**PhD Physics course at Bari University (XXXII Cycle)**

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| **Title** | Course on Physics at the Large Hadron Collider |
| **Proponent** | Michele Gallinaro, Nicola de Filippis |
| **# CFU**  **(1 CFU = 8 hours)** | 2 CFU |
| **Schedule** | 5 days: 8 hours of theory (morning)+ 4 hours of exercises (afternoon) |
| **Brief Summary of the course** | This is intended to be a specialized course on the Physics at the Large Hadron Collider (LHC) at Cern, and its experimental research program. The course is intended for graduate students with basic training in Particle Physics. The objective of the course is to introduce the physics concepts and goals, analysis methods, and discuss the results obtained and present the challenges of the different areas of research covered by the LHC experiments. Emphasis is placed on the search for new physics. Benchmark channels in proton-proton collisions are discussed in detail, covering the identification of the objects involved, the signal and background properties, the background estimation and the signal-to-background discriminants, the evaluation of systematical errors, and the extraction and interpretation of the results.  Lectures are based on a duration of 90 minutes, divided into two parts of 45 minutes each. Aproximately 10-15 minutes are added for the discussion with the students. |
| **Programme** | - Experimental program at the LHC  The LHC physics case. The LHC experimental program. The LHC machine. The experiments. Experimental challenges: Cross-sections, rates. Trigger. Pile-up. Radiation. QCD and parton densities. Monte Carlo generators. Luminosity and cross-section measurements. QCD and jet physics. Jet algorithms. Jet energy scale. Jet cross-section measurements. W and Z bosons as standard candles at the LHC.   - Detectors and particle identification  Particles and their decays into stable particles. Detector layout and geometry. Calorimetry. Electromagnetic and hadronic showers. Vertex and tracking detectors. Track reconstruction, momentum measurement. Muon detectors. Trigger: Level~1 and High Level Trigger.   - Top quark physics and beyond  Early searches and discovery. Comparison of the studies at the Tevatron and at the LHC. Objects used in top quark events. Top quark production. Properties: mass, spin correlation, etc. Decays: branching ratios, taus, heavy flavor content of top quark pair events, Vtb. Top quark studies in the search for New Physics. New particles decaying to top quarks. BSM top decays. Top-like signatures. Boosted top.   - Higgs boson physics and BSM  The Higgs mechanism. Production and decay of the Higgs boson. Models, properties, and interpretation (couplings, width, etc). Summary of results from the discovery in the different channels. Search for new physics in the Higgs sector. Extensions of the SM, minimal and non-minimal extensions. High mass searches. MSSM Higgs searches: neutral, charged. Light pseudoscalar, resonant and non-resonant Higgs pair production. Short reminder of SUSY and Exotica searches. |
| **Recommended texts** | - F. Halzen and A.D.Martin, ' Quarks and Leptons ', John Wiley and Sons (1984)  - D. Perkins, `Introduction to High Energy Physics', Cambridge University Press (2000) |
| **Assessment methods** | A Lecture/Seminar on a specific topic (to be identified on a case-by-case with the student). |