Taller de Altas Energías 2013

Effect of the implementation of extra intermediate strips in the spacial resolution of a silicon strip detector

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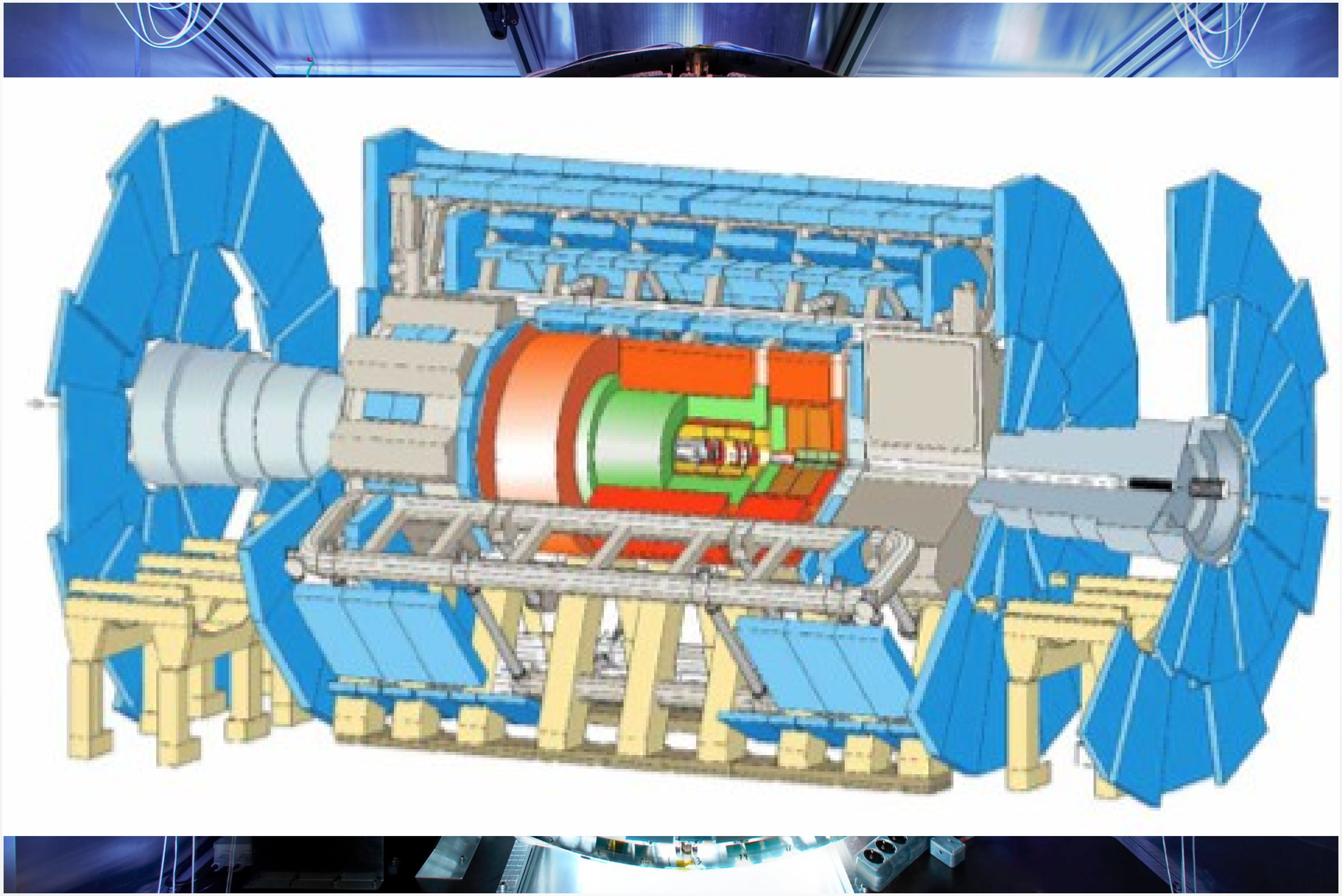
- **Silicon microstrip sensors**
- **Detector design**
- **Experimental setup**
- **Charge distribution function**
- **Summary & conclusions**

Silicon microstrip sensors

Silicon microstrip sensors

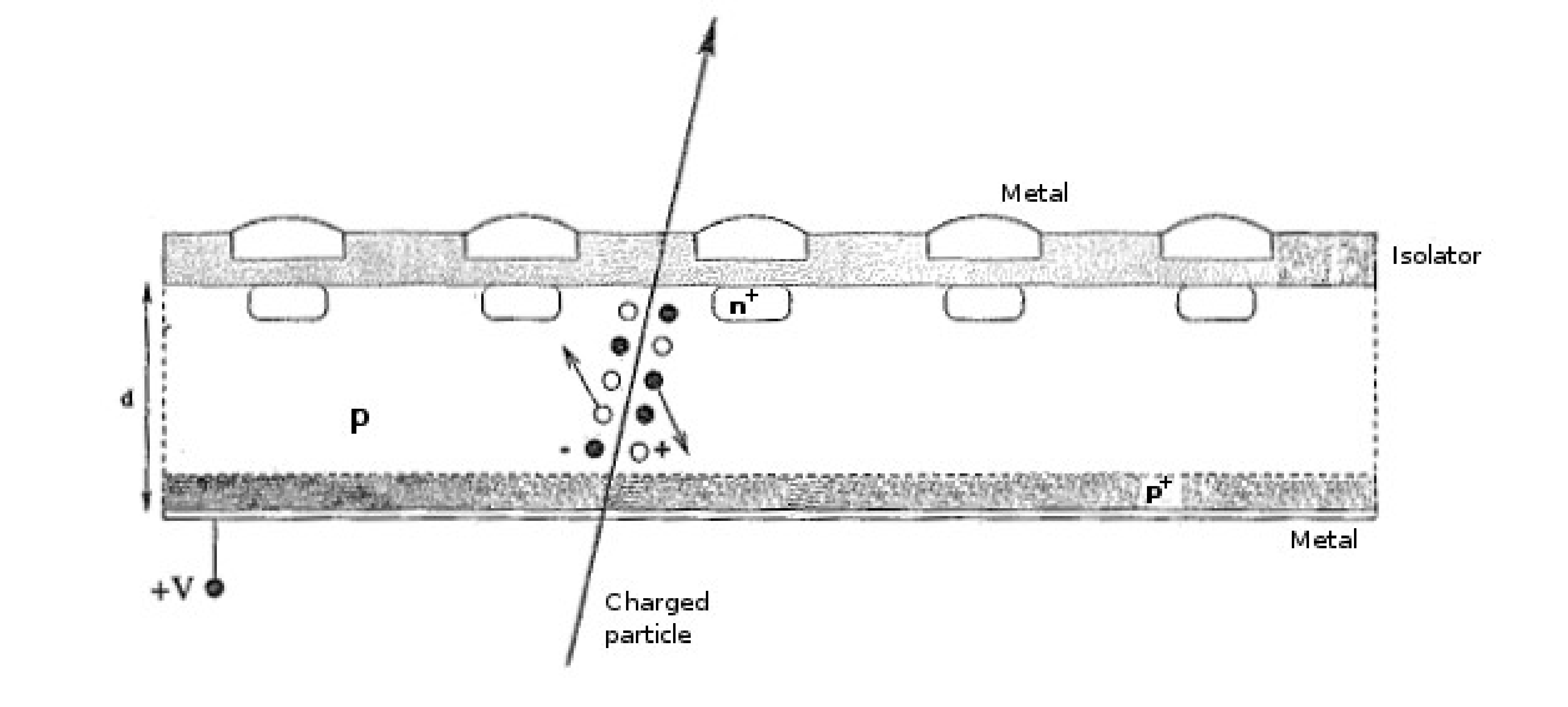
Silicon microstrip sensors are a widely used detector in particle physics experiments

They are used intracking systems as the SCT of the ATLAS inner detector



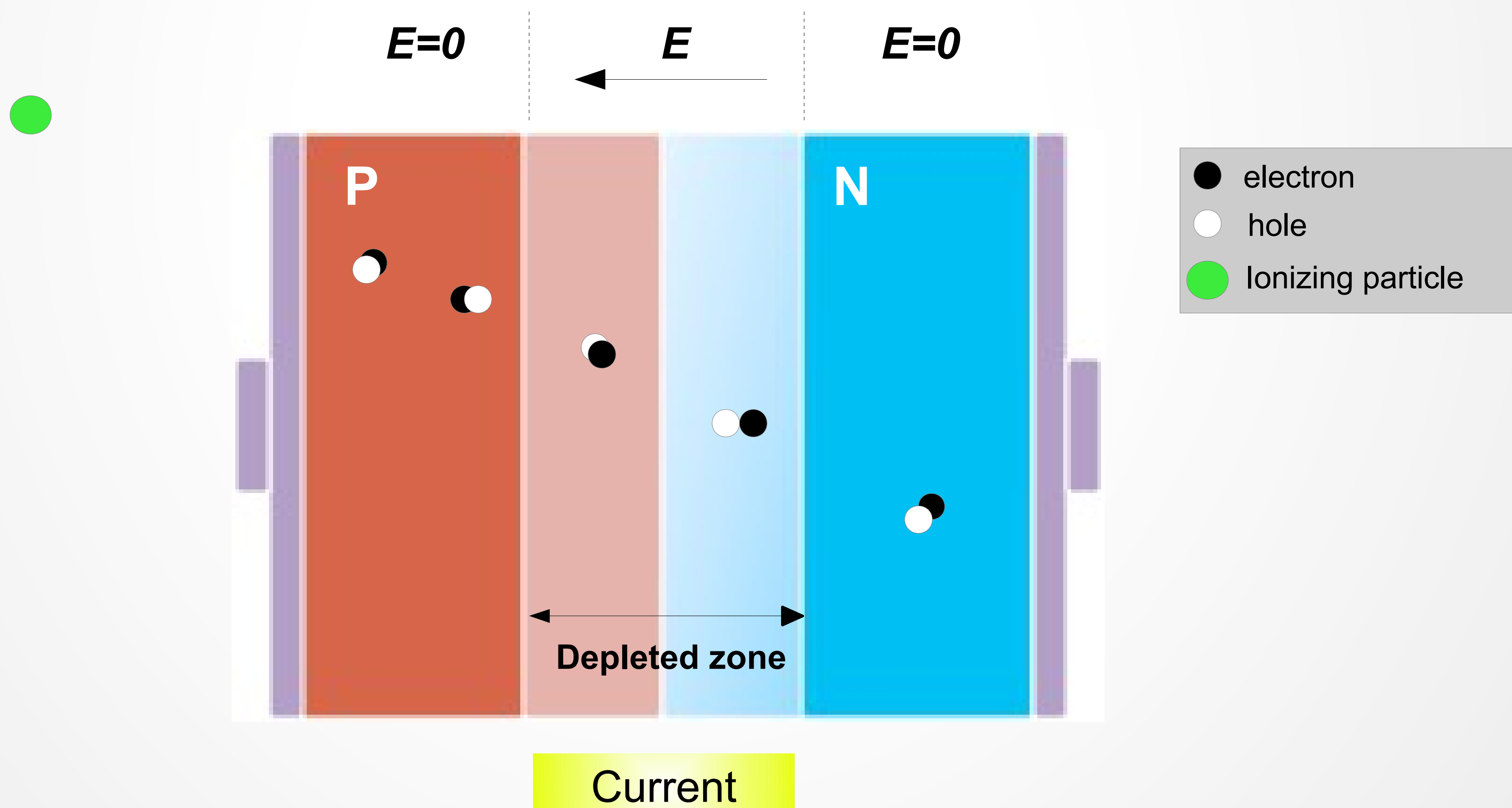
Silicon microstrip sensors

- It is based in a inverse biased PN junction.
- Highly doped silicon strips are placed on a wafer of silicon.
- Each strip is read independently. Position can be measured.



Silicon microstrip sensors

- Charged particles going through the detector create multiple electron-hole pairs by ionization.
- The electric field inside the depleted zone sweeps the pairs to the electrodes.
- The drift of electrons and holes induce a current that can be measured.

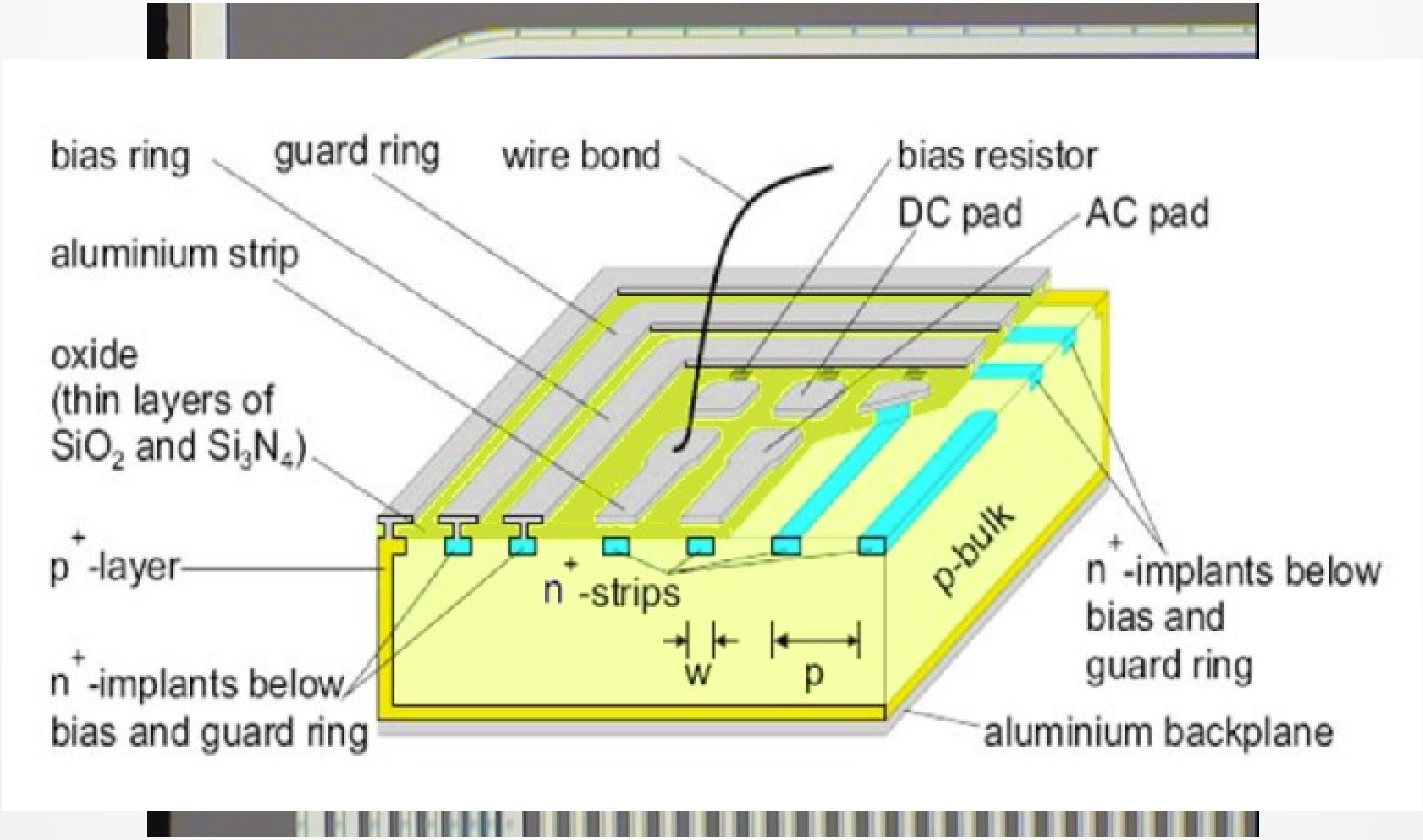


Detector design

Detector design

number of strips	Type	Strip's width	Pitch	Wafer's thick
128	n+ over p	25 μm	80 μm	305 μm

Eight **guard rings** and a **bias ring**. Connections through **poly-silicon resistors**.



Detector design

Two different designs have been used.

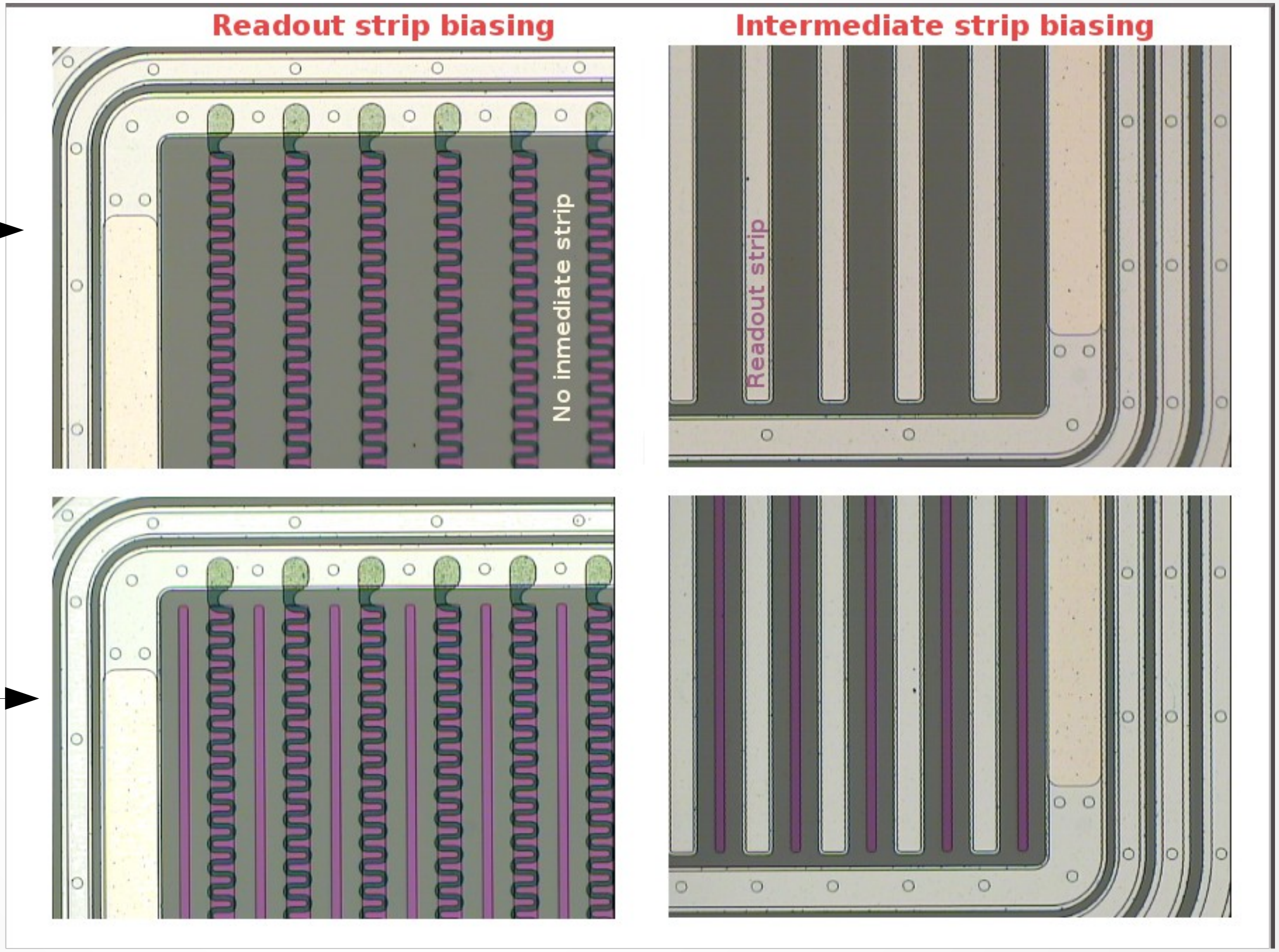
Model **M-14**

No intermediate strip.

Model **M-8**

Additional strips.

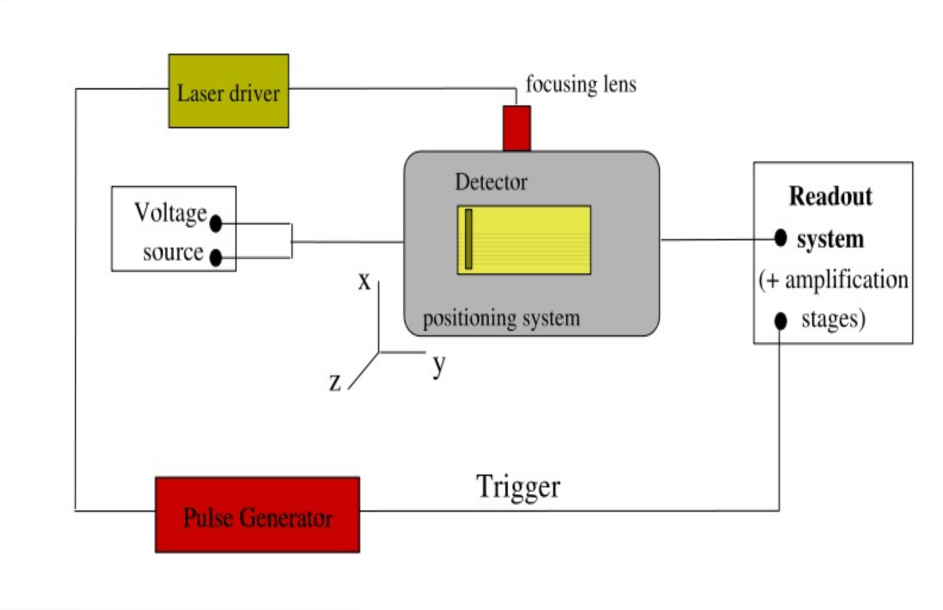
10-µm wide



Intermediate strips are left *unbiased*, so they are called *floating intermediate strips.*

Experimental setup

Experimental setup



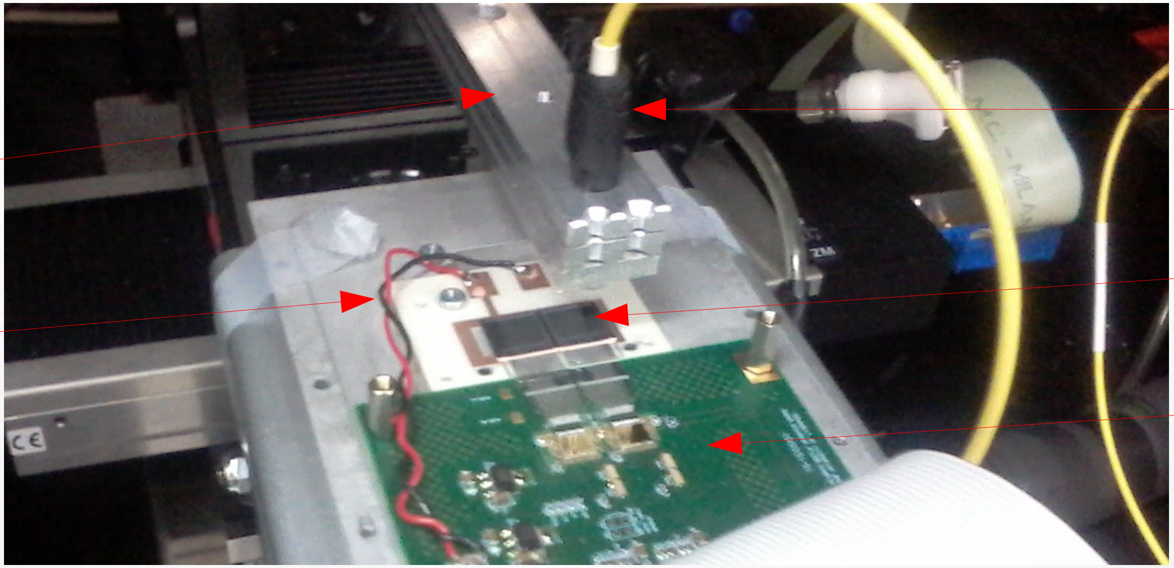
Laser setup properties:

- Predetermined trigger
- Fast data acquisition
- Known emission direction

- Photoelectric effect

Positioning system

Biasing



Laser lens

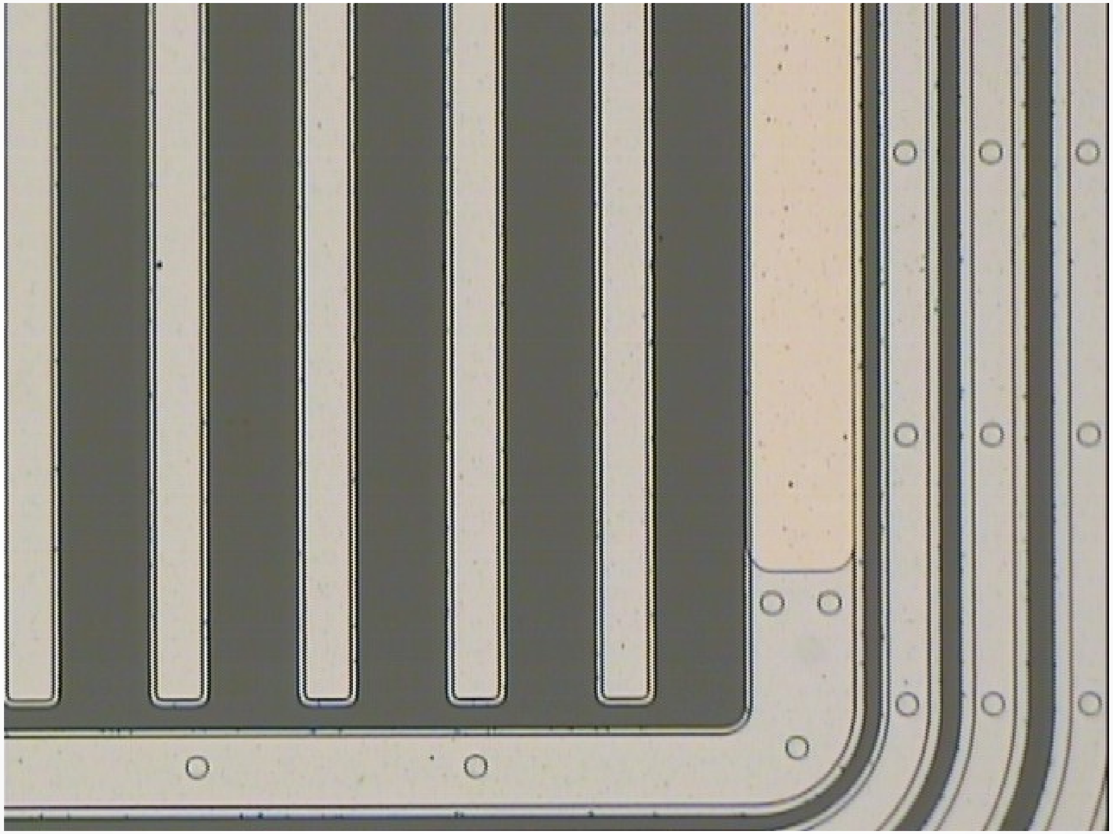
Detectors

Daughter board

Charge distribution function

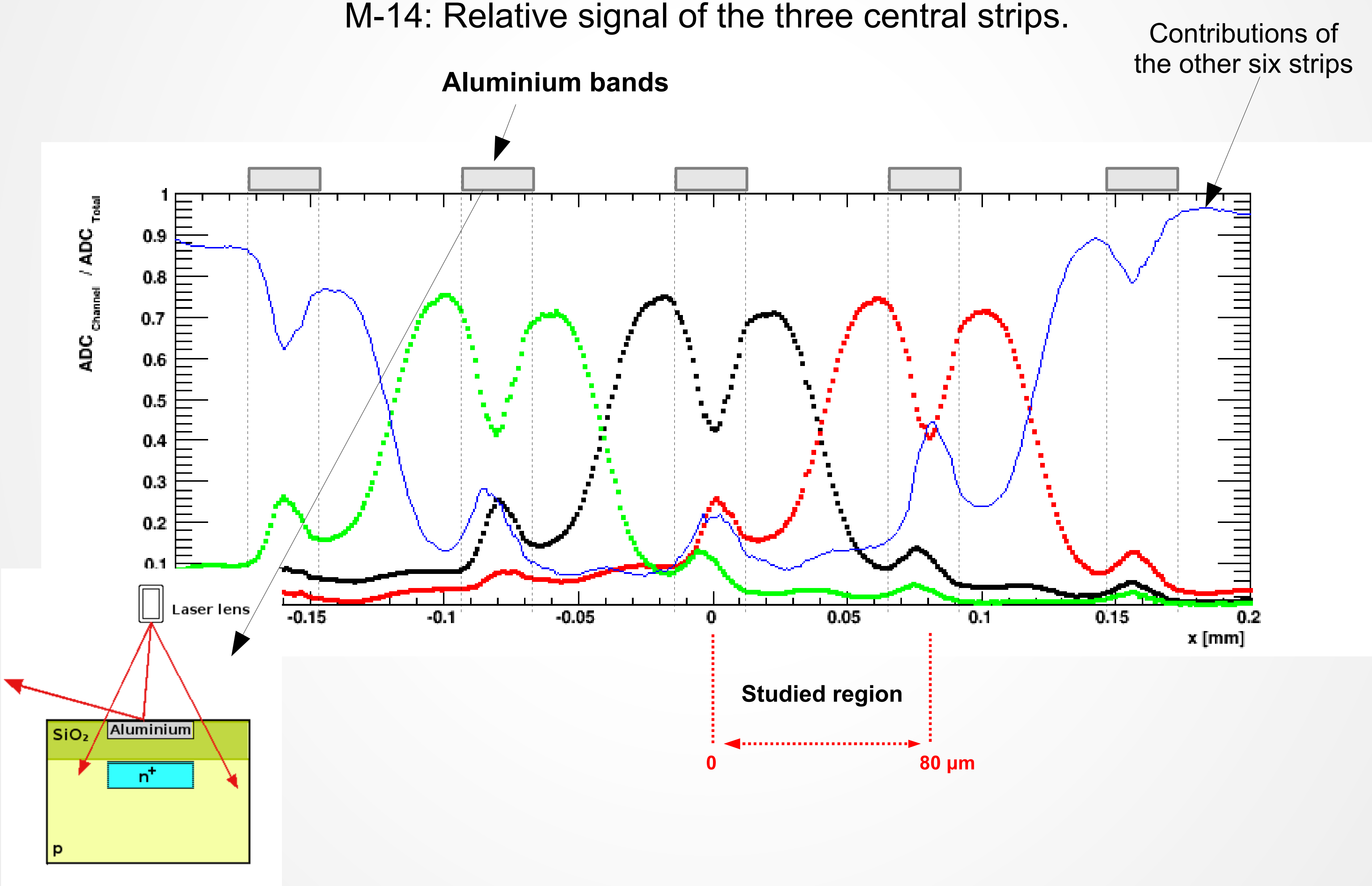
Charge distribution function

M-14 : No intermediate strip

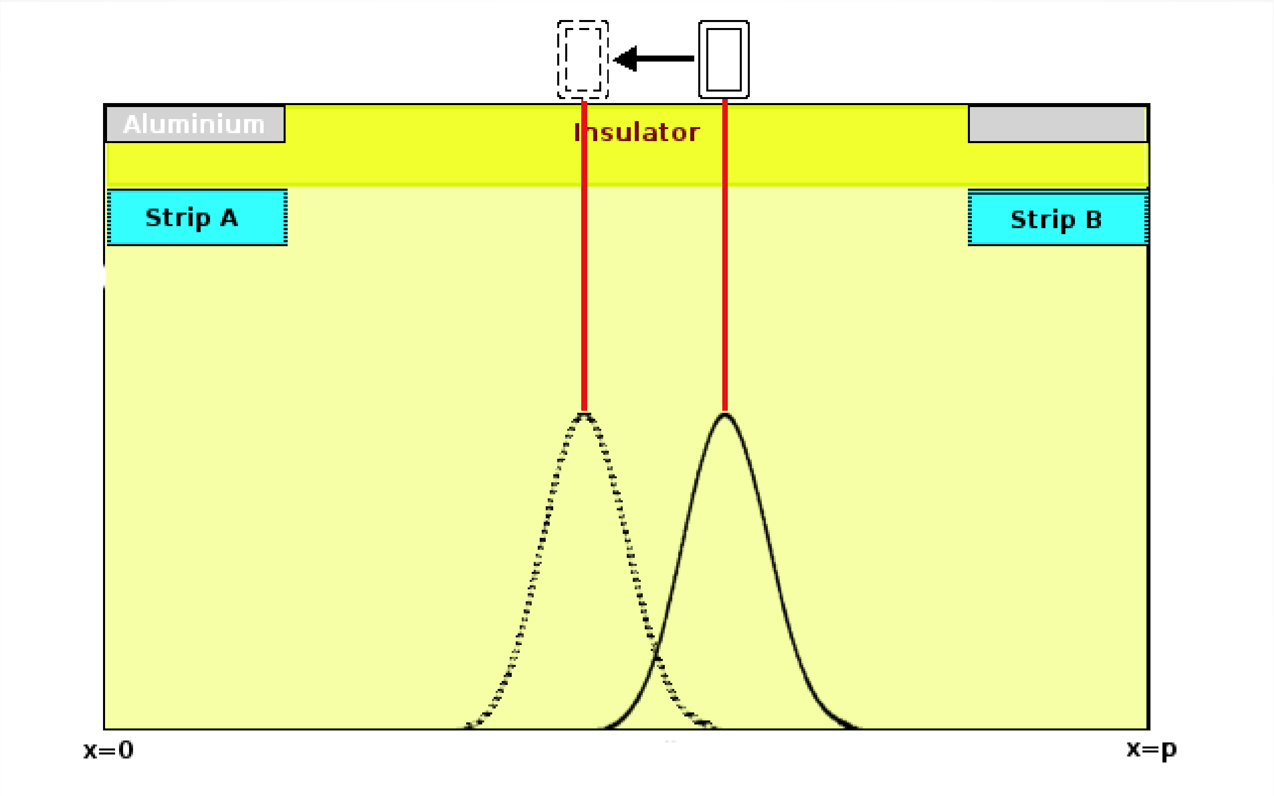


Intermediate-strip-free model

M-14: Relative signal of the three central strips.



Effect of the laser beam shape

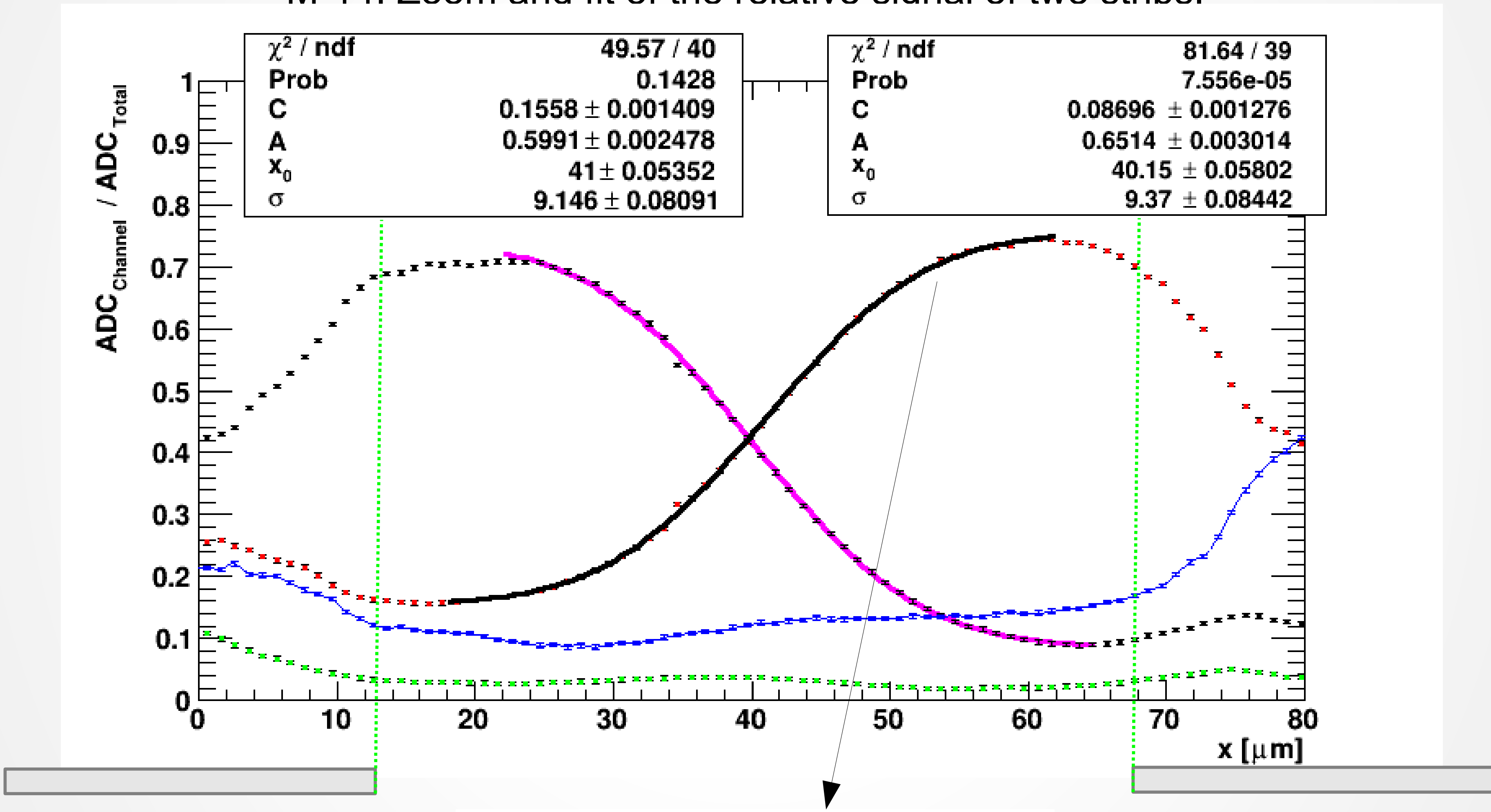


As the laser beam shape follows a gaussian distribution, when laser is centered in a position x, a small region is lightened. What is measured then is the convolution of the detector charge distribution function, *q(x)*, with the gaussian profile of the laser beam, given by:

$$Q(x) = \int_{-\infty}^{+\infty} q(x')e^{\frac{1}{2}(\frac{x'-x}{\sigma})^2}dx'$$

Intermediate-strip-free model

M-14: Zoom and fit of the relative signal of two strips.



$$f(x) = A \int_{-\infty}^{x} e^{\frac{1}{2}(\frac{x'-x_o}{\sigma})^2} dx' + C$$

Intermediate-strip-free model

q(x) is what we want to measure

What we are really measuring

$$Q(x) = \int_{-\infty}^{+\infty} q(x') e^{\frac{1}{2}(\frac{x'-x}{\sigma})^2} dx'$$

Gaussian shape of the laser beam

Experimentally, we obtain that data fits

$$f(x) = A \int_{-\infty}^{x} e^{\frac{1}{2}(\frac{x'-x_o}{\sigma})^2} dx' + C = Q(x)$$

Intermediate-strip-free model

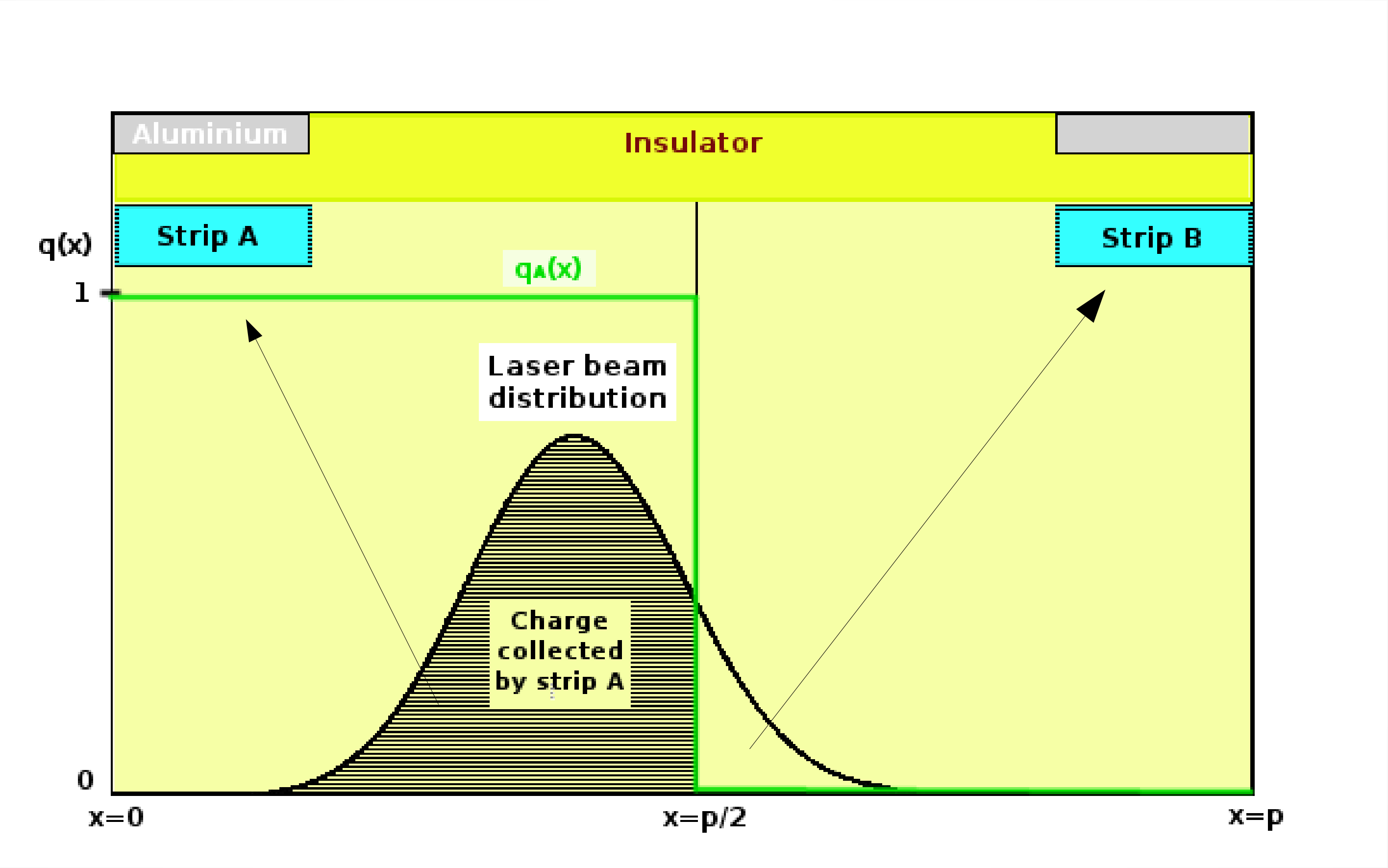
Left strip $$q(x) = \begin{cases} 1 & x < x_o \simeq p/2 \\ 0 & x \geq x_o \simeq p/2 \end{cases}$$

Right strip $$q(x) = \begin{cases} 0 & x < x_o \simeq p/2 \\ 1 & x \geq x_o \simeq p/2 \end{cases}$$

Is the only charge distribution function, q(x), that connects both equations

$$Q(x) = \int_{-\infty}^{+\infty} q(x') e^{\frac{1}{2}(\frac{x'-x}{\sigma})^2} dx'$$ **&** $$f(x) = A \int_{-\infty}^{x} e^{\frac{1}{2}(\frac{x'-x_0}{\sigma})^2} dx' + C = Q(x)$$

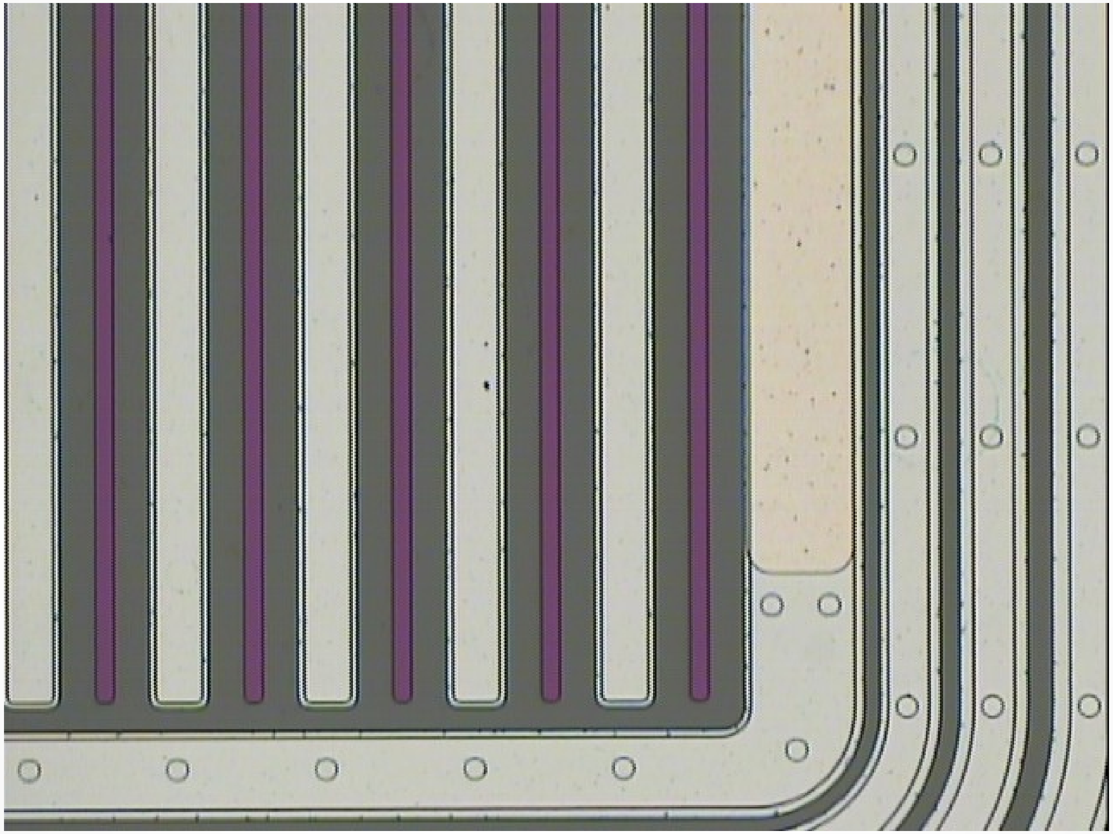
Intermediate-strip-free model



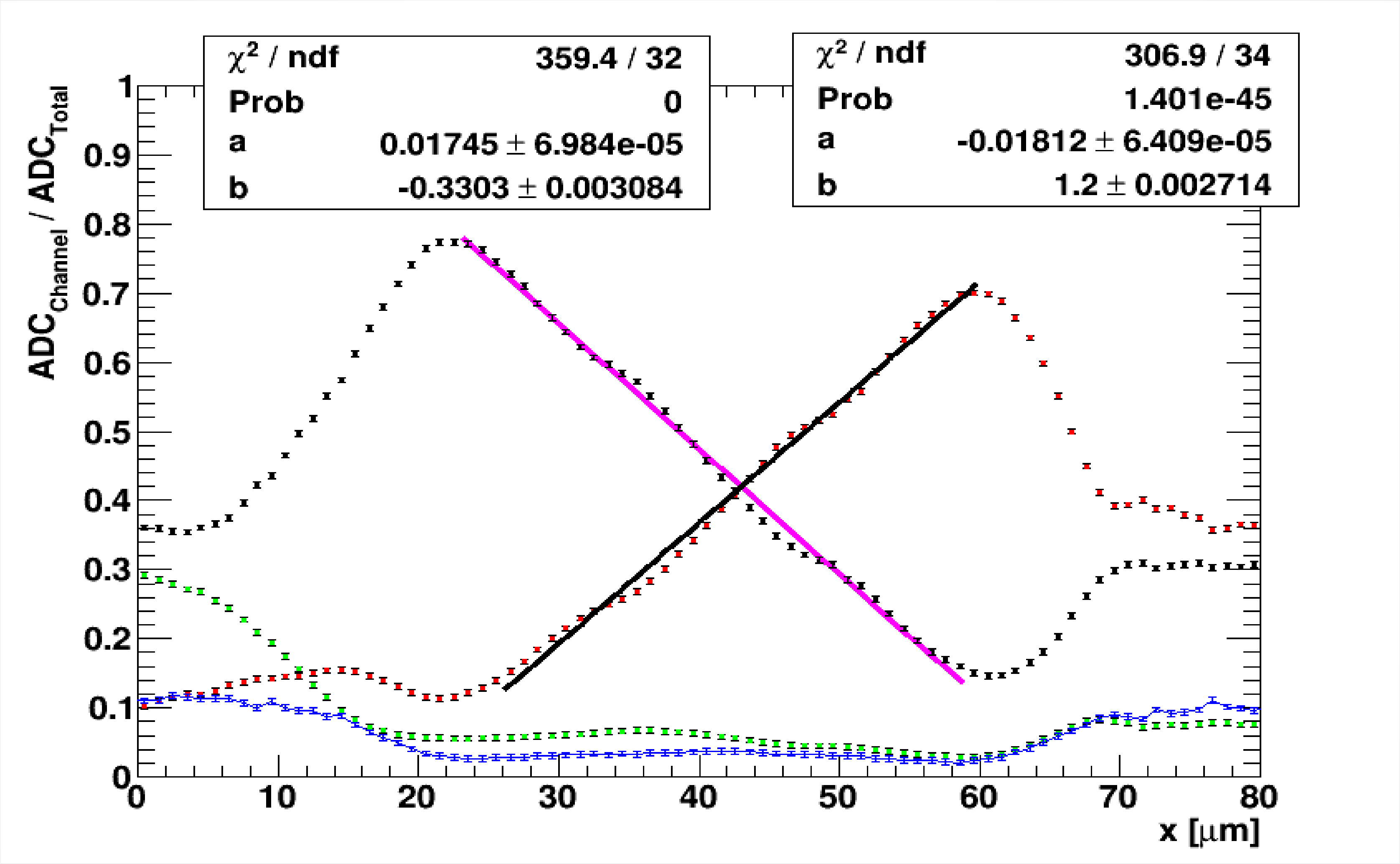
q(x) is a step function → Similar to the digital read out mode

Charge distribution function

M-8 : Floating intermediate strip

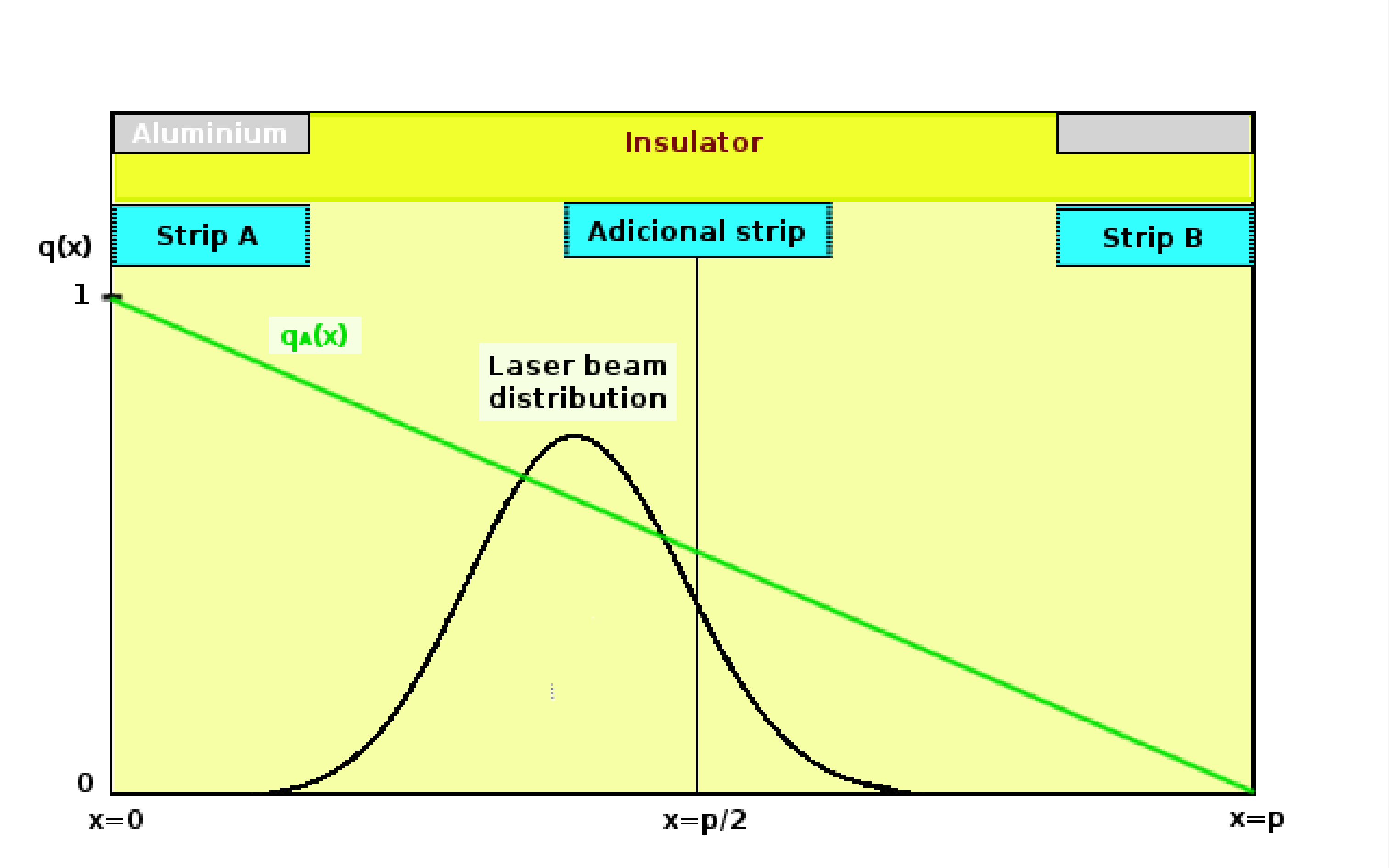


Floating-intermediate-strip model



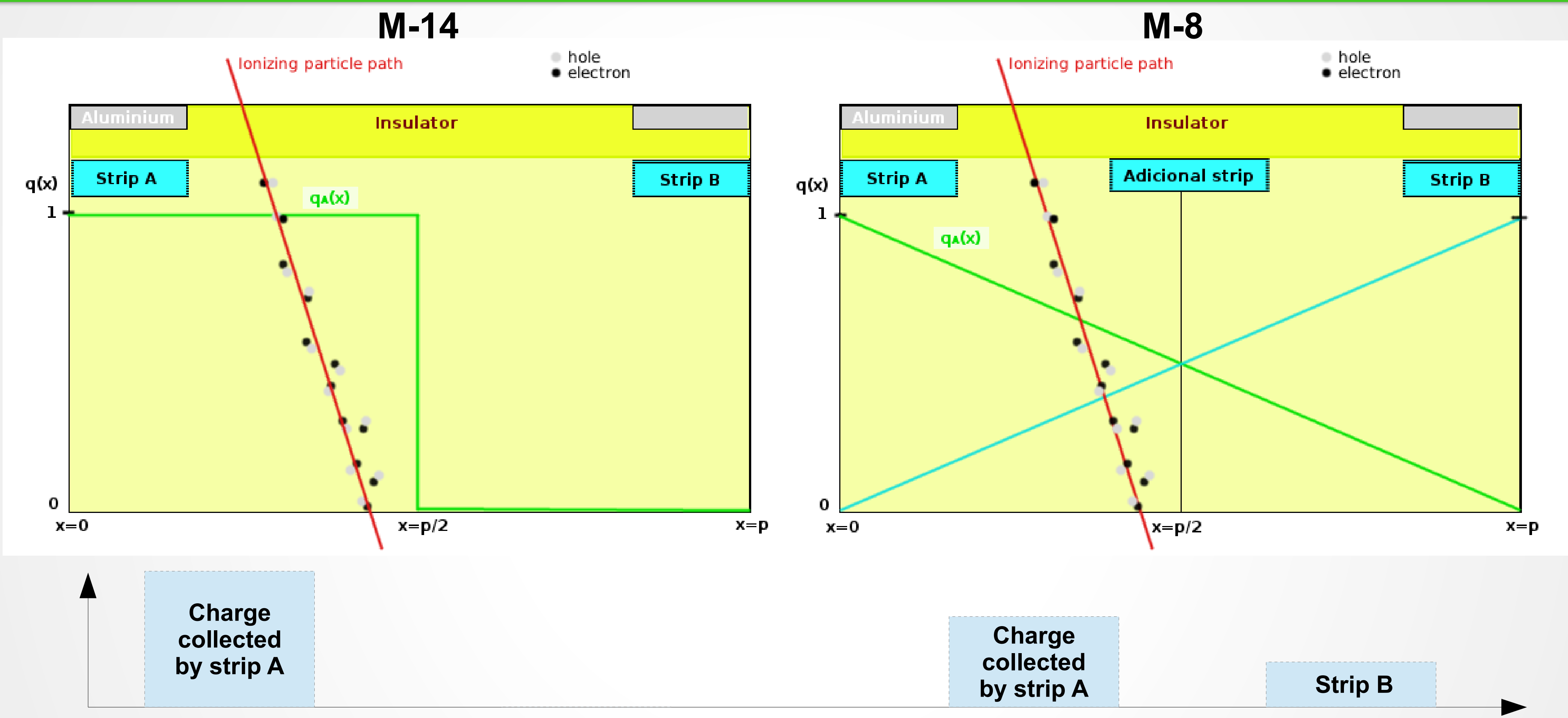
$$Q(x) = ax + b \longrightarrow q(x) = \frac{p - x}{p}$$

Floating-intermediate-strip model



q(x) is a linear function → It allows the use of weighting techniques

M-14 & M-8



As the distribution charge function of the interstrip-free model is a step function, strip A collects all the charge created by the incoming particle in detector **M-14**.

In detector **M-8**, charge is shared between both strips due to the linear charge distribution function. This allows an improvement of the resolution by a weighted of the signals.

Summary & conclusions

When studying the charge distribution function, the laser beam has introduced many problems:

- As **laser light does not transmit through aluminium**, the region of study has been limited to the central area between strips.

- The **high dispersion of the laser beam** has masked the results of the charge distribution function measures, as we were really measuring the convolution of this last one with the shape of the laser beam.

A better focusing of the laser beam must be achieved in future measurements in order to get a preciser parametrization of the charge distribution function of each device.

The implementation of an **intermediate strips seems to improve the resolution** of the detector, as the charge distribution transforms from a step function in M-14 to a linear function in M-8.