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Teilchenphysik 2 — W/Z/Higgs an Collidern

Sommersemester 2019

Exercises No. 5

Discussion on July 2, 2019

Please read the paper:

Precise Measurement of the W-Boson Mass with the CDF II Detector,
Phys. Rev. Lett. 108, 151803 (2012)

NB: Access to PRL is only free within the KIT-network. An alternative perprint-version of the paper is available http://arxiv.org/abs/1203.0275.

Please prepare answers to the following questions:

a) What does "CDF" stand for? Why is the accelerator called "Tevatron", where is it located, and how is it different from LEP and the LHC?

b) Which decay channels are used for the measurement of the W-boson mass? Which other decay channels exist and why are they not used in this measurement?

c) How can you explain the different size of the datasets? Why does this publication from 2012 only use data taken in the years 2002 to 2007?

d) How is the W-boson mass used to predict the Higgs-boson mass? Discuss the predicted value for m_{H}.

e) What is meant by "initial-state QCD radiation"? What experimental effects does it have in the detector?

f) How are muons reconstructed and selected from individual detector signals? Which sub-detectors are important?

g) How are electrons reconstructed and selected from individual detector signals? Which sub-detectors are important?

h) What is the pseudorapidity η? Why are only electrons with $|\eta| < 1.0$ selected?

i) How is the background from Z-bosons suppressed?

j) What is the "transverse mass"? How do you interpret equation (1)?

k) How the experimental variables m_T, p_T^{ll}, and p_T^{ν} used to extract the W-boson mass? How are Monte-Carlo simulations involved?

l) What are "PDFs" and why are the needed?

m) A detailed understanding of the muon energy is necessary to measure the W-boson mass. How is the muon energy calibrated and how is the calibration verified?

n) Which effects complicate the electron energy calibration compared to the muon energy calibration.

o) Table 1 summarises the fit results for the sensitive variables. Which variable allows for the most precise measurement? What is the difference between the statistical and systematic uncertainty?

p) What is the largest systematic uncertainty in the measurement of the W-boson mass?

q) What are the important backgrounds that need to be taken into account in the measurement?

r) How is the final value of the W-boson mass extracted? Compare it to the previously available value.

s) Explain Figure 4 (only in the PRL version).