# Luminosity Spectra (Updates)

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Second ECFA Workshop on $e^+e^-$ Higgs/EW/Top Factories

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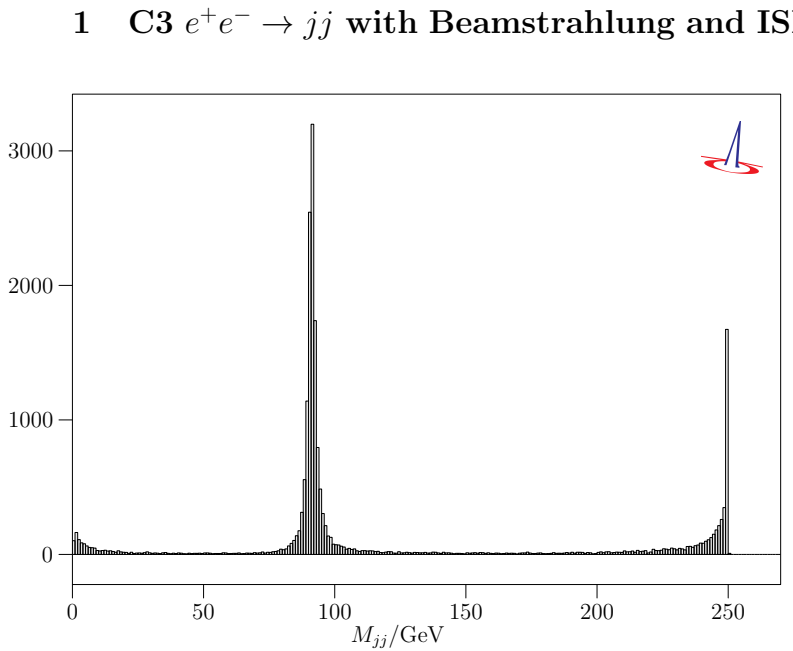
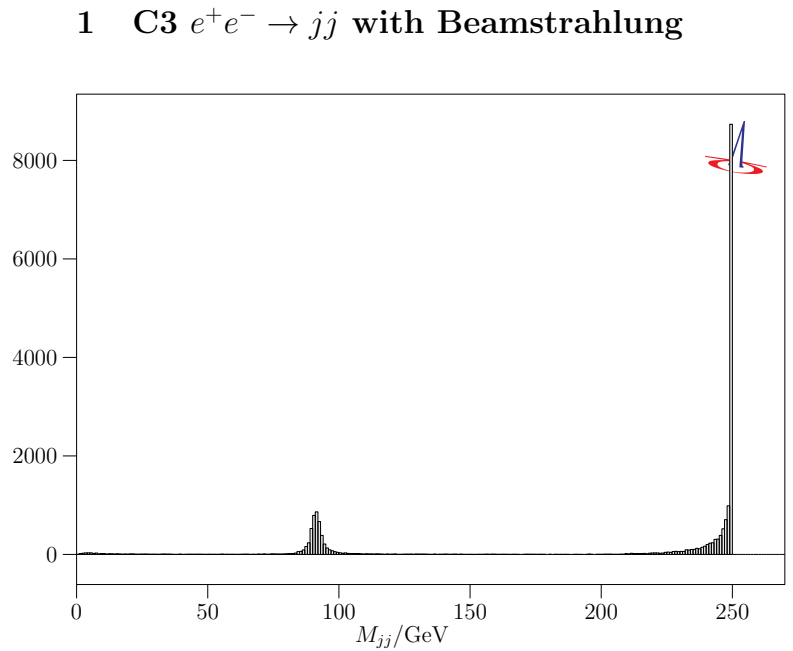
Lindsey Gray and Elias Metter did everything by the book

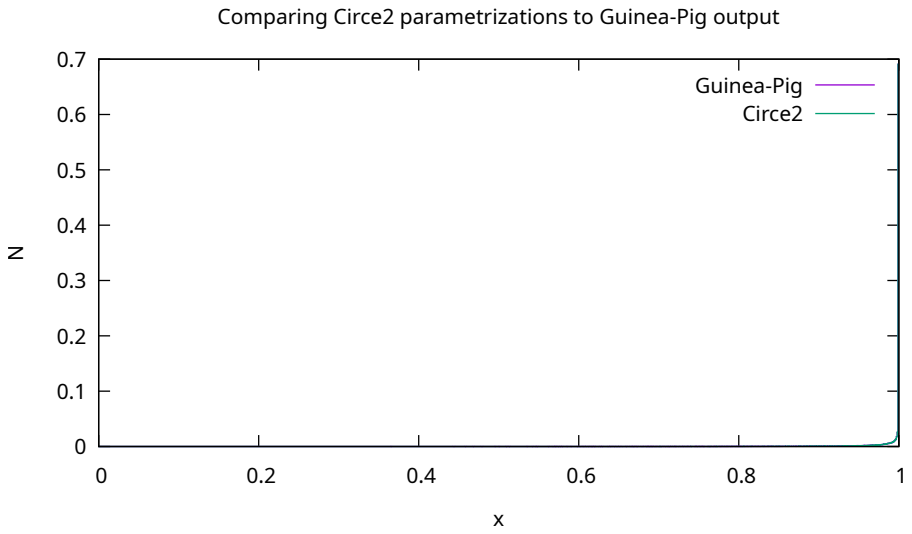
- simulate the beam beam interaction with Guinea-Pig
- parametrize the result with Circe2
- use the result with Whizard to simulate $e^+e^- \to \mathrm{jj}$ at $\sqrt{s} = 250\,\mathrm{Gev}$

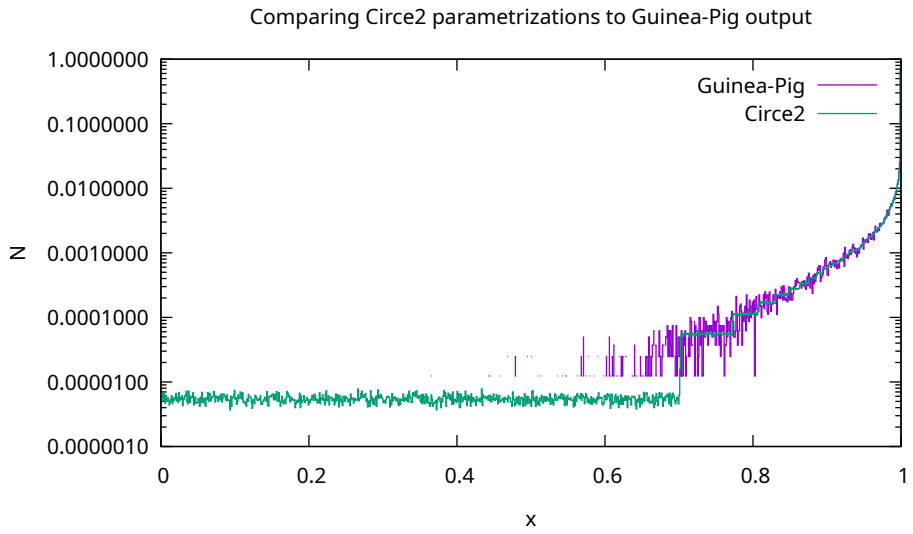


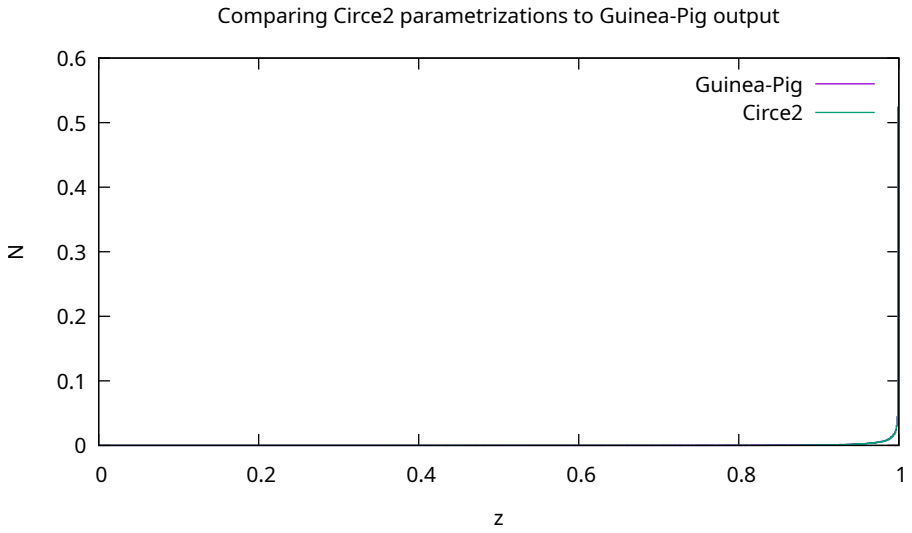



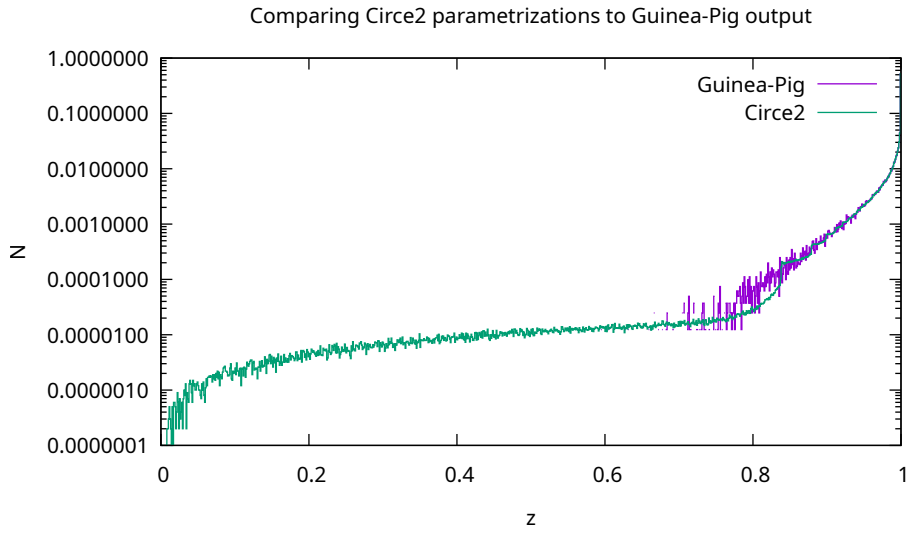

- the radiative return with ISR makes sense
- the sizable $Z$ peak without ISR does not!

- compare Circe2 parametrization to 80 000 $e^+e^-$ pairs from Guinea-Pig
- NB: $z = \sqrt{x_1 x_2}$ and $M_Z/\sqrt{s} \approx 0.37$



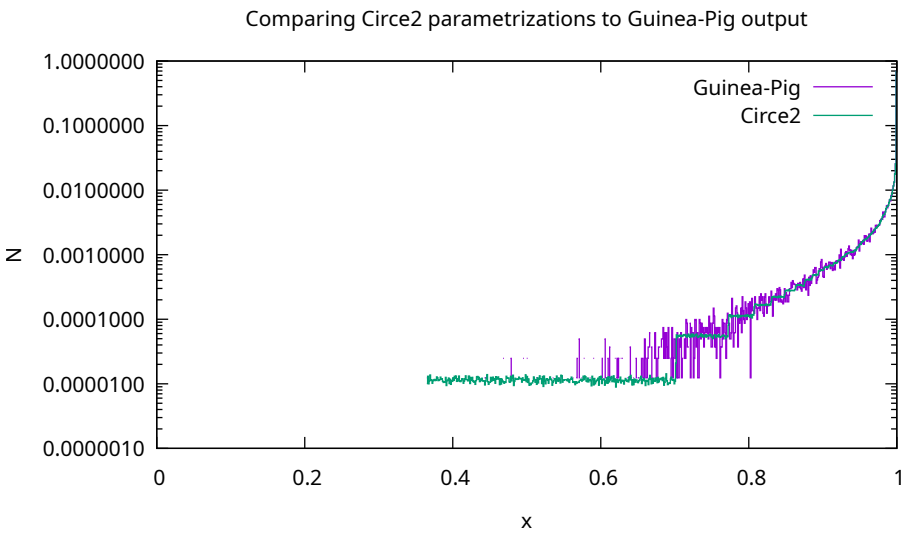



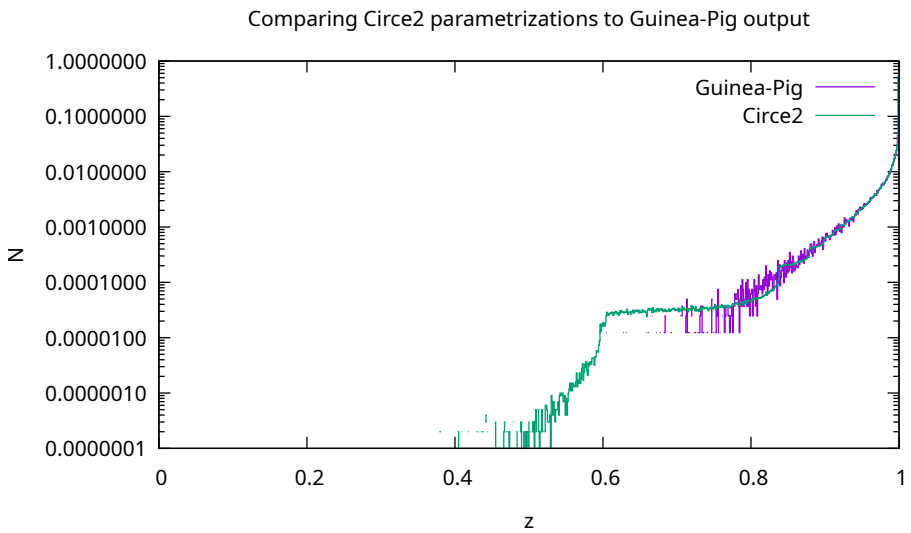
- we can to better by not fixing the lower boundary at 0, ie. replacing

  `min = 0 max = 1 fix = *`

  by

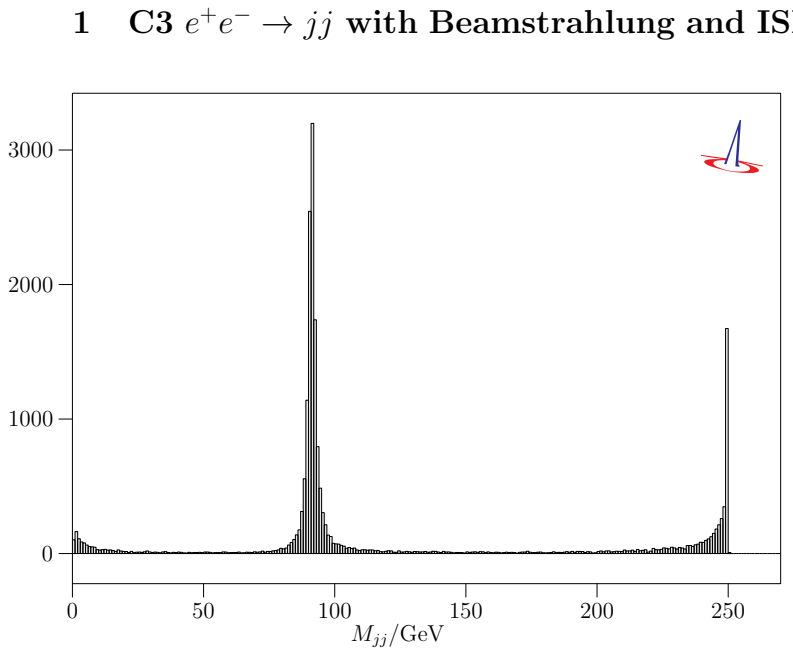
  `min = 0 max = 1 fix = max`

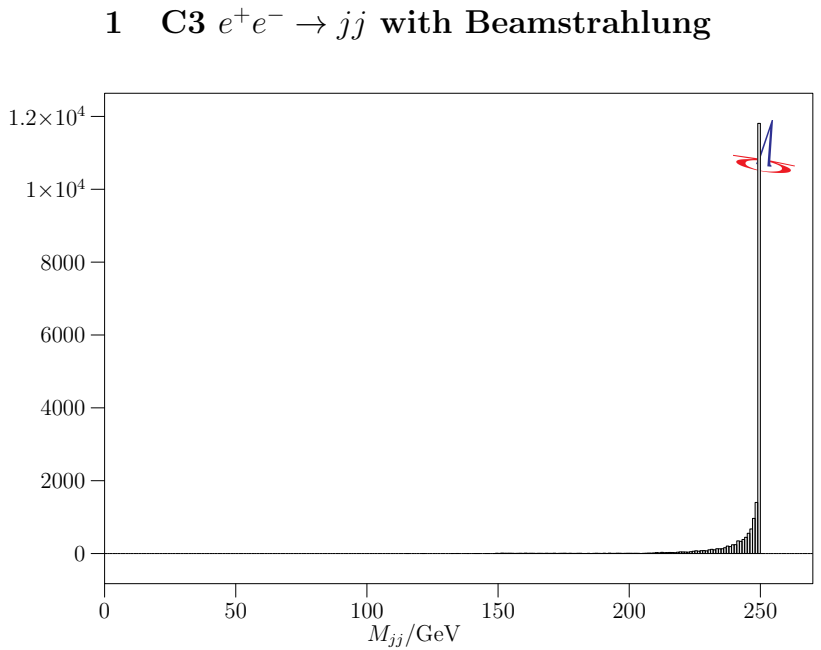



- nevertheless, a single Guinea-Pig event with very low $x_{1,2}$ will still produce a tail, even though . . .

- . . . it no longer stands out in the Whizard results



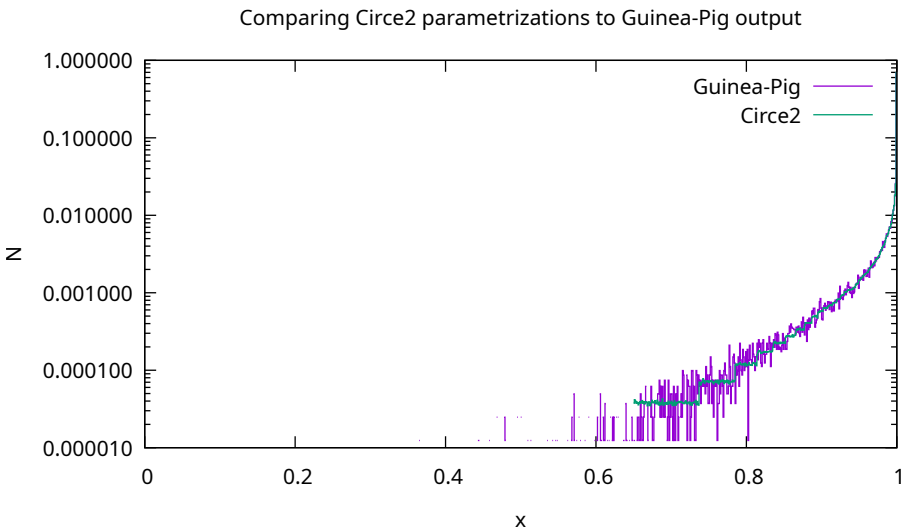



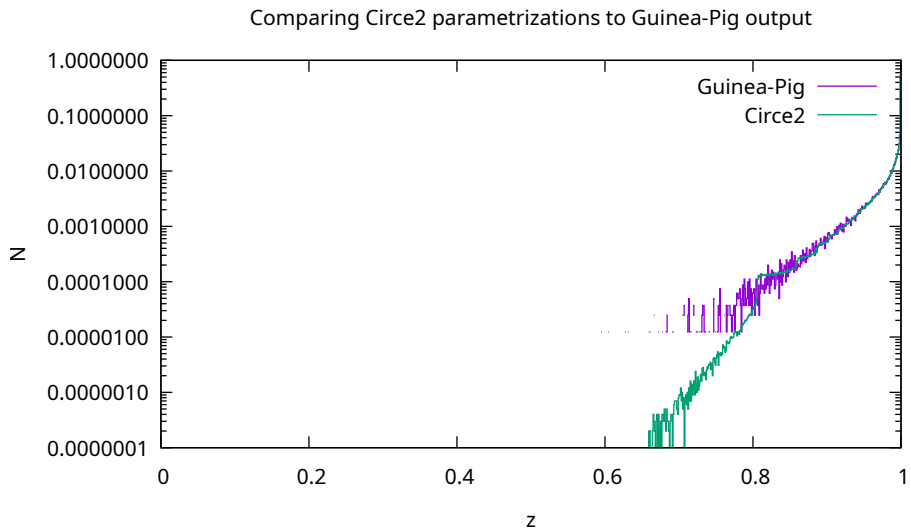

- nevertheless, there remains an unphysical tail
- not visible in the plot and overshadowed by ISR
- NB: the highest energy bin is 7 times higher w/o ISR!

- new Circe2 feature “null maps” that force the distribution to vanish in a given range
- eg.

  ```
  map = null { 1 [0, 0.65] }
  ```

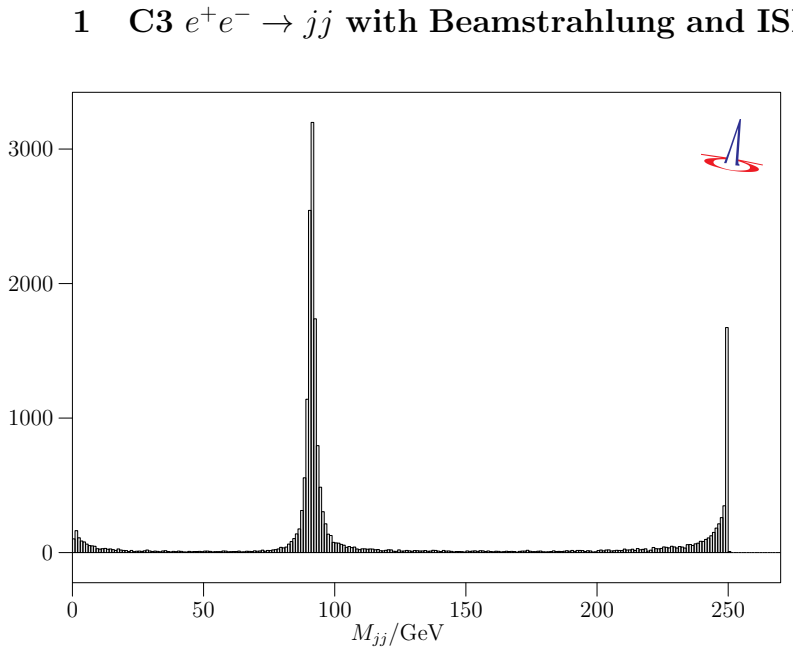
  adds a single bin ranging from 0 to 0.65 in which the distribution always vanishes
- implemented to play nice with the adaption and smoothing of the grid

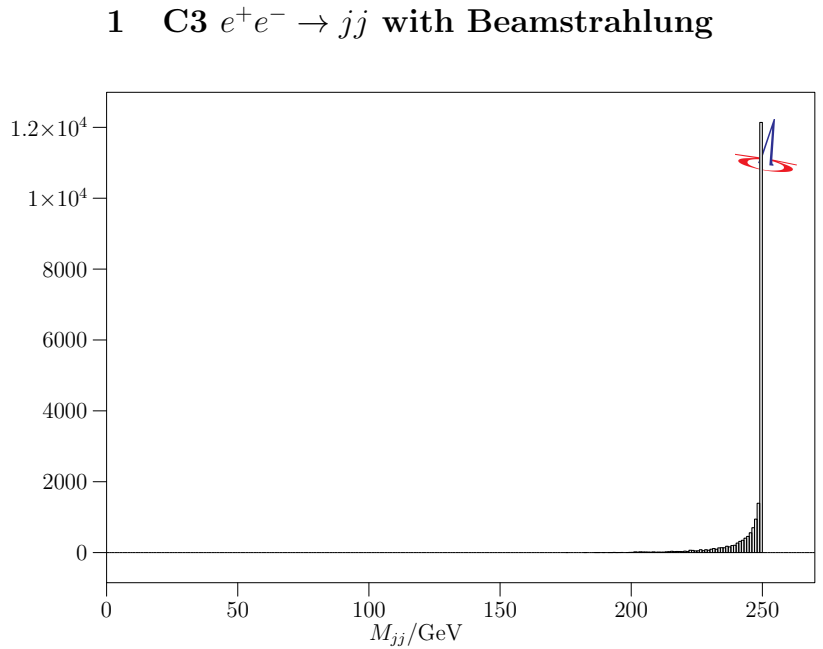



- publicly available since last Friday with Whizard 3.1.3

- now the simulation of $e^+e^- \to \mathrm{jj}$ gives correct results




- *moral of the story*: out-of-the-box, Circe2 produces reasonable parametrizations in regions where there is "enough" information from Guinea-Pig
- by itselt, it does not know where to stop and will produce tiny, but positive weights in the neighborhood of every outlier
- combined with a huge resonance close enough to the beam energy, there will be artifacts, unless the problematic region is excluded by hand.

- running Guinea-Pig for the 2023 beam parameters produces not a lot of average energy loss

$$@\,\mathrm{Z} : \approx 1.0 \cdot 10^{-3}$$
$$@\,W^+W^- : \approx 1.0 \cdot 10^{-3}$$
$$@\,\mathrm{ZH} : \approx 1.5 \cdot 10^{-3}$$
$$@\,\mathrm{t\bar{t}} : \approx 2.0 \cdot 10^{-3}$$

- these numbers match the energy spread including beamstrahlung reported by the FCC accelerator physicists
- these numbers also match the simulated equilibrium energy distribution after 8000 turns (provided by Katsunobu Oide)
- the energy distribution is a slightly skewed gaussian

- quantitatively characterize the small deviation of the equilibrium energy distribution from a Gaussian
- produce reliable Guinea-Pig spectra for FCC with the equilibrium energy distribution as input
- ☹ yet ready for public consumption due to some bugs in my unit conversions
- since the beamstrahlung spectrum at FCC is very narrow, the results of $C^3$ exercise will be very helpful for reducing artifacts in Circe2 parametrizations