First semester report

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Thesis title:
Precision electroweak measurements with the CMS detector at the LHC

Introduction

Direct searches for new phenomena are optimized for specific models featuring New Physics, such as the appearance of new heavy particles. They are thus very efficient in looking for known unknowns. On the other hand, precision measurements looking for small deviations in experimental observables due to the presence of some New Physics at a higher energy scale are more general and potentially are able to catch the unexpected. In particular, measurements of di-electroweak-vector-boson production can provide information on anomalous gauge couplings due to New Physics and thus point to certain extensions of the SM. Differential di-boson cross-section measurements – even in the absence of an evidence for New Physics – will contribute to our understanding of the SM gauge interactions and of electroweak symmetry breaking, challenging the SM precision theoretical calculations.

Studying di-boson final states either to search for the presence of new resonances or in the absence of them for enhanced production in the high-energy tail providing a measure of anomalous gauge boson couplings can thus provide information on the so far hidden New Physics. The LHC will provide unprecedented statistics for these studies and thus act as an electroweak-scale microscope to study gauge boson self-interactions.

Differential cross-section measurements are valuable irrespective whether New Physics is found at LHC or not. For example, the study of the distributions of additional jets in di-boson events offers a stringent test of the higher-order perturbative calculations within the Standard Model.

Description of research work carried out in current semester

During the 1st year I need to fulfill the CMS Collaboration's requirements to become a full member (an author). This requires significant contribution to a central technical task of the experiment.

In preparation for physics analysis and the fulfilment of my experimental physics responsibility I had the following tasks this semester:

- Study particle physics (the Standard Model and its possible extensions).
- Learn C++, python and the CERN ROOT analysis framework.

Studies in current semester

I followed 4 courses this semester:

- Particle Physics (4 credits) by Dr.Giordano Matteo
  - Elementary particles and their interactions. Parity and CP violation in weak interactions. Isospin symmetry in strong interactions. Quark model and SU(3) symmetry. Scattering cross-section and S-matrix. Basics of QFT. Feynman diagrams and scattering matrix element.
- Group Theory (2 credits) by Prof. Peter Bantay
  - Groups and Symmetries. Structure Theory. Lie Groups. Representation Theory.
- Complex Detector Systems in Particle and Nuclear Physics (6 Credits) by Prof. Gabriella Pásztor and Prof. Gábor Veres
  - Interaction of radiation with matter. Tracking detectors. Calorimetry. Particle identification. Detector readout and trigger system. Data processing. Neutrino detectors. Particle accelerators.
- Experimental Methods in Particle Physics II (6 Credits) by Prof. Gabriella Pásztor and Prof. Gábor Veres
  - Tracking. Muon Reconstruction. B-tagging. Tau reconstruction. Jet reconstruction, particle flow, jet substructures, top tagging, missing transverse energy reconstruction. Background estimation, in-situ corrections. Cross-section measurements, unfolding, limits on New Physics. Luminosity Measurements.

Attendance on regular seminars, meetings

ELTE Ortvay seminars, ELTE Particle Physics seminars, Hungarian CMS Group seminars, ELTE CMS meetings.