Digitization code optimization

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Saturation effect: OLD method

- After the smearing effect, and the multiplication on the GEM1 and GEM2 we have an array of x,y,z of the electrons

  We defined a fixed volume:

  - **1000 < x < 1300**
  - **1000 < y < 1300**
  - **0 < z < 200**

- We created a 3D histogram of such dimensions, and we applied the saturation effect:

$$N_{GEM3}^{(sat)} = \sum_{i}^{voxels} \frac{n_i \cdot A \cdot G_3}{1 + \beta \cdot G_3 \cdot n_i}$$

Problem: we were wasting time on many empty voxels!

Saturation effect: NEW method

- After the smearing effect, and the multiplication on the GEM1 and GEM2 we have an array of x,y,z of the electrons

- **We find the max and min for x,y,z and we round them up.**

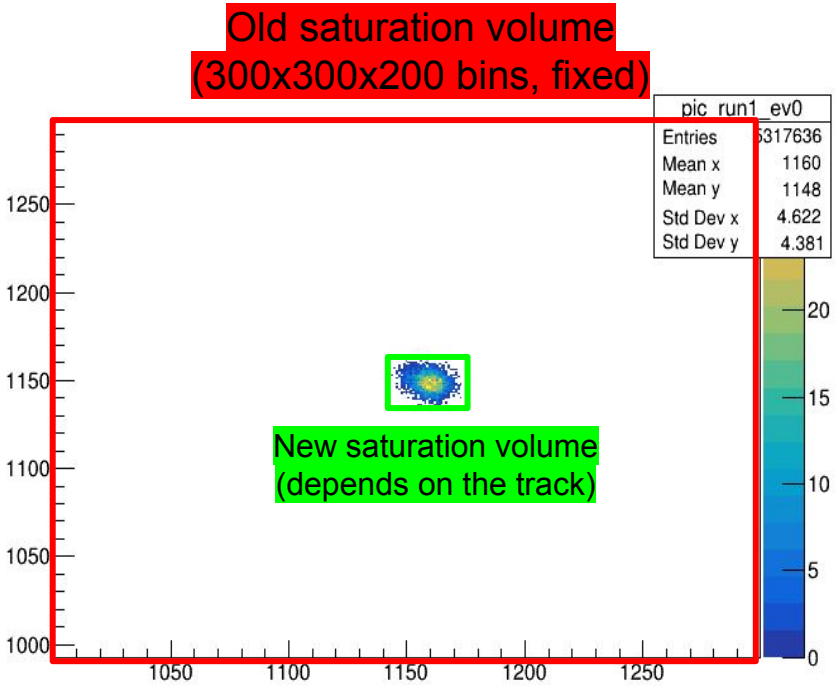
- **We define the smallest volume as:**
  - **x_min - 2 < x < x_max + 2**
  - **y_min - 2 < y < y_max + 2**
  - **z_min - 2 < z < z_max + 2**

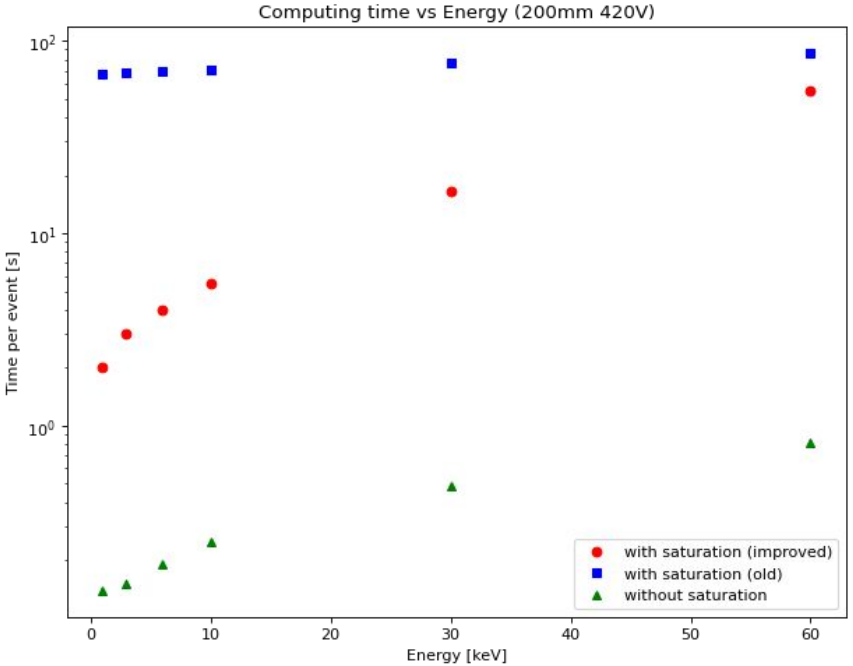
- We create a 3D histogram of such dimensions, where we apply the usual saturation effect:

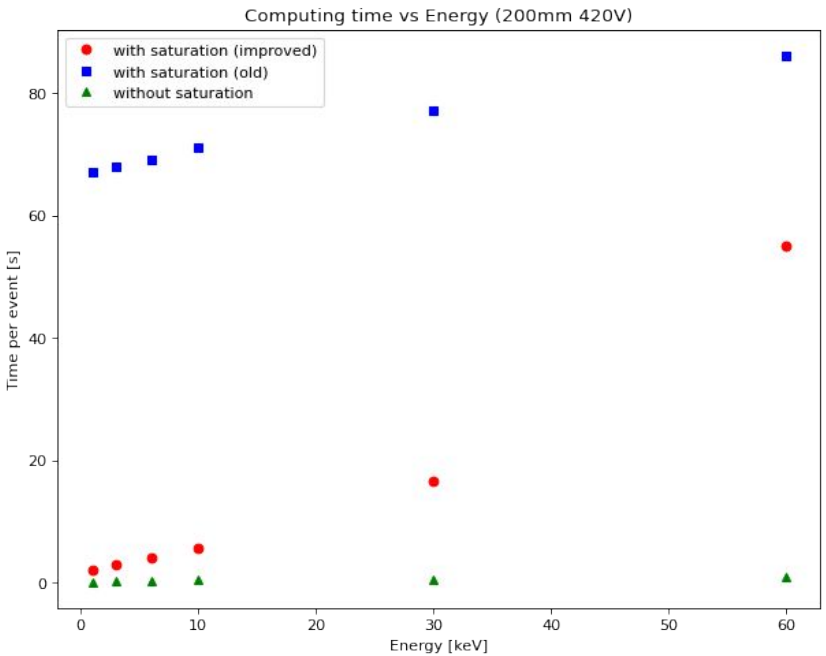
$$N_{GEM3}^{(sat)} = \sum_{i}^{voxels} \frac{n_i \cdot A \cdot G_3}{1 + \beta \cdot G_3 \cdot n_i}$$

Consistency check: final images with old and new method were compared bin by bin (with fixed seed), and there are no differences.

Visual description

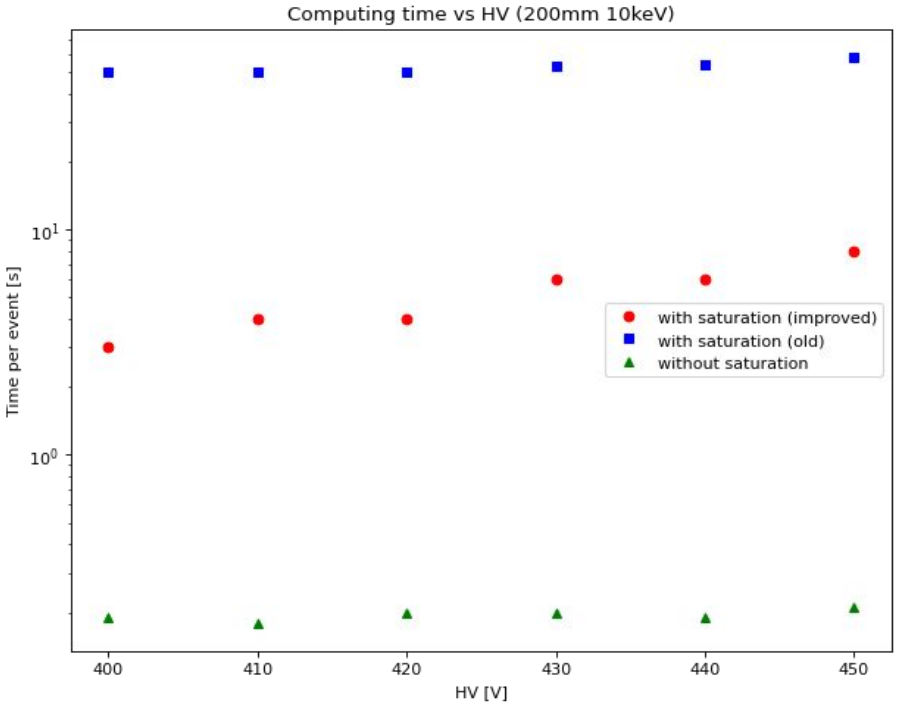


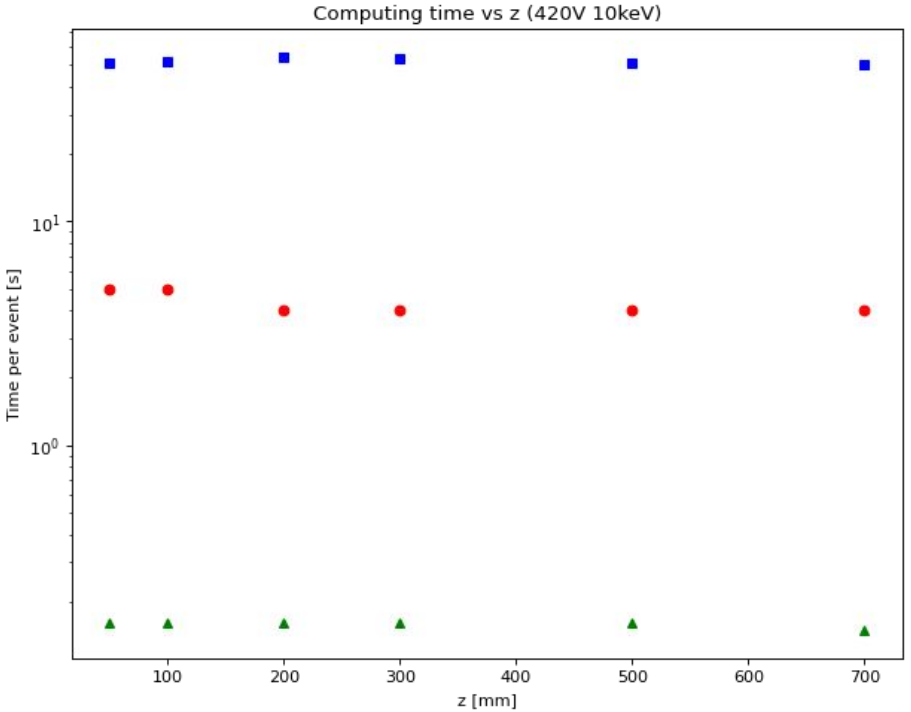




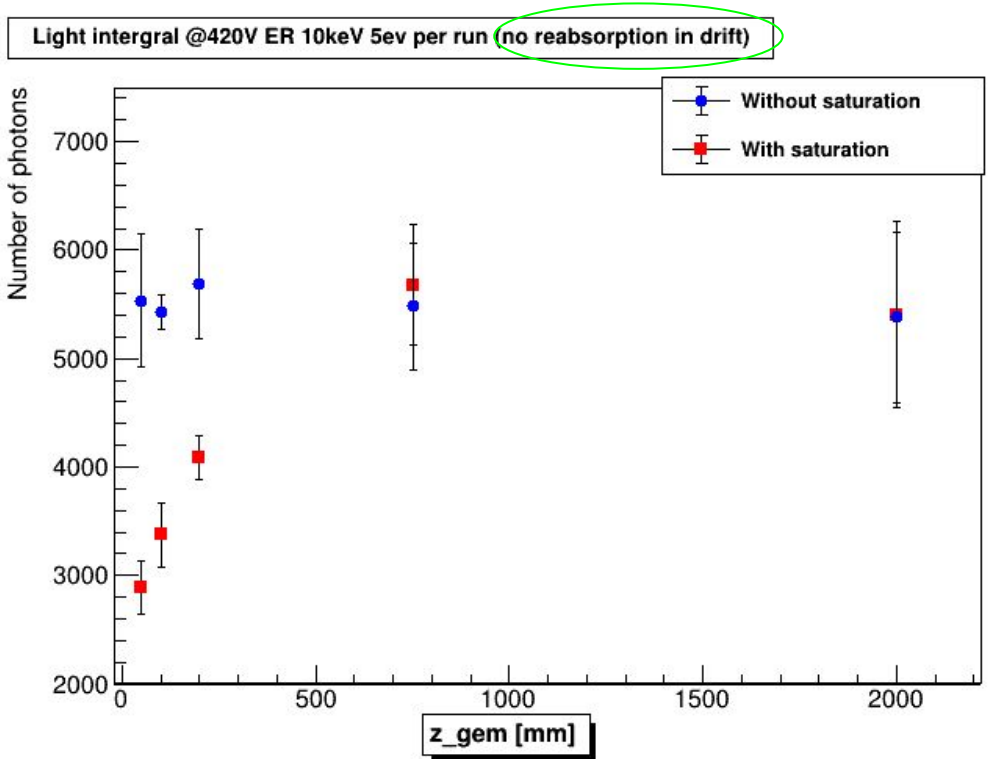
energy_keV	time_with_sat_new_s	time_without_sat_s	time_with_sat_old_s
1	2.0	0.14	67
3	3.0	0.15	68
6	4.0	0.19	69
10	5.5	0.25	71
30	16.5	0.49	77
60	55.0	0.81	86

Time dependence on HV and z





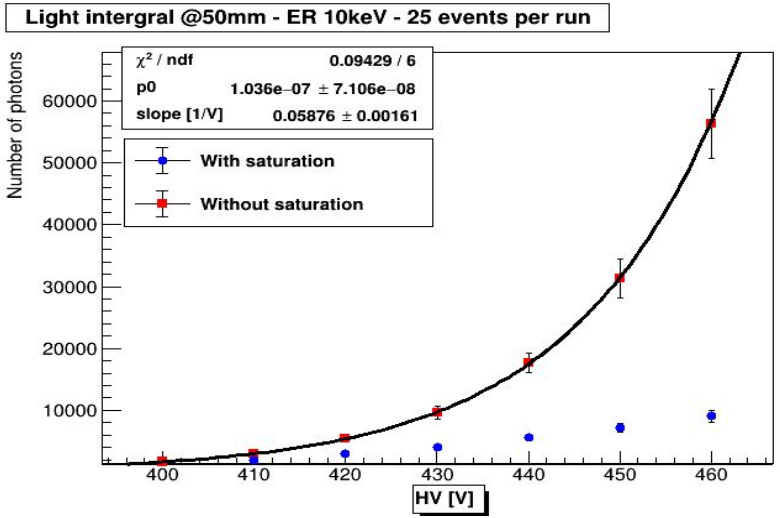
Some consistency checks: scans with saturation VS without saturation

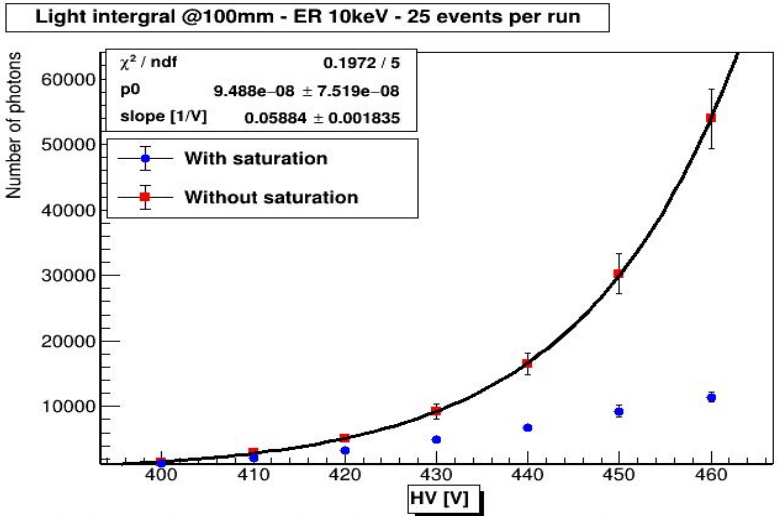


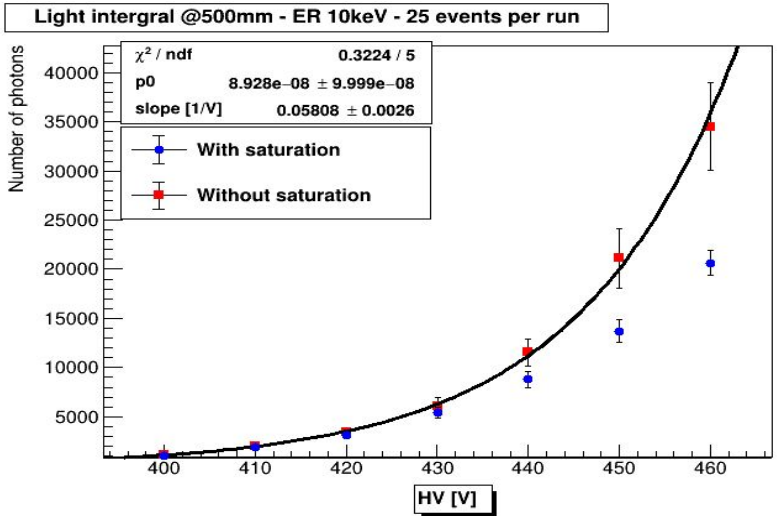
Next steps

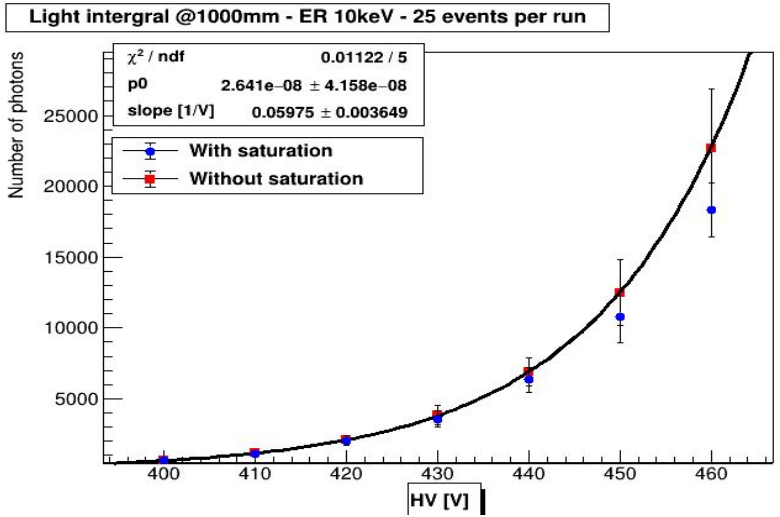
- do other consistency checks: compare HV and z scans between the new method and the old one
- further possible improvements by using numpy (parallel processing) instead of ROOT (serial processing) for saturation effect
- do some consistency checks with noise

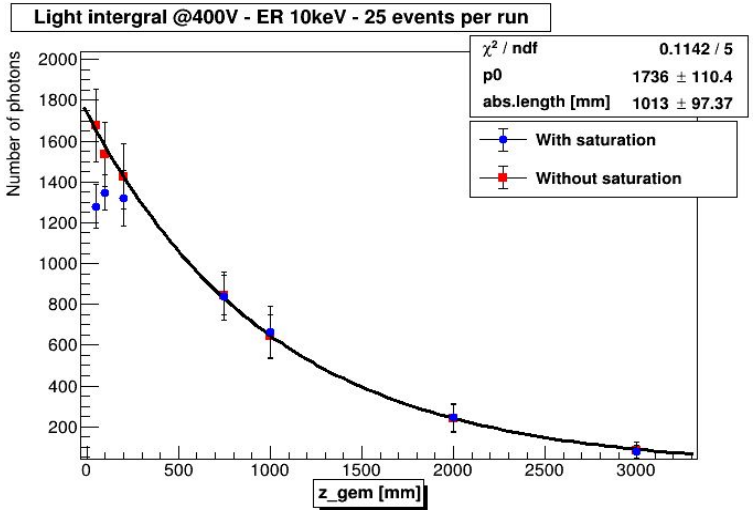
Other checks

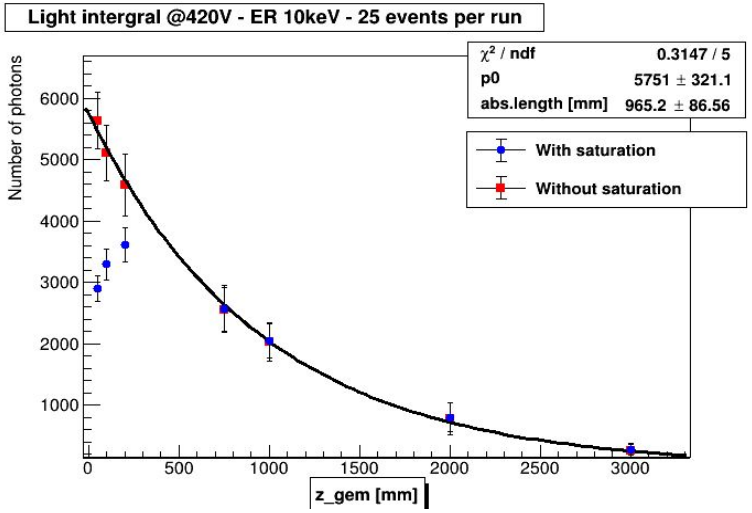

Light intergral @50mm - ER 10keV - 25 events per run
χ² / ndf 0.09429 / 6
p0 1.036e−07 ± 7.106e−08
slope [1/V] 0.05876 ± 0.00161
With saturation
Without saturation
Number of photons
HV [V]

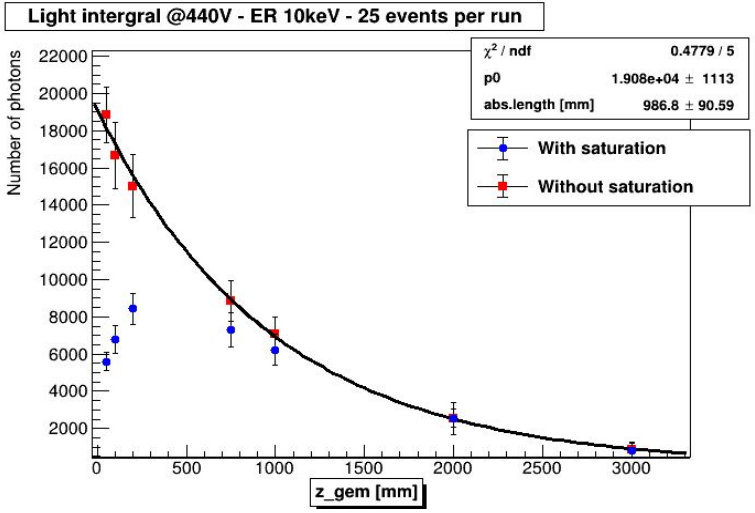

Light intergral @100mm - ER 10keV - 25 events per run
χ² / ndf 0.1972 / 5
p0 9.488e−08 ± 7.519e−08
slope [1/V] 0.05884 ± 0.001835
With saturation
Without saturation
Number of photons
HV [V]

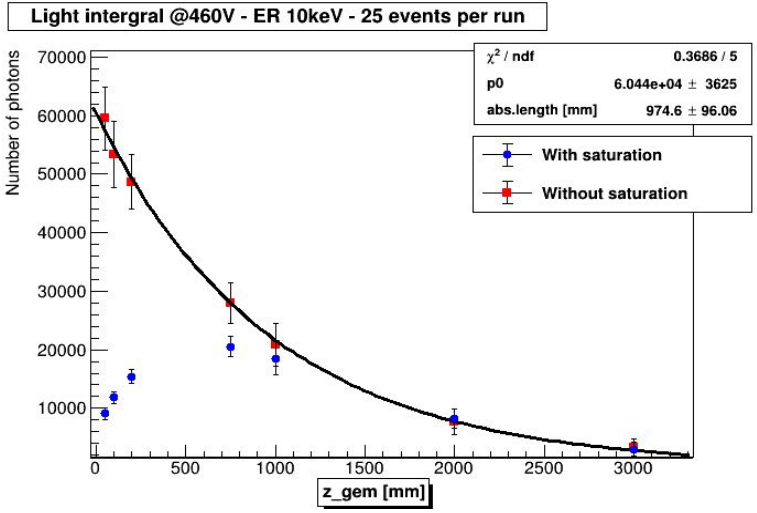

Light intergral @500mm - ER 10keV - 25 events per run
χ² / ndf 0.3224 / 5
p0 8.928e−08 ± 9.999e−08
slope [1/V] 0.05808 ± 0.0026
With saturation
Without saturation
Number of photons
HV [V]


Light intergral @1000mm - ER 10keV - 25 events per run
χ² / ndf 0.01122 / 5
p0 2.641e−08 ± 4.158e−08
slope [1/V] 0.05975 ± 0.003649
With saturation
Without saturation
Number of photons
HV [V]


Light intergral @400V - ER 10keV - 25 events per run
χ² / ndf 0.1142 / 5
p0 1736 ± 110.4
abs.length [mm] 1013 ± 97.37
With saturation
Without saturation
Number of photons
z_gem [mm]


Light intergral @420V - ER 10keV - 25 events per run
χ² / ndf 0.3147 / 5
p0 5751 ± 321.1
abs.length [mm] 965.2 ± 86.56
With saturation
Without saturation
Number of photons
z_gem [mm]


Light intergral @440V - ER 10keV - 25 events per run
χ² / ndf 0.4779 / 5
p0 1.908e+04 ± 1113
abs.length [mm] 986.8 ± 90.59
With saturation
Without saturation
Number of photons
z_gem [mm]


Light intergral @460V - ER 10keV - 25 events per run
χ² / ndf 0.3686 / 5
p0 6.044e+04 ± 3625
abs.length [mm] 974.6 ± 96.06
With saturation
Without saturation
Number of photons
z_gem [mm]