Apples to Apples in Jet Quenching

ML4JETS
DESY - Hamburg

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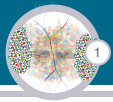
Content



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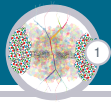

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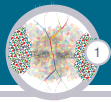

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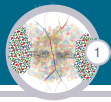

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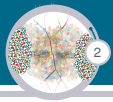

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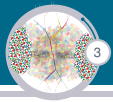
Apples to Oranges



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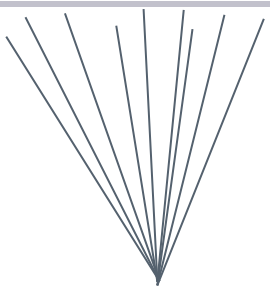

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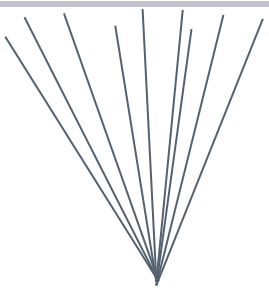

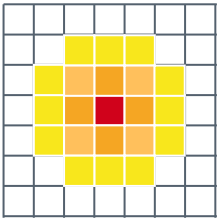

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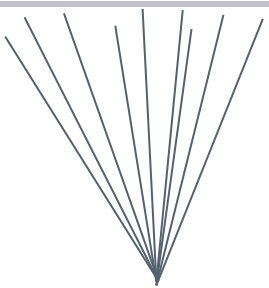

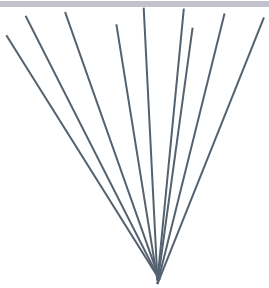

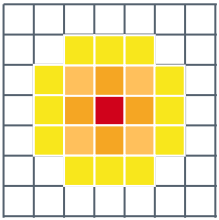

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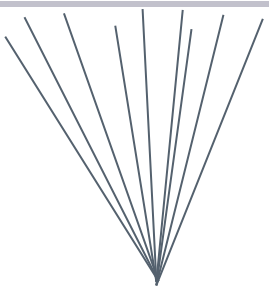

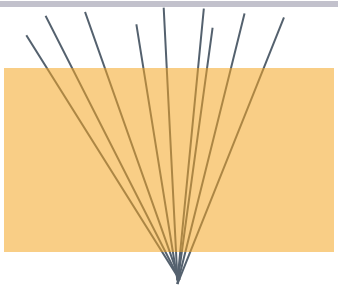

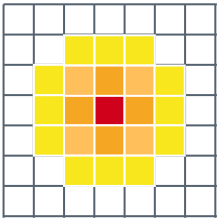

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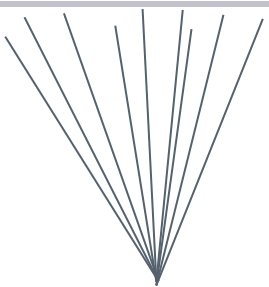

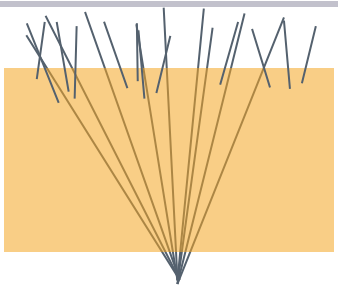

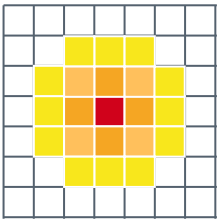

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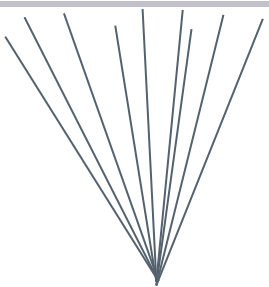

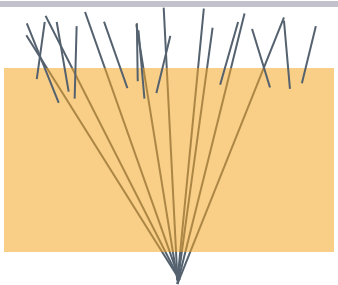

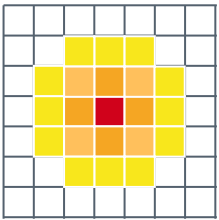

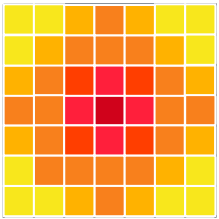

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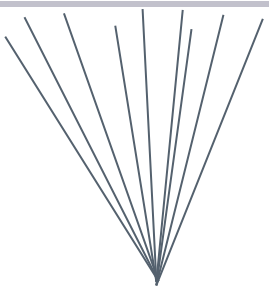

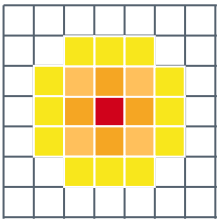

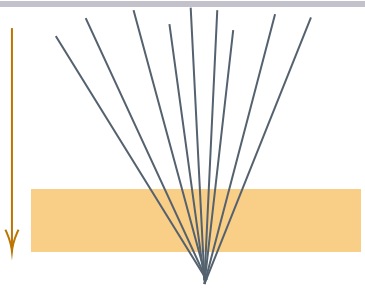

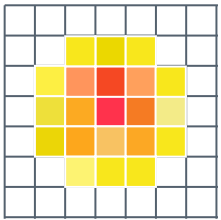

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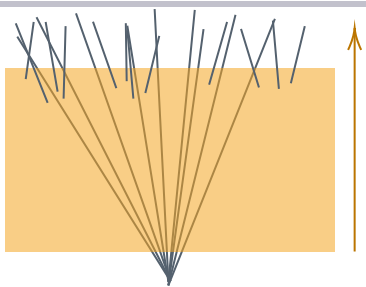

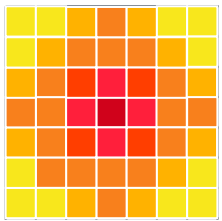

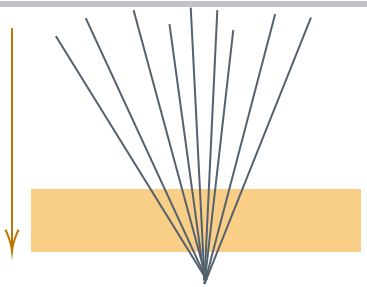

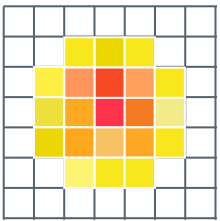

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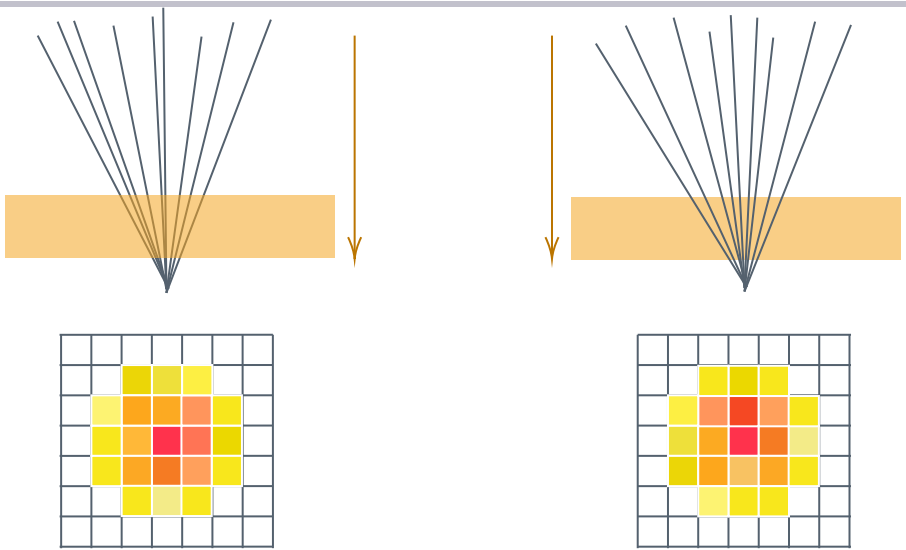

Outline

Analysis Details
Generation and Reconstruction Details

Generation Details		
Process		dijets
Centrality		$[0, 10]\%$
τ_i	$=$	0.4
T_i	$=$	590 MeV
$\sqrt{s_{NN}}$	$=$	5.02 TeV
$\widehat{p}_t$	$>$	50 GeV
$\lvert\eta\rvert$	$<$	4

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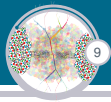
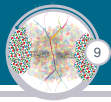
Reconstruction Details

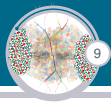
p_t^{part}	>	100 MeV
$\lvert\eta^{part}\rvert$	<	4
Jets		0.4 anti_kt
$\lvert\eta^{jets}\rvert$	<	3
$\Delta\phi$	<	$5\pi/6$
p_t^{lead}	>	120 GeV
$p_t^{sublead}$	>	50 GeV

Analysis Details
Underlying Event Generation Details





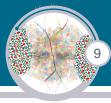
Experimentally motivated UE generation steps:



Experimentally motivated UE generation steps:

1. Fit the pseudo-rapidity spectrum of the UE measured experimentally from [1]. We have used a polynomial fit.

[1] Phys.Lett.B 772 (2017) 567-577, 2017.



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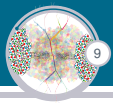
[2] JHEP 11 (2018) 013, 2018.



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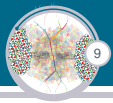

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4. Take the number of particles per UE to follow a Gaussian distribution of experimentally motivated average value and standard deviation.
5. For each particle to be generated, sample a value for p_T, η and ϕ from the considered distributions.
6. Considering only pions, sample randomly and uniformly one of the three species, and use its mass to complete the four-momentum of the particle.

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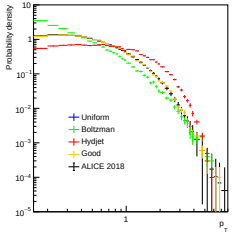
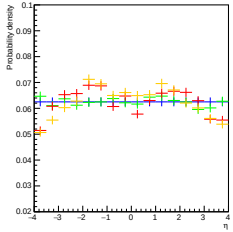
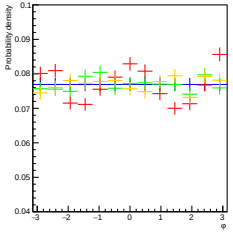
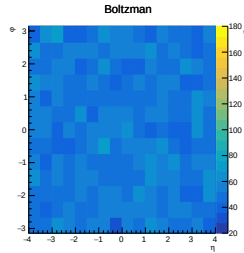
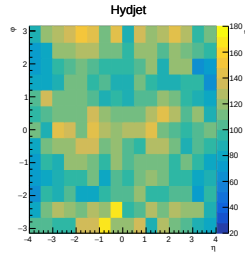
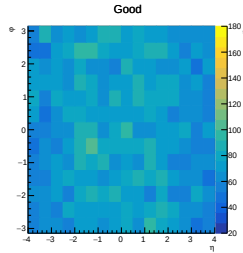


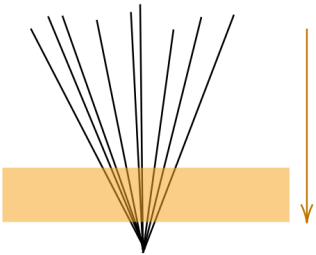


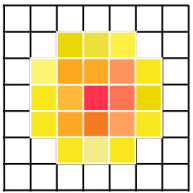


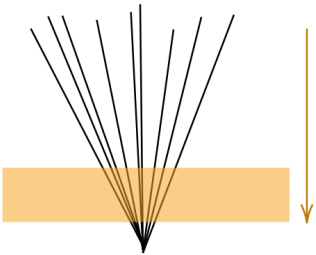




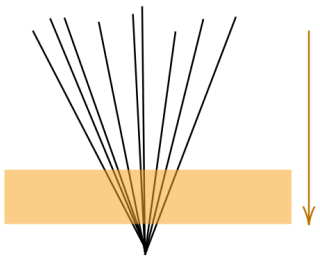








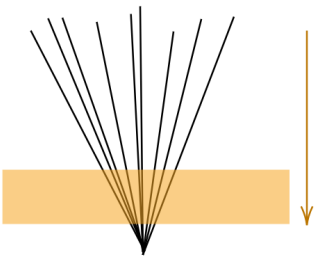
We have performed two different types of subtractions:

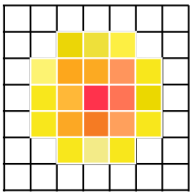


We have performed two different types of subtractions:

1. JEWEL's "perfect" recoil subtraction (only for PbPb and this is always performed before embedding) [3]

[3] Eur.Phys.J.C 82 (2022) 11, 1010





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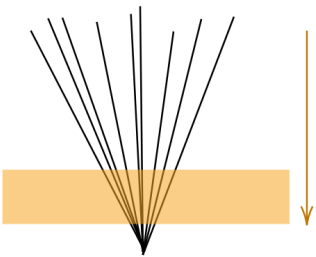
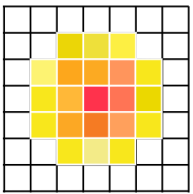
2. Iterative Constituent Subtraction which we apply to both pp and PbPb embedded events [4]

[3] Eur.Phys.J.C 82 (2022) 11, 1010
[4] JHEP 08 (2019) 175





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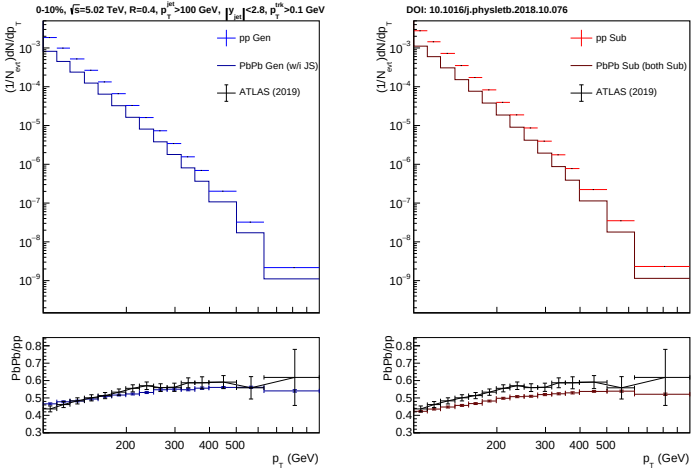
We have used the parameters suggested in [4] for 0.4 anti-kt jets.

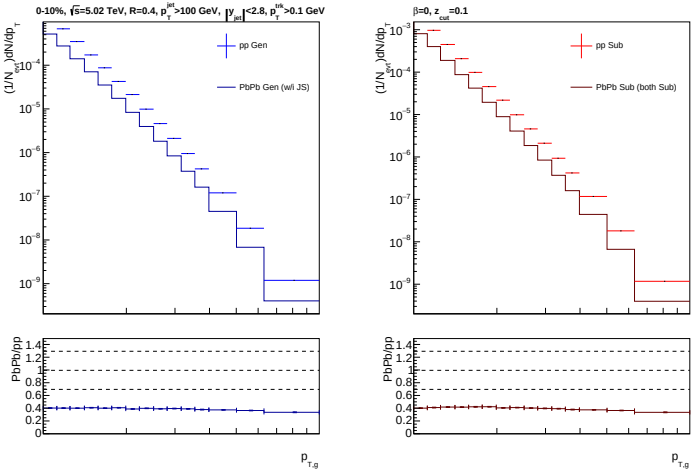
[3] Eur.Phys.J.C 82 (2022) 11, 1010
[4] JHEP 08 (2019) 175

Outline

Results
Observable Robustness

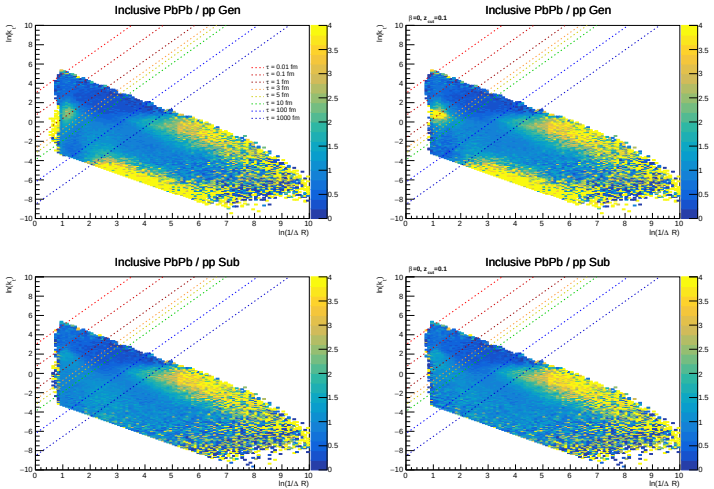


The jet's p_T spectra and their ratios, suffer non-negligible modifications from the subtraction and begin to deviate from data.



The groomed transverse momenta spectra and their ratios appear to be more robust.

Results
Observable Robustness



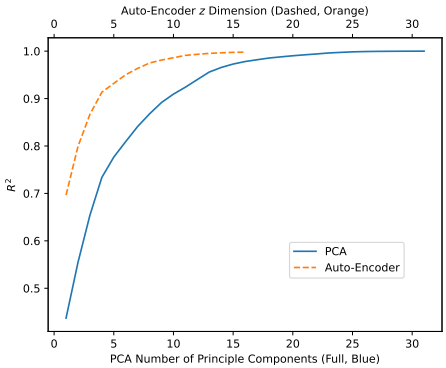
Grooming seems to increase the signal in the medium time window, but the subtraction always depletes the signal in this region.

Observable	Type
y_{SD} ϕ_{SD} $\Delta p_{T,SD} = p_{T,jet} - p_{T,jet_{SD}}$ m_{SD} $n_{\text{const,SD}}$	Jet Momenta and Constituent Multiplicity
$\bar{r}_{SD} = \frac{1}{n_{\text{const,SD}}} \lambda^0_{1,SD}$ $\bar{r}^2_{SD} = \frac{1}{n_{\text{const,SD}}} \lambda^0_{2,SD}$ $rz_{SD} = \lambda^1_{1,SD}$ $r^2 z_{SD} = \lambda^1_{2,SD}$ $\bar{z}^2_{SD} = \frac{1}{n_{\text{const,SD}}} \lambda^2_{0,SD}$ $p_T D_{SD} = \sqrt{\sum_{i \in jet_{SD}} p^2_{T,i}} / p_{T,jet,SD}$	Angularities
$\tau_{2,SD}$, $\tau_{3,SD}$ $\tau_{1,2,SD}$, $\tau_{2,3,SD}$	N-subjettiness
$\lvert Q^{0.3}_{SD}\rvert$, $\lvert Q^{0.5}_{SD}\rvert$, $\lvert Q^{0.7}_{SD}\rvert$, $\lvert Q^{1.0}_{SD}\rvert$,	Jet-Charges
R_g, z_g, n_{SD}	SoftDrop Grooming Intrinsic
$R_{g,A}$, $z_{g,A}$, κ_A with $A \in \{TD, ktD, zD\}$	Dynamical Grooming Intrinsic

[5] 10.48550/arXiv.2304.07196

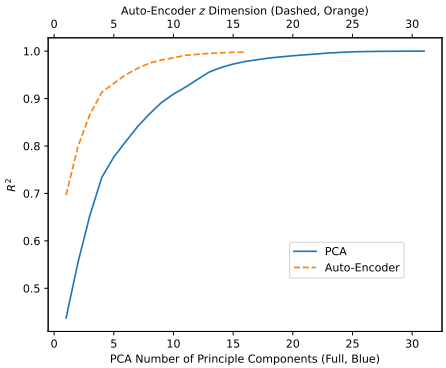
Results
ML Robustness

Original

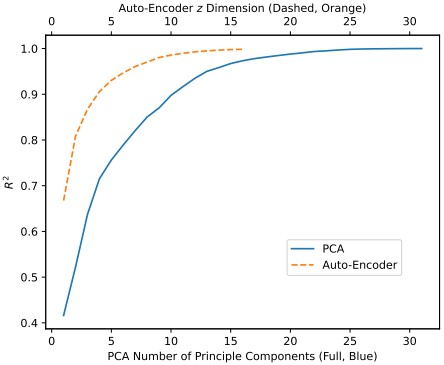


[5] 10.48550/arXiv.2304.07196

Original



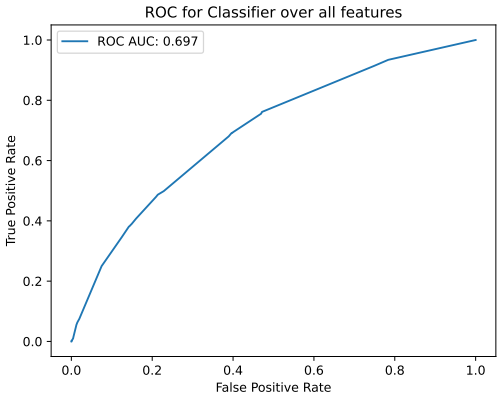
Embedded and subtracted



[5] 10.48550/arXiv.2304.07196

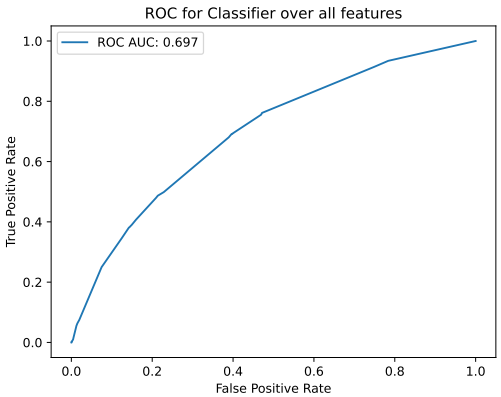
Results
ML Robustness

Original

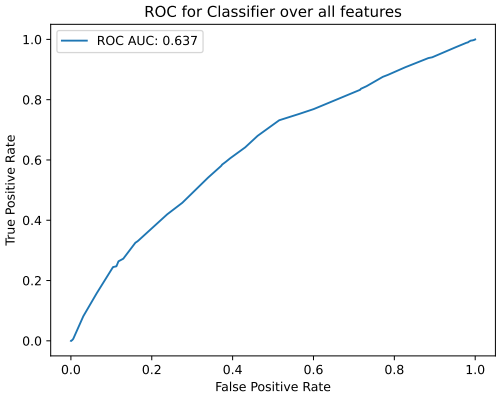


[5] 10.48550/arXiv.2304.07196

Original



Embedded and subtracted



[5] 10.48550/arXiv.2304.07196

Outline

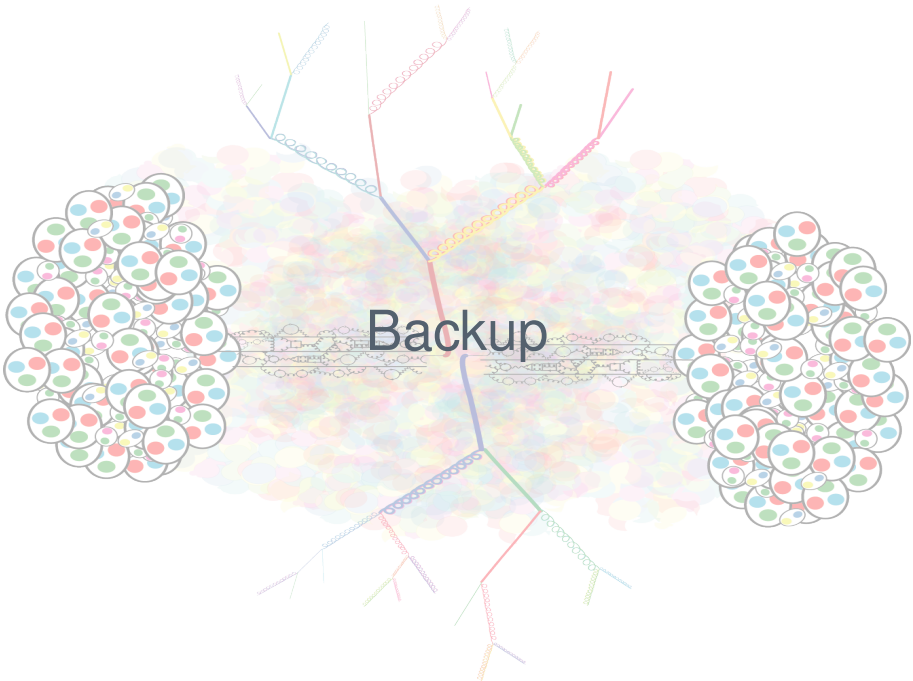
Conclusions

1. The comparison we have made between jets in pp and PbPb collisions so far has not been fair, we have been comparing apples to oranges.
2. This is due to the different environments in which these jets are formed and in particular due to the necessary intense and fluctuating Underlying Event subtraction procedure in PbPb jets, which will inevitably yield fluctuations potentially identifiable by ML algorithms.
3. In order to compare apples to apples, such that our algorithms hunt the physics not procedural fluctuations, one needs to embed the pp jets in a "as similar as possible" UE, uncorrelated with the hard scattering, and perform the same procedure as in PbPb jets.
4. The way we model this "fake" UE is crucial for our final results, but more crucial even for the possibility of a fair usable jet-by-jet quenching tagger in experiment, theory and phenomenology.
5. Modelling this UE directly through data seems to be our best option.

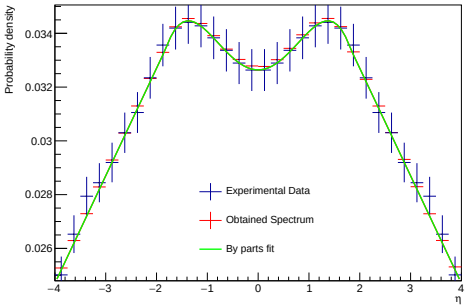
Future Work

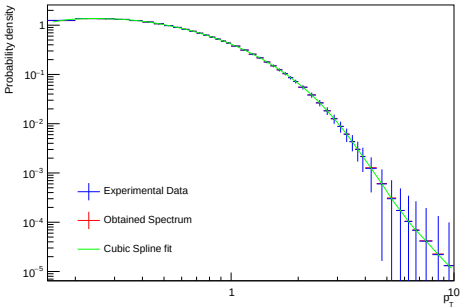
1. We intend to take this work further and study the impact of this procedure on different Neural Networks architectures, through supervised, unsupervised and semi-supervised learning.
2. The inclusion of some data-driven modelling for ϕ would make the comparison between pp and PbPb jets fairer.
3. The inclusion of pile-up subtraction effects should be studied.
4. The inclusion of other particle species other then pions according to their measured abundance in experiment, would make the comparison even fairer, although we expect these effects to be rather small and may only become relevant, when we strive for a greater level of precision.


Thank you for your attention!

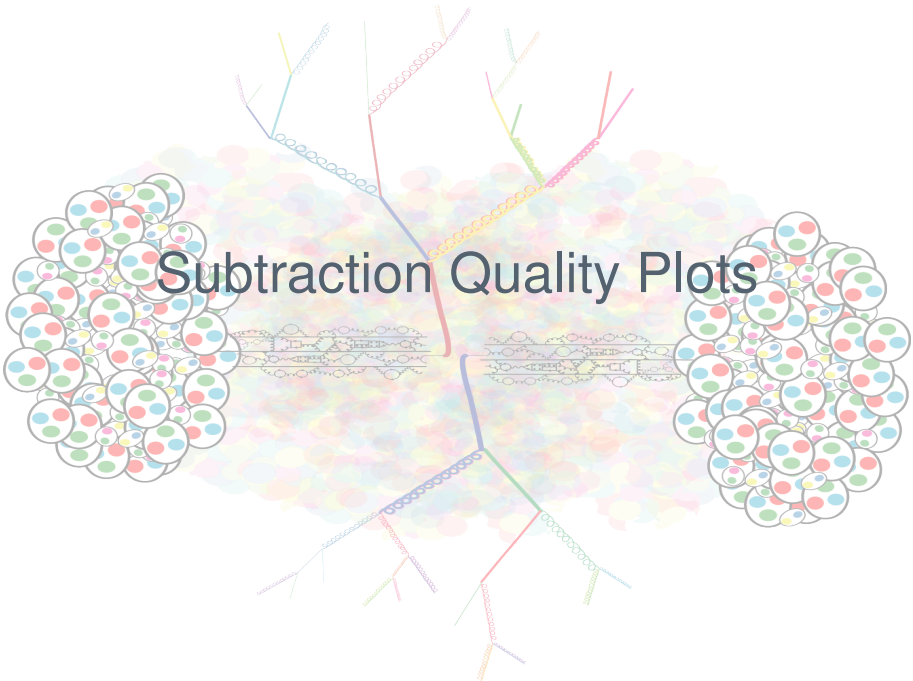

Backup

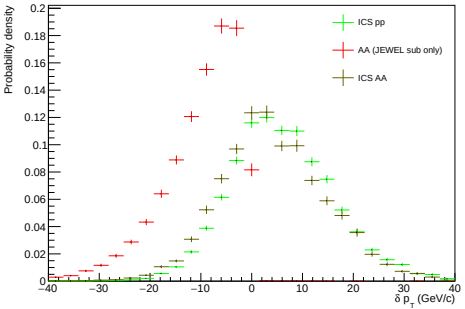
Underlying Event Fits

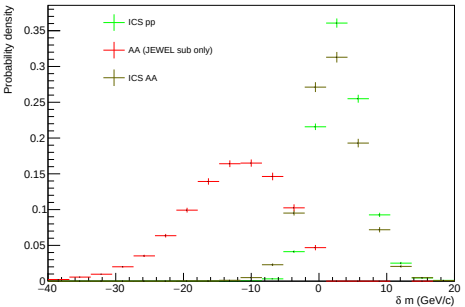

Probability density
0.034
0.032
0.03
0.028
0.026
−4
−3
−2
−1
0
1
2
3
4
η
Experimental Data
Obtained Spectrum
By parts fit


Probability density
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
p_T
Experimental Data
Obtained Spectrum
Cubic Spline fit

Subtraction Quality Plots

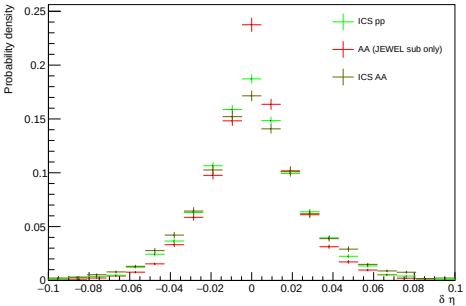


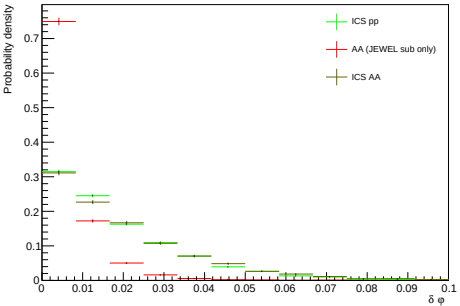




$$\delta p_T = p_T^{sub} - p_T^{gen}$$

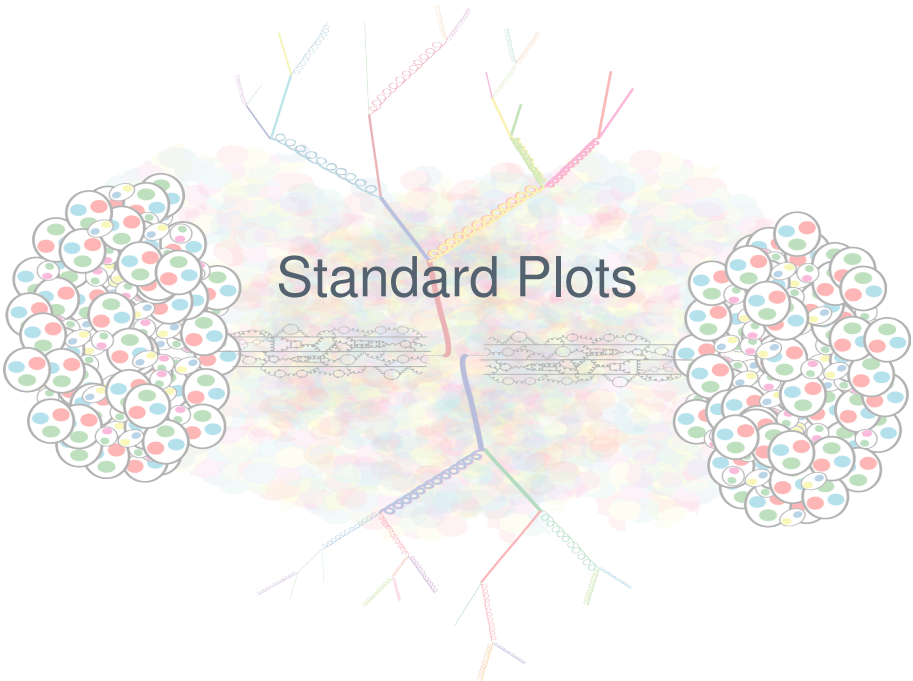
$$\delta m = m^{sub} - m^{gen}$$

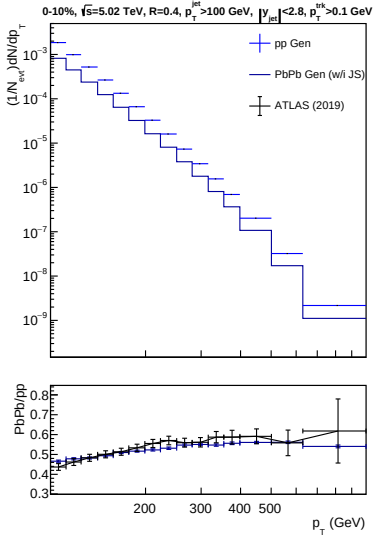


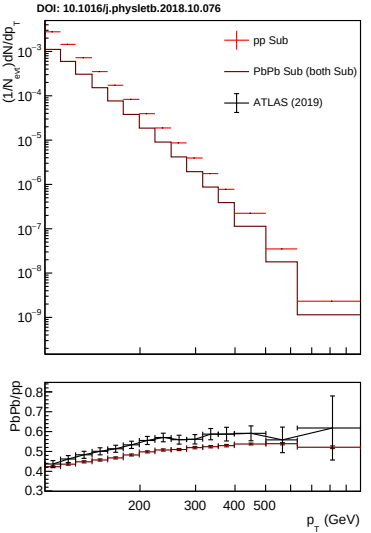


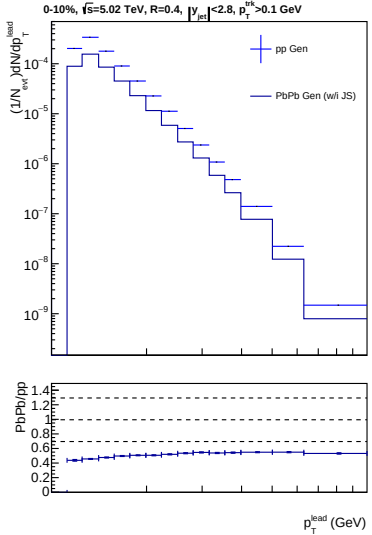
$$\delta\eta = \eta^{sub} - \eta^{gen}$$

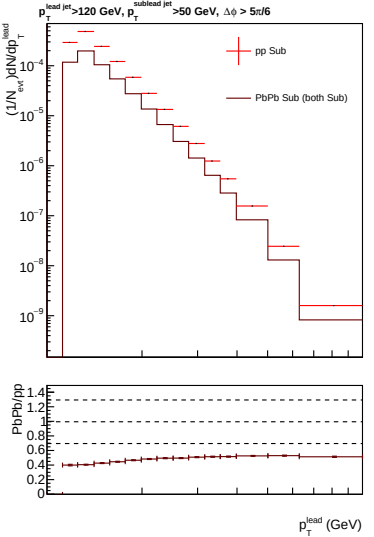
$$\delta\phi = \phi^{sub} - \phi^{gen}$$

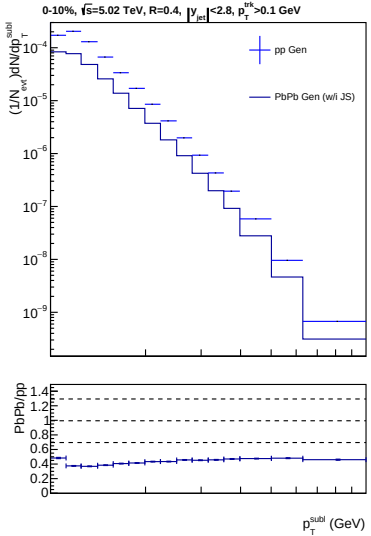

Standard Plots

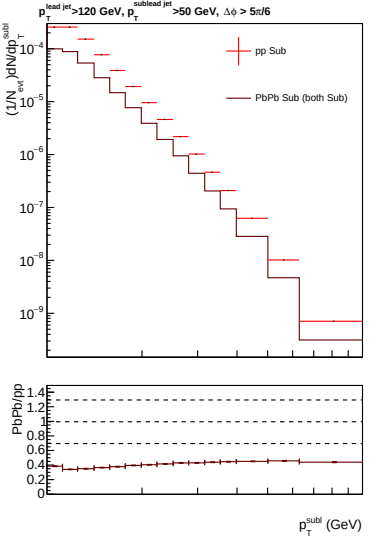

0-10%, √s=5.02 TeV, R=0.4, p_T^jet>100 GeV, |y_jet|<2.8, p_T^trk>0.1 GeV
(1/N_evt)dN/dp_T
pp Gen
PbPb Gen (w/i JS)
ATLAS (2019)
PbPb/pp
p_T (GeV)

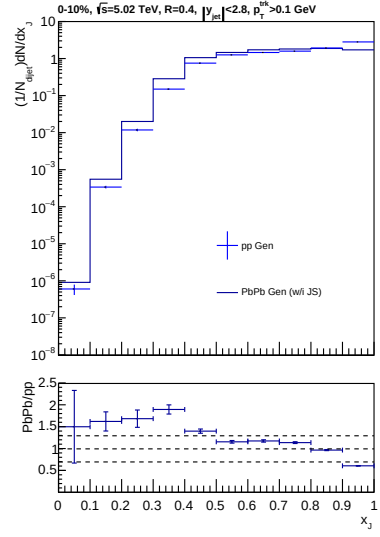

DOI: 10.1016/j.physletb.2018.10.076
(1/N_evt)dN/dp_T
pp Sub
PbPb Sub (both Sub)
ATLAS (2019)
PbPb/pp
p_T (GeV)

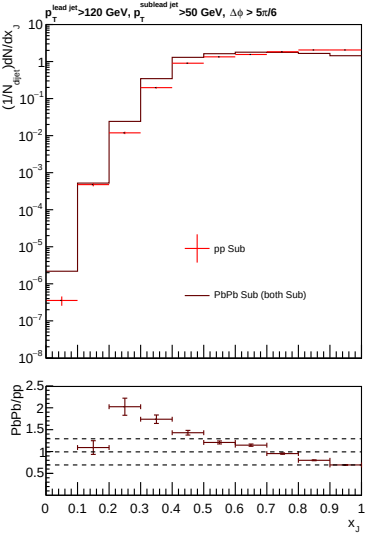

0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt)dN/dp_T^lead
PbPb/pp
p_T^lead (GeV)


p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
pp Sub
PbPb Sub (both Sub)
(1/N_evt)dN/dp_T^lead
PbPb/pp
p_T^lead (GeV)

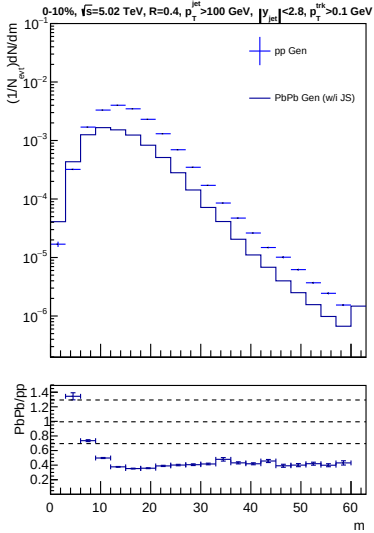

0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt)dN/dp_T^subl
PbPb/pp
p_T^subl (GeV)

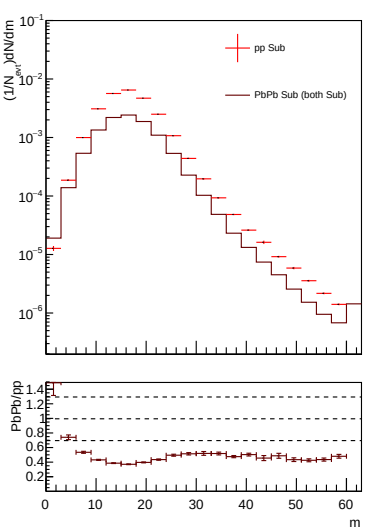

p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
pp Sub
PbPb Sub (both Sub)
(1/N_evt)dN/dp_T^subl
PbPb/pp
p_T^subl (GeV)

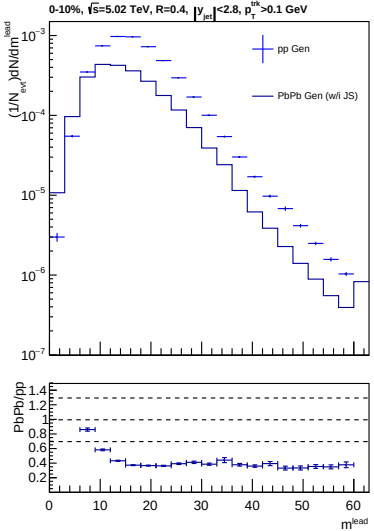


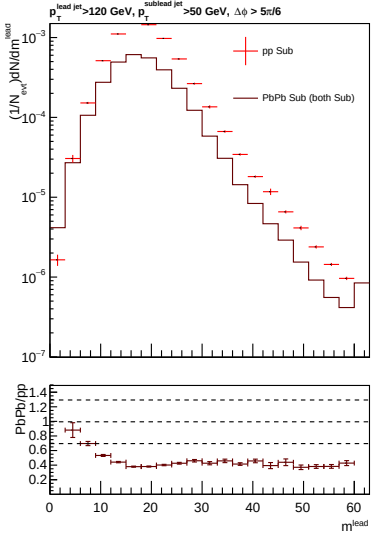


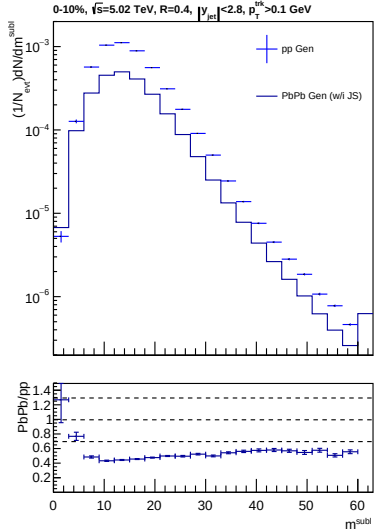
$$x_j = p_T^{sublead} / p_T^{lead}$$

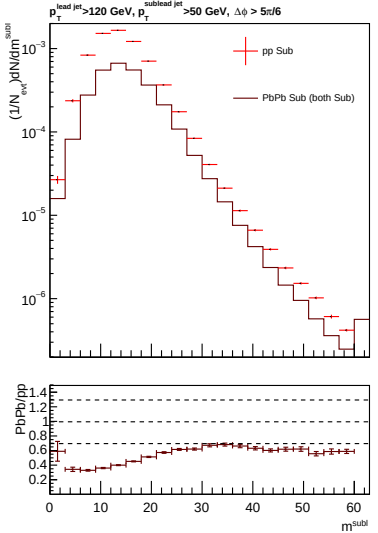

0-10%, √s=5.02 TeV, R=0.4, p_T^jet>100 GeV, |y_jet|<2.8, p_T^trk>0.1 GeV
(1/N_evt)dN/dm
pp Gen
PbPb Gen (w/i JS)
PbPb/pp
m

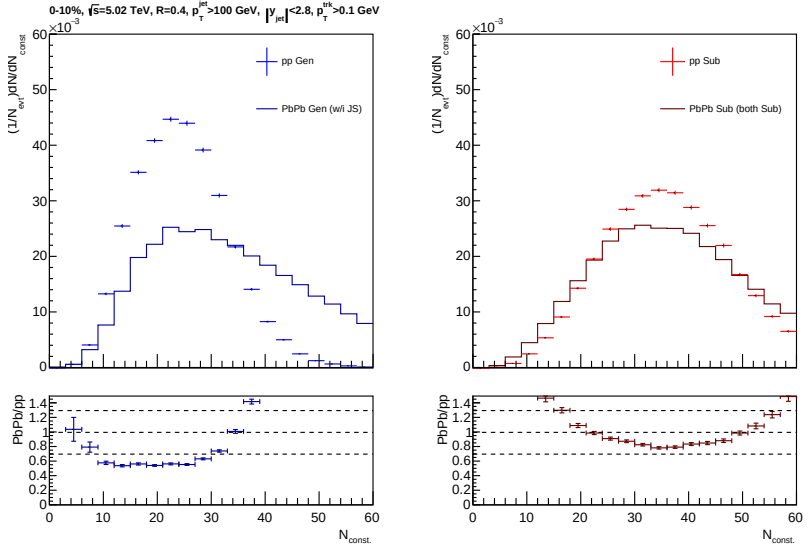

(1/N_evt)dN/dm
pp Sub
PbPb Sub (both Sub)
PbPb/pp
m


0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt^lead)dN/dm^lead
PbPb/pp
m^lead

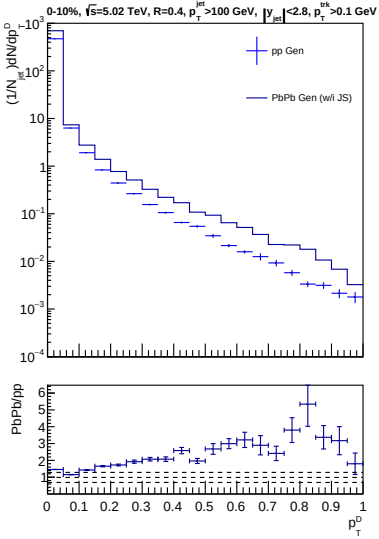

p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
pp Sub
PbPb Sub (both Sub)
(1/N_evt^lead)dN/dm^lead
PbPb/pp
m^lead

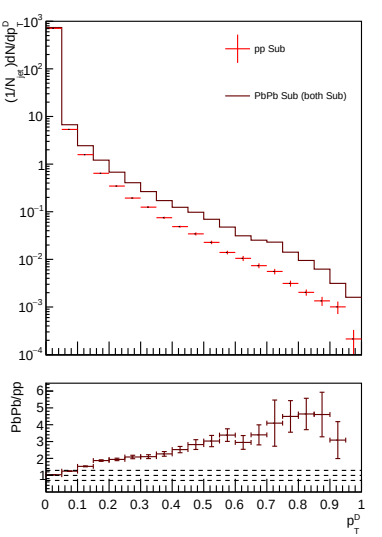

0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt)dN/dm^subl
PbPb/pp
m^subl


p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
pp Sub
PbPb Sub (both Sub)
(1/N_evt)dN/dm^subl
PbPb/pp
m^subl

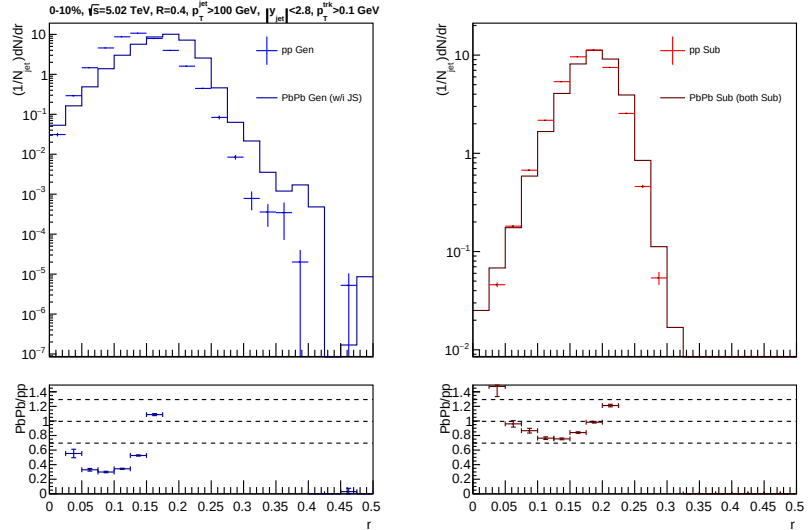


$$N_{cts} = \sum_{consts} 1$$

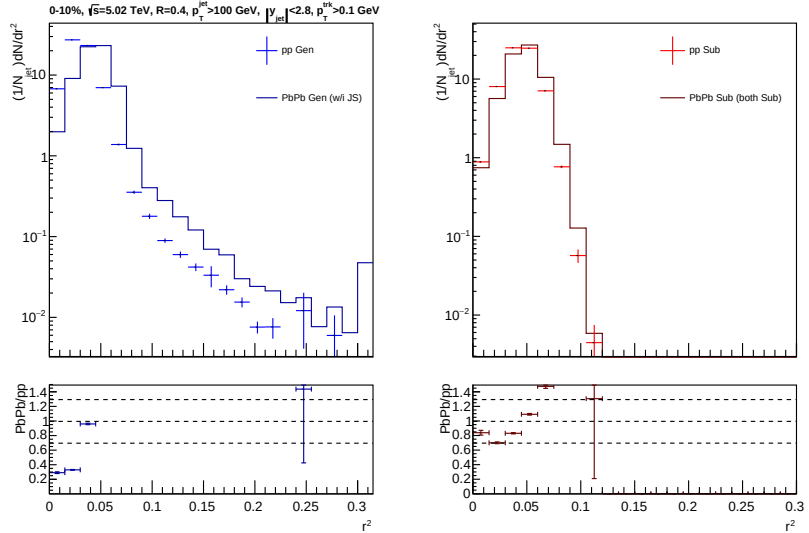




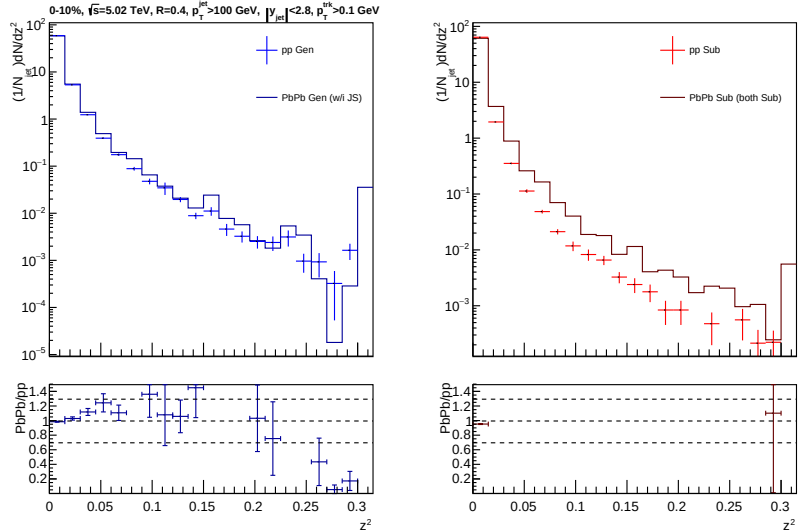
$$p_T^D = \left(\frac{p_T^i}{p_T^{jet}}\right)^2 cos^2(r); r = \sqrt{(\phi_i - \phi_{jet})^2 + (\eta_i - \eta_{jet})^2}$$



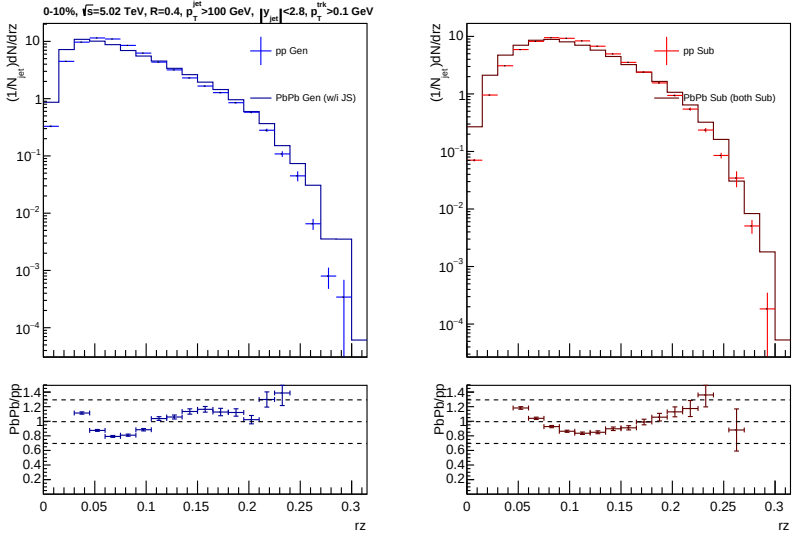
$$r = \sum_{consts} \frac{1}{N_{consts}} \sqrt{(\phi_i - \phi_{jet})^2 + (\eta_i - \eta_{jet})^2}$$



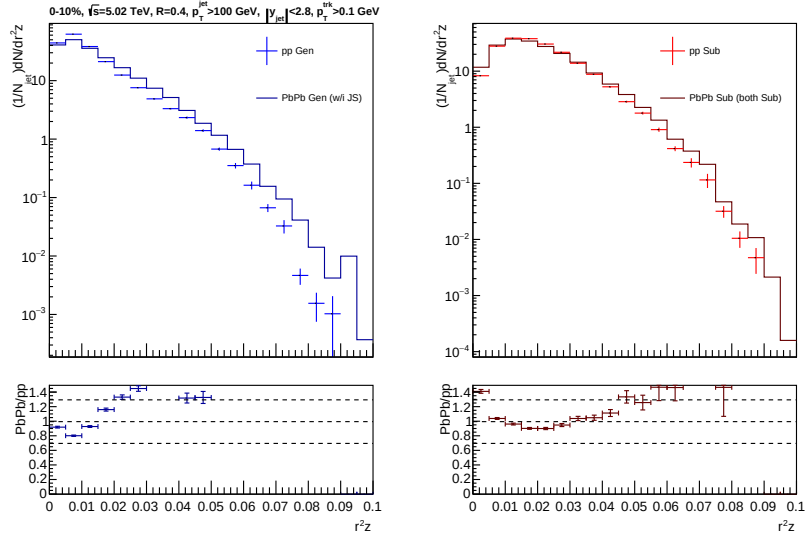
$$r^2 = \sum_{consts} \frac{1}{N_{consts}} |(\phi_i - \phi_{jet})^2 + (\eta_i - \eta_{jet})^2|$$



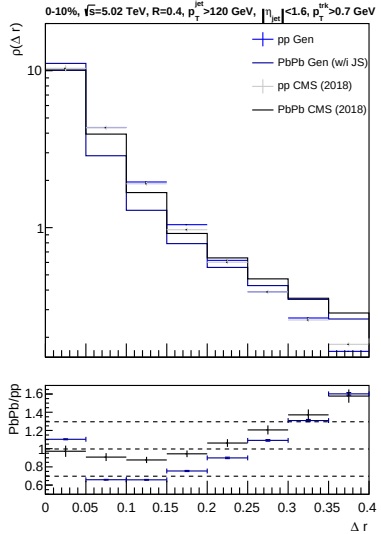
$$z^2 = \sum_{consts} \frac{1}{N_{consts}} \left(\frac{p_T^i}{p_T^{jet}} \right)^2$$

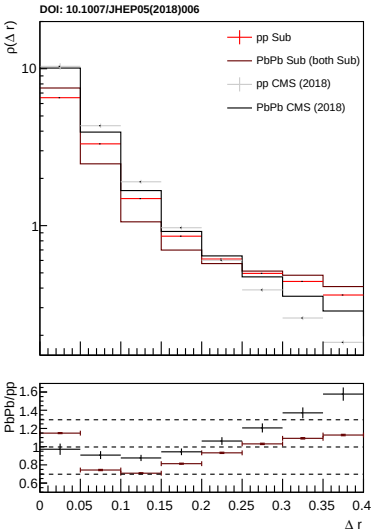


$$rz = \sum_{consts} \frac{1}{N_{consts}} \left(\frac{p_T^i}{p_T^{jet}} \right) \sqrt{(\phi_i - \phi_{jet})^2 + (\eta_i - \eta_{jet})^2}$$

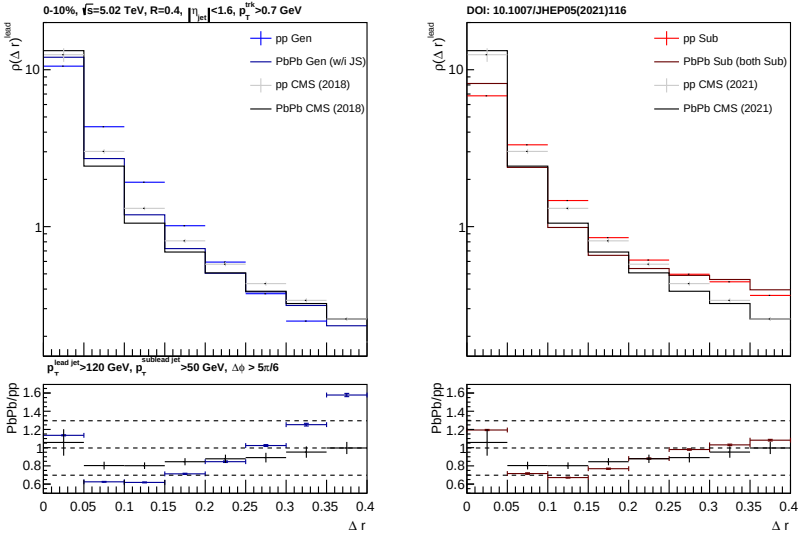


$$r^2 z = \sum_{consts} \frac{1}{N_{consts}} \left(\frac{p_T^i}{p_T^{jet}} \right) |(\phi_i - \phi_{jet})^2 + (\eta_i - \eta_{jet})^2|$$

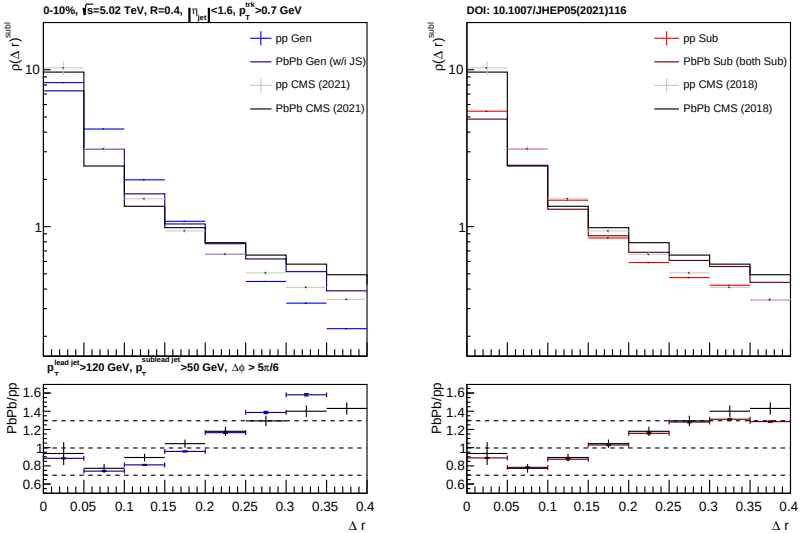




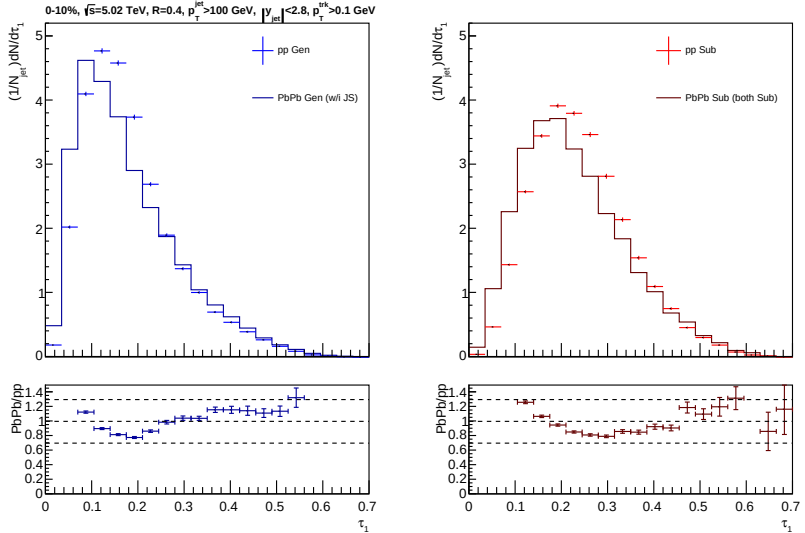
$$\rho(\Delta r) = \frac{1}{\delta r}\frac{1}{N_{jets}}\sum_{consts \in \Delta r} p_T^{const}$$



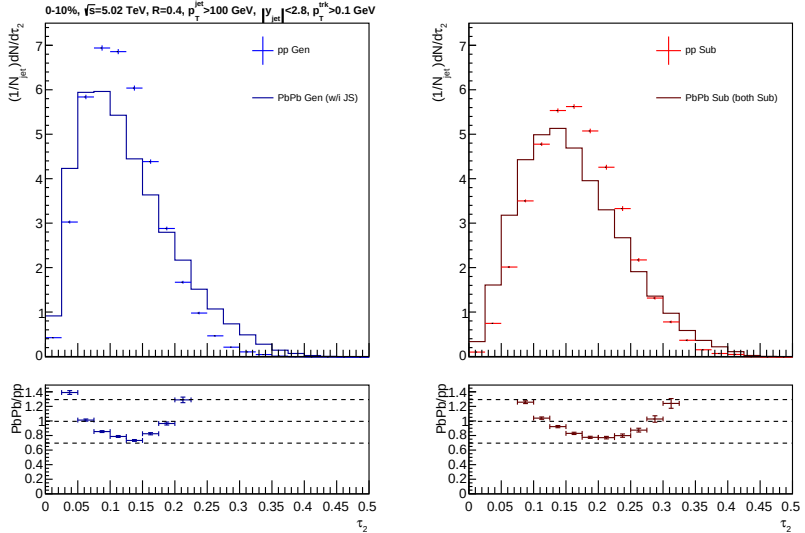
$$\rho(\Delta r) = \frac{1}{\delta r}\frac{1}{N_{jets}}\sum_{consts \in \Delta r} p_T^{const}$$



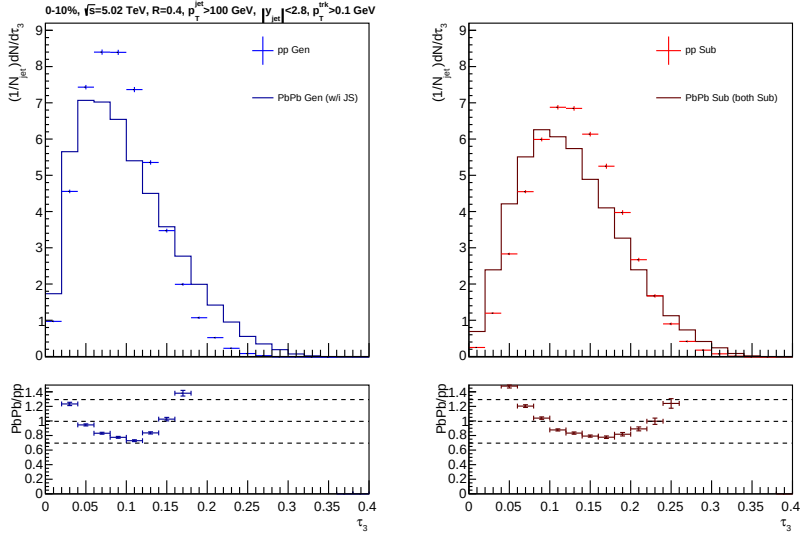
$$\rho(\Delta r) = \frac{1}{\delta r}\frac{1}{N_{jets}}\sum_{consts\in\Delta r} p_T^{const}$$



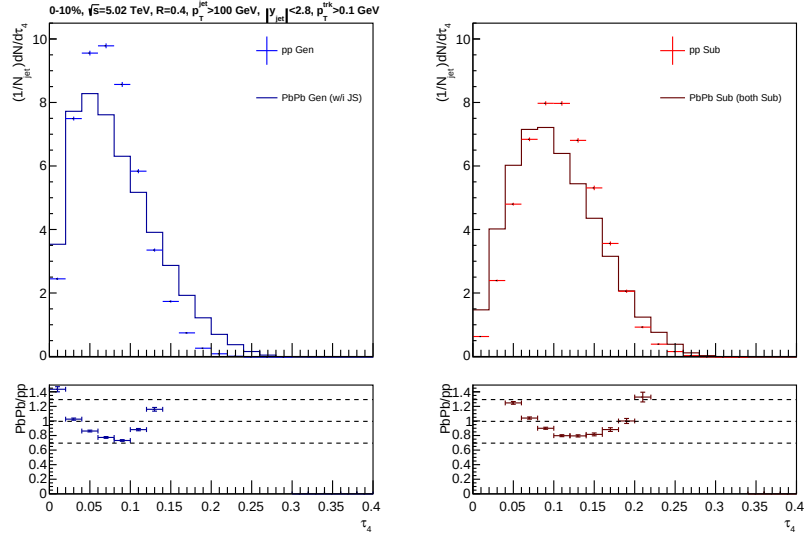
$$\tau_1 = \sum_{consts} p_T^{const} \Delta R_{subjet1,const}$$



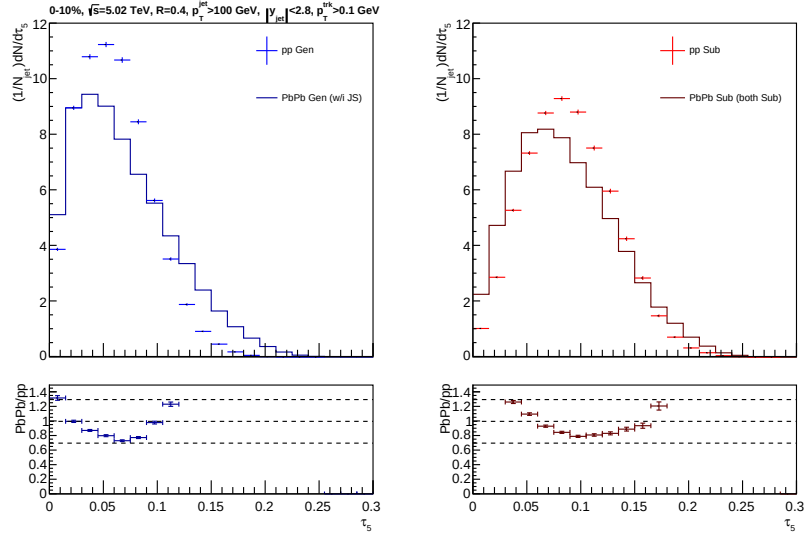
$$\tau_2 = \sum_{consts} p_T^{const} min(\Delta R_{subjet1,const}, \Delta R_{subjet2,const})$$



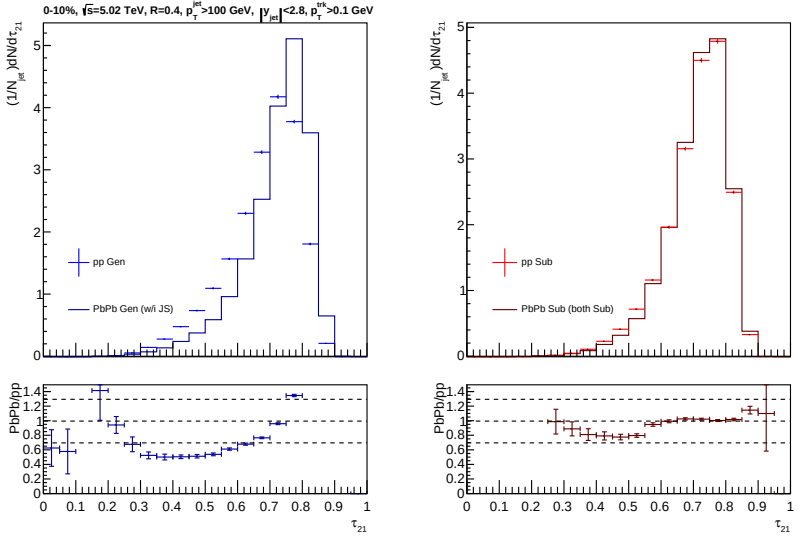
$$\tau_3 = \sum_{consts} p_T^{const} \, min(\Delta R_{subjet1,const}, \Delta R_{subjet2,const}, \Delta R_{subjet3,const})$$



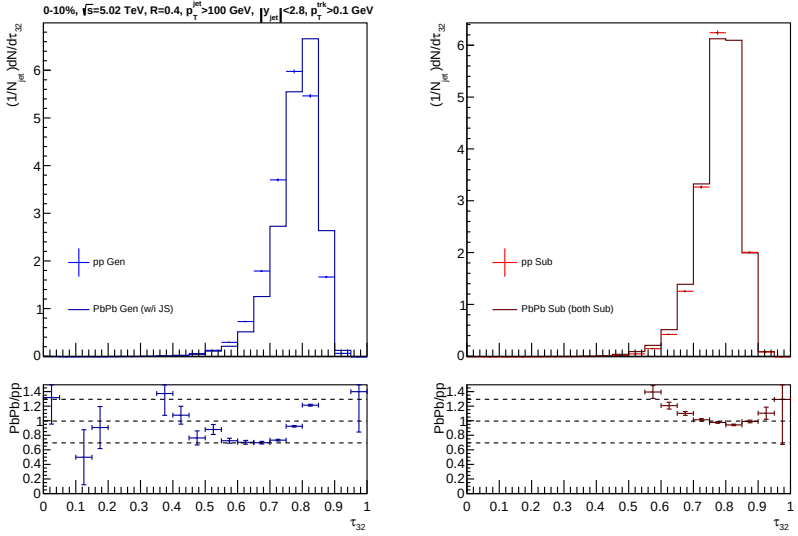
$$\tau_4 = \sum_{consts} p_T^{const} \, min(\Delta R_{subjet1,const}, \Delta R_{subjet2,const}, \Delta R_{subjet3,const}, \Delta R_{subjet4,const})$$



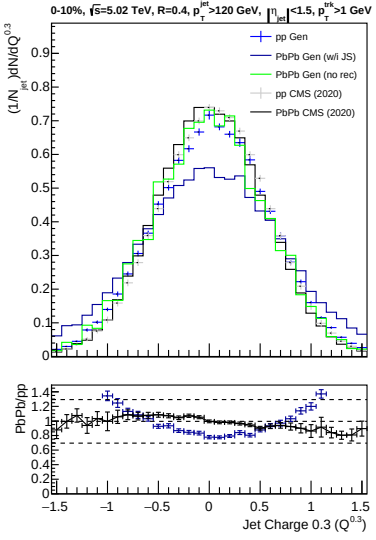
$$\tau_5 = \sum_{consts} p_T^{const} \, min(\Delta R_{subjet1,const}, \Delta R_{subjet2,const}, \Delta R_{subjet3,const}, ..., \Delta R_{subjet5,const})$$

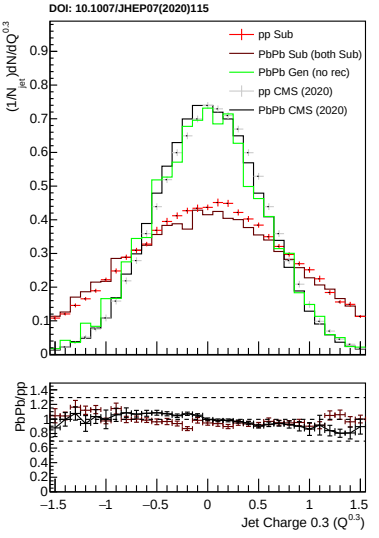


$$\tau_{21} = \frac{\tau_2}{\tau_1}$$

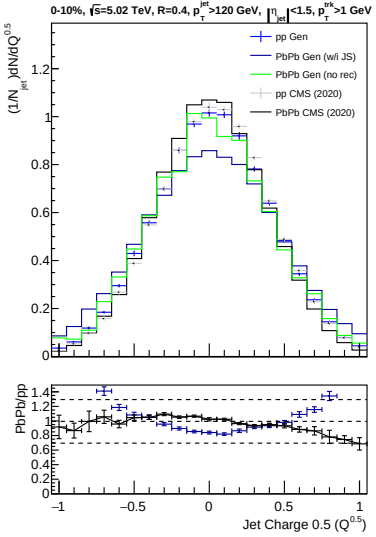


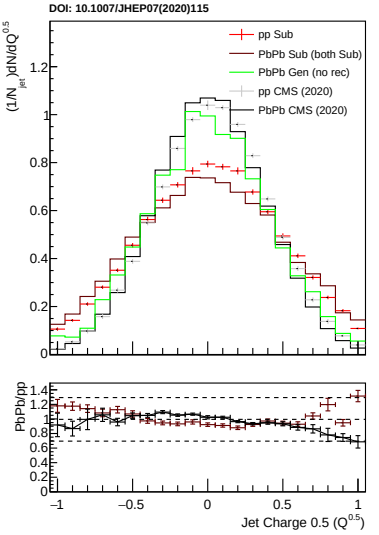
$$\tau_{21} = \frac{\tau_3}{\tau_2}$$



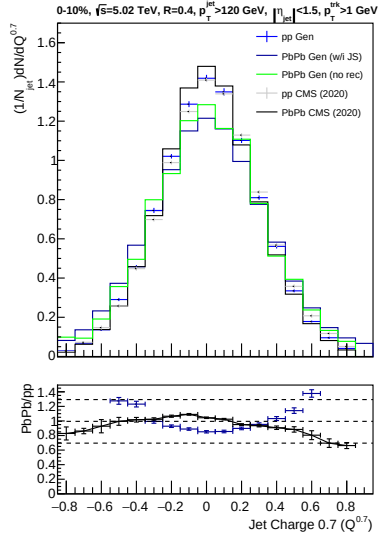


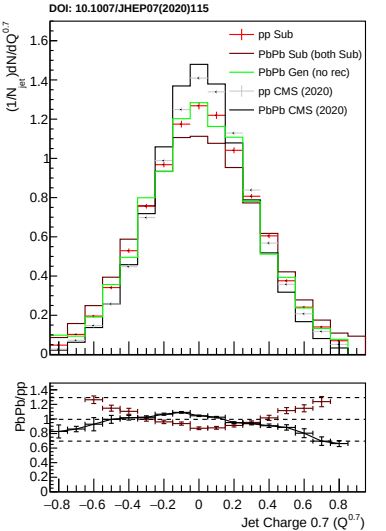
$$Q^{0.3} = \frac{1}{(p_T^{jet})^{0.3}} \sum_{consts} q^{const} (p_T^{const})^{0.3}$$



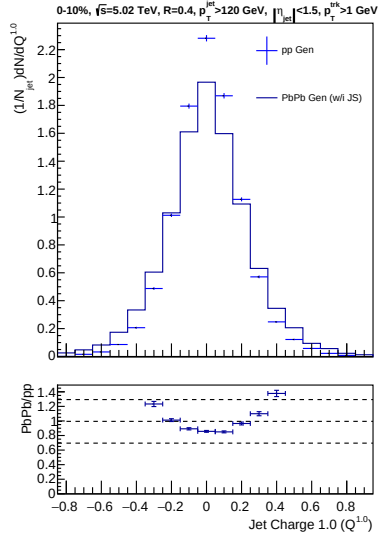


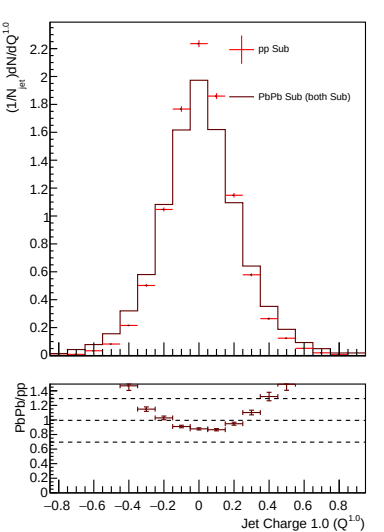
$$Q^{0.5} = \frac{1}{(p_T^{jet})^{0.5}} \sum_{consts} q^{const} (p_T^{const})^{0.5}$$



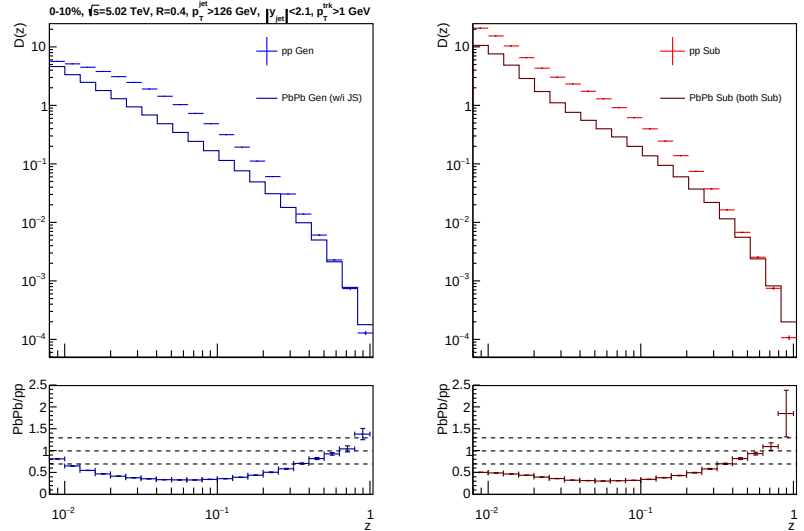


$$Q^{0.7} = \frac{1}{(p_T^{jet})^{0.7}} \sum_{consts} q^{const} (p_T^{const})^{0.7}$$

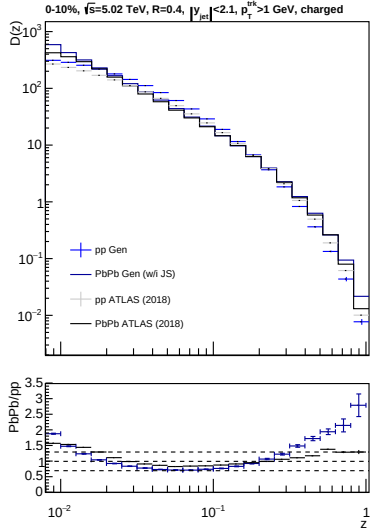


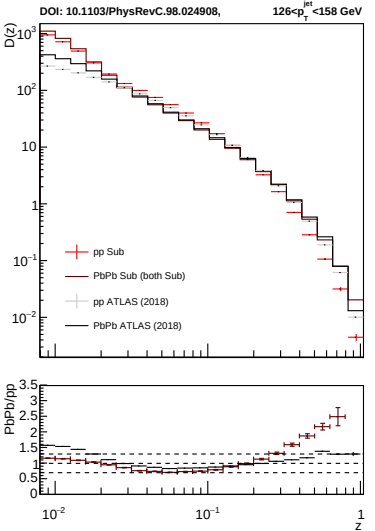


$$Q^1 = \frac{1}{p_T^{jet}} \sum_{consts} q^{const} p_T^{const}$$

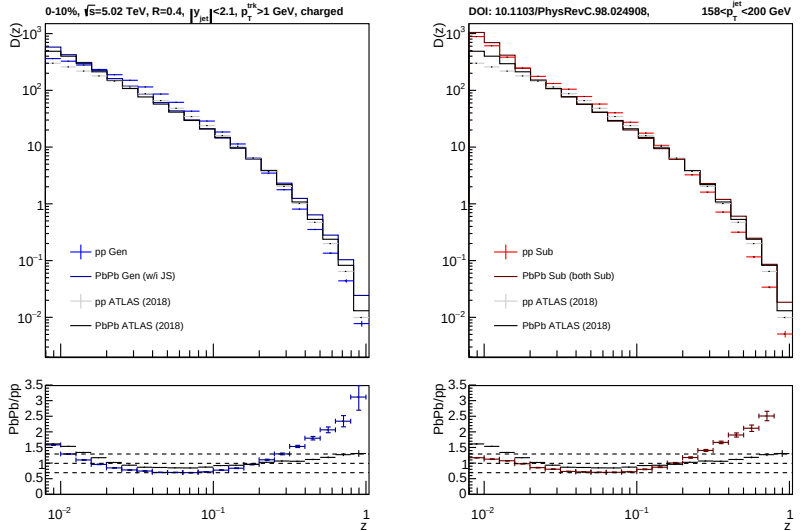


$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$

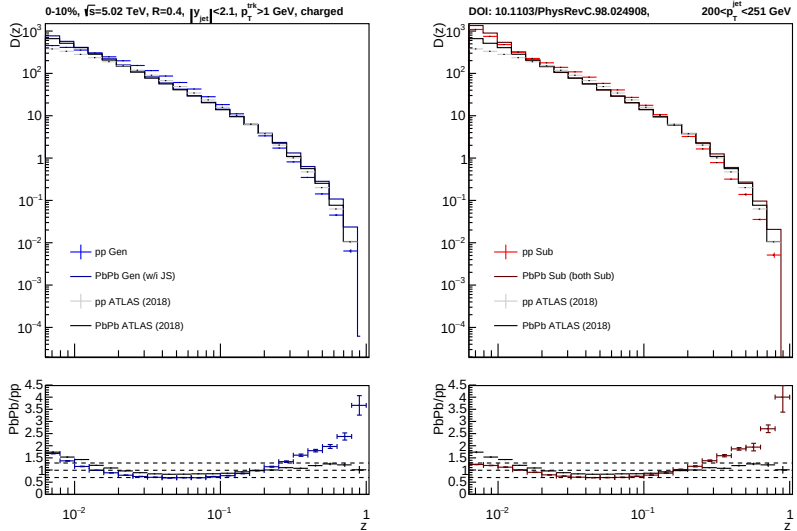




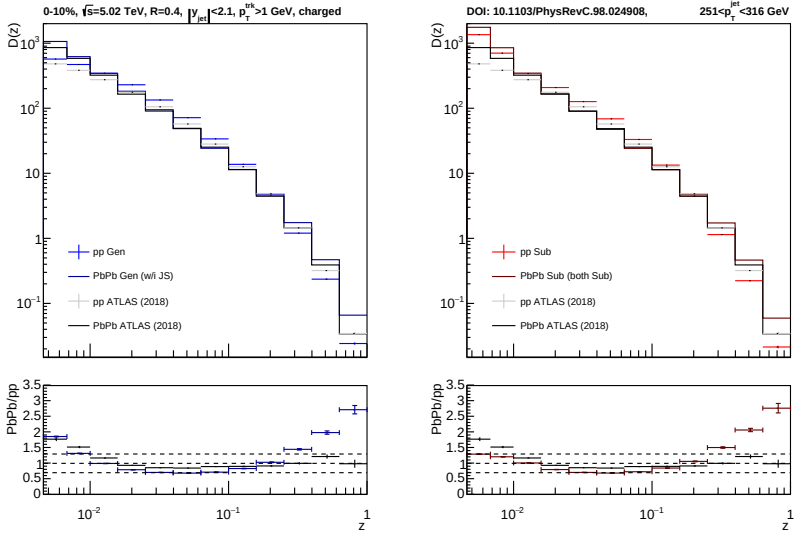
$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$



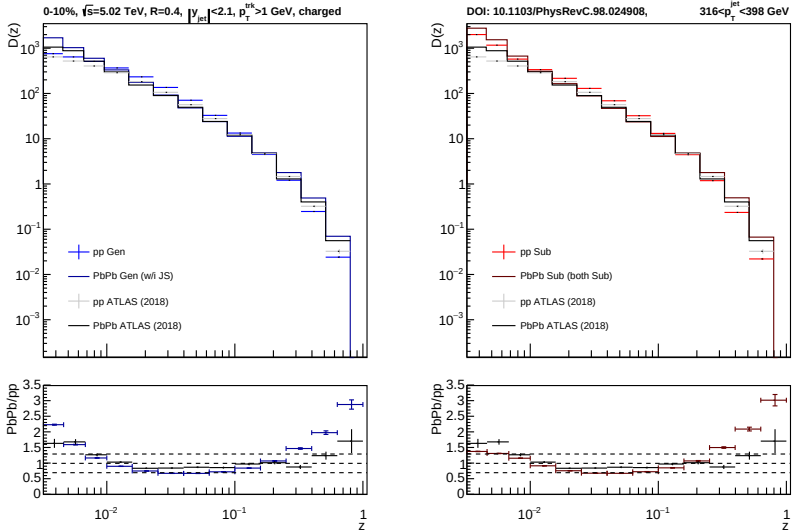
$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$



$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$

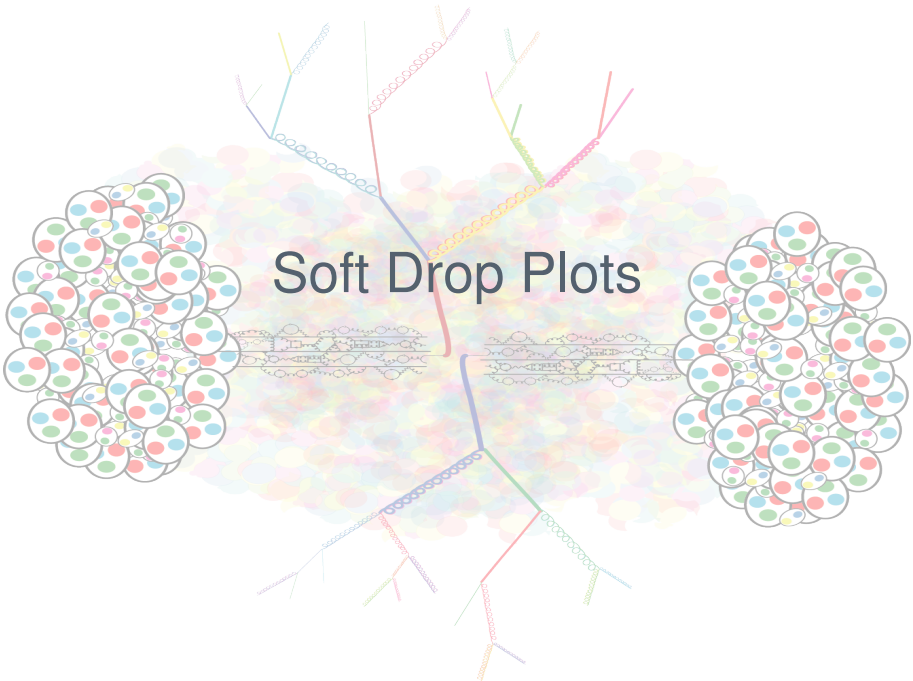


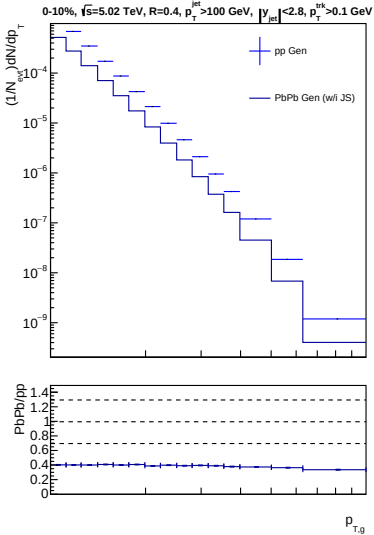
$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$

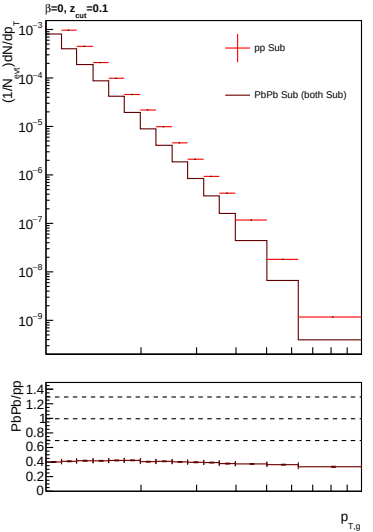


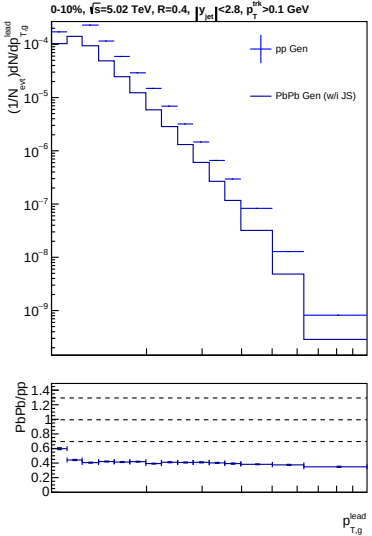
$$D(z) = \frac{1}{N_{jet}} \frac{dN_{chg}}{dz}; z = \frac{p_T^{const} cos(\Delta R)}{p_T^{jet}}$$

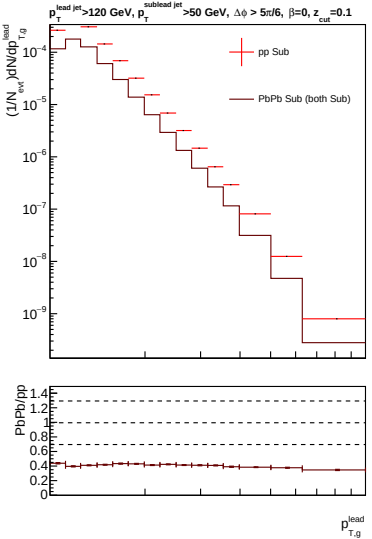
Soft Drop Plots

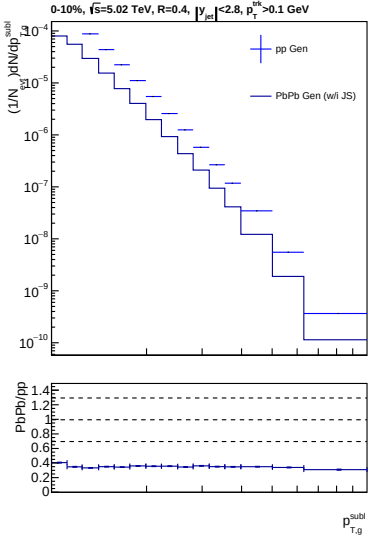


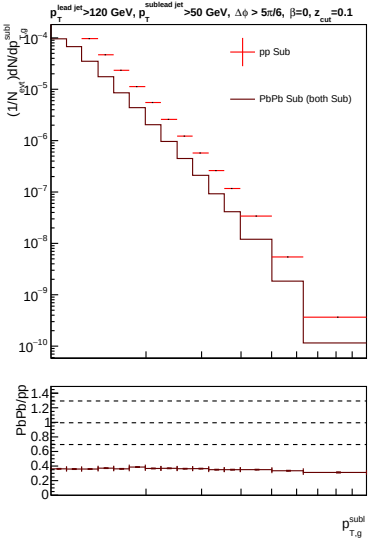

0-10%, √s=5.02 TeV, R=0.4, p_T^jet>100 GeV, |y_jet|<2.8, p_T^trk>0.1 GeV
(1/N_evt)dN/dp_T
pp Gen
PbPb Gen (w/i JS)
PbPb/pp
p_T,g

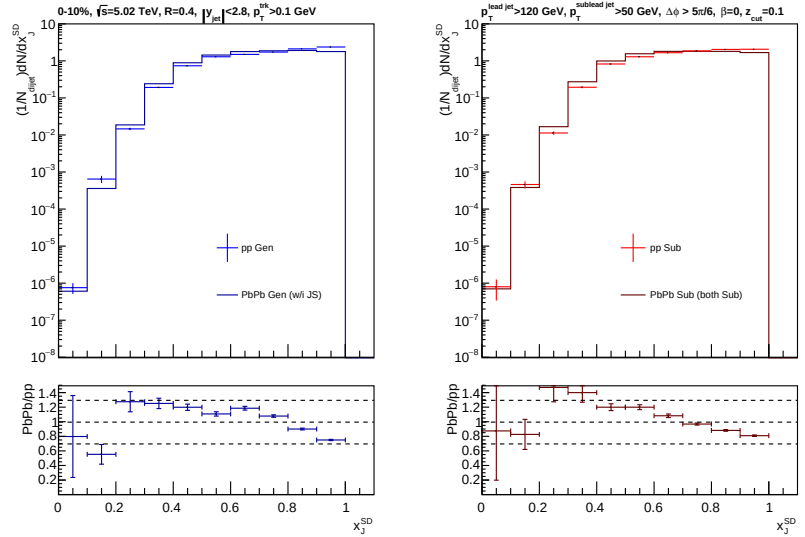

β=0, z_cut=0.1
(1/N_evt)dN/dp_T
pp Sub
PbPb Sub (both Sub)
PbPb/pp
p_T,g


0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
(1/N_evt)dN/dp_T,g^lead
pp Gen
PbPb Gen (w/i JS)
PbPb/pp
p_T,g^lead

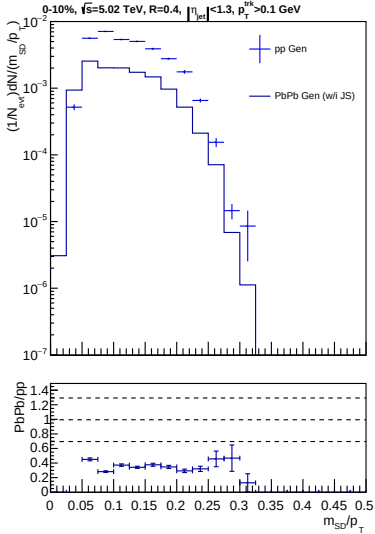

p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6, β=0, z_cut=0.1
(1/N_evt)dN/dp_T,g^lead
pp Sub
PbPb Sub (both Sub)
PbPb/pp
p_T,g^lead

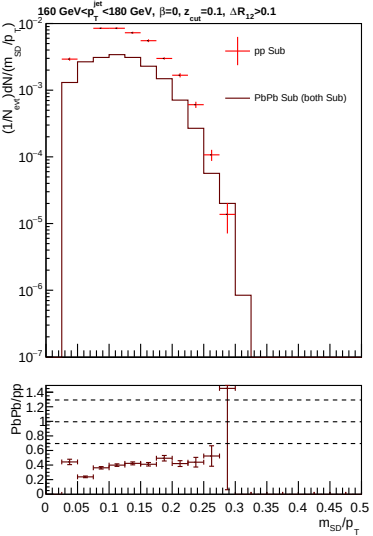

0-10%, √s=5.02 TeV, R=0.4, |y_jet|<2.8, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_jet^subl)dN/dp_T,g^subl
PbPb/pp
p_T,g^subl

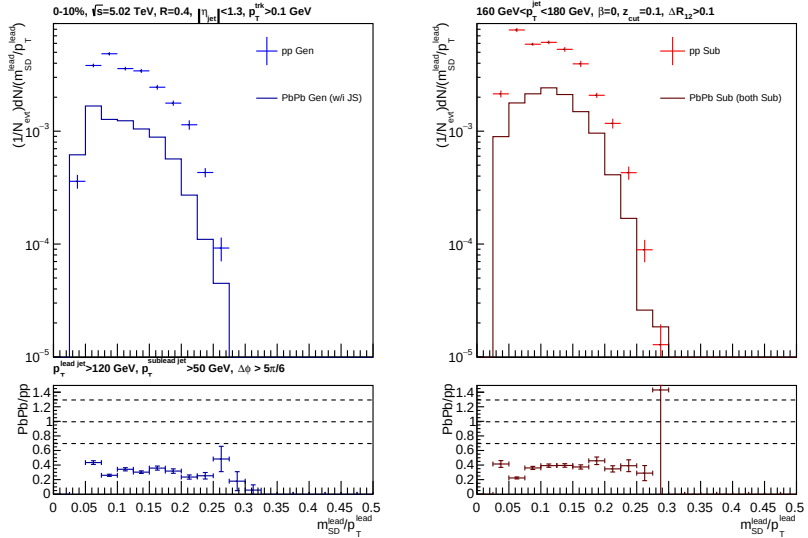

p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6, β=0, z_cut=0.1
pp Sub
PbPb Sub (both Sub)
(1/N_jet^subl)dN/dp_T,g^subl
PbPb/pp
p_T,g^subl

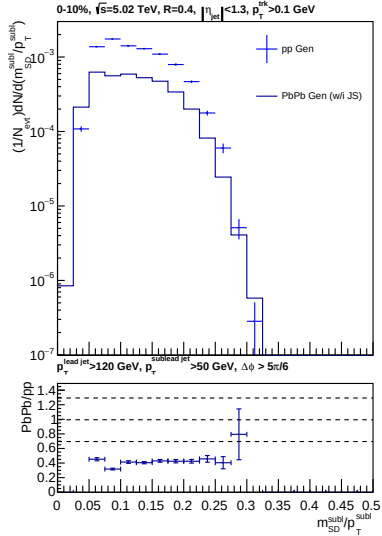


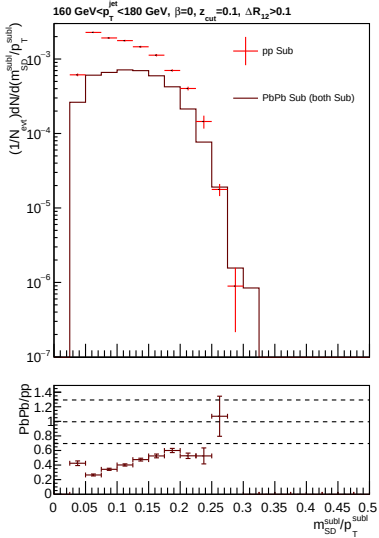
$$x_j^{SD} = p_{T,g}{}^{sublead} / p_{T,g}^{lead}$$

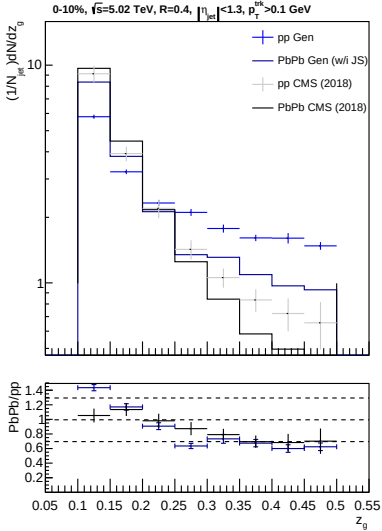

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_evt)dN/(m_SD/p_T)
pp Gen
PbPb Gen (w/i JS)
PbPb/pp
m_SD/p_T

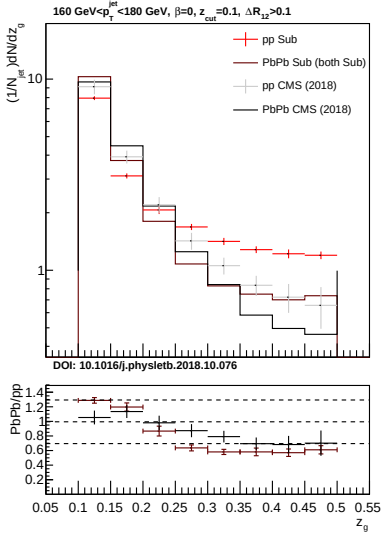

160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_evt)dN/(m_SD/p_T)
pp Sub
PbPb Sub (both Sub)
PbPb/pp
m_SD/p_T


0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt)dN/(m_SD^lead/p_T^lead)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
m_SD^lead/p_T^lead
160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
pp Sub
PbPb Sub (both Sub)


0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
pp Gen
PbPb Gen (w/i JS)
(1/N_evt) dN/d(m_SD^subl/p_T^subl)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
m_SD^subl/p_T^subl


160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
pp Sub
PbPb Sub (both Sub)
(1/N_evt) dN/d(m_SD^subl/p_T^subl)
PbPb/pp
m_SD^subl/p_T^subl





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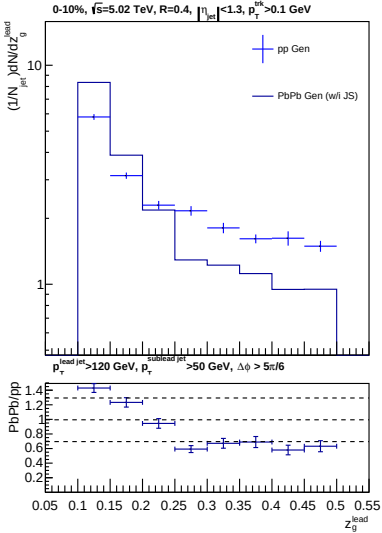
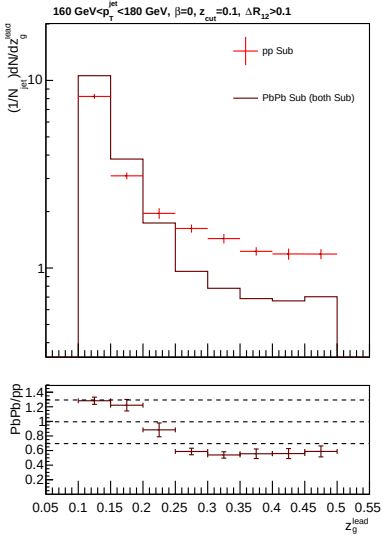
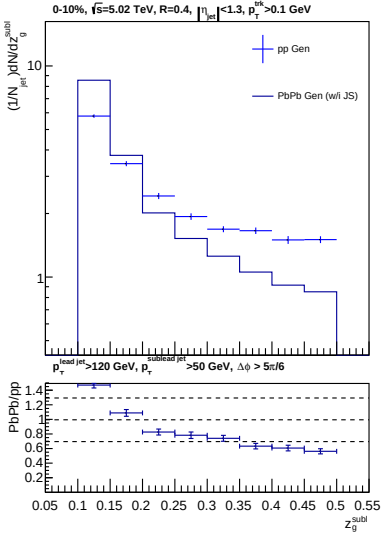
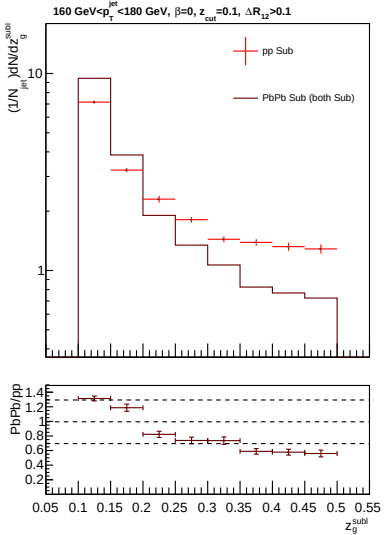
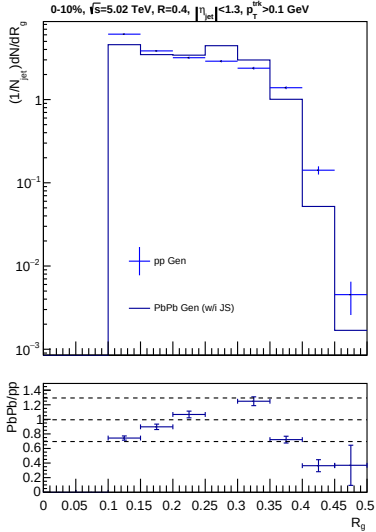
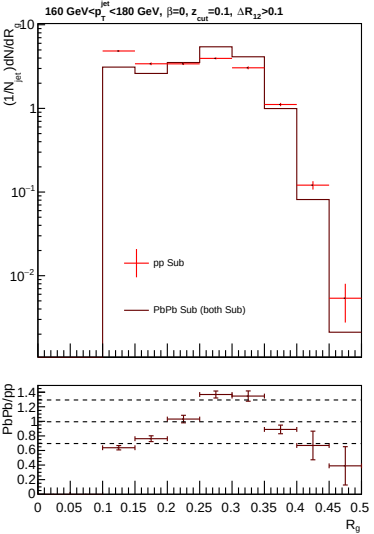

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet)dN/dz_g^lead
pp Gen
PbPb Gen (w/i JS)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
z_g^lead

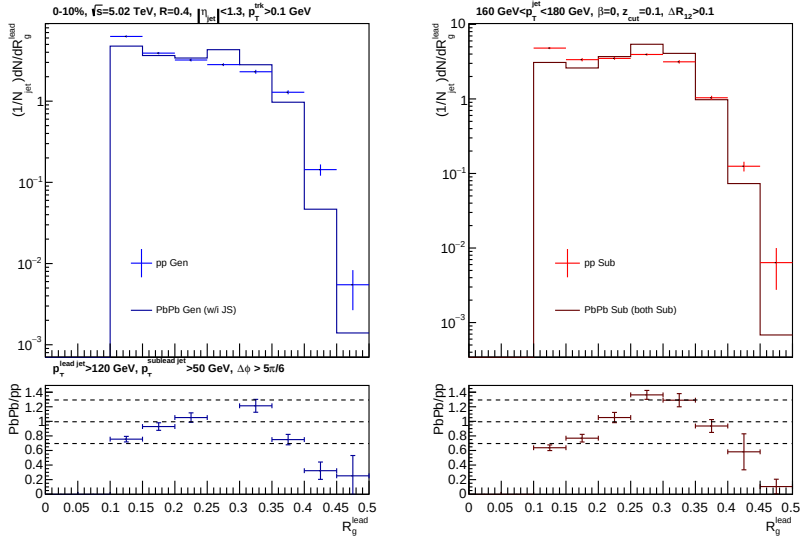

160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet)dN/dz_g^lead
pp Sub
PbPb Sub (both Sub)
PbPb/pp
z_g^lead

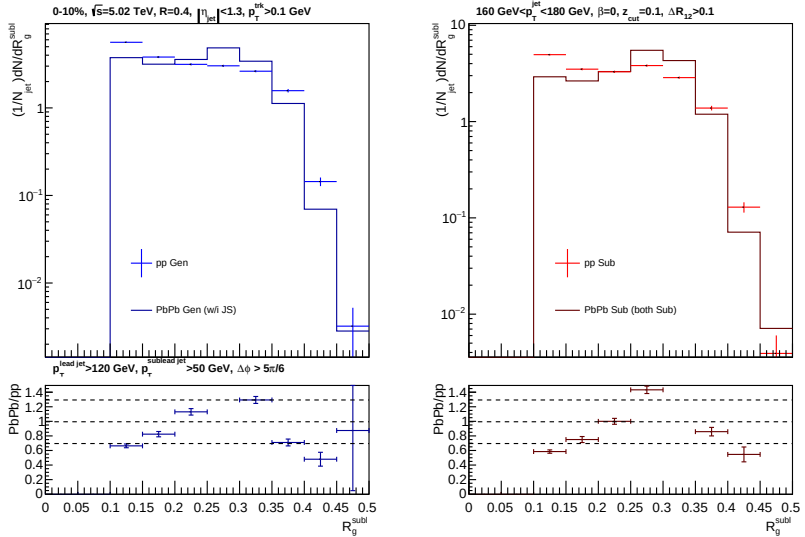

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet) dN/dz_g^subl
pp Gen
PbPb Gen (w/i JS)
10
1
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
1.4
1.2
1
0.8
0.6
0.4
0.2
0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
z_g^subl

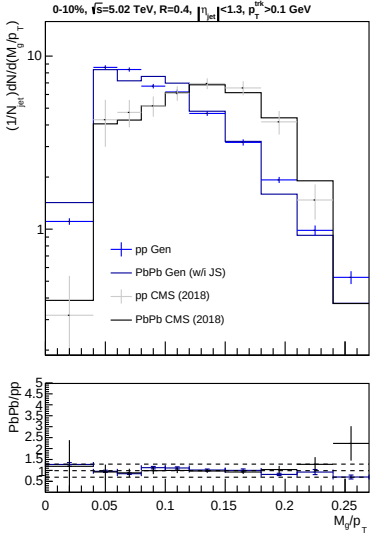

160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet) dN/dz_g^subl
pp Sub
PbPb Sub (both Sub)
10
1
PbPb/pp
1.4
1.2
1
0.8
0.6
0.4
0.2
0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55
z_g^subl

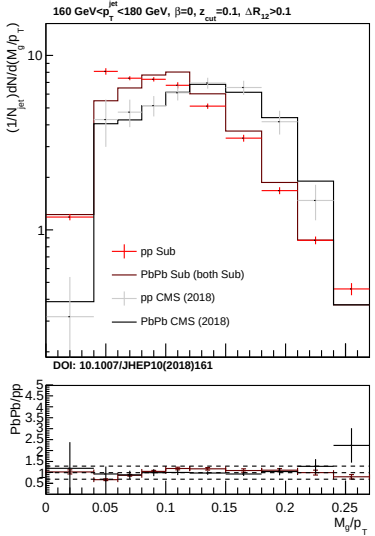

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet)dN/dR_g
pp Gen
PbPb Gen (w/i JS)
PbPb/pp
R_g

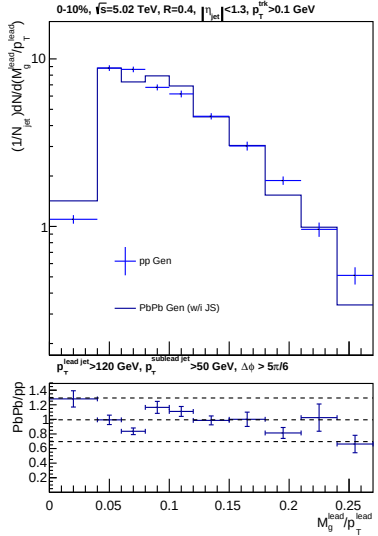

160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet)dN/dR_g
pp Sub
PbPb Sub (both Sub)
PbPb/pp
R_g

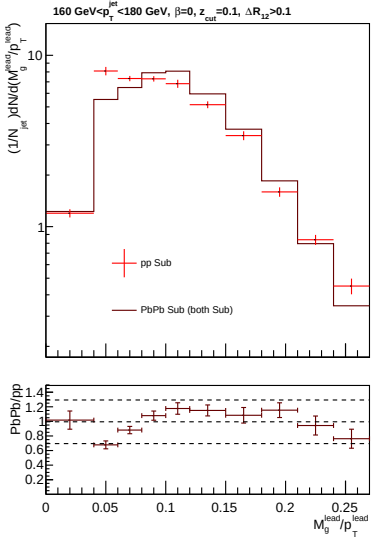

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet) dN/dR_g^lead
pp Gen
PbPb Gen (w/i JS)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
R_g^lead
160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
pp Sub
PbPb Sub (both Sub)

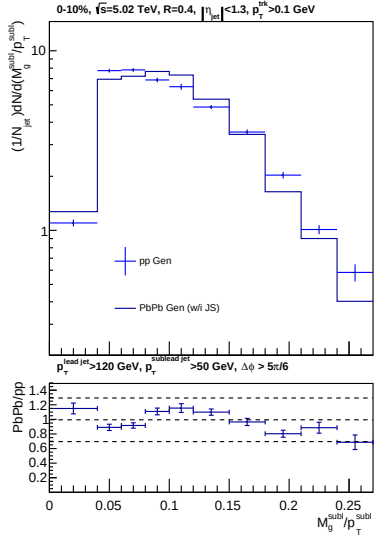

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet^lead)dN/dR_g^subl
pp Gen
PbPb Gen (w/i JS)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
R_g^subl
160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
pp Sub
PbPb Sub (both Sub)

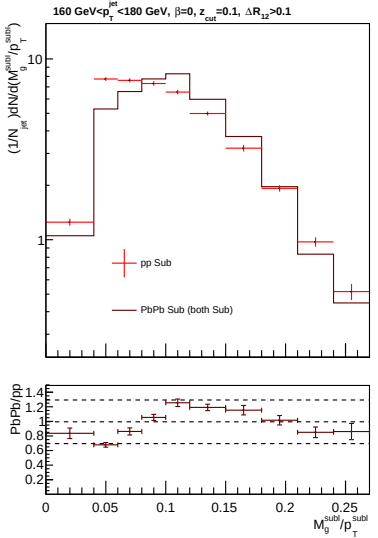

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet)dN/d(M_g/p_T)
pp Gen
PbPb Gen (w/i JS)
pp CMS (2018)
PbPb CMS (2018)
PbPb/pp
M_g/p_T


160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet)dN/d(M_g/p_T)
pp Sub
PbPb Sub (both Sub)
pp CMS (2018)
PbPb CMS (2018)
DOI: 10.1007/JHEP10(2018)161
PbPb/pp
M_g/p_T

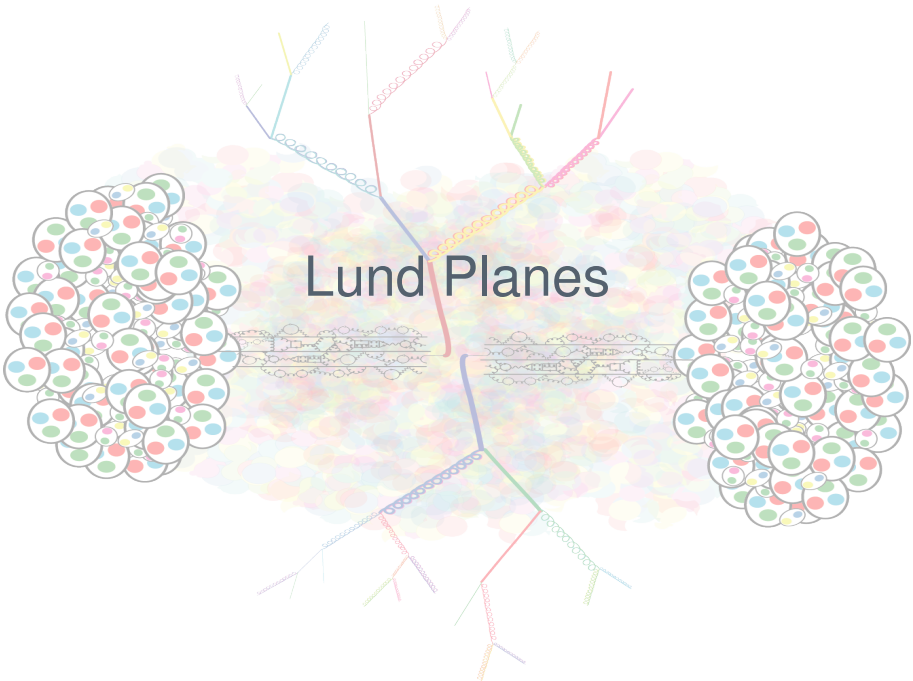

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet) dN/d(M_g^lead/p_T^lead)
pp Gen
PbPb Gen (w/i JS)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
M_g^lead/p_T^lead


160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet) dN/d(M_g^lead/p_T^lead)
pp Sub
PbPb Sub (both Sub)
PbPb/pp
M_g^lead/p_T^lead

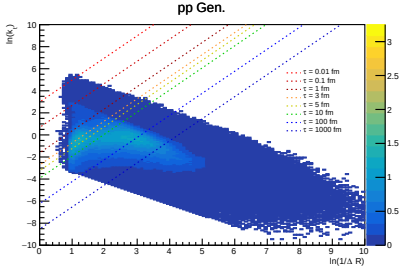

0-10%, √s=5.02 TeV, R=0.4, |η_jet|<1.3, p_T^trk>0.1 GeV
(1/N_jet) dN/d(M_g^subj/p_T^subj)
pp Gen
PbPb Gen (w/i JS)
p_T^lead jet>120 GeV, p_T^sublead jet>50 GeV, Δφ > 5π/6
PbPb/pp
M_g^subj/p_T^subj

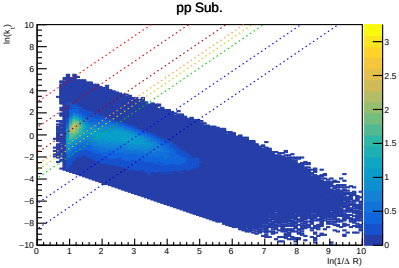

160 GeV<p_T^jet<180 GeV, β=0, z_cut=0.1, ΔR_12>0.1
(1/N_jet) dN/d(M_g^subj/p_T^subj)
pp Sub
PbPb Sub (both Sub)
PbPb/pp
M_g^subj/p_T^subj

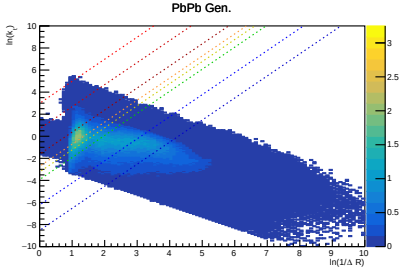
Lund Planes

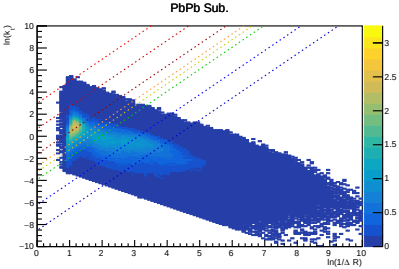


Lund Planes - Full Inclusive

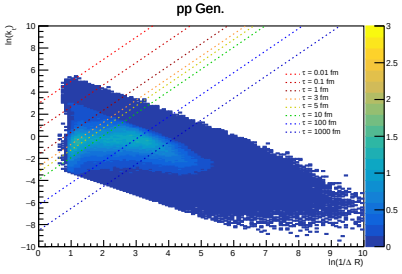


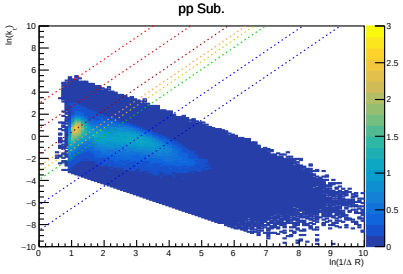


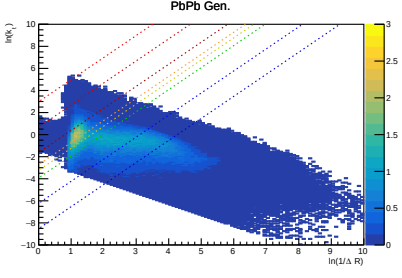


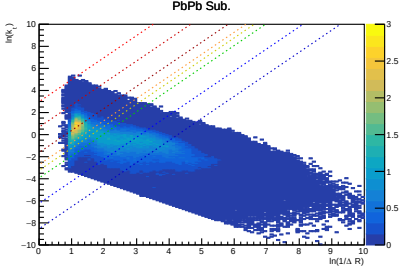


Lund Planes - Full Leading

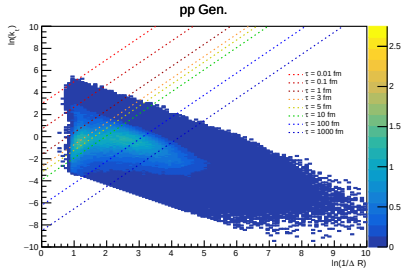


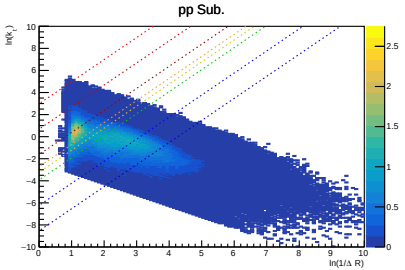


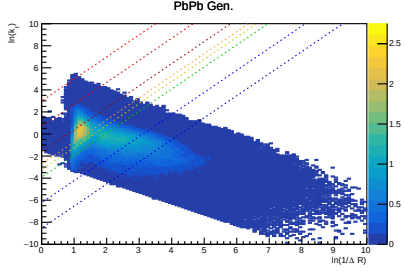


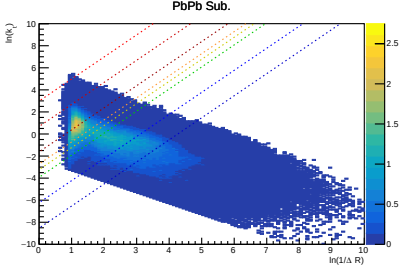


Lund Planes - Full Subleading

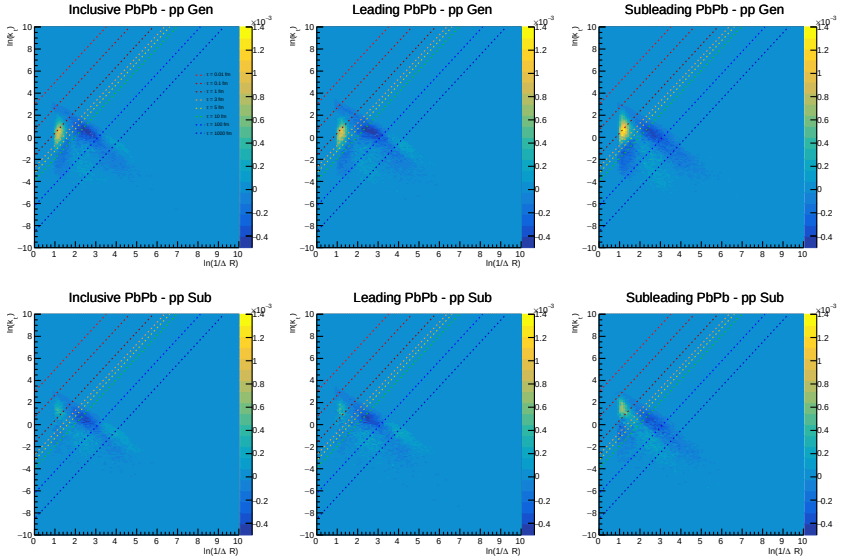






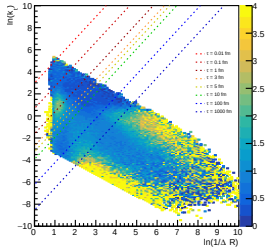


Lund Planes - Full Difference

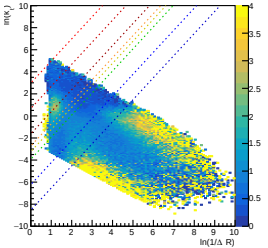


Lund Planes - Full Ratio

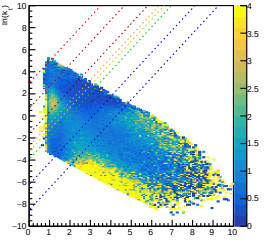
Inclusive PbPb / pp Gen



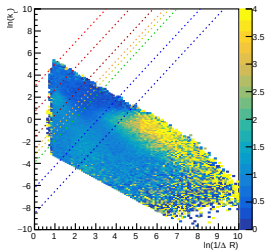
Leading PbPb / pp Gen



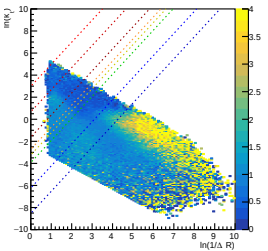
Subleading PbPb / pp Gen



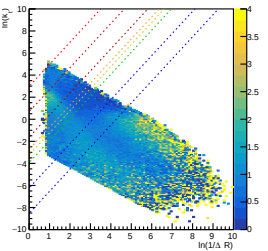
Inclusive PbPb / pp Sub



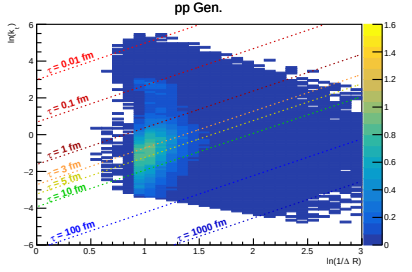
Leading PbPb / pp Sub

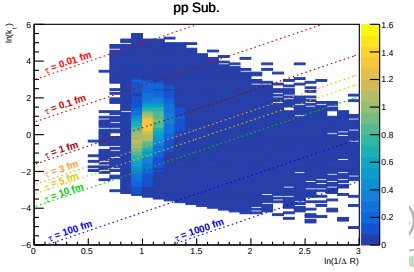


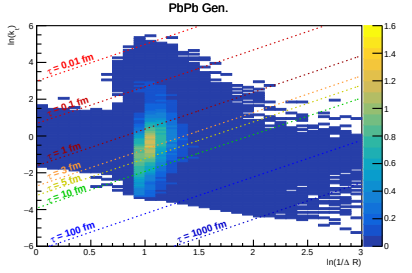
Subleading PbPb / pp Sub

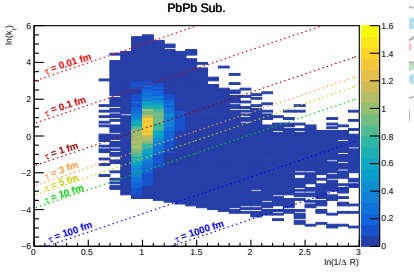


Lund Planes - First Splitting Inclusive

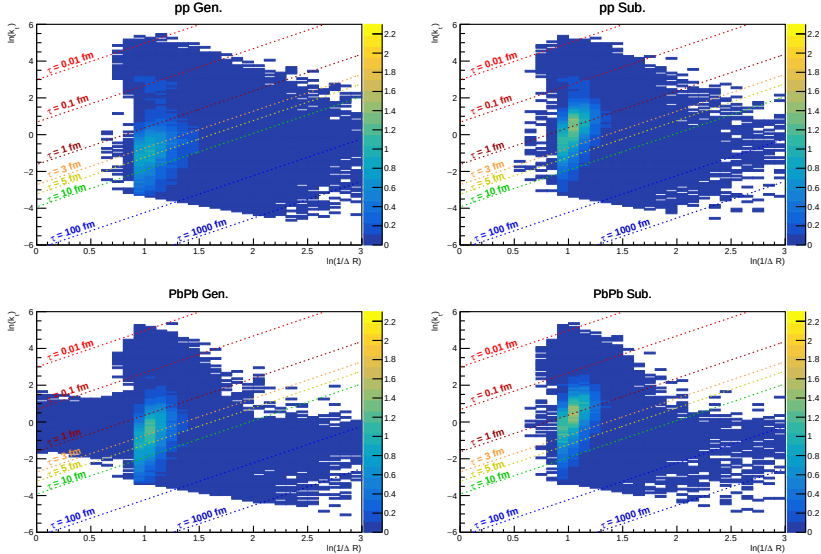




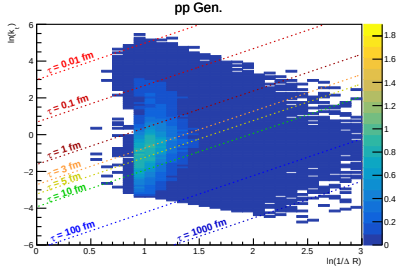


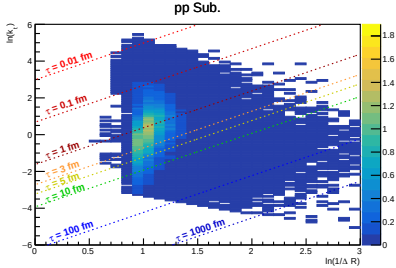


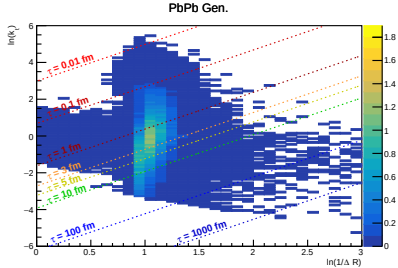
Lund Planes - First Splitting Leading

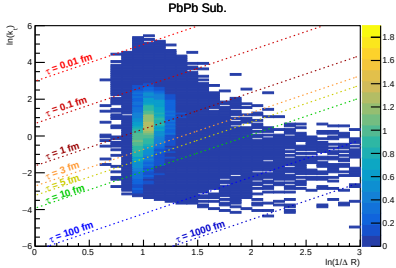


Lund Planes - First Splitting Subleading

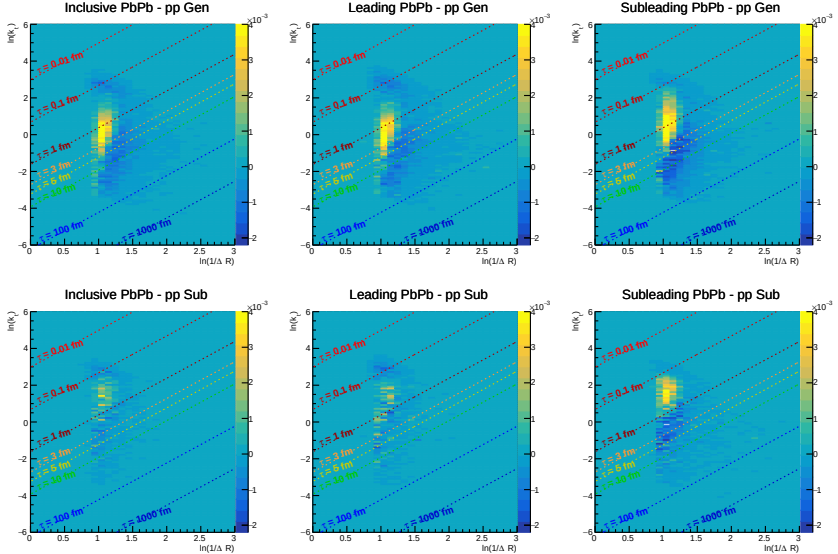




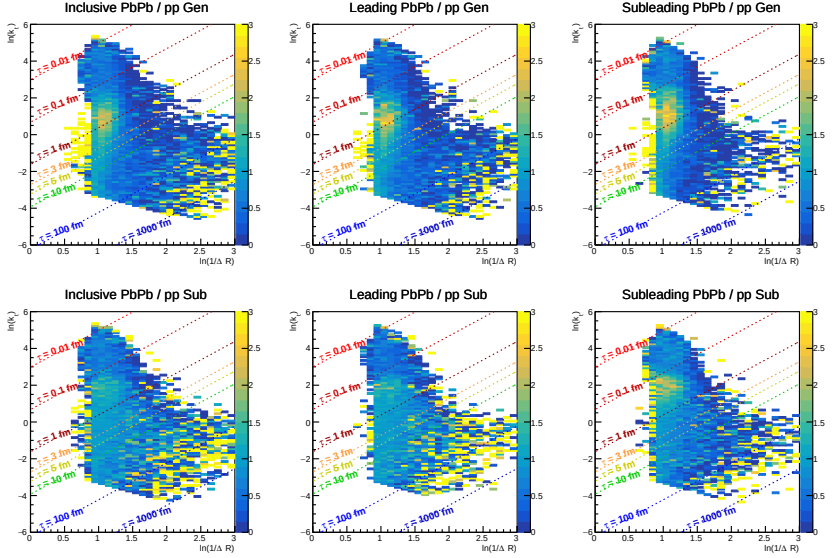




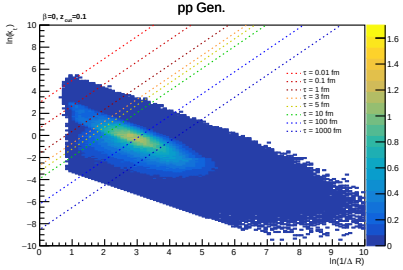
Lund Planes - First Splitting difference

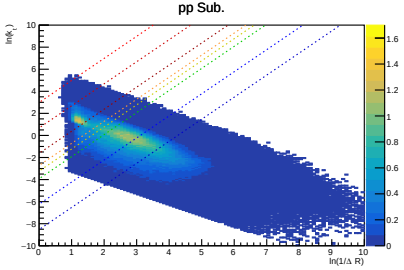


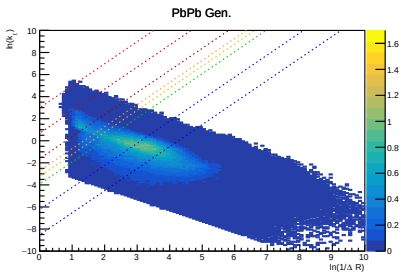
Lund Planes - First Splitting Ratio

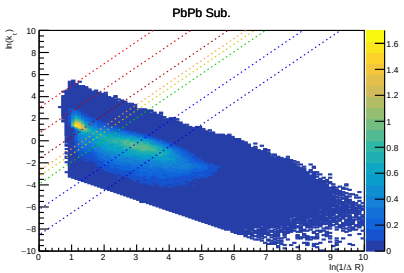


Lund Planes SD - Full Inclusive

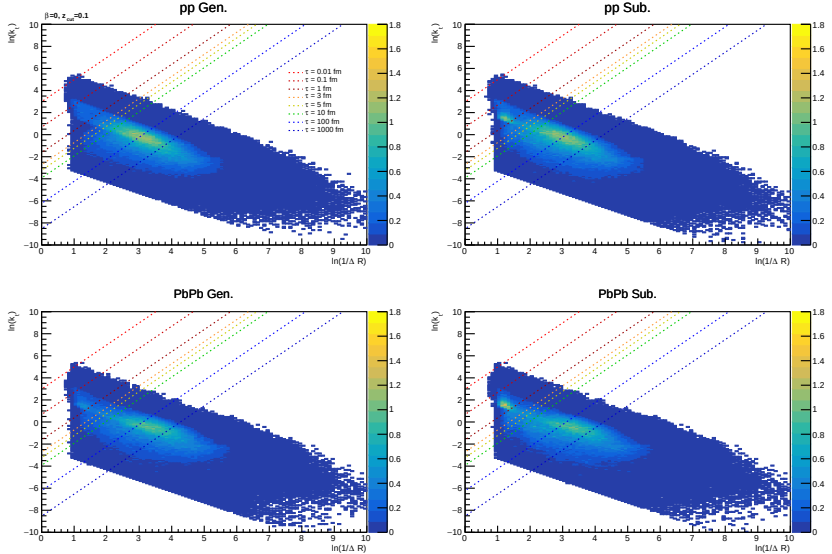




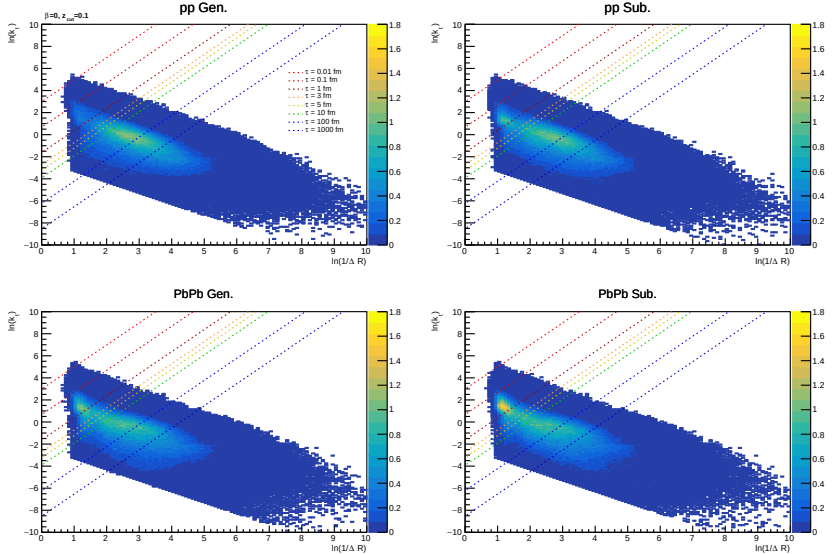




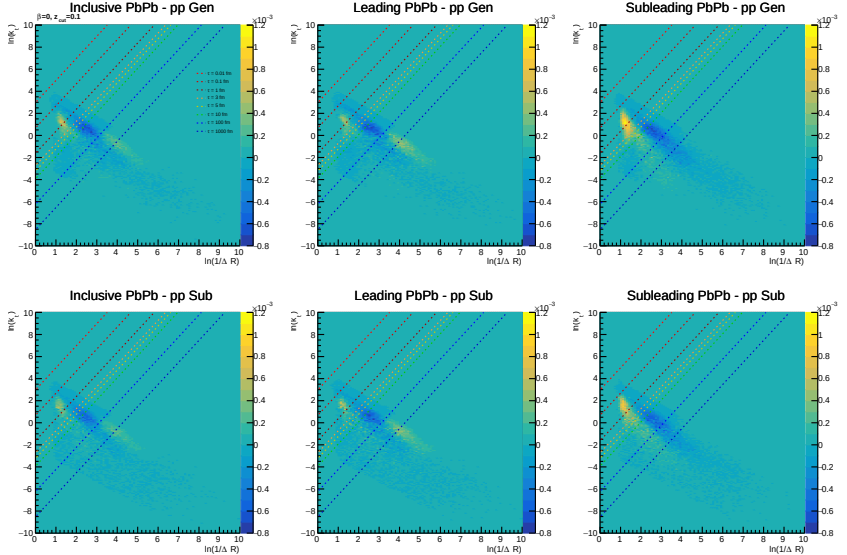
Lund Planes SD - Full Leading



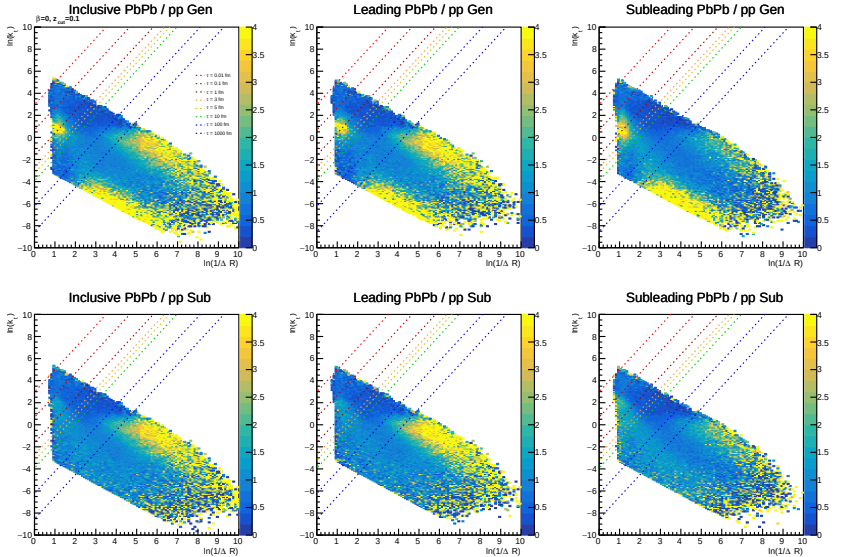
Lund Planes SD - Full Subleading



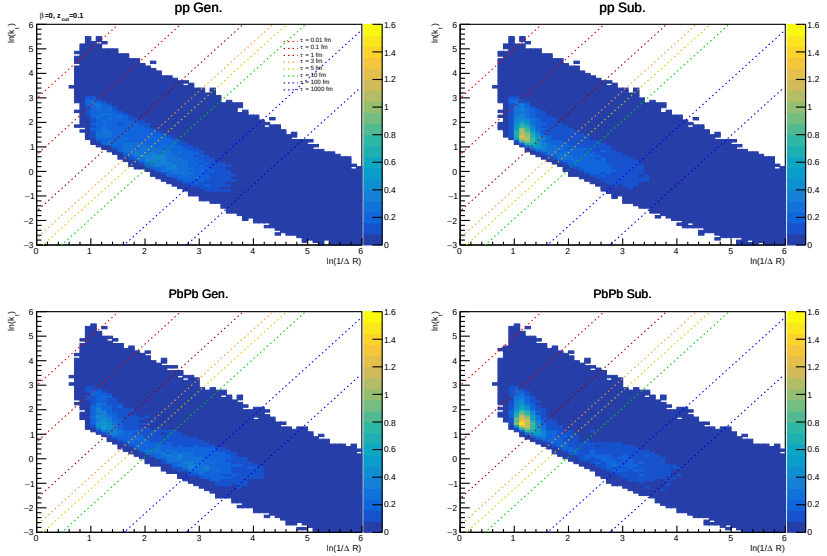
Lund Planes SD - Full Difference



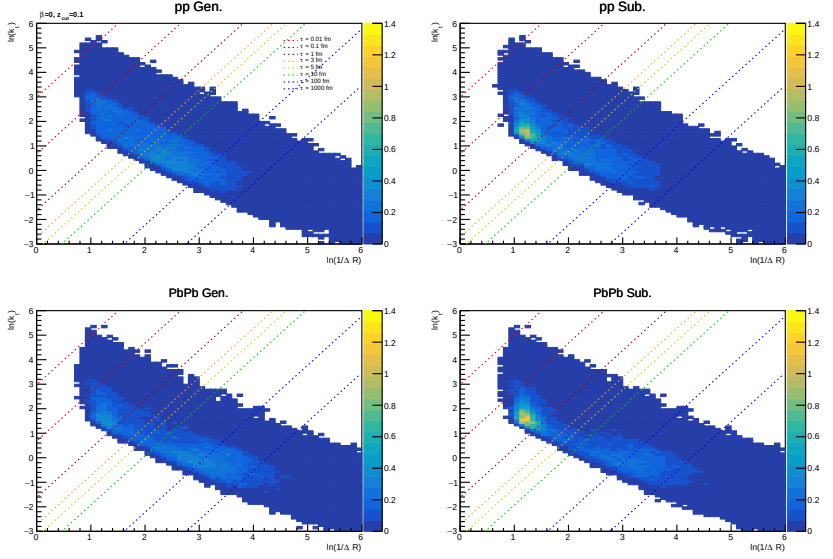
Lund Planes SD - Full Ratio



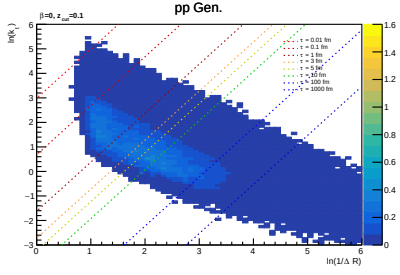
Lund Planes SD - First Splitting Inclusive

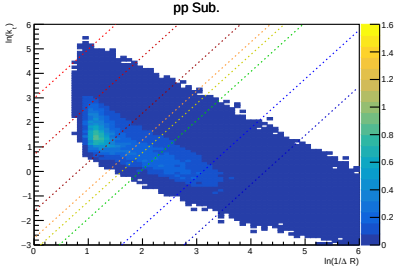


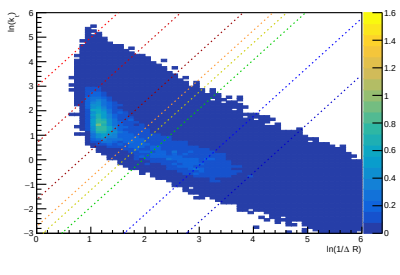
Lund Planes SD - First Splitting Leading

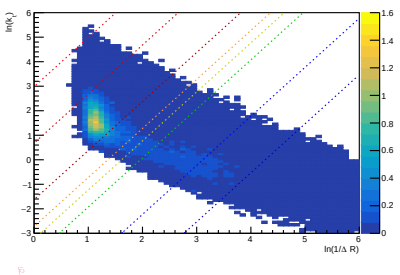


Lund Planes SD - First Splitting Subleading

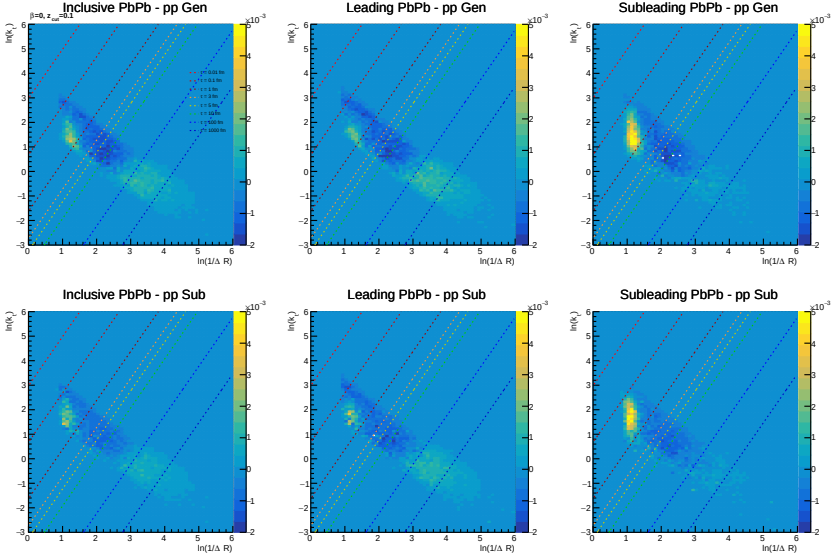








Lund Planes SD - First Splitting difference



Lund Planes SD - First Splitting Ratio