Task 3: Telescope alignment

Introduction

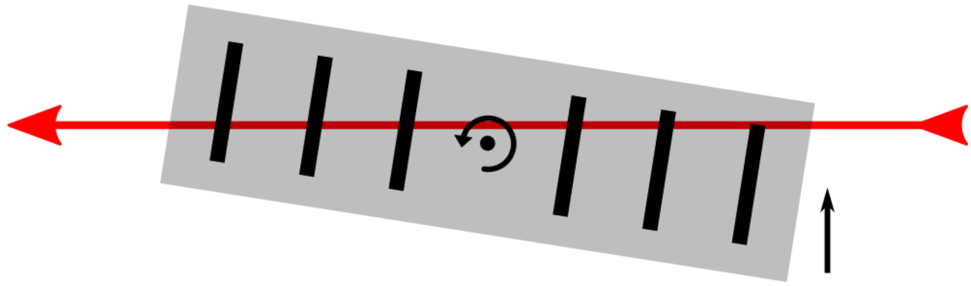
One of the most important test beam equipment is a telescope for **particle tracking**. Beam telescopes allow to investigate future particle detection sensors (DUT = Device Under Test). At DESY, so-called **EUDET-type beam telescopes** based on Mimosa26 sensors, see Task 1, are available as high-precision tracking tool for detector developers. This type of beam telescope originated from a EUDET project before 2010, and replicas of Mimosa pixel telescopes are as well operated at CERN, SLAC and ELSA (Bonn) nowadays.

EUDET-type telescopes provide a ~2 m-**precision** for particle tracking, a sufficient event rate (~ 2 kHz rate) and active area 2cm x 1cm, and an easy integration capability of DUTs. Operated by the **EUDAQ** framework (DAQ software) and analysed with **EUTelescope** (offline beam reconstruction software), these beam telescopes offer the whole infrastructure for detector development from measurement till results. The **beam** consists of electrons generated at DESY II synchrotron with energies ranging from 1 to 6 GeV.

Task

Align the telescope – as best as possible!

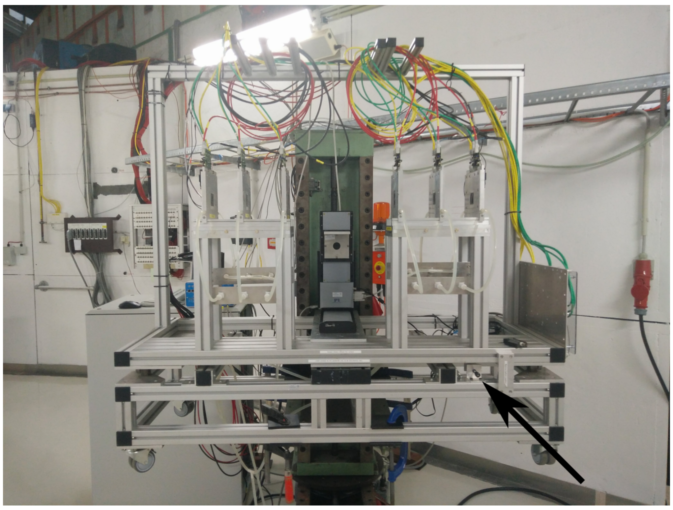
- **Hardware alignment:** Move the telescope that the beam spot is in the middle of all six telescope planes. Before move something, design a adjustment strategy and discuss it with your tutor!
    - Possible movements
        - x-y using the movable support of the telescope ("green stage")
        - rotation around y-axis of telescope
    - Your tools
        - Laser alignment system and phone and eyes.
        - Beam (using different lead collimators) and trigger frequency and correlation plots of Online Monitor, see below.



- Software alignment: Offline alignment for aligning sensors on a sub-micron level:
    - Use Corryvreckan for track finding and reconstruction and fine-alignment of the telescope planes.
    - go to ~/EDIT2020/config, there are a few files prepared:
        - geometry_initial.geo - the description of your telescope setup
        - reco_prealignment.conf - a Corryvreckan configuration file for performing prealignment (shifting the planes according to residuals)
        - reco_alignment.conf - a Corryvreckan configuration file for performing alignment by minimizing the track chi2
    - Run Corryvreckan via "corry -c <config_file>" after setting the proper data file from your data taking
    - Observe residuals, track chi2 and other plots in the produced histogram ROOT file

Moving the telescope

Since you control the movable support ("green stage") inside the control hut, one person has to be in the area for movements > 5cm to check that there is no stress on the cable or something similar ⚠️ The unit of the x-y-control is mm. If there is no movement, check the power switches at the stages or the power/signal connections.
The telescope frame can be rotated around the x-axis in the middle of the telescope. You can turn a mum-precise screw for that.

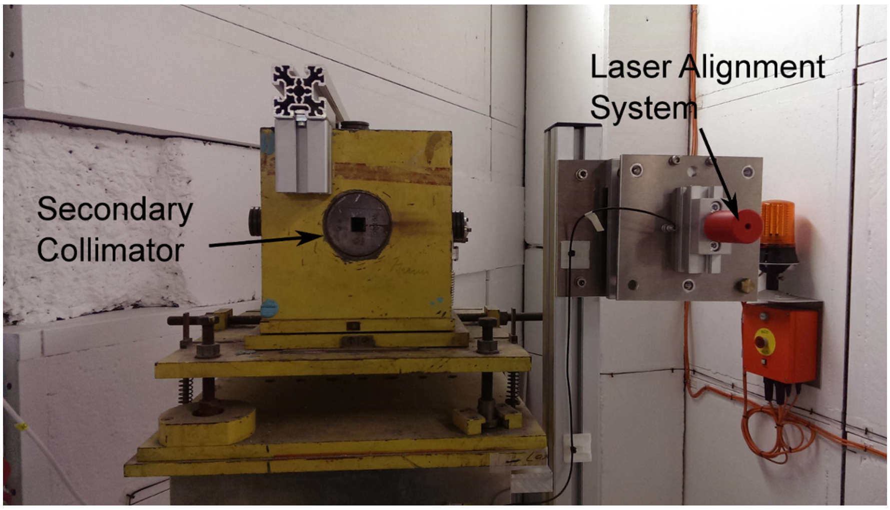


Using the laser-alignment system

You can switch on horizontal and one vertical laser line creating a cross as the expected beam center. Although it is a class 1 laser (red), please be careful since the beam and the laser height is ~1.70 m which perfectly match someone's eyes level ⚠️

Change the collimator

You can change the lead collimator inside the area to change the beam shape. You have to use gloves ⚠️ and be careful since the inlets are heavy. For this task, it is helpful to use no or a small collimator having an opening 5x5 mm2 or 2x2 mm2.



Switching on the beam

You learn the beam operation during the safety lecture and your tutor can open the shutter. Here the steps in a nutshell:

- Set the interlock and close the area.
- Open the shutter and use the beam monitor (LED panel) for a particle rate inside the area
- Place the fiber in the orbit – already done or done by the Control Room -3500
- Open the 1st collimator to 10mm each direction – probably already okay
- Switch on the magnet for momentum selection by set 2 GeV (= highest rate) for example.
  (If this magnet is not in use longer than 30 minutes, please ramp it down and switch it off.)

Operating the Telescope and Online Monitoring

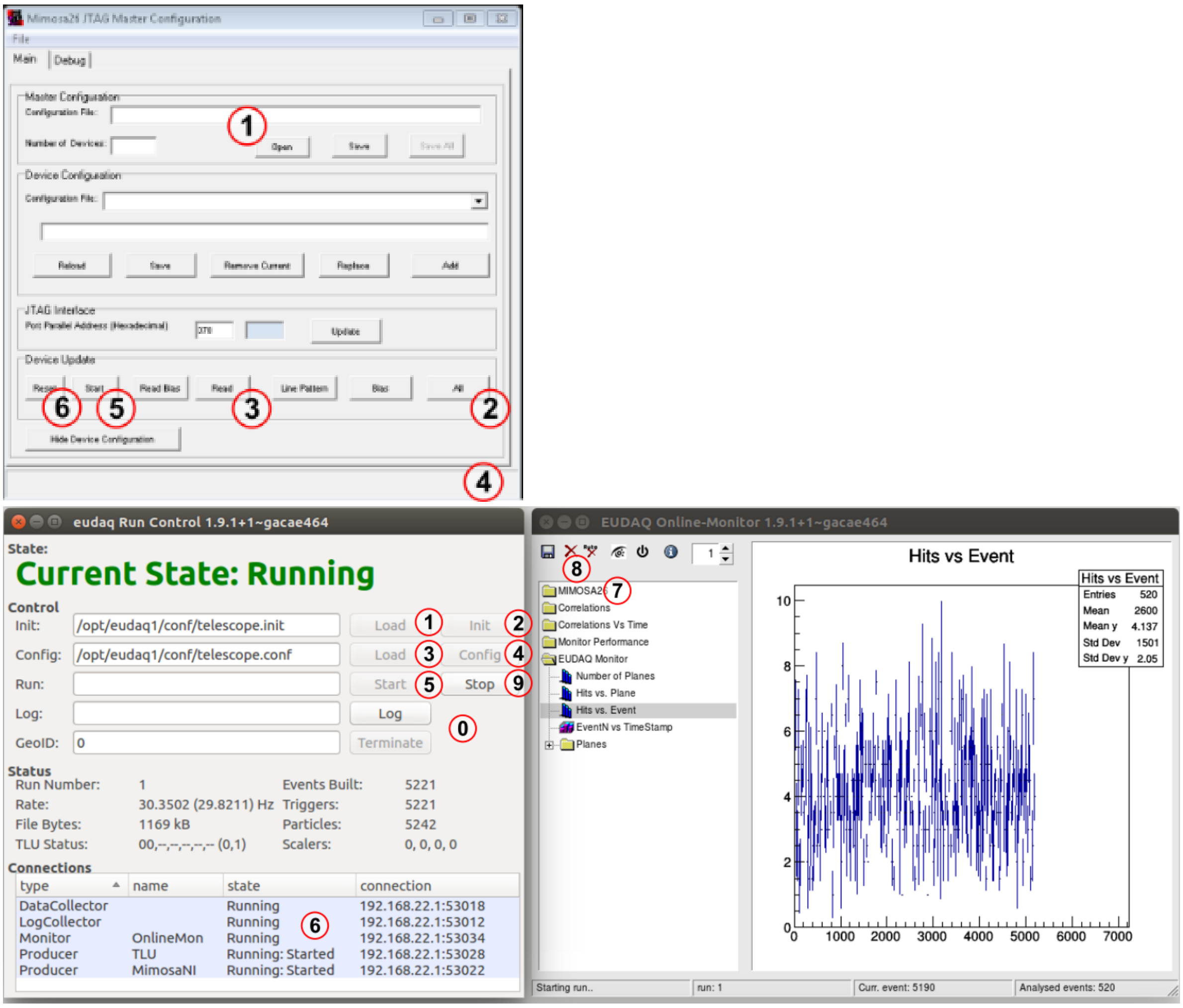
Having beam, you can use the Telescope TDAQ system (see Taks 1) to monitor the beam particles passing the telescope. Find the EDIT branch here: https://github.com/dreyling/eudaq/tree/EDIT

Start the data-taking and the Online Monitoring

1. Establish remote connections (via Remmina to the NiCrate/fhldatura and via ssh fhlrcdatura)
2. Start the LabView interface on the NiCrate/fhldatura
3. Program and **Start the sensor (JTAGing)** on the NiCrate/fhldatura
   a. Open the Mi26 JTAG software and the Agilent power control software by clicking the Icons at the Desktop
   b. Power the Mimosa26 sensors, the clock board and the Jtag boards with 8V (preset at Agilent). The power consumption should be ca. **2.0 A (stand-by/reset)** for two sensors.
   c. Select threshold file "thresh6_datura.mcf" (OPEN a "Configuration File" in the "Master Configuration" section, see 1 in figure) and press ALL (see 2 in the figure). Now all registers at the sensor are programmed and the current should rise to ca. **3.0 A (ALL)**.
   d. By pressing READ (see 3 in the figure) the power consumption should stay at **3.0 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).
   e. By pressing START (see 5 in the figure) the current should go to ca. **3.6 A (Start)**. Now the sensors are running and you can continue with 4. and starting EUDAQ.
   f. (At each time you can press RESET (see 6 in the figure) and program the sensor again starting with 3.)
4. Log into the Run Control PC via **teleuser@fhlrcdatura**
5. **Start EUDAQ2** by

   a. Go to "cd ~/EDIT2020/"
   b. Executing the "source setup.sh" script if you have a fresh terminal
   c. Executing the script "source align_tele_edit.sh" in a terminal
   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)
6. 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.
7. Configure the system by LOADing "lab_tele_edit.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 coincidence logic of the 4 Scintillator/PMT-devices** by changing the parameter AndMask (It is a BitMask: 15 = coincidence of all 4, 3 = coincidence of the first 2, ...).

8. 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).
9. 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). The Online Monitor provides a **data interpretation of the Mimosa26 data stream** and first analysis of the frames. For this task,
    a. the raw hit maps showing active pixels ("fired"), as well as
    b. the x- and y-projections, and
    c. the correlation plots between the telescope planes are very important.
10. After stopping a run (STOP) (see 9 in the figure), you can directly re-start, or first re-configure and start again...
11. (Pressing RESET (see 0 in the figure) is resetting the system and you have to re-do 5-7 to start again.)



Cleaning up

Missalign the telescope for the next group!

References

- DESY II Test Beam Facility: paper and website
- EUDET-type beam telescopes: paper and user manual