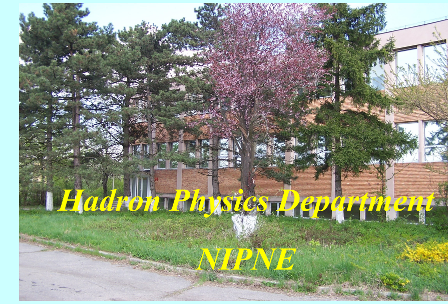

High counting rate, differential, strip read-out, multi gap, timing RPC

M. Petrovici[1], M. Petriş[1], V. Simion[1], D. Bartoş[1], G. Caragheorgheopol[1], F. Constantin[1], L. Rădulescu[1],

J. Adamczewski-Musch[3], I. Deppner[2], K. Doroud[3], N. Herrmann[2], S. Linev[3], P. Loizeau[2] and M. C. S. Williams[4]

[1]NIPNE, Bucharest, Romania;
[2]Physikalisches Institut der Universität Heidelberg, Germany;
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[4]INFN, Bologna, Italy

XI Workshop on Resistive Plate Chambers and Related Detectors
INFN - Laboratori Nazionali di Frascati
5-10 February, 2012

OUTLINE

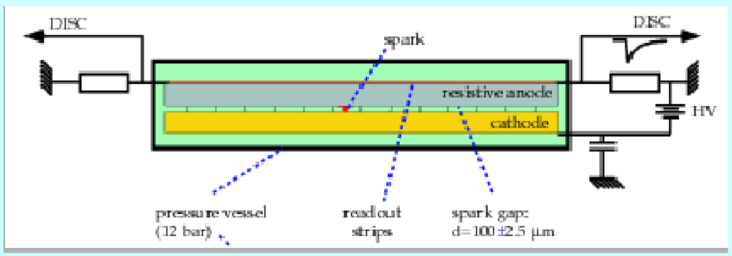
- ***Short reminder***
- ***High granularity, symmetric, differential strip architecture***
  - ***- architecture details***
  - ***- efficiency***
  - ***- time resolution***
  - ***- two dimensional position resolution***
  - ***- performance as a function of counting rate***
- ***Towards final architecture for CBM inner TOF Wall***
- ***Outlook***

Short reminder

Status of the field in 1999

Pestov Counter	Single Cell RPC	MGRPC - pad rows readout

Pestov Counter



Y.V.V. Pachomchuck et al. , Nucl. Instr. And Meth. A 93(1971) 269

A. Devismes, et al. NIM 482A(2002)179

Advantages:

-Very good σ_t (~25 ps)

- Position information: x, y

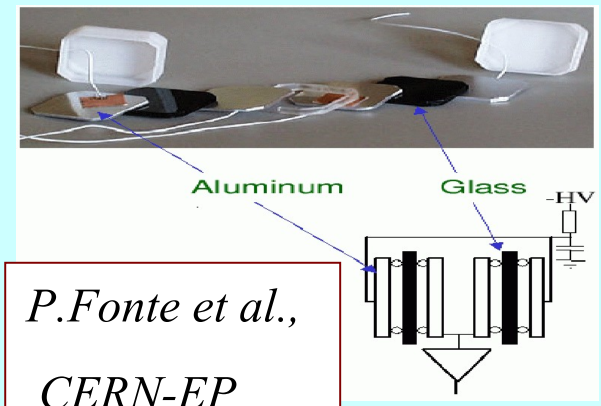
Drawbacks:

- high pressure operation

- tails in the time spectrum

- needs special glass

Single Cell RPC



P.Fonte et al.,

CERN-EP

27/9/99

Advantages:

- Very good σ_t (~44 ps)

- commercial glass

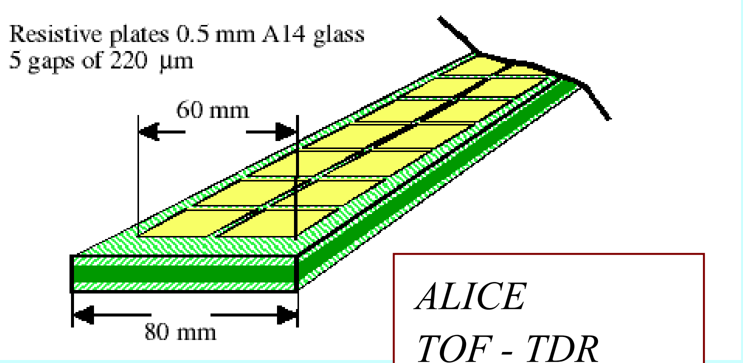
- 1 atm pressure operation

Drawbacks:

- edge effects

- unrealistic for large area configuration

MGRPC - pad rows readout



ALICE
TOF - TDR
CERN / LHCC
2000-12

Advantages:

- Very good σ_t (~60 ps)

- commercial glass

-1 atm pressure operation

Drawbacks:

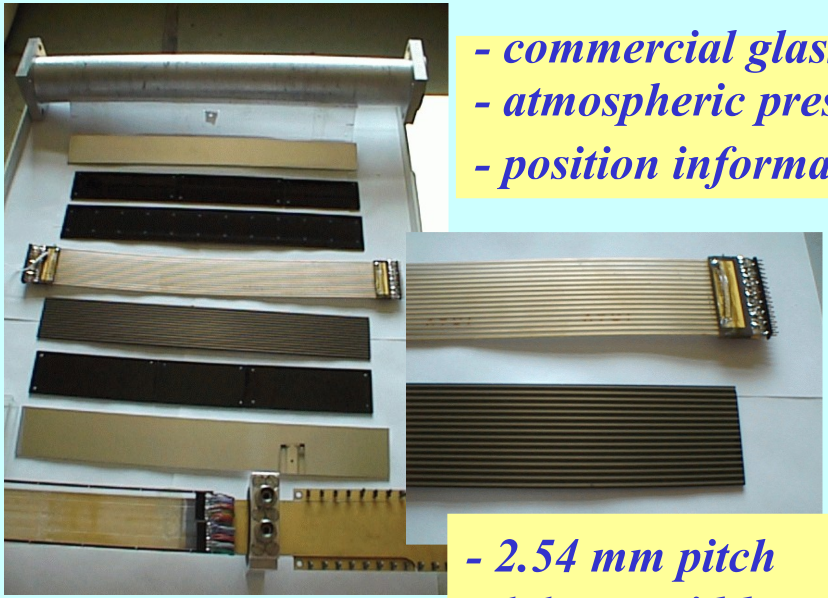
- edge effects, cross talk

- no position information over the pad sizes; tracking device is needed for position dependence correction

Short reminder

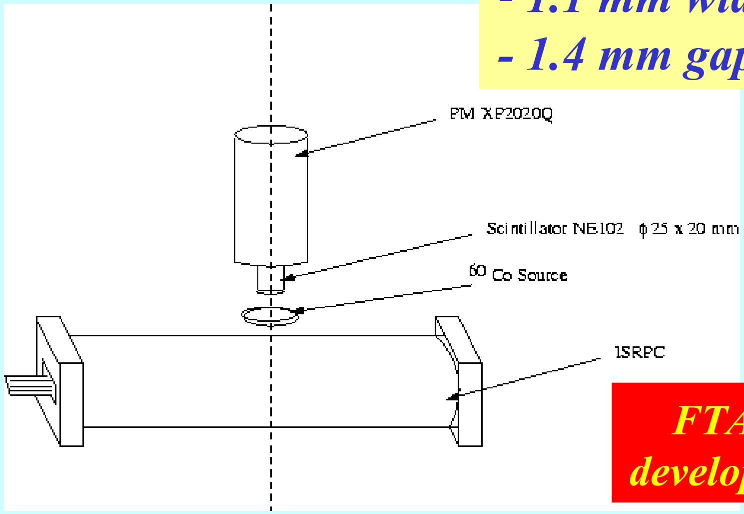
Our proposal for a MSMGRPC - *autumn 1999*

First prototype , 30 cm length, built and tested early 2000 with ^{60}Co source



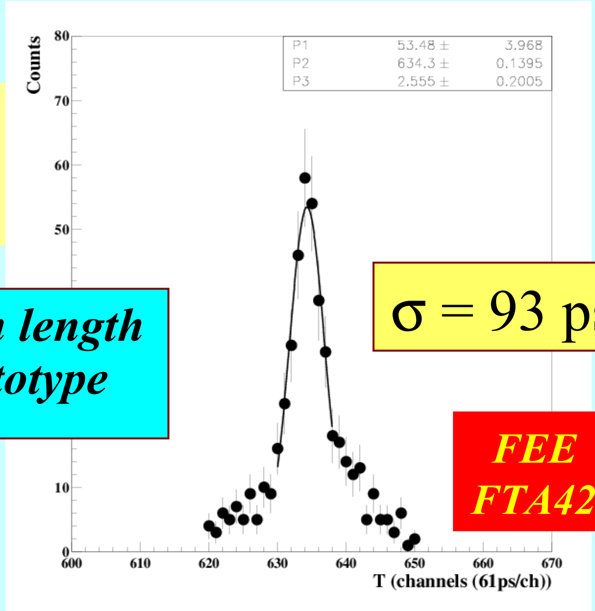
- *commercial glass*
- *atmospheric pressure operation*
- *position information: x, y*

- *2.54 mm pitch*
- *1.1 mm width*
- *1.4 mm gap*



FTA ⇒ Beskow
developed for PPAC @ GSI

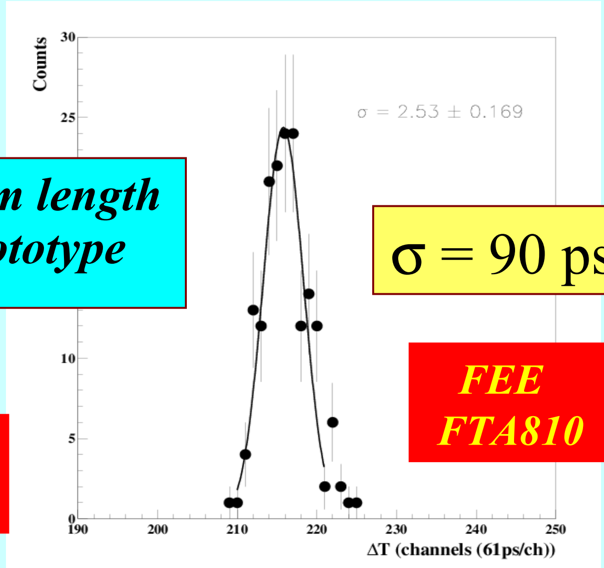
30 cm length prototype



σ = 93 ps

FEE FTA420

90 cm length prototype



σ = 90 ps

FEE FTA810

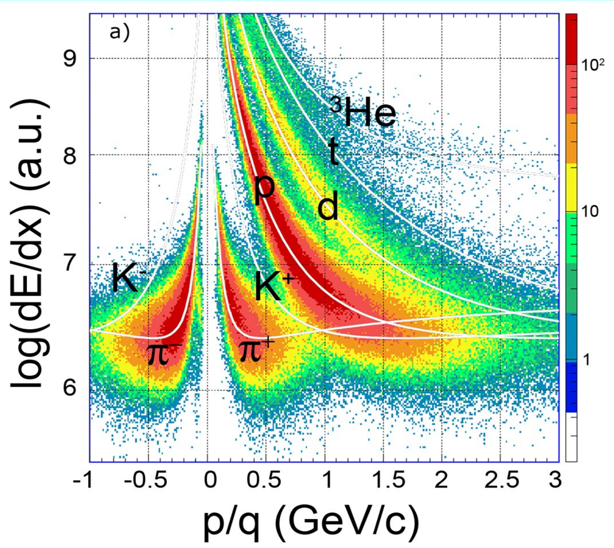
M. Petrovici et al, VI Workshop on Resistive Plate Chambers and Related Detectors, Coimbra, Portugal, 26-27, November, 2001
M. Petrovici et al. NIM, A487(2002)337
M. Petrovici et al. NIM, A508(2003)75

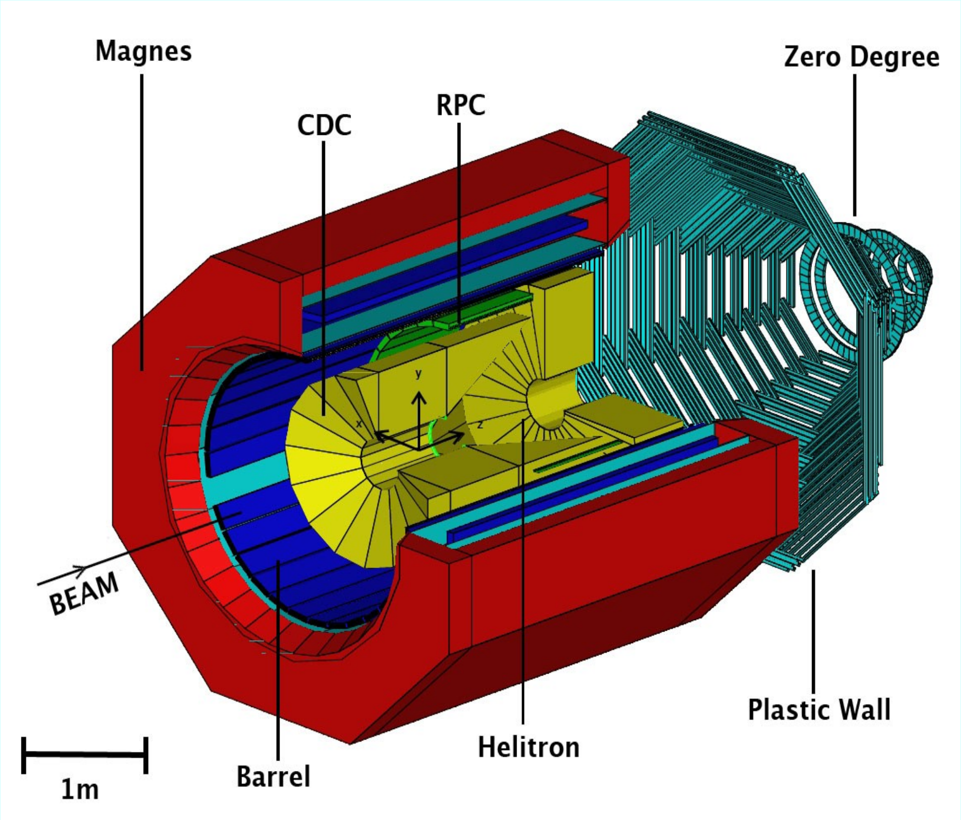
Short reminder

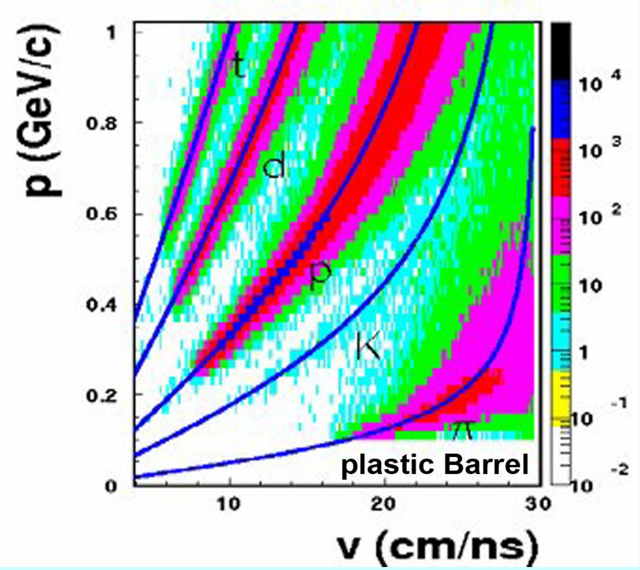
FOPI – RPC-TOF Barrel based on MSMGRPC

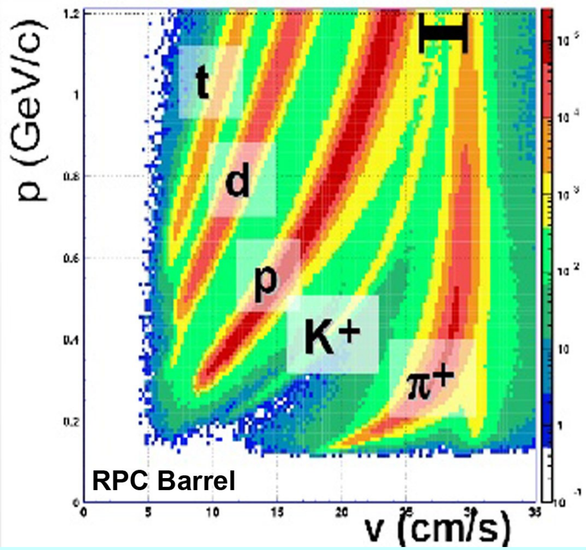
A. Schüttauf et al. NIM, A533(2004)65

M. Kiš et al, NIM, A646(2011)27

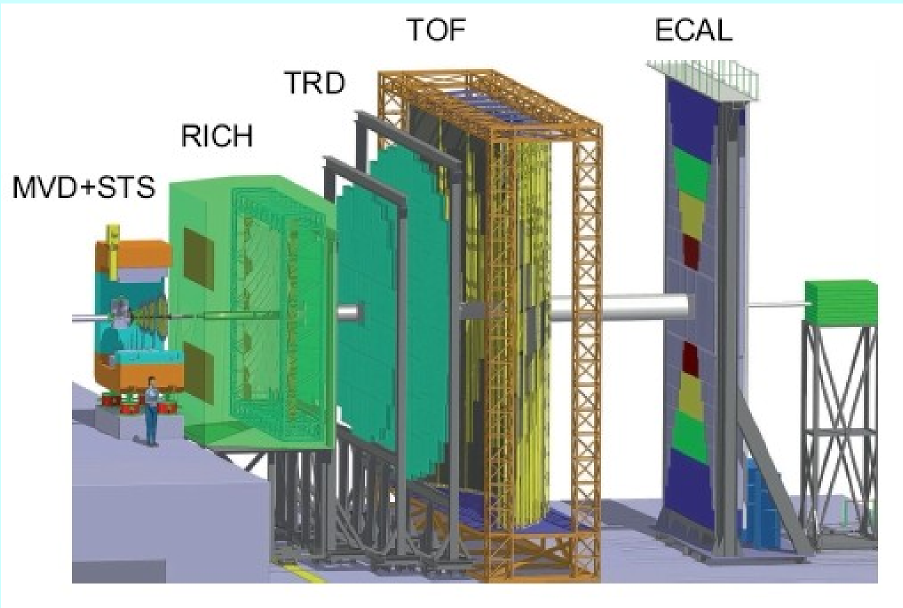


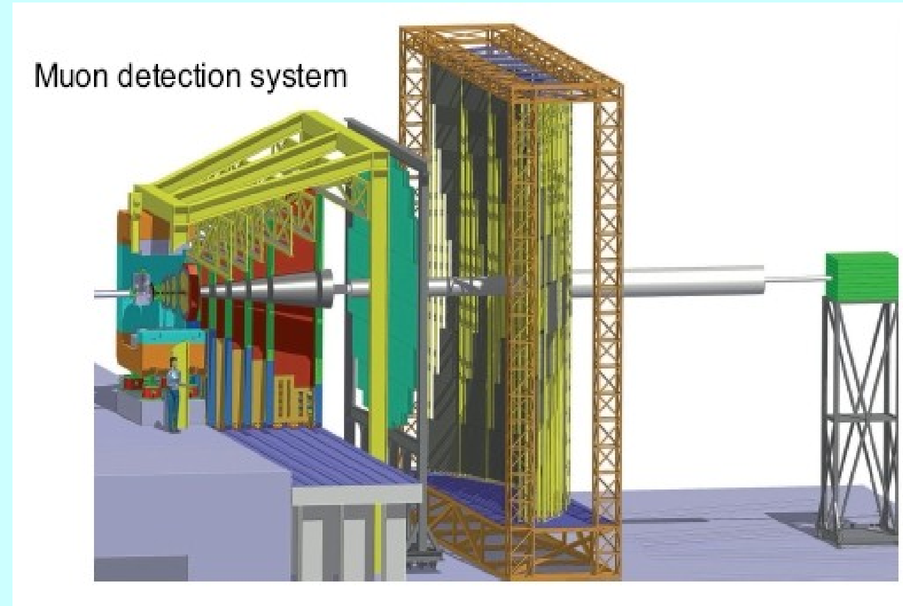






New challenge - CBM-TOF wall





- *Interaction rate 10^7Hz (~1000 tracks/event)*
- *TOF wall at 10 m from 3º to 27º*
  - ⇒ *large area (~150 m²)*
- *Rate from 1 kHz/cm² (27º) to 20 kHz/cm² (3º)*
  - ⇒ *large counting rate*
- *Hit density from $6 \cdot 10^{-2}$/dm² to 1/dm²*
  - ⇒ *huge number of cells for <5% occupancy*

particle	S/B ratio	Efficiency %	S/B ratio	Efficiency %
ω	0.13	1.8	0.3	1.6
φ	0.05	3.8	0.11	3.5
η	0.002	0.9	0.008	0.8
ρ	0.001	1.6	0.005	1.4

CBM Experiment Technical Status Report,
Darmstadt, February 2005

Single-ended – strip readout Pestov glass RPC

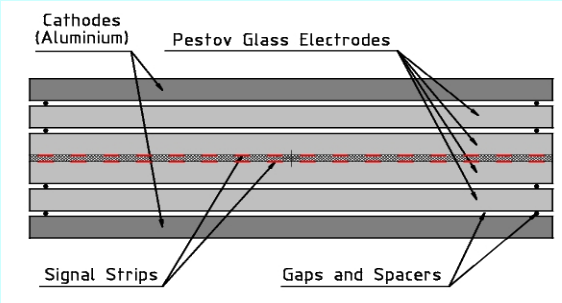
Construction Details

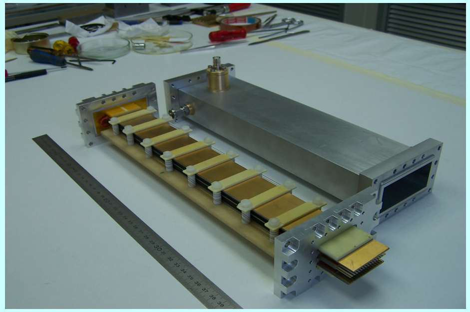
Gap size = 300 µm

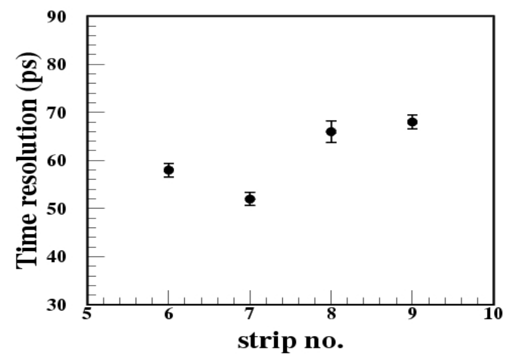
Active area 300 mm x 40.6 mm

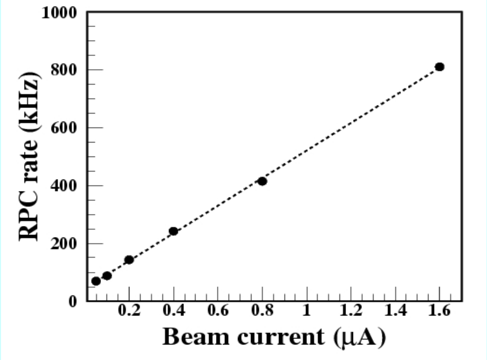
- electron beam, 30 MeV, ELBE

- signal amplification: FEE1 developed for FOPI at GSI









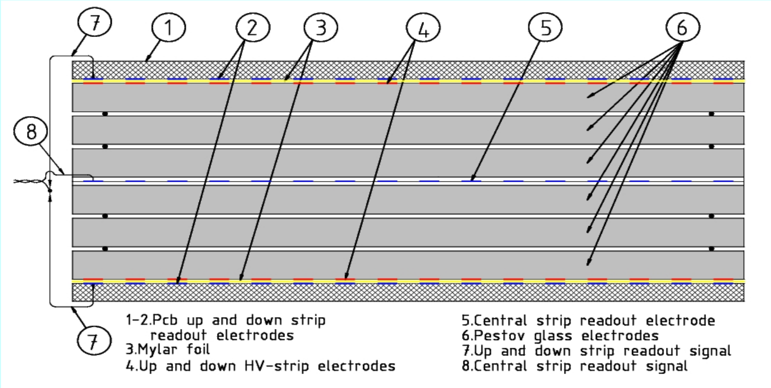
pitch: 2.54 mm, 1.10 mm width, 1.44 mm gap

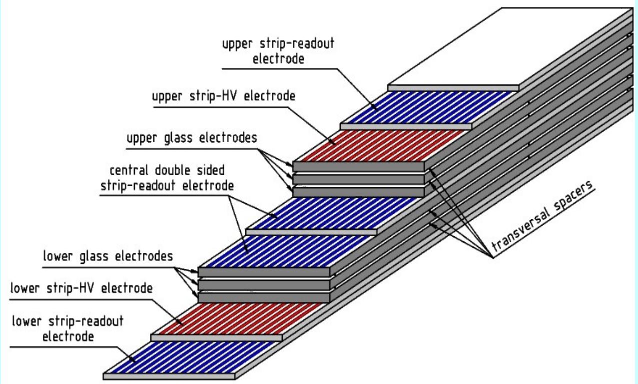
Differential – strip readout Pestov glass RPC

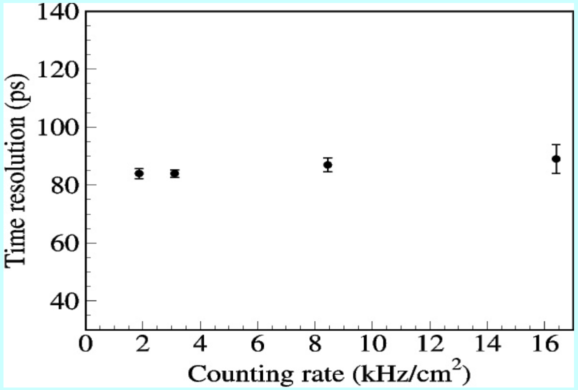
D. Bartos et al., 2008 Nuclear Science Symposium
19-25 October, Dresden, Germany

- electron beam, 30 MeV, ELBE

- differential readout based on NINO chip developed within ALICE Collaboration







Towards higher granularity

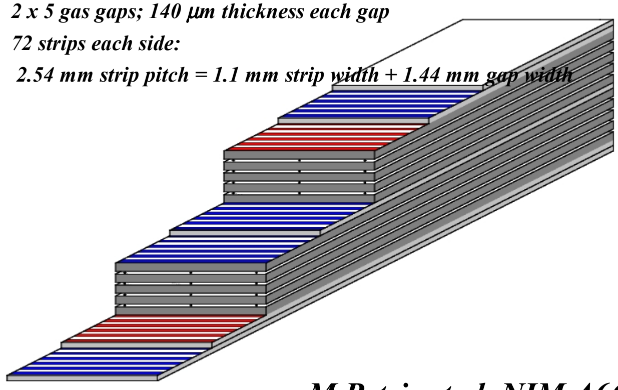
- proton beam, 3.1 GeV, SIS

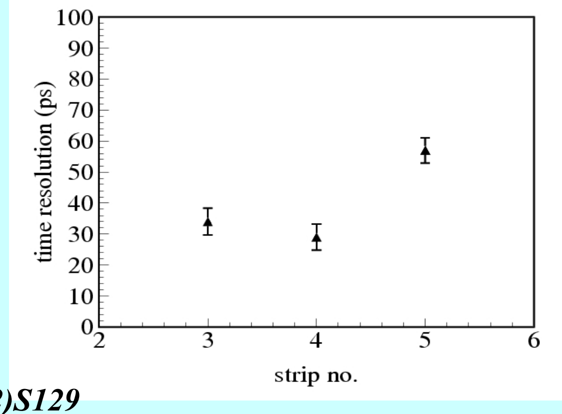
Float glass: 0.5 mm

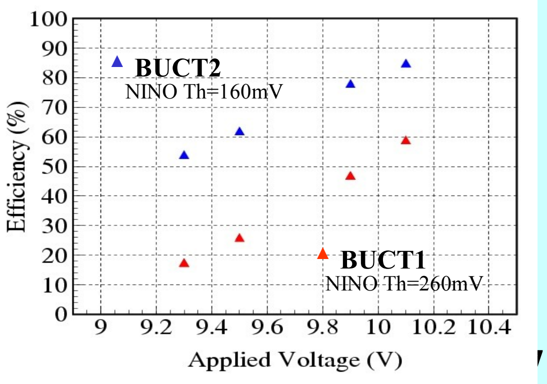
2 x 5 gas gaps; 140 µm thickness each gap

72 strips each side:

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



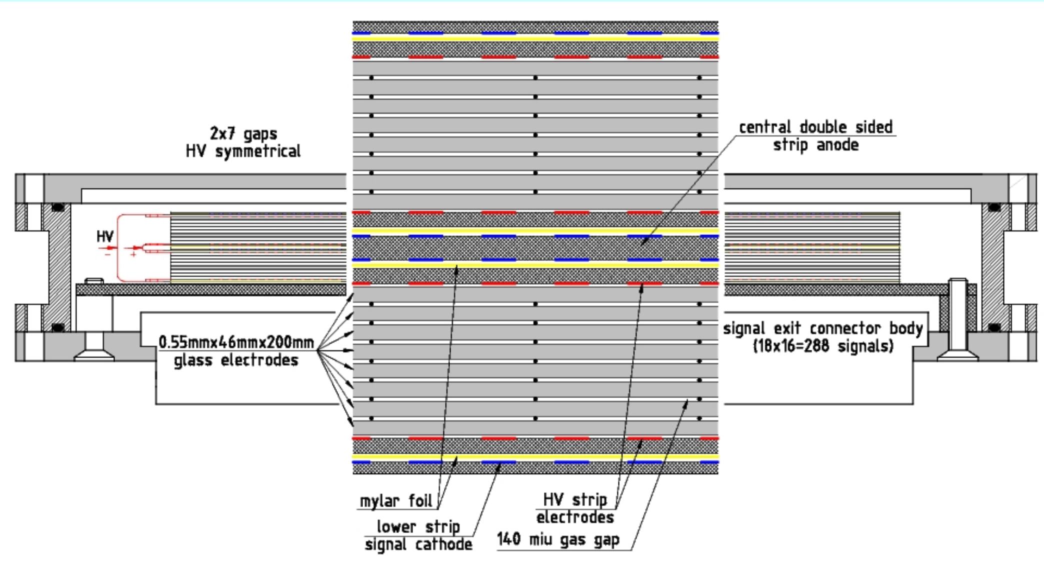


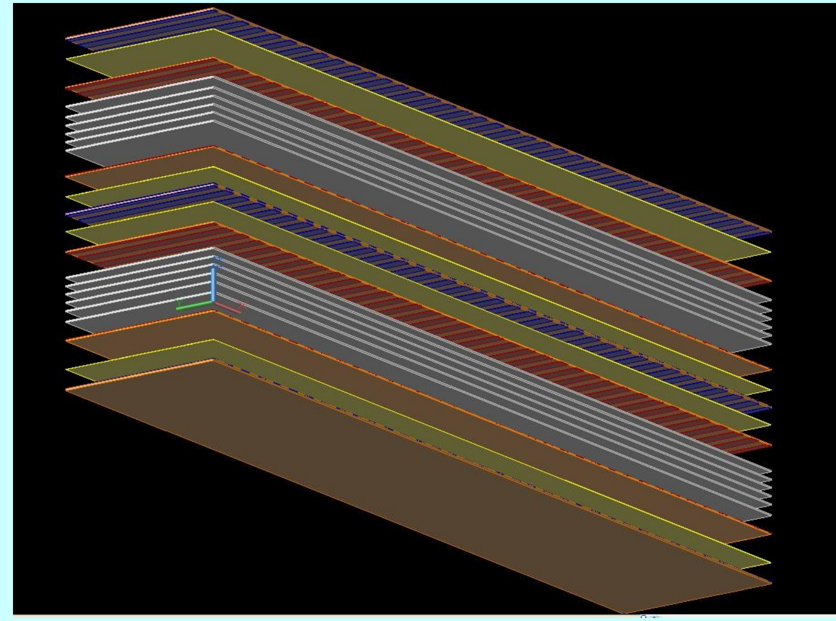


M.Petris et al, NIM A661(2012)S129

High granularity, differential, strip read-out, multi gap, timing RPC

2 x 7 gaps – cross section
High voltage electrodes for both polarities





Symmetric two stack structure, differential readout
Active area 46 x 180 mm²
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

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

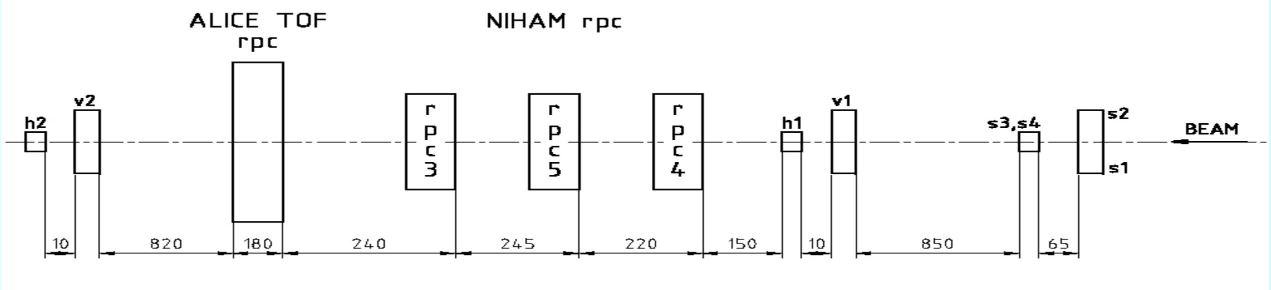
RPC5:
- strip structure high voltage electrodes for both polarities

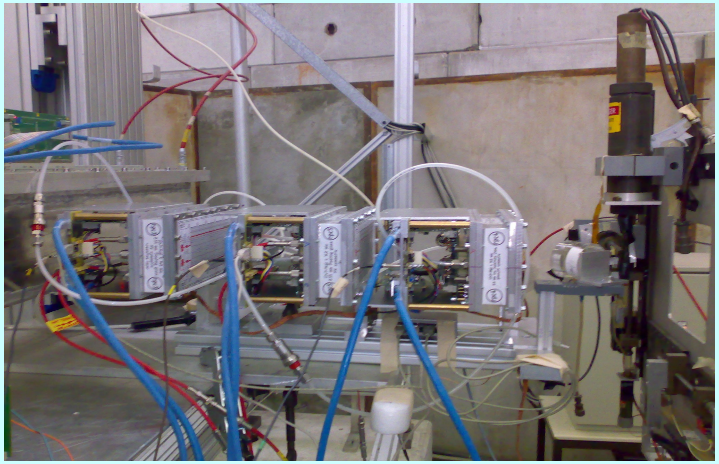
⊕ high counting rate timing RPC

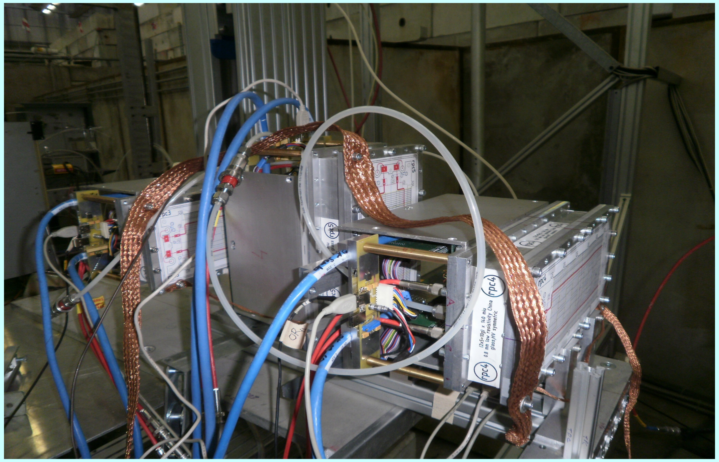
Electrodes: low resistivity glass: 0.7 mm (Chinese glass)
2 x 5 gas gaps; 140 µm thickness each gap

RPC4:
- strip structure high voltage electrodes for both polarities

In-Beam Tests







Experimental set-up:

- pion beam, 6 GeV/c momentum, PS-CERN

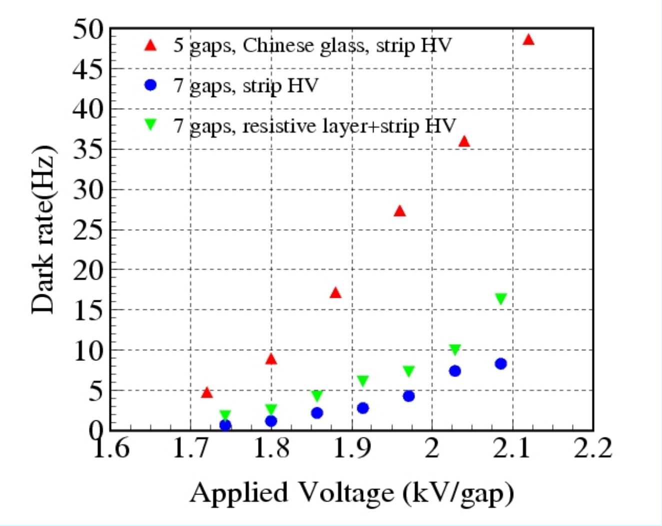
- 2 plastic scintillators 2 x 2 cm² overlap, used as reference (S1S2/S3S4)

- 2 plastic scintillators 1 x 1 cm² overlap used for active collimation (h1/v1&h2/v2)

- FEE: differential readout based on NINO chip developed within ALICE Collaboration

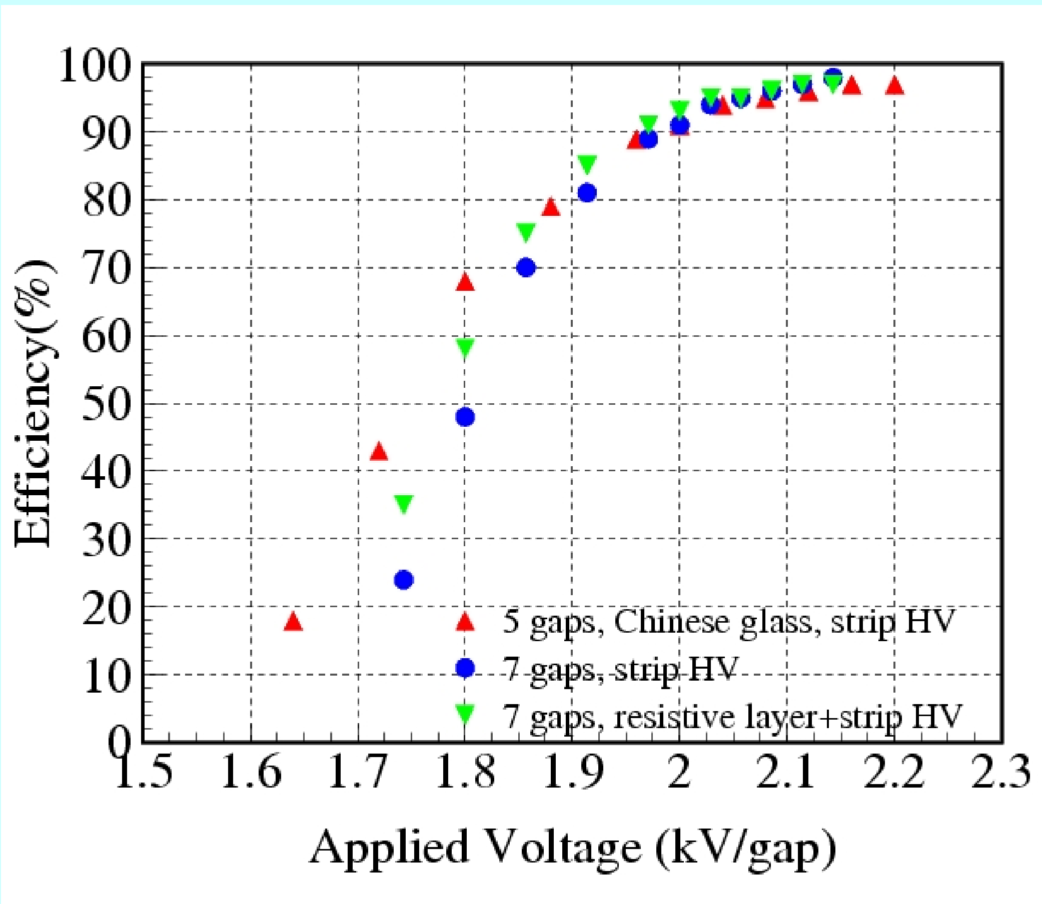
- digital converters: CAEN TDC V1290A

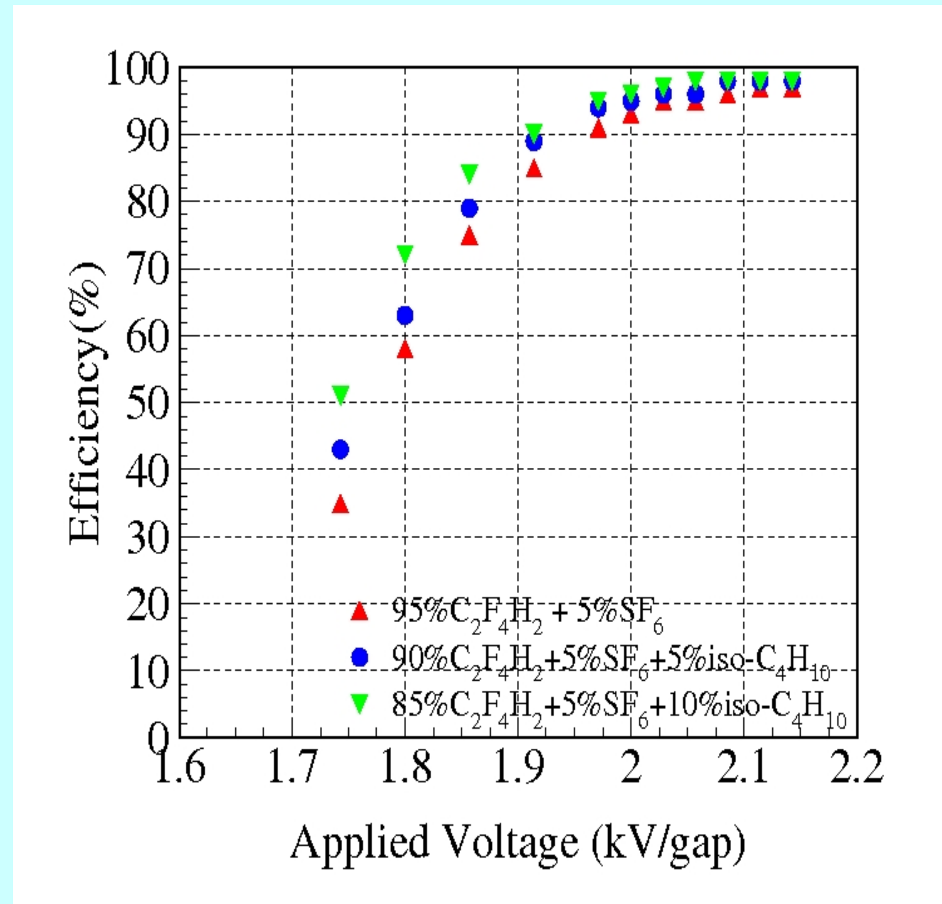
- information recorded for 16 strips readout at both ends for each RPC.



Active area = 18.694 cm²

Efficiency





RPC4 – Chinese glass:

NINO FEE1 **Th = 160 mV**

NINO FEE2 **Th = 160 mV**

RPC5 – strip HV:

NINO FEE1 **Th = 130 mV**

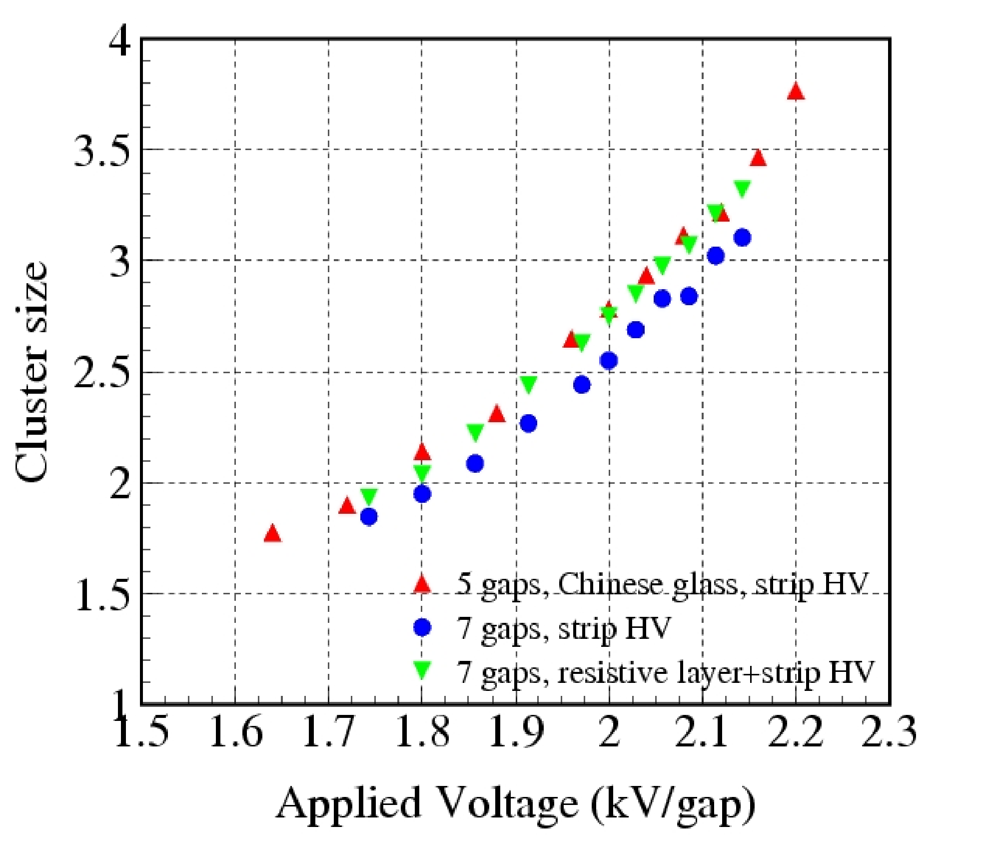
NINO FEE2 **Th = 130 mV**

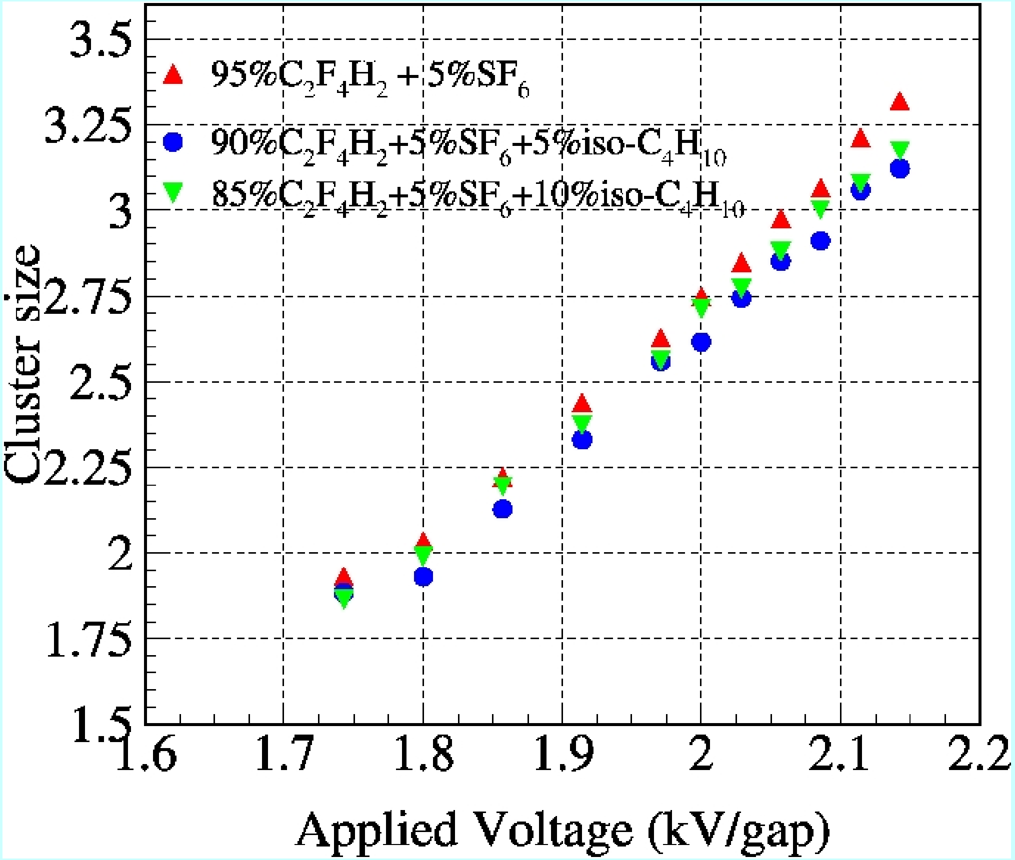
RPC3 – resistive layer +strip HV:

NINO FEE1 **Th = 130 mV**

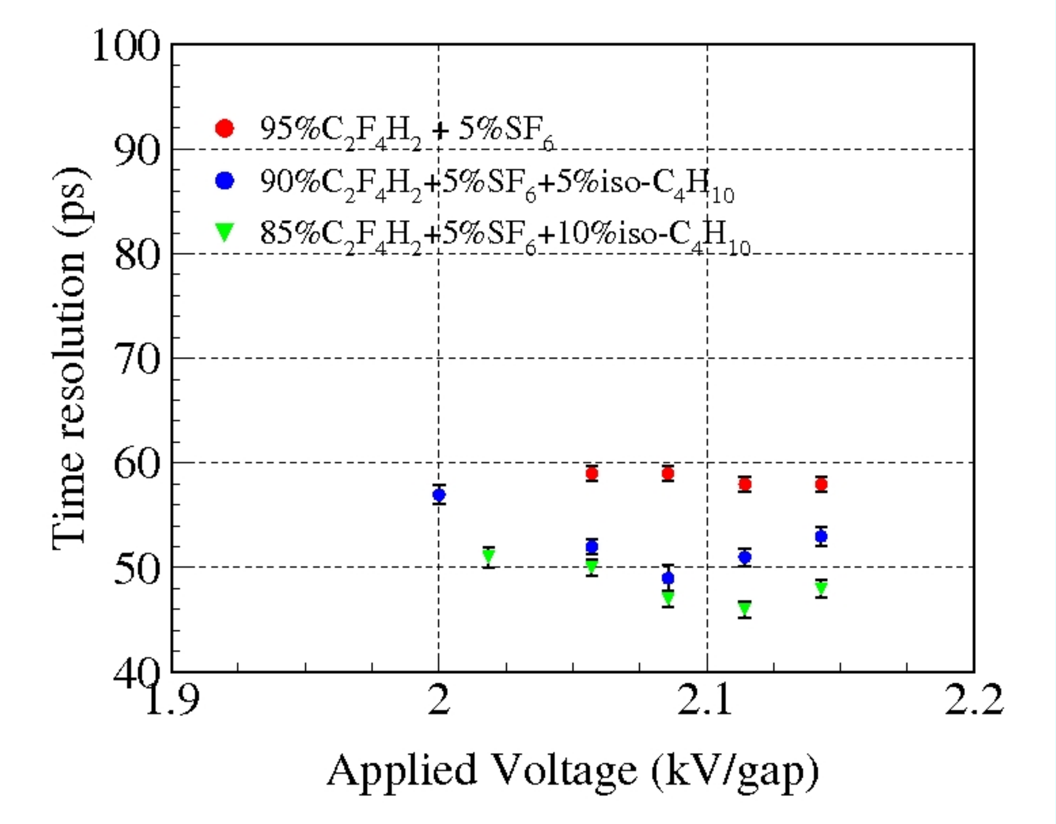
NINO FEE2 **Th = 130 mV**

Cluster size





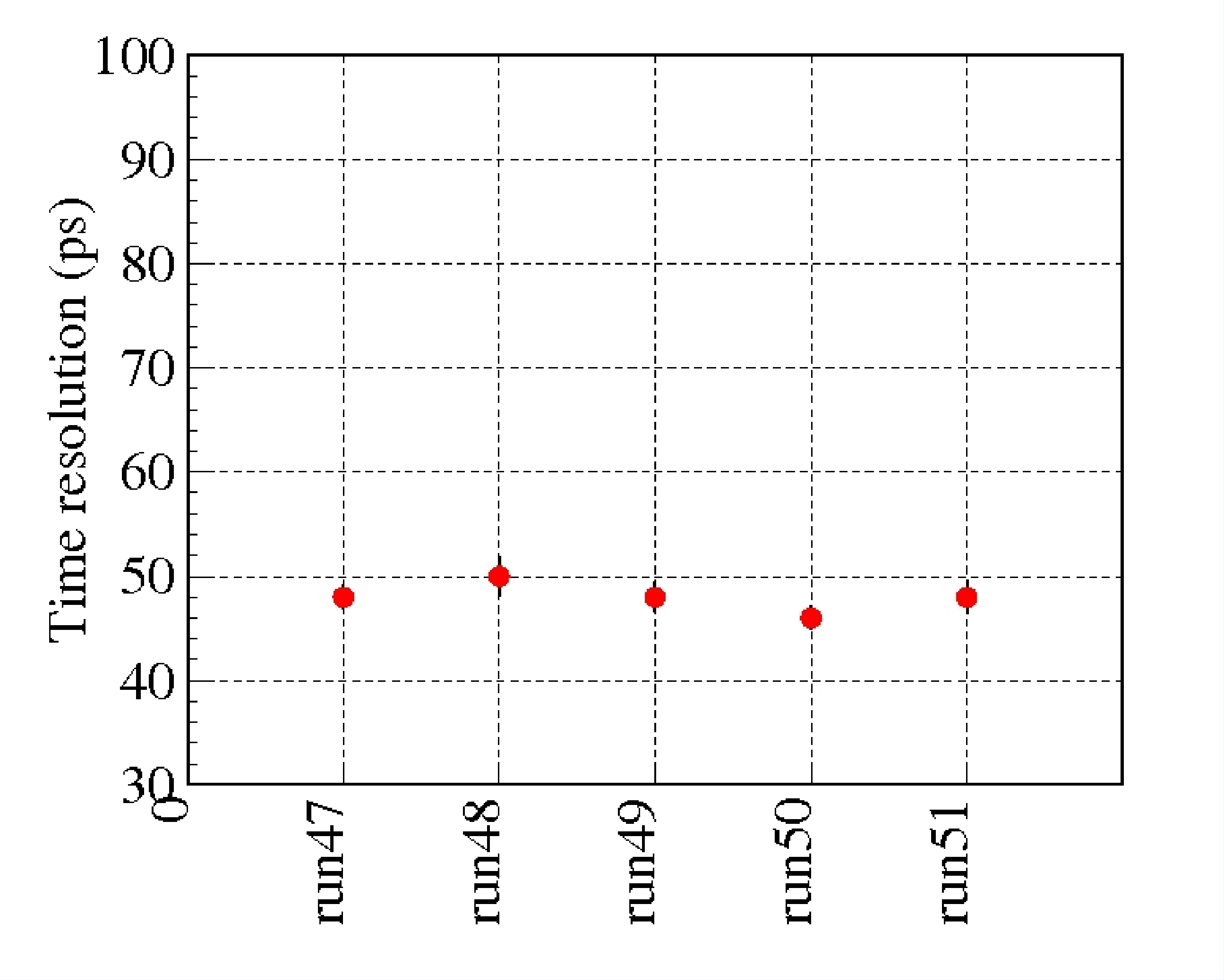
Time resolution using as reference a plastic scintillator readout at both ends



- 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

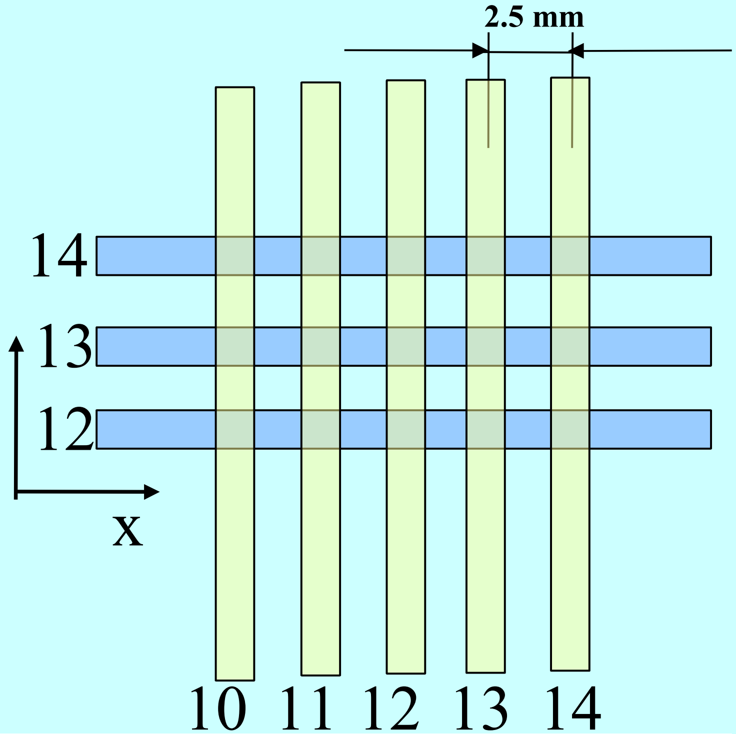
Time resolution using RPC4 (Chinese glass) vs. RPC5 (strip HV)

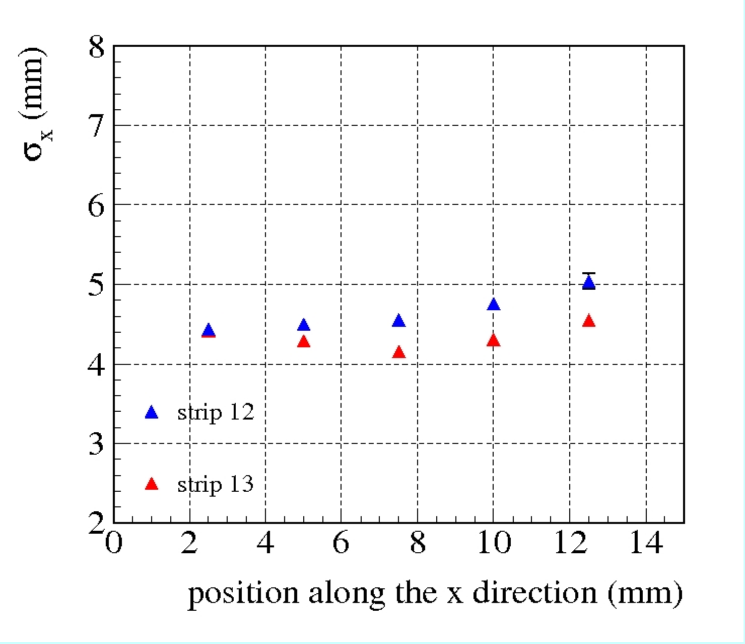


HV RPC4 = 10.6 kV -> 2.12 kV/gap

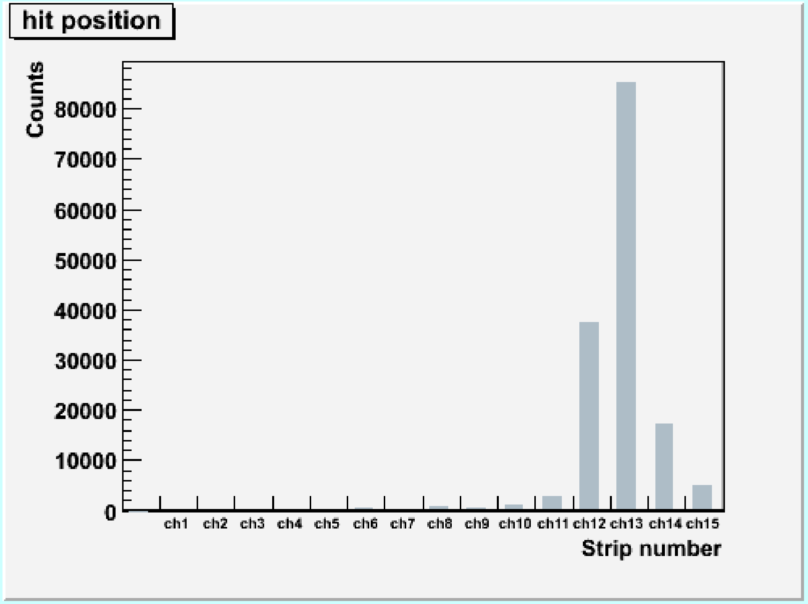
HV RPC5 = 14.6 kV -> 2.086 kV/gap

Position information along the strip

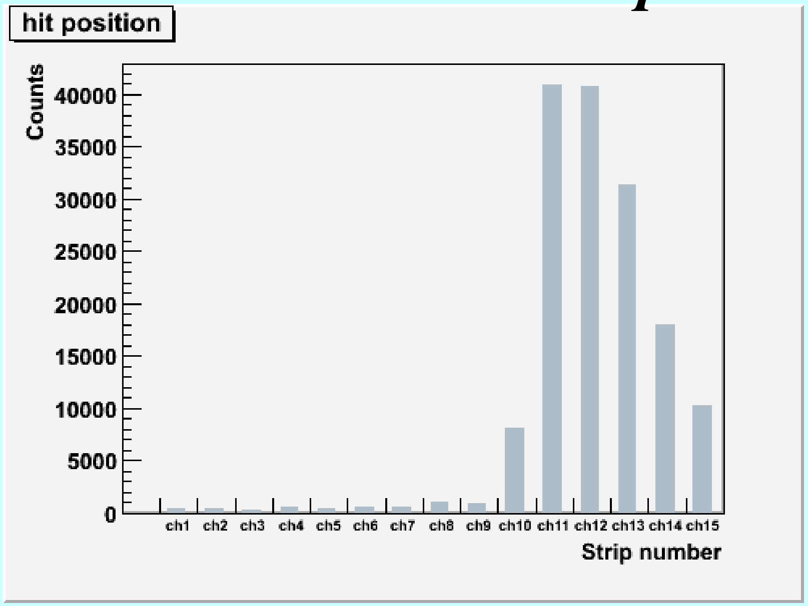




RPC5 – horizontal strips



RPC3 – vertical strips



Position information across the strips

Method – Gaussian PRF

using the ToT of the most significant strip and the ToT of the two adjacent strips

$$x = w\frac{\ln Q_{L-1} - \ln Q_{L+1}}{2\left(\ln Q_{L-1} - 2\ln Q_{L} + \ln Q_{L+1}\right)}$$

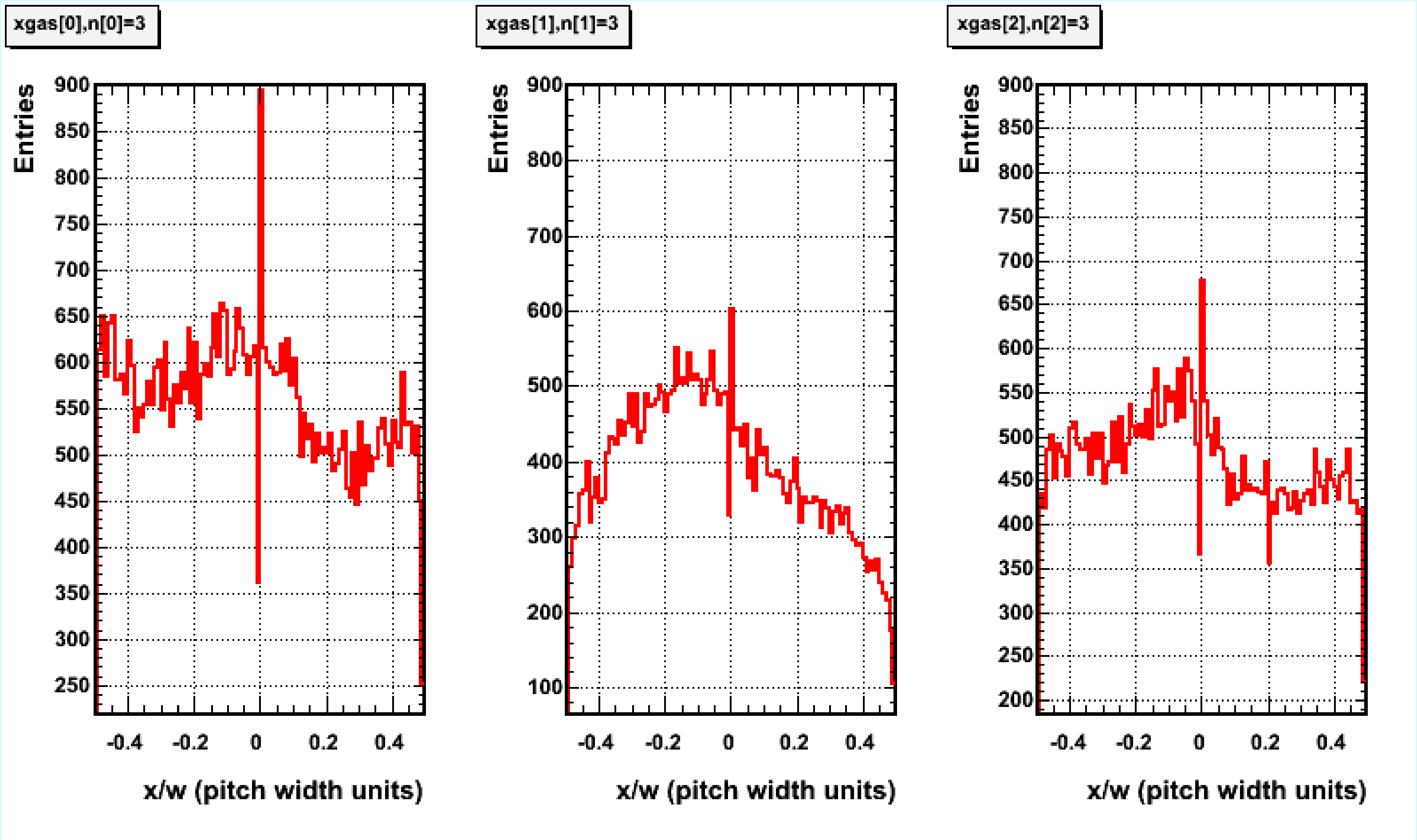
where:

(ToT)Q_L = the charge of the most significant strip

(ToT)Q_{L-1} = the charge of the left adjacent strip

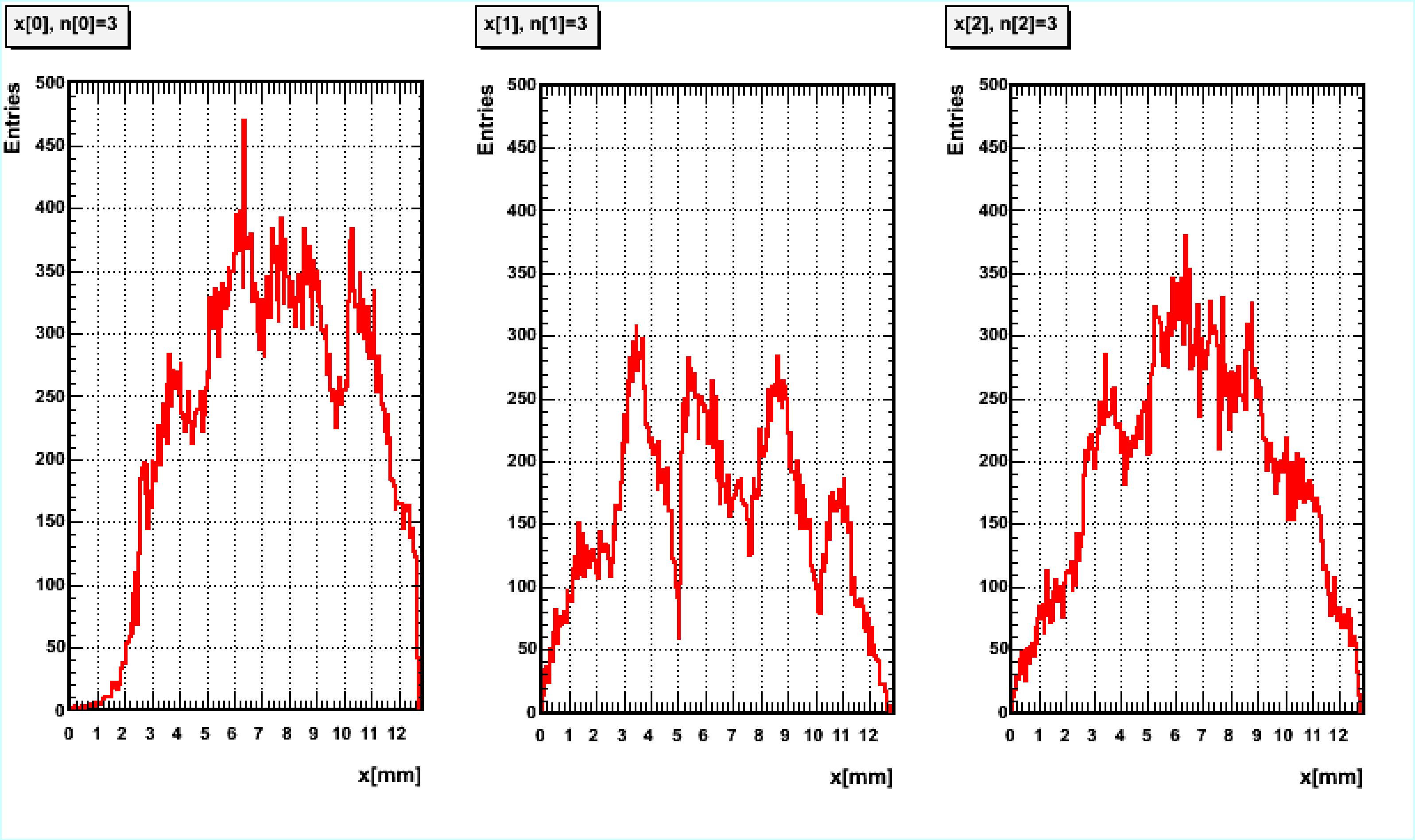
(ToT)Q_{L+1} = the charge of the right adjacent strip

Position reconstruction on a pitch width using three strips with signal



RPC4 – Chinese glass **RPC5 – strip HV** **RPC5 – resistive layer + strip HV**

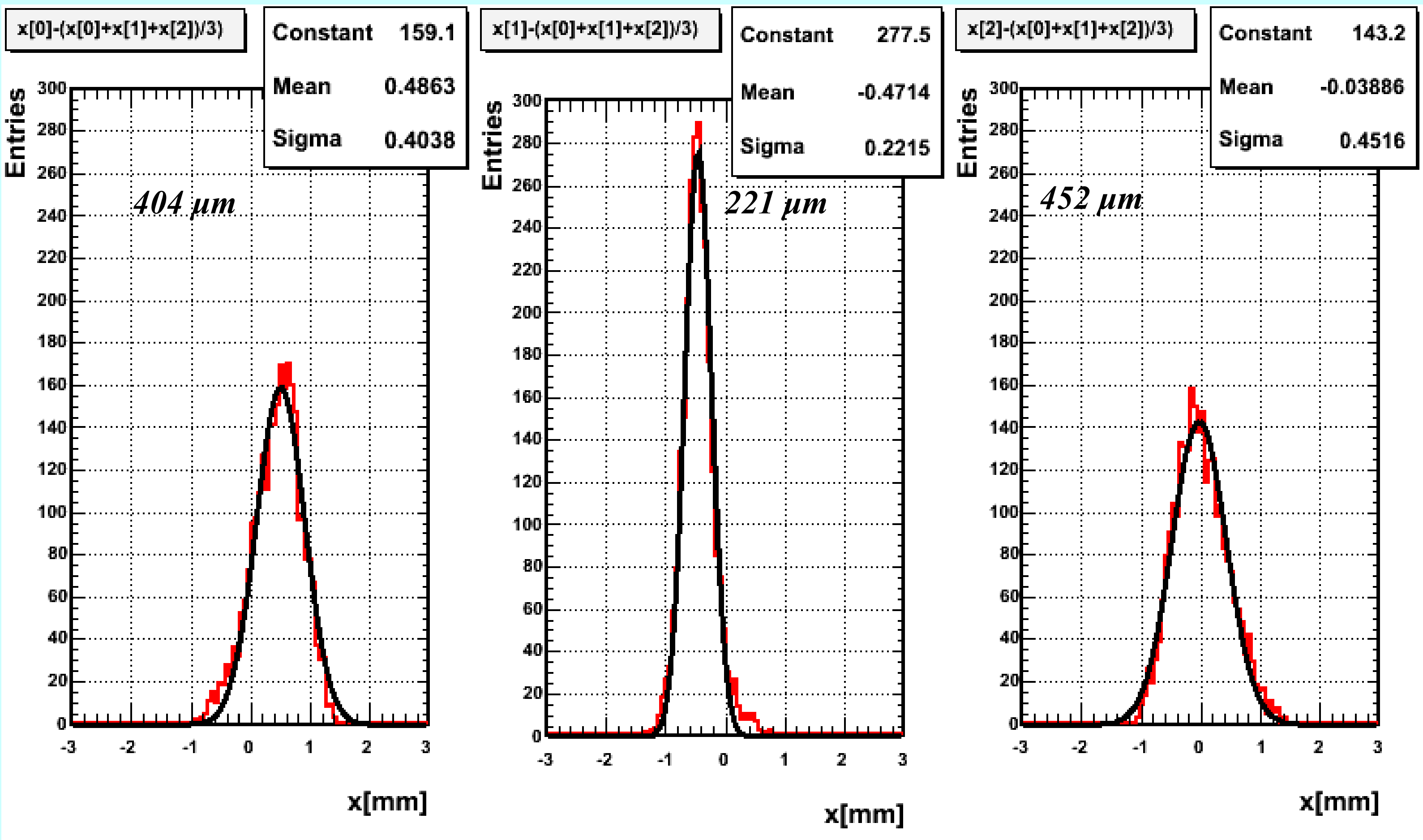
Position reconstruction across the strips using three strips with signal



<u>**RPC4 – Chinese glass**</u>   <u>**RPC5 – strip HV**</u>   <u>**RPC5 – resistive layer + strip HV**</u>

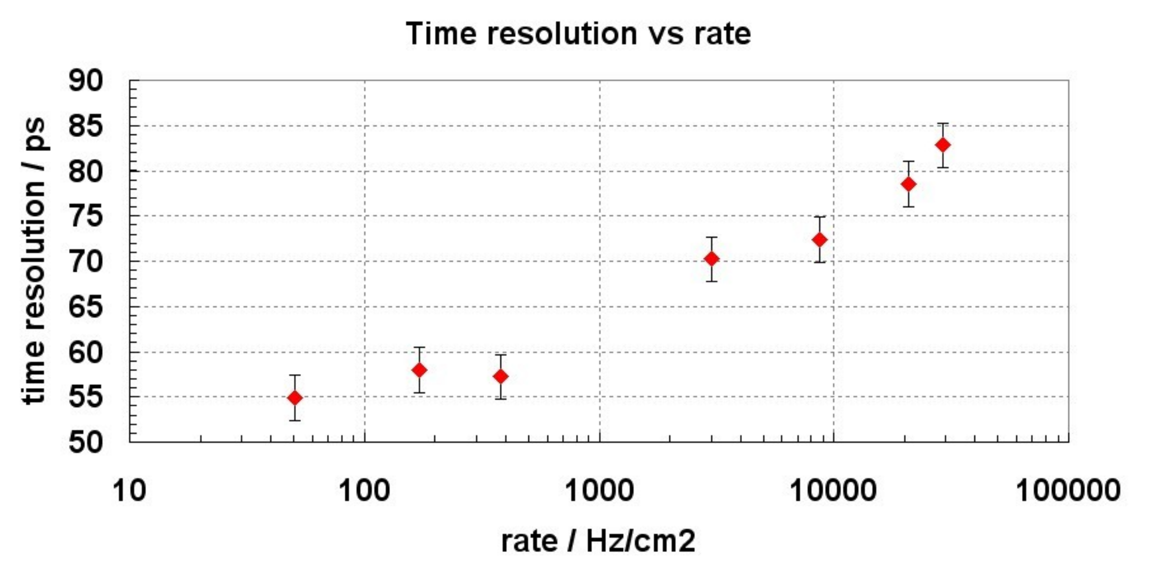
Position resolution across the strips using three strips with signal

The track is defined by all three RPCs; the main strip is the same in all counters

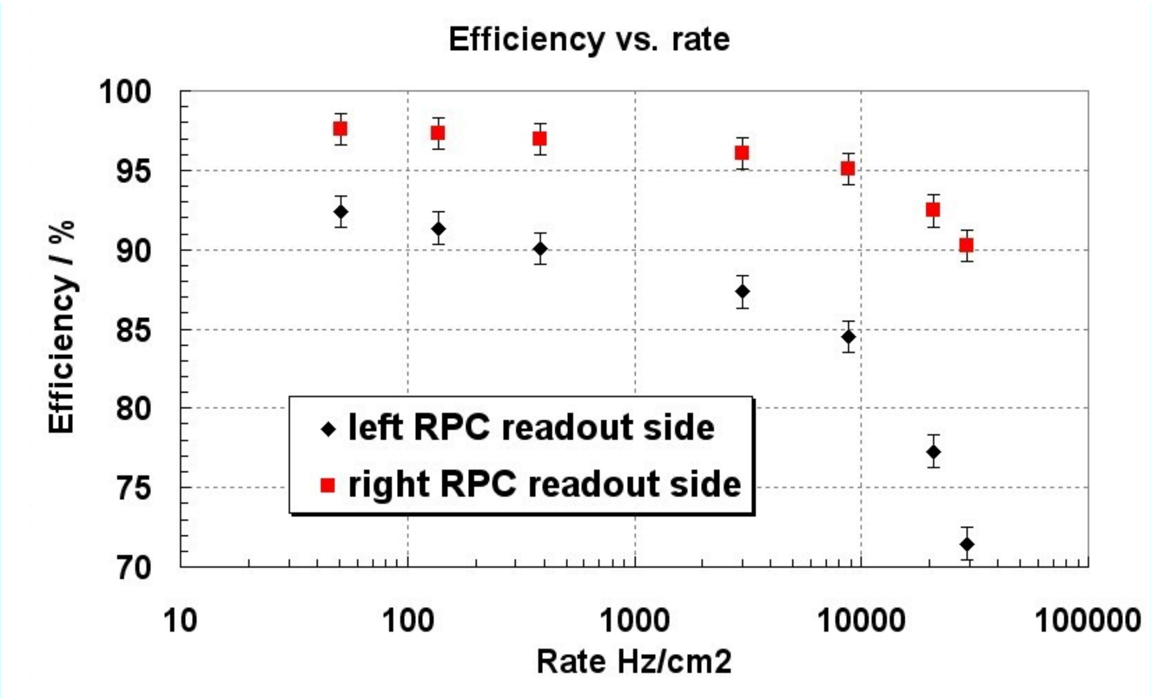


<u>**RPC4 – Chinese glass**</u> <u>**RPC5 – strip HV**</u> <u>**RPC5 – resistive layer + strip HV**</u>

Time resolution and Efficiency vs. Counting rate for low resistivity glass MRPC (RPC4) – in beam test @ COSY

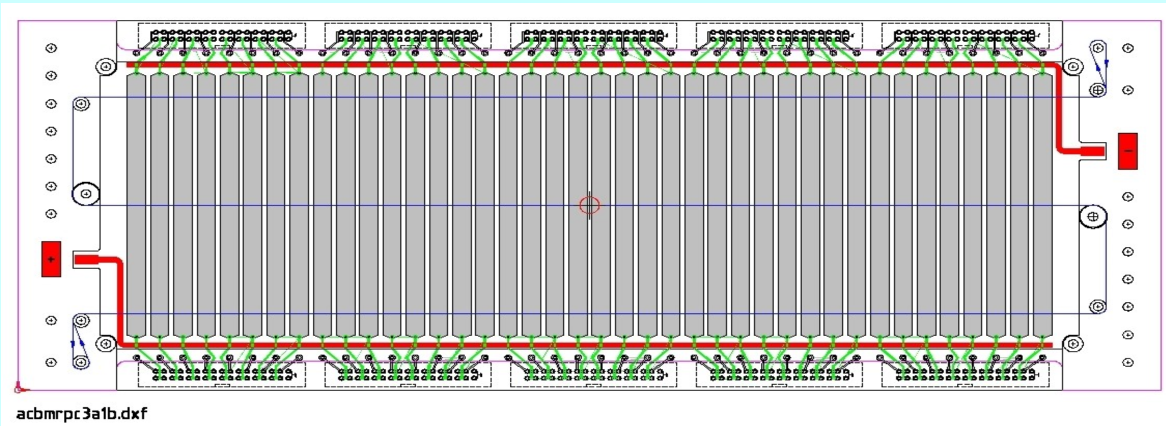


➢ **Time resolution is about 55 ps for low rates and goes up to 80 ps for 30 kHz/cm²**

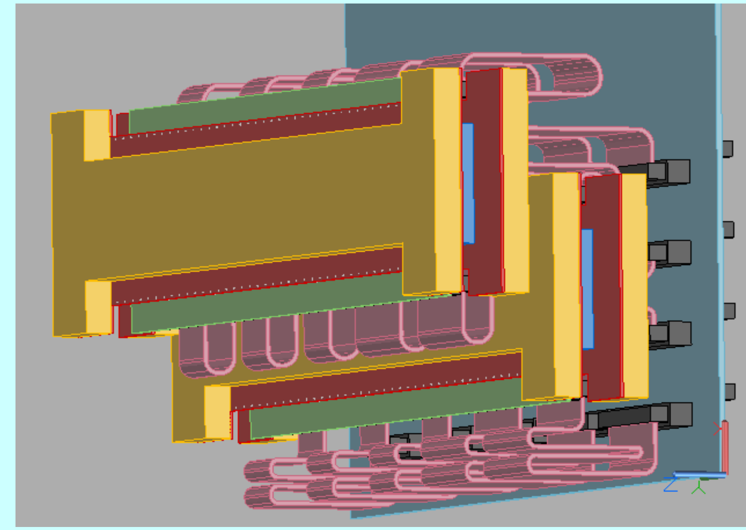


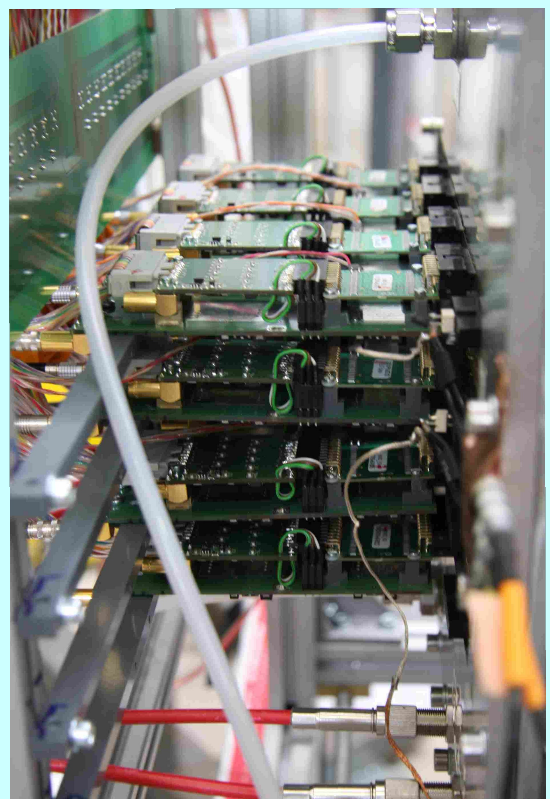
➢ **The efficiency is still higher than 90% at 30 kHz/cm²**

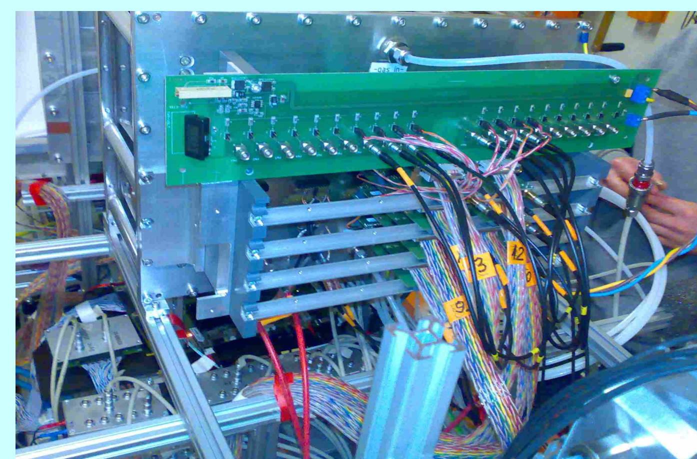
Towards RPC cell architecture for CBM TOF-RPC inner wall – construction details

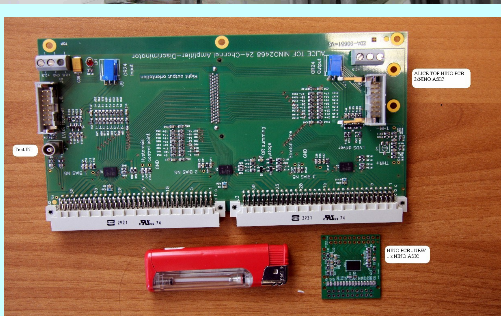


7.112 mm pitch = 5.588 mm strip width + 1.524 mm gap width



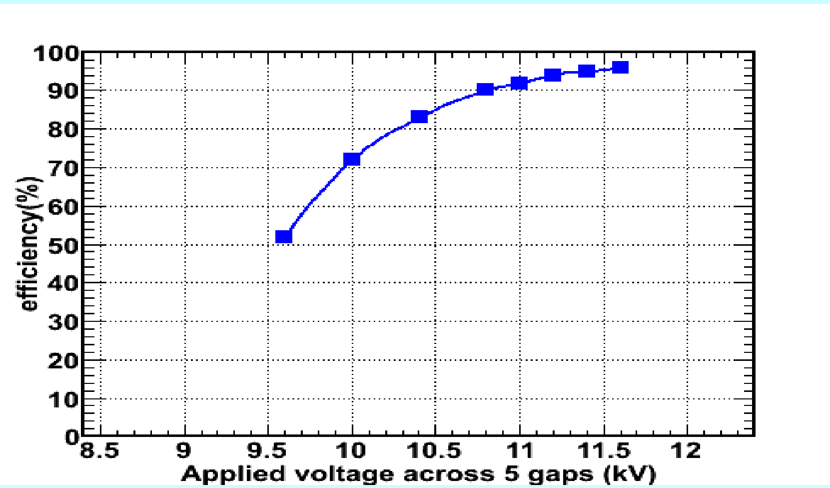


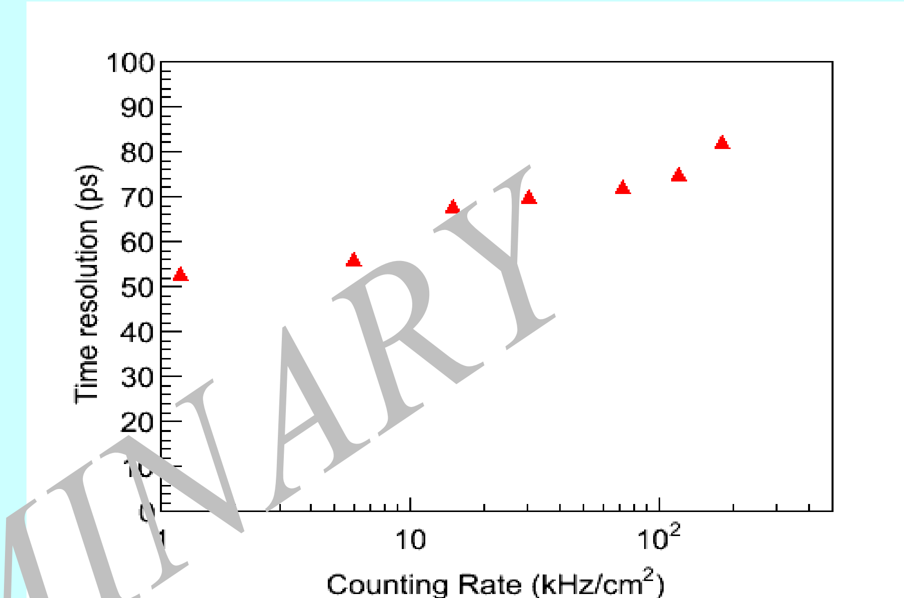


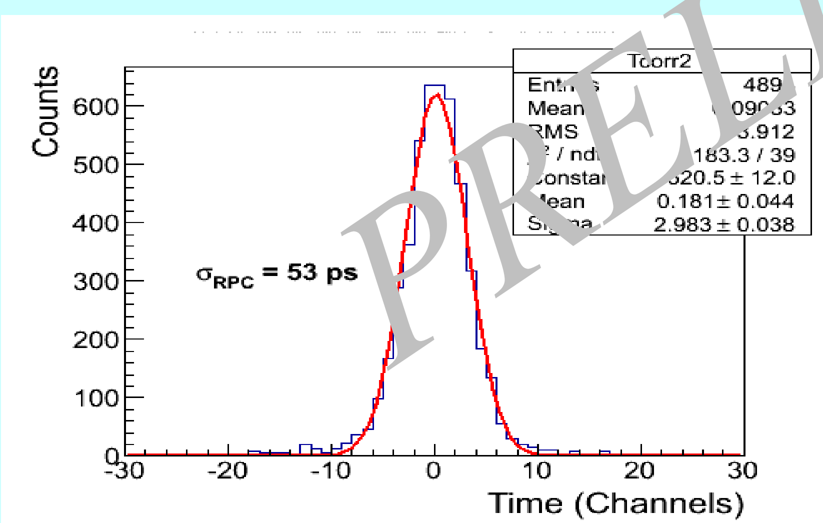


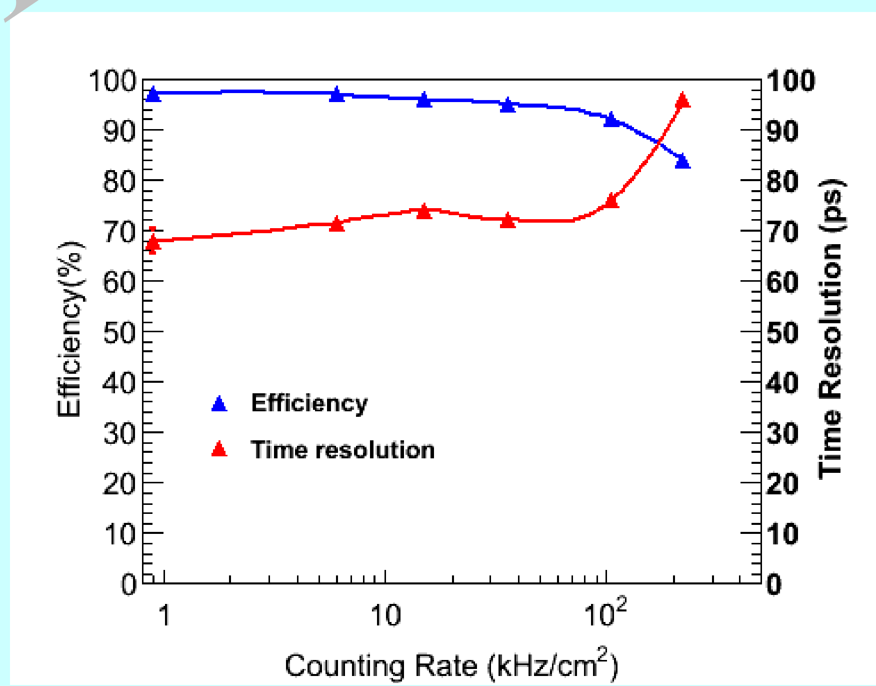
Towards RPC cell architecture for CBM TOF-RPC inner wall - performance

PRELIMINARY

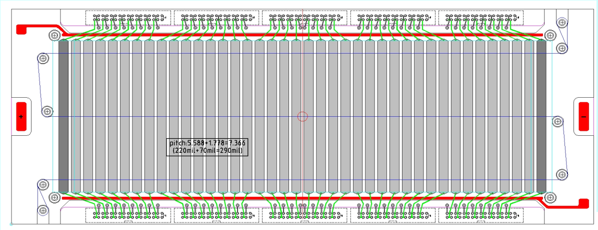


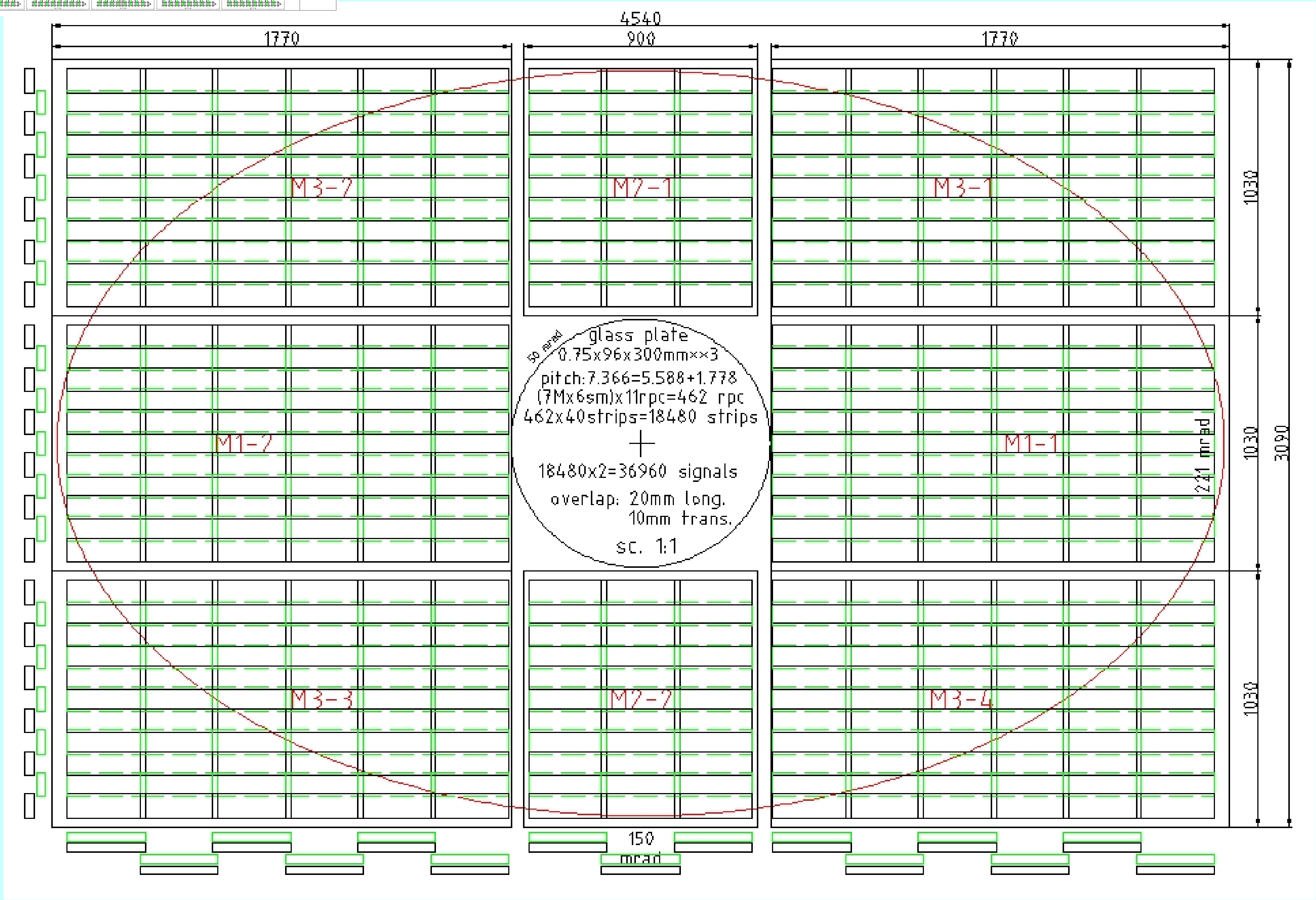






Inner wall layout
300 mm x 96 mm glass electrodes





Conclusions & Outlook

In-beam test results show:

- detection efficiency better than 97%

- cluster size of 3 – 3.1 strips @ 2.1 kV/gap

- time resolution better than $\lesssim$ 50 psec

- position resolution along the strip of ~ 4.5 mm

- position resolution across the strips $\lesssim$ 500 μm

- high counting rate performance:

@ 100.000 particles/sec.cm^2 :

- time resolution < 80 psec

- efficiency > 90%

⇒ Differential, strip read-out, multi gap, RPC based on low resistivity glass is the way to go