BSM@EIC: Study CLFV at EIC

Yasser Corrales, MingLiu
MIT & LANL
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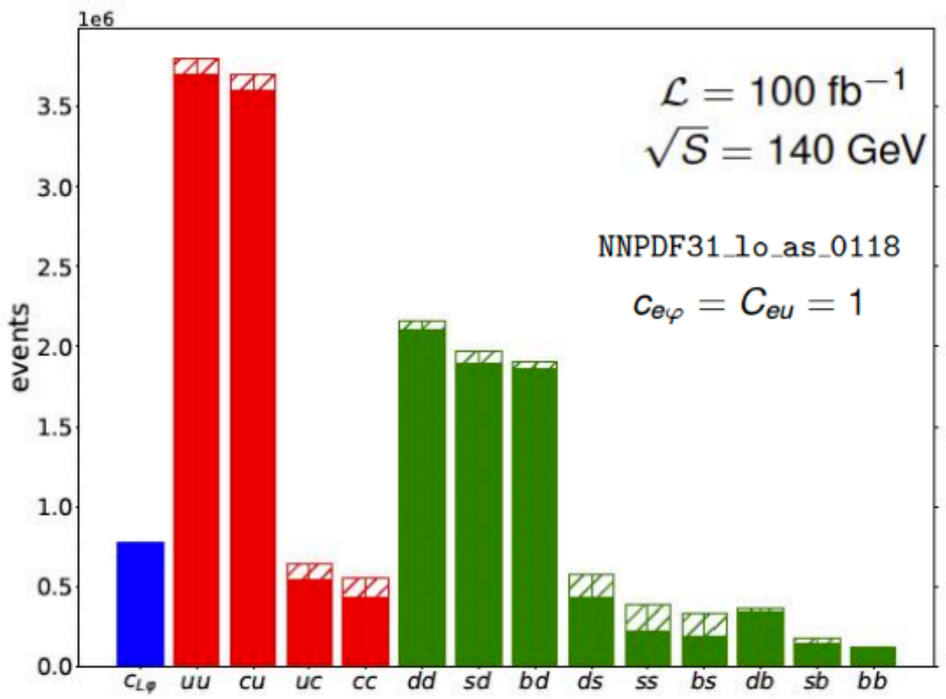
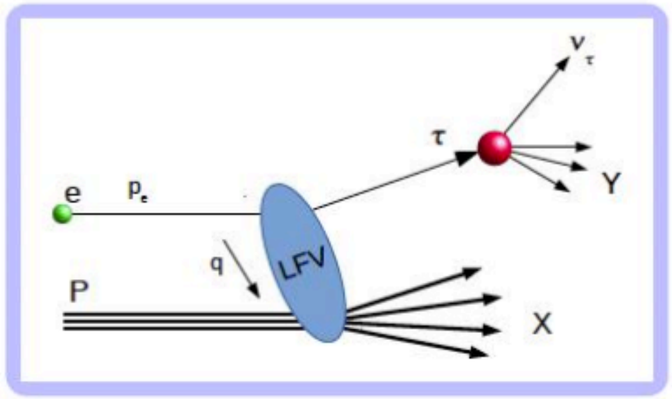
CLFV Deep Inelastic Scattering



B. Yan, K. Fuyuto, E. Mereghetti



Right handed τ_R, e_R
Right handed u_R, d_R

- most cross sections in the 1-10 pb range, for $\Lambda = v$
- realistic values of Λ obtained by simple rescaling
- heavy flavors c, b suppressed by factor ten

- consider **two** specific operator: righ-handed Z couplings and four-fermion operators

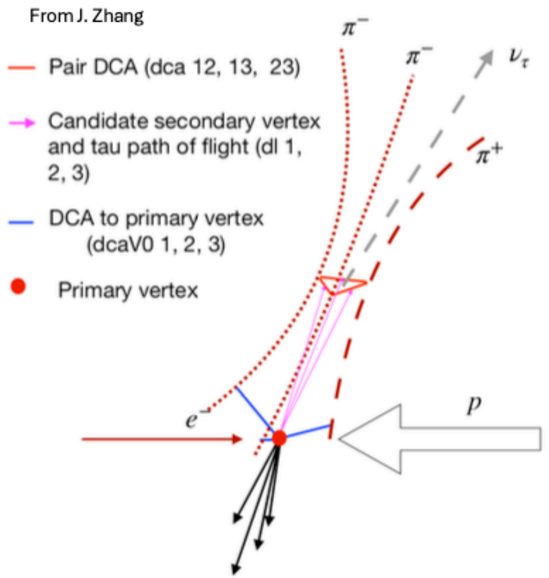
$$\mathcal{L} = -\frac{g}{2c_W} c_{e\varphi} Z_\mu \bar{\tau}_R \gamma^\mu e_R - \frac{4G_F}{\sqrt{2}} \bar{\tau}_R \gamma^\mu e_R \left(C_{eu}^{ij} \bar{u}_R^j \gamma_\mu u_R^j + C_{ed}^{ij} \bar{d}_R^j \gamma_\mu d_R^j \right) \qquad C_{eu},\, C_{ed} = \mathcal{O}\left(\frac{v^2}{\Lambda^2}\right)$$

- the dimensionless coefficients $c_{e\varphi}$, C_{eu}, C_{ed} scale as two inverse powers of the BSM scale Λ

CLFV and Tau tagging at EIC

EIC provides:

- a precise electron - quark collider
- highly polarized electron and proton beams
- great opportunity to search BSM physics signal with displaced vertices.



1. $ep \to \tau X \to e + \not{E} + X$
2. $ep \to \tau X \to \mu + \not{E} + X$
3. $ep \to \tau X \to X_h + \not{E} + X$

CLFV study via novel τ-tagging method using ML technique with the ePIC detector:

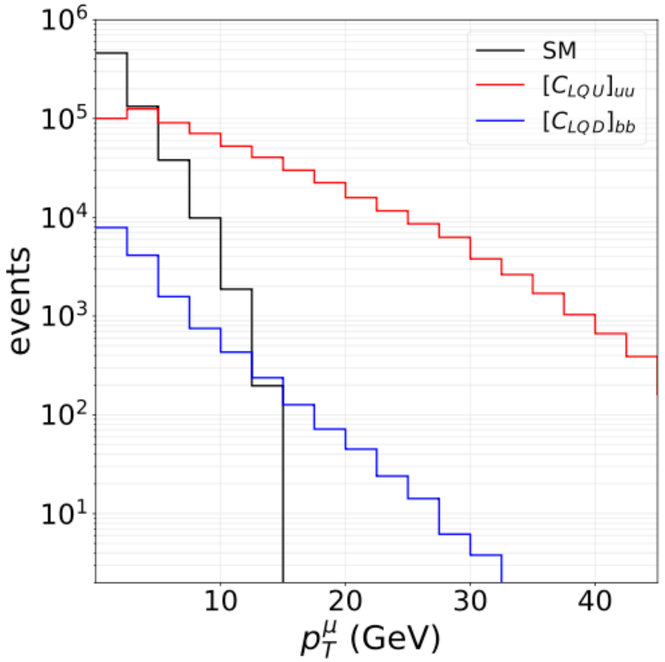
- Required full ePIC simulation with events containing τ decays
- We did not find official ePIC simulation useful for this study

However…

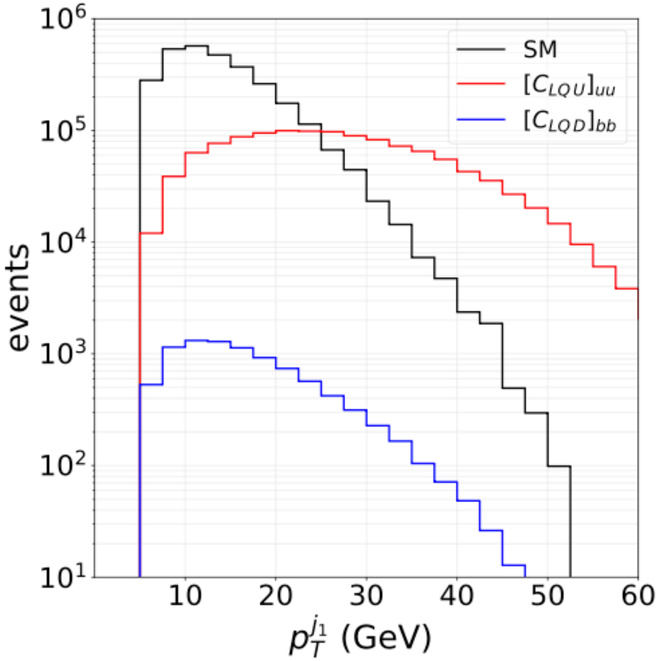
Tau lepton pythia simulation at EIC

LANL theoretical can provided mixing SM & SMEFT pythia8 + Delphes generated events (ep->τX) -> integrate in the ePIC simulation framework

$\tau \to \mu\nu_\mu\nu_\tau$ channel



τ hadronic decays



Tau lepton pythia simulation at EIC

As requested before submit request, we tested the simulated model with the ePIC framework locally:

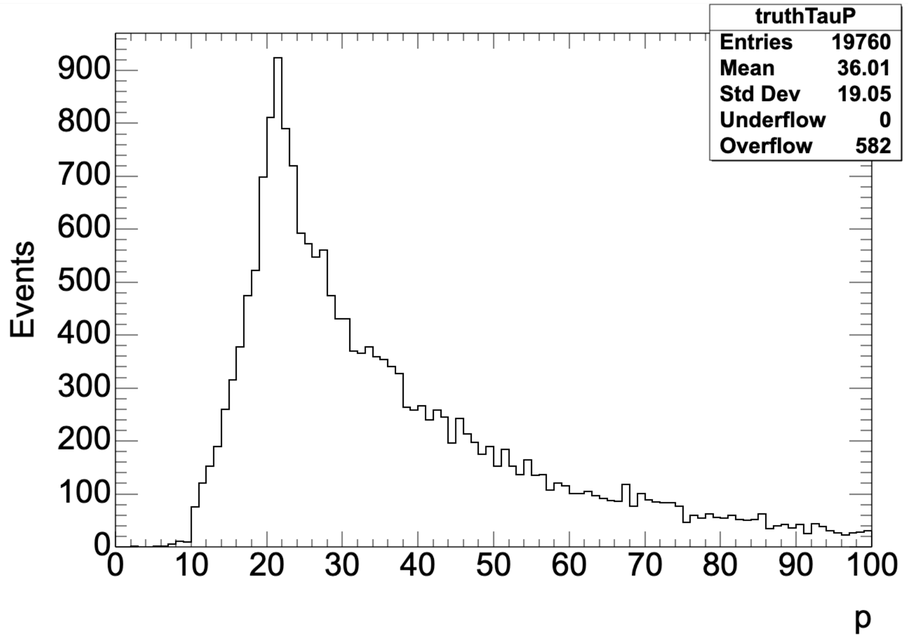
- Apply afterburner and convert dataset from hepmc3 to root file using *abconv* & *hepmc3ascii2root* tools
  - Input dataset was created using a non standard EIC proton energy setup (250 GeV), changed input file manually for testing, but we should use correct beam energy setup in the future.
- Use instruction from the landing page to run the simulation and reconstruction with the Epic framework:
  - npsim "${common_flags[@]}" “${uncommon_flags[@]}”;
  - eicrecon -Ppodio:output_file=“${RECO_OUT_FILE_NAME}" -Pjana:nevents="${EVENTS_PER_TASK}" -Pdd6hep:xml_files="${DETECTOR_PATH}/${DETECTOR_CONFIG}.xml" "${SIM_OUT_FILE_NAME}"

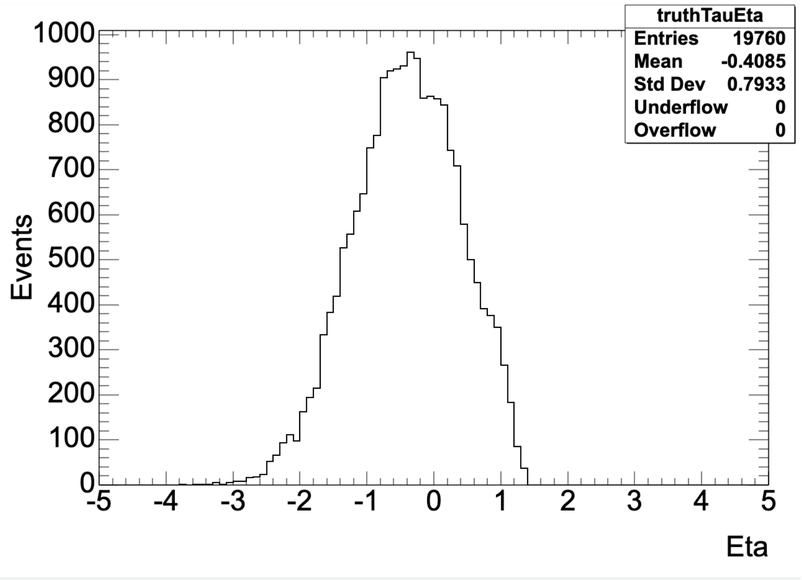
```
common_flags=(
  --random.seed "${SEED:-1}"
  --random.enableEventSeed
  --printLevel WARNING
  --filter.tracker 'edep0'
  --numberOfEvents "${EVENTS_PER_TASK}"
  --compactFile "${DETECTOR_PATH}/${DETECTOR_CONFIG}".xml
  --outputFile “$SIM_OUT_FILE_NAME"
)
```

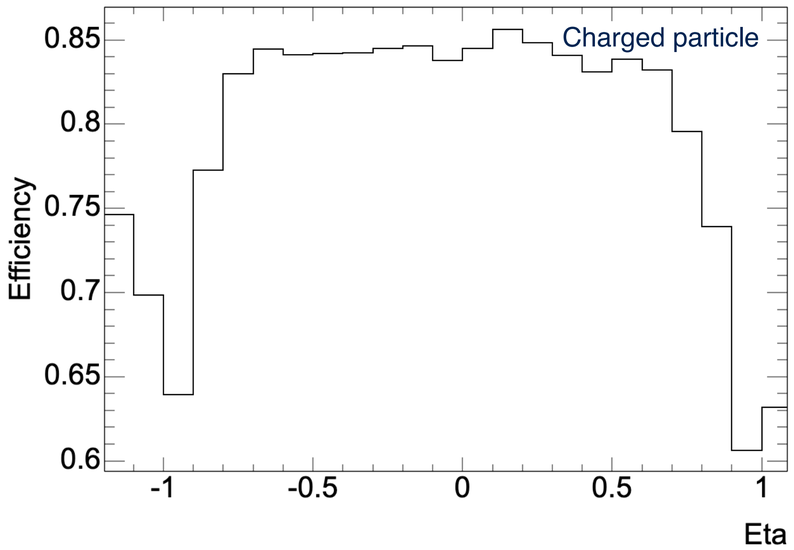
```
uncommon_flags=(
--runType batch
--skipNEvents "${SKIP_N_EVENTS}"
--hepmc3.useHepMC3 "${USEHEPMC3:-true}"
--physics.alternativeStableStatuses "${STABLE_STATUSES}"
--physics.alternativeDecayStatuses "${DECAY_STATUSES}"
--inputFiles "${INPUT_FILE}"
)
```

simulation & reconstruction output

Generated τ momentum and pseudo rapidity distribution







Charged particle tracking efficiency vs pseudorapidity

Next step

- Check $\tau \rightarrow 3\pi^{\pm} + \nu_{\tau}$ reconstruction capability, as well as $\tau \rightarrow \mu + \nu_{\tau} + \nu_{\mu}$
- Check the τ vs reconstructed daughters (p_T, eta) correlations
- Request LANL theory group to generate 1-10M events using with right EIC energy setup [275x10]?.
- Request production in ePIC official simulation campaign?