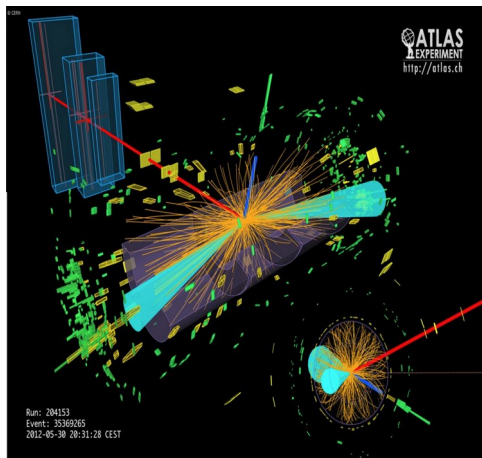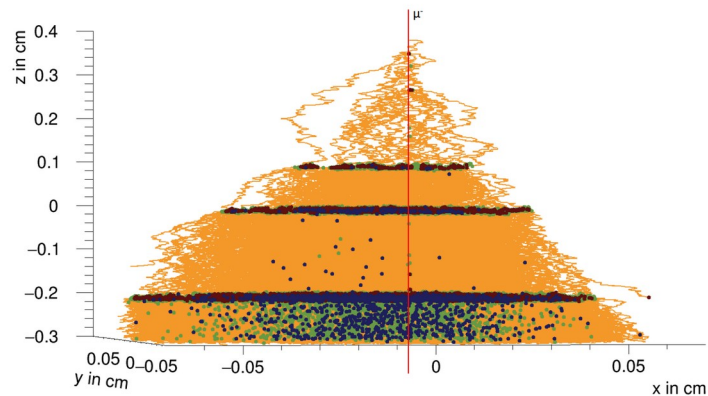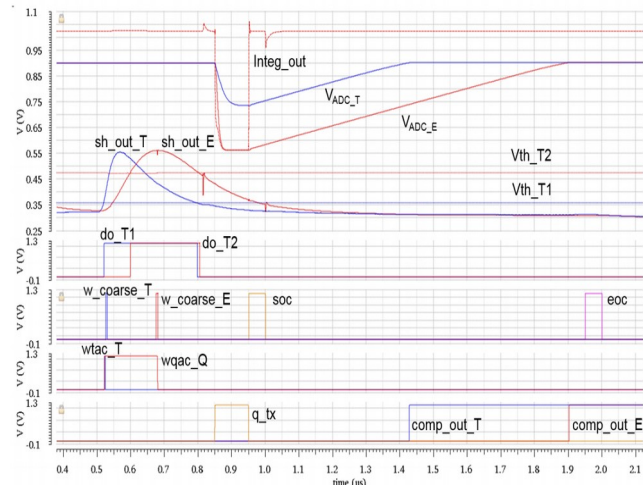# Challenge in MPGD Simulation ad Calibration
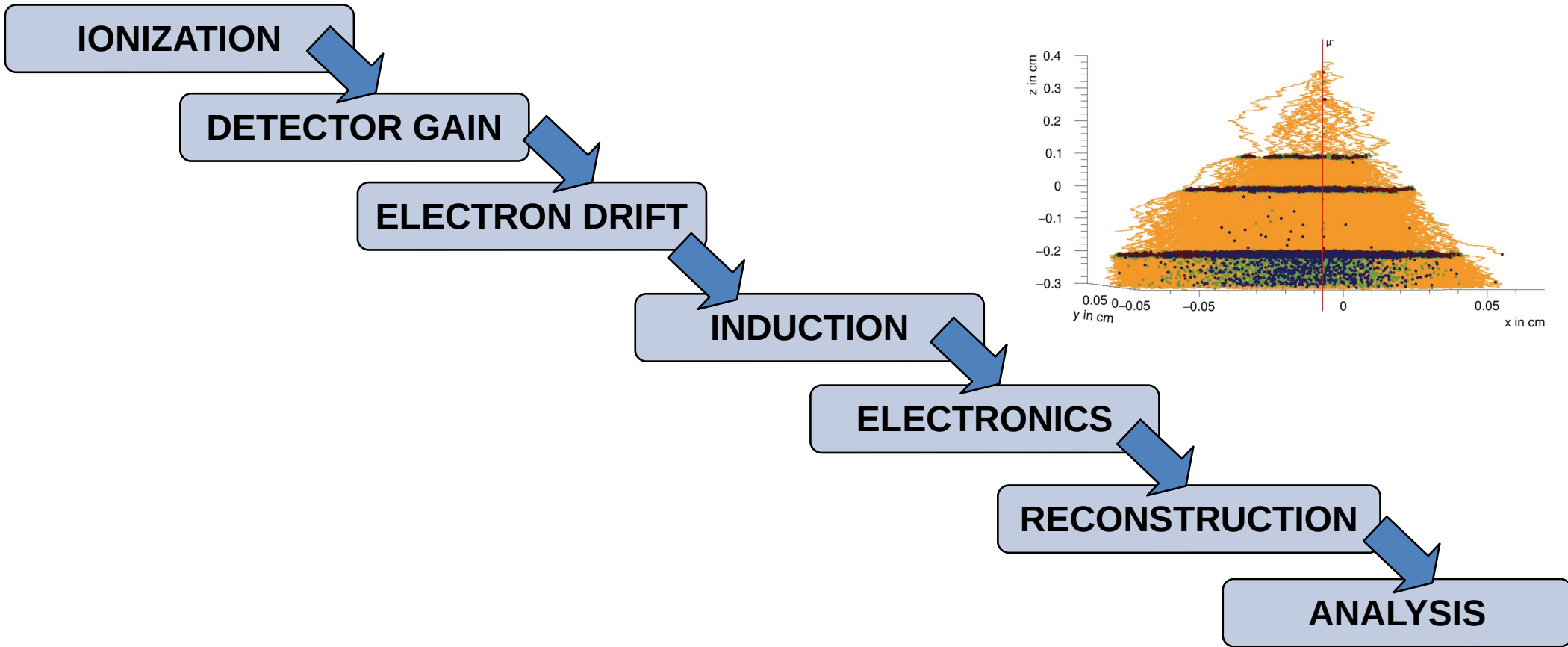
Detailed simulation tools

GEANT4
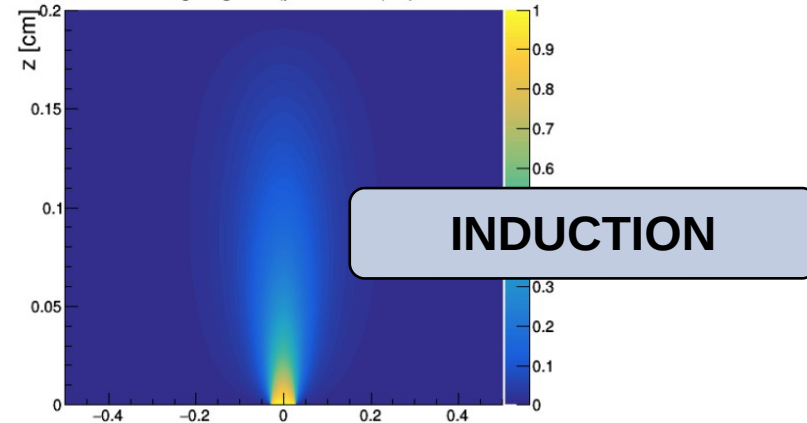for particle
interaction

Garfield++
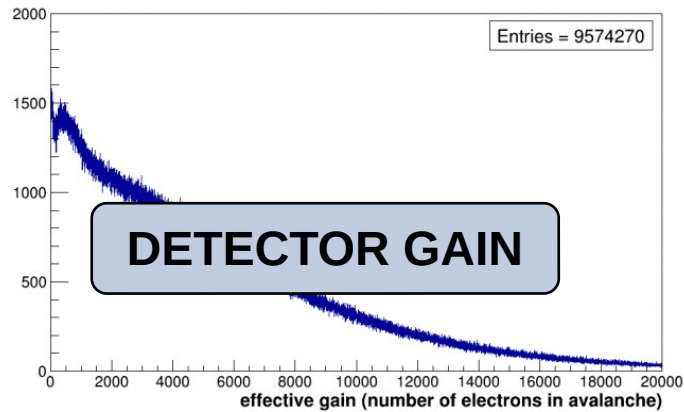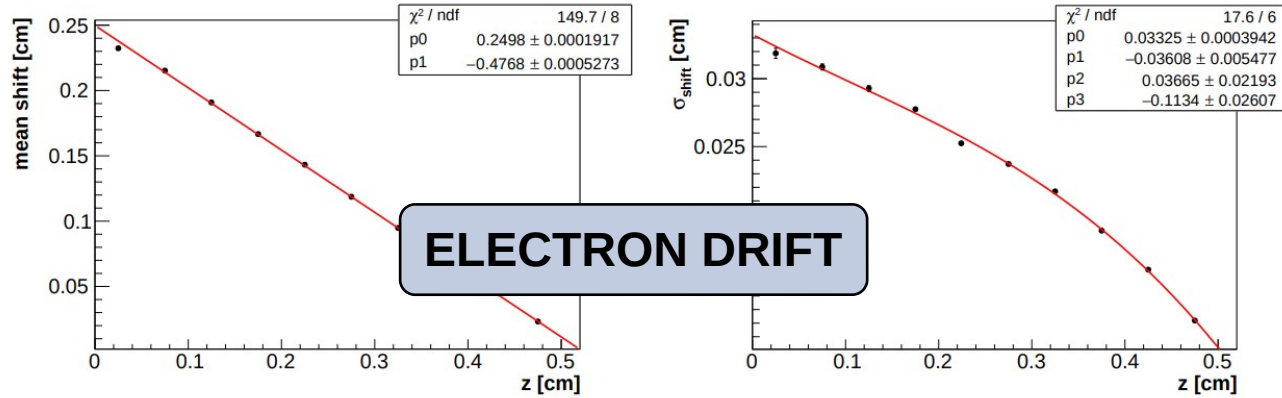for ionization and
electron motion
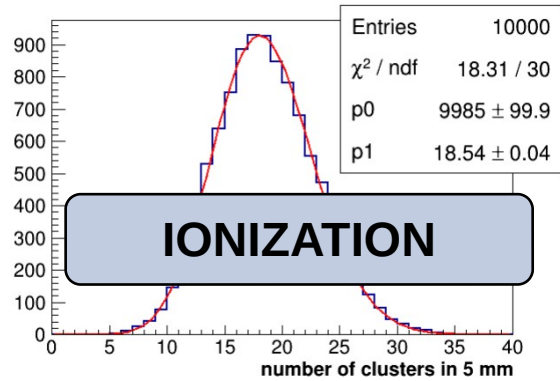

Spice and others for the
electronics response

Workflow in parametrized simulation

IONIZATION

DETECTOR GAIN

ELECTRON DRIFT

INDUCTION

ELECTRONICS

RECONSTRUCTION

ANALYSIS

Workflow in parametrized simulation

IONIZATION

ELECTRON DRIFT

DETECTOR GAIN

INDUCTION

Tuning of a simulation
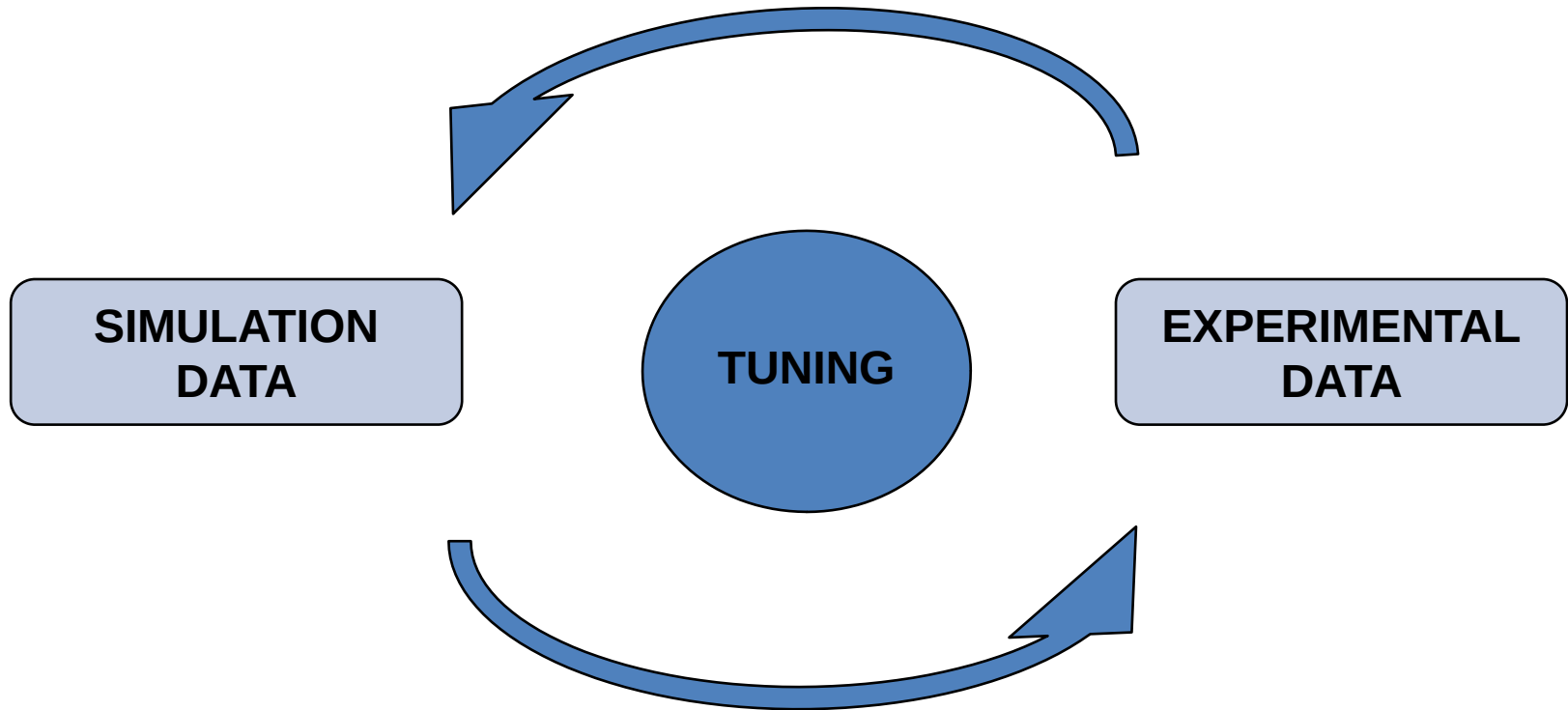
Triple-GEM simulation and tuning

Signal formation in simulation

(a) INDUCTION SIGNAL

(b) PRE-AMPLIFIER

(c) SHAPER

(d) REAL

Fermi Dirac fit
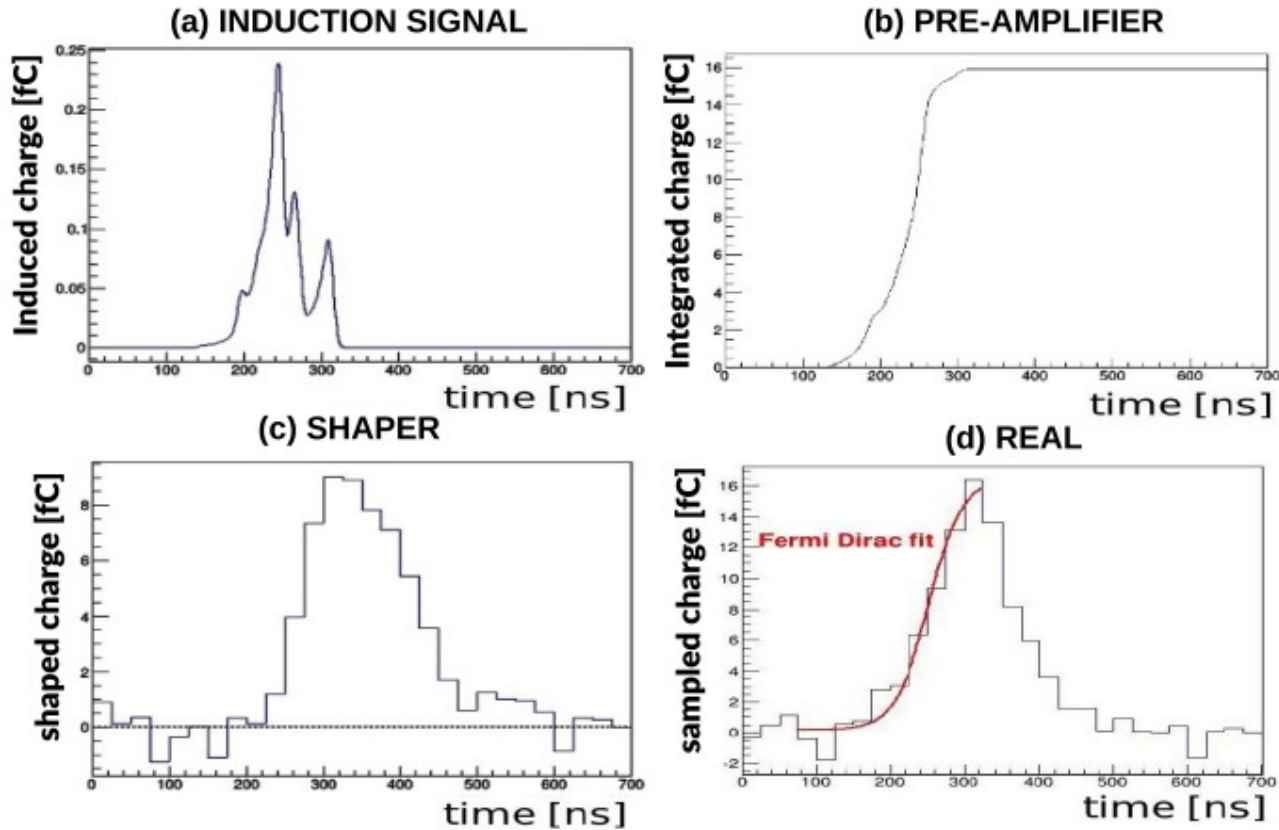
Signal formation in simulation

Charge and time measurements

Charge and Time based algorithms

Charge centroid

anode strip

q_i

anode

G3

G2

G1

gap

cathode

$$x_{CC} = \frac{\sum_i^{N_{hit}} Q_{hit,i}\, x_{hit,i}}{\sum_i^{N_{hit}} Q_{hit,i}}$$

Micro-TPC

anode

G3

G2

G1

gap

cathode

$z = ax + b$
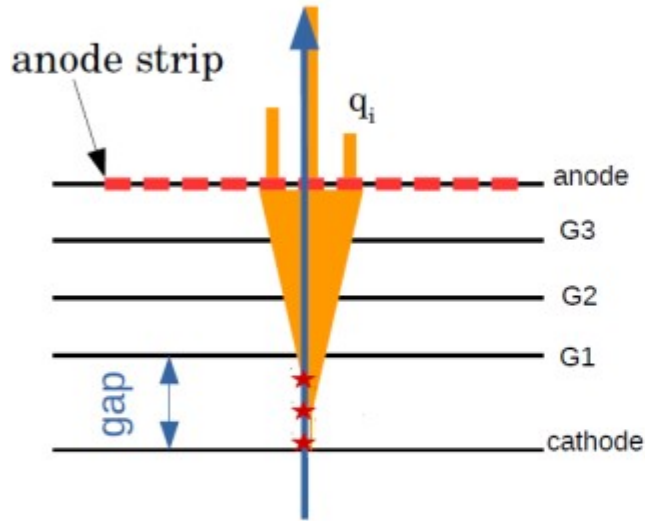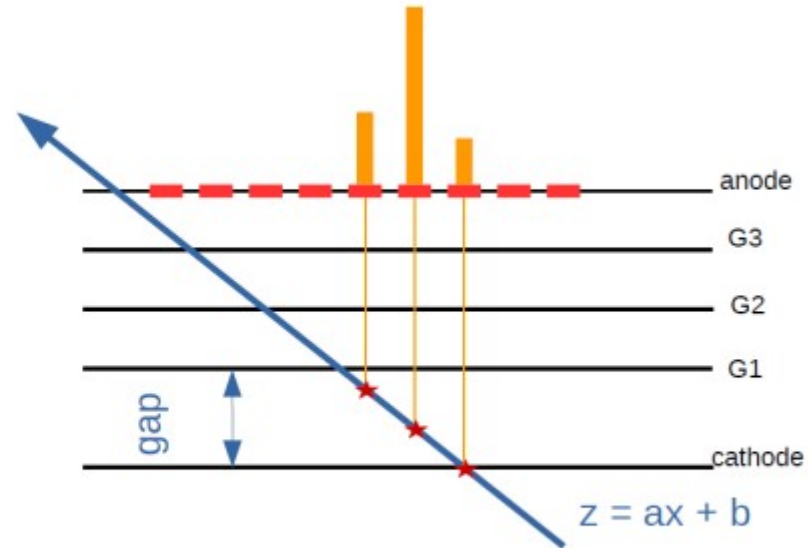
$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$

Signal formation in simulation

Signal duration impact
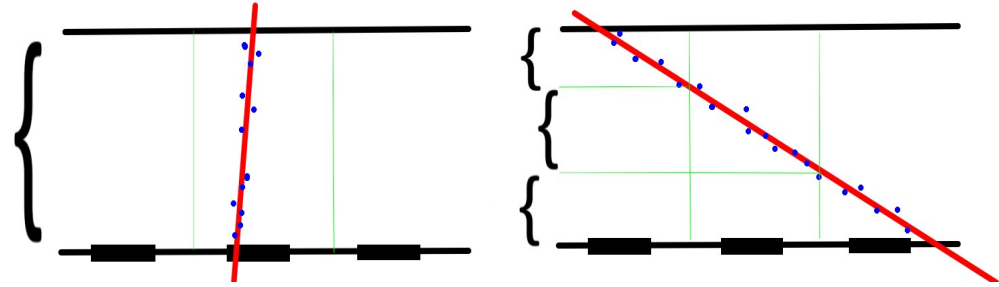
The signal duration depends strictly on the incident angle: if the track is orthogonal then the duration length is maximum, then its impact on the charge and the time measurements.
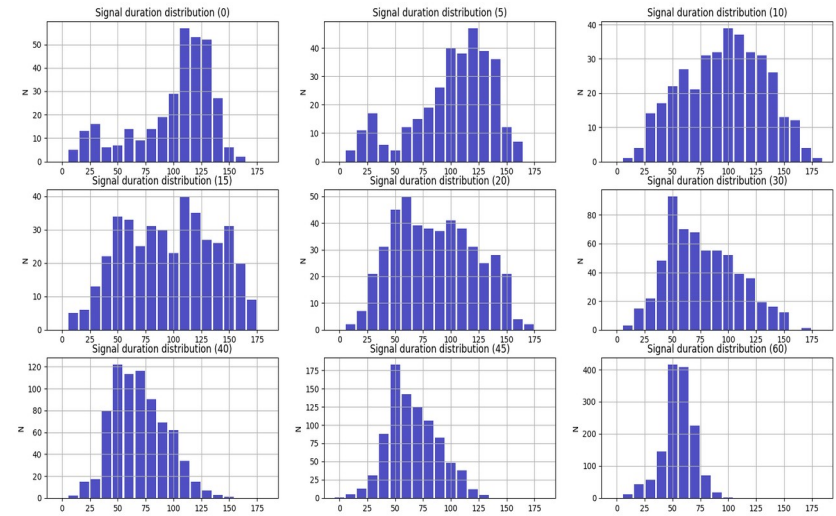
Signal duration impact: charge

Ballistic deficit vs signal duration (E-branch)

Q_{loss} from 0% to 21% for signals from 10ns to 250ns

Signal duration impact: time

Signal duration impact: time
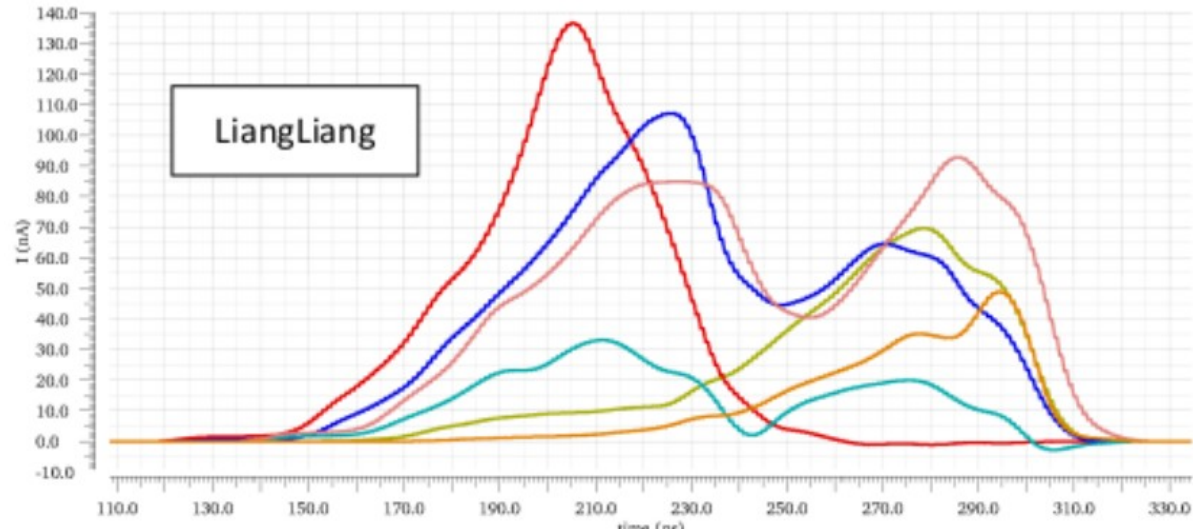
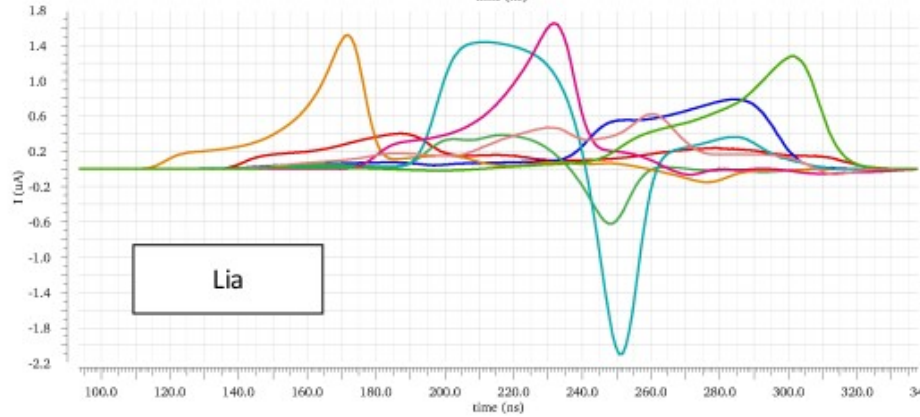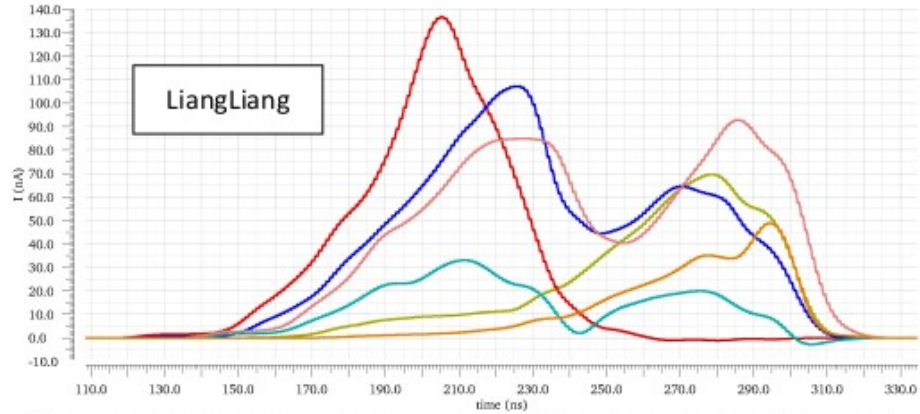# Charge and Time based algorithms

Charge centroid

anode strip

q_i

anode

G3

G2

G1

gap

cathode

$$x_{CC} = \frac{\sum_i^{N_{hit}} Q_{hit,i}\, x_{hit,i}}{\sum_i^{N_{hit}} Q_{hit,i}}$$

Micro-TPC

anode

G3

G2

G1

gap
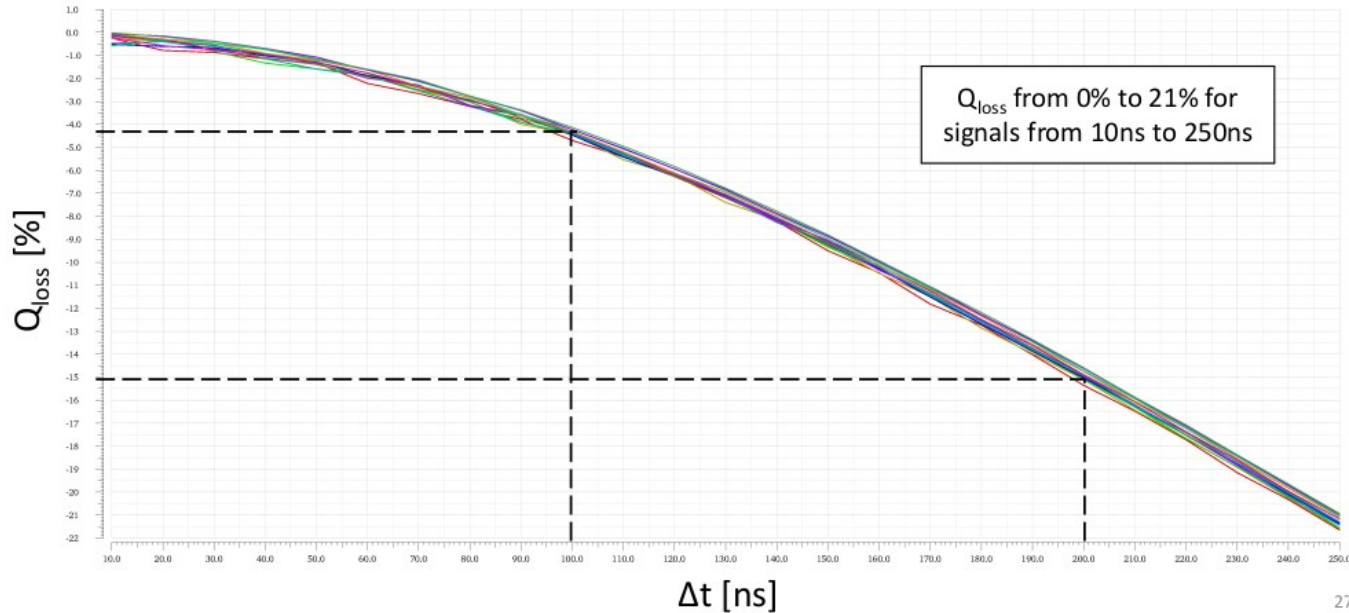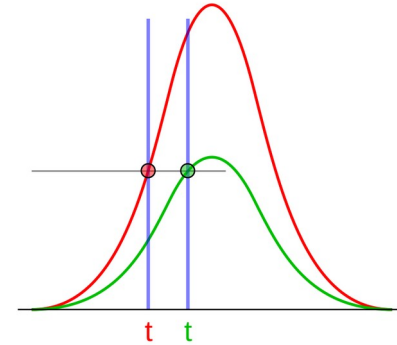
cathode

$z = ax + b$
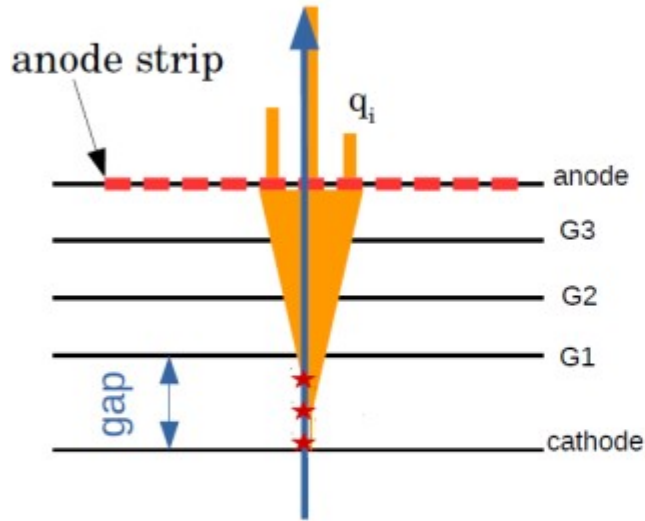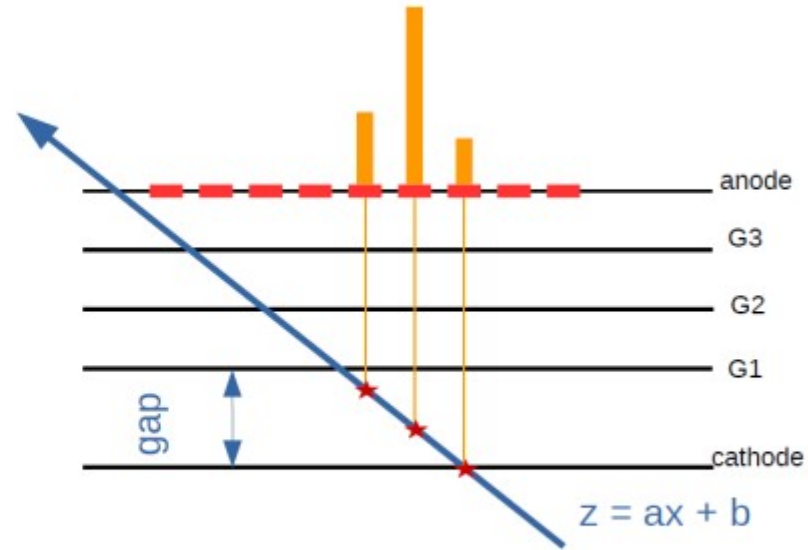
$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$
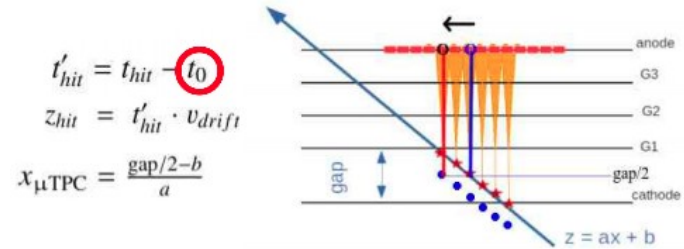
Impact on the time measurements

Time-walk: the signal amplitude affects the time measurement. The correlation between charge and time is studied as a function of the threshold levels

      0-80 ns contributions

Time-reference: Tiger chip are synchronized but the time measurement of the same event can differ due to geometrical differences (i.e. routing, strip length, etc)
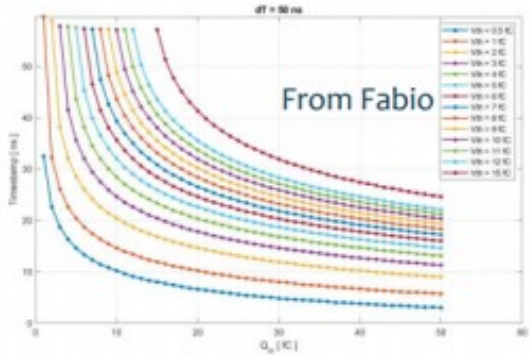
      0-40 ns contributions

$$t'_{hit} = t_{hit} - t_0$$
$$z_{hit} = t'_{hit} \cdot v_{drift}$$
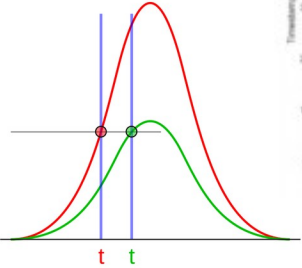$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$

Time-propagation: The signal propagation from the induction point on the strip and the electronic channel affects the time measurements

      0-5 ns contributions
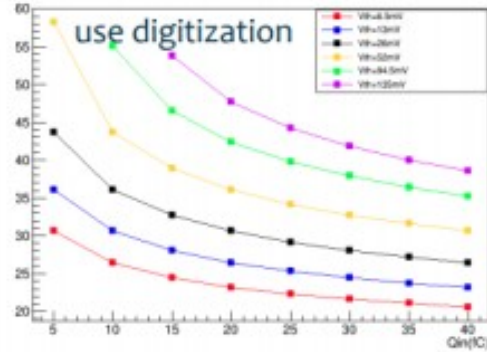
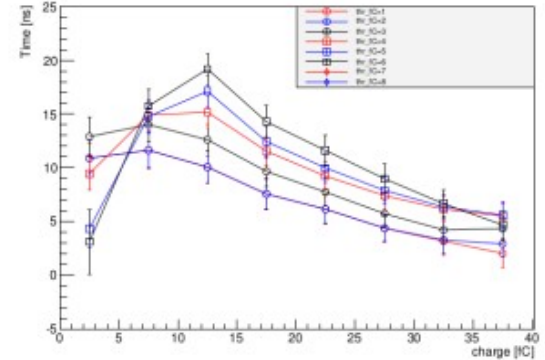|	Strip X	Strip V
Layer 2	$0.51c$	$0.59c$
Layer 3	$0.35c$	$0.57c$

The example of the Time-Walk

Experimental with injected signal

Simulation

Experimental with real signal

Outlook

- Detector knowledge depends on the experimental and simulation measurement

- Simulations are very powerfull to test the detector in a wide range of configuration but it needs an accurate tuning

- The results interpretation from experimental and simultaions depends strongly by the tools used and the analysis performed

- Charge and time measurement depends both by the detector and the electronics

- Good spatial resolution performance needs an homogeneous time measurement