Study of jet shapes in Monte-Carlo generator JEWEL at RHIC

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Overview

RHIC

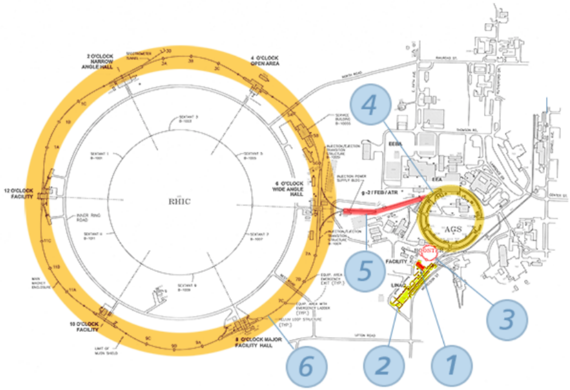


Figure : RHIC complex. 1 - Electron Beam Ion Source (EBIS), 2 - Linear Accelerator (Linac), 3 - Booster Synchrotron, 4 - Alternating Gradient Synchrotron, 5 - AGS-to-RHIC Line, 6 - RHIC [1].

[1] https://www.bnl.gov/rhic/

The **S**olenoidal **T**racker at **RHIC**

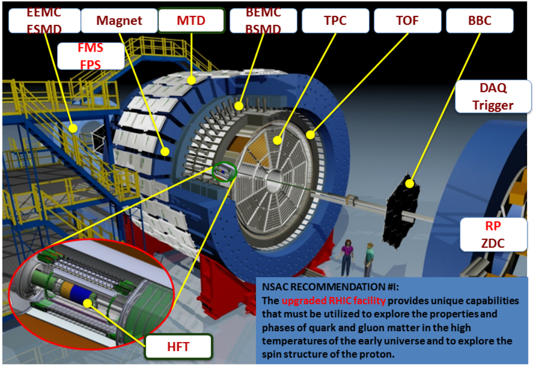


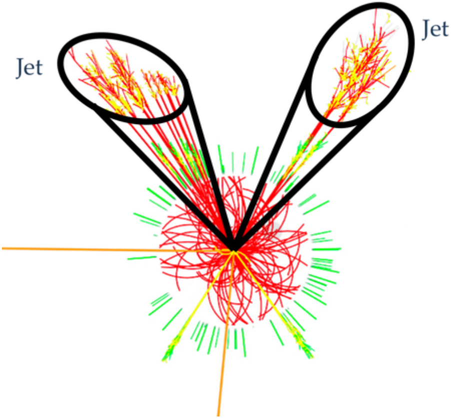
Figure : STAR detector system [2].

[2] https://www.star.bnl.gov/

Jet

Jet

A narrow cone of hadrons and other particles produced by the hadronization of a quark or gluon in particle physics or heavy-ion experiment



Jet shapes

In order to understand the mechanisms of energy loss of partons in the medium and the properties of the medium itself, one should measure the modifications of the jet yield and fragmentation relative to p+p collisions. For this aim different jet shape observables are used:

- **Radial moment** g
- **Momentum dispersion** $p_T D$
- *LeSub*
- Mass etc.

The radial moment

The **angularity** g measures the radial energy profile of the jet. The radial moment is given by the equation:

$$g = \sum_{i \in jet} \frac{p_{\mathrm{T}}^{\mathrm{i}}}{p_{\mathrm{T,jet}}} |\Delta R_{\mathrm{i,jet}}| \tag{1}$$

where $p_{\mathrm{T}}^{\mathrm{i}}$ represents the momentum of the ith constituent and $\Delta R_{\mathrm{i,jet}}$ is the distance in $\eta \times \phi$ plane between the constituent i and the jet axis [4].

[4] S. Acharya et al. Medium modification of the shape of small-radius jets in central Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$, *JHEP* 10:139, 2018

The momentum dispersion

The **momentum dispersion** $p_T D$ measures the second moment of the constituent p_T distribution in the jet. It is defined as follows [4]:

$$p_T D = \frac{\sqrt{\sum_{i \in jet} p_{\mathrm{T,i}}^2}}{\sum_{i \in jet} p_{\mathrm{T,i}}}. \tag{2}$$

[4] S. Acharya et al. Medium modification of the shape of small-radius jets in central Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$, *JHEP* 10:139, 2018

LeSub

The difference of the leading track p_{T} ($p_{\mathrm{T,track}}^{\mathrm{lead}}$) and sub-leading track p_{T} ($p_{\mathrm{T,track}}^{\mathrm{sublead}}$) or *LeSub* is defined as [4]:

$$LeSub = p_{\mathrm{T,track}}^{\mathrm{lead}} - p_{\mathrm{T,track}}^{\mathrm{sublead}}. \quad (3)$$

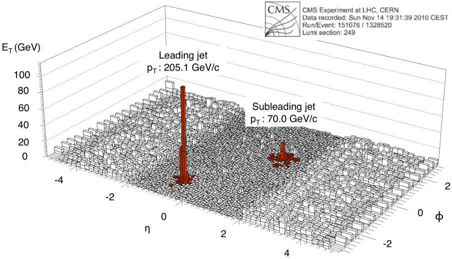


Figure : An example of jet pair in Pb+Pb collision at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV [5].

[5] S. Salur, A Brief Review of CMS Jet Measurements, *J. Phys. Conf. Ser.* 589(1):012017, 2015

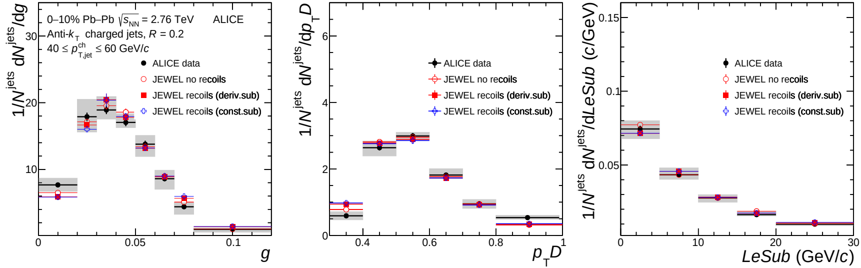


Figure : Jet shape distributions in 0–10% central Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV for $R = 0.2$ in range of jet $p^{ch}_{T,jet}$ of 40–60 GeV/c compared to JEWEL with and without recoils with different subtraction methods. The colored boxes represent the experimental uncertainty on the jet shapes [4].

[4] S. Acharya et al. Medium modification of the shape of small-radius jets in central Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76\,\text{TeV}$, *JHEP* 10:139, 2018

Anti-kT jet finding algorithm

- **Cluster type jet finding algorithm** $\longrightarrow$ based on successive pair-wise recombination of particles.
- The hard particle is found first.
- The algorithm:
  - Find the minimum distances via

$$d_{ij} = \min(k_{ti}^{-2}, k_{tj}^{-2}) \frac{\Delta_{ij}^2}{R^2}, \tag{4}$$

$$d_{iB} = k_{ti}^{-2}, \tag{5}$$

where $\Delta_{ij}^2 = (y_i - y_j)^2 + (\phi_i + \phi_j)^2$.

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  - Find the minimum distance $d_{\min}$ between all the d_{ij} and d_{iB}.
  - Repeat the first two steps until no particles left.

[3] M. Cacciari, G. P. Salam, Dispelling the N^3 myth for the k_t jet-finder. *Phys. Lett.* B 641:57-61, 2006

JEWEL

Jet **E**volution **W**ith **E**nergy **L**oss

Name of parameter	Name in JEWEL	Value	
Parton Distribution Function set	PDFSET	10100	
Number of events	NEVENT	100000	
Mass number of Au nucleus	MASS	197	
The CMS energy of the colliding system	SQRTS, [GeV]	200	
Minimum p_T in matrix element	PTMIN, [GeV]	3	
Maximum p_T in matrix element	PTMAX, [GeV]	-1	
The switch of keeping recoils	KEEPRECOLIS	T	F
The rapidity range	ETAMAX	2.5	

Table : Parameters of JEWEL vacuum simulation for central and peripheral "recoils on/off" collisions [6].

[6] K. C. Zapp, JEWEL 2.0.0: Directions for use. *Eur. Phys. J.*, C74(2):2762, 2014.

JEWEL

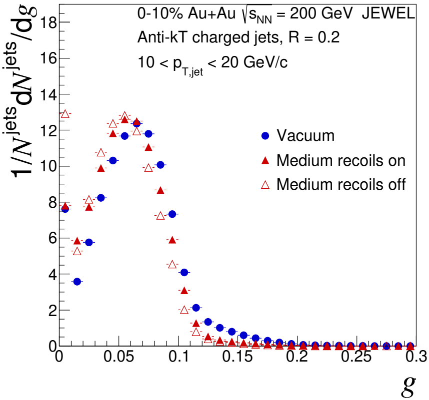
Name of parameter	Name in JEWEL	Value	
The initial (mean) temperature	TI, [GeV]	0.28	
The initial time τ_i	TAUI, [fm]	0.6	
An integer mass number of colliding nuclei	A	197	
The lower end of centrality range	CENTRMIN, [%]	0	60
The upper end of centrality range	CENTRMAX, [%]	10	80
The nucleus-nucleus cross-section	SIGMANN, [fm^2]	4.2	

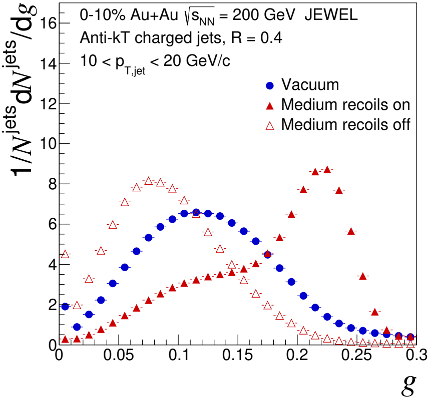
Table : Parameters of JEWEL simulation with medium for central and peripheral "recoils on/off" collisions [6].

[6] K. C. Zapp, JEWEL 2.0.0: Directions for use. *Eur. Phys. J.*, C74(2):2762, 2014

Results

Angularity for Au+Au central collisions at $\sqrt{s_{\rm NN}} = 200$ GeV





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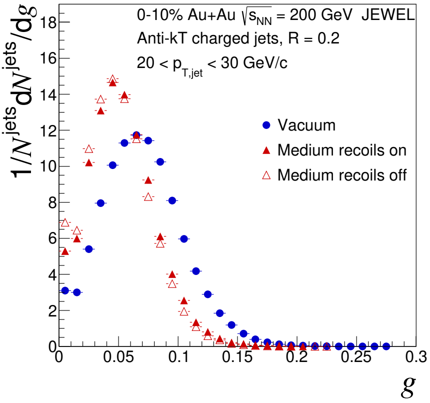
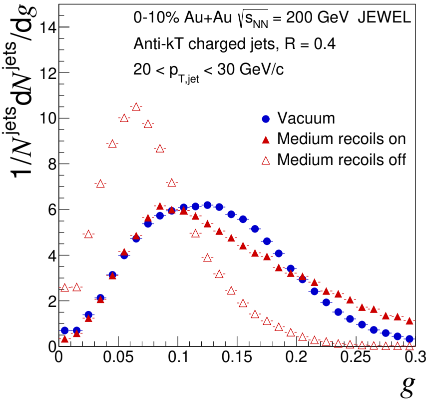
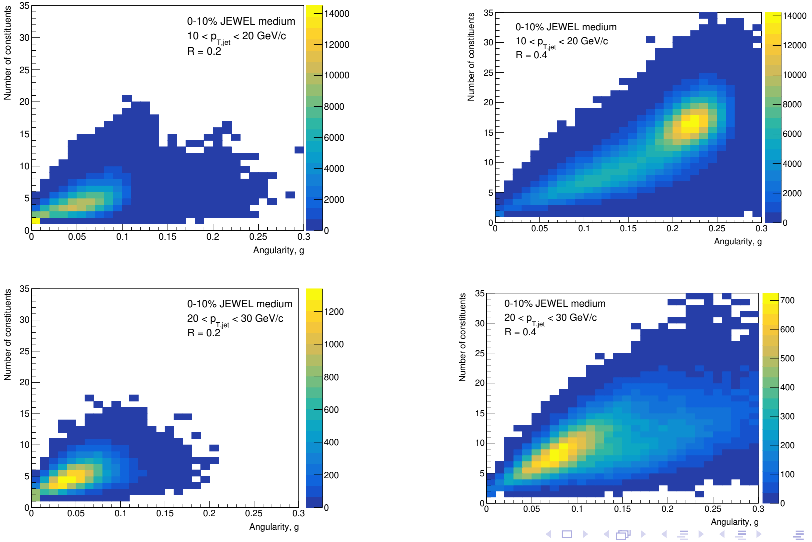




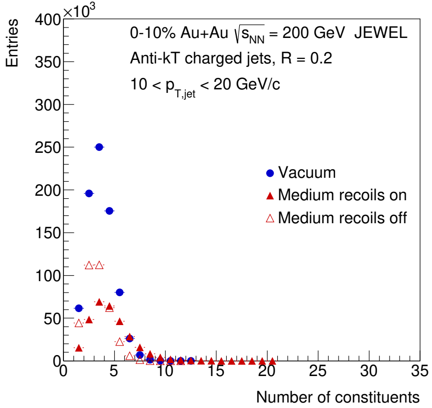
2D Statistics

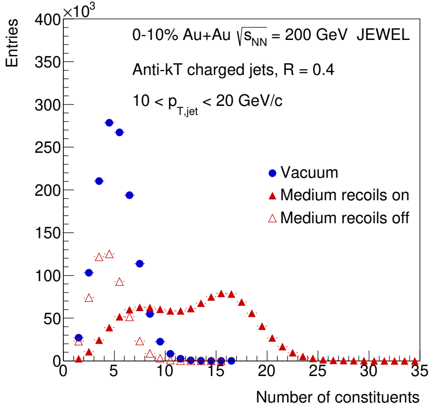
Central recoils on Au+Au collisions simulated for medium model at $\sqrt{s_{NN}} = 200$ GeV



Statistics

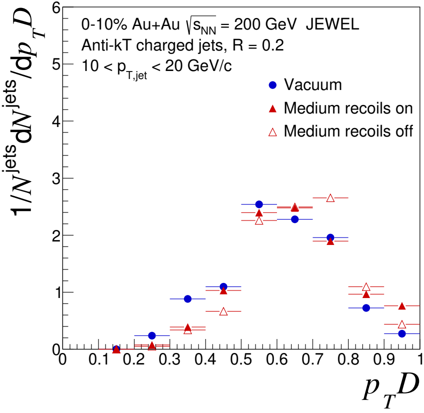
Central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

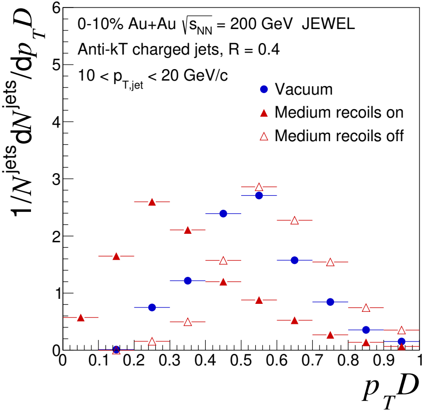




Results

The momentum dispersion for central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV





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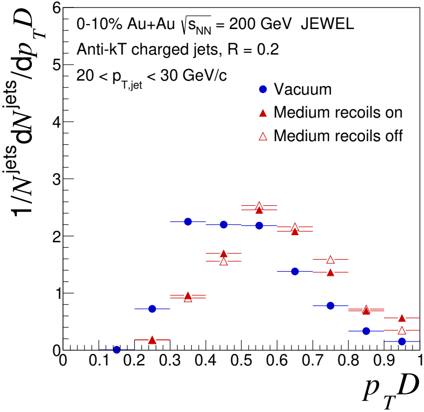
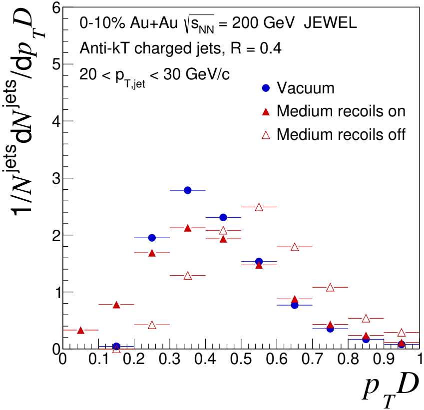
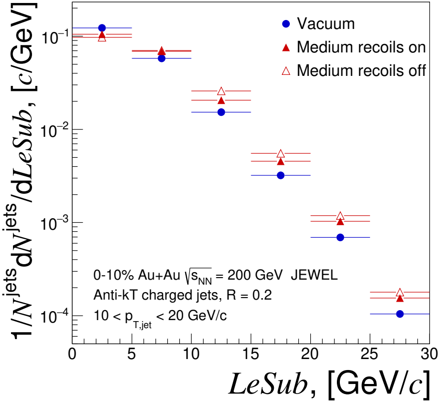
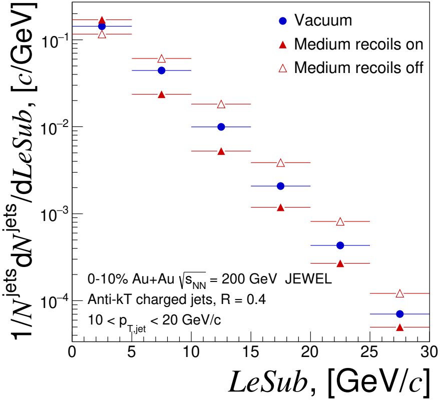




Results

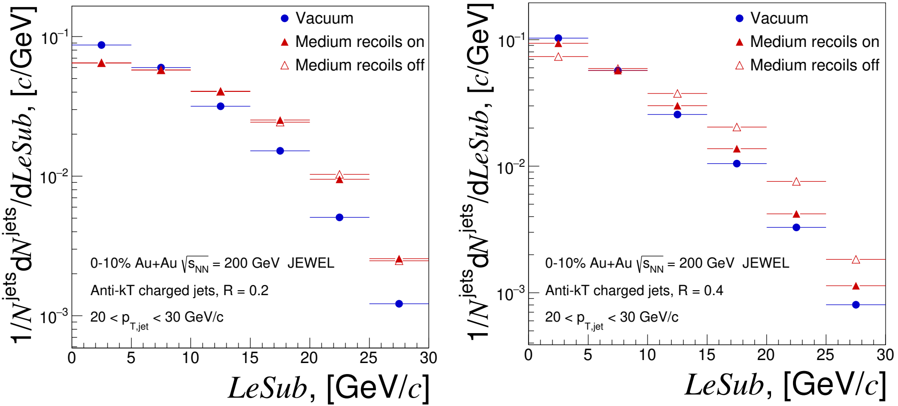
LeSub for central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV





Results

LeSub for central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV



Summary

- The practical application of the anti-kT jet finding algorithm and the chosen jet shape observables on the simulated data with/without nuclear medium model at particle level in the MC generator JEWEL at $\sqrt{s_{\rm NN}} = 200$ GeV.
- Discussion of the obtained results for jet shapes as a function of the transverse momentum of jet and the centrality in vacuum and nuclear medium.

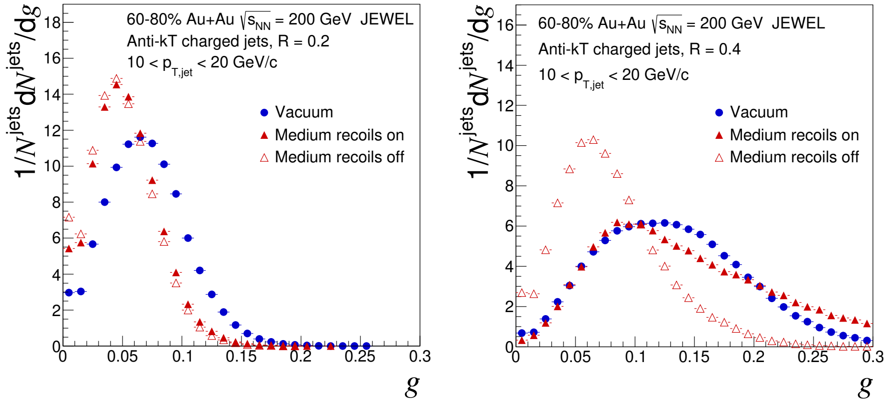
Future goals:

- To perform the background subtraction similarly to the ALICE experiment.
- To apply methods on experimental data from STAR.
- To compare the obtained results with the simulation made in JEWEL and the results from the LHC collaborations.

Backup

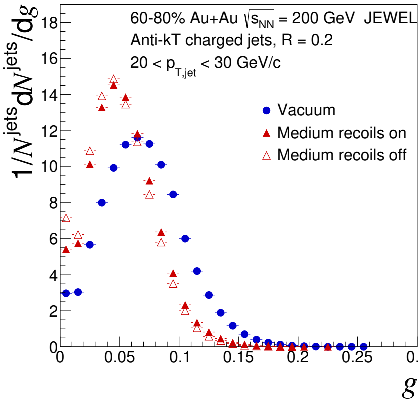
Results

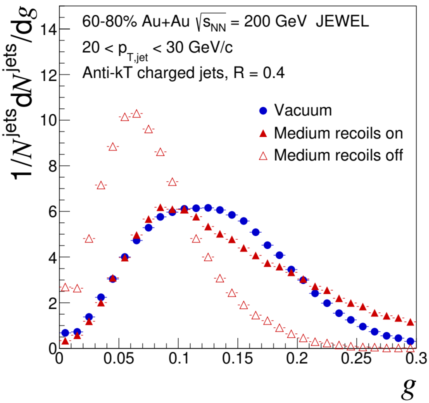
Angularity for Au+Au peripheral collisions at $\sqrt{s_{NN}} = 200$ GeV



Results

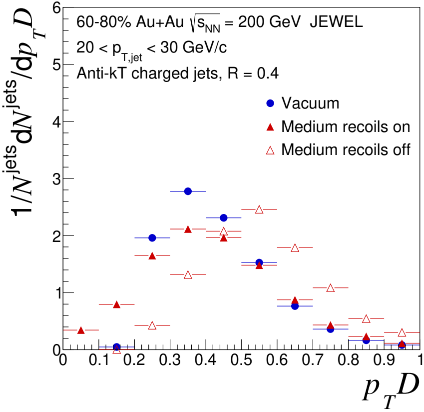
Angularity for Au+Au peripheral collisions at $\sqrt{s_{NN}} = 200$ GeV

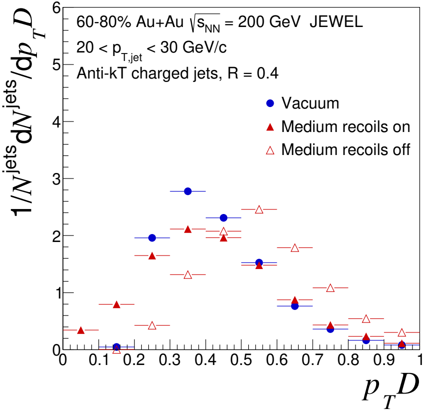




Results

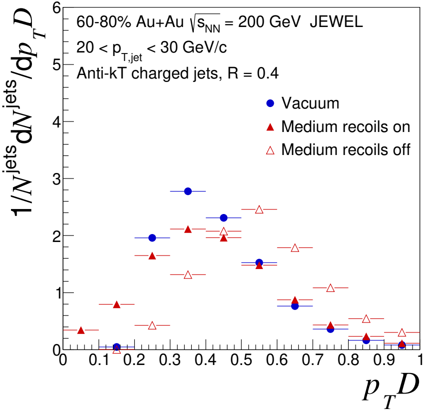
Momentum dispersion for Au+Au peripheral collisions at $\sqrt{s_{NN}} = 200$ GeV

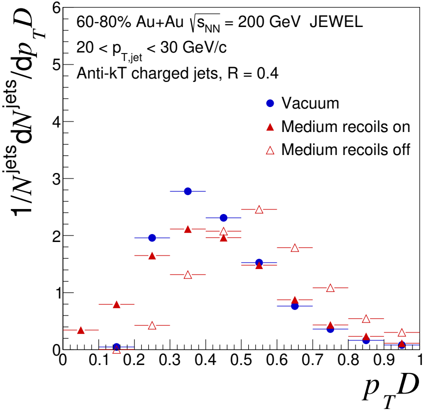




Results

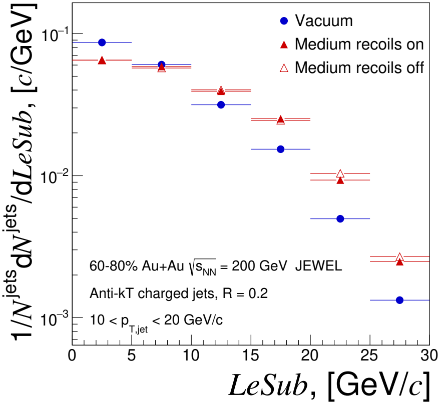
Momentum dispersion for Au+A peripheral collisions at $\sqrt{s_{NN}} = 200$ GeV

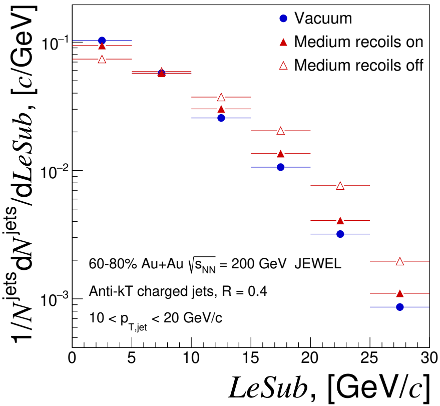




Results

LeSub for Au+Au peripheral collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV





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