Analysis of the CMD-3 detector data: searching for low-energy electron-positron annihilation into $KK\pi$ and $KK\pi\pi^0$

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We explored the process $e^+e^-\rightarrow KK\pi$ with the CMD-3 detector at the electron-positron collider VEPP-2000. The data amassed by the CMD-3 detector in the energy range of $1.2-2$ GeV during the 2011, 2012, 2017, 2019 runs, with a total luminosity integral of $\sim 120pb^{-1}$ backs the analysis.

In light of the recent anomalous magnetic moment discrepancy broadening to 4.2σ, see Fermilab article https://arxiv.org/abs/2104.03281. Community, searching for New Physics, demands sharper Hadronic Vacuum Polarization - HVP - estimate. In its turn, HVP computation relies heavily on hadronic cross-sections measurement.

That's why, the analyzed cross-section is valuable for the physics of light hadrons from u, d, s quarks, clarifying the hadronic contribution to the anomalous magnetic moment of the muon $(g-2)_\mu$, and independently measuring the resonance parameters of both $\phi(1680)$, $\rho(1450)$. Also, the intermediate dynamics of this process attracts interest, allowing us to check the isotopic relations and prove the dominance of the neutral $K^*(892)$ channel.

We developed a novel algorithm for signal events extraction. So, the data processing pipeline adopts a new step - multi-staged kinematic regression. By adding the second stage, we cut the background ~ 5 more times. This stage depends on a rigorous study of the background. Since we pinpointed - the main physical background (false positives) to be the process $e^+e^-\rightarrow 4\pi$.

The outline of the designed selection algorithm:

1. Applying multi-staged kinematic regression with 4 charged tracks.

2. Matching tracks to particles. Hypothesizing K_S meson particles from data ; Building distribution by invariant mass and decay vertex.

3. Restricting the energy of γ not bound to tracks; Filtering out fake-signal based on decay path difference.

4. Selecting target events based on 2D-analysis of four-track events distribution by energy imbalance ΔE and momentum vector sum modulus of all four particles Δp.

5. Simulating sought process by Monte-Carlo to find detection efficiency ε and gauge systematic errors.

So, as a result of this work we not only designed a new selection algorithm, but also studied the theoretical aspect of the cross-section in the Vector Meson Dominance Framework. Therefore, we improved the world precision of $\phi(1680)$, $\rho(1450)$ and measured the cross-section of $e^+e^-\rightarrow KK\pi$ with the best accuracy.

Significance

Before, we reported studying the process $e^+e^- \to KK\pi$ without the additional, yet crucial, step of kinematic regression.

Now, with this new approach in mind, we present the results not only with better statistical accuracy, but with significantly reduced systematic errors.

Moreover, only now we reveal the intermediate resonance parameters because we applied the theoretical framework of Vector Meson Dominance and extracted these physical constants of interest.

References

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