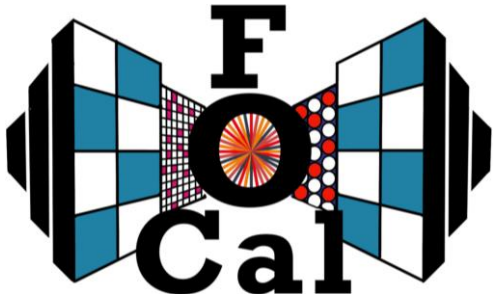
Jet Reconstruction Performance in FoCal

ALICE-STAR India Collaboration Meeting, IOP Bhubaneswar

24/06/2024 to 27/06/2024



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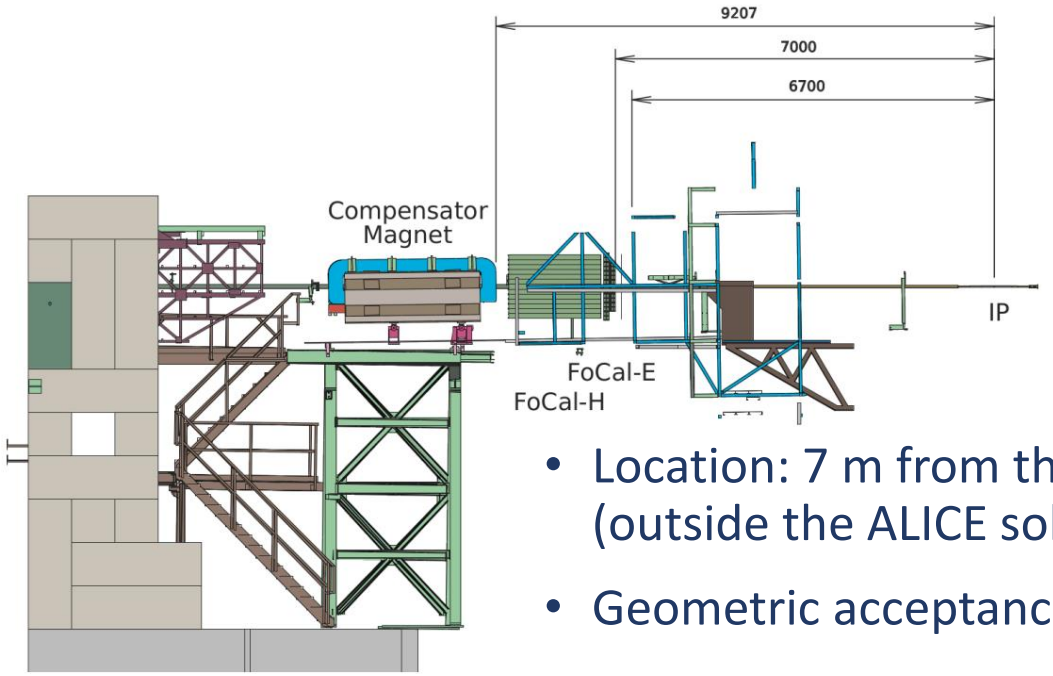
Outline

- Introduction to FoCal
- Jets
- Analysis method
- Results
- Summary & Outlook

The Forward Calorimeter

Physics Goals:

- To explore non-linear QCD evolution
- Quantify nuclear modification of the gluon density at small x
- Investigate the origin of long-range flow-like correlations
- Explore jet quenching at forward rapidity

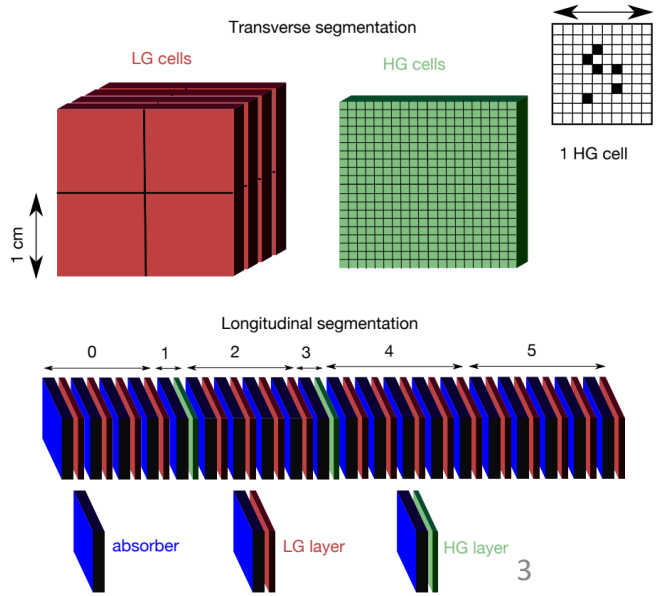


- Location: 7 m from the interaction point (outside the ALICE solenoid magnet)
- Geometric acceptance: $3.4 \leq \eta \leq 5.8$

The FoCal Design:

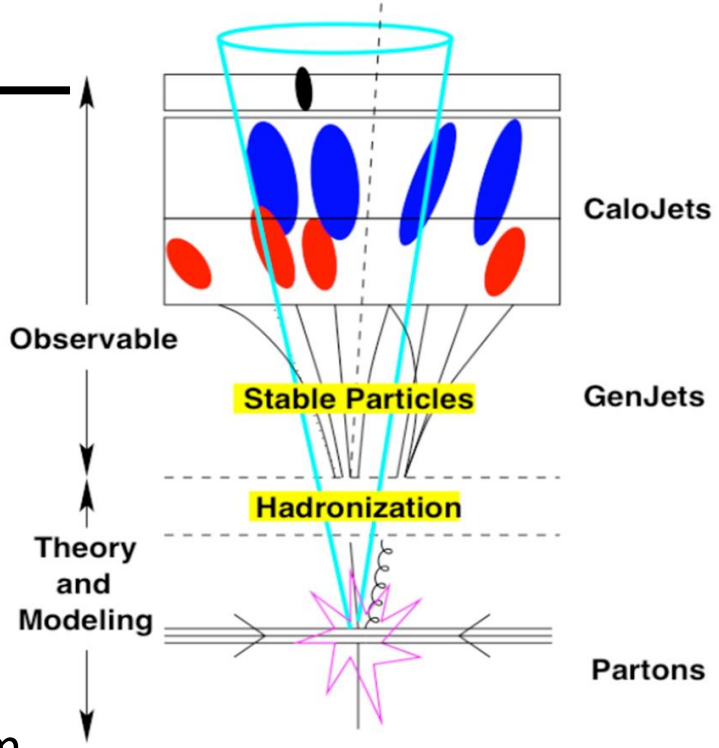
- Ability to discriminate decay photons from neutral pions from prompt photons
- A small size shower is beneficial to optimize the photon shower separation
- Tungsten is chosen as the absorber material for its,
  - Smaller Molière radius $R_M = 9$ mm &
  - Small radiation length $X_0 = 3.5$ mm

	LG	HG
pixel/pad size	≈ 1 cm²	≈ 30x30 µm²
total # of pixels/pads	≈ 2.5 x 10^5	≈ 2.5 x 10^9



Jet analysis in FoCal

- A jet is a collimated bunch of hadrons flying roughly in the same direction
- Jets can act as a natural probe to study the QCD matter created in collision
- The classification of particles into jets is best done using a clustering algorithm



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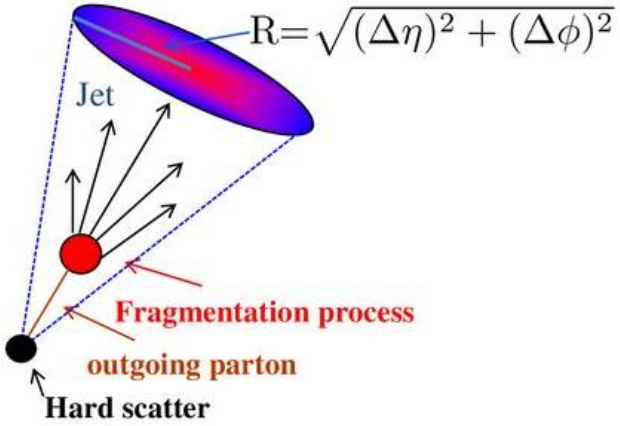


Jet Reconstruction Algorithm

- Two main classes of jet algorithms: Cone algorithm (iterative cone, SIS cone) and sequential clustering algorithms (k_t, anti-k_t)
- Here we are using anti- k_t algorithm, which is IRC safe
- The algorithm includes a **jet definition** that contains a jet algorithm name, its parameters, and the recombination scheme

- Here the E-Scheme procedure is used to combine the momenta while merging the particles during clustering

Data set:

- p+p (pythia triggered decay photon p_T>5 GeV/c), can be found in /alice/cern.ch/user/f/focal/sim/v1.5_root6/pythiaTrigDirGamma/simDecayGamma_ptmin5
- Number of events: ~50 K
- Focal acceptance 3.2 < η < 5.8
- Minimum jet p_T ($p_{T_{min}}$) = 5.0 GeV
- Jet Radius R = 0.2,0.4,0.5,0.6,0.8
- Jet matched_distance < 0.25
- Anti-kt algorithm

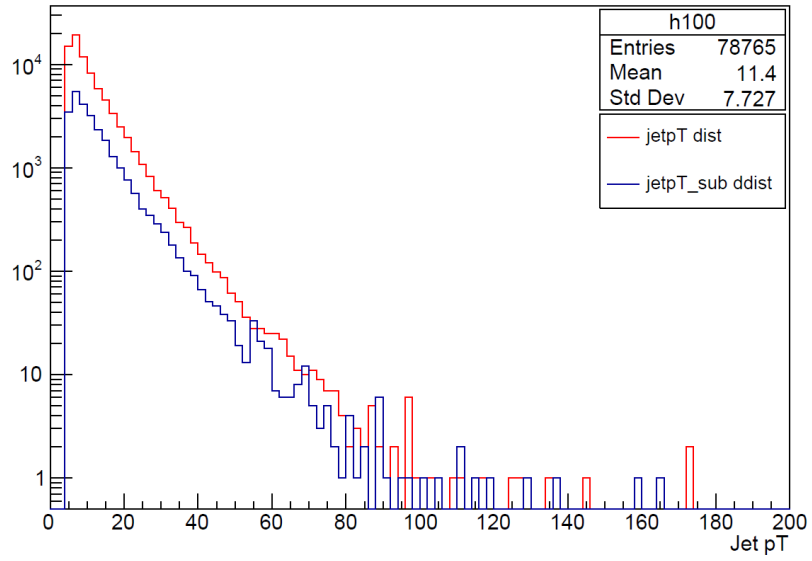
Box (single photon)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:box	200000	v1.5_root6/box/singlePhoton
Box (single electron)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:box	200000	v1.5_root6/box/singleElectron
p+Pb (Hijing + direct photon pt>4 GeV/c)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:PA_cocktail_dirgam	50000	v1.5_root6/pythiaTrigDirGamma/simPAFragGamma_ptmin4
p+Pb (Hijing + decay photon pt>4 GeV/c)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:PA_cocktail_MBtrig	50000	v1.5_root6/pythiaTrigDirGamma/simPADecayGamma_ptmin4
p+p (pythia min bias)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:pythia	500000	v1.5_root6/pythiaTrigDirGamma/simPythiaMinBias
p+p (pythia triggered decay photon pt>5GeV/c)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:pythia_MBtrig	50000	v1.5_root6/pythiaTrigDirGamma/simDecayGamma_ptmin5
p+p (pythia triggered decay photon pt>10GeV/c)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:pythia_MBtrig	50000	v1.5_root6/pythiaTrigDirGamma/simDecayGamma_ptmin10
p+p (pythia triggered decay photon pt>15GeV/c)	v1.5 (SiPad 300 microns)	3	6	Upgrade:FOCAL_Generators:pythia_MBtrig	50000	v1.5_root6/pythiaTrigDirGamma/simDecayGamma_ptmin15

Underlying Event (UE) subtraction

No of events ~ 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.8
Jet pTmin = 5.0 GeV

- The method of perpendicular cone is used to measure and subtract UE contribution
- Event-by-event calculation is done for UE based on circular region perpendicular to the leading p_T jet (in same η)
- For p_T;
  - $\rho_{perpcone} = p_{T\,perpcone}/\pi R^2$
  - Now for each jet

$$p_{T\,corrected} = p_{T\,jet} - \rho * \text{jetarea}$$



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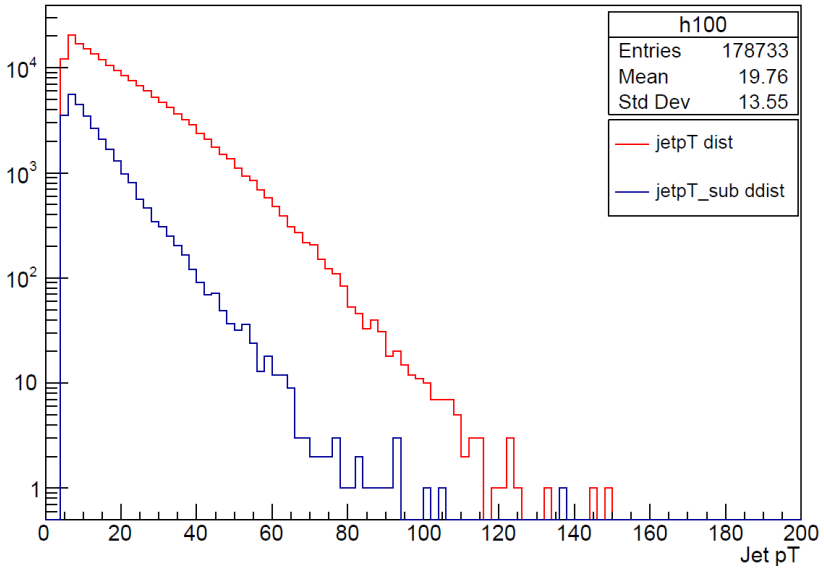
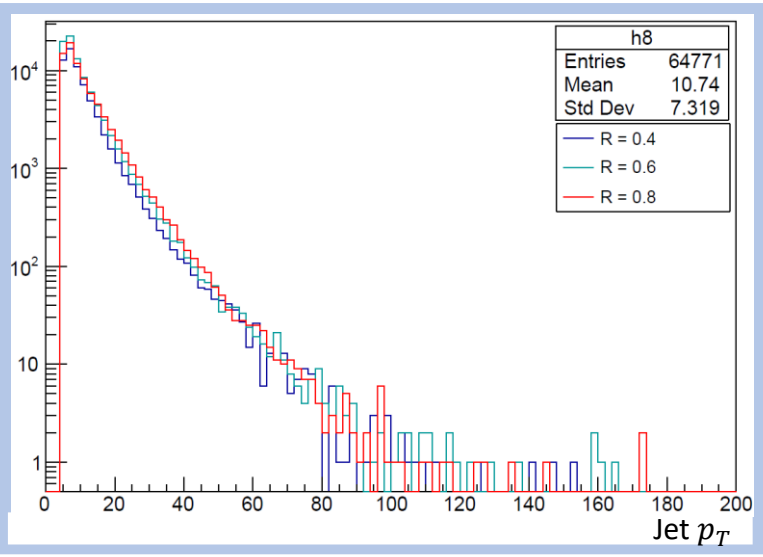
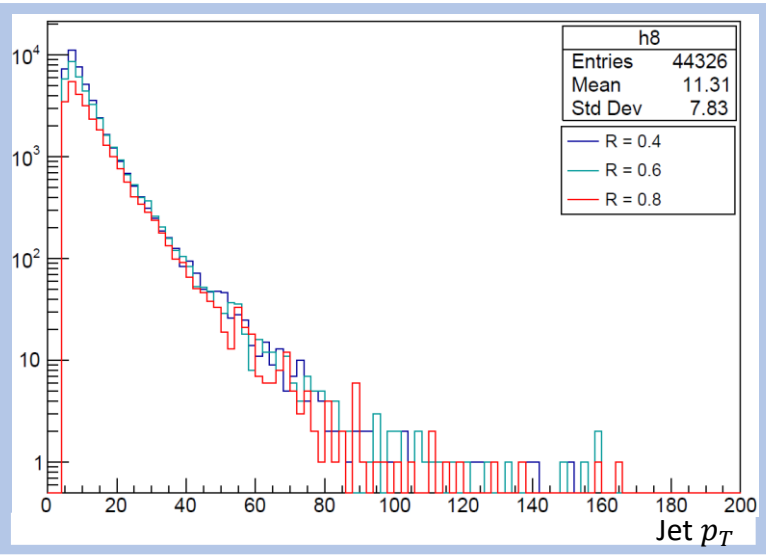


p-pb

Jet p_T distributions

No of events ~ 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV





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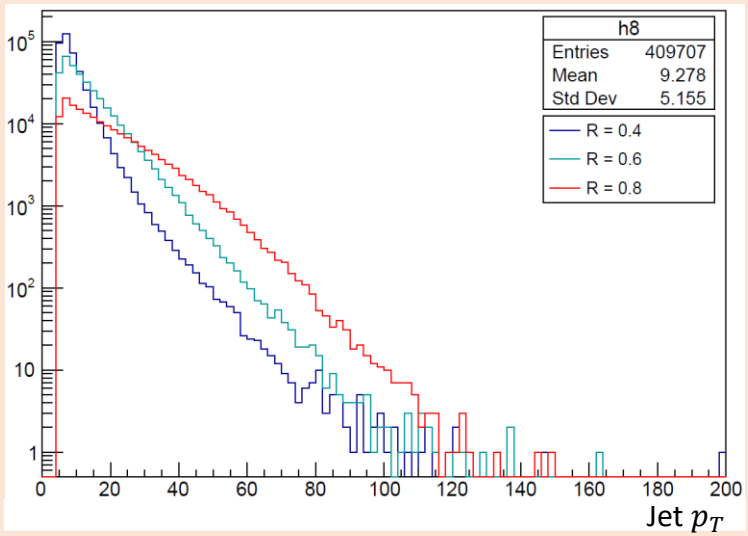
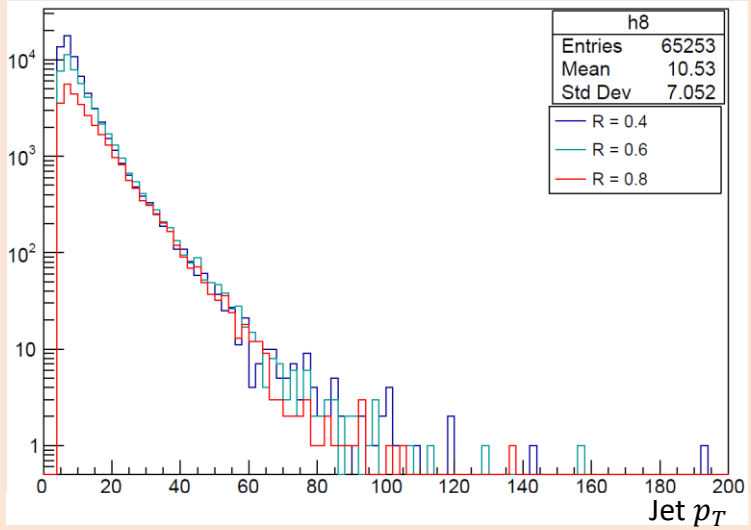




p-pb

R dependence of pT spectra without UE subtraction

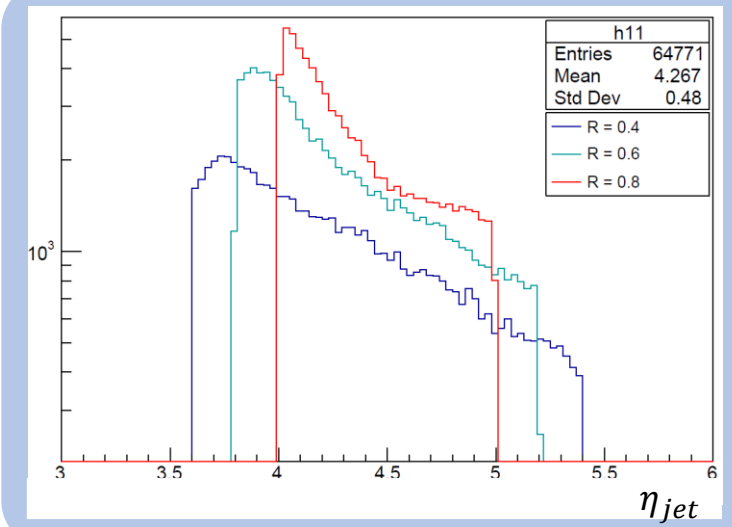
R dependence of pT spectra with UE subtraction

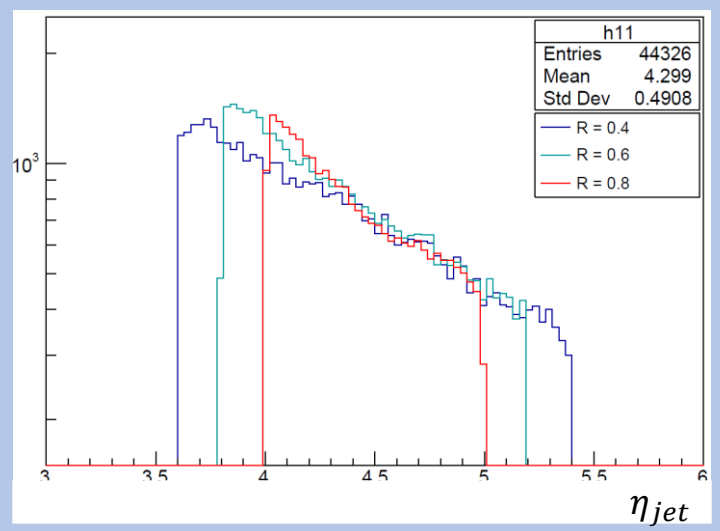
The R dependencies almost vanish after UE subtraction in both pp and p-pb system

Similar for jet Energy

η distributions

No of events ~ 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV





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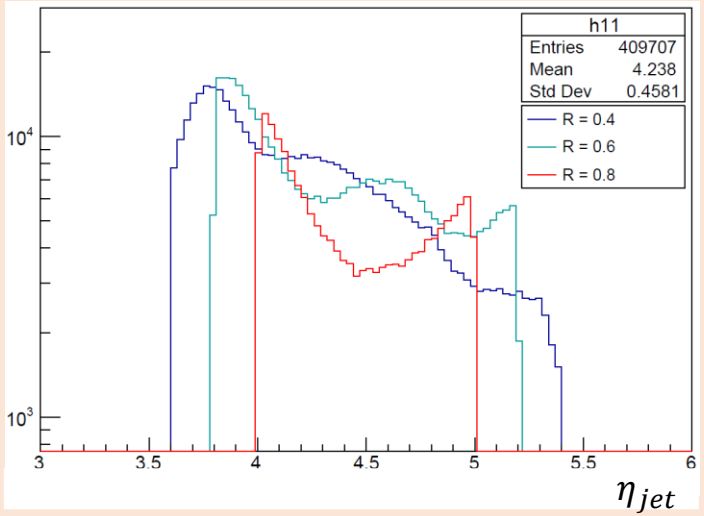
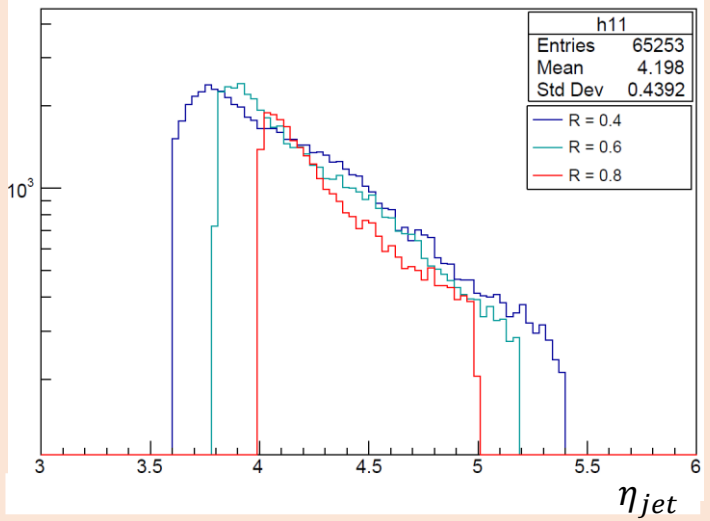




p-pb

- The R dependencies almost vanish after UE subtraction in both pp and p-pb system

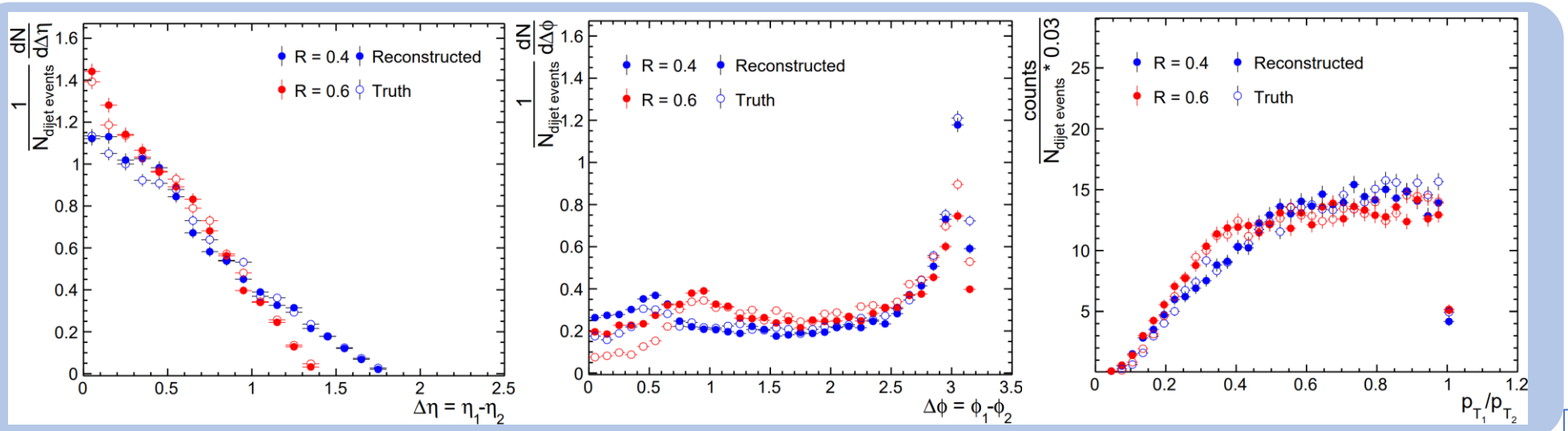
R dependence of η without UE subtraction

R dependence of η with UE subtraction

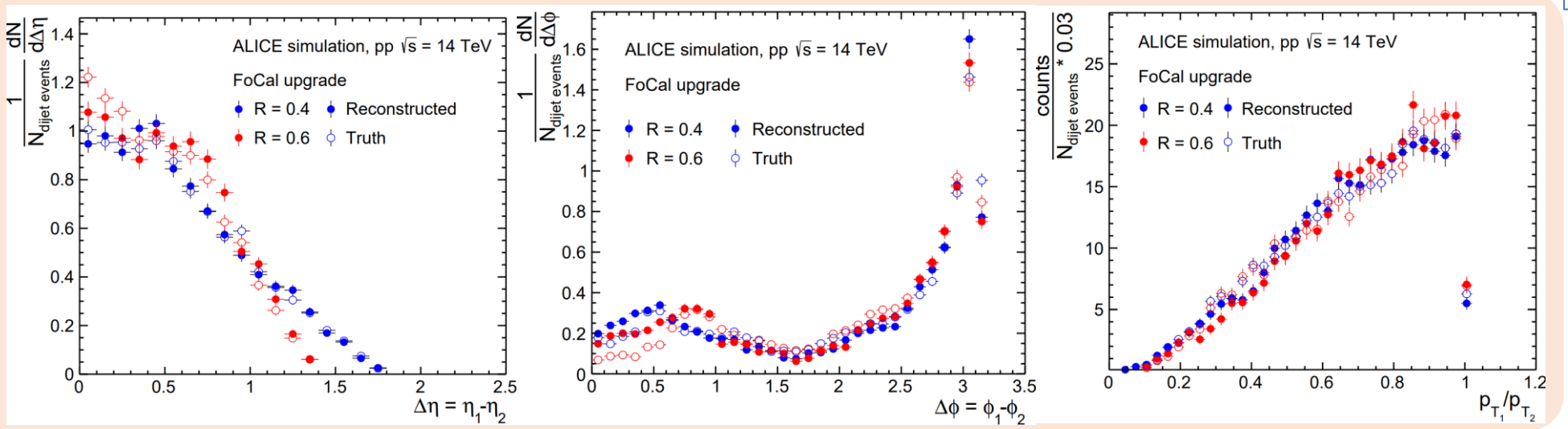
$\Delta\eta$ & $\Delta\phi$ distribution (Di-jets) (pp)

No of events = 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV

Before UE subtraction



After UE subtraction

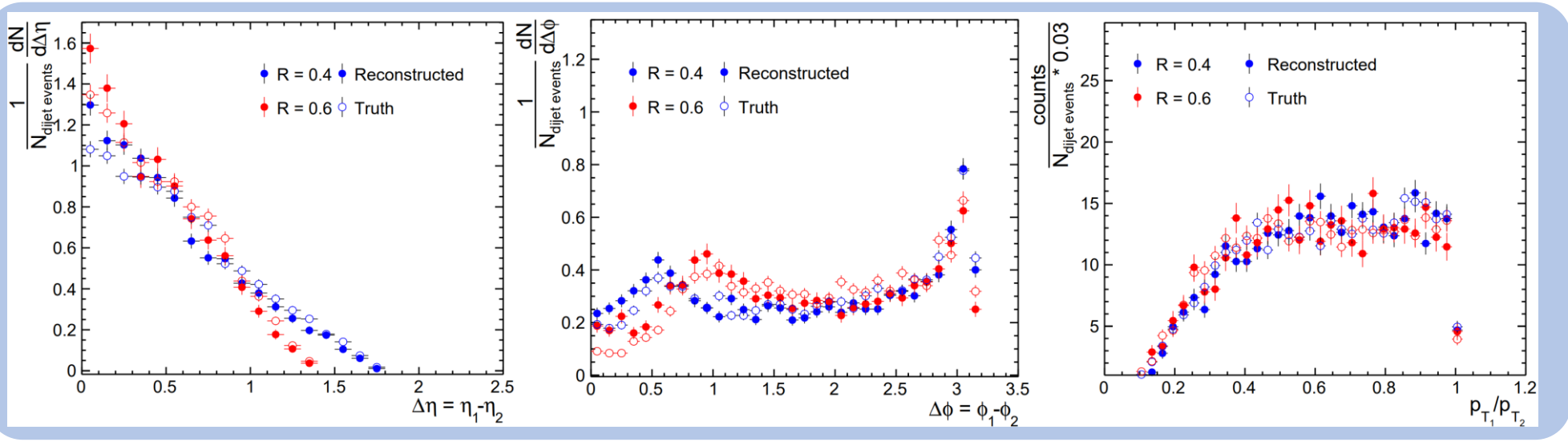


The η *and* ϕ are taken if $p_{T\,corrected} > 5.0\ GeV$

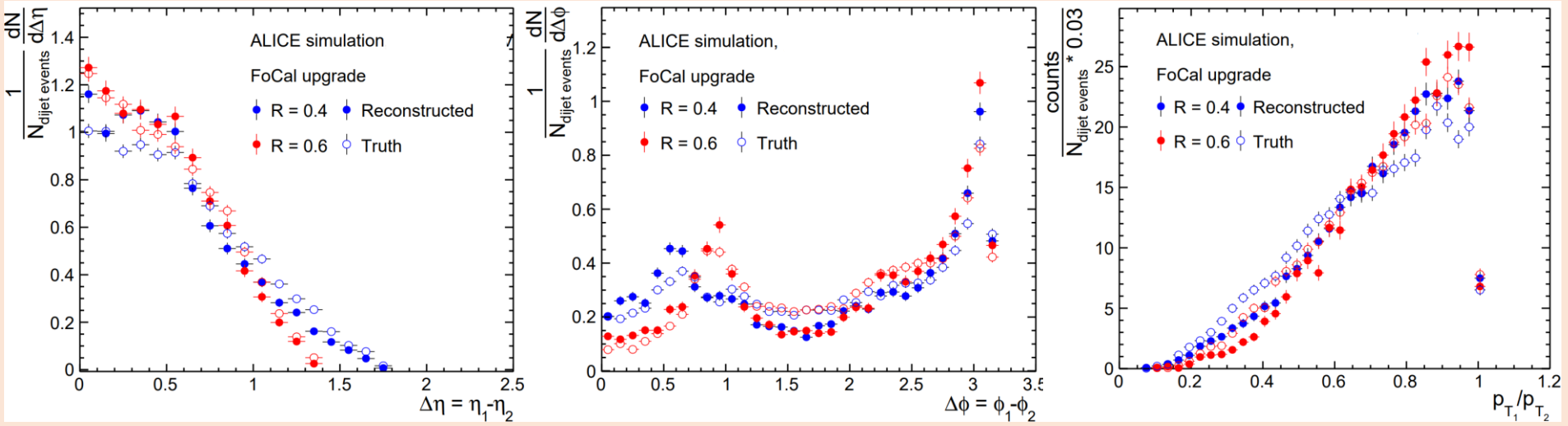
$\Delta\eta$ & $\Delta\phi$ distribution (Di-jets) (p-Pb)

No of events = 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV

Before UE subtraction



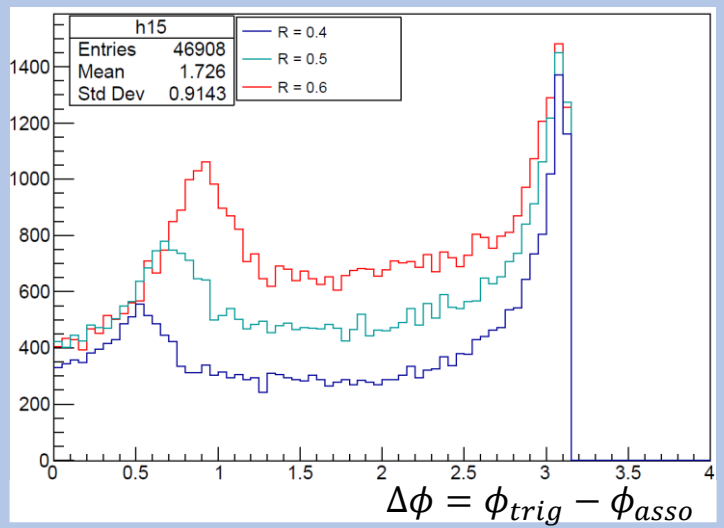
After UE subtraction

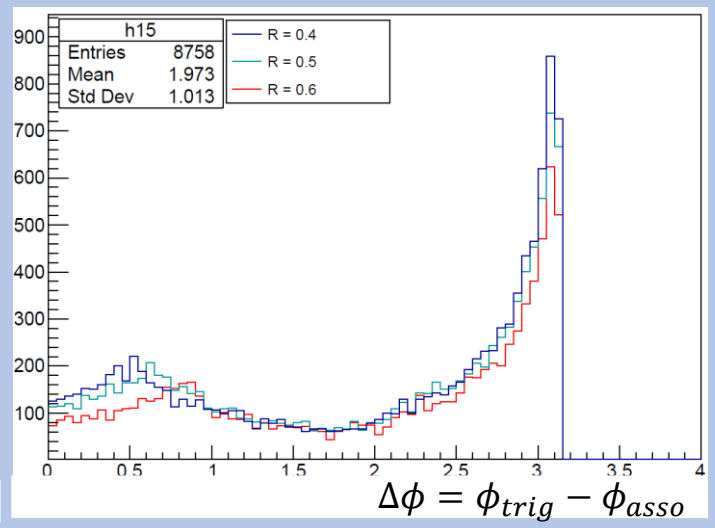


The η *and* ϕ are taken if $p_{T\,corrected} > 5.0\ GeV$

Δϕ distribution (If jet no >= 2)

No of events = 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV





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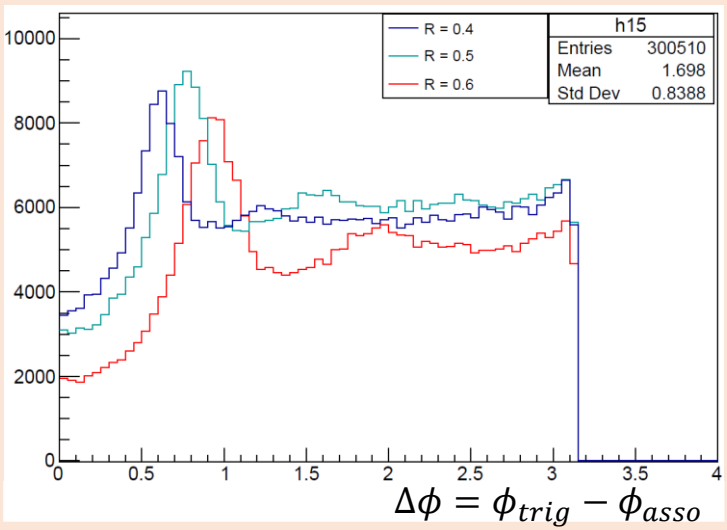
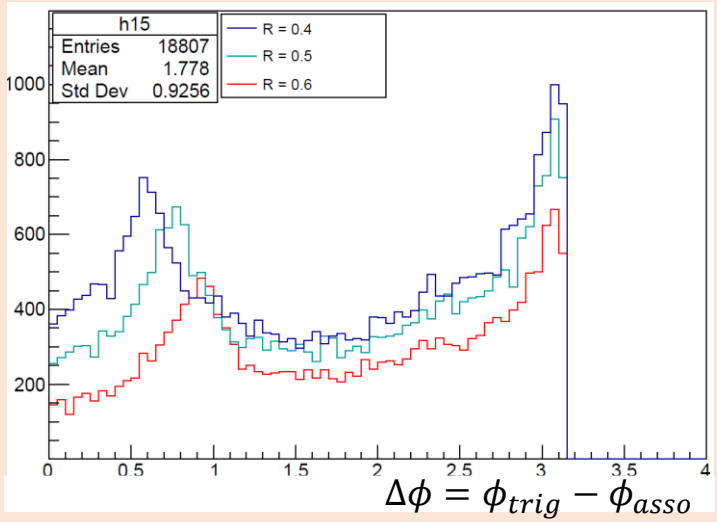




p-pb

- Trigger jet = highest p_T jet
- Associate jets = all others

The η and ϕ are taken if $p_{T\,corrected} > 5.0\ GeV$

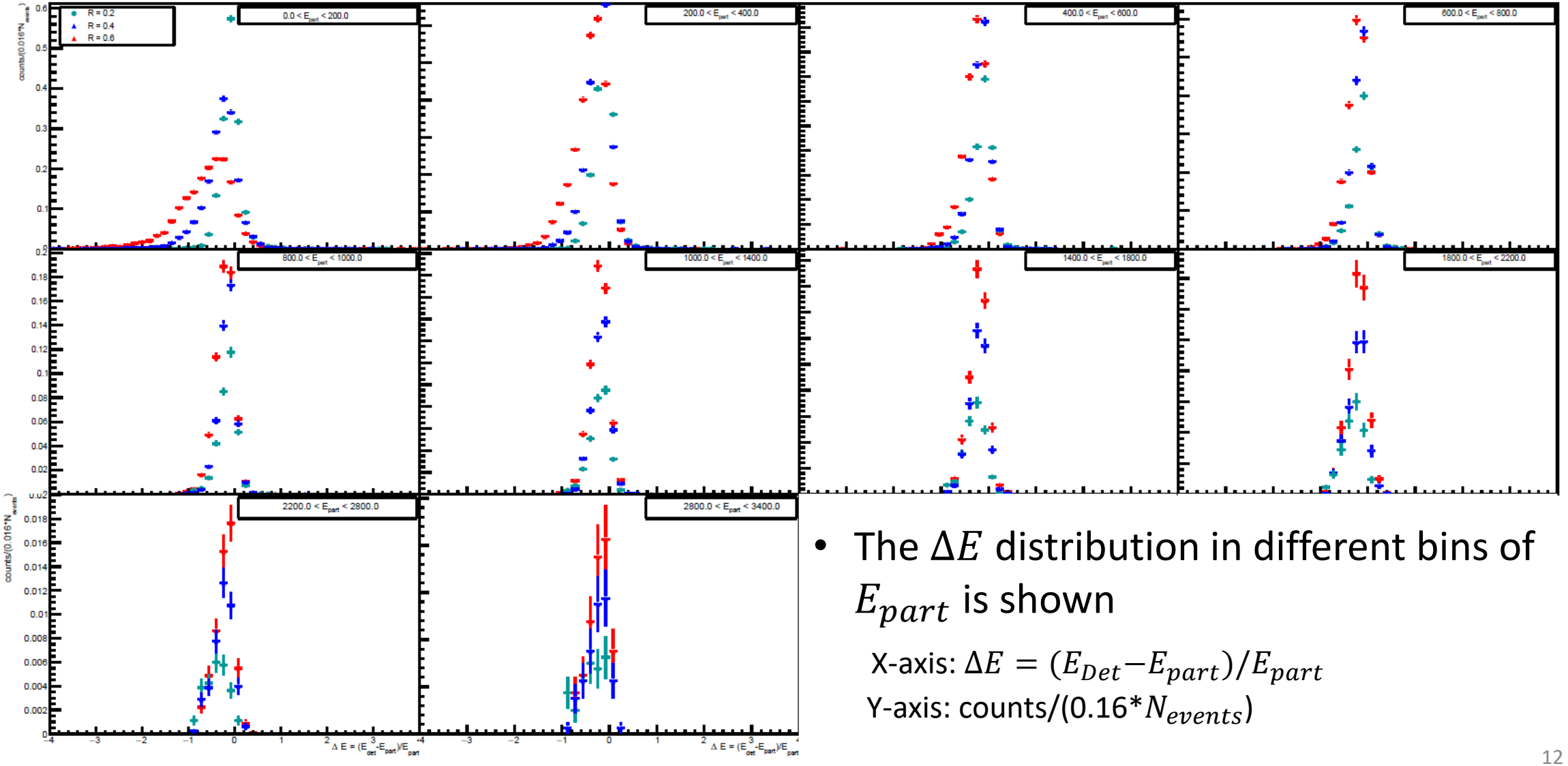
- For pp, there is no R dependence after UE subtraction
- For p-pb, there is still some R dependence

Without UE subtraction

With UE subtraction

Energy resolution (pp)

No of events = 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.4, 0.6, 0.8
Jet pTmin = 5.0 GeV



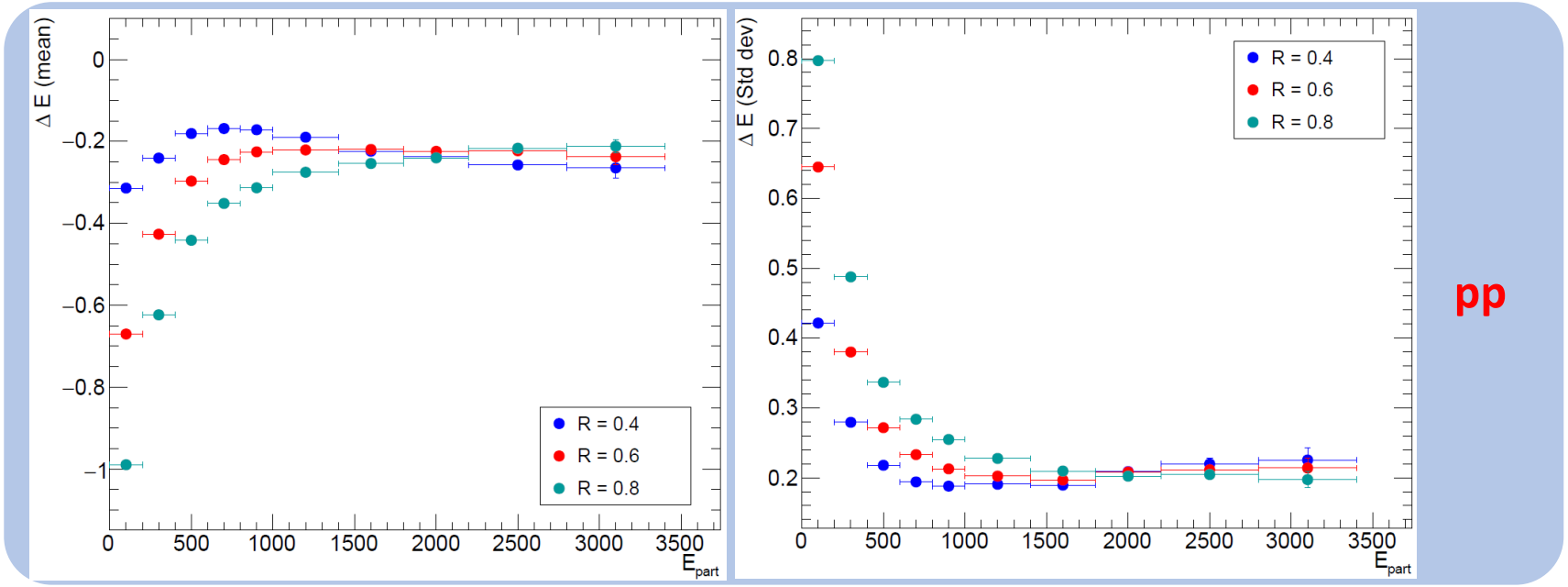
- The ΔE distribution in different bins of E_{part} is shown

  X-axis: $\Delta E = (E_{Det} - E_{part})/E_{part}$

  Y-axis: counts/(0.16*N_{events})

Energy resolution

No of events = 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.4, 0.6, 0.8
Jet pTmin = 5.0 GeV



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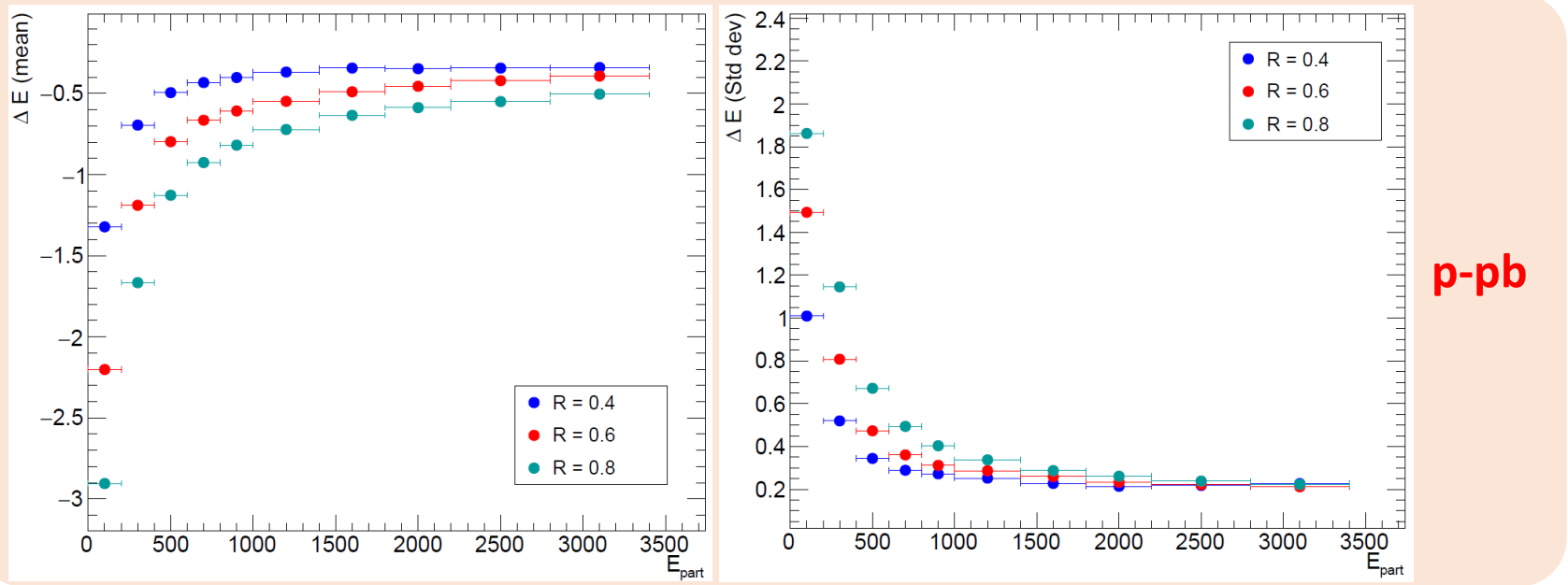


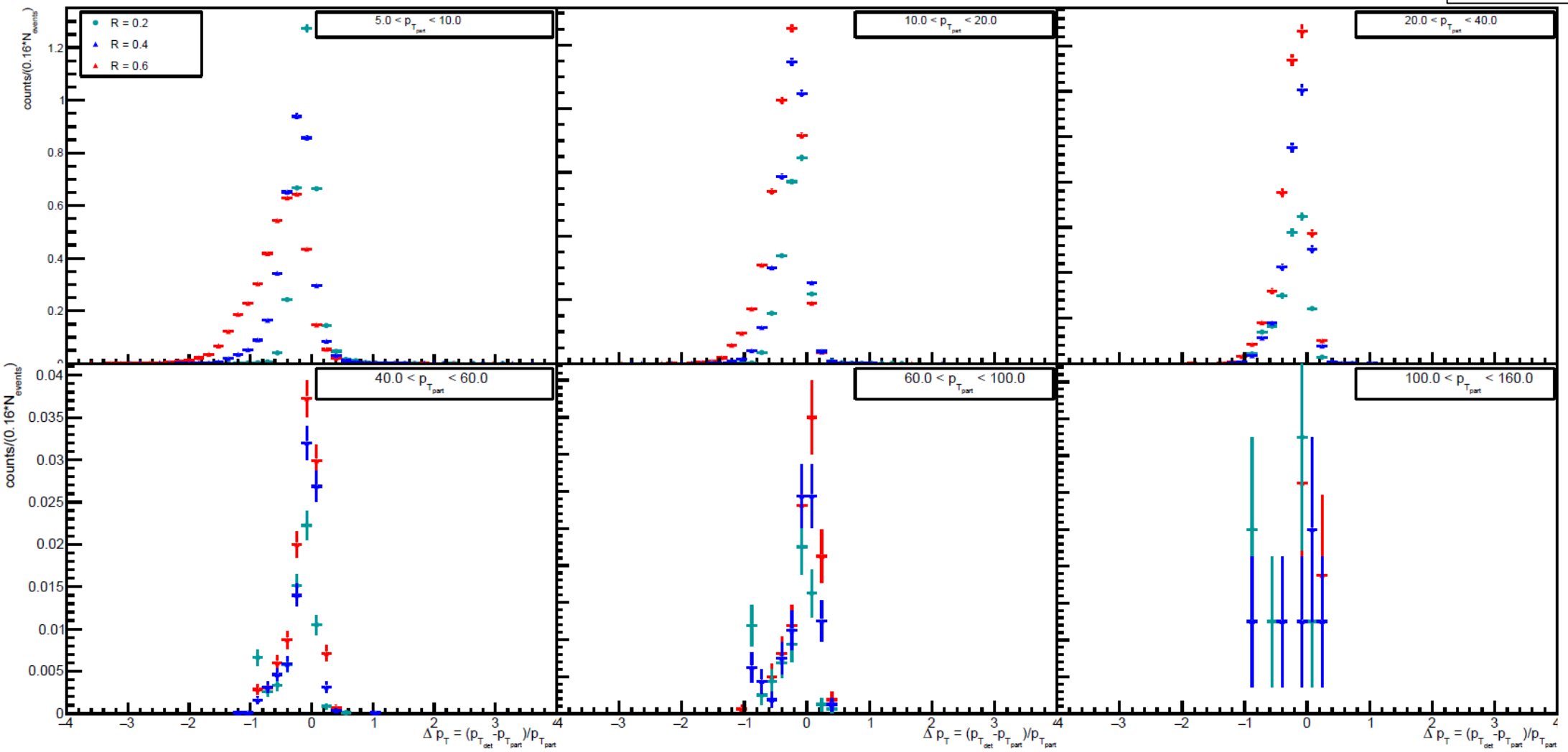
p-pb

- Mean and std dev are taken by using; GetMean(), GetStdDev(),And Same for the errors
- Results are shown for three different Jet radius R

Where, $\Delta E = (E_{Det} - E_{part})/E_{part}$

p_T resolution (pp)

No of events = 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.4, 0.6, 0.8
Jet pTmin = 5.0 GeV

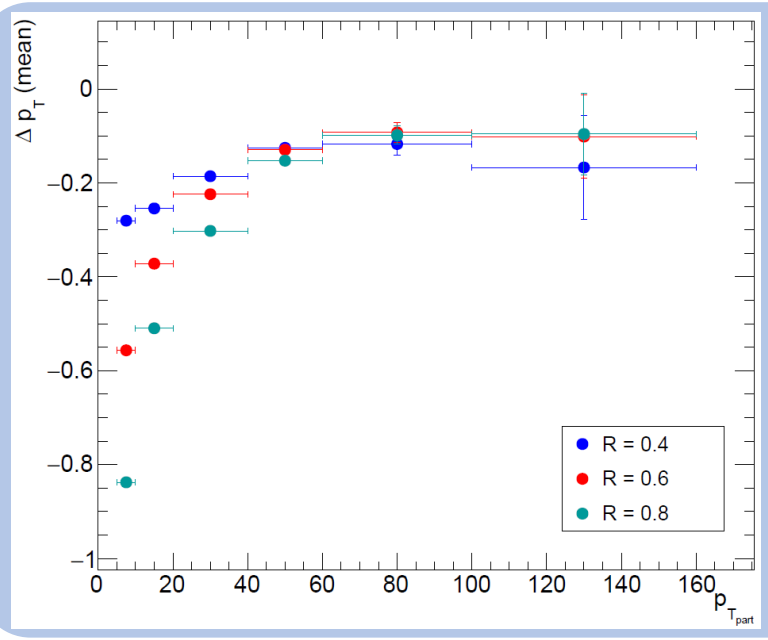


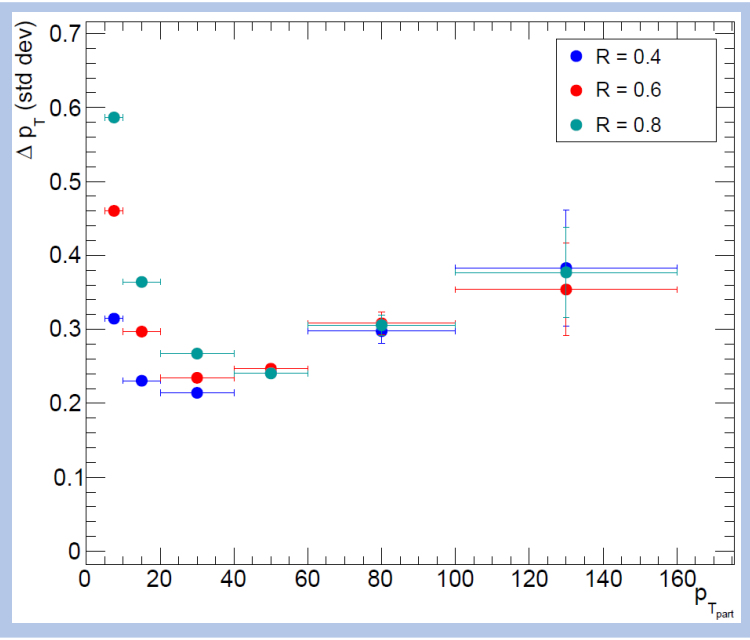
X-axis: $\Delta p_T = (p_{T\,Det} - p_{T\,part})/p_{T\,part}$

Y-axis: counts/(0.16*N_{events})

p_T resolution

No of events = 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.4, 0.6, 0.8
Jet pTmin = 5.0 GeV





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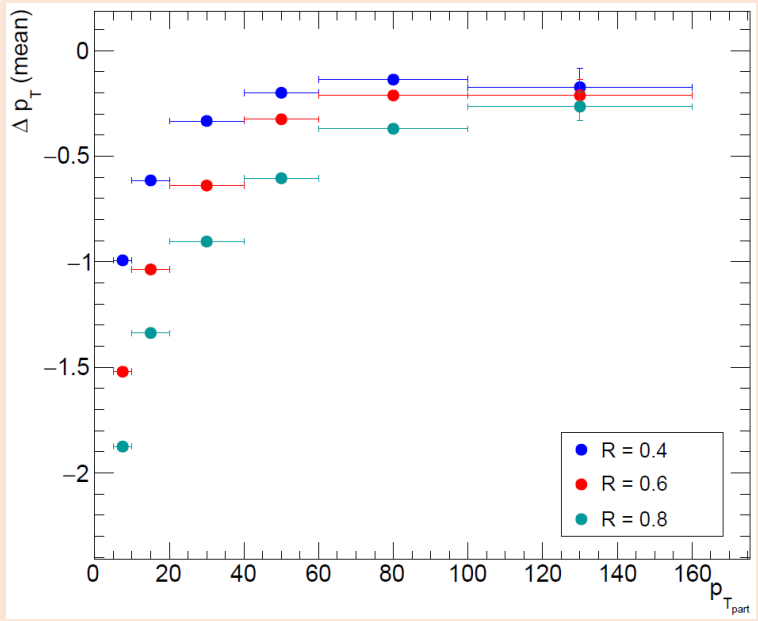
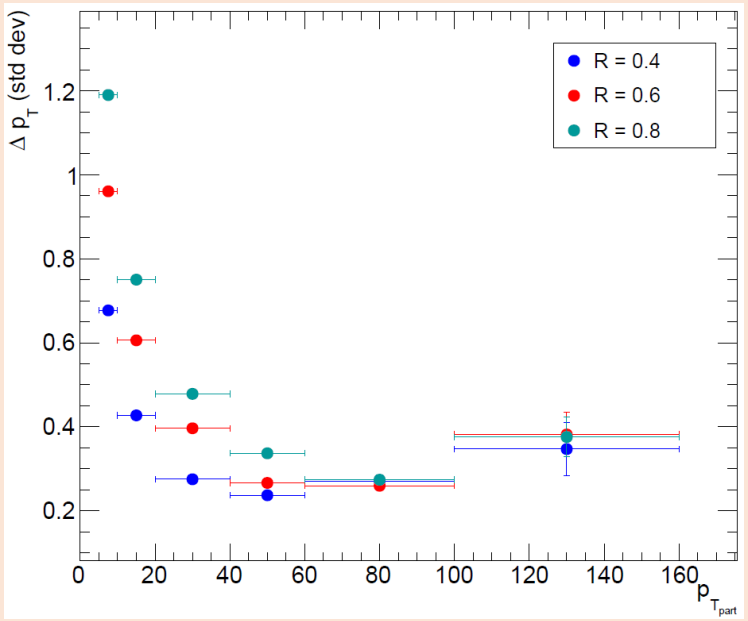




p-pb

- Mean and std dev are taken by using; GetMean(),GetStdDev(),And Same for the errors
- Results are shown for three different Jet radius R

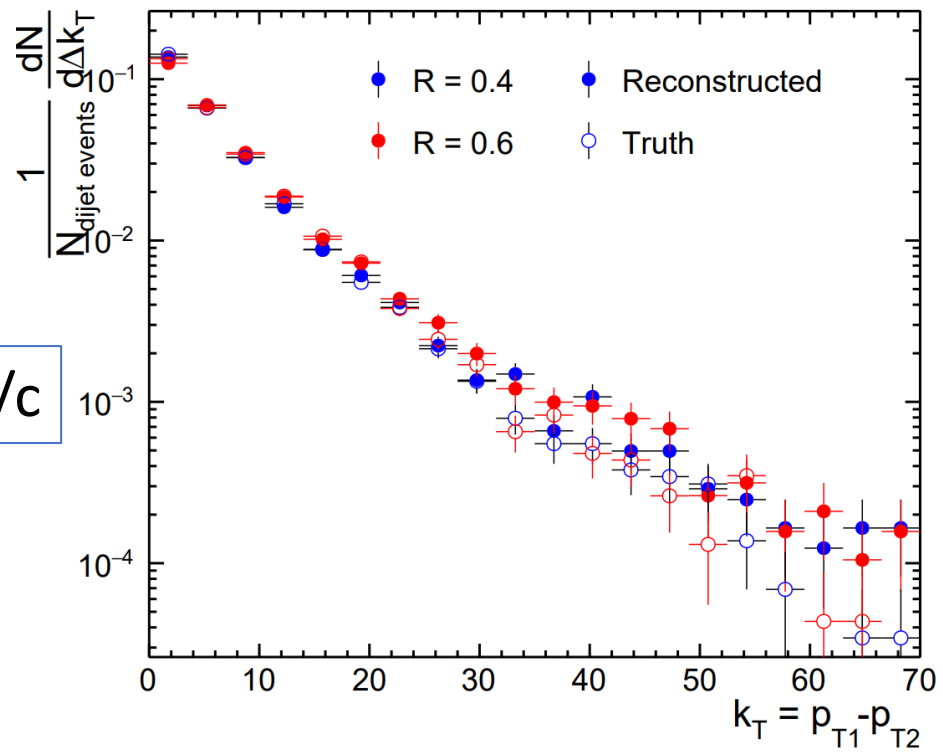
Where, $\Delta p_T = (p_{T\,Det} - p_{T\,part})/p_{T\,part}$

k_T distribution (di-jets)

No of events = 50 K
3.2 <η< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet pTmin = 5.0 GeV

- In case of di-jets, the variable k_T is defined as the difference of the transverse momentum of the two jets

Min jet p_T = 5.0 GeV/c



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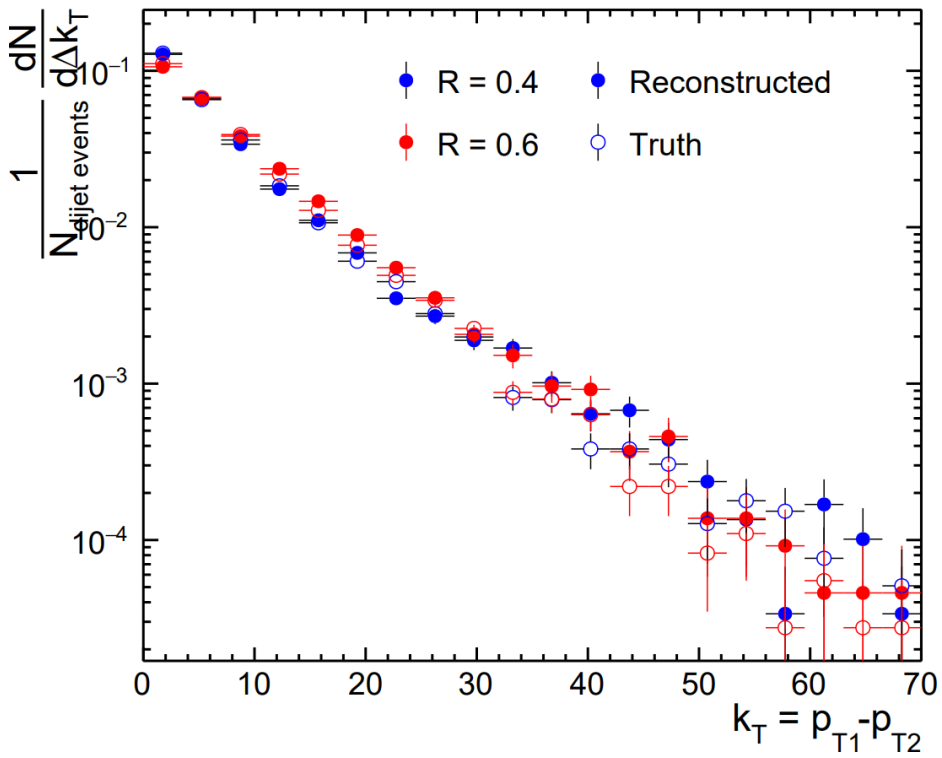
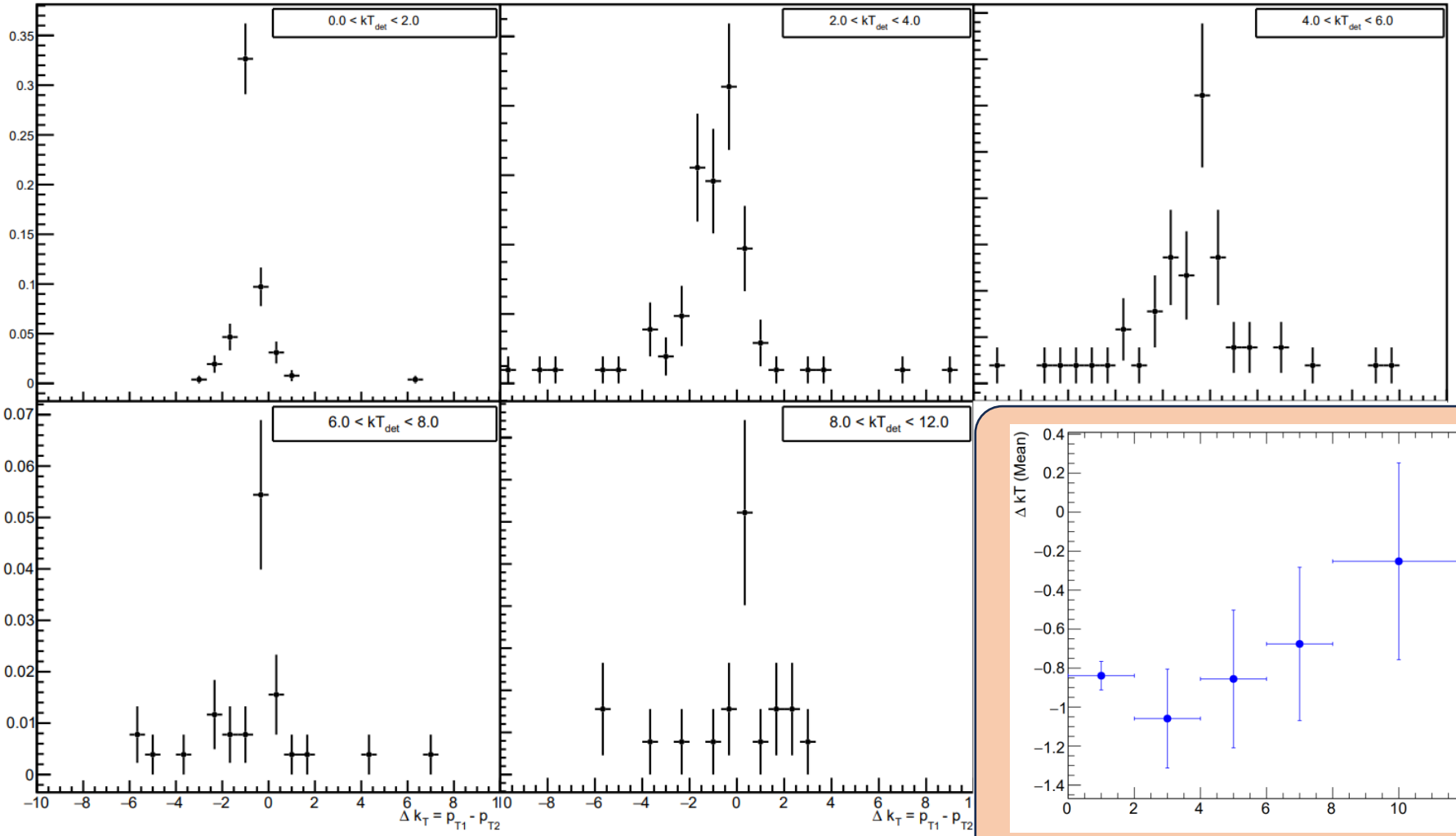


(p-Pb)

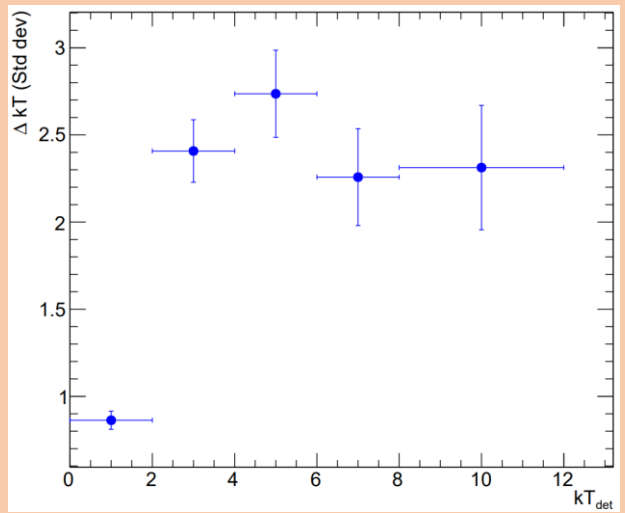
k_T resolution (di-jets)

No of events = 50 K
3.2 <eta< 5.8
3.2 + R < jet_eta < 5.8 - R
Jet Radius = 0.4, 0.6, 0.8
Jet pTmin = 5.0 GeV



Where, $\Delta k_T = (k_{T\,Det} - k_{T\,part})/k_{T\,part}$

Min jet p_T = 5.0 GeV/c



Summary & Outlook

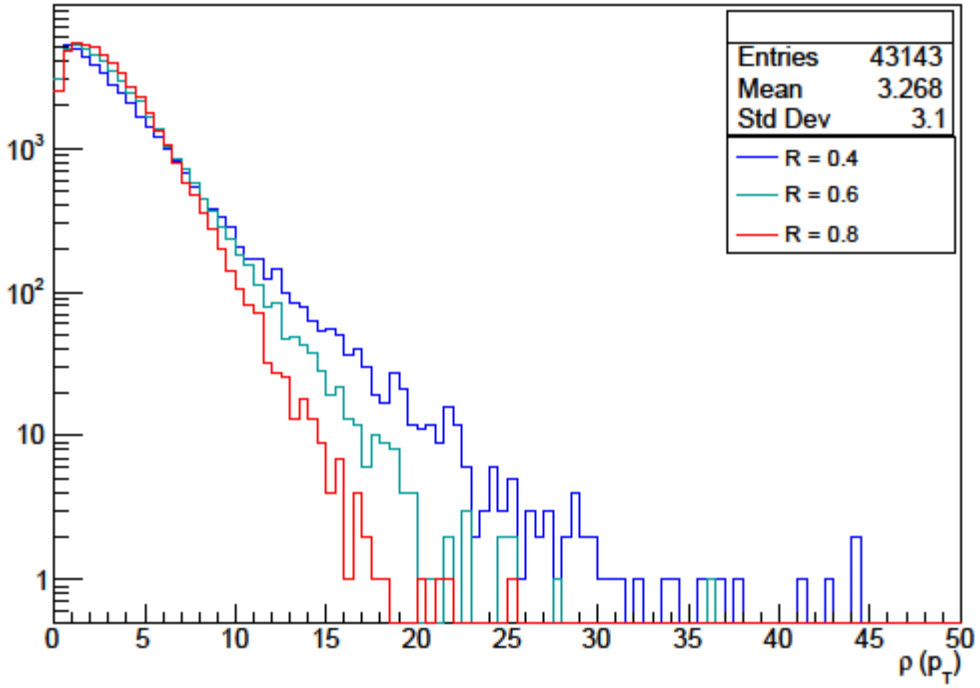
- The jets are reconstructed using anti-k_T algorithm and the p_T, η, ϕ etc., are studied for different resolution parameter, R
- The underlying event contribution is measured and subtracted from the jets
- The $\Delta\eta, \Delta\phi$ distributions are studied along with the energy and p_T resolution in both pp and p-pb system
- The k_T distribution and k_T resolution part is yet to be completed

THANK YOU

Backup

Underlying Event properties

$$\rho = p_{T_{perpcone}}/(\pi R^2) \qquad p_{T\,jet} = p_{T\,jet} - \rho \times Area$$



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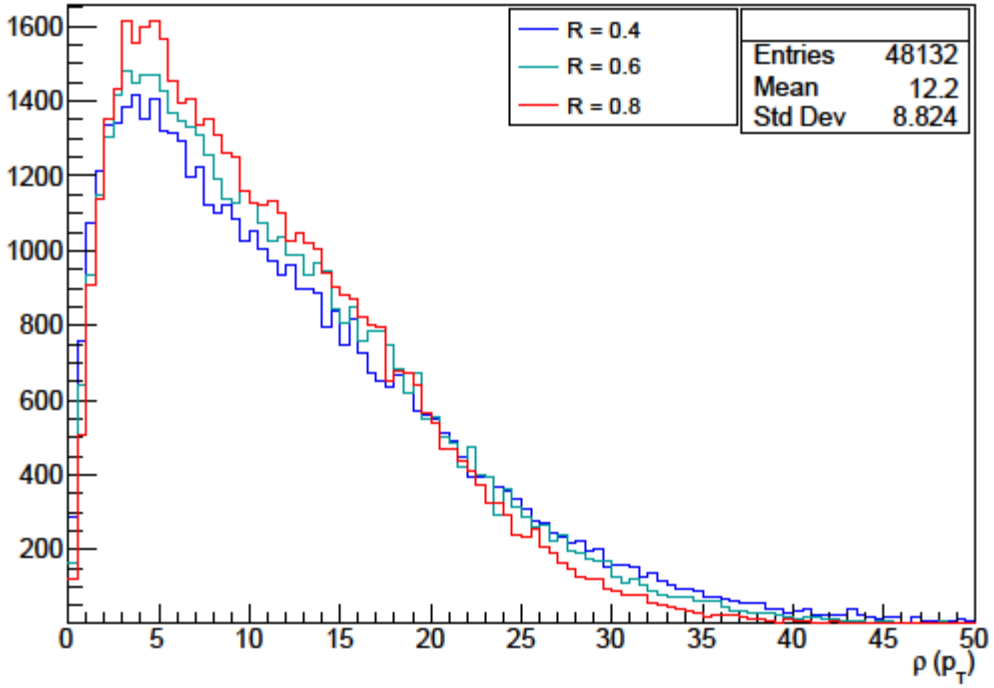


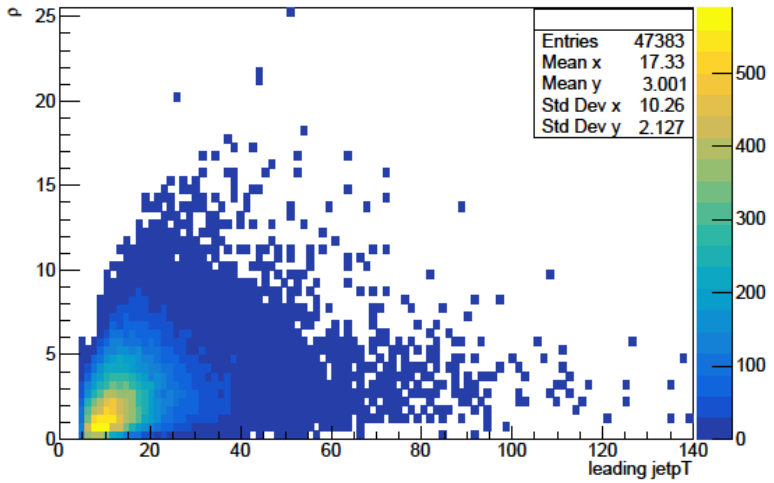
p-pb

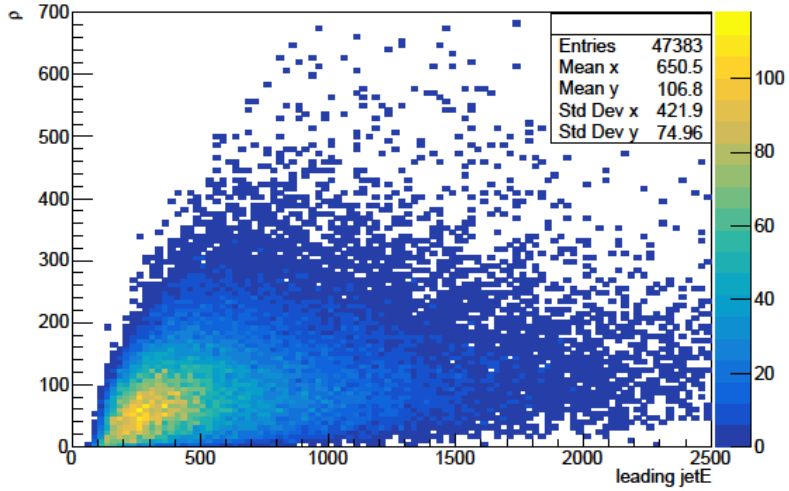
Underlying Event properties

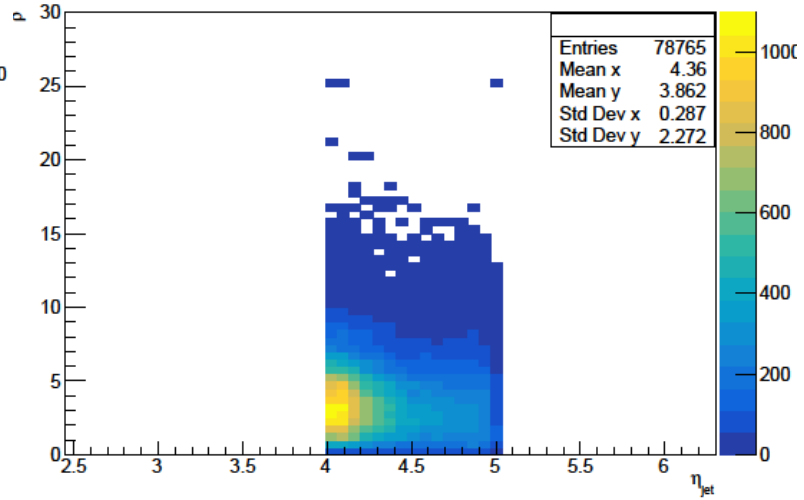
$$\rho = p_{T_{perpcone}}/(\pi R^2)$$

- In studying Rho, for now I have taken 5000 events locally. The 50 K events grid data will be followed for analysis

$$p_{T\,jet} = p_{T\,jet} - \rho$$







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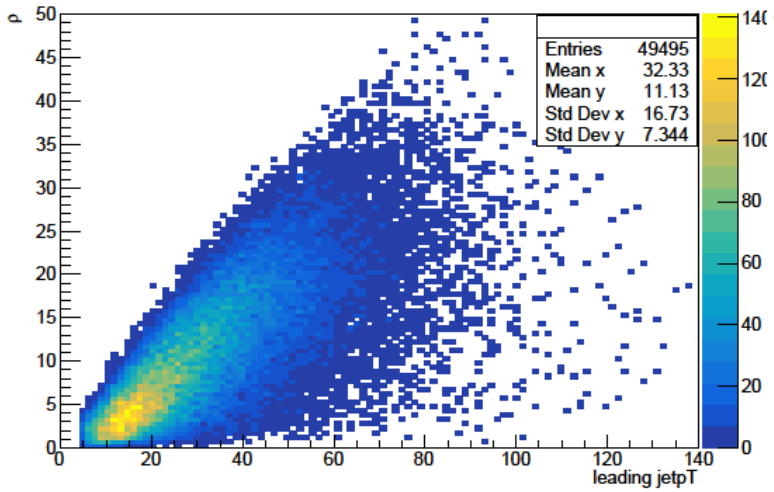
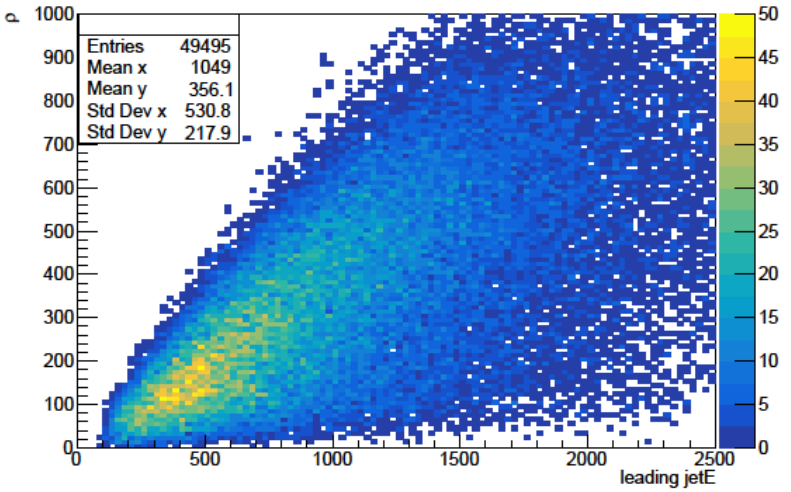
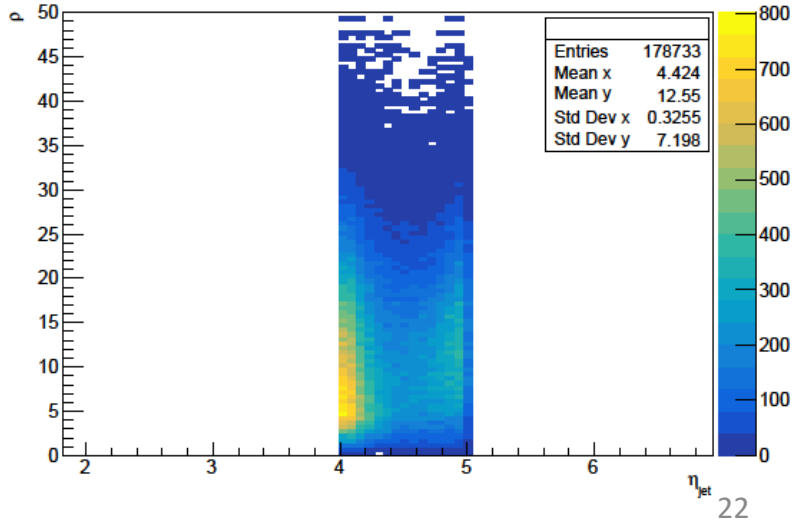


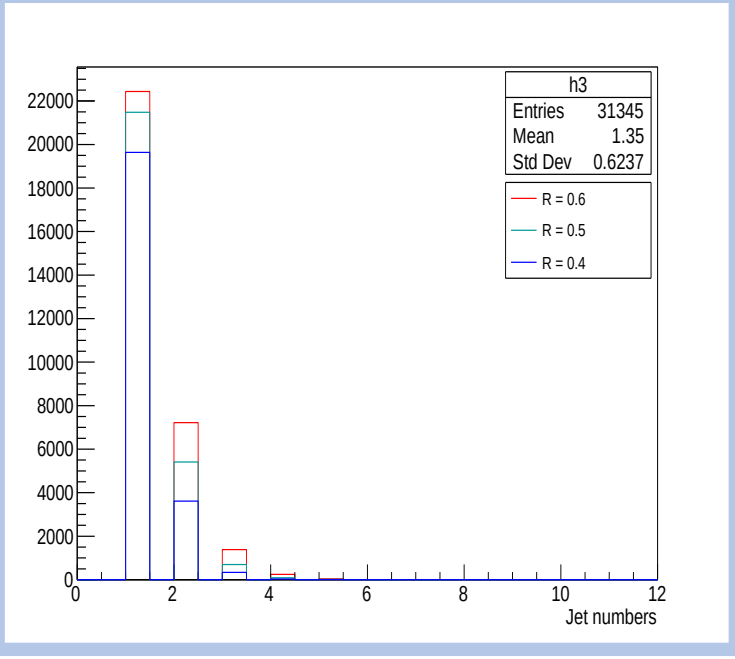


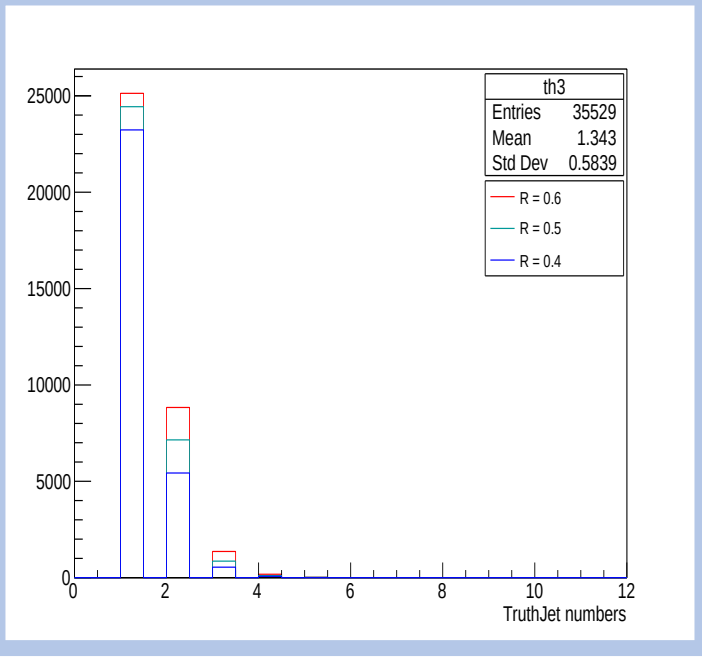


p-pb

Jet numbers

No of events = 50 K
3.2 <eta< 5.8
3.2 <jet_eta <5.8
Jet Radius = 0.6
Jet pTmin = 5.0 GeV





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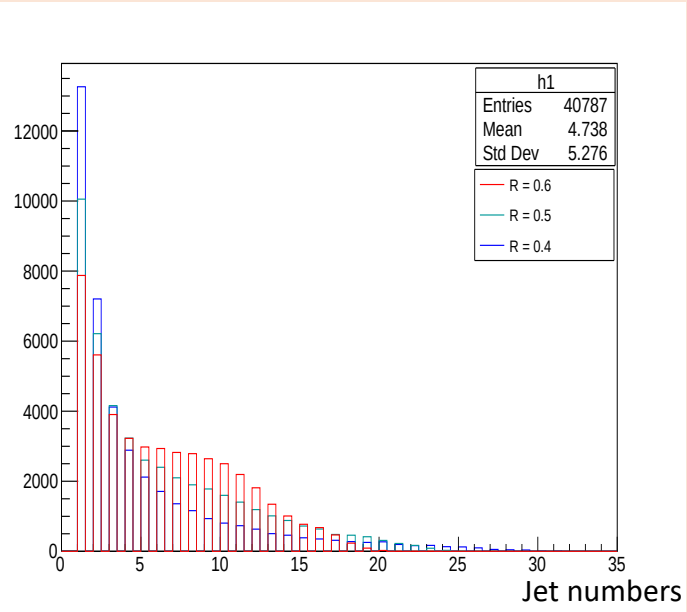

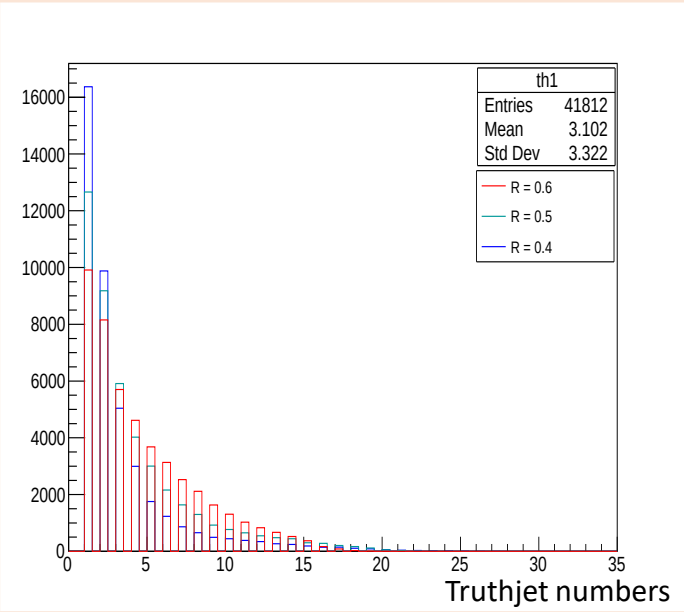

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