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

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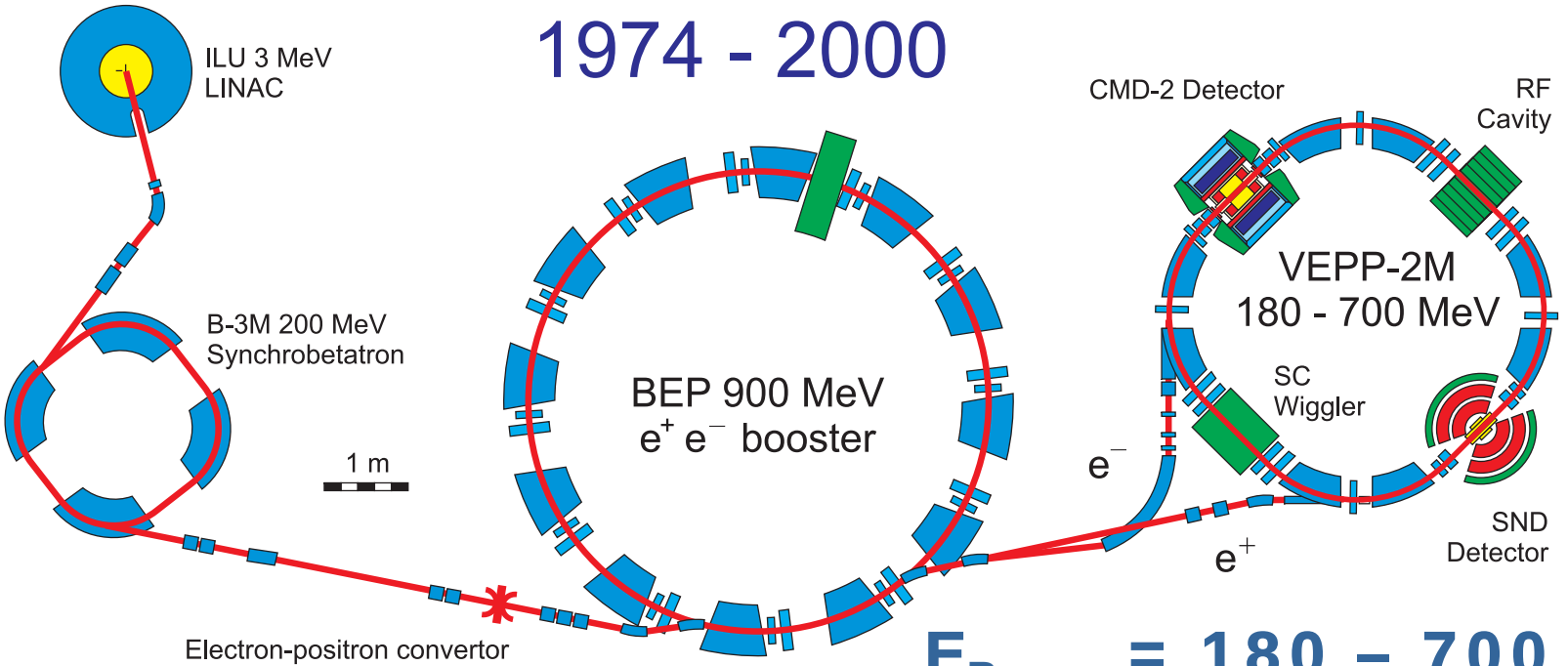
Outline

- Motivation
- Collider and Detector
- Experiment
- Selection criteria
- Analysis
- 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_LK_S to K^+K^- production cross sections

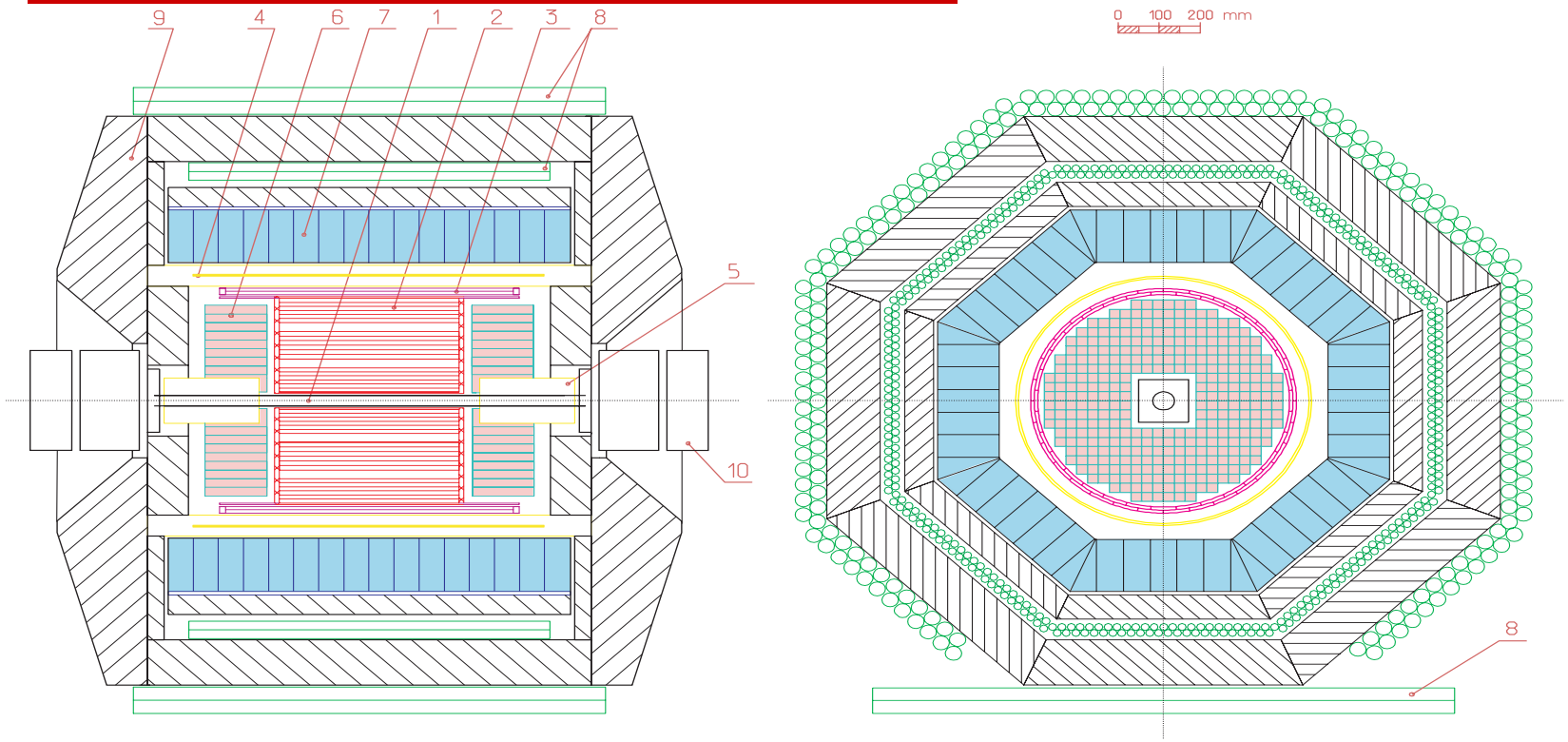
VEPP-2M Collider



E_{Beam} = 180 – 700 MeV

$\mathcal{L} = 3 \cdot 10^{30}$ cm^{-2}·s^{-1}

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

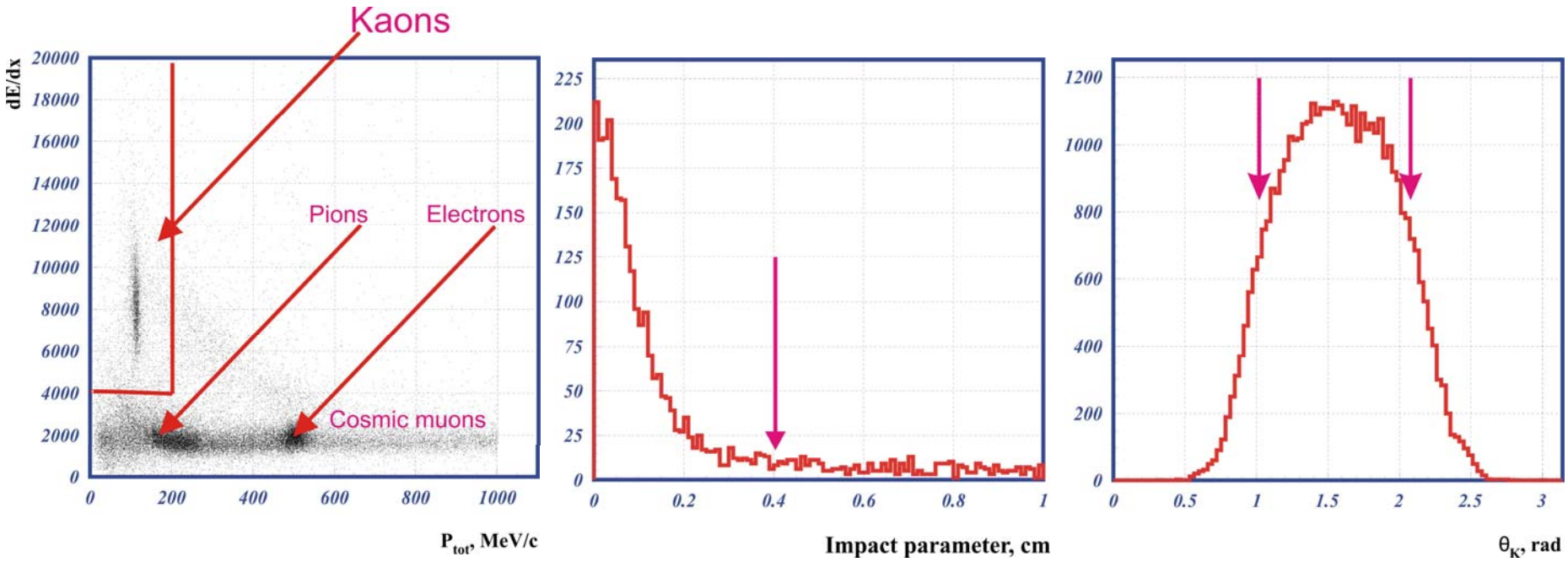
For the first stage of the analysis, reported here, we used data of

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

Selection criteria

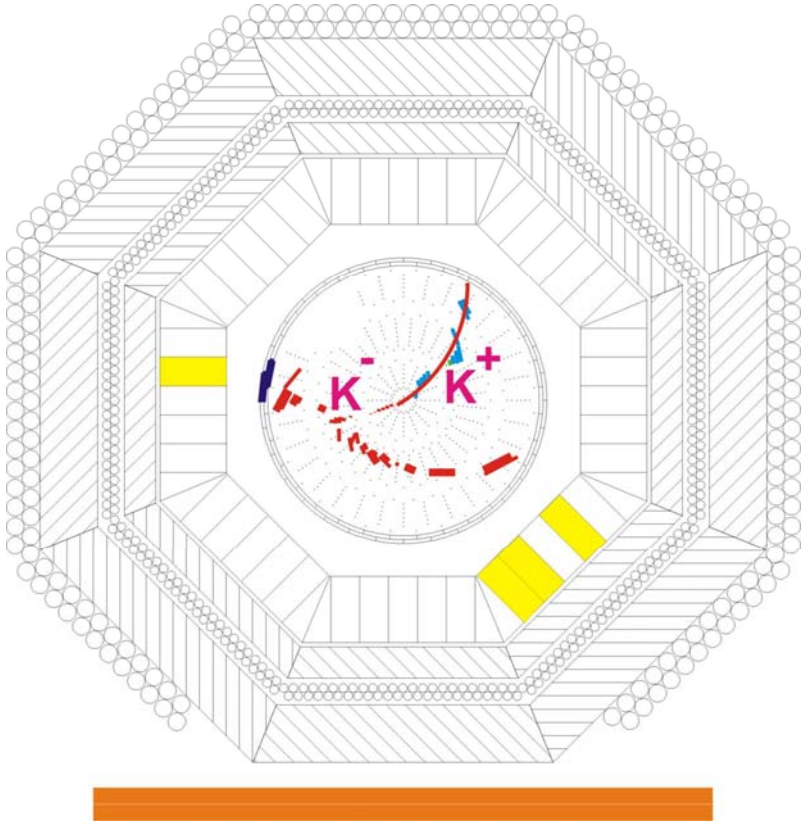
We define "good" kaon as:

$P_{tot} < 200$ MeV/c
$dE/dx > 4000.0$ ($dE/dx_{MIP} = 2000$)
ImpactParameter < 0.4 cm
$1.0 < \theta_K < \pi - 1.0$

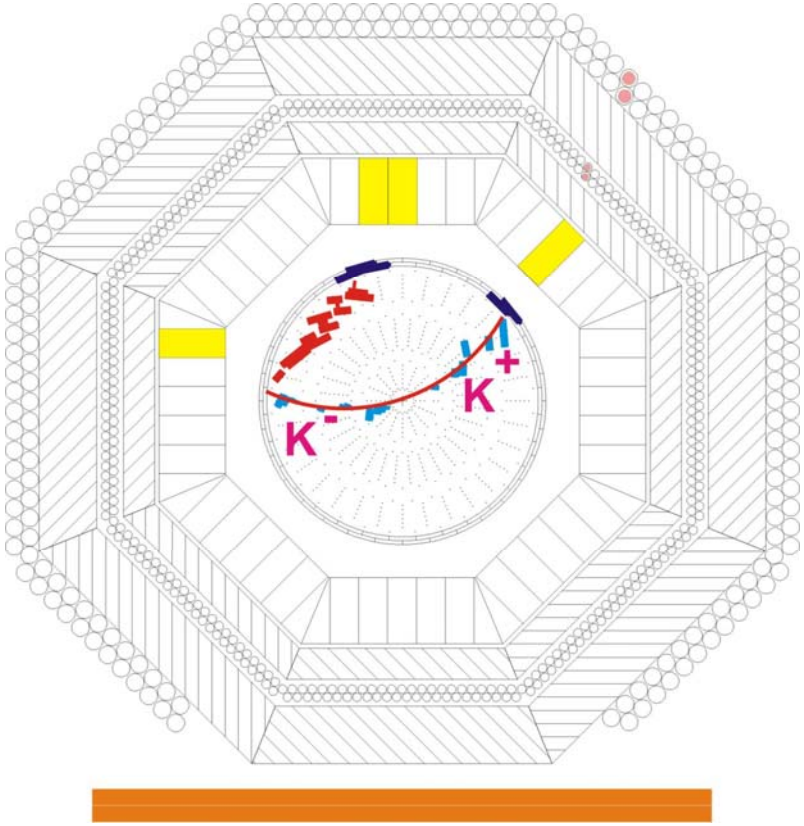


We select events with one or two "good" kaons found

Events Examples



1 “GOOD” KAON EVENT



2 “GOOD” KAONS EVENT

Analysis

At each energy point:

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

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

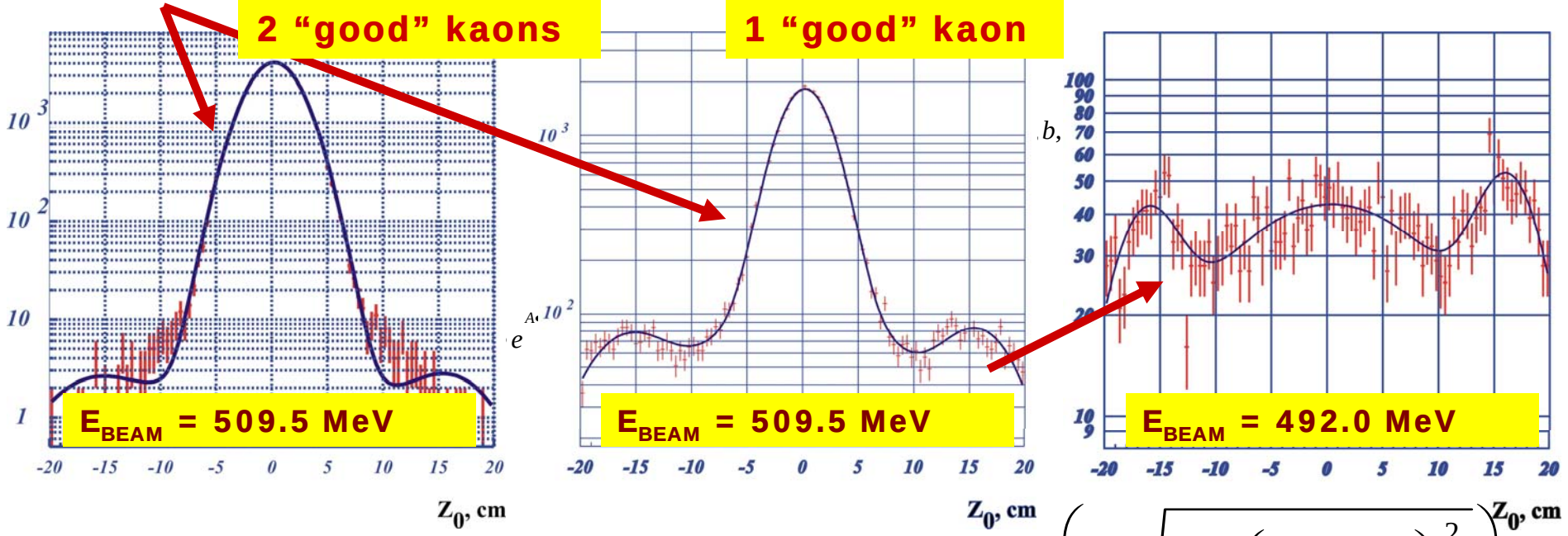
$\Delta_{EXP}(E)$ – Probability to loose both kaons in an experimental event

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

Number of events

Effect is fitted with HGauss **Background is fitted with 3 Gauss**

2 "good" kaons **1 "good" kaon**



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

N_{1good} = 1.20·10⁵ **N_{2good} = 2.43·10⁵**

Luminosity and ISR Radiative corrections

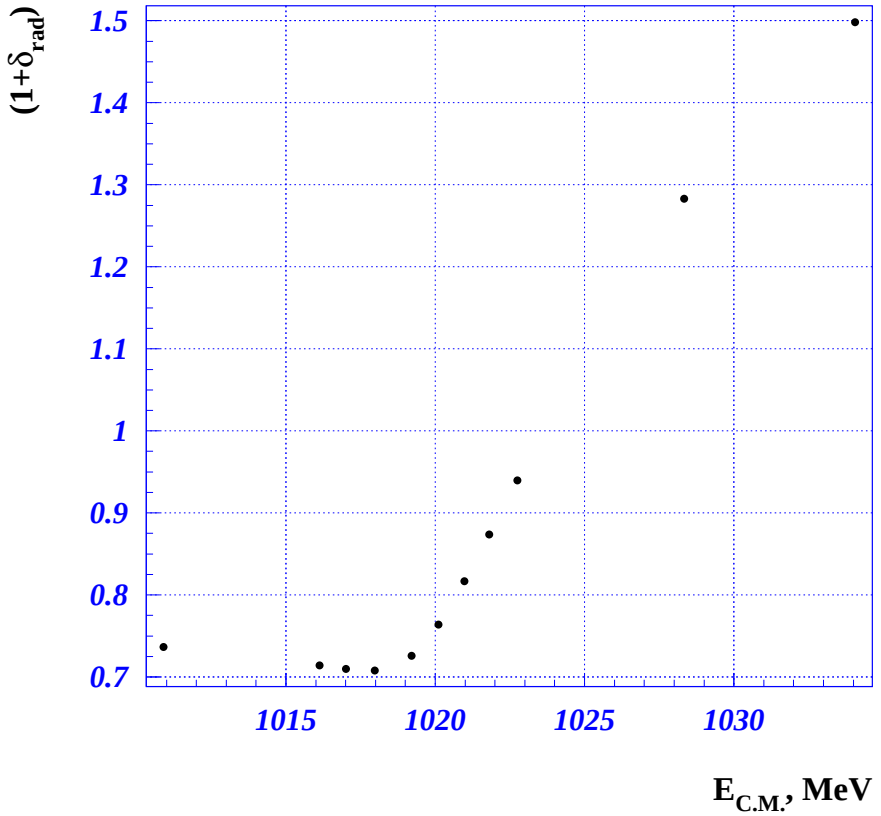
Luminosity

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:

$$\varepsilon = \varepsilon_{Trig} \bullet \varepsilon_{Accept}$$

determined by using 50000 MC events (at each energy point) of the process

$e^+e^- \to K^+K^-(\gamma)$

$\varepsilon_{Accept} \sim 0.64$ $\varepsilon_{Trig} \sim 0.89$

Probability to loose both kaons

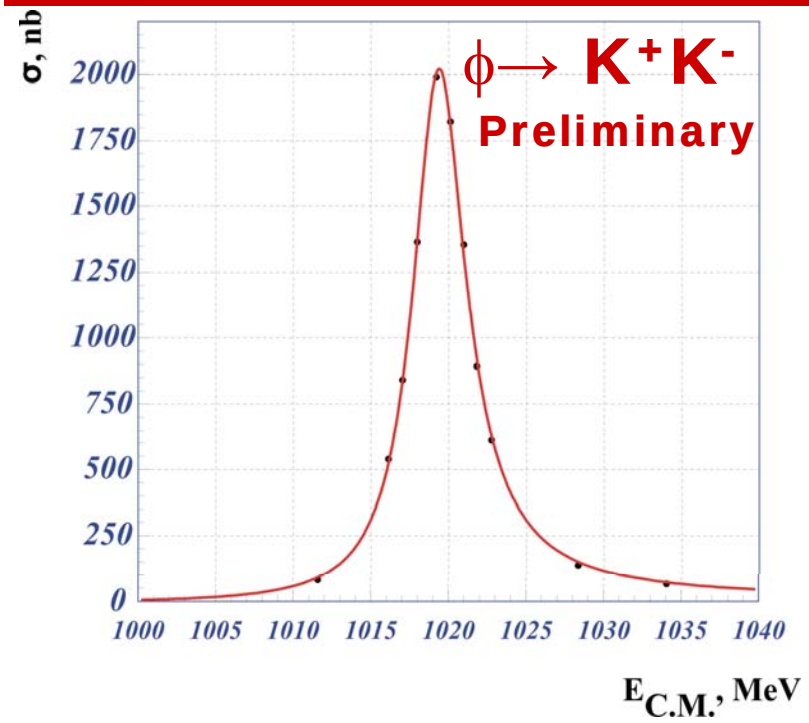
$\Delta_{EXP}(E_{Beam} = 510.0\ MeV) = 0.039$

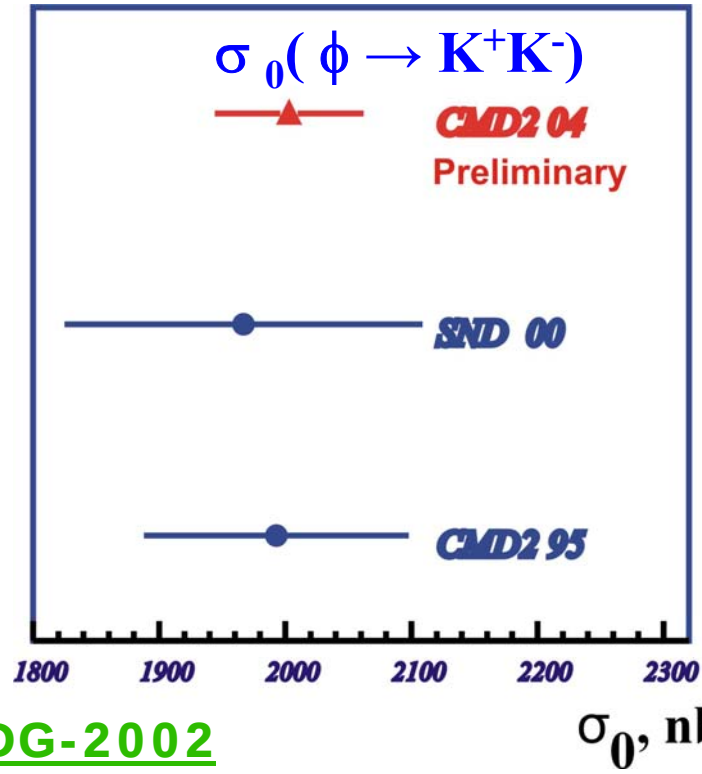
$\Delta_{SIM}(E_{Beam} = 510.0\ MeV) = 0.043$

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





σ_0 = 2003 ± 20 ± 56 nb

m_ϕ = 1019.469 ± 0.010 ± 0.080 MeV/c²

Γ_ϕ = 4.24 ± 0.03 ± 0.03 MeV

PDG-2002

m_ϕ = 1019.456 ± 0.020 MeV/c²

Γ_ϕ = 4.26 ± 0.05 MeV

Conclusion

✓ **Most precise measurement of $e^+e^- \to K^+K^-$ 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 $\phi \to K+K-$ 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**