Internship offer – Year 2013-2014

Internship level: **M2** **Can be also adapted to M1/L3**

Duration : **4 months**

For M2 internship:

- **Possibility of opening to a thesis : Yes**
- **Type of funding proposed: Mixed France/Finland, not yet guaranteed**

Supervisor : **Maxime Gouzevitch (IPNL, France) / Mikko Voutilainen (HIP, Finland)**

Phone : **+33660848119**

Mail : **mgouzevi@ipnl.in2p3.fr / Mikko.Voutilainen@cern.ch**

Address : **IPNL – Bureau 121**

Domaine Scientifique de la Doua – Bât. P. Dirac

4 rue Enrico Fermi – 69622 Villeurbanne Cedex - France

Team coaching :

Title of the internship : Search for new strongly coupling physics in the Dijet final state using Run II data from CMS experiment, LHC

Summary of work required :

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A new data taking period, referred to as *Run II*, with collisions at the c.o.m. energy of 13 TeV will start in May 2015 and last up to 2016. The larger amount of data to be collected (factor of 5) and more than 1.5 times increase in the c.o.m. energy opens new tantalizing possibilities to explore the strongly coupling models in dijet bump hunting approach: for example at the c.o.m. energy of 8 TeV the existence of a Q* was excluded

up to 3.5 TeV using the full available data sample of 20 fb-1. The same result at 13 TeV could be achieved with only 0.1 fb-1 and the 100 fb-1 that one expects to collect before the next shutdown would allow to explore this model up to 6 TeV!

The new energy scale horizon brings new experimental challenges. The main one is related to the reconstruction of the jets. The typical energy of the jets in the region of interest under consideration increases from 1.5 to 3 TeV. This implies a higher energy density within the core of the jet and a more narrow jet core due to the Lorentz boost. The technique used to reconstruct jets at CMS is called *Particle Flow*. It relies on a combination of the main detectors: tracker embedded into a powerful 4T magnetic field, calorimeters and muon chambers to reconstruct and identify particles. Those particles are subsequently used to build jets. Many elements of this reconstruction technique need serious rethinking for very high energy jets:

- Charged particles represents 60% of the jet energy and heavily rely on the quality of CMS tracking. When the energy of particles increases the curvature of tracks is reduced and the occupancy of the tracker and pixel detectors in the region of the hot core of the jet increases.
- The CMS calorimeter embedded into the solenoid is rather short (6 standard units of interaction in the barrel). Showers produced in high energy jets can leak out of the calorimeter and be measured by the so-called tail catcher detector. This detector was not used during Run I, but its usage and calibration becomes critical in the new energy regime.
- The QCD radiation properties and detector response were never tested for so energetic jets. A new fundamental effort of jet energy calibration (JEC) would be necessary to keep the high sensitivity of the search.

The inclusive dijet bump search is expected to be extended to identify jets coming from the hadronic decay of the electroweak bosons Z, W and H using the jet substructure techniques. Such kind of analyses were already performed at 8 TeV, but the c.o.m. energy increase brings there a large sensitivity improvement as for the inclusive search. The substructure variables are particularly sensitive to the above mentioned developments especially in tracking.