multigap resistive plate chambers

a device for use at CLIC?

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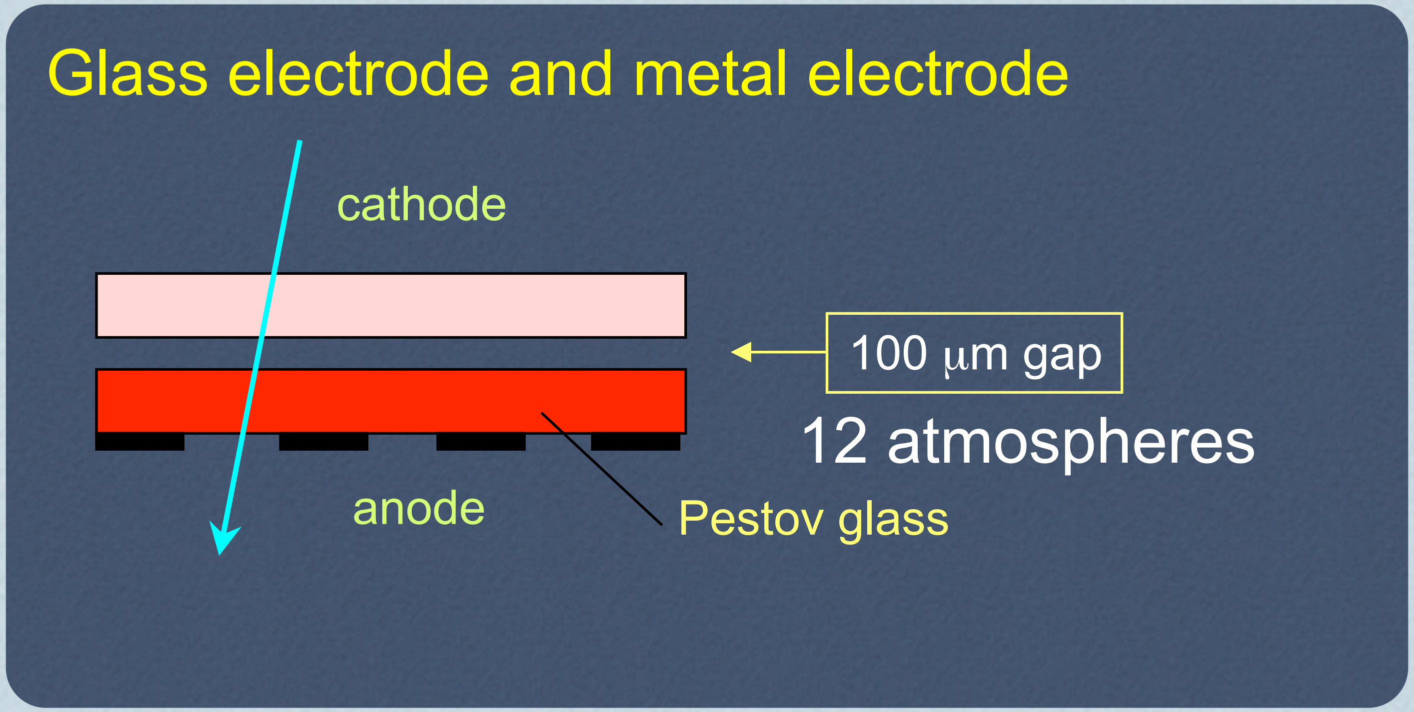
Parallel plate chambers : small widths have good timing

❖ for example: Pestof counters (-1970)

Excellent time resolution ~ 50 ps or better!



multigap rpc : instead of one small gas gap at 12 atmospheres - has many small gas gaps at atmospheric pressure

Problems

- long tail of late events
- mechanical constraints due to high pressure
- non-commercial glass
- very special gas mixture

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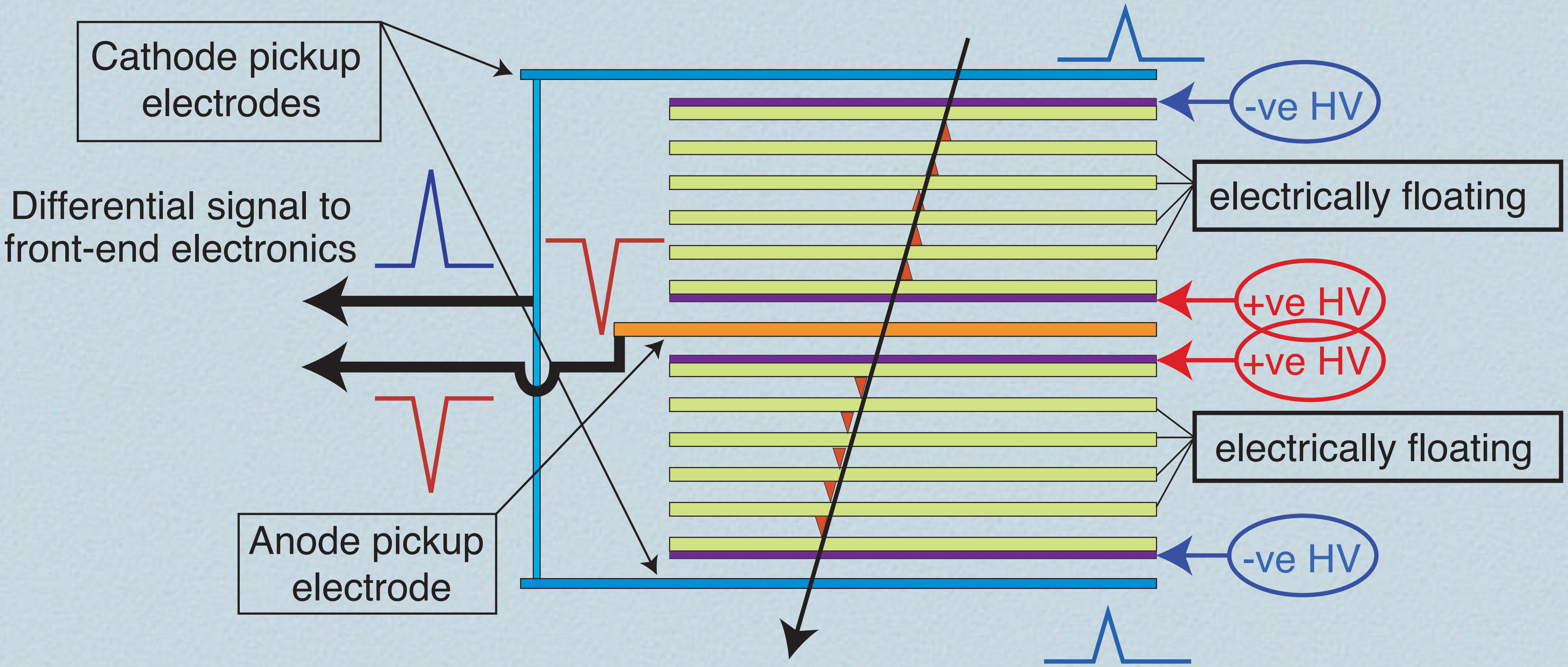
ALICE MRPC for TOF

schematic view

ALICE-TOF has 10 gas gaps (two stacks of 5 gas gaps) each gap is 250 micron wide

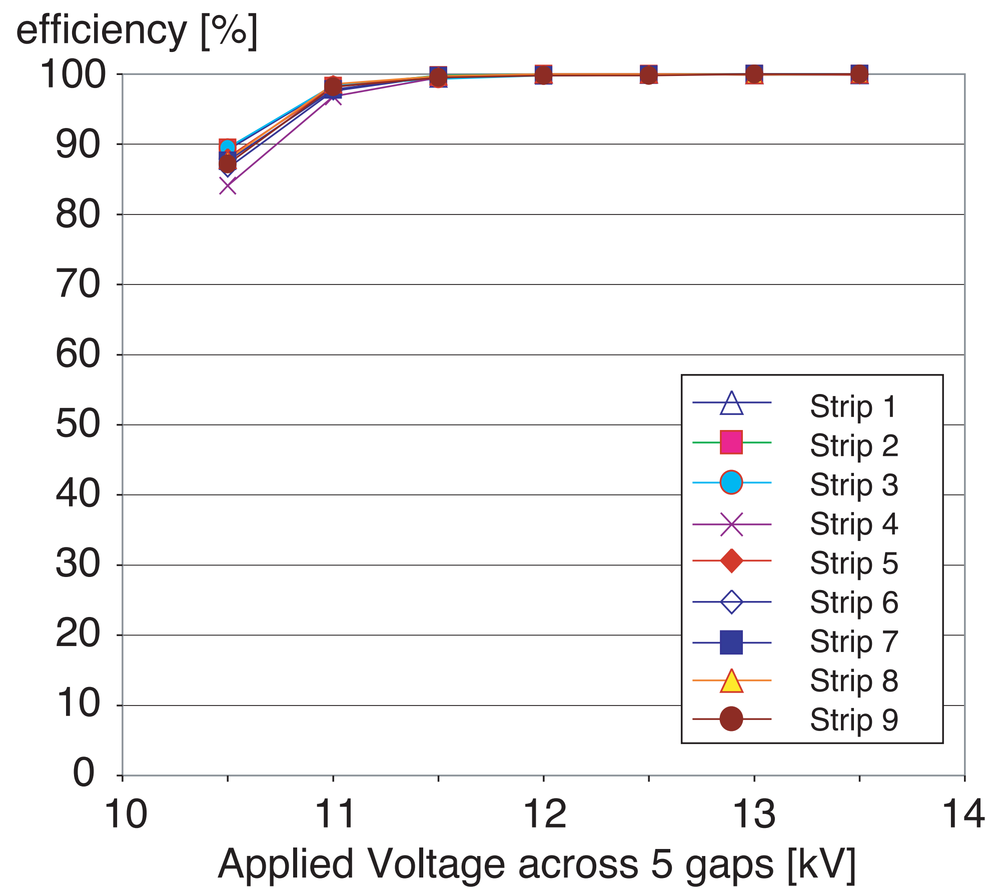
Built in the form of strips, each with an active area of 120 x 7.2 cm^2, readout by 96 pads

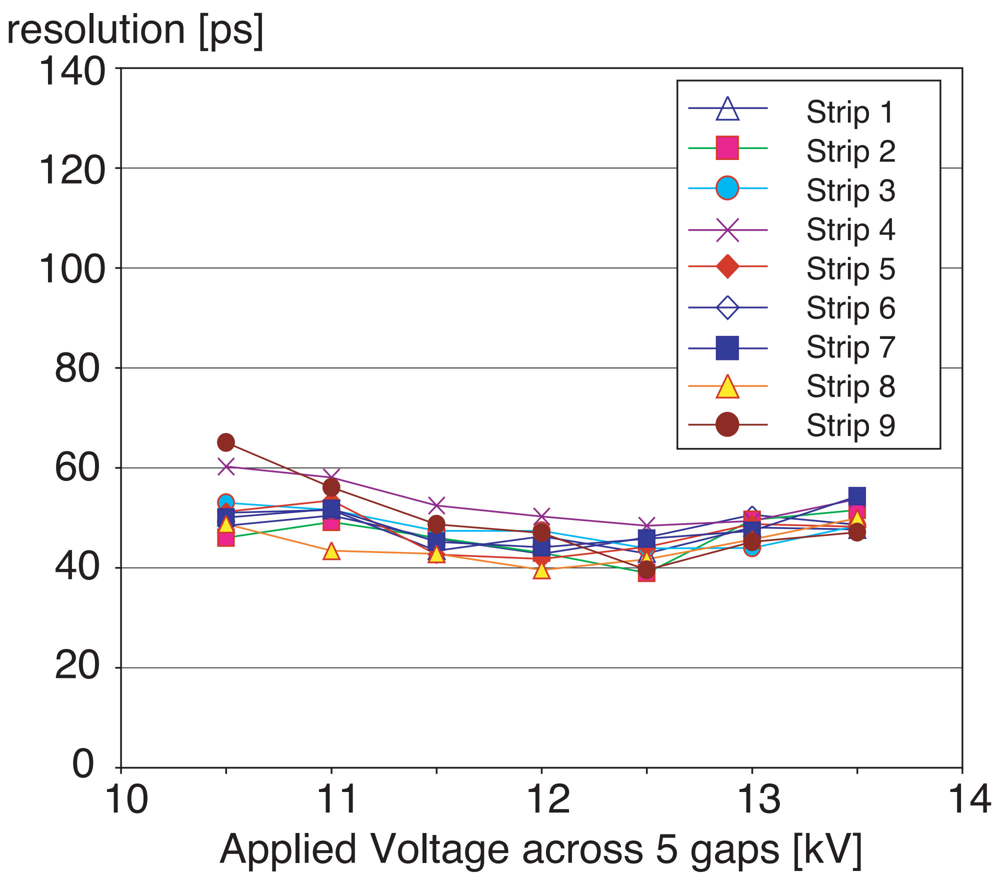


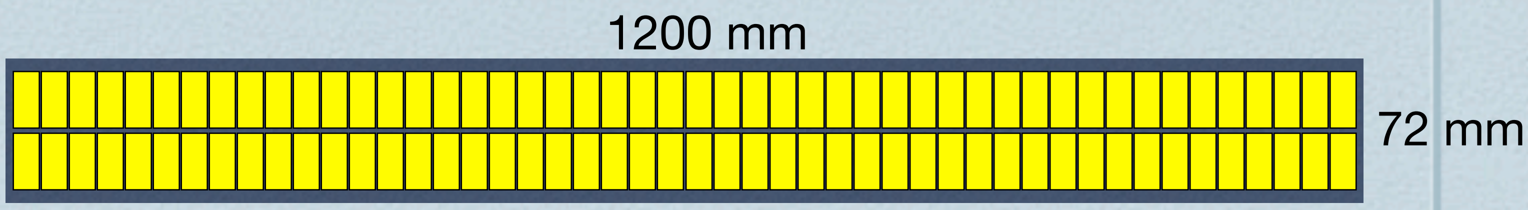
Note : HV only applied to outer surfaces of each stack of glass (internal glass sheets electrically floating) this makes it very easy to build.

ALICE Time-of-Flight array

ALICE TOF strips



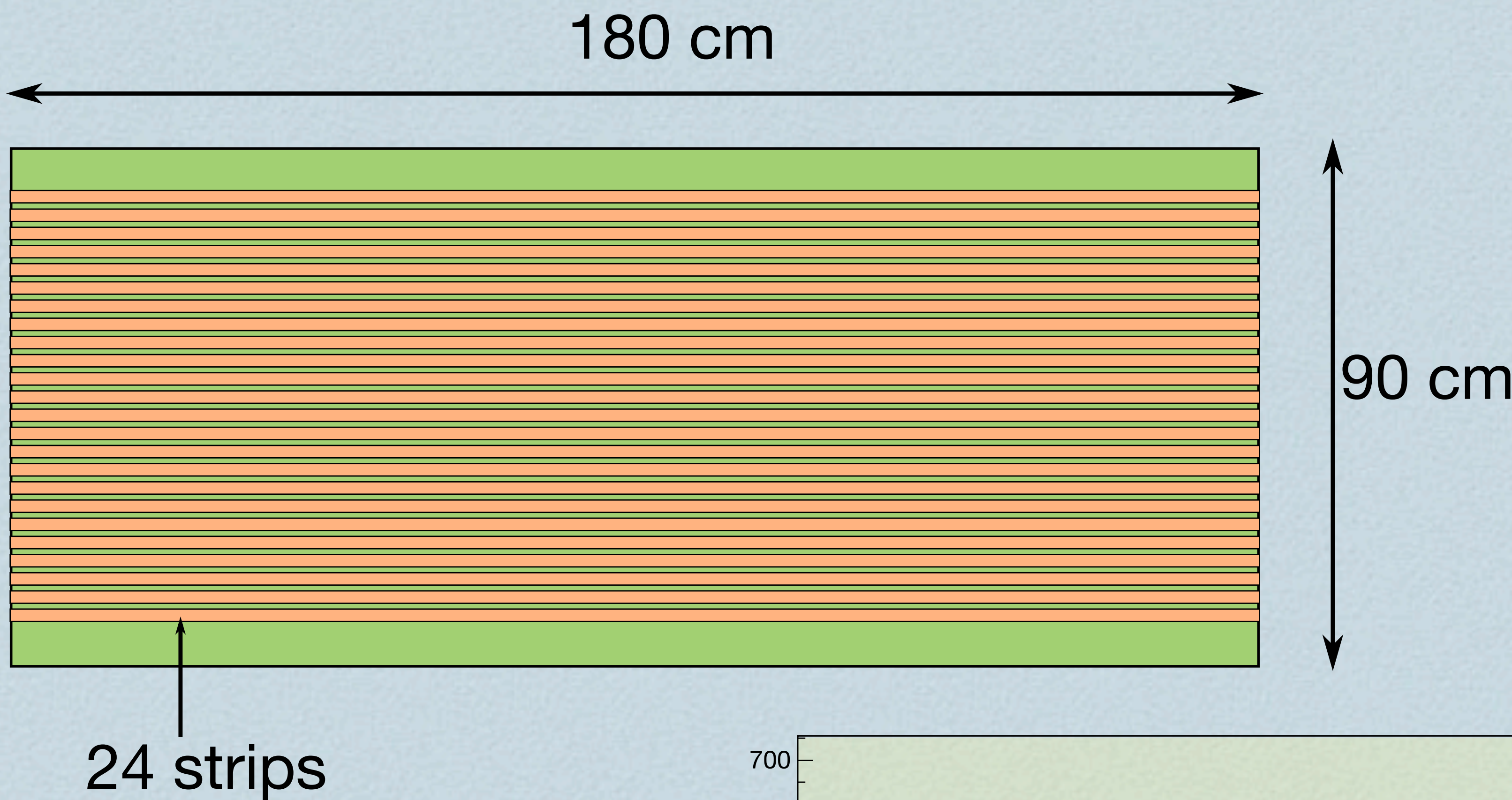


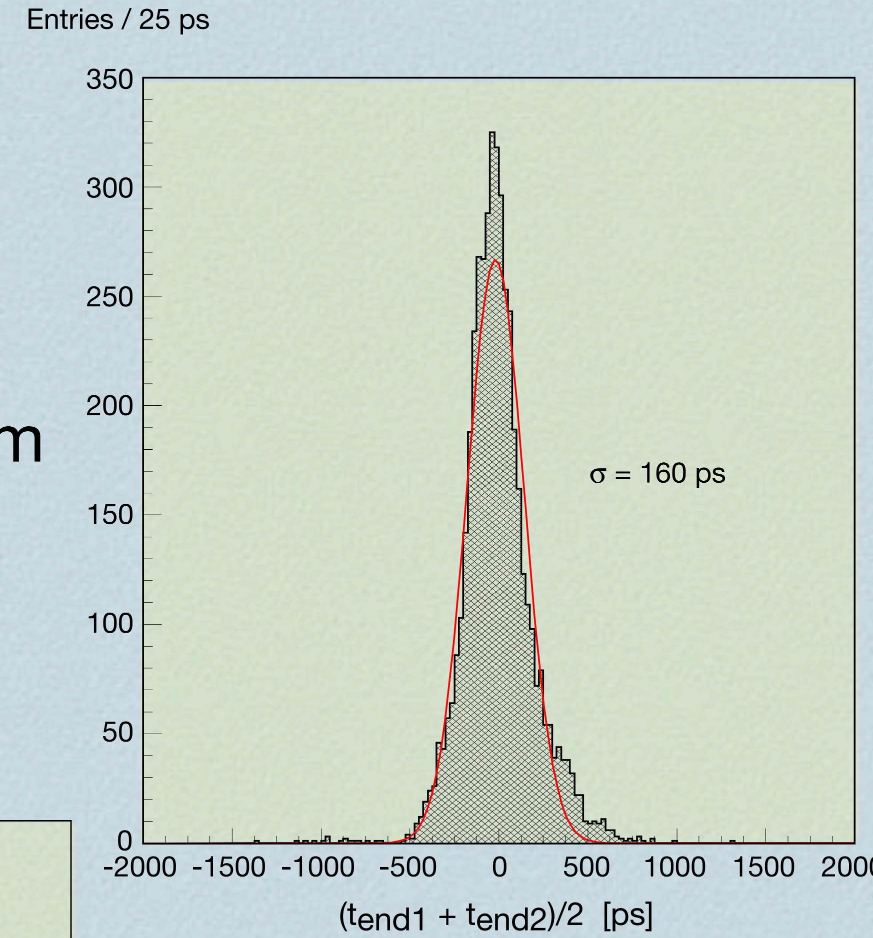


96 pads - each 25 x 36 mm^2

(a) long efficiency plateau
(b) time resolution 40-50 ps (after slewing corrections)

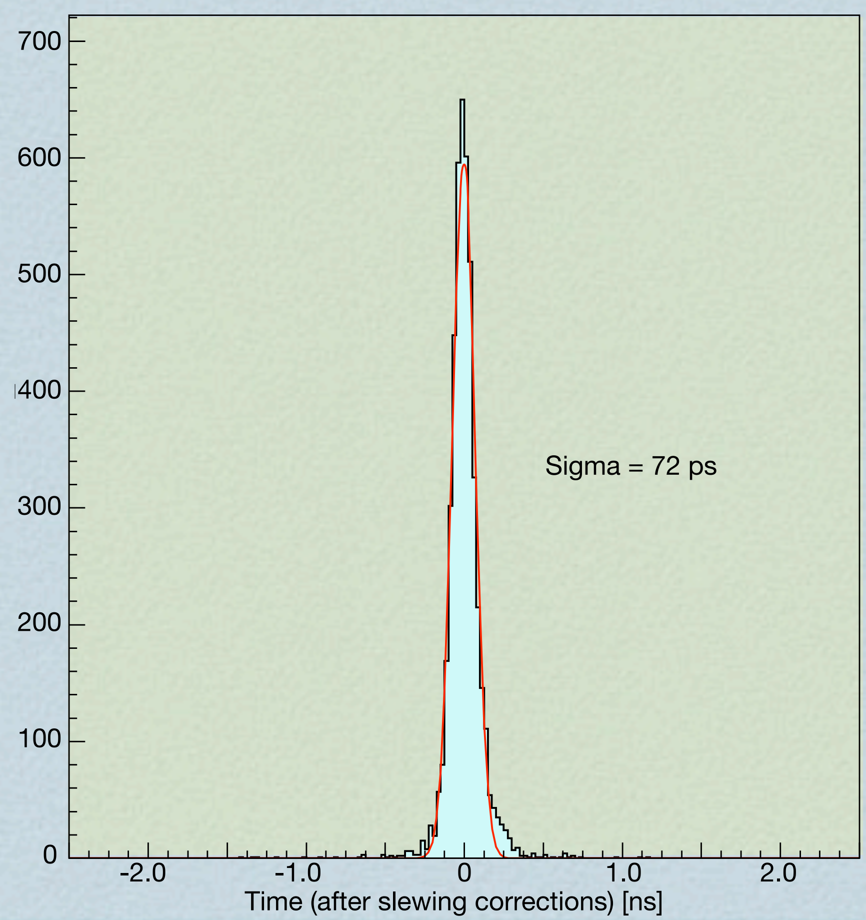
EEE planar chambers





6 gas gaps of 300 μm

after slewing corrections



no corrections

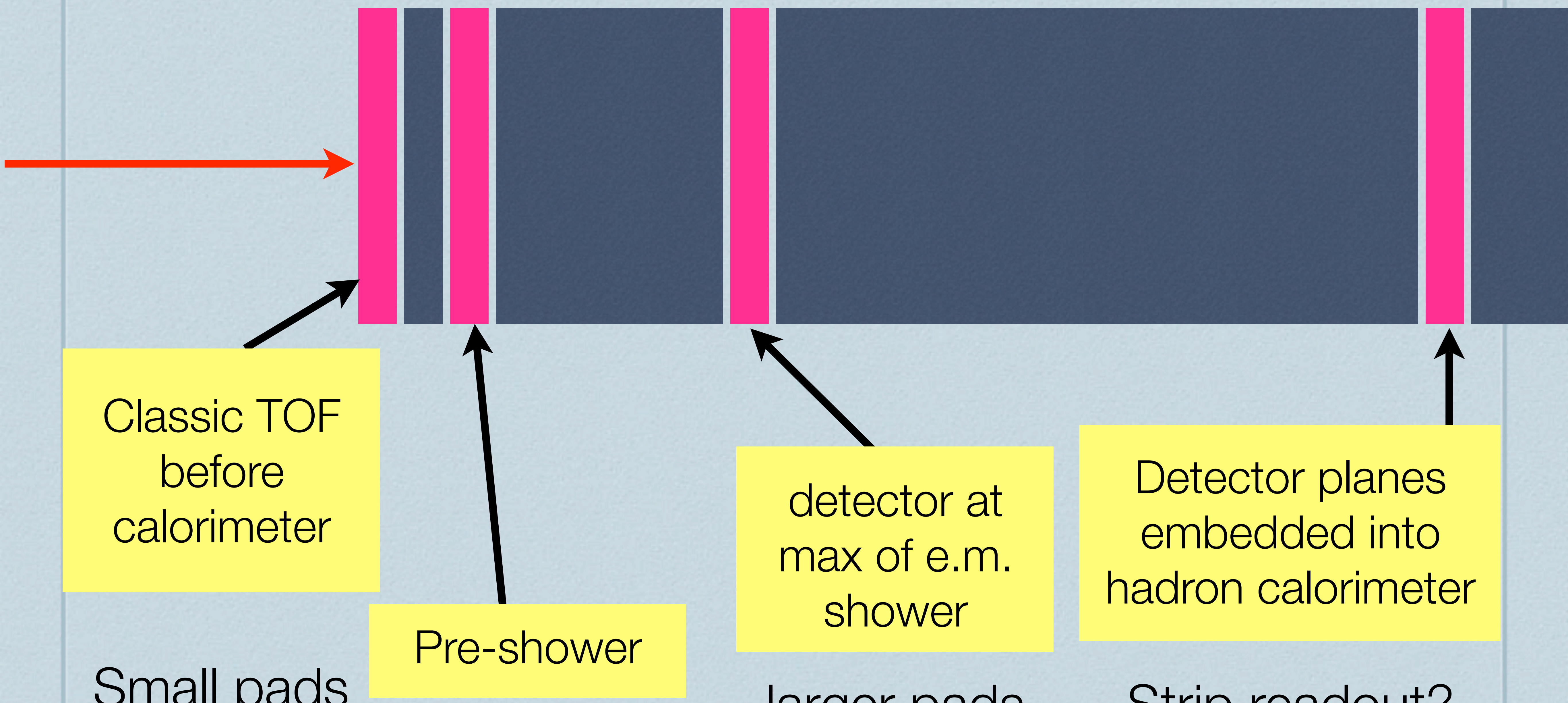
bottom line

- mrpc is a detector that has excellent timing capabilities
- easy to segment readout into whatever is convenient

CLIC - bunch crossing every 0.67 ns

- Need timing system to assign particles to correct interaction
- Untangle overlapping hadron showers in calorimeters

Various possibilities for detector with excellent timing - obviously the segmentation and required electronics will depend on expected use



Small pads high eff.

larger pads low efficiency

Strip readout? low efficiency

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Electronics

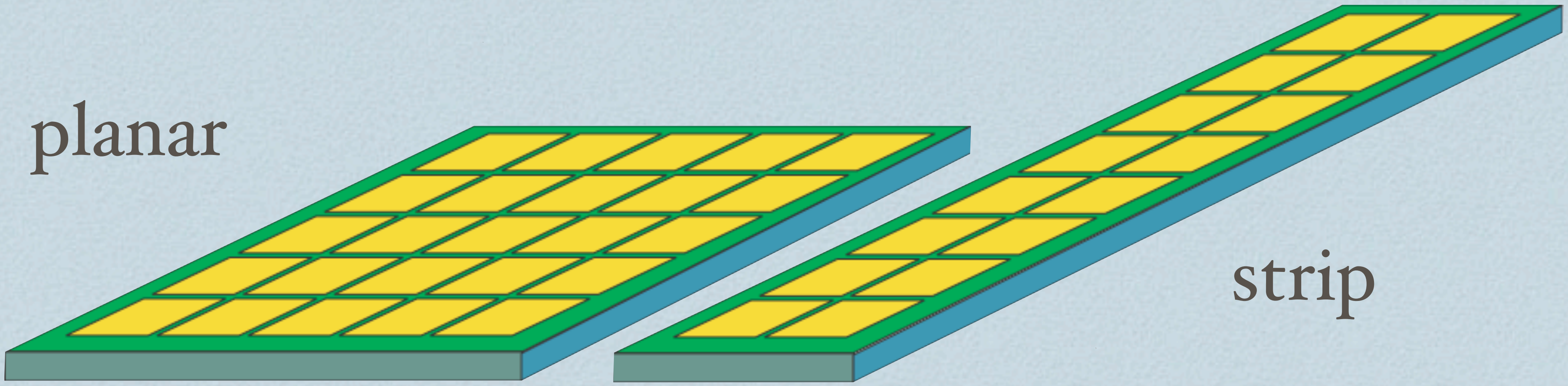
For the ALICE TOF we use the NINO asic - developed at CERN (Jarron+Anghinolfi+...)

- Fast (1 ns peaking)
- low power (45 mW channel)
- differential architecture throughout, output width related to input charge (time over threshold)

Time Jitter (noise)

Minimise noise : good detector design as well as good electronics

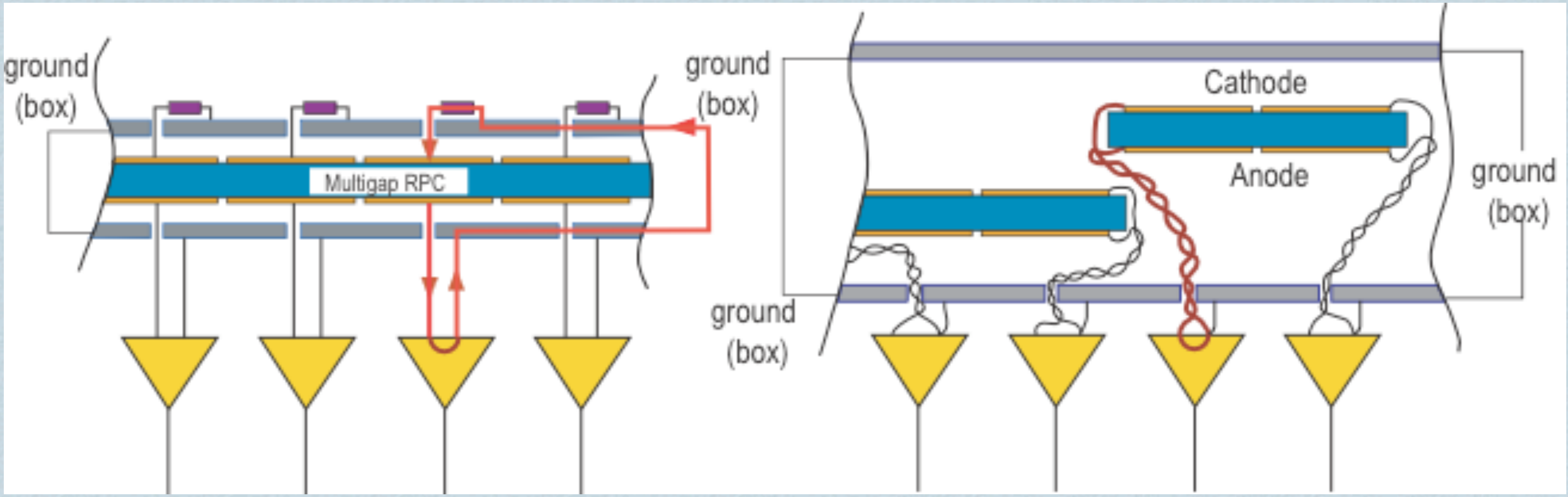
Consider the case of the planar versus the strip MRPC detector



ALICE TOF: Strip has some advantages concerning the geometry but very large advantage for the readout electronics

Differential readout

Big reduction in noise if care is taken with the signal return



Measure signal w.r.t ground box

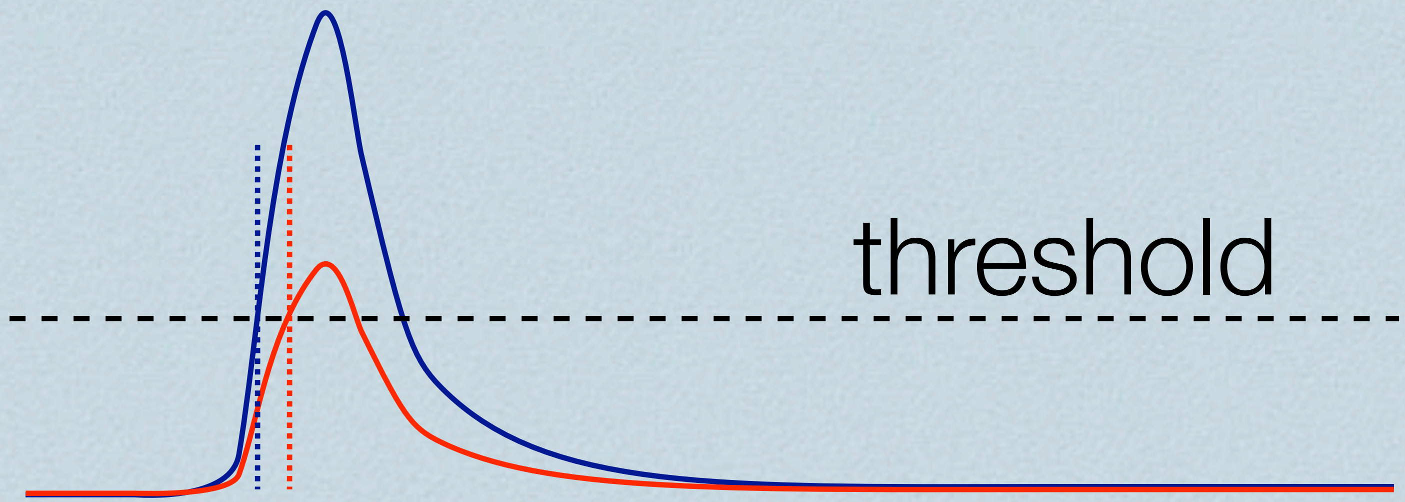
Measure signal on anode pad w.r.t signal on cathode pad

Think hard about differential architecture to minimise noise/time jitter

✓ NINO : differential architecture throughout

Time slewing

time delay introduced by fixed thresholds and finite signal rise time

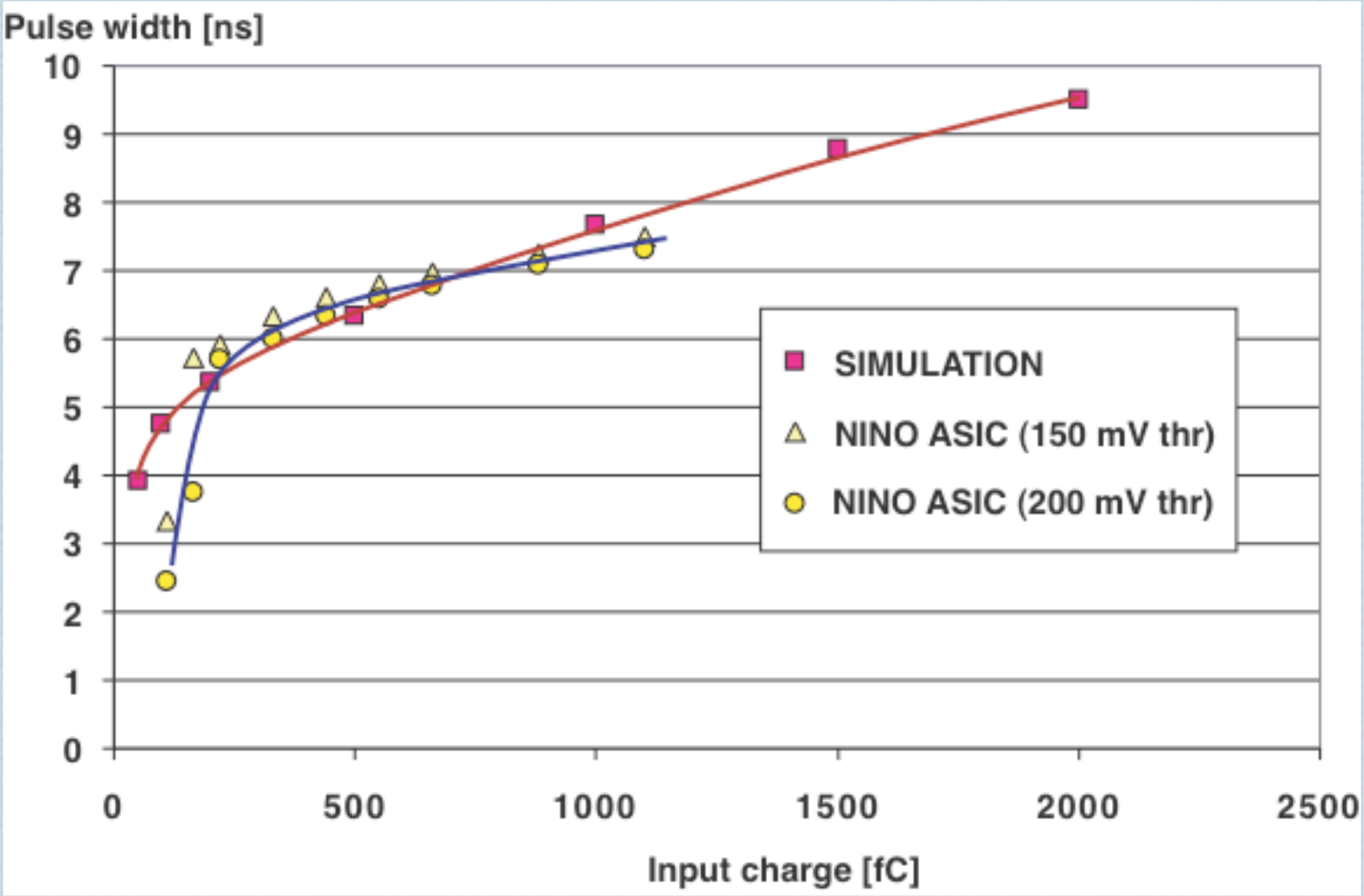


correct by either:

(a) measuring pulse height and applying correction offline

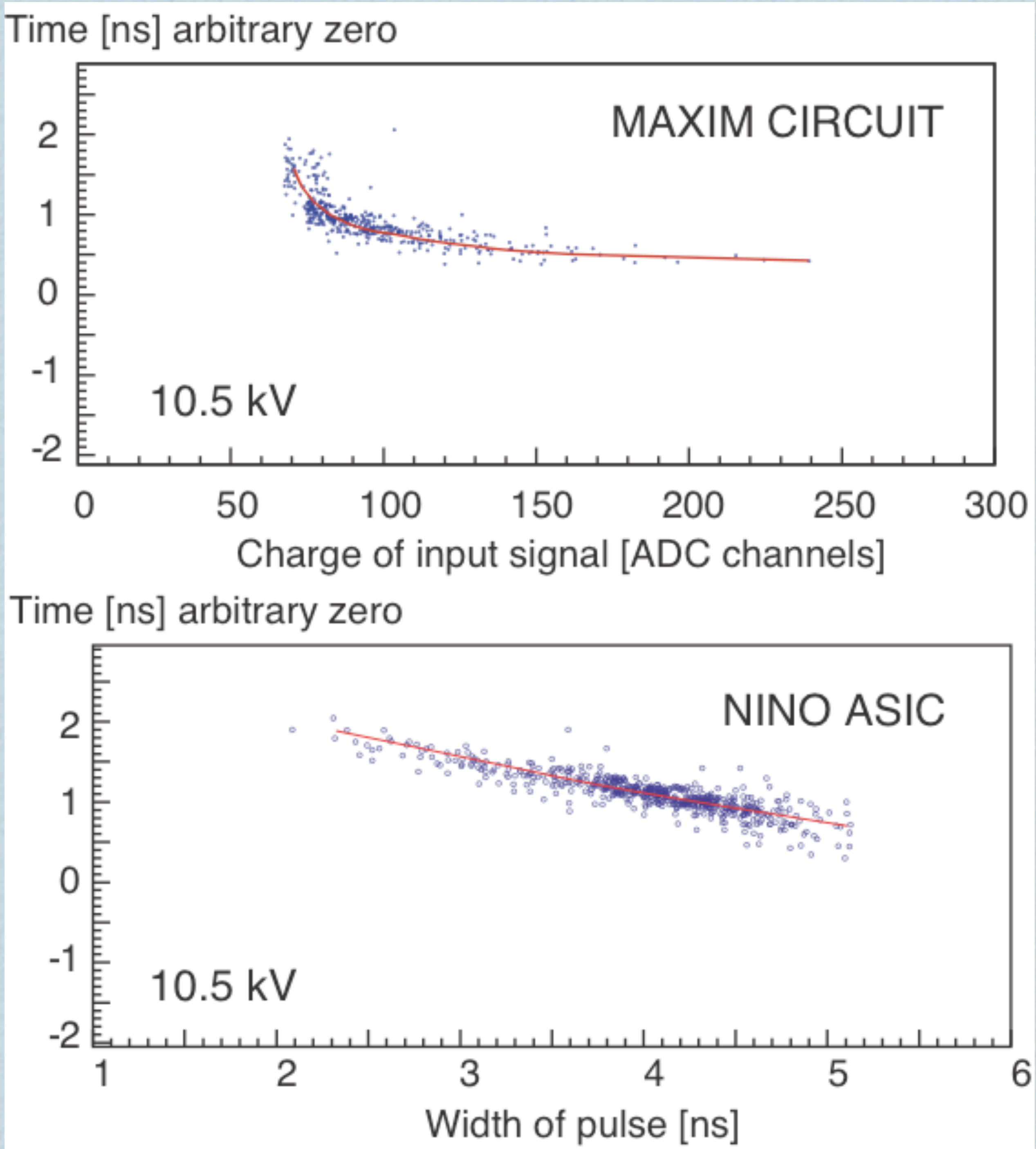
(b) build front end with correction circuit (constant fraction discriminator)

NINO ASIC -non linear relation ship between input charge and width



just what we need

slewing correction continued

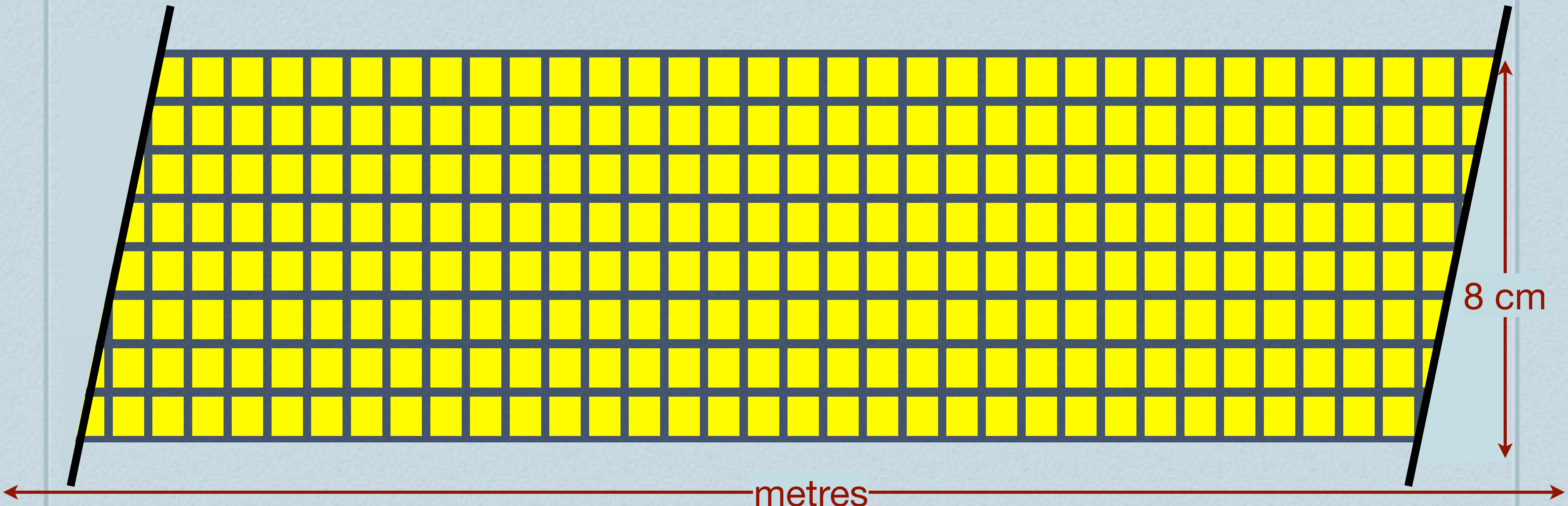


classical slewing correction
using ADC

slewing correction
using non-linear TOT (NINO)

R&D questions

For example : consider building long strips with 1 cm^2 'pixel' readout



details of detector and electronics depends on what is exactly needed
but 10,000 pixels/m^2

Detector Questions

What time resolution is desired?

200 ps is somewhat trivial while 25 ps possible with difficulty

Small gas widths give better time resolution - but need more gaps to keep efficiency high

More gaps - more material

What segmentation needed?

need differential readout for good time resolution (ie access to anode and cathode pad/strip)

Some R&D topics

resistive plate materials

very thin glass (50 micron?) or other materials?

gas : use very heavy gas

detector design (# gaps, width of gap, pads/strips, ...)

Electronics R&D

Front-end electronics

- NINO asic good start -
- decrease power consumption
  NINO I 45 mW/channel
  NINO II some mW/channel
- slewing correction - built-in (CFD) or offline?

Timing - ALICE (and others) uses HPTDC that uses ‘time stamping’ (in my opinion this is the way to go)

however

- precise timing uses power - what time resolution is really needed?
- should each input channel have its own tdc - or is an OR of 64 channels (for example) sent to a single tdc channel (slewing correction built into front end electronics)
- mega-channel systems - front end and tdc should be integrated onto single asic

conclusion

- MRPC provides precise timing - could (and should) be used at CLIC - (variation with low efficiency (suitable for embedding in calorimeter) and coarse timing)
- Front-end electronics could be developed that would be perfect - but now is the time to discuss details of ideal device
- TDCs - time stamping technique and should be integrated with the front end electronics ..

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