THE ALICE TIME OF FLIGHT AND THE MULTIGAP RESISTIVE PLATE CHAMBER

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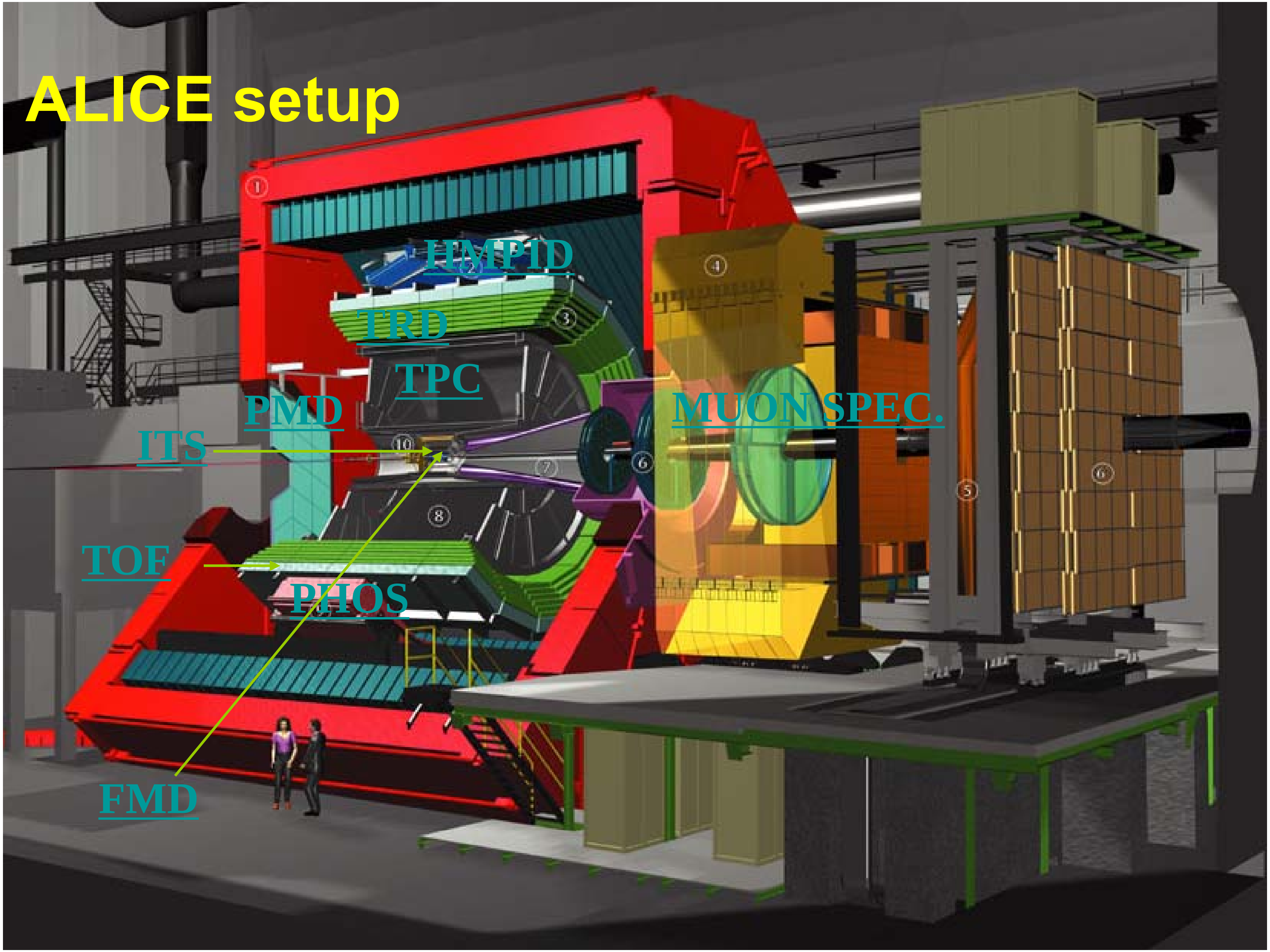
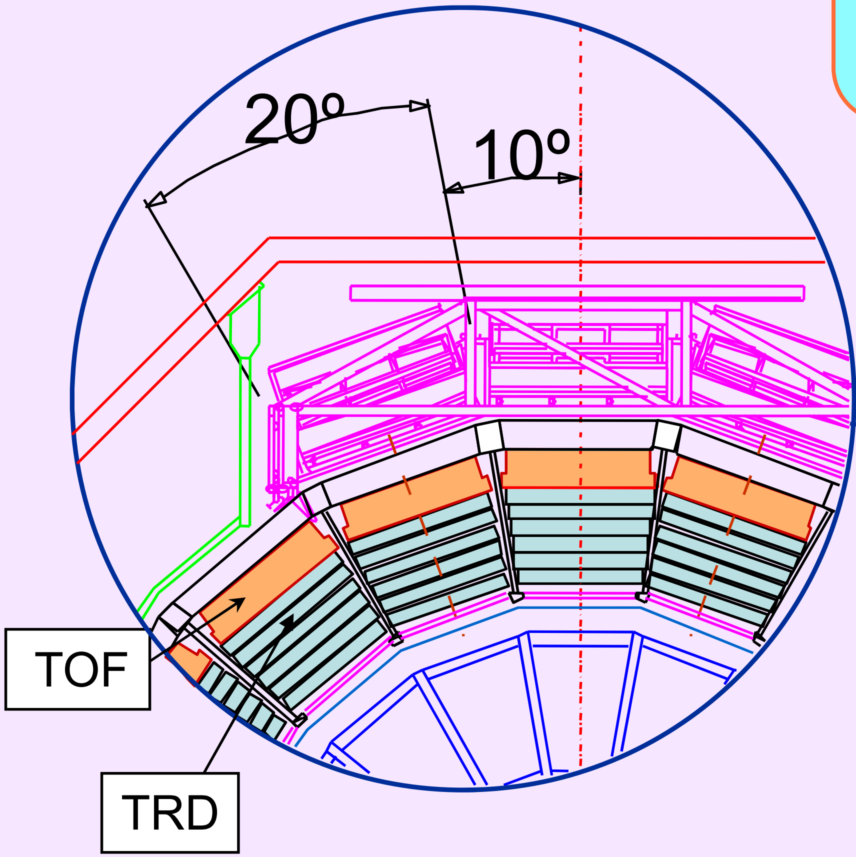
- The ALICE TOF system
- The Multigap Resistive Plate Chamber strip (detector element)
- Performance
- Electronics
- The TOF as a trigger device

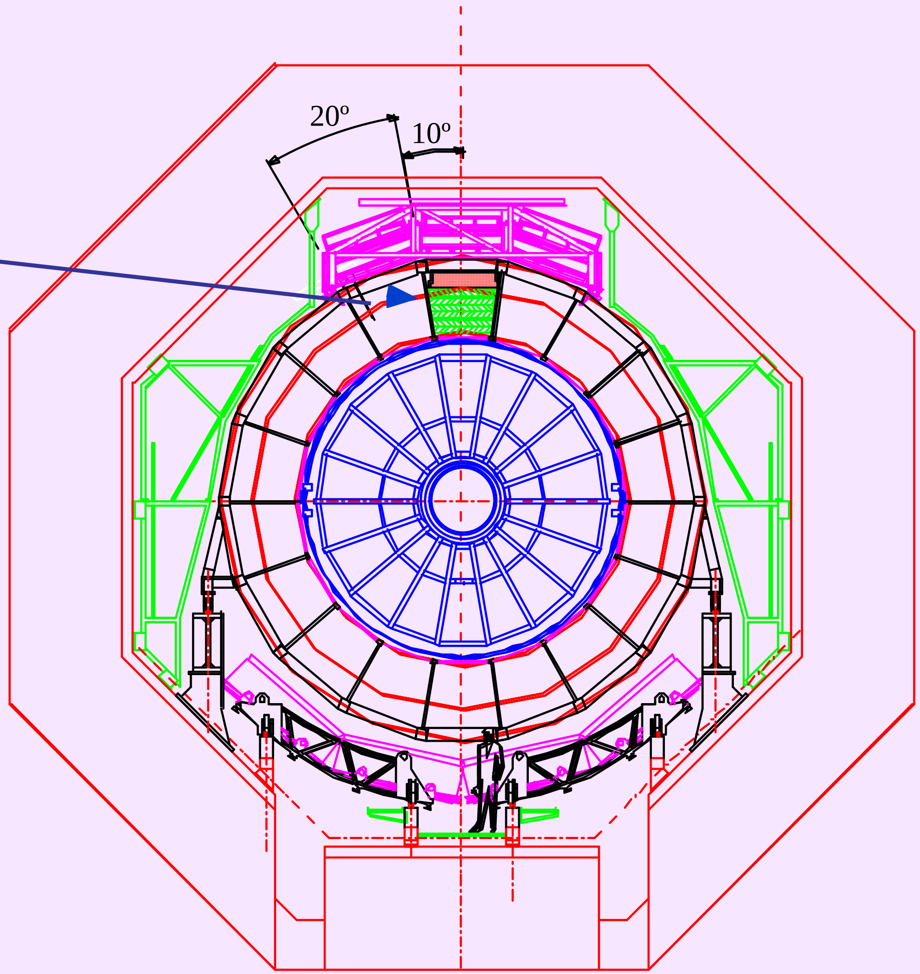
- Further R&D : the 24 gap MRPC (20 ps time resolution)
- Implementation of MRPCs in DHCAL

ALICE setup



Cross section of ALICE detector





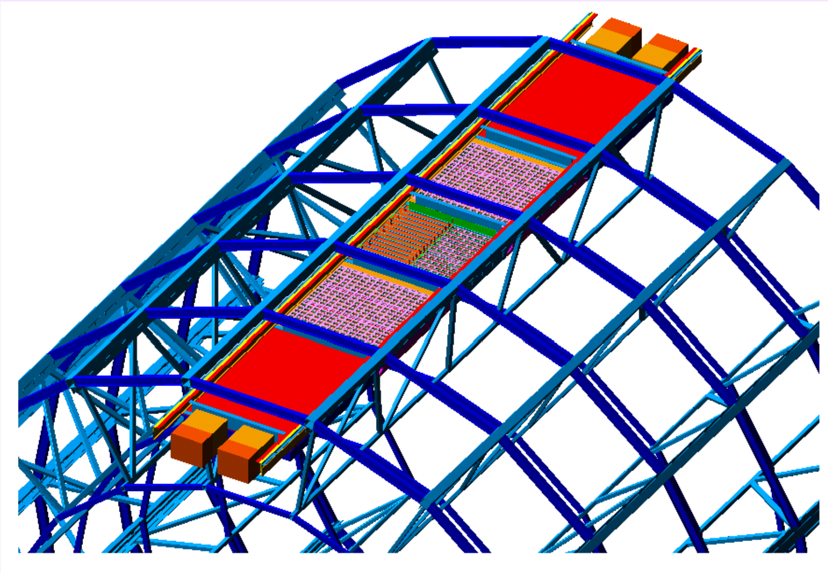
TOF ARRAY arranged as a barrel with radius of 3.7 m
Divided into 18 sectors

Along the beam direction
each sector divided into 5 modules

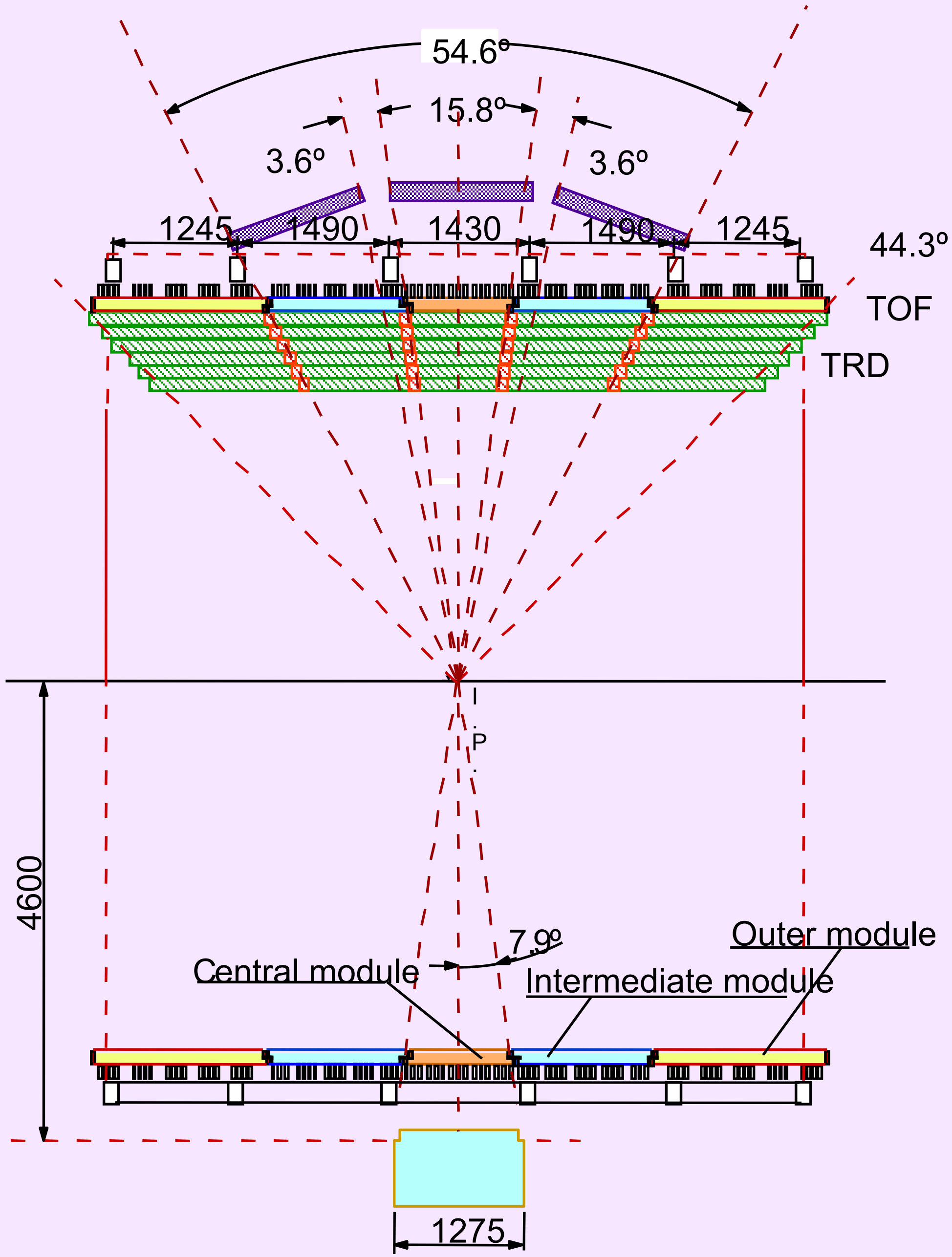
i.e 5 x 18 = 90 modules in total

1638 MRPC strips in total

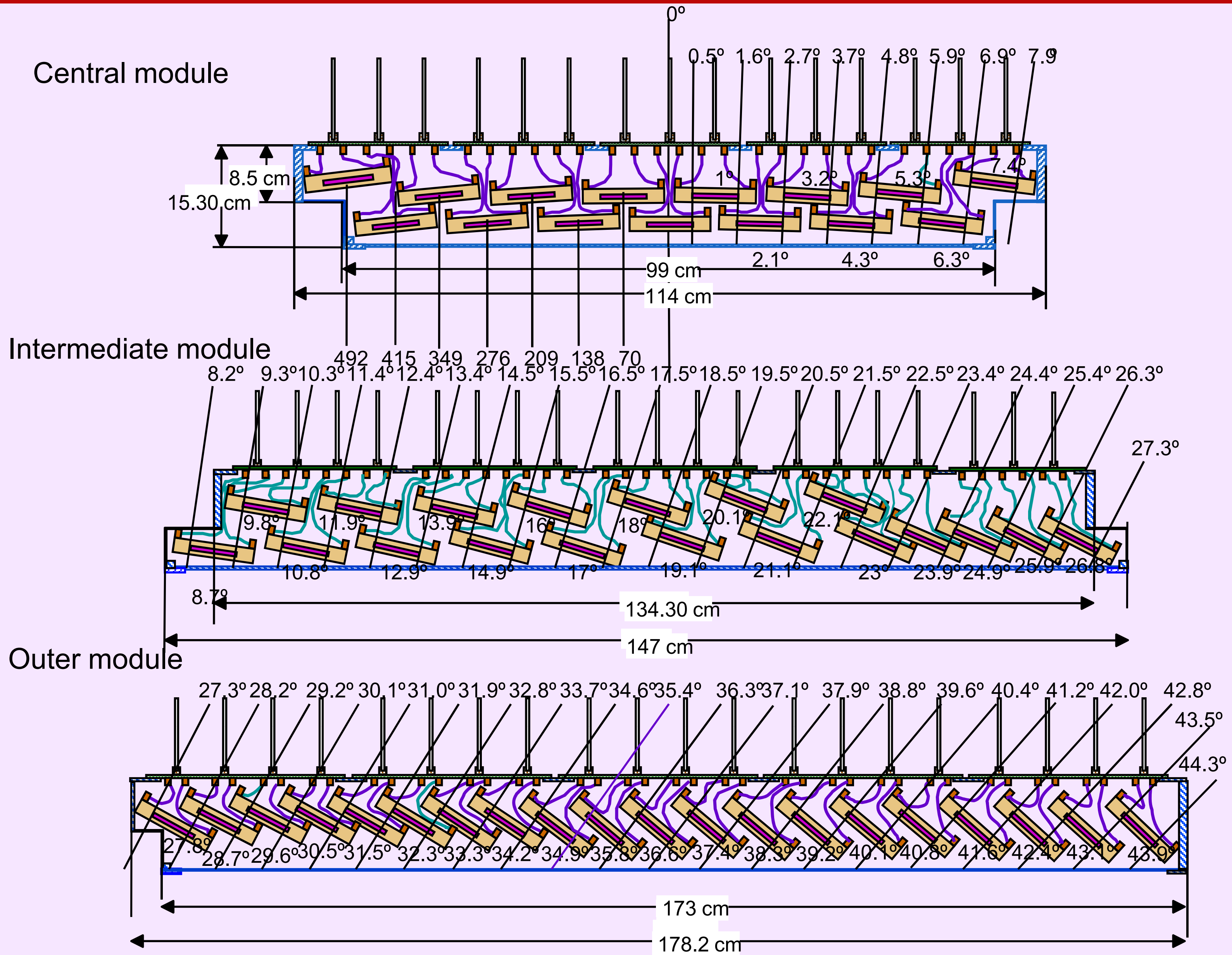
~150 m^2 and 157 248 channels



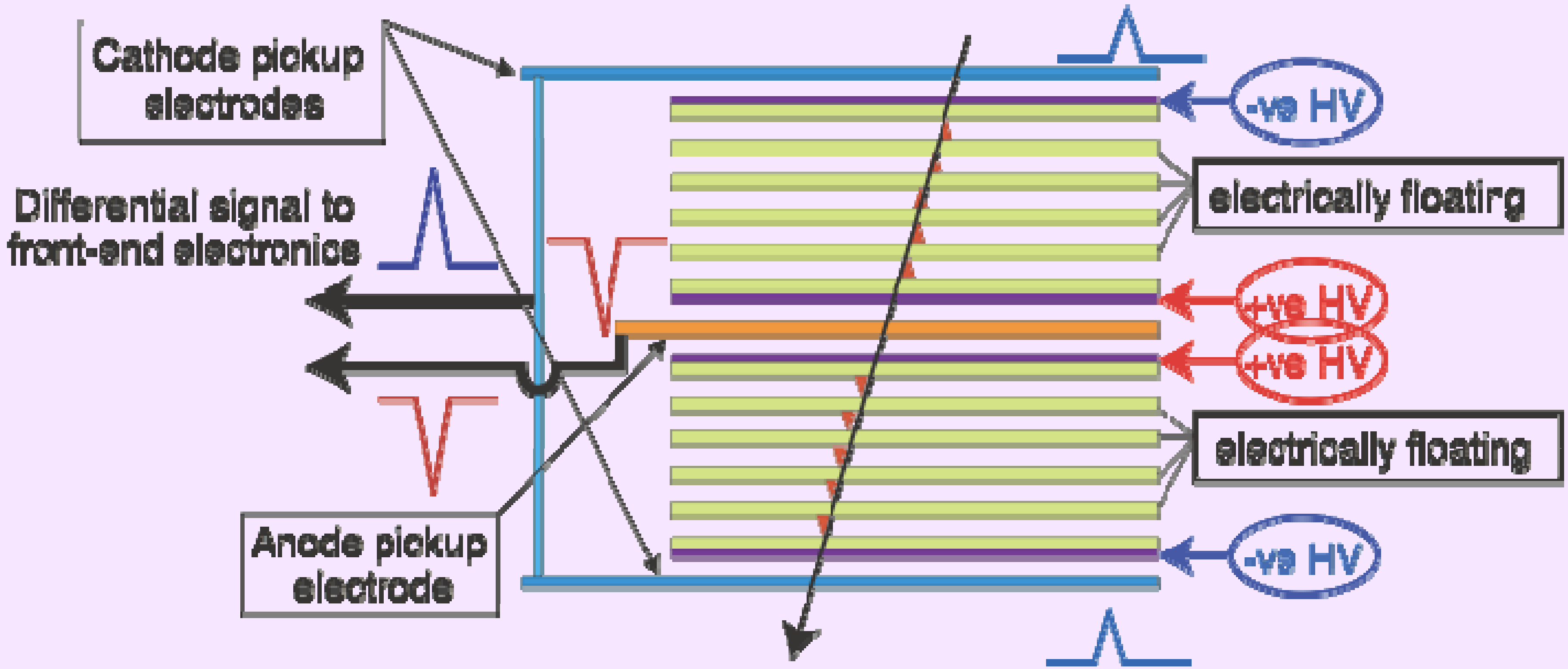
All (18 supermodules) installed in ALICE



Choice of strip geometry allows tilting so that we can have detector normal to incoming particles in r-phi plane

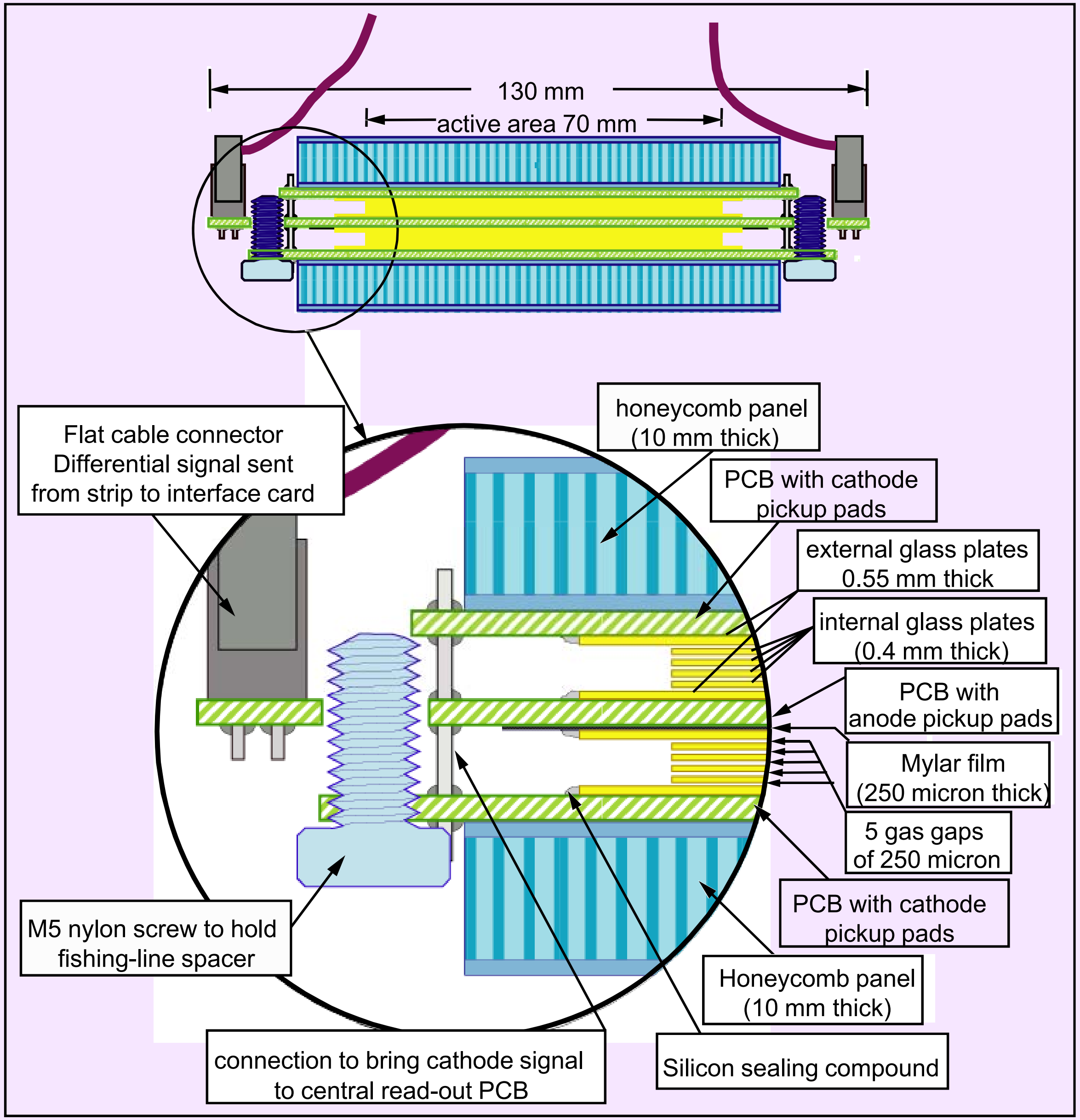


The MRPC for the ALICE-TOF has 10 gas gaps, each of 250 micron width Built in the form of strips, each with an active area of 120 x 7.2 cm^2, read out by 96 pads (each 2.5 x 3.6 cm^2)



Timing depends on individual gap width
Efficiency depends on total gas gap (10x250 mm)

Cross section of double-stack MRPC for the ALICE TOF



Specifications

Double stack
5 gaps / stack,10 gaps in total

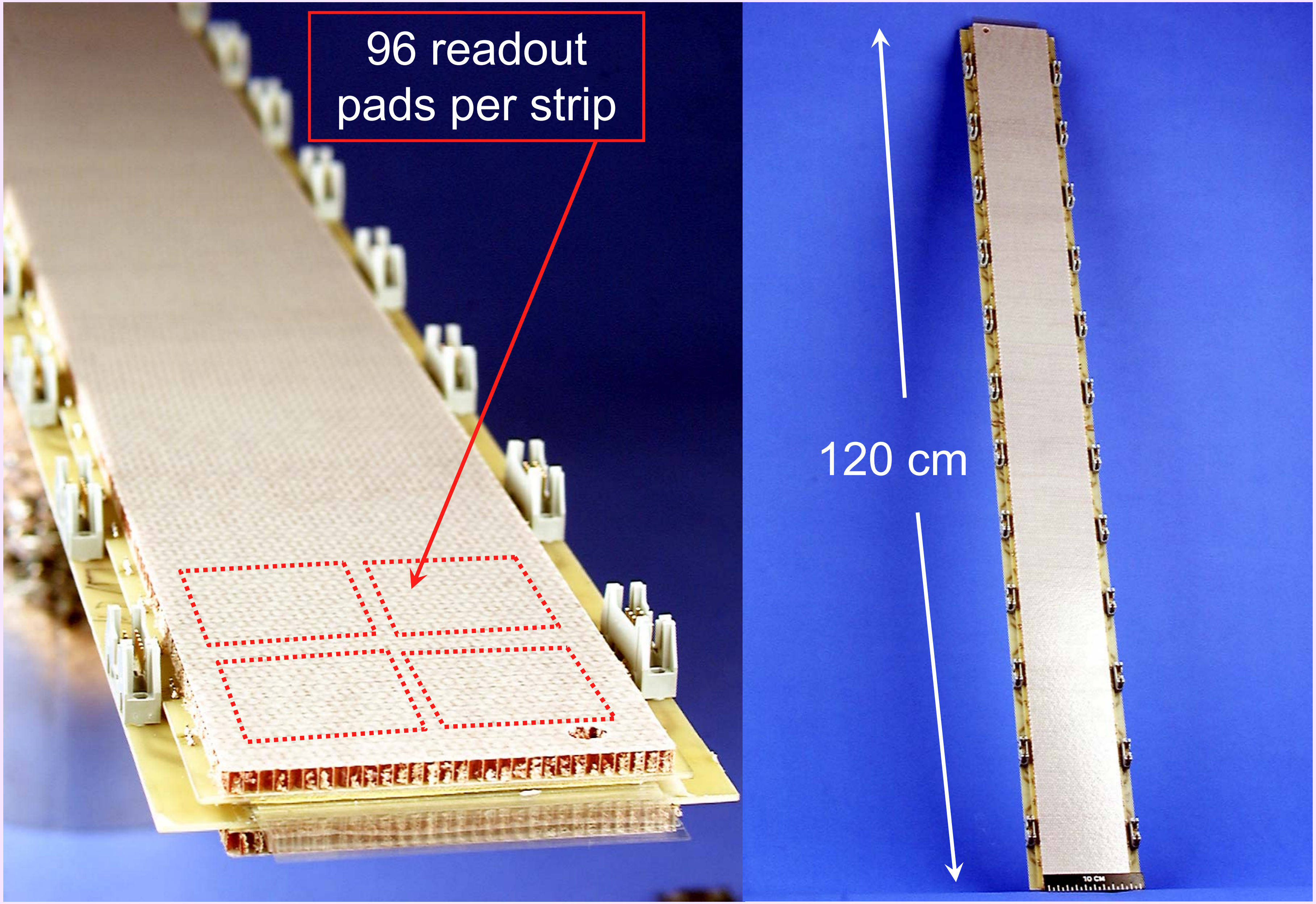
Gap width : 250 microns
spacers : nylon fishing line

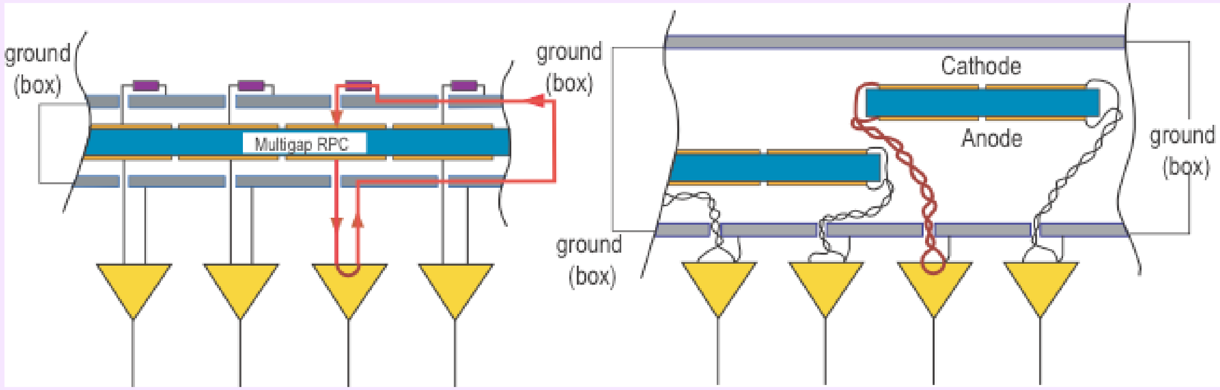
Resistive plates 'off-the-shelf'
soda lime glass
$\rho=5\times10^{12}\ \Omega$ cm

400 micron internal glass
550 micron external glass

Resistive coating
5 MΩ/square

Each item of this list important for performance of MRPC - see ALICE TOF TDR Addendum for details

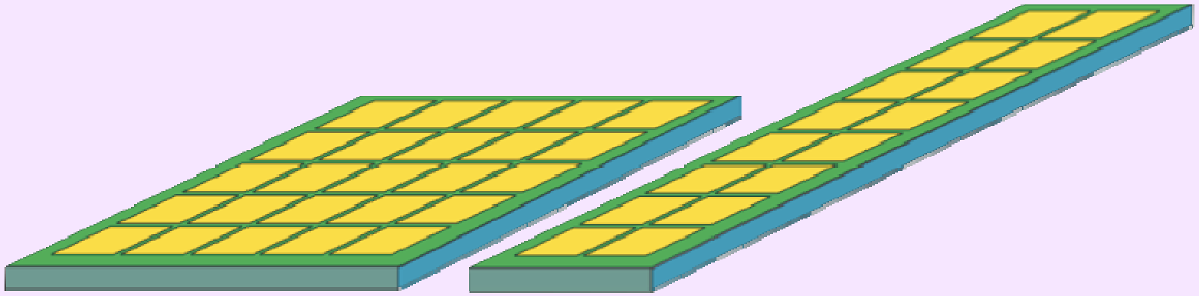

96 readout
pads per strip
120 cm



Differential readout
Big reduction in noise

Measure signal w.r.t ground box

Measure signal on anode pad w.r.t signal on cathode pad

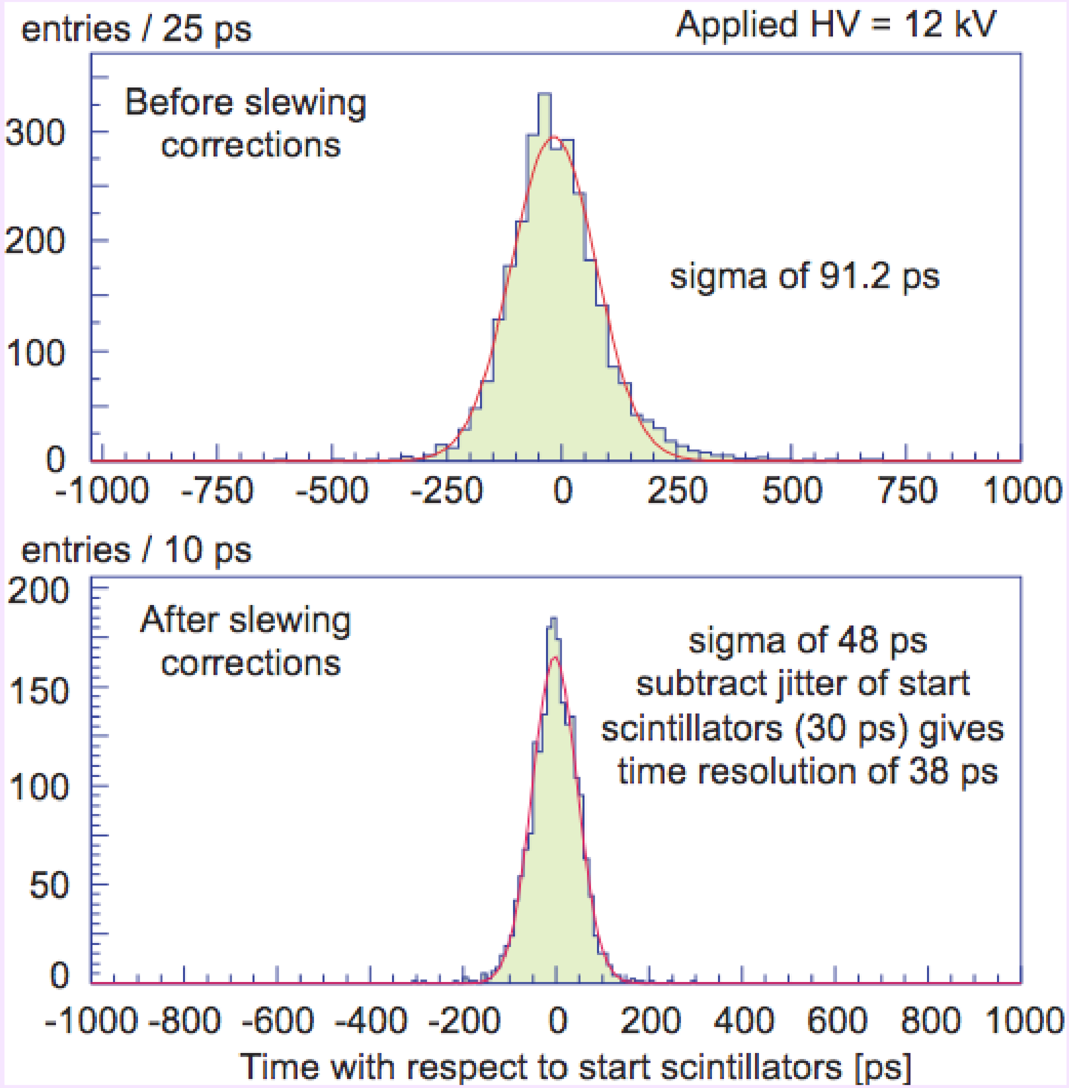


Planar geometry

Strip geometry

Strip geometry allows easy access to both anode and cathode signals

TIME RESOLUTION



quoted time resolution σ = 38 ps

σ^2=(σ of gaussian)^2- (jitter of start)^2

start : average of 4 time measurements from 2 crossed fast scintillator bars equipped with 2 photomultipliers each

(jitter σ = 30 ps)

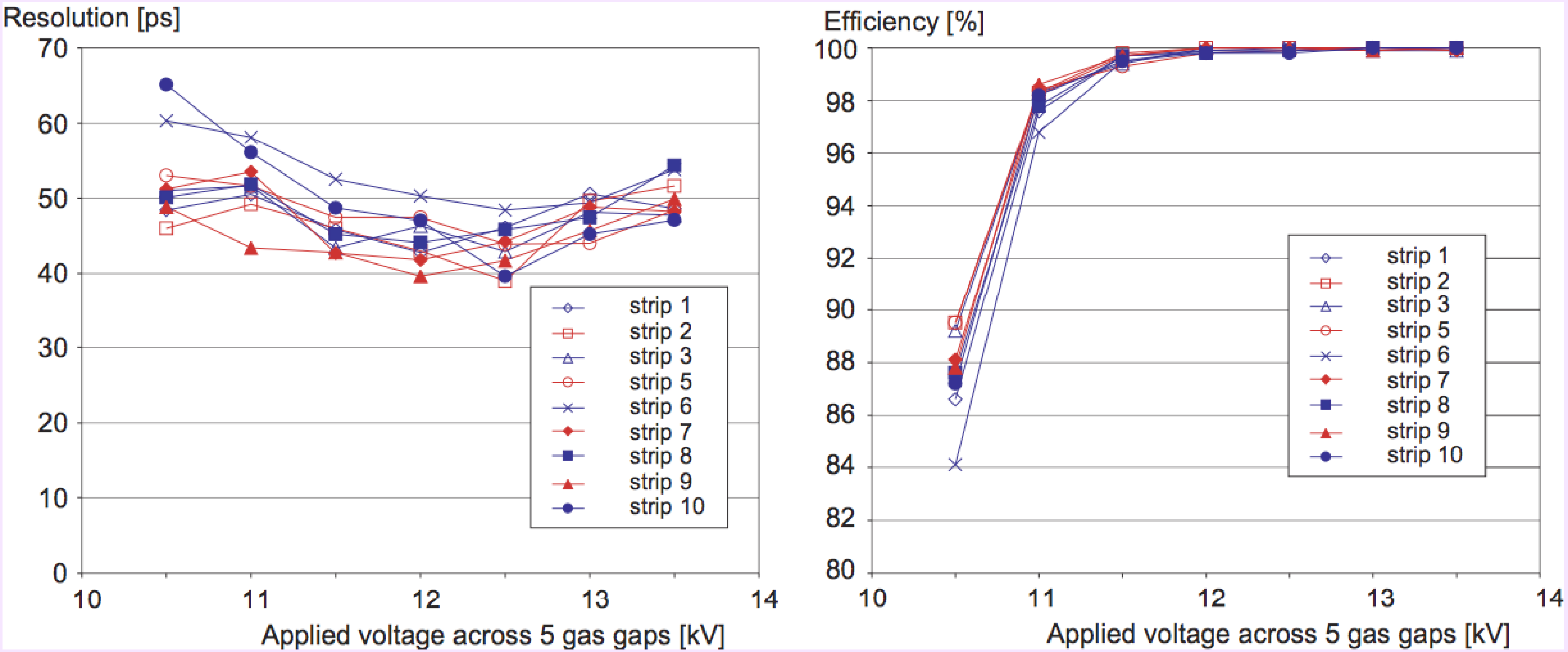
Gas mixture : 93% $C_2F_4H_2$ 7% SF_6

7 GeV/c beam of π^-, μ^- (T10/PS East Hall)

1 cm^2 beam spot selected by trigger
Particle flux ~100 Hz/cm^2

Pulse amplitude (ADC) initially and now TOT (time width=trailing edge-leading edge) used for slewing correction

Uniformity of performance



Online results from 9 MRPC (preproduction) strips tested at T10 during October 2003

All tests of samples of production strips with beam (2004, 2006) gave full efficiency and time resolution 40-50 ps

Electronics

Front End : 24 channel cards (made by Digitec) with 3 NINO ASICs

The NINO ASIC : developed at CERN by Anghinolfi, Jarron etc
0.25 micron CMOS technology
Fast preamplifier + discriminator
Peaking time 1 ns
Differential input (signals from anode / cathode of MRPC);
Differential architecture throughout
LVDS output
Power consumption : 45 mW / channel
Adjustable threshold : 10-100 fC

QuickTime™ and a decompressor are needed to see this picture.

Output width depends on input charge (no ADC needed for slewing correction)

Readout : custom made TRM (made by CAEN) with 30 HPTDC chips - 240 channels

HPTDC developed by microelectronics CERN group
8 channels/chip in high resolution mode (25 ps bin)
Leading edge and trailing edge time --> time width
40 MHz clock / time stamp

QuickTime™ and a decompressor are needed to see this picture.

NOTE ON THE QUOTED TIME RESOLUTION

Factors contributing to the quoted resolution

- **Front End Electronics (NINO ASIC) and cables** — **20 ps**
- **Readout electronics** — **20 ps**
  HPTDC 25 ps bin
  The time shown : difference between two time measurements $t = t_{MRPC} - t_{REF.SCINT.}$
- **Beam spot 1 cm^2 (50 ps/$\sqrt{12}$)** — **14.4 ps**
- **Intrinsic MRPC resolution** — **25 ps**

add in quadrature: $20^2 + 20^2 + 14.4^2 + 25^2 = 40.4^2$

The TOF as a trigger

Right now ALICE is enjoying the additional benefit of MRPC : very quiet (low noise) detector

Typical value of noise : ~0.2 Hz/cm^2

- MRPC → fast detector (L0, pre-trigger)
- Low noise → can trigger on low multiplicity
- The large area (~150 m2) → high geometrical efficiency

48 pads OR = 1 channel to the Local Trigger Module

→ Used during commissioning with Cosmics

Event display of events triggered by TOF with and without magnetic field (Annalisa de Caro)

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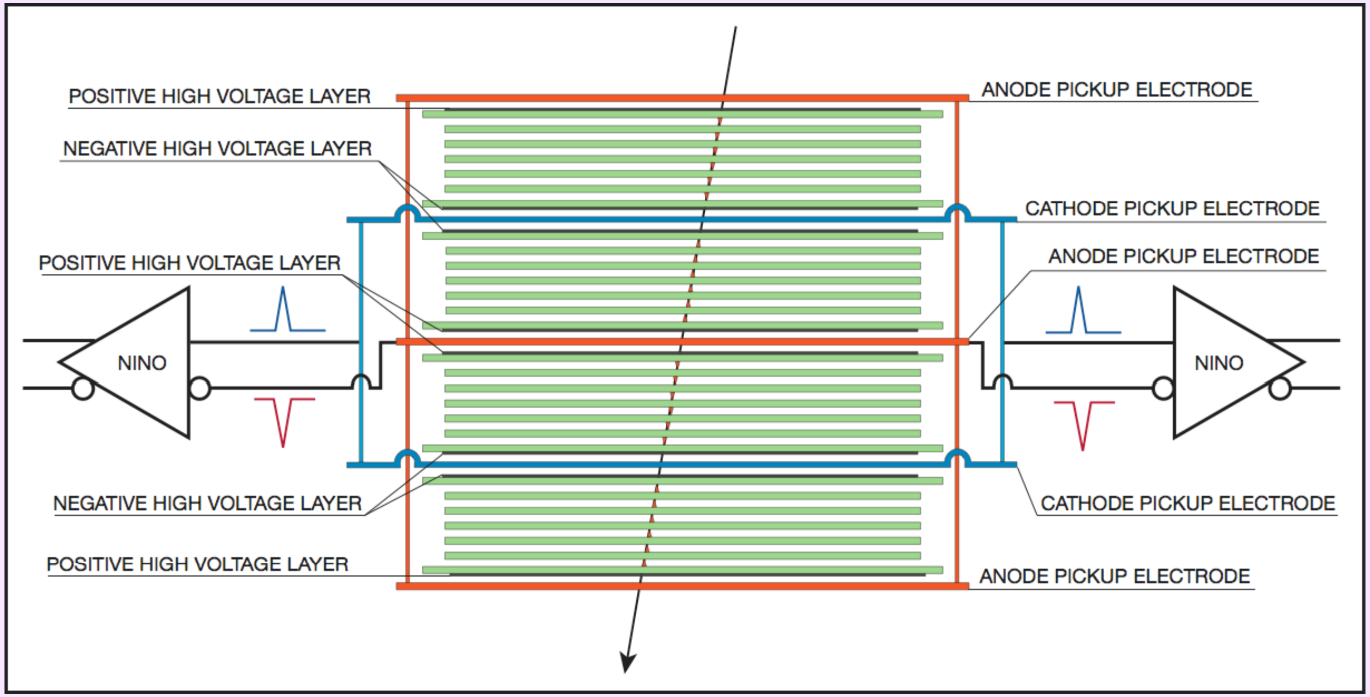
Pushing the limits of time resolution : the 24 gap MRPC



24 gaps of 160 microns each arranged in 4 stacks

Glass plates 400 μm / 550 μm

pickup pads : 2.5 x 7.4 cm^2 read out at both ends

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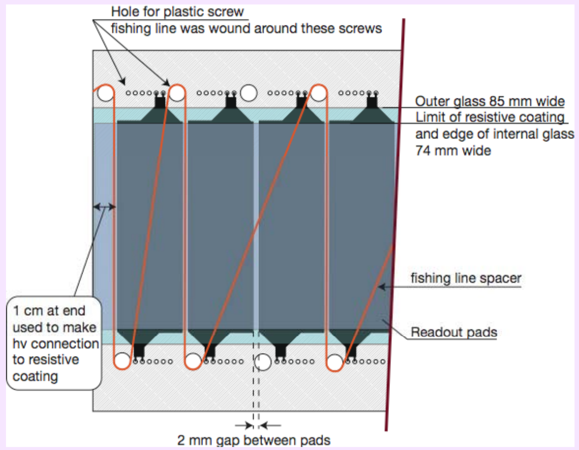
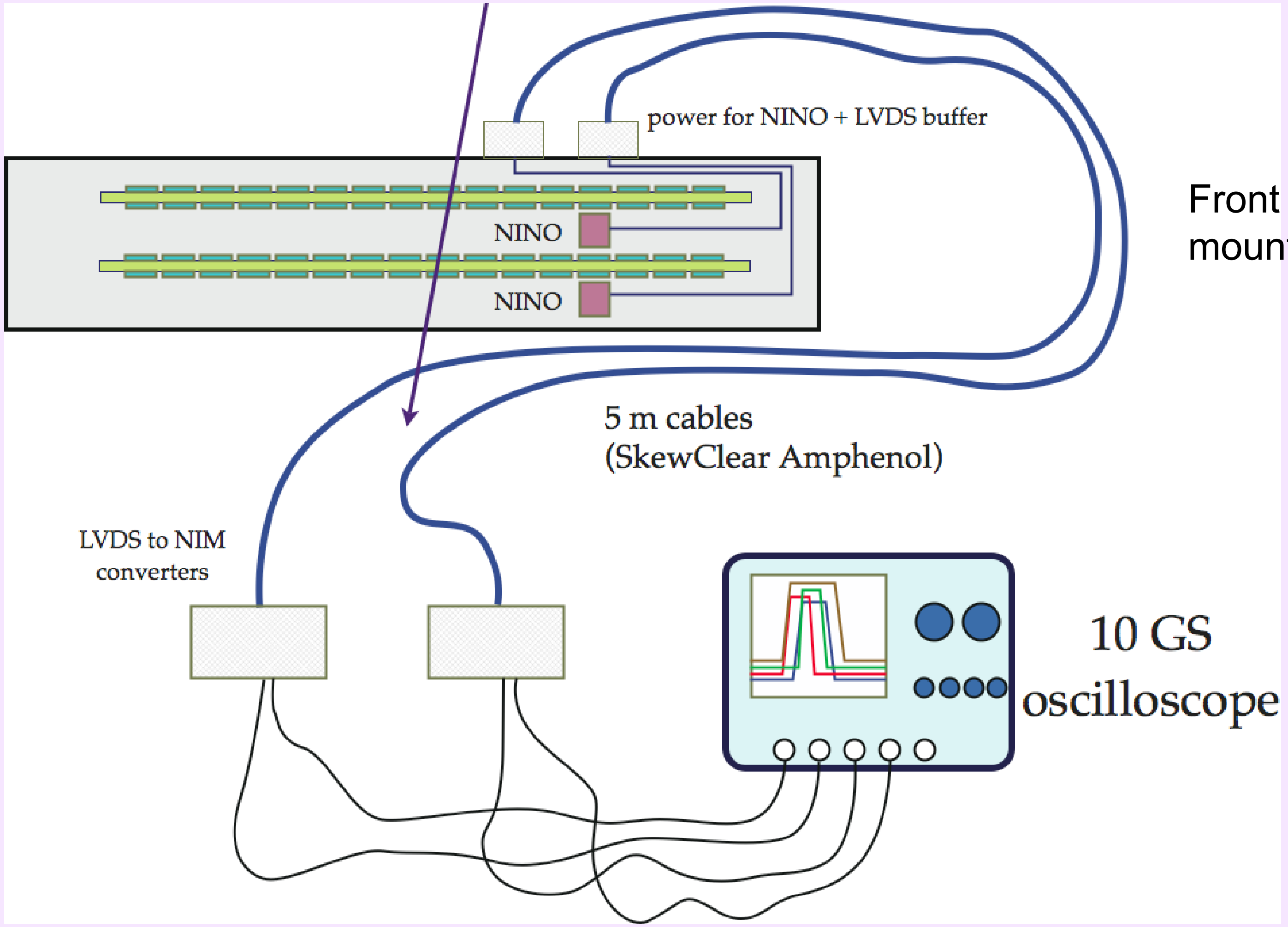
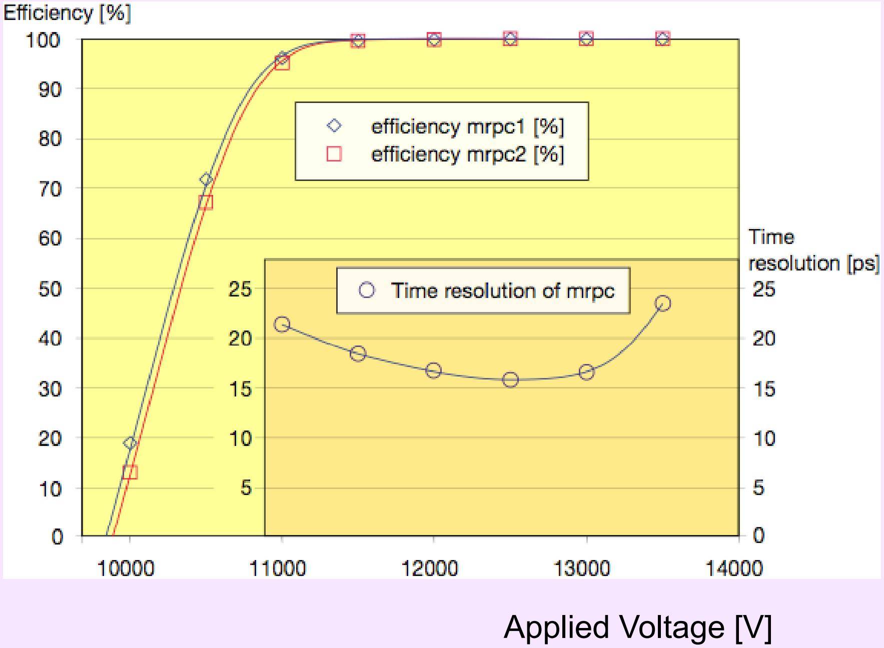
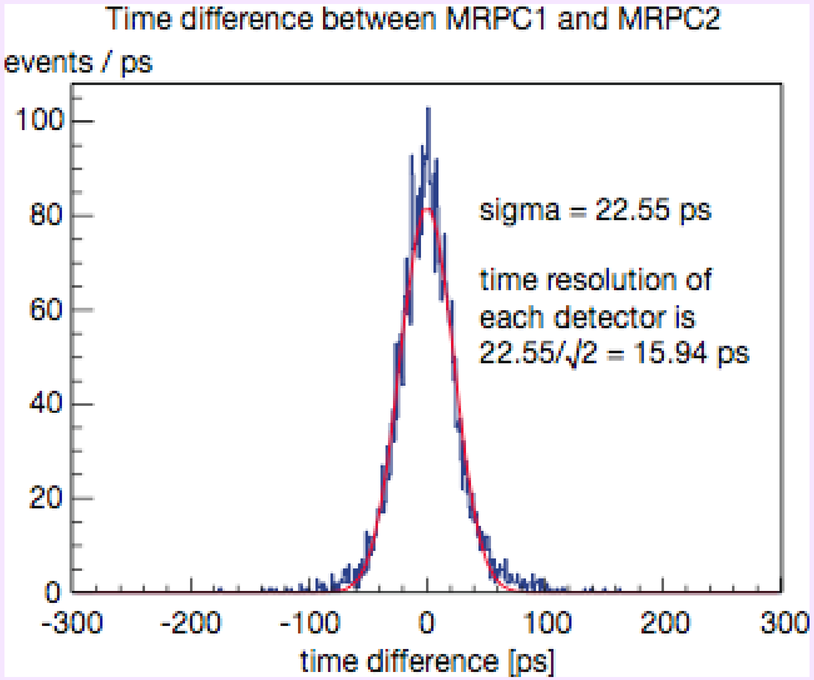




Front end electronics mounted inside gas box

Data Acquisition using LeCroy WM8300 + labview program





Improvement in time resolution due to

- Reduction in gap width
- Read out of both ends eliminates position dependence
- Front end electronics directly attached to readout pads
- TDC resolution (oscilloscope) : some ps

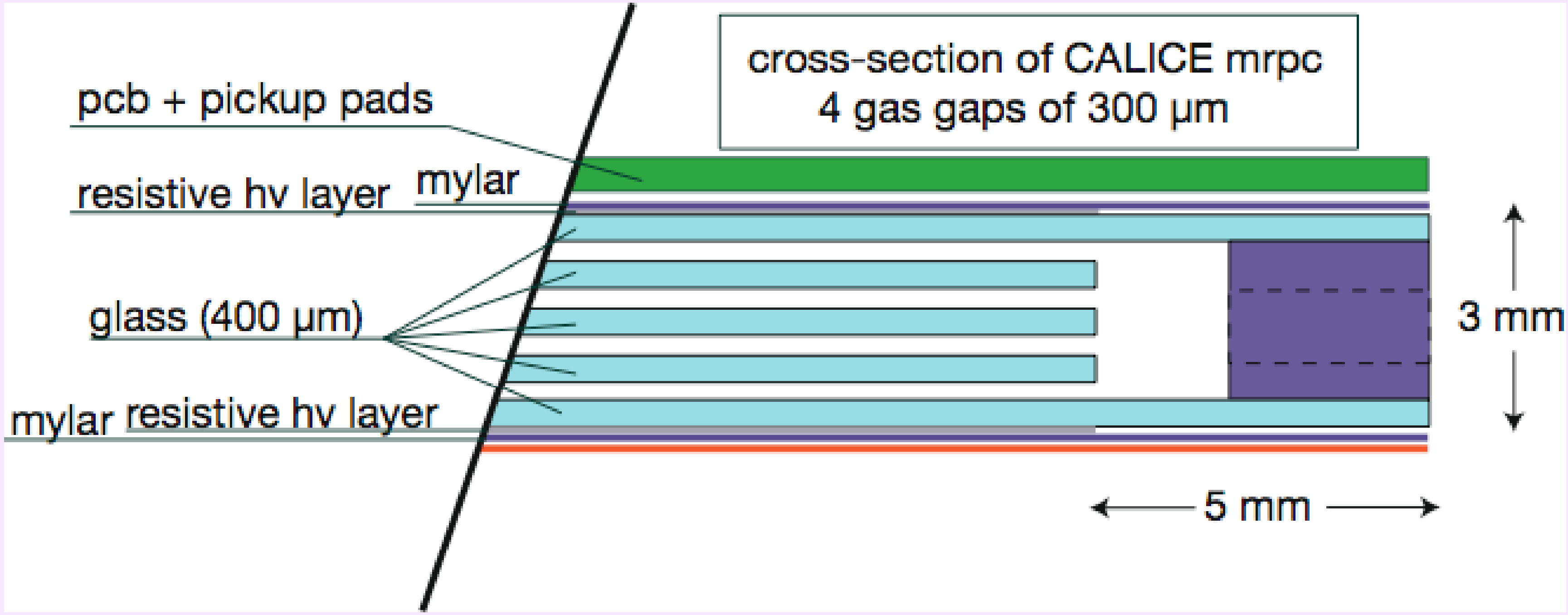
Time of each MRPC : $1/2(time_{end1}+time_{end2})$

MRPCs for the DHCAL of CALICE

Detectors under study for the Digital Hadron Calorimeter : Glass RPCs with 1 gap, MRPCs, Micromegas

Limitation : space available between iron plates

Build Multigap RPC with 1 m^2 surface and read out with 1x1 cm^2 pads



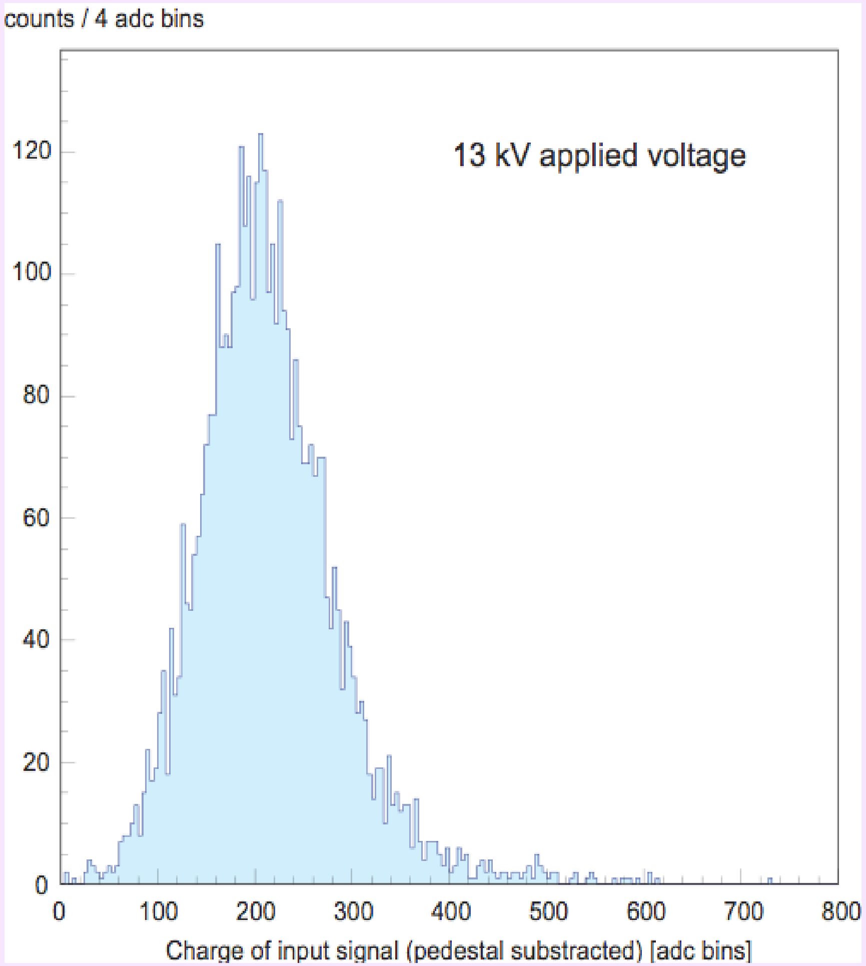
Reason for MRPC in the DHCAL

Shape of charge distribution :

- better (narrower) when many gaps, easier to set the threshold
- may be able to separate single particle from multiparticles on 1 cm^2 pickup pad

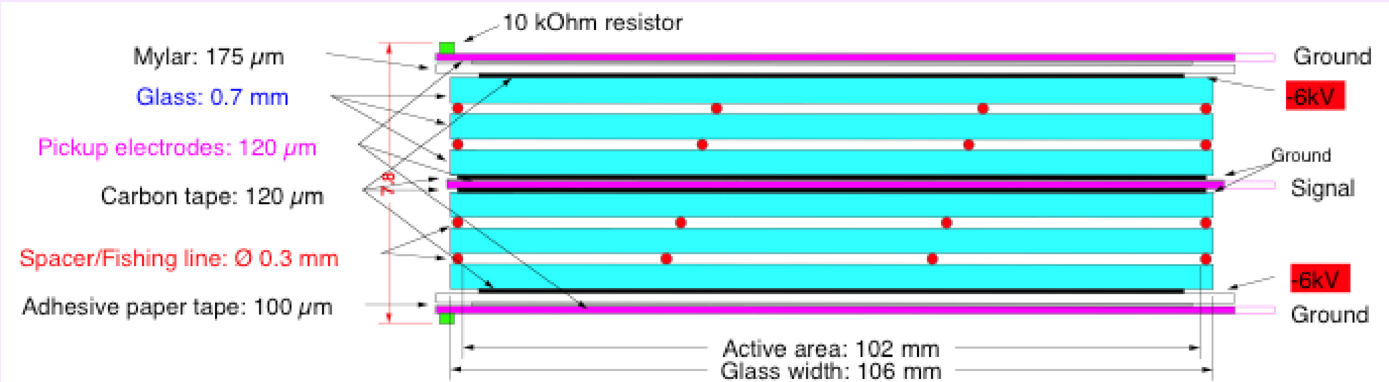
Can provide comfortably 150 ps timing

- or better (see HARP)
- can be used to assign particles to correct interaction
- (CLIC bunch crossing 0.670 ns)
- this allows to untangle overlapping hadron showers in calorimeters



THE HARP MRPC

- 4-gap glass RPC
  - Active volume:1.92m x 106mm x 7.6mm
  - Glass plates: 0.7 mm
  - Gap size: 0.3 mm (fishing line)
  - HV: -6 kV (over two gaps)
  - Central readout electrode for all four gas gaps



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RPC2003

Preamplifier connected to 8 strips (strip = 3 x 10.4 cm^2)
Time resolution in the range: σ = 140 – 180 ps

Conclusions

- The multigap RPC provides precise timing
- The design of the ALICE TOF used for PID is expected to have a system time resolution of the order of 70 ps
- MRPCs can certainly be used at CLIC for providing a time stamp of the event

- Electronic development : integration of front end NINO and HPTDC ?

reminder

- Time resolution depends on the gap width (intrinsic - detector)
- Time resolution depends on the size/geometry of readout pads/strips (time walk 50 ps/cm)
- Efficiency depends on the amount of gas traversed by through-going particle