Soft and Hard interactions at LHC energies

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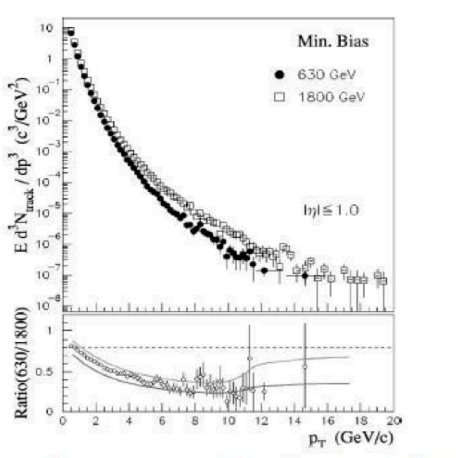
Motivation

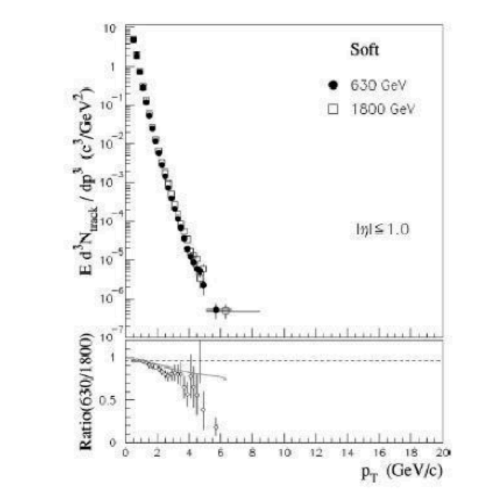
❖ Non diffractive proton-proton collisions have a “soft: and a “hard” (or “semi hard”) components

❖ “Hard” (or “semi hard”) event: involves hard parton-parton sacttering due to large momentum transfer, resulting into jets

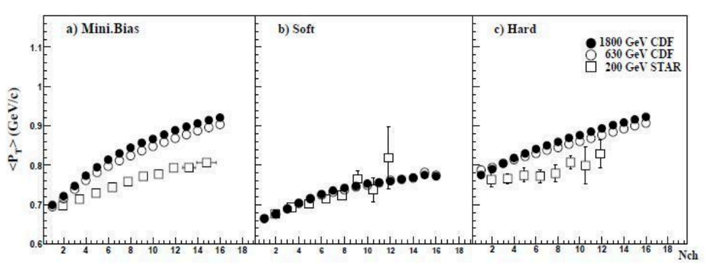
❖ An event without a jet (or minijet) is a soft event



Transverse momentum distributions for the full MB samples at 1800 and 630 GeV. In the bottom panel the ratio of the two distributions is shown. The two continuous lines delimit the band of all systematic uncertainties (see Sec. VI of text). N_{track} refers to the number of charged tracks in a unit η interval.

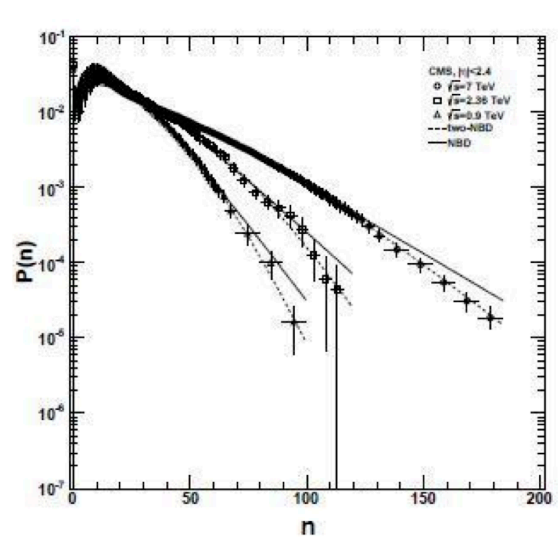


Same for the *soft* samples. The continuous line in the ratio plot shows the upper limit of the systematic uncertainties. The lower limit overlaps the data points.



The mean transverse momentum $<P_T>$ dependence on the multiplicity Nch in minimum bias, soft and hard events. The errors bars are statistical errors only. The STAR acceptance is extended from $|\eta|<0.5$ to $|\eta|<1.0$ by HIJING to compare the results with CDF.

Energy invariance in the properties of “soft” events observed by CDF [1] and STAR [2] collaborations



Negative Binomial Distribution (NBD) Function

$$P(n,\langle n\rangle,k)=\frac{\Gamma(k+n)}{\Gamma(k)\Gamma(n+1)}\left[\frac{\langle n\rangle}{k+\langle n\rangle}\right]^n\times\left[\frac{k}{k+\langle n\rangle}\right]^k \quad (1)$$

where $\langle n\rangle$ is the average multiplicity and the parameter k is related to dispersion D, $(D^2=\langle n^2\rangle-\langle n\rangle^2)$ by

$$\frac{D^2}{\langle n\rangle^2}=\frac{1}{\langle n\rangle}+\frac{1}{k}. \quad (2)$$

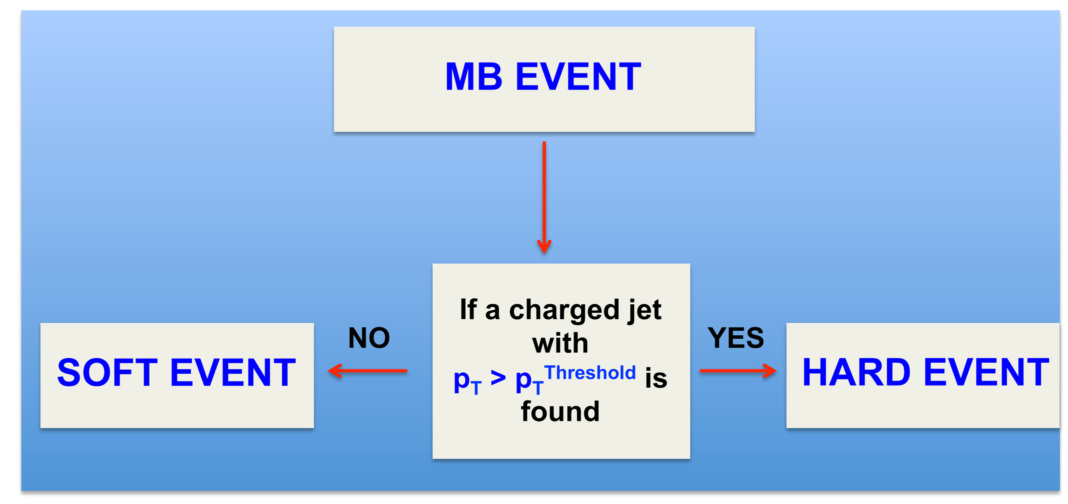
Two-NBDs

$$P_n(\sqrt{s},\eta_c)=\alpha_{soft}(\sqrt{s})\, P_n[\langle n\rangle_{soft}(\sqrt{s},\eta_c),k_{soft}(\sqrt{s},\eta_c)]+[1-\alpha_{soft}(\sqrt{s})]\, P_n[\langle n\rangle_{semihard}(\sqrt{s},\eta_c),k_{semihard}(\sqrt{s},\eta_c)] \quad (3)$$

$\sqrt{s}$(TeV)	k_s	$\langle n\rangle_s$	k_{sh}	$\langle n\rangle_{sh}$
0.9	2.44 ± 0.32	14.78 ± 1.99	8.13 ± 2.34	35.11 ± 3.90
2.36	2.57 ± 0.52	15.74 ± 2.98	6.27 ± 2.21	41.92 ± 6.21
7.0	2.38 ± 0.34	15.06 ± 1.48	3.25 ± 0.49	46.86 ± 3.45

Indication of Energy invariance in the properties of “soft” component at LHC [3]

Selecting “Soft” and “Hard” events



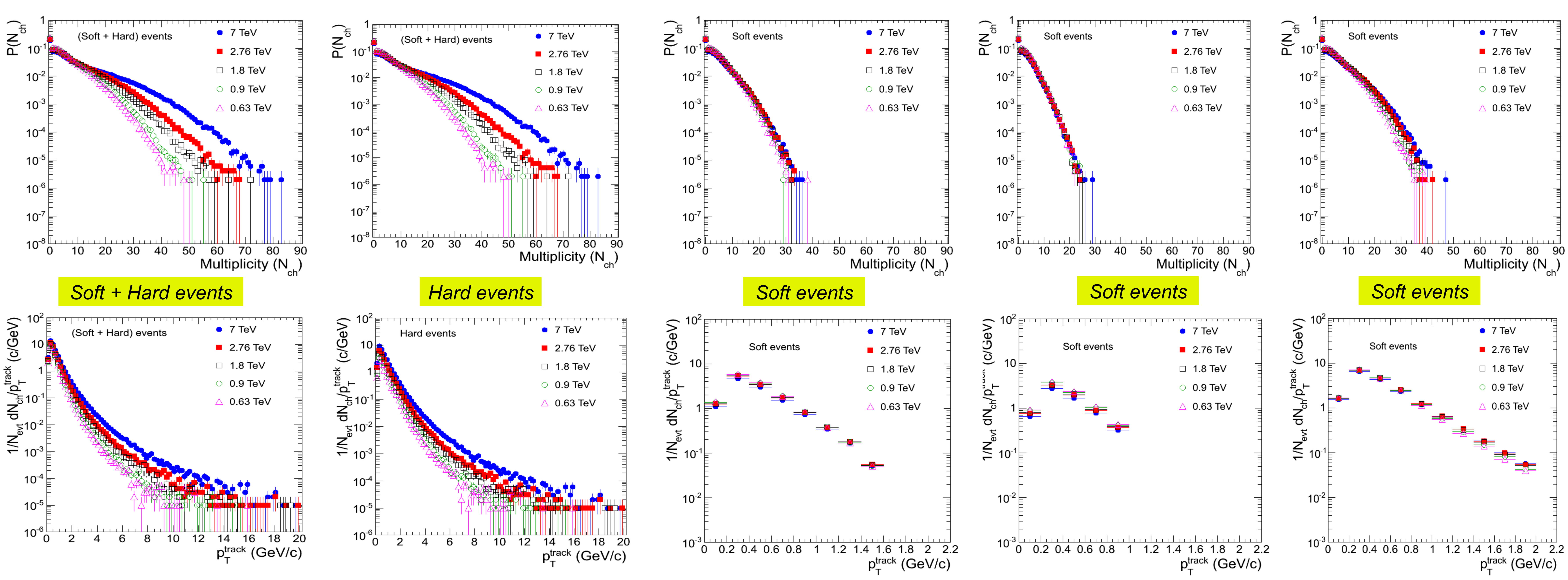
Simulation details

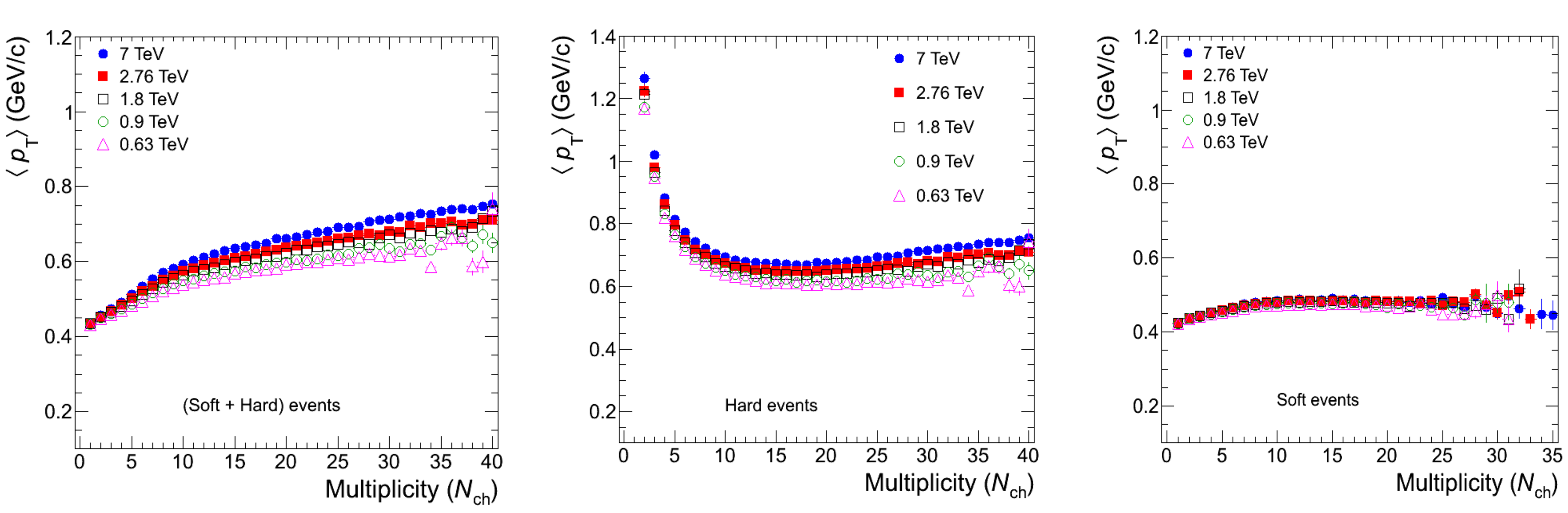
- Charged jet reconstruction
  - FASTJET anti-k_T [4]
  - Resolution parameter R = 0.4
  - Track p_T > 0.150 GeV/C
  - $|\eta|$ < 1.0
- Jet p_T threshold
  - 2 GeV/c
  - 1.5 GeV/c
  - 1.0 GeV/c
- Event generator: PYTHIA tune Perugia 2011
- $\sqrt{s}$ = 0.630, 0.9, 1.8, 2.76, 7 TeV
- Number of events: 500 k at each energy

Multiplicity and Transverse momentum distributions (PYTHIA)

Jet pT threshold = 1.5 GeV/c | Jet pT threshold = 1.5 GeV/c | Jet pT threshold = 1.0 GeV/c | Jet pT threshold = 2.0 GeV/c

Soft + Hard events | Hard events | Soft events | Soft events | Soft events





Summary and outline

- Multiplicity and Transverse momentum distributions are studied for sample of Soft and Hard events
- Events are categorized into soft and hard events based on presence of charged jets
- Multiplicity and transverse momentum distributions of charged tracks show energy invariance behavior in wide range of $\sqrt{s}$ in PYTHIA

References

[1] CDF Collaboration, Phys. Rev. D65 072005 (2002)

[2] Shengli Huang for the STAR Collaboration, arXiv:nucl-Ex/0403038

[3] Premomoy Ghosh, Phys. Rev. D85 054017 (2012)

[4] M. Cacciari, G. P. Salam and G. Soyez, JHEP 04, 63 2008

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