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Development of a new front-end electronics in Si and SiGe technology for the Resistive Plate Chamber (RPC) detector for high-rate experiments

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Summary. — The Resistive Plate Chamber (RPC) detector Front-End (FE) for high-rate experiments is being developed. A mixed technology in silicon and silicon-germanium is used in order to enhance its performances: a preamplifier in silicon with a very low inner noise ($1000\,e^-$ rms) and a new kind of discriminator in SiGe technology with a threshold of the order of 1 mV.

1. – RPC rate capability and possible improvements for high-rate experiments

The RPC [1, 2] rate capability is mainly limited by the current that can be driven by the high-resistivity electrodes. It can be improved working on a number of highly interconnected parameters based on the following equation:

$$V_{gas} = V_a - \rho \cdot \frac{d}{S} \cdot \langle Q \rangle \cdot S \cdot \Phi_{particles} = V_a - \rho \cdot d \cdot \langle Q \rangle \cdot \Phi_{particles}. \tag{1}$$

The chosen approach consists in the reduction of the average charge per count $\langle Q \rangle$ which is the only one that permits to increase the rate capability while keeping the detector current fixed. In order to reduce $\langle Q \rangle$ a new FE must be developed. This new FE electronics must be very sensitive with an excellent signal-to-noise ratio along with high suppression of the noise originated both by the detector itself and by external sources. For the development of this new FE a preamplifier in Si BJT and a discriminator in SiGe HJT will be used.

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Voltage supply	3–5 Volt	B.W.	10–100 MHz
Sensitivity	2–4 mV/fC	Power consumption	10 mW/ch
Noise (independent from detector)	1000 e^- RMS	Rise time $\delta(t)$ input	300–600 ps
Input impedance	100–50 Ohm	Radiation hardness	1 Mrad, 10^{13} n cm^{-2}

Fig. 1. – Performances of custom charge amplifier in Si BJT technology.

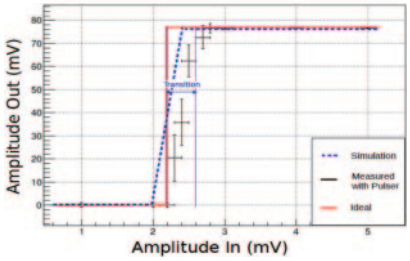

Fig. 2. – Characteristic function of the discriminator in Si-Ge HJT.

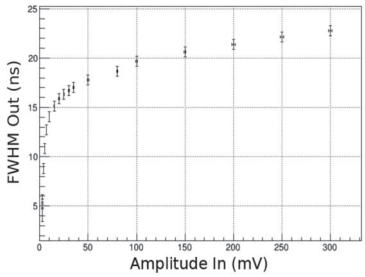

Fig. 3. – TOT dynamic of the discriminator in SiGe HJT.

1˙1. *Amplifier*. – The new amplifier developed for the RPCs is made by means of silicon BJT technology. It is based on the concept of a fast charge integration with the possibility to match the input impedance to a transmission line [3, 4]. Its performances are shown in the table reported in fig. 1.

1˙2. *Discriminator*. – The new full-custom discriminator dedicated to the RPCs is developed by using the Si-Ge HJT technology [5]. The main idea behind this new discriminator is the limit amplifier. The main features are an optimal characteristic function with the possibility of an easy regulation of the threshold from a minimum value of few mV (see fig. 2), a very small transition region of around 300 μV and the possibility to realize the time-over-threshold measurement directly with the discriminator (see fig. 3).

2. – Conclusion

Thanks to the performances achieved by the Si BJT amplifier along with the full-custom discriminator in SiGe HJT, this new FE will be able to detect signals of around 25 μV, which corresponds to a prompt charge of around 1 fC. Thanks to all these features, this new FE electronics will allow the RPC to work with higher rate of incident particles.

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