



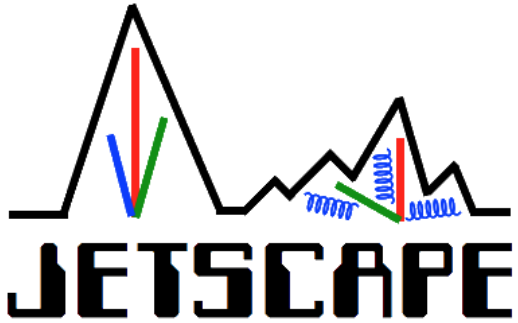


# A Systematic Study of In-Medium Hadronization of Jet Showers with JETSCAPE and Hybrid Hadronization

**Arjun Sengupta**

Texas A&M University

On behalf of the JETSCAPE Collaboration

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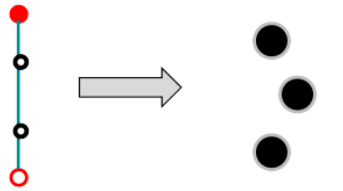
# Hybrid Hadronization (HH)[1] Model

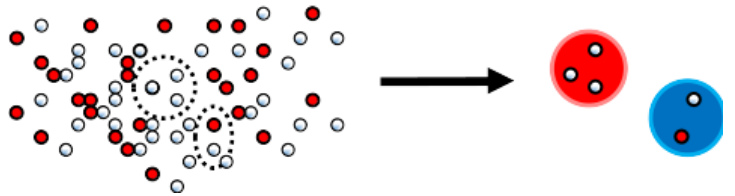
[1] K.C. Han et. al., Phys. Rev. C 93 (2016) 4, 045207

Combines two phenomenological models of hadronization:

1. String fragmentation (low-density systems):
   - Color flux tubes in QCD vacuum at large distances → string-like behavior.
   - Quarks connected with strings; gluons are part of these strings – these strings are then broken to form hadrons.



2. Recombination (high-density systems):
   - Quarks can directly recombine into hadrons
   - Successful phenomenology in heavy-ion collisions



**GOAL:** Systematically study hadronization of jets in a QGP medium

1. Baryon/meson ratios
2. Elliptic flow scaling

# JETSCAPE[1,2,3] Setup for HH Studies

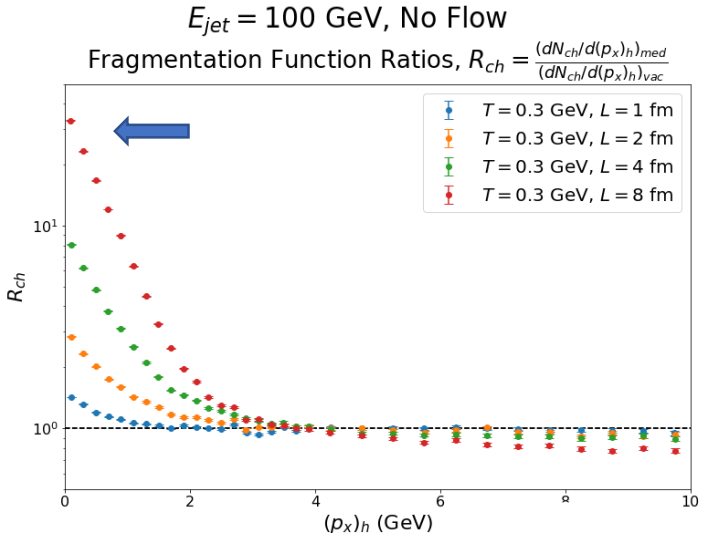
[1] J.H. Putschke et. al., arXiv:1903.07706, [2] A. Kumar et. al., Phys. Rev. C **102**, 054906 (2020), [3] A. Kumar et. al., arXiv:2204.01163

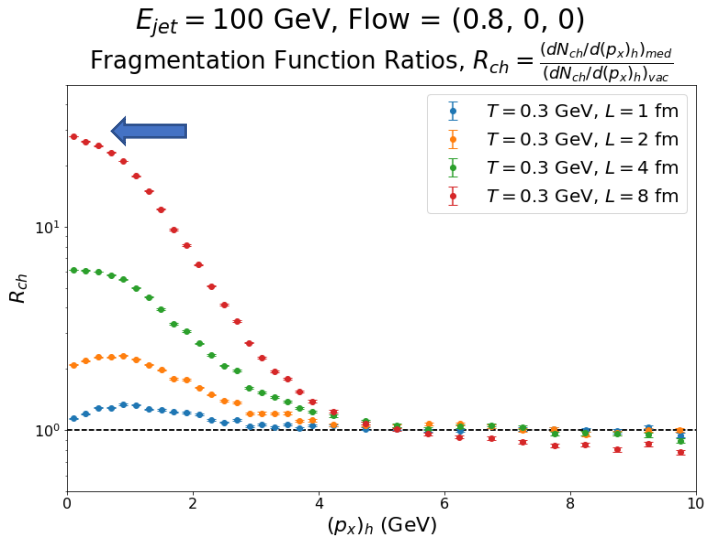
Run 3 modules in a QGP brick medium:

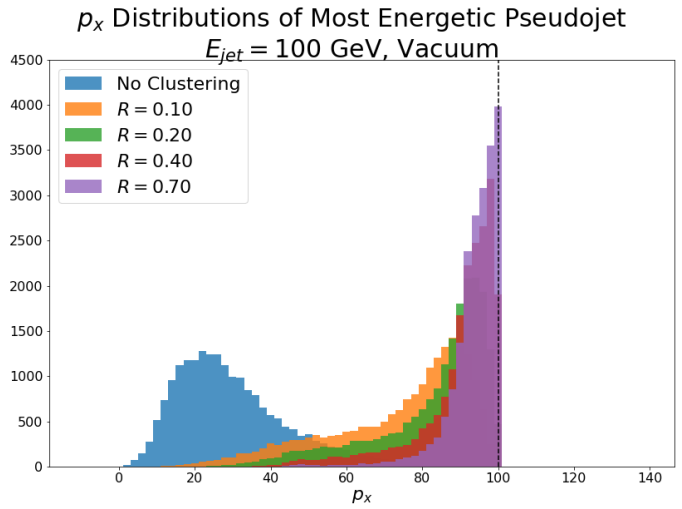
1. **MATTER** – propagates and splits an initial jet parton (in the **x-direction**), rapidly dropping its virtuality until it falls below a threshold $Q_0$ ( = 1.2 GeV)
2. **LBT** – propagates low-virtuality and real partons through the QGP
3. **Hybrid Hadronization** – hadronizes partons through recombination and string fragmentation:

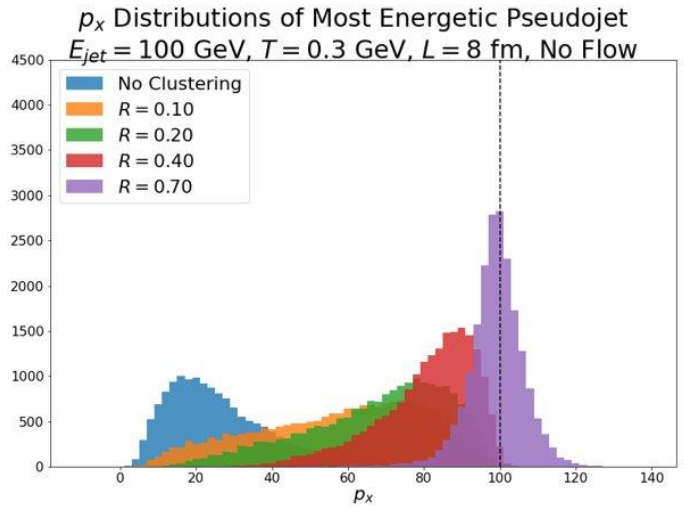
| | |
|---|---|
| Input | Shower (MATTER, LBT) & thermal partons (sampled QGP brick) – momentum, position, color information |
| Recombination | Sample probabilities for random quark pairs and triplets to recombine into hadrons, using color flow information from a shower Monte Carlo |
| String Prep | Prepare remnant partons on a string-by-string basis for PYTHIA – constructing a fake history for junction containing strings |
| String Fragmentation | Call PYTHIA to perform string fragmentation on remnant strings and handle hadron resonances |
| Output | Recombined and fragmented hadrons, including space-time information |

# Longitudinal Flow Effects




Charged hadron production **grows with medium size**, as expected with recombination

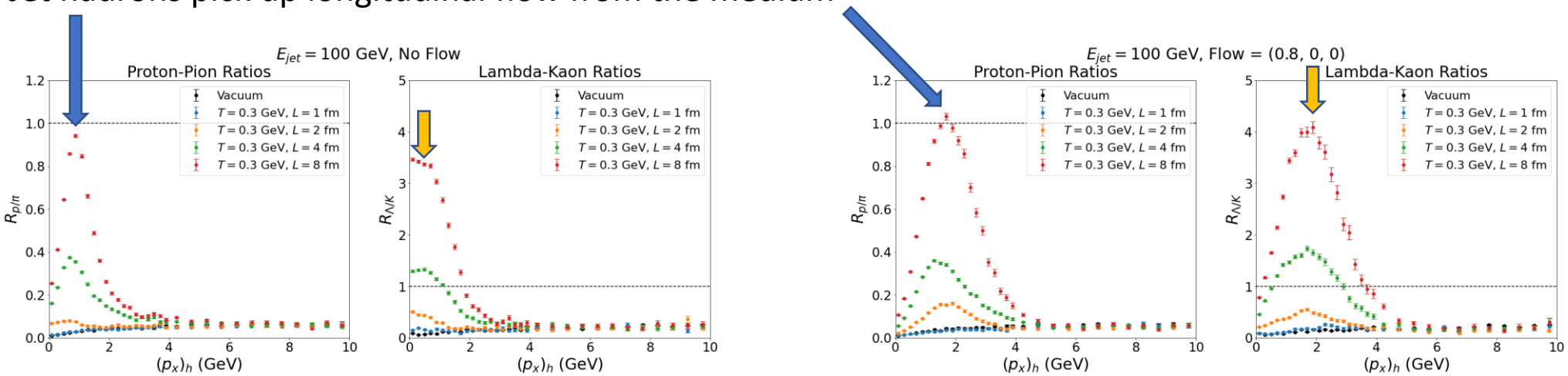
Flow effects visible as **shoulders** in in-medium fragmentation functions

Most energetic event-by-event pseudojets, clustered using the **anti-kT algorithm**

R=0.7 jets tend to (on average) capture the original jet energy

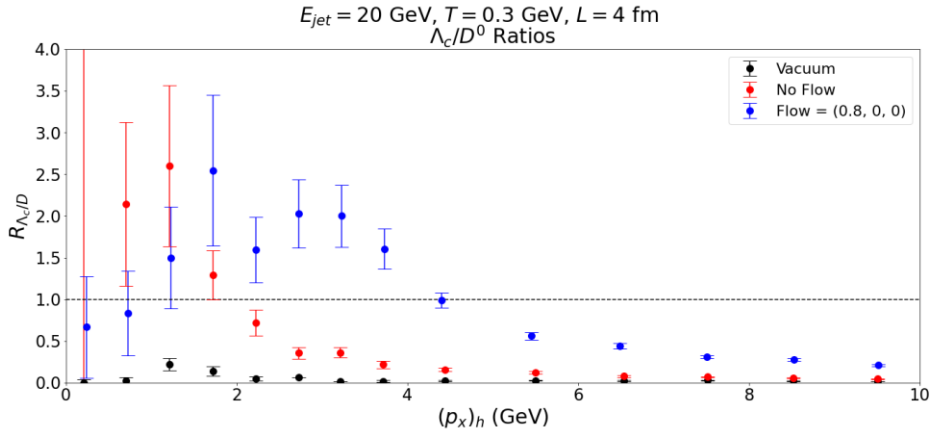
# Longitudinal Flow Effects

Jet hadrons pick up longitudinal flow from the medium

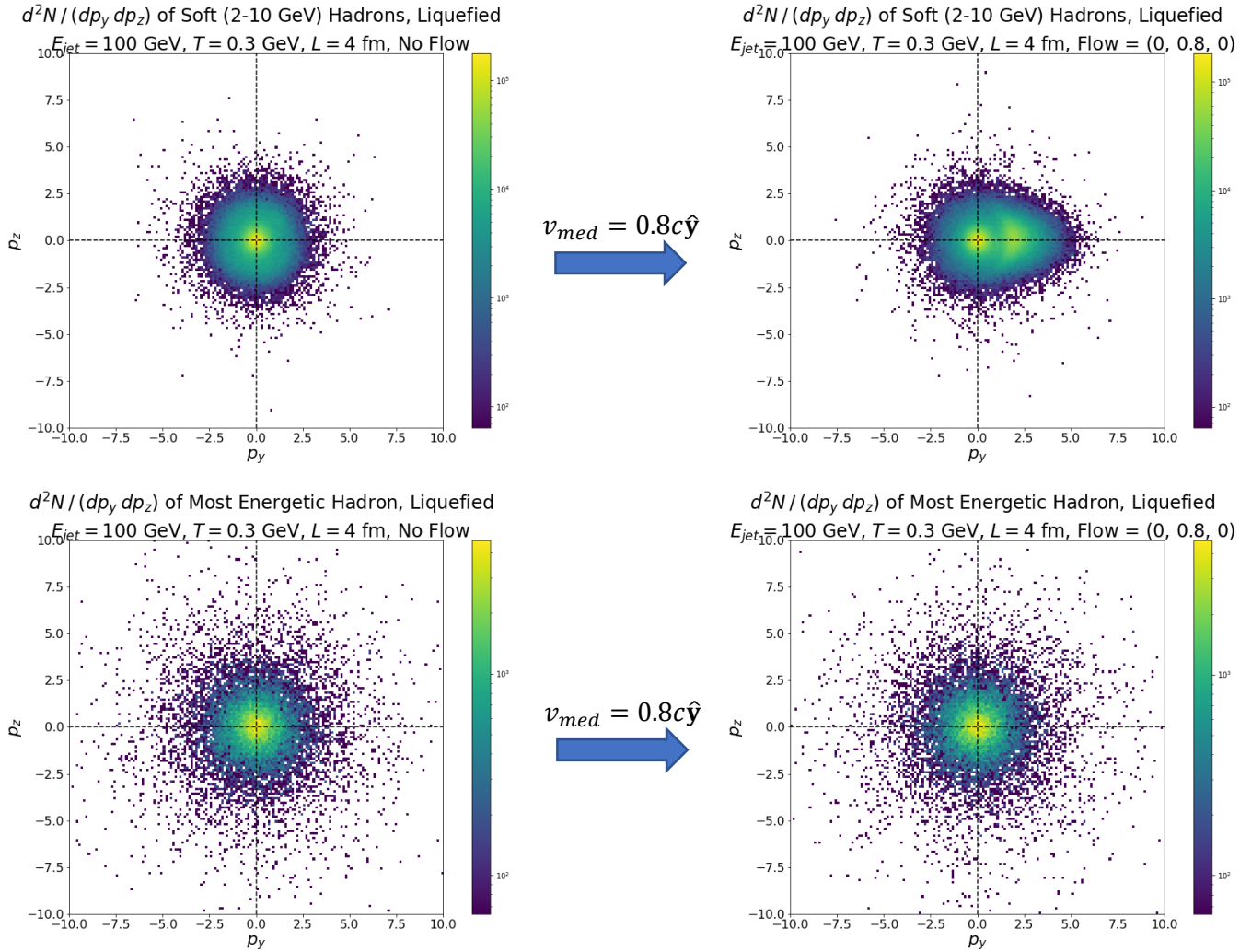



Baryon/Meson enhancement **grows with medium size**, as expected with recombination

B/M ratios are also enhanced in the **charm sector** (c-quark jets), and charmed hadrons can pick up medium flow.



# Transverse Flow Effects




Soft jet partons are likely to coalesce with thermal partons during hadronization

$\longrightarrow$ Hadronization in a medium with transverse flow induces flow for **soft** jet hadrons

… whereas **hard** jet partons are unlikely to coalesce with thermal partons, and don't pick up the flow