Fermilab Library
0 1160 0026271 1
UCLA-PPH 005-4-6/93

The Search for Flavor Changing Neutral Currents in Rare B Decays*

David B. Cline
University of California Los Angeles, Department of Physics
405 Hilgard Avenue, Los Angeles, CA 90024-1547

UCLA-PPH0054-6/93

Abstract

The search for tree level FCNC with heavy flavors is sensitive to physics beyond the standard model. We discuss three types of FCNC experiments, (i) Precise study of $b \to s + \gamma$, (ii) Search for $B_s^\circ \to \tau^+\tau^-$, and (iii) $B \to \mu^+\mu^- X$. We also comment on the UA1 limit for $B \to \mu\bar{\mu}X$.

(1) Introduction

Even before the discovery of weak interaction processes that occur without the change of charge in 1973 the issue of the existence of process that also change the Flavor of the quarks was raised. Indeed the early absence of these processes helped the Rise of the Standard Model of Elementary Particles. Recently a large number of new possibilities have been raised concerning these effects, it is now believed that the experimental observation could be a key indicator of Physics beyond the standard model.

As the evidence for the standard model's correctness grows it is important to look for processes that will be particularly sensitive to physics beyond the standard model. We note that even though ~ 3 million Z°'s have been collected, there is still no evidence for loop corrections. Thus it is important to look for processes that are either completely due to a loop (i) or that should be very small in the standard model, (ii) and (iii). An example of these processes that are studied here are:

$$\text{(i) } B \to X_s + \gamma$$
$$\text{(ii) } B_s^\circ, d \to \tau^+\tau^-$$
$$\text{(iii) } B \to \mu^+\mu^- X$$

* For the Proceedings of the 1993 Snowmass Workshop

Historically, the search for FCNC has been a key component in the rise of the standard model, as illustrated in Table 1[1]. The search for Flavor Changing Neutral Currents (FCNC) was carried out with strange particles mainly in the period 1963-1970[2]. The first definitive search for Neutral Currents that change the Flavor was undertaken by the author and his colleagues using the Lawrence Berkeley Laboratory Kaon Beam. In the mid seventies the absence of FCNC prompted the concept of "Natural Flavor Conservation" for the Neutral Currents[3]. The GIM model was also partially invented to explain these results[4]. This has come to be a key development in the "Rise of the Standard Model" and strongly limits the types of quarks that exist in nature. This is an example of how null experiments can strongly influence the direction of a field of science. In Figure 1 we trace some of the early and more recent experimental search for FCNC processes[5]. The impact of the null search for FCNC in the standard model is powerful, as is illustrated in Table 1[6].

We sketch the current status of the FCNC amplitude limits in Figure 1. There have been several recent estimates of the expected branching ratios for Rare B decays. We quote the recent report from A. Ali (reported at the Santa Monica Meeting on "30 Years of Weak Neutral Currents", February 1993) and it is reproduced in Table 2[1,8,9]. A more complete analysis of FCNC decays that comes from a B Physics study at this Snowmass meeting is given in Table 3[7]. We now turn to the individual decay and missing processes indicated above and attempt to justify the numbers reported in Table 2. These three processes represent a wide range of processes that are either 3rd Family, 2nd Family, or $3^{rd} \rightarrow 2^{nd}$ transitions. Figure 2 shows some Feynman diagrams that would give rare FCNC B decays and would imply new physics beyond the standard model[8,9].

There are potentially two types of elementary processes that can give rise to a FCNC reaction

(i) Through Quark Processes

(ii) Through Higgs Boson Processes

In the early seventies a model put forward by Glashow, Illiopoulous and Maiani (GIM) explained why process (i) should be strongly suppressed provided a fourth quark existed (charm)[4]. In 1974 this quark was discovered in the J/Ψ experiments at Brookhaven National Laboratory and at the Stanford Linear Accelerator Center. Later a concept called "Natural Flavor Conservation" NFC was advocated by Glashow and Weinberg to forbid process (ii). It has not been questioned until very recently. If NFC fails, a whole world of new elementary particle physics processes become possible albeit it at a rather small rate. Recently L. Hall at UCB and Steve Weinberg (UT Austin) have advocated that NCF could fail[10]!

In the past few years another concept has gained ground in Elementary Particle Physics, namely the Supersymmetric Theory. This theory indicates that nature is sym-

metric at very high energy, where for every particle we now know there will be a super pardner, with different properties. Again this theory also provides for FCNC processes.

Thus we see that two leading theories indicate the existence of FCNC, other theories do as well, in fact FCNC detection maybe the most important experimental task ahead for Elementary Particle Physics. We now turn to the current and possible future search and study of FCNC processes at accelerators and colliders around the world.

We consider two type of detectors and hadron collisions in this report

(I) High Luminosity Multi TeV Collider and a Solenoid Detector. We take as an example the Compact Muon Solenoid Detector to be constructed at the CERN LHC, and assume that the LHC operates at the luminosity of $10^{33}\text{cm}^{-2}\text{sec}^{-1}$ that will produce $10^{13}\text{B}\bar{\text{B}}$ pairs per year. Special trigger for the rare B decays discussed here would be employed. Our group is a member of this detector collaboration.

(II) An Advanced Fixed Target Experiment at Either Fermilab or SSC. We consider the proposal experiments 865 and 867 at FNAL as well as the Super Fixed Target Detector proposal for the SSC. At FNAL an effective sample of $\sim 10^{-8}$ $\bar{B}B$ pairs can be obtained where as at the SSC the number would be about 10^{10} (with SFT). Special triggers for the B decays discussed here would be employed. Our group is a member of E771, P867 and the SFT proposal to the SSC.

(III) Remarks on the Significance of the Limit $B \to \mu\bar{\mu}X$ from UA1[11].

This limit is an example of the power of these type of experiments the limit is 5 x 10^{-5} to 90% CL. It was carried out by the UCLA component of UA1 under my guidance. Figure 3 shows the region of the decay phase space that was used for the search. With this limit we can safely state that the size of direct FCNC contributions can't be more than an order of magnitude larger than the Standard Model. However, this may not provide a strong constraint for processes like $B \to \tau\bar{\tau}$ that are for pure 3rd Family transistors!

(2) Rare B Decays

(i) Sensitive Study of $B \to X_s\gamma$ at a Fixed Target Experiment[12]

The decay mode $b \to s + \gamma$ is of great theoretical interest, and could provide constraint on SUSY the charge Higgs sector and other possible deviation from the standard model! The work reported here has been carried out by a UCLA group (D. Cline, J. Park and J. Rhoades).

Simulation studies are being conducted of the photons from the inclusive decay $b \to s\gamma$ using the Monte Carlo program PYTHIA to generate b events. Since $b \to s\gamma$

decays are not implemented in PYTHIA, we treat the decay as a two body decay, assuming that the s and spectator quarks hadronise into a state with a mean mass halfway between the K^* and the K_4^*. This generates a mass distribution with FWHM equal to the $K_4^* - K^*$ mass difference. The shape is a Gaussian, truncated at the low end at the mass of the K^* and at the high end at the mass of the B.

We assume an energy resolution of $\frac{10\%}{\sqrt{E}}$, an angular resolution of 1 m rad for γ's, and (since the calorimetric photon measurement will dominate the resolution) a perfect momentum resolution for hadrons.

The transverse momentum distributions for γ's from B events have been obtained. The B background includes all γ's; the signal includes only those γ's originating from the b quark. The $b \rightarrow s\gamma$ photons are broadly peaked in the transverse momentum, with a mean of 2.3 GeV and rms width of 0.8 GeV, while the photons from B background events had a mean P_t of 0.2 GeV, and the distribution fell off somewhat more slowly than exponential. The p_t spectrum of γ's from 1,000 non-B events was also obtained to permit background subtraction. The transverse momentum of the photons had a mean p_t of 0.17 GeV and dropped off at a p_t of 2.5 GeV.

Figure 4 shows the p_t distributions of γ's from 250,000 B background events superimposed with 1,000 B signal events after the π° mass range cut of $0 \leq m_{\gamma\gamma} \leq 0.2$ GeV is applied and with the mass cut $0 \leq m_{\gamma\gamma} \leq 0.2$ GeV and with $\eta \rightarrow \gamma\gamma$ suppression. For the region $p_t \geq 3.6$ GeV the background is completely suppressed, but the signal is statistically significant. The signal retention is 6.34%.

Table 4 shows the numbers of γ's from 1,000 $B \rightarrow X_s\gamma$ events and from 250,000 B background events as functions of the minimum p_t cut. The threshold p_t of 3.6 GeV is not sensitive to an E_γ cut. It is clear from the analysis that a dedicated $B \rightarrow X_s\gamma$ measurement could be carried out at a hadron fixed target or even possible colliding beam machine, assuming a wide band trigger (like the optical trigger) is used.

(ii) <u>Search for $B_s^\circ \rightarrow \tau^+\tau^-$ and Other Rare B Decays</u>

(a) $B \rightarrow \mu^+\mu^- X_s$

We follow the UA1 results which indicate that, in the mass range of 3.8 to 4.4 GeV, a signal may be detected[11]. For a branching ratio of $\sim 5\text{x}10^{-6}$ we would expect that (10^{10}) $B\bar{B}$ production would be required to obtain a signal or ~ 10 events above background. Since the signal is background limited, it will require a careful study of the background and a detailed subtractor. This may be possible with the CDF or D_o detectors at FNAL over the next few years. This would be very difficult for fixed target experiments at FNAL or even e^+e^- B factories to detect. At the LHC or SSC it should be rather straight forward. Some theoretical estimates for this process can be found in the references.

(b) $B \rightarrow \mu^+\mu^-$

This decay represents a process that is likely to provide an excellent signal, if the detector has adequate mass resolution, but will be severely rate limited if the branching fraction is $\sim 2\text{x}10^{-9}$, as expected in the standard model[11]. Again, using the detection efficiency obtained in the UA1[11] experiment for this decay mode of ~ 4 percent and a branching fraction of $\sim 10^{-9}$ and a 10 events signal, we estimate that a sample of 10^{11} $B\bar{B}$ events will be required to clearly detect this signal. Of course, models beyond the standard model could enhance this branching fraction by a factor of ~ 10, but not much more since we know that $B \rightarrow \mu^+\mu^-$ is within a factor of 10 of the standard model prediction. Thus, an interesting search could be carried out when $\sim 10^{10}$ $B\bar{B}$ events have been produced.

(c) $B \rightarrow \tau + \bar{\tau}$ (Reference 9)

This process has only 3rd family particles and may be sensitive to new types of theories that are beyond the standard model. It also presents perhaps the greatest challenge for detection of any FCNC B decay since the experimental signature is so complex and the branching ratio so small, even in beyond the standard model estimates. The estimated branching ratio in the standard model is $3.8x10^{-7}$. There are estimates for the branching ratio in some models that can go to $\sim 10^{-4}$. In addition, this process is not constrained directly by the UA1 limits on $B \rightarrow \mu^+\mu^-X$ and thus, any sensible search and limit is likely to be interesting. The method of detection and backgrounds for this process are discussed in Ref. [7]. We summarize these results here. For the branching ratio $\sim 10^{-5}$, there seems to be little background, but at $\sim 10^{-6}$ the process

$$B_s^\circ \rightarrow D_s + \tau + \bar{\nu}_\tau$$
$$\hookrightarrow \bar{\tau} + \nu_\tau$$

will likely become an important source of background[7].

We have suggested some kinematic tricks to reduce this background in the Snowmass working group. A Monte Carlo study similar to that for $B \rightarrow X + \gamma$ is being started at UCLA. Table 3 lists some of the possible rates for the various processes discussed here from the Snowmass workshop.

(3) Sensitivity of the FCNC to New Physics

There are several classes of models that may have FCNC processes. We list them in a generic sense.

1. Supersymmetric Theory
2. Technicolor

3. Multiple Scalars
4. 4th Family

We believe that these four classes of theories covers most of the reports in the literature. However, it could be that the discovery of FCNC processes may be unpredicted by any extant theory and could lead to the correct theory.

There is general belief that FCNC must exist in almost all models that go beyond the standard model, since the concept of Flavor Conservation is ad hoc and the Higgs sector is more complex than that assumed by the standard model[13]. In Figure 2 we show some of the diagrams that give FCNC processes from some of the theories. Clearly, the search for FCNC in B decays is of great importance.

(4) Novel Triggers for Beauty Selection

The production of $\bar{B}B$ pairs at hadronic machines is very large. As a rule of thumb here are the kinds of rates expected per year for various machines:

a) Fixed Target at FNAL $\sim 10^8$ $\bar{\mathrm{B}}\mathrm{B}$/year

b) Colliding Beams at FNAL $\sim 10^9 - 10^{10}$ $\bar{\mathrm{B}}\mathrm{B}$/year

c) Dedicated Fixed Target Experiment at the LHC or SSC $\sim 10^{10}$ $\bar{\mathrm{B}}\mathrm{B}$/year

d) LHC or SSC Collider $\sim 10^{12} - 10^{13}$ $\bar{\mathrm{B}}\mathrm{B}$/year

As a rule of thumb (from the UA1 experiment) the overall detection efficiency for rare processes is unlikely to exceed $\sim 10^{-2}$ [11]. Thus, in order to detect all the various decays discussed in Section 3, we will need the full range of B production, up to the Super Colliders.

The major issue in using these very large $\bar{B}B$ rates is the event trigger selection. The total hadronic event production per year will vary from $10^{12} - 10^{15}$. These events must be sorted through somehow to extract the $(10^{-5} - 10^{-3})$ fraction of $\bar{B}B$ events and then to find the rare events a factor of $10^{-4} - 10^{-9}$ is required. This is obviously an extremely difficult undertaking.

The key to the use of the large $\bar{B}B$ rates is the event trigger. We will discuss two concepts for event triggers that we believe hold promise for the FCNC studies and describe two extremes:

1. Trigger $J/\Psi \rightarrow \mu^+\mu^-$ events to tag a $\bar{B}B$ event. This is currently being used in the E771 experiment at FNAL. In principle this could give a trigger with an efficiency of $\sim 10^{-3}$.

2. Trigger on the impact parameter displacement of charged tracks from the $B/\bar{B}$ decay using a fast Cherenkov light signal (optical trigger). Future use of a new type of photo detector (VLPC) may be important for this technique.

There are other concepts, like the detection of an impact parameter using a nearby silicon tracking array, and the expected different track multiplicity for events with $\bar{B}B$, and the total events, that we will not discuss.

(5) Conclusions

We have illustrated in this brief report the importance of a dedicated search for FCNC rare B decays at present and future hadronic machines. We also showed that the small branching factors for these processes very likely require their study at hadron machines. In order for this to be accomplished, novel trigger techniques will be required. The optical trigger is one such clever idea. The continuing search for FCNC processes is of great importance. In Table 5 we list some of the models that can be tested by these rare decay modes.

I wish to thank the Rare B - FCNC group at Snowmass for helpful discussions.

(6) References

1) Proceedings of the International Symposium on 30 Years of Neutral Currents: from Weak Neutral Currents to the (W)/Z and Beyond, to be published by the American Institute of Physics, editors D. Cline and A.K. Mann.

2) D. Cline, The Search for Weak Neutral Currents, Proc. of Ecol Int. Hecg Novi (1967), and Thesis at Univ. of Wisconsin (1965); U. Camerini, et. al., Phys. Rev. Lett 13 318 (1964); J. Klems, et.al., Phys. Rev. Lett. 24 1086 (1070); U. Camerini, et.al., Phys. Rev. Lett 23 1086 (1969); Report on the SLAC meeting on the Rise of the Standard Model, to be published (1992).

3) S. Glashow and S. Weinberg, Phys. Rev. D15 (1977) 1968; E.A. Paschos, Phys. Rev. D15 (1977) 1966.

4) S. Glashow, J. Illiopoulous and L. Maiani, Phys. Rev. D2 1285 (1970).

5) D. Cline, The Continuing Search for Flavor Changing Weak Neutral Currents, Cmnts. in Part. Phys. (1987); D. Cline, The Search for Rare B Decays and B - B° Mixing, Pub. in Proc. of Third Topical Seminar on Heavy Flavors, San Miniato, Italy (1991), and Proc. of the meeting on Rare B and K Decays and Novel Flavor Factories, AIP Book, July 1992.

6) S. Glashow, Nucl. Phys. 22 579 (1961); S. Weinberg, Phys. Rev. Lett. 19 1264 (1967); A. Salam, Proc. 8th Nobel Symposium, Aspenasgarden, 1968, editor N. Svartholm, Published by Almqvist and Wisell, Stockholm, 1968, p. 367.

7) D. Cline, unpublished

8) See Reference 1, Report of M. Ito for the rare K decay situation.

9) See Reference 1, Report of A. Ali for rare B decays predictions.

10) L. Hall and S. Weinberg, LBL Preprint (1993).

11) C. Albajar, et.al., (UA1 Collaboration); Phys. Lett. B262 (1991) 163; K.M. Ankoviak, Ph.D. Thesis, University of California, Los Angeles, 1991.

12) D. Cline, J. Park, J. Rhoades and M. Atac, UCLA Report.

13) See for example and other references P.J. O'Donnell, M. Sutherland and H.K.K. Tung, Phys. Rev. D46 (1992) 4091.

TABLE 1

Impact of FCNC Search on the Rise of the Standard Model

PROCESS	PERIOD	IMPLICATION
$s \not\to d$	$\sim$ 1963	FCNC Absent at first level of
$(K^+ \to \pi^+ \nu\bar{\nu})$	$\sim$ 1970	Weak Interaction [GIM Mechanism]
$s \not\to$ Loop $\not\to d$	$\sim$ 1960-74	New Quark in Loop, $m_q \sim 2$ GeV
$K^\circ - \bar{K}^\circ$,		
$K_S - K_L$ mixing		(Charm)
$s \not\to d$	$\sim$ 1970's	Natural Flavor Conservation for NC
$c \not\to u$		implies that only Q = 1/3, Q = 2/3 quarks
etc.		exist in doublets in nature
$b \not\to d$	$\sim$ 1980's	Necessary existence of
$b \not\to s, B^\circ - \bar{B}^\circ$		(massive) t quark
STRONG LIMITS ON		
$s \not\to d$	$\sim$ 1990's	Limits on supersymmetric interactions
$b \not\to d$		and other exotics
$\nu_e \not\to \nu_\mu$		
$K \not\to \mu e$		

TABLE 2

Estimates of the branching fractions for FCNC B-decays in the Standard Model for $m_t = 150\,\mathrm{GeV}$ and $f_B = 200\,\mathrm{MeV}$. Note that the CKM-suppressed decays, given in row 3 and 4, depend on $|V_{td}|$, and the numbers correspond to $|V_{td}| = 0.007$. Experimental upper limits are also listed.

B FLAVOR CHANGING NEUTRAL CURRENTS (A. Ali)[20] ($m_t = 150\,\mathrm{GeV}$, $f_B = 200\,\mathrm{MeV}$, $\mu = m_b$)		
DECAY MODES	Br	EXP. UPPER LIMITS (90% C.L.)
$(B_d,\ B_u) \to X_S\gamma$	4.0×10^{-4}	8.4×10^{-4} [CLEO] *(a)*
$(B_d,\ B_u) \to K^*\gamma$	$(4.0 - 7.0) \times 10^{-5}$	0.92×10^{-4} [CLEO] *(a)*
$(B_d,\ B_u) \to X_d\gamma$	$(0.5 - 3.0) \times 10^{-5}$	-
$(B_d,\ B_u) \to \rho + \gamma$	$(1.0 - 3.0) \times 10^{-6}$	-
$(B_d,\ B_u) \to X_S e^+e^-$	1.2×10^{-5}	-
$(B_d,\ B_u) \to X_S \mu^+\mu^-$	6.7×10^{-6}	5.0×10^{-5} [UA1] *(b)*
$(B_d,\ B_u) \to K e^+e^-$	4.4×10^{-7}	5.0×10^{-5} [PDG] *(c)*
$(B_d,\ B_u) \to K \mu^+\mu^-$	4.4×10^{-7}	1.5×10^{-4} [PDG] *(c)*
$(B_d,\ B_u) \to K^* e^+e^-$	3.7×10^{-6}	-
$(B_d,\ B_u) \to K^* \mu^+\mu^-$	2.3×10^{-6}	2.3×10^{-5} [UA1] *(b)*
$(B_d,\ B_u) \to X_S \mu\bar{\mu}$	6.6×10^{-5}	-
$(B_d,\ B_u) \to K \nu\bar{\nu}$	5.2×10^{-6}	-
$(B_d,\ B_u) \to K^* \nu\bar{\nu}$	2.0×10^{-5}	-
$B_S \to \gamma\gamma$	2.0×10^{-8}	-
$B_S \to \tau^+\tau^-$	3.5×10^{-7}	-
$B_S \to \mu^+\mu^-$	7.5×10^{-9}	-
$B_S \to e^+e^-$	4.0×10^{-14}	-

(a) E.H. Thorndike (CLEO Collab.), Contr. #531, LP-HEP 91 Conf., Geneva, Switz.
(b) C. Albajar, et al., (UA1), Phys.Lett. B262 145 (1991).
(c) K. Hikasa, et al., (Particle Data Group), Phys.Rev. D45 1 (1992).

TABLE 3

Future Search for Rare B FCNC Decays

MODE	BR ON STD. MODEL	POSSIBLE NO. EVENTS COLLECTED PER YEAR OF OPERATION	B SOURCE AND PROPOSED DETECTOR	REMARKS ON BACK-GROUND
$B^{\pm} \to K^{+}\mu^{+}\mu^{-}$ $e^{+}e^{-}$	$\sim 10^{-6}$	~5000	pp Collider (LHC)/CMS $P_{\perp B} > 10\,GeV/c$	$B \to D\mu\upsilon$ $\hookrightarrow K\mu\upsilon$ $-[S/B]>1$
$B^{\circ} \to \pi^{\circ}e^{+}e^{-}$ $\mu^{+}\mu^{+}$	5×10^{-8}	~100	Fixed Target LHB or SFT at SSC	$B \to D\mu\upsilon$ $\hookrightarrow \pi^{\circ}\mu\upsilon$ $S/B>1$
$B_s^{\circ} \to \tau\bar{\tau}$	3×10^{-7}	30 - 180 But Back-ground at 10^{-6} Level!	Fixed Target or Collider (LHC) (CMS)	Serious Back-ground in $B_S \to D_S\bar{\tau}\upsilon$ $\hookrightarrow \tau\bar{\upsilon}$
$B_s^{\circ} \to \mu^{+}\mu^{-}$	2×10^{-9}	$\gtrsim$ 20	Collider (High L) LHC/CMS	$S/B \gg 1$
$B^{\circ} \to \phi\tau\bar{\tau}$	$\sim 10^{-7}$	~ 30	Collider (High L) LHC/CMS	$B \to \phi D_S\bar{\tau}\upsilon$ $\hookrightarrow \tau\bar{\upsilon}$ $S/B>1$

TABLE 4. **Numbers of γ's from 1,000 $B \rightarrow X_s\gamma$ events and from 250,000 B Background Events as Functions of the Minimum p_t Cut, with the Mass Cut $0 \leq m_{\gamma\gamma} \leq 0.2$ GeV and with $\eta \rightarrow \gamma\gamma$ Suppression.**

p_t (GeV/c)	No. of γ's from 1K Signal	No. of γ's from 250K Background	Normalized Background using BR of 4×10^{-4}	(Signal/Bkg)
2.8	127	22±4.69	220±46.9	0.58
3.0	101	$14^{+4.1}_{-3.4}$	140^{+41}_{-34}	0.72
3.2	72	$7^{+3}_{-2.35}$	$70^{+30.}_{-23.5}$	1.028
3.4	56	$3^{+2.15}_{-1.45}$	$30^{+21.5}_{-14.5}$	1.33
3.6	46	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
3.8	34	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
4.0	26	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
4.2	19	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
4.4	15	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
4.6	10	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	
4.8	6	$0^{+1.15}_{-0.}$	$0^{+11.5}_{-0.}$	

TABLE 5

Impact on the Existence of New Families of Particles
an the Search and Observation of FCNC

FCNC Process	Theory	Present Result	Future Prospsect
$B \to \mu^+\mu^- X_s$	Technicolor; New Scalar Particles (Hall/Weinberg)	Limit 5×10^{-5} from UA1 Experiment at CERN	Observation or Limit to 5×10^{-6} at FNAL
$B \to X_s + \gamma$	Super Symmetry; Technicolor; 4th Family of Elementary Particles	Current Limit of 5×10^{-4} (Cornell)	Observation of a Similar Reaction $B \to K^*\gamma$ - Study in Progress at UCLA to Observe at High Rate
$B \to \tau\bar{\tau}$ (3rd Family to 3rd Family)	New Scalars; SUSY; Technicolor 4th Family	No Current Search	Crucial for all Theories Study of Detection in Progress at UCLA

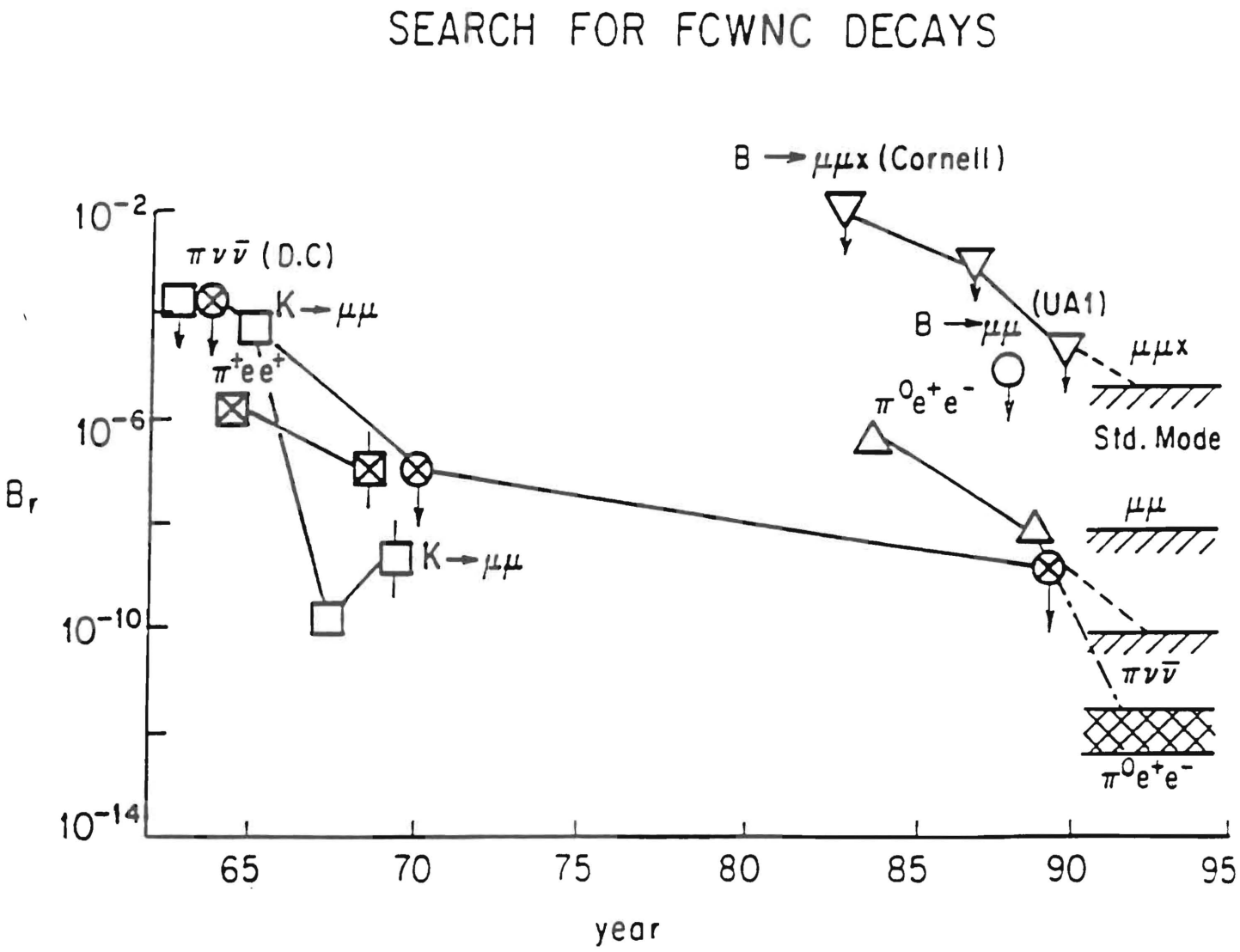

Figure 1 A plot of the limits on FCNC - Rare K, B and Charm decays as a function of time (from reference 5).

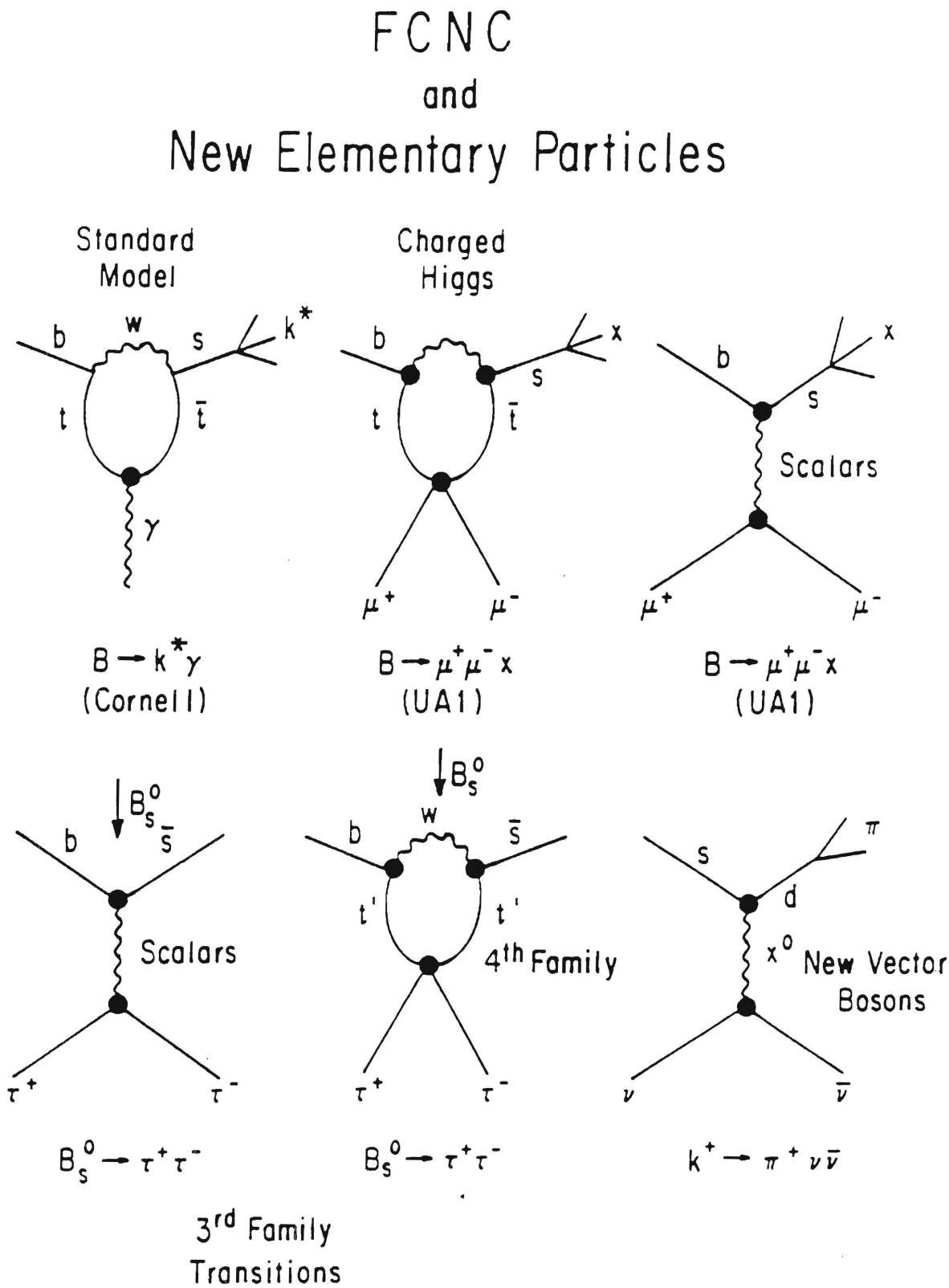

Figure 2 Some examples of Feynman diagrams for FCNC - Rare B and K decays that arise through new physics (beyond the standard model) [reference 5].

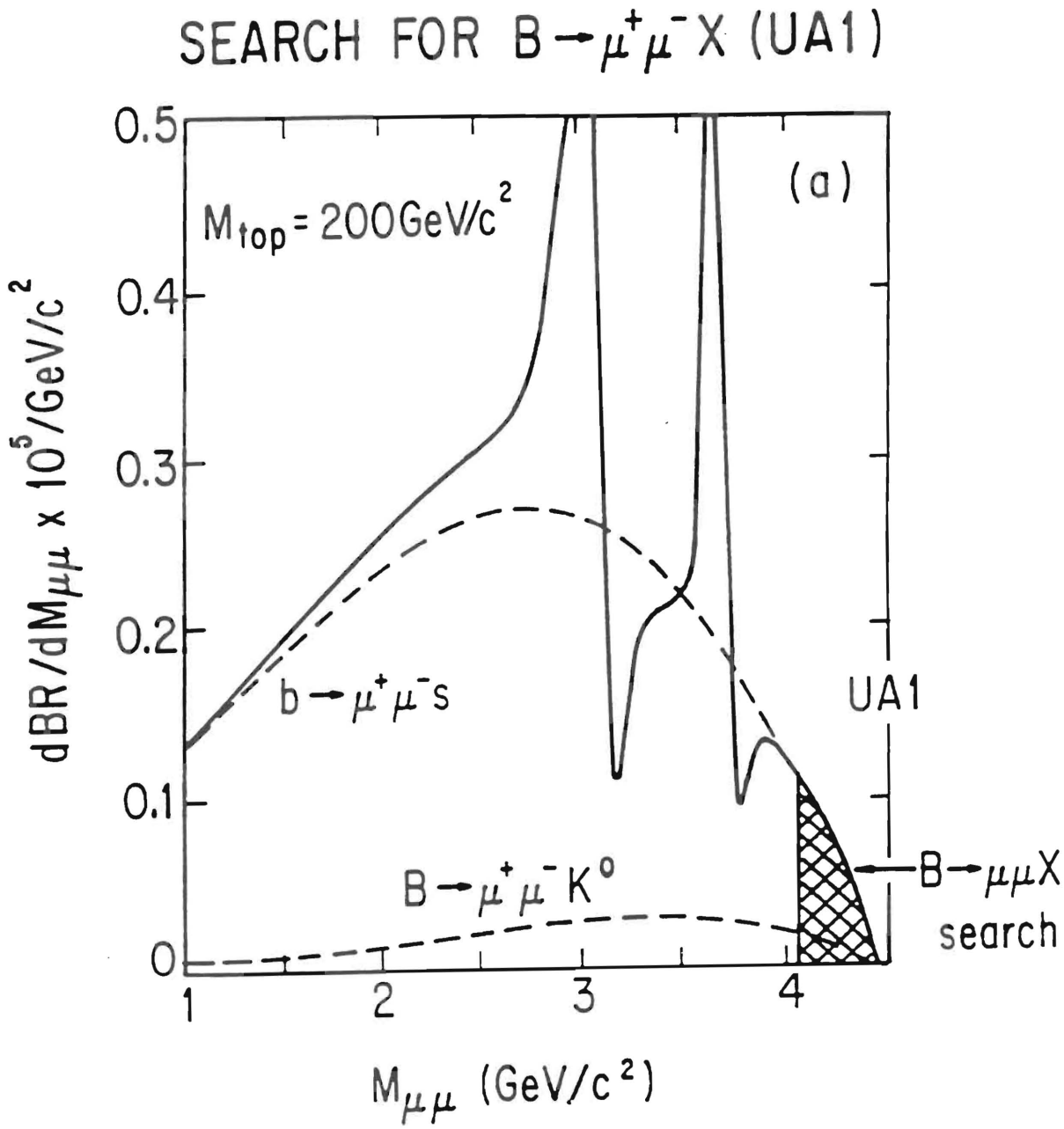

Figure 3 The $M_{\mu\bar{\mu}}$ $B \to \mu\bar{\mu}X$ decay spectrum and the region used by the UA1 group (the UCLA component) to search for this decay mode.

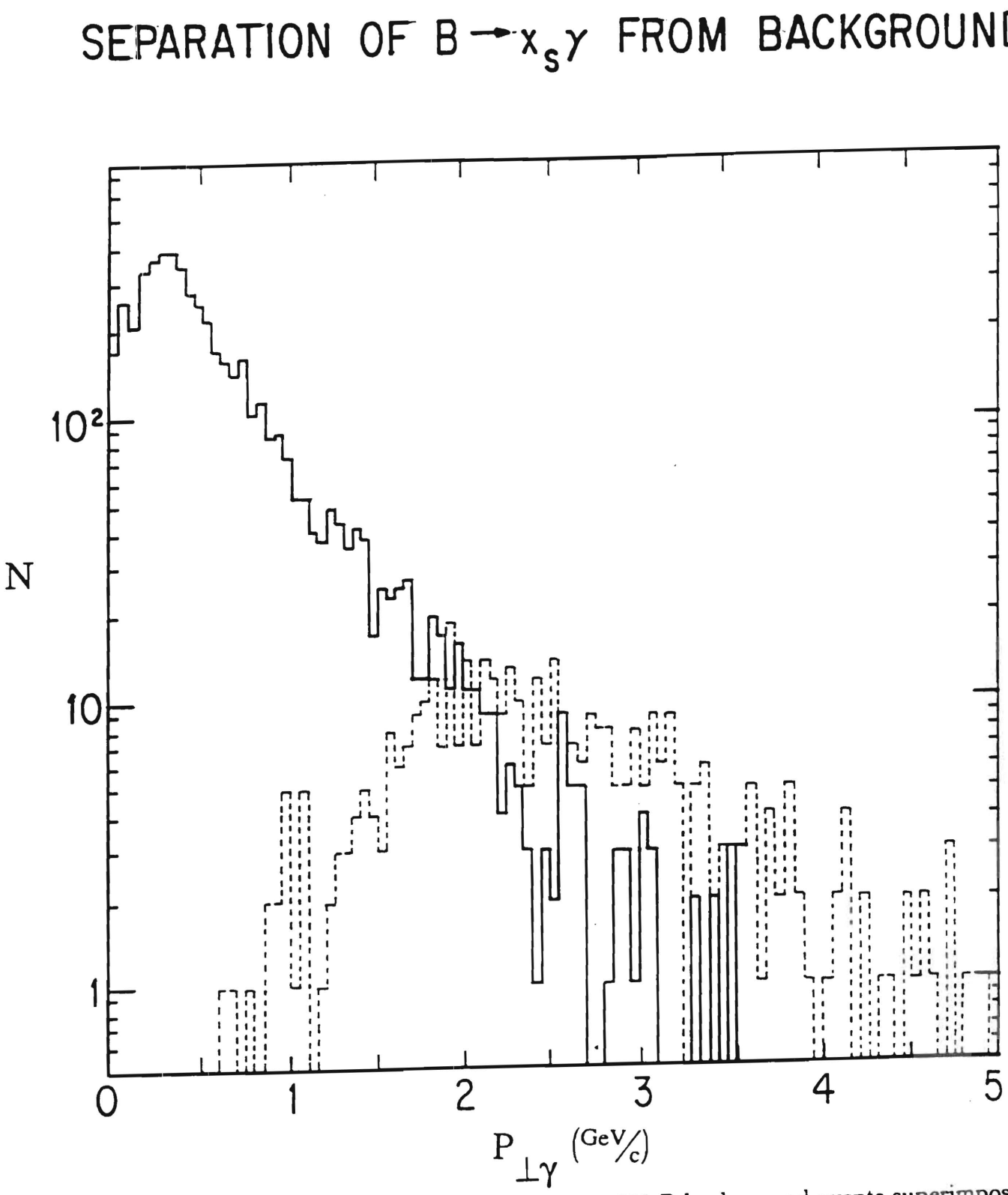

Figure 4 The p_t distributions of γ's from 250,000 B background events superimposed with 1,000 B signal events after the π° mass range cut of $0 \leq m_{\gamma\gamma} \leq 0.2$ Gev is applied with $\eta \rightarrow \gamma\gamma$ suppression. For the region $p_t \geq 3.6$ GeV the background is completely suppressed, but the signal is statistically significant.