Background simulations on Charged-Lepton Flavor Violation (CLFV) in the Leptoquark framework at the EIC

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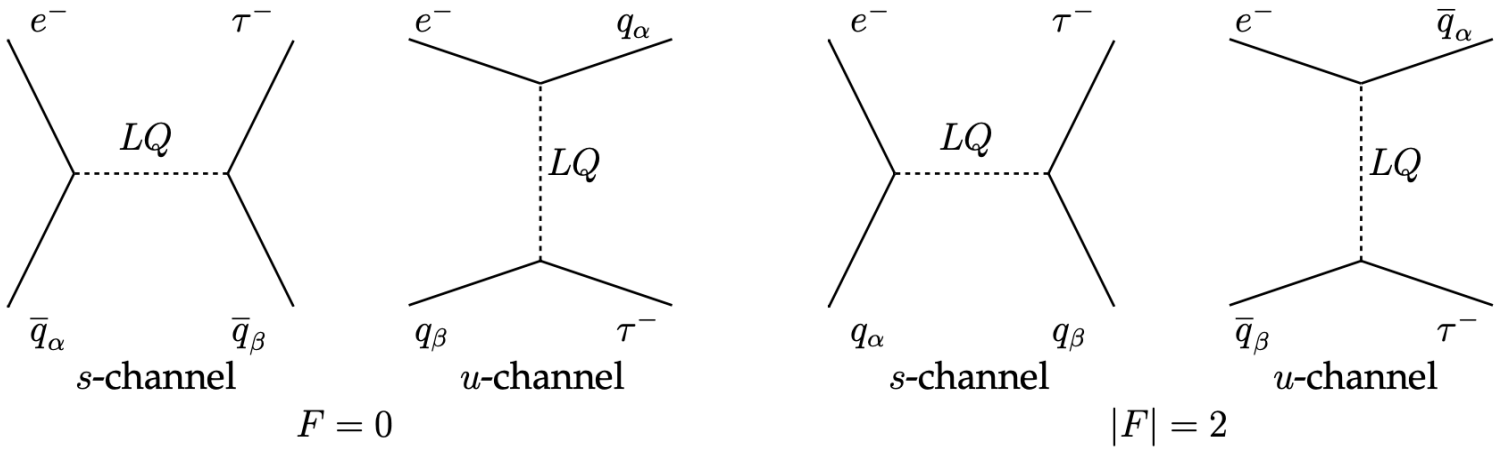
Charged-Lepton Flavor Violation in the leptoquark framework

Leptoquarks are color triplet bosons that carry both lepton (L) and baryon (B) numbers, coupling leptons to quarks and mediating the $e + p \rightarrow \tau + X$ CLFV process at tree-level



$F = 0$ $\quad\quad$ $|F| = 2$

arXiv:1006.5063v1

We carry out the simulation analysis for determining sensitivity to the CLFV process $e+p \rightarrow \tau + X$ in the leptoquark framework.

Simulation

- The goal of this work is to study charged lepton flavor violations at the EIC based on the real **ePIC** detector simulations concentrating on three main background events:

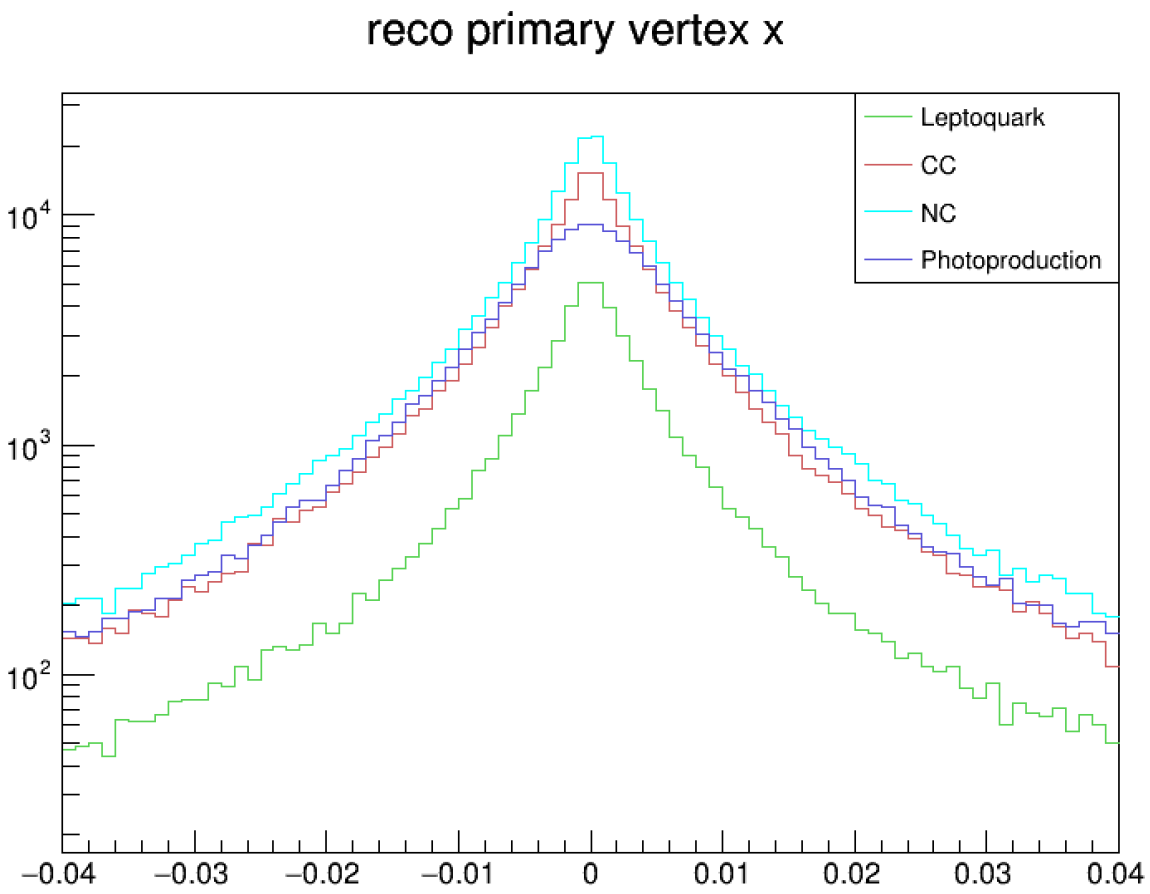
1. Charged Current Deep Inelastic Scattering (CC DIS)
2. Neutral Current Deep In- elastic Scattering (NC DIS)
3. Photoproduction

- Study the potential of searching for $e^- \rightarrow \tau^-$ conversion event by ECCE indicates that the dominant τ decay modes can be categorized into “1-prong” and “3-prong”

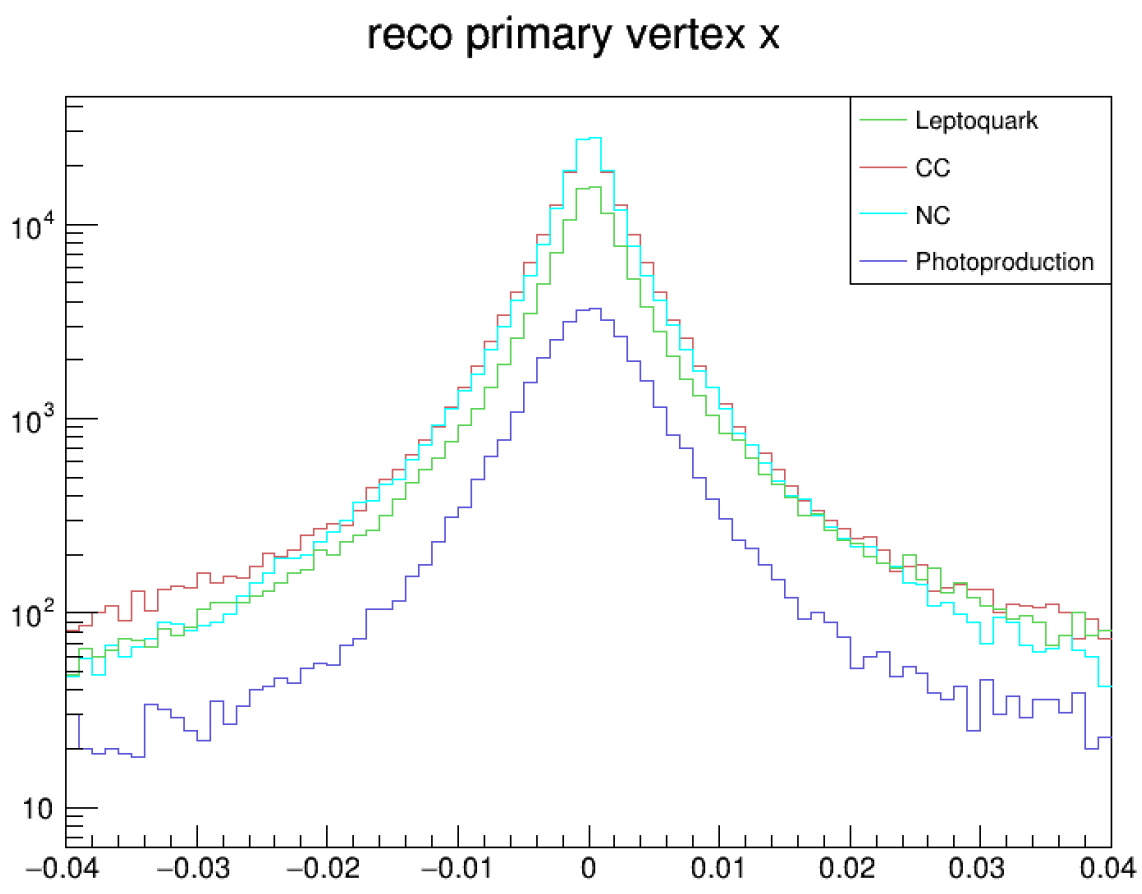
DIS background NC and CC events generated with **Djangoh**

Photoproduction background generated using **Pythia**

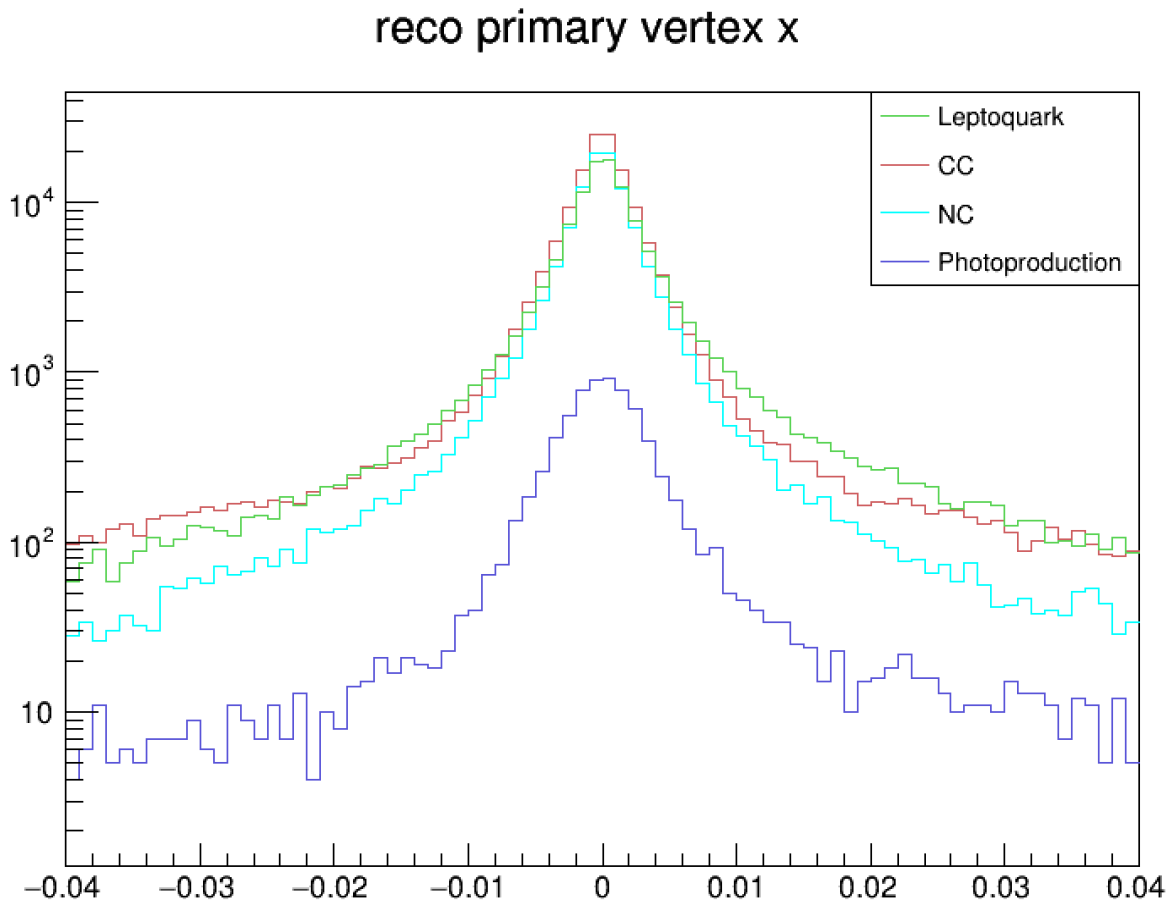
What is done so far!



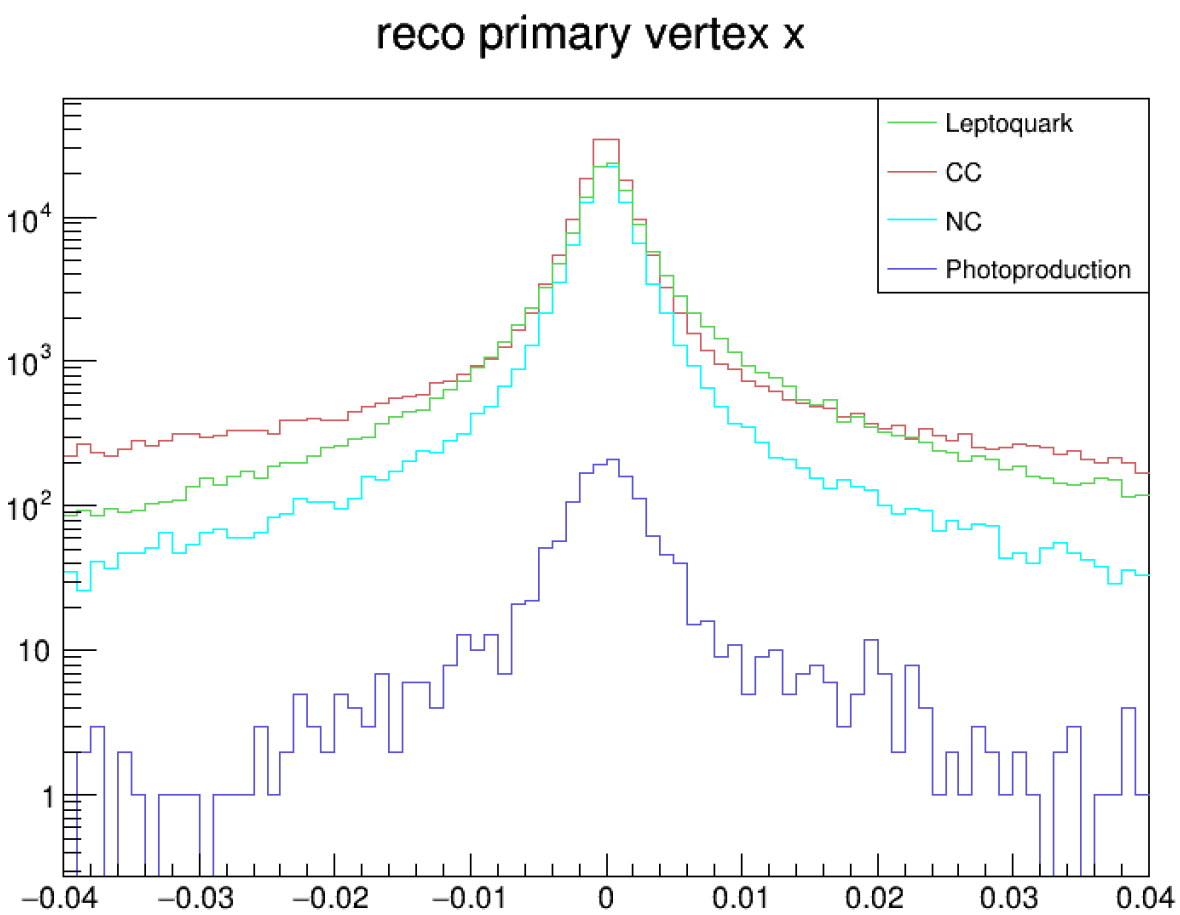
Number of tracks < 4



Number of tracks < 6

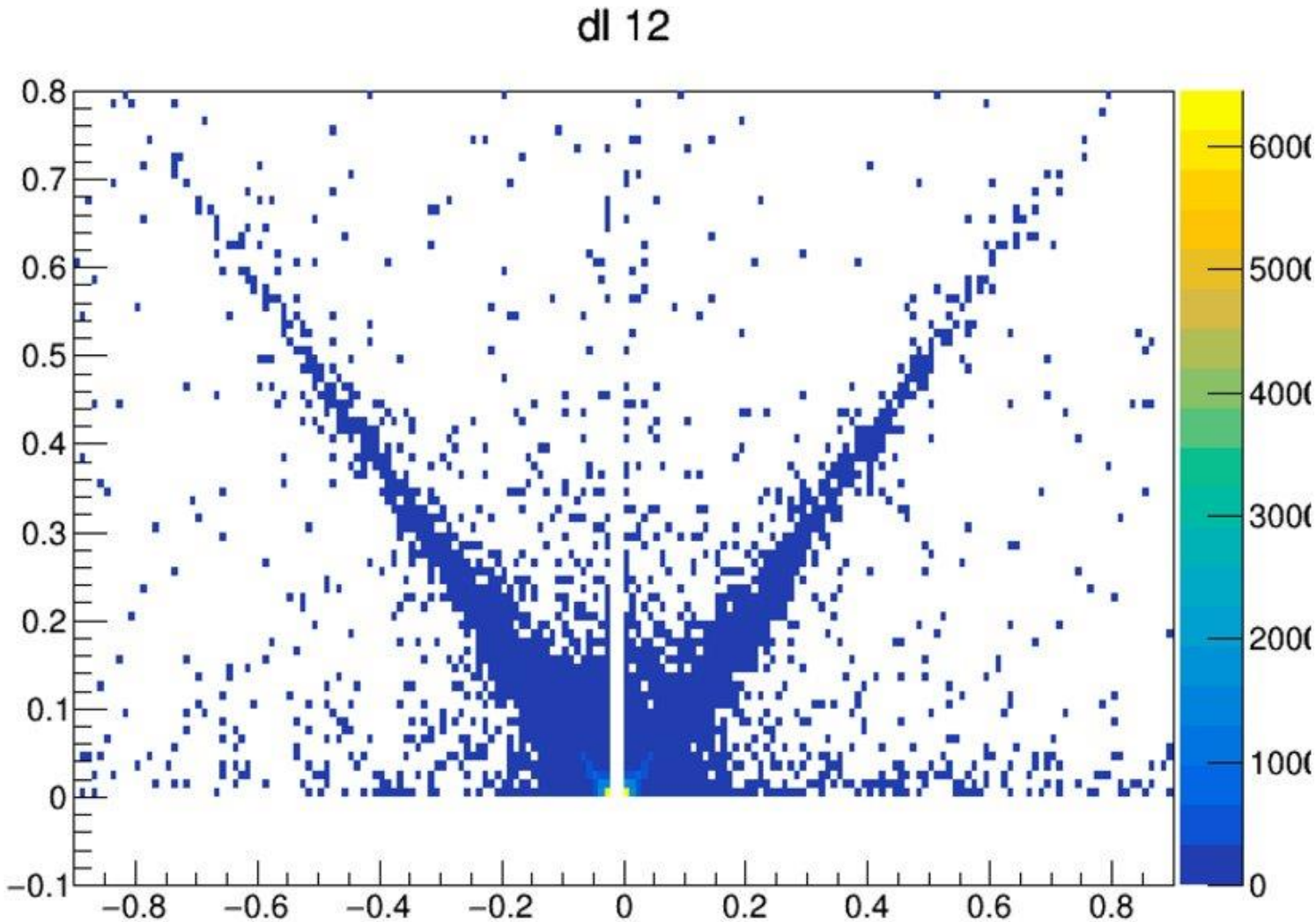


Number of tracks < 8



Number of tracks < else

To reconstruct the secondary vertex, we first look for 3-π candidates.

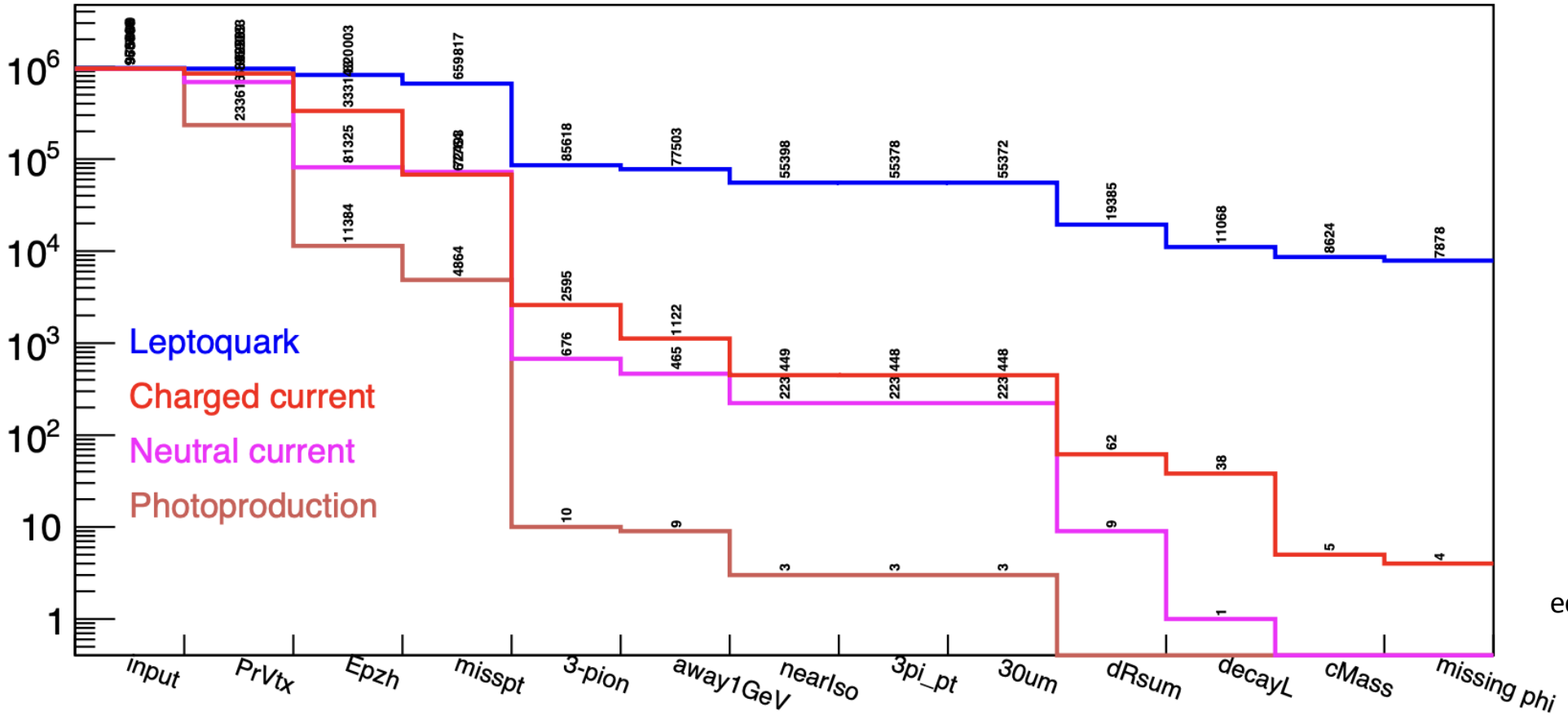


Coincidence between two of the three “intermediate” vertices (either left or right half) is usually enough to indicate a “3-prong" secondary vertex.

Coincidence among three “intermediate” vertices for 3-π event identification

Sensitivity to Leptoquarks

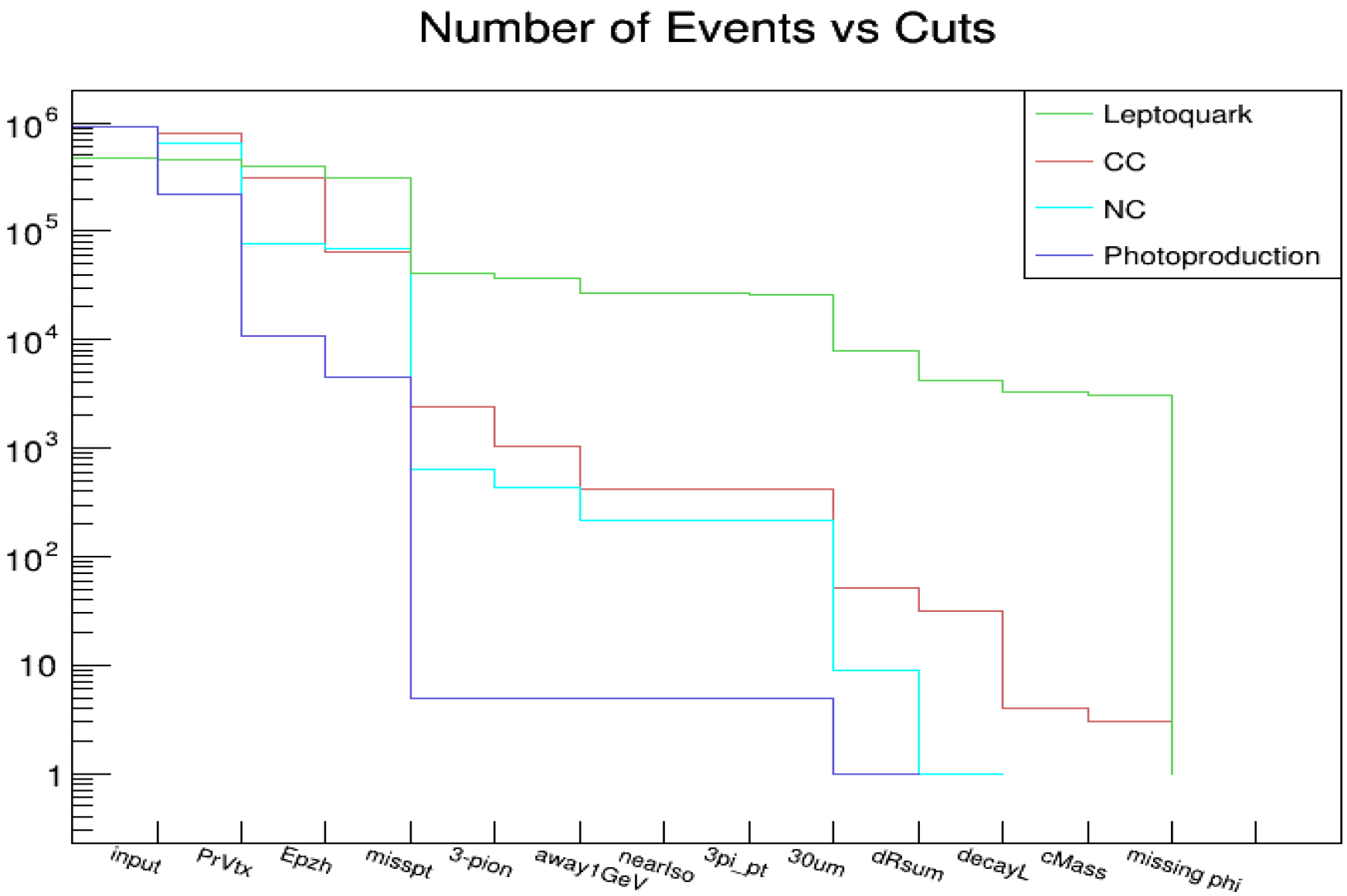
The sensitivity to the leptoquark signal cross section based on simulations of the 3-prong decay mode of the tau lepton



ecce-note-phys-2021-14 v1.0

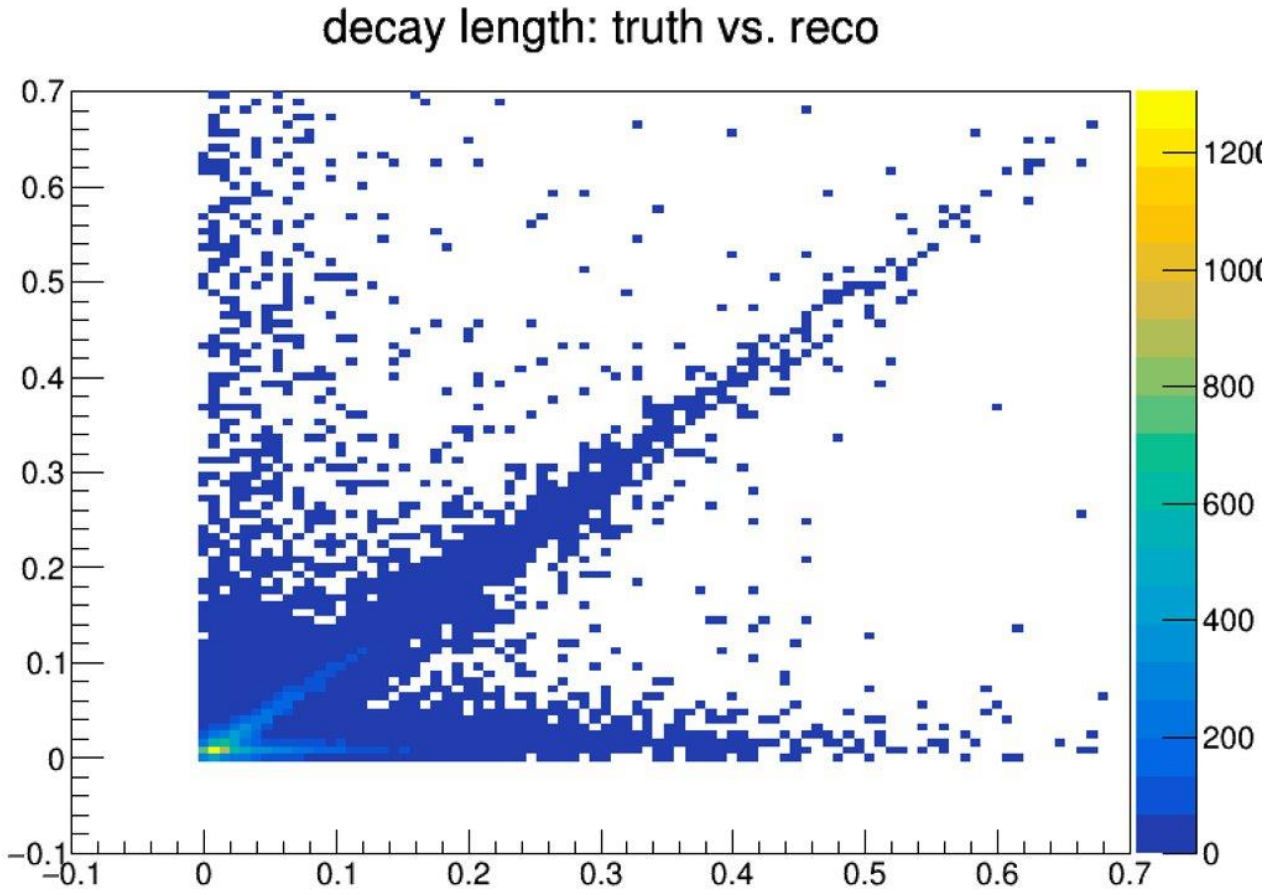
1M MC event samples are generated for each of the four processes: the leptoquark mediated signal process e + p → τ + X, and three backgrounds.

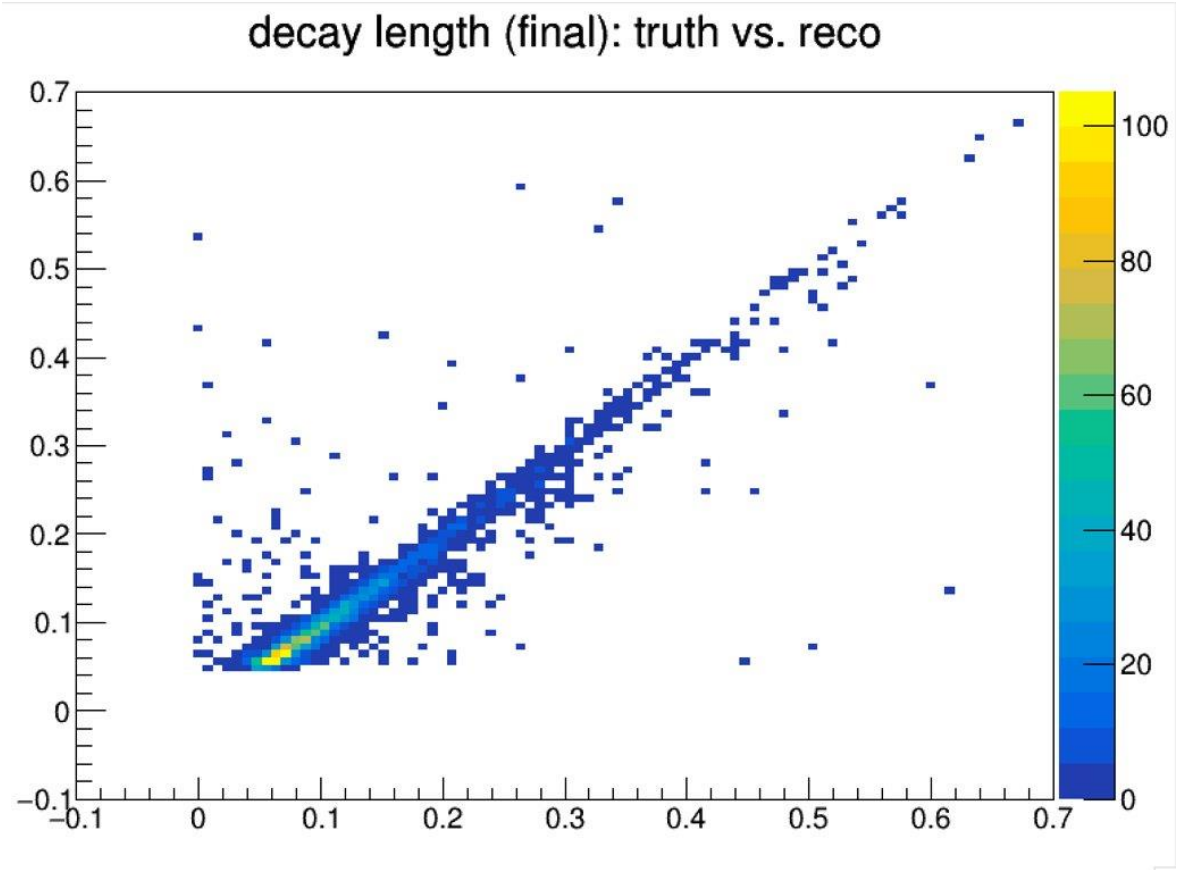
Sensitivity to Leptoquarks



the e → τ events can be effectively selected with these preliminary cuts

using ***decayL*** as one of the event selection criteria , which is the average of the reconstructed decay lengths from three pair combinations of the 3-π candidate





comparison between the true decay length from the generator and the decay length reconstructed from tracks at the detector level

Planning for the future work

- higher statistics up to 10M background events from input files provided by ECCE work
- output files for background simulation for higher statistics are ready but running the event generation in **Djangoh** and **Pythia**, then pass those events through the **ePIC** detector simulation is not done yet
- Optimize selection criteria of events
- Compare S/B by using for example multivariable technique (Machine learning with ROOT) TMVA https://root.cern/manual/tmva/
- Working towards "1-prong" modes which are more demanding to identify experimentally