INFIERI2019 SCHOOL at HUST
Laboratory sessions Summer School (05/05/2019)

Laboratory Topic	Organizers
FRONT-END ELECTRONICS ORIENTED LABS	
1) Front-End Electronics on Deep Sub-Micron CMOS technology **for the next generation of pixel based detectors (Particle Physics):** Pixel front-end characterization *This is an introduction to VDSM (Very Deep Sub-Micron Technology)* The focus of the lab will be the experimental characterization of a front-end channel for pixel detectors in a 65 nm CMOS technology. Pixel Front-End ASICs are located at the very beginning of the Signal Processing chain in pixel-based detectors used in many fundamental and applied research fields. So, generally speaking, testing of front-end circuits in advanced microelectronic technologies is an important part of the implementation of modern radiation detection systems. During the laboratory session, after a short introduction on the device under test and the test set up, students will learn how to use basic electronic instrumentation (a power supply, a digital scope, a waveform/arbitrary function generator) to configure the circuit and measure the main electrical parameters. While no previous experience in pixel front-end characterization is required, basic knowledge on electronic circuit operation and standard bench top instrumentation can be of some help.	**Prof. Lodovico RATTI (Pavia U.)** *IEEE Member and member of the RD53 R&D international Collaboration (among some others cutting-edge R&D's).*
2) Digital SiPM The lab will focus on the test of a unique device, an array of CMOS SiPM, composed of	**Prof. Nicola d'ASCENZO (HUST, CN)**

256 pixels, individually read-out. The device is able to provide the position of the photon with an unprecedented accuracy of 50 um. In the experiment the students will study the light emitted by a fast Pulsed Diode Laser, at 410 nm. A series of filters interposed between the laser and the sensor will reduce the optical power at the sensor surface to few photons/mm^2. The measured space detection pattern of multi-photon states will be studied & several possibilities analyzed.	
3) **Introduction to FDSOI pixel detectors** The Lab will 1) explain the concept and requirements of tracking in the future e^+e^- collider. 2) An ideal detector i.e. a sheet of silicon sensitive to the traversing charged particles in its full volume and capable of high granular & intelligent readout without adding dead material will be discussed and critical issues identified and treated with practical measures. 3) An SOI chip and readout system will be setup to capture the passage of cosmic rays as experimental demonstrator.	**Dr Yunpeng LU (IHEP, CAS)**
4) **New sensors characterization** This Lab will introduce the students to new pixel technology namely the HV-CMOS pixels that look promising for instance for the future electron-positron machine in projects. It is a characterization of these new sensors prototype using a simple ALIBABA based test set-up which is widely used in several worldwide research Labs and Universities.	**Dr Sven WONSAK, Liverpool U.** **and Prof GL CASSE Liverpool U., FBK Trento**
5) **2,5 and 3D Technology*: Introduction to 3D Interconnect technology design***** In this lab, students will be exposed to integrated circuit technology, 3D integrated circuit design flows and their related CAD tools. The students will use CAD tools to create simple 2D and 3D IC designs, implementing these in schematics and layout. Prior experience with CAD tools or integrated circuit design is not required. CAD Tools used in the lab: MicroMagic, MAX, SUE	**Dr. Robert PATTI, NHANCED semiconductors USA**

6) Static SiPM characterization Novel SiPMs in 350 nm CMOS technology were realized. In this lab we provide an introduction on how to use a probe station to conduct current/voltage and capacitance/ voltage characterization measurements in a clean room. The physical and technological basis of the experiment will be also presented.	**Lin WANG** **JONBOIN Technology Co., Ltd.(Hubei)** *(Organized transport to Ezhou)*
DATA TRANSMISSION LAB	
1) **Optical fibers and communication Laboratory** Wuhan is a top worldwide class place in this high technology and related research domain.	By member of the **National Laboratory of optoelectronics, Wuhan (WLNO)**
ASTROPHYSICS OR HEP BASED LABS	
1) **Detection Lab: Characterization of a CCD Detector (Astrophysics)** The lab consists in characterizing a CCD camera by measuring: • The readout noise • The dark current • The linearity range • The CCD gain	**Dr. Jean Gabriel CUBY (LAM-CNRS/INSU, FR)**
Also according the weather conditions some observational sessions will be organized	*Jean Gabriel CUBY (LAM-CNRS/INSU, FR)*
2) **Introduction to Dark Matter detection** *The Dark Matter (DM) of our Galaxy can scatter from the nuclei of detectors.* *If the DM has a mass of 100 GeV/c2, the recoil energies of the nuclei are in the 1-100 keV range*. **Direct detection of DM can be observed with Ge/Sidetectors, Scintillating crystals or liquids, or gaseous detectors.** **This Lab will have 2 of the 3 main types of detectors sensitive to keV signals :** **1) germanium (or Silicon) with electronics and data acquisition** **2) NaI crystal with PMT and associated electronics and data acquisition** The goals of the lab are to - Understand the different types of detectors	**Prof. Charling TAO (CCPM-CNRS, FR & Tsinghua U, CN)**

and learn to set up, trigger and acquire data. - Measure the responses of the detectors to a calibration source (eg Fe55, Cd109, Na22). - Compare the energy resolutions of each type of detector. - Measure the responses of the detector to a neutron source to mimick nuclear recoils - Introduce the concept of "quenching factor" (Cannot be demonstrated on site) - Compare with the expected rate for DM. The rates indicate the level of background. Conclusions?	
3) **Use of SiPM in Astrophysics experiments** In this lab we will introduce the students to the characterization of the basic properties of a SiPM including dark rate, cross talk, response to low photon flux and gain.	**Prof Ricardo PAOLETTI (Siena U. and INFN, IT)**
4) **Electron Beam Tomography of a basic element of the High Granularity Calorimetry for HL-LHC (CMS)** In this lab, students implement a simple particle tracking algorithm and apply it on real beam test data for measuring the material budget of a printed circuit board exposed in an electron beam. For this, reconstructed data taken with the DATURA beam telescope during an CMS HGCal beam test at DESY in 2018 are provided. First, students are supposed to assess the quality of the track measurement deploying basic monitoring algorithms. Secondly, they evaluate the impact of misalignment of the tracking planes on the pointing resolution. Afterwards, the distribution of kink angles from track-triplets in front and behind the device under test (DUT) is measured for different DUT thicknesses. The theoretical relation of the mean kink angle with respect to the material budget will be confirmed. Ultimately, students compute the mean kink angle as a function of the track impact position onto the DUT and as result will obtain its tomography image. Both a reduced and the full available dataset will be analysed for the last part to examine the requirement of	**Thorben QUAST, Physikalisches Institut 3A, RWTH Aachen , GE / CERN , CH** **Dr. David BARNEY, CERN, CH**

sufficient statistic for obtaining high resolution images.	
LABs DEDICATED to MEDICAL PHYSICS	
1) **NEMA measurement of PET/CT system sensitivity** Aim of the lab: Students will measure the sensitivity of a PET scanner according to the NEMA standard and will provide an interpretation of the measurement with reference to the physics of PET systems.	**Bo ZHANG** **RaySolution Digital Medical Imaging Co.,Ltd**. *(Organized transport to Ezhou)*
2) **Small Animal PET mouse acquisition** (according to what is there in that time) *Aim of the lab: Students will perform tau staining of mice brain in a biology laboratory and understand the basic techniques used for basic neurology science.*	**TONGJI HOSPITAL**
3) **Digital Small Animal PET mouse image analysis (Radiomics)** *The data collected in (3) will be analyzed in a radiomics analysis framework. Students will learn how to perform the radiomic analysis of PET images and how to extract reasonable quantities.*	**Prof. Nicola d'ASCENZO, PETLAB, HUST**
4) **Behind a Published Paper - From Bench to Medical Community** Publishing a scientific paper is the only way by which scientists, from different backgrounds, communicate with each other. The application of multidisciplinary approaches and the synergy between researchers is a prerequisite for high-quality discoveries and publications. The overall aim of the lab is to create an interactive environment that may guide students through a virtual process for the production of a scientific paper and consolidate the idea that science benefits greatly from a community that approaches problems in a variety of creative ways. In particular, students will be made aware of the entire process of doing medical research and learning to practice the	**Alba di PARDO, Medical Geneticist, NEUROMED (IT)**

activities of scientists - asking questions, performing experiment, collecting and analyzing data as well as thinking of new questions to explore, with the ultimate goal to conduct research aimed at improving overall human health. After a brief introduction of the topic and the discussing of the objective of the study, students will be divided into groups and each of which will be given videos and/or representative images from experiments previously performed in order to let them to extrapolate and analyse numerical data, build representative graphs and interpret the results under a medical point of view. Students will be encouraged then to discuss the data obtained and to approach the preparation of the manuscript in light of their interpretations, strengths and interests. Such Lab is designed to give students the possibility to get closer to medical science and stimulate them to implementing it with their own expertise. Scientific community from different background is better able to generate new research methods, explanations, and ideas, which can help science over challenging hurdles and shed new light on problems.	
COMPUTATIONAL LABS	
1)Introduction to INTEL FPGA BASED LAB Zhu Zhaojun will help to create all accounts to **access the new FPGA cloud** and he also will prepare the workshop material which can be running on the FPGA cloud for this class. Zhu Zhaojun (Felix) joined Altera (now Intel Programmable School Group, PSG) in August 2014 as Regional Applications Engineer with expertise in OpenCL/HLS/HyperFlex technologies. He has been working closely with key customers to optimize their designs, customize OpenCL BSP and fix tough issues.	**ZHU Zhaojun (Felix)** **INTEL Regional Applications Engineer with expertise in OpenCL/HLS/HyperFlex technologies**

2) Massive Parallel Computing (session 1) This is the first session of 3 hours dedicated to Massive Parallel Computing by Dr. R. Iope (UNESP) and Prof. L. Sato (USP). The details of this session will be provided soon This hands-on training has been designed to be a comprehensive, practical introduction to the fundamentals of parallel programming based on Intel Many Integrated Architecture (MIC) and programming models, aiming to demonstrate the processing power of the Intel Xeon / Xeon Phi product families. Activities start with a brief overview of the second-generation Intel Xeon Phi processors, followed by a series of simple exercises. Attendants will learn how to compile and run trivially simple C/C++ source codes for native execution on dedicated servers based on the Intel Xeon Phi processor. They will also have the opportunity to work with shared-memory parallelism with OpenMP (Open Multi-Processing) and distributed-memory parallelism with MPI (Message-Passing Interface), and learn the fundamentals on code optimization using the vectorization support provided by the Intel compilers.	**Dr Rogerio IOPE Dr. Raphael COBE, Dr. Silvio STANZANI, Mr. Jefferson FIALHO (São Paulo State University – UNESP, São Paulo, Brazil) and Prof. Liria SATO (University of São Paulo – USP, São Paulo, Brazil)**
3) Massive Parallel Computing (session 2) This is the second session of 3 hours dedicated to Massive Parallel Computing descried here above.	**Dr Rogerio IOPE Dr. Raphael COBE, Dr. Silvio STANZANI, Mr. Jefferson FIALHO (São Paulo State University – UNESP, São Paulo, Brazil) and Prof. Liria SATO (University of São Paulo – USP, São Paulo, Brazil)**
4) Machine Learning & Deep Learning applied to Astrophysics ; it includes Two tutorials based on real astronomical applications. In the first tutorial we will approach a classification problem and we will compare the results obtained with classical ML with the ones obtained with Deep Learning. In the second tutorial we will test a Convolutional Neural Network for a regression problem, reproducing the	**Dr. Lara LLORET IGLESIAS, And Dr. Diego TUCCILLO , Institute of Physics of the University of Cantabria, UC-CSIC, SP.**

results obtained in Tuccillo et al (2018) for estimation of galaxy parameters.	
5) Deep Learning with Keras I+II Introduction to Deep Learning with general examples (in part I) and a specific example (heavy resonance tagging) from particle physics (in part II). The advanced part II is not necessarily restricted to particle physicists, the techniques are of general interest. The part II will be a 'playground' to explore ideas on a demanding example where the best performing implementations will be presented at the end of the school.	**Drs. Dirk KRUCKER, Mareike MEYER, Patrick CONNOR (DESY-Ge) &** **Lisa BENATO and Prof. Gregor KASIECZKA, University of Hamburg, GE.**
6) **Introduction to new FPGAs software platform** The sheer amount of computing resoruces required to run modern cloud workloads has put a lot of pressure on the design of power efficient cluster nodes. To address this problem, INTEL (HARP) has proposed CPU-FPGA integrated architectures that can deliver efficient power-performance executions this tutorial presents HardCloud and extension of Open MP 4.X standard that eases the task of offloading FPGA modules to cluster accelerators. Participants will be able to do hands-on experiments with Hard Cloud to program FPGAs in order to accelerate code of INTEL Altera HARP2 architecture. It will cover basic concepts on programming with Open MP and introduce to System Verilog.	**Prof. Guido ARAUJO, Dr. Marcio PEREIRA, Ramon NEPOMUCENO (UNICAMP, SP, BR)**
7**) INTRODUCTION to GPU COMPUTING** **Session 1:**,Students will obtain first experience with programming GPUs using Nvidia's framework CUDA. The lab consists of two sessions: In the first session, an introduction to CUDA is given, followed by exercises during which the students implement vector addition and matrix multiplication. During these exercises, the students will study different levels of parallelization and the usage of different memory types	**Dr. Dorothea Vom BRUCH** **LPNHE Laboratory Sorbonne Université, Paris Diderot Sorbonne Paris Cité, CNRS/IN2P3, Paris, FR**

8**) INTRODUCTION to GPU COMPUTING** **Session 2:** The topic of the second session is track reconstruction for a particle physics detector. A set of straight-line tracks will be provided, where every track is a collection of 3D space points. The task consists in finding the direction and its uncertainty at the end of the track, i.e. the track state. For this, the students will implement a Kalman filter and parallelize it to run efficiently on the GPU.	**Dr. Dorothea Vom BRUCH** **LPNHE Laboratory Sorbonne Université, Paris Diderot Sorbonne Paris Cité, CNRS/IN2P3, Paris, FR**

RUN EACH DAY

Presentation (8' max each) May 13th in plenary session

.May 14th – May 18th 14:00 – 17:00 and May 20th -May 24th 14:00 – 17:00