Study of $\tau^- \rightarrow h^- h^+ h^- \nu_\tau$ decays.

Alexander Bobrov

Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russia

Novosibirsk State University, Russia

A.V.Bobrov@inp.nsk.su

1. Motivation

Recent results from Belle and BABAR on the branching ratios of $\tau^- \rightarrow h^- h^+ h^- \nu_\tau$ show notable difference for some modes.

Branching fraction has the following hierarchy: $B_{\tau^- \rightarrow \pi^- \pi^+ \pi^-} \sim 3$, $B_{\tau^- \rightarrow K^+ K^- K^-} \sim 50$.

We presented a study of $\tau^- \rightarrow K^- K^- h^- \nu_\tau$ decays at Belle. The dominant systematic uncertainties of the branching fraction is related to the $K^- h^-$ identification (PID). There two sources of the uncertainty: insufficient accuracy of the misidentification efficiency data for the low momentum $h^-$ from $\tau^- \rightarrow h^- h^+ h^- \nu_\tau$ events and impact of the additional $h^-$ in the PID efficiency. To improve PID efficiency data we utilize $K_{\tau^-} \rightarrow \pi^- + \pi^+ + \nu_\tau$ decays. To suppress additional $h^-$ we evaluate special criteria $\gamma$-veto. The decrease of the systematic uncertainty is monitored by specially constructed scale factor (SF).

Abstract

We presented a study of $\tau^- \rightarrow K^- K^- h^- \nu_\tau$ decays at Belle. The dominant systematic uncertainties of the branching fraction is related to the $K^- h^-$ identification (PID). There two sources of the uncertainty: insufficient accuracy of the misidentification efficiency data for the low momentum $h^-$ from $\tau^- \rightarrow h^- h^+ h^- \nu_\tau$ events and impact of the additional $h^-$ in the PID efficiency. To improve PID efficiency data we utilize $K_{\tau^-} \rightarrow \pi^- + \pi^+ + \nu_\tau$ decays. To suppress additional $h^-$ we evaluate special criteria $\gamma$-veto. The decrease of the systematic uncertainty is monitored by specially constructed scale factor (SF).

2. KEKB factory and Belle detector

Belle PR D61 113007

BaBar PRL 100011801

3. Selection criteria

- 4-track events with zero charge
- Lepton ($\mu, e$) and three hadrons ($K, \pi$)
- Neutral veto, $\gamma$
- KOD $> 0.1$ for $K$; $\text{eOD} > 0.1$ for leptons
- $|\gamma_c s| < 0.5 ~ \text{cm}$, $s < 2.5 ~ \text{cm}$
- $\text{max} E > 3.5 ~ \text{GeV}$
- $17.5 \pi < m_{h^-} < 17.8 ~ \text{GeV}$
- $E_{\gamma} < 0.35 ~ \text{GeV}$
- $D^* > 0.35 ~ \text{GeV}$
- $\text{HV} > 30 ~ \text{cm}$
- $E_{\gamma} > 0.35 ~ \text{GeV}$

4. Branching fractions calculation

We analyze $\tau^- \rightarrow e^- \pi^- \pi^+ \pi^-$, $\tau^- \rightarrow \mu^- K^+ K^- K^-$, $\tau^- \rightarrow \pi^- K^+ K^- K^-$, $\tau^- \rightarrow K^- K^+ K^- K^-$, simultaneously. Take into account cross-feed background from $\tau^- \rightarrow K^- \pi^-$ misidentification.

5. Events with wrong charge configuration

An idea is to take into account $K^- K^- \pi^-$ and $\pi^- \pi^- \pi^-$ events. We assume that $B_{\tau^-} = B_{\tau^- \rightarrow K^- K^- \pi^-} = B_{\tau^- \rightarrow \pi^- \pi^- \pi^+} = 1$. 2 additional equations. Number of signal events can be obtained from fit $\chi_i^{(N_{\text{true}})} = \chi_i^{(N_{\text{MC}})}$, where $\chi_i$ = all possible combinations, $p$ = tau decay modes ($e^\pm \nu_e$, $\mu^\pm \nu_\mu$, $\tau^\pm \nu_\tau$).

6. Scale factor for $\tau \rightarrow \text{misID}$

The consistency of the procedure was tested with large MC sample. However in the fit of experimental data we got large $\chi^2$, which indicates systematic effect in the $K^- \pi^-$ and $K^- h^-$ identification. We introduce additional factor SF to correct $\chi^2(\tau \rightarrow K^-)$.

$SF = 1.140 \pm 0.015(\text{stat}) \pm 0.03(\text{sys})$.

7. PID in $\tau^- \rightarrow h^- h^+ h^- \nu_\tau$ MC samples

- $K^- K^- h^- \nu_\tau$ sample and $D^* \tau$ sample are different
- $\gamma$-veto

8. PID correction from $K \rightarrow \pi^+ \pi^- \pi^0$ decays

Cell number is coded by the following formula: cell-polar angle range/particle momentum range.

9. Results

With the new PID correction for experimental data $SF = 1.00 \pm 0.01(\text{stat}) \pm 0.03(\text{sys})$. This indicates that the new PID efficiency data ($K \rightarrow \pi^+ \pi^- \pi^0$) agree better with real experimental PID efficiencies.

Branching fractions variation

10. Conclusions

- We developed procedure the branching fractions measurement
- It was tested with large MC sample
- Identification efficiency data for $\tau \rightarrow e^- \pi^- \pi^+$ has insufficient accuracy
- Additional $\gamma$-veto impact to the PID