Particle Physics Phenomenology Spring 2026

Final topics for oral exam

The topics classified as difficult marked by a (*)

Topics related to the Relativistic kinematics (chapter 1):

1. Basic kinematics concepts: Lorentz transformations, radipity & pseudorapidity, phase space, luminosity, cross-section & decay width.
2. Two-particle scattering: invariants, phase space integral, relation to three particle decays & multi-particle interactions.
3. Deep inelastic scattering: definition, kinematics, proton content, parton distribution functions and their evolution & determination.

Topics related to the Standard Model (chapters 2 & 3):

4. Standard Model: family structure and gauge group.
5. QCD: definition, colours of quarks, hadrons and their mass, running of α_s, confinement and asymptotic freedom.
6. Lagrange formalism, gauge invariance, interactions in gauge theories.
7. Electroweak unification: definition, couplings of neutral and charged currents, gauge self-interactions.
8. Spontaneous symmetry breaking, the Higgs mechanism, the Higgs boson.
9. Electroweak tests: LEP, electroweak radiative corrections, Z precision measurements, global electroweak fits. (*)

Topics related to Beyond Standard Model models (chapter 4):

10. Dark matter: definition, evidence, possible candidates (WIMPs & Axions)
11. Energy scales & couplings: Energy dependence of amplitudes, physical meaning, hierarchy problem, Higgs field stability. (*)
12. Grand unification: definition, manifestation, and implications.
13. Supersymmetry: definition, motivation, manifestation, parameters, particle spectrum, SUSY breaking, R-parity, Higgs sector, SUSY searches. (*)
14. Extra dimensional models: definition, G_N, models with large extra dimensions and with non-factorizable geometry, manifestations. (*)

Topics related to Hadron collider phenomenology (chapter 5):

15. Hadron-hadron interaction: inelastic low p_T interactions and diffraction, optical theorem, and total cross-section (chapter 1), pileup.
16. Hadron-hadron interaction: hard (high p_T) interactions: definition & modeling, parton fragmentation functions, triggering.
17. Top quark physics at LHC: uniqueness of top, production at LHC & decay, mass measurement & definition, quantum entanglement & toponium (*)
18. Higgs physics at LHC: production at LHC and decay, Higgs discovery, measurement of couplings, width and self-coupling, HL-LHC prospects. (*)