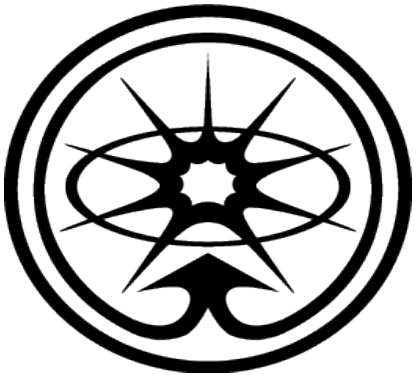

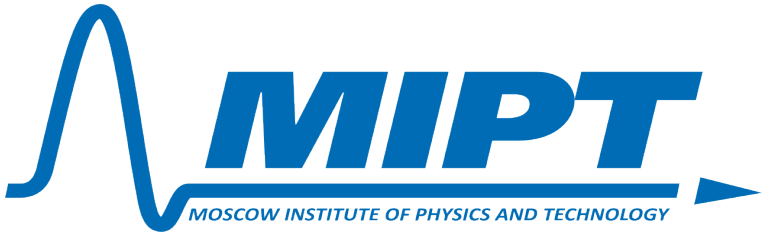



# New Phenomenological Model for Hadroproduction Tested with DIS at HERA

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On behalf of H1 Collaboration

Moriond QCD and High Energy Interactions
9-16 March, 2013

# Introduction

- Hadroproduction is studied in pp, ep, $\gamma\gamma$ collisions for 50 years
- Underlying dynamics of particle production is still not understood
- A new unified phenomenological approach is introduced

# Qualitative model

## Two contributions to hadron production

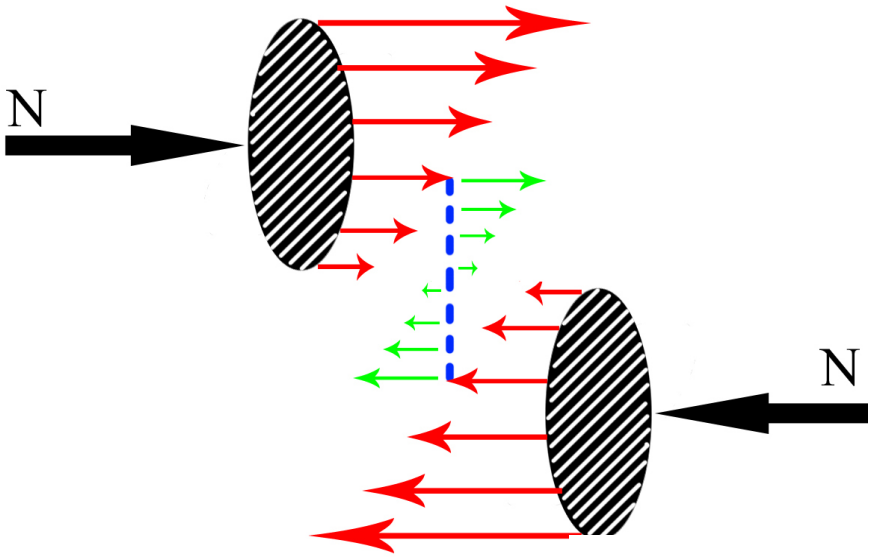
1. Radiation of hadrons by valence quarks

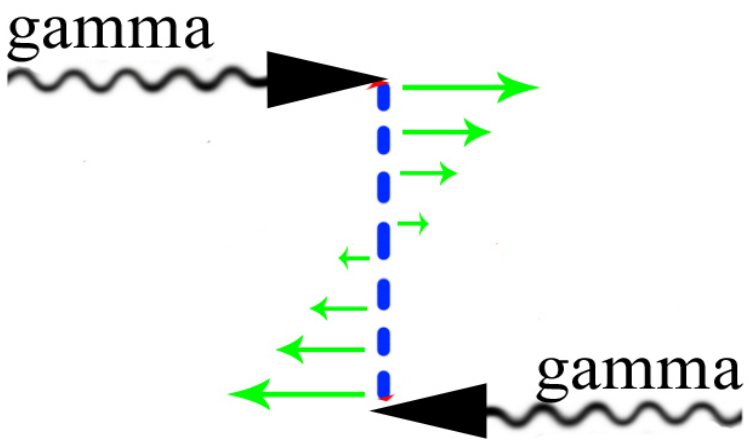
Theses partons exist long before the interaction and considered as a thermalized statistical state

⇨ Boltzmann-like exponential distribution

2. Virtual partons exchanged between colliding partonic systems

⇨ power-law spectrum (typical for pQCD)

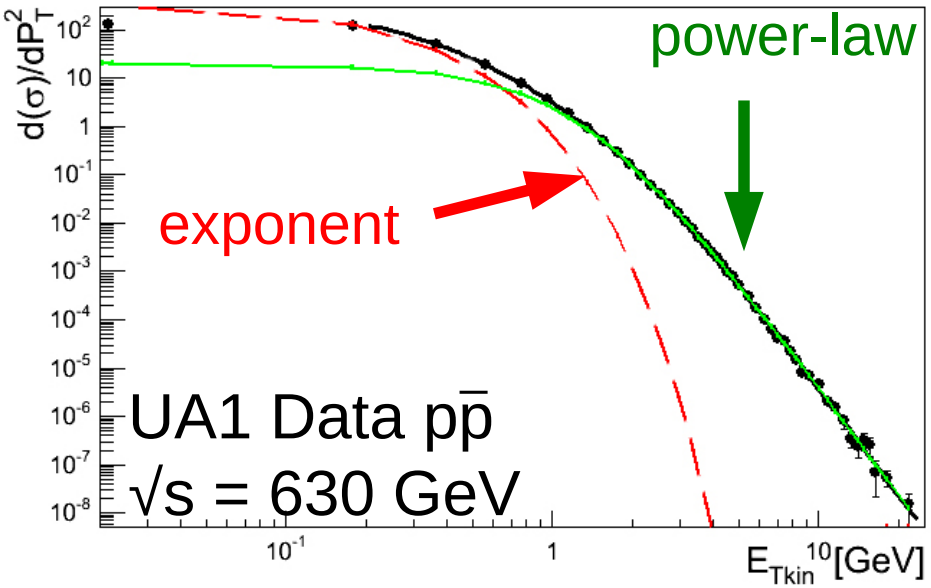


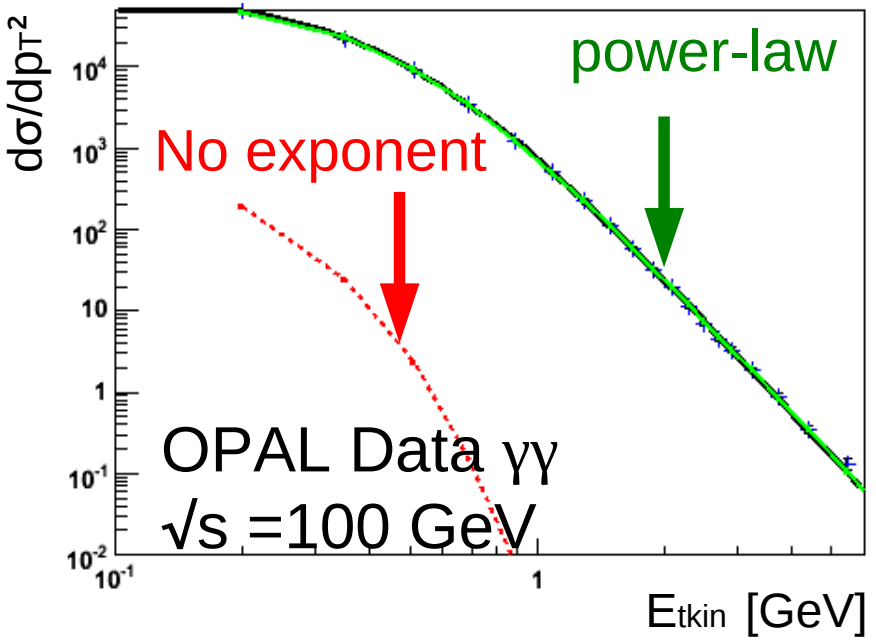




$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$

# Comparison of pp and γγ Spectra

$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$



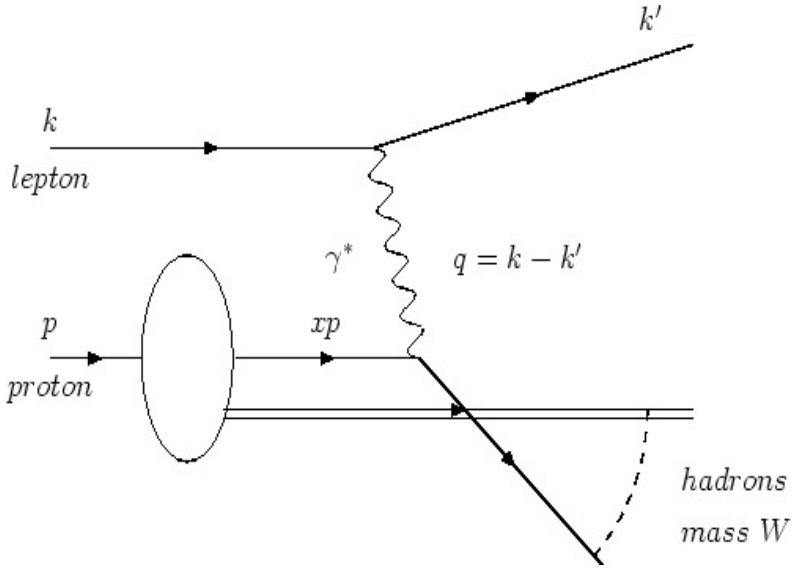



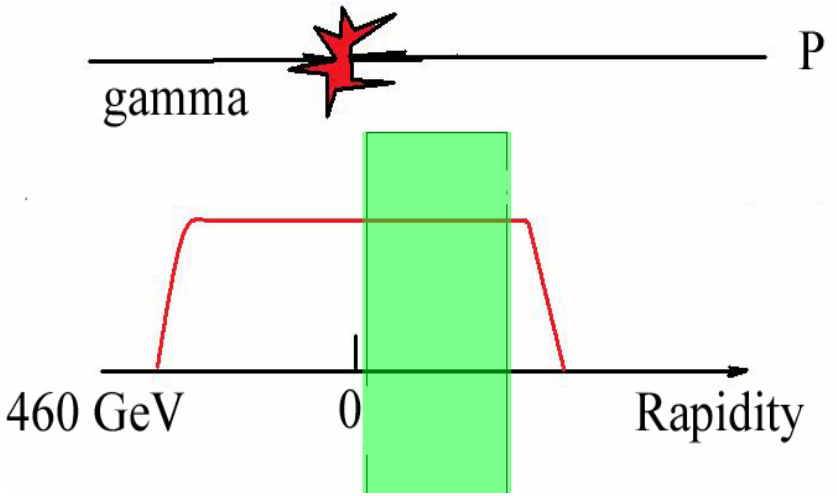

pp-collisions have large exponential term contribution

γγ-interactions are described by the power-law only

# What is in ep collisions?

## DIS at HERA is the unique possibility to study the change in hadroproduction dynamics



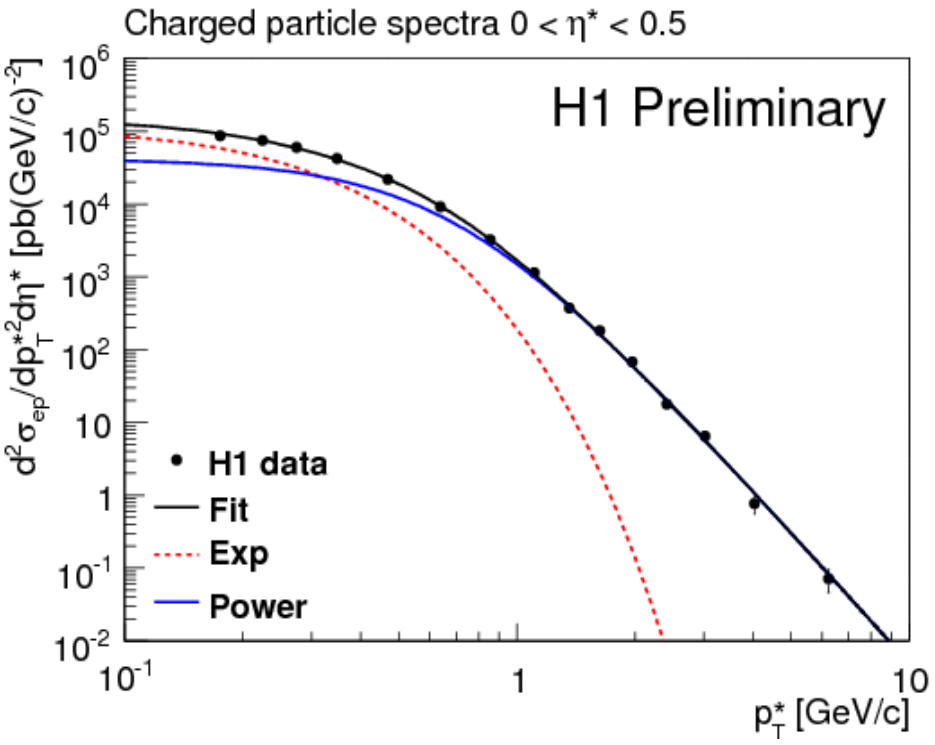

7 η* bins $0 < \eta^* < 3.5$

## New preliminary H1 results:

1. First Measurement of charged particles spectra in DIS at $\sqrt{s} = 225$ GeV (Ep = 460 GeV) $\mathscr{L} = 12.45 \text{pb}^{-1}$
2. High Y-values $0.35 < y < 0.8$
3. Low $Q^2$ $5 < Q^2 < 10$ GeV$^2$

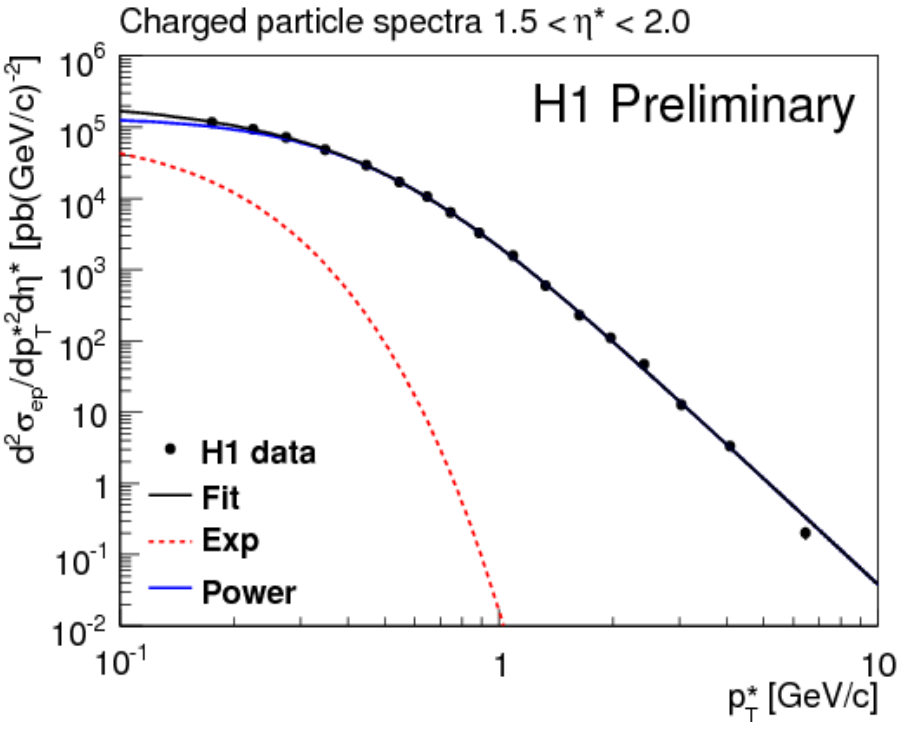
# Double differential cross-section

## Central rapidity




Large exponential contribution

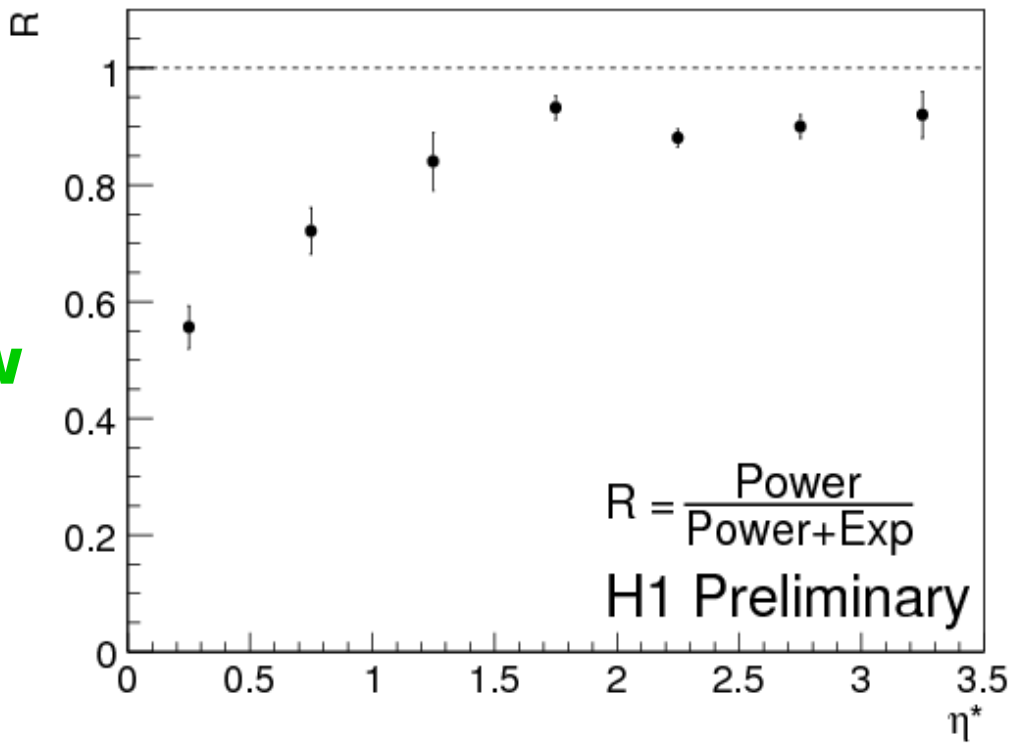
## Forward direction




Small exponential contribution

# Power-law term contribution

$$R = \frac{\text{Power-law}}{\text{Exp + Power-law}}$$




The power-law term contribution decreases with approaching the proton fragmentation region

As it is predicted by our model

# Conclusion

1. Qualitative model of charge particle production was introduced
2. The first measurement of DIS $d^2\sigma/dp^*T^2d\eta^*$ at $\sqrt{s} = 225$ GeV in H1 experiment was performed in seven $\eta^*$ bins.
3. The change in hadroproduction dynamics between proton and photon sides was studied.
4. Agreement between qualitative prediction of the proposeded phenomenological model and experimental data was found.

Thank you for your attention!

# Other predictions of the introduced model have been already tested

1. Exponential term is due to valence quarks

   → Spectra in yy-collisions should have power-law term only

   [1] Systematic studies of hadron production spectra in collider experiments
   *A.Bylinkin and A.Rostovtsev*, **arXiv:1008.0332 [hep-ph].**

2. QCD-fluctuations are democratic to quark flavour

   → Kaon spectra should have less exponential distribution then pion

   [2] Anomalous behavior of pion production in high energy particle collisions
   *A.Bylinkin and A.Rostovtsev,* **Eur.Phys.J.C 72(2012)1961,**

   [3] Comparative Analysis of Pion, Kaon and Proton Spectra Produced at PHENIX
   *A.Bylinkin and A.Rostovtsev*, **arXiv:1203.2840 [hep-ph].**

3. Charge multiplicity is proportional to the number of Pomerons involved

   → Exponential contribution will decrease with the increase of multiplicity

   [4] An analysis of charged particles spectra in events with different charged multiplicity. *A.Bylinkin and A.Rostovtsev*, **arXiv:1205.4432 [hep-ph].**

4. In proton fragmentation region the role of valence quarks is more important

   → Dominance of exponential term in the high rapidity region

   [5] A variation of the charged particle spectrum shape as function of rapidity in high energy pp collisions. *A.Bylinkin and A.Rostovtsev*, **arXiv:1205.6382.**

5. The number of pomerons involved is increasing with the growth of the collision energy

   → Power-law contribution will increase with the increase of √s

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# R Value

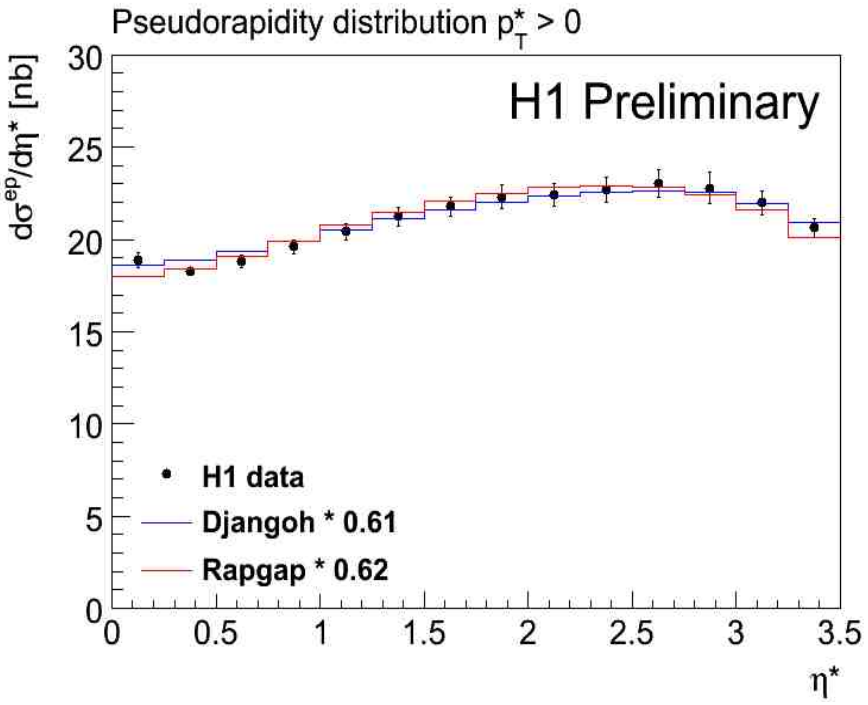
The relative contribution of exponential and power-law terms can be calculated by integrating each term by transverse momentum from 0 to the upper bound of the kinematical region

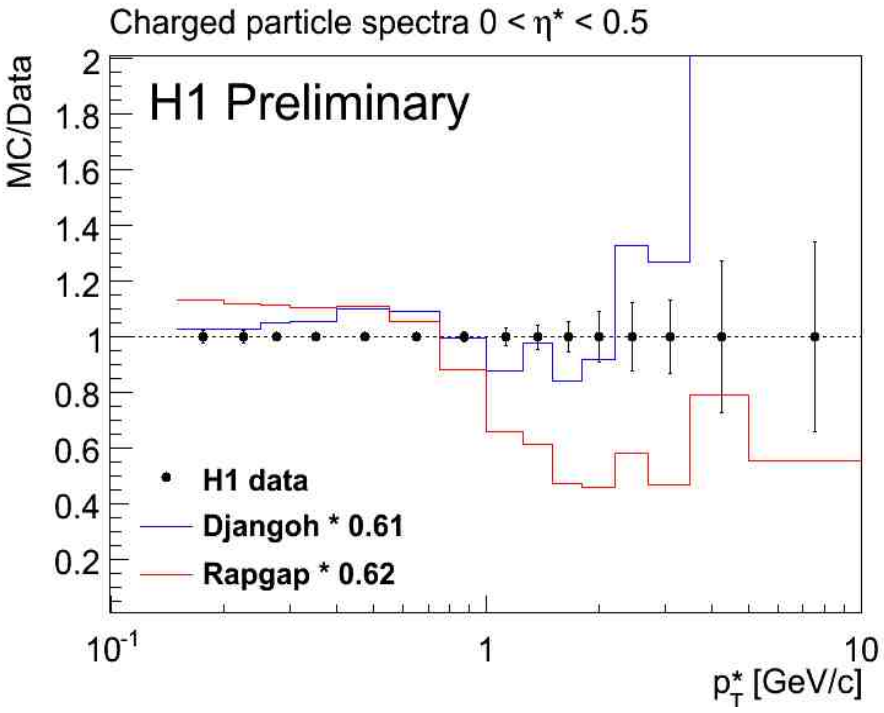
$$\int_0^\infty \frac{A}{(1+\frac{P_T^2}{TN})^N} dP_t^2 = \frac{ANT}{N-1}$$

$$A_e \int_0^\infty exp(-E_{Tkin}/T_e) dP_t^2 = A_e(2mT_e + 2T_e^2)$$

$$R = \frac{ANT}{ANT + A_e(2mT_e + 2T_e^2)(N-1)}$$

# Comparison with MC



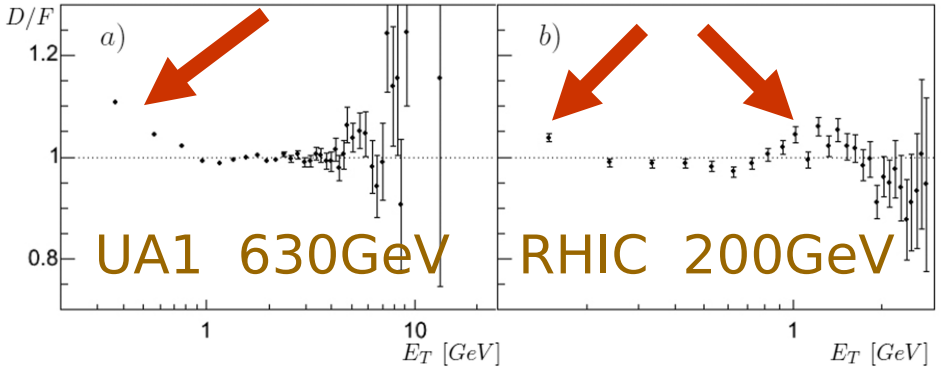



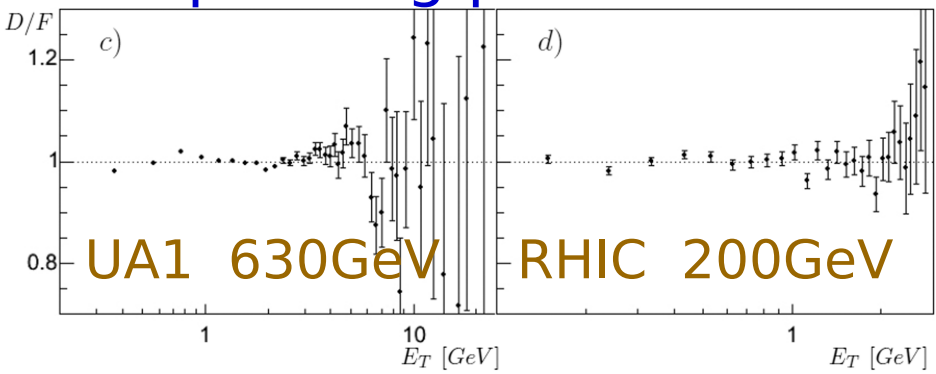

Monte Carlo describes the η* distribution rather well, but NOT the spape of the $P_T$ spectra

# Why our approach is better?

Systematic defects in the data description using traditional approach

Experimental data divided over the values of the fit function in corresponding points



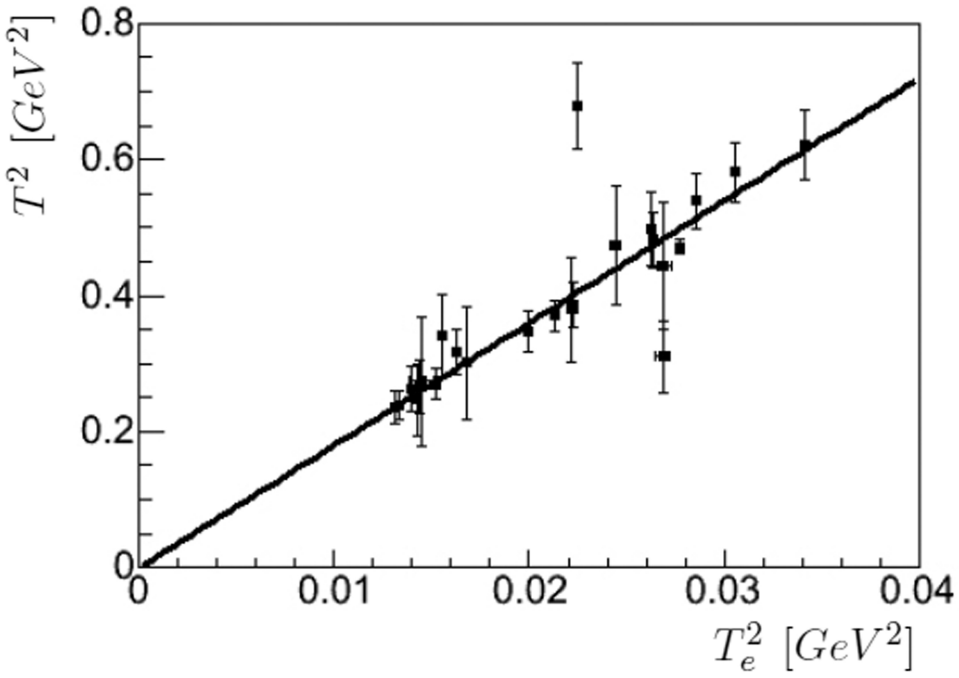

$\chi^2$/ndf = 288/44 $\chi^2$/ndf = 87/25 $\chi^2$/ndf = 54/42 $\chi^2$/ndf = 22/23

$$\frac{d^2\sigma}{\pi dy d(p_T^{\,2})} = \frac{A}{(1+\frac{E_{Tkin}}{T*N})^N}$$

$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$

The new parameterization shows much better approximation of the experimental data.

# Correlation Between Parameters




T and Te parameters in the power-law and exponential terms of the fit function are strongly correlated with each other

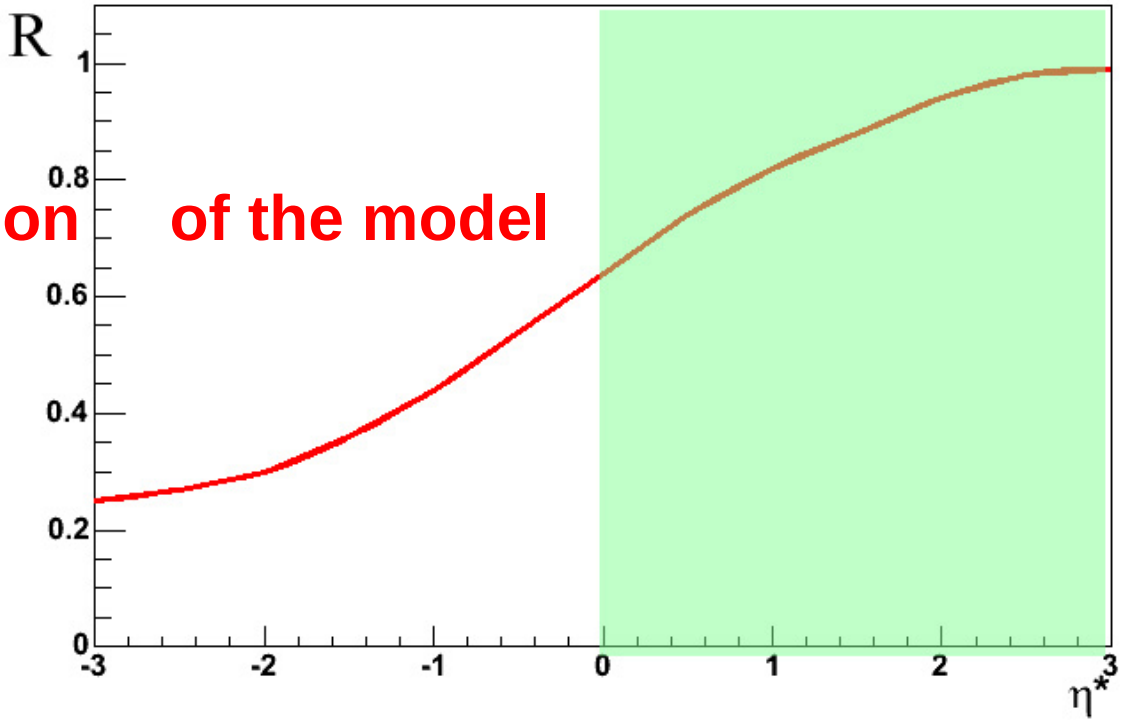
$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$

Better approximation is not just a result of exceeding the number of parameters of the fit function

# Expected Results for DIS

$$\frac{d^2\sigma}{\pi dy(dp_t^2)} = A_1 exp(-E_{Tkin}/T_e) + \frac{A_2}{(1+\frac{P_T^2}{T^2 N})^N}$$

**Qualitative prediction of the model**

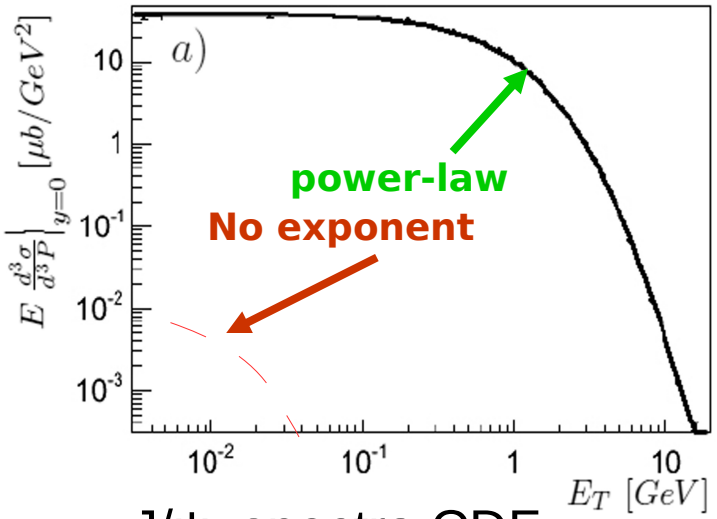


# Type of produced particle

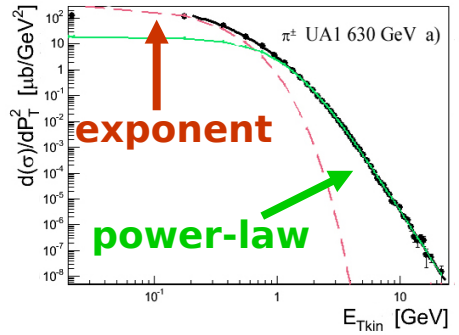
QCD-fluctuations are democratic to quark flavour while valence quark radiation can't produce heavy flavours

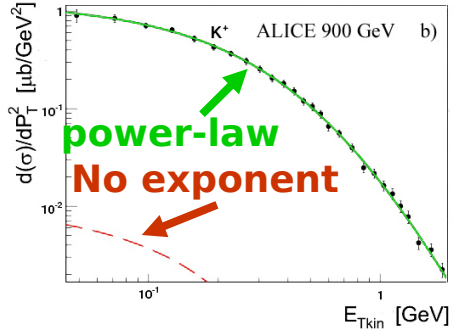
**Prediction:** Kaon (and J/ψ) spectra should have less exponential contribution then pion

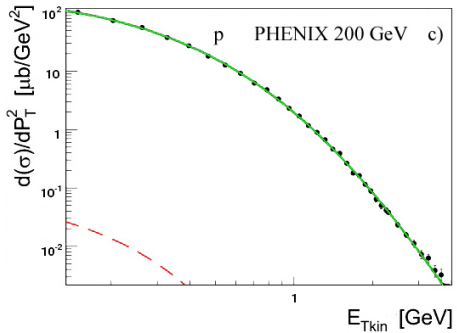
$$R = \frac{\text{Power-law}}{\text{Exp + Power-law}}$$

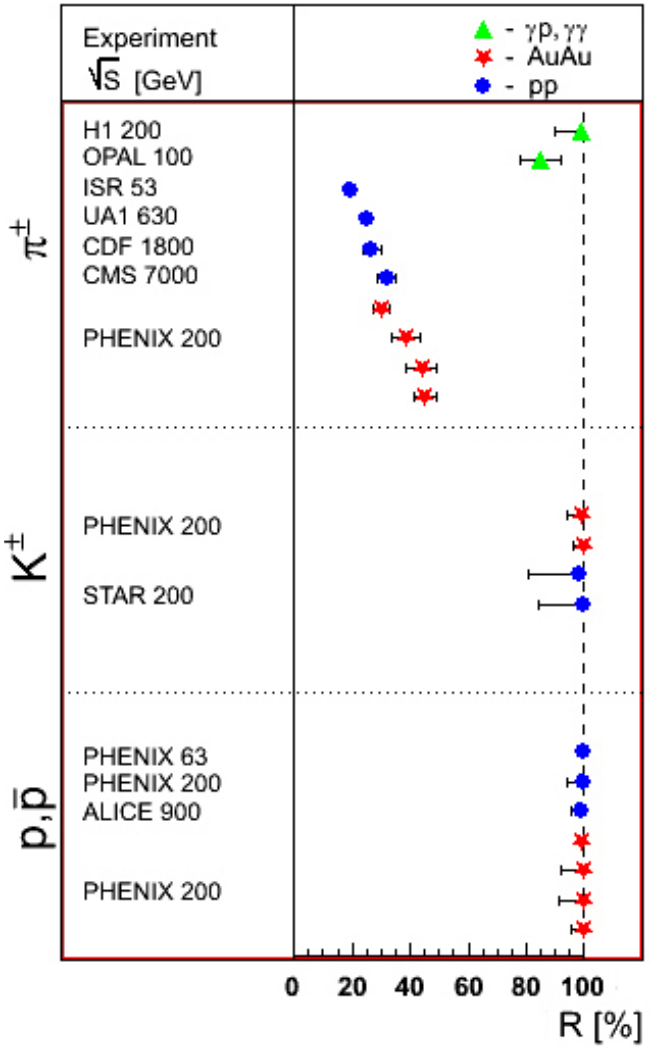



J/ψ spectra CDF
√s = 1.96 TeV



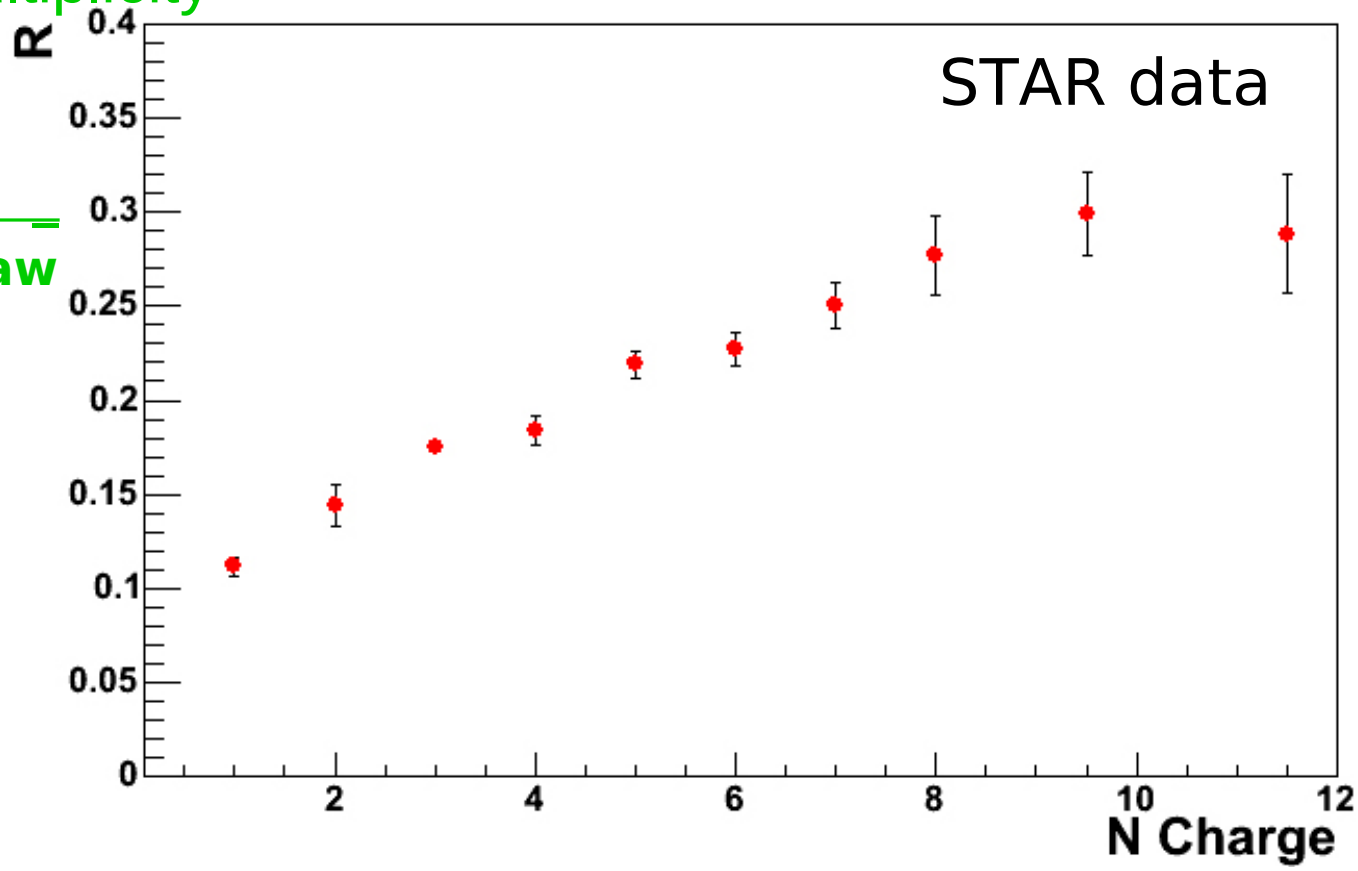



# Dependence of the spectra shape on multiplicity

Charge multiplicity is proportional to the number of Pomerons involved

Prediction: Power-law contribution will increase with the increase of multiplicity

$$R = \frac{\text{Power-law}}{\text{Exp + Power-law}}$$

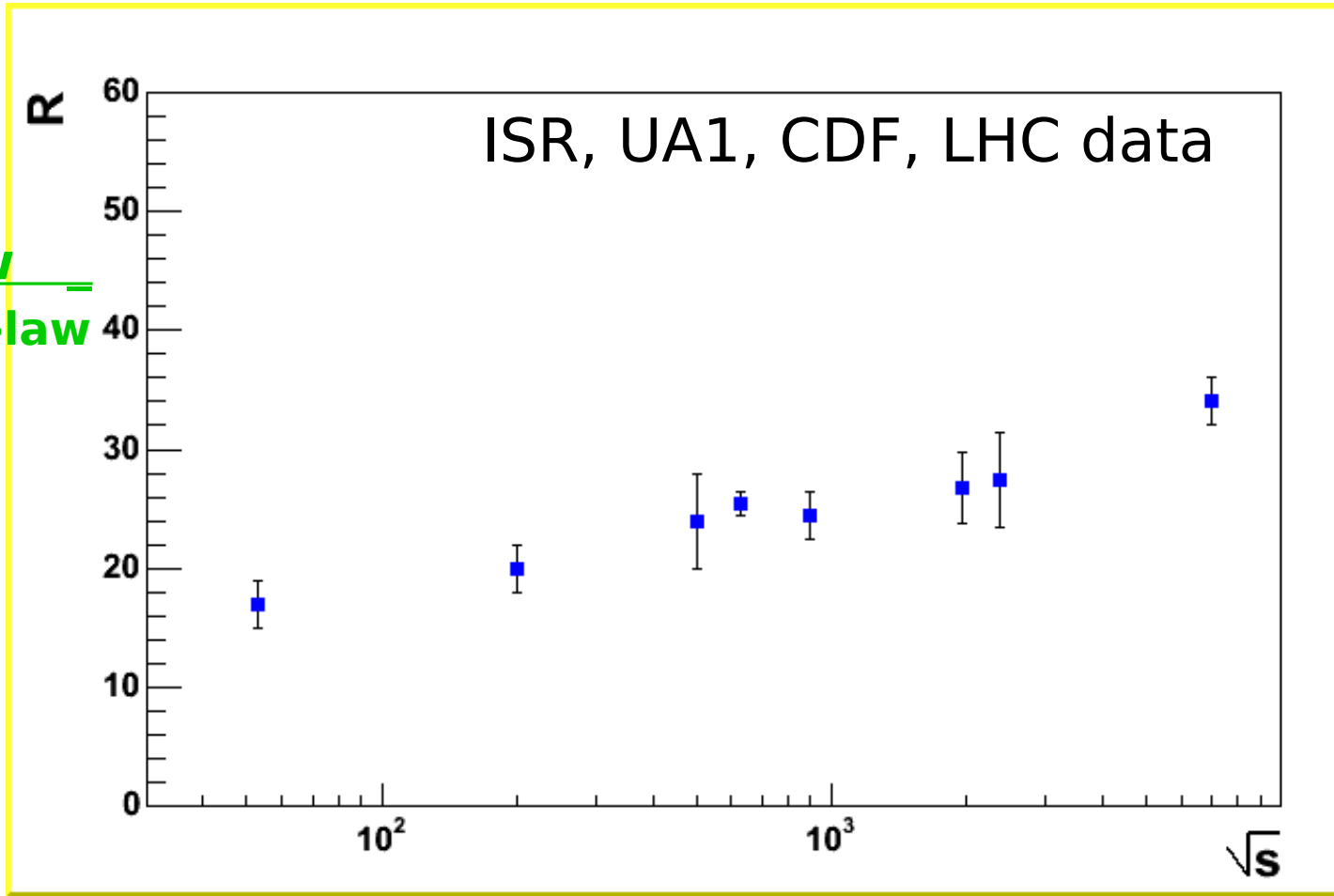


# Energy of Collision

The number of pomerons involved is increasing with the growth of the collision energy

Prediction: Power-law contribution will increase with the increase of √s

$$R = \frac{\text{Power-law}}{\text{Exp + Power-law}}$$



# Dependence of the spectra shape on pseudorapidity

In proton fragmentation region the role of valence quarks is more important

Prediction: Dominance of exponential term in the high rapidity region

Charge particle pseudorapidity distribution at √s ~ 630 Gev