Toy-MC for gain fluctuations simulation in digitization

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With inputs from Davide

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Gain & fluctuations

So far, a constant value of 1ɣ/2eV deposit energy is used as conversion factor (for LEMON)

→ **we have to describe charges collection and gain fluctuations**

Start from the number of primary ionization electrons ($\mathbf{N_{primary}}$)
and consider (*in a simple statistical model*):

1) The probability that an electron, produced in the drift zone, arrives in the transfer area crossing a channel of the GEM foil (**electron transparency**);

2) The number of secondary electrons produced in the **multiplication** in a GEM foil.

Gain & fluctuations – primary electrons

Unfortunately, our simulations (both G4 and SRIM) do not return the number of primary electrons but only the energy loss

→ *we have to find a walkaround to estimate $N_{primary}$ and its fluctuations*

For the moment focus on the other parts of the problem…

→ Use the 55Fe case (good also for exp comparison):

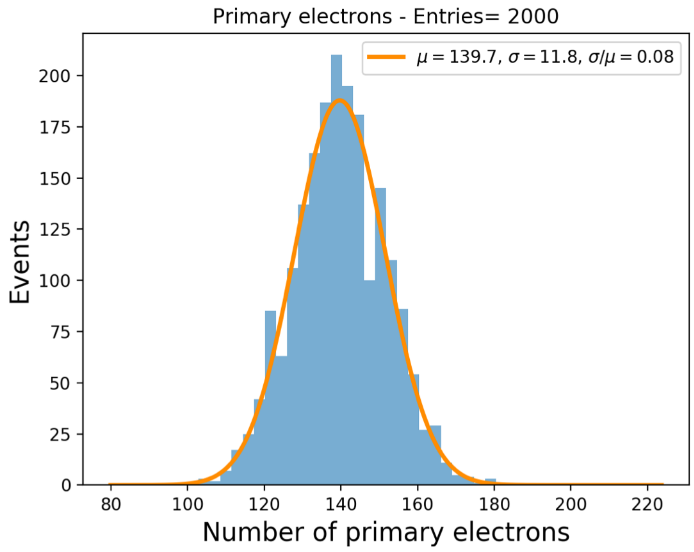
- The mean number of primary electrons in He is

$\overline{N_{primary}}$ = 5900 [eV] /42 [eV/pair] = 140

→ Generate $\mathbf{N_{primary}}$ according to a Poisson distribution

Shouldn't we consider a Fano factor (which is quite small for He mixtures…)?

$\sigma = \sqrt{F \cdot \overline{N_{primary}}} \rightarrow {}^{\sigma}/_{\mu} \sim \mathbf{0.05}$ **if F~ 0.25**



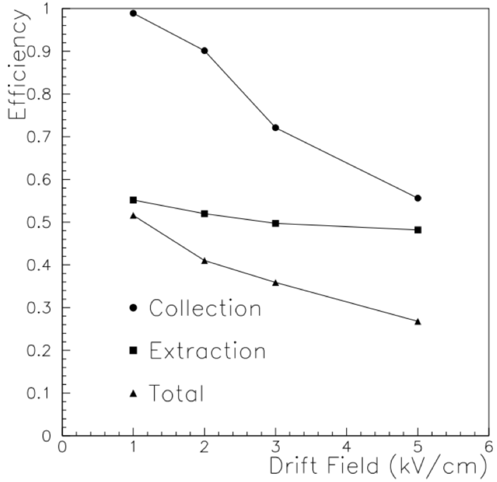
Gain & fluctuations – electron transparency

From simulations we can assume for each primary electron:

- $\varepsilon \sim 0.5 \div 0.6$

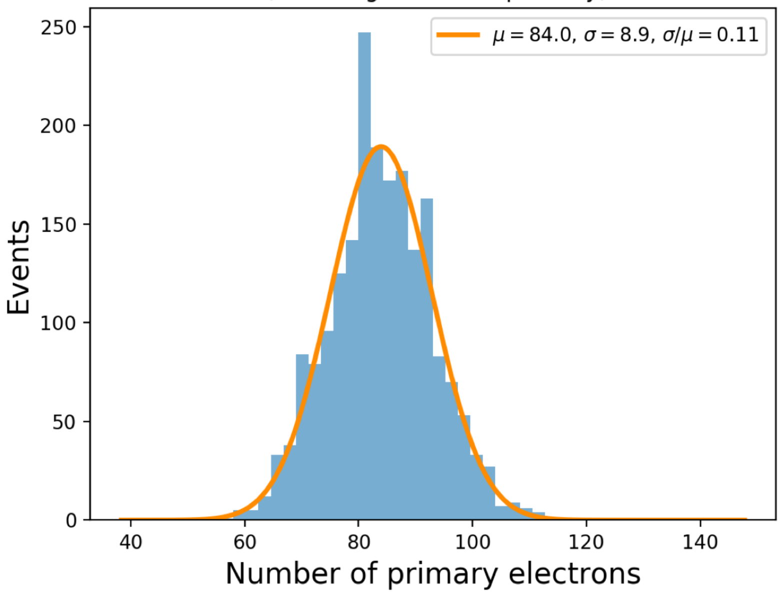
(low drift field, ε_{Coll} saturates at 1 and ε_{Extr} smoothly increasing)

a Maxwell simulation from Veenhof



Generate the number of electrons to be considered in the multiplication (n.e.$_{GEM}$)

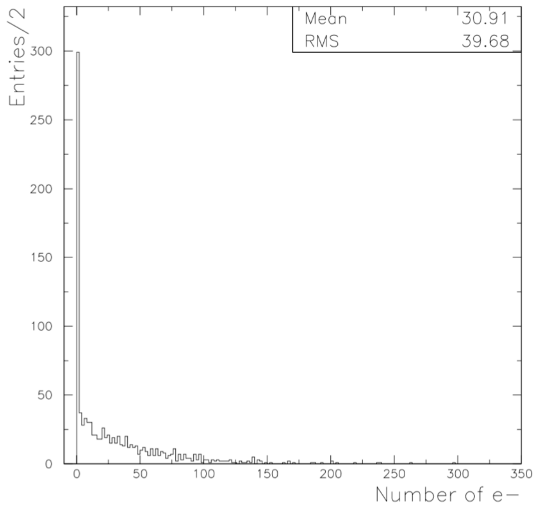
from a binomial distribution with parameters $N_{primary}$ and p=0.6



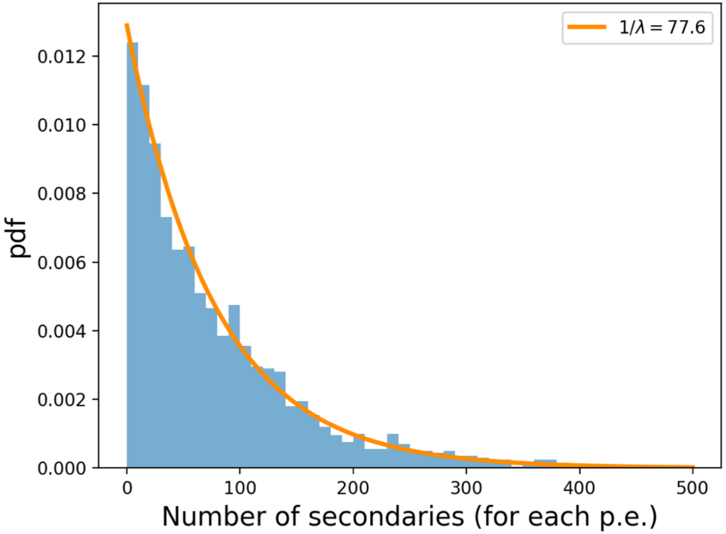
Gain & fluctuations – multiplication (I)

the number of secondaries is described by an exponential (leaving the bin at 0 that is the inefficiency)

a simulation from Pinci?

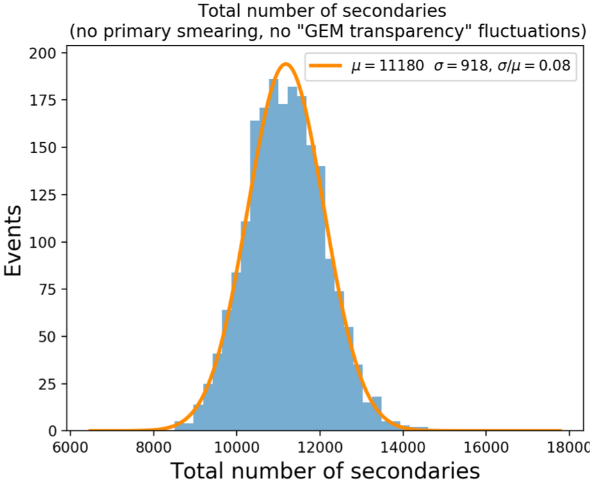


For each electron to be multiplied (n.e.$_{GEM}$) a number of secondaries is generated according to an exponential distribution with μ=σ=80 (assumed GEM gain) and then added to obtain the total number of secondaries

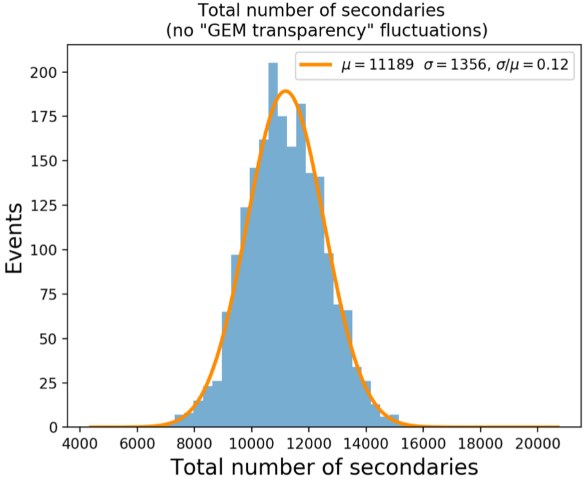


Gain & fluctuations – multiplication (II)

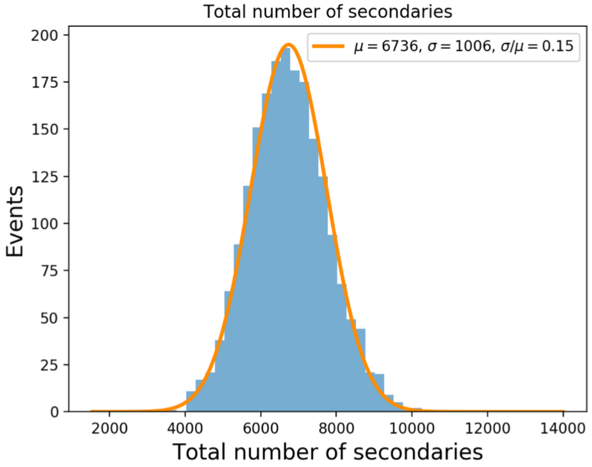
Only the effect of the exponential multiplication on $N_{primary} \equiv 140$



Considering also the Poisson fluctuations on $N_{primary}$



Considering also the Poisson fluctuations and the binomial fluctuations (transparency) on $N_{primary}$



Gain fluctuations induced by the other two GEMs foils is too time-consuming but should definitly be negligible (at least in this semplified model)