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MANYCOMPONENT DESCRIPTION OF INCLUSIVE AND SEMI-INCLUSIVE PROCESSES

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I. What is Manycomponent Description?

A hypothesis that secondaries are not of the same origin, but are produced due to two or more different mechanisms is one of the interesting ideas in phenomenology of multiparticle production. The schemes and models based on this hypothesis are called manycomponent description.

The efforts to combine two extreme approaches have served as a starting point of such a trend.

The first one proceeds from the fact that the production of secondaries is due to the fragmentation of the colliding objects. The secondaries of this type possess information about a colliding hadron and a target particle. These are "grateful" particles as they remember their "parents". We call such an approach a diffraction excitation (DE).

The second one considers "ungrateful" secondaries which do not remember their "parents". Schemes based on the idea of independent emission of particles (IE) or their definite associations (clusters, resonances, etc.) can be referred to such a category.

It is natural to combine two extreme approaches since even a number of simple characteristics can hardly be explained if one keeps to simple positions.

For instance, even topological cross sections obtained at Serpukhov, Batavia, ISR accelerators deviate from the predictions of the schemes with IE on DE only.

Note that these extreme approaches are sometimes classified in the language of the correlations of secondaries. The approach DE is specified by strong long range correlations, and IE is either the absence of correlations or the existence of weak short range ones.

II. The Way of the Manycomponent Description

It should be mentioned that the idea to separate the contributions of different mechanisms to multiparticle cross sections was initiated by A.A. Logunov et al. (see, e.g. review [1]).

Different realizations of multicomponent description were proposed in a number of papers[2-6] during 1971-73.

a) The two-component model:

This model is one of the most clear realizations of the idea we are interested in.

It is based on the multiplicity distribution which can be written as the sum:

$$\sigma_n = \alpha\sigma_n^{(1)} + \beta\sigma_n^{(2)}. \qquad (1)$$

The first term (or component) in this formula corresponds to the approach DE and the second one to IE. It is assumed that these mechanisms work in different acts of the interaction.

Using the two-component model one may succeed in describing the multiplicity distribution in the interval from 20 GeV to 200 GeV. The increase of the second correlation parameter $f^2 = \langle n\rangle^2 - \langle n(n-1)\rangle$ specifing this model is in good agreement with experiment. The "play" of two components results in a weak dip between the components which can be verified experimentally at higher energies (~1500 GeV).

However, the topological cross sections ... the energies higher or equal to 200 GeV and the deviation of the predictions of this model from experimental data on high correlation moments should be considered in a more complicated way [7,8].

b) The model of two mechanisms.

Let us consider now the manycomponent description of the multiparticle production which can be realized using the phenomenological model of two mechanisms (TMP-model). The model was first proposed at Dubna[9,11] as a concrete phenomenological scheme based on the consideration of the quantum field theoretical (QFT) models in straightline-paths and eikonal approximations[10]. Owing to an interest in the charged-neutral correlations this model is worth-mentioning. Note that the straightline-path method allows one to obtain from QFT the leading particle effects and boundness of transverse momentum.

The TMP-model starts from the idea about the existence of the two following mechanisms of the secondaries production:

i. There exist the leading particles which can dissociate with local conservation of isospin;

ii. In the interaction process hadron associations are also produced in a statistically independent way, and they decay into pions.

In this model the probability of cluster production at given dissociation channels of the leading particles has the form:

$$W^{ij}_{n_1 n_2 \ldots} = \alpha_i \beta_j \, P_{n_1}(\langle n_1\rangle) \cdot P_{n_2}(\langle n_2\rangle) \ldots \qquad (2)$$

$\alpha_i \, \beta_j$ - are the probabilities of the dissociation channels, $n_k(\langle n_k\rangle)$ are the numbers (average numbers) of associations produced independently.

One can clearly see that the TMP-model ... to the distribution over a number of secondary particles which has the form of the superposition of the Poisson factors. Manycomponent character of the distribution arises as a result of the summation of formula (2) over a number of possible dissociation channels of the leading particles.

Such a scheme gives a good description of the topological cross sections, it represents correctly the basic features of the charged-neutral correlations and allows to study the dependence of these correlation on the number and mass of clusters.

There is a number of new investigations in this field. For instance, Biebl, Klein and Nahuhauer[12] obtained positive charged-neutral correlations in the framework of the correlated jet model where independent π-meson and ρ-resonance production was considered taking into account the total isospin conservation.

I should like also to note that the old schemes are reconstructed in accordance with manycomponent ideology. In order to explain experimental data on charged distributions and correlation dependancies in multi-Regge scheme, the assumption is used about the necessity of considering diagrams with a large number of showers (or clusters) at high energies[13]. This is also equivalent to the multicomponent structure of distributions over multiplicity. Unfortunately, it is impossible to obtain in the framework of these schemes the fine structure of charged-neutral correlations. For instance, a decrease of charged-neutral correlation curve at large n, as well as a number of other characteristics is well described in the model of the independent cluster emission by S.Pokorski and L. Van Hove [14], if one takes into account the energy momentum conservation law (see contributed paper by R.Kirshner [15]).

I mention only the paper by J.Benecke, A.Białas and S.Pokorsky[16] which comprises many interesting consequences in the framework of the idea about the multicomponent strusture of spectra.

III. New Applications of the Manycomponent Description

Manycomponent representation became highly useful when analysing the inclusive distributions in the process $e^+ e^- \to$ hadrons.

M.Gorenshtein, G.Zinoviev and V.Petrov[17] developed the two-component model in which the fast partons are described by the parton distribution function and the region of wee x by the fireball mechanism. An interesting property of this model is that both mechanisms work simultaneously in each individual act of the e^+e^- annihilation. This fact results in a number of consequences which agree with experiment. Manycomponent description was also used when studying the semi-inclusive spectra.

In paper [18] we established the validity of the following "automodelity" law for the behaviour of the semi-inclusive cross section:

$$\langle n(\vec{p})\rangle \frac{d\sigma_n}{d\vec{p}} \Big/ \frac{d\sigma^{incl.}}{d\vec{p}} = \psi(n/\langle n(\vec{p})\rangle).$$

This relation does not start from the assumption of the Feynman scaling and provides a good agreement with experiment [11,19].

Note, however, that to study the distributions in a wide interval p, one should consider a many-component description. It requires a simultaneous account of soft particles and production of jets (hadronic associations).

Let us consider a simple model[11] with the two-component structure: (see also ref.[20])

$$\frac{d\sigma(n)}{d\vec{p}} \sim \frac{d\sigma_n^{(1)}}{d\vec{p}} + \frac{d\sigma_n^{(2)}}{d\vec{p}}.$$

If one chooses the components with the following behaviour:

$$\frac{d\sigma^{(1)}}{d\vec{p}} \sim a(\vec{p})e^{-np} \qquad \frac{d\sigma^{(2)}}{d\vec{p}} \sim b(\vec{p})^{-p/n}$$

then the average associated multiplicities have the form

$$\langle n^{(1)}\rangle \sim \frac{1}{p}, \quad \langle n^{(2)}\rangle \sim p.$$

We see that the components correspond to the behaviour of the associated multiplicity in the same and opposite hemispheres.

It is interesting to note that such a two-component scheme with strong correlations between n and p satisfies the above mentioned "automodelity" law. Obviously, this is an indication to its universality.

A number of papers submitted to the conference is devoted to the field theoretical validity of the contributions of different mechanisms [21-23].

In particular, one can succeed in obtaining the "automodel" solution of the equation of the renormalization groups within the method of the renormalization groups [22]. The method allows one to consider the deviation from the "automodelity" law of semi-inclusive spectra.

IY. Conclusion

In conclusion I should like to note that the idea of the manycomponent description which first arose as an attempt to combine the approaches of diffractive excitations and of independant emission while being developed became more profound.

At present, this idea is a convenient way to describe the processes of multiparticle production for which a number of mechanisms (which are not only DE and IE) is responsible. In the language of the manycomponent description, one can study the role of these mechanisms and their contributions to different regions of the phase space volume and different energy intervals.

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Overlapping Independent Emission in the Fragmentation Region

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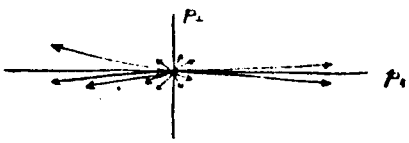
1. Introduction

In these days of jets I am concerned here with the old-fashioned ones,



the ones at small $p_\perp$ in hadronic collisions ($p_\parallel$ is in the direction of the incident hadrons in the cms). The central region of particle production, which is also indicated in the above sketch, seems to be the same for the case of high-$p_\perp$ jets (current-induced or quark-induced) as well as for low-$p_\perp$ hadron-induced jets. Also the transverse momentum distribution (transverse with respect to the jet axis) seems to be roughly the same for all of these cases. But as the momenta along the respective jet axes get large, there are characteristic differences in the longitudinal spectra of hadrons: the small-$p_\perp$ jets, as sketched above, are unique in the sense that they contain the leading particle effect and the diffractive peak.

The leading particle spectrum and also forward-backward correlations at high energies are related in a simple way to the multiplicity distribution. This is shown in refs. [1] and [2], on which my report is based largeley. I am going to describe the inclusive spectra along the $p_\parallel$-axis as power laws

$$(1-|x|)^\lambda , \qquad x = 2p_\parallel/\sqrt{s} .$$

This resembles the case of high-$p_\perp$ jets, where the exponent is determined by quark counting rules [3]. But in our case, the power λ is a variable rather than a fixed number, and will be integrated over.

Our description arises from a generalization of the Bremsstrahlung model [4] which I want to call "overlapping independent emission". The Bremsstrahlung analogy is suggested to us by the observation of

(i) soft pion production [x)],

$$\frac{dN}{dx} = \frac{\lambda}{x} \qquad \text{for small } x, \qquad (1)$$

and

(ii) the leading particle effect,

$$\langle x_{proton} \rangle = 0.5$$

in pp collisions, which says that the proton looses on the average only half its energy in the collision.

The concept of cluster production accounts for short range y-correlations: the objects emitted via Bremsstrahlung are understood to be clusters (of mostly pions) with average transverse mass $\sqrt{m^2 + \langle p_\perp^2 \rangle} \approx 1.2\ GeV/c^2$. Their multiplicity distribution for a fixed value of λ is a Poisson distribution, as in any independent emission picture; its mean value is $\bar{n}(\lambda) = \lambda \ln s$.

The experimentally observed multiplicity distribution is known, however, to deviate from Poisson and to show Koba-Nielsen-Olesen scaling, i.e.

$$n \frac{\sigma_n}{\sigma} = \Psi\left(\frac{n}{\bar{n}}\right) , \qquad \bar{n} \text{ large},$$

with a universal function Ψ which does not explicitly depend on energy. We want to take KNO scaling seriously by assuming that Ψ retains an essentially energy-independent width at asymptotic energies. If this is the case, the multiplicity distribution reveals the presence of long range y-correlations among clusters. In the following, I am going to exploit the information on long range correlations

x) For the report at hand, I want to disregard the rising central plateau at x = 0, as observed recently at the ISR. Presently the variation of the plateau height with energy at rapidities $y \neq 0$ is unknown.