New studies on the rate capability of resistive gaseous detectors

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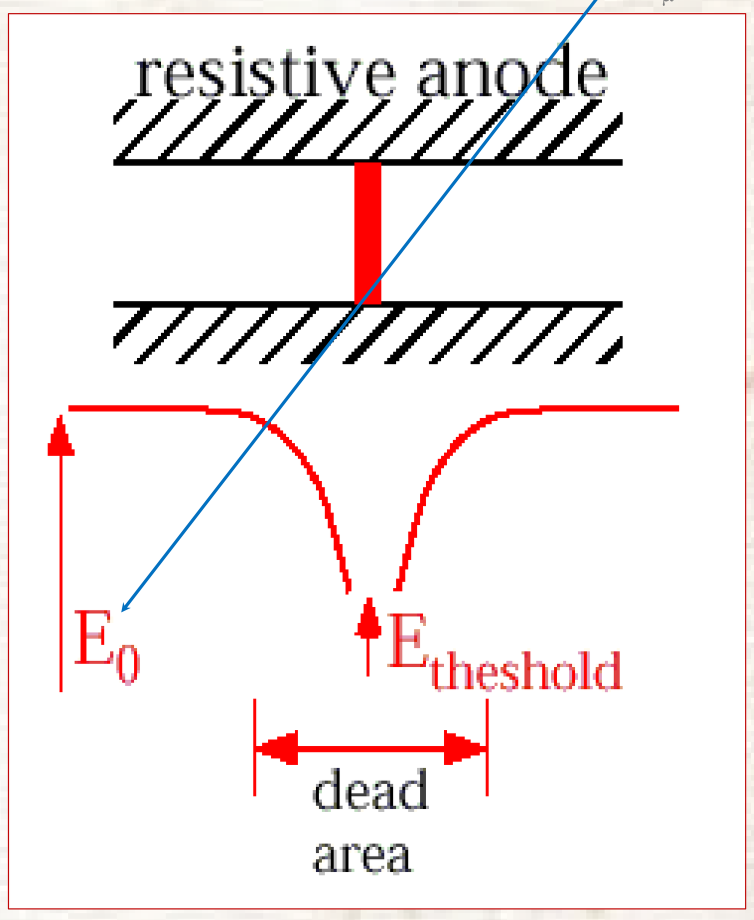
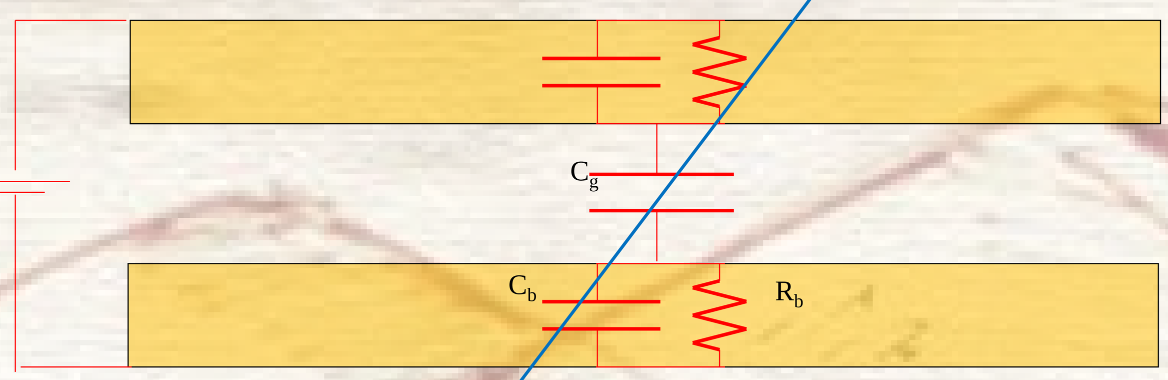
Dating back to 1990s, the extensive use of resistive elements in gaseous detectors has been a real breakthrough, since it provided them with auto-triggering capabilities, spark protection and long term stability. Though, it implies a limitation on the maximum flux of particles that can be measured without efficiency loss, and this is of major relevance both for the operation of the experiments at the High Luminosity LHC, and for the design of the detection systems at the next generation of accelerators.

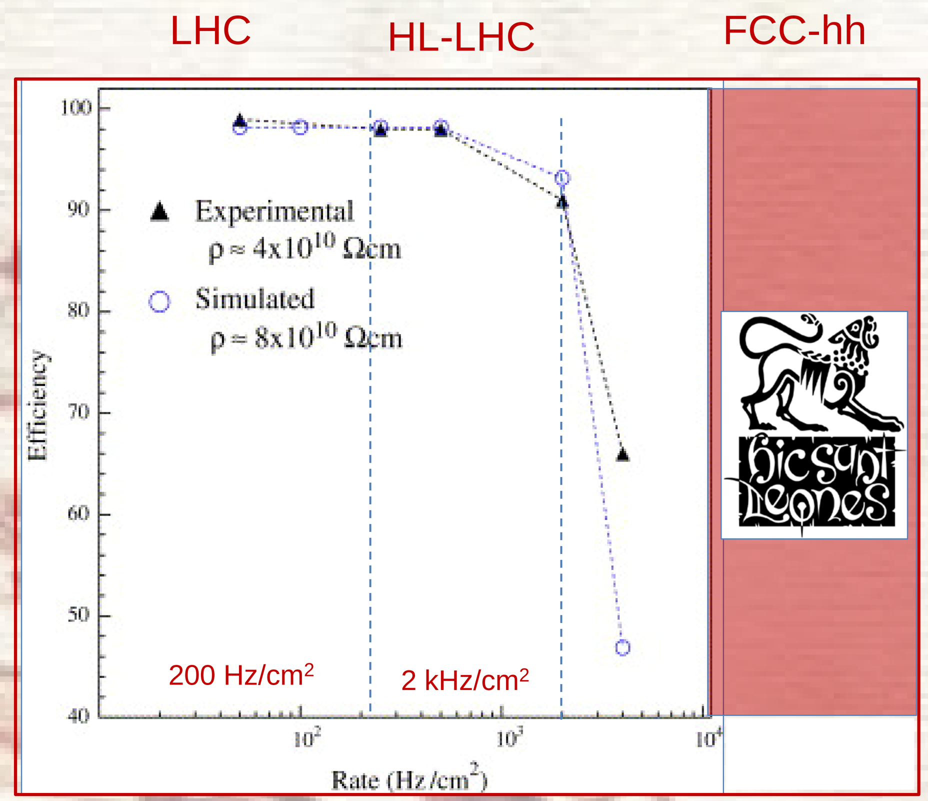




Generally the complex process taking place in resistive gaseous detectors at high rate are modeled with simple circuital equivalents. The lowest order approximation isconsider just the Ohmic drop in the resistive materials. In a more refined approach, the time constant is computed as:

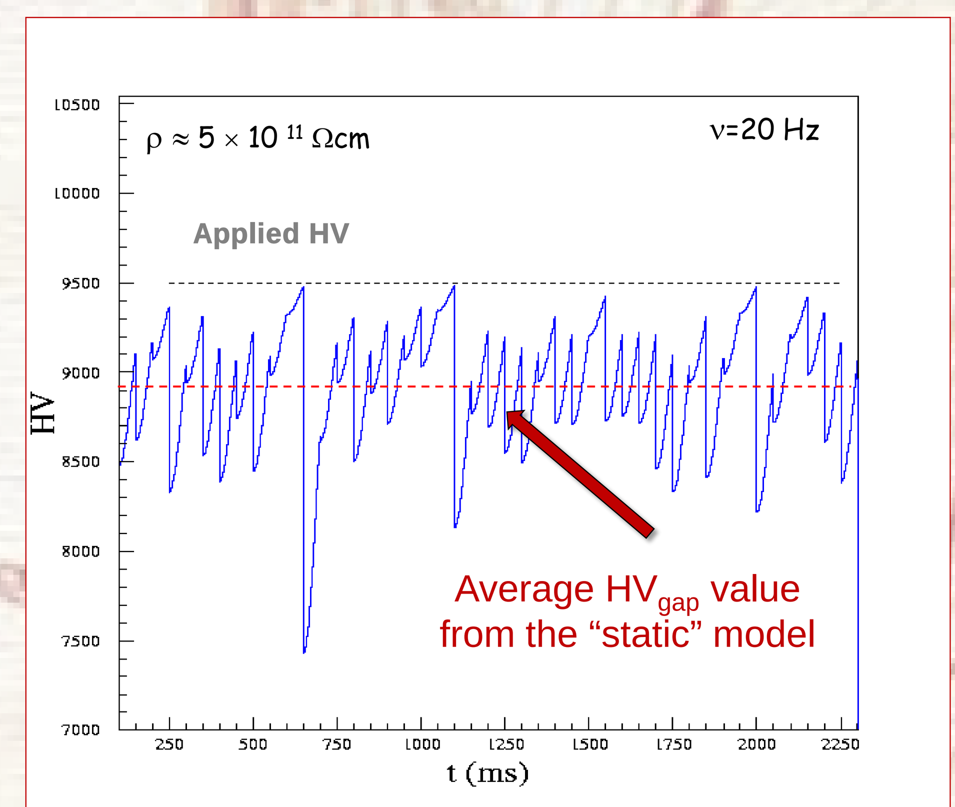
$$\tau = 2R_b(2C_b + C_g) = 2\rho_b\varepsilon_0(2\varepsilon_r + \frac{d}{g})$$

and the voltage in the gas volume is computed as a function of time. **Even this approach has limitations, though.**

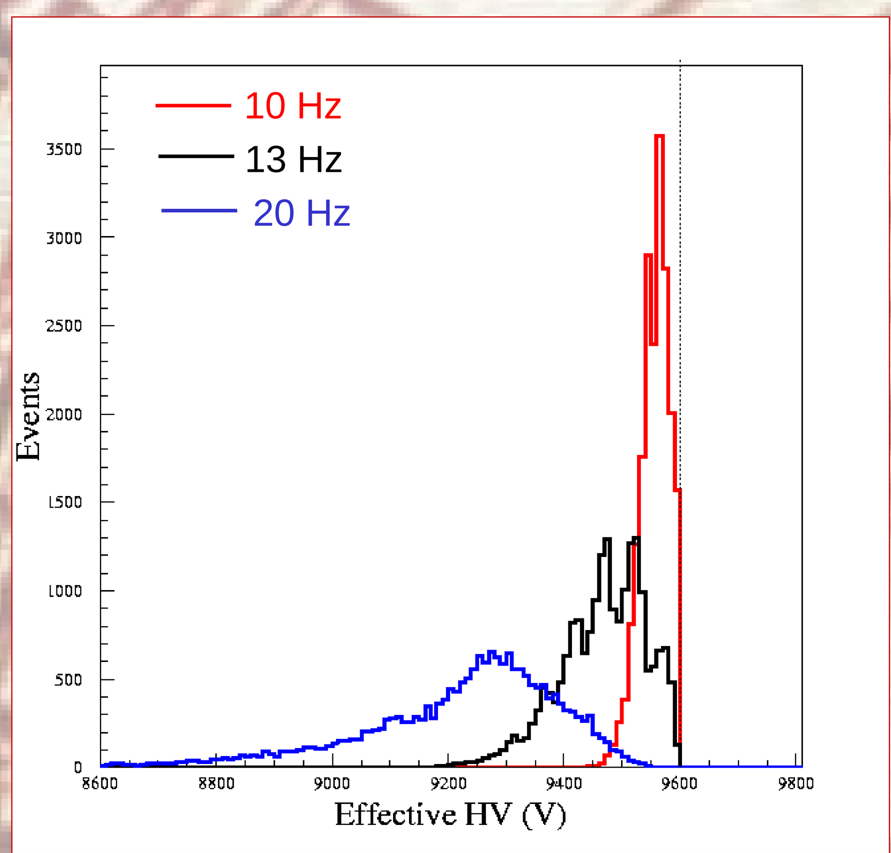


Example of the rate capability needed for present and future muon systems. Probably, more than an order of magnitude increases will be needed for the experiments and the Future Circular hadron Collider.

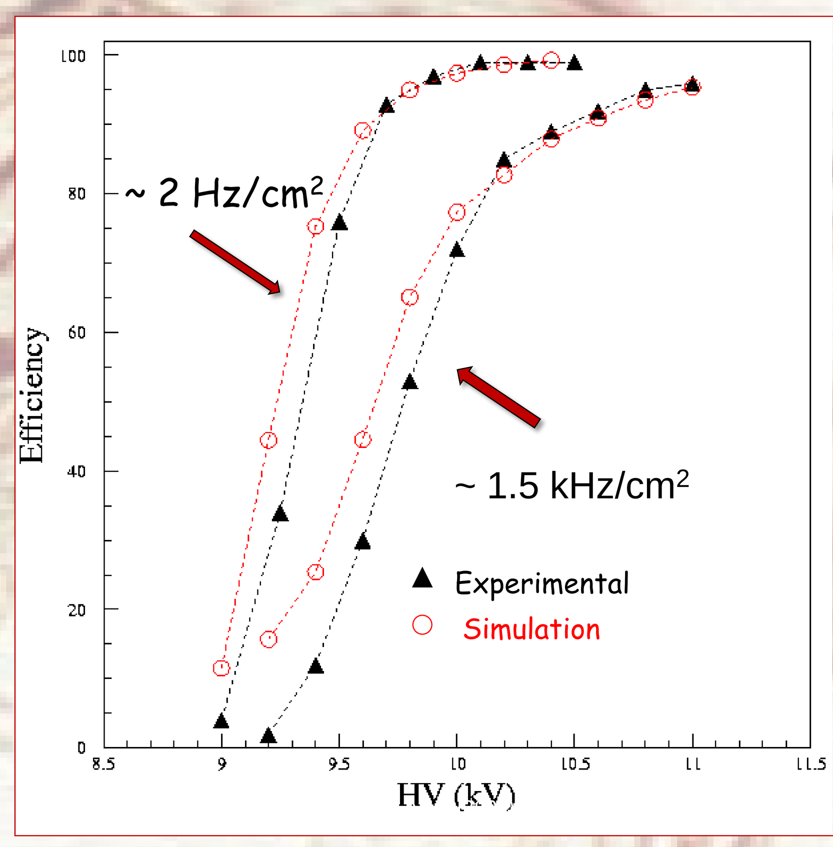
Instantaneous voltage in gaseous resistive detectors



In a gaseous detector operated at high rate, the instantaneous voltage applied to the gas volume undergoes rapid variations, which have to be carefully modeled and taken into account to understand the performance of these devices.

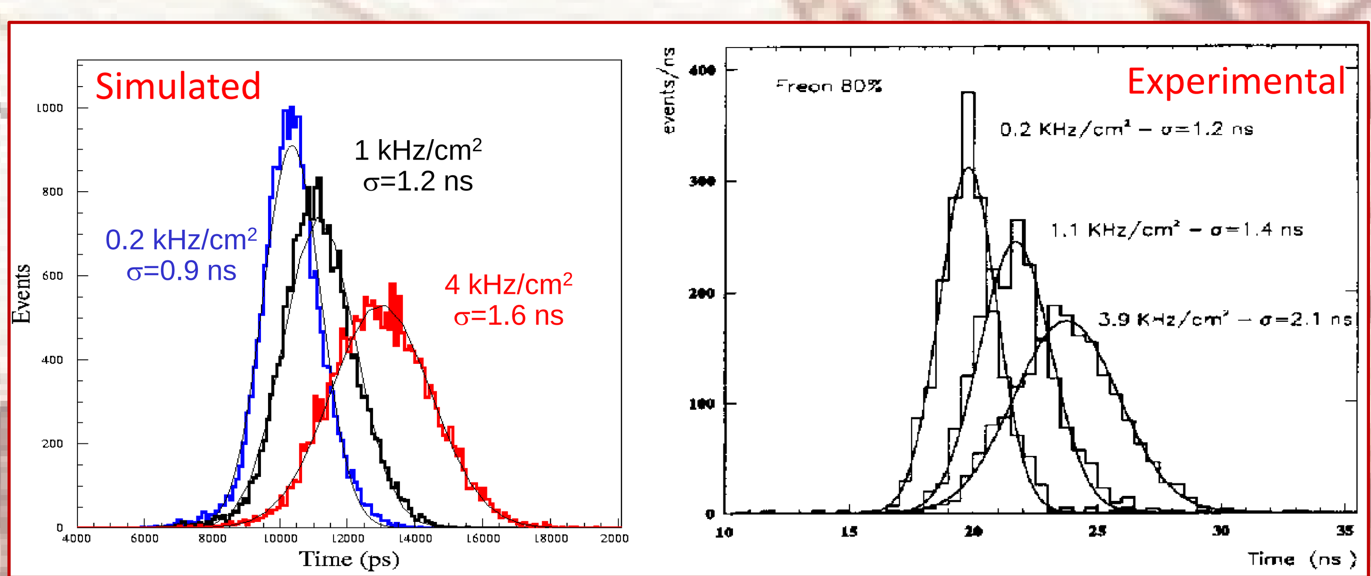


The average value of the instantaneous voltage lowers with increasing rate, and its fluctuations as well. This last aspect cannot be described using the Ohm's law.

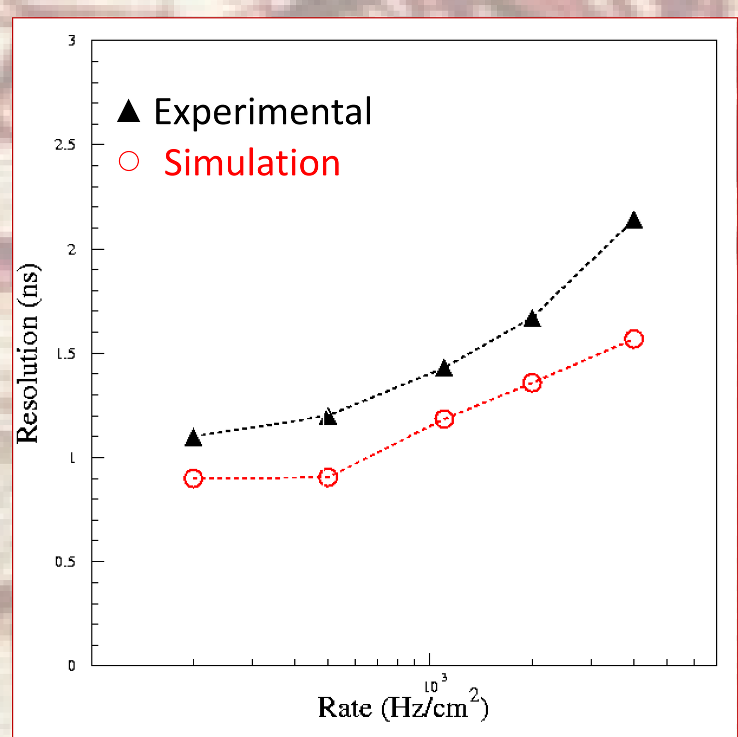


Efficiency at low and high rate: here a comparison between experimental and simulated results is shown, demonstrating that these basic effects are well understood.

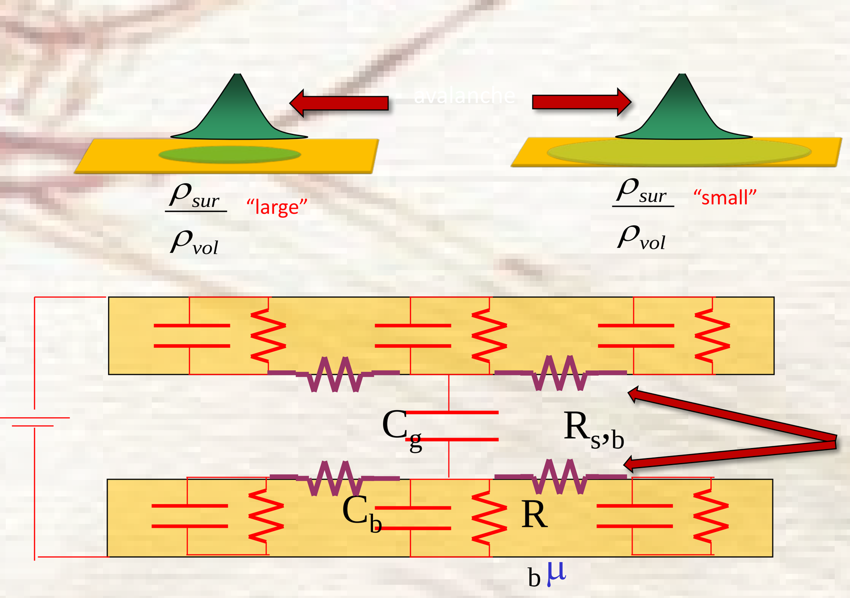
Toward higher rate capability: understanding basic physical processes



Time distributions, simulated and experimental. Here two effects are present at the same time: a lowering of the average voltage in the gas volume, and increased fluctuations around this average value, both affecting time resolution.

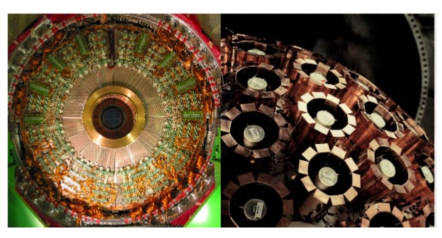


Time resolution vs. rate for single gap RPC of the type currently used in the LHC experiments, simulated and experimental



Multiple-cells model: In a more refined simulation, also charge spreading and surface current onto the resistive plates has to be taken into account. An accurate simulation in this case is still missing.

It is of paramount importance to understand the physics processes at the base of the limitations in rate capability of resistive gaseous detectors, in order to design a next generation of devices where the necessary improvements will be correctly implemented.
In this field, the most refined approach included the thorough description of the local behavior of the voltage applied to the gas volume, and the use of a time dependent weighting field, in order to provide a complete description of the dynamic processes taking place in these devices.
Just part of the studies needed to arrive to a complete understanding and simulation of resistive gaseous devices at high rate has been completed. Also, some of the parameters needed to describe the charge-discharge process, are, at the moment, unknown, and they have to be tuned by hand.
The effort needed will open new and original pathways to follow for the optimization of resistive gaseous detectors at the experiment of the future large accelerators.



TIPP 2021 International Conference on Technology and Instrumentation in Particle Physics