Comparing $\gamma\gamma \to q\bar{q}$ from WHIZZARD and PYTHIA
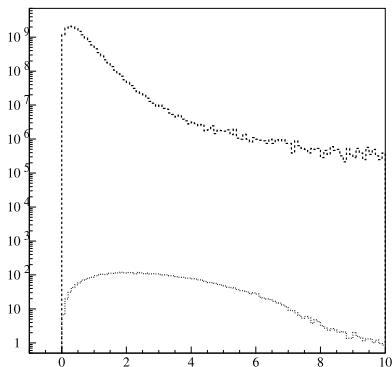
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[1]DESY

ILD optimisation meeting, April 16, 2008

Cross-section and event-generation time

PYTHIA obtains a total cross-section for $e^+e^- \rightarrow \gamma\gamma e^+e^- \rightarrow q\bar{q}e^+e^-$ at $E_{CMS} = 500$ GeV of 35.5 nb

The signal is SUSY point D' (M_{lsp}=212 GeV, $M_{\tilde{\tau}}$=217 GeV).
Cross-section 10.1 fb ...

$\gamma\gamma$ classes

The $\gamma\gamma \to q\bar{q}$ process can be 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.
- DIS: The γ is highly virtual, and the interaction is best described as deep inelastic electron scattering on a vector-meson.
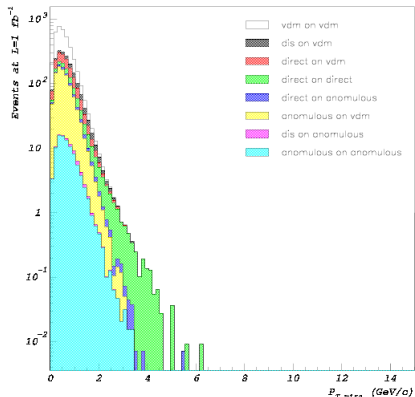- Diffractive

PYTHIA can generate all combinations of the nature of the two γ. WHIZZARD only generates *Direct-on-Direct*

Cross-sections per class

The total cross-section of 35500 pb breaks down like this:

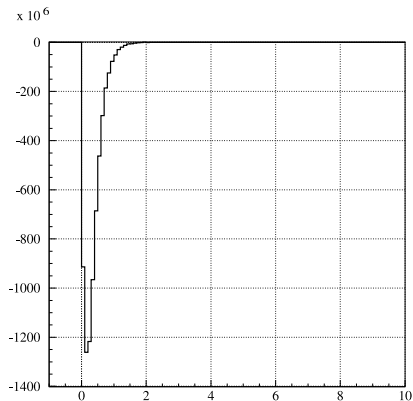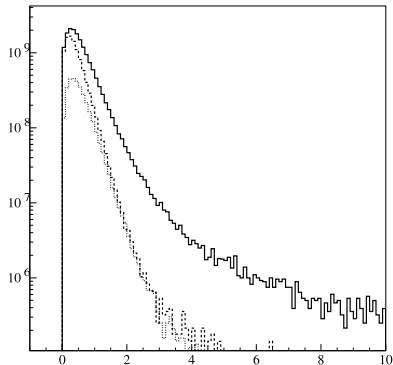| Class	Cross-section [pb]
VDM-VDM	15770
A-A	505
D-D	2370
VDM-A	5554
VDM-D	2246
A-D	483
DIS-VDM	909
DIS-A	435
Diffractive	7170

P_T distribution of the classes

Note that high P_T is completely dominated by *Direct-on-Direct*.
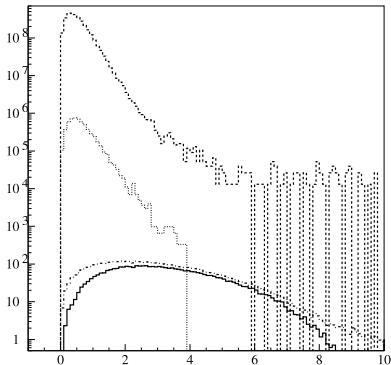
Importance of *Direct-on-Direct*

Diffractive: no contribution above P_T = 2 GeV.

Importance of *Direct-on-Direct*

Apply pre-selection cuts:

- $2 \leq N_{Charged} \leq 10$ (two τ:s).
- $P_{jet}^{max} < 8\,GeV$ (kinematic limit).
- $E_{below\,30\,deg} < 100\,GeV$ (killing the tagged $\gamma\gamma$ events).
- $\Theta_{Thrust} > 30\,deg$ (staus are scalars, $\gamma\gamma$ is t-channel).
- $Q_{tot} = 0$ (cuts events with one lost charged particle).
- $M_{vis} > 1\,GeV$ (likely for the signal, unlikely for $\gamma\gamma$).

Reduce background by 3 orders of magnitude, signal by 20 %
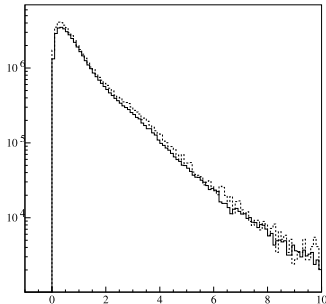
Importance of *Direct-on-Direct*

After pre-selection cuts: Only *Direct-on-Direct* contributes in the region where the signal might be detectable, above $P_T = 2$ GeV.
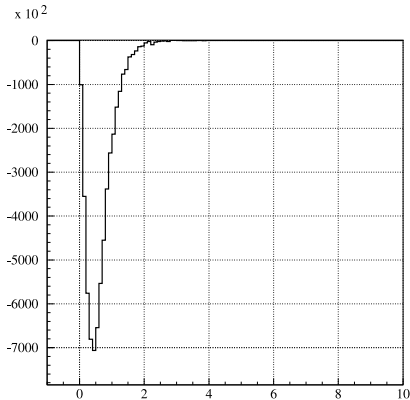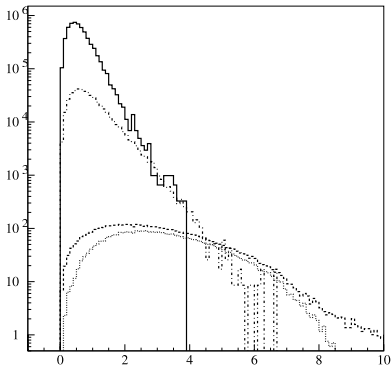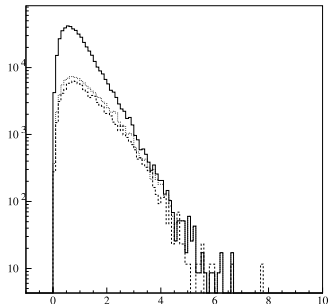
Comparing WHIZZARD with PYTHIA

Generate a PYTHIA sample of only *Direct-on-Direct*. Apply the same generator-level cuts as for the SLAC samples: $Q^2 < 16 GeV$, $W > 10 GeV$, All $(P^{\mu}_{\gamma^*} - P^{\mu}_{quark})^2 > 4 GeV$.

Cross-sections: WHIZZARD 88.8 pb, PYTHIA 99.5 pb. PYTHIA:s cross-section is 12 % higher

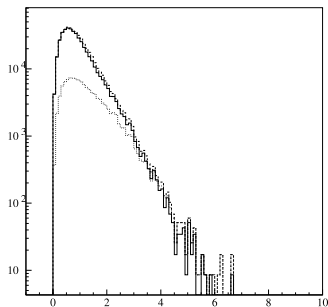# Comparing WHIZZARD with PYTHIA: generator cuts

Preselect events. Compare PYTHIA with or without the WHIZZARD cuts, and to WHIZZARD.

A large fraction of the events passing pre-selection does not pass the generator cuts. Now, PYTHIA:s cross-section is 22 % higher.

# Comparing WHIZZARD with PYTHIA: generator cuts

Preselect events. Compare PYTHIA with or without the WHIZZARD cuts, and to PYTHIA with it's own generator cuts: $0.009 < x_B < 0.08$ and $W > 9 GeV$ (See my talk in the SUSY session in Valencia)

The optimised PYTHIA cuts leaves the preselected sample intact.

Comparing WHIZZARD with PYTHIA: generator cuts

Now go to the (almost) final selection: $P_T > 2.5 Gev$ and $E_{below 30 \deg} < 10 GeV$. Plot ρ, (=E_T wrt. the thrust-axis of the two jets).
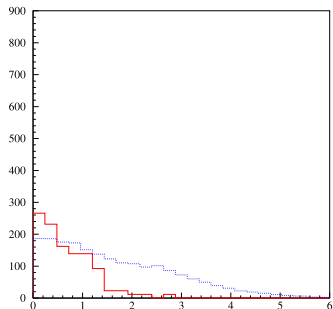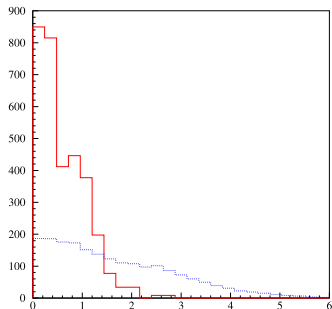
Now the difference between PYTHIA and WHIZZARD is a factor 2.9 ! However, after the last 2-dim cut in the the ρ-P_T plane, the result is the same - but the statistics is too low to draw any firm conclusion.

The Q^2-cut and crossing-angle

The cut in Q^2 is a cut on the defection angle of the out-going electron/positron.
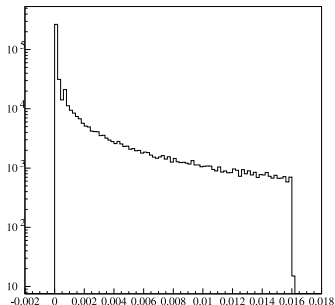
No events with the electron deflected more than 16 mRad are generated. A part of the dead area towards the out-going beam is therefore not covered.

More remarks

With 1 Mevents, the integrated luminosity is 11.3 fb^{-1}, ie. each event has a weight of 44.4.

Non-observation of any background only gives the right to conclude that the background is below 133.2 events (95% CL) ...

The dominating background is from $\gamma\gamma \to c\bar{c}$. This channel corresponds to about half the total cross-section.

WHIZZARD-files with about 1.5 Mevents of $\gamma\gamma \to c\bar{c}$ are already generated.

Conclusions

- That WHIZZARD only produces *Direct-on-Direct* events is no problem at this stage.
- A surprising difference of 12 % in cross-section was found, but at this stage it is no problem.
- A much more serious difference was found for the most signal-like events. Needs to be understood.
- The Q^2-cut is too low. A part of the hole for the other beam-pipe is not covered. Can it be added ? The best is to do no Q^2-cut at all !
- The suggested sample-size is at the limit to be useful for low ΔM SUSY. By adding 1 Mevents of $\gamma\gamma \rightarrow c\bar{c}$ (already generated), the situation would be much better.