Task 1: TDAQ performance

Preparation

1. Startup the PCs
    a. Ubuntu (fhlteledev)
    b. NiCrate/Win7(fhldevel)
2. Login with
3. Check if EUDAQ version is running: EDIT branch in Github: https://github.com/dreyling/eudaq/tree/EDIT

Introduction

In this task, the **trigger data-acquisition (TDAQ) system** of the Mimosa26-based beam telescopes (EUDET-type telescopes, paper and user manual) is studied. First, the programming and the data stream of the **continuous read-out or so-called "self-triggered" Mimosa26** pixel sensors are understood. Second, together with an FPGA-based DAQ, a Trigger Logic Trigger Unit (TLU) and a DAQ software (EUDAQ) a system is built which records **events at a trigger** signal. Using an **internal trigger generator** the noise performance of the sensors and the system can be studied, using an **external trigger signal** as the PMT signal of the blinking LED the system can be operated as in a particle beamline, see Task 3 and Task 4.

Inspect the data lines of a Mimosa26 sensor

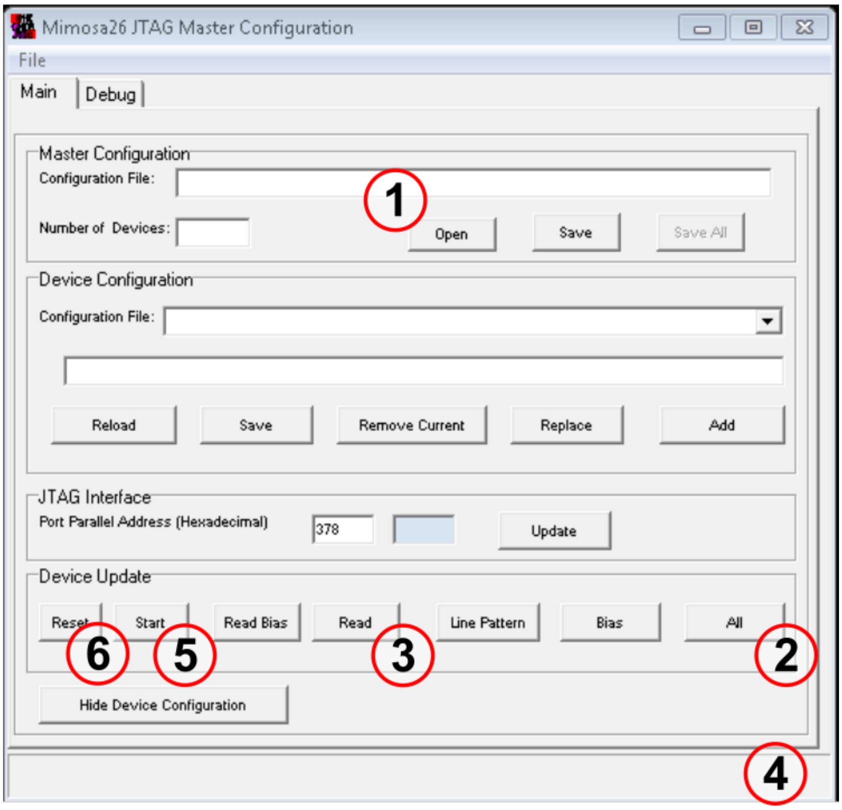
The Mimosa26 sensor is a 576 (rows) x 1152 (columns) pixel monolithic active silicon sensor. In a test beam operation, it is **continuously read-out by a rolling shutter** mode, which means row after row is subsequently read-out and reset. A complete frame (all rows) is buffered in memory before the data is transferred through the red data (ethernet) cable. In this first step, we will inspect with a scope the **4 data lines**.

For that, we have to program the sensors, basically the threshold value, which defines, when a pixel will be read out as active by a signal or noise. The **binary** pixels are active if they exceed a threshold value. The Mimosa26 sensor has four matrices (4x 288 columns) and each matrix an individual threshold value. Threshold values are provided in files, you can set **thresholds between 3 and 12** in units of the width of the noise distribution.

Have a look at the sample Mimosa26 sensor.

Program and start the sensor (JTAGing)

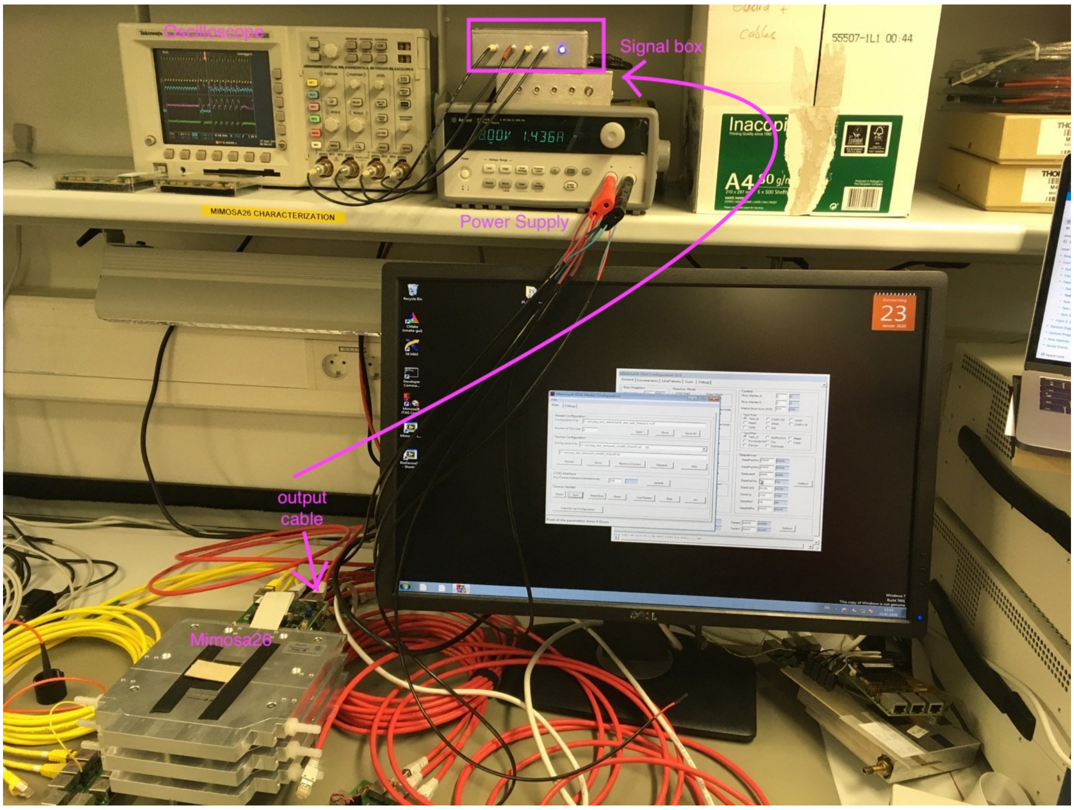
1. Open the Mi26 JTAG (Join Test Action Group) software by clicking the Icon at the Desktop.
2. Power the Mimosa26 sensors, the clock board and the Jtag boards with 8V (preset at Agilent). The power consumption should be ca. **0.9 A (stand-by/reset)** for two sensors.
3. Select a threshold file (OPEN a "Configuration File" in the "Master Configuration" section, see 1 in figure) and press ALL (see 2 in the figure). Chose the files with two sensors. Now all registers at the sensor are programmed and the current should rise to ca. **1.2 A (ALL)**.
4. By pressing READ (see 3 in the figure) the power consumption should stay at **1.2 A (READ)** and if the communication for programming was successful the JTAG software should indicate **"0 errors"** in the notification bar (see 4 in the figure).
5. By pressing START (see 5 in the figure) the current should go to ca. **1.45 A (Start)**. Now the sensor is running and we should see a data stream at the data output, see below.
6. At each time you can press RESET (see 6 in the figure) and program the sensor again starting with 3.

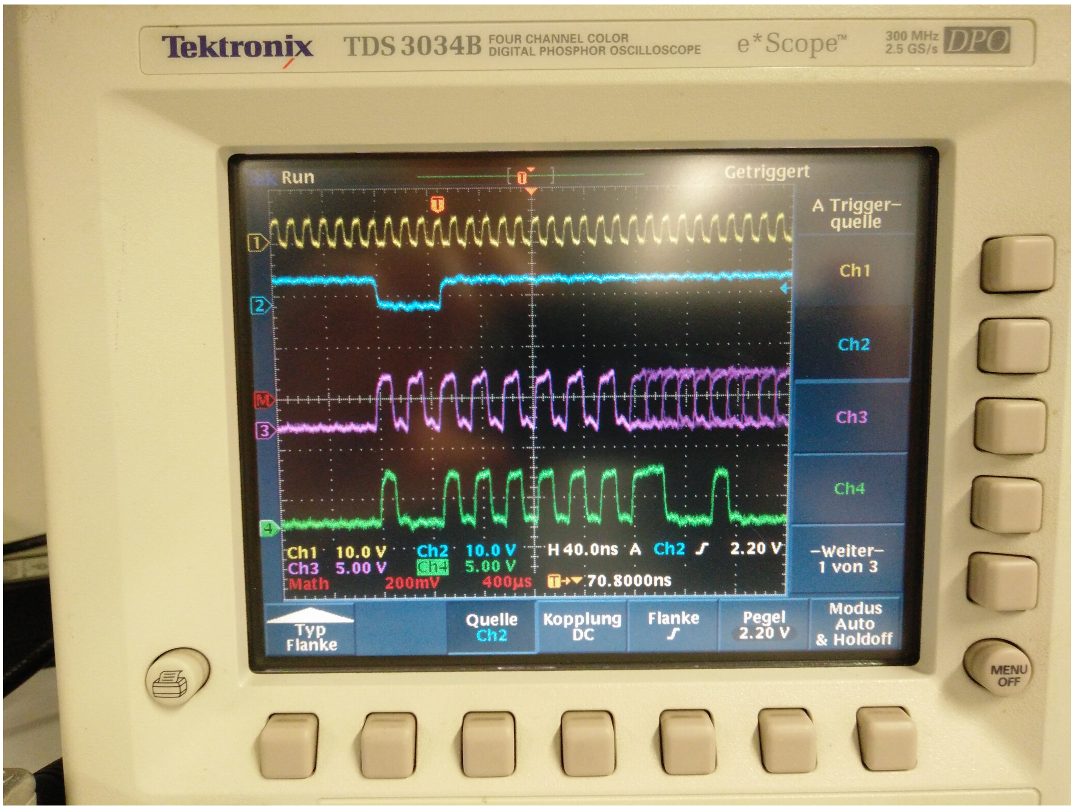


Be careful with the Mimosa26 detectors. Those, compared to the ones in the testbeam area, are not refrigerated and should not be overheated.

Connect the red data cable to the scope

1. Connect the ethernet cable to the LVDS-TTL adaptor box.
2. Connect the 4 LEMO outputs to a scope
3. Interpret the 4 lines: There is one **Clock**, one **Marker** (beginning of frame), and two **data lines**.
   a. ***TASK/QUESTION***: What is the clock frequency?
   b. ***TASK/QUESTION***: What is the frame rate?
4. Change the Threshold values and interpret the changes at the data lines.
   a. ***TASK/QUESTION***: How many bits per frame read-out can be potentially used for data encoding?

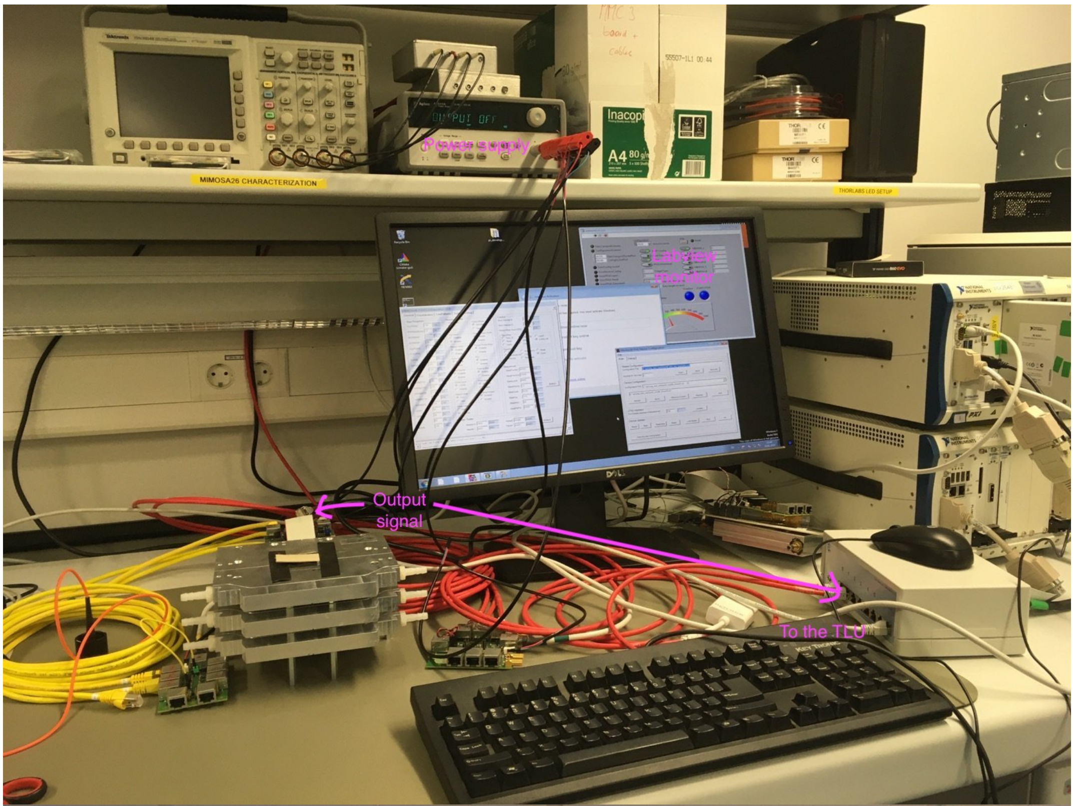


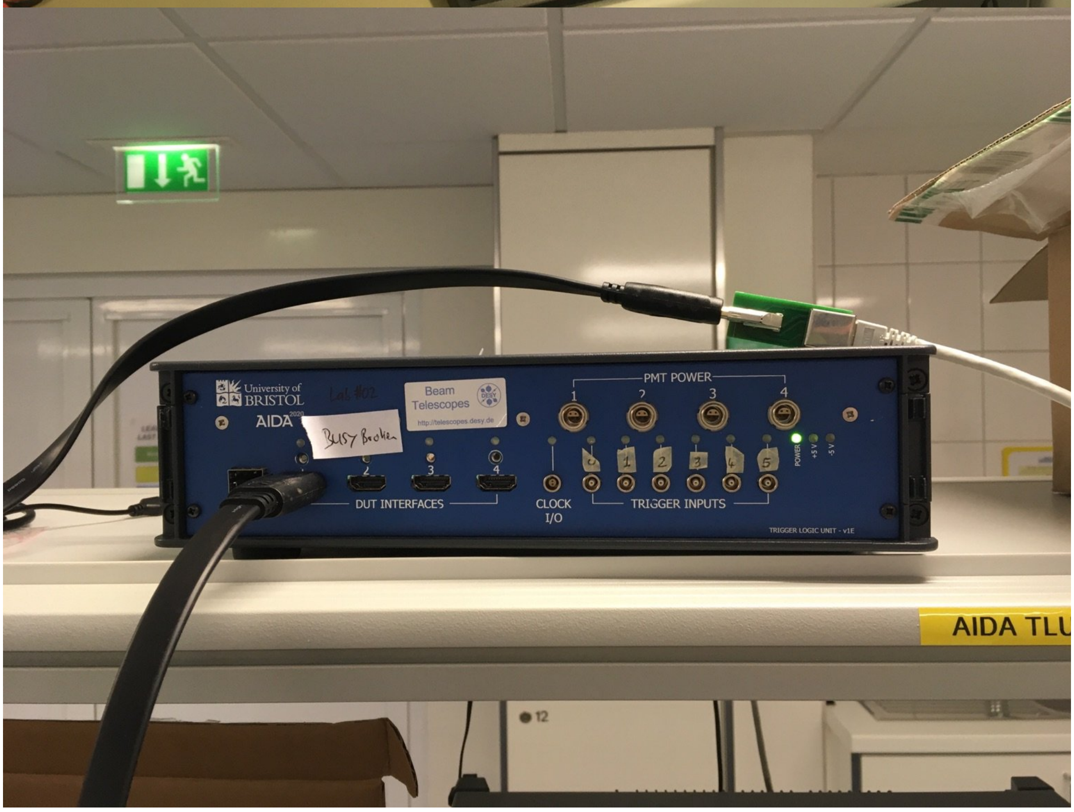


(Possible Tutor explanation: Zero-suppression, and data line organization: states...)

Data Taking using EUDAQ and TLU

After that, the data line is connected to the FPGA-based MimosaDAQ (see figure) and we can see the data in the EUDAQ Online Monitor (see figure).





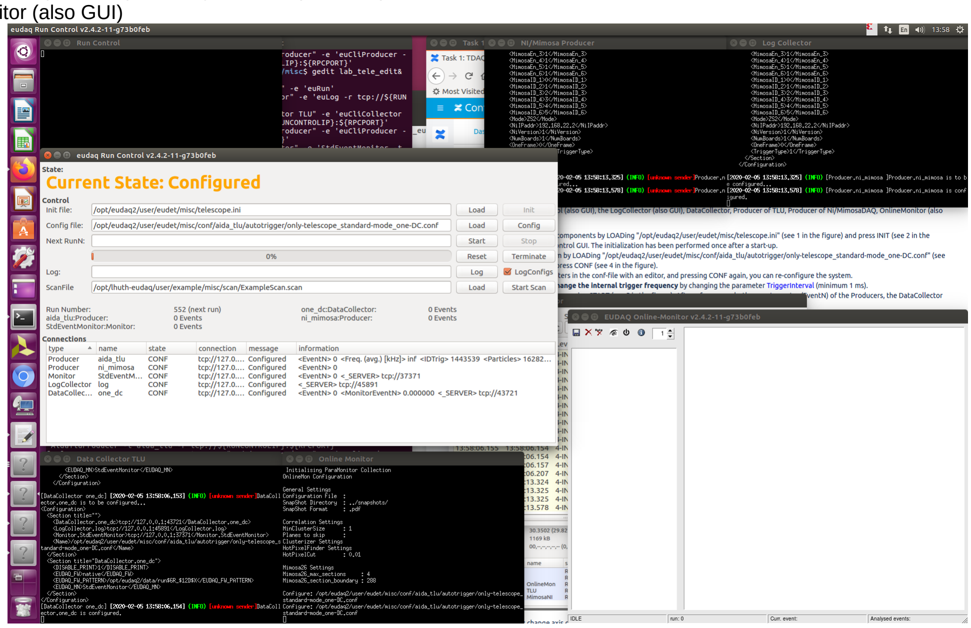
The FPGA of the MimosaDAQ records two subsequent frames as one event at a trigger. ***QUESTION:*** Why two frames are recorded?

The Online Monitor provides a **data interpretation of the Mimosa26 data stream** and first analysis of the frames. For example, the raw hit map is showing active pixels ("fired") and is adding up active pixels during a run (see run number at 1 in the figure). Other interesting plots are x- and y-projection and cluster size distribution.

Start the "autotriggered" data-taking

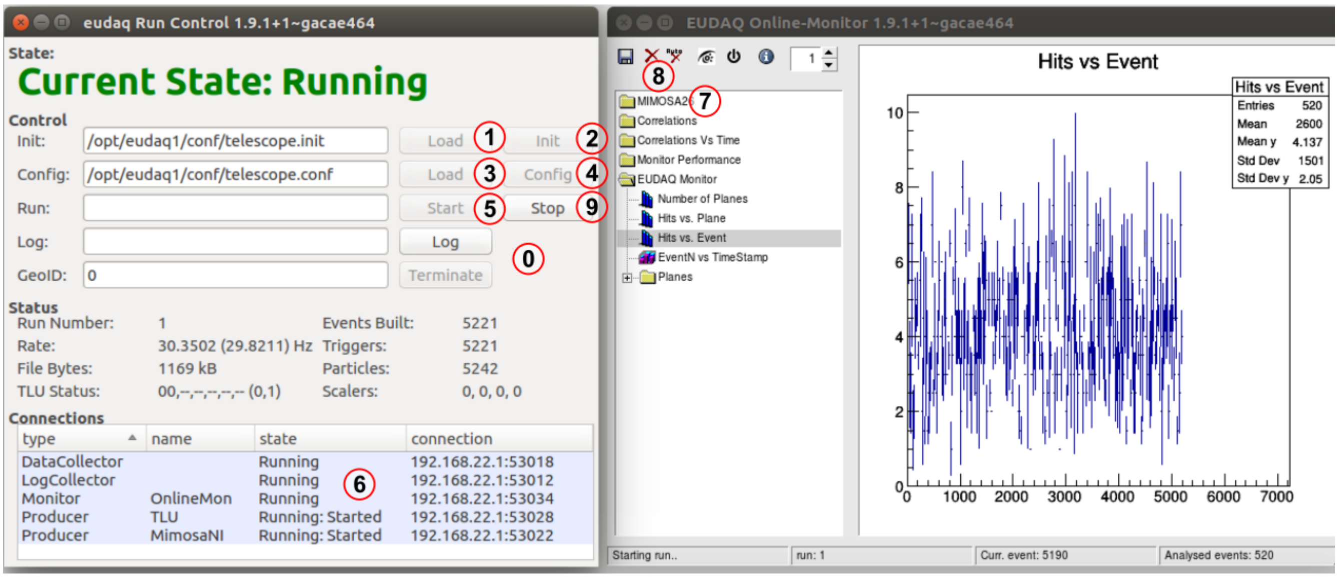
1. Connect the data line to the grey adaptor box to the first channel (see figure).
2. Start the LabView interface on the NiCrate
3. Start the sensors, as above, if not running still
4. Start EUDAQ2 by executing the script "./lab_tele_edit" in a terminal

a. go to "cd /home/teleadm/lennart/eudaq/user/eudet/misc"
b. Execute "source setup_eudaq2_aida-tlu.sh"
c. "source lab_tele_edit"
d. This should open multiple terminals each with a different EUDAQ process which are connected via TCP/IP: the RunControl (also GUI), the LogCollector (also GUI), DataCollector, Producer of TLU, Producer of Ni/MimosaDAQ, OnlineMonitor (also GUI)



1. Initialize all EUDAQ components by LOADing "lab_tele_edit.ini" (see 1 in the figure) and press INIT (see 2 in the figure) in the Run Control GUI. The initialization has been performed once after a start-up.
2. Configure the system by LOADing "lab_tele_edit_auto.conf" (see 3 in the figure) and press CONF (see 4 in the figure). By changing parameters in the conf-file with an editor, and pressing CONF again, you can re-configure the system. In this file you can **change the internal trigger frequency** by changing the parameter InternalTriggerFreq (minimum 1 ms).
3. Start the data run by pressing START (see 5 in the figure). After a few seconds, the event counter (EventN) of the Producers, the DataCollector and the Monitor should count up (see 6 in the figure).
4. Look at the Monitor and the graphs of "MIMOSA26" (see 7 in the figure). You are able to reset these entries by clicking the cross (see 8 in the figure).
5. After stopping a run (STOP) (see 9 in the figure), you can directly re-start, or first re-configure and start again...
6. (Pressing RESET (see 0 in the figure) is resetting the system and you have to re-do 5-7 to start again.)

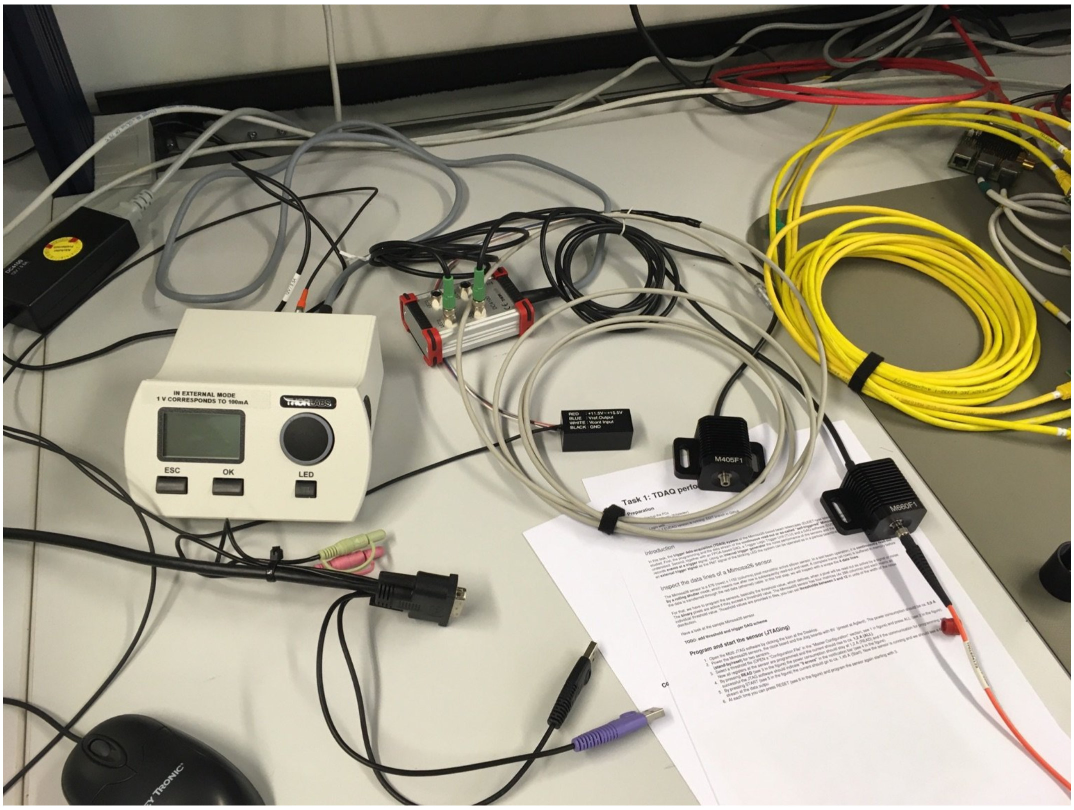
TASK: Change the thresholds (at least 3 settings) of the Mimosa26 sensors and determine a Fake-Hit-Rate (FHR) = Noise hits (= fired pixel) per second per pixel. Use plots from the OnlineMonitor to extract the number of hits. Draw FHR vs. threshold in a graph.



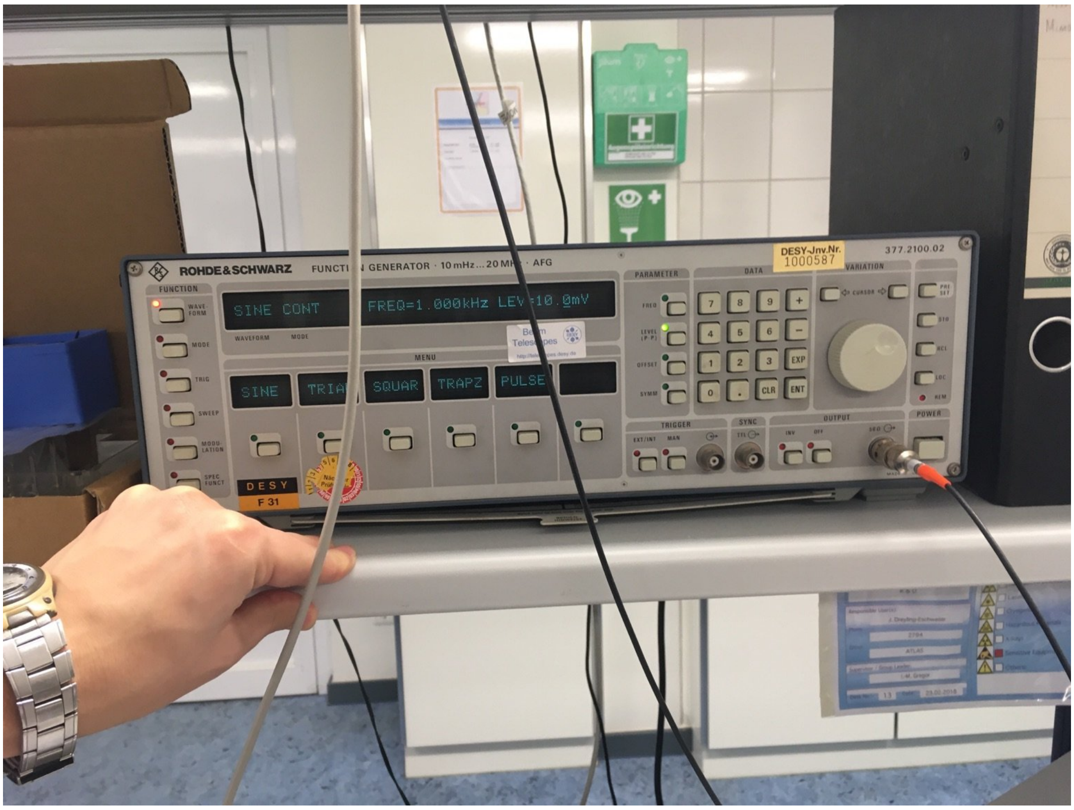
(possible TODO: change axis of Online Monitor, auto reset active at start up)

LED pulse and PMT signal for external trigger

Take a look at the config file. You can try to change the trigger for 1 PMT, you can take a look at the AIDA TLU manual, https://www.ohwr.org/project/fmc-mtlu/raw/master/Documentation/Main_TLU.pdf?inline=false. Page 29 shows the configuration for different PMT connections.



Using a PMT as trigger input at the TLU, the system can be externally triggered. You will need the function generator as the one in the picture.

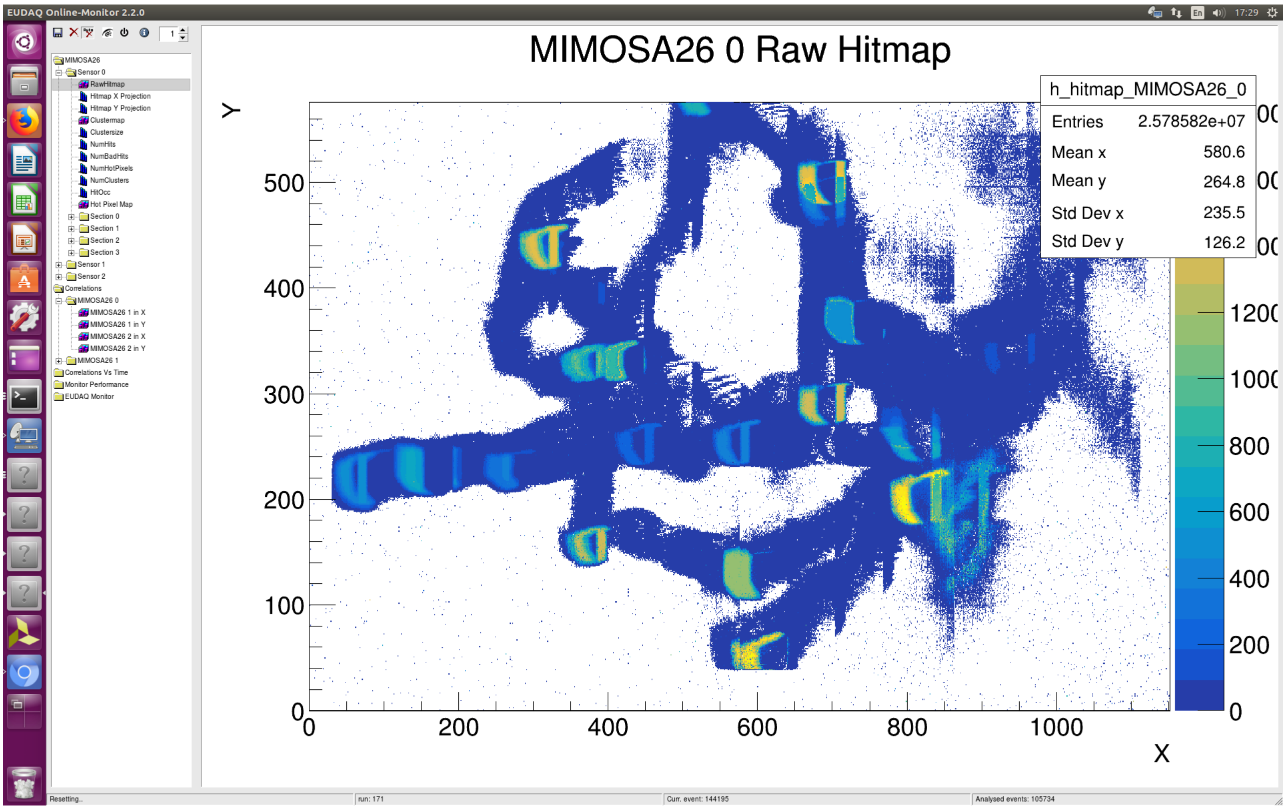


The LED system with two synchronous LEDs (blue for PMT and red for Mimosa26) can **imitate a particle beam**: The blue LED causes the trigger signal in the PMT and the red LED brings light to the sensor. For that, you have to open **carefully, carefully** the foil shielding the sensor in the Aluminum frame and hold the LED above the sensitive silcion area. There is only one side that responds to light.

1. Connect up everything as depicted (see the figure)
2. Operate the LEDs by a function generator:
    a. Switch to external mode at the LED driver.

b. Set a pulse with 0 to 4 V (height) and a width of 10 us. Select a moderate frequency of ~100 Hz.

3. Hold the blue LED to the PMT (covered) opening. First, check the PMT signal at the scope, it should be negative higher than -40 mV, which corresponds to the internal discriminator of the TLU.
4. Second, take this signal as first trigger input and adjust the EUDAQ conf-file "lab_tele_edit_pmt.conf". Set "InternalTriggerFreq = 0" and "trigMaskLo = 0x00000002" in the TLU section.
5. Hold the LED light above the Mimosa sensor and observe the Online Monitor...



Optional TASKs:

- If you have time compare this triggered data taking with an auto-triggered data taking: Set the system in 1 kHz auto-trigger mode and use a constant (cw) LED light on the sensor.
- Use the beam splitter and illuminate both sensors. Check the correlation plots in the Online Monitor.

Cleaning up!!!

Turn off the power supply for the mimosa sensor, and the power to the TLU, the lasers and the function generation once you are finished.