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THE ANALYSIS OF POSSIBLE FREE QUARKS PRODUCTION PROCESS AT HADRON COLLIDERS

Moscow 1990

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Рассматривается процесс образования свободных b-кварков в протон-антипротонных соударениях при энергиях строящихся коллайдеров. В качестве триггера предлагается использовать пару мюонов разного знака с поперечными импульсами $p_\perp > 5$ ГэВ/с. Дополнительно предлагается измерять слабый ионизационный сигнал, даваемый свободным s-кварком, образовавшимся в распаде b-кварка. Проведены расчеты сечений рождения пары свободных $b\bar{b}$-кварков с учетом потерь энергии на преодоление потенциального барьера в цветовом поле. Отмечено, что область поперечных импульсов распадных лептонов, соответствующая максимальному сечению образования свободных b-кварков, не зависит от пороговой энергии и примерно та же, что и в случае рождения обычных b-мезонов.

Получены оценки на число триггеров от полулептонных распадов очарованных, прелестных адронов и процесса Дрелла-Яна, а также на вероятность перекрытия ионизационного сигнала s-кварка и заряженного адрона из адронного сопровождения рассматриваемого процесса.

The authors regard the process of free b-quark production in proton-antiproton collisions at energies of new colliders. It is suggested to use the pair of unlike sign moons with transverse momenta in the range $p_\perp > 5$ GeV/c to trigger this process. Additionally it is suggested to measure a weak ionization signal from free s-quark from b-quark decay. The calculations of free $b\bar{b}$-quarks production cross-sections have been made taking into account their energy losses in strong colour field. It is shown that the most effective range of lepton transverse momenta for observation of the process does not depend on threshold energy and is approximately equal to one for usual b-mesons.

Estimates are made for number of triggers from semileptonic decays beaty, charm hadrons and from Drell-Yan pairs and for probability of ionization signals from s-quark and usual hadrons to be overlapped.

1. Introduction.

In the theoretical papers [1, 2] on the base of hypothesis of incomplete confinement of colour quarks the general analysis of experimental and theoretical situation on the problem of free quarks production has been done and the idea of experiment to search for their production at the electron-positron and hadron-hadron colliders has been suggested. This considerations is based on the fact that the dressed gluons interaction between two colour quarks can be simulated by some effective potential, which has an asymptotic free form at short distances (r < 1 fermi), linear growth in the range 1 < r < 10 fermi and falls like 1/r at infinity, i.e., has a form of some potential barrier with a height V_0 . The threshold energy for free quark creation is estimated as [3]

$$E_{th} = 2m_Q + V_0 + \frac{V_0^3}{m_Q^2} \qquad (1.1)$$

where the third term describes the radiation losses of quark with mass m_Q moving in a force field V(r) from the creation point to maximum of the potential. It follows from the Eq. (1.1), that for light quarks the value of E is very high and their creation even at the new colliders is practically impossible. Even for $c\bar{c}$-pair E_{th} > 500 GeV. Similar it is impossible to create a free gluon. So, it is really possible the production of the free colour b-quarks only, what has been considered in the paper [2]. Note, that the pair of free quarks should be in the singlet colourstate.

The strongest limit for value of V_0 follows from the absence of free quarks in e^+e^--annihilation up to energy 42 GeV [4]. Hence, E_{th} > 42 GeV, V_0 > 8 GeV and the distance R_0, where the potential has maximum $V_0 = V(R_0)$ is equal to:

$$R_0 \simeq \frac{V_0}{a^2} \qquad (1.2)$$

a = 420 MeV - is well known slope parameter for linear potential (string tension). Note, that R_0 can not be much higher then (1.2). Otherwise, as it is shown in [5], one will have a contradiction with experimental limits on hadron Van-der-Vaals long range interaction.

The present paper considers in more details the process of the free bb-quarks pairs production at hadron colliders from the point of view of their experimental detection.

2. The process simulation.

Note, that all the results of this paper have been calculated for one of the all possible semileptonic decay modes of b-quark, and under lepton we shall understand either muon or electron. We also shall not take into account the semileptonic decay of the b-quark onto τ-lepton, because the branching ratio of the semileptonic τ-lepton decay is small, about 20%.

In difference of paper [2], it is proposed here to register the production of free b-quark in all decay modes of the c-quark, but not in the semileptonic modes only, i.e., to register the process

$$
\begin{array}{l}
p + \bar{p} \longrightarrow b + \bar{b} + X \\
\quad \bar{b} \to \bar{c} + \ell_2^{+} + \nu_{e_2}, \quad \bar{c} \to \bar{s} + all \\
\quad b \to c + \ell_1^{-} + \tilde{\nu}_{e_1}, \quad c \to s + all
\end{array}
\qquad (2.1)
$$

s-quark with charge 1/3 is already a longliving object which decays outside the confinement region. Note, that it is possible a creation of free u-quark with charge 2/3 in hadronic decay modes of c-quark. But, as it is easy to estimate, that relative part of such decays is small and they will not be considered here.

The lepton pairs produced in the semileptonic decays of b- and $\bar{b}$-quarks can be used to select the events with free quarks creation and s-quark can be registered due to its ionization of the detector matter. This effect could serve as a direct confirmation of the free quarks production.

The heavy quarks production in hadron collisions is described by diagrams at Fig.1. The contribution into production of quarks in free state comes from diagram Fig.1.(c) only [2].

The further calculations have been done for the central rapidity region, $|y| < 1.2$, for existing universal detectors. At small angles to beam axes due to high multiplicity of charged particles at few TeVs energies the experiment is more complicated and it is necessary to carry out a special consideration.

To carry out the calculations for free quarks production with decays (2.1) we used the Monte-Carlo technique.

For simplicity the decay (2.1) was simulated like two successive decays $b \to c + l + \nu$ and $c \to s +$ all in the phase-space approximation. We have checked, that the correct form of matrix element of the b-quark weak decay does not practically influence onto decay products distributions. The expression for production cross-section of bb-quarks pair in the relative colourless state due to gluon interactions has been taken from [2] and is:

$$
\frac{d\hat{\sigma}}{dt} = \frac{\pi \alpha_s^2}{48 \hat{s}^2}\left[\frac{a}{b} + \frac{b}{a} + 2\left(\frac{m_b^2}{a} + \frac{m_b^2}{b}\right) - \left(\frac{m_b^2}{a} + \frac{m_b^2}{b}\right)^2\right] \qquad (2.2)
$$

$$
a = (m_b^2 - \hat{t})/2, \quad b = (m_b^2 - \hat{u})/2
$$

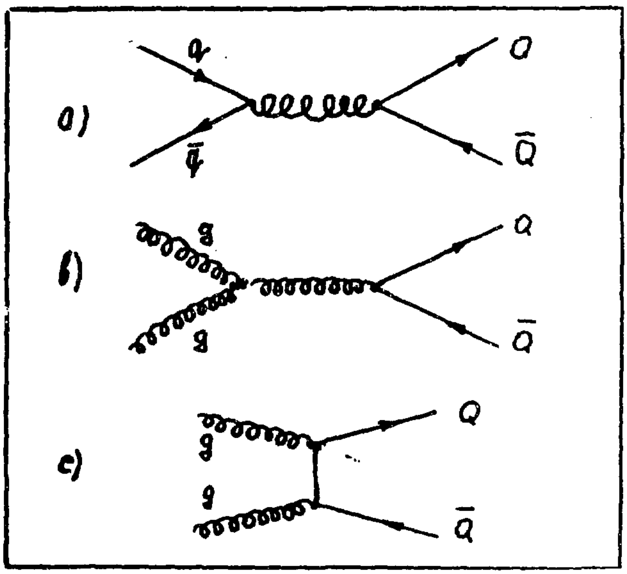

Fig.1. Diagrams describing the production of bound (a,b) and free (c) quark

This expression was used for simulation of the production of $b\bar{b}$-quarks pair with energy $\sqrt{\hat{s}} > E_{th}$. We used the well known parameterization EHLQ [6] to describe the gluon distribution and for momentum traversed Q we chose the value:

$$Q^2 = \frac{2\hat{s}\hat{t}\hat{u}}{\hat{s}^2 + \hat{t}^2 + \hat{u}^2} \tag{2.3}$$

The probability for b-quark to stay free, i.e., not to discolour during its evolution, is unknown. The estimate for this probability in nonrelativistic approximation has been done in paper [2] and is:

$$W(E) = \frac{4\sqrt{E(E-E_{th})}}{(\sqrt{E} + \sqrt{E-E_{th}})^2} \exp\left[- \frac{R_0 \lambda}{\gamma(E)}\right] \tag{2.4}$$

where $\gamma(E)$ is some effective gamma-factor. Generally speaking, it is a rather complicated function of energy of b-quark, moving in a colour field. We suggested for calculations, that value γ in Eq.(2.4) is simply:

$$\gamma(E) = \frac{E}{m_Q} \tag{2.5}$$

where E - is the initial energy of produced b-quark, because the b-quark can be discoloured capturing a light soft antiquark inside the confinement radius region, but the energy losses of b-quark in this area are small [7,8].

The decay of c-quark was simulated as three-body decay onto s-quark and two π-mesons, one of which is charged, because the simulation of multibody c-quark decay does not lead to significant variations of s-quark inclusive distributions comparatively to approximation regarded.

The value of the QCD parameter λ has been chosen equaled to λ = 100 MeV [2] (*).

The calculations have been carried out for three values of threshold energy: E_{th} = 50, 100 and 200 GeV and for energies of hadron colliders in FNAL ($\sqrt{s}$ = 1.8 TeV), LHC ($\sqrt{s}$ = 17 TeV) and SSC ($\sqrt{s}$ = 40 TeV). The results for FNAL Tevatron can be practically applied to UNK in the collider regime 3 x 0.4 Tev ($\sqrt{s}$ = 2.2 TeV). The values of total cross-sections for free $b\bar{b}$-quarks pairs production are shown at Fig.2.

(*) The value of λ is driven from the solution ofpotential task for bound states of charmonium and bottonium. The preliminary data of LEP show, that the value of λ is possibly equal to λ = 200 MeV. In this case the total cross-sections for free b-quarks production will be less then it is calculated in present paper.

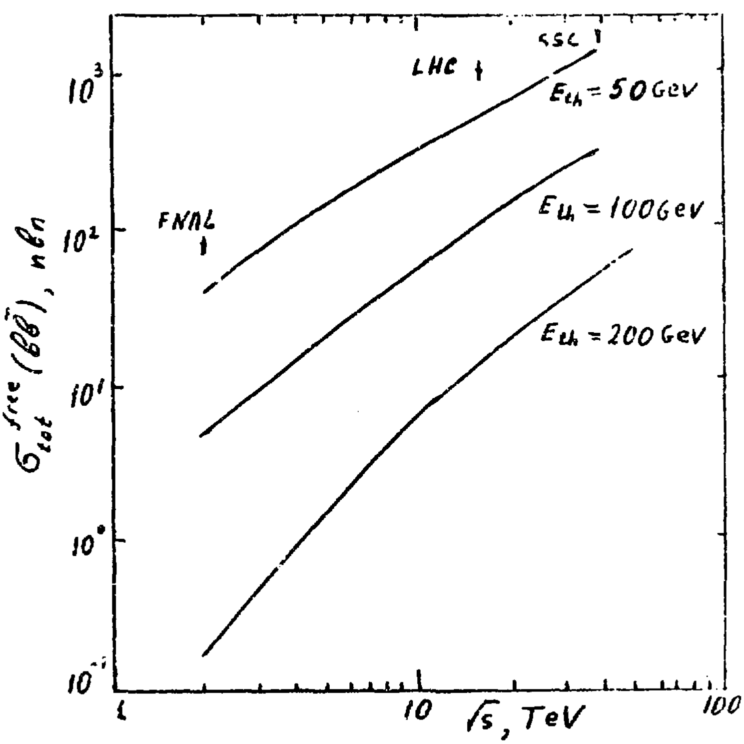

Fig.2. The dependence of the total cross-sections for pair offree $b\bar{b}$-quarks production on energy of colliding proton and antiproton $\sqrt{s}$ for various values of the threshold energy E_{th} .

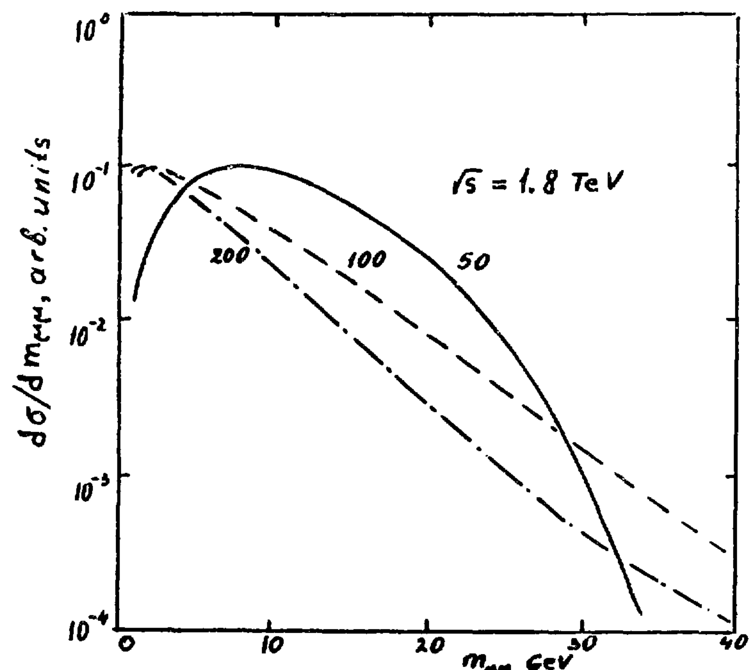

Fig.3. Normalized onto unit effective mass distribution oflepton pair, produced in semileptonic decays of free $b\bar{b}$-quarks at various values of threshold energy E_{th} .

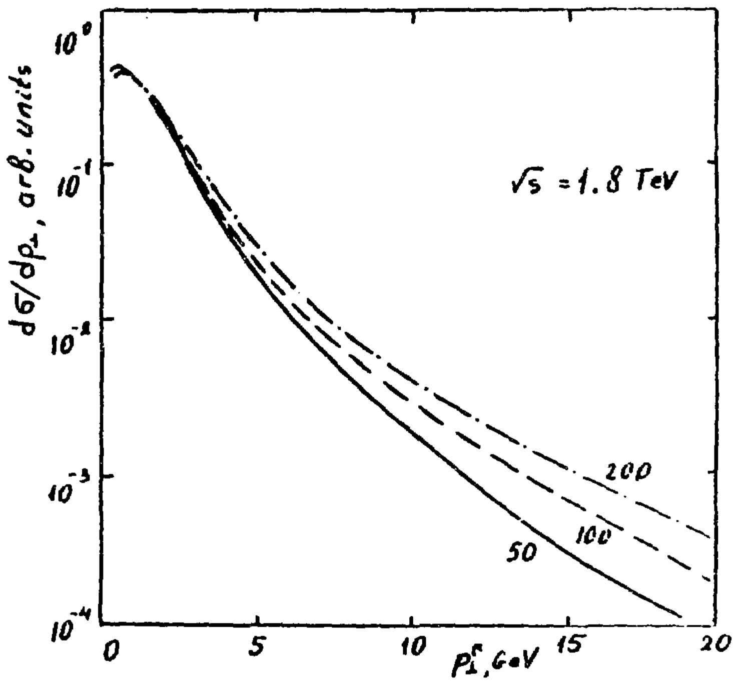

Fig.4. Normalized onto unit transverse momentum distributions of leptons at $\sqrt{s}$ = 1.8 TeV and various values of $E_{\mu\mu}$

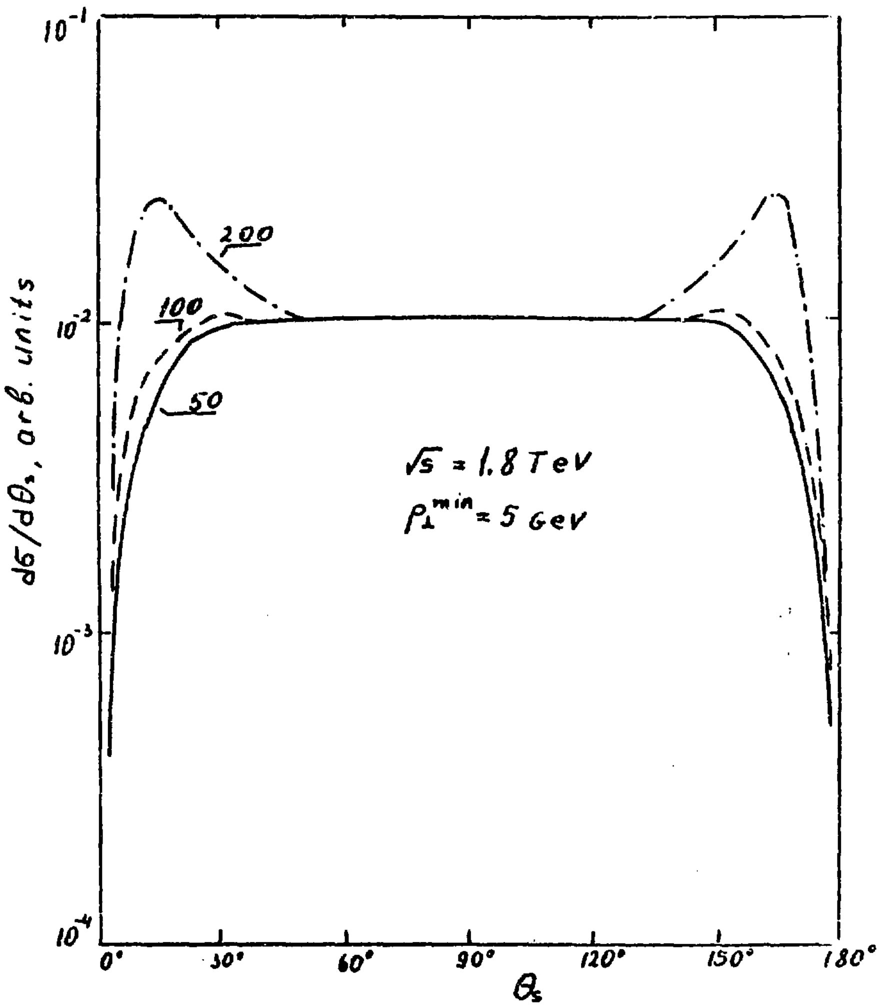

Fig. 5. Normalized onto unit angular distributions of s-quark at $p_{\perp}^{min}$ = 5 GeV and various E_{jet} .

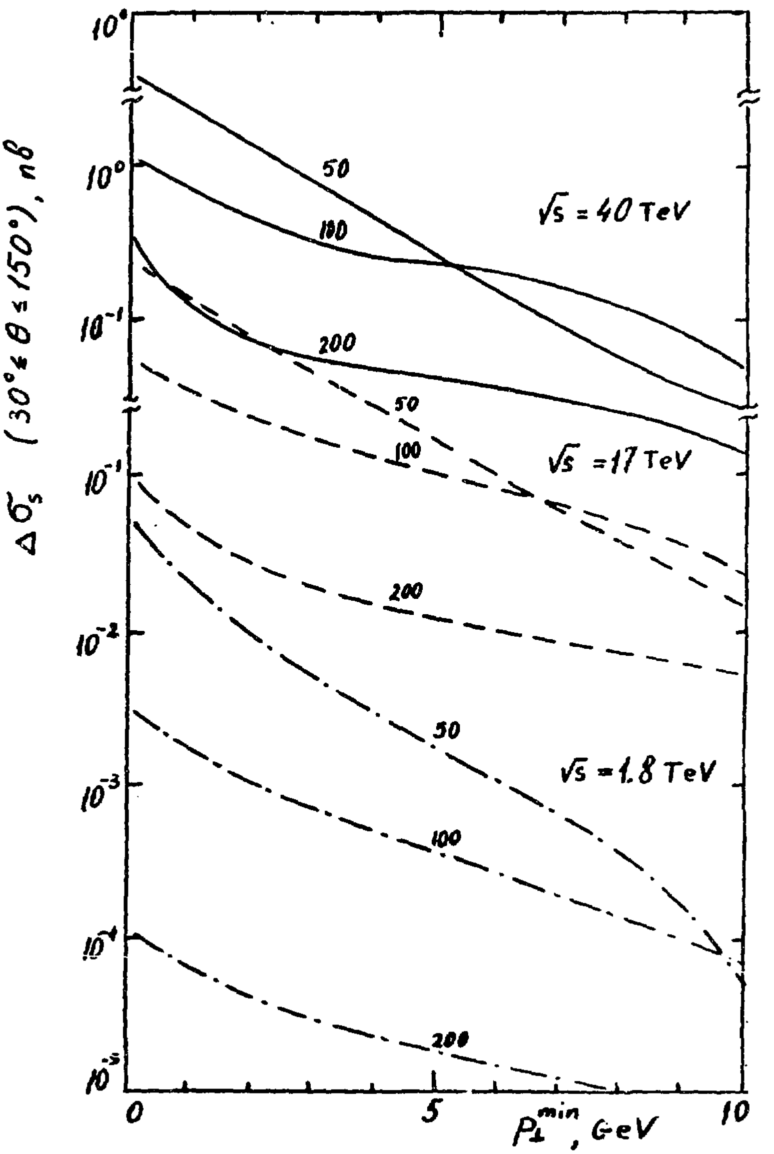

Fig. 6. Integral cross-sections for free s-quark production in decays (2.1) within the angular interval $30° < \theta < 150°$ versus the threshold value of transverse momentum of leptons $p_\perp^{min}$ for various E_{th} and $\sqrt{s}$.

At Fig. 3 we show the normalized onto unit distributions of lepton pairs from free b-quarks decays (2.1) over their effective mass. One can see from this figure, that the effective mass of lepton pair are not large, around $m_{eff} \simeq 2 m_t \simeq$ 10 GeV. This fact allows, in particular, to select the lepton pairs from leptonic decay of Z^0-boson. Comparatively small value of lepton pair effective mass, despite the high effective mass of parent $b\bar{b}$-quark pair $m_{b\bar{b}} > E$ is explained by the big energy losses due to gluon radiation.

Note the following fact. It is known, that the maximum in inclusive spectra for multibody decay product when the transverse momentum of parent particle is restricted should be about $p_\perp \simeq M/2$ [9], where M - is a mass of parent particle (in our case under "parent mass" one should understand the effective mass of $b\bar{b}$-pair). Thus, the effective range of leptons transverse momenta from semileptonic decays of free b-quark lies at

$$p_\perp \simeq \frac{2m_t}{4} \simeq (2 \div 3)\ GeV. \qquad (2.6)$$

This qualitative consideration is being confirmed by the lepton distributions over their transverse momentum shown at Fig. 4 (the distributions are normalized onto unit).

It is reasonable to choose the threshold value of trigger leptons transverse momenta equal to $p_\perp^{min} \geqslant 5$ GeV to suppress the contribution from leptonic decays of usual hadrons with small transverse momenta and, at the same time, to have sufficiently large value for production cross-section of free s-quarks.

Fig. 5 shows the normalized onto unit s-quark distributions over its polar angle at the threshold transverse momentum of leptons $p_\perp^{min} = 5$ GeV. One can see that the s-quark distribution is practically constant in the central region of angles.

Fig. 6 shows the integral inclusive cross-sections of free s-quarks production in the angular range $30^\circ < \theta < 150^\circ$ versus the threshold value of trigger leptons transverse momentum $p_\perp^{min}$ for various E_{e} and $\sqrt{s}$. The values, which are shown at Fig. 6, have been calculated for semileptonic branching ratio of free b-quark Br(b -> l + X) = 0.1 and for angular range of leptons $30^\circ < \theta < 150^\circ$.

3. The hadronic accompaniment of the process.

The overlapping in the same element of detector of s-quark and a hadron with unit charge, produced in the same collision, leads to impossibility to select the ionization signal of s-quark, i.e., to decreasing of the registration efficiency of free s-quark. The hadronic accompaniment is produced due to, first, the soft hadronic "halo", produced by the fragmentation of colliding protons and, second, due to hadrons, produced in the hadronization of bremsstrahlung gluons, radiated by b-quark, when it moves in colour field.

To estimate the soft hadronic "halo" we used the LUND model [12] (JETSET, version 6.3). The simulation has shown, that the probability of overlapping of signals from soft hadrons and from s-quark in the central rapidity interval at quite reasonable space resolution of a detector and at the threshold value of leptons transverse momentum $p_\perp^{min} > 5$ GeV is negligible.

The main contribution into hadronic accompaniment comes from the second process - the bremsstrahlung radiation of gluons by b-quark in strong colour field within the region $r_h < r < R_\bullet$, which leads to energetic hadronic jet. The quantitative estimate of such a radiation can be done on the base of the space-time evolution picture of quark [10].

When a quark has been created in the hard process its branching process is being started due to successive decays:

$$\begin{aligned} Q &\to Q + g \\ g &\to g + g \\ g &\to q + \bar{q} \end{aligned} \qquad (3.1)$$

The probabilities of such decays for heavy quark are not large because the argument of α_s has a big value

$$k_\perp^2 + z \cdot m_Q^2$$

where m_Q - is a mass of heavy quark and z - is its relative momentum ($z \sim 1$). In the Leading-Log approximation of quantum chromodynamics those decays occur independently and this process allows the probabilistic parton interpretation. Thus, the initial quark during the time

$$\tau \sim \frac{E}{m_Q} r_h$$

where r_h - is a hadron radius, radiates the bremsstrahlung gluons, producing a partonic jet. In a heavy quark case, the emitted gluons are soft ones, and they start immediately to interact with each other. As a result of this intensive interaction they produce a jet of colourless soft hadrons. As it has been already noted, the heavy quark is being discoloured usually at the distances $r < r_h$ and, hence, can leave the confinement area without further energy losses.

In the model under consideration of free colour quark creation its energy losses in the area $r < r_h$ are also controlled by the branchings (3.1) and are small. So, we shall not regard them in further calculations. But, if the heavy quark has not been discoloured in this area, it comes into strong colour field and starts intensively to radiate the bremsstrahlung gluons. Let us try to get a reasonable estimates for parameters of hadronic jet, produced by such a bremsstrahlung process in a linear field.

Let us show first, that, the emission of each bremsstrahlung gluon and its hadronization can be considered independently. Really, in the linear colour field the intensity of bremsstrahlung radiation should be approximately constant. Thus, the mean number of radiated soft gluons is:

$$\langle n_g \rangle \simeq \ln\left(\frac{E_Q}{Q_{min}}\right) \qquad (3.2)$$

where, E_Q - is the total energy, radiated by heavy quark and in our case is equal to $E_Q \simeq V_0^2/2m_Q^2$, Q_{min} - is some minimal virtuality of a bremsstrahlung gluon. The energy, carried by such a gluon is, in average, equal to

$$\langle E_g \rangle \sim \frac{E_Q}{\langle n_g \rangle}$$

and a size of gluon wave function along the b-quark momentum direction is

$$\langle \ell_g \rangle \sim \frac{Q_{min}}{E_Q} r_h$$

From another hand, at constant intensity of bremsstrahlung the mean distance between successively radiated gluons is equal to:

$$\langle \Delta r_g \rangle \sim \frac{R_0}{\langle n_g \rangle}$$

So, one can conclude, that the ratio

$$\frac{\langle \Delta r_g \rangle}{\langle \ell_g \rangle} \sim \frac{R_0}{r_h} \cdot \frac{E_Q/Q_{min}}{\ln^2(E_Q/Q_{min})} >> 1$$

i.e., the distance between successively radiated bremsstrahlung gluons is much greater, than their longitudinal size and, thus, their wave functions are not overlapped. Other words, the hadronization of each initial bremsstrahlung gluon should occur independently at all reasonable energies E_{th} . The mean number of bremsstrahlung gluons $\langle n_g \rangle$ is restricted by few units. For example, for threshold energies in the range E_{th} = (50 - 500) GeV for $\langle n_g \rangle$ one gets

$$\langle n_g \rangle \simeq 3 \div 5$$

Due to the fact, that the radiation of soft gluons can be considered quasiclassically, the probability to radiate n_g bremsstrahlung gluons is defined by Poisson distribution with the mean value $\langle n_g \rangle$ from Eq.(3.2).

Further, because the gluons radiated by a heavy quark, are soft ones, it is possible in the first approximation not to consider the process of their further breeding due to branchings (3.1), i.e., the process of the partonic cascade developing and to simulate the hadronization of each of the initial gluons immediately into final hadrons. Moreover, the destructive interference of soft colour gluons [11] leads to suppression of radiation of gluons with small rapidities and enhances the effect of angles ordering in the sequence of elementary decays (3.1). This means, that angles between successive daughter partons and their parents go down. From the phenomenological point of view one can regard, that each initial soft gluon, emitted by b-quark, gives, in fact, one final hadronic jet and the hadronic accompaniment of s-quark can be roughly considered as consisting of small number n_g of sufficiently energetic hadronic jets with summary energy equal to total energy, radiated by the heavy quark passing throw the potential barrier.

If the bremsstrahlung radiation intensity is constant (due to linear potential), the total energy E_Q , radiated by heavy quark, should be randomly distributed between the bremsstrahlung gluons and, hence, between the hadronic jets, produced in gluon hadronization process. So, one can count, that each hadronic jet carries energy $E_j = E_Q/n_g$.

Because the hadronization of initial gluons should occur independently, one can use some of the already developed phenomenological models of independent fragmentation of gluon to simulate a production of hadronic jet with energy E_j and radiated along the b-quark momentum direction. Choosing the radiation direction along the heavy quark momentum, we overestimate the probability to overlap the signals from s-quark and from usual charged hadron in the same detector cell. It is natural to make the simulation of bremsstrahlung radiation in center of mass of initial colliding gluons, where the production of free $b\bar{b}$-quarks in effective potential V(r) is considered. Note, that this choice of reference frame agrees with approach of LUND model [12] and leads to significant variations in hadron distributions in jet comparatively to the usual simulation of fragmentation of a parton in the center of mass of initial colliding protons.

So, the radiation process can be considered quasiclassically as independent emission of comparatively small number n_g of soft energetic gluons and a hadronic jet, accompanying this process is a result of their independent hadronization.

The above analysis of heavy quark evolution has been used for simulation of hadronic accompaniment of s-quark. For number of bremsstrahlung gluons the following natural restriction was introduced:

$$1 < n_g < \frac{V_0^3}{2\, m_Q^2\, Q_{min}}$$

where Q_{min} - is some minimal virtuality of parton (gluon), after which its hadronization takes place. The same value enter the Eq.(3.2) for mean number of radiated gluons $\langle n_g \rangle$.

For Q_{min} there has been taken a value Q_{min} = 4 GeV [13,14]. The concrete value of minimal virtuality of gluon influences onto number of hdronic jets weakly, logarithmically. The Field-Feynman model of independent fragmentation [14,12] was used for successive fragmentation of those gluons into observable hadrons. The hadronization process was simulated in the center of mass of scattering gluons frame, after what the boost of all the hadrons and s-quarks momenta into center of mass of colliding protons were being performed.

Let us compare the results of present paper for multiplicity of charged hadrons with computations for e^+e^--annihilation.

Fig. 7 compares the multiplicity of charged hadrons, calculated in present paper, with the cluster model predictions [13] for two gluon jets "produced" in e^+e^--annihilation (instead of two quark jets). As one can see, the multiplicity calculted in present paper, is significantly higher due to intensive gluon bremsstrahlung in strong colour field.

Fig. 8 shows the dependence of the value $d\sigma/d\Omega$ versus s-quark polar angle, i.e., the mean number of hadrons hitted the unit solid angle simultaneously with s-quark at $\sqrt{s}$ = 1.8 TeV and various threshold energies E_{th} . It is seen from the figure, that the probability of such an overlapping depends, of course, on energy E_{th} . But, for solid angles order of $\sim 10^{-3}$ this probability is sufficiently small and does not lead to essential losses of useful events with s-quarks.

4. The lepton pair yield from the main background sources.

Due to the fact, that it was proposed to use a lepton pairs to trigger the process regarded, it is desirable to have an estimate for yield of such pairs from processes not connected with free quark production.

The main contribution into lepton pair yield at transverse momenta of leptons $p_\perp$ > 5 GeV should come from semileptonic decays of charm and bottom particles and, also, from the Drell-Yan process [15].

Fig. 9 shows the integral production cross-sections of lepton pairs with $p_\perp > p_\perp^{min}$ for above processes, computed in the leading order of QCD for the polar angles of leptons in the range $30° < \theta < 150°$ versus the threshold value of transverse momentum p for $\sqrt{s}$ = 1.8 Tev. For the case of b-hadrons the additional contribution from leptons, produced in the successive weak decay of charm hadron has not been taken into account. Those decays increase the lepton yield on 10-20% comparatively to Fig. 9. It is seen from Fig. 9, that the contribution from Drell-Yan process is significantly less than one from charm and bottom mesons. Hence, it is not necessary to take into account the

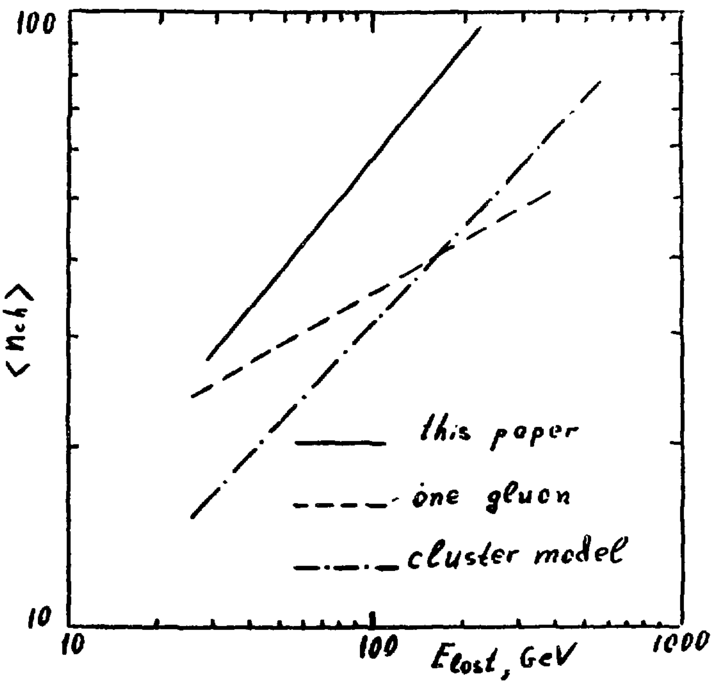

Fig. 7. The mean multiplicity of charged particles for energy E_{lost} radiated by pair of free bb-quarks, calculated in this paper. The dashed line shows mean multiplicity in case when each b-quark radiates one gluon with energy $E_{lost}/2$. Dot-dashed line shows the predictions of the cluster model of hadronization [13] for two gluon jets, "produced" in e^+e^--annihilation at the $\sqrt{s_{ee}} = E_{lost}$.

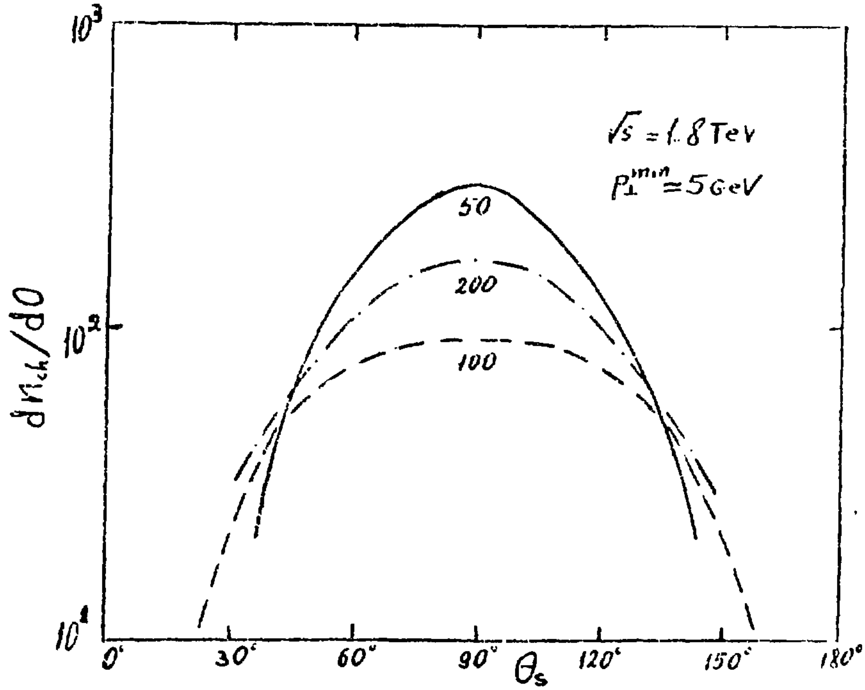

Fig. 8. The number of charged hadrons, overlapped with s-quark in the unit solid angle at various E_{th} versus production angle of s-quark at $\sqrt{s}$ = 1.8 TeV.

contribution from Drell-Yan process with additional hard gluon emission, which is order of $\alpha_s \sim 0.1$ (**).

Fig. 9 shows also the contribution from $Z^0 \to l^+ l^-$ decay into measured cross-section of lepton pairs. This contribution is significant. But, the main contribution from Z^0-boson sits in the lepton transverse momentum range $p_\perp \approx M_Z/2 \approx$ 40-50 GeV (see, e.g., [16]), and their effective mass is equal, naturally, to mass of Z^0-boson, $M_Z \simeq 90$ GeV. Thus, those pairs can be easily identified at the trigger or at the off-line level.

Fig. 10 shows the dependence of the ratio of s-quark and background lepton pairs integral production cross-sections versus threshold value of lepton transverse momentum $p_\perp^{min}$ for three threshold energies E_{th} and $\sqrt{s}$ = 1.8 TeV.

As it was noted in Part 2, the final effective mass of free bb-quarks pair should be practicaally the same, as for bound ones. Thus, the decay products distributions from bound and free heavy quarks will not be significantly different. The range of transverse momenta of leptons for maximal value of free b-quarks production cross-section depends weakly on threshold energy E_{th}. It follows from this fact, that the increasing of trigger $p_\perp^t$ threshold will not change the order of magnitude for ratio of s-quark yield to number of triggers. At the same time the increase of trigger threshold leads, of course, to sharp fall of number of useful events with free s-quarks. Thus, the value of trigger threshold p should be not very high, about (5 - 6) GeV, sufficient to suppress the contribution from leptonic decays of soft π- and K-mesons and to leave sufficiently big yield of free s-quarks.

5. The analysis of the results.

From the results of present paper one can estimate the main conditions of the experimental search for free quarks at hadron colliders.

From integral cross-sections at Fig. 6 it is easy to estimate the inclusive yield of free s-quarks. For E_{th} = (50 - 100) GeV, energy $\sqrt{s}$ = 1.8 TeV aand luminocity $L = 10^{31}$ $cm^{-2} s^{-1}$, during one year of accelerator run in the given solid angle the yield of s-quarks at $p_\perp^{min}$ = 5 GeV is about of (40 - 200) q/year (see aalso footnote (**)). From the background leptons yield calculations (semileptonic

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(**) Note, that the results at Fig. 9 were computed for unlike-sign muon pair. If one does not analyse the lepton type, the results at Fig. 9 should be multiplied by factor about four, because the processes of muon and electron pairs production are completely similar (if the contribution from soft π- and K-mesons decays is negligible).

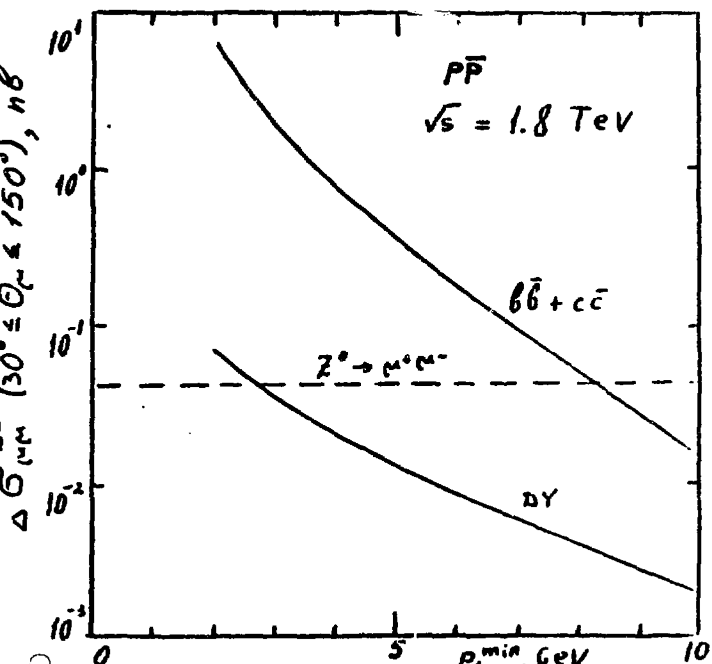

Fig. 9. Integral cross-section for background lepton pairs production at $p_\perp > p_\perp^{min}$ within angular interval 30° < θ^* < 150° versus their threshold transverse momentum $p_\perp^{min}$ for $\sqrt{s}$ = 1.8 TeV.

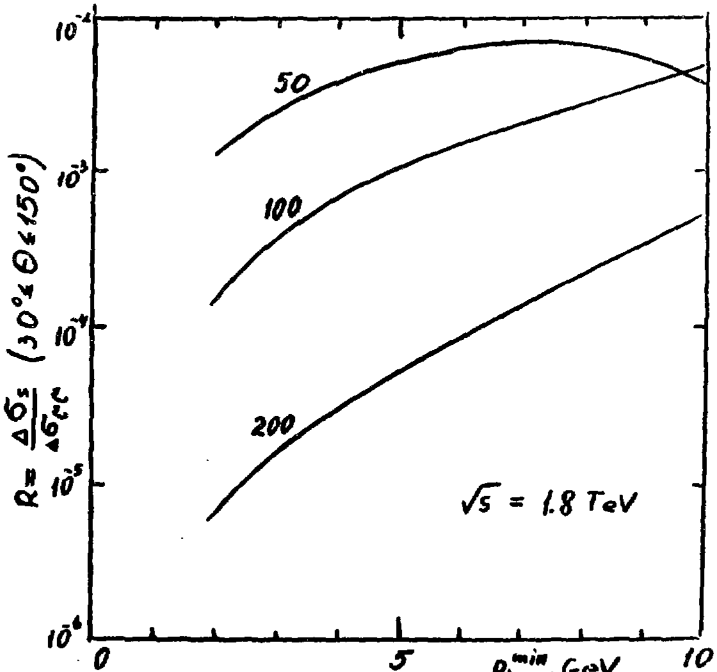

Fig.10. The dependence of the ratio of integral cross-sections of s-quark and lepton pairs on threshold value of lepton transverse momentum $p_\perp^{min}$ for various $E_{м}$ within the angular range $30° < \theta < 150°$ and $\sqrt{s}$ = 1.8 TeV.

decays of bound b- and c-quarks and Drell-Yan process), at the Fig. 9, one can estimate, that number of triggers for those experimental conditions should be about $3 \cdot 10^4$ trigg./year.

As a detector to register s-quarks we propose to use a multilayers silicon detector, consisting of 10^4 - 10^5 elements (channels of registration). The estimates for number of background events caused by noises in the detector and electronics show, that at above number of triggers and 6 layers of q-detector it is possible to get less then 1 background event for one year of work.

It follows from estimates for probability for ionization signals of s-quark and charged hadron to be overlapped, that the detector, registering s-quark, should have a high space resolution. As it follows from Fig. 8, the element of the detector (registration channel), situated at the distance R from the interaction vertex, should have a square order of $10^{-3} R^2$ to have a probability of s-quark and hadron overlap, to be about 10% at E_{th} = 100 GeV and $\sqrt{s}$ = 1.8 TeV. Note, that for higher energies of pp-beams and for higher threshold energies E_{th} this probability grows and, for example, at $\sqrt{s}$ = 40 TeV and E_{th} = 200 GeV is few times greater. Note also, that the hadronic jets with $E^{had} \approx E^{b}/2$, accompaning s-quark, can serve as additional indication onto process searched. To analyse the opportunity of using the E^{had}($E_{\perp}^{had}$, or multiplicity) in trigger it is necessary to carry out more detail simulation of bremsstrahlung radiation and the methods of hadronic jets selection.

The above estimates concern to searching for inclusive production of s-quark. But at sufficiently large acceptance of q-detector the significant number of events will have both s- and $\bar{s}$-quarks. For the angular range $30^\circ < \theta < 150^\circ$ the part of such two quarks events will be about 50%. But, in this case one will have much higher reliability of free quarks registration.

It is necessary to take into account during the experiment, that this scheme with incomplete confinement predicts big value for cross-section of free quark interaction with usual nucleii of matter, order of $\sigma_{int} \sim 10$ bn and does not depend, in the first approximation, on atomic number of matter A. Such a big value of cross-section requires a minimal amount of matter before the detector of quarks, measuring the ionization. Beside this, when using a multilayer detector the opportunity exists for direct measuring of the interaction length of s-quark in a matter, placing a light absorber with total thickness of (1-2) cm in the gaps between last layers of the detector.

On the base of above analysis and simulation we can conclude, that there exist a real experimental opportunity for registration of a process of free $b\bar{b}$-quarks pair production at energy of few TeVs and more in the center of mass of proton-(anti)proton collisions.

The concrete experimental set-up and the choice of an optimal geometry of silicon detectors, e.g., vertex microstrip detector, registering simultaneously the pass length of b-quarks, needs more detail calculations. At the present time this work is in progress.

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