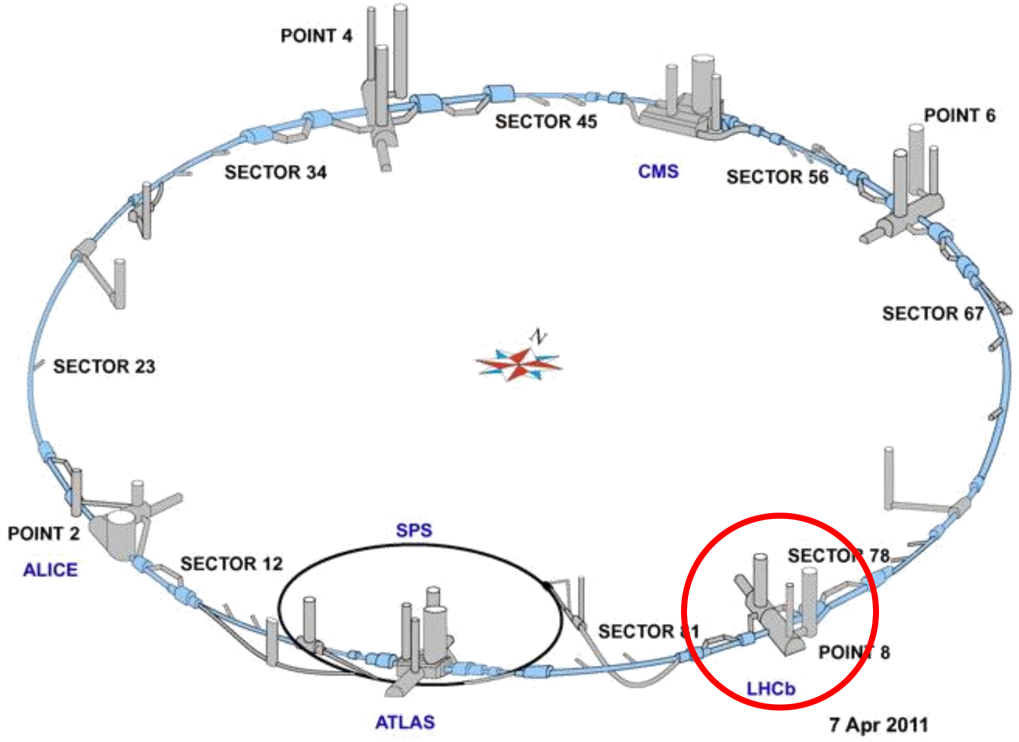
# CERN Projectweeks

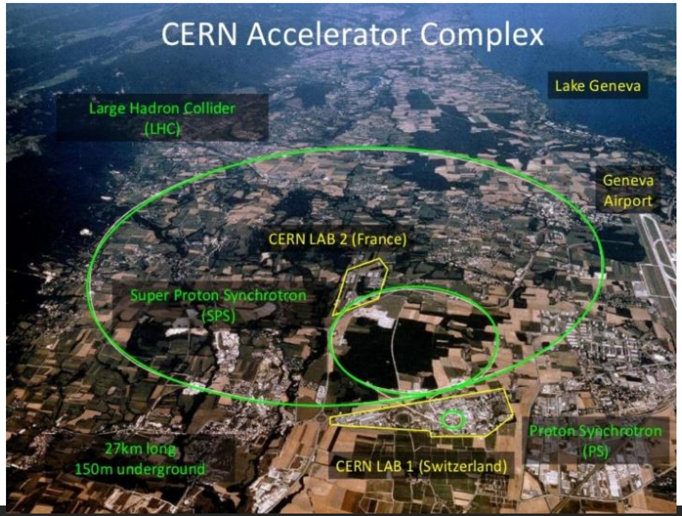
PRESENTATION

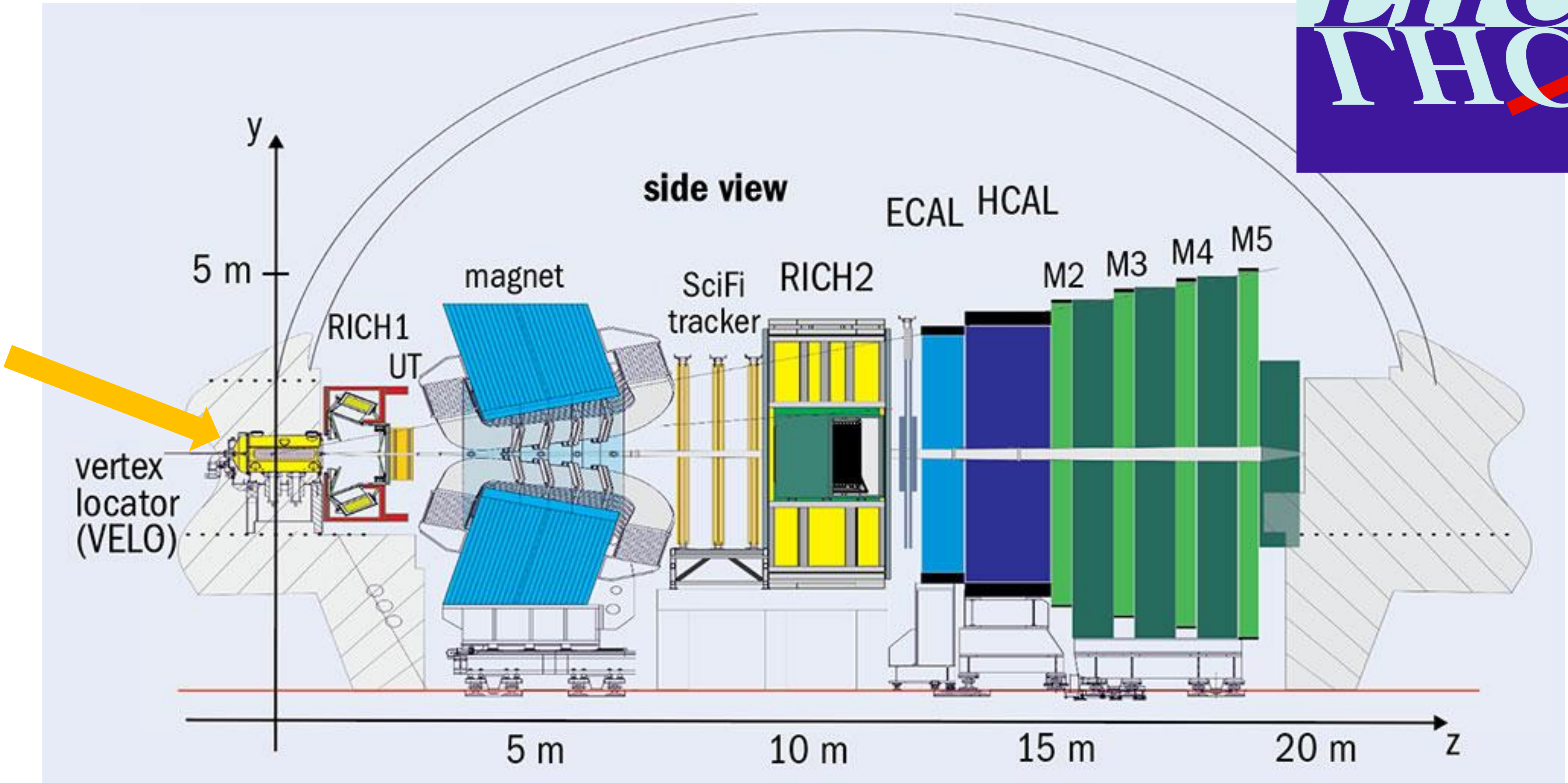
# Overview

# CERN



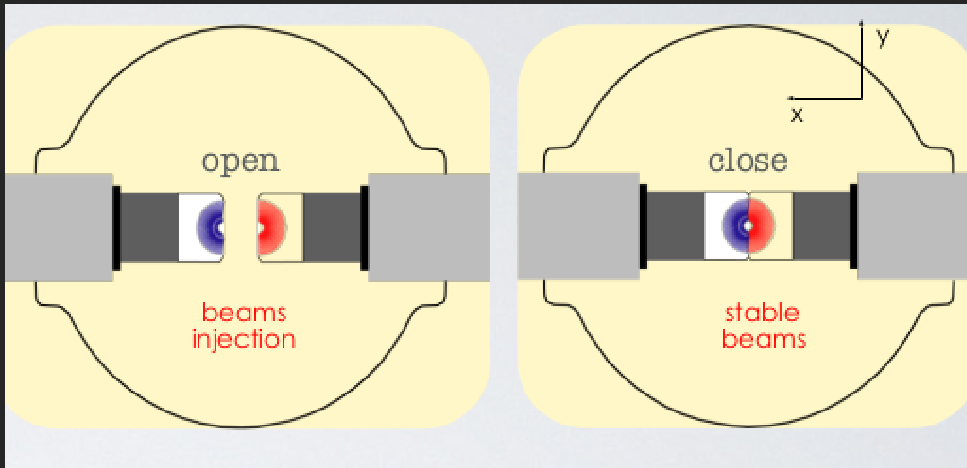

- **Geneva**
- **Conseil européen pour la recherche nucléaire**
- **LHC is an accelerator at CERN**
- **There are four collisionpoints at LHC and on each of those, a big experiment : ATLAS, CMS, ALICE and LHCb**
- **26.7 km circumference**
- **25 ns bunch spacing**

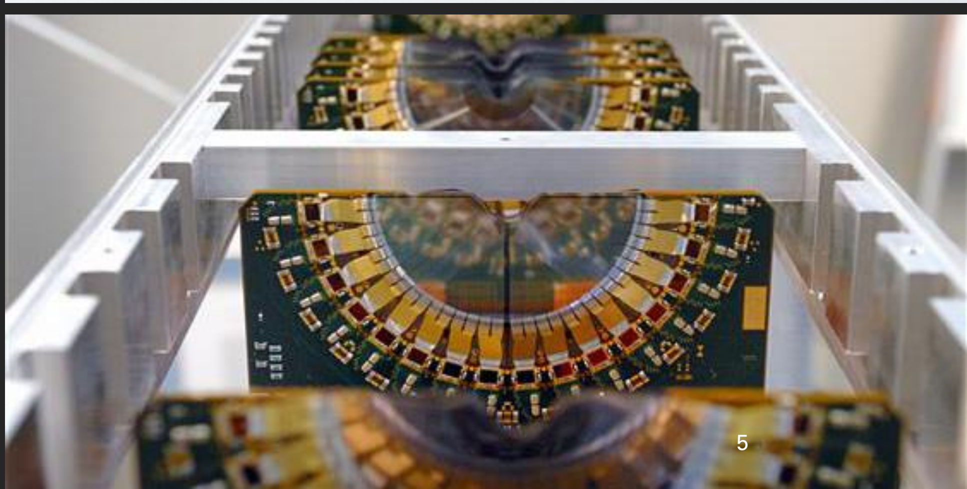



side view
y
5 m
RICH1
UT
magnet
SciFi
tracker
RICH2
ECAL
HCAL
M2
M3
M4
M5
vertex
locator
(VELO)
5 m
10 m
15 m
20 m
z

# Velo

- VErtex LOcator
- Sillicon Pixel detector
- resolution 10µm (before the upgrade)
- Luminosity $4 \times 10^{32}\ cm^{-2}\ s^{-1}$
- 21 Layer (42 modules)
- It is very close to the beam and the collisionpoint
- It is not as close to the beam when the particles are injected, but when the beam is stabelized the silicon elements are moved towards the beam mechanically
- operates in vacuum, but the vacuum of VELO is separeted from the vacuum of the beampipe

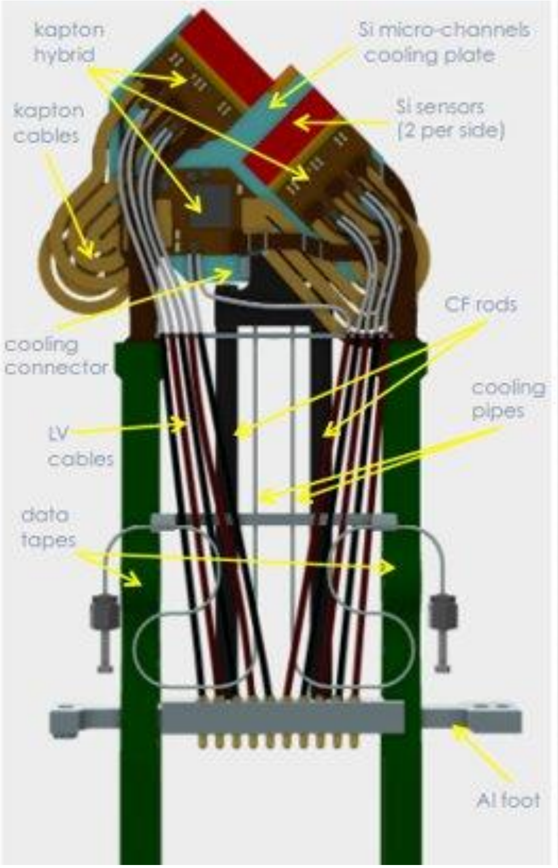


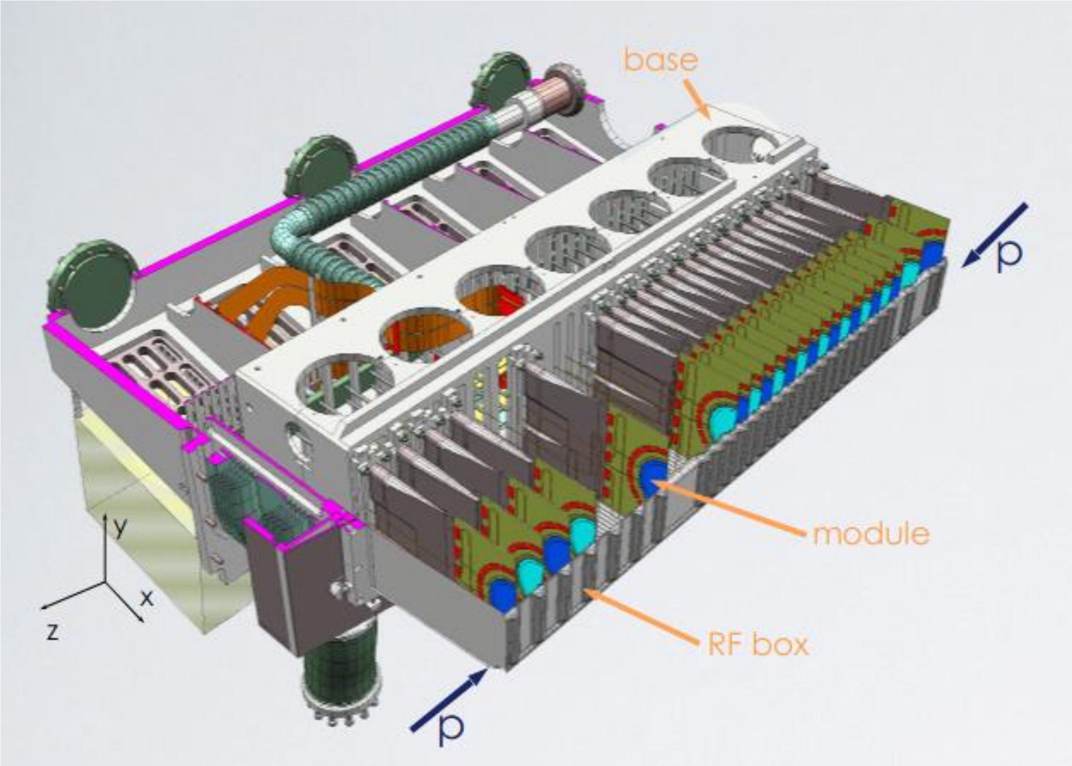
# VELO Upgrade (LS2)

| | Vor LS2 | Upgrade |
|---|---|---|
| resolution | 10µ | 8.5-9.5µ |
| modules | 42 | 52 |
| layers | 21 | 26 |
| detector | strips | pixles |
| Readout | 1 MHz | 40 MHz |
| Temperature | -10°C | -20°C |
| Voltage (max) | 500V | 1000V |

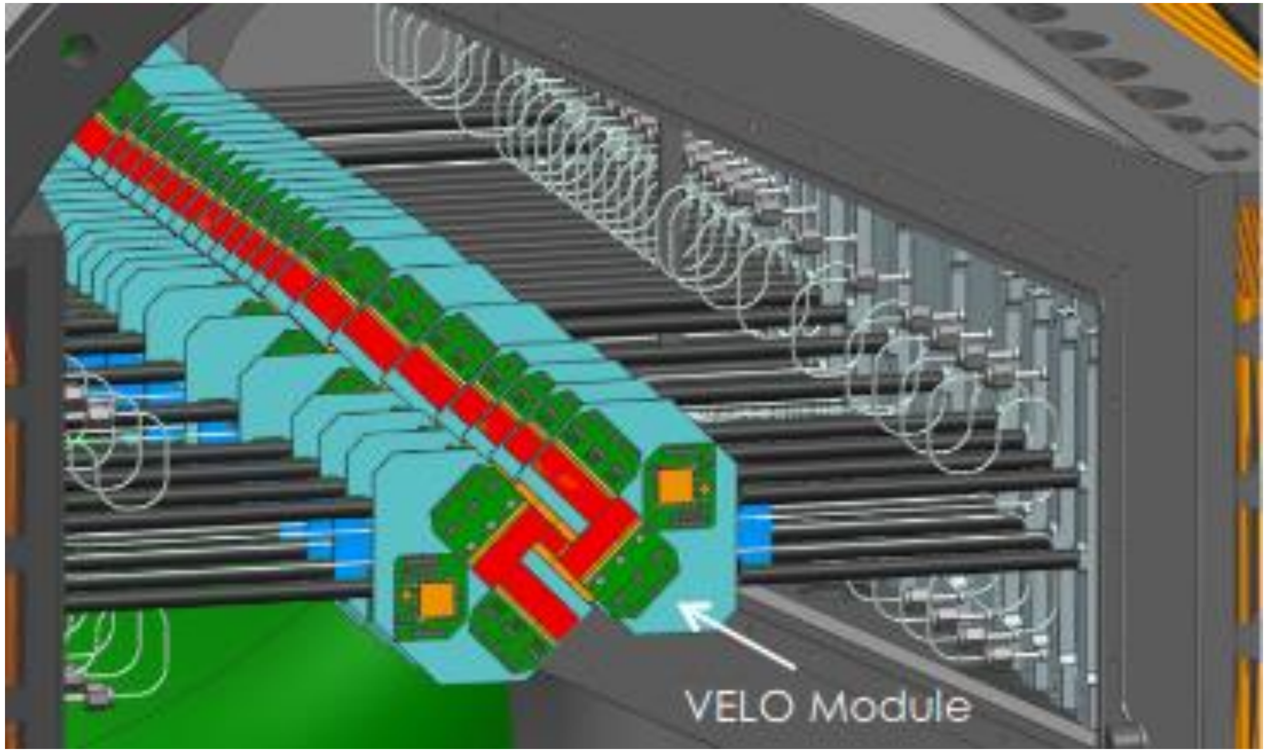
- the Readout has to become faster, because the luminosity (Luminosity $2 \times 10^{33}\ cm^{-2}\ s^{-1}$) in LHC will be higher after LS2
- radiationtolerant
- L-shaped modules (not halvemoonshaped anymore)
- Each module has four sensor Tiles



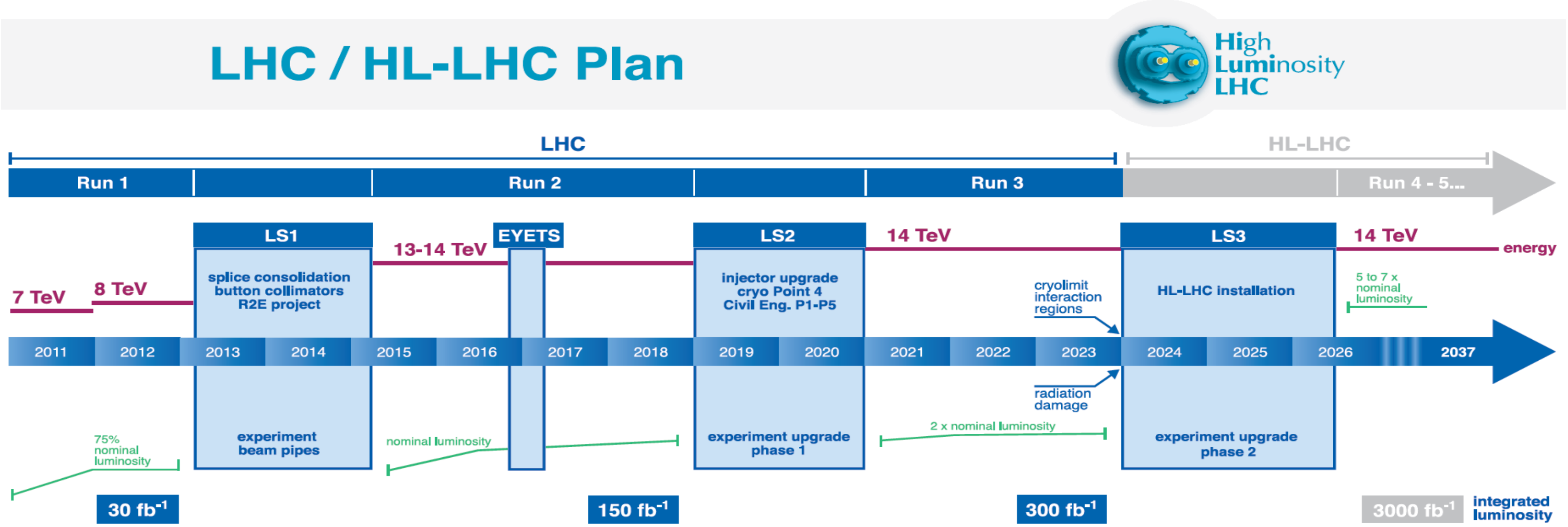
VELO 1



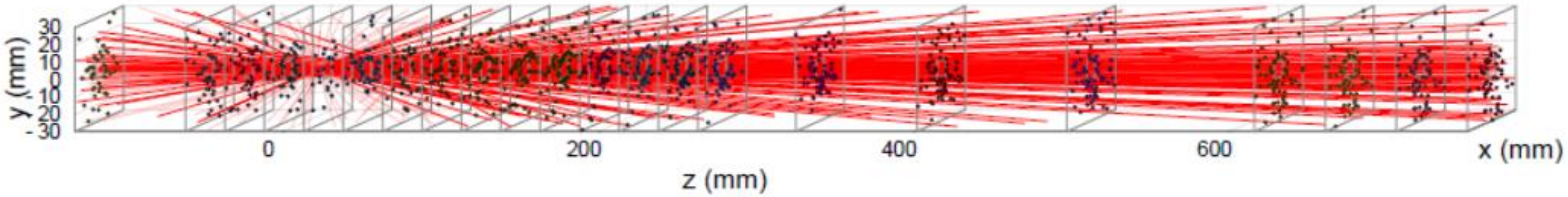

VELO 2 (LS2)



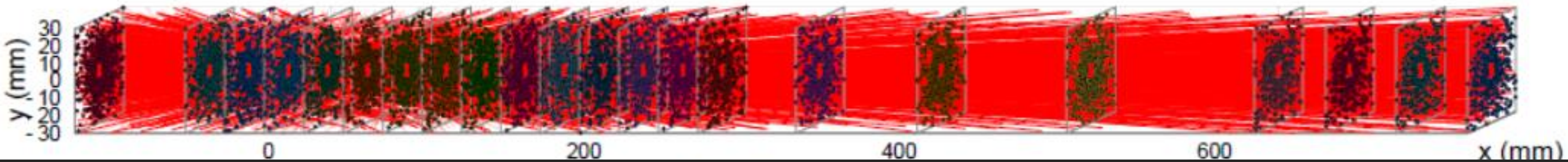
# Upgrade 2 (LS3)




- faster and better Readout, because of the higher luminosity in LHC
- radiationtolerant
- thinner sensors, thinner ASICs, smaler pixels -> for higher resolution



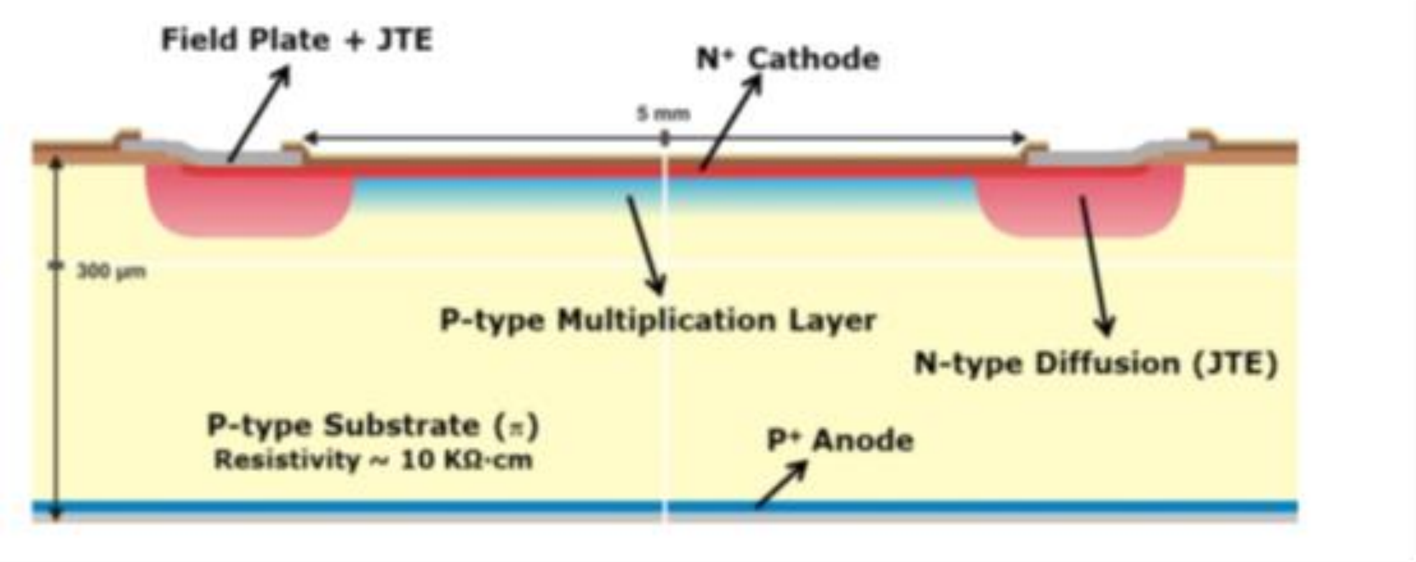

**Velo Upgrade 1 (LS2)**




**Velo Upgrade 2 (LS3)**

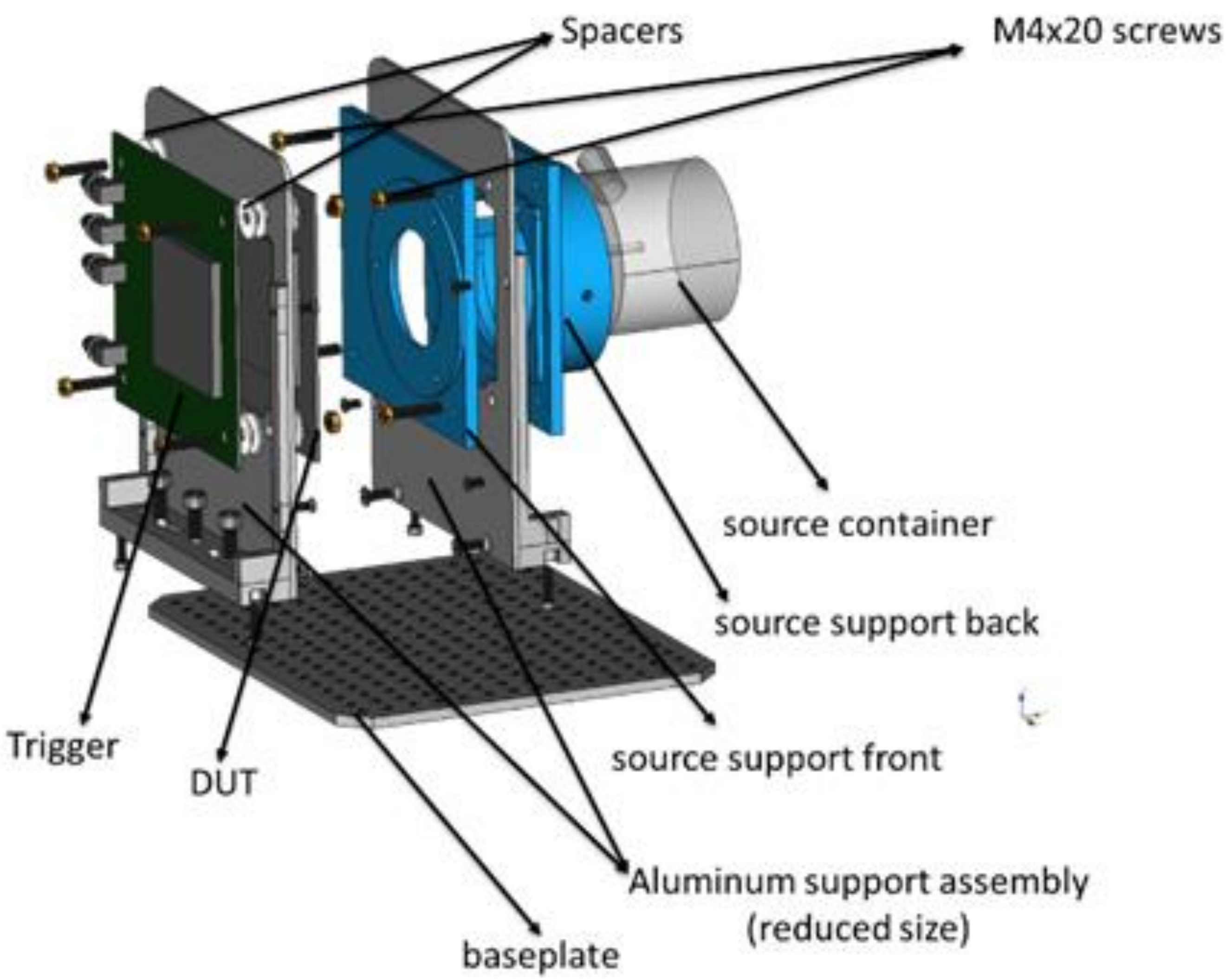
# Low Gain Avanlanche Diode

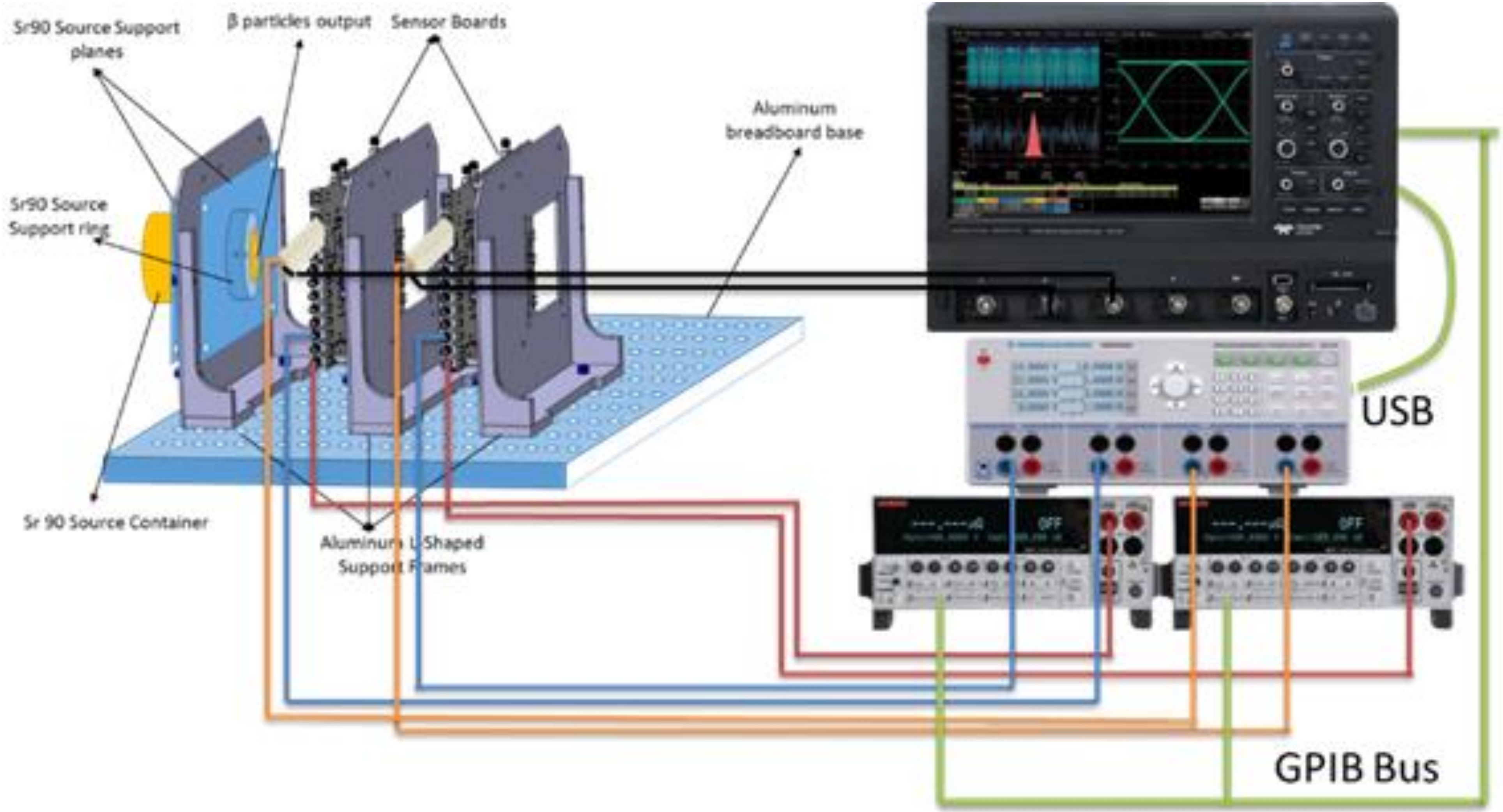
- Electron collecting n-in-p-sensor
- 200µm thick
- amplifies the signal
- good time resolution
- could be used for the LS3-VELO-Upgrade

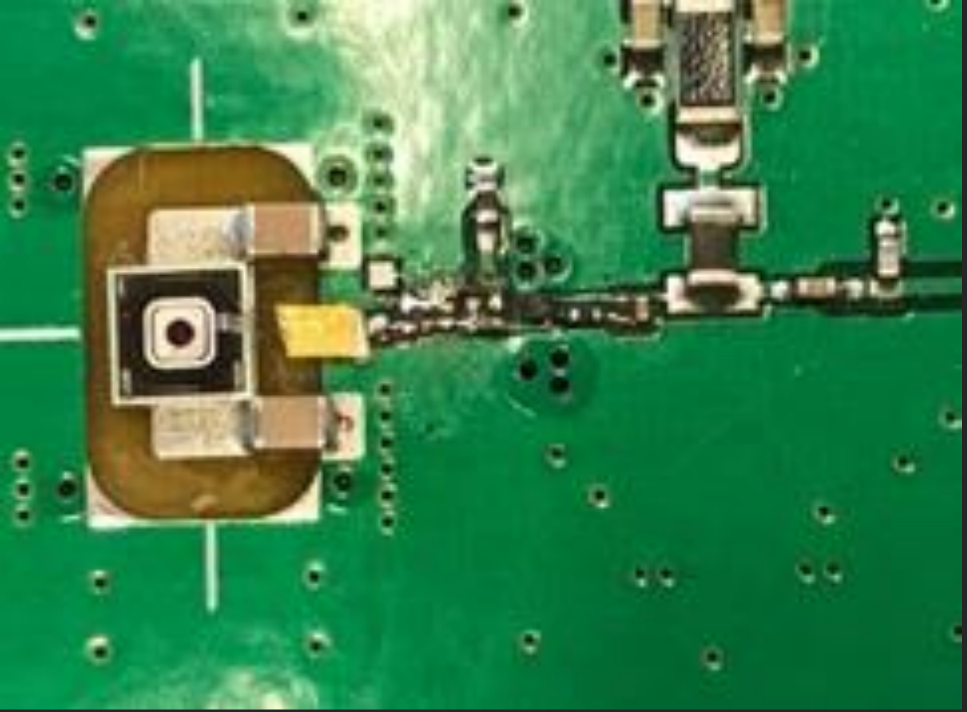


# Charged particle measurementsysthem

- coincidencemeasurements
  - to check that the signals are straight and not noise (Trigger)
  - to have one sensor as good known time reference
- Particlesource is Strontium-90
- the sensors fixed on the boards and protected by a thin layer of foil during the measurement

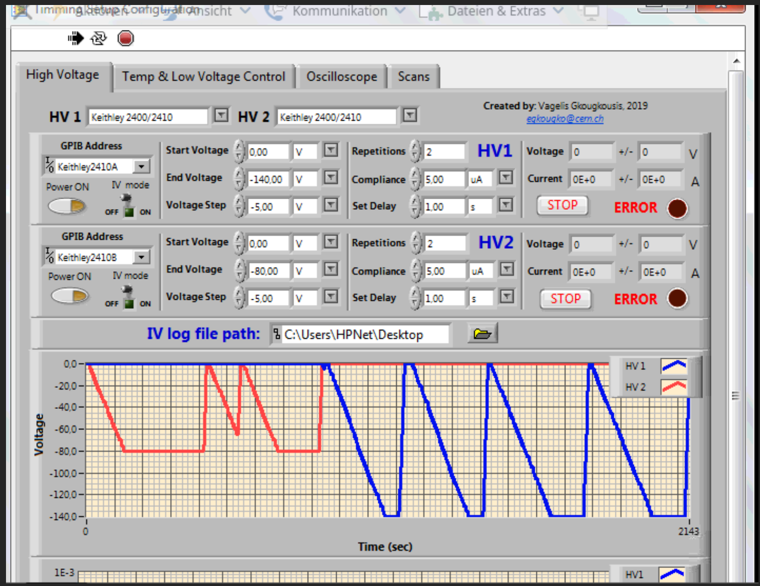


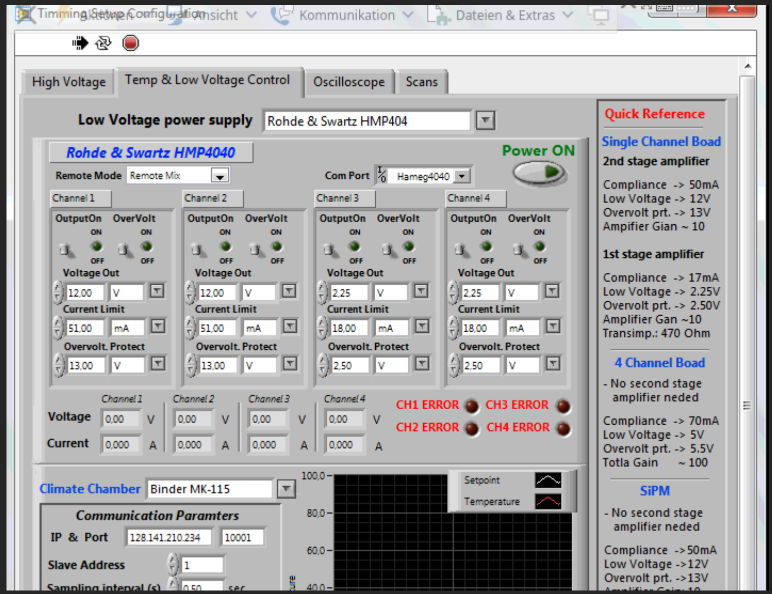

Sr90 Source Support planes
β particles output
Sensor Boards
Aluminum breadboard base
Sr90 Source Support ring
Sr 90 Source Container
Aluminum U-Shaped Support Frames
USB
GPIB Bus

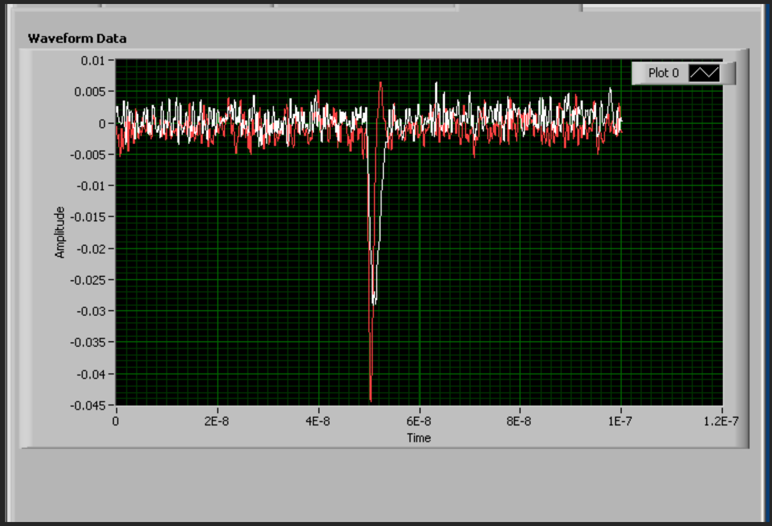



# Readoutboard

- LOW GAIN AVANLANCHE DETECTORS (LGAD)
- SEMICONDUCTORSENSORS
- THE SENSORS ARE VERY SMALL AND HAVE TO BE FIXED ON THE BOARDS WITH A MICROSCOPE
- THE AIM IS A FAST SIGNAL AND LOW NOISE
- AMPLIFIERS ARE NEEDED AND HAVE TO BE VERY CLOSE TO THE SENSORS
- TO PROTECT THE SENSOR THERE IS A FARADAY CAGE AROUND IT



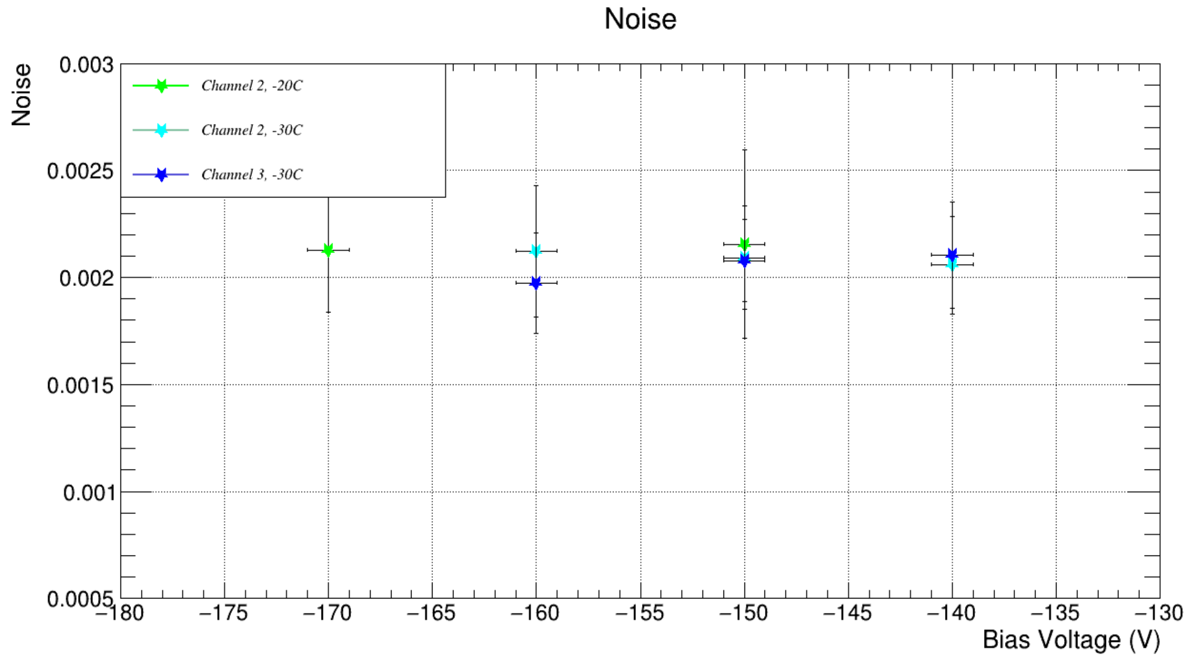

# Controling the measurements

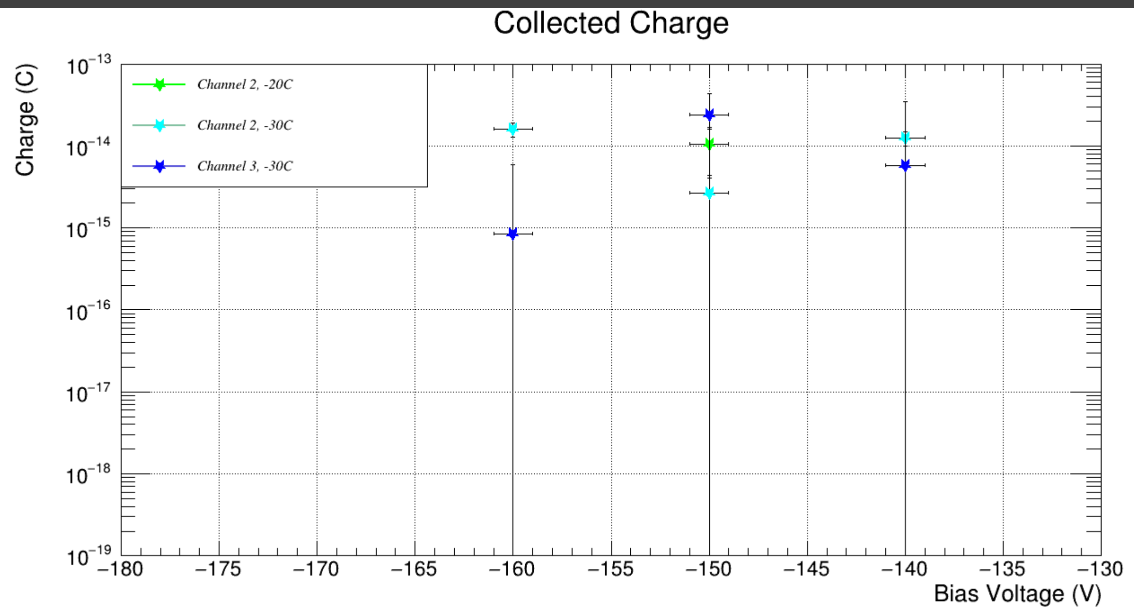
- the measurements can be controlled by a program that is based on LabView

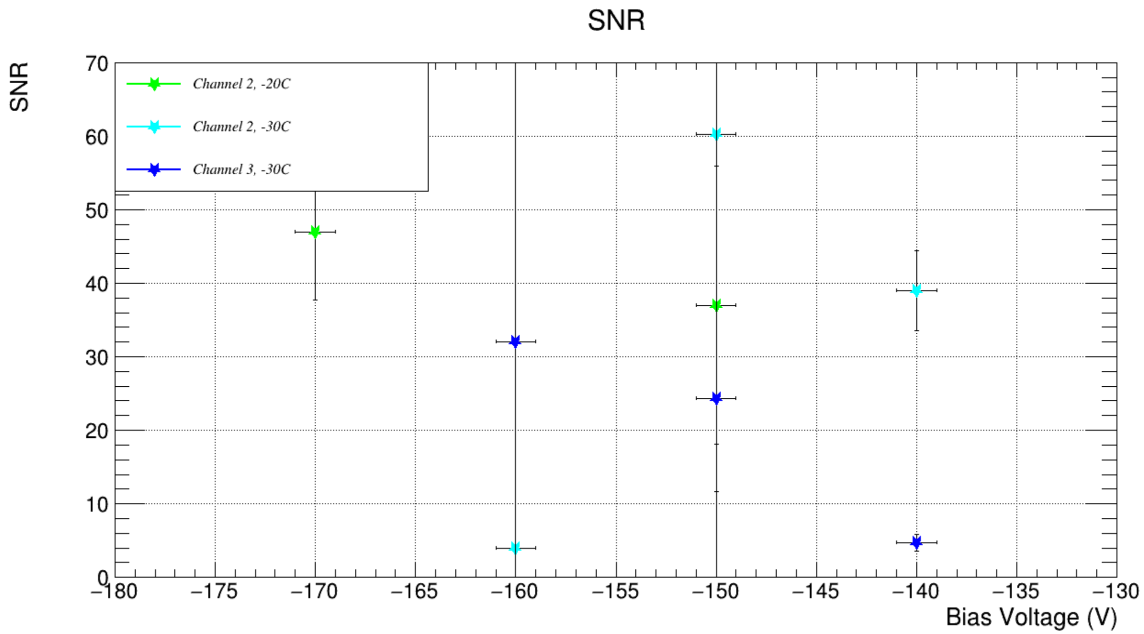
- the measurements can be programmed with this program

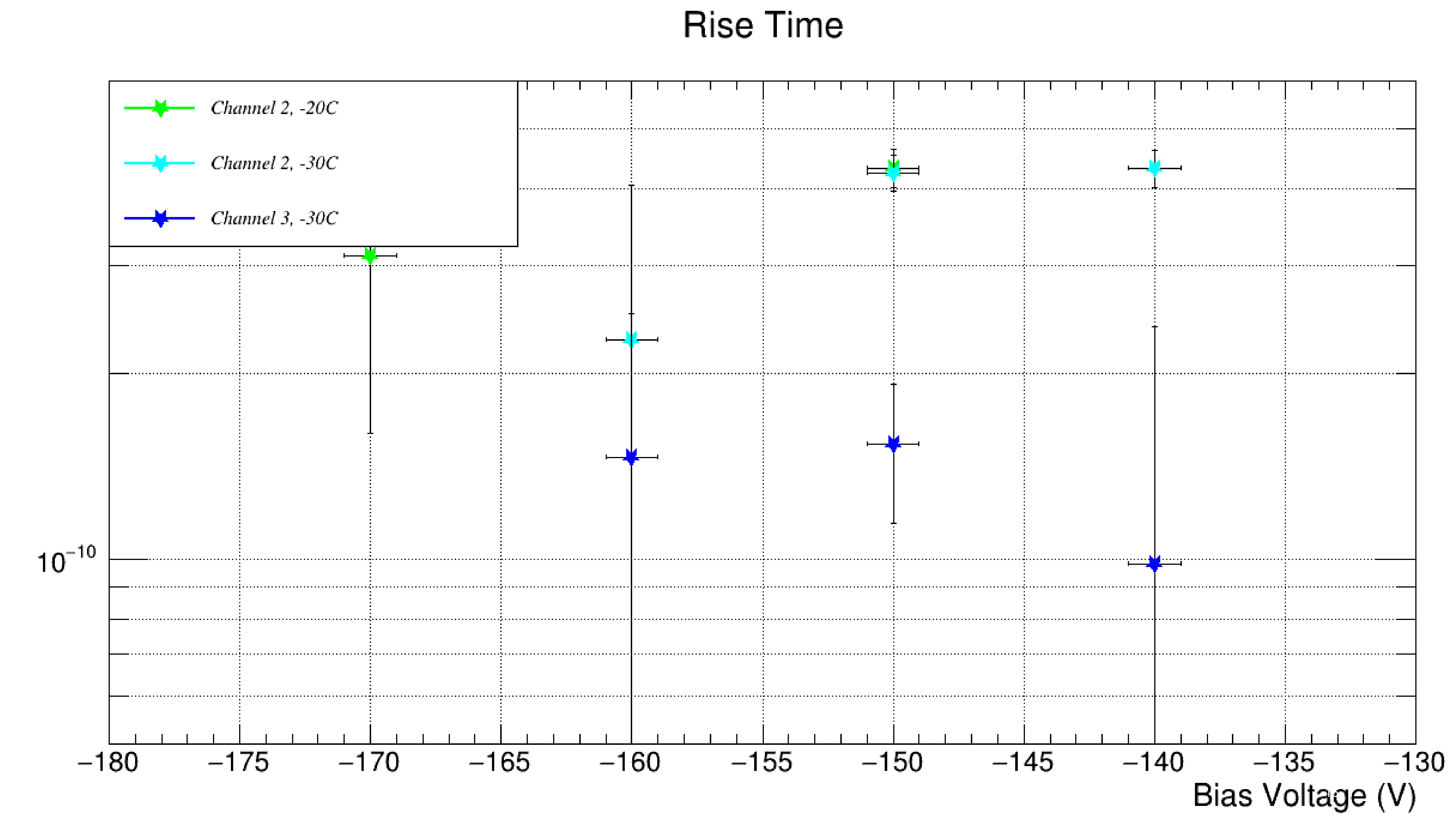
# Analysis

- Analysis with the Framework LGADUtils based on root
- The framework can be found on GitLab : https://gitlab.cern.ch/ifaepix/lgad-timing-analysis
- calculates different values from the data like for example the collected charge or the noise


Noise
Channel 2, -20C
Channel 2, -30C
Channel 3, -30C
Noise
Bias Voltage (V)


Collected Charge
Channel 2, -20C
Channel 2, -30C
Channel 3, -30C
Charge (C)
Bias Voltage (V)


SNR
Channel 2, -20C
Channel 2, -30C
Channel 3, -30C
SNR
Bias Voltage (V)



Rise Time
Channel 2, -20C
Channel 2, -30C
Channel 3, -30C
$10^{-10}$
−180
−175
−170
−165
−160
−155
−150
−145
−140
−135
−130
Bias Voltage (V)

# Conclusion

- every time when the LHC is upgraded in a shut down the detectors also have to be upgraded, because they need a higher resolution for measurings with a higher luminosity and also a faster readout system
- for this upgrades different types of electronics needs to be tested very percisely
- during the two weeks I learned:
  - analysing Data with Root in different ways (TH2D Histograms and TGraph Plots)
  - how such measurements are working (for example)

# Sources

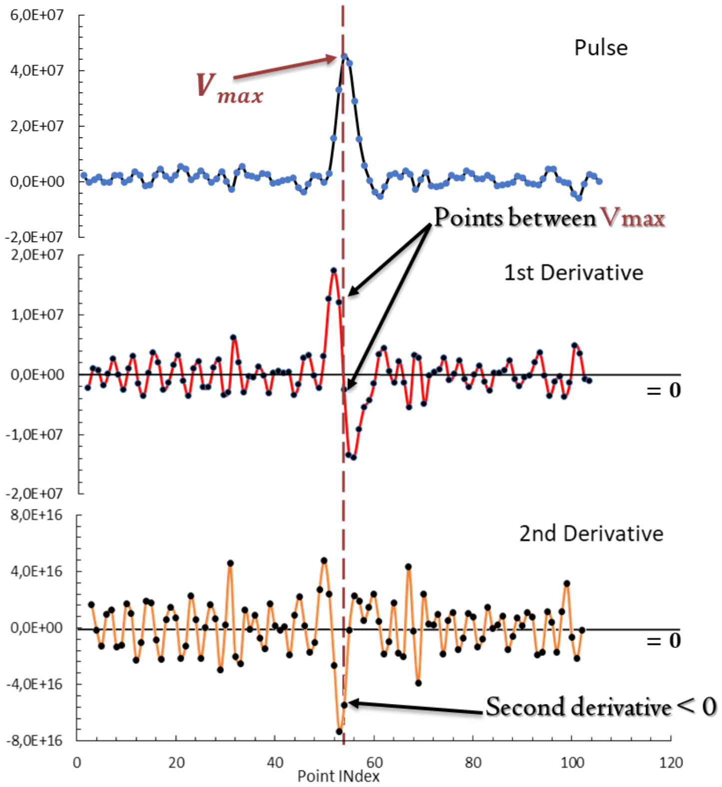

- The LHCb VELO Upgrade, Kristof De Bruyn (On behalf of the LHCb VELO group),13th “Trento” Workshop on Advanced Silicon Radiation Detectors, Munich – February 19th, 2018
- Low Gain Avalanche Diodes – Technology Overview, Evangelos –Leonidas Gkougkousis, Experimental Particle and Astro-Particle Physics Seminar, University of Zurich, May 25 , 2020
- https://lhcb-public.web.cern.ch/en/detector/VELO2-en.html
- Timing analysis framework, HGTD Test beam analysis Group Meeting, V. Gkougkousis, CERN – 9 / 1 / 2019
- Timing measurement control software, Vagelis Gkougkousis, IIFAE Pixel Group, 2019

The LHCb VELO Upgrade, Dónal Murray, PIXEL 2018, Taipei

Tje LHCb Velo Upgrade, Stefano de Capua, 2018

# Backup Slides

# How does the Framework analise Data?




- It calculates analytical the first and second derivative for each waveform
- It seeks for the zero crossing point for the first derivative to localise the first local extremum
- Then it calculates with the second derivative whther the signal is positiv or negativ
- After this it constructs vectors containing the extremum amplitude and calculates the standard deviation and mean value for each vector

# LHCb

Large Hadron Collider beauty

Physics

- CP-Violation
- Rare Decays
- B- and C-Pyhsics
- Forward EW Physics
- Spectroscopy
- Ions

| | |
|---|---|
| VELO | VErtex LOcator, Pixeldetector |
| RICH1 | Cherenkovdetector |
| SiFi | Silicon tracker |
| RICH2 | Cherenkovdetector |
| ECAL | Electromagnetic Calorimeter |
| HCAL | Hadronic Calorimeter |
| Myon Chambers | |

| | Erklärung | Erwünschtes Ergebnis / Erwartung |
|---|---|---|
| Collected charge | Ladung | Sollte bei Erhöhung der Spannung exponential steigen |
| Noise | | Sollte klein sein, damit das Signal gut wargenommen werden kann, möglichst stabil |
| Noise uncertency | | |
| Rise time | | |
| Jitter (RMS) | Zeitliches Taktzittern bei der Übertragung von Digitalsignalen, leichte Genauigkeitsschwankungen im Übertragungstakt | Unerwünscht, sollte klein sein |
| Jitter (Rise/SNR) | | |
| Max dV/dT | Gibt die Geschwindigkeit der Steigung des Signasl an | |
| CFD ToT | Constant Fraction Discriminator Time over Treshold | |
| Signal FFT | Frequenz des Signals | |
| SNR | Signal to Noise Ratio | Sollte möglichst groß sein, damit man Events besser vom Noise unterscheiden kann, sollte bei Erhöhung der Spannung ansteigen (da Noise konstant bleiben sollte) |