# RPC HV cable pick-up noise issue

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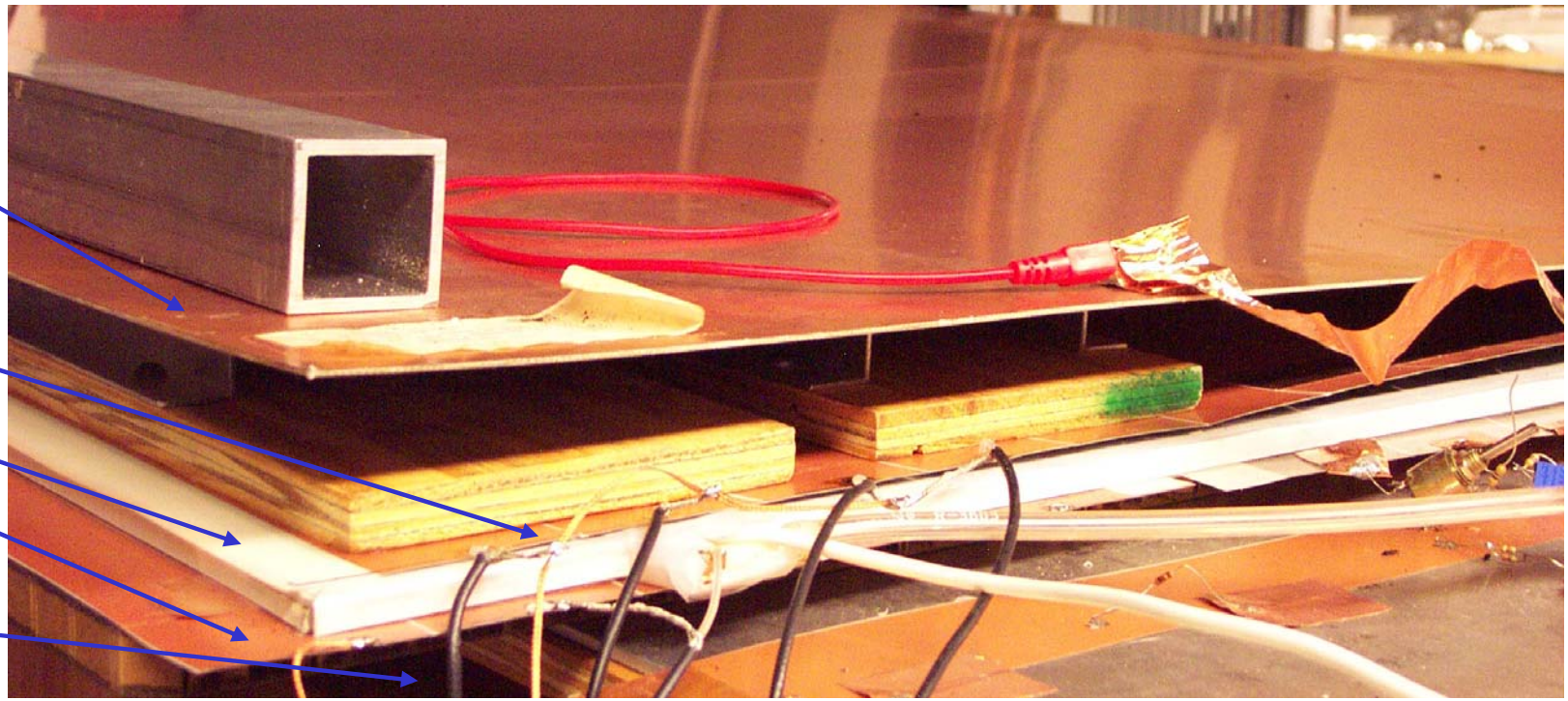
I pulled out some slides from my old DocDB files (DocDB#2209 and #406), and add few more new slides. Based on the existing information gathered from various RPC sub-systems a sketch diagram of the cable connection for the entire RPC system is provided.



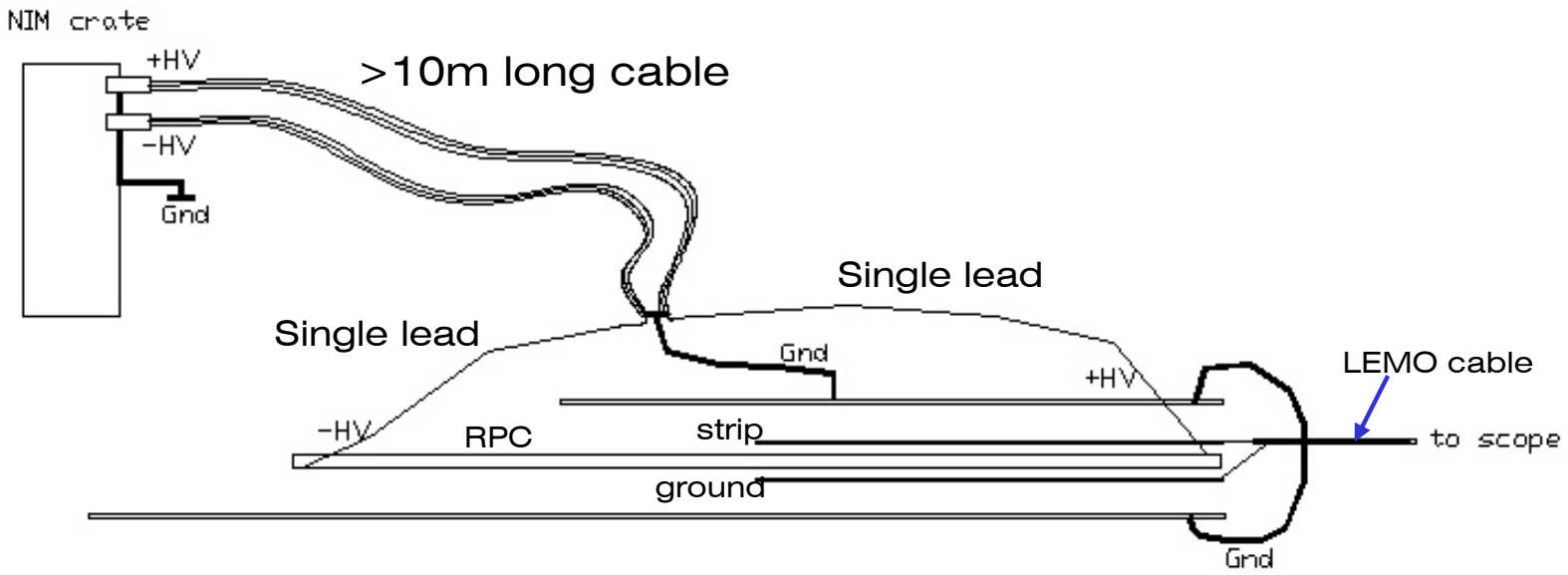
# Would pickup noise on HV cable cause any trouble to streamer mode RPC?

The following 4 slides are excerpts from DocDB 2209. A lab setup is used to study how bad/good the pickup noise due to HV cable can be.

# Test arrangement



# Pick-up noise when HV cables are connected




The room is using fluorescent light.

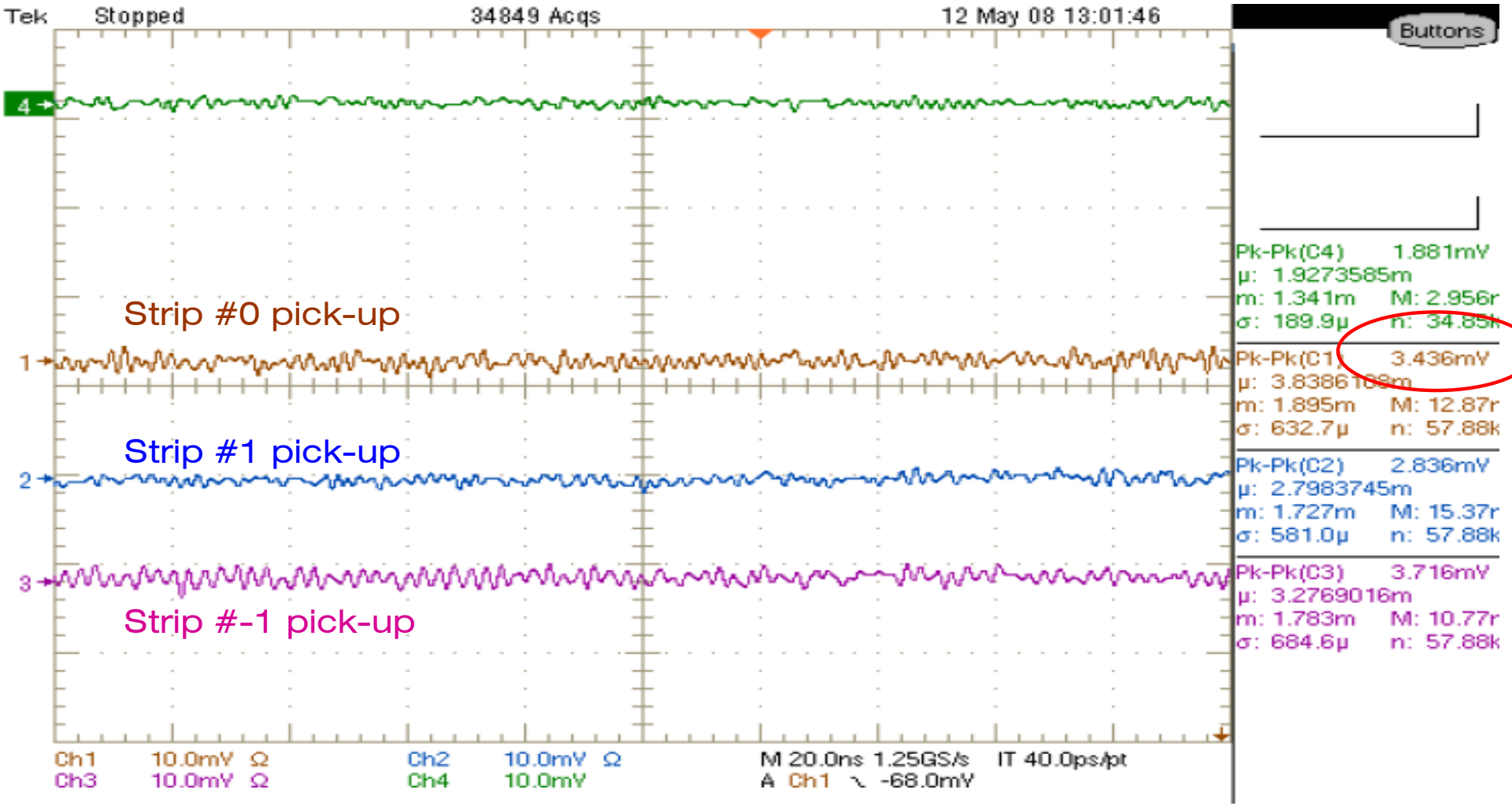
The following two slides show the pick-up noise on strip #0 for two grounding schemes:

(1) two ends grounded separately;

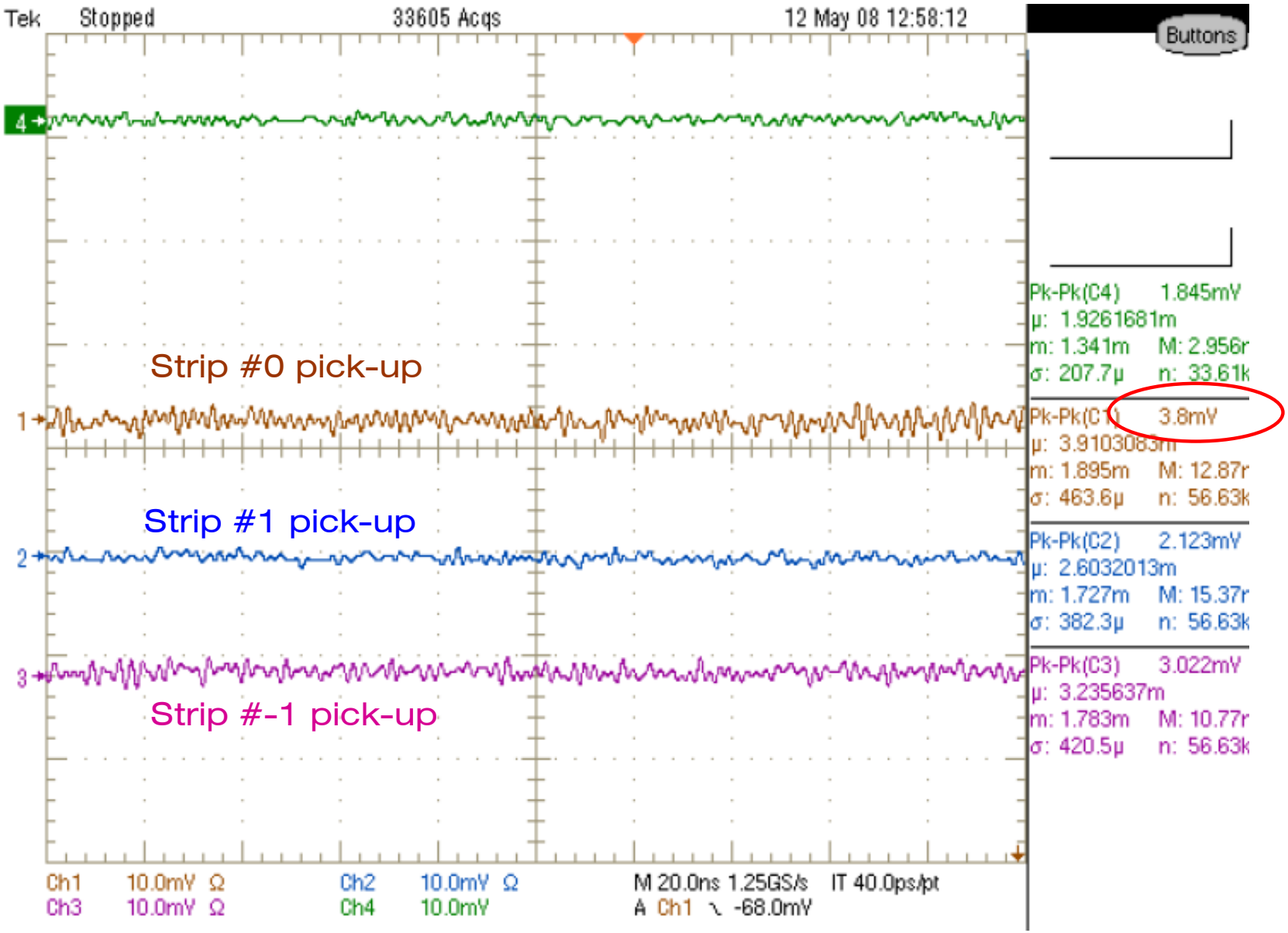
(2) only HV supply (Bertan power supply) side is grounded (through AC power plug).

There is no difference between them.

# Ground two ends separately

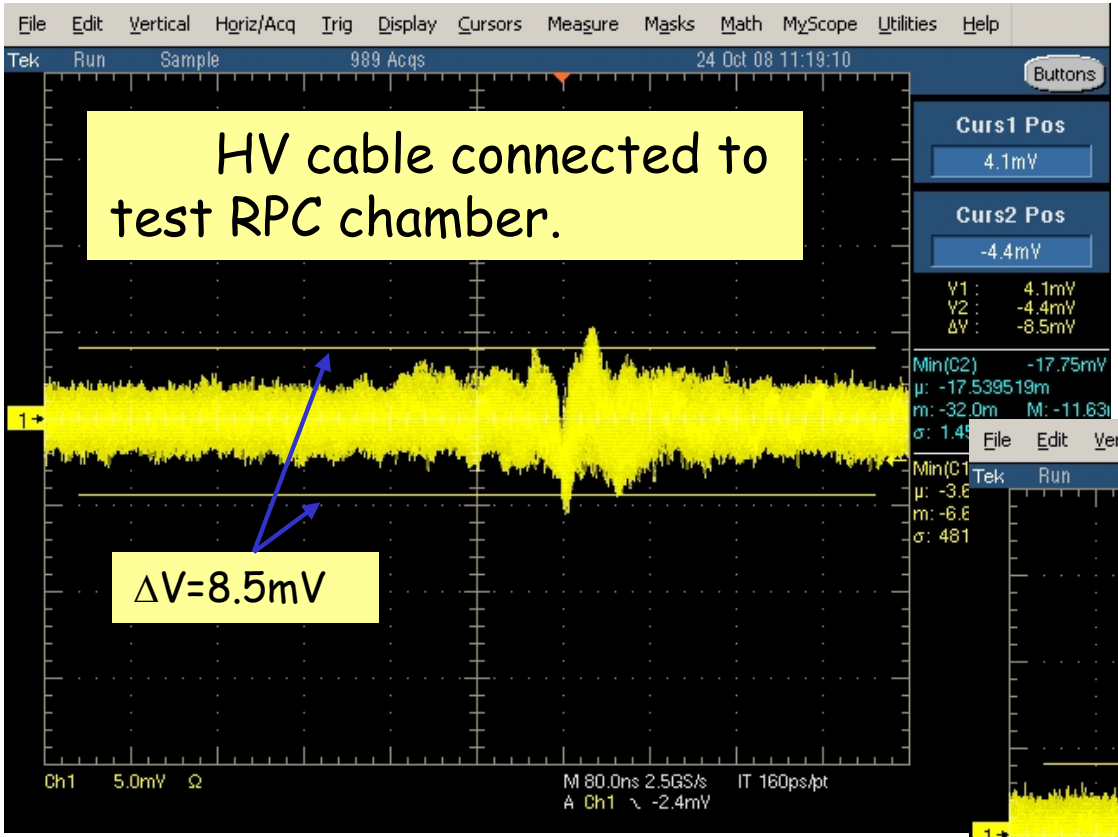


# Ground at HV supply side only

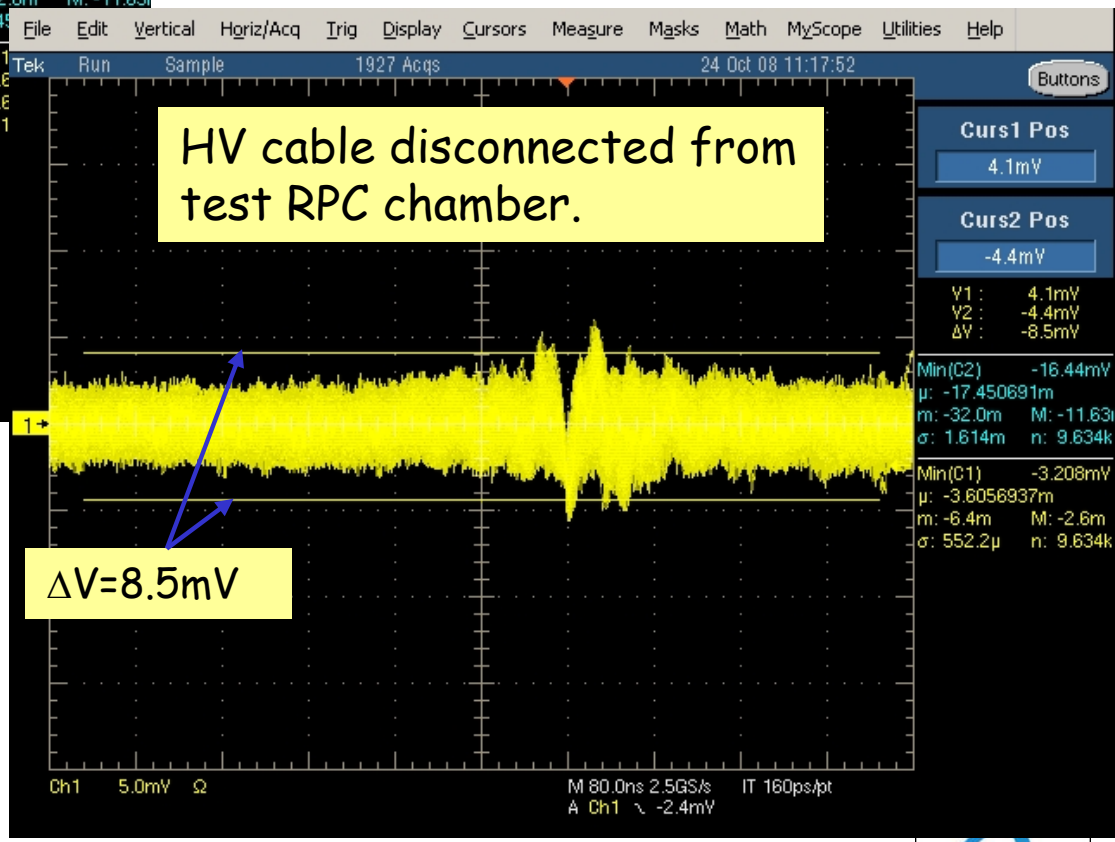


# Long HV cable (~33m)

The HV cable length from mainframe to fanout is 44 – 55m, from fanout to RPC is 5.5 – 23m.



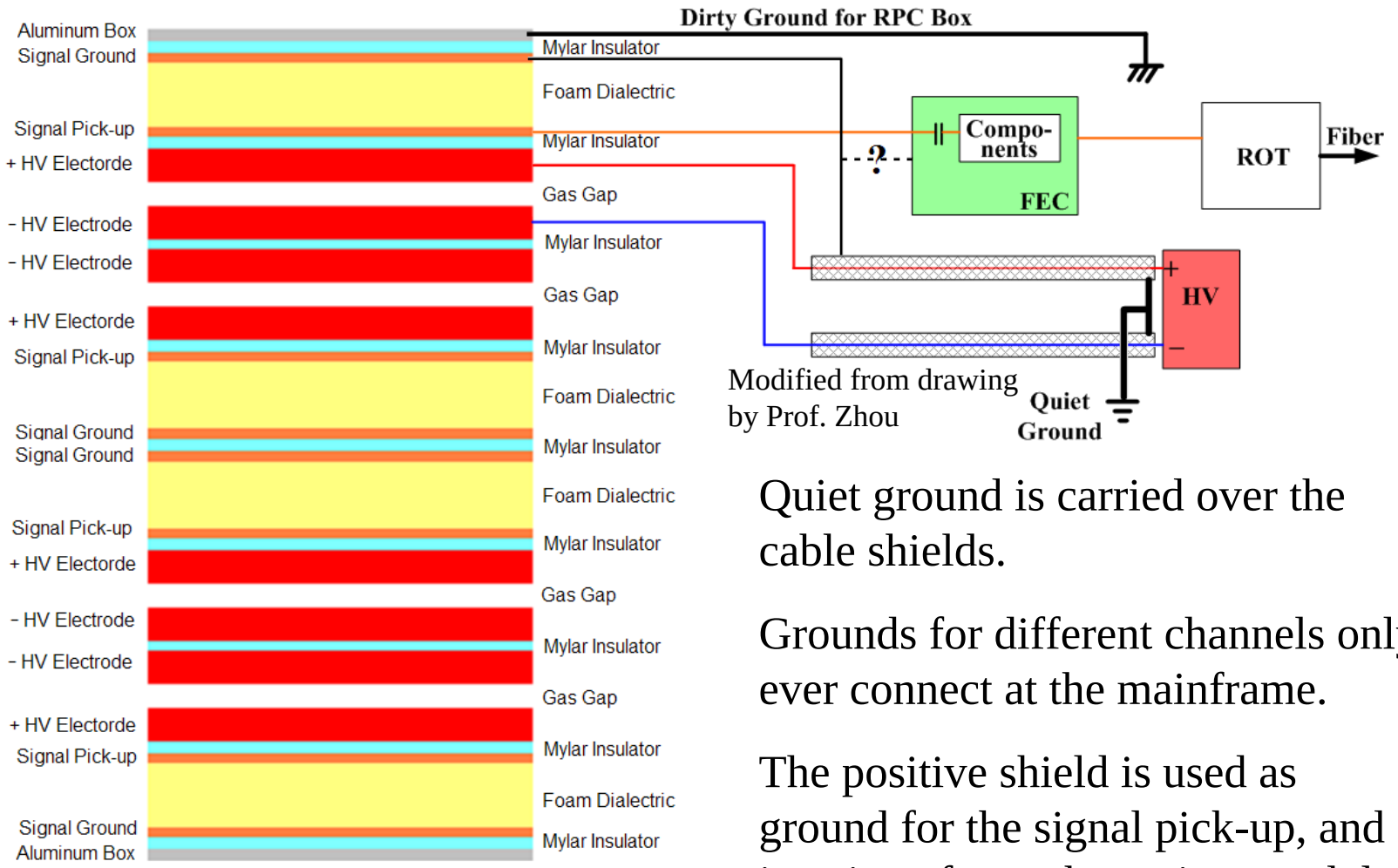

The Bertan HV power supply is in a NIM crate of next lab, power switch is ON, but HV = 0. The NIM crates in two rooms are grounded through the ground pole of the AC plug, so in this case they are grounded separately.




There is no difference on noise seen from strip transmission btw connected and disconnected the HV cable.

# Comment on two different module designs

## The New Grounding Diagram (J. Link)

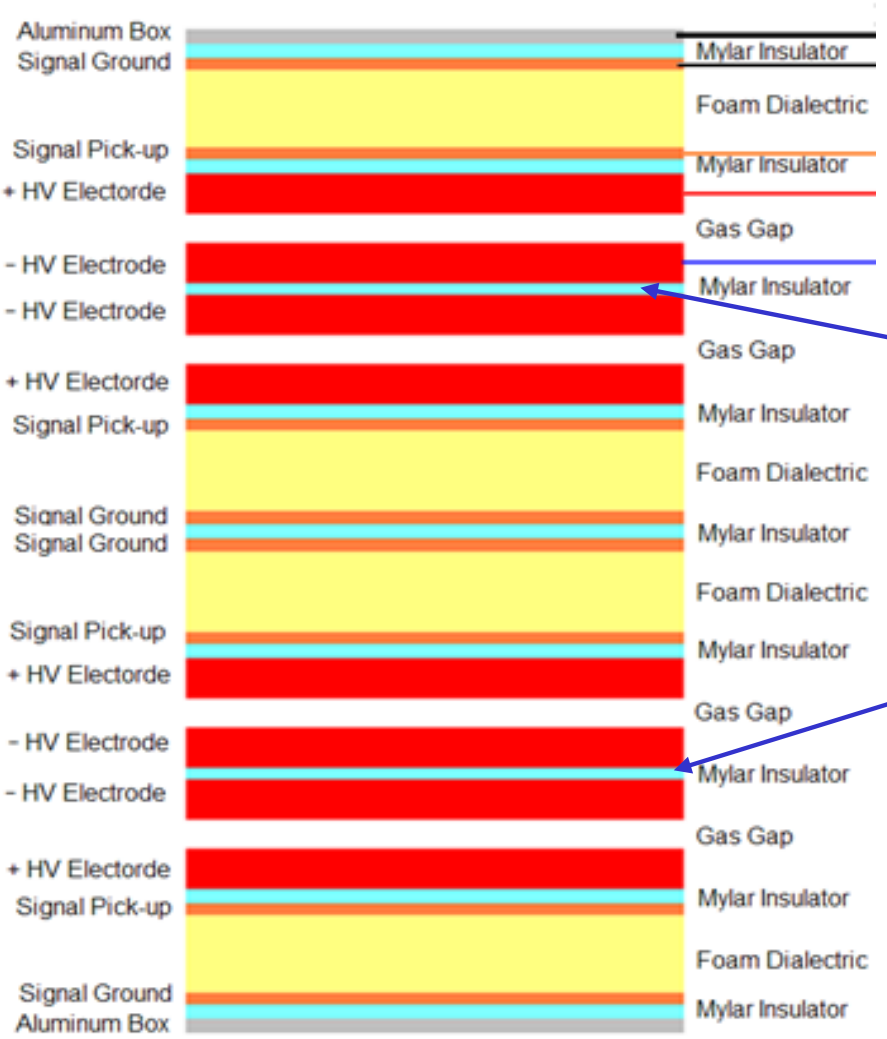



Quiet ground is carried over the cable shields.

Grounds for different channels only ever connect at the mainframe.

The positive shield is used as ground for the signal pick-up, and is unique for each gap in a module.

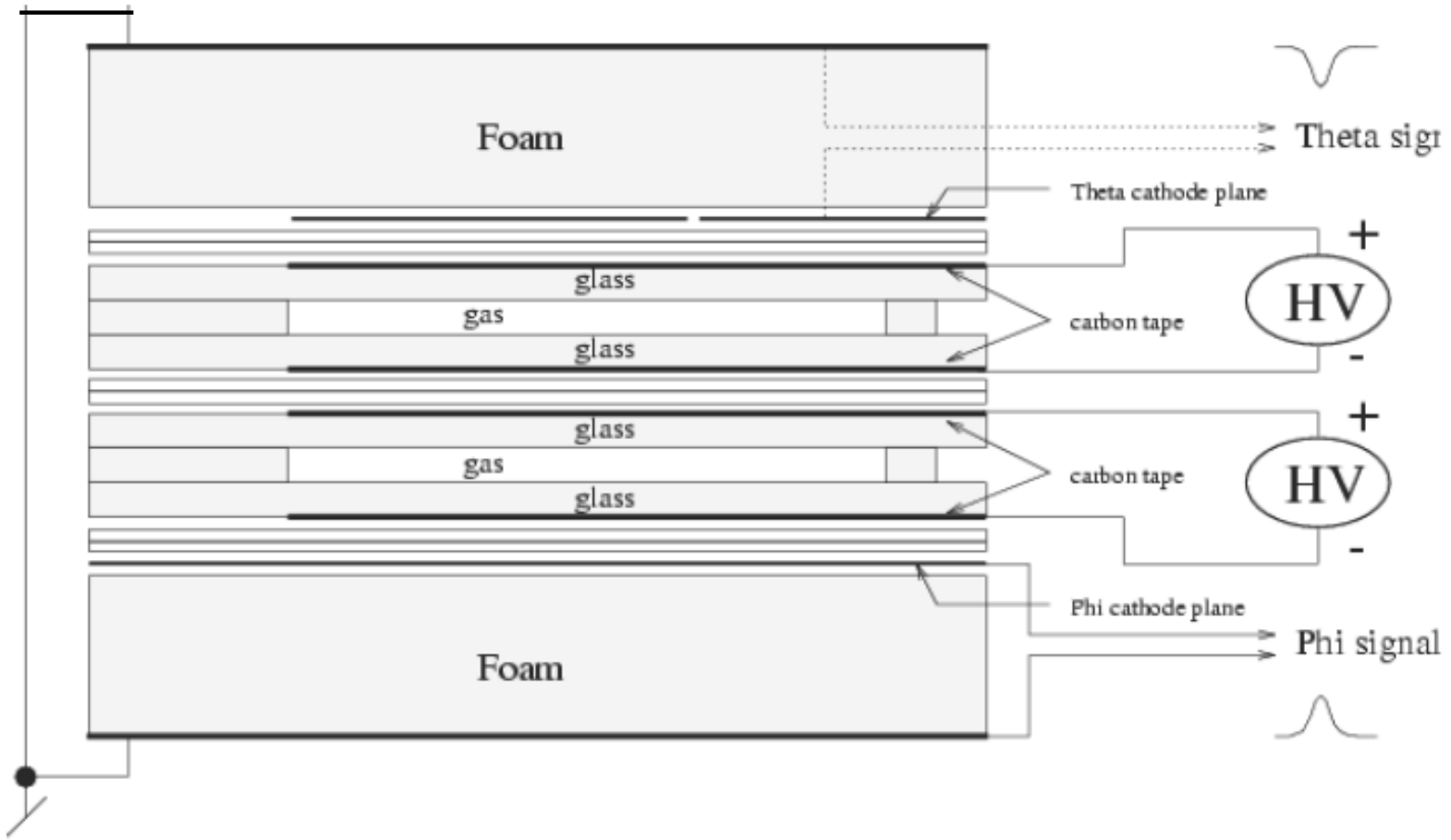
# HV polarity in two gaps



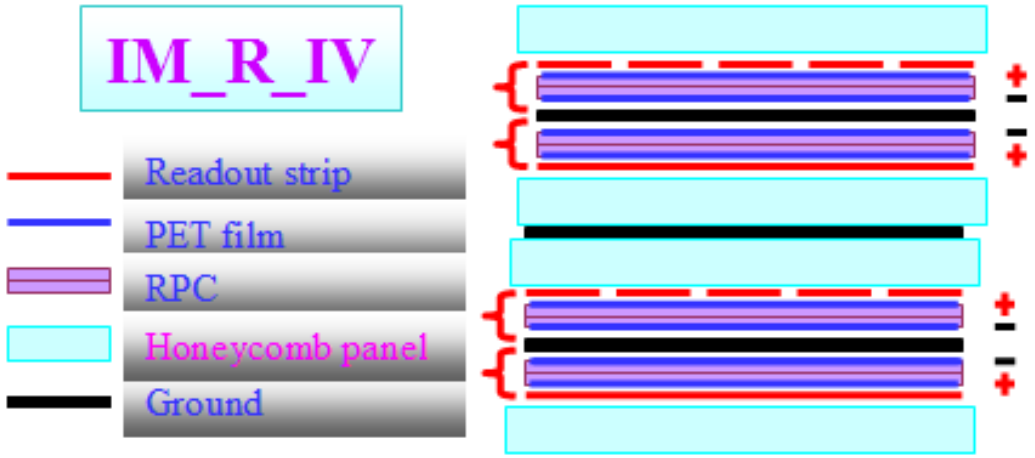

- This RPC module won't work: the polarities in two gaps of one pair RPCs are opposite, so the induced signals seen by the pickup strip from two gaps will cancel each other, strip will get no signal!
- To correct this problem we have to apply same HV polarity for both RPCs in a pair, that means the gap btw two RPCs will see full potential: ~8000V. Belle RPC used this configuration, see next slide, which is excerpted from my DocDB #406, there is detailed discussion on this issue.

# Belle Double gap RPC (DocDB #406, slide #7)

If we use BELLE's double gap configuration, two dimensions are readout from top and bottom sides:

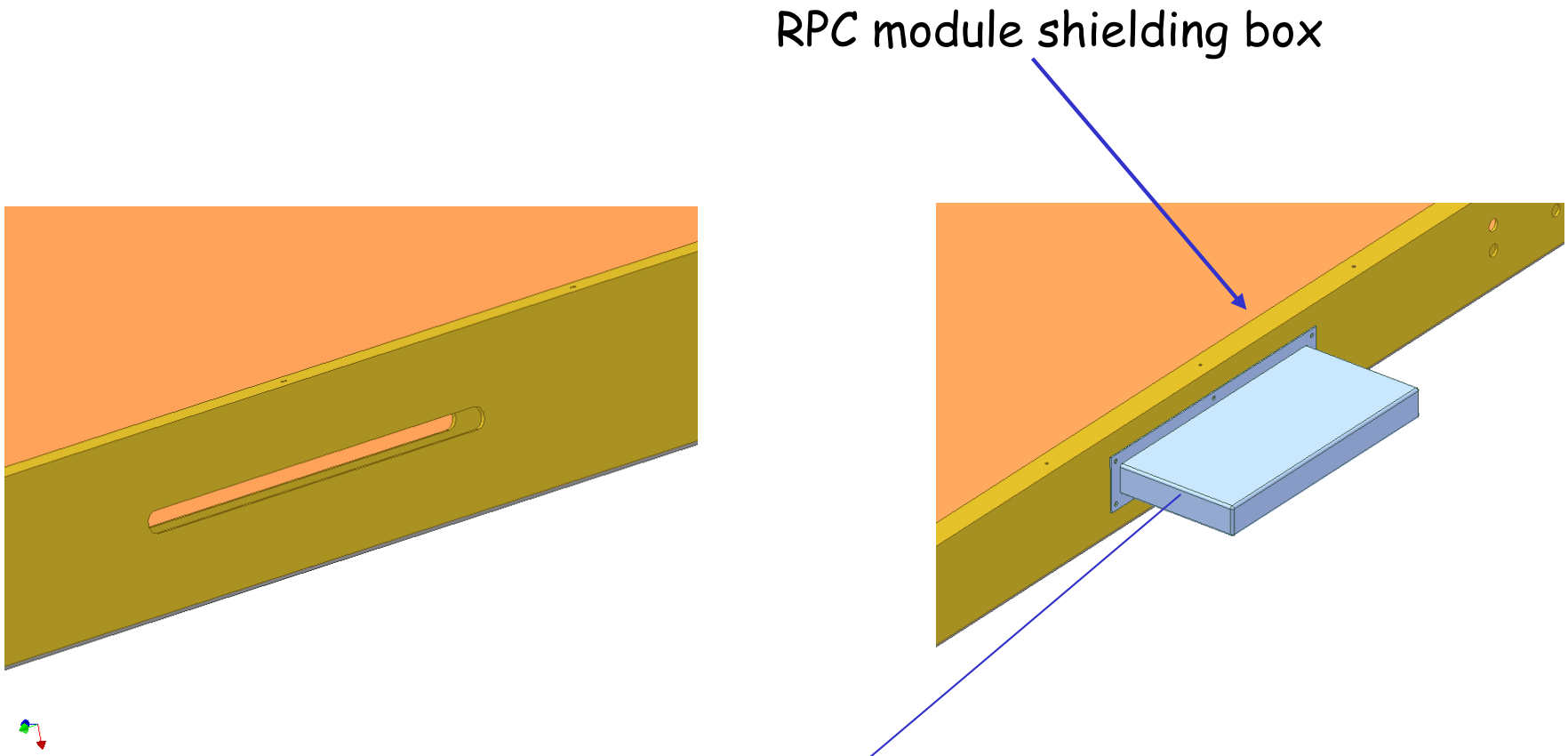


# IHEP's design




I don't see any problem with this design. As I mentioned before the pickup noise won't cause trouble to streamer mode RPC, there is no need to split the middle ground to two and isolated them. We still can apply HV to four layers of RPC independently, all three ground planes can connect together. Because the FEC box is directly attached to the module shielding box, after the FEC the signal will be digital (discriminator's output signal), and will send to ROT (Read Out Transceiver), which then through optical fiber will be linked to ROM (Read Out Module). Entire detector (RPC) and FEC are enclosed in a same shielding box (see next slide), that is much better than most of the existing streamer RPC system.

# FEC (Jiawen Zhang & Xiaoyan Ma, DocDB #1980)




4 flat Signal cables are connected to FEC which screwed on the top panel

# Noise suppression in FEC design

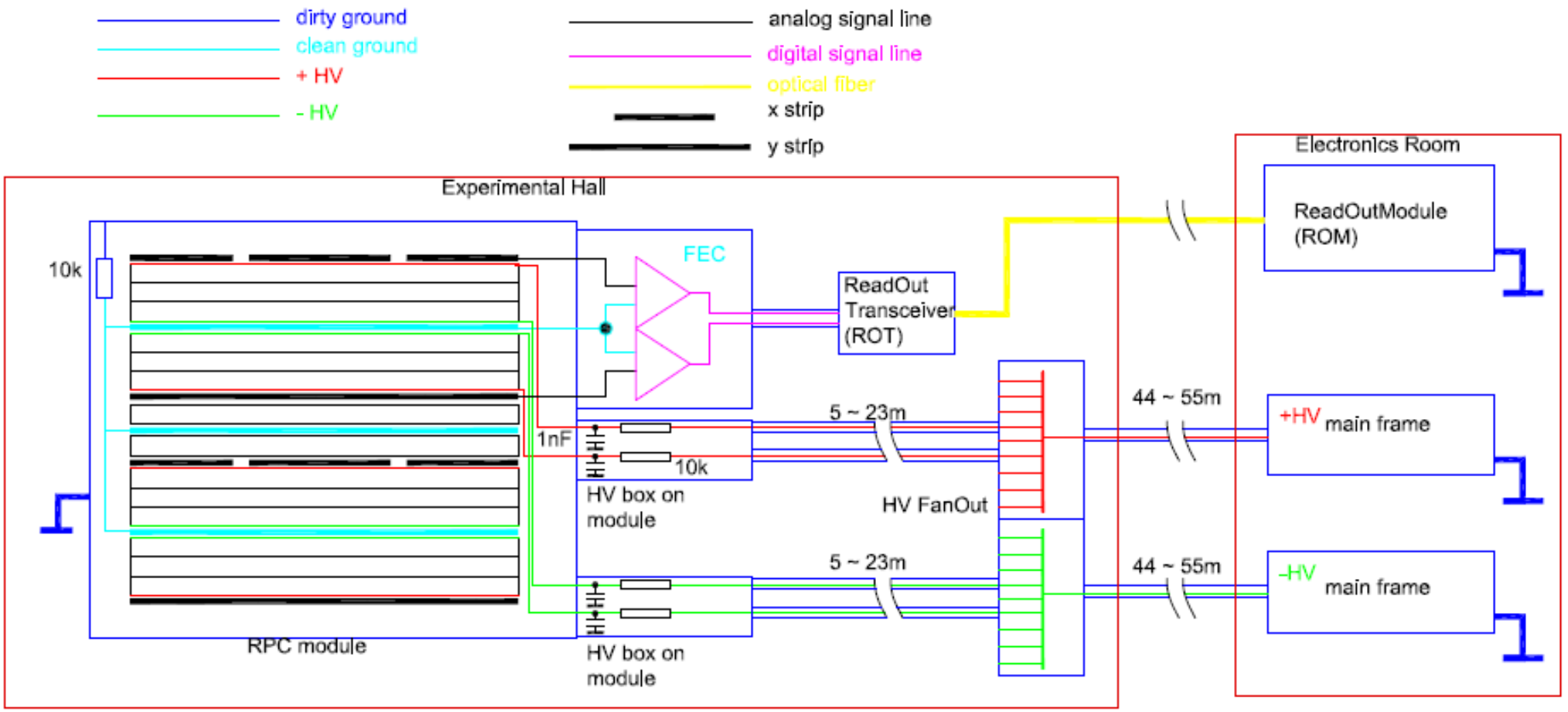
USTC has paid attention to suppress the possible noise in the FEC circuit, the following is excerpt from "DayaBay RPC Front End Card Final Design Report" (DocDB #2432)

*3.3.4 Power Supply Decoupling and Anti-inference Designs*

The DYB RPC FEC uses multiple power supplies including +2.5V analog, +5V, +3.3V,+3.3V for comparators, +2.5V digital power supplies and a +1.2V FPGA Core power supply. All power regulators providing those powers has a pair of capacitors to decouple the lines, each power input pin on major components owns separated decoupling and hiss-filtering capacitors. For FPGA consideration, not only does each FPGA power pin has its own decoupling capacitor valued 0.1 μ F, each I/O bank has its own 22 μ F capacitors to filter high-frequency noises. Thus integrality of FPGA signals can be ensured. Also, in anti-interference considerations, we added necessary inductors, magnet beads, choke loops etc. to limit the effect of ground noise and other possible interferences to make sure that FEC would function normally under harsh circumstances.

# Cable connection in RPC system

I gathered information from the recent published Daya Bay DocDB files and private communication (Jiawen, Jon, Kirk, Hao Liang …), made a following sketch diagram to show the internal cable connections for the entire RPC system. Even there is noise on the dirty ground, but the detector and FEC are enclosed in a same electric enclosure, the noise will be shown as common mode to the strip/ground return, which are the inputs to FEC, will be canceled out.



# Will the huge streamer signal be the noise source for PMT?

Should we concern the huge streamer signal of the RPC be the noise source of PMT?

- The entire RPC system is enclosed in a metal enclosure, the outmost layers of the RPC chambers are grounded, there is no RF noise can escape to the environment;
- Jon has added a low pass filter before connecting HV cable to RPC electrodes, thus RF noise will be suppressed;
- The HV cable is coaxial RG59B, the shielding is grounded.

Based on these precautions I think we can put this concern into rest.

# Conclusion

The lab test results show:

- The HV cable grounding (single end ground or both ends are separately grounded) won't introduce large noise (compare to streamer signal) to the readout strip, thus for streamer RPC this is not critical;

- For long HV cable (~33m) and both ends are grounded separately, there is no noticeable noise difference for cable connected or disconnected to the test RPC chamber. The maximum noise level of ~ 10mV peak to peak in my lab is far below streamer signal (unipolar signal > 30mV). Therefore the long Daya Bay RPC HV cable won't cause serious pickup noise neither.

- The HV/ground arrangement in IHEP's module design looks OK. The HV of four layer's RPC can be powered independently. There is no need to split the middle ground plane to two isolated ground planes.

- The huge RPC streamer signal won't be the noise source of PMT.