



Measurement of
 $e^+e^- \rightarrow \phi \rightarrow K^+K^-$ cross section
with CMD-2 detector
at VEPP-2M collider



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Outline

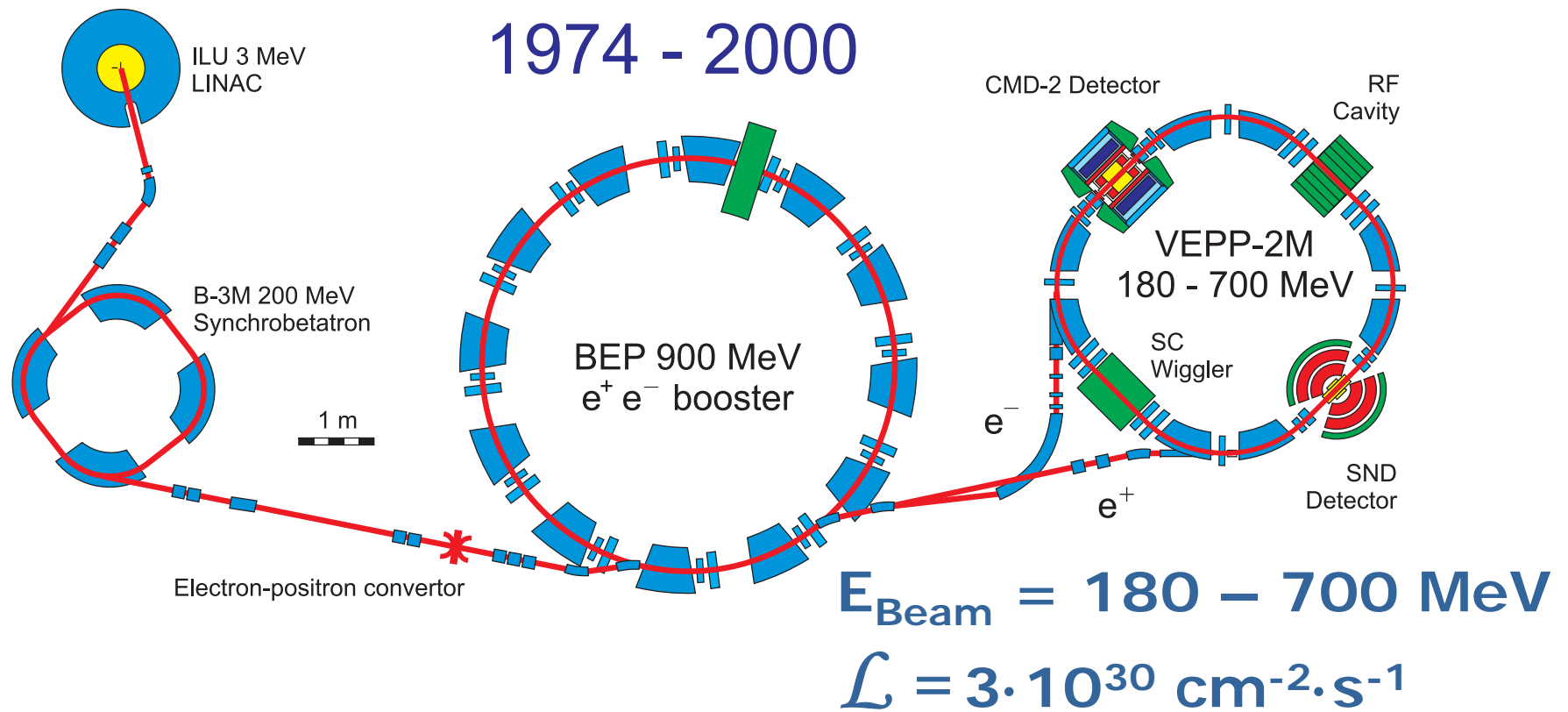
- Motivation
- Collider and Detector
- Experiment
- Selection criteria
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- Conclusion



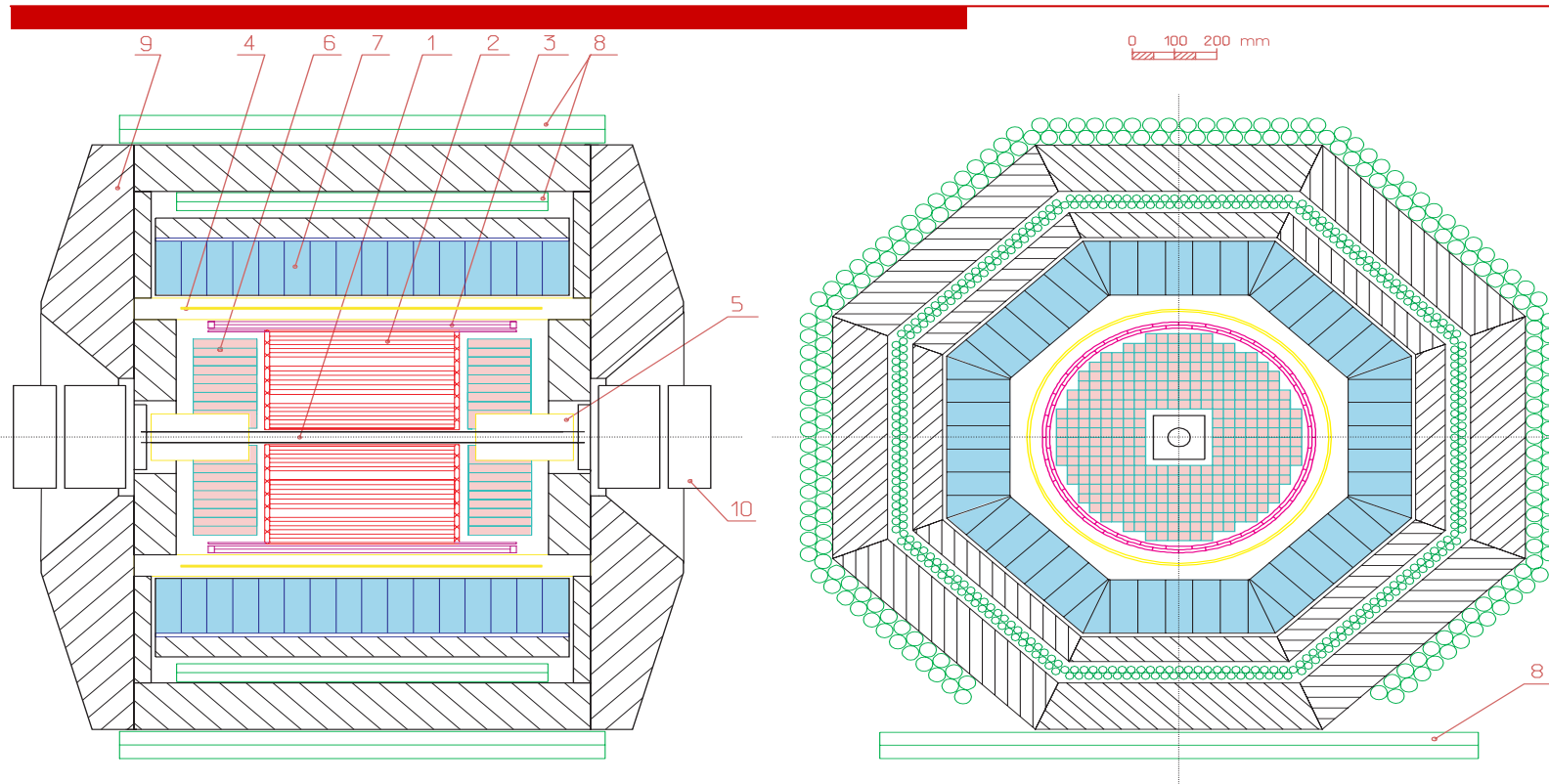
Motivation

- $\phi \rightarrow K^+K^-$ is the main ϕ meson decay, $B(\phi \rightarrow K^+K^-) = 0.492$, measured with poor (5-7%) accuracy.
- Study of $e^+e^- \rightarrow K^+K^-$ production around 1 GeV \Rightarrow measurement of ϕ meson parameters in $\phi \rightarrow K^+K^-$ decay channel
- Study of $\phi \rightarrow K^+K^-$ decay \Rightarrow measurement of ϕ leptonic width in combined analysis of 4 major ϕ decay modes
- Cross section of $e^+e^- \rightarrow K^+K^- \Rightarrow$ calculation of hadronic contribution to $(g-2)$ of muon
- Test of isotopic symmetry studying of ratio $K_L K_S$ to K^+K^- production cross sections

VEPP-2M Collider



CMD-2 Detector (1992-2000)



1 - vacuum chamber
 2 - drift chamber
 3 - **Z**-chamber
 4 - main solenoid

5 - compensating magnet
 6 - **BGO** endcap calorimeter
 7 - **CsI** barrel calorimeter
 8 - muon range system

9 - iron yoke
 10 - storage ring lenses



Experiment

For the first stage of the analysis, reported here, we used data of

- 1 scan (6% of data, collected at ϕ)
CM energy range 1010 – 1040 MeV
- 0.74 pb⁻¹ of integrated luminosity

Selection criteria



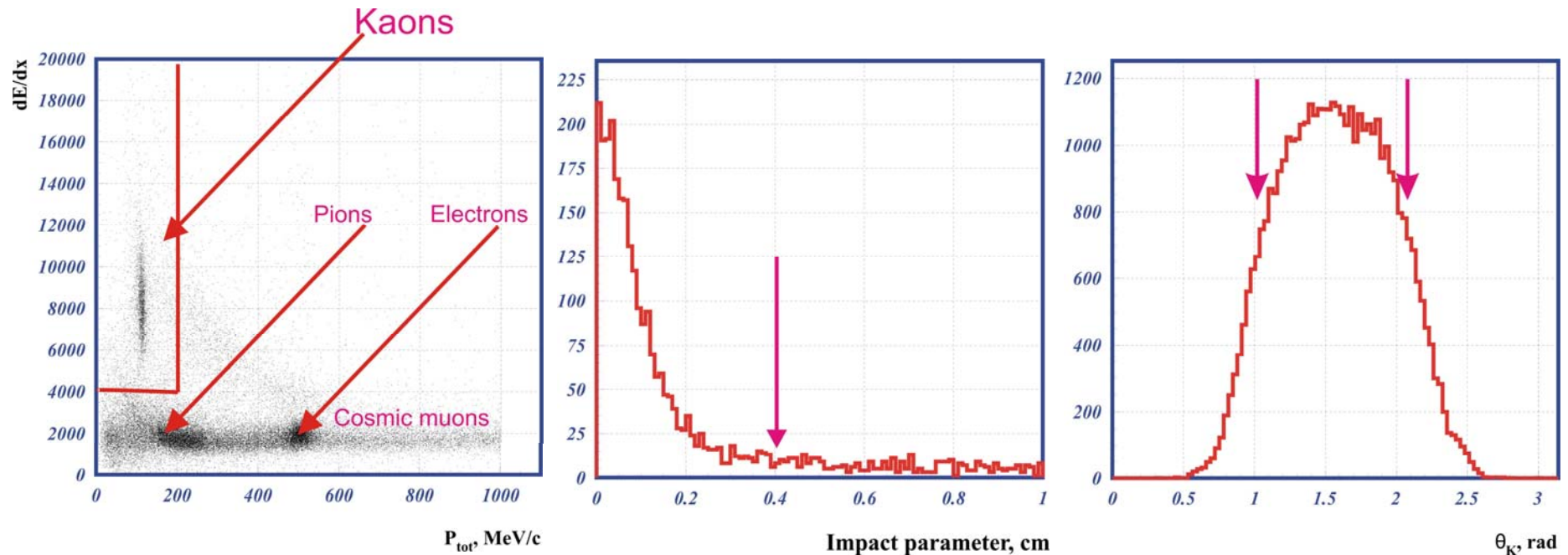
We define **“good” kaon** as:

$$P_{\text{tot}} < 200 \text{ MeV}/c$$

$$dE/dx > 4000.0 \text{ (} dE/dx_{\text{MIP}} = 2000 \text{)}$$

$$\text{ImpactParameter} < 0.4 \text{ cm}$$

$$1.0 < \theta_K < \pi - 1.0$$



We select events with **one or two “good” kaons** found

Analysis



At each energy point:

$$\sigma = \frac{(N_1 + N_2)}{\varepsilon \cdot L \cdot (1 + \delta_{rad})} \cdot \left(\frac{1 + \Delta_{EXP}(E)}{1 + \Delta_{SIM}(E)} \right)$$

N_1 – Number of events with one “good” kaon found

N_2 – Number of events with two “good” kaons found

ε – Detection efficiency

L – Integrated luminosity

$(1 + \delta_{rad})$ – ISR radiative correction

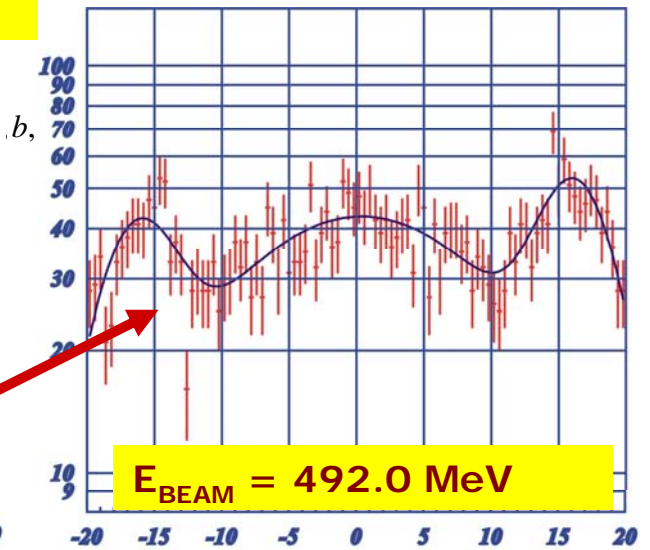
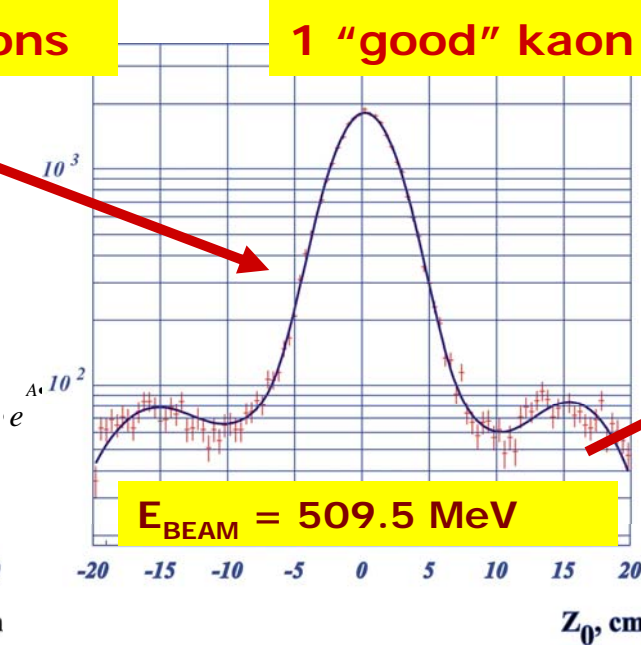
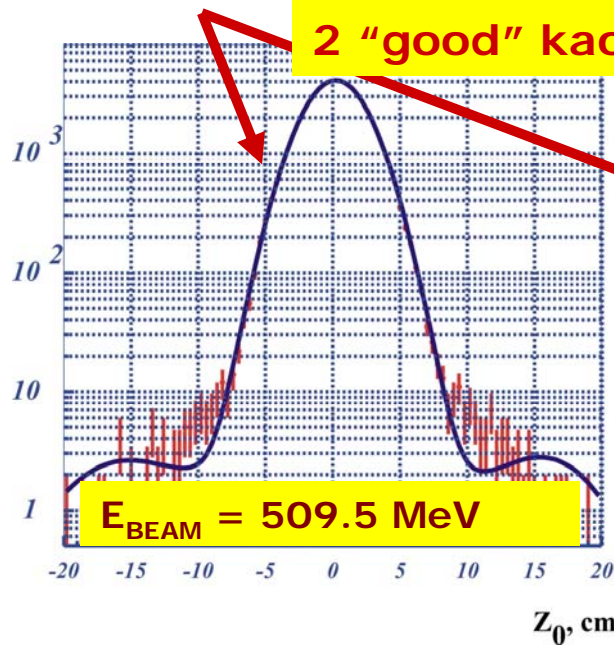
$\Delta_{EXP}(E)$ – Probability to loose both kaons in an experimental event

$\Delta_{SIM}(E)$ – Probability to loose both kaons in a simulated event

Number of events

Effect is fitted with HGauss

Background is fitted with 3 Gauss



$$HGauss(a, b, \mu) = N \cdot \exp \left(-a \sqrt{1 - \left(\frac{x - \mu}{b} \right)^2} \right)$$

$N_{1\text{good}} = 1.20 \cdot 10^5$

$N_{2\text{good}} = 2.43 \cdot 10^5$

Luminosity and ISR Radiative corrections



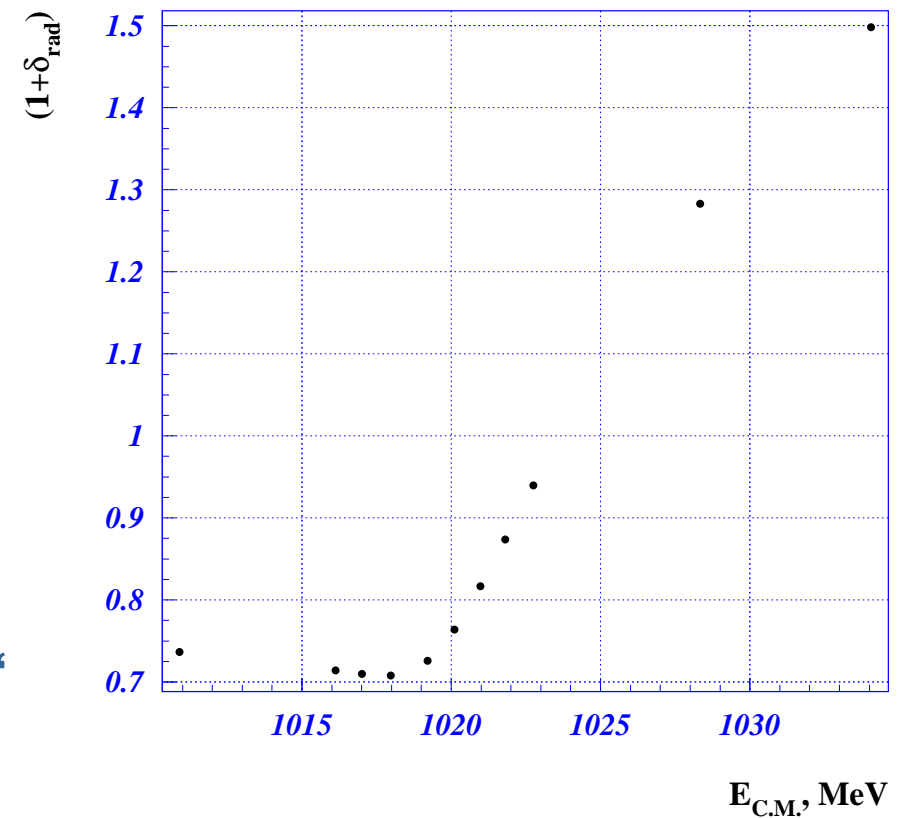
Luminosity

determined by using Large angle Bhabha scattering events

ISR Radiative corrections

“E.A.Kuraev, V.S.Fadin

Sov. J. of Nucl. Phys. v41, 1985, p.466”





Detection efficiency

Detection efficiency is a product of acceptance and trigger efficiency:

$$\mathcal{E} = \mathcal{E}_{Trig} \cdot \mathcal{E}_{Accept}$$

determined by using 50000 MC events (at each energy point) of the process
 $e^+e^- \rightarrow K^+K^-(\gamma)$

$$\mathcal{E}_{Accept} \sim 0.64$$

$$\mathcal{E}_{Trig} \sim 0.89$$

Probability to loose both kaons

$$\Delta_{EXP}(E_{Beam} = 510.0 \text{ MeV}) = 0.039$$

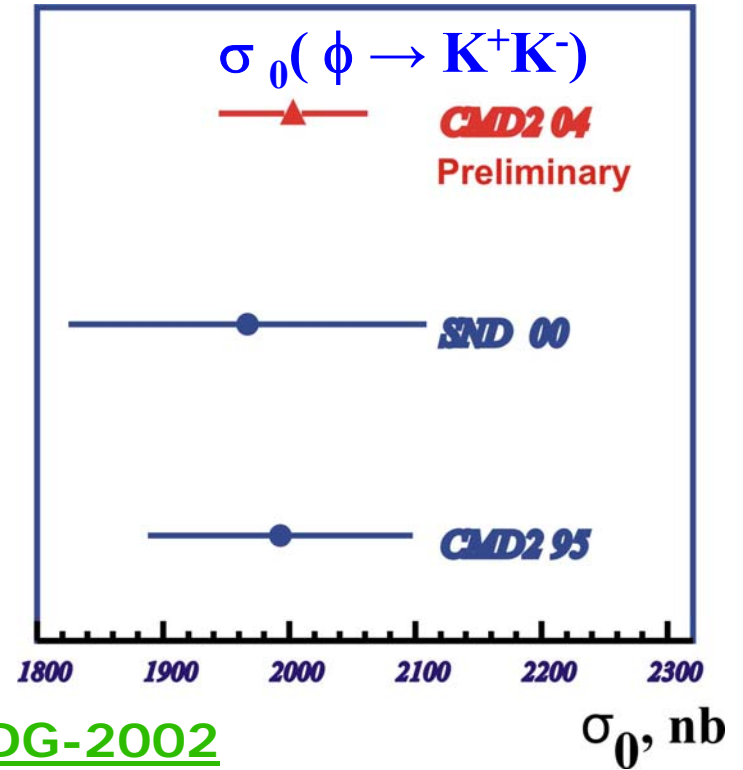
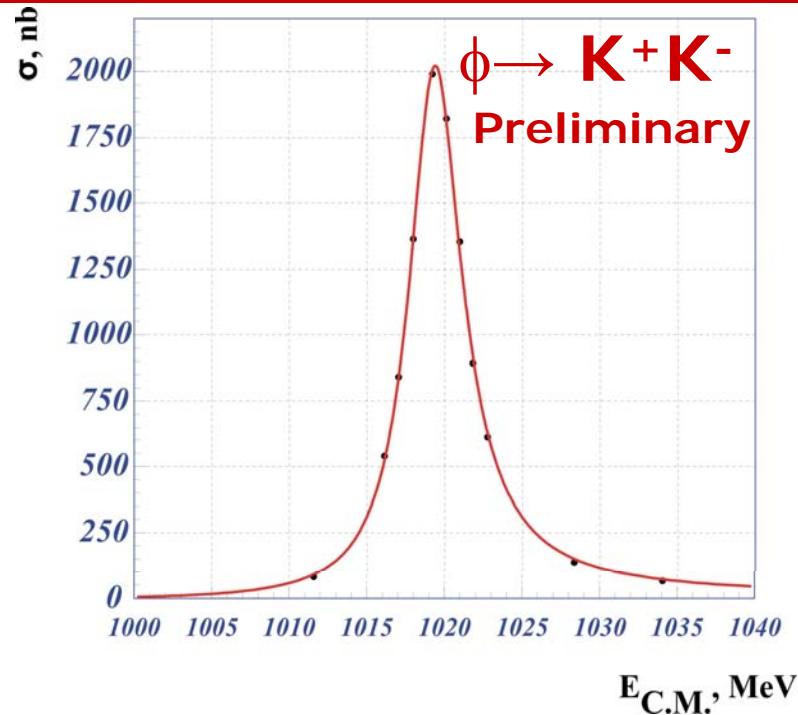
$$\Delta_{SIM}(E_{Beam} = 510.0 \text{ MeV}) = 0.043$$



Cross Section Systematic Error

Source	Contribution, %
Trigger Efficiency	2
Selection Criteria	1.4
Luminosity	1
Acceptance	0.7
Radiative correction	0.5
Total	2.8

Cross Section and Fit to Data



$$\sigma_0 = 2003 \pm 20 \pm 56 \text{ nb}$$

$$m_\phi = 1019.469 \pm 0.010 \pm 0.080 \text{ MeV}/c^2 \quad m_\phi = 1019.456 \pm 0.020 \text{ MeV}/c^2$$

$$\Gamma_\phi = 4.24 \pm 0.03 \pm 0.03 \text{ MeV}$$

$$\Gamma_\phi = 4.26 \pm 0.05 \text{ MeV}$$

Conclusion



✓ Most precise measurement of $e^+e^- \rightarrow K^+K^-$ cross section in energy range 1010 – 1034 MeV was performed using about **$3.63 \cdot 10^5$ events** corresponded to 0.74 pb^{-1} of integrated luminosity, collected with CMD-2 detector

✓ The following **preliminary** values of ϕ meson parameters in $\phi \rightarrow K^+K^-$ decay channel were obtained:

$$\sigma_0 = 2003 \pm 20 \pm 56 \text{ nb}$$

$$m_\phi = 1019.469 \pm 0.010 \pm 0.080 \text{ MeV}/c^2$$

$$\Gamma_\phi = 4.24 \pm 0.03 \pm 0.03 \text{ MeV}$$

✓ Systematic error in the cross section value is estimated to be about 2.8 %

✓ We plan to process the rest part of data and perform precise m_ϕ measurement by using data with energy determined by RDM