Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

This **call for a PhD position,** to address the development of an innovative Positron Emission Tomography (PET) detector by the ETH Zurich, is announced in the context of the A*Midex (Aix-Marseille University Academy of Excellence) Program, which intends to reinforce international collaborative experiences between the university of Aix-Marseille in France with dedicated high schools.

Research activity on a dedicated pre-clinical PET detector for highly innovative ultra-fast PET/MRI acquisition has recently started at the ETH Zurich – Institute for Particle Physics (IPP, group of Prof. Dissertori). The goal is the conception, construction and complete characterization of a novel PET detector, fully MRI compatible, to be used for pre-clinical dynamic PET acquisitions, able to operate at high injected activities up to ~ 500 MBq.
The ETH-IPP group is currently focusing on all the aspects of the detector development, ranging from hardware to software topics. In this context, we are looking for a PhD student who, depending on his/her prior knowledge and interest, is willing to have a strong impact in one of the two following subjects:

a) Development and test of dedicated ASIC(s) for high-rate front-end readout electronics of SiPM-based detectors.

The baseline concept for the foreseen PET detector is the usage of SiPM arrays coupled to crystal arrays in a one-to-one correspondence. When high rates of events are required, special emphasis must be put on the reduction of the pile-up and dead-time, induced respectively by the long pulse duration of the SiPM output (few 100 ns) and by the dark count rate (few kHz/mm^2). A dedicated ASIC for a high-rate PET detector must be developed, addressing solutions for pile-up and dead-time, preserving at the same time excellent timing resolution (<50 ps) and good charge resolution (<5%). Typically, the timing information is obtained using a leading edge discriminator and the amplitude information is obtained applying a time-over-threshold method. Alternative methods are thinkable if favorable in terms of performance and/or power consumption. The ASIC should feature 32 or more identical readout channels. A reduction in the number of output signals by at least a factor 8, preferably 16, compared to the input is desired, using analog logic. Including the output multiplexing stage, the system must allow signal rates of >0.5 MHz with no dead-time and with a pile-up rate smaller than 1%. The work involves all the aspects of the readout system design, including its overall concept, simulation of the expected performance, ASIC implementation and performance testing. The multi-channel system tests will be performed using crystal matrices coupled to SiPM arrays, with radioactive sources of high activity.

b) Development of a simulation and reconstruction software framework for high-rate dynamic PET imaging.

The subject implies development of dedicated simulation and reconstruction tools, leading eventually to a 4D-PET image reconstruction algorithm for the high-rate PET detector. The reconstruction algorithms will be tested and fully validated with simulated data. Further studies will be performed with real coincidence data from a demonstrator, when available. The software framework, providing a complete processing chain from simulated data to reconstructed images, will strongly rely on existing software packages and libraries. In a second step the framework will be applied to optimize parameters for the new ultra-fast PET insert. Here standard reconstruction algorithms, such as filtered backprojection and iterative algorithms like maximum-likelihood expectation maximization (ML-EM), ordered subset ML-EM (OSEM) and others will be used. The main task comprises the selection, implementation and test of a 4D-reconstruction algorithm for the specified PET system. 4D PET-image reconstruction is an emerging field and stands for the reconstruction of the 3D volumetric tracer distribution as a function of time, with adequate spatial resolution and good temporal resolution. Dedicated 4D reconstruction algorithms are expected to yield a better performance than simple application of standard algorithms to dynamic PET imaging data. A concept for the simulation of dynamic PET data has to be developed and implemented, eventually completing the simulation-reconstruction chain for 4D PET-images.

The PhD thesis will be co-supervised by Prof. C. Morel at the Aix-Marseille University and by Prof. G. Dissertori at ETH Zurich. The student is expected to spend most of his/her time at the Aix-Marseille University and to defend the thesis there. However, extended research visits at ETH Zurich are also foreseen.

The grant implies a three years appointment, starting on 1st October 2014. Candidates must have completed their Master Degree, possibly not in France and preferably within a Swiss institution.

Interested candidates should **contact Prof. Günther Dissertori (dissertori@phys.ethz.ch) as soon as possible, and not later than 20th April 2014.**

Further information about the A*Midex Program can be accessed at the address: http://amidex.univ-amu.fr.