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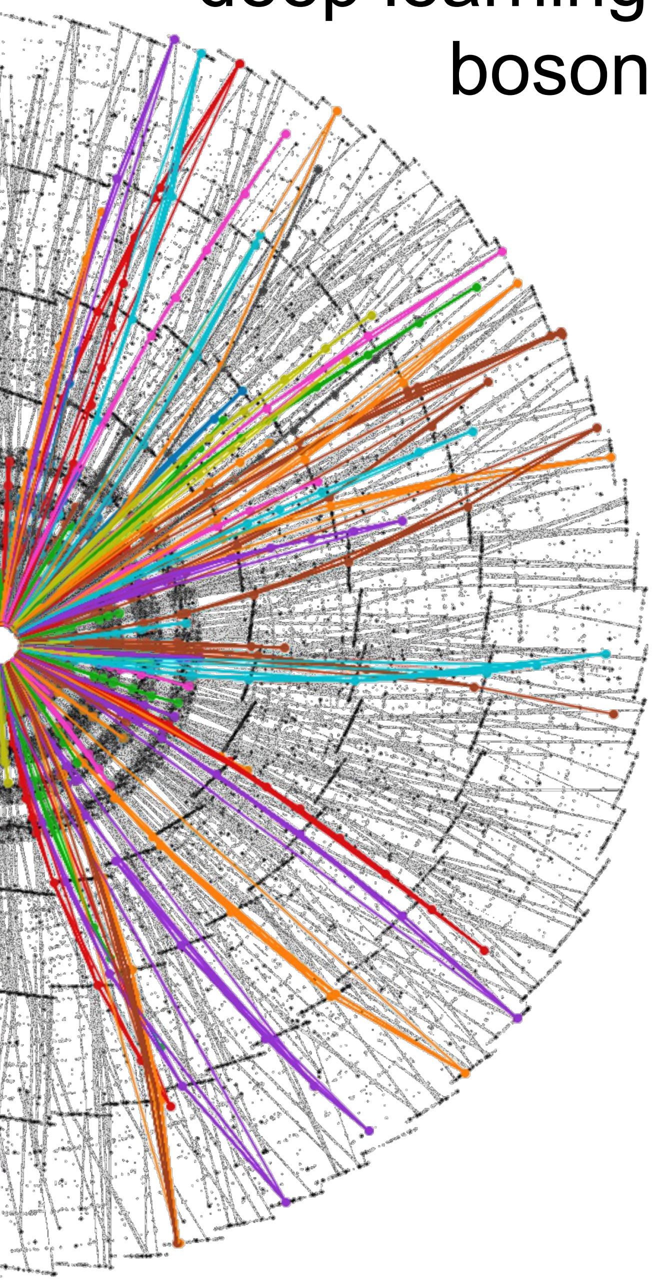
Charged particle trajectography using a novel geometric deep learning algorithm and search for additional Higgs-boson-like particles in ATLAS Run 2 data



Charline Rougier

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Maison de la Recherche et de la Valorisation
75 cours des sciences
Amphithéâtre 2

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The particle discovered in 2012 matched the expected properties of a 125 GeV Higgs boson H as predicted by the Standard Model (SM), within the experimental uncertainties. However the experimental uncertainties do not exclude that H may have a small mixing with additional scalar bosons that remained to be discovered, and may be part of an extended Higgs sector. This thesis presents a search for the resonant production of a heavy scalar X decaying into a Higgs boson and a new lighter scalar S, through the process $X \to SH \to b\bar{b}\gamma\gamma$, where the two photons are consistent with the Higgs boson decay. The search is conducted using 140 fb^{-1} of LHC Run 2 data recorded by ATLAS.

The LHC collider and the associated experiments are undergoing major upgrades in preparation for the upcoming High-Luminosity phase. The upgraded collider will be able to deliver collision with an instantaneous luminosity of $L = 7.5\times 10^{34} cm^{-2}s^{-1}$, about three times larger than the highest instantaneous luminosity reached during the last years of the LHC phase. During this new phase, each of the general-purpose experiments ATLAS and CMS will accumulate at least 3000 fb^{-1} of data, enabling precise measurements in the Higgs sector. As a direct consequence of the increased luminosity, the average number of inelastic proton-proton collisions per beam crossing will be increased to 200, increasing the complexity of the events and leading to a steep increase in computing resources needed to process and analyze the data. Assuming a flat budget, the expected improvements in computing hardware will not be able to provide this increase. The amount of data that experiments can collect and process will be limited by affordable software and computing, and therefore the physics reach during HL-LHC will be limited by how efficiently these resources can be used. The CPU resource needed for event reconstruction tends to be dominated by charged particle reconstruction (tracking). This thesis presents a novel tracking algorithm based on a geometric deep-learning solution involving a Graph Neural Network model. The algorithm developed is intended to be fully run on parallel architecture, such as GPU, enabling a sharp timing acceleration. The efficiency reached is promising and already competitive with the traditional algorithm.

Un pot convivial sera proposé après la soutenance.

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