International Conference "Synchrotron and Free electron laser Radiation: generation and application (SFR-2016)"
4-8 July 2016, Novosibirsk, Russia

Synchrotron radiation research and application at VEPP-4

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VEPP-4 team

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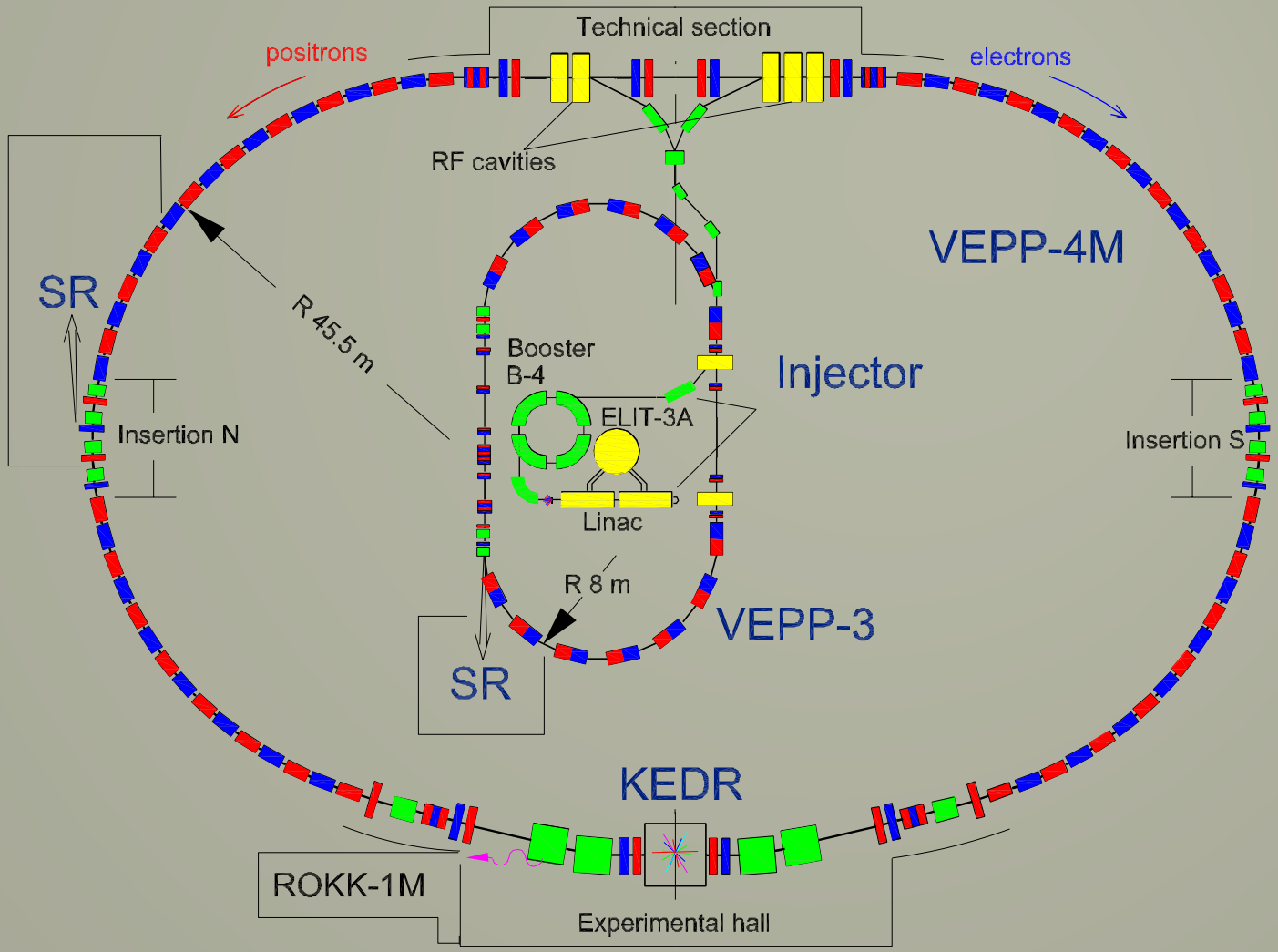
physics program

- high energy physics at VEPP-4M with detector KEDR
- synchrotron radiation at VEPP-3 & VEPP-4M
- nuclear physics experiments at VEPP-3 with Deuteron facility
- test beam facility at VEPP-4M
- accelerator physics activity

VEPP-4 layout



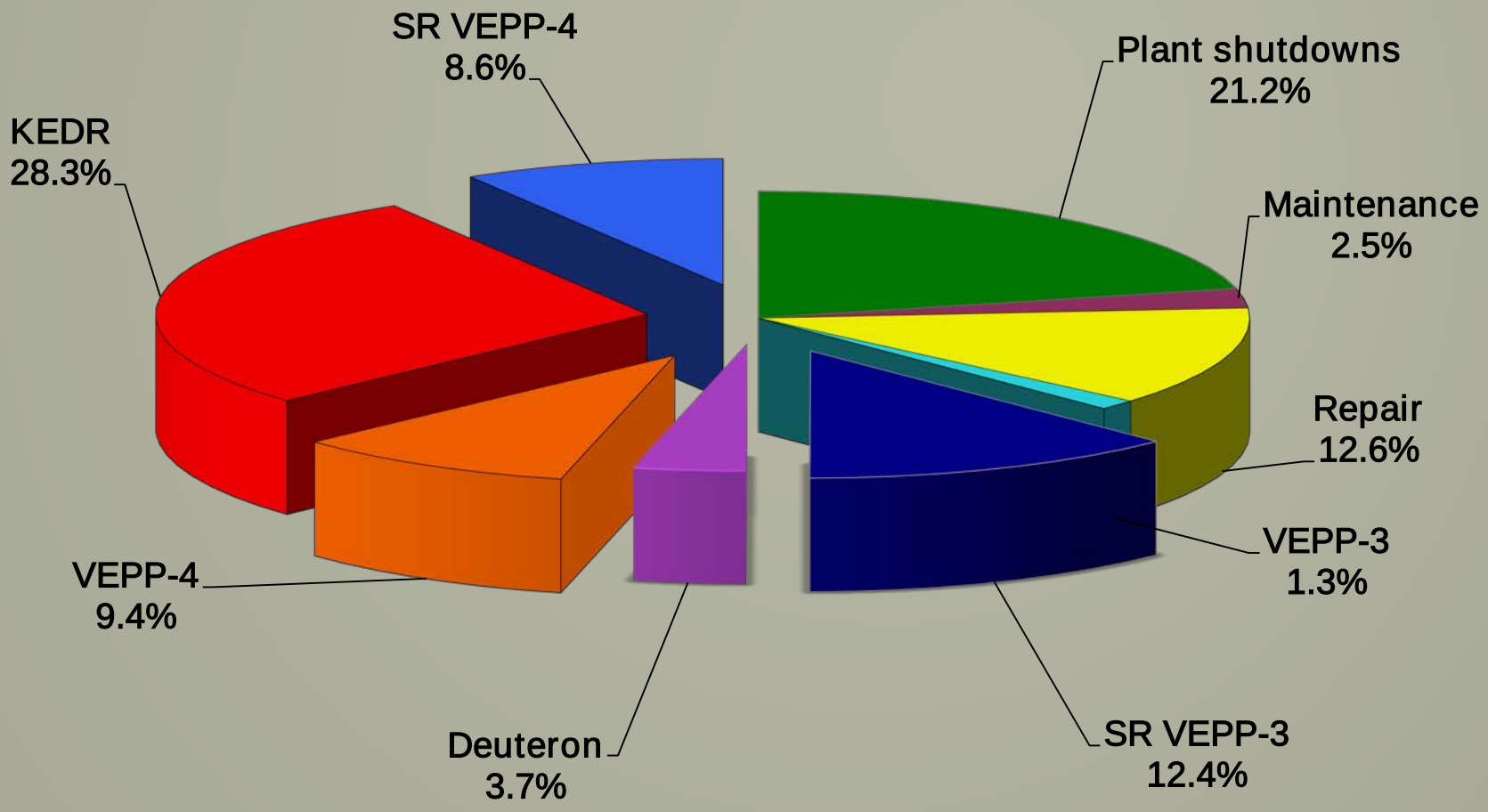
VEPP-3 parameters

Energy	**0.350÷2.0**	**GeV**
Circumference	**74.40**	**m**
Number of bunches	**2e±**	
Harmonic number	**2/18**	
Betatron tunes, h/v	**5.124/5.179**	
Emittance	**290**	**nm·rad**
Coupling	**0.05%**	
Energy spread	**$7 \cdot 10^{-4}$**	
Bunch length	**9**	**cm**
Beam current	**150**	**mA**
Energy losses	**230**	**keV**

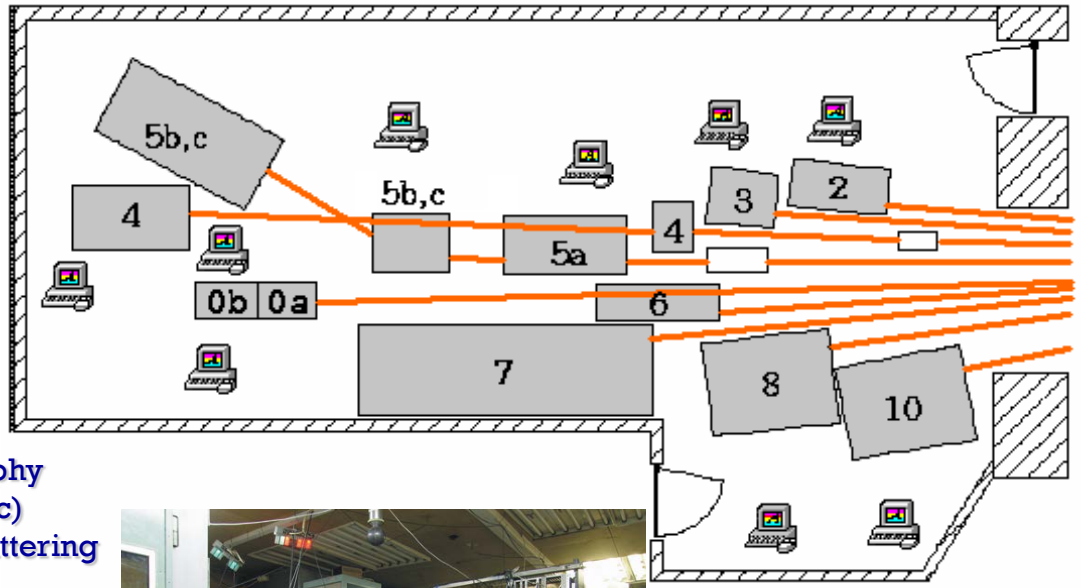
VEPP-4M parameters

Energy	**0.925 ÷ 4.75 (5.2)**					**GeV**
Circumference	**366.075**					**m**
Number of bunches	**2e+ x 2e- (16e-)**					
Harmonic number	**222**					
Betatron tunes, h/v	**8.54/7.57**					
Compaction factor	**0.0168**					
Coupling	**0.05%**					
Bunch length	**5**					**cm**
Beam Energy	**1.5**	**1.8**	**3**	**4.7**	**5.2**	**GeV**
Emittance	**16**	**25**	**67**	**167**	**200**	**nm·rad**
Energy Spread	**2.5**	**3.0**	**4.9**	**7.8**	**8.5**	**$\cdot 10^{-4}$**
Bunch Current	**1.6**	**3.0**	**12**	**25**	**25**	**mA**
Luminosity	**0.9**	**2.0**	**14**	**44**	**25**	**$\cdot 10^{30}$ cm$^{-2}\cdot$s^{-1}**

time distribution in 2015



synchrotron radiation beamlines @ VEPP-3



0a – LIGA-technology and X-ray lithography
0b – Fast dynamic process (detonation etc)
2 – Precise diffraction and anomalous scattering
3 – X-ray fluorescence analysis
4 – High pressure diffraction
5a – X-ray microscopy and microtomography
5b – Time resolved diffraction
5c – Small angle scattering
6a – Time resolved luminescence
6b – Precise diffraction-2
7 – SR monitoring station
8 – EXAFS-spectroscopy

synchrotron radiation beamlines @ VEPP-4M

1. «Cosmos» (metrology in VUV and soft X-ray range 10-2000 eV)
2. Phase contrast microscopy, microtomography and hard X-ray fluorescence
3. «Vzryv-2» (nanosecond diagnostics)
4. «High presure» – assembling
5. «Plamya» beamline – developing
6. Precise difractometry (planning)

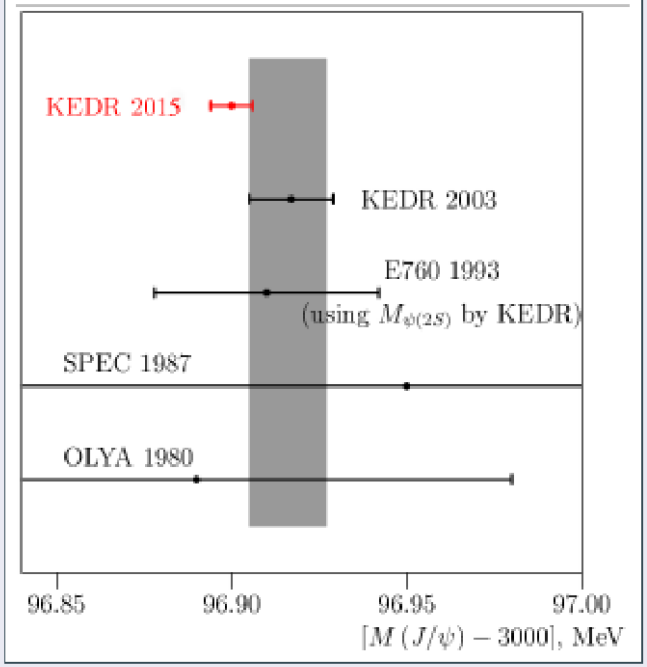
particle rest mass in PDG table

Массы J/ и (2S) – мезонов 1

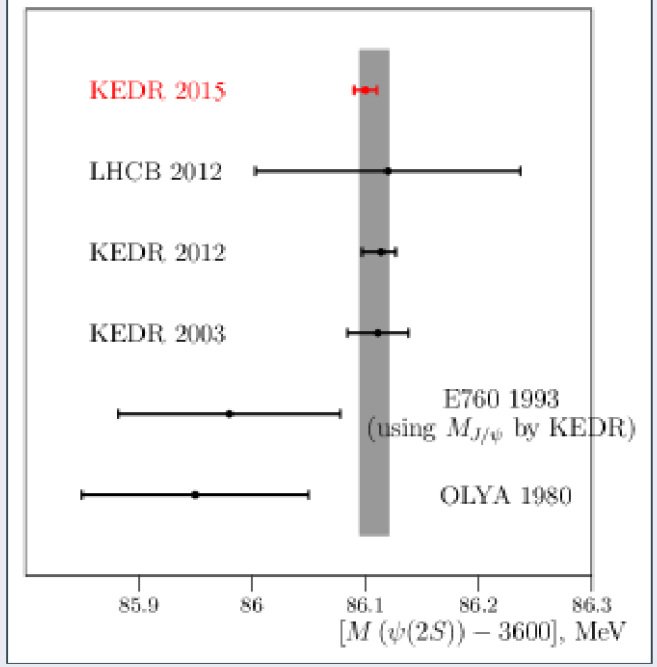
$M(J/\ ) = (3096.900 \pm 0.002 \pm 0.006)$ МэВ, (2.0 ppm)

$M(\ (2S)) = (3686.099 \pm 0.004 \pm 0.009)$ МэВ, (2.9 ppm)

Масса J/

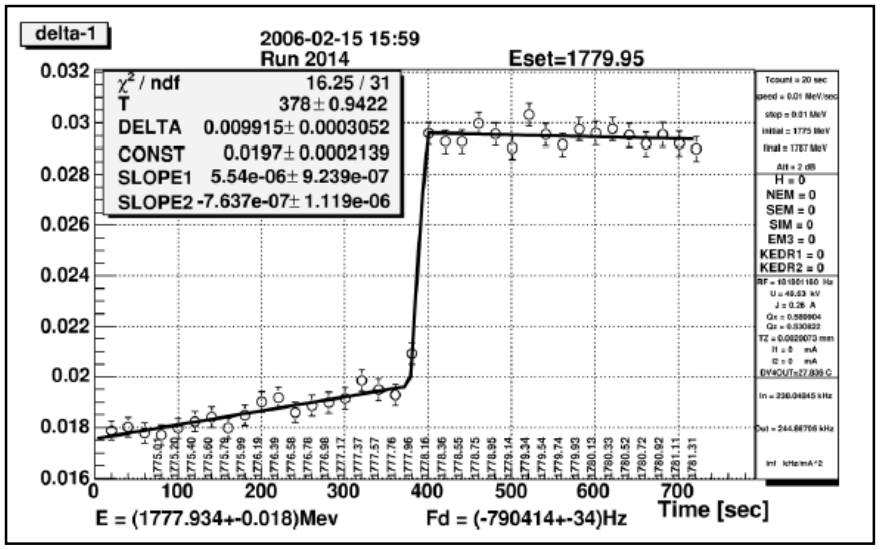


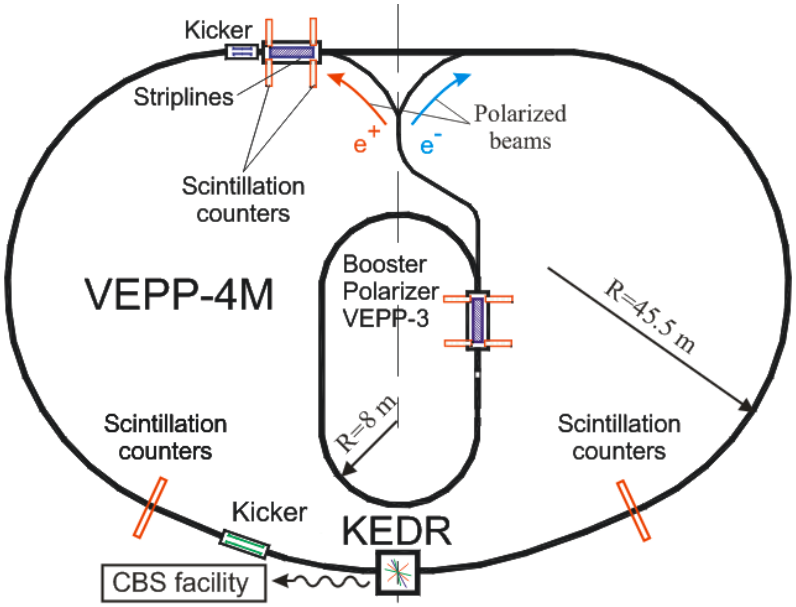
Масса (2S)



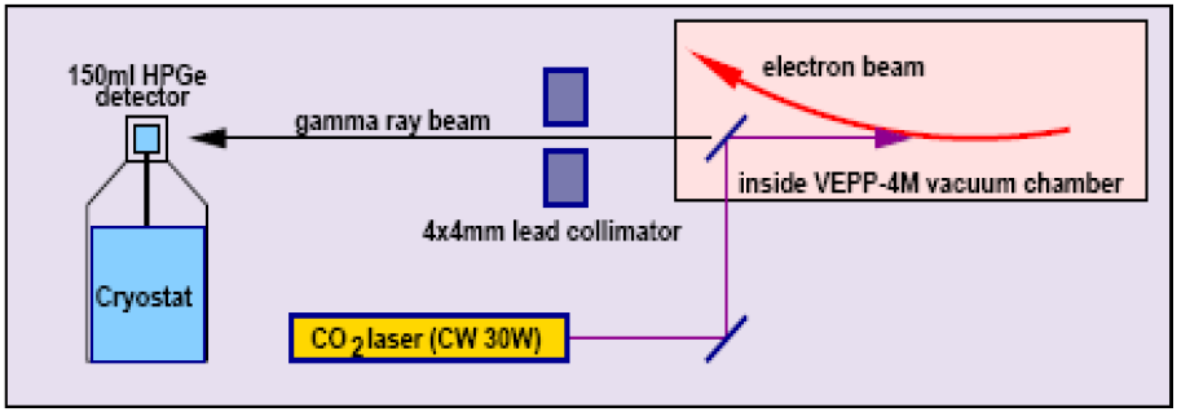
beam energy calibration resonance depolarization

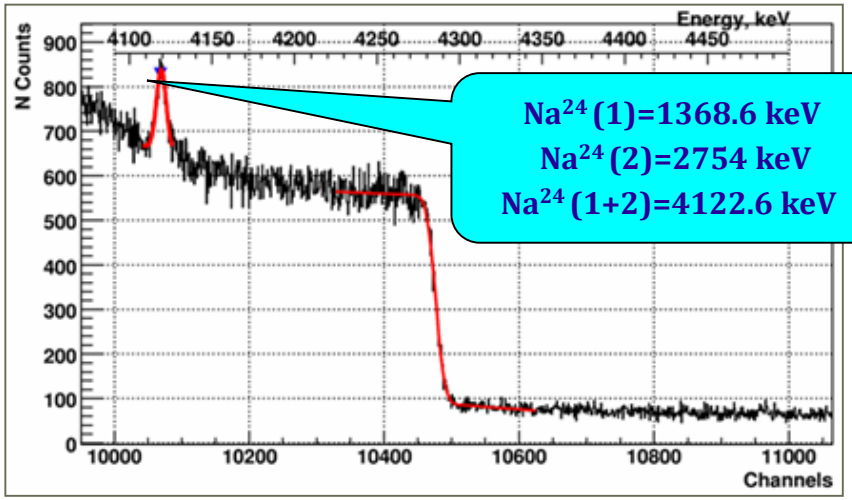
- **Accuracy ~ 10^{-6}**
- **Needs polarized beam**
- **Up to 2-3 serial measurements possible with the same beam**
- **Polarized beam obtained in ranges E = 1.5÷2 GeV and 3.8÷5 GeV**





beam energy calibration Compton backscattering

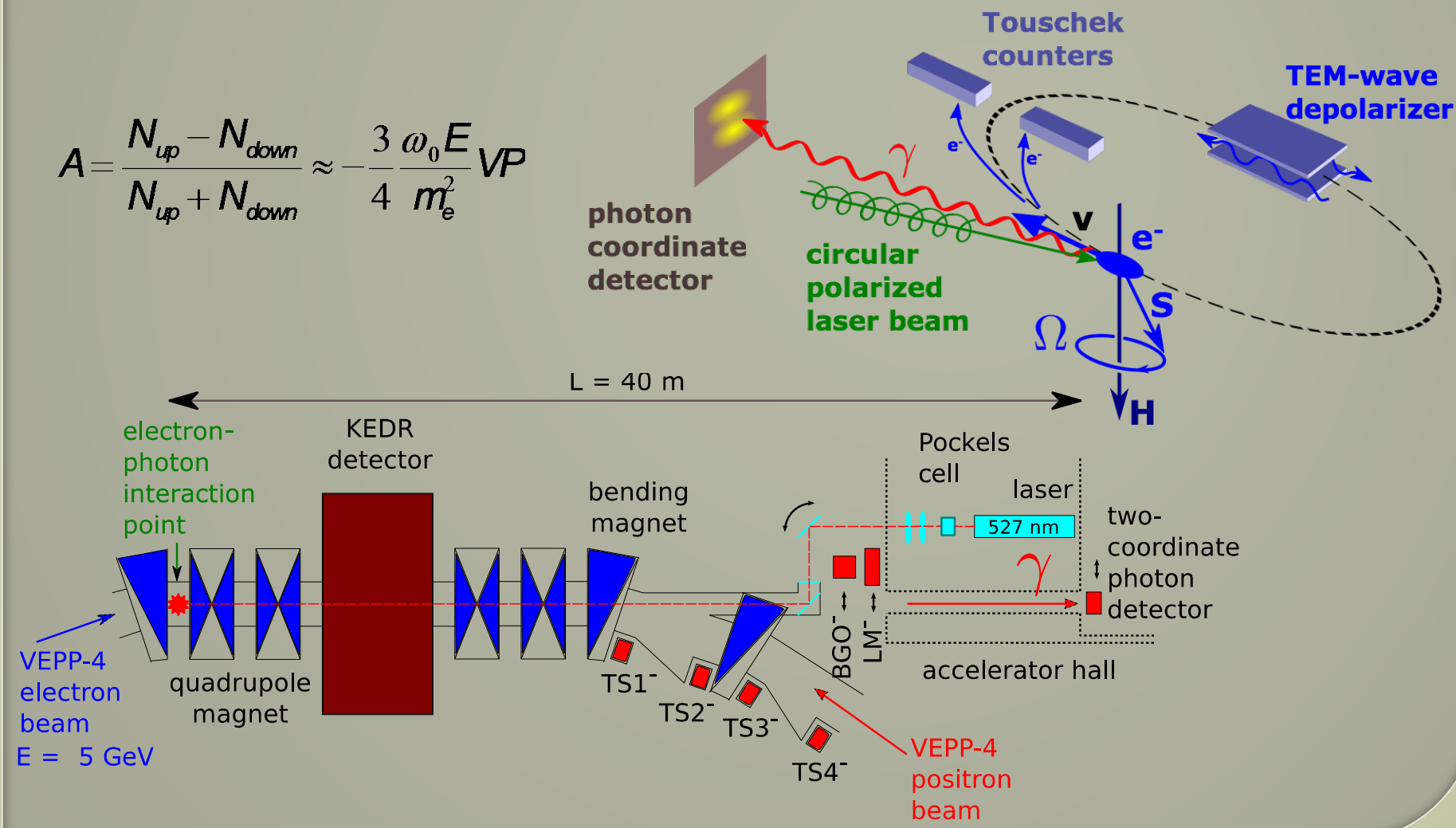




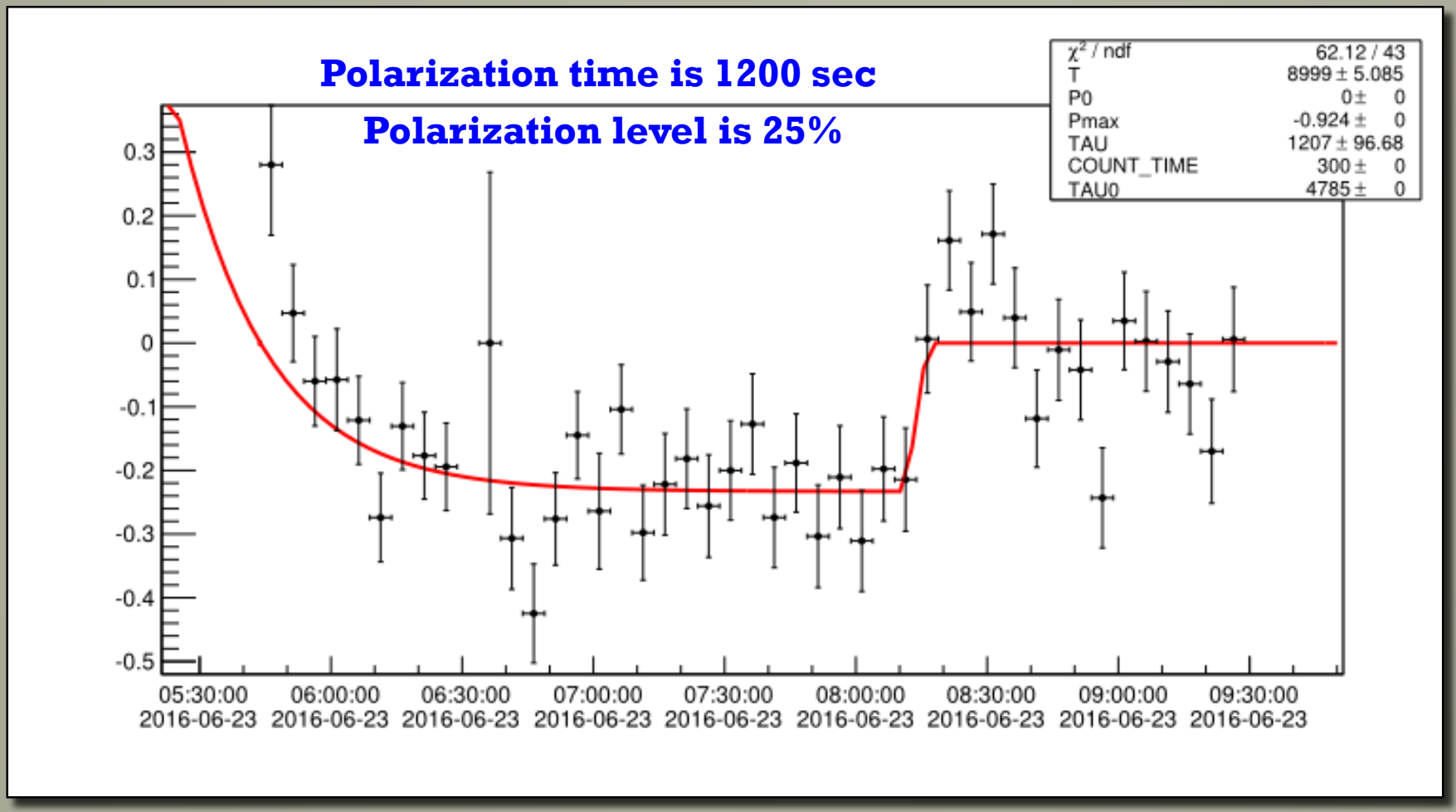
- **Accuracy ~ $5 \cdot 10^{-5}$**
- **Measurement time ~ 10 min**
- **Beam energy spread ~10%**
- **During statistics acquisition**
- **E < 3.5 GeV**

beam energy calibration laser polarimeter

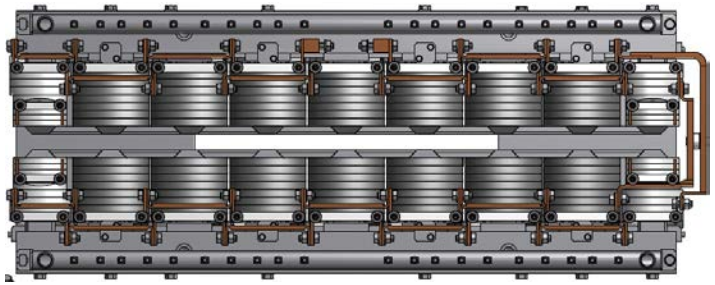
$$A = \frac{N_{up} - N_{down}}{N_{up} + N_{down}} \approx -\frac{3}{4}\frac{\omega_0 E}{m_e^2} VP$$

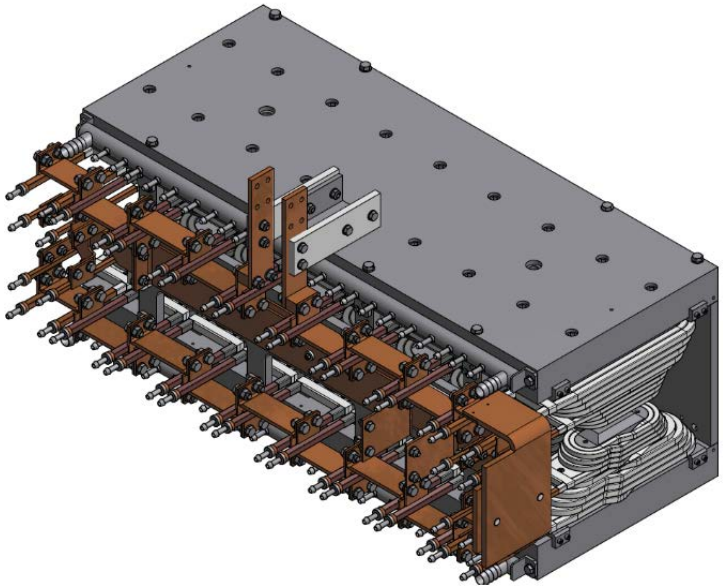


laser polarimeter first experimental data

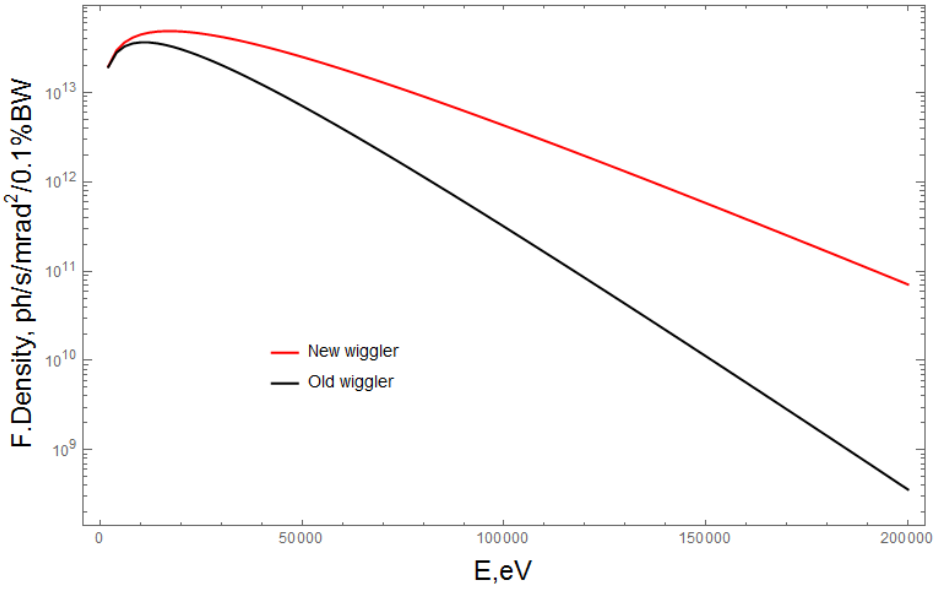


20 kGs wiggler @ VEPP-4M

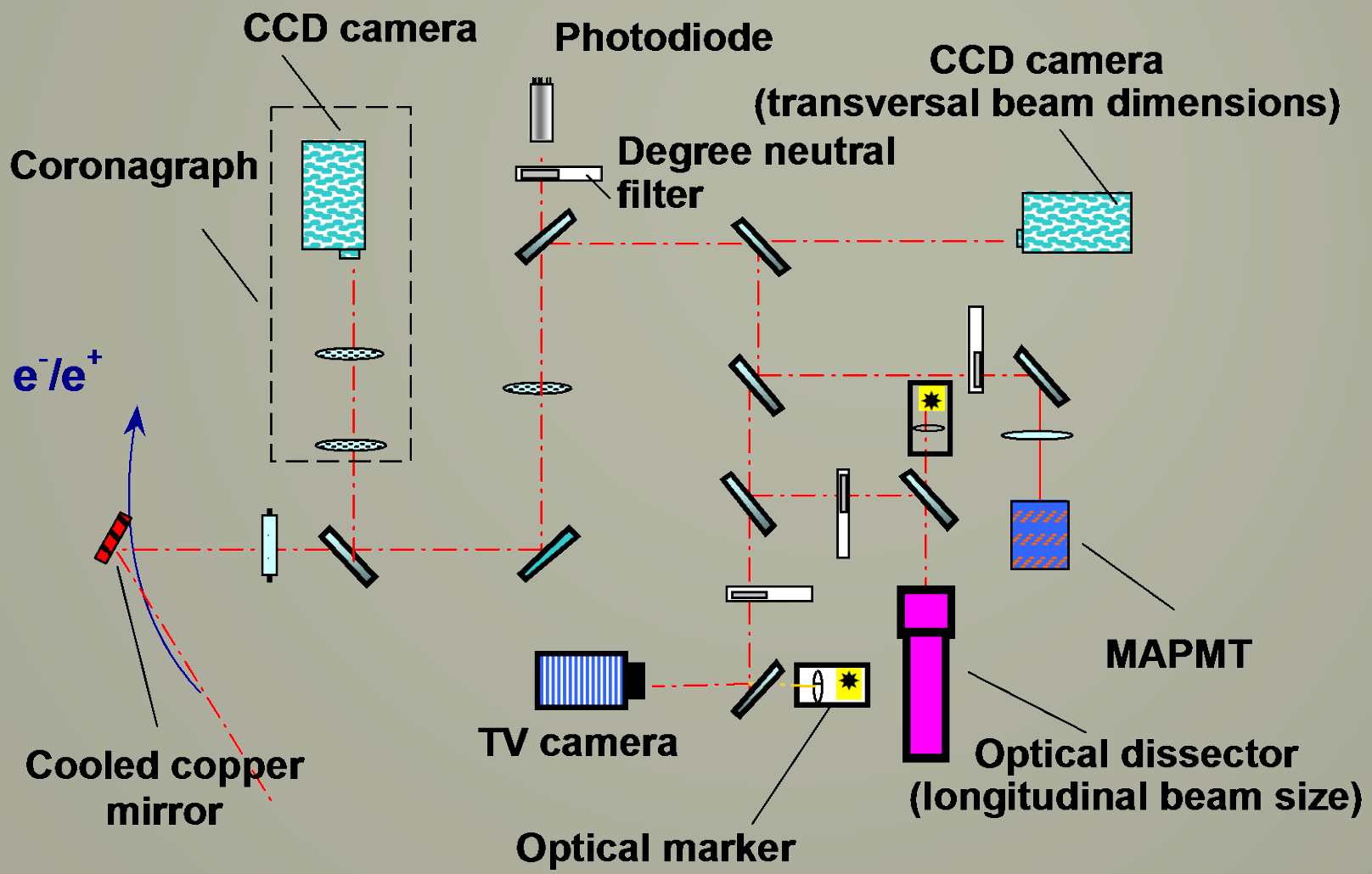




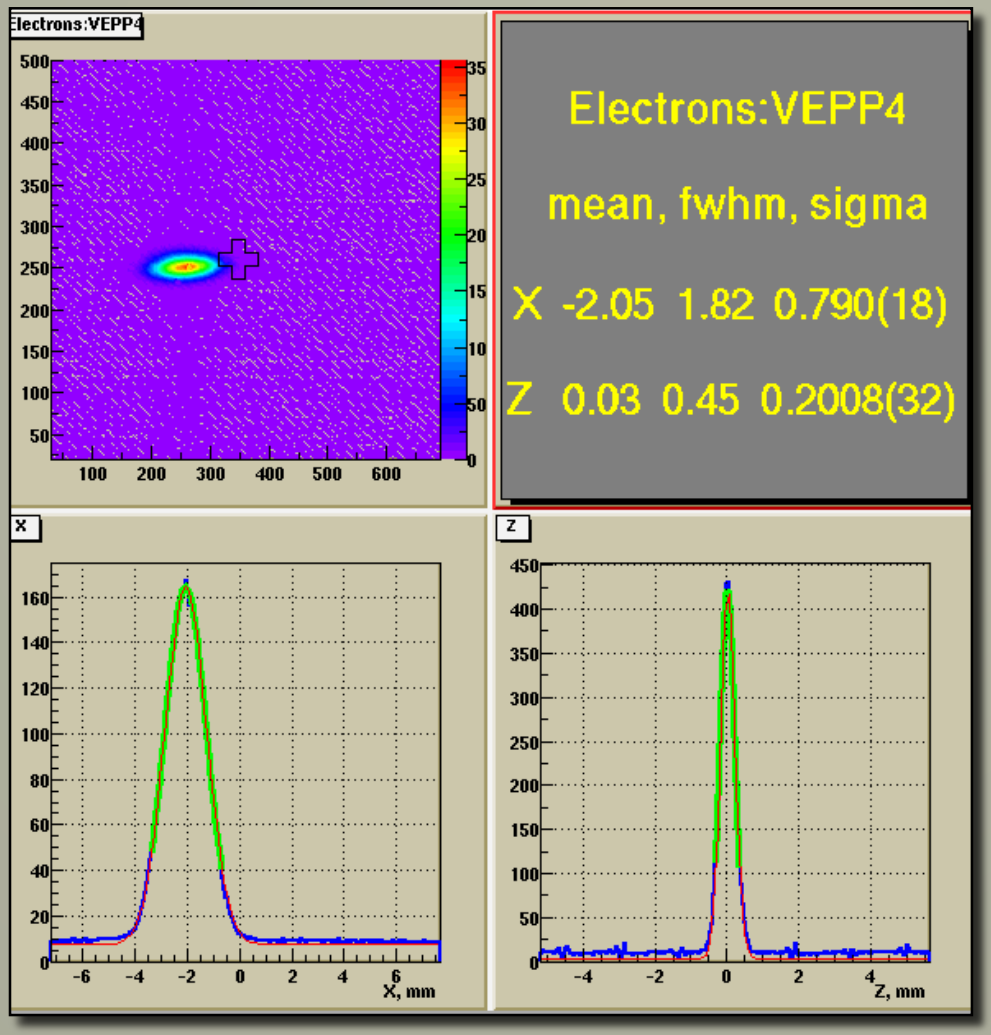
	Old	New	Unit
Field	13	20	kGs
Period	40	28	cm
Number of poles	5+2	7+2	
Gap	4	3	cm



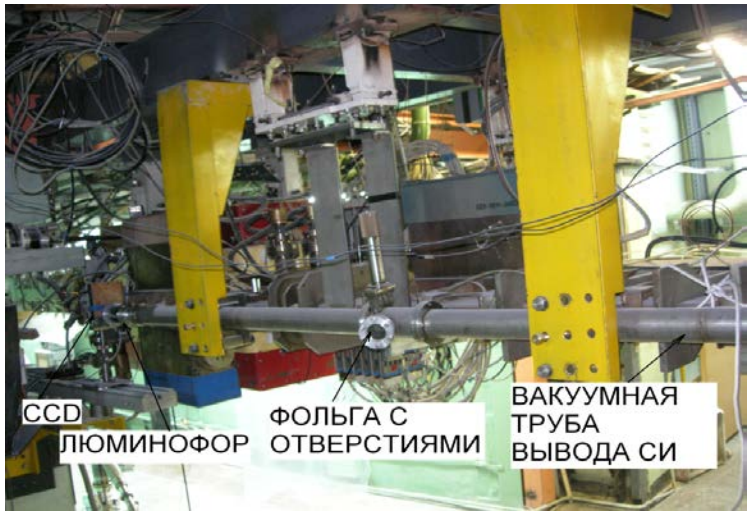
optical diagnostics

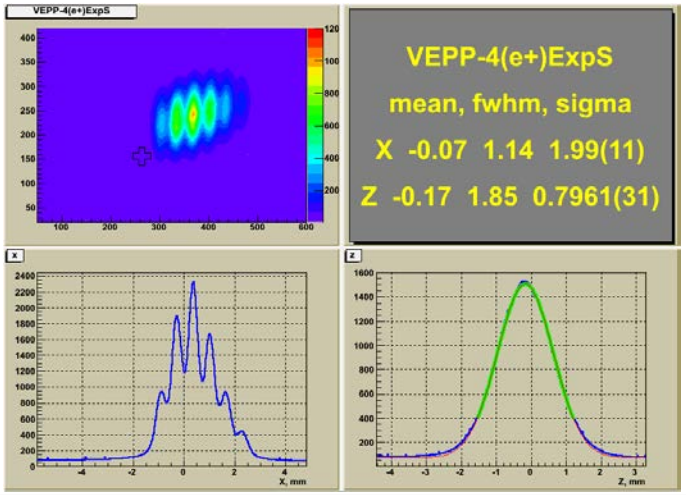


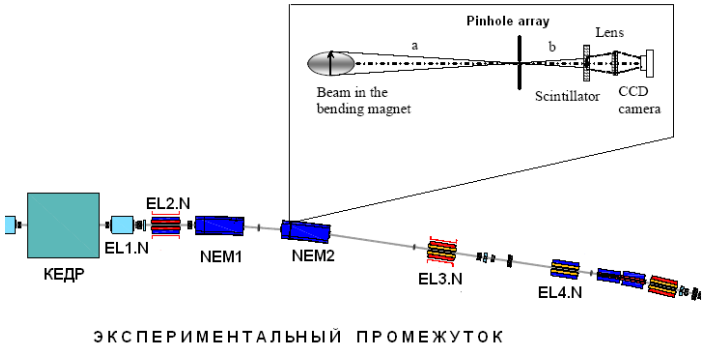
CCD-camera

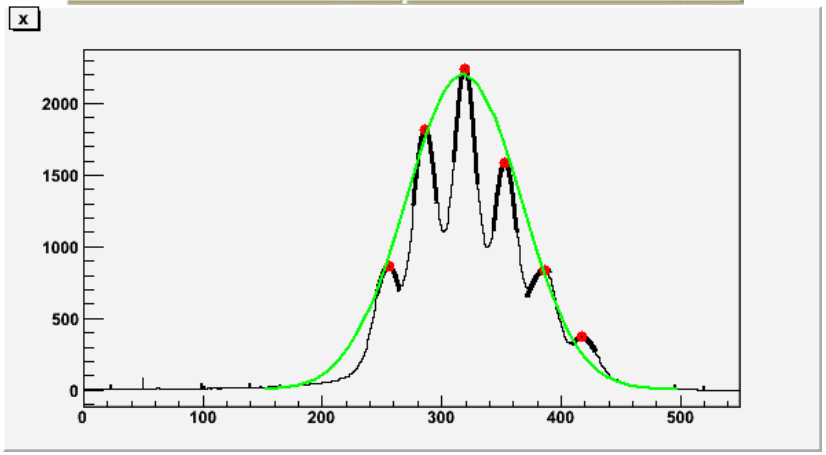

Electrons:VEPP4
Electrons:VEPP4
mean, fwhm, sigma
X -2.05 1.82 0.790(18)
Z 0.03 0.45 0.2008(32)
X
X, mm
Z
Z, mm

multi-pinhole camera



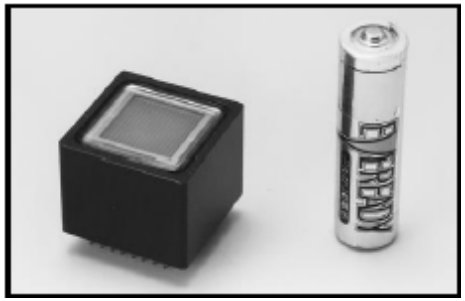


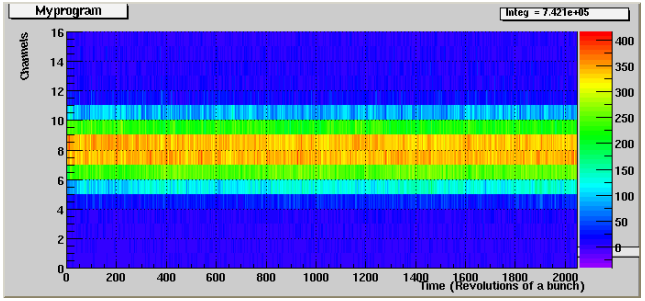


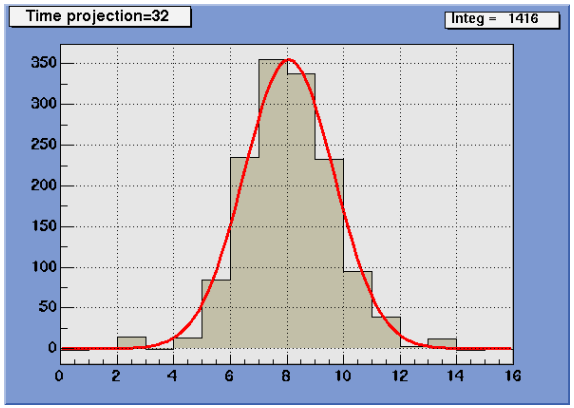


Multy-anode Photo Multiplier Tube (MAPMT)

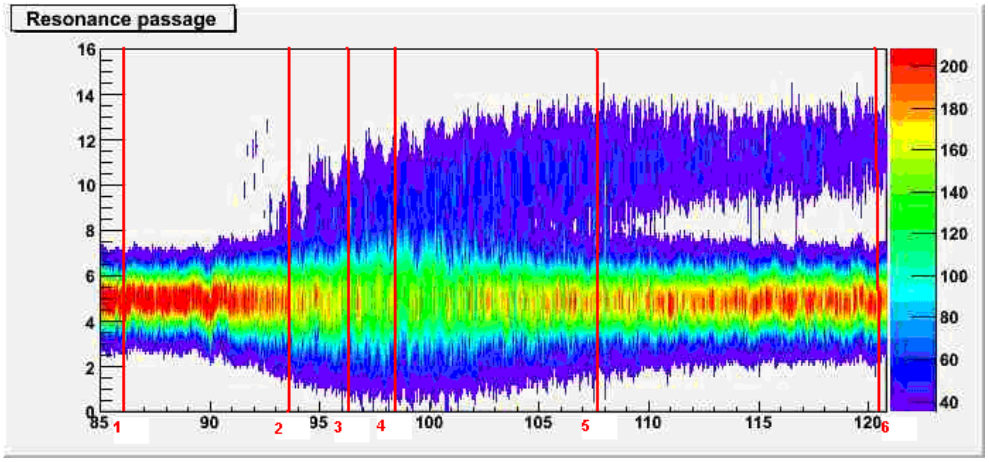
Behavior of transversal cross-section of the beam during a time (stable beam)

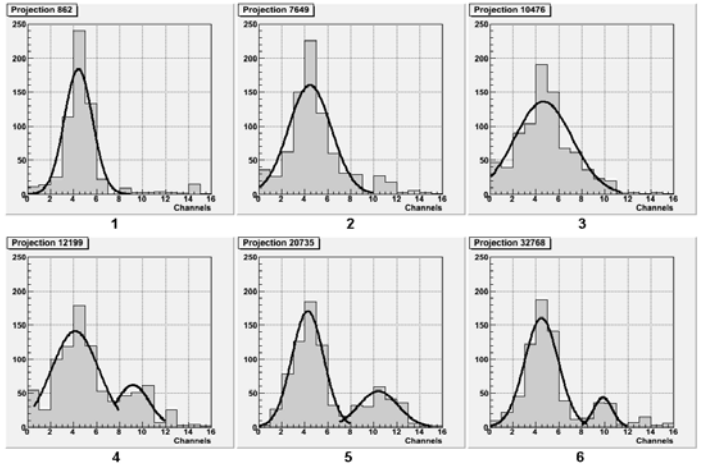






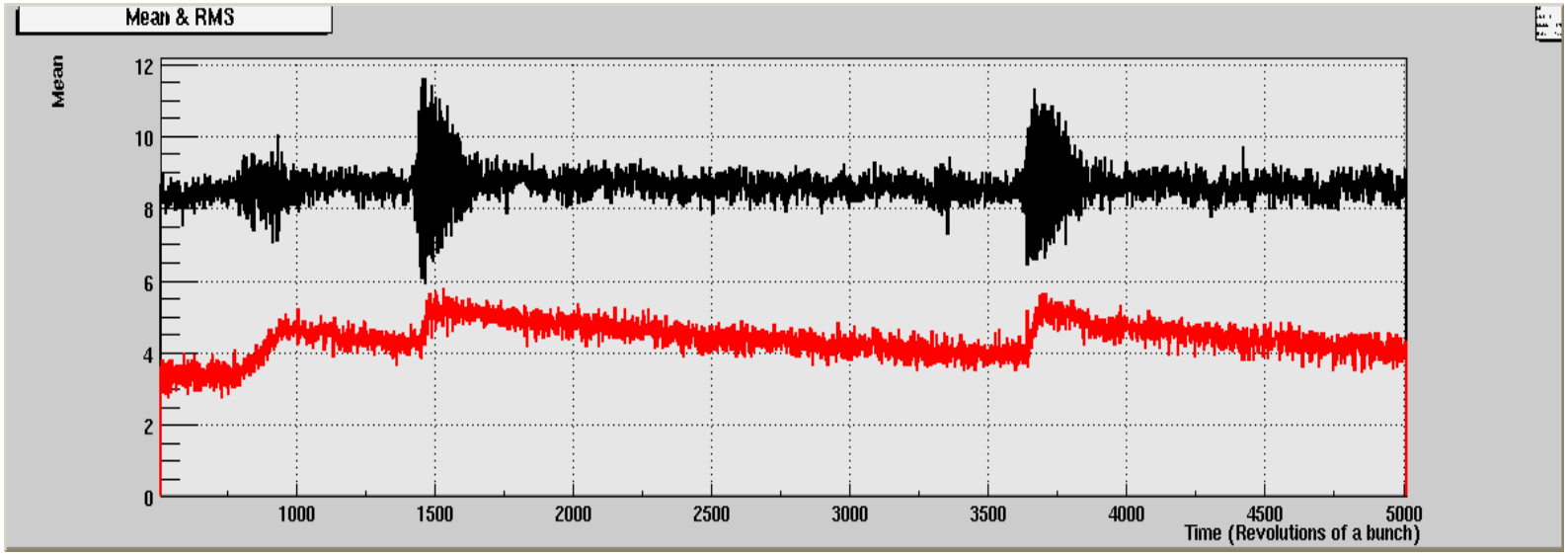
Transversal distribution of particles during crossing of betatron resonance 3Qz





Multi-anode PMT studies of beam instabilities

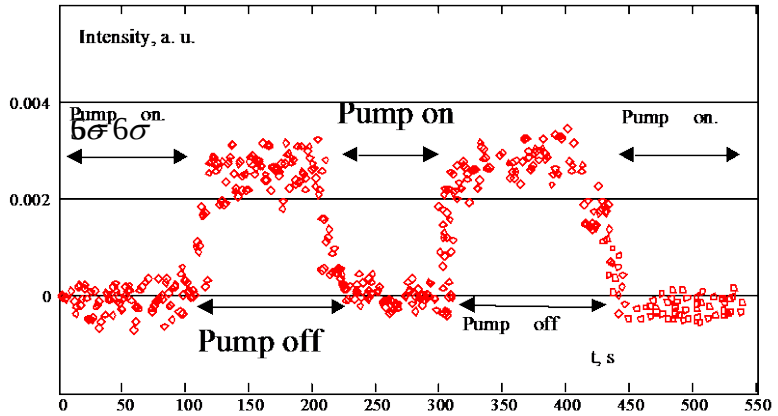
Ie+ = 3.5 mA, Ie- = 3.3 mA; E = 1870 MeV



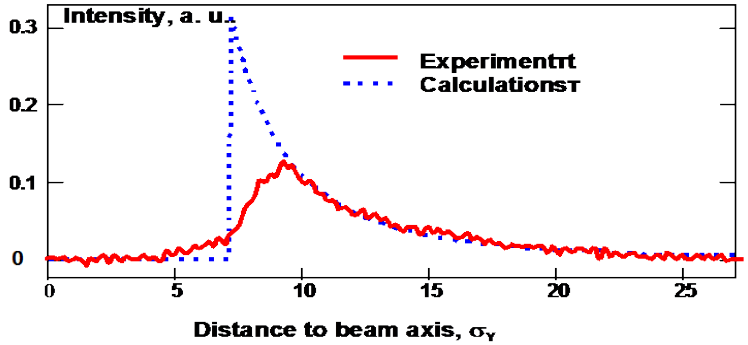
Behavior of electron beam center of mass (black curve) and vertical size (red curve) during electron and positron beams convergence at the interaction point. The dipole oscillations as well increase od vertical beam size are clearly seen.

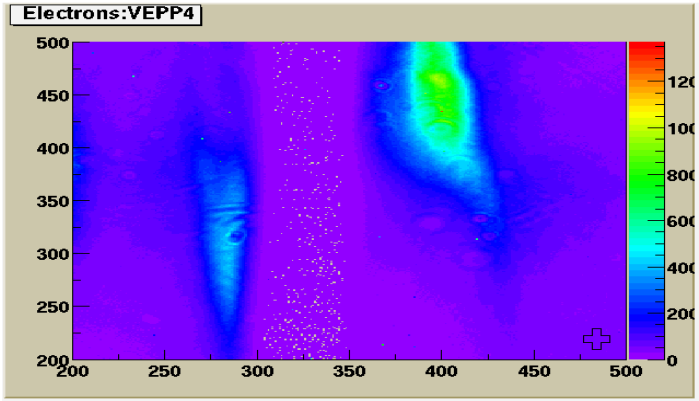
coronagraph study of beam tails

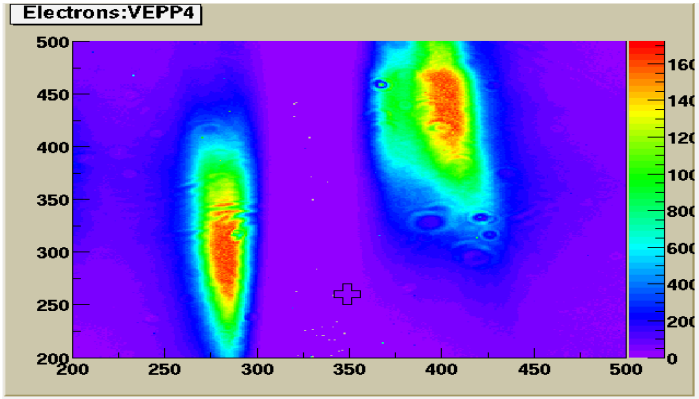
Integral "tails" density during driven variation of the vacuum.



Comparison of measured and calculated "tails" distribution



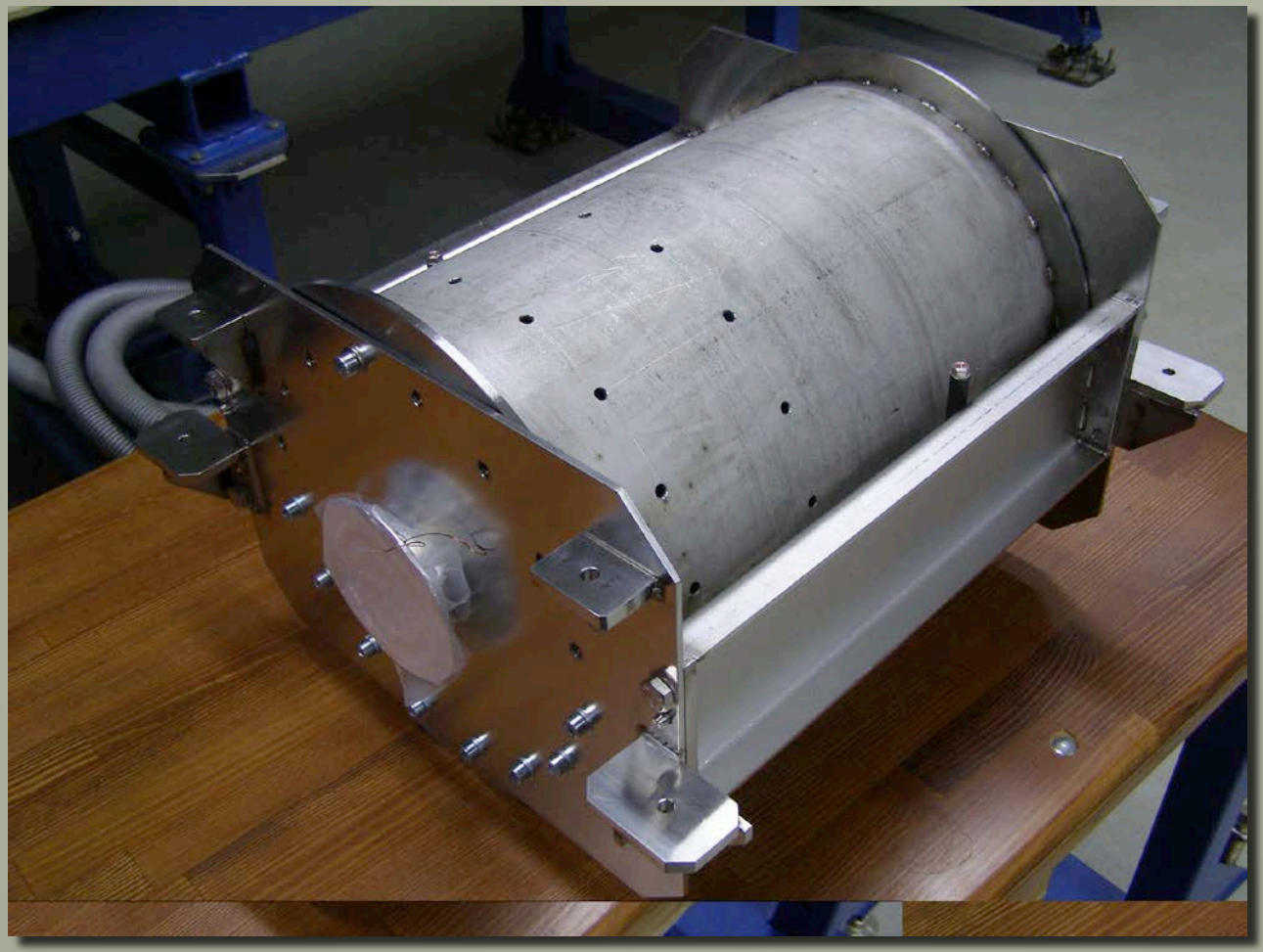




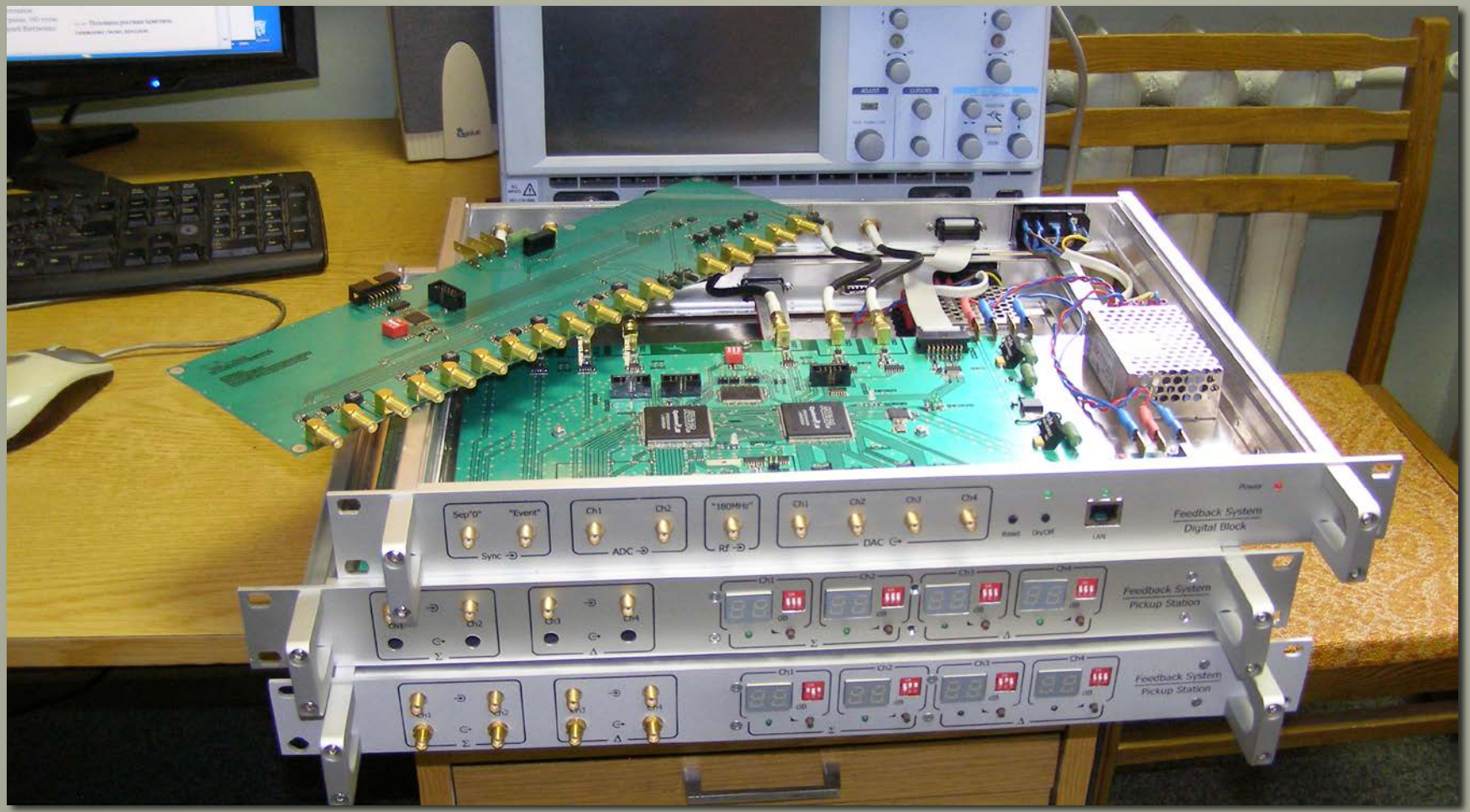
"Tails" appearance after convergence of the beams at the interaction point

new e^+e^- injector

VEPP-3 longitudinal feedback



VEPP-4M transverse feedback

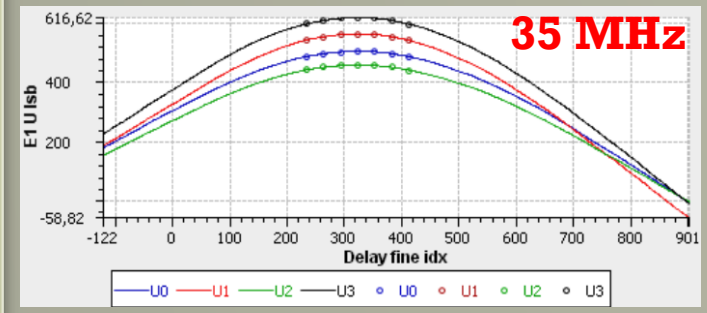


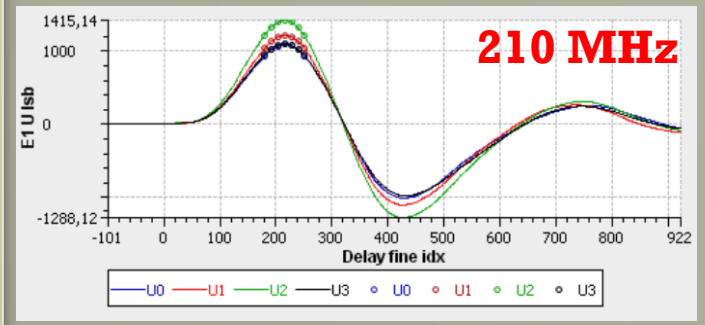
BPM upgrade

54 BPMs @ VEPP-4M

- electron-positron bunches
- injection measurement
- turn-by-turn measurement
- betatron function measurement
- time-back mode

18 BPMs @ VEPP-3

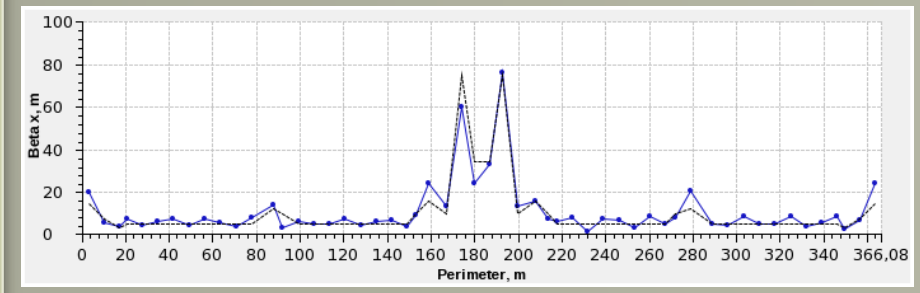


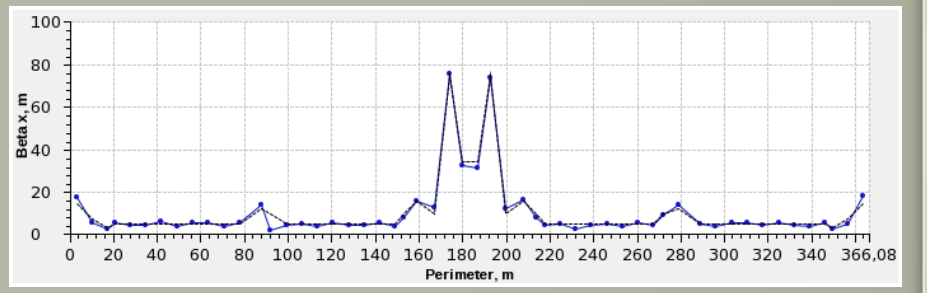


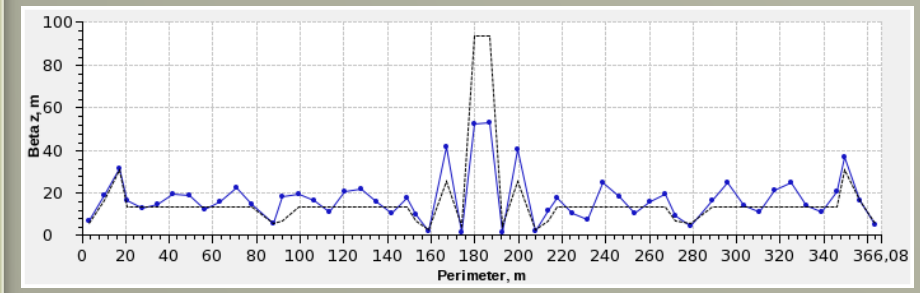
betatron function correction

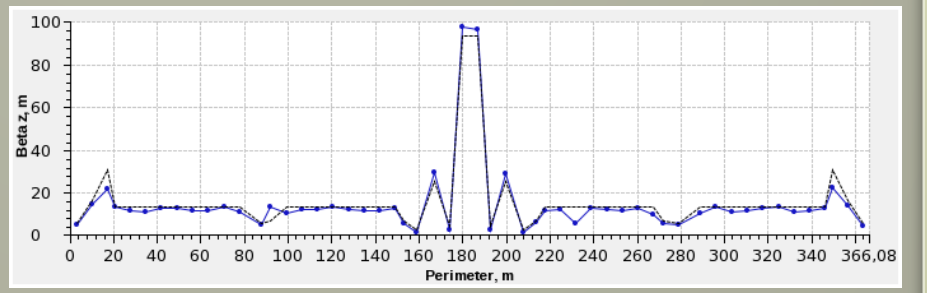
Measurement ~ 1 sec

One correction iteration ~ 1 min









thank you

for attention