Study of jet modifications in heavy-ion collisions by investigating intra-jet properties with JEWEL

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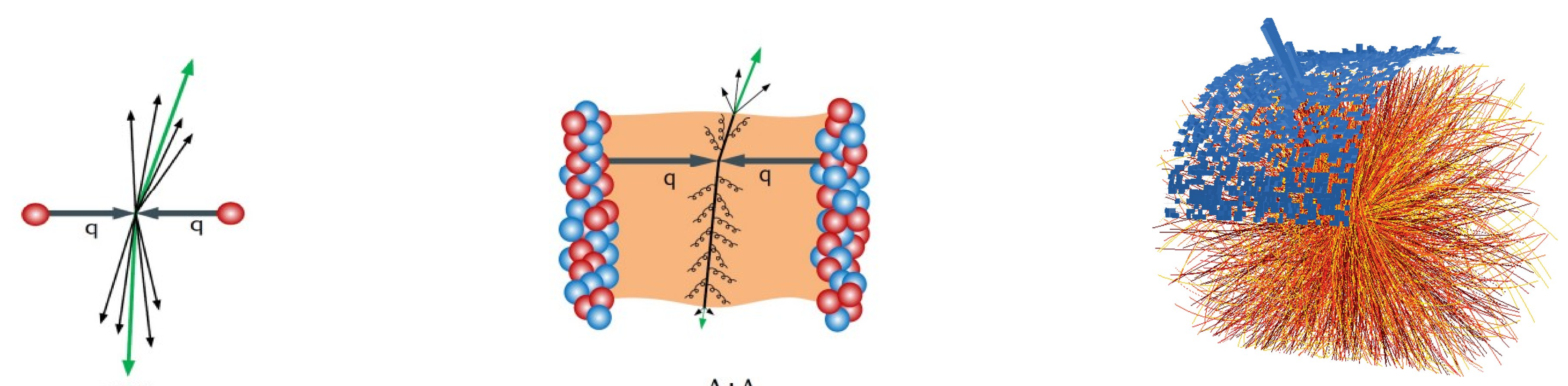
HARD PROBES 2018

Abstract: The modification of hadron yields and jet production cross section in central heavy ion (HI) collisions at high p_T compared to number of ``binary collision" scaled pp reference has now been established as a compelling evidence of energy loss of hard scattered partons when propagating through dense medium of partonic constituents or the Quark Gluon Plasma. (QGP). This modification is often quantified in terms of nuclear modification factor, R_{AA}. Here we have studied the modification of jet production cross section in different centrality of Pb-Pb collisions at $\sqrt{s}$ = 5.02 TeV within the framework of a model that implements jet evolution with energy loss (JEWEL[1]). We also report modification of jet fragmentation functions of Inclusive dijets, implementing a JEWEL-compatible technique of background subtraction procedure.

Jet : A calibrated probe of QGP

-- Heavy ion collisions at relativistic energies produce a dense medium of deconfined quarks and gluons, the Quark Gluon Plasma (QGP).

-- The QGP has been characterized as a strongly interacting plasma owing to its capability to quench jets.



Jets: -- An experimental proxy for initial hard scattered partons manifested as a collimated stream of hadrons.

-- QCD factorization allows, jet yields to be reliably calculated both in a vacuum and QGP medium.

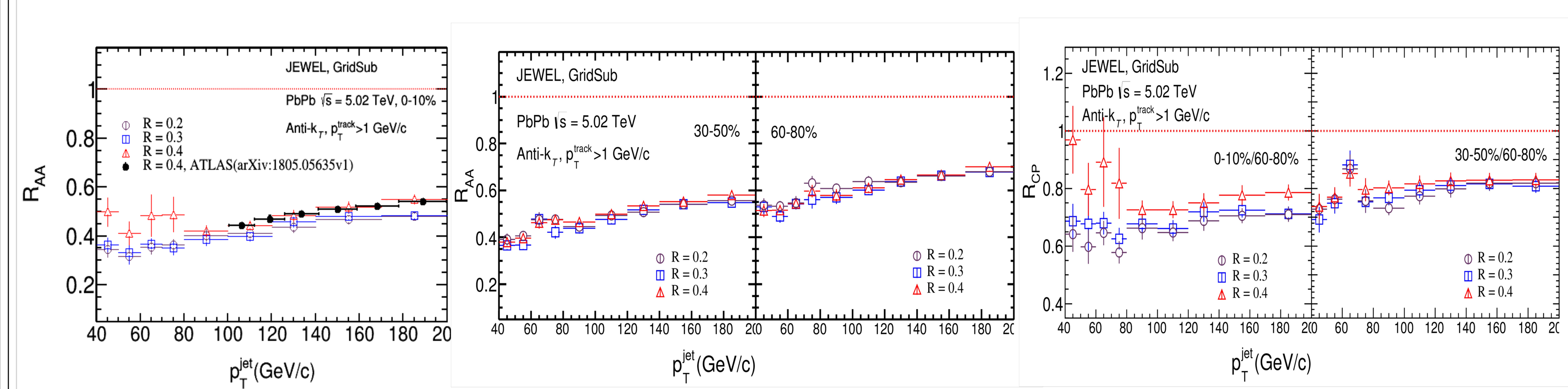
-- Modification of jet yields and its internal structures in HI collision encodes the characteristic features of jet energy loss commonly referred as "Jet Quenching".

-- Since the original proposal by Bjorken, jet quenching is accounted among the confirmatory evidence Of the formation of strong interacting QGP (sQGP) in relativistic hadron /nuclear collisions.

Jet Quenching

Modification (suppression) of inclusive jet yields in A-A compared to $<N_{coll}>$ scaled pp (or A-A peripheral) reference

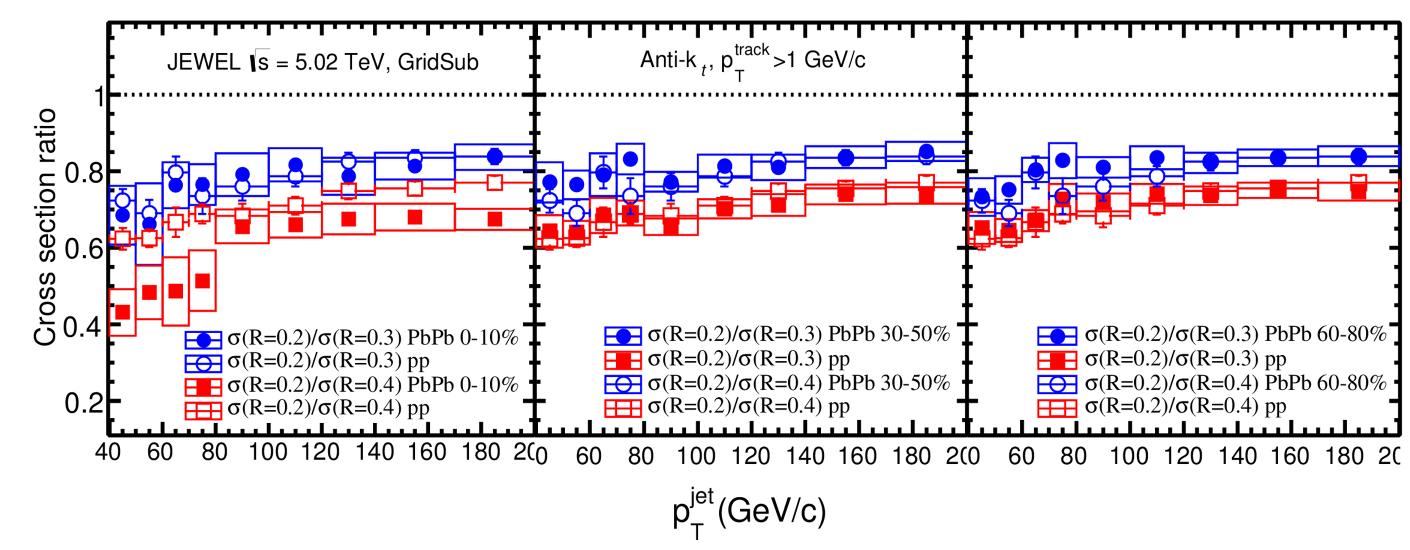
$$R_{AA} = \frac{\frac{dN^{A-A}}{dp_{T,jet}}}{\langle N_{coll}\rangle \times \frac{dN^{p-p}}{dp_{T,jet}}} \qquad R_{CP} = \frac{dN^{\rm central}}{\langle N^{\rm central}_{\rm coll}\rangle dp_{T,jet}} \Big/ \frac{dN^{\rm peripheral}}{\langle N^{\rm peripheral}_{\rm coll}\rangle dp_{T,jet}}$$



- Jets are strongly suppressed (R_{AA} << 1) in 0-10 % HI collisions.
- Good agreement with ATLAS results for R=0.4.
- R_{AA} is predicted for R=0.2 and R=0.3, no significant change.
- R_{CP} is also predicted for R = 0.2, 0.3 and 0.4.

Jet cross section ratio at different R

Ratio of jet cross sections at different R is complementary to the transverse shower profile distribution and it modifications in pp and AA, respectively:



➔ No significant modification except for R=0.4 in 0-10% collisions.
➔ Transverse jet shapes in central and peripheral collisions are consistent with vacuum jets (pp).
➔ An ordering is observed σ(0.2)/σ(0.3) > σ(0.2)/σ(0.4) at all centralities.

JEWEL

A microscopic description of jet evolution with energy loss

-- A dynamical framework to simulate jet-medium interaction.

-- Scattering between jet-partons and medium constituents are described by 2- to-2 p-QCD matrix elements including a MC implementation of LPM effect.

*The medium is modeled as a collection of quasi-free partons and its evolution is governed by boost-invariant expansion of an ideal quark gluon gas.

*The medium properties are characterized by three parameters:
-- initial proper time τ_i
-- the initial temperature T_i, initial energy density $\varepsilon_i \propto T_i^4$
-- critical temperature for phase transition Tc

σ_{NN}	τ_i	T_i	Parton PDF	Nuclear PDF
72 mb	0.4	590 MeV	CTEQ6LL	EPS 09

– Scatterings are terminated when $T < T_c$, (170 MeV) followed by hadronization via Lund string fragmentation.
-- Include recoil partons to mimic background activity, necessary for describing Intra-jet obersevables, like jet-shape and fragmentation functions.

Jet Reconstruction

Jet finding algorithm: Sequential Recombination Anti-k_T

-- Consider objects (tracks / EMCal hits) to be clustered as proto-jet.
-- Calculate d_{iB} for each proto-jet & d_{ij} for each pair of proto-jet
-- Find min{ d_{ij}, d_{iB}}
-- if (d_{ij} == min)
- combine i and j
-- else
- declare i as jet
-- Repeat until all particles are part of a jet

$$d_{ij} = \min\left(\frac{1}{p_{ti}^2}, \frac{1}{p_{tj}^2}\right) * \frac{R_{ij}^2}{R}$$

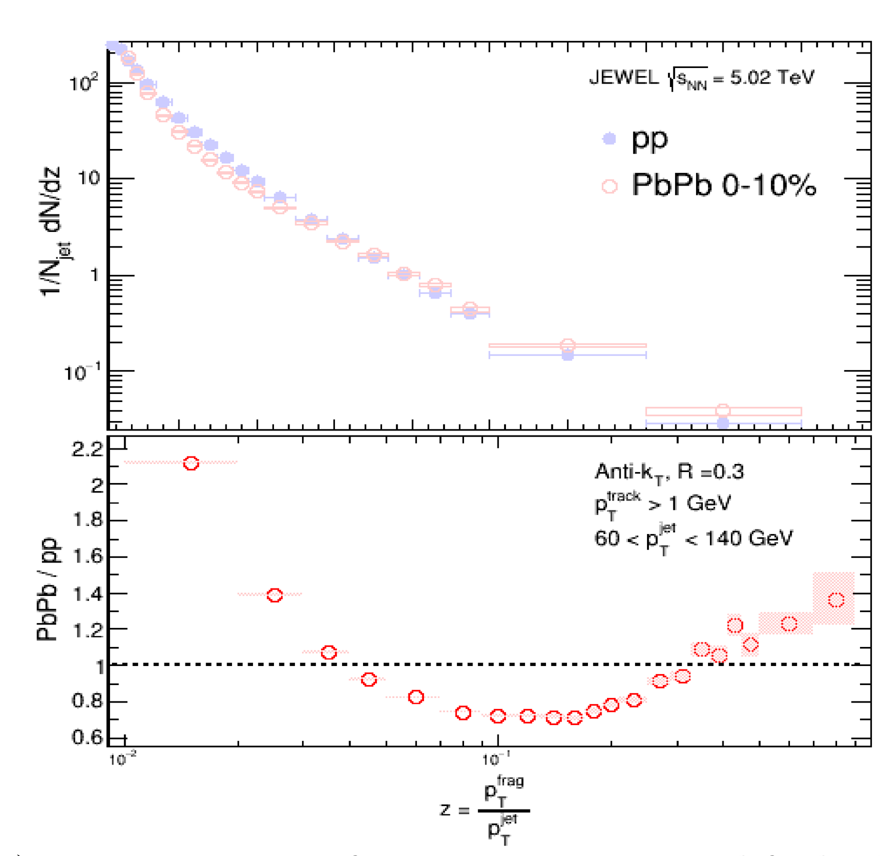
$$d_{iB} = \frac{1}{p_{ti}^2}$$

$$R_{ij}^2 = (\varphi_i - \varphi_j)^2 + (\eta_i - \eta_j)^2$$

Jet Fragmentation Functions

Manifest the momentum distributions of jet constituents (fragments) relative to jet momentum itself.

Defined as $z = \frac{p^{frag}}{p_{jet}}$ or $\xi = ln(1/z)$



➢ Fragmentation function in A-A is modified relative to pp.
➢ A depletion is observed at intermediate z.
➢ Followed by an enhancement in low and high z.
➢ A consistent picture with experimental results.

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Acknowledgment S.C gratefully acknowledges financial support granted by Dr. Saikat Biswas under SERB (DST) sponsored ``Ramanujan Fellowship". Thanks to Raghav Kunnawalkam Elayavalli, for suggestion at different stages of this work.