Subjects of the lectures 2019-20

23-9-2019 **2 h** – Introduction to the course. Passage of charged particle through the matter. Cross sections. Energy loss for ionization. Bethe and Bloch formula. Density effect and shell correction.

27-9-2019 **2h** – Bragg's curve, range. Landau distribution. Multiple coulombian scattering. Bremsstrahlung, energy loss for electrons and positrons, critical energy. Radiation length. Pair production- Photoelectric effect. Compton scattering.

30-9-2019 **2h** - Electromagnetic showers. Bremsstrahlung and pair production at very high energy. Energy loss for high energy muons. / Gaseous detectors, general considerations. Primary and secondary ionization.

4-10-2019 **2h** - Gaseous detectors. Diffusion of ions and electrons, drift velocity. Proportional counter, Amplification, signal from a proportional counter. Signal in the gaseous detector with a wire.

7-10-2019 **2h** - Ageing. MWPC. Drift chamber. Resolution, space-time relation, ionization measurement, Lorentz angle.

9-10-2019 **2h** – Ionization measurements. Examples: CD in CERN-UA1 experiment. TPC. MPGD: MSGC, GEM, micromegas. RPC.

11-10-2019 **2h** – Photon detection. Photomultiplier. Solid state photon detector. Scintillators.

14-10-2019 **2 h** – Cherenkov counters. Threshold and differential counters. RICH detectors. Examples of RICH in present experiments. Example: Cherenkov and scintillation light in a BGO crystal.

16-10-2019 **2 h** – RICH detectors. Examples of RICH in present experiments. Example: Cherenkov and scintillation light in a BGO crystal. / Electromagnetic calorimeters. Dimensions. Resolution.

18-10-2019 **2 h** – Position detectors. Example of an electromagnetic calorimeter. Hadronic showers. Energy components in the shower..

21-10-2019 **2 h** – Compensation in hadronic calorimeters. Energy resolution for calorimeters. Calibration. Homogeneous and sampling calorimeters.

23- 10-2019 **2 h** - Calorimeters with scintillating fibers. Readout of the signals. Examples of calorimeters. Dual readout calorimetry.

25-10-2019 **2 h** – Example: Cherenkov and scintillation light in a BGO crystal. / pn junction. Silicon detectors with microstrips and pixels. Vertex detectors and trackers. Examples (NA11, DELPHI, CDFII).

28-10-2019 **2 h** – PID detectors: ionization measurement, TOF detectors,

30-10-2019 **2 h** – TDR transition radiation detectors. Structure of the experiments at colliders and at fixed target. Spectrometers.

4-11-2019 **2 h** - Sources of particles. Van de Graaf and Cockcroft-Walton accelerators. Cyclotron, betatron.

8-11-2019 **2 h** – Motion of a particle in the electromagnetic field. Betatron oscillations. Phase stability. Acceleration

11-11-2019 **2 h** – Synchrotron oscillations. Alternating gradient focusing. Motion in the phase space.

15-11-2019 **2 h** – Betatron oscillations in phase space. Transport matrices, quadrupole. Matrix for FODO cell, Hill's equation / Synchrotron radiation. Linacs. CERN SPS.

18-11-2019 **2 h** –Collider. Luminosity, p-pbar colliders, stochastic cooling.

22-11-2019 **2 h** – ATLAS.

25-11-2019 **2 h** – LHC.

29-11-2019 **2 h** – Future accelerators: LHC program, Linear colliders ILC, CLIC. Futur circular colliders, muon collider.

2-12-2019 **2 h** – CMS. - Exercise: example of the setup for an antiproton beam preparation (only first part).

3-12-2019 Visit to the Virgo Experiment in Cascina (Pisa)

6-12-2019 **2 h** – Neutrino detectors, neutrino oscillations.

18-12-2019 **2h** - New acceleration techniques. (prof. M.Ferrario)

20-12-2019 **2 h –** Neutrino Experiments – Future experiments.

8-01-2020 **2 h** – Neutron detection. CNAO and detectors for health physics.

10-01-2020 **2h** –Elastic and total cross sections at hadron colliders. TOTEM experiment. Last part of the exercise.

13-01-2020 Visit to the Laboratori Nazionali di Frascati dell'INFN.
(Lectures by Professors C.Milardi, E. De Lucia, A.Cianchi, R.Pompili)

15-01-2020 **2 h** – Detectors for rare events @ Gran Sasso. (prof. F.Bellini)