Internship offer – Year 2016-2017

<table>
<thead>
<tr>
<th>Internship level:</th>
<th>M2</th>
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<td>Duration:</td>
<td>4 months</td>
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<td>For M2 internship:</td>
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<td>- Possibility of opening to a thesis: Yes</td>
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<td>- Type of funding proposed: IN2P3 grant</td>
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**Team coaching:** D.Autiero, D.Caiulo, L.Chaussard S.Galymov, J.Marteau, E. Pennacchio

**Title of the internship:**  
*The next challenging measurements in neutrino oscillations with the liquid argon time projection chamber with double-phase charge readout. Study of the detector performance with a complete prototype at CERN and of its physics potential for future measurements like the search for CP violation in the neutrino sector and the search for proton decay.*

**Summary of work required:**  
Liquid argon time projection chambers are the modern version (fully electronic, large size and with no dead time) of bubble chambers, keeping equivalent imaging, calorimetric and particle identification performances. Massive liquid argon time projection chambers are actually the most promising experimental technique in view of addressing key physics questions like CP violation in the neutrino mixing, the search for proton decay and the accurate observation of supernovae neutrinos.

In order to achieve the physics sensitivity for these measurements a large active detector mass is needed. This is related to the possibility of drifting over long distances in the liquid argon, of the order of a few tens of meters, the ionization deposited by the tracks of the charged particles in the final state of the interactions/decays occurring in the detector.

The attenuation of the ionization over long drift paths, due to residual electronegative impurities still present in the ultra-pure liquid argon, can be compensated by a novel technique called “double-phase charge readout”. This technique consists in extracting from the liquid phase the electrons from the primary ionization by using a strong electric field and in and amplifying these charges in the gas phase, in avalanches occurring within some special micro-pattern detectors. The gain obtained by this double-phase charge collection scheme provides, even after having compensated for the losses related to the drift over large detector dimensions, a very large signal.
to noise ratio for tiny ionization signals. This opens the way to enhanced physics capabilities, when compared to the standard readout technique, where charges are collected by a system of wires immersed in the liquid argon not providing any amplification of the primary ionization.

The dual-phase liquid argon TPC is a detector envisaged for the next generation international neutrino oscillations experiment DUNE hosted in the USA. An intensive prototyping activity, in which the IPNL neutrino group is deeply involved, is going on at CERN in order to demonstrate the performance of this detector technology on giant detector sizes. A detector of 6x6x6 m³ active volume in under construction in the CERN North Area and will be exposed to beams on charged particles (electrons and hadrons) in order to study with unprecedented resolution and granularity the response to electromagnetic and hadronic showers and the performance on particles identification. A smaller size detector 3x1x1 m³, which has been fundamental to prototype many parts of the 6x6x6 detector, has been already built at CERN and it is entering in operation. IPNL has also a complete liquid argon laboratory infrastructure, unique in France, with a prototype of 300 liters fiducial volume, with a complete instrumentation for specific tests in a controlled environment.

The stage will focus on the experimental assessment of the performance of the double-phase detectors with the analysis of the data of the 3x1x1 detector at CERN and on the study of the physics impact of this new detector technology on the next generation of experiments on neutrino oscillations and astro-particle physics.

The stage will put the candidate in the ideal condition to contribute, with a thesis starting in the fall 2017, to the realization of the 6x6x6 m³ detector at CERN and its operation and data analysis in 2018. This complete experimental activity until 2019 will be a major breakthrough in view of the preparation of the DUNE experiment. It will allow the candidate to gather a strong experience on neutrino physics and on neutrino detectors. For this very rich opportunity and challenging task we are looking for high level students.