Background Subtraction and Jet Quenching on Jet Reconstruction

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Preliminary: work in progress…

Hard Probes
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Introduction

- Ultra-relativistic heavy-ion collisions:
  - Hard probes to characterize the medium produced:
    - Spectra of high-momentum particles
    - Jets:

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      - High jet momentum imbalance in dijet events (asymmetry increases with centrality)
      - Azimuthal distribution has minor changes with respect to pp
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Generation of medium-modified jet events and a realistic background

Reconstruction of jets and subtraction of background as close as possible as the experimental analysis

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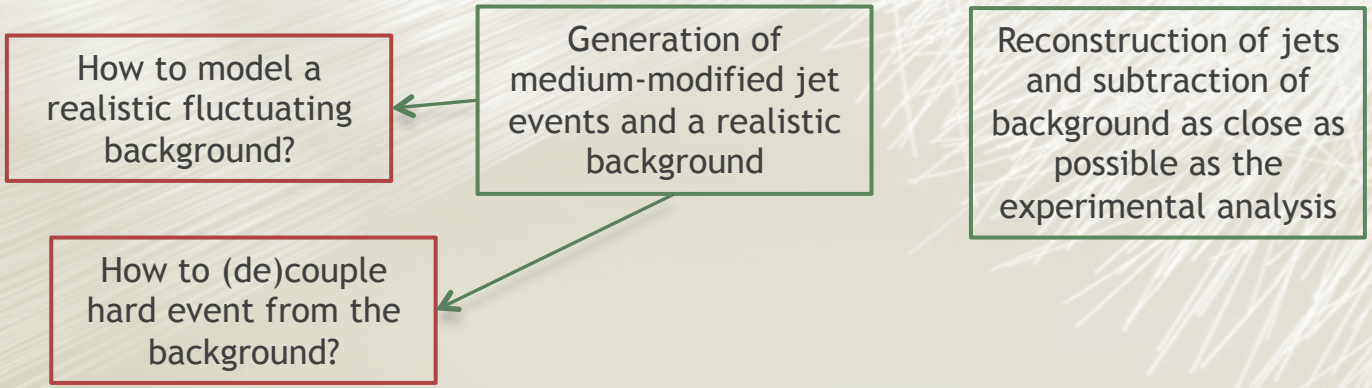

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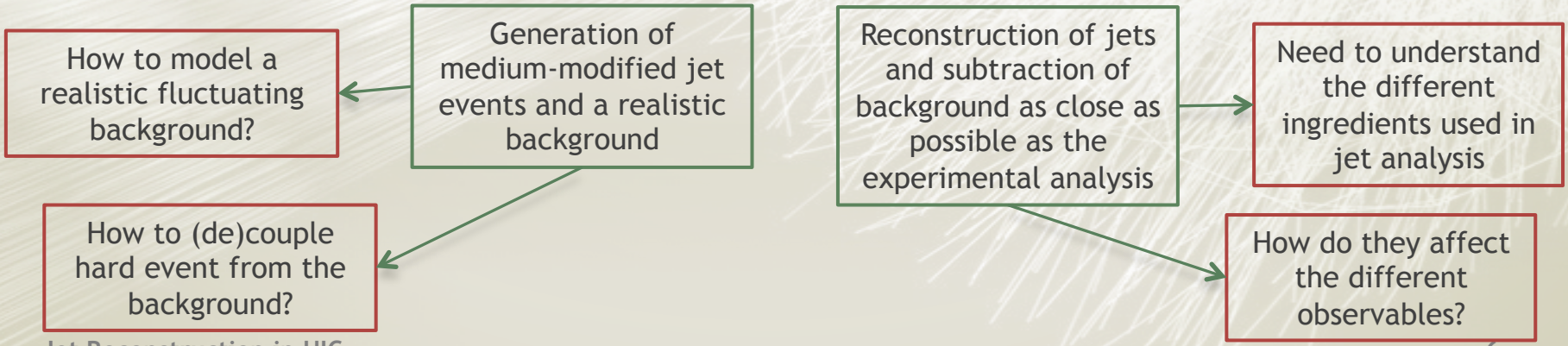

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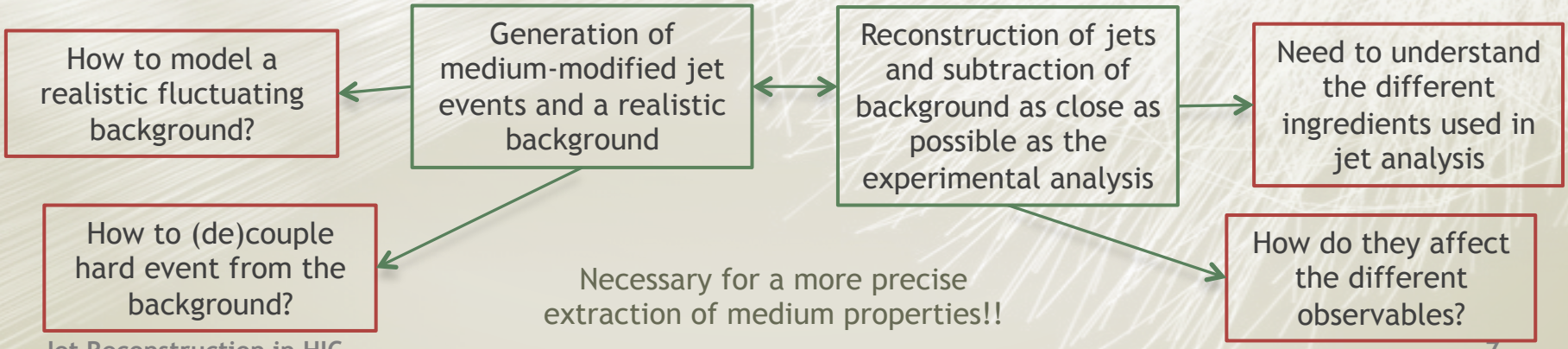

Necessary for a more precise extraction of medium properties!!

Our Analysis

- Main Goal:
  - Investigate the effect of background fluctuations and subtraction on several jet observables
  - Assess the degree of quenching of the data

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  - Q-PYTHIA jets embedded in a simulated background:
    - Toy model based on a thermal spectrum $f(p_T) = \begin{cases} e^{-p_T/T} & p_T \leq \alpha T \\ e^{-\alpha}\left(\frac{\alpha T}{p_T}\right)^{\alpha} & p_T > \alpha T \end{cases}$
      - Background particle distribution in Φ modeled by $\frac{dN}{d\phi} \propto 1 + \sum_n 2v_n \cos(n\phi)$

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Compared with PSM with same σ for FastJet (Similar Results)

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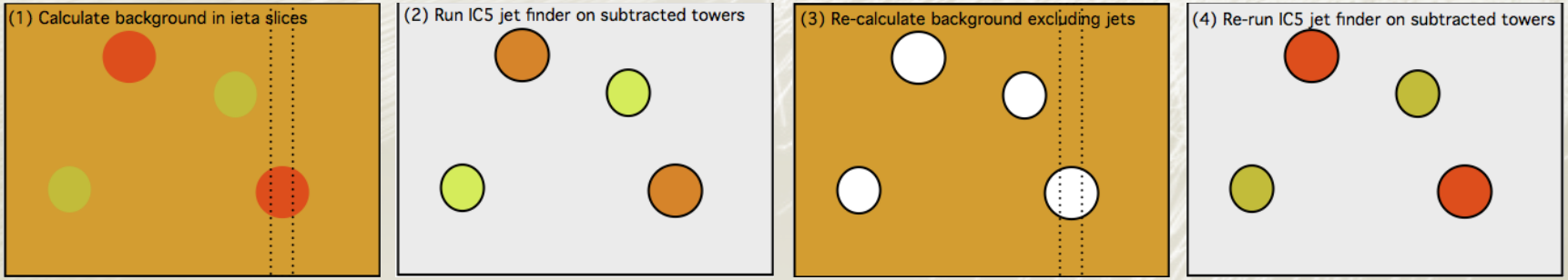
      - Background particle distribution in Φ modeled by $\frac{dN}{d\phi} \propto 1 + \sum_n 2v_n \cos(n\phi)$
  - Jet reconstruction algorithm
    - Anti-kt with R = 0.3
  - Jet background subtraction
    - ATLAS-like (FastJet): kt with R = 0.4
    - CMS-like: variant of “noise/pedestal subtraction” technique

Compared with PSM with same σ for FastJet (Similar Results)

Related works:
Cacciari et al 1010.1759
Casalderrey et al. 1012.0745
Qin at al. 1012.5280
He et al. 1105.2566
Young et al. 1103.5769
Lokhtin et al. 1103.1853
Renk 1202.4579

CMS-like Method

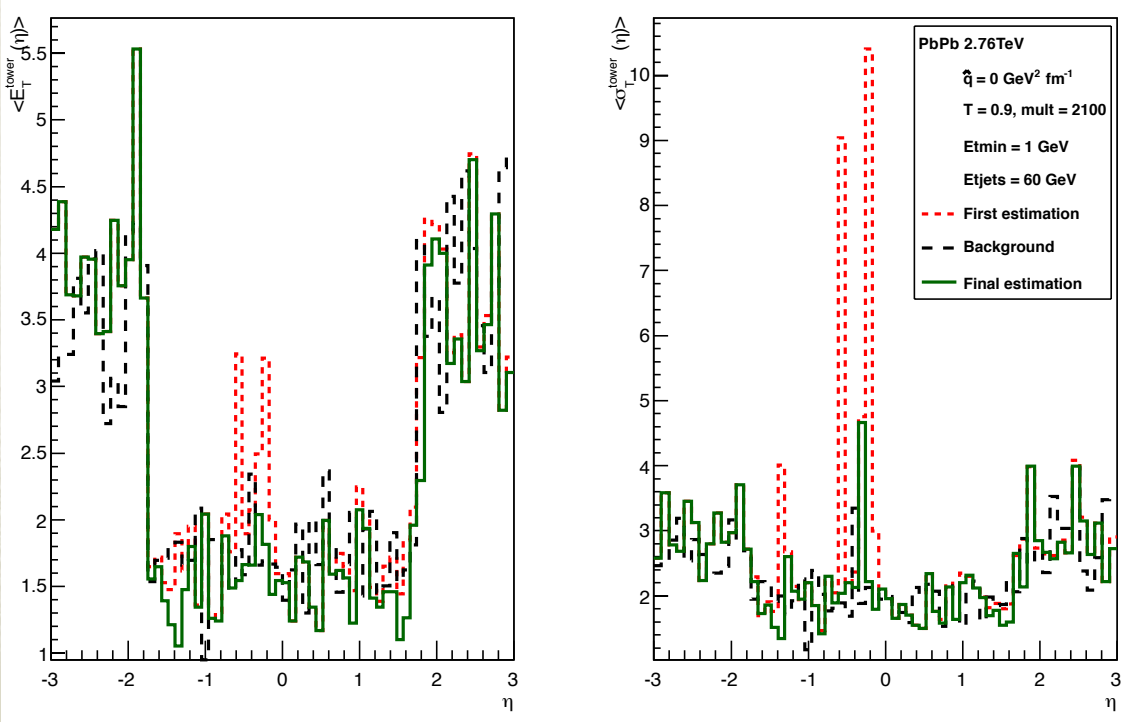
- CMS-like subtraction method (Kodolova et al EPJC50 (07) 117):
  - Background estimation:
    - Variant of an iterative “noise/pedestal subtraction” technique:
      - 1.1) Background estimation in each stripe ($<E_T^{tower}(\eta)>$, σ_T^{tower})
      - 1.2) Correct each cell by: $E_T^{tower*} = E_T^{tower} - <E_T^{tower}(\eta)> - \sigma_T^{tower}$
      - 2.1) Jet finding algorithm over the activated towers
      - 3.1) Background estimation excluding jets from the previous list with $E_T > E_{Tjets}$
      - 3.2) Correct each cell with the new values
      - 4.1) Re-run of jet finding algorithm



[B. Wyslouch]

CMS-like Method

- CMS-like subtraction method (background with $E_T < E_{Tjets}$)
  - Background estimation:
    - CMS tune: E_{Tjets} = 15 GeV in step 3.1)
    - For our background: E_{Tjets} goes from 40 to 70 GeV (depends on T)



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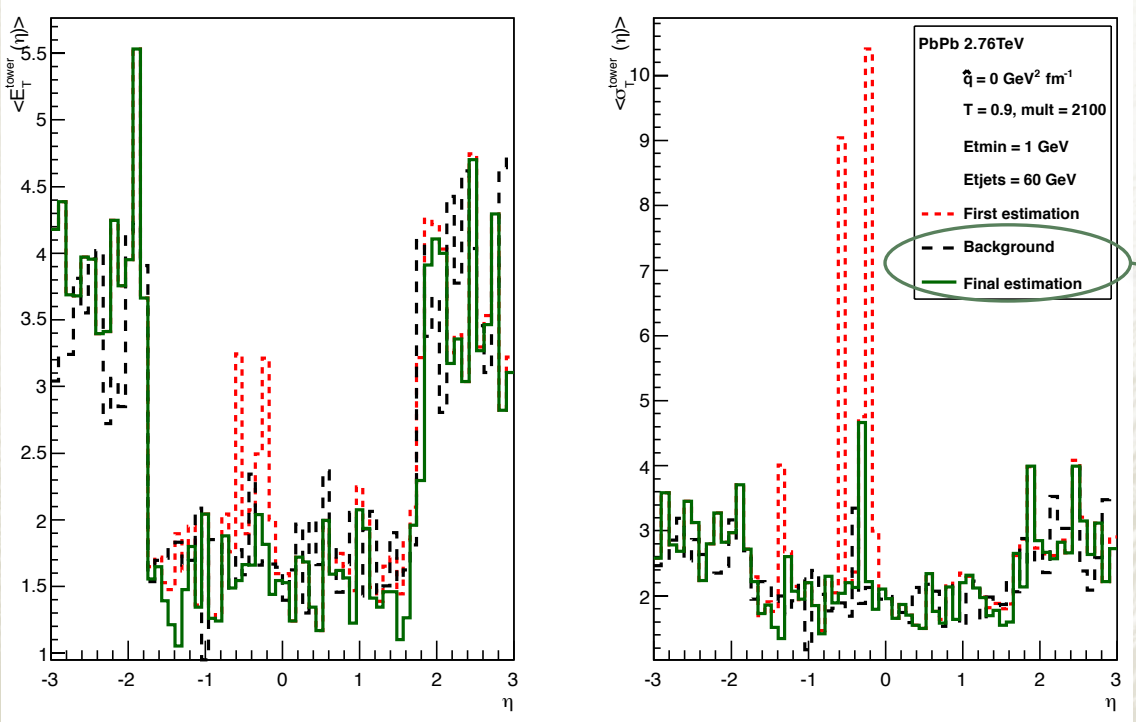


Best E_{TJets} parameter found through the relation:

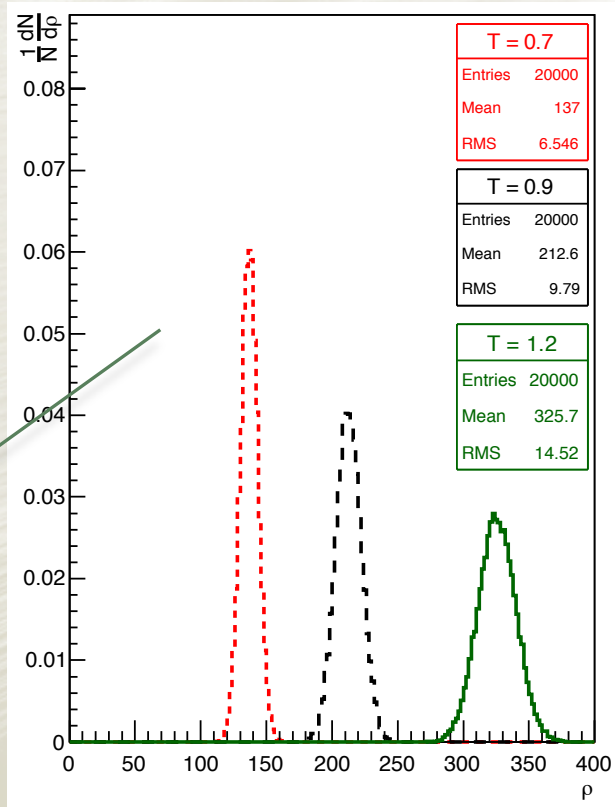
$$\frac{\text{True bkg parameters}}{\text{Final bkg estimation}} \sim 1$$

Toy Model

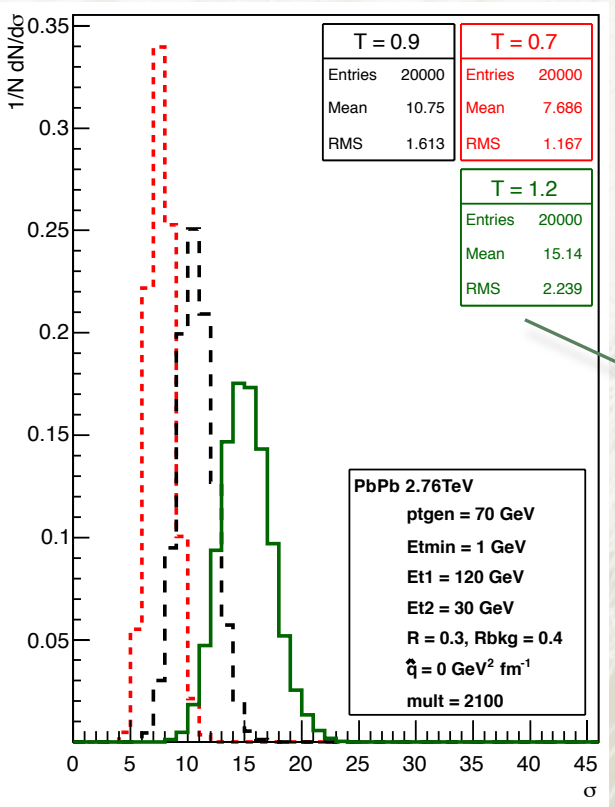
- Values of ρ and σ:
  - Multiplicity fixed to dN/dη~2100

$p_{\mathrm{t}}^{\mathrm{min}}$ (GeV/c)	$\langle\rho\rangle$ (GeV/c)	$\sigma(\rho)$ (GeV/c)
0-10%		
0.15	138.32 ± 0.02	18.51 ± 0.01
1.00	59.30 ± 0.01	9.27 ± 0.01
2.00	12.28 ± 0.01	3.29 ± 0.01

ALICE:1201.2423



Larger than experimental values…



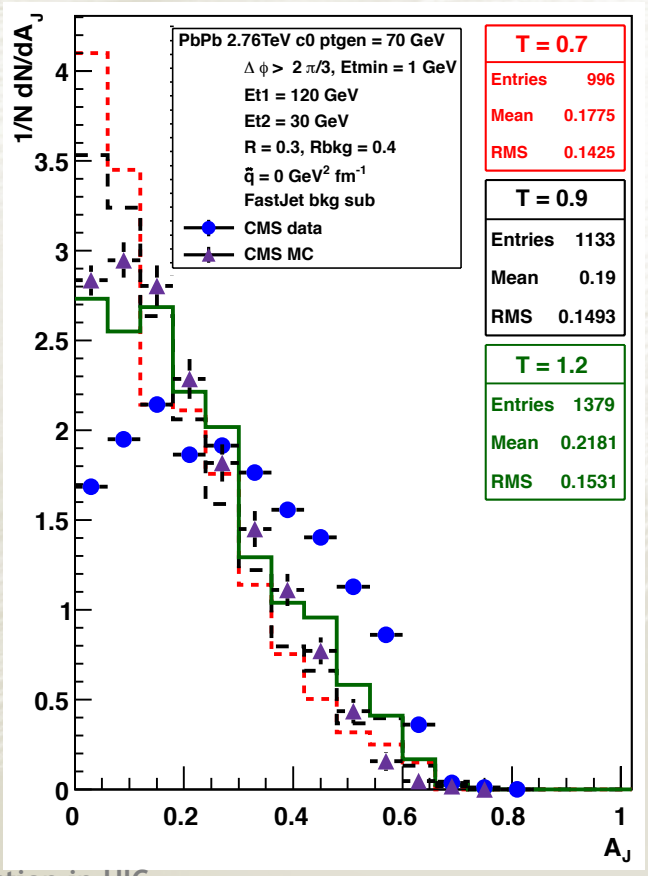
Reasonable values of σ (T = 0.9 can reproduce σ from ALICE corrected for neutral particles)

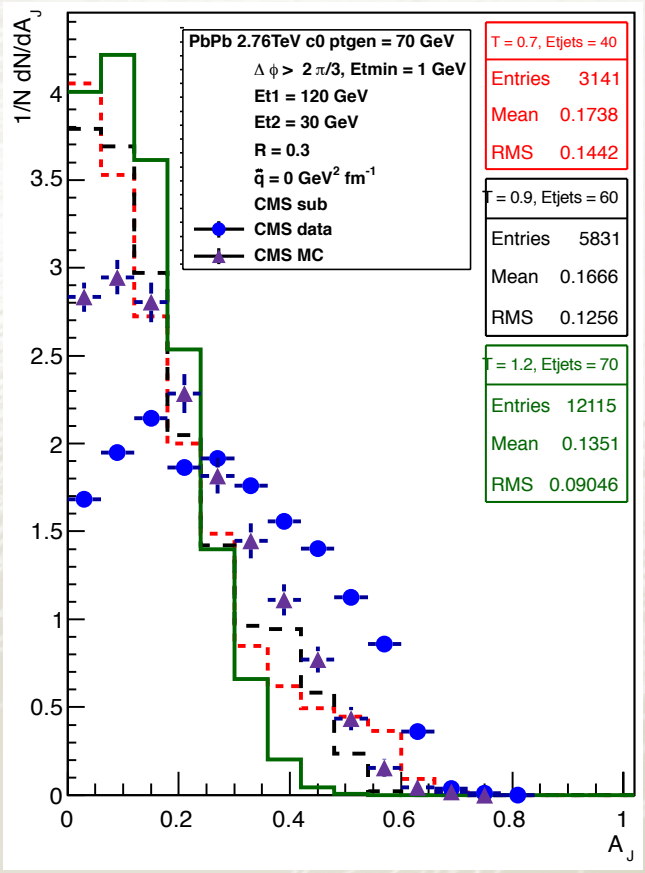
Jet Reconstruction and Jet Subtraction (without quenching)

Comparison of the background subtraction methods (ATLAS-like and CMS-like)

Fluctuations

- Influence of the fluctuations on A_J:
  - CMS data from 2011 run (arXiv:1102.5022: particle flow method and R = 0.3)





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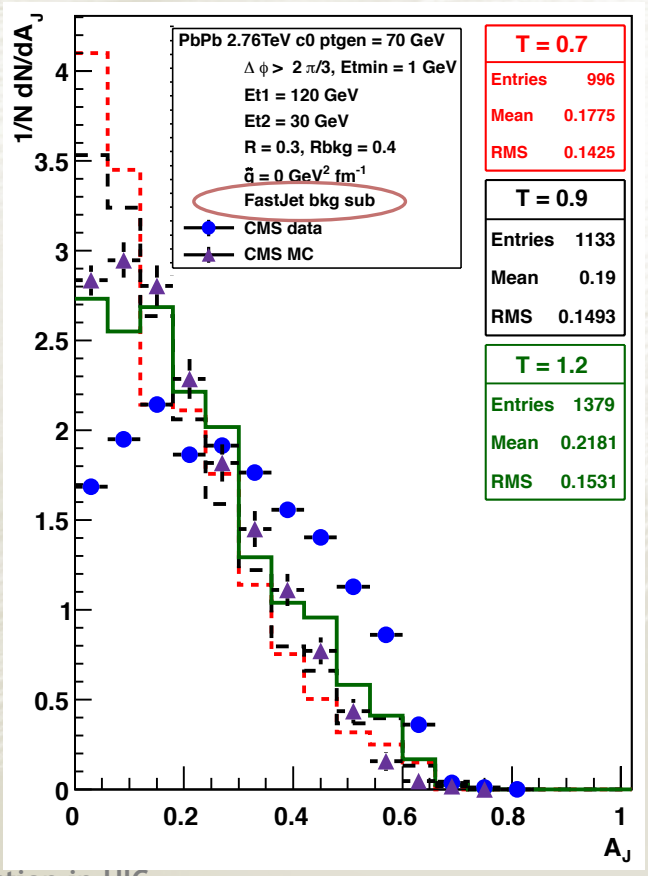
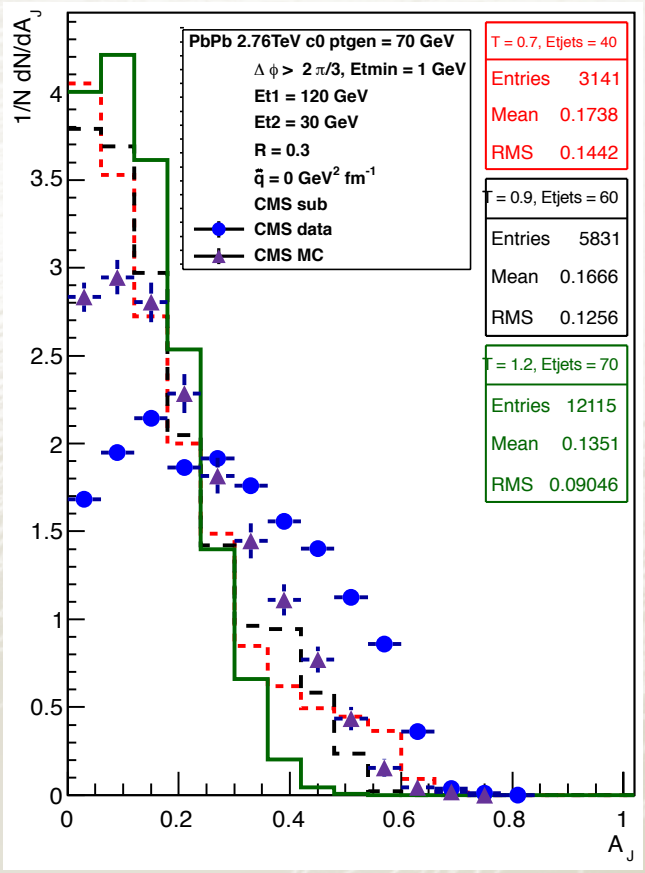
FastJet subtraction: Fluctuations goes in the same direction than data but no "realistic" fluctuations can account for the large asymmetry





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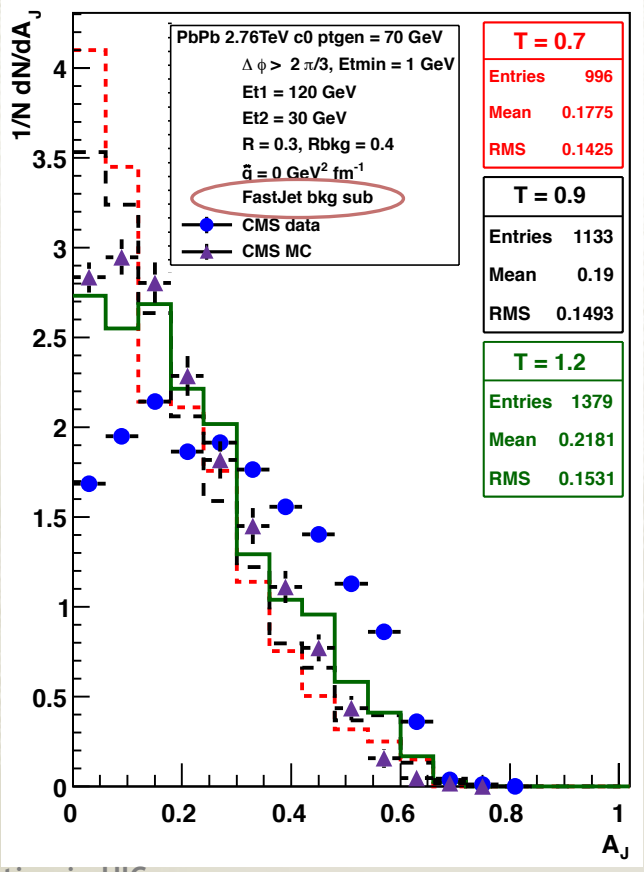
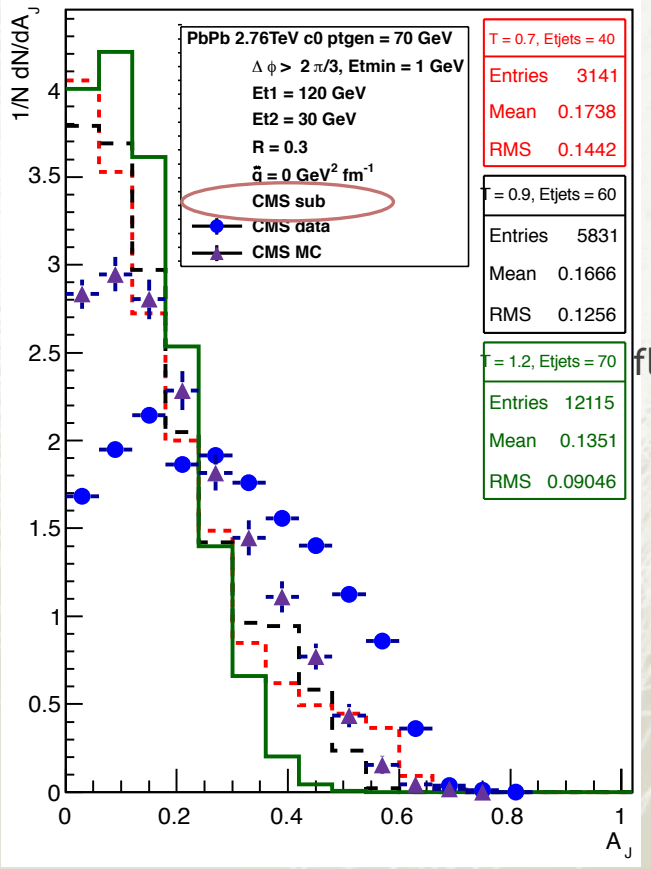
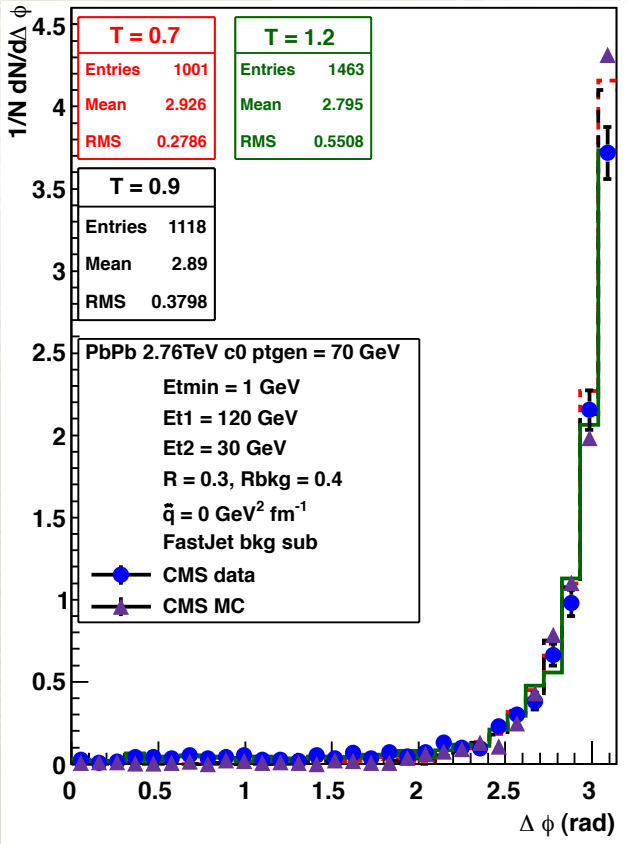


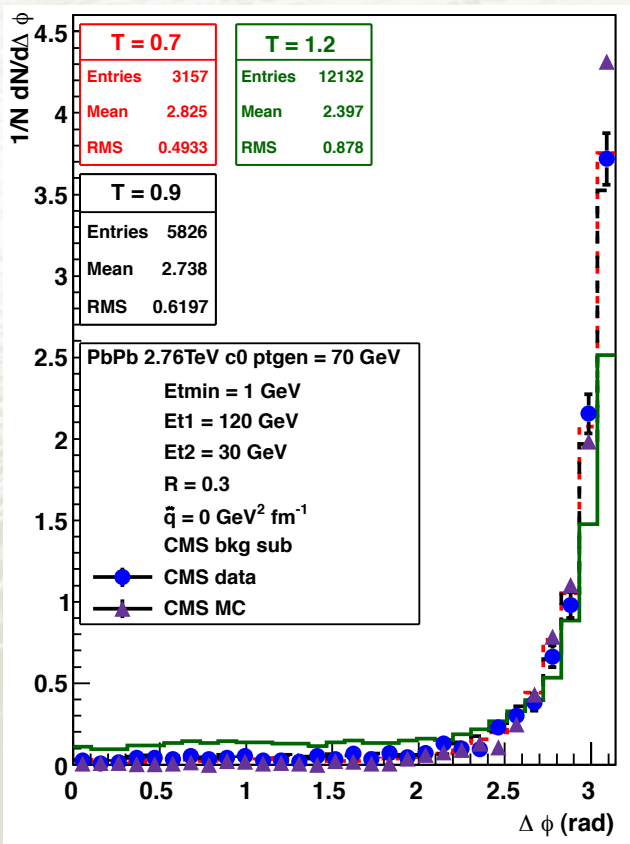


CMS-like subtraction: Smaller dependency with fluctuations up to σ~11 (red and black curve)

Fluctuations

- Influence of the fluctuations on ΔΦ:
  - CMS data from 2010 run (arXiv:1102.1957: no particle flow method and R = 0.5)





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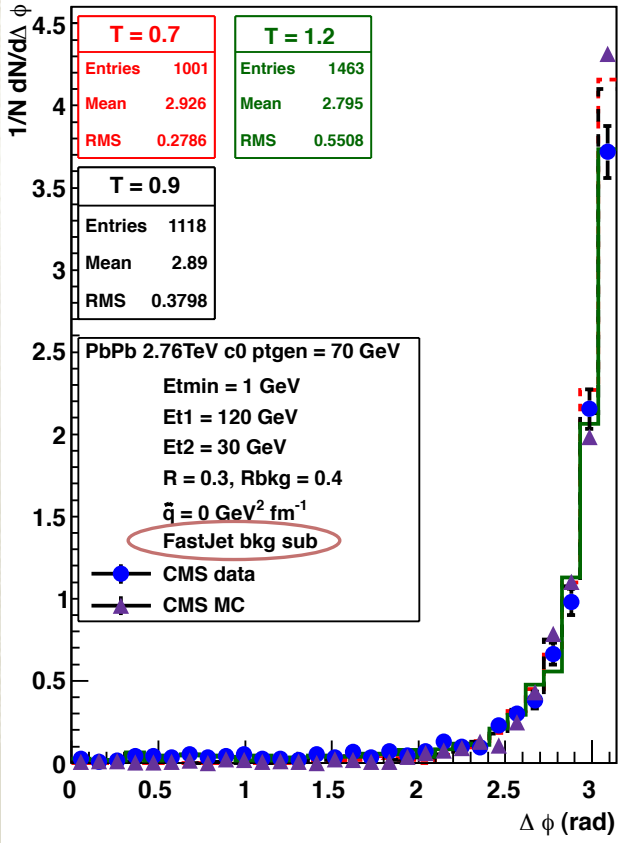
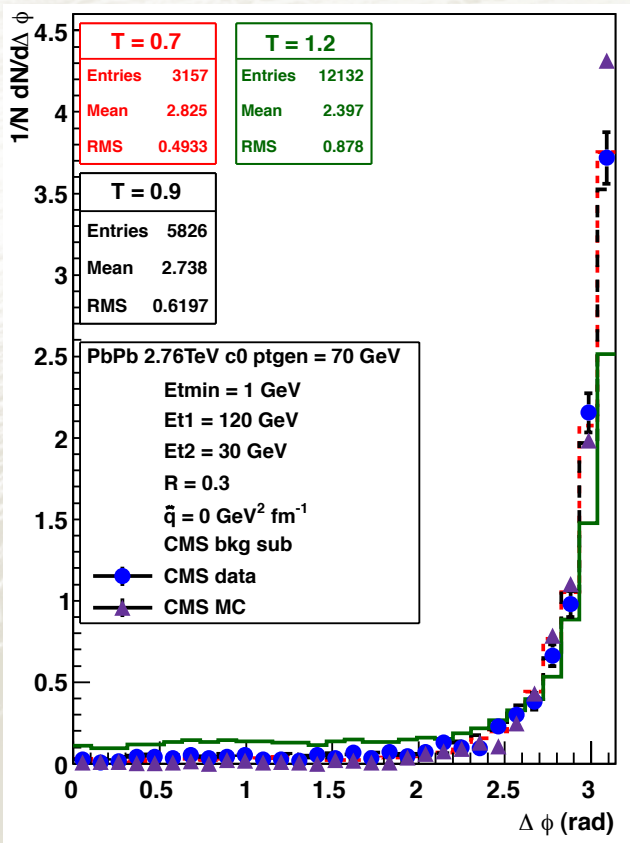
FastJet subtraction does not present significant deviations





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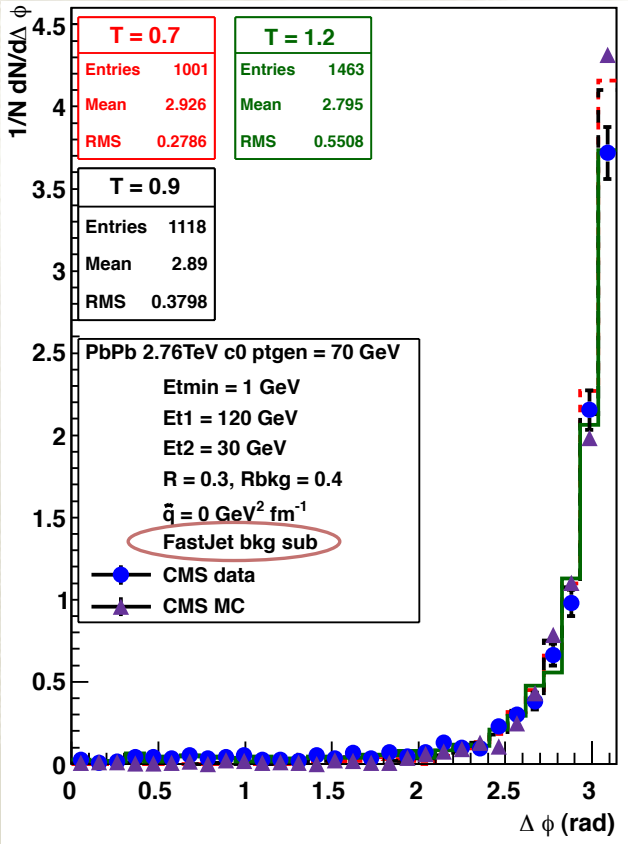
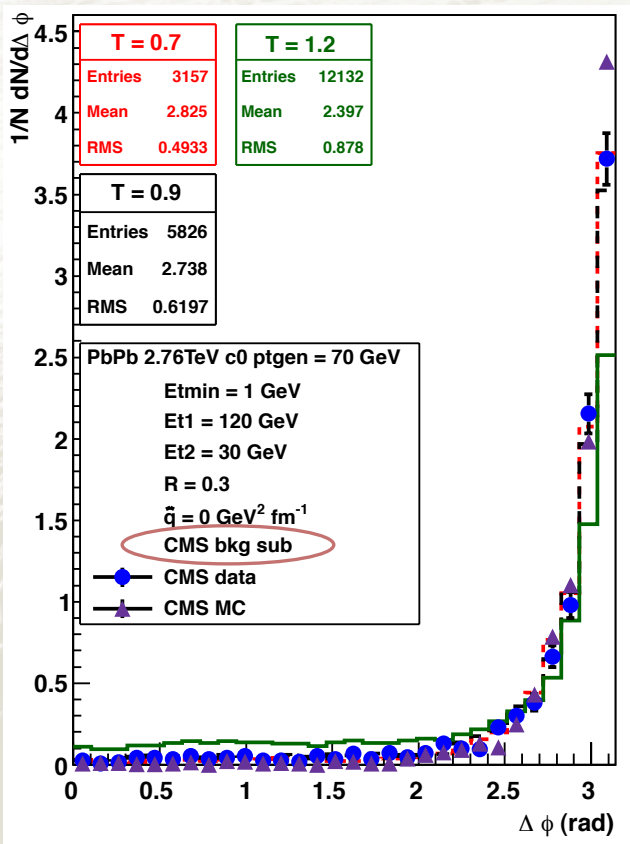
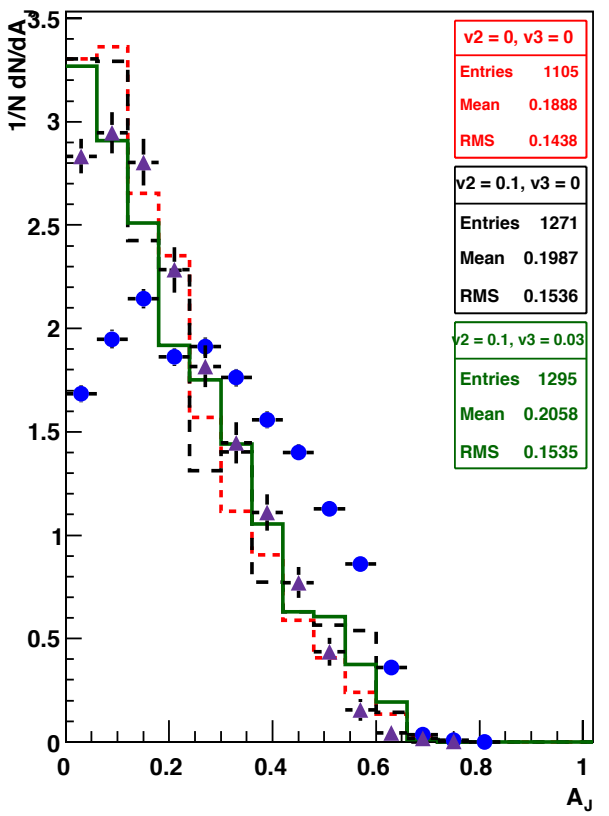


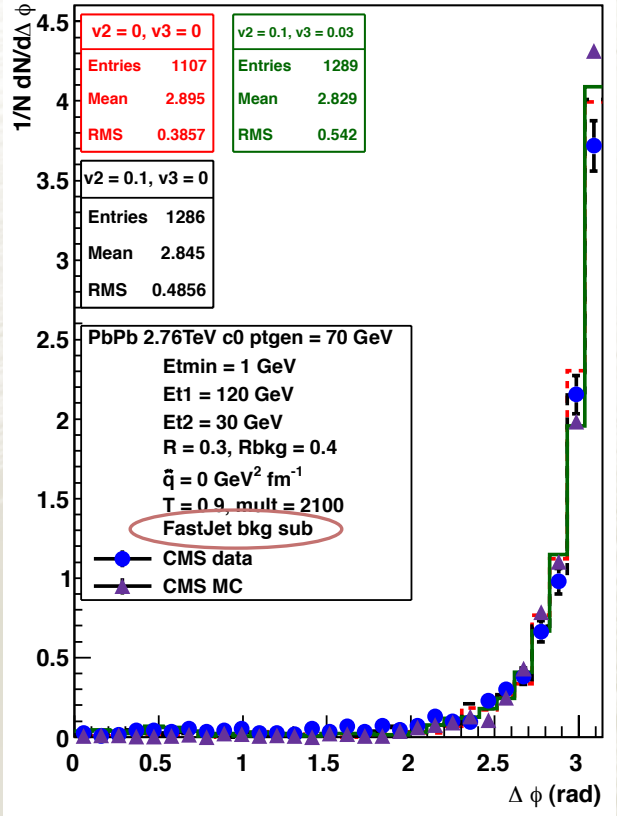


CMS-like method, seems to present a higher deviation for larger fluctuations (for this kind of background)

Flow

- Influence of v_2 and v_3 with the FastJet subtraction method:





No meaningful change with "realistic" values of flow (v_2 up to 0.1 and v_3 up to 0.03) (Start only to present deviations when σ ~ 20 GeV)

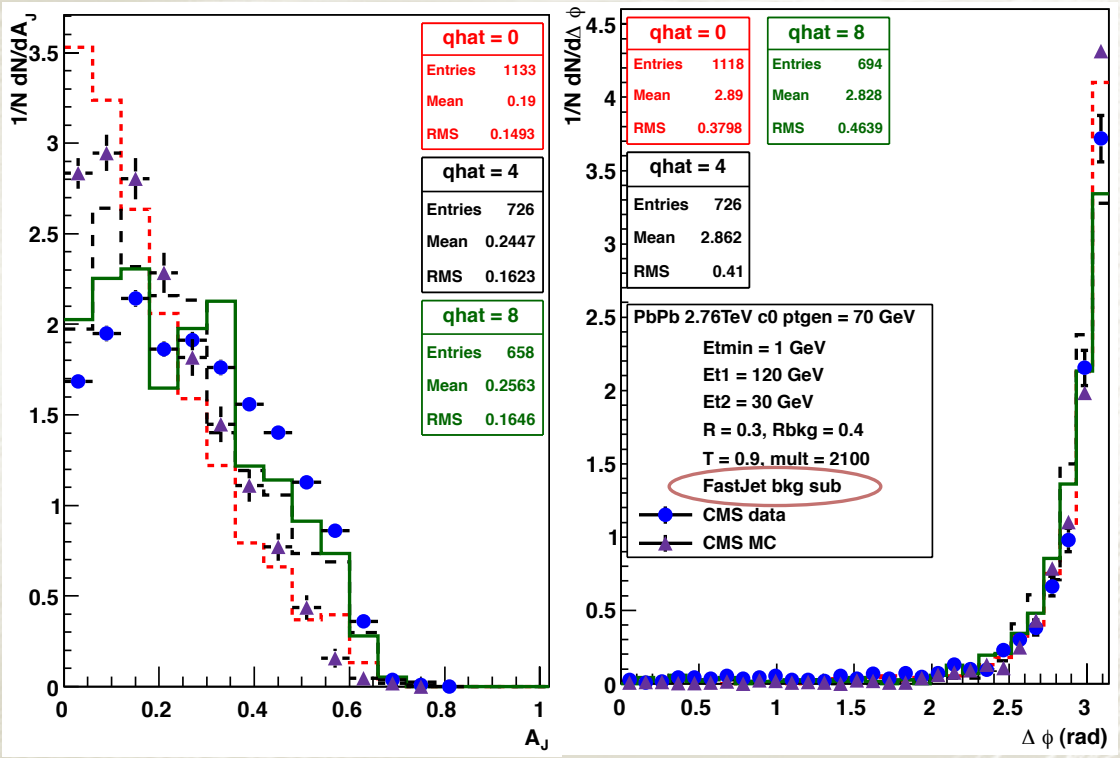
Quenching Effects

Q-PYTHIA MC = PYTHIA + BDMPS-like splitting functions into FSR routines

qhat α $T_A T_B$ (PQM)

Asymmetry

- Comparison for the two subtraction techniques:



Q-PYTHIA seems to go in the same direction than data

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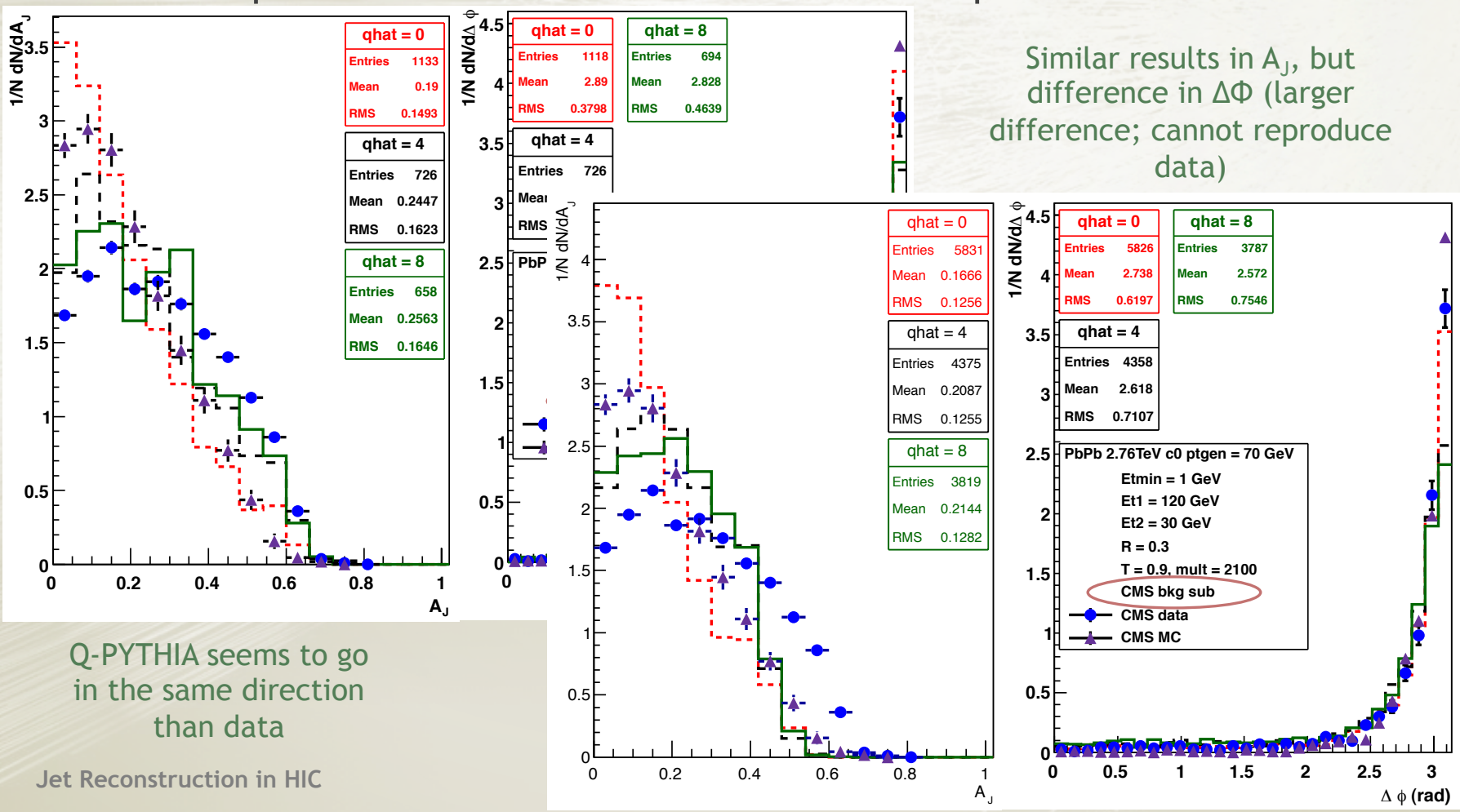


Similar results in A_J, but difference in $\Delta\Phi$ (larger difference; cannot reproduce data)

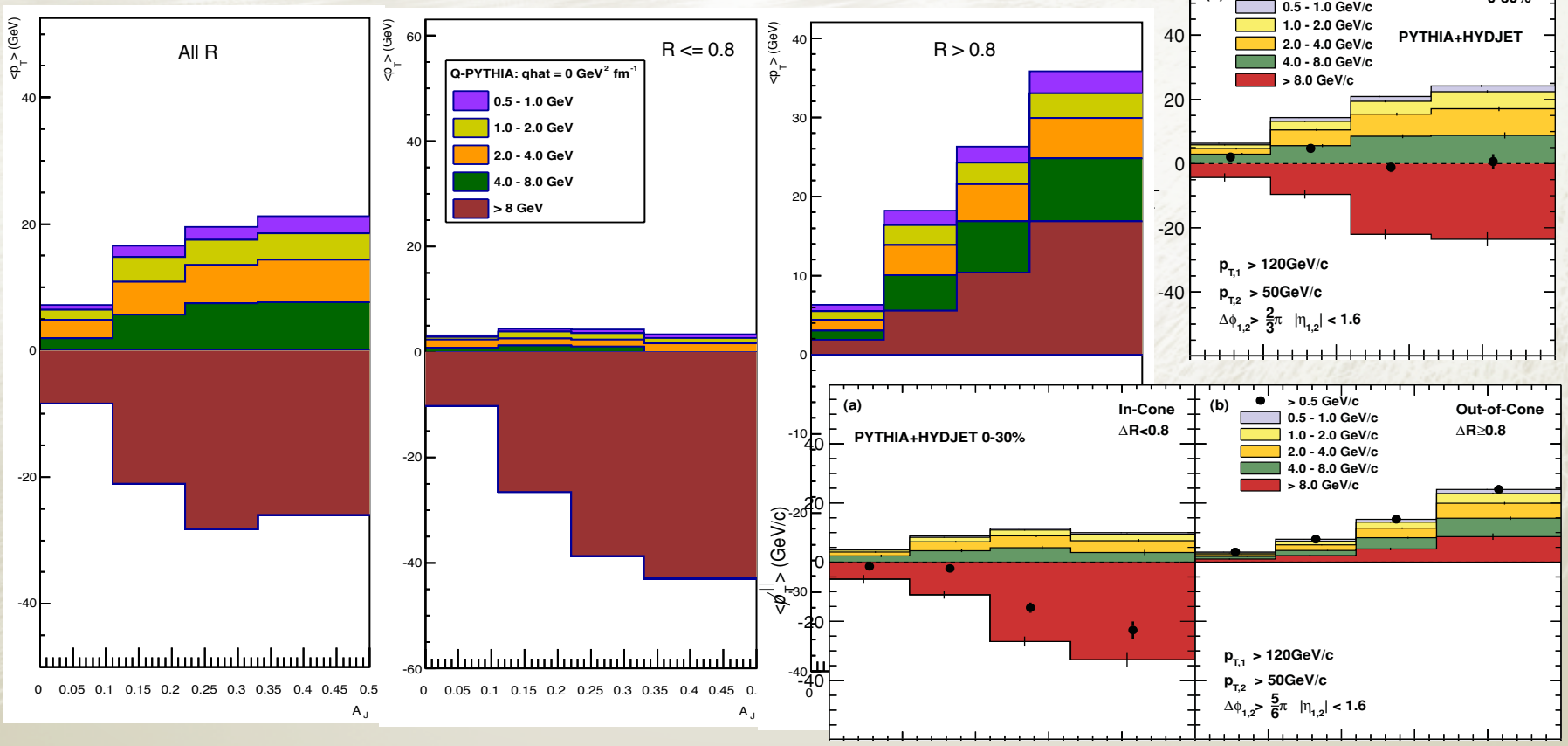
Q-PYTHIA seems to go in the same direction than data

Missing p_T

(Average Missing Transverse Momentum)

- Only Q-PYTHIA simulation (without background)
  - qhat = 0 GeV^2 fm^{-1}

$$\left\langle \not{p}_T^{\parallel} \right\rangle = \sum_i -p_T^i \cos(\phi_i - \phi_{\text{leading jet}})$$



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(Average Missing Transverse Momentum)

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    - In qualitative agreement with CMS simulation

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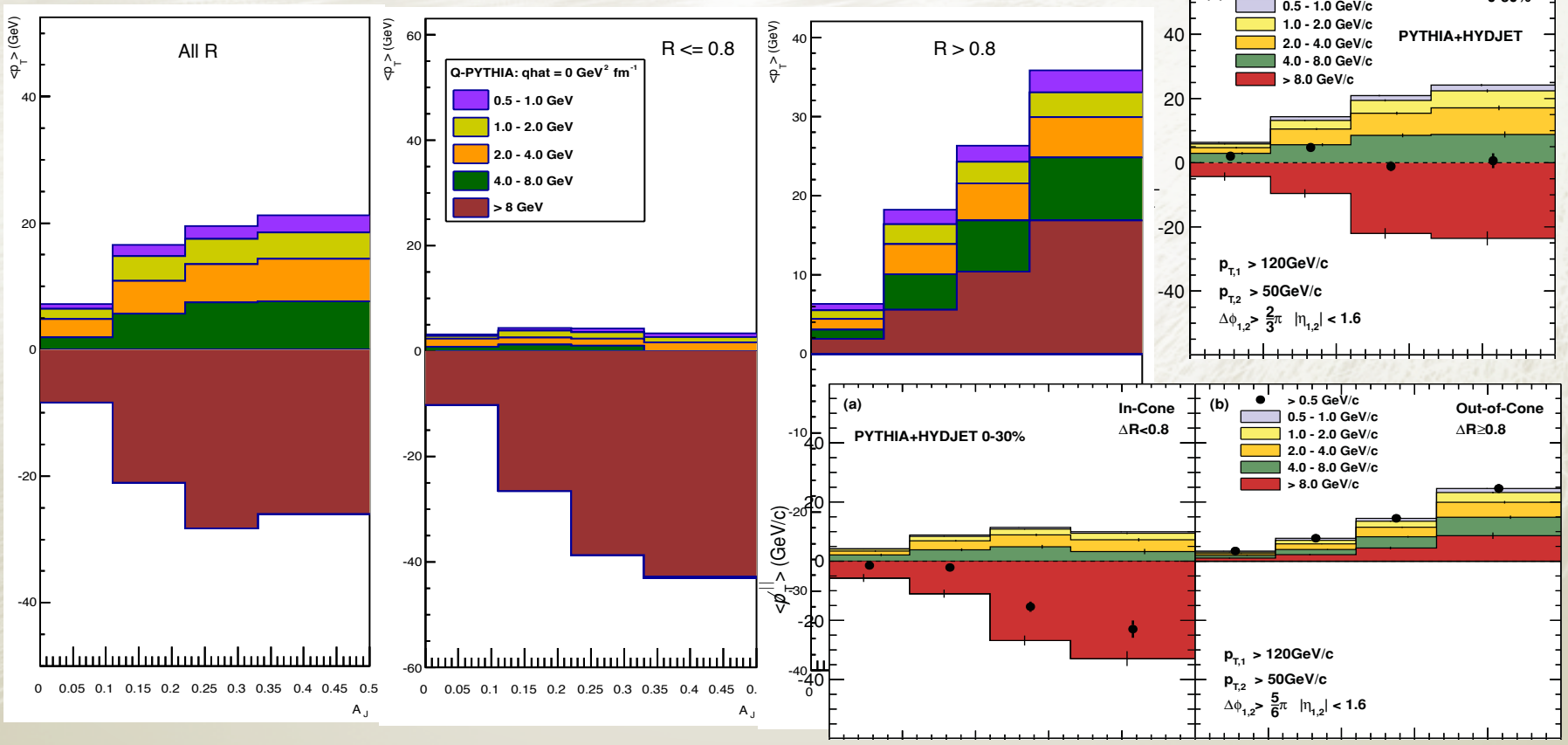
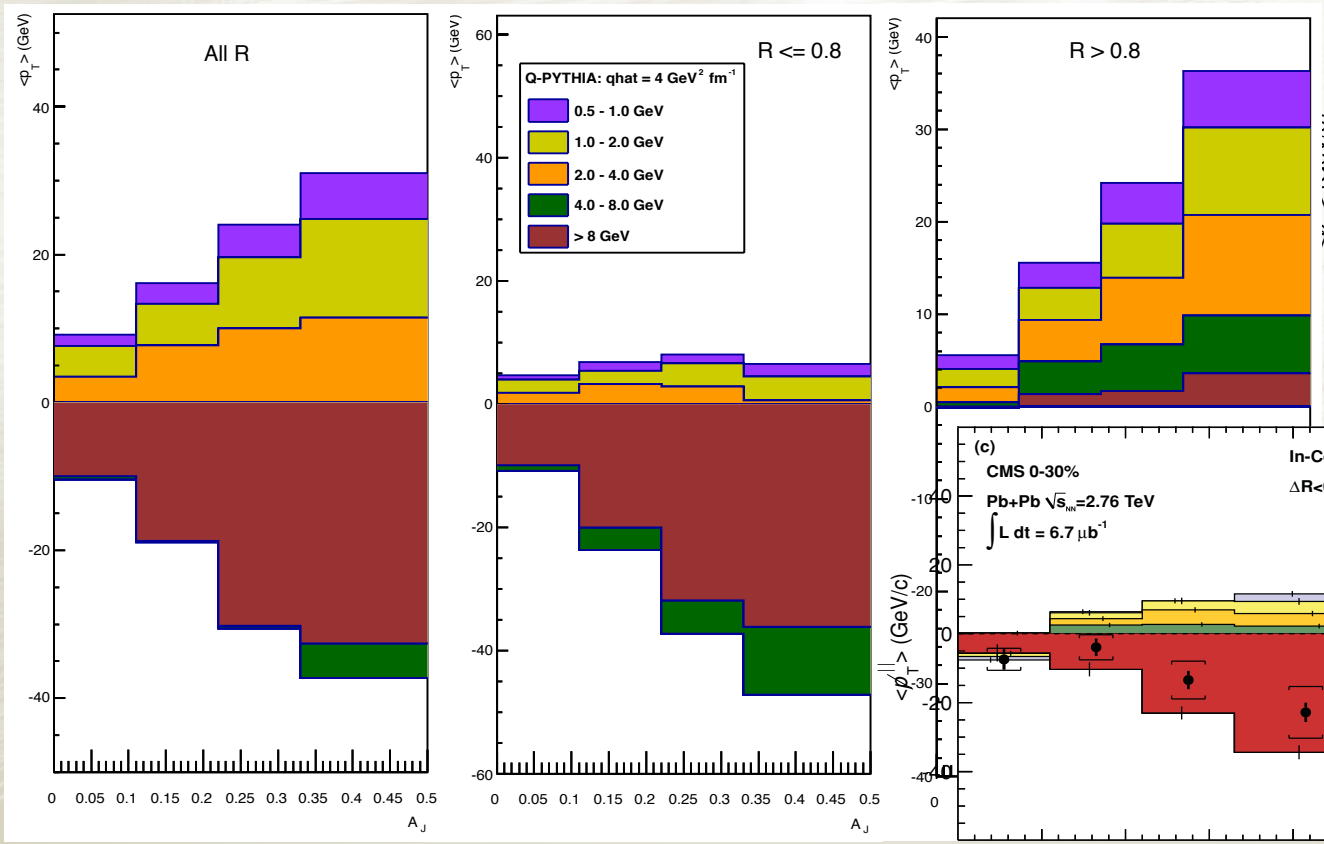


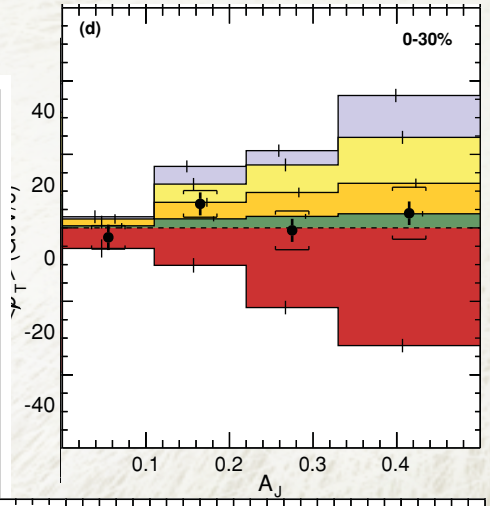
Missing p_T

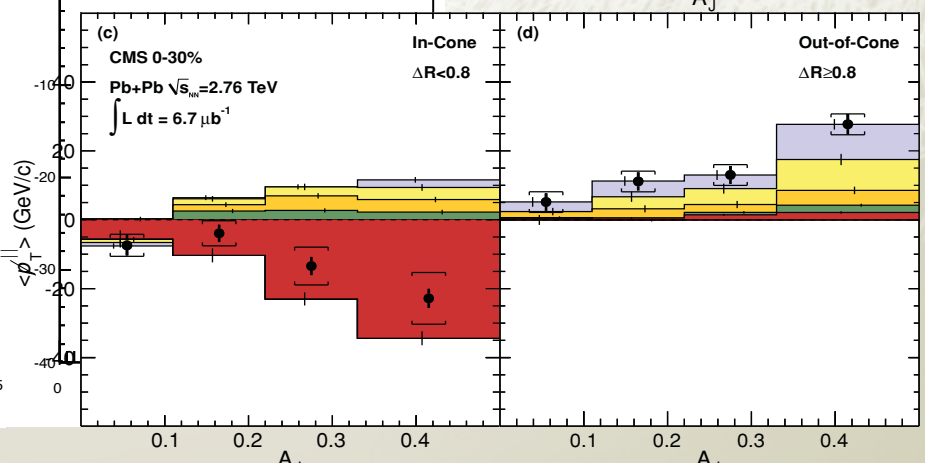
(Average Missing Transverse Momentum)

- Only Q-PYTHIA simulation (without background)
  - qhat = 4 GeV^2 fm^{-1}

$$\left\langle \not{p}_T^{\parallel} \right\rangle = \sum_i -p_T^i \cos(\phi_i - \phi_{\text{leading jet}})$$





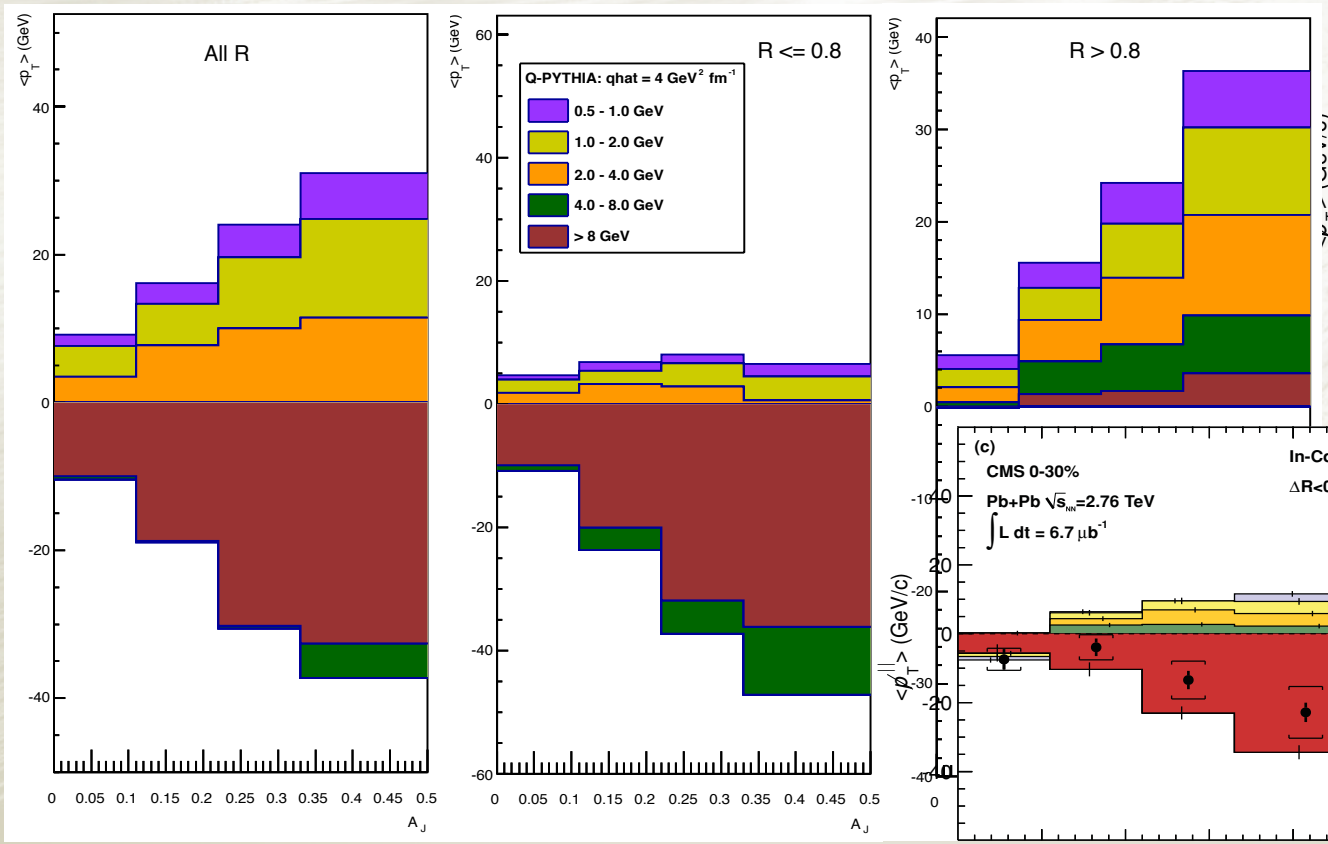


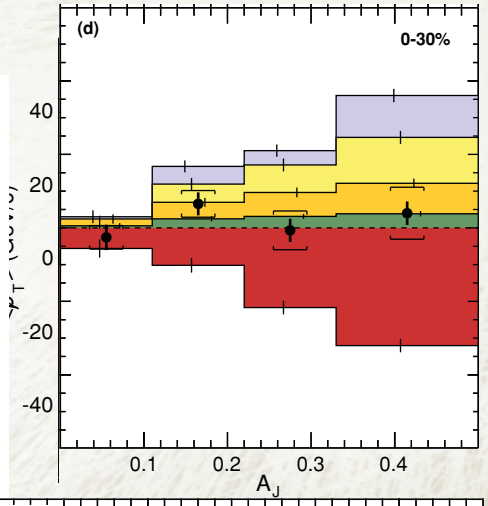
Missing p_T

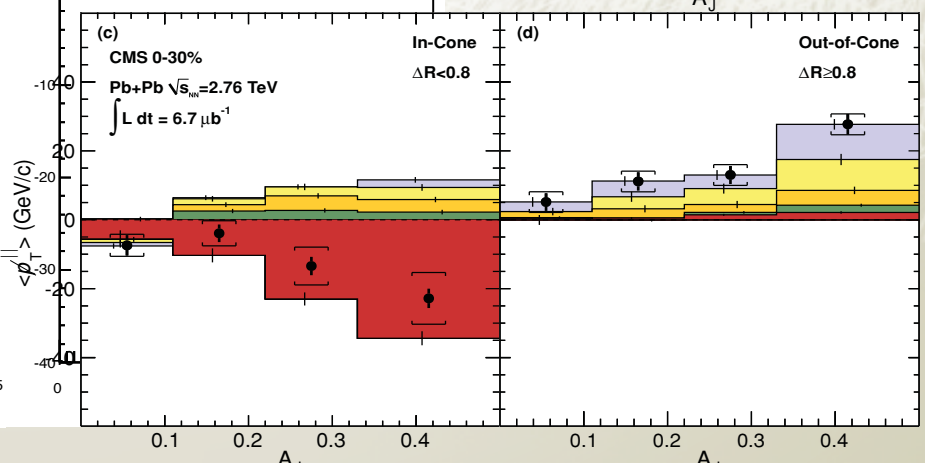
(Average Missing Transverse Momentum)

- Only Q-PYTHIA simulation (without background)
  - qhat = 4 GeV^2 fm^{-1}
    - Qualitatively, goes in the same direction than data!

$$\left\langle \not{p}_T^{\parallel} \right\rangle = \sum_i -p_T^i \cos(\phi_i - \phi_{\text{leading jet}})$$

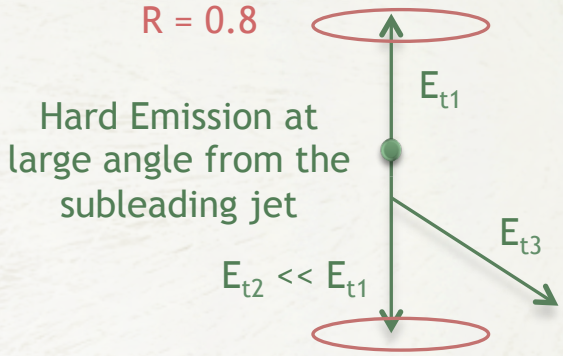






Missing p_T

- Higher difference for larger values of A_J:
  - Already in pp there are events with $A_J > 0.3$:
    - Presence of tracks with $p_T > 8$ GeV outside cone of R = 0.8 in simulation and PYTHIA



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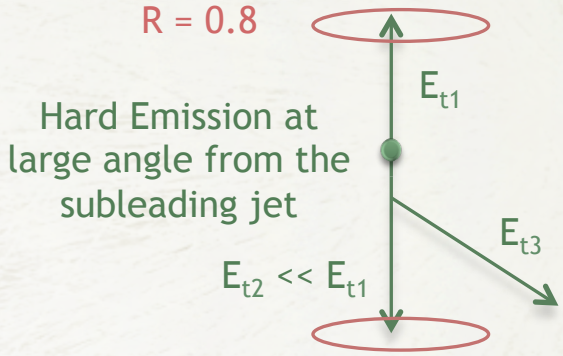
  - In data (PbPb), these tracks disappear, and also in Q-PYTHIA



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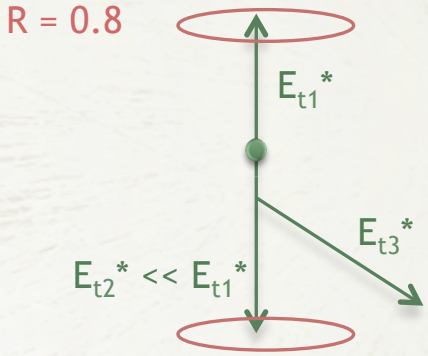

- Higher difference for larger values of A_J:
  - Already in pp there are events with $A_J > 0.3$:
    - Presence of tracks with p_T>8 GeV outside cone of R = 0.8 in simulation and PYTHIA
  - In data (PbPb), these tracks disappear, and also in Q-PYTHIA
    - Same events than before, but the third jet is now quenched (E_t*< E_t)
      - No compelling need of large angle emission mechanisms?

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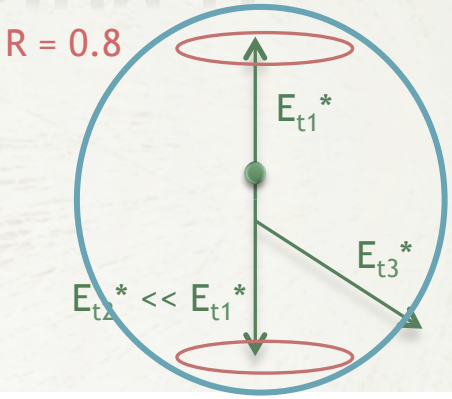

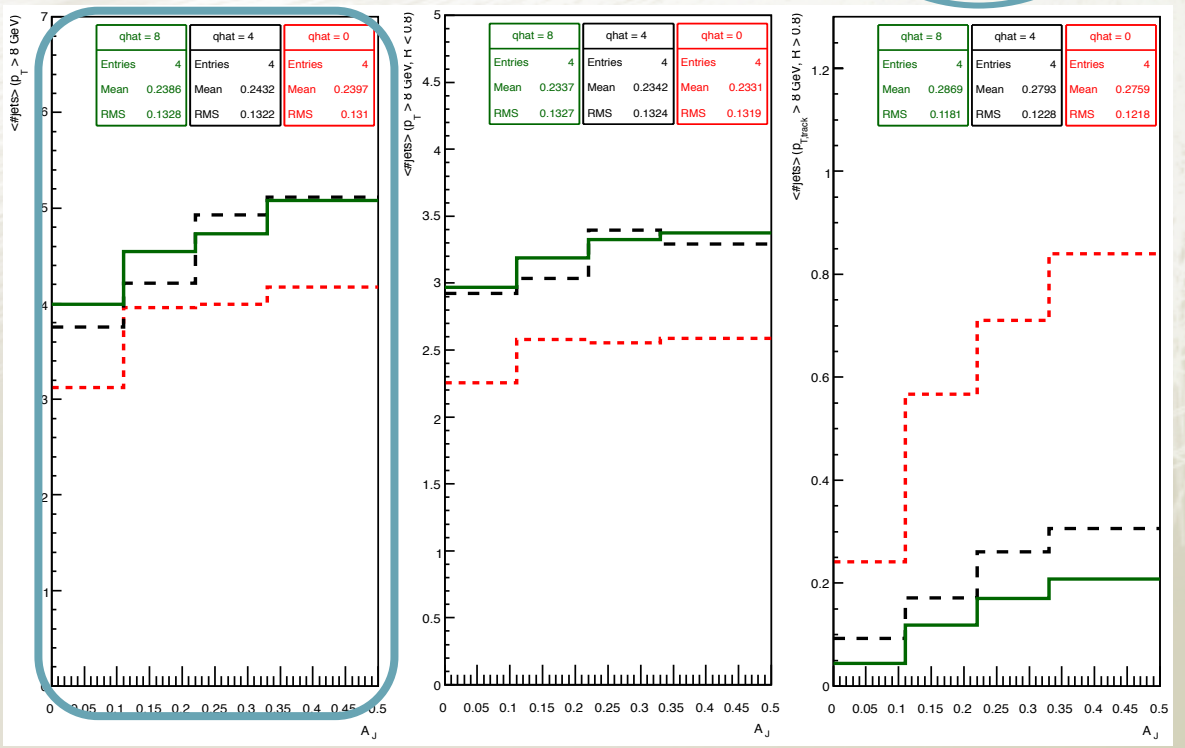

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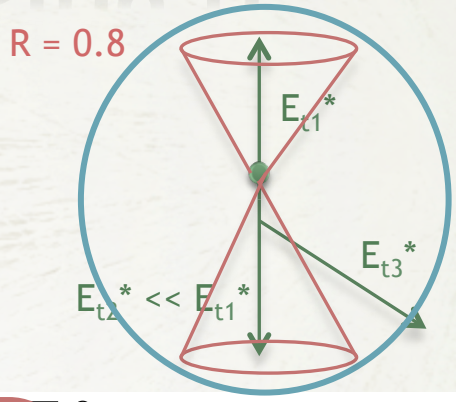

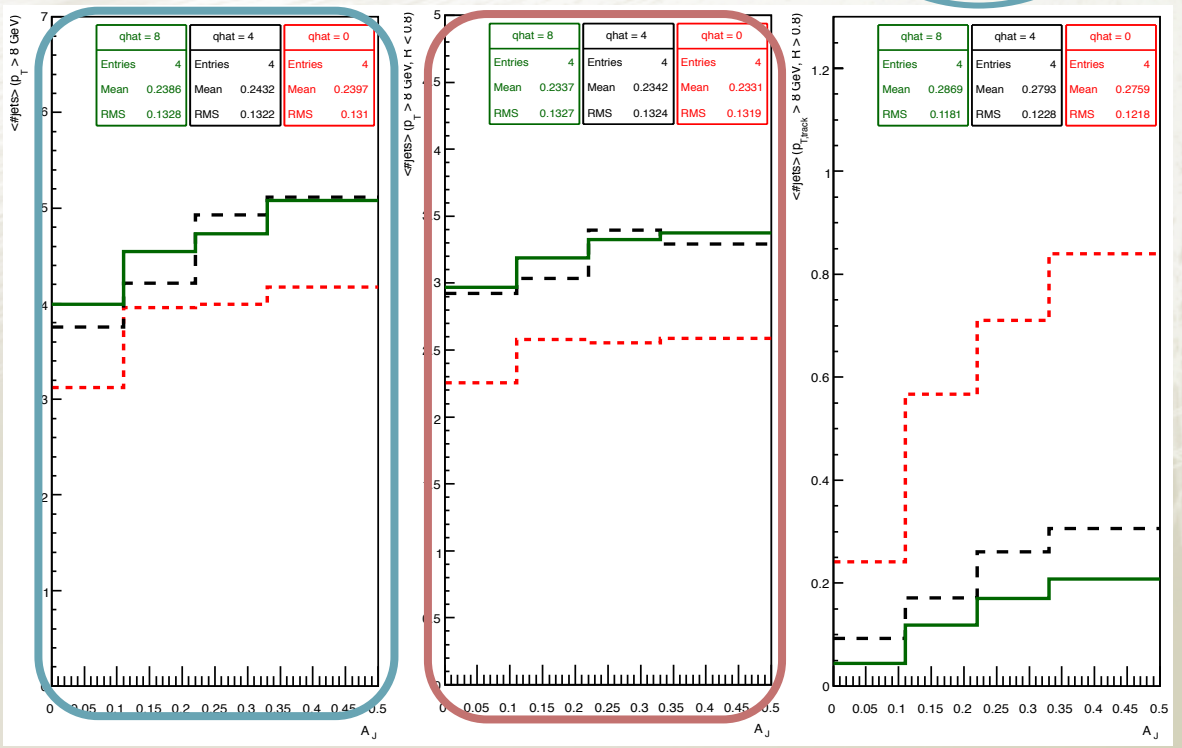

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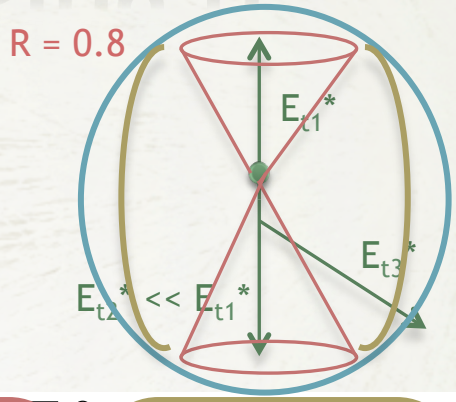

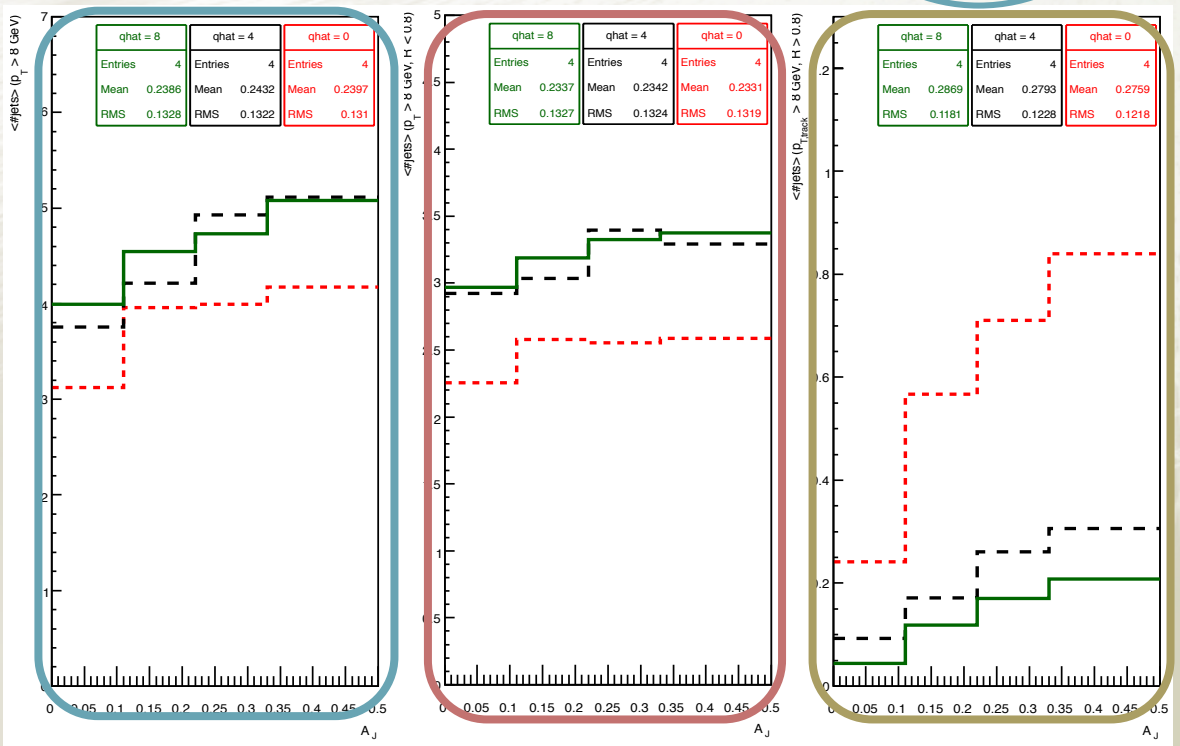

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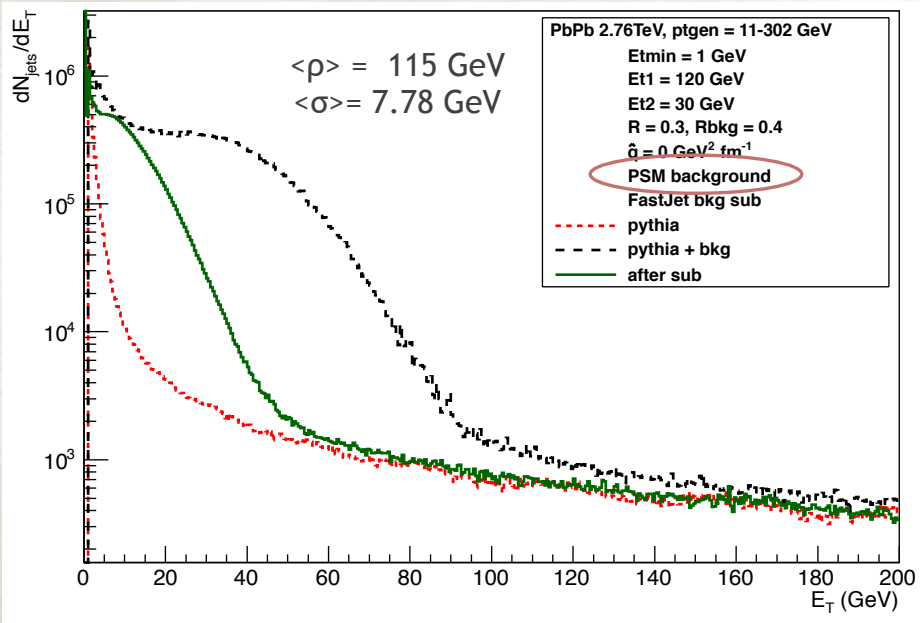
    - To characterize a background, may be needed more than an effective ρ, and σ
- Quenching with Q-PYTHIA model:
  - Goes in the same direction than CMS data for the asymmetry
  - Angular deviation still inside limits (for FastJet subtraction)
  - Goes in the right direction of the presence of the higher amount of soft particles at large angle (missing p_T)

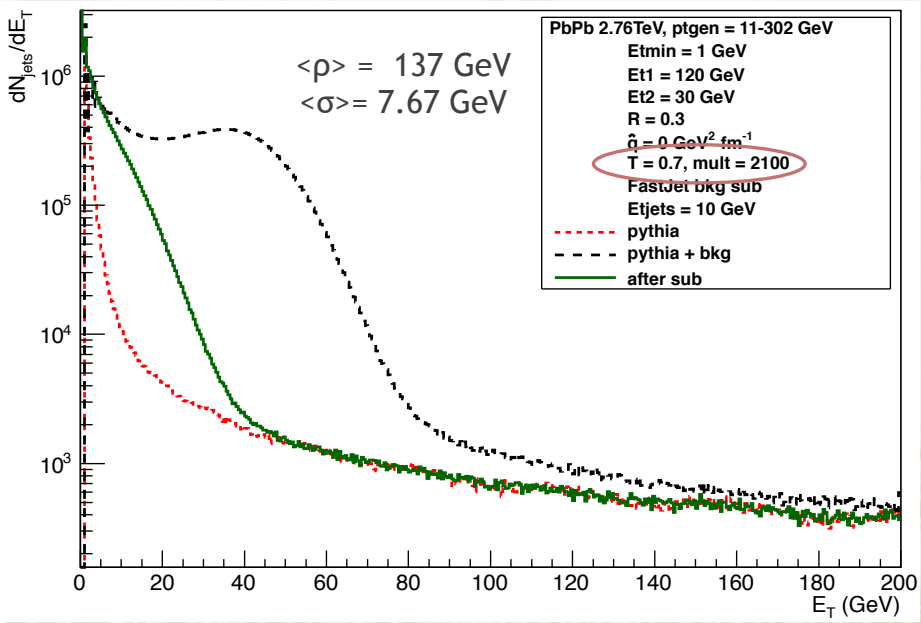
Thank You!

Backup Slides

PSM vs Toy Model

- Comparison of the jet spectrum subtracted:
  - Subtraction method: FastJet (jet areas)





Close results:

Our toy model is a good approximation for jet studies
(pythia spectrum recovered for Etjets > 40 GeV for this background parameters)
Background subtraction method based on jet areas seems to be able to handle quite well changes is the background structure