Alpha parameter measurements

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- Principle
- Measurement
- conclusion.

Aim of the work

The **α** parameter is an ad hoc correction measured at P5 few years ago by Marchello Abbreschia.

$$HV_{app} = HV_{eff}\left[(1-\alpha) + \alpha \frac{P}{P_0}\frac{T_0}{T}\right]$$

Where: T0 = 293k and P0 = 990 mbar

Motivation: P/T factor corrects for the Townsend coefficient evolution with P and T. The coefficient in front of the factor is gas and chamber dependant.

2 mm gap: **α** = 0.8

1.4 mm gap: **α** = ???

Principle

The idea is to modify P and calculate the value of α in such a way that gain at HVapp stays independent on P.

Q1: how do we change P?

A1: we wait a week with bad weather (low P) and follow the improving meteo

Q2: What about T?

A2: we keep it constant inside QC4 lab.

Q3: How do we see the gain inside the chamber?

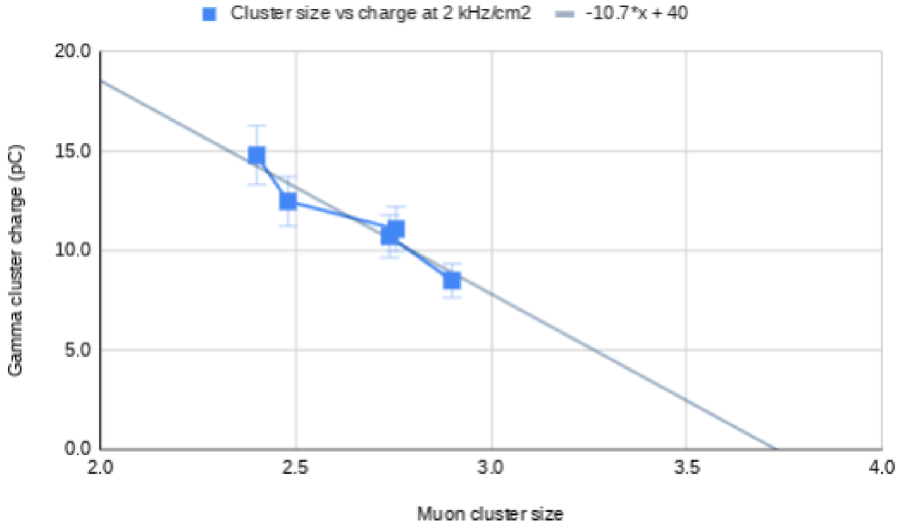
A3: How do see the cluster charge.

Principle: A3

The cluster charge is easy to measure in GIF++ with the source. But it is technically complicated to organise.

IDEA: there is a clear anti-correlation between cluster charge and cluster size

PROOF: cosmics tests in GIF++



Principle of the measurement: A4

A4.1 We perform a first S-curve scan to measure the relation

$HV_{eff}^{0.8} = f(cs)^{0.8}$ assuming **α** = 0.8 WP ~ 7.2 kV

A4.2 We take at different P the scan at HVapp = 7 kV (roughly at WP)

A4.3 At each P we measure the cluster size

A4.4 We fit **α** from the relation $\frac{HVapp}{HVeff} = (1-\alpha) + \alpha \frac{P}{P0}\frac{T0}{T}$ using $\frac{7kV}{f^{\alpha=0.8}(CS)} = (1-\alpha_1) + \alpha_1 \frac{P}{P0}\frac{T0}{T}$

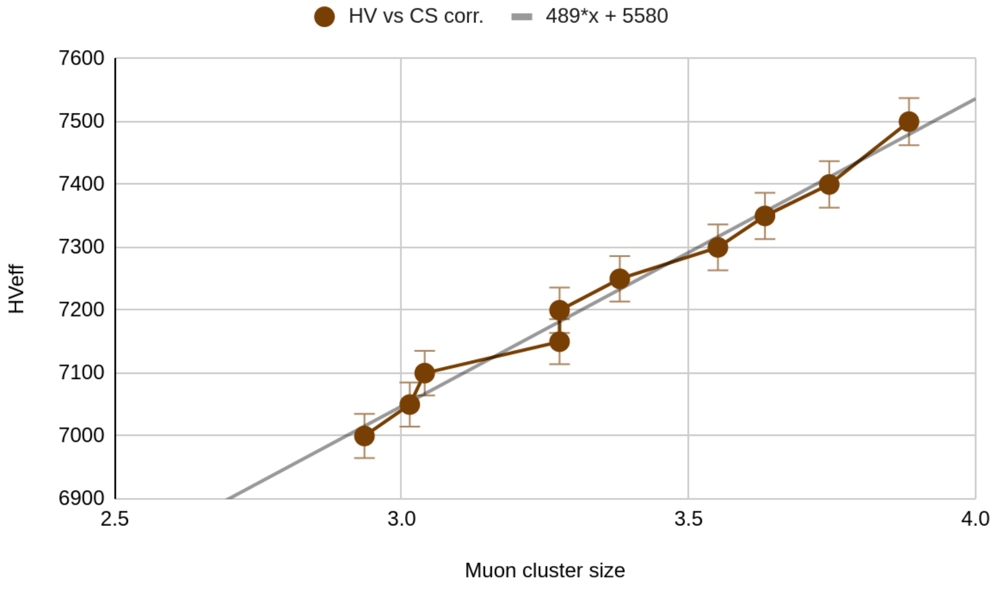
A4.6 With obtained **α** value we recalcute A41 $HVeff^{\alpha=\alpha_1} = f^{\alpha=\alpha_1}(CS)$

A4.7 We check the self-consistent result $\frac{7kV}{f^{\alpha_1}(CS)} = (1-\alpha_1) + \alpha_1 \frac{P}{P0}\frac{T0}{T}$

Measurement: A4.1

A4.1 We perform a first S-curve scan to measure the relation

$HVeff^{\alpha=0.8} = 489 * CS + 5580$ assuming $\alpha = 0.8$ WP ~ 7.2 kV

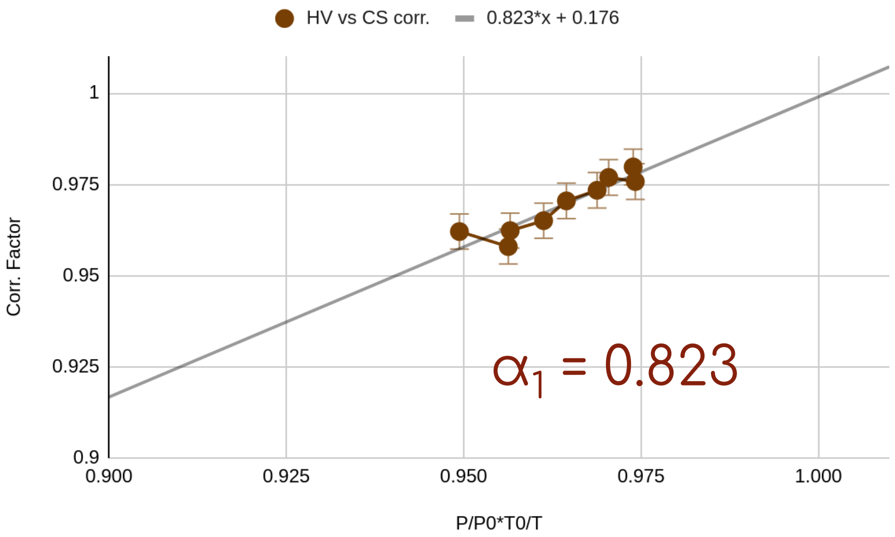


Measurement: A4.2-A4.4

A4.2 We take at different P the scan at HVapp = 7 kV (roughly at WP)

A4.3 At each P we measure the cluster size

A4.4 We fit **α** from the relation $\frac{HVapp}{HVeff} = (1-\alpha) + \alpha \frac{P}{P0}\frac{T0}{T}$ using $\frac{7kV}{f^{\alpha=0.8}(CS)} = (1-\alpha_1) + \alpha_1 \frac{P}{P0}\frac{T0}{T}$



No constraint on point (1,1) mposed but well verified: 0.823+0.176 = 0.999

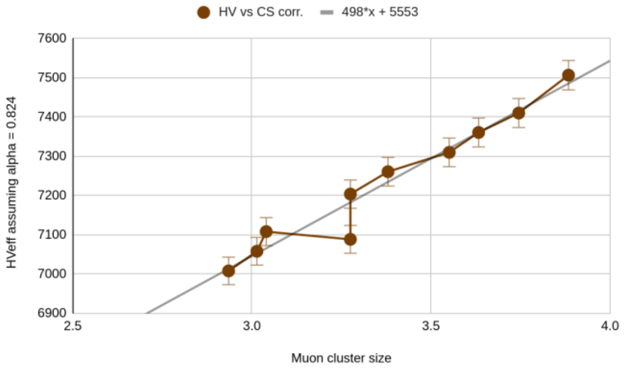
$$\frac{7kV}{f^{\alpha=0.8}(CS)} = 0.823\frac{P}{P0}\frac{T0}{T} + 0.176$$

Principle of the measurement: A4.6-A.4.7

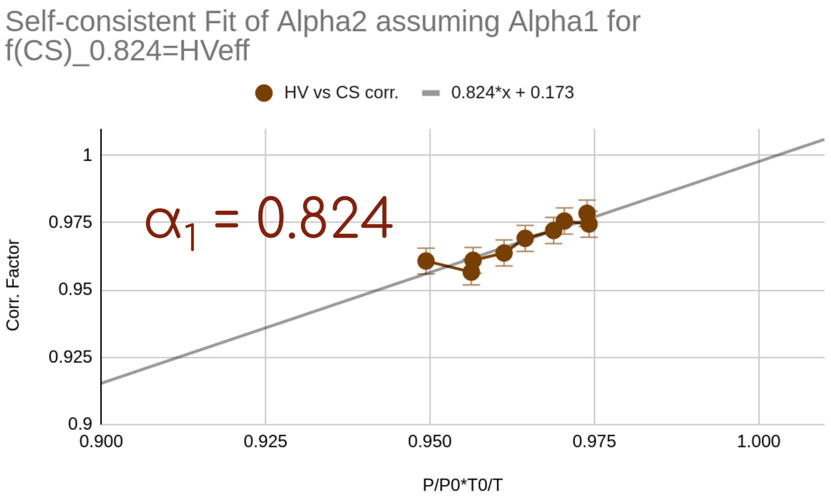
A4.6 With obtained **α** value we recalcute A4.1

$$HVeff^{\alpha=0.8} = 489 * CS + 5580$$

$$HVeff^{\alpha=0.823} = 498 * CS + 5553$$



A4.7 We check the self-consistent result



CONCLUSION

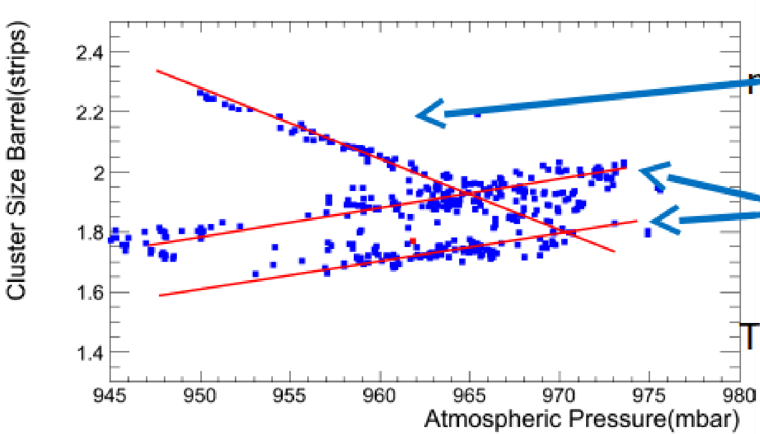
- Scan 800 with P-T correction under different HV at alpha =0.8 on feb13 RE31/192.
- We took 9 scans without P-T correction under different P with wp=7kv
- The corrected alpha from the analytical method =0.824
- Uncertainties are not properly estimated
- But alpha has changed with small factor by 0.024

CONCLUSION: we recommend to keep α =0.8

But assign an uncertainty of **10 V** on WP from P correction.

BACKUP

The Problem... in the barrel



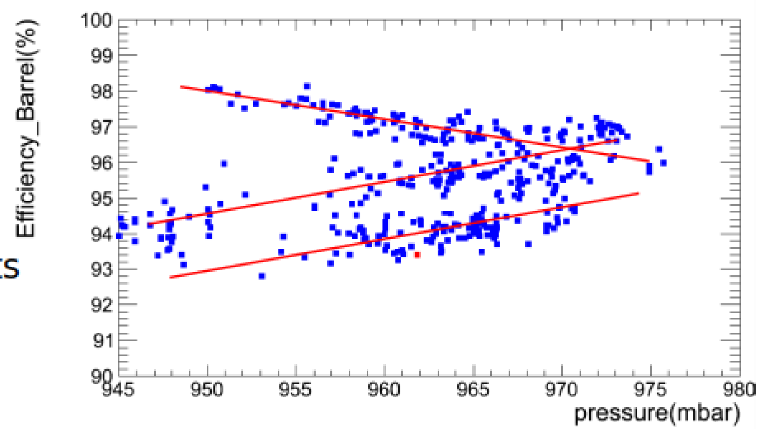
no p correction applied

p correction applied

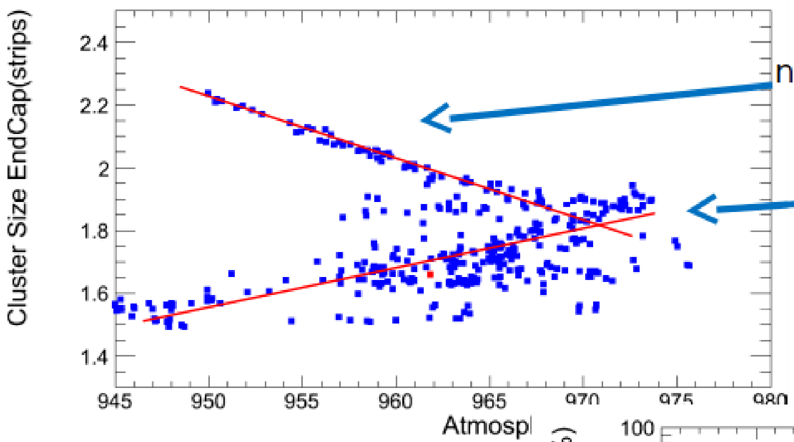
This is the most clear case ever…

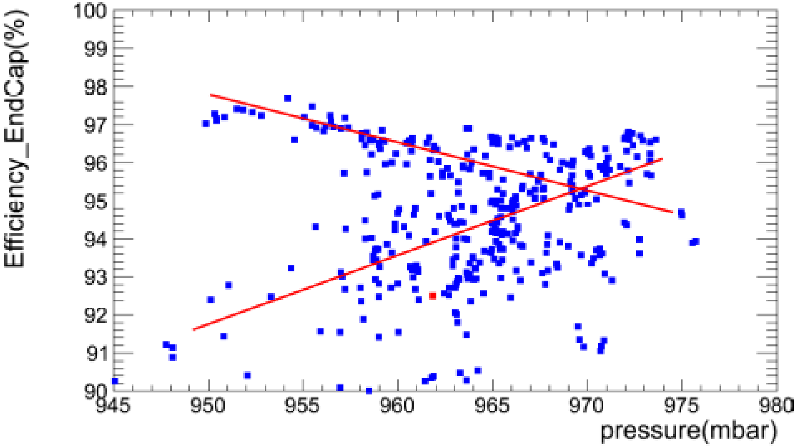
Note that the efficiency curve goes in plateau toward the right, and has a steep decrease toward the left

The slope of the fitted points has not a direct relation with the position of the working point



And in the endcap...





The conclusion is tha
it seems we are
“overcorrecting” p
effects

What we do now

- We believe that the processes in the gap are governed by the effective field inside the gap:

$$HV_{eff} = HV_{appl} \frac{p_0}{p} \frac{T}{T_0}$$

- Essentially the formula derives from imposing that the avalanche processes take place in the same way when the reduced electric field (E/density) is the same
- We know it is not an exact formula:
  - ✓ Logarithmic terms for correction
  - ✓ Nevertheless, seemed to be confirmed by experimental data for several years
- If we believe it is now overcorrecting, the easiest thing to do is
  - ✓ Start from:

$$HV_{to\_apply} = HV_{eff} \frac{p}{p_0} \frac{T_0}{T}$$

A few calculations...

Compute the correction:

$$\Delta(HV) = HV_{to\_apply} - HV_{eff} = HV_{eff}\left(\frac{p}{p_0}\frac{T_0}{T} - 1\right)$$

And reduce the correction applied:

$$\Delta(HV) \Rightarrow \alpha\Delta(HV)$$ with: $$0 < \alpha \leq 1$$

So that:

$$HV_{to\_apply} = HV_{eff} + \Delta(HV) = HV_{eff} + \alpha HV_{eff}\left(\frac{p}{p_o}\frac{T_0}{T} - 1 =\right)$$

$$\boxed{= HV_{eff}\left(1 - \alpha + \alpha\frac{p}{p_0}\frac{T_0}{T}\right)}$$

A few considerations...

- Introduced in this way α seems to be an empiric parameter (and the procedure as well).

- Introducing it in a more formal way, would mean:
  - ✓ Assume an unknown functional f dependance of HV_eff on p
  - ✓ Develop this function f in a Taylor series
  - ✓ Take into account only of the first term (containing the first derivative $f'(p\_0)$ and the linear term)

    - Trivial, so I am not doing it here
  - ✓ The relation between $f'(p\_0)$ and α is immediate too

Nothing to do with a possibile miscalibration of pressure sensors:

Introduction

- Alpha parameter (Townsend coefficient):

  This parameter is used to determine the gas gain as a result of moving charged particle in the RPC gas.

$$n = n_0 e^{\alpha x}$$

Where: n0: is the number of primary electron.

n:the number of electrons after moving distance x

➔ The Townsend coefficient (α) depends on the nature of the gas, Pressure and Temperature.

Introduction

The applied HV effects by the environmental pressure and temperature.

The correction of the applied voltage of the RPC chamber is to maintain its gain constant against environmental changes that would modify the working point of the chamber.

The relation between the applied and effective high voltage :

$$HV_{app} = \beta HV_{eff} \quad (1)$$

$$HV_{app} = HV_{eff}\left[(1-\alpha) + \alpha \frac{P}{P_0}\frac{T_0}{T}\right] \quad (2)$$

where :T0=293 K , P0=965mpar and alpha is the gain constant.

Another approach

For irpc the applied voltage =7kv. So,

$$HV_{app} = \beta HV_{eff} \qquad (1)$$

$$\frac{7000}{HV_{eff}^{\alpha}} = [(1-\alpha) + \alpha \frac{P}{P_0} \frac{T_0}{T}] \qquad (2)$$

As the effective high voltage is a function of the cluster size at alpha=0.8:

$$HV_{eff}^{o.8} = f(cs)^{o.8}$$

From equation (1)

$$\frac{(HV_{eff})_1}{(HV_{eff})_2} = \frac{\beta_2}{\beta_1}$$

Where:

$$(HV_{eff})_1 = HV_{eff}^{0.8} = f(cs)^{0.8}$$

$$\beta_1 = \beta^{o.8} \text{ where } \alpha = 0.8$$

$$\Longrightarrow \quad \frac{f(cs)^{0.8}}{HV_{eff}^{\alpha}} = \frac{\beta^{\alpha}}{\beta^{o.8}}$$

$$HV_{eff}^{\alpha} = \frac{\beta^{0.8}}{\beta^{\alpha}} f(cs)^{0.8}$$

By substitution in equation (2):

$$\frac{7000}{\frac{\beta^{0.8}}{\beta^{\alpha}} f(cs)^{0.8}} = [(1-\alpha) + \alpha \frac{P}{P_0} \frac{T_o}{T}] \Longrightarrow \frac{7000}{f(cs)^{0.8}} = [\frac{\beta^{0.8}}{\beta^{\alpha}}(1-\alpha)] + [\frac{\beta^{0.8}}{\beta^{\alpha}} \alpha \frac{P}{P_0} \frac{T_0}{T}]$$

Let :

$$K_1 = \frac{\beta^{0.8}}{\beta^{\alpha}}(1-\alpha) \Longrightarrow K_1 = \frac{\beta^{0.8}}{(1-\alpha) + \alpha \frac{P}{P_0} \frac{T_0}{T}}(1-\alpha)$$

$$b = \frac{P}{P_0} \frac{T_0}{T}$$

where P and T the same of scan 800

$$\beta^{0.8}(1-\alpha)=k_1(1-\alpha)+k_1\alpha b$$

$$(\beta^{0.8}-K_1)(1-\alpha)=k_1 b\,\alpha$$

$$(\beta^{0.8}-K_1)-(\beta^{0.8}-K_1)\,\alpha=K_1 b\,\alpha$$

$$\alpha=\frac{\beta^{0.8}-K_1}{\beta^{0.8}-K_1+K_1 b}$$

To solve this equation, we have :

Average value of b = 0.9531255664

Beta(0.8)= (1-0.8)+(0.8*0.95312)= 0.9625004531

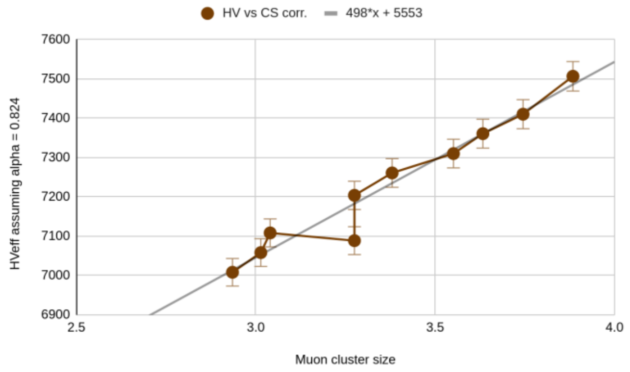
K1=176. From equation(8)

The corrected alpha = 0.824

we repeated the calculations using the corrected alpha =0.824

1. beta* of the corrected alpha = 0.9613657407
2. Then we re-calculated the effective voltage HV_eff*=HV_app/beta*
3. Draw a relation between HV_eff* and the cluster size of scan 800
4. By the fitting we got

HV_eff*=498Cs+5553



1. Using the above equation to calculate

   the correction factor

6. We draw a reaction between the correction factor and P/P0*T0/T

7. From the fitting we proved that alpha

From the fitting is the same alpha corrected

=0.824

$\alpha_1 = 0.823$

Self-consistent Fit of Alpha2 assuming Alpha1 for f(CS)_0.824=HVeff