# STUDY OF THE CHARGE-UP EFFECT IN RESISTIVE MICROMEGAS DETECTORS

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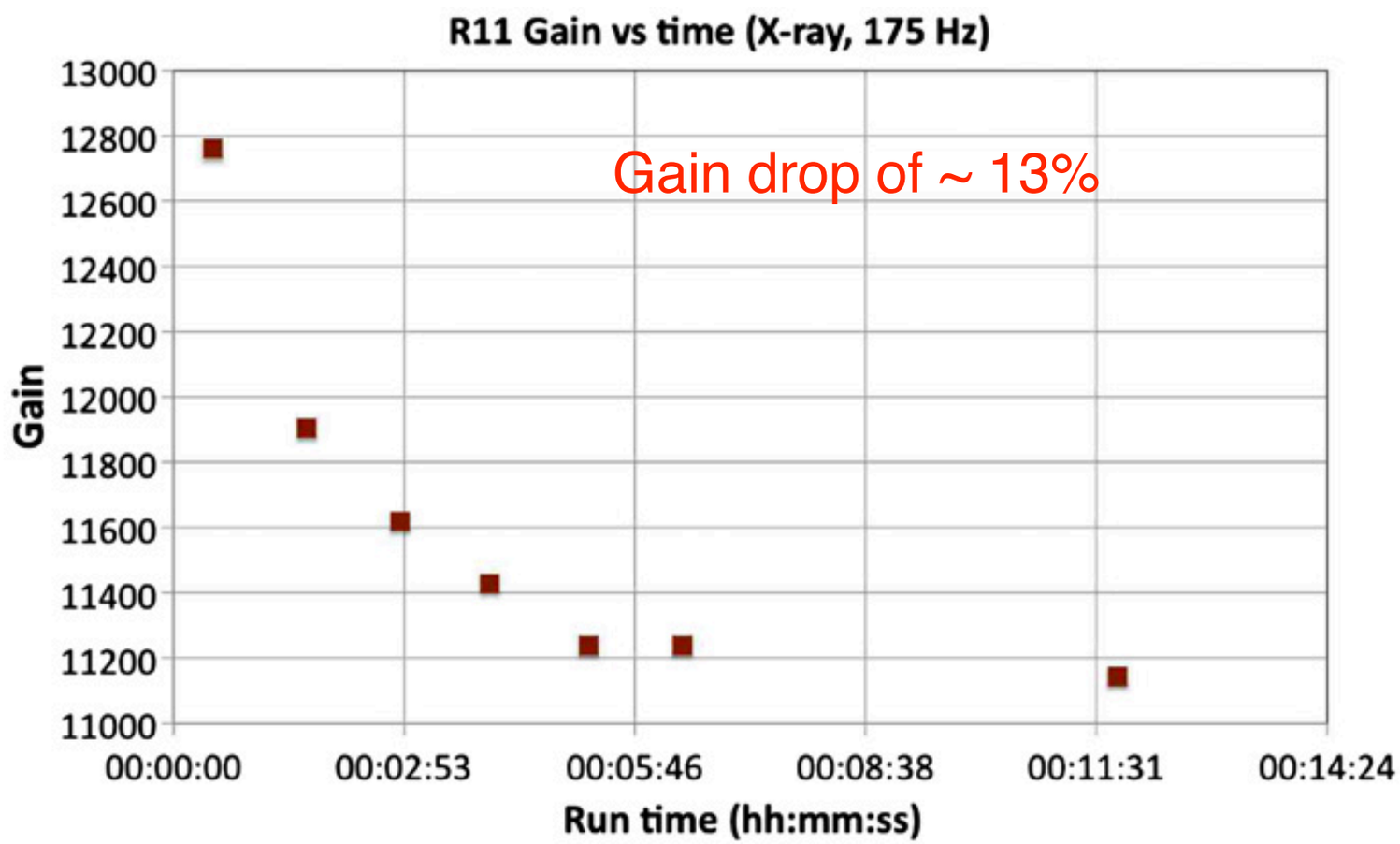
# Introduction

The charging up effect is well-known in detectors containing dielectric materials and it is due to the charges created in an avalanche and collected on the dielectric surfaces




T. Alexopoulos et al., *NIMA 640* (2011), 110-118

R11 chamber characteristics : 250 $\mu$m strip pitch, 150 $\mu$m resistive strip and 100 $\mu$m insulator



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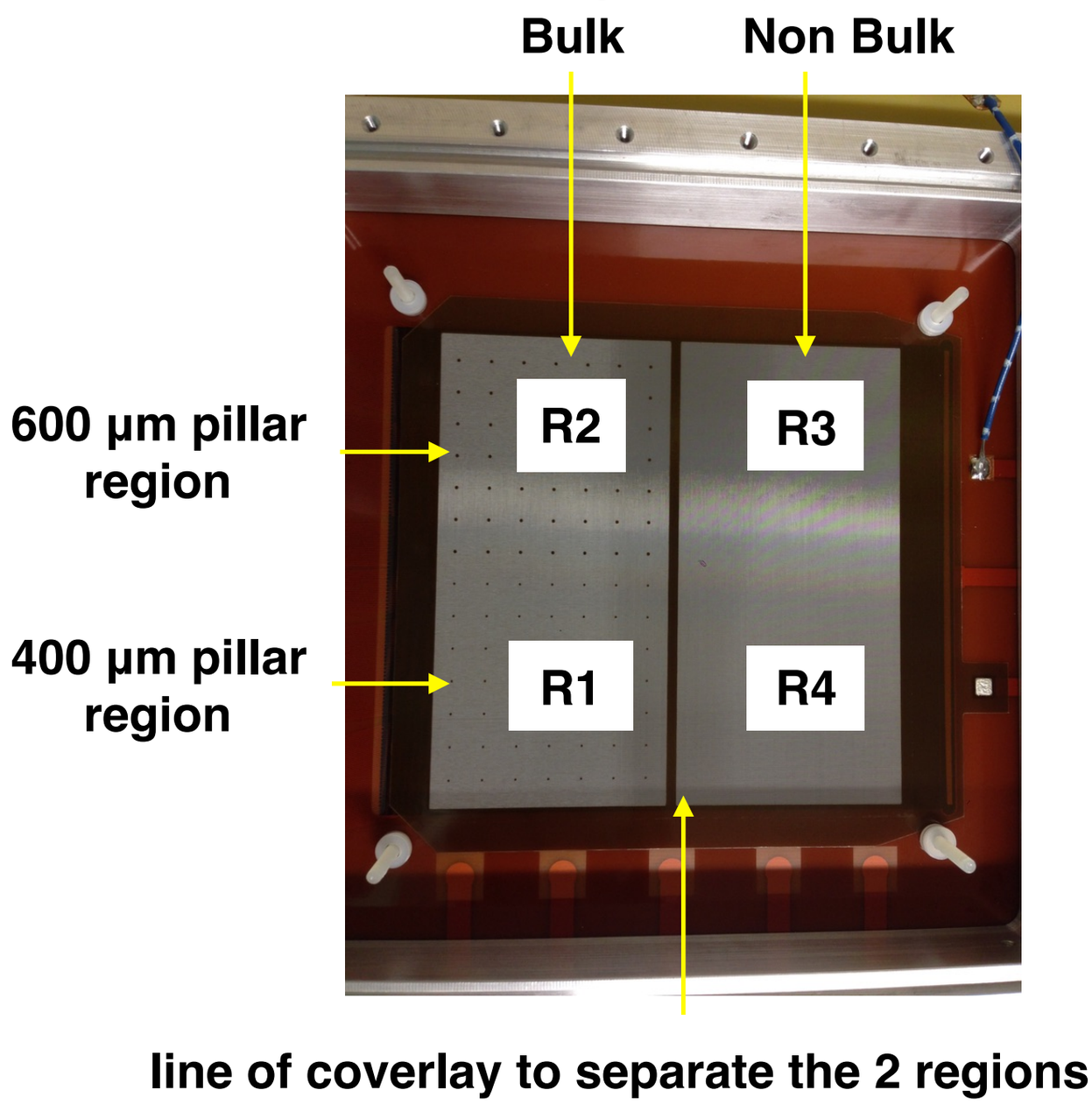
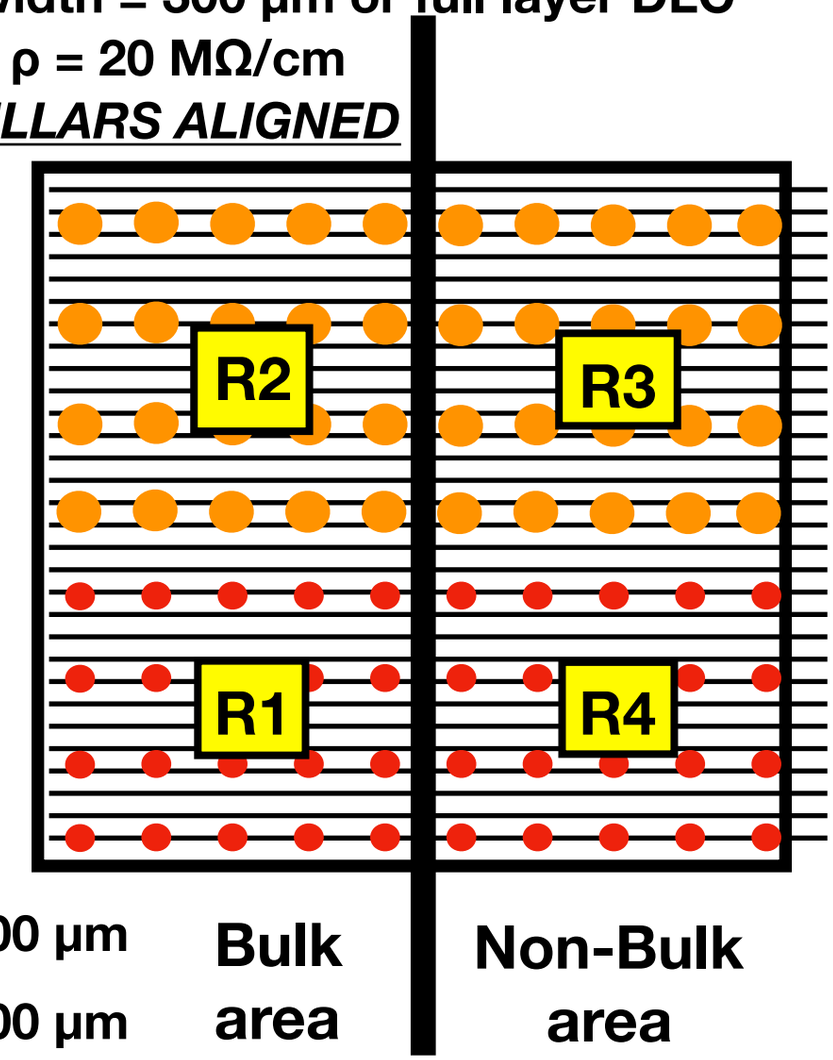
# Description of the different chambers

*Chambers built @ CERN (Rui)*




**T chamber layout : strip pitch = 400 µm**
**width = 300 µm**
**gap = 100 µm**
**Resistive strip width = 300 µm or full layer DLC**
**ρ = 20 MΩ/cm**
***PILLARS ALIGNED***




● ∅ pillars : 400 µm
● ∅ pillars : 600 µm
**Pillar pitch = 7 mm**

**2 chambers built with this geometry : 1 DLC and 1 resistive strips**

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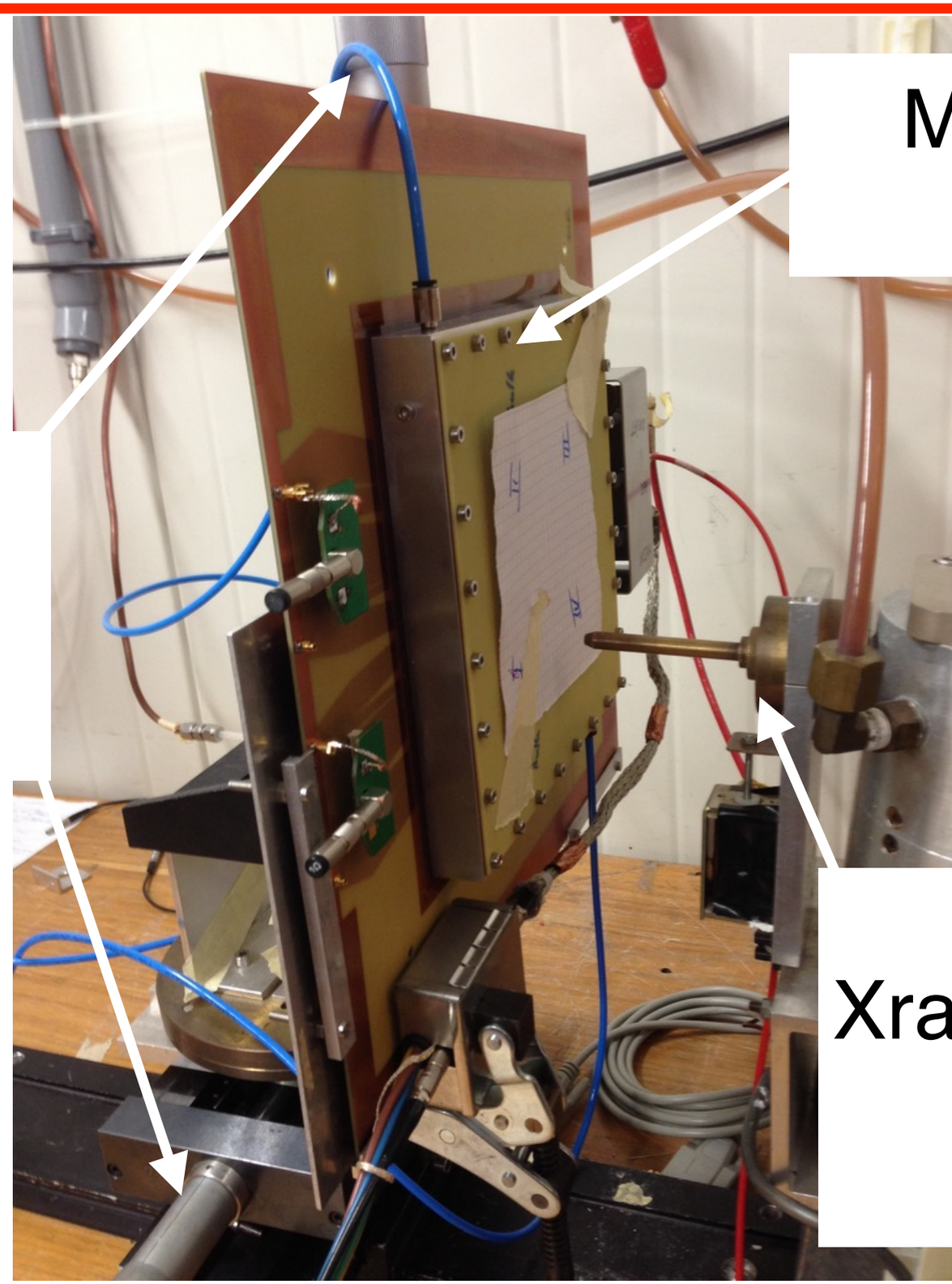
# Description of the setup




*Measurements have been performed in the RD51/GDD lab @ CERN.*



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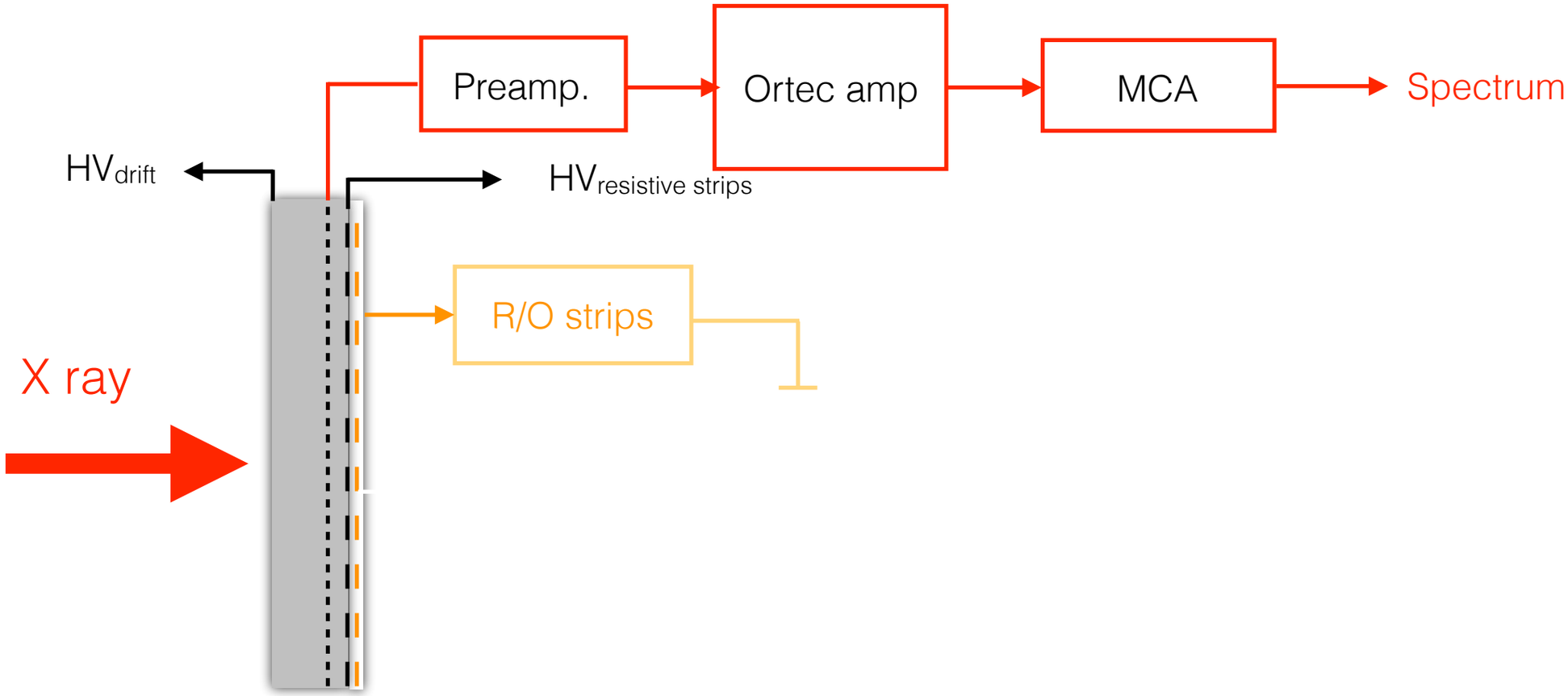
# Measurement setup




**Goal :** **use the response of the detector to 8 keV X-rays to study the charge up**

**Constant parameters :**

1. **HV drift = -300 V**
2. **HV resistive strips = 540V (non bulk) and 530V (bulk)**
3. **HV X-ray = -16 kV**
4. **Collimator : ∅ 1mm (spot of ∅ 3.6mm)**

***The setup is common for resistive-strip and DLC chambers.***



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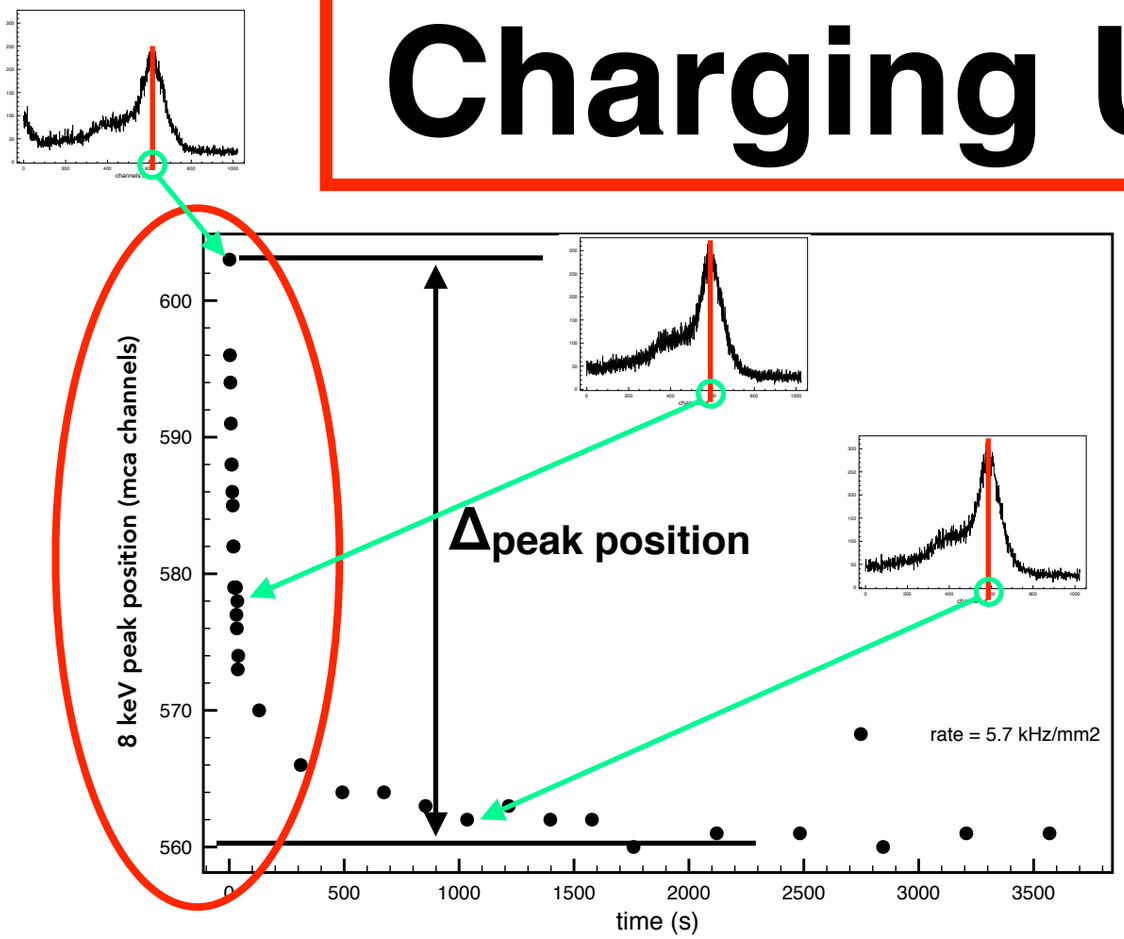
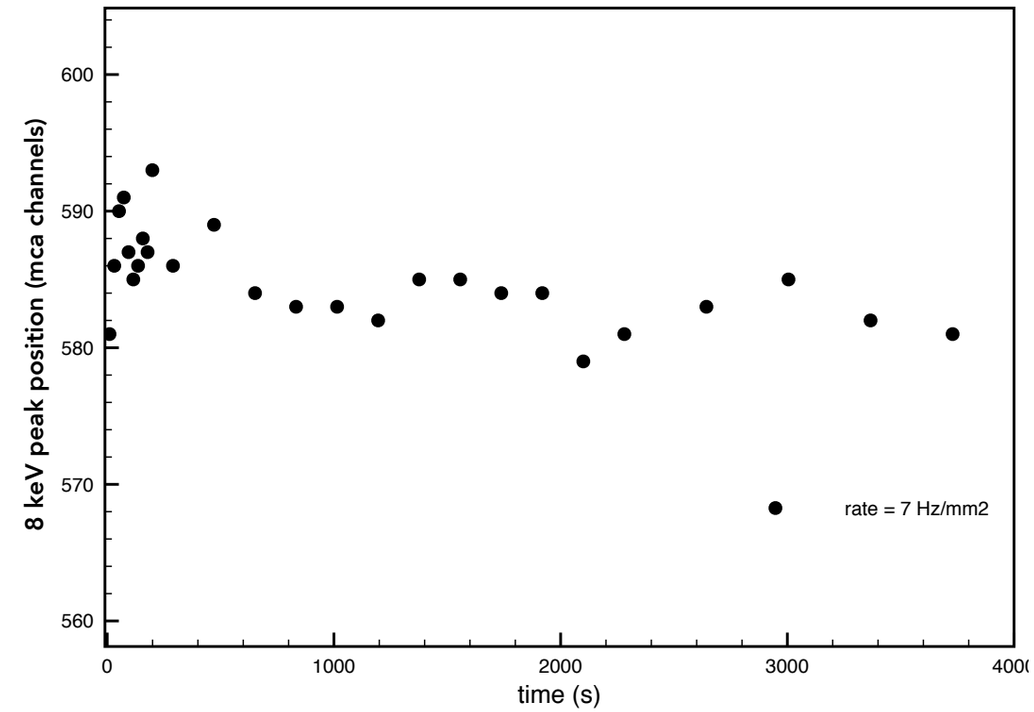
# Charging Up parameters



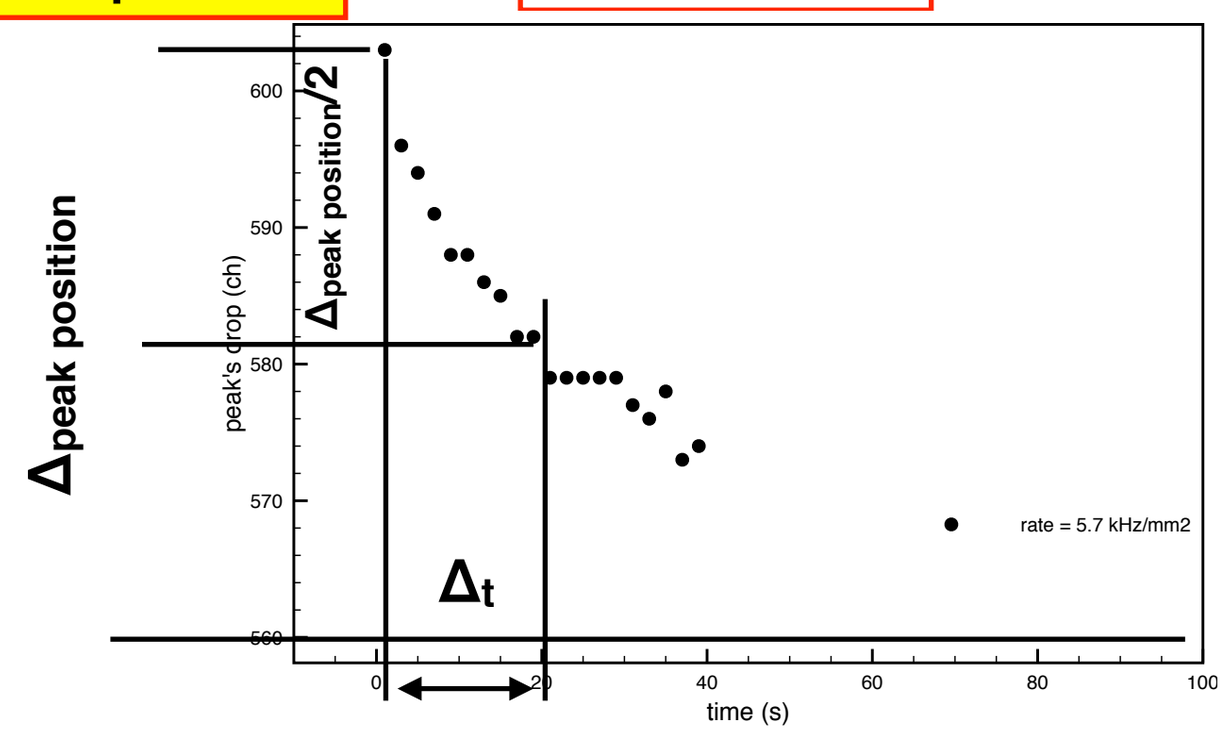

High rate

Peak position drop vs time

Low rate

**Charging up parameters definition**

1. $\Delta_{peak}$ is equivalent to the gain drop
2. $\Delta t$ corresponds to the time it takes to reach half of the peak drop (arbitrary choice)




Dropping time $\Delta_t$

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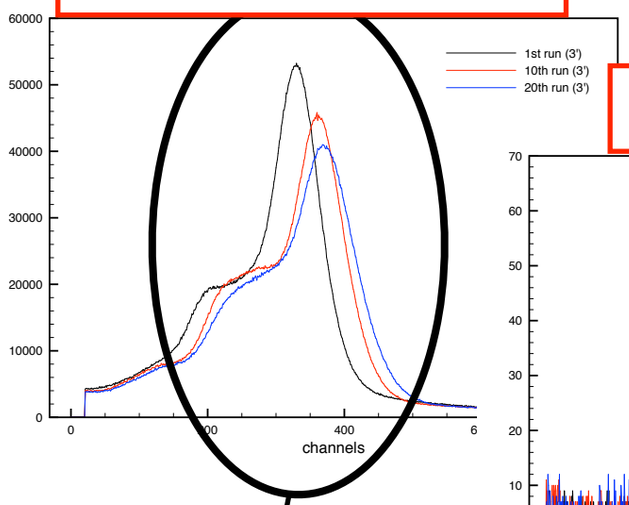
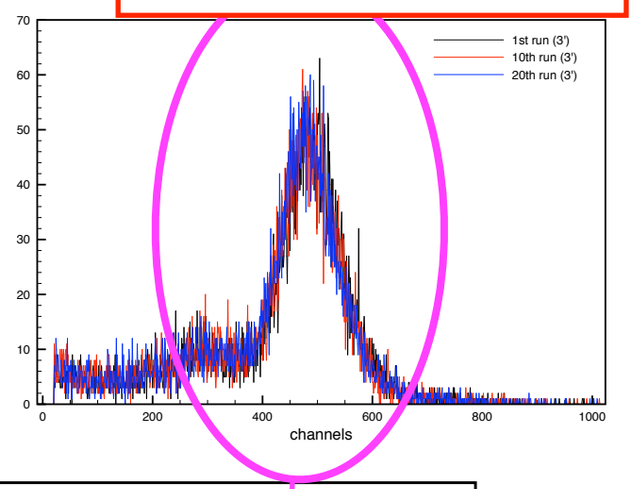
# Charging up in the strip chamber

**Rate = 4.7 kHz/mm²**

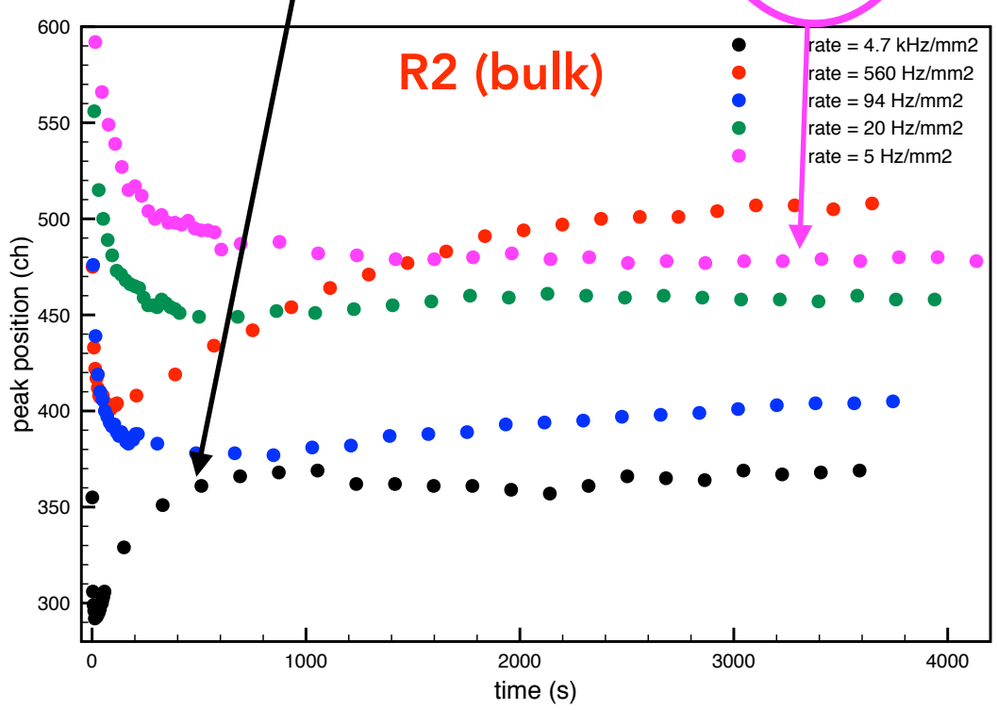


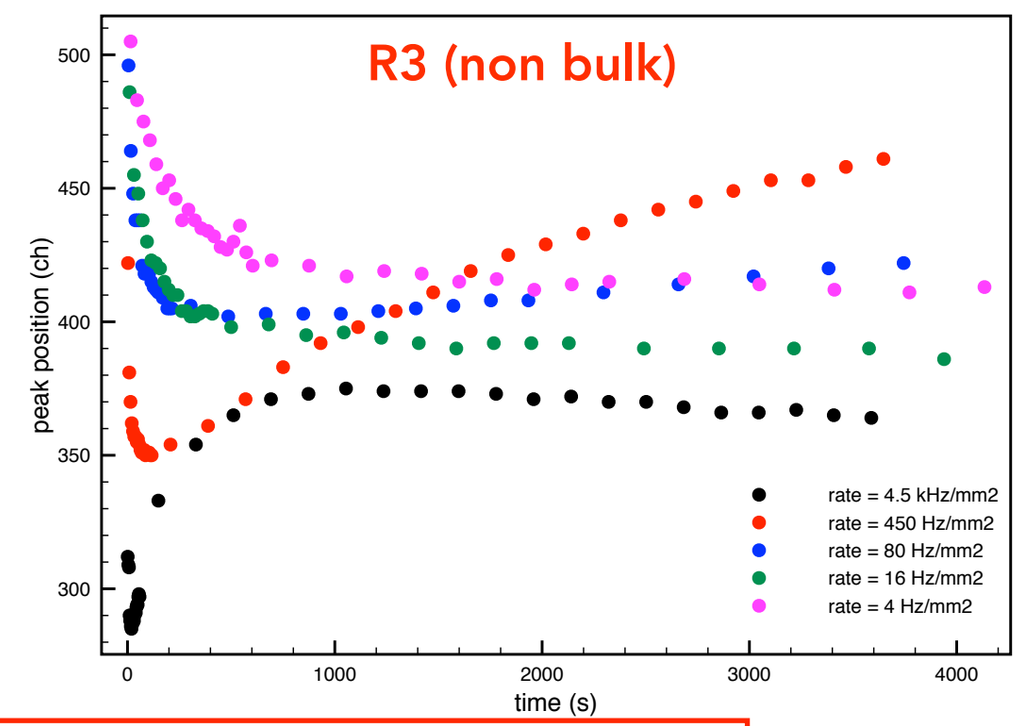

**Rate = 5 Hz/mm²**




**Data taken between pillar**

1. At lower rate : observe only the drop and stable situation
2. At high rate : observe a drop and rise to a kind of equilibrium (not yet understood)
3. Bulk and non bulk region show a similar behaviour




**The bulk region has a higher gain : higher response with 10V lower on the res. strips than for the non bulk region. The reasons is the larger amplification gas gap in the non-bulk region**



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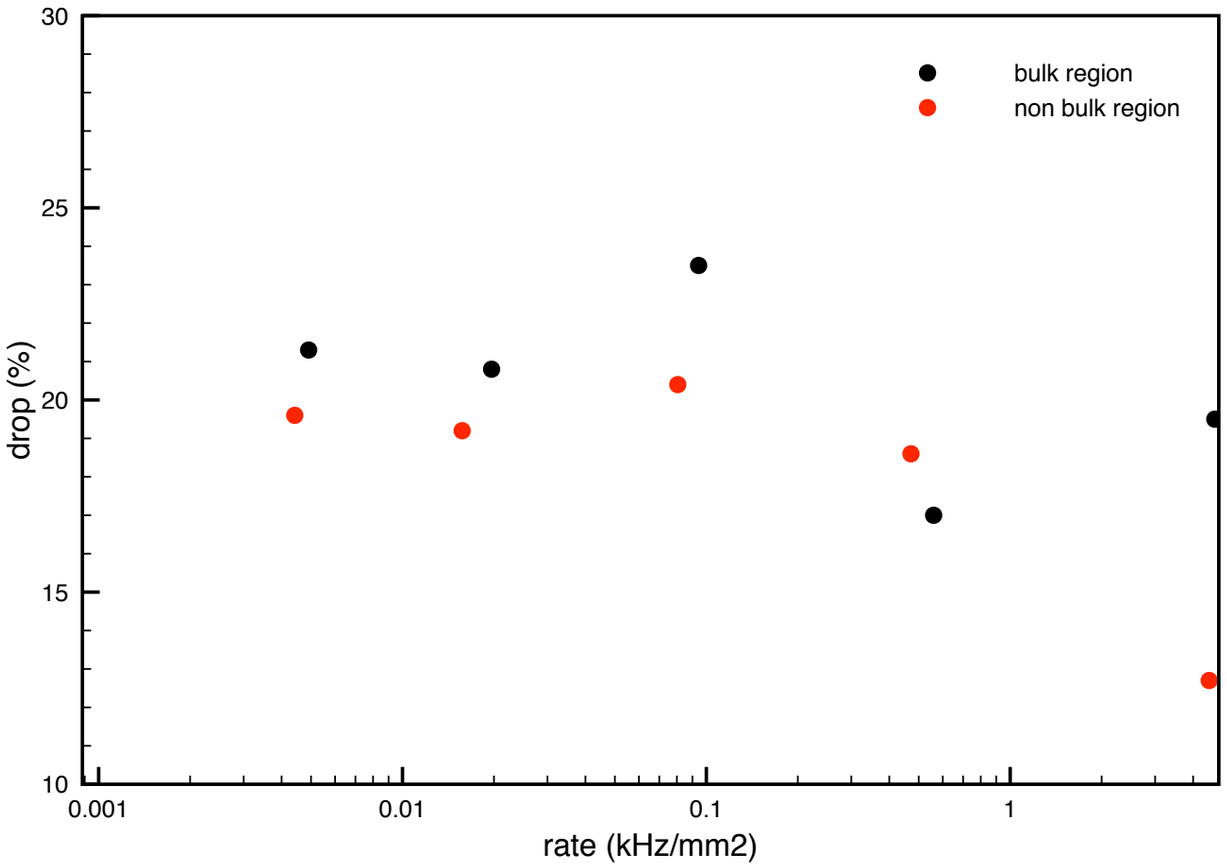
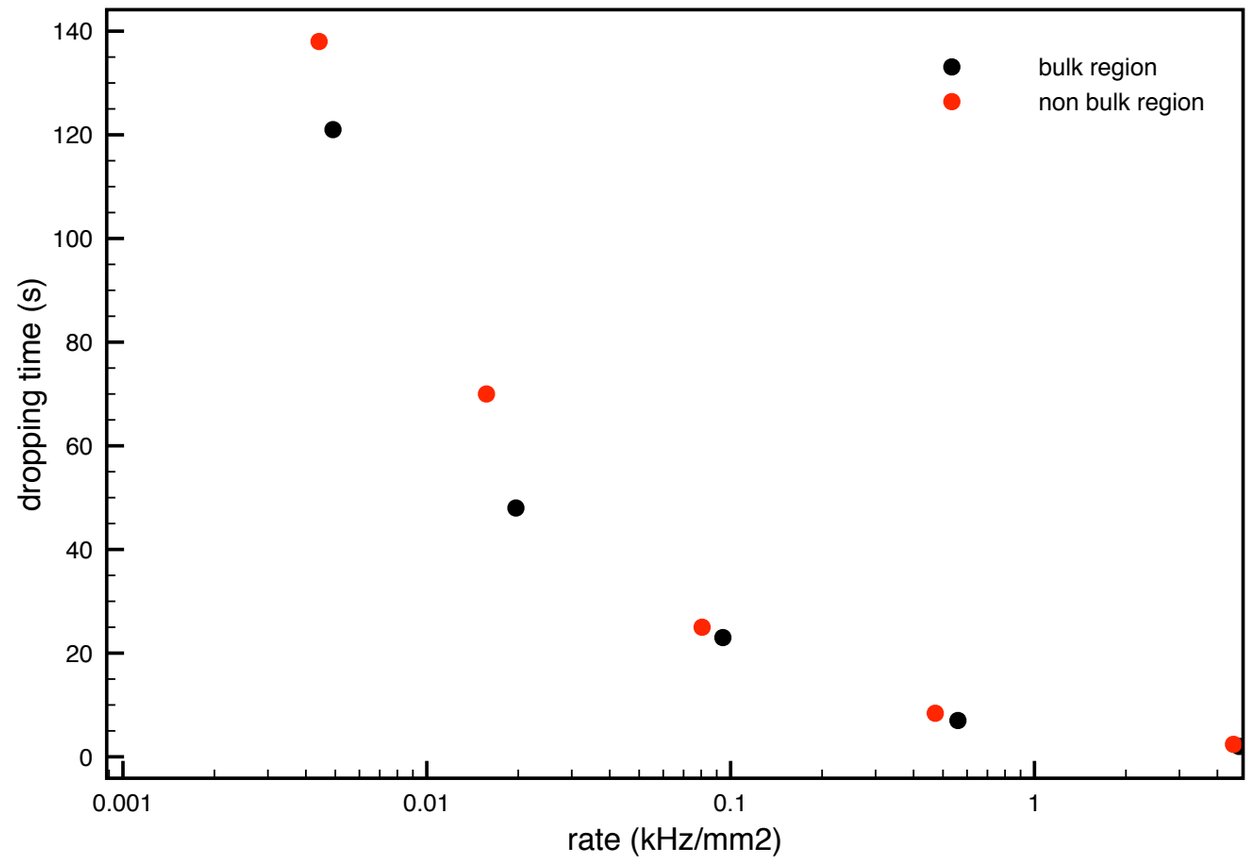
# Charging up in the strip chamber

**Data taken between pillar**




1. **Relative drop vs rate seems to be constant (O 20 %) except for the last point (non bulk @ 4.7 kHz/mm²)**
2. **The 'dropping' time increases with a decrease of the rate (i.e. ~ 2s @ 4.7 kHz/mm² to ~ 100s @ 5 Hz/mm²)**
3. **For both parameters (relative drop and time), do not observe any significant difference between bulk and non bulk region**

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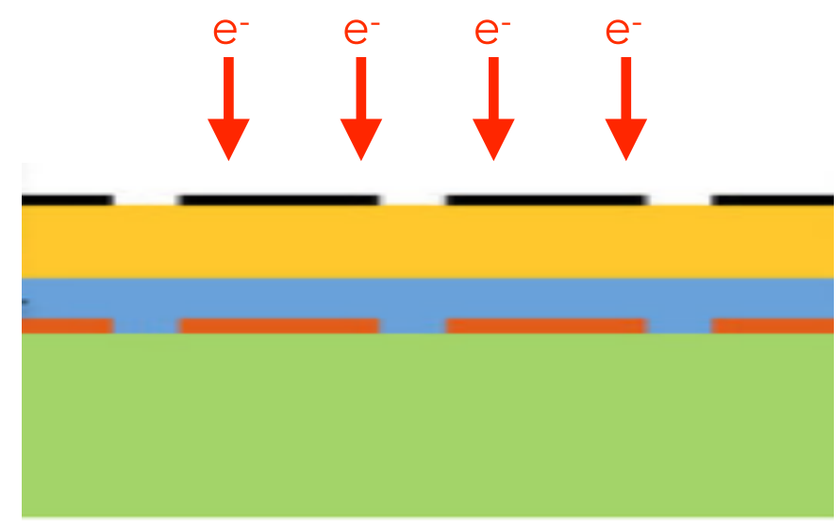
# Charging up in the strip chamber

**Possible scenario**


res strips @ 540 V (but also the insulating layer between the strips)

Drop of the voltage on the insulating layer

1. **Without irradiation : All the surface is @ 540 V (resisitive strips and insulating material between strips).**
2. **When irradiating ⇒ start to deposit $e^-$ on the dielectric (and to some extend @ very high rate on the res strip) leading to a drop of the voltage of the insulating material (creating a dead area (no gain) on top of the insulating material) ⇒ drop of gain (move the peak to lower channels).**



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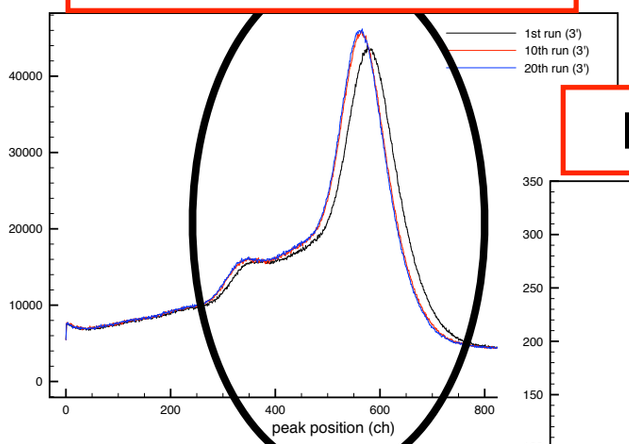
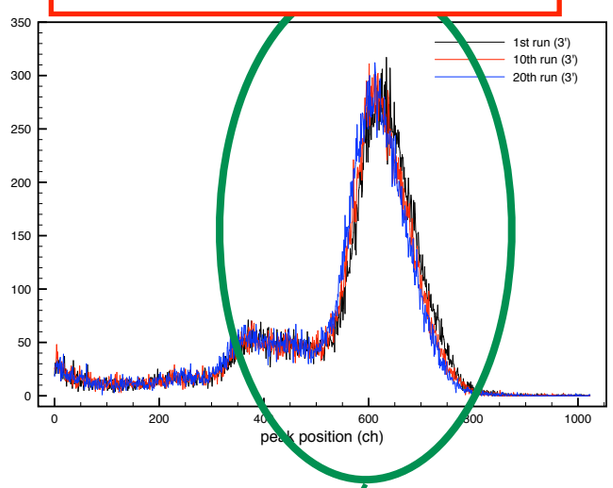
# Charging up in the DLC chamber

**Data taken between pillar**

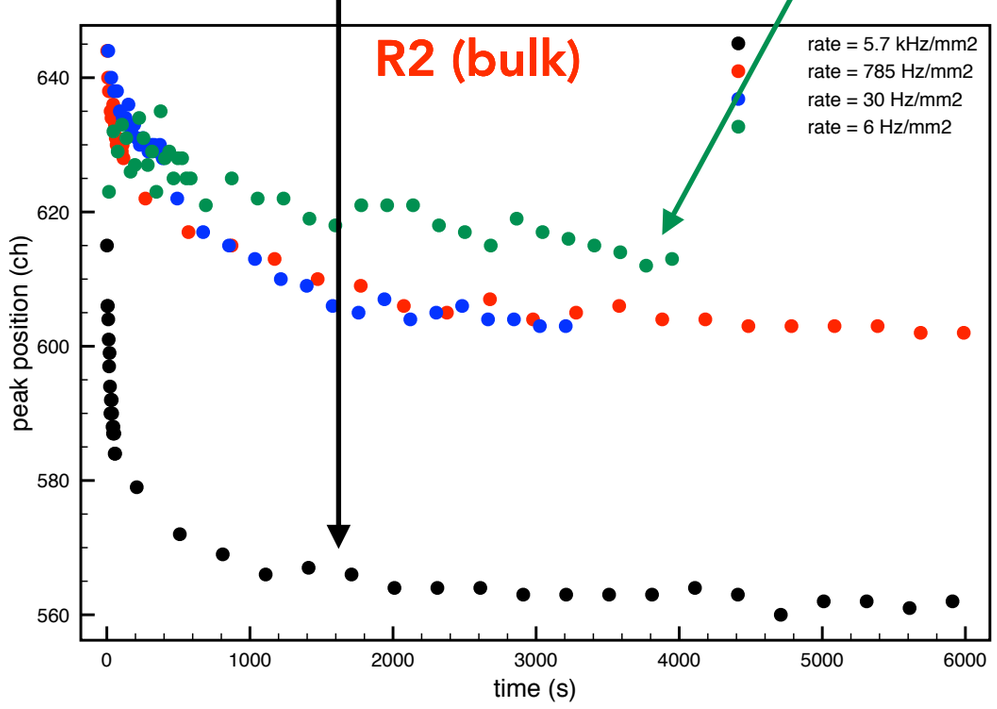
**Rate = 5.7 kHz/mm²**

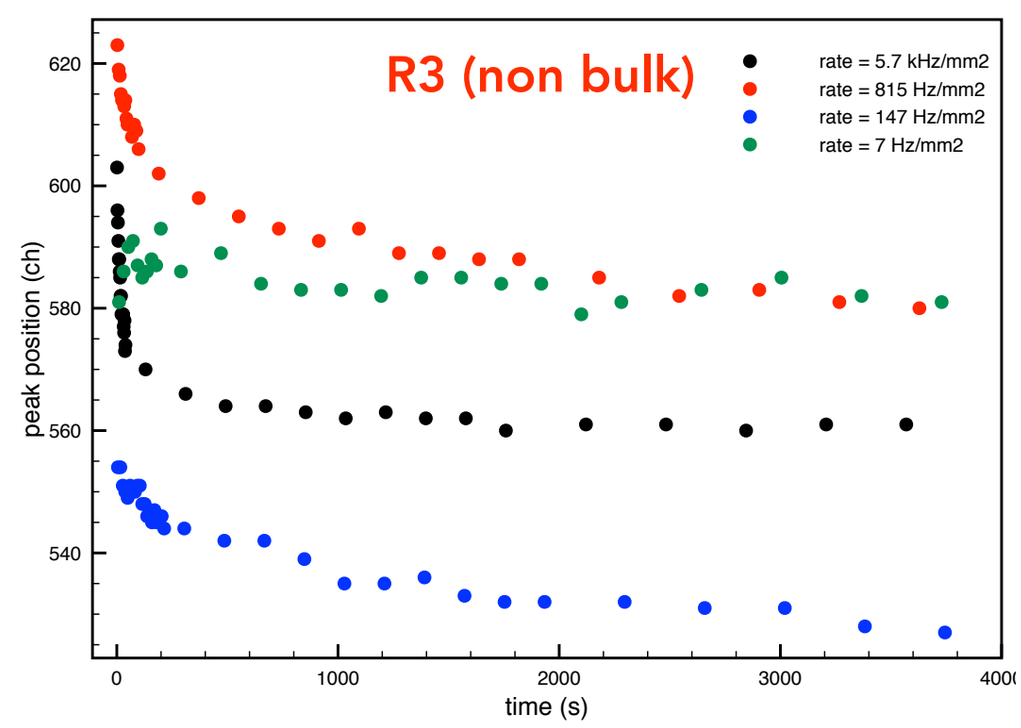



**Rate = 5 Hz/mm²**




1. Contrary to what one could expect we observe also a charge-up effect in the DLC detector.
2. Observe a slight drop with a rate increase
3. Bulk and non bulk region show a similar behaviour

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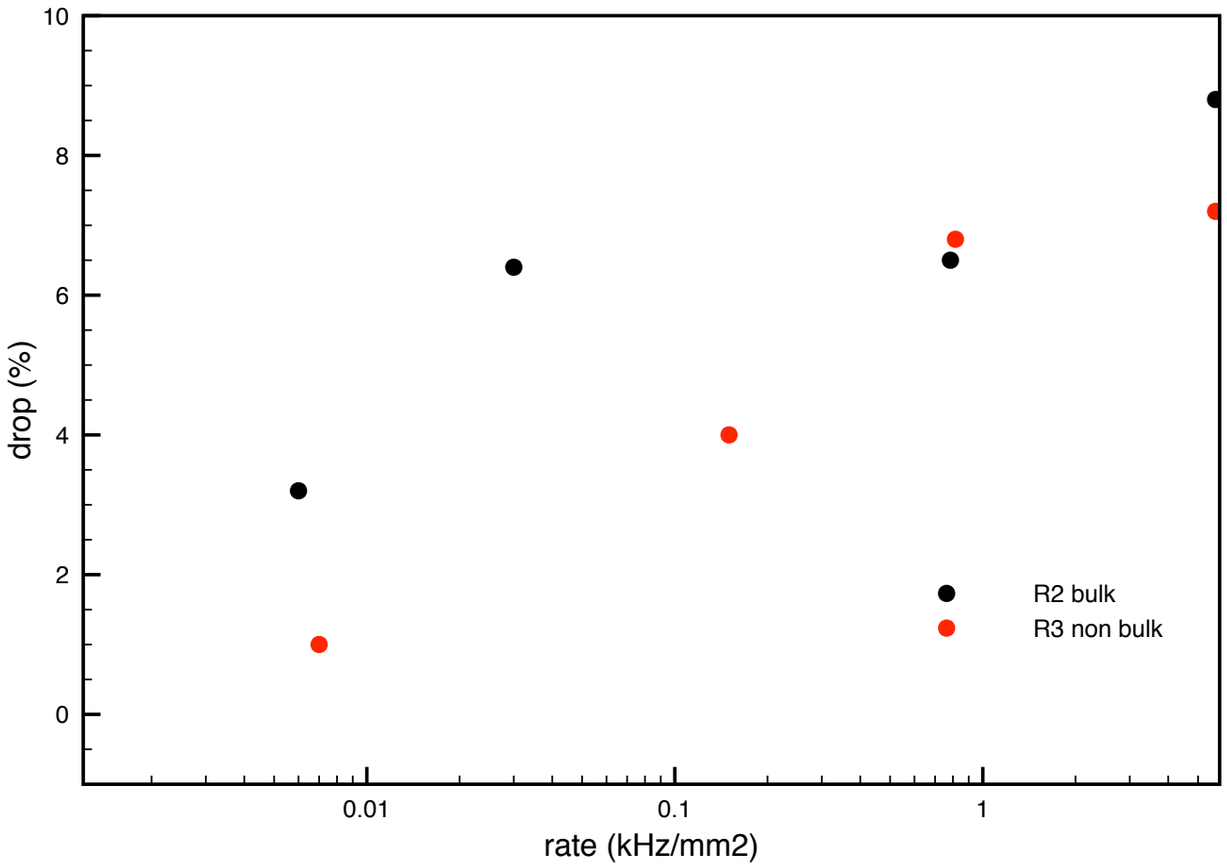
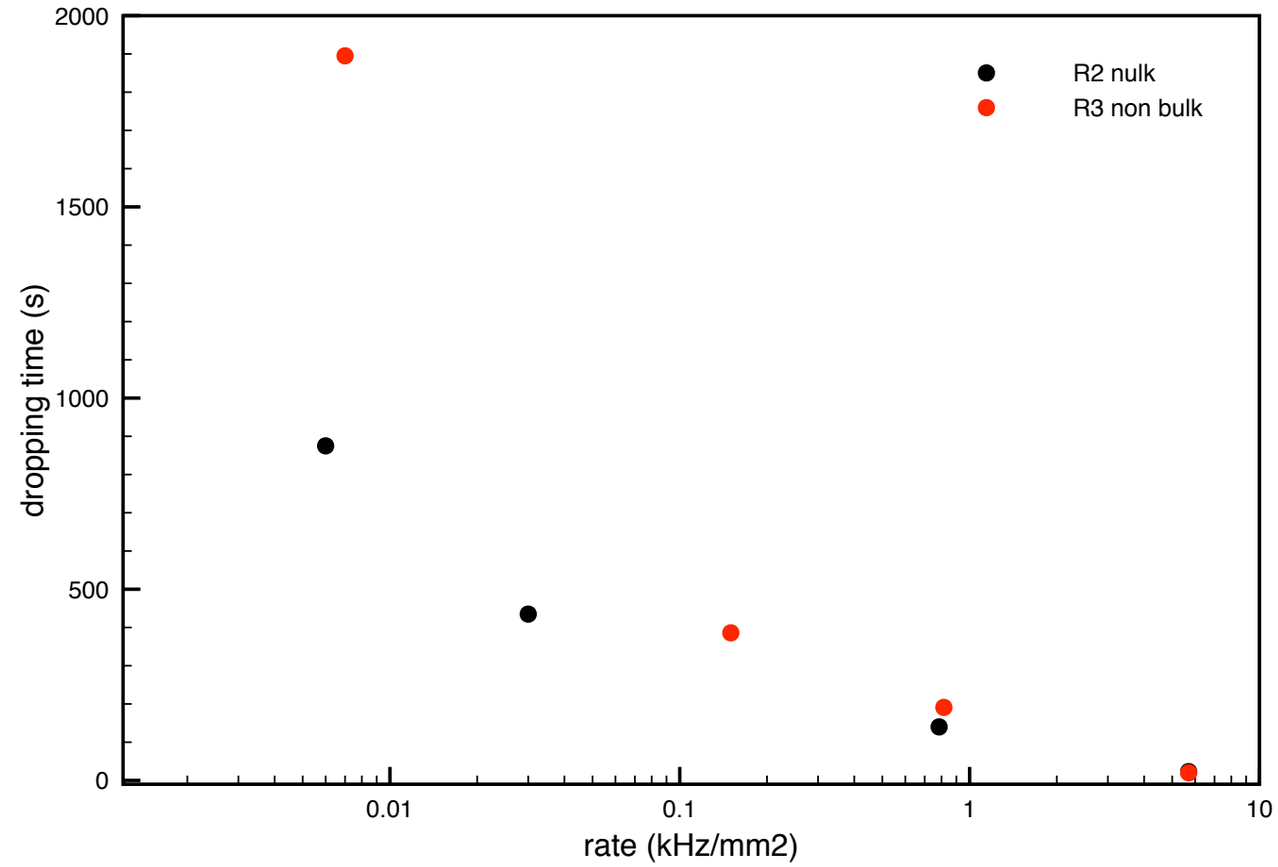
# Charging up in the DLC chamber

**Data taken between pillar**




1. **Observe an increase of the relative drop with the rate (from ~ 2% @ 5 Hz/mm² to 8% @ 5.7 kHz/mm²) but less than with the strip chamber (~ 20%)**
2. **The 'dropping' time increases with a decrease of the rate (i.e. ~ 20s @ 5.7 kHz/mm² to ~ 1800s @ 5 Hz/mm²) but slower than with the strip chamber @ similar rate**

**The slight relative gain drop (especially at high rate) could be an effect of voltage drop as the detector has only one HV connection point on the side. A true charging-up effect could be due to non uniformity**



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# Effect of the pillars

1. In earlier studies (see PhD thesis O. Sidiropoulou) we had observed a small increase of the gain with time when irradiating an area close to a pillar.

2. In order to study this effect further, we performed measurements irradiating an area on top of a pillar in both region (bulk and non bulk region).

3. This measurement has been done in the DLC geometry and on top of the large pillars (∅ : 600 μm) to observe only the effect of the pillar (and not any additional effect that could be due to the insulator between the strips).

4. The measurement was done with a collimator of 1 mm diameter placed directly above a pillar.

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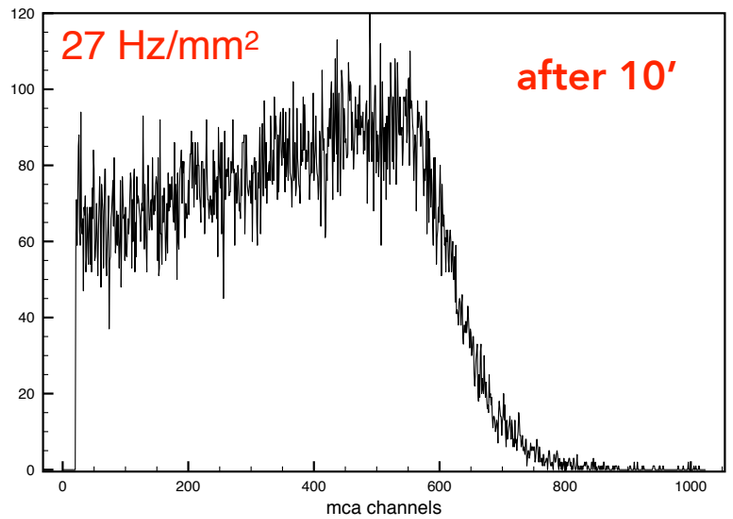
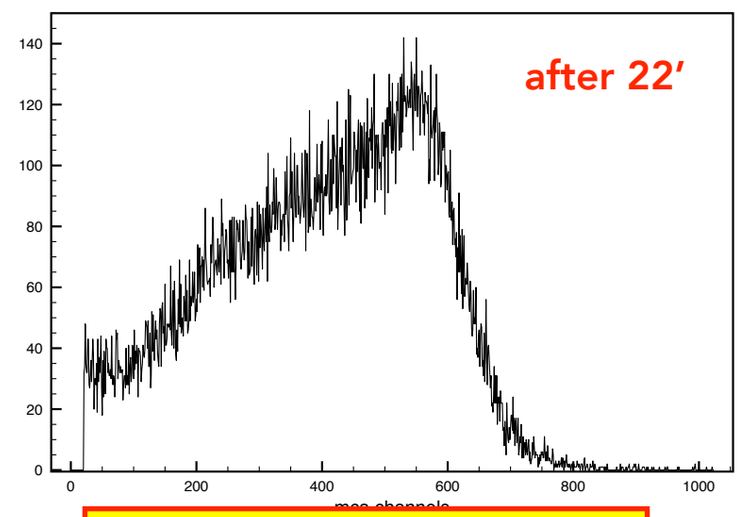
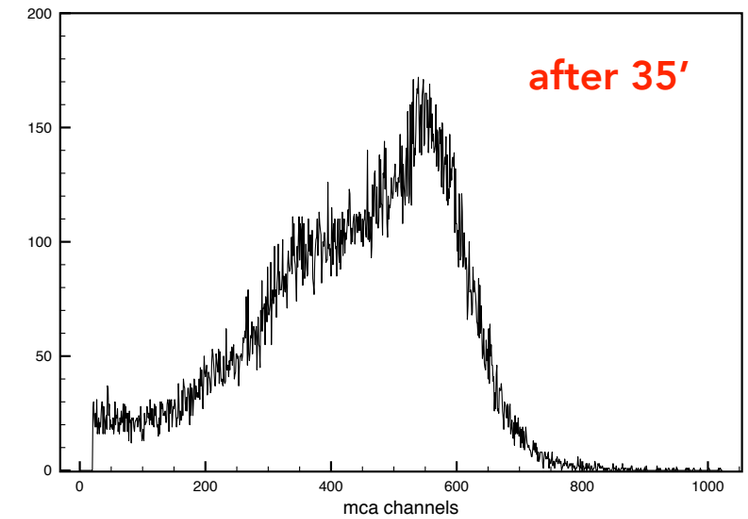
*This effect has been observed for both detectors, i.e. the DLC and the res. strips ones.*

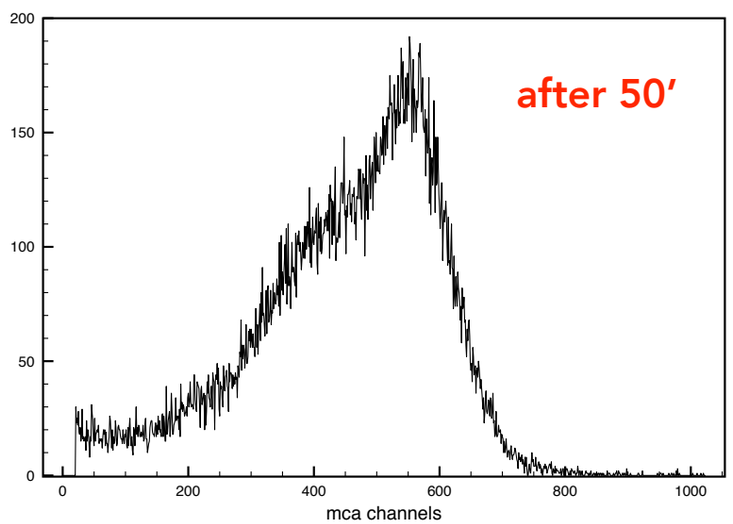
# Effect of the pillars

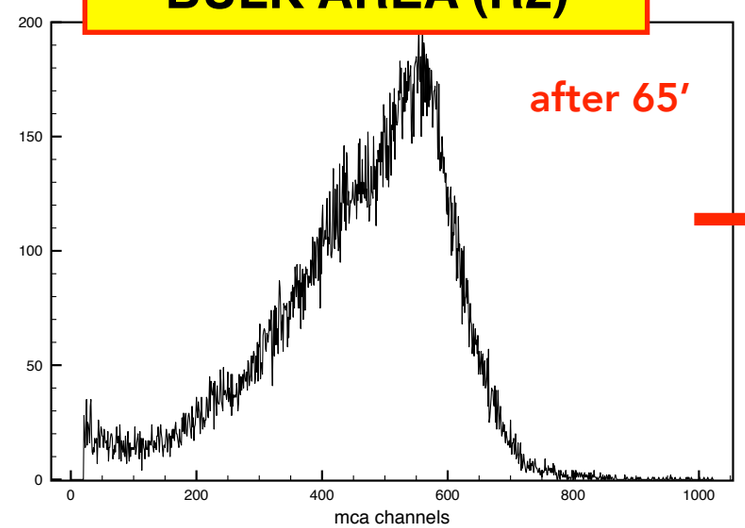


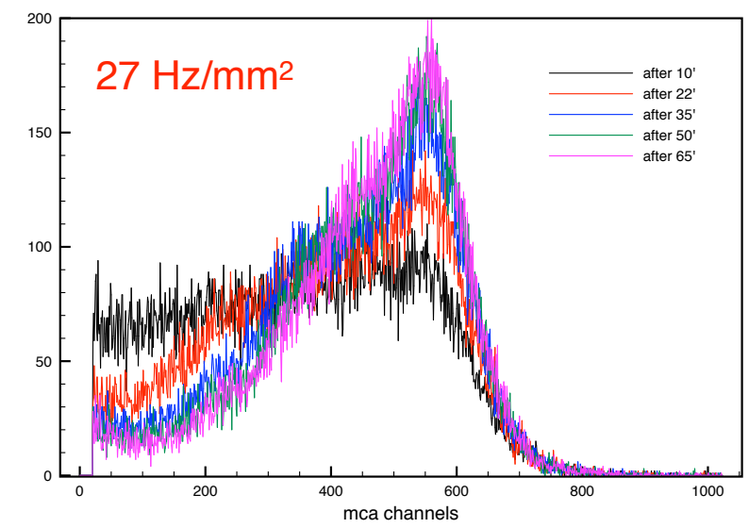




**BULK AREA (R2)**

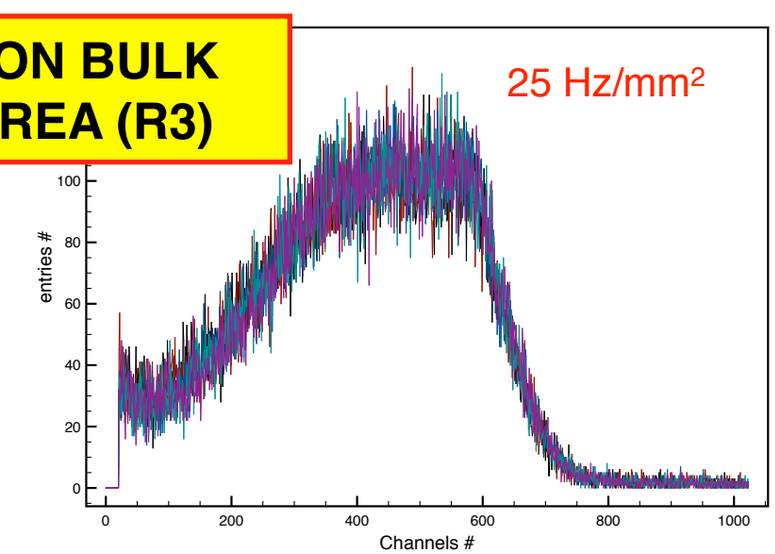



**When irradiating the area on top of a pillar, we observe an improvement of the 8 keV peak resolution with the time, which is NOT the case in the non bulk region**

**NON BULK AREA (R3)**



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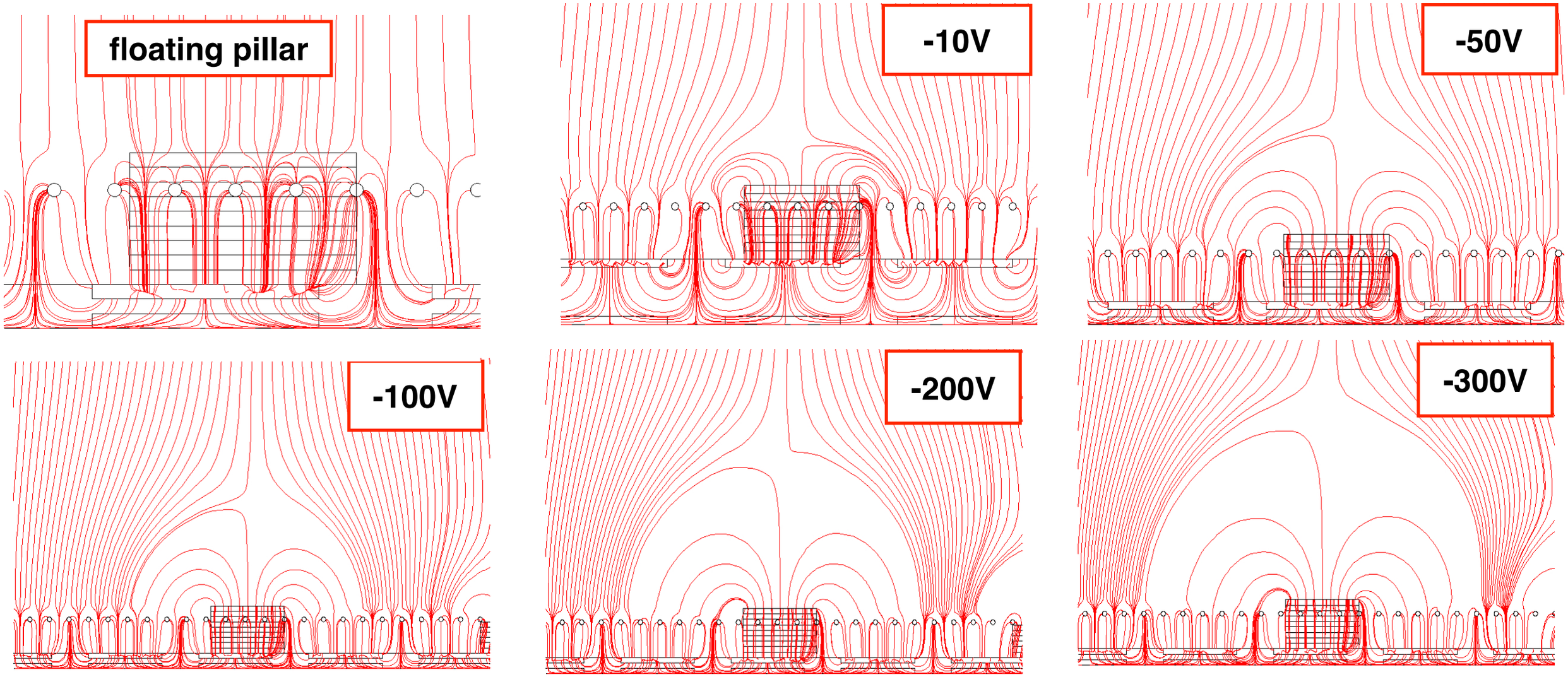
# Effect of the pillars

**Explanation**




**When the $e^-$ start to be accumulated on top of the pillar, it creates a negative potential that deviates the field lines around the pillar which lead to a full collection in the amplification region and a narrower peak.**
**This will not be the case in the non bulk region because the surface of the pillar will not be charged.**
**At high rate (57 kHz) it seems that in both cases there is a charging of the pillar (even in the non bulk region)**



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# Preliminary conclusions

1. The charging up effect is present for both detectors (DLC and strip)
2. It is rate dependent : the higher the rate, the faster is the drop
3. The DLC detector is less affected by this effect (factor ~ 4 - 5, i.e. 4 to 5% for the DLC vs 20% for the strip chamber)
4. We have a better understanding of the effect
5. We have observed and understood an interesting phenomena related to the pillars

## Future measurements

It would very interesting to be able to quantify this effect (i.e. to correlate with the amount of insulating material…)

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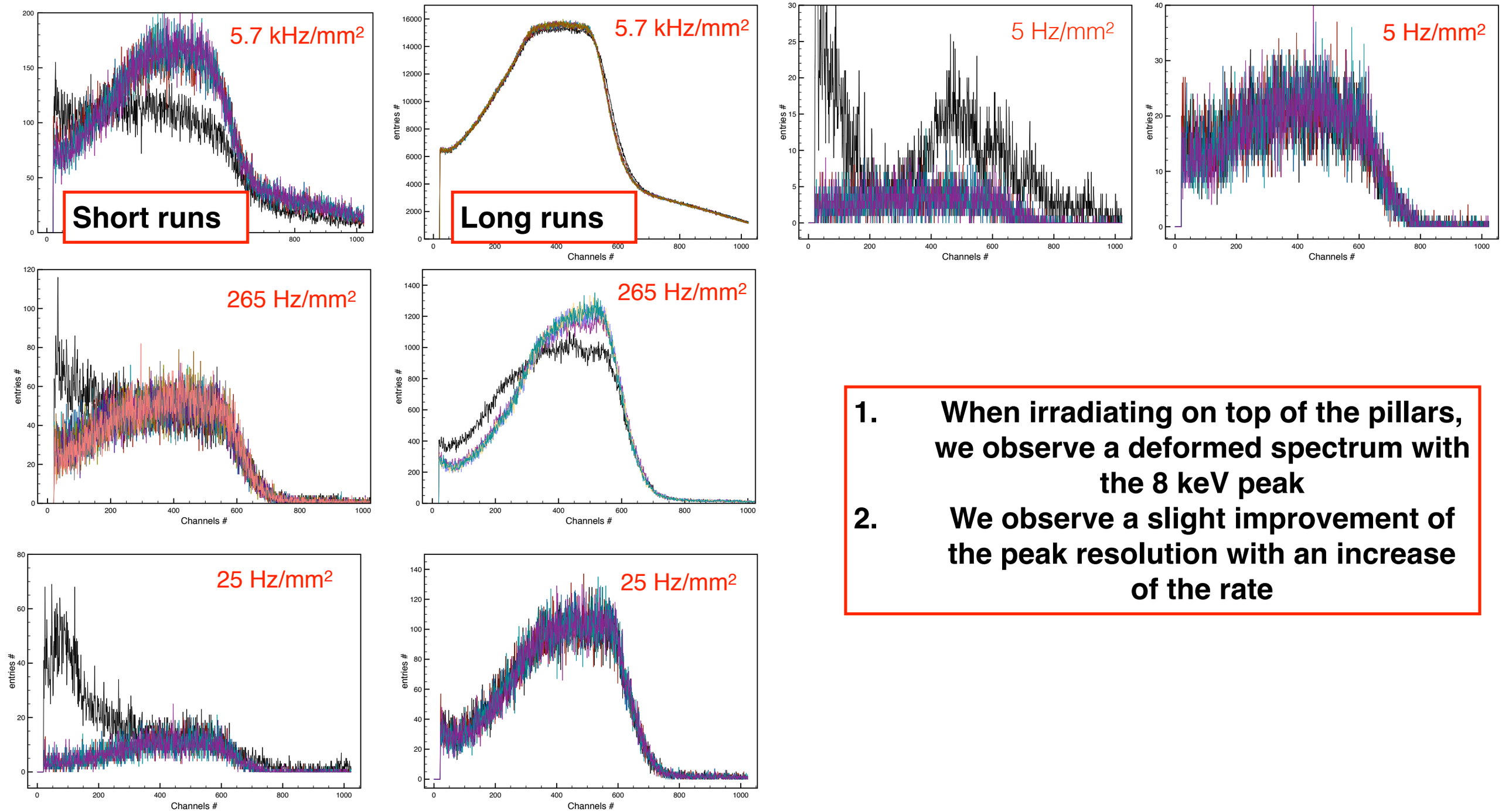
$S_{large\ pillar} = 0.28\ mm^2$
$S_{spot} = 10.18\ mm^2$

# Effect of the pillars




1. When irradiating on top of the pillars, we observe a deformed spectrum with the 8 keV peak
2. We observe a slight improvement of the peak resolution with an increase of the rate

**NON BULK AREA (R3)**

*This effect has been observed for both detectors, i.e. the DLC and the res. strips ones.*

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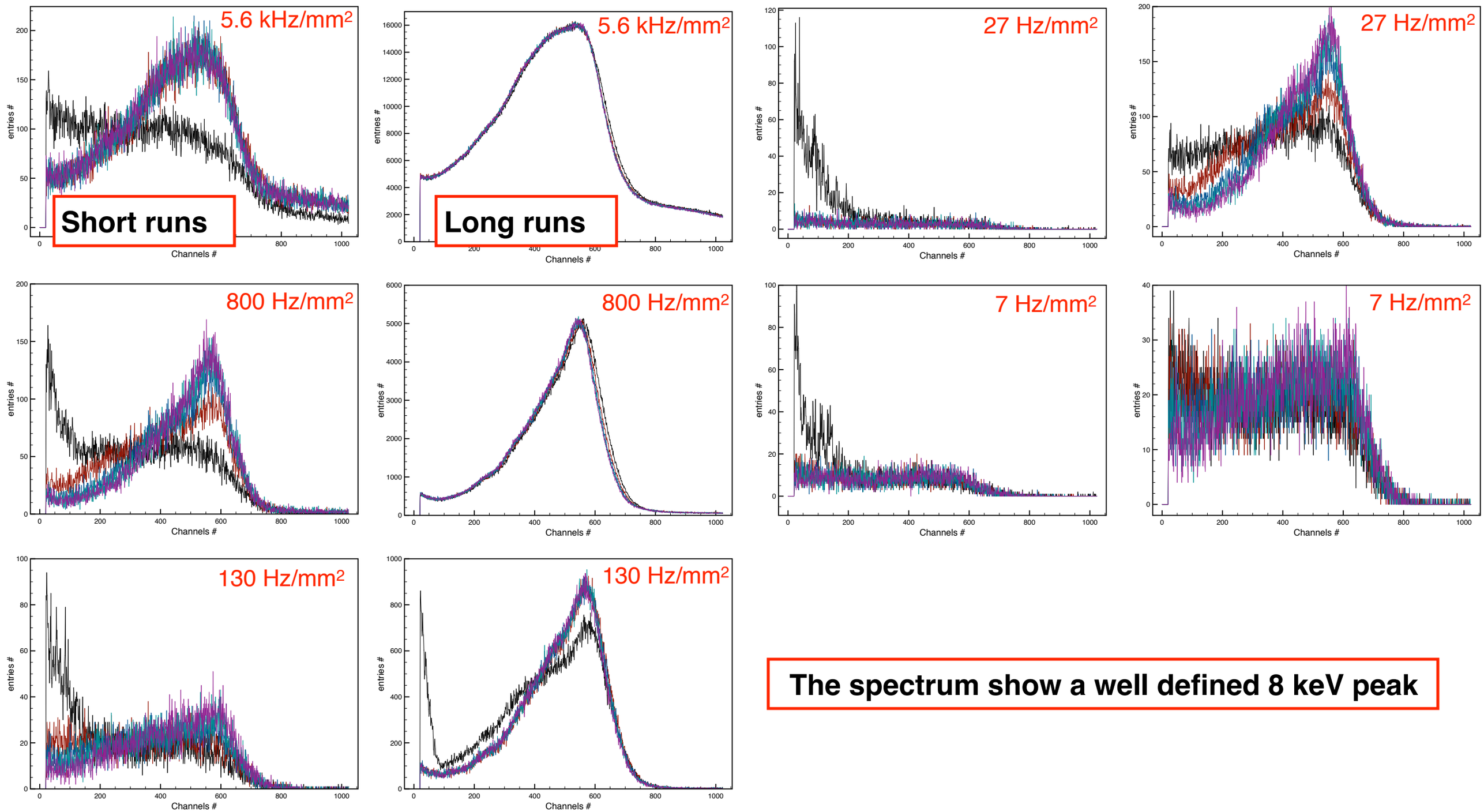
# Effect of the pillars




**The spectrum show a well defined 8 keV peak**

## BULK AREA (R2)



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