# RPC HV cable pick-up noise issue

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(6/17/2008)

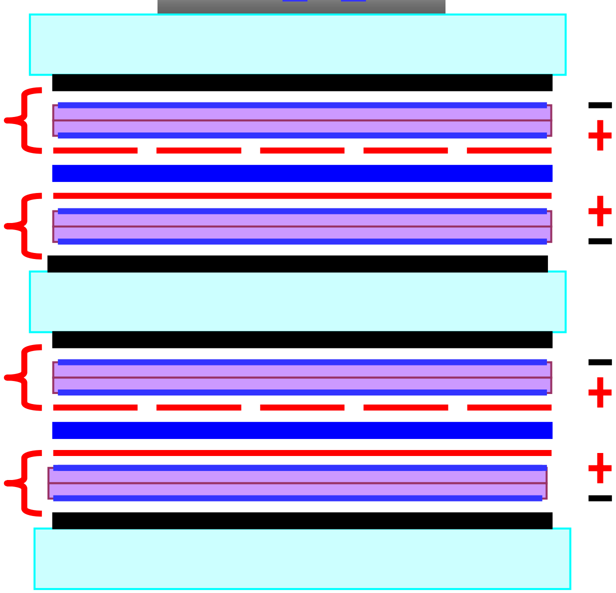
# Compare

## Module Design of RPC

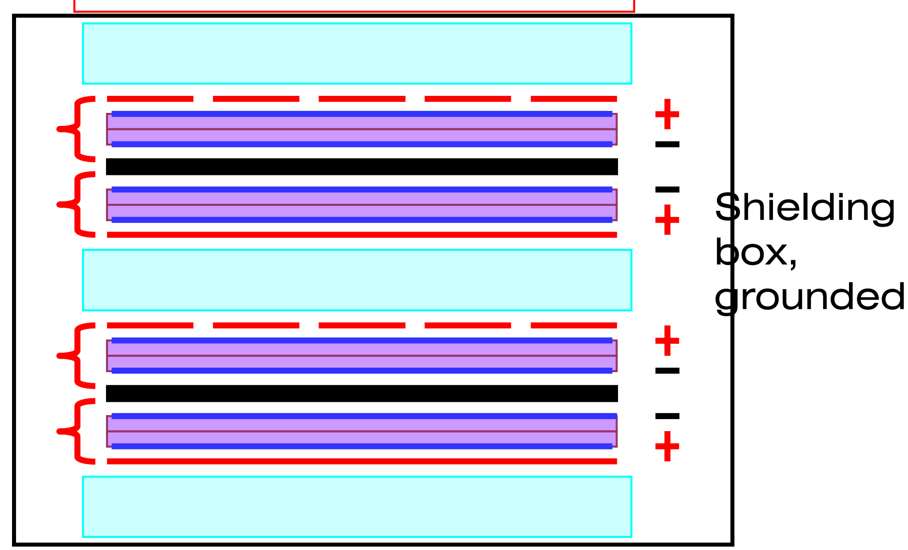
Yu guang Xie, 10 July, 2007

| TYPE | IM_R_I | IM_R_II | IM_H_I | IM_H_II | IM_RH_I | IM_RH_II |
|---|---|---|---|---|---|---|
| Cross talk | ? | ++ | + | + | + | + |
| Thickness (mm) | 58 | 78 | 68 | 78 | 68 | 78 |
| Matching | + | + | - | - | - | - |
| Assemble | + | + | + | + | - | - |
| Ground | + | + | - | - | - | - |

**IM_R_I**



**Maybe the best choice**

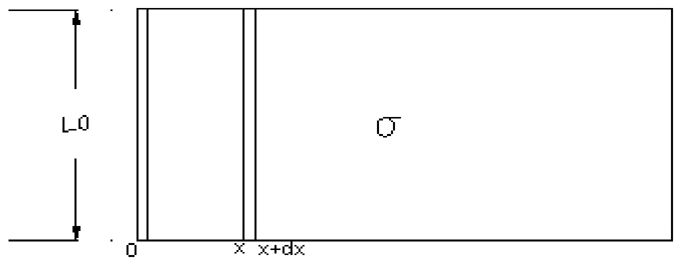


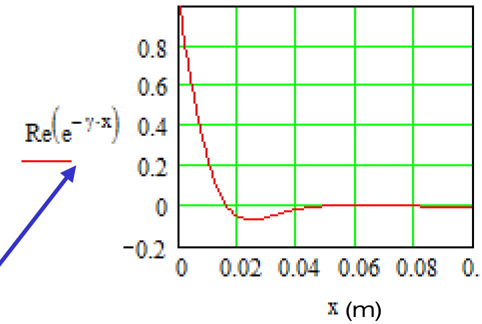

**Least materials, thinness, compact, less cross talk, should be tested**

# Signal propagation on graphite coating

Because of the large surface resistance the pickup noise from HV cable via graphite coating is negligible.

A parallel plate transmission line model:




Consider two surfaces of RPC graphite coating as a transmission line, 1cm wide transmission line,

$dR=2\sigma dx/L_0$, $dC=\varepsilon L_0 dx/g$, $dL=\mu_0 g dx/L_0$,

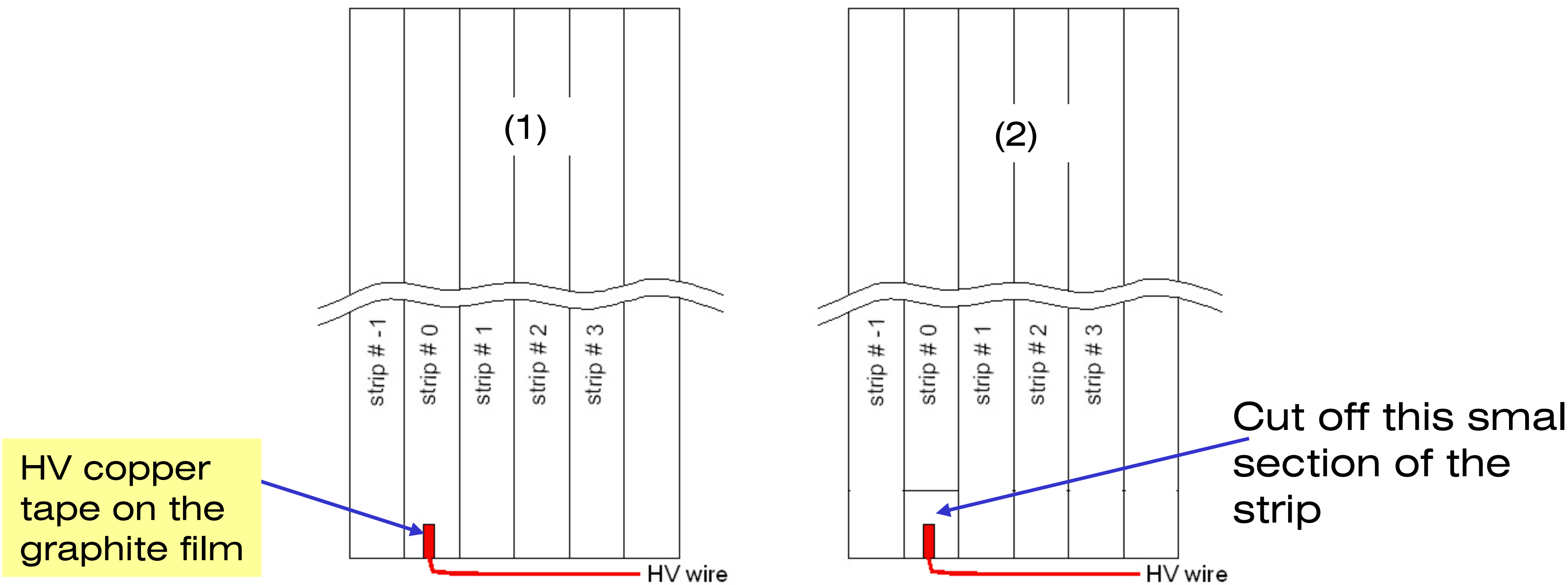
Signal propagation constant $\gamma$ : $\gamma=((R+i\omega L)i\omega C)^{1/2}$.

Signal V(x) at x: $V(x)e^{i\omega t}=V(0)e^{-\gamma x+i\omega t}$.

Assume $\sigma=1M\Omega/\square$, $g=0.006m$, $L_0=1cm$, and $\varepsilon=8.85\times10^{-12}F/m$, $\mu=4\pi\times10^{-7}H/m$, $\omega=2\pi\times10^8Hz$, the real part of $e^{-\gamma x}$ at 3.6cm would drop to 3%, $\Rightarrow$ the signal attenuation length is very short, the graphite contribution to the noise pickup is negligible.

# Noise pickup on the strips

The arrangement of the IHEP RPC readout strips and HV tape on the graphite surface can have following two configurations: (1) The strip covers up to the edge of the RPC, there will be a direct coupling between strip #0 and HV tape (only a Mylar film for DC insulation); (2) Cut off small section of the strip, no direct coupling between strip #0 and HV tape.



# Test arrangement

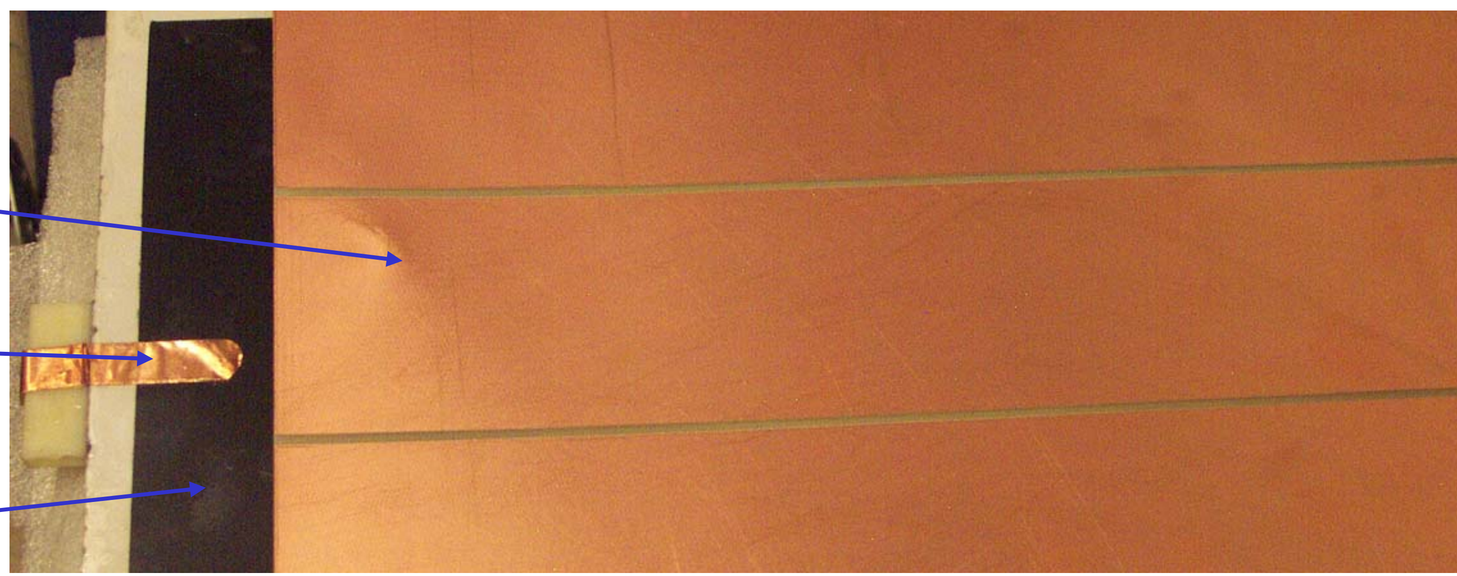
Top shielding

Read out strip

RPC chamber

Read out ground

Bottom shielding

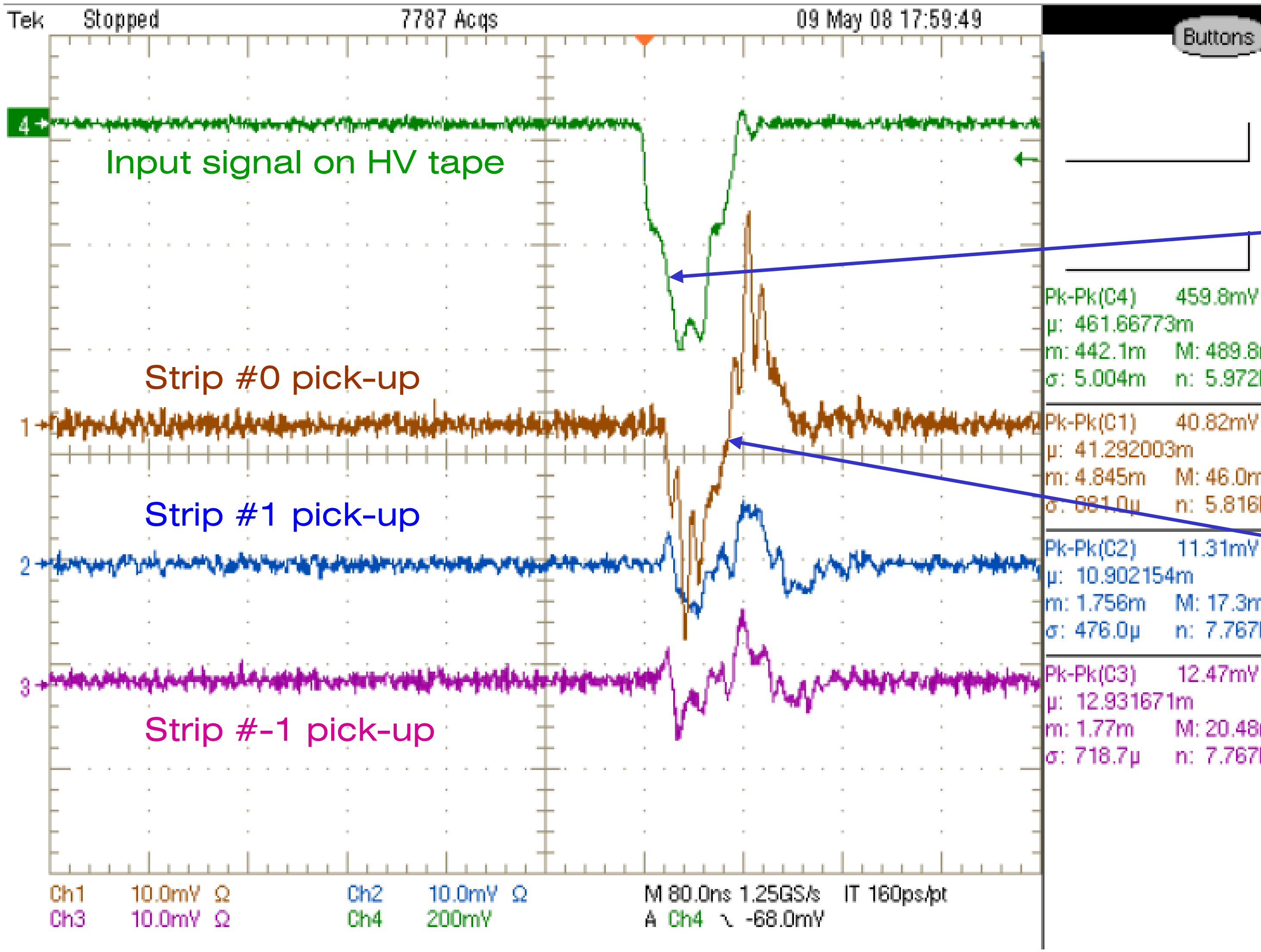


Read out strip

HV copper tape

Black graphite coating, covered by a Mylar film

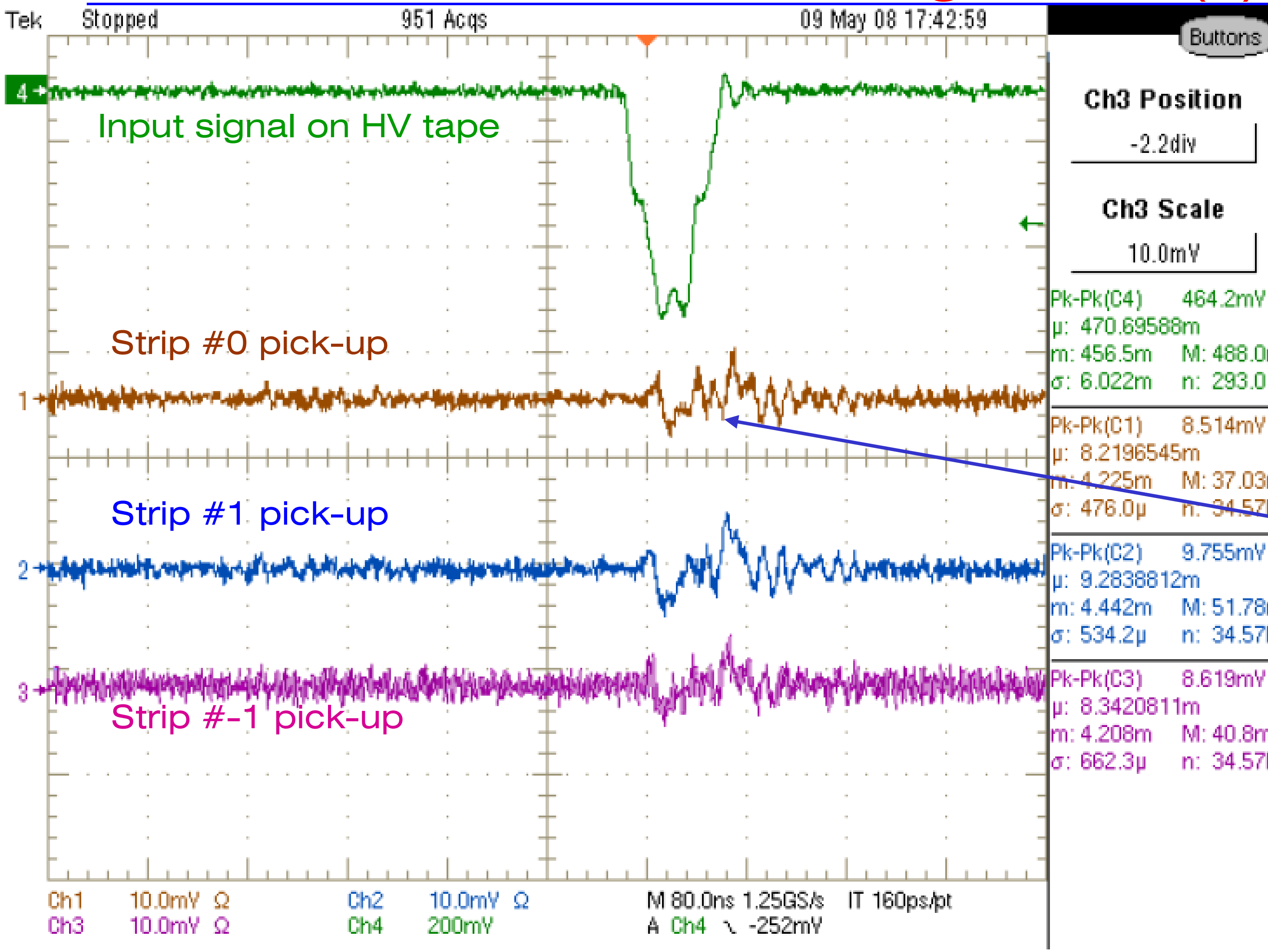
# Test result for configuration (1)




200mV input pulse on HV tape, reflection at the unterminated end of the cable can be clearly seen.

The pick-up noise is ~5% of the source noise on HV cable (the negative pulse is ~-20mV).

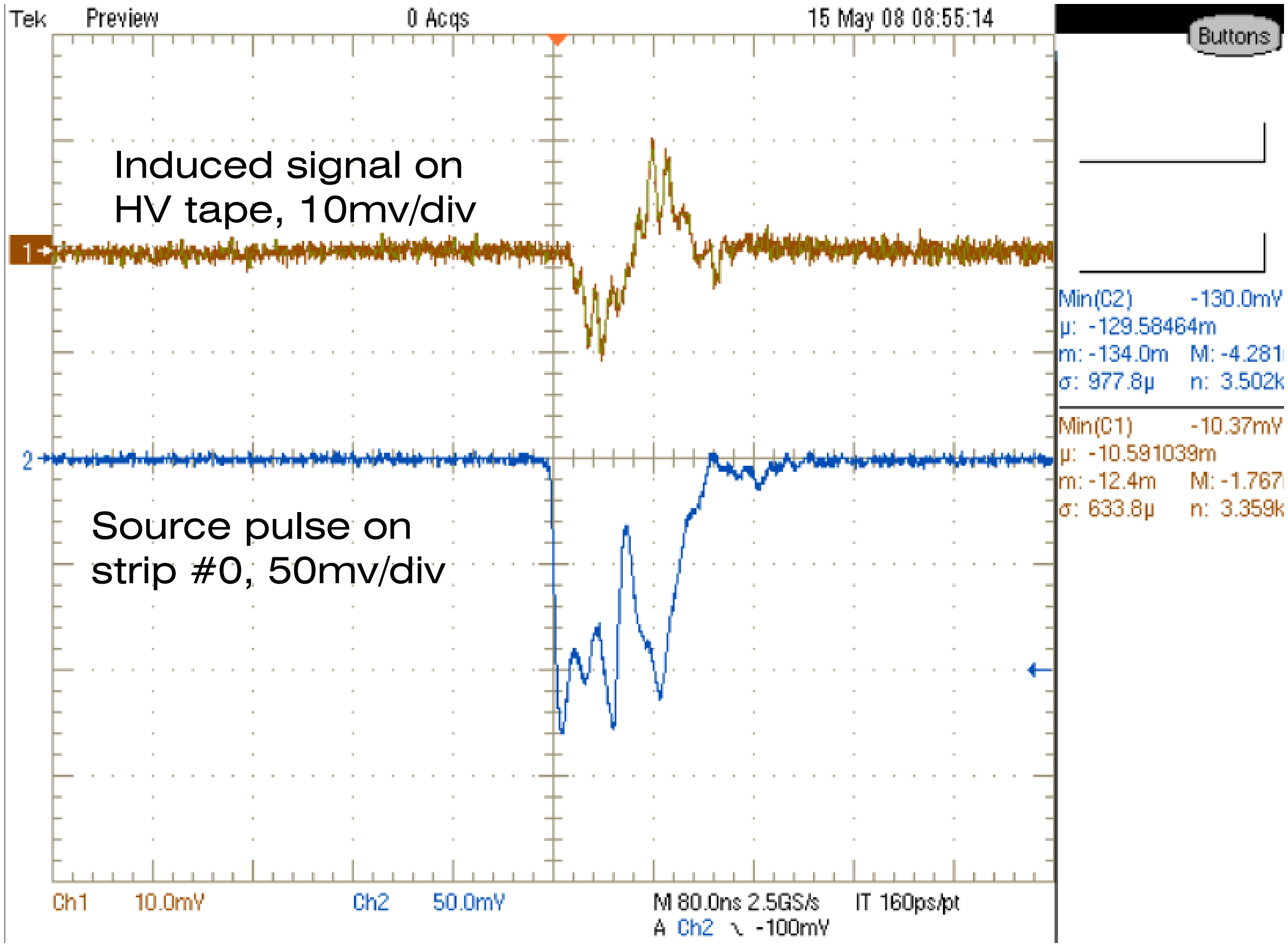
# Test result for configuration (2)




The pick-up noise is ~1% of the source noise on HV cable.

# Induced signal on HV tape

As Jon suggested I also tested the induced signal on the HV tape when connect the pulse signal to strip #0:

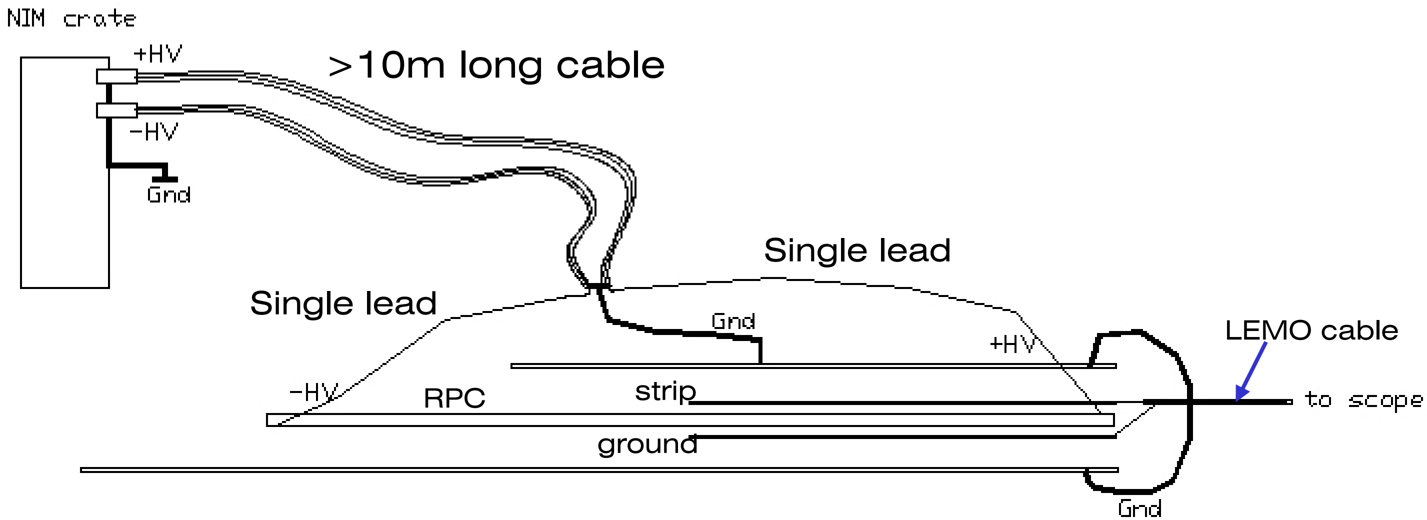



The induced signal on strip #0 is ~10mV, the source signal on HV tape is ~ 130mV, the ratio is ~ 8%. This pick-up signal will distribute to all other HV tapes on same branch of HV distribution system, then picked up by #0 strips on other RPCs. The overall pick-up signal on other RPCs is only 5%*8%=0.4%. Completely negligible!

# For the muon right punching through the HV tape

For the very small chance of the muon punching through the HV tape (~1cm$^2$ out of 2m$^2$), the induced signal on the HV tape will reach other RPC HV tapes that are on the same HV branch. In this case ~5% of this induced signal will be generated on the relevant strips. These signals will be too small to be concerned.

# Pick-up noise when HV cables are connected




The room is using fluorescent light.

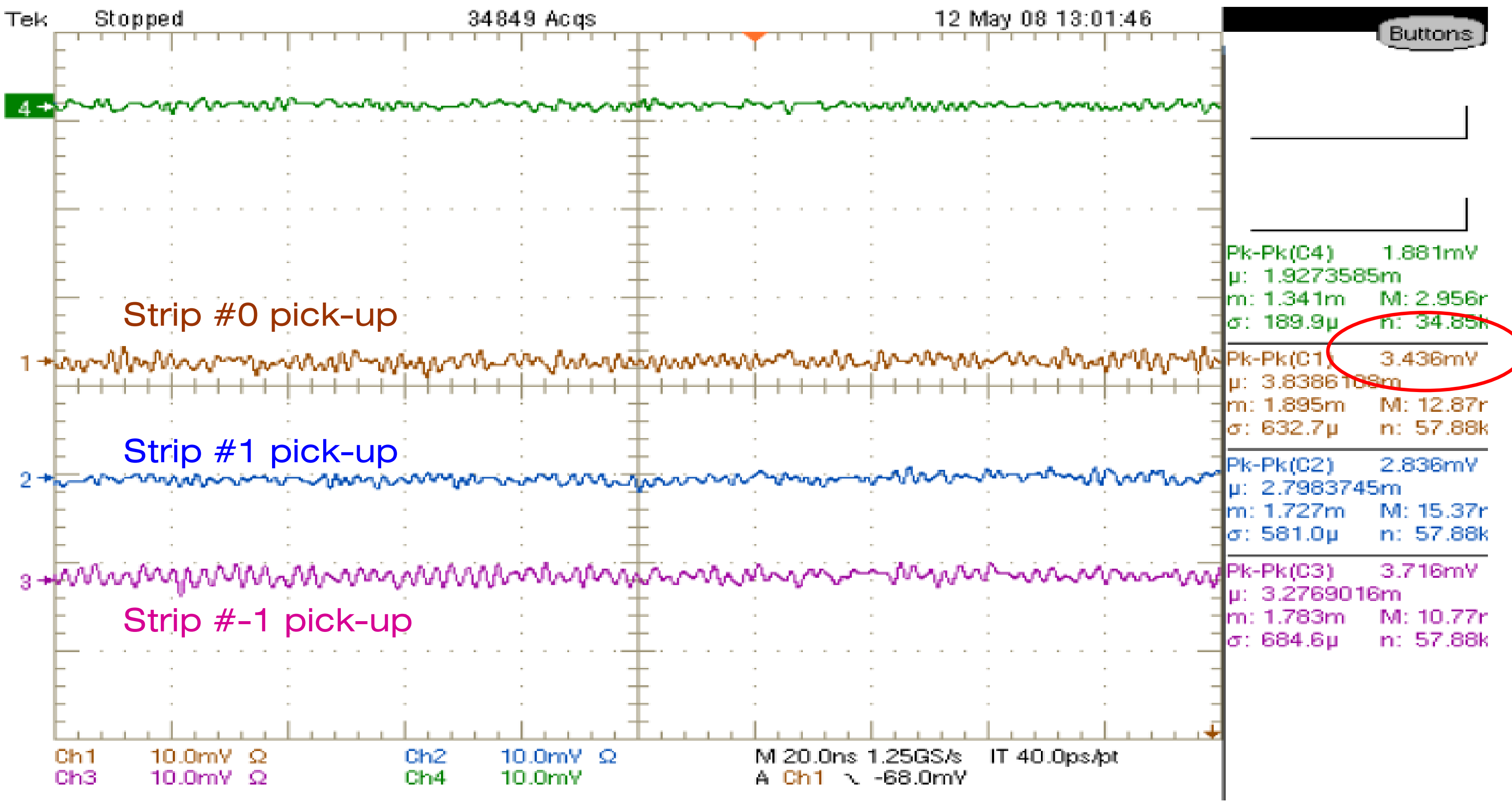
The following two slides show the pick-up noise on strip #0 for two grounding schemes:

(1) two ends grounded separately;

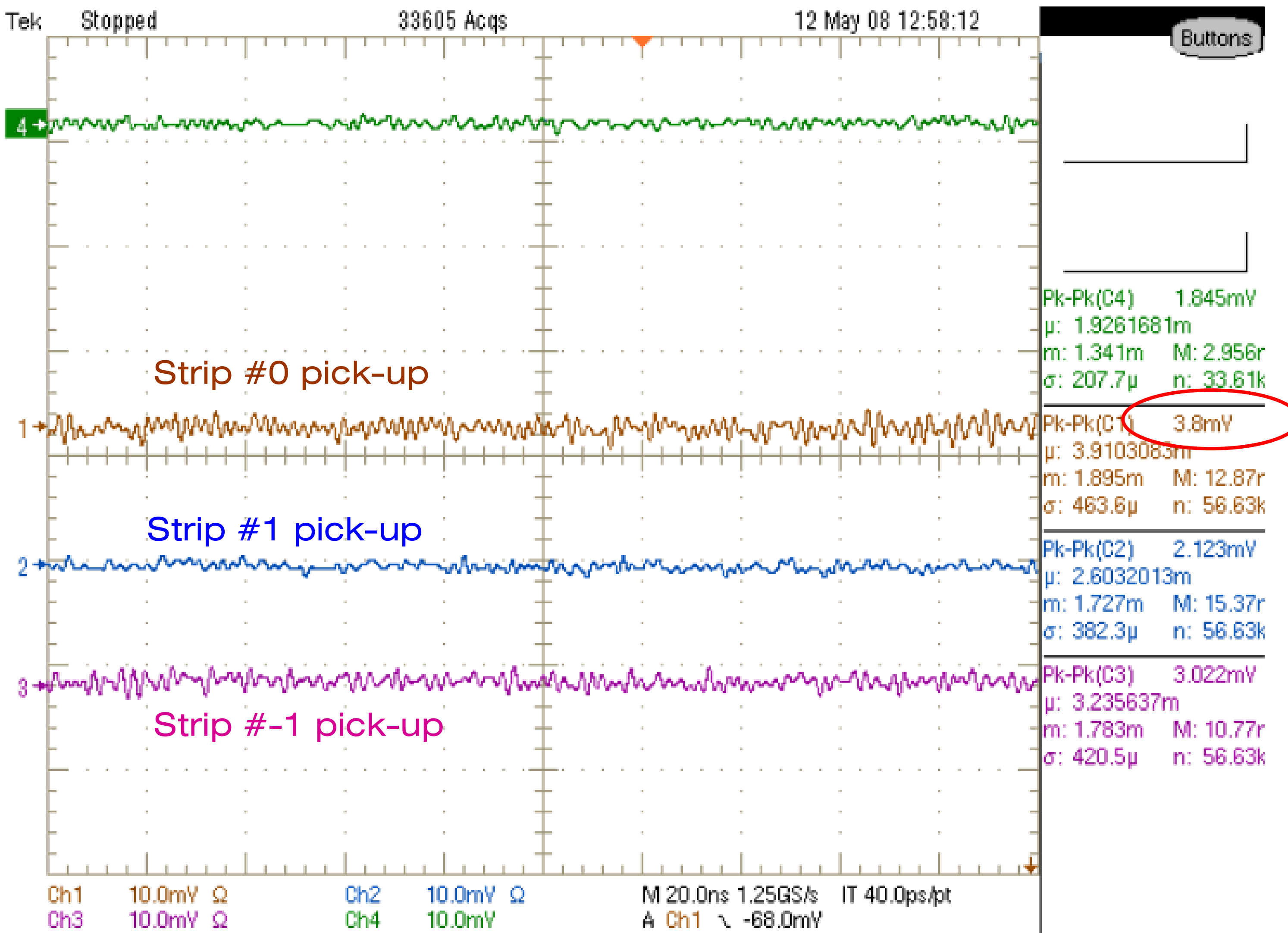
(2) only HV supply (Bertan power supply) side is grounded (through AC power plug).

There is no difference between them.

# Ground two ends separately



# Ground at HV supply side only



# Conclusion

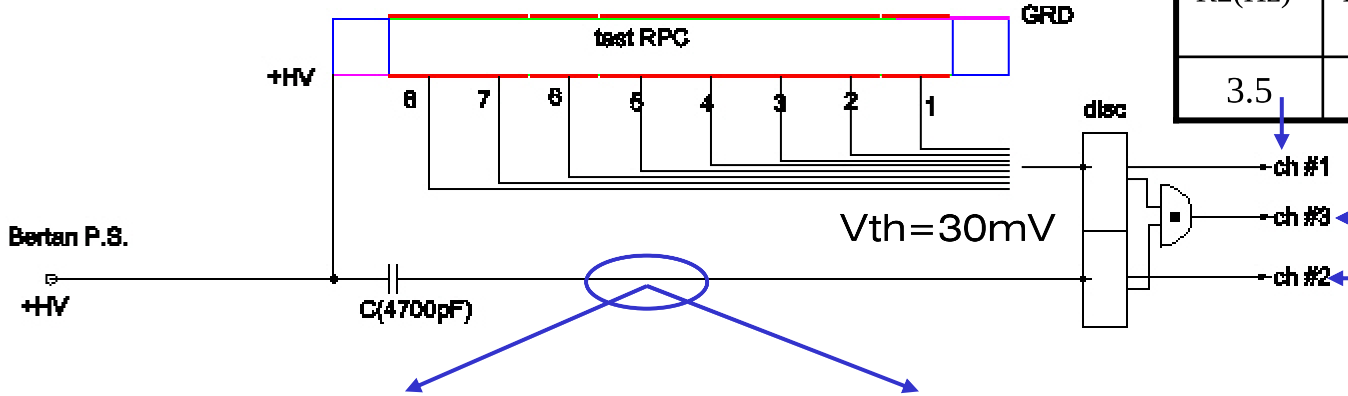
The preliminary test results show:

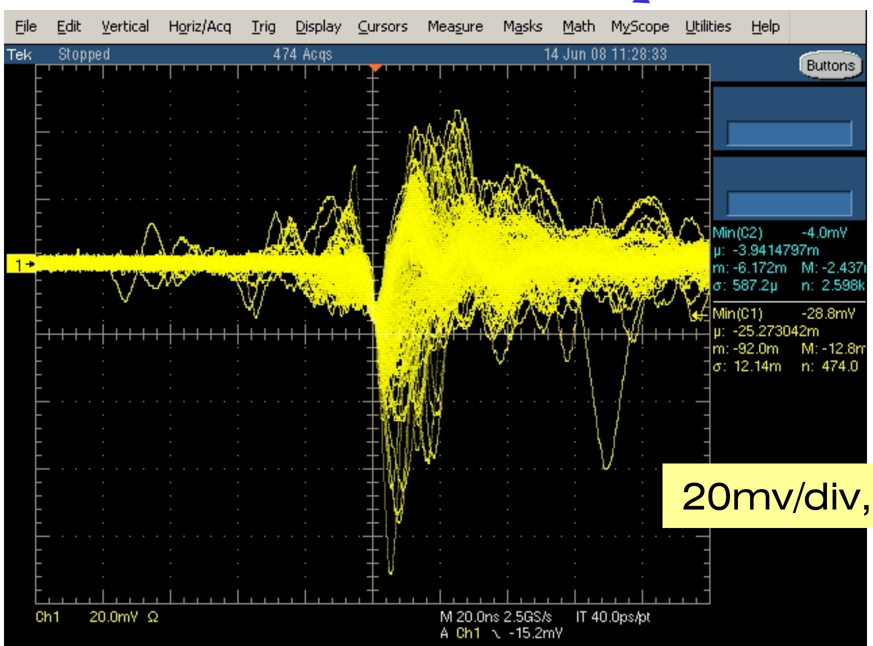
- The readout strip direct above the HV contact tape will pick-up ~5% of the noise on the HV cable, if cut off small end section of this strip to avoid the direct pick-up, this number can drop to 1%;
- The HV cable ground scheme (single end ground or both ends are separately grounded) won't introduce large noise (compared to streamer signal) to the readout strip, thus for streamer RPC this is not critical.

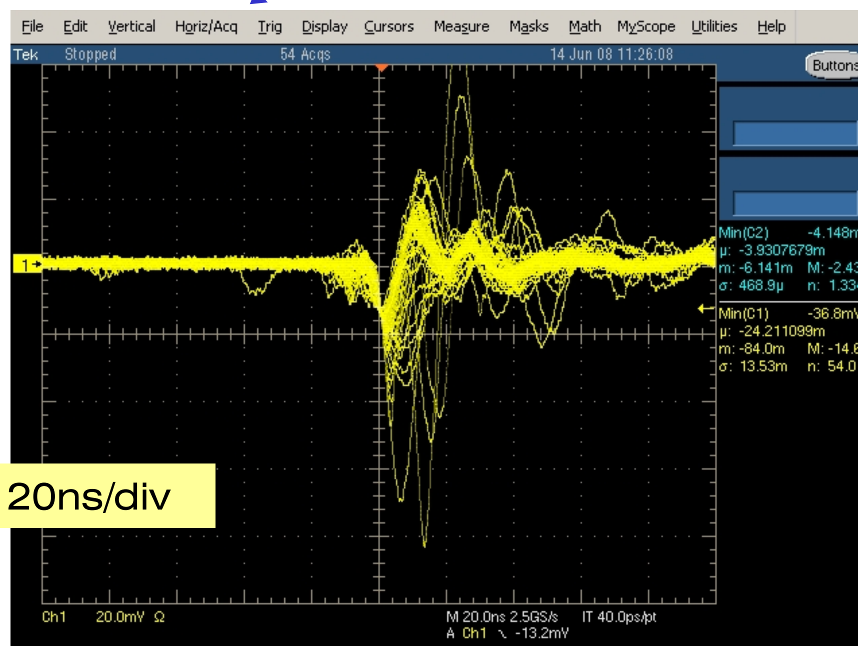
# Real noise pulse on HV cable

Rate

| R2(Hz) | R3(Hz) | R1(Hz) (strip#8) |
|---|---|---|
| 3.5 | 1.3 | 1110.9 |



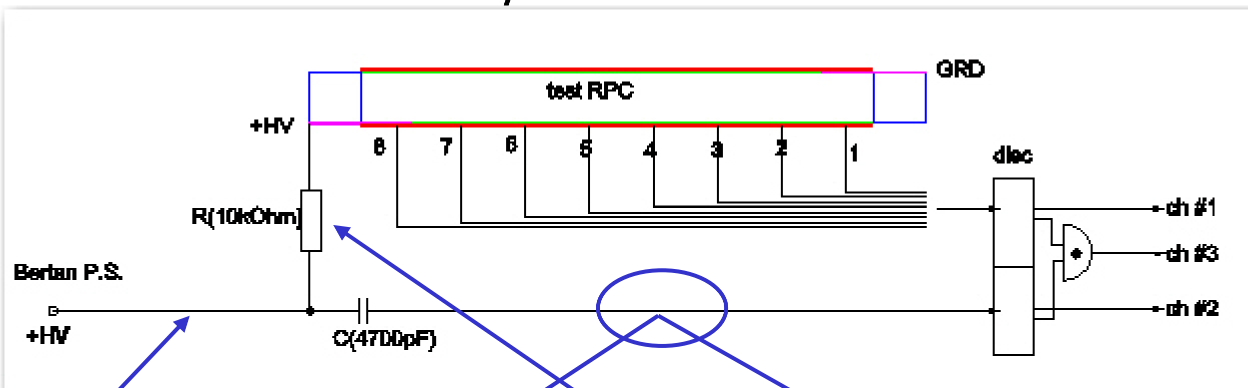



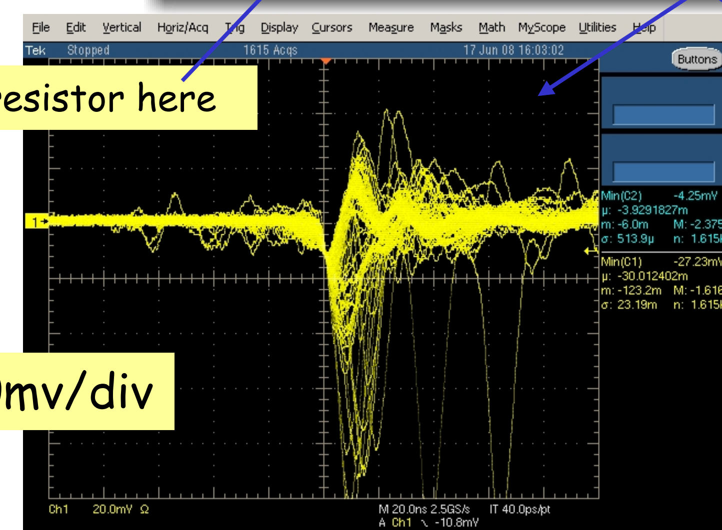



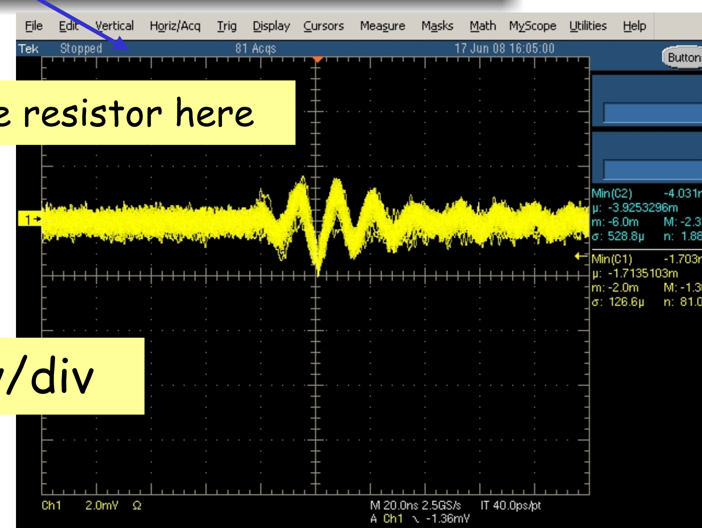

20mv/div, 20ns/div

# Isolate sub-branches from each other

Kirk suggested to add a resistor into each sub-branch, such as 10k$\Omega$, to isolate the sub-branches from each other, we may can eliminate this cross talk. My test shows it works!




Put the resistor here

Put the resistor here

20mv/div

2mv/div

# Comments

The source of the pulse on HV cable is not completely studied yet. At least it tells us the HV power supply output line is not virtual zero impedance. Part of these pulses might be due to

(1) The streamer developed at the HV copper tape area,
(2) The discharge between HV copper tape and strip,
(3) Streamer current drawn from HV supply,
(4) Pick up RF noise (but the shape looks not likely).
(5) etc.

Further study is needed.

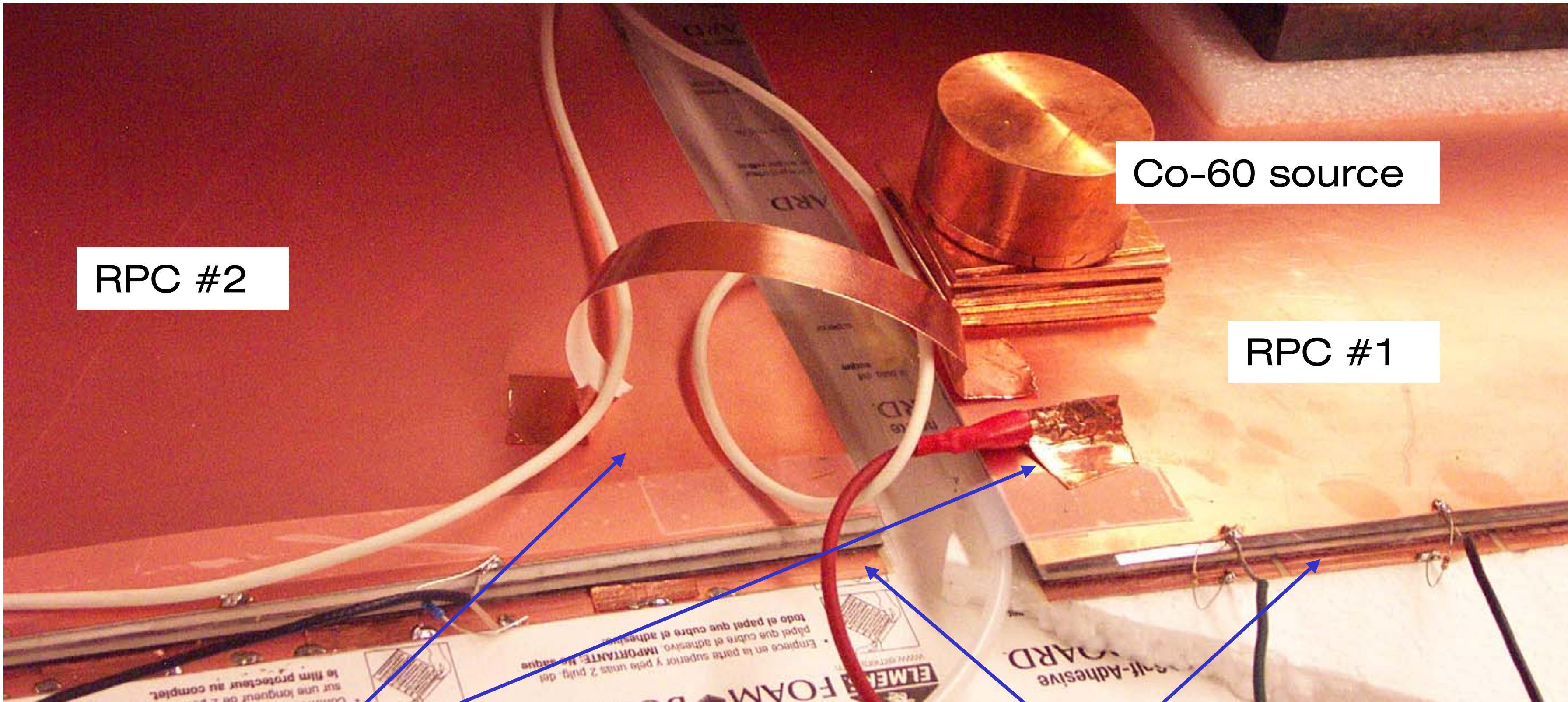
# Coincidence pulse

We would like to see the noise on the working RPCs.

Use two 50 x 50 $cm^2$ prototype RPCs in this study.

Two RPCs are connected to same HV channel, one RPC is directly connected to HV, the other RPC is through a capacitor. For the later one although the DC HV is isolated, the AC pulse still can propagate to this RPC from anywhere in HV line.

# Test arrangement

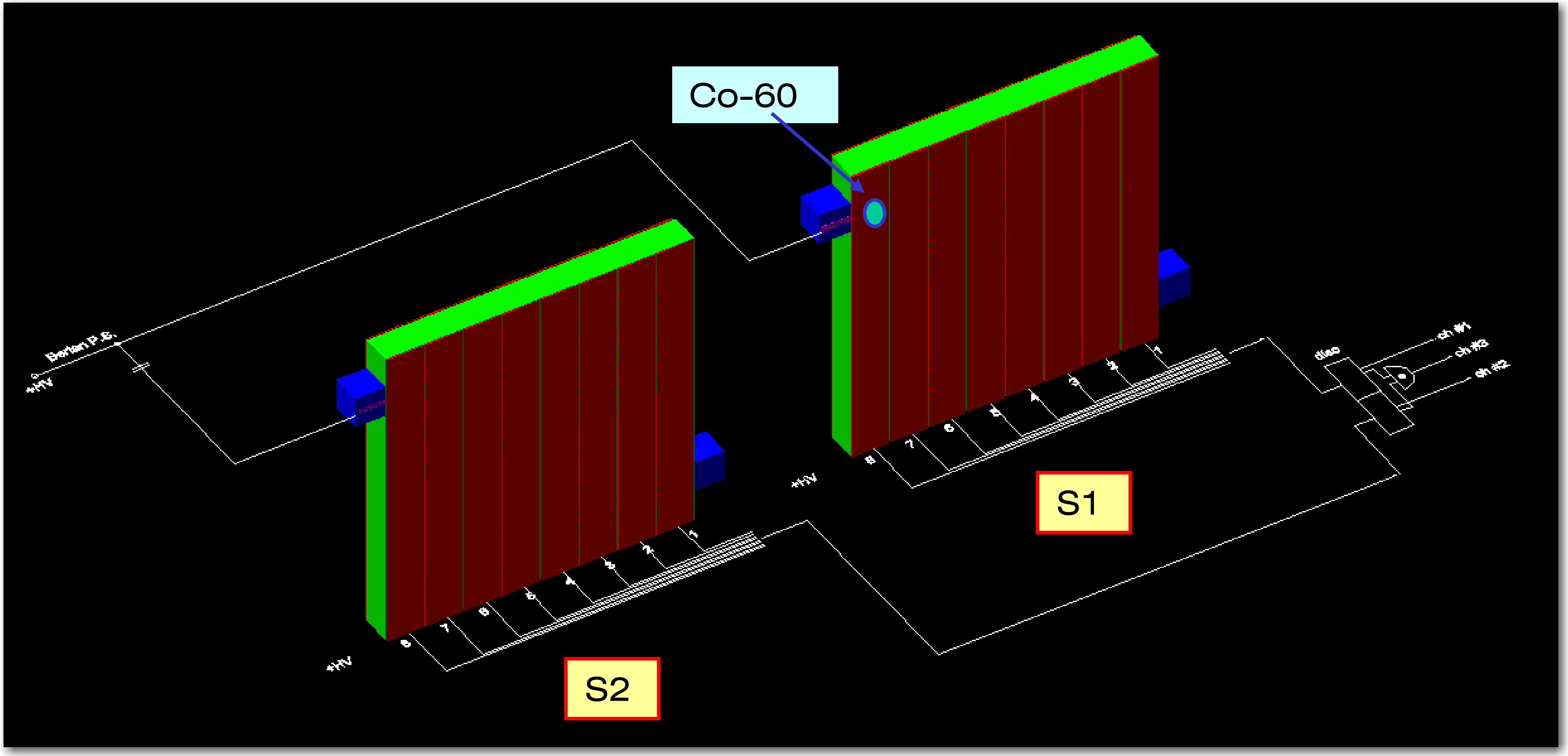



Readout ground

Readout strip

There is no additional shielding for the test RPCs, outside noise source may enter the readout transmission line.

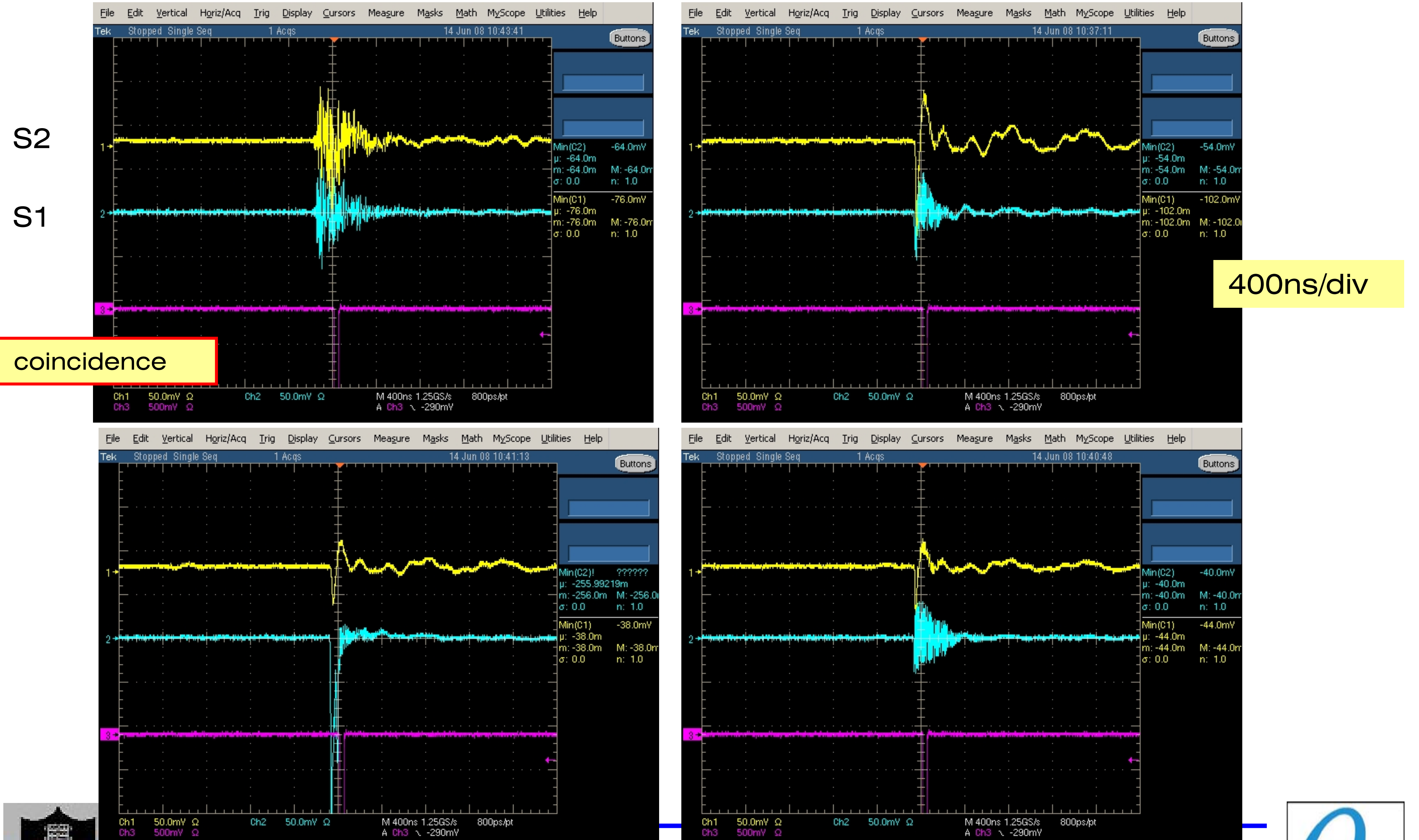
# Noise pulse




| | S1 strip # | S2 strip # | S1 rate (Hz) | S2 rate (Hz) | S1•S2 rate (Hz) |
|---|---|---|---|---|---|
| Rate(Hz) | 8 | 8 | 1136.9 | 0.209 | 0.1 |
| | 8 | 7 | 1147.1 | 0.093 | 0.062 |
| | 8 | 3+2 | 1169.5 | 0.727 | 0.169 |

Not accidental coincidence

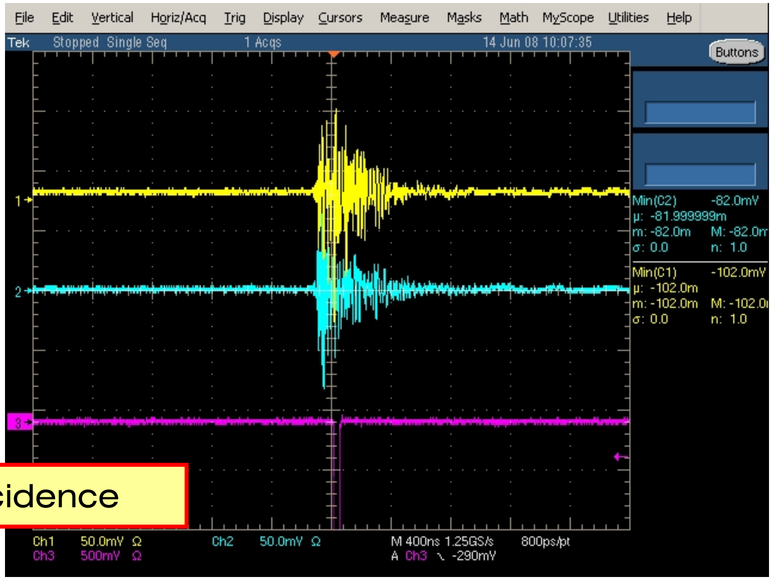
# Coincident pulse (S2 strip #6, S1 strip #8)

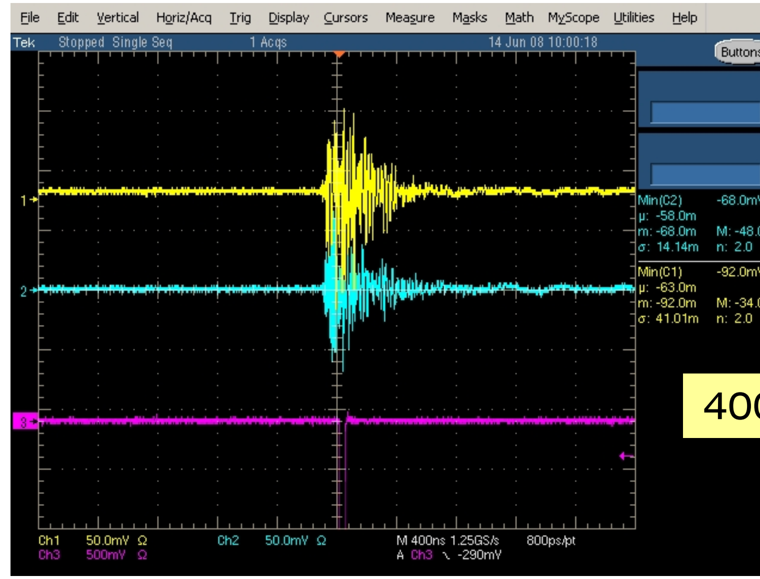


# Coincident signals (S2 strip #8, S1 strip #8)

S2

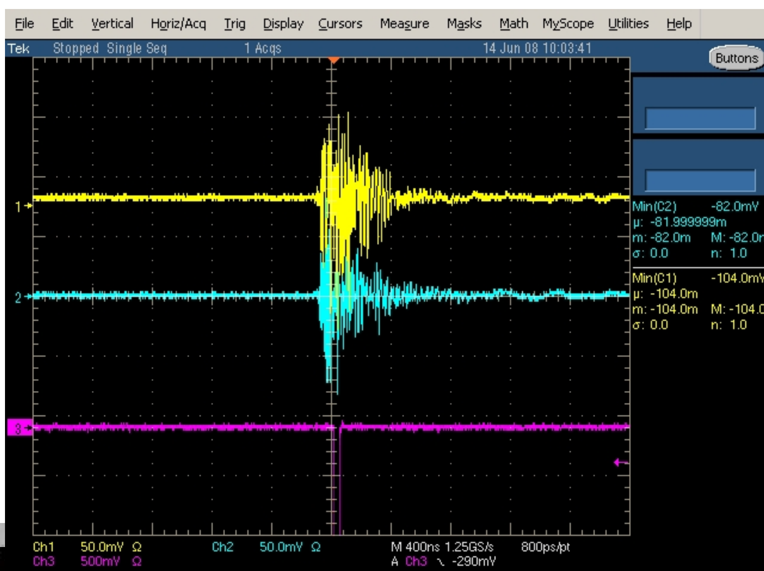
S1

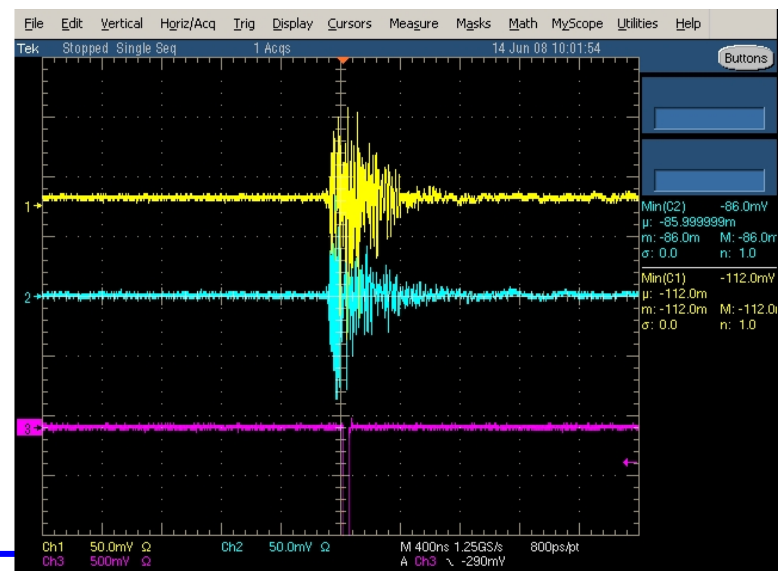


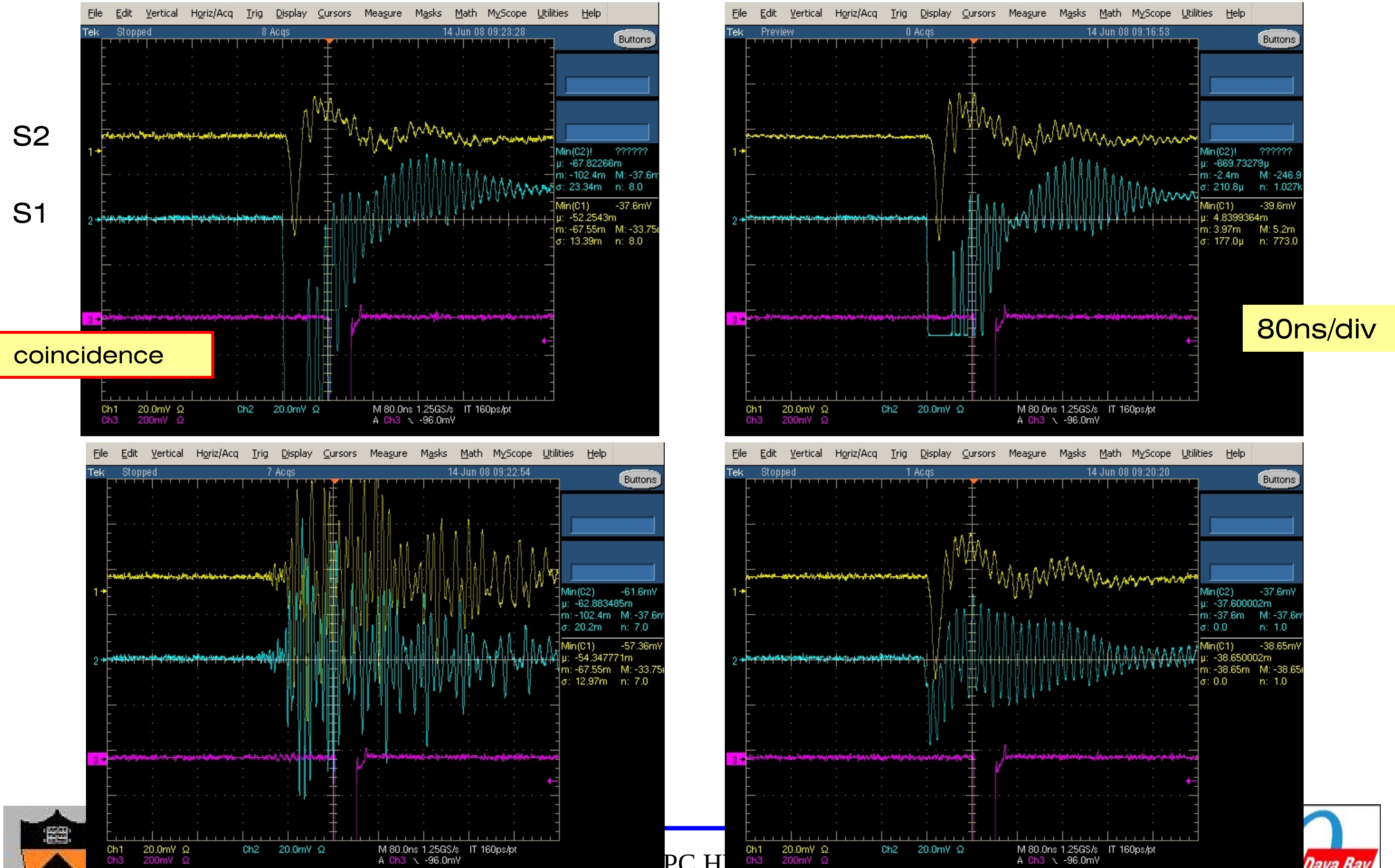

400ns/div

coincidence



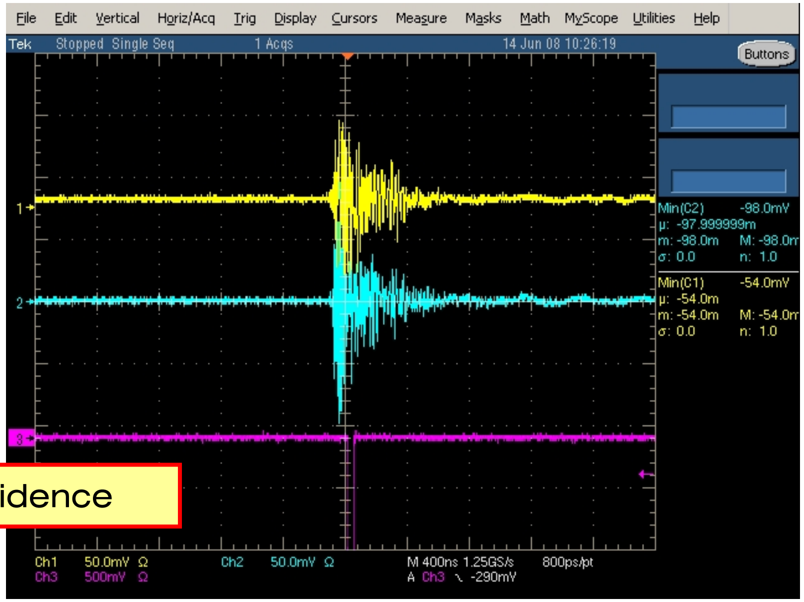
# Coincident signals (S2 strip #7, S1 strip #7)

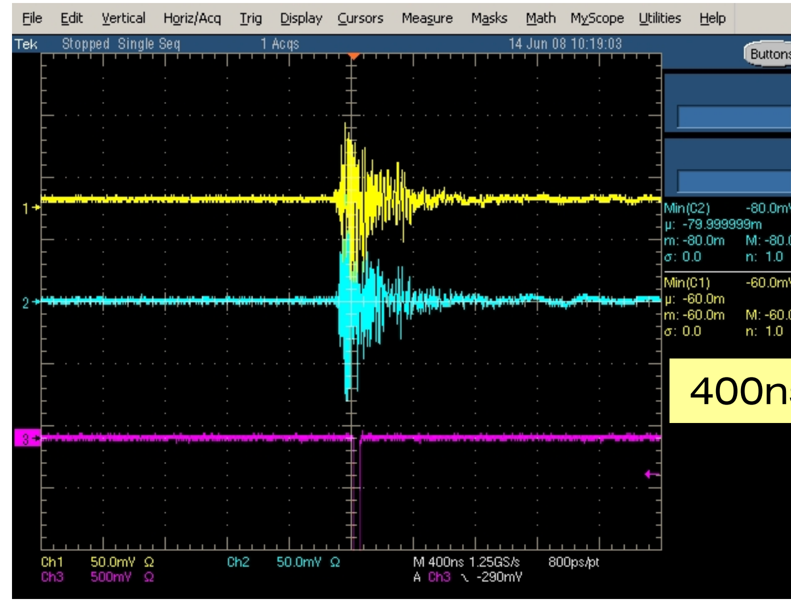


# Coincident signals (S2 strip #7, S1 strip #8)

S2

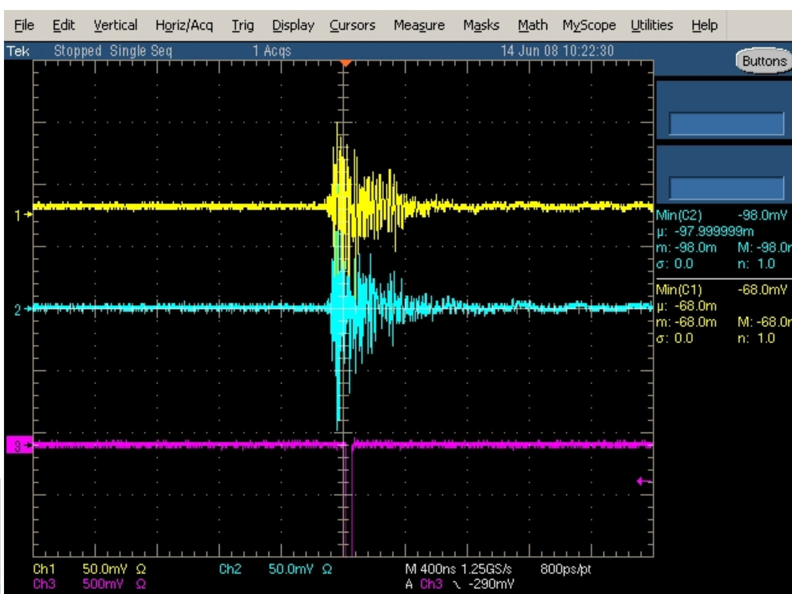
S1

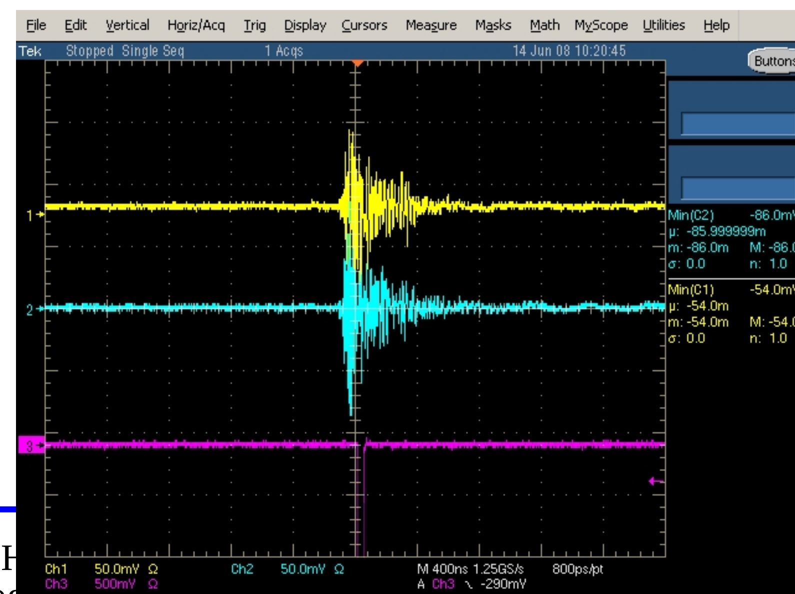


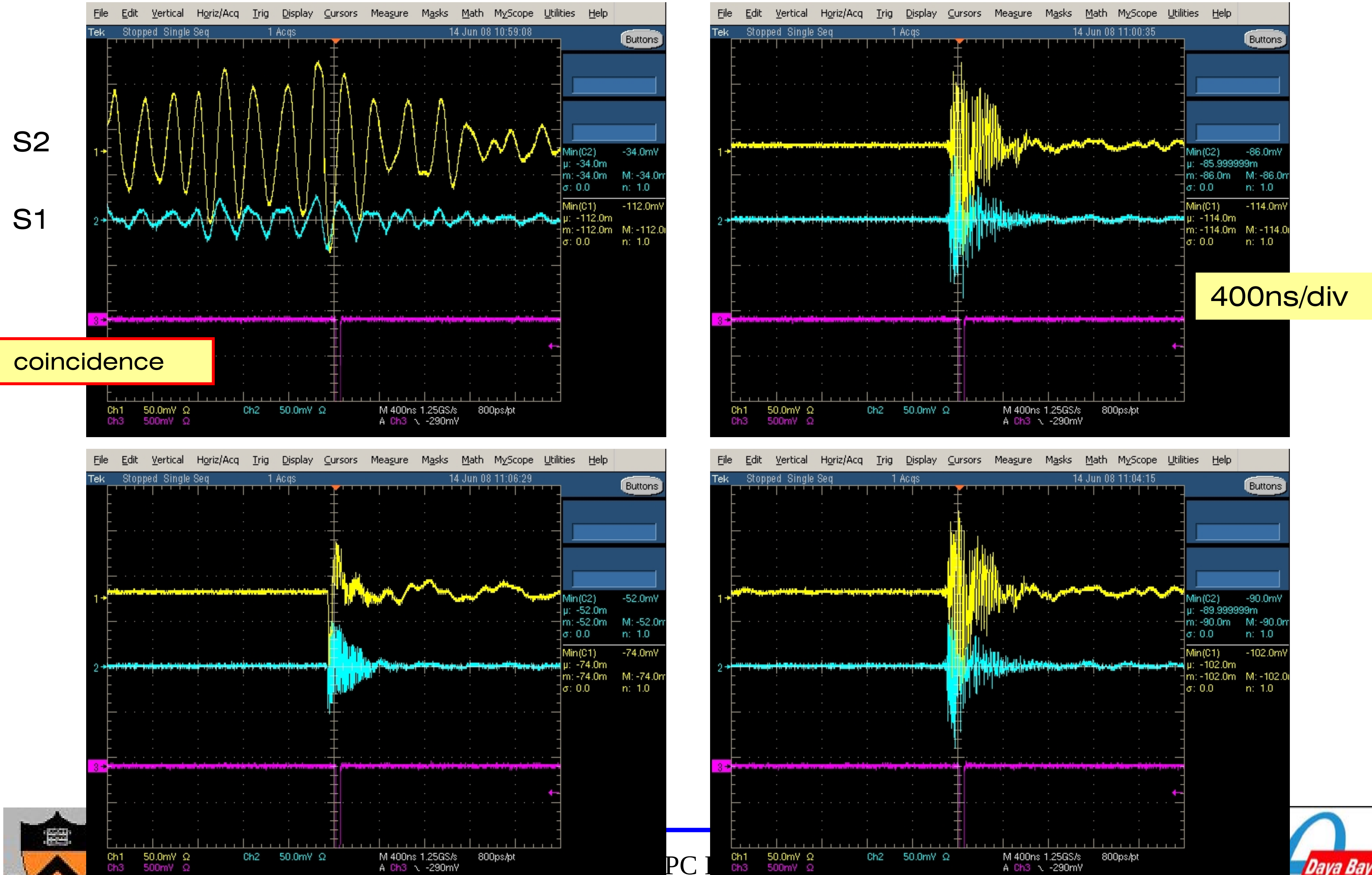

400ns/div

coincidence



# Coincident signals (S2 strip #3+2, S1 strip #8)



# Comments

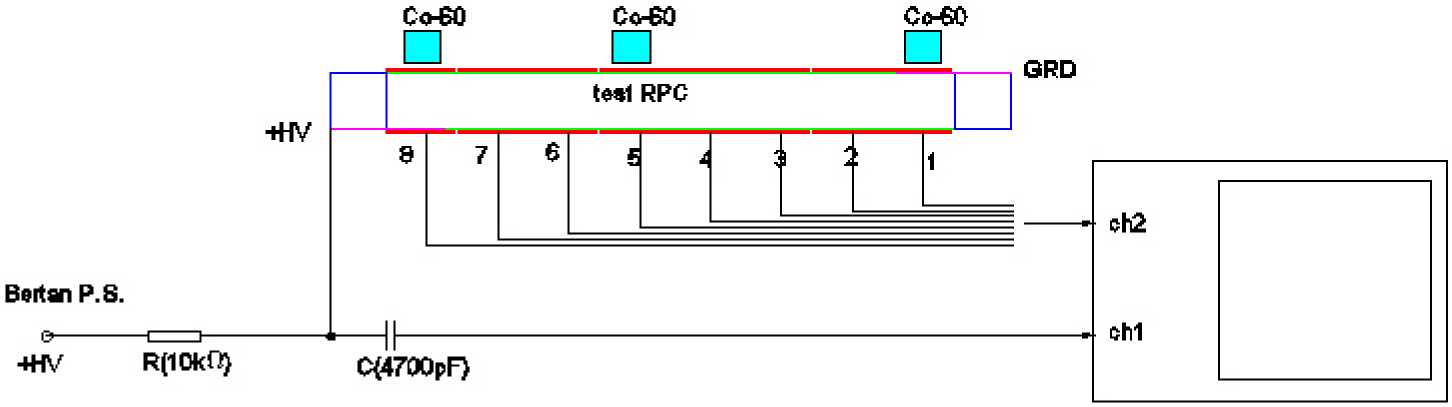
The source of the coincident events between two RPCs (placed side by side, one is connected to HV, the other is AC coupling to HV line, but DC isolated) could be

(1) Common RF noise source;

(2) Huge RPC #1 signal induces noise pulse on RPC #2 strip.

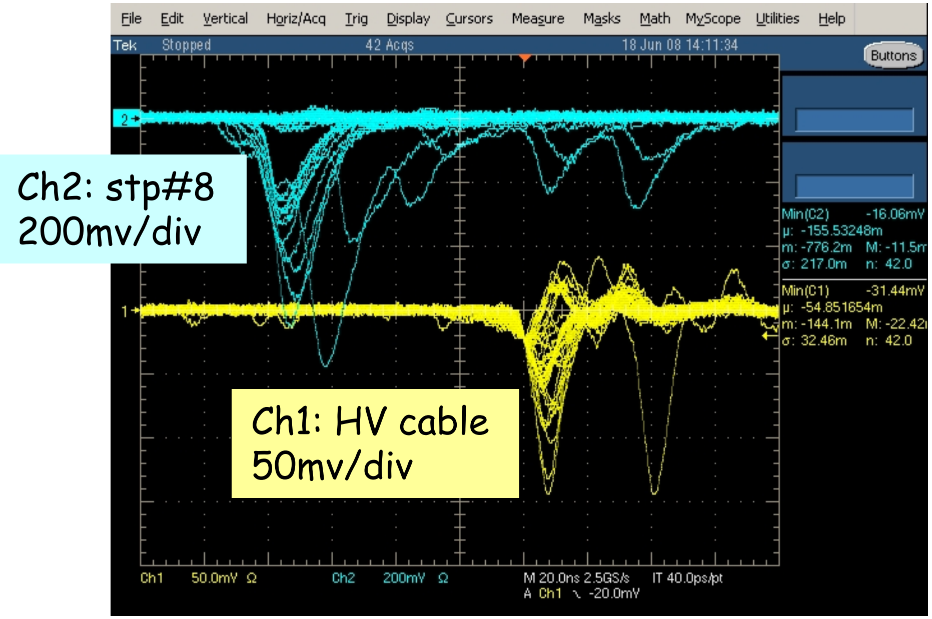
Compared to strip signal rate (>1kHz) the coincidence rate (~0.1Hz) is very low. Add additional shielding surrounding the test chambers might be able to remove most of these coincident events.

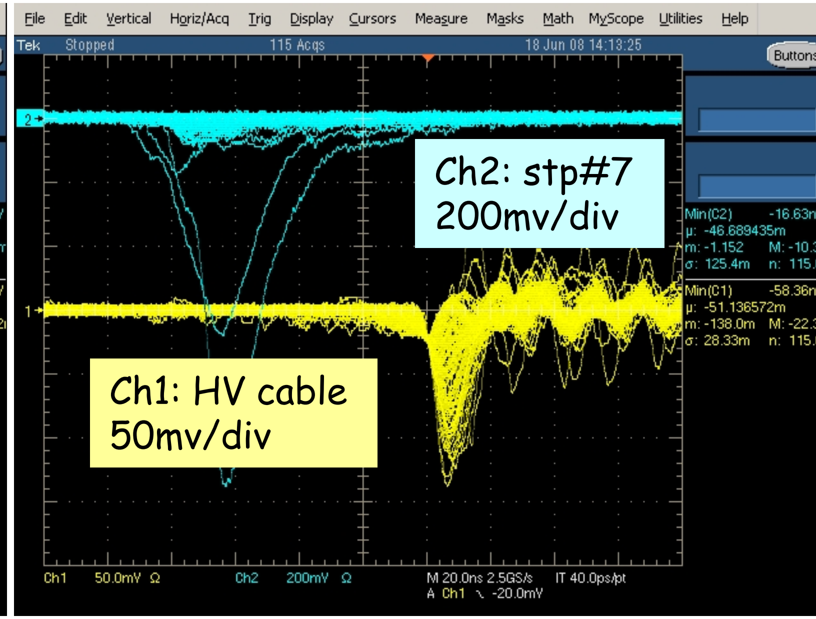
# Where does the signal on HV cable come from?



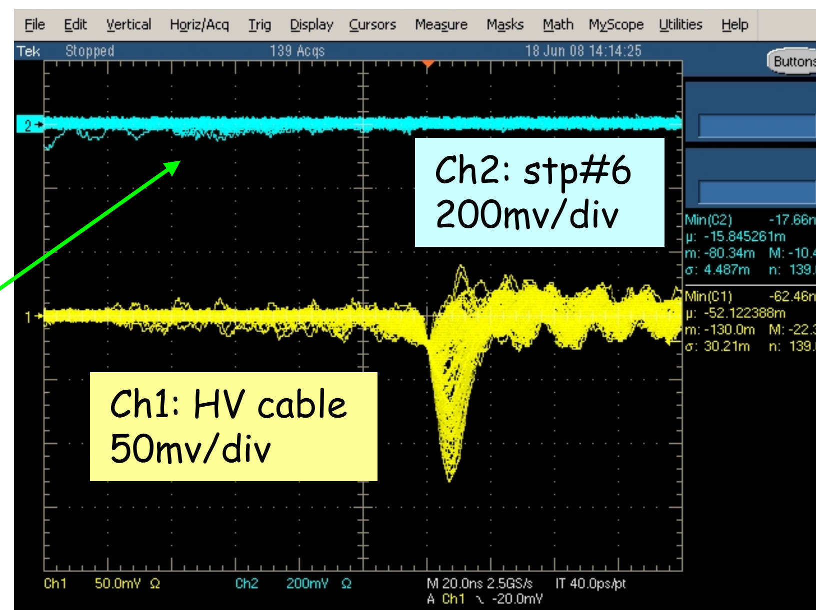

Triggered on ch1, record both ch1 and ch2. Co-60 is on the location of strip #1, ch2 records strip #8, #7 and #6 separately.

# Scope signals

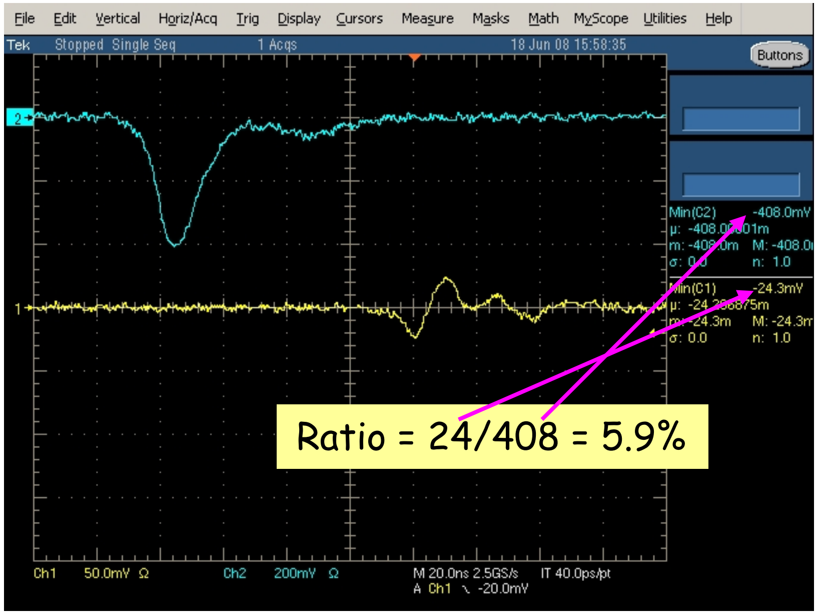


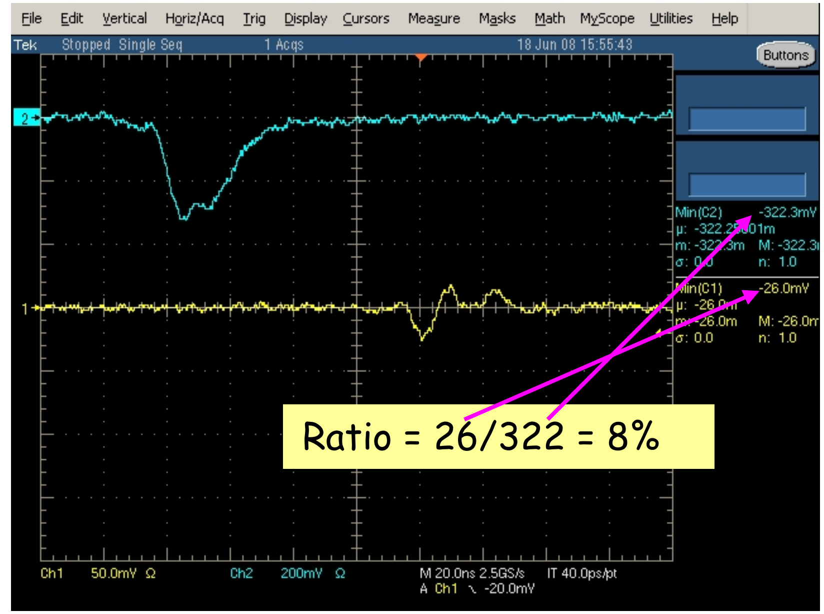




It is clear that when triggered by the pulse on HV cable, the rate of the coincident pulse on strip strongly depends on the strip position: the highest is strip #8, which is overlap the HV copper tape, then strip #7. Strip #6 almost sees nothing.

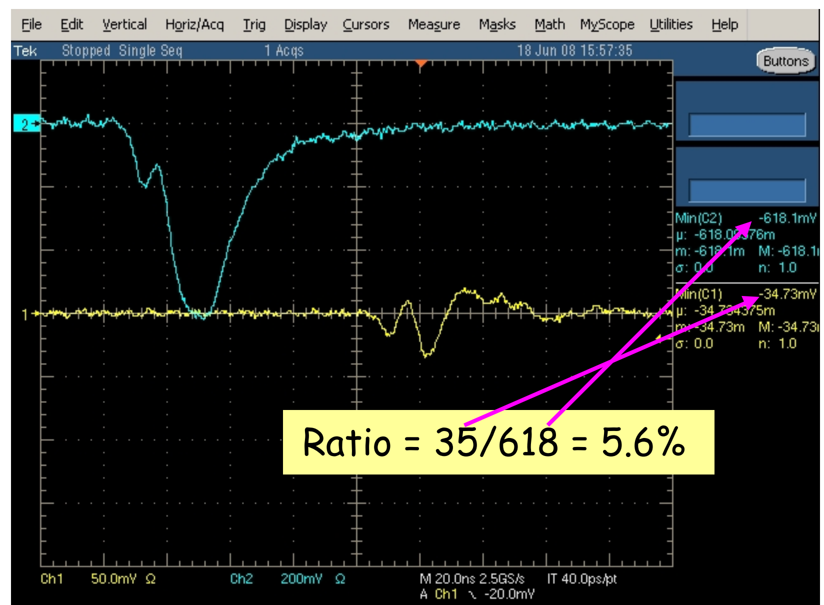


# Scope signals (cont'd)




The coupling ratio between HV cable and strip signal is ~ 5.6 – 8% (consistent with previous observation – slide #8).




Now we can identify the source of these pulses on HV cable: they come from the coupling between HV copper tape and strips. If the streamer signal on strip very big, >600mv, the pickup signal on HV cable can be >30mv.

# Scope signals (cont'd)

Although the signal on HV cable can be large enough to cross 30mv threshold, in order to be able to produce a fake signal, they must be picked up by the strip on other RPC. This is another fact of 20 reduction (5%) as we mentioned on slide #6. Overall reduction is 0.4% (slide #8). It means that the original strip signal needs >7.5v, the pickup signal on other strip might be >30mv, that chance is very rare. So we may not need to worry about this problem.