Study of the underlying event characteristics in function of the multiplicity and leading particle transverse momentum

(Did we miss the "melting" of partons in pp collisions)

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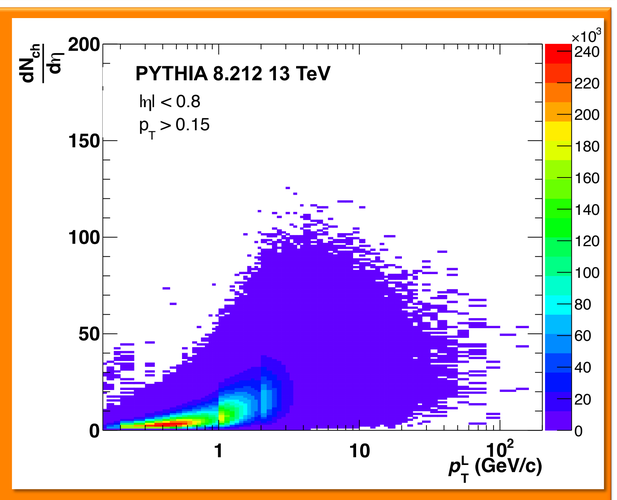
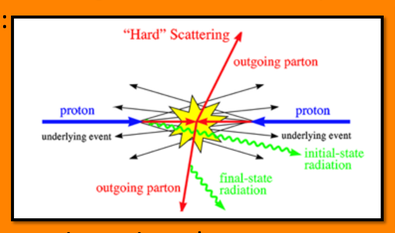
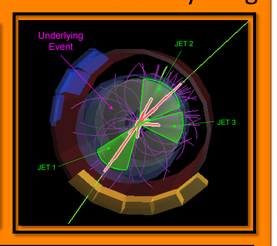
Introduction

- The high multiplicity events in pp collisions events replicate some of the characteristic properties of particle production in the Little Bangs.
- No experimental analysis could give evidence for the "jet quenching" in pp collisions.
- The study of the simulation of Pythia at highest multiplicities (highest densities) show interesting features.
- At high multiplicities, an important modifications of the particle momenta and a simultaneous increase of the yield of the Underlying Event (UE) are observed.
- Don't have, yet, experimental proof of a similar mechanism.



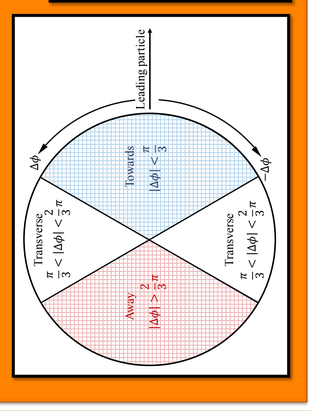
- **Underlying Event (UE):** In parton-parton scattering, the UE is usually defined to be everything except the two outgoing hard scattered partons:
  Beam-beam remnants.
  Additional parton-parton interactions.
  Initial and final state radiations
  etc.....



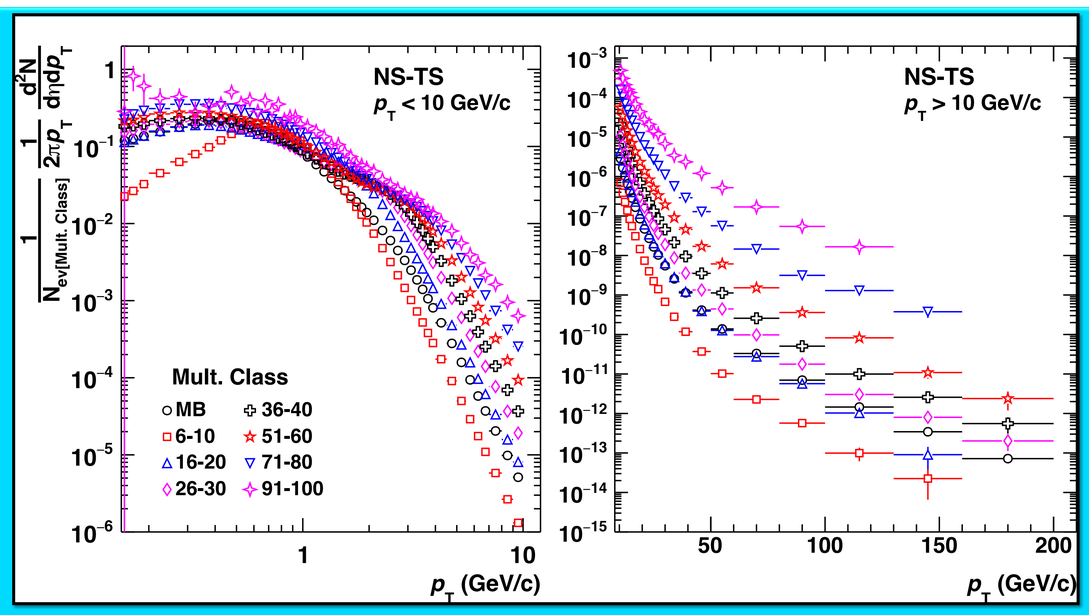


- Particle with highest p_T in the particular event is assigned as a leading pT of the event. The azimuthal angle with the leading particle will be the new reference for other particles belonging to the event.
- **Traditional UE measurement:** according to the azimuthal direction of leading charged particle, three distinct topological regions are defined:
  - Near Side (NS): $|\Delta\Phi| < \pi/3$
  - Away Side (AS): $|\Delta\Phi| > 2\pi/3$

  } (sensitive to Jet fragmentation)
  - Transverse Side (TS): $\pi/3 < |\Delta\Phi| < 2\pi/3$ (sensitive to UE)

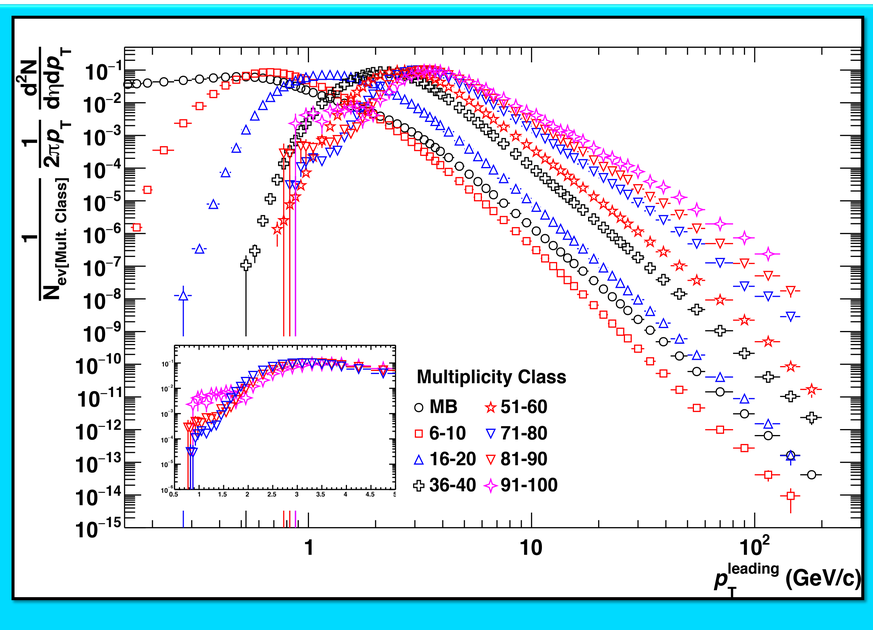


Observation: Hard/Jetty spectra (NS-TS)



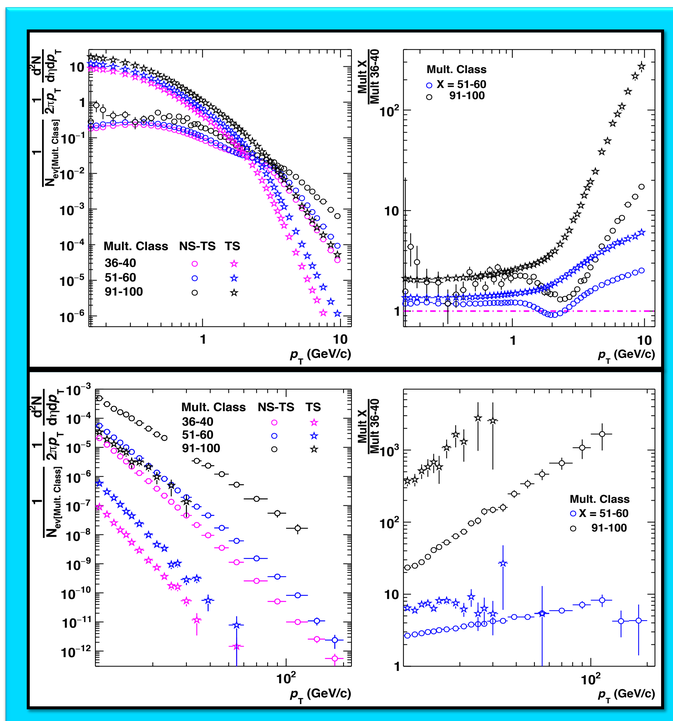
- The spectrum labeled NS-TS which is obtained by subtracting the TS spectrum from the NS spectrum.
- The spectra exhibit a hardening with multiplicity.
- At higher multiplicities the slope of the spectra continues decreasing without producing higher momentum particles!

Observation: Leading Particles Spectra



- The low pT-part of the highest multiplicity bins spectra develop a "kink" at around 1 GeV/c.
- **This supports the previous observation that the leading particles have been "degraded"?**

Observation: NS-TS and TS spectra

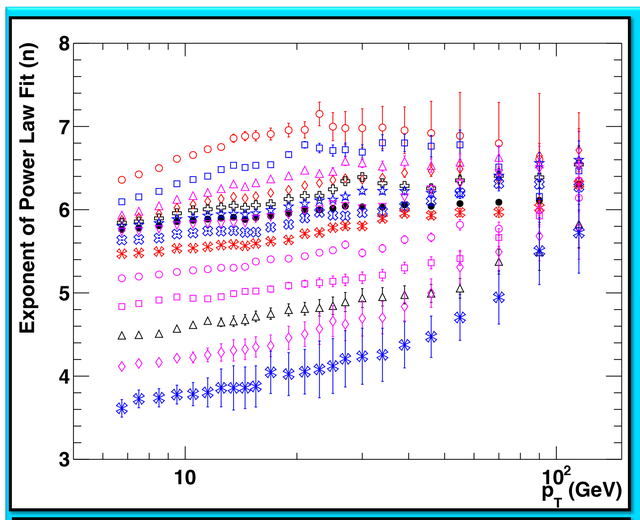


- The spectra in BOTH regions exhibit a hardening with multiplicity.
- Increase in RATIO is much greater for the highest multiplicity than for the lower one (more than an order of magnitude) at pT ~ 100 GeV/c !
- The TS spectra show an even larger ratio with the transverse momentum
- In the low part of the spectra (below 1 GeV/c) the yield of charged particles is growing with the multiplicity of the events!
- At higher multiplicities the slope of the spectra contin- ues decreasing without producing higher momentum particles!

At multiplicities above ≈ 50 the production of the highest momentum particles seems to be decreasing while the mean transverse momentum in the TS continues rising!

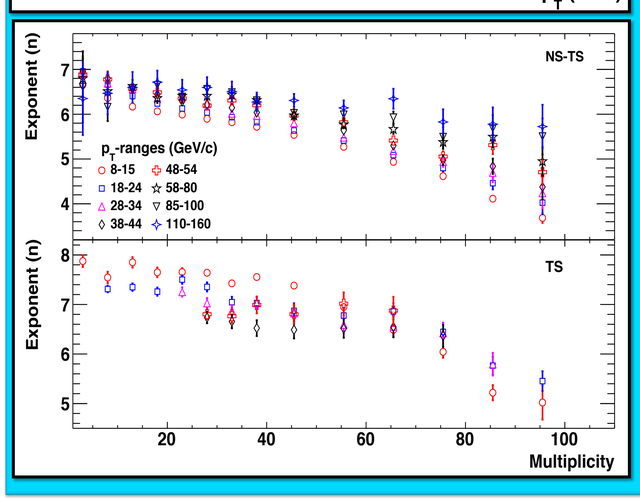
Are we observing some kind of **"melting"** of the highest p_T-particles at high multiplicities: producing particles at lower-p_T, increasing thus the **multiplicity and mean p_T**?

Observation: Exponents



Pythia pp 13 TeV (|η| < 0.8)

● MB	✚ 21 to 25	○ 51 to 60
○ 0 to 5	✖ 26 to 30	□ 61 to 70
□ 6 to 10	▽ 31 to 35	△ 71 to 80
△ 11 to 15	⊠ 36 to 40	◇ 81 to 90
◇ 16 to 20	✳ 41 to 50	❄ 91 to 100



- At densities below ~ 50 the slopes of all the multiplicity bins are approximately equal while above the critical charged particle density the slopes gets gradually smaller.
- At multiplicities above ~ 50, the production of the highest momentum particles seems to be decreasing while the mean transverse momentum in the TS continues rising!
- We observe that in the low pT region a rather important variation in the power-law exponent beyond the multiplicities cor- responding to the maximum leading transverse momenta, while in the higher pT bins this tendency is much smaller

Observation: Exponents

- ☑ The maximum reachable multiplicities are not accompanied by an increase in the maximum leading particle momentum. The proportionality between maximum pt and increasing multiplicity breaks down at multiplicity densities of around ~50.
- ☑ Beyond multiplicity density ~ 50, the NS-TS spectra continue to get flatter, increasing the mean transverse momentum, seemingly at the expense of the maximum reachable momentum
- ☑ Beyond the particle density corresponding to the maximum p_T reach both the TS and the NS-TS regions suffer a sudden hardening.
- ☑ At very low momenta the high multiplicity events present also a specific evolution by augmenting the yield of the smallest transverse momenta . The feature is observed both in the NS-TS spectra as well as in the leading particle spectra

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