Status of e^+e^- collider VEPP-2000

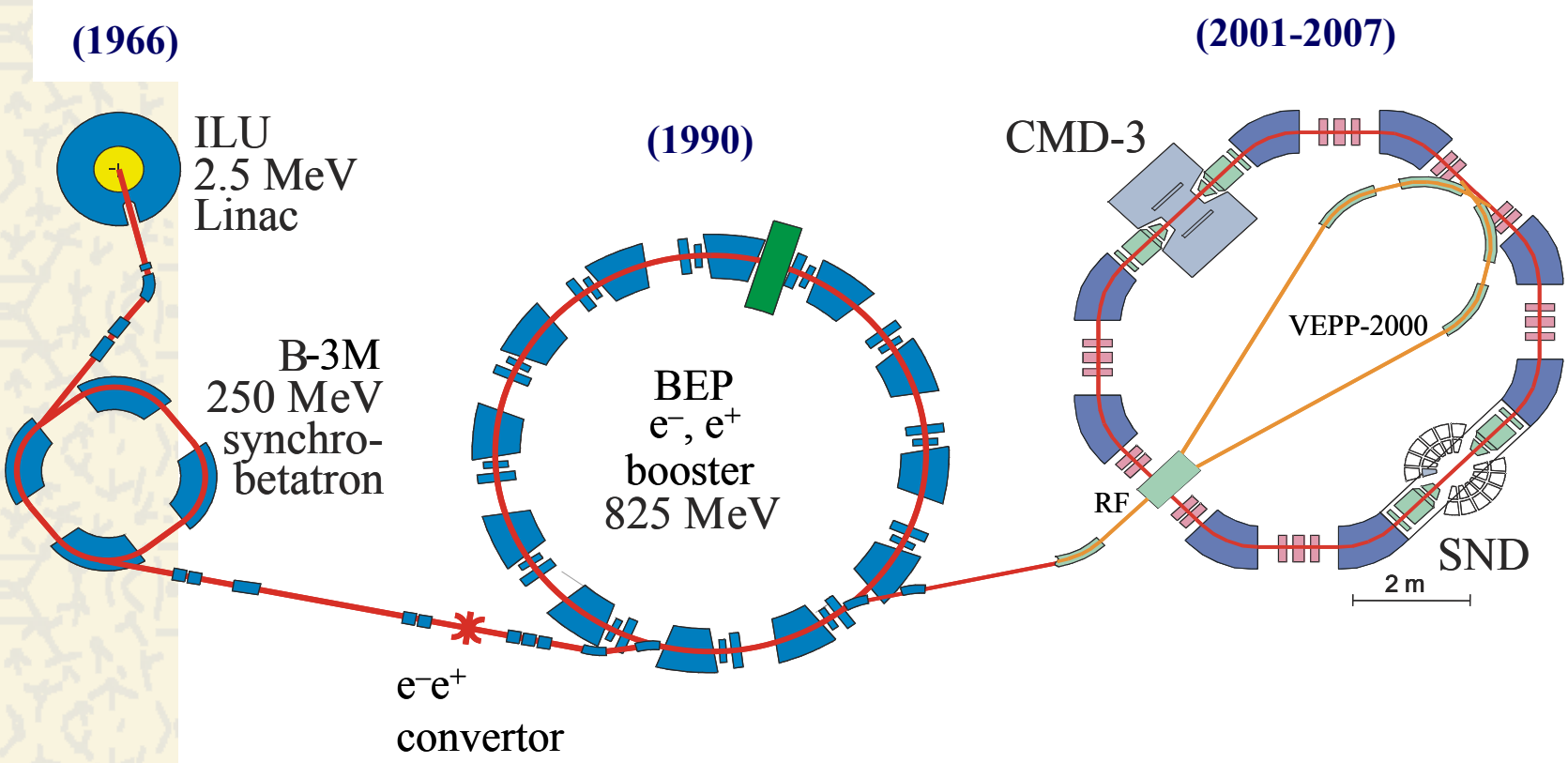
Yu.Shatunov for the VEPP-2000 team

Saint-Petersburg
24.09.2012

Outline

- Historical remarks
- Round beams concept
- VEPP-2000 overview
- Machine tuning
- Beam-beam study
- Round beam luminosity
- First experimets at 2010-2012
- Energy calibration
- Upgrade plans
- Conclusion

Layout of VEPP-2000 complex



The Concept of Round Colliding Beams

- Small and equal β-functions at IP: $\beta_x = \beta_z$
- Equal beam emittances: $\varepsilon_x = \varepsilon_z$
- Equal betatron tunes: $\nu_x = \nu_z$

Angular momentum conservation: $M_y = x'z - xz'$

Beam-beam parameter $\xi = \dfrac{N^- r_e}{4\pi\gamma\varepsilon} \approx 0.15$

Collider overview

$L = 24.39$ m

$f_{acc} = 172$ MHz

$V_{acc} = 120$ kV

$E = 0.2 – 1$ GeV

$B_{bend} = 2.4$ T

$B_{sol} = 13$ T

$\beta^* = 2 – 10$ cm

$\sigma_s = 3$ cm

$\varepsilon = 1.4 \times 10^{-7}$ mrad

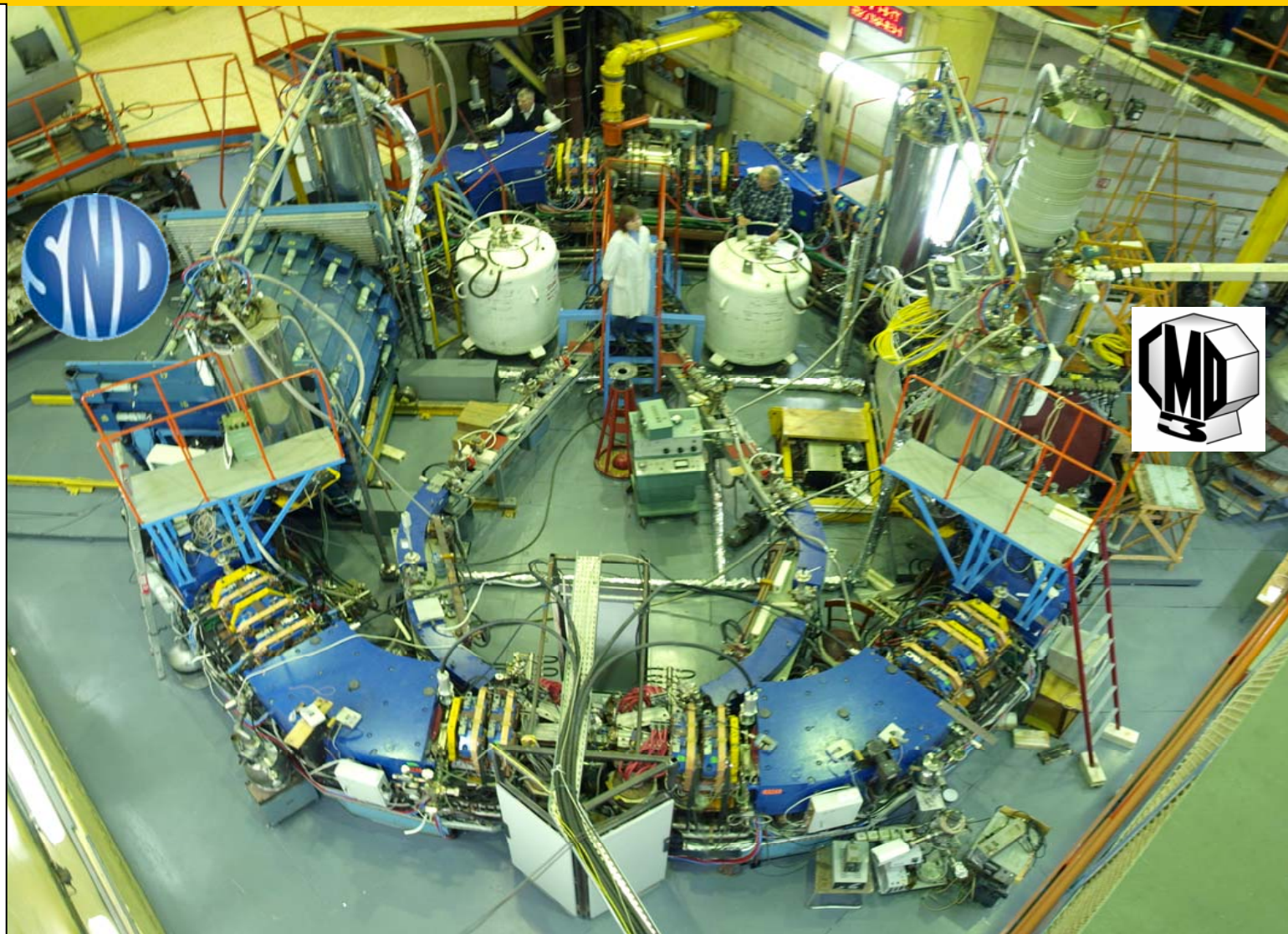
$\nu_{x,z} = 2.1; 4.1$

$A = 0.036$

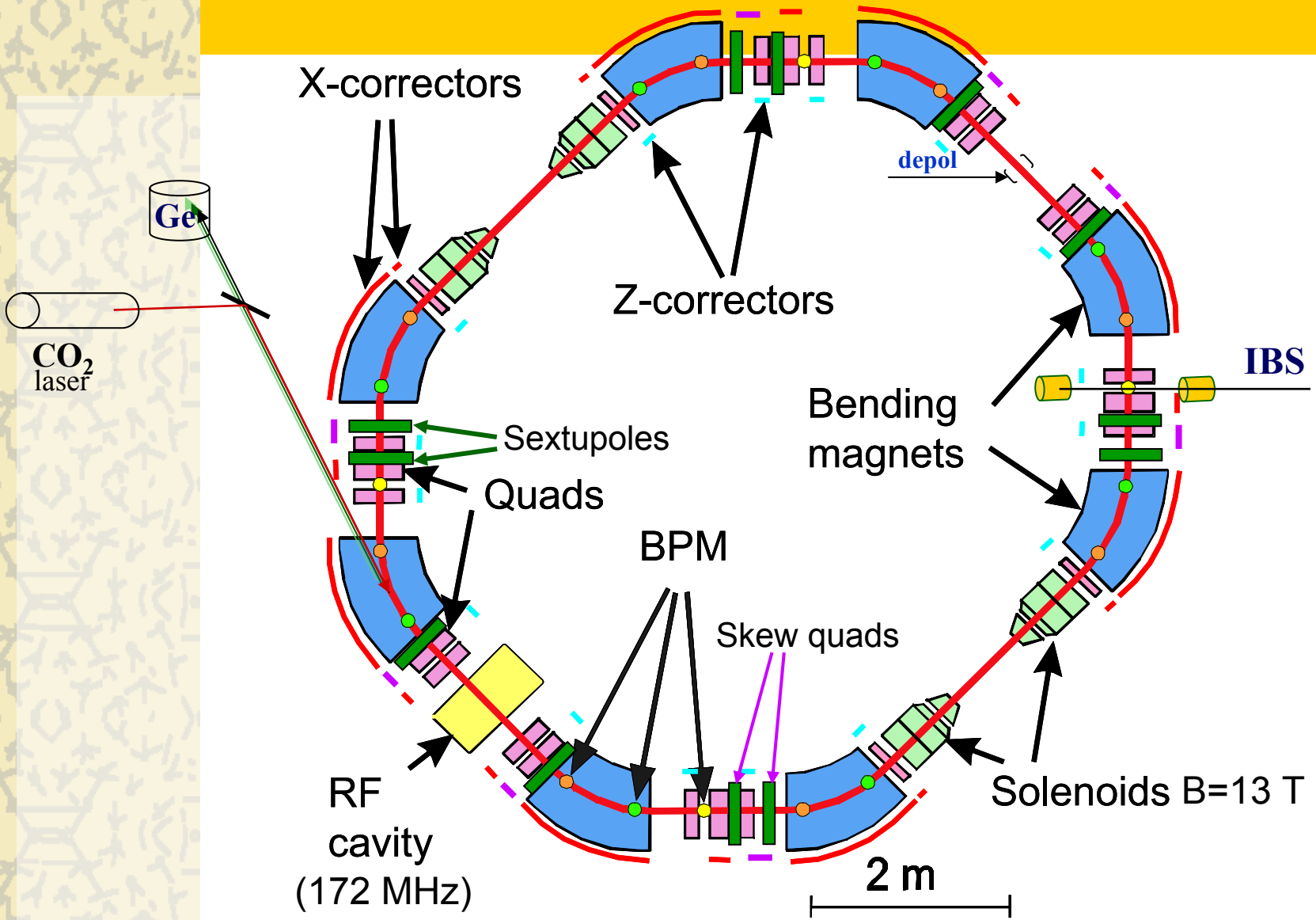
$\xi = 0.15$

$N^{\pm} = 10^{11}$

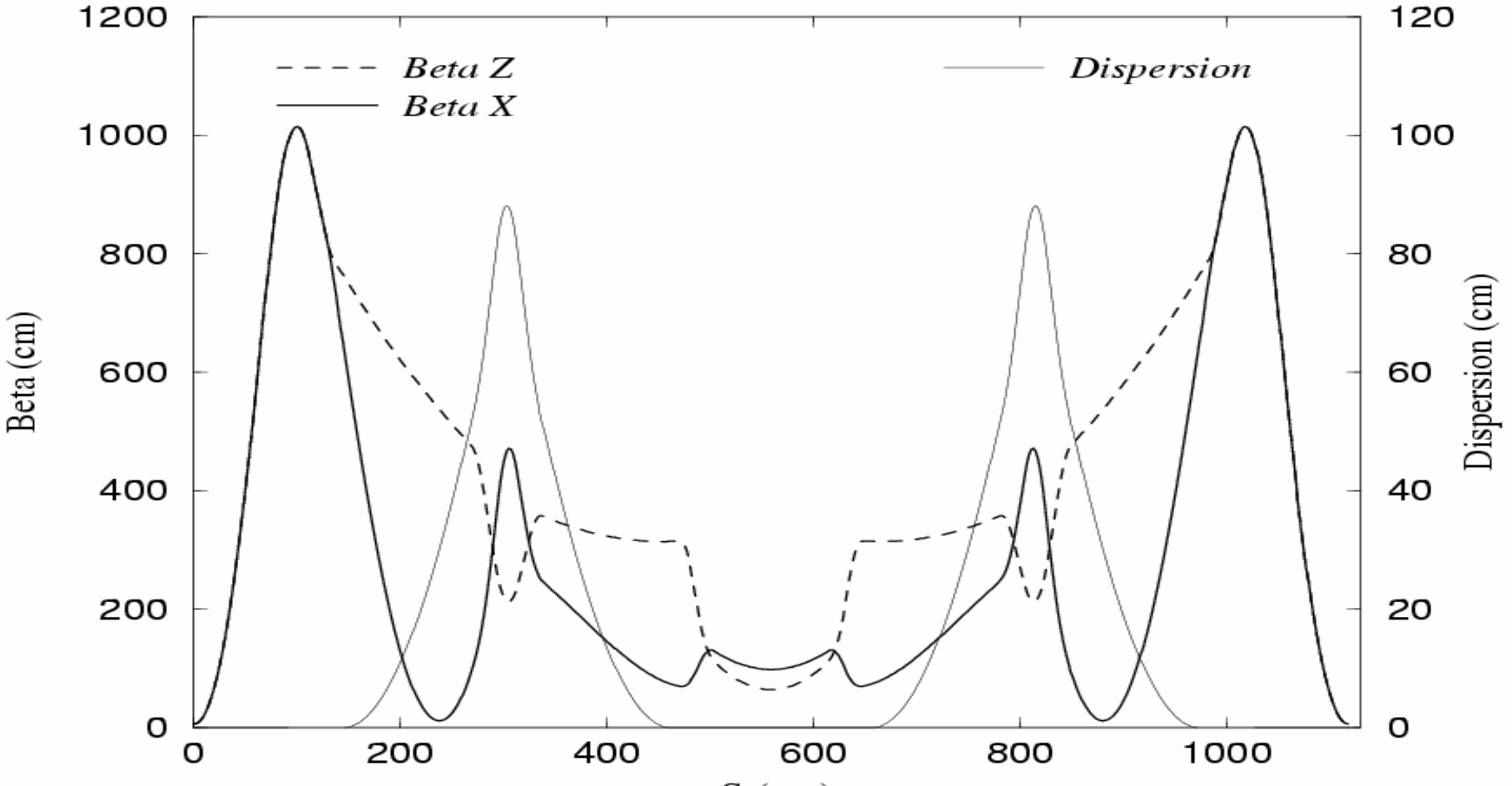
$L = 1 \times 10^{32} cm^{-2} s^{-1}$



Instrumentions



VEPP-2000 lattice



Machine tuning

- **Closed Orbit corrections**

  Pick-ups Orbit Response Matrix to focusing offsets (4⊗32)

  SVD analysis ⟹ steering coil corrections

  2-3 iterations + minimizing of ΣI_{cor} ⟹ correctors setting

  Δ_x; $\Delta_z \simeq \pm 0.2$ mm

- **Lattice corrections**

  BPMs ORM to steering coils modulations (20⊗36)

  SVD analysis ⟹ focusing corrections (quads +solenoids)

  3–4 iterations ⟹ lattice setting

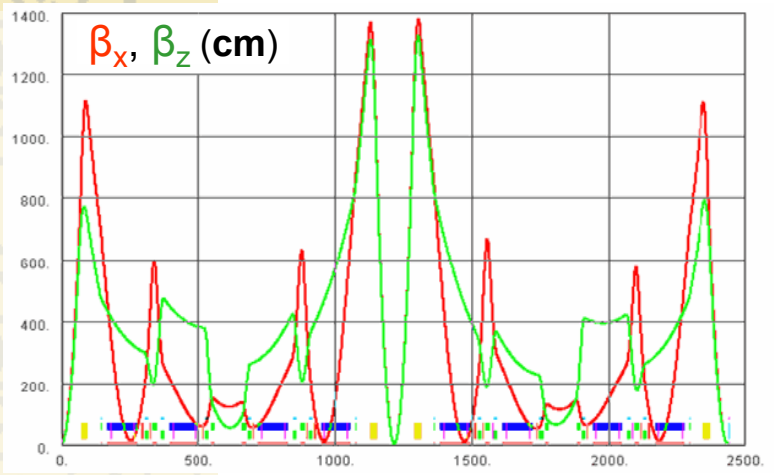
  β*; zero dispersion outside achromats;

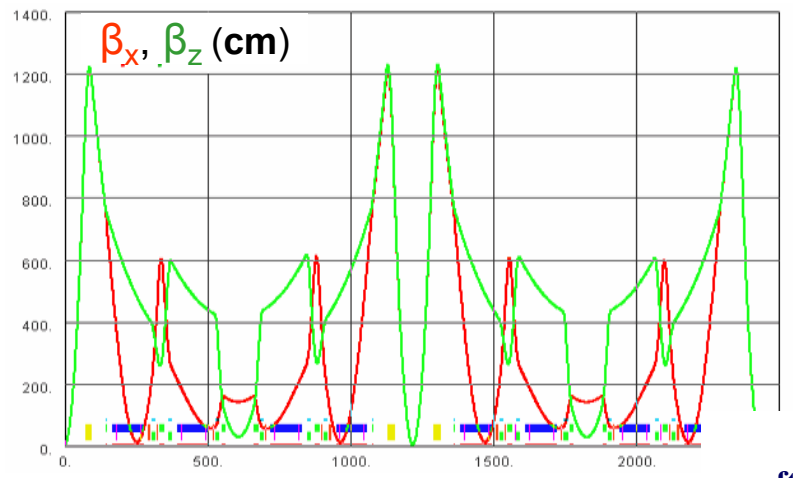
- **Coupling compensation**

  1.5 Tm field of CMD detector + solenoids compensating coils

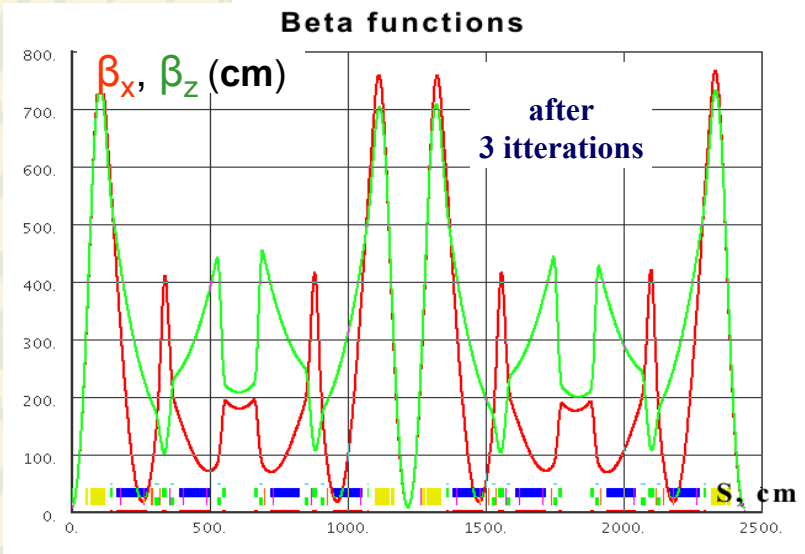
  3 families of skew quads ⟹ **$\nu_1 - \nu_2 < 0.003$**

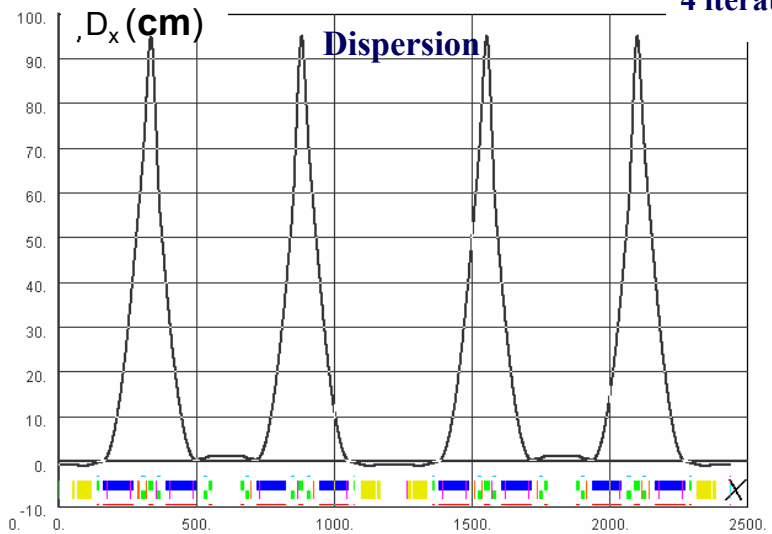
Lattice corrections



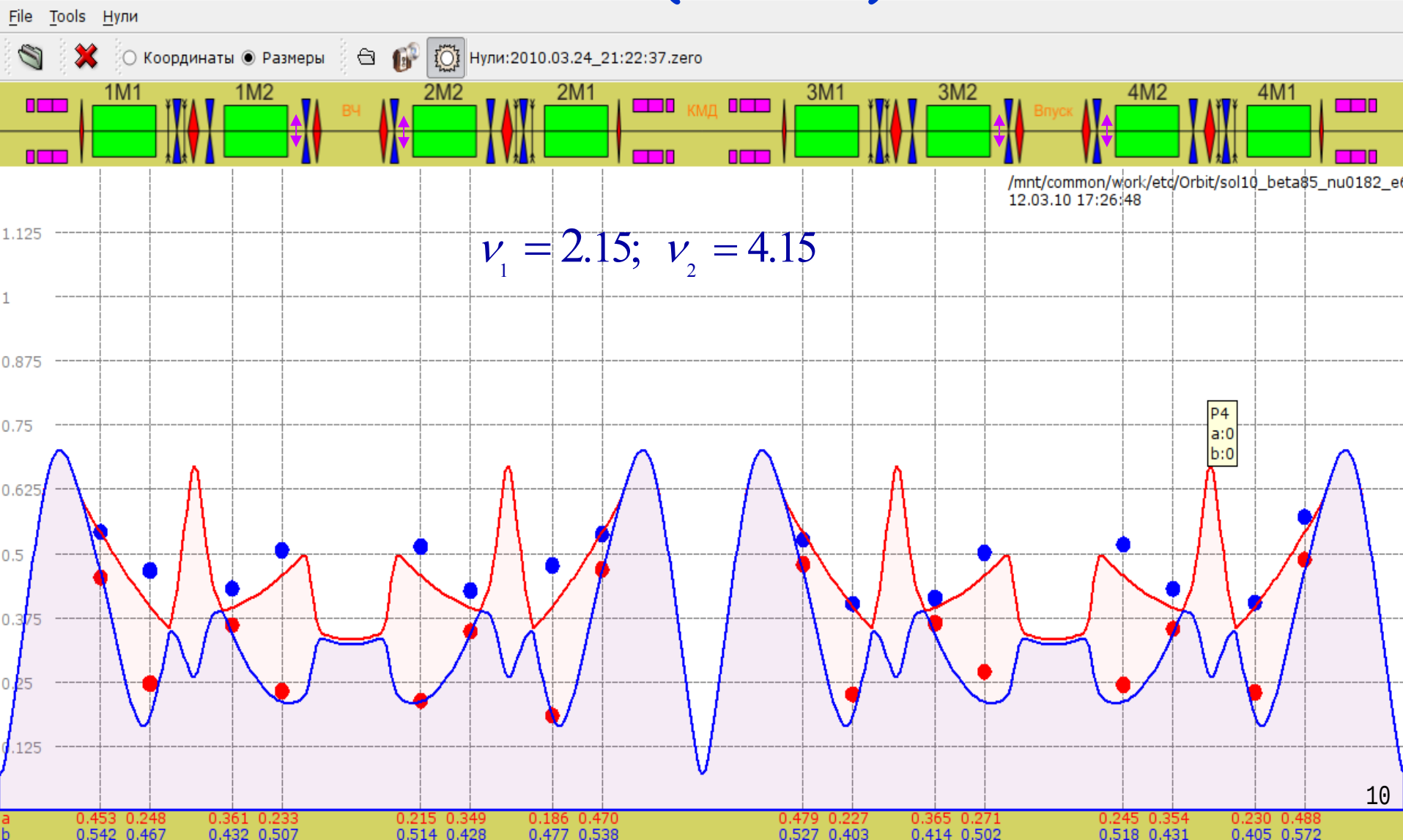


after
4 iterations

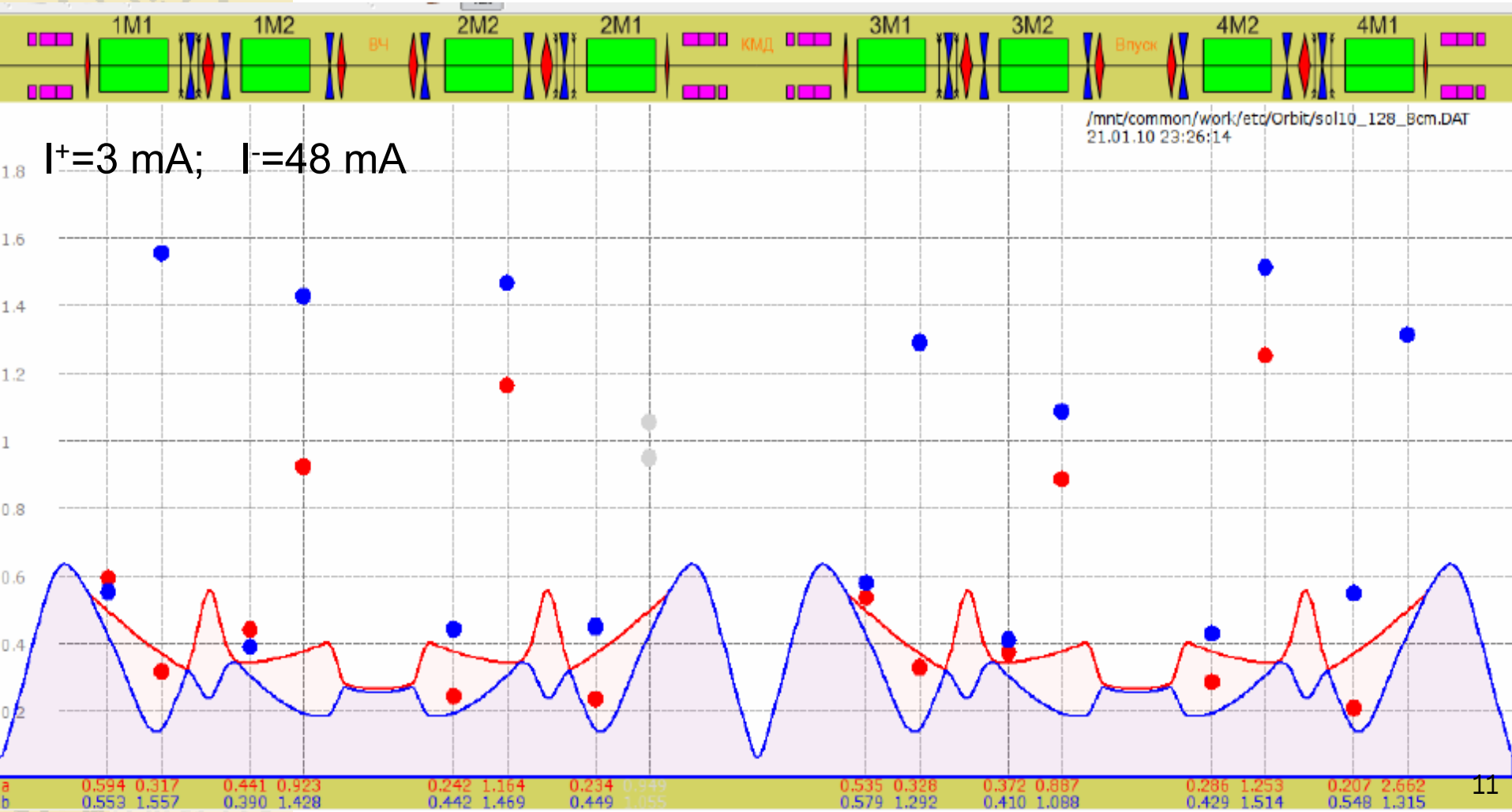




Lattice and beam sizes
($I^{\pm}$ <1mA)

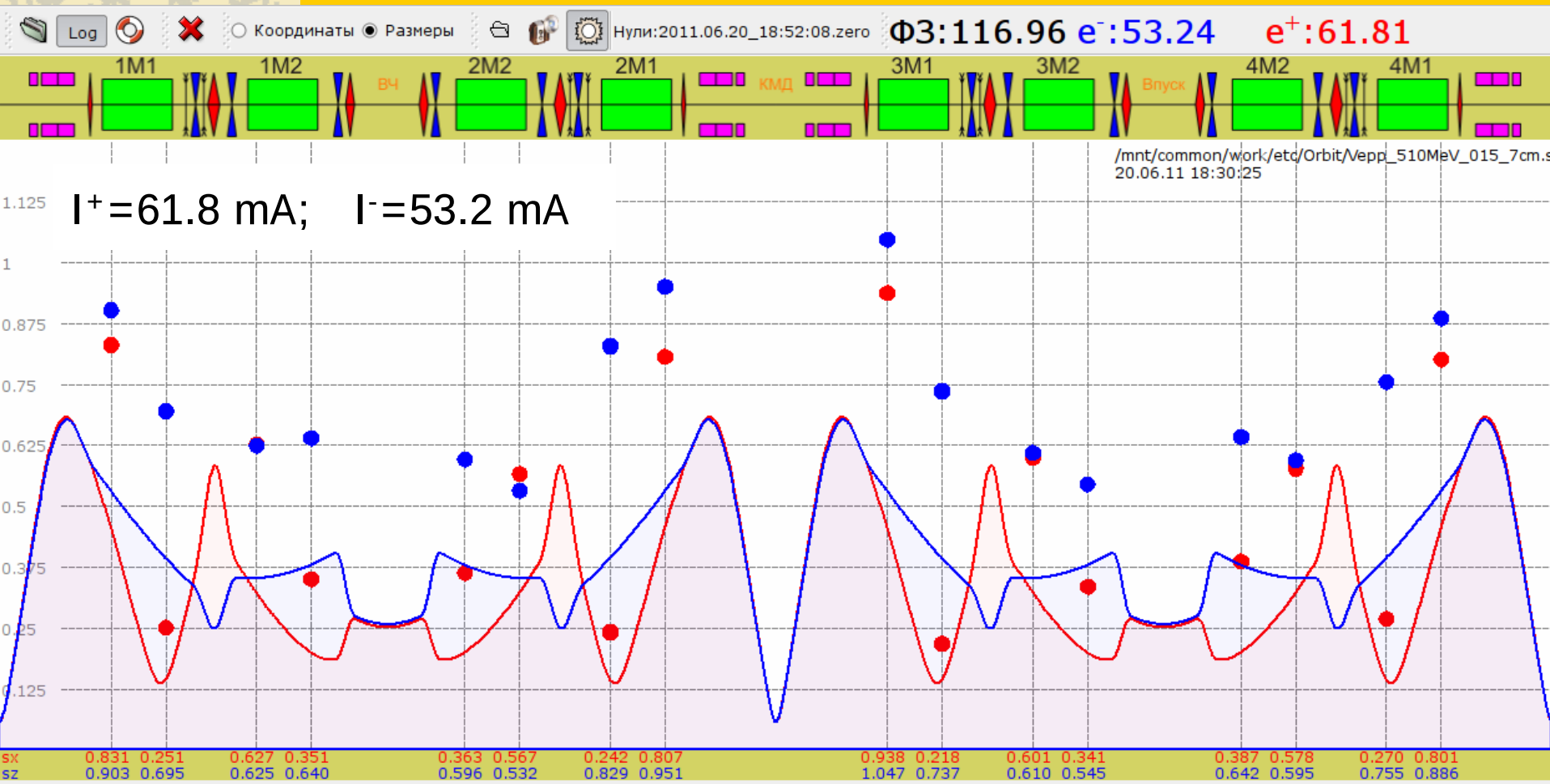


"Week-strong" beam-beam
("dynamic beta and emittance")

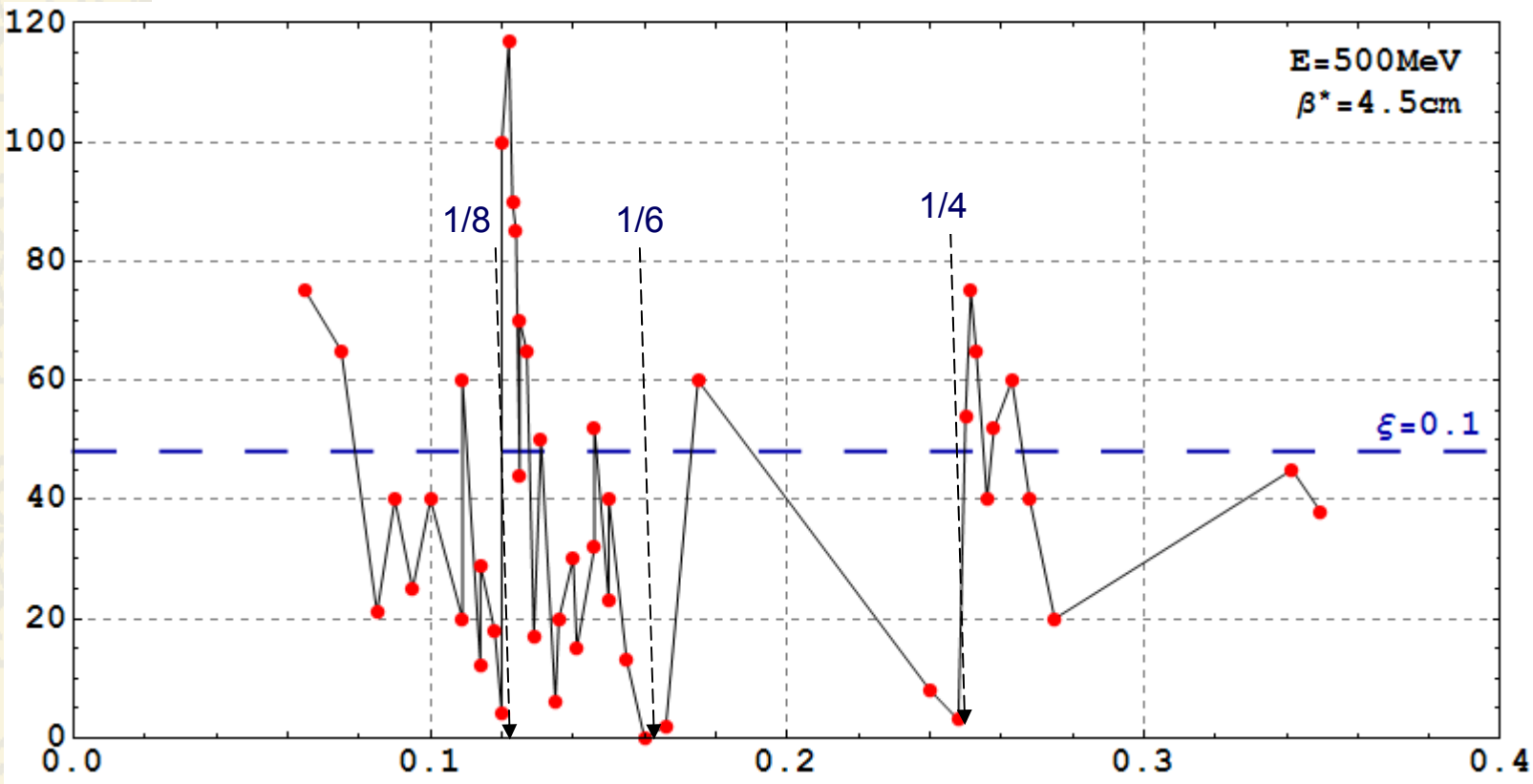


“Strong-strong” beam-beam

(“dynamic beta and emittance”)



Threshold current vs.tune
("week-strong")



Luminosity measurements

Bhabha scattering in the SND and CMD detectors

$\theta_{scatt} \geq 0.5$

Main disadvantage: ⇛ low counting rate

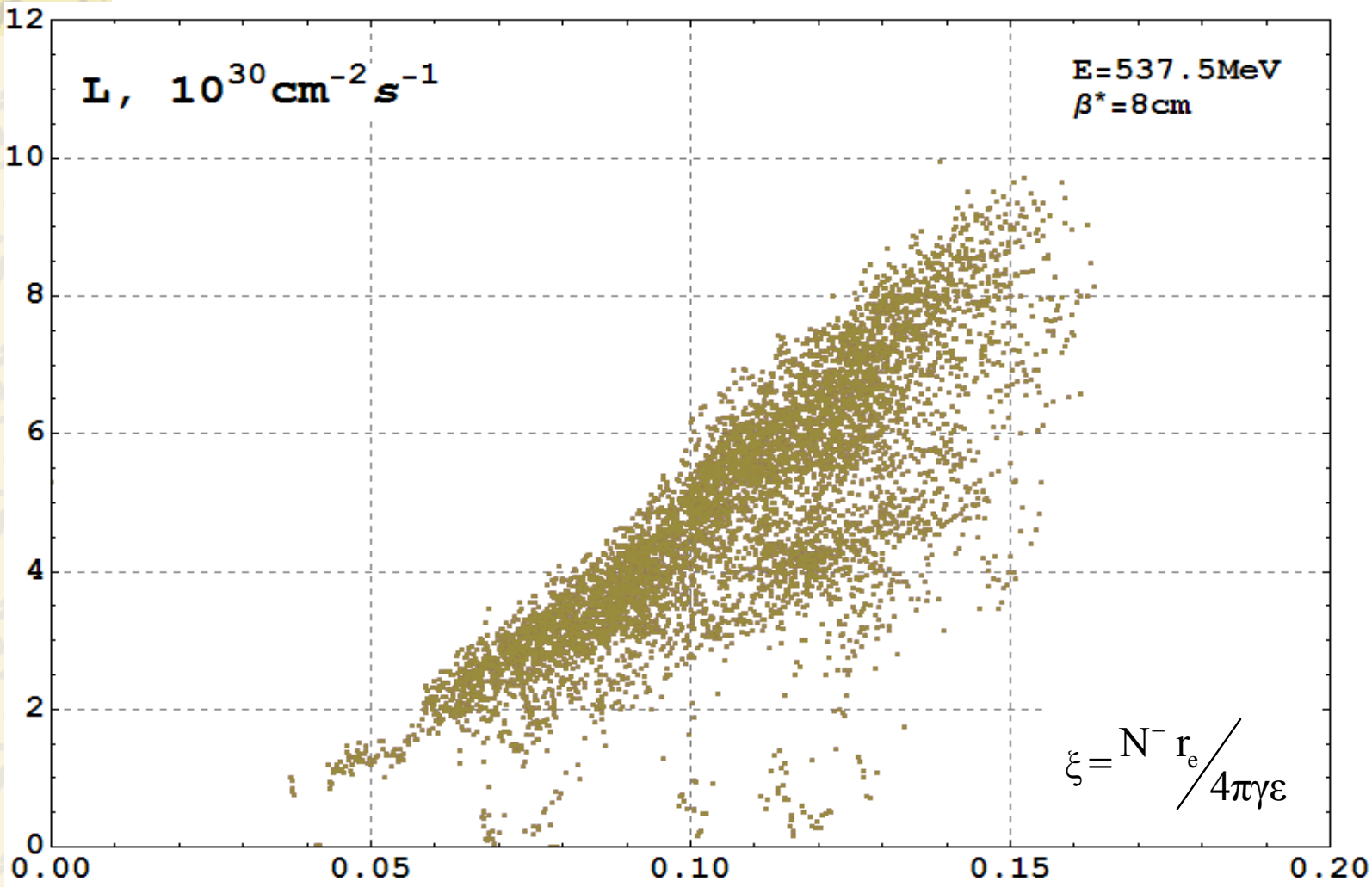
$\dot{n} \simeq 10$ Hz at $L=1 \square 10^{31}$ cm^{-2}s^{-1}

Basic formulae of the luminosity: $$L = \frac{f_0 \cdot N^+ \cdot N^-}{4\pi \cdot \Sigma^*_+ \cdot \Sigma^*_-}$$

Beam profile measurements at 16 points ⇛ $$\Sigma^* = \sqrt{(\sigma^*_x)^2 + (\sigma^*_z)^2}$$
with dynamic β-functions and beam emittance, but under assumption: no other lattice distortions besides counter beam.

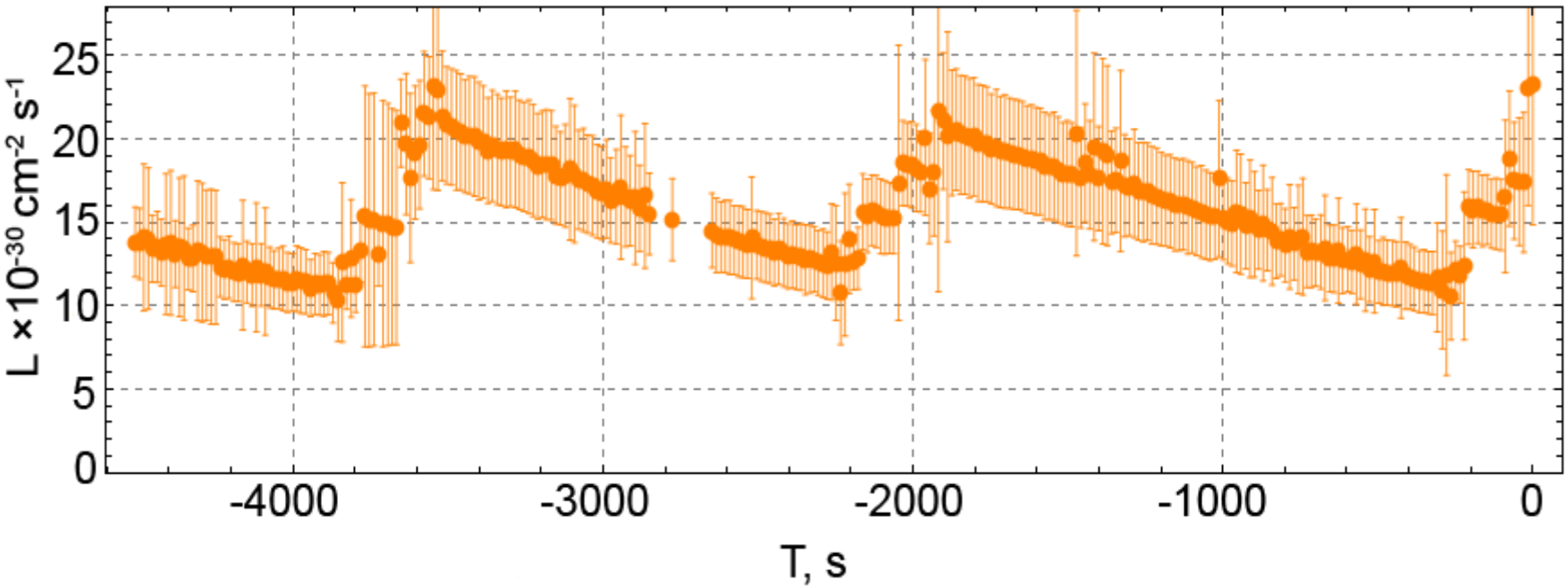
Time of measurement $\simeq$ 1 s at any energy.

Luminosity vs.ξ



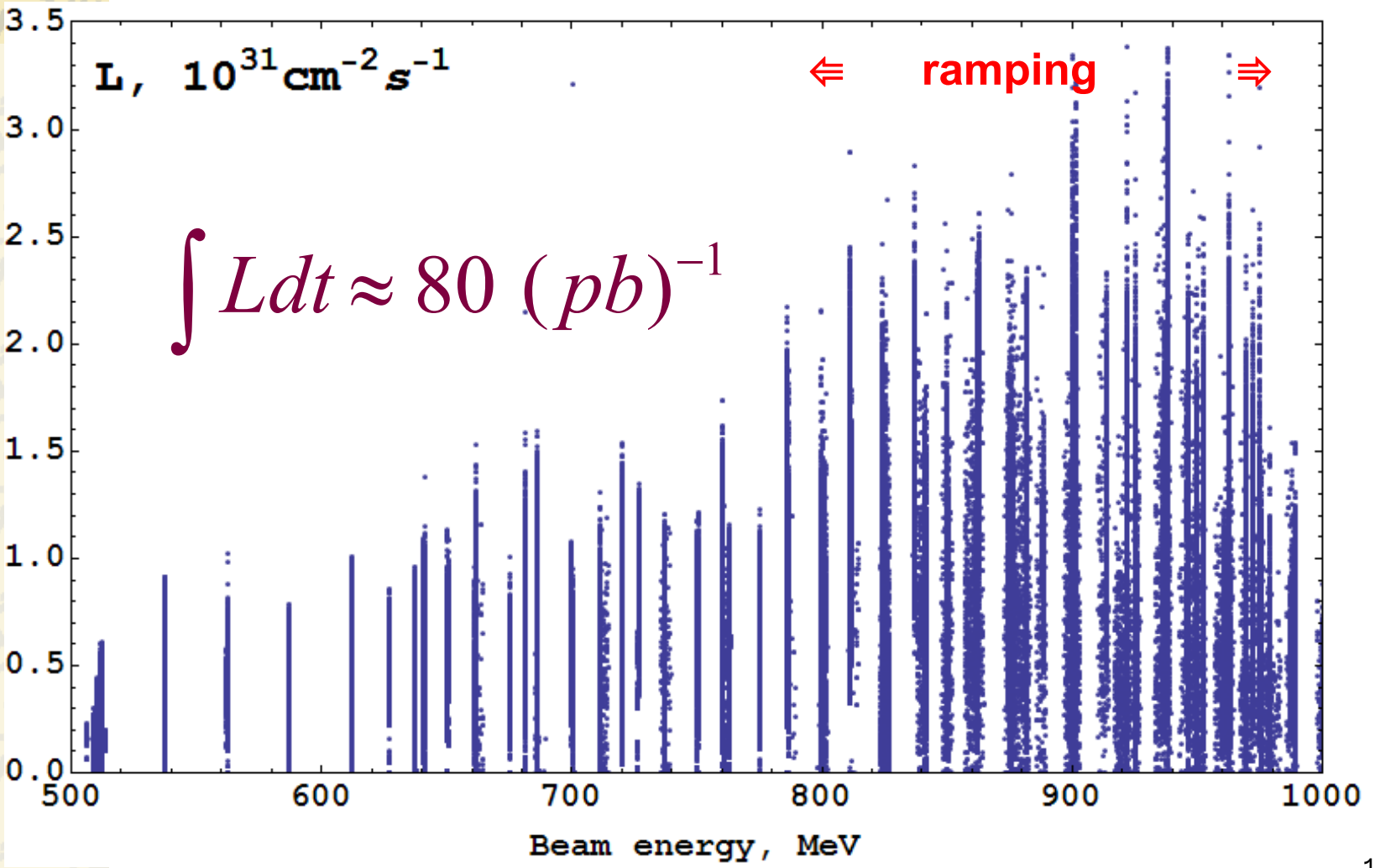
Luminosity measurements

(E = 837 MeV; Run 2011)



E=	837.035	β^*=	8.50539	ν0=	0.181983	Lnom=	1.44769×10^{31}	ξnom=	0.0542719
I+=	62.45	I−=	79.3375	N+=	3.17547×10^{10}	N−=	4.03416×10^{10}		
βx^+=	6.61923	βz^+=	7.30896	βx^-=	6.33846	βz^-=	7.55464		
$\epsilon x^+/\epsilon 0$=	1.19075	$\epsilon z^+/\epsilon 0$=	1.28085	$\epsilon x^-/\epsilon 0$=	1.18568	$\epsilon z^-/\epsilon 0$=	1.29095		
σx^+=	0.0895587	σz^+=	0.0976045	σx^-=	0.0874519	σz^-=	0.0996221		
Lspec=	0.289726	Lerr=	1.89×10^{30}	ξ=	0.0447				

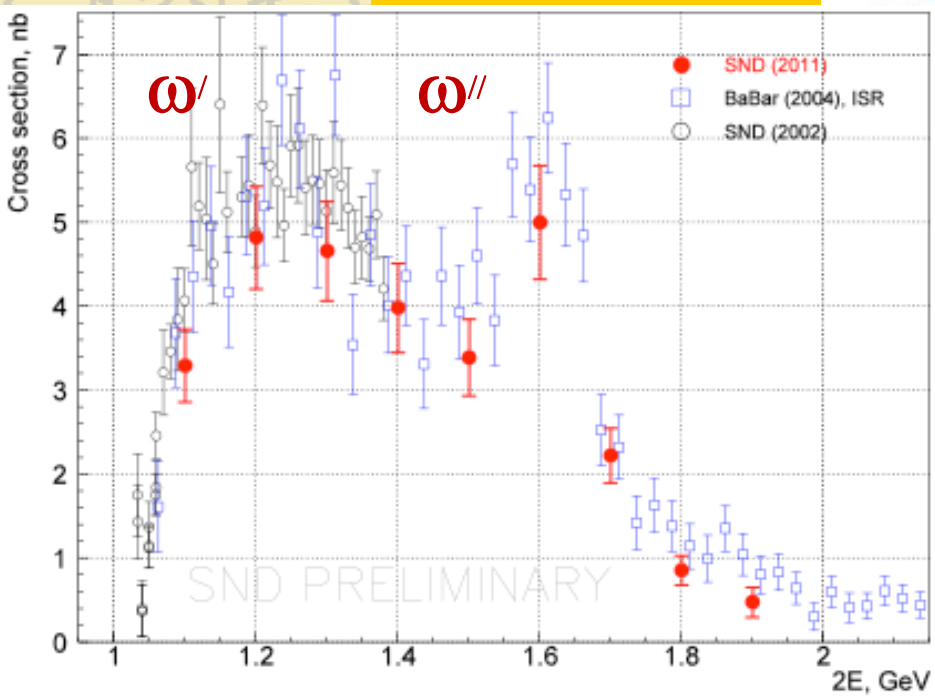
Luminosity at runs 2010-2012
(CMD data)

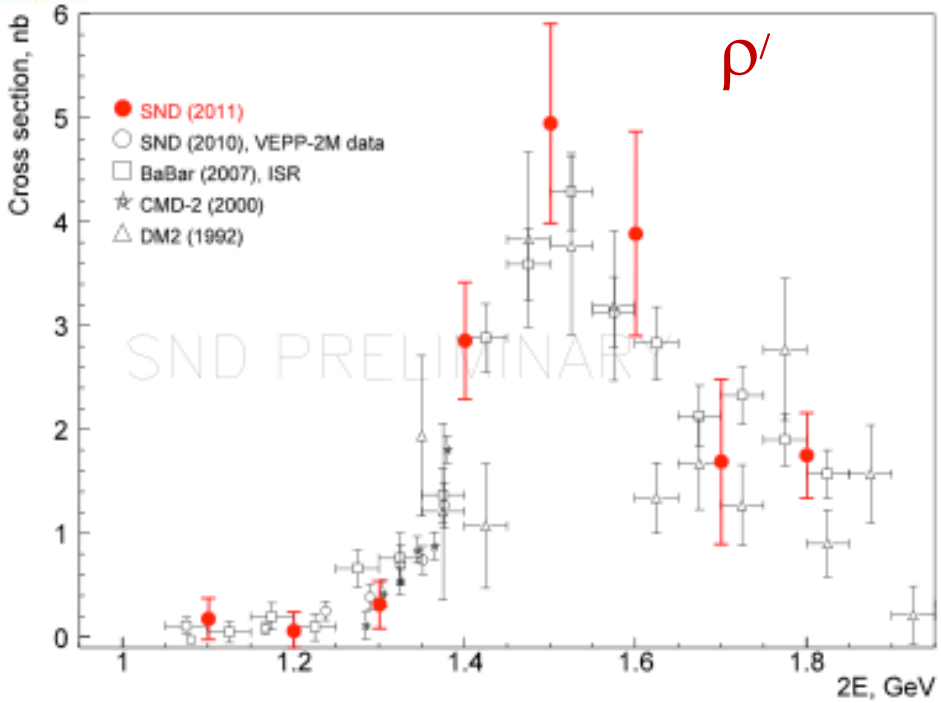


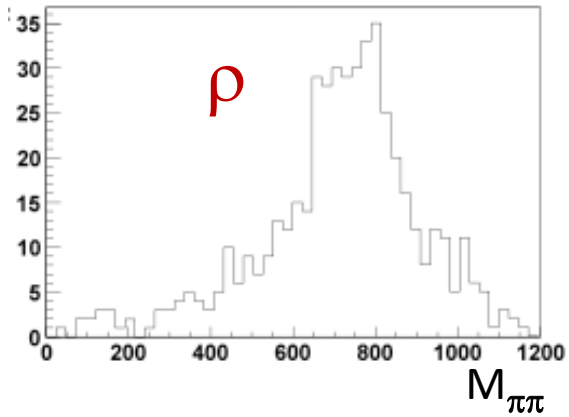
SCAN 2010

$e^+e^- \to \pi^0\pi^+\pi^-$

$e^+e^- \to \eta\,\pi^+\pi^- \to \eta\rho$

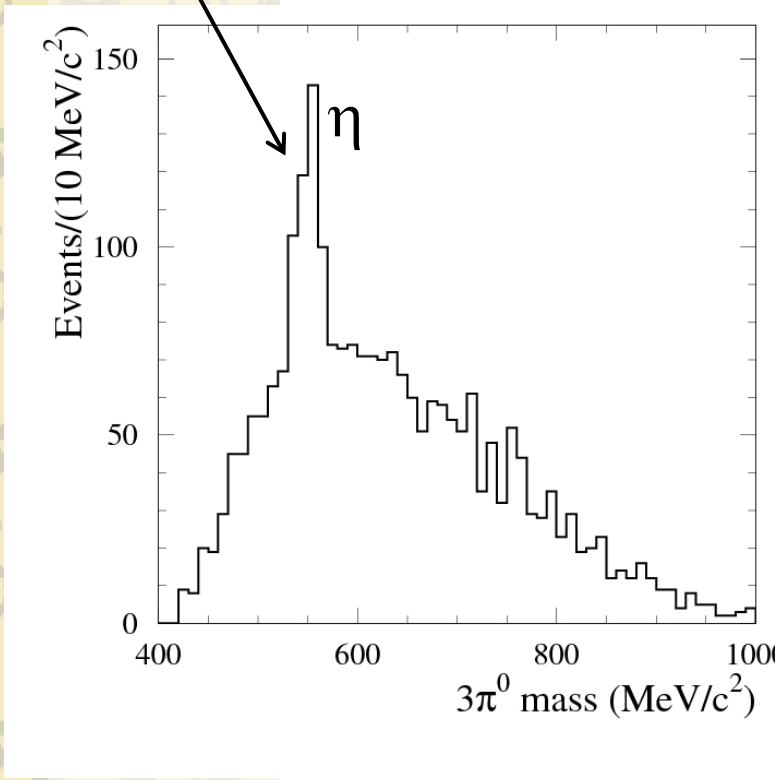


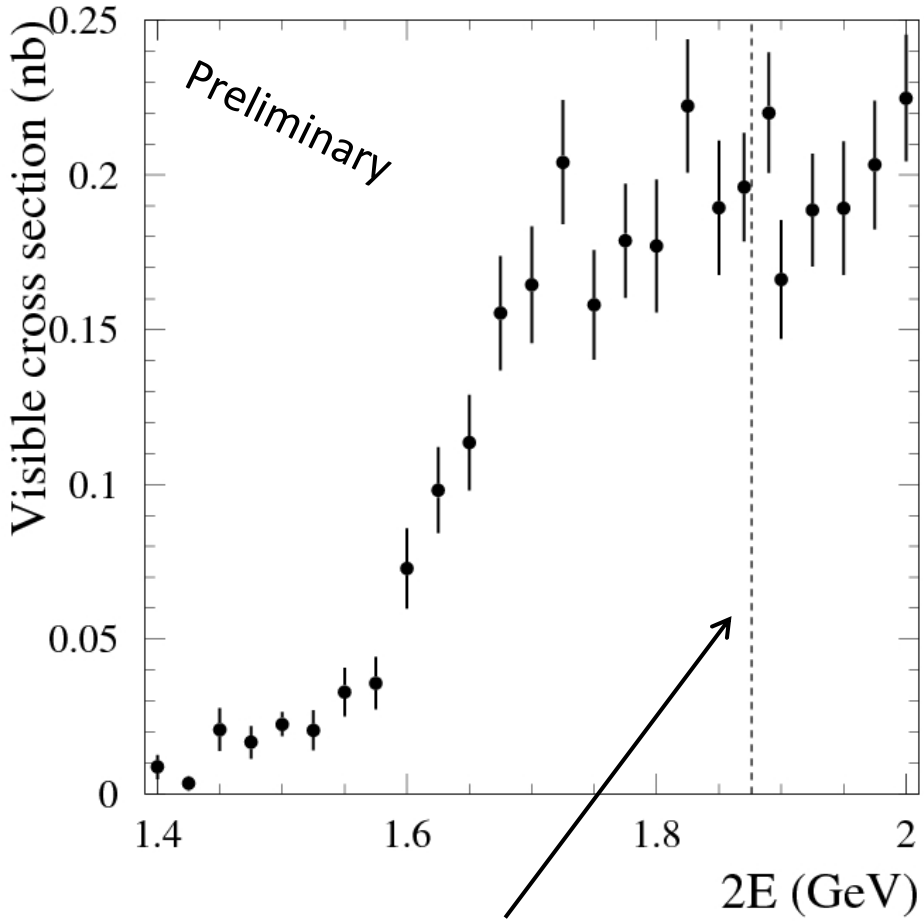




$e^+e^- \to \pi^+\pi^-\pi^0\eta$ ($\omega\eta$,$\phi\eta$)

$e+e- \to \pi+\pi-\pi^0\pi^0\pi^0\pi^0 \to \pi+\pi-\ 8\gamma$

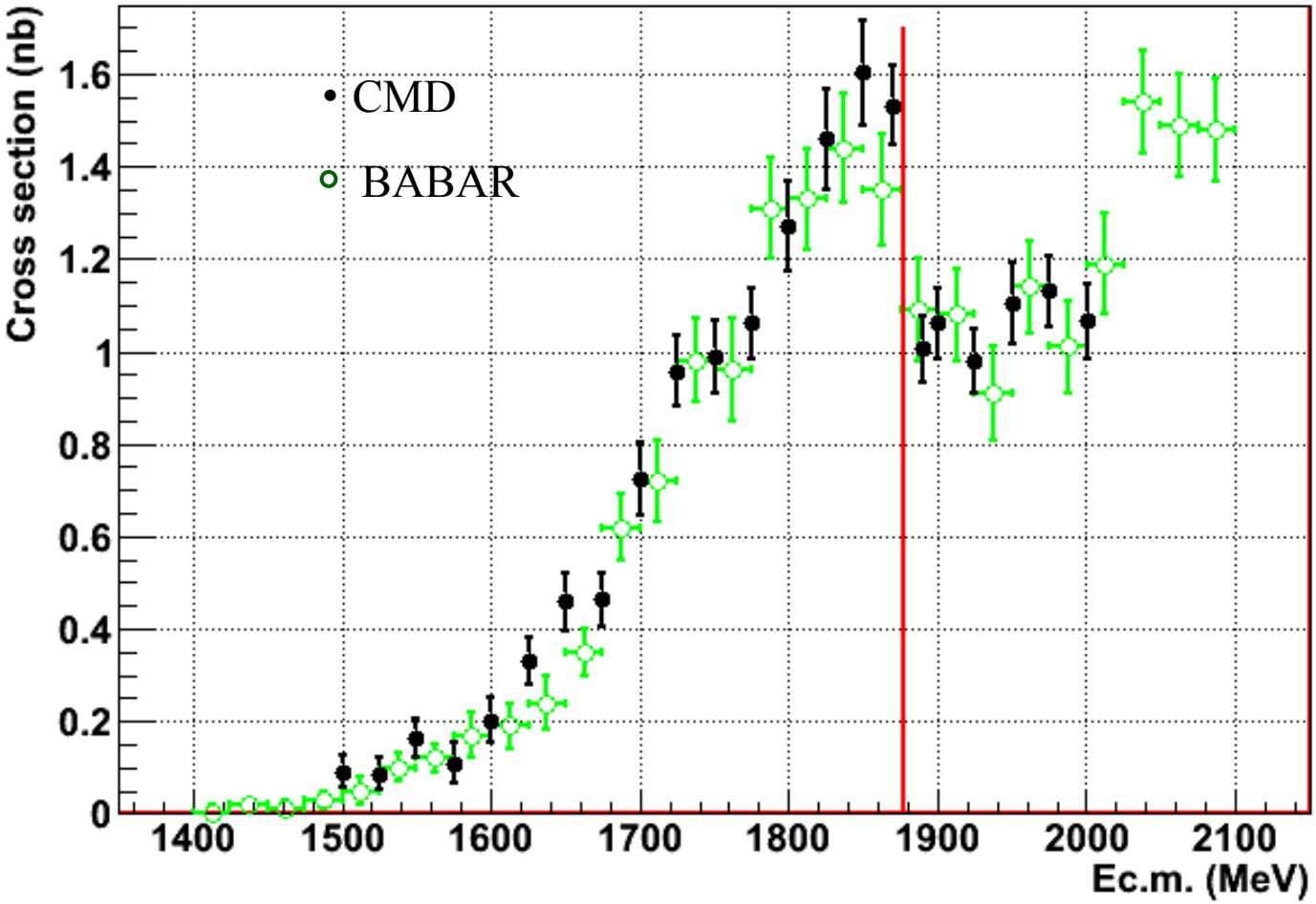




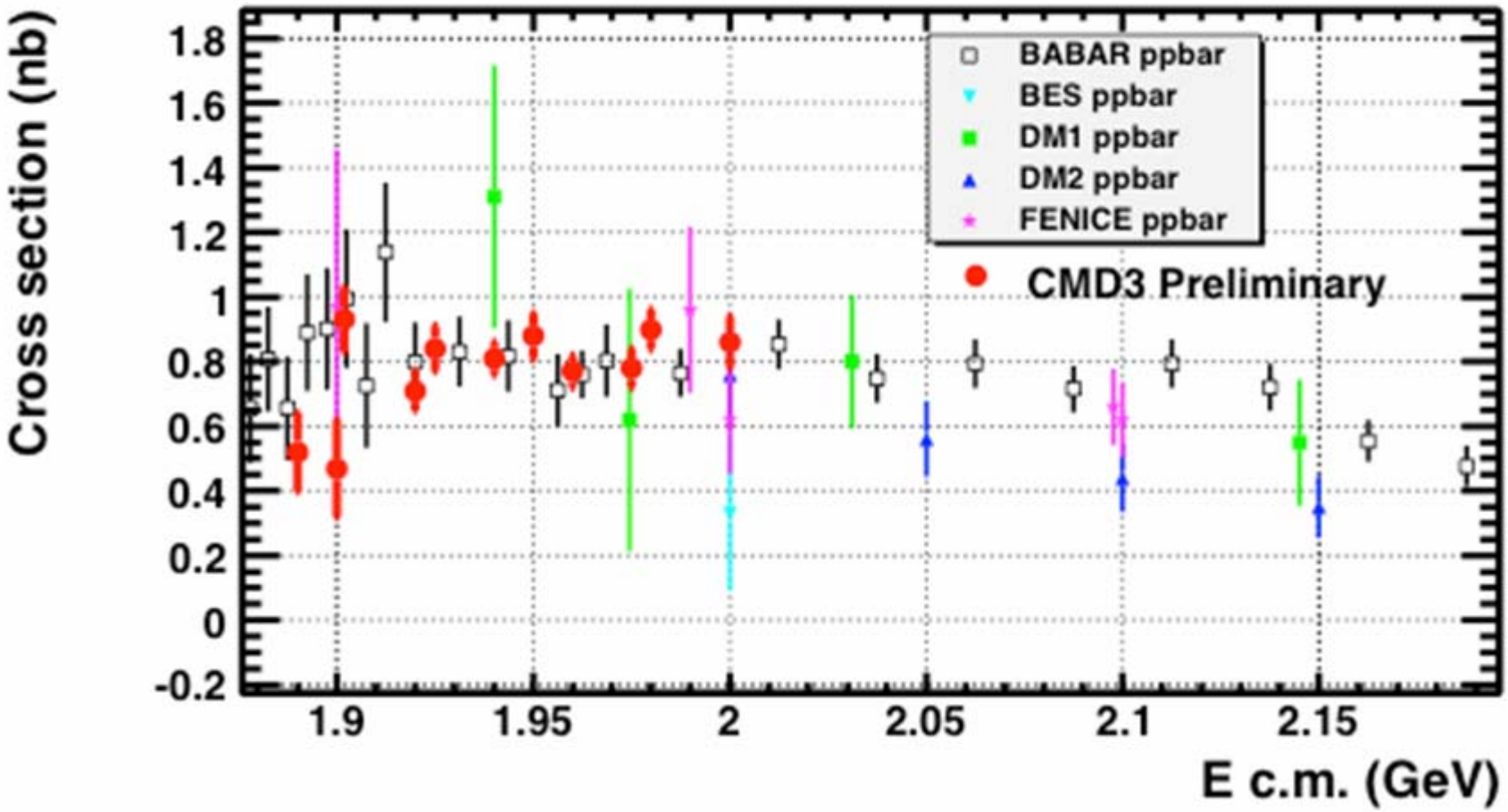
First observation !

p bar-p threshold

$e^+e^- \to \pi^+\pi^-\pi^+\pi^-\pi^+\pi^-$



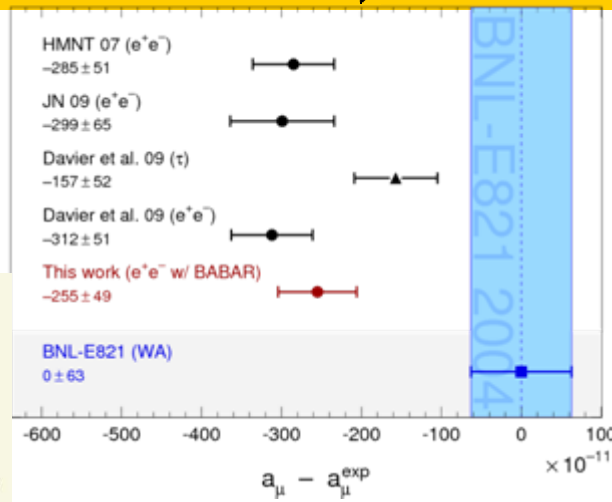
$e^+ e^-$ -> Pbar P


Cross section (nb)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
1.9
1.95
2
2.05
2.1
2.15
E c.m. (GeV)
BABAR ppbar
BES ppbar
DM1 ppbar
DM2 ppbar
FENICE ppbar
CMD3 Preliminary

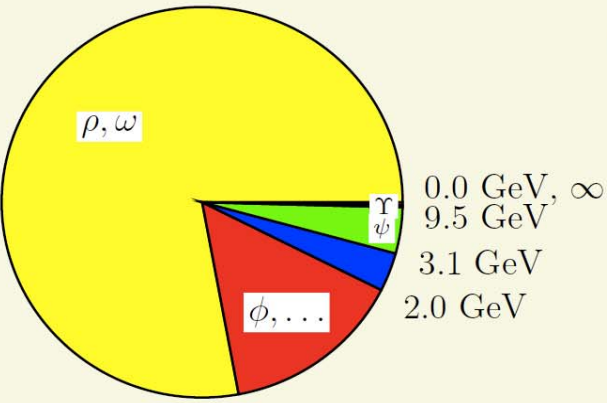
Hadronic contribution to muon g-2

$$a_\mu(\text{had}) = \left(\frac{\alpha m_\mu}{3\pi}\right)^2 \int_{4m_\pi^2}^{\infty} \frac{ds}{s^2} K(s) \left(\frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}\right)$$

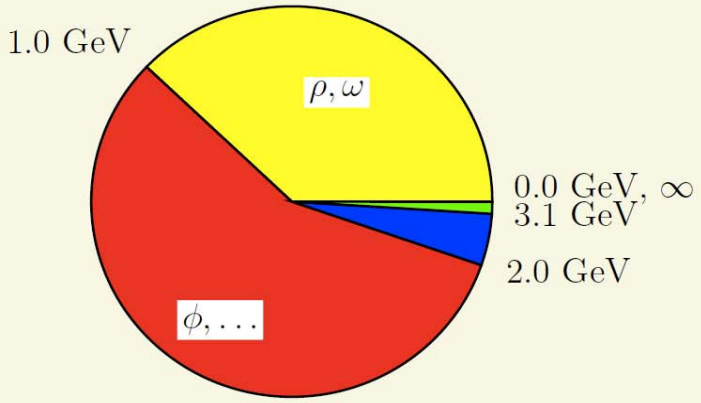
VEPP-2M, BaBar, KLOE reduced errors $\Delta \approx 3.6\,\sigma$



VEPP-2000 task!



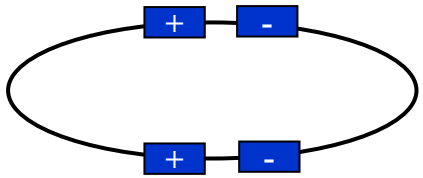
contribution

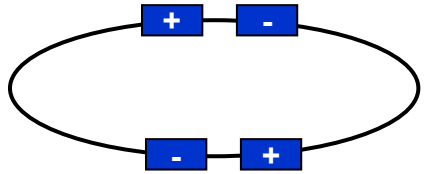


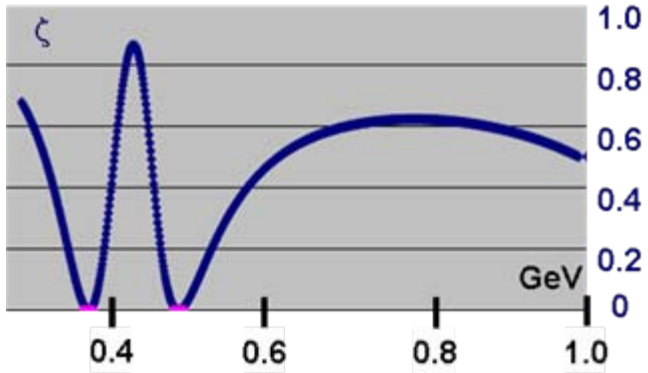
error²

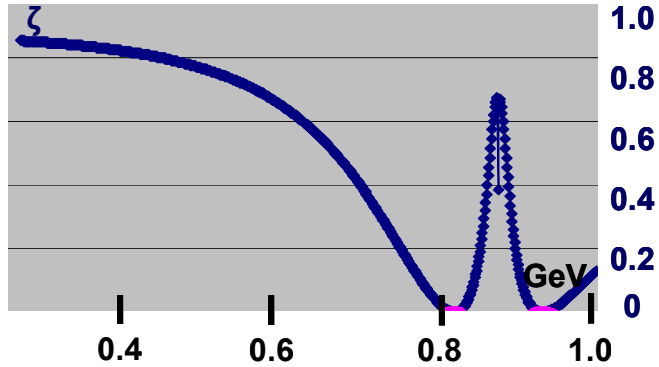
- **< 1% systematic error for most of the channels is needed!**
- **Absolute energy calibration ≃10^{-4} must be done in whole energy range**

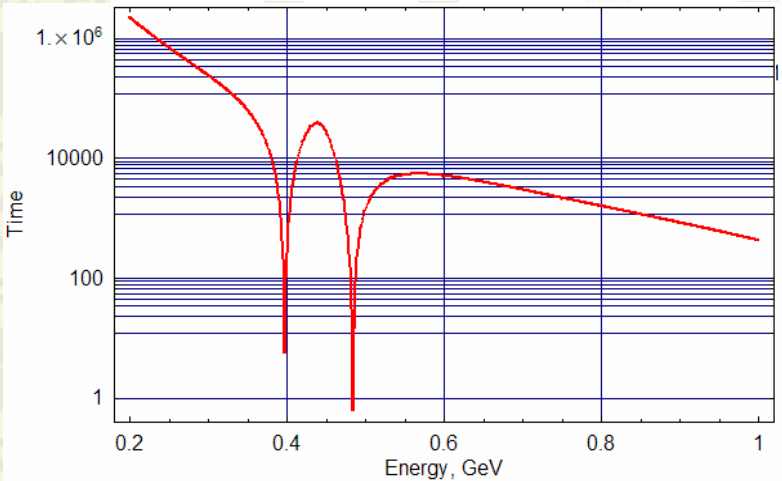
Radiative polarization

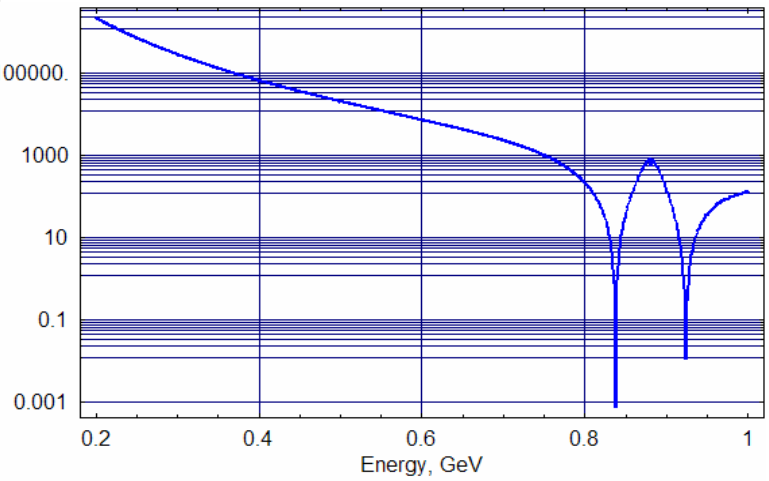




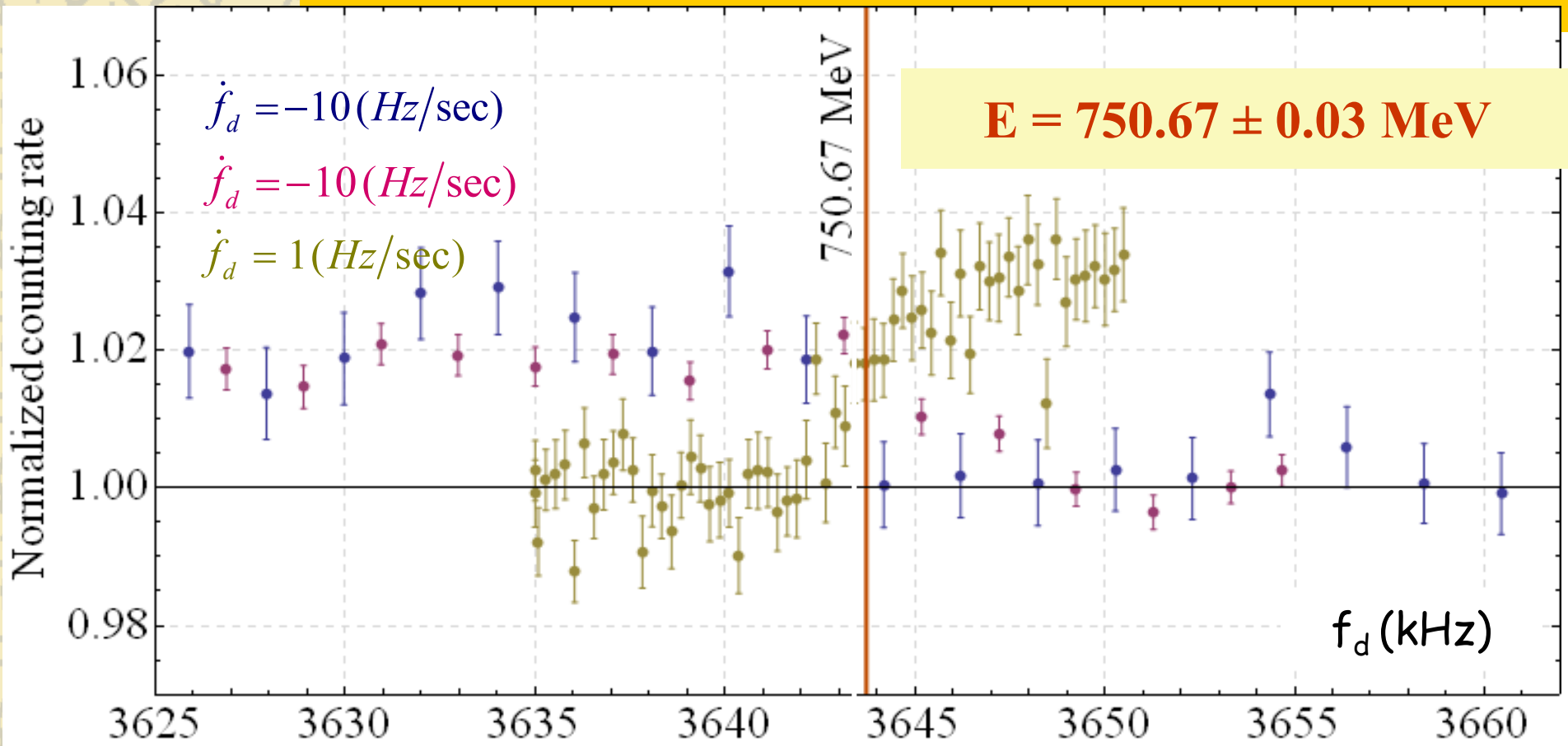








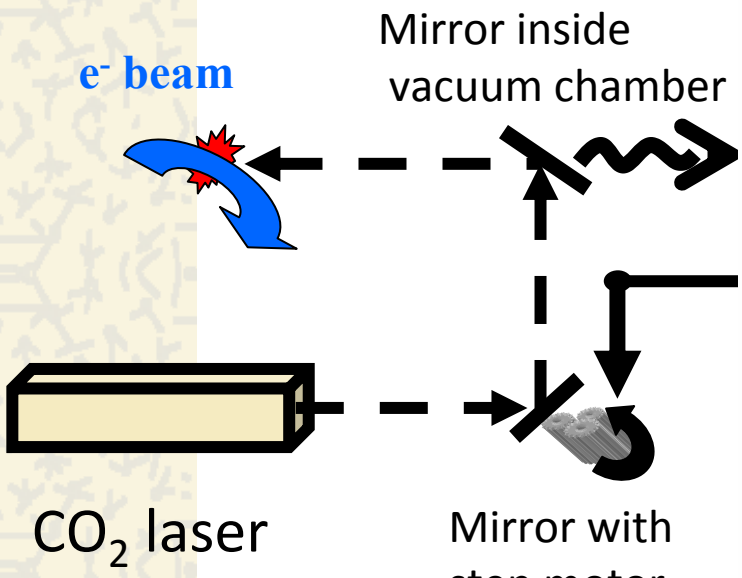
Beam energy calibration

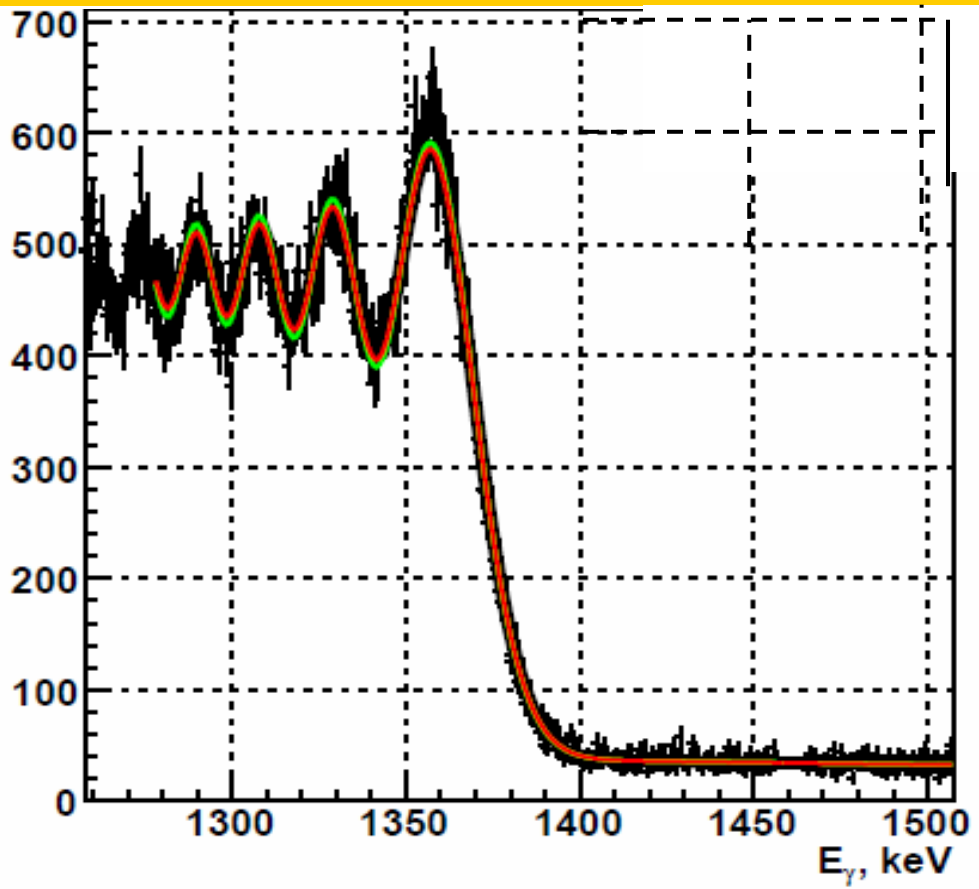


E = 750.67 ± 0.03 MeV

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

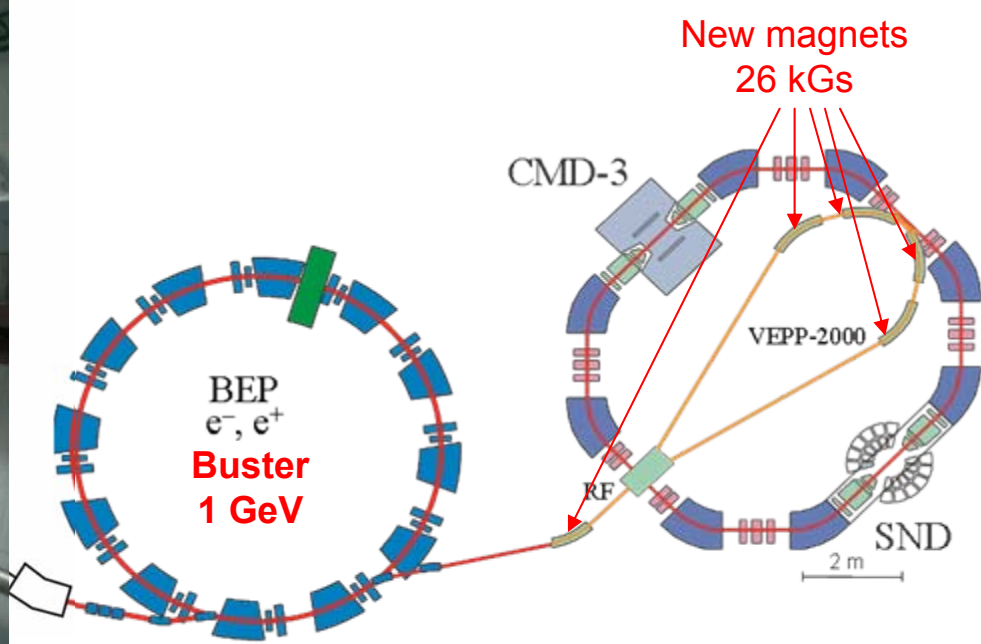
Back Compton Scattering energy measurement VEPP-2000





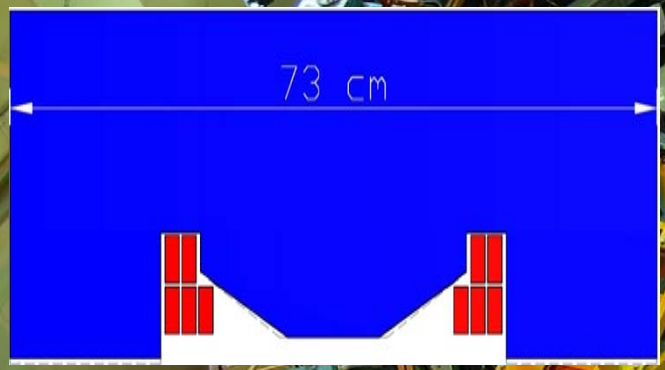
E=990 MeV; δE/E≃0.2 MeV

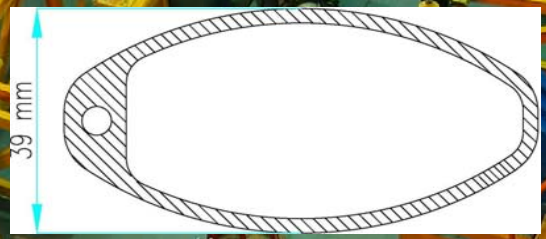
VEPP-2000 complex upgrade

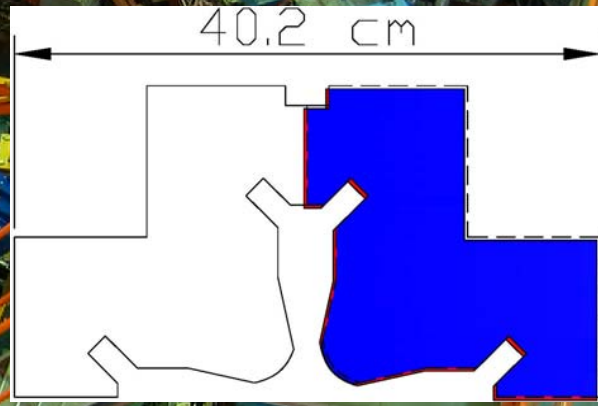


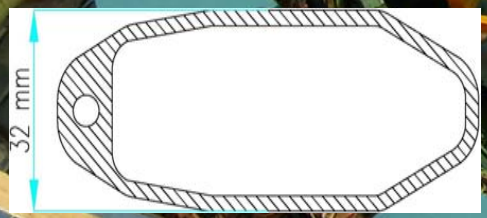
RuPAC'12

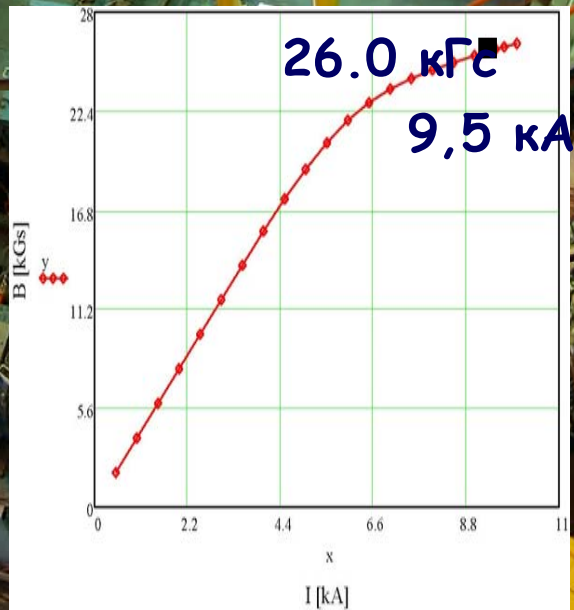
BEP upgrade (1GeV)

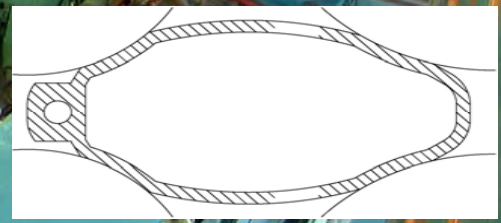












Conclusion

- Round beams give a serious luminosity enhancement.
- The beam-beam parameter achieves a value $\xi = 0.15$.
- Data taking is going with 2 detectors up to 1 GeV
- Precise beam energy calibration is in progress.
- To reach the target luminosity ($L=1\times10^{32}\ cm^{-2}\ s^{-1}$): more positrons and booster BEP upgrade for beam transfer at 1GeV are needed.

Thanks for your attention!

Yu.Shatunov for the VEPP-2000 team

Saint-Petersburg
24.09.2012