Characterization of State-Of-The-Art Intrumentation for Timing RPC Detectors

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INTRODUCTION

A brief summary of knowledge crucial to understanding the experiment present

Detectors

Why do they exist?

As physics grew into its atomic and quantum branches, the human eye (and even our most powerful microscopes) ceased being the best method of detection. No amount of lensing could provide focused enough images to be reliable, the particles are too small, too fast, and, in the quantum world, too uncertain.

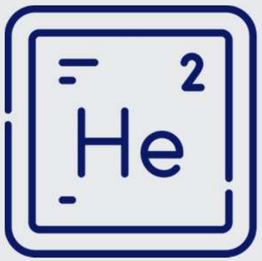
When are they used?

For this reason, detection stopped being a matter of seeing, and more of a matter of sensing, not by humans, but by machines. Detectors were then born to gather the information that was barred from us until then, like the position and energy of fundamental particles.

What makes a detector?

Medium

For it to be detected, the particle has to interact with something existing in the detector. That job, obviously, is given to the medium. They can be solids, liquids, or gases, each fulfilling their niche in detecting particles.



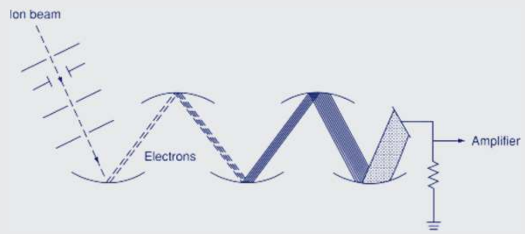
Primary Interaction

The interaction itself has a crucial role in the construction of a detector. These can be separated into two branches because of what is produced: other secondary charged particles or photons.

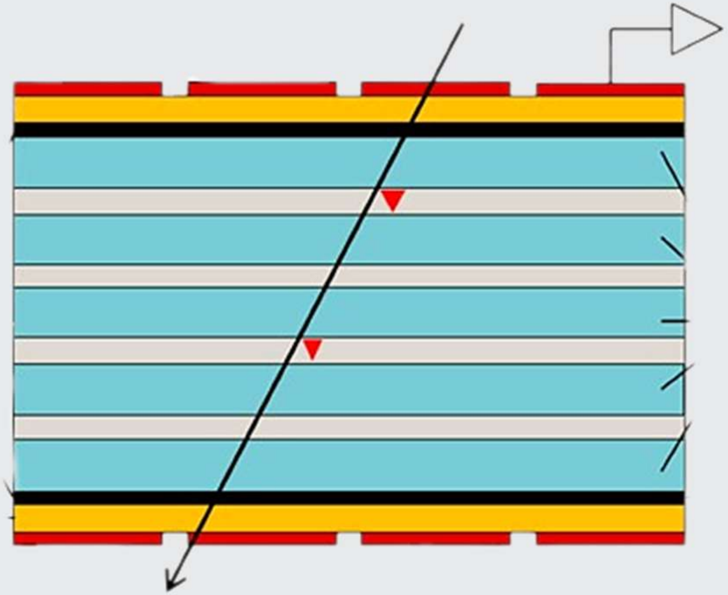
$$\underset{(udd)}{n} \rightarrow \underset{(udu)}{p} + e + \bar{\nu}_e$$

Amplification Method

Most interactions do not emit enough particles/energy to be discernible from background noise. Therefore, a mechanism to amplify the signal is necessary for the detector to be worth manufacturing.



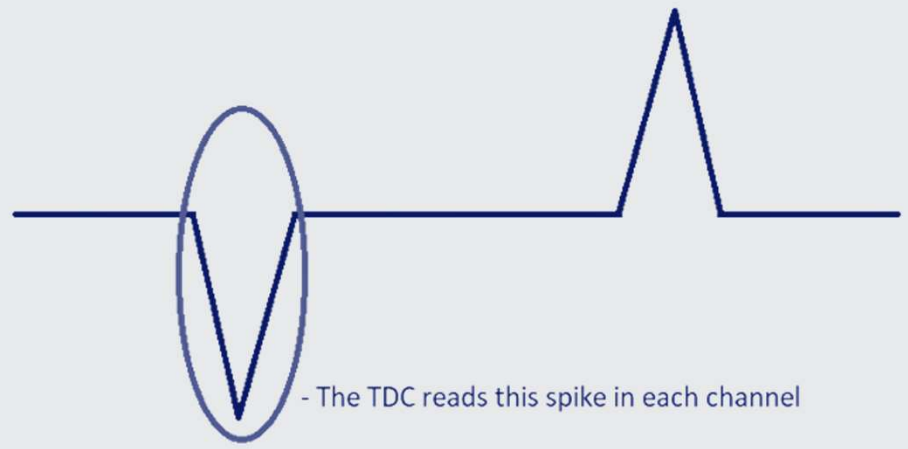
RPC



RPCs, or Resistive Plate Chambers, are gaseous, very fast detectors suited for muon triggering and time-of-flight systems. As CERN defines it, they "consist of two parallel plates, a positively-charged anode and a negatively-charged cathode, both made of a very high resistivity plastic material and separated by a thin gas volume".

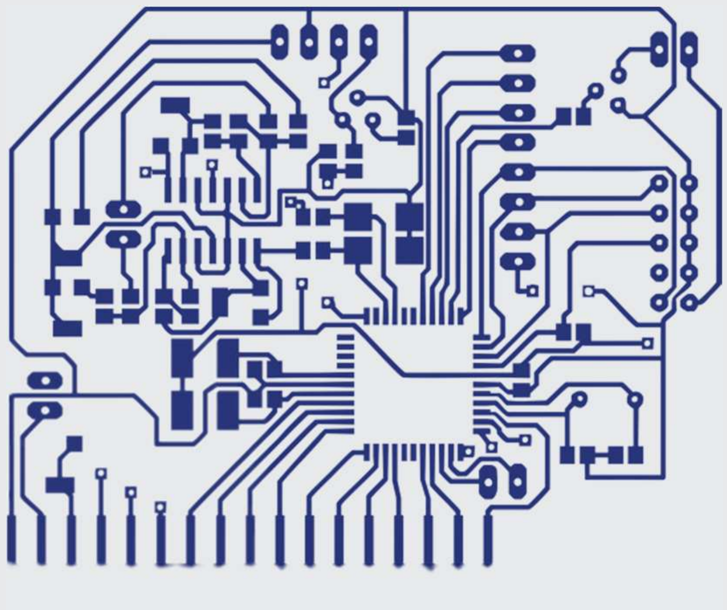
TDC

TDC, or Time digital converter, does, exactly, what gives it its name: Converting the time at which electrical signals are produced into digital data capable of being handled and analyzed. Subtle knowledge of the workings behind this component is essential to understanding the characterization of the timing RPC detector's electronics.



The ▲ Setup

For this distinct characterization, many setups were constructed to better achieve the results warranted. In every case, the build was always some variation of an injector connected to a signal converter, an oscilloscope, and the timing RPCs' electronics. The former and latter connected to the TDC which was itself connected to a power supply.



Objective

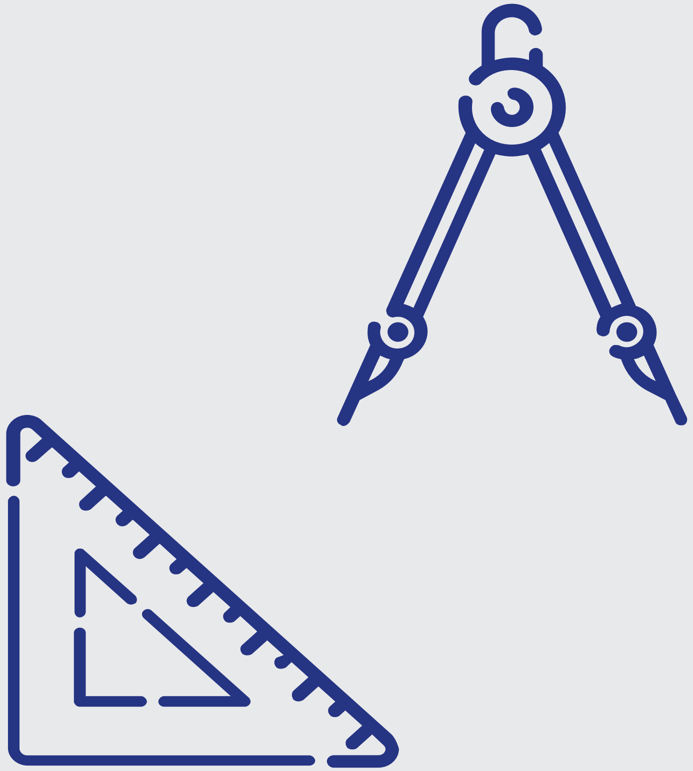
- Timing RPC detectors' electronics' resolution
- Numerically represented by σ_{ELEC}
- Additional critical variables: σ_{REF}, $\sigma_{FEE\text{-}Ref}$ and $\sigma_{Ref\text{-}Ref}$
- These sigmas (σ) correspond to the normal distribution error values

$$\sigma_{REF} = \frac{\sigma_{Ref-Ref}}{\sqrt{2}}$$

$$\sigma_{ELEC} = \sqrt{\sigma^2_{FEE-Ref} - \sigma^2_{REF}}$$

CHARACTERIZATION

Experimentation done in the LIP laboratory

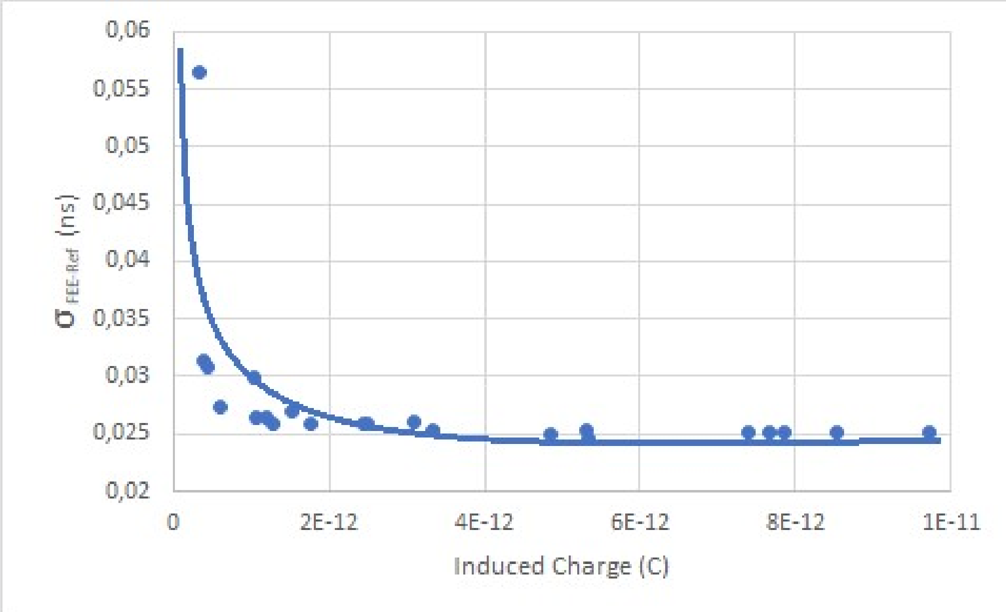


Reference

The first step does not involve the timing RPC’s electronics yet. A reference being established is critical before any characterization can commence. Thus, the beginning setup simply entails an injector connected to both a signal converter and an oscilloscope, the former being connected to the TDC through channels 1 and 2 which is itself connected to a power supply.

Charge-dependent Resolution

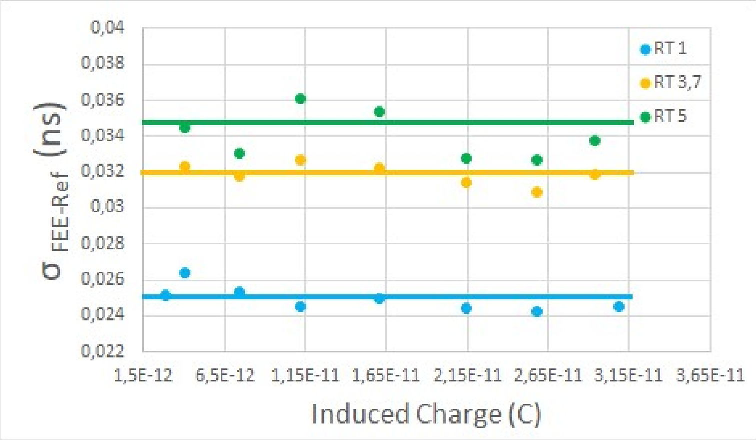
After establishing the reference setup and script, the timing RPC detectors' electronics were added through channel 20. This, naturally, forced a reform in the setup and the script. Nevertheless, as expected, when the σ_{ELEC} was plotted against the induced charge, an inverted exponential-like function appeared.

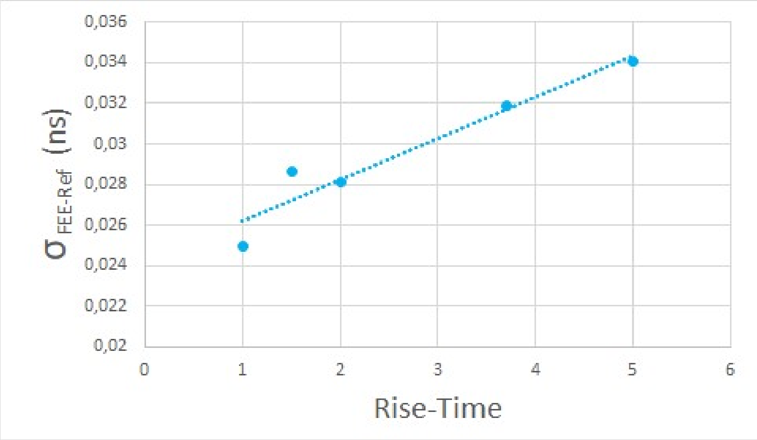


Rise-time-dependent Resolution

Theoretical knowledge of how the RPC detector's electronics work results in believing an increase in rise time might dampen the system's resolution. As observed here, the experiment verifies the theory.

It also provides a slope for the change in resolution with rise-time variance. This section was possible due to a distinct, more recent injector that permitted analog modification of the signal's rise time.



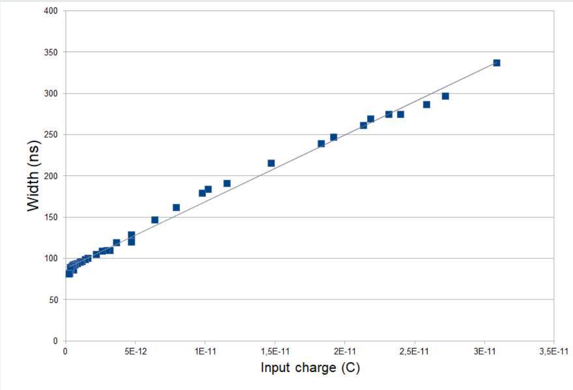


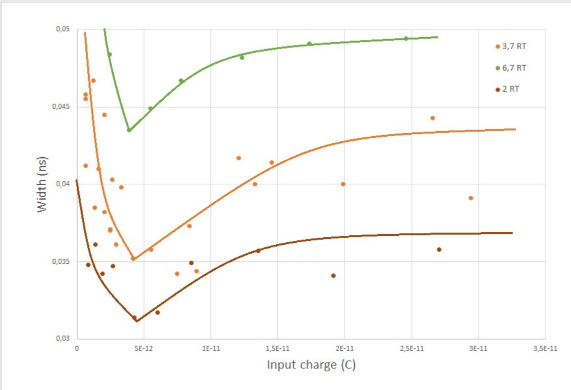
Miscellaneous Testing

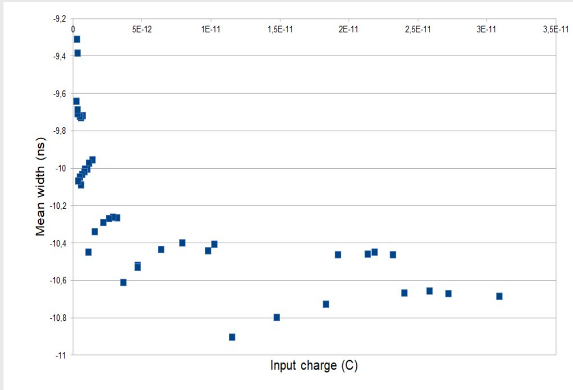
The link between induced charge and signal width was quickly ascertained to have a constant positive slope. Lower charges implied lower signal widths.

Furthermore, while the σ_{REF} was predicted to shift due to improper calibration, the shape of the function for σ_{ELEC} also differed in a strange manner.

Attenuation did have a noticeable effect on the signal's normal distribution mean. It followed this bizarre curve:







CONCLUSION & ACKNOWLEDGMENTS

In conclusion, this characterization culminated in a further understanding of how the electronics from a timing RPC detector work. Additionally, some miscellaneous testing revealed interesting results that require further testing to be fully understood. However, everything fell into believable values.
This project was made possible through the support of Doctor Alberto Blanco.

Thank you

Do you have any questions?