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Charged Lepton Flavor Violation at the EIC

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We present a comprehensive analysis of the potential sensitivity of the Electron-Ion Collider (EIC) to charged lepton flavor violation (CLFV)
in the channel $ep \to \tau X$, within the model-independent framework of the Standard Model Effective Field Theory (SMEFT).
We compute the relevant cross sections to leading order in QCD and electroweak corrections and perform simulations of signal and SM background events in various τ decay channels, suggesting simple cuts to enhance the associated estimated efficiencies. To assess the discovery potential of the EIC in τ-e transitions, we study the sensitivity of other probes of this physics across a broad range of energy scales, from $pp \to e\tau X$ at the Large Hadron Collider to decays of B mesons and τ leptons,
such as $\tau \to e\gamma$, $\tau \to e\ell^+\ell^-$, and crucially the hadronic modes $\tau \to eY$ with $Y \in \{\pi, K, \pi\pi, K\pi, ...\}$.
We find that electroweak dipole and four-fermion semi-leptonic operators involving light quarks are already strongly constrained by τ decays, while operators involving the c and b quarks present more promising discovery potential for the EIC. An analysis of three models of leptoquarks confirms the expectations based on the SMEFT results. We also identify future directions needed to maximize the reach of the EIC in CLFV searches: these include an optimization of the τ tagger in hadronic channels, an exploration of background suppression through tagging b and c jets in the final state, and a global fit by turning on all SMEFT couplings, which will likely reveal new discovery windows for the EIC.

Primary author: YAN, Bin (IHEP)

Presenter: YAN, Bin (IHEP)

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