T 64: Invited Topical Talks III

Time: Thursday 13:45–15:45 Location: AudiMax

Invited Topical Talk T 64.1 Thu 13:45 AudiMax

Charting the Higgs Sector with Effective Field Theories — •Ilaria Brivio — Dipartimento di Fisica e Astronomia, Universita' di Bologna and INFN, Sezione di Bologna, via Irnerio 46, Bologna, Italy

With no clear signs of new resonances at the LHC, searches for physics beyond the Standard Model are increasingly targeting small indirect effects potentially induced by heavy physics beyond the collider's reach, which are captured by Effective Field Theories (EFTs). While the Standard Model EFT (SMEFT) is the established framework for this purpose, there is growing interest in scenarios that lie outside its underlying assumptions. An interesting way to explore them is by adopting the Higgs EFT (HEFT) – also known as electroweak chiral Lagrangian – which provides a more general EFT extension of the SM.

In this talk, I will introduce the basic ideas behind HEFT and explain how it differs conceptually from SMEFT. I will highlight the kinds of phenomenological signatures that distinguish the two approaches and provide an overview of the state of the art in the theoretical development of HEFT and its application at the LHC.

Invited Topical Talk T 64.2 Thu 14:15 AudiMax

Probing CP invariance of Higgs boson production and decay and its interpretation in effective field theories with the ATLAS detector — •Lorenzo Rossini — University of Freiburg

The origin of the observed baryon asymmetry in the universe is one open question that can be explained if the three Sakharov conditions are fulfilled. One of these conditions includes the violation of the invariance under combined charge (C) and parity (P) conjugation. However, the magnitude of CP violating effects in the Standard Model (SM) is not enough to explain the observations. The Higgs boson is a promising candidate to search for additional CP-violating interactions.

The ATLAS experiment at the LHC has a vast program of measurements of the properties of the Higgs boson, and in particular its CP properties in interactions with gauge bosons or fermions. This talk will summarize tests of CP invariance of Higgs boson production and decay, and the interpretation of the results using Effective Field Theory, with focus on analyses in which the decay mode into a pair of tau-leptons is exploited

Moreover, comparison (and future combinations) with other ATLAS analyses will be discussed. This talk will present results from analyses based on proton-proton collision data collected by the ATLAS experiment at a center-of-mass energy of $\sqrt{s}$=13 TeV and $\sqrt{s}$=13.6 TeV during Run 2 and early Run 3.

Invited Topical Talk T 64.3 Thu 14:45 AudiMax

b-tagging unlocks the Higgs potential — •Nicole Hartman — Technical University of Munich — ORGINS Data Science Lab

The Higgs potential governs electroweak symmetry breaking, but its form has yet to be experimentally verified and could impact the future stability of the universe. A first experimental probe of the Higgs potential will come from measuring the simultaneous production of two Higgs bosons (di-Higgs), an exceptionally rare process. This talk presents the latest results from ATLAS on measurements for di-Higgs in the most abundant final state with four b-quarks, as well as searches for additional Higgs bosons predicted in beyond the SM scenarios. The central challenge for these analyses is an accurate prediction of the quantum chromodynamics background, and generative AI techniques (normalizing flows) are showcased to model these challenging-to-simulate backgrounds in high dimensions.

In our quest to discover di-Higgs, the discovery channels will all include b-jets. The state-of-the-art for b-jet identification (or b-tagging) on ATLAS is a transformer model, and we present the latest developments in b-tagging with multi-task, multi-modal models. By increasing the size of these models, we demonstrate that particle physics can benefit from the foundation model scale that launched the AI revolution of Large Language Models. By casting jet taggers as a first foundation model for LHC physics, they can also be customized for our physics goals. We highlight how an end-to-end optimizable analysis can fine-tune a jet-tagger for a HH physics search, and how differentiable building blocks can automate future scientific discovery.

Invited Topical Talk T 64.4 Thu 15:15 AudiMax

Modern Machine Learning for LHC Event Generation — •Ramon Winterhalder — TIFLab, Università degli Studi di Milano & INFN Sezione di Milano, Italy

High-precision simulations from first principles are a cornerstone of LHC physics. With the upcoming high-luminosity phase of the LHC and the significant increase in experimental data, traditional simulation pipelines face growing challenges in terms of computational cost and efficiency. In this talk, I will discuss how modern machine-learning methods and computing paradigms can accelerate event generation while preserving theoretical accuracy. I will focus on three distinct and complementary approaches: neural importance sampling, as implemented in the MadNIS framework; machine-learned surrogate models for expensive matrix-element calculations; and hardware-aware implementations that exploit GPU acceleration and parallelization for efficient large-scale deployment. Together, these developments significantly reduce computational cost and pave the way towards the first ML-based event generator.