IHEP Full Size RPC Study

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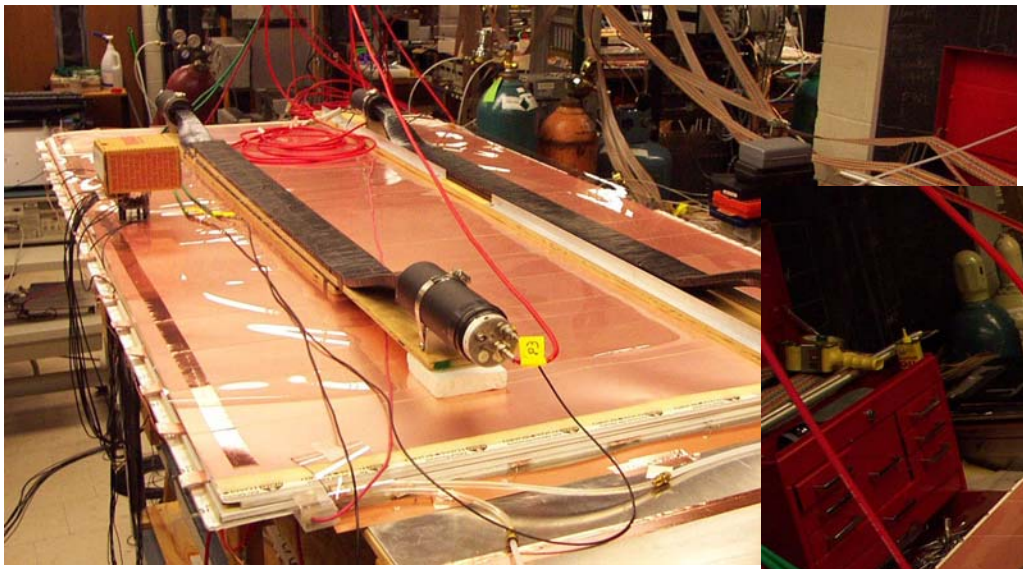
Outlines

- Test setup;
- Double gap RPC;
- Dark current;
- Cross talk on neighboring strips;
- The effect of strip termination on the pulse shape;
- Charge spectrum, Q vs HV;
- Efficiency plateau;
- Strip termination study;
- Single's rate;
- Reconstructed cosmic ray hit map.

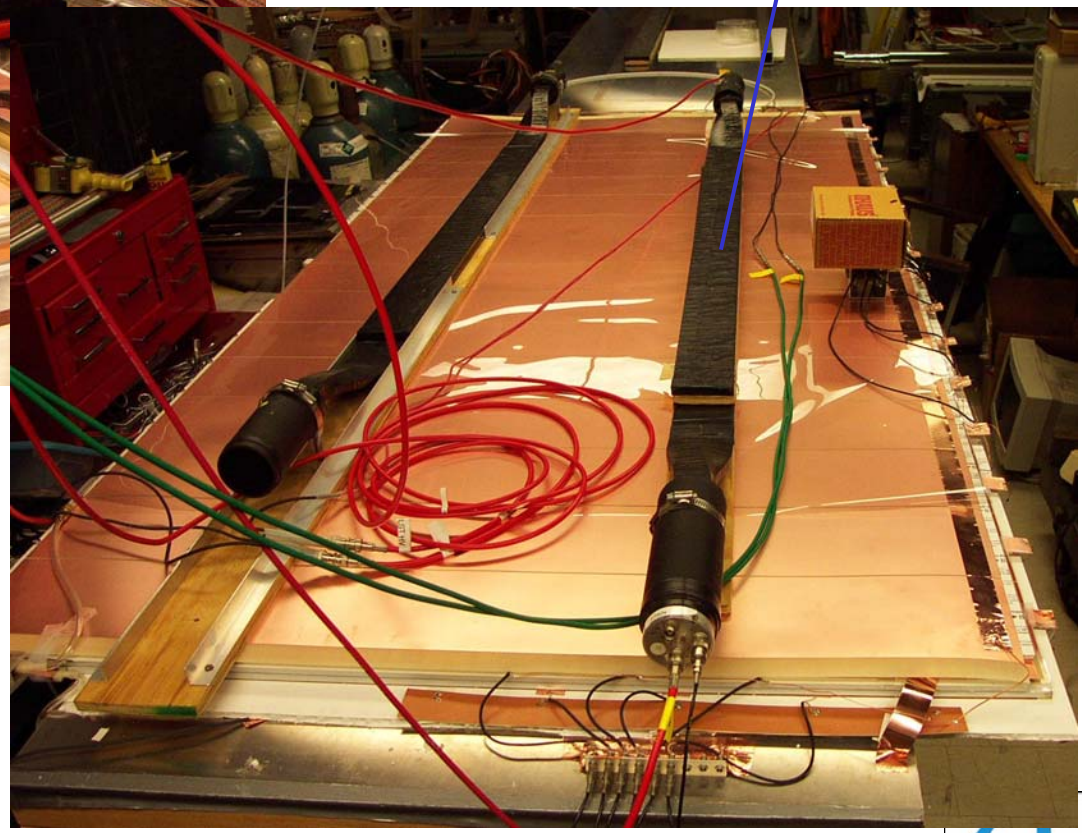
Test setup and gas mixture



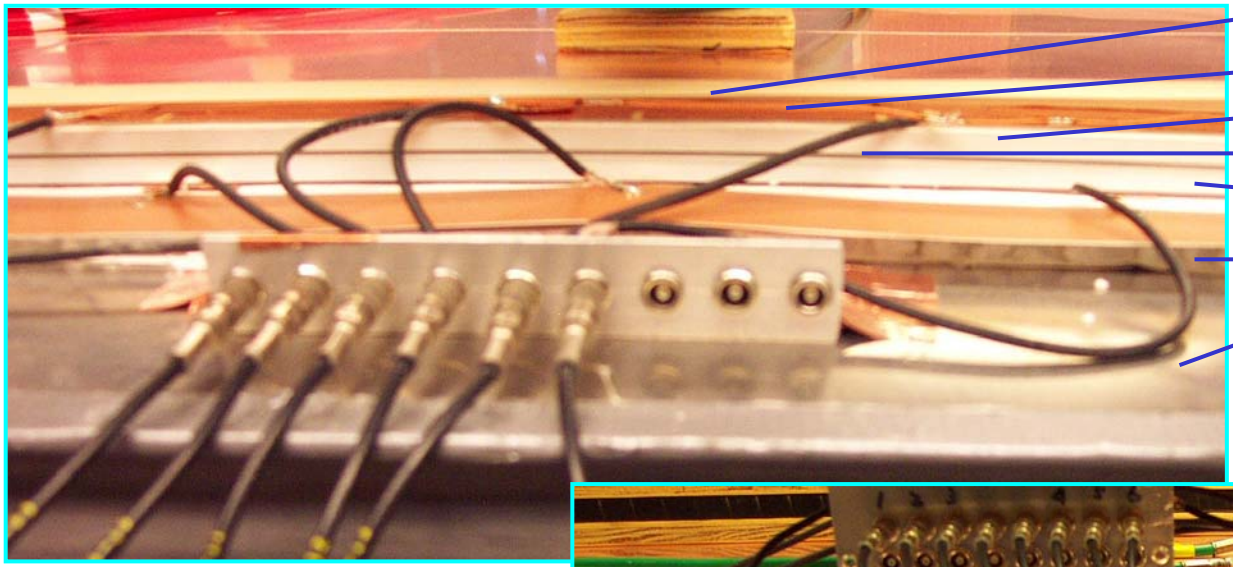
Double-gap RPC

Trigger counters

(7.2cm wide, 100cm long, 1cm thick)



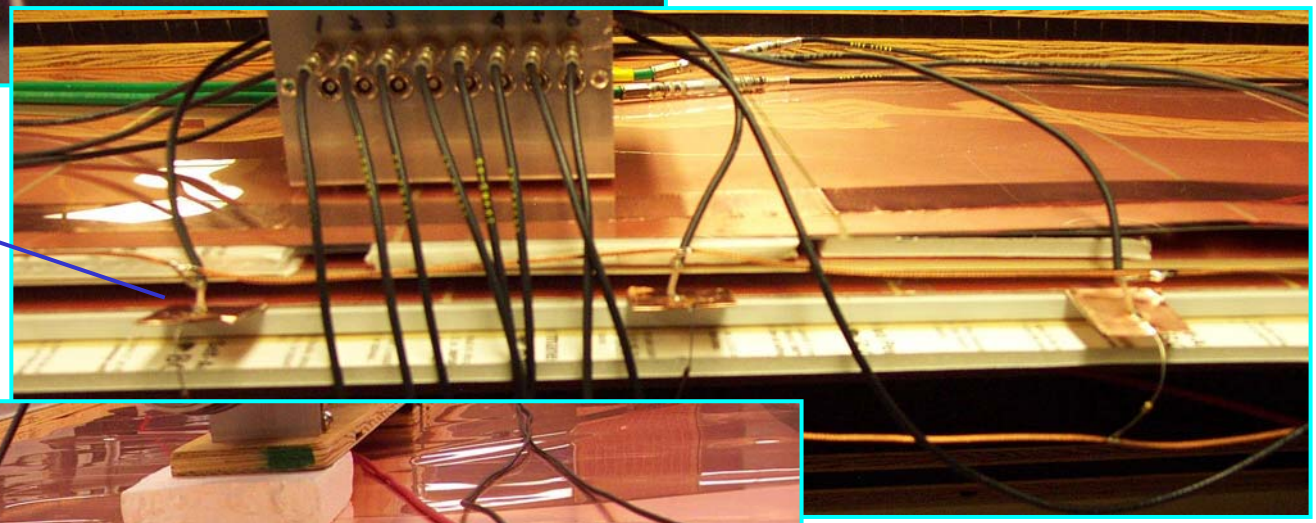
The gas mix and flow rate used in this test: R134A/Isobutane/Ar (10/1.9/12 sccm), e.g. the mixing ratio is (41.8/8/50.2%)

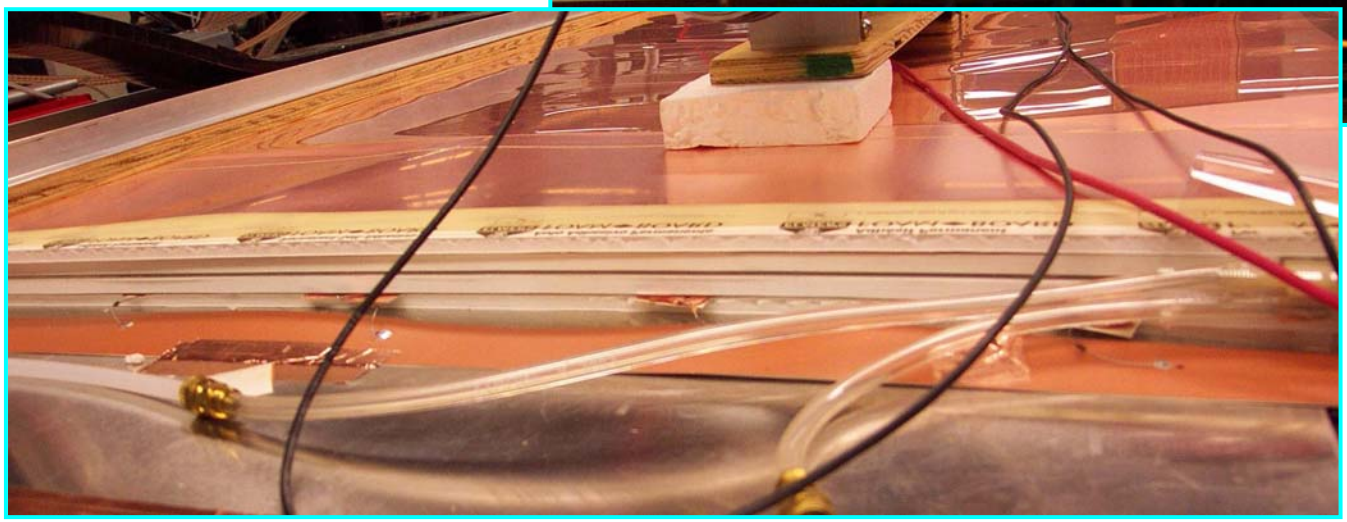


Horizontal near end

Side view

Middle strip plane

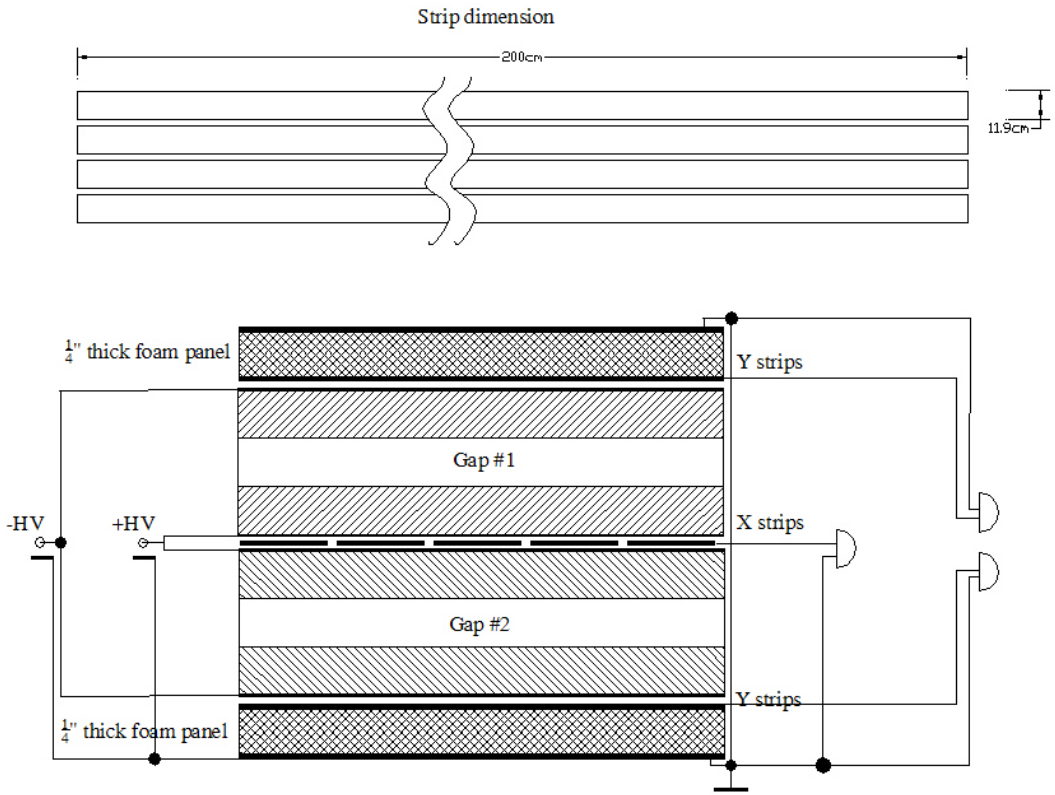




Horizontal far end

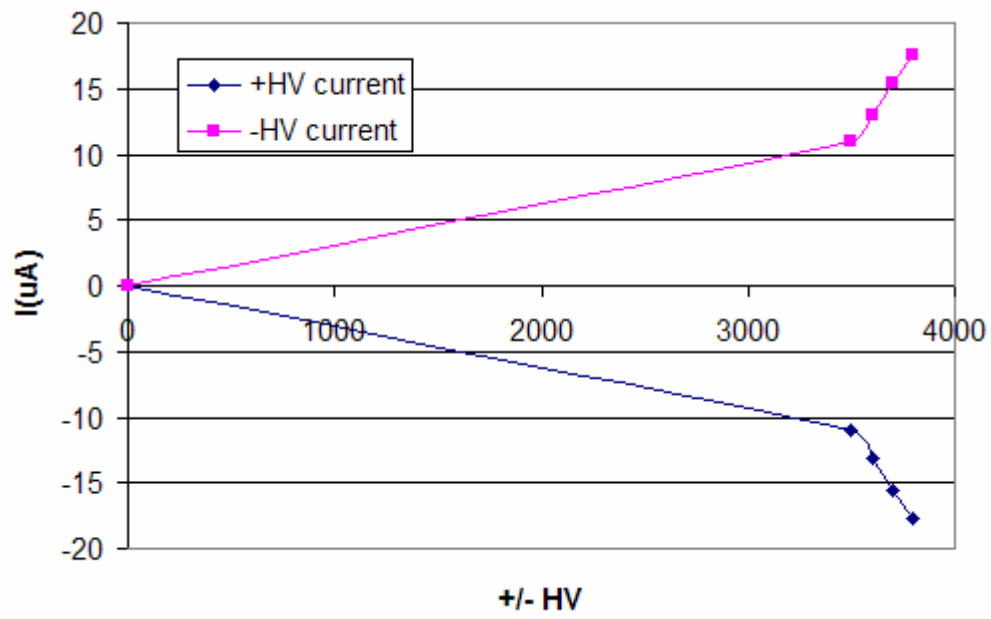
Double-gap RPC

Strip dimension and double gap RPC structure:



Drawing currents from +/- HV supplies

The drawing currents from +/-HV supplies (Bertan) are almost identical, it indicates that there is no leakage current through outside surface of the RPCs. Otherwise it would show the unbalance +/-HV currents.



Cross talk on neighboring strips

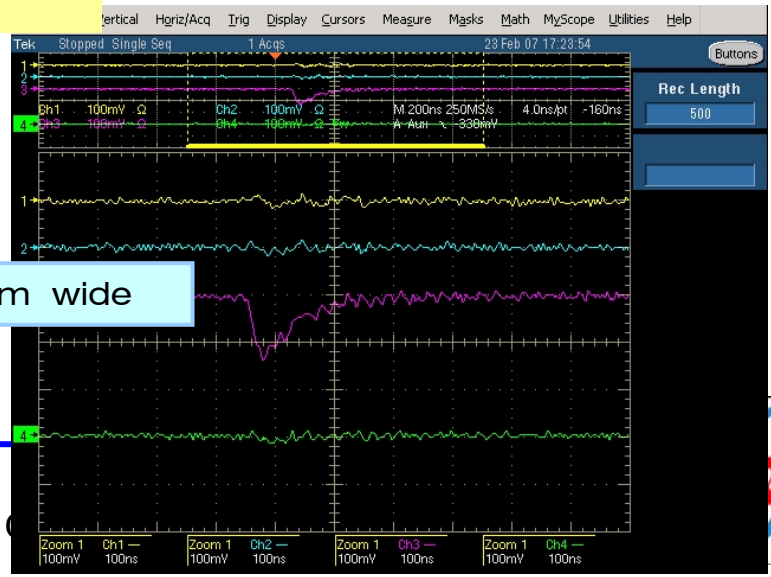
S1
S2
S3
S4

Trigger counters are located above strip #3

100ns/div,

100mV/div

Horizontal strip, 11.9cm wide

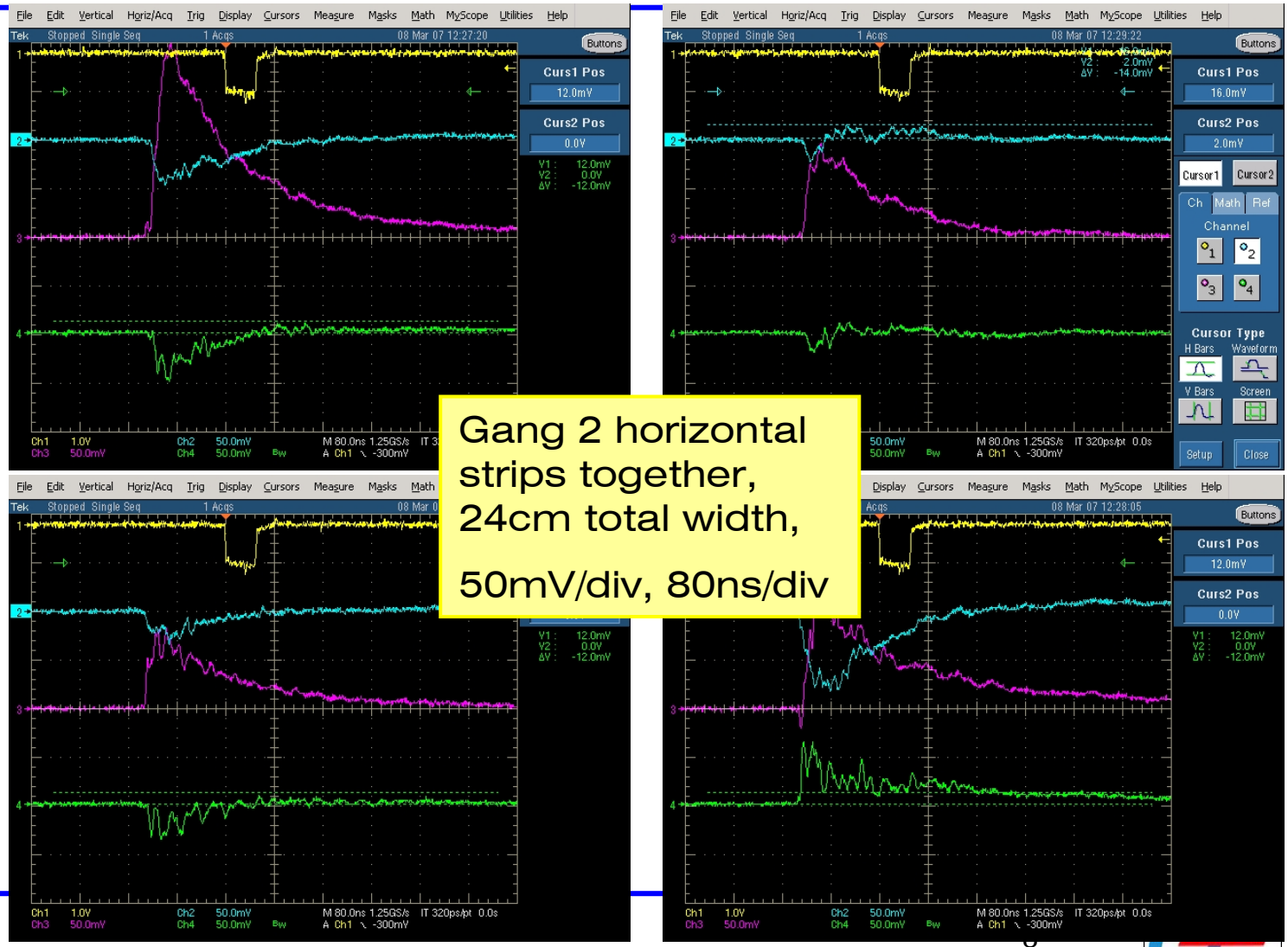


Cross talk on neighboring strips (double strip width)

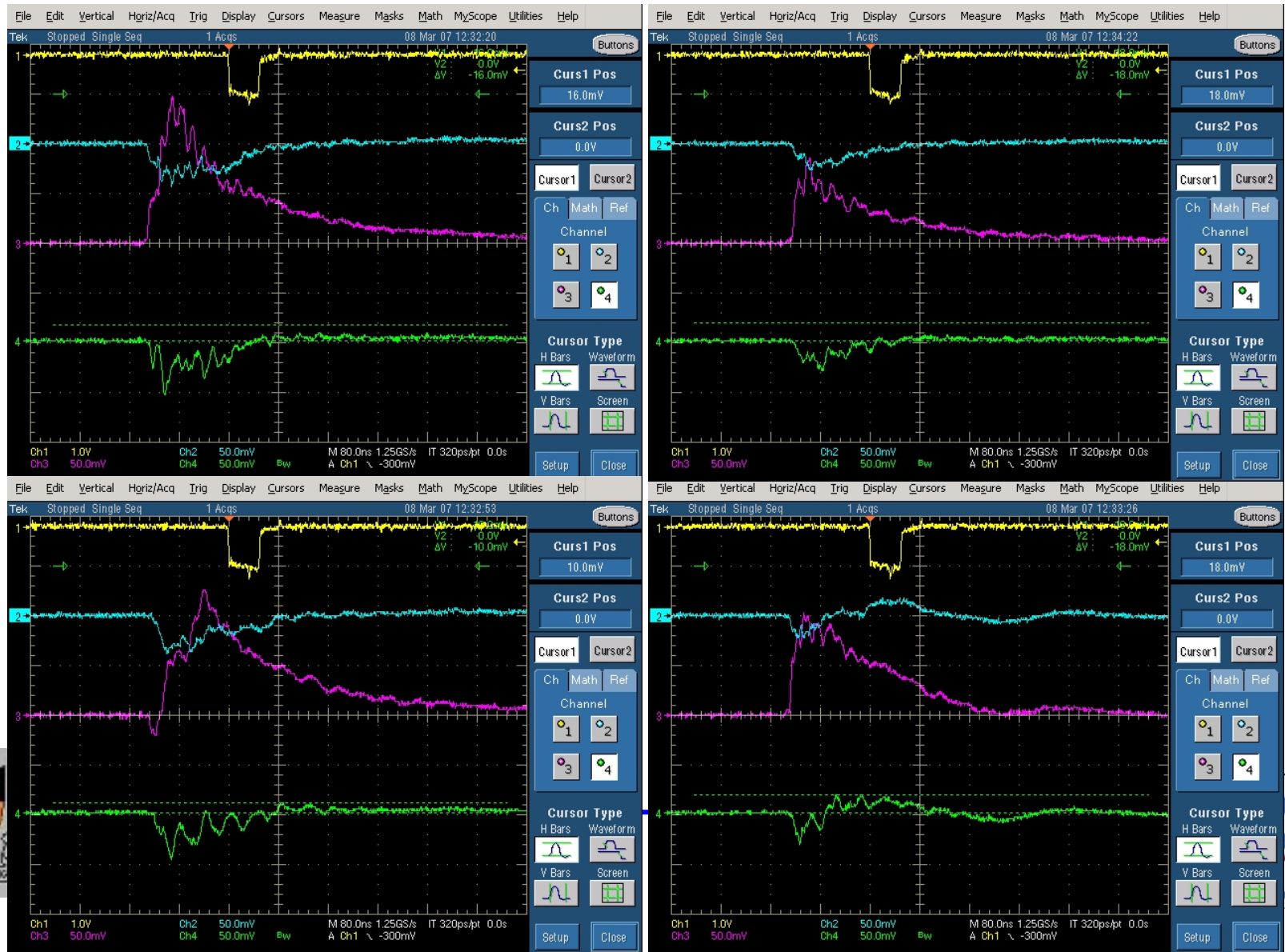
Neighboring strip

Strip aligned with trig.

Neighboring strip



More screen captures of the cross talk signals (double strip width)



... More cross talk ...

(double strip width)

When doubled the strip width, the cross talk signal changes polarity. They won't trigger the polarity defined discriminator. This is a very nice feather!

The main signal width becomes broader, amplitude smaller, but looks still large enough! Need to use discriminators to check efficiency.

Effect of the strip terminator on the signal shape

Strip far end terminated with 1kΩ

Pulse size larger!

Strip far end terminated with 18Ω

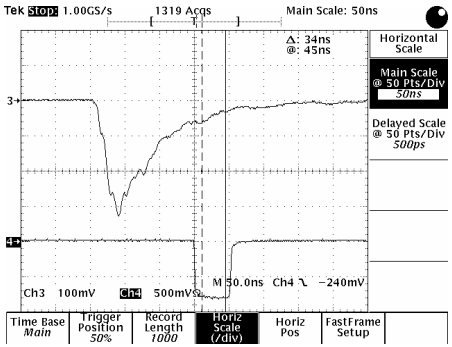
Pulse size much smaller!

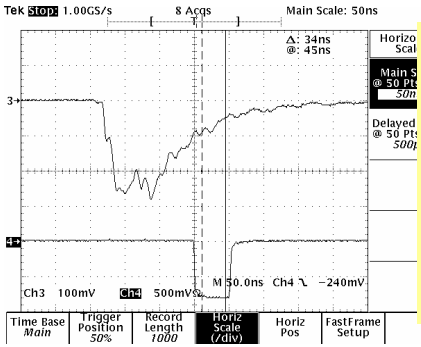
Y scale:

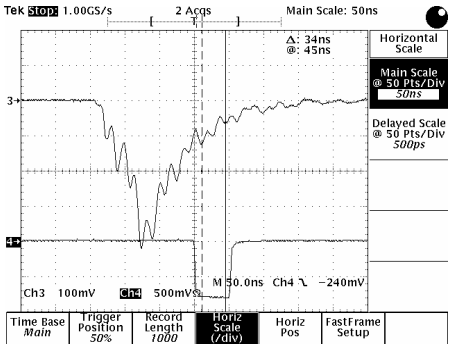
100mV/div

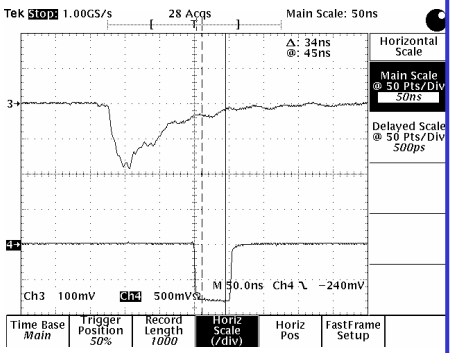
X scale:

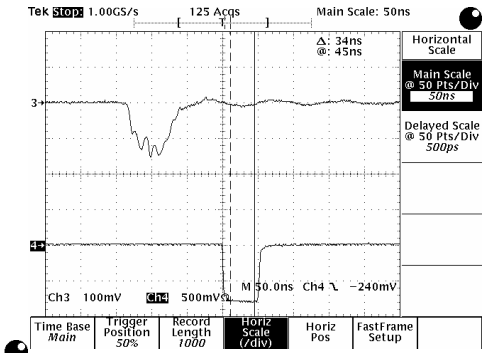
50ns/div

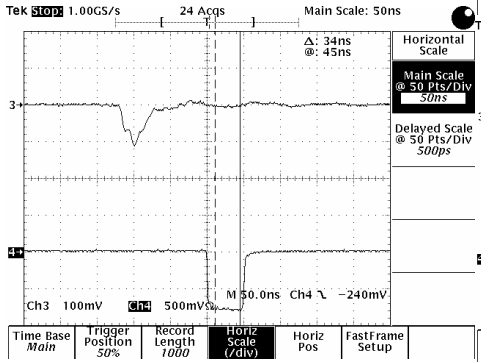


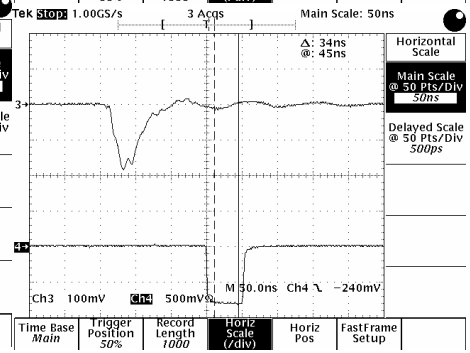








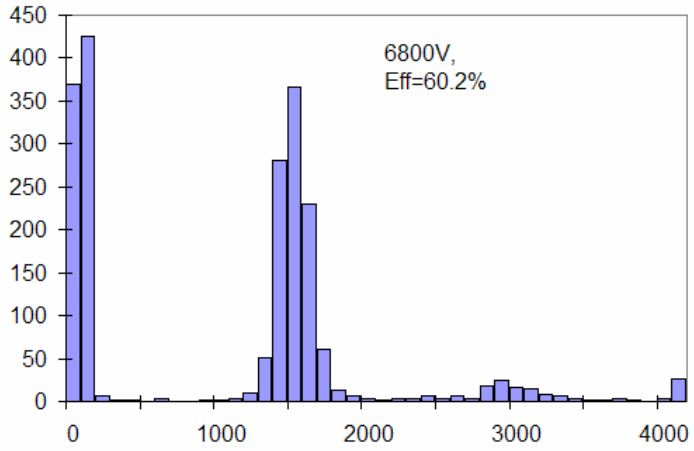


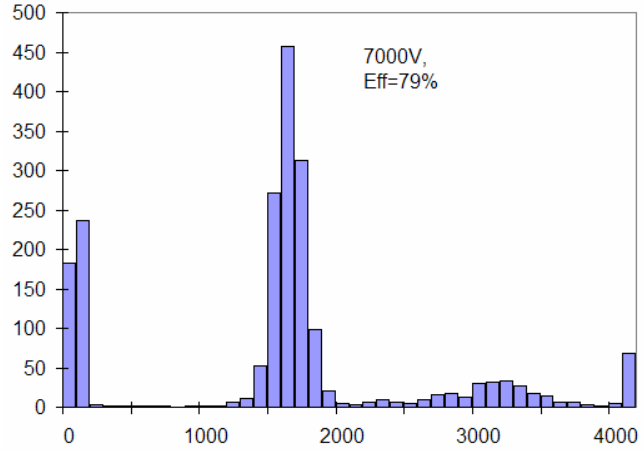


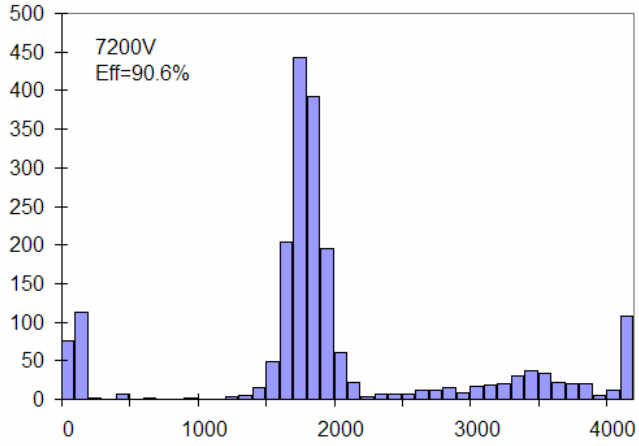
Reflection due to impedance unmatched ends

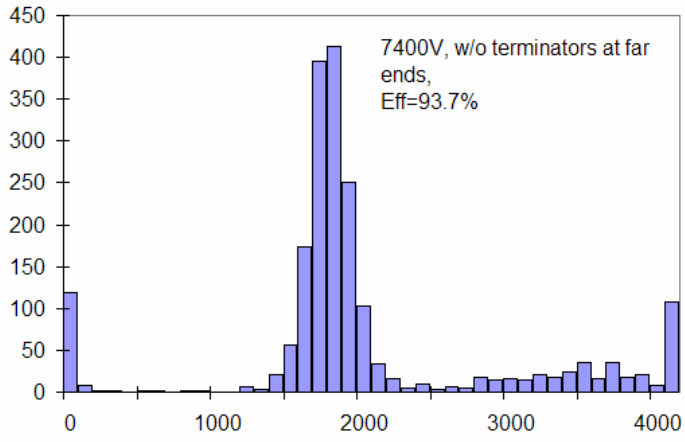
Strip far end is terminated by 1kΩ, far bigger than characteristic impedance ~18Ω. Strip length 2m, signal propagation speed ~4ns/sec, one round trip needs ~16ns, the ringing cycle is ~16~17ns.

Charge spectrum of single gap RPC



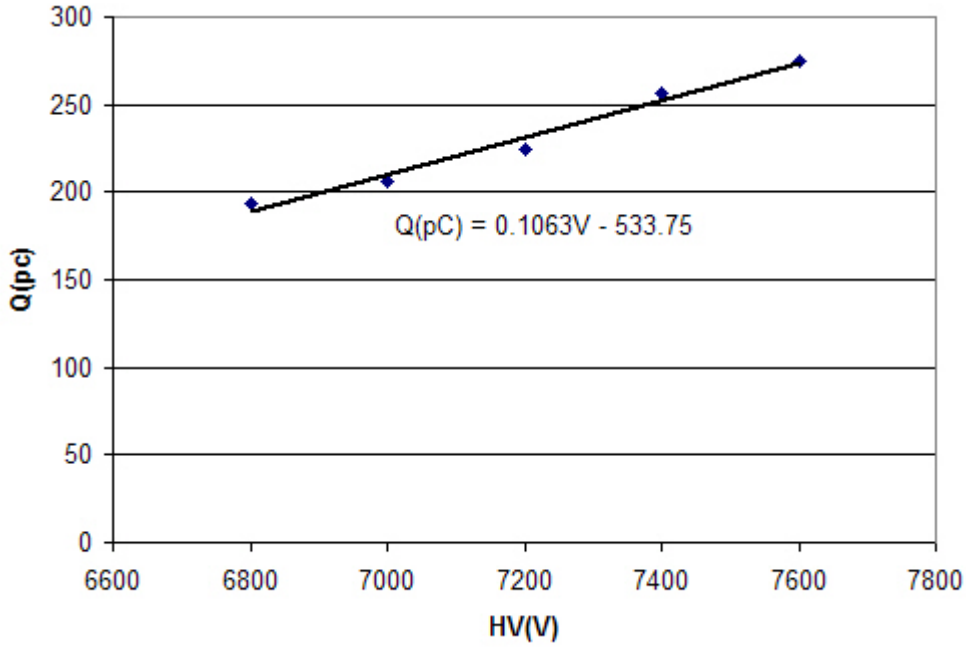






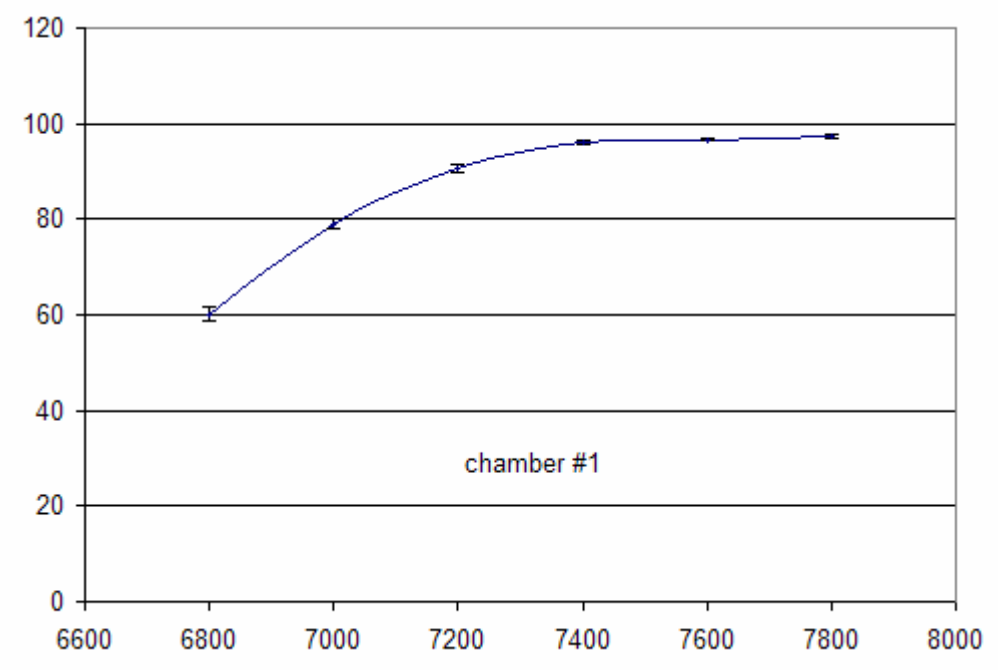
Charge vs. HV in single gap RPC

Plot the charge at the largest peak of the spectrum vs. HV:



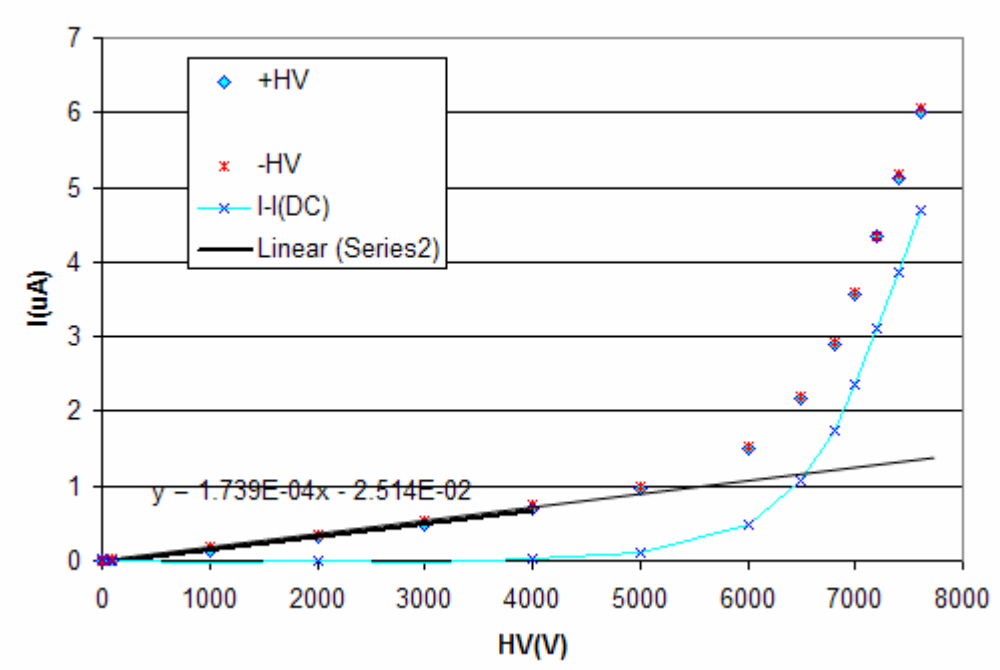
Efficiency plateau for single gap RPC

For single gap RPC at HV = 7400V it reaches efficiency plateau ~94%.



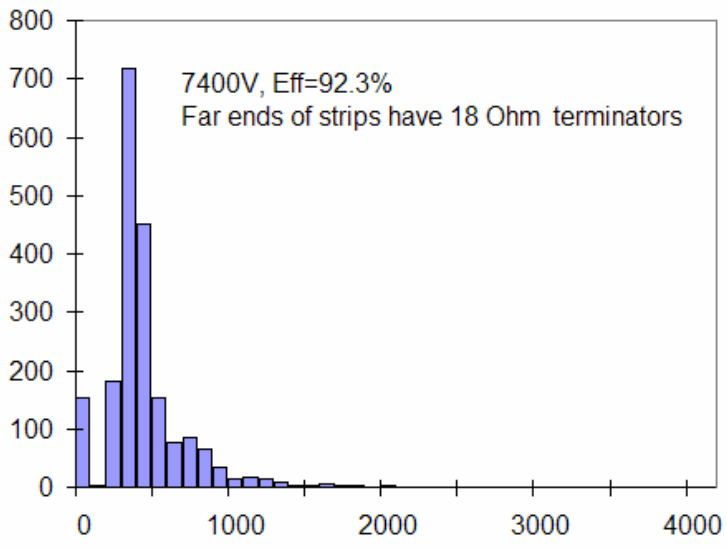
Dark current due to streamers

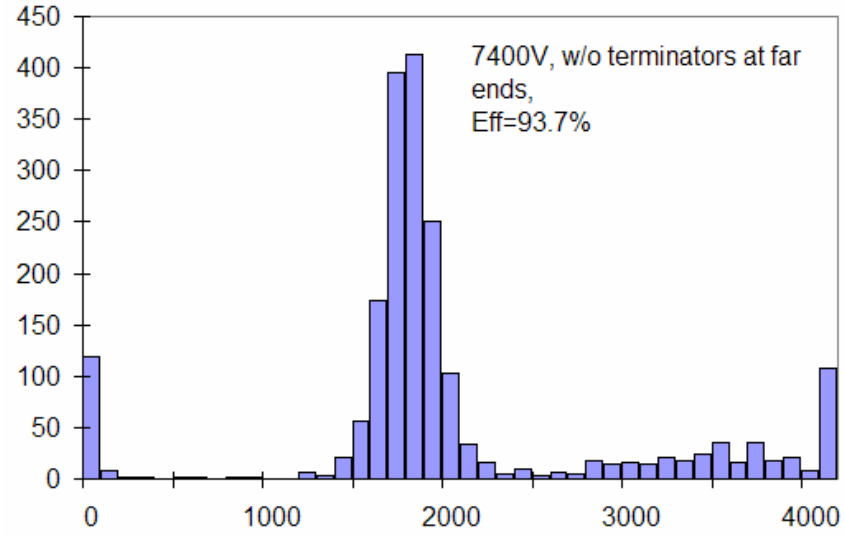
The linear part of the curve between 0V and 4000V shows the DC Ohmic leakage current, subtract this linear current from the total current the green curve represents current due to streamers. +/-HV draw almost identical current.



Match the impedance at the far end

The characteristic impedance of the strip transmission line is ~18Ω, terminates the far end with 18Ω will reduce the signal size:

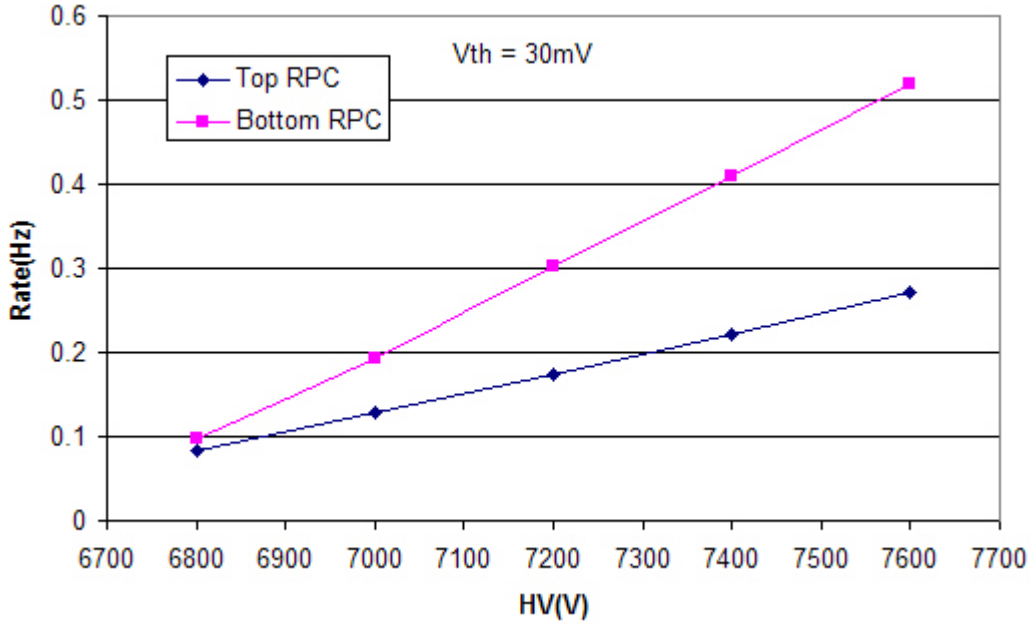




Do we need to consider the impedance match at the far end?

Single's rate for two RPCs of a double gap module

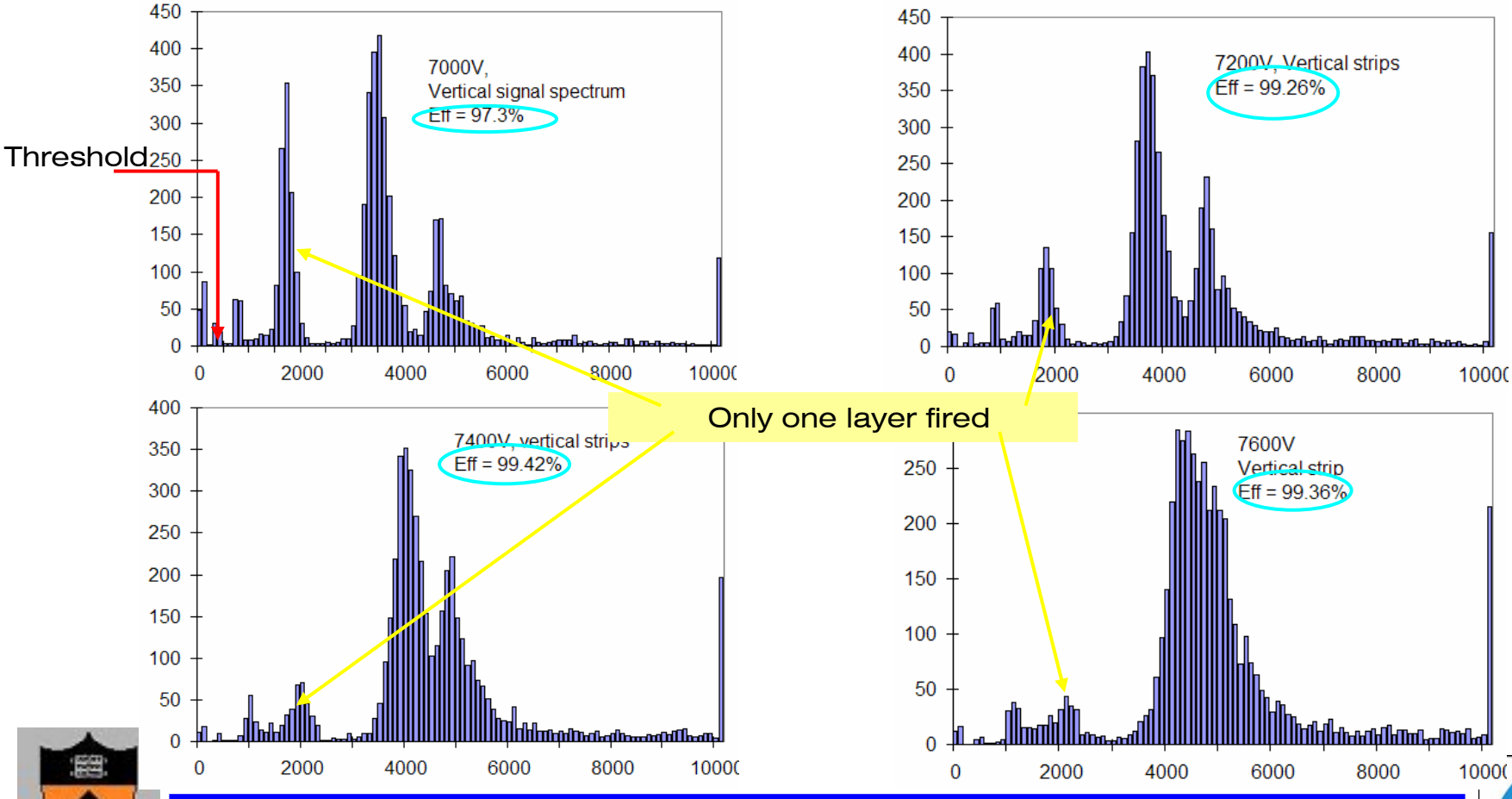
Test single's rate under following condition: V_{th} = 30mV, τ = 400ns.



The rate includes the cross talk from the neighboring strips. Two RPCs have different S.R. their ratio is ~1.1 – 1.9.

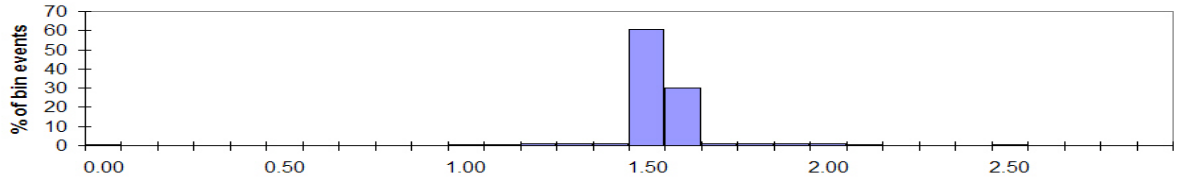
Charge spectrum from middle strip of a double gap RPC

Use QDC system to test the charge spectrum at various HV.

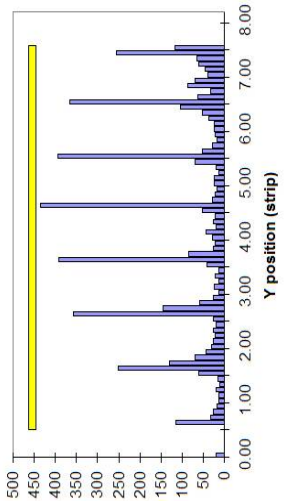


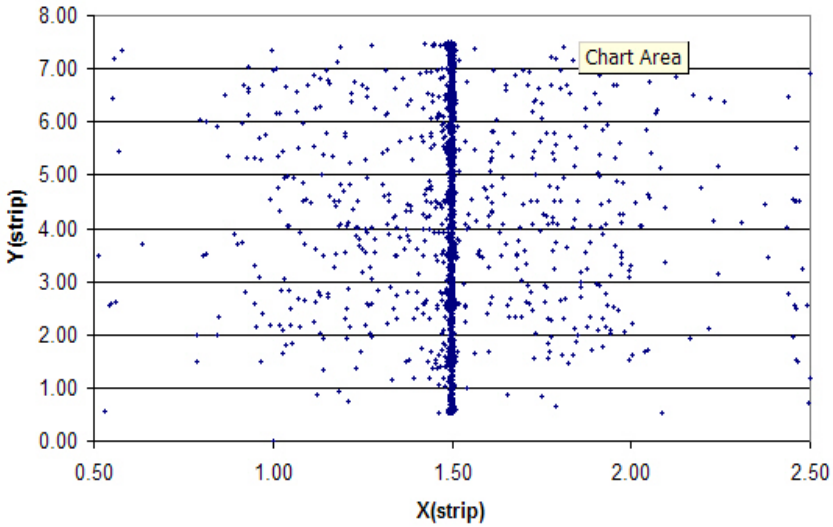
Reconstructed cosmic ray hit map on the double gap RPC

Projection to the horizontal axis



Projection to the vertical axis

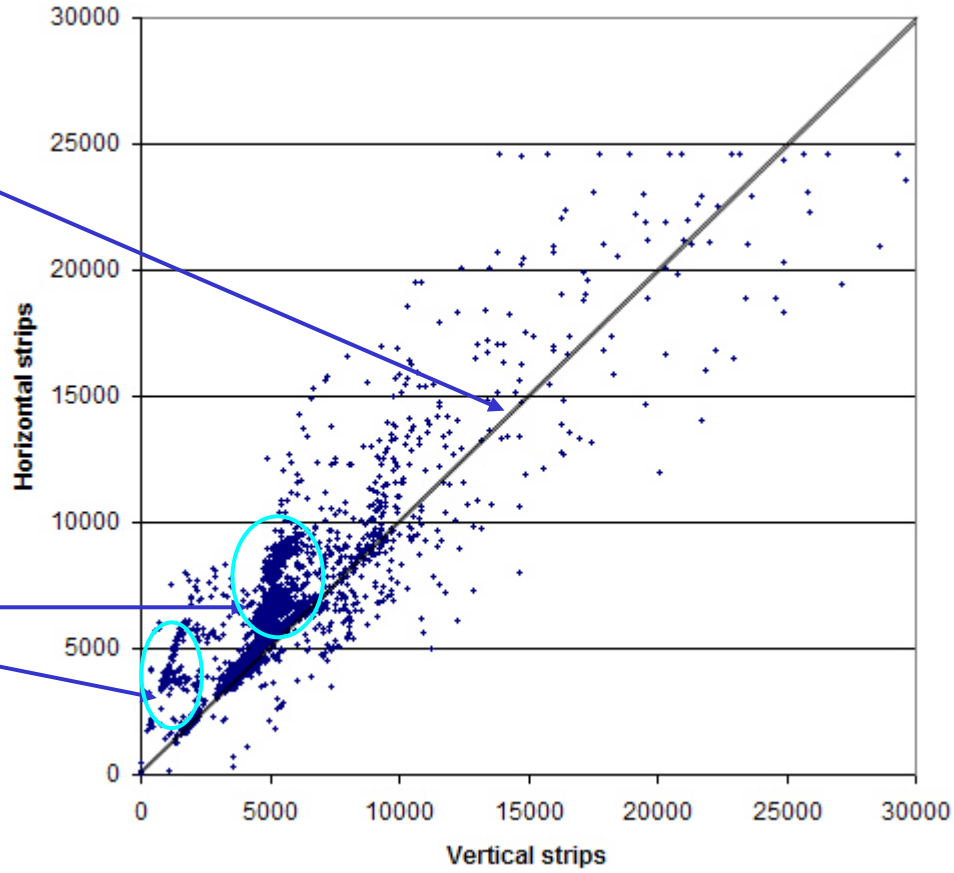




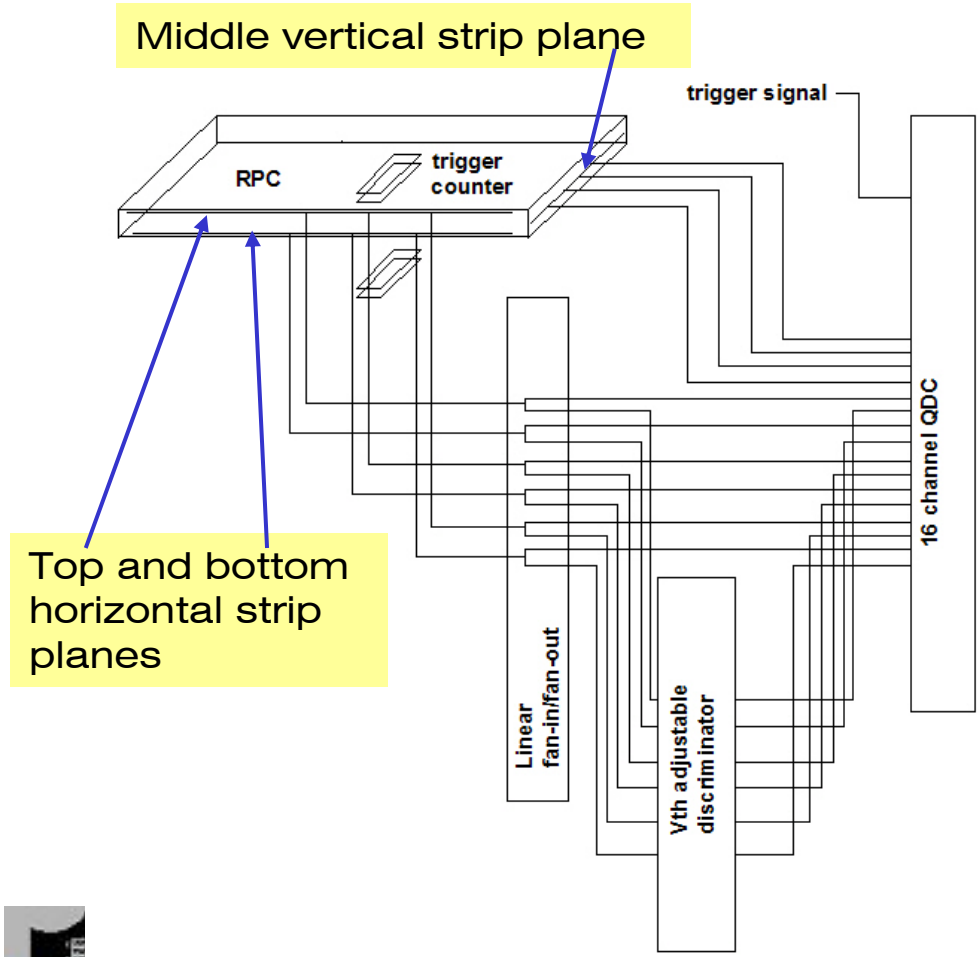
Scatter plot

Scatter plot of the induced charge on anode/cathode sides

Most events fall into the diagonal strip area. Because the total covered areas by vertical and horizontal strips are not the same, some events collect more charge by horizontal strips than by vertical strips.



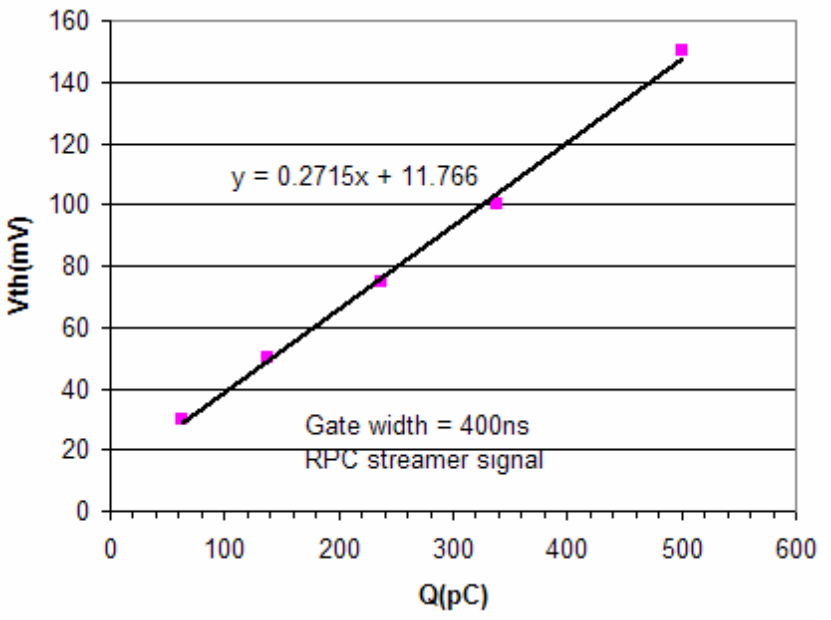
Calibration of Q vs. $V_{threshold}$

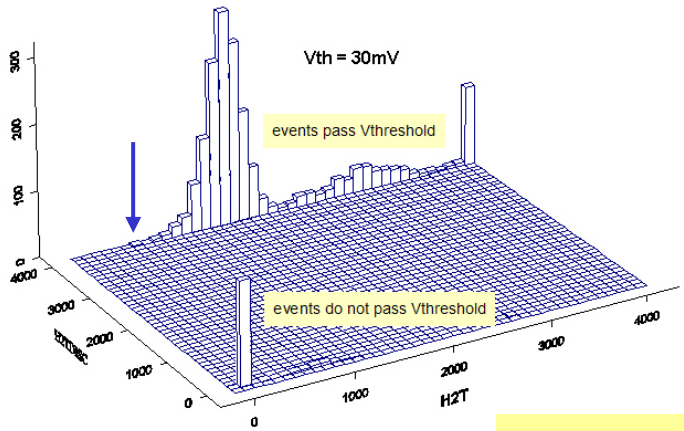


We use linear fan-in/fan-out module to invert the positive pulse (from cathode side of RPC), one fan-output signal direct enters QDC, the other fan-out signal goes to a discriminator, its output enters next channel of the QDC. If the signal triggers the discriminator, this channel of QDC will get saturated, and record 4095, otherwise 0. Thus we can obtain both analog Q and digital signal (4095|0 for $>|<V_{threshold}$).

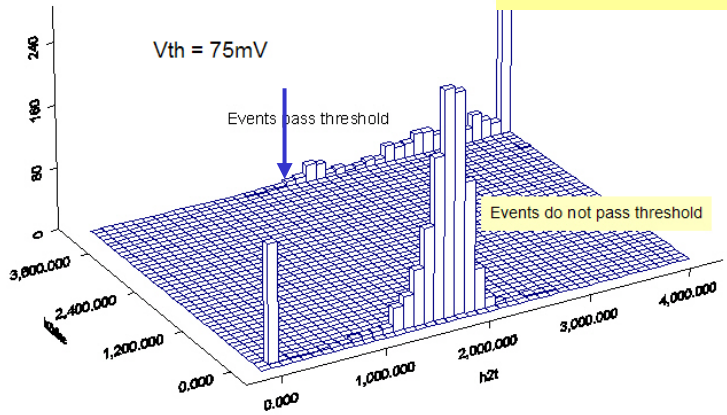
Q vs Vthreshold

Study the leading edge of the charge spectrum of the events, which pass Vth, we can obtain the corresponding charge value.





1ch = 0.125pC



30mV corresponds to 67pC (for 24cm wide strip).

Summary

Two RPCs made by IHEP have been tested at Princeton, they behave very nicely:

- The efficiency for the double gap structure can reach >99% at 30mV threshold;
- Dark current is around 6μA for a single gap RPC at 7600V;
- Single's rate is around 0.2 – 0.4Hz/cm^2 @ 7400V (full efficient);
- Without proper termination at the far end of the strip, there is some ringing of the signal, but won't affect the performance in our application;
- 2D reconstruction shows good position resolution;
- ...