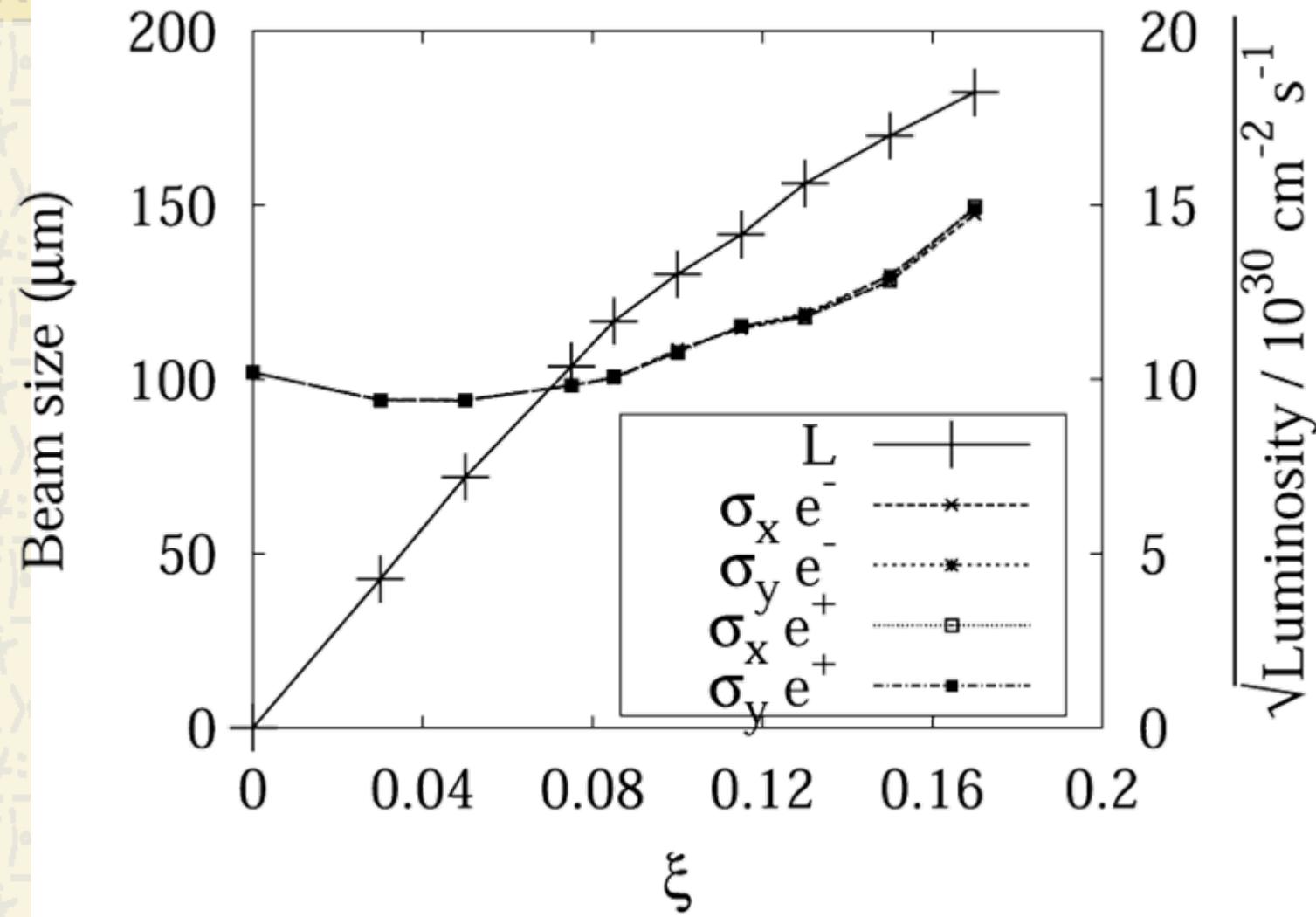
(V.V.Danilov et al., EPAC'96, Barcelona, p.1149, (1996))

Vertical size dependence on beam-beam parameter ξ

"Weak-Strong" Beam-Beam Simulations

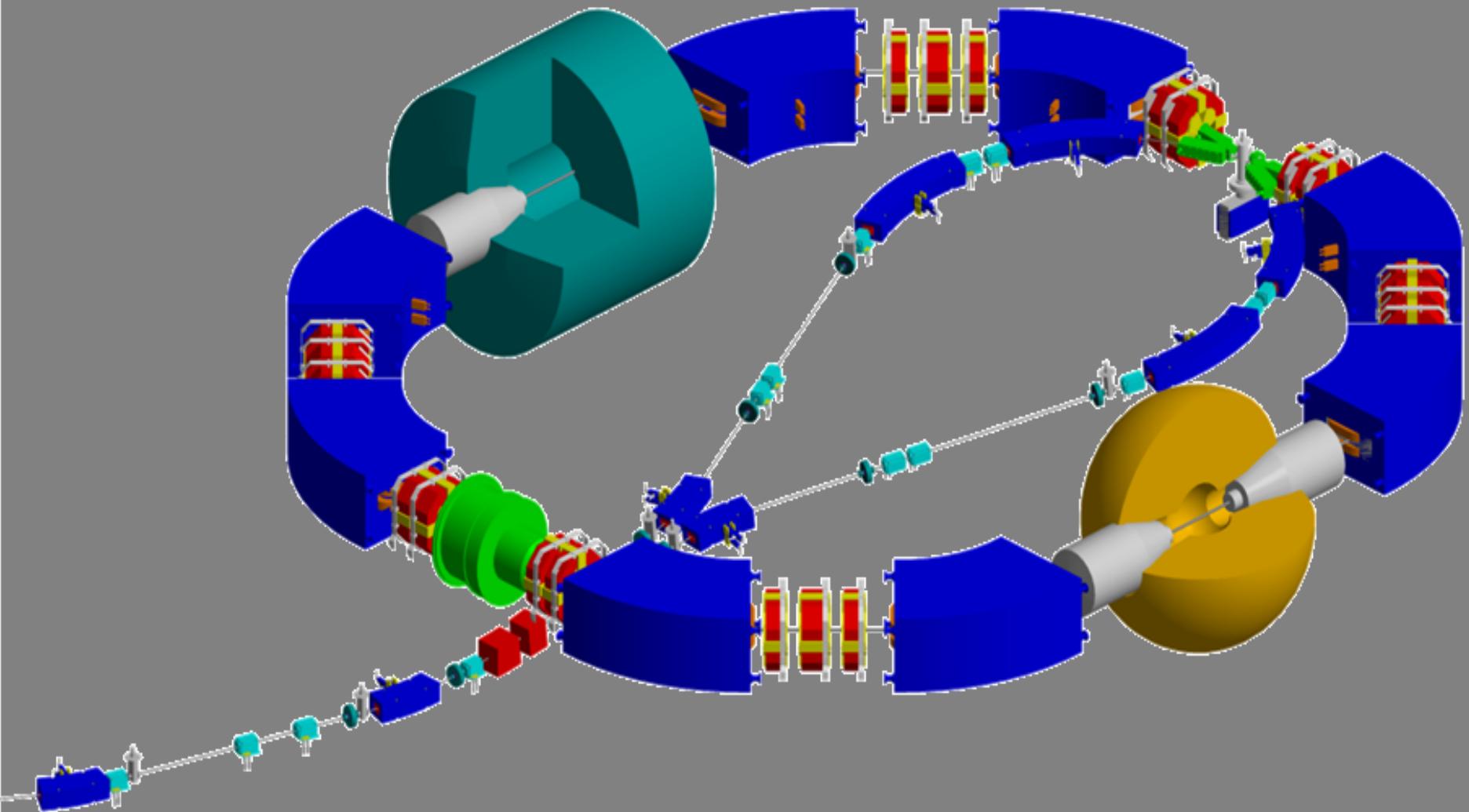


“Strong-Strong” Beam-Beam Simulations

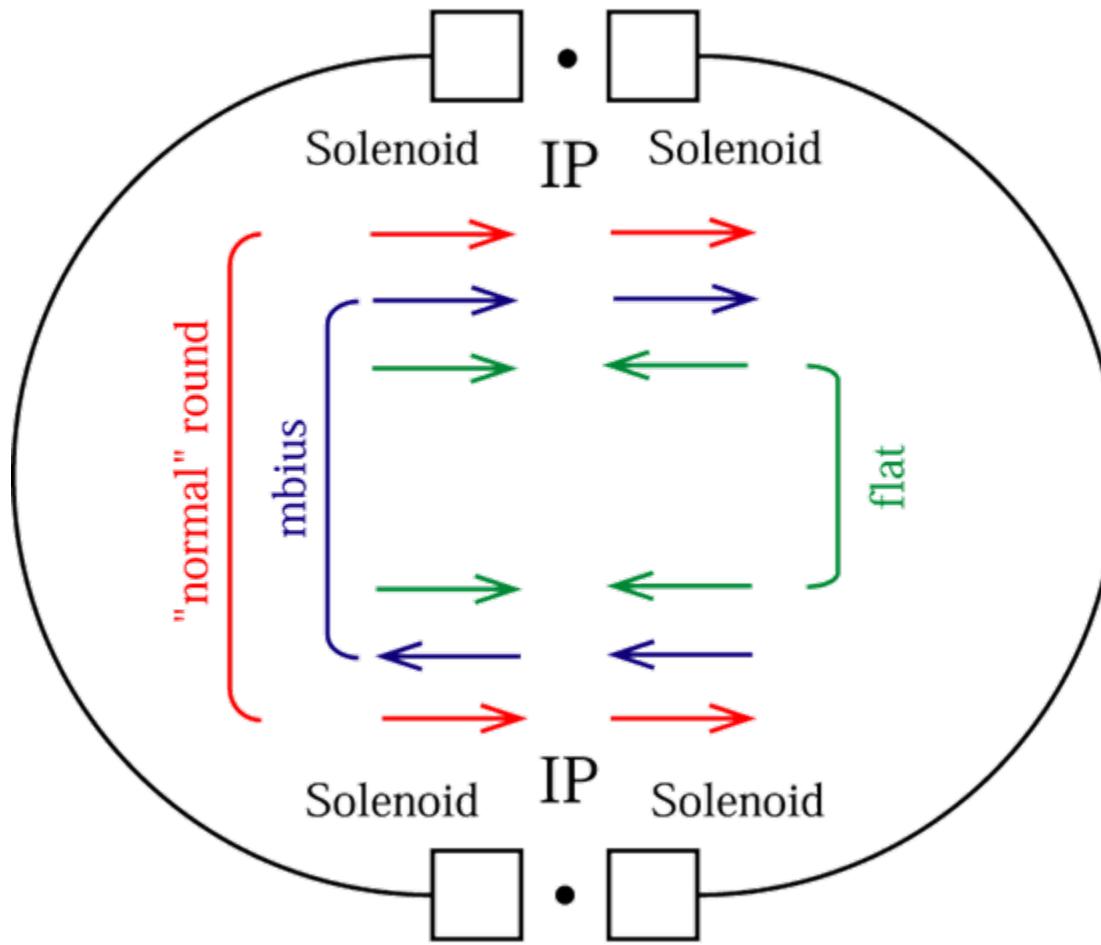




Practical Realization of Round Beams Options for VEPP-2000



Practical Realization of Round Beams Options for VEPP-2000



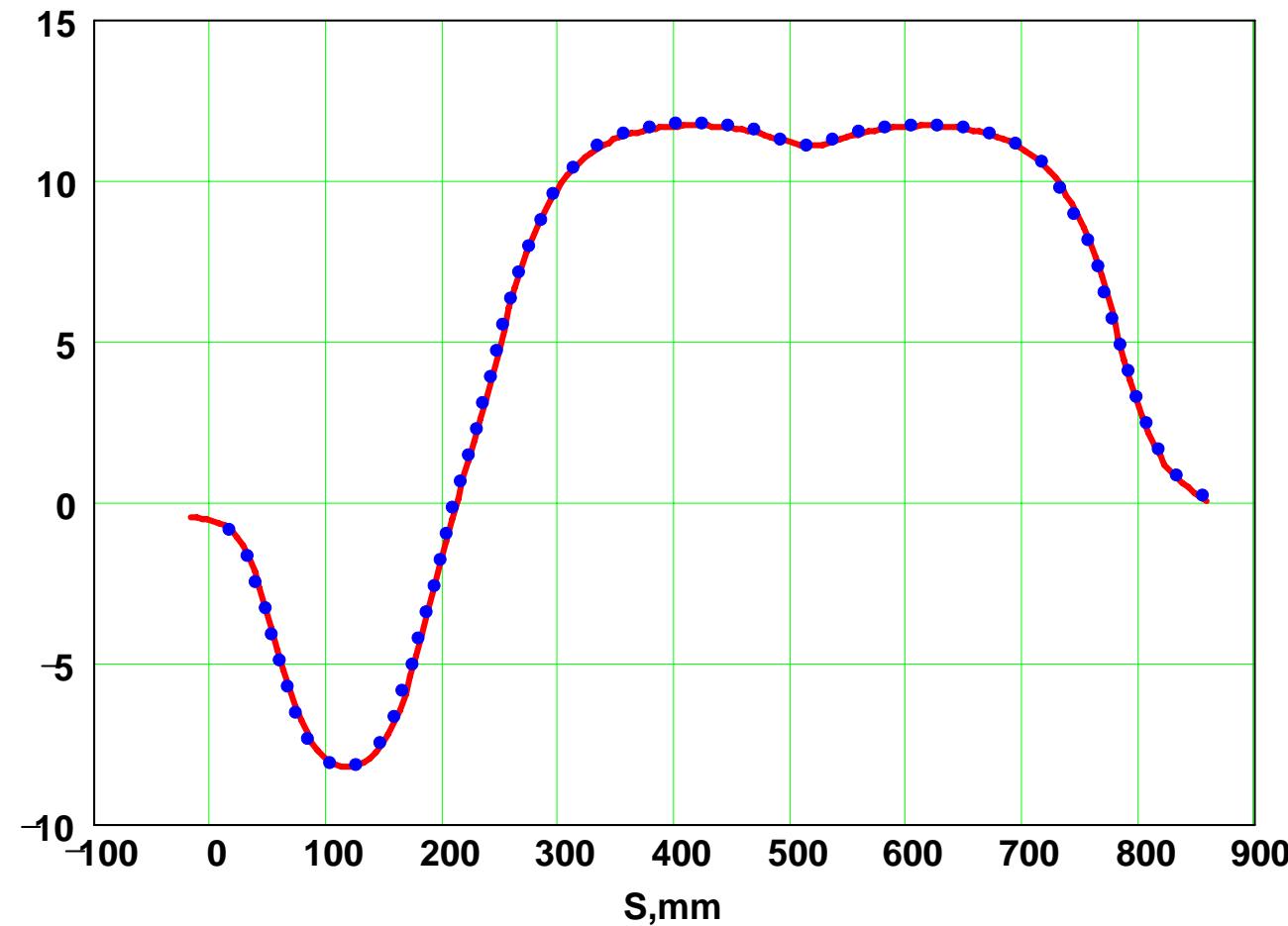


Solenoid 13.0 T



VEPP-2000
SC solenoid

Solenoid Test



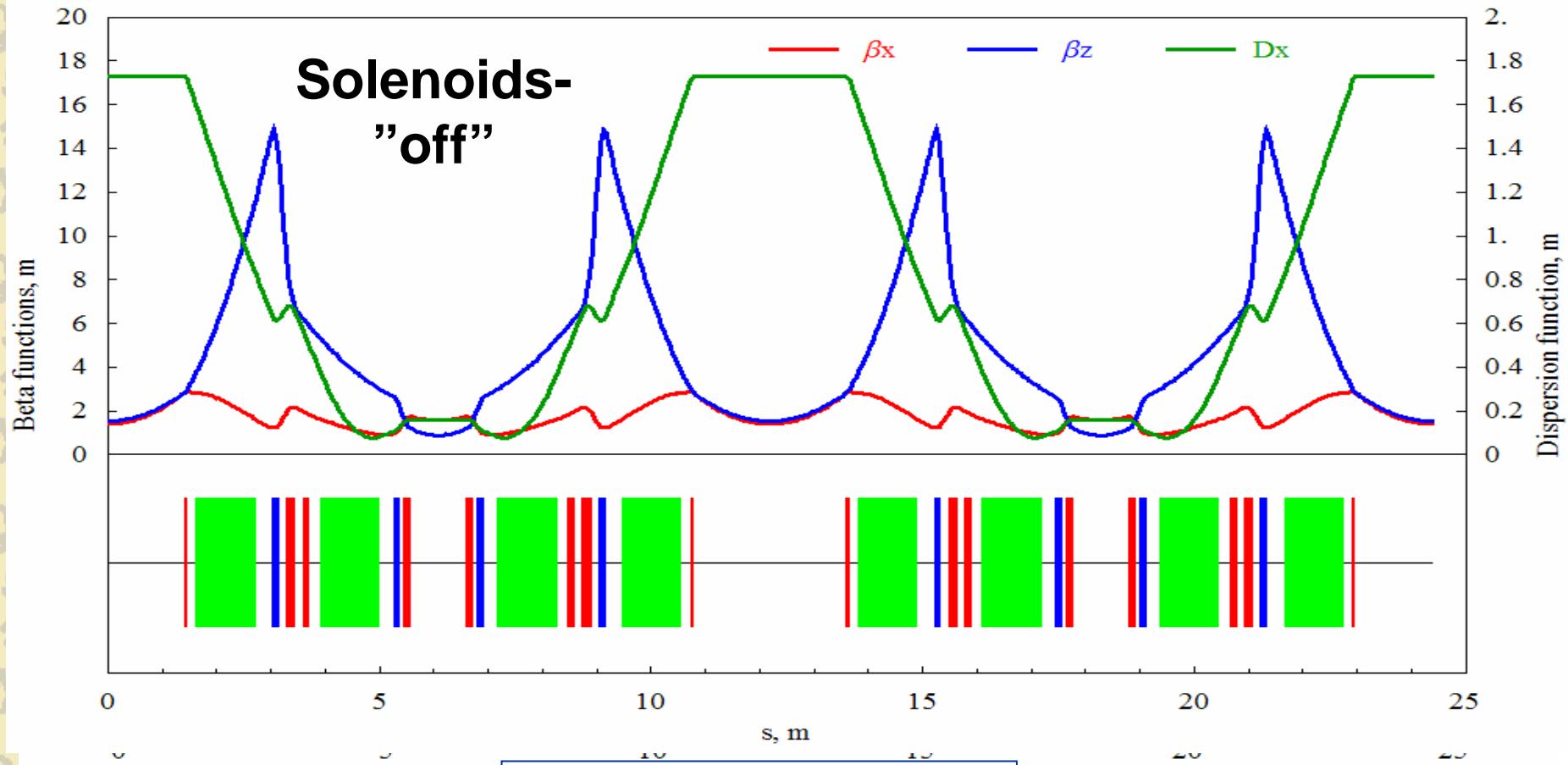


VEPP-2000



VEPP-2000 Lattice

Solenoids-
"off"

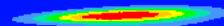


$$\nu_z = 1.38; \quad \nu_x = 2.44$$

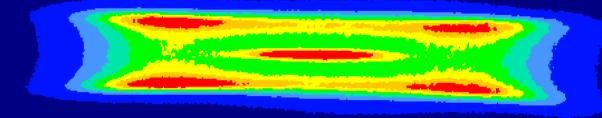


Beam's CCD pictures

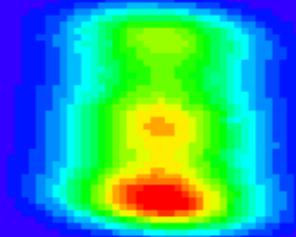
regular



kicked



tune mes.

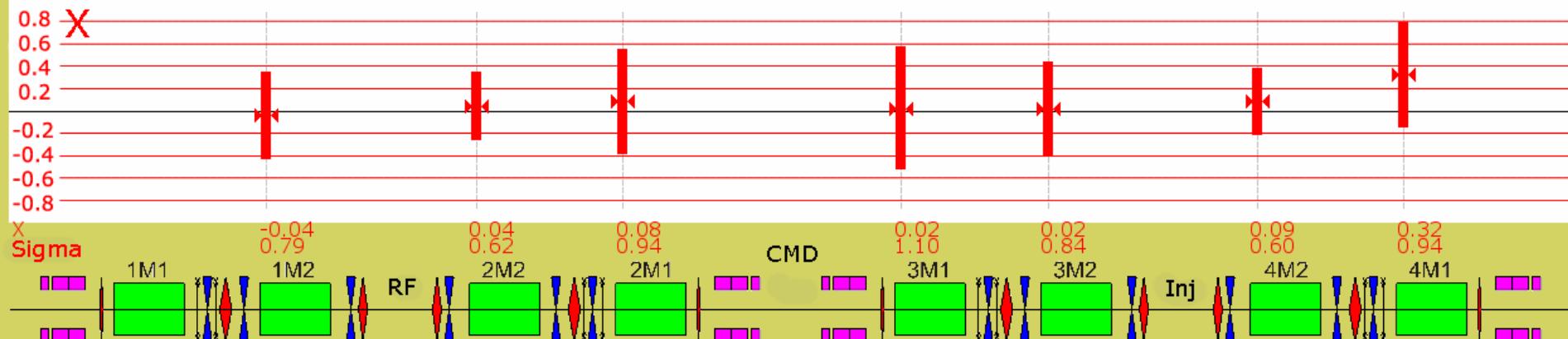


CO and Beam Sizes (solenoids “off”)

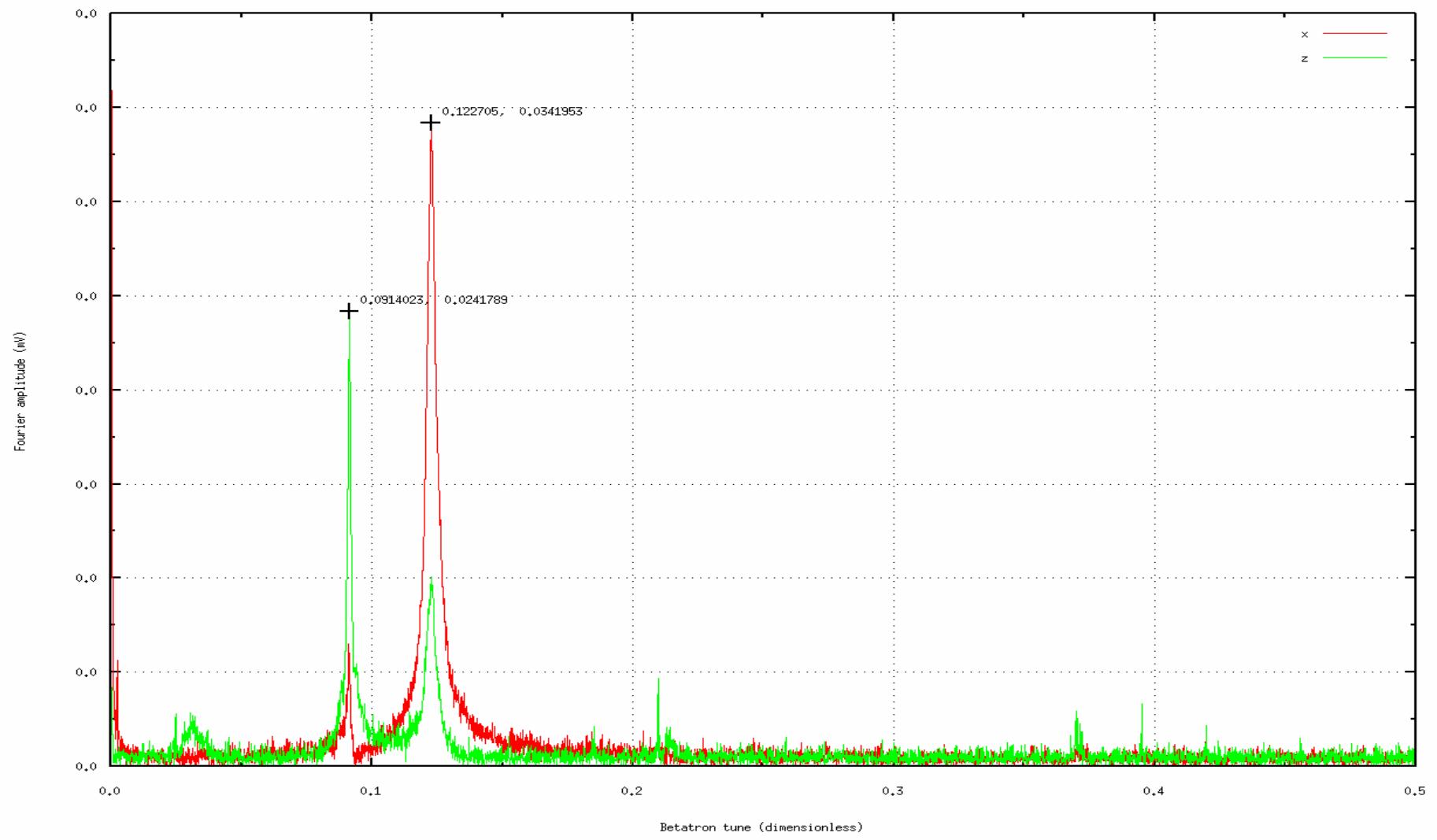
File Tools



Limit: 1 ▾

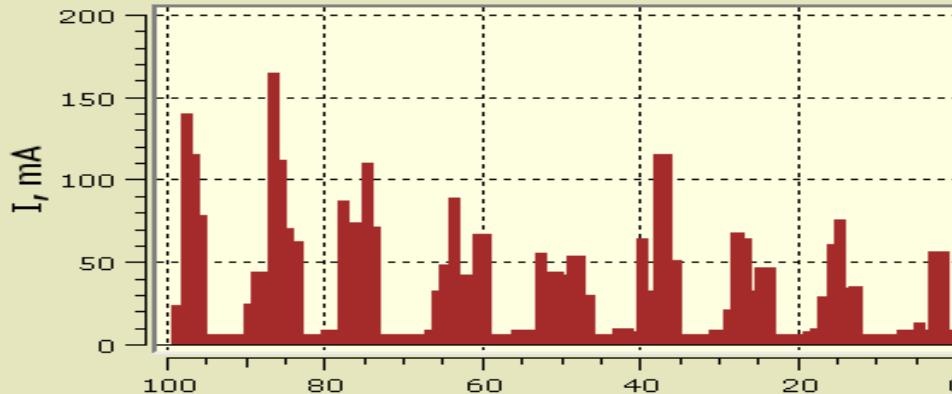


Pick-up diagnostics



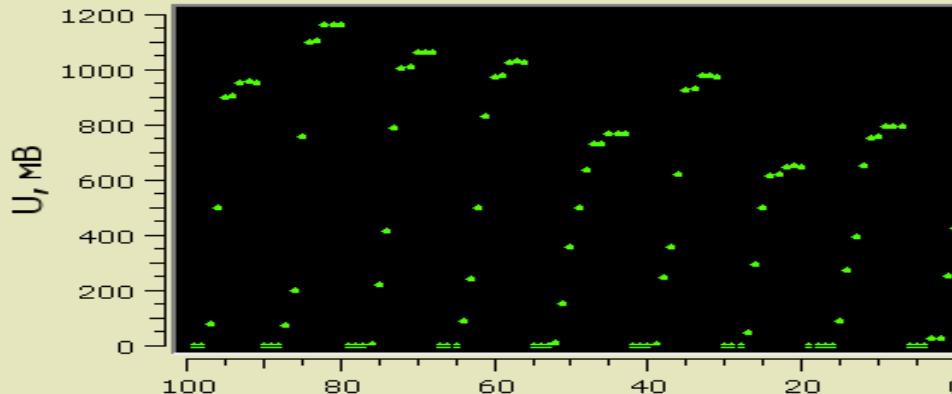
Beam currents

БЭМ



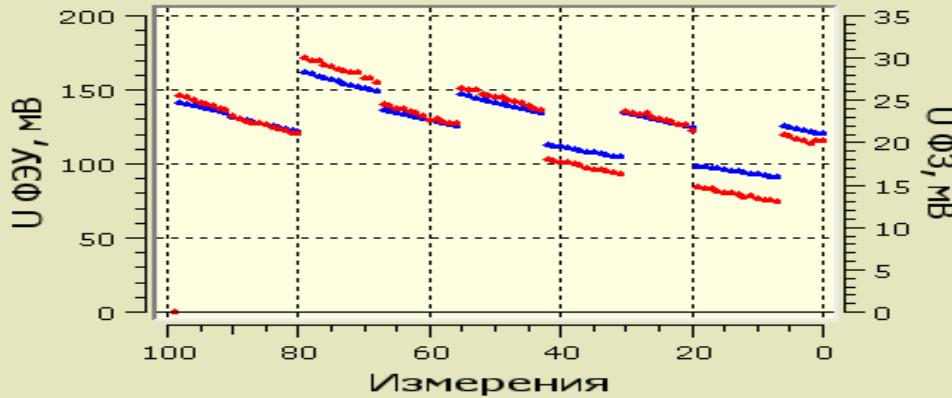
Synchrotron B-3M

БЭП



Booster BEP

ВЭПП-2000



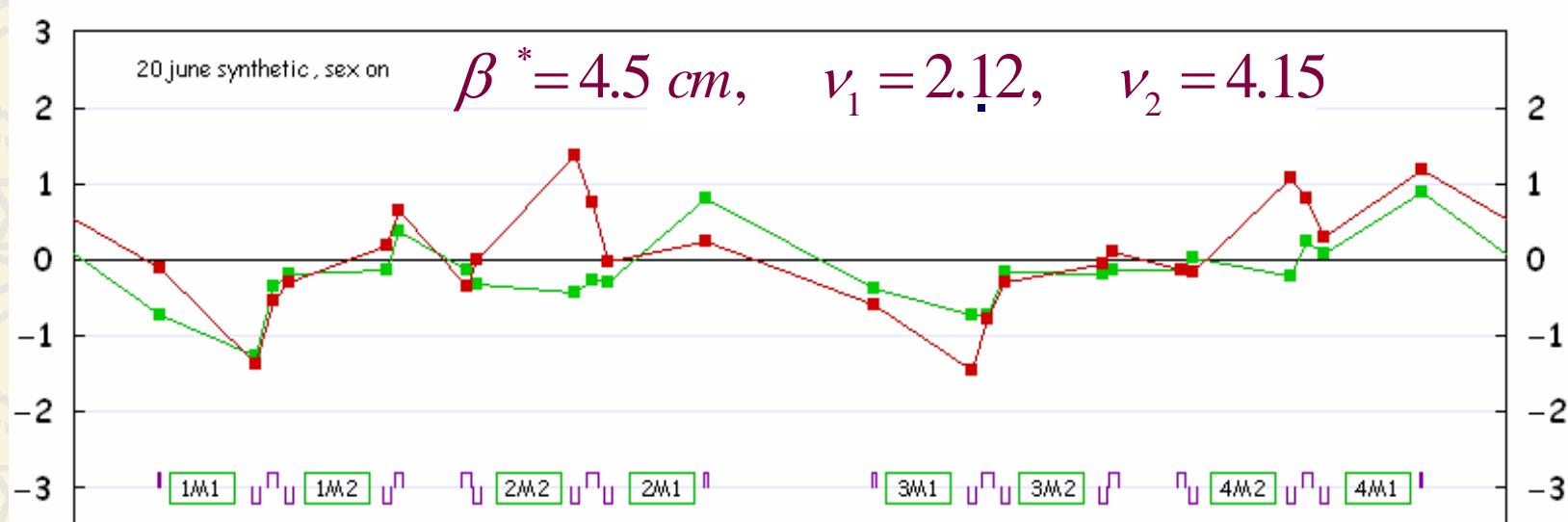
VEPP-2000

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

$$\tau(1 \text{ mA}) \geq 10 \text{ hours}$$

Round beam operation

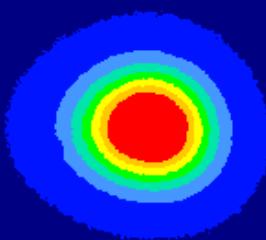
✖ $E = 508 \text{ MeV}$



✖ Orbit response matrices on dipole and quadrupole corrections + Singular Values Decomposition

Round beams (solenoid field 10 T)

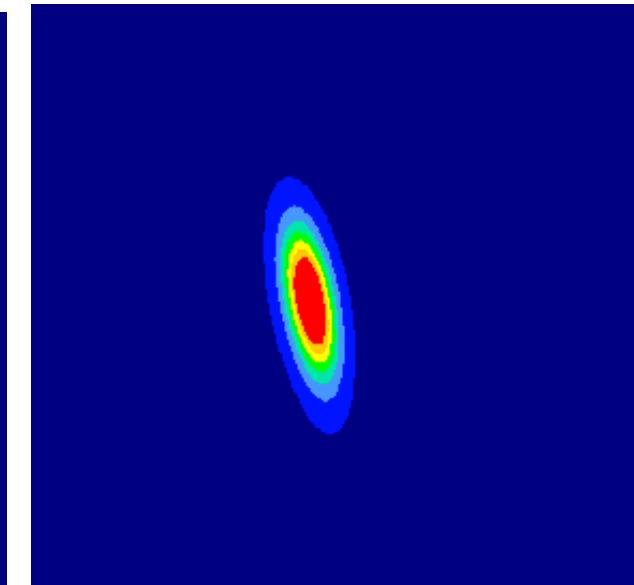
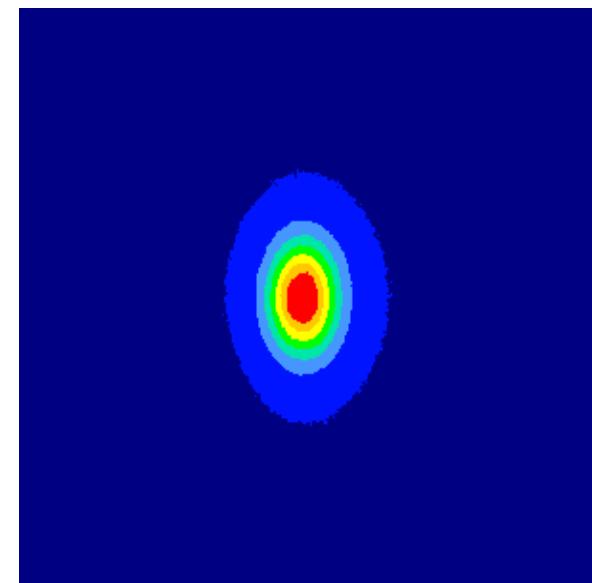
positron beam



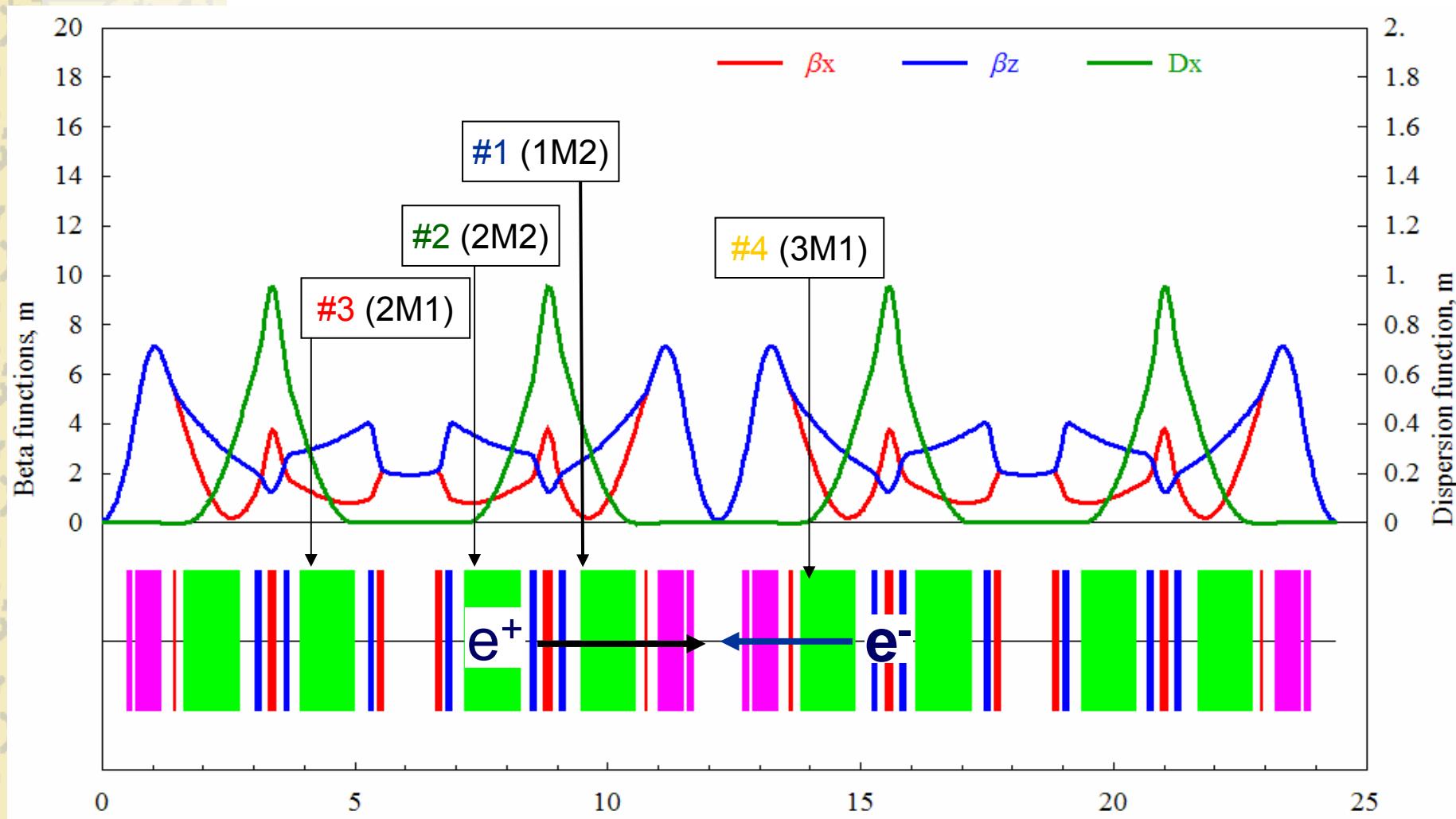
#1 (1M2)

#2 (2M2)

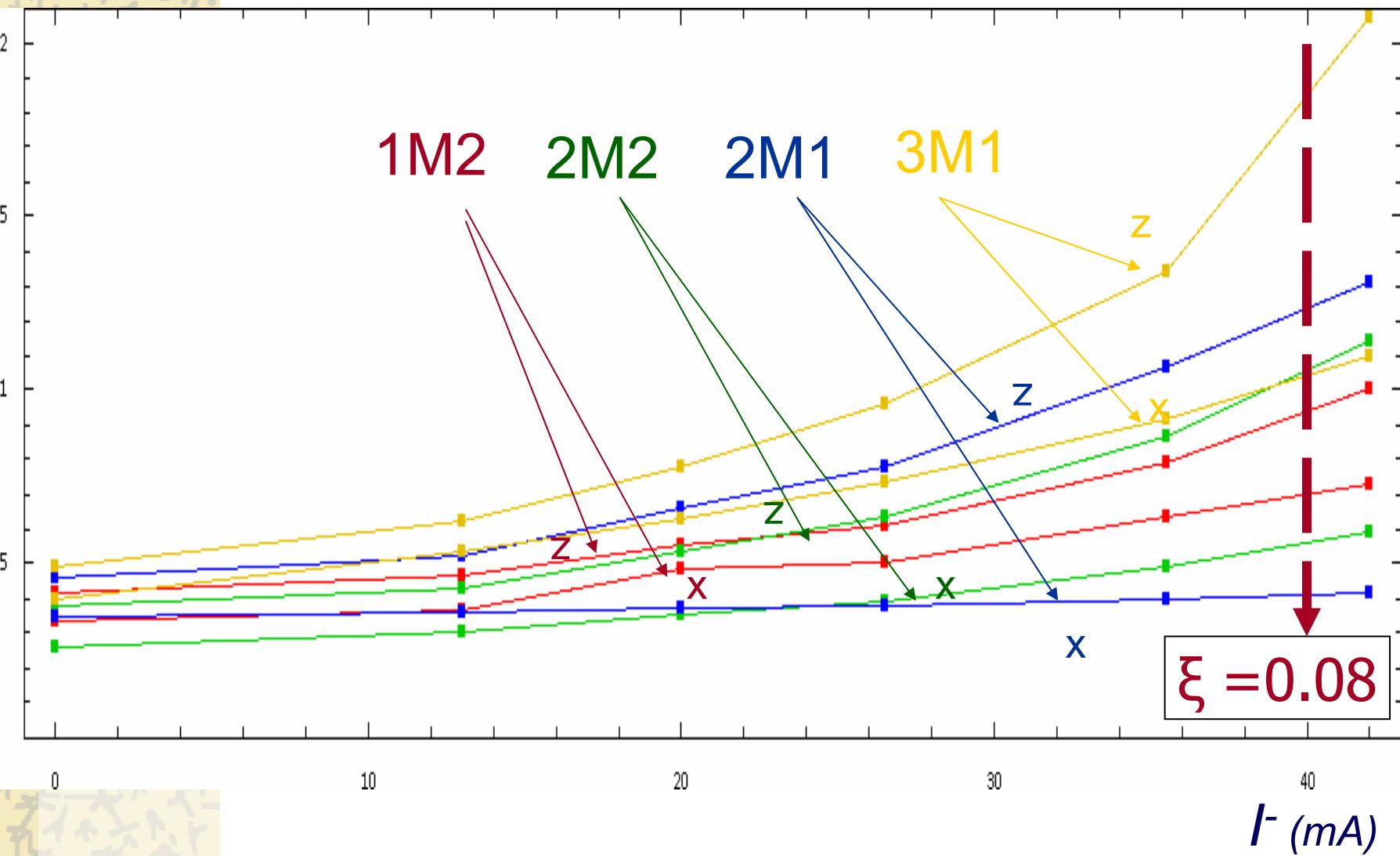
#3 (2M1)



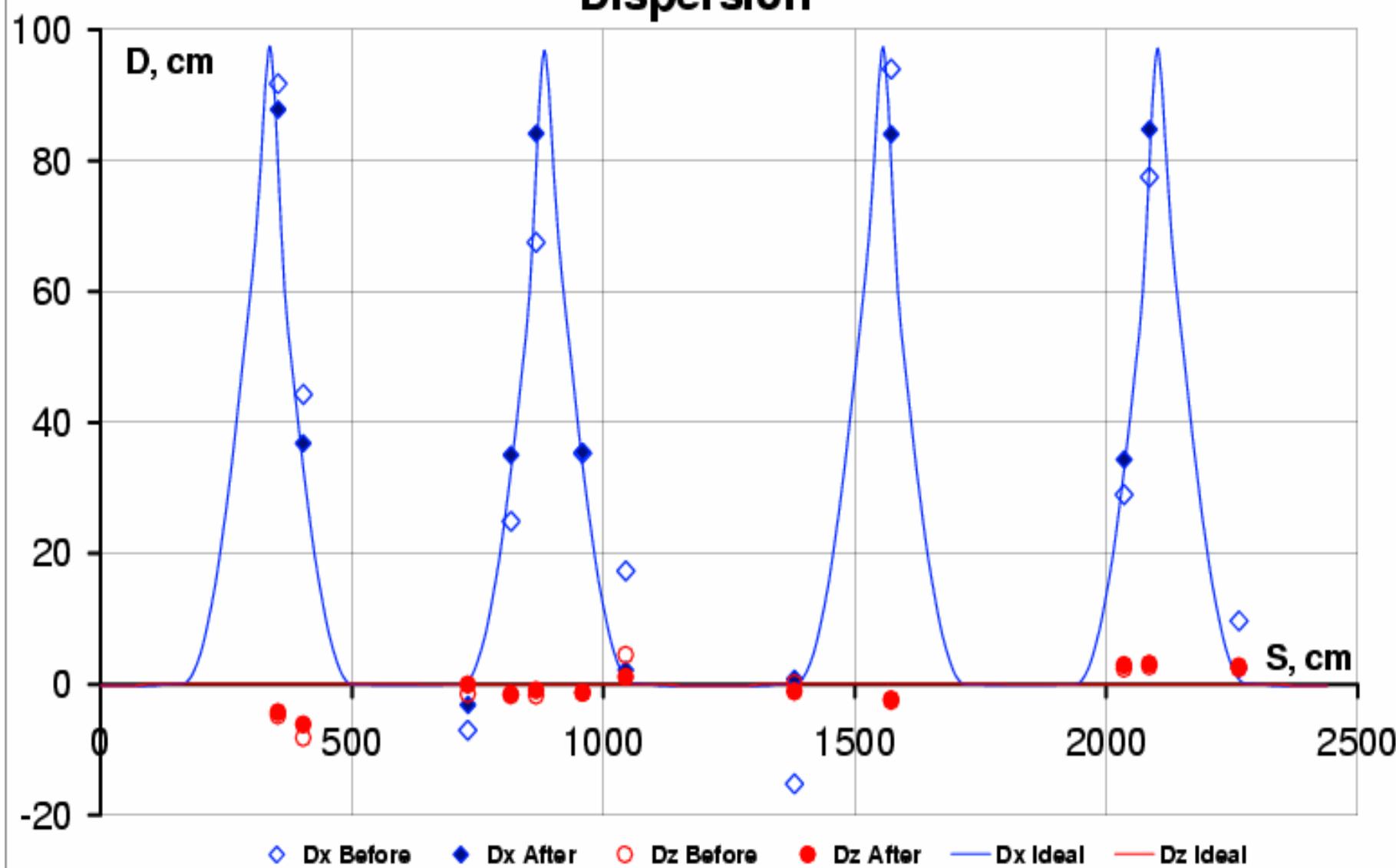
Round beam lattice



“Weak-strong” beam-beam study

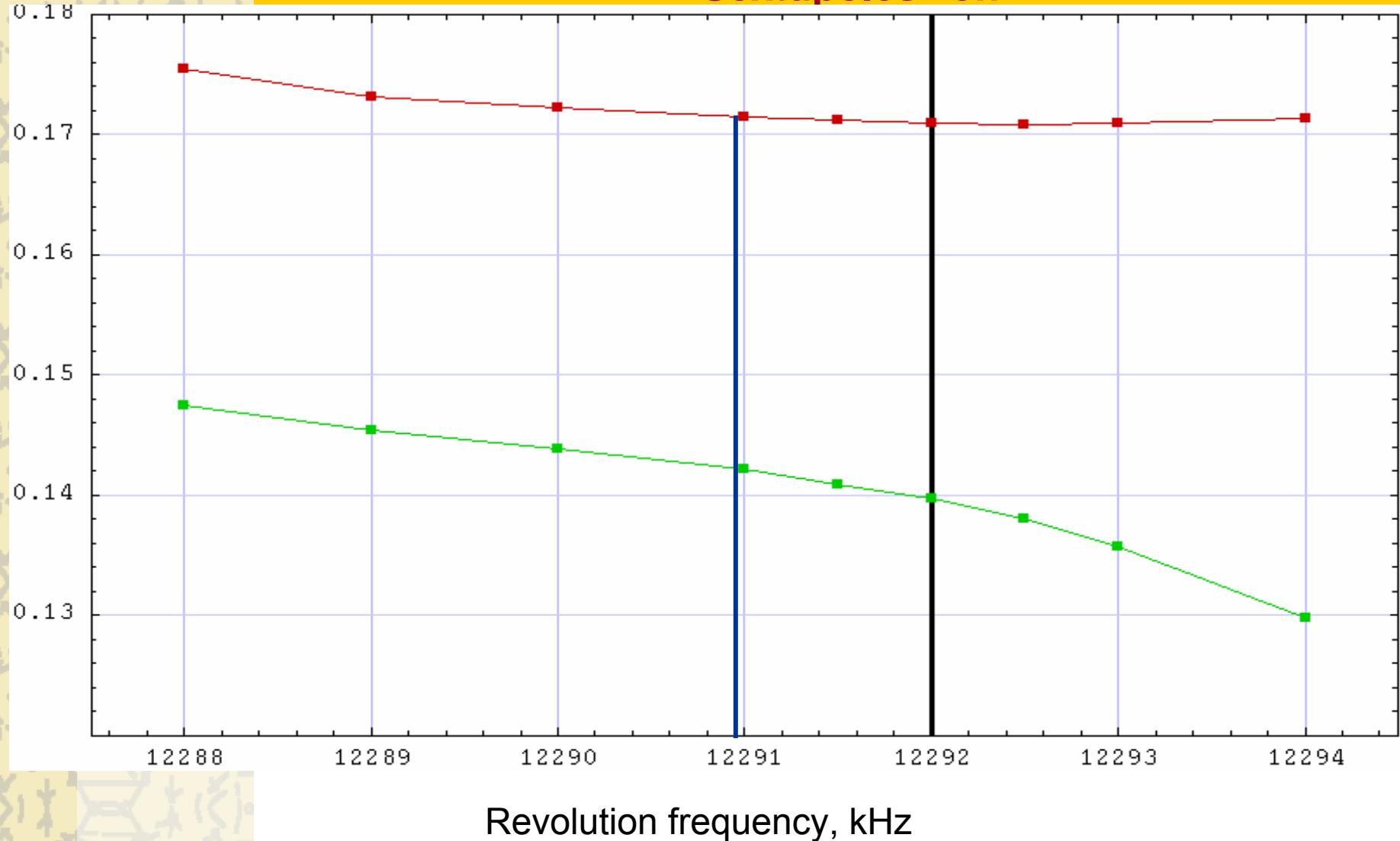


Dispersion

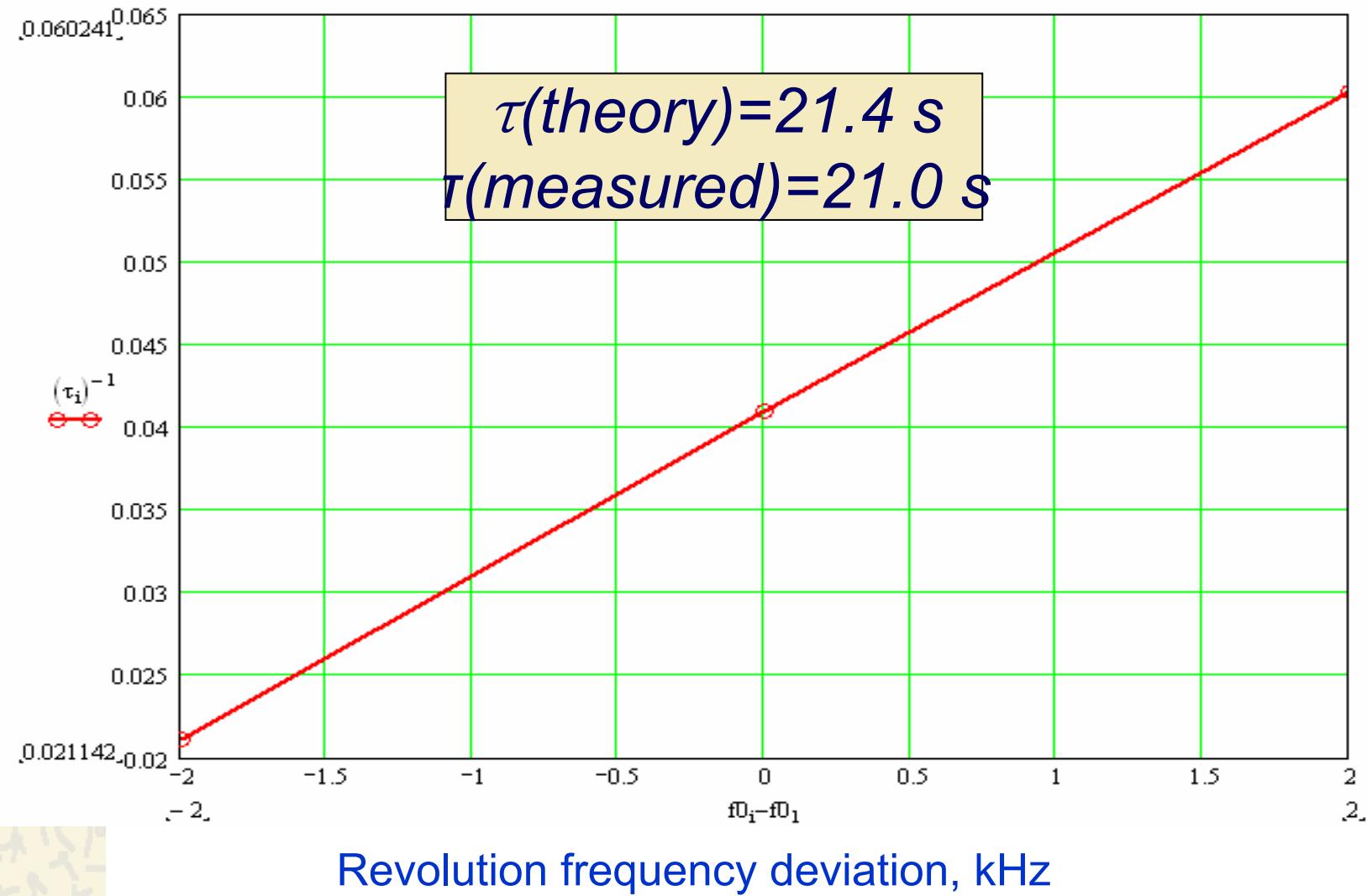


Tune chromaticity measurements.

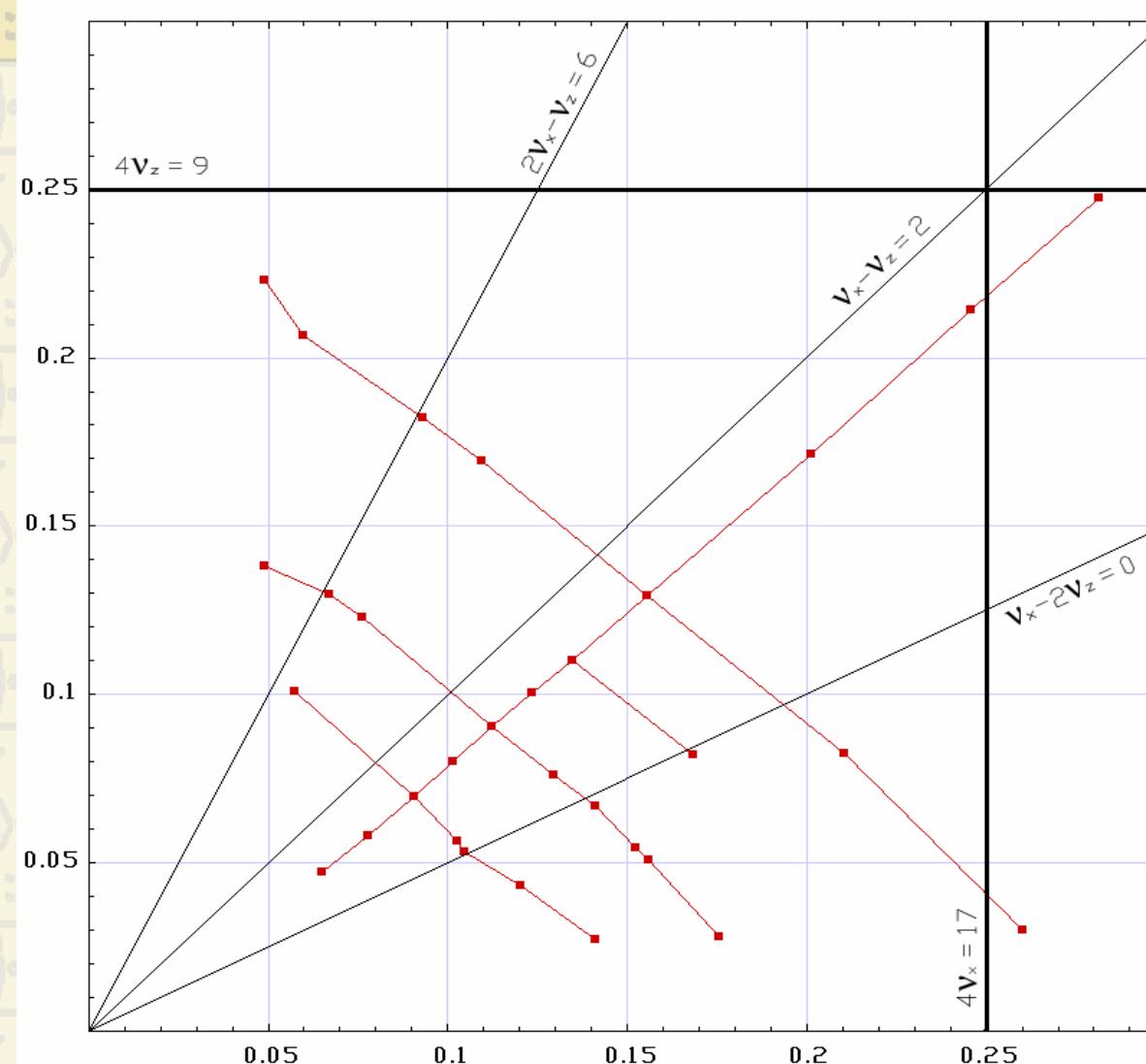
Sextupoles “on”.



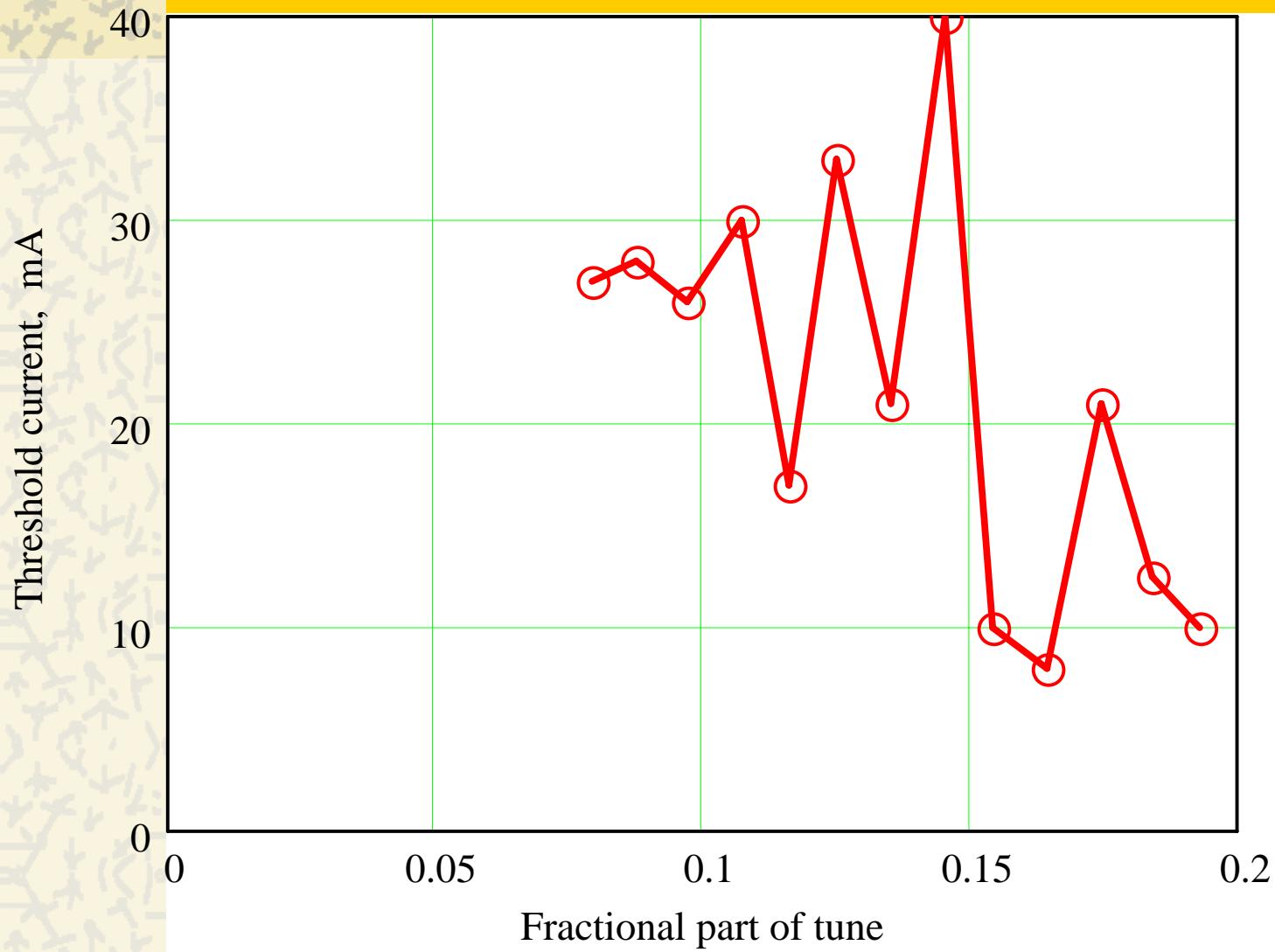
Measurement of damping time



Dynamic aperture scan



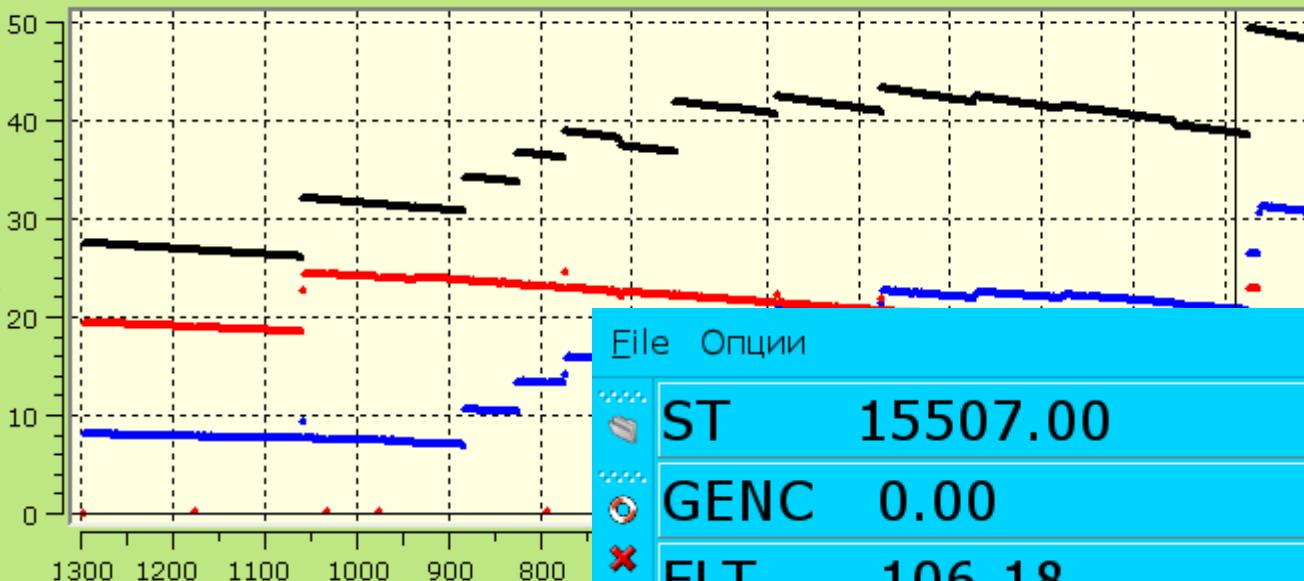
Threshold current dependence on tune



VEPP-2000 23.01.08, 22.00



ВЭПП



File Опции

ST	15507.00	●
GENC	0.00	●
FLT	106.18	●
L	530.53×10^{28}	●
dL	18.28×10^{28}	●
IEAVG	28.0 mA	●
IPAVG	20.61 mA	●

Ф3: 48.06 mA

т: -414.484

Перепуск:-0.08 k:-0.15%

L/(I*I):0.86

BPM e: 30.54 mA

т: -234.8

BPM p: 17.52 mA

т: 3846.53

Набрать фон

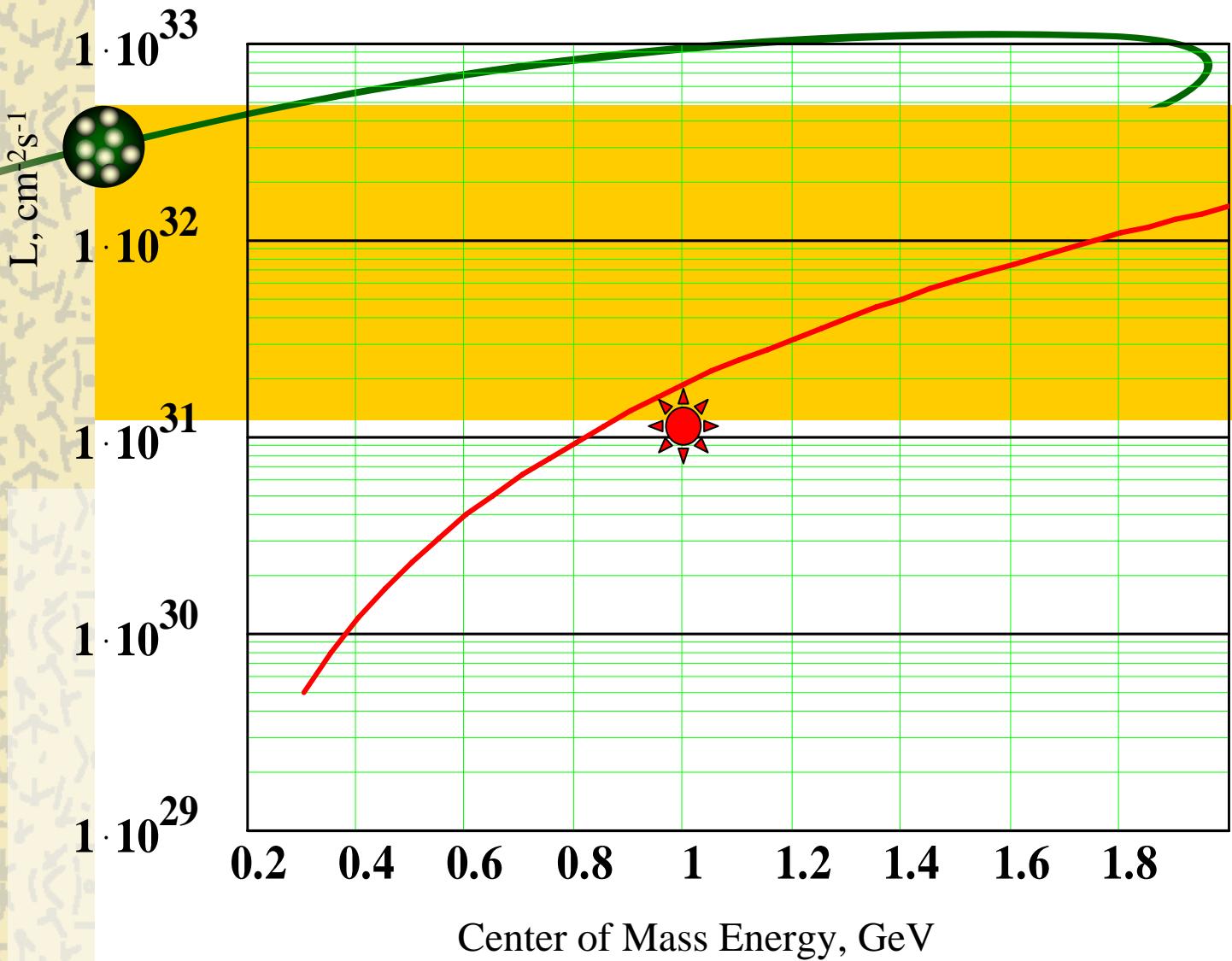
Сбросить Фон

3 Проброс Выкл

Best luminosity run

	File	Опции
ST	42476.82	●
GENC	0.00	●
FLT	105.92	●
L	$1033.75 * 10^{28}$	●
dL	$24.64 * 10^{28}$	●
IEAVG	39.57 mA	●
IPAVG	41.13 mA	●
IPRODAVG	365.86 mA^2	●

VEPP-2000 Luminosity





Conclusion

- 💥 VEPP-2000 is working
- 💥 «Round beams» – not a bad idea!
- 💥 Max. Lumi. achieved $1 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$ at ϕ -meson energy
- 💥 Potentially $2 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$ possible at ϕ and $1.6 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ at 2 GeV
- 💥 More positrons required!