Jet-based approach for underlying event characterization

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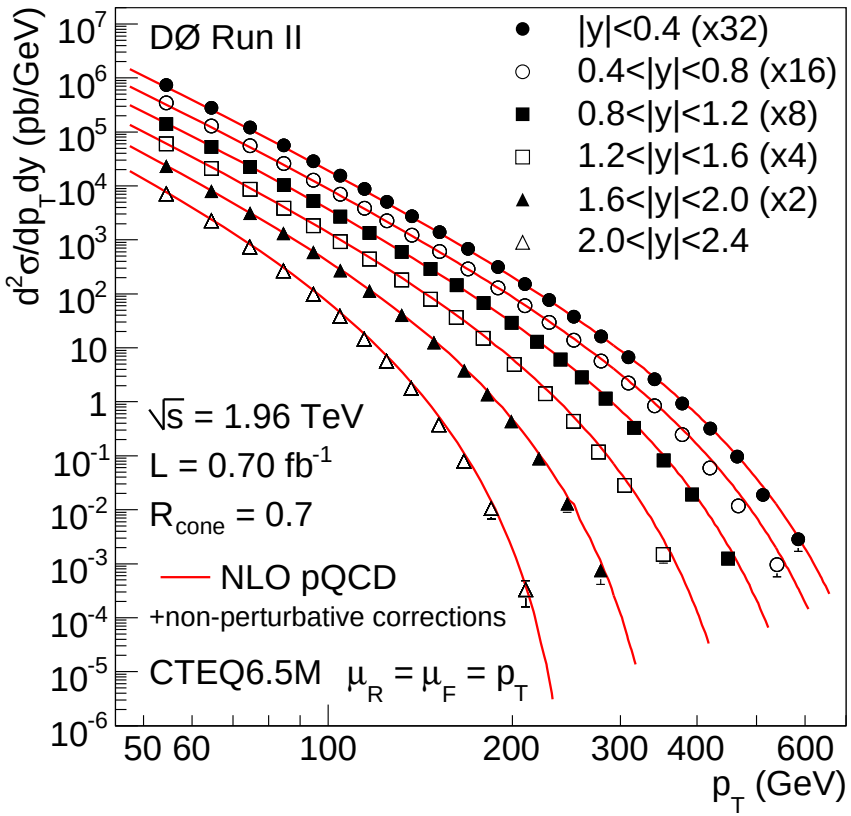
Why information about underlying event may be useful?

- UE modifies up to $\sim$ 50 % of the inclusive jet spectrum



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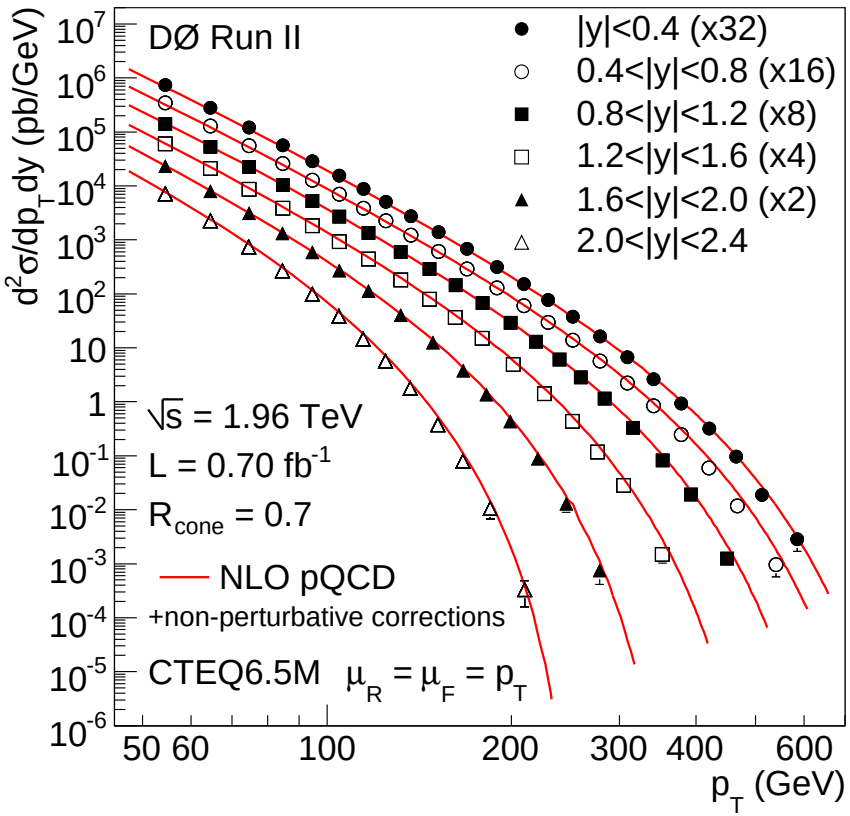

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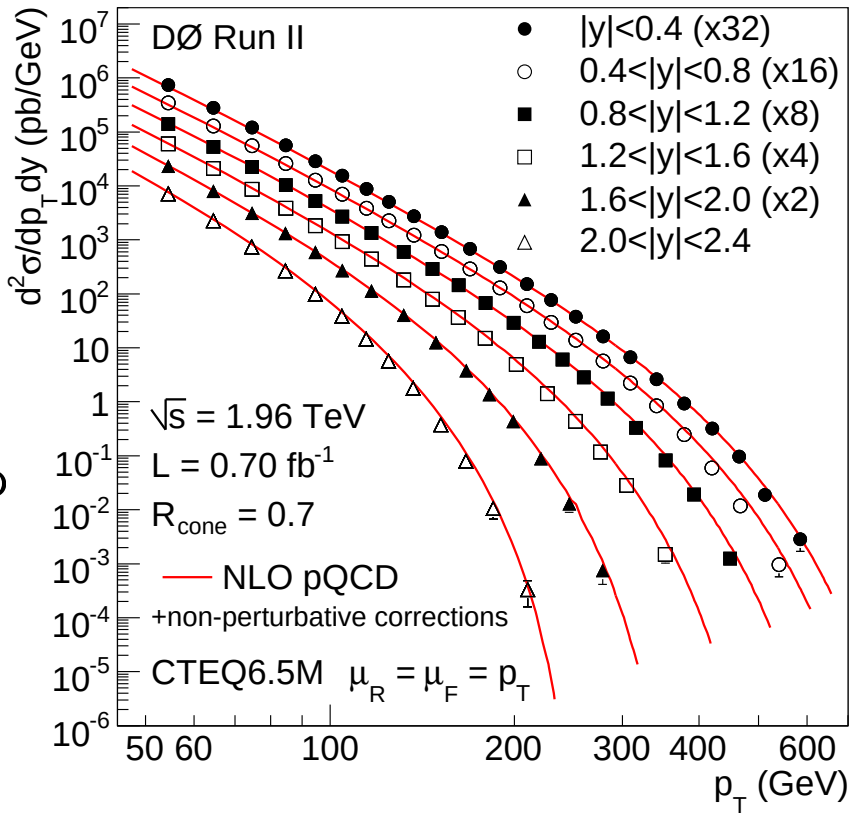

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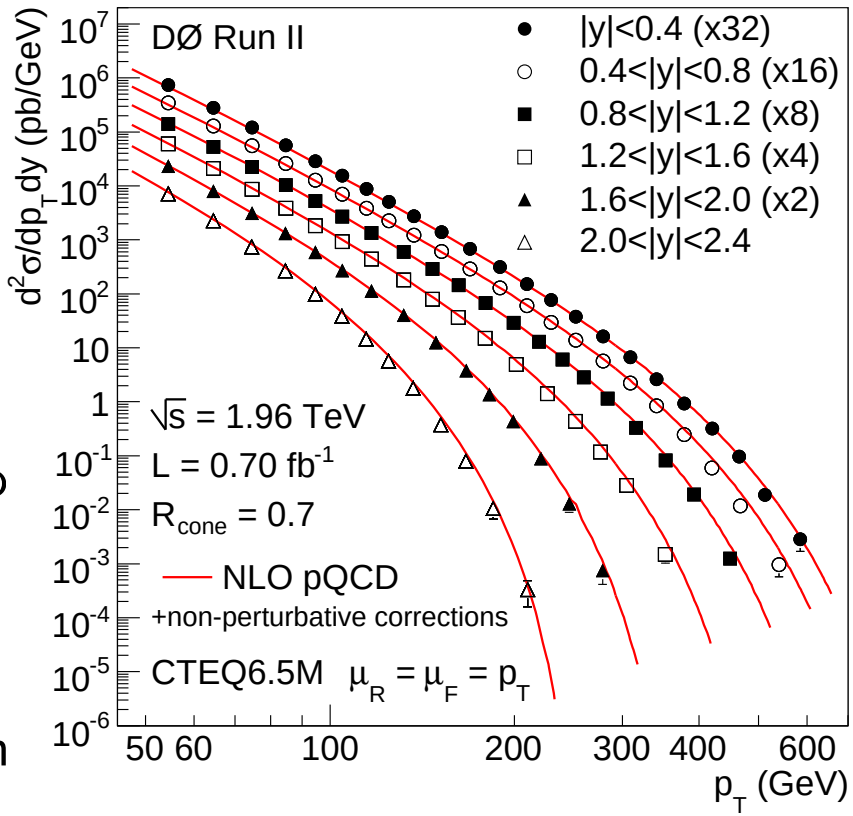

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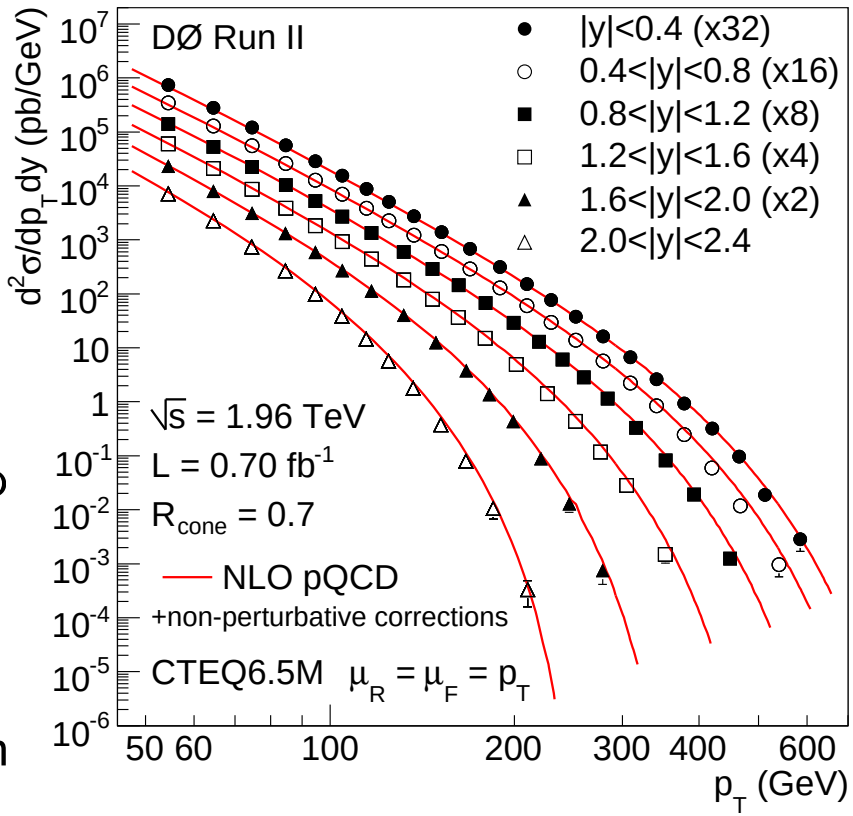

Measuring UE is necessary for tuning MC generators that in turn is required for data analysis. Moreover it is important to further constrain the implemented models of UE.

The relevant characteristics of UE

- level of transverse momentum per unit area (we denote it by ρ)
- rapidity dependence of ρ
- point-to-point fluctuations within a single event
- fluctuations from event to event
- point-to-point correlations

Separation between hard jets and UE – the method

[Cacciari, Salam, Phys. Lett. **B 659** (2008); Cacciari, Salam, Soyez, JHEP **04**(2008)]
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$$\rho = \text{median}\left[\left\{\frac{p_{t,j}}{A_j}\right\}\right]$$

   and its uncertainty σ

   - median gives a typical value of p_t/A for a given event
   - using median is a way to dynamically separate hard and soft parts of the event

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- ρ may be used e.g. to correct hard jet transverse momentum

$$p_{t,j}^{(\mathrm{sub})} = p_{t,j} - \rho \times A_j$$

since jet area measures the jet susceptibility to the soft radiation

Analysis of UE

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An important issue: tension between

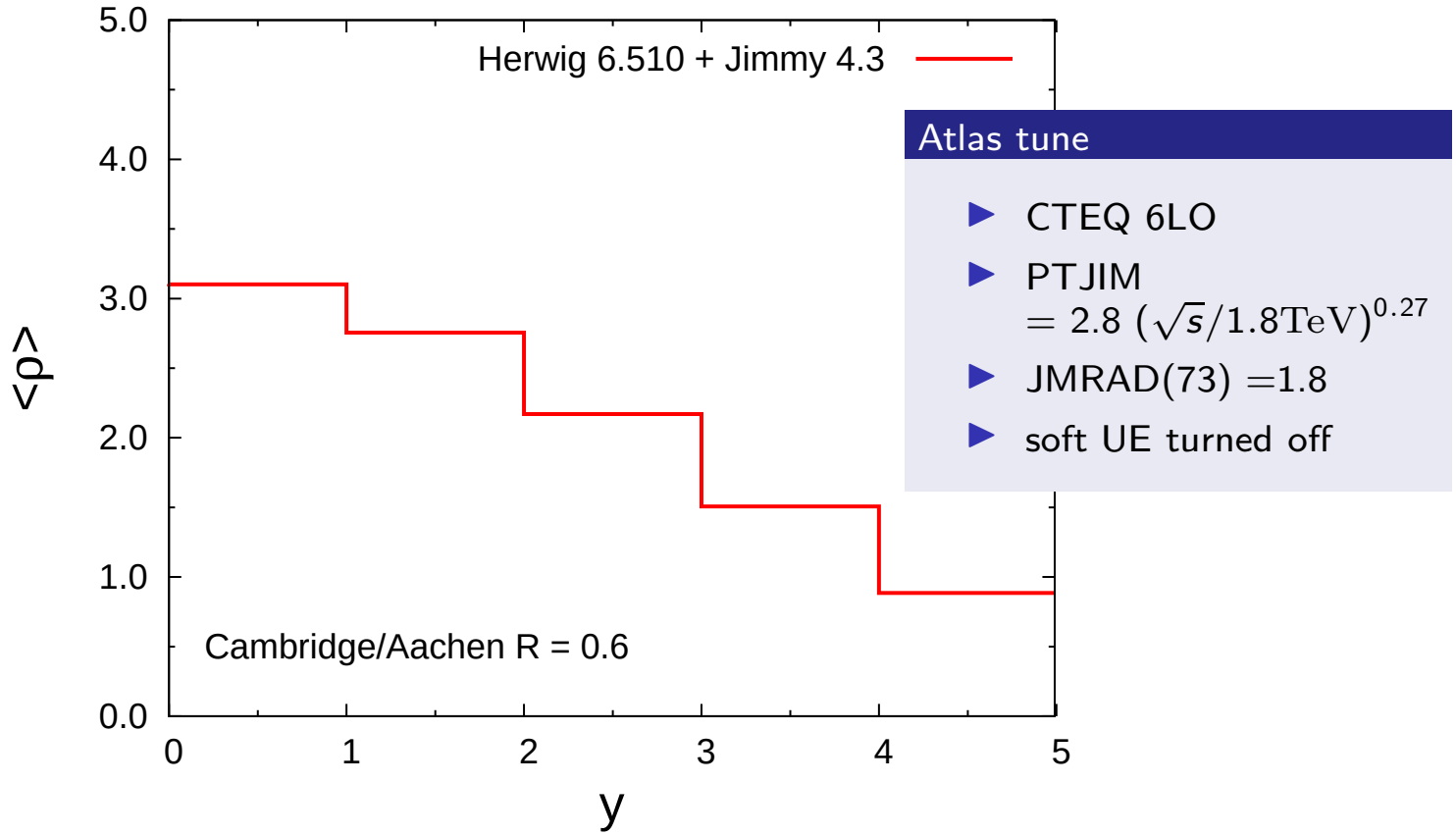
- statistics (median from too few jets will be biased by hard jets)

&

- requirement of being differential (ranges of y and ϕ should be small enough)

Average ρ as a function of y

- dijets at the LHC, $\sqrt{s} = 14$ TeV, $p_{t,\min} = 50$ GeV



- significant y dependence

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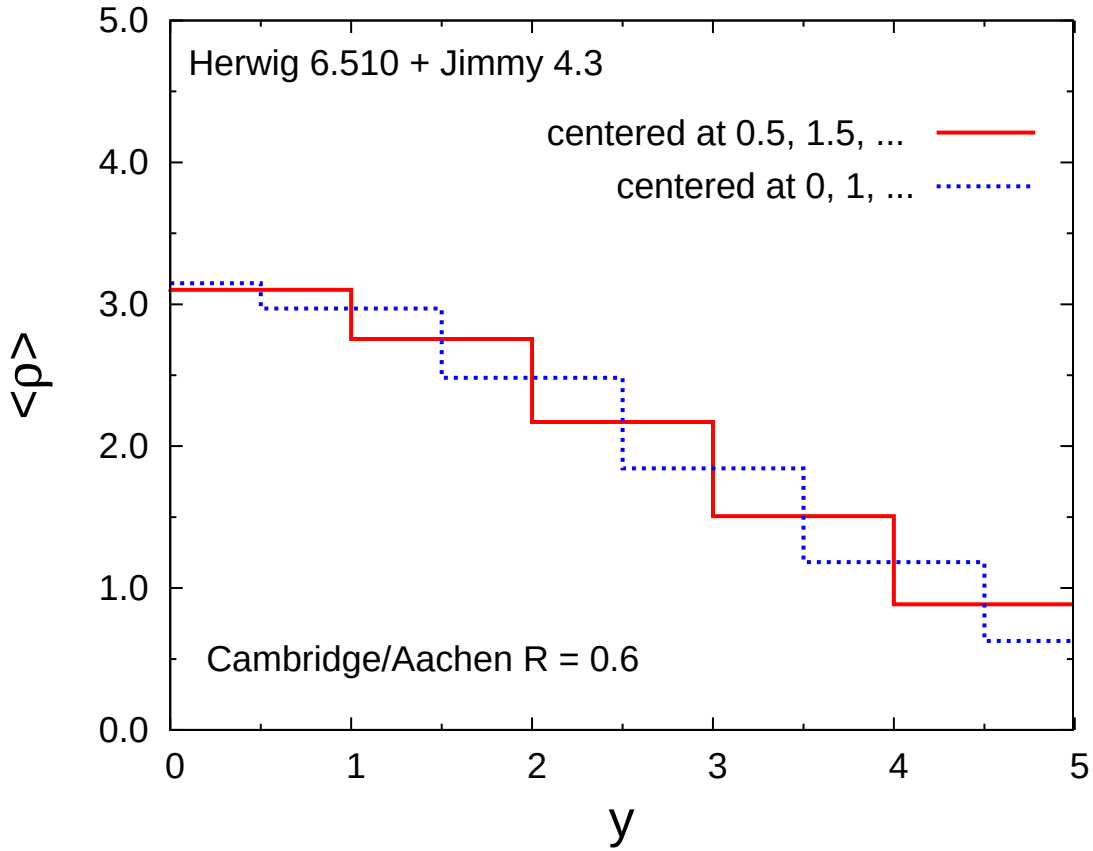

- number of jets for median determination must be $\gtrsim 10$
- a good compromise: rapidity strips of width $\Delta y \sim 1$

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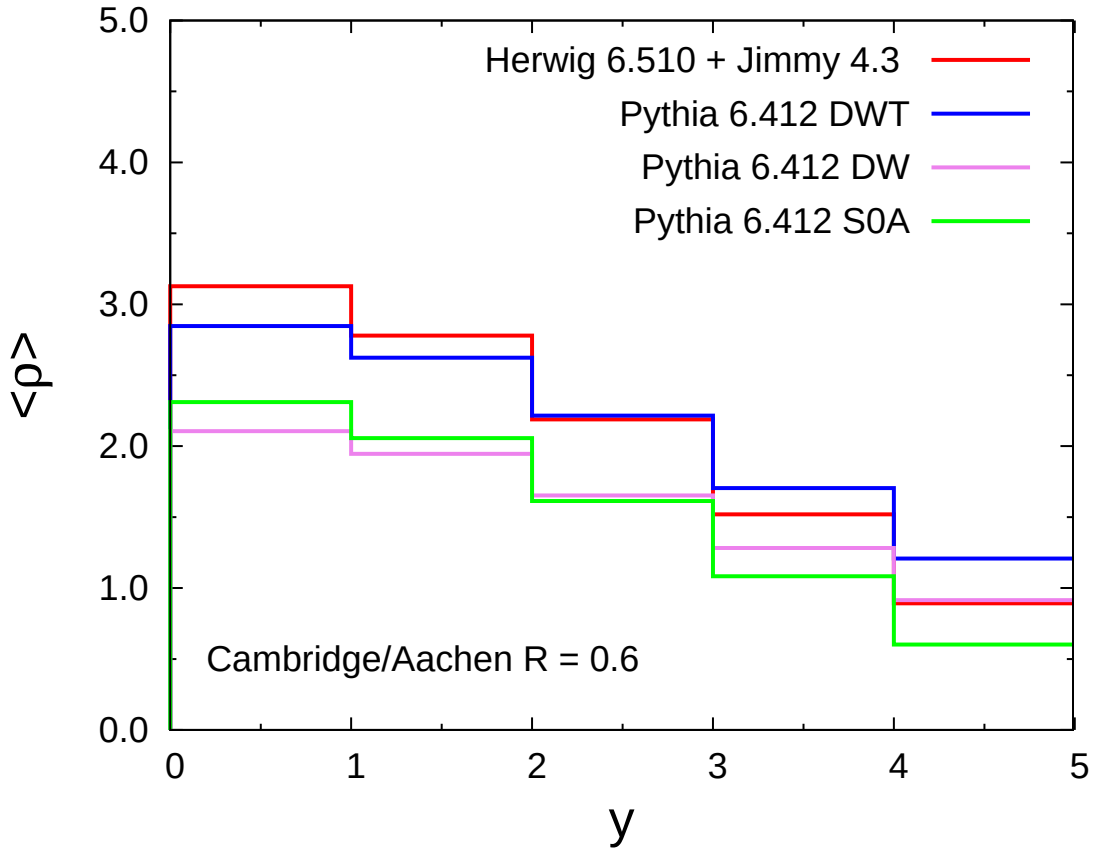


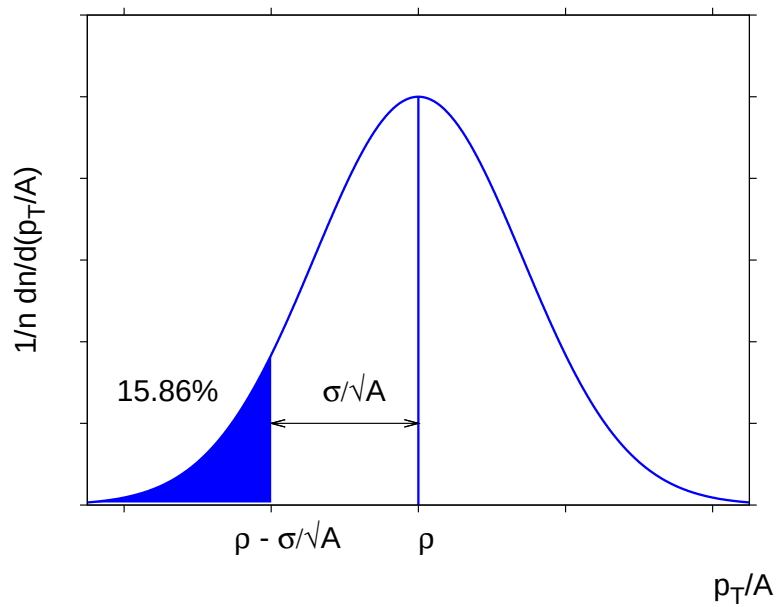
Fluctuations within an event

[Cacciari, Salam, Phys. Lett. **B 659** (2008)]

- σ measures fluctuations within the rapidity strip $\Delta y = 1$
- defined such that in case of Gaussian distribution 68.27% of jets satisfy

$$\rho - \frac{\sigma}{\sqrt{A_j}} < \frac{p_{t,j}}{A_j} < \rho + \frac{\sigma}{\sqrt{A_j}}$$

- determined from the sorted list of $\{p_{t,j}/A_j\}$ and given by the value for which 15.86% of jets have smaller $p_{t,j}/A_j$



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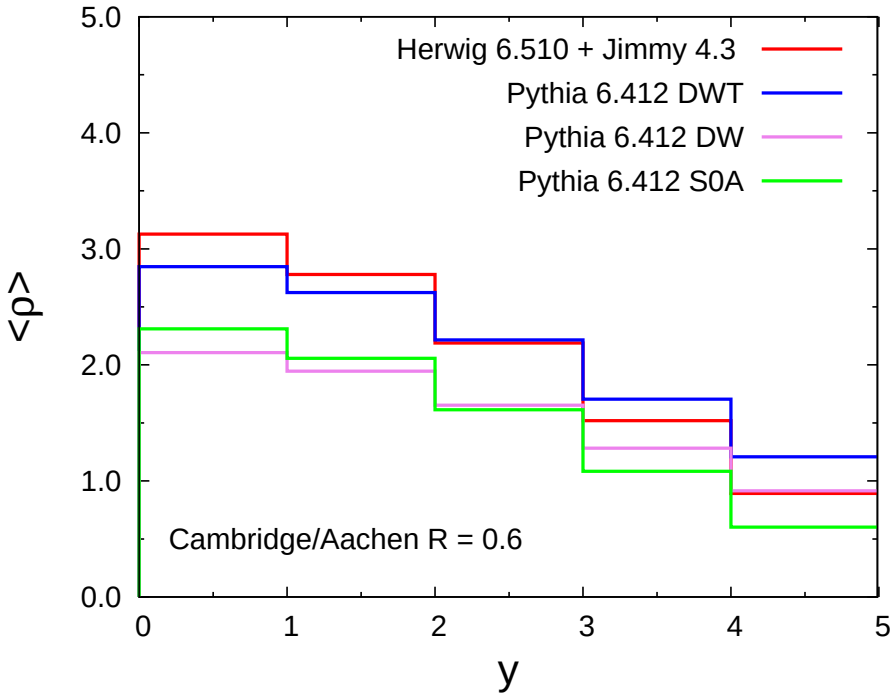
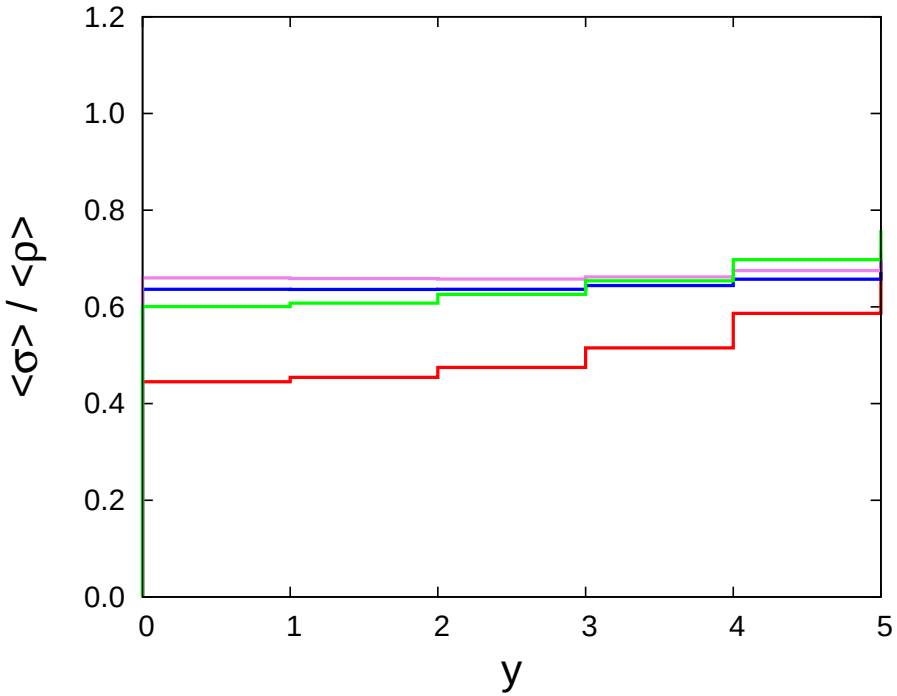
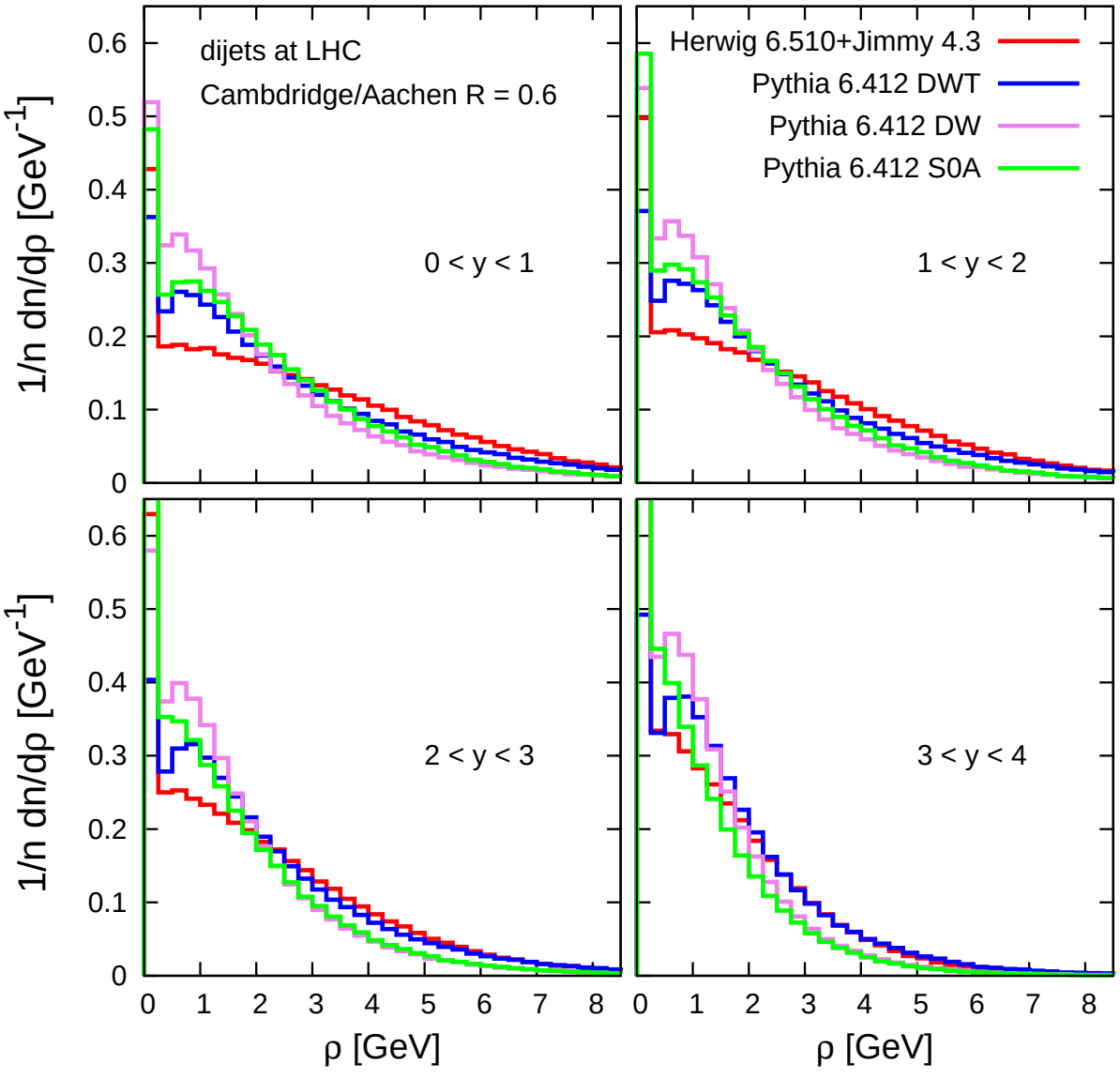




- fluctuations are large
- difference between Herwig+Jimmy and Pythia

Distributions of ρ – fluctuations from event to event



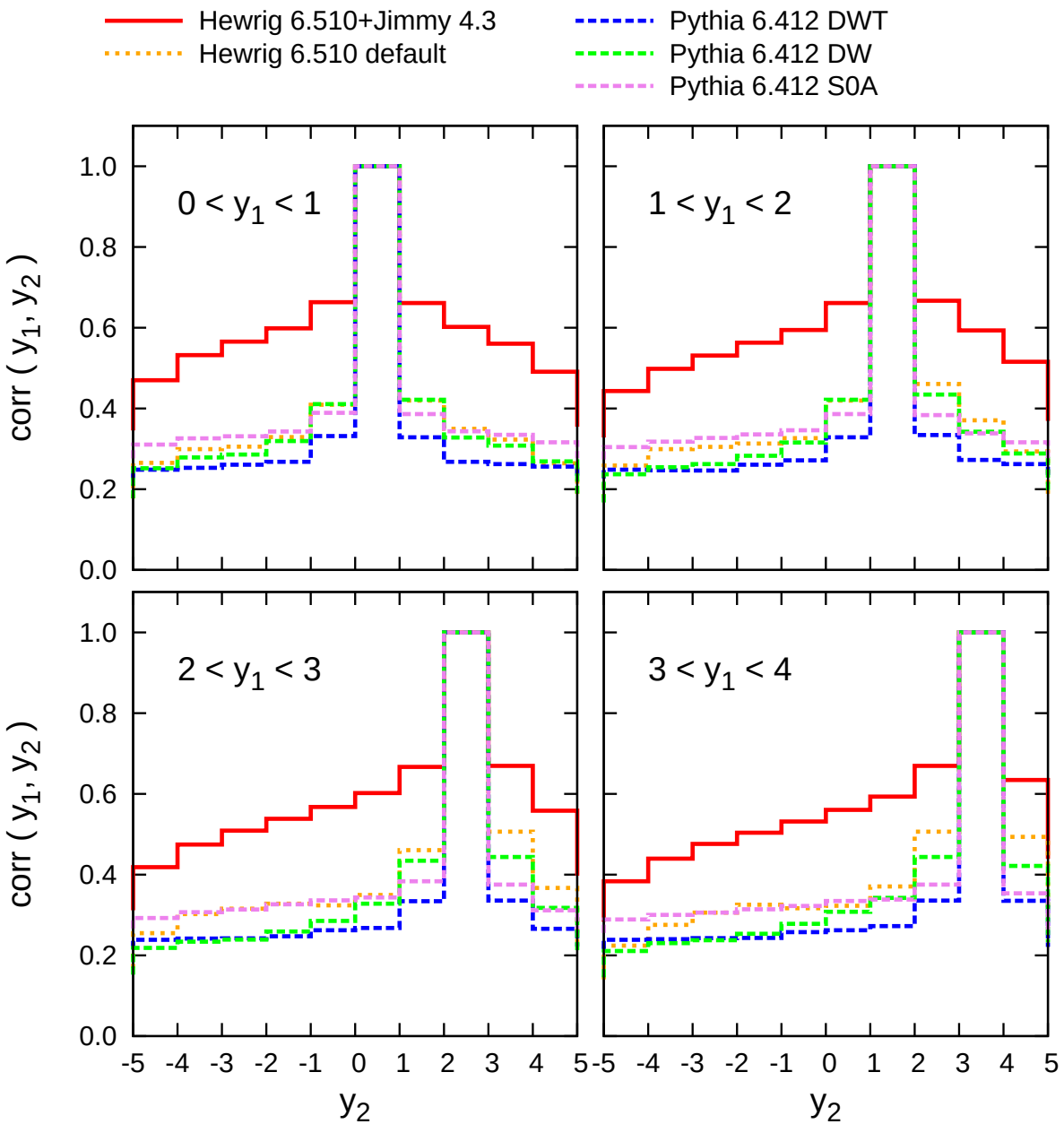
Correlations

The correlation coefficient

$$\mathrm{corr}(y_1, y_2) = \frac{\left\langle \rho(y_1)\rho(y_2) \right\rangle - \left\langle \rho(y_1) \right\rangle \left\langle \rho(y_2) \right\rangle}{\sqrt{\left\langle \rho(y_1)^2 \right\rangle - \left\langle \rho(y_1) \right\rangle^2} \sqrt{\left\langle \rho(y_2)^2 \right\rangle - \left\langle \rho(y_2) \right\rangle^2}}$$

- y_1, y_2 – rapidity bins of width $\Delta y = 1$
- $\left\langle \ldots \right\rangle$ – average over many events

Correlations



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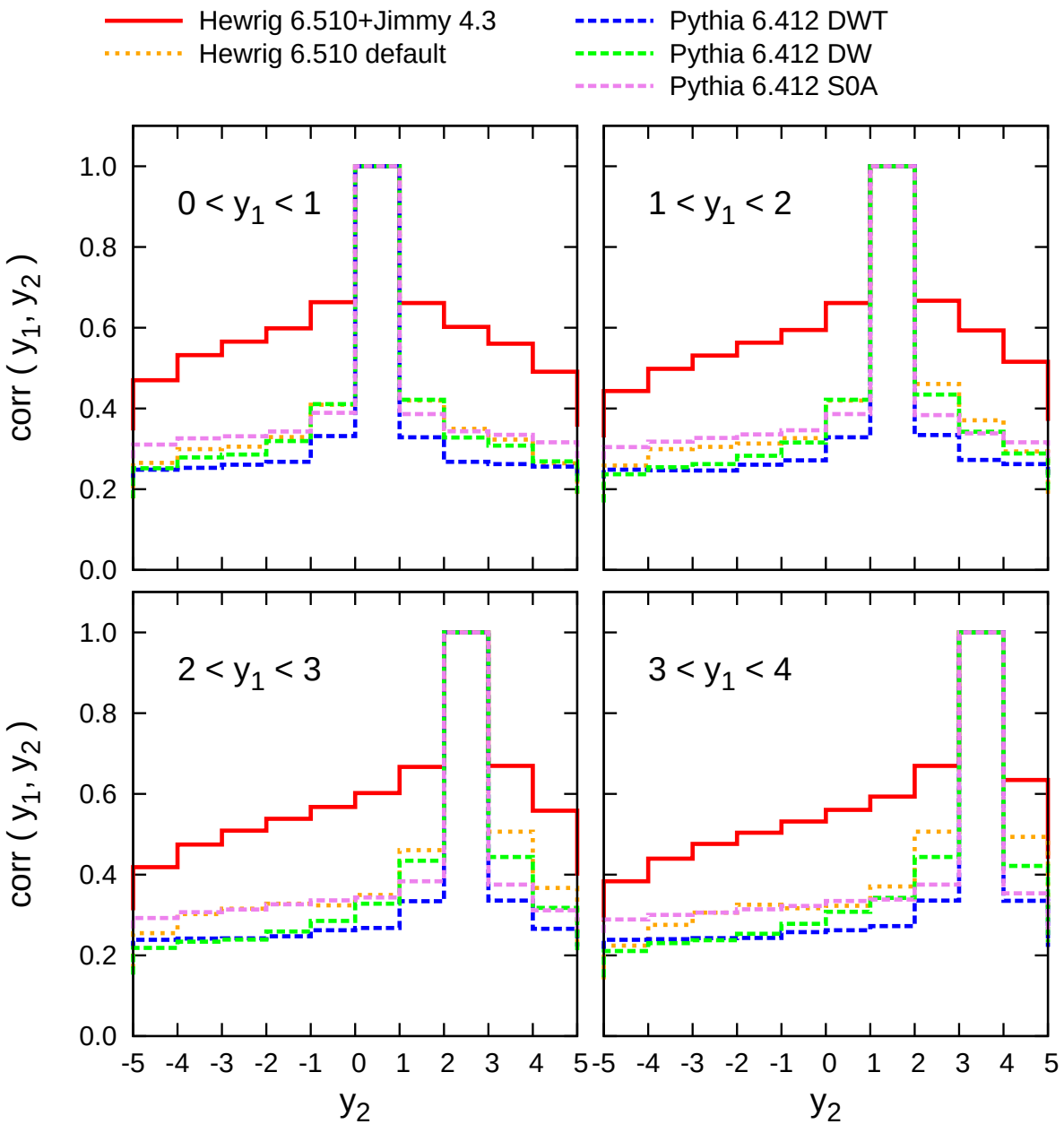

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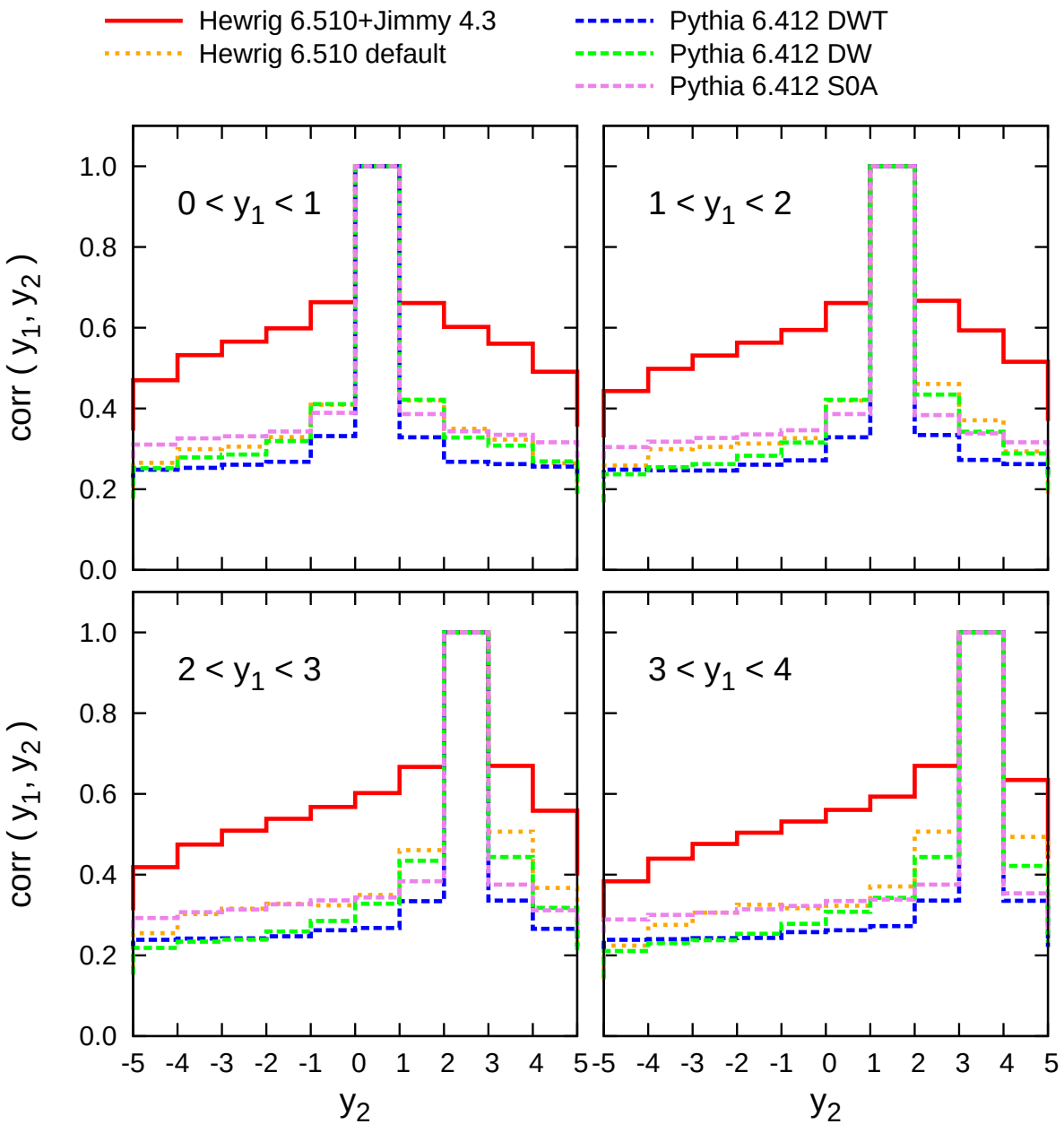
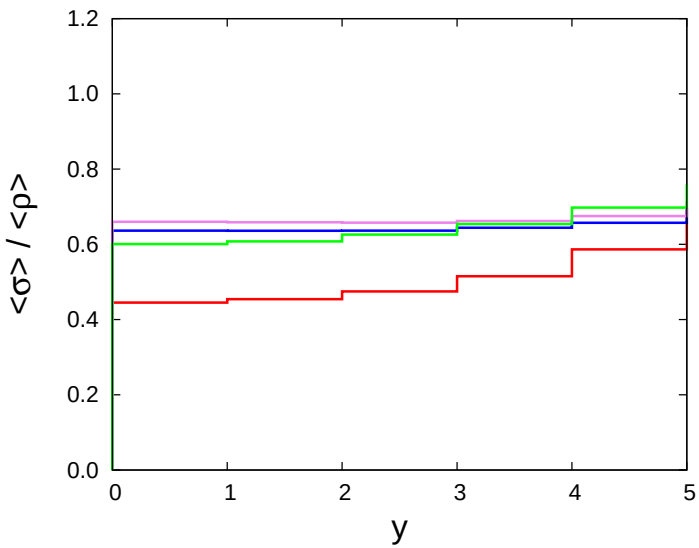
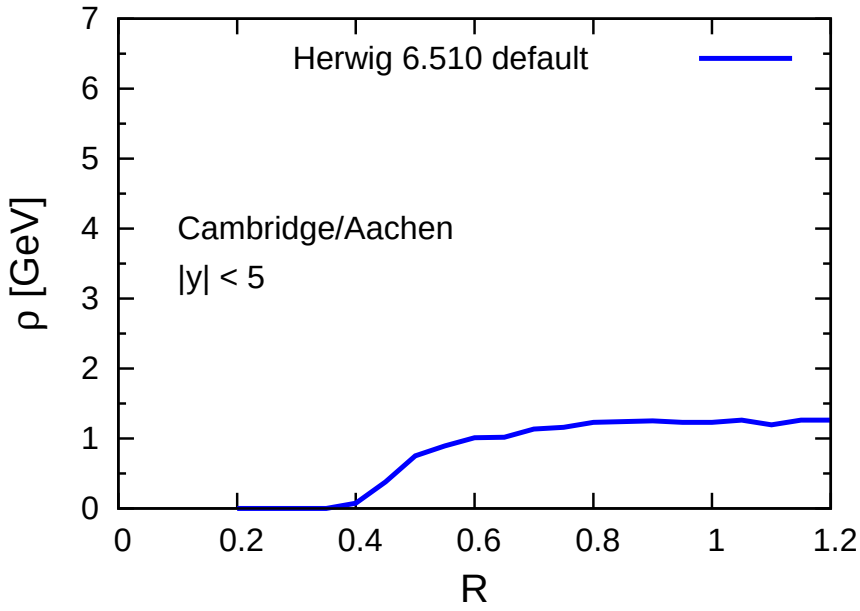
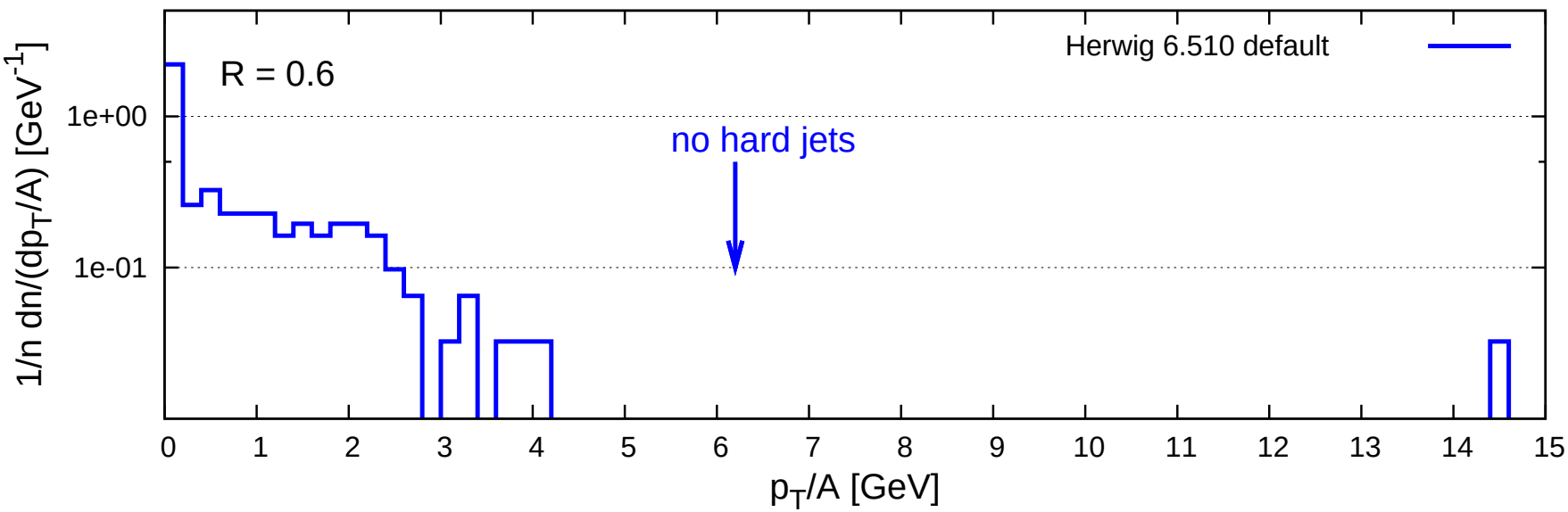


- significant difference between Herwig + Jimmy and Pythia
- qualitatively consistent with $\langle\sigma\rangle/\langle\rho\rangle$: smaller fluctuations within event $\Leftrightarrow$ larger correlations



R dependence – typical single event





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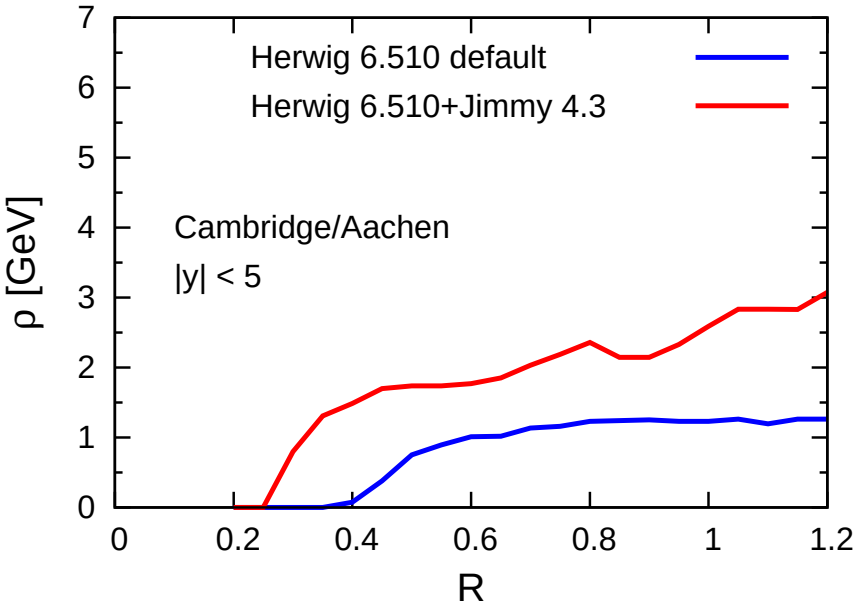

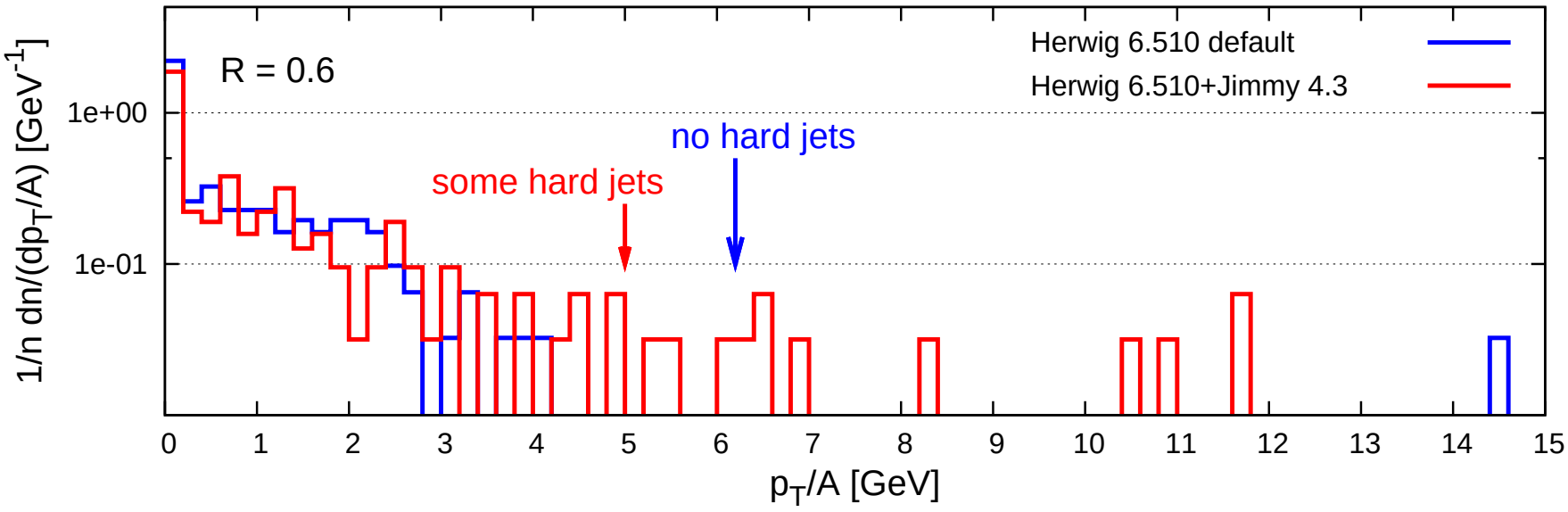

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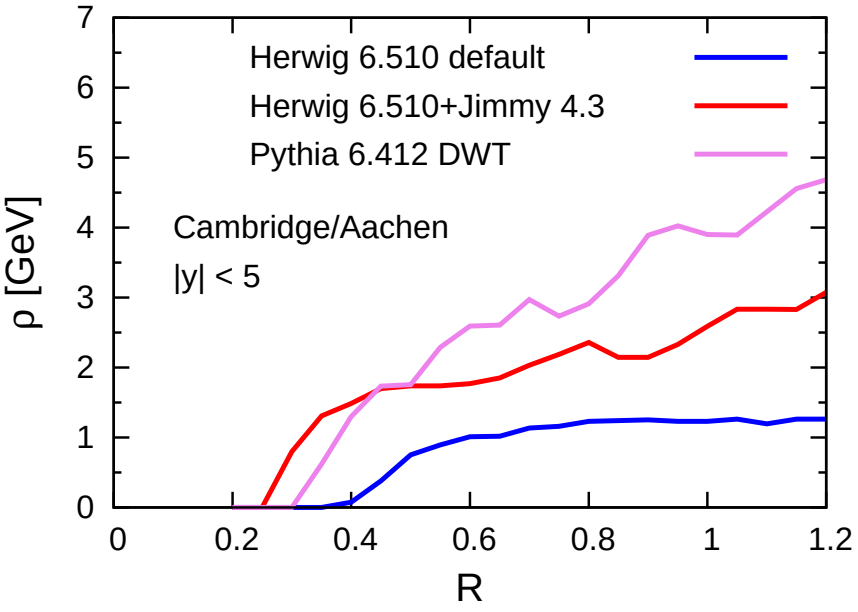
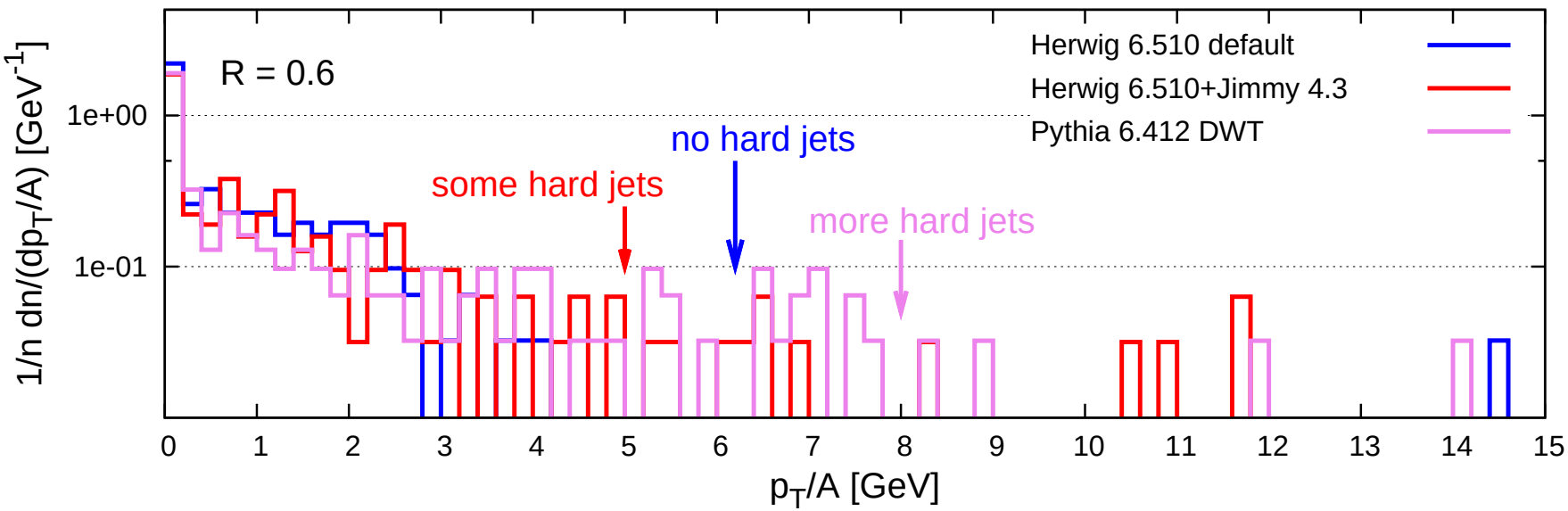


- tails of distribution of p_t/A produce growth of ρ with R
- we believe that difference between Herwig+Jimmy and Pythia consistent with analysis of fluctuations and correlations



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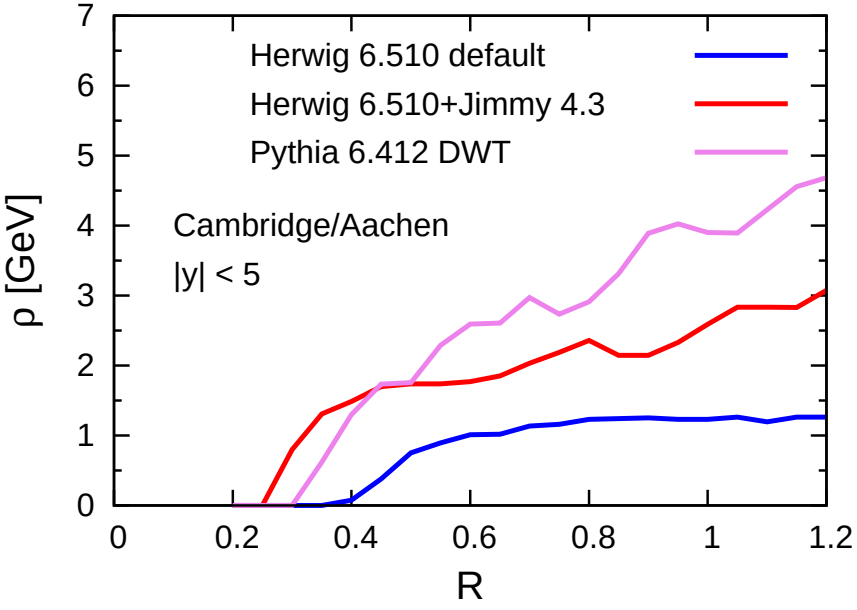
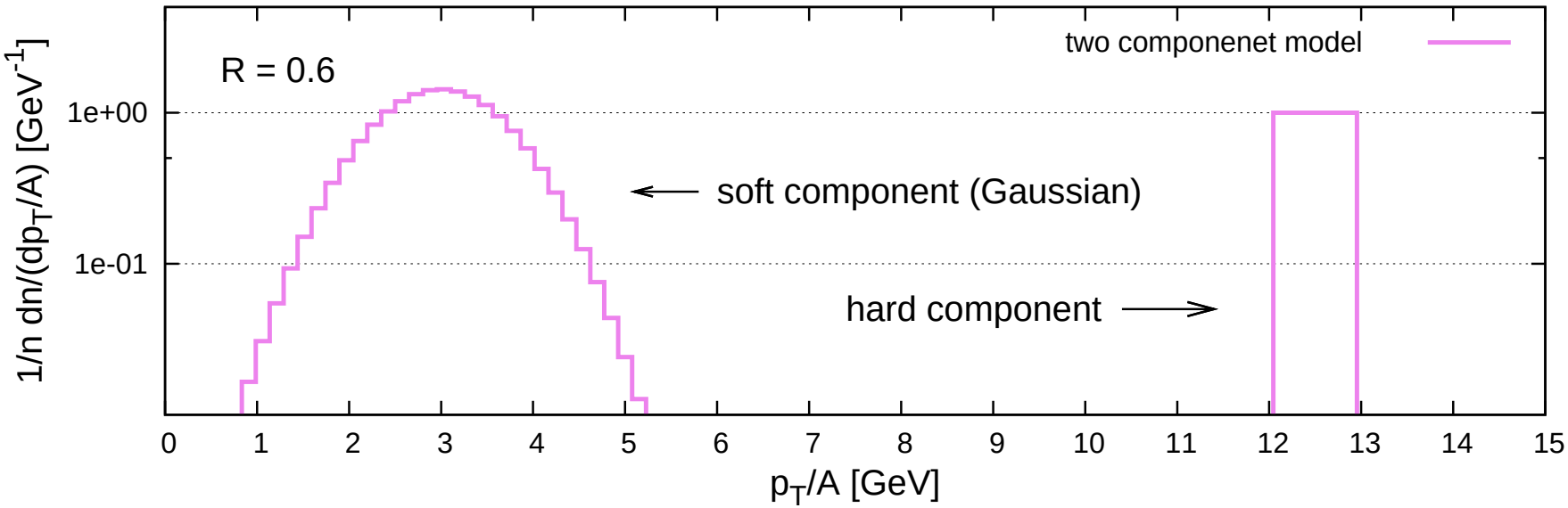


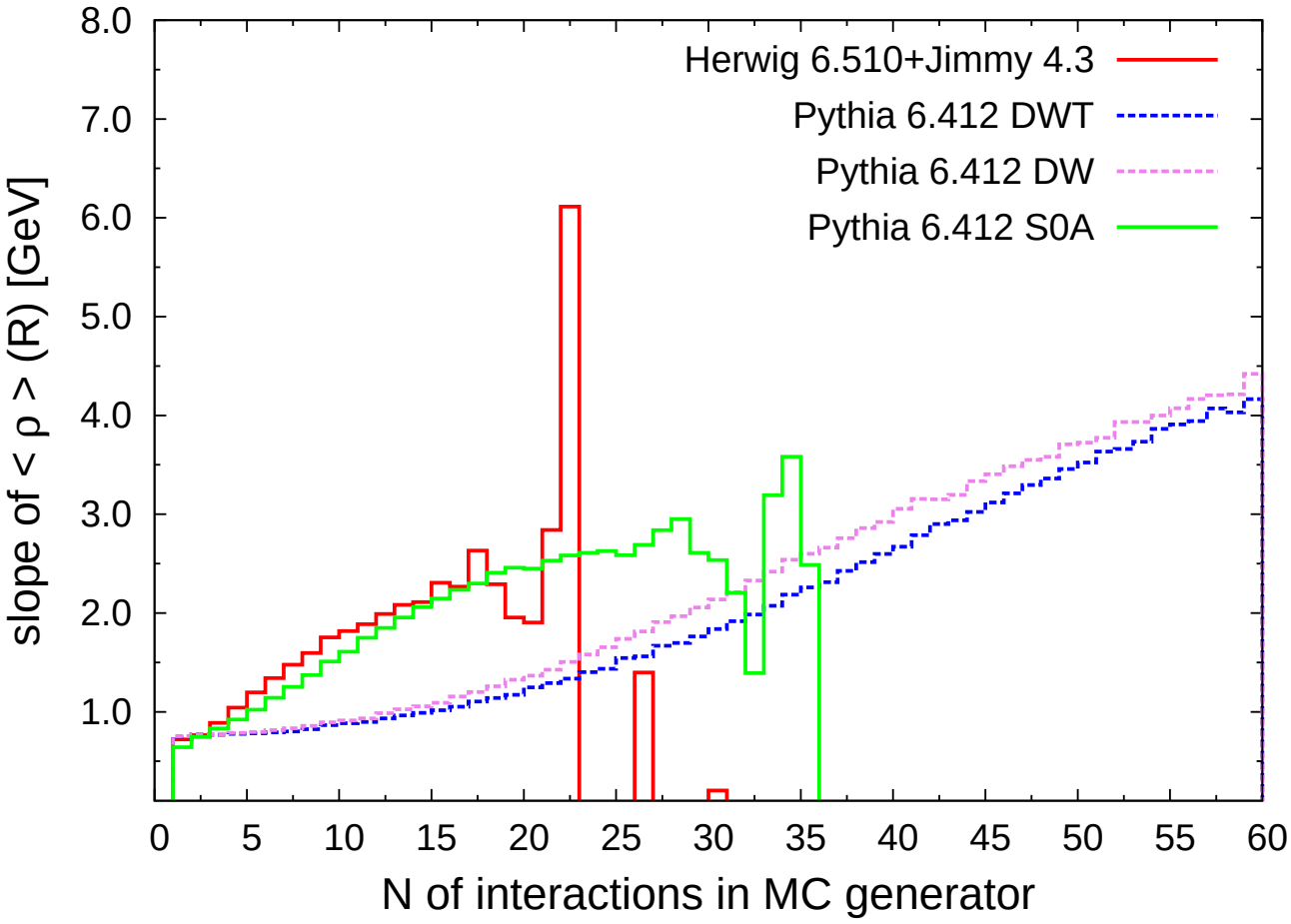
- two component model gives

$$\rho = \Theta(R - R_0)(\rho_0 + \sigma n_h R)$$

n_h – number of hard jets



Possible relations with multiple parton interactions



Summary

The presented method of UE analysis

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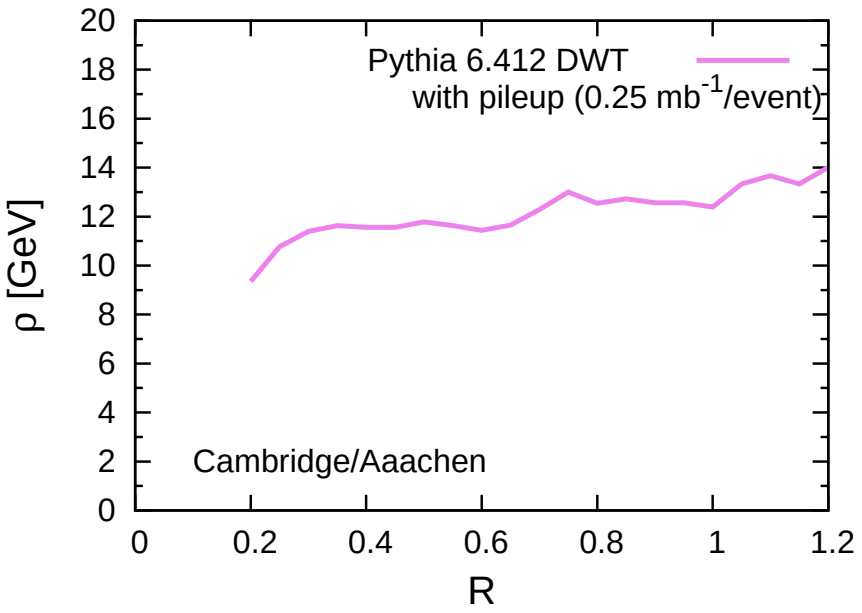
We observe that

- it is important to go differential since UE
  - depends on rapidity
  - fluctuates within an event – significant differences between Herwig+Jimmy and Pythia
  - fluctuates from event to event – significant for all generators/tunes
  - is correlated – large differences between Herwig+Jimmy and Pythia
- the obtained level of transverse momentum per unit area grows with R (stronger for Pythia than for Herwig+Jimmy)

BACK-UP SLIDES

R dependence – typical single event with pileup



- smaller relative change of ρ with R than for UE