CREMLINplus detector school at Novosibirsk
Examples of what CERN can contribute

- Provide 1 member for the scientific organising committee, and help with the overall organisation of the school;
- Send 1 to 2 experienced teachers for giving lectures on detector technology;
- Provide hands-on **hardware** exercises and send the corresponding material to BINP:
  - For example: SiPM exercise, Solid State Detector exercise
- Provide hands-on **software** exercises based on real data taken with detectors at the test beam
  - For example: test beam data analysis wit corryvreckan, tomography
- Send ~3 young detector experts for supervising the hardware and software exercises.

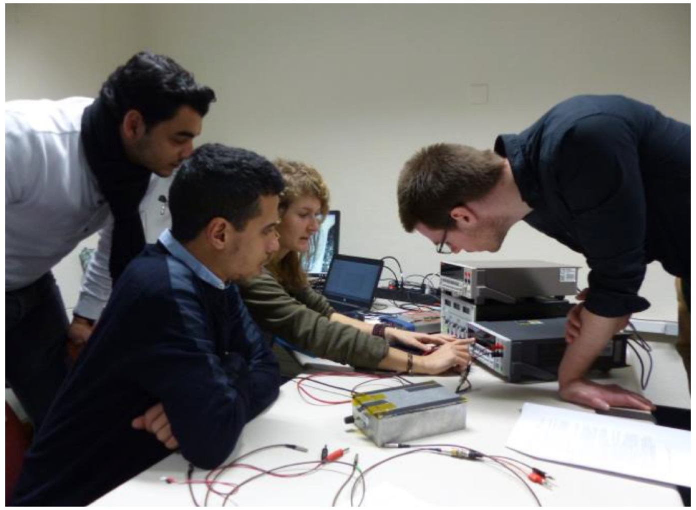
SiPM hands-on hardware exercise

Characterisation of Silicon Photomultipliers

- The hands-on exercise introduces the technology of Silicon Photomultipliers (SiPM). We use a measurement setup for the characterization of single SiPM assemblies. Basic properties such as the *value of the quenching resistors*, the *breakdown voltage*, the *noise rate*, the *cross talk* and the *gain* are extracted.
- The set-up consists of: SiPM, light injection and biasing circuit, HV source meter, temperature monitor, oscilloscope, Labview control/readout.
- Duration of the exercise ~2-3 hours, 2 students work together on one set-up
- CERN can provide 2 set-ups

See attached file for a full description

Dominik Dannheim et al.



Solid state detector exercise

Michael Moll, Pedro de Almeida,
Mateus Vicente et al.

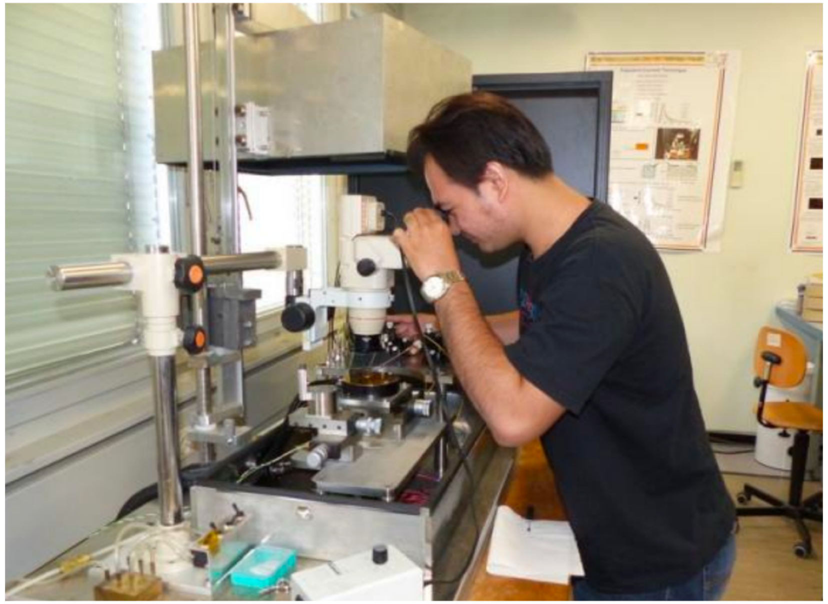
Operation of silicon particle sensors as detectors for ionising radiation, using silicon diode test structures of p-/n-doped electrodes implanted in an intrinsic silicon bulk material.

The first part of the lab session (*CV/IV measurement*) demonstrates the *development of the depletion region* and the *sensors capacitance* as a function of the bias voltage. Furthermore, this part includes the determination and calculation of intrinsic sensor parameters relevant for the operation of the sensor such as the *effective doping concentration* and the *electrical resistiv*ity.

The second part of the lab session (*Transient Current Technique measurement*) demonstrates how size and shape of the induced signal vary with bias voltage for front and back side illumination using a red laser with a wavelength of 660 nm. Based on the measurement it becomes possible to calculate the *mean velocity of the generated charge carriers*.

See attached file for a full description

NOTE: For this exercise we still need to see which parts of the set-up are sufficiently transportable to BINP. The set-up also uses a laser. We will adapt our plans to realistic possibilities to get a complete set-up at BINP. Possible collaboration between CERN and DESY.



Software-based hands-on exercise: Tomography

Thorben Quast et al.

Tomography of Thin Materials with Electron Beam

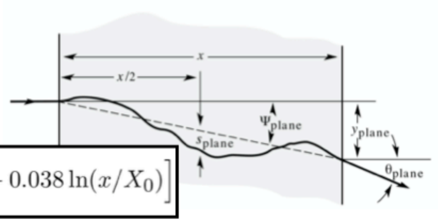
1. Goal

Measurement of the material budget of a prototype PCB for the CMS HGCAL upgrade.

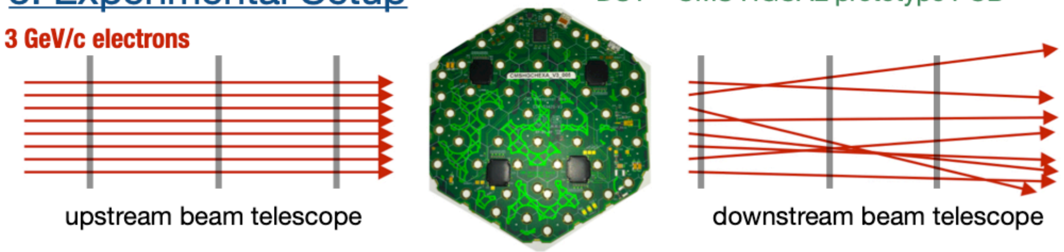
2. Principle=Coulomb Scattering

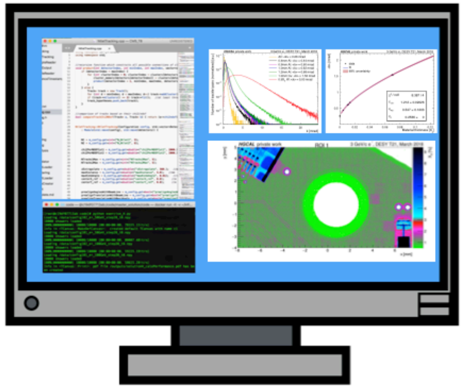
Material distorts trajectory of charged particles

$$\theta_0 = \frac{13.6\ \mathrm{MeV}}{\beta c p}\, z\, \sqrt{x/X_0}\left[1 + 0.038\ln(x/X_0)\right]$$



3. Experimental Setup





This is a data analysis exercise!

4. The task(s)-at-hand

➡Start: DATURA beam telescope data, pre-processed with corryvreckan

- Data quality monitoring of raw telescope data
- Software alignment of the telescope arms
- Calibration of kink angle variation w.r.t. material budget
- Material budget imaging of the PCB

(•)Bonus: Impact of material budget on calorimeter response

Exercise templates and instructions:
https://gitlab.cern.ch/tquast/electron-beam-tomography

Software-based hands-on exercise: Test beam reconstruction

Hands-On: Test-beam Data Analysis with Corryvreckan

Jens Kröger,
Simon Spannagel et al.

- introduction to test-beam data analysis
  for **silicon pixel sensor development + characterization** for HEP
- work on **real data** recorded at the Super Proton Synchrotron (SPS) at CERN
- analyse data to evaluate **performance of a real pixel sensor prototype**

- **Objectives:**
  - understanding of the functionality of modern silicon pixel sensors
    (and how they are operated and tested)
  - basic data analysis and data visualization skills (using ROOT and Corryvreckan)
- **Links:**
  - Corryvreckan Project website:
    https://www.cern.ch/corryvreckan/
  - manual for tutorial at University of Heidelberg (basis for this course):
    https://www.physi.uni-heidelberg.de/Einrichtungen/FP/anleitungen/F96.pdf
- **Remarks:**
  - suitable for last-year Bachelor students + Master students
  - time ~ 2 days (can be adjusted according to available time)
  - course can be done in classroom or purely virtual