Particle Physics Phenomenology Spring 2024

Topics for oral exam Fri 10.5.2024, Thu 16.5.2024 and Fri 17.5.2024 at 10-14

The topics classified as difficult marked by a (*)

Topics related to the Relativistic kinematics (chapter 1):

- 1. Basic kinematics concepts: Lorentz transformations, 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. Higgs boson: production and decay at LHC, Higgs discovery at LHC, measurement of Higgs couplings and self-coupling, Higgs width. (*)