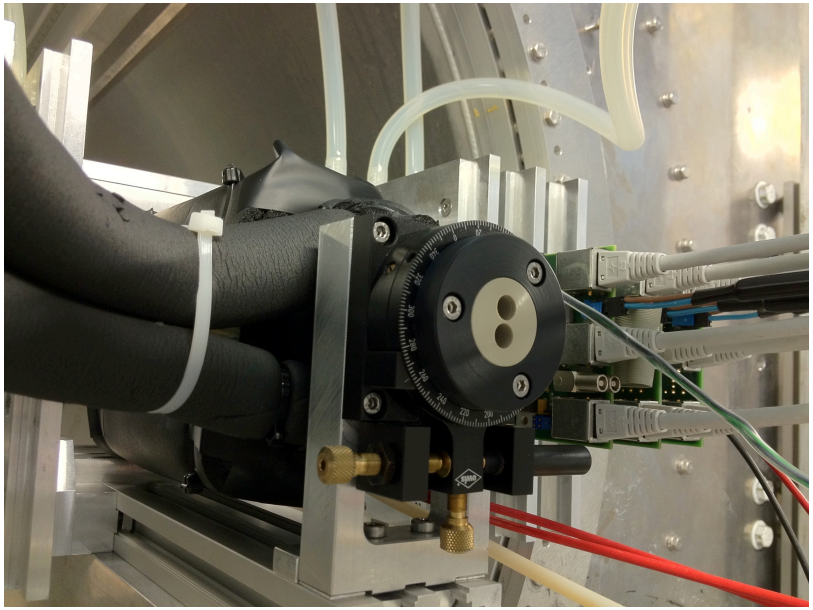
Calibration of Alibava Readout System

For Lorentz Angle Measurement Experiment



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2013 Summer Student Program

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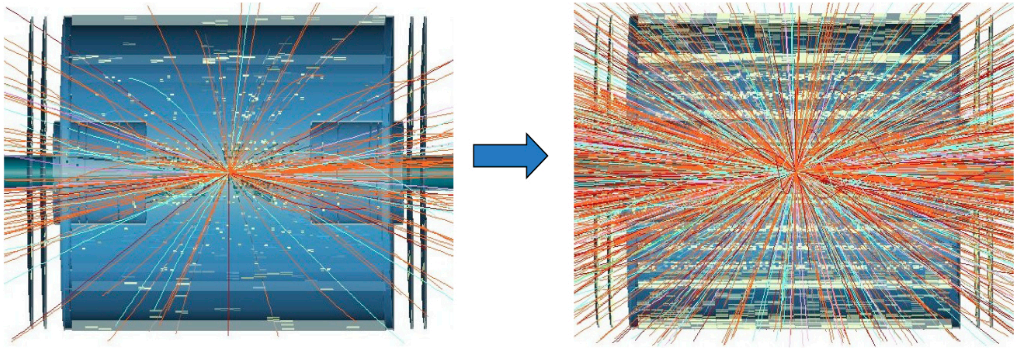
DESY - Hamburg, 5/9/2013

Contents

Radiation Damage in HL-LHC

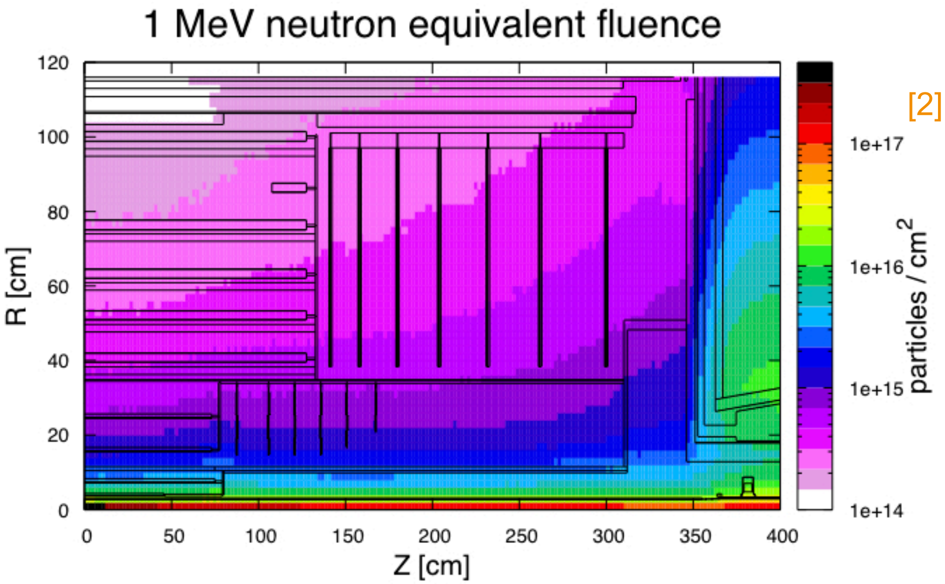
- In ~ 2020 the LHC will need an upgrade to increase its total luminosity (rate of collisions) by a factor of **10**.

[1]



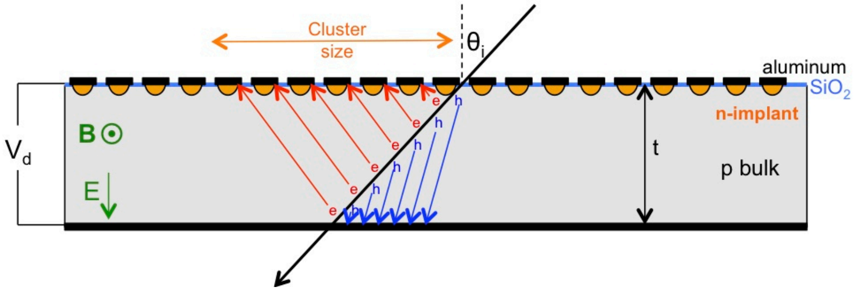
LHC in 2011: 1×10^{33} cm^{-2} s^{-1} HL-LHC : 5×10^{34} cm^{-2} s^{-1}

The Radiation background simulations

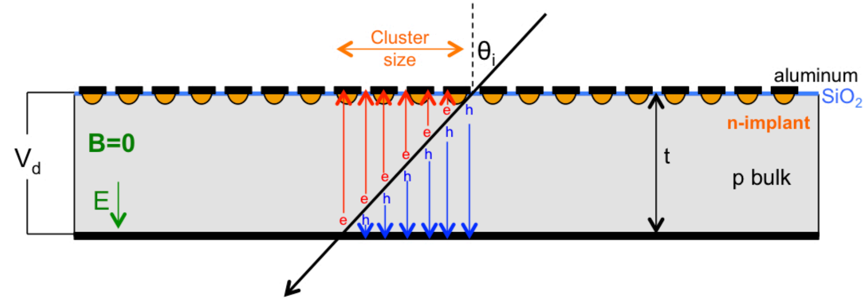


[1] H.Zhu-HEP-LHC, 20-22 November 2012, Protvino, Russia
[2] ATLAS Letter of Intent: Phase II Upgrade *CERN-LHCC-2012-022*

Lorentz Angle



With Magnetic field



Without Magnetic field

$$\text{Cluster Size} \approx t \cdot tan\theta_i$$

> The Lorentz angle Θ_L, by which charge carriers in a silicon sensor are deflected in a magnetic field B transverse to the drift direction, is given by [2]

$$\tan(\theta_L) = \mu_H B = r_H \mu_d B$$ [3]

Hall Mobility

Drift Mobility

Hall Factor

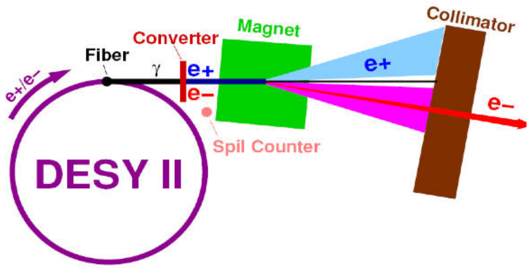
$$\mu_d = \frac{\upsilon_s / E_c}{[1 + (E/E_c)^\beta]^{1/\beta}}$$

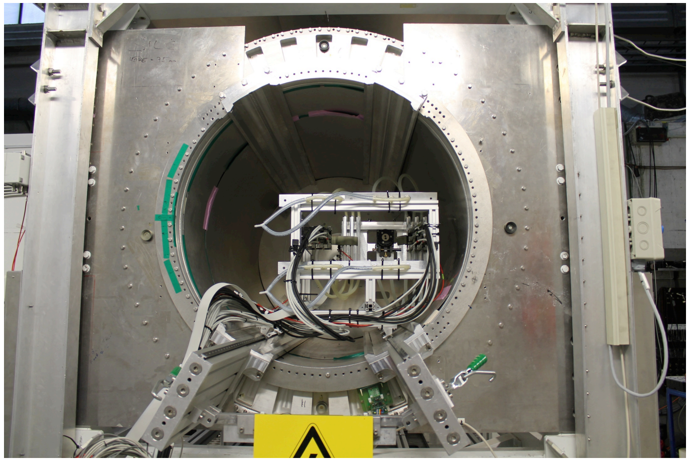
[2] Lorentz angle variation with electric field for ATLAS silicon detectors *ATL-INDET-2001-004*

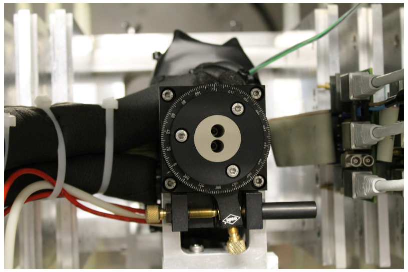
[3] E.Yidlirim, DPG Dresden March 4, 2013

The LAM Setup

- Beam
  - Beam from DESY II test beam facility (1-5 GeV).
- Magnetic Field
  - 1 T superconducting solenoid.
- Particle tracking with pixel beam telescope.
- Device Under Test (DUT)
  - Future ATLAS sensor miniature
  - **Alibava Readout System**
  - Cooling system for irradiated samples.







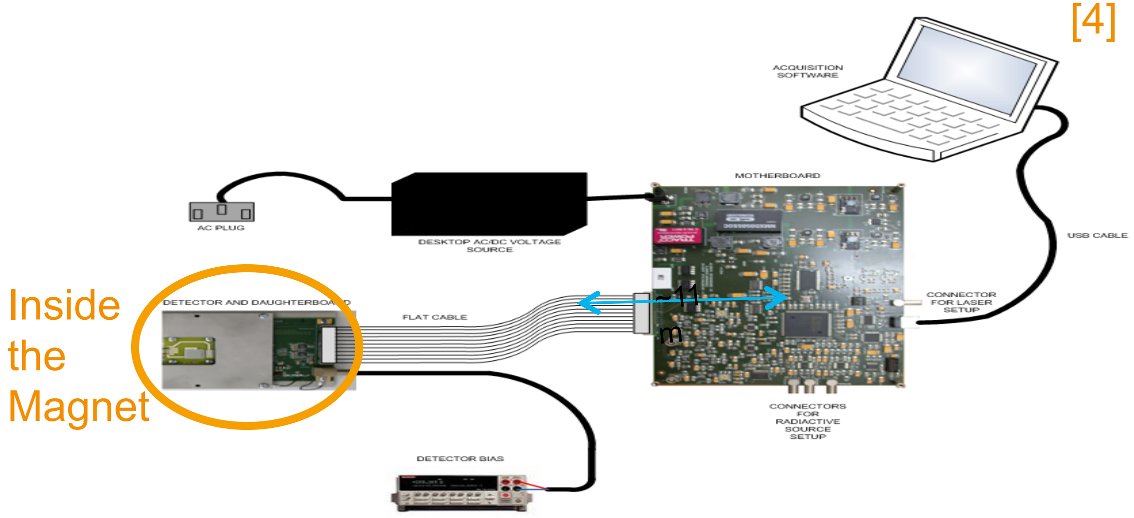
*More details on test beam and beam telescope in **Tobias Bisanz's** presentation*

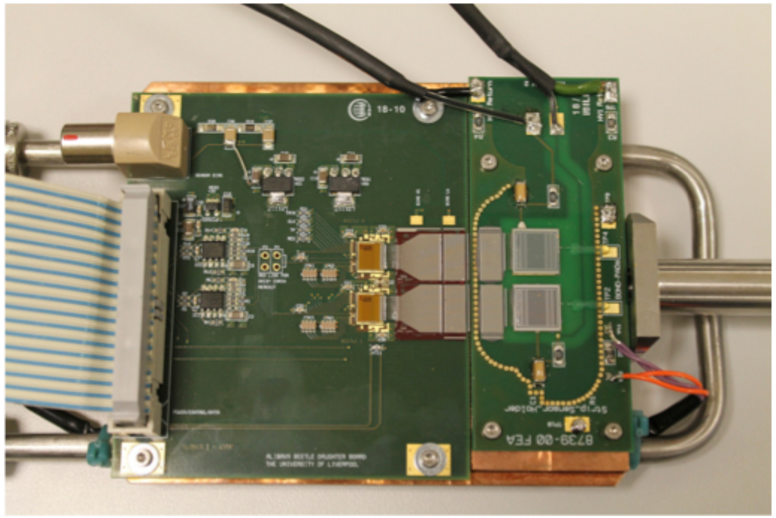
The Alibava Readout System

> Main System Components

- Daughter board
  - A small board that contains two Beetle readout chips (used in *LHCb*) , has fan-ins to interface the sensors.
- Mother board
  - Process analogue data that comes from the readout chips.
  - Process trigger input signals (RS), generate triggers (Laser).
  - Control hardware part (FPGA) and communicate with PC via USB.
- Software
  - Control the whole system and produce output files for data analysis.

[4]

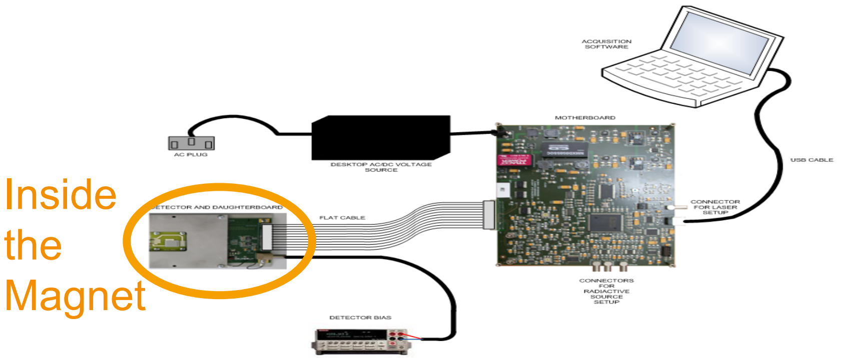




[4] Marco-Hernández, Alibava System Hardware
15th RD50 Workshop, 16-19 November 2009, CERN

Motivation for the Calibration of Alibava

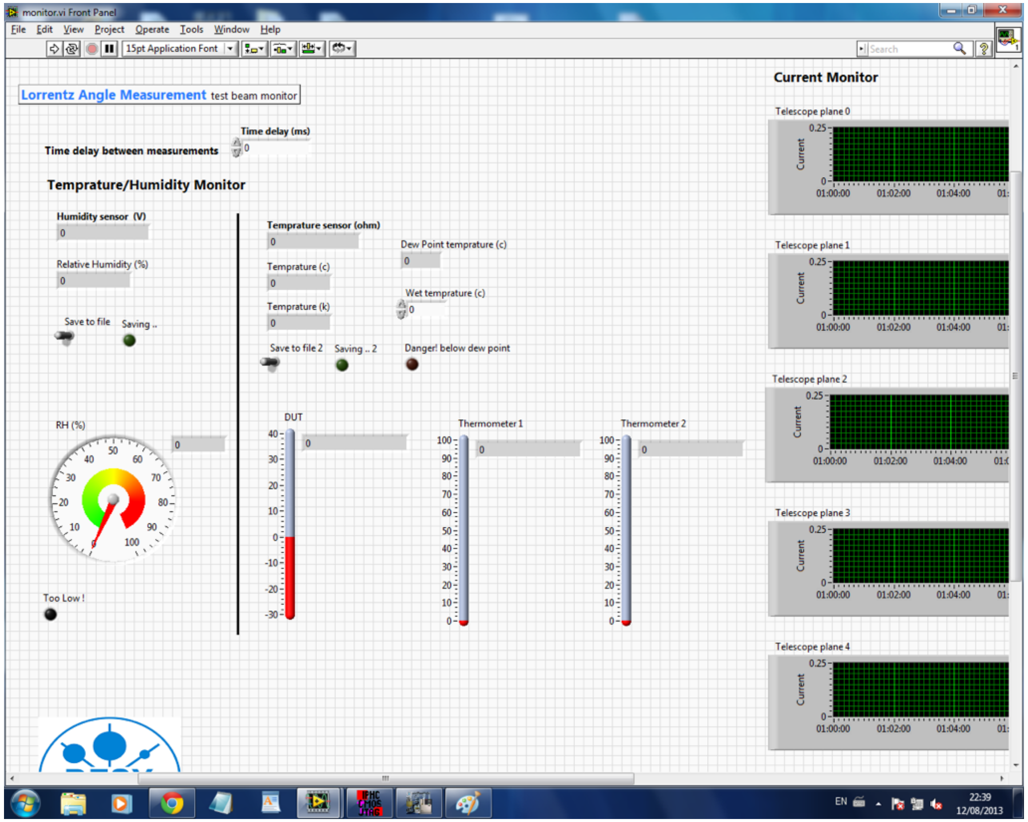
- Due to experiment setup (usage of high magnetic field), Alibava daughter and mother board are connected via a long (~11 m) cable.
- In Addition, the DUT will be connected to a cooling system.
- To account for the effects of the setup on the calculated signal, calibration investigation at the different setup settings has to be carried out to find how signal changes with **cable length, temperature and high magnetic field** (we expect no change).
- Also, if any changes are encountered calibration will help do the corrections.



Monitoring of DUT parameters

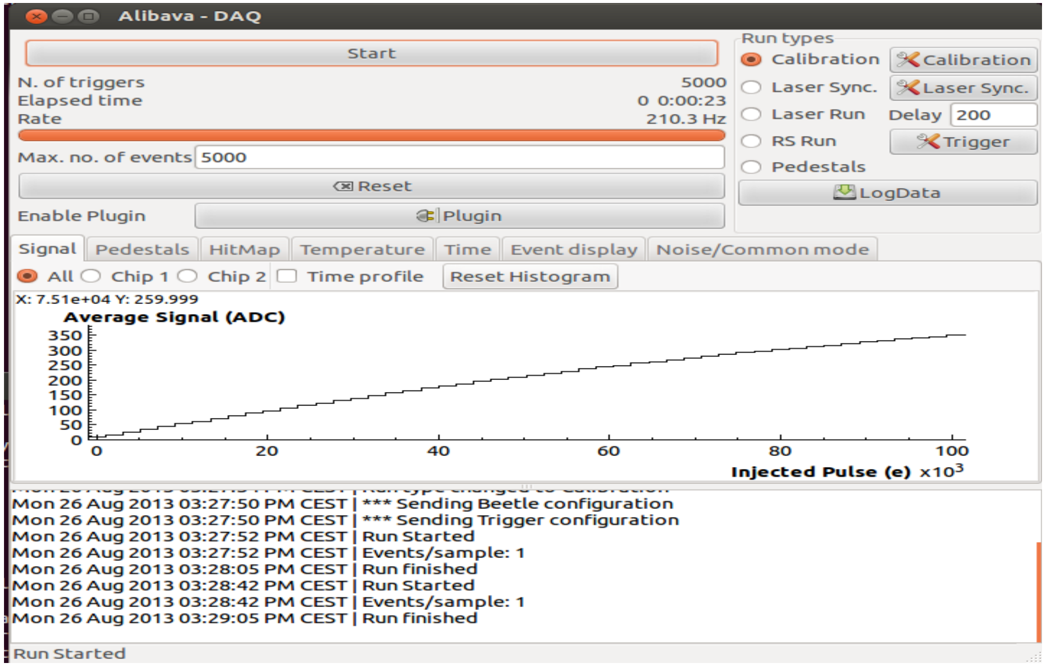
- In order to monitor DUT different parameters (Temperature of DUT, humidity and temperature of air inside DUT), in addition to current monitoring of the EUDET telescope Mimosa chips, a monitoring interface was created with NATIONAL INSTRUMENTS LabVIEW

- Also, the monitor calculated the dew point temperature from sensors, to avoid the condensation of water vapor due to cooling inside DUT.



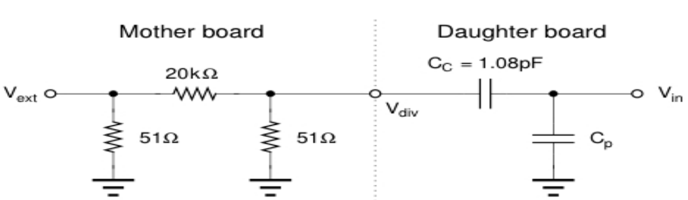
Calibration process

- The aim of calibration process is to determine the Signal (ADCs) per charge injected (e^-) , to be used for Signal/ Charge collected.
- The Alibava daughter board has a charge injection circuit.
- Charge injection can be also to test dead channels.



Inside the magnet

[5]

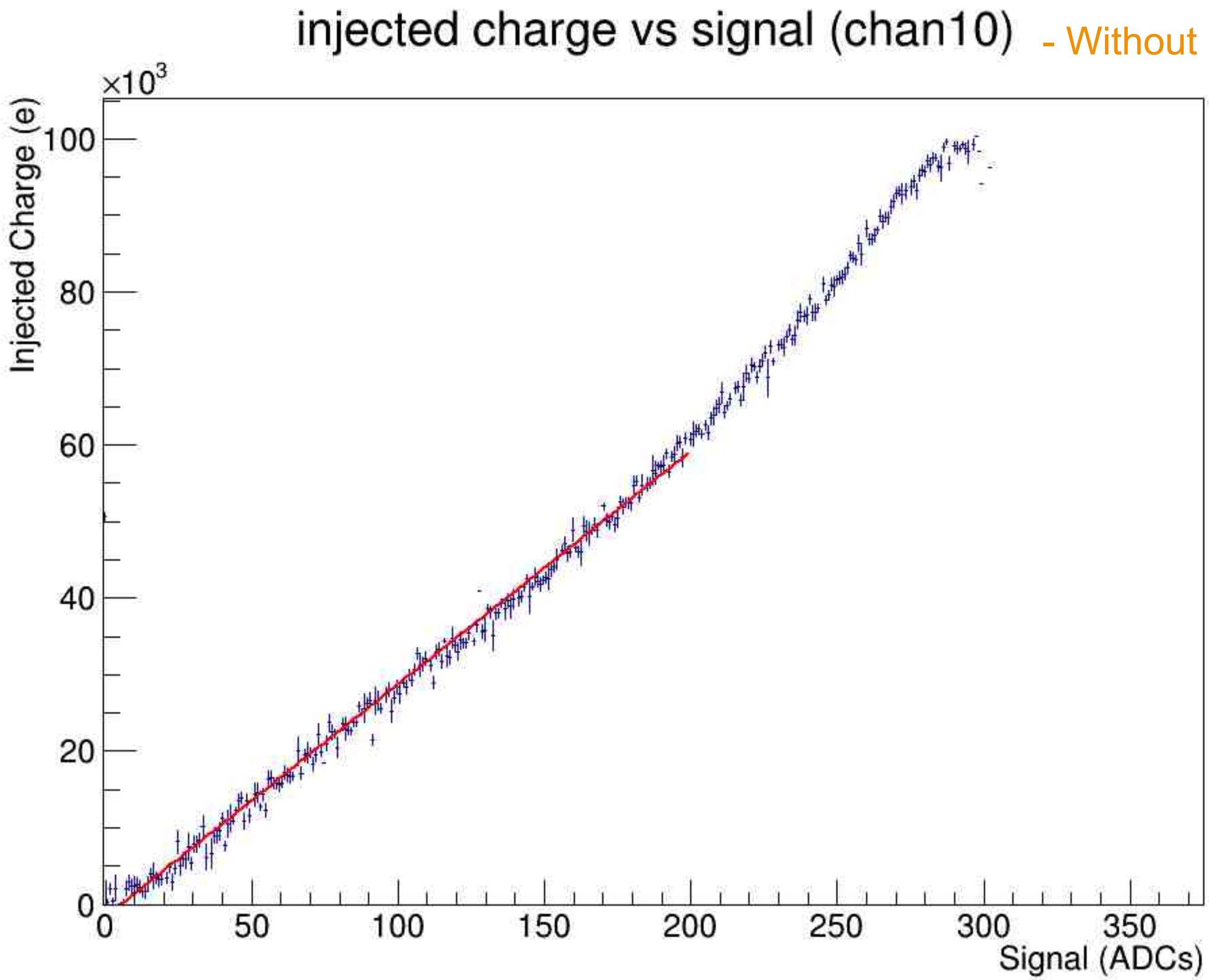


$$Q_{in} = \frac{V_{ext}}{2} \cdot \frac{51}{20\,000} \cdot C_C$$

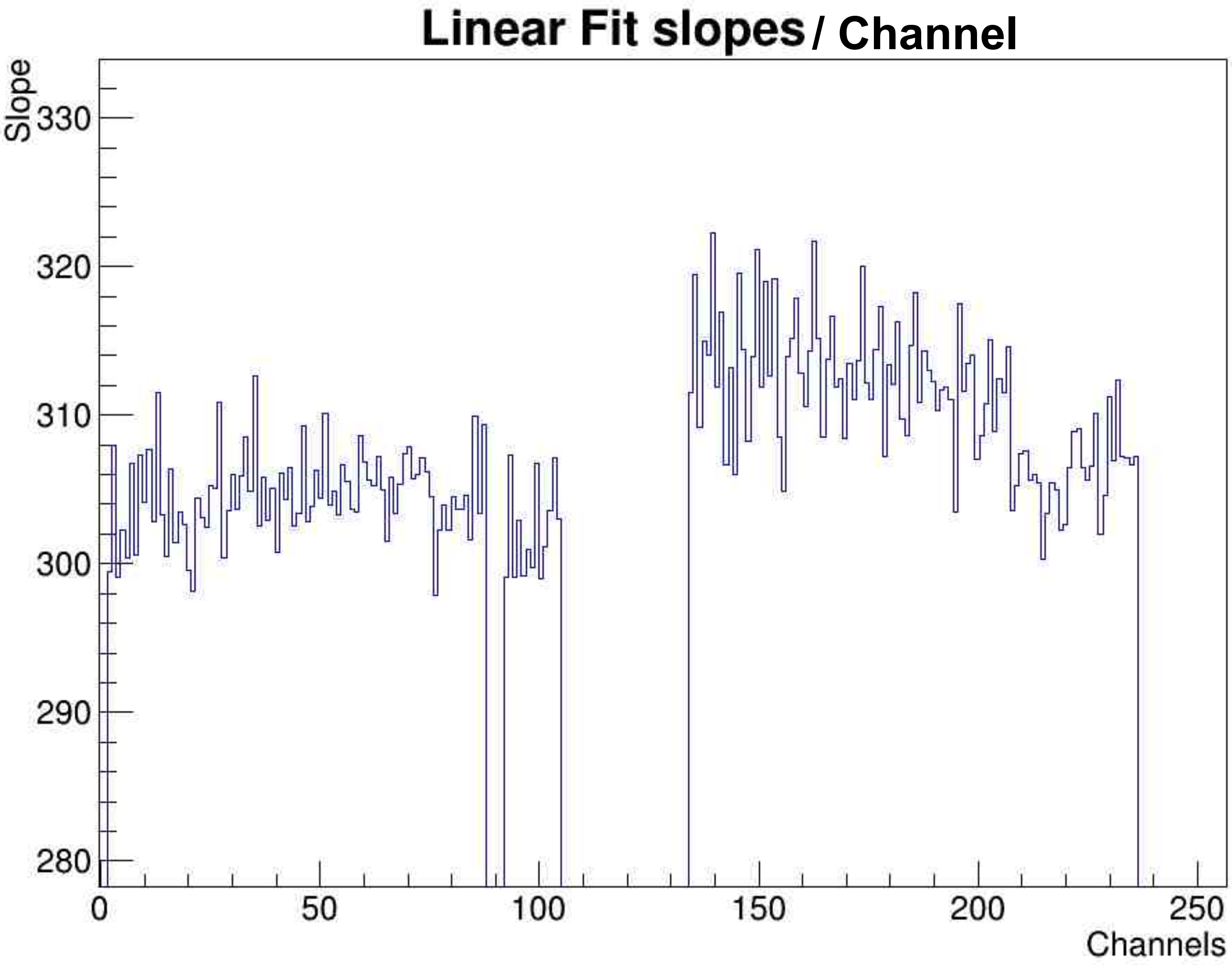
[5] S.L.¨ochner . PhD dissertation
University of Heidelberg, Germany

Results – Finding Calibration parameters/Channel

- Without cooling

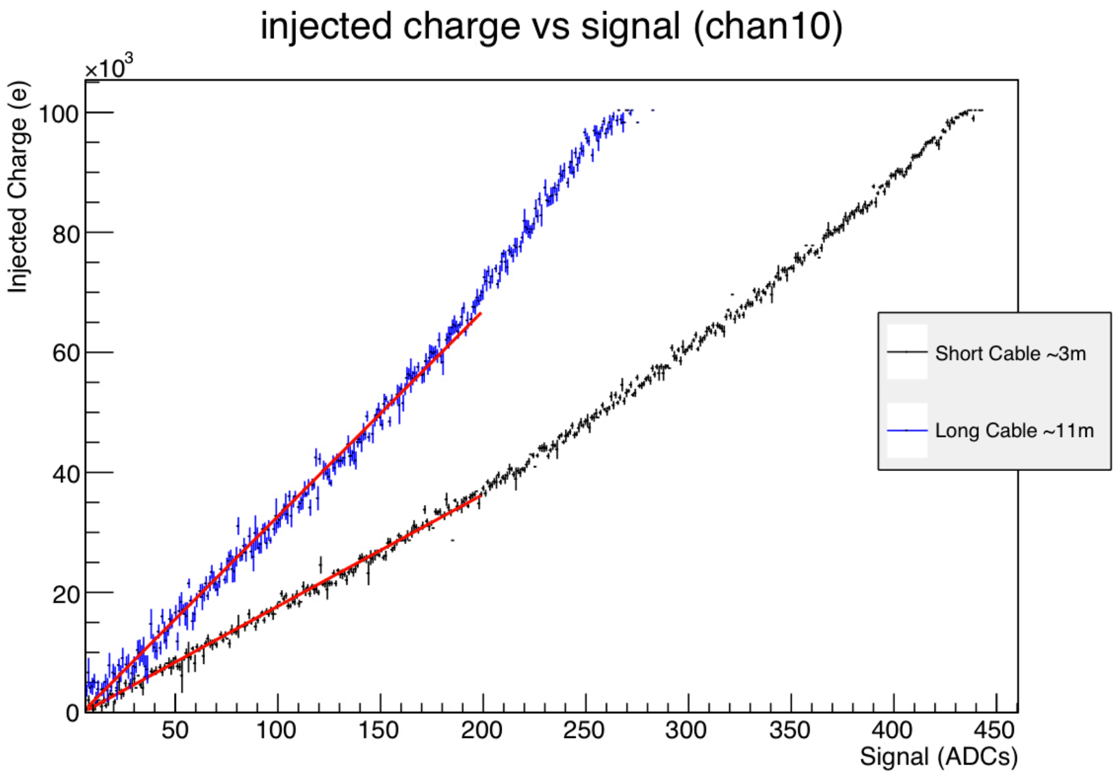


Calibration parameters – without cooling



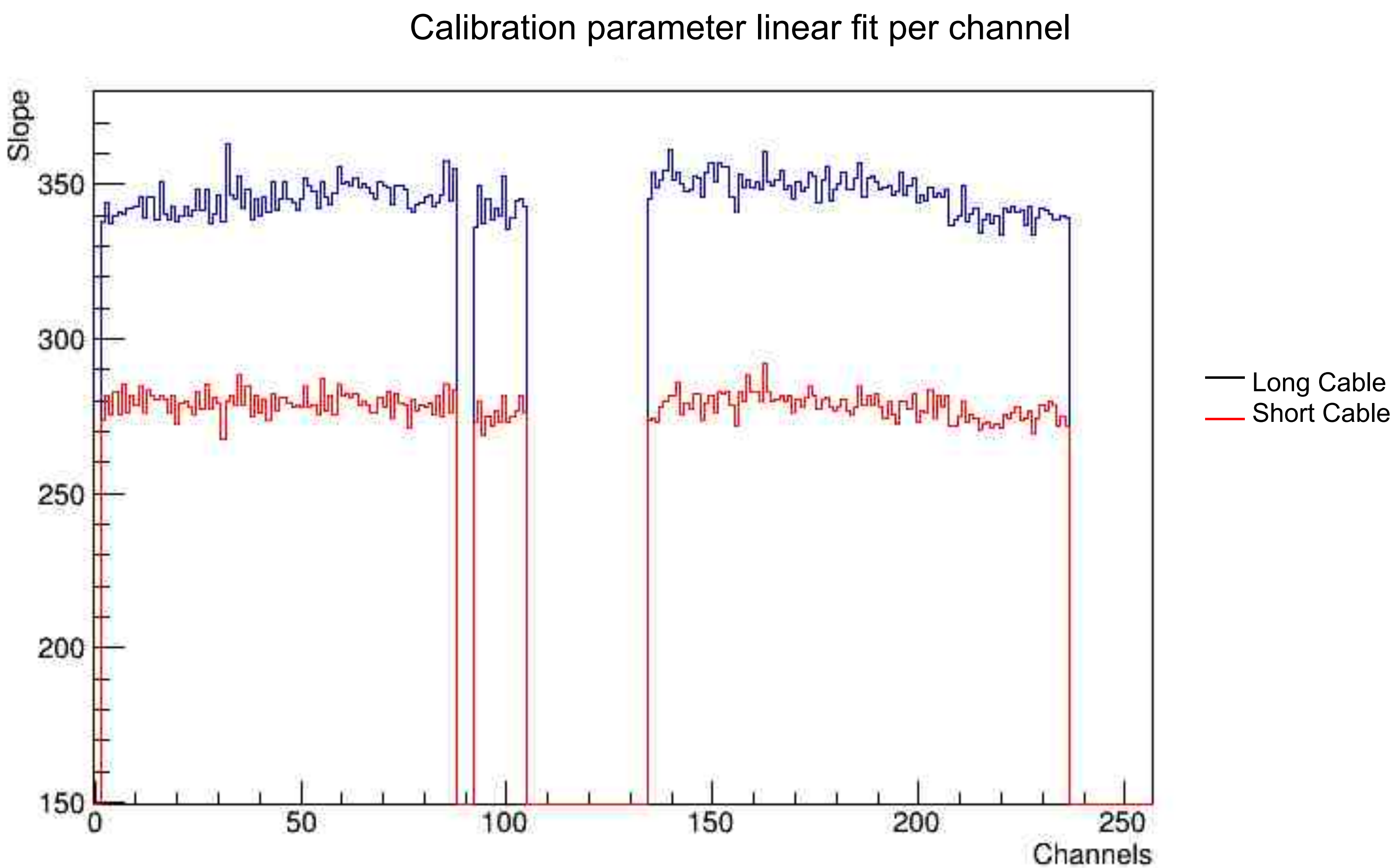
Results – Cable Length Dependence

- A flat cable is used to connect the Alibava “daughter board” to the “mother board”.
- We used cables with length ~ 3m for laboratory setup, and 11 m for test beam setup.



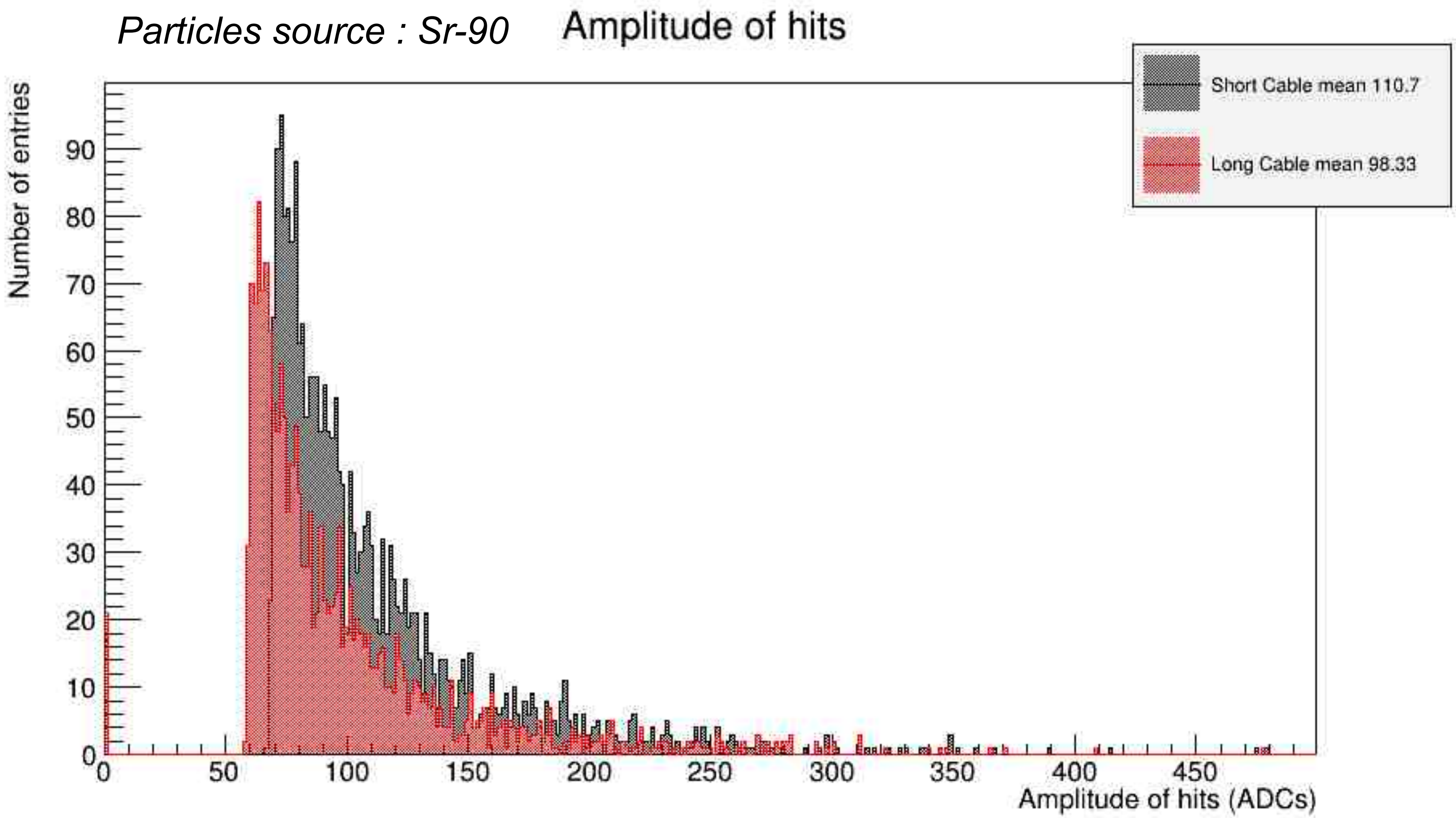
- Calibration values depend on cable length!

Results – Cable Length Dependence



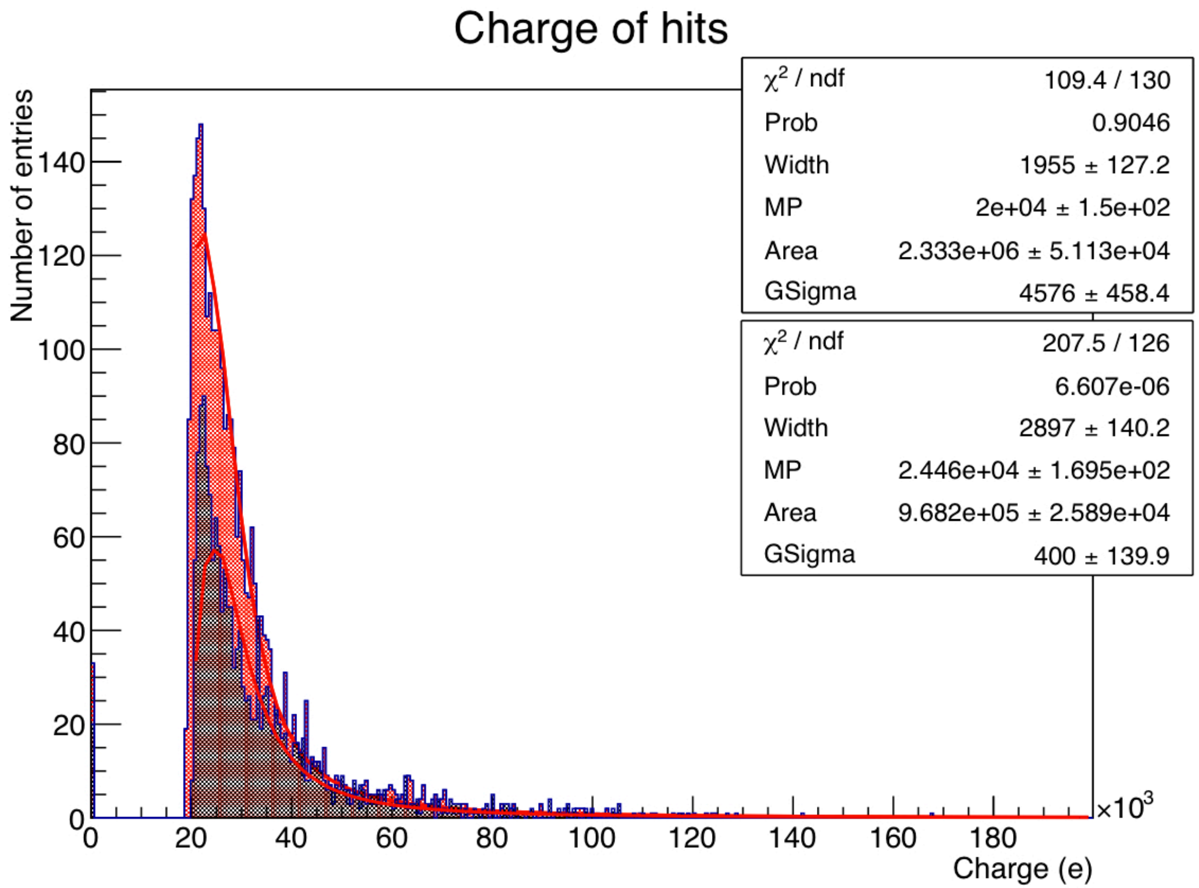
Results –Signal reconstruction without Cal. corrections

Particles source : Sr-90



Results – Signal reconstructed with Cal. corrections

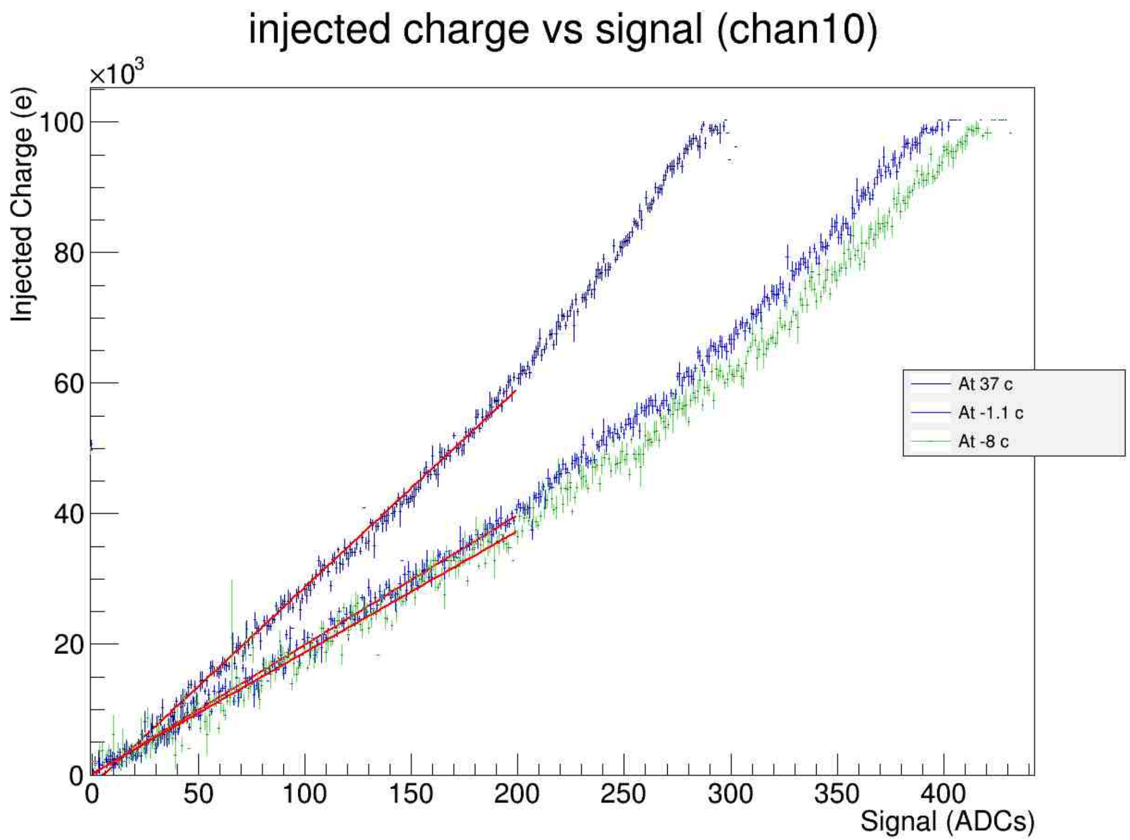
- The next step was to reconstruct signal from charge collected. This will correct the signal according to calibration values.



Results – Temperature dependence (Cal. Runs)

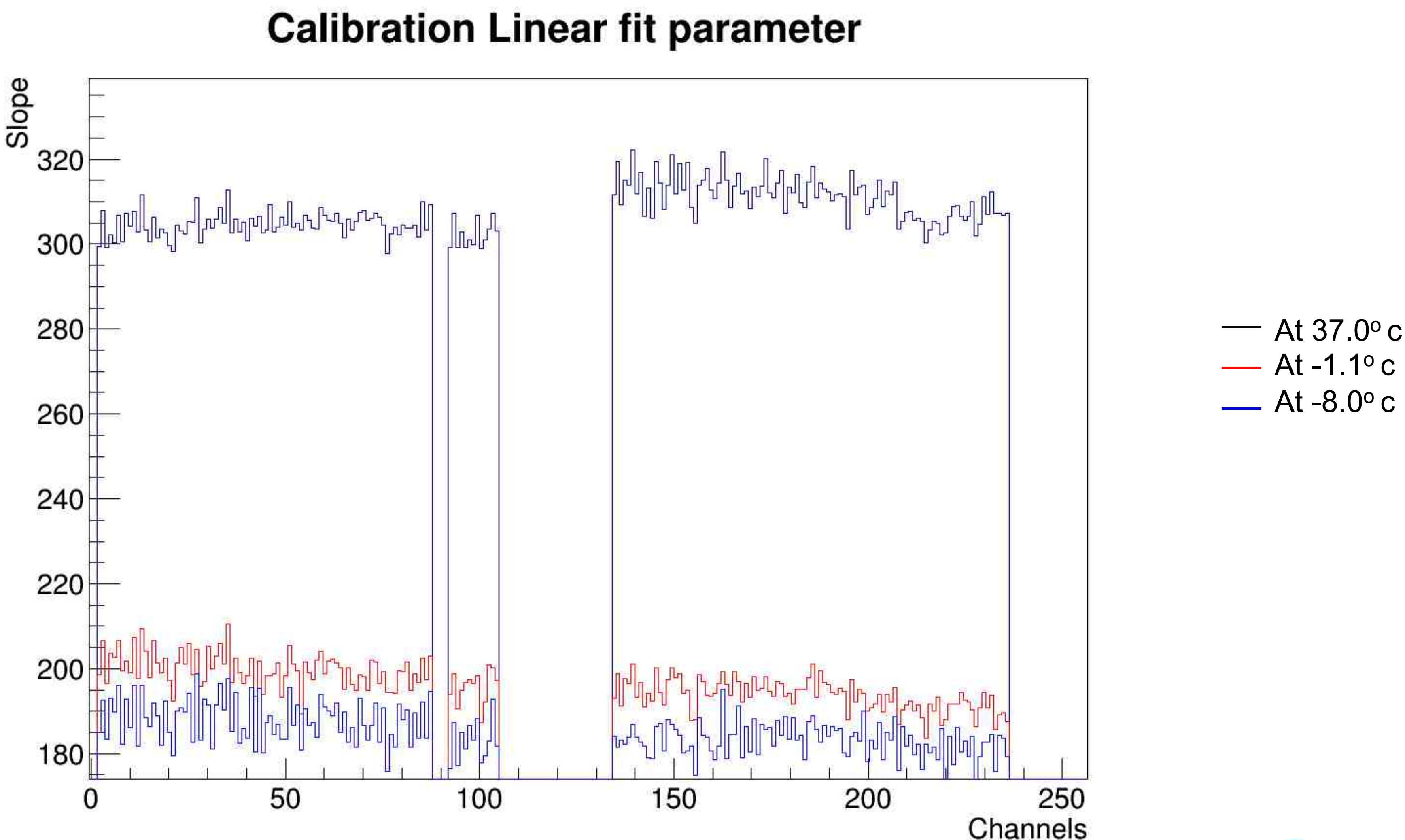
Calibration values at different temperatures

Due to cooling problems we had very limited set of different temperature data.



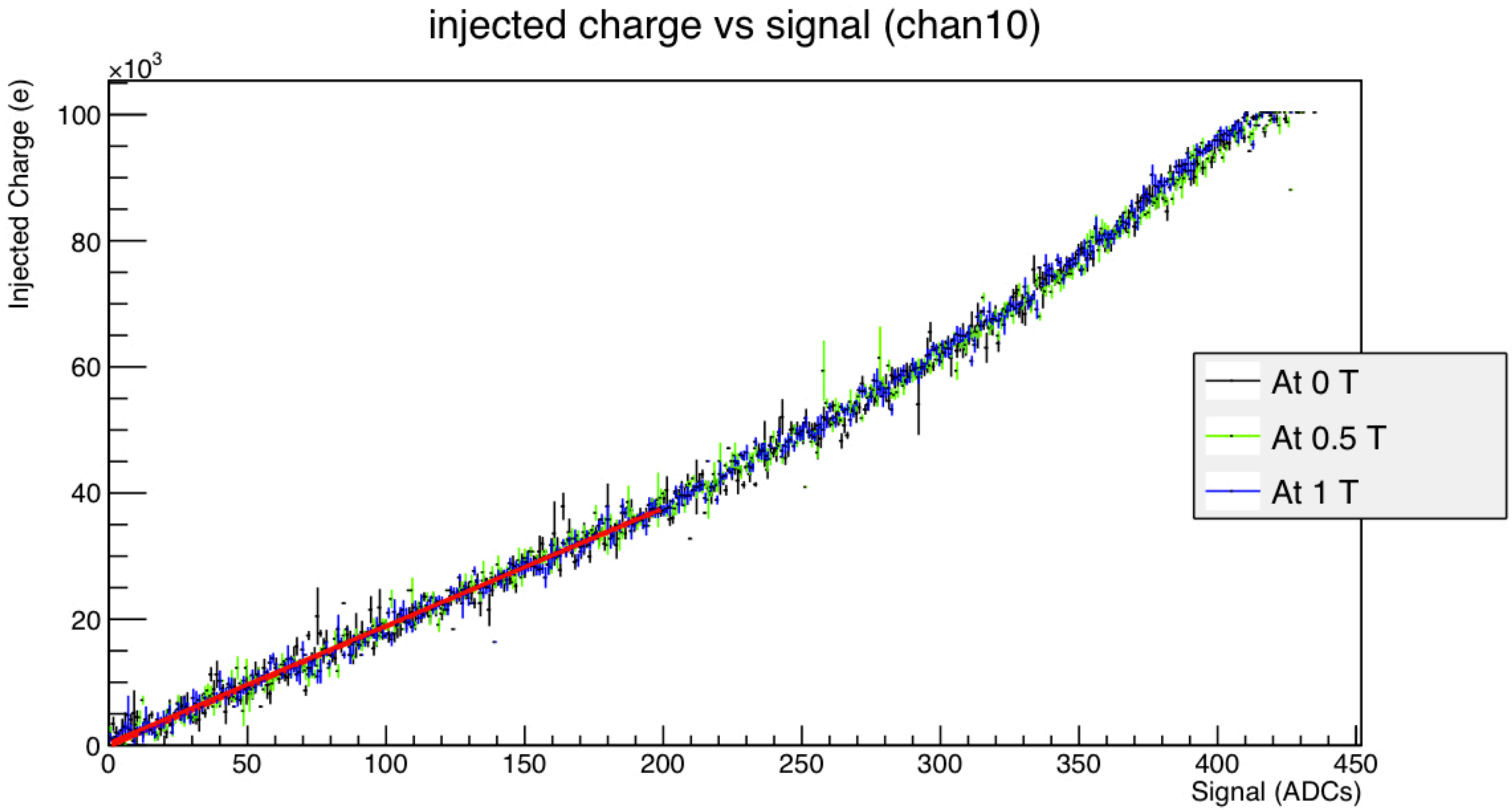
> Calibration values depend on Temperature!

Results – Temperature dependence (Cal. Runs) - 3



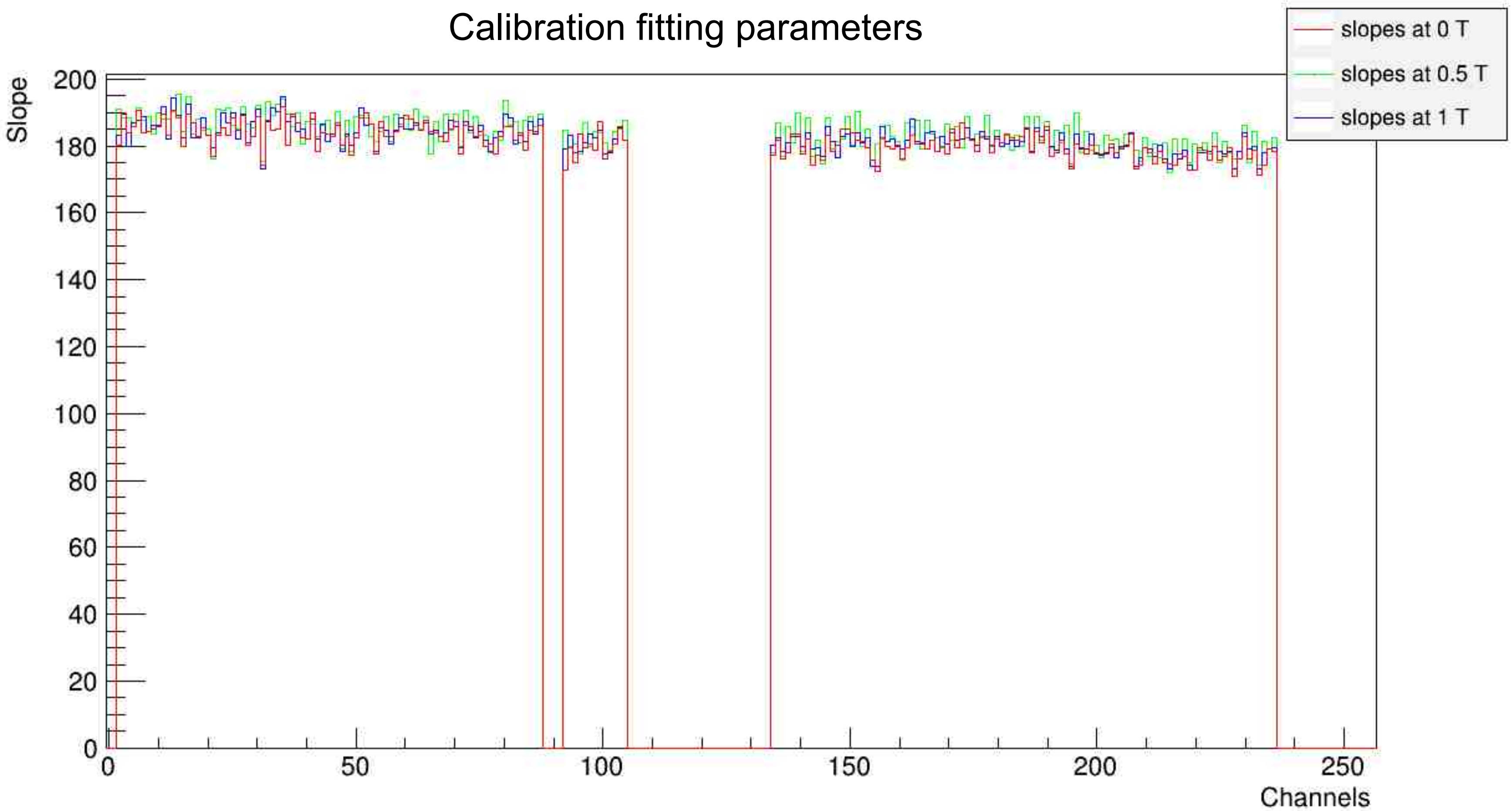
Results – Magnetic Field Dependence (Cal. Runs) - 5

Calibration values at different magnetic fields



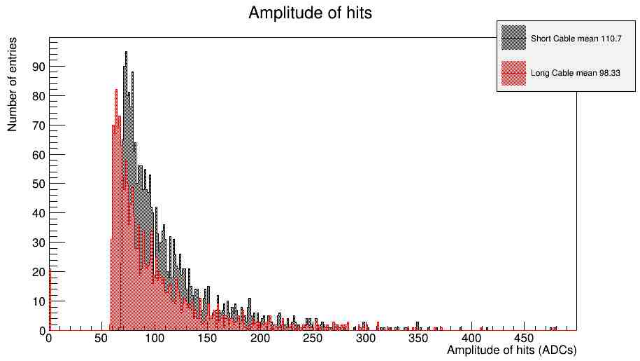
- Calibration values don't depend on magnetic field!

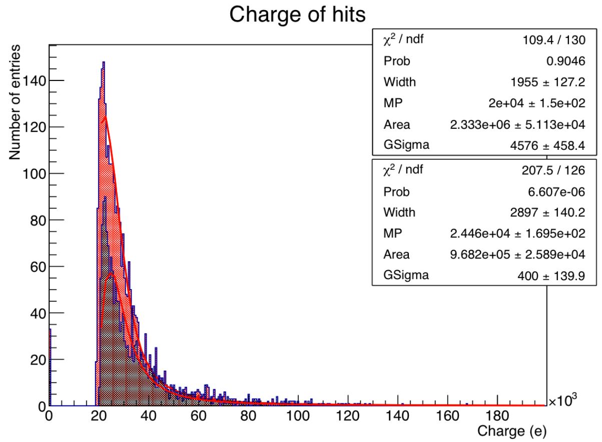
Results – Magnetic Field Dependence (Cal. Runs) - 6



Summary

- Calibration values differ directly with the temperature of the DUT and cable length. However, it does not change with Magnetic field (as expected) .
- With Calibration corrections we are able to calculate the signal for different setup settings.
- The LabView VI can be used to monitor different setup parameters.



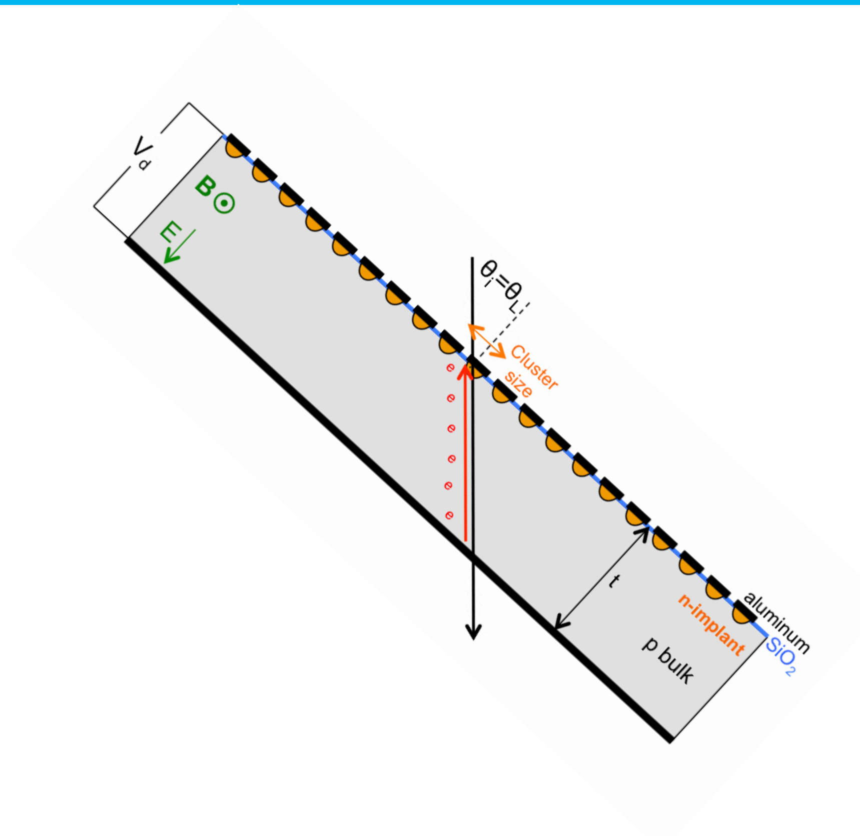


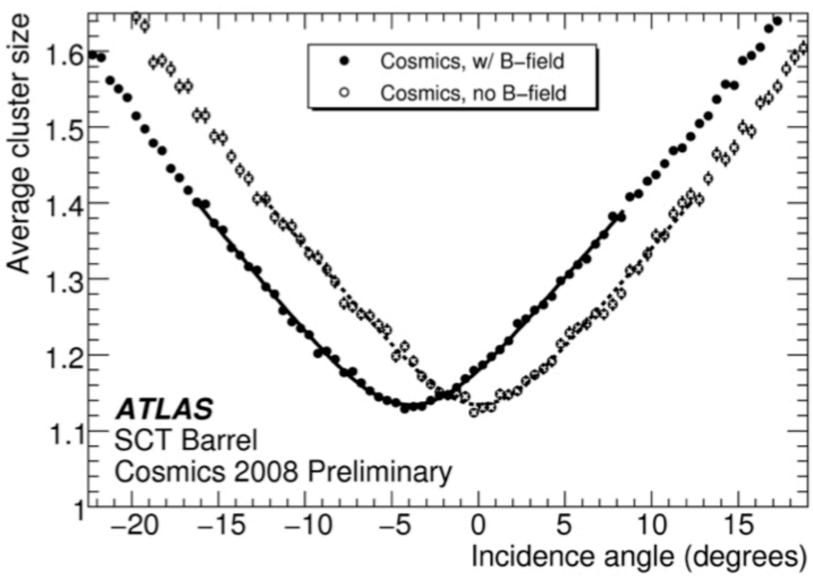
THANK YOU FOR YOUR ATTENTION!

Back Up

The Lorentz Angle Measurment Experiment

- To measure the Lorentz Angle, we need to find the angle of incidence that corresponds to the minimum cluster size.
- The Device Under Test (DUT) is tilted under magnetic field to change the angle of incidence.





[8]

Lorentz angle measurement on ATLAS SemiConductor Tracker (SCT)

[8] Lorentz Angle and Cluster Width Studies for the ATLAS SCT *ATL-COM-INDET-2009-039*

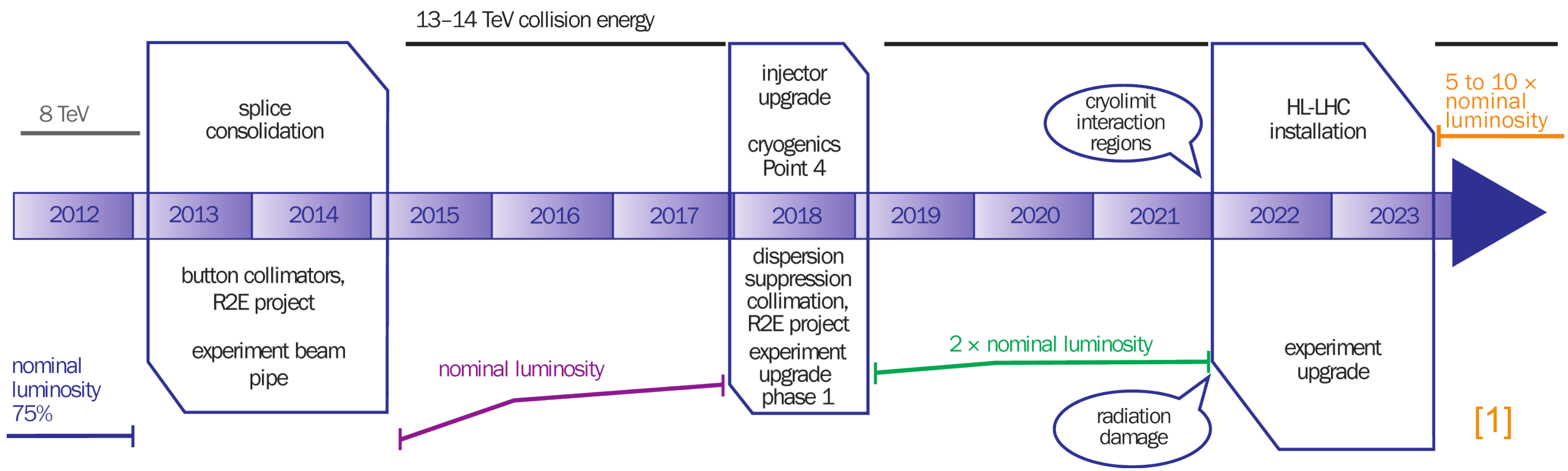
Lorentz Angle - 3

- Lorentz Angle needs to be taken into account in order to reconstruct track information correctly.
- Drift velocity and depletion voltage will change with irradiation
- The effect of radiation damage on Lorentz angle is not well understood

$$\mu_d = \frac{\upsilon_s / E_c}{[1 + (E / E_c)^{\beta}]^{1/\beta}}$$

High Luminosity LHC

- In ~ 2020 the LHC will need an upgrade to increase its total luminosity (rate of collisions) by a factor of 10.
- This new phase of the LHC life, named as High Luminosity LHC (HL-LHC) has the scope of enabling to attain the astonishing threshold of 3000 fb-1 .
- The HL-LHC will rely on a number of key innovative technologies, such as cutting-edge 13 Tesla superconducting magnets, very compact and ultra-precise superconducting cavities for beam rotation, and 300-metre-long high-power superconducting links with zero energy dissipation.[2]



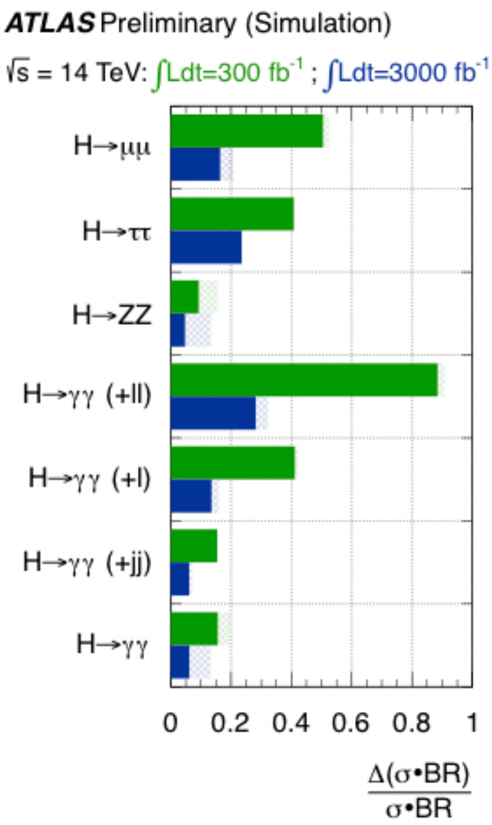
[1]

[1] http://hilumilhc.web.cern.ch/HiLumiLHC/images/
[2] http://hilumilhc.web.cern.ch/hilumilhc/index.html

Motivations for the HiLumi-LHC

- Measure the properties of the recently observed Higgs-like boson at the LHC: Yukawa and self-couplings, spin and CP quantum numbers etc.

- Continue and extend the searches for physics beyond the Standard Model: SUSY, extra-dimensions …



[3]

[3] ATL-PHYSPUB-2012-001