Anuj Raghav

$H \to WW$ NanoAOD Analysis Framework: A Guide to LHC Data Analysis

Anuj Raghav
August 2025

Mentors: David Lange (Princeton University), Peter Elmer (CERN), Arun Kumar (University of Delhi)

Abstract

This project will demonstrate the workflow of a Higgs boson to WW ($H \to WW$) analysis at the LHC, focusing on providing beginners and early-career researchers with a clear, step-by-step guide to collider data analysis fundamentals. Using NanoAOD datasets, the project emphasizes realistic and reproducible methods with widely used tools such as ROOT and Python.

The importance of the $H \to WW$ decay channel lies in its role for probing the Higgs boson's properties and testing the Standard Model. Participants will acquire hands-on experience navigating experimental data with industry-standard software. The final product will be a publicly accessible, well-documented GitHub repository serving both as a functional analysis workflow and a comprehensive learning tool.

Project Description

Accurate measurements of the Higgs boson's decays, particularly to W bosons, provide critical tests for the Standard Model. NanoAOD data format facilitates approachable yet authentic analyses by simplifying data structure while retaining rich physics content, enabling new learners to engage with realistic LHC data analyses.

Objectives

- Develop and document a clear, reproducible $H \to WW$ analysis workflow using NanoAOD data.
- Produce instructive, well-commented code illustrating key analysis phases: event selection, object identification, background estimation, and result plotting.
- Provide foundational educational materials linking technical steps with underlying physics concepts.

Expected Outcomes

- **Analysis Code:** Complete scripts that perform $H \to WW$ candidate event selection and processing.
- **GitHub Repository:** A structured and documented codebase providing example workflows and setup instructions.
- **Analysis Documentation:** Concise yet thorough explanation of the methodology and example outputs.
- **Workflow Synopsis:** A clear outline of analysis stages for guided self-study or teaching.

Professional Background

I hold a master's degree in Physics from the University of Delhi, with a specialization in Nuclear Physics and Experimental High Energy Physics. During my academic tenure, I worked on the analysis of Drell-Yan process data using the CERN-ROOT framework, developing an approach to effectively isolate the signal from background processes.

I am committed to contributing meaningfully and can dedicate up to 20–30 hours per week as needed.

Work Plan

3-Month Project Flow

- **Month 1:** Software installation, dataset acquisition, introductory material review.
- **Month 2:** Building analysis scripts, implementing event and object selection, background studies.
- **Month 3:** Finalizing analysis, creating plots, thorough documentation, sharing repository.

Risk Mitigation

- **Data Access:** Use locally downloaded NanoAOD files; provide clear instructions for data acquisition and organization.
- **Computing Environment:** Manual setup with installation guides and a requirements file for environment replication.
- **Learning Curve:** Modular, well-documented code and practical instructions to support beginners.

Conclusion

This project provides a meaningful bridge between introductory physics education and cutting-edge particle physics analysis. Its thoroughly documented, reproducible approach to the $H \to WW$ analysis channel using NanoAOD data will form an enduring educational resource for the HSF-INDIA community and the wider particle physics research domain.