Modelling high energy neutrino scattering at the FPF

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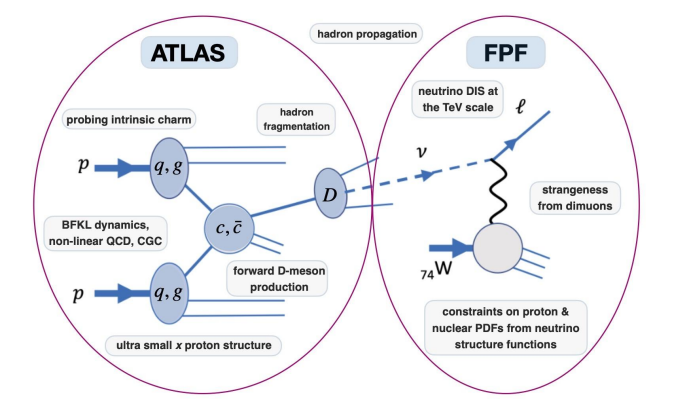
Based on work in progress together with Valentina Schutze Sanchez, Peter Krack, Melissa van Beekveld and Juan Rojo

The need for a more precise event generator

- Possibility to detect high energy neutrinos originating from the LHC
- Make theory framework around FPF more complete
- Current event generators LO+obsolete parton shower (PYTHIA6)
- We want NLO+PYTHIA8 for more precise cross sections at high energies
- Small-x PDF constraints



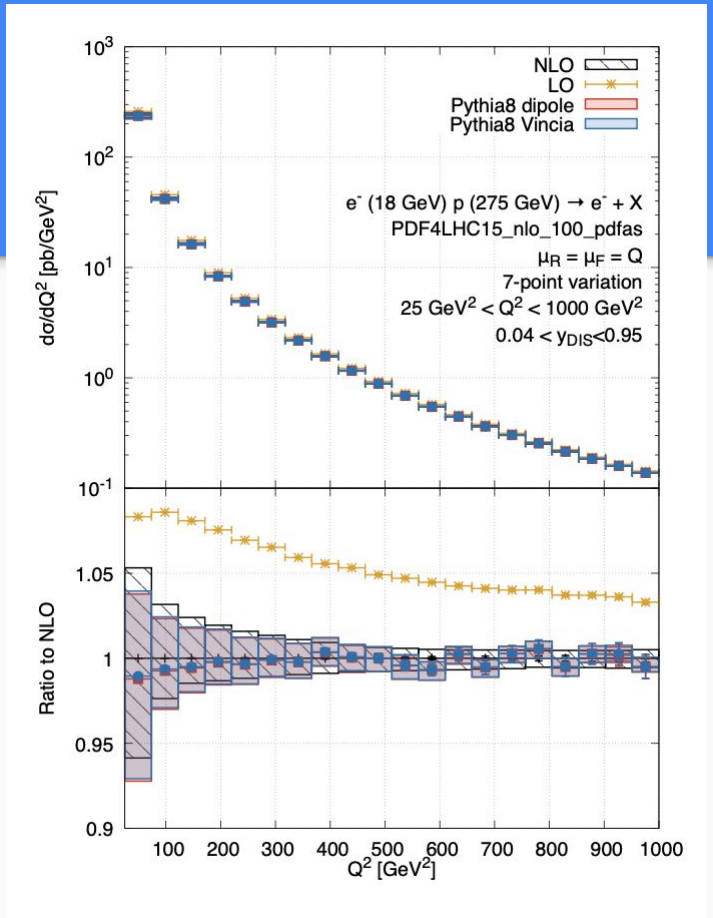
Starting point: POWHEG(electrons)

A POWHEG generator for deep inelastic scattering

Andrea Banfi, Silvia Ferrario Ravasio, Barbara Jäger, Alexander Karlberg, Felix Reichenbach, Giulia Zanderighi

We present a new event generator for the simulation of both neutral- and charged-current deep inelastic scattering (DIS) at next-to-leading order in QCD matched to parton showers using the POWHEG method. Our implementation builds on the existing POWHEG BOX framework originally designed for hadron-hadron collisions, supplemented by considerable extensions to account for the genuinely different kinematics inherent to lepton-hadron collisions. In particular, we present new momentum mappings that conserve the special kinematics found in DIS, which we use to modify the POWHEG BOX implementation of the Frixione-Kunszt-Signer subtraction mechanism. We compare our predictions to fixed-order and resummed predictions, as well as to data from the HERA ep collider. Finally we study a few representative distributions for the upcoming Electron Ion Collider.

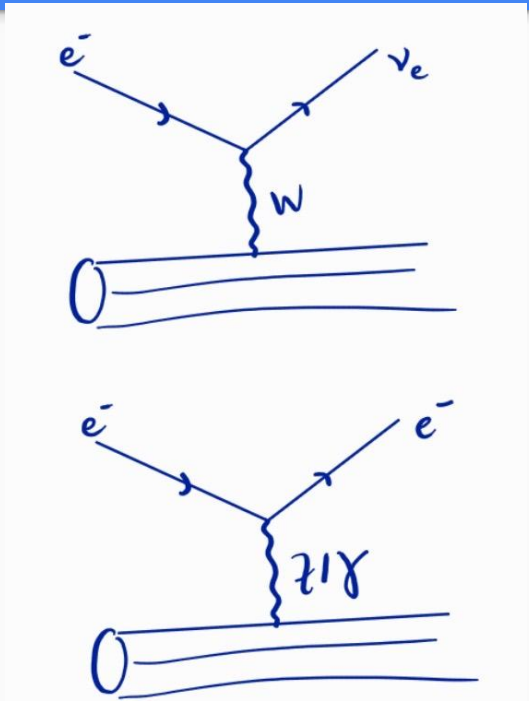
arXiv:2309.02127



arXiv:2309.02127

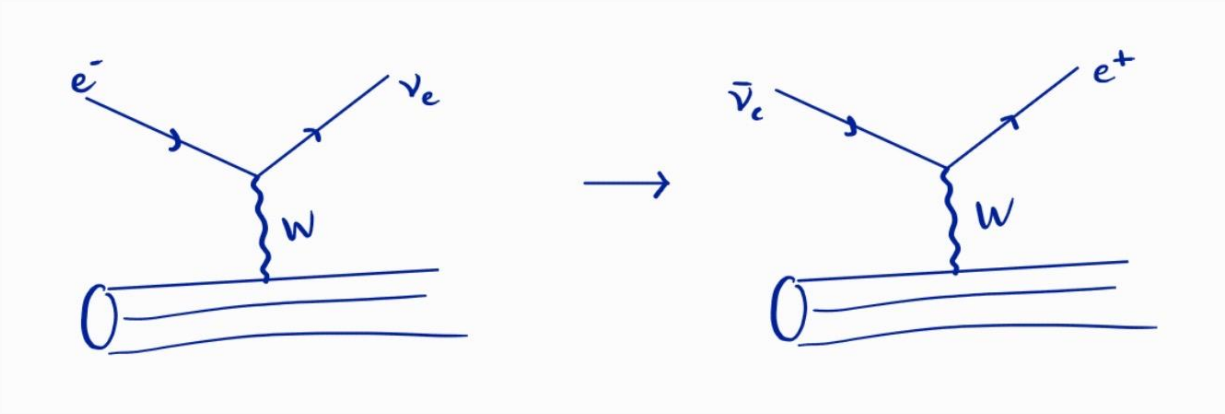
POWHEG(electrons)

- Event generation from PDFs
- Delta function as incoming electron ‘PDF’
- Accounts for ISR & FSR
- LO+PS & NLO+PS matching with PYTHIA8
- Computes theory errors from variation around renormalisation & factorisation scale
- EIC

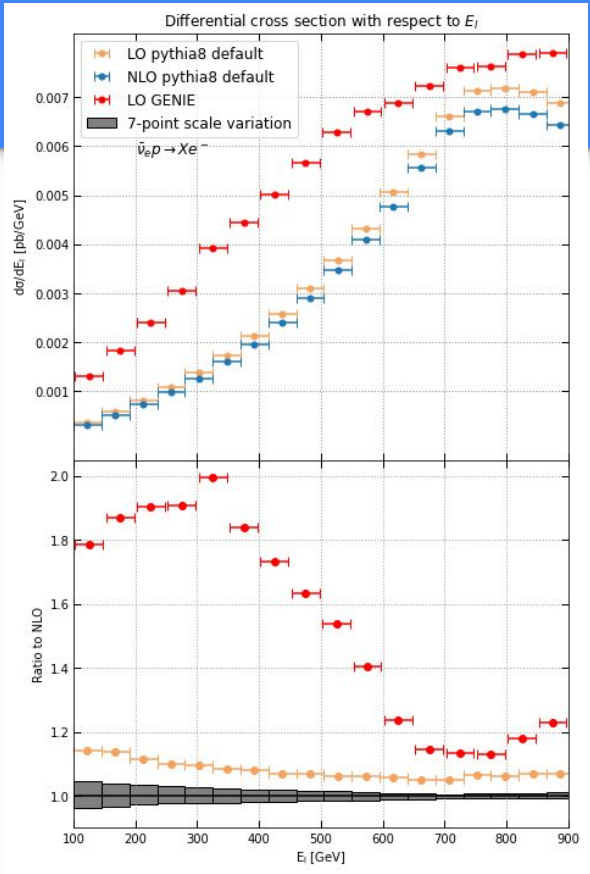


POWHEG(neutrinos)

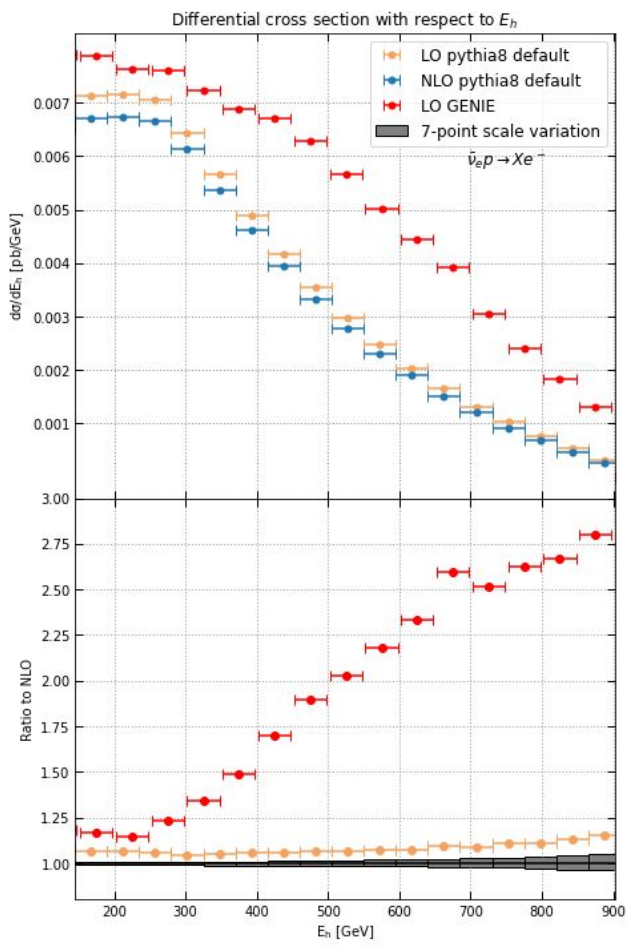
- Use charged current vertex
- Neutrino in initial state
- Neutrino flux as a neutrino ‘PDF’ → LHAPDF grid with

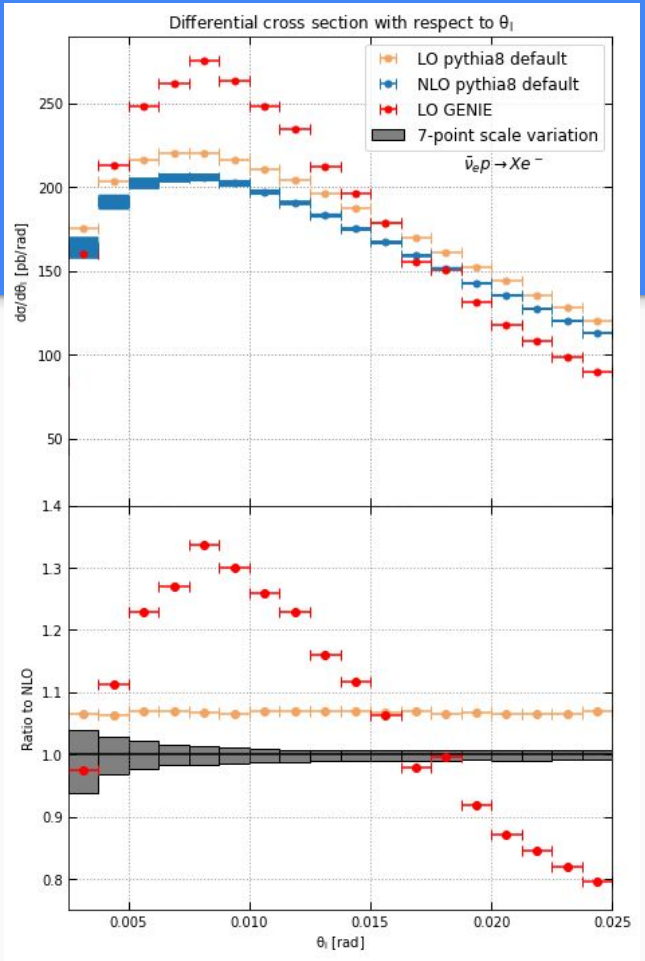


Cross sections for final state kinematics



- E_l, E_h, θ_l
- FASER acceptance cuts
- NLO QCD correction is important for final state kinematics


Differential cross section with respect to E_h
LO pythia8 default
NLO pythia8 default
LO GENIE
7-point scale variation
$\bar{\nu}_e p \to X e^-$
$d\sigma/dE_h$ [pb/GeV]
Ratio to NLO
E_h [GeV]


Differential cross section with respect to θ_l
LO pythia8 default
NLO pythia8 default
LO GENIE
7-point scale variation
$\bar{\nu}_e p \to X e^-$
$d\sigma/d\theta_l$ [pb/rad]
Ratio to NLO
θ_l [rad]

Outlook

- So NLO correction should be accounted for
- Account for neutrino fluxes
- Validate POWHEG(neutrinos) with FASER or SND@LHC data
- Make the code public
- Use it! E.g. constraining small-x PDFs, looking at deviations from fixed-order QCD