Contribution ID: **112** Type: **Poster**

# Segregating prompt and non-prompt production of charm hadrons in proton-proton collisions at the Large Hadron Collider using machine learning

The studies of heavy flavor (charm or bottom) hadrons in relativistic collisions provide an undisputed testing ground for the theory of strong interactions, quantum chromodynamics (QCD). As the majority of the heavy flavor particles are produced in the initial stages of the heavy-ion collisions, they experience the whole QCD medium evolution. The lightest open charm meson, $D^0$, and hidden charm vector meson, J/$\psi$, are particularly useful as they are abundantly produced as compared to other open and hidden charm hadrons, respectively. The $D^0$ and J/$\psi$ mesons that are either directly formed during initial scattering or as the decay products of higher charm stages are referred to as the prompt production, which is essential to probe the QCD medium. On the other hand, the non-prompt $D^0$ and J/$\psi$ mesons are usually formed as the decay products of beauty hadrons and can provide a key understanding of beauty hadrons.

In this contribution, we use machine learning (ML) models to segregate the prompt and non-prompt productions of $D^0$ and J/$\psi$ mesons in proton-proton (pp) collisions at $\sqrt{s} = 13$ TeV using the track-level information of the particles like an experimental environment. We have used the PYTHIA8 event generator to simulate the events for the study, which provides a good qualitative description of experimental measurements. We have considered the $D^0 \to \pi^+ K^-$ and J/$\psi \to \mu^+\mu^-$ decay channels for our study. To separate prompt from non-prompt sector of charmonia and open charm mesons, topological production of $D^0$ and J/$\psi$ are considered. We have used XGBoost, CatBoost, and Random Forest models for $D^0$ related studies, whereas for J/$\psi$, we have used XGBoost and LighGBM models. For $D^0$, we have used invariant mass ($m_{\pi K}$ ), pseudoproper time ($t_z$ ), pseudoproper decay length ($c_\tau$ ), and distance of closest approach ($\mathrm{DCA}_{\mathrm{D}_0}$ ) as the training inputs. For J/$\psi$ meson, the input sample is chosen keeping ALICE Run 3 muon forward tracker upgrade in mind, which includes, invariant mass ($m_{\mu\mu}$ ), transverse momentum, pseudorapidity, and $c_\tau$. The machine learning models provide up to 99\% accuracy to dissect the prompt and non-prompt production of both $D^0$ and J/$\psi$. Transverse momentum, rapidity and multiplicity differential comparisons between the true and predicted values are compared to evaluate the performance of the models. Experimental comparisons are also made wherever applicable. The ML methods used in the present study can replace the traditionally used fitting method with the added advantage of track label identification. The present ML-based identification of prompt and non-prompt charm hadrons can be useful in experiments that require precise measurements.

## Category

Theory

## Collaboration (if applicable)

**Authors:** SAHOO, Raghunath (Indian Institute of Technology Indore (IN)); GOSWAMI, Kangkan (Indian Institute of Technology Indore); Mr PRASAD, Suraj (Indian Institute of Technology Indore (IN)); MALLICK, Neelkamal

(University of Jyväskylä); MOHANTY, Gagan (Tata Inst. of Fundamental Research (IN))

**Presenter:** SAHOO, Raghunath (Indian Institute of Technology Indore (IN))

**Session Classification:** Poster session 2

**Track Classification:** Heavy flavor & quarkonia