DOSSIER DE CANDIDATURE LABEX P2IO
ANNEE 2013

POST DOCTORANTS

LABORATOIRE :

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IPNL (Lyon), University of Cambridge, KEK, DESY

PROJET SCIENTIFIQUE

Titre : *Intégration d'algorithmes avancés de Particle Flow et application sur prototypes*
Thèmes P2IO : P1) Les symétries dans le monde subatomique et/ou **R3)** Traitement de données
Durée demandée : 2 ans

RÉSUME DU PROJET SCIENTIFIQUE

Intégration d'algorithmes avancés de Particle Flow et application sur prototypes

Particle physics now stands at the beginning of a fascinating era. The recent discovery of a Higgs-like particle at the LHC opened the vast domain of the Tera Scale physics. To fully understand the nature of this new physics, a new machine will be required, optimally running coincidently with the LHC. This machine must allow the much higher precision measurements of these physics processes. The leading contender for such a machine is a linear electron positron collider, which will provide a clean, well controlled initial state of elementary particles, allowing for low-background clean final state of the particle collisions. The expected improvement covers almost all envisaged processes.
There are presently two well studied projects for such a machine: the International Linear Collider (ILC) and the Compact LInear Collider (CLIC), which are being designed to provide electron positron collisions in the TeV energy range. Such a Linear Collider (LC), if approved and funded, may be ready for physics studies in the 2020s. The Japanese HEP community has recently[1] bid the offer to host such a LC, with a staged approach (250 GeV then 500, with an option for 1 TeV).

The results of the particle collisions at such an accelerator will be recorded by a general purpose particle physics detector. Recent advances in technology (particularly miniaturisation) and algorithms will allow this detector to have significantly better performance than those installed at today's machines, allowing measurements to be made which are not possible with present detectors. A number of groups are studying the design and performance of such a detector. Attached to the ILC accelerator project, two groups (the International Large Detector (ILD) and the Silicon Detector (SiD)) are developing detector concepts. These both have a relatively classical detector layout, with a ultra-light vertex detector and tracking system, and electro-magnetic and hadronic calorimeters inside a strong magnetic field, allowing the measurement of the nature, energy and direction of particles created as a result of the initial particle collision. As an intermediate stage of project approval, the detectors proposed for the ILC are each required to publish by end of 2012 a Detector Baseline Document (DBD) outlining the proposed technologies to be used in the detector, and its expected performance.

The processes one can imagine occurring at a Linear Collider will often lead to final states consisting of hadrons (composite particles made of quarks). The measurement of these types of final states is notoriously difficult, since there are large fluctuations in the interactions of hadrons with the detector material, which are used to estimate their energy and nature. The particle flow (PF) technique[2] has been designed to minimise the effect of these fluctuations on the measurements of final states' energy by

1 In August 2012l the recommendations for the future of high-energy physics in Japan was released. See the Status of Asia-pacific region by prof. Masanori Yamauchi (KEK) (ESPP'12: Open Symposium for the European Strategy for Particle Physics) in September 2012 and the Japanese roadmap for the future of HEP by prof Toshinori Mori at the LCWS'12 : Workshop of Future Linear Colliders in October 2012.

combining information from tracking detectors with that from the calorimeters. This technique, successfully implemented by the CMS experiment, optimally requires new approaches to calorimeter design, with an emphasis on the reconstruction of interactions produced by single particles impinging on the calorimeters. This is different to present day approaches, where the deposited energy is generally integrated over a relatively large area which will usually have contributions from several particles. The PF approach therefore shifts the emphasis from raw energy resolution onto granularity.
Two «imaging calorimeter» (i.e. very high granularity) have been built in France and are the base of our studies: a Silicon-Tungsten ECAL and a gaseous Semi-Digital HCAL in which a channel response is coded on 2 bits only (⇔ 3 thresholds).

Several new ideas and tools have been developed and tested in the participating labs (DESY, KEK, Cambridge, LAL and LLR) during the recent years. The most advanced available tool, presently being used to assess the performance of the various design of the ILD, is PandoraPFA. It has recently been rewritten, to become a full fledge framework. But it hasn't yet been well adapted to the (semi-)digital HCAL.
The algorithms developed at LLR and pattern recognition techniques being developed at LAL, thanks to a previous P2IO Post-doctoral allowance, will have to be tested in the PandoraPFA framework first and the overall performances estimated on various benchmark physics channels. This will be the first task of the post-doc, to be pursued in collaboration with our colleagues from the ILC community (Cambridge, DESY & KEK). Depending on the performances reached, an uphold of the complete architecture might be envisaged.

The prototypes have been built and tested in the scope of the CALICE collaboration[3], in which an intensive R&D took place on miniaturised, low power electronics, thermal and mechanical integration and SW tools.
First a physical prototype of a silicon tungsten Electromagnetic CALorimeter (SiW ECAL) with 10×10 mm² cells was thoroughly tested[4]. Its large data sample is still providing input for advanced reconstruction algorithms and simulation tuning. A technological upgrade, integrating all the contingencies of a large detector such as the ILD (embedded readout-chips, power-pulsing, cooling, mechanical tolerances) featuring 5×5 mm² cells (6000 cells/cm³), is being built at LLR and LAL[5]. Provisional beam tests in 2012-2013 will allow to understand the response of the sensors and adjust the simulation.
A 1 m³ technological prototype of a Semi-Digital Hadronic CALorimeter (SDHCAL) was successfully tested at the SPS in May and August 2012; it features a 6 λI stainless-steel structure equipped with 50 layers of Glass Resistive Chamber (GRPC) finely segmented (1×1 cm²), readout by power-pulser embedded electronics. The first results are very encouraging[6], showing a good `raw' response (energy estimation by cell numeration), but its full potential resides in the application of PF algorithms.
Applying and tuning these algorithms on the ECAL and SDHCAL data and preparing a combined beam test (SiW ECAL + SDHCAL) will be the second part of the work of the post-doc.

JUSTIFICATION DES LABORATOIRES ASSOCIES ***(si applicable)***

L'ensemble des laboratoires cités est impliqué dans le travail préparatoire pour le collisionneur linéaire et dans le développement d'algorithmes de reconstruction.

Le prototype de Calorimètre électromagnétique Silicium Tungstène (Si-W ECAL) à très haute granularité est en cours de fabrication en collaboration très forte entre le LLR et le LAL (Roman POESCHL). Il sera testé en faisceau au DESY en 2012 & 2013 puis au CERN en 2014, seul et en combinaison avec le SDHCAL.

2 J.-C. Brient and H. Videau, "The calorimetry at the future e+ e- linear collider," in Proceedings of APS / DPF / DPB Summer Study on the Future of Particle Physics (Snowmass 2001), pp E3047. 2002. arXiv:hep-ex/0202004.
3 CALICE page: https://twiki.cern.ch/twiki/bin/view/CALICE/WebHome
4 See https://twiki.cern.ch/twiki/bin/view/CALICE/CalicePapers
5 CALICE Collaboration, R. Poschl, "A large scale prototype for a SiW electromagnetic calorimeter for a future linear collider," arXiv:1203.0249 [physics.ins-det].
6 talk on SDHCAL results at LCWS'12

Le laboratoire en charge du SDHCAL est l'IPNL (prof. Imad LAKTINEH).

Un effort de valorisation des efforts français de ces dernières années sur le Particle Flow est en timidement en train de se concrétiser ; notamment autour de l'inclusion d'algorithmes de pattern recognition (Balázs KÉGL, LAL), d'analyse d'interaction (Roman PEOSCHL, LAL), et de reconstruction de gerbes hadronique (Vincent BOUDRY, LLR). Cela débutera dans le framework de PandoraPFA (Mark THOMSON, Cambridge).

Nos collègues du KEK (prof. Akiya MIYAMOTO) et du DESY (Franck GAEDE) travaillent sur les algorithmes de reconstruction de traces, qui une fois adaptés, permettraient d'améliorer la reconnaissance de forme dans les calorimètres.

VISIBILITÉ DU LABEX P2IO

Beaucoup d'efforts ont été fait en France (LLR, LAL, IPNL) sur le développement d'algorithmes originaux ; ces efforts ont toutefois été conduits de manière indépendante, et peu coordonnée. L'expertise gagné par le LAL et le LLR dans l'intégration grâce à ce PostDoc permettra fédérer ces efforts et de rendre plus visibles nos contributions pour l'ensemble de la France, bien sûr à l'intérieur de la communauté ILC, mais également de l'Europe (programme AIDA) et de la communauté HEP (algorithmes PF pour les expériences LHC ou ions lourds, par ex.).

Le candidat retenu sera donc tenu de participer aux conférences et workshop touchant à ces domaines et pourra y présenter l'ensemble des développements et résultats de manière cohérentes, sous l'étiquette du LABEX, ce qui lui assurera une large visibilité.