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A Simple Model to Describe Smoke Ring Shaped Beam Profile Measurements with Scintillating Screens at the European XFEL

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Standard beam profile measurements of high-brightness electron beams based on optical transition radiation (OTR) may be hampered by coherence effects induced by the micro-bunching instability which render a direct beam imaging impossible.
For the European XFEL it was decided to measure transverse beam profiles based on scintillating screen monitors using LYSO:Ce as scintillator material. While it is possible to resolve beam sizes down to a few micrometers with this kind of scintillator, the experience during the commissioning of the XFEL showed that the measured emittance values were significantly larger than the expected ones. In addition, beam profiles measured at bunch charges of a few hundreds of pico-Coulomb show a 'smoke ring'shaped structure. While coherent OTR emission and beam dynamical influence can be excluded to explain this observation, it is assumed that the beam profile distortions are caused by effects from the scintillator material. Following the experience of calorimetry in high energy physics, a simple model was developed which takes into account quenching effects of excitonic carriers inside a scintillator in a heuristic way. Based on this model, the observed beam profiles can be understood qualitatively. Together with the model description, first comparisons with experimental results will be presented, and possible new scintillator materials suitable for beam profile diagnostics at the XFEL are proposed.

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