Hadronization at EIC: looking at heavy quarks

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Exposing Novel Quark and Gluon Effects in Nuclei
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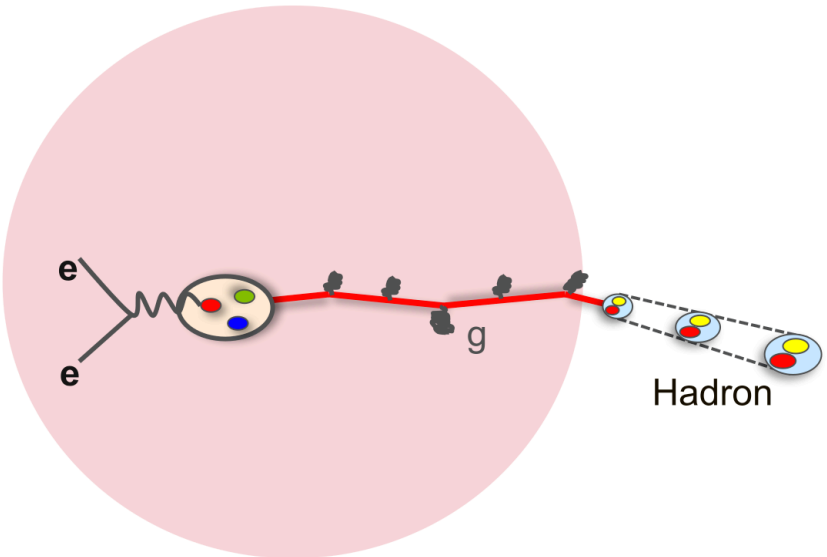
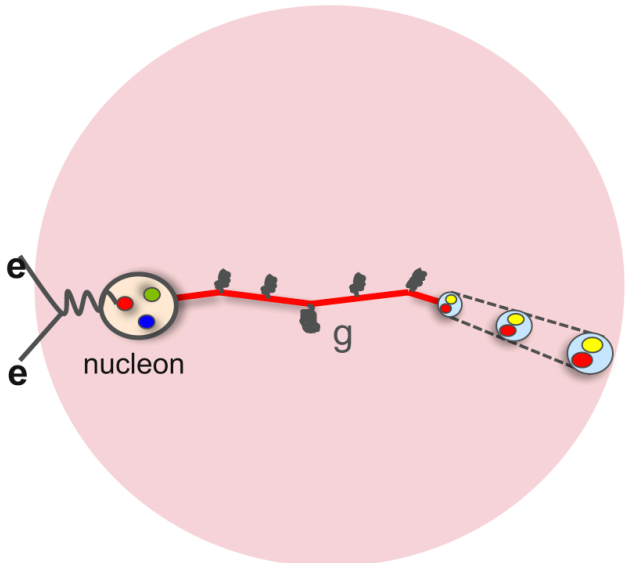
Hadronization

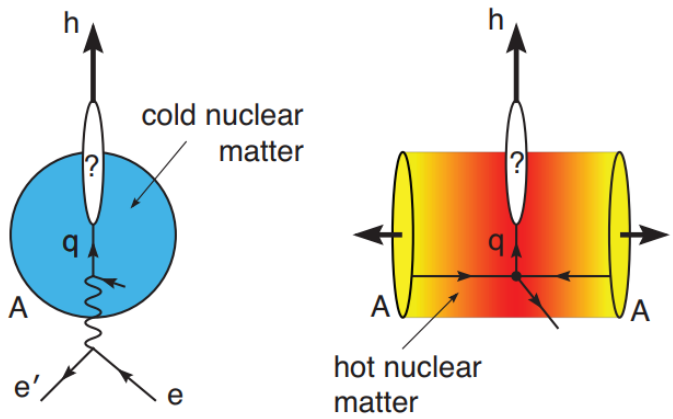
- Quarks cannot be freed due to confinement. If struck they form hadrons: this is the hadronization process
- At the frontier between perturbative QCD (pQCD) and nonpertubative QCD
  - Cannot be calculated and needs to be modeled and measured
- To study hadronization, we do:
  - Hadronization in vacuum (accessible at high energies)
  - Hadronization in nuclear matter (accessible at low energies)





What can we learn from hadronization ?

- Parton and hadron propagation in the nuclear medium
  - Distance travelled in the medium
- Parton energy loss, jet studies
  - Calculable in pQCD
  - Characterize the medium (density, temperature, ...)



For the EIC:

- Particularly interested by heavy quarks
- Comparison possible with LHC data
  - Test the mass scaling of pQCD energy loss calculation

Parton energy loss

- Struck parton loses some energy in the medium (gluon emission)
- Dominant at high energies, relevant for EIC

Transport coefficient $\hat{q}$: scattering power of the medium

$$\hat{q} = \frac{k_\perp^2}{L}$$

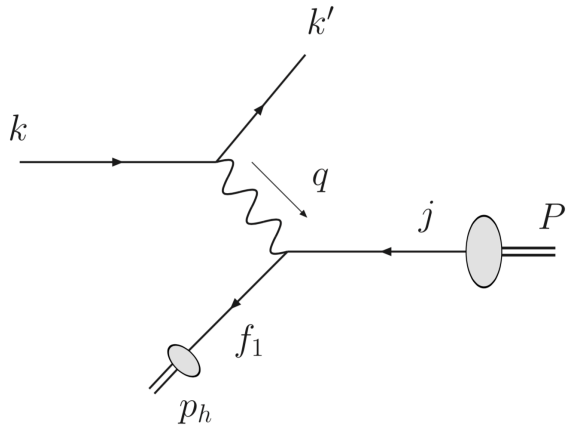
- $k_\perp$: gluon transverse momentum of the parton induced by the medium
- λ : length of the medium

- Linked to gluon density:

$$\hat{q} = \frac{4\pi^2 \alpha_s C_R}{N_C^2 - 1} \rho x G\left(x, Q^2\right)$$

Experiments

eA experiments (DIS)

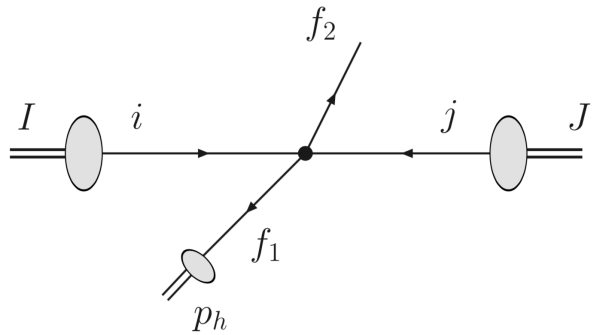


$$\nu = k - k'$$

$$z = \frac{E_h}{\nu}$$

$$R_A^h = \frac{N_A^h / N_A^e}{N_D^h / N_D^e}$$

AA experiments

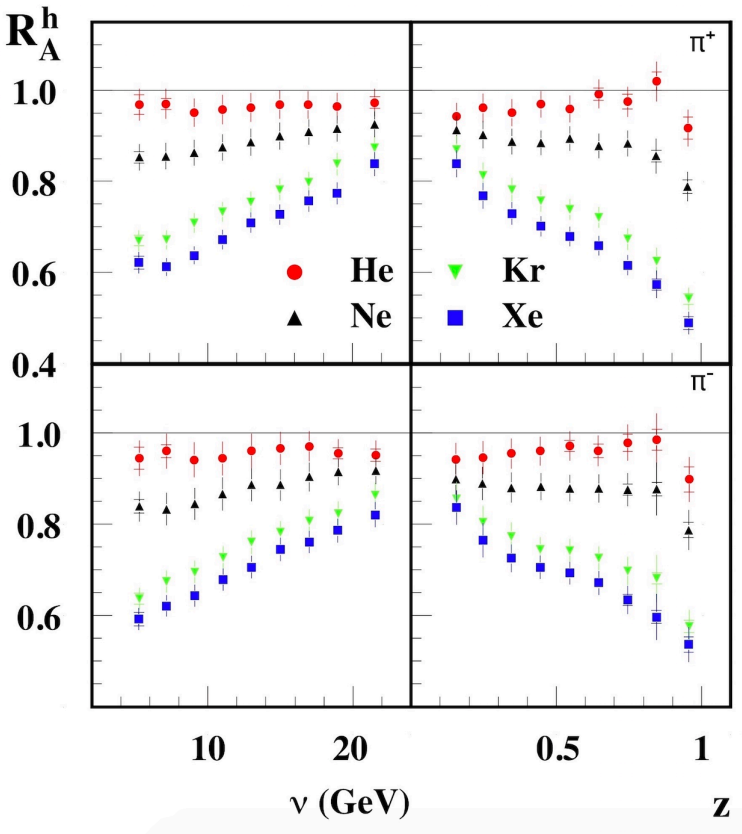


$$p_T$$

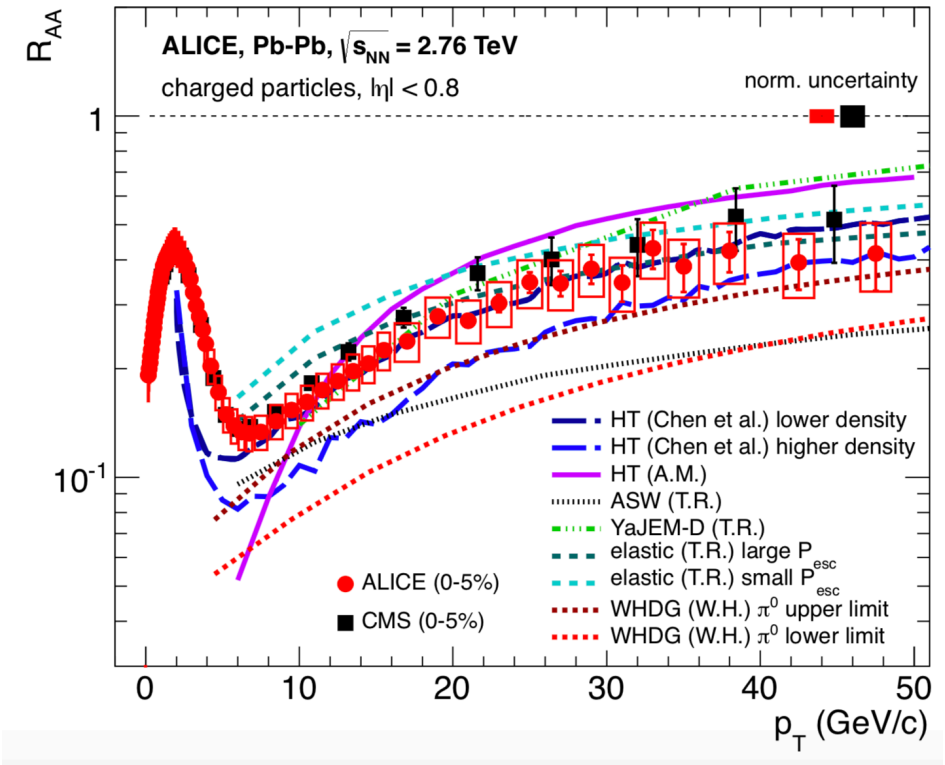
$$y = \frac{1}{2} \ln \left(\frac{E + p_z}{E - p_z} \right)$$

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{N^{AA}}{N^{pp}}$$

Experiments

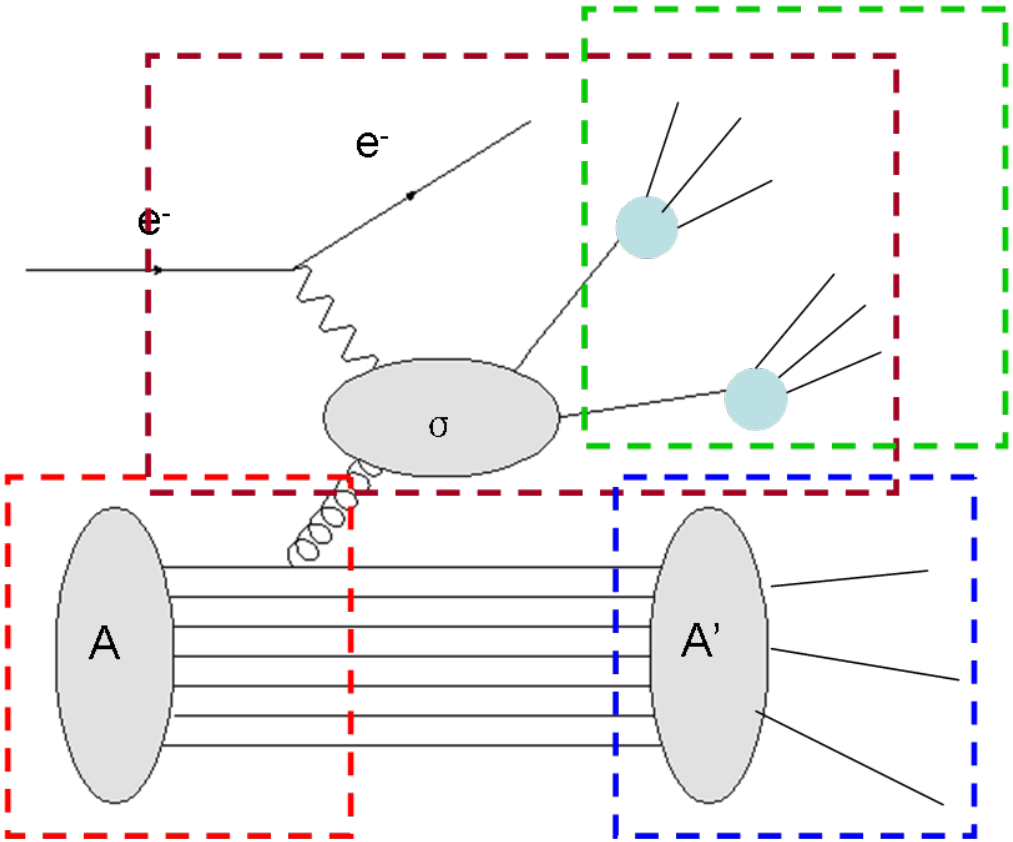


Multiplicity ratios from HERMES



Nuclear modification factors measured by ALICE and CMS (+ model calculations)

Benchmark eA Generator for LEptoproduction (BeAGLE)

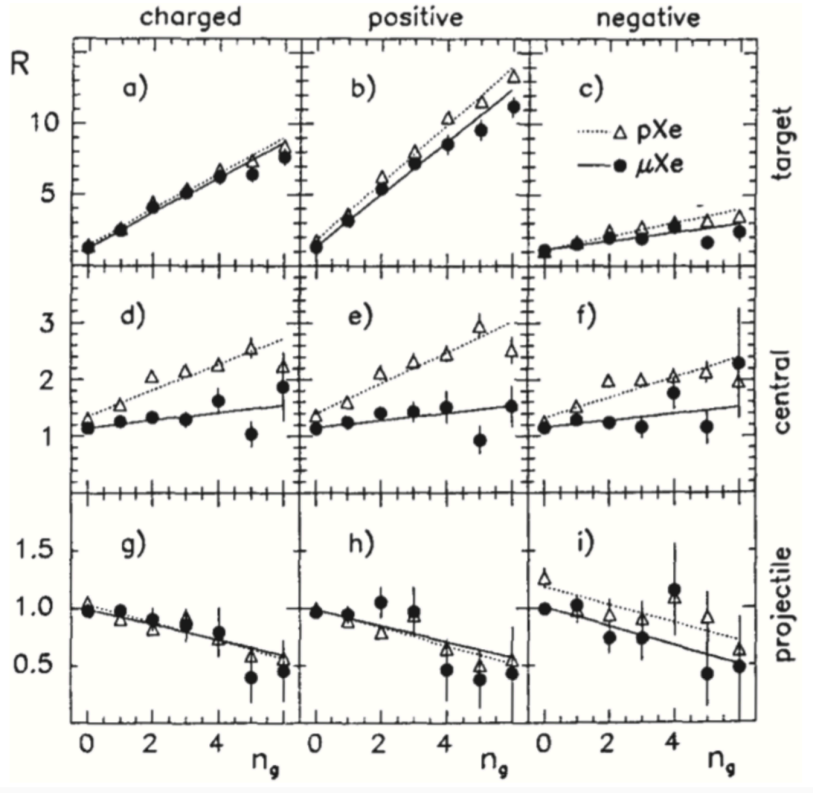


- Parton level interaction & hadronization
  - PYTHIA
- Energy loss
  - Quenching weights calculation
    [Salgado & Wiedemann]
- Nuclear evaporation
  - DPMJet
- Nuclear structure
  - DPMJet
  - EPS09 nPDF

In collaboration with: Jefferson Laboratory, Brookhaven National Laboratory, Argonne National Laboratory, Hampton University, Old Dominion University, Universidad Técnica Federico Santa María, ...

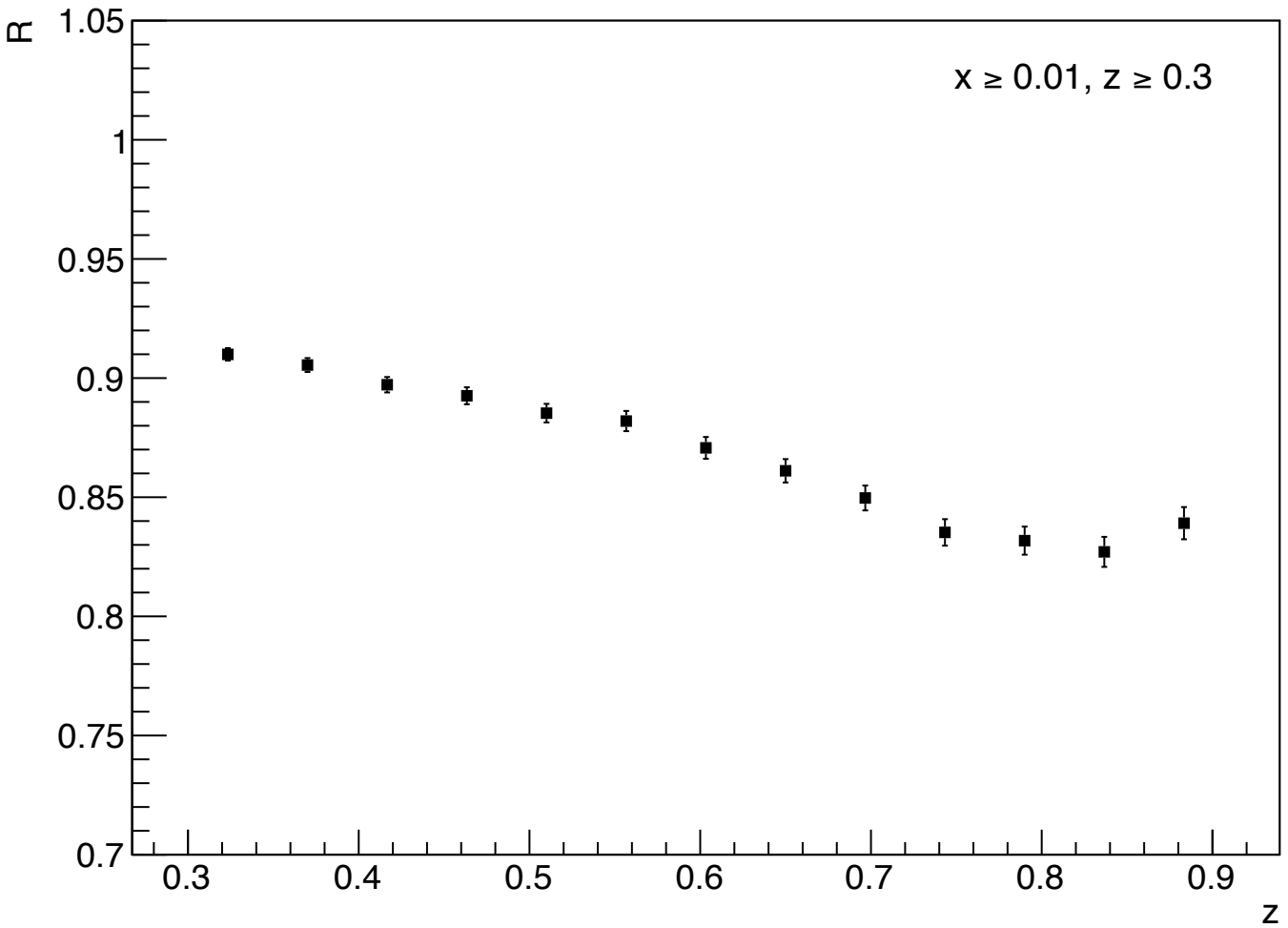
BeAGLE Preliminary Tests

- 470 GeV e^-
- Pb target (0 GeV)
- $\hat{q} = 0\ \mathrm{GeV}^2/\mathrm{fm}$ (no energy loss)
  $= 0.36\ \mathrm{GeV}^2/\mathrm{fm}$
- 10^7 events
- Particles looked at : $\pi^{+/-}$ and D^0
- Ratios comparison $R^{\frac{\hat{q}=0.36}{\hat{q}=0}}$
  - z distribution
  - ν distribution
- Cuts:
  - $x \geq 0.01$
  - $z \geq 0.3$



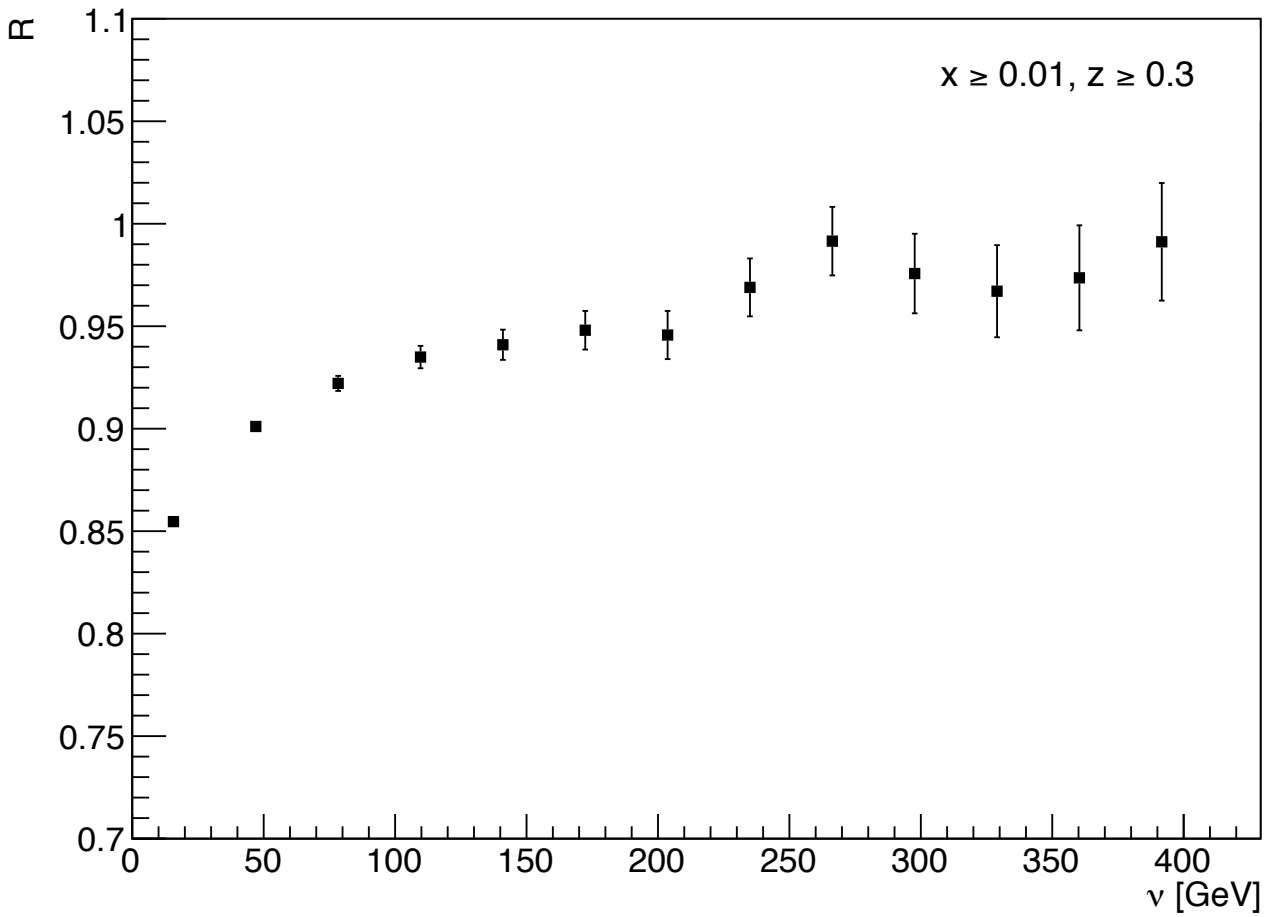
Data from E665

$\pi^{+/-}$ - z Ratio



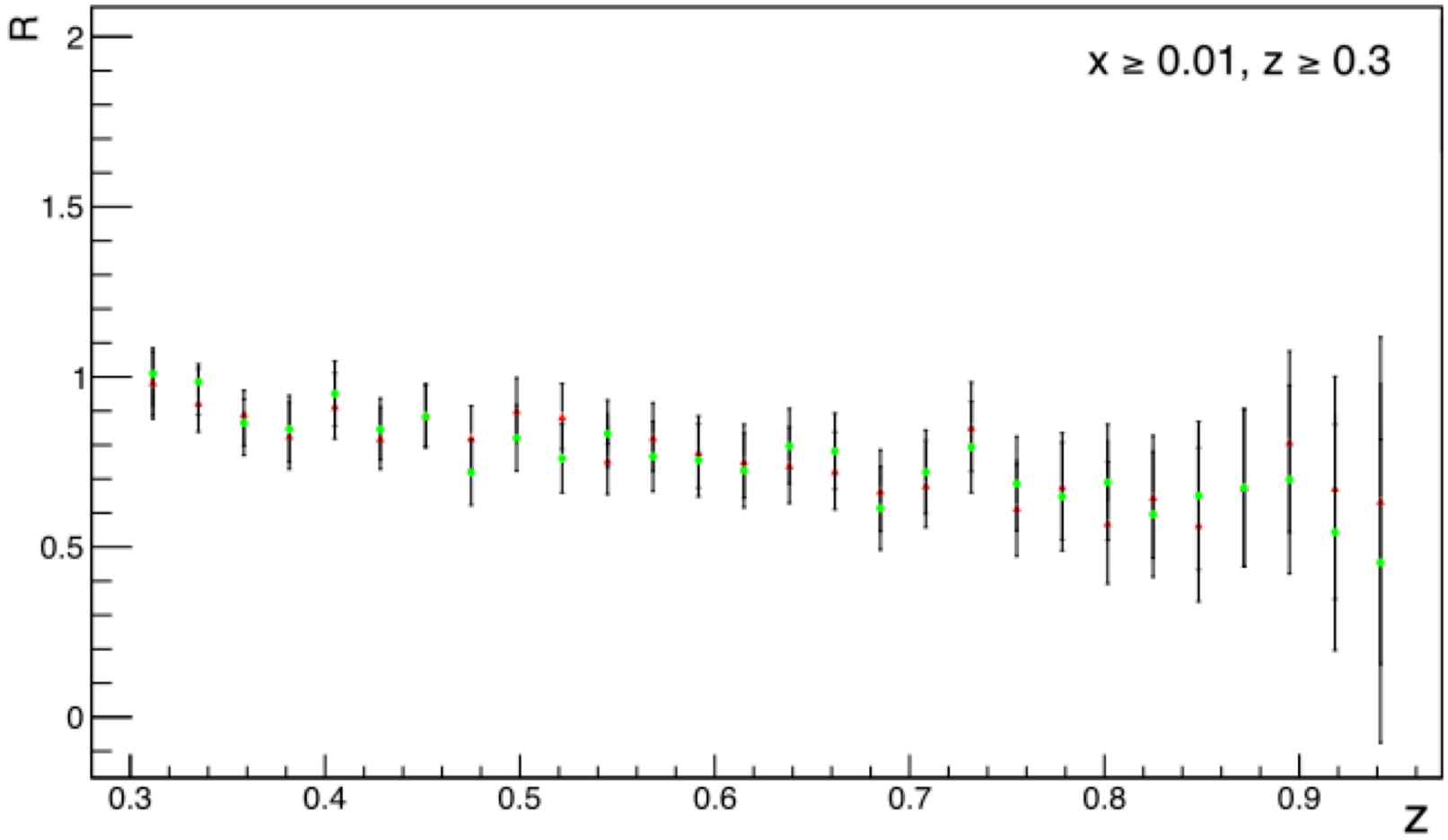
- Form of the nuclear effect driven by the fragmentation function form

$\pi^{+/-}$ - ν Ratios



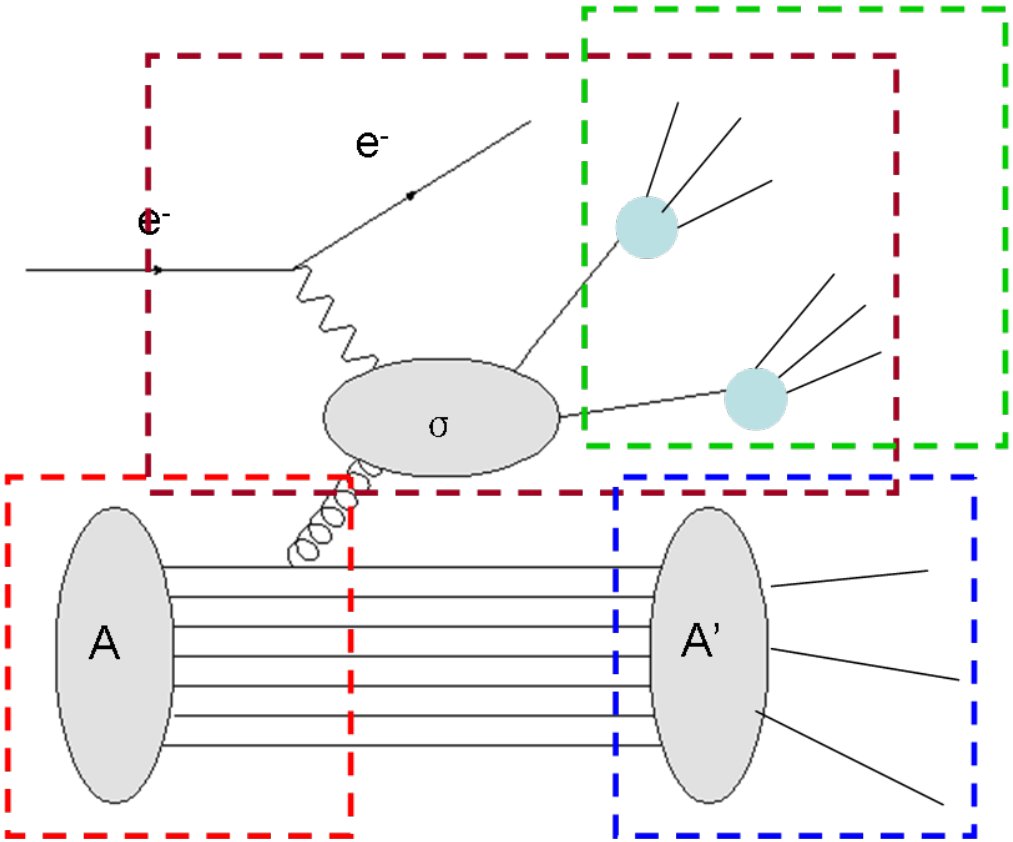
- ν is directly linked to the initial quark energy
- Direct prediction of the energy dependence of the calculation

D^0 - z Ratios



- Comparison 2 different Salgado & Wiedemann codes
- Low statistic

Conclusion & Future



- Start the production of more data
- Comparison with existing data (HERMES, Fermilab, LHC, ...)
- Add the emission of gluon(s)
  - Link to the nuclear evaporation module