Monte-Carlo Tools and Simulation

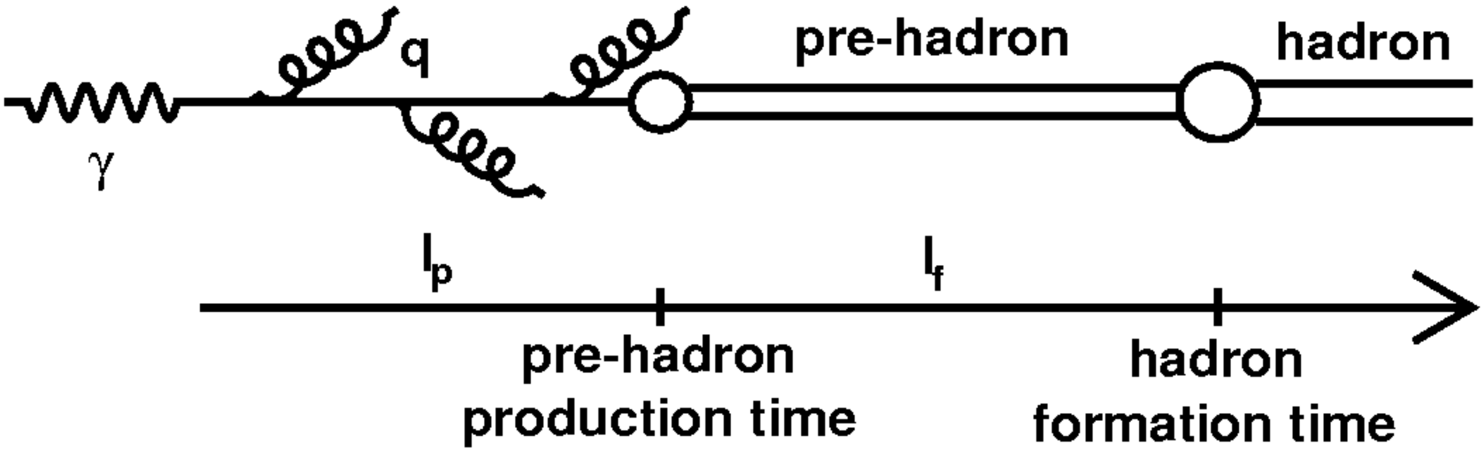
Raphaël Dupré

Argonne National Laboratory

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 it to cold nuclear matter geometry (Accardi, Ploszkon)
  - Extend it to treat HT energy loss (Majumder)

- GiBUU
  - Already tested simulation

Observables

- Light Quarks
  - π^0, η comparison (energy loss vs prehadron absorption)
  - Verify that Ratio → 1 at large ν 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)

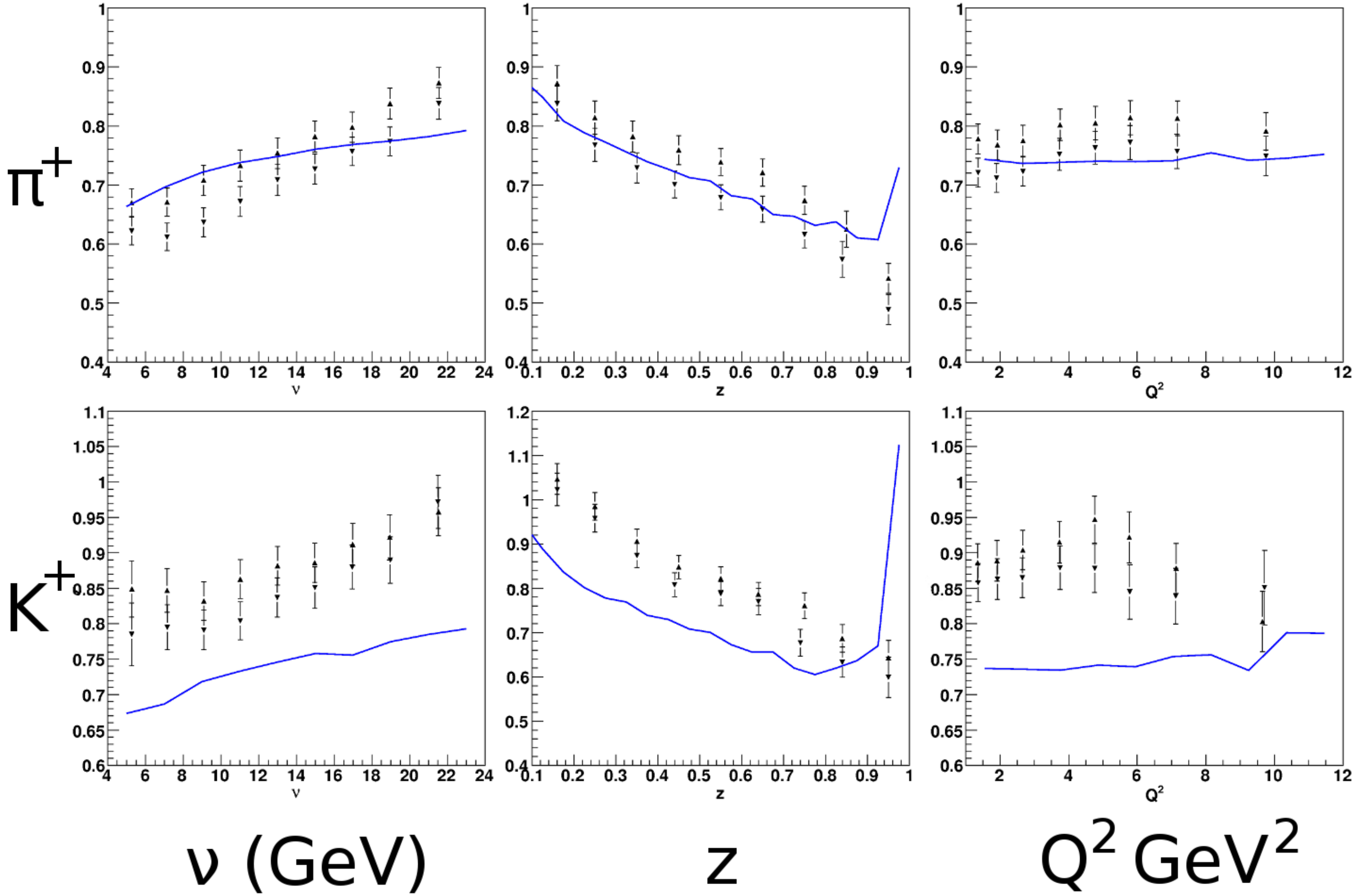
- Jets
  - Jet rates as a function of cone radius - gluon radiation will broaden jets
  - Semi-inclusive jet p_T-broadening – direct parton p_T-broadening
  - Compare to jets at RHIC

Energy Loss Based Simulation

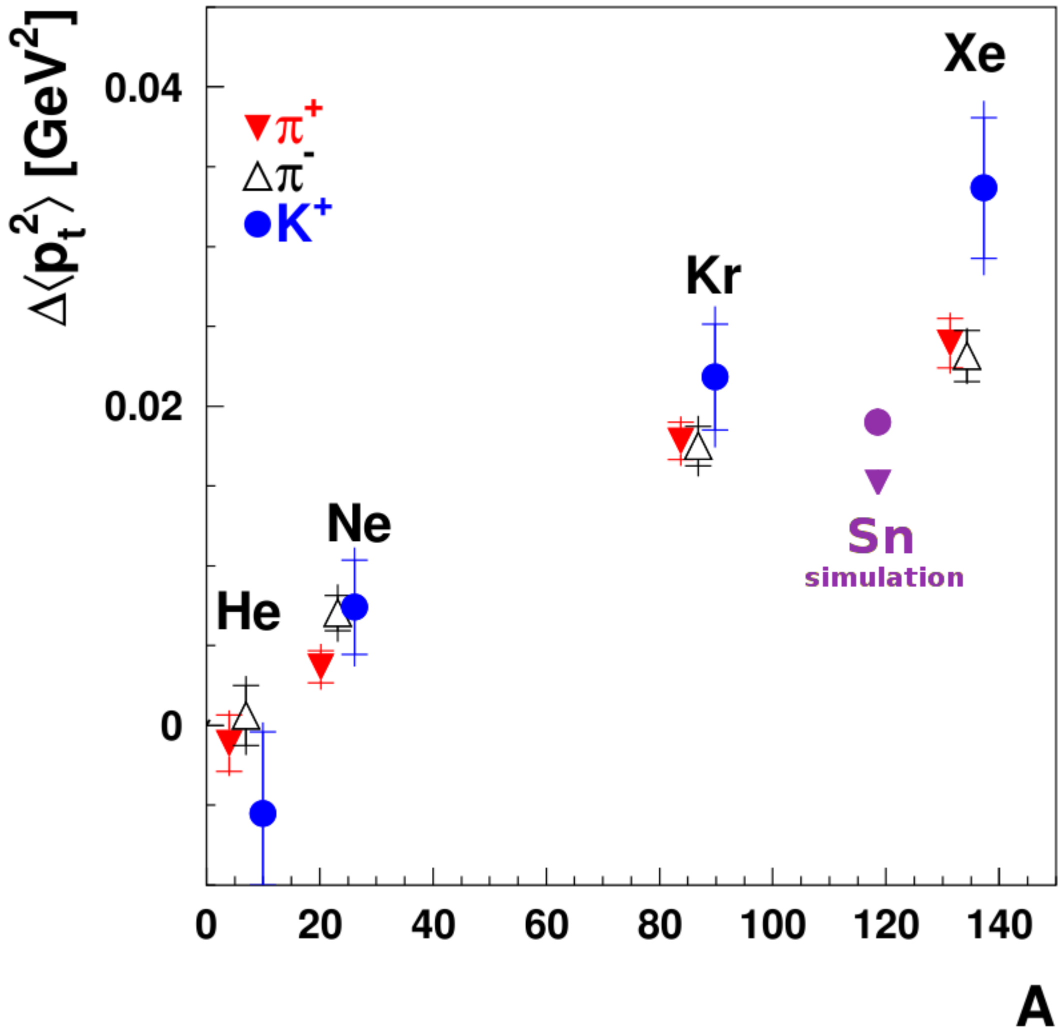
- PYTHIA is both used for
  - Parton level generator
  - Lund fragmentation of the products
- Include Fermi motion
- Apply BDMPS energy loss to produce partons
  - Calculation from Salgado and Wiedmann (2002)
  - Attribute a transverse momentum according to the energy loss

Simulation Compared to HERMES Data

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



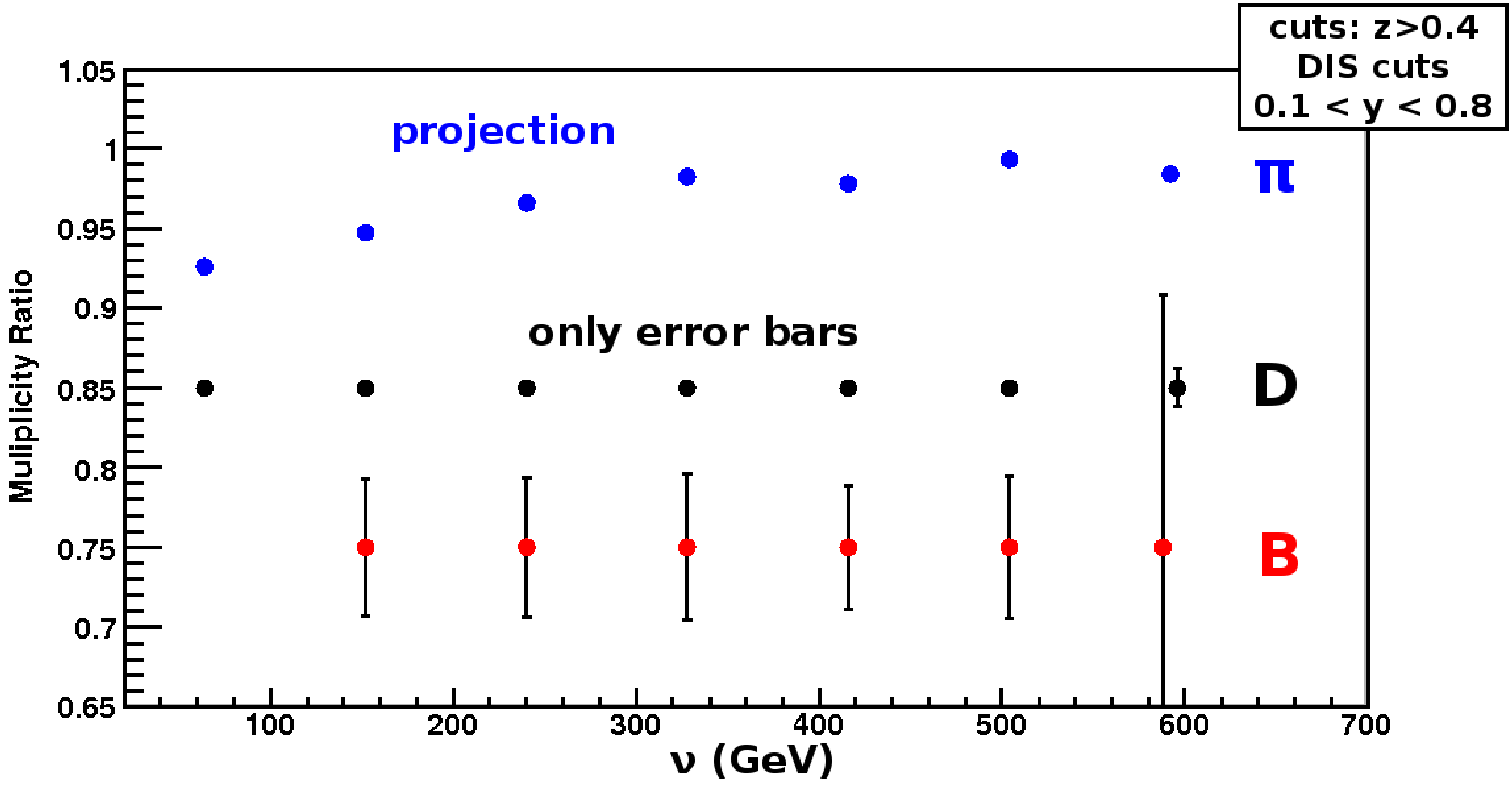
Simulation Compared to HERMES Data



What needs to be elaborated ?

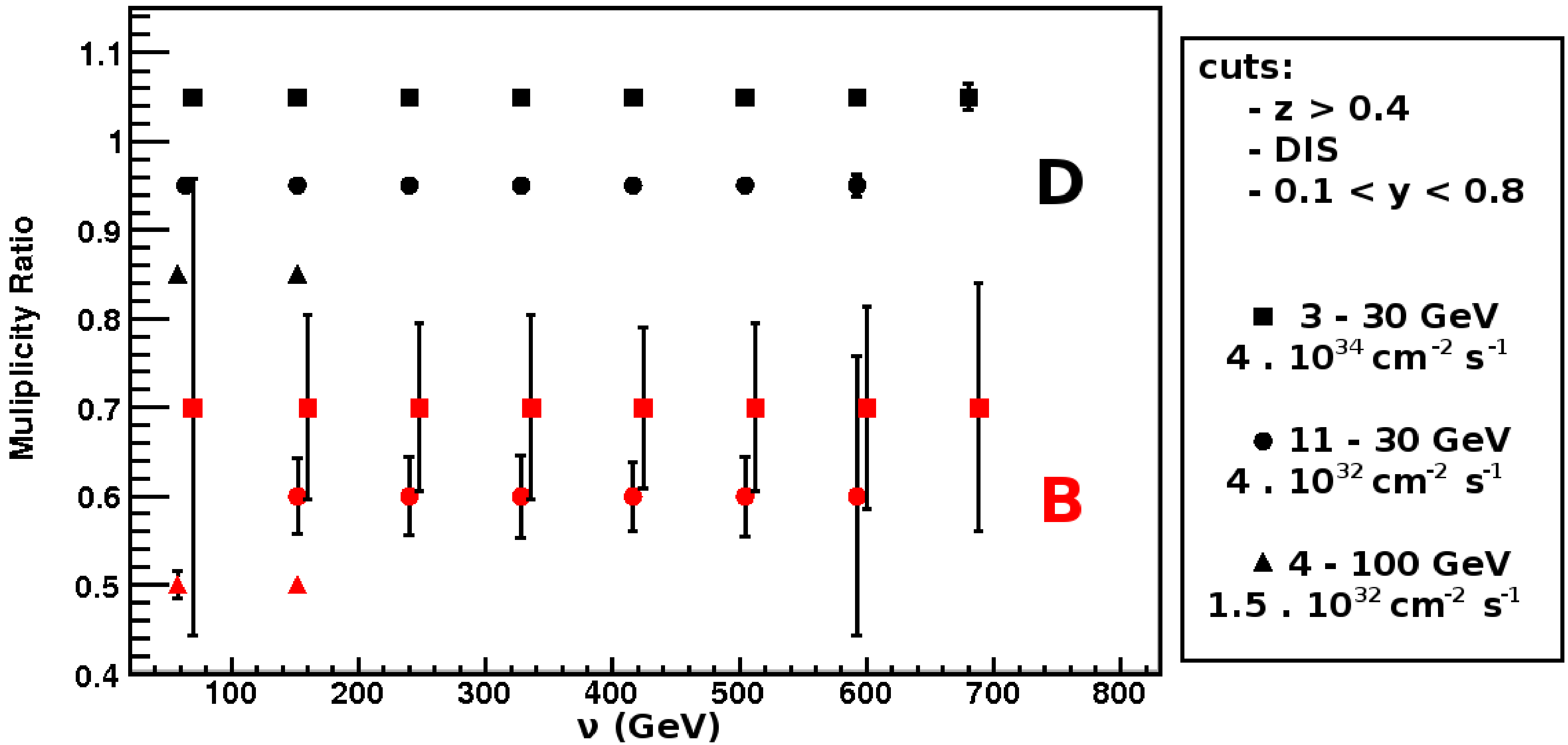
- Model reliable at high z only
  - Create gluons to compensate energy loss
  - Give part of the energy loss to spectator nucleon?
- P_T is approximated
  - Generate transverse momentum more carefully
  - Actually only mean value is given, needs a physical distribution

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)

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

Summary

- PYTHIA simulation seems 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 ΔP_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