UNIVERSITY OF LIVERPOOL

5th Summer School on INtelligent signal processing for FrontiEr Research and Industry

Front End Electronics Lab 3:
New Sensors Characterisation
- Charge Collection Measurement -

ATLAS EXPERIMENT

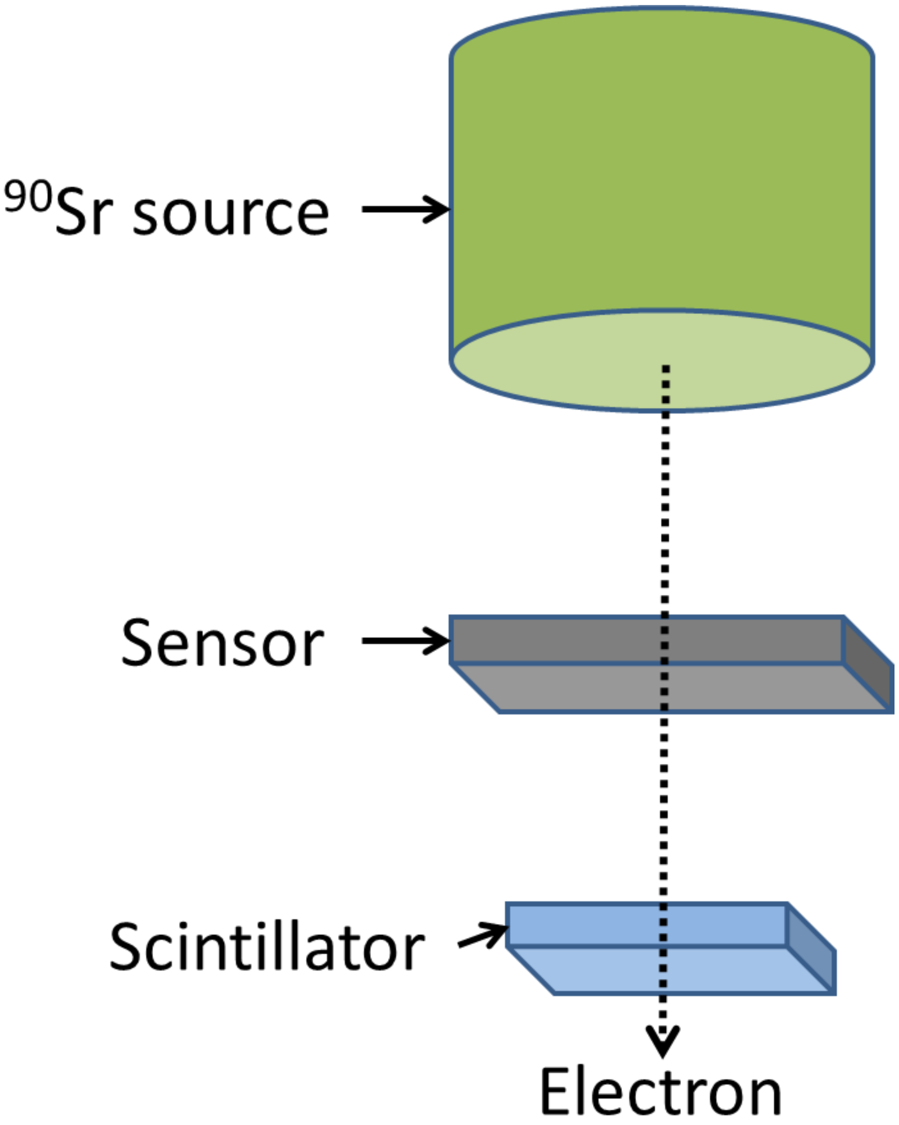
Lab Aim

- Give a short introduction into the ALiBaVa system for charge collection measurements
  - Perform some measurements with an un-irradiated silicon strip sensor at different bias voltages
    - Overview of charge collection behaviour of a silicon sensor
  - Analyse data from previous measurements of un-irradiated and irradiated samples
    - Compare the collected charge of irradiated samples with un-irradiated

- In this lab session silicon strip sensors are used to introduce the measurement principle, but the same method can be used for other sensor types for characterization

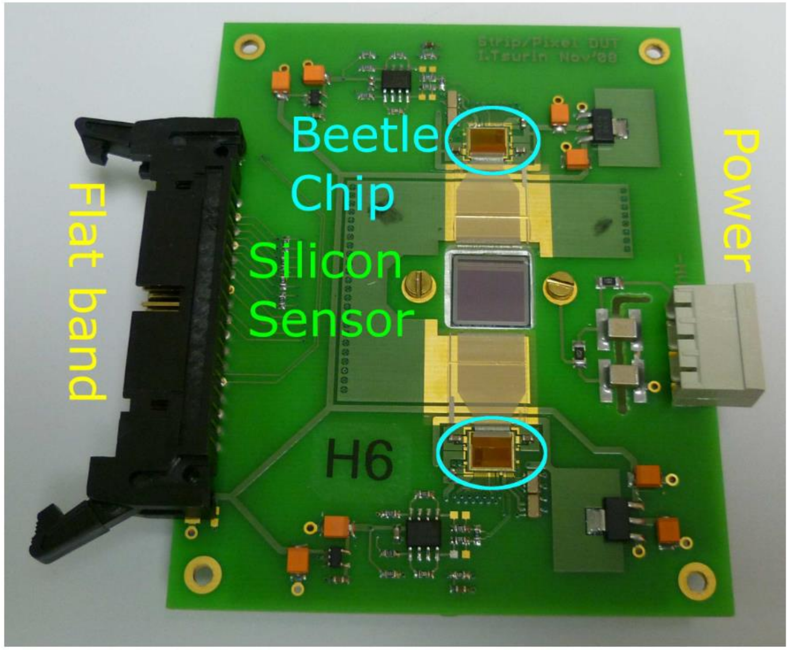
Measurement System

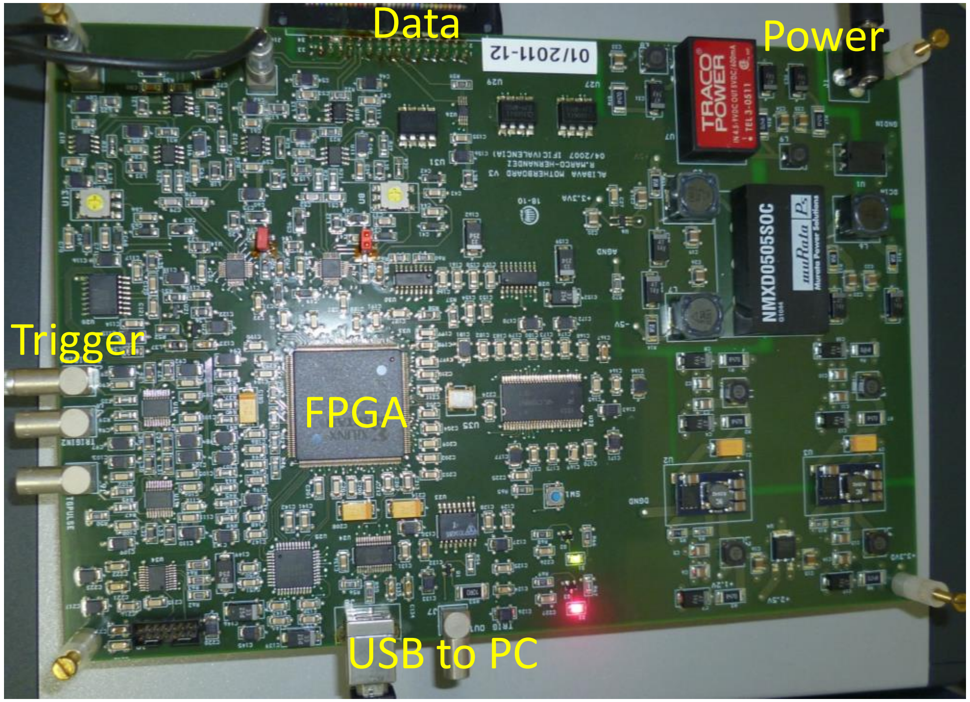
- ALiBaVa: a joined development of groups in **Li**verpool, **Ba**rcelona and **Va**lencia.
- Uses the beetle ASIC from the LHCb vertex locator
  - Analogue read-out => direct measurement of the collected charge
- Radioactive source (Sr90, beta-source) creates charge carriers in silicon
  - Electrons are minimum ionising particles (MIPs), therefore the expected collected charge in silicon for a fully depleted sensor is well known
- A Scintillator is used for triggering the readout



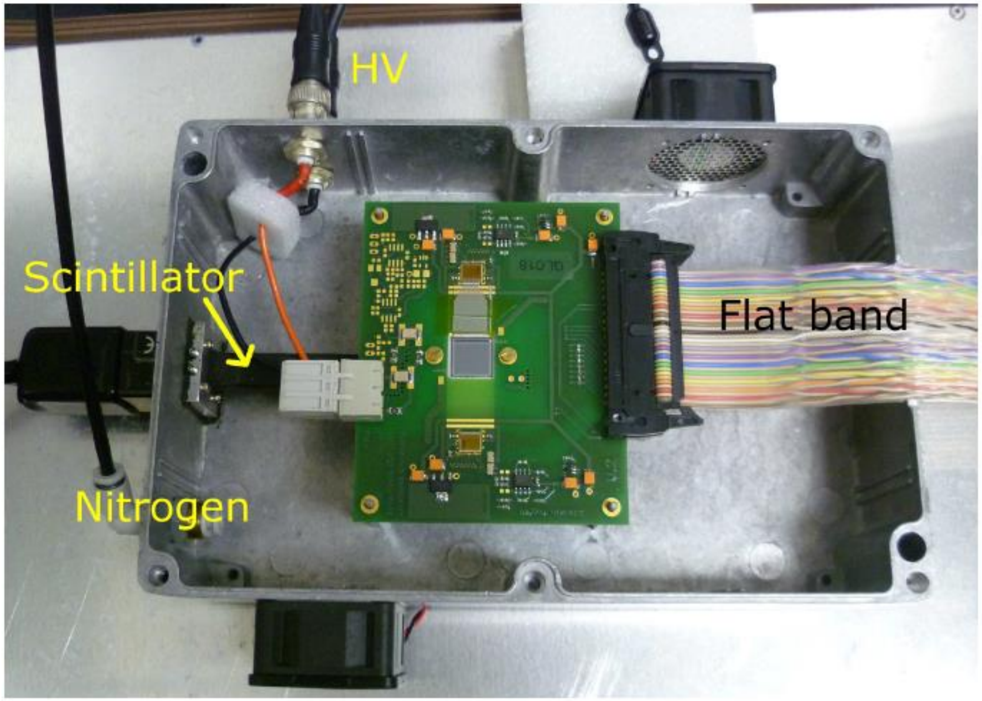
System

The beetle chip (in this case two) are mounted on a daughterboard, together with the silicon sensor.
Each front-end channel of one beetle chip is wire-bonded to a strip of the sensor (maximum 128 channels).
In addition the sensor is supplied with high voltage to bias it.
The data is processed/collected by a custom made FPGA board, that sends it to the control PC.





- Daughterboard is mounted in test-box with the scintillator below. A lid with an opening for the source is placed above.
- Usually the system is in a freezer to be able to measure irradiated devices (prevent annealing and reduce high leakage current caused by radiation damage).
- Fans and nitrogen feed improve cooling and prevent condensation.



BACKUP

Charge

$$N_{e/h} = \begin{cases} \frac{d}{3.68} \cdot (100.6 + 35.35 \cdot \ln(d)) & \text{for } 13\,\mu\text{m} < d < 110\,\mu\text{m} , \\ \frac{d}{3.68} \cdot (190.0 + 16.30 \cdot \ln(d)) & \text{for } 110\,\mu\text{m} < d < 3000\,\mu\text{m} , \end{cases}$$

- Number of electron/hole pairs in depleted silicon (MIP) where d is the sensor thickness in µm.

Data Analysis

- Pedestal measurement:
  - Random trigger, collect 10000 events
  - Calculates base-line for measurements (middle of ADC range)
    - For each channel individually, gaussian distributed where sigma is associated with the (electronic) noise
  - Calculate common mode noise shift (for each event)
    - Caused by external interference, all channels shift by the same value
- Source measurement:
  - Collect 100000 events, triggered by the scintillator
  - First do pedestal correction and common mode subtraction
  - Time cut reduces number of events to 10% (remove events that are not directly caused by the MIP)
  - Cluster building: pick channel with highest signal and compare against seed cut (signal-to-noise ration above seed threshold), add all neighbouring channels that are above low-threshold to build full cluster and calculate cluster charge
  - Fill cluster charge in histogram and fit with convoluted Landau-Gauss distribution (energy loss of electrons in matter follows Landau distribution, caused by high energy transfer from delta-electrons).
    - The most probable value (maximum of distribution) corresponds to the collected charge (in ADC units)

- Using the plateau region of a fully depleted un-irradiated sensor (and its known thickness) allows to determine the ADC-to-electron conversion factor