An Eikonal Approach for Inelastic pp/p(bar)p Collisions

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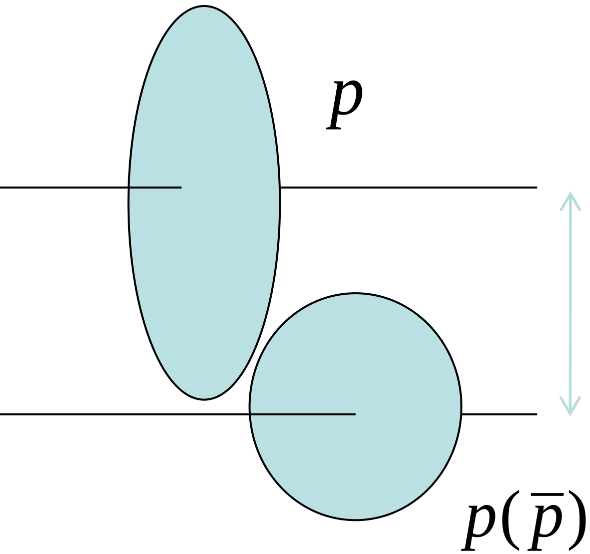


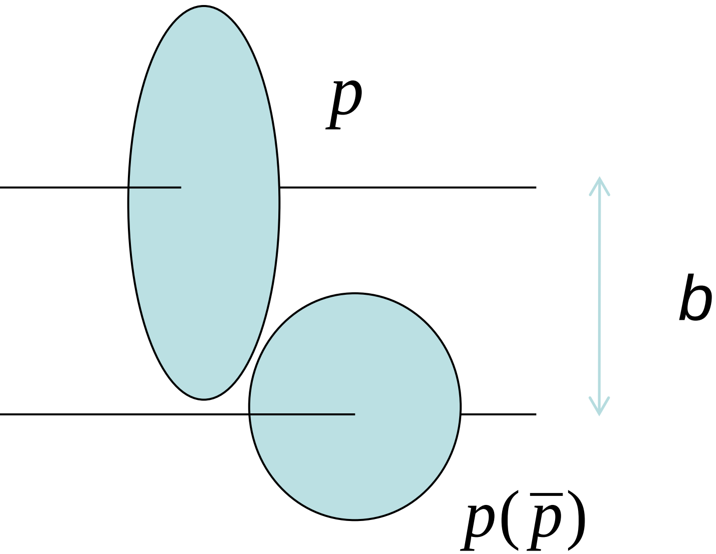
b → impact parameter

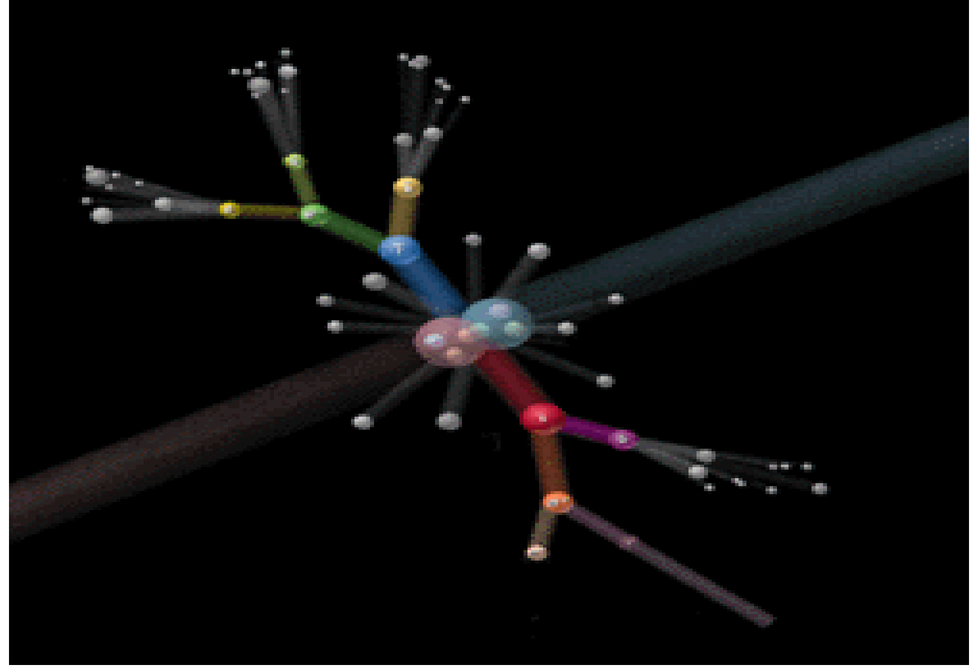
(distance between the two collinding centers)

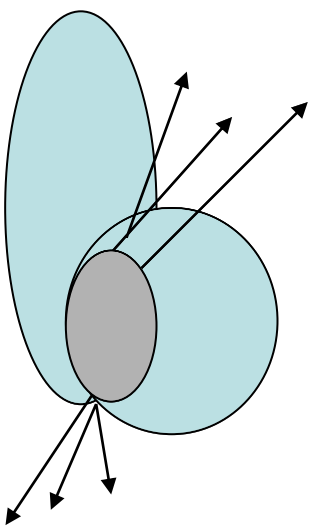
Proton / antiproton → treated as spatially extended objects and the the impact parameter formalism is used.

This approach alows description of experimental data (from elastic and inelastic channels) if the **eikonal function** is given.

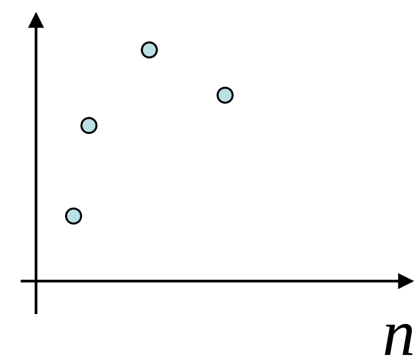
(total and elastic differential cross sections, multiplicity distribution, inelasticity...)







Multiplicity Distribution - or -
Probabilities of n-particle production → P_n



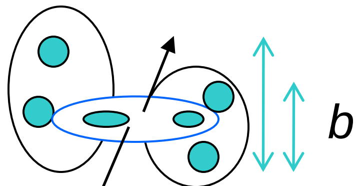
$$P_n(s) = \frac{\sigma_n(s)}{\sigma_{in}(s)}$$

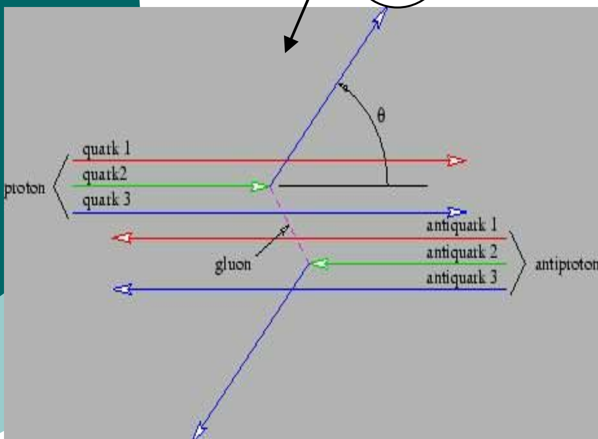
$\sigma_n(s)$ → topological cross section →(Cross section of n-particle production)

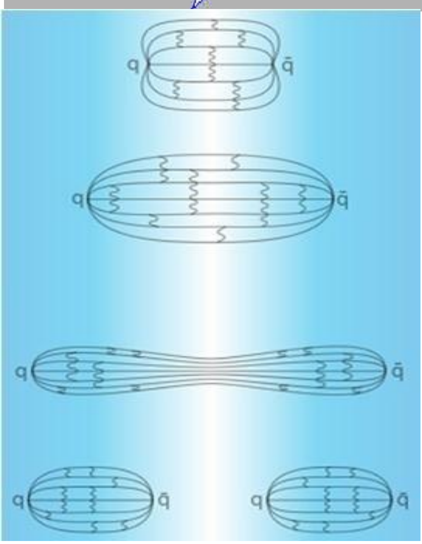
$\sigma_{in}(s)$ → Inelastic cross section

$$P_n(s) = f(b)$$

PHYSICAL PICTURE







- BASIC FORMALISM -

$$P_n(s) = f(b)$$ → *may* be constructed by summing contributions coming from *pp* collisions taking place at fixed impact parameter *b*

$$P_n(s) = \frac{\sigma_n(s)}{\sigma_{in}(s)} = \frac{\int_0^\infty Gin(s,b)\left[\frac{\sigma_n(s,b)}{\sigma_{in}(s,b)}\right] bdb}{\int_0^\infty Gin(s,b)bdb}$$

$\sigma_n(s)$ → (is) decomposed into contributions from each *b*

Gin(b) → INELASTIC OVERLAP FUNCTION (weight function)

Gin is related with the Eikonal by →

$$Gin(s,b) = 1 - e^{-2\chi_I(s,b)}$$

$$\chi_{pp}{}^{p\bar{p}}(s,b) = \chi_R(s,b) \pm i\chi_I(s,b)$$

Assumed:

- quantity in brackets → obey KNO scaling;

$$P_n(s) = \frac{\int d^2b \frac{G_{in}(s,b)}{} \left[\frac{\sigma_n(s,b)}{\sigma_{in}(s,b)} \right]}{\int d^2b G_{in}(s,b)}$$

- *<n(s,b)>* → average multiplicity at *b* (and √s)

$$P_n(s) = \frac{\int d^2b \frac{G_{in}(s,b)}{< n(s,b) >} \left[< n(s,b) > \frac{\sigma_n(s,b)}{\sigma_{in}(s,b)} \right]}{\int d^2b G_{in}(s,b)}$$

- multiplicity distribution (for each *b*) is introduced : $\Psi(\frac{n}{< n(s,b) >}) = < n(s,b) > \frac{\sigma_n(s,b)}{\sigma_{in}(s,b)}$

- factorizes as : *<n(s,b)>=<N(s)>.f(s,b);*
- *<N(s)>* → average multiplicity at √s;
- *f(s,b)* → multiplicity function;

$$P_n(s) = \frac{\int d^2b \frac{G_{in}(s,b)}{< N(s) > f(s,b)} \left[\Psi(\frac{n}{< N(s) > f(s,b)}) \right]}{\int d^2b G_{in}(s,b)}$$

$$< N(s) > P_n(s) = \frac{\int d^2b \frac{G_{in}(s,b)}{f(s,b)} \left[\Psi(\frac{z}{f(s,b)}) \right]}{\int d^2b G_{in}(s,b)}$$

$$z = \frac{n}{< N(s) >}$$

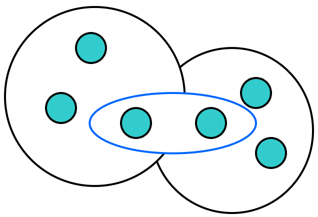
"Master Equation"

$$< N(s) > P_n(s) = \frac{\int d^2b \frac{G_{in}(s,b)}{f(s,b)} \left[\Psi\left(\frac{z}{f(s,b)}\right) \right]}{\int d^2b G_{in}(s,b)}$$

"Master Equation"

from the Master Equation we can construct two models:

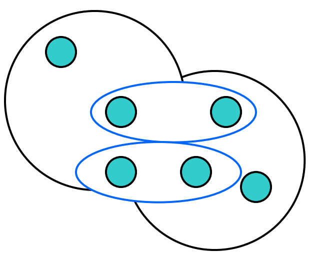
Simple One String Model: → we are assuming that just one string is created



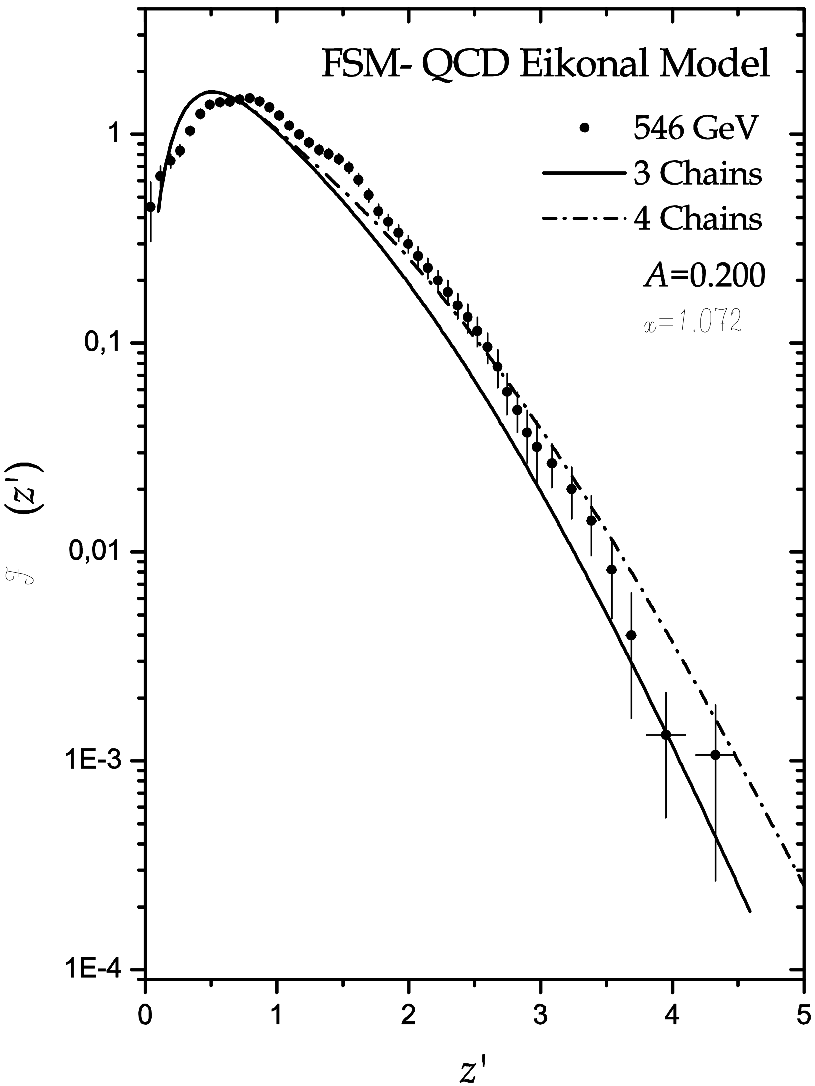
Talk → SOSM

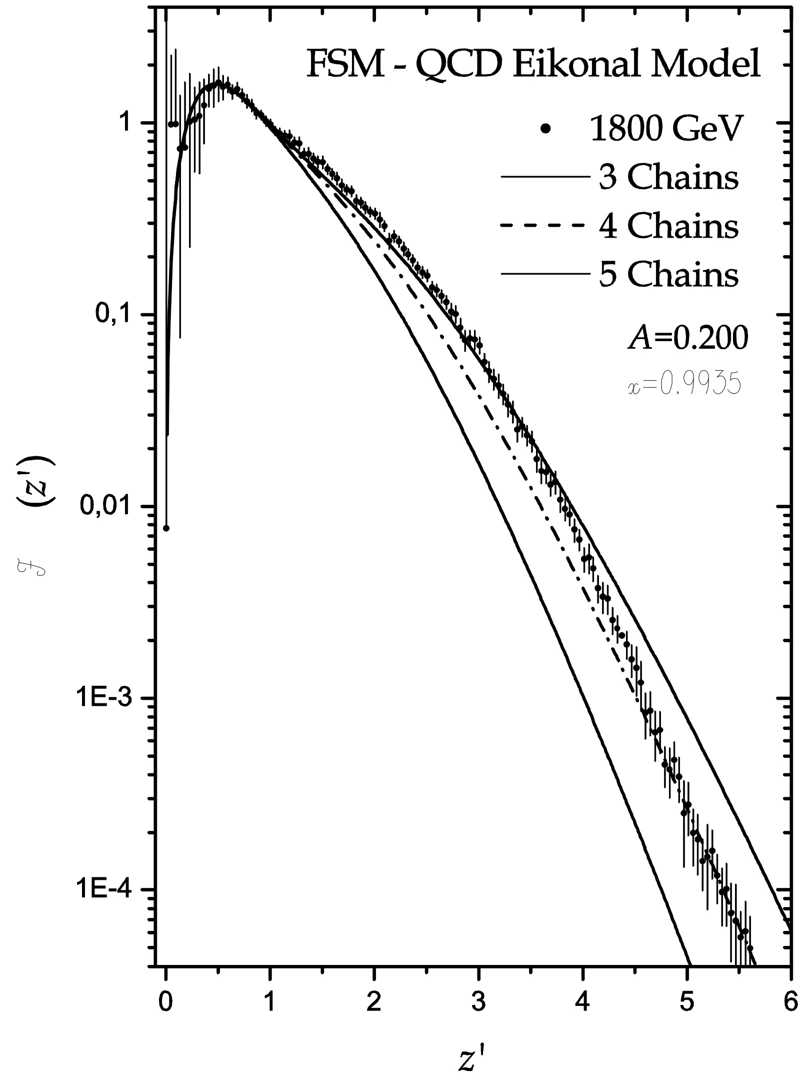
Multiplicity distributions; Inelasticity;

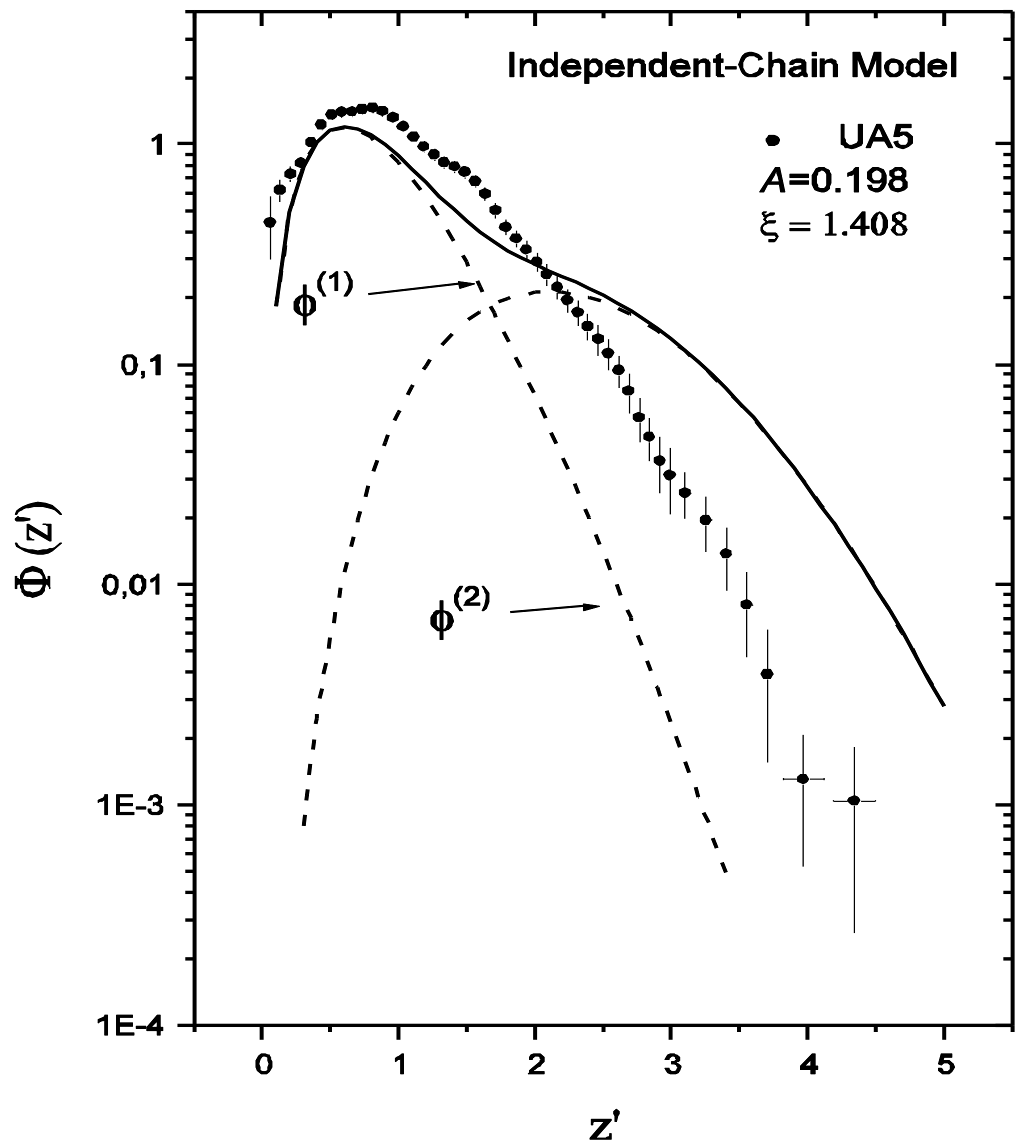
Fused String Model → in each parton-parton collision a string is created;
→ Multistring formation.



$$Gin(s,b) = 1 - e^{-2\chi_I(s,b)} = \sum_{i=1}^{\infty} \frac{[2\chi_I(s,b)]^i}{i!} e^{-2\chi_I(s,b)} \equiv \sum_{i=1}^{\infty} G^{(i)}(s,b)$$


FSM- QCD Eikonal Model
546 GeV
3 Chains
4 Chains
A=0.200
x=1.072
z'


FSM - QCD Eikonal Model
1800 GeV
3 Chains
4 Chains
5 Chains
A=0.200
x=0.9935
z'



Independent-Chain Model
UA5
A=0.198
ξ = 1.408
φ(1)
φ(2)
Φ (z')
z'
1
0,1
0,01
1E-3
1E-4
0
1
2
3
4
5

Simple One String Model:

Master Equation :
$$< N(s) > P_n(s) = \Phi(s,z) = \frac{\int d^2b \frac{G_{in}(s,b)}{f(s,b)}\left[\Psi\left(\frac{z}{f(s,b)}\right)\right]}{\int d^2b G_{in}(s,b)}$$

$$f(s,b) \to \chi_{pp}^{p\bar{p}}$$

$$1) < n(s,b) >= \gamma.(E_{eff})^A$$

$$2) E_{eff} = \beta(s)\chi_I(s,b)$$

$$\longrightarrow$$

$$< n(s,b) >= \gamma\beta(s)^{2A}[\chi_I(s,b)]^{2A};$$

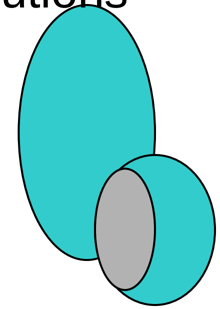
$$< n(s,b) >=< N(s) > f(s,b)$$

$$\downarrow$$

$$f(s,b) = \xi(s)[\chi_I(s,b)]^{2A}$$

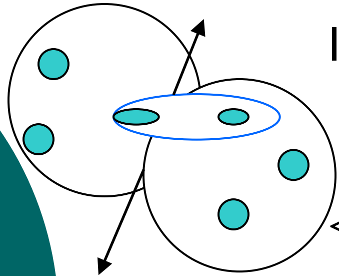
Multiplicity Distribution Equation → SOSM
$$< N(s) > P_n(s) = \Phi(z) = \frac{\int d^2b \frac{[1-e^{-2\chi_I(s,b)}]}{\xi(s)[\chi_I(s,b)]^{2A}}\left[\Psi\left(\frac{z}{\xi(s)[\chi_I(s,b)]^{2A}}\right)\right]}{\int d^2b[1-e^{-2\chi_I(s,b)}]}$$

Eq. (2) → Physical motivation: Eikonal → may be interpreted as an overlap, of two colliding matter distributions



→ S. Barshay, Phys. Rev. Lett. 49 (1982) 380.

Eeff → is the energy deposited at *b* for particle production



INPUTS and RESULTS :

$$< N(s) > P(s) = \Phi(s,z) = \frac{\int d^2b \frac{[1-e^{-2\chi_I(s,b)}]}{\xi(s)[\chi_I(s,b)]^{2A}} \left[\Psi\left(\frac{z}{\xi(s)[\chi_I(s,b)]^{2A}} \right) \right]}{\int d^2b[1-e^{-2\chi_I(s,b)}]}$$

INPUTS: We have adopted...

$$\chi_{pp}^{p\bar{p}}(s,b) = \chi_{R(s,b)} + i\chi_I(s,b)$$ →from work of Block et al.

$$\chi_{pp}^{p\bar{p}}(s,b) = \chi_{qq}(s,b) + \chi_{qg}(s,b) + \chi_{gg}(s,b) \pm \chi^{-}(s,b)$$

$$\Psi(z) = 2\frac{k^k}{\Gamma(k)}[z]^{k-1}e^{-k[z]} \longrightarrow \quad k = 10.8$$ → *gg* contribution dominates at high energies

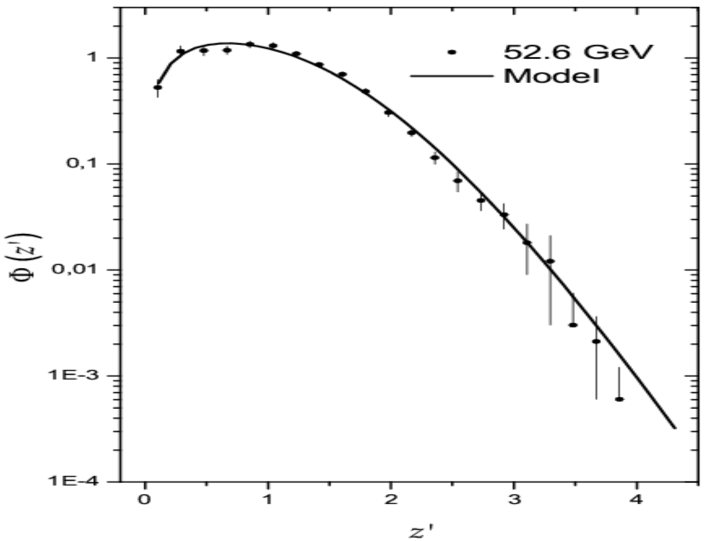
$$A = 0.258 \longrightarrow \quad < n(s,b) >= \gamma.(E_{eff})^A$$

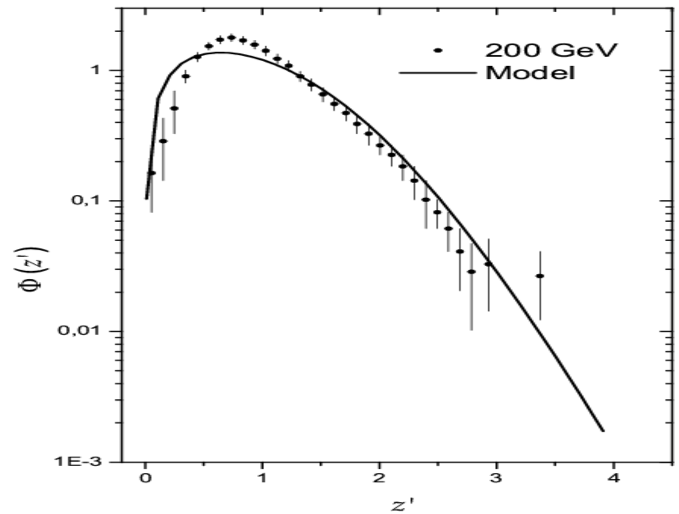
$$\int_0^\infty \Phi_{(s,z)}.z.dz = 2 \rightarrow \xi(s) = \frac{\int d^2b[1-e^{-2\chi_I(s,b)}]}{\int d^2b[1-e^{-2\chi_I(s,b)}][\chi_I(s,b)]^{2A}}$$

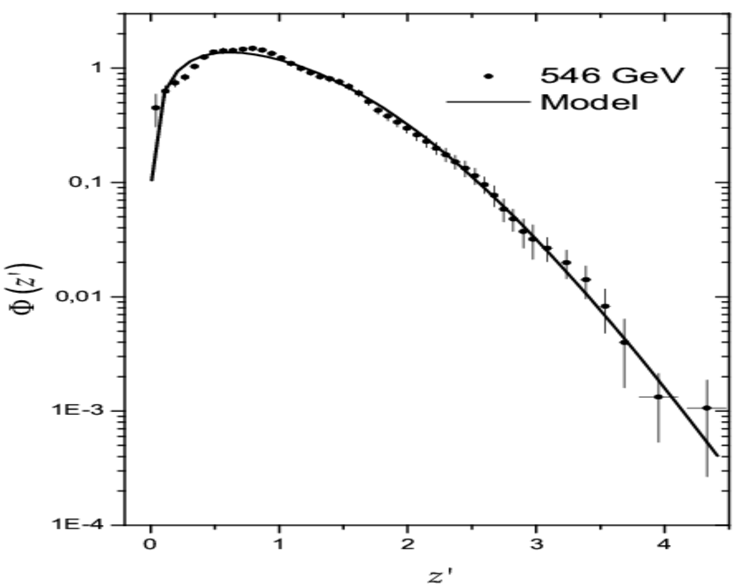
RESULTS....

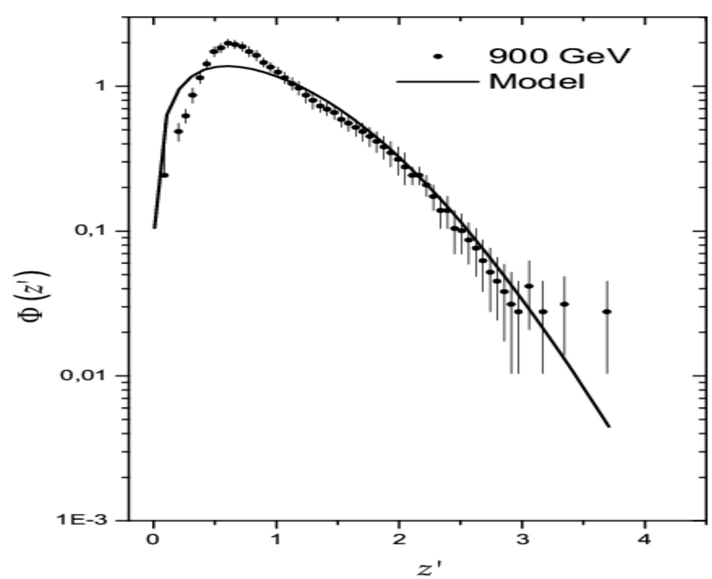
obtained from normalization condition on MD

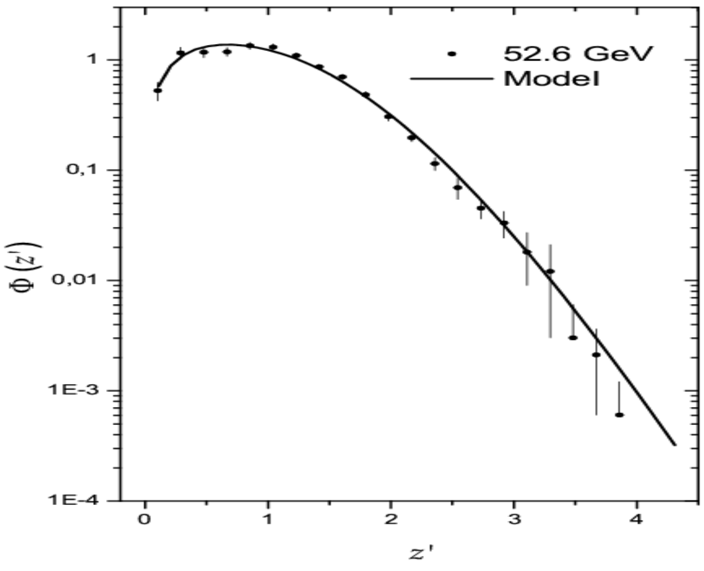
RESULTS→ Multiplicity Distributions: 52,6, 200, 546 and 900 GeV



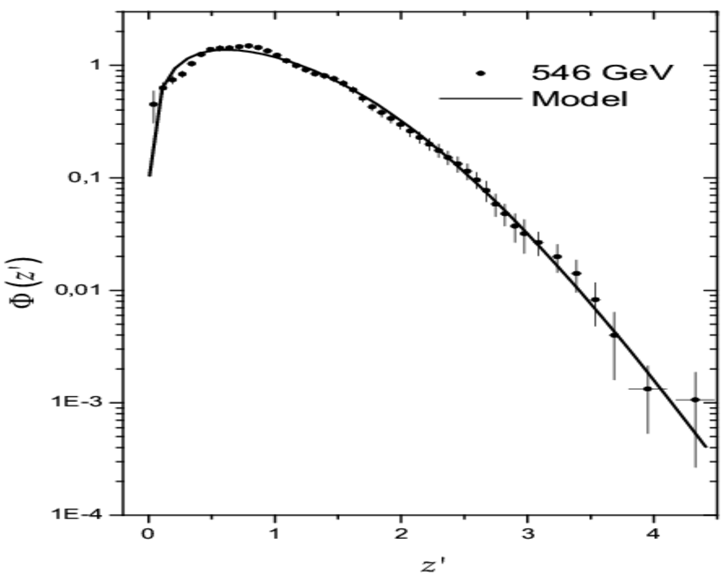






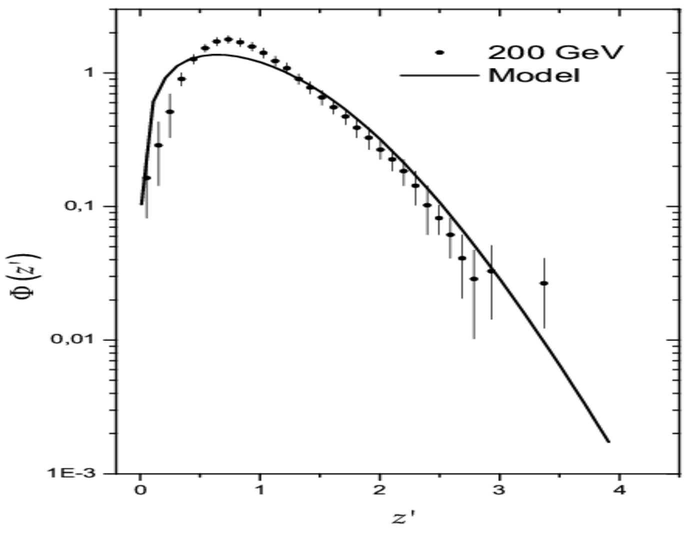


pp-ISR - CERN



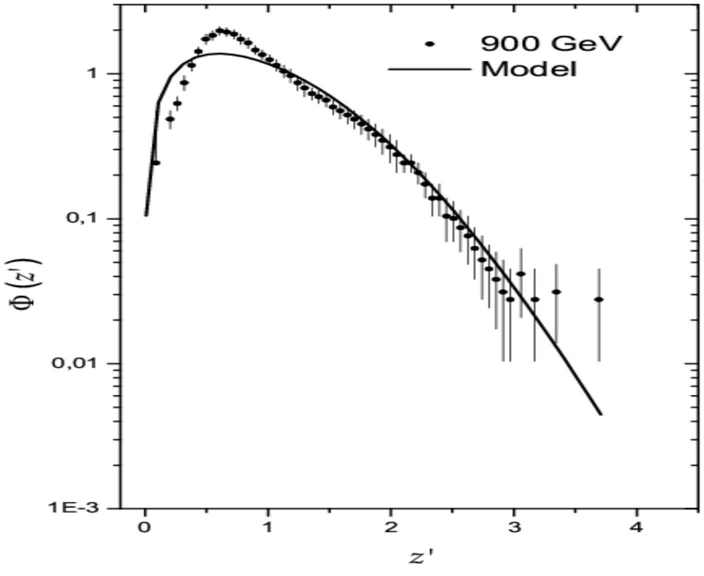
p(bar)p Collider CERN

The curves shows excellent agreement with data

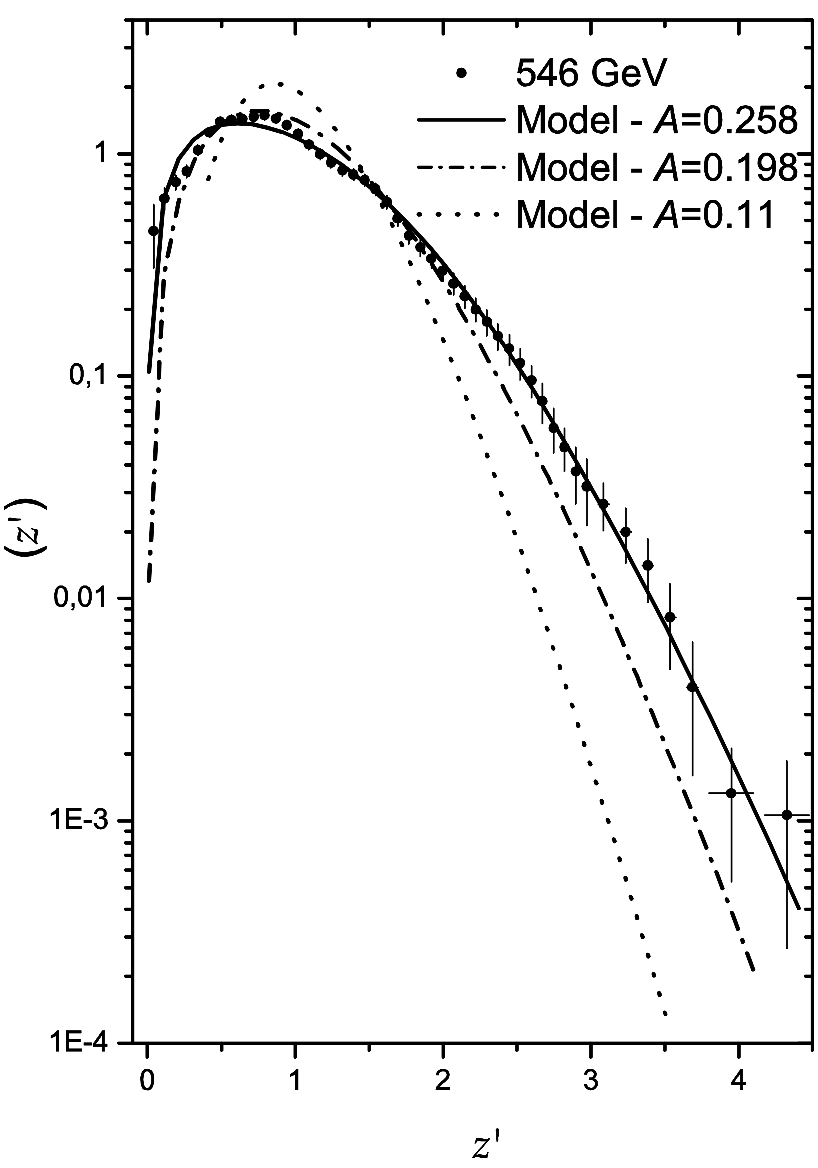


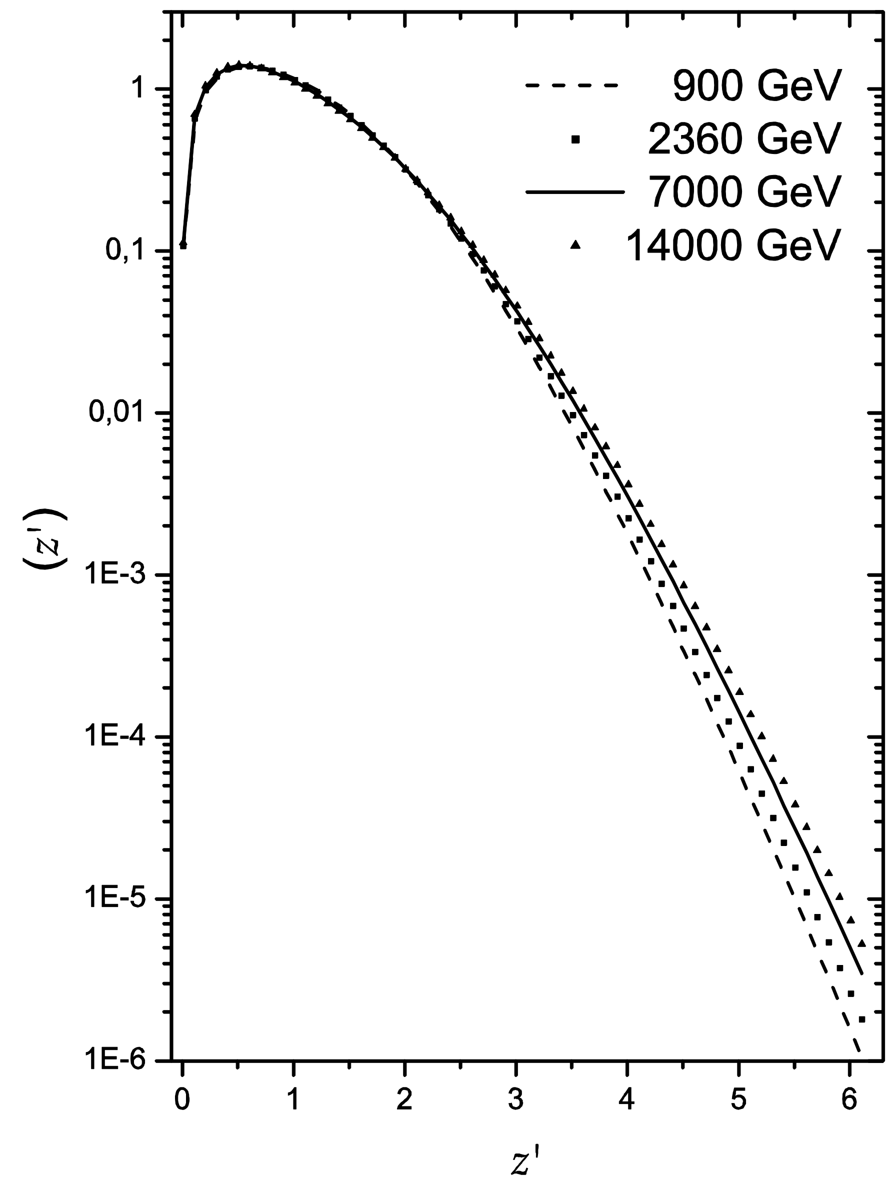
p(bar)p Collider CERN :

The curves agree with data for z > 1



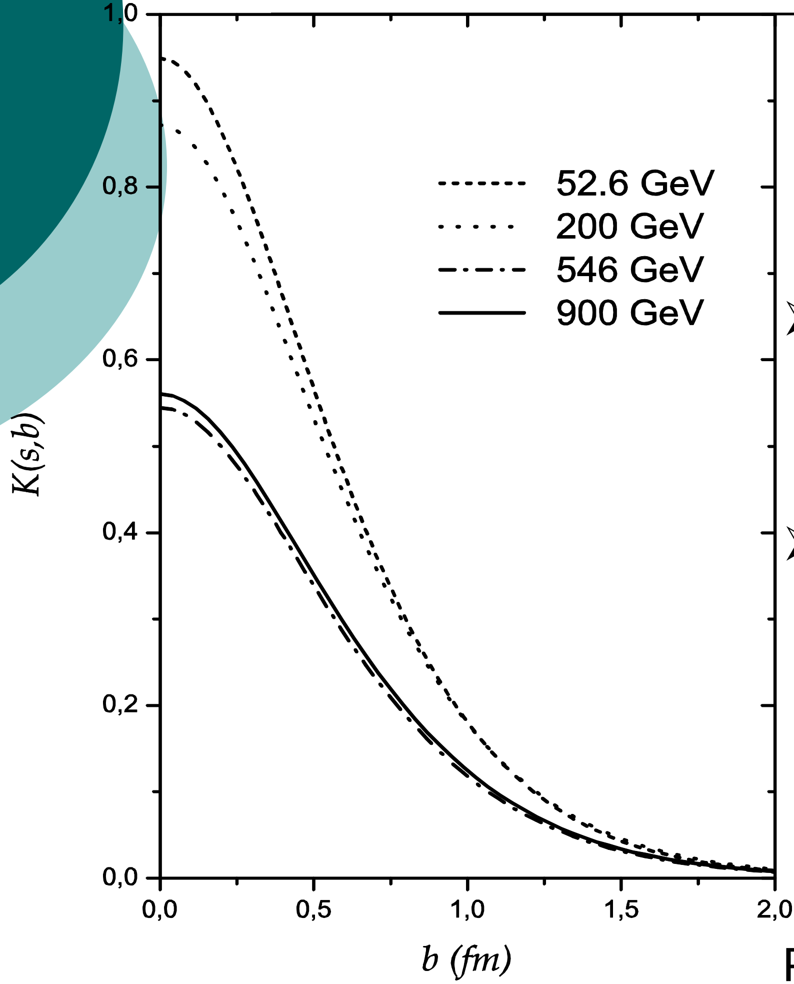
Agreement with data seems reasonable


546 GeV
Model - A=0.258
Model - A=0.198
Model - A=0.11
(z')
z'
1E-4
1E-3
0,01
0,1
1
0
1
2
3
4


900 GeV
2360 GeV
7000 GeV
14000 GeV
(z')
z'
1E-6
1E-5
1E-4
1E-3
0,01
0,1
1
0
1
2
3
4
5
6

RESULTS → Inelasticity *K* : → defines the energy available for particle production

Inelasticity is related to the eikonal by → $$K(s,b) = \frac{\beta(s)\chi_I(s,b)}{2(\sqrt{s})_{pp}}$$



- (Naturally)→ *K* decreases as fuction of b;
- In the interval 52 – 900 GeV → *K* decreases as √s increases;
- The *K* behavior is the same at 546 and 900 GeV;

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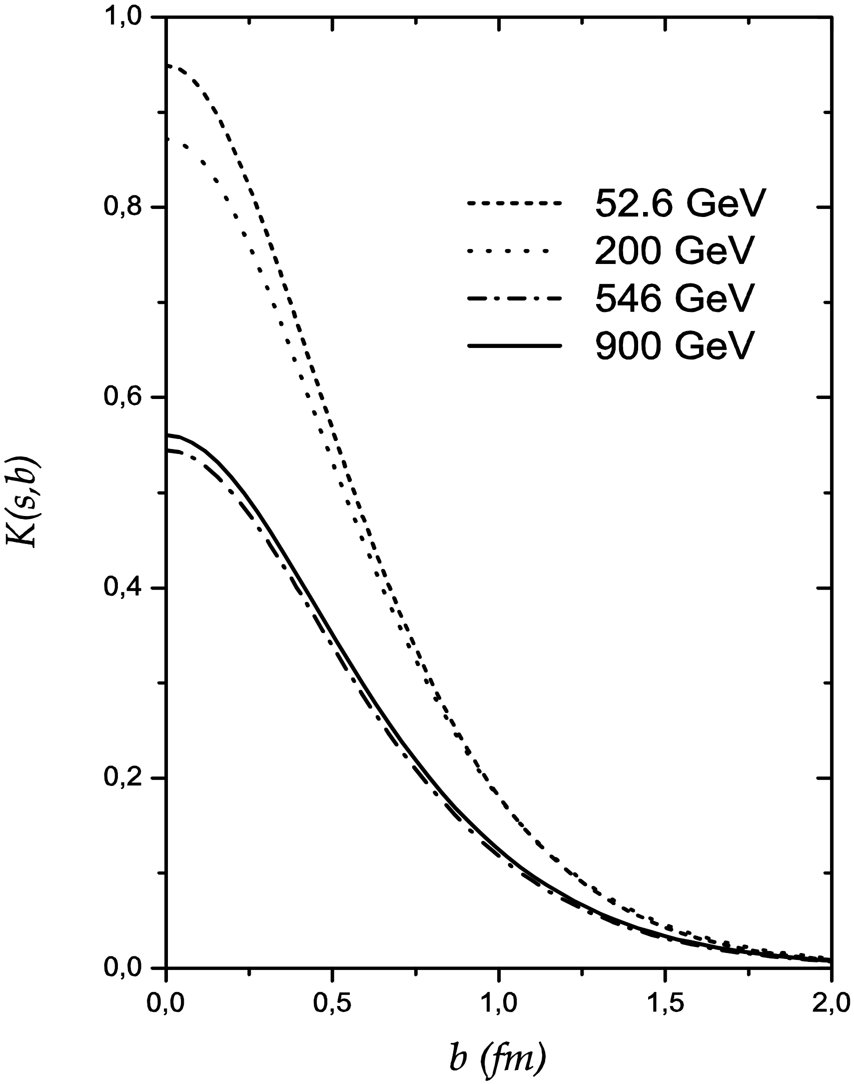
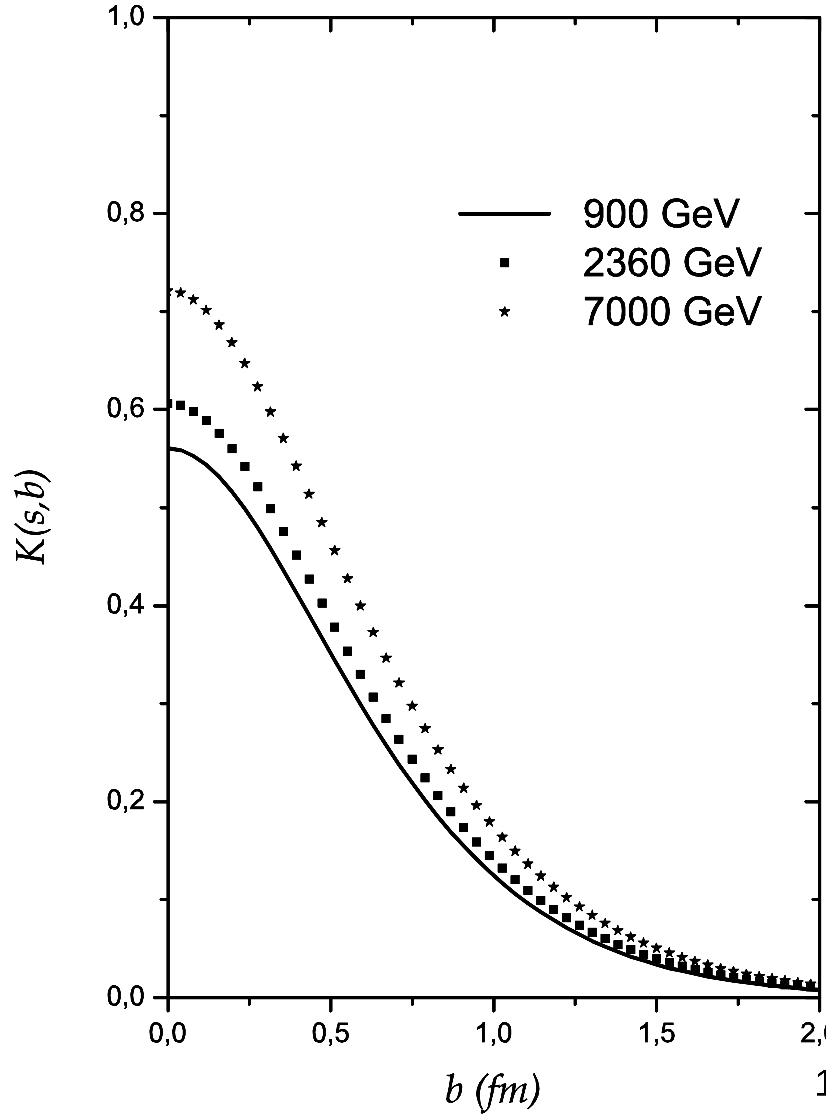
At LHC energies → 2360 and 7000 GeV

the results suggest that *K* increases

as the collision energy also increases





Final Remarks

- SOSM→ able to describe MD in interval 52.6 – 900 GeV

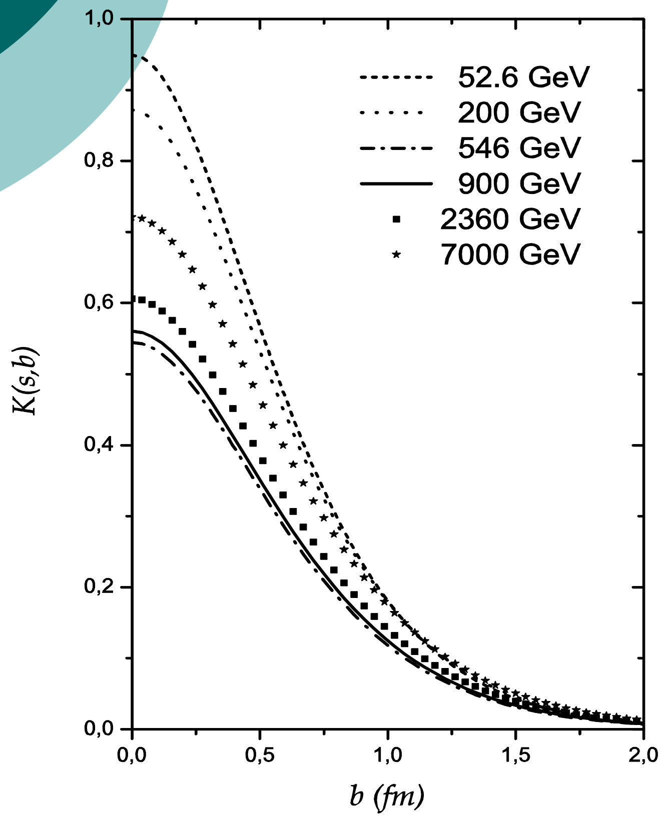
  → without free parameters

- Inelasticity related with the Eikonal

- Same behavior of inelasticity at 546 and 900 GeV

  → may have implications for the gluon-gluon dynamics

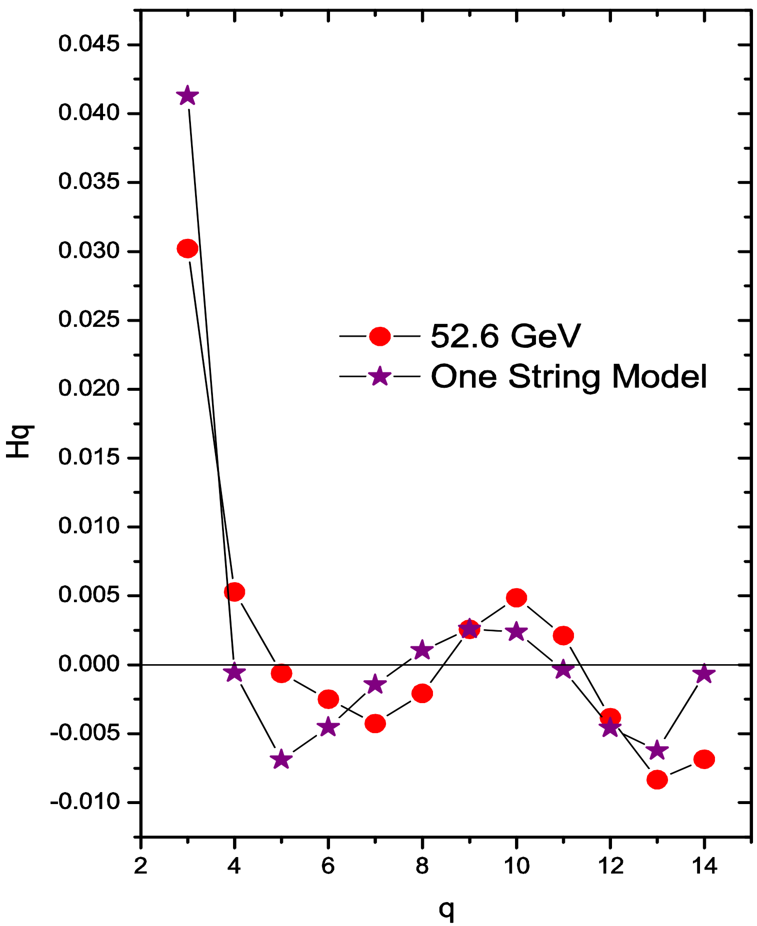
→ Dynamical gluon mass Eikonal Model

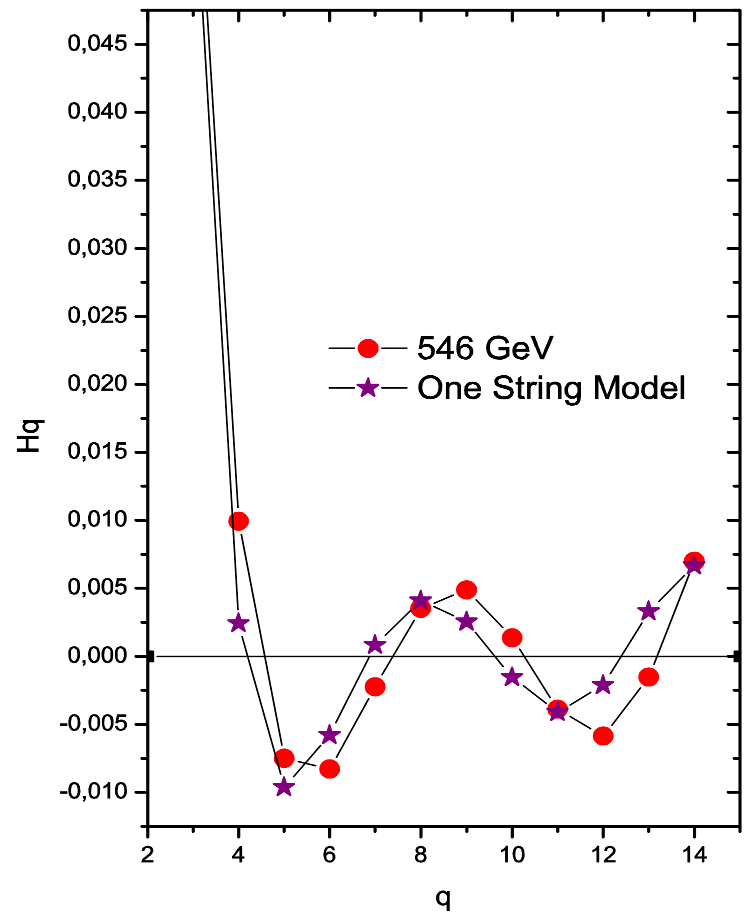


THANKS A LOT

$$\Psi(z) = 2\frac{k^k}{\Gamma(k)}[z]^{k-1}e^{-k[z]} \rightarrow$$

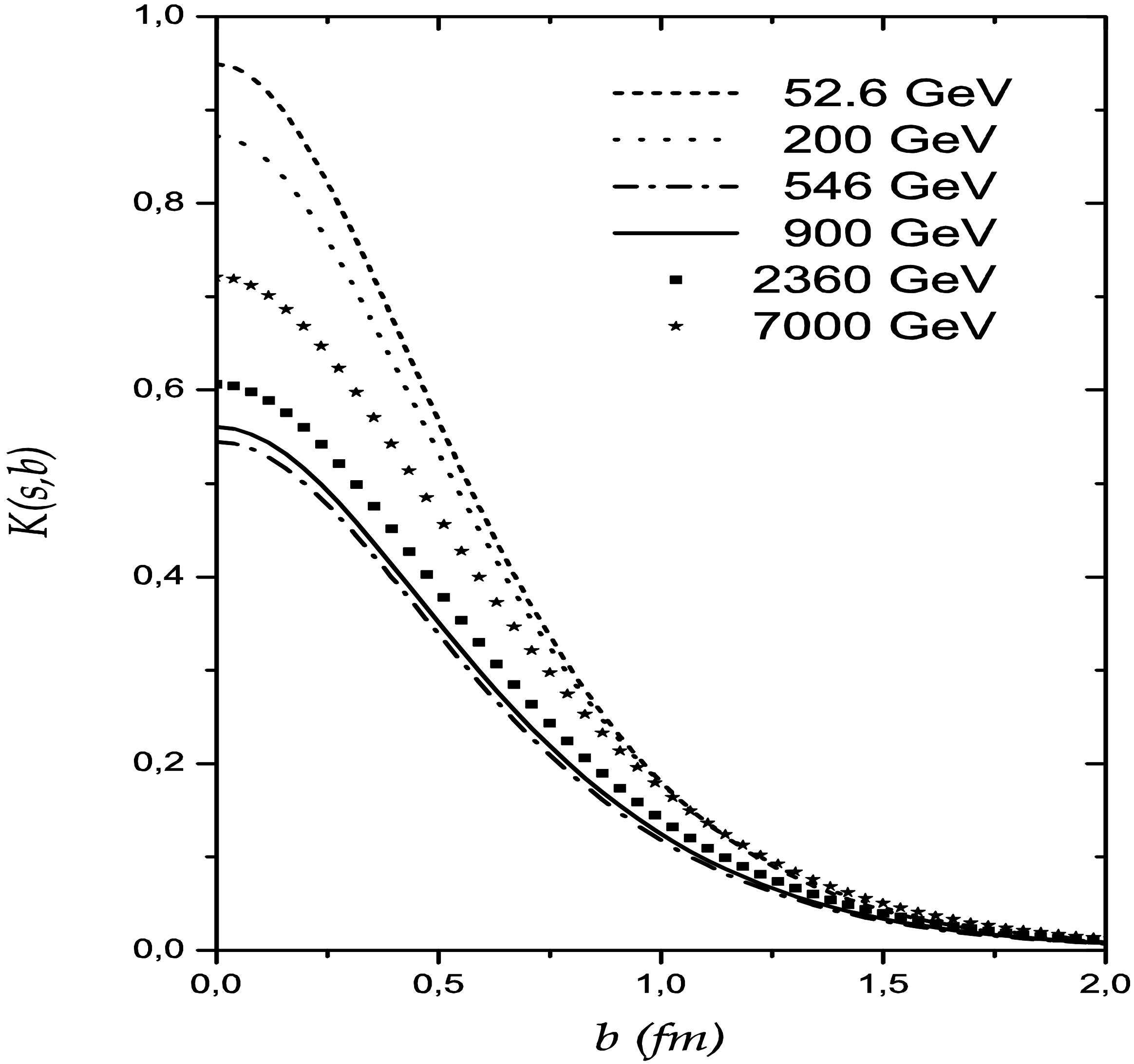
Gamma dist. is know to arise as limiting form for the parton number variable, when the dynamical theory (as in QCD case) allows each existing parton to act as a source to emit additional partons (parton branching)

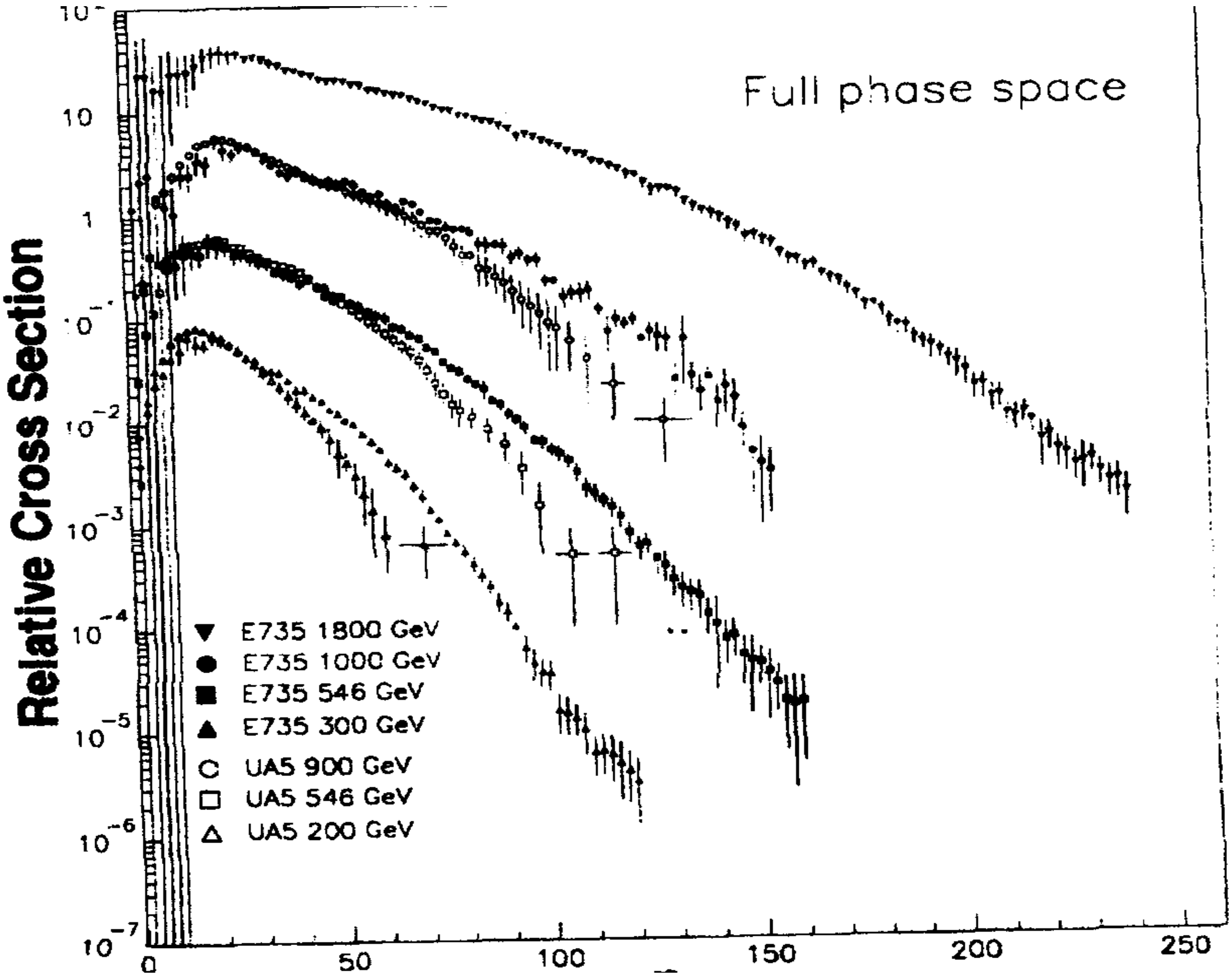

52.6 GeV
One String Model
Hq
q


546 GeV
One String Model
Hq
q

Obtive: Inelasticidade dependente da FÇ. EICONAL

$$K(s,b)=\frac{\beta_{(s)}\chi_{I(s,b)}}{(\sqrt{s})_{PP}}$$




Relative Cross Section
Full phase space
E735 1800 GeV
E735 1000 GeV
E735 546 GeV
E735 300 GeV
UA5 900 GeV
UA5 546 GeV
UA5 200 GeV
10
1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
50
100
150
200
250