Crosstalk free multi-strip Resistive Plate Chambers?

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Because of its highly-quenched operating mode, a gaseous detector of the Resistive Plate Chamber type (RPC) can work at constant fields in excess of 100 kV/cm at ambient conditions. The very fast avalanche dynamics can thus result in exponential signal rise-times down to $t_{rise} = 100$ ps, when not space-charge limited. The associated time resolution $\sigma_t = 50-100$ ps is a consequence of this fact.

A most intriguing technological problem is the routing of such signals out of the RPC detector itself, usually made of densely packed multi-strip electrodes. Next generation RPCs (CBM, NeuLAND-R3B, iTOF-R3B) aim at doing it over up to 2 m with little signal shaping and, as much as NeuLAND and CBM are concerned, with little or no crosstalk also. Present 'state-of-the-art', 1 m long multi-strip RPCs (from the '4-pi' experiment at GSI) show, indeed, a fairly large cluster size of 4.5 strips/track.

The problem of signal transmission can be tackled through a N-conductor transmission line simulation. However, the structure of the solutions is complicated enough that no simple analytical estimates can be obtained in general. We have introduced in [1, 2] an analytical technique for obtaining the complete lossy solution, that is suited for RPC structures and allows for simple solutions in several practical cases. As a result, some approximate RPC characteristics can be deduced (see [2] for details):

1. The low-frequency/short-distance crosstalk is proportional to the capacitive coupling C_{mutual}/C_{ground}.
2. The high-frequency/long-distance crosstalk is approximately proportional to the unbalance between the capacitive and the inductive coupling $C_{mutual}/C_{ground} - L_{mutual}/L_{self}$, the detector length, and the inverse of the signal rise time.
3. Losses are dominated by the glass loss-tangent and the counter length D, largely independent from phenomena 1, 2. Typical glass-based counters have a cutoff frequency of ~ 1 GHz for 2 meters (Fig. 1 bottom).
4. In a high-frequency/long system, the best transmission properties are obtained by accurate balance of the inductive and capacitive coupling.
5. Such a situation can be achieved through a compensation scheme (hereafter 'electrostatic compensation') based on the fine adjustment of the system dielectrics.
6. As long as the coupling to the over-next neighbour is small, typical RPCs can be electrostatically compensated in general. We show in Fig. 1 the experimental verification of such a procedure for 2-strip RPCs in both the time and frequency domain.

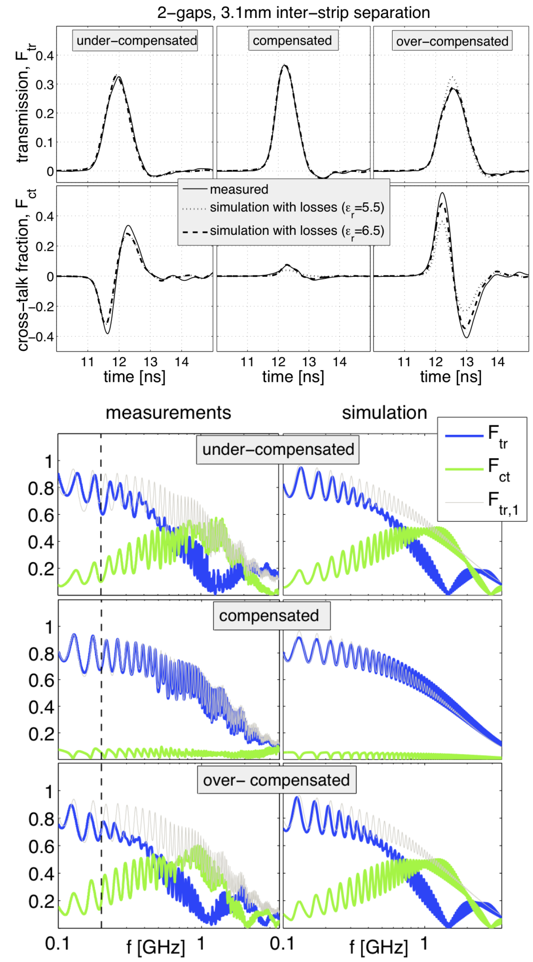

Figure 1: (Top) Transmission characteristics for a 2 m long 2-strip RPC in the time domain. Shown is the measured transmission F_{tr} and crosstalk fraction F_{ct} $(-)$ for different degrees of compensation. Simulations overlaid as $\cdot\cdot$, $--$. (Bottom) Transmission characteristics in the frequency domain (measurements: left column, simulations: right column). $F_{tr,1}$ is the transmission for a single strip, that approximately represents the theoretical limit of a compensated system. See [2] for details.

This development opens the way to the construction of timing RPCs of virtually unlimited size, with performances similar to those achievable in small cells in terms of resolution, efficiency and crosstalk.

References

[1] D. Gonzalez-Diaz, Nucl. Instrum. Meth. **A** (2010), doi:10.1016/j.nima.2010.09.067

[2] D. Gonzalez-Diaz, H. Chen and Yi Wang, submitted to NIM, arXiv:1102.1389v1