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New physics signals in global event properties in pp collisions at LHC

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Phys. Rev. D 68:034009 (2003)
talk at ALICE PPR meeting (CERN, 16 May 2003)

Introduction (I)

The weighted superposition mechanism of two classes of events in high energy collisions explains a series of experimental facts assuming that the multiplicity distribution (MD) P_n for each class of events is described in terms of a NB MD with characteristic parameters $\bar{n}$ and k.

$\bar{n}$ is the average charged multiplicity

$$\frac{D^2}{\bar{n}^2} = \frac{1}{\bar{n}} + \frac{1}{k}$$

D^2 is the variance of the MD

Weighted superposition of soft and semihard components:

$$P_n = \alpha_{\text{soft}} P_n^{\text{(NB)}}(\bar{n}_{\text{soft}}, k_{\text{soft}}) + \alpha_{\text{semihard}} P_n^{\text{(NB)}}(\bar{n}_{\text{semihard}}, k_{\text{semihard}})$$

$$\alpha_{\text{soft}} + \alpha_{\text{semihard}} = 1$$

A.Giovannini, R.U. Phys. Rev. D 59, 094020 (1999)

Introduction (II)

The experimental facts explained are:

A. Shoulder structure in the intermediate multiplicity range.

B. Quasi oscillatory behaviour of the ratio of factorial cumulants, K_n, to factorial moments, F_n, when plotted as a function of its order n (after an initial sharp decrease towards a negative minimum at $n \approx 5$)

C. Energy dependence of the strength of forward-backward multiplicity correlations

⇩

Relevance of NB regularity for classifying different classes of events

and

its interpretation in terms of clan concept

A.Giovannini, R.U. Phys. Lett. B 374, 231 (1996); Phys. Rev. D 66, 034001 (2002)

The NB distribution...

The multiplicity distribution

$$P_n(\bar{n}, k) = \frac{k(k+1)\cdots(k+n-1)}{n!} \frac{\bar{n}^n k^k}{(\bar{n}+k)^{n+k}}$$

The generating function:

$$G_{\text{NB}}(z; \bar{n}, k) \equiv \sum_0^\infty z^n P_n(\bar{n}, k) = \left[1 - \frac{\bar{n}}{k}(z-1)\right]^{-k}$$

$$= G_{\text{Poisson}}\left(G_{\text{log}}(z; b); \bar{N}\right)$$

with

$$G_{\text{Poisson}}(z; \bar{N}) = \exp\left[\bar{N}\,(z-1)\right] \qquad G_{\text{log}}(z; b) = \frac{\log(1-bz)}{\log(1-b)}$$

$$\bar{N} = k\log(1 + \bar{n}/k) \qquad b = \bar{n}/(\bar{n}+k)$$

...its interpretation

Clan structure and the two-step mechanism

CLAN = set of particles of common ancestry

- Each clan contains at least one particle (the ancestor)
- Clans are independently produced — they follow a Poisson distribution in $\bar{N} = k \ln(1 + \bar{n}/k)$
- Particles in a clan follow a logarithmic distribution in $\bar{n}_c = \bar{n}/\bar{N}$
- Correlations among particles are exhausted within each clan

A. Giovannini, L. Van Hove, Z. Phys. C30, 391 (1986); Acta Phys. Pol. B19, 917 (1988)

Extrapolations

We extrapolated to high energy the two components:

- I - the soft component satisfies KNO scaling
- II - three scenarios for the semihard component:

  ① also obeys KNO scaling (disfavoured by Tevatron)

  ② k^{-1} grows as $\log s$ (max violation)

  ③ k^{-1} grows as $\sqrt{\log s}$ (QCD-inspired)

A.Giovannini, R.U. Phys. Rev. D 59, 094020 (1999)

The problem

Behaviour of the semihard component from 900 GeV to 14 TeV:

		$\bar{N}$ (900 GeV)		$\bar{N}$ (14 TeV)	$\bar{n}_c$ (900 GeV)		$\bar{n}_c$ (14 TeV)
②	$k_{\text{sh}} \sim (\log \sqrt{s})^{-1}$ strong KNO violation	23	↘	11	2.5	↗	7
③	$k_{\text{sh}} \sim (\sqrt{\log s})^{-1}$ QCD-inspired behaviour	22	↘	18	2.6	↗	5

From GeV to TeV, $\bar{N}$ decreases and $\bar{n}_c$ increases, implying clan aggregation and higher particle population per clan.

Maximum clan aggregation for $\bar{N} = 1$ ➠ $\bar{n} = k(e^{1/k} - 1)$ and being $\bar{n} > k$ it implies

$$k < 1$$

An asymptotic property of the semihard component, or the characteristic property of an effective third class of events to be added to the soft and semihard ones?

Three classes

$$P_n^{\text{total}} = \alpha_{\text{soft}} P_n^{\text{soft}} + \alpha_{\text{sh}} P_n^{\text{sh}} + \alpha_{\text{third}} P_n^{\text{third}}$$

———

$$\alpha_{\text{soft}} + \alpha_{\text{sh}} + \alpha_{\text{third}} = 1$$

- I class: soft events (no minijets)

$\bar{N}_{\text{soft}}$ large and growing, $\bar{n}_{c,\text{soft}}$ quite small

$P_{n,\text{soft}}$ obeys KNO scaling ➠ k_{soft} constant

- II class: semihard events (with minijets)

$\bar{N}_{\text{semihard}}$ decreasing, $\bar{n}_{c,\text{semihard}} > \bar{n}_{c,\text{soft}}$

KNO scaling is violated k_{semihard} decreases

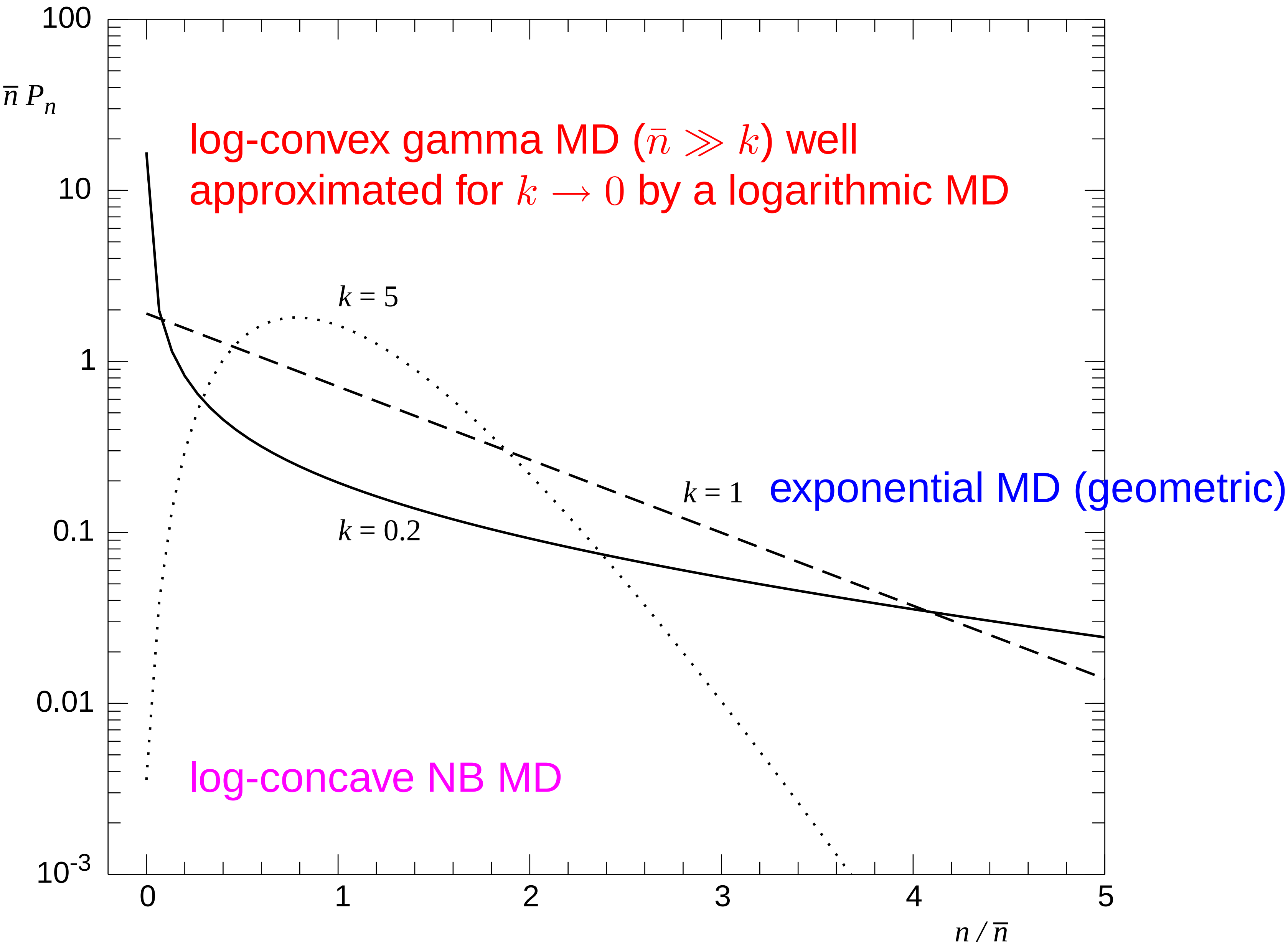
- III class: $k_{\text{third}} < 1$: the benchmark of the new class of events.

Being $\bar{N}_{\text{third}} \simeq 1$, quite large FBMC are expected!

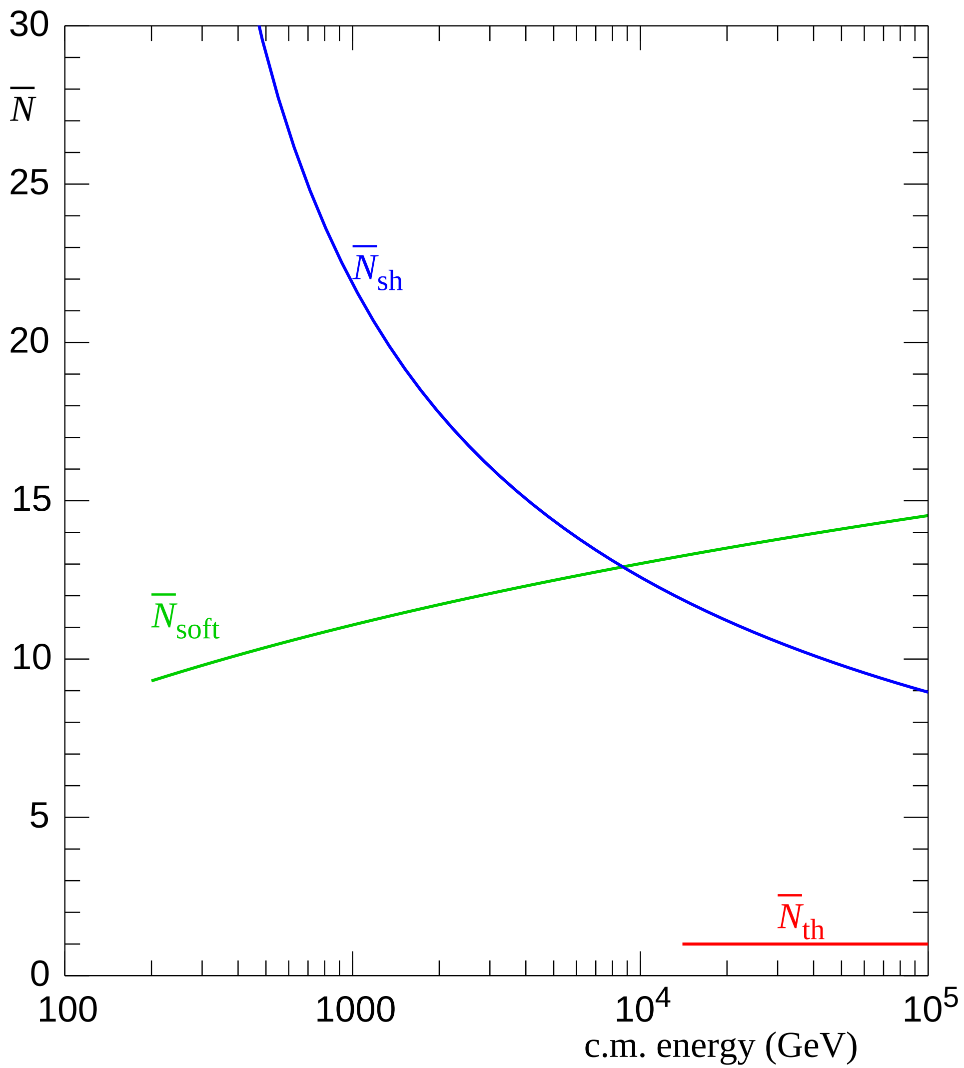
Leakage parameter from one hemisphere to the opposite one is close to maximum.

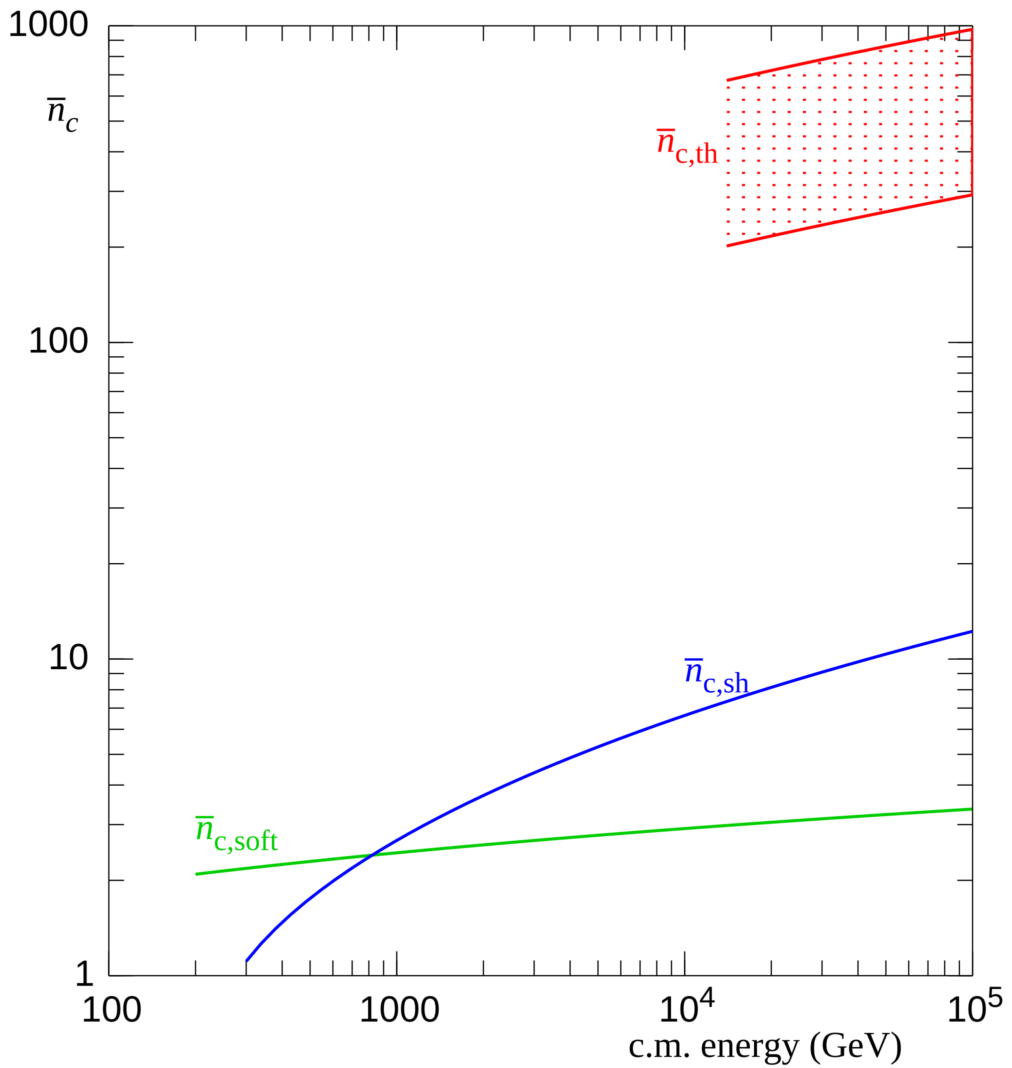
At parton level, huge colour exchange from a relatively small number of high vituality ancestors would probably indicate a mechanism harder than in both other components

Distributions



Clan parameters

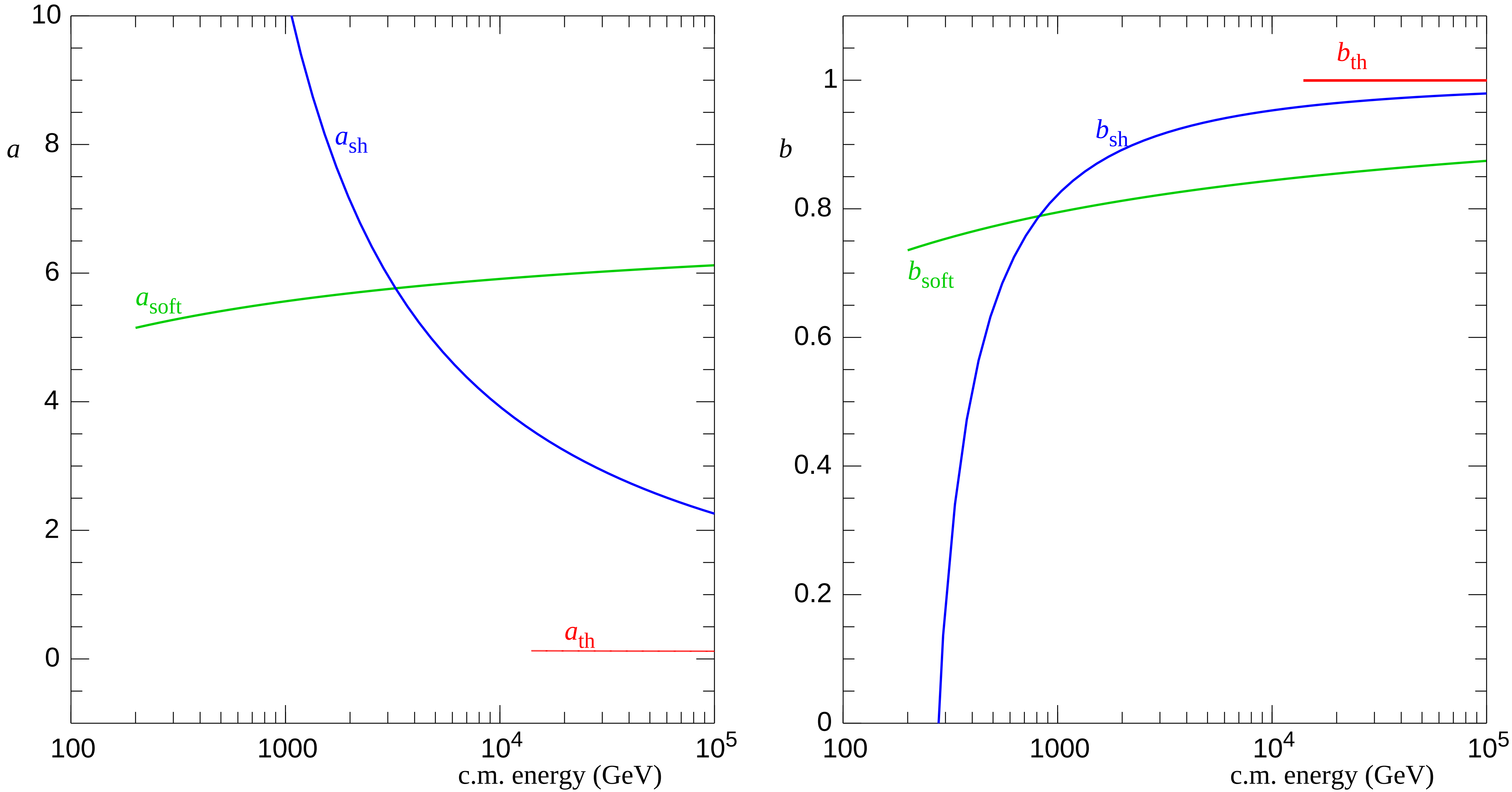




$\bar{N}$ avg number of clans

$\bar{n}_c$ avg num of particles per clan

a and b parameters



$$(n+1)P_{n+1} = (a+bn)P_n$$

$a = 0$ geometric with mean $b/(1-b)$

$b = 0$ Poisson with mean a

Clan aggregation and correlations

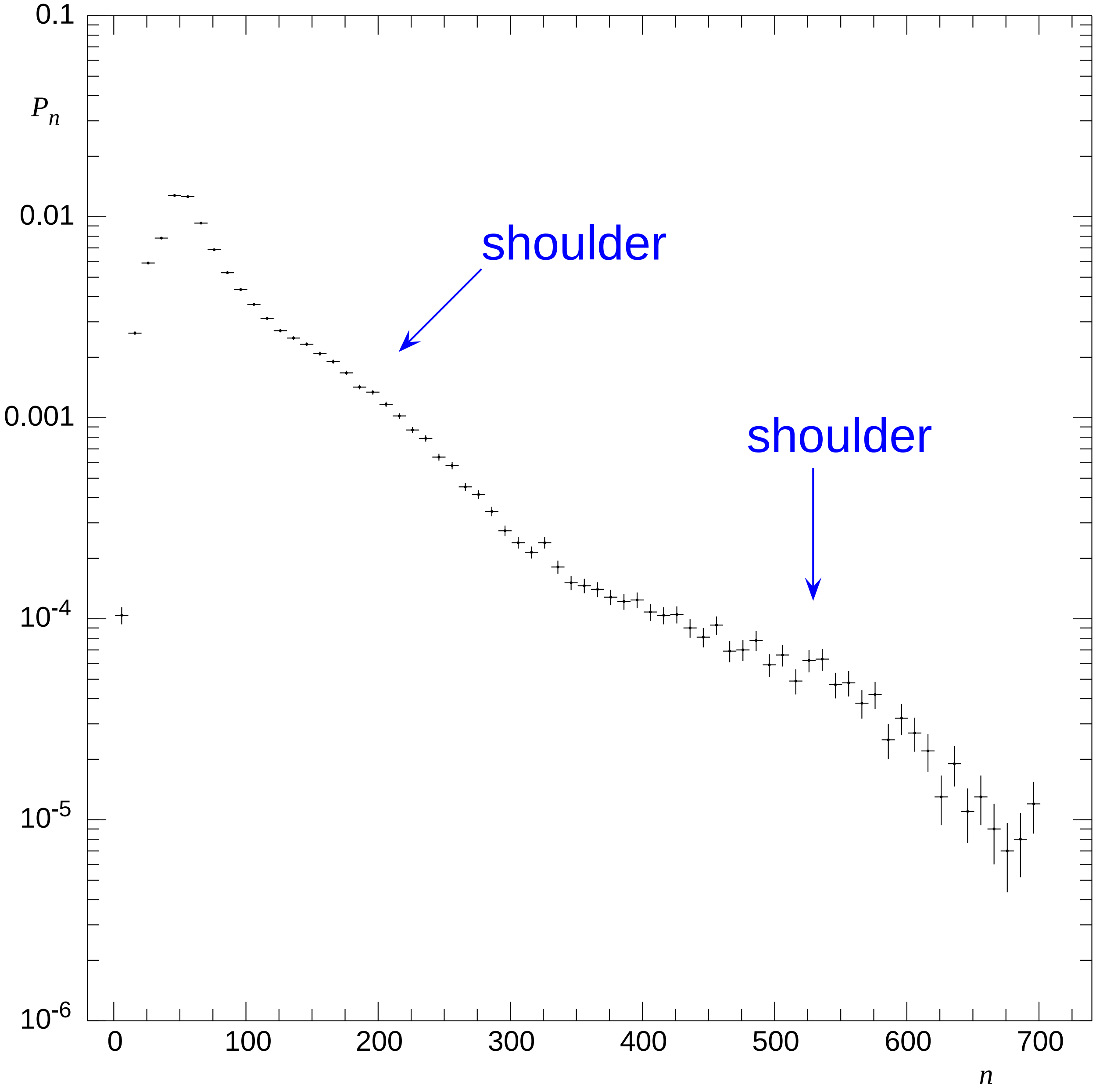
$k_{\text{third}} < 1$ implies:

- $$\frac{\bar{n}^2_{\text{third}}}{k_{\text{third}}} = \int C_2(\eta'_1, \eta''_2) d\eta'_1 d\eta''_2 > \frac{\bar{n}^2_{\text{semihard}}}{k_{\text{semihard}}}$$
- Cumulants depend on $1/k_{\text{third}}$ and are expected to be also much larger than in the semihard component
- Forward-backward multiplicity correlations

$$b_{\text{FB,th}} = \frac{2b_{\text{th}}p_{\text{th}}(1-p_{\text{th}})}{1-2b_{\text{th}}p_{\text{th}}(1-p_{\text{th}})},$$

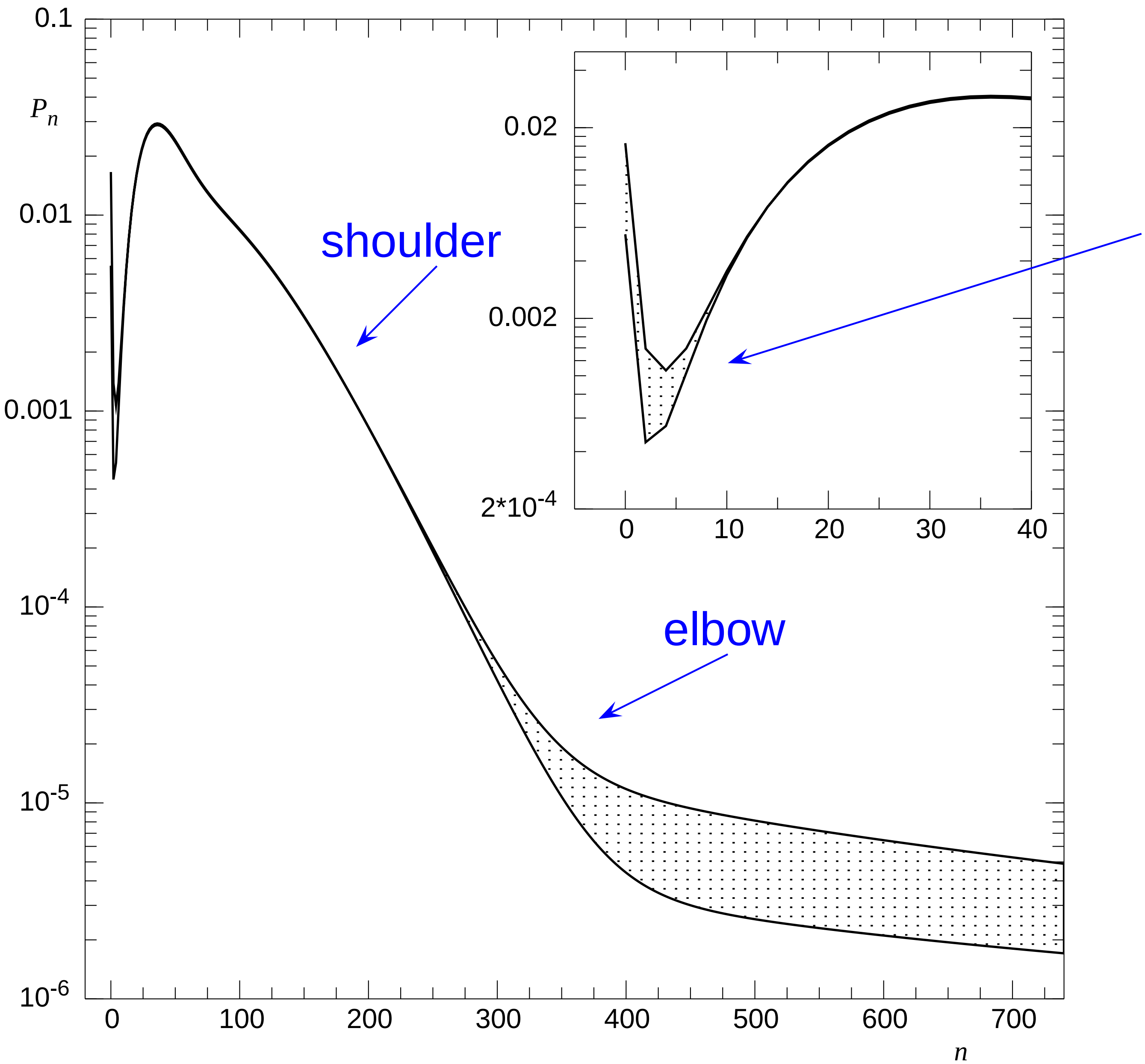
$\bar{N}_{\text{third}} = 1$ ➠ maximum leakage, i.e., $p_{\text{th}} = 1/2$; since $b_{\text{th}} \simeq 1$ then $b_{\text{FB,th}} \to 1$ (i.e., $b_{\text{FB,th}} \gg b_{\text{FB,sh}}$)

Phythia results



Minimum bias events in full phase-space from version 6.210, default parameters, double Gaussian matter distribution (model 4)

Our results (I)

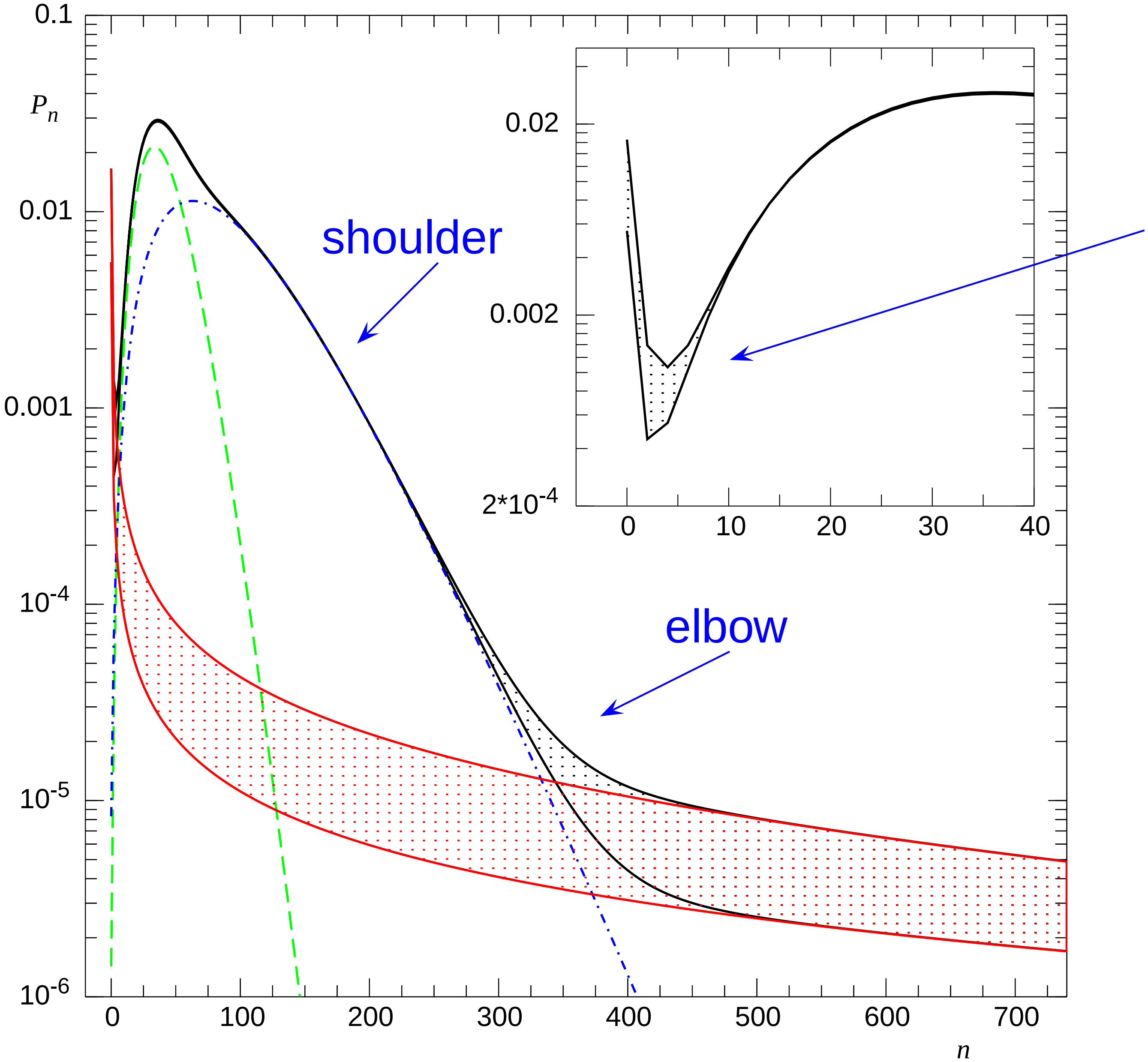


superposition of I and II class

shoulder = superposition of I and II class

elbow = superposition of II and III class

Our results (II)



superposition of I and II class

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