Requirements for new Monte Carlo productions

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Main generator: Whizard

- Whizard remains the generator of choice for e^+e^-.
- Full matrix-element evaluation. Only at tree-level but:
  - Can do $2 \to 8$ processes.
  - Polarised beams.
  - Full helicity treatment.
  - Full colour flow, passed from the hard interaction to the P.S. code.
  - Can handle beam-spectrum, using Circe2.
- ... which is more important than NLO for e^+e^- !
- The subsequent parton-shower and hadronisation is done by PYTHIA6.4.
  - LCGG has tuned hadronisation using input from OPAL at LEPII.
- The process-definition given in the Whizard steering file (aka the *sindarin*) is also the driver for the scripts that organises the production: One ring to rule them all.
- Use powerful grouping and aliasing capabilities of sindarin to assure that no processes are over-looked.

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Process classification

The classes

1. Initial state
   - ee, eγ or $\gamma\gamma$
   - e - polarisation and γ type (real or virtual)
2. Final state multiplicity
   - Number of fermions (0 to 8)
3. Final state flavours
   - Flavour-grouping: W or Z, or ambiguous
4. Final state lepton/hadron mix
   - leptonic, hadronic, semi-leptonic (+ neutrino only, for Z-leptonic)
5. Beam-polarisation
   - LR, RL, RR, LL (100% always implied)

- Special Considerations
  - Eg. 4f with $|L_e|$=2 ⇒ dominated by single W or single Z (t-channel !)

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Beam effects

- Beam-spectrum.
  1. Incoming beam-spread
  2. But also: very strongly focused beams ⇒ Beam-beam interactions
- Photons
  1. How many photons?
  2. Are they virtual or real?
- Incoming beam-spread from damping-rings and ondulator: External input from machine-scientists.
- Need beam-beam interaction simulation input.
- Simulate interaction region: GuineaPig. Gives:
  - Beam-spectrum for electrons and positrons independently
  - Distribution of interaction point
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Spurious interactions ("pile-up")

Two types:

- Pair-background: Pair-creation of photons in the beam by the strong fields. GuineaPig also gives us this.
- low-p$_\perp$t hadrons, ie. $\gamma^{(*)}\gamma^{(*)}$ interaction with small invariant masses
  - ME can't do this, so need different generator
  - PYTHIA is good down to $M_{\gamma\gamma} \sim 2$ GeV
  - A lot happens below that, but is basically not known theoretically ⇒ need to fit to data
  - Data is scarce, and ambiguous ...
  - ⇒ Custom generator developed for this.

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- These backgrounds need to be passed on to simulation, but in a different mode.
- Eg. can't simulate $\sim 10^5$ pairs on each physics event.
- Actually, can't generate that either: time for 1 BX 5-10 minutes
- Find the few tracks that do hit the tracking (< 100/BX). Do $\sim$ 100000 BXes, and pick a random one from the pool to overlay to each physics event.
  - Done using the fast detector simulation code SGV, which faithfully evaluates detector acceptance.
- Also, use some ($\mathcal{O}(100)$) BXes to simulate pairs hitting the BeamCal, to build a map of the background, to be used in the BeamCal simulation.
- Similar for low-$p_\perp$ hadrons, but here also the number per BX is random, and their production point.

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What next ? : Other E_{CMS}

- Straight-forward: 500 GeV
  - Process-definitions and scripts directly from the 250 production.
  - All beam-related issues are there after the IDR effort: Circe2 beam-spectrum, low p_T-hadrons, seeable pairs.
  - Only caveat: Move of BeamCal: not quite correct background-map.
- Some issues: 1 TeV
  - As 500 GeV, but:
    - For γe: No Circe2 beam spectra, nor Circe inputs from GuineaPig.
    - Minor issue: clear path to produce these, just takes time and effort.
    - Need to redo seeable pairs (straight forward).
    - Need to redo low p_T-hadrons: The competence to do this is gone!
- Issues: 350 GeV, M_Z
  - As for 1 TeV, + no GuineaPig output at all (i.e. not for e^+e^- either)
- Major Issues: Anything else (550-600 GeV, WW-threshold, > 1 TeV ...)
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What next ? : Future developments

Whizard developments

- gluon matching between ME and PS:
  - Now: no gluons included in ME (setting α_s = 0) to avoid double-counting with (unmatched) parton shower in PYTHIA.
  - Whizard 2 can do it's own parton-shower with "MLM matching". Exploit this !
- Medium-term wishes for Whizard:
  - γ ISR/FSR matching
  - Work out priority processes for EW-NLO (!)

In general it would be nice to also have other generators

- BHWide for better Bhabhas.
- BDK/BDKRC for $\gamma\gamma \rightarrow \ell\ell$
- Pythia8, MadGraph, Sherpa for double-checks.
- Pythia8 instead of Pythia6 for hadronisation.

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