3.2 ELEMENTARY CONSIDERATIONS ON RATE LIMITATIONS

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I consider the following simplified model of the triggers:

1) Pre-trigger is an interacting beam,

2) Trigger is some p_T in the calorimeter. (I ignore the bias, since that merely changes the effective threshold.)

I further assume that we use a target with a probability A of interacting. For all particles which do interact I assume we can represent the probability of producing a signal at least as great as $p_1 = A \exp(-Kp_T)$.

Then we have some average effective rate R of beam but there is an additional duty factor D such that the probability of at least one particle in a gate of width G is RG but the probability of two particles is $D(RG)^2$, ignoring the probability of more than 2.

If the veto works well then events in which only one particle interacts will be vetoed. If both interact then we satisfy the pretrigger condition and we can estimate the availability of the calorimeter triggering. This is just the probability of the p_T from both of the interactions adding up to the threshold, so

$$P_2 = \int_0^\infty Kdp_1 \int_{T-p_1}^\infty Kdp_2 \, e^{-K(p_1 + p_2)} = e^{-KT} (KT + 1).$$

The rate of triggers on 2 interactions is $N_2 = D R^2 A^2 G^2 p_2$, to be compared to $N_1 = R A G p_1$ the rate for triggers on single interactions.

So

$$N_2/N_1 = D R A G (KT + 1).$$

The table on the next page shows a few sets of values which might be within the range we can expect.

These events with two separate interactions may be hard to disentangle. The admixture of these events into the jet sample might well give misleading results, since it could cloak any differences due to jet structures emerging at high p_T.

Examples of the Effect of Multiple Interactions.

$D = 2,\ A = 0.1,\ K = 3\ GeV^{-1}$

beam flux (R) (s^{-1})	gate (G) (ns)	threshold p_T (T) (GeV)	Ratio of Double/Single N_2/N_1
10^6	100	5	0.32
3×10^6	100	5	0.96
10^7	100	5	3.2
3×10^6	20	5	0.19
10^7	20	5	0.64
10^7	20	10	1.2

The "gate" used here is the time it takes to resolve the signals. For current detectors 100 ns is a short time, so that rates are limited to $<3\times10^6\ s^{-1}$. For the future it is difficult to see more than a factor of 5 improvement.

It should be noted that these considerations are only slightly dependent on the detailed model, but depend mostly on the steeply falling spectrum.