Hit position reconstruction with Resistive Silicon Detectors (RSDs) using Machine Learning techniques

Resistive Silicon Detectors (RSDs, aka AC-LGADs) are *n-in-p* silicon sensors, based on the LGAD technology, featuring an unsegmented gain layer over the whole sensor active area. The innovative feature of these sensors is that the signal induced by an ionizing particle spreads over several pixels, allowing position reconstruction techniques that combine the information of many read-out channels: in such a way, RSDs can achieve, for a given pitch size, a better spatial resolution than standard silicon pixel detectors with binary read-out. The devices presented in this work come from the second RSD production manufactured at FBK (RSD2).

In order to reconstruct the hit position with RSDs, analytical laws based on the sharing of the signal between the read-out channels have been developed: they perform well, but they do not make use of all the RSD signal characteristics (area, slew rate, width), which is the key to achieving ultimate accuracy. Machine learning algorithms, instead, can be trained with many signal characteristics as input features, with no need to know the underlying analytical laws, and then used to reconstruct the position, thus representing an ideal tool to fully exploit the peculiar features of the RSDs.

In this work, in particular, I will give an overview of all the different machine learning models, from simple decision trees to more sophisticated graph neural networks, examined in 3 years of development of the RSD position reconstruction technique, highlighting their strengths and weaknesses, and comparing the results to the analytical laws ones.

The experimental results come from data collected either in the lab, using a TCT laser setup, or during several beam test campaigns performed at the DESY beam test facility with 4 GeV electrons, using a EUDET pixel telescope to provide the reference hit positions. Various sensor designs will be presented: 2x2, 3x3, and 3x4 matrices with very different pitches, from 50 μm to 1.3 mm.

The achieved spatial resolution range from ~2 μm obtained with a 50 μm-pitch sensor in ideal conditions, to about 100 μm for the sensor with the widest pitch measured at the test beam.

<u>References:</u>

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