Luminosity Spectra for Lepton Colliders

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1st ECFA Workshop on e^+e^- Higgs/Electroweak/Top Factories

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  - energy spread
    - perturbative ISR
    - nonperturbative beam interactions

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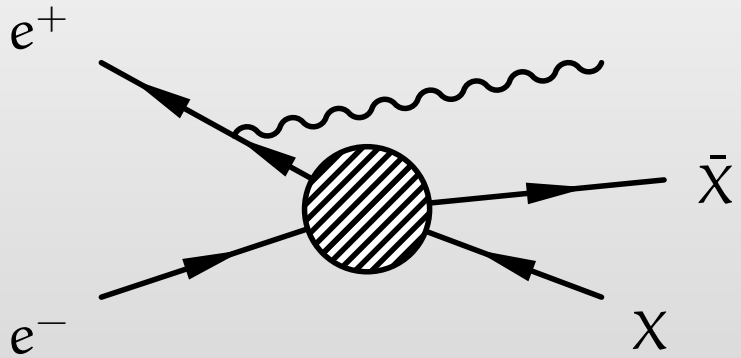

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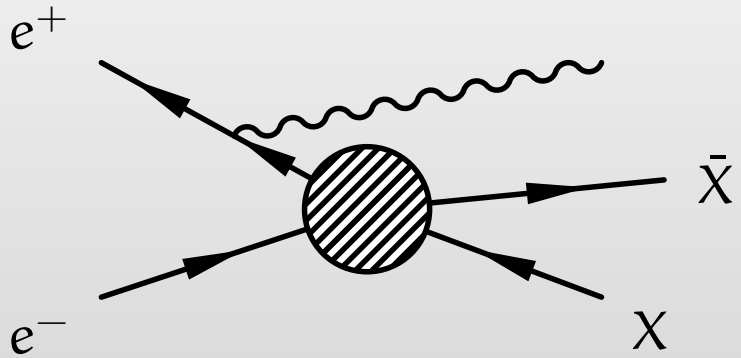

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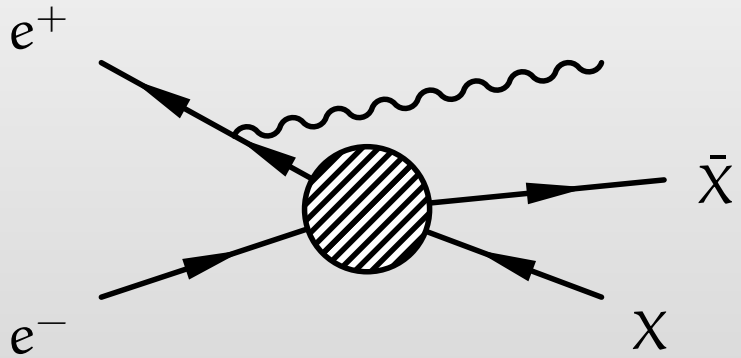

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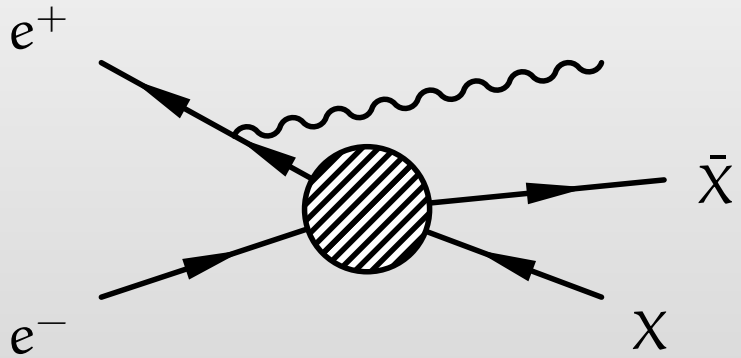

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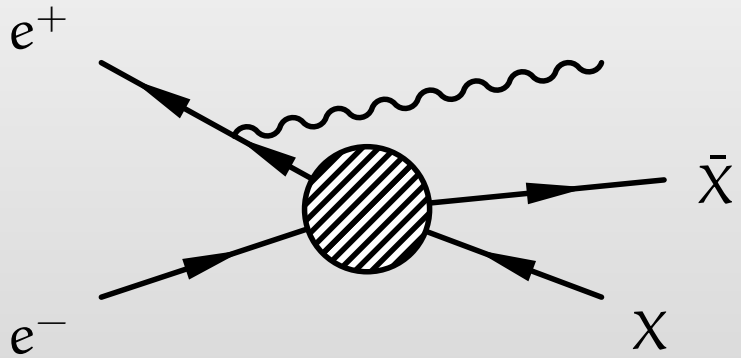

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- $\therefore$ can and must be handled by the event generators for the hard "partonic" scattering process

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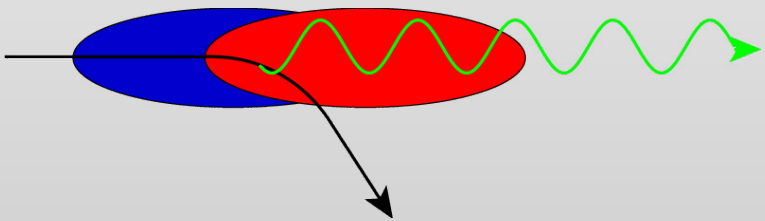

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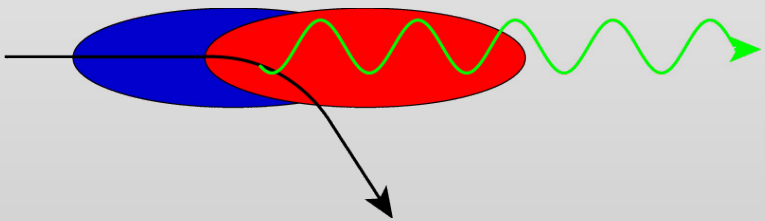

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- ab-initio description of beamstrahlung outside of the scope of event generators for the hard "partonic" process
  - ∵ depends on bunch shapes and beam optics
  - ∵ completely independent of the hard partonic process

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  - not just gaussian energy spreads

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- need "blessed" (x_1, x_2) samples for different designs

beam-beam simulations must undergo
quality control from accelerator physicists

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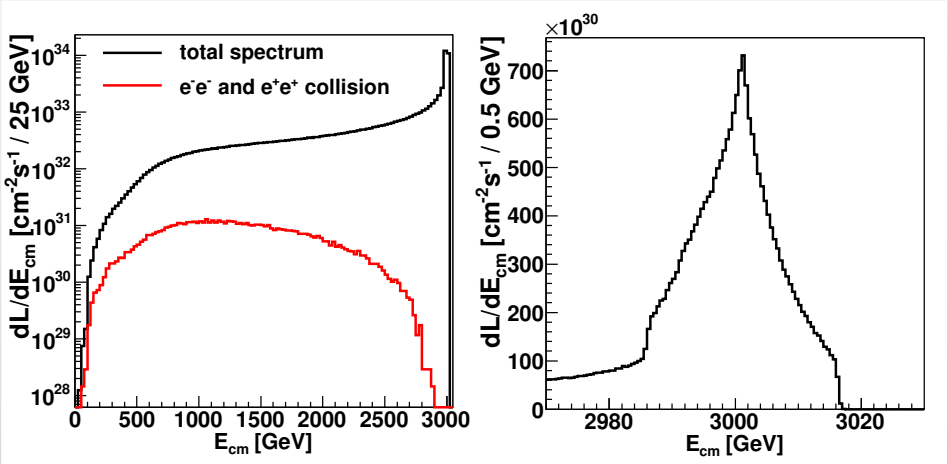
- Factorized 6-parameter ansatz (where $p_i \in \{e^\pm, \gamma\}$)

$$D_{p_1 p_2}(x_1, x_2) = d_{p_1}(x_1) d_{p_2}(x_2)$$

with δ-peaks for unaffected electrons/positrons and β-distributions for the integrable singularities at $x \to 1$ and $x \to 0$, as suggested by theory

$$d_{e^\pm}(x) = a_0 \delta(1-x) + a_1 x^{a_2} (1-x)^{a_3}$$
$$d_\gamma(x) = a_4 x^{a_5} (1-x)^{a_6}$$

- while the low energy tail can still be described by power laws, the peak looks much more complicated at CLIC (wakefields &c):



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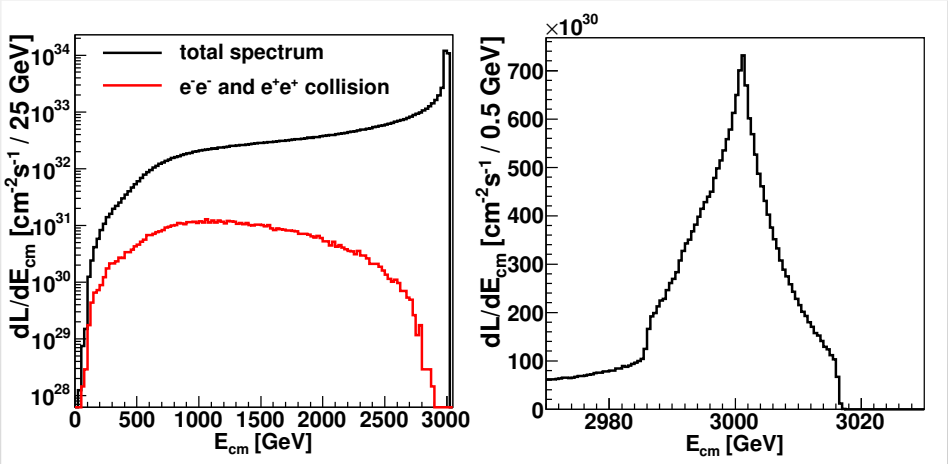

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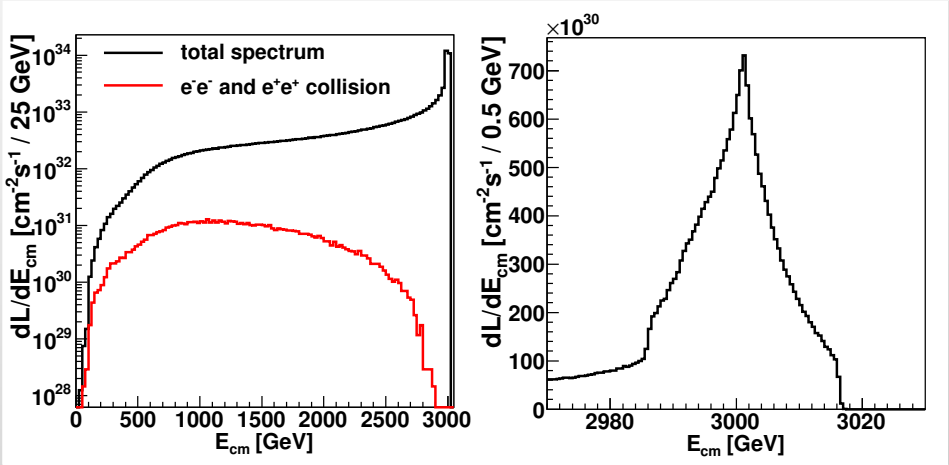

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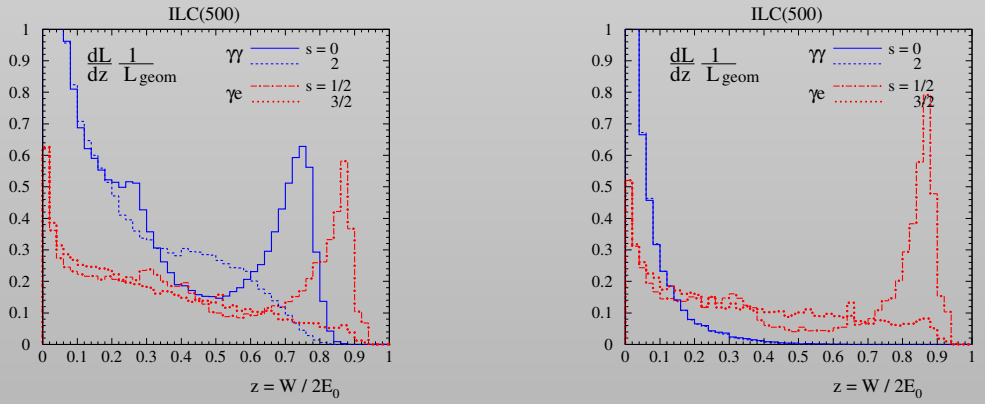
- NB: even worse for $\gamma\gamma$ and $e^-\gamma$ collisions at a photon collider



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- hybric approach KKMCee [Arbuzov, Jadach, Was, Ward, Yost, 2021]
  - gaussion beam energy spread
  - adapted (x_1, x_2) grid using FOAM [Jadach, 2000ff]

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  - ∵ limited statistics from CAIN or Guinea-Pig
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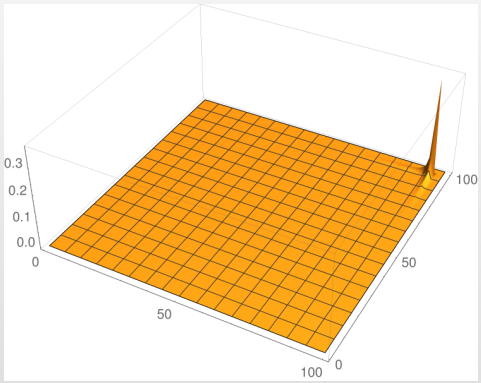

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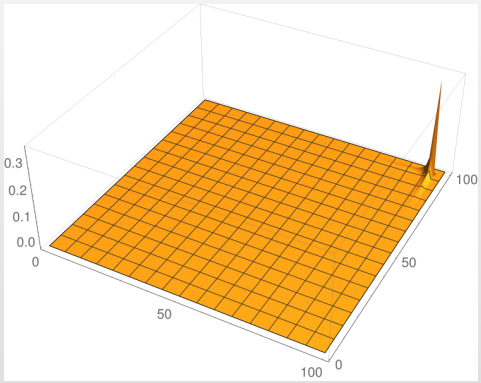

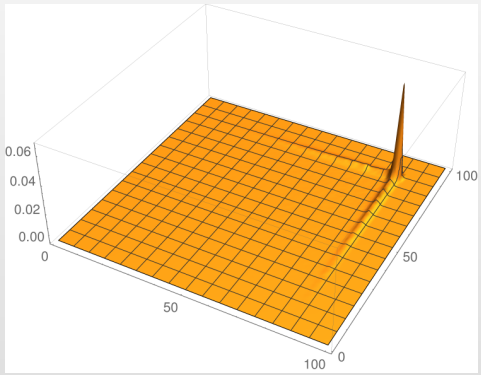

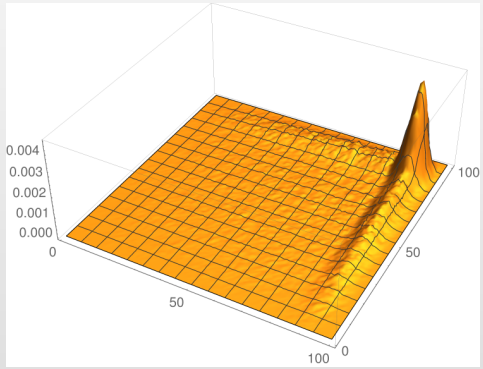

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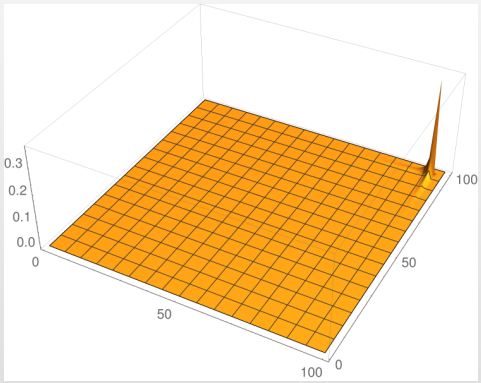

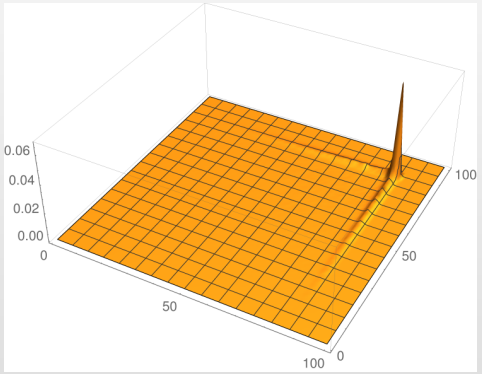

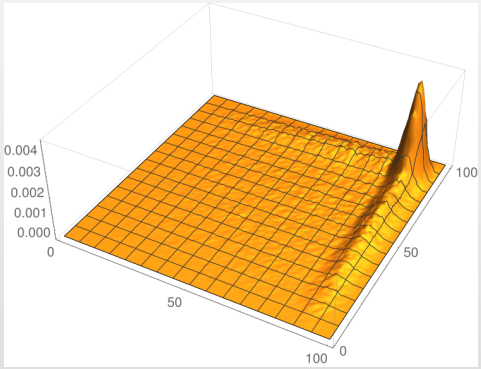

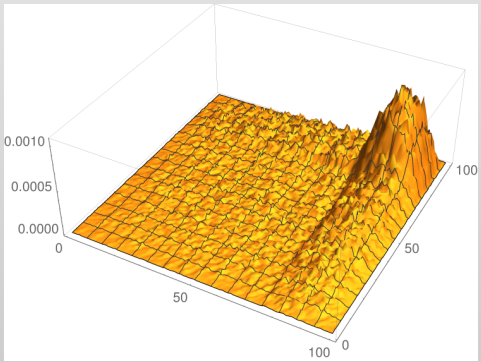

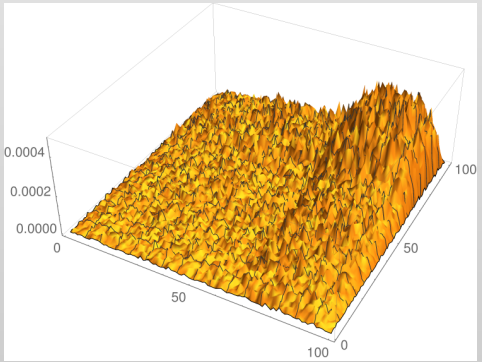

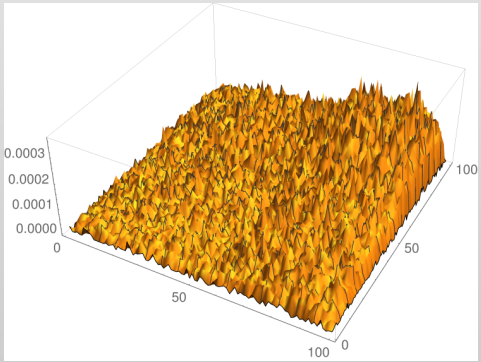

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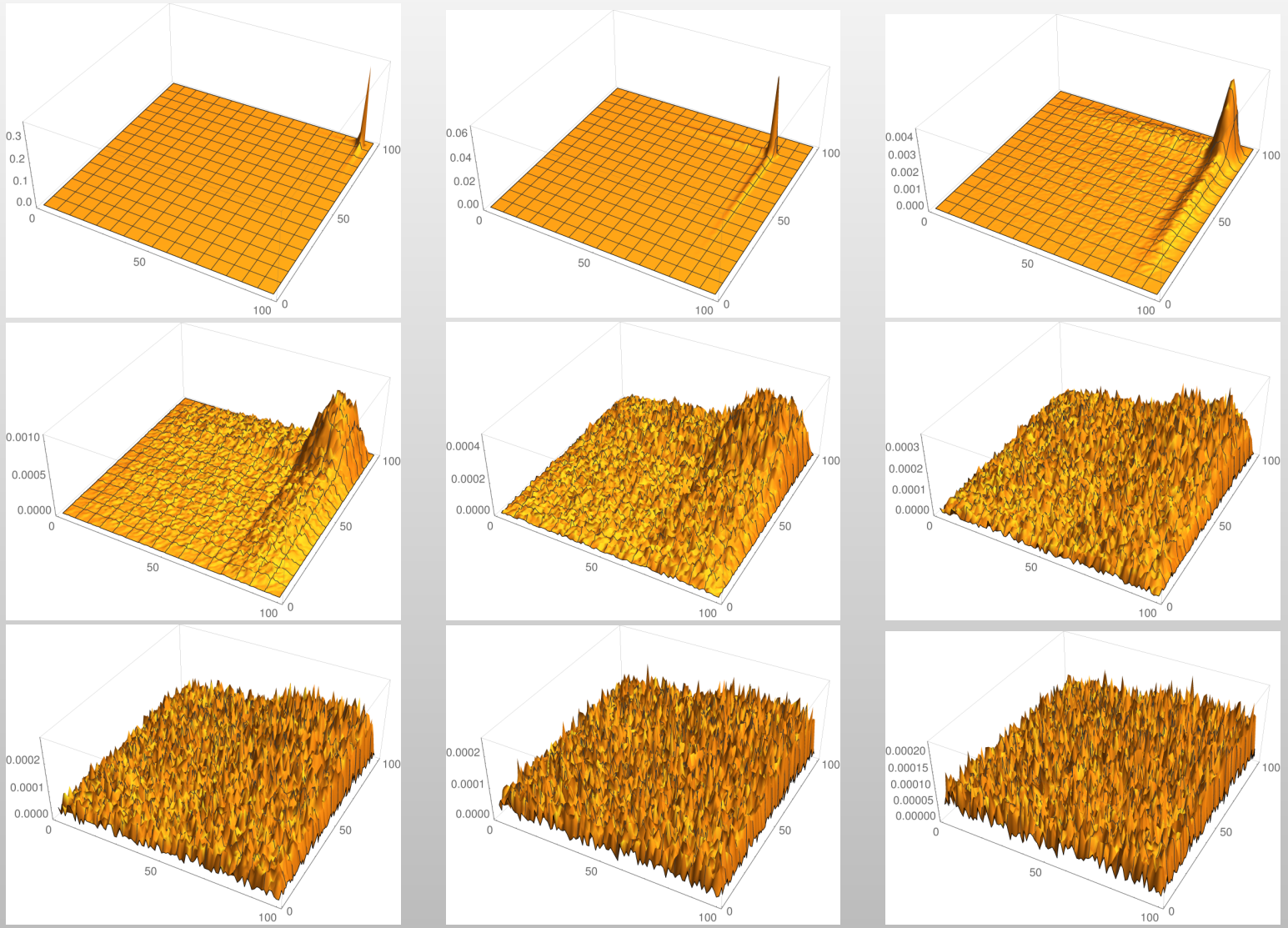
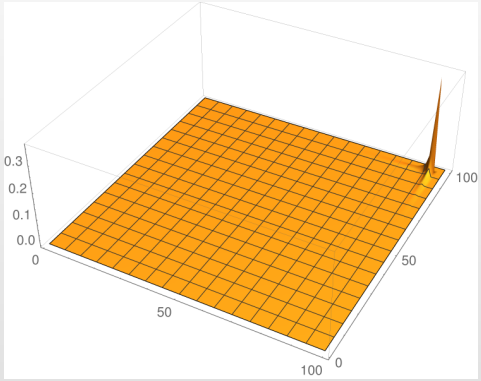
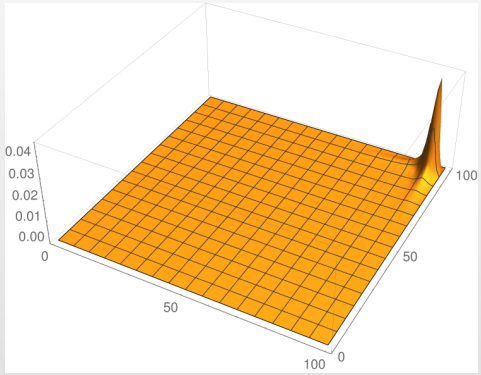
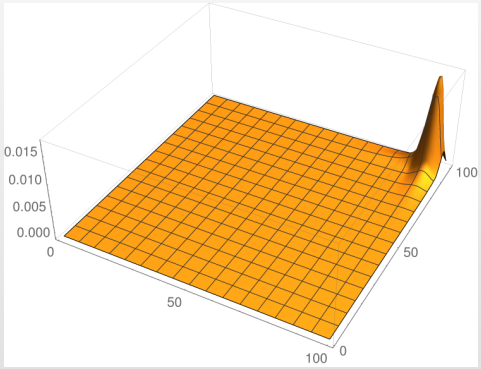


(171.306 Guinea-Pig events in 10.000 bins)

- `iterations` $= 0$ and `smooth` $= 0, 3, 5$:







CIRCE2: Gaussian Smearing of Histograms

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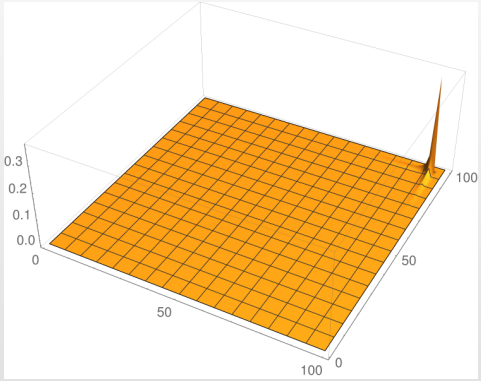
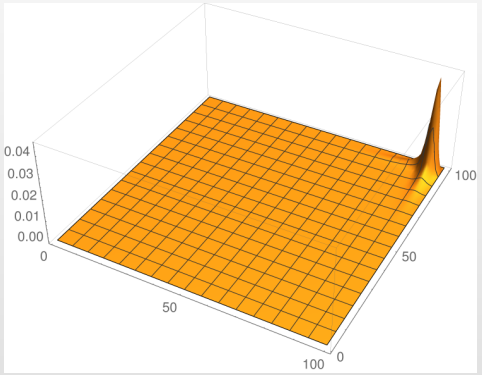
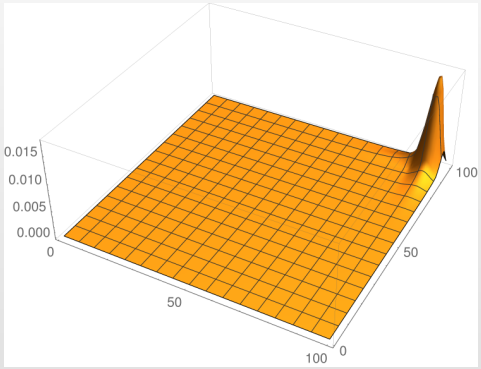
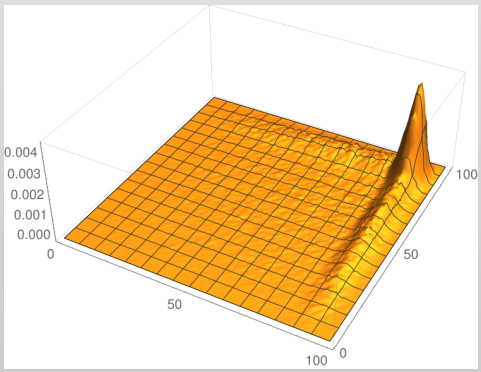
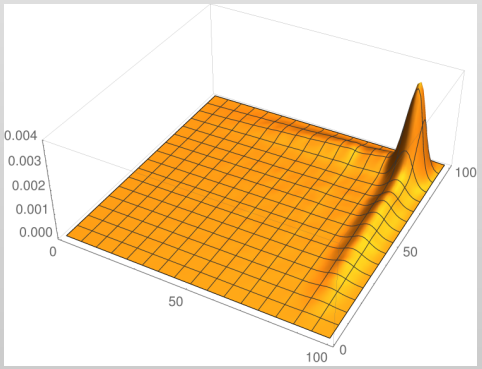


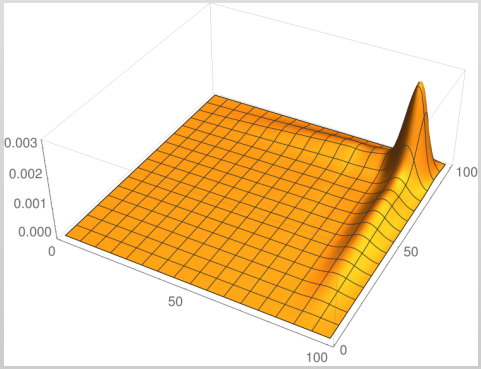




- `iterations` $= 2$ and `smooth` $= 0, 3, 5$:







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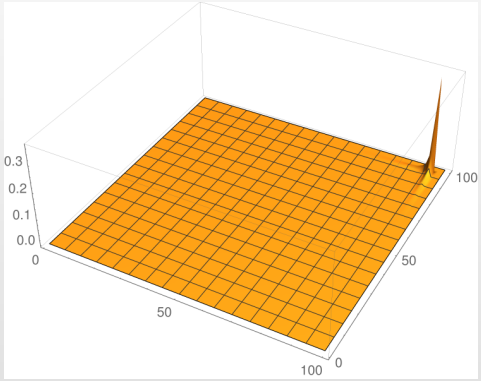
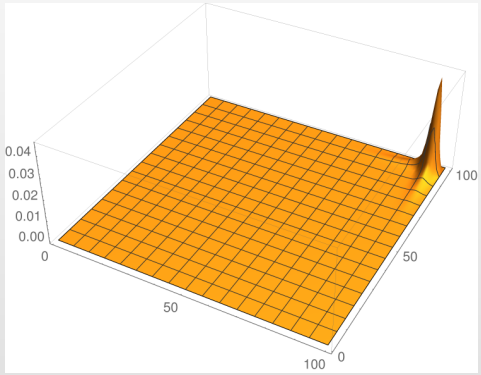
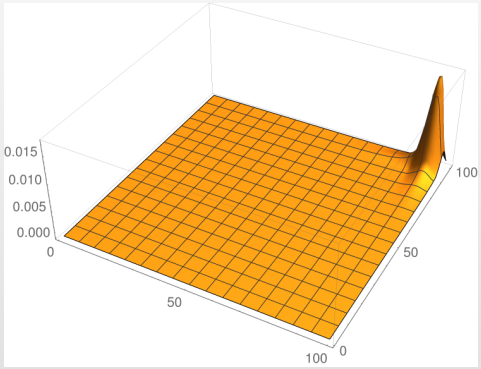

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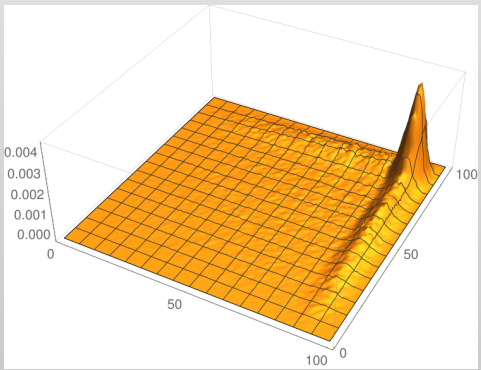
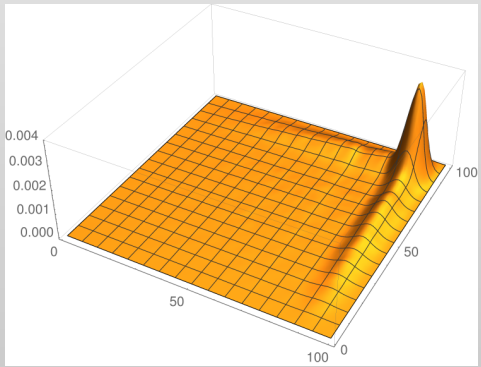
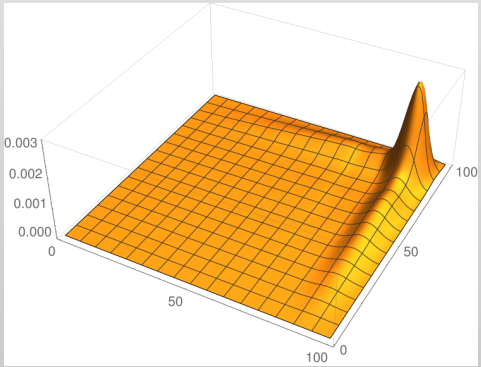

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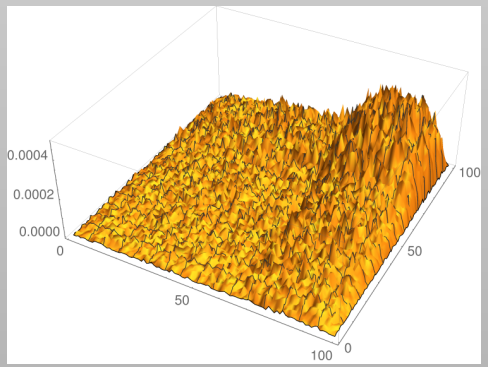
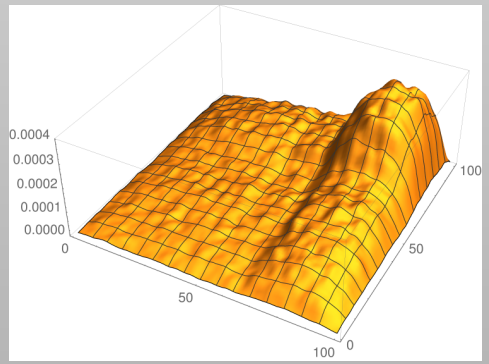
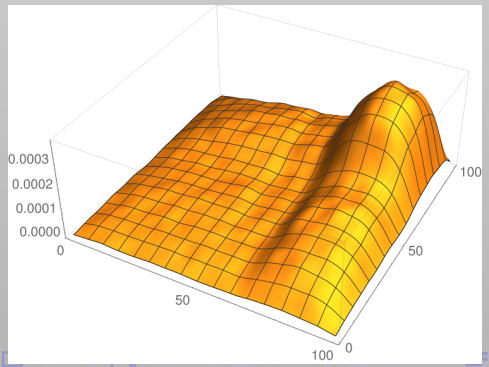

Things to Come

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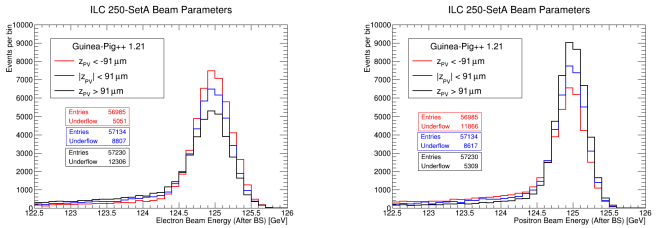

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Thus both $\sqrt{s}$ and $p_z = E_- - E_+$ distributions depend on z. Likely needs to be taken into account for $\sqrt{s}$, $dL/d\sqrt{s}$, Higgs recoil, kinematic fits ...

Graham W. Wilson (University of Kansas) ILCX2021 Workshop October 27, 2021 31 / 36

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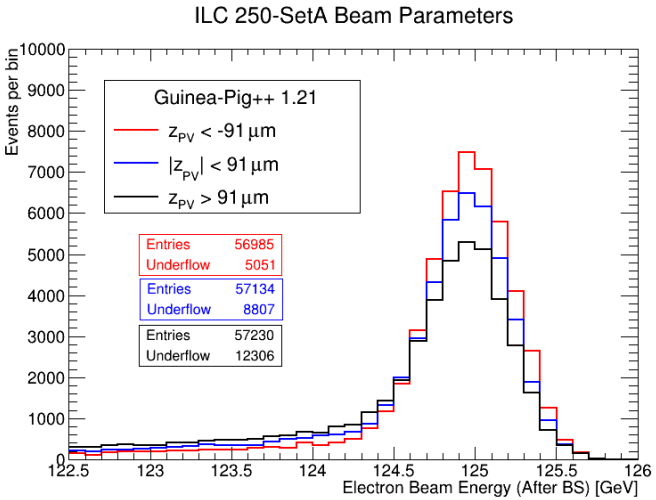

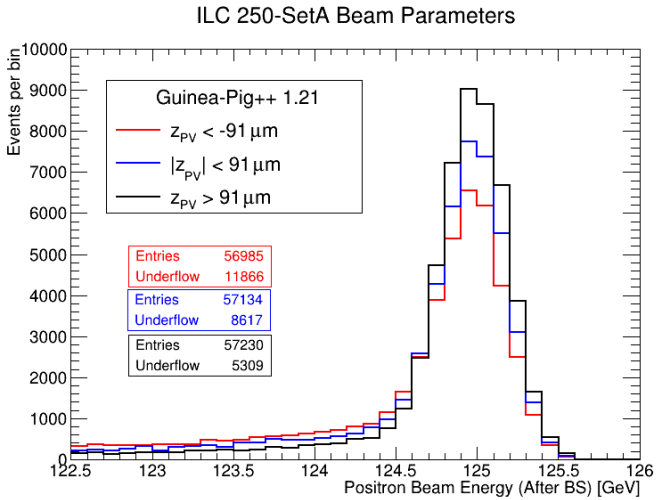

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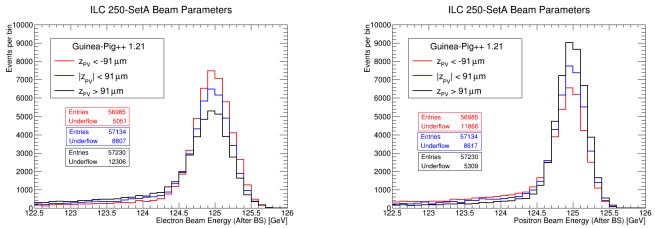

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- NB: transversal dependence also expected due to the particle density profile, but transversal position will probably not be resolved

Graham Wilson: Beam Spectrum - z_{vertex} Correlations

Of import to MDI and physics studies generally

- Vertex z measured with μm precision in $\mu^+\mu^-$ events
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- New handle to understand beamstrahlung/luminosity spectrum

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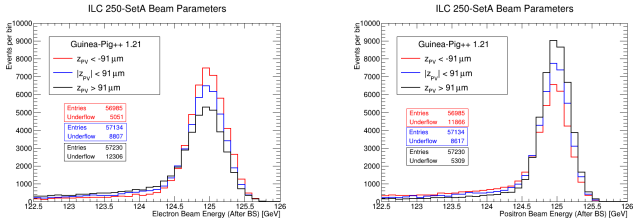

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Graham W. Wilson (University of Kansas) ILCX2021 Workshop October 27, 2021 31 / 36

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Graham Wilson EW Summary, ILCX2021 October 28, 2021 9 / 9

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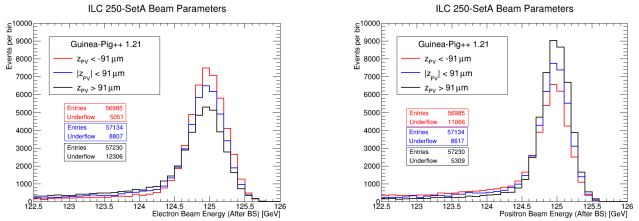

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Graham Wilson | EW Summary, ILCX2021 | October 28, 2021 | 9 / 9

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