Round Beam Collisions at VEPP-2000

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Outline

- Historic remarks
- Round beams concept
- VEPP-2000 overview
- Lattice options
- Dynamic aperture
- Beam-beam study
- Round beam luminosity
- First experimental runs 2010-2011
- Energy calibration
- Conclusion

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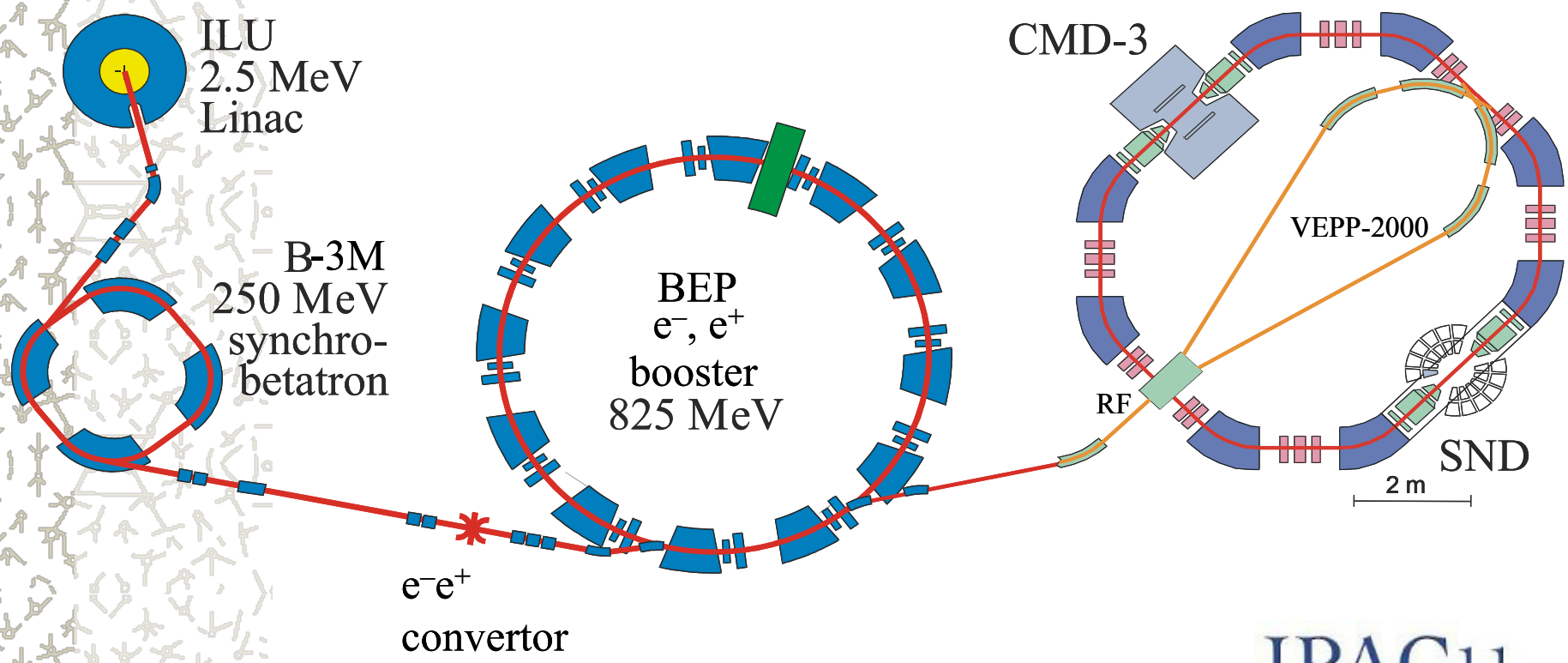
Layout of VEPP-2000 complex



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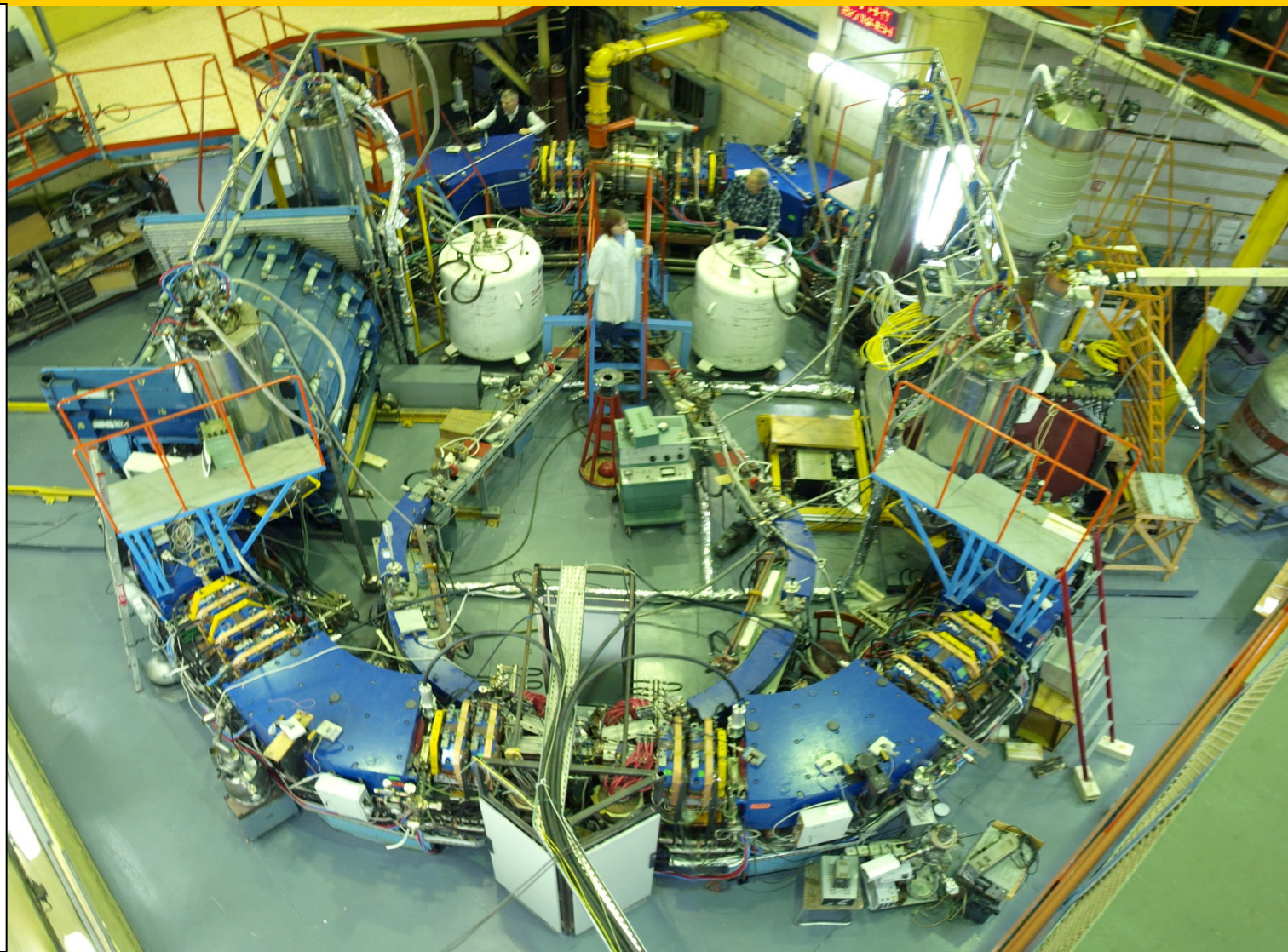
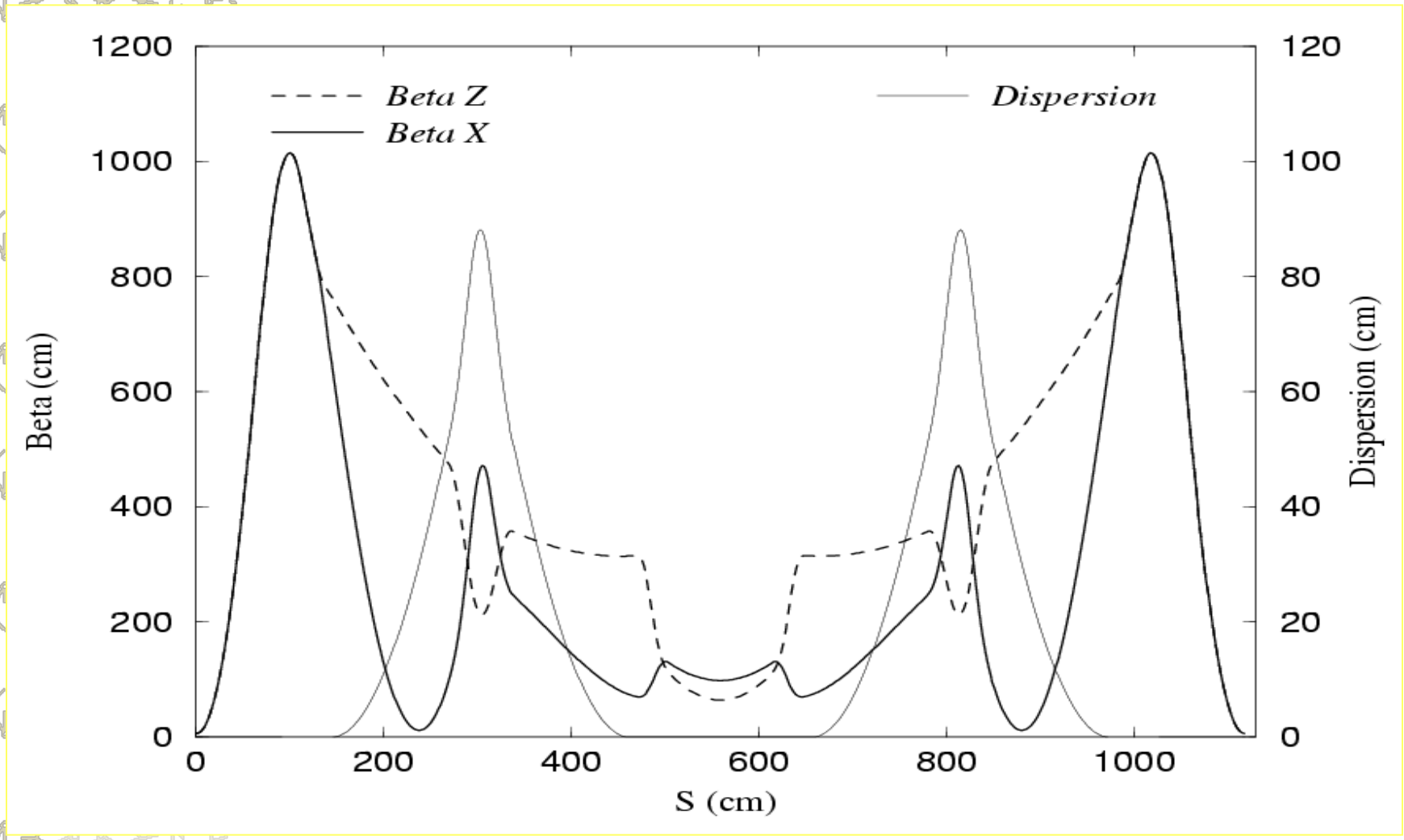
Collider overview

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
β^*=2 – 10 cm
σ_s = 3 cm
$\varepsilon=1.4\cdot10^{-7}$mrad
$\nu_{x,z}$= 2.1; 4.1
α = 0.036
ξ = 0.15
$N^{\pm} =1\cdot10^{11}$
$L=1\cdot10^{32}cm^{-2}s^{-1}$



VEPP-2000 lattice

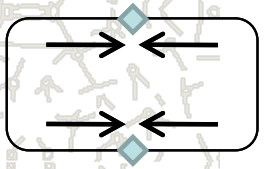


The Concept of Round Colliding Beams

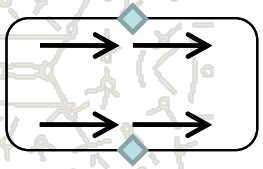
- Angular momentum conservation: $M_y = x'z - xz'$
- Small and equal β-functions at IP: $\beta_x = \beta_z$
- Equal beam emittances: $\varepsilon_x = \varepsilon_z$
- Equal betatron tunes: $\nu_x = \nu_z$
- Small and positive fractional tunes

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

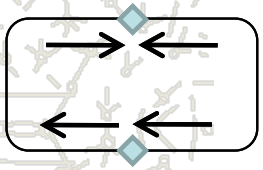
Round beam options



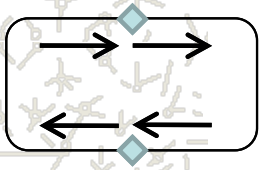
"Flat"



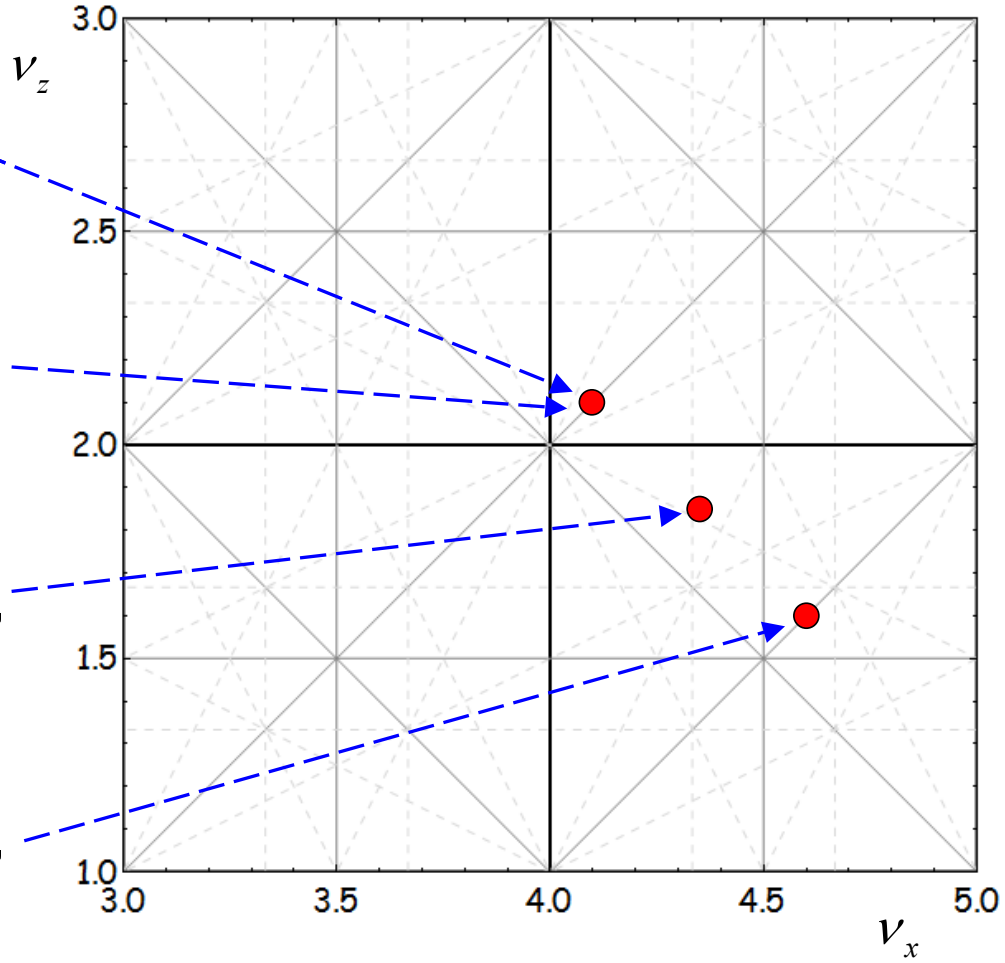
"Normal Round"



"Single möbius"



"Double möbius"



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

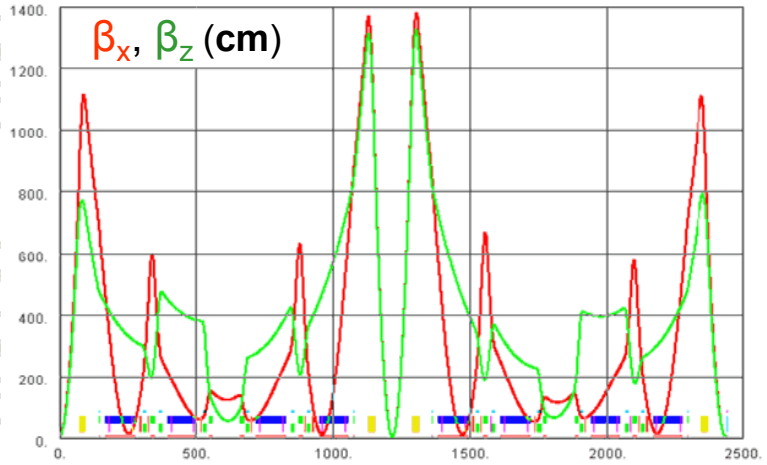
β*; zero dispersion outside achromats;

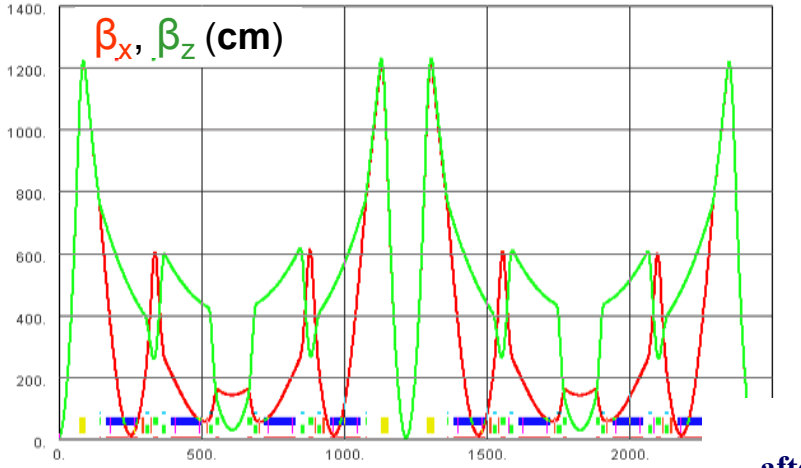
Coupling compensation

1.5 Tm field of CMD detector + solenoids compensating coils

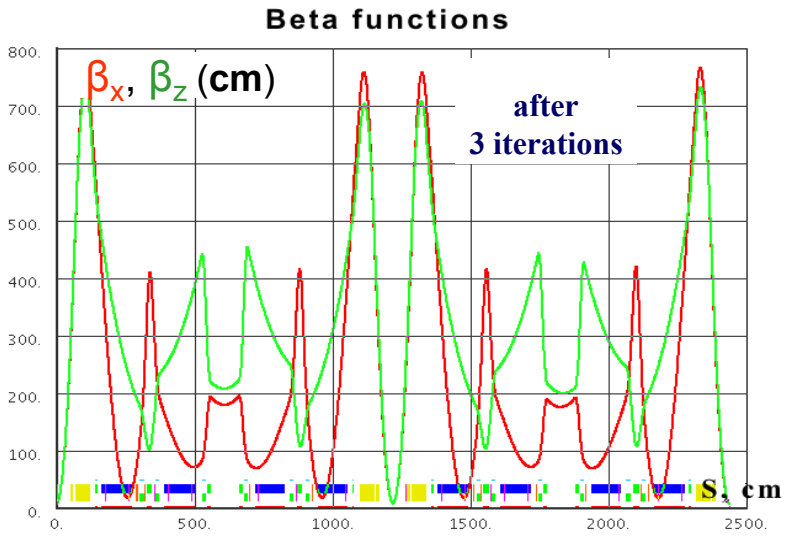
3 families of skew quads ⟹ **$\nu_1 - \nu_2 < 0.003$**

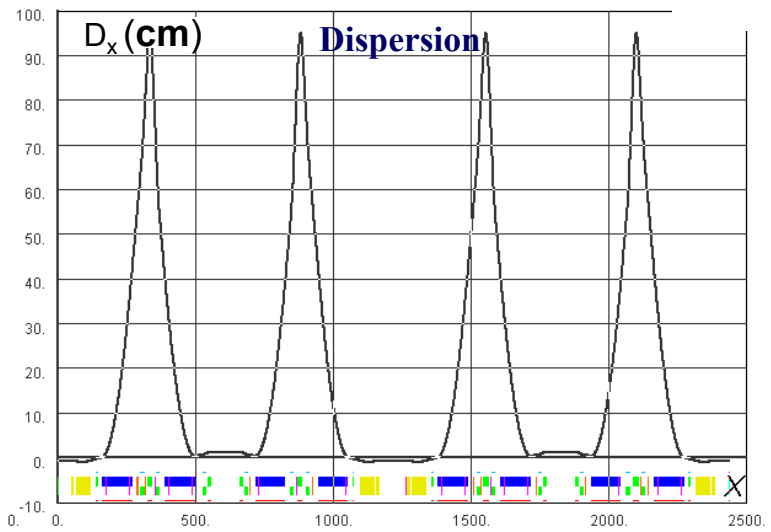
Lattice corrections



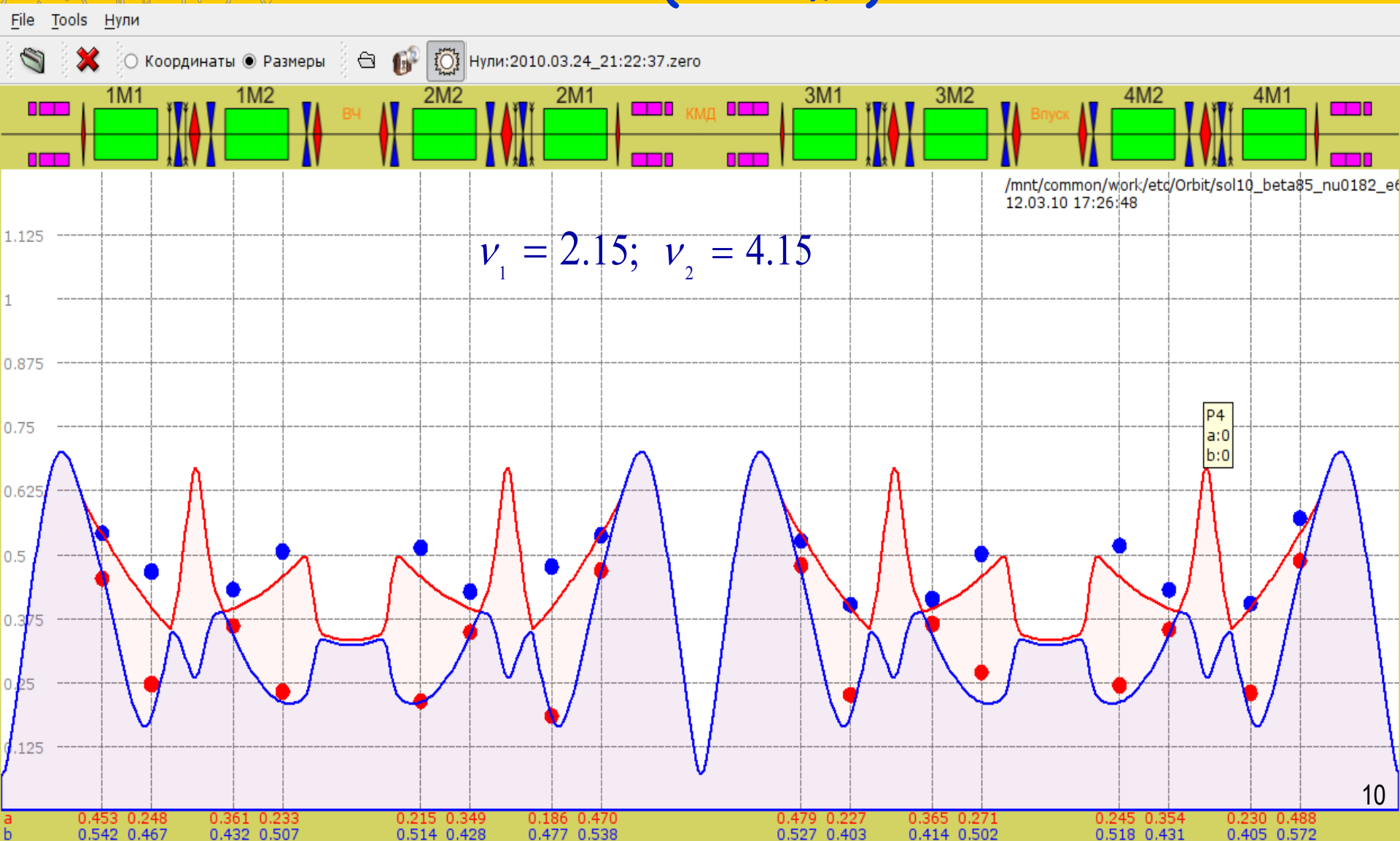


after
4 iterations

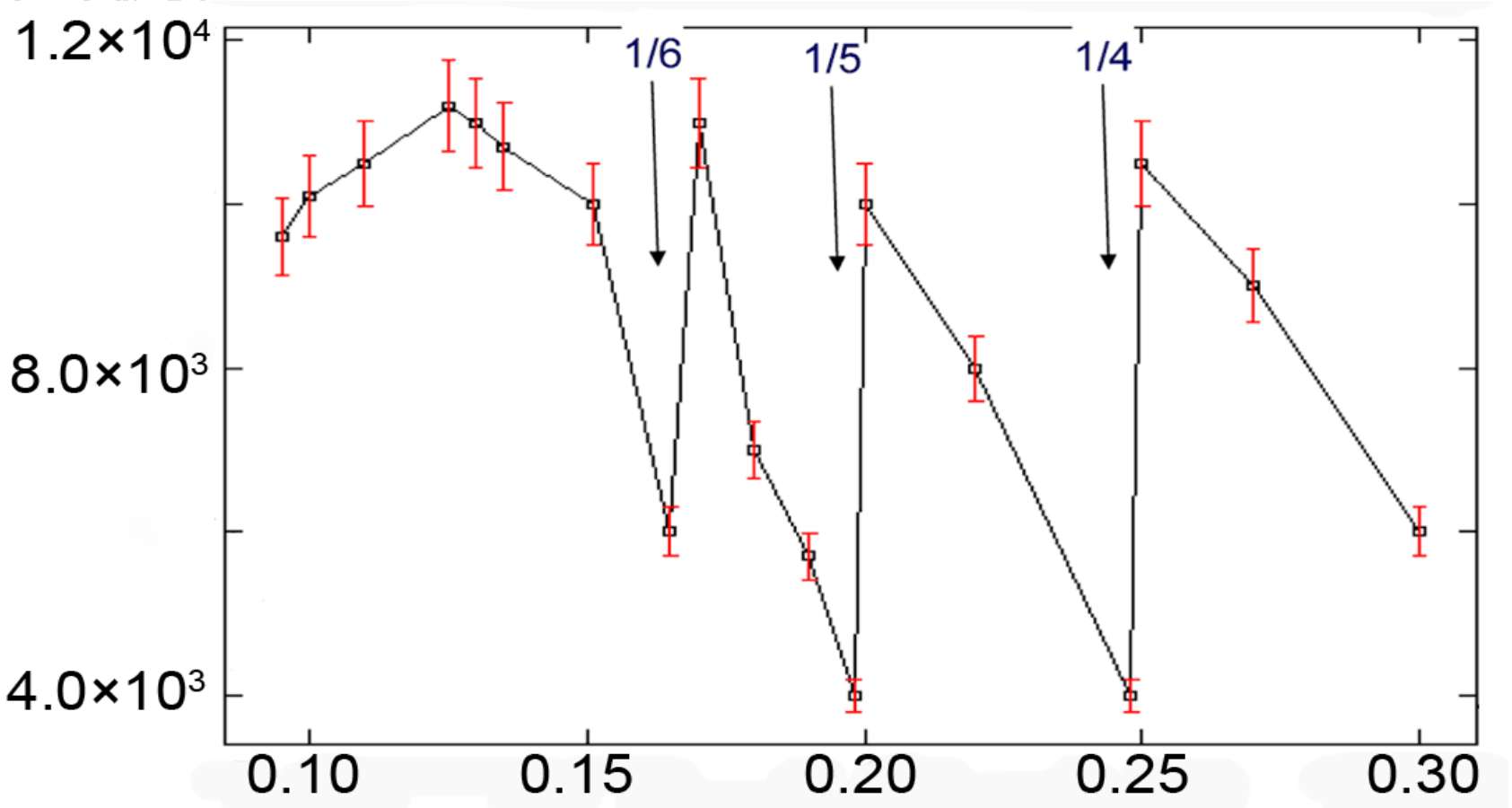




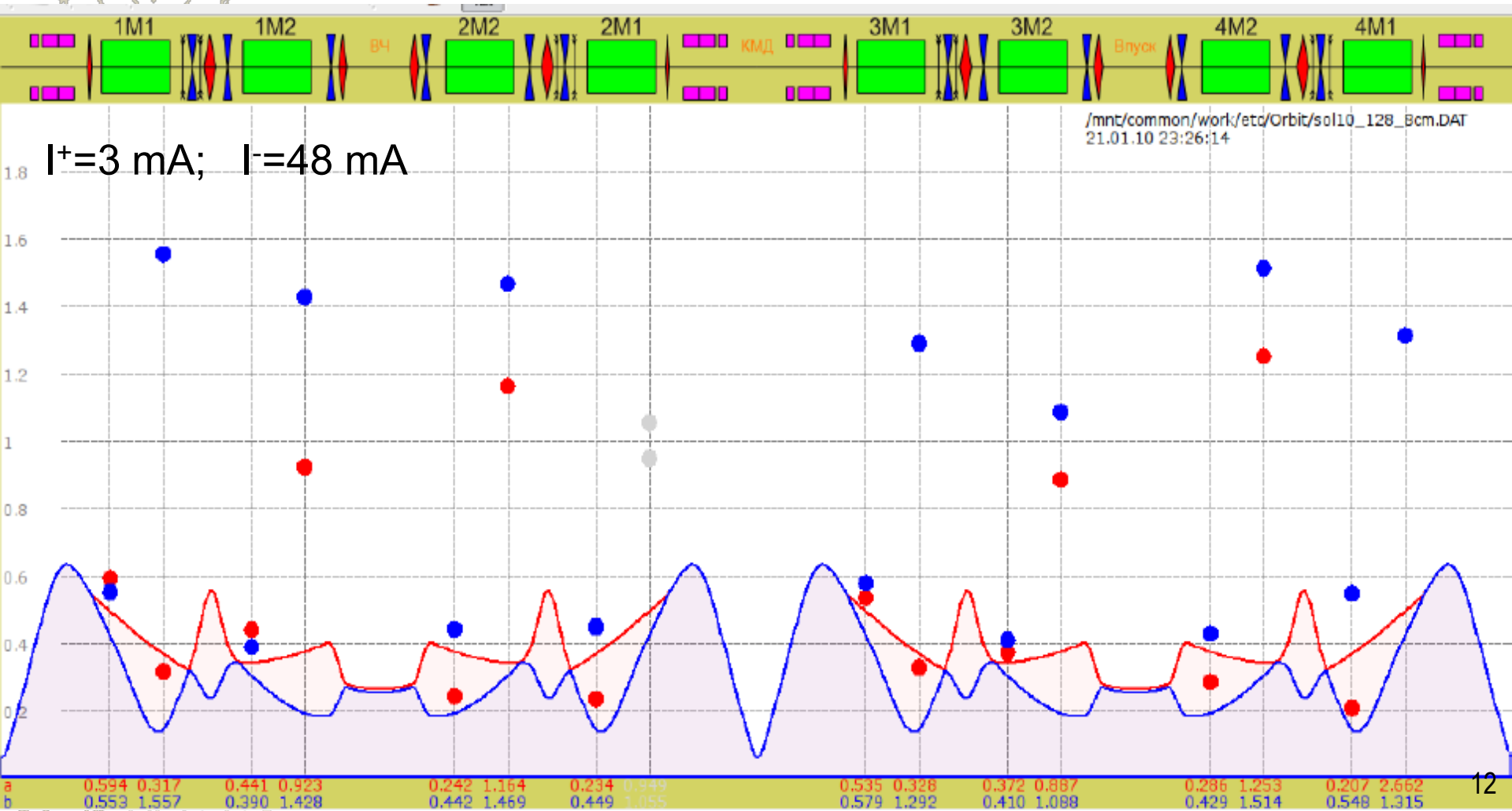
Lattice and beam sizes
($I^{\pm}$ <1mA)



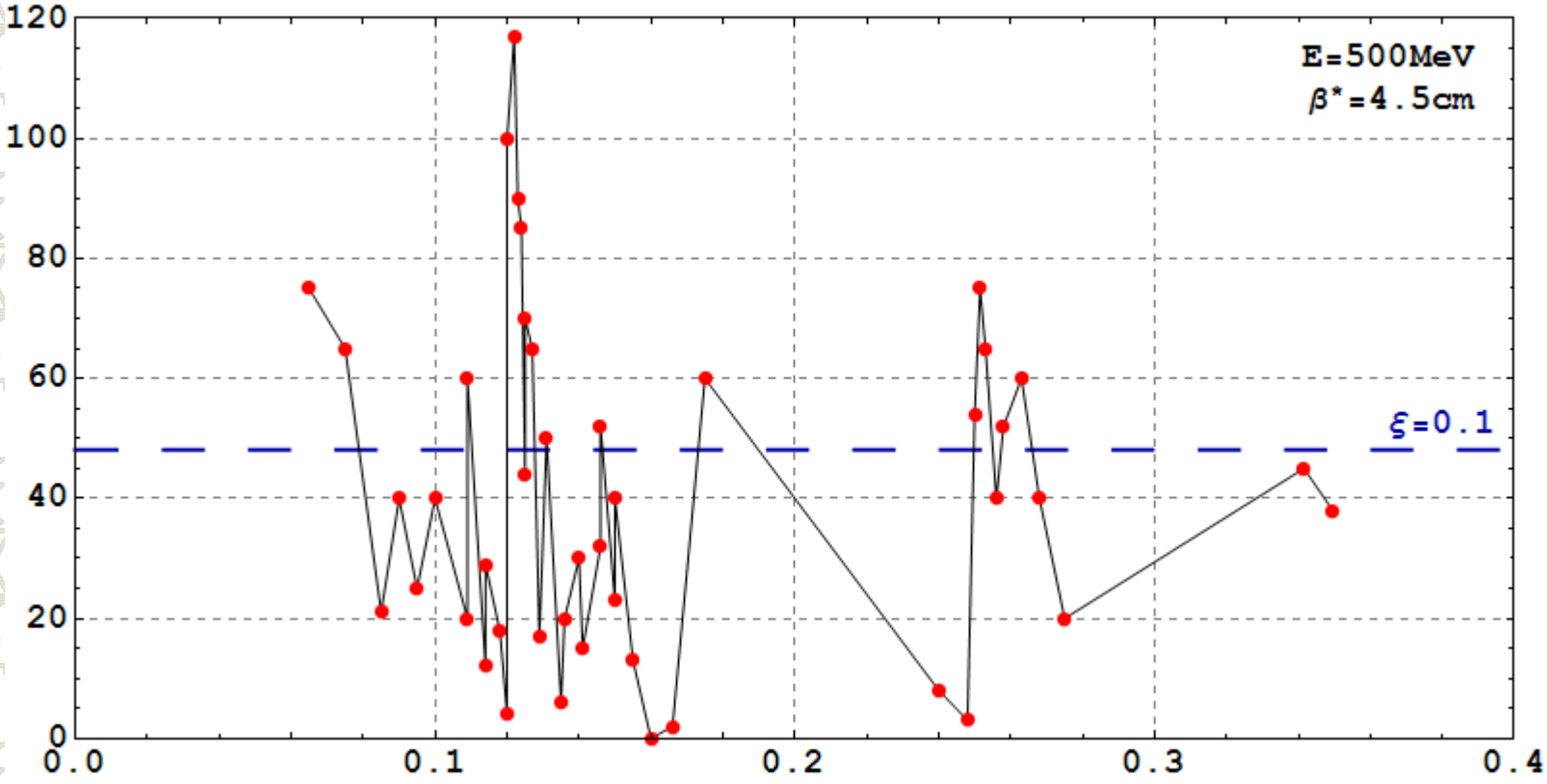
Positron beam lifetime
(I^+ = 20 mA)



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

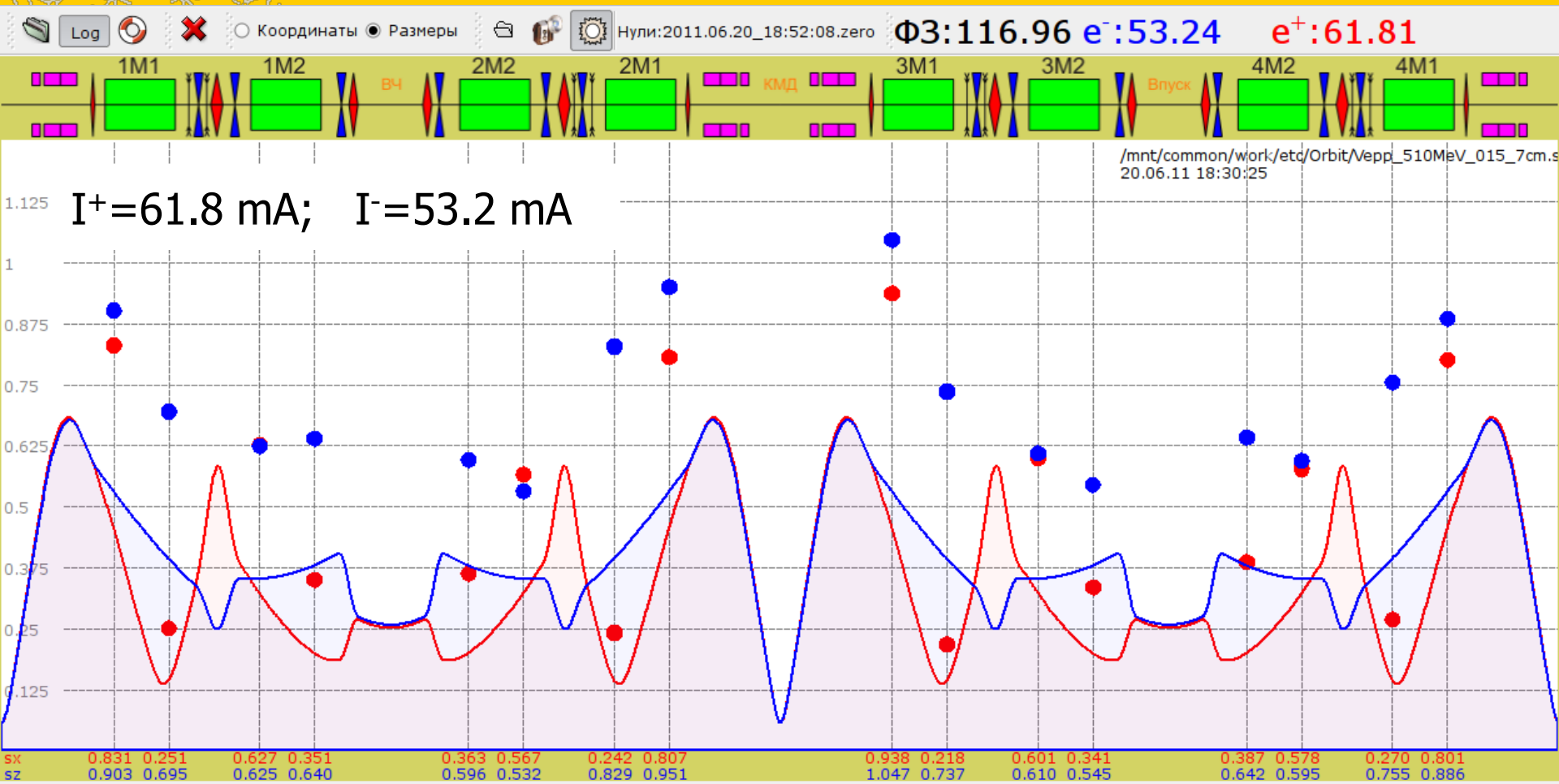


Threshold current vs.tune
("week-strong")



"Strong-strong" beam-beam

("dynamic beta and emittance")



Luminosity measurements

Bhabha scattering in the SND and CMD detectors

$\theta_{scatt} \geq 0.5$

Main disadvantage ⇛ low counting rate

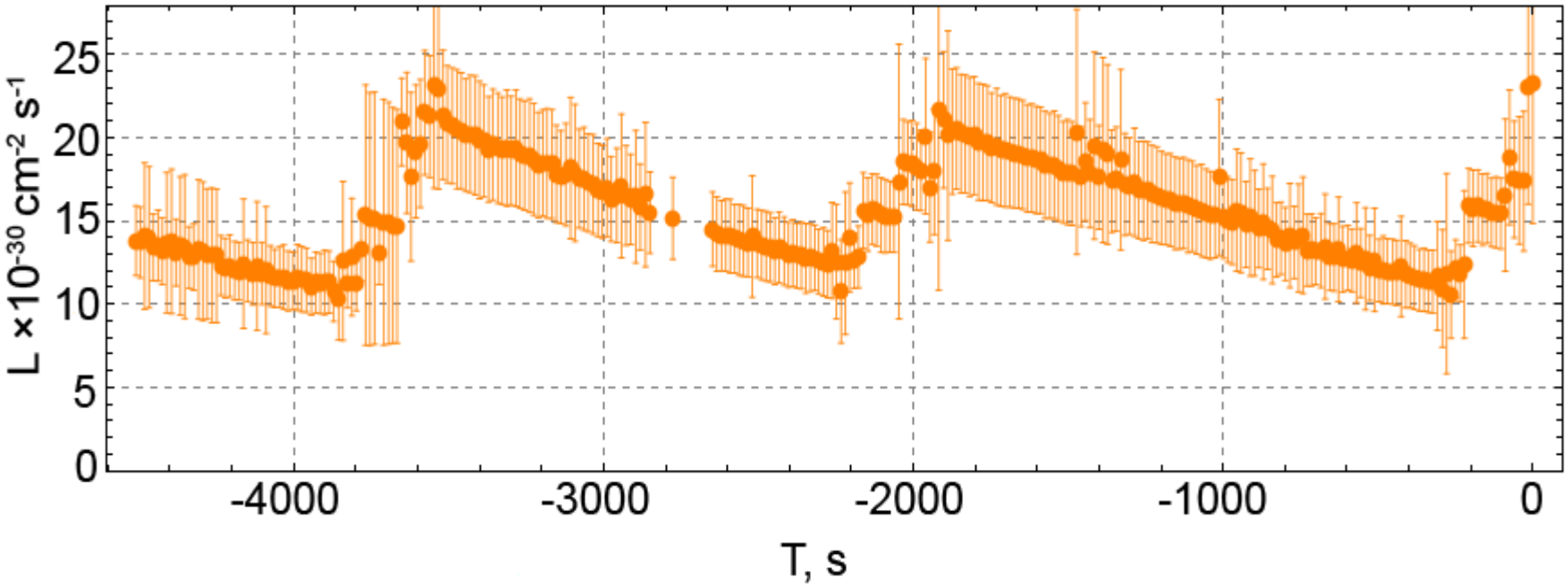
$\dot{n} \simeq 10$ Hz at $L=1\cdot10^{31}$ cm^{-2}s^{-1}

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

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 ≃ 1 s at any energy.**

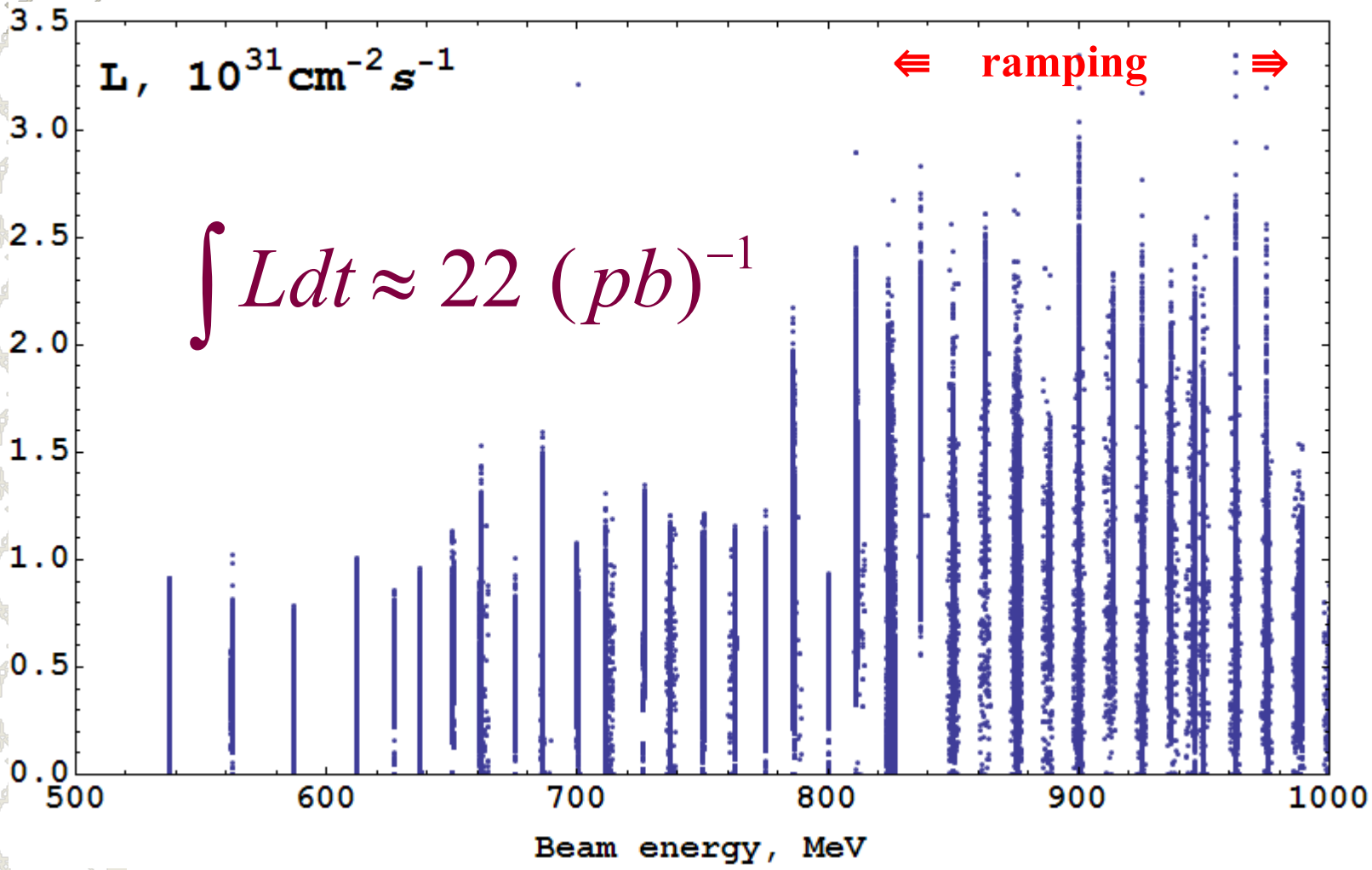
Luminosity measurements

(E = 837 MeV; Run 2011)

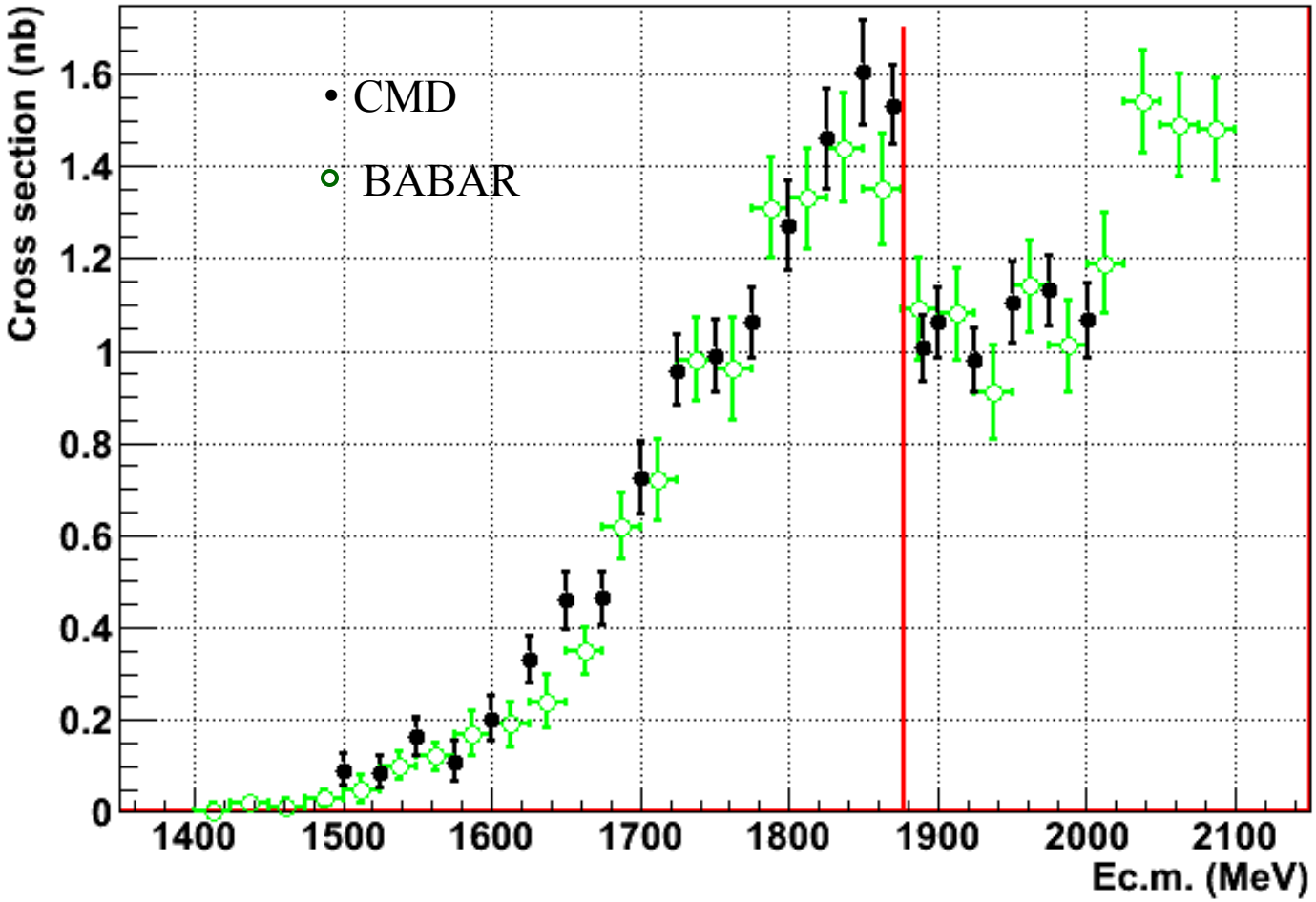


E=	837.035	β^*=	8.50539	ν0=	0.181983	Lnom=	1.44769×10^{31}	ξnom=	0.0542719
I+=	62.45	I−=	79.3375	N+=	3.17547×10^{10}	N−=	4.03416×10^{10}		
βx^+=	6.61923	βz^+=	7.30896	βx^-=	6.33846	βz^-=	7.55464		
$\epsilon x^+/\epsilon 0$=	1.19075	$\epsilon z^+/\epsilon 0$=	1.28085	$\epsilon x^-/\epsilon 0$=	1.18568	$\epsilon z^-/\epsilon 0$=	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				

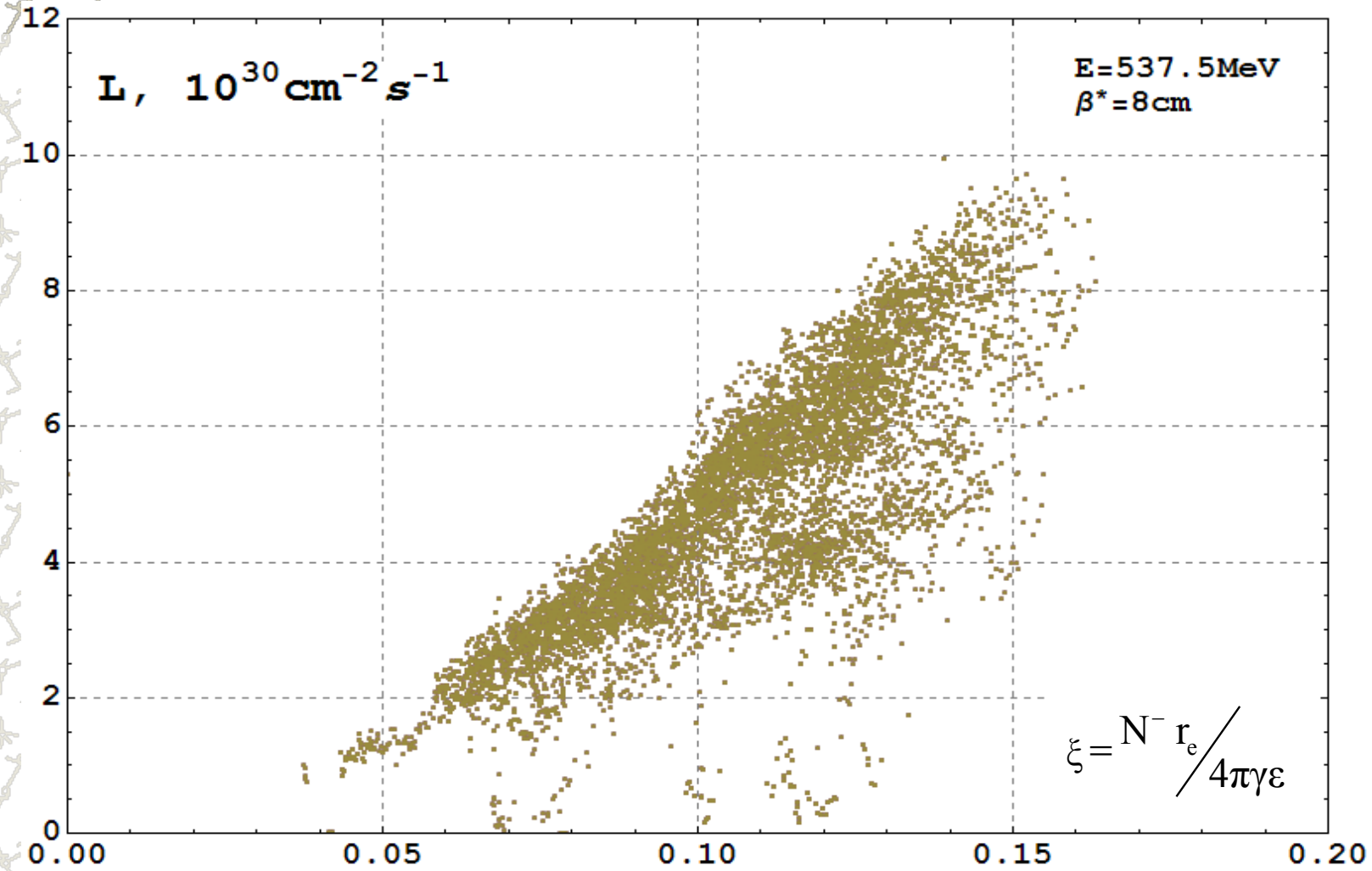
Luminosity at run 2011
(CMD data)



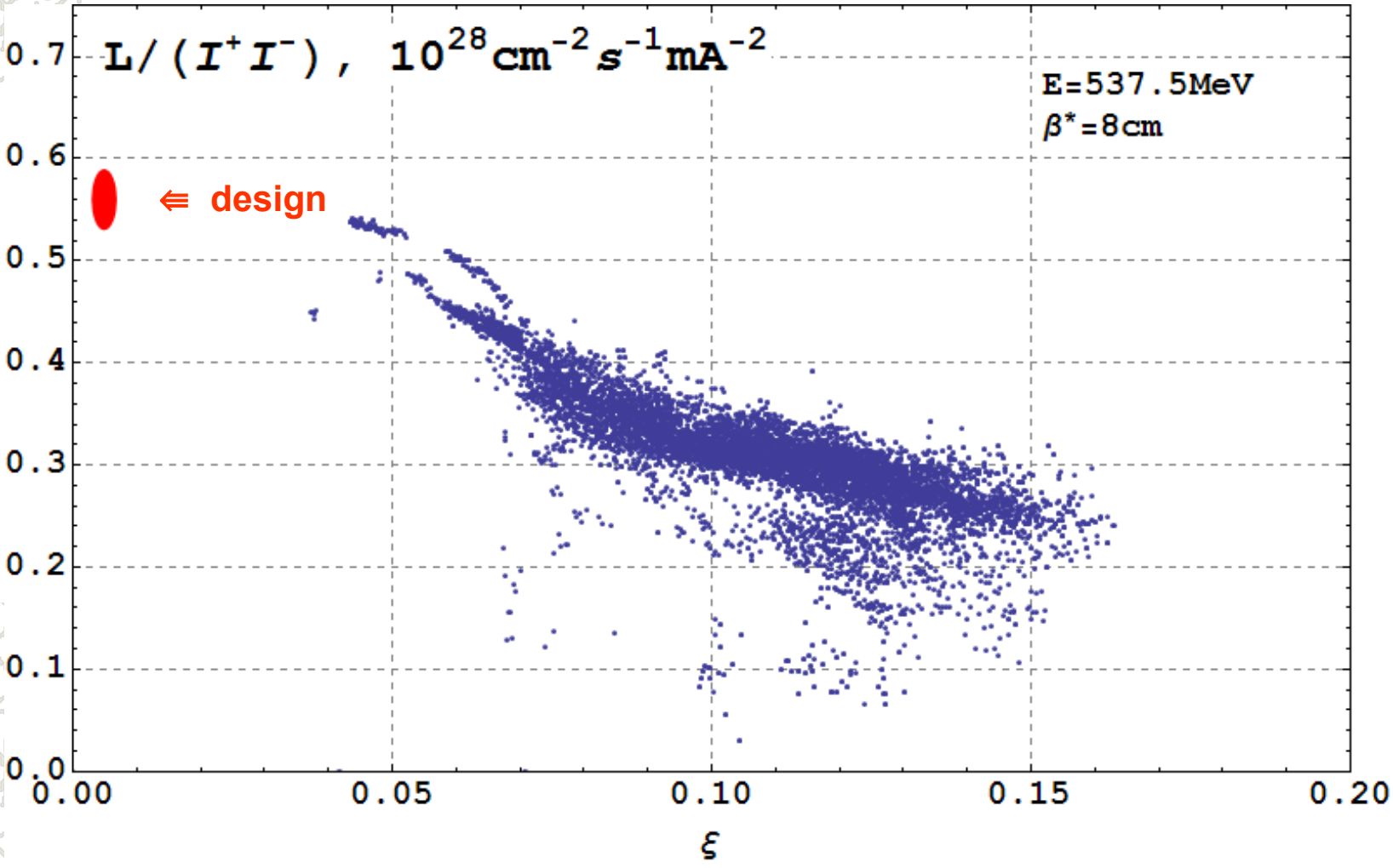
6 π-mesons production
(preliminary)



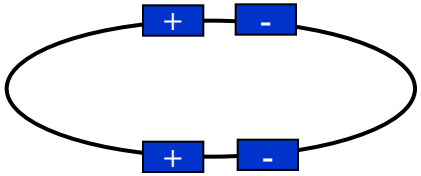
Luminosity vs.ξ

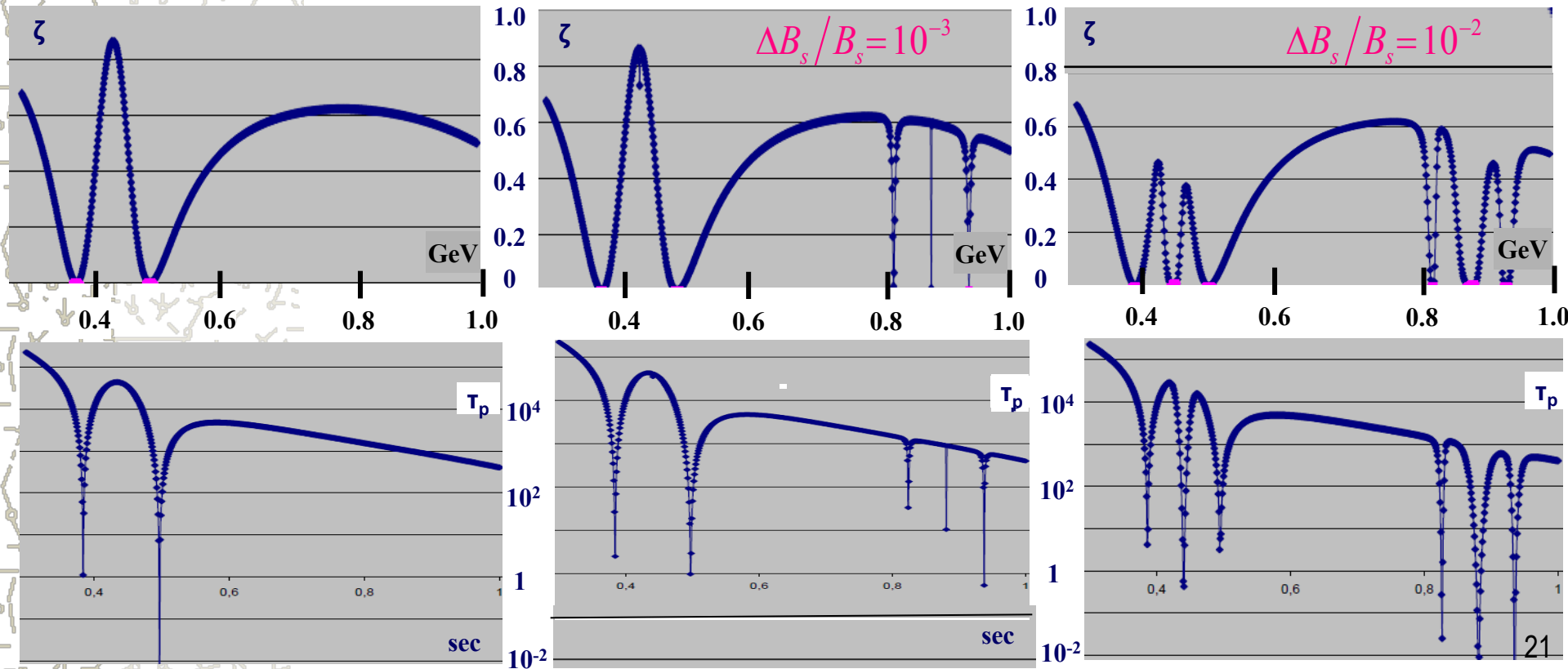


Specific luminosity vs.ξ

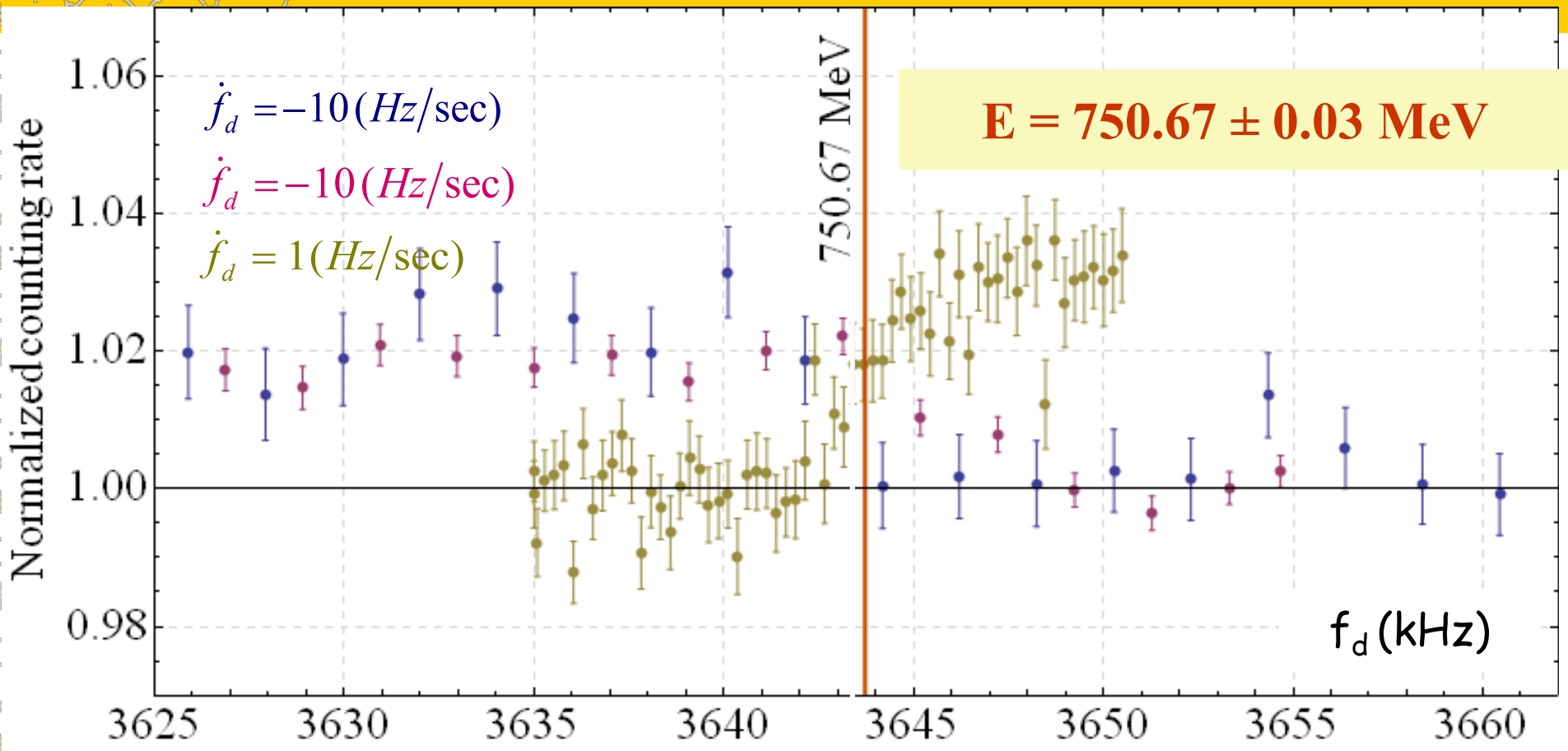


Radiative polarization



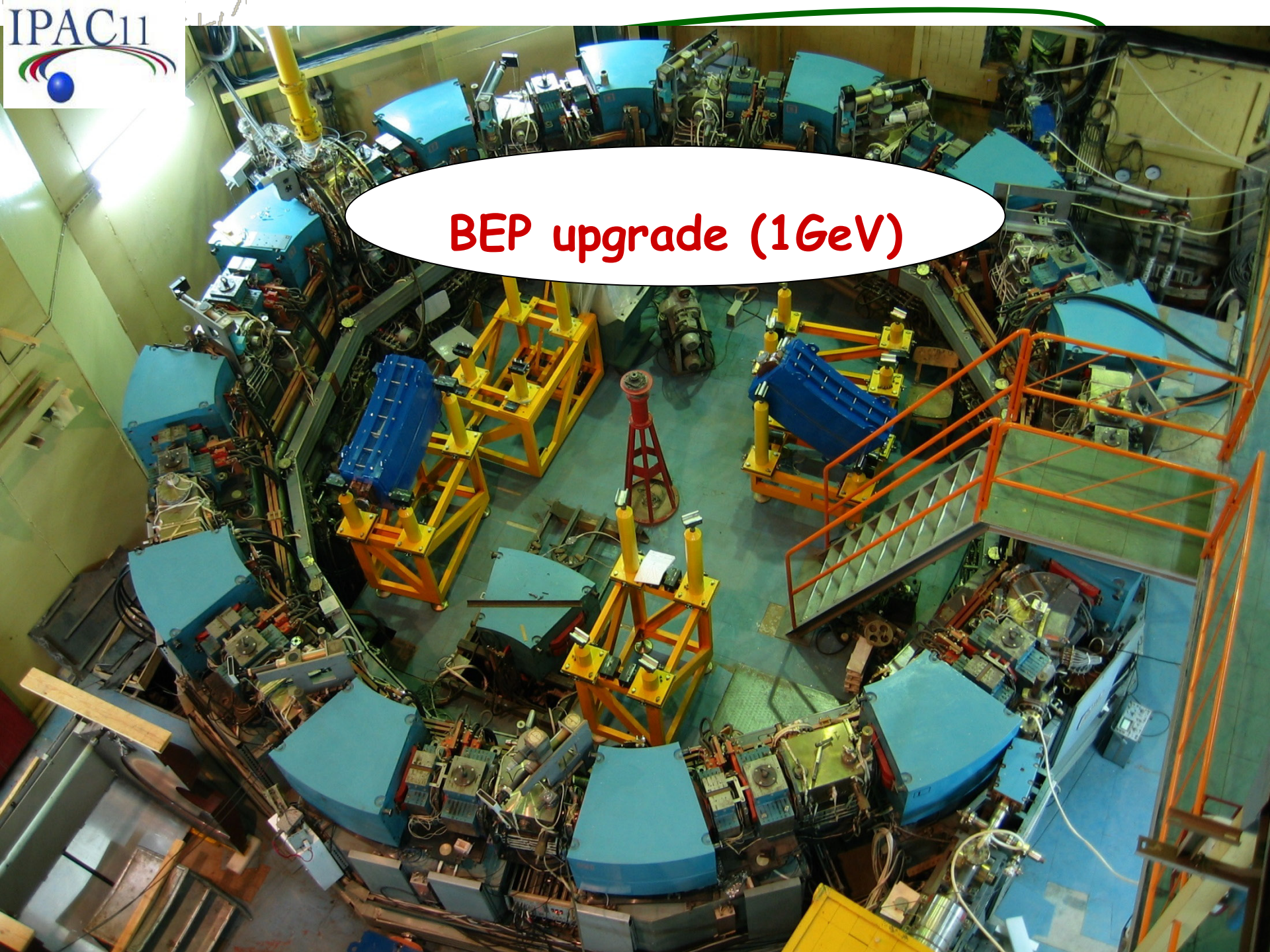


Beam energy calibration



E = 750.67 ± 0.03 MeV

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

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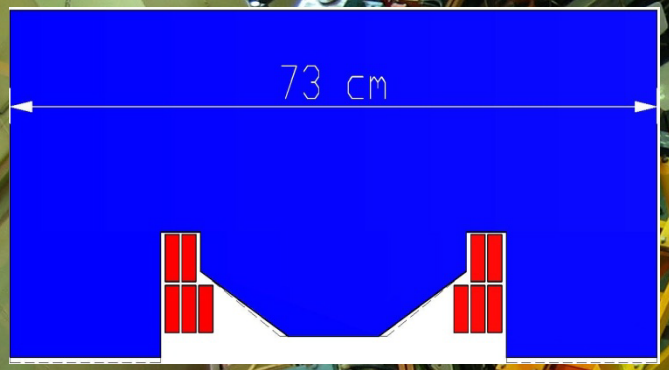
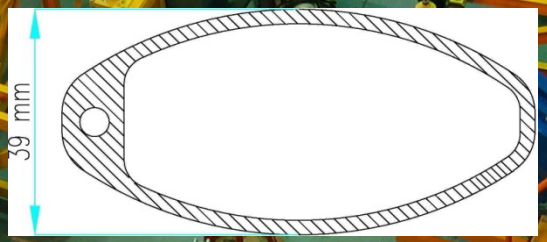
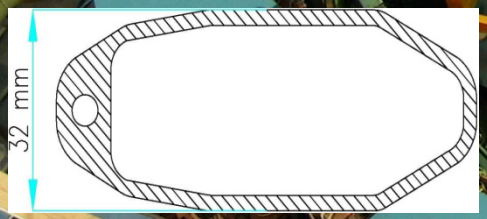
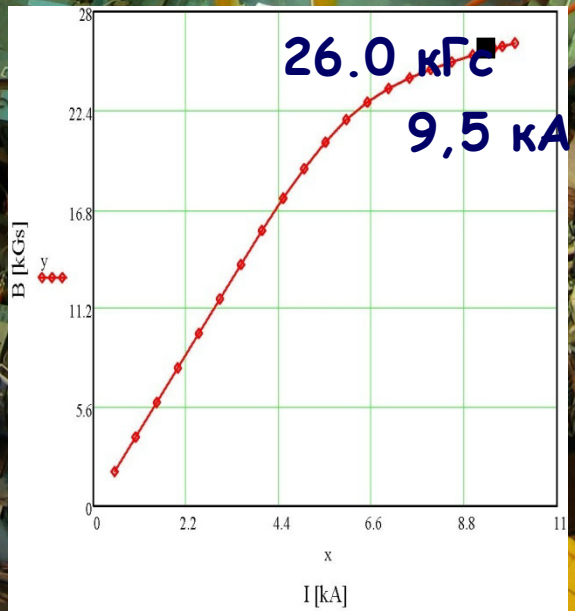
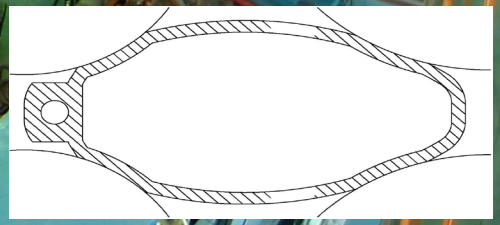
BEP upgrade (1GeV)











Conclusion

- Round beams give a serious luminosity enhancement.
- The beam-beam parameter achieves a value $\xi = 0.15$.
- VEPP-2000 started up for data taking with 2 detectors.
- Precise beam energy calibration is in progress.
- To reach the target luminosity, more positrons are needed.
- Booster BEP upgrade for beam transfer at 1GeV is being prepared.

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Thanks for your attention!

San-Sebastian
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