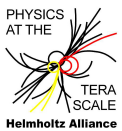
Beam properties for ILC with GuineaPig

Mikael Berggren[1]

[1]DESY, Hamburg.

IDT-WG3-MDI, online, September 30, 2021



CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE

MC requirements for linear colliders

- Future LCs aim for extremely high precision measurements.
  - $\Rightarrow$ Need excellent detector, well controlled machine conditions
  - But also the best possible estimate of backgrounds.
- MC statistics or lacking channels must not be a major source of systematic errors $\Rightarrow$
  - All SM channels yielding at least a few events under the full lifetime of the projects need to be generated, with statistics largely exceeding that of the real data.
  - Also machine conditions need to be accurately taken into account.
- In addition: at an LC ALL events are interesting, and often fully reconstructed. More like a B-factory than LHC!

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Generating the full SM

Generate the full SM? What's the problem?

- Just select a generator, and press <RET>, right?
- Noooo..., not really. Lots of details:
  - What collides ($e^{+/-}$ or γ ?)
    - What energy do they have, and how are they polarised?
  - Where do they collide ?
    - Beam-spot properties
  - What else happens?
    - Beam-strahlung gives pairs
      - Do they hit anything ? Maybe forward calorimetry, or the tracking system ?
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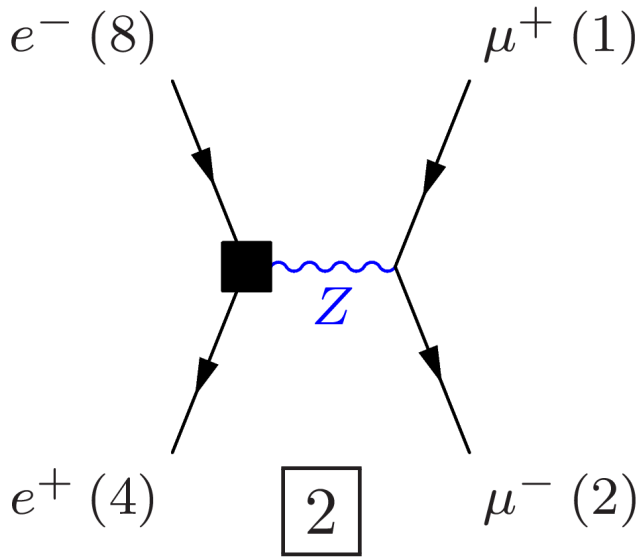
Process classification

- Final state
  - Number of fermions (1 to 8)
  - Flavour-grouping: W or Z, or ambiguous
  - leptonic, hadronic, semi-leptoni (+ neutrino only, for Z-leptonic)

But also:

- Initial state
  - ee, $\gamma\gamma$ or eγ
  - e - polarisation and γ type (real or virtual)
- Special considerations
  - Eg. 4f with $|L_e|$=2 $\Rightarrow$ dominated by single W or single Z (t-channel !)
  - Avoid double-counting: Eg. $\gamma^*\gamma^* \to f\bar{f}$ vs. $e^+e^- \to e^+e^-f\bar{f}$.



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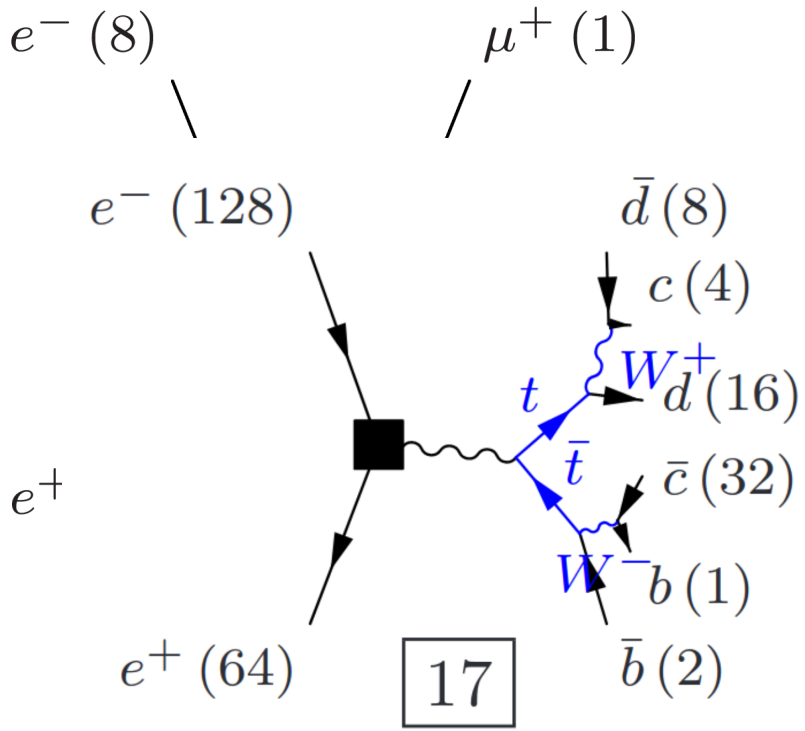

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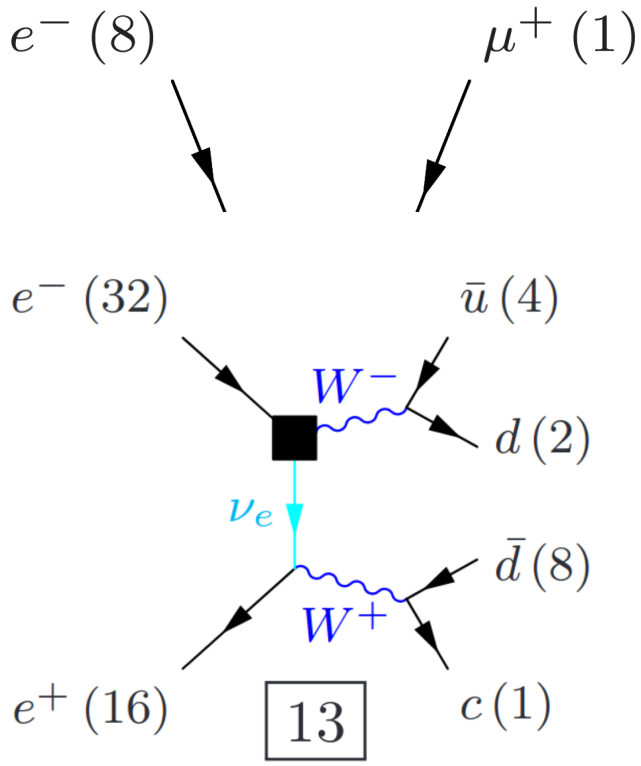

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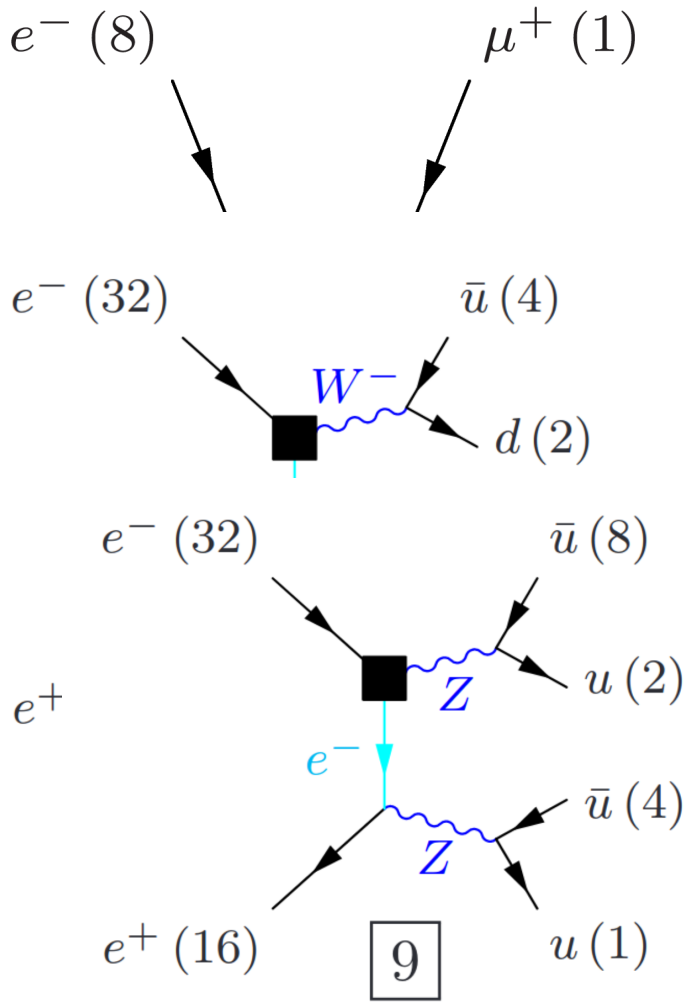

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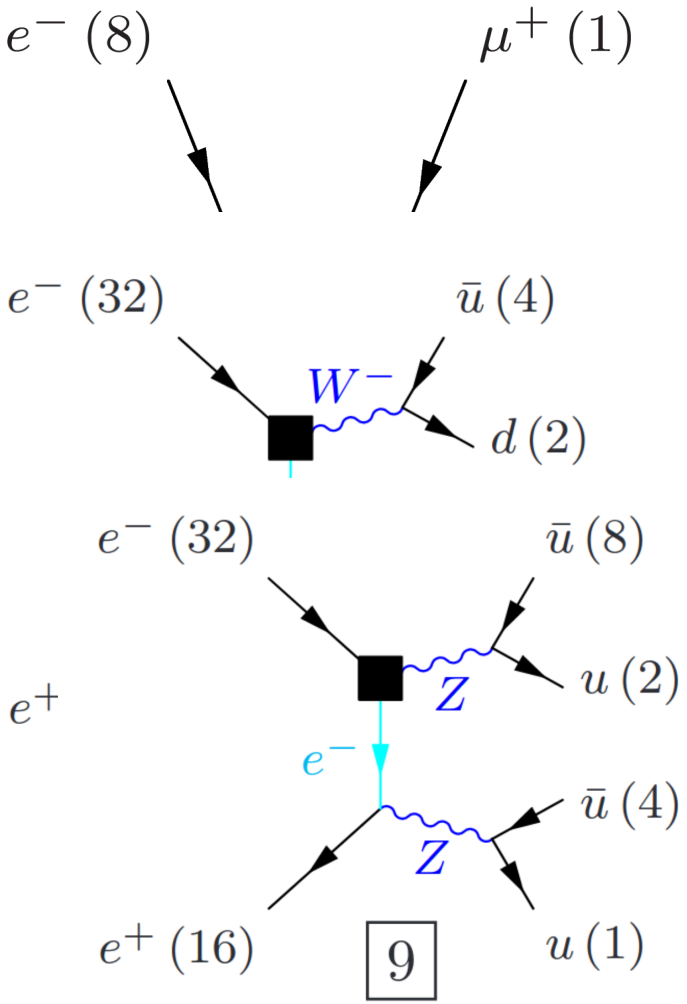

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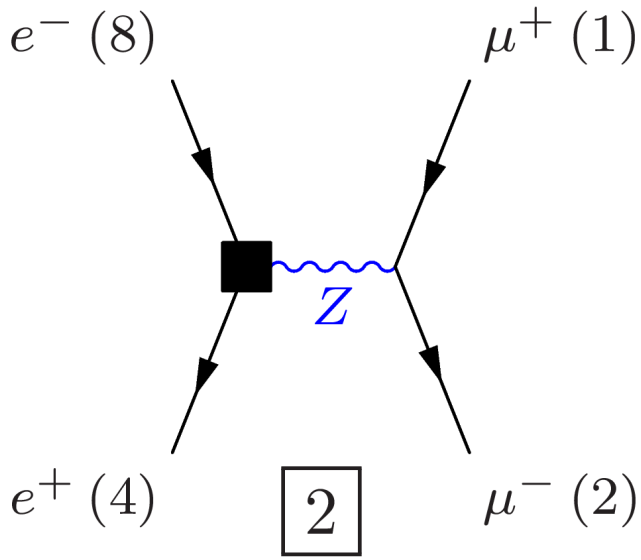

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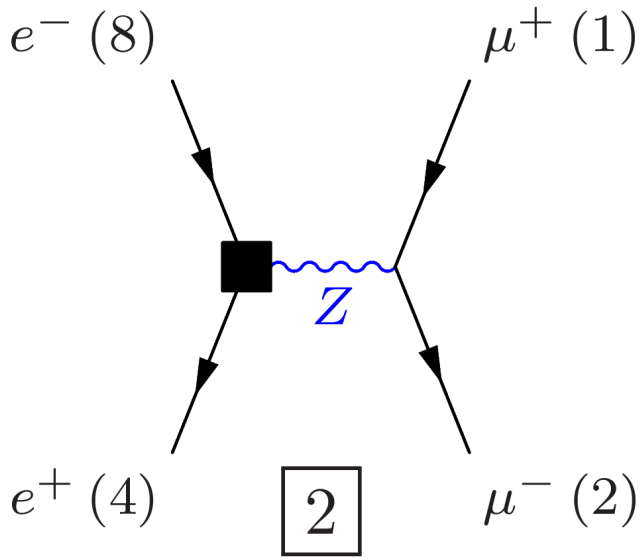

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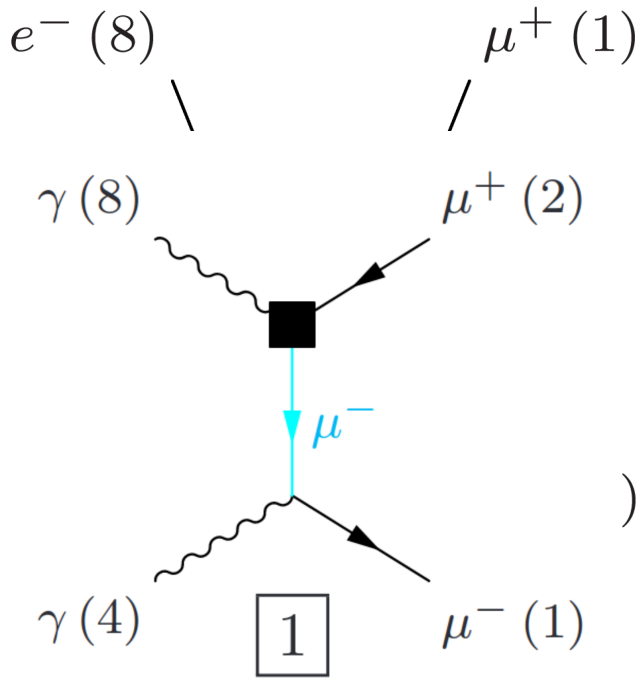

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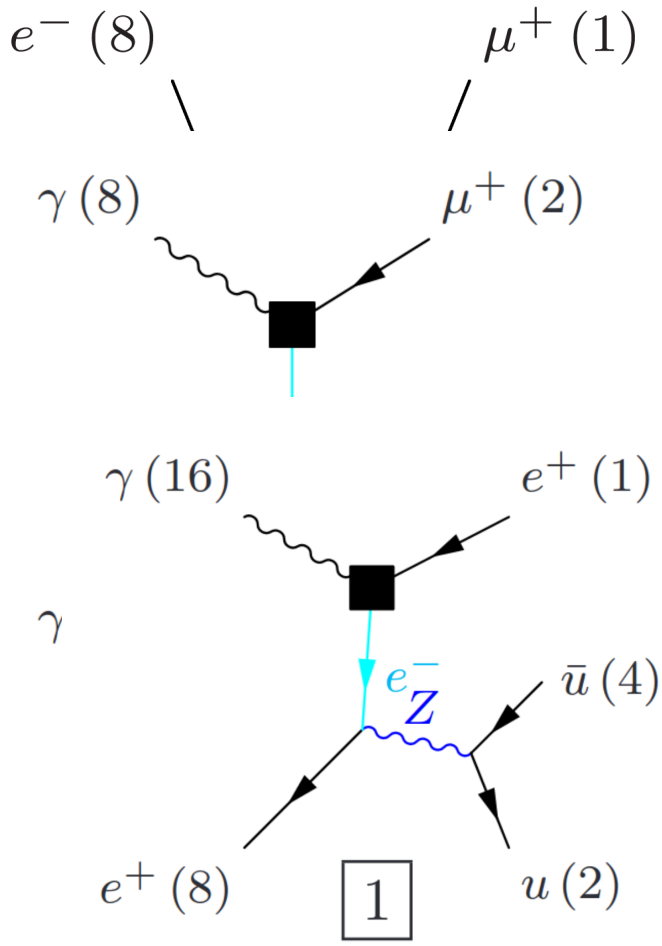

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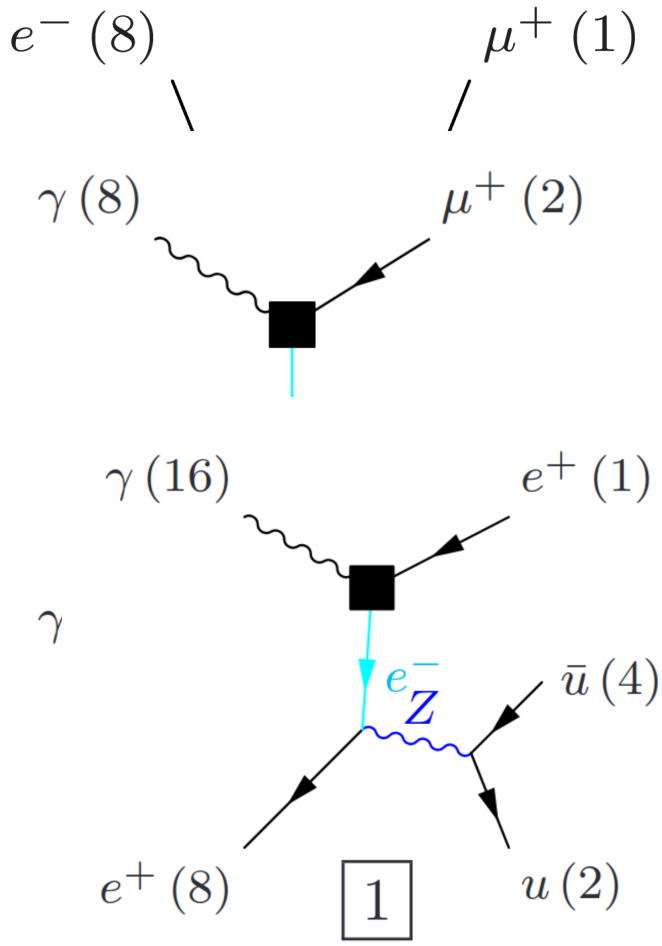

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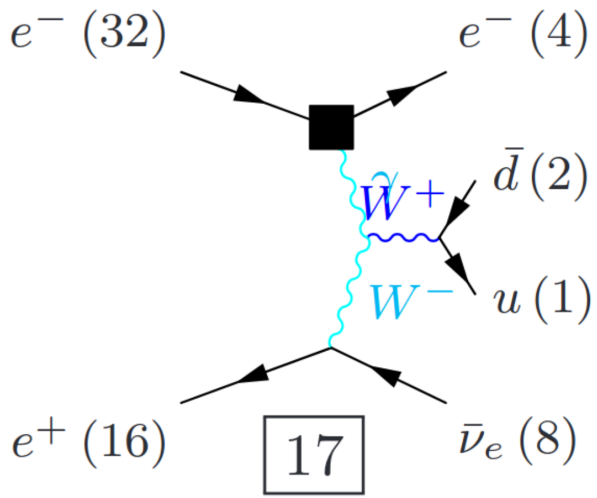

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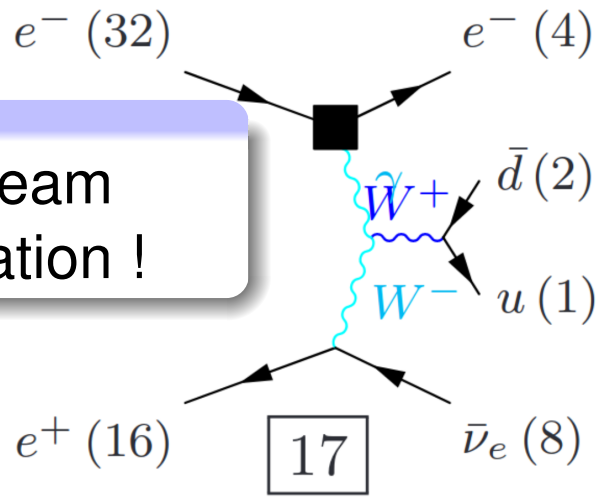
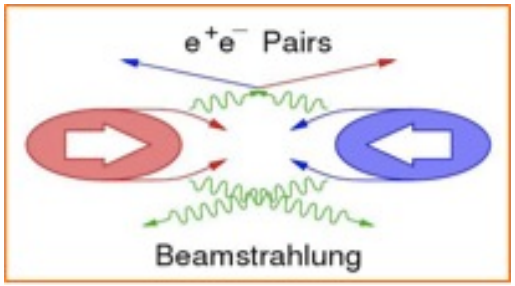


Beam effects

- Beam-spectrum.
  1. Incoming beam-spread
  2. But also: very strongly focused beams $\Rightarrow$ Beam-beam interactions
- Photons
  1. How many photons?
  2. Are they virtual or real?
- Need beam-beam interaction simulation input.



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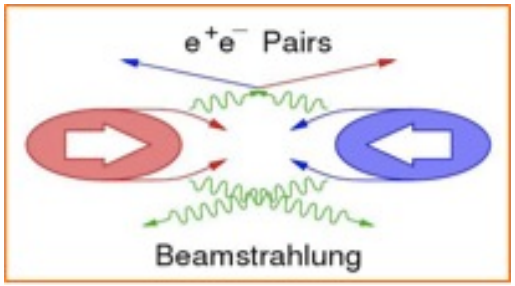

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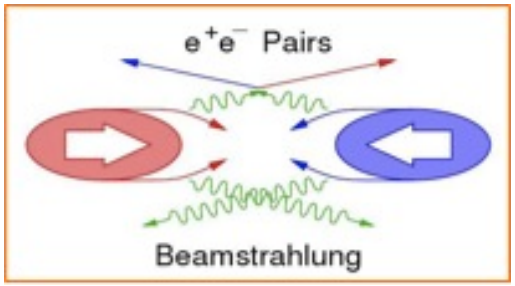

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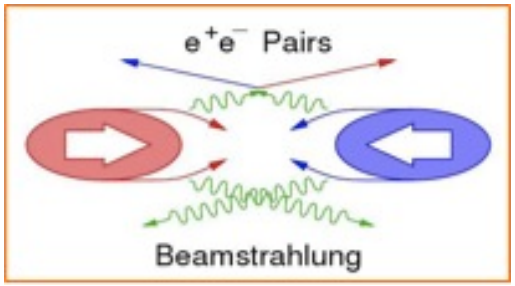
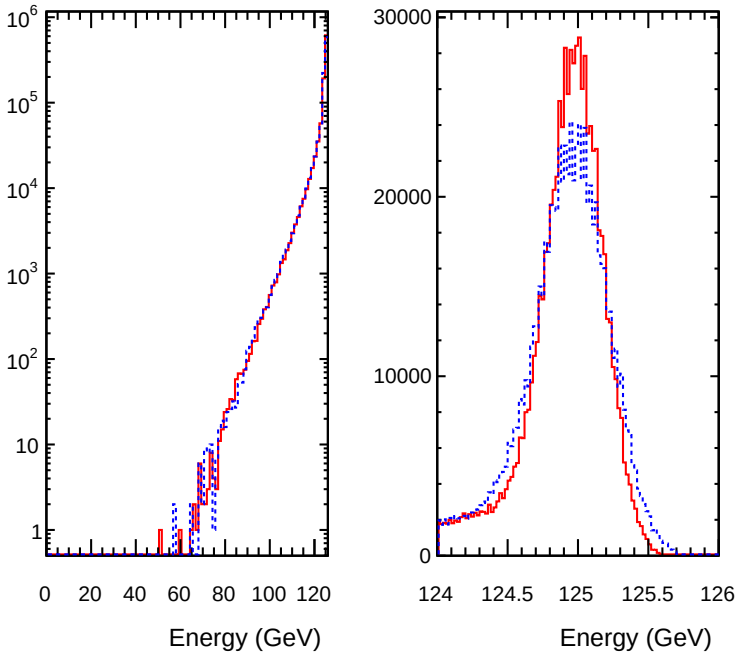
- Simulate interaction region: GuineaPig [CERN-PS-99-014-LP]. Gives:
  - Beam-spectrum for electrons and positrons independently
    - Actual simulation: CIRCE 2 (part of WHIZARD)
    - Use GUINEAPIG output to "automatically" create an MC-generator of the beam-spectrum. But: need quite some expertise to get good fidelity ...
  - Amount and spectrum of real photons
  - Distribution of interaction point





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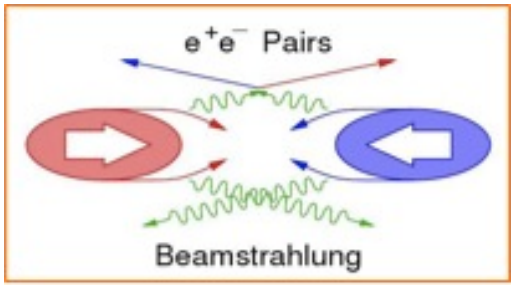

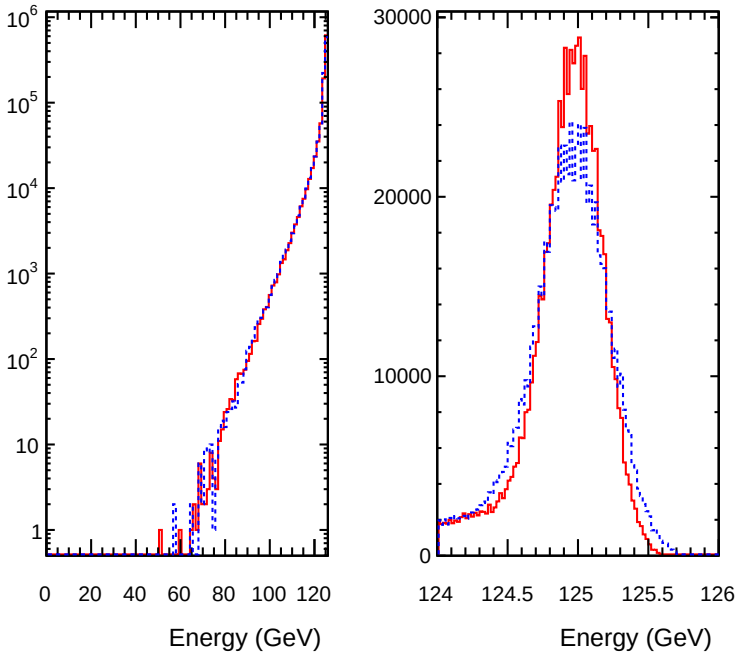

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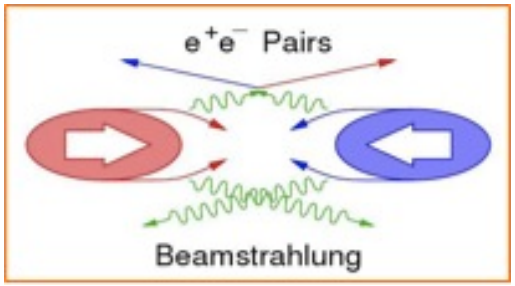

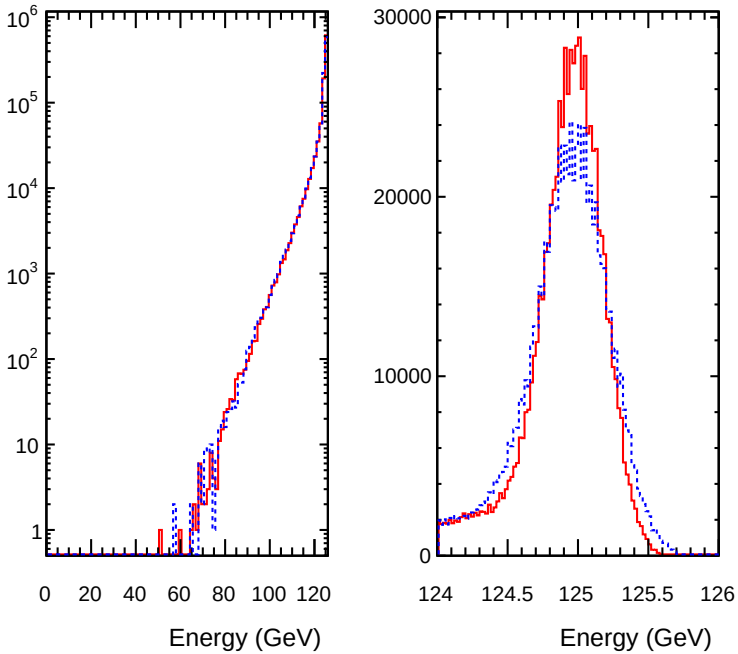

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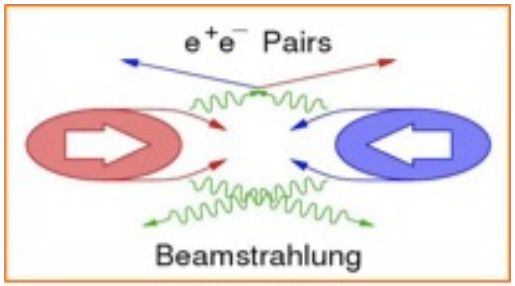

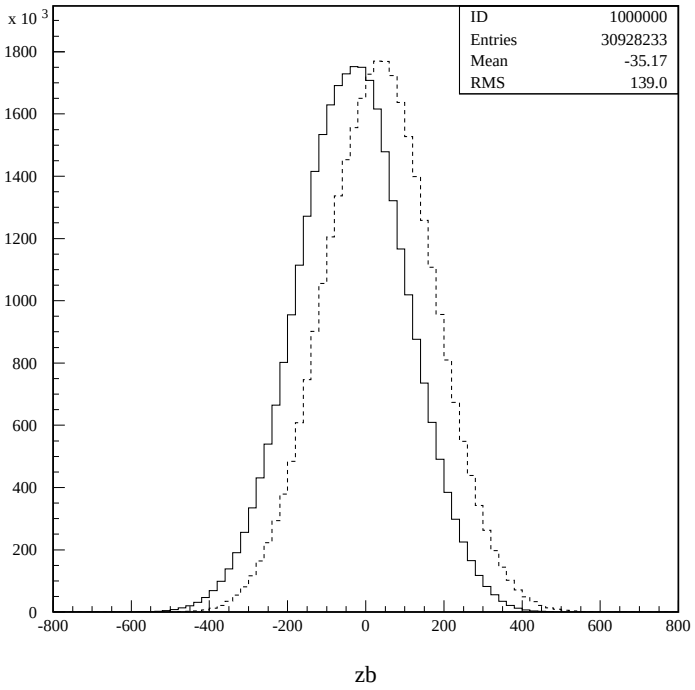

Spurious interactions ("pile-up")

Two types:

- Pair-background: Pair-creation of photons in the beam by the strong fields. GuineaPig can generate the full activity during a beam-crossing (a "BX").
- low-$p_\perp$ hadrons, ie. $\gamma^{(*)}\gamma^{(*)}$ interaction with small $M_{\gamma\gamma}$ and multiplicity. NB: only $\mathcal{O}(1)$/BX !
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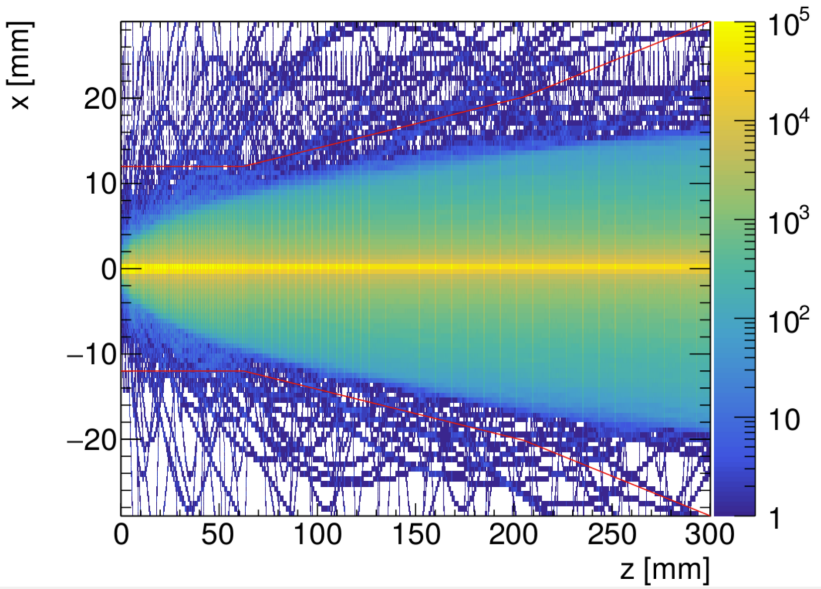
  - Below: fit to data - Custom generator developed by LCGG.



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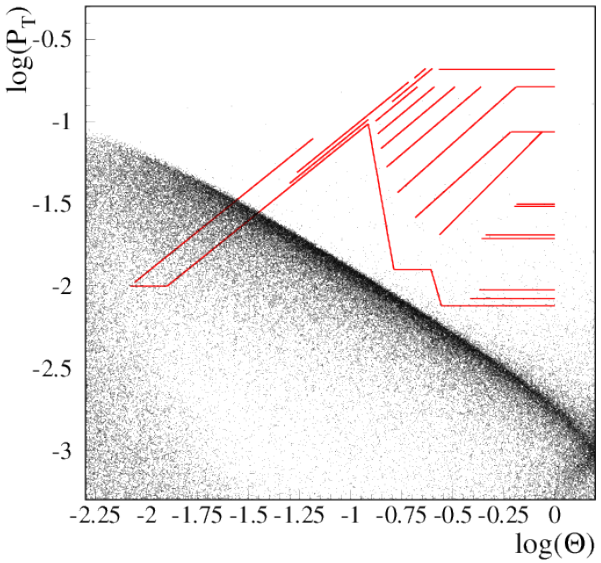

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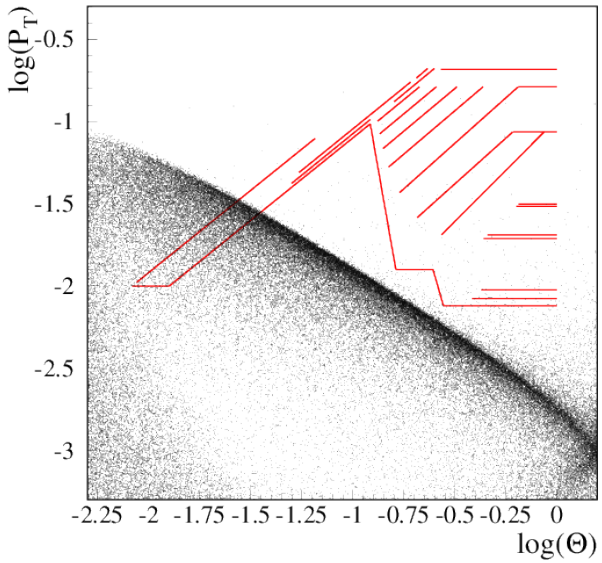
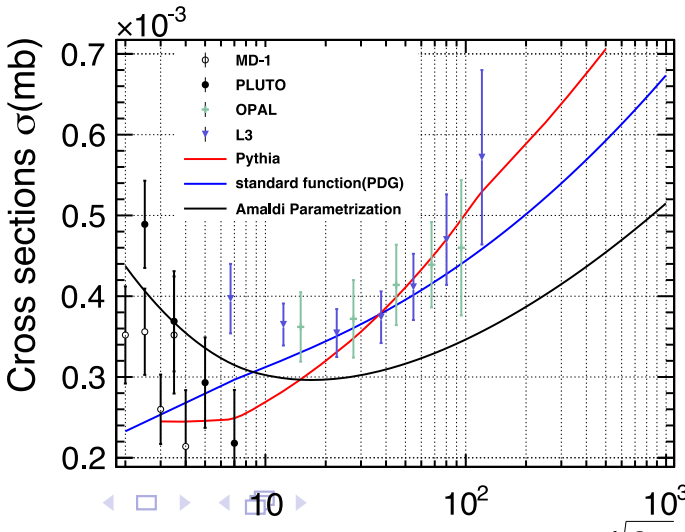
- Pair-background: Pair-creation of photons in the beam by the strong fields. GuineaPig can generate the full activity during a beam-crossing (a "BX").
- low-$p_\perp$ hadrons, ie. $\gamma^{(*)}\gamma^{(*)}$ interaction with small $M_{\gamma\gamma}$ and multiplicity. NB: only $\mathcal{O}(1)$/BX !
  - ME can't do this, and PYTHIA is good down to $M_{\gamma\gamma} \sim 2$ GeV.
  - Below: fit to data - Custom generator developed by LCGG.





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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.
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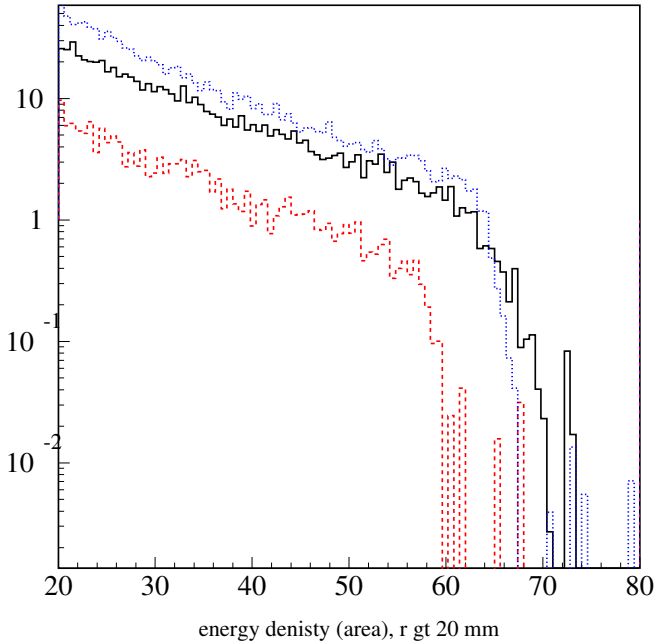
BeamCal hits

- Also, use some ($\mathcal{O}(100)$) BXes to simulate pairs hitting the BeamCal,
- Compare different beam parameters and energies.
- Build a map of the background, to be used in the BeamCal simulation.



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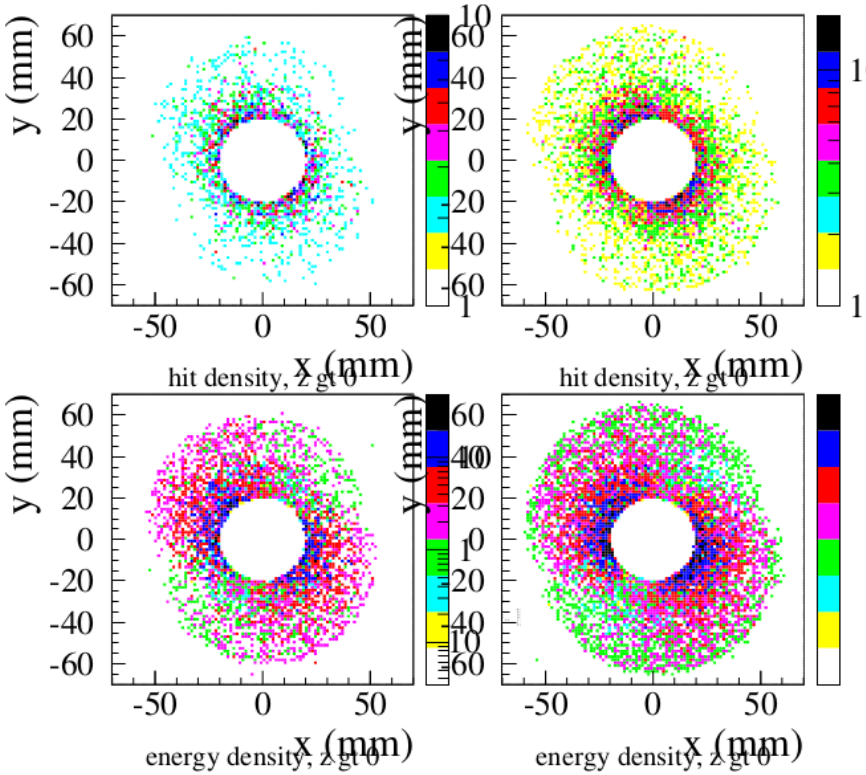

Conclusion – Summary of steps to simulate ILC beam conditions

Beam-conditions etc:

- Beam background with GuineaPig, 100000 BXes
  - Pair background
    - Need to create files with real tracks
    - One event with 1 BX
    - SGV is used to do this.
  - Beam-spectrum and Circe2 parametrisation.
  - Beam-spot size and position.
  - Input for BeamCal background maps.
- aa_lowpt for “pile-up”
  - Events to overlay.
  - Average number per BX evaluated.