# Monte-Carlo Tools and Simulation

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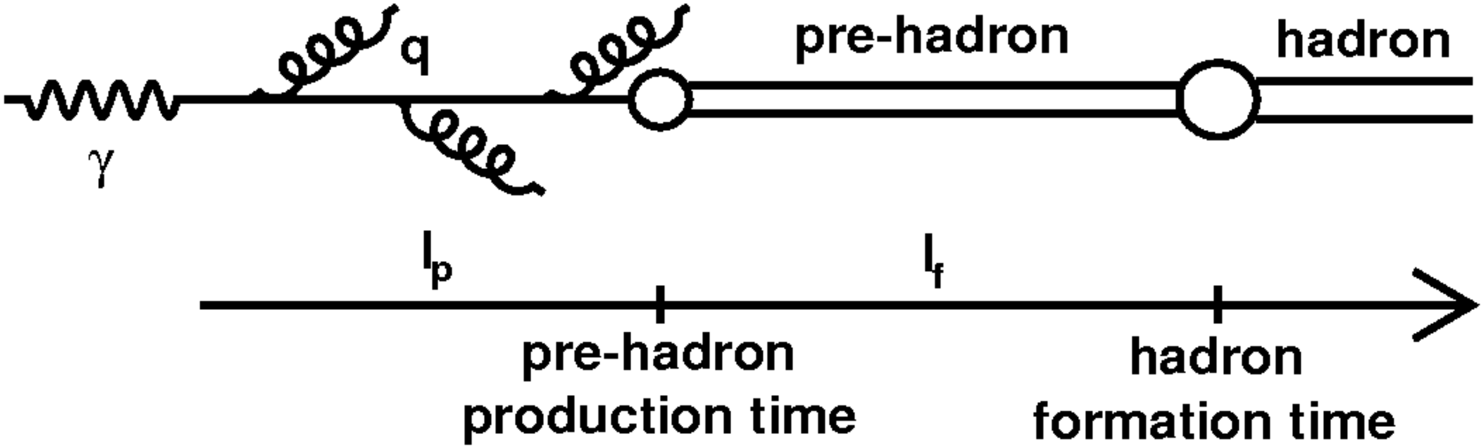
# Outline

- Overview of the MC efforts
- Quark Energy Loss Simulation
- EIC Projections
- Future Work and Summary

# Parton Propagation and Fragmentation




- What are we measuring and why?
  - The fragmentation time scales to understand the dynamic of hadronization
  - The in-medium energy loss to characterize our medium

# Overview of the MC efforts

- PYTHIA add-on
  - Fermi motion, BDMPS energy loss with Lund fragmentation (Dupré and Accardi)
  - BDMPS energy loss and fragmentation with Fragmentation Functions (Daniel)

- PYTHIA modification (based on Q-PYTHIA)
  - Adapt to cold nuclear matter geometry (Accardi, Ploszkon)
  - Extend it to treat HT energy loss (Majumder)

- GiBUU
  - Already tested simulation

# Observables

- Light Quarks
  - $\pi^0$, $\eta$ comparison (energy loss vs prehadron absorption)
  - Verify that Ratio → 1 at large $\nu$ as indicated by EMC
  - $p_T$-broadening:
    - vs. Q2 – to understand HERMES data growing values
    - vs. z - for precision tests of theory models
  - Cronin effect at large $p_T$ - test of fragmentation vs. recombination

- Heavy Quarks
  - heavy vs. light mesons in general
  - B vs D mesons (heavy flavor puzzle)

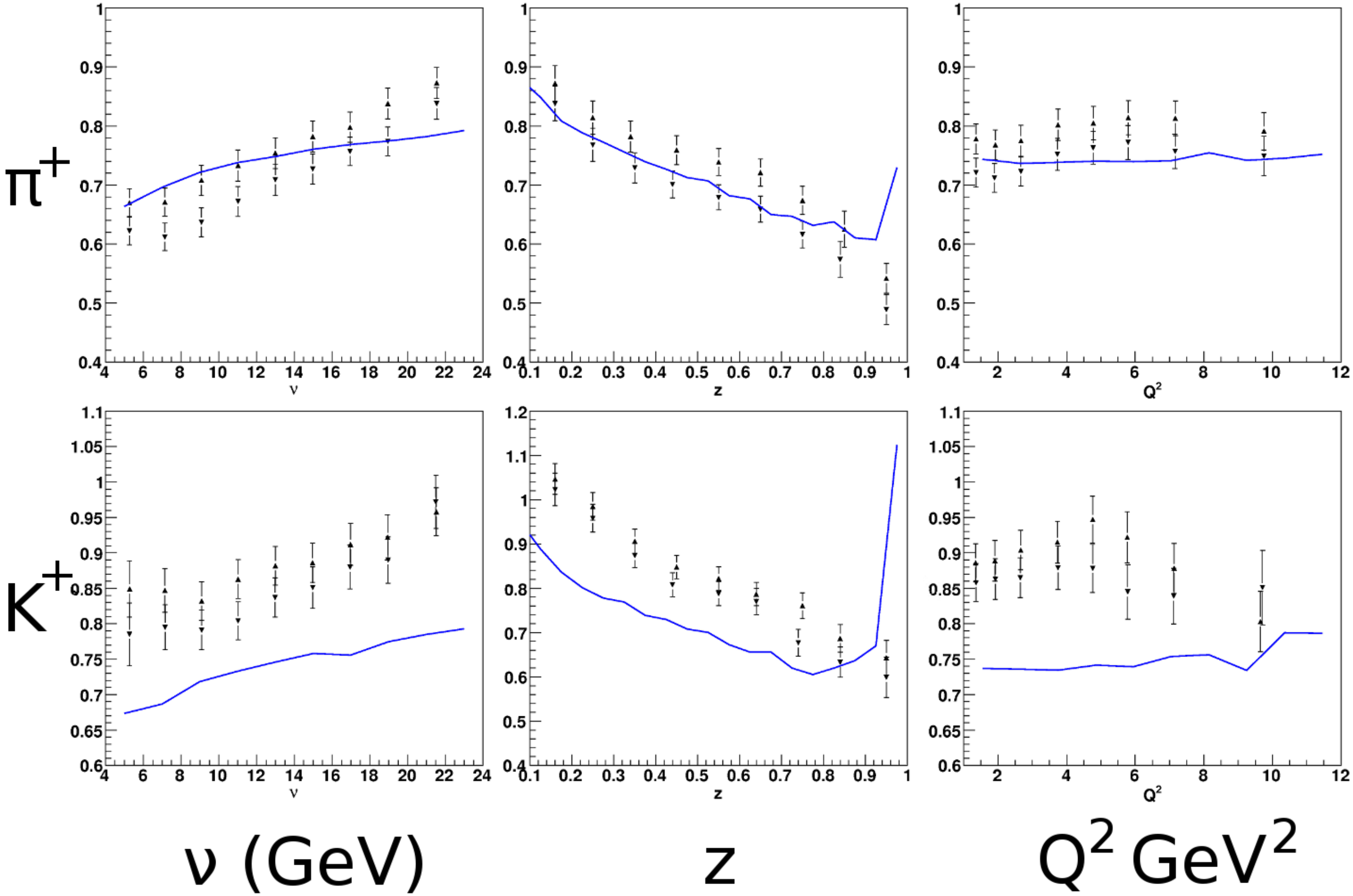
- Jets
  - Jet rates as a function of cone radius - gluon radiation will broaden jets
  - Semi-inclusive jet $p_T$-broadening – direct parton $p_T$-broadening
  - Compare to jets at RHIC

# Energy Loss Based Simulation

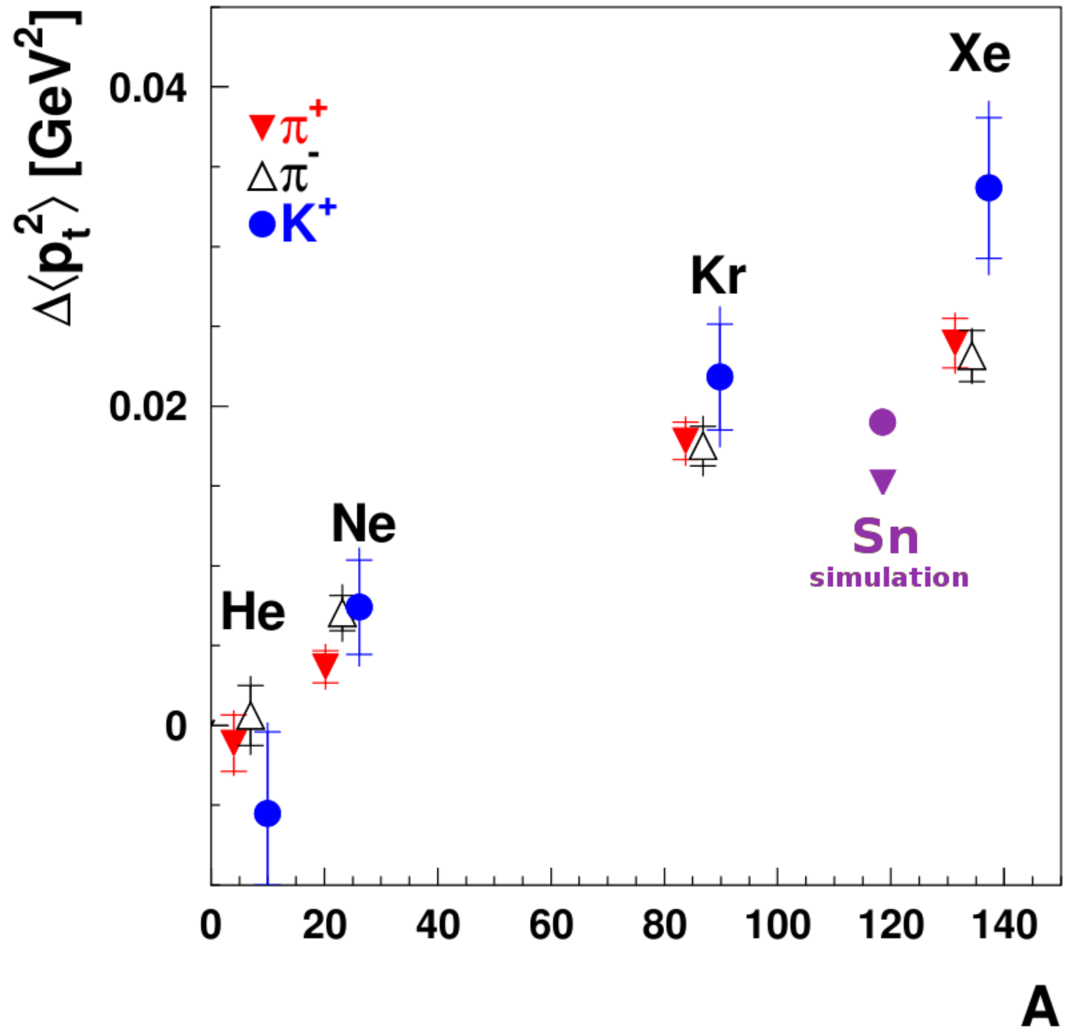
- PYTHIA is both used for
  - Parton level generator
  - Lund fragmentation of the products
- Include Fermi motion
- Apply BDMPS energy loss to produce partons
  - Calculation from Salgado and Wiedmann (2002)
  - Attribute a transverse momentum according to the energy loss

# Simulation Compared to HERMES Data

**HERMES data (Kr & Xe) - Simulation $\hat{q} = 0.4\ GeV^2\ fm^{-1}$ (Sn)**



# Simulation Compared to HERMES Data

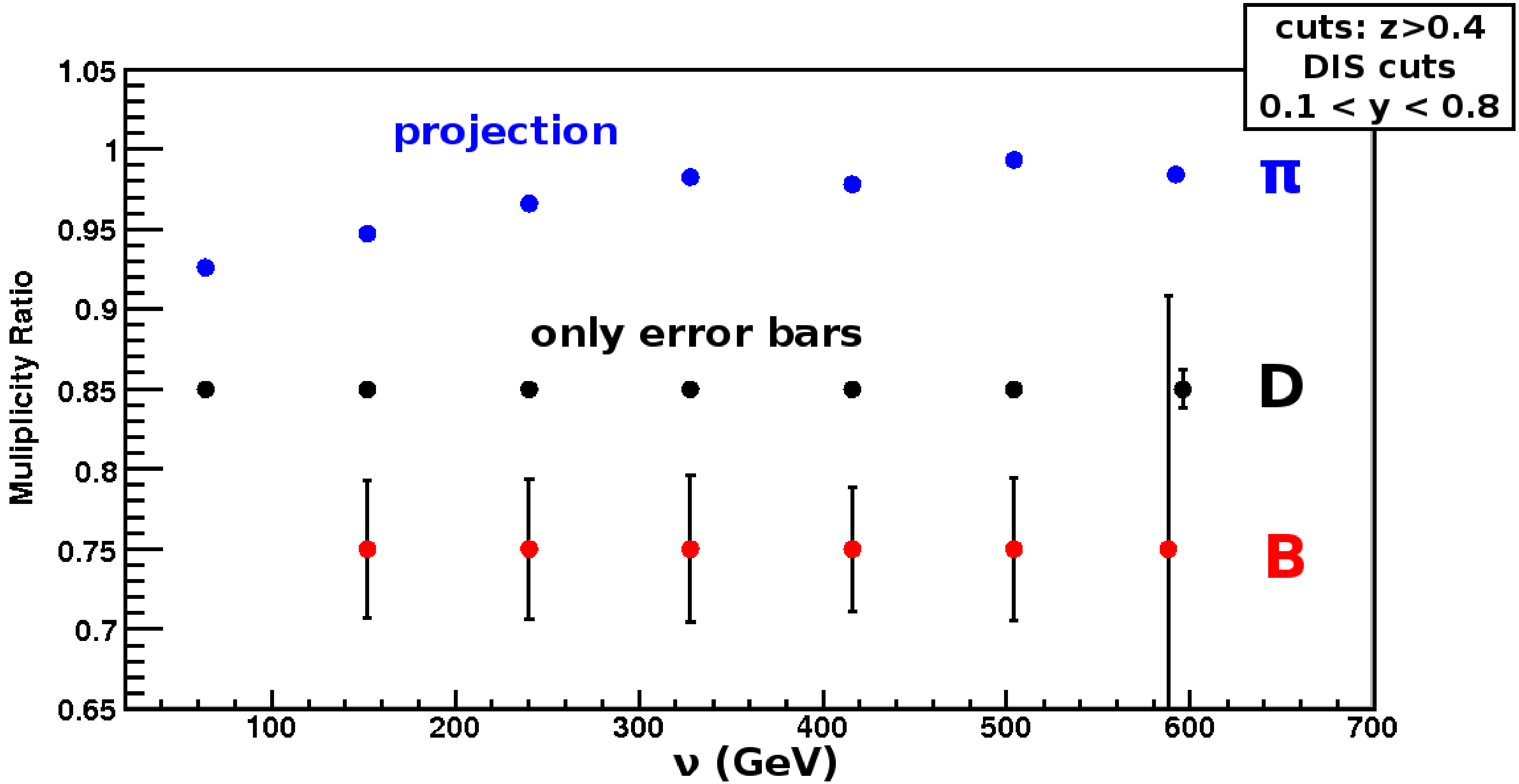


# What need to be elaborated ?

- Model reliable at high z only
  - Create gluons to compensate energy loss
  - Give part of the energy loss to spectator nucleon?

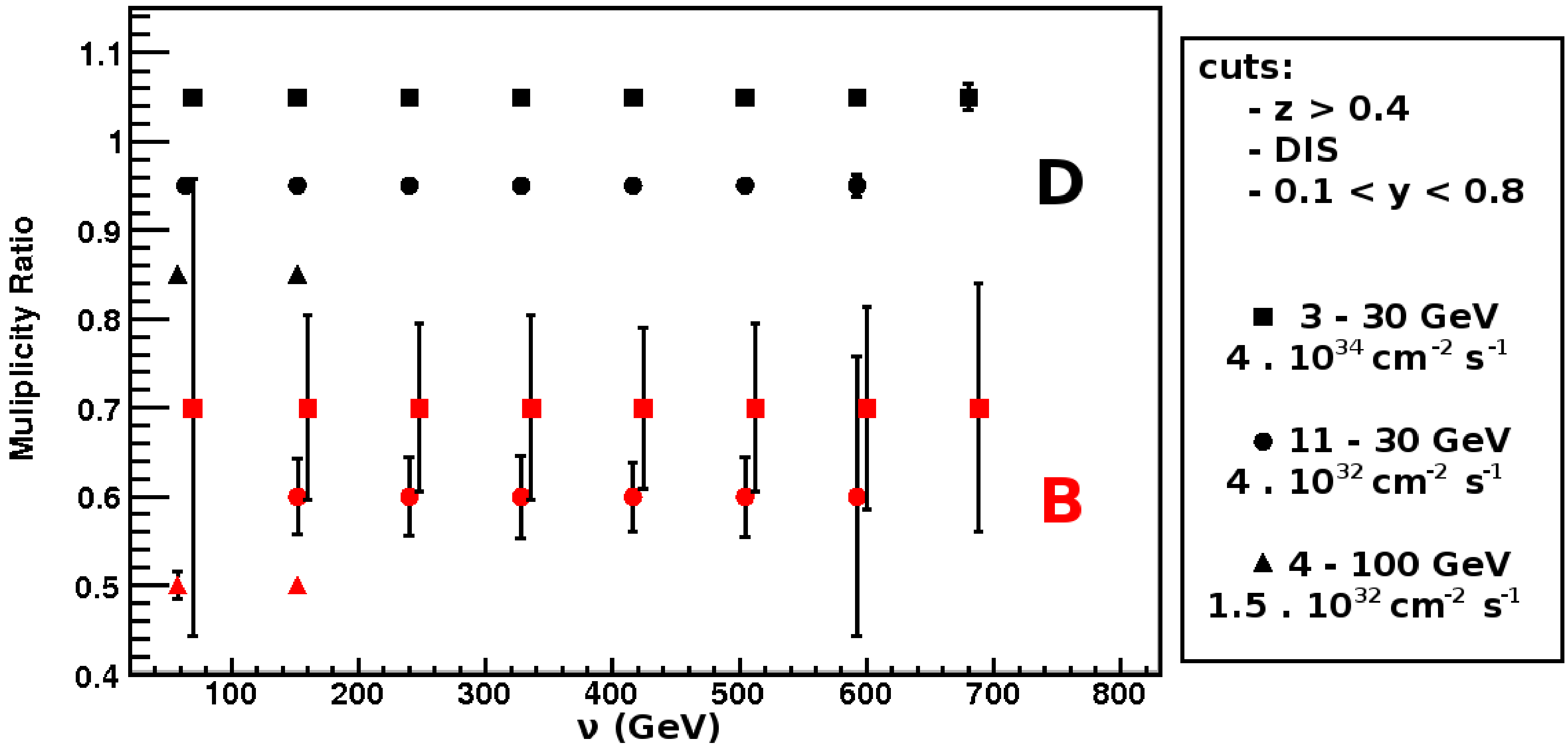
- $P_T$ is approximated
  - Generate transverse momentum more carefully
  - Actually only mean value is given, need a physical distribution

# Projection at EIC energies




11 GeV $e^-$ on 30 GeV/n iron at L = 0.4 $10^{33}$ $cm^{-2}$ $s^{-1}$ for a month

# Projection at EIC energies



# Which EIC configuration?

- For light particles, all configurations can give good results
- The main parameter for heavy quark production is the luminosity
- It would be interesting to cover ν in those regions:
  - $\nu < 100$ GeV to measure multiplicity ratios
  - $\nu > 300$ GeV to measure pure energy loss (through jets for example)

    $\rightarrow s \sim 1000\ \text{GeV}^2$
- We need a strategy for heavy quark detection

# Summary

- PYTHIA simulation seem to give a good picture for EIC kinematic
- For lower energy configuration the multiplicity ratio is still an interesting variable
- Heavy quarks fragmentation can be studied
- Future Work
  - Give more realistic transverse momentum to the quenched partons
  - Evaluate $\Delta P_T^2$ for the different particles
  - Reconstruct jets from the Monte-Carlo
  - Use jets to measure directly partons kinematic
  - Introduce detector uncertainty in the simulation