A STUDY OF THE $e^+e^- \to K_S K_L \pi^0$ PROCESS UP TO 2 GeV WITH THE CMD-3 DETECTOR AT THE VEPP-2000 COLLIDER

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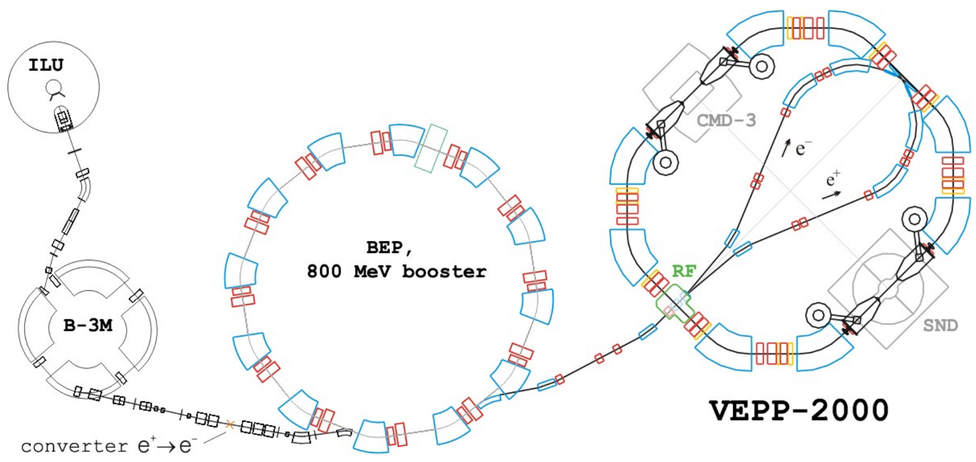
INTRODUCTION

The physics program of the VEPP-2000 project includes the high-precision measurement of the inclusive $e^+e \to hadrons$ cross-section in the low energy limit, a calculation of the hadronic contribution to the muon anomalous magnetic moment $(g-2)_\mu$ in the frame of the Standard Model and verification of the Vector Meson Dominance Theory. The final states with two K-mesons and one π^0-meson have 12% contribution into the hadronic cross-section. In this study we obtain the preliminary results about the process $e^+e^- \to K_S K_L \pi^0$ and present in this poster. The current study is based on integrated luminosity of 33 pb^{-1} obtained in 2011 and 2012 seasons in the energy range from 1.1 GeV to 2 GeV.

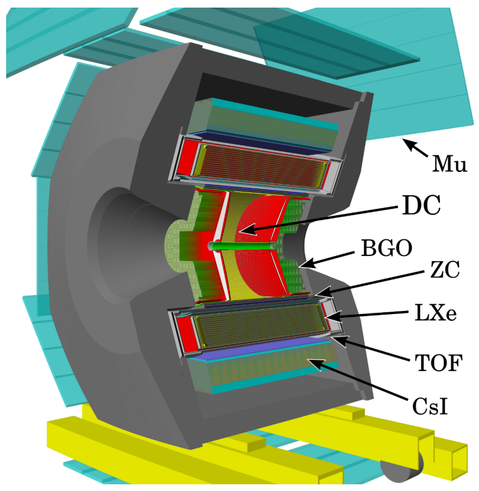
VEPP-2000

The VEPP-2000 is an electron-positron collider at Budker Institute of Nuclear Physics, Novosibirsk, Russia [1]. A distinctive feature is the using of the concept the circular cross section of the beam, which increases the collider luminosity up to $1 \times 10^{32}\,\text{cm}^{-2}\,\text{s}^{-1}$ (project). The measurement of the integral luminosity is based on the determination of the event number of processes $e^+e^- \to e^+e^-, e^+e^- \to \gamma\gamma$.



- $\sqrt{s} = 0.3$–2.0 GeV
- beam current — 0.2 A
- beam length — 3.3 cm
- beam energy spread — 0.7 MeV
- $L = 1 \times 10^{32}\,\text{cm}^{-2}\,\text{s}^{-1}$ at $\sqrt{s} = 2.0$ GeV
- $L = 2 \times 10^{31}\,\text{cm}^{-2}\,\text{s}^{-1}$ at $\sqrt{s} = 1.0$ GeV

CMD-3



Cryogenic magnetic detector [2]

- DC — drift chamber
- ZC — z-chamber
- LXe — liquid xenon calorimeter
- CsI — calorimeter
- TOF — time-of-flight system
- Mu — muon system
- BGO — calorimeter

Type	BGO	LXe	CsI
Structure	680 crystals	256 towers 2112 strips	1152 crystals
X_0	13.5	5.4	8.1
θ	0.3–0.8 rad 2.34–2.84 rad	0.8–2.34 rad	
σ_E/E	$\frac{0.024}{\sqrt{E/GeV}} \oplus 0.023$	$\frac{0.034}{\sqrt{E/GeV}} \oplus 0.02$	

SELECTIONS

The process was studied in decay modes $K_S \to \pi^+\pi^-$ and $\pi^0 \to \gamma\gamma$. A candidate event should fulfil the following conditions:

- two oppositely charged tracks
- $\xi_\pm < 1.6$ (Ionization losses)
- $\theta_{track} \in (0.9; \pi - 0.9)$
- $\cos(\vec{P}_{K_S}, \vec{r}_{vert})_{XY} > 0.8$
- radial length from the beam axis to the K_S vertex is more than 0.2 cm
- at least two photons
- photon candidate should have clusters in LXe-calorimeter or in BGO-calorimeter
- both photon candidates don't have clusters in BGO-calorimeter
- angle between photon candidates is more than theoretical minimum

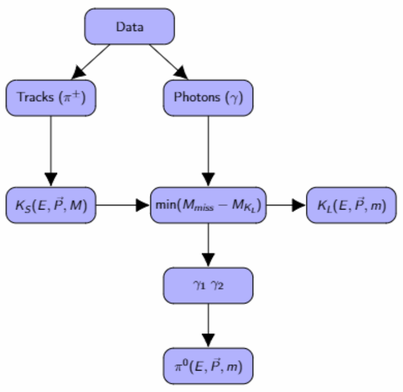
The following processes pass the criteria and form the main background events:

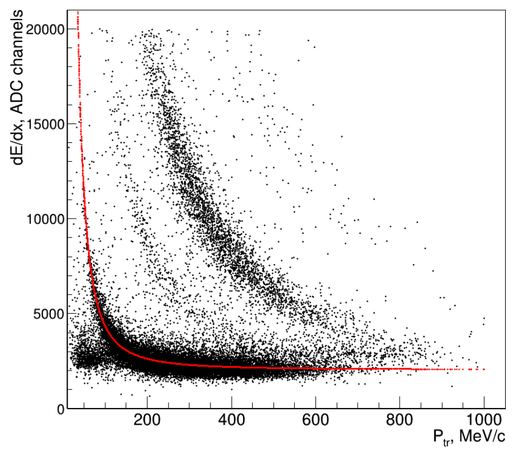
- $e^+e^- \to K_S K_L \gamma$
- $e^+e^- \to \pi^+\pi^-\pi^0\pi^0$
- $e^+e^- \to K_S K_L \pi^0\pi^0$

RECONSTRUCTION

- reconstruction of the K_S parameters $(E, \vec{P}, M_{inv})$
- correction photon polar angles to the intersection point with the beam axis and with the K_S momentum
- selection of two photons
  - using the Laws of Conservation choose two photons which has closest missing mass to the K_L-meson
- reconstruction of the K_L parameters $(E, \vec{P}, M_{inv})$
- reconstruction of the π^0 parameters $(\epsilon, \vec{p}, m_{inv})$

Therefore, the invariant masses of the K_S and π^0 mesons are free parameters.

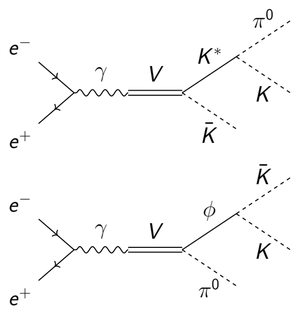




$$\frac{dE}{dx}(p_{track}) = a + \frac{b}{p^2_{track}}$$

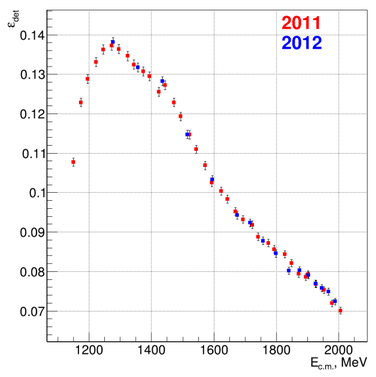
a=2047.2 , b=2.3 ·10^7

THE MONTE-CARLO SIMULATION AND DETECTION EFFICIENCY

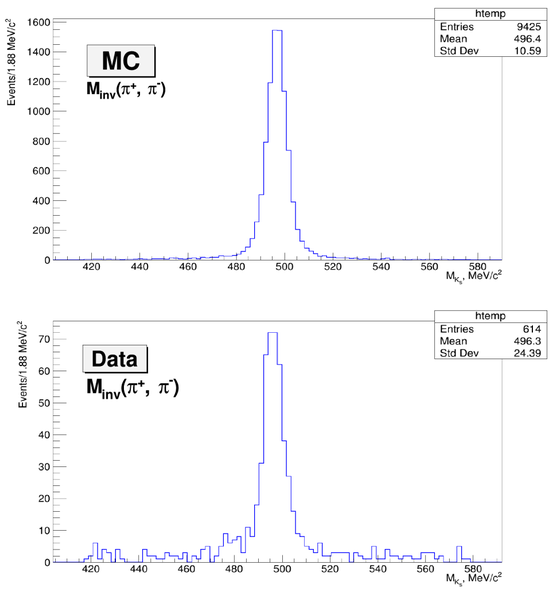


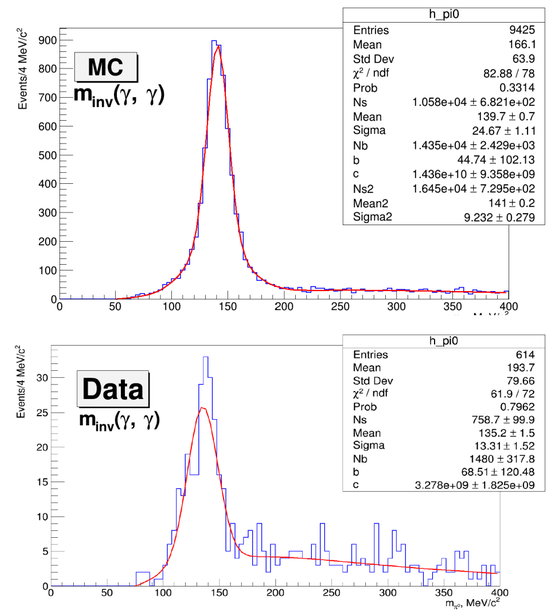
The Monte Carlo simulation is preformed in two models: $e^+e^- \to K^*\bar{K}, \bar{K}^*K$ and $e^+e^- \to \phi\pi^0$ with ISR.

The Monte Carlo simulation of the CMD-3 is used to determine the detection efficiency ε_{det} after the applying of the selection criteria. In the analyse we used 10^5 events for every energy point taking into account the peculiarities of the season.



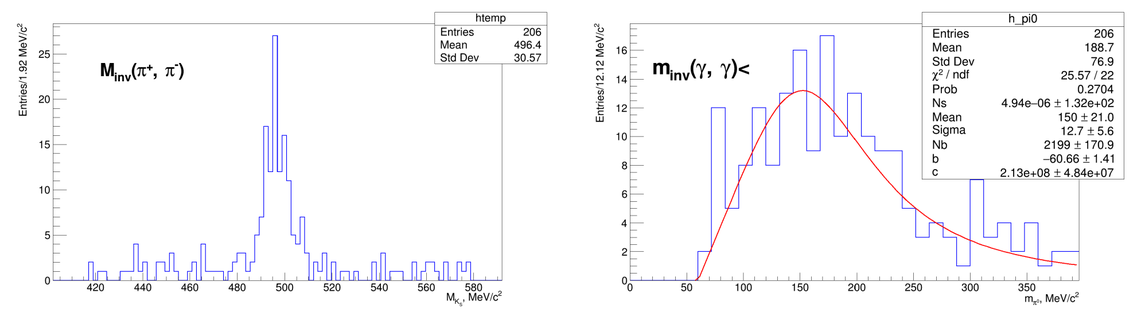
THE RESULTS OF THE SELECTION





$$N_{\pi^0}\frac{1}{\sqrt{2\pi}\sigma}exp\left(-\frac{(x-x_0)^2}{2\sigma^2}\right) + N_b\frac{1}{A}\frac{x-a}{(x+b)^4+c}$$

BACKGROUND PROCESSES



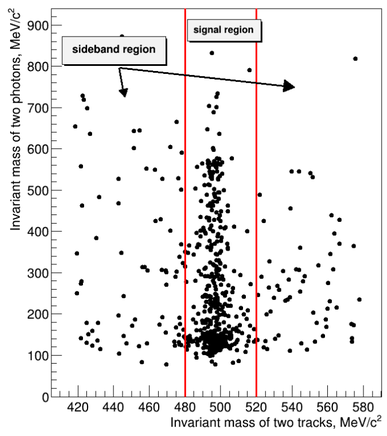
According to the results of MHG2000 Generator

NUMBER OF EVENTS

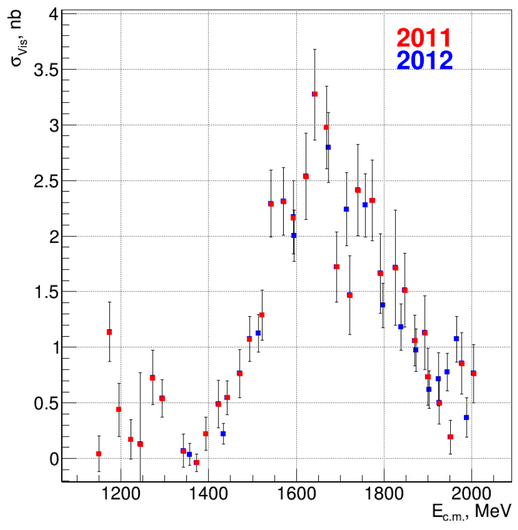
We determine the number of events with π^0 by fit of the invariant mass of two photons in the signal and sideband ranges. Then we obtain the number of events by the next expression:

$$N_{result} = N^{signal}_{\pi^0} - \alpha N^{sideband}_{\pi^0}$$

Where $\alpha \approx 0.33$ — ratio between number of background events in the sideband and signal ranges which are evaluated by fitting of substrate of the invariant mass of two tracks.

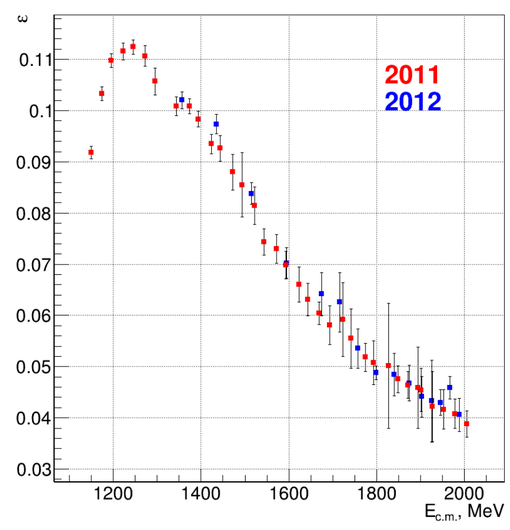


CROSS SECTION



$$\sigma_{Vis} = \frac{N_{result}}{L \cdot \varepsilon}$$

FINAL EFFICIENCY



$$\varepsilon_{det} = \frac{N_{out}}{N_{in}},\ \varepsilon_{\pi^0} = \frac{N_{\pi^0}}{N_{out}},\ \varepsilon_{K_S} = \frac{N^{signal}}{N_{out}} \to \boxed{\varepsilon = \varepsilon_{det} \cdot \varepsilon_{\pi^0} \cdot \varepsilon_{K_S}}$$

CONCLUSION AND OUTLOOK

- The preliminary results of 2011 and 2012 seasons are obtained
- To obtain preliminary results in new seasons in the nearest future
- To study of systematic uncertainties and radiation corrections

REFERENCES

[1] M. N. Achasov et al. The VEPP-2000 electron-positron collider: First experiments. *JETP*, 113:213–220, 2011.

[2] B. Khazin. Physics and detectors for VEPP-2000. *Nucl. Phys. Proc. Suppl.*, 181-182:376–380, 2008.

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