Lecture Notes in Physics

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The Lecture Notes in Physics

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Statistical Methods for Data Analysis in Particle Physics

Second Edition

Springer

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Preface

This book started as a collection of material from a course of lectures on Statistical Methods for Data Analysis I gave to Ph.D. students in physics at the University of Naples Federico II from 2009 to 2017 and was subsequently enriched with material from other seminars and lectures I have been invited to give in the last years.

The aim of the book is to present and elaborate the main concepts and tools that physicists use to analyze experimental data.

An introduction to probability theory and basic statistics is provided mainly as refresher lectures to students who did not take a formal course on statistics before starting their Ph.D. This also gives the opportunity to introduce Bayesian approach to probability, which is a new topic to many students.

More advanced topics follow, up to recent developments in statistical methods used for particle physics, in particular for data analyses at the Large Hadron Collider.

Many of the covered tools and methods have applications in high-energy physics, but their scope could well be extended to other fields.

A shorter version of the course was presented at CERN in November 2009 as lectures on Statistical Methods in LHC Data Analysis for the ATLAS and CMS experiments. The chapter that discusses discoveries and upper limits was improved after the lectures on the subject I gave in Autrans, France, at the IN2P3 School of Statistics in May 2012. I was also invited to conduct a seminar about Statistical Methods at Gent University, Belgium, in October 2014, which gave me the opportunity to review some of my material and add new examples.

Note to the Second Edition

The second edition of this book reflects the work I did in preparation of the lectures that I was invited to give during the CERN-JINR European School of High-Energy Physics (15–28 June 2016, Skeikampen, Norway). On that occasion, I reviewed, expanded, and reordered my material.

In addition, with respect to the first edition, I added a chapter about unfolding, an extended discussion about the best linear unbiased estimator, and an introduction to machine learning algorithms, in particular artificial neural networks, with hints about deep learning, and boosted decision trees.

Acknowledgments

I am grateful to Louis Lyons who carefully and patiently read the first edition of my book and provided useful comments and suggestions. I would like to thank Eliam Gross for providing useful examples and for reviewing the sections about the look elsewhere effect. I also received useful comments from Vitaliano Ciulli and from Luis Isaac Ramos Garcia.

I considered all feedback I received in the preparation of this second edition.

Napoli, Italy Luca Lista

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