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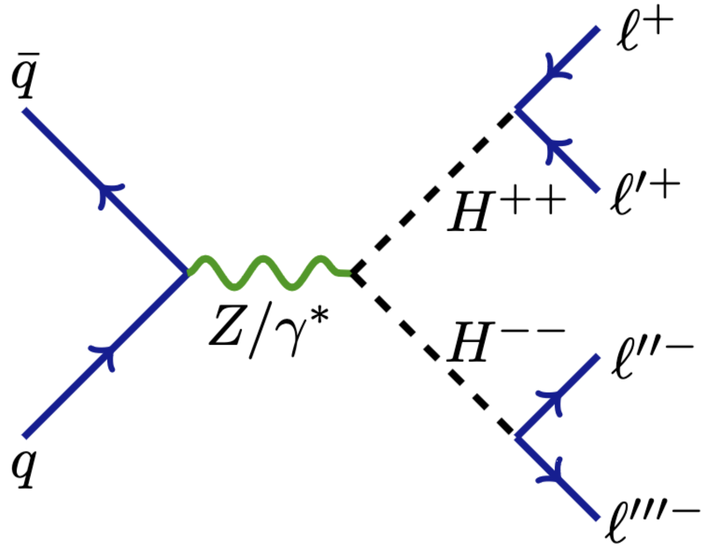

WORKSHOP IN LUND

SEPTEMBER 25 – SEPTEMBER 26 2023

Book of Abstracts

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Day 1 — Monday, 25th of September, 2023

09:00 AM – 11:15 AM

Part 1: Introduction to Type-II and Type-III seesaw models

Basics of neutrino mass origin

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The origin of neutrino mass remains a mystery in particle physics. In the first talk I will give an introduction to the celebrated seesaw mechanism and its various incarnations. We will learn the basics of Majorana fermions, the EFT picture and its logical UV realizations, ranging from type I, II, III and gauge extensions. In particular we will focus on the doubly charged scalars and their relevance for uncovering the spontaneous origin of neutrino mass.

Keywords: Seesaw mechanism, Majorana fermions, Doubly charged scalars

11:15 AM – 12:15 AM

Part 2: Qualification tasks talks

Tau lepton eVeto scale factors for Run 3

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Taus have a mass of 1.777 GeV and a proper decay length of 87 μm, hence decaying before reaching the detector. They are thus subject to reconstruction algorithms based on their decay products. We only consider the visible part of hadronic taus $\tau_{had-vis}$. Main background consists of jets from fragmenting quarks and gluons. Secondary background is from electrons and can mimic had-vis after jet-related cuts. This is why a dedicated algorithm exists to veto electrons faking tau leptons. The procedure is called eVeto and is based on the recurrent neural network (RNN) classifier. The main goal of this qualification project is to measure the performance and determine scale factors of the eVeto for Run 3. The scale factor is simply the ratio, $SF = \frac{\varepsilon_{data}}{\varepsilon_{MC}}$, where we consider efficiencies for data and MCThe measurement is setup with the available Run 3 data and MC, while the scale factor calculation uses full systematic treatment. This lightning talk will briefly introduce Tau CP group activities, the eVeto algorithm and the measurement and scale factor calculation procedure. In the later part of the talk, the current status of the project will be presented, and the results from likelihood fits will be presented and discussed.

Keywords: eVeto, Scale factor

Towards a Kalman Filter-based alignment solver for ATLAS

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In high energy physics (HEP), accurately reconstructing charged particle trajectories is a challenging task. The classical Kalman filter estimates track parameters with uncertainties through prediction, filter, and smoother steps. Precisely aligning detector components increases sensitivity to new physics and improves particle identification efficiency. The ATLAS alignment solver requires input information from the Kalman Filter. This project aims to implement a Kalman Filter-based alignment strategy for the larger structures that will group individual sensors in the ATLAS tracking framework to align the Inner Track- ing Detector (ITk). The current focus of the sensor alignment project involves addressing individual sensor misalignment through a correlated approach. Additionally, efforts are underway to align superstructures based on specific criteria and mutually exclusive group membership assumptions. The crucial steps in- clude conducting code reviews for both misalignment and superstructures align- ment subtasks, implementing selective misalignment, and studying the mech- anism's impact on ITk geometry within ACTS, all aimed at enhancing data accuracy.

Keywords: Alignment, Kalman Filter

Luminosity determination for the measurement of the total proton-proton cross section and the -parameter with the ATLAS experiment at the LHC

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ATLAS has measured the total cross section during the LHC Run-1 at $\sqrt{s} = 7$ and 8 TeV and in Run-2 at $\sqrt{s} = 13$ TeV using a luminosity dependent approach which exploits the relation ensured by the Optical Theorem between σ_{tot} and the imaginary part of the scattering amplitude in the forward direction. To reach values of the Mandelstam variable $-t$ down to 2.5×10^{-4} GeV^2 needed to probe the Coulomb-Nuclear interference region of the elastic cross section, a small LHC-beam divergence is needed, which is obtained with special high-β^* optics. During Run-2 $\beta^* = 90$ m and 2.5 km were used, resulting in very different beam-spot sizes and in an instantaneous luminosity up to 7 orders of magnitude lower than in standard data taking conditions and 3 orders of magnitude lower than the van der Meer runs used for the absolute calibration of the luminosity detectors. These conditions represent a challenge for the luminosity measurement, and the systematic uncertainty in the luminosity determination represents one of the dominant components of the overall uncertainty on σ_{tot} and the ρ-parameter, defined as the ratio of the real to the imaginary part of the elastic-scattering amplitude in the limit of the Mandelstam variable $t \to 0$.

Thanks to the excellent performance and sensitivity of the main ATLAS luminometer, LUCID, and of the ancillary measurement based on track-counting algorithms used to estimate the systematic uncertainty, a precision on the luminosity determination of 1.0% (2.15%) was obtained in the measurement at $\beta^* = 90$ m (2.5 km) acquired in 2018 (2016) at $\sqrt{s} = 13$ TeV.

In this talk, a description of the luminosity measurement in the Run-2 data takings at high-β^* aimed to measure σ_{tot} and ρ is given, with emphasis on the ATLAS approach, based on the redundancy of the luminosity information provided by different detectors and methods with different sensitivity to the LHC optic conditions, backgrounds, and systematic effects.

Keywords: Luminosity measurement, Optical theorem

High Granularity Timing Detector - HGTD

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Starting with Run 4 after the HL-LHC upgrade, the High Granularity Timing Detector (HGTD) will augment the new ITk tracking system of ATLAS by providing accurate $O(10\,ps)$ timing information of charged particle hits, with the primary purpose of providing a time for reconstructed tracks and vertices. My qualification task is focused on the vertex time reconstruction algorithm, specifically updating it, studying its performance, coming up with potential improvements, and updating the Athena tool providing this functionality. Afterwards, the focus will be on investigating potential alternative, superior algorithms for reconstructing the times of vertices in the scope of utilizing 4D tracking. Here I will provide an overview of the goals of my qualification task, the work plan, followed by a short report on the current status.

Keywords: High granularity timing detector,Vertex time reconstruction algorithm

Day 1 — Monday, 25th of September, 2023

13:15 PM – 15:00 PM

Part 3: Statistics and Machine learning

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We will review different approaches where Machine Learning (ML) can enhance proposed analyses and discuss the underlying ML theory. In particular, we shall explore the use of Machine learning for:

- Signal selection (e.g., Neural Networks (NN), Recurrent Neural Networks (RNN), Graph Neural Networks (GNN)).
- Anomaly detection for (semi-)model-independent searches (e.g., Variational Autoencoders (VAE)).
- Background modeling: generative models to improve statistics and strategies for enhancing fake particle determination.

Keywords: Signal selection, Graph Neural Networks (GNN)

Day 2 — Tuesday, 26th of September, 2023

09:00 AM – 13:00 PM

Part 1: TNAnalysis

Comprehensive Overview and Practical Tutorial with TNAnalysis

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This talk provides a comprehensive overview of the process that leads from derivations to histograms. It places a particular emphasis on the histogram- ming component within the code (TNAnalysis), offering insight into its diverse functionalities and fundamental configuration options. The second part of the session includes a practical, hands-on tutorial for attendees.

Keywords: Histogram generation, Analysis regions definition

11:30 AM – 13:00 PM

Part 2: TBA

Hands-on exercises within TNAnalysis framework

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During the hands-on session, scheduled following the introduction of the framework we will use for the final analysis, our focus will be on preparing a simple analysis, following these steps:

Keywords: TNAnalysis, Analysis regions

1. Installation and configuration of TNAnalysis environmental variables (5 minutes).
2. Preparation of Python files to define three analysis regions, one for each type - Control, Validation, and Signal Regions (15 minutes). If we have enough time, we will also explore the machine learning approach.
3. Familiarization with the framework's most important commands and running the analysis using only nominal ntuples (i.e., without systematics, for the purpose of expediting the process, 15 minutes).
4. Examination of generated plots, understanding them, and searching for possible additional cuts (5 minutes).
5. Implementation of new cuts and re-running the analysis (5 minutes).
6. Preparation of the fitting framework (15 minutes).
7. Running the fit with the Asimov dataset, after this we will use real data to perform the background-only and signal-plus-background fits (20 minutes).
8. Generating the final analysis plots (10 minutes).

14:00 PM – 16:00 PM

Part 3: Future aspects of the analysis

Review of recent developments in theory

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In the second talk we will focus on the phenomenology of neutrino mass models, with a focus on collider searches. We will review the status of current searches in vanilla type I, emphasizing the role of lepton number violation and complementary constraints from low energy experiments. Then we move on type II phenomenology, discuss the production and corrections, decay modes and final states. We will finish with a discussion of LRSM scalars and its mass scales, talk about Majorana Higgses and outlook on future colliders.

Keywords: Neutrino mass models, Lepton number violation