Third semester report

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Thesis title:

Precision electroweak measurements with the CMS detector at the LHC

Introduction: WW production from double-parton interactions

Hard-scale double parton interactions where two partons interact in the same proton-proton collision are becoming more and more accessible at the LHC with the increase in center of mass energy to 13 TeV and the excellent performance of the machine providing larger datasets.

Under the assumption of the factorization of the double parton density function, the cross section of a double parton scattering (DPS) process can be written as

$$\sigma_{AB}^{\mathrm{DPS}} = \frac{n}{2}\frac{\sigma_{\mathrm{A}}\sigma_{\mathrm{B}}}{\sigma_{\mathrm{eff}}}$$

where, A and B denote the single parton scattering (SPS) processes, and σ_{A} and σ_{B} their respective SPS cross sections. The factor n is unity if processes A and B are the same, and $n = 2$ if $A \neq B$. The parameter σ_{eff} is related to the extent of the parton distribution in the plane orthogonal to the direction of motion of the protons.

I joined the measurement of the process in which two W bosons of the same-charge are produced via double parton interactions based on the CMS full Run 2 dataset. This process provides interesting experimental features if the W bosons decays leptonically, by reducing standard model (SM) backgrounds. While there is evidence for the presence of this production mode, it has yet to be confirmed at 5σ. The measurement of its cross section can provide valuable input to Monte Carlo (MC) generators on whether the model for multi parton interactions is correct. Furthermore, this process constitutes a SM background for searches for new physics such as electroweak (EWK) searches for supersymmetry (SUSY), and therefore a measurement can provide increased confidence in background estimations in these searches.

Description of research work carried out in current semester

In this work I reproduced the 2016 and 2017 events count, that was made in the analysis note CMS AN-18-065, as a starting point toward reaching the 5σ discovery limit with the full run 2 dataset, i.e., including the 2018 dataset.

Here I compared different generator samples in signal (only $\mu^{\pm}\mu^{\pm}$) for the kinematic variables: p_{T} of the leading and the subleading leptons, $|\eta_1 + \eta_2|$, $\eta_1 \cdot \eta_2$, $\Delta\phi(l_1, l_2)$, $\left|\Delta\phi(l_1, E_T^{\mathrm{miss}})\right|$, $\Delta\phi(ll, l_2)$, E_T^{miss}, $m_{\mathrm{T}}(l_1, l_2)$, M_{T2}^{ll}, $m_{\mathrm{T}}(l_1, E_T^{\mathrm{miss}})$. The events with same-sign leptons, $\mu^{\pm}\mu^{\pm}$ or $e^{\pm}\mu^{\pm}$, are analyzed with a moderate requirement on the missing transverse momentum, and a veto on jets stemming from b-quarks as well as low number of jets. The same-sign requirement reduces the background contribution to a minimum and the kinematic differences between the WW DPS process and the remaining background can be exploited to optimize the signal-to-background ratio.

In the next semester I will apply the analysis on the new data reprocessed with improved calibration as well as try new analysis methods to reach the 5σ discovery limit by also including the full run 2 dataset.

As the CMS collaboration requires all of its members to contribute to common experimental tasks, I am responsible for physics validation of new software releases on behalf of the Standard Model Physics Analysis Group.

Studies in current semester

I followed 2 courses this semester:

- Quantum Chromodynamics (6 credits)
- Weak Interactions (6 Credits)

Attendance on seminars, meetings, workshops and schools

- Weekly ELTE CMS meetings.
- CMS Virtual Data Analysis School, September 23 – 30 2020.