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Cross-Talk between Right and Left Half of Barrel TRT Module

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1. Introduction

The barrel TRT modules can be read out from both ends because of the wire-joints thus the occupancy in a straw is reduced by a factor of two (Figure 1). A wire-joint utilizes a small capillary glass tube to join two segments of a sense wire. It should be noted that only the sense wire is cut and joined, but the straw tube is continuous.

Figure 1. A picture of a wire-joint still in a production jig. On can see two melted regions and the center melt, and wire. The length is ~ 5-6 mm.

One of the concerns for the wire-joint is the cross talk between the two halves of a module. Although the left and right side of the sense wires are independent, the left side and right side are connected through straws, the shell, ground cables, and shielding and could result in considerable cross talk. In this report, we present results on the cross talk measurement using one of the production modules (M2.30). This measurement only involves the module level cross talk.

2. First set up

The basic method for the cross talk measurement here is to produce signal (using Fe^{55} for example) at one side of a wire-joint and observe the cross talk signal at the other side of the wire-joint. The produced signal is used to trigger a scope and the cross talk signal is measured from another channel of the scope.

Figure 2 shows a diagram of the first set up. We have chosen a group of sixteen straws belonging to an ASDBLR electronic group. One end of these straws (right side of the wire-joints) is connected to a sixteen channel amplifier being used for our X-ray gain mapping. These were the CDF VTX detector amplifiers. The amplified signal from this end is fed into a Lecroy digital scope as a trigger.

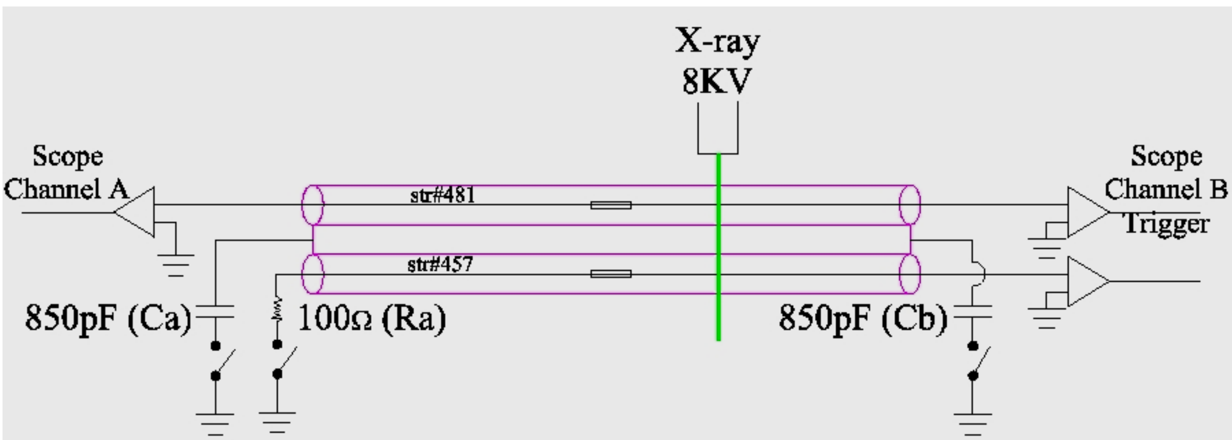

Figure 2. The first set up for the cross talk measurement.

From the other end (left side of the wire-joints) one straw (straw number 481) is connected to a broad band (1 GHz) Philips amplifier with 50 ohm input impedance. The signal from the amplifier is fed into another channel of the scope to measure the cross talk amplitude.

Three trigger straws are chosen (straw number 481, 457, 479) from the right side. The choice for 481 is obvious. Straw 457 shares the same HV group as 481, and 479 belongs to an adjacent HV group. We note that a HV group normally consists of eight straws sharing one filter capacitor (850 pF) at each end.

The same X-ray beam (8 KeV) used for the gain mapping is utilized to generate signals. First it is positioned at the left side of the wire-joints to measure the amplitude from the Philips amplifier. This amplitude is the reference to calculate the fraction of the cross talk later. The average amplitude from the 8 KeV X-ray beam is about 200 mV (to 50 ohm) after the amplifier. For this experiment, operating HV is raised to about 1650 volts to produce larger signal.

Next, the X-ray beam is moved to the right side of the wire-joints. The scope is triggered with signals from one of the three straws and 1000 signals from the Philips amplifier are averaged. The peak of the averaged amplitude divided by 200 mV is quoted as the magnitude of the cross talk.

The data is taken under several different conditions as shown in the table below (see Figure 2 for the notation). For example, in Case II, the filter capacitors at the left end are connected, the filter capacitors at the right end are not connected, and the straws are not terminated except 481 at the left end. All 16 straws in the right side are always terminated through the amplifier.

For each case, there are three measurements corresponding to the three trigger straws. It is again worthwhile to note that the straw number at the left side for the cross talk measurement is always 481.

	C_a(left side)	C_b(right side)	R_a(left side)
Case I	No	No	No
Case II	Yes (850 pf)	No	No
Case III	Yes	Yes	No
Case IV	No	No	Yes (100 ohm)
Case V	Yes	No	Yes
Case VI	Yes	Yes	Yes

3. Results from the first set up

Case I
This is when there are no filter capacitors and no terminating resistors. The results of the cross talk measurement are in Figure 4 and there are three plots. The top plot is when the trigger straw is 481, the middle plot is with the trigger straw 457 and the bottom plot is with the trigger straw 479. There are two curves in each plot. One (with a lot of fluctuation) is the averaged cross talk signal, and the smooth curve is an example of the trigger signal.

It is interesting that the largest cross talk occurs not within the same straw (481-481) but between the straws sharing the same HV pad (481-457). From the plots, we calculate that the cross talk within the same straw is about 1 %, the cross talk between different straws but sharing the same HV pad is about 2.5 % and the cross talk between different straws and not sharing the same HV pad is about 1 %. The table below summarizes the results.

Condition	Cross talk
481-481	~1 %
481-457	~2.5 %
481-479	~1 %

(481-457 in the table above means that the cross talk signal is observed from the left side of straw 481 while the trigger signal is from the right side of straw 457.)

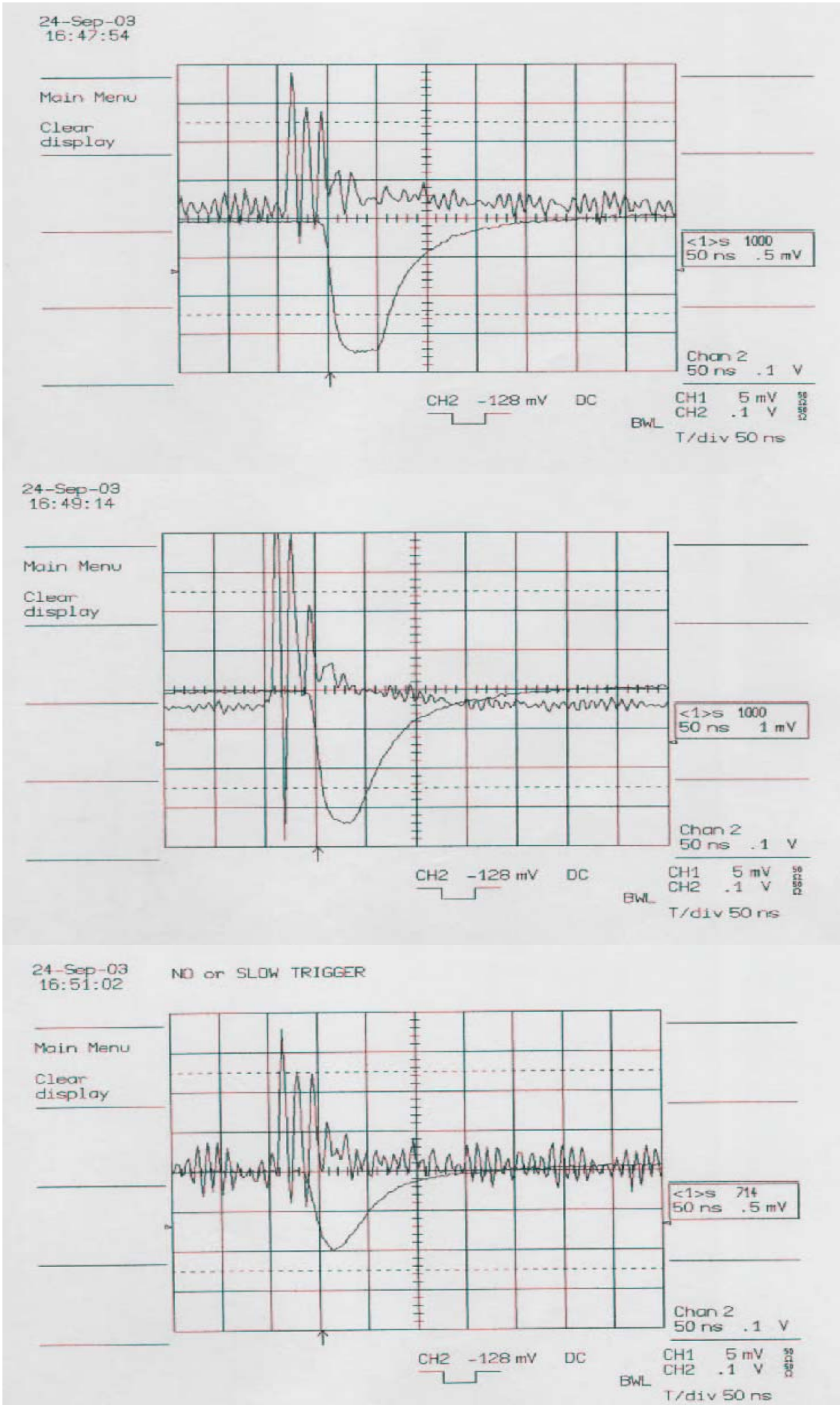

Figure 4. Top plot: 481-481, middle plot: 481-457, bottom plot: 481-479.
There are two curves in each plot. One (with a lot of fluctuation) is the averaged cross talk signal, and the smooth curve is an example of the trigger signal. The horizontal scale is 50 ns per division. The vertical scale for the averaged cross talk signal is 0.5 mV per division for the top and bottom plots and 1.0 mV per division for the middle plot.

Case II (see also Figure 5 for the cross talk plots)
The limit of our measurement is about 0.2%.

Condition	Cross talk
481-481	less than ~0.2 %
481-457	~0.5%
481-479	less than ~0.2%

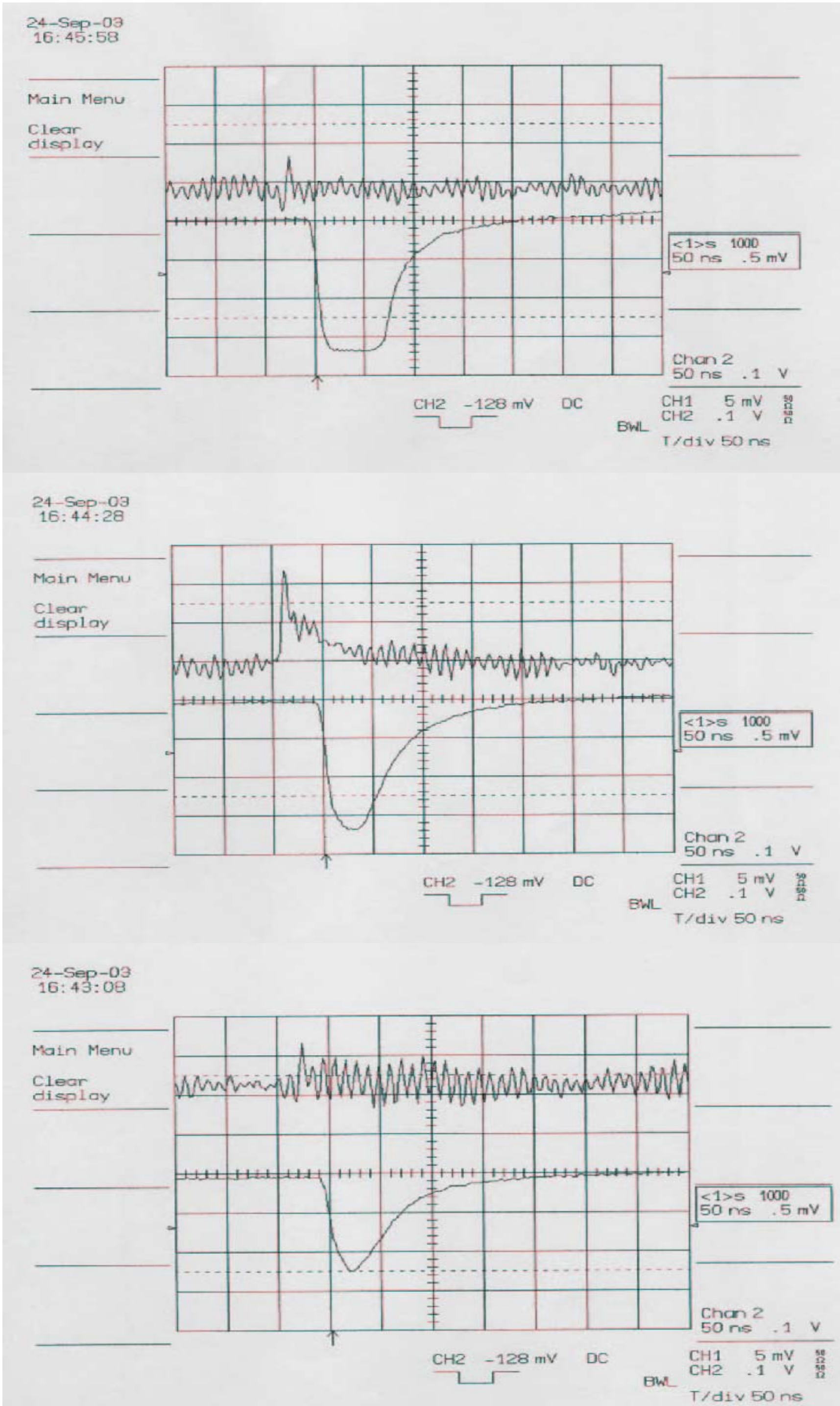

Figure 5. The horizontal scale is 50 ns per division. The vertical scale for the averaged cross talk signal is 0.5 mV per division.

Case III (see also Figure 6)

Condition	Cross talk
481-481	less than ~0.2 %
481-457	~0.2 %
481-479	less than ~0.2%

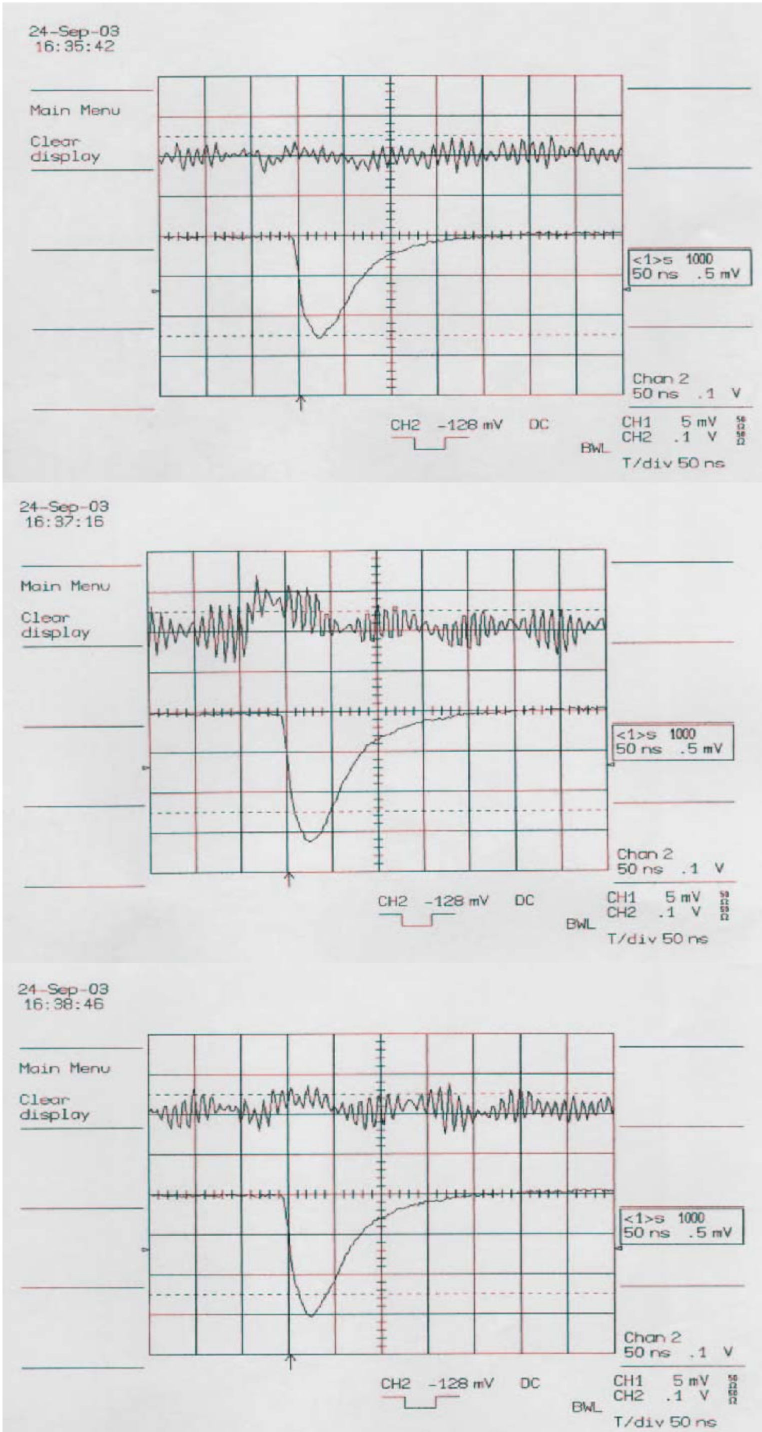

Figure 6. The horizontal scale is 50 ns per division. The vertical scale for the averaged cross talk signal is 0.5 mV per division.

From the three tables above, it is clear that the filter capacitors are critical in reducing the cross talk.

The following three cases are obtained under the same conditions as the previous three cases except the left end of straw 457 and 479 are terminated with 100 ohm resistors. This is to simulate more realistic running condition during the data taking.

Case IV

Condition	Cross talk
481-481	~0.5 %
481-457	~1.8 %
481-479	~ 0.5 %

Case V

Condition	Cross talk
481-481	Less than ~0.2 %
481-457	~0.2 %
481-479	Less than ~0.2 %

Case VI

Condition	Cross talk
481-481	less than ~0.2 %
481-457	less than ~0.2 %
481-479	less than ~0.2%

Compared with no terminator cases, the cross talk is reduced by ~30-50%. The cross talk plots for these cases are not shown because they are quite similar to previous cases except amplitudes.

4. Second set up and results

The second set up simulates the beam test set up just completed. The cross talk study in the beam test is to shoot beam to one side of a module and observe the cross talk in the other side (Figure 7). Similar to the beam test set up, all left side straws are grounded and the beam is replace with the X-ray beam. We observe any cross talk signal from the right side (through CDF VTX amplifier) using the digital scope. Since there is no trigger signal, we compare the scope trace with X-ray beam on to X-ray beam off condition.

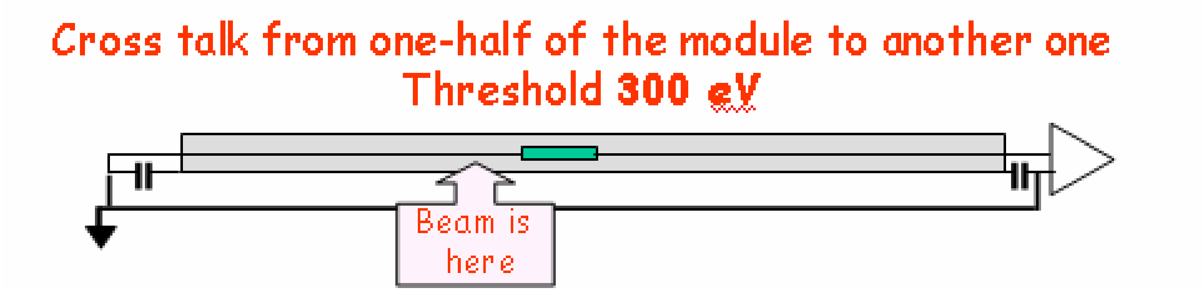

Figure 7. A diagram for the cross talk study in the beam test (8/2003). The beam is replaced with X-ray beam in our measurement.

Figure 8 shows a screen capture of cross talk signals without filter capacitors. It is about 7.5 mV. Knowing the signal strength of 8 KeV photon from the CDF VTX amplifier (~400 mV), the cross talk is about 2 %, which is consistent with the previous measurement (Case I or Case VI). We should point out that the X-ray beam width (perpendicular to the straw tubes) is about 5 cm such that the beam crosses not only the straw connected to the scope but also many neighboring straws.

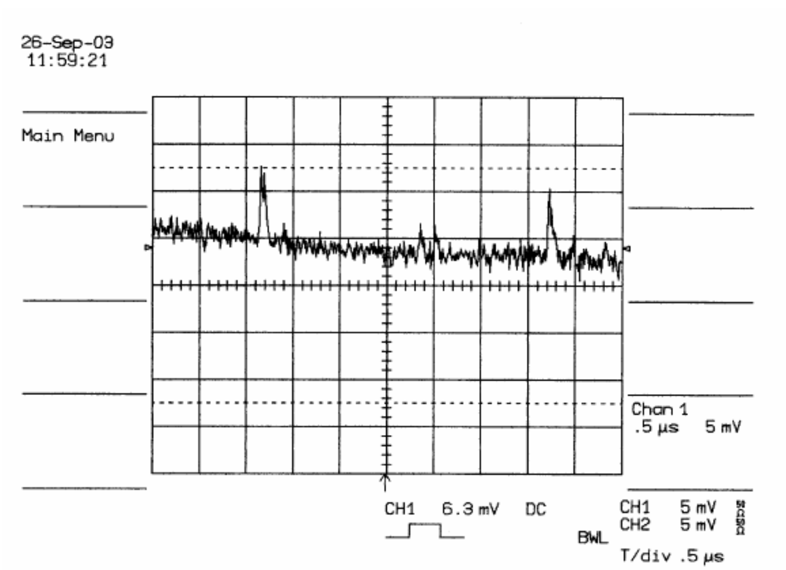

Figure 8. The cross talk signals observed without filter capacitor.

Figure 9 shows a screen capture but filter capacitors are inserted. There is no apparent cross talk present, which is also consistent with Case III or Case VI.

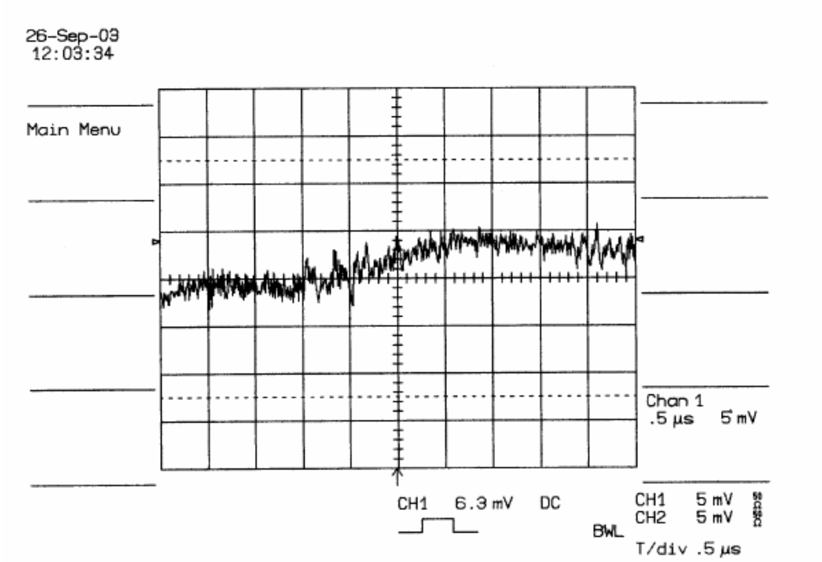

Figure 9. No apparent cross talk signals are observed with filter capacitors.

5. Summary and Conclusion

We report on the cross talk measurement between the two halves of a barrel TRT module. We find that the filter capacitors are very important in reducing the cross talk. Our measurement shows that the cross talk is largest between straws sharing the same HV pad. It is even larger than within the same straw. From this measurement, we could conclude that coupling (inductive and/or capacitive) between straws plays an important factor. Under the condition similar to the real experiment (Case VI), the cross talk is expected to be less than 0.2%.