Study of the $\gamma\gamma \to q\bar{q}$ background to SUSY point D'

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Outline

Cross-section and event-generation time

PYTHIA obtains a total cross-section for $e^+e^- \to \gamma\gamma e^+e^- \to q\bar{q}e^+e^-$ at $E_{CMS} = 500$ GeV of 28371 pb
(+ another 7170 pb if the diffractive and elastic components are included, but these classes do not contribute to high $P_{T\ miss}$-events)

- $\int Ldt = 500\ \text{fb}^{-1} \to 14 \star 10^9$ events are expected.
- 10 ms to generate one event.
- 10 ms to fastsim (SGV) one event.

10^8 s of CPU time is needed, ie more than 3 years. This goes to 3000 years with full simulation.

Clearly, there is need to reduce this number by one or two orders of magnitude, by using generator level cuts.

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$\gamma\gamma$ classes

The $\gamma\gamma \to q\bar{q}$ generated by PYTHIA 6 is sub-divided into a number of classes. γ:s might be:

- Direct: The γ interacts via a virtual fermion.
- VDM: The γ has fluctuated into a ρ, which interacts.
- Anomalous: The γ has fluctuated into a heavier vector-meson, which interacts.
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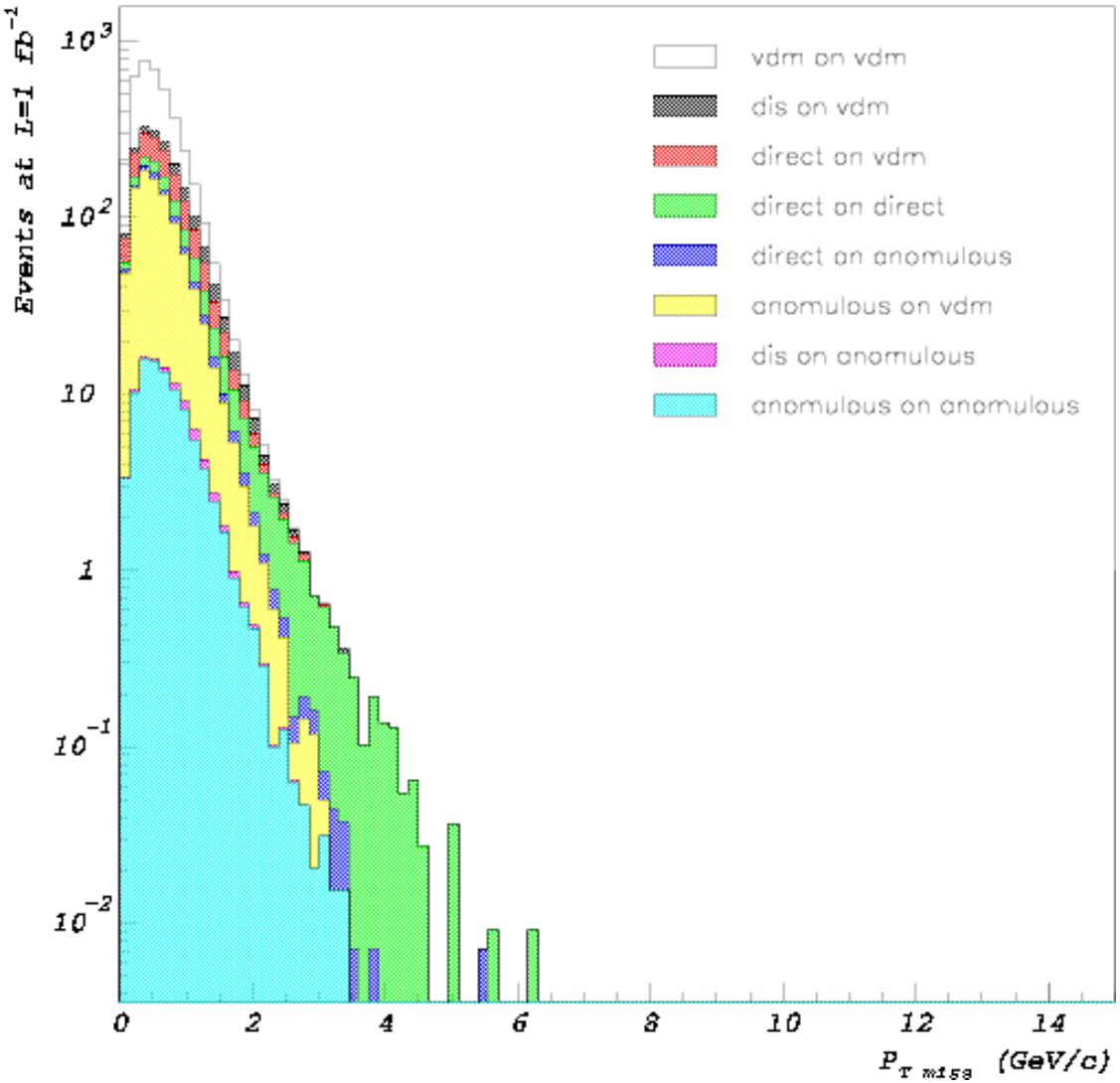
Cross-sections per class

The total cross-section of 28371 pb breaks down like this:

Class	Cross-section [pb]
VDM-VDM	15770
A-A	505
D-D	2370
VDM-A	5554
VDM-D	2246
A-D	483
DIS-VDM	909
DIS-A	435

P_T distribution of the classes



Generator-level cuts

PYTHIA allows to restrict event-generation to certain ranges in the key kinematic variables in $\gamma\gamma \rightarrow q\bar{q}$ reactions. :

- min and max x_B, first and second γ
- min and max Q^2, first and second γ
- min and max θ, first and second e
- min and max y_B, first and second γ
- min and max invariant mass of the $\gamma\gamma$ -system

Don't restrict θ: not much gain, might kill candidates
Cut on $Q^2 \equiv$ cut on θ.
$y_B \approx x_B \rightarrow$ only useful to cut on either of these.

Lower cut on $x_B \approx 0.005$: Events with $P_{T\ miss}$ below 2.5 GeV/c must be cut out (worst possible case of no-tag $\gamma\gamma$).

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Signal Preselection

SUSY point D' (M_{lsp}=212 GeV, $M_{\tilde{\tau}}$=217 GeV):

- Charged multiplicity between 2 and 10 (signal is two τ:s).
- No jet with P $>$ 8 GeV/c (the kinematic limit in point D').
- $<$ 100 GeV in 30deg forward cone (killing the tagged $\gamma\gamma$ events).
- Thrust axis above 30deg (staus are scalars, $\gamma\gamma$ is t-channel).
- Total charge 0 (cuts events with one lost charged particle).
- Seen mass above 1 GeV/c^2(likely for the signal, unlikely for $\gamma\gamma$).

Need to find generator cuts that doesn't touch $\gamma\gamma$ passing these cuts, and at the same time reduces those that doesn't pass the cuts by a large factor.

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The iterations

Can't find generator cuts that reduce the cross-section by more than a factor 3, while keeping the number of events passing the cuts unchanged, if the natural mix of the 8 classes is generated together.

→ need to treat each class separately.

Can't find the cuts in a single go: Takes to much time to get enough events in the signal-like region

→ need to iterate

In all iterations, 10 000 000 events were produced in each of the 8 classes. Plot $P_{T\ miss}$ vs the lowest x_B, vs the highest x_B, and vs W in each class. Determine the corresponding cuts.
The $P_{T\ miss}$distribution with and without cuts was checked.

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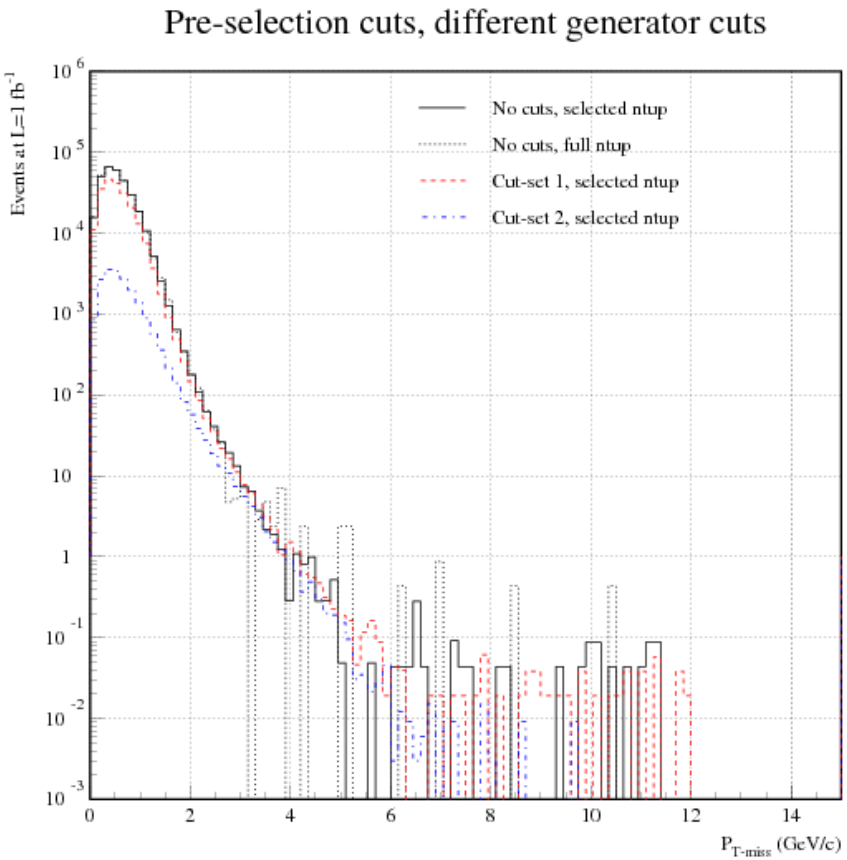
$P_{T\ miss}$ distributions for the different cut-sets.

- The total reduction of the cross-section is about an order of magnitude
- The curves coincide above $P_{T\ miss}$= 3 GeV.
- The signal emerging out of the background by consecutive cuts.



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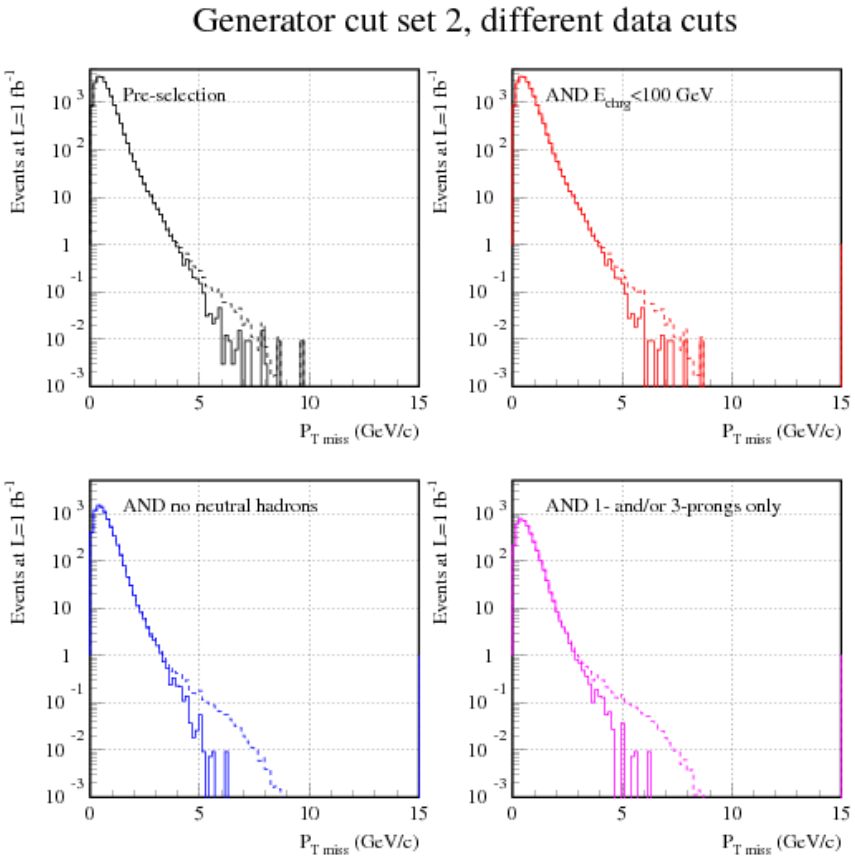

The iterations

The table shows the cuts after each iteration, and the cross-section after cuts.

Class	x_B min	max	W min	max	σ [pb]	x_B min	max	W min	max	σ [pb]
VDM-VDM	.005	.2	3.4	40.	8392	.014	.125	8.	40.	3328
A-A	.005	.2	3.	35.	134.5	.012	.1	7.	35.	51.85
D-D	.008	.15	2.	500.	232.5	.009	.08	9.	500.	91.66
VDM-A	.004	.25	3.	500.	2026	.01	.23	8.	50.	950.2
VDM-D	.005	1.0	5.	60.	1178	.012	.2	8.	60.	555.4
A-D	.008	.3	5.	500.	198.1	.011	.11	9.	30.	71.74
DIS-VDM	.0025	1.0	2.	500.	499.4	.008	1.0	10.	500.	204.2
DIS-A	.002	.15	1.5	500.	190.5	.01	.15	7.	500.	29.84

Conclusions

- One must be able to reduce the needed number of simulated $\gamma\gamma$ events by two orders of magnitude.
- By iteratively adjusting PYTHIA's generator-level cuts on x_B and W in such a way that the part of the phase-space that passes the preselection cuts of the analysis remains unchanged, this is doable.
- The adjustment needs to be done separately for each of the classes.
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