Comments on the "power law tail" from the SPS perspective

- The "power law tail" and its neighbors
- Collision energy dependence
- Connecting "soft" and "hard" domains

$m_T = (m^2 + p_T^2)^{1/2}$,

$E = m_T * cosh(y)$,

$f(m_T) = 1/m_T * dn/dm_T$

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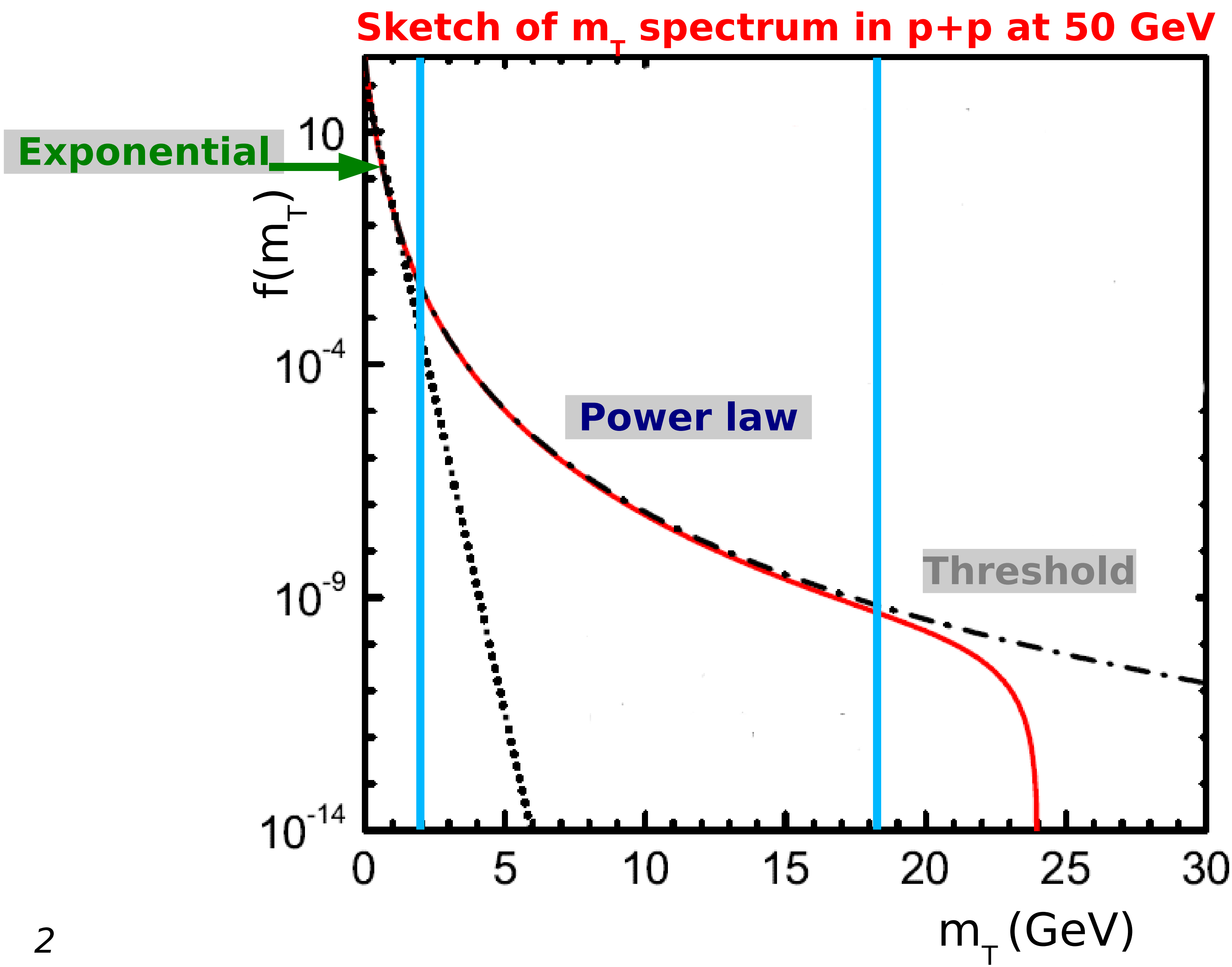
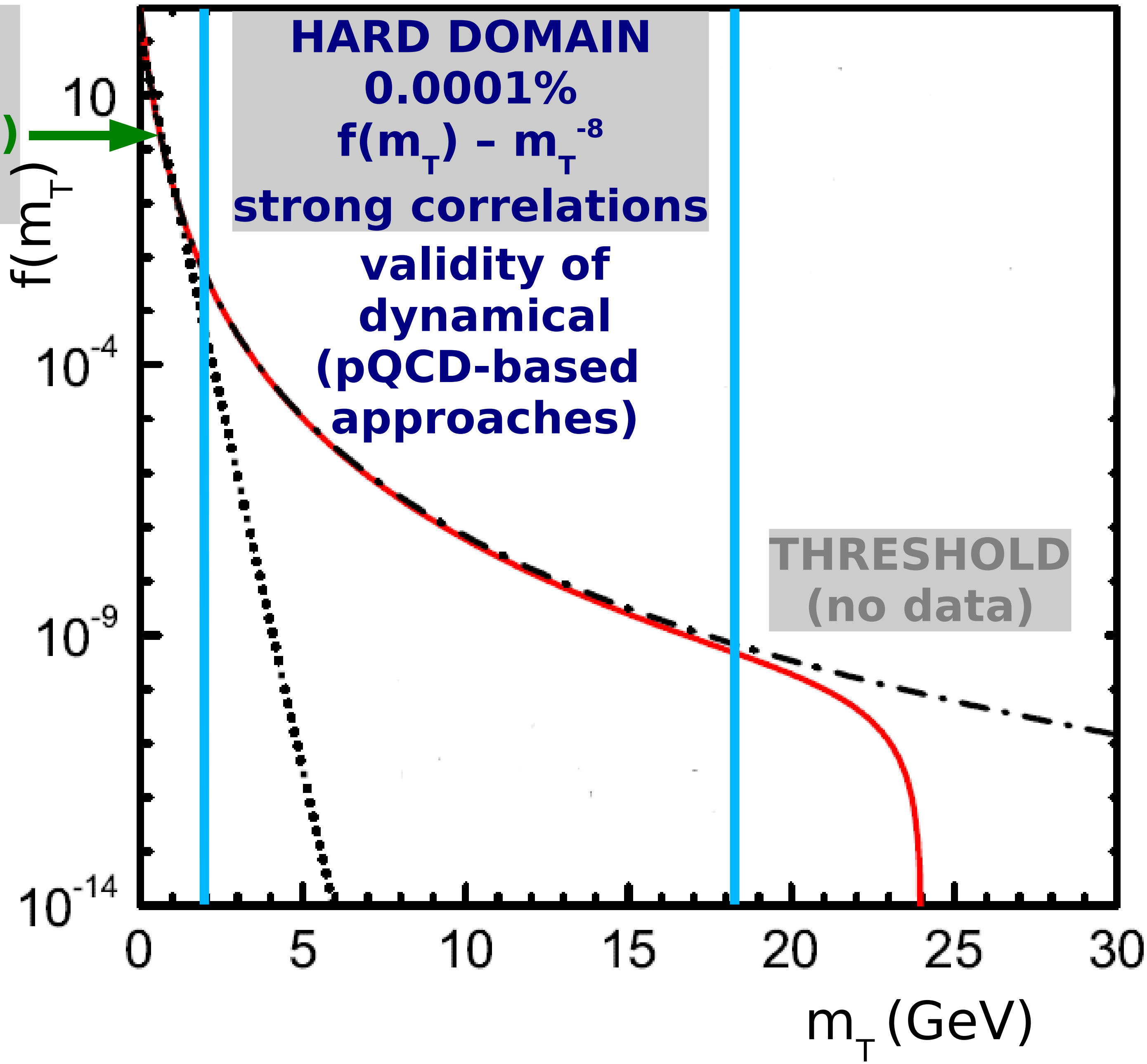
The “power law tail” and its neighbors

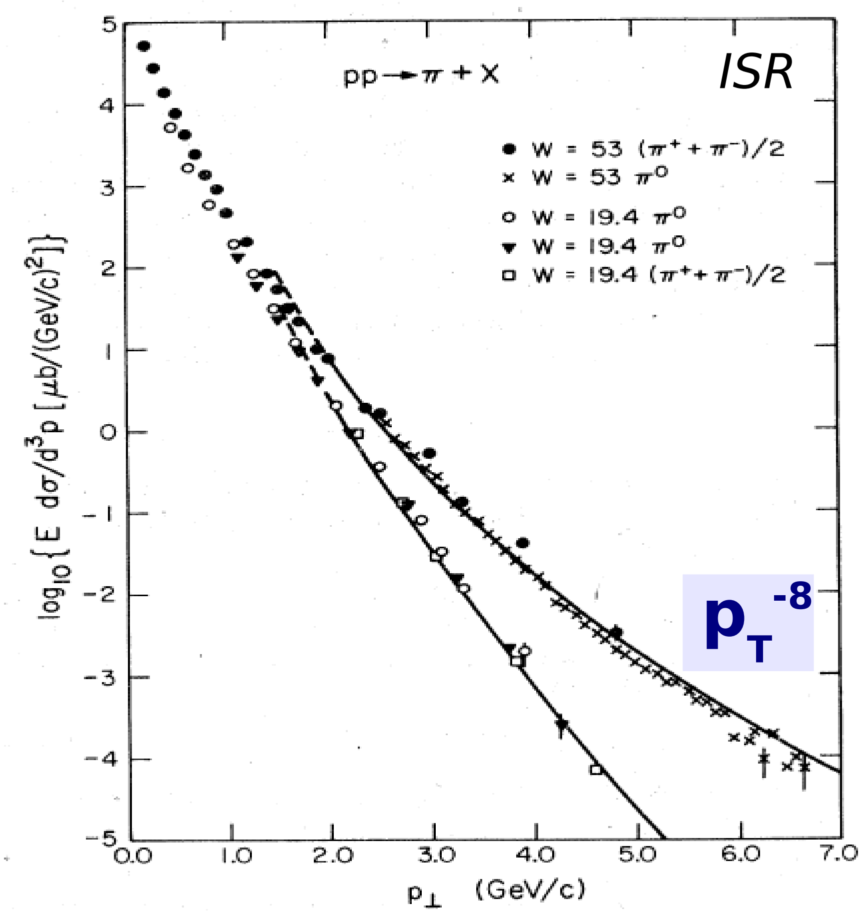


SOFT DOMAIN
99.9999%
$f(m_T) \sim \exp(-m_T/0.170)$
weak correlations

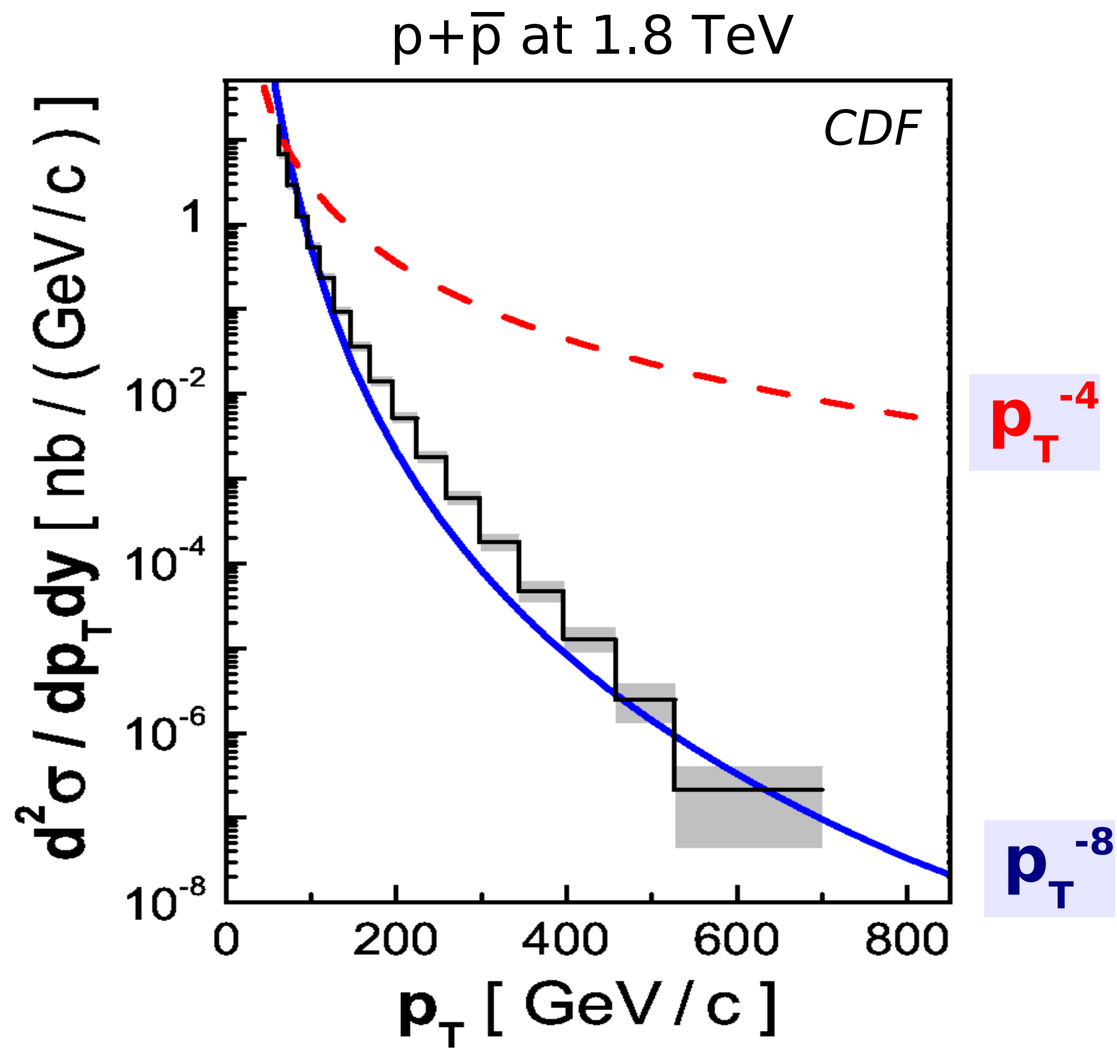
validity of statistical approaches



Collision energy dependence



Field, Feynman, PR D15 (1977) 2590



CDF: PR D64 (2001) 032001

In the collision energy range from tens of GeV (ISR) to several TeV (Tevatron, LHC)

the exponent of the power law tail is approximately independent of collision energy and p_T and it is about "-8"

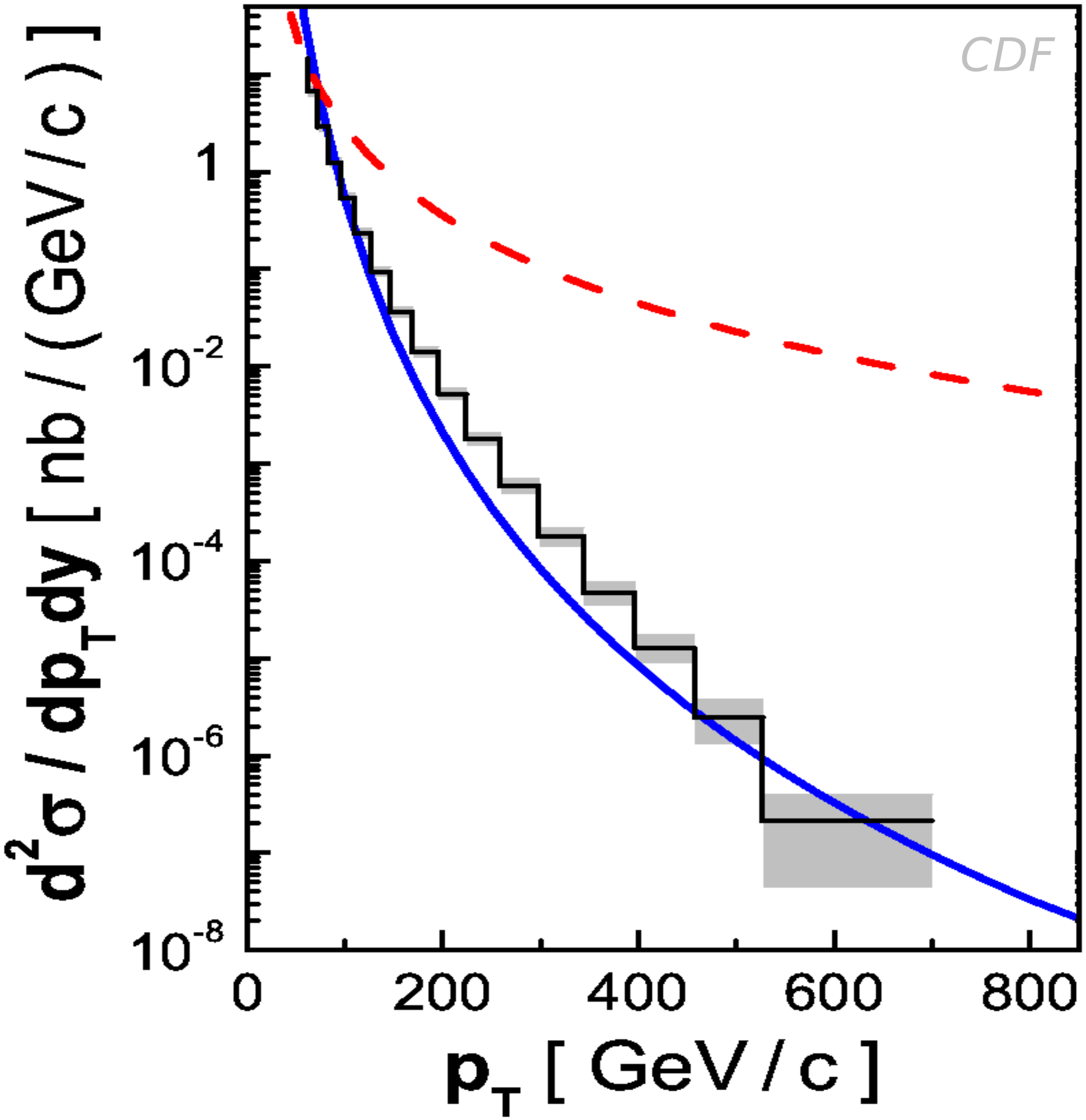
In 1976, based on the 50 GeV data, Field and Feynman wrote:

> Because of this, many theorists have suggested that we are not yet observing the fundamental interaction between partons, but some other more complex mechanism—and only at much larger energies will the expected $p_\perp^{-4}$ appear (after the other mechanism, falling as $p_\perp^{-8}$, has fallen away). There is no consensus on what this other mechanism, which is operating in the present experimental region, might be; very many theories are available.

Field, Feynman, PR D15 (1977) 2590

today many of us exlpain “-8” within
the QCD-based model of high p_T phenomena

p+$\bar{p}$ at 1.8 TeV



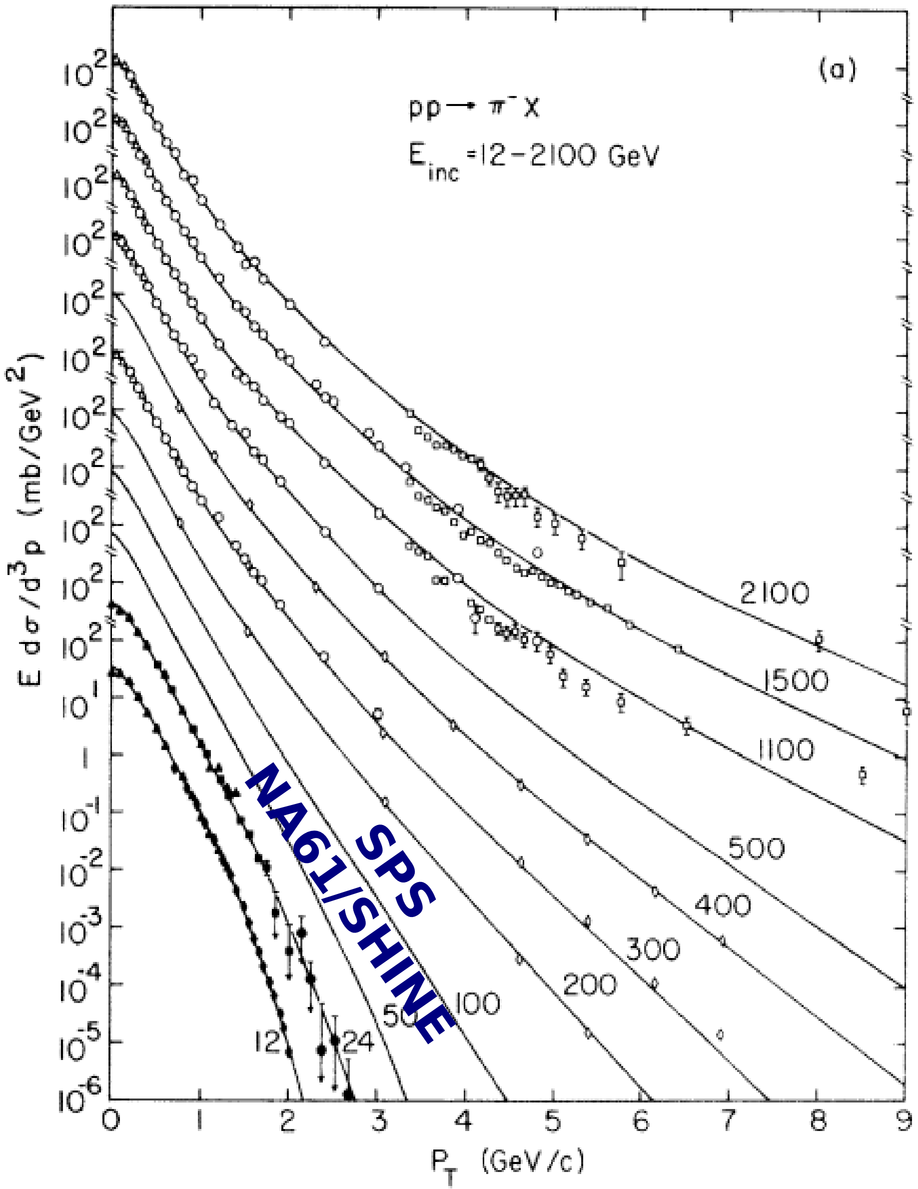
Field, Feynman:
asymptotic free theory:

p_T^{-4}

+
parton distribution,
parton fragmentation,
2 → 3 processes,
conservation laws

p_T^{-8}

The power law tail disappears in the SPS energy range



Phys. Rev. D18, 2235 (1978)

At about 10 GeV (LAB 100 GeV) **the longest exponential** decrease may be expected due to compensation of the power law and threshold trends

Connecting “soft” and “hard” domains

Statistical models of particle production are successful in describing mean multiplicities and spectra in the “soft” (exponential) domain.

For simplicity it is usually assumed that volume and energy of “statistically produced” matter does not vary from collision to collisions.

Collisions:

V, E

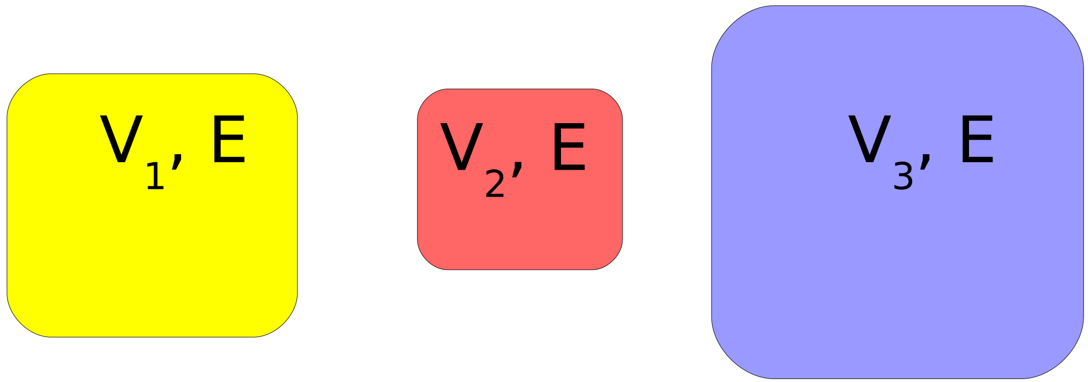
V, E

V, E

energy density in all collisions is the same and thus the spectra shape (exponential for $E \gg m$) varies only due to statistical fluctuations

Let us modify the most popular approach and assume that volume of "statistically produced" matter varies from collision to collisions.

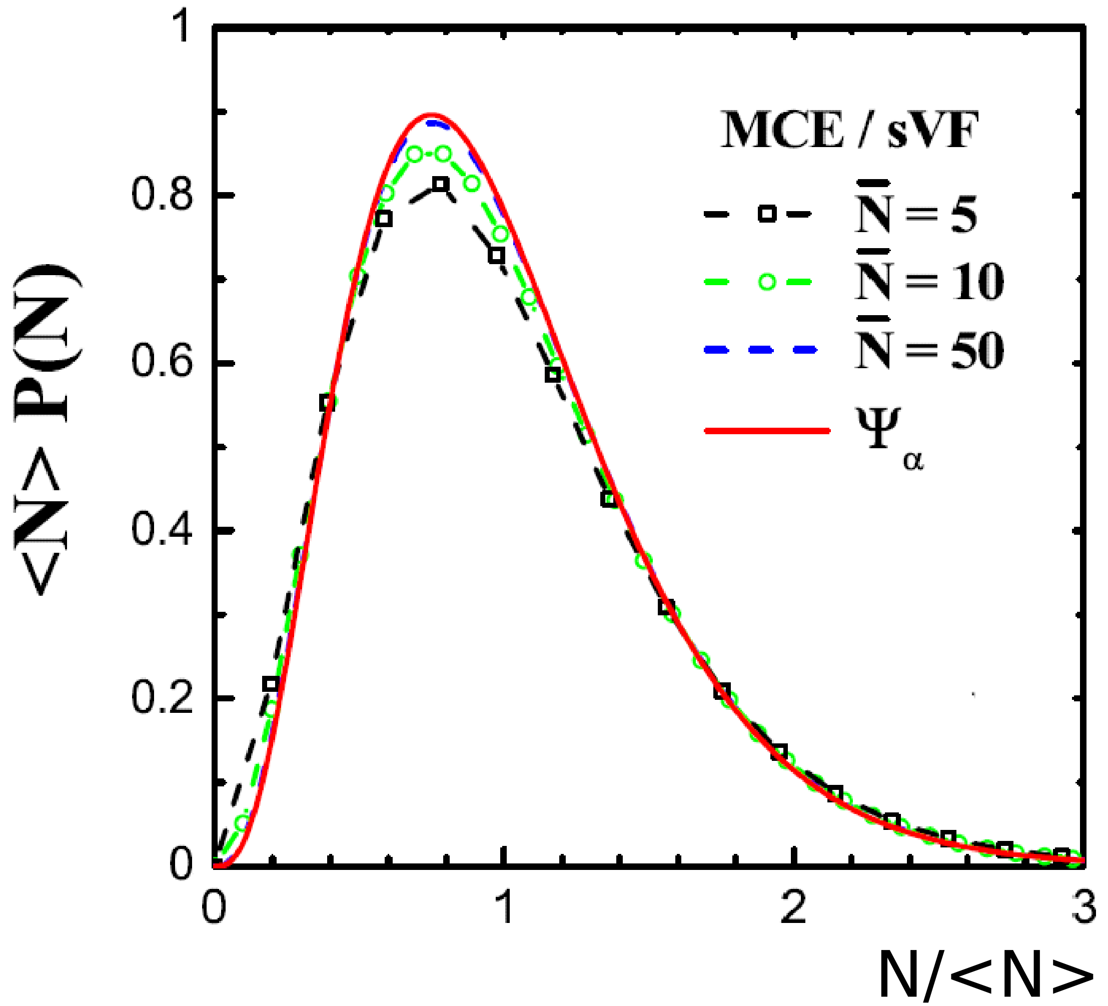
Collisions:



energy density varies from collision to collision and thus the spectra shape (exponetial for $E \gg m$) varies as well

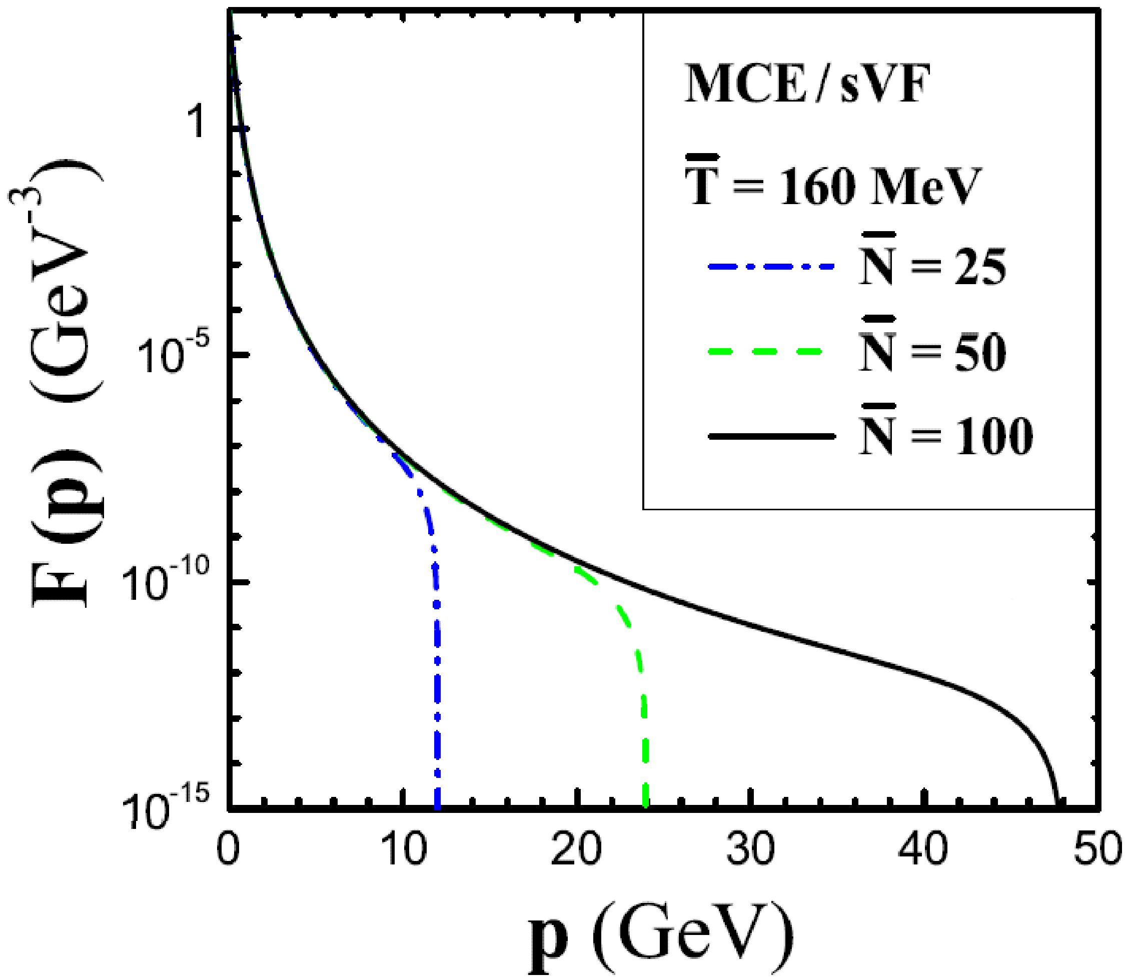
The resulting model is called
Micro-Canonical Ensemble with Scaling Volume Fluctuations, MCE/sVF
Phys.Rev. C78 (2008) 024904

The introduced volume distribution function can be fitted to multiplicity distribution of particles:



In p+p collisions multiplicity distributions obey the KNO scaling and thus the extracted volume fluctuations have a similar scaling property – collision energy dependence enters only via mean volume.

The resulting momentum spectra show surprising similarities to experimental data:



the exponential domain (assumed T = 160 MeV) is followed by the power law domain with the exponent “-8”
(it results from the model and the form of the KNO function)
which is terminated by the threshold decrease

Summary

The "power law tail" and its neighbors

The "power law tail" is surrounded by two narrow strips of the exponential and threshold decrease

Collision energy dependence

The exponent "-8" of the "power law tail" is approximately independent of collision energy and p_T from ISR to LHC energies

The "power law tail" disappears at the top SPS energies where the longest exponential domain is expected

Connecting "soft" and "hard" domains

Minimal extension of the statistical model by introducing volume fluctuations fitted to multiplicity distributions leads to the power law tail with the exponent "-8"