Study of saturation effects in GEM-3 with LEMON

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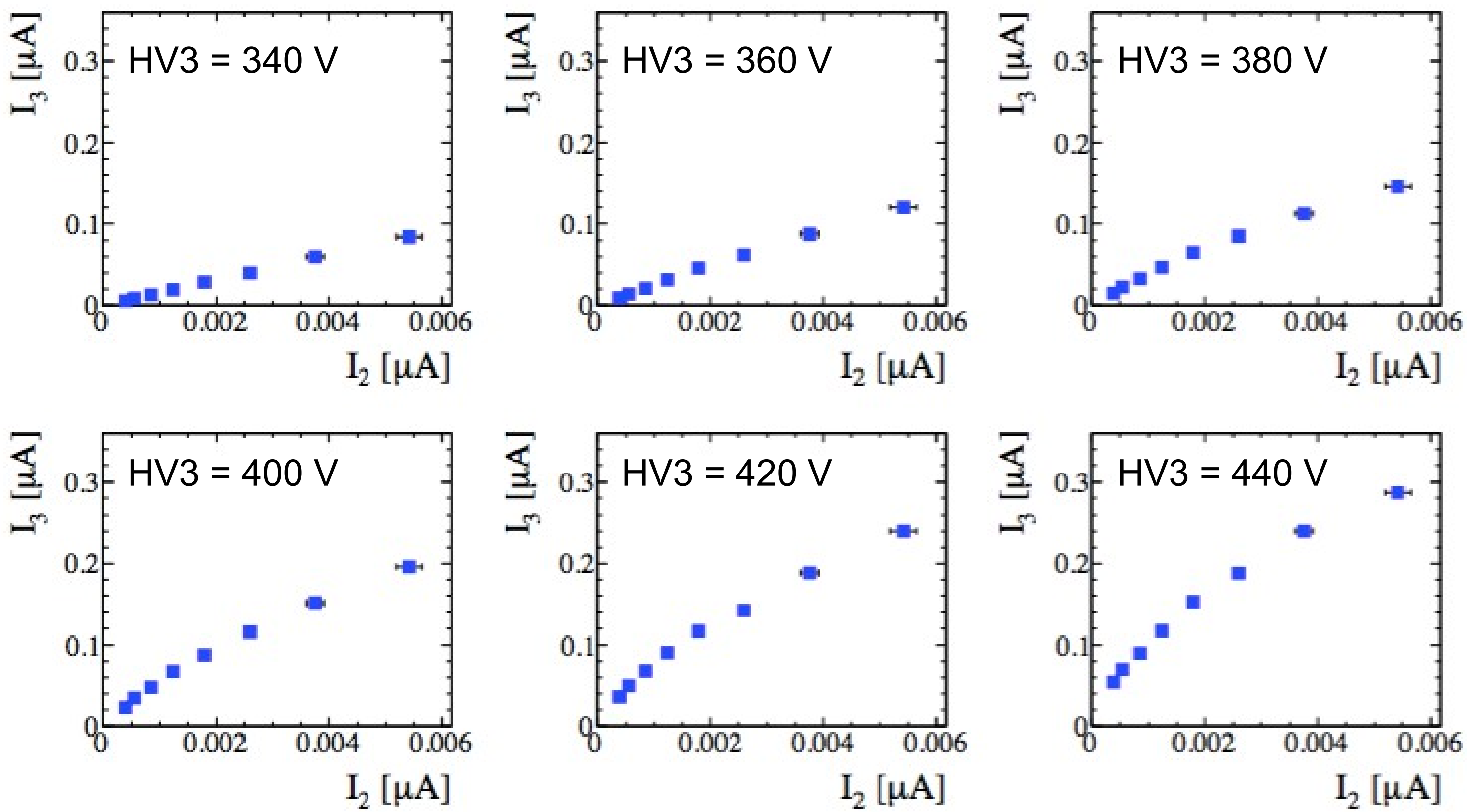
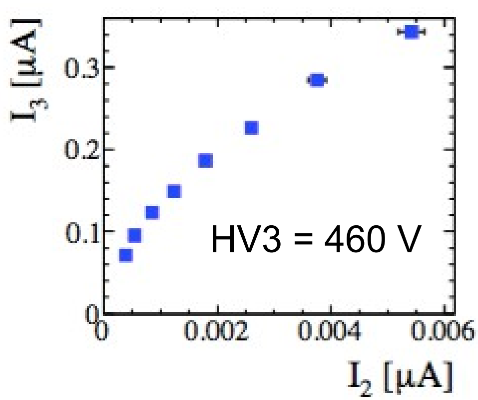
Reminder: Saturation of GEM3



^{55}**Fe**

HV_2 = 460 V

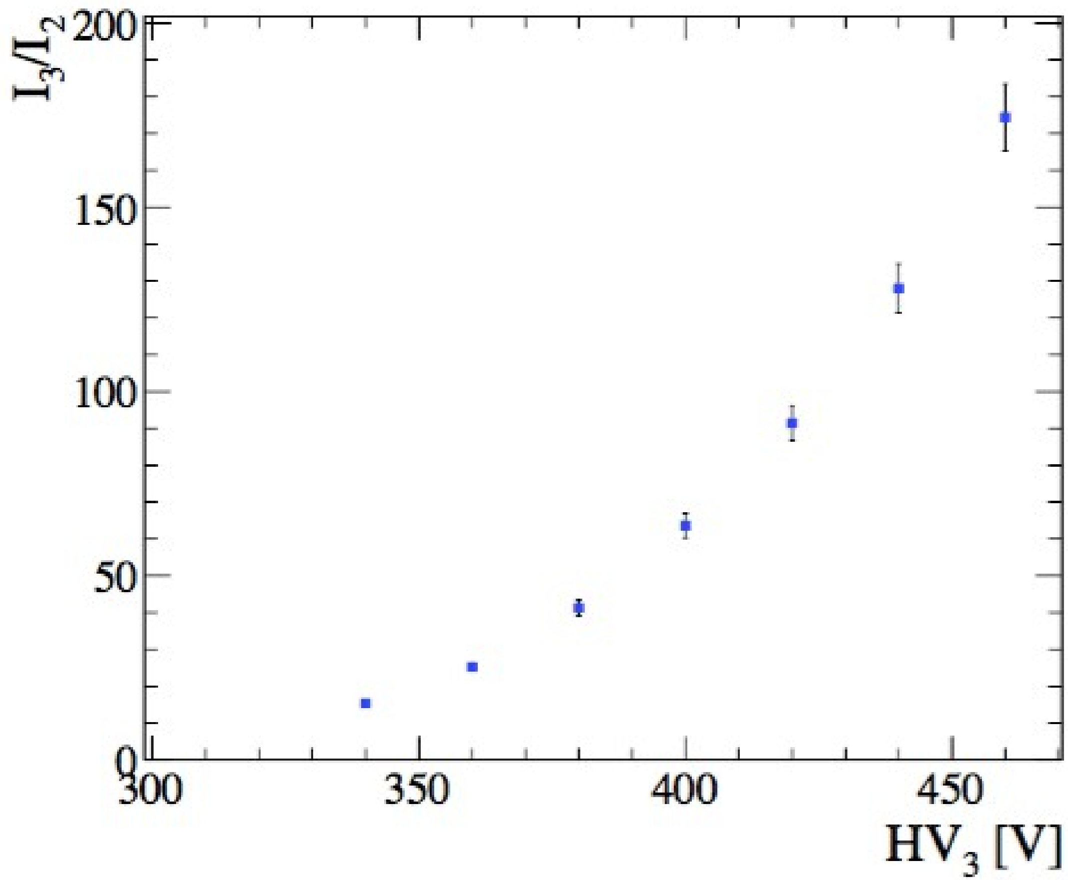


These plots give the charge coming out form GEM-3 as a function of the charge coming in

Good linearity only at HV_3 = 340 V

Reminder: GEM-3 gain (I_3/I_2) vs. HV_3

- *From previous plots: 460 V / 460 V / 340 V is not saturated*
- *We can assume that 340 V / 460 V / < 460 V is also not saturated*



Gain of a non-saturated GEM

Saturation and charge density

- Assumption:
  - saturation is due to space charge in each single all (no impact of charge in nearby holes)
- Consequences:
  - Saturation can be treated as an effect of *charge density* on GEM-3, as far as we consider regions of area not much larger than the hole pitch (140 x 140 μm^2)
  - the effect on charge densities will be the same for all sources
  - each CMOS pixel is 125 x 125 μm^2 on the GEM → we can correct pixel by pixel

Idea

- We use data taken at HV_3 = 460 V
- The charge arriving on GEM-3 is:

$$Q_{\rm in} \;=\; N_e\, e\, G(HV_1)\, G(HV_2)$$

- We would expect an output charge of

$$Q_{\rm out}^{\rm exp} = G(460\ V)\, Q_{\rm in}$$

- We measure instead:

$$Q_{\rm out} \;=\; \frac{I_3}{I_2}\, Q_{\rm in}$$

- We get a correction function Q_{exp} vs. Q_{out}
- We convert to charge density, dividing by a suitable surface Σ

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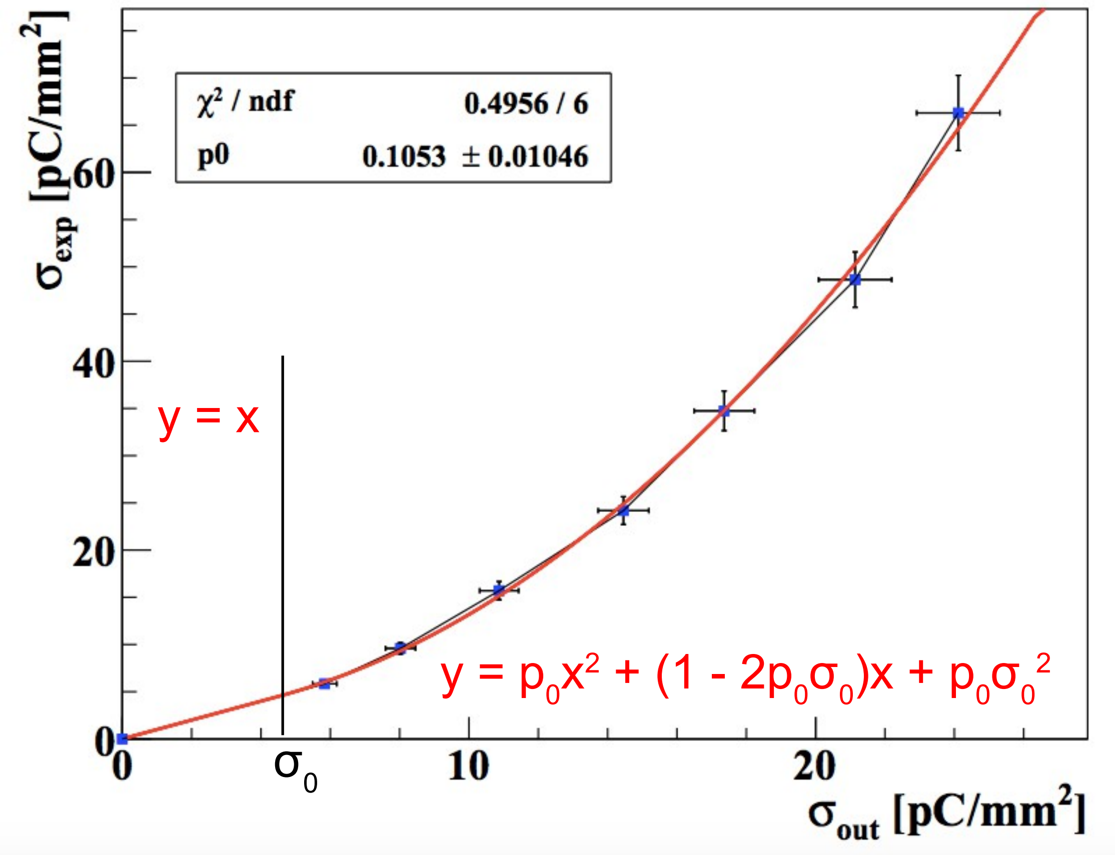
How to choose Σ?

- It can be demonstrated analytically that, if Q_{exp} vs. Q_{out} is modeled by a 2nd order polynomial, and we assume a 2D gaussian shape of the ^{55}Fe spots, the value of Σ to be used is $4\pi\sigma_x\sigma_y$



How to correct pixels

- The number of photons in a pixel is related to the charge density by:

$$\sigma = \frac{n_{ph}}{d_{px}^2} \frac{1}{\left\langle \frac{n_{ph}}{q} \right\rangle}$$

area covered by a pixel

Average number of photons per unit charge

$$n_{ph} = \frac{q}{e} \alpha \, \Omega$$

angle covered by the camera

0.08 in our mixture

$$\boxed{n_{ph}^{\exp} = a \left(\frac{e}{d_{px}^2 \, \alpha \Omega} \right) n_{ph}^2 + b \, n_{ph} + c \left(\frac{d_{px}^2 \, \alpha \Omega}{e} \right)}$$

To do

- We want to apply our method to the pictures recently taken at various distances of the source from the GEM, to see if we can recover a trend of light vs. distance similar to the one observed at BTF
  - CAVEAT: trend observed at BTF probably due to contaminations of the gas, purity conditions could be different in our ^{55}Fe data, quantitative comparison could be difficult
- Any suggestion for other tests?