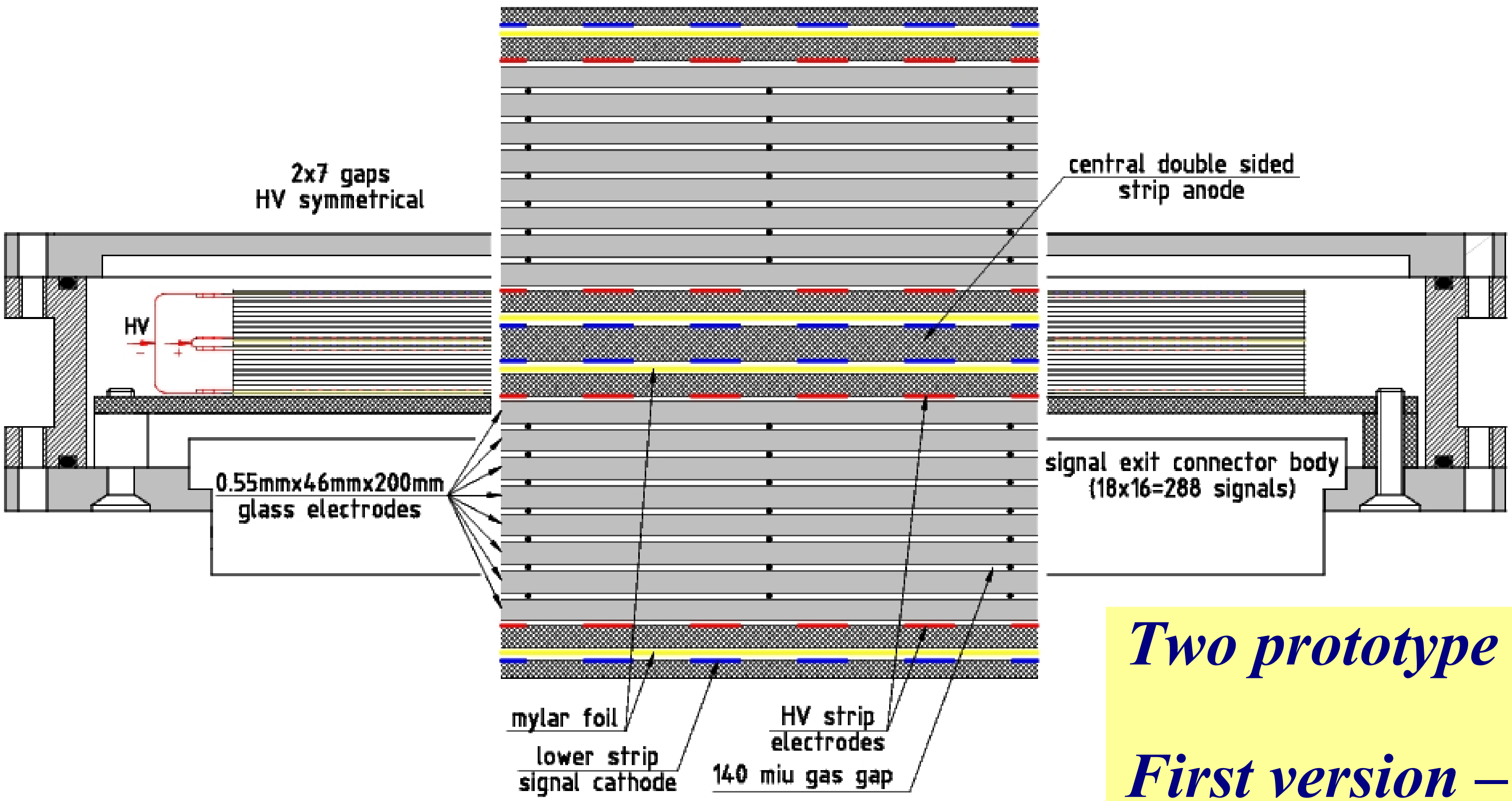
High granularity, symmetric, differential strip readout timing MRPC – in beam test results, CERN 2010

- *High granularity, symmetric, differential strip architecture – short review*
- *In-beam test @ PS – CERN*
  - *experimental set-up*
  - *results from in-beam tests (November 2010)*
    - *dark rate*
    - *cluster size*
    - *efficiency*
    - *time resolution*
    - *position resolution along the strip*
- *Conclusion & Outlook*

Mariana Petris, CBM Meeting, 4-8 April 2011, Dresden, Germany

2 x 7 gaps – cross section

High voltage electrodes for both polarities



Symmetric two stack structure, differential readout

Active area 46 x 180 mm^2

Electrodes: float glass: 0.55 mm

2 x 7 gas gaps; 140 µm thickness each gap

Readout electrodes: 1 double sided anode + 2 single sided cathodes made from pcb with copper strips: 72 strips:

2.54 mm strip pitch = 1.1 mm strip width + 1.44 mm gap width

Two prototype versions:

First version – RPC5:

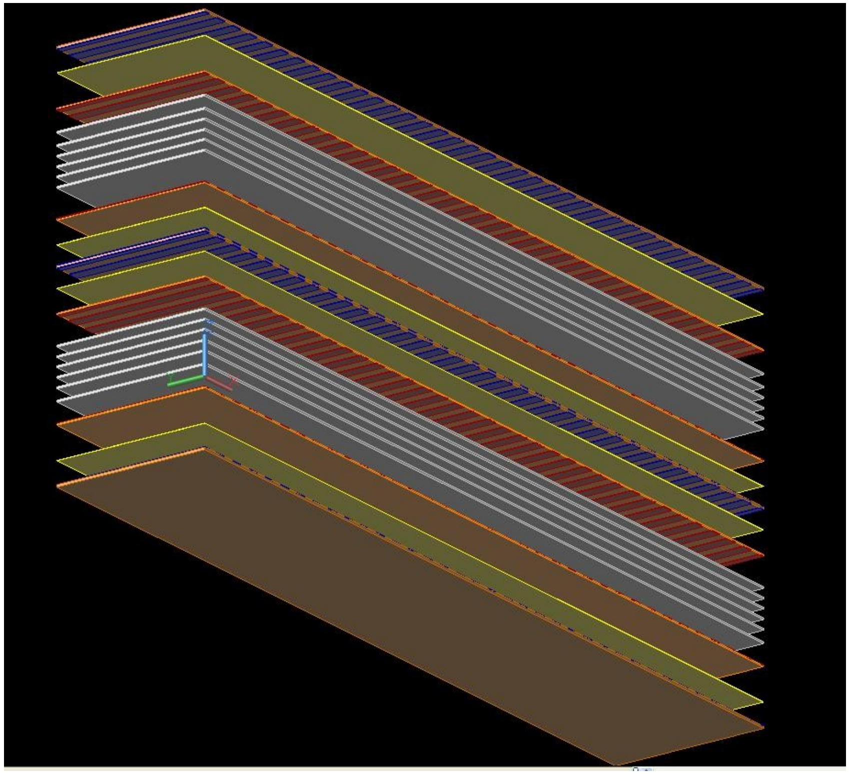
- strip structure high voltage electrodes for both polarities

Second version – RPC3:

- strip structure high voltage electrodes for both polarities in contact with a resistive layer

2 x 5 gaps – cross section

High voltage electrodes for both polarities



Symmetric two stack structure, differential readout

Active area 46 x 180 mm^2

Electrodes: low resistivity glass: 0.7 mm (Chinese glass)

2 x 5 gas gaps; 140 µm thickness each gap

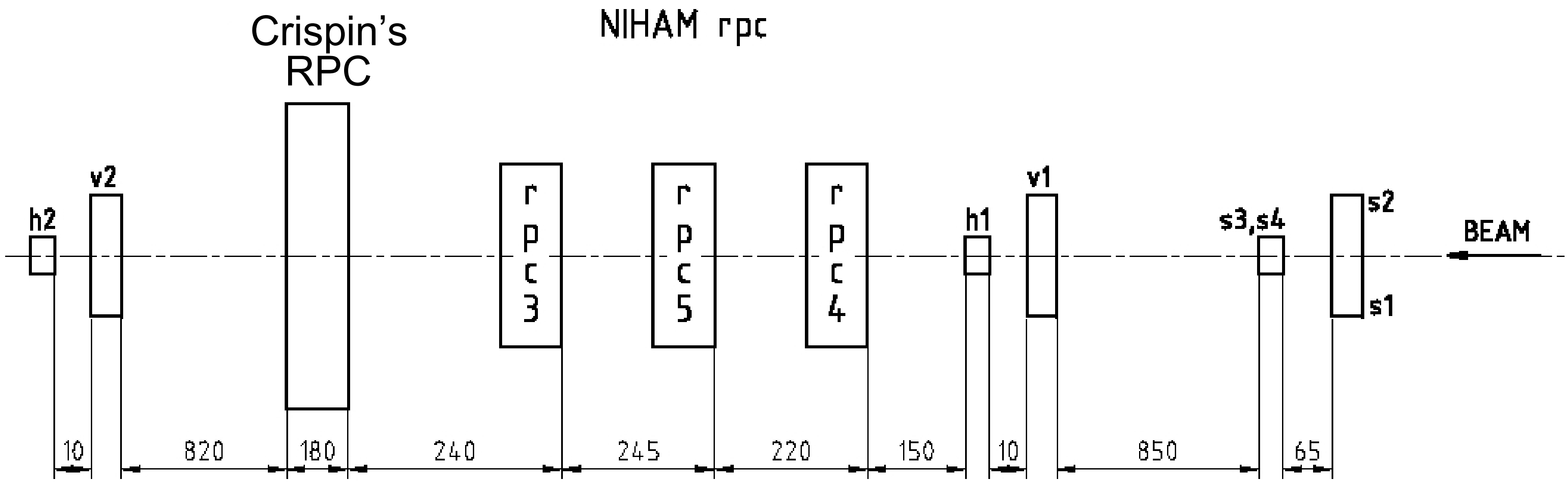
Readout electrodes: 1 double sided anode + 2 single sided cathodes made from pcb with copper strips: 72 strips:

2.54 mm strip pitch = 1.1 mm strip width + 1.44 mm gap width

Third version – RPC4:

- strip structure high voltage electrodes for both polarities

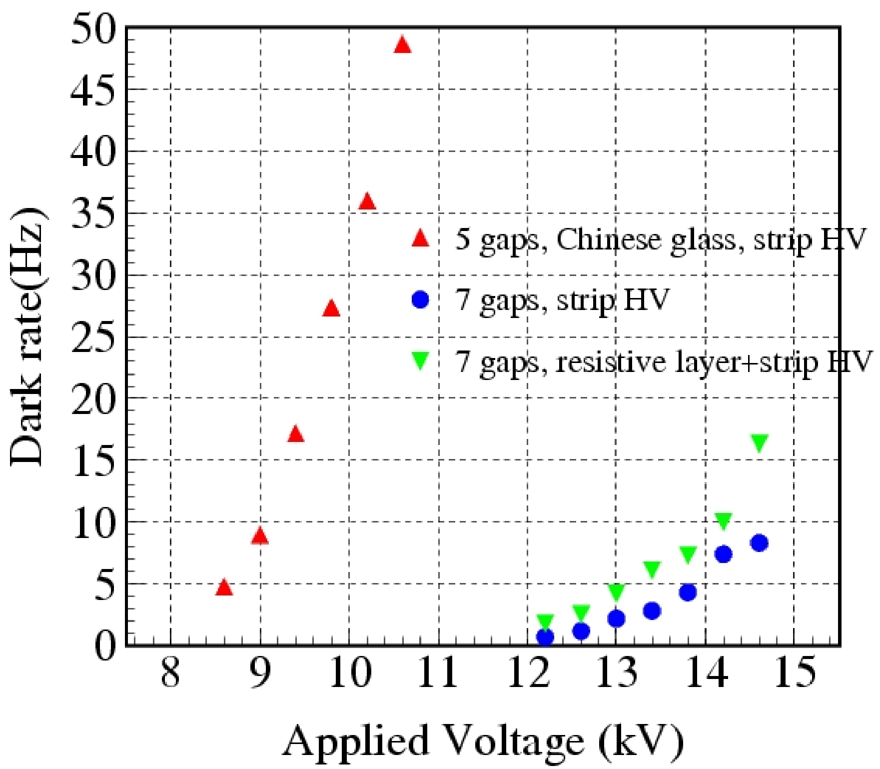
In-Beam Tests @ PS – CERN



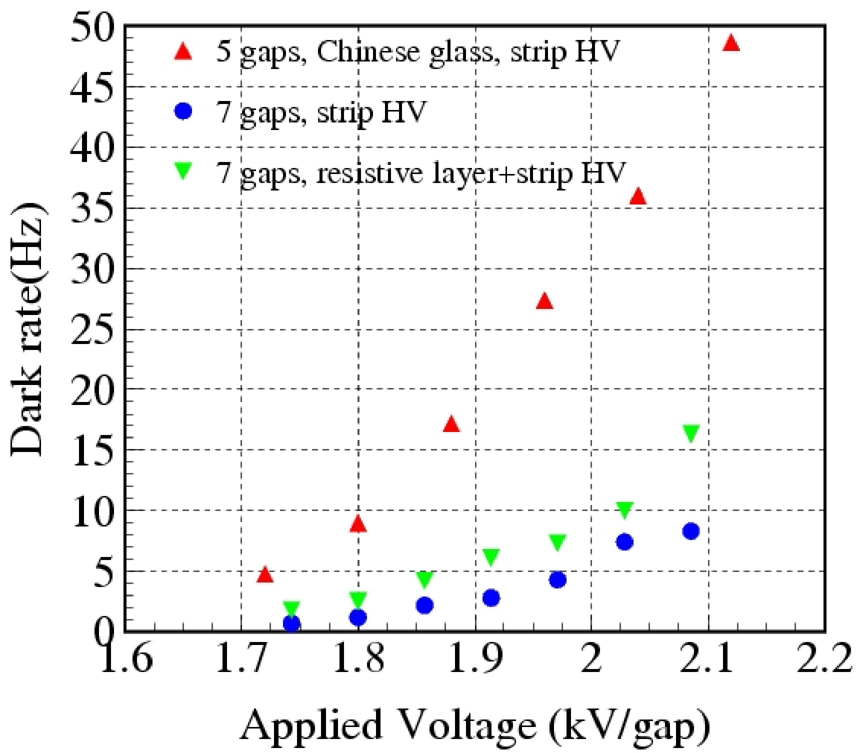
Experimental set-up:

- ***pion beam, 6 GeV/c momentum***
- ***2 plastic scintillators 2 x 2 cm^2 overlap, used as reference (S1S2/S3S4)***
- ***2 plastic scintillators 1 x 1 cm^2 overlap used for active collimation (h1/v1&h2/v2)***
- ***FEE: differential readout based on NINO chip developed within ALICE Collaboration***
- ***digital converters: CAEN TDC V1290A***
- ***information recorded for 16 strips readout at both ends for each RPC.***

Dark rate

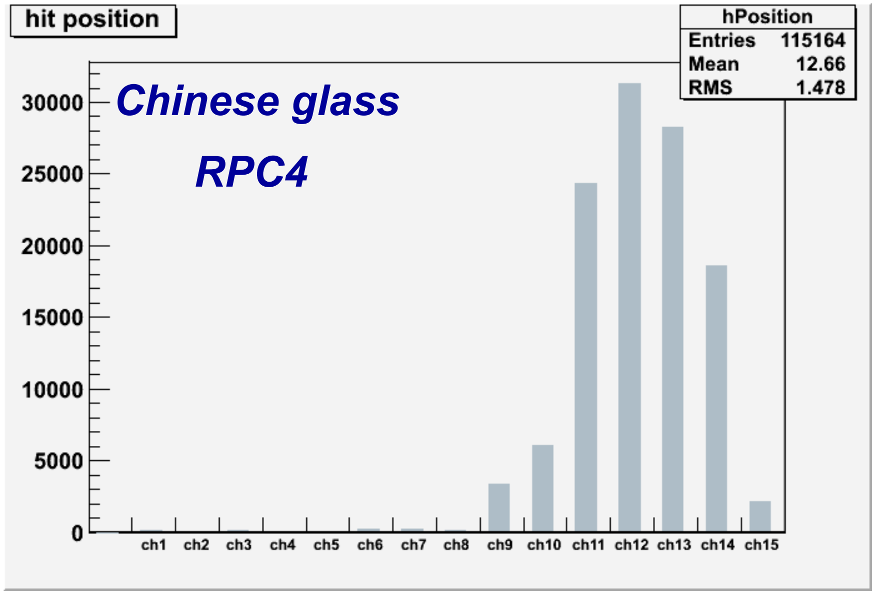


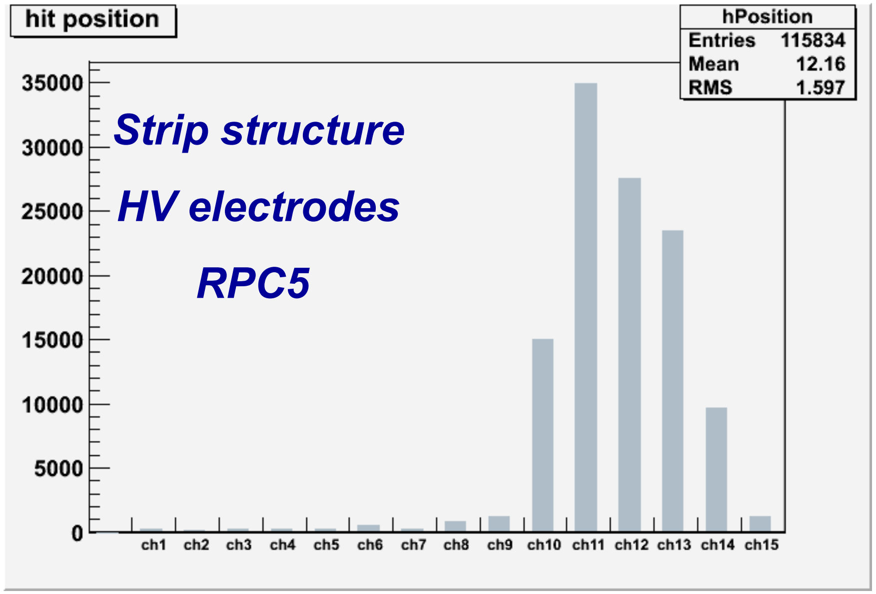
Dark rate(Hz)
50
45
40
35
30
25
20
15
10
5
0
8
9
10
11
12
13
14
15
Applied Voltage (kV)
5 gaps, Chinese glass, strip HV
7 gaps, strip HV
7 gaps, resistive layer+strip HV

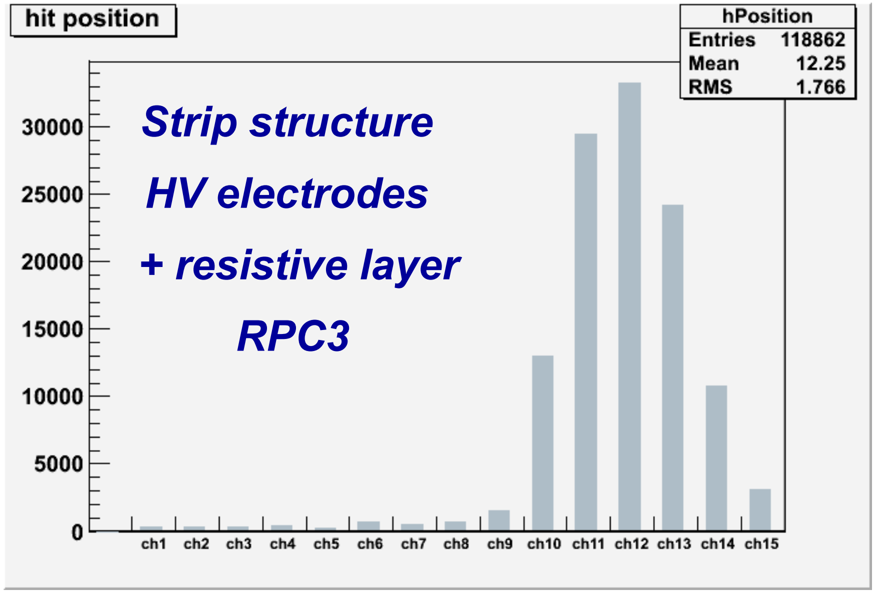


Dark rate(Hz)
50
45
40
35
30
25
20
15
10
5
0
1.6
1.7
1.8
1.9
2
2.1
2.2
Applied Voltage (kV/gap)
5 gaps, Chinese glass, strip HV
7 gaps, strip HV
7 gaps, resistive layer+strip HV

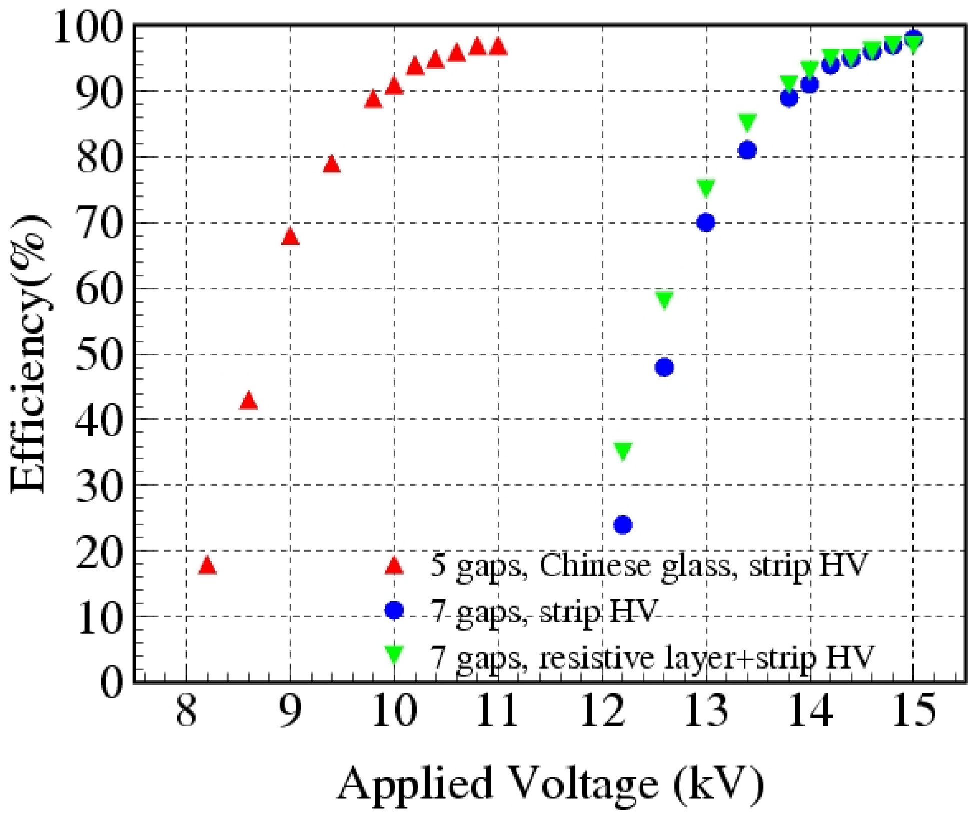
Beam Profile

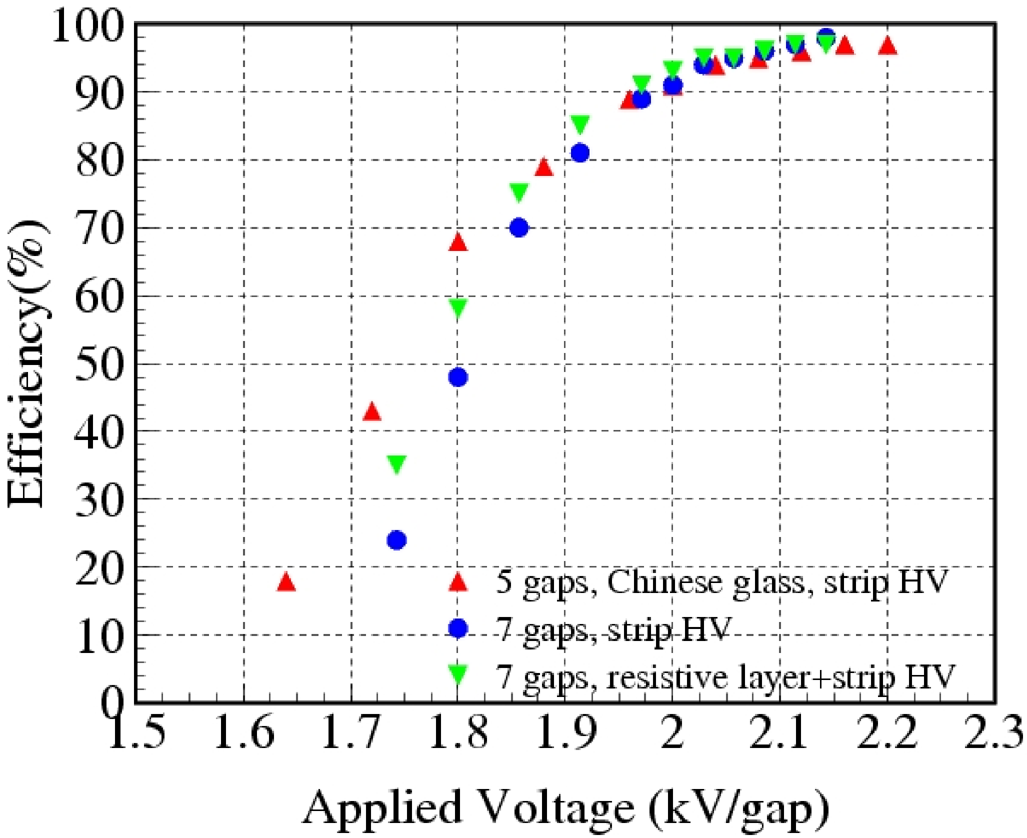






Efficiency





RPC4 – Chinese glass:

NINO FEE1 **Th = 160 mV**

NINO FEE2 **Th = 160 mV**

RPC5 – strip HV:

NINO FEE1 **Th = 130 mV**

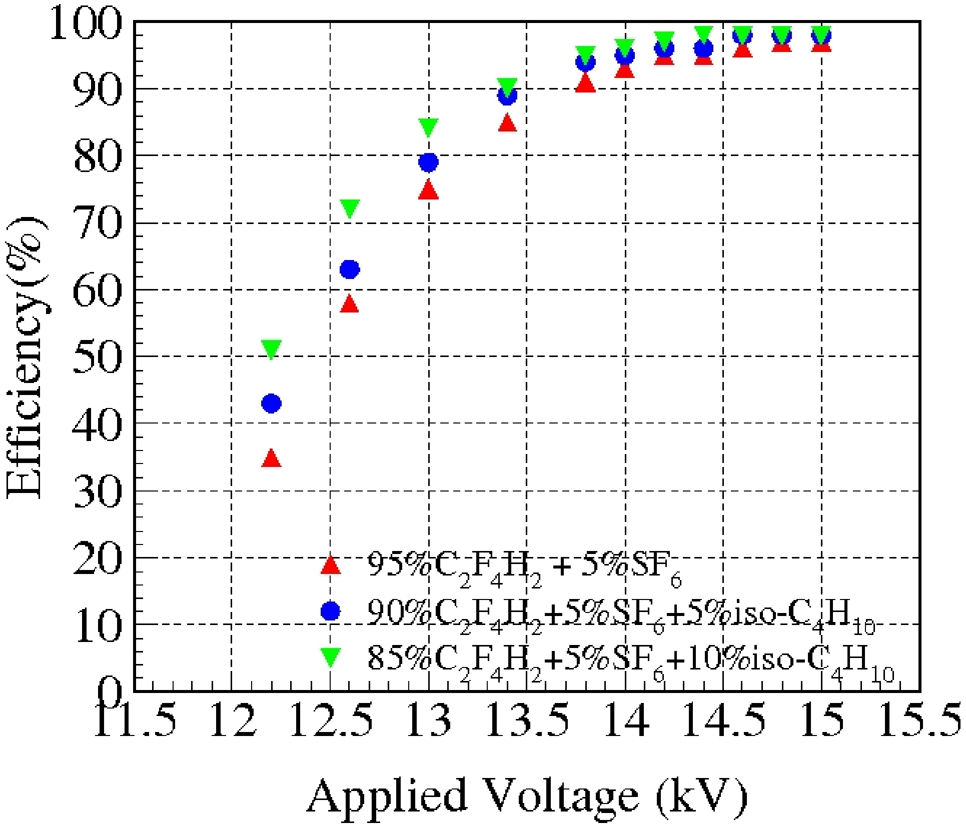
NINO FEE2 **Th = 130 mV**

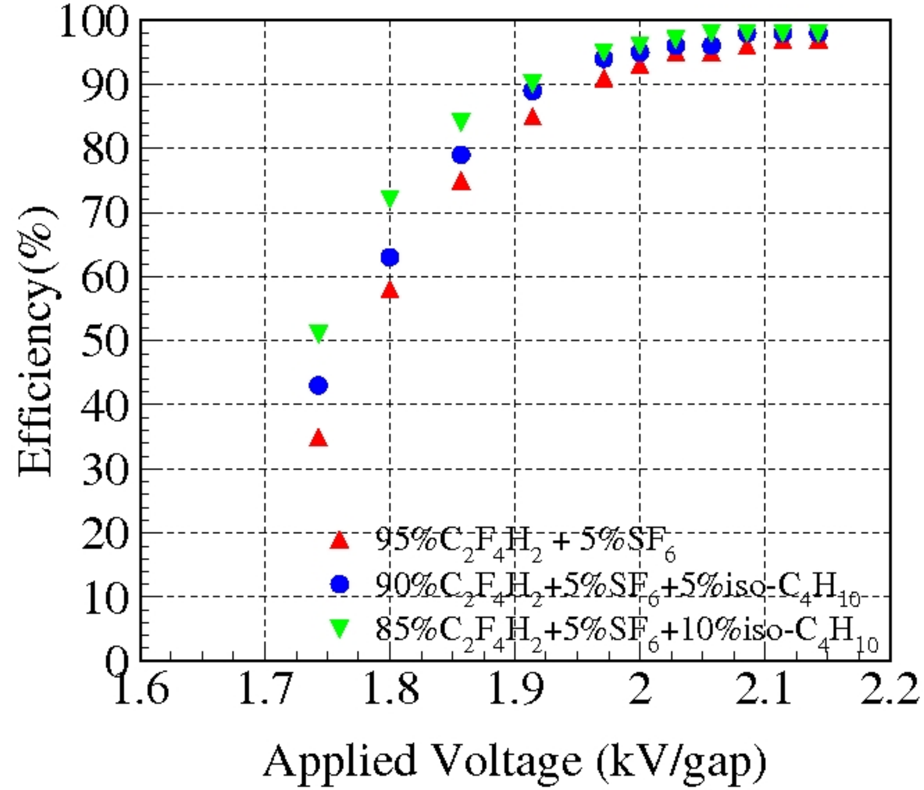
RPC3 – resistive layer +strip HV:

NINO FEE1 **Th = 130 mV**

NINO FEE2 **Th = 130 mV**

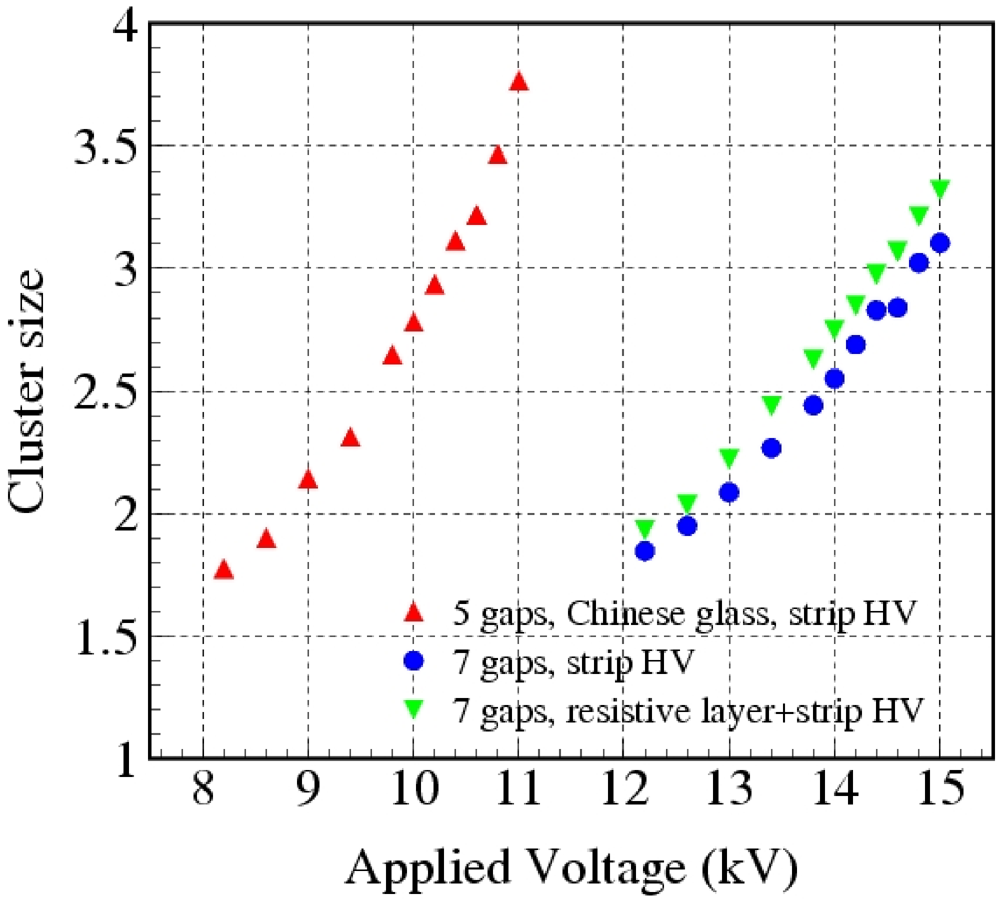
Efficiency @ different gas mixture

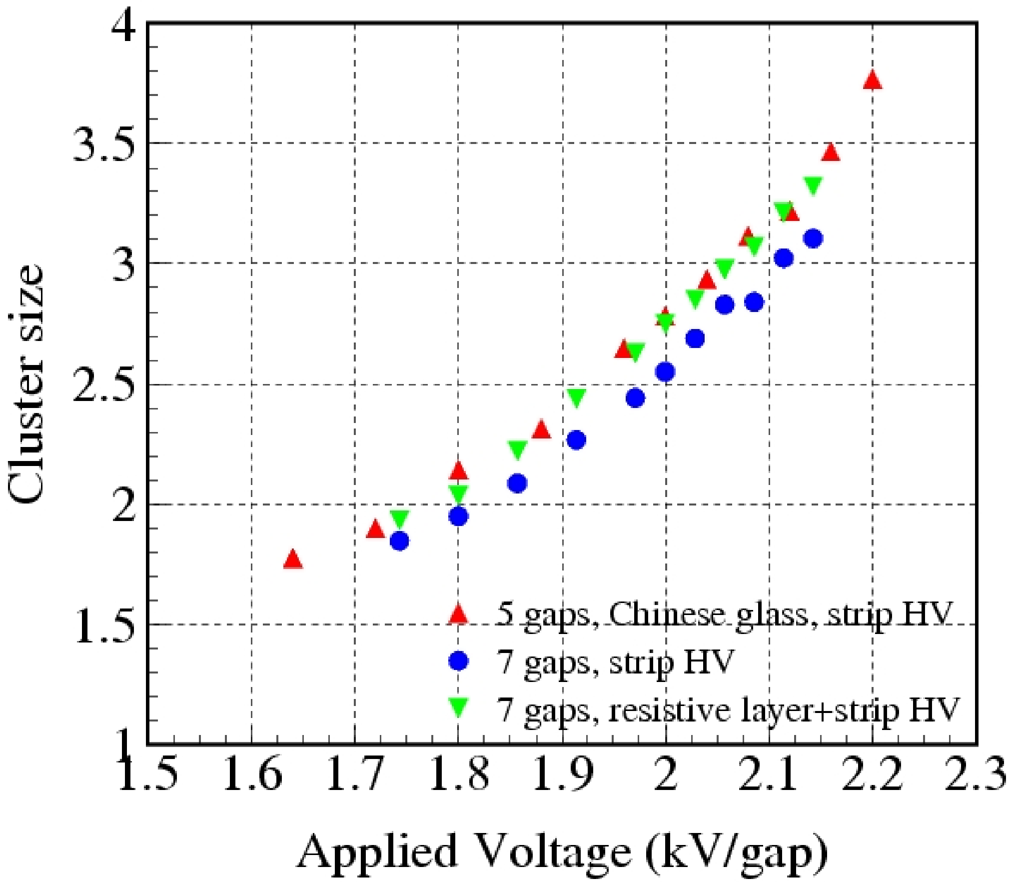




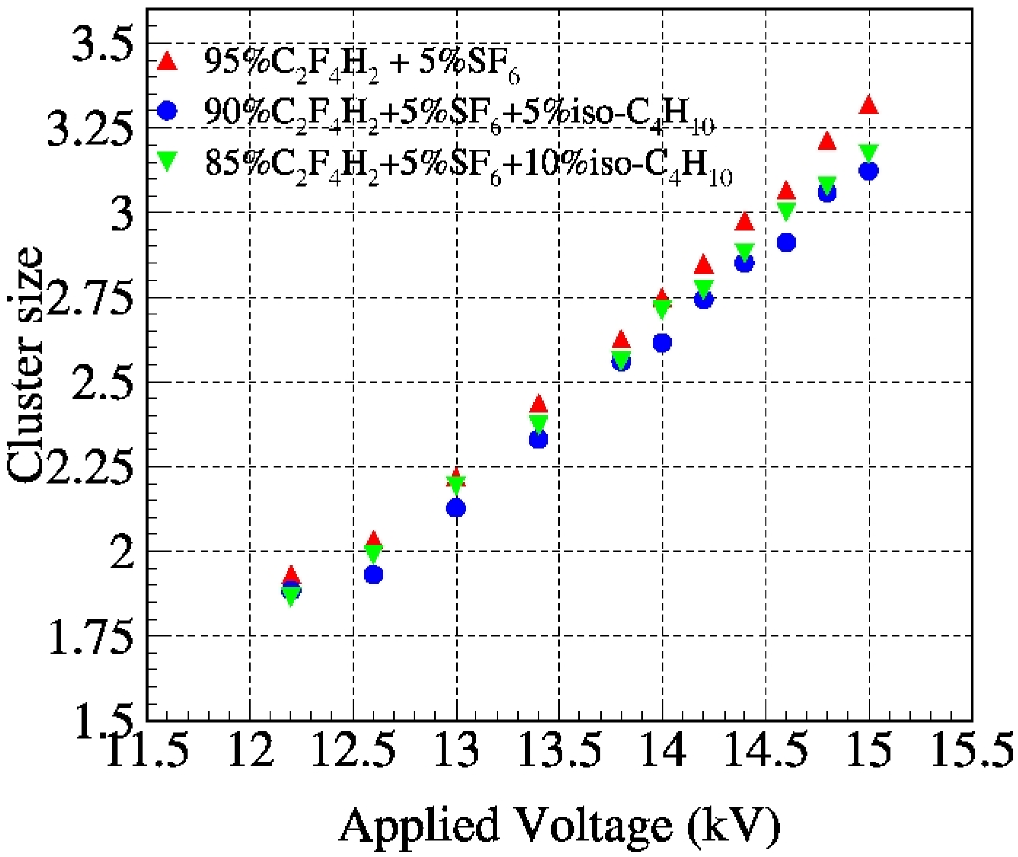
RPC3 – resistive layer + strip structure high voltage electrodes

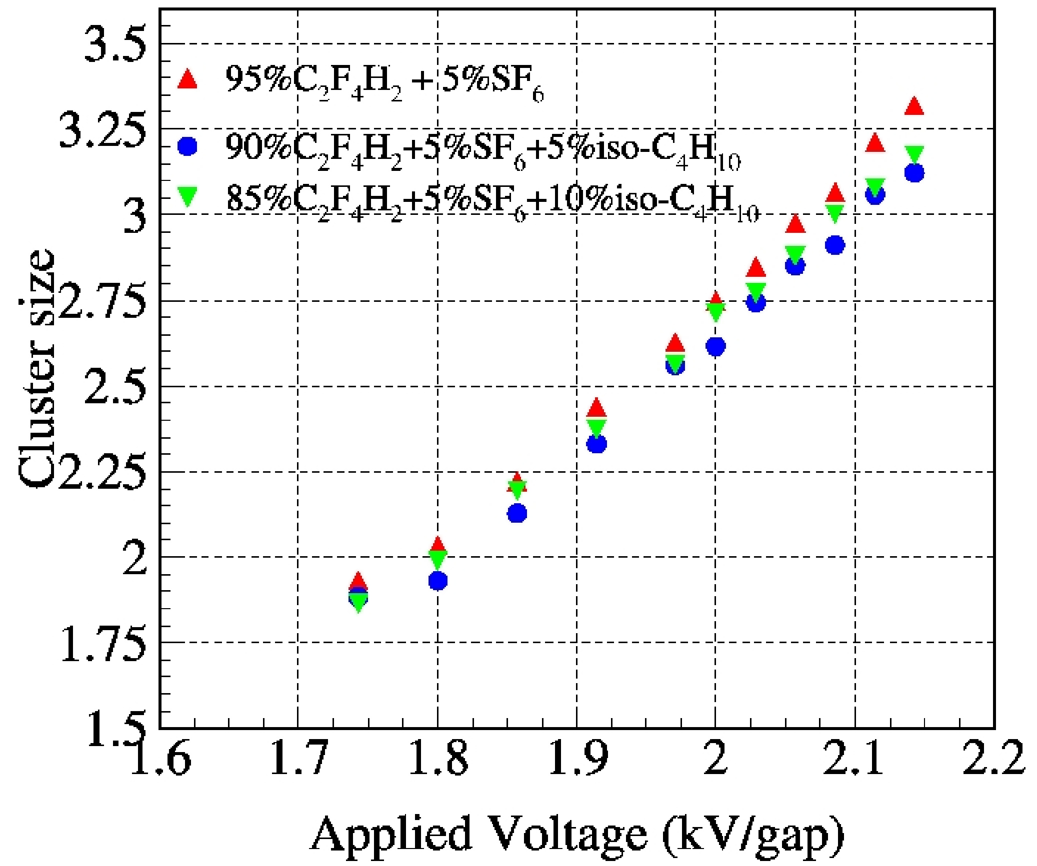
Cluster size





Cluster size @ different gas mixture

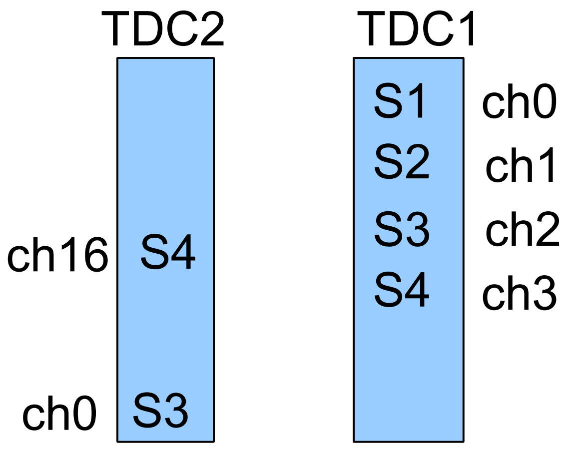




RPC3 - strip structure high voltage electrodes for both polarities in contact with a resistive layer

Time resolution using as reference

A: a plastic scintillator readout at both ends (S3S4)



$$\Delta t_{ref} = \frac{t_{PMT1} + t_{PMT2}}{2} - \frac{t_{PMT3} + t_{PMT4}}{2}$$

$$\sigma^2_{ref} = \sigma^2_{PMT,12} + \sigma^2_{PMT,34}$$

$$\Delta t_{TOF} = \frac{t_{PMT3} + t_{PMT4}}{2} - \frac{t_{RPC,l} + t_{RPC,r}}{2}$$

$$\sigma^2_{TOF} = \sigma^2_{PMT,34} + \sigma^2_{RPC,lr}$$

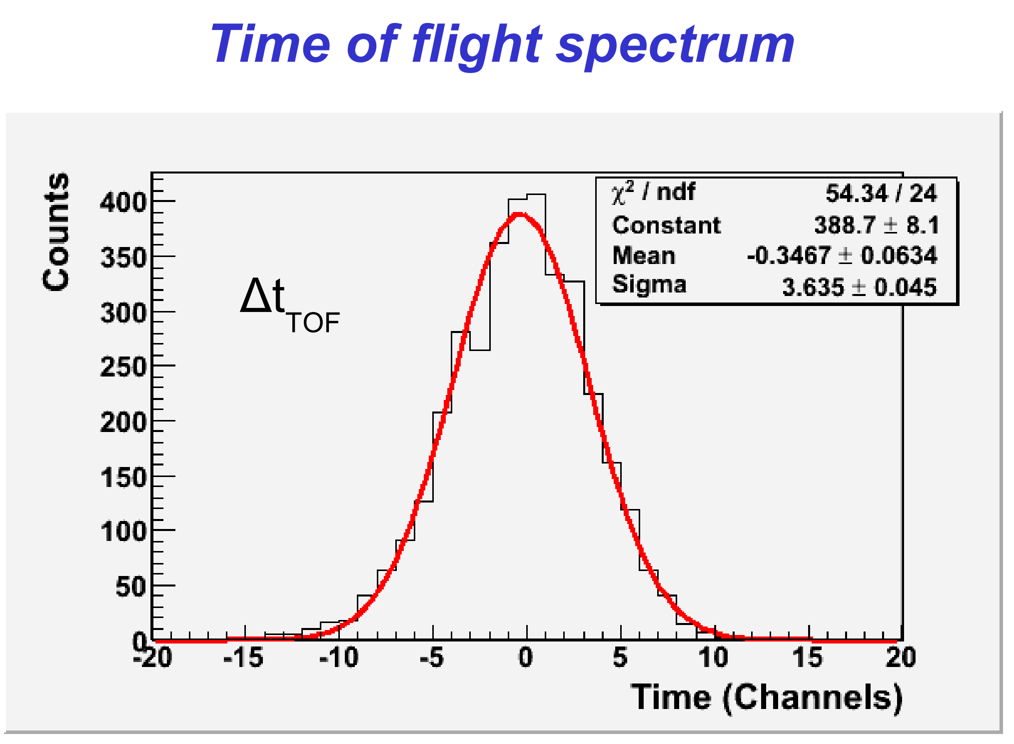
$$(\sigma^{int}_{TOF})^2 = \sigma^2_{TOF} - \sigma^2_{electronics}$$

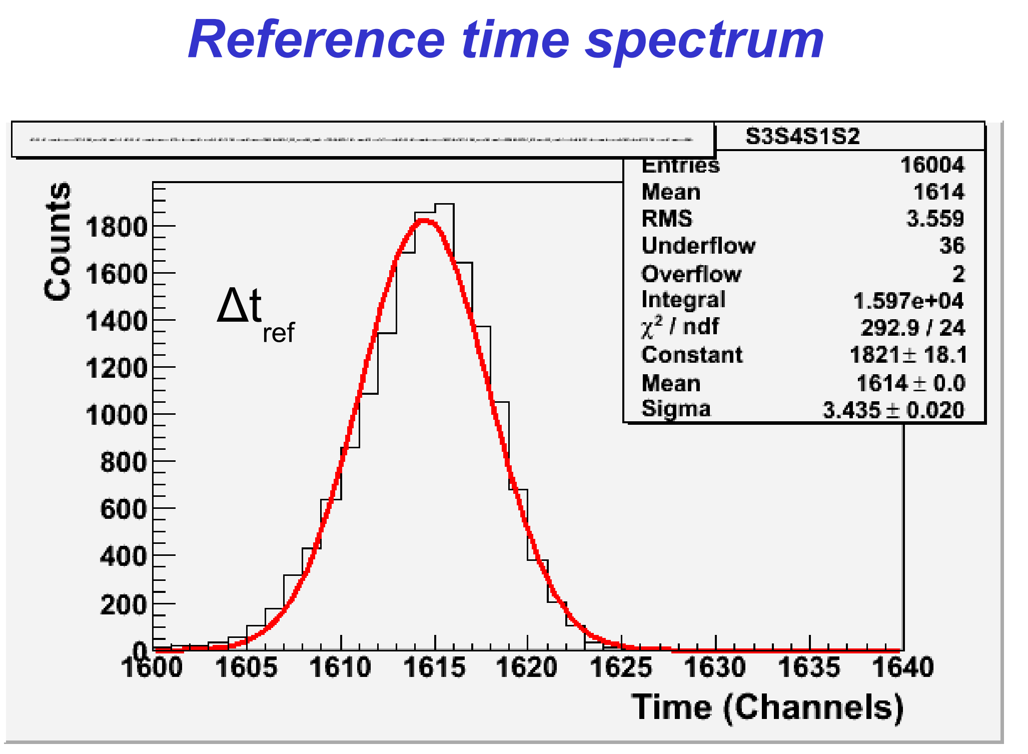
$$(\sigma^{int}_{ref})^2 = \sigma^2_{ref} - \sigma^2_{electronics}$$

$$\sigma^2_{RPC} = (\sigma^{int}_{TOF})^2 - (\sigma^{int}_{ref})^2 / 2$$

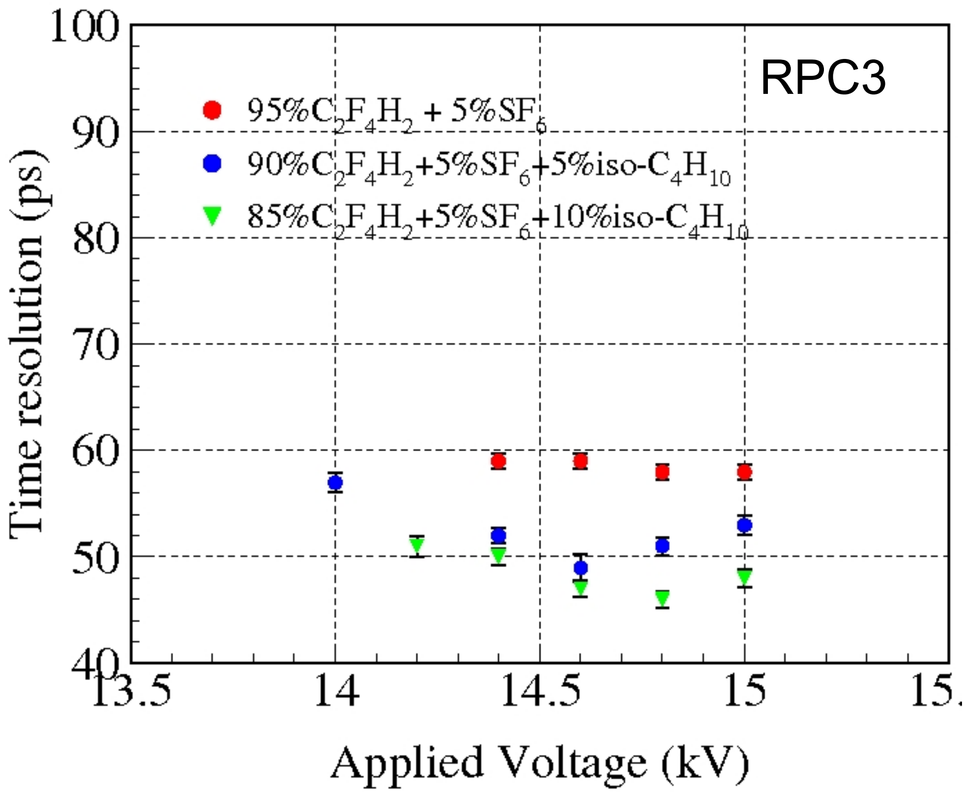
In all cases we extracted quadratically the contribution of the electronics (pulser data) from the corresponding sigma, using the same channel combinations

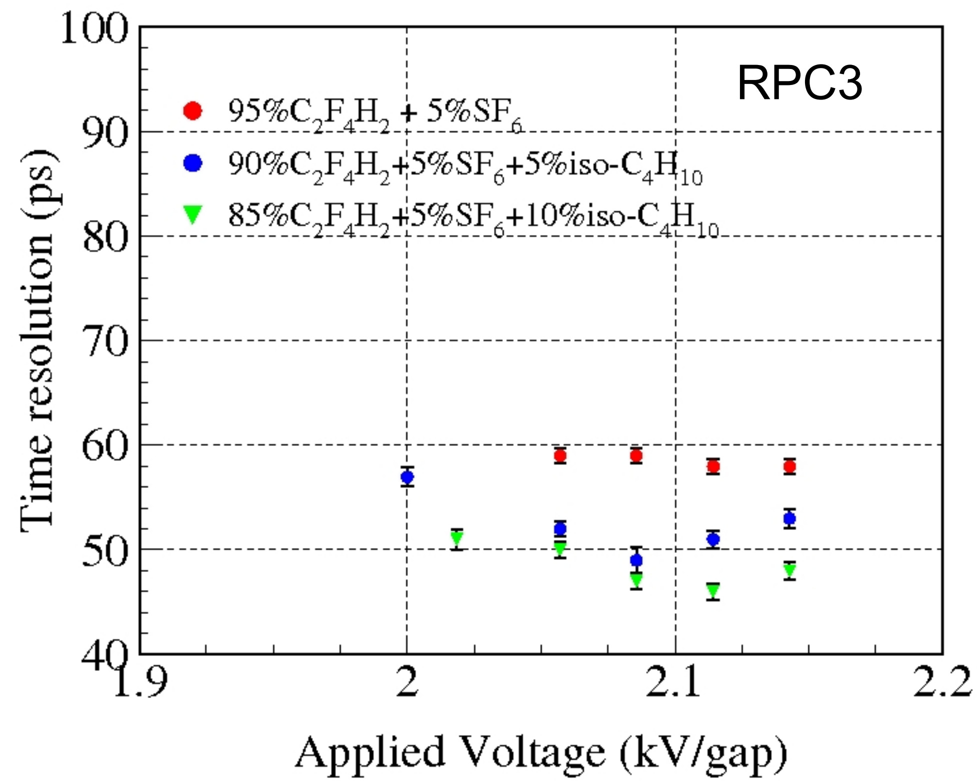
Time resolution using as reference a plastic scintillator readout at both ends (S3S4)





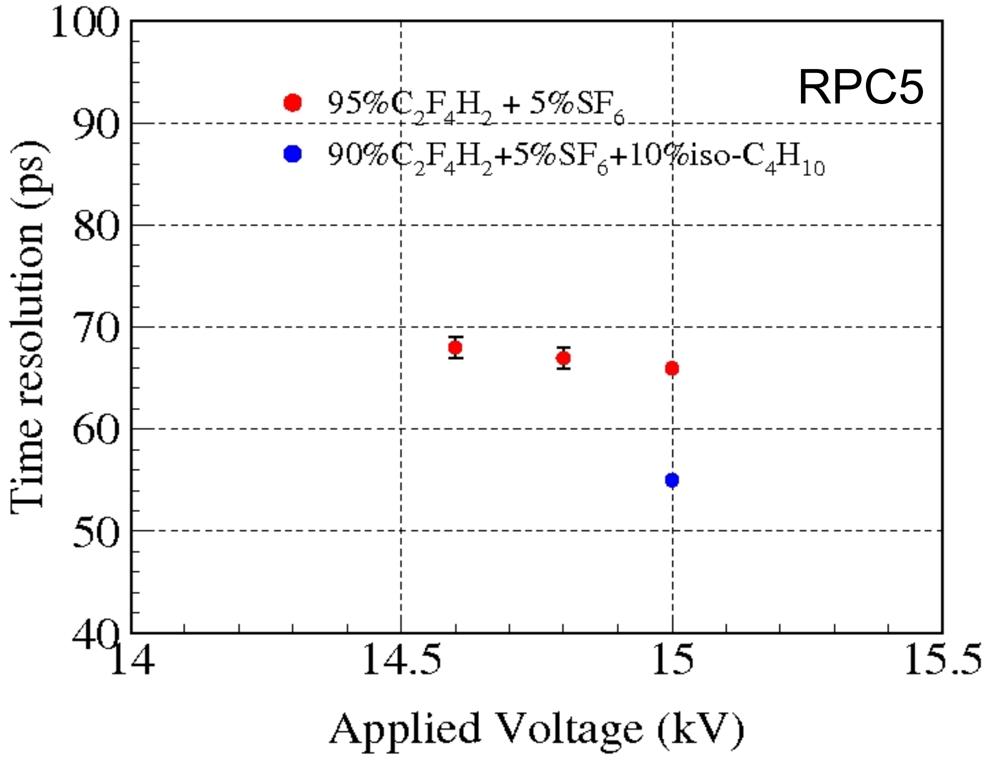
Time resolution using as reference a plastic scintillator readout at both ends

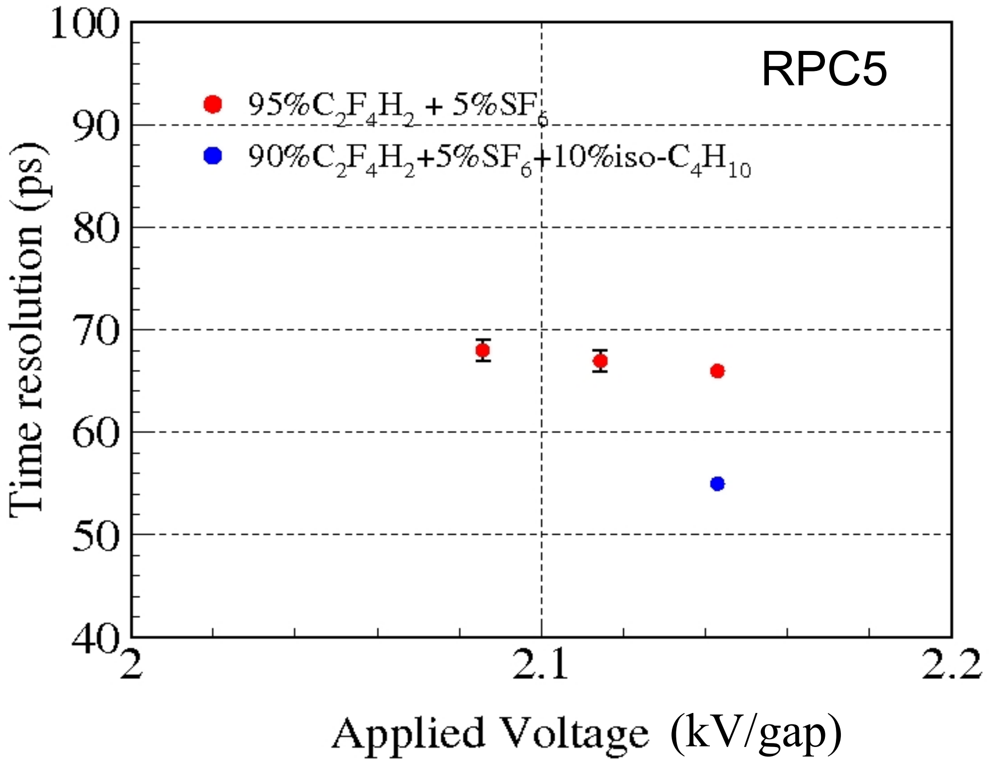




- ***RPC3 - strip structure high voltage electrodes for both polarities in contact with a resistive layer***
- ***the shown results are for the strip with the highest statistics***

Time resolution using as reference a plastic scintillator readout at both ends



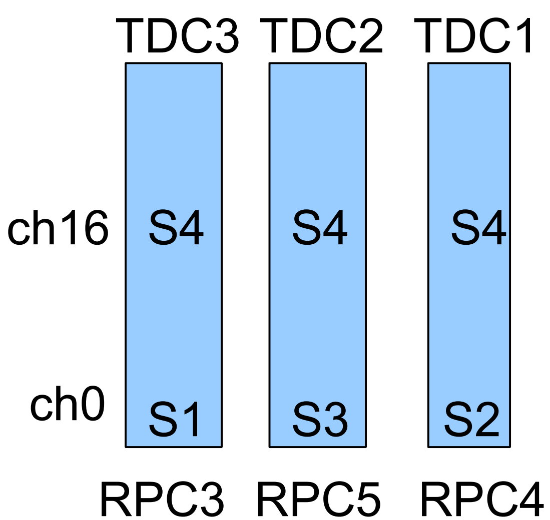


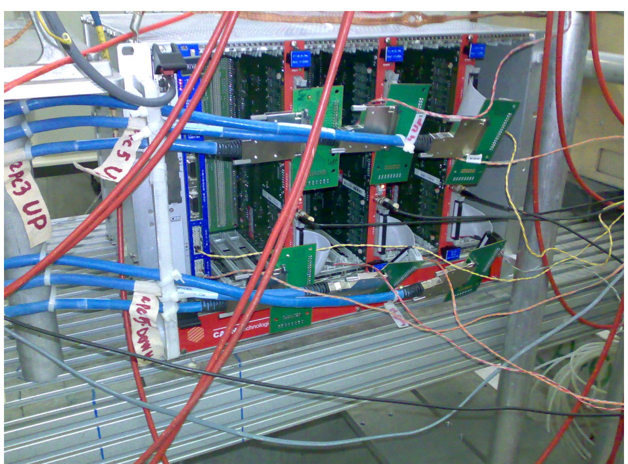
- ***RPC5 - strip structure high voltage electrodes for both polarities***
- ***the shown results are for the strip with the highest statistics***

Time resolution using

B: *RPC counter versus an other RPC counter*

Gas mixture: 95% $C_2F_4H_2$ + 5% SF_6





- S4 used for clock synchronization between TDCs in the measurements RPC versus RPC

$$\Delta t_{TOF} = \frac{t_{RPCn,l} + t_{RPCn,r}}{2} - \frac{t_{RPCm,l} + t_{RPCm,r}}{2}$$

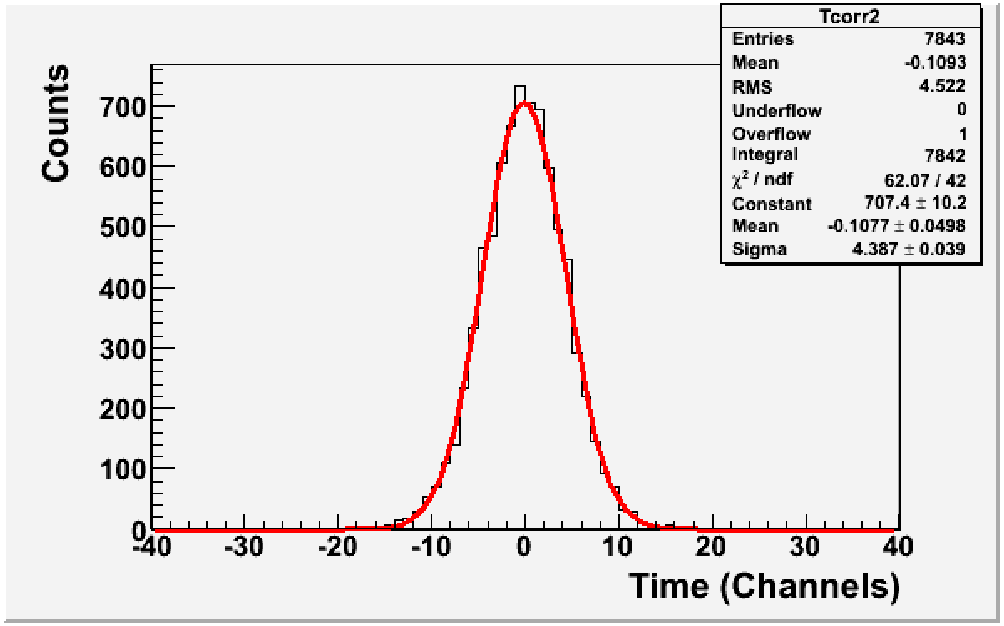
$$\sigma_{TOF}^{\text{int}} = \sigma_{TOF}^{2} - \sigma_{electronics}^{2}$$

$$\sigma_{RPC} = (\sigma_{TOF}^{\text{int}}) / \sqrt{2}$$

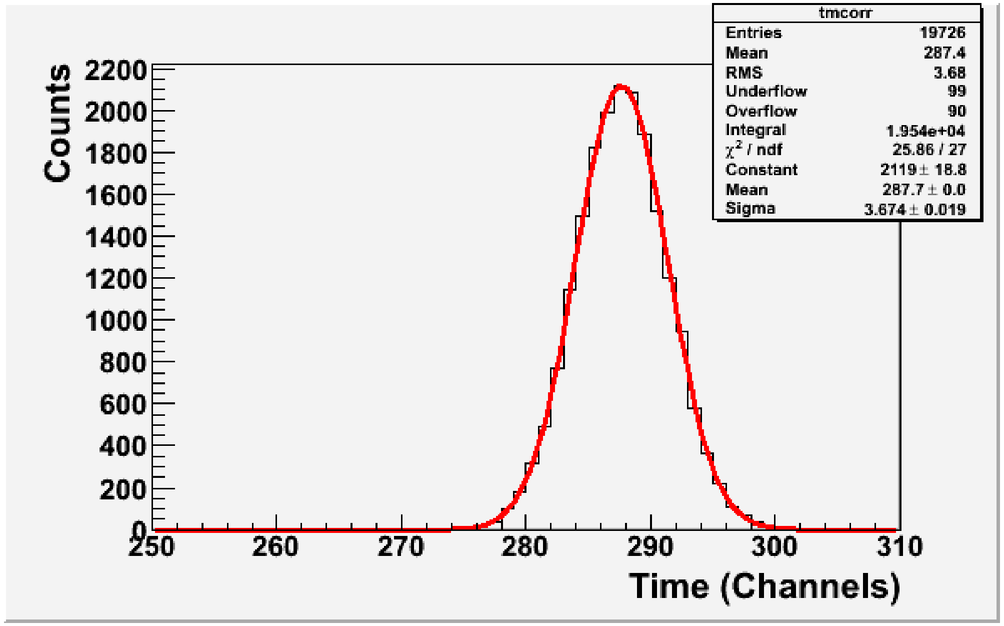
In all cases we extracted quadratically the contribution of the electronics (pulser data) from the corresponding sigma, using the same channel combinations

Time resolution using RPC4 (Chinese glass) vs. RPC5 (strip HV)

TOF spectrum



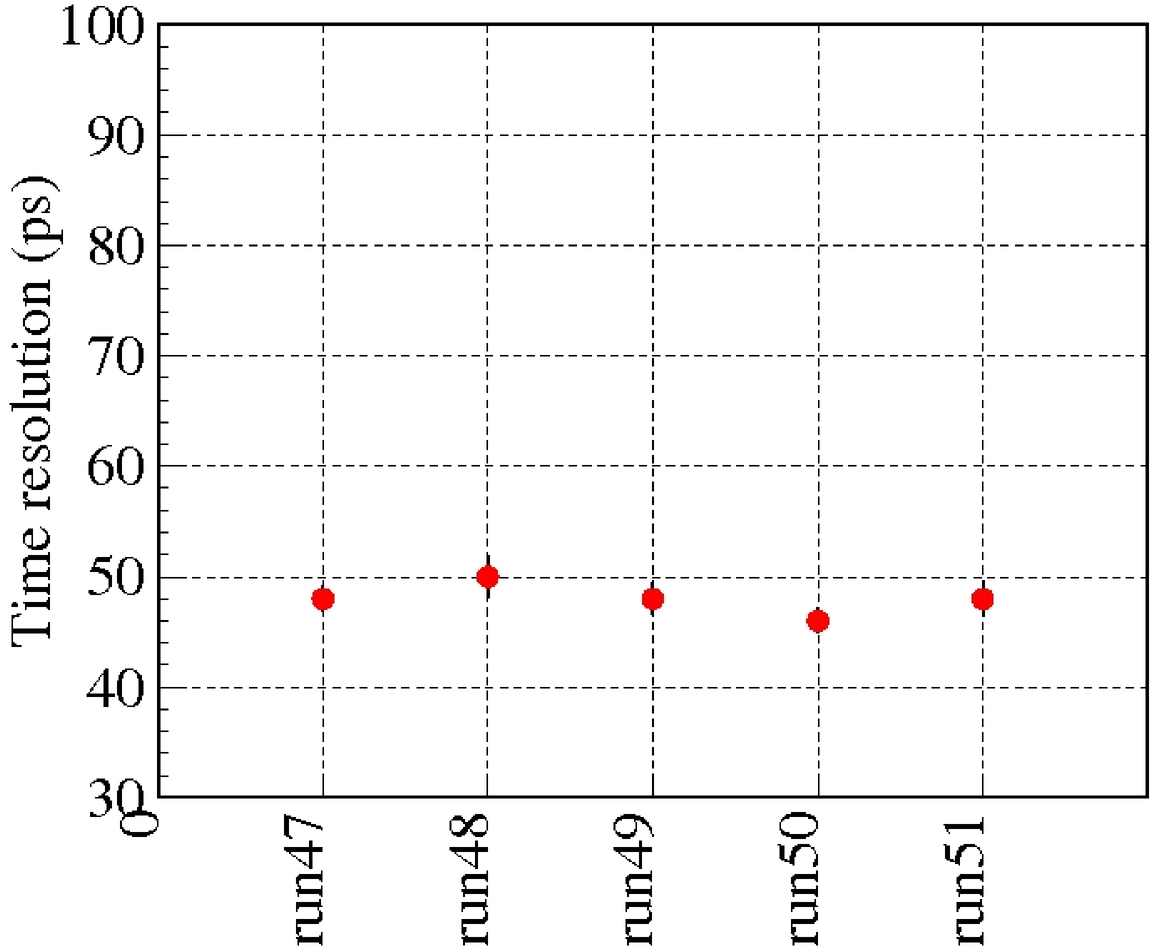
Pulser spectrum



HV RPC4 = 10.6 kV -> 2.12 kV/gap

HV RPC5 = 14.6 kV -> 2.086 kV/gap

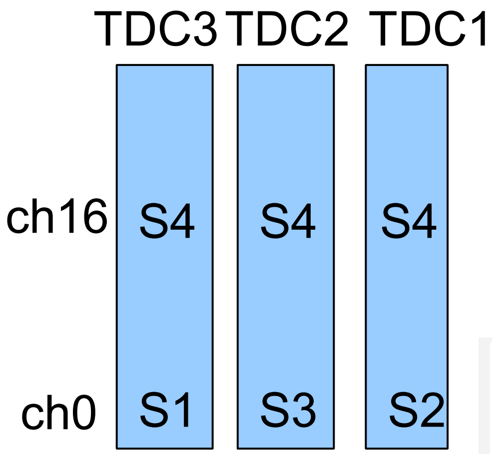
Time resolution using
RPC4 (Chinese glass) vs. RPC5 (strip HV)



HV RPC4 = 10.6 kV -> 2.12 kV/gap

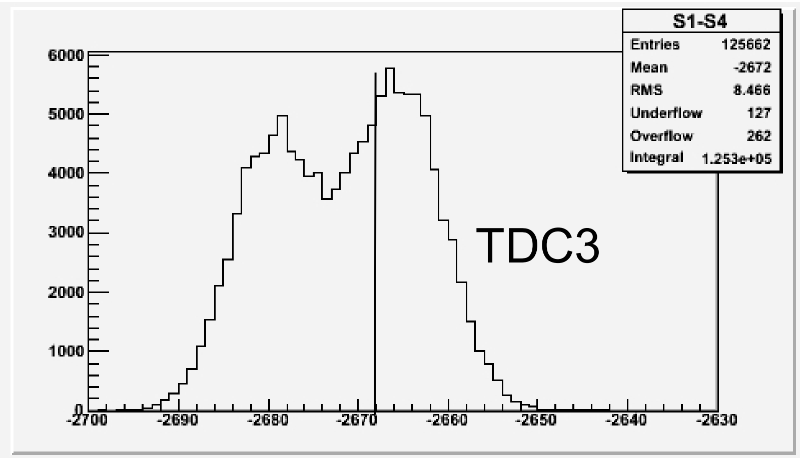
HV RPC5 = 14.6 kV -> 2.086 kV/gap

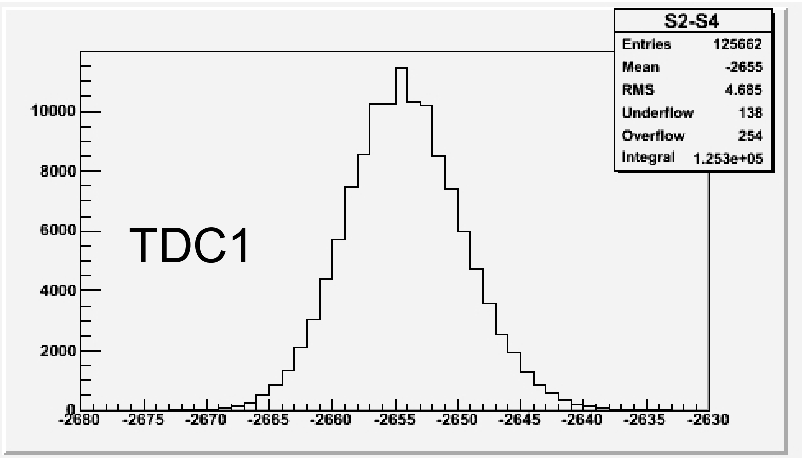
Some experimental details

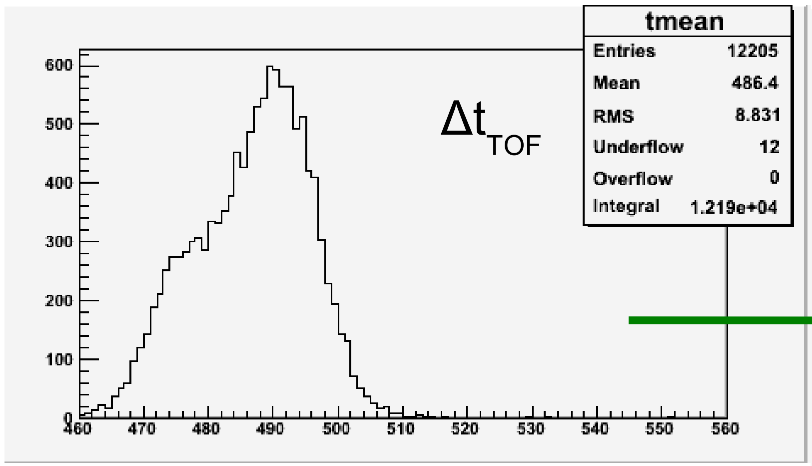


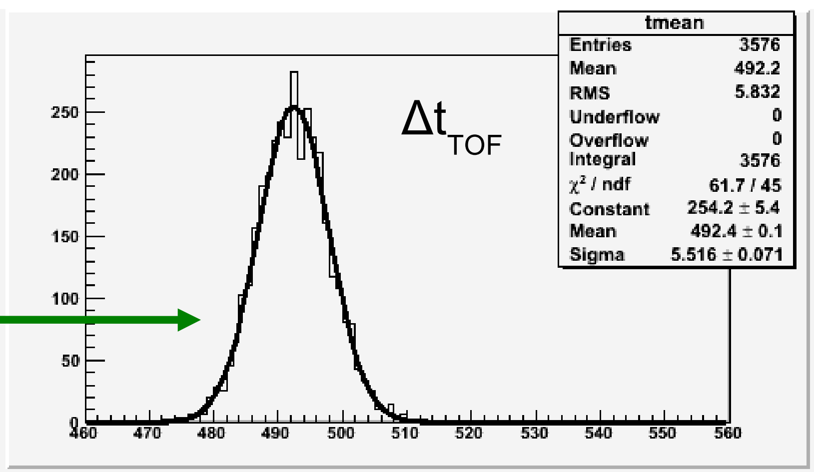
- S4 used for clock synchronization between TDCs in the measurements RPC versus RPC

Beam data

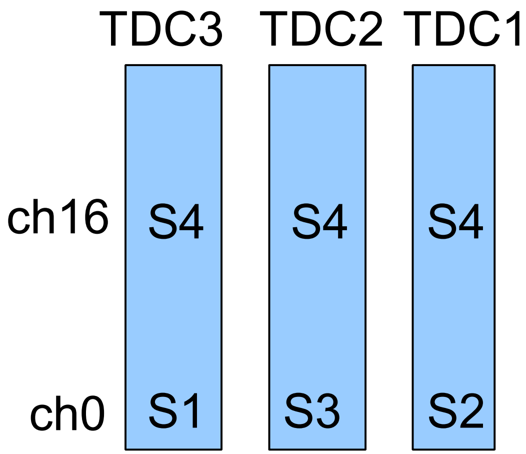




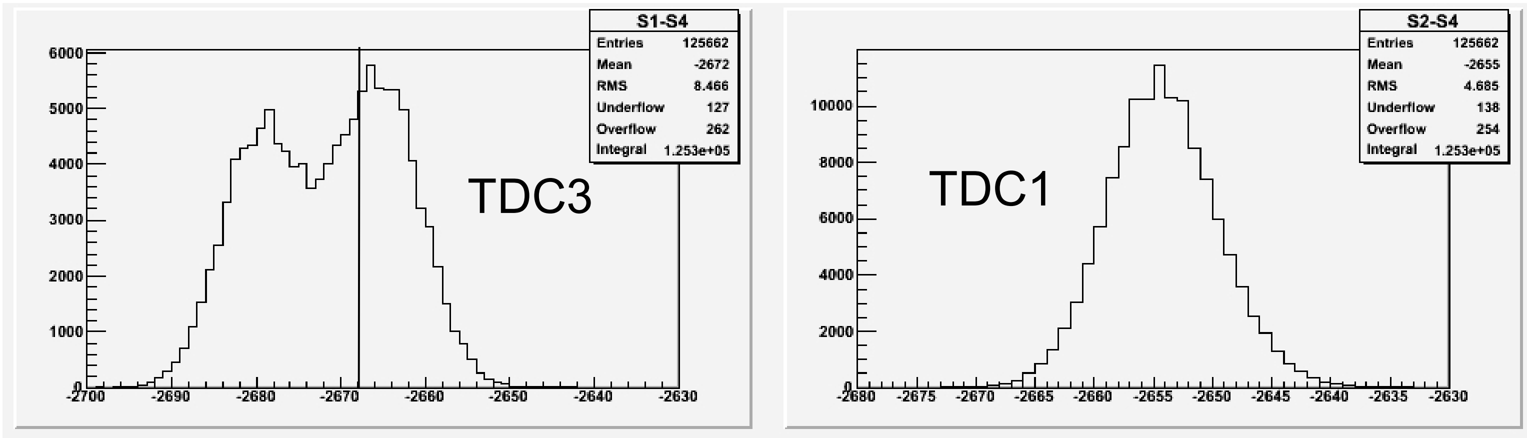




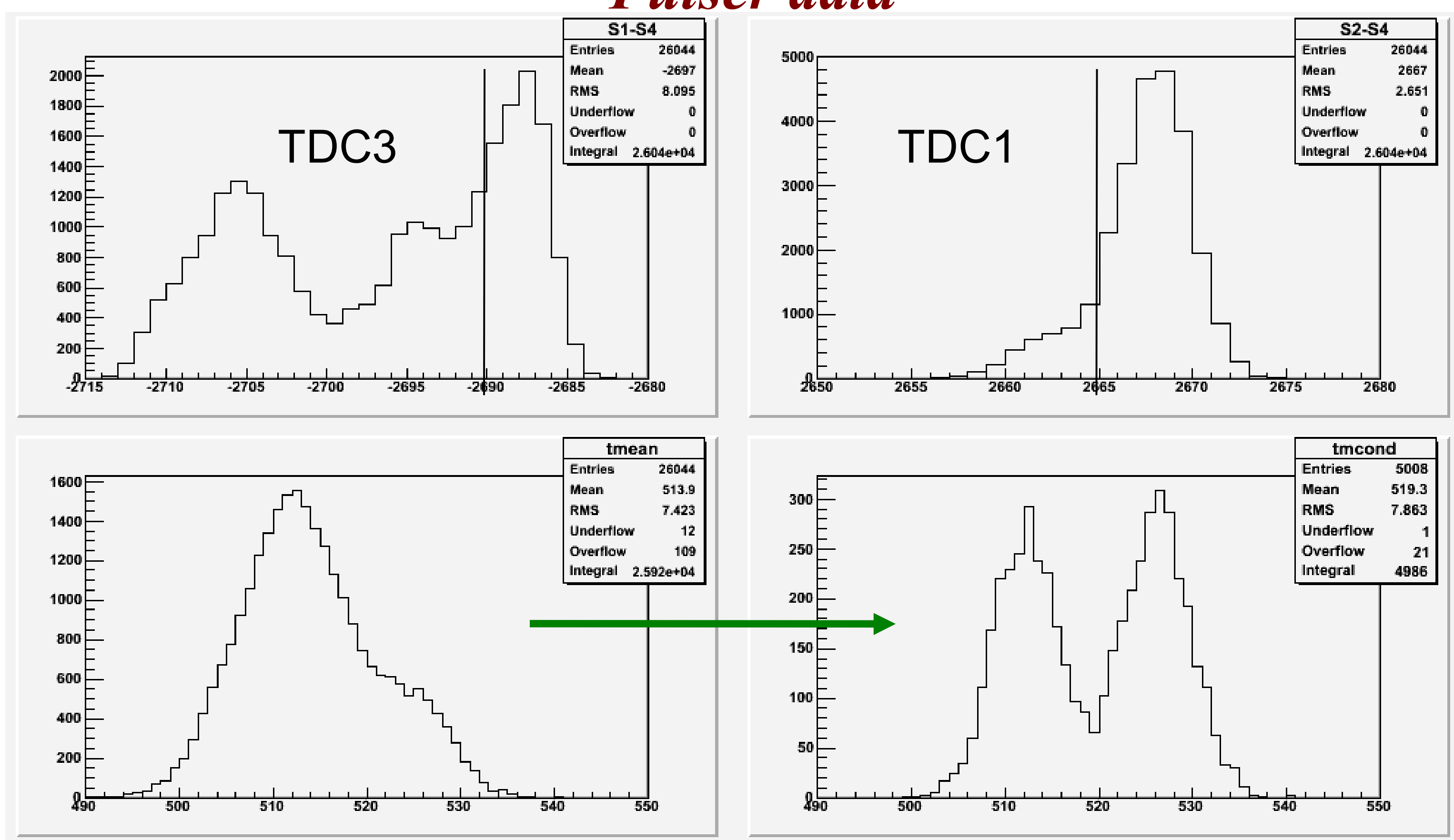
Some experimental details



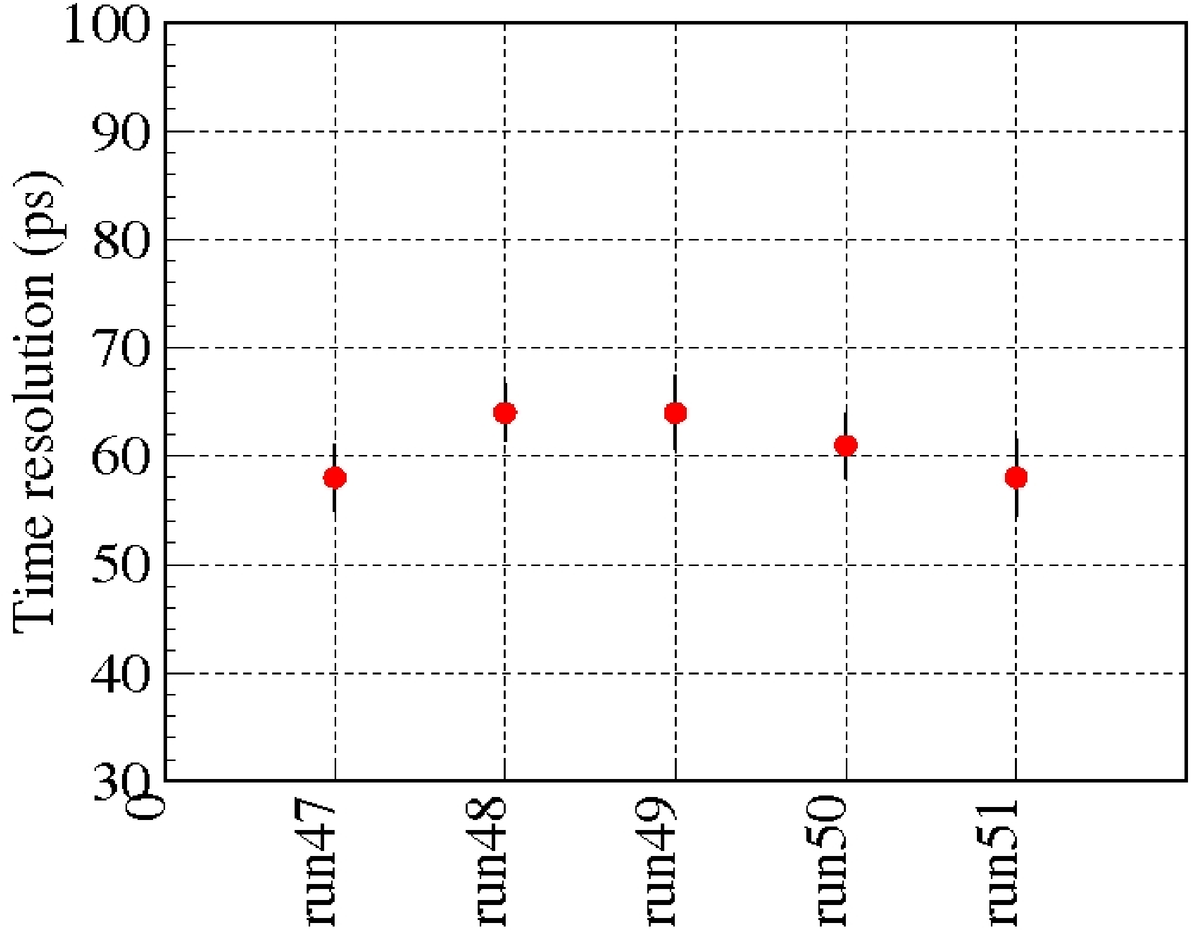
Beam data



Pulser data



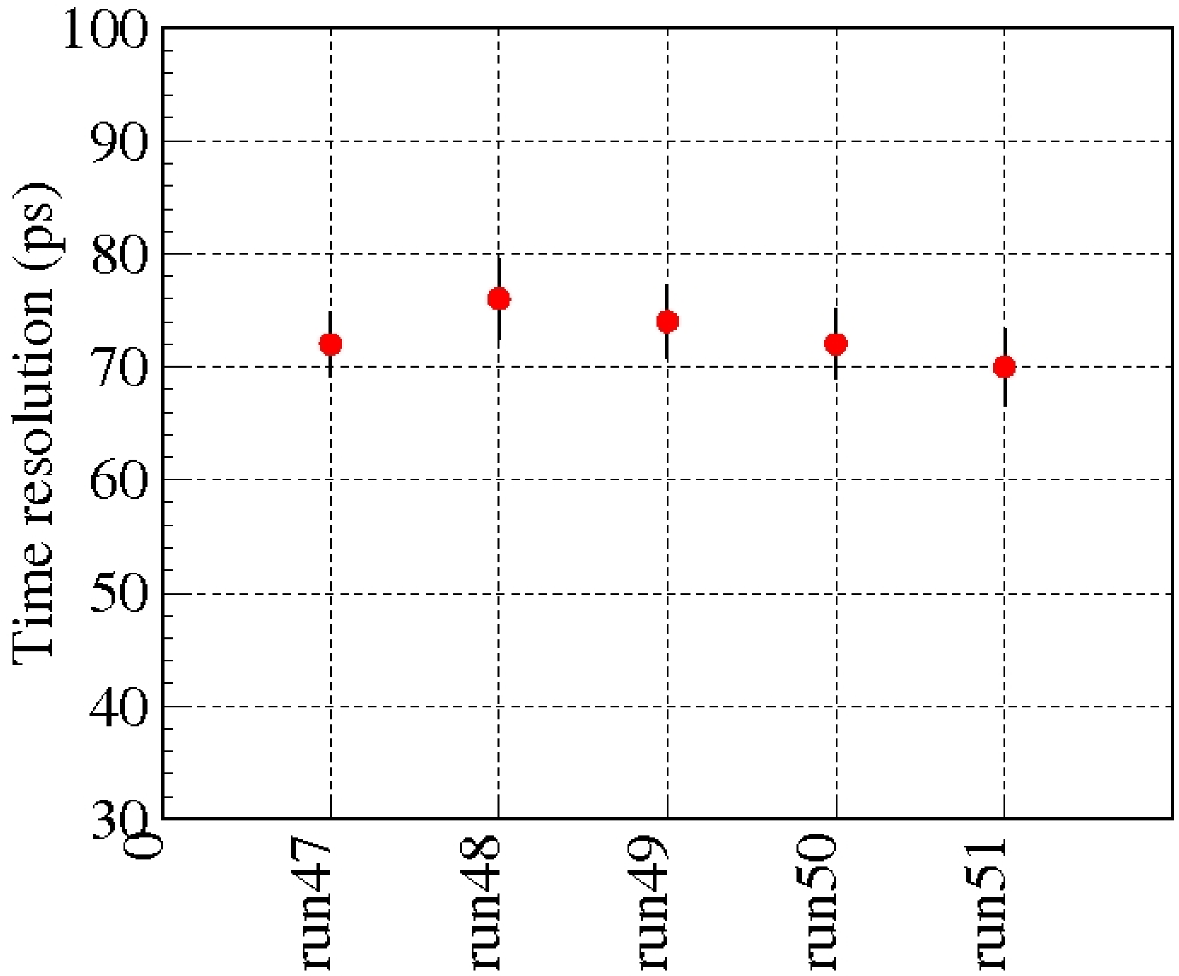
Time resolution using RPC4 (Chinese glass) and RPC3 (strip HV + resistive layer)



HV RPC4 = 10.6 kV -> 2.12 kV/gap

HV RPC3 = 14.6 kV -> 2.086 kV/gap

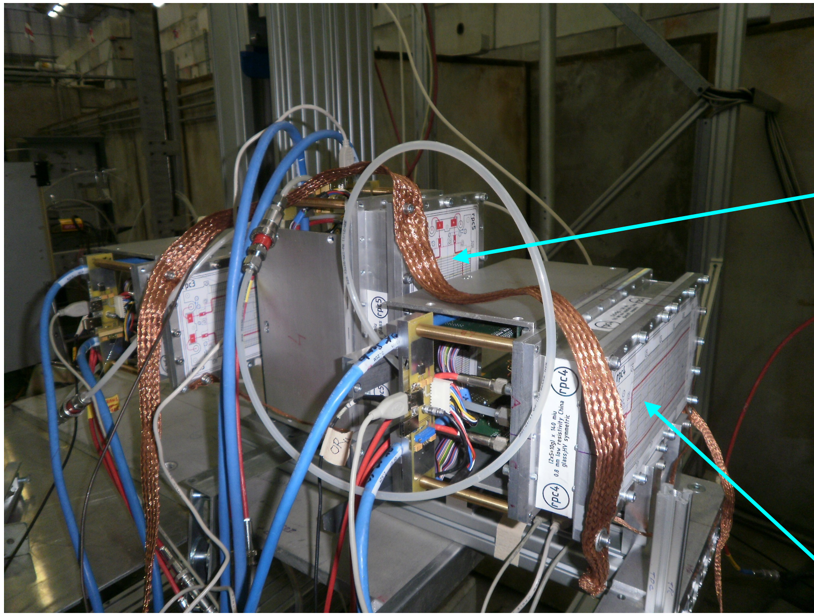
Time resolution using RPC5 (strip HV) and RPC3 (strip HV + resistive layer)

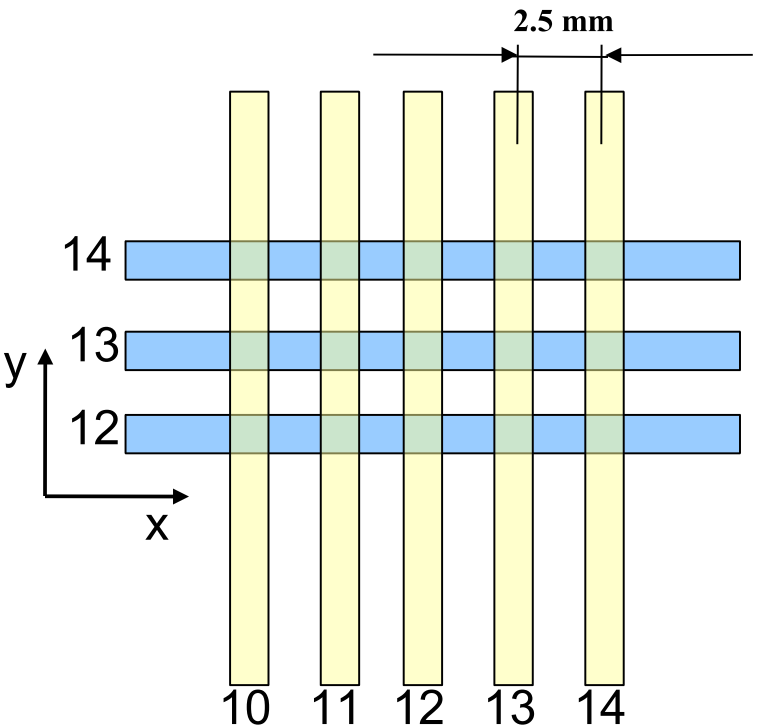


HV RPC4 = 14.6 kV -> 2.086 kV/gap

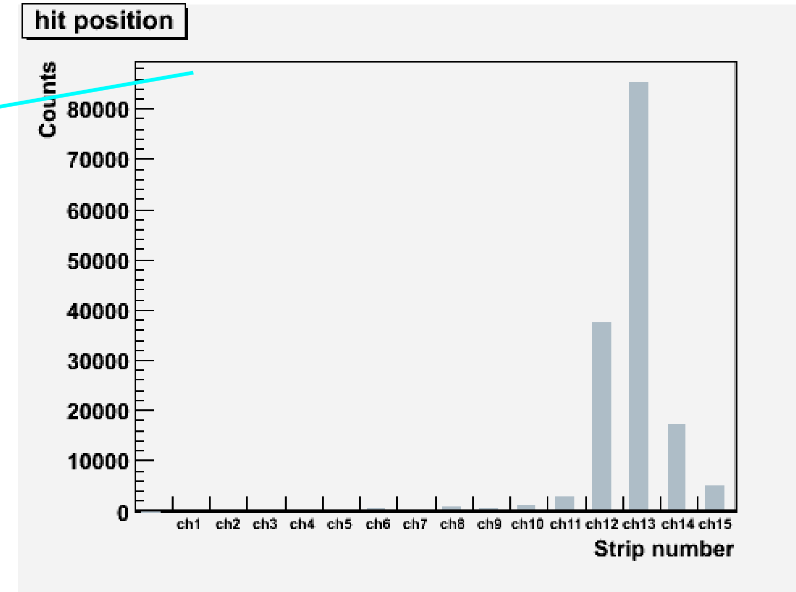
HV RPC3 = 14.6 kV -> 2.086 kV/gap

Position information along the strip

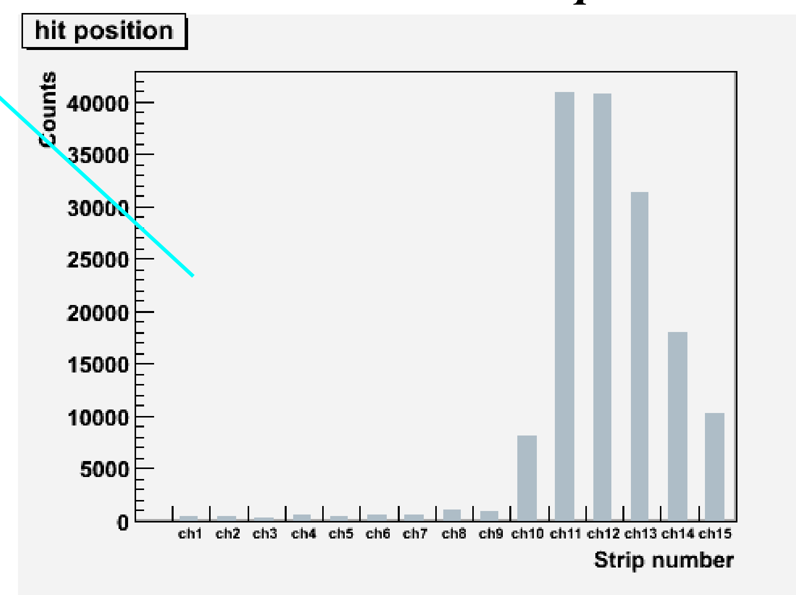




RPC5 – horizontal strips

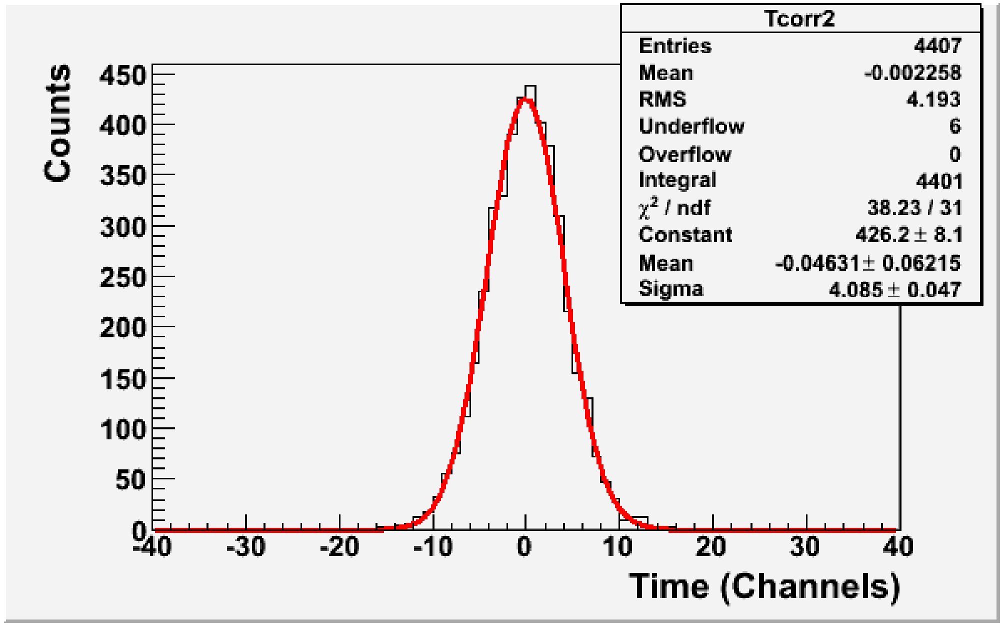


RPC3 – vertical strips

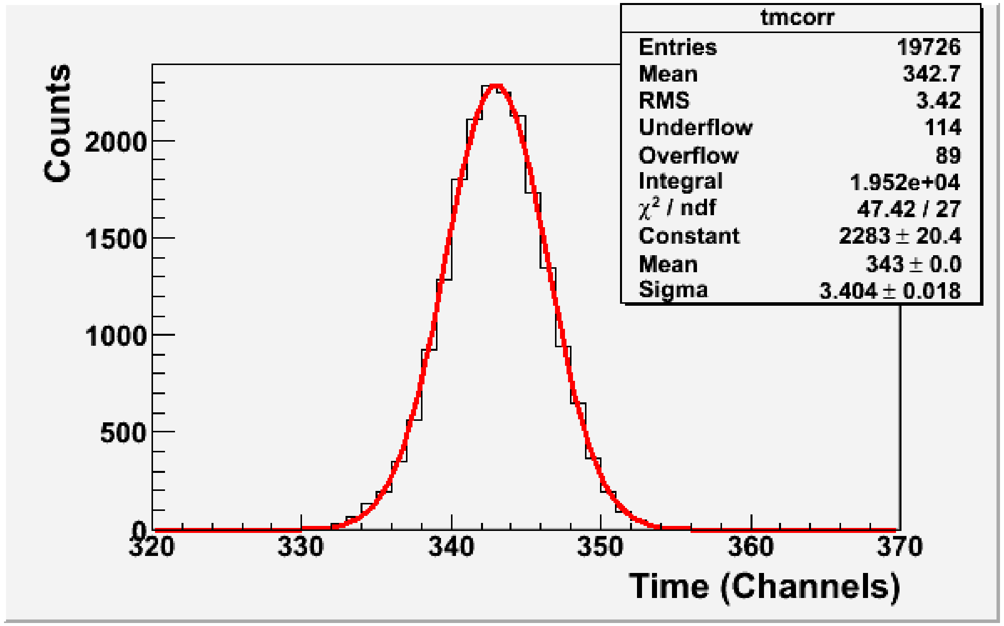


Time resolution using RPC4 (Chinese glass) vs. RPC5 (strip HV)

TOF spectrum



Pulser spectrum



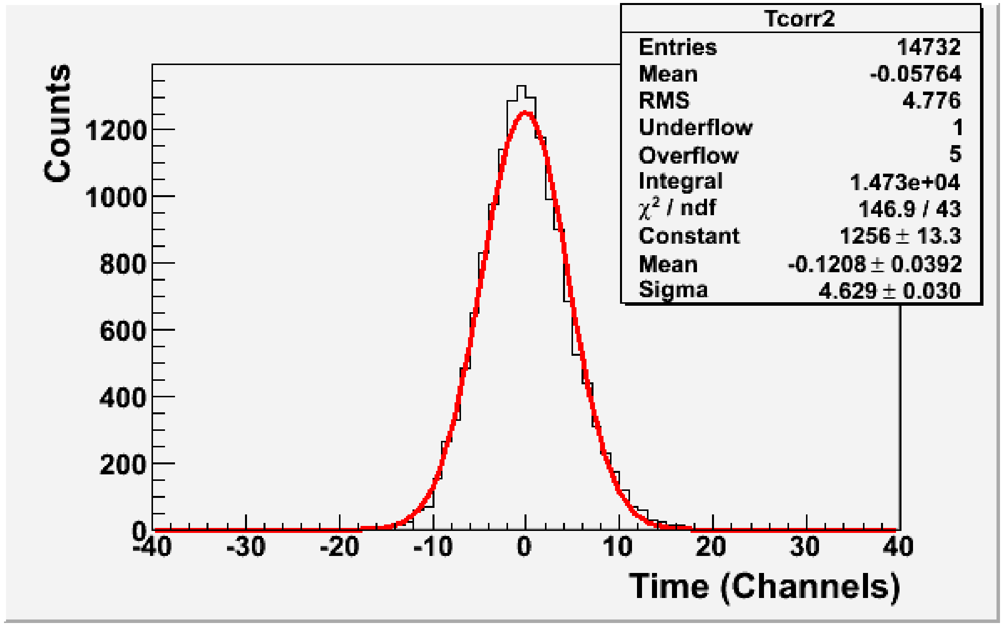
HV RPC4 = 10.8 kV -> 2.16 kV/gap

HV RPC5 = 14.8 kV -> 2.11 kV/gap

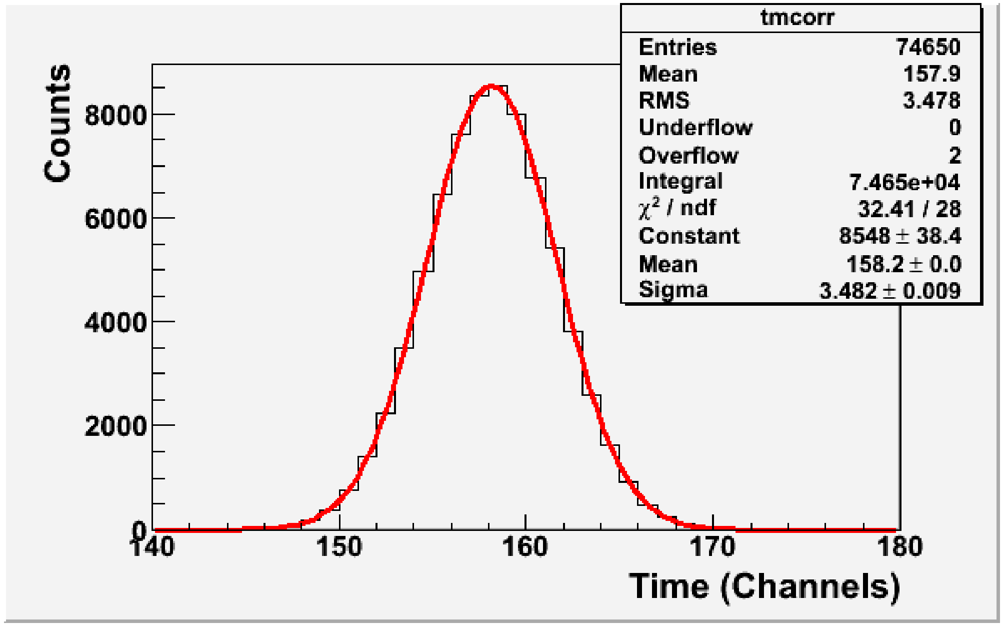
RPC5-HV (V)	σ_{RPC} *(ps)*
2x7300	*47*
2x7400	*40*

Time resolution using RPC3 (strip HV + resistive layer) vs. RPC5 (strip HV)

TOF spectrum



Pulser spectrum

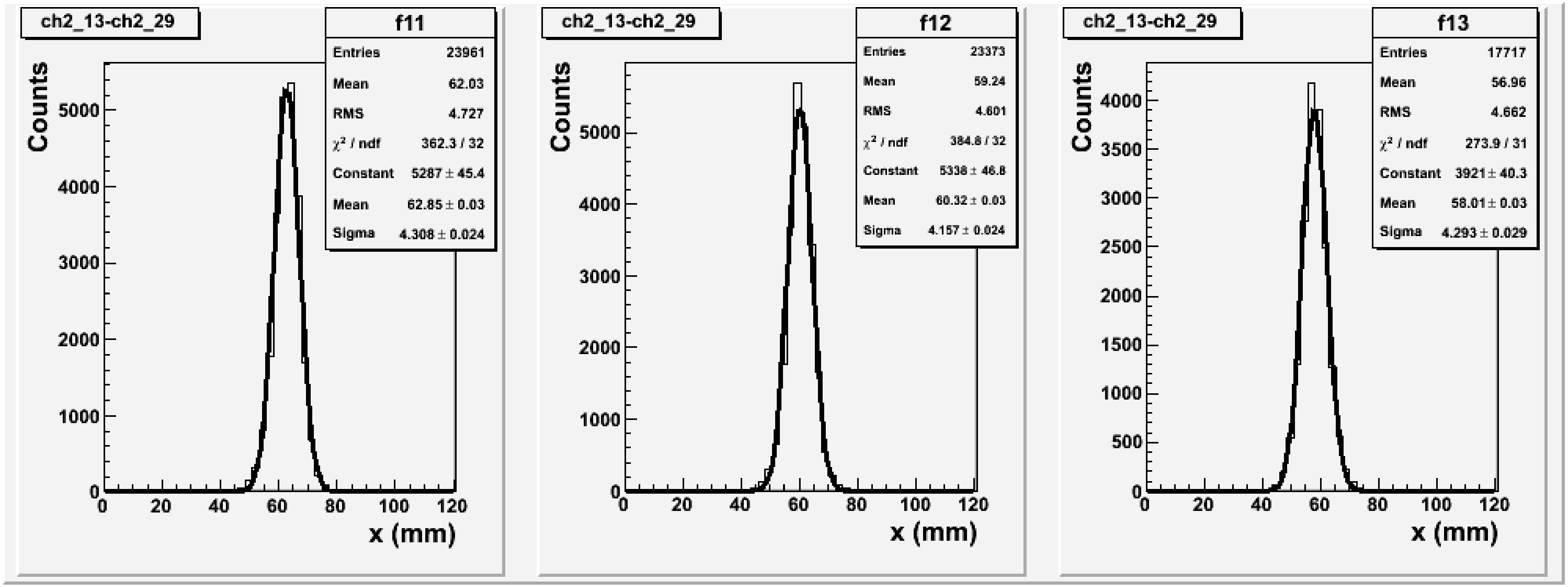


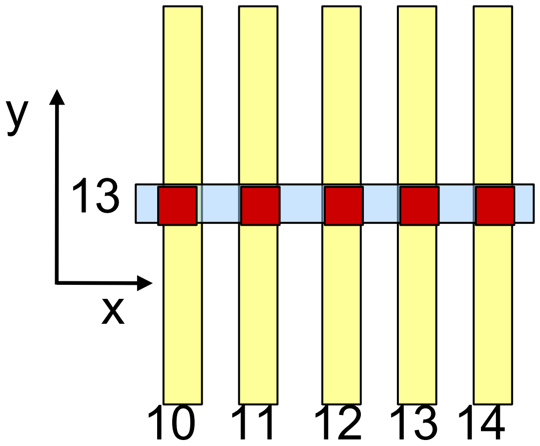
HV RPC4 = 14.8 kV -> 2.11 kV/gap

HV RPC5 = 14.8 kV -> 2.11 kV/gap

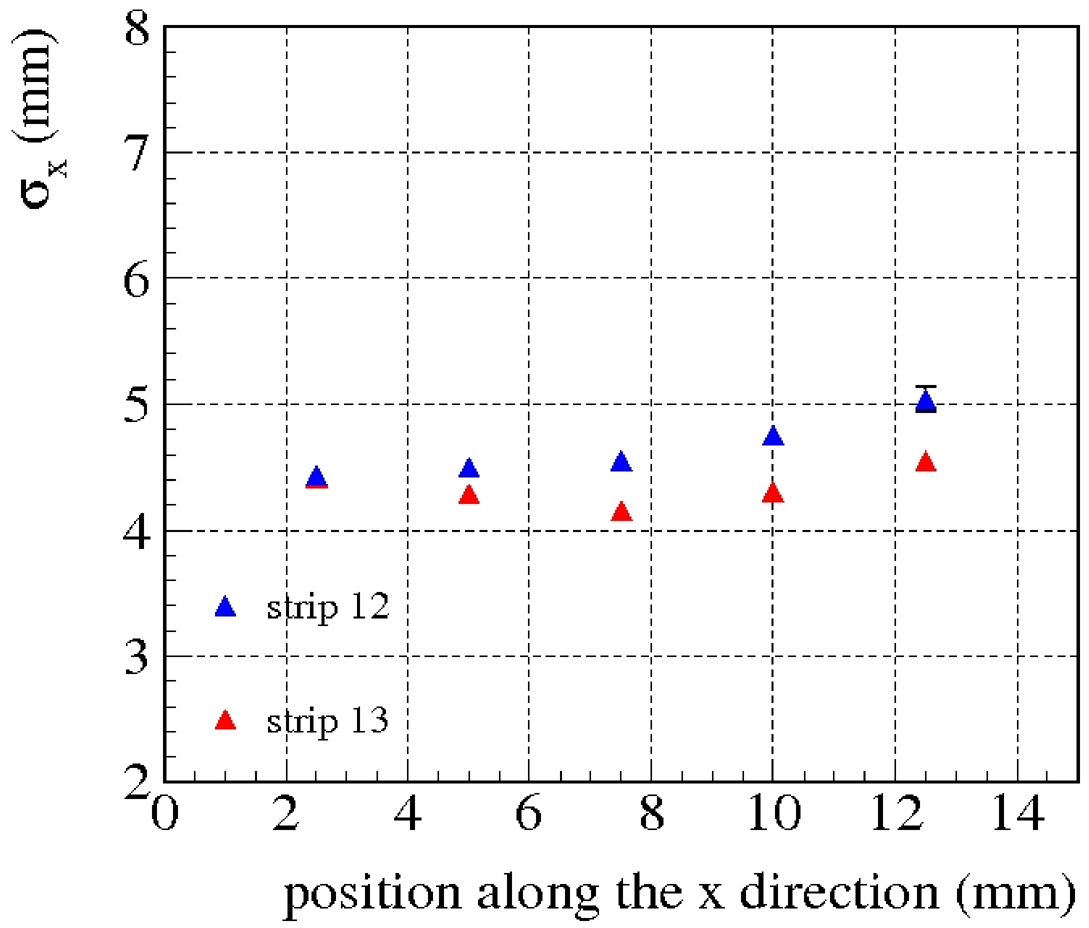
HV (V)	σ_{RPC} *(ps)*
2x*7400*	***56***

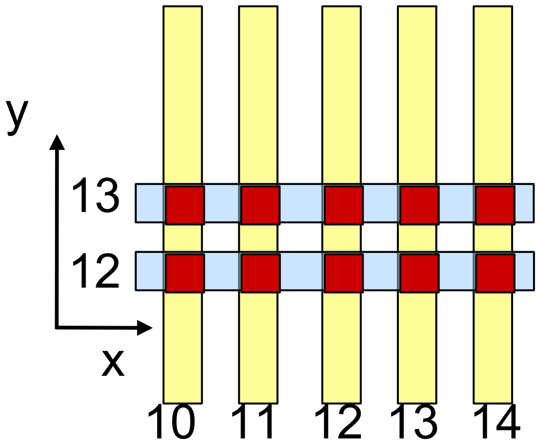
Position resolution along the horizontal strips - ch13



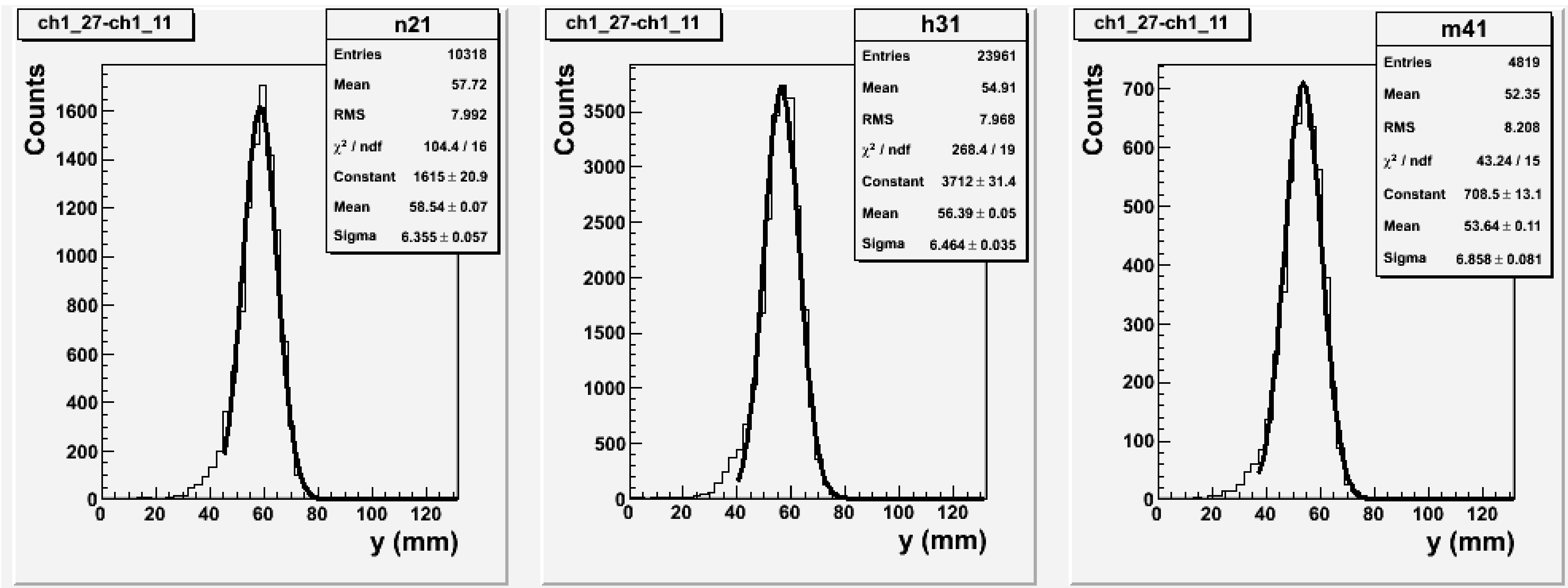


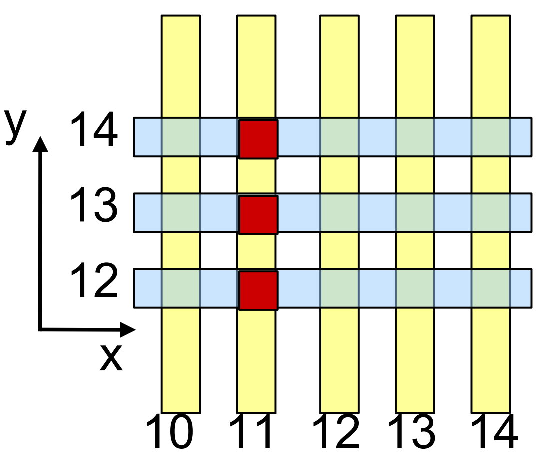
Position resolution along the horizontal strips



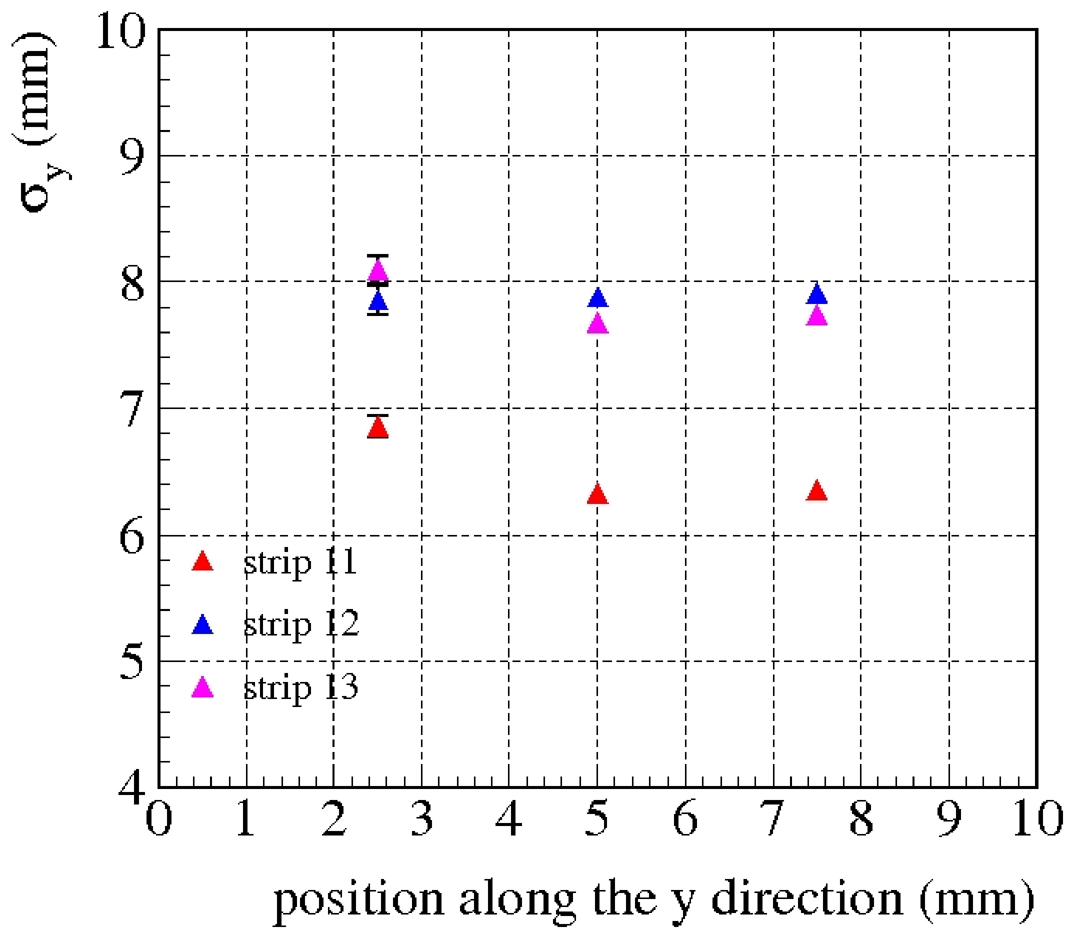


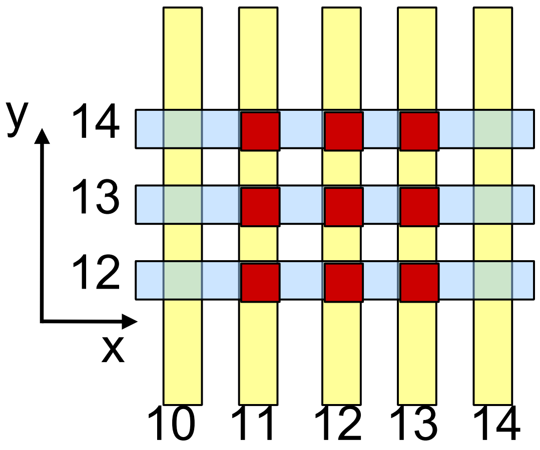
Position resolution along the vertical strips



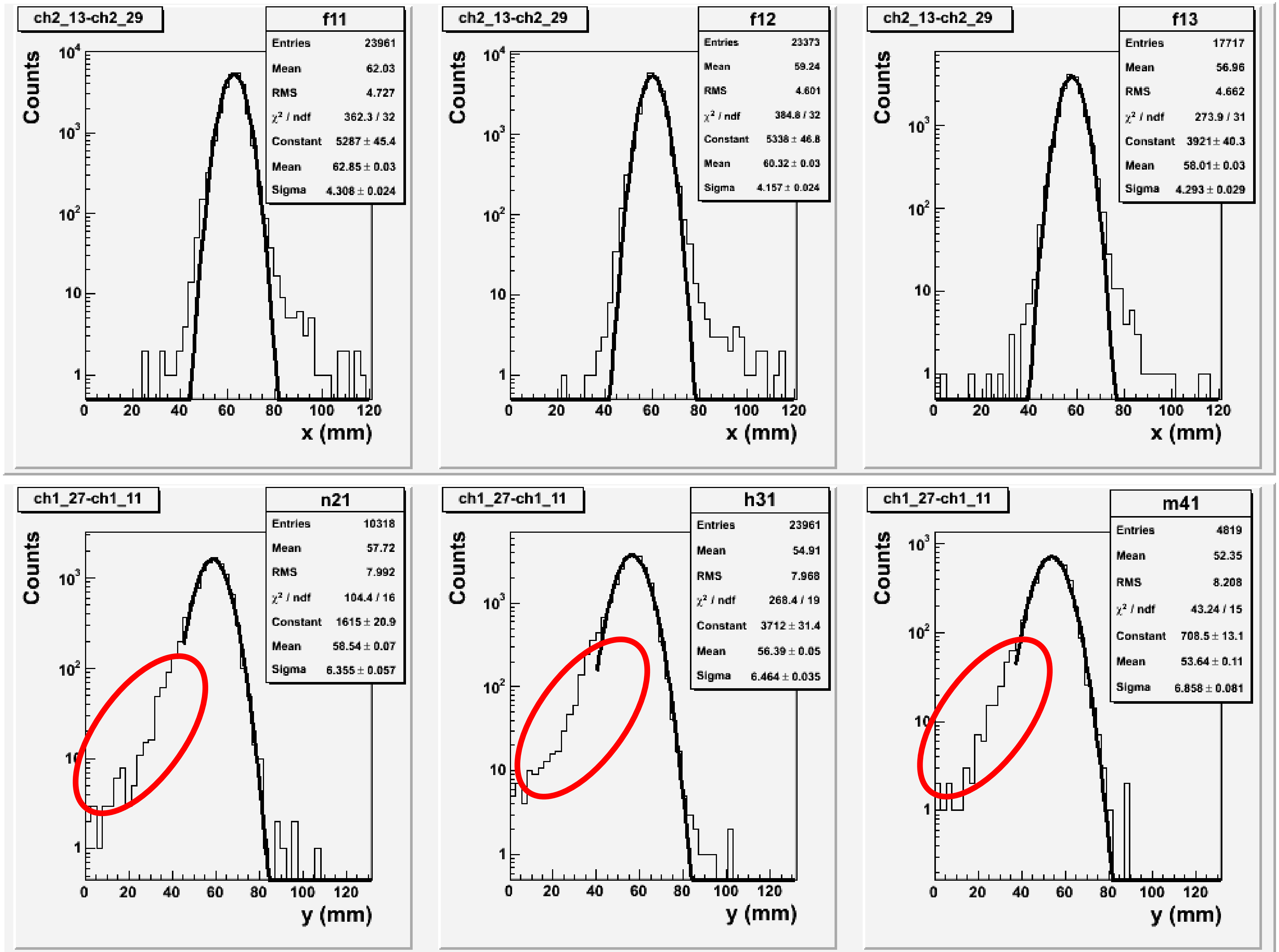


Position resolution along the vertical strips





Why differences between the position resolutions of the two counters?



TDC2

TDC1

Conclusions & Outlook

- ***The in-beam test results for the RPC prototypes show:***
  - ***a detection efficiency better than 97%***
  - ***a cluster size of 3 – 3.1 strips @ 2.1 kV/gap***
  - ***a time resolution better than 55 ps***
  - ***a position resolution along the strip of ~ 4.5 mm***
  - ***the obtained efficiency and cluster size are a bit lower for the RPC5 (2x 7 gaps, strip HV electrodes) prototype***
  - ***the time resolution is systematically better for the gas mixtures based on iso-butane***
- ***the presented results from in-beam tests @CERN & the results of the in-beam tests @ COSY, which will be presented by Ingo, recommend this structures as a real solution for the most inner part of CBM-TOF wall***

In progress:

- ***Tentative architecture for the most inner part of the TOF-wall (see Mihai's talk)***
- ***Associated FEE based on miniaturized eight channel NINO board (see Mihai's talk)***
- ***Precize position resolution across the strips***
- ***Detailed high counting rate tests***
- ***Multihit performance tests***
- ***Towards a "demonstrator"***

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