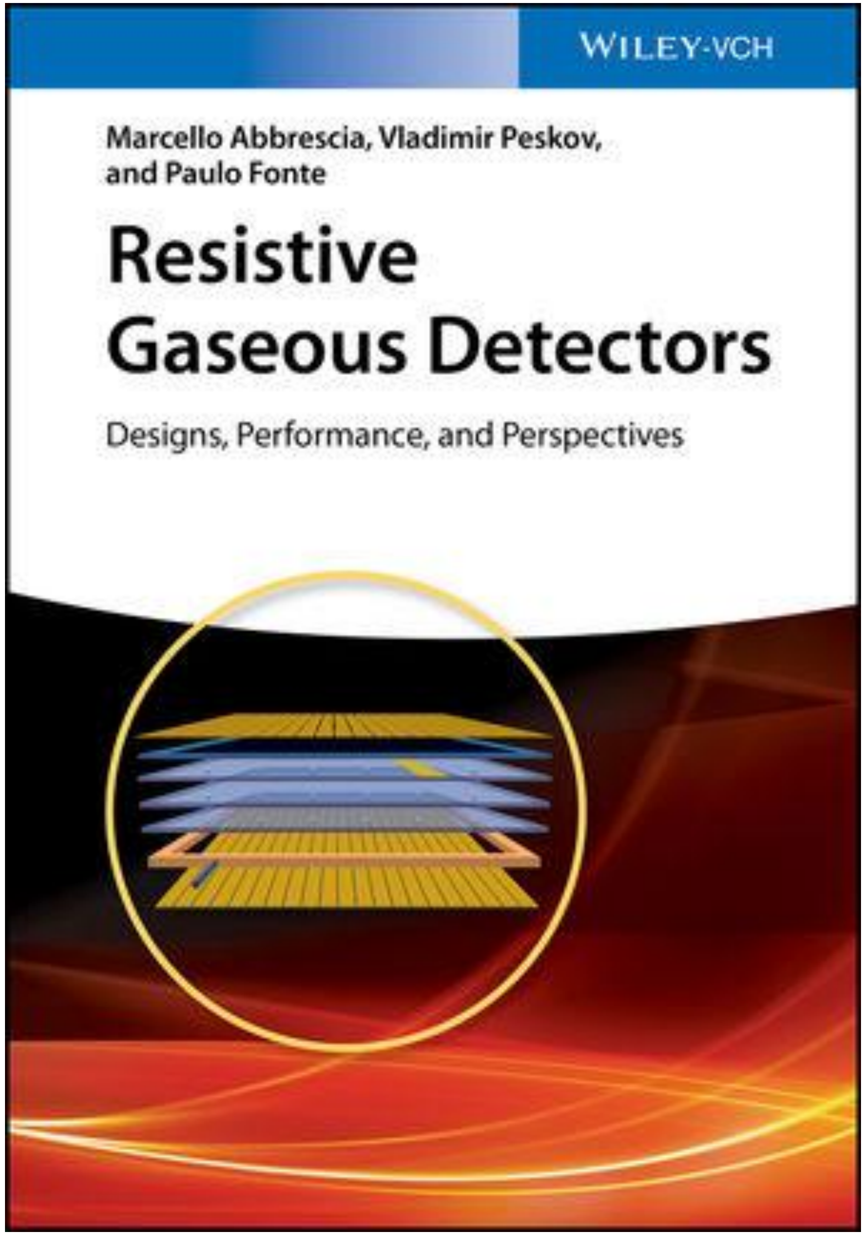


Resistive gaseous detectors: traditional and MPGD

Book presentation for the RD51 and the DISCO community

This first book to critically summarize the latest achievements and emerging applications within this interdisciplinary topic focuses on one of the most important types of detectors for elementary particles and photons: resistive plate chambers (RPCs).
In the first part, the outstanding, international team of authors comprehensively describes and presents the features and design of single and double-layer RPCs before covering more advanced multi-layer RPCs. The second part then focuses on the application of RPCs in high energy physics, materials science, medicine and security.
Throughout, the experienced authors adopt a didactic approach, with each subject presented in a simple way, increasing in complexity step by step.

Why this book is presenting at WG2 “Detector Physics and performance”?

…because it may be useful for RD51 community

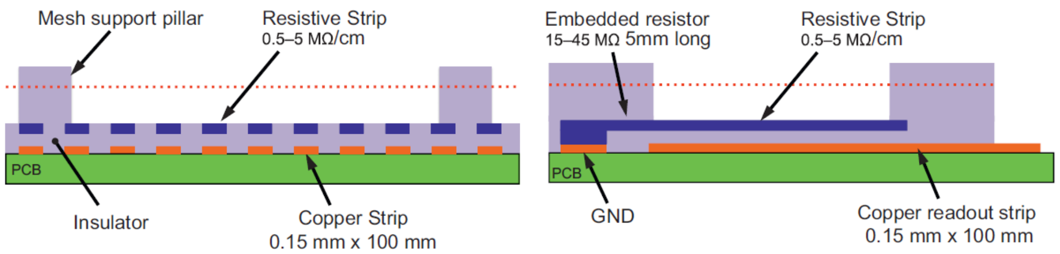
Indeed, there is a growing list of resistive MPGD, for example:

Resistive MOCROMEGAS

Resistive Micro well

Resistive GEM, etc.

T. Alexopoulos et al. / Nuclear Instruments and Methods in Physics Research A 640 (2011) 110–118



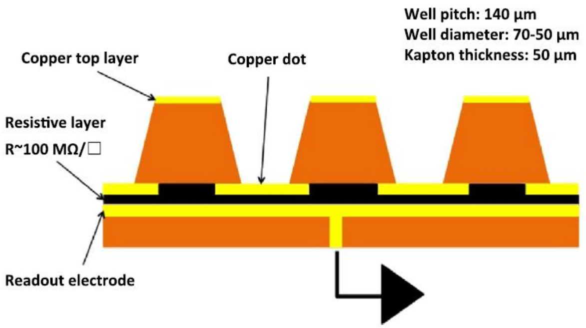
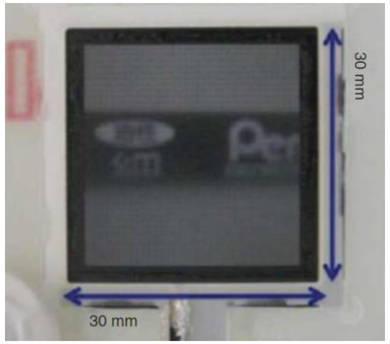
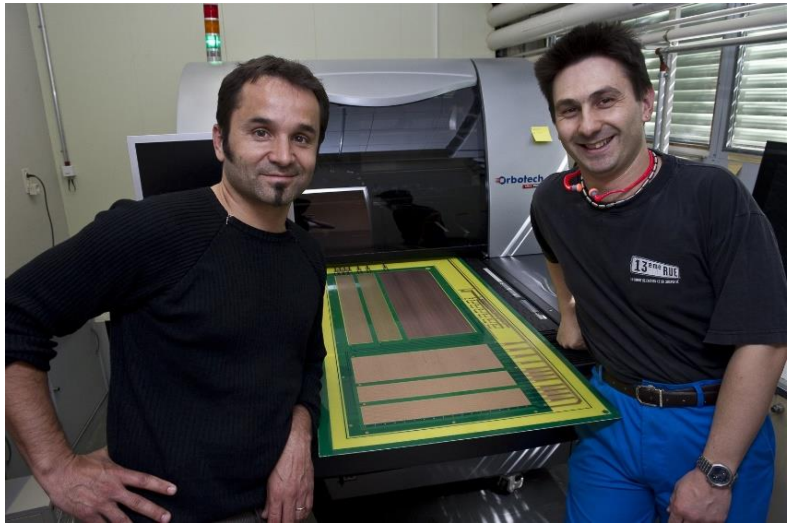


Fig. 1. Schematic drawing of the μ-RWELL PCB.



There is a famous statement from Rui: “All future micropattern detectors will be resistive!”

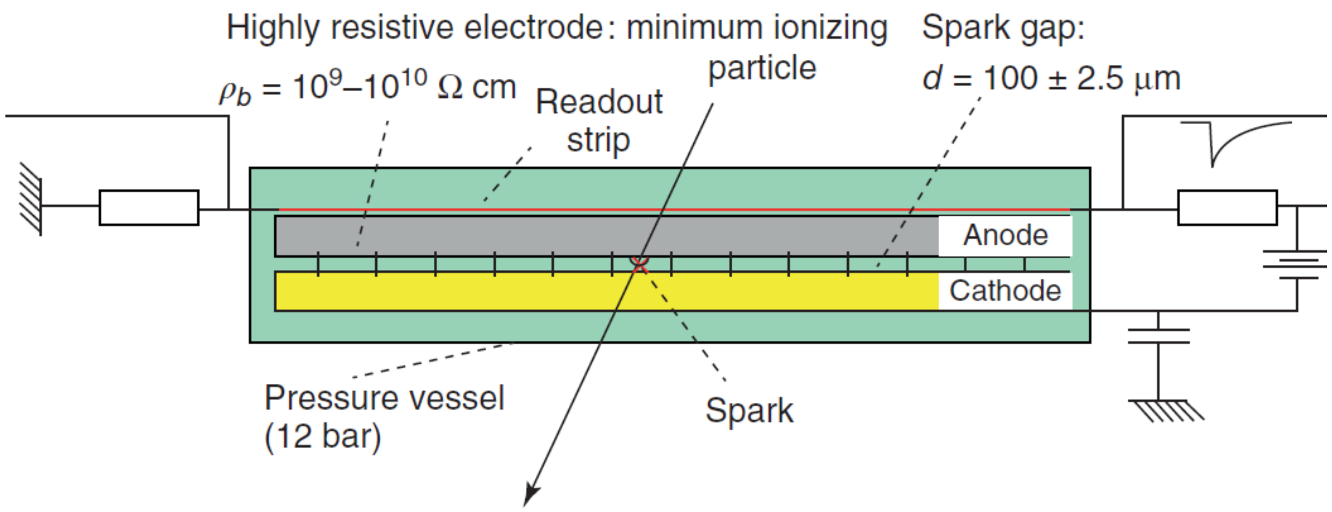


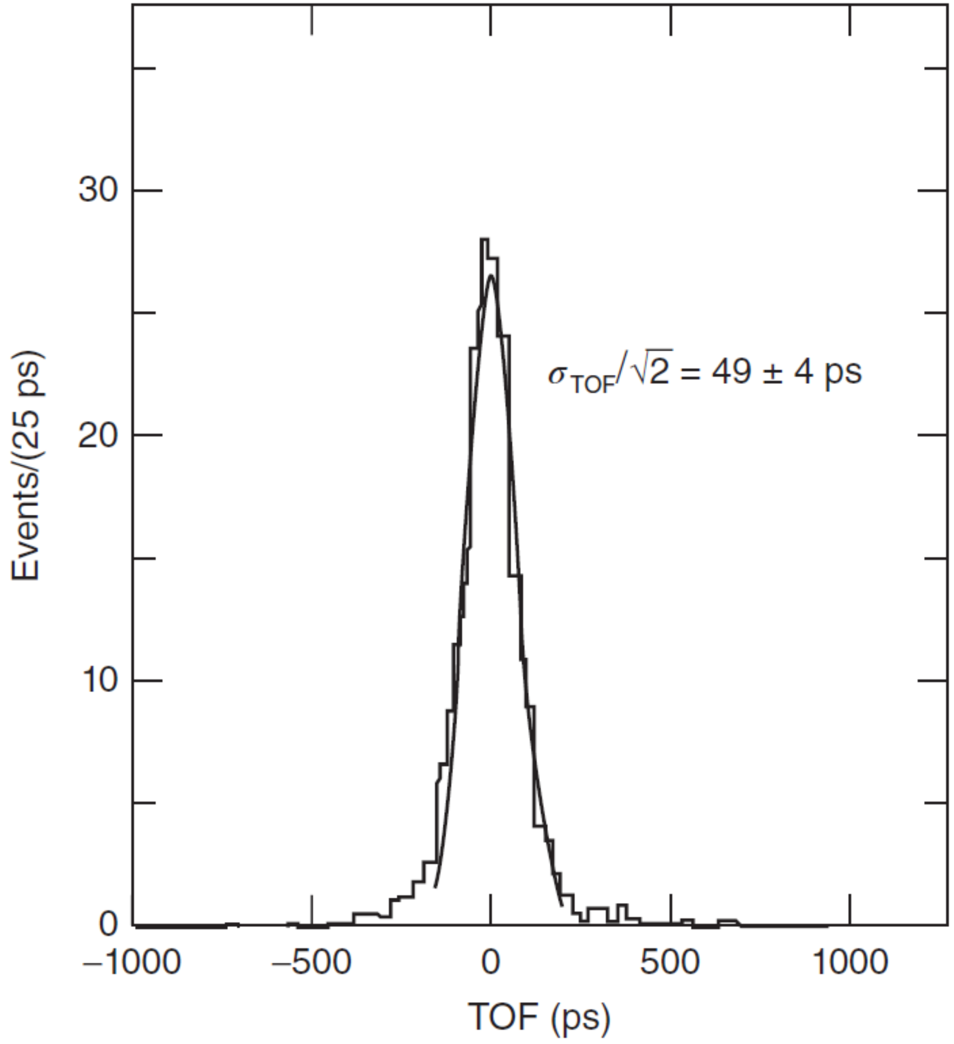
Contents:

Let's highlight some selected topics, which could be interesting for the RD51 community

I. Pioneers: "Pestov" counters

("quenched spark" mode)



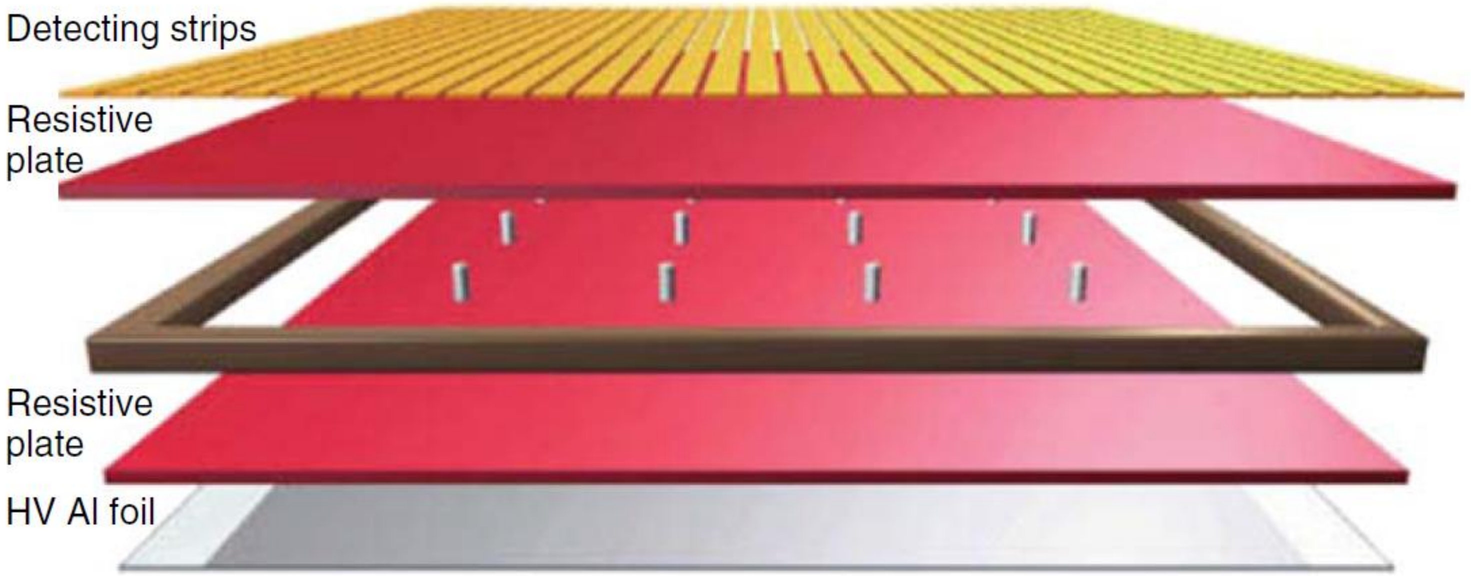


Designs with a few mm gap operating at 1 atm was tested as well.
Time resolution achieved by this team was 1 ~ns

Parkhomchuk, V.V. *et al.* (1971) A spark counter with large area. *Nucl. Instrum. Methods*, **93**, 269–270.

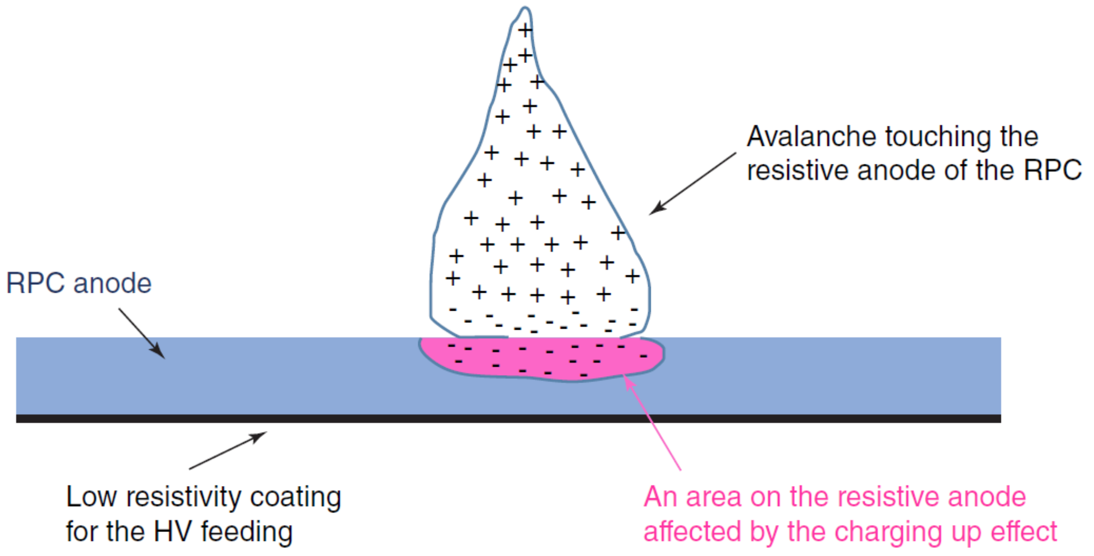
II. “Santonico” single and double-gap Bakelite RPCs

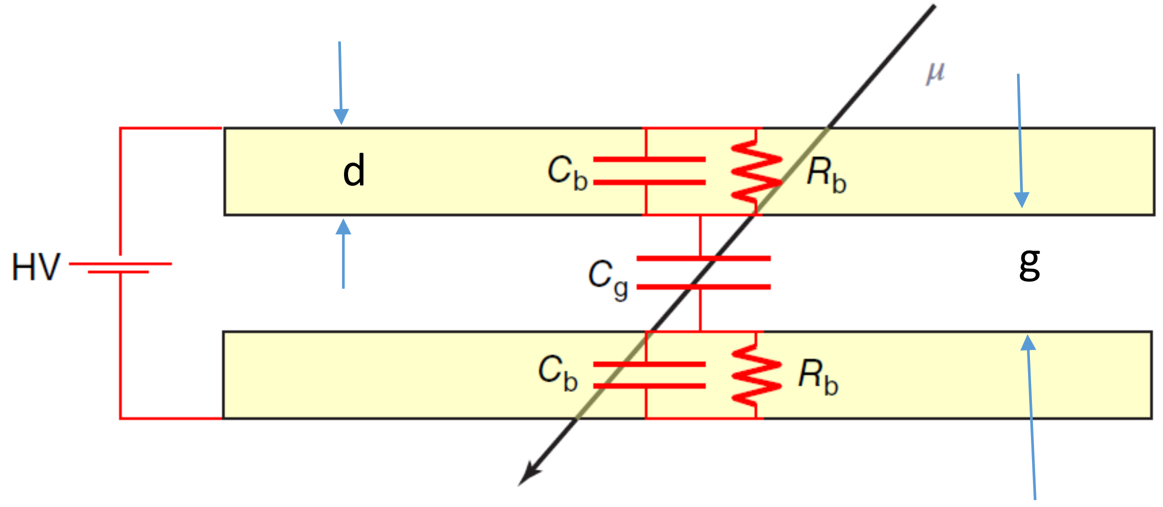
II.1. Operation in “streamer mode”



Santonico and his collaborators transformed the idea to practical realization-large area RPCS

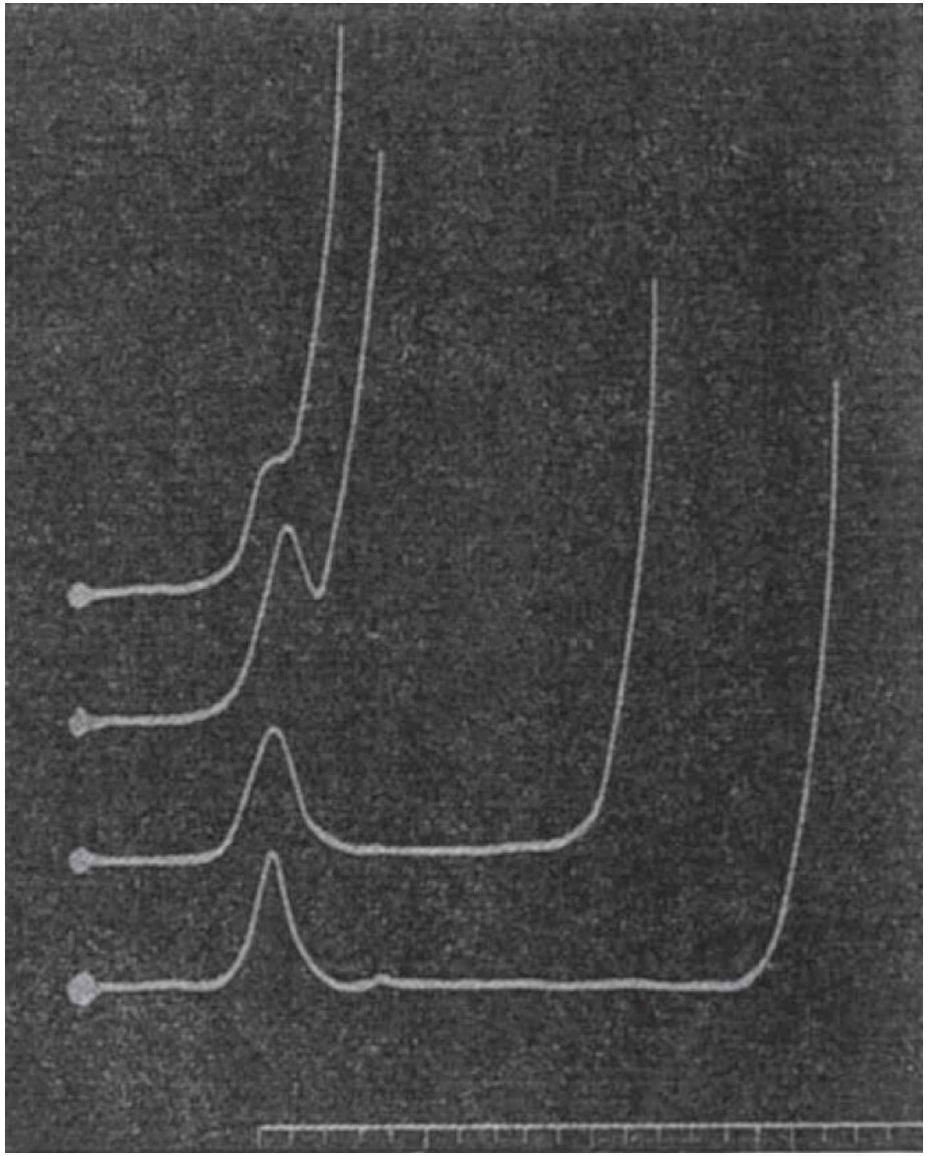
Physics behind their operation



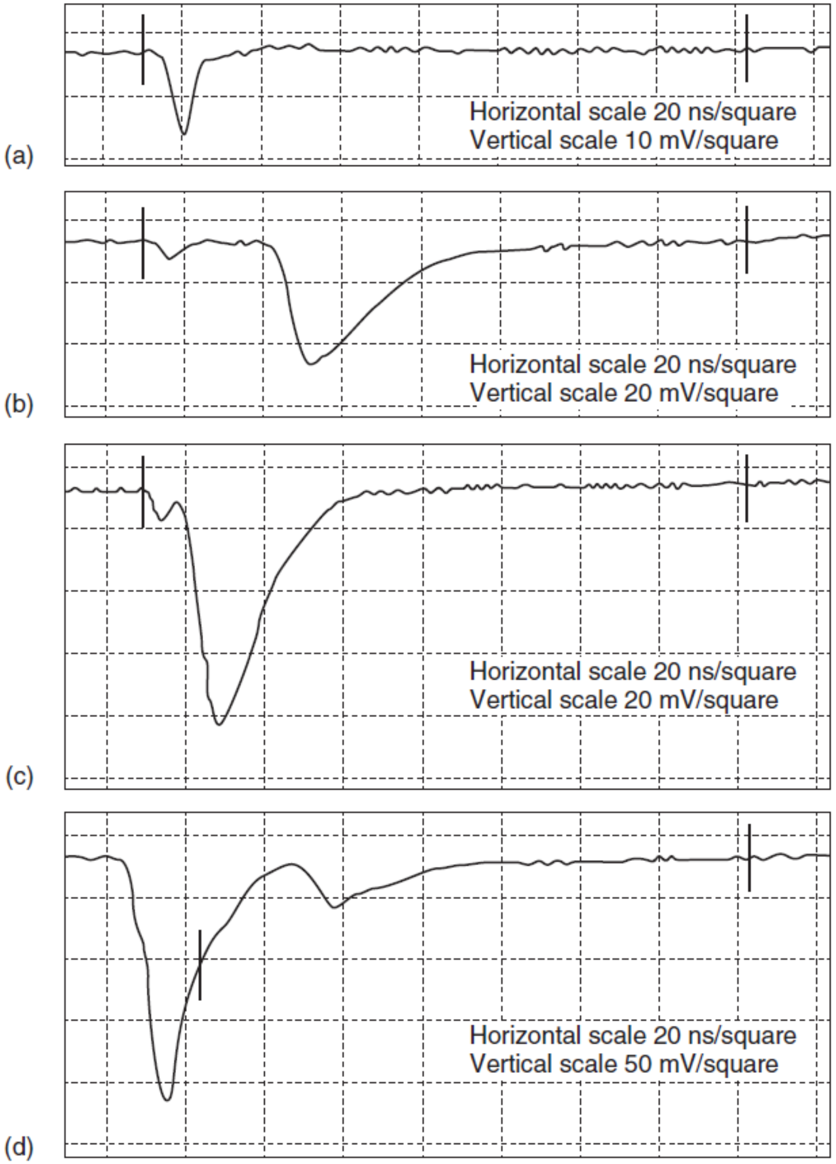


$$\tau = 2R_b\left(\frac{C_b}{2}+C_g\right) = 2\rho_b\frac{d}{S}\left(\frac{1}{2}\varepsilon_0\varepsilon_r\frac{S}{d}+\varepsilon_0\frac{S}{g}\right) = \rho_b\varepsilon_0\left(\varepsilon_r+2\frac{d}{g}\right)$$

Could be useful for RD51 community

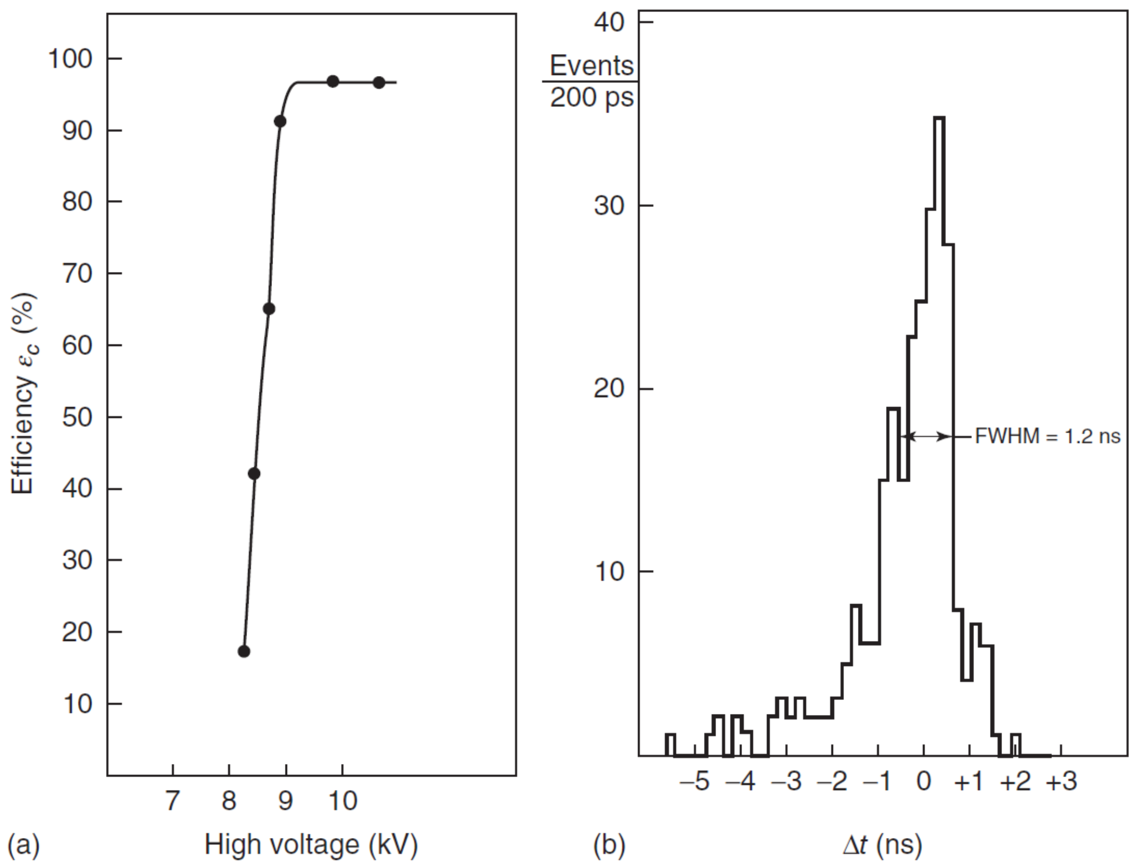


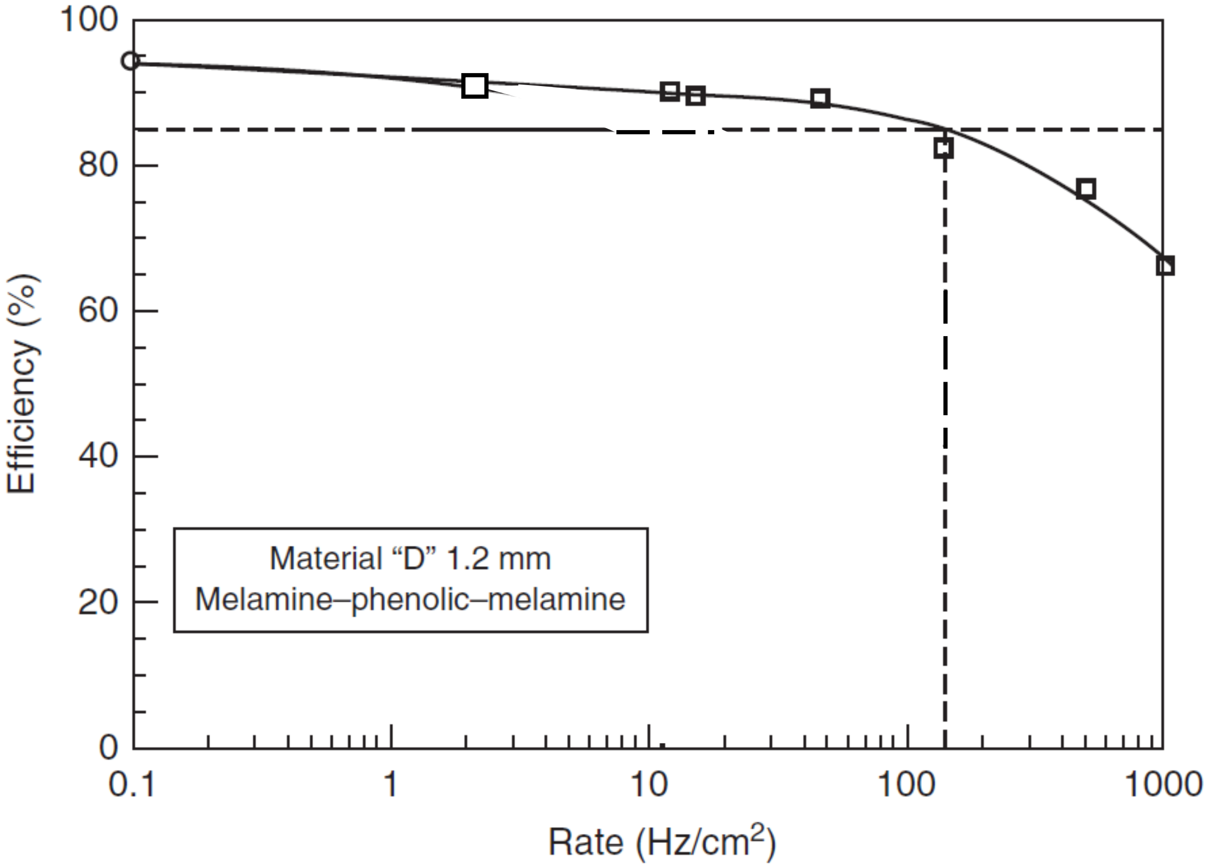
“Unquenched” sparks



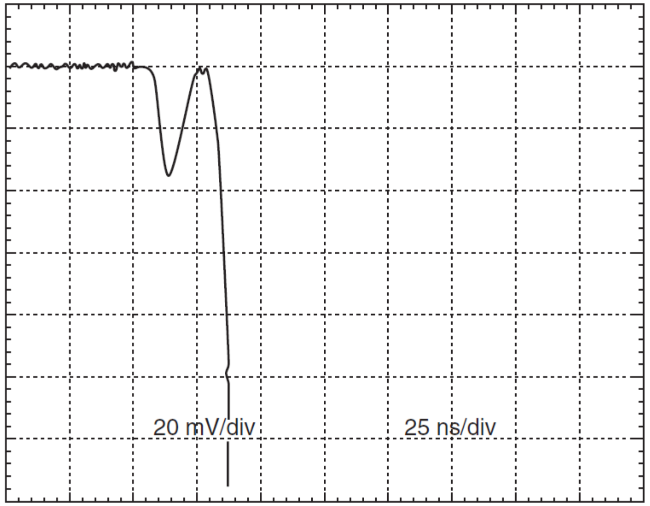
“Quenched” sparks (called by the RPC community as “streamer mode”)

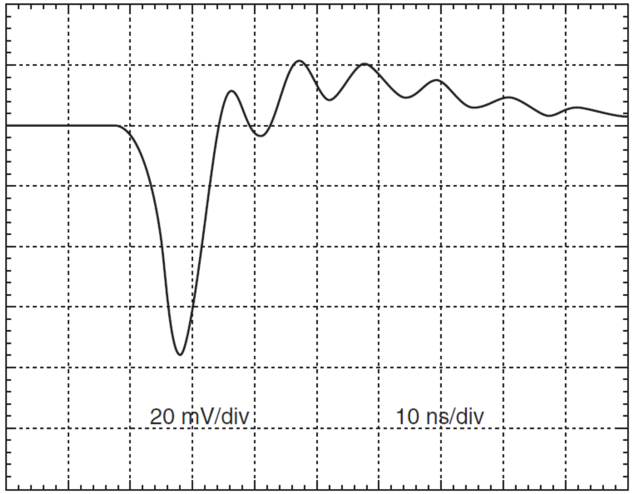
Main characteristics

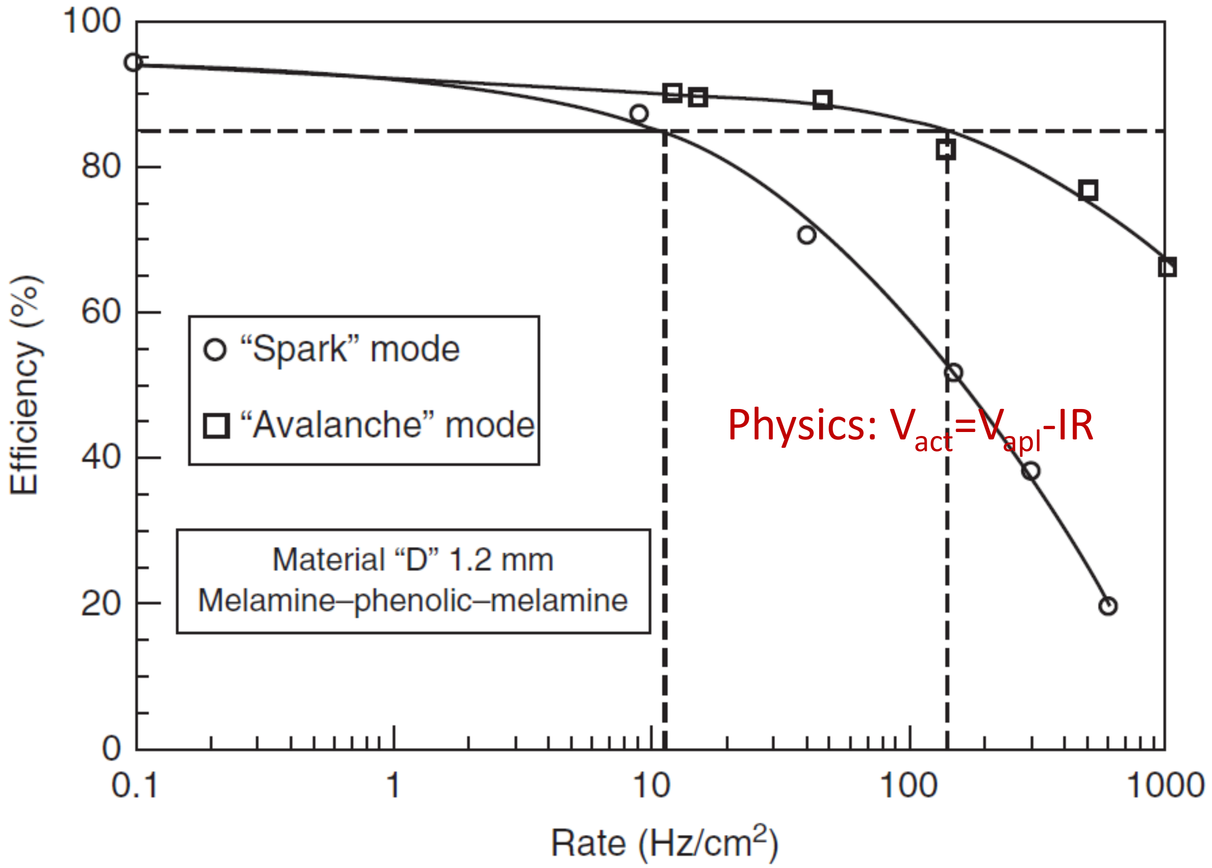




II.2. A breakthrough -avalanche mode







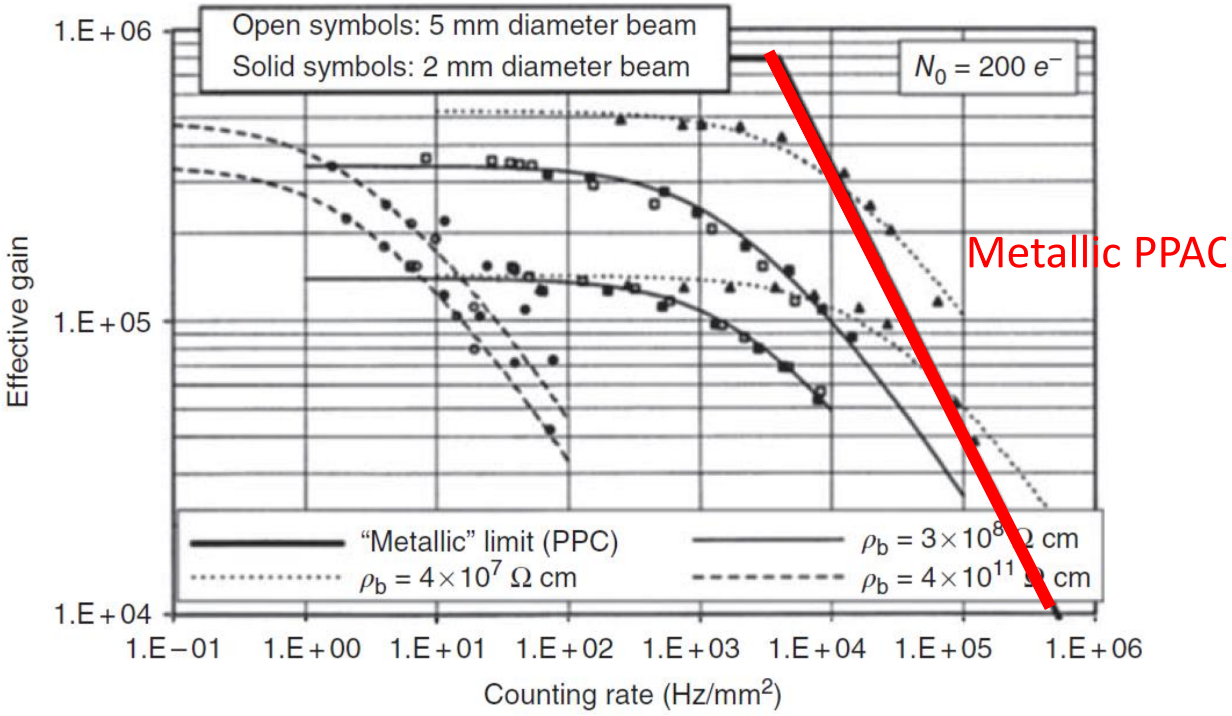
Avalanche mode was suggested in:

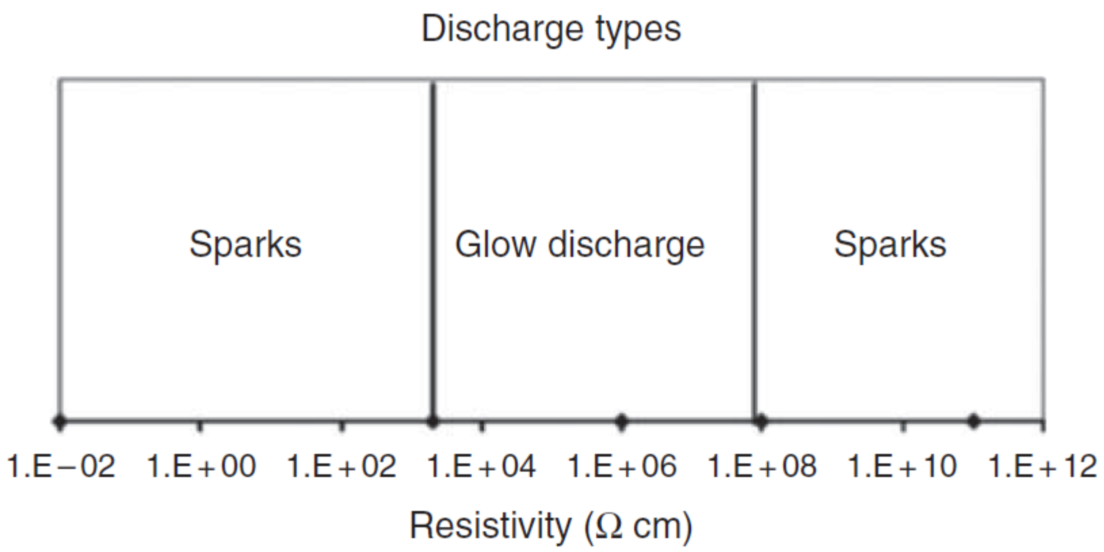
Crotty, I. *et al.* (1994) The non-spark mode and high rate operation of resistive parallel plate chambers. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **337**, 370–381.

Anderson, B.E. *et al.* (1994) High counting rate resistive plate chamber. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **348**, 324–328.

Duerdoth, I. *et al.* (1994) The transition from proportional to streamer mode in a resistive plate chamber. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **348**, 303–306.

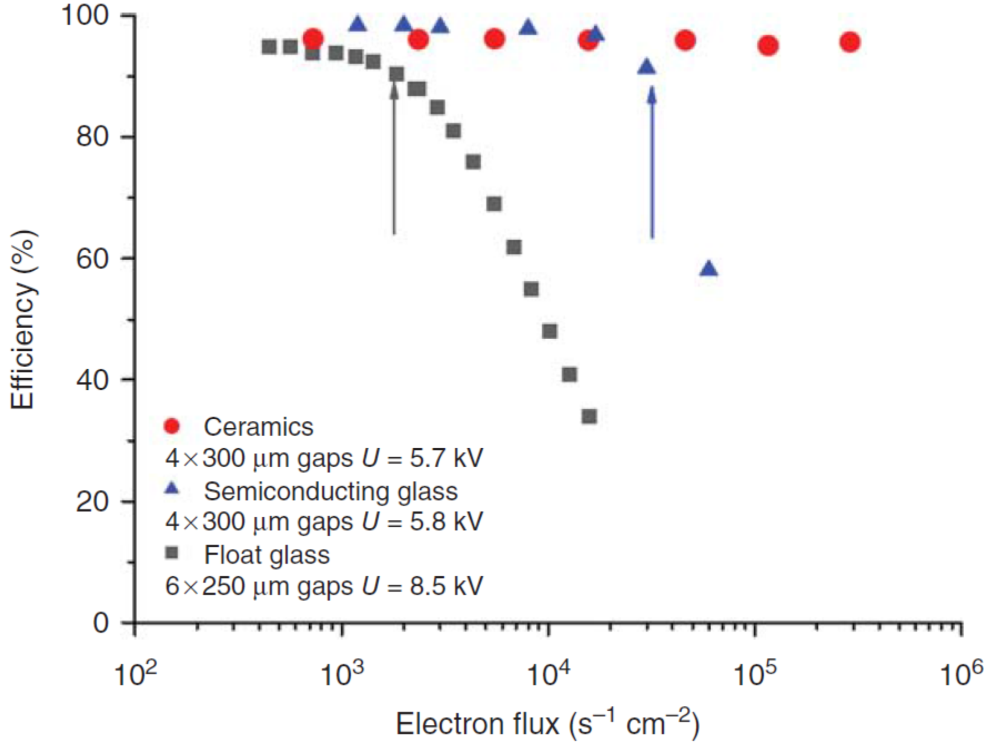
Advances in rate characteristics

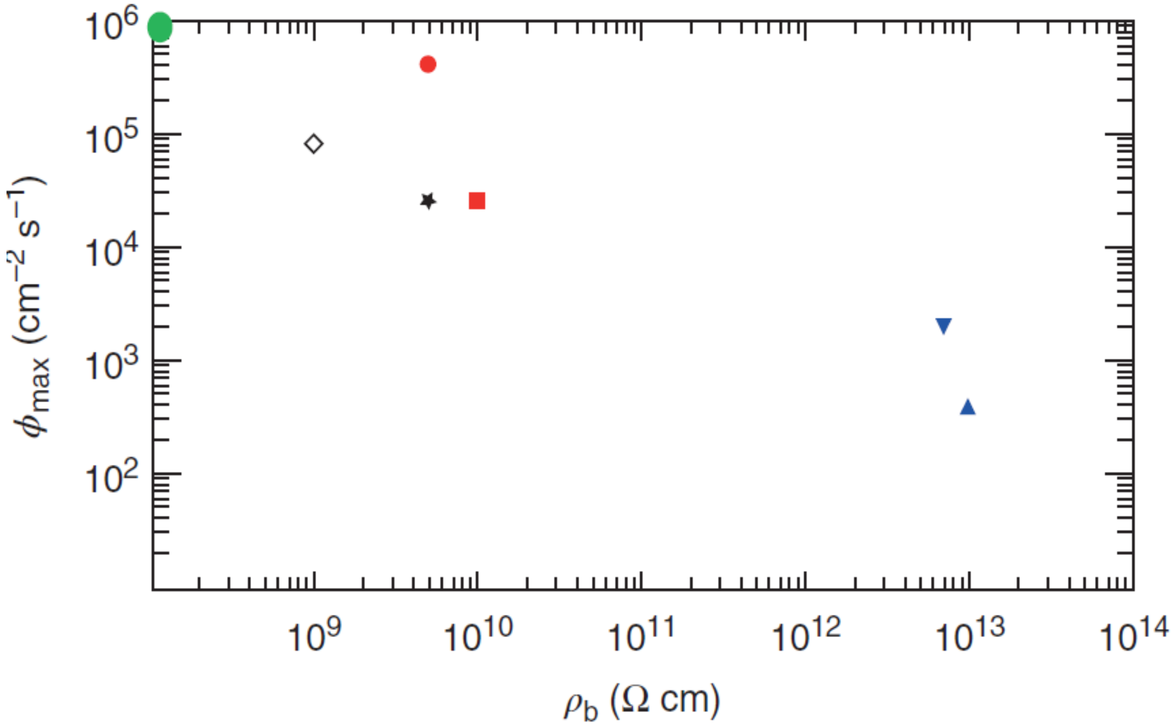




Could be useful for RD51 community

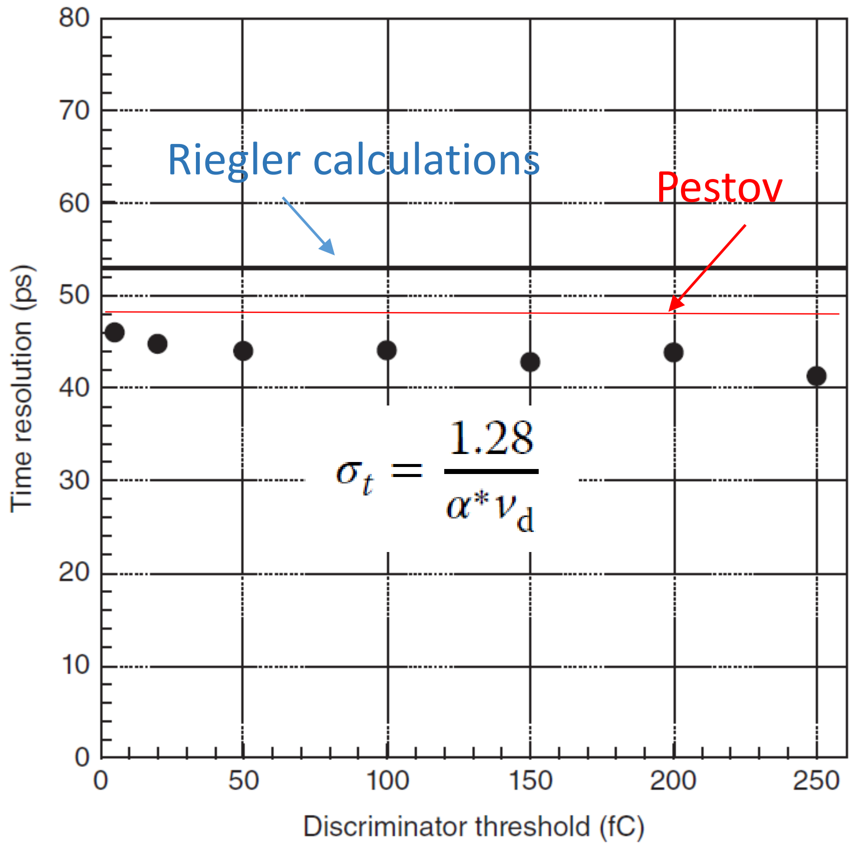
Further progress

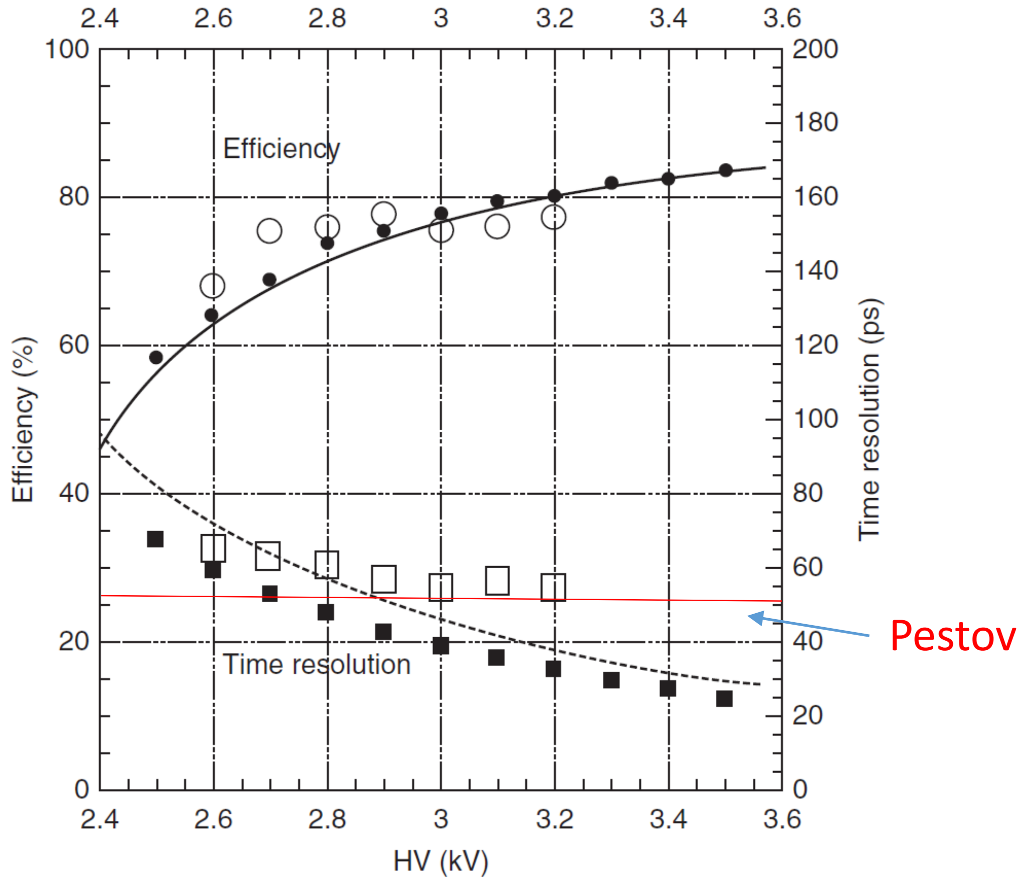




Nowadays is very popular so-called “Chinese glass” ≈ Pestov glass

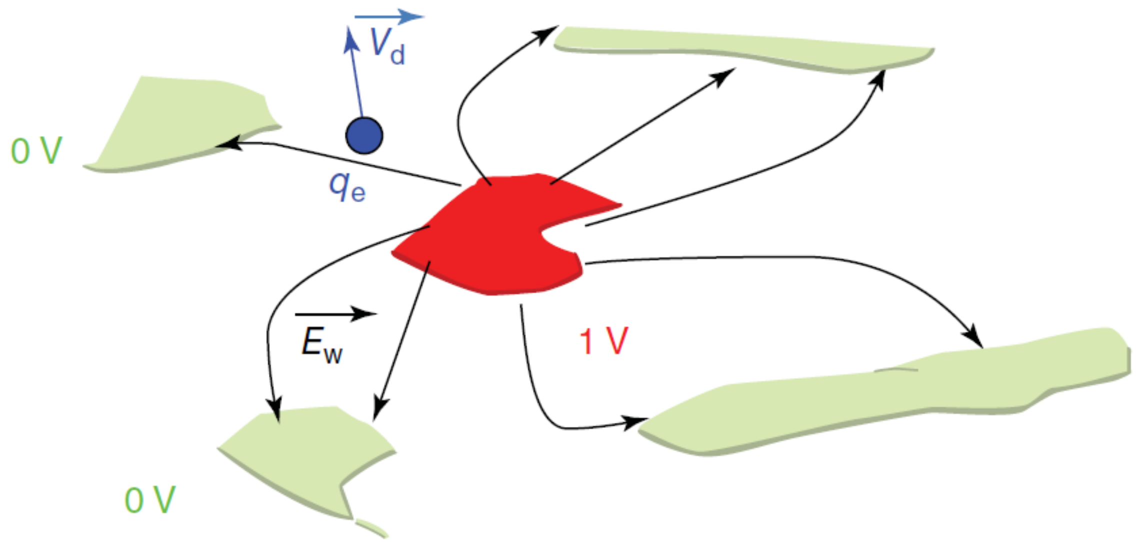
Timing in avalanche mode

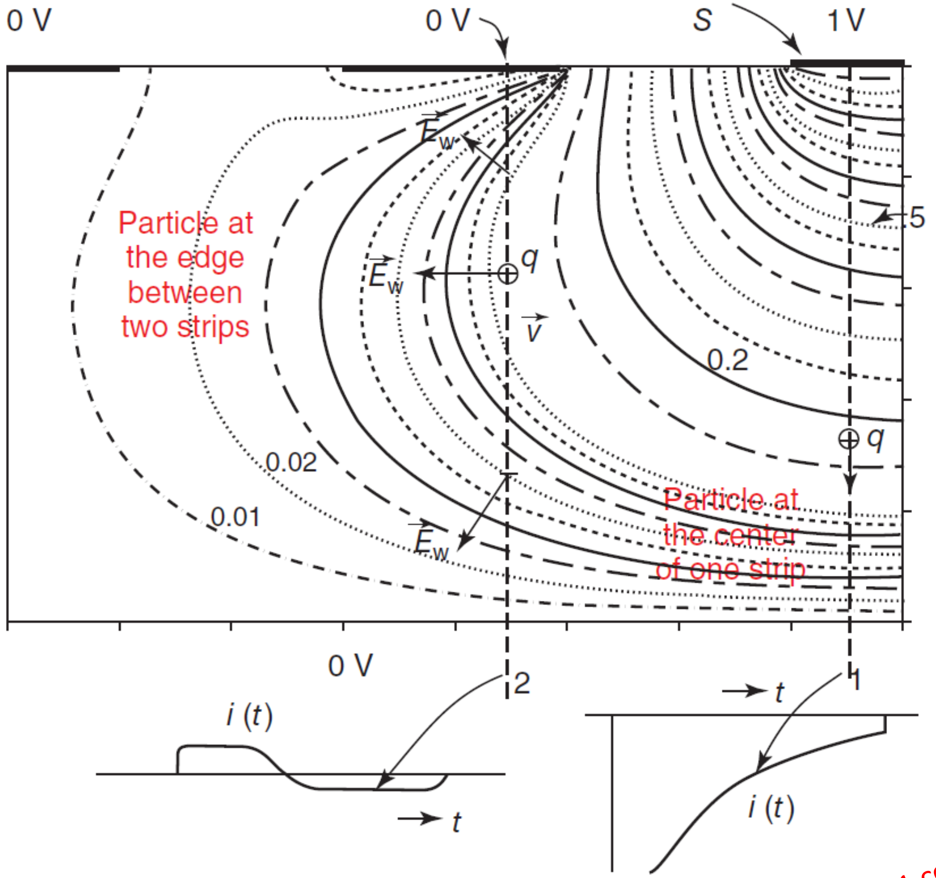




Signal induced on strips and spatial resolution

Ramo theorem(was already presented at the RD51 meeting by W. Riegler)

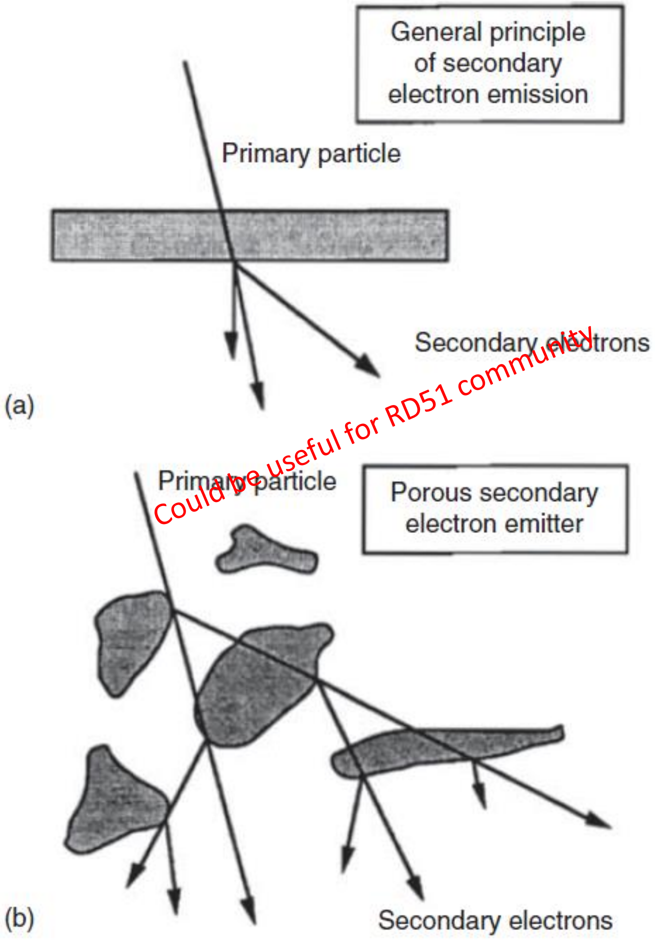




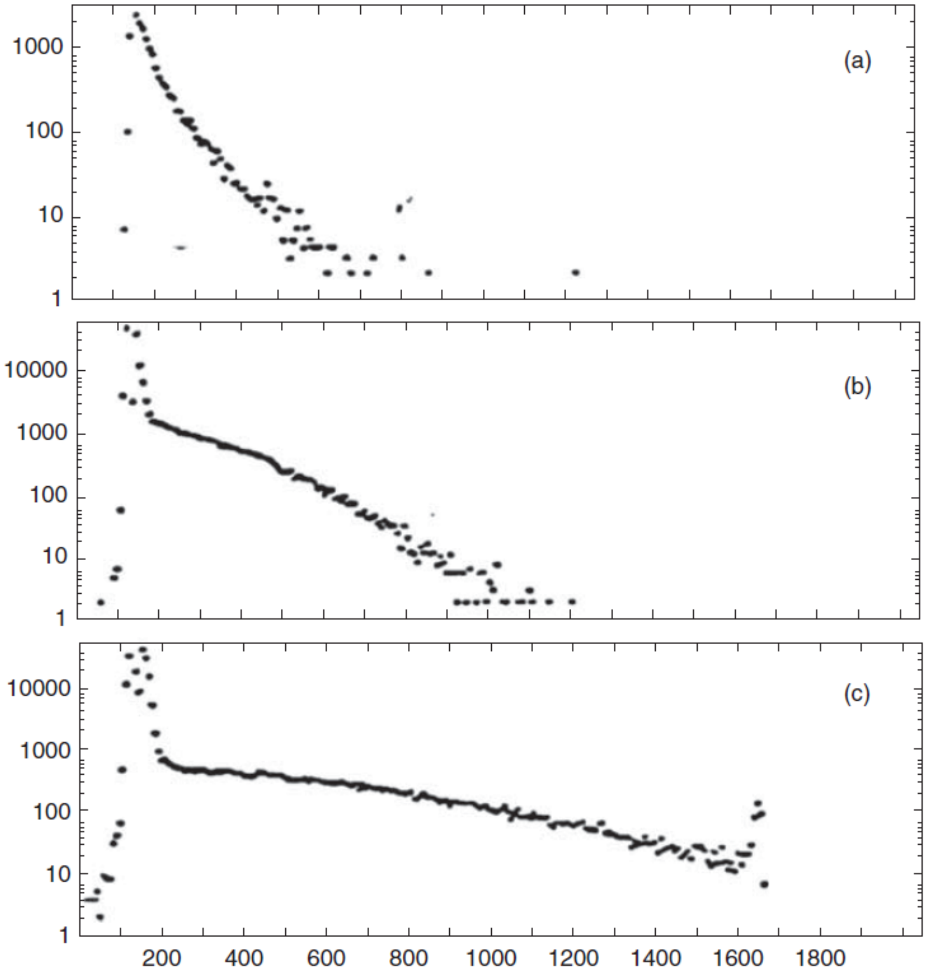
Usually , by using central of gravity method ~ mm

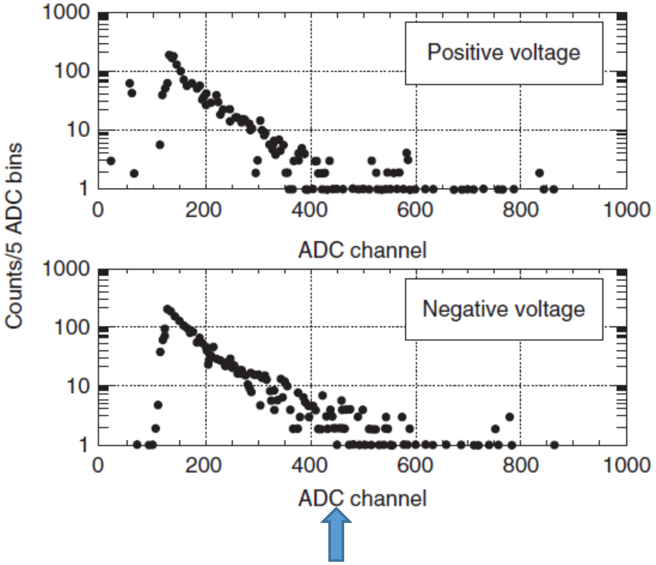
Could be useful for RD51 community

Special designs: RPCs with secondary electron emitters



Could be useful for RD51 community





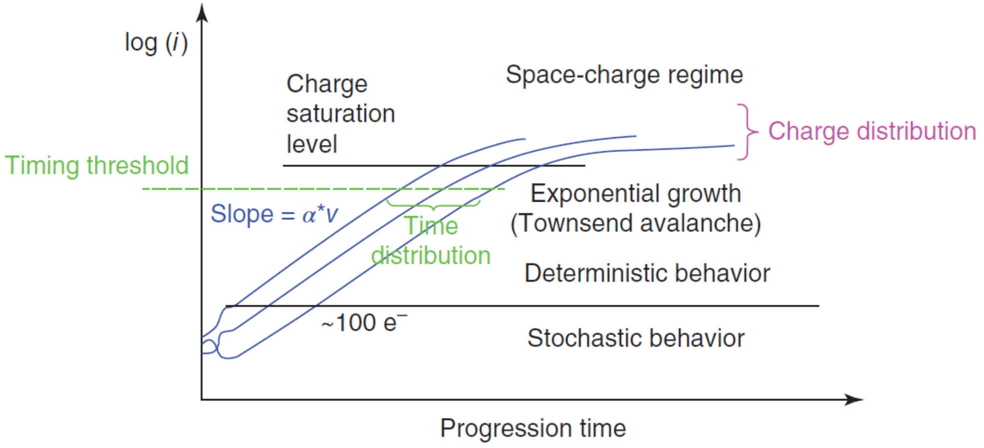
Pulse-height spectra in the case of ordinary RPCs (no secondary electron emitter)

Cerron Zeballos, E. (1996) New developments on RPC: secondary electron emission and microstrip readout. Proceedings of 3rd International Workshop on Resistive Chambers and Related Detectors. Scientifica Acta, vol. **XI**, p. 45.

Fonte, P. *et al*. (2000) Micro-gap parallel-plate chambers with porous secondary electron emitters. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **454**, 260.

III. Another breakthrough-Timing RPC

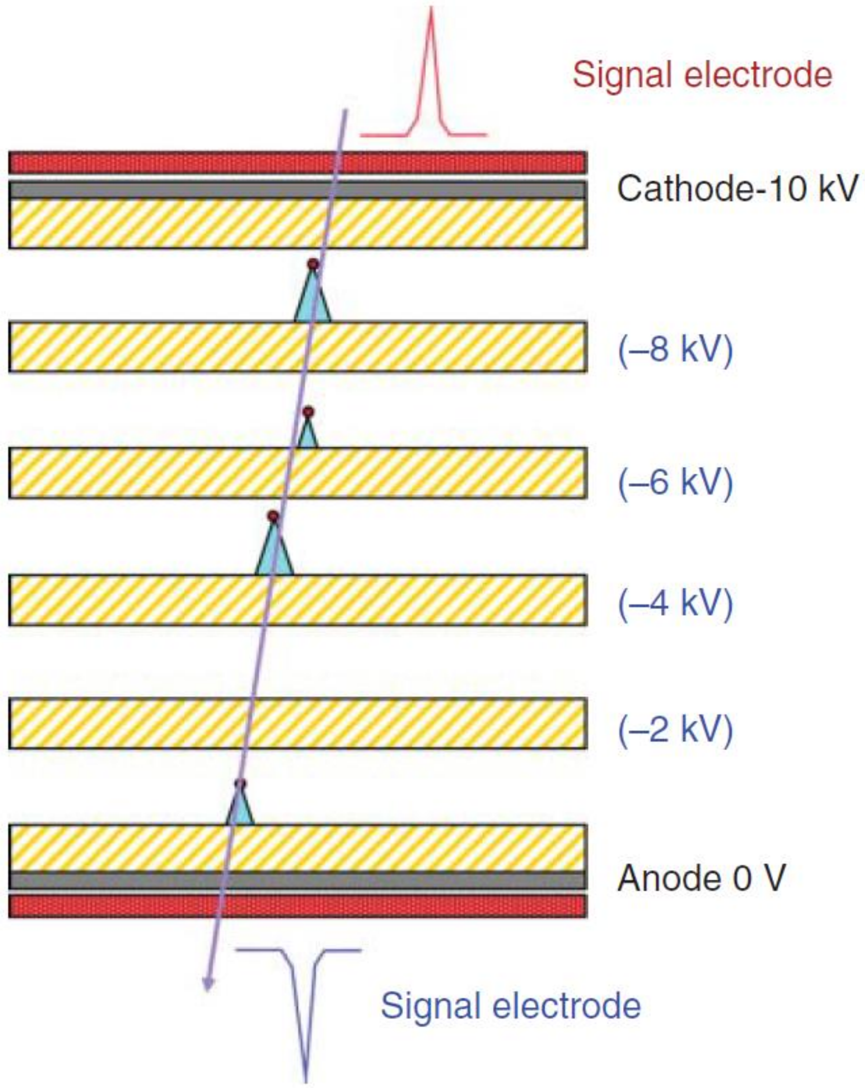
Avalanche mode

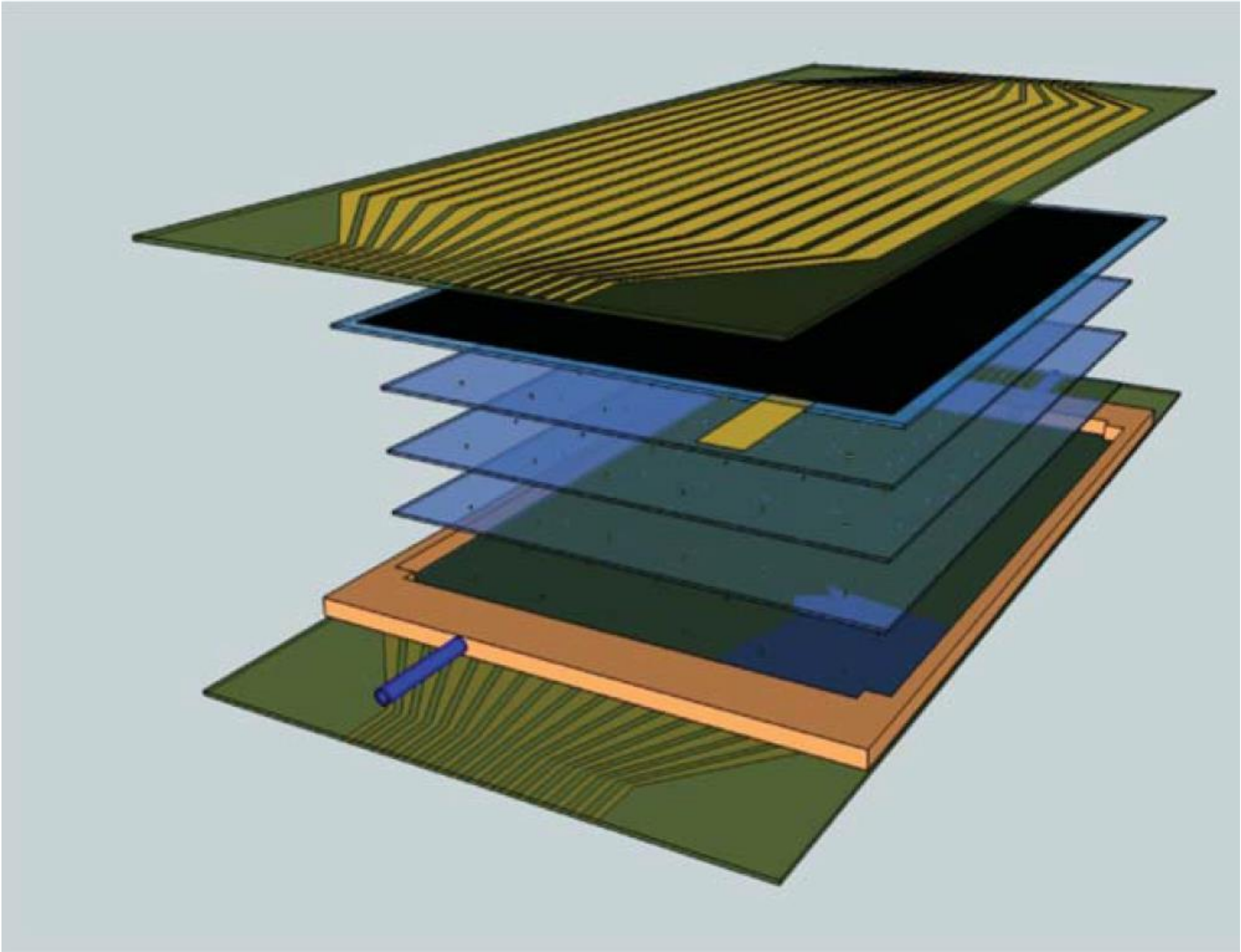


Fonte, P., Smirnitski, A., and Williams, M.C.S. (2000) A new high-resolution time-of-flight technology. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **443**, 201–204. doi: 10.1016/S0168-9002(99)01008-6.

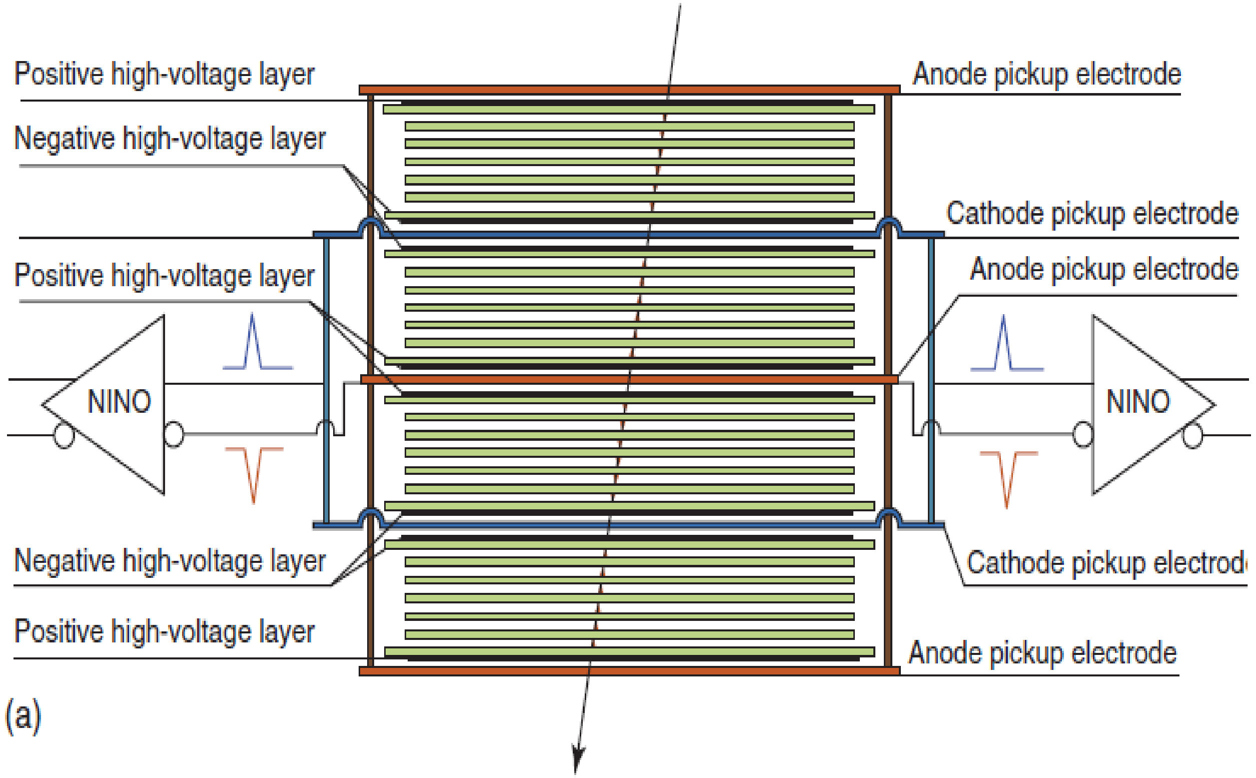
Fonte, P. and Peskov, V. (2002) High-resolution TOF With RPCs. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **477**, 17–22.

Multigap timing RPC



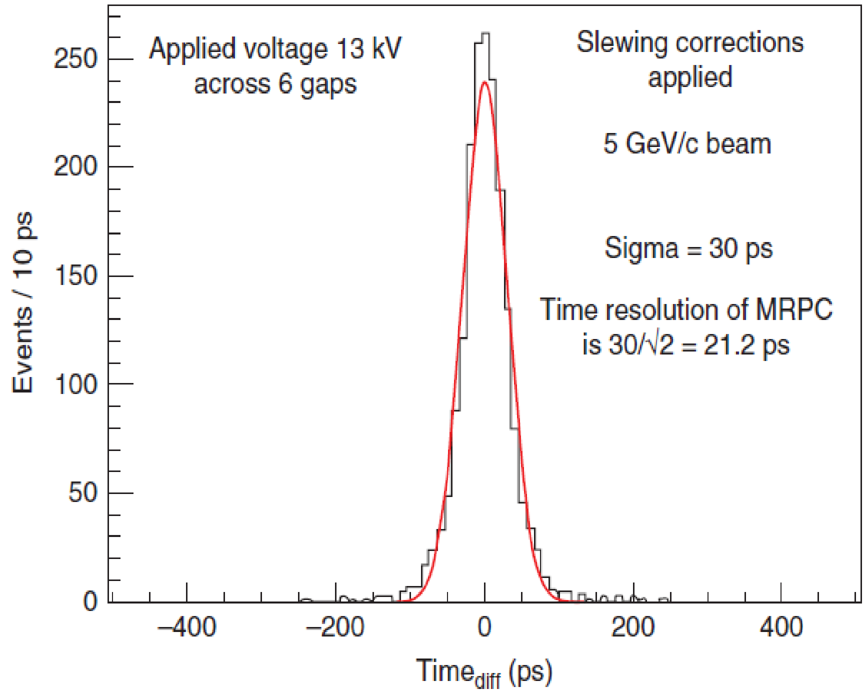


Proposed by W, Crispin and collaborators



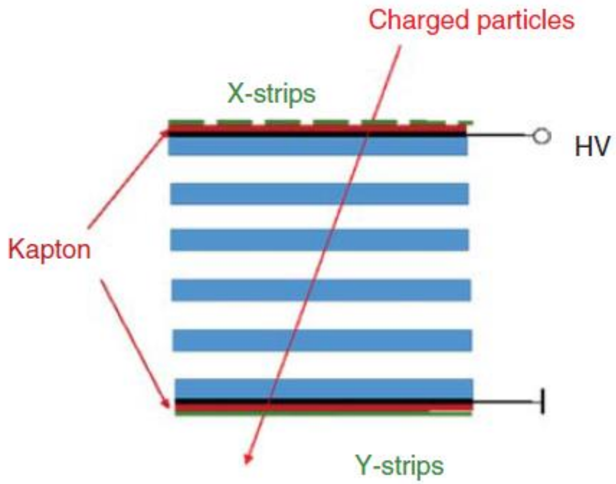
(a)

An, S. *et al*. (2008) A 20ps timing device — a multigap resistive plate chamber with 24 gas gaps. *Nucl. Instrum. Methods Phys. Res., Sect. A*, **594**, 39–43.

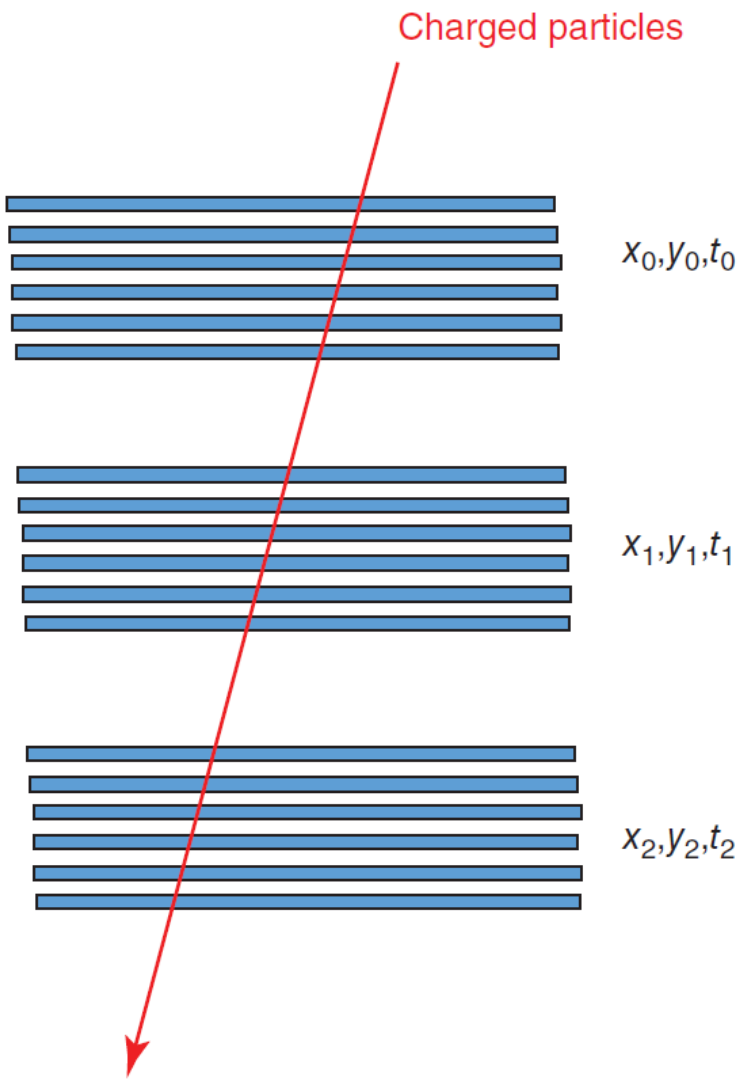


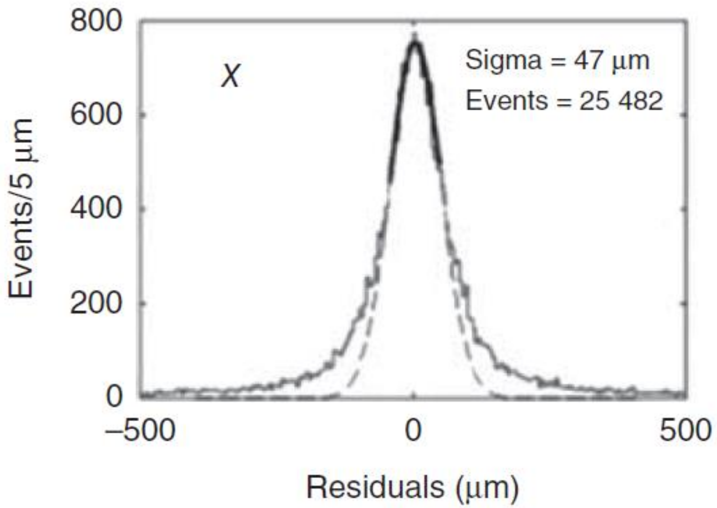
(b)

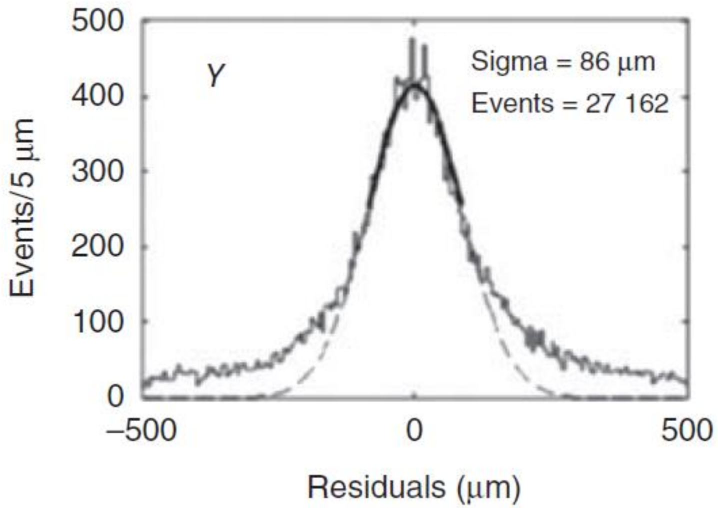
High position resolution timing RPCs!



$$77/\sqrt{3} = 44 \text{ ps.}$$

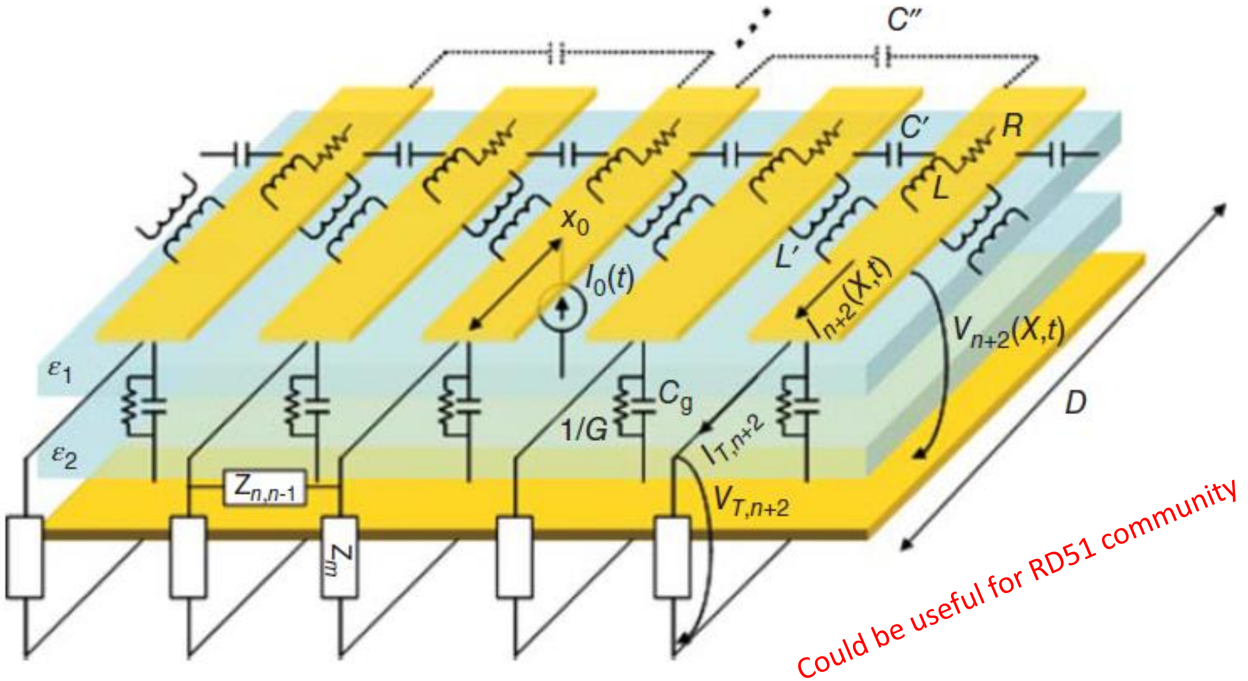






Blanco, A. *et al*. (2012) TOFtracker: gaseous detector with bidimensional tracking and time-of-flight capabilities. *JINST*, 7, P11012.

As follows from the martials presented in the book, to build and operate these state of art RPCs requires high experimental and electronic skills, and, of course, deep understanding of the RPC operation, signal formation a propagation



Equivalent circuit for consideration signal formation
And propagation in multistrip timing RPCs

Fonte, P. (2013b) Frequency-domain formulation of signal propagation in multistrip resistive plate chambers and its low-loss, weak-coupling analytical approximation. *JINST*, **8**, P08007.

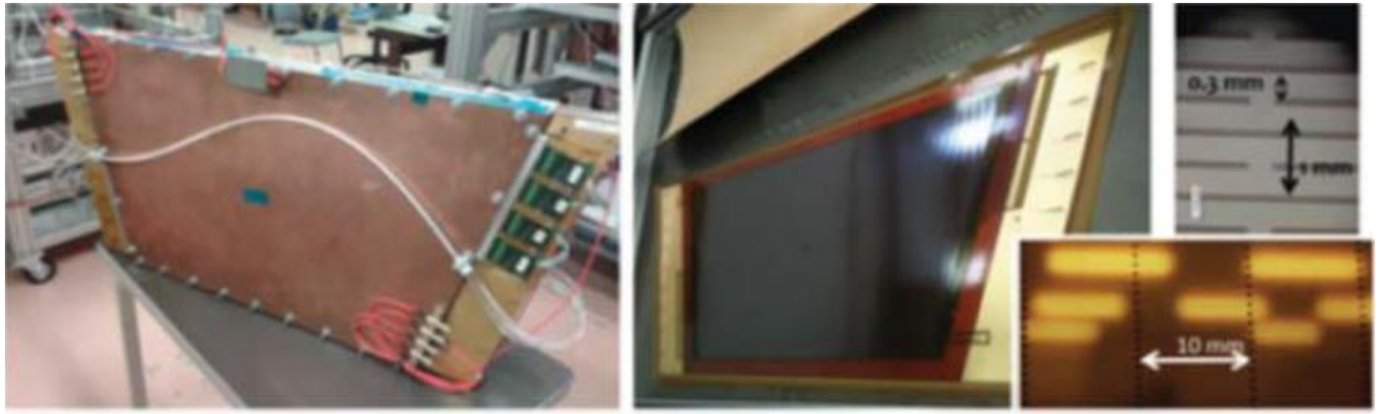
Could be useful for RD51 community

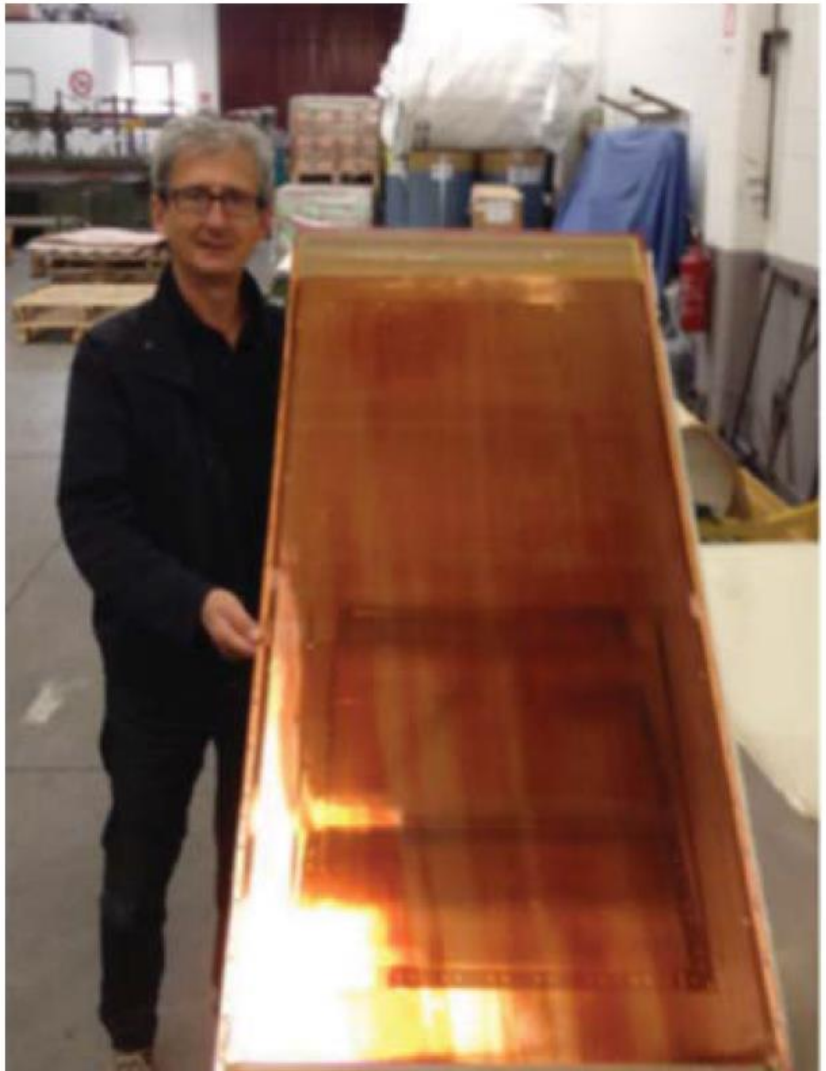
Chapter 8. New Developments in the Family of Gaseous Detectors: Micropattern Detectors with Resistive Electrodes -285

In this chapter

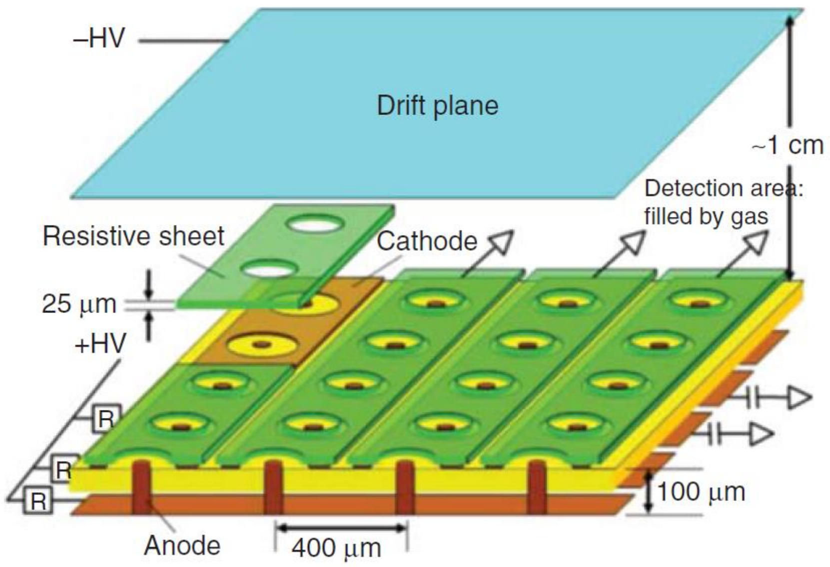
an exhaustive review of resistive micropattern detectors is given

Resistive MICROMEGAS for ATLAS





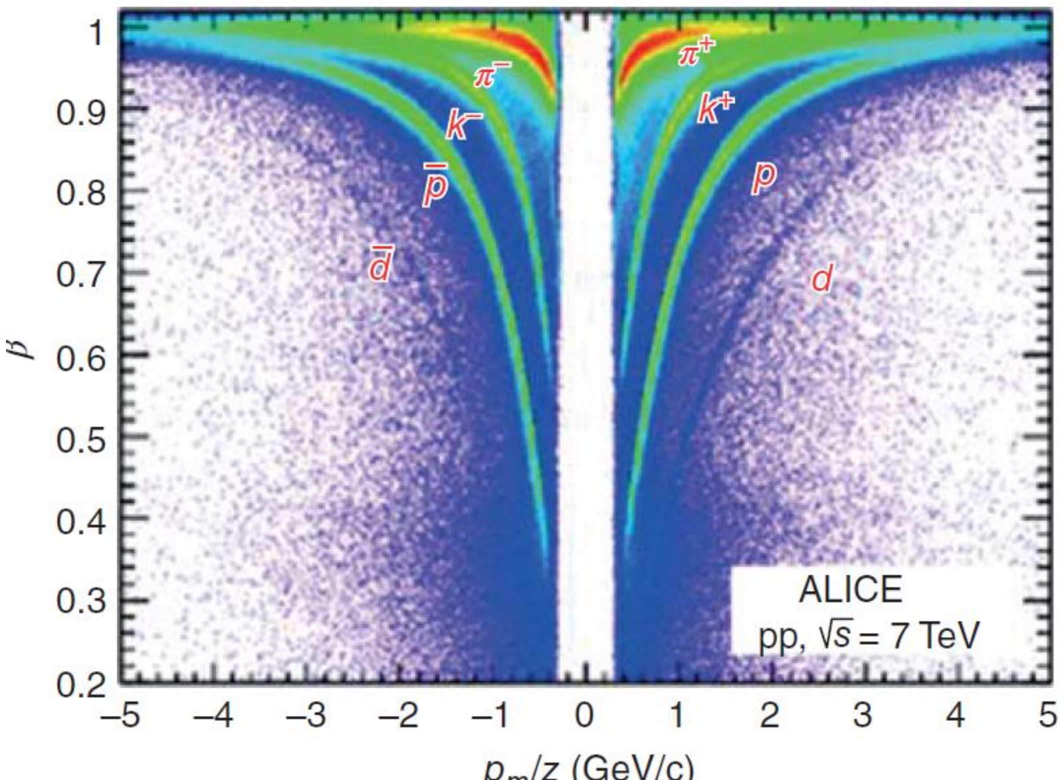
Large-area microwell
for CMS muon system
upgrade



Micropixel detector

III. Applications

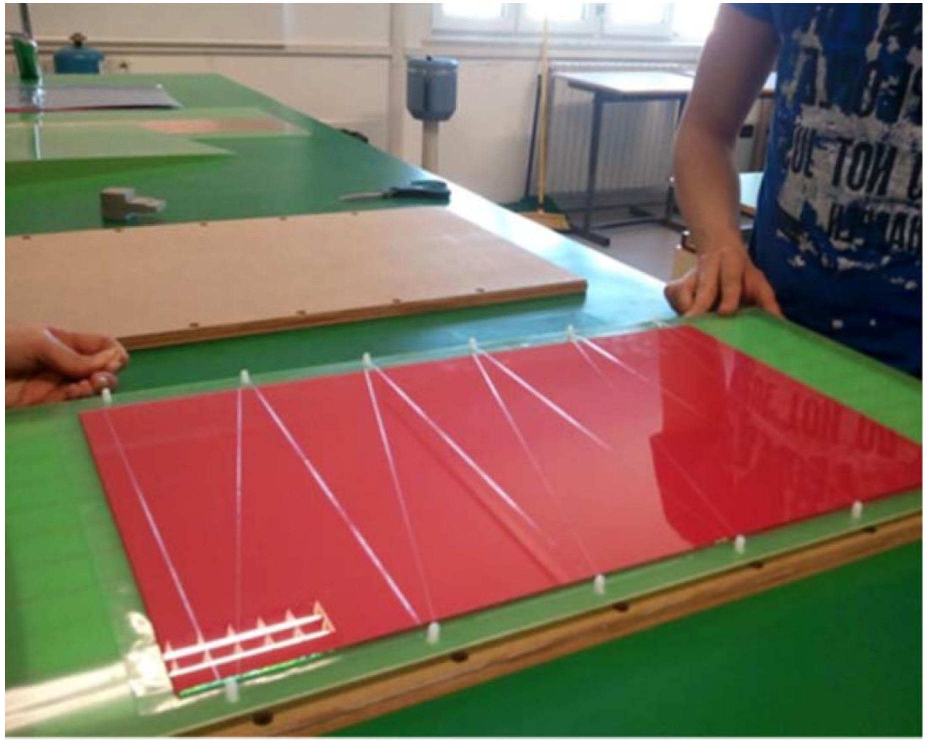
…RPC applications in high-energy and astrophysics experiments are well known

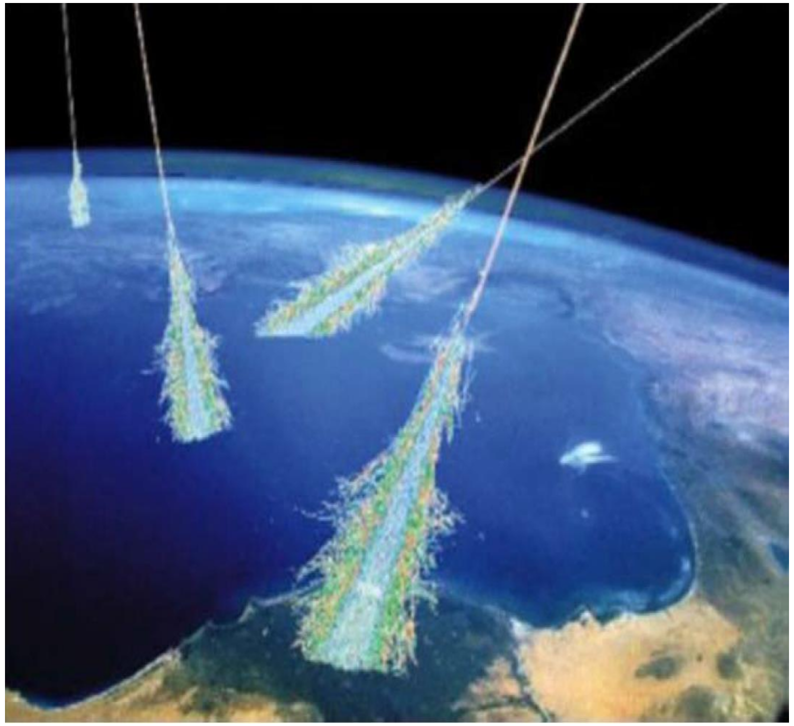


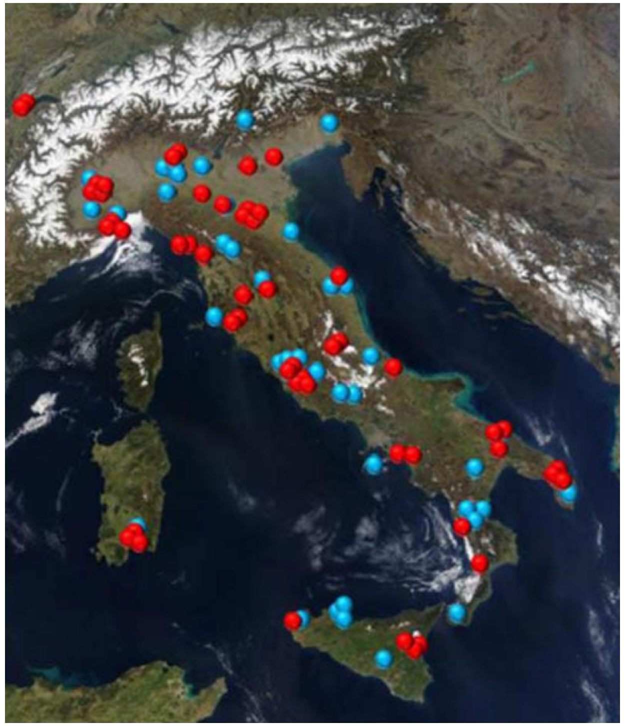
Nowadays Bakelite RPCs cover many thousand m2 in LHC and other experiments

Glass multigap timing RPCs also are successfully using in many experiments

Very exciting is a scientific/educational project- EEE



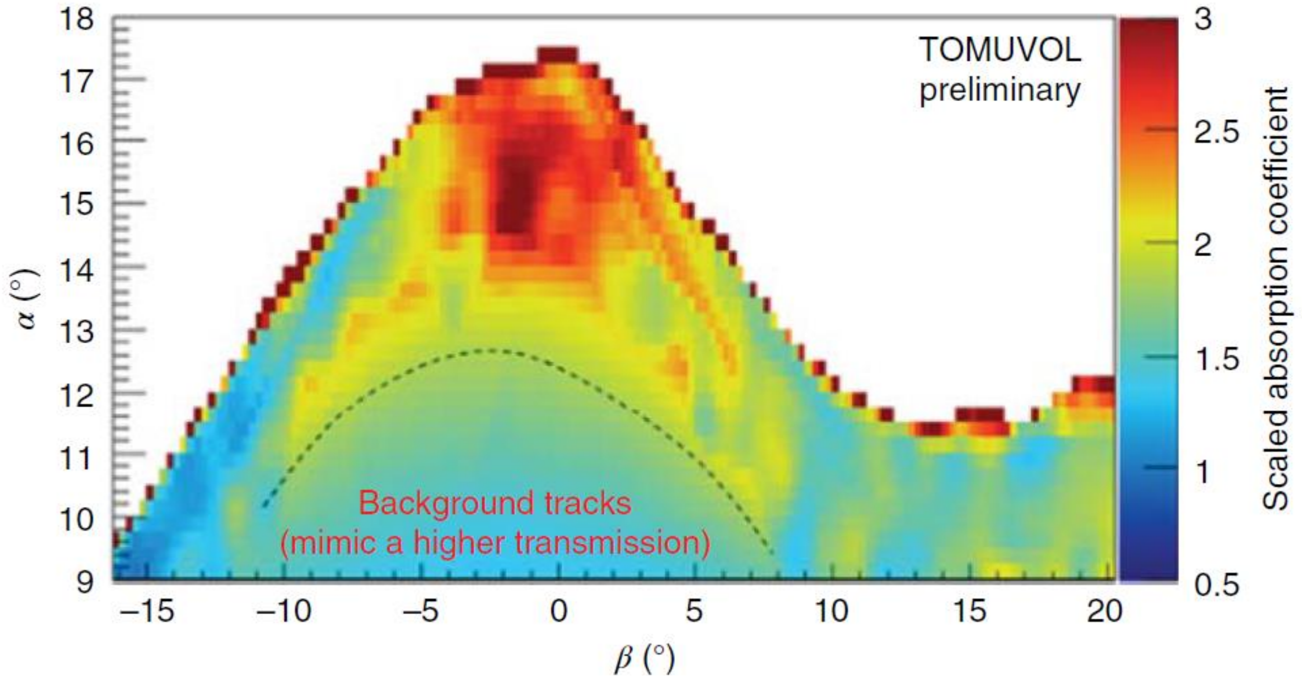




Search for 10^{20} eV or more

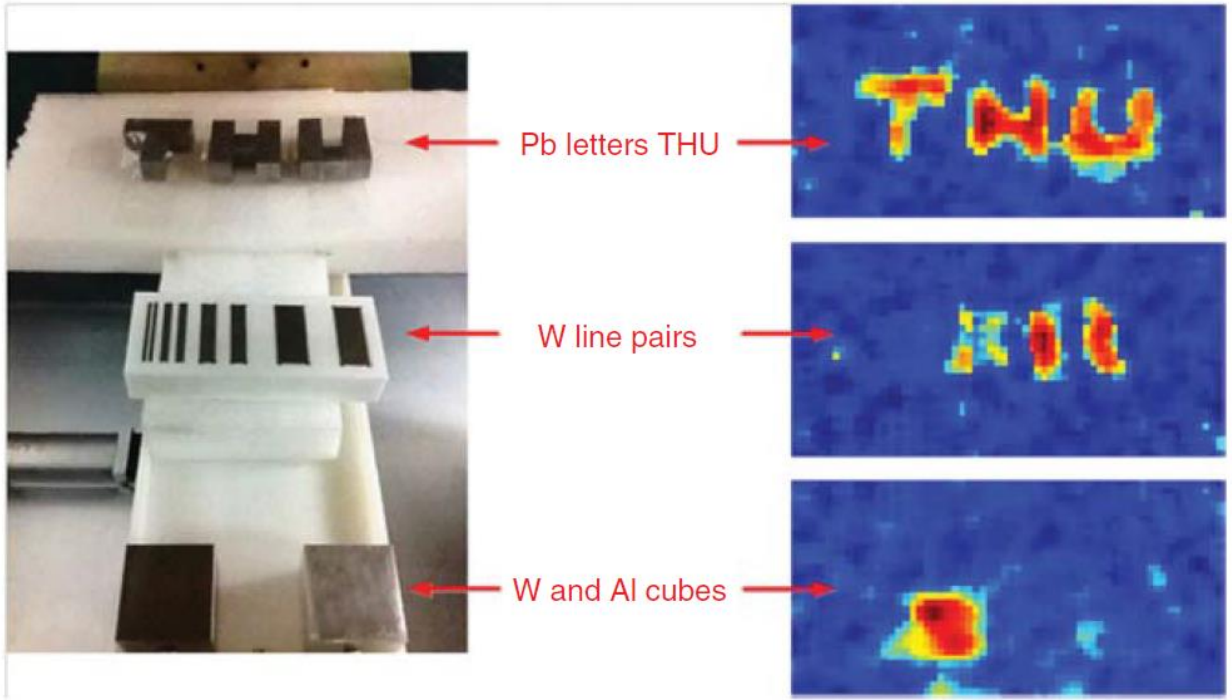
Highlights of applications beyond high energy physics

Muon tomography

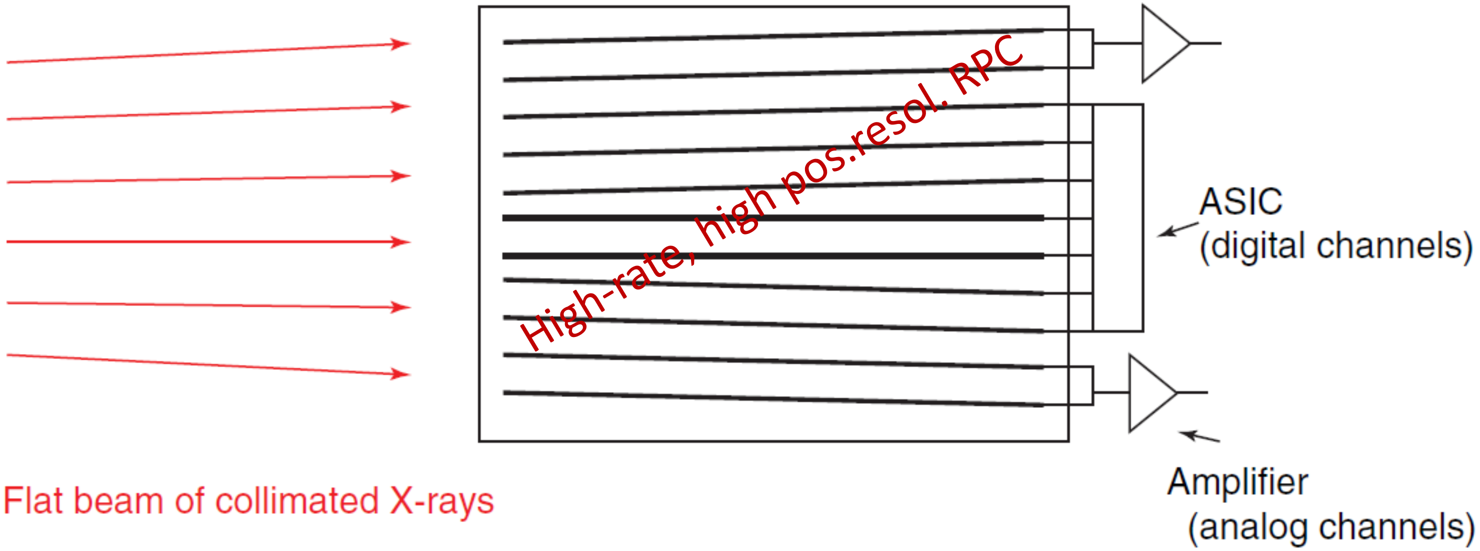


Map of the muon scaled transmission coefficient through the Puy de Dôme

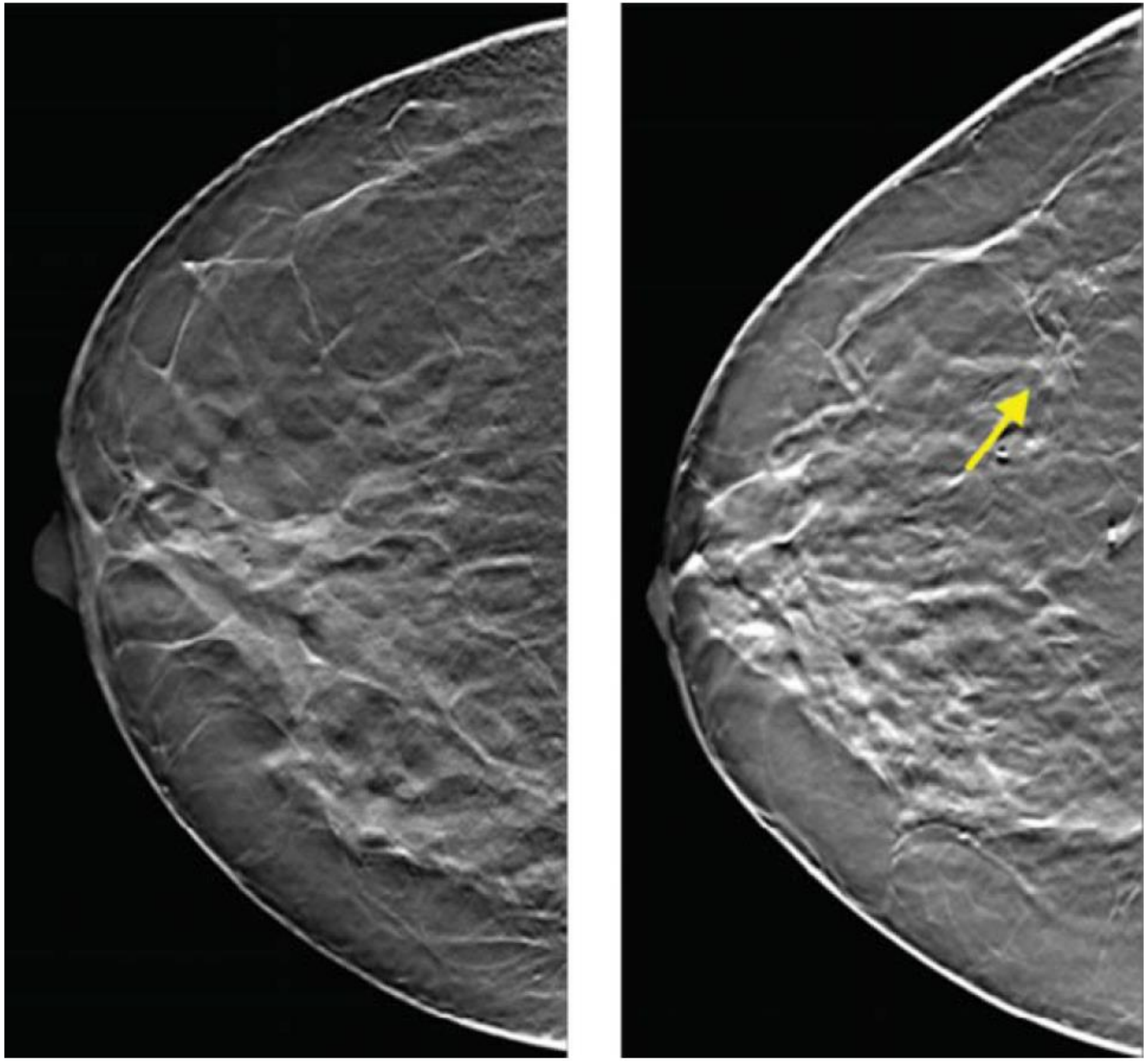
Home-land security



Mammographic scanner (XCounter)



Offers not only a high digital spatial resolution ,but also 5-10 times lower the delivered dose to the patient



Mammaographic tomosynthesis

Conclusions

This book is devoted to those gaseous detectors of elementary particles that incorporate resistive electrodes, whose most well-established instance is the resistive plate chamber. These detectors have several unique and important practical features, such as good spark protection and excellent time resolution, even down to few tens of picoseconds.

There are numerous scientific publications on many different instances of resistive plate chamber designs, and their operation and performance, but there are still few review papers, especially books, summarizing their basic principles of operation, historical development, latest achievements, and their growing applications in various fields.

This book is intended to cover the matters mentioned above and integrate them with the available physical modelling. It was meant to target a wide auditorium, including beginners of the discipline. We hope that this is achieved by an approach where the subject is presented first in a simple way, and later on with a slow increase in complexity.

At the same time, we believe that it will be very useful for the scientific community, where there is an established body of knowledge to be summarized and critically evaluated.

Both electronic and hard copies are available from the CERN library