Generator Group Status Report

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ILD meeting at ALCW, KEK, Apr, 2015

Outline

Introduction

- Group formed to select generator to generate physics events for the DBD benchmarks, including all relevant backgrounds.
- $\Rightarrow$ Generate the entire SM at 1 TeV. At least 500 fb^{-1}, except for very high cross-section processes ($\gamma\gamma$, Compton, Bhabha).
- Members:A. Miyamoto, T. Barklow, M. B., CLIC (at the time S. Poss, now P. Roloff)
- Also used to produce 250, 350 and 500 GeV data-sets.
- Presently, the group doesn't really exist - our mandate was for the DBD.
- However, we decided that now is a good time to get back into business, because:
  - New, better Whizard.
  - Developments in reconstruction.
  - Lack of statistics in some cases.
  - Things that went wrong in DBD & friends: Double-counted

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Kick-off Dinner Meeting on Monday with T. Barklow, M.B., J. List, J. Reuther (Whizard author)

Re-reconstructing

- In some analyses, SM MC statistics is currently too low.
- Any new massive event simulation should be based on WHIZARD2
- How does time-scale for ilc-whizard-2 match with timescales of:
  - New DD4HEP-based simulation
  - Implementation of recent improvements to reconstruction (eg dE/dx, calorimeter-hit based PID at low momenta, tracking improvements (cf. talk by Masakazu Kurata))

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Two options:

1. Quick re-reconstruction of simulated DBD files.
   Advantages:
   - Could be done on very short time-scale
   - Correct amount of overlay (but no better model)

   Draw-backs:
   - Cannot correct for missing vertex smearing
   - Probably not worth to increase statistics significantly?
2. A new set of SM samples based on Whizard 2 & Mokka(ILD_o1_v5), up-to-date digitisation & reconstruction
   Advantages:
   - Overlay corrected, maybe also generate better model.
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   - Generator samples could be reused for detector optimisation studies with DD4HEP-based simulation.

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Whizard 1 → Whizard 2

- Much improved steering: Sindarin.
- Samples from new BSM models much easier to create, using tools like SARAH.
- 8 fermion final states possible (*ttH* !). Was not (practically) possible with Whizard 1.95, so these DBD samples were made with Physim.
- Match hard gluon radiation from Whizard hard process with gluons in parton-shower and hadronisation. Can, within Whizard, compare this with DBD recipe ($\alpha\_s = 0$ in whizard + Pythia for both parton-shower and hadronisation) $\Rightarrow$ systematics evaluation.
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- Easier to study of impact of beam parameters: GUINEAPIG beam-simulation directly input to Whizard (the CIRCE2 component).

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Status of Whizard-2 for ILC: Output format and interfaces

- Correct stdhep output: Latest α release (2.2.6alpha) ha gone a long way, but still not acceptable. Fringe-benefit: when it works Whizard can also directly output LCIO.
- Interface to PYTHIA:
  - In Whizard 1.x, this was external to Whizard, and implemented in our user-routine, user.f90 (mostly by Tim)
  - In Whizard 1.95: Colour-flow from Whizard used to to set up the event-record for correct treatment in Pythia, also done by us.
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- Whizard produces correctly polarised τ:s $\Rightarrow$ need to correctly decay polarised τ:s $\Rightarrow$ TAUOLA.
- But: Pythia doesn't handle polarised decays; allows for user plug-in to do τ-decays.
- $\Rightarrow$ Need to "leap-frog" polarisation information from Whizard over the polarisation-blind Pythia to TAUOLA.
- ilc-whizard-1.95: done in user.f90.
- Whizard-2: no user.f90 anymore $\rightarrow$ How to do it now?
- Obviously, Whizard can only transfer the full spin correlation for τ's it knows about.
  - $\Rightarrow$ the spin correlation between the τ:s from a Higgs decay (done in Pythia) is lost in the DBD samples.
  - For Whizard 1, H had to be decayed by Pythia: Whizard is tree-level, ie. no loop-induced decays ($H \rightarrow \gamma\gamma$!)
  - In Whizard 2, effective vertices exist $\rightarrow$ loop decays of H possible $\Rightarrow$
  - Let Whizard *decay* H, with constraint on intermediate state = Higgs, $\Rightarrow$ polarised τ:s ! Caveat: Can one set BR's ?!

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Whizard 2 offers two possibilities

1. CIRCE 2: Do $\sim$ what user.f90 did - use GUINEAPIG output to automatically create an MC-generator of the beam-spectrum
   - Observed significant (factors > 1) slow down $\Rightarrow$ ask Authors to profile CIRCE2
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2. "direct read-in" of "beam event files": Works, also with polarisation
   - Draw-back: Needs huge statistics in GuineaPig files, probably not efficient for mass- production.
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- Technical requirements for mass production in batch mode:
  - Option to specify maximum file size + automatic file splitting.
  - Steering by command line options.
- For fast simulation: need callable interface (ie. no intermediate generator files).
- Double counting in $\mathrm{e}^+\mathrm{e}^- \to e^+e^-f\bar{f}$:
  - Problem: if γ^* and e massless, p_t-kick from Weizsäcker-Williams γ violates 4-momentum conservation ⇒ unphysically large p_t-kick on e ⇒ cut used to separate $\mathrm{e}^+\mathrm{e}^- \to e^+e^-f\bar{f}$ from $\gamma\gamma$ and from ZZ etc. fails ⇒ double-counting. Routes to solve this:
    1. Do $\mathrm{e}^+\mathrm{e}^- \to e^+e^-f\bar{f}$ down to $m_e > 0$ without cut-off? → needs quadruple precision in integration and event generation + work of > 1 month
    2. Simply reject events with p_t-kick of e larger than allowed by given Q^2 cut

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  - Now: no gluons included in ME (setting $\alpha_s = 0$) to avoid double-counting with (unmatched) parton shower in Pythia.
  - Whizard 2 can do it's own parton-shower with "MLM matching".
  - For now: stick with old scheme for mass-production, but make dedicated comparisons for multi-jet final states (eg $t\bar{t}$ background for ttH or ZZH)
- 8 fermions:
  - Whizard 1: Choked on 8 fermion →: source code generated by O'mega (the matrix element code generator) could reach several GB in size ⇒ Physsim in DBD for ttH
  - Whizard 2: Scaleble option: generated "byte code" running in a "virtual machine" (think Java!). Should work for 8f. Need to validate.
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- Dedicated radiative Bhabha generator:
  - LEP generators with treatment of collinear divergencies etc.
  - BHWIDE used for CLIC luminosity spectrum study (A.Sailer). Do the same.
- $\gamma\gamma \rightarrow$low-p_t hadrons:
  - Unphysical invariant mass distributions observed on files currently used in overlay.
  - Very simplistic model, probably current HERA/LEP tuned Pythia would be better.
  - New student at DESY will check current capabilities of Pythia in the next months.
- Similarly for $\gamma\gamma$ in general: Pythia is much more elaborate than Whizard. However, Pythia6 out-of-the-box can't handle beam-spectrum for these processes.

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- First point: lots of goodies in Whizard 2, so:
- Main issue right now: Make Whizard 2 fly for ILC.
- Discus if it can already be used on a time-scale of $\mathcal{O}$(1 month), in view of re-doing selected DBD samples.
- Further issues: Learn from lessons of DBD studies
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Current feeling:

There are several severe issues with Whizard right now, but nothing is fundamental, so there is hope that they can be ticked off in the near future $\Rightarrow$ re-doing selected DBD samples with Whizard 2 is a viable possibility.

- ...