

# MRPC prototype chambers for TOF

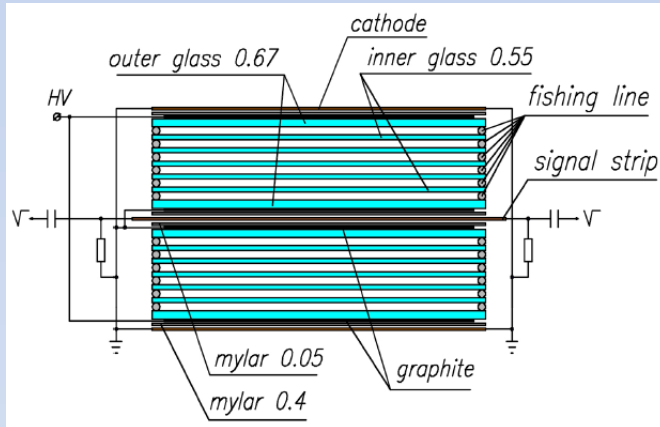
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<sup>1</sup> – Joint Institute for Nuclear Research, Dubna

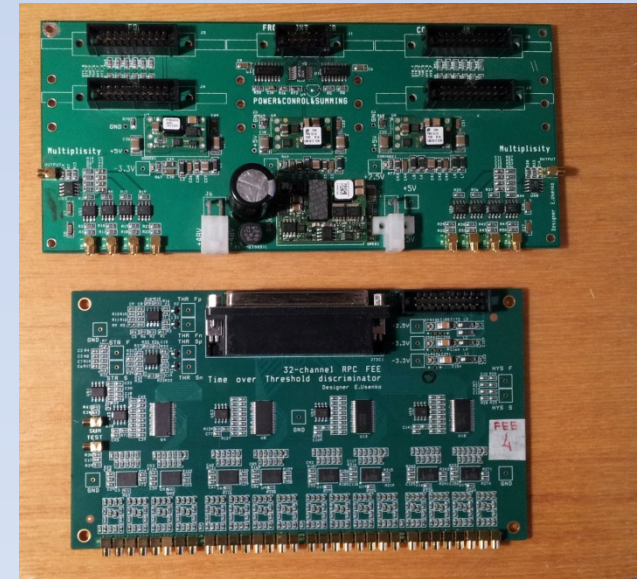
<sup>2</sup>- Institute for High Energy Physics, National Research  
Center Kurchatov Institute

# Our BM@N experience

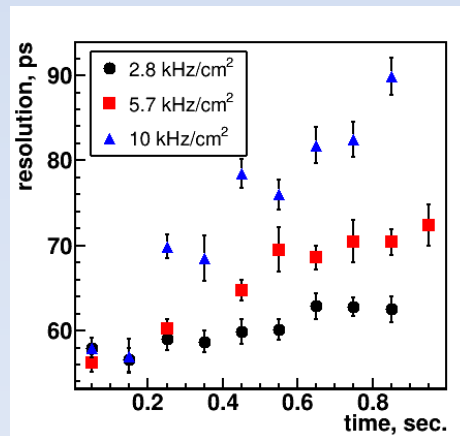
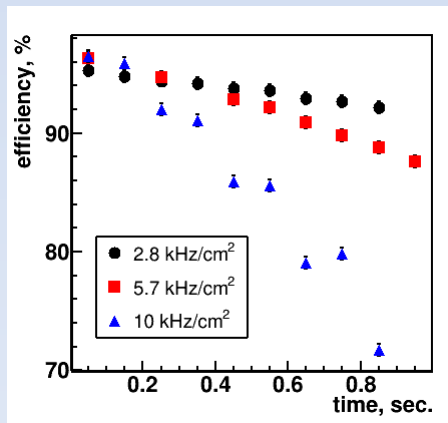
## Floating electrode MRPC structure



## Front end electronic based on NINO chips



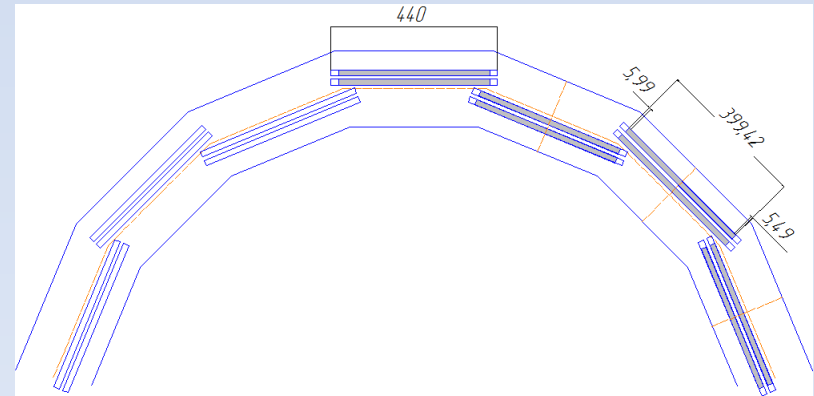
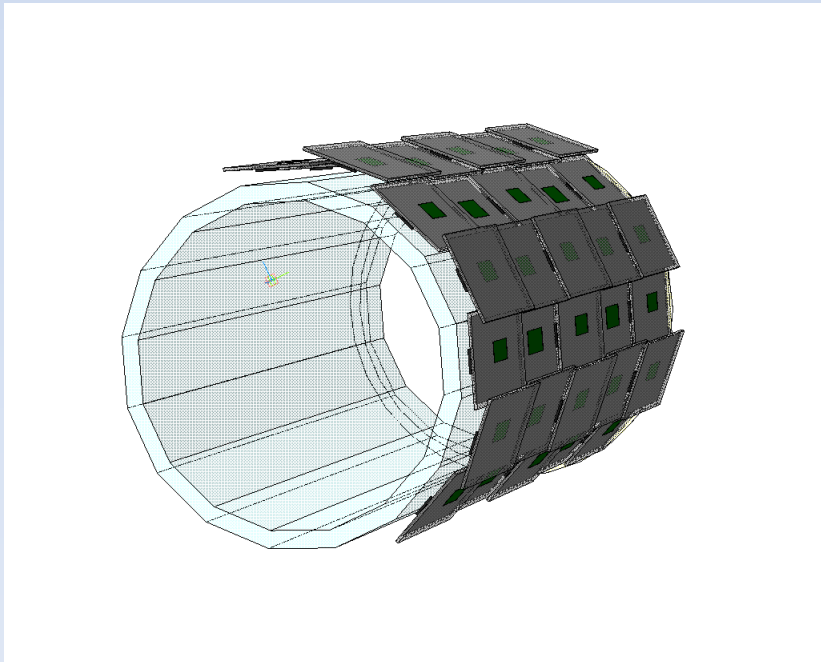
## Experimental results on muon beam at U70 accelerator



- The TOT method was used.
- The best resolution of ~56 ps is reached

# Our vision of the TOF system

- SPD TOF system could be designed with MRPC modules.
- We suggest using of 0.25 mm gas gap MRPC.
- Each MRPC consist of 10 gaps made of 0.33 mm glass.
- 16 read-out strips of 20 x 410 mm<sup>2</sup> size. Strip pitch is 21 mm.
- MRPCs active area is ~337 x 400 mm<sup>2</sup>.
- The ToF distance of ~1m lead to the requirement of  $\approx 30$ ps time resolution.

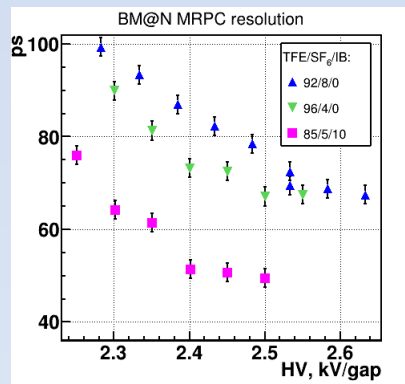
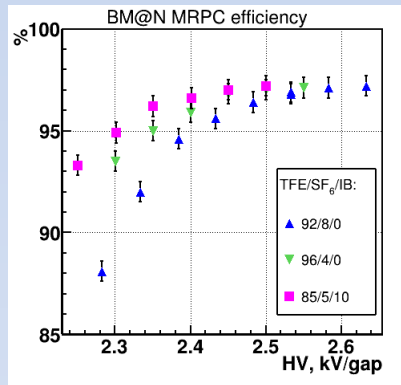


## Goals in 2019 – 2020 were

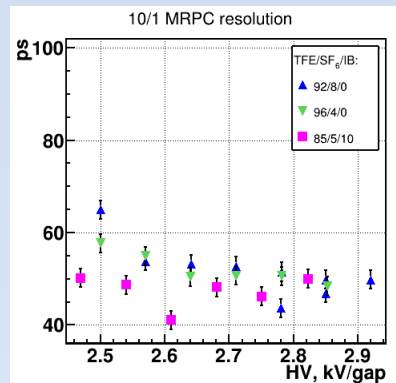
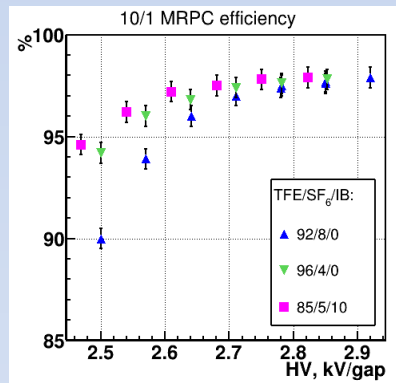
- to test MRPCs with different structure of HV electrodes
- to compare ‘Time Over Threshold’ and ‘Constant Fraction’ methods

# Results are showed at 07.06.2019 SPD Workshop

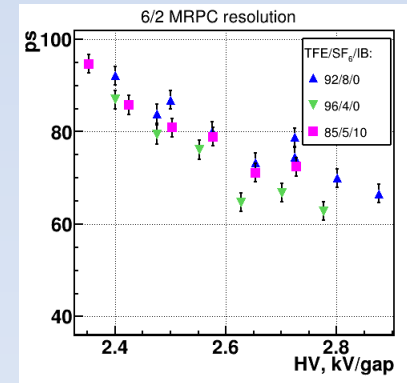
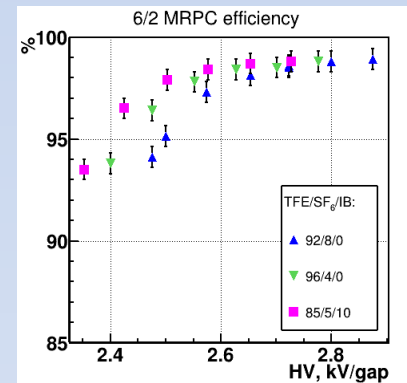
## BM@N chamber



## 10 independent gaps



## 6 double gaps



The best chamber

# 2019 test beam results:

3 MRPCs with independent gaps:

rpc1 is 10x0.25 mm chamber

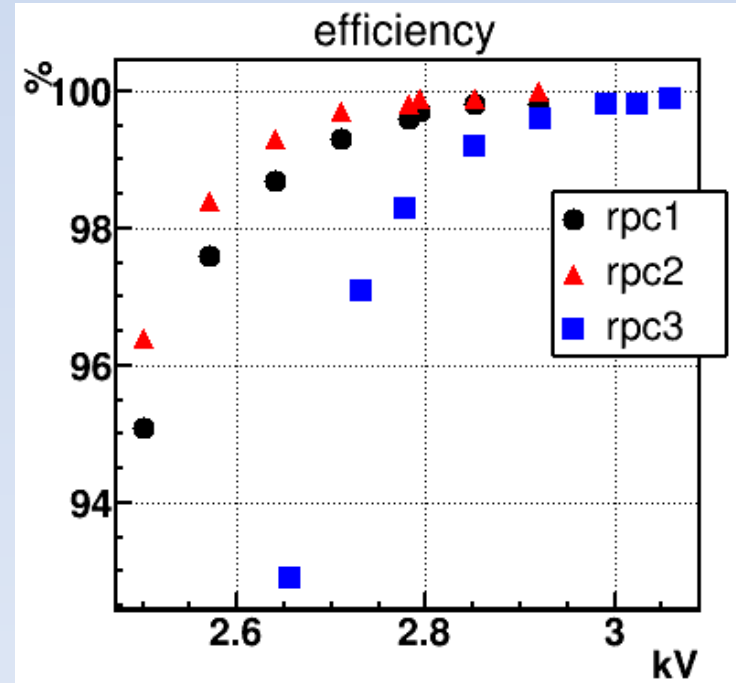
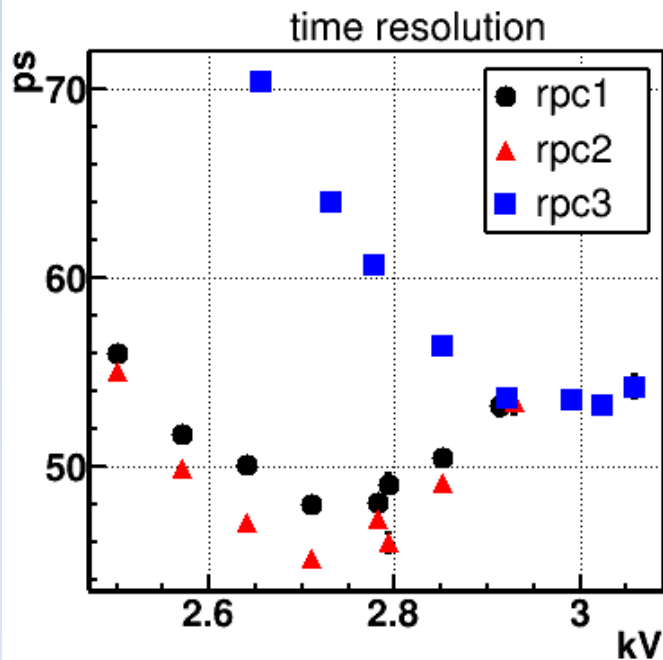
rpc2 is 12x0.25 mm chamber

rpc3 is 10x0.30 mm chamber

Strip size is 10x150 mm for all MRPCs.

Gas composition is TFE/*i*-C<sub>4</sub>H<sub>10</sub>/SF<sub>6</sub> = 85/10/5

These results were obtained with the Time Over Threshold (TOT) method



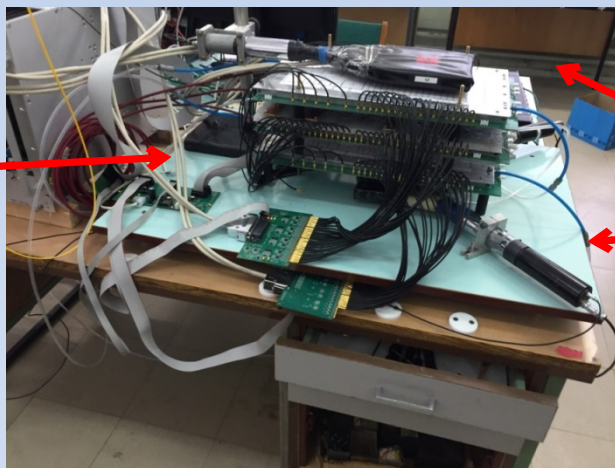
# Subsequent measurements with an oscilloscope:

- measurement of analog signals directly from a strip
- measurement of signals after fast GSI-amplifier
- measurement of signals after fast CF (Constant Fraction)
- measurement of signals after fast CF & GSI-amplifier

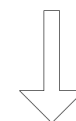
This work was performed both at the cosmic set-up and U70 beam.

# Cosmic test setup

3 MRPC's



3 Counters



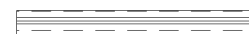
Cosmic muons



counter 1



RPC 1



RPC 2



RPC 3



Pb block



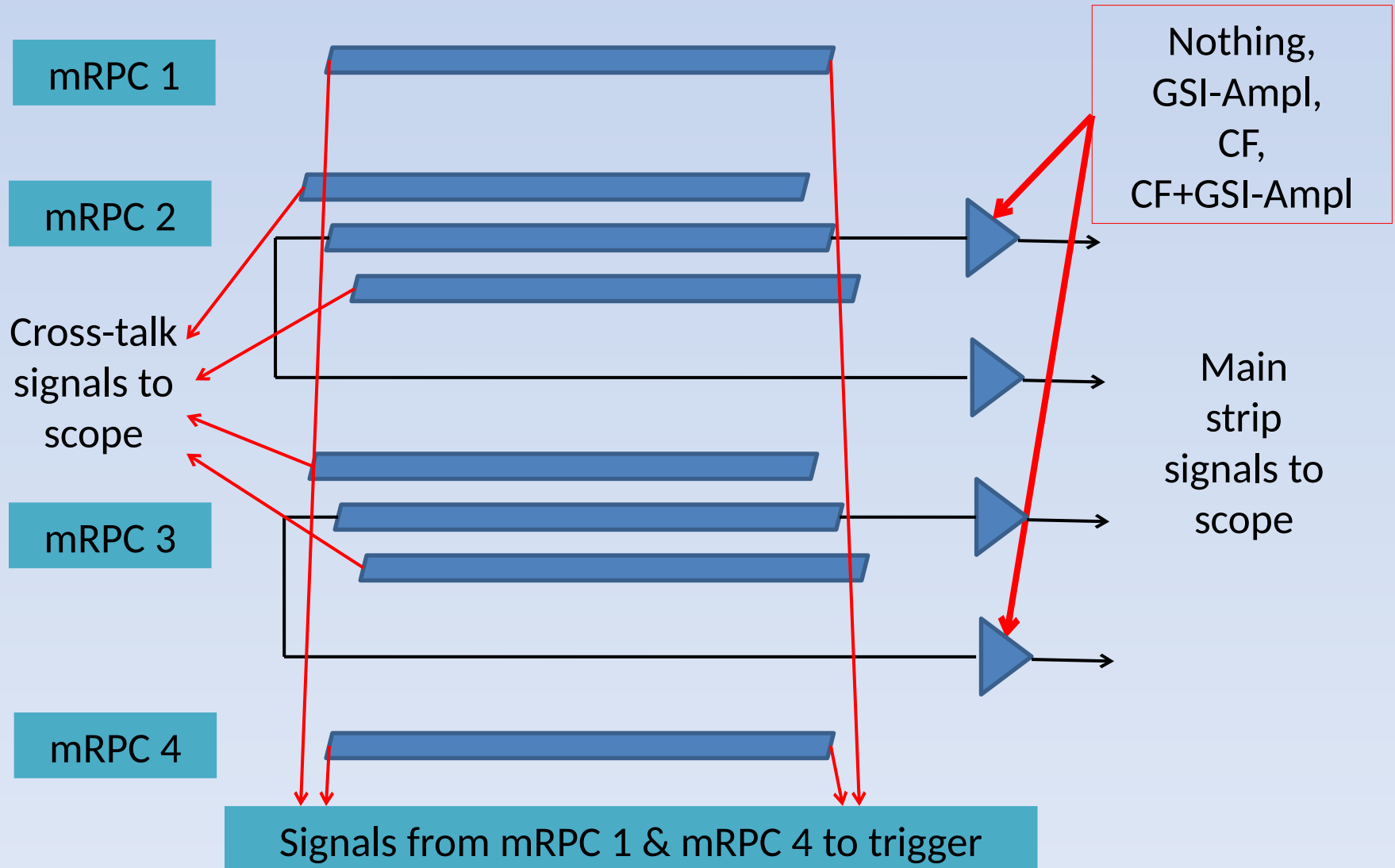
counter 2



counter 3



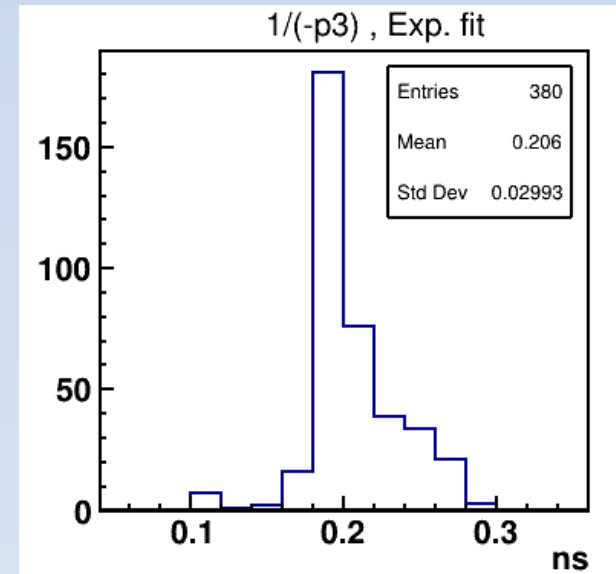
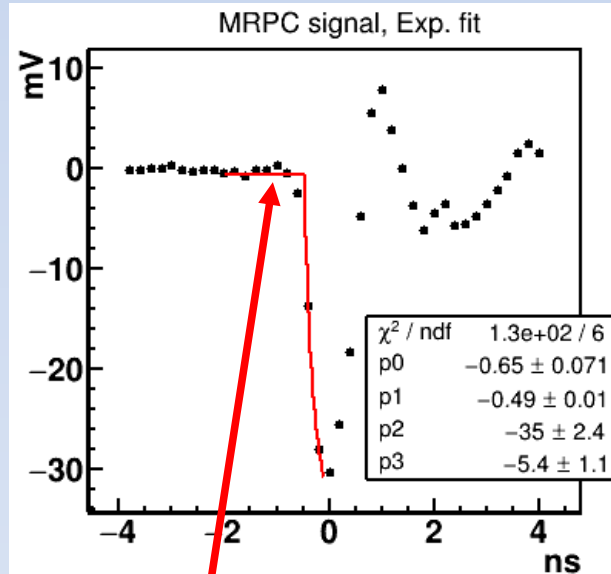
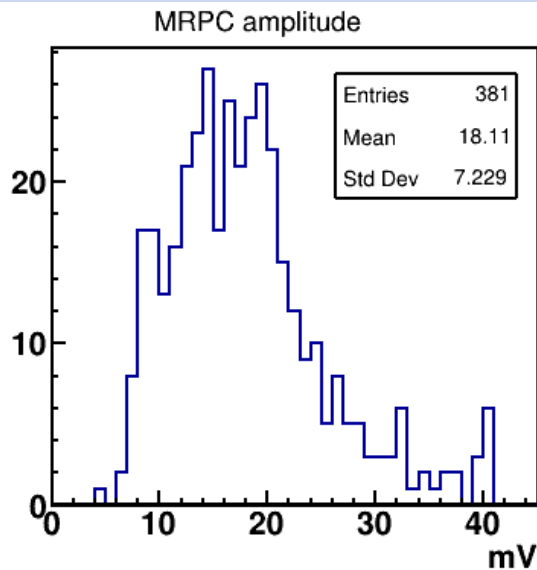
# Schematic of measurements



# Cosmic data example for 10 gaps MRPC at 2.73 kV

Signals are measured directly by oscilloscope

Signal front is fitted by  $F(t) \approx p_2 \cdot (1 - \exp\{p_3 \cdot (t - p_1)\})$

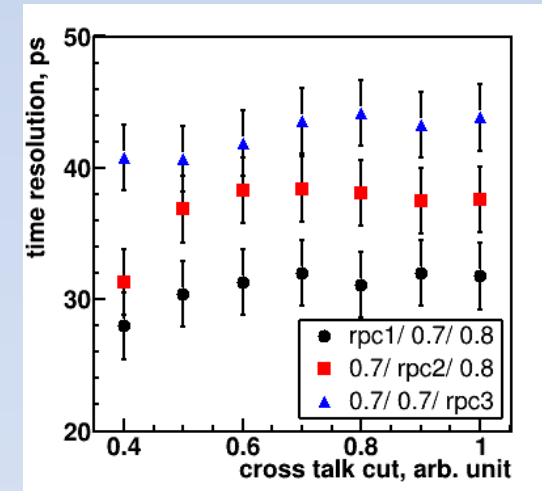
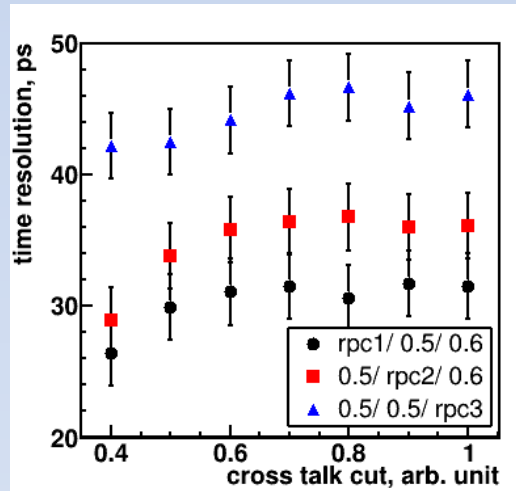
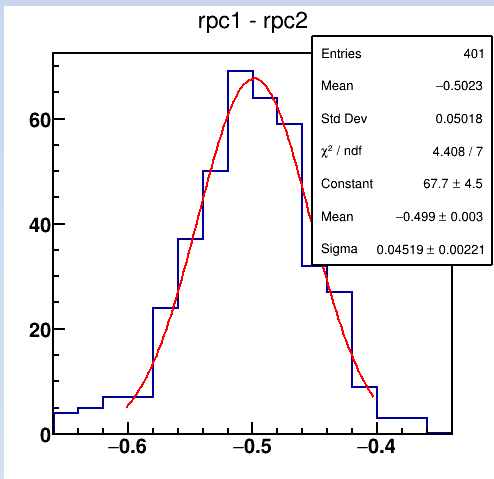


At this time particle crosses the chamber.

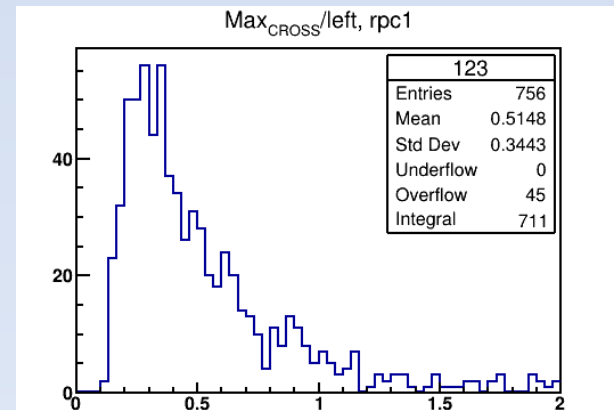
The real signal front is faster than we can see with our electronics!

# Oscilloscope measurements with cosmic setup.

Time resolution extraction by using amplified ( $\sim x10$ ) analog signal (linear fit to the time of discharge origin gives timing for 3 MRPCs)



- **rpc1** — 10x0.25 mm — hv = 2.7 kV
- **rpc2** — 12x0.25 mm — hv = 2.7 kV
- **rpc3** — 10x0.30 mm — hv = 2.9 kV



Distribution of the ratio of amplitudes of the adjacent and main strips - «cross talk»

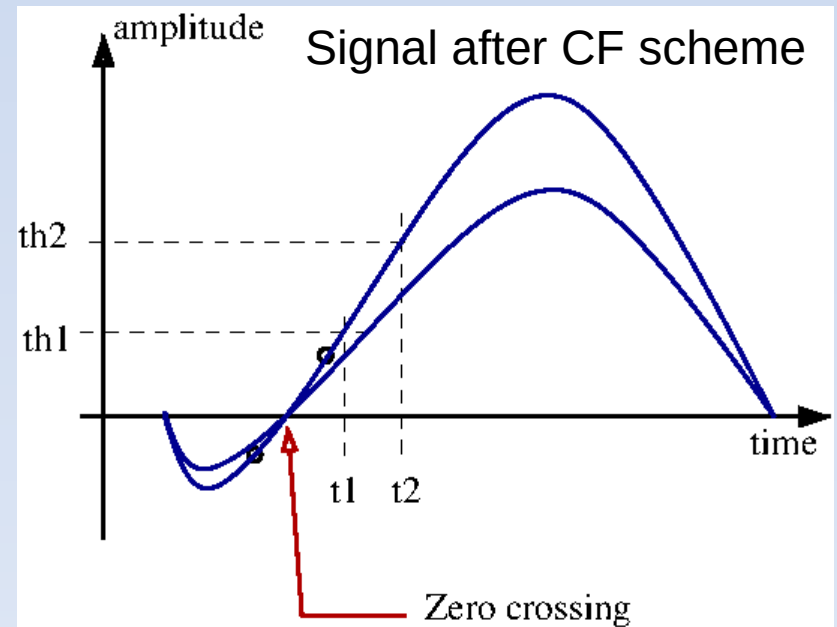
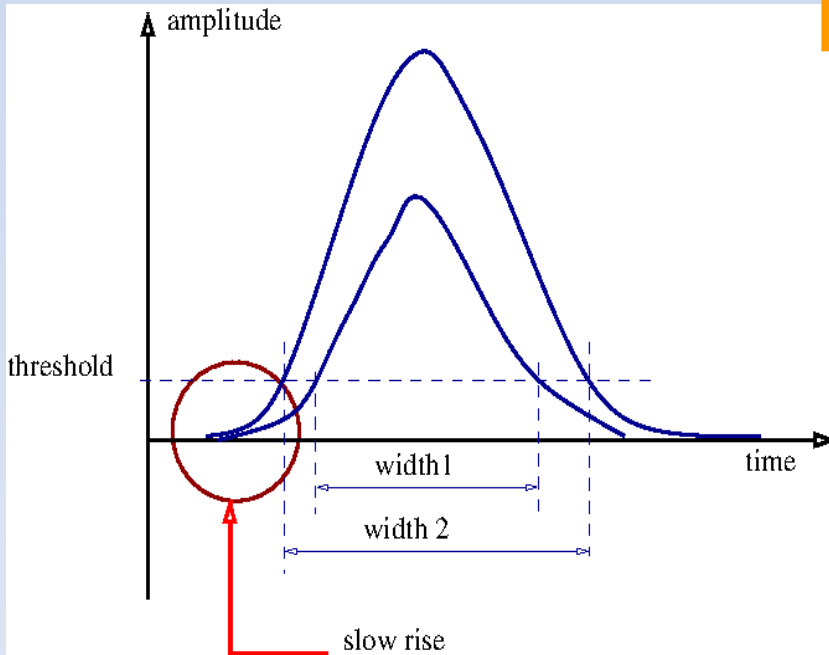
# Overview of two methods of signal time measurement

The TOT method use a averaged over many events the 'time - width' function

The Constant Fraction method allow individual signal correction.

3 possible methods:

- direct zero crossing detection (classical)
- one point above and one under zero line
- 2 points after zero crossing

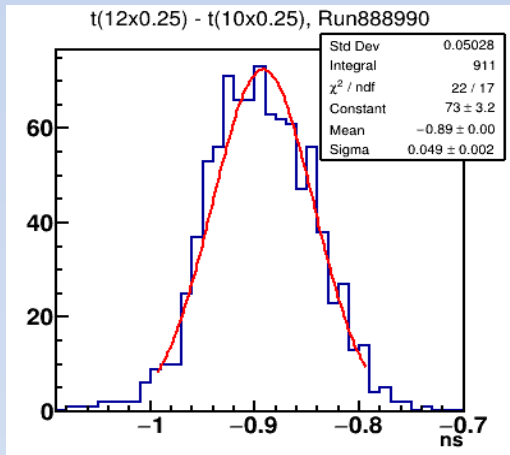
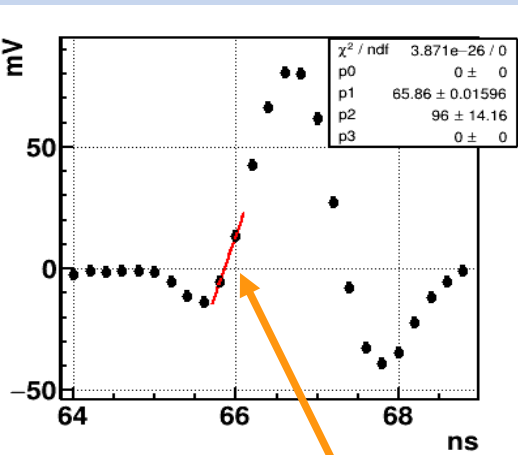


$$k = \frac{th2}{th1} \quad t_{zero} = \frac{k \cdot t1 - t2}{k - 1}$$

# Cosmic results with CF

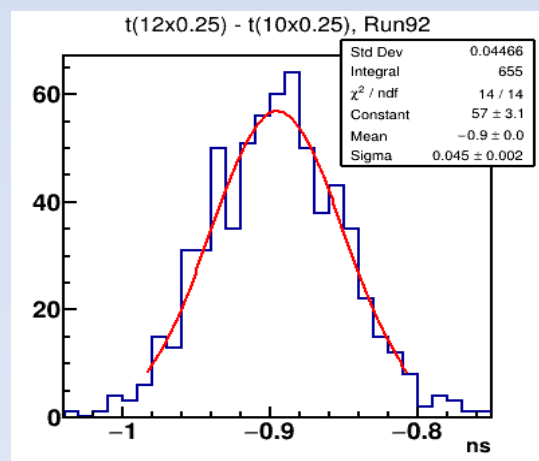
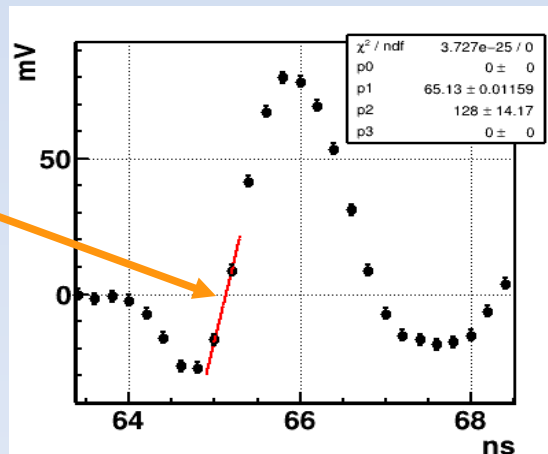
Measurement of MRPCs time difference by using 2 points linear approximation

200 ps CF delay



250 ps CF delay

Time reference  
(zero crossing)

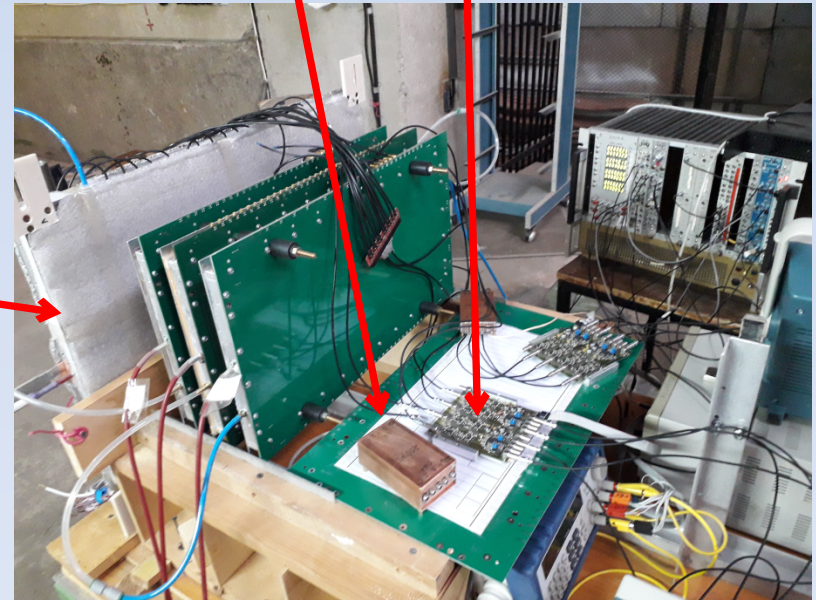


# U70 test beam setup (Dec 2020)



## Readout:

Oscilloscope DPO 1GHz  
CF (250ps) & GSI-amplifier (~1GHz)



## 4 MRPC's:

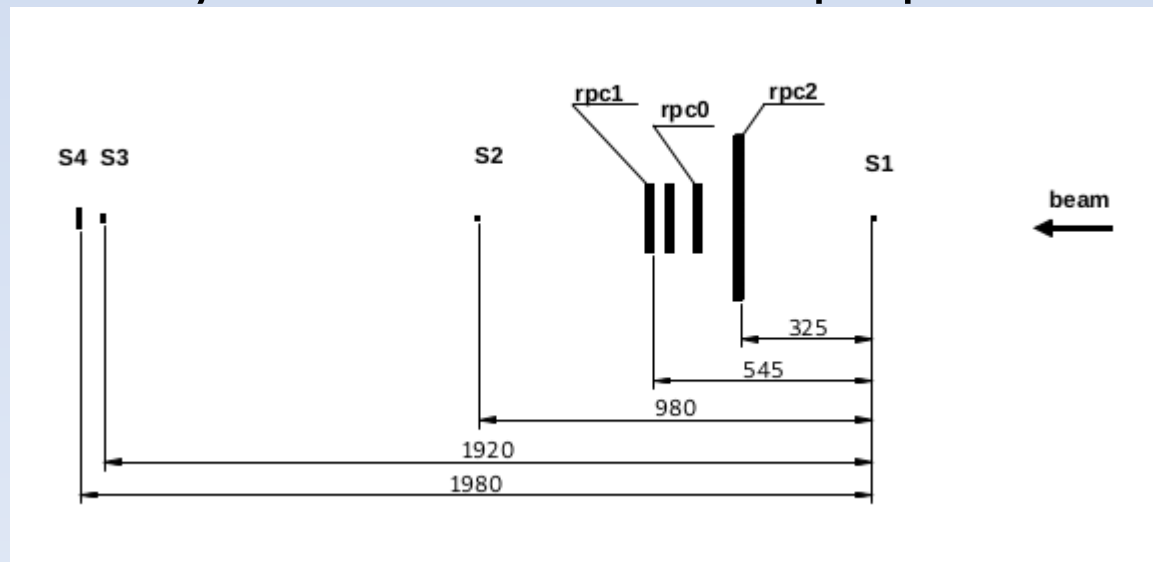
- 12gaps x 0.25mm, 10 x 160 mm<sup>2</sup> strips
  - 10gaps x 0.25mm, 10 x 160 mm<sup>2</sup> strips
  - 10gaps x 0.30mm, 10 x 160 mm<sup>2</sup> strips  
(has not been used)
  - 10gaps x 0.25mm, 25 x 310 mm<sup>2</sup> strips
- HV = 2.75 kV for all chambers

# U70 test beam setup description

Trigger system consist of two counters  $10 \times 10 \text{ mm}^2$  (S1&S2) and two counters  $20 \times 20 \text{ mm}^2$  (S3&S4)

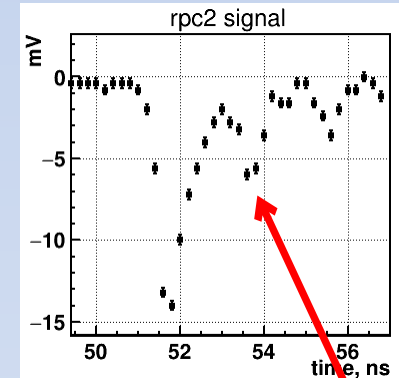
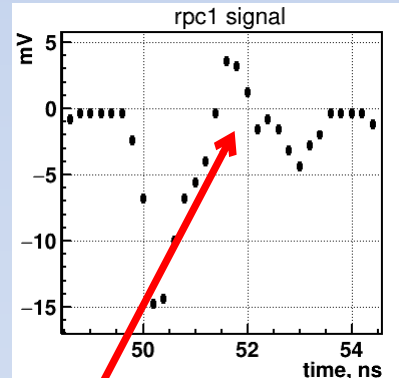
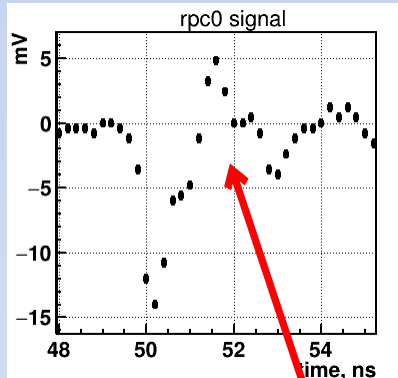
- **rpc0** – 2 stacks x 6gaps x 0.25mm, strips  $10 \times 150 \text{ mm}^2$
- **rpc1** – 2 stacks x 5gaps x 0.25mm, strips  $10 \times 150 \text{ mm}^2$
- **rpc2** – 2 stacks x 5gaps x 0.25mm, strips  $25 \times 310 \text{ mm}^2$

The **rpc2** geometry most close to the SPD proposed chamber.



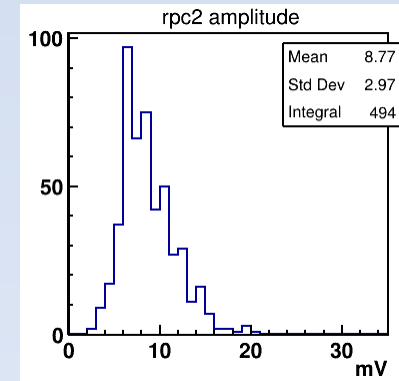
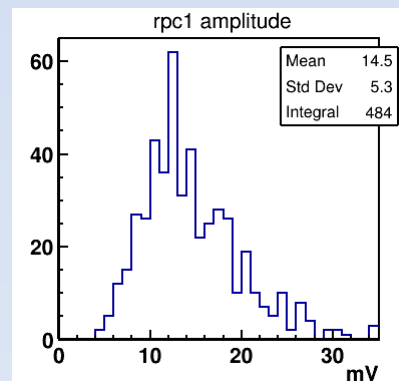
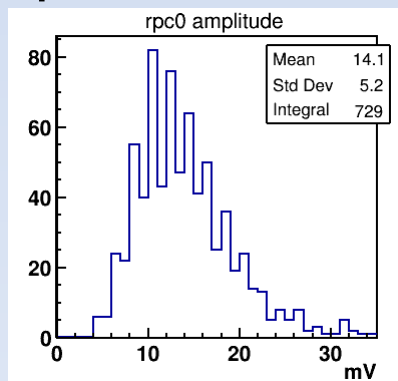
# U70 beam results (1):

- Examples of signals



Impedance of 10 mm strips higher than 50 Ohm, whereas for 25 mm - less

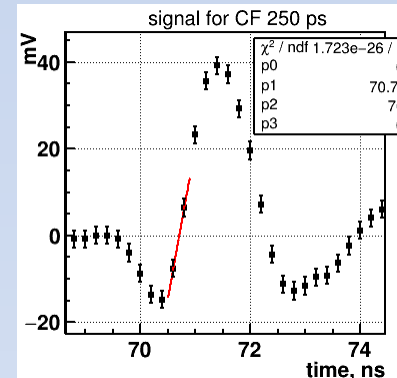
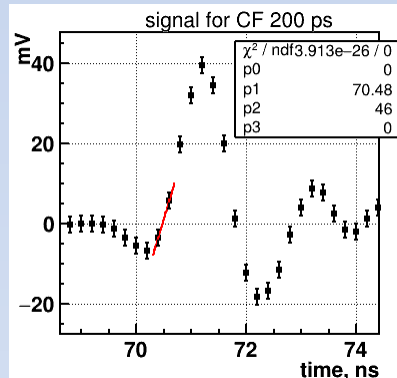
- Amplitude distributions



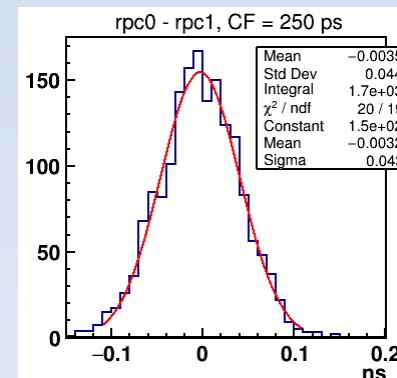
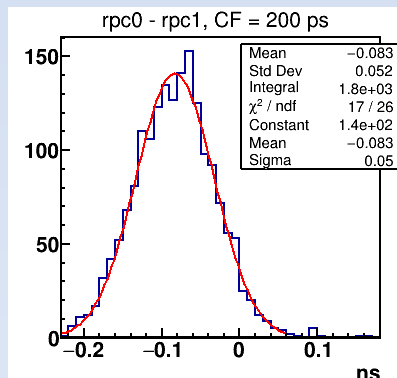


# U70 beam results (2):

- Examples of signals after CF (200ps and 250ps) and GSI-amplifier (gain ~4)

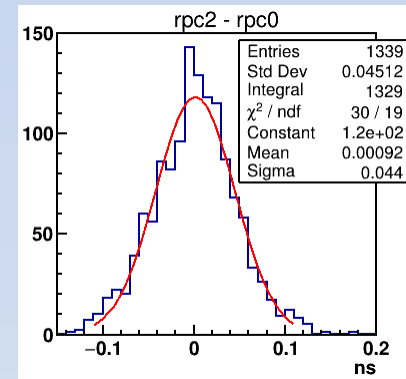
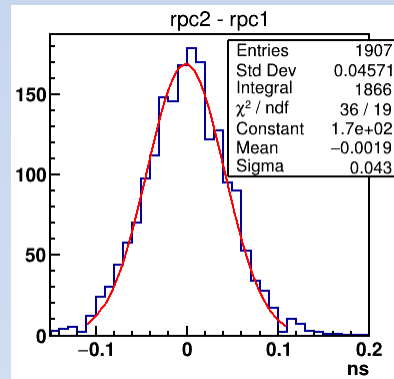
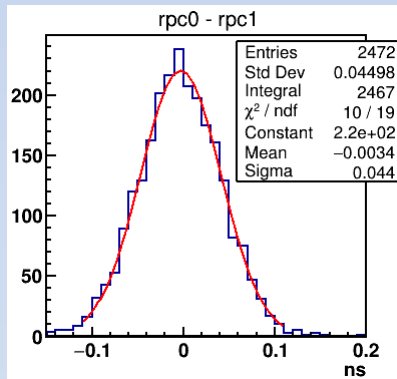


- RPCs time difference for CF with 200 and 250 ps delay

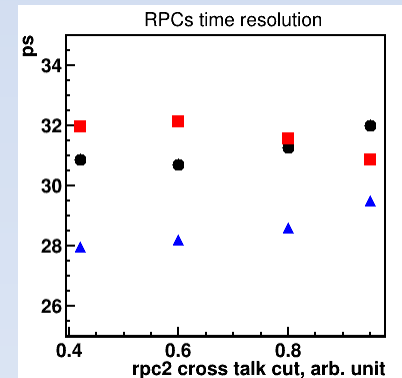
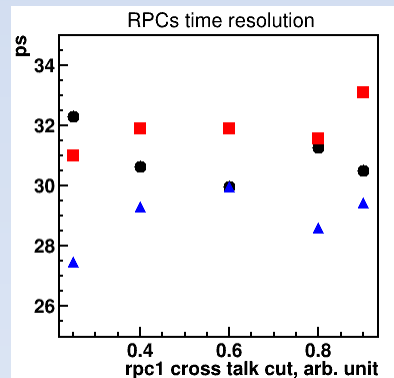
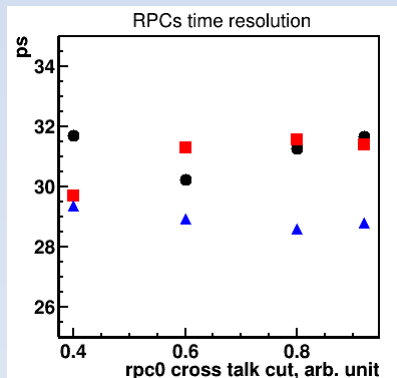


# U70 beam results (3):

- Time differences of 3 MRPC pairs for CF with 250ps delay



- Extracted MRPCs time resolution as function of a cross talk cut



rpc0 -black circles, rpc1 -red squares, rpc2 -blue triangles

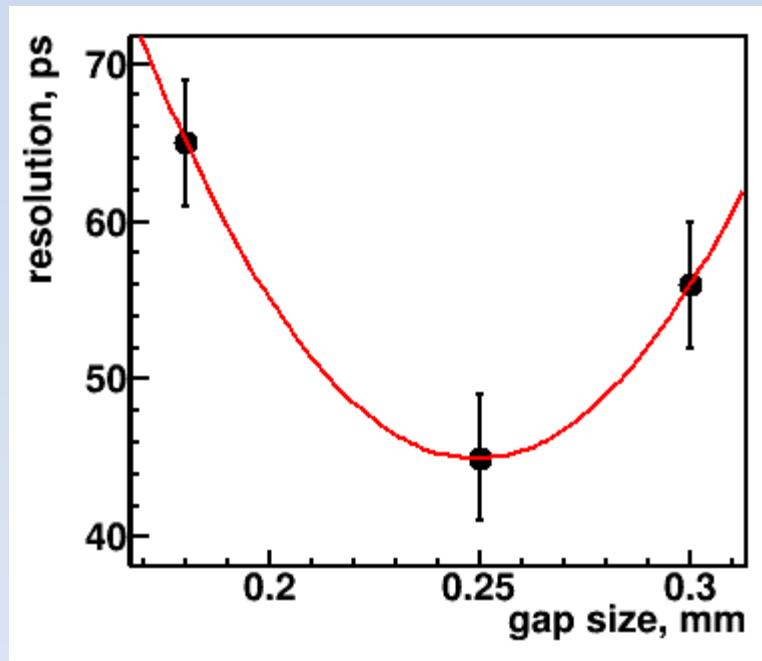
# Conclusions and Plans

- 10 independent gas gaps of 0.25 mm width is the best MRPC structure we found.
- Time resolution of our chambers with CF is measured at level of 30ps. However it include the time resolution of oscilloscope. Our large chamber is about to SPD purpose. We need to test thinner (0.33 mm) glass only.
- Three new MRPCs will build in few months
- We are ready to develop new FE board (CF) with commercial fast amplifiers and comparators
- At the beginning MRPCs + FEE have to be tested in the cosmic set-up.
- The subsequent evaluation of CF method should consider the possibility of development of a integrated chip. To do this we need to invite the appropriate developers.

**Thank for you attention!**

# Backup slide

2019 cosmic test

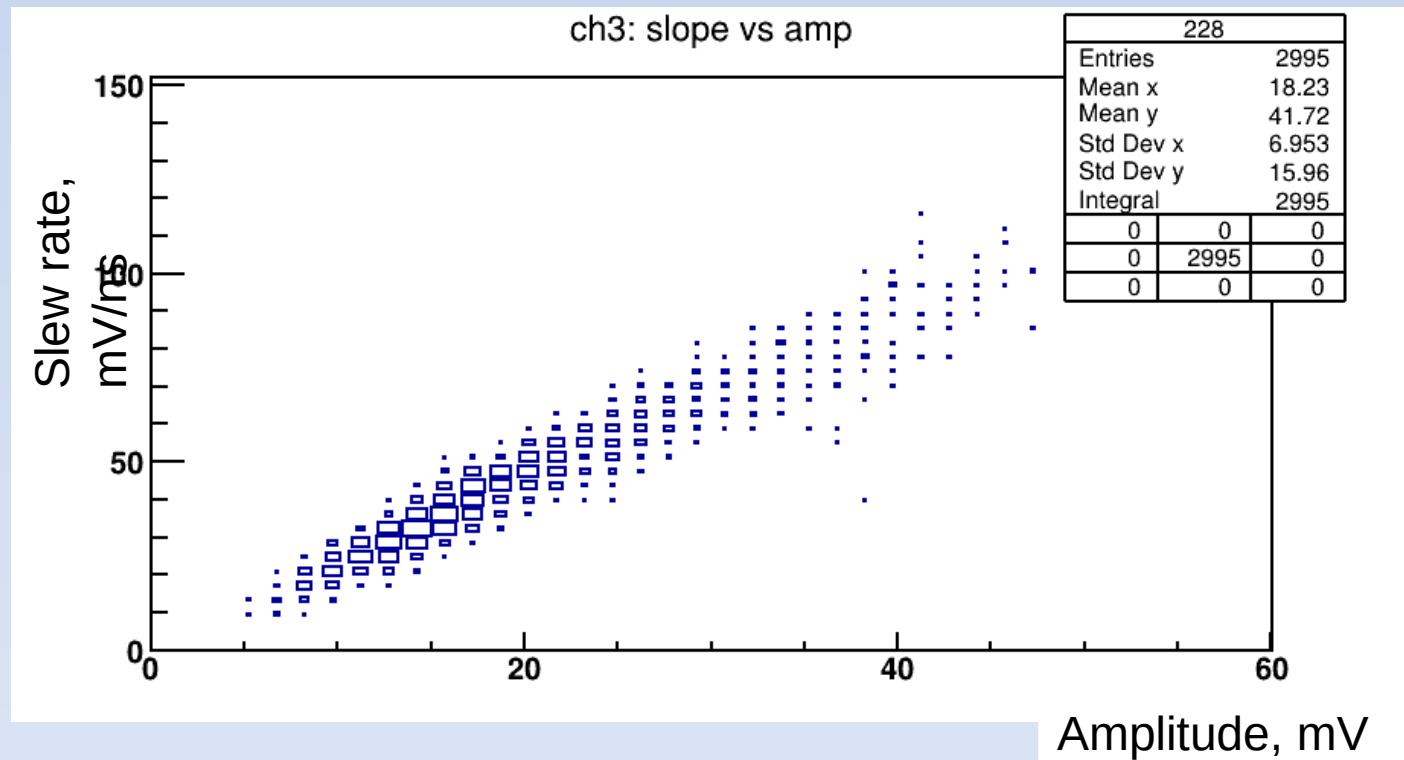


# Backup: Cosmic setup description

- Trigger system – 2 counters  $160 \times 160 \text{ mm}^2$  & 1 counter  $80 \times 80 \text{ mm}^2$  and two strips of neighboring chambers
- Trigger rate  $\sim 1 \text{ event}/300 \text{ sec}$
- Oscilloscope DPO 4104B (1GHz, 5Gs/sec) used to measure the signals from main strips
- Oscilloscope TDS 3054C (0.5GHz, 5Gs/sec) to measure the cross-talk signals in nearest strips
- We have tested few MRPC's with different structures: **2stacks x 6gaps x 0.25mm** , 1stack x 10gaps x 0.25mm, **2stacks x 5gaps x 0.25mm**, **2stacks x 5gaps x 0.30mm**, 2stacks x 6gaps x 0.18mm, 4staks x 3gaps x 0.25mm
- “**Red**” chambers have better signals than other and we consider them
- All strip sizes –  $160 \times 10 \text{ mm}^2$
- Data taking under LabVIEW program

# Backup: Can we use Constant Fraction Discriminator?

Signal slew rate (linear fit) via amplitudes for 10x0.25mm rpc



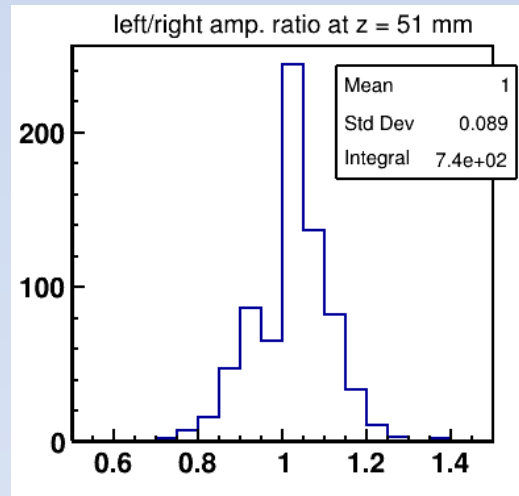
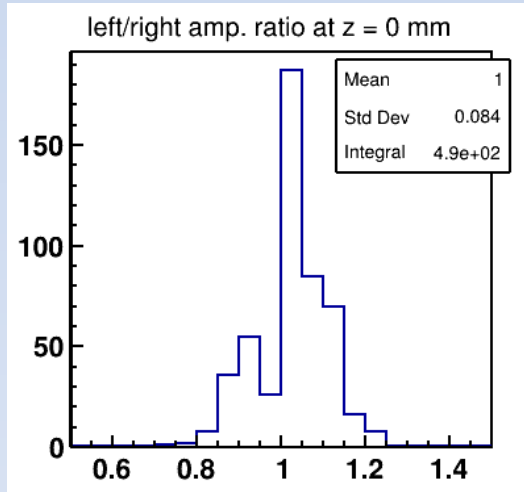
Yes it is possible!

# Backup: Test beam results (4):

Left to right signal amplitude ratio as function of position along the strip

10gaps x 0.25mm, 25 x 310 mm<sup>2</sup> strips

Middle of the strip



Close to the side of the strip

