THEORETICAL STUDIES FOR LEPTONS PRODUCTION
IN HADRONIC COLLISIONS

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Abstract : Predictions are given for the leptons pairs production
taking into account the new informations about the quark partons
(antipartons distributions from ν datas, charm, colour) and about
the vector mesons (heavy vector mesons and ψ particles). Applica-
tions are given for various hadronic beams and energies in the
cases where one detects either the pair of leptons or a single
lepton. Modifications of the partons model and additional contri-
butions are noticed.

Résumé : Nous donnons des prédictions pour la production de paires
de leptons tenant compte des informations nouvelles obtenues sur
les quark partons (distributions d'antipartons à partir des expé-
riences neutrinos, charme, couleur) et sur les mésons vecteurs
(mésons lourds et particules ψ).Nous faisons des applications pour
divers faisceaux hadroniques et diverses énergies dans les cas où
l'on détecte soit la paire soit un seul lepton. Nous signalons la
possibilité de modifications du modèle à partons ainsi que de
contributions supplémentaires.

We reconsider globally the effects of a set of new informations[7,8,9] which modify our expectations about the leptons production in hadronic collisions, i.e. constraints on antipartons distributions inside the nucleon from DIS of neutrinos, existence of charmed and coloured states, higher vector mesons and new ψ particles. We give new predictions for cross-sections with various hadronic beams in a large energy range. In the first part we use the parton model with the Drell-Yan mechanism[1,2,3] in which a $q\,\bar{q}$ pair annihilates into one photon which gives then the leptons pair. In the 2nd part we consider the vector meson production (ρ, ω, ϕ, $\psi_{3.1}$) and their series of higher masses) ; this production is described by two processes, annihilation diagrams (A) and Bremstrahlung of vector mesons by the initial hadrons (B). In both parts we give applications for collisions of p, $\bar{p}$, π^+, π^-, K^+, K^-, K°, $\bar{K}^\circ$ on protons at various energies and with measurements of $\frac{d\sigma}{dQ^2}$, $\frac{d\sigma}{dQ^2 d\xi}$ and $\frac{\ell^\circ d\sigma}{d_3\ell}$ for a single lepton.

Detailed results can be found in

"Leptons production in hadronic collisions, partons, vector mesons and new particles", Preprint Montpellier PM/75/3, to be published in Il Nuovo Cimento A.

Let us just notice some discussions :

We believe that the contributions of the process (A) to the vector meson production is in a sense "dual" to the point-like Drell-Yann mechanism but that the process (B) is an additionnal term which may also have a dual counter part in a Bremstrahlung process of a $\bar{q}q$ pair by a single initial hadron. Those connections between partons and vector mesons have already been discussed[4] in the case of deep inelastic scattering and e^+e^- annihilation[5]. We observe then that the sum of (A) and (B) approaches the famous 10^{-4} ratio for ℓ/π in the range $1 < \ell_T < 7$ GeV/c for p + p collisions. Of course for $\bar{N}$ and π beams the cross-sections are much larger.

Additional contributions can be imagined.

First a modification of the Drell-Yan mechanism due to gluons effects is possible[6]. For example for vector meson production and more generally time-like photons one can require the extraction from the initial hadrons of more partons than the valence pair, i.e. the complete set of configurations with other pairs and gluons which constitute the sea of any hadronic state. Knowing[7] from DIS that in a nucleon state there are in average 49 % of gluons the effect can be important. In a very simple model with Poissonian

distributions of pairs and gluons in the sea ($P^h(n) = e^{-g} \frac{g^n}{n!}$ in h and $P(n) = e^{-g'} \frac{g'^n}{n!}$ in the vector meson or photon) one gets the correction factor to the Drell-Yan formulas :

$$(11) \qquad\qquad K = (1 + gg')\, e^{g'(g-1)}$$

If the sea of gluons is sharply x dependant (like some power of $(1-x)$) one may have a τ dependance in eq (11) through $g(\tau) \equiv g(1 - \tau)^k$; g' is related to the hadrons produced in e^+e^- annihilation: $g' \approx \frac{\langle n(n-1)\rangle}{\langle n\rangle}$ [8] ; here also the shape of $\frac{q^2 d\sigma}{dx}$ and its scaling violations [8] (apart from threshold effects for example of charmed particles) can be related to the opening of the sea configurations of the time-like photon (notice the similarity of the regions in x : x < 0.5 for scaling violations in $\frac{q^2 d\sigma}{dx}$ and for the sea contributions to $F(x)$). For reasonable values of g and g' one can get from eq (11) an enhancement factor for small τ and ℓ_T and a flatening or depression factor for large τ and ℓ_T ; exactly what seems to be required by experiments [9].

In addition new vector meson states (non singlet colour representations, Han-Nambu's) can still appear with high masses and contribute to large $\ell_T \approx \frac{m_V}{2}$. Finally single charged lepton production due to weak decays of new pairs of (charmed) particles is also possible but difficult to evaluate [10].

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