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Modelling signal induction in detectors with resistive elements

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A growing proportion of detector technology development incorporates resistive materials into their readout architectures to improve performance and stability in order to meet the stringent requirements for measurement precision under increasingly challenging conditions in High Energy Physics (HEP) experiments. With the rising prevalence of these resistive detectors, updating modeling capabilities to reflect this progress is essential. With Garfield++ and a finite element method-based approach a new numerical framework was developed to calculate the induced signal in the presence of resistive elements that is applicable to a wide range of detectors, most of which are inaccessible through analytical means.

By applying an extended form of the Ramo-Shockley theorem, we investigated the induced current response of various devices, including (Multi-gap) Resistive Plate Chambers (MRPCs), Resistive Silicon Detectors, and resistive strip Micromegas. Different techniques were developed to obtain the key quantity of the time-dependent weighting potential of the readout electrodes, particularly for large area structures. In addition, laboratory and test beam measurements were performed to calibrate and validate the simulation framework, which was subsequently used to inform the design of innovative detector readout structures.

Through simulation and measurement, we have explored novel solutions in MRPCs, Micro Pattern Gaseous Detectors, and solid-state sensors incorporating materials with finite conductivity. These studies can be employed for advancing the design and optimization of future detectors, tailored to meet the specific demands of HEP experiments and other applications.

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