Saturation Scouting

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Saturations Scans 8+14/03/2024

Summary

Scouting runs to look for a better HV configuration for less saturation

- **Ladder VGEM**, same gain more diffusion (first GEM amplifies more than 2nd and 3rd→ proposed in Fine Pitch GEMs in Triple GEM detectors - CERN Document Server)
- **Transfer Field Scan** (increase diffusion between GEMs, loss of electron extraction efficiency)
- **Drift Scan** (increase diffusion of primary charge, no gain loss)

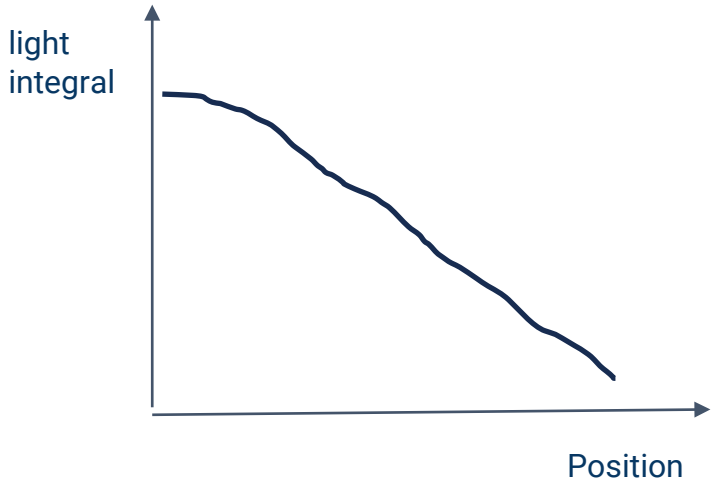
Measuring the response to 5.9 photoelectron at different source positions

→ **Indirect way to estimate ~~measure~~ the saturation**

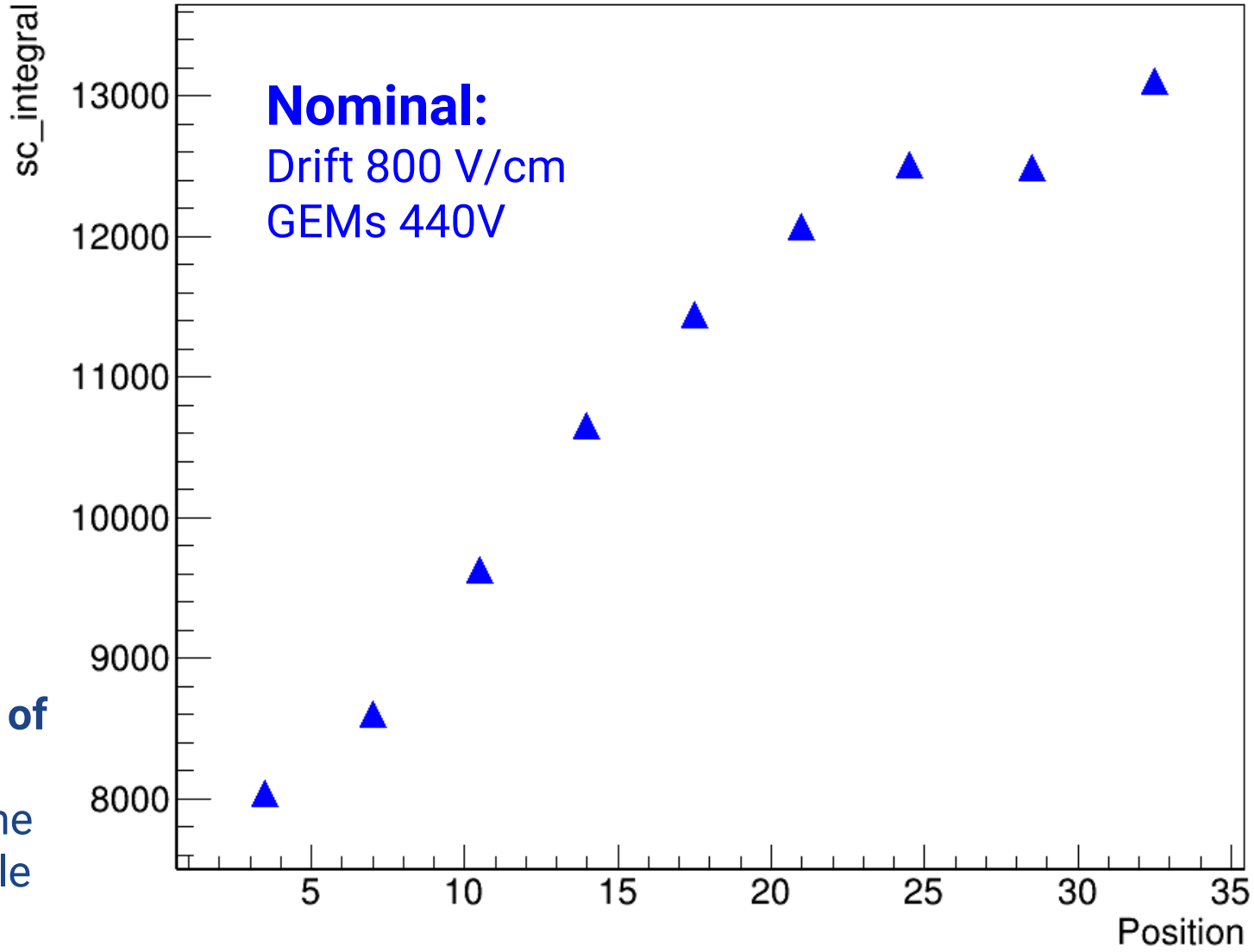
Comment	Drift	G1	T1	G2	T2	G3	Offset
GEM ladder scan_440	960	440	500	440	500	440	10
	960	445	500	440	500	435	10
	960	450	500	440	500	430	10
	960	455	500	440	500	425	10
GEM ladder scan_420	960	420	500	420	500	420	10
	960	425	500	420	500	415	10
	960	430	500	420	500	410	10
	960	435	500	420	500	405	10
GEM ladder scan_400	960	400	500	400	500	400	10
	960	405	500	400	500	395	10
	960	410	500	400	500	390	10
	960	415	500	400	500	385	10
Drift field scan	960	440	500	440	500	440	10
	840	440	500	440	500	440	10
	720	440	500	440	500	440	10
	600	440	500	440	500	440	10
	480	440	500	440	500	440	10
Transfer filed scan	960	440	400	440	400	440	10
	960	440	300	440	300	440	10
	960	440	200	440	200	440	10
	960	440	100	440	100	440	10
VGEM410-DRIFT SCAN	360	410	500	410	500	410	10
	480	410	500	410	500	410	10
	600	410	500	410	500	410	10
	720	410	500	410	500	410	10
VGEM420-DRIFT SCAN	360	420	500	420	500	420	10
	480	420	500	420	500	420	10
	600	420	500	420	500	420	10
	720	420	500	420	500	420	10
VGEM430-DRIFT SCAN	360	430	500	430	500	430	10
	480	430	500	430	500	430	10
	720	410	500	410	500	410	10
	360	430	500	430	500	430	10

Where we are

We Expect a **constant light output** as a function of the z position, **with a decrease** as the position increase due to electron attachment

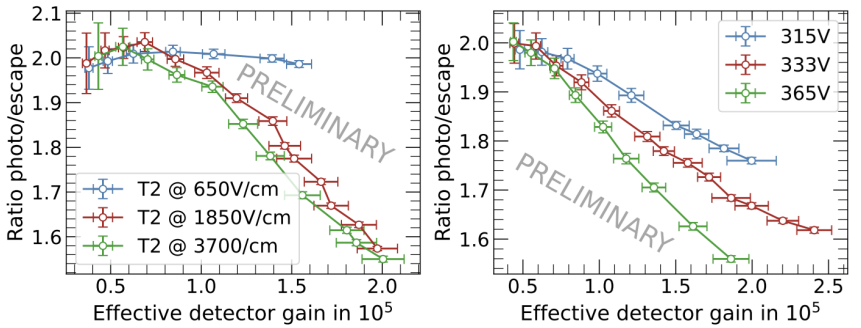


Because of saturation we observe an **increase of light output with the position**. Electron clouds more near to the GEMs diffuse less so the same charge is shared among less holes. In each hole the charge density for saturation is reached



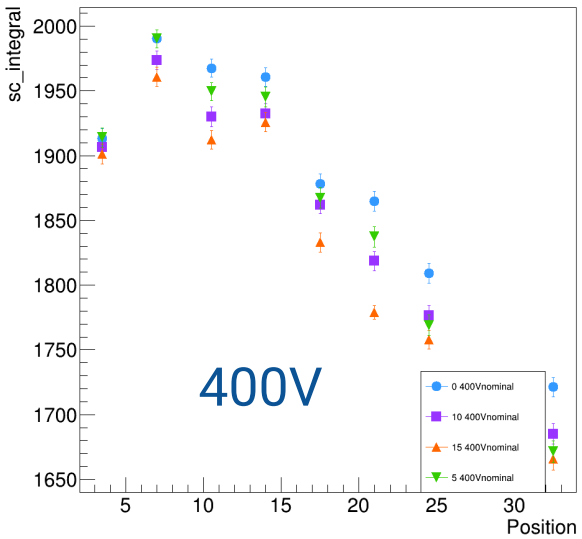
VGEM ladder scan

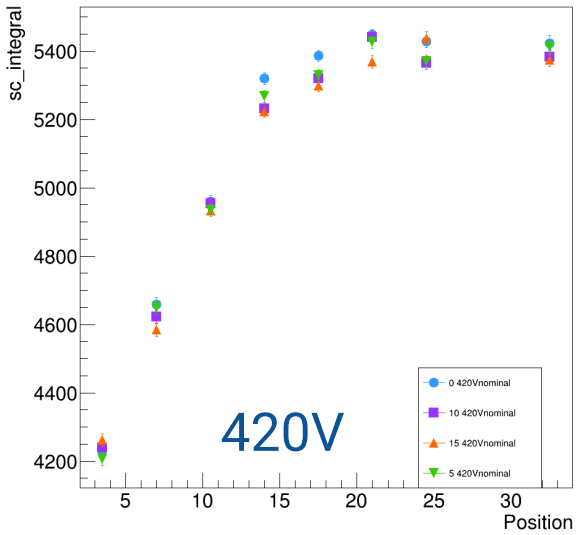
- Adopted by COMPASS/CMS GEMs to reduce charge density for spark suppression
- Proposed by RD51 group to mitigate saturation
  Fine Pitch GEMs in Triple GEM detectors - CERN Document Server

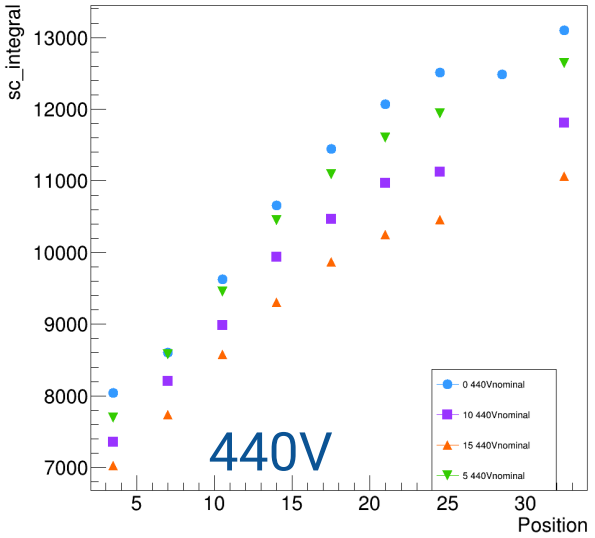


Left: VG3 scan with different T2
Right: VG3 fixed scan in VG1-VG2
NB Ar/CO2 70/30

Drift 800 V/cm, 4scans with 0,5,10,15V difference in each GEM, the sum is conserved





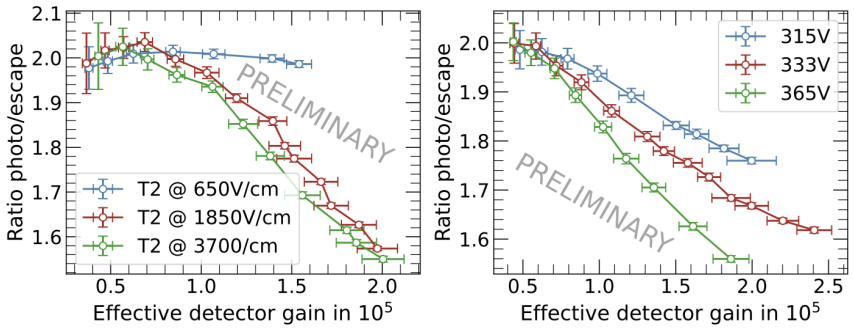


- No evident Saturation mitigation
- VGEM difference too small, indeed we are not seeing any change in sc_tgaussigma ot sc_lenght
  - Should increase the difference to appreciate the effect
- DavideP won the battle but he'll not win the war

NB-> MAXV reached for GEM3 so the sum of voltages is not conserved

Transfer Field Scan

- Reduce the Transfer field to increase longitudinal diffusion thus charge density
- We expect a loss of gain due to the reduction in electron extraction efficiency
  - Should compensate with larger VGEM like Fine Pitch GEMs in Triple GEM detectors - CERN Document Server



Left: VG3 scan with different T2
Right: VG3 fixed scan in VG1-VG2
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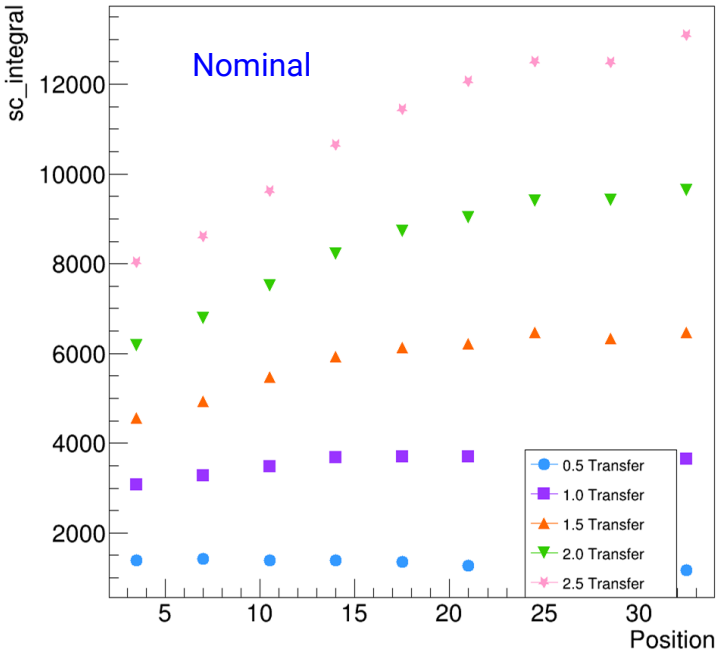
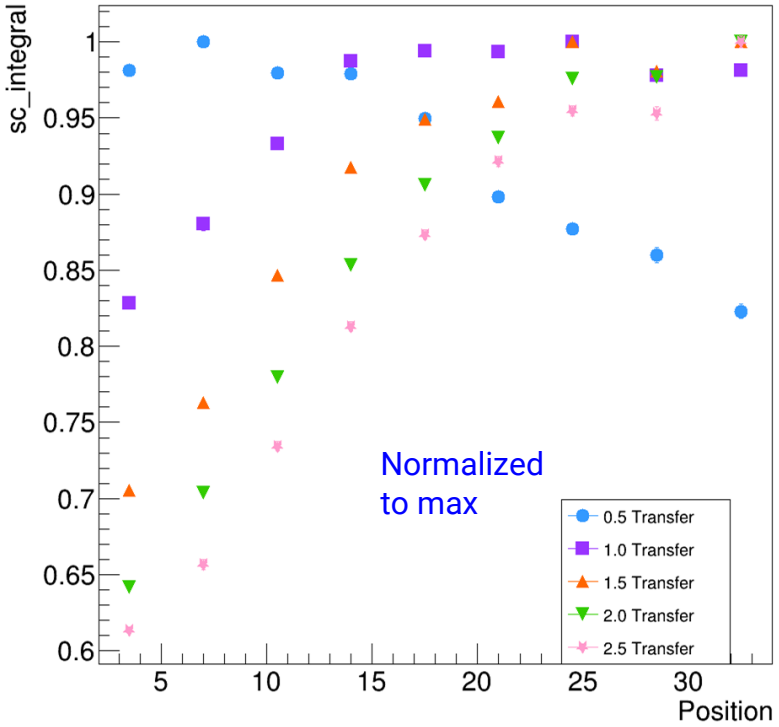


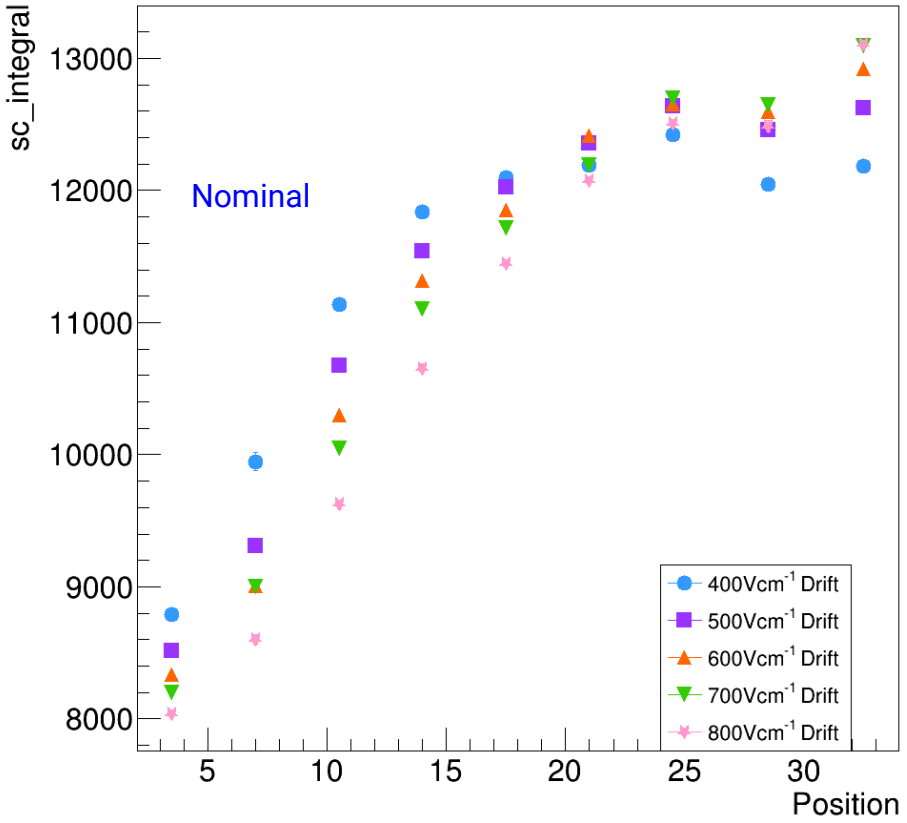


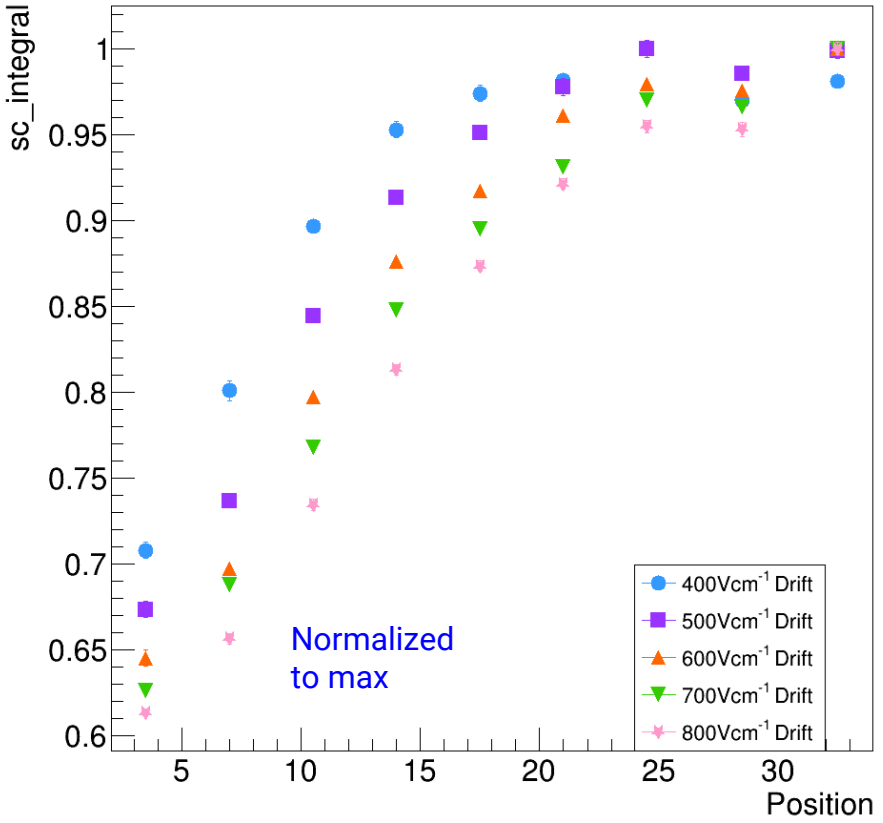
Since the gain decreased a lot we cannot disentangle the effect of diffusion and the one of reduced gain no conclusion has been made :(

Drift Field scan

- Reduce the Drift field to increase longitudinal diffusion thus charge density
- We expect a loss of primary charge at large distances because of the larger attachment

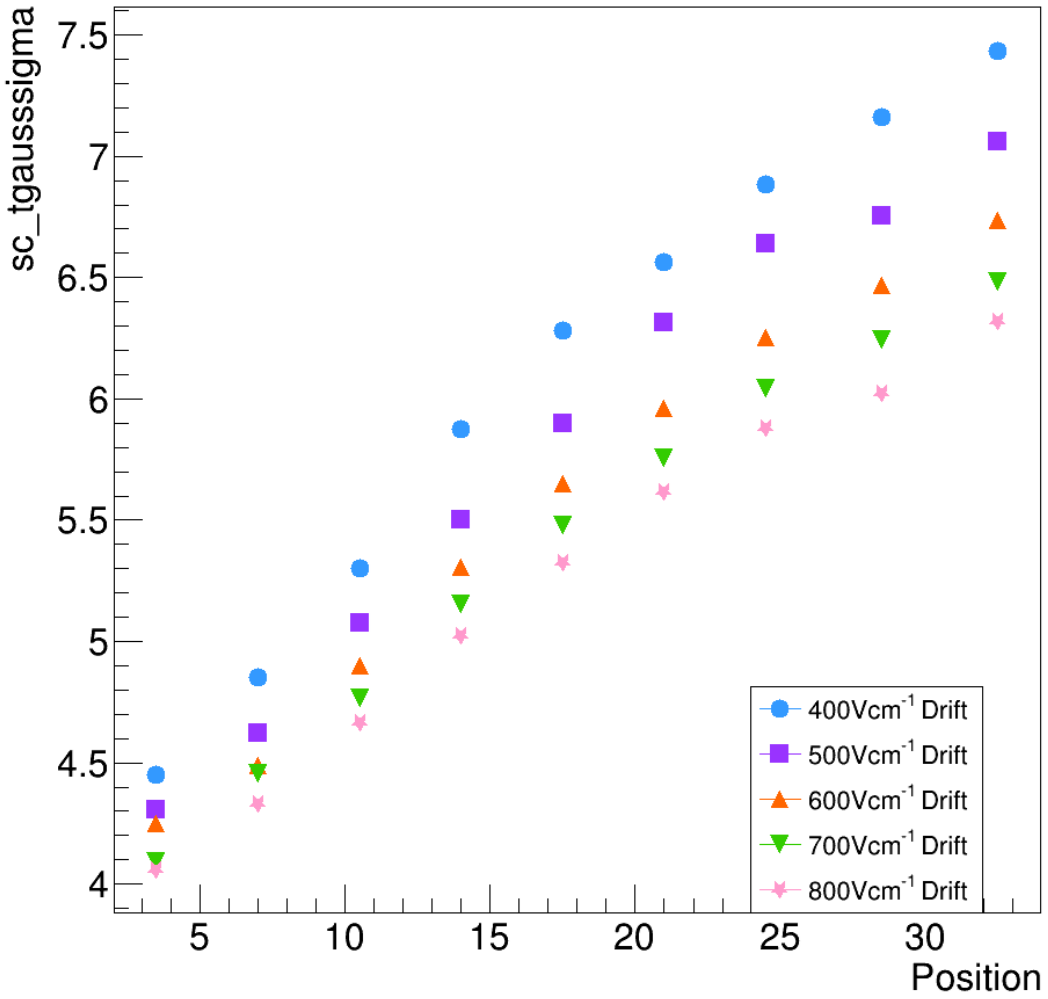
VGEMs @ 440V



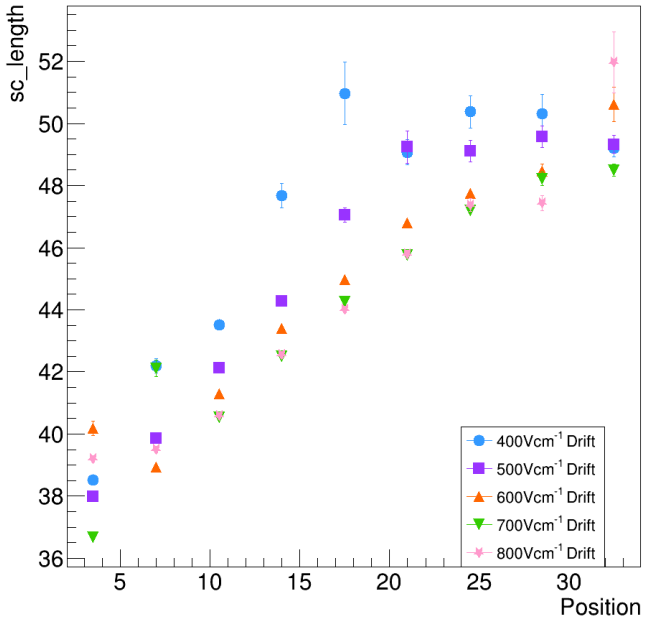


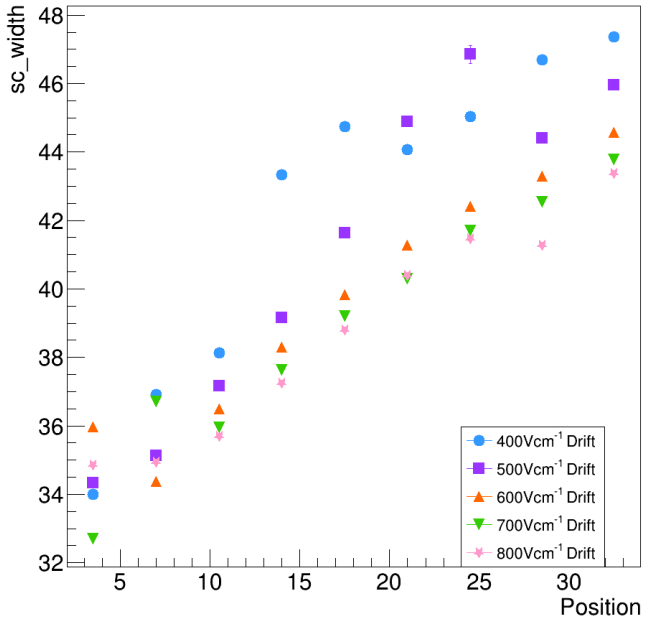
Clear Effect on saturation: the plateau is reached at lower positions i.e. the larger diffusion helps to share the same charge on more GEM holes

Drift field scan

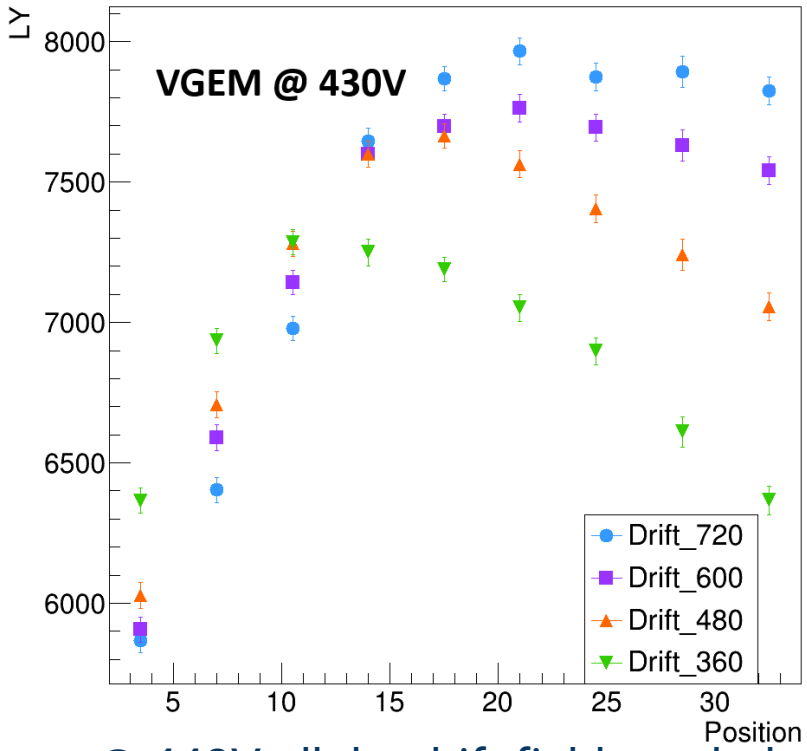


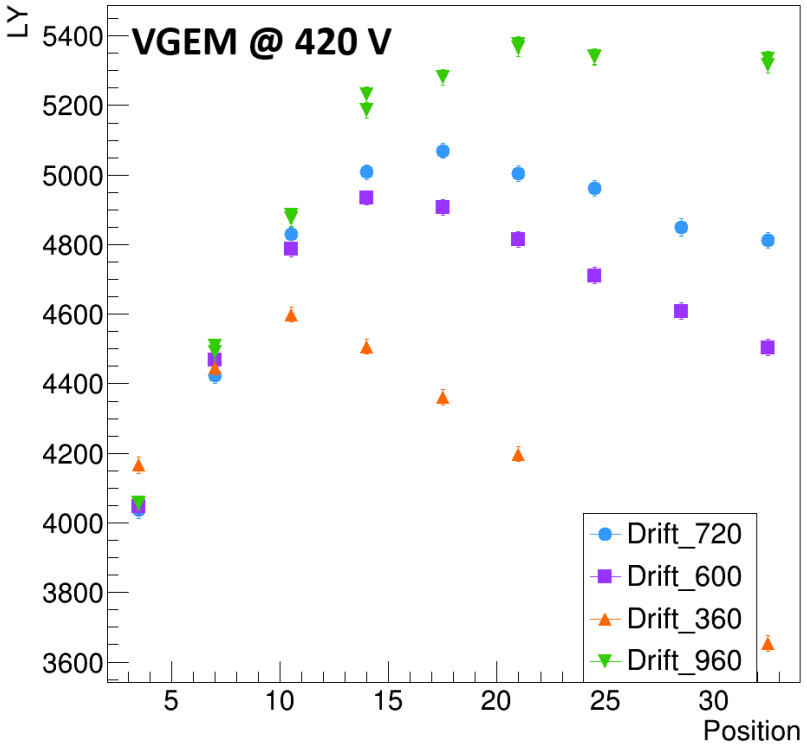
The saturation reduction is strictly correlated with the increase of the diffusion!

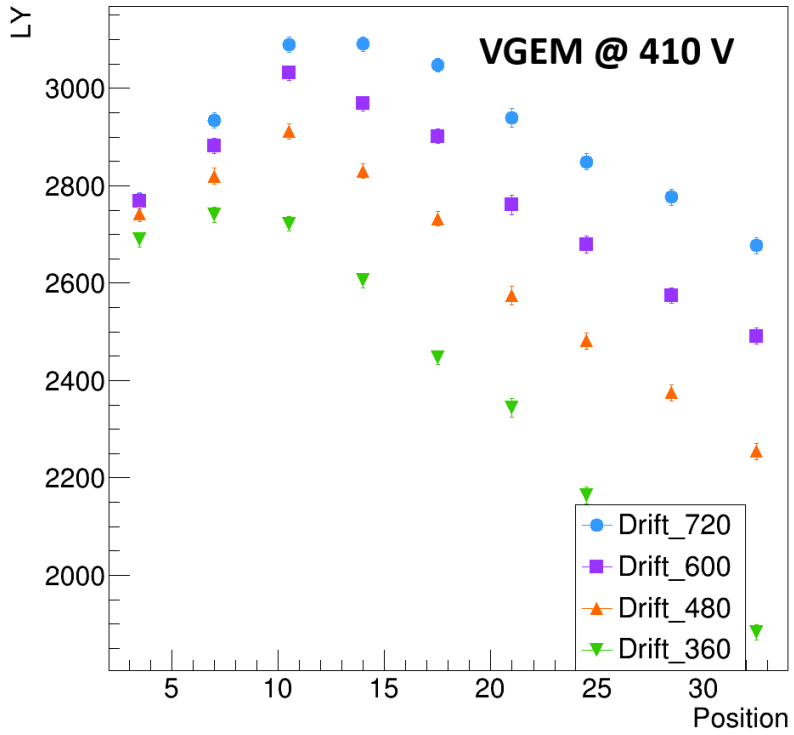




Drift Field Scan
430-420-410

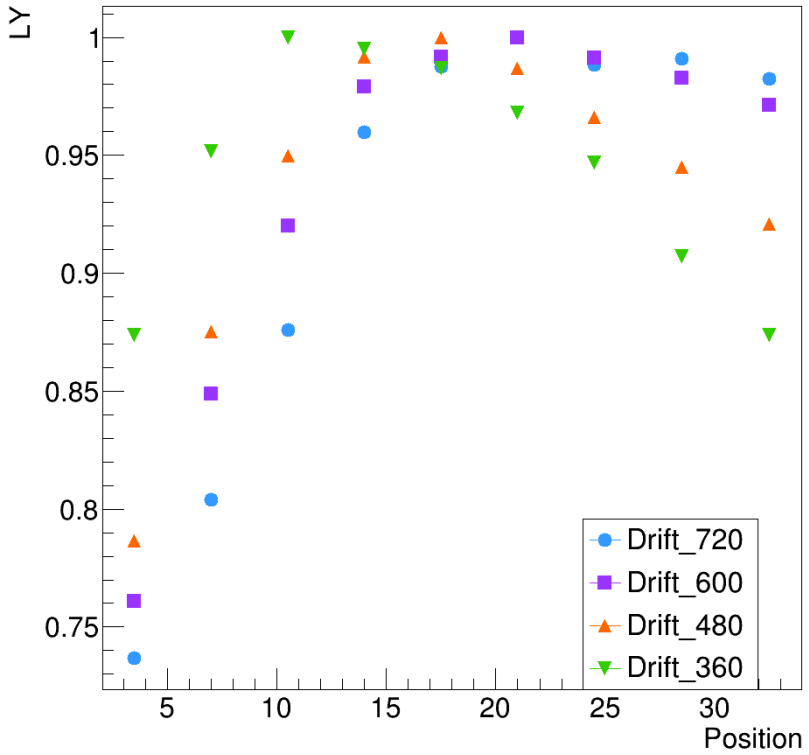


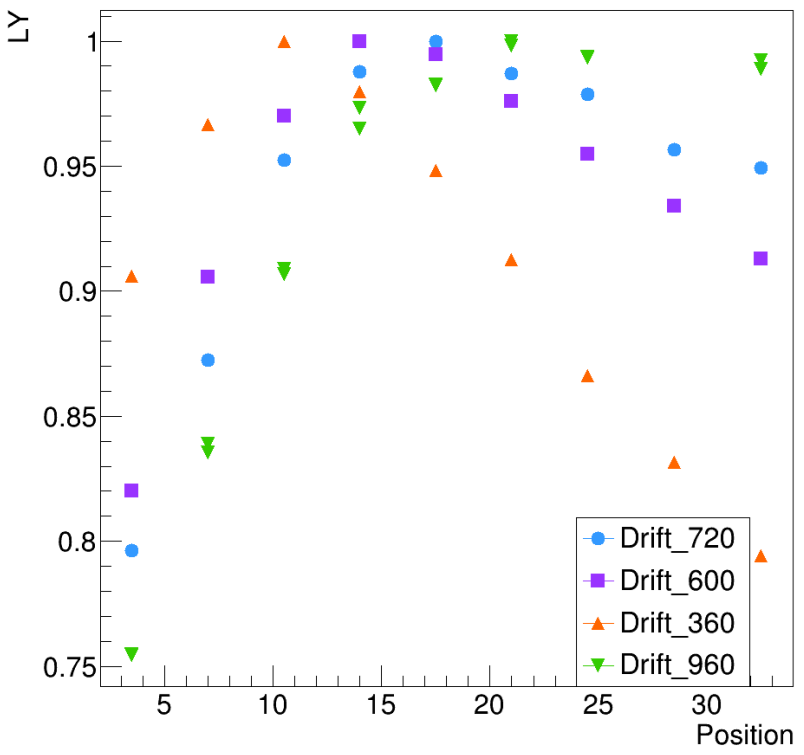


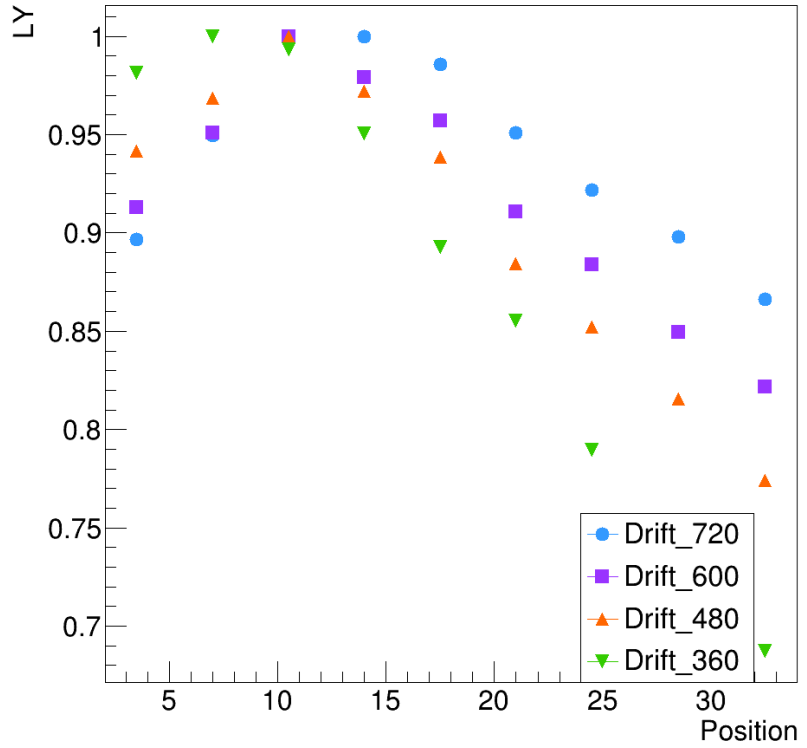


- @ 440V all the drift field reach the same light plateau
- Lower amplifications do not reach the same plateau, where is the charge?
  - Saturation mimic a lower recombination+attachement

Drift Field Scan
430-420-410 normalized







- @ 440V all the drift field reach the same light plateau
- Lower amplifications do not reach the same plateau, where is the charge?
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Conclusions

Measuring the light output as a function of the source distance

- **Indirect way to estimate the saturation!**

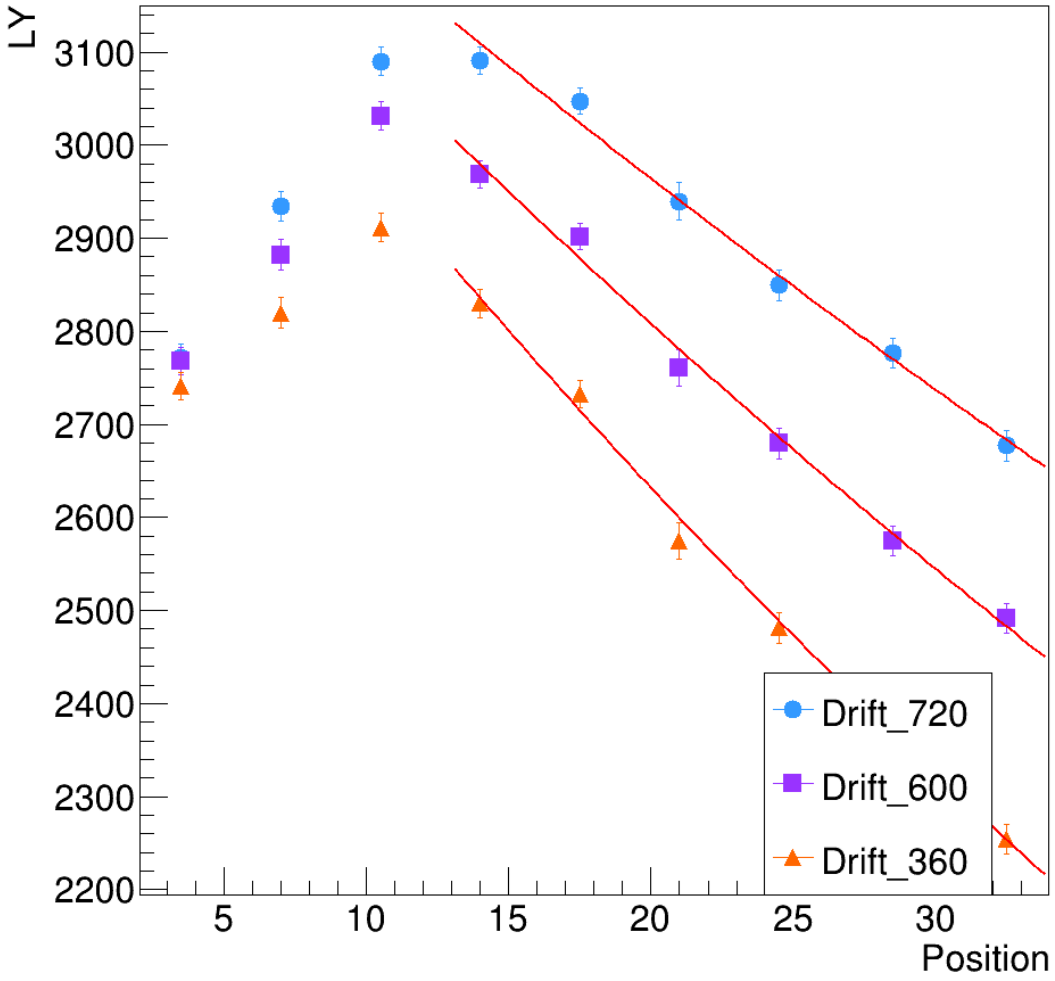
- **Ladder in VGEM** did **not** have any effect on saturation
  - Voltage difference too low indeed no variation in 5.9keV spot dimension
- **Transfer field scan** did **not** have any effect on saturation
  - Impossible to disentangle gain reduction from increase in diffusion
- **Drift field scan worked**, reduction of saturation is directly correlated with increased diffusion
  - GEM @ 440V showed a lower saturation without loss of light
  - Working @ lower V means also to lose plateau light
- If we need to find a HV configuration to **completely eliminate the saturation** and **maximize the light output** we need to do dedicated measurements!

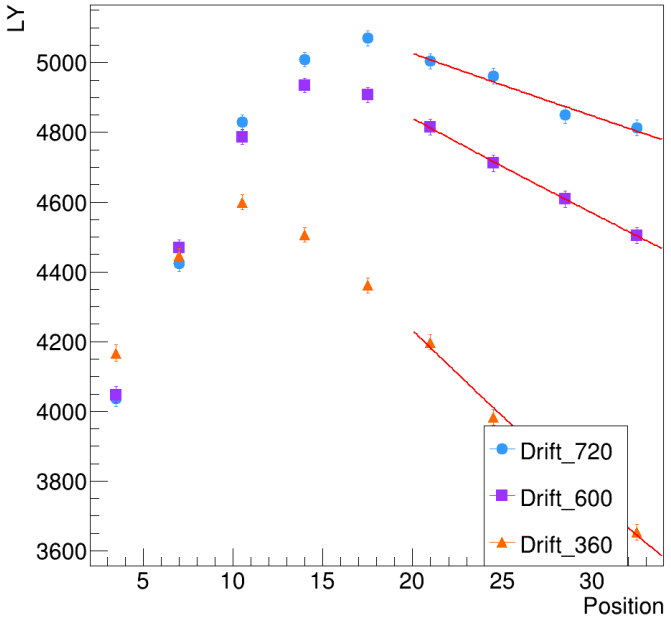
Attenuation Length

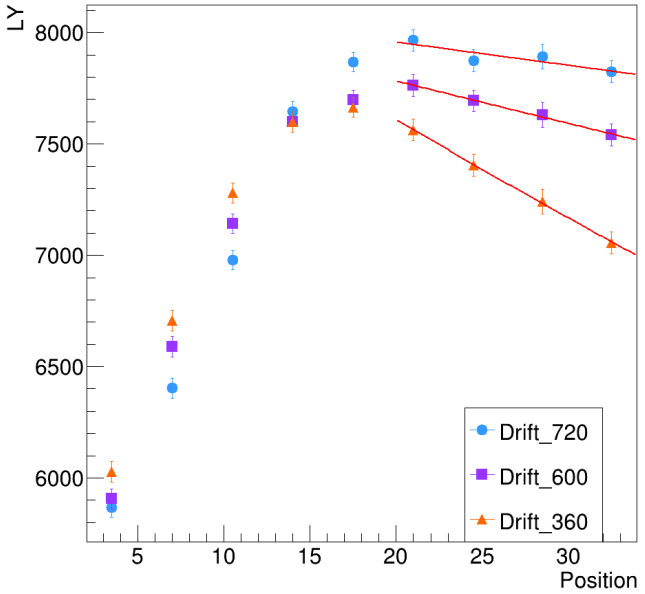
Attenuation length

Fit on descending part

Only possible on Drift scans 430-420-410
No descending part in 440VGEM

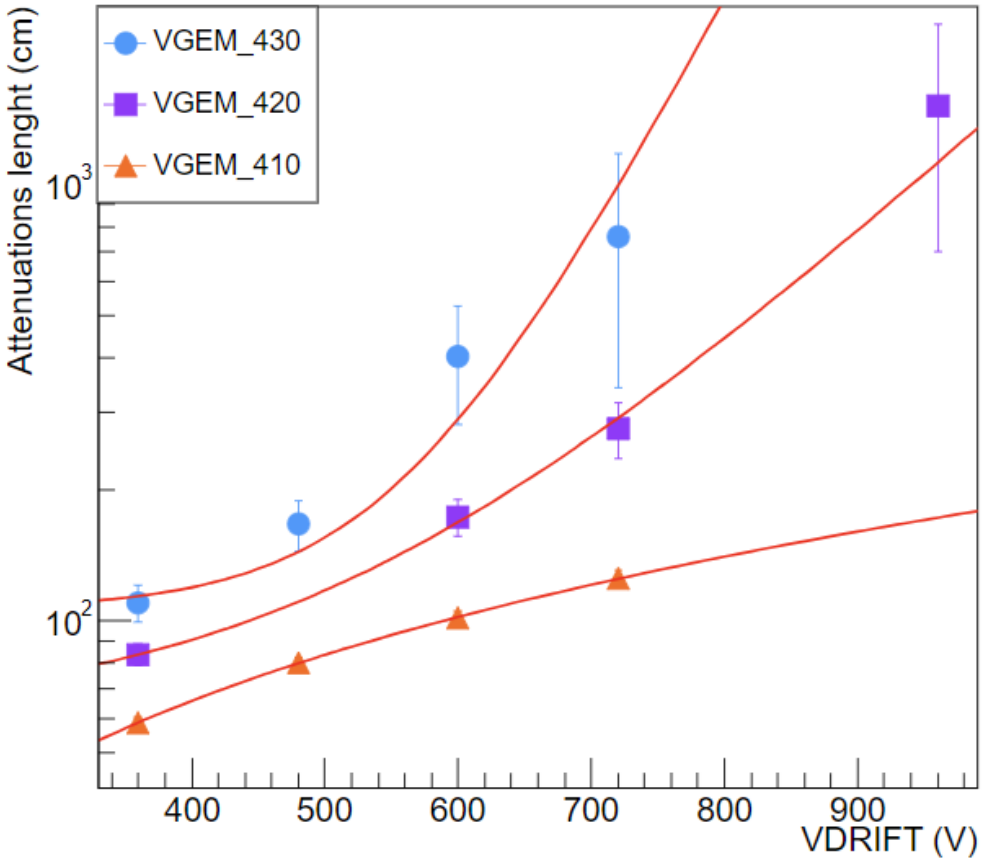






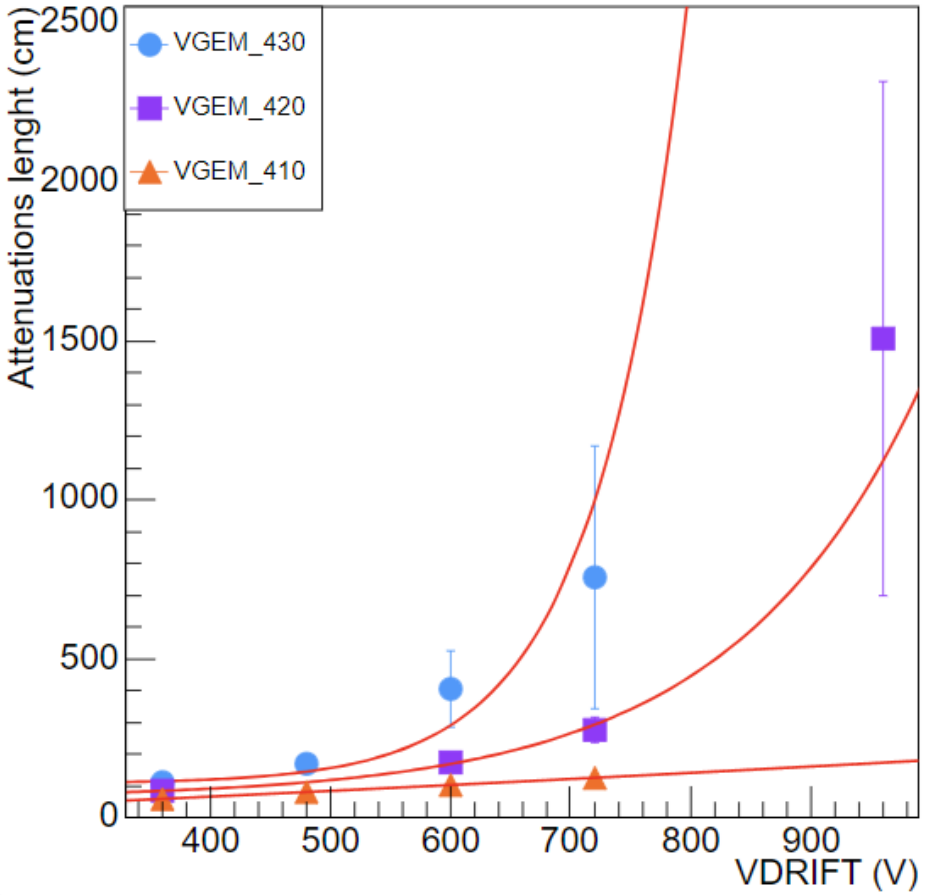
Attenuation length

Attenuation length measured in LIME…
If no saturation → the 3 curves should be the same!

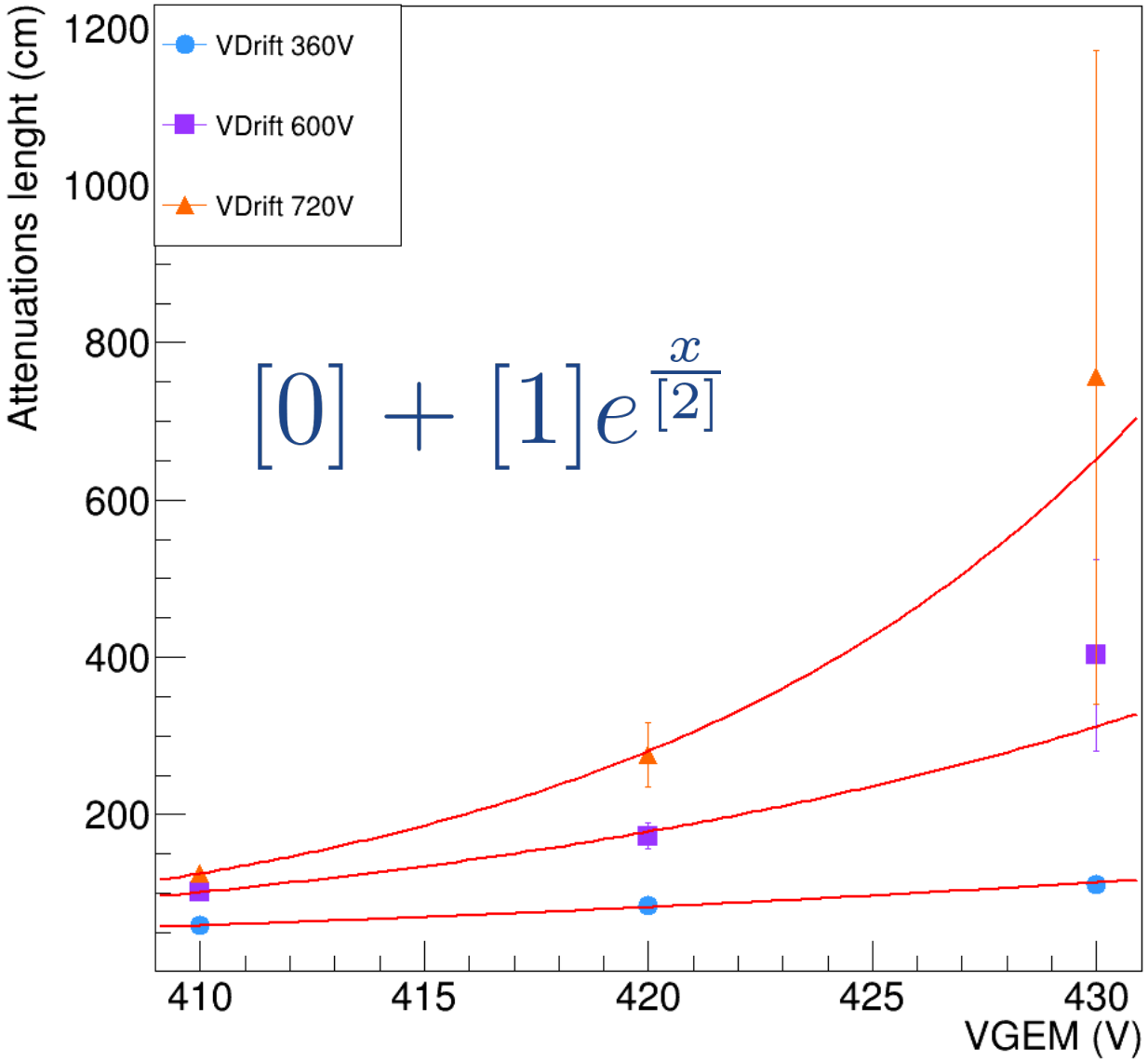


Saturation mimic a lower diffusion i.e. a larger attenuation length

$$[0] + [1]e^{\frac{x}{[2]}}$$



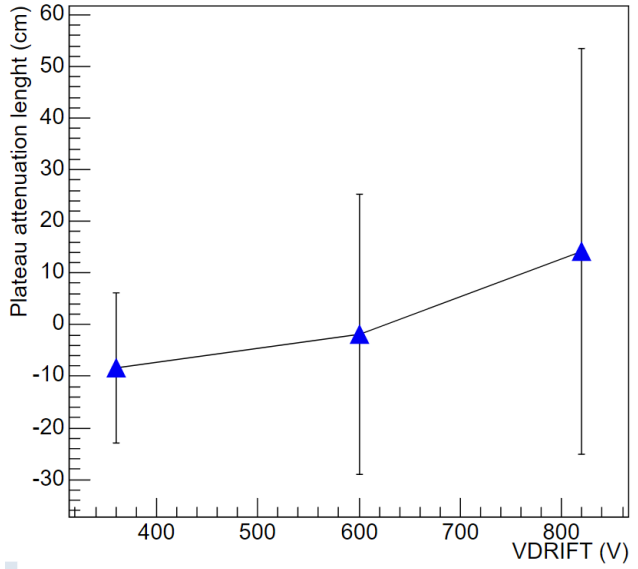
Check for asymptote



When Drift field is the same we may look for asymptote for attenuation length (like Raphael did with VGEM scan)

- Such dataset is not suited for that (only 3 VGEM point
- Average of the 3 asymptote:

  -4.9 +/- 12.2 cm



Saturation measurement proposal

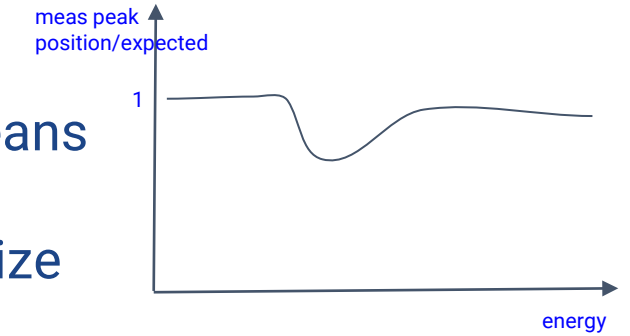
Measurement proposal for Saturation/Gain optimization

Goal → No Saturation at 1cm (or less) drift distance, Highest Light output possible

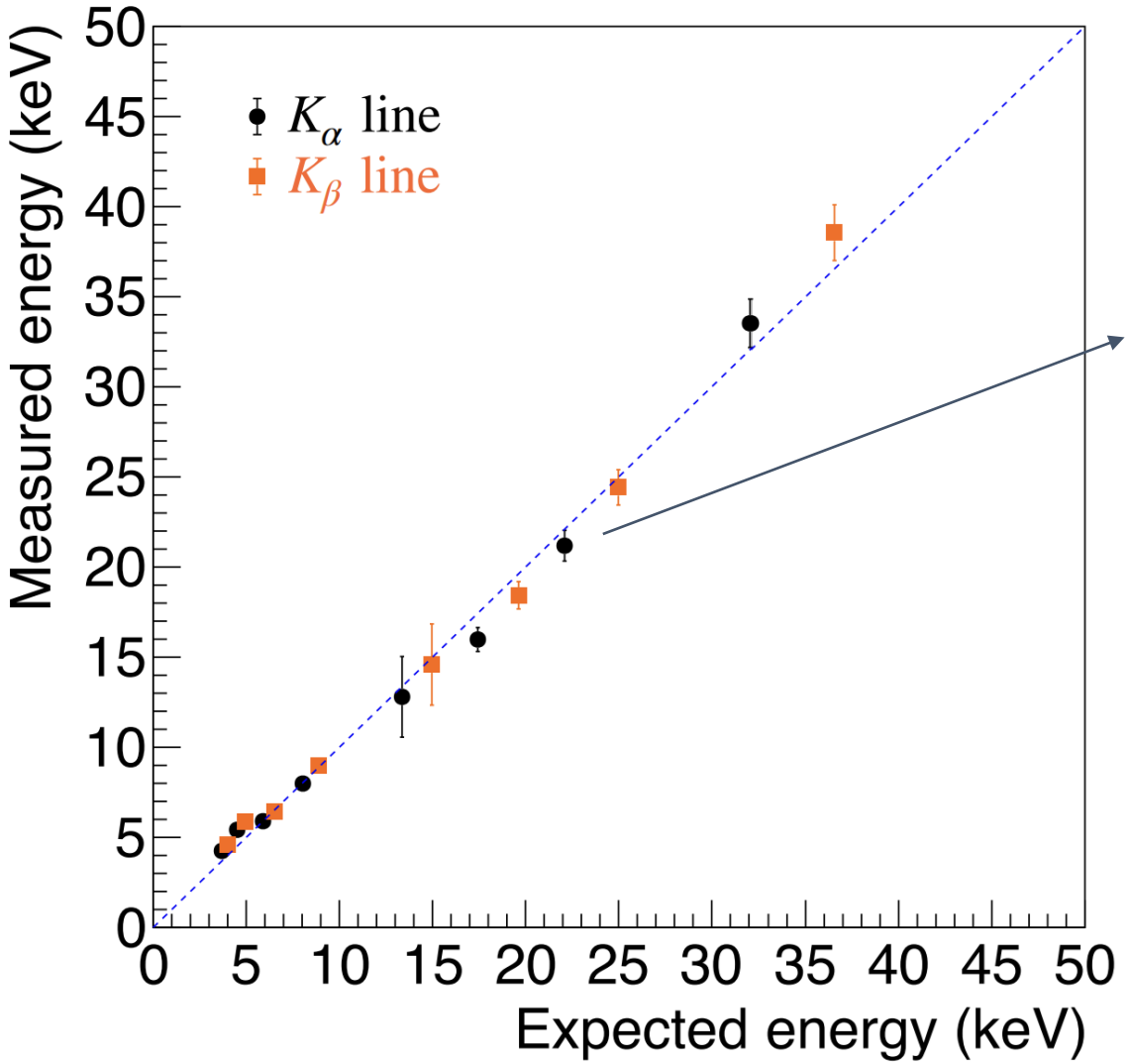
How → Measure the absolute saturation at a certain energy!

Element	k_α [keV]	k_β [keV]
Cu	8.04	8.91
Rb	13.37	14.97
Mo	17.44	19.63
Ag	22.10	24.99
Ba	32.06	36.55
Tb	44.23	50.65

- We need multiple energy peaks:
  - The first one should be lower as possible (3.7keV Ca and/or 4.5 keV Ti)
  - Larger energies peaks will be used to measure the saturation
  - e.g. Iron spots at 5.9keV 1.6 times larger than 3.7keV reference means no saturation at 5.9keV
  - Then it is matter to play with Drift/Transfer/GEM voltages to optimize the light output while having a flat saturation curve



Try with LIME commissioning data



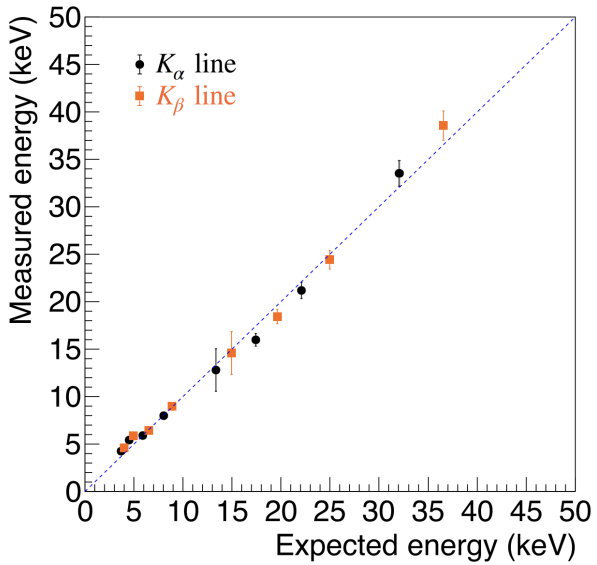
Data taken at LNF with multiple sources

2022-10-19-collmeet-roma (infn.it)

Data extracted with webplotdigitizer!!!!

Numbers	Description	PMT
5790-5860	Multi-source High Statistics	No
5861-5911	55Fe: BKG and High Statistics + Water Cooling	No
6121-6141	Titanium + BKG High Statistics	Yes
6143-6290	Calcium + Pedestal Very High Statistics	Yes

Try with LIME commissioning data

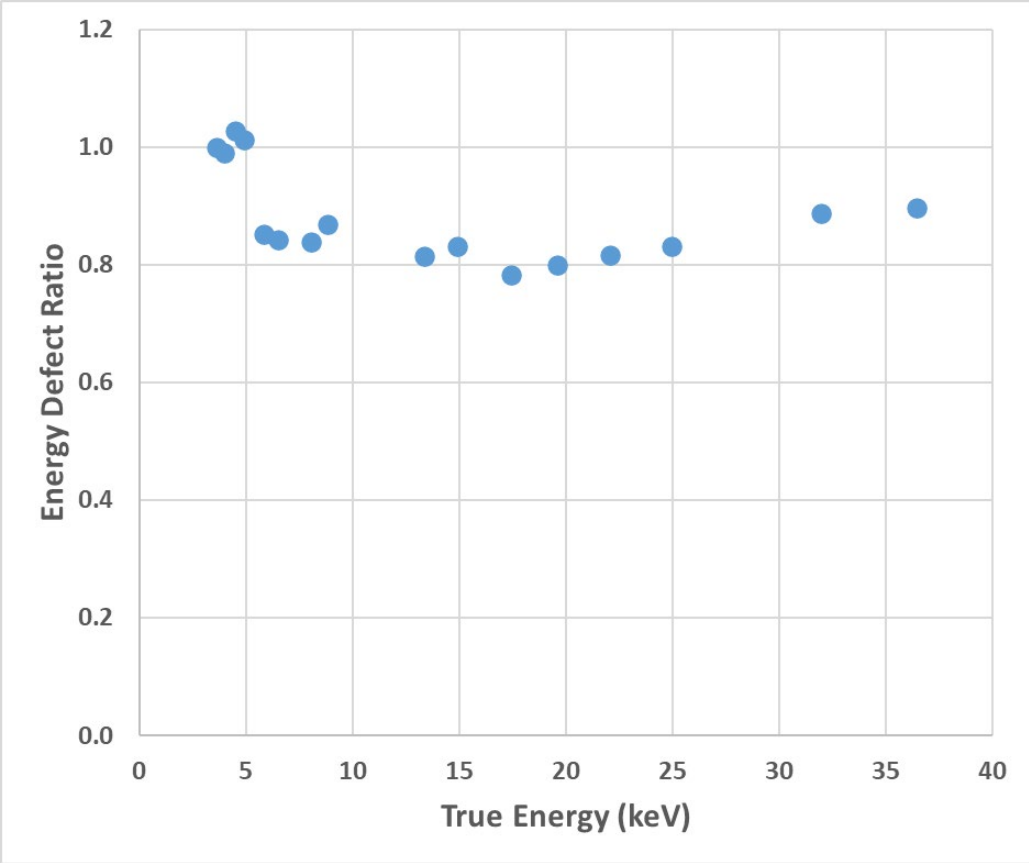


- **Expected distance of a peak from the Ca_Ka one**

$$E^{meas} / E^{meas}_{Ca_{K\alpha}}$$

- **Measured distance of a peak from the Ca_Ka one**

$$E^{expec} / E^{expec}_{Ca_{K\alpha}}$$



If the 2 ratios are equal there is **no saturation**

I.e. The ratio of ratios is equal to 1

This data shows huge saturation from iron energy up to → ALWAYS

I didn't find any info about LIME WP during this test :(