Proposition stage M2 & Thèse

Performance of a Tera-Scale Higgs-factory with an imaging calorimetry in tau decay channels.

Performance d'une usine à Higgs au TeV avec une calorimétrie ultra-granulaire dans les canaux tau.

The next particle accelerator in the Tera-Scale range is likely to be a lepton collider running at centre-of-mass energies from 250 GeV to 1 TeV (e.g. ILC, CLIC). Such a machine will bring unprecedented precision to the measurement of particle physics at the tera-scale, for example the properties of the Higgs-like boson newly found at LHC, top quark sector and (yet to be found) supersymmetric particles.

Studies are underway to develop detectors which will record the products of the particle collisions at such an accelerator. Recent advances in technology, particularly in the field of micro-electronics, allow significant advances in the construction of these detectors.

The CALICE/ILC group at LLR is developing ultra-granular («imaging») calorimeters to be used at future particle colliders. These will have a readout granularity several orders of magnitude finer than those of current-day detectors, allowing the optimal use of Particle Flow (PF) reconstruction techniques. PF promises to give significant improvements in the measurement of the results of particle collisions, in particular of hadronic final states.

The LLR group studies both the technical realisation of such calorimeters, including the design, construction and testing of prototype detectors and their associated data acquisition systems, and the PF reconstruction algorithms which can be used to best treat t he information recorded by the calorimeters.

A first generation electromagnetic calorimeter has been tested in particle beams over the last few years. A second generation prototype with 10 000 channels and including several important improvements in design, is presently under development. Their optimal design depends on the physics performances. One of the key channel to evaluate them is the decays of the Higgs in 2 tau's $H \rightarrow \tau\tau$, which should opens unique precision on the Higgs CP states.

Subject of training

The ECAL sensors are highly resistive silicon wafers; theirs edges have to be shielded by so-called guard ring which may affect the physical response to high energy electromagnetic showers. A precision study of the response will be done using an IR laser at LLR and a beam test conducted at the PHIL facility in Orsay. The student will participate to the set-up, measurement and analysis of the data.

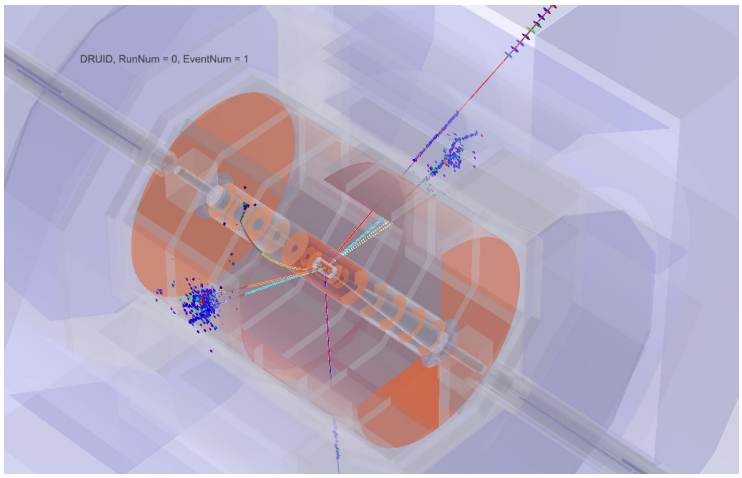
Subject of thesis

- Participation in and data analysis of test beam campaigns of 2nd generation ECAL prototype. First tests took place in 2012 and 2013; large-scale tests are foreseen in 2015 at CERN.
- Development of calorimeter reconstruction algorithms for Particle Flow. Dedicated pattern recognition algorithms are required to make the most of the very detailed information provided by the calorimeter detectors. These will be studied both in simulations of a complete detector, and in real data collected in test beams.
- Studies of the potential for physics measurements at a future collider. Numerous studies are possible, according to the affinity of the student. Reconstruction of Tau's with the help of improved pattern reconstruction techniques and evaluation of the performances for the Higgs coupling estimation and for the Higgs CP state.

Regular travel both inside and outside France will be required: CERN (Geneva) and/or DESY (Hamburg) for beam tests, as well as for regular meetings of the CALICE and ILC communities (typically in Japan, US, and Europe).

About the group

The ILC/CALICE group of LLR is a key player in the development of this novel type of calorimeters. Its scope of expertise ranges from broad detector design and optimisation, using parametric geometry for detailed simulation, data analysis and advance reconstruction algorithms, to detector prototype realisation implying all the technological challenging aspects of a strongly integrated calorimetry (silicon sensor design, mechanics, thermic, electronics and readout).
A dozen of physicist and research engineers are involved.



$ee \to Z \to ZH$; $Z \to \mu\mu$, $H \to \tau\tau$ in one of the ILD models.

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