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Signatures of the b' quark at e^+e^- colliders

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We investigate a scenario in which a fourth generation quark b' exists with mass $m_{b'} < m_t$ such that flavor changing neutral current decay modes dominate its width. In this scenario the signatures of b' quark production will be different than what have been examined so far at the Fermilab Tevatron and there are implications for b' quark searches at e^+e^- colliders. We study a flavor-distinguishing signature of the b' quark production relevant in this scenario. We show that the background to this signature at CERN LEP 1 is not very large. At LEP 2 a suitable choice of cuts can make the background manageable.

I. INTRODUCTION

One of the important features of the standard model is the existence of more than one generation of quarks and leptons. Within the standard model there is no theoretical upper bound on the number of possible generations. However, since each generation contains one neutrino, an empirical bound on the number of neutrinos gives rise to a bound on the number of generations. Significant bounds on the number of *light* neutrinos come, apart from the collider experiments, from big bang nucleosynthesis[1] and the observation of the products of supernova 1987A.[2] These bounds, at least until recently, did not rule out a fourth generation. In this paper, we discuss a possible detection scheme for the fourth generation down type quark, usually labeled as the b'. The most recent results on *light* neutrino counting at the SLAC Linear Collider[3] (SLC) and the CERN collider[4] LEP 1 indicate the existence of only three varieties of *light* neutrinos and thus, in the context of the standard model, only three generations of quarks. In this case the search for a fourth generation quark becomes even more interesting. The discovery of a fourth generation would represent a deviation from the standard model and could indicate ways to extend or modify the standard model.

If the b' quark exists, it is possible that its mass is smaller than the mass of the missing third generation quark, the top quark. The recent increase in the experimental lower bound on the mass of the top quark[5] makes such a possibility plausible. Recently, Barger, Phillips, and Soni[6] suggested that, if $m_{b'} < m_t$, then the $b' \to bg$ decay mode can have a non-negligible branching ratio. Starting from the same assumption, Hou and Stuart[7,8] analyzed all the various decay channels of the b' quark and found that the flavor changing neutral current (FCNC) decay modes of the b' quark could, in fact, dominate over the charged current (CC) decay modes. In particular, they noted that it is consistent with the current bound on the Cabibbo-Kobayashi-Maskawa (CKM) matrix element V_{ub} (for the third generation b quark) that the rate of the FCNC decay $b \to sX$ be at the same level as the CC $b \to uX$ rate. If m_b were smaller than m_c, the latter process would be the dominant CC decay mode. By analogy in the four generation case, with $m_{b'} < m_t$, it is possible that the FCNC $b' \to bX$ decay modes are comparable to or even dominate over the CC $b' \to cX$ decay modes. It is important to note that the FCNC decay branching ratio for the decay of the bottom quark b is larger than that for the strange quark s. Thus, as pointed out by Hou and Stuart, the structure of the CKM matrix required in order for the FCNC decay modes of the b' quark to be dominant is not unreasonable.[9] Therefore it is interesting to investigate a limiting scenario where $m_{b'} < m_t$ and the branching ratios of the CC decay modes[10] of the b' quark are assumed to be truly negligible as compared to the FCNC decay modes. Such an investigation will yield an upper limit on the number of possible events from the FCNC decay channels of the b' quark. The analysis of such a limiting scenario with only FCNC decay modes contributing is actually made simpler by the fact that the branching ratios of the various decay modes do not depend on the specific values of unknown CKM matrix elements. Therefore our results will depend on only a few unknown parameters. Specifically, for a given value of $m_{b'}$, the only unknown parameters are m_t and $m_{t'}$, where the t' quark is the fourth generation up type quark.

In what follows we focus on the case when $m_{b'}$

$< M_Z + m_b$ so as to be relevant to LEP1 and LEP2. We note that, if $m_{b'} > M_Z + m_b$, the dominant decay mode is $b' \to bZ$.[8] We make the reasonable assumption that the Higgs boson is heavy enough to be kinematically inaccessible to the decay of the b' quark.[8] We also neglect the decay mode $b' \to bgg$. There are reasons to believe that the width of this decay mode is indeed comparatively negligible[11] although a complete gauge invariant calculation for this decay mode is not available. With these assumptions the important decay modes of the b' quark are $b\gamma, bg, bq\bar{q}$. Among these decay modes $b' \to bg$ is expected to dominate. Recently, Hou and Stuart have computed the partial widths for the decay modes $b' \to bl^+l^-, b\nu\bar{\nu}$.[11] As compared to the above decay modes, these are higher order electroweak processes. They also computed higher order electroweak corrections to $b' \to bq\bar{q}$. Contrary to expectations, these higher order FCNC decay modes can make significant contributions to the width of the b' quark. This situation arises because of the rather strong dependence of the partial widths of these decay modes on the values of m_t and $m_{t'}$.[11] We will discuss the implications of this possibility for our analysis.

In our scenario, the production of pairs of b' quarks yields the final states $\gamma + 3$ jets, $\gamma + 4$ jets, $2\gamma + 2$ jets, 4 jets, 5 jets, and 6 jets. These final states either contain photons or are purely hadronic. In this case, b' quarks may already have been produced at the $p\bar{p}$ colliders and gone undetected. The conventional signatures, which are explored at such colliders, involve only "$e^\pm\mu^\mp$" and "isolated $e^\pm(\mu^\pm)$ + multijets" events. In our scenario b' quark production does not give rise to such events. This scenario will also influence the bounds on the b' quark mass obtained at the e^+e^- colliders. If the higher order decay modes $b' \to bl^+l^-, b\nu\bar{\nu}$ are important, we can have several other final states. If the higher order electroweak corrections to $b' \to bq\bar{q}$ are important, there can be a relative enhancement of this mode. In this case the signatures 5 jets, 6 jets, and $\gamma + 4$ jets can become more important. In particular, the flavor-distinguishing signature "isolated $\gamma + 4$ jets" can become as important as "isolated $\gamma + 3$ jets."

At e^+e^- colliders hadronic final states are usually analyzed in terms of shape variables. The analysis of purely hadronic final states in terms of shape variables will not help us to distinguish between the top quark and the b' quark. The *flavor distinguishing signature* for the production of b' quarks are events with isolated photons. Since the top quark essentially always decays through CC decay modes, the production of top quarks will not give rise to such events. The distinctive signature for the top quark production will be "isolated $e^\pm(\mu^\pm)$ + multijet" events.

On the basis of shape variable analyses of the final states, lower bounds on the masses of the top quark and b' quark have been established at the KEK collider TRISTAN, SLC, and LEP1. At TRISTAN, events with isolated photons have also been investigated to put a lower bound on the mass of the b' quark. The AMY Collaboration[12] used the shape variables thrust, acoplanarity, and a new specially designed variable "lesser biwidth" to put the lower bound of 27.2 GeV on the mass of the b' quark. The VENUS Collaboration[13] also looked for isolated photon events at TRISTAN and corroborated the results of the AMY Collaboration. At SLC, the Mark II Collaboration[14] used a different shape variable which measures the mass out of the event plane to put a lower bound of 42.7 GeV on the mass of the b' quark. The Mark II Collaboration also looked for isolated photon events. They assumed the branching ratio for $b' \to b\gamma$ to be greater than 25%.[15] With this assumption they put a lower bound on the mass of the the b' quark of 45.4 GeV. Thus considering all possible decay channels, including CC decay modes, Mark II put a lower bound of 42 GeV on the b' quark mass. More recently, the OPAL Collaboration[16] at LEP1 reported a lower bound of 45.2 GeV on the basis of the measurement of the acoplanarity variable. Finally the ALEPH Collaboration[17] at LEP1 has performed a more complete analysis of the various signatures of the b' quark production including FCNC decays. Using an analysis similar, but not identical, to that described below they exclude a b' quark mass in the range 26 to 46 GeV at 95% C.L.

Here we concentrate on $e^+e^- \to b'\bar{b}' \to \gamma + 3$ jets. This is not only the most distinctive signature, if b' quarks are produced and decay predominantly through the FCNC decay modes, but also is expected to be the dominant final state with a photon. The lower bound on the top quark mass from the Tevatron has already placed the top quark out of the reach of LEP1 and, in the near future, may very well put it out of the reach of LEP2. Still, if one detects heavy quarks at LEP1 or LEP2 in multijet events, they should not be automatically assumed to be the b' quarks. Instead one should look at the "isolated $\gamma + 3$ jets" events. This is the best signature to identify the b' quarks. The paper is organized as follows. We begin by explaining how we calculated the expected rate for this signature, including both b' production and background processes. Then, as a first example, we analyze the situation for this signal at LEP1 where, as noted above, an experimental analysis focusing on events with photons has already been performed.[17] At LEP1 the background to this signal is quite small. Finally we consider LEP2 where, in contrast with LEP1, the background rate is at least an order of magnitude larger than the signal. In this case a judicious choice of cuts is essential in order to isolate the signal. We close with a discussion of the uncertainties in the calculation and our general conclusions.

II. CALCULATIONS

To illustrate the efficacy of the "isolated $\gamma + 3$ jets" signature we compute the cross-section and various distributions for the b' quark production and decay and the background coming from the direct production of "$\gamma + 3$ jets." For the background processes we use am-

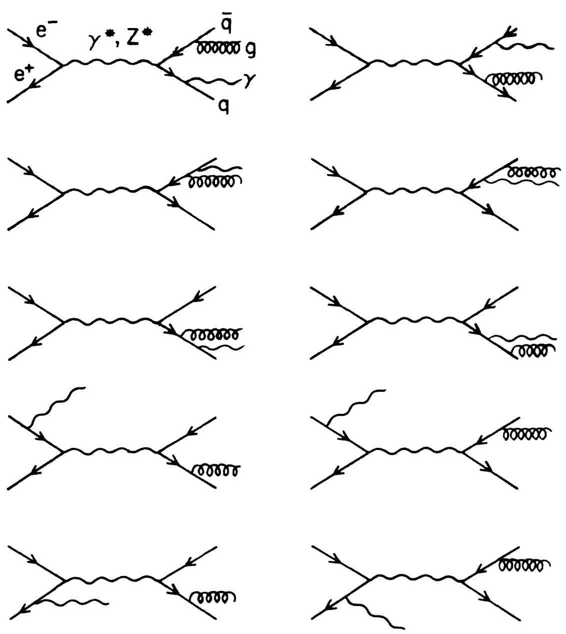

FIG. 1. Feynman diagrams contributing to the amplitude of the production of "γ + 3 jets" events.

plitude level spinor and recursive techniques[18,19] for the computation.[20] At the relevant energies diagrams with Z^0 exchange cannot be ignored. Therefore there are 20 diagrams contributing to the amplitude for the background. These diagrams are displayed in Fig. 1. At LEP1 the signal will arise primarily through the process $e^+e^- \to Z^0 \to b'\bar{b}'$. The one loop diagrams that contribute to the FCNC decay modes of b' quarks have been computed by Hou and Stuart[8]. The relevant diagrams in the unitary gauge are displayed in Fig. 2. The actual calculation was done in the Feynman gauge for reasons of simplification. Their results can be expressed in the form of a effective current:[8]

$$J^\mu = \left(\frac{1}{4\pi}\right)^2 \frac{1}{{M_W}^2}\bar{b}(p)(q^2\gamma^\mu F_1 L + i\sigma^{\mu\nu}q_\nu m_{b'}F_2 R)b'(p'). \tag{1}$$

Here $L = (1-\gamma_5)/2, R = (1+\gamma_5)/2$, and $q = p - p'$. F_1 and F_2 are form factors and were calculated using computer algebra techniques. They are complicated functions of m_t, $m_{t'}, m_{b'}$, and M_W. Using this effective current we compute the cross section for $b'\bar{b}'$ production and subsequent decay into "γ+3 jets." There will, in general, be experimental cuts applied to the observable physical quantities. The event defining cuts that we apply to simulate the actual experimental cuts are

$$p_T(\gamma, j) > 5\,\text{GeV}\,, \quad y(j_k, j_l) > 0.01\,, \quad \angle(\gamma, e^\pm) > 30^\circ;$$
$$\angle(\gamma, j) > 30^\circ\,, \qquad \angle(j, e^\pm) > 5^\circ.$$

Here $y(j_k, j_l) = (p_{j_k} + p_{j_l})^2/W^2$ is the scaled invariant mass squared of jet pair (k,l) where p_j is the four-momentum of a jet. This variable is a measure of the separation of jets. The angle $\angle(l,n)$ is the angle between the momenta of l and n. The transverse direction is with respect to the beam direction (i.e., the direction of the incoming $e^\pm$). Note that these event defining cuts are somewhat different from those employed by the ALEPH Collaboration.[17]

For our calculations we take $M_Z = 91.1$ GeV with the width Γ_Z given by the standard model value including all decay channels. Thus for LEP2 we take the width of Z^0 to be 2.47 GeV. For LEP1, where we assume a lighter b' quark, we add to this value the contribution of $Z^0 \to b'\bar{b}'$. For the unknown parameters, we consider m_t in the range 80 to 120 GeV and $m_{t'}$ in the range 200 to 300 GeV. Then, for various values of $m_{b'}$, the branching ratio for $b' \to b\gamma$ ranges from about 15% to 20% and the branching ratio for $b' \to bg$ is between 65% and 70%. We shall discuss the detection of b' quarks at LEP1 and LEP2 separately.

III. LEP1

For parameters relevant to LEP1 the background has the feature[20] that almost 95% of the events arise when a photon is emitted either from the e^+ or the e^- in the initial state. Therefore these events do not exhibit a peak at a center-of-mass energy $W = M_Z$ but instead peak at about $W = 100$ GeV. Thus the background is an increasing function of the total energy W near $W = M_Z$. To illustrate this effect we first take $W = 90$ GeV and assume an integrated luminosity of $\mathcal{L} = 1$ pb^{-1}. The number of events for the signal and the background are displayed in Table I for various values of the mass parameters. We see that the signal is much larger than the background. We should note that the cuts described above have reduced the signal by approximately 50% to 70% but we can make the cuts less stringent without affecting the signal to background ratio significantly. If we increase the energy to $W = 92$ GeV, the signal remains essentially the same while the background almost doubles leading to a significant reduction in the signal to background ratio. Therefore, it is better to search for b' quarks with W below M_Z rather than above it.

To test the dependence of these results on the param-

TABLE I. Number of events at LEP1 with $\mathcal{L} = 1$ pb^{-1} and $W = 90$ GeV for various mass values (in GeV) and for the kinematic cuts specified in the text.

	Signal			
$m_{b'}$	$m_t = 80$, $m_{t'} = 200$	$m_t = 80$, $m_{t'} = 300$	$m_t = 120$, $m_{t'} = 300$	Background
30	53	63	80	12
40	34	42	55	12
43	13	17	20	12

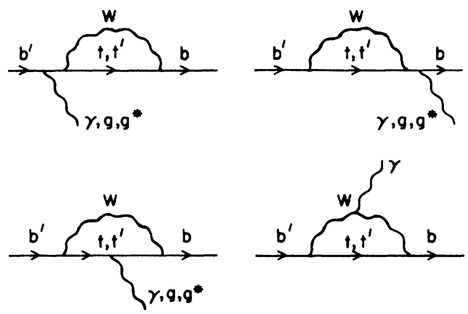

FIG. 2. Feynman diagrams, in unitary gauge, contributing to the amplitudes of the FCNC decay modes of b' quarks.

TABLE II. Number of events at LEP2 with $\mathcal{L} = 100$ pb^{-1} and $W = 190$ GeV for various mass values (in GeV) and for the kinematic cuts specified in the text.

$m_{b'}$	Signal $m_t = 80$, $m_{t'} = 200$	Signal $m_t = 80$, $m_{t'} = 300$	Signal $m_t = 120$, $m_{t'} = 300$	Background
60	14	16	20	393
70	12	13	16	393
80	8	9	11	393
90	3	3	4	393

eters m_t and $m_{t'}$ we varied m_t from 80 to 120 GeV and $m_{t'}$ from 200 to 300 GeV as indicated in Table I. It is important to recognize that, if the value of m_t is near $m_{t'}$, there is a cancellation between the contributions arising from each of these two (virtual) quarks and the width of each of the FCNC decay modes decreases. Therefore we require the value of these parameters to be sufficiently far apart so as make our assumption of the dominance of the FCNC decay modes tenable. The signal is seen to be a monotonically increasing function of both parameters varying by approximately 15% to 30% in the ranges studied for all relevant values of $m_{b'}$. This dependence on m_t and $m_{t'}$ can be qualitatively simply understood if we look at the diagrams contributing to the form factors. It is convenient to look at this in the unitary gauge. The appropriate diagrams (four in the case of photon emission) are displayed in Fig. 2. In the first and second diagrams the photon is emitted from the initial and final quarks, respectively. In the third, the photon is emitted from the intermediate quark (the t or t' quark), while in the fourth diagram the photon is emitted by the W vector boson. This last diagram is absent in the case of gluon emission. Since the first and the second diagrams function mainly to cancel the divergence of the third diagram, we focus on the third and the fourth diagrams. If we increase m_t and/or $m_{t'}$ (maintaining a suitably large difference), the third diagram is suppressed relative to the fourth due to the extra intermediate quark propagator. Hence the decay with gluon emission, which has no contribution from the fourth diagram, is suppressed relative to photon emission and the branching ratio to the photon mode increases. Note that the fourth diagram has instead two W vector boson propagators and in this calculation we always take $m_t > M_W$ and $m_{t'} > M_W$.

As mentioned earlier, the partial widths for the decay modes $b' \to bl^+l^-, b\nu\bar{\nu}, bq\bar{q}$ may make significant contributions to the width of b' quark. In this case the signal will be reduced by 40% to 50%. However, even in this situation, the signal-to-background ratio for LEP1 is still favorable. We should also note that, if bottom quark jets can be identified, this will lead to substantial reduction in the background since two of the three jets in the signal are generated by bottom quarks. Bottom jets have been identified at e^+e^- colliders, using the semileptonic[21] or the hadronic decay channels[22] of bottom quarks. Both of these two tagging schemes should be useful at LEP1.

IV. LEP2

Moving to the more challenging situation at LEP2, we choose $W = 190$ GeV and, for purposes of illustration, $\mathcal{L} = 100$ pb^{-1}. The results corresponding to Table I are given in Table II. The signal is no longer enhanced by a direct resonance and we see that now the background is one to two orders of magnitude larger than the signal. But the situation is not hopeless. Again more than 99% of the background arises from a photon radiated by the initial state particles, e^- and e^+. Of these background events about 80% come from $e^+e^- \to \gamma Z^0$ where the Z^0 subsequently decays into the three jets. Therefore most of the background events will have the photon and the Z^0 coming out back to back with the energy of the photon given by

$$E_\gamma = (W^2 - M_Z^2)/2W = 73.12 \text{ GeV} \qquad (2)$$

with our values of the parameters. Because of the finite width of the Z^0, the actual E_γ will be spread around this value. The mass of the three-jets system in these $e^+e^- \to \gamma Z^0$ events will also be near M_Z. Therefore a suitable cut on E_γ or the mass of the three-jet system will eliminate about 80% of the background events. Presumably the E_γ cut is simpler experimentally. The results of requiring $E_\gamma < 66$ GeV are displayed in Table III. We notice that, although the background is substantially reduced, the

TABLE III. Number of events at LEP2 with $\mathcal{L} = 100$ pb^{-1}, $W = 190$ GeV, $m_t = 80$ GeV, $m_{t'} = 300$ GeV, and with kinematic cuts identical to those in Table II plus $E_\gamma < 66$ GeV.

$m_{b'}$ (GeV)	Signal	Background
60	14	76
70	11	76
80	8	76
90	3	76

TABLE IV. Number of events at LEP2 with $\mathcal{L} = 100$ pb^{-1}, $W = 190$ GeV, $m_t = 80$ GeV, $m_{t'} = 300$ GeV, and with kinematic cuts identical to those in Table III except $p_T(\gamma) >$ 15 GeV and $|M(\gamma j_1) - M(j_2 j_3)| < 7.5$ GeV.

$m_{b'}(GeV)$	Signal	Background
60	11	10
70	9	10
80	6	10
90	2	10

signal-to-background ratio is still not favorable.

We need to make at least one more cut to improve upon this situation. We can use the fact that in the signal events, two of the jets come from the decay of a b' quark ($b' \to bg$). Thus the mass of this two-jet system, $M(jj)$, will be around $m_{b'}$ with a theoretical width given by the very small natural width of the b' quark.[23] The mass of the pair composed of the remaining jet and the photon, $M(\gamma j)$, will likewise be around $m_{b'}$. Assuming that we cannot differentiate experimentally among the jets from the different quark flavors and gluons, we adopt the following strategy. The three jets can be paired in three different ways. Choose one pair of jets and evaluate its mass and that of the third jet and photon pair. If the difference in the masses of the two systems is below a certain value, keep this event. Otherwise, go to the next pair of jets and repeat the same procedure. Similarly, apply procedure for the third pair. If, in each of the three cases, the difference in the masses of the two systems is larger than a suitably chosen value, discard the event. We choose for this mass difference cut a value of 7.5 GeV. Therefore the additional cut that we apply is $|M(\gamma j_1) - M(j_2 j_3)| < 7.5$ GeV, for at least one of the permutations of j_1, j_2, and j_3.

Experimentally the energies of the photon and the jets can only be measured up to a finite accuracy, although the energy of the photon can presumably be measured more accurately than that of a jet. To simulate these uncertainties, we smeared the energies of the photon and the jets with a Gaussian distribution characterized by a width σ. In the case of the photon energy we choose $\sigma = 1$ GeV while we smeared the jet energies with $\sigma = 4$ GeV. The result of applying this extra cut on the mass difference with smeared energies is illustrated in Table IV. Note that we also increased the cut on $p_T(\gamma)$ to 15 GeV. This improves the signal-to-background ratio further since, in the background events, the photon is produced through bremsstrahlung. Now the signal-to-background ratio is quite acceptable for the lowest $m_{b'}$ value. For $m_{b'} > 75$ GeV further improvement can be accomplished by increasing the value of the cut on $p_T(\gamma)$. The results for $p_T(\gamma) > 25$ GeV and $p_T(\gamma) > 35$ GeV are displayed in Tables V and VI respectively. The improvement in the signal-to-background ratio is obtained at the price of a reduced number of events for $m_{b'} < 75$ GeV. A possible strategy would be to search for the b' quarks up to about 75 GeV with a smaller cut on the $p_T(\gamma)$ and then increase the cut on the $p_T(\gamma)$ to search at higher values of $m_{b'}$. The correlation of the $p_T(\gamma)$ with the b' mass is easy to understand since the $p_T(\gamma)$ spectrum is relatively harder in the case of relatively heavier b' quarks. Finally note that the integrated luminosity for one year at LEP2 is expected to be about a factor of three larger than the number we are using so that the number of available events should not be prohibitively small.

TABLE V. Number of events at LEP2 with $\mathcal{L} = 100$ pb^{-1}, $W = 190$ GeV, $m_t = 80$ GeV, $m_{t'} = 300$ GeV, and with kinematic cuts identical to those in Table IV except $p_T(\gamma) > 25$ GeV.

$m_{b'}$ (GeV)	Signal	Background
60	8	6
70	7	6
80	5	6
90	2	6

TABLE VI. Number of events at LEP2 with $\mathcal{L} = 100$ pb^{-1}, $W = 190$ GeV, $m_t = 80$ GeV, $m_{t'} = 300$ GeV, and with kinematic cuts identical to those in Table IV except $p_T(\gamma)$ > 35 GeV.

$m_{b'}$ (GeV)	Signal	Background
60	5	4
70	4	4
80	4	4
90	2	4

To study the dependence on the parameters m_t and $m_{t'}$ we varied these parameters over the same range as we did for LEP1. We see from the results indicated in Table II that the behavior is as we would expect from the earlier discussion.

If the partial widths for $b' \to bl^+l^-, b\nu\bar{\nu}, bq\bar{q}$ decay modes are significant,[11] then the signal will be reduced by 40% to 50% for large values of m_t and $m_{t'}$ as was the case at LEP1. However, the signal will still be about 60% of the background for our choice of the cuts for most values of $m_{b'}$.

Finally we note that, just as for LEP1, bottom quark jet identification can help to substantially reduce the background. However, with our choice of cuts, the tagging scheme utilizing the semileptonic decay channels of bottom quarks will not work. We use a cut on the mass difference of the various two-jet systems and the mass of a two-jet system containing a bottom quark that decays semileptonically cannot be measured accurately due to the presence of the neutrino in the decay. However, the tagging scheme using the hadronic decay channels should be useful.

V. UNCERTAINTIES

The numerical results which we have presented involve uncertainties from several sources. Since they are based on calculations that are at lowest order in the strong coupling, there is the question of the choice of scale at which the strong coupling constant is evaluated. The variation of the results with this choice is some estimate of the error made by leaving out higher order terms in the perturbation expansion. We have chosen this scale to be $W/4$. Actually, since both the signal and the background are linear in the strong coupling α_s the ratio is rather insensitive to the choice of scale. However, we should still ascribe an uncertainty of at least $\pm 10\%$ to this perturbative approximation. The signal is more strongly dependent on our ignorance of the values of the masses of the t and t' quarks. As discussed earlier, this introduces an uncertainty of order 20%. Finally our results for LEP2 depend on the accuracy with which the experiment can reconstruct the energy of photons and jets to which we apply various cuts. We have attempted to study this issue by studying the dependence of our results on the width of the Gaussian smearing functions which we introduced to simulate the experimental uncertainties. By varying these σ's over a range of order ± 1 GeV, we find an associated uncertainty of order $8-17\%$. Thus our numerical results are uncertain at the level of at least $\pm 30\%$. However, our general conclusions about the level of the signal and background rates and the efficacy of various generic types of kinematic cuts should be independent of this uncertainty.

VI. CONCLUSIONS

In this paper, we probed a scenario where a fourth generation quark b' exists but $m_{b'} < m_t$. In this case it is possible that the FCNC decay modes dominate the width of the b' quark. We pointed out that, if we see a signal of heavy quark production at LEP1 or LEP2 based on shape variable analyses, it should not automatically be assumed, based on the bound on m_t from hadron colliders, to be either the top quark or the b' quark. Rather, one should look at flavor-distinguishing signatures. Therefore, we examined the most promising of these signatures, "isolated $\gamma + 3$ jets" events. We showed that at LEP1 the background to this signature is not large. In fact, an experimental analysis of a related signature involving a single photon plus hadrons has already been performed successfully at LEP1.[17] The primary conclusions of our analysis concern the situation at LEP2. There the background to our preferred signature will be large. We have studied the question of how to exploit the special properties of the background in order to deal with this situation. In particular, we examined the effect on the signal-to-background ratio of various kinematic cuts on the final state particles chosen to selectively reduce the background. While we have made no attempt to determine "optimum" cuts, we have demonstrated that a judicious choice of cuts can serve to make the identification of b' quarks at LEP2 possible.

ACKNOWLEDGMENTS

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