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Five lectures on QCD and SM at Colliders

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Abstract: This is a set of five lectures for first years graduate students. It is intended for both theorists and experimentalists. The emphasis of the presentation is on understanding the relationship between the many concepts appearing in collider physics. To make the discussion more transparent we have tried to avoid the technical aspects of the various theoretical derivations. These would be of interest to a smaller audience and should, ideally, be covered in a dedicated lecture course.

Contents

1 Introduction to SM. Where are the bound states?

2 Physics at e^+e^- colliders

2.1 Parton-hadron duality

2.2 Calculation of inclusive cross-sections: $e^+e^- \to hadrons$

2.3 First differential calculation; encountering many difficulties

- IR singularities
- Modelling of hadrons (as opposed to partons)

3 IR singularities

4 Factorisation

The most important thing one needs to know!

5 Modelling of hadrons: fragmentation

6 Modelling of hadrons: jets

7 Physics at hadron colliders

How do we go from e^+e^- to hadron colliders? Just invert the diagram (and a bit more).

7.1 Parton distributions of the proton

7.2 Kinematical variables

7.3 Major hadron collider processes

8 Resummation

Factorisation = Evolution = Resummation

9 Parton showers

10 B-physics

11 Practicalities

11.1 Scales and scale settings

11.2 Decays of unstable particles: Narrow width approximation

11.3 HEP computational software

12 Recap: what did we learn?

- Approximations, approximations, approximations

- Do not be afraid of approximations
- Working approximately is not a sign of weakness or inferiority; it is a grand mastery!
- We use many schemes, approximations and modelling at intermediate stages. Nonetheless everything we do is fully consistent and observables are eventually scheme- and modelling-independent.

References