T 34: Data, AI, Computing, Electronics IV

Time: Tuesday 16:15–18:45 Location: KH 02.014

T 34.1 Tue 16:15 KH 02.014

SysVar: A new tool for enhancing consistency in the treatment of systematic — •Agrim Aggarwal[1], Georgios Alexandris[1], Florian Bernlochner[1], Stefanie Meinert[1], Felix Metzner[1], Giacomo De Pietro[2], Markus Prim[1], Slavomira Stefkova[1], and Ilias Tsaklidis[1] — [1]Universität Bonn — [2]Karlsruhe Institute of Technology

SysVar provides an end-to-end, consistent machinery to build template histograms and their systematic variations with correlations preserved. To account for effects such as detector acceptance and calibration, physics reweighting, event-by-event correction weights are applied to the Monte-Carlo templates which have systematic uncertainties. For a typical template fit spanning multiple channels, multiple templates and multiple observables keeping book of all correlations becomes nontrivial.

In this talk, we present SysVar - A python package that streamlines the treatment of systematic uncertainties for collider-physics analyses that rely on Monte-Carlo template fits. SysVar produces outputs compatible with popular HEP template-fitting libraries such as cabinetry and pyhf. It was originally developed within the Belle II context, but its design and interfaces are experiment-agnostic.

By having consistency across systematics and preserving correlations, this also enables the combination of a measurement from different analysis based on orthogonal selections

T 34.2 Tue 16:30 KH 02.014

MC-Run: Monte Carlo Workflows for Precision Phenomenology — Maximilian Horzela[1] and •Cedric Verstege[2] — [1]Georg-August-Universität Göttingen, Germany — [2]Karlsruhe Institute of Technology, Germany

Reliable Monte Carlo (MC) predictions are a key ingredient for precision phenomenology in high-energy physics, in particular for the derivation of non-perturbative and electroweak correction factors. We present MC-Run, a lightweight framework that enables reproducible end-to-end MC studies, from event generation to Rivet-based analyses and further processing.

Originally developed for the determination of non-perturbative corrections, MC-Run has been successfully applied in phenomenological analyses and HEP publications, supporting large-scale production campaigns at the level of O(100k) CPU hours. More recently, the framework has been extended to studies of electroweak corrections and can be readily adapted to different physics processes and observables.

This talk will give an overview of MC-Run, its modular workflow design, built-in support for grid computing, how to extend it to other MC generators and adapt it for further physics analyses.

T 34.3 Tue 16:45 KH 02.014

FeynGraph - A Modern High-Performance Feynman Diagram Generator — •Jens Braun — Institute for Theoretical Physics, Karlsruhe Institute of Technology

We present FeynGraph, a modern high-performance Feynman diagram generator designed to integrate seamlessly with modern computational workflows to calculate scattering amplitudes. FeynGraph is designed as a high-performance Rust library with easy-to-use Python bindings, allowing it to be readily used in other tools. With additional features like arbitrary custom diagram selection filters and automatic diagram drawing, FeynGraph strives to be a fully-featured Feynman diagram toolkit at any loop order.

T 34.4 Tue 17:00 KH 02.014

Differentiable Setup for a Top-Higgs Analysis — •Felix Zinn[1], Peter Fackeldey[2], Benjamin Fischer[1], Nina Herfort[1], and Martin Erdmann[1] — [1]RWTH Aachen University — [2]Princeton University

In high energy physics (HEP), the measurement of physical quantities often involves intricate data analysis workflows that include the application of kinematic cuts, event categorization, machine learning techniques, and data binning, followed by the setup of a statistical model. Each step in this process requires careful selection of parameters to optimize the outcome for statistical interpretation.

This presentation introduces a differentiable approach to the data analysis workflow utilizing the python package evermore for statistical model building. Built on top of JAX, the models created in evermore benefit from automatic differentiation. By leveraging this feature alongside neural networks, we can apply optimization across all stages of the analysis. This method allows for a more systematic selection of parameter values while also ensuring that the optimization process accounts for systematic uncertainties included in the analysis.

We apply this approach to a CMS analysis targeting the production of a Higgs boson in association with one or two top quarks and demonstrate how each individual step can be implemented in a differentiable manner. A setup for a differentiable analysis workflow is presented.

T 34.5 Tue 17:15 KH 02.014

Exploring future Monte-Carlo generators: MC Validation in ATLAS with PAVER — •Dominic Hirschbühl, Johanna Kraus, Anna Bingham, Frank Ellinghaus, and Tim Beumker — Bergische Universität Wuppertal, Wuppertal, Germany

Monte-Carlo (MC) simulations play a key role in high energy physics, for example at the ATLAS experiment. MC generators evolve continuously, so a periodic validation is indispensable for obtaining reliable and reproducible physics simulations. For that purpose, an automated and central validation system was developed: PMG Architecture for Validating Evgen with Rivet (PAVER). It provides an MC event generator validation procedure that allows a regular evaluation of new revisions and updates for commonly used MC generators in ATLAS as well as comparisons to measured data. The result is a robust, fast, and easily accessible MC validation setup that is constantly developed further. This way, issues in simulated samples can be detected before generating large samples for the collaboration, which is crucial for a sustainable and low-cost MC production procedure in ATLAS.

T 34.6 Tue 17:30 KH 02.014

Implementation of a reliable ML model life cycle for the CMS Phase-2 L1 Trigger Upgrade — •Leon Joel Kerner[1,2] and Alexander Schmidt[1] — [1]Physics Institute IIIA, RWTH Aachen University, (DE) — [2]CERN, (CH)

To achieve the ambitious goals of the High-Luminosity LHC upgrade, a new Level-1 trigger must be developed for the CMS experiment. Machine Learning based models will be deployed in the trigger system, which introduces a range of new challenges. The development of such models involves many individual steps. Any change in the configuration or the data can require repeating the entire workflow, and these steps are currently carried out manually by the model developers. In addition, the deployment of trained models in the trigger requires robust procedures that ensure long-term quality and stability. To address these issues, methods from machine learning operations (MLOps) must be integrated into the workflow.

To address this problem, a GitLab CI/CD pipeline and a training infrastructure consisting of a MLflow server and a WebEOS instance was created to log and manage model training sessions.

T 34.7 Tue 17:45 KH 02.014

A Common Language for Complex Particle Decays: demonstrated on $B^+ \to D^{*\pm} D^{\mp} K^+$ — •Alexander Kazatsky, Mikhail Mikhasenko, and Marian Stahl — Experimental Physics I, Ruhr-University Bochum, Germany

The Amplitude Model Serialization (AMS) project of the DEMOS (DEMocratizing MOdelS) consortium aims to provide a standardized format for the description of particle decay processes of varying complexity. This enables more straightforward reproduction of existing analyses, offers a framework for performing new amplitude studies, and facilitates the integration of complex decay chains into external systems such as Monte Carlo generators. In this work, the translation of a partial-wave analysis from the TensorFlow Partial Wave Analysis (TF-PWA) framework, which is widely used in experiments like LHCb and BESIII, is demonstrated. While the AMS format has so far been applied to singular three-body decays, the present analysis of $B^+ \to D^{*\pm} D^{\mp} K^+$ features a more complex topology. Namely, the decay of $D^{*\pm} \to D^0 \pi^\pm$ needs to be accounted for. The branching structure of two-body decays inherent to TF-PWA is translated into a system of three- and two-body decays in the AMS format. This coupled-channel analysis, which previously revealed new tetraquark candidates (PRL 133 (2024) 13, 131902), was reproduced using TF-

PWA, translated, and repeated in the AMS framework. A standardized workflow for translating models from TF-PWA into the AMS system is presented.

T 34.8 Tue 18:00 KH 02.014

Python framework for the topological track reconstruction in JUNO — •Mikhail Smirnov, Daniel Bick, Milo Charavet, and Caren Hagner — Institute of Experimental Physics, University of Hamburg, Hamburg, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a new-generation kiloton-scale neutrino detector based on liquid scintillator (LSc). With a target mass of 20 kilotons, it is the largest LSc detector in the world. Utilizing the antineutrino flux from two nuclear power plants at a baseline of approximately 53 km, JUNO aims to determine the neutrino mass ordering with high statistical significance and to perform precision measurements of neutrino oscillation parameters. JUNO has successfully started to operate in August 2025. Topological Track Reconstruction (TTR) was originally developed to reconstruct energetic muon events in large unsegmented LSc detectors. The algorithm exploits the time and spatial distributions of PMT first-hit times to reconstruct a three-dimensional photon-emission density inside the detector. In the original C++ implementation, this density is obtained via deterministic kernel summation, which provides a heuristic estimate but lacks a well-defined statistical interpretation. This talk presents pyTTR, a Python-based reimplementation and conceptual extension of the TTR. The new framework reformulates TTR as a likelihood-based inverse problem, naturally separating detector geometry, photon propagation, PMT response, and statistical inference, and provides increased flexibility for future physics analyses

T 34.9 Tue 18:15 KH 02.014

LEGEND Analysis with the JuLeAna Software Stack — •Andreas Gieb[1], Florian Henkes[2], Susanne Mertens[1], Jonas Schlegel[1], Oliver Schulz[3], and Christoph Wiesinger[1] for the LEGEND-Collaboration — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Technische Universität München, Munich, Germany — [3]Max-Planck-Institut für Physik, Munich, Germany

The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND) is a staged experimental program searching for the neutrinoless double-beta ($0\nu\beta\beta$) decay of ^{76}Ge. The first stage of the experiment LEGEND-200 is currently taking data at the Gran Sasso Underground Laboratory. Data analysis within LEGEND-200 is carried out using two dedicated software stacks. This talk will focus on the structure and analysis workflows of the JuLeAna software stack.

T 34.10 Tue 18:30 KH 02.014

Data- and Metadata Management at HZDR — •Stefan E. Müller, Thomas Gruber, Oliver Knodel, David Pape, and Martin Voigt — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The integrity and utility of research output critically depends on both data and metadata. While data comprise the primary outputs of experiments, simulations or analyses, metadata describe the origin, structure, semantics, and context of the data, enabling the interpretation, discovery, and reuse. Metadata are essential for ensuring compliance with the FAIR principles (Findable, Accessible, Interoperable, and Reusable), and failure to adequately define or manage metadata leads to poor reproducibility and limited interoperability.

At HZDR, the Helmholtz-Zentrum Dresden-Rossendorf, researchers profit from the "Rossendorf Data Repository" RODARE, which allows them to publish their research data. Especially for large data sets, which can contain up to several Terabyte of data, a good description of the metadata is required to allow a practical reuse of the data sets. The SciCat metadata catalog is used at HZDR to provide the corresponding metadata together with a RODARE data publication.

The presentation will describe how SciCat and RODARE are used together to make a large data set FAIR.