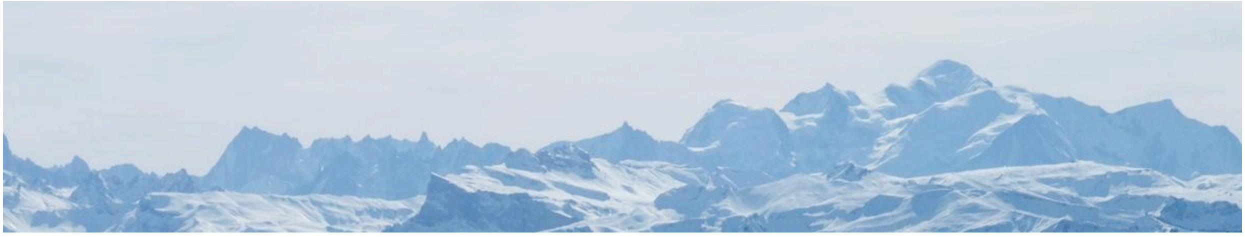

EDIT 2011: scientific program

Excellence in Detectors and Instrumentation Technologies
CERN, Geneva, Switzerland - 31 January - 10 February 2011

EDIT2011 School offers a scientific program constituted by two days of plenary lectures and eight days of theoretical classes interleaved with laboratories courses, for a total of 8 plenary lectures, 19 lectures spread in the topical courses and 36 laboratories.

The scientific arguments covered during the school are:

1. Calorimetry: from the basic concepts to the energy flow
2. Detection of scintillation and Cherenkov light from crystals and fibres
3. 4. From basic to advanced electronics and FPGA programming
5. Gaseous detectors: present features and future role
6. Photo-detectors: principles, performance and limitations
7. Pixels detectors for LHC and for Linear Colliders
8. Silicon strips technologies

The detailed programs, the transparencies of the lectures, the documentation explaining in details the exercises executed during the laboratories sessions can be found at: http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=96989

In this document we briefly summarize the contents of the topical courses and we indicate the names of professors and tutors.

1. Calorimetry: from the basic concepts to the energy flow

Convener: Ana Henriques (CERN)

Lectures:
1. Principles of calorimetry - *R. Wigmans (Texas Tech. Un.), D. Fournier (LAL, Orsay), M. Diemoz (INFN, Roma 1)*
2. Main techniques in present and future HEP experiments - *R. Wigmans (Texas Tech. Un.), D. Fournier (LAL, Orsay), M. Diemoz (INFN, Roma 1)*

The theoretical lectures review the principle of Calorimetry and the main techniques used in present and future HEP experiments with emphasis on calibration and on the steps necessary to go from raw data to physics objects. The following basic questions are addressed and answered:

- Signal generating mechanisms
- The signal from sampling and longitudinally segmented calorimeters
- Composition of a shower and its evolution as it develops
- Linearity and calibration for sampling and longitudinally segmented calorimeters
- e/h and its impact on hadronic energy resolution, response function, signal linearity
- Factors determining e/h
- Calorimeter clusters and noise suppression
- Particle reconstruction and identification in a calorimeter
- The jet energy scale
- The particle flow and the use of tracking to improve the calorimeter calibration
- R&D projects aimed at improving the quality of calorimetric measurements in future experiments

<u>Laboratories:</u>

1. Calibration of an ATLAS Tile calorimeter using a moveable ^{137}Cs source – *A. Henriques (CERN), O. Solovyanov (IHEP), S. Solodkov (IHEP), J. Starchenko (IHEP), H. Wilkens (CERN)*

   Content of the laboratory:
   - Hydraulics and electronics of the source calibration system
   - Online control and data acquisition, graphical user interface
   - Scans with radioactive source and high voltages optimization
   - Analysis of calibration data
2. Characterisation of the optical properties of a scintillating plastic tile using a ^{90}Sr source – *A. Henriques (CERN), O. Solovyanov (IHEP), S. Solodkov (IHEP), J. Starchenko (IHEP), H. Wilkens (CERN)*

   Content of the laboratory:
   - Optimization of the optical properties of the tile calorimeter in terms of light yield, attenuation, uniformity and hermeticity
   - Measurements of the light output of a scintillating tile coupled to an WLS fibre and photomultiplier in 2 dimensions
   - Evaluation of the light yield and light attenuation length
   - Measurements the uniformity of the light response with single and dual readout
3. Characterisation of the optics properties of PbWO4 CMS crystals and detection of cosmic muons passing through a Lead Tungstate crystal – *F. Tedaldi-Nessi (ETHZ), C. Casella (ETHZ)*

   Content of the laboratory:
   - Interaction of muons with matter
   - Calorimetric energy measurement from scintillation light using a digital scope
   - Thermal photocathode noise
   - Setting of an energy trigger for cosmic muon detection
   - Acquisition of a muon energy deposition spectrum
   - Signal to noise ratio
4. A MC exercise with Particle flow method using the CALICE calorimeter set-up – *F. Sefkow (DESY), Angela Lucaci-Timoce (CERN), E. van der Kraaij (CERN)*

Content of the laboratory:
- Technologies for highly segmented imaging calorimeters
- Topology of electromagnetic and hadronic showers, event-to-event fluctuations
- Finding the shower start point
- Particle flow algorithms at work: interactive jet energy reconstruction

Professor of excellence in the Calorimetry course: Adam Para (FNAL)

2. Detection of scintillation and Cherenkov light from crystals and fibers

Conveners: Etiennette Auffray Hillemanns (CERN), Paul Lecoq (CERN)

Lectures:
1. Fundaments of scintillators – *Paul Lecoq (CERN), Stefaan Tavernier (Vrije Un. Brussel), Remi Chipaux (CEA, Saclay)*
2. Applications of scintillators – *Paul Lecoq (CERN), Stefaan Tavernier (Vrije Un. Brussel), Remi Chipaux (CEA, Saclay)*

The theoretical courses address the following points:
- Scintillation mechanisms in inorganic scintillators
- Production of Cerenkov light in heavy scintilators and interest for dual readout calorimetry
- Light collection in scintilators
- Defects and radiation damage in inorganic scintillators
- Scintillators production methods, bulk54 versus fibers

Laboratories:
1. Discover a crystals' laboratory: infrastructure for the construction of the CMS electromagnetic calorimeter – *Etiennette Auffray Hillemanns (CERN)*
   - Presentation of the different steps of CMS_ECAL from crystal characterisation to super-module assembly
2. Transmission and luminescence properties of scintillating crystals – *Etiennette Auffray Hillemanns (CERN), Remi Chipaux (CEA Saclay), Ioan Dafinei (INFN – Roma1)*
   - Principle of the transmission and luminescence measurement
   - Effect of radiation damage on the crystal transmission (measurement of an irradiated and non irradiated crystal)
   - Effect of the doping on the crystal transmission (measurement of a doped and non-doped crystal)
   - Measurement of emission and excitation spectra for different types of scintillators, influence of the doping
   - Correlation with transmission and excitation spectra
   - Importance of the monitoring system in a detector

3. Mastering the parameters that can compromise the Light Yield - *Kristof Pauwels (CERN, LPCML, Lyon)*
   - Principle of light yield measurement
   - Measurement of the energy spectra for different types of scintillator using various sources
   - Determination of the light yield and energy resolution for the different scintillators
4. Characterization of scintillators via the Decay Time - *Benjamin Frisch (CERN)*
   - Principle of the decay time measurements
   - Measure of decay time spectra of different types of scintillators
   - Determination of decay time characteristics
   - Importance of the scintillator timing properties for a time of flight detector

3.& 4. From basic to advanced electronics and FPGA programming

Convener: Sandro Marchioro (CERN)

Lectures:
1. Basic electronics – *Xavier Llopart Cudie (CERN)*
2. Analog electronics – *Christophe de La Taille (IN2P3/LAL Orsay)*
3. Microelectronics – *Sandro Marchioro (CERN)*
4. FPGA and programmable devices – *Jan de Cuveland (Frankfurt Un.), Stefan Kirsch (Frankfurt Un.), Dirk Hutter (Frankfurt Un.)*

Laboratories:
1. Simulation of basic electronics with SPICE – *Xavier Llopart Cudie (CERN) and Rafael Ballabriga (CERN)*
   This laboratory refreshes elementary circuits, namely:
   - Digital and Analog Domains
   - Analog Circuits
   - Analog electronics design tools
     - Circuits with passive components (R,C and L)
     - Circuits using active components (OP-Amps)
   - Elementary Feedback theory
2. Hands-on analog electronics circuits – *Christophe de La Taille (IN2P3/LAL Orsay)*
   This laboratory addresses the analog signal processing with Matlab exercises on FE design. More specifically it deals with the following questions:
   - Amplification - From a bunch of electrons to a plot on the screen
   - Filtering - What is a shaper and why do we need it?
   - The mysterious A to D converter: how to understand it
   - If analog is good, why is digital better?
3. Experience with microelectronics design flow – *Sandro Marchioro (CERN)*
   Content of the laboratory:
   - Impact of Microelectronics on Instrumentation
   - Microelectronics Technology

    - Future microelectronics technologies and how they may impact Instrumentation for HEP
    - Radiation effects on chips
4. Learning tools and languages to program FPGAs – *Jan de (Frankfurt Un.), Stefan Kirsch (Frankfurt Un.), Dirk Hutter (Frankfurt Un.)*
   Content of the laboratory:
    - Tools and languages to create FPGA designs
    - Why are FPGA so useful and popular?
    - How do I create an FPGA design?
    - Compare FPGAs to microprocessors and DSP
    - FPGA in trigger applications

5. Gaseous detectors: present features and future role

Convener: Mar Capeans (CERN)

Lectures:

1. Gaseous detectors: principles, performance and limitations – *Fabio Sauli (TERA Foundation), Rob Veenhof (CERN), and H.Schindler (CERN)*
   The theoretical courses address the following points:
    - Introduction to gaseous detectors (energy lost, primary and secondary, d-rays…)
    - Drift, diffusion and electron capture
    - Charge multiplication, Townsend, avalanche and operating modes
    - Proportional detectors: from the single wire to the Micro-patterns

Laboratories:

1. Large gas detector systems at LHC, the ATLAS TRT Detector – *Anatoli Romaniouk (Moscow Physical Engineering Inst.)*
    - Transition Radiation working principle and main detector elements
    - Signal from particles and signal shape
    - Drift-time distribution (hit arrival time, trailing edge)
    - Cosmic particle track characterization
    - Noise identification
    - Understanding misbehaving channels
    - Mapping the straws with particles
    - Straw efficiency and drift-time accuracy
    - Drift-time accuracy as a function of threshold
    - Tracking at high occupancy and noise suppression
    - Basic principles of the particle Identification
2. Principles of straw detectors and their FE electronics – *Hans Danielsson (CERN), Peter Lichard (CERN), Antonino Sergi (CERN)*
    - Detector working principles
    - HV scan to find a suitable voltage for operating the detector

- Trigger on cosmic rays and on 55Fe and observe the response of the individual straw by the analog output
- Change threshold for one or more channels to investigate the intrinsic noise
- Determination of FE electronics sensitivity

3. Drift Tubes, gas mixtures and drift velocities – *Joerg Dubbert (Max-Planck-Institut fur Physik), Joerg von Loeben (Max-Planck-Institut fur Physik)*
   - Monitored Drift Tube Chambers: working principle and principles of momentum measurements
   - Study the difference between signals from cosmic muons and signals created by photons from an 55Fe source.
   - Dependence of the pulse height on the high voltage applied to the anode wire.
   - Measure the length of the drift time spectrum at standard operating conditions (gas mixture Ar/CO2 (93/7), pressure 3 bar absolute, high voltage 2730 V). Use the provided analysis programs to determine the rt-relation and the spatial resolution of the drift tubes.
   - Influence of multiple scattering
   - How to estimate the drift tube resolution from a simple geometric approach.
   - Study of drift time spectrum as a function of high voltage and variation of the gas mixture
   - Study the necessity of a quencher in the drift gas by operating the drift tubes with pure argon.
4. GEM Detectors: assembling and functioning – *Leszek Ropelewski (CERN), Giovanni Bencivenni (Laboratori Nazionali di Frascati (LNF))*
   - MPGD principles of operation
   - Construction techniques
   - Assembly of MPGD
   - Operation of a GEM-based cosmic telescope and data analysis
5. GridPix: fundamental concepts and charge detection – *Harry Van Der Graaf (NIKHEF)*
   - Working principle of GridPix, Gossip and Medipix and comparison with Si based detectors
   - Performance, measurements of fundamental parameters, tracking
6. Micromegas: fundamental concepts and charge detection – *Paul Colas (IRFU - CEA Saclay), David Attie' (CEA Saclay), Arnaud Giganon (CEA Saclay)*
   - Measurement of gain curve and maximal gain for an Ar-CF4-isobutane mixture with the standard Micromegas detector (Wasbox)
   - Normalisation of the gain
   - Measurement of the resolution of a Microbulk detector
   - Comparison of collection curves between a Standard Micromegas and a Microbulk
   - Measurement of electron drift velocity in T2K gas in the TPC
7. Muon spectrometers: TGC – *George Mikenberg (Department of Particle Physics, Weizmann Institute of Science), Meir Shoa (Department of Particle Physics, Weizmann Institute of Scienze)*
   - TGC working principle
   - Needs of a resistive layer and quenchers
   - Use of TGCs as trigger chambers
   - Signal studies and determination of the width of the avalanche.
   - Investigate malfunctioning and non uniformities

8. Muon spectrometers: RPC – *Roberto Guida (CERN), Giuseppe Iaselli (INFN Bari), Paolo Vitulo (Un. Pavia)*
   - Avalanche VS streamer modes
   - RPC timing properties
   - The working point at LHC
   - Understanding the signal and the influence of environmental parameters and gas purity
9. Simulation of drift-tubes – *Stephen Biagi, Heinrich Schindler (CERN), Rob Veenhof (CERN)*
   - Simulations techniques: Garfield/Magboltz
   - Fundamental aspects of gas detectors
   - Simulation exercises and comparison with experimental measurements

6. Photo-detectors: principles, performances and limitations

Convener: Christian Joram (CERN)

Lectures:

1. Photodetection: principles, performances land imitations – *Christian Joram (CERN), Nicoletta Dinu (LAL, Orsay), Thierry Gys (CERN), Samo Korpar (University of Maribor and JSI Ljubljana), Yuri Musienko (Fermilab / INR), Veronique Puill (LAL, Orsay), Dieter Renker (TU Munich)*
2. Photodetectors and their applications – *Christian Joram (CERN), Nicoletta Dinu (LAL, Orsay), Thierry Gys (CERN), Samo Korpar (University of Maribor and JSI Ljubljana), Yuri Musienko (Fermilab / INR), Veronique Puill (LAL, Orsay), Dieter Renker (TU Munich)*

The theoretical courses address the following points:

- Basics (photoelectric effect, Internal vs. external photo-effect, electron affinity, photo-detection as a multi-step process…)
- Requirements on photo-detectors (sensitivity, linearity, signal fluctuations, time response, rate capability / aging, dark count rate, operation in magnetic fields, radiation tolerance)
- Photosensitive materials
- Types of photo-detectors (PMT, MAPMT, MCP-PMT, HPD, HAPD, Photosensitive gas detectors (MWPC / MPGD), PIN diode (design), APD, G-APD / SiPM
- Applications

Laboratories:

1. Absolute measurement of the quantum efficiency of a classical PMT – *Christian Joram (CERN), Sune Jakobsen (CERN)*
   - Principle of the QE determination
   - Determination of photon flux
   - Measurement of the QE of a PMT in the wavelength interval 200 to 800 nm

2. Evaluation of the cross-talk of a multi-anode PMT – *Christian Joram (CERN), Sune Jakobson (CERN)*
3. Characterization of a micro channel plate PMT – *Samo Korpar (JSI Ljubljana)*
   - Evaluation of the gain and the single photon timing resolution
   - Observation of photoelectron backscattering
   - Evaluation of charge sharing
   - Measure the timing distribution for multiphoton pulses
4. Single photon counting measurements with a hybrid photon detector – *Thierry Gys (CERN)*
   - Measurements of spectra with various (low/high) LD light intensities
   - Measurements of spectra at non-optimal diode bias (under depletion) and high voltage
   - Contribution of photo-electron: energy dissipation in Silicon, back-scattering, electronics noise
5. Measurement of the gain and excess noise factor of an APD – *Dieter Renker (Paul Scherrer Institute)*
6. Characterization of the static and dynamic properties of a SiPM – *Nicoleta Dinu (LAL, Orsay), Véronique Puill (LAL, Orsay)*
   - Measurement of the current-voltage (IV) reverse characteristic
   - Determination of the breakdown voltage VBD and the Geiger mode V_{bias} range
   - Measurement of the dark count rate (DCR) as a function of V_{bias} and threshold
   - Analysis of different SiPM noise contributions: thermal generated carriers, after-pulses, cross-talk
   - SiPM in the dark or light conditions: measurement of the charge histogram and gain calculation as a function of V_{bias}

7. Silicon strips technologies

Conveners: Paula Collins (CERN), Michael Moll (CERN), Petra Riedler (CERN)

Lectures:
1. Introduction to Silicon Detectors - *Frank Hartmann (Karlsruhe Institute of Technology), Manfred Krammer (HEPHY, Wien)*
2. Data Analysis and Tracking - *Andrey Nomerotski (Oxford Un.), William Trischuk (Toronto Un.)*
3. Radiation tolerant Silicon Detectors – *Mara Bruzzi (INFN Firenze), Gianluigi Casse (Liverpool Un.)*

The theoretical lectures include an introduction to LHC silicon detectors and sensor production, review the features and performances of irradiated detectors and end with an overview of large systems operating in experiments. The following basic questions are addressed and answered:
- How does the silicon diode work?
- How is the detector processed and what do the different features look like?
- How to handle and inspect wafers, sensors, bond-wires and modules

- What does “extreme radiation environment” really mean? What damage can the particles do? What do irradiated objects look like?
- Introduction to what is going on at the microscopic level. How will the signal coming from your detector evolve with accumulated dose?
- Learn about the impact of the detector design on the physics performance

Laboratories:

1. Hands on: Silicon Diodes – *Lars Ecklund (Glascow Un.), Doris Eckstein (CERN), Gregor Kramberger (JSI, Ljubljana), Nicola Pacifico (CERN), Jose Garcia (CERN)*
2. Wire bonding, interconnect and reliability testing - *Alan Honma (CERN), Ian McGill (CERN), Adam Drozd (CERN), Florentina Manolescu (CERN)*
3. Hands on Silicon Strip Detectors - *Richard Bates (Glasgow Un.), Irena Dolenc Kittelmann (CERN), Marco Milanovic (JSI, Ljubljana)*
4. Laser induced Signals - *Nicola Pacifico (CERN), Gregor Kramberger (JSI, Ljubljana)*
5. The Medipix System - *Richard Plackett (University of Glasgow), Kazu Carvalho Akiba (NIKHEF), Gabriel Blaj, Jan Buytaert (CERN)*

The supporting laboratory classes cover:

- Getting up close and personal with a diode: measure its current, capacitance and depletion voltage
- Observe the change in the depletion depth versus bias voltage measured by the capacitance voltage relationship and measure the charge collection versus bias voltage for front and back side illumination
- Observe the noise of a silicon strip detector as a function of bias voltage.
- Observe the signal spectra due to a minimum ionising particle in a silicon detector and demonstrate the Landau distribution shape of collected charge.
- Observe the physical size of a charge cluster from a minimum ionising particle and relate this to the position resolution of the detector
- Try to measure devices on the metrology machine, and vibrate bond wires in a magnetic field
- Measure some irradiated devices and understand the signal properties! How can one improve the signal?
- Use an advanced laser based technique (TCT) to learn about the electric field shape inside a silicon detector and learn the differences between electron and hole drift velocities

Professors of excellence in the Silicon Detector course: Robert Klanner (Hamburg Un.) and Helmut Spieler (LBL)

8. Pixels detectors for LHC and for Linear Colliders

Conveners: Paula Collins (CERN), Michael Moll (CERN), Petra Riedler (CERN)

Lectures:

1. Hybrid Silicon Pixel Detectors – *Markus Keil (U.Göttingen/CERN)*
2. Monolithic Pixel Detectors – *Marc Winter (IReS), Jerome Baudot (IPHC)*

3. Pixel Detectors in HEP and HI Experiments - *Vito Manzari (INFN & Bari Un.)*
4. Pixel Systems at the LHC - *Heinz Pernegger (CERN), Daniel Dobos (Fachbereich Physik)*
5. Future developments and challenges – *Heinz Graafsma (DESY), Michael Campbell (CERN), Simon Kwan (Fermilab)*

The theoretical courses, among others, address the following points:

- Components of a pixel detector module and sensor processing
- Connections between sensor and electronics
- Introduction to different types of pixel detectors: 3D, diamond
- Pixels: what's the big deal with analog vs digital?
- Main features and limitations of CMOS sensors and read-out architectures
- Pixel Tracking telescopes
- Complexity of a Pixel systems in HEP experiments

Laboratories:

1. Handling of Silicon wafers and chips – *Markus Keil (U.Göttingen/CERN), Simon Kwan (Fermilab), Mauro Dinardo (Un. of Colorado at Boulder)*
2. The MIMOSA detector - *Marc Winter (IReS), Jerome Baudot (IPHC), Costanza Cavicchioli (CERN)*
    - Estimation of the charge calibration factor (ADC units per electrons collected in a pixel) and the equivalent noise charge of the sensor.
    - Estimation of the charge collection efficiency of the pixel sensor
3. Operate a mini HEP experiment - *Vito Manzari (INFN and Bari Un.), Annalisa Mastroserio (INFN and Bari Un.), Marian Krivda (Birmingham Un.), Costanza Cavicchioli (CERN), Romualdo Santoro (INFN and Bari Un.)*
    - Estimation of the rate of cosmic with an array of ALICE pixel detector modules.
    - Evaluation of the self-triggering capability of the detector.
    - Evaluation of the detector efficiency
4. Pixel Systems at the LHC – *Heinz Pernegger (CERN), Daniel Dobos (Fachbereich Physik), Alessandro La Rosa (CERN), Christian Gallrapp (CERN)*
    - Front-end tuning: pulse injection, threshold scan, time over threshold calibration
    - Source measurement with ^{241}Am

Plenary lectures:

1. Forty years of achievements and failures with gaseous detectors (1 hour) - *Fabio Sauli (TERA Foundation)*
2. Integrated semiconductor detectors for tracking and energy measurement: how to use new technologies (1 hour) - *Erik Hejne (CERN-IEAP/CTU-NIKHEF)*
3. A critical analysis from past to future techniques in Calorimetry (1 hour) - *Richard Wigmans (Texas University)*
4. Trackers and the effect of material on impact parameter and momentum resolution (1 hour) - *Pippa Wells (CERN)*

5. & 6. The energy flow concept: from LEP to LHC (2 hours) – *Patrick Janot (CERN)*

7. & 8. Silicon read-out: where the bugs can hide (2 hours) - *Helmut Spieler (LBL)*