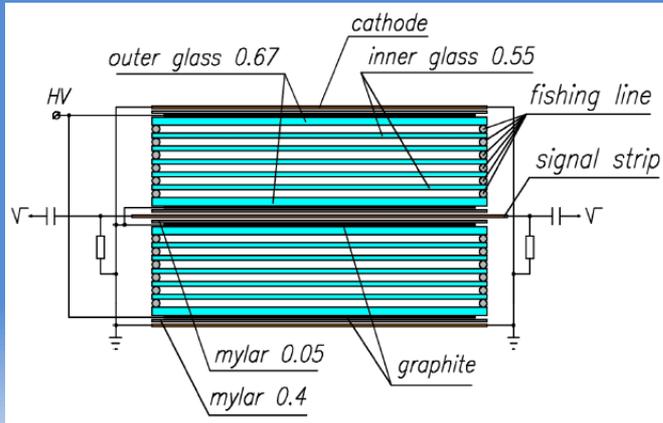# An experience of MRPCs research for a TOF systems

E.Ladygin, S.Nagorniy (JINR)

A.Semak, A.Golovin (IHEP)

Past BM@N experience
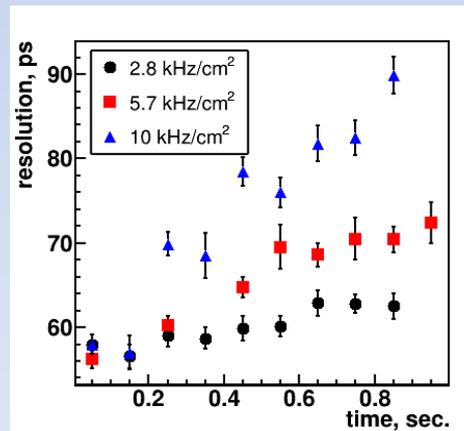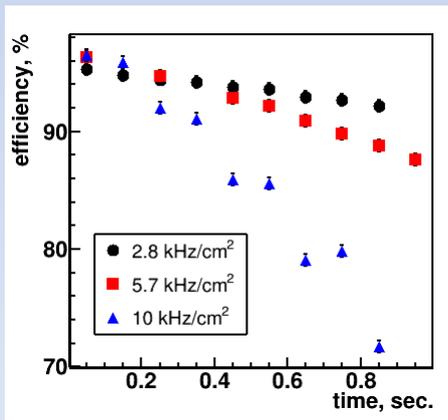
Floating electrode MRPC structure

Experimental results on muon beam at U70 accelerator
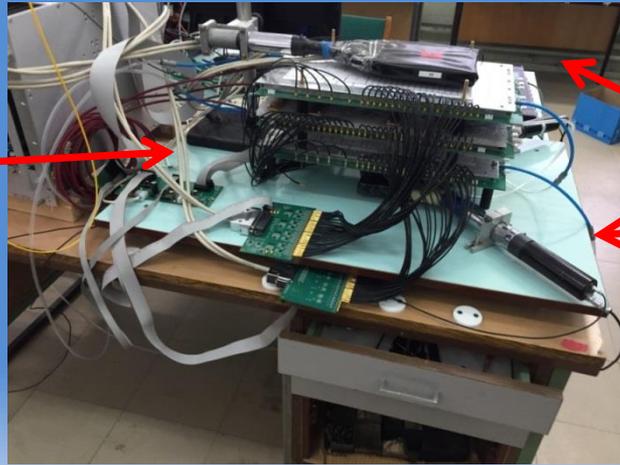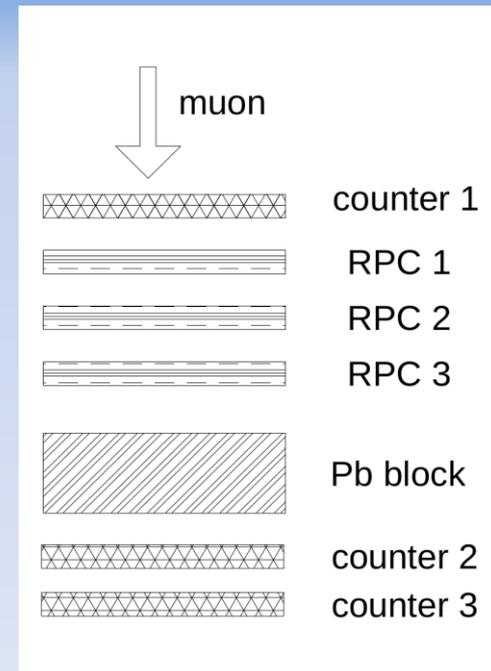

Front end electronic based on NINO chips

Best resolution is reached ~56ps
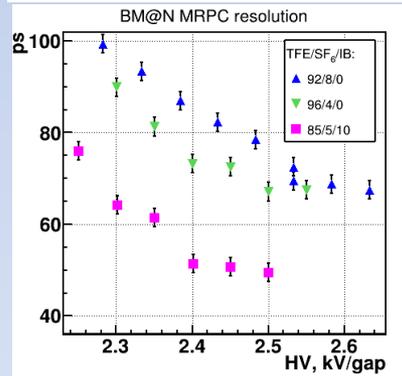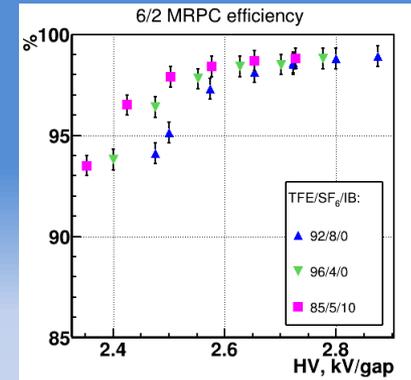
Cosmic test setup

4 MRPC's

3 Counters

muon

counter 1

RPC 1

RPC 2

RPC 3

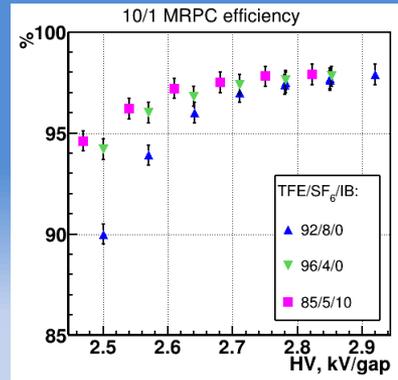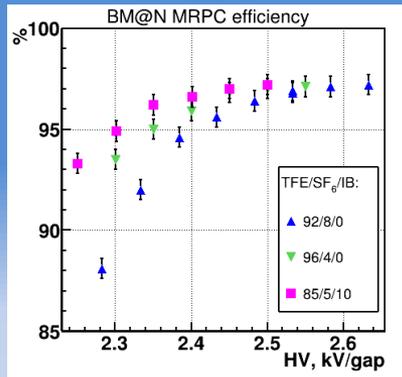Pb block

counter 2
counter 3

Results are showed at SPD Workshop 07.06.2019

BM@N chamber

10 independent gaps chamber

6 double gaps chamber
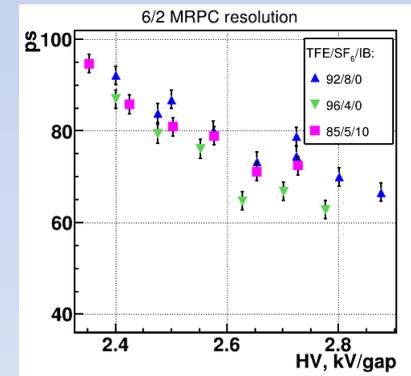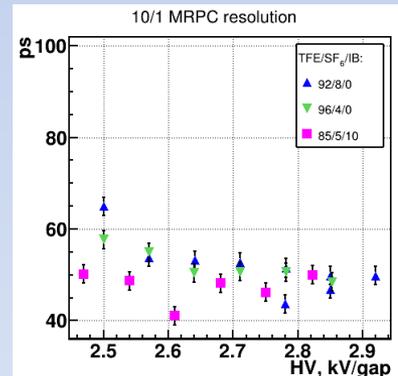
These measurements has been done with BM@N electronics

2019 winter beam results:

3 MRPCs with independent gaps:
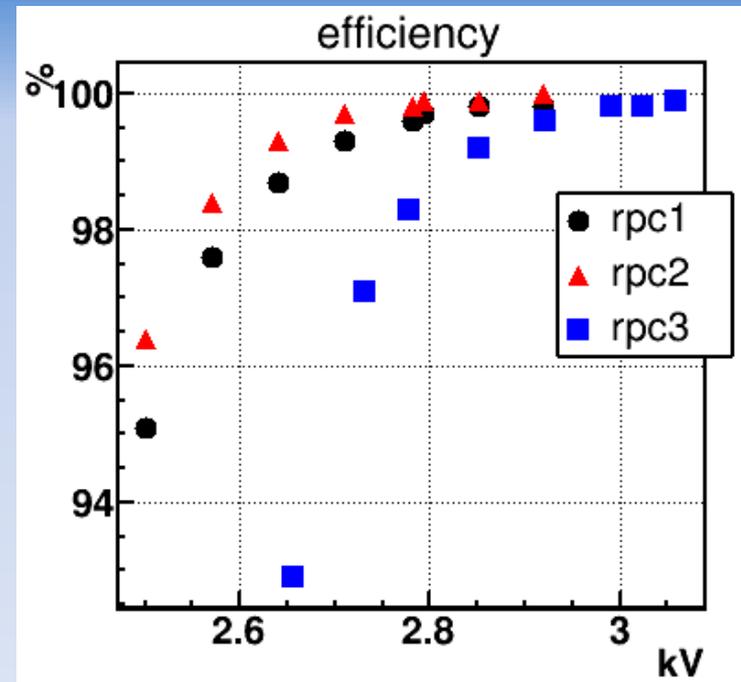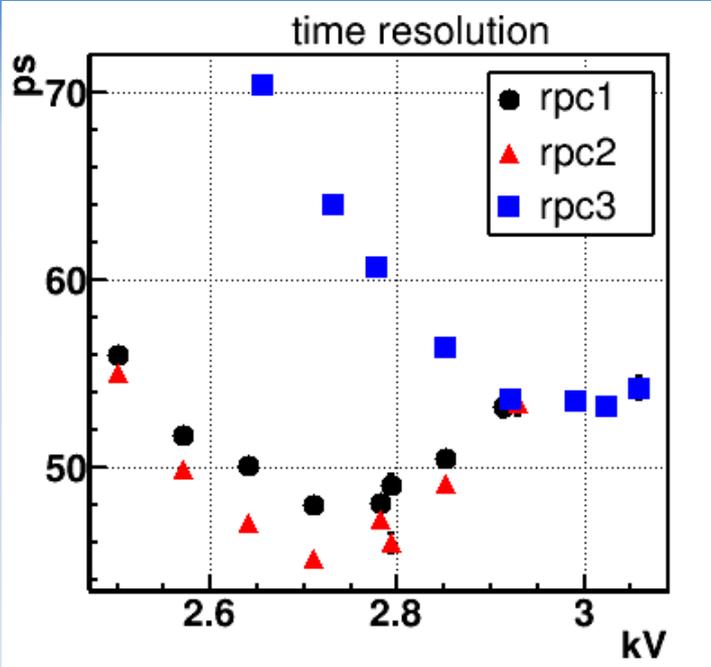rpc1 is 10x0.25 mm chamber
rpc2 is 12x0.25 mm chamber
rpc3 is 10x0.30 mm chamber
Strip size is 10x150 mm for all MRPCs.
Gas composition is TFE/i-C H /SF = 85/10/5

All results were obtaned with the
Time Over Threshold (TOT) method

Goals:

Intention of this work is to probe a time resolution of different structure chambers and reach maximal resolution using the different electronic setups:

- Study of different stack structures of mRPC and different readout electrodes

- Gas $C2H2F4$ / i-$C4H10$ / $SF6$ = 84% / 9.7% / 6.3%

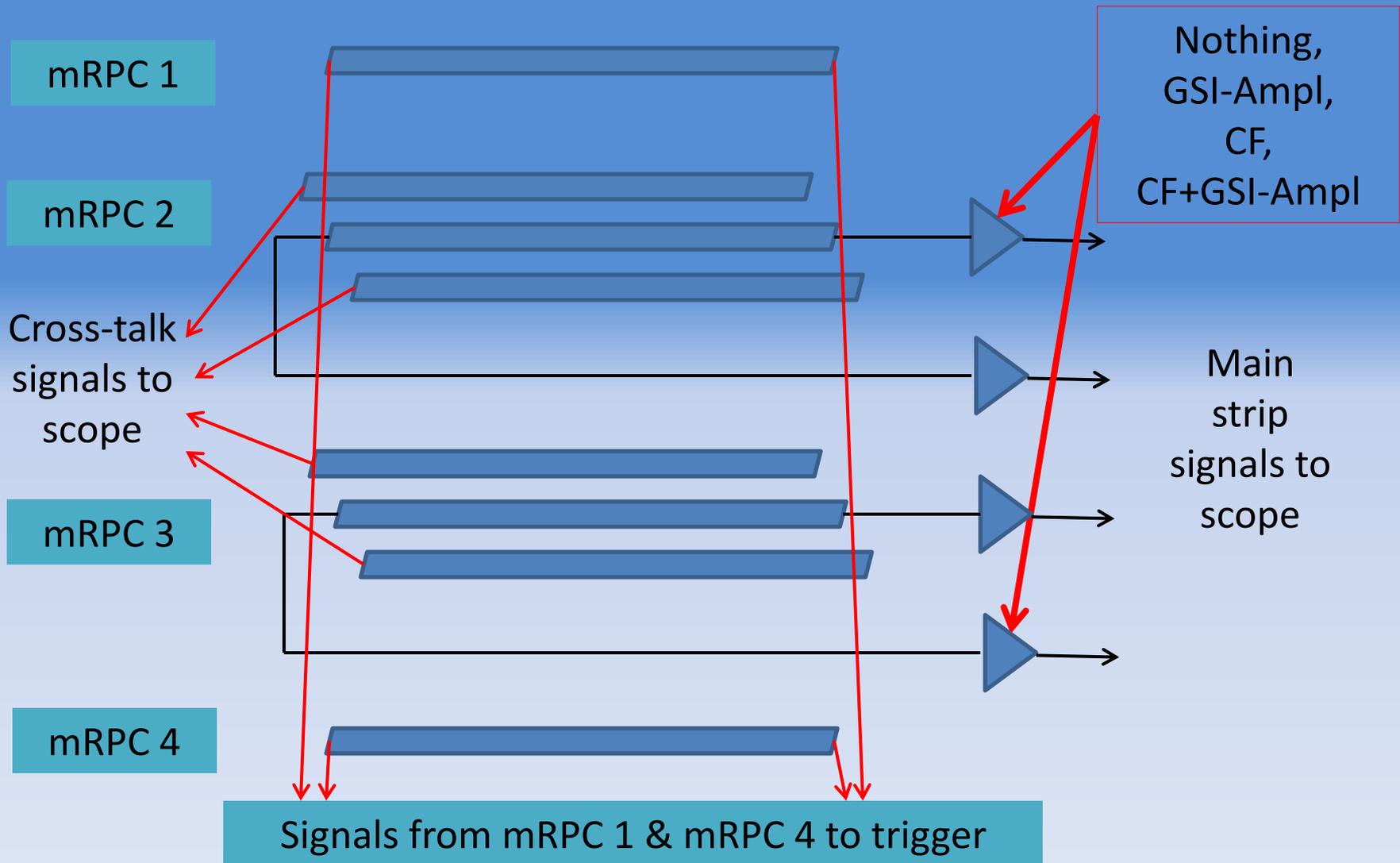- Study of different readout schematics

List of measurements:

- Direct measurement of analog signals from strips by scopes

- Measurement of signals after fast GSI-amplifier by scopes

- Measurement of signals after fast CF (Constant Fraction) by scopes

- Measurement of signals after fast CF & GSI-amplifier by scopes

Cosmic setup description

- Trigger system – 2 counters 160x160 mm^2 & 1 counter 80x80 mm^2 and two strips of neighboring chambers

- Trigger rate ~ 1 event/ 300 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

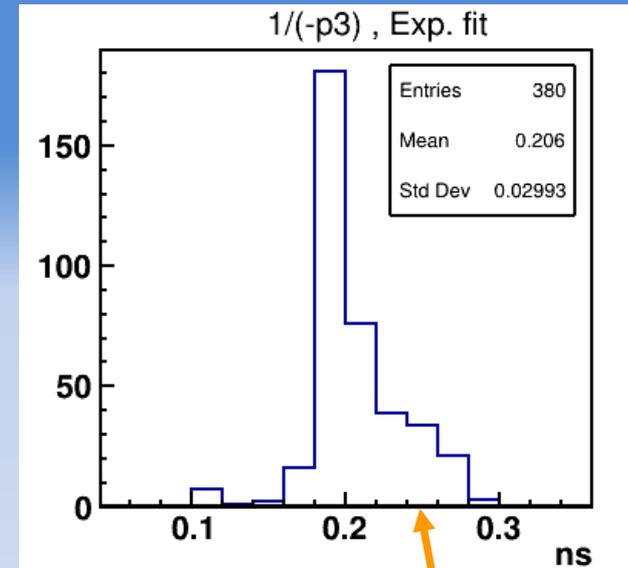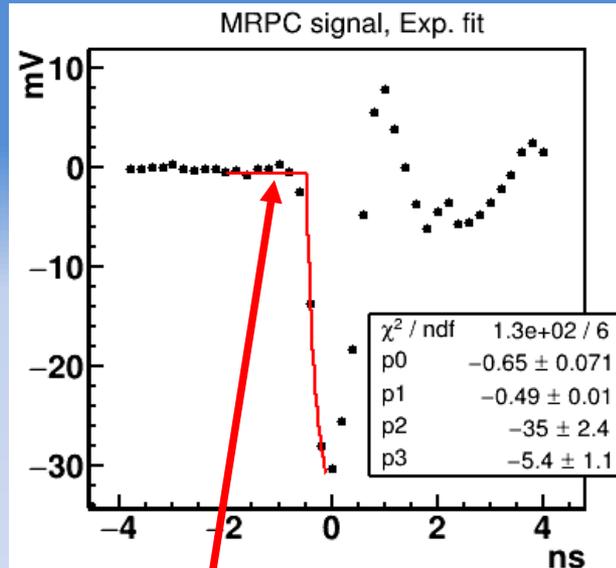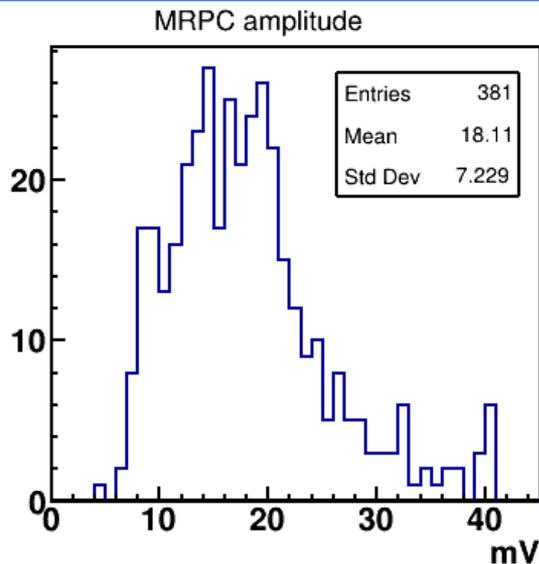- All strip sizes – 160x10 mm2

- Data taking under LabVIEW program

Schematic of measurements

mRPC 1

mRPC 2

Cross-talk signals to scope

mRPC 3

mRPC 4

Nothing, GSI-Ampl, CF, CF+GSI-Ampl

Main strip signals to scope

Signals from mRPC 1 & mRPC 4 to trigger

Cosmic data example :

Signal front is fited by $F(t) \approx p \cdot (1-\exp\{p \cdot (t-p)\})$

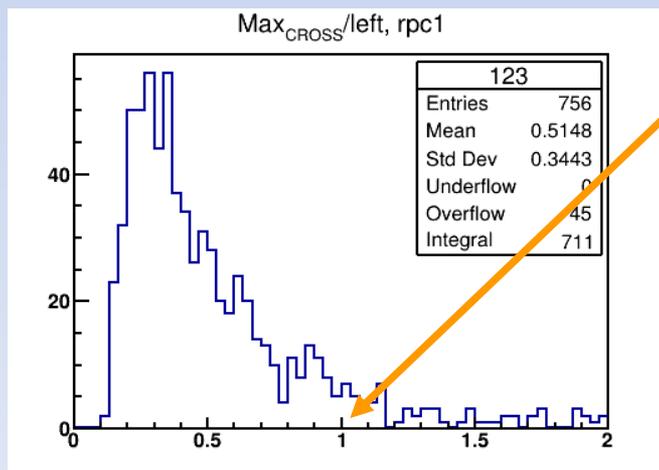At this time particle cross the chamber.

Oscilloscope rising time

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

Cosmic setup results:

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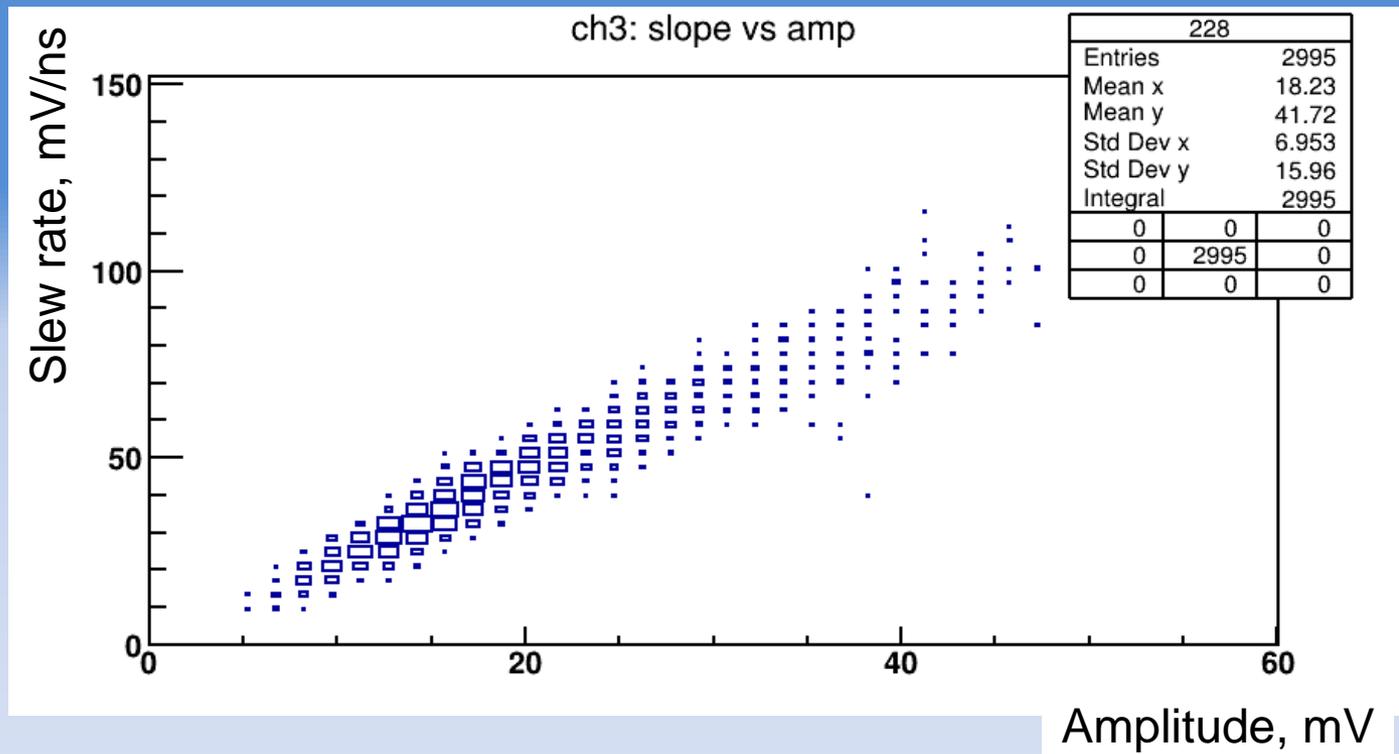

- rpc1 — 10x0.25 мм — hv = 2.7 кВ
- rpc2 — 12x0.25 мм — hv = 2.7 кВ
- rpc3 — 10x0.30 мм — hv = 2.9 кВ
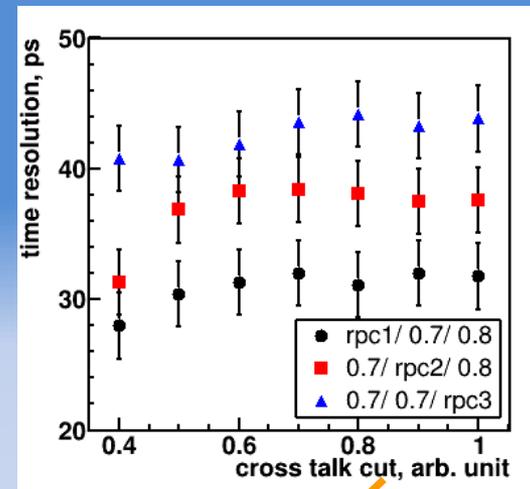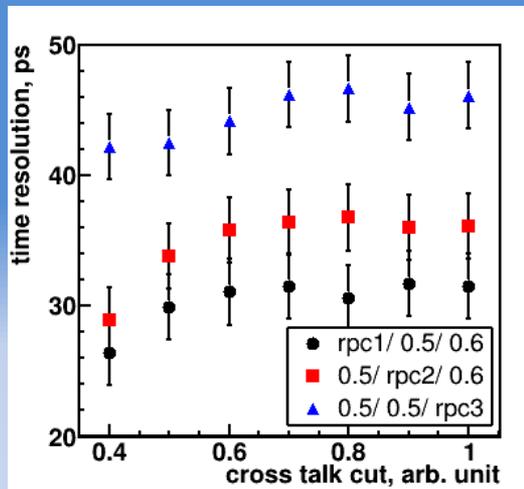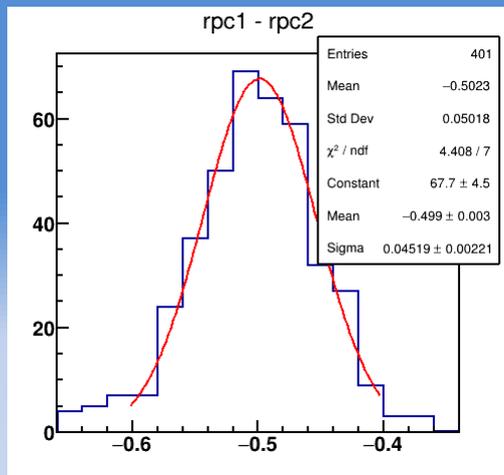
Can we use Constant Fraction Discriminator?

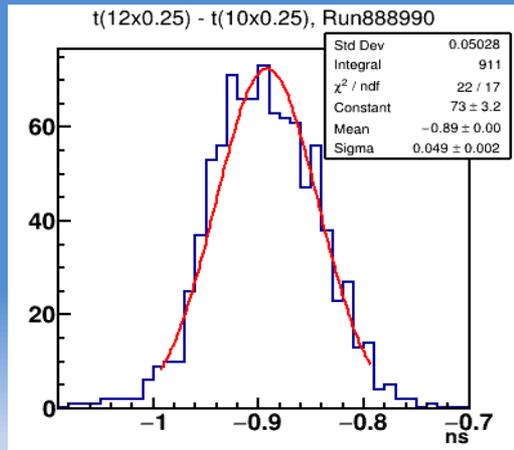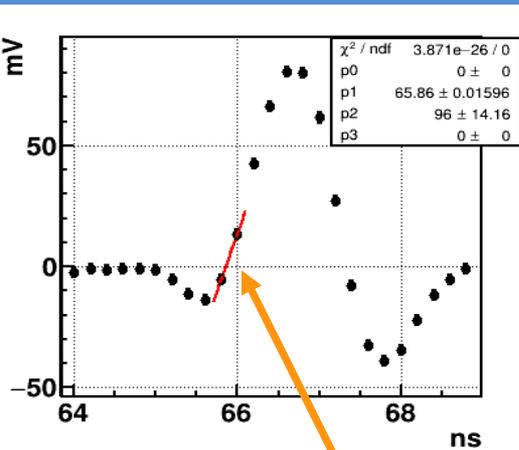Signal slew rate (linear fit) via amplitudes for 10x0.25mm rpc
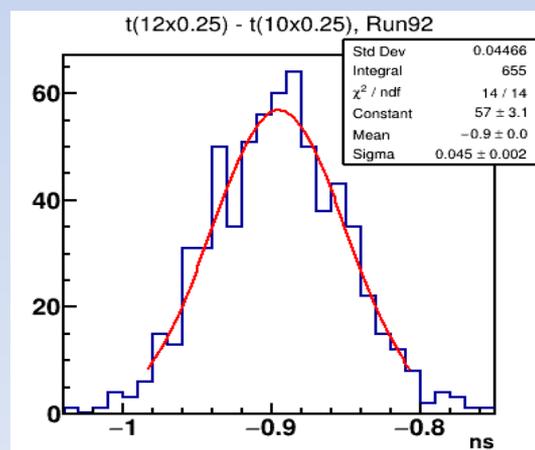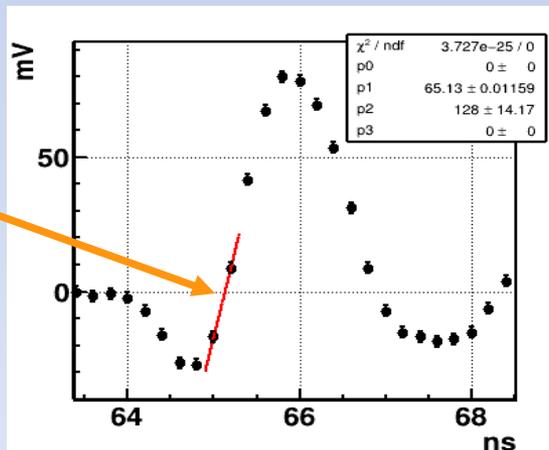

Yes it is possible!

Cosmic setup results:
MRPCs time difference measurement by using (amplifier + CF)
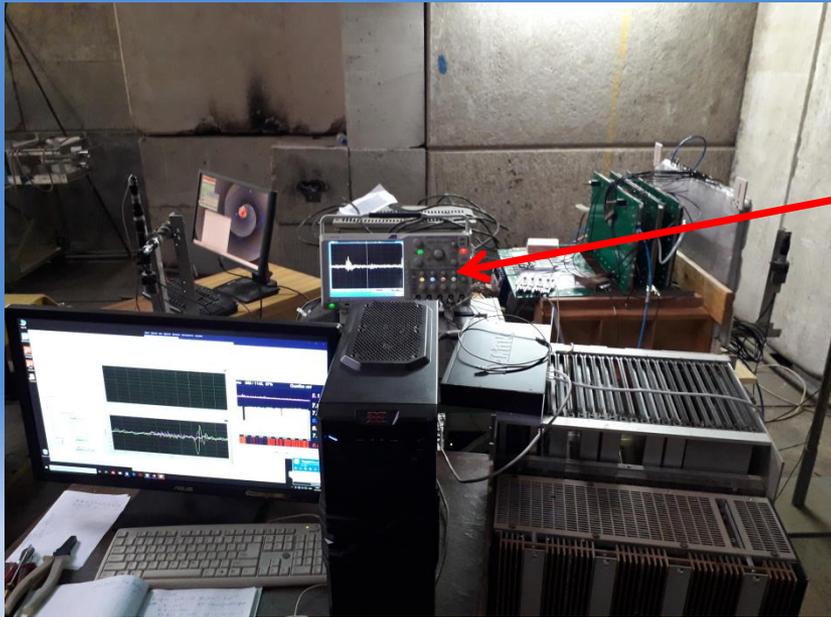
200 ps CF delay

250 ps CF delay

Time reference (zero crossing)
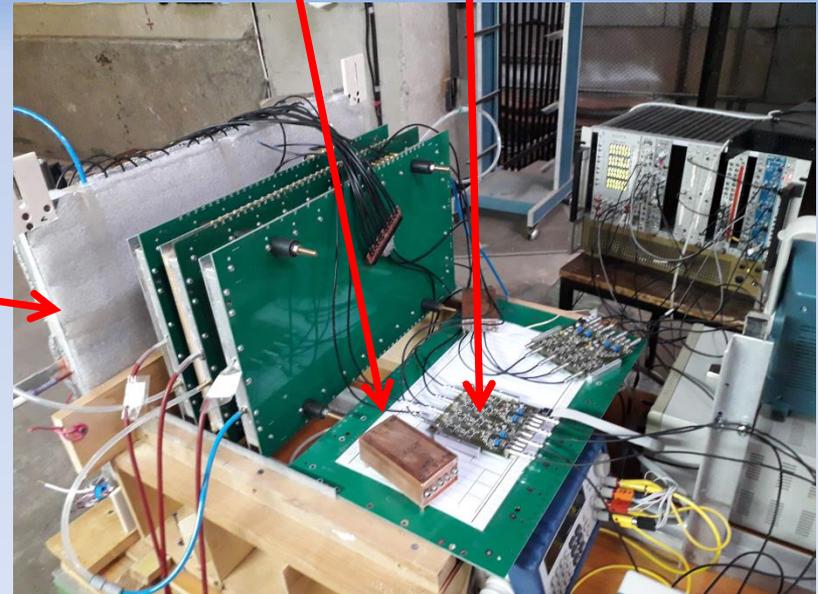
U70 test beam setup (Dec 2020)

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

4 MRPC's:
12gaps x 0.25mm, 10 x 160 mm² strips
10gaps x 0.25mm, 10 x 160 mm² strips
10gaps x 0.30mm, 10 x 160 mm² strips
(has not been used)
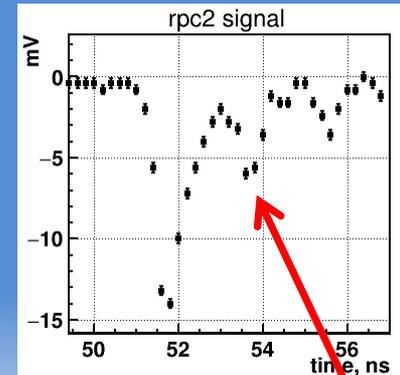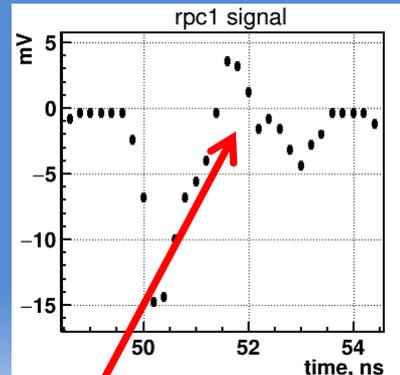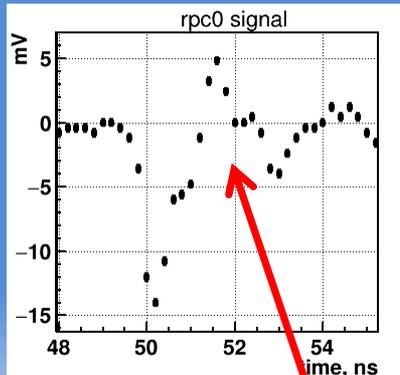10gaps x 0.25mm, 25 x 310 mm² strips
HV = 2.75 kV for all chambers

U70 test beam setup description

- Trigger system – two counters 10x10 mm^2 (S1&S2) and two counters 20x20 mm^2 (S3&S4)

- rpc0 – 2 stacks x 6gaps x 0.25mm, strips 10 x 150 mm^2

- rpc1 – 2 stacks x 5gaps x 0.25mm, strips 10 x 150 mm^2
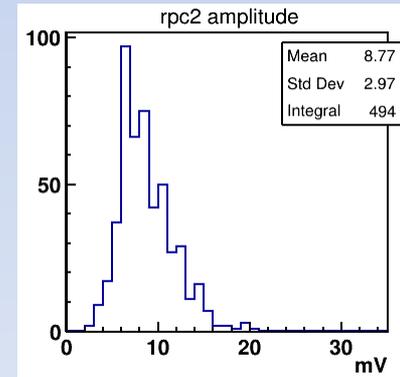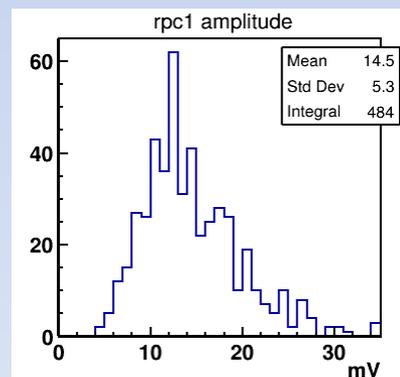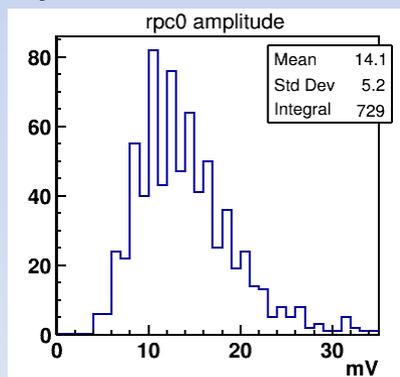
- rpc2 – 2 stacks x 5gaps x 0.25mm, strips 25 x 310 mm^2
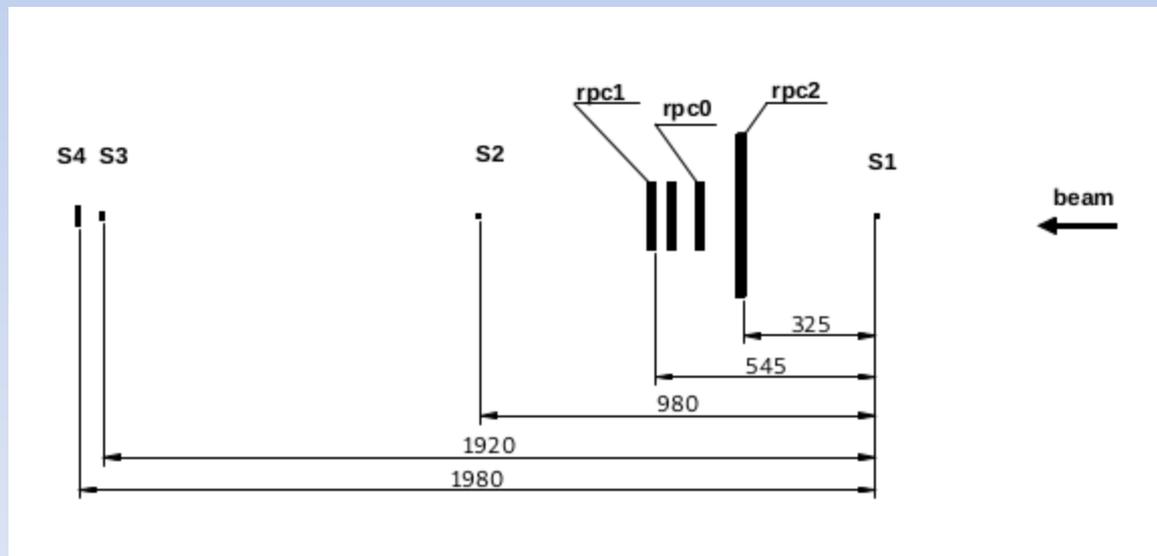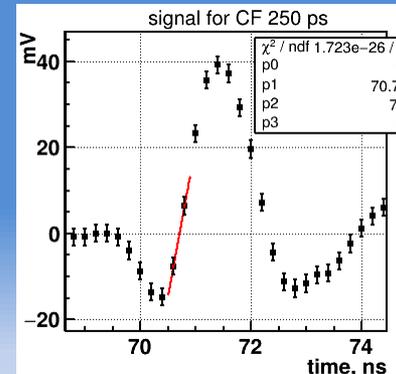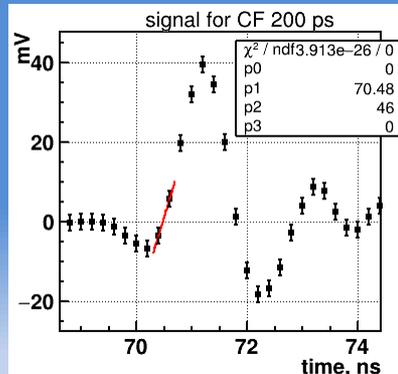
Test beam results (1):

- Examples of signals

Impedance of rpc0 and rpc1 strips higher than 50 Ohm, and rpc2 - less
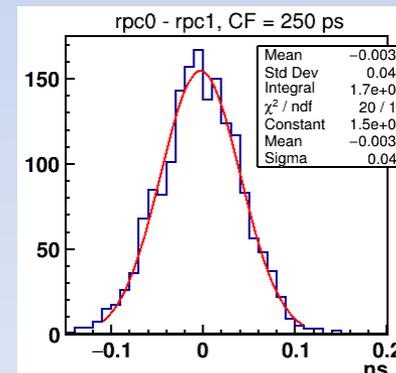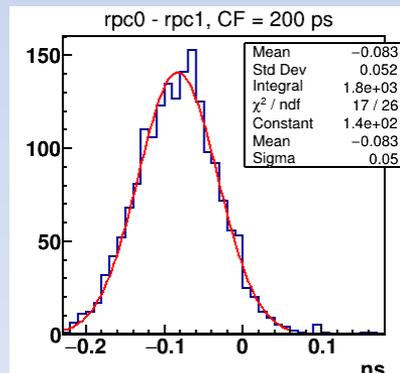
- Amplitude distributions

Test beam results (2):

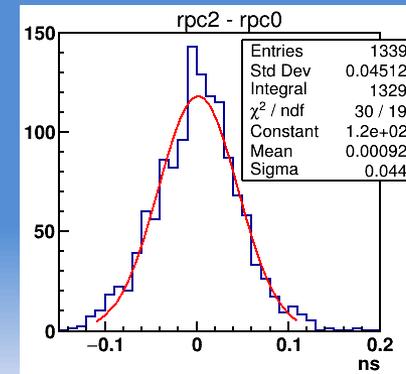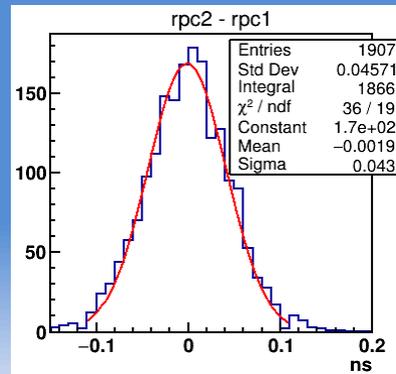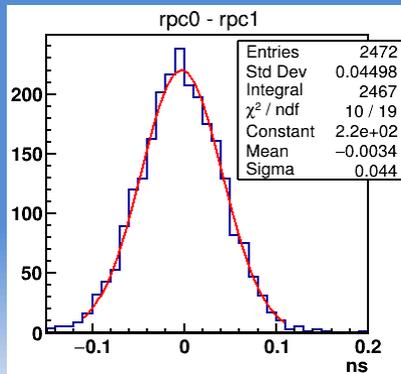- Examples of signals after CF (200ps and 250ps) and GSI-amplifier (gain ~4)

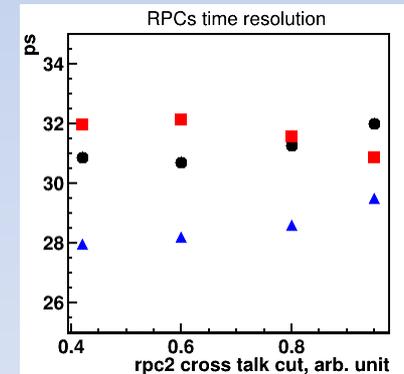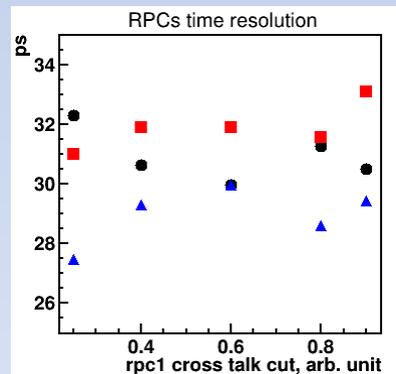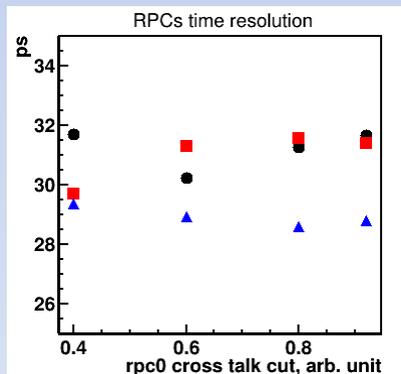- RPCs time difference for CF with 200 and 250 ps delay

Test beam results (3):

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

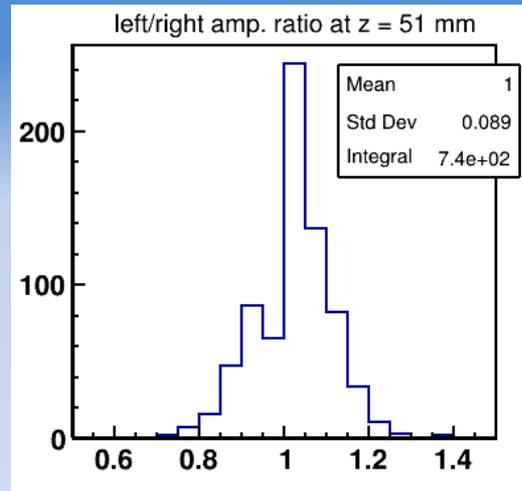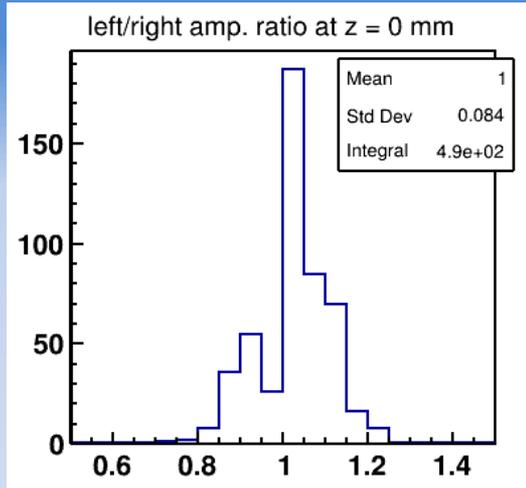- Extracted MRPCs time resolution as function of a cross talk cut

rpc0 –black circles, rpc1 –red squares, rpc2 –blue triangles
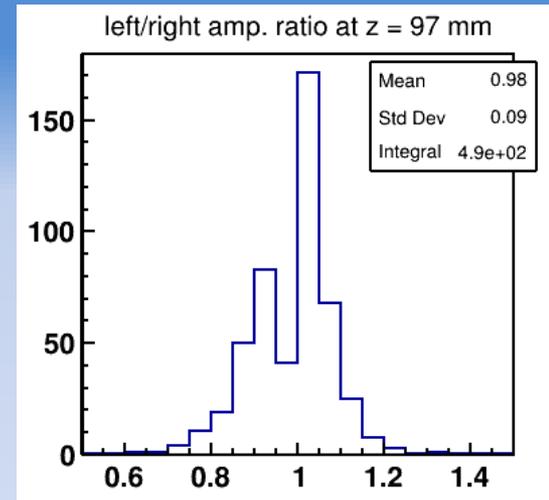
Test beam results (4):

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

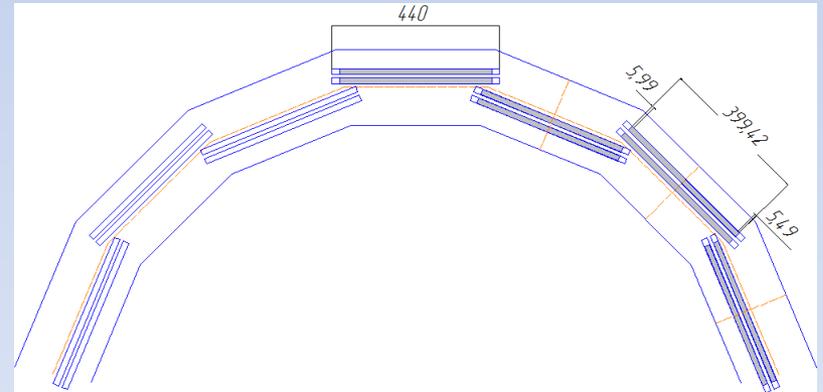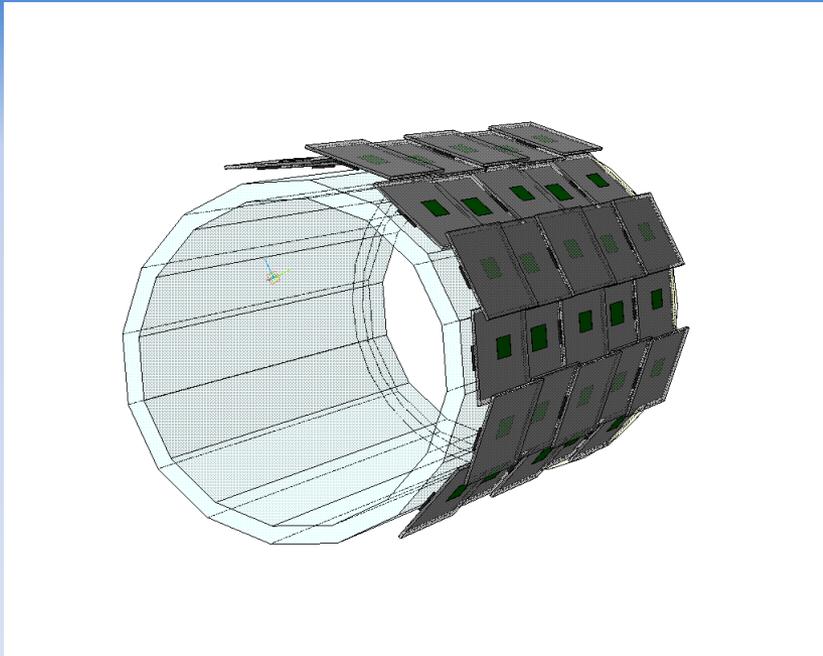10gaps x 0.25mm, 25 x 310 mm² strips

Middle of the strip

Close to the side of the strip

SPD purpose

- SPD the PID (TOF) system could be designed using glass MRPC
- Size of such MRPC should be ~300 x 450 mm^2
- Width of strips is around 20-25 mm

Conclusions and Plans

- Time resolution of our chambers is measured at level of 30ps, but here time resolution of oscilloscope is included

- Our big size chamber is about to SPD purpose only we need to test thinner glass (~0.3 or 0.4 mm)

- For new readout we need fast amplifier (>1GHz)

- CFD could be done using fast transistors and fast comparator

- In new design should be used Pico-TDC (question to S.Basylev)

- Any new designs require money support

Thank for you attention!

Backup slide

2019 cosmic test