Inclusive V_{us} with τ decays

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Decay channels

Decay	Contribution	BR [%]
$\tau^+ \rightarrow \pi^+ K_S X$	Vus, Vud	~1.7
$\tau^+ \rightarrow \pi^+ K_S K_S X$	Vud	~0.02-0.05
$\tau^+ \rightarrow \pi^+ K_S K_L X$	Vud	~0.1-0.2

Strategy

- To extract V_{us} inclusively from $\tau^+ \rightarrow \pi^+ K_s X$ we need to subtract the V_{ud} contributions of $\tau^+ \rightarrow \pi^+ K_S K_S X$ and $\tau^+ \rightarrow \pi^+ K_S K_L X$.

BR(V_{us} inclusively): $$\frac{N(\tau^+ \rightarrow \pi^+ K_s X)}{\epsilon_1} - \frac{N(\tau^+ \rightarrow \pi^+ K_S K_S X)}{\epsilon_2} - \frac{N(\tau^+ \rightarrow \pi^+ K_S K_L X)}{\epsilon_3}$$

Focus on these decays.

- ϵ_1, ϵ_2 and ϵ_3 are the efficiencies for each channel.

Selection

- Applied the latest correction on MC:

  1. photon energy bias: PhotonEnergyBiasCorrection_MC15rd_June2023
  2. Lepton ID correction: leptonid_official_rel6_mc15rd

- Selection

  1. Tag side: $\tau^+ \to \ell\nu\nu$
  2. Signal side: $\tau^+ \to \pi^+ K_s X$, $\tau^+ \to \pi^+ K_s K_s X$ with nAllTracks<7
  3. Reconstruct only $K_s \to \pi^+\pi^-$.
  4. Applied loose selection on the K_s flight distance (>3 mm).
  5. Applied a lepton ID cut on electron (0.5) and muon (0.5) for the tag side.
  6. Applied standard cut on photons (thetaInCDCacceptance, clusterNHits>1.5 …)

- Need to apply a PID cut on pions.

First check

- Reconstruct exclusively both $\tau^+ \to \pi^+ K_s X$ and $\tau^+ \to \pi^+ K_s K_s X$ decays requiring a total number of tracks < 7 (max 5 for the signal side + 1 for the tag side).
- Reconstruct only MC with a mdst file corresponding to 0.4fb^{-1}.
- Using Tauola to check the number of signal candidates.

N($\tau^+ \to \pi^+ K_s X$) with nAllTracks<7 = 1317 events

N($\tau^+ \to \pi^+ K_s K_s X$) with nAllTracks<7 = 20 events

N($\tau^+ \to \pi^+ K_s K_s X$) ~ 1/66 of N($\tau^+ \to \pi^+ K_s X$) comparable with the ratio of BRs in slide 2.

Signal efficiency

- Signal efficiencies are estimated using:

$$\epsilon_{sig} = \frac{N_{sig}}{2 \cdot BR_{sig} \cdot BR_{tag} \cdot N_{\tau\tau}}$$

- N_{sig} are the number of signal events.
- BR_{sig} are the branching fractions of the two signal decays (~1.7% and ~0.03%).
- BR_{tag} is the branching fraction of the tag side $BR(\tau \to \ell\nu\nu)$ ~ 35%.
- $N_{\tau\tau}$ are the number of tau pairs evaluated using the lumi ($0.4\mathrm{fb}^{-1}$ and the $\sigma(\tau\tau)$).

$$\epsilon_{sig}(\tau^+ \to \pi^+ K_S K_S X) = \frac{N_{sig}}{2 \cdot BR_{sig} \cdot BR_{tag} \cdot N_{\tau\tau}} \sim 26\,\%$$

$$\epsilon_{sig}(\tau^+ \to \pi^+ K_S X) = \frac{N_{sig}}{2 \cdot BR_{sig} \cdot BR_{tag} \cdot N_{\tau\tau}} \sim 30\,\%$$

Next steps

- Check the multiplicity in the events and optimize the selection.
- Try to filter the $\tau^+ \to \pi^+ K_S K_S X$ contribution from the $\tau^+ \to \pi^+ K_s X$ decays.
- Run on data and check data/MC agreement for $\tau^+ \to \pi^+ K_S K_S X$.