PROJECT PROPOSAL

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Project Title: DsTau

1 PROJECT SUMMARY

Neutrinos are leptons like electrons and, there are six leptons (electron, muon, tau and their neutrino counterparts). Since neutrinos are nearly massless and chargless unlike charged leptons, neutrino detection is a challenging process. Moreover, detecting Tau neutrino is even tougher than the others because most of the time Tau neutrinos produced by the oscillation of the other neutrinos. Therefore, cross-section measurement of the Tau neutrinos is considerably less accurate than the other neutrinos. So, the point of this experiment is decrease the uncertainty in the measurement of cross-section of Tau neutrinos. The method is using more effective Tau neutrino source which is a proton nucleus scattering and using machine learning techniques to separate background processes from the desired process. The plan is reconstructing the scattering process by a event generator then estimating parameters with the result.

2 BACKGROUND

Measuring the cross-section of the neutrinos is crucial to understand Lepton Universality, which is an important principle for the Standard Model. In this experiment, proton-nucleus interaction used as a Tau neutrino source, but Tau neutrinos are not produced directly after scattering occurs. Instead after proton-nucleus interaction D and D_s charmed leptons produced, and D_s meson decays into Tau and Tau neutrino (see Figure 1). Therefore, to calculate cross-section of the Tau neutrino cross-section of D_s also must be known. [1]

Because of the lack of measurements of the D_s production cross-section, longitudinal dependence (n) is unknown. In order to estimate n value an event generator (Pythia [4]/Fluka) can be used. Also, with the help of the reconstructed experiment kink angle and flight length can be estimated. By using these estimated values the accuracy of the emulsion layer for efficient

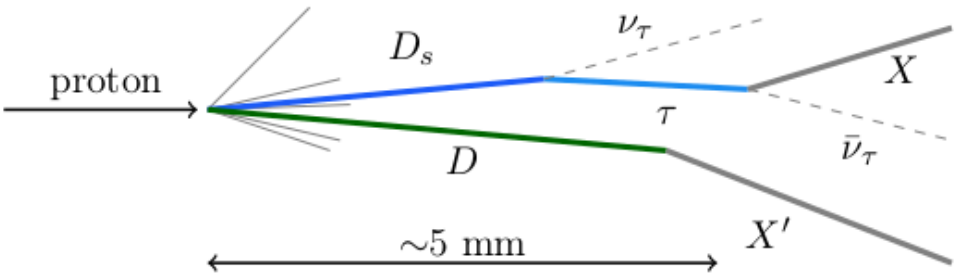

Figure 1: Tau neutrino production diagram.

measurement can be calculated. After parameters are obtained the experiment can be conducted and cross-section data can be collected. Then, with the help of TMVA desired data can be separated from background noise and errors. However, the efficiency of the measurements is still low, but it can be increased by applying thresholds to the parameters of particles.

3 METHOD

In this experiment, proton-nucleus interaction occurs. So, charmed particle production differential cross-section can be approximated as

$$\frac{d^2\sigma}{dx_f \cdot dp_t{}^2} \propto (1 - |x_f|)^n \cdot e^{-b \cdot p_t^2} \tag{1}$$

Where x_f [3] is Feynman x, p_t is transverse momentum, b is transverse dependence and n is longitudinal dependence parameter. As mentioned in the Background Section 2 n parameter depend on D_s which unknown due to lack of measurement of cross-section D_s. Moreover, scattering occurs in deep inelastic regime. Therefore cross-section formula can be approximated as

$$\sigma_{\nu_\tau} = \sigma_{\nu_\tau}^{const} \cdot E \cdot K(E) \tag{2}$$

Where $\sigma_{\nu_\tau}^{const}$ is energy independent cross-section, E is Energy of the neutrino and $K(E)$ is Kinematic effect due to lepton mass [2]. After n obtained from the event generator, it can be put inside the equation.

4 WORK PACKAGES AND TIMELINE

Weeks													
	2	3	4	5	6	7	8	9	10	11	12	13	14
WP 1	X	X	X										
WP 2			X	X	X								
WP 3					X	X	X	X					
WP 4								X	X	X			
WP 5										X	X	X	X
WP 6											X	X	

Description of Work Packages	
WP 1	Literature Search
WP 2	Learn root sofware, analyze pythia/fluka monte carlo root files
WP 3	Learn TMVA software, find discriminator parameters for signal events
WP 4	Using machine learning techniques seperate signal from background
WP 5	Prepare the written report
WP 6	Prepare the poster

References

[1] Shigeki Aoki, Akitaka Ariga, Tomoko Ariga, Sergey Dmitrievsky, Elena Firu, Dean Forshaw, Tsutomu Fukuda, Yuri Gornushkin, Ali Murat Guler, Maria Haiduc, and et al. Dstau: Study of tau neutrino production with 400 gev protons from the cern-sps, Jun 2019.

[2] K. Kodama, N. Ushida, C. Andreopoulos, N. Saoulidou, G. Tzanakos, P. Yager, B. Baller, D. Boehnlein, W. Freeman, B. Lundberg, and et al. Final tau-neutrino results from the donut experiment, Apr 2016.

[3] Jan Olsson. Measurement of feynman-x spectra of photons and neutrons in the very forward direction in deep-inelastic scattering at hera. *Proceedings of XXII. International Workshop on Deep-Inelastic Scattering and Related Subjects — PoS(DIS2014)*, 2014.

[4] Torbjörn Sjöstrand, Stephen Mrenna, and Peter Skands. A brief introduction to pythia 8.1, Oct 2007.