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Using Machine Learning to Speed Up and Improve Detector R&D

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Design of new experiments, as well as upgrade of ongoing ones, is a
continuous process in the experimental high energy physics.
Frontier R&Ds are used to squeeze the maximum physics performance using cutting edge detector technologies.
The evaluation of physics performance for a particular configuration
includes sketching this configuration in Geant, simulating typical
signals and backgrounds, applying reasonable reconstruction
procedures, combining results in physics performance metrics.
Since the best solution is a trade-off between different kinds of
limitations, a quick turn over is necessary
to evaluate physics performance for different techniques in different configurations.
Two typical problems which slow down the evaluation of physics performance
for particular approaches to calorimeter detector technologies and
configurations are:
- Emulating particular detector properties including raw detector
response together with a signal processing chain to adequately
simulate a calorimeter response for different signal and background
conditions. This includes combining detector properties obtained from the general Geant simulation with
properties obtained from different kinds of bench and beam tests of detector and electronics prototypes.
- Building an adequate reconstruction algorithm for physics
reconstruction of the detector response which is reasonably tuned
to extract most of the performance provided by the given detector
configuration.

Being approached from the first principles, both problems require
significant development efforts. Fortunately, both problems may be
addressed by using modern machine learning approaches, that allow
combining available details of the detector techniques into
corresponding higher level physics performance in a semi-automated way.

In the presentation, we discuss the use of advanced machine learning techniques to speed up and improve
the precision of the detector development and optimisation cycle, with an emphasis on the experience and
practical results obtained by applying this approach to optimising the electromagnetic calorimeter design as
a part of the upgrade project for the LHCb detector at LHC.

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