Jet Shapes and Fragmentation Function

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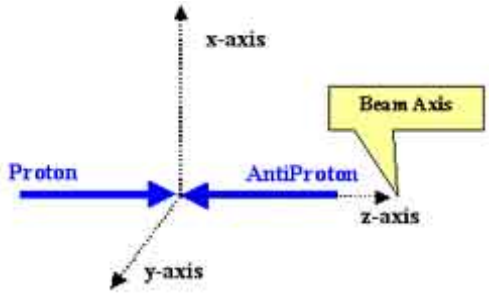
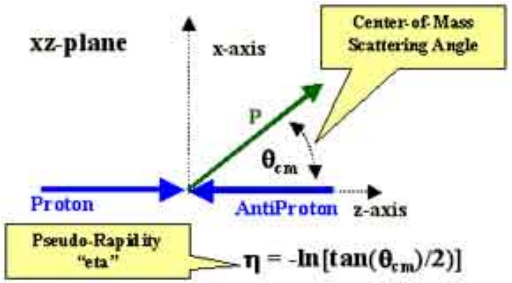
Overview

1. Pseudorapidity
2. Jet Reconstruction Algorithm
3. Jet Shapes and Fragmentation Function
4. Calculation of Fragmentation Function
5. Calculation of jet shape for hard particles
6. Calculation of jet shape for soft particles

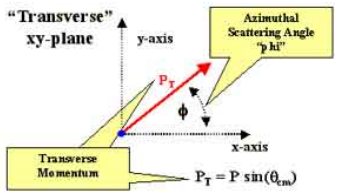
Pseudorapidiy, Azimuthal Angle and Transverse Momentum



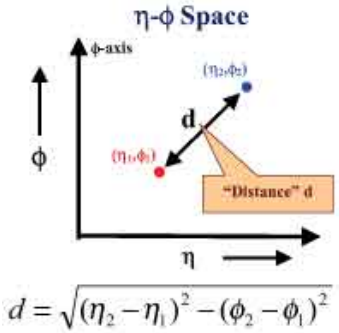
(a) Axes Position



(b) Azimuthal Angle

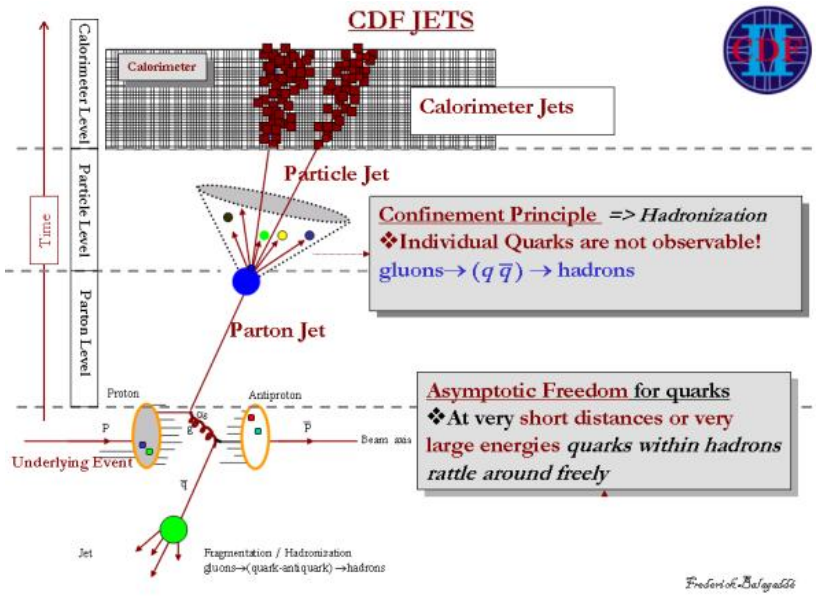


(c) Transverse Momentum

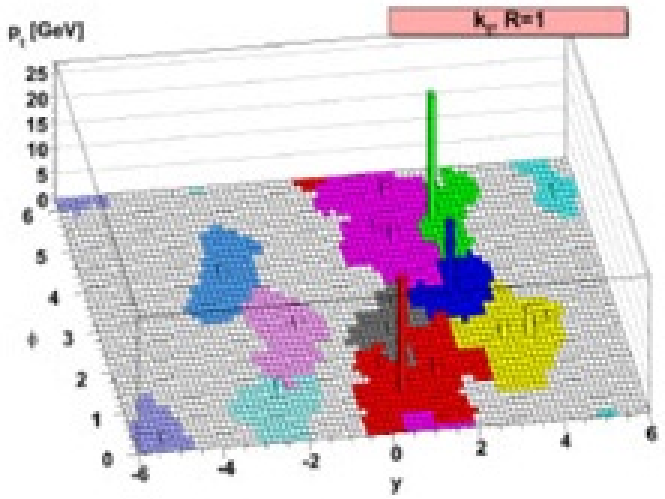


(d) distance with η and ϕ

Jets and Reconstruction of Jets



(a) Different Jets



(b) Shapes for jets algorithms reconstructing the same event.

Jet Algorithms

Different Jet Reconstruction Algorithms

- Jet reconstruction requirements: collinear and infrared safety, minimal sensitivity to underlying event, hadronization and pile-up
- Cone type algorithm: Midpoint Cone, Iterative Cone, SIS-cone
- Sequential Clustering Algorithm : Kt, Anti-Kt, Cambridge-Aachen

Anti-Kt algorithm

It is IRC-safe and still circular shaped jet is obtained

Jet Shapes-I

Integral Jet Shape,

$$\rho(r) = \frac{1}{N_{jet}} \frac{1}{r} \sum_{jets} \frac{\sum_{tracks[0,r]} P_t}{P_t^{jet}} \quad (1)$$

where, r is the distance from the jet axis.
Differential jet shape,

$$\rho(r) = \frac{1}{N_{jet}} \frac{1}{dR} \sum_{jets} \frac{\sum_{tracks[r_a,r_b]} P_t}{P_t^{jet}} \quad (2)$$

where, r_a and r_b are distances from the jet axis and $dR = r_b - r_a$.
Hence the differential area that is considered is like $2\pi r_a dR$
- N_{jet} in the equation is the number of jets in the definite energy range
- P_t is the transverse momentum of the particle

Jet Shape-II

Motivation for calculating jet shapes:

- Main motivation of this work is if we apply the cut in particle momentum during the reconstruction of jet and investigate how the jet shapes change for hard particles and soft particles
- Calculated differential jet shape for hard particles ($P_t > 4$ GeV) and soft particles ($P_t < 4$ GeV) separately
- The target is to examine how the jet shapes differ in different energy range for hard particles and the soft particles
- The ultimate target is to find some variable which makes the change in jet shape in different energy regime to a minimum

Fragmentation Function

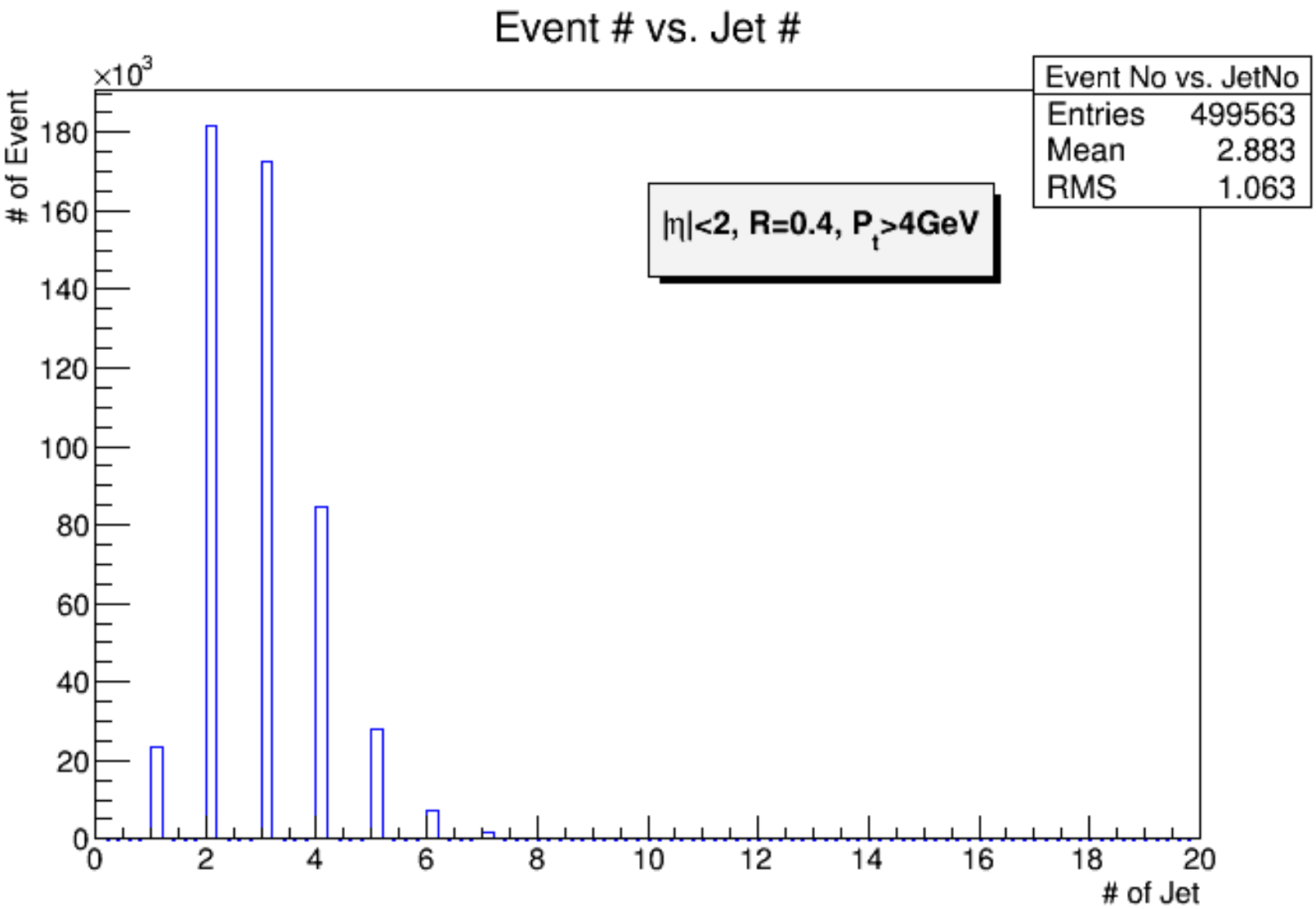
Fragmentation function is defined as,

$$z = \frac{P_t^{track}}{P_t^{jet}}$$

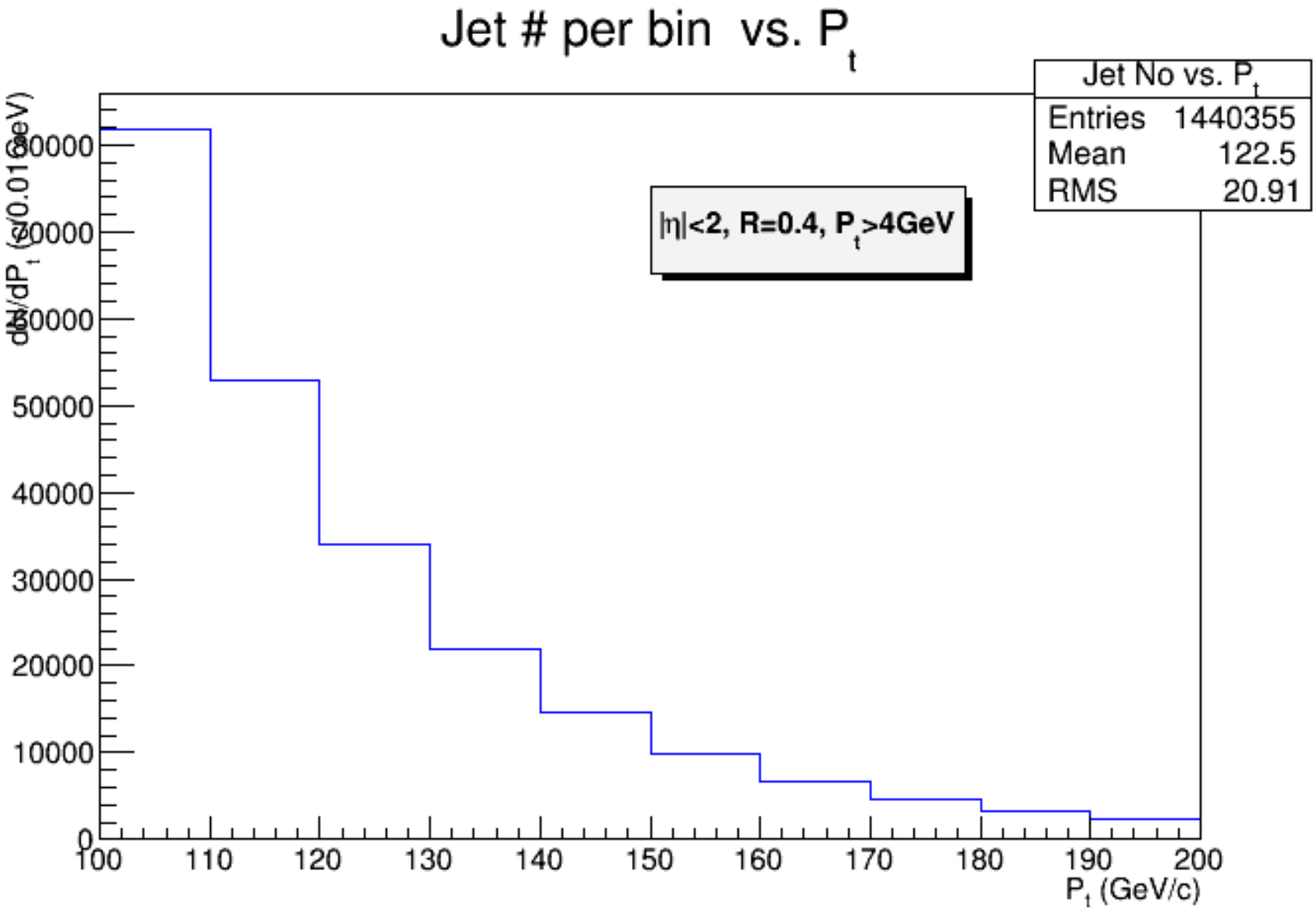
But for better scaling usually the following definition is used for plotting,

$$\zeta = \ln \frac{1}{z}$$

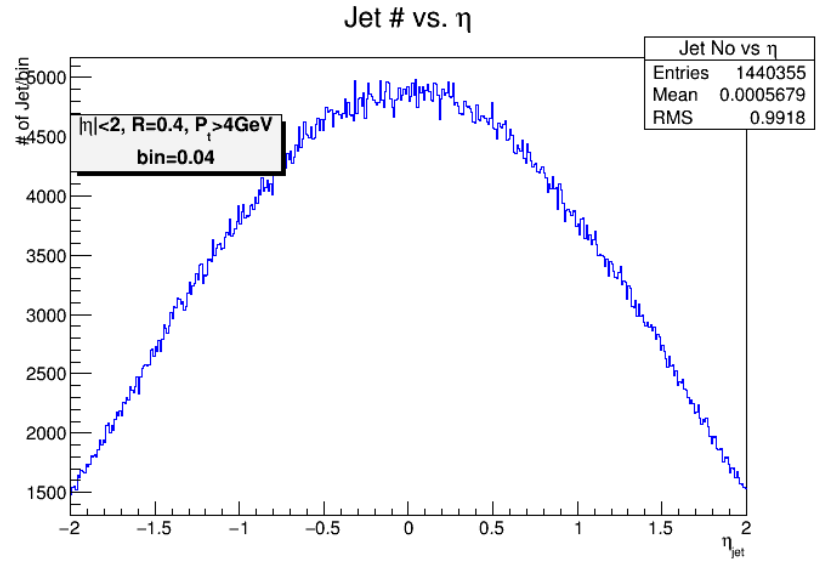
Results-I

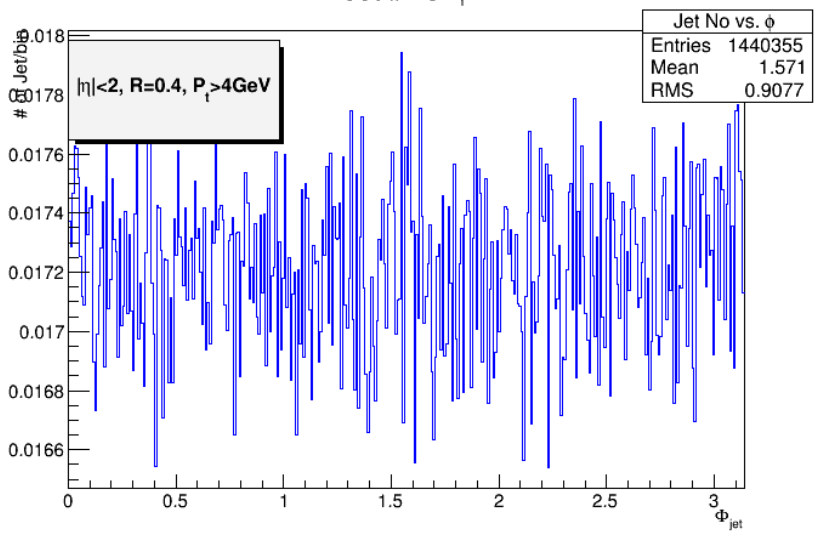

Event # vs. Jet #
Event No vs. JetNo
Entries 499563
Mean 2.883
RMS 1.063
|η|<2, R=0.4, P_t>4GeV
×10^3
# of Event
# of Jet
0
20
40
60
80
100
120
140
160
180
0
2
4
6
8
10
12
14
16
18
20

Results-II

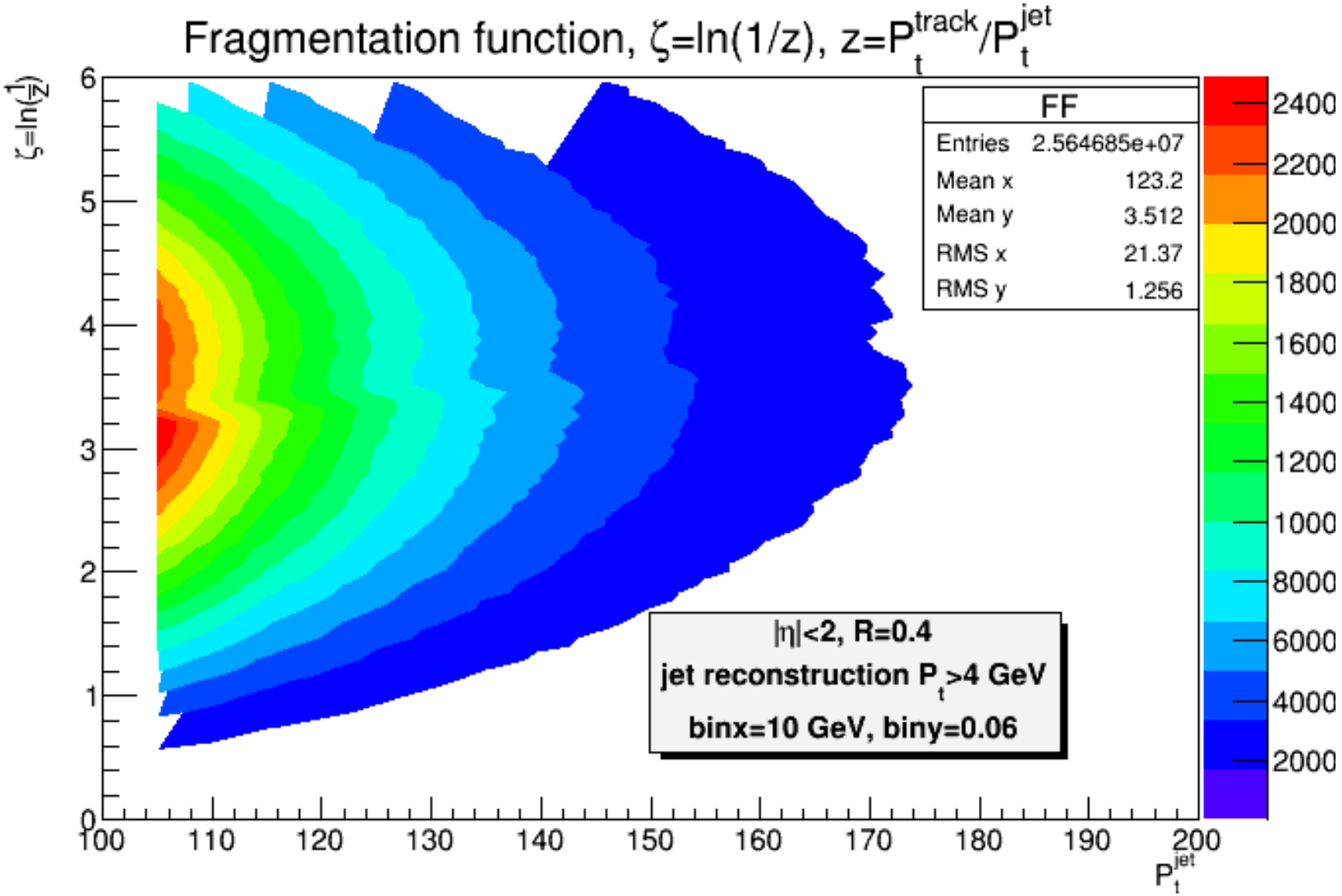

Jet # per bin vs. P t
Jet No vs. P t
Entries 1440355
Mean 122.5
RMS 20.91
|η|<2, R=0.4, P t >4GeV
dN/dP t (c/0.01GeV)
60000
50000
40000
30000
20000
10000
0
100
110
120
130
140
150
160
170
180
190
200
P t (GeV/c)

Results-III

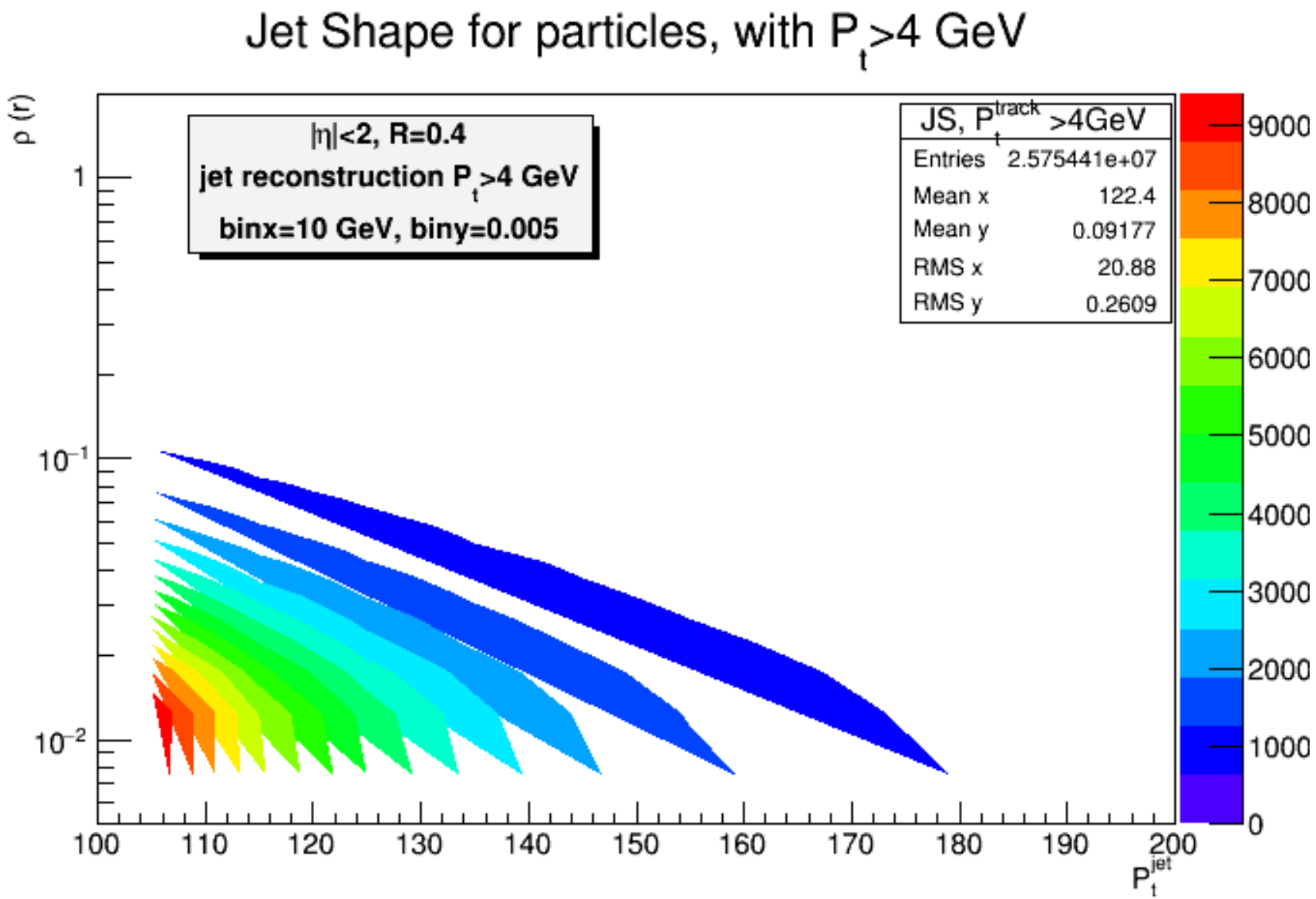

Jet # vs. η
Jet No vs η
Entries 1440355
Mean 0.0005679
RMS 0.9918
|η|<2, R=0.4, P_t>4GeV
bin=0.04
# of Jet/bin
η_jet


Jet # vs. ϕ
Jet No vs. ϕ
Entries 1440355
Mean 1.571
RMS 0.9077
|η|<2, R=0.4, P_t>4GeV
# of Jet/bin
Φ_jet

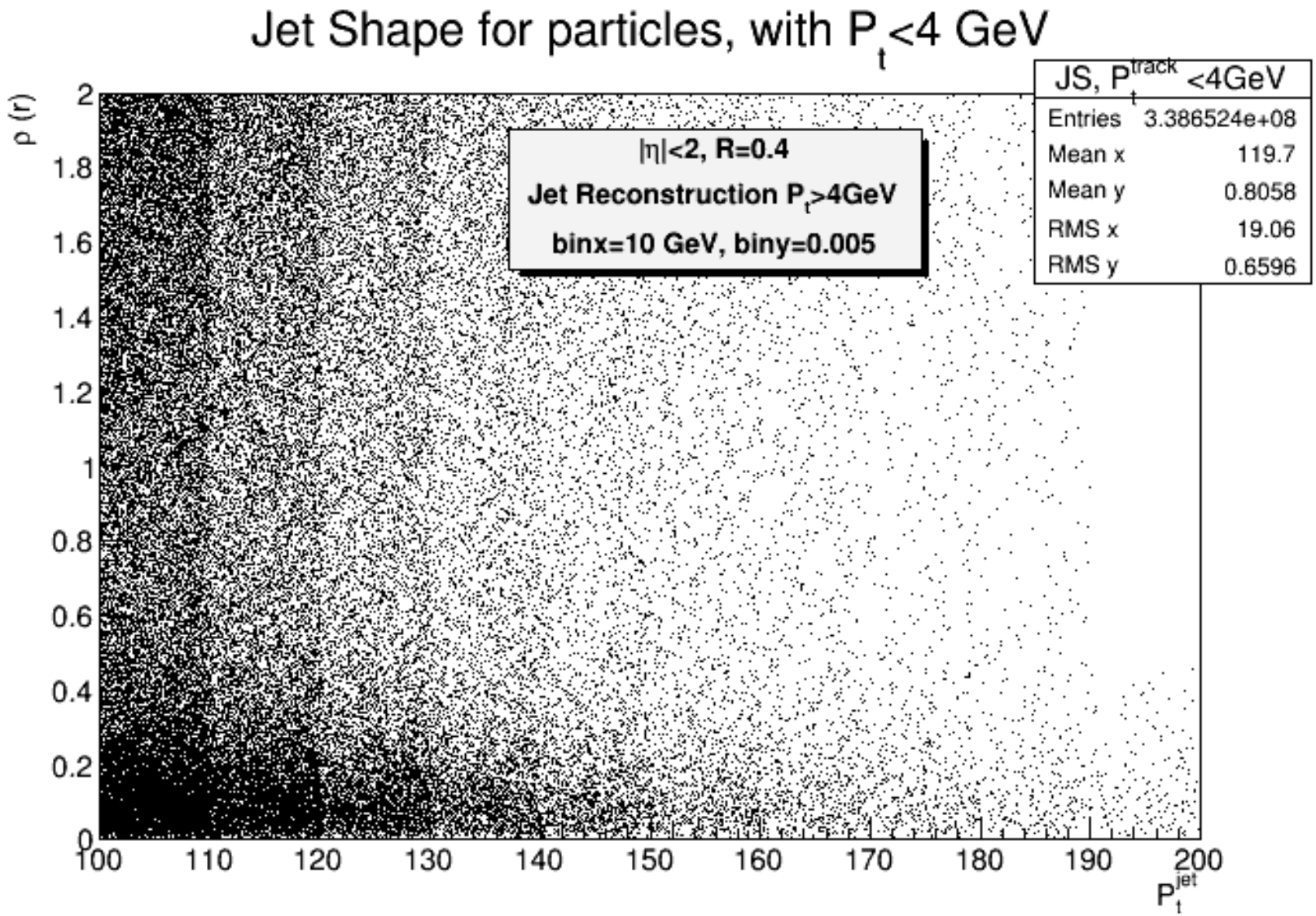
Results-IV


Fragmentation function, ζ=ln(1/z), z=P_t^track/P_t^jet
ζ=ln(1/z)
P_t^jet
FF
Entries 2.564685e+07
Mean x 123.2
Mean y 3.512
RMS x 21.37
RMS y 1.256
|η|<2, R=0.4
jet reconstruction P_t>4 GeV
binx=10 GeV, biny=0.06
0
1
2
3
4
5
6
100
110
120
130
140
150
160
170
180
190
200
2400
2200
2000
1800
1600
1400
1200
1000
8000
6000
4000
2000

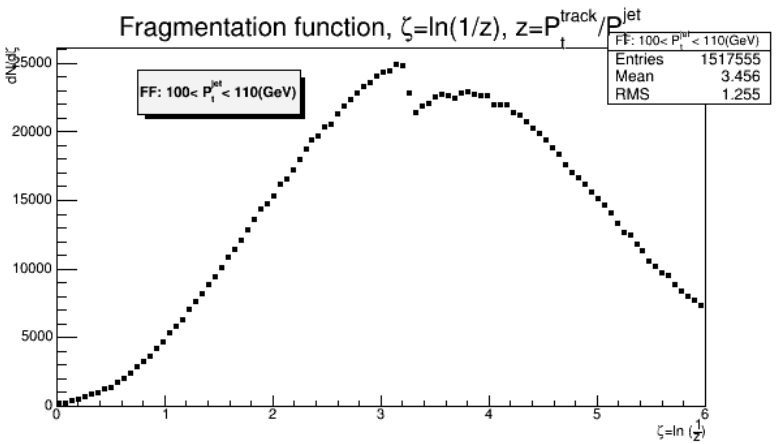
Results-V

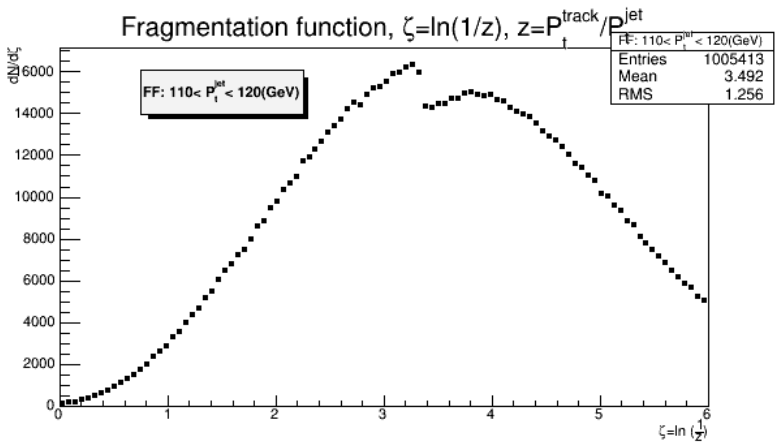

Jet Shape for particles, with P_t>4 GeV
ρ (r)
|η|<2, R=0.4
jet reconstruction P_t>4 GeV
binx=10 GeV, biny=0.005
JS, P_t^track >4GeV
Entries 2.575441e+07
Mean x 122.4
Mean y 0.09177
RMS x 20.88
RMS y 0.2609
1
10^-1
10^-2
100 110 120 130 140 150 160 170 180 190 200
P_t^jet
9000 8000 7000 6000 5000 4000 3000 2000 1000 0

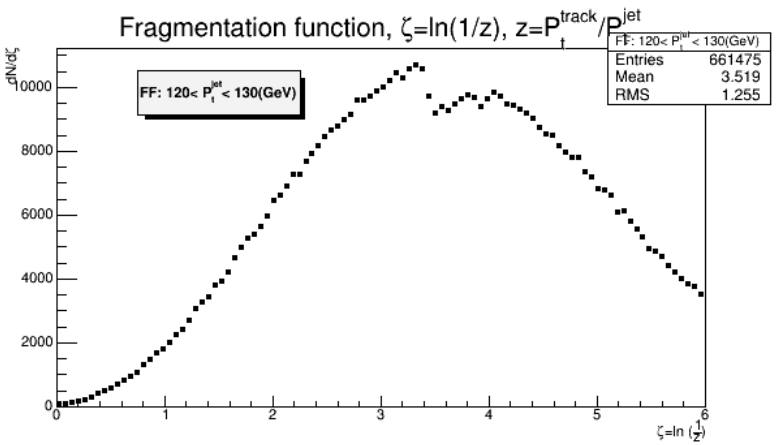
Results-VI

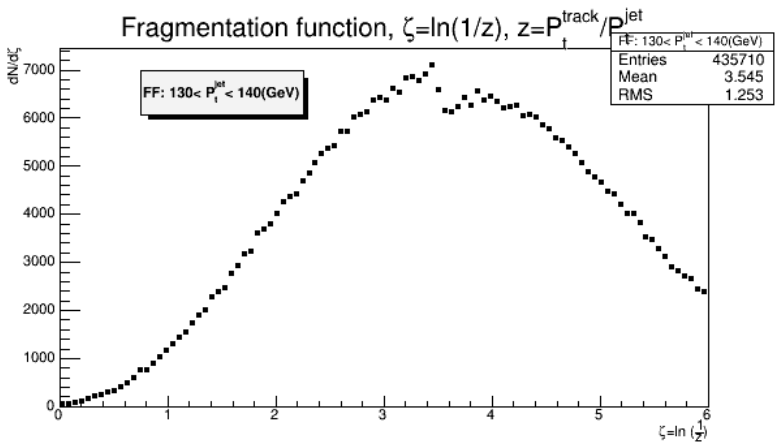

Jet Shape for particles, with P_t<4 GeV
ρ (r)
P_t^{jet}
|η|<2, R=0.4
Jet Reconstruction P_t>4GeV
binx=10 GeV, biny=0.005
JS, P_t^{track} <4GeV
Entries 3.386524e+08
Mean x 119.7
Mean y 0.8058
RMS x 19.06
RMS y 0.6596

Results-VII

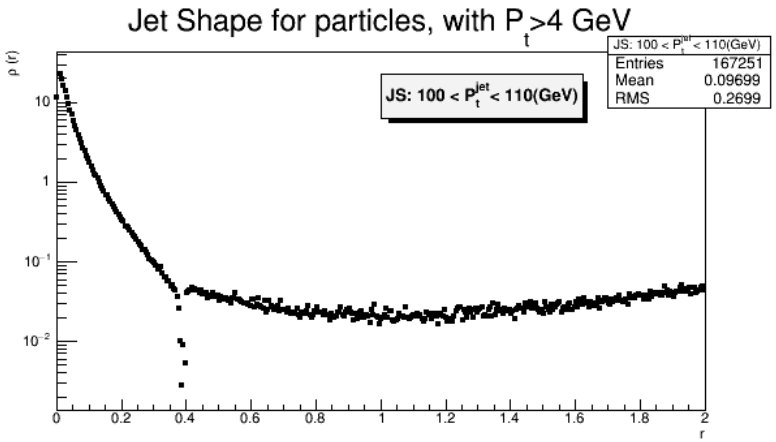

Fragmentation function, ζ=ln(1/z), z=P_t^track/P^jet
FF: 100< P_t^jet < 110(GeV)
Entries 1517555
Mean 3.456
RMS 1.255
dN/dζ
ζ=ln(1/z)

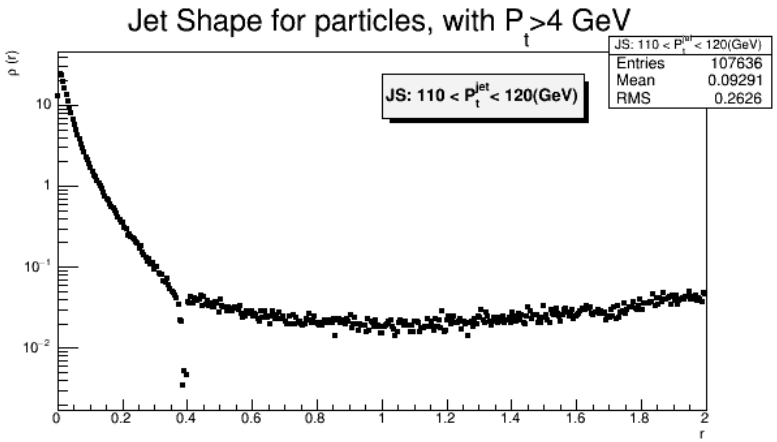

Fragmentation function, ζ=ln(1/z), z=P_t^track/P^jet
FF: 110< P_t^jet < 120(GeV)
Entries 1005413
Mean 3.492
RMS 1.256
dN/dζ
ζ=ln(1/z)

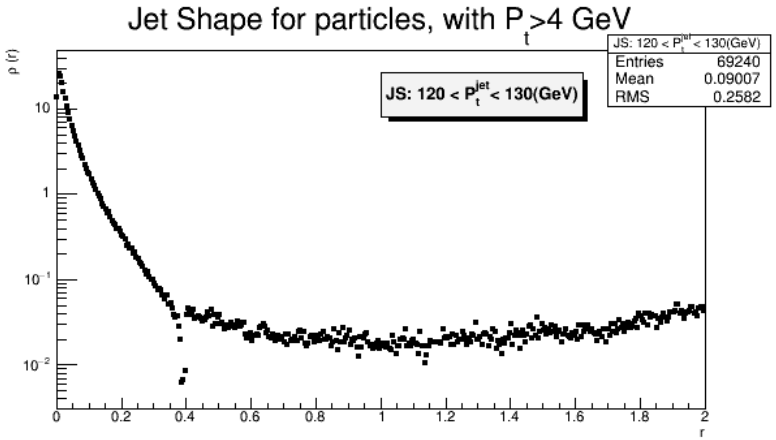

Fragmentation function, ζ=ln(1/z), z=P_t^track/P^jet
FF: 120< P_t^jet < 130(GeV)
Entries 661475
Mean 3.519
RMS 1.255
dN/dζ
ζ=ln(1/z)

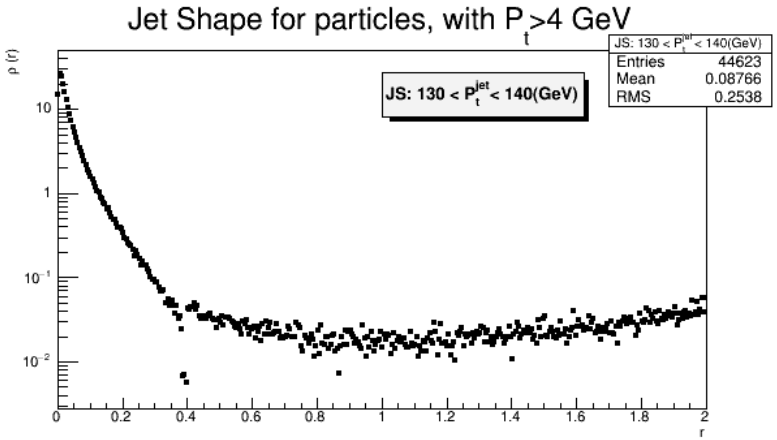

Fragmentation function, ζ=ln(1/z), z=P_t^track/P^jet
FF: 130< P_t^jet < 140(GeV)
Entries 435710
Mean 3.545
RMS 1.253
dN/dζ
ζ=ln(1/z)

Results-VIII

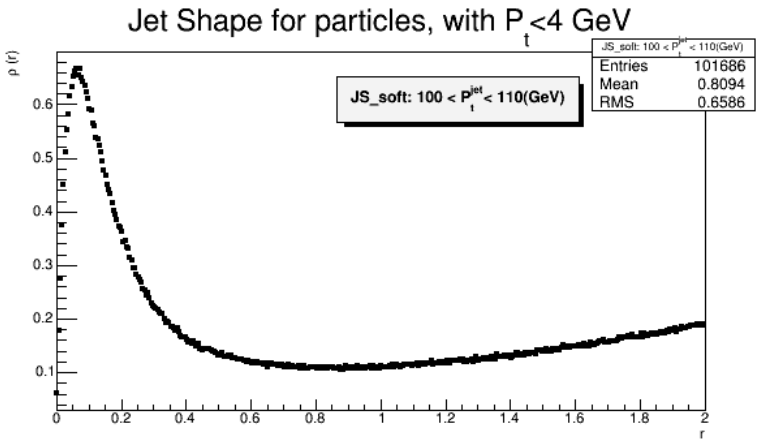


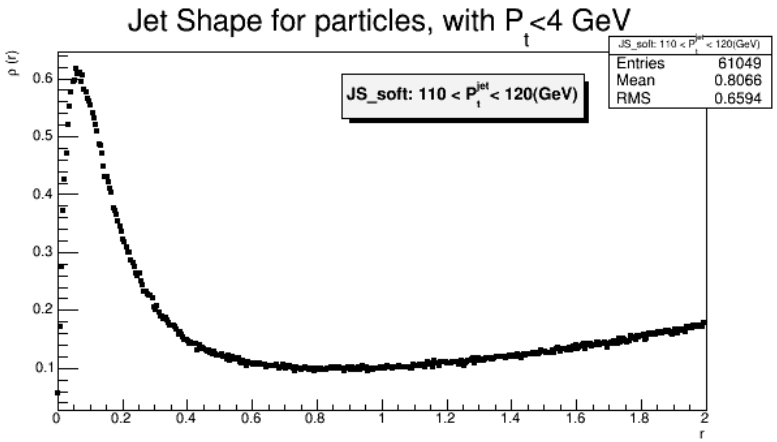


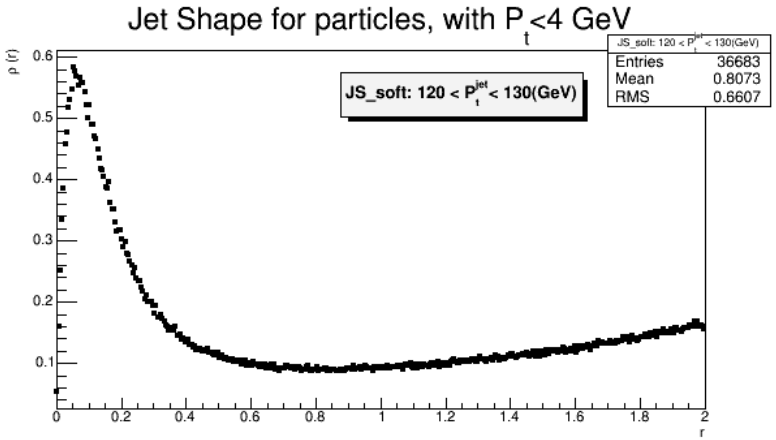


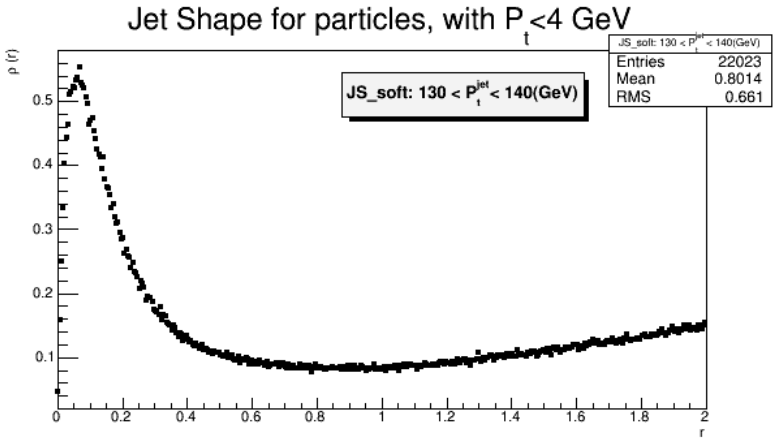


Results-IX


Jet Shape for particles, with P_t<4 GeV
JS_soft: 100 < P_t^jet < 110(GeV)
Entries 101686
Mean 0.8094
RMS 0.6586
ρ (r)
r


Jet Shape for particles, with P_t<4 GeV
JS_soft: 110 < P_t^jet < 120(GeV)
Entries 61049
Mean 0.8066
RMS 0.6594
ρ (r)
r


Jet Shape for particles, with P_t<4 GeV
JS_soft: 120 < P_t^jet < 130(GeV)
Entries 36683
Mean 0.8073
RMS 0.6607
ρ (r)
r


Jet Shape for particles, with P_t<4 GeV
JS_soft: 130 < P_t^jet < 140(GeV)
Entries 22023
Mean 0.8014
RMS 0.661
ρ (r)
r

Next Steps

- Calculate the jet shapes using the data and compare with the presented Pythia Monte-Carlo Simulation results
- To scale x-axis such that the Jet shape plots become similiar in different energies
- To invistigate the reason why the jet shapes are so similar in case of hard particles with the presented parameters

Next to Next Steps

- To investigate jet shapes for much higher energy range
- To invistigate jet shapes in Pb-Pb collisions, to investigate the centrality dependence
- To compare the jet shapes of p-p collision and Pb-Pb collision