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# Module tests for the tracker upgrade of the CMS experiment at HL-LHC

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The CMS collaboration, which analyzes proton-proton collisions at the Large Hadron Collider (LHC) at CERN, is upgrading its detector for the high luminosity phase of the LHC (HL-LHC). In this context, the tracker, the innermost part of the detector, will be completely replaced in order to guarantee excellent reconstruction resolution of tracks and vertices in the HL-LHC environment, and to cope with the very high irradiation. The tracker uses, depending on the layer, silicon micro-strip or pixel modules. The signals recorded by these modules are filtered and read by a data acquisition system. The IPHC group is heavily involved in the preparation of the external part of this new tracker. The CYRCé cyclotron, at IPHC, is one of the few accelerators making it possible to test these detectors and their readout electronics with a high intensity beam of a time structure similar to the frequency of 40MHz at the LHC, although of lower energy.

The M2 internship will focus on validating the Readout electronics and Data acquisition of pre-production modules, which will then be produced in large quantities and installed in the future tracker. The student is expected to participate in these tests with at the CYRCé cyclotron. He or she will subsequently be asked to reconstruct and analyze the recorded data and to evaluate the correct functionality. A presentation of the results within the working group meeting at CERN will be considered.

The internship is followed by a **PhD thesis proposal**, consisting of two different parts: About two third of the time will be dedicated on measuring the polarization of tau leptons originating from the decay of Z bosons, collected with LHC's Run 2 and Run 3 data. The polarization (the helicity asymmetry measures the different couplings of the Z boson to left and right handed fermions due to its electroweak nature, quantified by the effective electroweak mixing angle  $\sin^2\theta_W$ ). The goal is to improve an existing very competitive result [1] based only on a part of the available data. This result was obtained by work within the CMS-research group at IPHC. The improvements for this measurement will be achieved not only by the larger data samples but in particular by new spin reconstruction techniques being developed in parallel within the Higgs CP-analysis consortium, where the IPHC group plays a leading role. These improvements are at the core of the thesis and will finally lead a determination of  $\sin^2\theta_W$ , which could be comparable in precision to LEP.

For the second part of the thesis the student will participate in the installation and integration of the new tracker into the CMS detector. Several periods of presence at CERN will be necessary for this part.

Further information: <http://www.iphc.cnrs.fr/-CMS-.html>

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[1] CMS Collaboration, Measurement of the  $\tau$  lepton polarization in Z boson decays in proton-proton collisions at  $\sqrt{s} = 13$  TeV, <https://doi.org/10.48550/arXiv.2309.1240>, [CERN Courier](#)