Kénitra High Energy Physics Group Activities

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Kénitra University

My name is Mohamed Gouighri, Professor of physics at the faculty of Sciences, Ibn-Tofail University, Kénitra city.

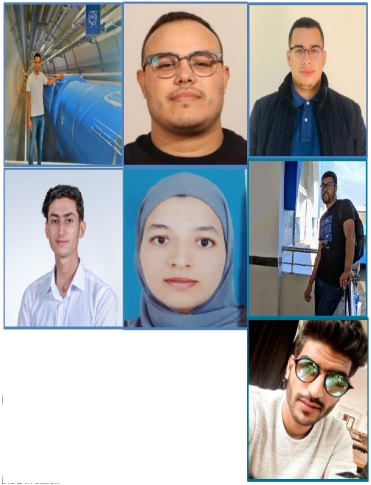
- Ibn Tofaïl University located in the heart of the Maâmora forest, and approximately 40 Km from Rabat the capital.
- University established on October 23, 1989.
- Established on 8 hectares, the UIT today supports more than 85,000 students within a campus composed of 11 institutes.

Figure: Faculty of Sciences.

Kénitra High Energy Physics (HEP) Group

The Kénitra HEP group is joining two international collaborations : **Hyper-Kamiokande** Collaboration in Japan and the **ATLAS** collaboration at CERN :

- ATLAS collaboration members
  - Prof. Mohamed Gouighri & Four PhD Students : Yassine El Ghazali, Mourad Hidaoui, Saad El Farkh & Hassan Assalmi.
- Hyper-Kamiokande members
  - Two Seniors : El Mahjoub Chakir & Mohamed Gouighri
  - Three PhD students : Rafik Er-rabit, Abderrazeq El Abassi & Assia El Kaftaoui.



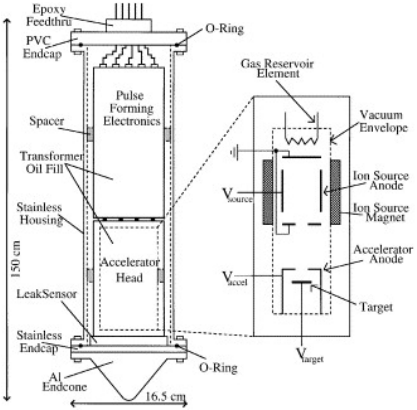
Main Contributions : Hyper-K

The Kénitra HEP group is joining two international collaborations : Our group is active in the hardware and software developments and physique analysis searching for hints of physics BSM.

- Hardware :
  - Far detector calibration Tasks
    - D-T Generator (Collaboration with USA Universities : LSU and UCI)
    - Pre-calibration of Photosensors (shared with other Institutes)
    - Source deployment System (Collaboration with University of Tokyo)
- Software : Our group involves in few tasks that needs development of new technics based on machine learning
  - Search for rares signals on subjects such as : Proton decay, Supernovae events and CP violation pushes the use of complex algorithms
- Physics analysis Tasks :
  - Proton decay search through two main channels : $p \to e^+\pi^0$ and $p \to \nu K^+$
  - Search for CPV and neutrino oscillation
  - Search for physics potential of a long-baseline neutrino oscillation experiment using a J-PARC neutrino beam

D-T Generator & Source Deployment System

Need a D-G Generator (**new generation**) which will fulfill similar functionality as the one used for the Super-Kamiokande.



The prototype deployment system using to deploy the Ni/Cf and AmBe source at the Hyper-K is the same as used for the Super-K.

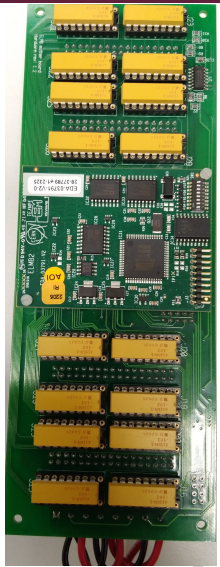
Main Contributions : ATLAS

The Kénitra HEP group is working on the analysis of several channels searching for hints of new physics BSM.

- Hardware level :
  - DCS development for the up-grade for the HL-LHC phase (HGTD)
  - Electronic calibration of the LAr Calorimeter : Crosstalk correction study for dead modules, investigate problematic channels.
- Software level : Our group involves in few tasks that needs development of new technics based on machine learning.
  - Our group investigate a lot on the MC generators to deal with the high pile-up at the HL-LHC phase.
- Physics analysis level :
  - Search of high mass resonances decaying into pairs of di-bosons
  - Di-Higgs searches in bbVV* decay channel : two modes (resonant and non-resonant)
  - Search for the charged Higgs boson decaying via $H^+ \to h(\gamma\gamma)W^+$ with 0 & 1 lepton in the final state at $\sqrt{S} = 13\ TeV$

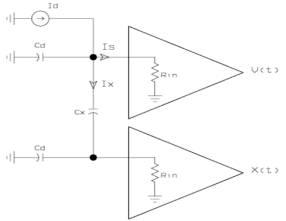
DCS development for HGTD

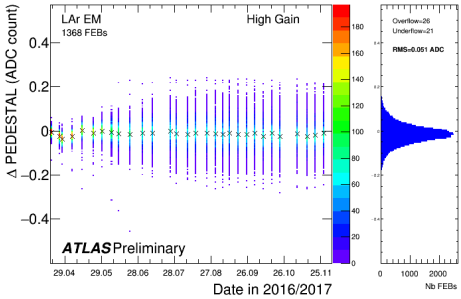
- Development of the OPC-UA server software for the communication through ELMB2
- ELMB2 is a general purpose plug-on I/O module for the monitoring and control of subdetector front-end equipment
- ELMB2 is based on the industry standard CANbus and CANopen
  $\Longrightarrow$ high-level communication protocol are implemented.
- Mostly Used read analog inputs (such as temperature sensors, voltages, etc.) and for digital input and output
- Used Wincc OA and JCOP framework
- Build a 4 wire connection to read Pt10k temperature sensors
- Pt10k will be installed in the inlet and outlet CO_2 cooling pipes
- Setup was done at CERN

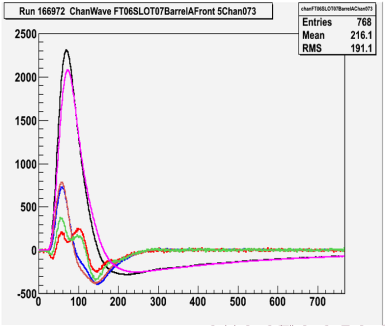


LAr Electronic Calibration

The Electromagnetic Calorimeter cells share a part of their collected current via: capacitances in Sampling 1, HV ink resistors collect S1 and S2, or via mutual inductances S2, S3. Effect on DB constants => energy computation







Future contributions with ePIC

- The participation of our group into the HGTD project which is based on the use of 50 µm-thick Low Gain Avalanche Detectors (LGADs) that provide precise time measurements might be the reason of our interest in joining the AC-LGAD-TOF tasks force.
- Our group expertise on the DCS might be useful for the monitoring of the AC-LGAD-TOF sub-detector and maybe other detector parts.
- Participation to the commissioning phases and other items ...
- Hire a PhD student next year to start a dedicated task

Thank you very much for your attention

Pre-Calibration System

- Measurement of the PMTs properties (gain as a function of HV, noise rate, relative detection efficiency ...) will help to tune the detector for both Simu and data.
- Need to define a Pre-calibration system to test 20" MPTs before their installation.
- Share this task with other institutes. Since it needs more technical efforts.

Overview of diboson resonance search

Search for high-mass resonances decaying into pairs of WW, WZ, ZZ, ZH, WH using Full Run II dataset collected with the ATLAS experiment at the LHC.

Semileptonic final states

Very good compromise between the high $\mathcal{BR}$ and the clean signature

One boson decays leptonically

3 channels

- 0-lepton: $Z \to \nu\nu$
- 1-lepton: $W \to l\nu \qquad l = (e, \mu)$
- 2-lepton: $Z \to ll$

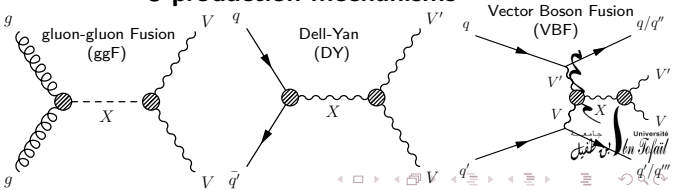
The other decays hadronically

- $V \to qq$ or $H \to b\bar{b}$
- 2 reconstruction techniques
  - ▷ **Resolved**: 2 Small-R jets $(R = 0.4)$
  - ▷ **Merged**: 1 large-R jets $(R = 1.0)$

Benchmark models

- Spin-1: HVT $W' \to WH/WZ$
- Spin-1: HVT $Z' \to ZH/WW$
- Spin-0: bulk RS Radion $\to WW/ZZ$
- Spin-2: bulk RS $G_{\text{KK}} \to WW/ZZ$

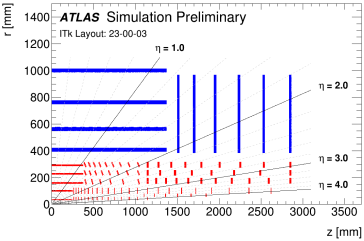
3 production mechanisms

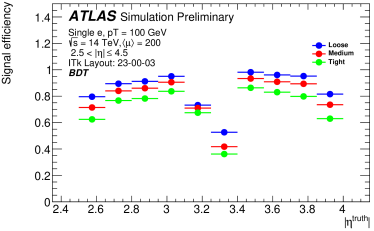


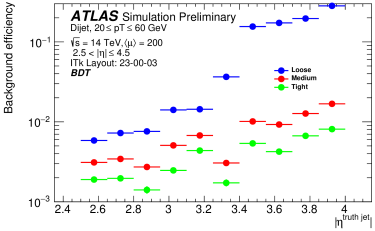
Forward electrons reconstruction and identification with ITk

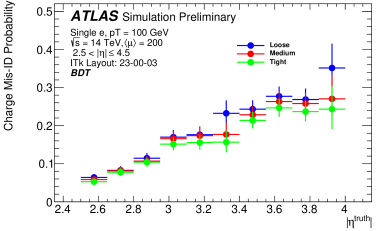
- Performed a performance study on forward electrons using ITk
- Clusters from calorimeter are matched to ITk Tracks
- Build a BDT to identify electrons fron bkgs and define WPs
  - $\Longrightarrow$ Used cluster shape variables, $\Delta\eta$ and $\Delta\phi$
  - $\Longrightarrow$ Two sets of training for ECAL and FCAL
  - $\Longrightarrow$ $3.2 < |\eta| < 3.35$ excluded

	$2.5 < \|\eta\| < 3.2$	$3.35 < \|\eta\| < 4.0$
Loose	$-0.045 < \text{BDT} < 0.095$	$-0.365 < \text{BDT} < 0.125$
Medium	$0.095 < \text{BDT} < 0.165$	$0.125 < \text{BDT} < 0.195$
Tight	$\text{BDT} > 0.165$	$\text{BDT} > 0.195$









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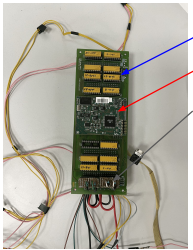
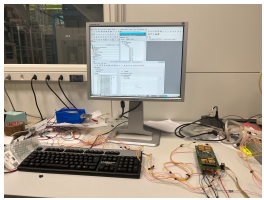
Development of a Detector Control System for the HGTD

Link

Monitoring through the ELMB

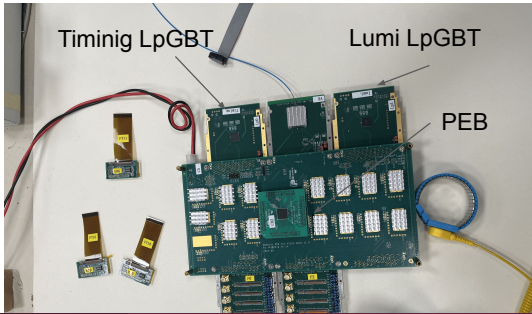
- DCS is a crucial component to ensure a safe and coherent operation of HGTD
- Monitoring of the temperature with Pt10K and NTCs sensors
- Use Embedded Low Monitor board to communicate the HW with SW





Monitoring through FELIX

- Monitor the temperature and the voltage of the PEB, LpGBT ALTIROC
- communication with FELIX to access to registers of

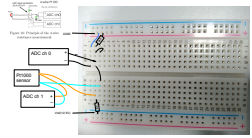


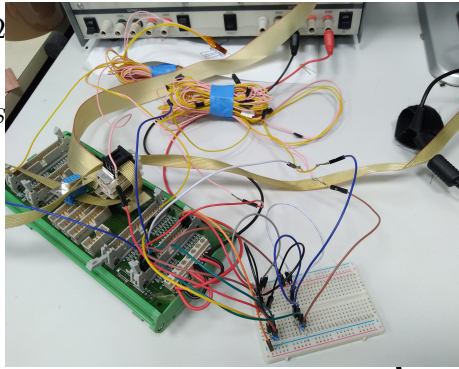
4 wire connection

- Use 4-wire connection to read Pt10k sensor
  $\Longrightarrow$ **pros**: Minimize the voltage drop in wires
  $\Longrightarrow$ Two ADC channels are used
- Two types of resistors are used for the adapter
  - For a Pt10k sensor: $R_S = 10$ kΩ and $R_C = 400$ kΩ
- The sensor resistance is gotten from: $R(T) = \frac{ch1.R_S}{ch0}$
  $\Longrightarrow$ Performance of the sensor is driven by quality of R_S
- Assume $R(T) = R_0(1 + at + bt^2)$
- Temperature is given by:

$$T = \frac{-a + \sqrt{a^2 - 4b(1 - R(T)/R_0)}}{2b}$$

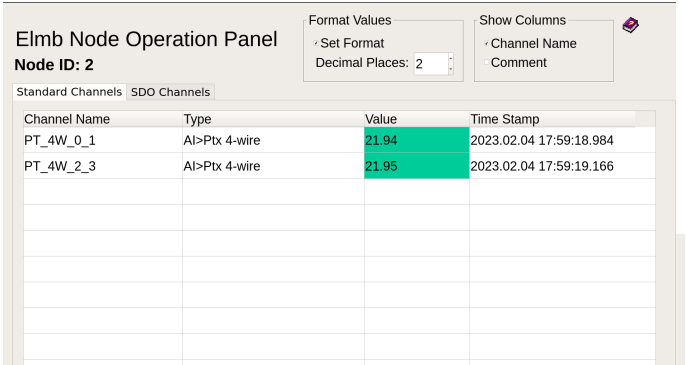
$a = 3.9083.10^{-3}$, $b = -5.775.10^{-7}$ and $R_0 = 10$ kΩ

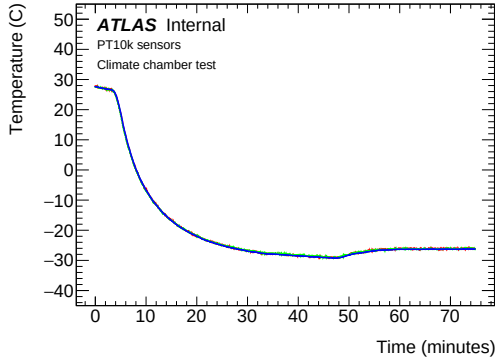




Monitoring through ELMB2

- Software is developed to monitor cooling pipes through ELMB2
- Hardware can be monitored through Wincc OA





- Sensors tested at low temperature using climate chamber