Essential Course Information	
Course title	Collider Particle Physics
Degree Course title	PHYSICS
ECTS	6
Compulsory attendance	YES
Course teaching language	ENGLISH

Teacher	Giuseppe	Bruno

ECTS Details	Disciplinary area	SSD	ECTS
	Characterizing	FIS/04	6

Time management and teaching activity type	Period	Year	Lesson type
	2nd semester	Ist	Lessons (32h) Laboratory (30h)

Time management	Total hours	In-class/in-lab study hours	Out-of-class study hours
	150	62	88

Course calendar	Starting date	Ending date
	March 2021	June 2021

Syllabus	
Prerequisites	**Element of particle physics, Particle Detector Physics, Element of Statistical Data analysis, basic knowledge of the C++ programming language**
Expected learning outcomes (according to Dublin Descriptors)	The course will provide an extended knowledge of the physics at the particle accelerators, with a focus on current and future particle colliders, and a broad view of the specific issues in projecting, realizing and conducting a modern particle physics experiment. ● *Knowledge and understanding:* Knowledge of the functionality, scope and interplay of different particle detectors within large experimental apparatus for specific measurements or broader physics programme at particle accelerator facilities. Basics of the accelerator physics. Approaches and tools for global event reconstruction, charged particle tracking and "vertexing", and particle identification. Scope and tools for Monte Carlo simulations of the experimental apparatus. Scope and case studies of event generators. Treatment, estimation and reduction of the statistical and systematic uncertainties in typical measurements at particle colliders. ● *Applying knowledge and understanding:*

	Apply the knowledge of the particle physics, detector physics, computing and data analysis to the broader contest of physics programme at particle accelerator facilities. Develop the skills to project and conduct a physics experiment at a particle collider. Numerical exercises, hands on simulation and reconstruction tools, and problem solving are fundamental aspects of this course. ● *Making judgments:* Ability to analyze the complex problem of projecting a large experimental apparatus on the basis of the physics scope it is intended for. Establishing the most appropriate solutions in complex systems like the large detectors at particle colliders. Acquiring the basic knowledge of *project management* and *risk assessment*, which are indispensable tools in this contest. ● *Transferable communication skills:* Ability to work in a group and to develop strategies for problem solving by comparing with colleagues and teacher. Capability of communicating scientific concepts in direct, complete and precise way. ● *Lifelong learning skills:* In general and in any context: capability of approaching complex problems in an open minded, critical and creative way. In the specific context of the research in particle physics: the course provides indispensable skills for gathering the knowledge in detector physics, particle physics and other basic ancillary competences (statistical methods, programming skills, etc…) thus forming a physicist with the competence for doing high-level research, who can compete in selection procedures for research jobs or for applying to research grants.
Course contents summary	
Detailed syllabus	Still to be refined, in particular the order of the different arguments (mostly based on an expansion of the previous course of "Experimental apparatus for nuclear and sub-nuclear physics") Functions of the different particle detectors within large experimental apparatus at accelerator facilities, and their relative interplay: ● micro-vertex detectors ● tracking systems ● systems for particle identification ● calorimeters ● muon detectors ● trigger systems ● multi-purpose detectors ● peculiarities at colliders: geometry, timing properties Fundamental parameters and figures of merit of the detectors within large experimental apparatus at particle colliders: ● material budget

	• acceptance • occupancy • spatial resolution for tracking detectors • momentum resolution for tracking detectors • energy resolution • timing properties Tools and methods for determining the above parameters and for projecting a large apparatus: • analytical derivations of the figure of merits with critical assessment of the used approximations • numerical approach based on Monte Carlo simulations, in laboratory sessions. • basic aspects and a few examples of "event generators" Basic concepts on the particle accelerators: sources and injectors, storage rings, accelerators. Basic properties of the delivered beams at the interaction points in collider mode and fixed target mode. General overview of the electronics, the data acquisition systems, the data storage, data skimming and the off-line reconstruction in large experiments at a collider. From raw data to physical objects: • clustering algorithms • track reconstruction: global fit methods and Kalman filter approaches • vertex reconstruction • an example of a physical object: the HF jets Treatment, estimation and reduction of the statistical and systematic uncertainties in typical measurements at particle colliders. The Barlow approach for the systematic uncertainties. Discoveries and observations. Critical discussion of the design specifications of a few large experiments at particle colliders (e.g. one or two of the LHC experiments) Critical discussion of recent proposals of detector upgrades or new experiments (e.g., LHC upgrades, Electron Ion Collider). How to project a new experiment: the students will be divided in groups (~3 students/group) and they will design their own apparatus (under the guidance of the teacher) on the basis of an assumed physics goal.
Books	*I want to update the list of few books that were used for the course* "apparati della fisica"
Notes	
Teaching methods	Classroom lessons supported by video projector and with the help of networked PCs. Hands-on sessions in laboratory for clusterisation, tack reconstruction, event reconstruction and data analysis (from "raw data" to "physical objects" and to a "figure of cross-section

	measurement" for a publication). Design of a detector using simulation tools in laboratory in groups of max. 3 students
Assessment of final mark	Oral examination and discussion of a laboratory relation.
Evaluation criteria	The student **Knows** the functions, properties and limitations of the different detectors within large apparatus at particle colliders and the interplay among the different parts of the apparatus; **Knows** the technique for event reconstruction and detector simulation **knows how** to design and simulate a detector to be used within a large apparatus to perform a specific physics measurement; **know how** to write a laboratory report; **know how** to present the results of a simulation study effectively in written and oral form;.
Other	