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On the saturation of response of inorganic scintillators to slow charged particles

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Inorganic scintillators, mostly in a form of scintillating crystals, are widely used in precision calorimetry, mostly electromagnetic. Their use for large scale hadron/jet calorimetry may be limited by practical considerations, like cost, but on a smaller scale they might offer an attractive possibility of precise total absorption calorimetry. The sub-percent energy resolution of electromagnetic calorimetry based on crystals, even in large systems, has been demonstrated in many experiments. Their energy resolution in hadron calorimetry applications may be limited by several effects. A significant fraction of energy of hadronic showers is deposited by slow protons and nuclear fragments, which may produce significantly lower light signals thus inducing the additional contribution to energy resolution. Extensive studies of response of various crystals to low energy protons and ions have been reported and large saturation effects have been observed and parameterized as a function of the energy, atomic number and charge of beam particles. Significant nonlinearity of response have been reported recently for low energy electromagnetic showers as well and a major effort has been devoted to the studies of the physical origins of this 'non-proportionality'. These studies are limited to the case of electromagnetic calorimetry.

We present a simple physical model of the saturation of the crystal response to slowly moving charge and demonstrate that such a model provides an universal description of the observed saturation effects for all hadrons and electromagnetic particles.

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