Electron momentum resolution for our next Delphes samples

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Tracks in Delphes: account for MS but not for secondary interactions, brems.

Spring2021 samples: same resolution for electron tracks and muon tracks

- resolution of reco'ed electrons appeared worse, but that was due to non optimal configuration of the Pflow module

Would be overdoing to implement brems in Delphes…
Still, some accounting of the effect is desirable, via some simple ad-hoc smearing of electrons.

Electron smearing: recap from last time

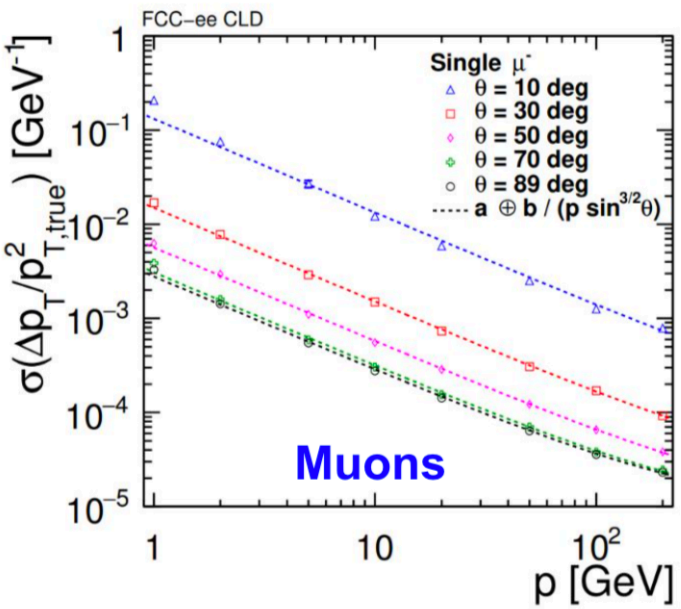
November Phys. Perf meeting, slides from Jan Eysermans :

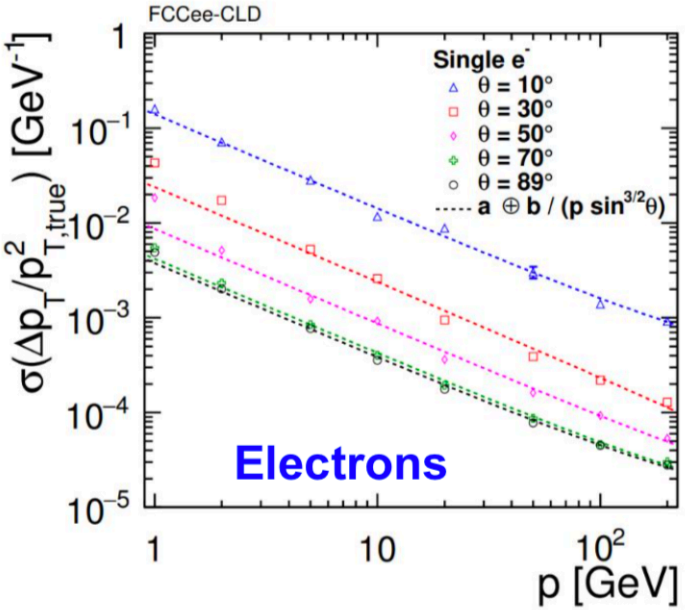
Question arises how much the Bremsstrahlung impacts the electron resolution

- Scales ~ linearly with material X_0
- Impact suppressed by measuring curvature at beginning and end of track in drift chamber

A good estimation requires a full simulation of IDEA, which is not available yet

- CLD did this study (see ref), comparing muon and electron resolutions
- Roughly factor of 2 worse resolution (with X/X_0 (CLD) ~ 2 X/X_0 (IDEA))





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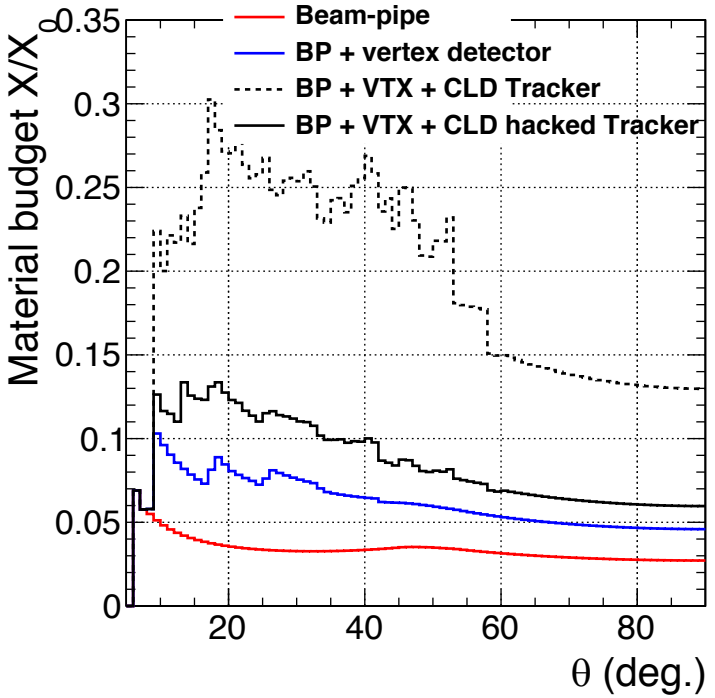
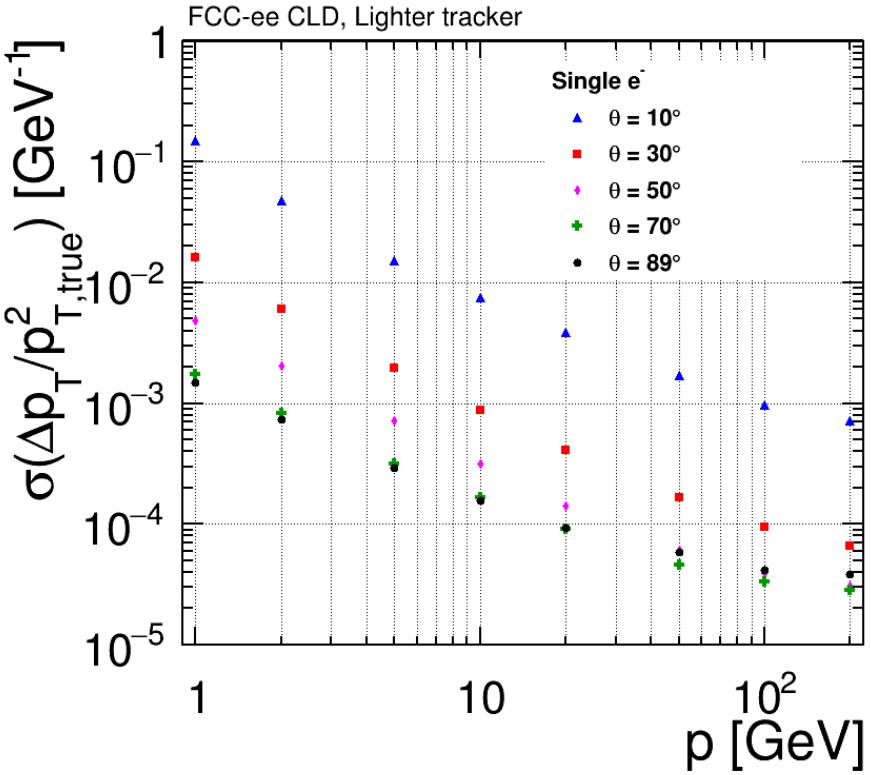
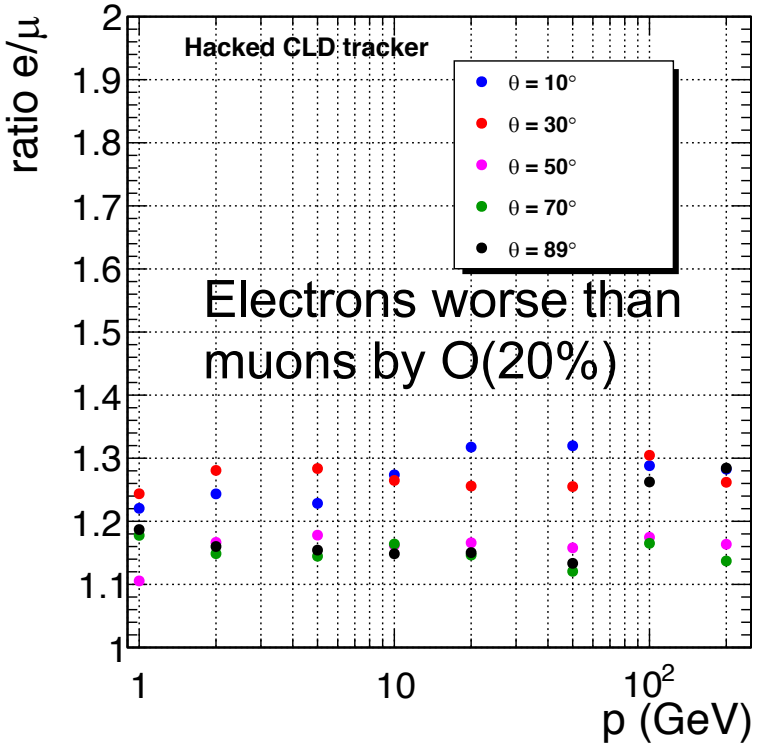
Repeat the CLD study with a “lighter tracker”

Reduce the material of the Si tracker of CLD such that the total material budget is similar to that of IDEA.

Rerun the full simulation with this hacked model (and with nominal), for e and mus. Thanks to André Sailer for sharing the CLD tools !





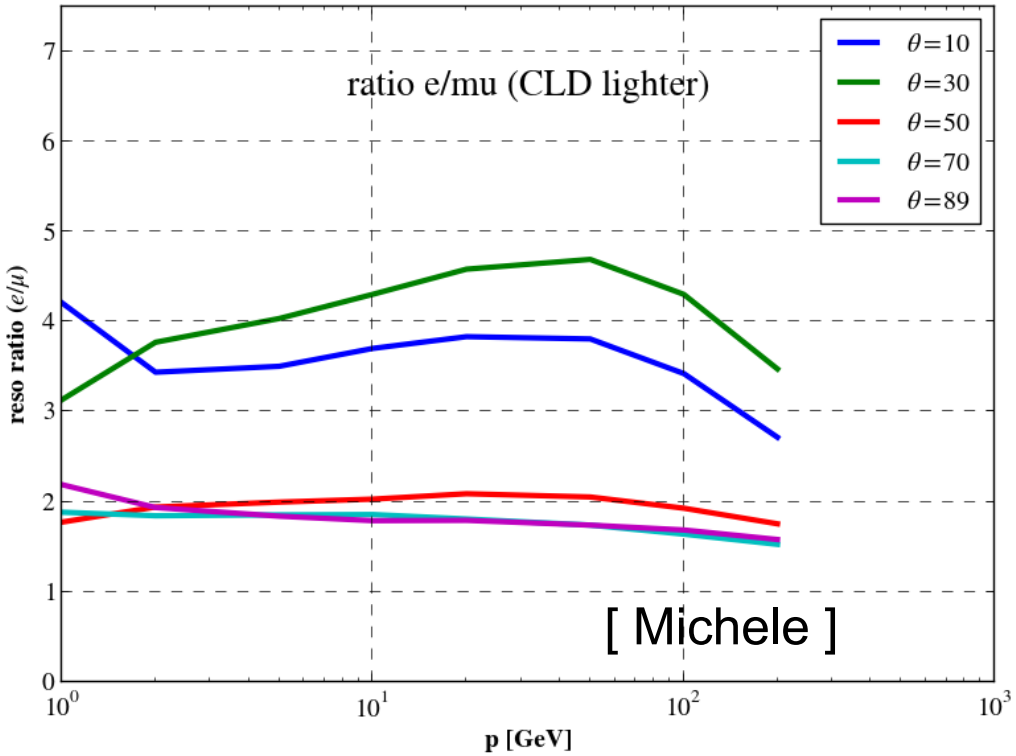


Non gaussian brem tails

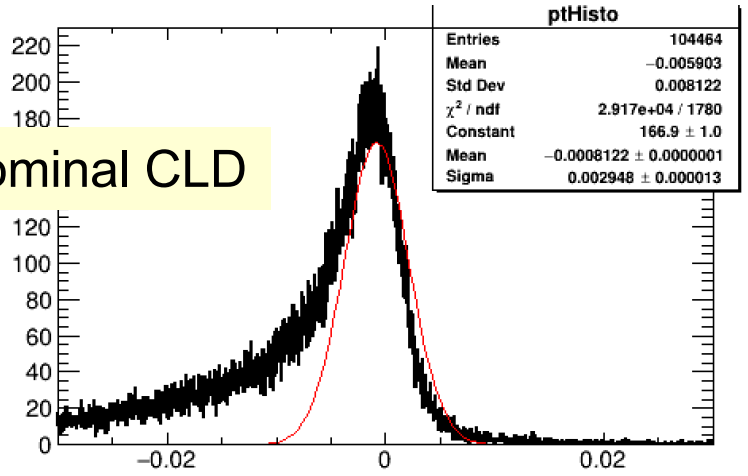
The resolutions on the previous slides :

- The σ of a Gaussian fit to the core of the distribution
- The electron p is that of the track. KF fit.

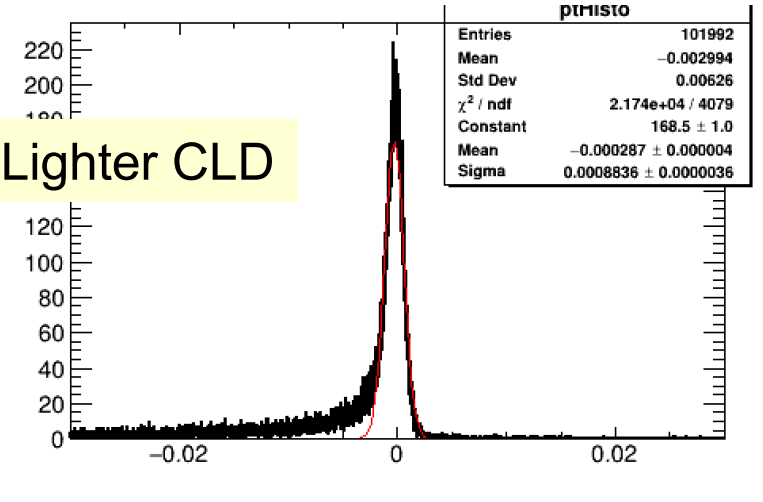
Of course, considerable tails due to bremstrahlung. E.g. p = 10 GeV at 30 deg.
Plots of $\Delta pT/pT^2$ in GeV^{-1}



Nominal CLD



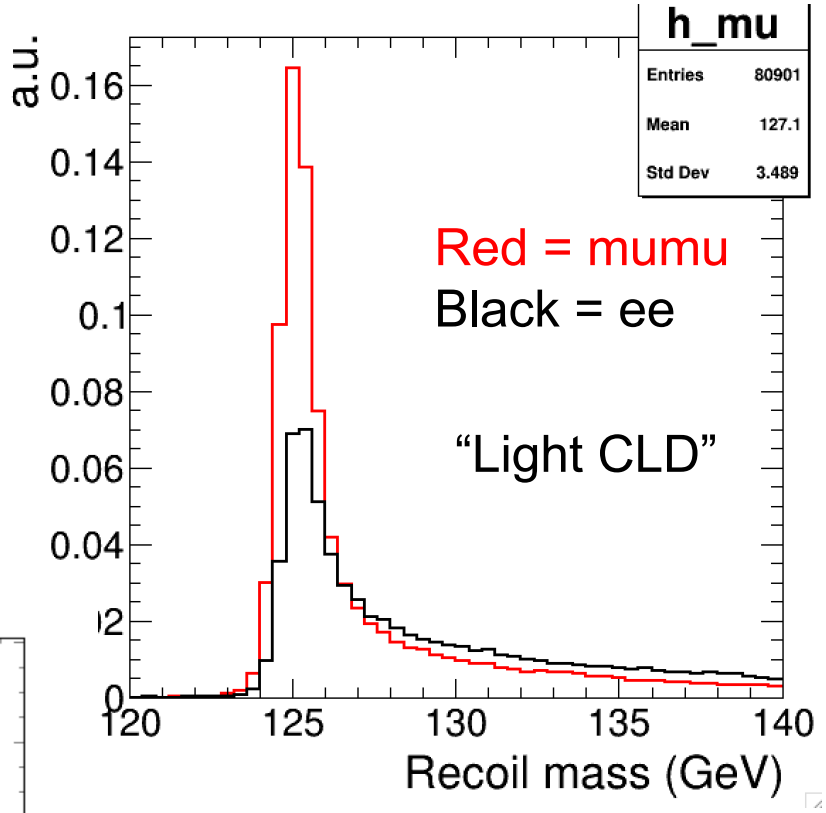
Lighter CLD



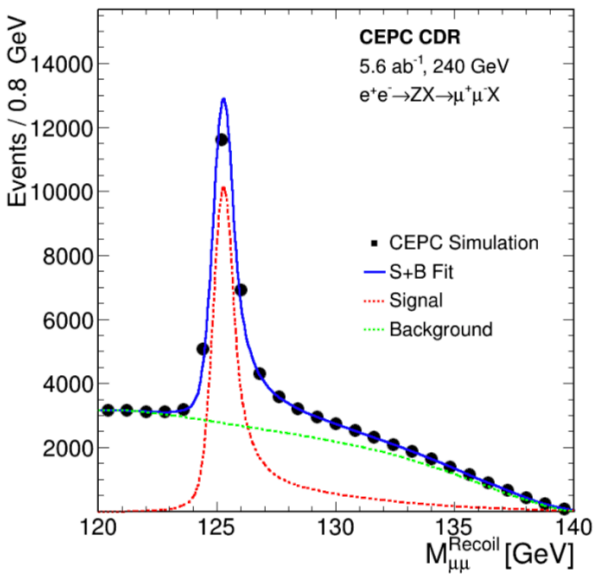
Ratio of effective resolution (68% of the distribution):
Electrons worse than muons by O(2) in central region, even worse in fwd.

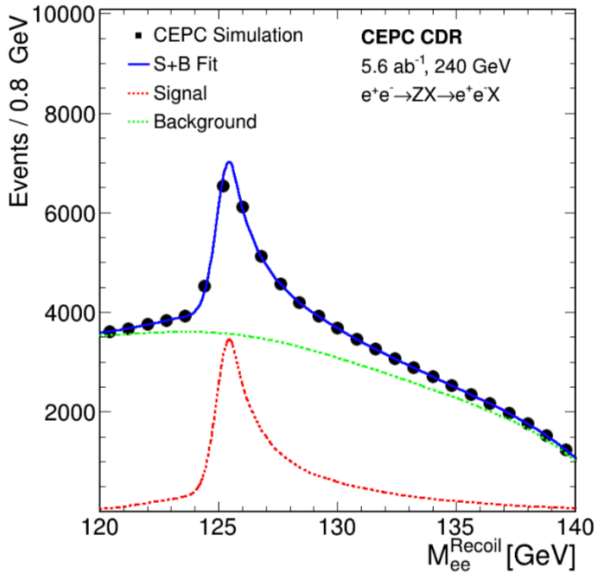
Effect on the recoil mass in ZH events

Full simulation of Z(ll)H events in the “light” CLD:



Signal distribution actually similar to what is shown in the CEPC CDR [arXiv. 1811.10545] :





Shall we indeed degrade the electron resolution (w.r.t. muons) by a factor of 2 – as done in the “pre-winter2023” samples ?

Probably over-conservative…

Usage of Gaussian Sum Filtering tracking as in CMS, instead of linear KF.

W. Adam,
https://arxiv.org/pdf/physics/0306087.pdf

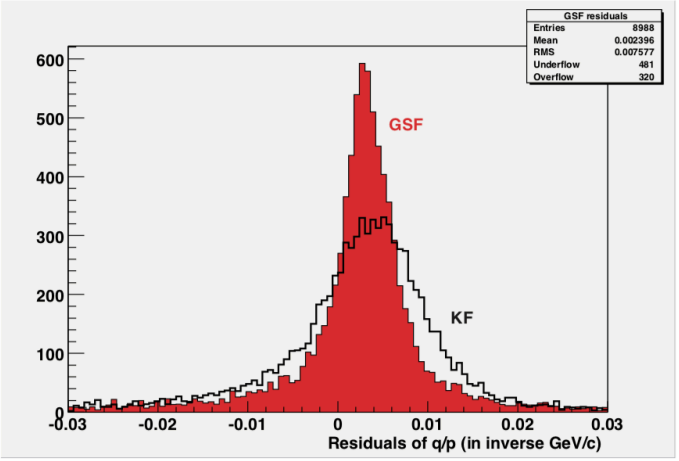
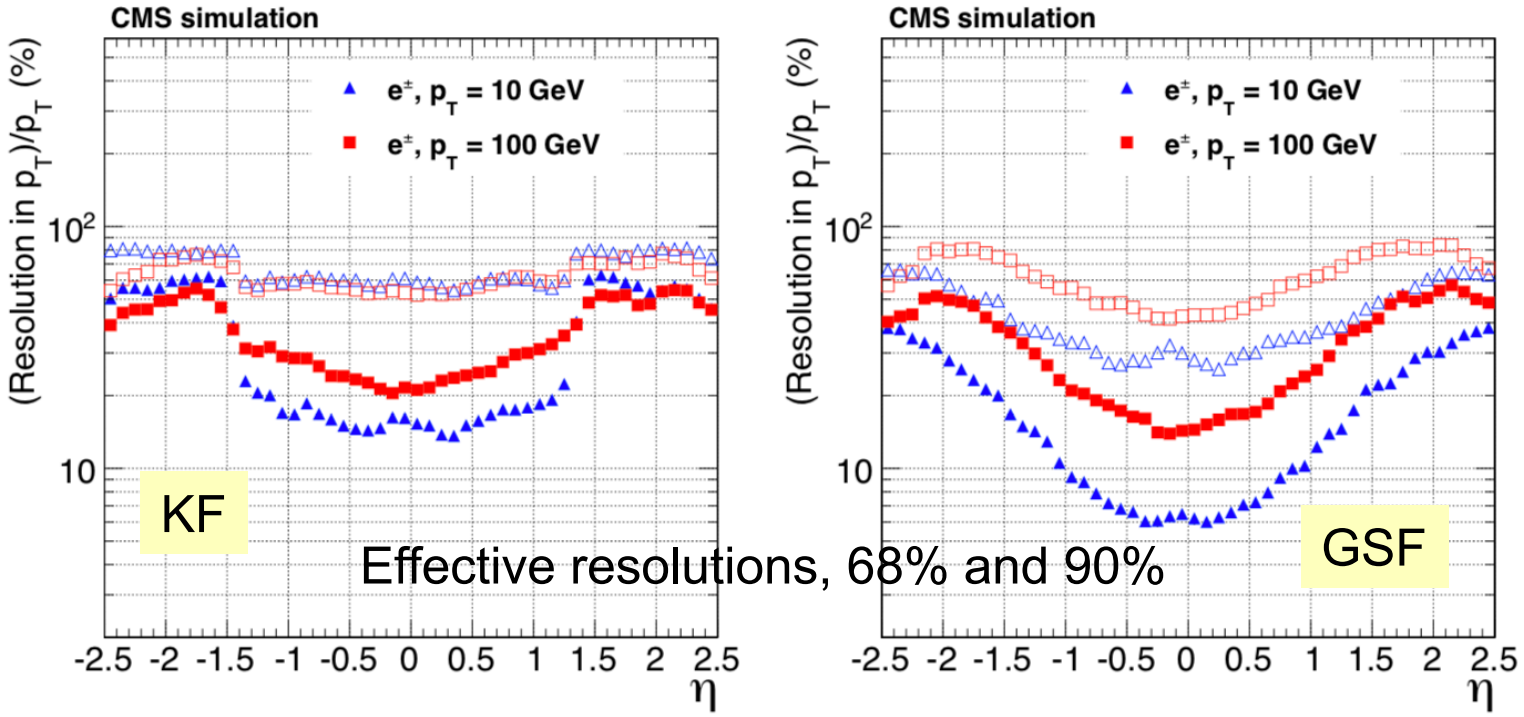


Figure 13: Residuals of the estimated q/p with respect to the true value at the transverse impact point for the KF and the GSF. The reconstruction algorithms have been run on tracks from a full simulation.

CMS, JINST 9 P10009 (2014)



Effective resolutions, 68% and 90%

GSF improves by O(2).

Still, in CMS, GSF electrons are a factor of O(6) worse than muons (in central, about 50% X0)

E.Perez

Probably over-conservative…

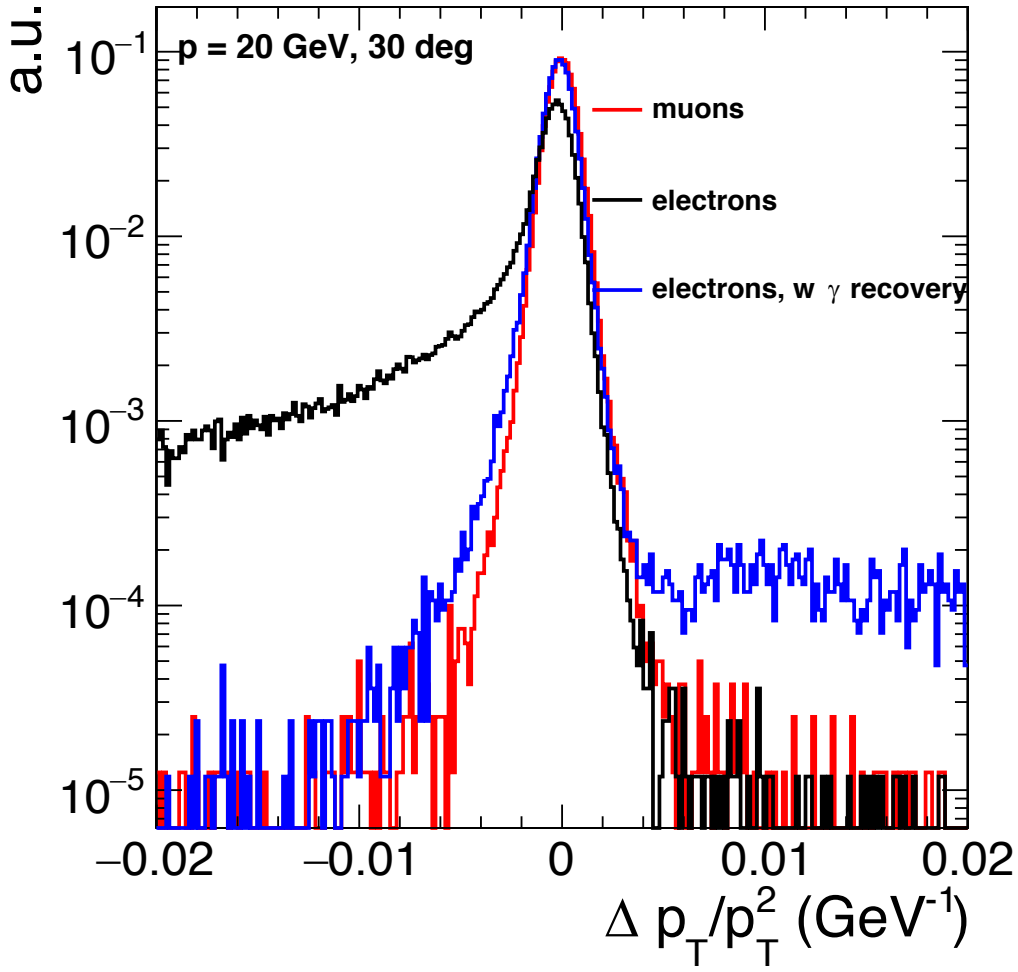
Can also recover the brems in the calorimeter.
The gain will depend on the resolution of the ECAL.

Simple exercise…
Single electron events, Full Sim with "lighter CLD" (key4hep).

Use the track angles at the IP, and the angles at the calorimeter entrance, to define an angular window in which I sum up the photons.

Recover the brem photons assuming ideal calo resolution.

FullSim CLD "Light tracker"



For the winter2023 Delphes samples ?

- Quantifying the improvements that we can expect from GSF and from a calorimeter photon recovery is beyond the time scale of the winter2023 production
  - we would like to start the production before Xmas

- Make a guess between O(20%) seen from the Gaussian core, and O(2) seen from effective resolutions.
  - Guess from GSF expert: the gain with 5-10% X0 should not be as large as the factor of two seen in CMS.