0.1 Comparison of the results of the Counting Experiment with SM Expectations

0.1.1 The Numerical Results

Table 1 presents the number of events observed, the number expected from SM sources, and the probability of observing that number or more of events. The probability is calculated from a Poisson distribution whose mean number of expected events is drawn from a Gaussian distribution with mean equal to the central value, and whose variances are the (asymmetric) variances listed in the Table.

The channel with the largest discrepancy is the $\ell\gamma\not{E}_t$ channel, which is also the one which was chosen *apriori*[1]. For this channel we expect $5.84^{+0.60}_{-0.42}$ events, giving a probability of 6.4×10^{-4} of seeing 16 events or more.

Comparison of Expected and Observed Numbers				
Signature	# Expected	# Observed	Prob. of $\geq$N	" Sigma "
$\ell\gamma X$	$16.42^{+1.06}_{-0.91}$	25	3.41×10^{-2}	2.1
$e\gamma X$	$8.93^{+0.79}_{-0.73}$	9	5.34×10^{-1}	0.6
$\mu\gamma X$	$7.49^{+0.70}_{-0.54}$	16	6.26×10^{-3}	2.7
$\ell\gamma\not{E}_t X$	$5.84^{+0.60}_{-0.42}$	16	6.42×10^{-4}	3.4
$e\gamma\not{E}_t X$	$2.47^{+0.41}_{-0.31}$	5	1.15×10^{-1}	1.5
$\mu\gamma\not{E}_t X$	$3.37^{+0.44}_{-0.29}$	11	1.19×10^{-3}	3.2

Table 1: The number of events expected from SM processes, the number observed, and the probability of observing that number or greater from the SM expectation. The probability is calculated using a Poisson distribution with the mean number expected 'smeared' with the appropriate Gaussian distributions corresponding to the asymmetric uncertainties of Table xxx. We also give, although we don't recommend it, the number of standard deviations ('sigma') for a Gaussian distribution to have a fluctuation either up or down (two-sided) with the same probability, for those who like this way of thinking about fluctuations. One of the 5 $e\gamma\not{E}_t$ events is the $ee\gamma\gamma\not{E}_t$ event; the $\mu\mu\gamma\gamma jj$ event is not one of the 11 $\mu\gamma\not{E}_t$ events or the 16 $\mu\gamma$ events (see text).

The expected numbers of events from Standard Model sources and the measured numbers are shown in Figure 1 as hatched areas and solid points, respectively. For one of the channels, $e\gamma + X$, there is a good agreement. The main contributions to this channel involve the Z^0; when we require $\not{E}_t$ the number of events drops substantially, and the agreement becomes less obvious. Although the agreement is still fine statistically, the number of events is reduced so much that one cannot conclude whether or not there is an excess (2.5 expected, 5 observed, one of which is the $ee\gamma\gamma\not{E}_t$ event).

0.1.2 Are Electrons and Muons Different?

The *apriori* question we asked in 1996 when we began the two searches motivated by the $ee\gamma\gamma\not{E}_t$ event[2, 1] was whether or not there were 'cousins' of this event, i.e. related signa-

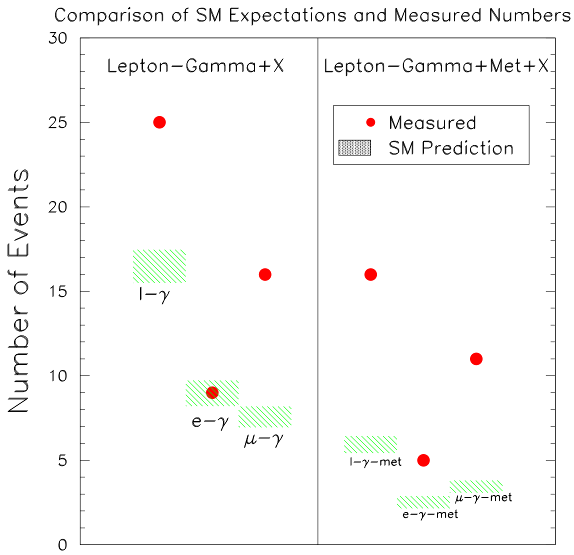

Figure 1: The Standard Model predictions (hatched area) and the observed number of events (solid dots) in the lepton-gamma + X and the lepton-gamma-met+X channels. The height of the hatched area deliminates the uncertainty in the SM prediction in the mean at $\pm$ 1 σ. Also shown is the breakdown by electron and muon channel. We remind the gentle reader that because of the low statistics, probabilities cannot be estimated by eye from this plot; they are tabulated in the accompanying Table.

tures, in the $\gamma\gamma + X$ and $\ell\gamma\not{E}_t + X$ channels. Both searches were motivated by the same idea, that if the the $ee\gamma\gamma\not{E}_t$ event came from the decay of a pair of heavy new particles, there could be additional cases in which only one of them had been made but with a different partner. In particular, the $\ell\gamma + X$ channel was motivated by the idea that the production of a charged parent object that decayed into two particles, one of which would be charged and give a charged lepton, and the other would be neutral, could be larger than the neutral case, as in the production of $e\nu$ from W decays versus e^+e^- from Z decays (i.e. the charged current versus the neutral current). The primary number from this analysis is thus the comparison of the observed $\ell\gamma\not{E}_t + X$ rate versus the expected.

One can, and we did, ask after the fact whether the electron and muon rates were discrepant. We observe 16 $\ell\gamma\not{E}_t$ events, with 11 having a muon and 5 an electron. Because we expect a total of 5.8 events, we do not really know how we expect the excess to distribute itself among muons and electrons, but the acceptances are roughly equal, as gauged by the $W\gamma$ expectations. Assuming we expect the 16 observed events to divide equally between events containing electrons and muons, the probability of 16 events having 11 or more of either muon or electron events is 10.5%. We conclude that there is no reason to conclude that there is a difference between electron and muon events with a photon and $\not{E}_t$ from these data.

0.2 The $ee\gamma\gamma\not\!\!E_t$ and $\mu\mu\gamma\gamma jj$ events

One of the 5 events in the $e\gamma\not\!\!E_t$ sample is the well-known $ee\gamma\gamma\not\!\!E_t$ event, which has been carefully scrutinized [3]. There is also an event in the inclusive $\ell\gamma$ sample of 79 events with, in addition to the central photon and muon, a good photon in the plug calorimeter, and a stiff (> 60 GeV) isolated track that penetrates to the CMU and CMP, and makes a good match with them. This track, however, fails one (and only one) of the tight central muon cuts: it deposits 6.5 GeV in the hadron calorimeter, and the cut is at 6.0. However the probability of a 60 GeV track leaving only 6.5 GeV in the calorimeter is much lower than the probability of a muon leaving 6.5 GeV, and the probability of punchthrough to the CMP is also very small. The most likely object for this track to be is a muon. When this track is accounted for in the $\not\!\!E_t$ accounting, the event has very small $\not\!\!E_t$ (everything balances). The event is thus most likely a $\mu\mu\gamma\gamma jj$ event. The kinematic quantities of the event, which are very similar in many ways to that of the $ee\gamma\gamma\not\!\!E_t$ event, are described in detail in Ref. [4]

The event is not counted in either the xx $\ell\gamma$ or the 25 $\ell\gamma\not\!\!E_t$ events for (slightly humorous) technical reasons: since it has only one (central) photon, and only one muon (the other fails the muon cuts), it is required to pass the back-to-back cut, which is applied to all events with only one lepton and one photon. It fails this cut, and consequently is not included in the final $\ell\gamma$ and $\ell\gamma\not\!\!E_t$ samples.

0.3 What Do We Say?

The lack of agreement in the $\ell\gamma\not\!\!E_t$ channel with SM expectations will invite comment when we present it. It will be important to have a clear idea of what picture the listener will carry away.

Unlike in the case of the top quark, where we knew what signature we were looking for, so that 2.8σ was "Evidence for...", we do not want to claim that 3.4σ is evidence for new physics. Instead, we would like to show that we have developed a valid methodology, "signature-based" searches in channels that are related, and have done a careful job without tuning cuts or bending the data. We have an intriguing result. However, deciding whether or not there is new physics in these channels will have to wait for new data. But, and this is the key idea we would like to convey to the outside listener, we now can 'call', in the sense of specifying beforehand the cuts and Standard Model predictions for Run 2.

0.3.1 Strategy for Run 2.

The strategy for Run 2 will be do this analysis *apriori*. Specifically:

- The thresholds on the lepton, photon, and $\not\!\!E_t$ will be 25 GeV.
- The electron and muon identification will be the agreed-upon EET (Electroweak, Exotic, and Top) group standards.
- Any changes to the ID cuts will be made before any data are taken (for example, we are working now on better photon isolation cuts; the UCLA group has developed better lepton isolation cuts).
- We propose to do the analysis 'blind'.

References

[1] J. Berryhill, R. Culbertson, H. Frisch, and D. Toback, *A Search for SUSY Cousins of the $ee\gamma\gamma\not\!\!E_{\rm T}$ Event in the $l\gamma\not\!\!E_{\rm T}$ Channel*, CDF/ANAL/EXOTICS/3555, Feb. 1996.

[2] R. Culbertson, H. Frisch, and D. Toback, *Search for Cousins of the $ee\gamma\gamma\not\!\!E_{\rm T}$ Event In the Diphoton Channel*, CDF/ANAL/EXOTICS/3456, Dec. 1995.

[3] F. Abe et al., *Searches for New Physics in Diphoton Events in $\bar{p}p$ Collisions at Root(s)=1.8 TeV* , to be published in Phys. Rev. Lett., (hep- ex/9801019); F. Abe et al., *Searches for New Physics in Diphoton Events in $\bar{p}p$ Collisions at Root(s)=1.8 TeV* , submitted to Phys. Rev. D, June 1998 (hep- ex/9806034); D. Toback, Ph.D. thesis, University of Chicago, 1997.

[4] D. Toback, Ph.D. thesis, University of Chicago, 1997.