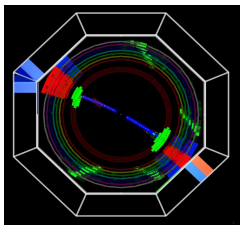
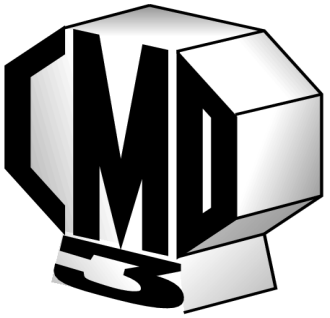




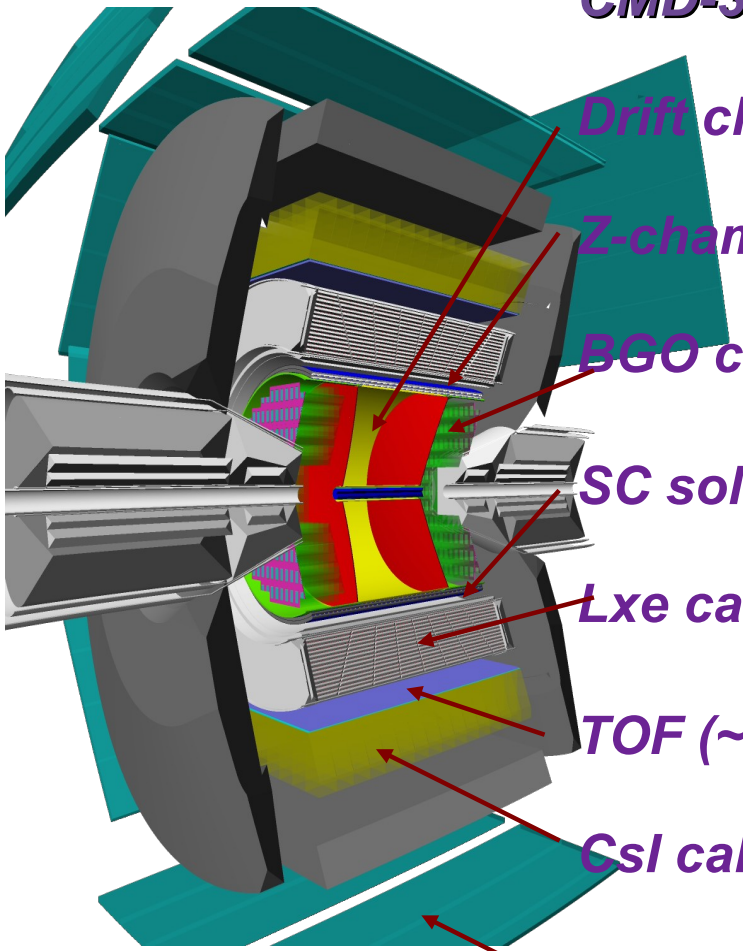


Luminosity measurement with the CMD-3 detector at the VEPP-2000 e+e- collider

Artem Ryzhenenkov

CMD-3 Collaboration
BINP, Novosibirsk

VEPP-2000 and CMD-3



CMD-3

Drift chamber

Z-chamber

BGO calorimeter(13X_0)

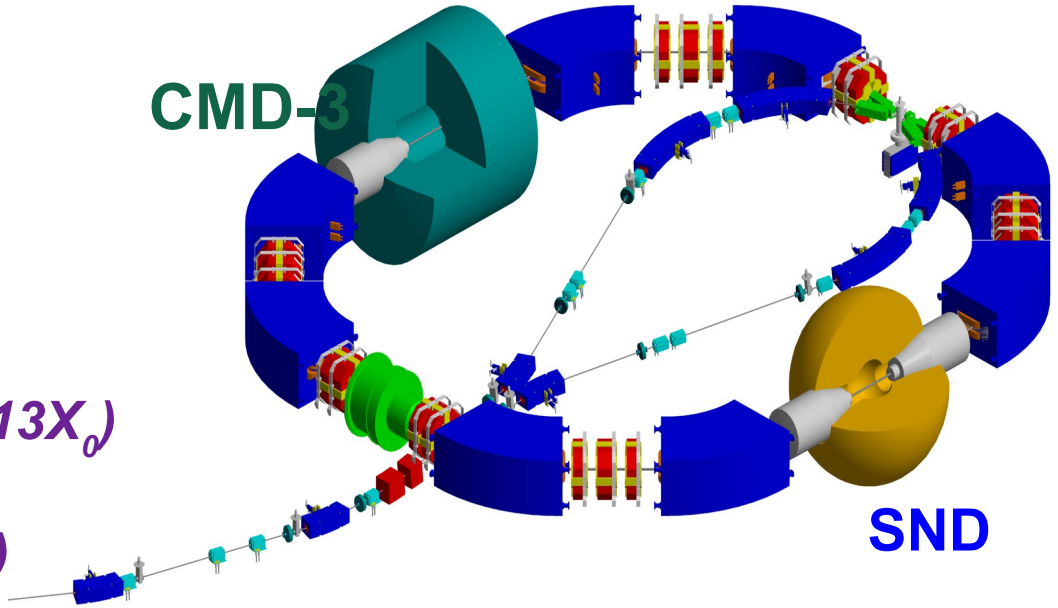
SC solenoid (1.3T)

Lxe calorimeter(5.4X_0)

TOF (~1ns)

CsI calorimeter (8.1X_0)

Muon system



VEPP-2000

Collision time –82ns
Beam current – 200 мА
Beam energy dispersion – 0.7 MeV
Project luminosity:
$L = 10^{32}$ см$^{-2}$с$^{-1}$ at 2.0 GeV
$L = 10^{31}$ см$^{-2}$с$^{-1}$ at 1 GeV

Luminosity

Percise luminosity measurement is a key part for many experiments which study the hardrinic cross sections on e+e- colliders.

One of the physical aim of VEPP-2000 Collider is the measurement of total cross section e+e- → hardrons.

Integrated luminosity is deternined by using of two QED processes:

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

$e^+e^- \to \gamma\gamma$

$$\int L\,dt = \frac{N}{\sigma_{vis}\,\varepsilon}$$

N — number of registered events

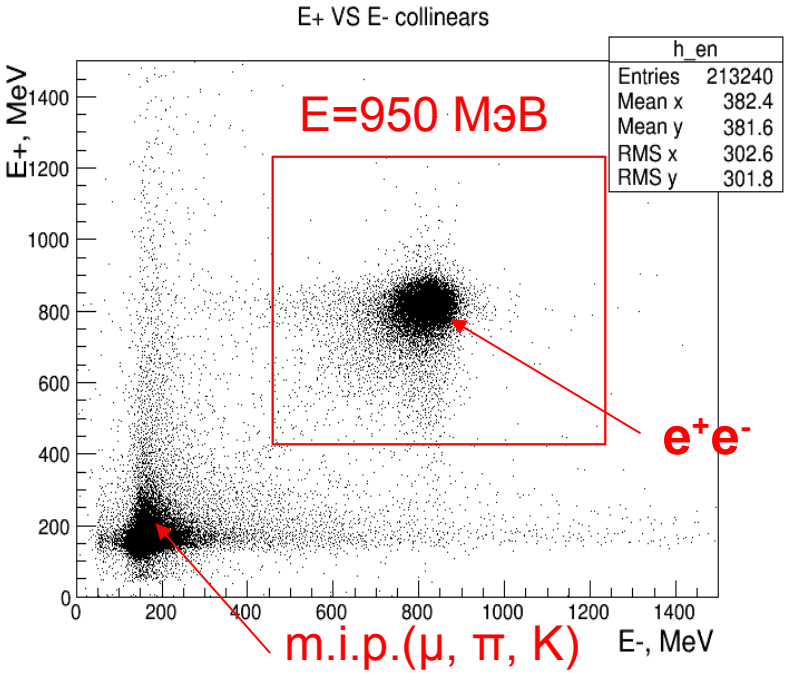
σ — visible cross section

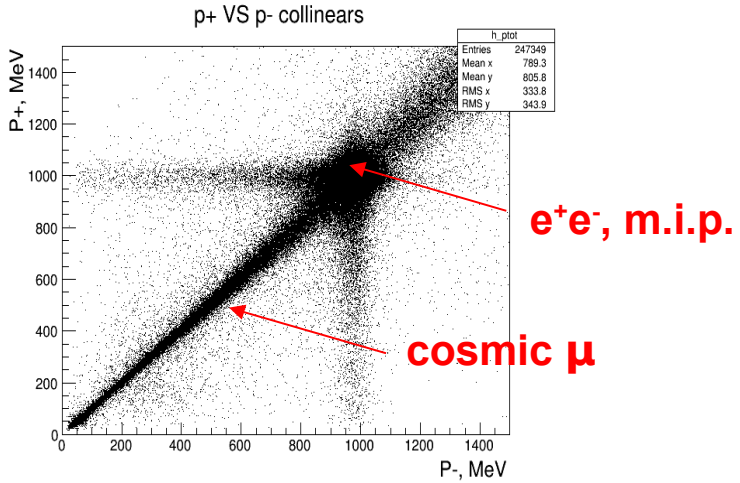
ε — efficiency of registration, selection and event reconstruction

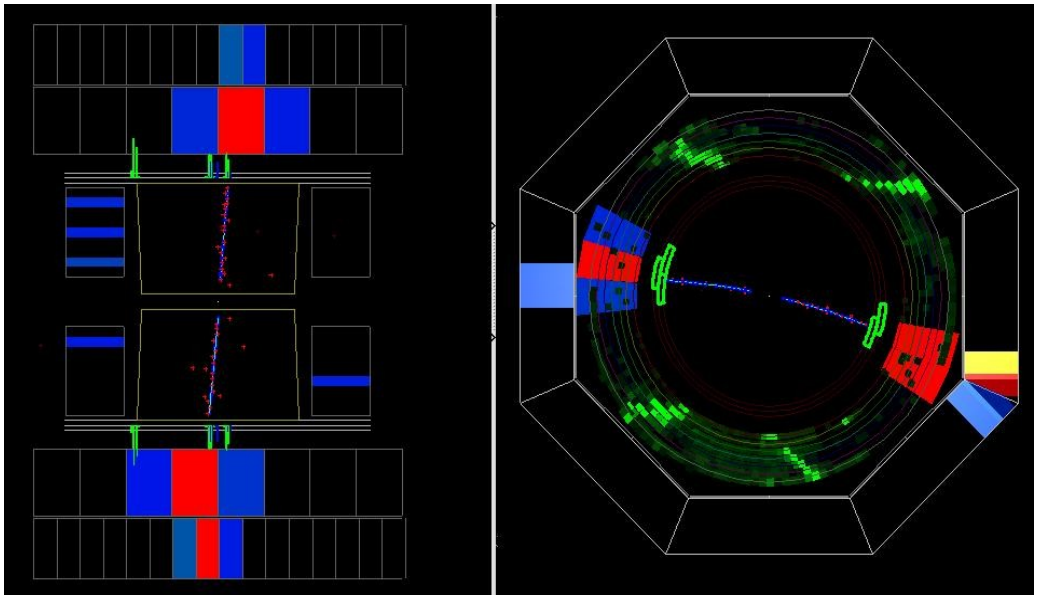
Events selection

$e^+e^- \rightarrow e^+e^-$

- 2 collinear tracks
- total charge = 0
- $|| \varphi_1-\varphi_0|-\pi | < 0.15$ rad
- $| \theta_1 + \theta_0 -\pi| < 0.25$ rad
- π-1.0rad > $(\theta_0 +(\pi- \theta_1))/2 > 1.0$ rad
- $E_{beam}/2 < \mathbf{P_2,P_1}$
- $E_{beam}/2 < \mathbf{E_2,E_1} < 3*E_{beam}/2$



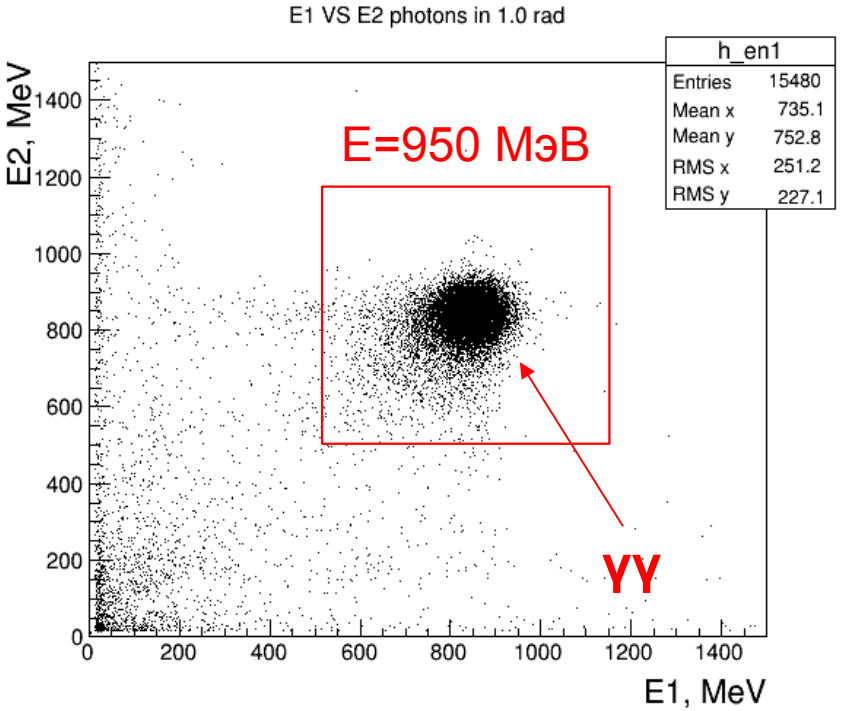


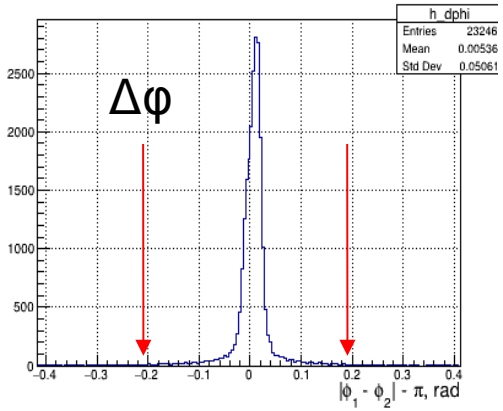


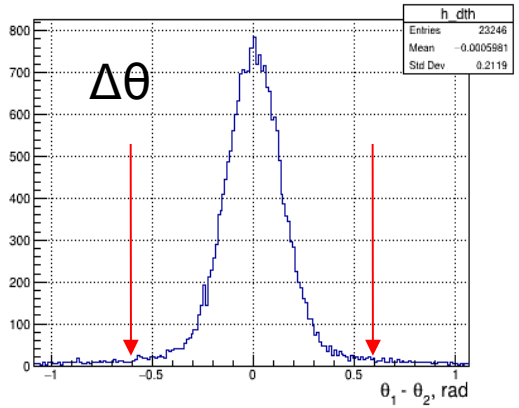
Events selection

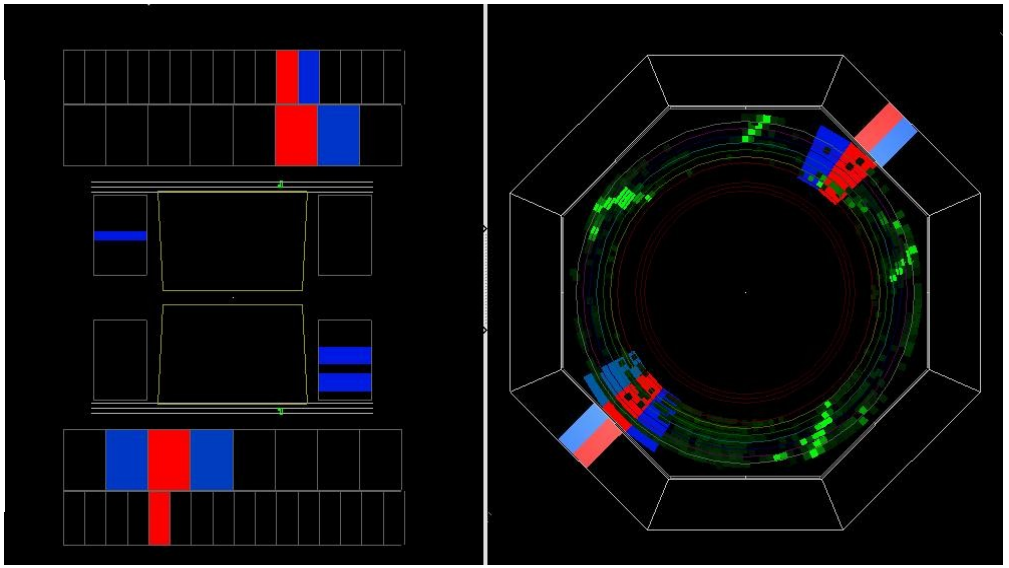
$e^+e^- \rightarrow \gamma\gamma$

- No central tracks in the chamber
- 2 collinear clusters in Ecal
- $|| \varphi_1-\varphi_0|- \pi | < 0.2$ rad
- $| \theta_1 + \theta_0 -\pi| < 0.6$ rad
- $\pi-1.0$ rad $> (\theta_0+(\pi-\theta_1))/2 > 1.0$ rad
- $E_{beam}/2 < E_2,E_1 < 3*E_{beam}/2$









Efficiency of detection, reconstruction and selection of events

$e^+e^- \to e^+e^-$: $\varepsilon = \varepsilon_{DC}\,\varepsilon_{Tr.}\,(1+\delta_{pipe})\,(1+\delta_{\varphi})(1+\delta_{z})$

$e^+e^- \to \gamma\gamma$: $\varepsilon = \varepsilon_{Lxe}\,\varepsilon_{N.Tr.}\,(1+\delta_{pipe})\,(1+\delta_{\varphi})$

1) ε_{DC} - Two tracks reconstruction efficiency in drift chamber(DC) (~***99.9%***)

2) ε_{Lxe}- Cluster reconstruction efficiency in calorimeter (~99.5%)

3) $\varepsilon_{Tr.}$ - Trigger efficiency (~99.8%)

4) $\varepsilon_{N.Tr.}$ - Nutral trigger efficiency (~99%)

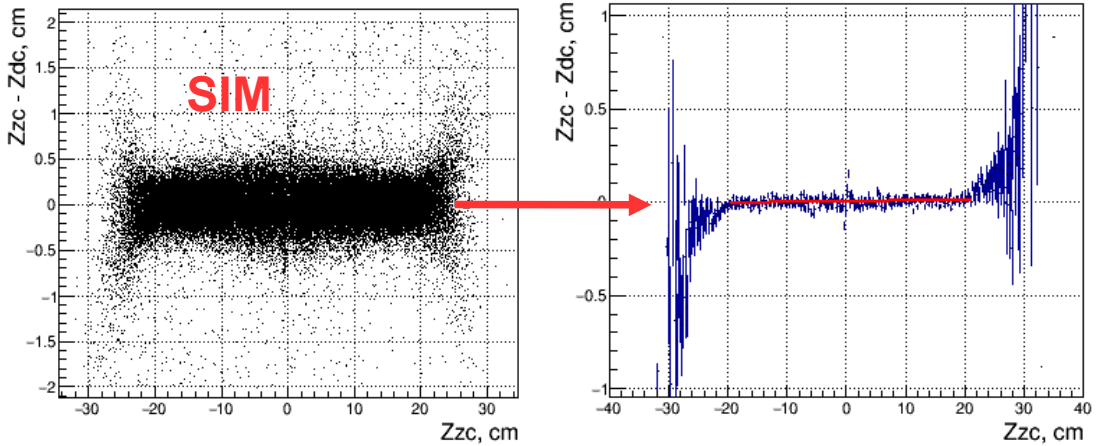
5) δ_{pipe} - Correction related to event loss in the wall of the vacuum chamber(~1.2%)

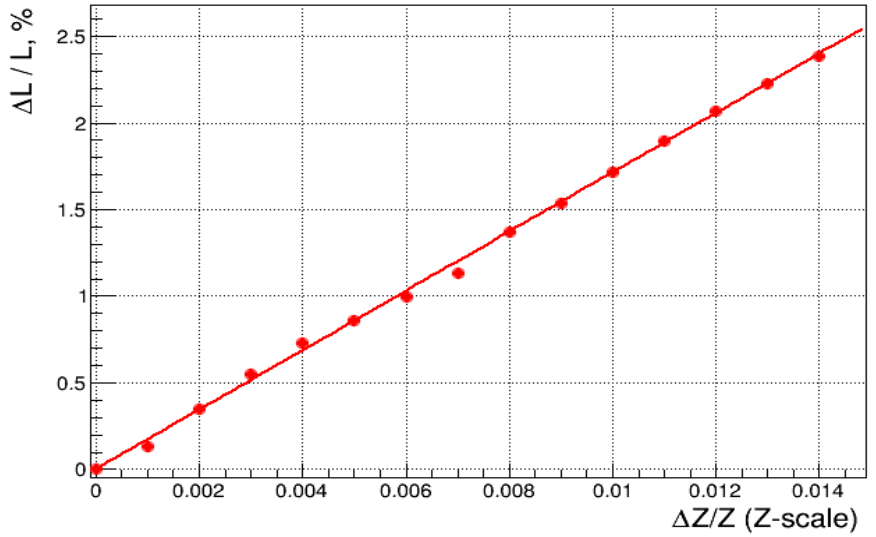
6) δ_{φ} - Correction related to the DC angular resolution (~0.2%)

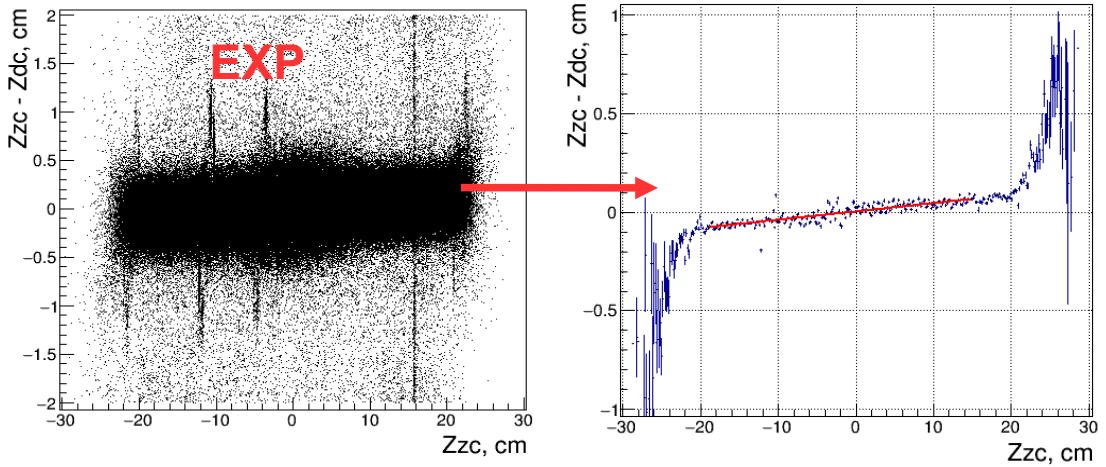
7) δ_{z} – Correction related to the DC z-coordinate calibration (~0.5%)

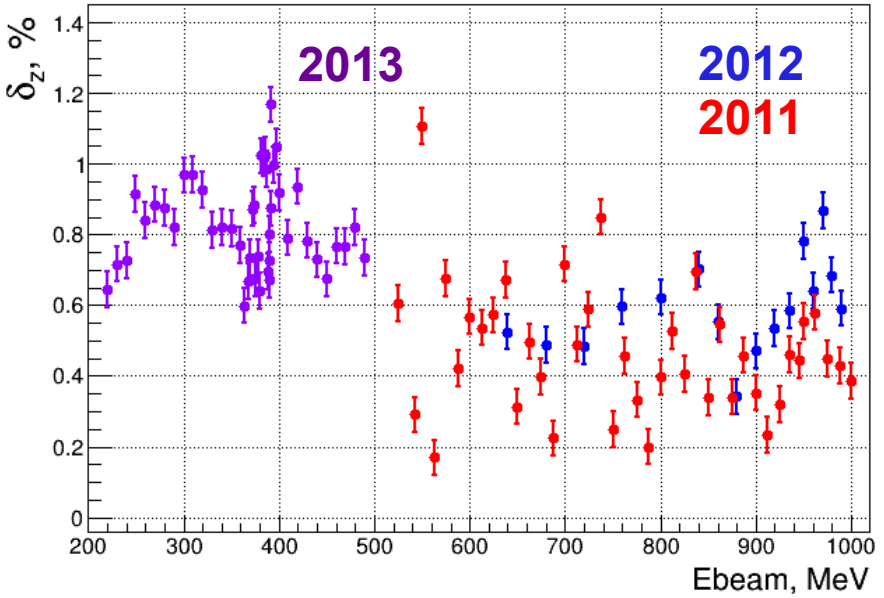
DC Z-coordinate scale

Deviation (**Zzc - Zdc VS Zzc**) is plotted.





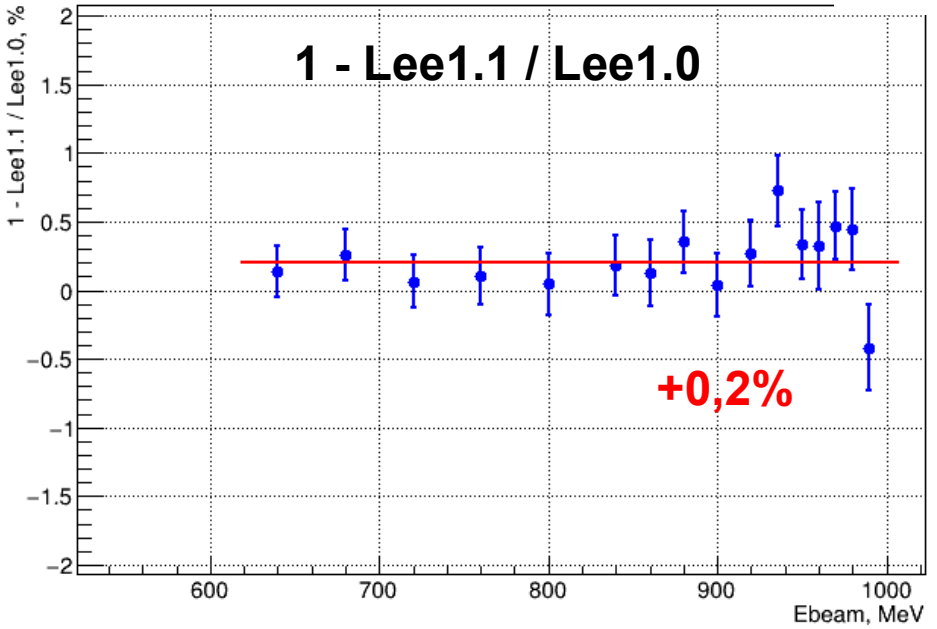


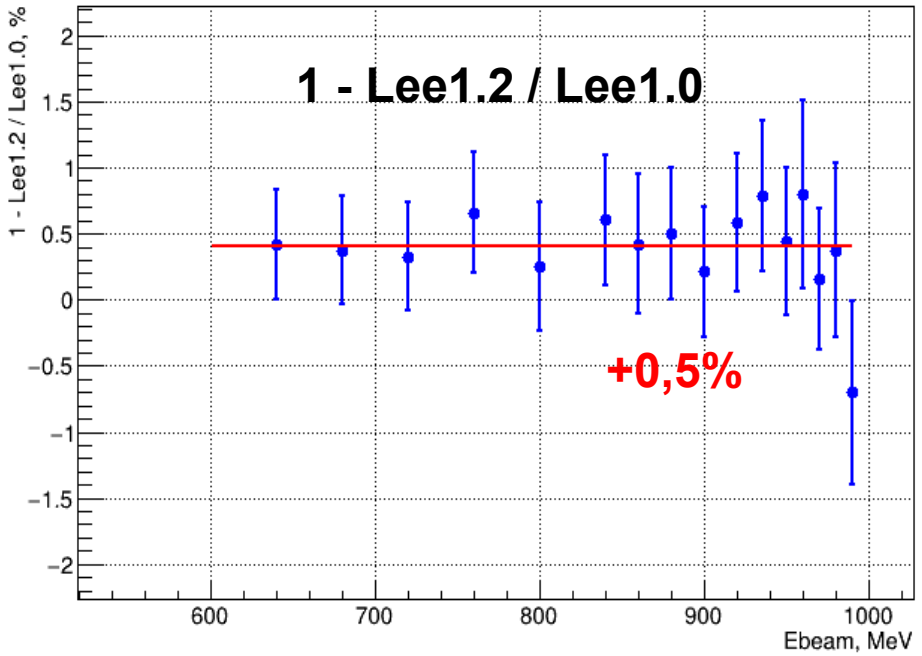


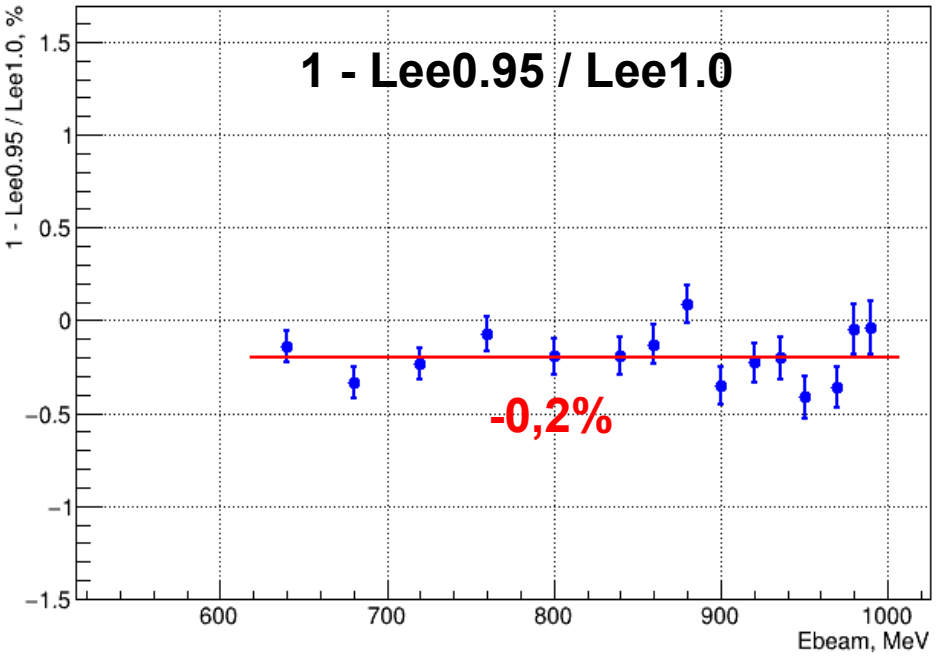
DC theta systematic

Luminosity measurement precision is mainly determined by polar angle systematic.

Ratio of luminosity measured at different polar angles(**0.95, 1.0, 1.1 и 1.2 rad**) is plotted for theta syatematic estimation.







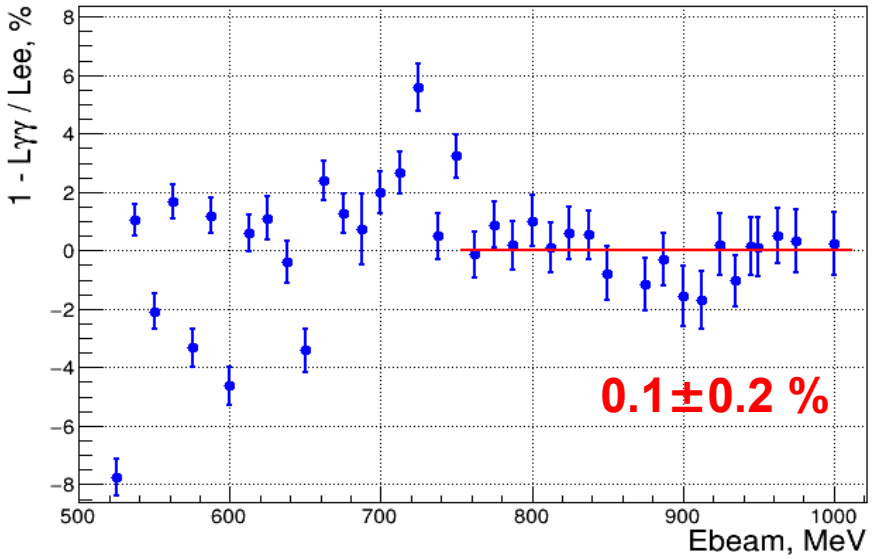
Systematic errors

Source \ run	2011	2012	2013
Rad. corrections	0,2%	0,2%	0,2%
Separation errors	0,2%	0,2%	0,2%
Beam energy	0,8%	0,27%	<0,05%
Vacuum champer	0,2%	0,2%	0,2%
Trg. Efficiency and track reconstruction	<0,1%	<0,1%	<0,1%
Θ distribution	0,5%	0,5%	0,6%
Total (max.)	***1 %***	***0,7%***	***0,7%***

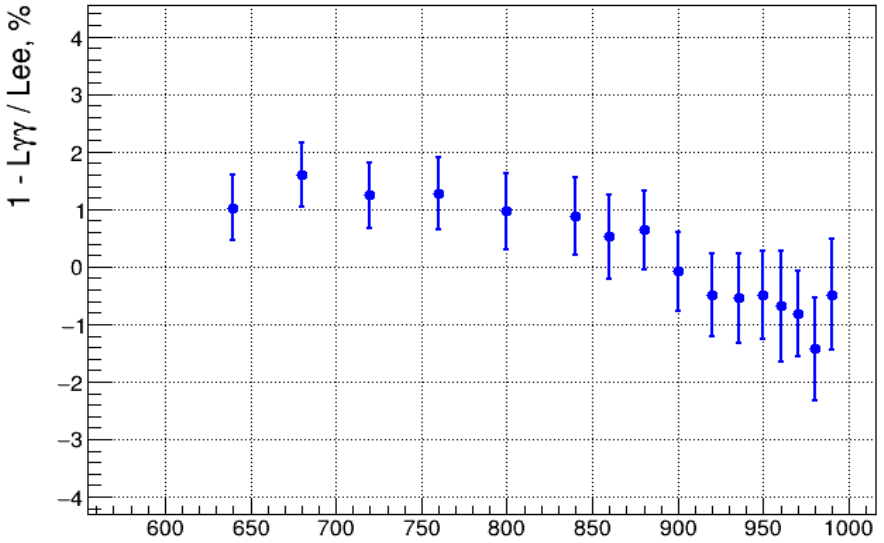
Luminosity ratio

Luminosity ratio calculated by using of e+e- and γγ is shown in the graphs.

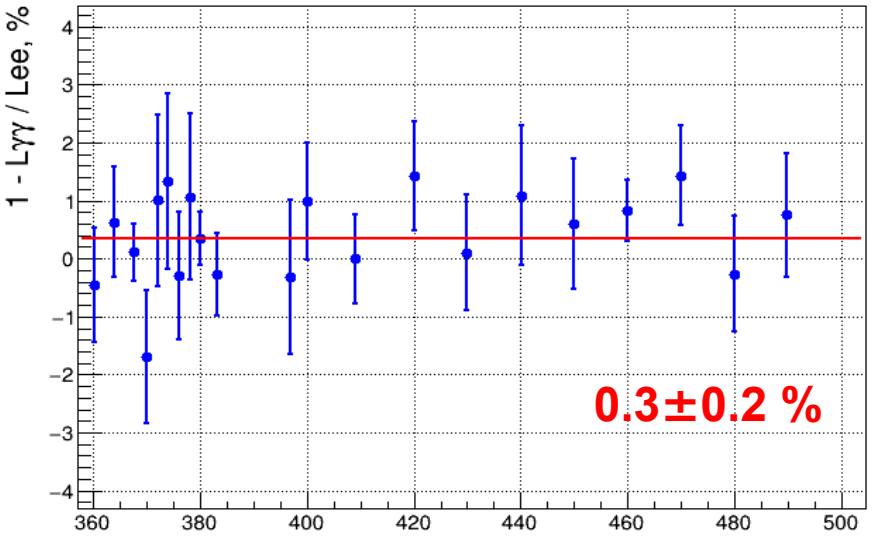
$$1-\frac{L\gamma\gamma}{Le+e-}$$



Scan2011(above φ)



Scan2012 (above φ)



run2013

Conclusion

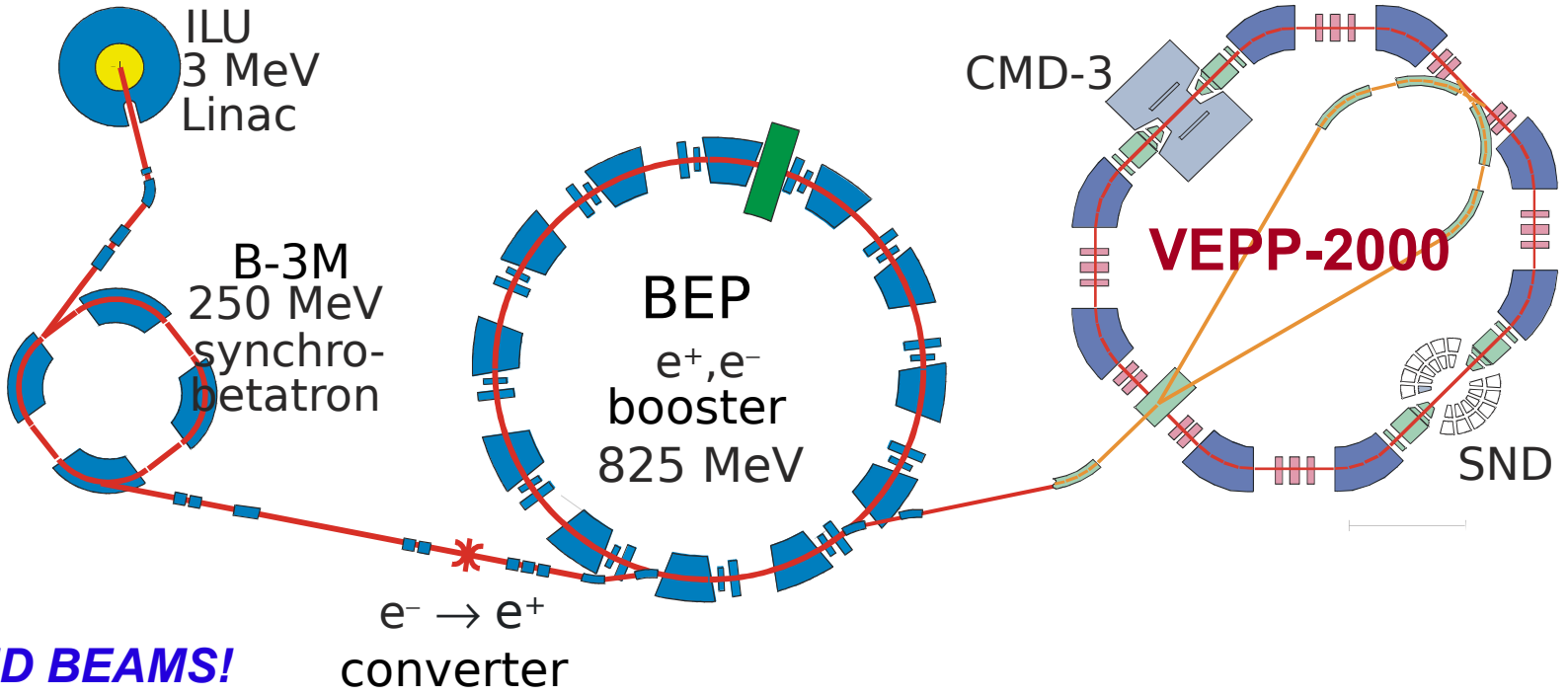
1) Luminosity measurement technique is developed for two processes $e^+e^- \to e^+e^-$ and $\gamma\gamma$.

2) Procedure for monitoring DC calibration is developed (DC Z-scale).

3) Luminosity measurement accuracy at the moment is 1%.

Spare slides

VEPP 2000



ROUND BEAMS!

Collision time – 82 ns

Beam current – 200 мА

Beam energy dispersion – 0.7 MeV

Project luminosity:

$L = 10^{32}$ см$^{-2}$с$^{-1}$ at 2.0 GeV

$L = 10^{31}$ см$^{-2}$с$^{-1}$ at 1 GeV

Collected luminosity

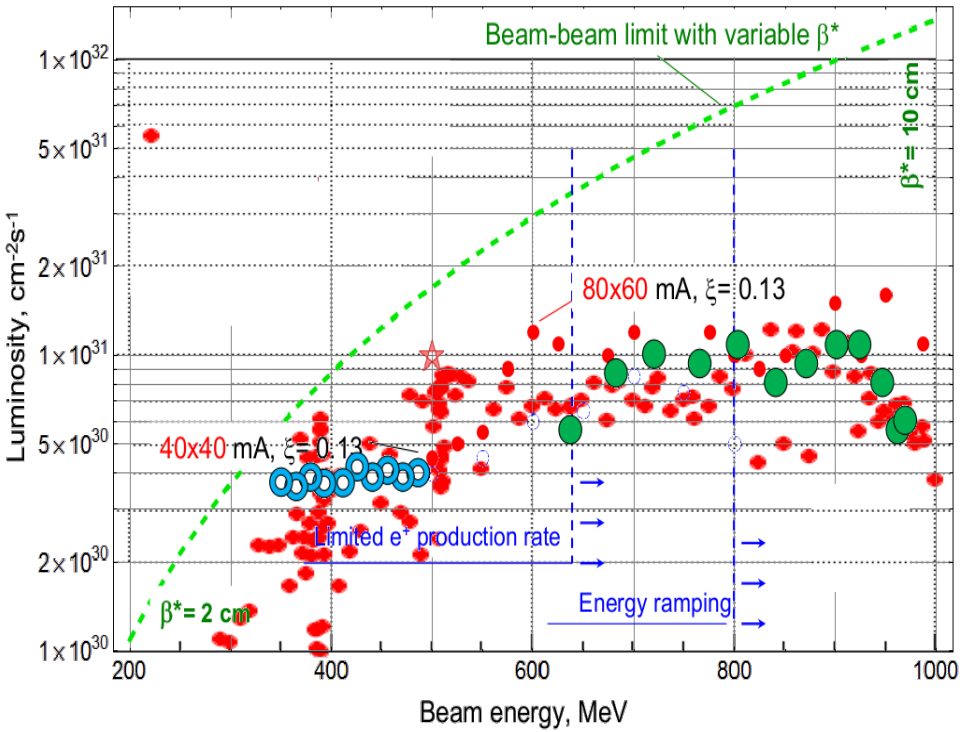
Total collected luminosity for 2011-2013 is ~ ***59 pb^{-1}***

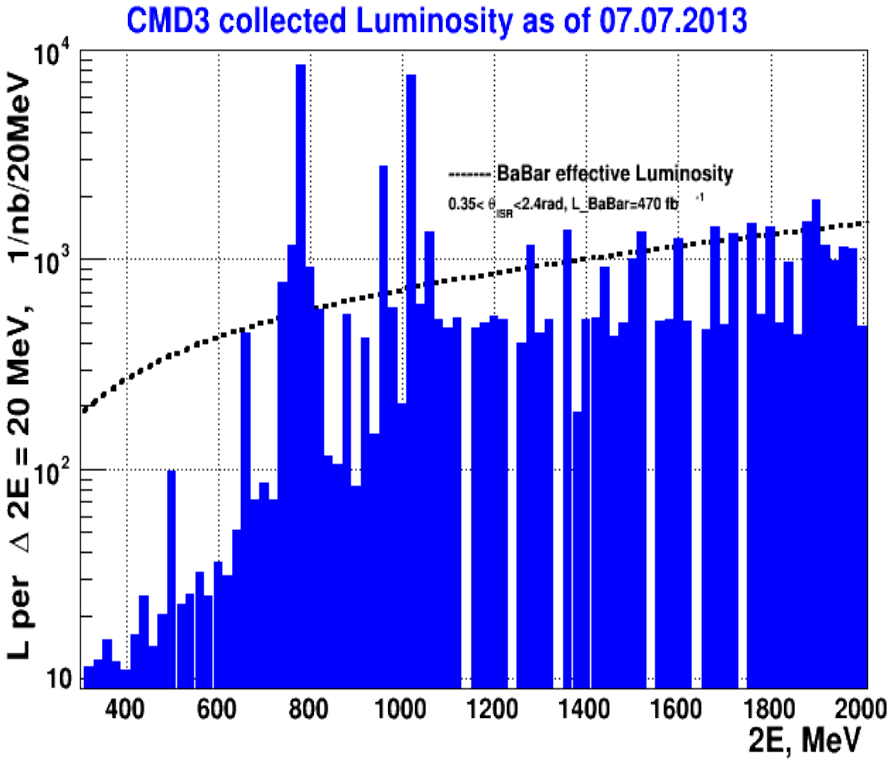
8.3 pb^{-1} — ω-meson region

8.4 pb^{-1} — φ-meson region

35 pb^{-1} — > 1.04 ГэВ

Current systematic error ***~ 1.5 %***

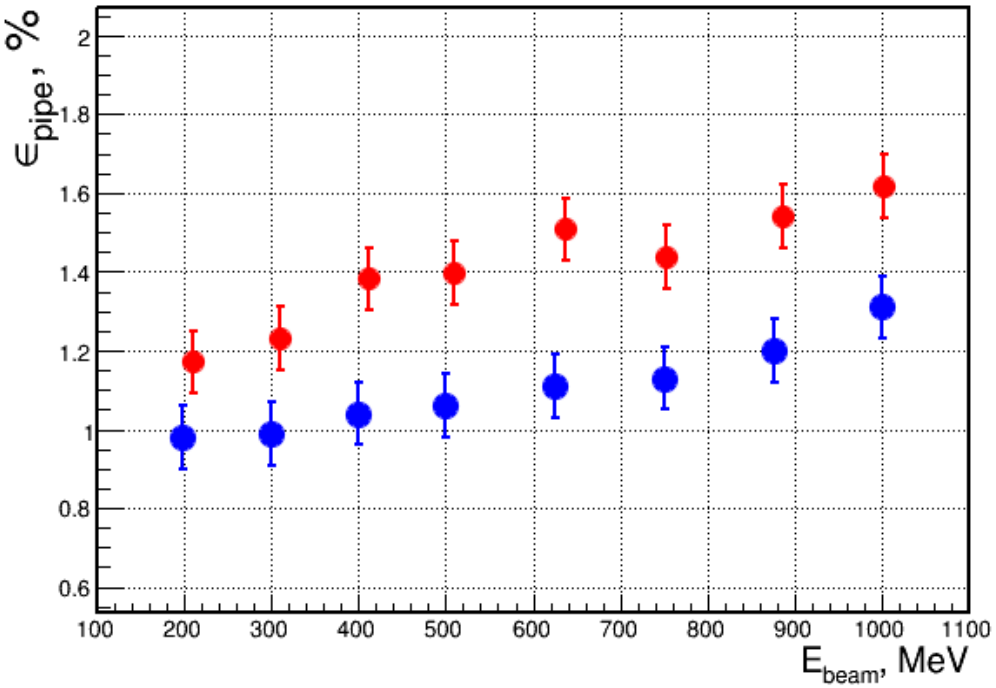




Eevents loss on the vacuum pipe

$$\varepsilon_{pipe} = \frac{N_{pipe}}{N_{total}}$$

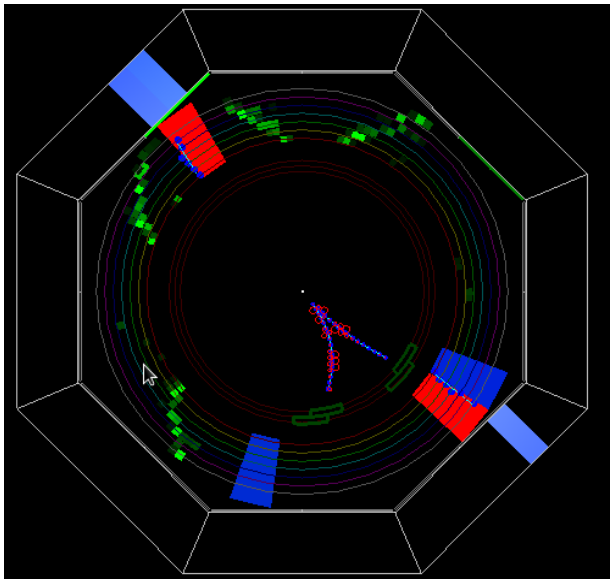
$$N_{real} = \frac{N}{1-\varepsilon_{pipe}}$$



$e^+e^- \rightarrow \gamma\gamma$

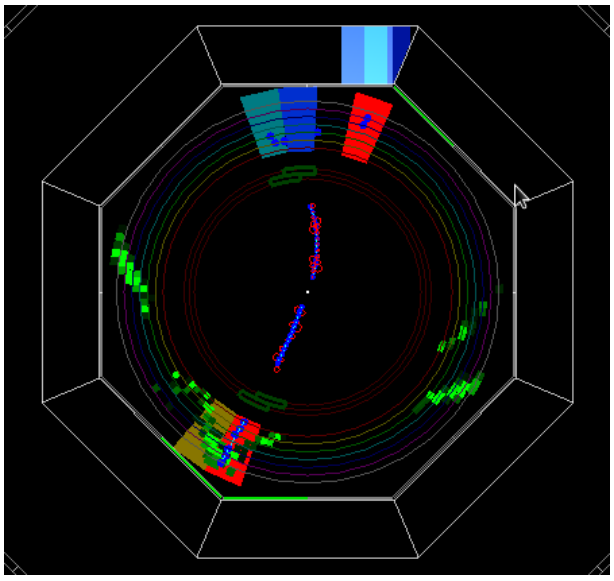
$\gamma \rightarrow e^+e^-$

(1.1-1.6 ±0.3 %)



$e^+e^- \rightarrow e^+e^-\gamma$

(1.0 - 1.2 ±0.3 %)

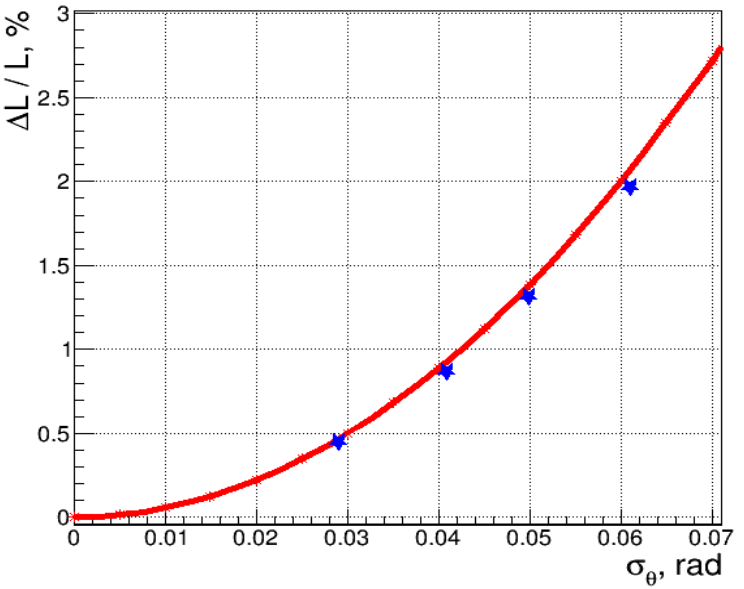


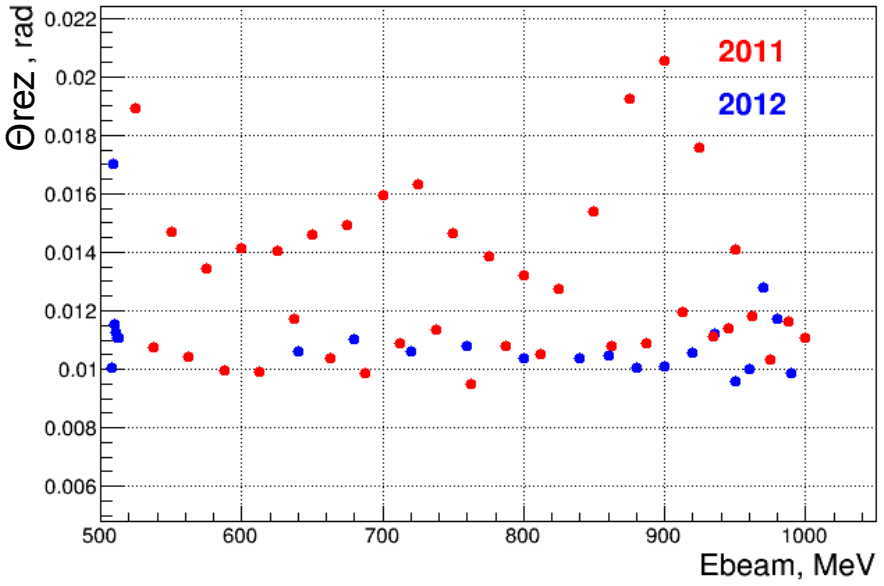
DC angular resolution

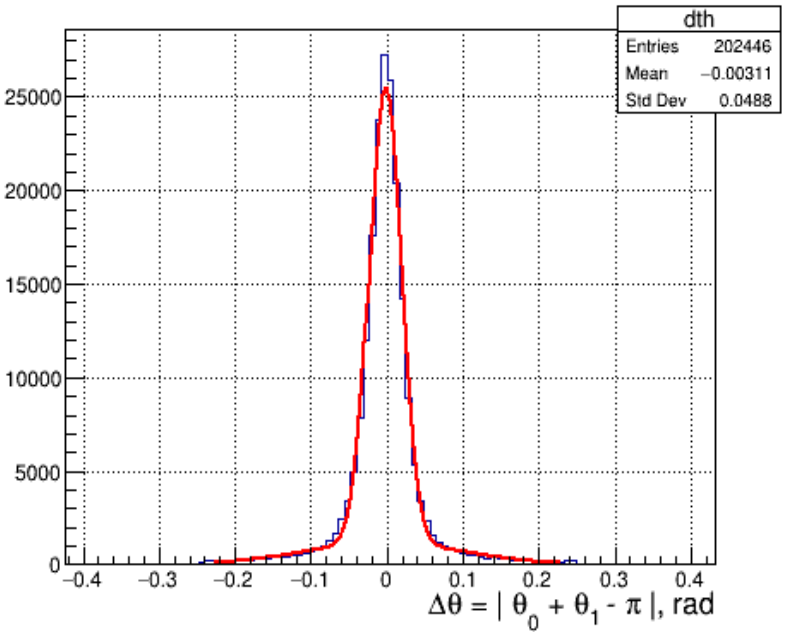
The systematic error due to the DC angular resolution:

$$\frac{\Delta\sigma}{\sigma} = A(\theta)\,\sigma_\theta^2$$

For σ_θ ~ 0,01 rad, correction ~ 0,1%







Two track reconstruction efficiency

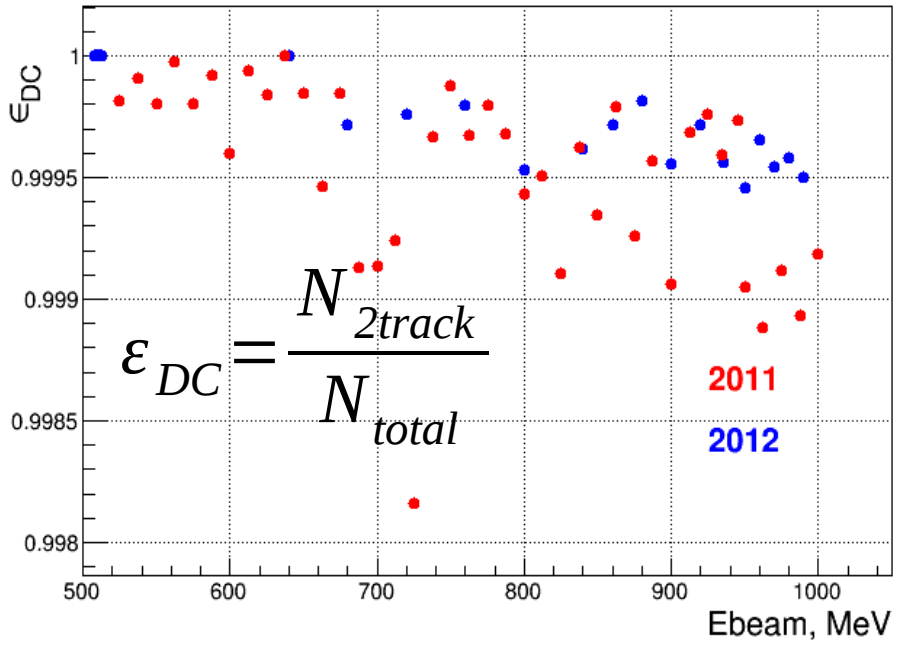
e+e- test events are selected according to the following criteria:

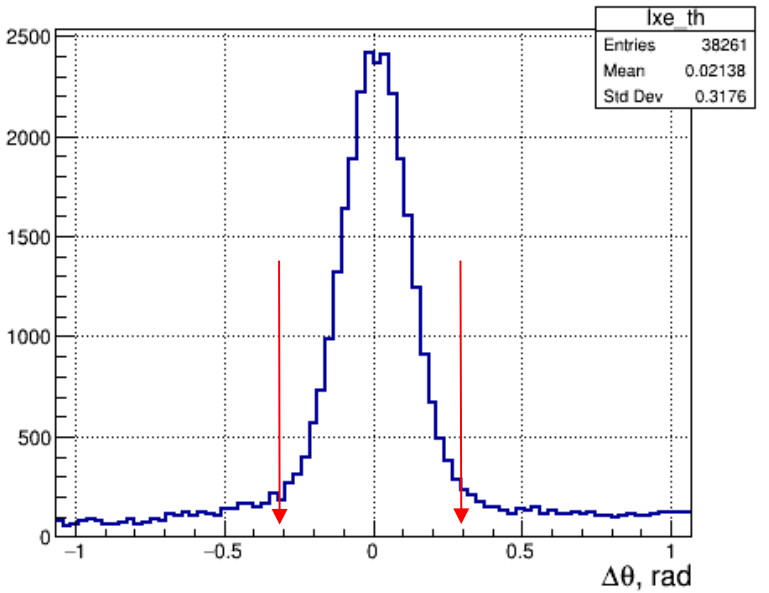
1) $|\theta_{1\,lxe} + \theta_{0\,lxe} - \pi| < 0.3$ rad

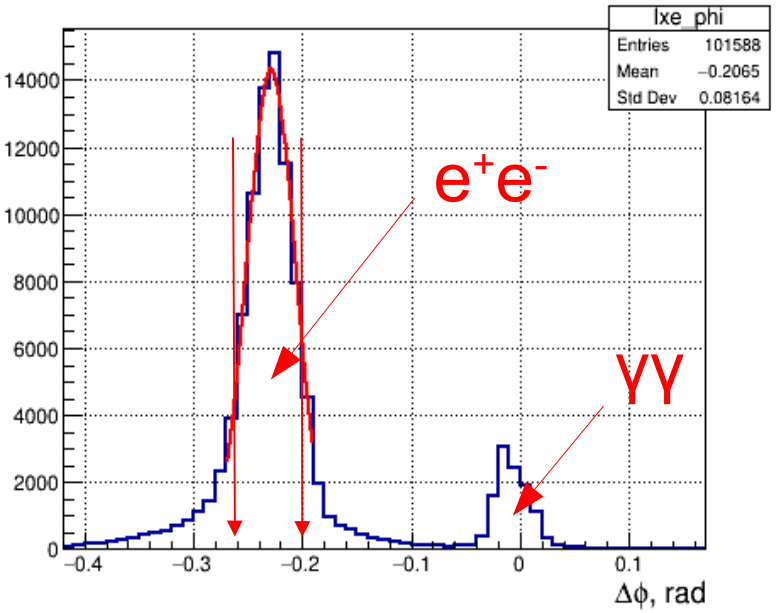
2) $| |\varphi_1 - \varphi_0 - \pi| - \varphi_{rot} | < 0.03$ rad

3) $E_{beam}/2 < E_2, E_1 < 3*E_{beam}/2$

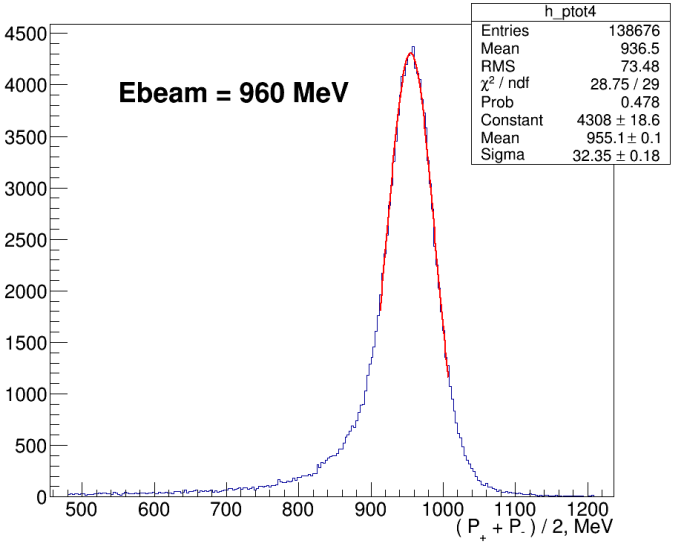
4) $\pi - 1.0$ rad $> (\theta_0 + (\pi - \theta_1))/2 > 1.0$ rad

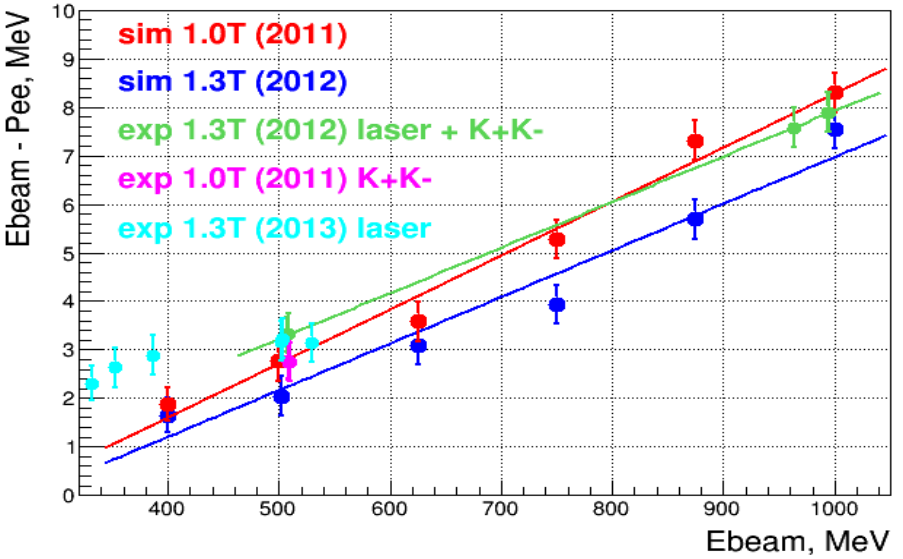






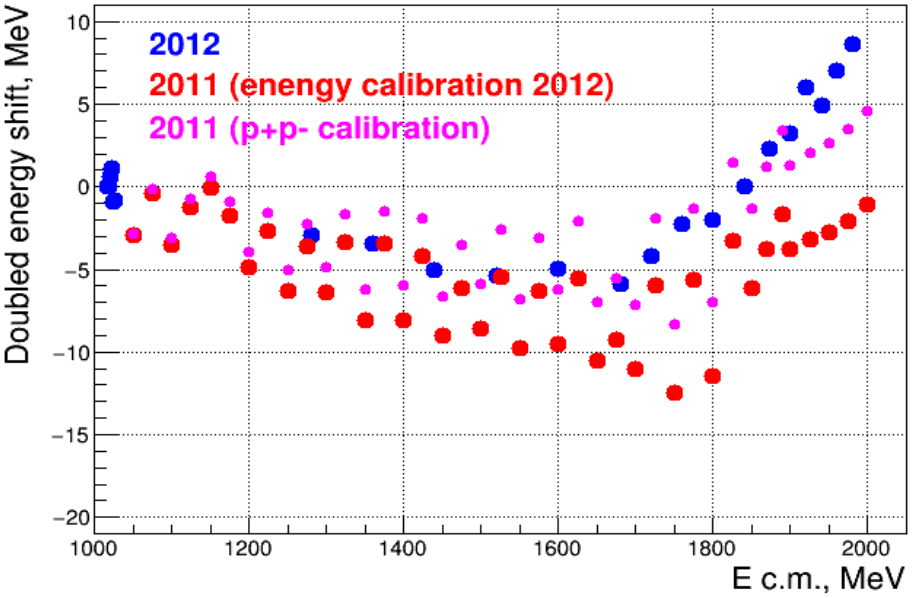
Beam energy measurement in run2011 and run2012





Measurement accuracy:

2011: ΔE ~ 3 MeV
2012: ΔE ~ 1 MeV
2013: ΔE ~ 0.1 MeV



Conclusion

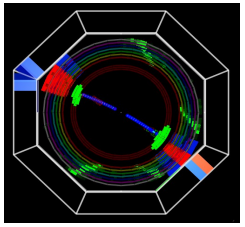
1) Разработана процедура измерения интегральной светимости по двум процессам $e^+e^- \to e^+e^-$ и $\gamma\gamma$.

2) Разработана методика измерения энергии пучков в заходах 2011 и 2012 г.

3) Разработана процедура учета «плавного изменения» масштаба z-координаты ДК.

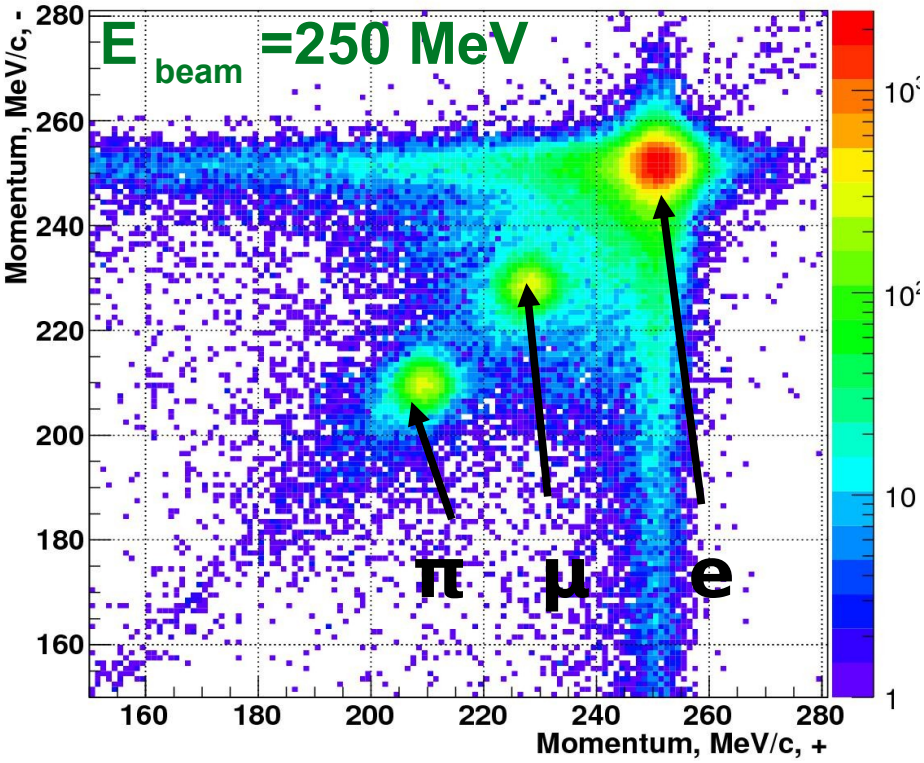
4) Систематическая ошибка измерения светимости на текущий момент составляет 0.7% (цель -0.3%).

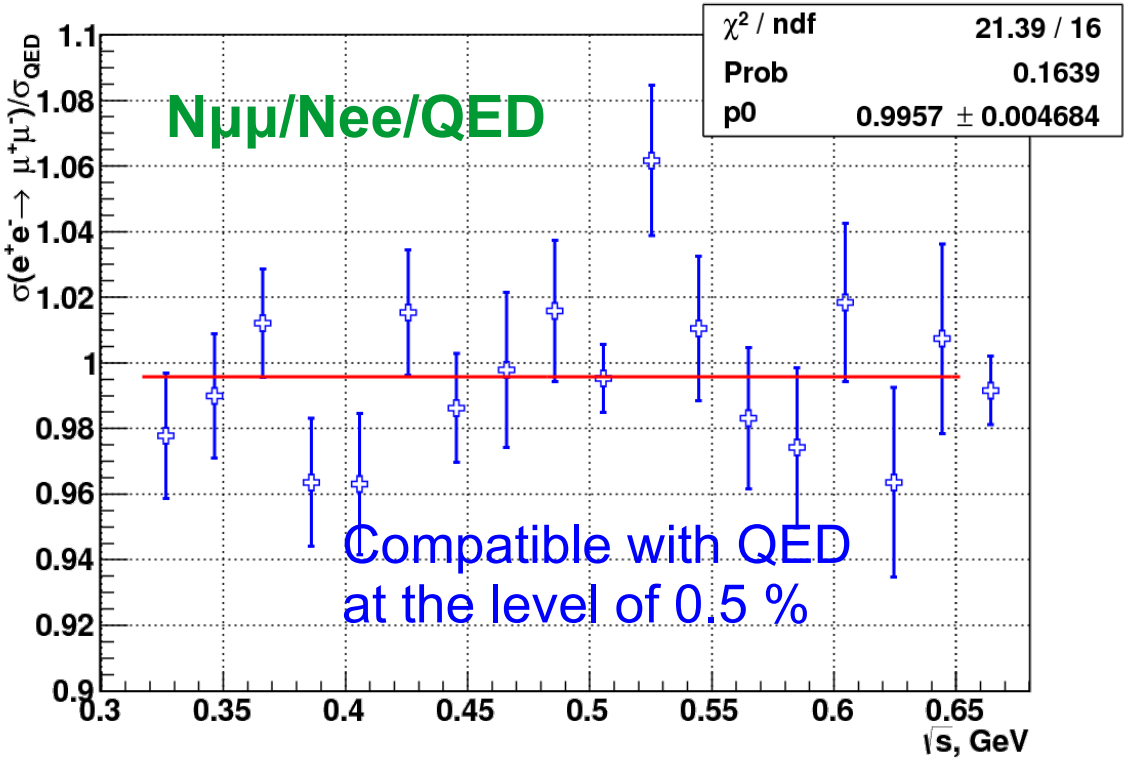
5) Всего в заходах с детектором КМД-3 набрано 59 $пб^{-1}$.



QED check

$e^+e^- \rightarrow \mu^+\mu^-$





This method works at $E_{beam} < 0.33$ GeV