Studiul dependentei parametrilor functionali ai detectorilor RPC si TRD pentru CBM functie de fluxul de particule incidente

***Proiect* PN 09 37 01 03**

Director Proiect: Prof. Dr. Mihai Petrovici

OUTLINE

- ***Motivation***
- ***SIS18 – GSI, April 2014 experimental setup***
- ***Experimental results***
  - ***Current & HV for RPC 2013 & RPCref @ counting rate***
  - ***Current & HV for TRD2012 & RPC2012 @ counting rate***
- ***Conclusions and Outlook***

Motivation

The RPC rate capability is limited with the time interval needed for the localized charge avalanche to dissolve from the glass electrode. The drop of the electric field in the gas gap at high particle rates affects efficiency and time resolution. For a single gap of width b the average field reduction is:

$$\langle \Delta E \rangle = \rho (a/b) \Phi \langle Q \rangle$$

ρ = glass resistivity

a = glass thickness

Φ = the particle flux

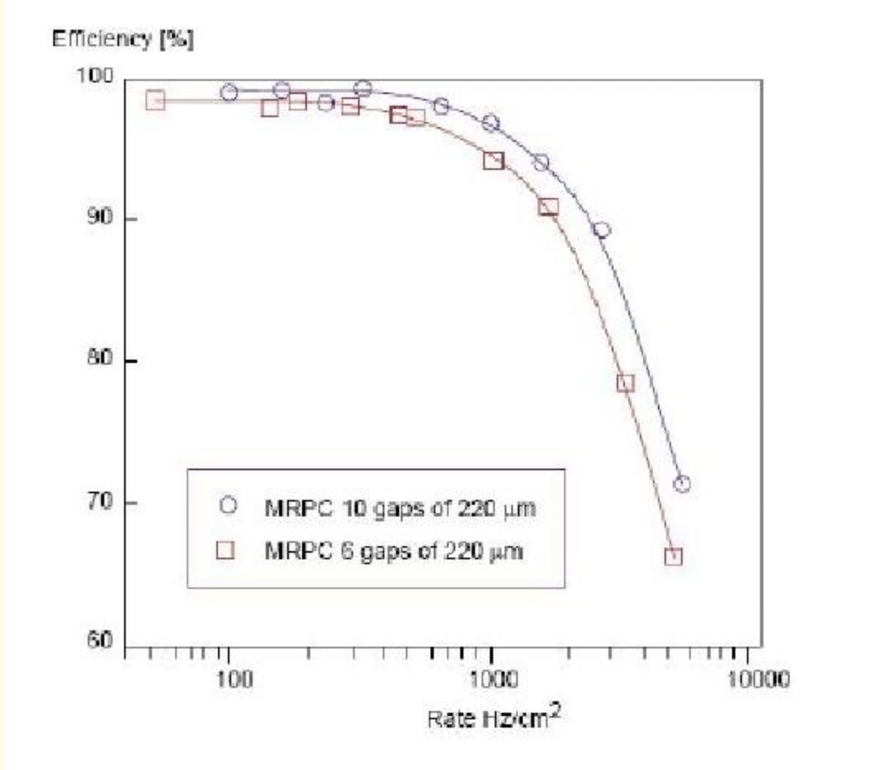
Q = the avalanche charge

$$\langle \Delta V \rangle = IR = \rho a \Phi \langle Q \rangle$$

Timing RPC –in present: intensive R&D activity for high counting rate performance:

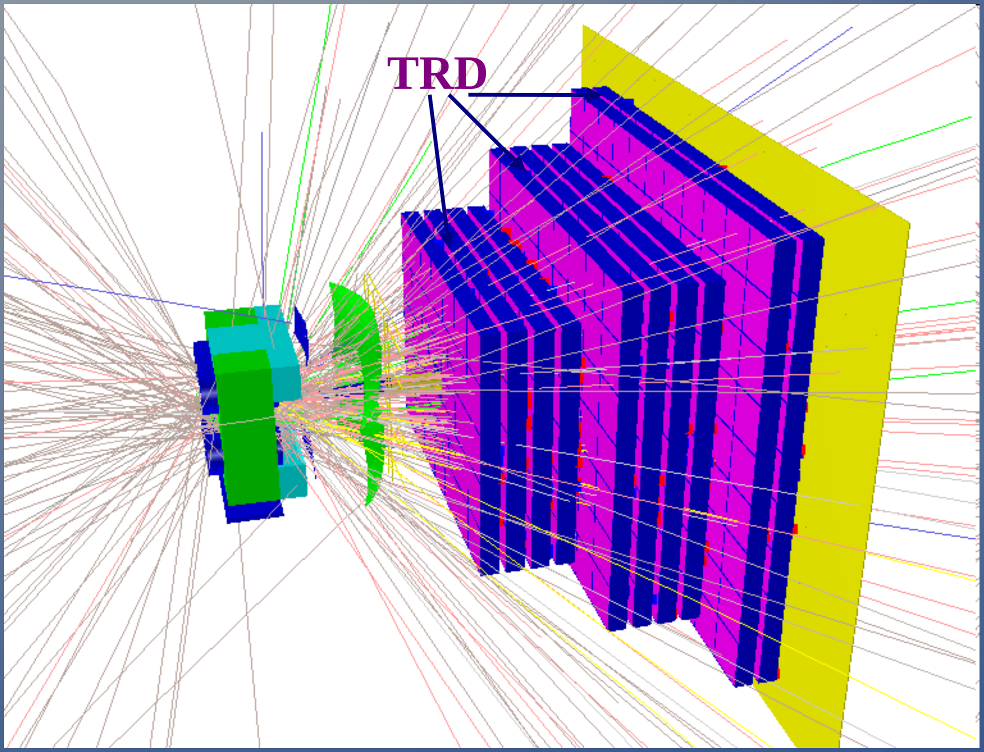
- ***time resolution better than 100 ps ,***
- ***high efficiency (> 95%)***

ALICE-MRPC: Resistive electrodes - float glass of $10^{12} - 10^{13}$ Ωcm resistivity



ALICE-TOF TDR CERN/LHCC 2000-12

Motivation



585 m² surface
708 modules
785.408 channels

matching STS & TOF acceptance

The CBM-TRD requirements

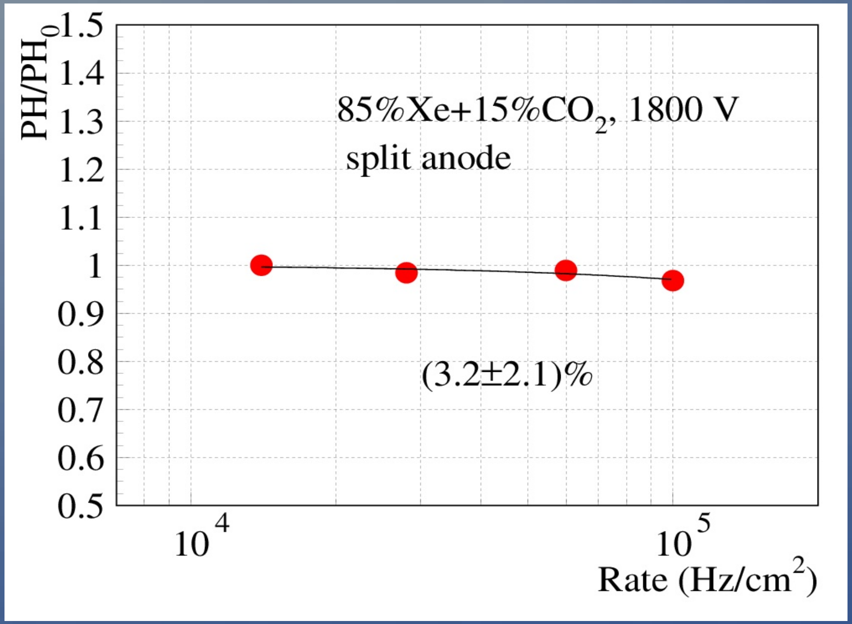
TRD subdetector – possible scenario:

- *3 stations @ 4.5, 6.75, 9 m from target*
- *Highly granular and fast detectors which can stand counting rates up to 10^5 part/cm^2·sec*
- *Tracking of all charged particles with a position resolution of:*
  - *- 200 – 300 μm across the pads*
  - *- 3 – 30 mm along the pads*
- *Identification of high energy electrons (γ > 1000) with a pion rejection factor > 100 @ 90% electron efficiency*

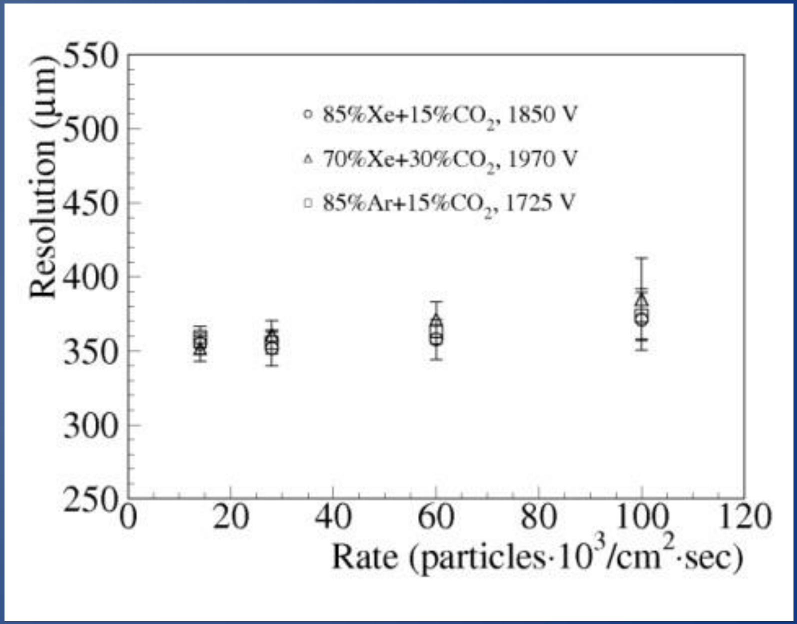
Motivation

TRD High Counting Rate Effect
Ion space charge with consequences on

Pulse Height – e/pi discrimination



Position Resolution



M. Petris et al., Nucl. Instr. and Meth. A 581(2007), 406

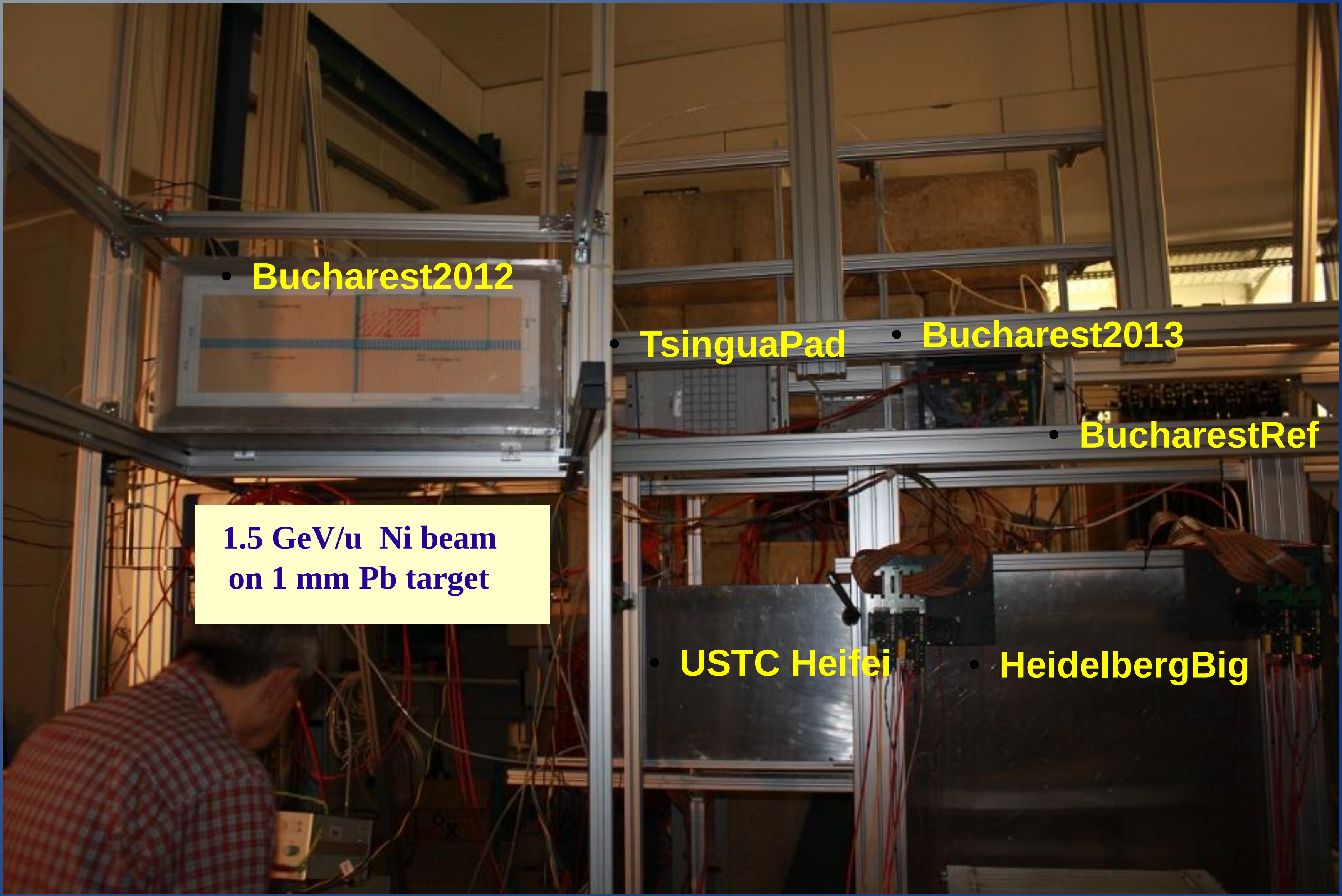
M. Petrovici et al., Nucl. Instr. and Meth. A 579(2007), 961

M. Petris et al,. Rom. Journ. Phys., Vol.55, Nos. 3-4 (2010), 324

Motivation

- Proper choice of the HV power supplies for both CBM-TOF & CBM-TRD detectors

GSI Beam time April2014



1.5 GeV/u Ni beam
on 1 mm Pb target

Photo of the Experimental Setup

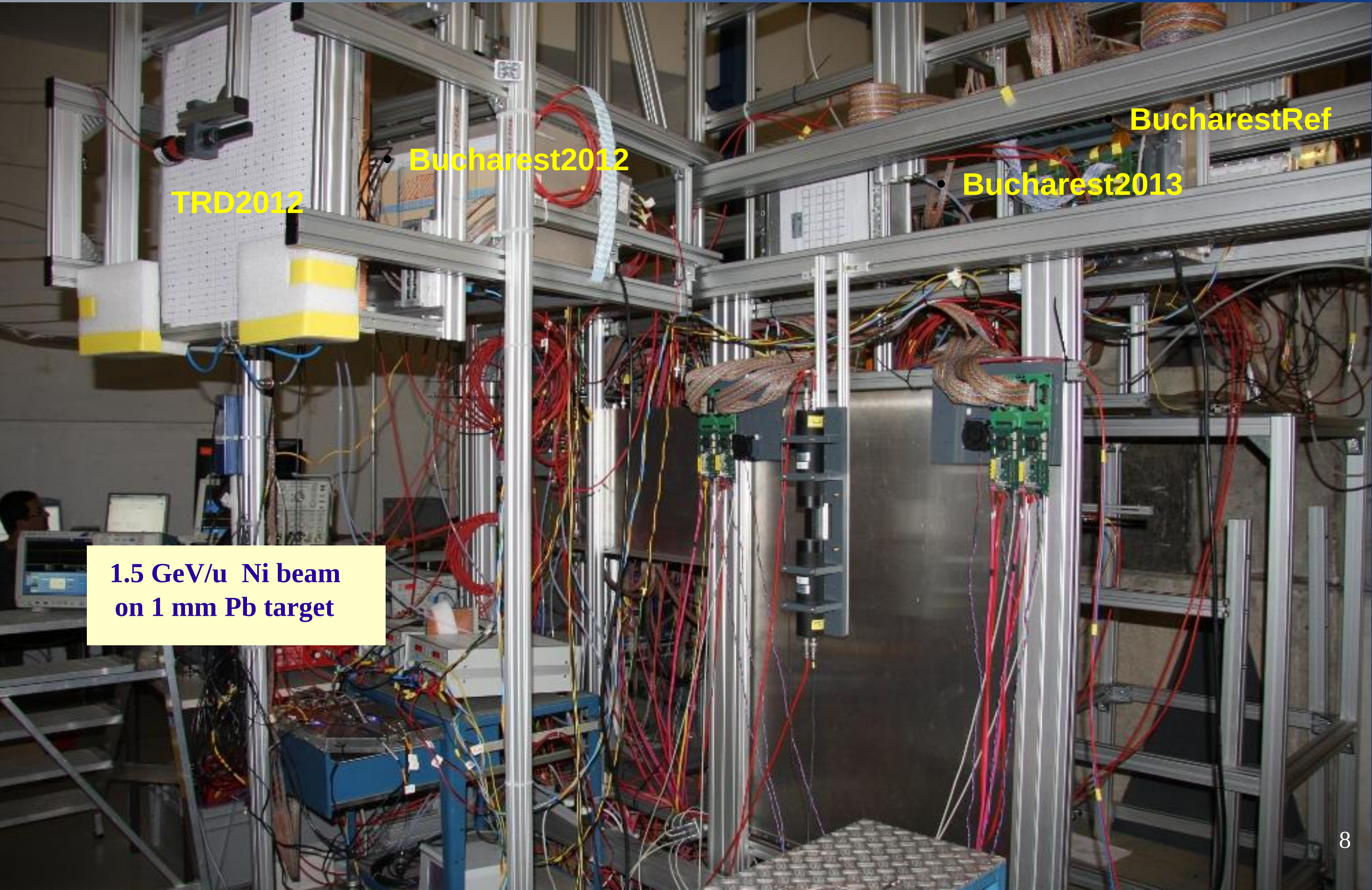


Photo of the Experimental Setup

RPC 2013:

FEE - PADI8

Converter: TRB3

RPC Reference:

FEE – PADI3 + spliters

Converter: TRB3

4 counter RPC 2012:

FEE - NINO

Converter: CAEN TDC

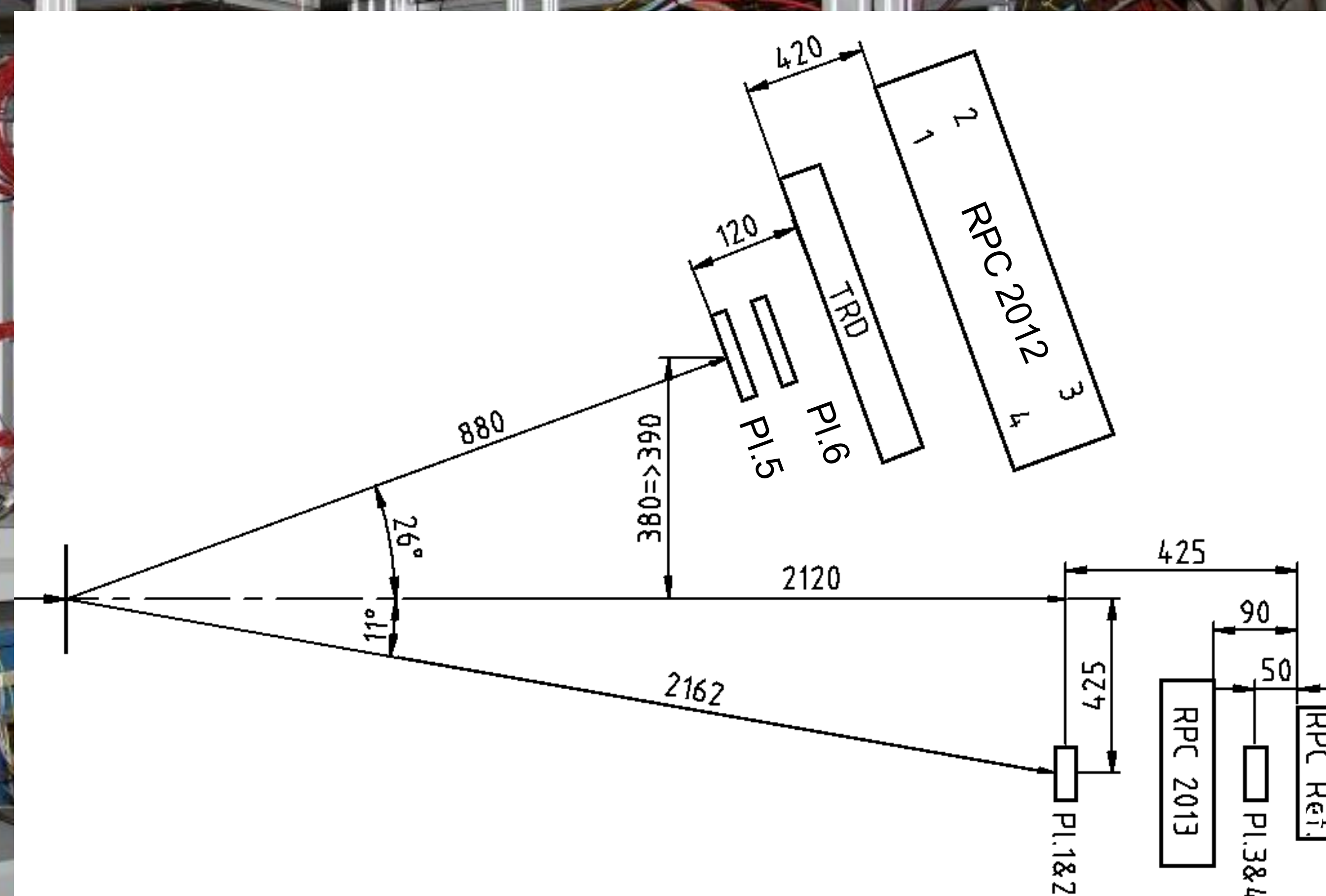


Photo of the Experimental Setup

TRD gas mixture: 80%Ar+20%CO_2

RPC gas mixture:

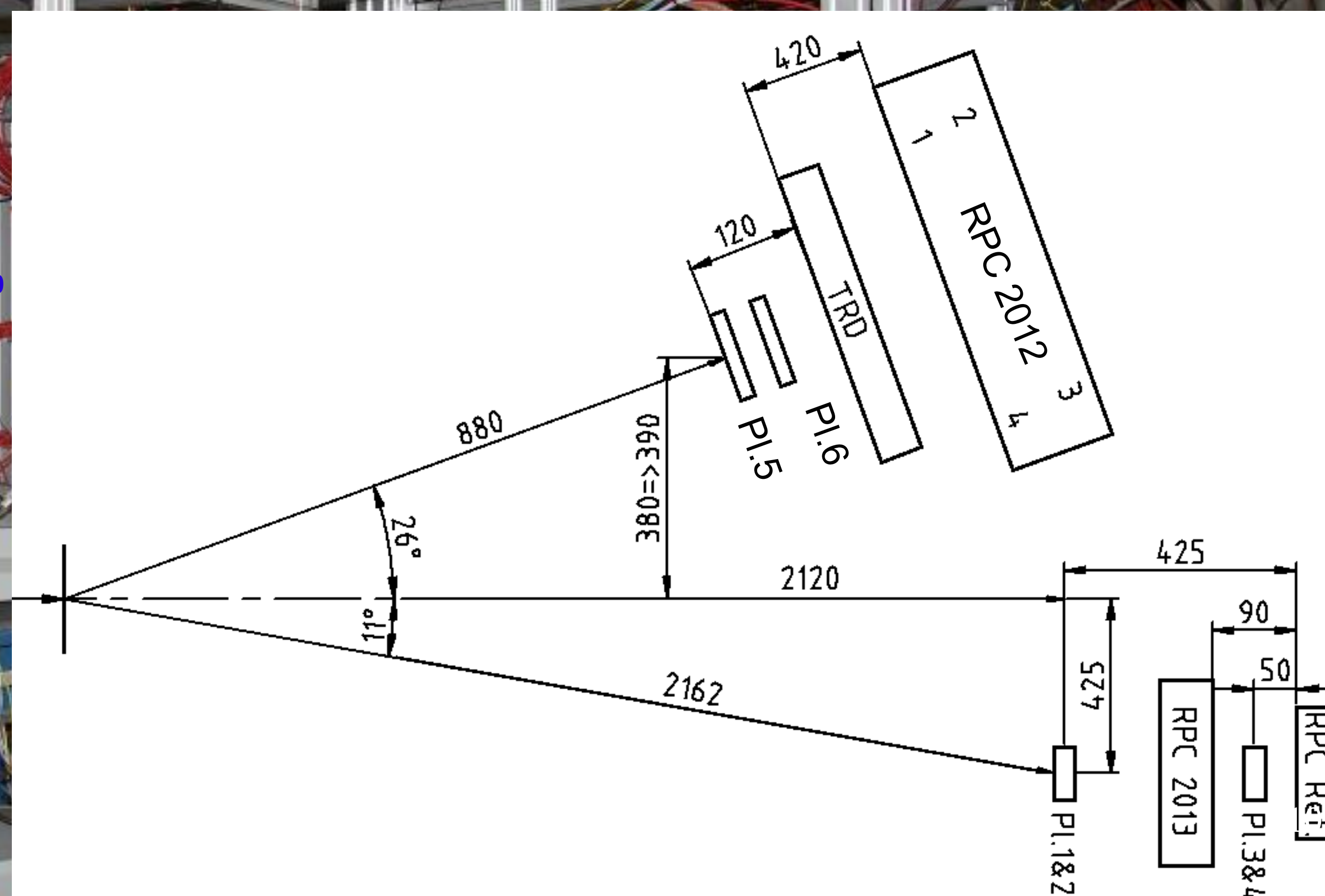
85% $C_2F_4H_2$ +10% SF_6 + 5% iso-C_4H_{10}

Scaler 2: Pl.1& Pl.2 (1.6 cm x 8 cm)

Scaler 3: Pl.3 &Pl.4 (1.6 cm x 8 cm)

Scaler 4: Pl.5 & Pl.6 (2 cm x 9 cm)

HV power supply: CAEN A1526
N/P polarity, 10 nA current resolution
0 – 15 kV HV range, 100 μA/1 mA full scale
Current & high voltage protection



Currents & HV @ different rates

Time evolution of current and high voltage were recorded during the measurements.

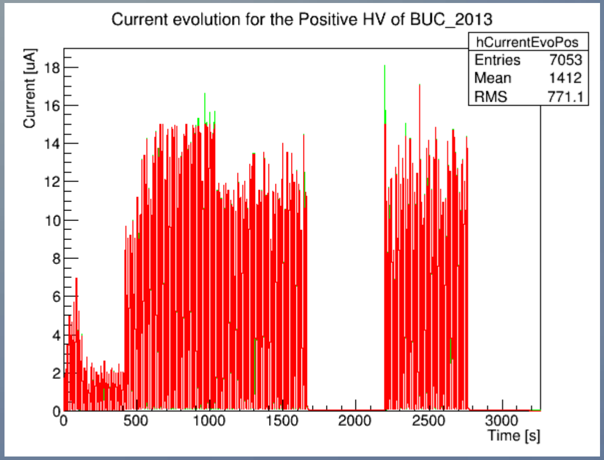
Detector current data have been combined with the DAQ scalers for rate estimation in the off-line analysis .

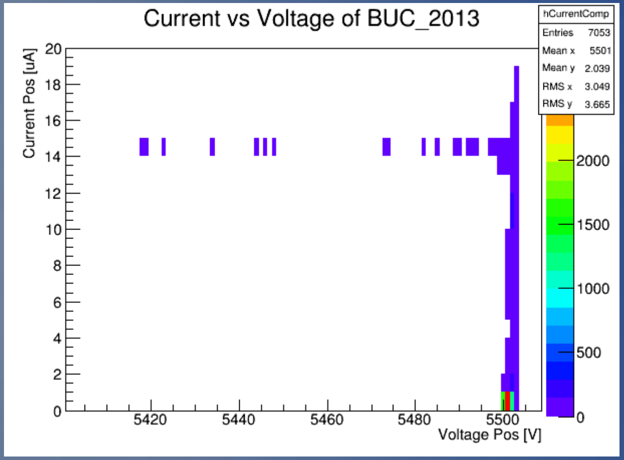
The scalers were the plastic scintillators.

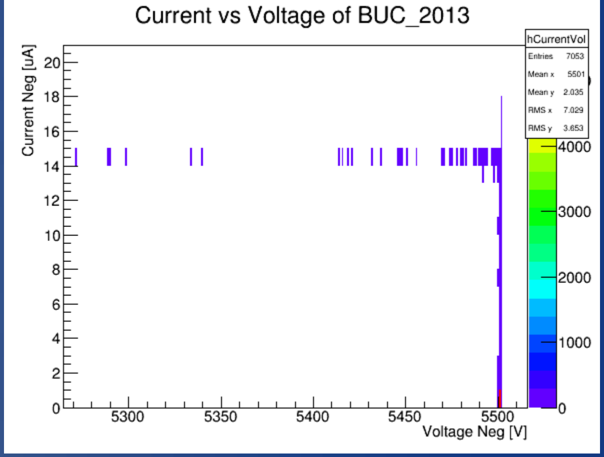
The mean value of the two scalers was considered in the counting rate estimation.

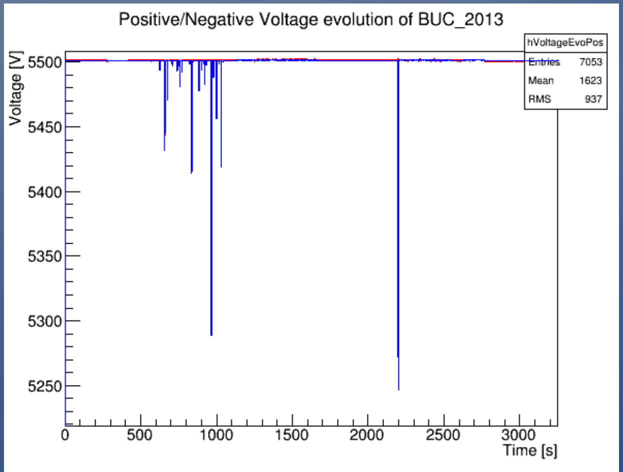
Current & HV evolution for RPC2013

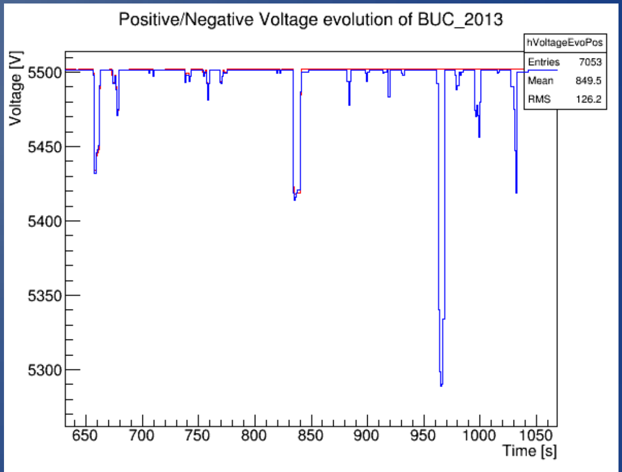
Run230414_2204









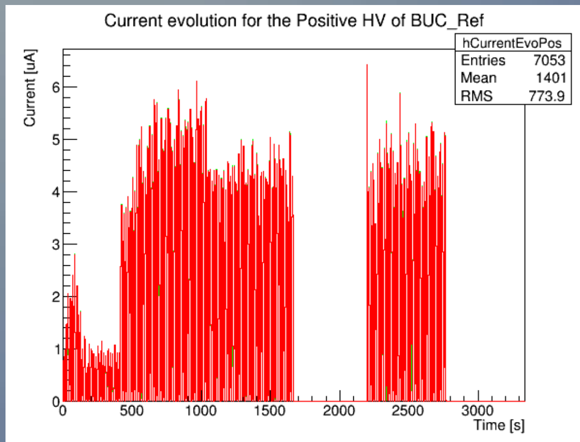


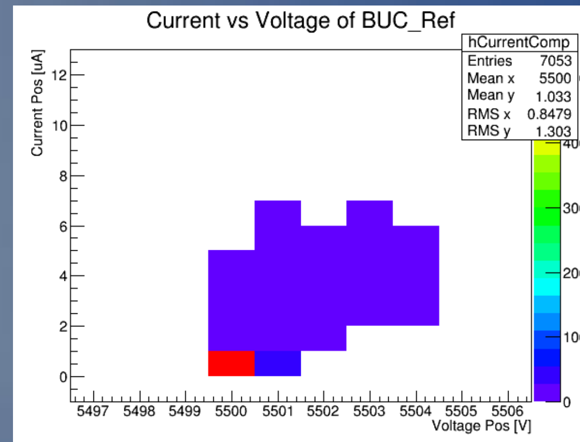
Negative & positive current have almost the same values
Negative and Positive HV have different behaviour @ the same current
Current protection setting?

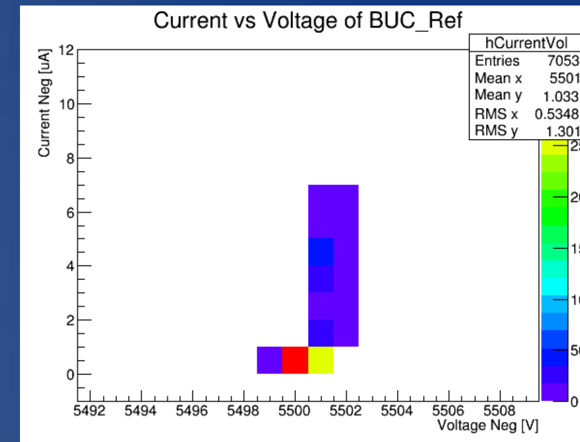
$$\Delta V_P = 5500\text{ V} - 5420\text{ V} = 80\text{ V}$$
$$\Delta V_N = 5500\text{ V} - 5250\text{ V} = 250\text{ V}$$

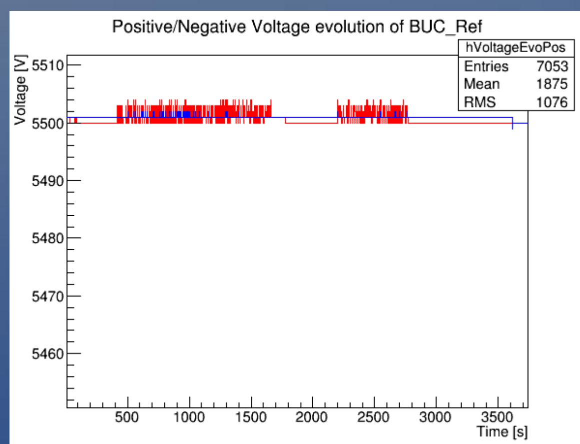
Current & HV evolution for RPCref

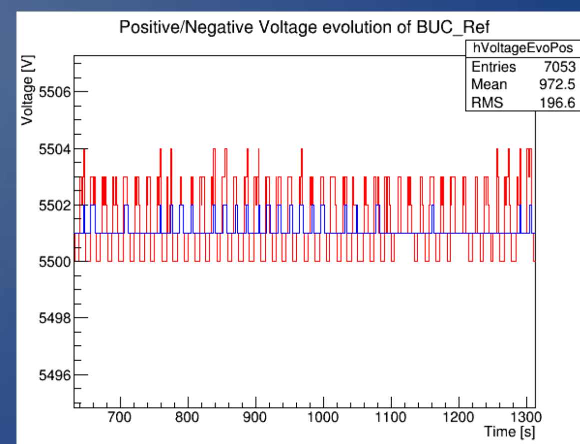
Run230414_2204







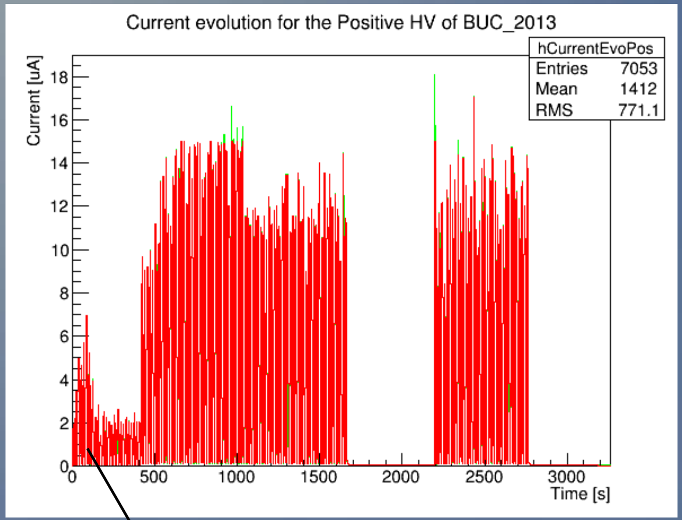


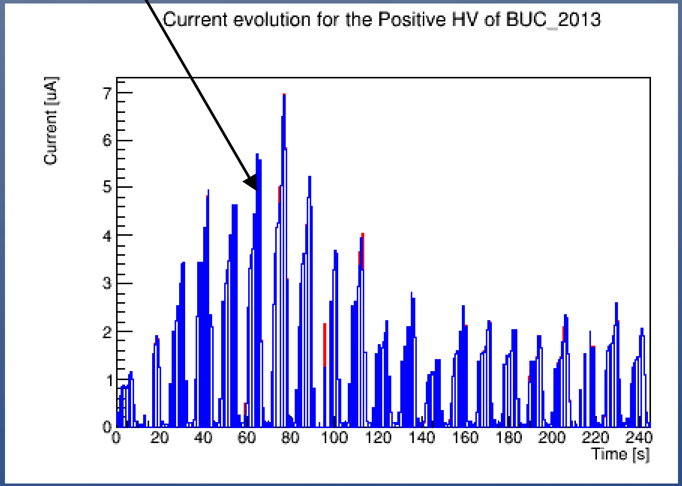


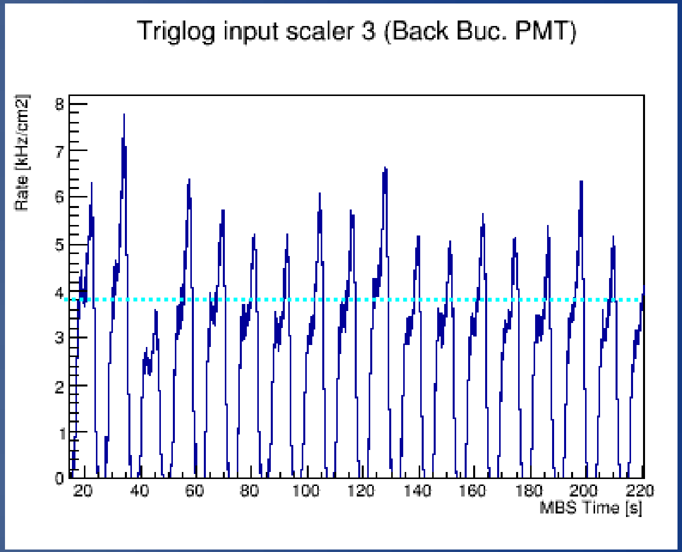
Stable behaviour of reference RPC

Current/rate estimation for RPC2013

Run230414_2204







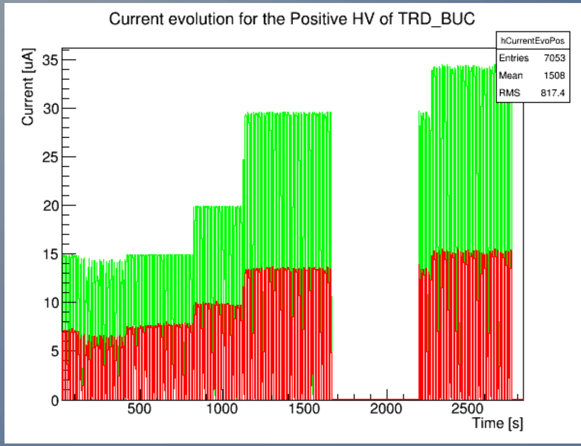
DAQ didn't work more for the time period of this csv file

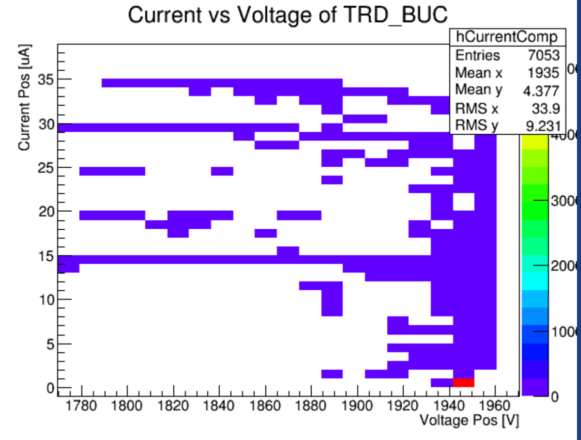
Active area = 532 cm^2

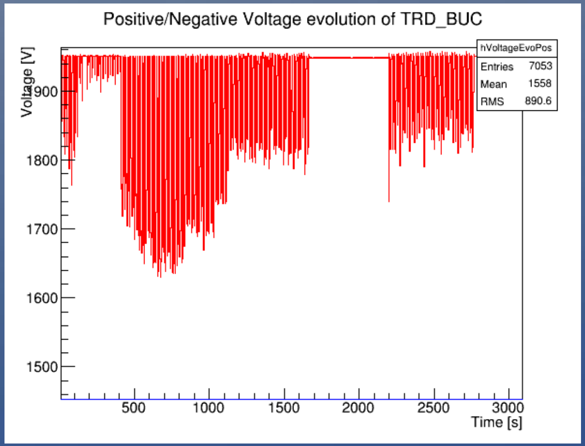
I $\lesssim$ 12 nA/cm^2 @ ~4 kHz/cm^2

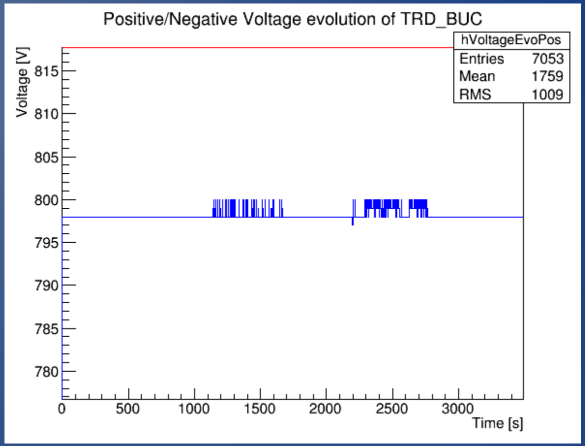
Current & HV evolution for TRD2012

Run230414_2204







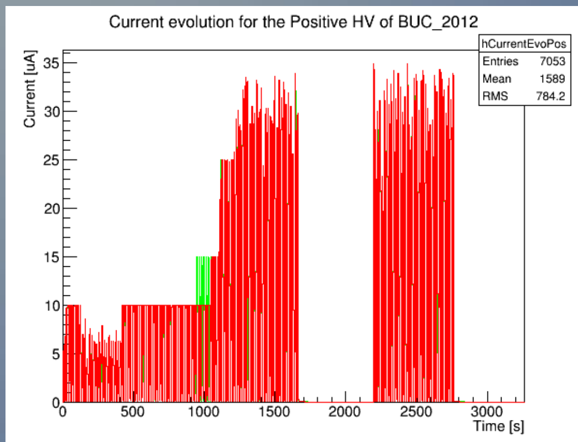


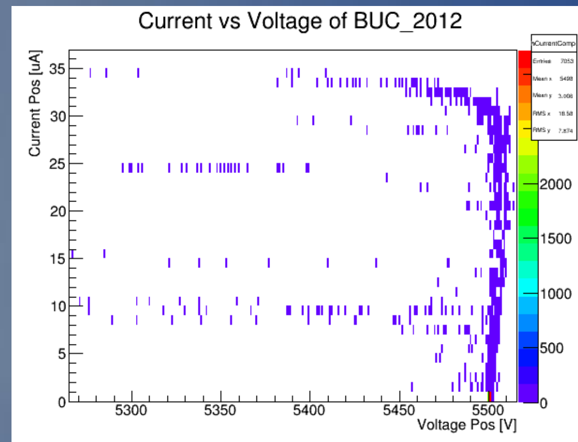
I_{TRD} = 15 - 35 µA @ V_{ANODE} = 1950 V – 1630 V = ΔV = 320 V

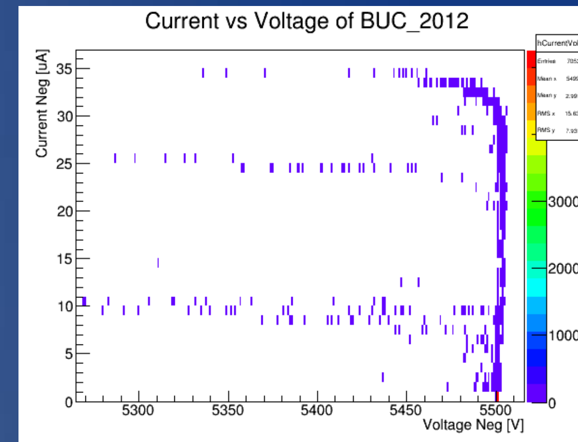
HV variations due to the current protection setting

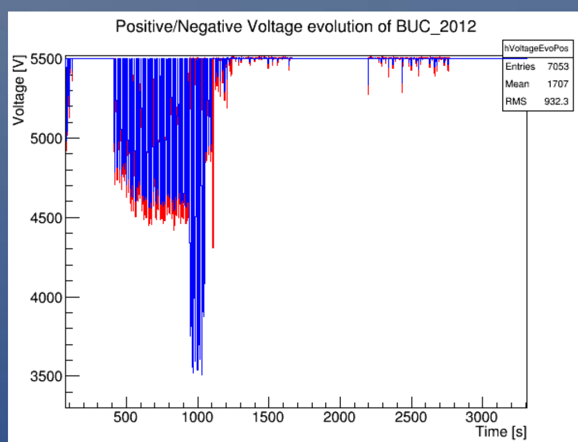
Current & HV evolution for RPC2012

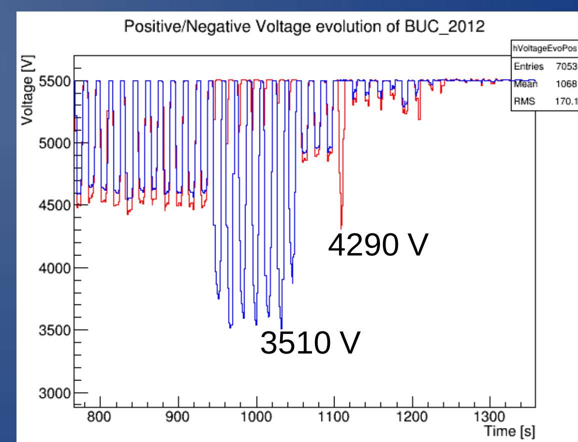
Run230414_2204









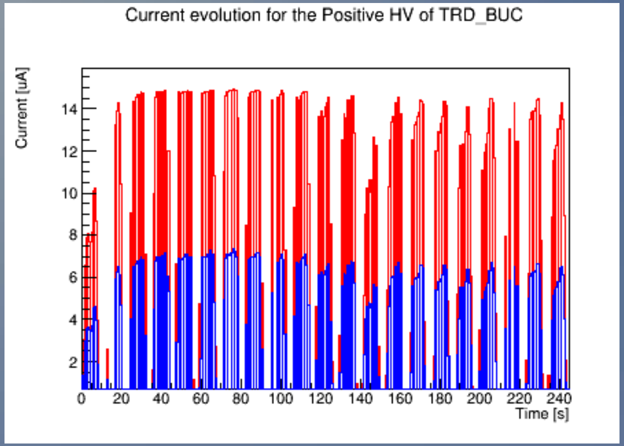


ΔV_P = 5500 V – 4290 V = 1210 V
ΔV_N = 5500 V – 3510 V = 1990 V

Large HV variations due to the current protection setting;
Smaller variations could be due to the counting rate

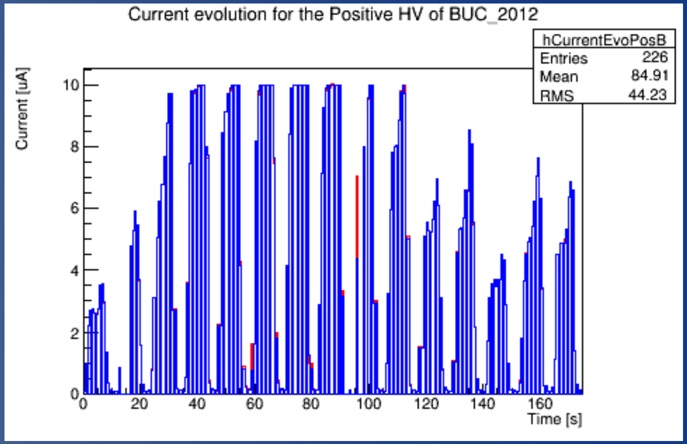
Current/rate estimation for

TRD2012



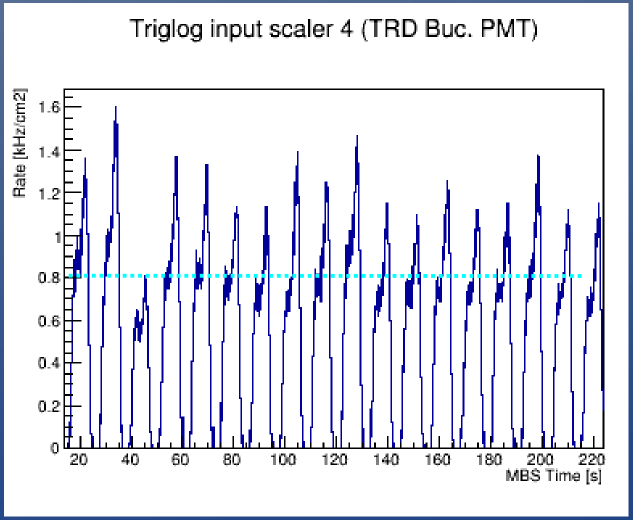
Active area 54 cm x 56 cm = 3024 cm^2
I> 12.6 nA/cm^2 @ ~0.8 – 0.9 kHz/cm^2

RPC2012



Active area = 1090 cm^2

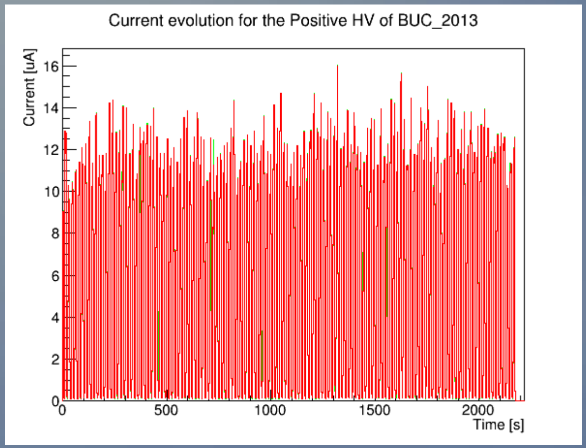
I > 9 nA/cm^2 @ ~0.8 – 0.9 kHz/cm^2

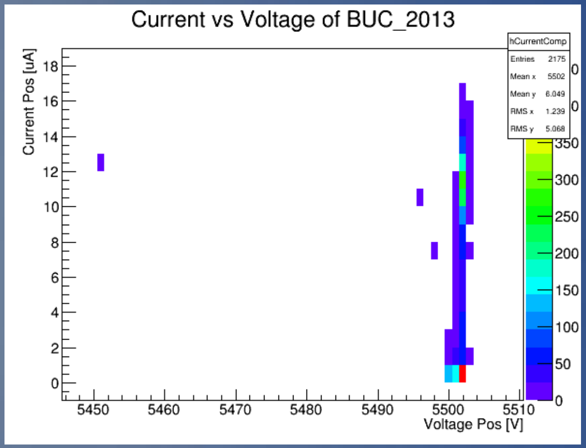


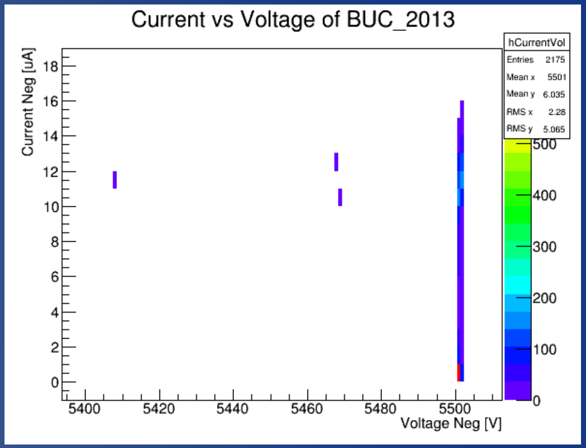
- the exposure was not uniform,
- larger on the side closer to the target
- linear rate extrapolation at the TRD edge: 4.21 kHz/cm^2

Current & HV evolution for RPC2013

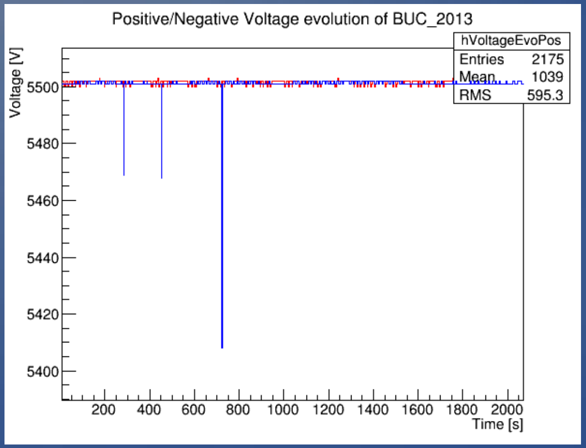
Run230414_2336







Current protection setting was not reached

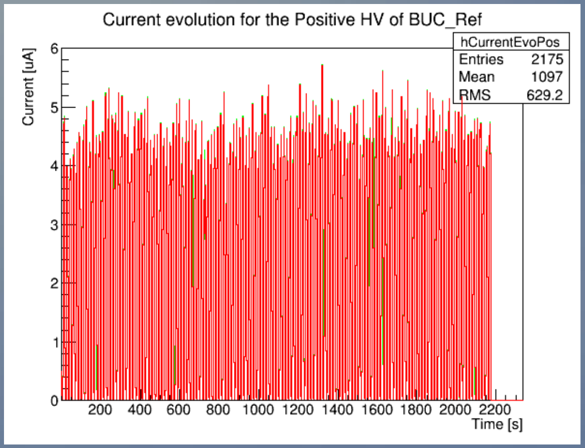


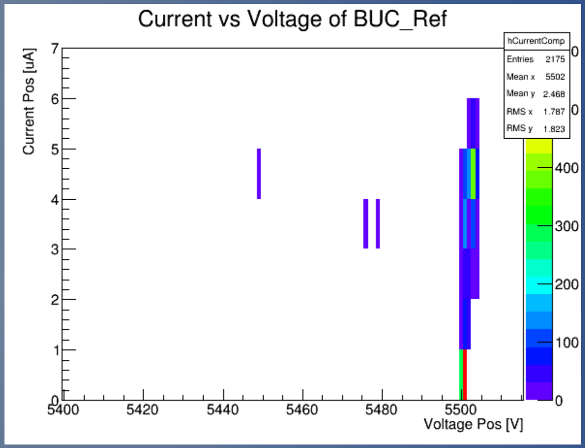
ΔV_P = 5500 V – 5450 V = 50 V
ΔV_N = 5500 V – 5410 V = 90 V

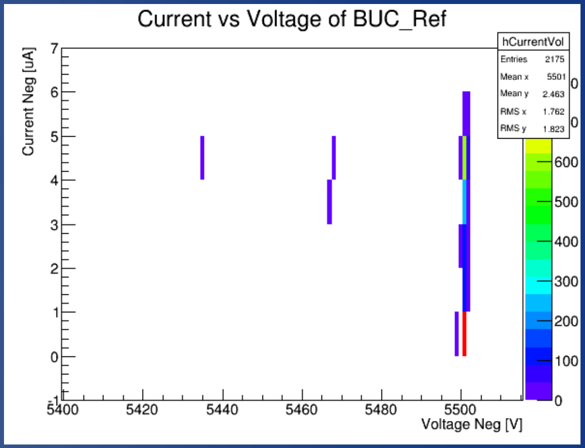
HV variations due to the high counting rate

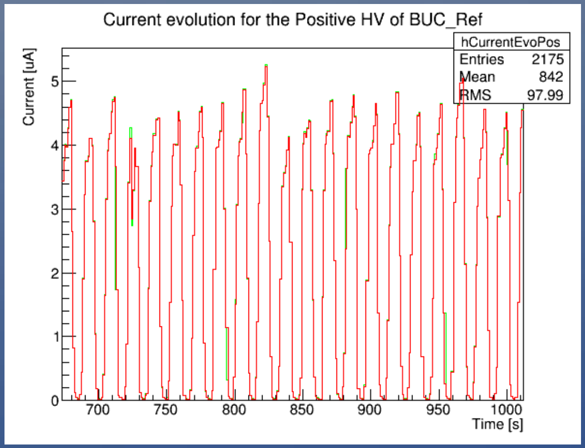
Current & HV evolution for RPCref

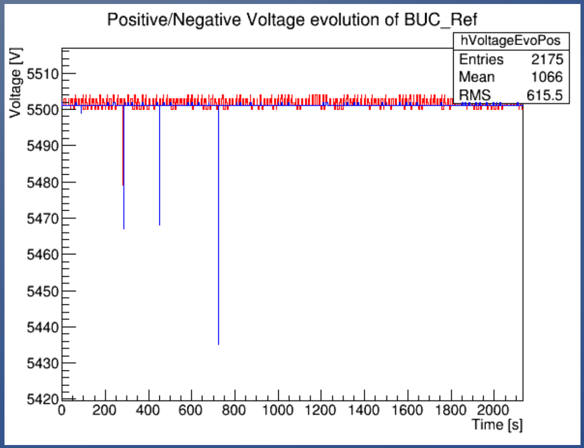
Run230414_2336

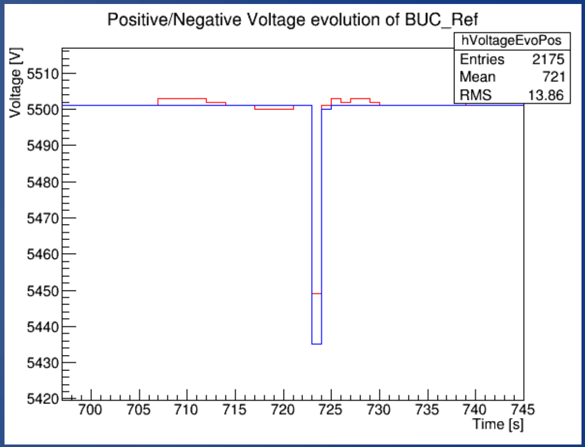










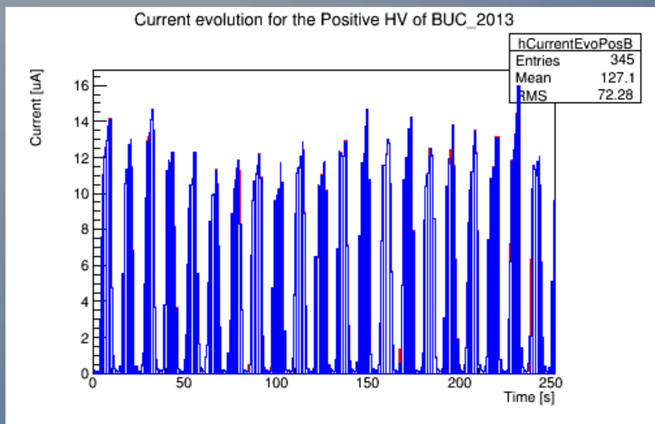


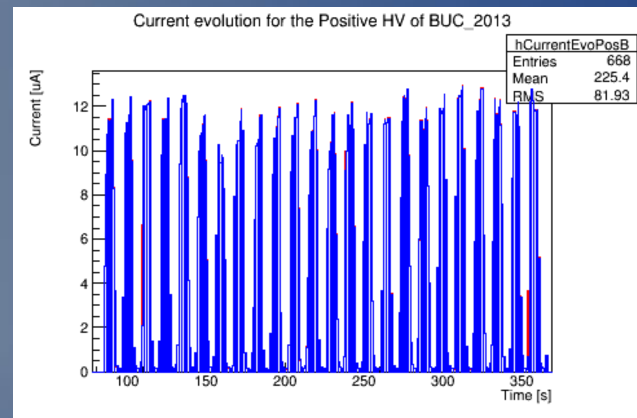
ΔV_P = 5500 V – 5450 V = 50 V
ΔV_N = 5500 V – 5435 V = 65 V

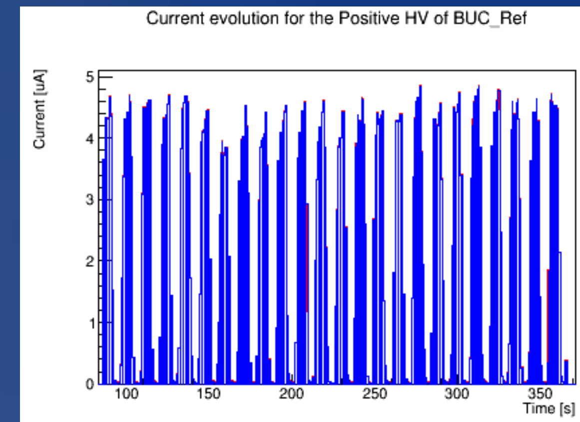
HV variations due to the high counting rate

Current/rate estimation for

RPC2013 *RPCref*





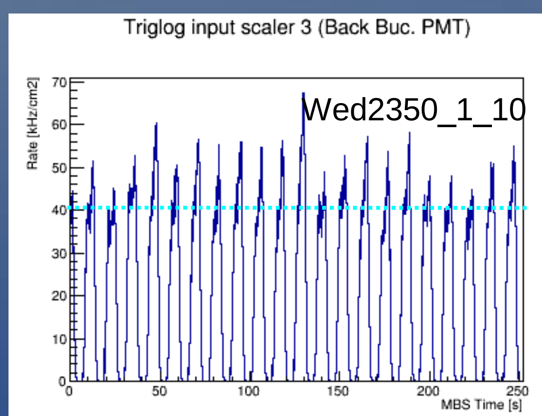


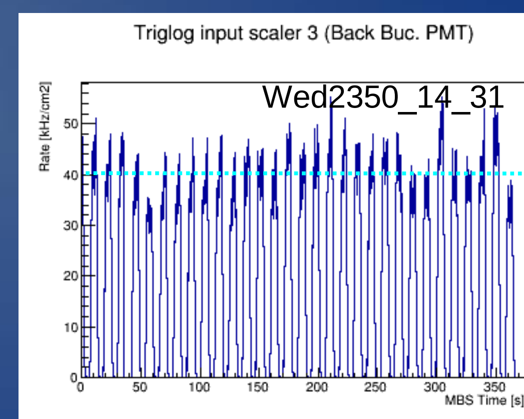
Active area = 532 cm^2

I = 25 - 30 nA/cm^2 @ ~35 – 40 kHz/cm^2

Active area = 84 cm^2

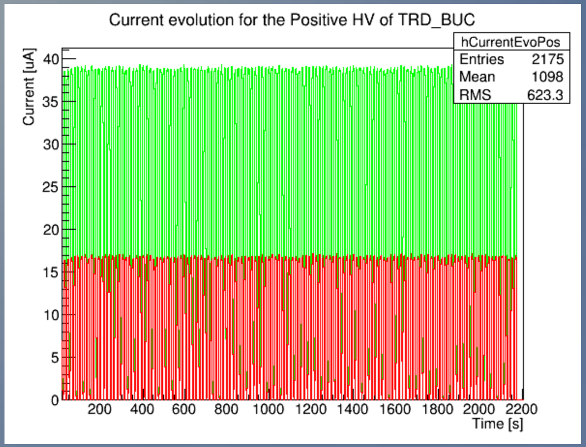
I = 55 - 60 nA/cm^2 @ ~35 – 40 kHz/cm^2

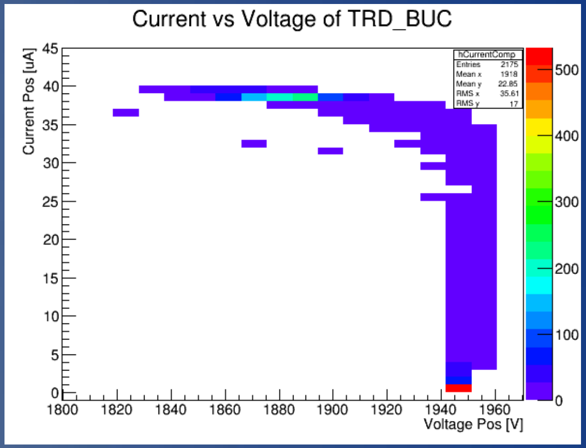


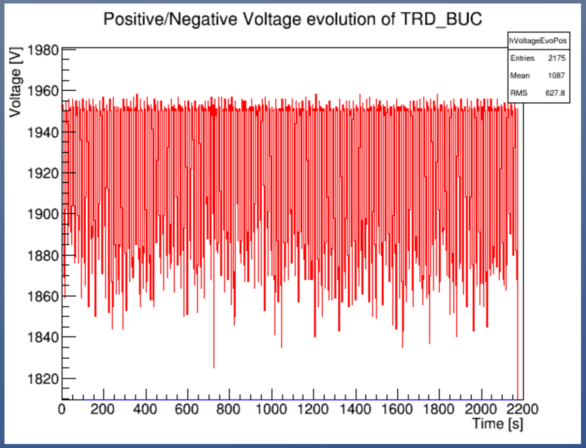


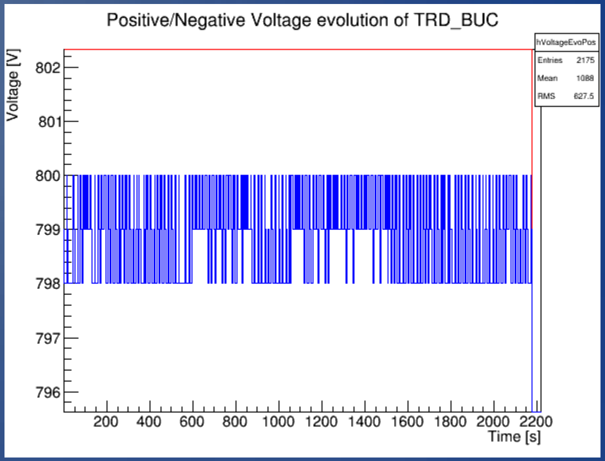
Current & HV evolution for TRD2012

Run230414_2336







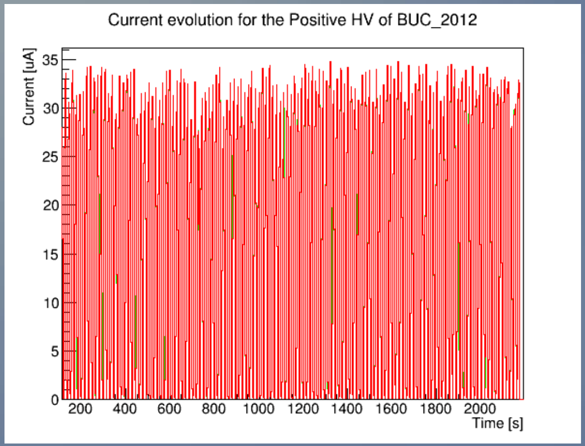


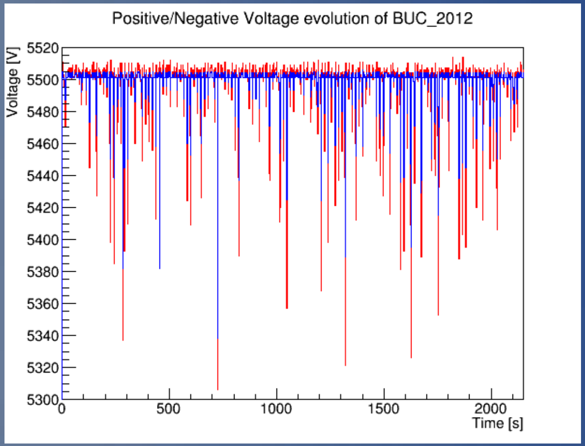
ΔV_{ANODE} **= 1950 V – 1825 V = 125 V**

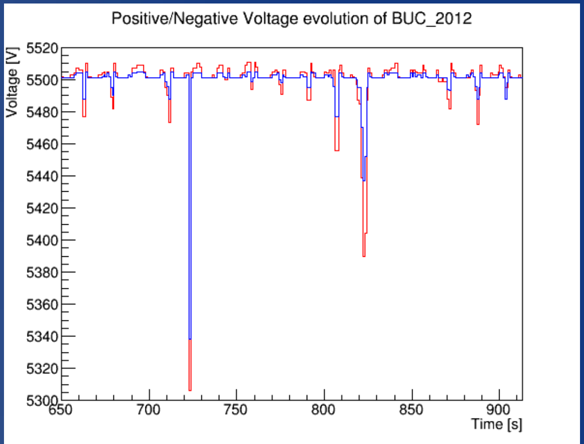
HV variations due to the current protection setting

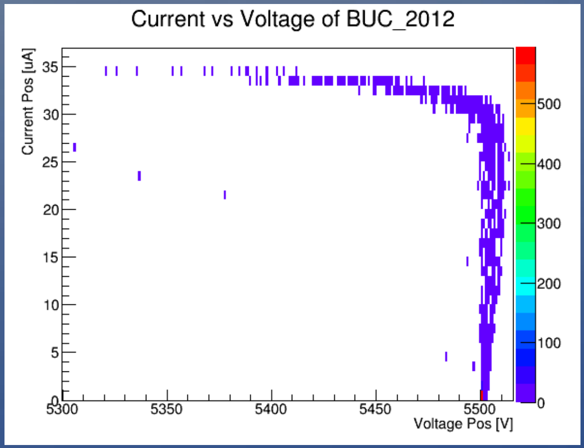
Current & HV evolution for RPC2012

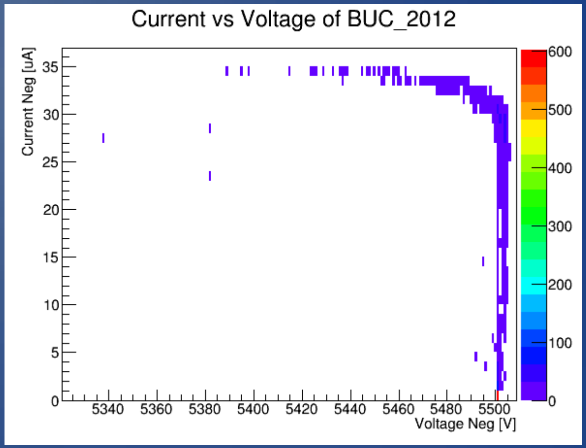
Run230414_2336









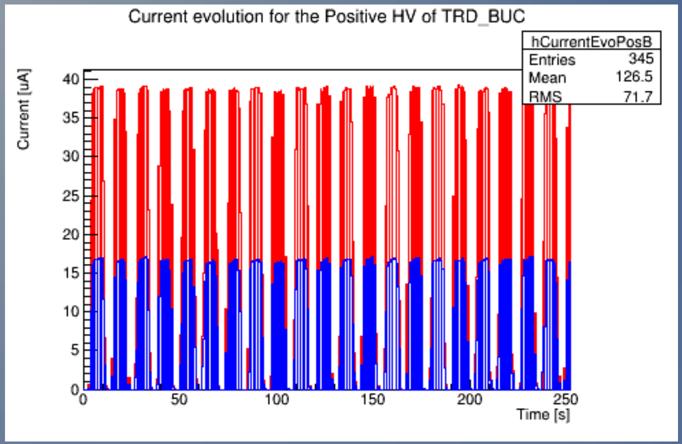


ΔV_P = 5500 V – 5305 V = 195 V
ΔV_N = 5500 V – 5335 V = 165 V

HV variations due to the high counting rate ?

Current/rate estimation for

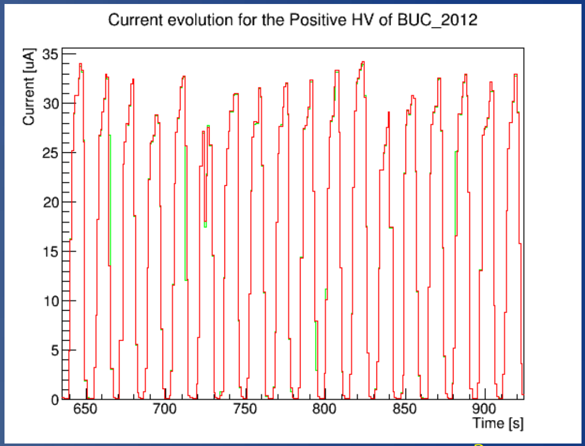
TRD2012



Active area 54 cm x 56 cm = 3024 cm^2

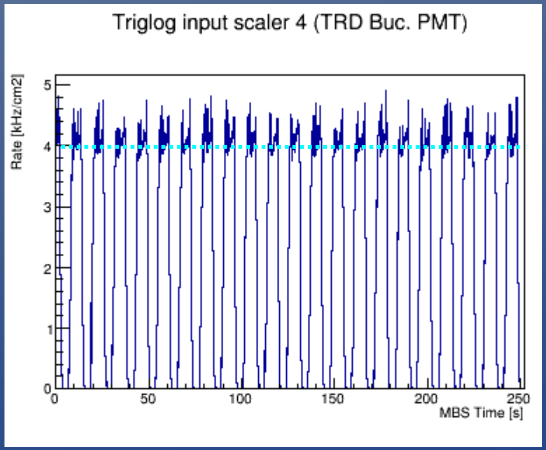
I> 12.6 nA/cm^2 @ 4 kHz/cm^2

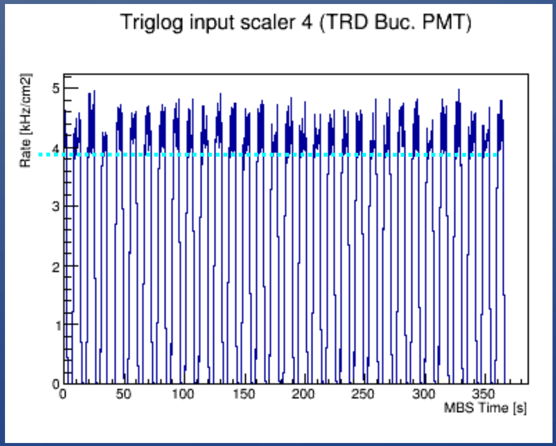
RPC2012



Active area = 1090 cm^2

I = 31 nA/cm^2 @ ~4 kHz/cm^2

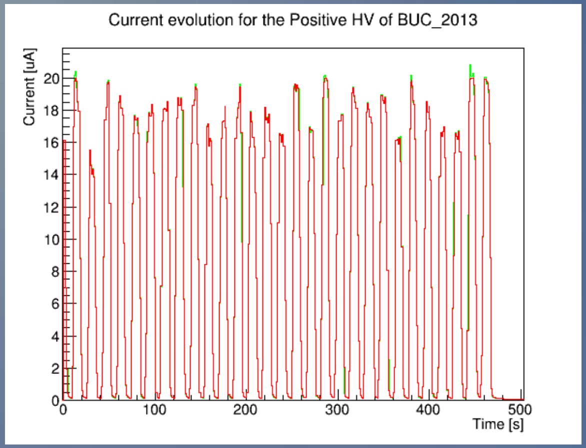


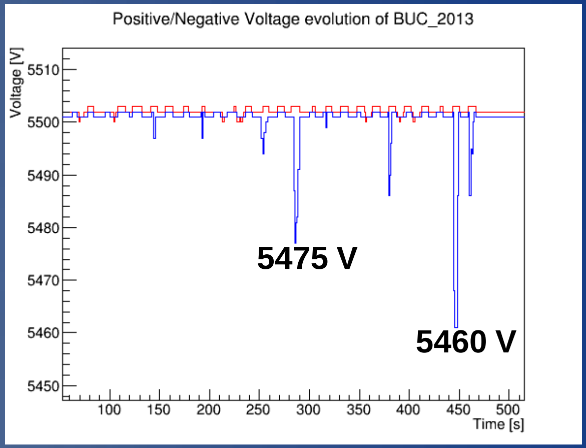


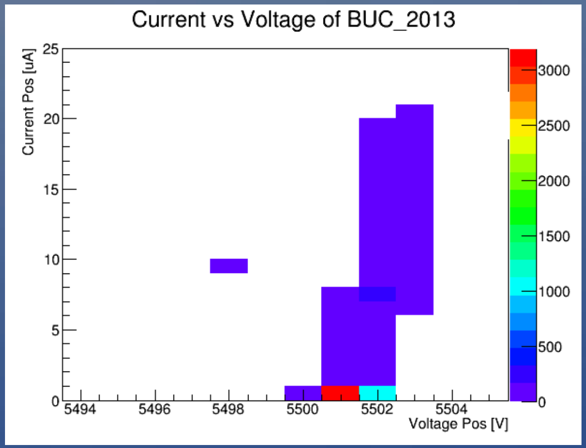
- the exposure was not uniform,
- larger on the side closer to the target
- linear rate extrapolation at the TRD edge: 42.4 kHz/cm^2

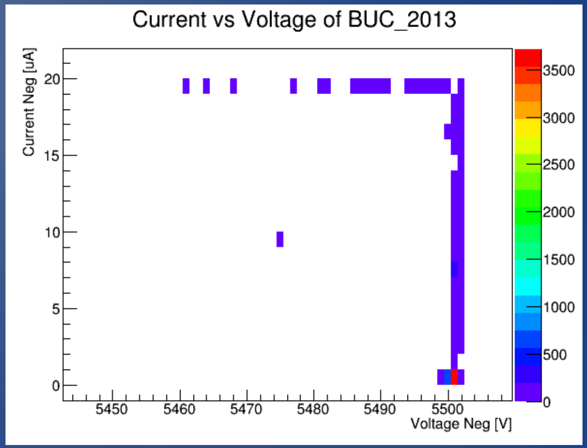
Current & HV evolution for RPC2013

Run240414_0041









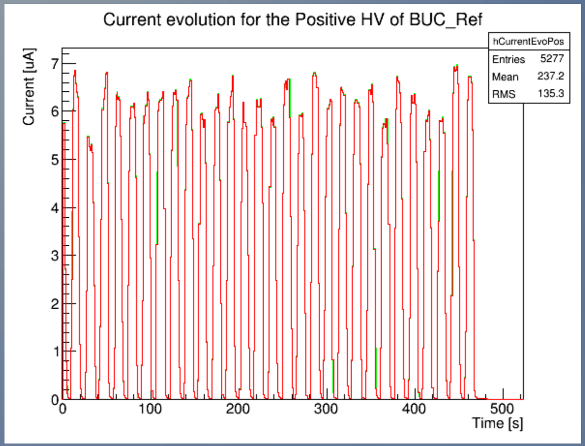
ΔV_P = 5503 V – 5500 V = 3 V

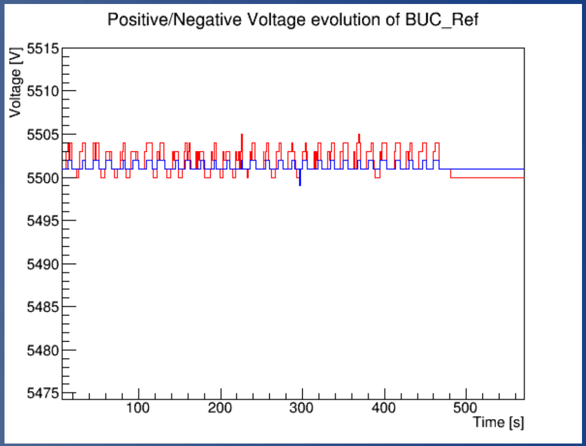
ΔV_N = 5500 V – 5460 V = 140 V

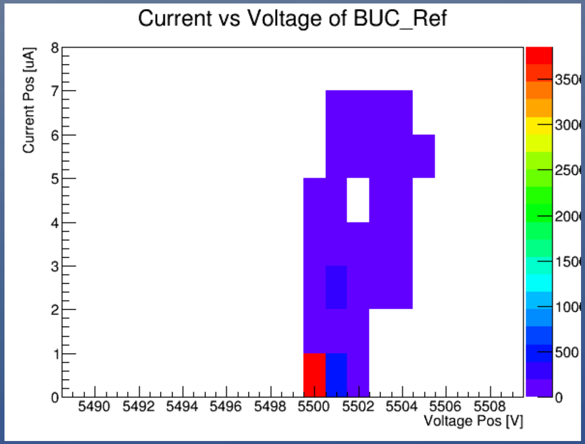
HV variations due to the high counting rate

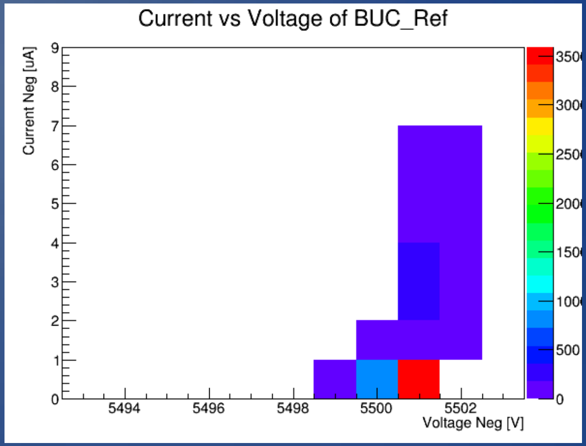
Current & HV evolution for RPCref

Run240414_0041







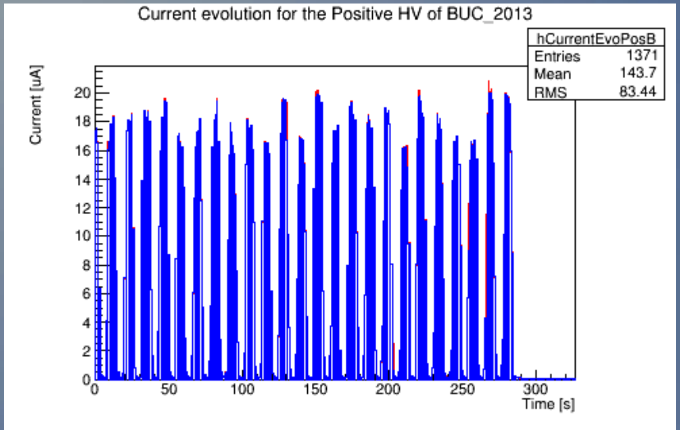


ΔV_P = 5505 V – 5500 V = 5 V
ΔV_N = 5499 V – 5503 V = 4 V

Stable behaviour

Current/rate estimation for

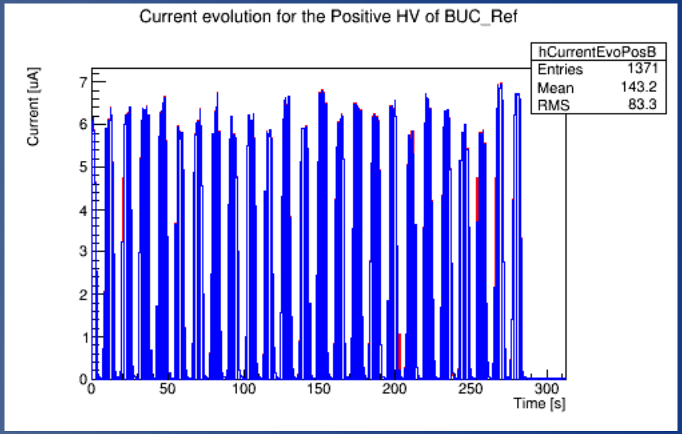
RPC2013 & RPCref



Active area = 532 cm^2

Highest current RPC2013 = 20 μA;

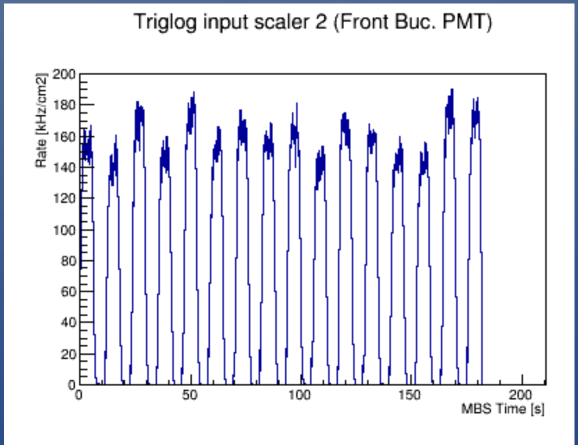
I = 37.5 nA/cm^2 @ 65 kHz/cm^2

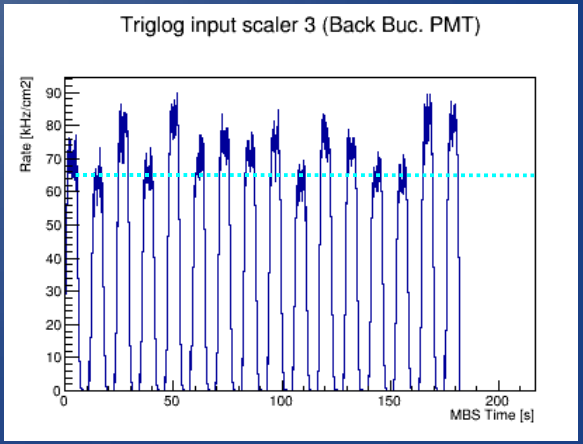


Active area = 84 cm^2

Highest current RPCref = 7 μA;

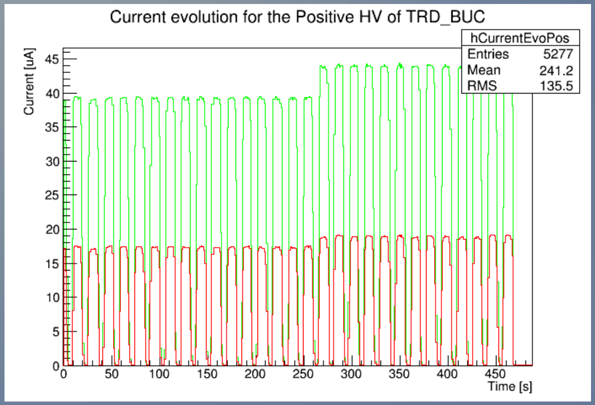
I = 83 nA/cm^2@ 65 kHz/cm^2

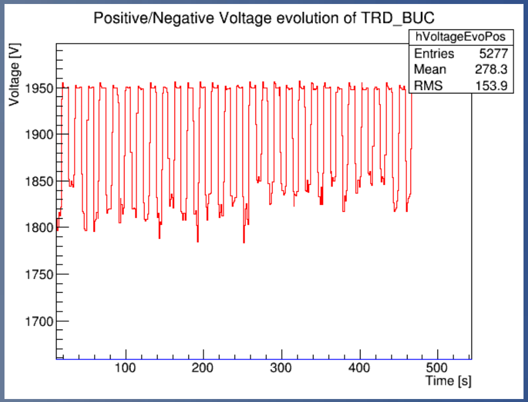


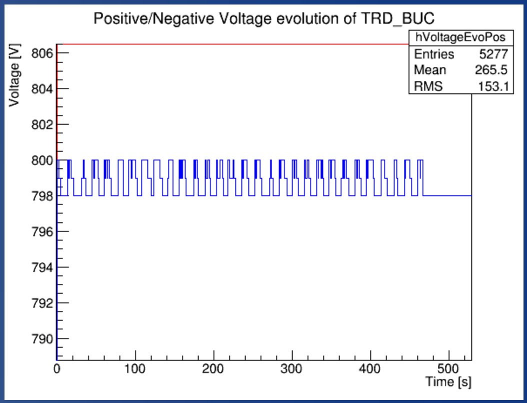


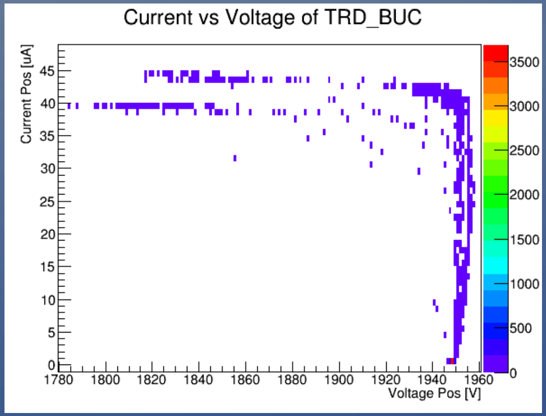
Current & HV evolution for TRD2012

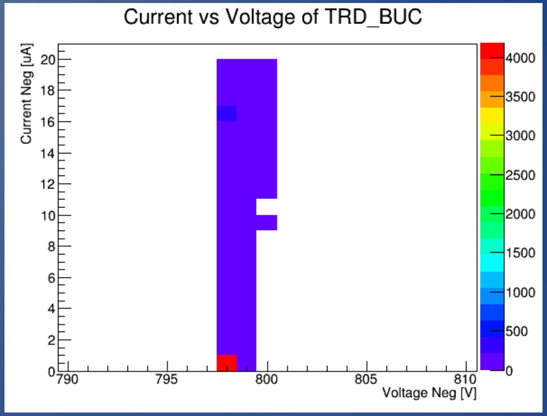
Run240414_0041









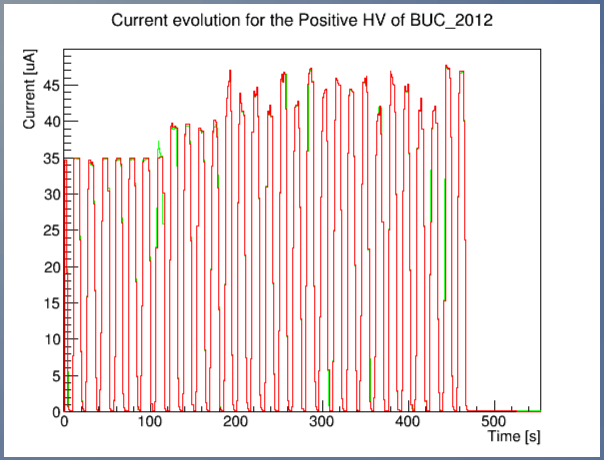


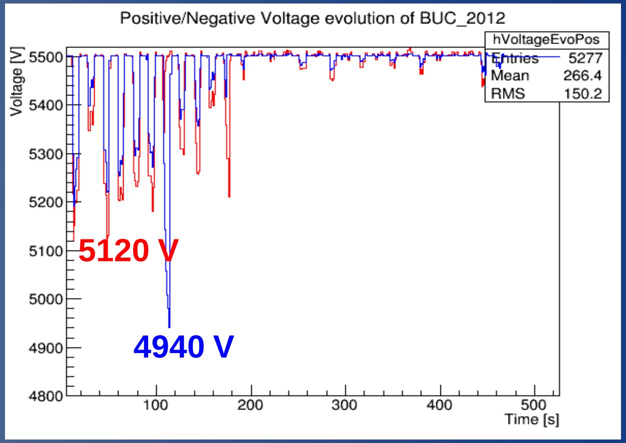
I_{TRD} = 38 -43 µA; V_{ANODE} = 1950 V – 1785 V = ΔV =165 V

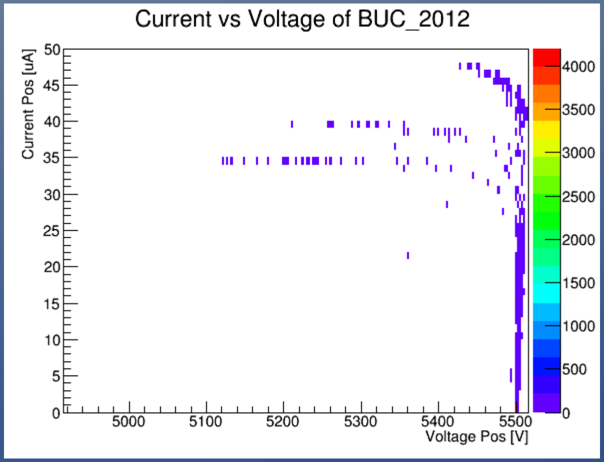
HV variations due to the current protection setting

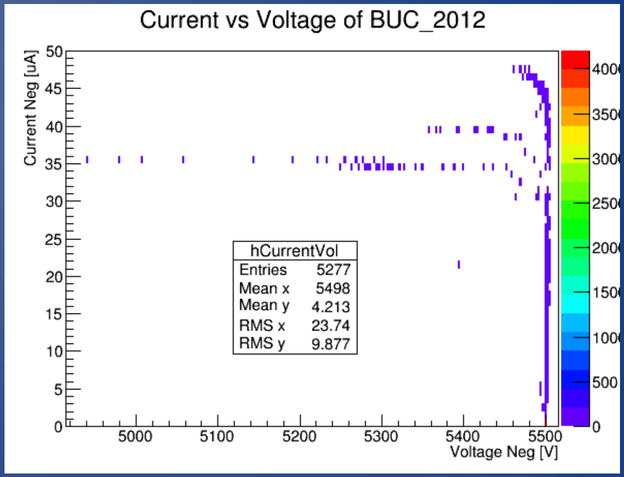
Current & HV evolution for RPC2012

Run240414_0041







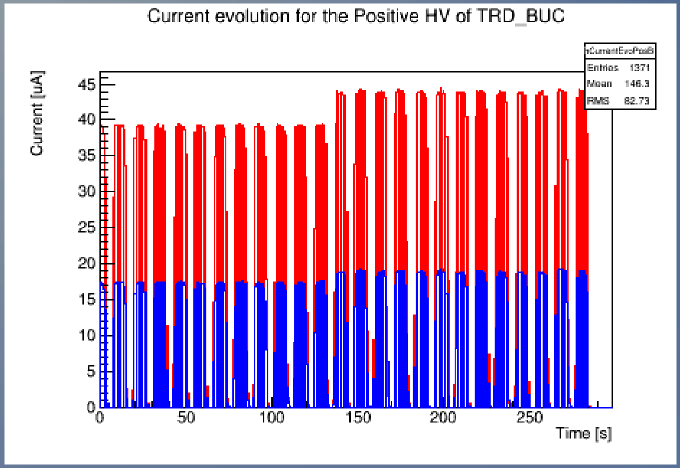


ΔV_P = 5500 V – 5120 V = 380 V
ΔV_N = 5500 V – 4940 V = 560 V

Large HV variations due to the current protection setting, smaller variation when the protection was removed

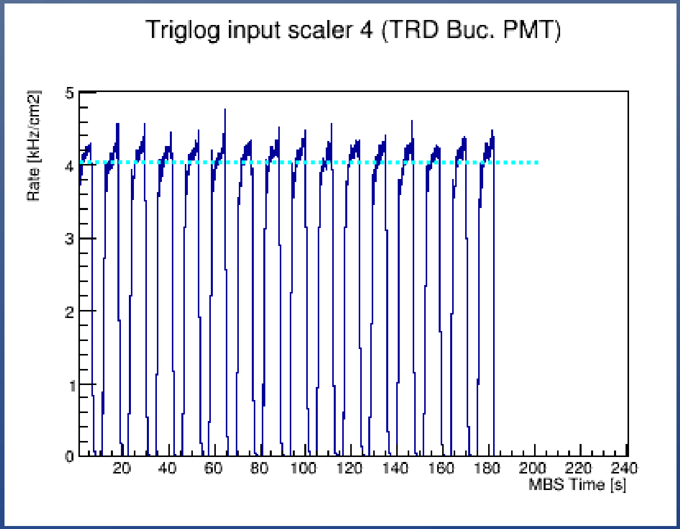
Current/rate estimation for

TRD2012

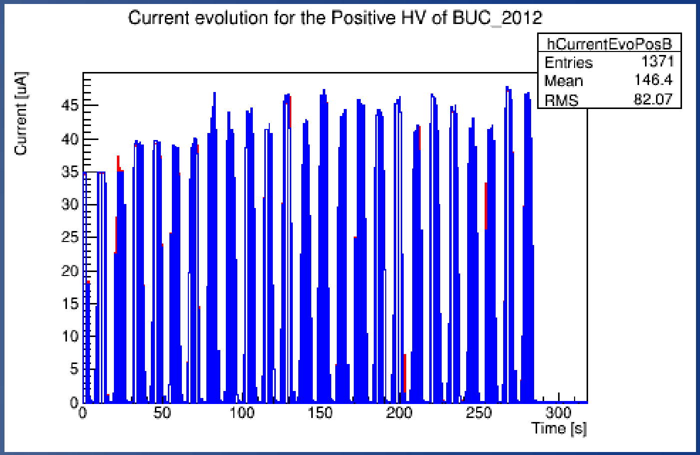


Active area: 54 cm x 56 cm = 3024 cm^2

I > 15 nA/cm^2 @ ~4 kHz/cm^2



RPC2012



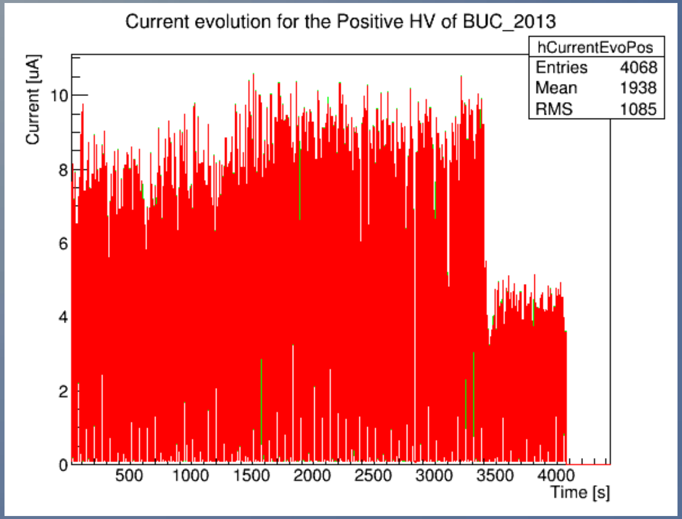
Active area = 1090 cm^2

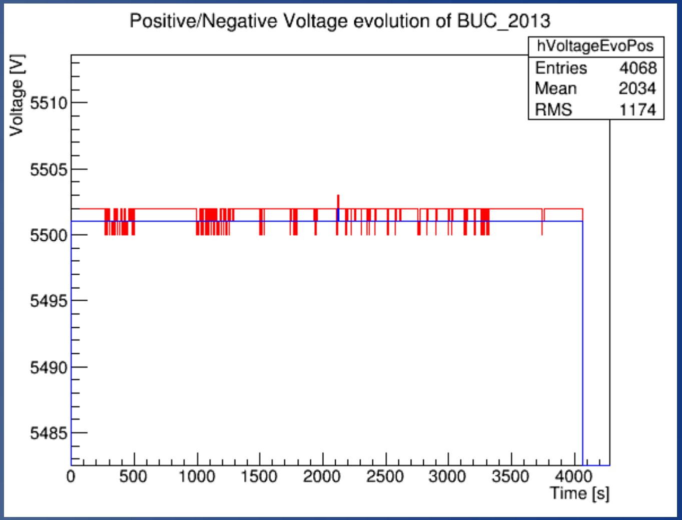
I = 41 nA/cm^2 @ ~4 kHz/cm^2

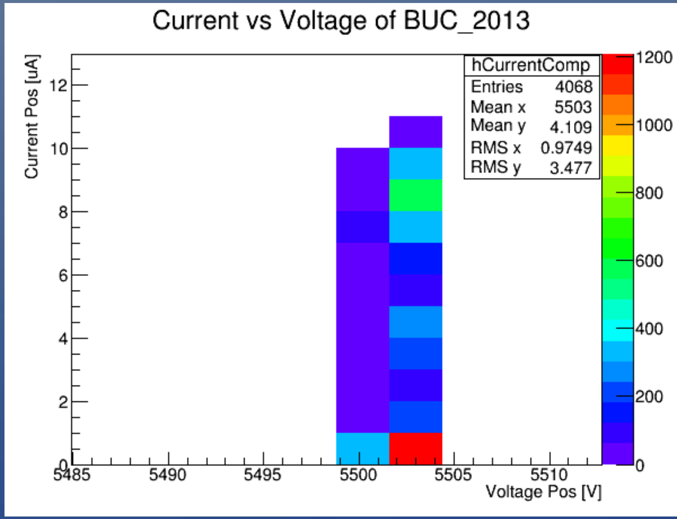
- the exposure was not uniform,
- larger on the side closer to the target
- linear rate extrapolation at the TRD edge: 69 kHz/cm^2

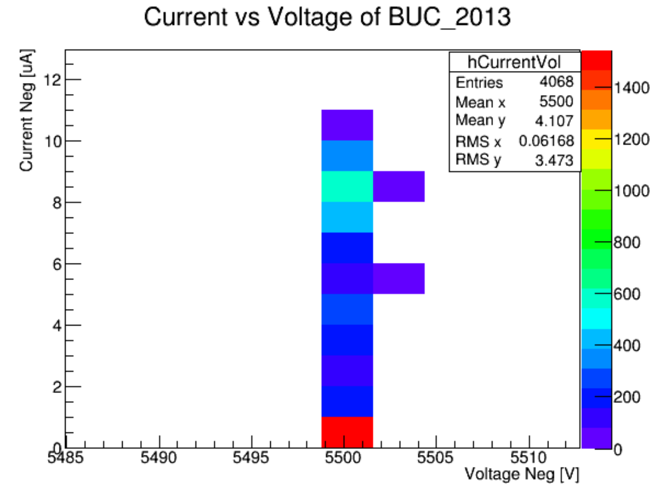
Current & HV evolution for RPC2013

Run240414_0244





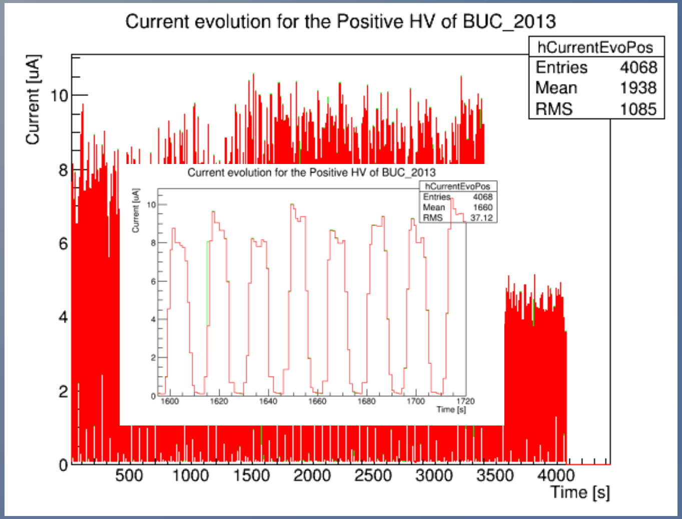


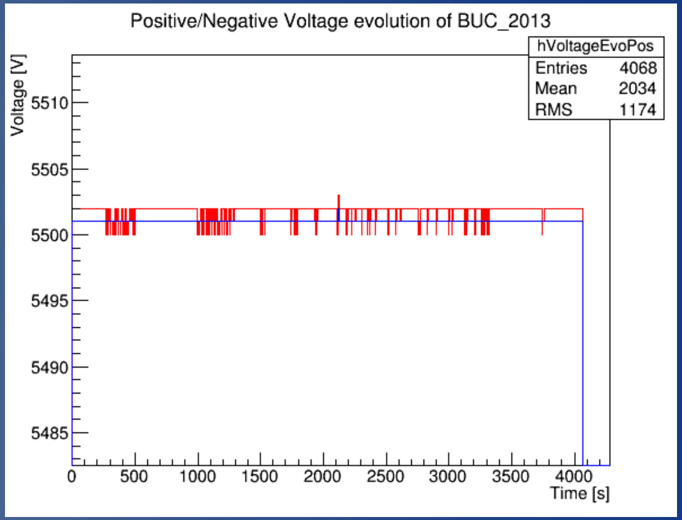


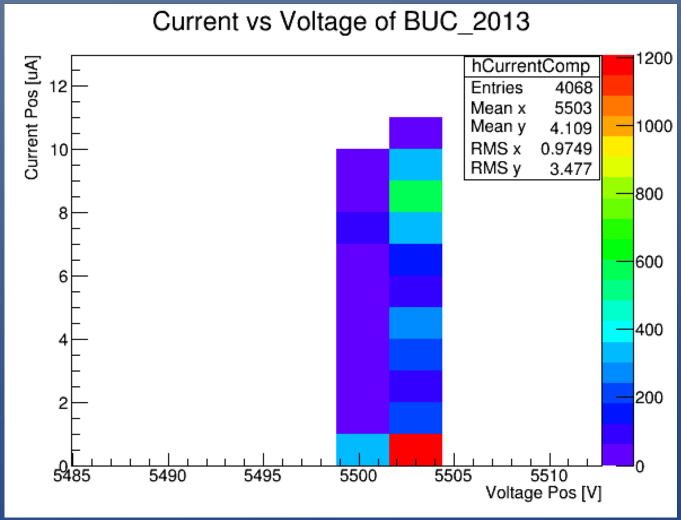
Stable behaviour of RPC 2013

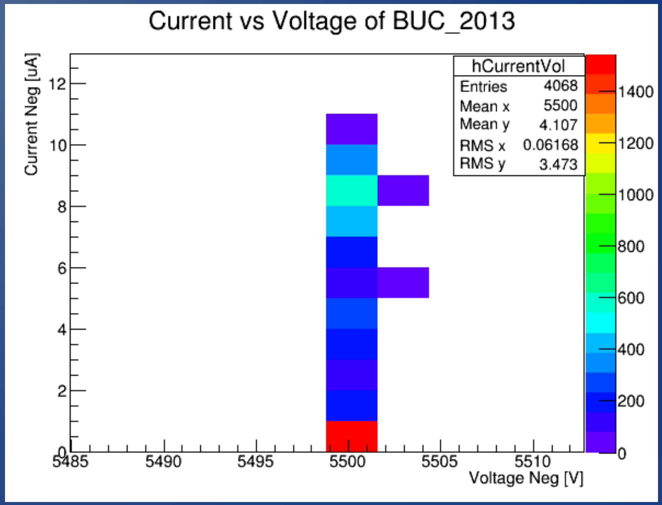
Current & HV evolution for RPC2013

Run240414_0244





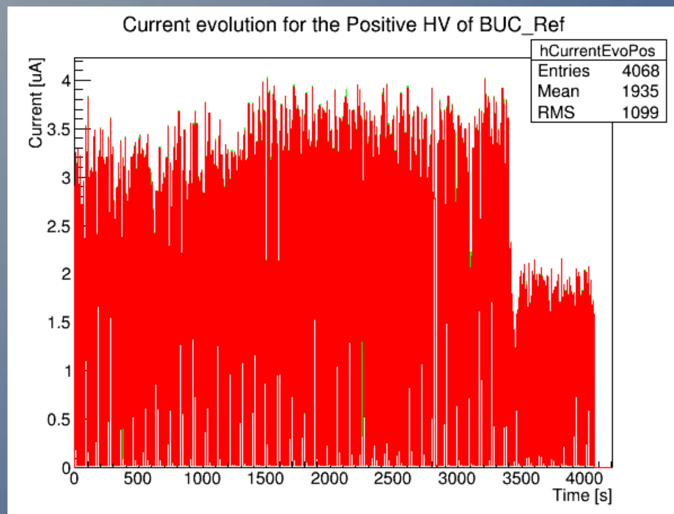


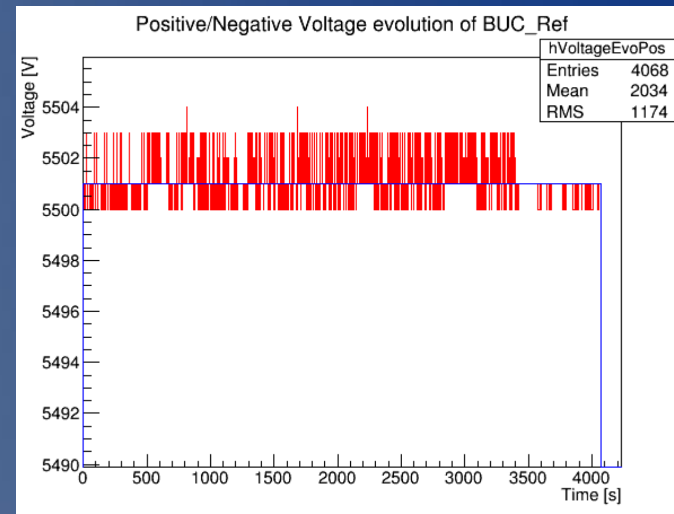


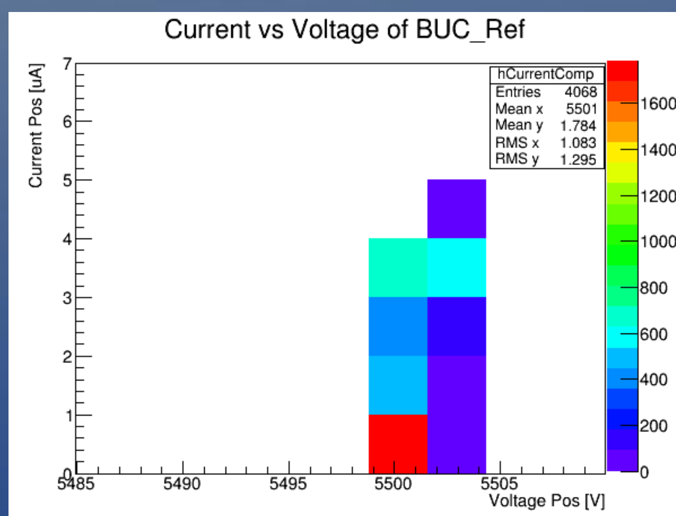
Stable behaviour of RPC 2013

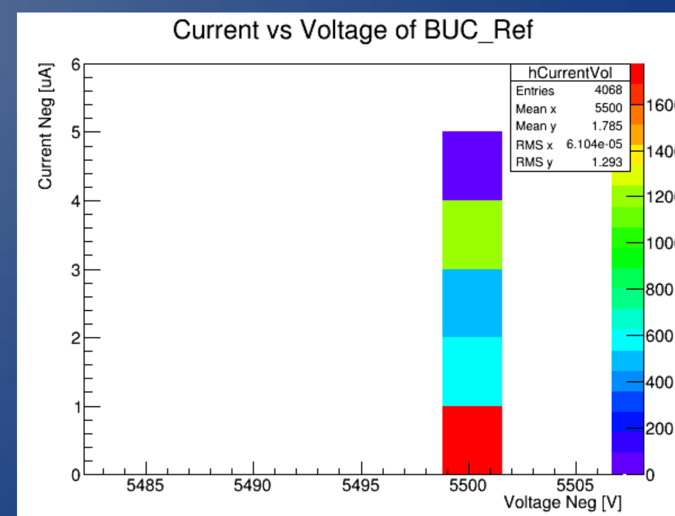
Current & HV evolution for RPCref

Run240414_0244





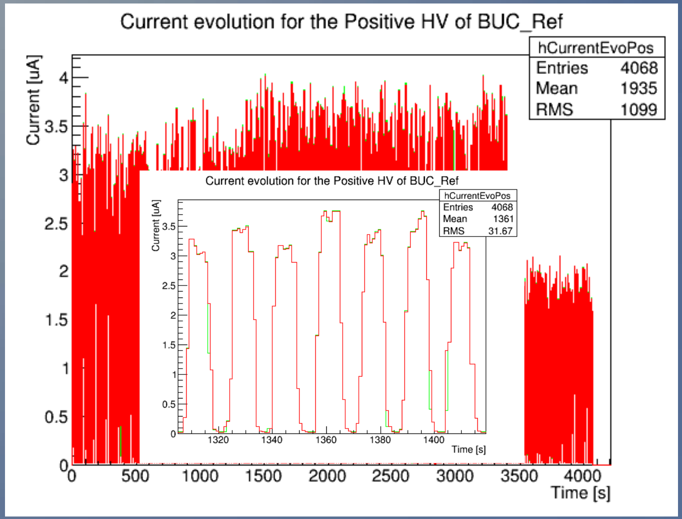


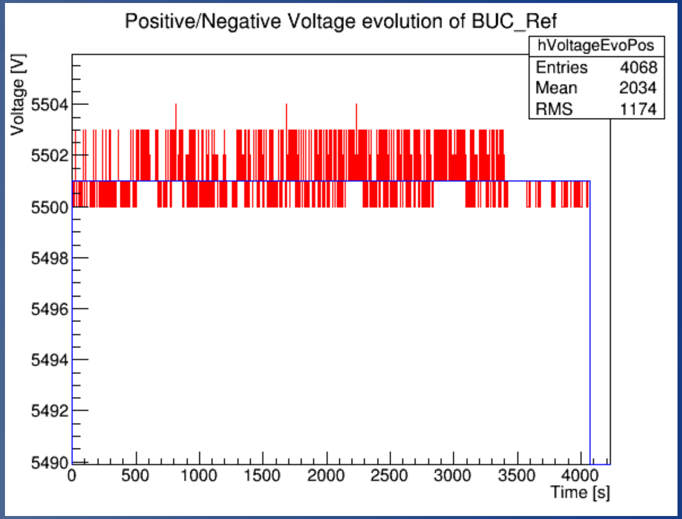


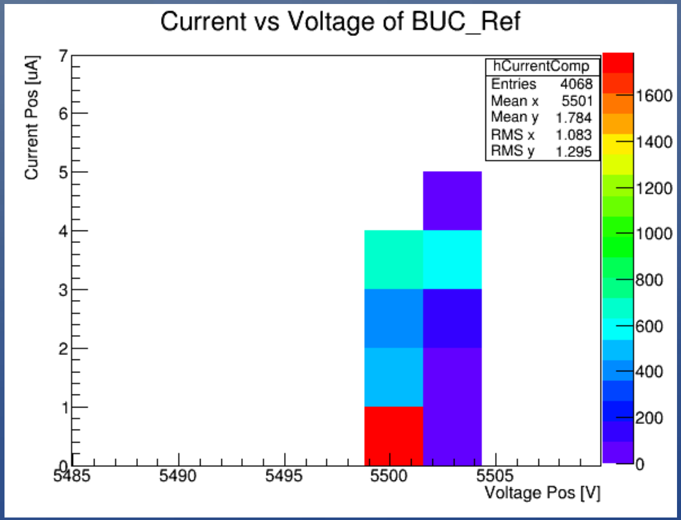
Stable behaviour of reference RPC

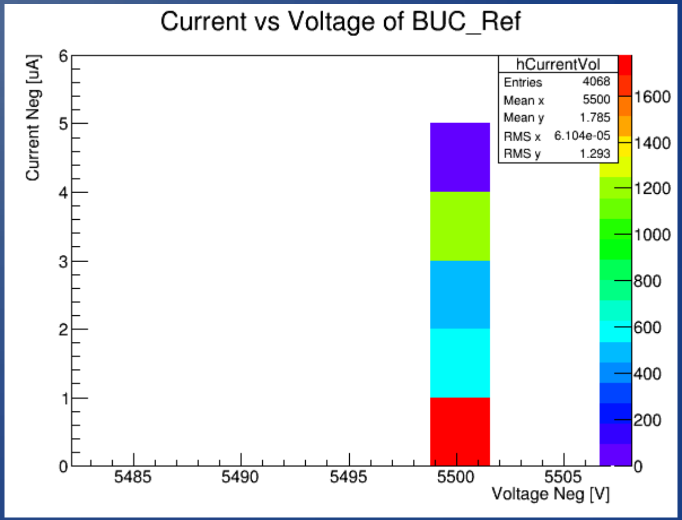
Current & HV evolution for RPCref

Run240414_0244



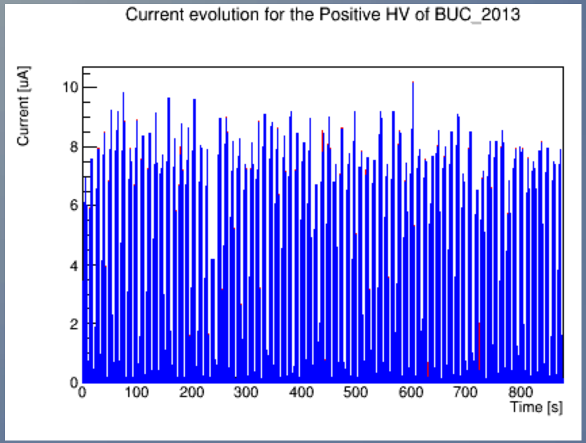






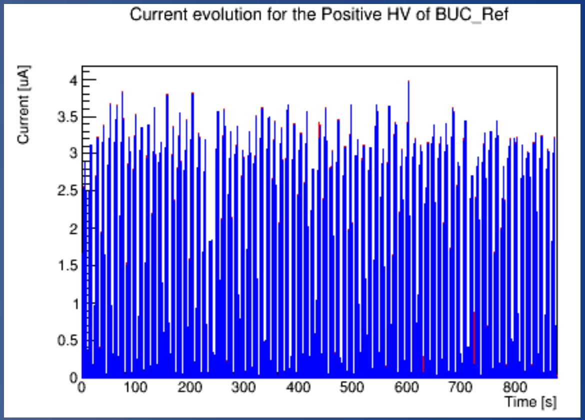
Stable behaviour of reference RPC

Current/rate estimation for
RPC2013 & RPCref



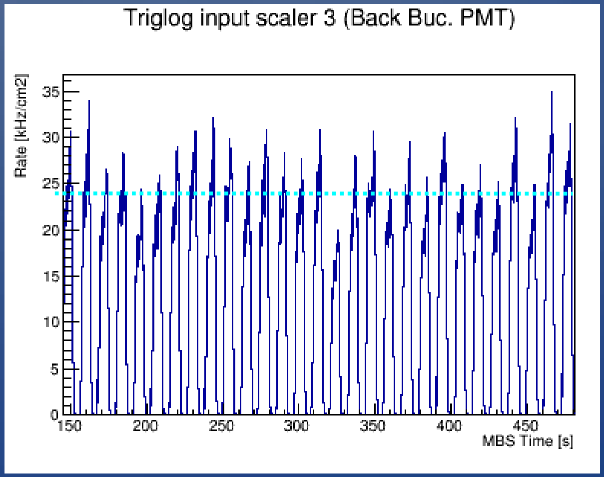
Active area = 532 cm^2

I = 16 nA/cm^2 @ ~24 kHz/cm^2



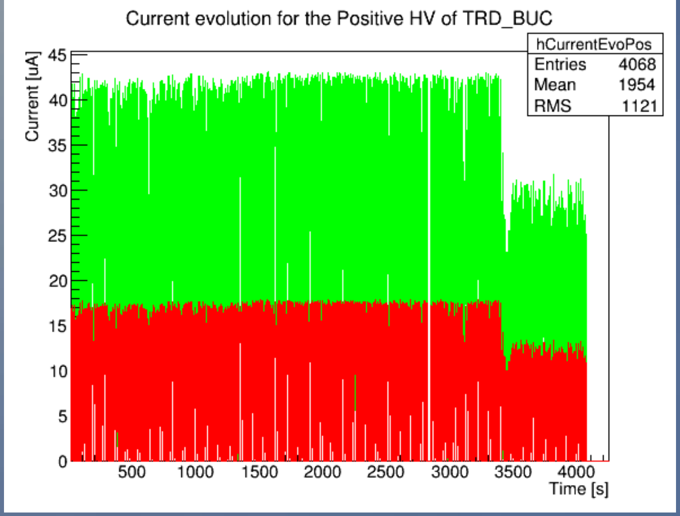
Active area = 84 cm^2

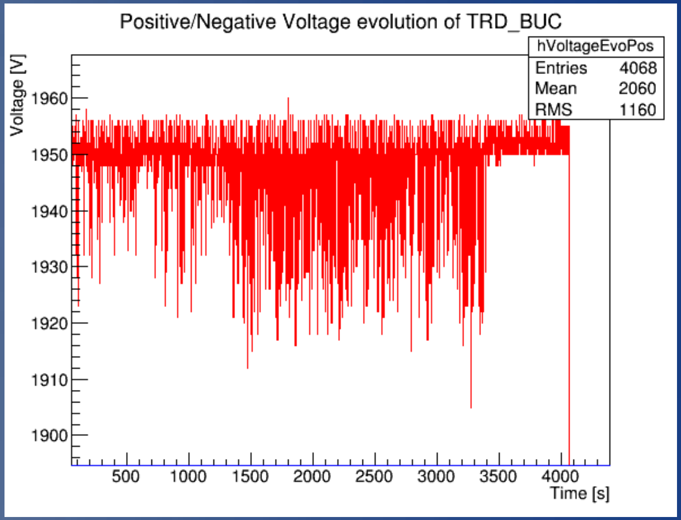
I = 42 nA/cm^2 @ ~24 kHz/cm^2

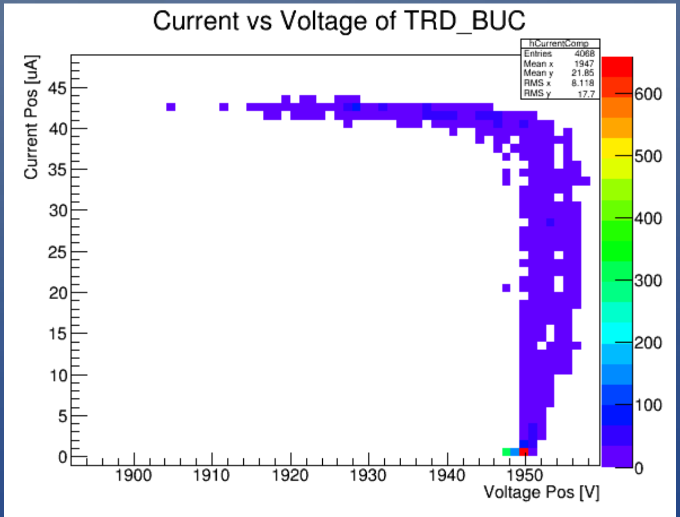


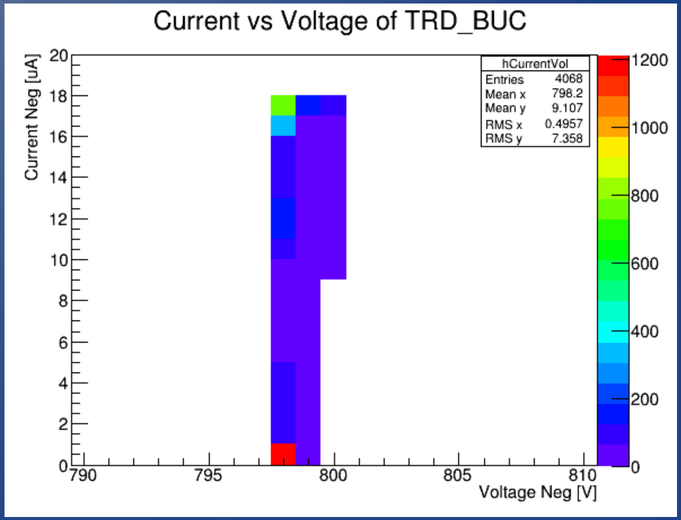
Current & HV evolution for TRD2012

Run240414_0244





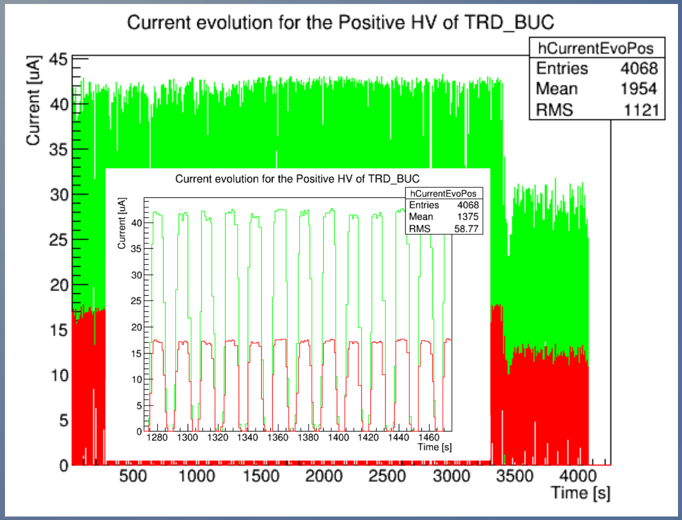


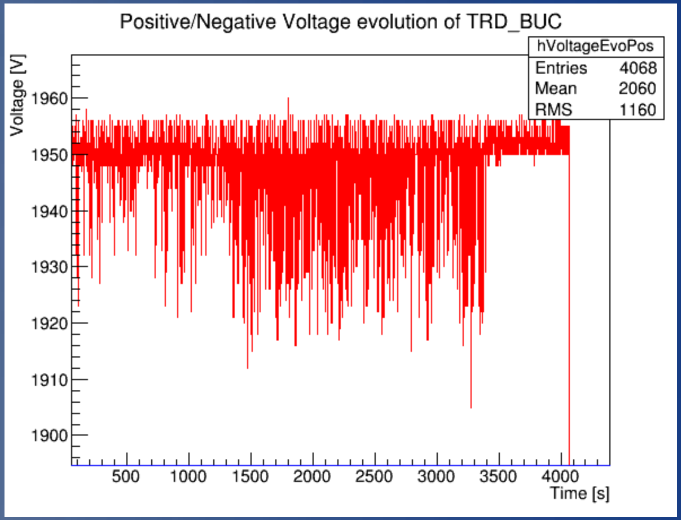


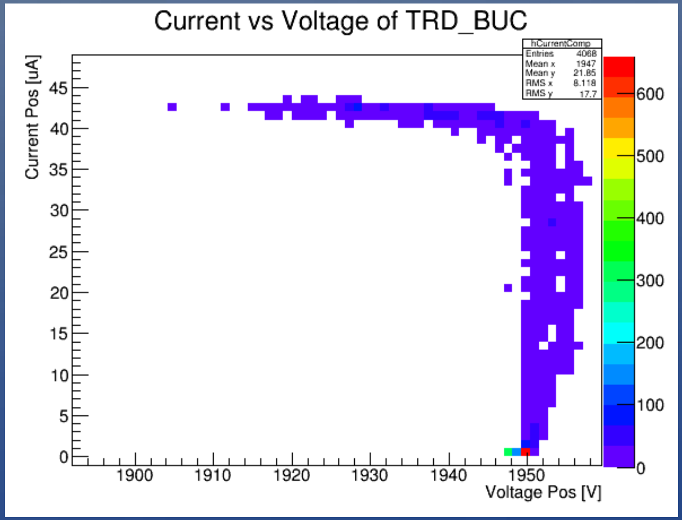
HV variations due to the current protection setting

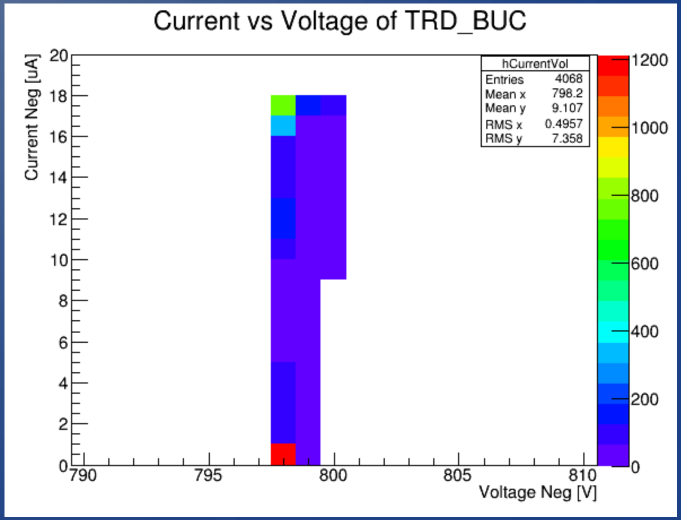
Current & HV evolution for TRD2012

Run240414_0244





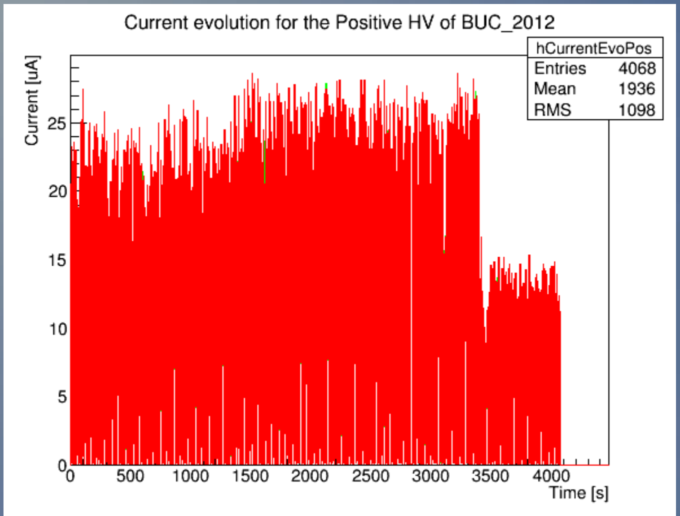


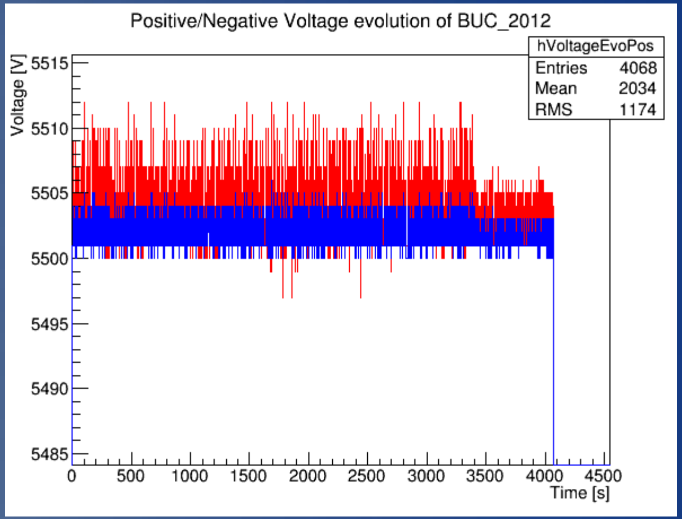


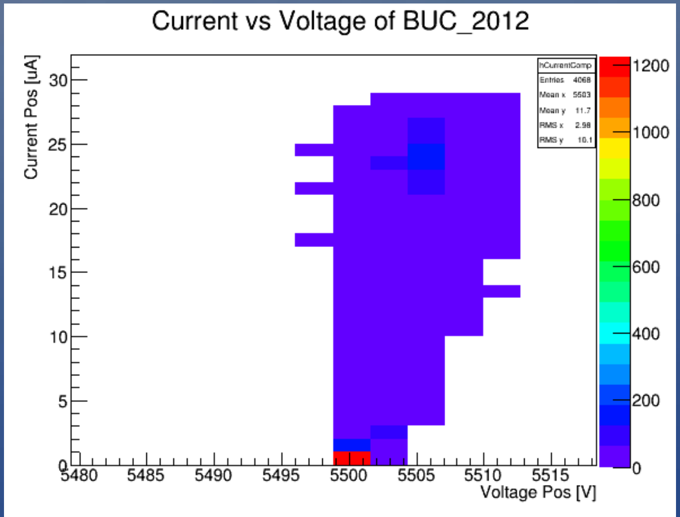
HV variations due to the current protection setting

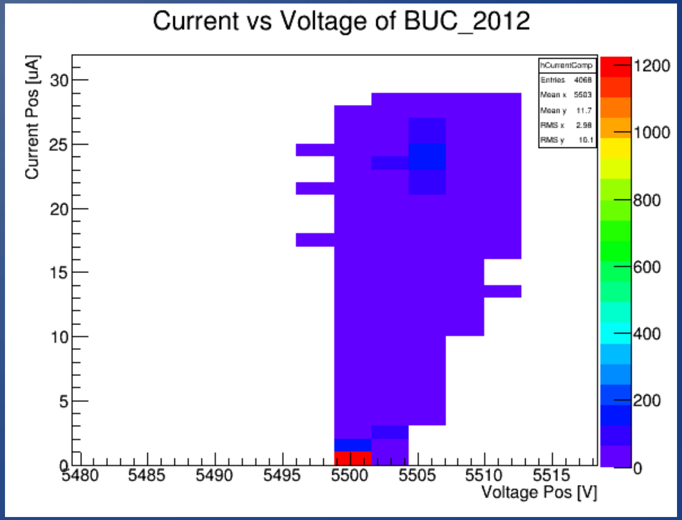
Current & HV evolution for RPC2012

Run240414_0244





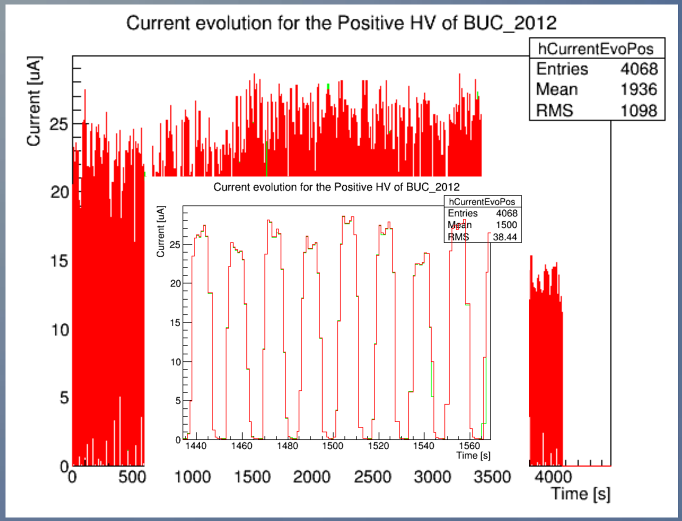


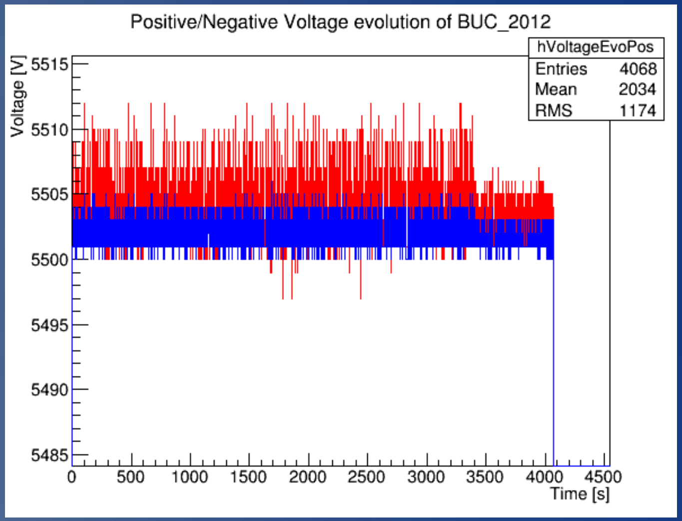


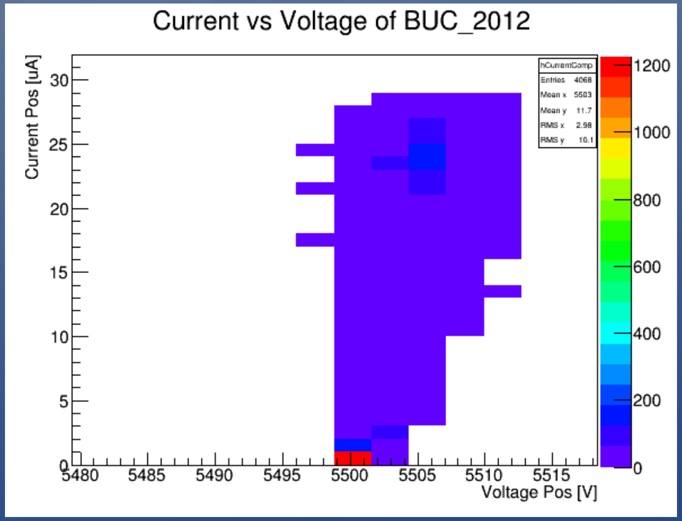
Stable behaviour of RPC2012

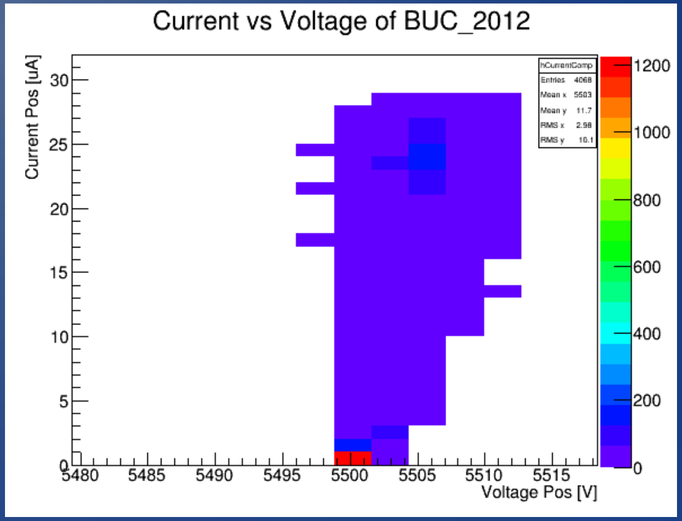
Current & HV evolution for RPC2012

Run240414_0244





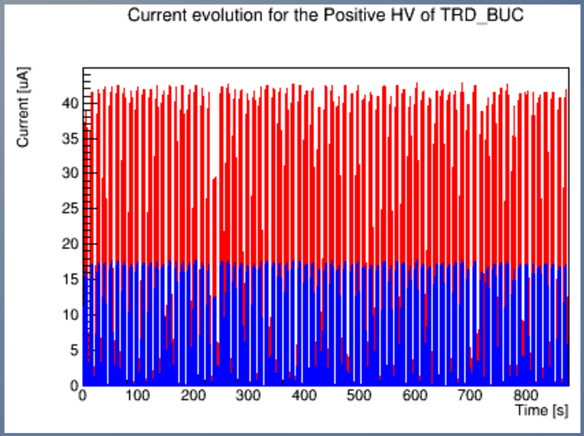




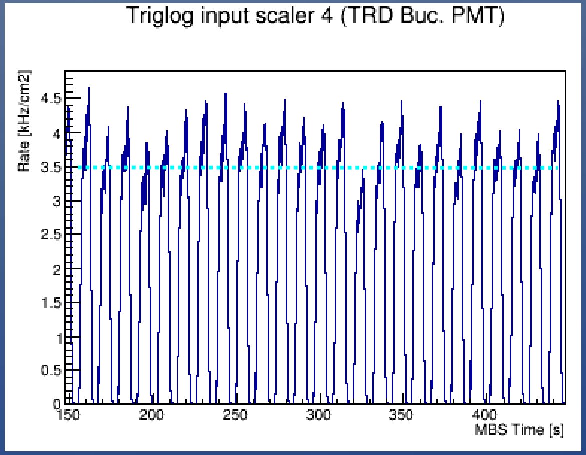
Stable behaviour of RPC2012

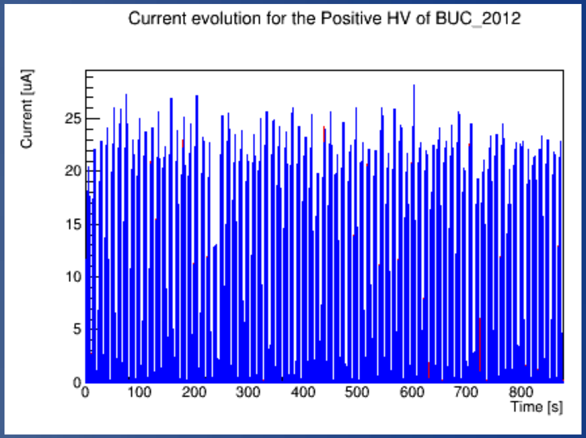
Current/rate estimation for

TRD2012 *RPC2012*



Active area: 54 cm x 56 cm = 3024 cm^2
I > 15 nA/cm^2 @ ~4 kHz/cm^2

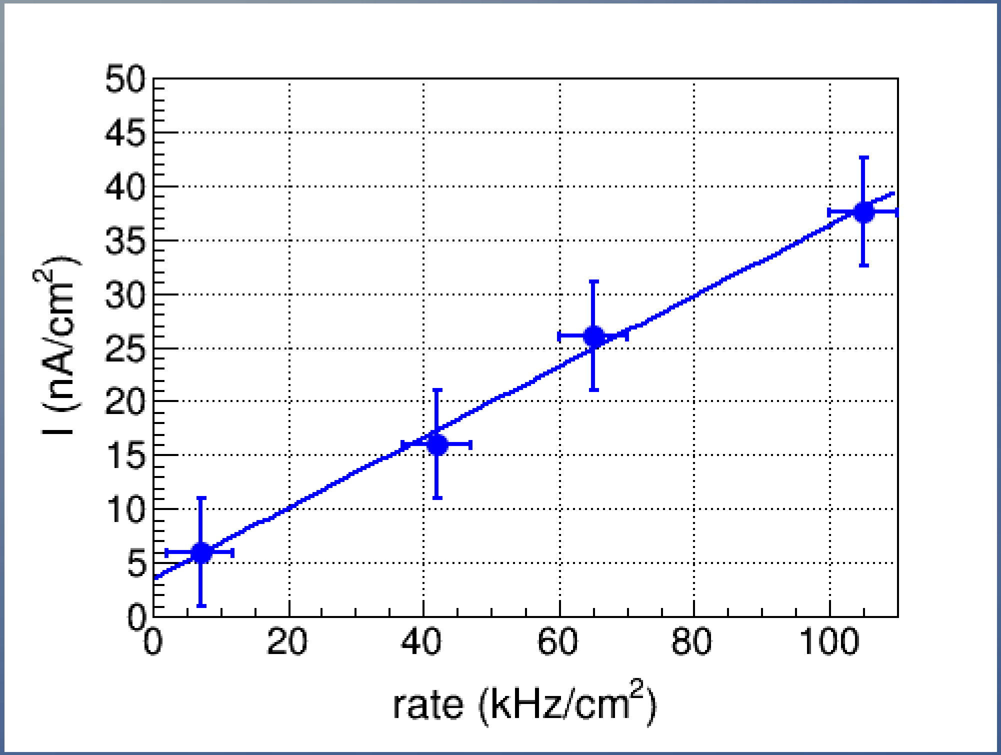




Active area = 1090 cm^2
I = 41 nA/cm^2 @ ~4 kHz/cm^2

- the exposure was not uniform,
- larger on the side closer to the target
- linear rate extrapolation at the TRD edge: 25.37 kHz/cm^2

Current & HV @ rate for RPC2013



$\langle V_{drop} \rangle = \langle I(nA/cm^2) \rangle * \rho(\Omega cm) * (nd)$

n = number of glass plates

d = glass thickness

ρ = glass resistivity

The largest measured current value was of about 0.037 μA/cm^2 at the highest counting rate of 105 kHz/cm^2

The total voltage drop on the all five gaps is 165 V.

For a counting rate of 25 kHz/cm^2, the calculated voltage drop on all five gaps is 50 V.

As the detector is supposed to be operated within the efficiency plateau, this voltage drop has no consequences on the detector performances.

Dissipated power in RPC counters due to the high current

Counter	Strip width (w) (mm)	Strip gap (g) (mm)	64 x (w+g) (L) mm	Strip length l (mm)	I (μA)	S = L x l (cm^2)	I ($\mu A/cm^2$)	R (MΩ)	Dissipated power (mW)
RPC2013	2.16	2.03	266	200	20	532	0.04	17	6.765
MRPC2	2.18	2.54	299.8	200	22.54	599.64	0.04	15	7.62
MRPC1	2.18	2.54	299.8	100	11.27	299.82	0.04	30	3.81

$R\ (\Omega) = \rho^*(l/S) = 1.5 \cdot 10^{10}\ \Omega cm \times (6 \times 0.1 cm)/S$

6 = number of glass plates

0.1cm = glass thickness

M1: 24 x 7.62 mW + 8 x 3.81 mW = 213 mW

M2: 15 x 7.62 mW + 12 x 3.81 mW = 160 mW

M3: 42 x 7.62 mW = 320 mW

Summary

RPC

Not identical behaviour off positive and negative voltage

Detectors recovered even after large HV trips

TRD

Non-uniform exposure of the TRD surface -> the rate for TRD & RPC2012 was underestimated

due to the position of the plastics used as scallers !

Large anode HV variations due to the current protection setting

It would be better to apply anode HV on groups of anode wires (split anode configuration)

Insignificant drift voltage variations

General remarques:

FEE was not affected by the large variations of the detector high voltage.

Further systematic studies are needed in the upcoming beam times.

The obtained results were reported in:

M. Petris et al., CBM Collaboration Meeting, 8-12 September 2014, Krakow, Poland

CBM Collaboration, CBM-TOF TDR