Status of Charm Particle Analysis in Proton-Nucleus Interactions at the NA65/DsTau Experiment

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Introduction

Tau neutrinos are one of the three neutrino flavors in the Standard Model, but its reaction cross section has been measured with significantly less precision than those of the other neutrinos, leaving a large uncertainty.

The DsTau experiment has been designed to address this issue. A 400 GeV proton beam from the CERN SPS is directed onto tungsten or molybdenum targets, and the decays of D_S mesons produced in the interactions are observed using high-resolution nuclear emulsion detectors. By precisely measuring the differential production cross section of D_S mesons, the uncertainty in tau neutrino production can be greatly reduced. As a result, the systematic uncertainty on the tau neutrino interaction cross section can be suppressed to about 10%, providing essential input to future neutrino experiments such as SHiP.

The DsTau detector uses a layered high-resolution nuclear emulsion structure to observe the two-step decay $D_S \rightarrow \tau \rightarrow X$. After exposure to the 400 GeV proton beam, the emulsion films are developed and scanned with automated microscopes, allowing the three-dimensional reconstruction of charged particle tracks.

Experimental Procedures

In the search for D_S mesons, we exploit the fact that charm particles are always produced in pairs in proton–nucleus interactions. By requiring two charm hadron candidates in a single interaction (the "double-charm cut"), the background can be greatly reduced. In this context, the proper reconstruction of neutral charm hadrons is essential, as it allows efficient identification of events containing both neutral and charged charm hadrons, directly leading to an improvement in analysis sensitivity.

Neutral particles do not leave tracks in nuclear emulsion films, so their presence must be inferred indirectly. This is achieved by identifying decay vertices reconstructed from charged particle tracks, where the absence of a visible parent track indicates the decay of a neutral particle. In this way, decays of neutral particles and their characteristic topologies can be observed.

Based on reconstructed simulation data, selection criteria are being developed to efficiently distinguish signal events from background. Kinematic and topological variables such as flight length, opening angle, and impact parameter are studied to suppress background while maintaining signal efficiency. Ongoing efforts focus on optimizing these cuts, with the next step being their application to real experimental data.

Results and Discussion

At present, the analysis of neutral charm hadrons is being studied using Monte Carlo simulations. As the signal, D^0 mesons are selected, since they are the most abundantly produced neutral charm hadrons in the energy range of the DsTau experiment. The main backgrounds are taken to be γ and K_S^0. For simulations, PYTHIA is used to generate signal events, while EPOS is employed for background events.

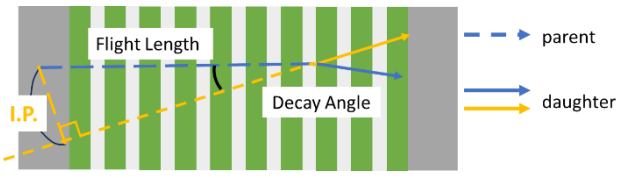

Fig 1. Description of each parameter

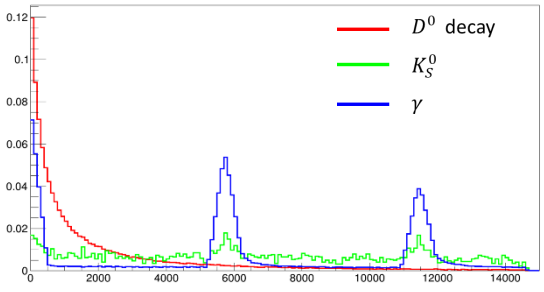

Fig 2. Distribution of flight length (MC truth)

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