TIDPAN Valencia 2026

del 15 al 26 de junio

Basic Principles of Silicon Microstrip Detectors

C. García y C. Escobar

CPAN NETWORK ON INSTRUMENTATION AND DETECTORS

CSIC Consejo Superior de Investigaciones Científicas

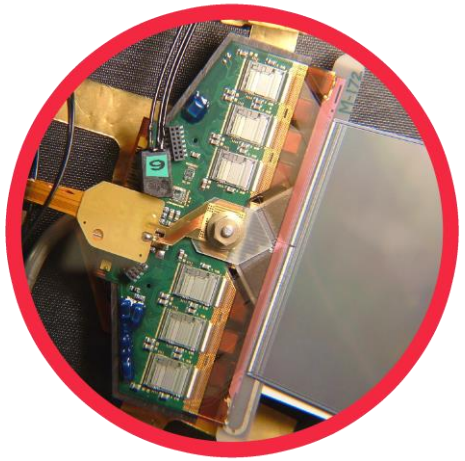
Universitat de València

IFIC Institut de Física Corpuscular

Excelencia Severo Ochoa

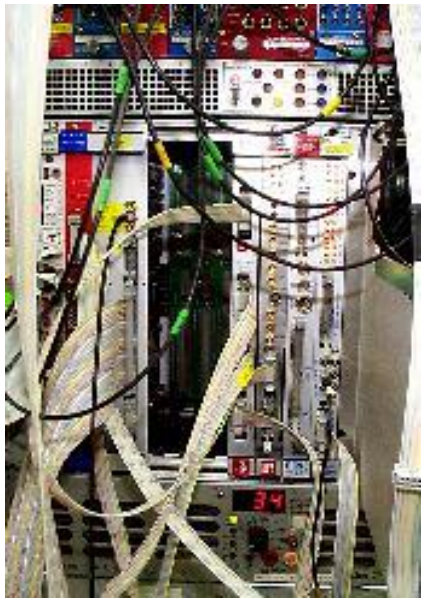
Setup components @ Lab.

Components of a silicon microstrip detectors



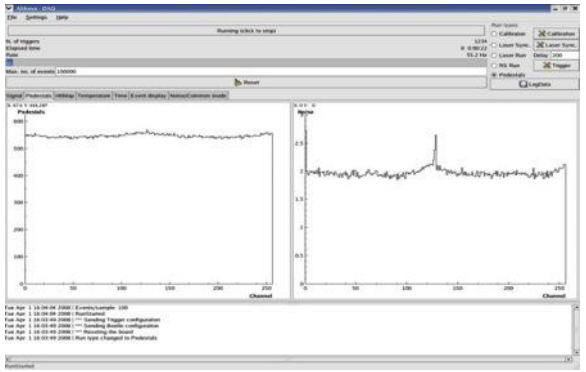
Sensor + ASIC

HV power supply



Control unit

Trigger



Data acquisition and monitoring

Source of particle

Laser

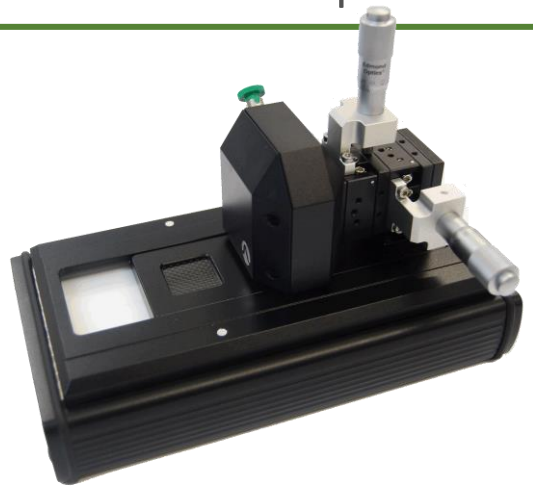
Radioactive source

ASIC: application-specific integrated circuit

EASY system

Control unit

- Data Acquisition Control.
- Processing of the sensor and trigger data
- Adjustable HV unit for microstrip sensor bias, with voltage and current display.
- Include the laser source
- Communication with computer software via USB



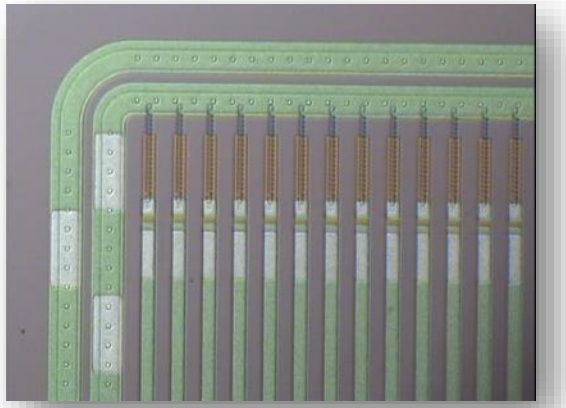
Sensor unit

- Silicon microstrip sensor and the Beetle chip.
- Opaque carbon fibre window to place radioactive source.
- Laser micropositioner and focus system.
- A diode placed under the detector provides a trigger signal.

EASY system

Silicon microstrip

- P-on-N Detector
- Size: 20x20 mm2
- Thickness: 300 µm
- Channels: 128
- Interstrip pitch: ??? µm

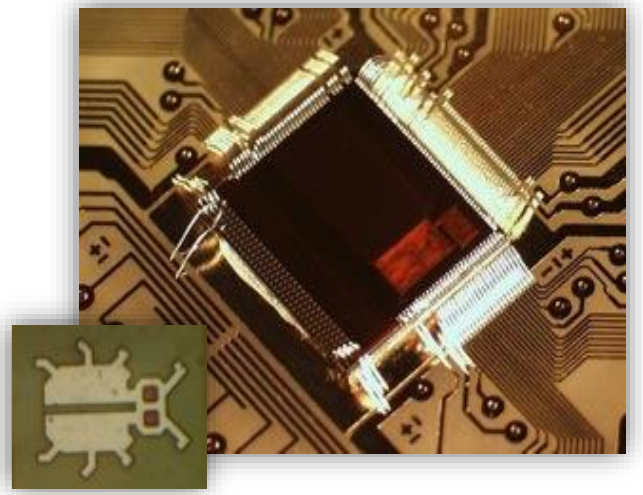


Laser source

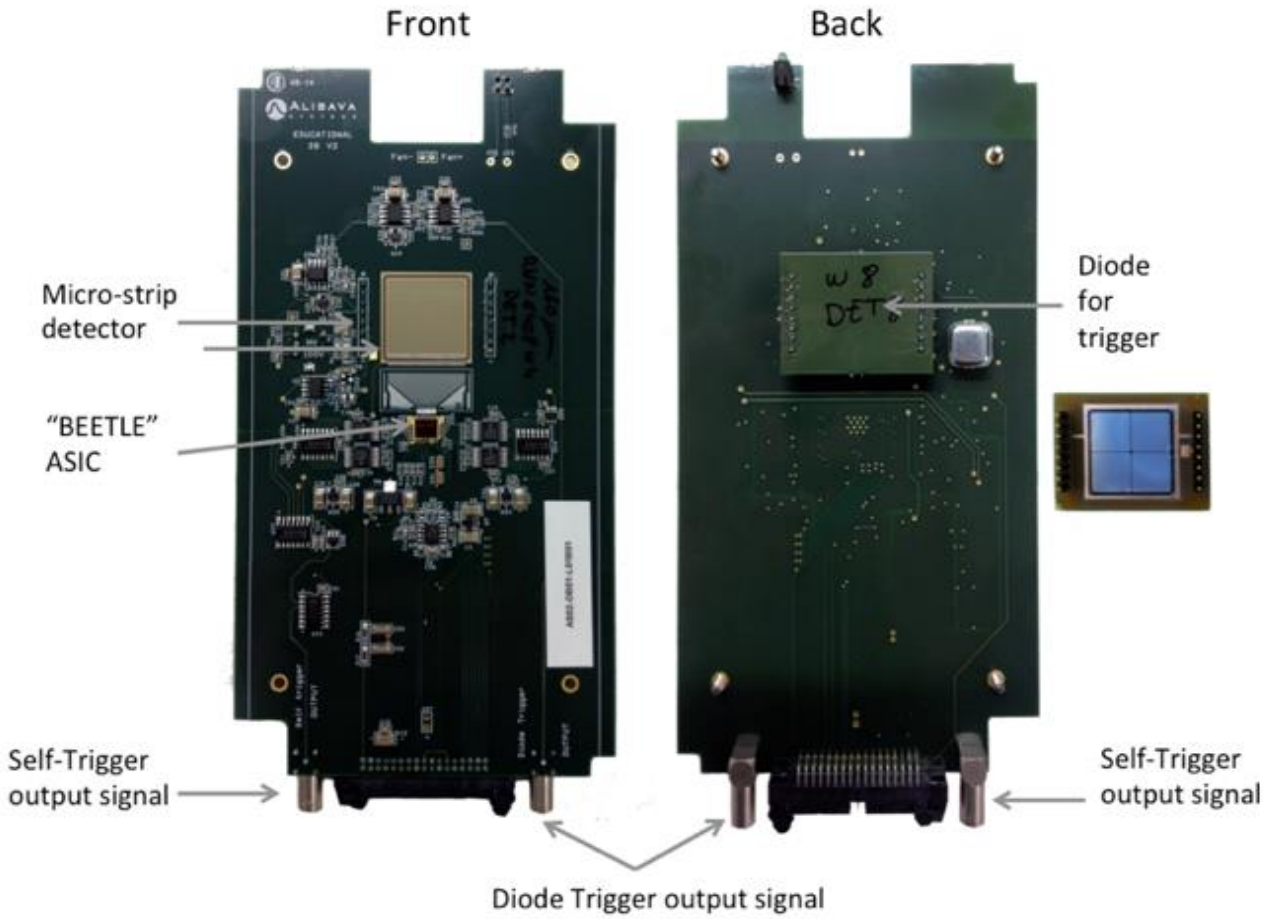
- Wavelength: 980nm
- Pulse width: 5 ns
- Laser Spot: 20 µm
- Micropositioner resolution: 10 µm

Beetle Characteristics

- Low noise ASIC developed for CERN/LHC experiments
- 128 channels

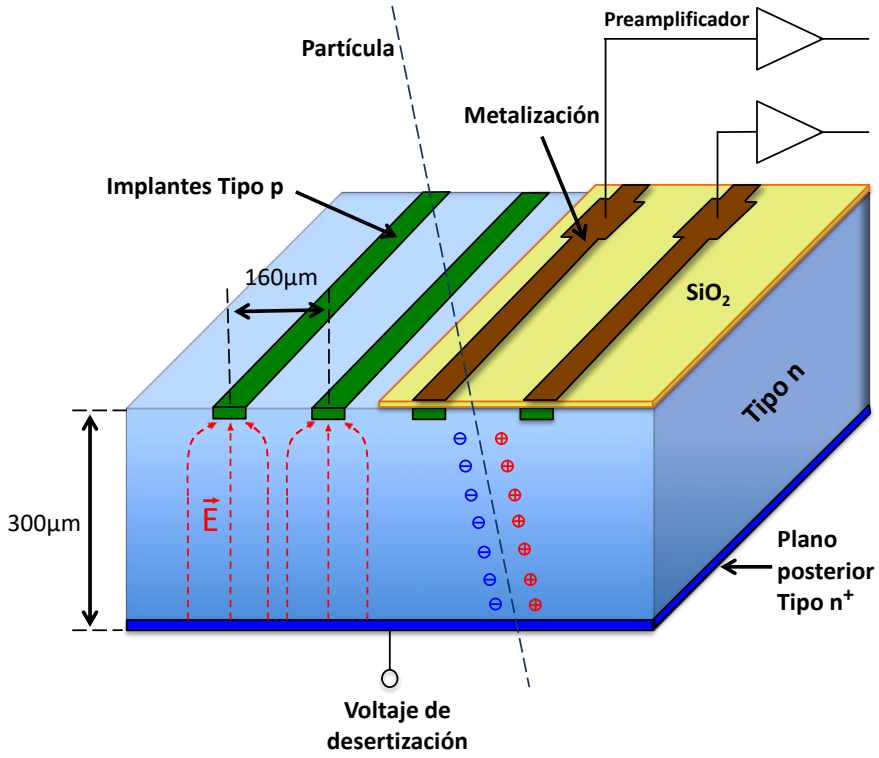


Trigger


Front
Back
Micro-strip detector
"BEETLE" ASIC
Diode for trigger
Self-Trigger output signal
Self-Trigger output signal
Diode Trigger output signal

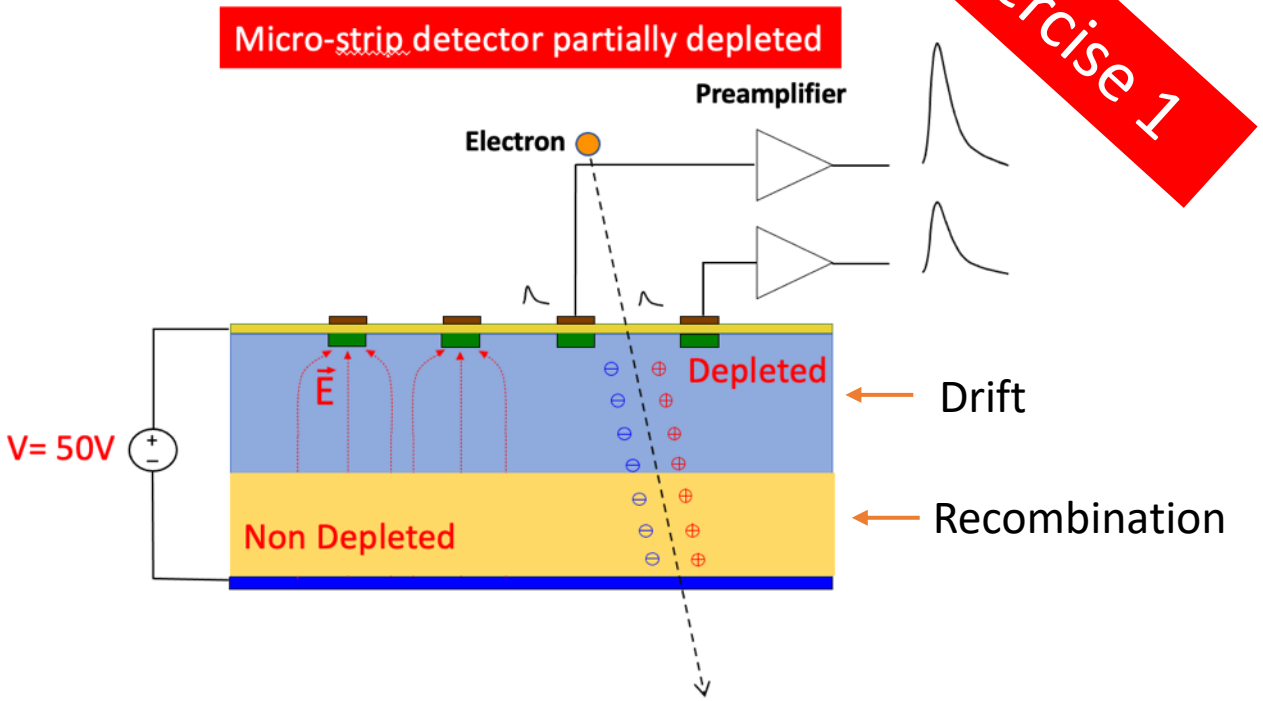
EASY

Basic principle



Strips of p-type silicon on a n-type substrate.
Each strip creates a p-n juntion

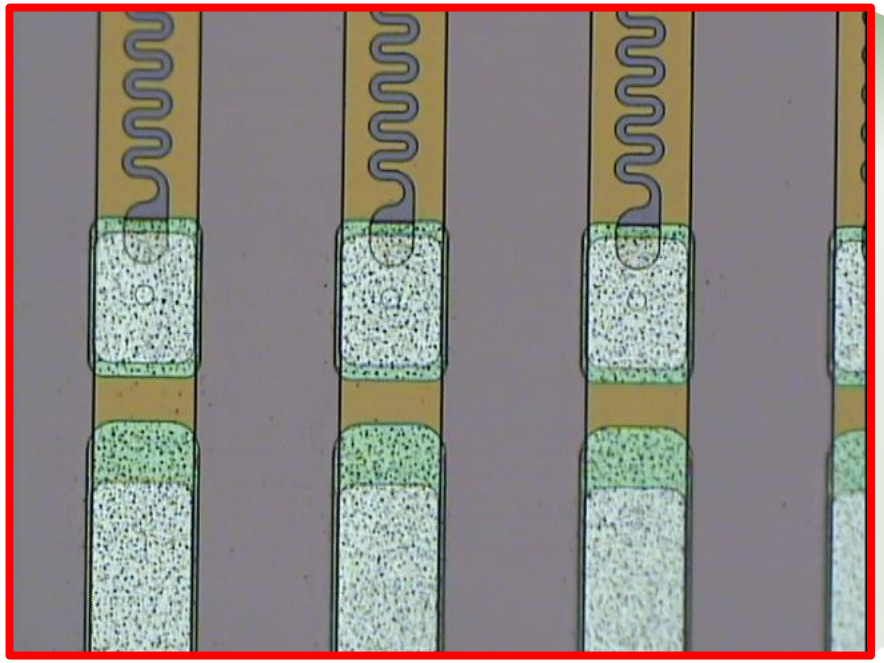
Exercise 1

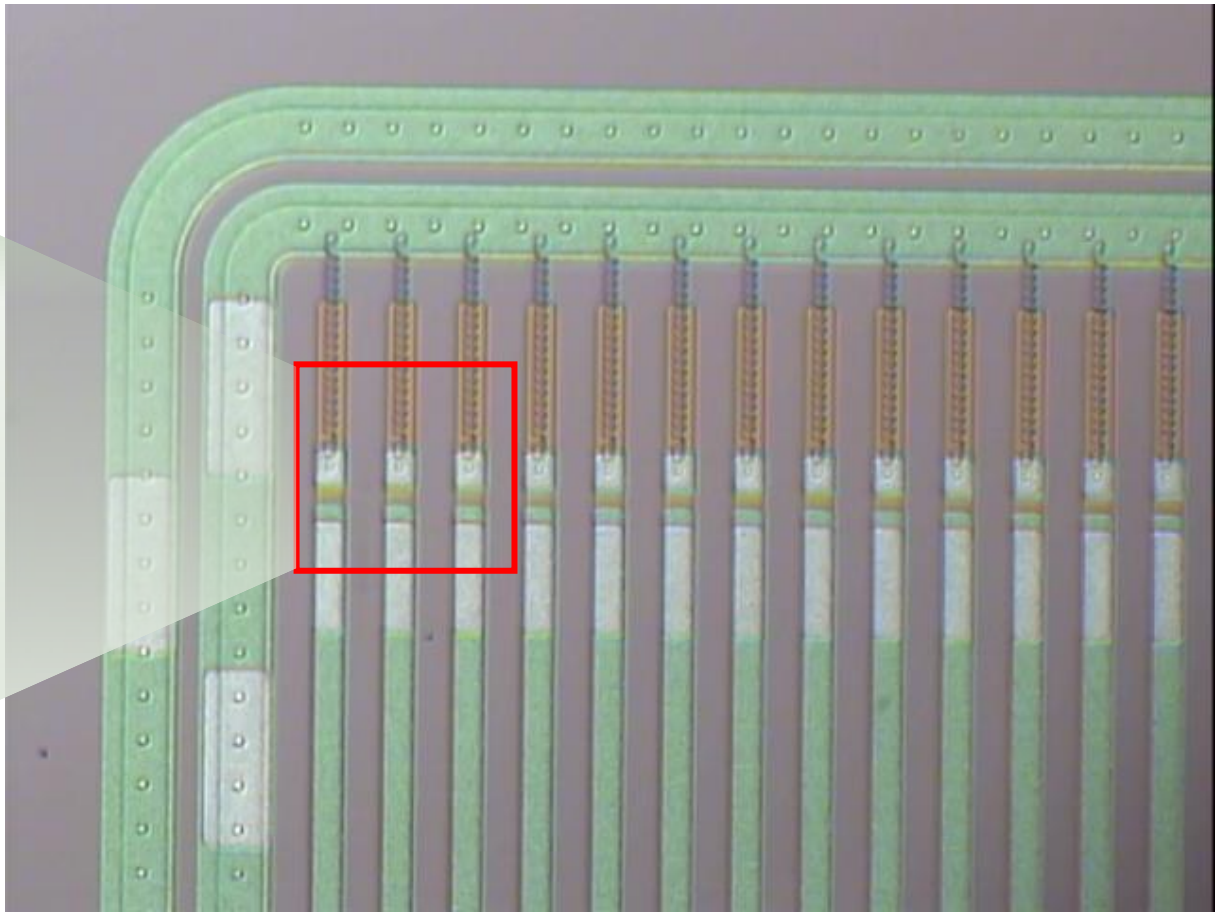


Charge collected is proportional to the depletion area

Basic principle

EASY sensor





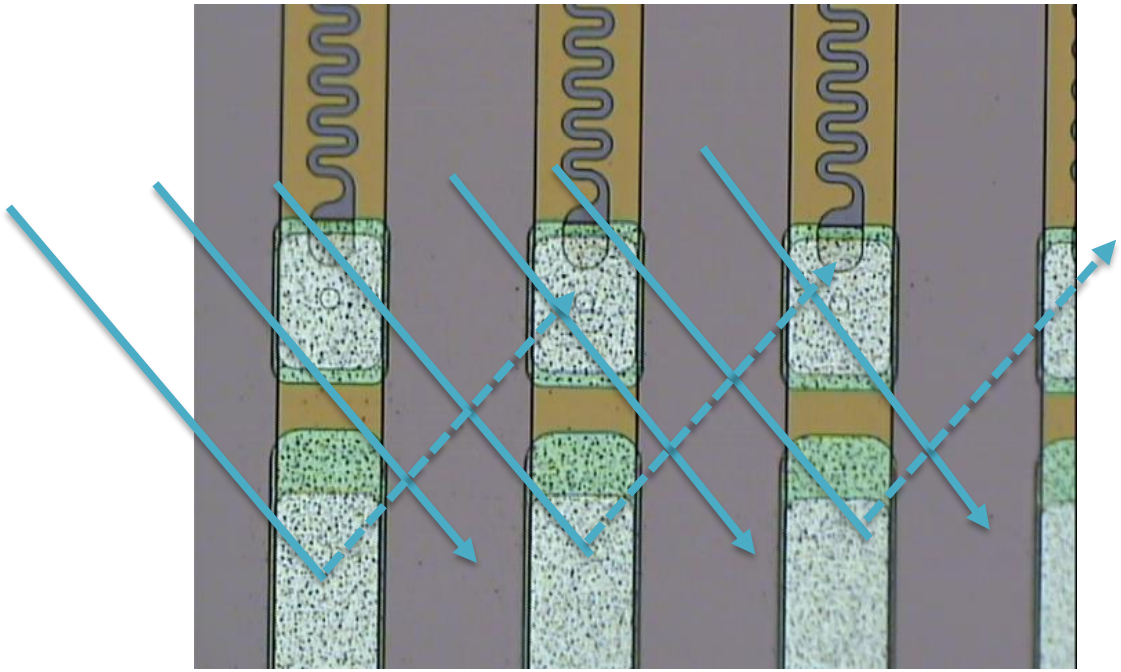
EASY

Basic principle

Exercise 2

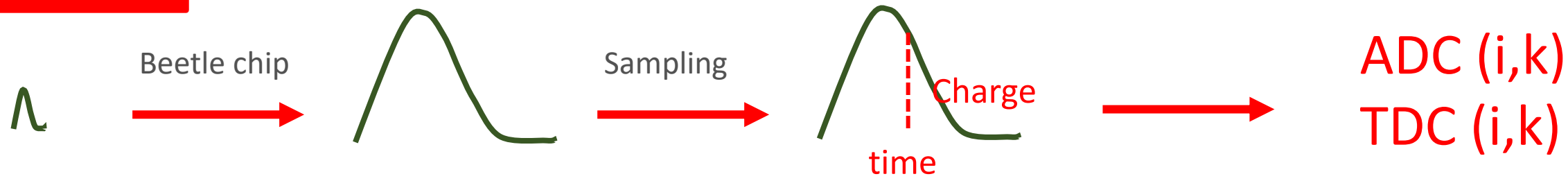
Steps of 10µm

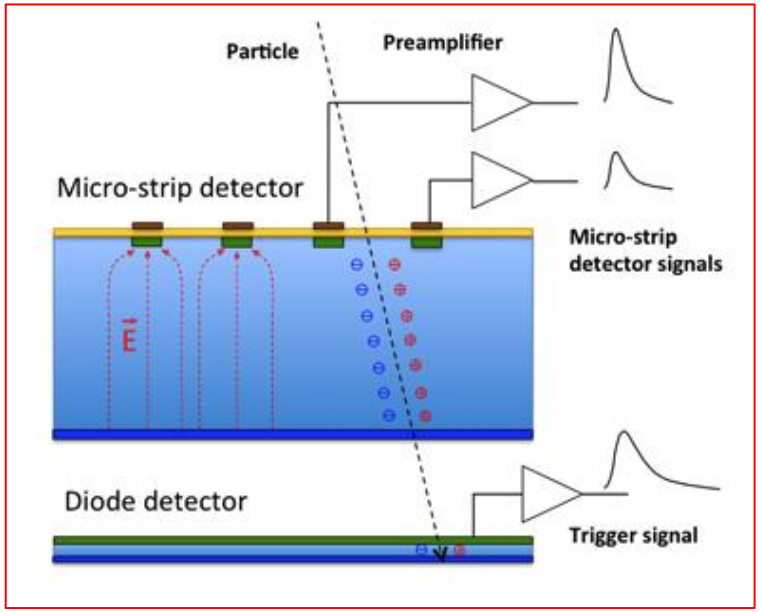
Laser

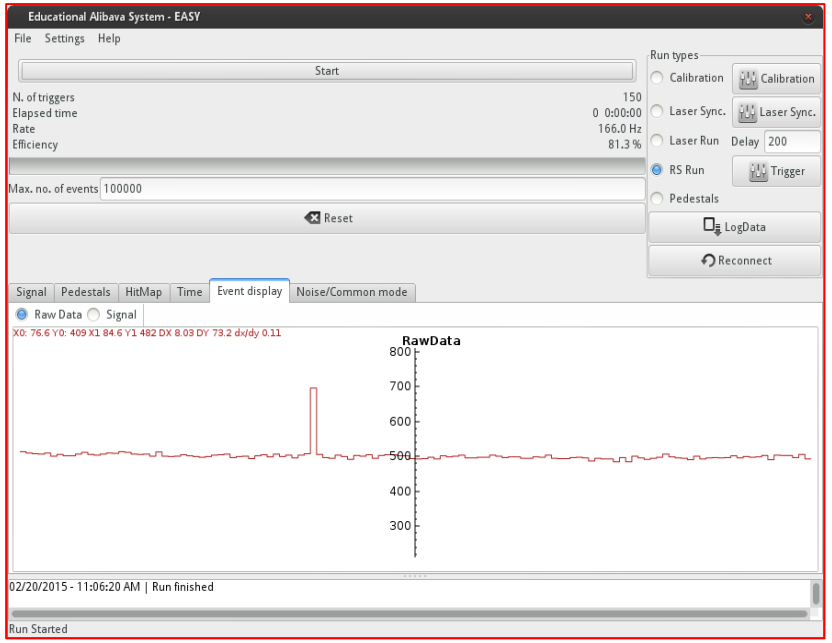


Charge collection

Strip *i* , Event *k*







Charge collection

Strip *i* , Event *k*

ADC(*i*,*k*)= Offset (*i*)+ Common Noise (*k*)+ Electronic Noise (*i*) + Charge (*i*,*k*)

$$P(i) = \frac{1}{N}\sum_{k=1}^{N} ADC(i,k)$$

$$D(k) = \frac{1}{128}\sum_{i=1}^{128}(ADC(i,k) - P(i))$$

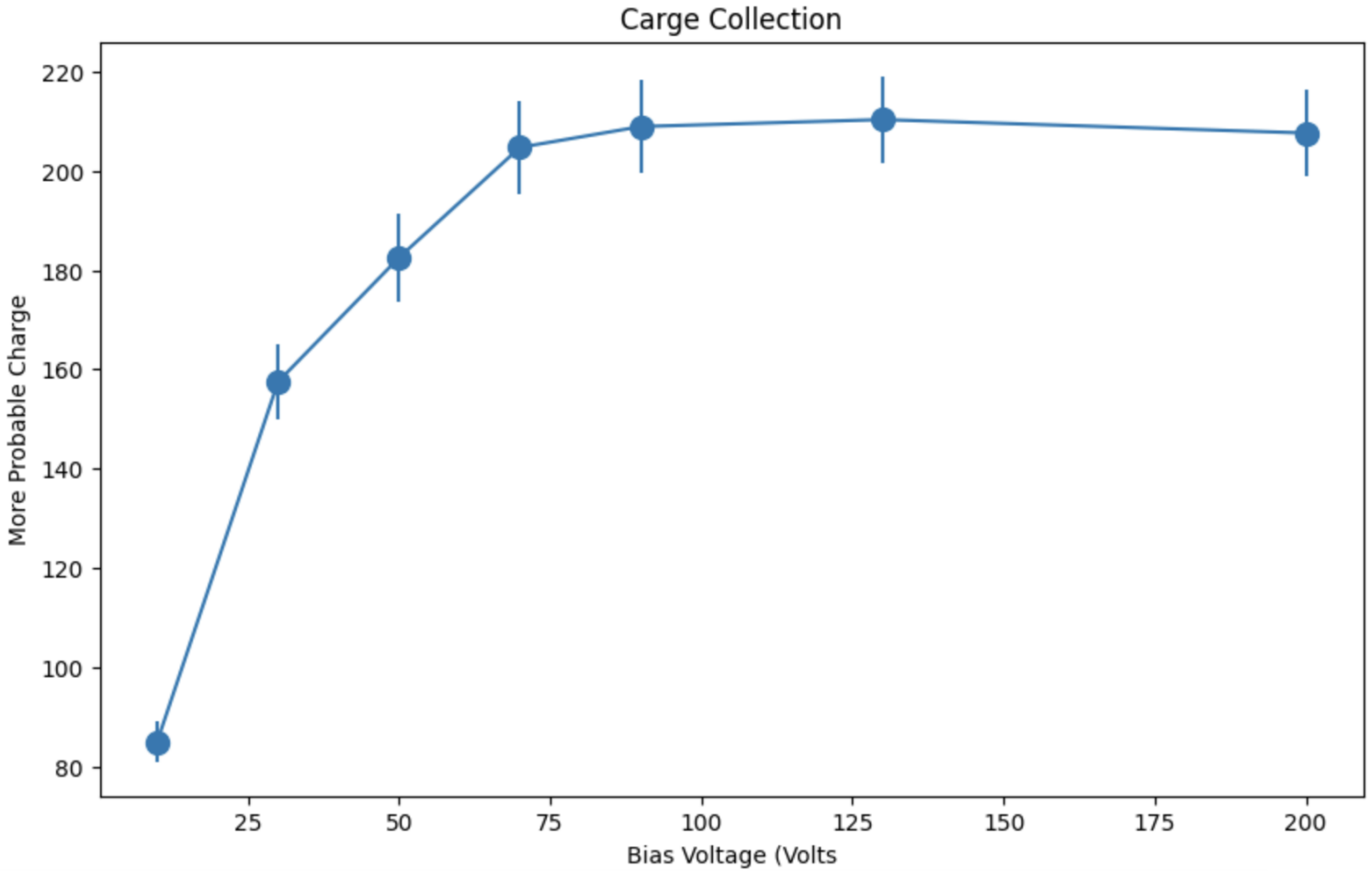
$$Noise(i) = \sqrt{\frac{1}{N-1}\sum_{k=1}^{N}(P_c(i) - \overline{P}_c(i))^2}$$

N events
128 channels

EASY

Depletion Voltage

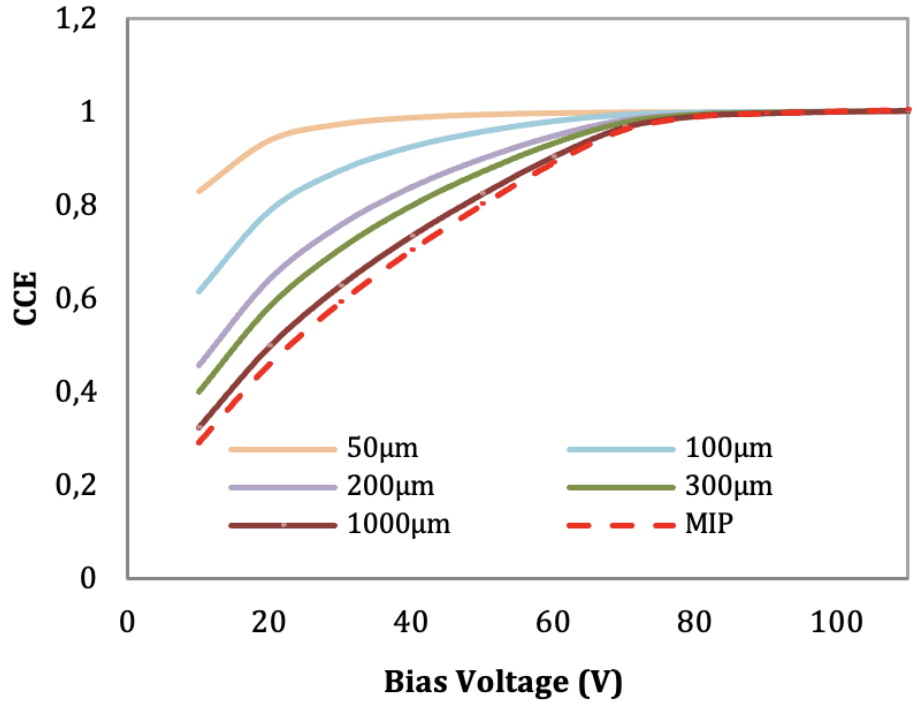
Exercise 1

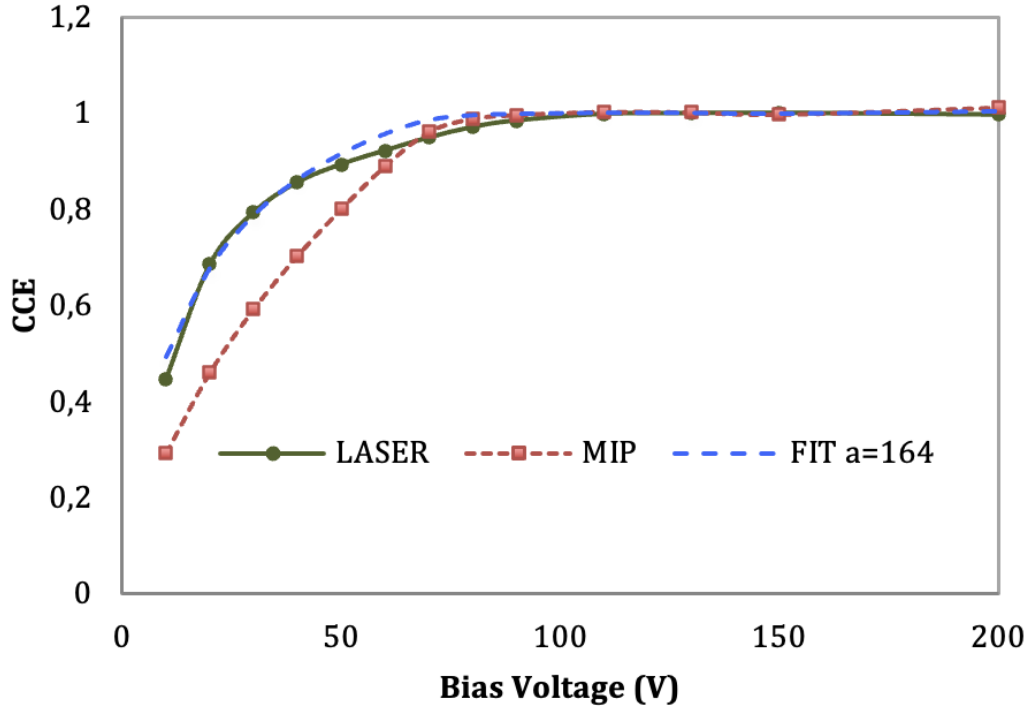


CCE mip vs Laser

Exercise 1

$$E(y) = E_0\left(1 - e^{-y/a}\right)$$





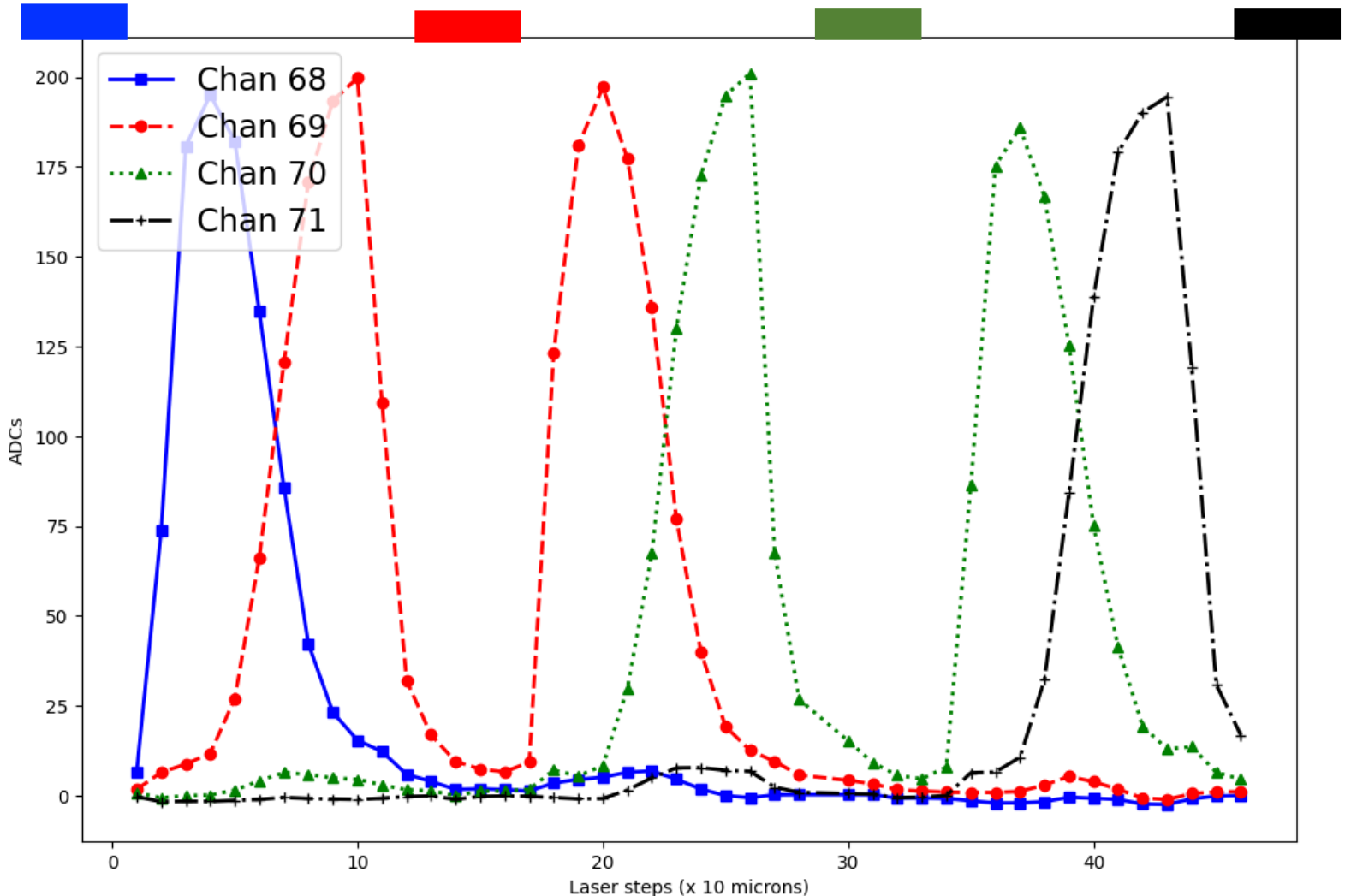
1000µm sensor

EASY

Charge Sharing

LASER

Exercise 2

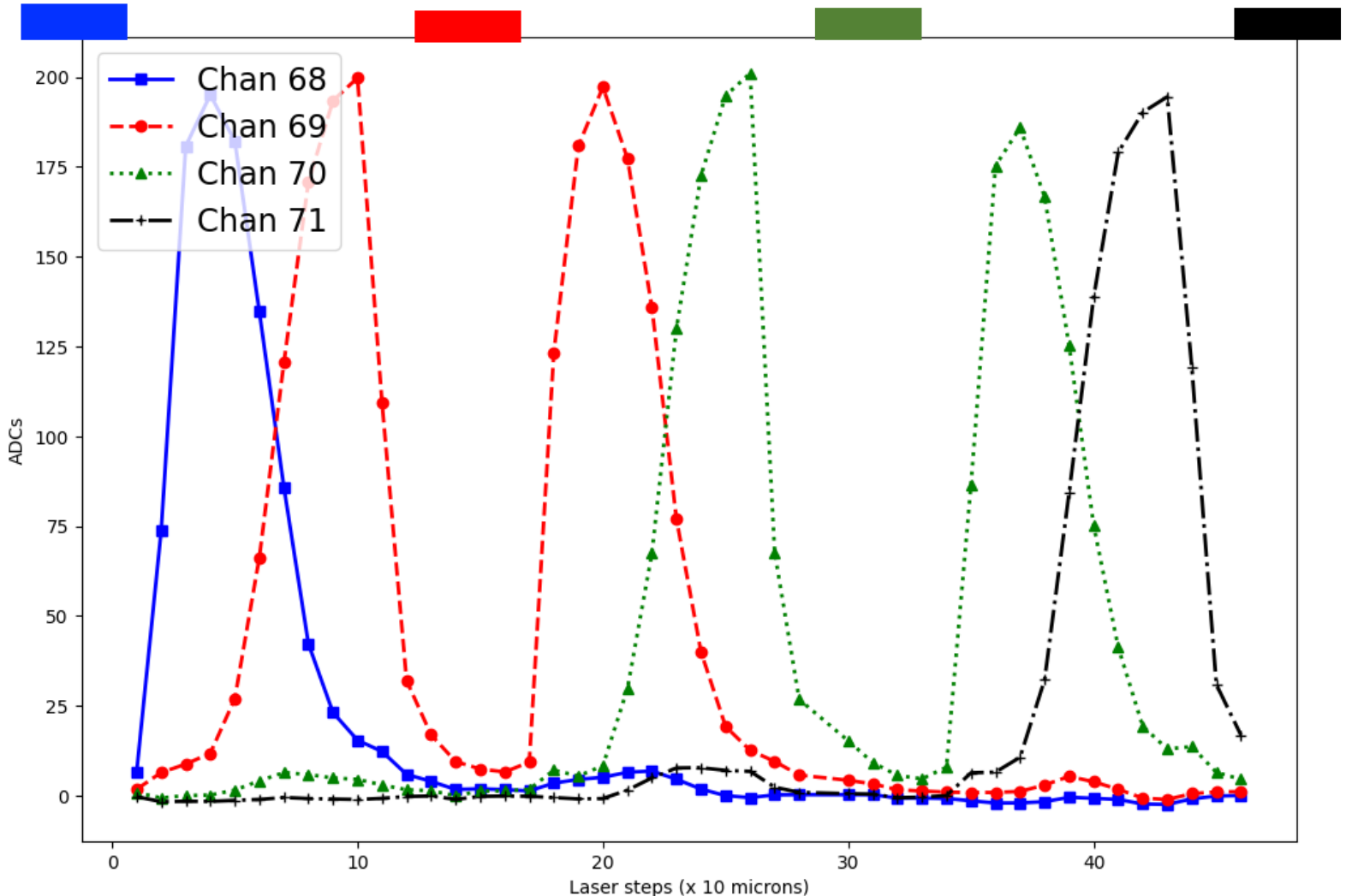


EASY

Charge Sharing

LASER

Exercise 2

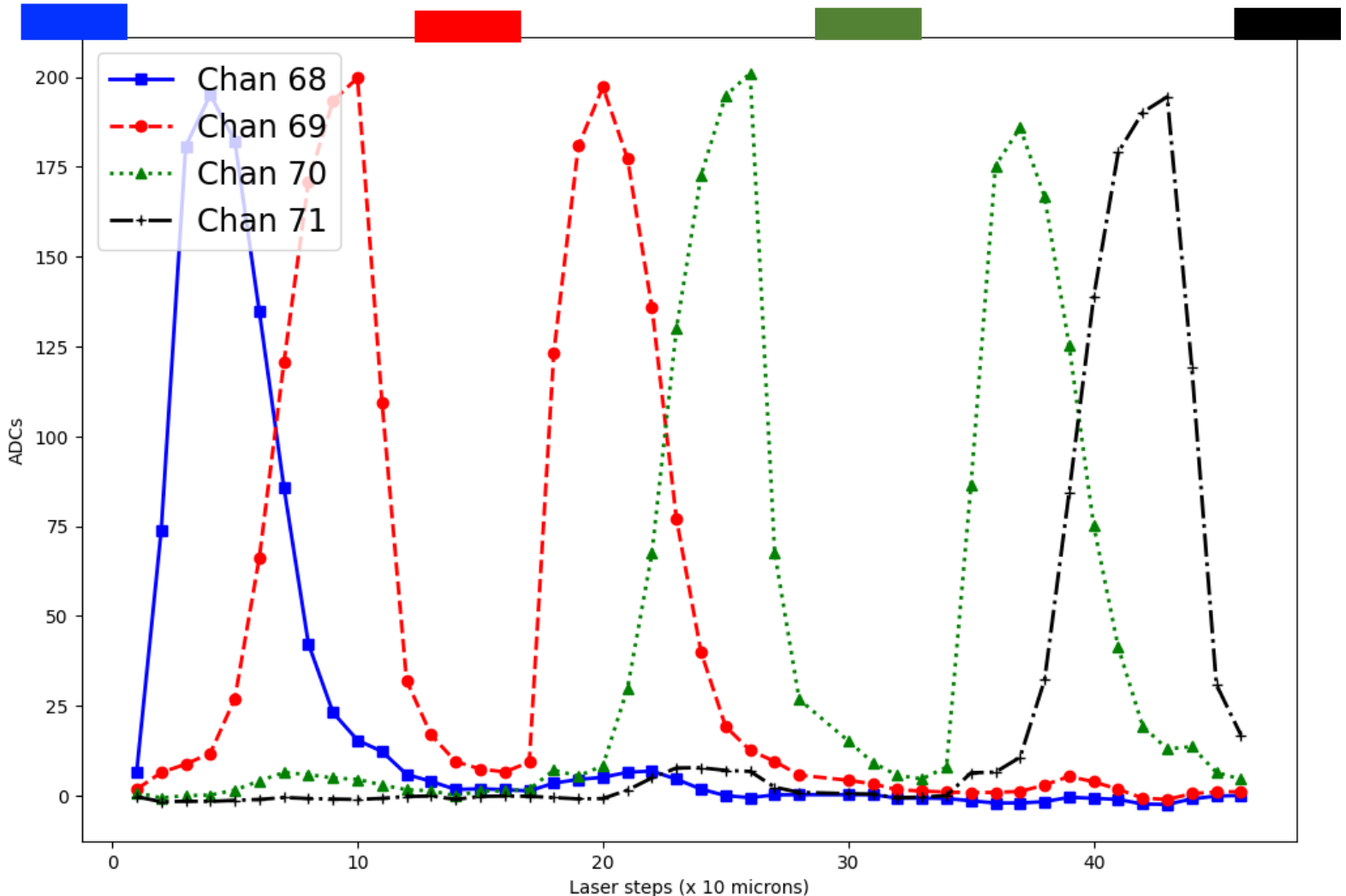


EASY

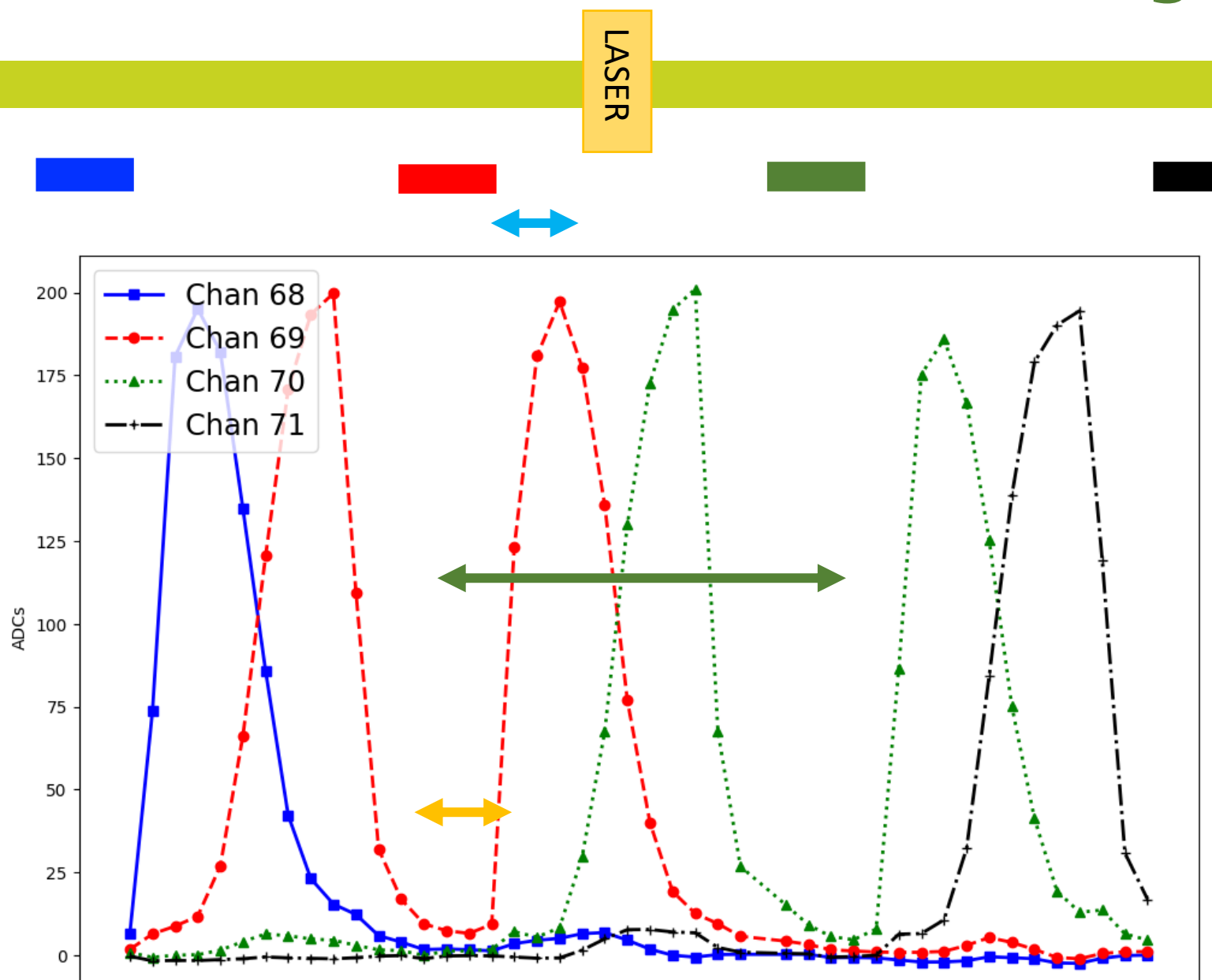
Charge Sharing

LASER

Exercise 2



Charge Sharing

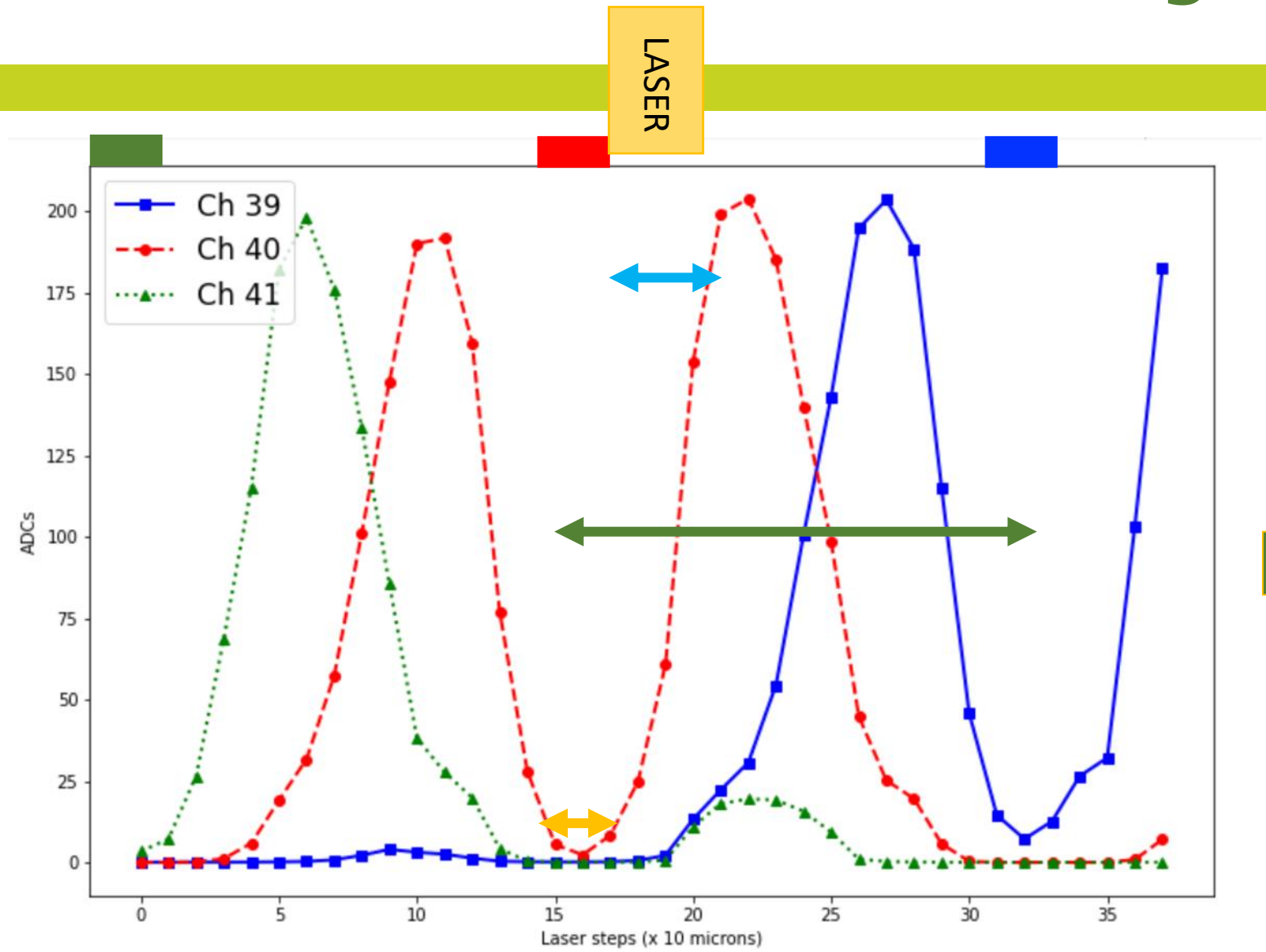


Laser beam Spot

Pich

Strip width

Charge Sharing



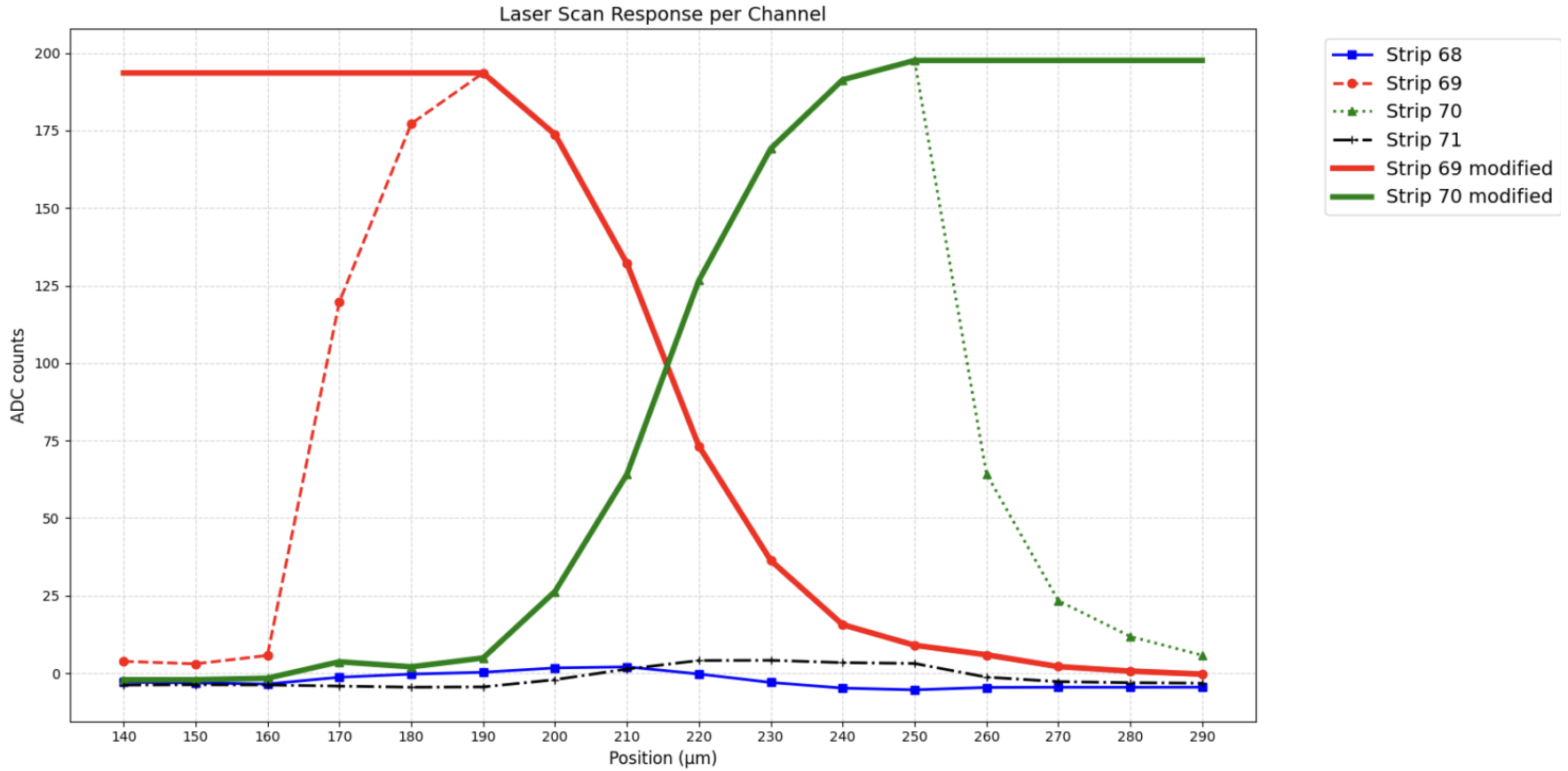
Laser beam Spot

Pich

Strip width

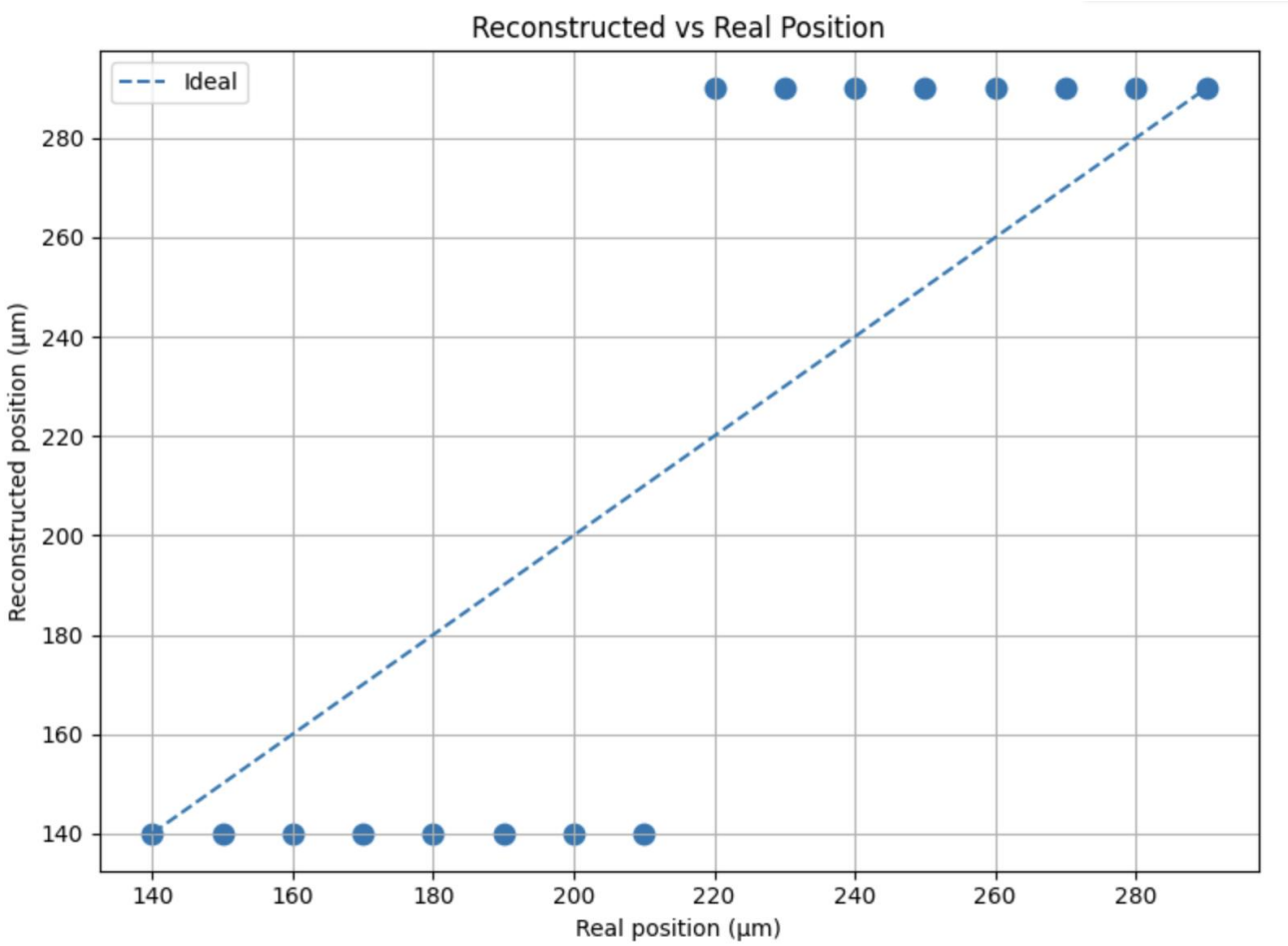
EASY

Spatial resolution



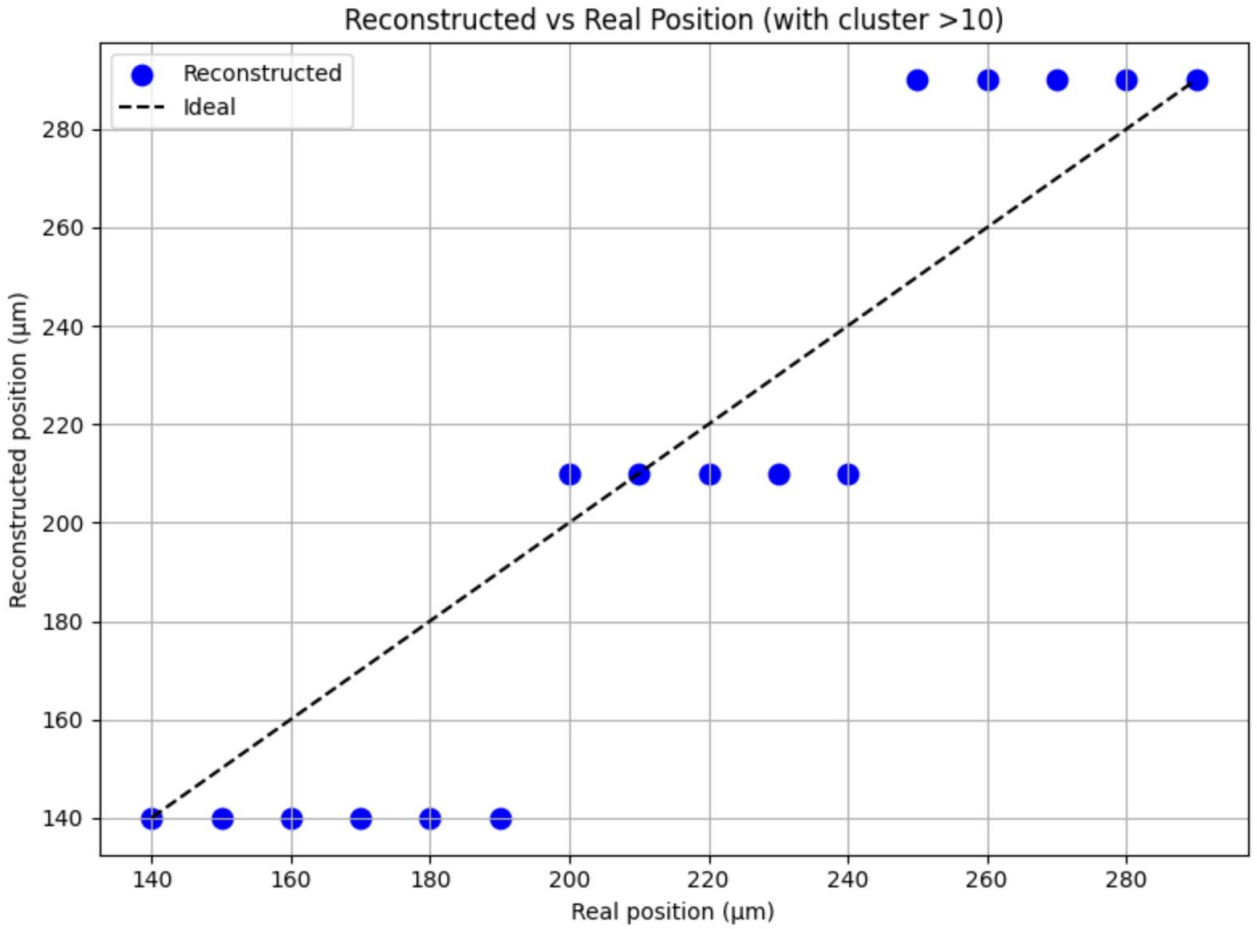
Spatial resolution

```
Mean residual = 0.0 µm
Std residual  = 41.83300132670378 µm
```



Spatial resolution

```
Mean residual = -6.25 µm
Std residual  = 24.206145913796355 µm
```



Spatial resolution

```
Mean residual = -6.603350639343262 µm
Std residual  = 32.728168995772435 µm
```

η-algorithm

$$x_{\text{rec}} = x_i + \eta\, p$$

$$\eta = \frac{Q_{i+1}}{Q_i + Q_{i+1}}$$