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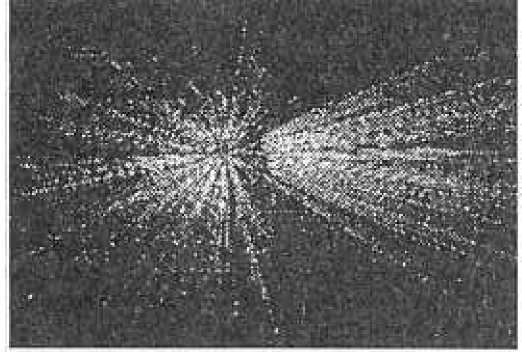

Bose-Einstein correlations in Pythia

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Bose-Einstein Correlations: Enhanced probability for the emission of identical bosons with similar momenta.

Provides information about space-time characteristics of the particle emission region

The two-particles correlation function is given by : $C_2(p_1,p_2)=\frac{P(p_1,p_2)}{P(p_1)P(p_2)}$

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$P(p_1,p_2)$ - two-particles probability density function

$P(p_1)$, $P(p_2)$ - single particle probability

$$C_2(Q)=N(1+\lambda\times e^{-R^2Q^2})$$

The construction of correlation function is given by:

is the two-particles four-momentum difference distribution

is the corresponding reference sample.

Bose-Einstein effect in Pythia 6.205

There is a possibility to include Bose-Einstein correlations, but it is only a first approximation to BE effect.

First of all the Q_{ij} value is evaluated: $Q_{ij} = \sqrt{(p_i + p_j)^2 - 4m^2}$

And then the shifted Q'_{ij} is found as the solution to the equation:

$$\int_0^{Q_{ij}} \frac{Q^2 dQ}{\sqrt{Q^2 + 4m^2}} = \int_0^{Q'_{ij}} C_2(Q) \frac{Q^2 dQ}{\sqrt{Q^2 + 4m^2}}$$

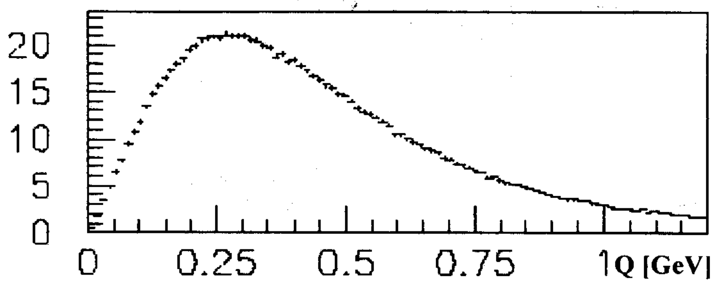
$$C_2(Q) = 1 + \lambda \times e^{-\left(\frac{Q}{d}\right)^r}$$

And finally after evaluation of all Q'_{ij} the original momenta are really shifted.

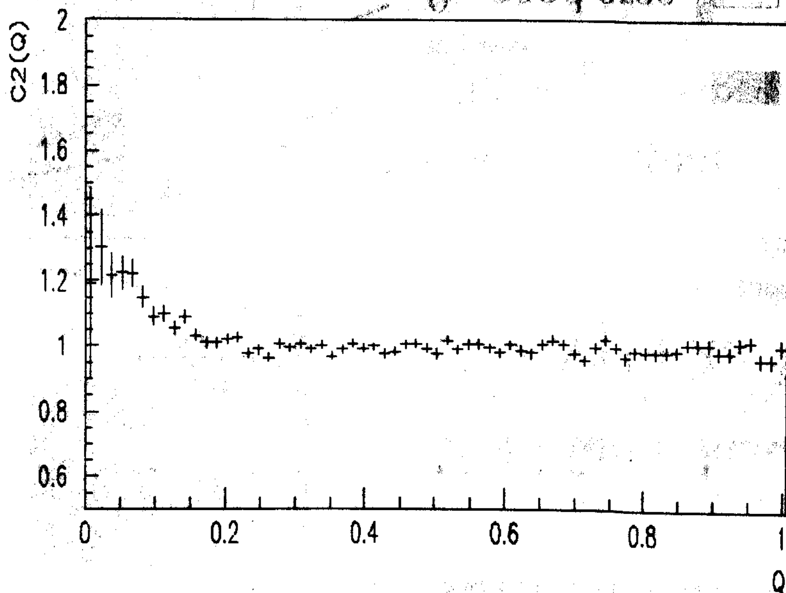
Pythia simulations

In Pythia collisions at 1.96 TeV (Tevatron CDF) are simulated .

Correlation spectrum *N(Q)* for π^+:



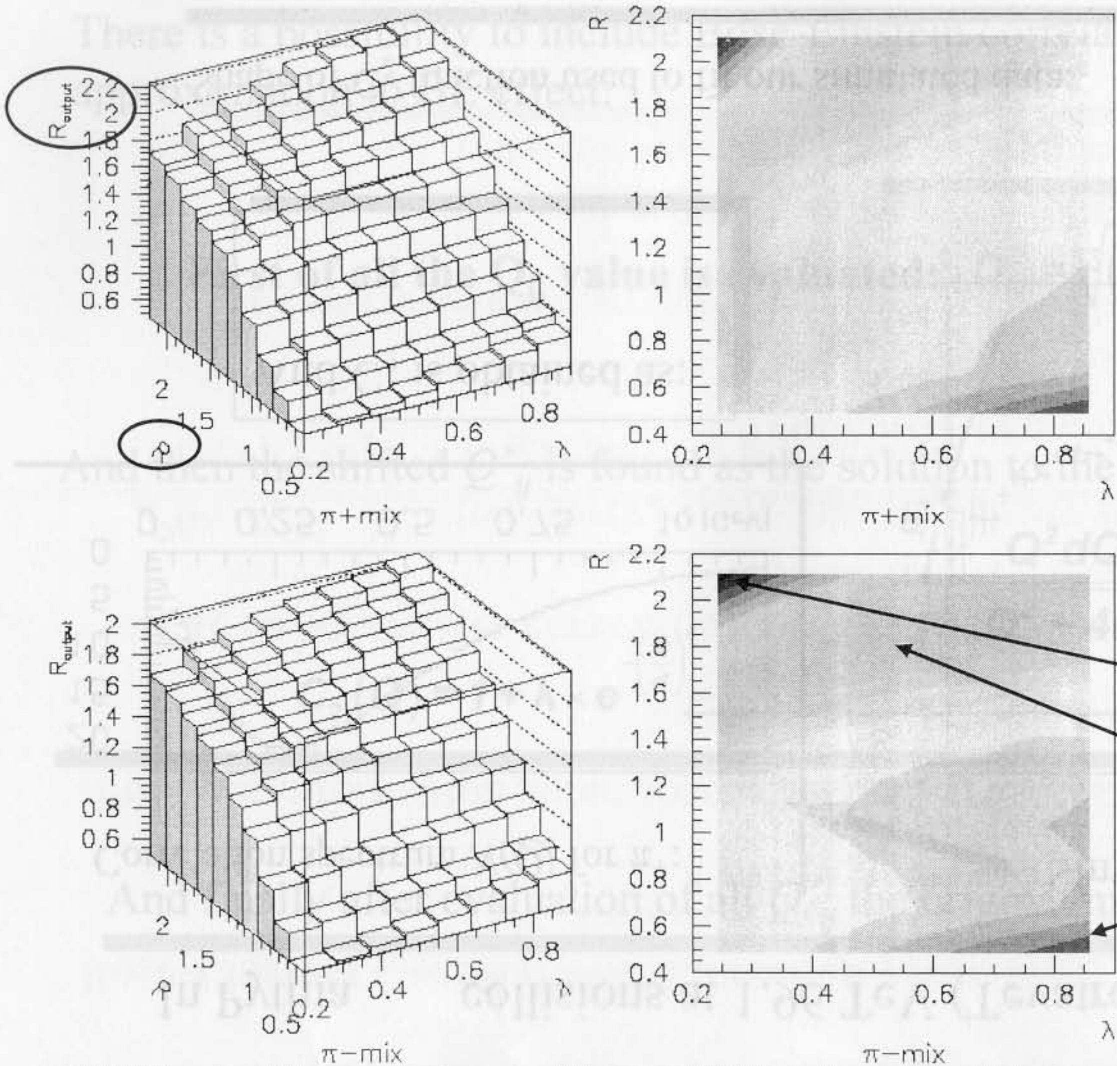
Similar spectrum for $N^{ref}(Q)$



And C_2 is obtained as:

Shape of C_2 function used to fit our simulated data:

Reproduction of input parameters



Dependence of the output parameter R on the input parameters λ and R

Used formula:

$$C_2 = N\left(1 + \lambda e^{-R^2 x^2}\right)$$

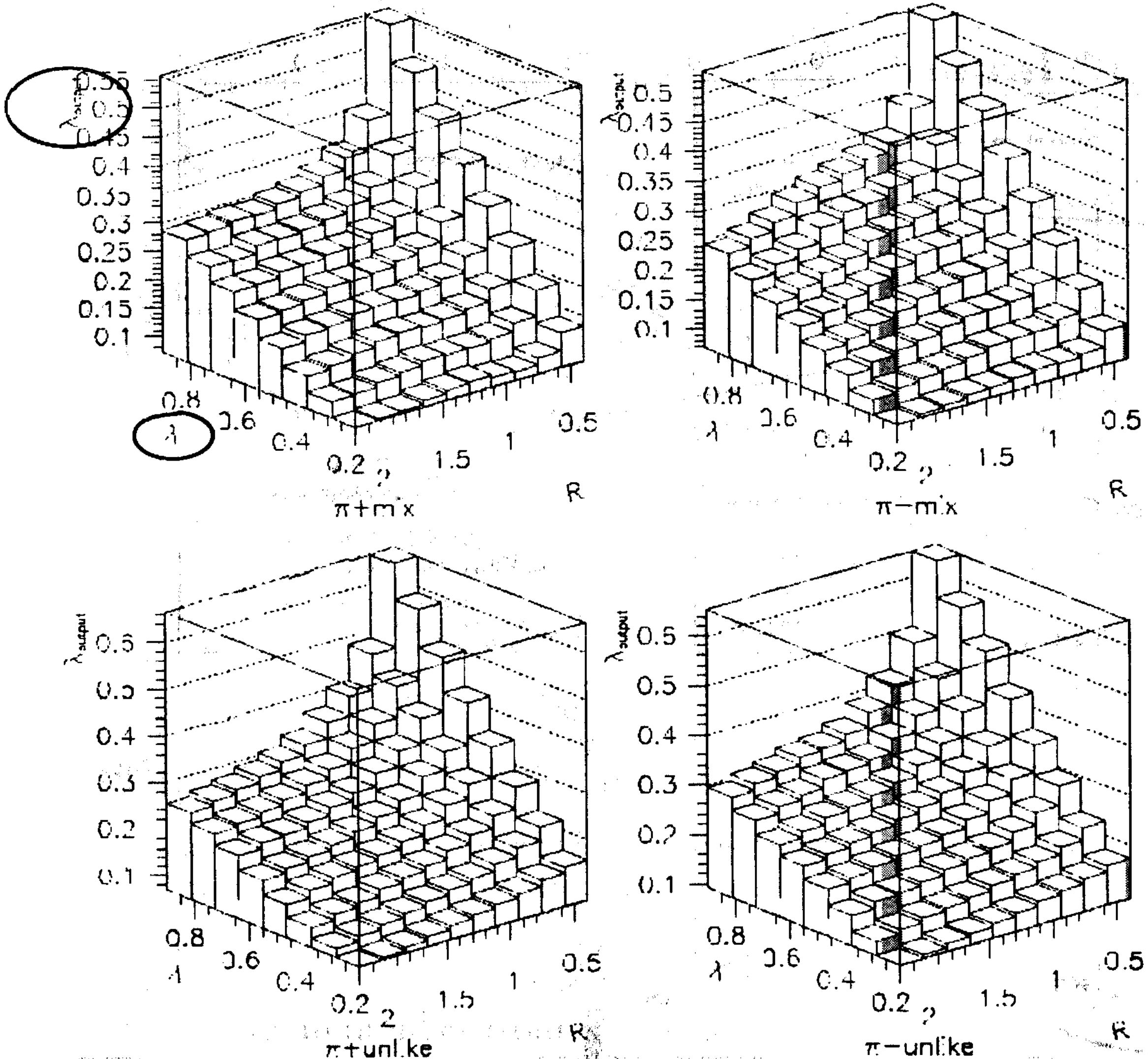
Color spectrum:

- 0.5

0 good area

+ 0.2

Reproduction of input parameters



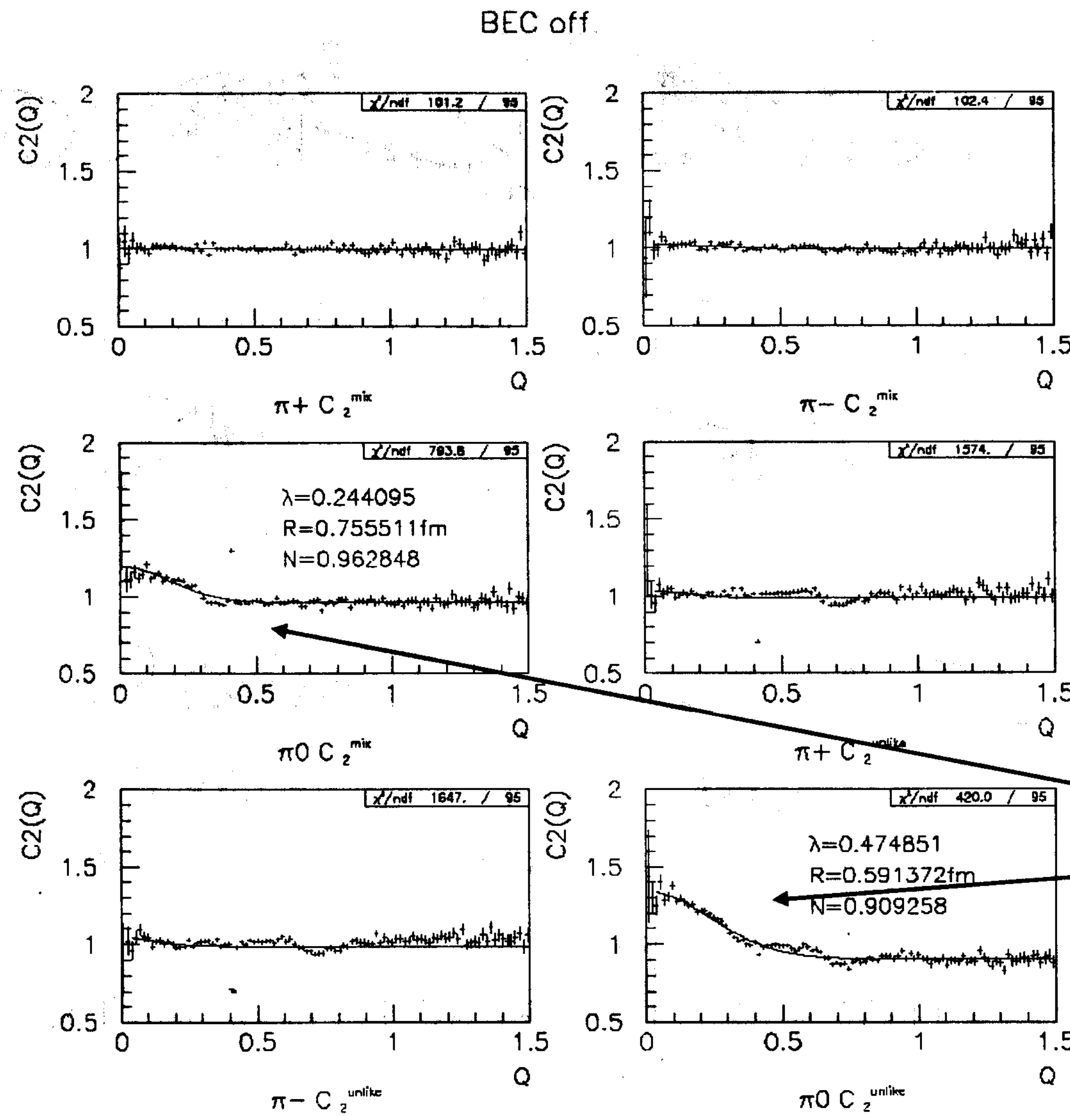
Dependence of the output parameter λ on the input parameters λ and R

Used formula:

$$C_2 = N\left(1 + \lambda e^{-R^2 x^2}\right)$$

There is no green area!

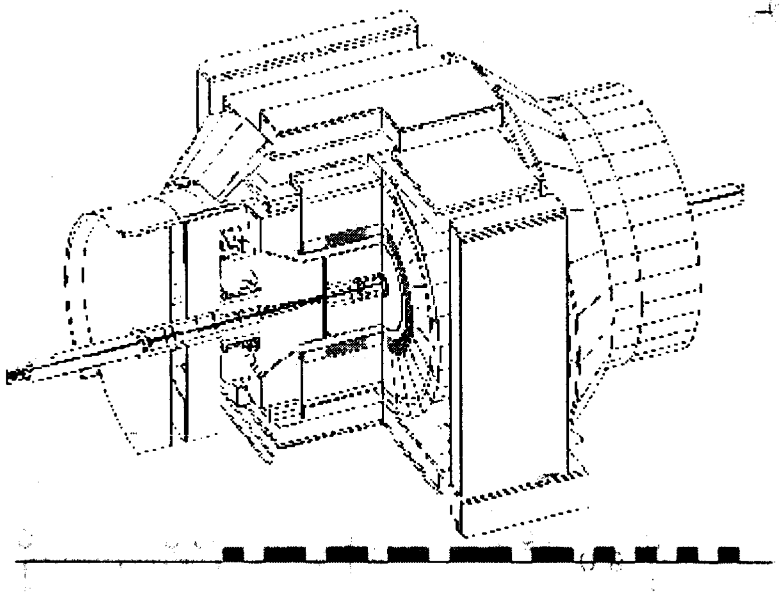
The case when correlations are not included.



It is expected that correlations disappear when they are not included in Pythia

There is a problem with π^0

Detector CDF



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Central Outer Tracker

Momentum Resolution: $\frac{\delta p_t}{p_t} \approx 0.15\% p_t [GeV^{-1}]$

Central Calorimeter Hadron Calorimeter

Energy Resolution: $\frac{\delta E}{E} \quad 0.5/\sqrt{E}[GeV]$

But the energy is too small for some pions to reach hadron calorimeter.

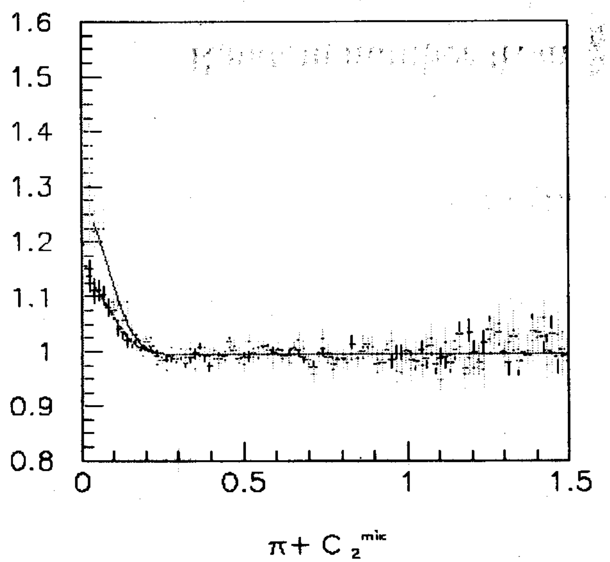
To blur all momenta we used the formulas: $p'_{x,y} = p_{x,y} + r p_t^2 \frac{0.15\%}{\sqrt{2}}$, $p'_z = p_z + r p_z^2 \frac{0.15\%}{\tan(\theta)}$

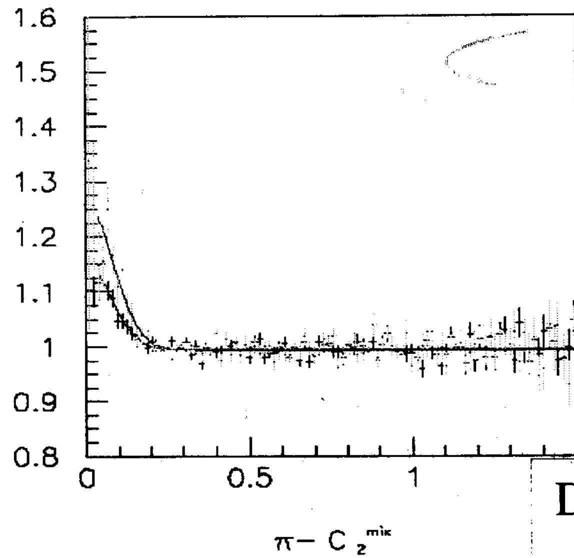
Then using this momenta the new energy for all pions was calculated:

Random number from Gaussian distribution

$$E_{new} = \sqrt{p_x^2 + p_y^2 + p_z^2 + m_\pi^2}$$

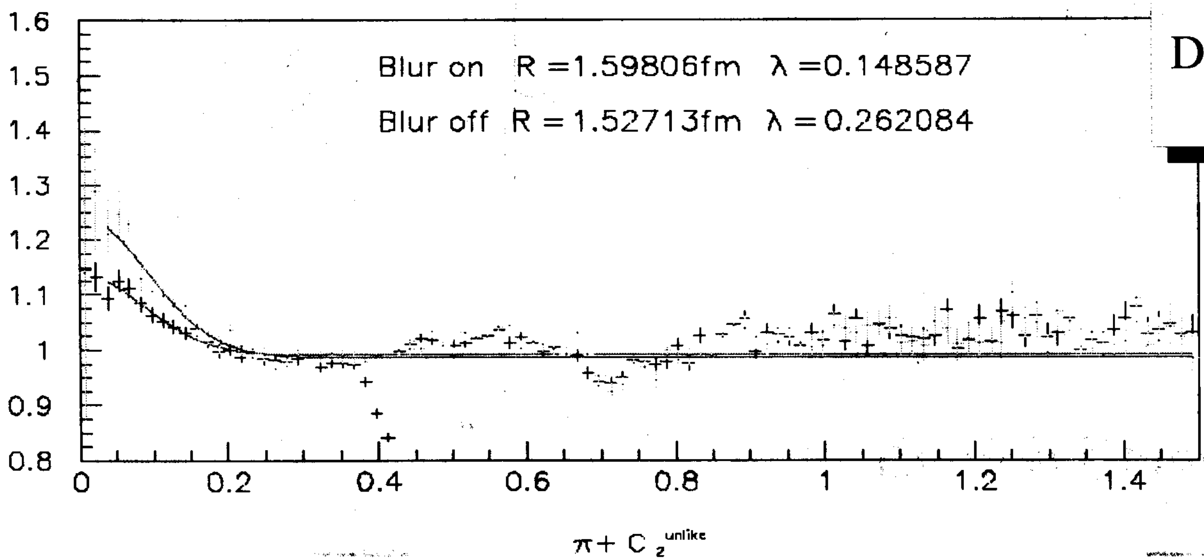
More realistic simulation: Momentum blurring





Input parameters:
R = 1.6fm
λ = 0.8

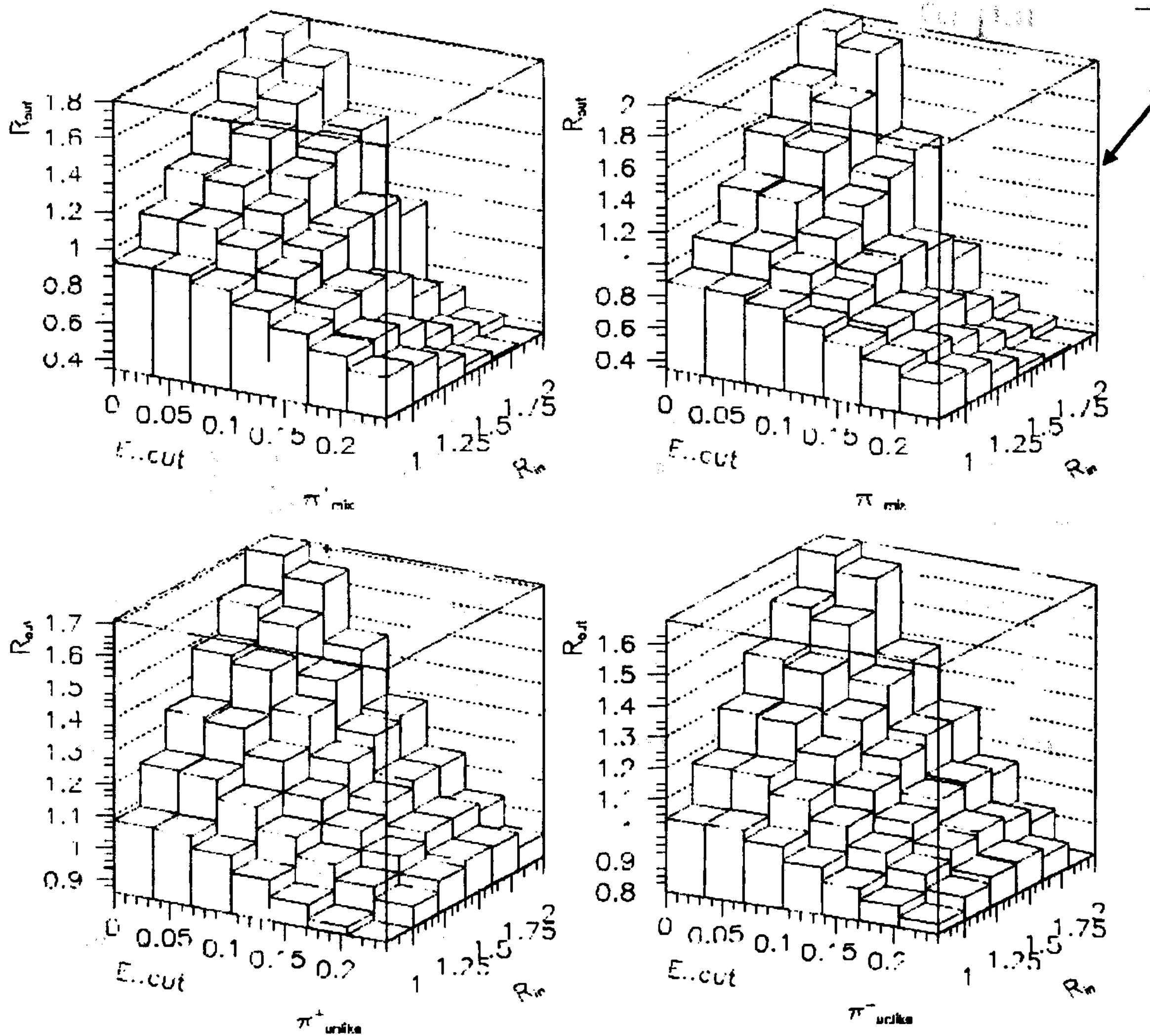
Data simulated with blurring on:
The blue ones
Data simulated with blurring off:
The green ones



The red curves are fitting lines

More realistic simulation: Energy cut

λ set to 0.8



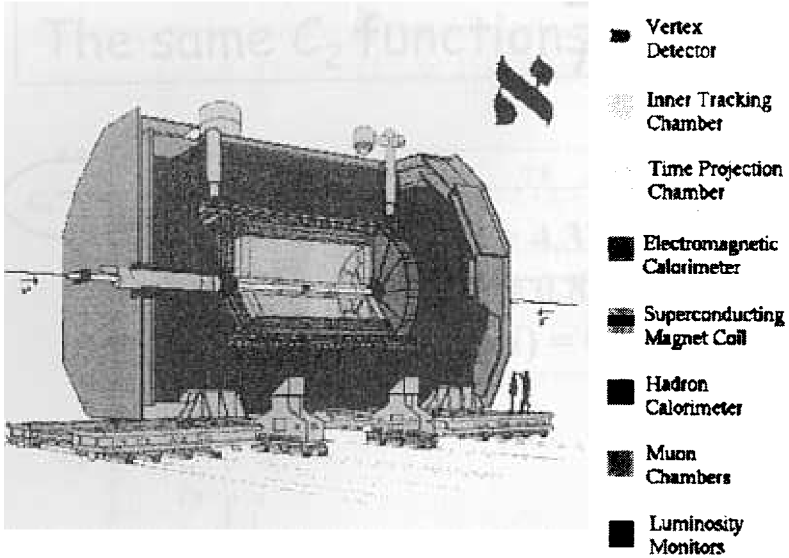
Dependence of the output parameter R on energy cut and on the input parameter R

We can see the importance to register low energy particles

Conclusion of 1^{st} part

- Pythia:
  - Parameter R has bounded area of good reproduction
  - Parameter λ has no area of good reproduction
  - There are non vanishing correlations for π^0 mesons.
- It is important to register low energy particles.

Experinent ALEPH



Standard parameterization:

$$C_2(Q) = N[1+\lambda\exp(-(RQ)^2)](1+\varepsilon Q+...)$$

- λ coherence strength factor.
- R is related to the size of the boson emission region.

$$R_2(Q) = \frac{\rho_2(p_1,p_2)}{\rho_0(p_1,p_2)}$$ - **Two-particle correlation function**

$\rho_2(p_1,p_2)$ - **Two-particle density distribution**

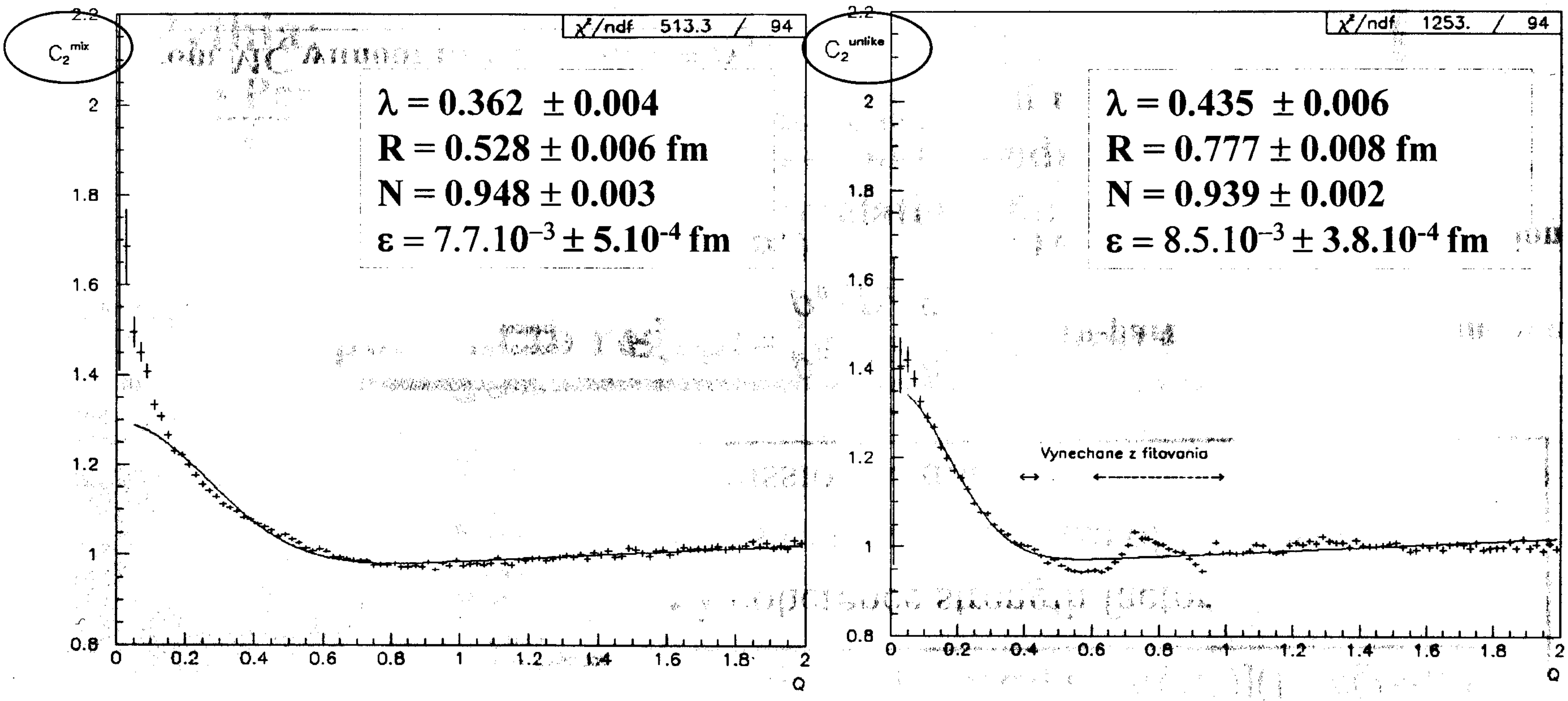
Detector inadequacies, effects introduced by the reference sample are obtained from MC without BEC: $R_2^{MC} = N_{\pm\pm}^{MC} / N_{ref}^{MC}$

The measured correlation function is given by:

More informations in:
Eur. Phys. J. C36: 2004, 147

ALEPH fit

C_2 function for ALEPH data and different reference samples fitted with $C_2(Q) = N\left(1+\lambda e^{-(QR)^2}\right)[1+\varepsilon Q]$

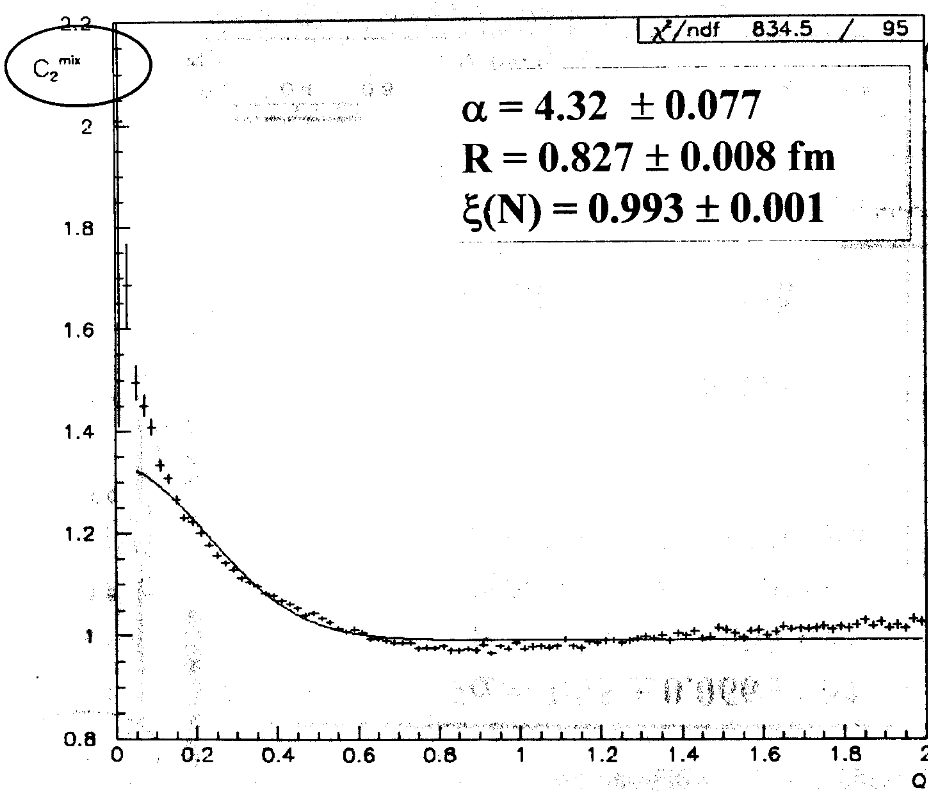


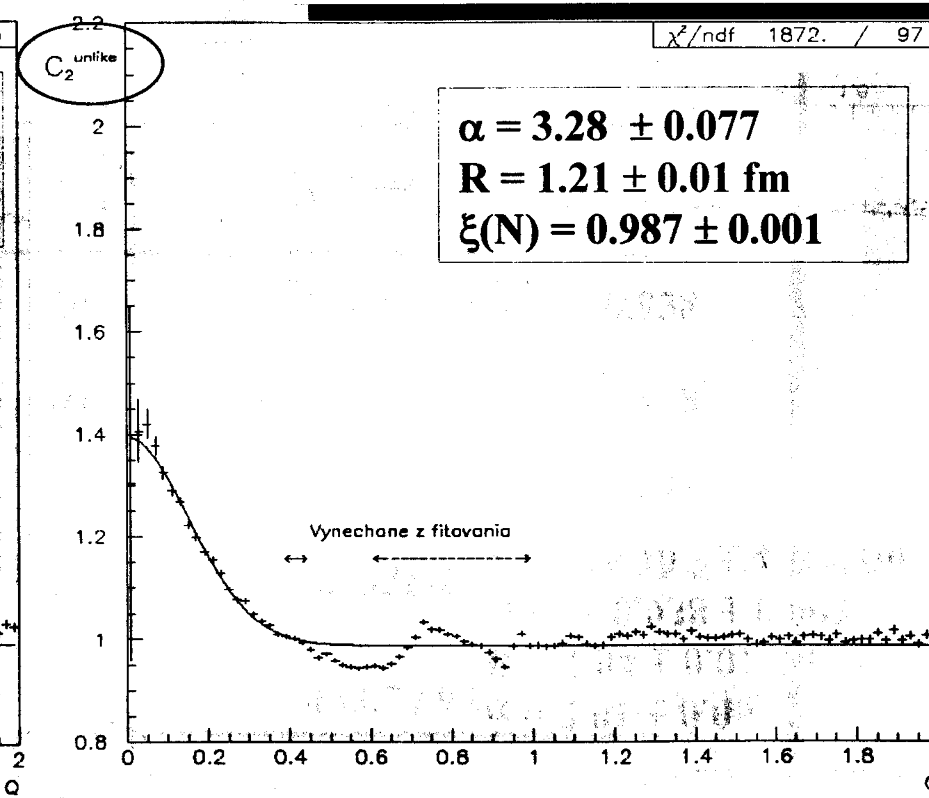
We reproduce their results.

Kozlov fit

The same C_2 functions versus Kozlov theory

QFT based, Langevin evolution equation used.
Ref: arXiv:hep-ph/0304091 v3



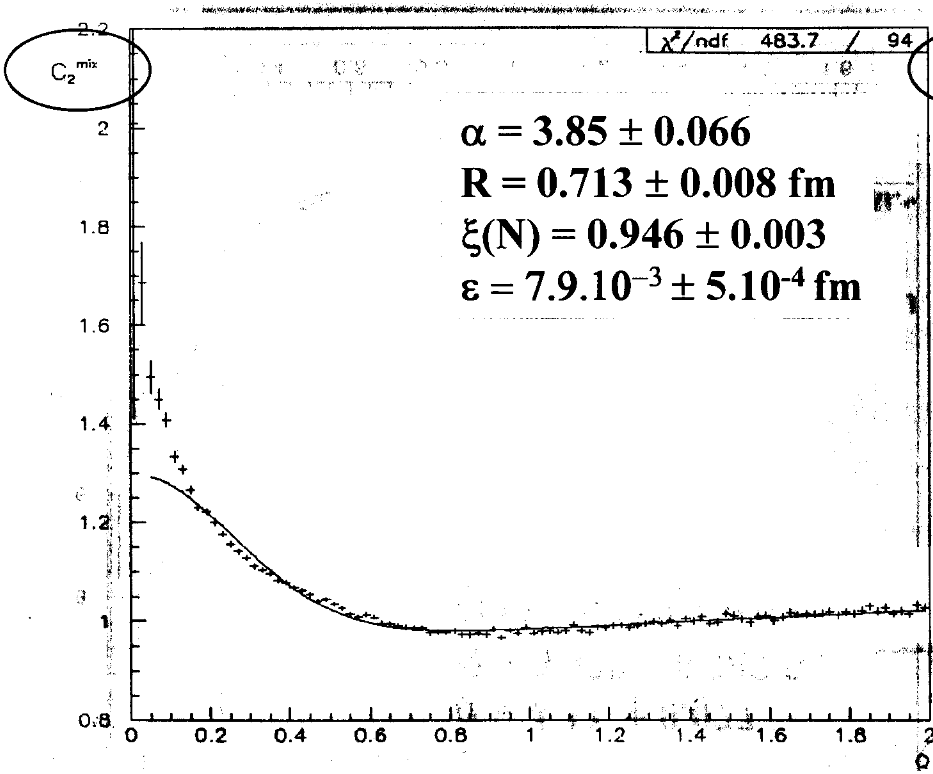


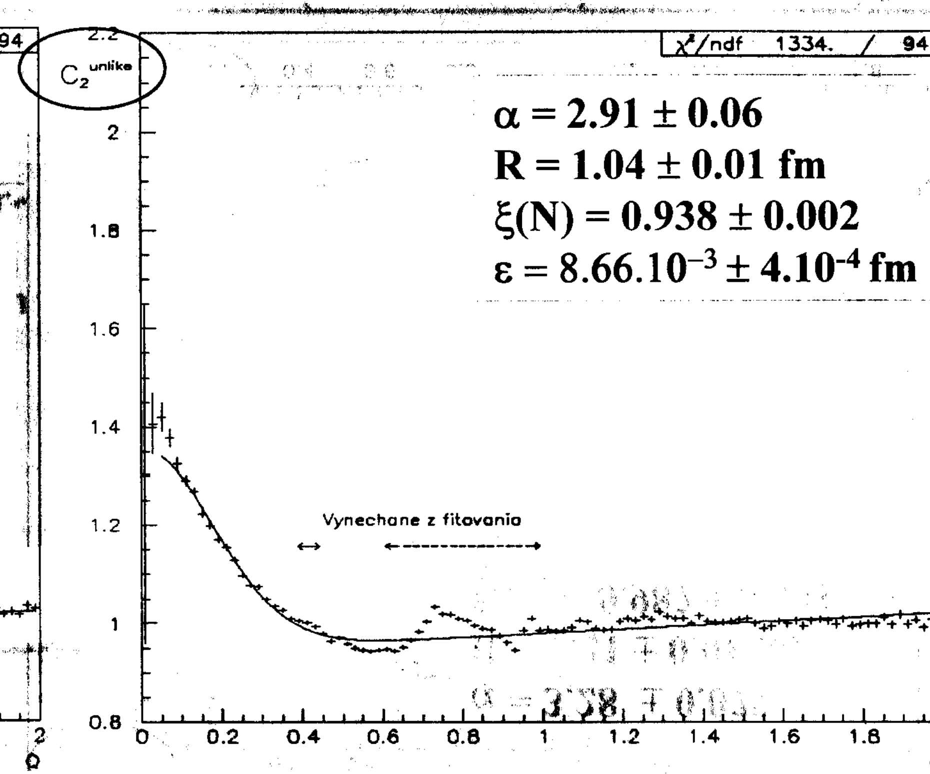
The function used to fit ALEPH data:

$$C_2(Q) = \xi(N)\left(1 + \frac{2\alpha}{(1+\alpha)^2} e^{-\frac{(QR)^2}{2}} + \frac{1}{(1+\alpha)^2} e^{-(QR)^2}\right)$$

Modified Kozlov fit

The same C_2 function versus modified Kozlov C_2 function.





Modified function of Kozlov approach:

$$C_2(Q) = \xi(N)\left(1 + \frac{2\alpha}{(1+\alpha)^2} e^{-\frac{(QR)^2}{2}} + \frac{1}{(1+\alpha)^2} e^{-(QR)^2}\right)(1+\varepsilon Q)$$

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Summary table of our results:

	Aleph C_2	
	$C_2^{mix}(Q)$	$C_2^{+-}(Q)$
N	**0.948**	**0.939**
λ	**0.362**	**0.435**
R (fm)	**0.5287**	**0.7777**
ε (fm)	**0.769e-2**	**0.852e-2**
χ^2 / ndf	**513 / 94**	**1253 / 94**

	Kozlov C_2	
	$C_2^{mix}(Q)$	$C_2^{+-}(Q)$
ξ(N)	**0.946**	**0.938**
α	**3.848**	**2.918**
R (fm)	**0.713**	**1.043**
ε (fm)	**0.793e-2**	**0.867e-2**
χ^2 / ndf	**483.7 / 94**	**1334 / 94**

Conclusions of 2^{nd} part.

- **Correlation analysis of ALEPH data was done in frame of Kozlov model**
- **To explain the increase of $C_2(Q)$, modification factor $(1+\varepsilon Q)$ should be edit to the theoretical C_2 function**
- **This factor can be explained by the presence of the non equilibrium processes (?) – In Kozlov approach stationary (equilibrium) state is assumed.**