FCC Bologna meeting

Test Beam data analysis and µRWELL simulation

R. Farinelli

Communication:
IDEA Italia collaboration wants to submit an article on the IDEA detector

We are asked to write the part for the Pre-shower and the Muon systems.

- Systems description (Marco);
- Detector description (Gianni, Marco, Gianfranco);
- Layouts results (Marco, Riccardo, Matteo);
- Electronics (Gigi, Riccardo)
- Simulation (Mahmoud);

The deadline for the FCC community is mid December

An internal deadline for the μRWELL at the end of October.

Do we want to include any other contribution/contributor?

List of studies

1. Data analysis APV TB2022 -> high gain effects on efficiency
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4. PARSIFAL µRWELL simulation: code update

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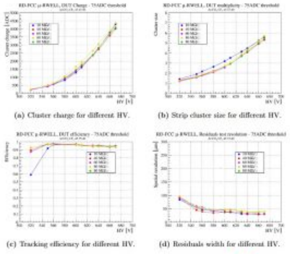
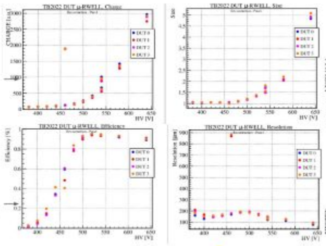
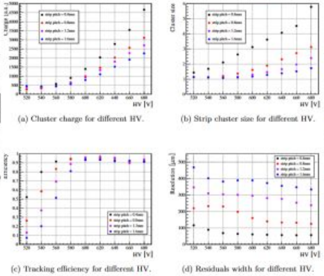
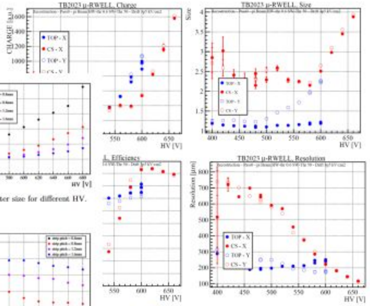
R&D for FCC

TB with DC + pre-shower + CALO+ Muon









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1D PERFORMANCE

2D performance

TIGER

2020

2021

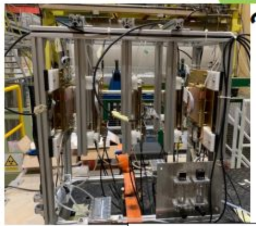
2022

2023

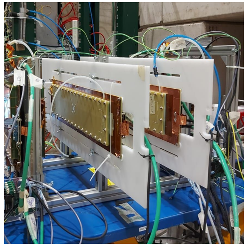
2024

Resistivity Scan @ fixed pitch

Pitch Scan @ fixed resistivity & 2x1D performance



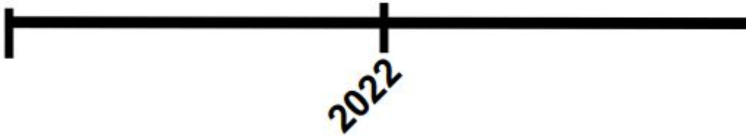
2D layouts

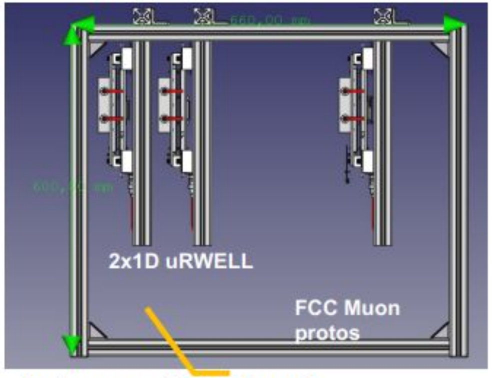


Pitch Scan w/ TIGER

INFN

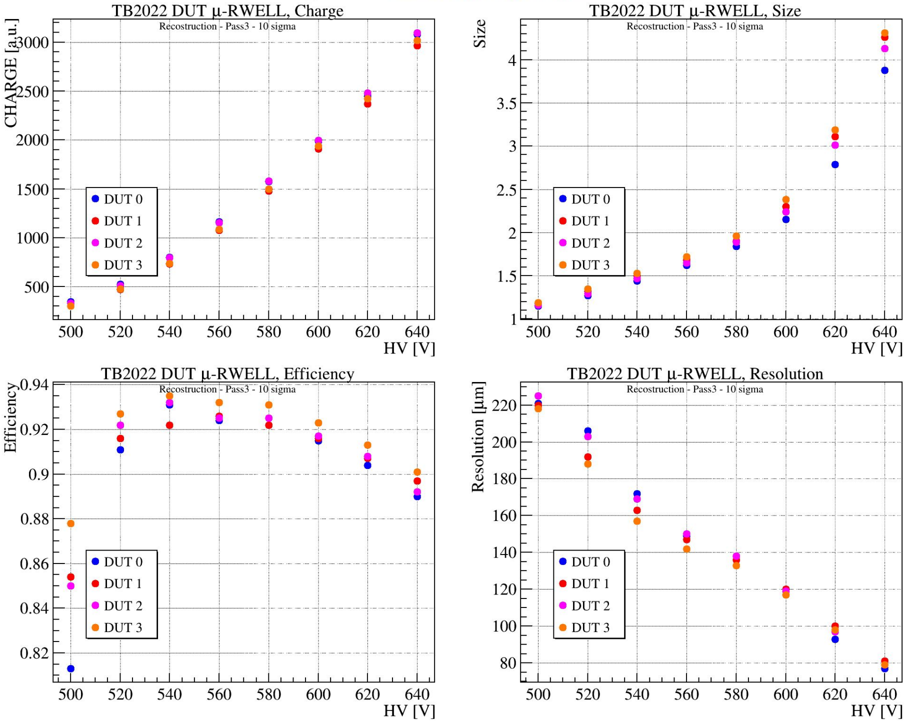
2x1D R/out





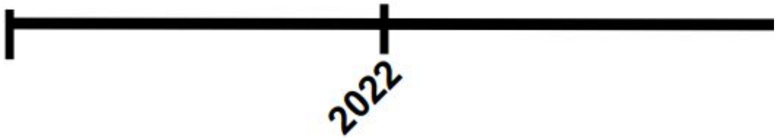
Active area= 100x100 mm2
Pre-preg thickness= 20 um
Resistivity= 50 MΩ/
Strip pitch= 0.76 mm
Strip width = 0.3 mm
Ratio p/w= 2.53

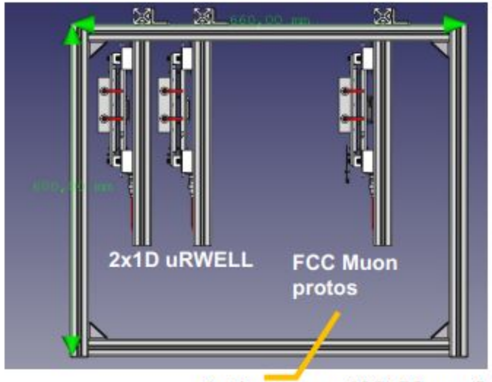
2x1D performance



The 1D proto show very good performace @ 500 V to be compared with 2D ones (TB 2023)
Efficiency knee @ 500 V & σx < 200 um for a strip pitch ~ 0.8 mm

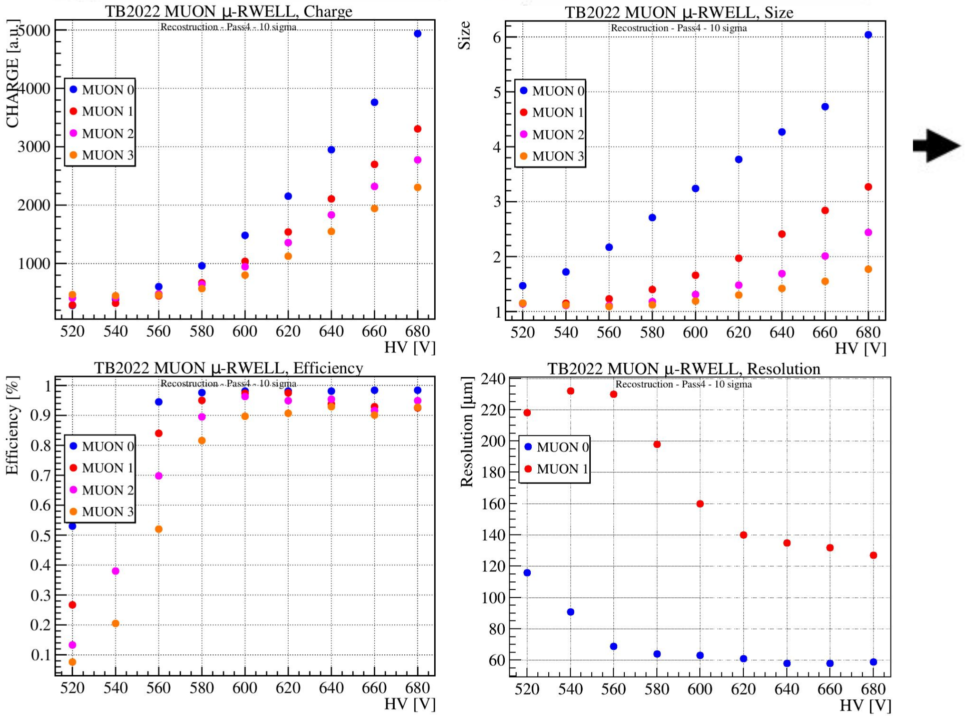
1D R/out strip pitch





Active area= 400x50 mm2
Pre-preg thickness= 50 um
Resistivity= 30 MΩ/
Strip pitch= 0.4-1.6 mm
Strip width = 0.15 mm
p/w ratio= 2.66 – 10.66

R/O pitch scan @ fixed resistivity



Larger is the strip pitch, lower is the charge signal requiring a higher gain to reach full efficiency.

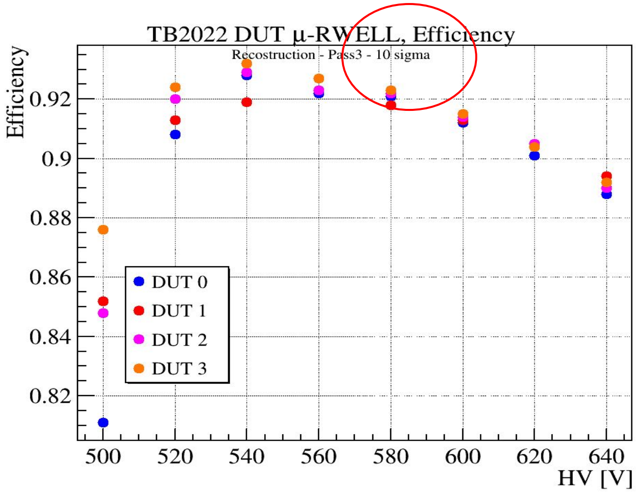
Efficiency knee @ 600 V & σ_x < 400 um for a strip pitch = 1.6 mm

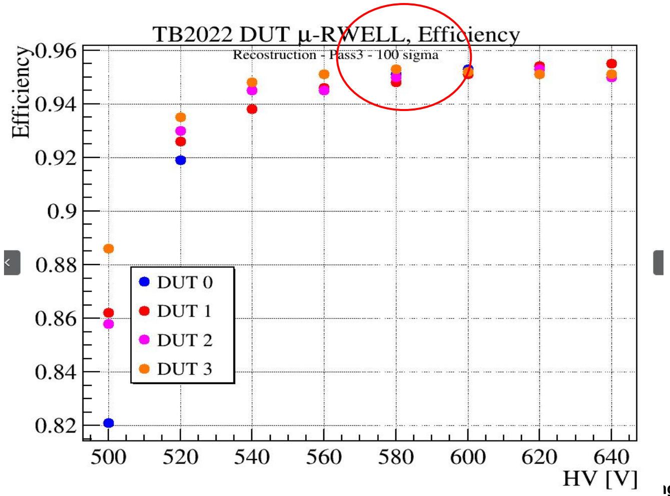
A high p/w ratio implies a worsening of the detector performance

Check efficienza - da 10 a 100 sigma

Abbiamo analizzato l'efficienza delle DUT (μRWELL 1D - pitch 760μm - 80 MΩ/□).

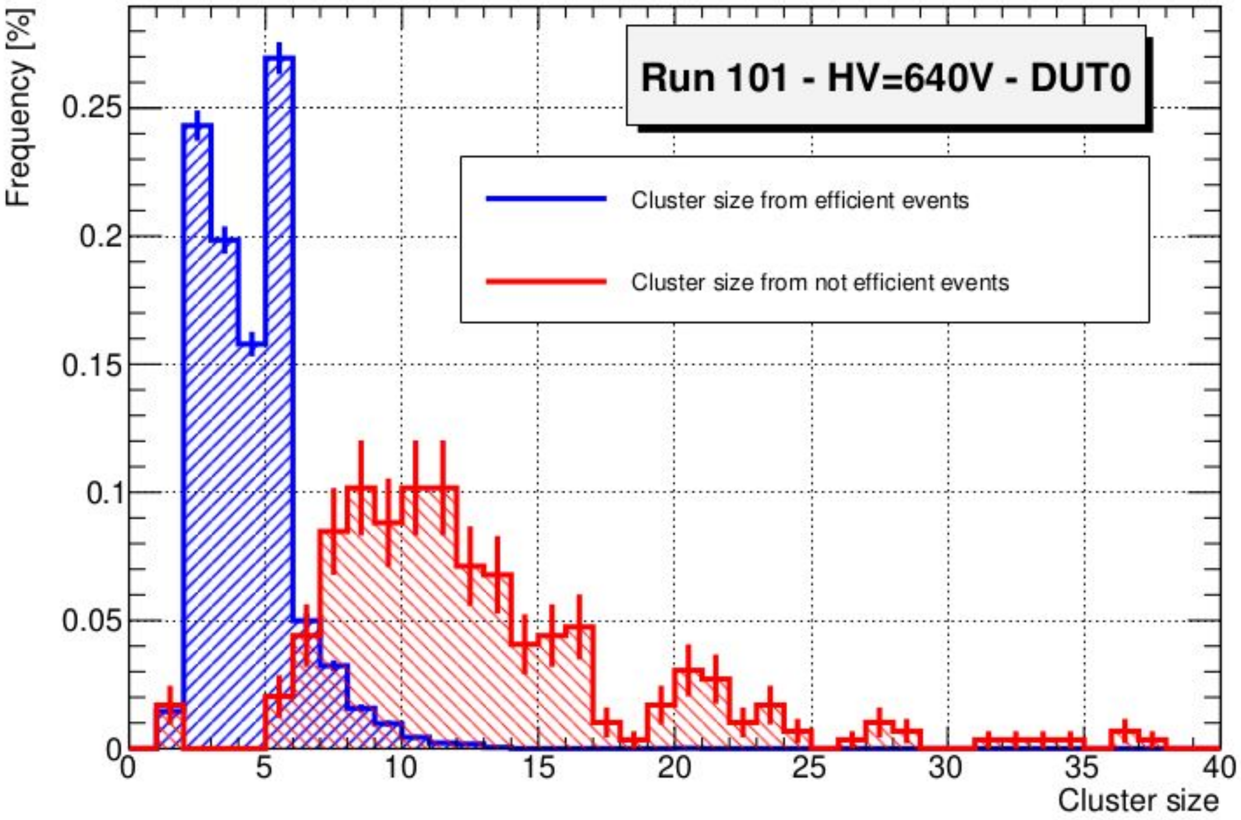
Aumentando la finestra da 10 a 100 sigma per dichiarare la camera efficiente si vede una variazione nel calo di efficienza. Questo implica che il cluster c'è ma è molto lontano.





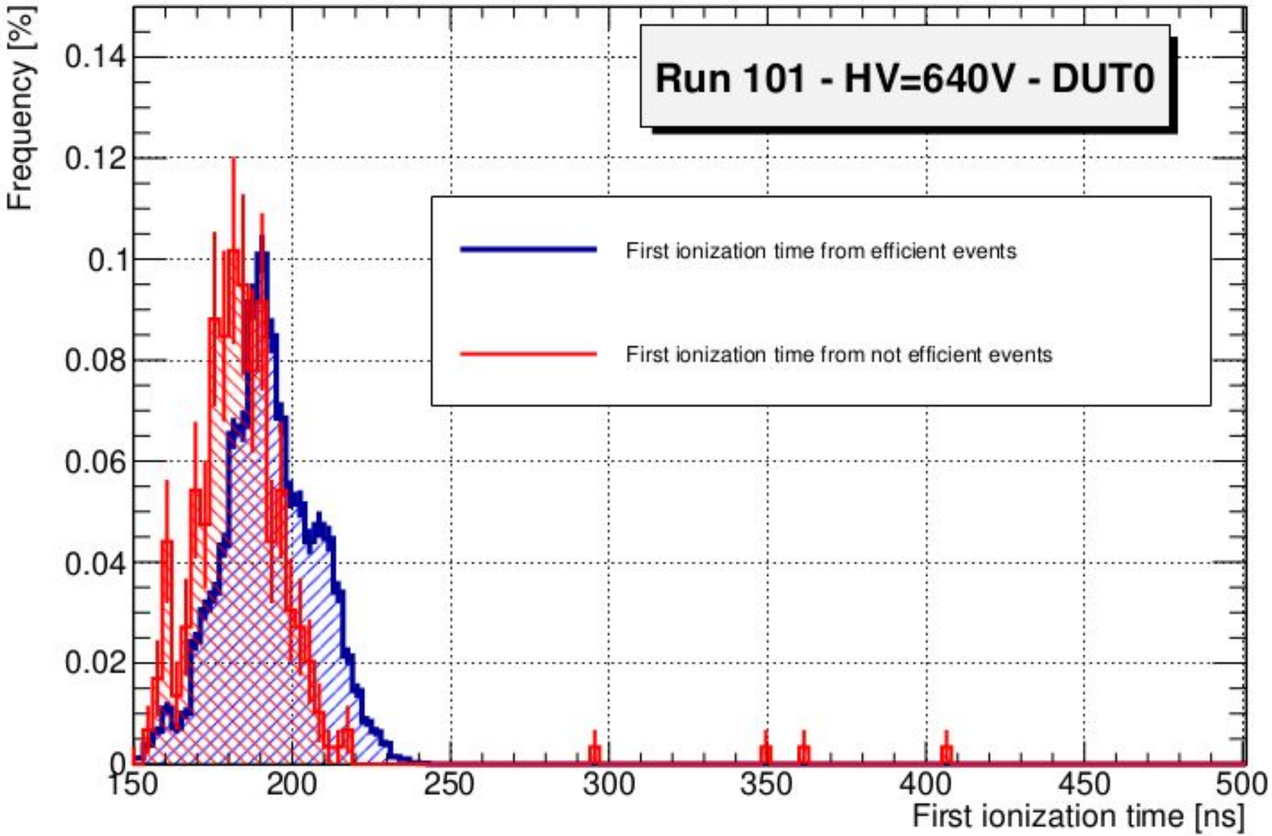
TB 2022 | run 101 | HV=640V | DUT 0

The cluster size of the NOT efficient events is about the double of the good ones



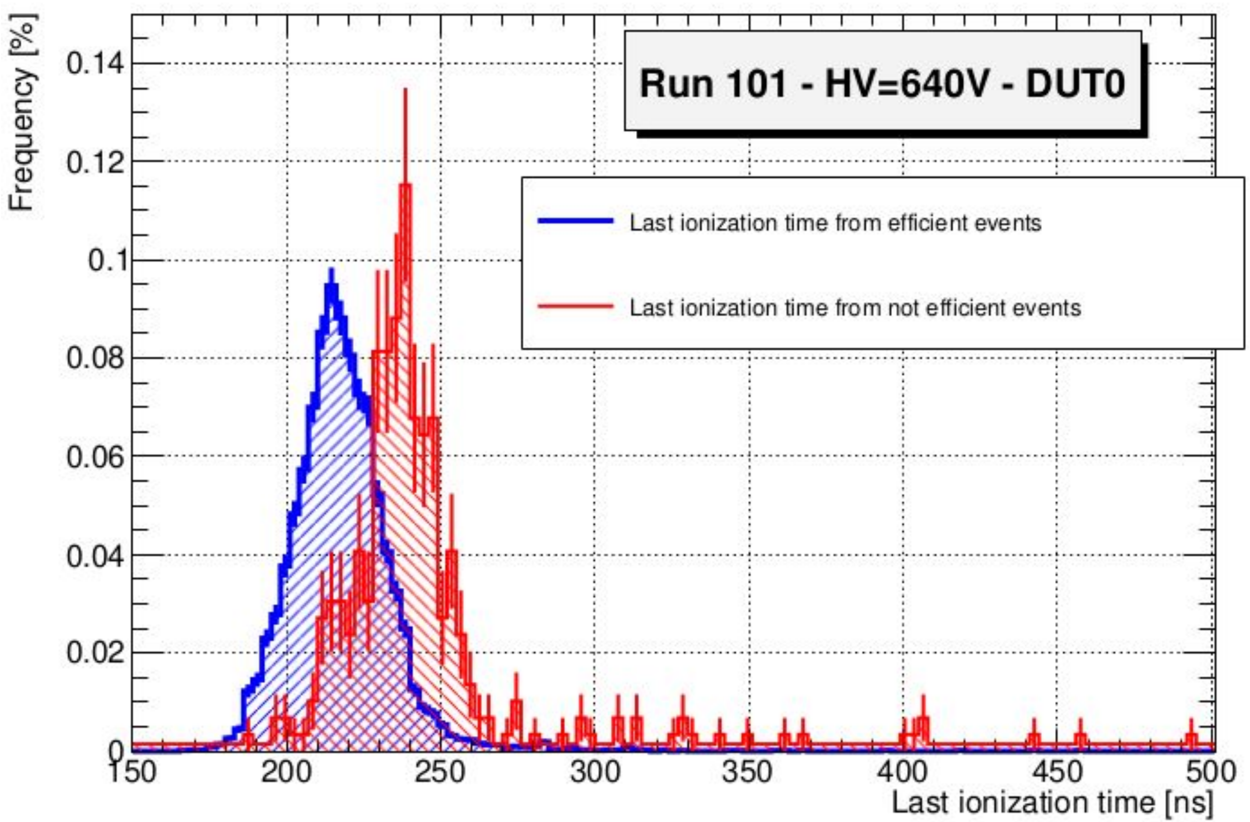
TB 2022 | run 101 | HV=640V | DUT 0

The faster time in the cluster for good and bad event is shifted of ~ **10~20 ns**



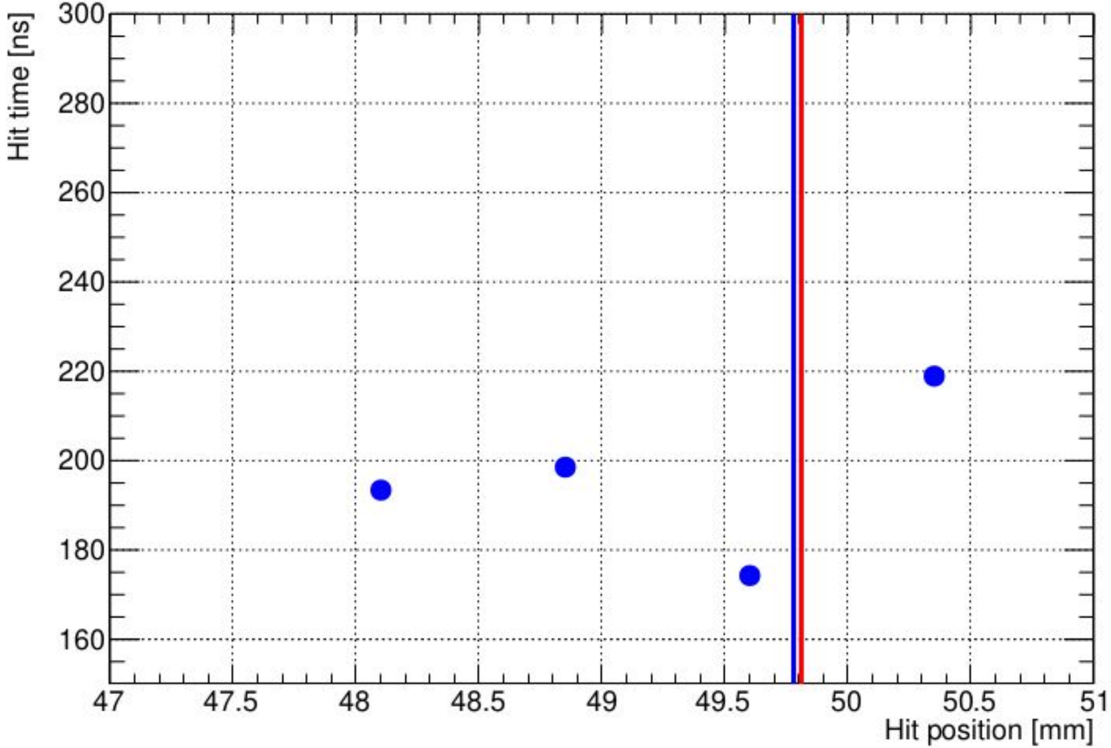
TB 2022 | run 101 | HV=640V | DUT 0

The slowest time in the cluster for good and bad event is shifted of **+ 30~40 ns**



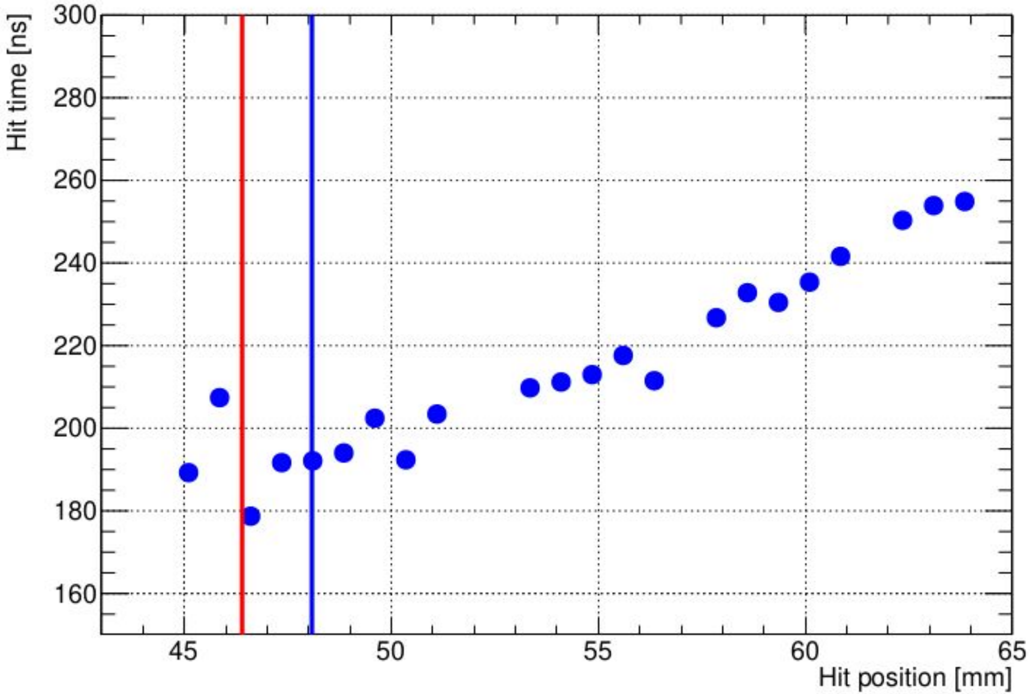
TB 2022 | run 101 | HV=640V | DUT 0

A good event example, shows the agreement between test chamber (blue line) and tracking system (red line). Charge centroid is used to evaluated the position in the test chamber.



TB 2022 | run 101 | HV=640V | DUT 0

A bad event example, shows the directional displacement of the hits from the expected position (red). The blue line is the reconstructed position.



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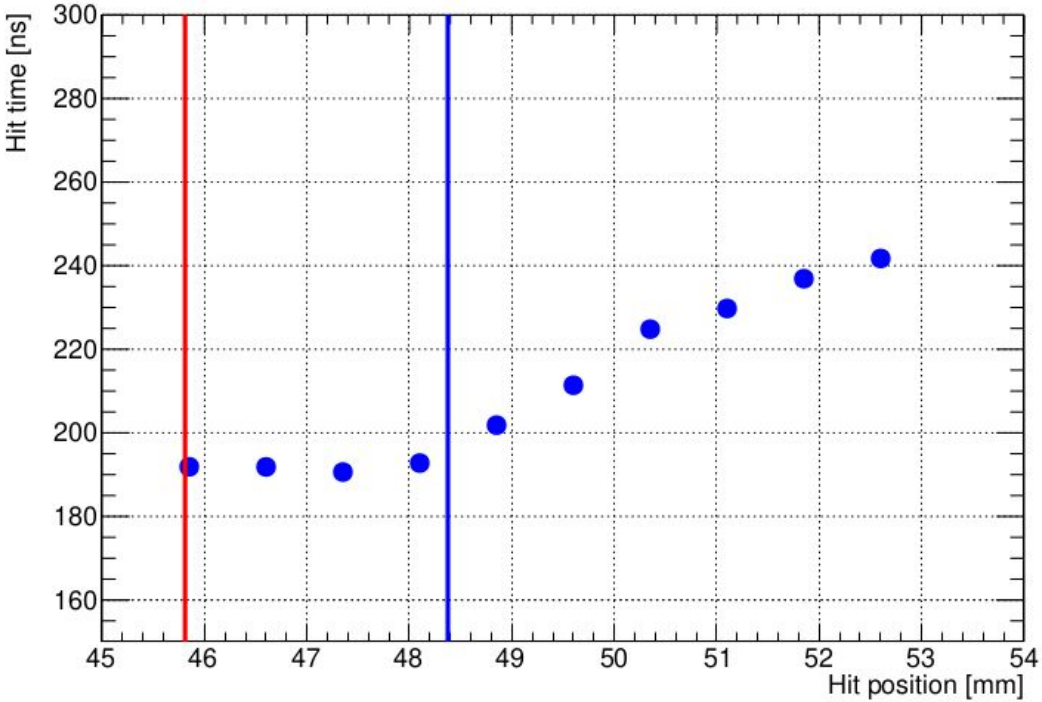
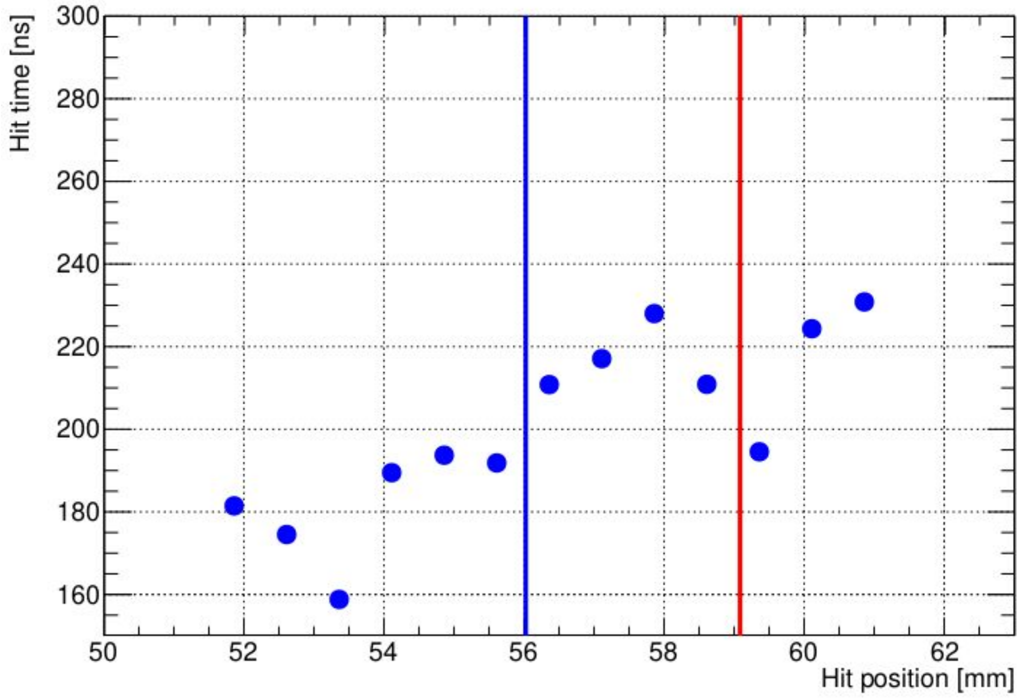


TB 2022 | run 101 | HV=640V | DUT 0

A bad event example, shows the directional displacement of the hits from the expected position (red). The blue line is the reconstructed position.
Here an example where the hits away from the red line are faster than the others.



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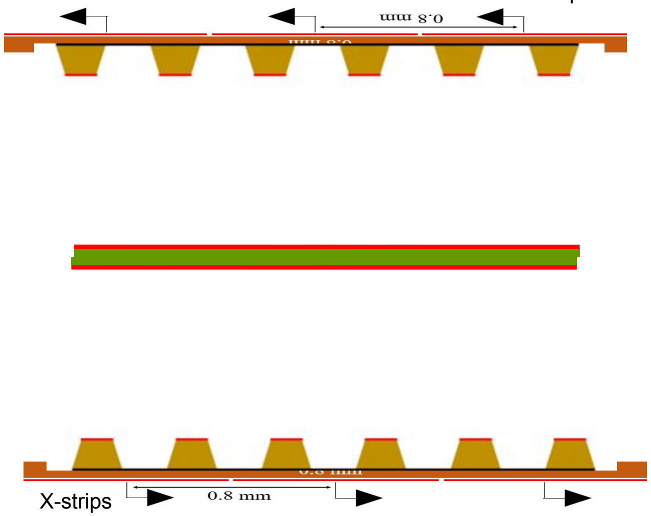
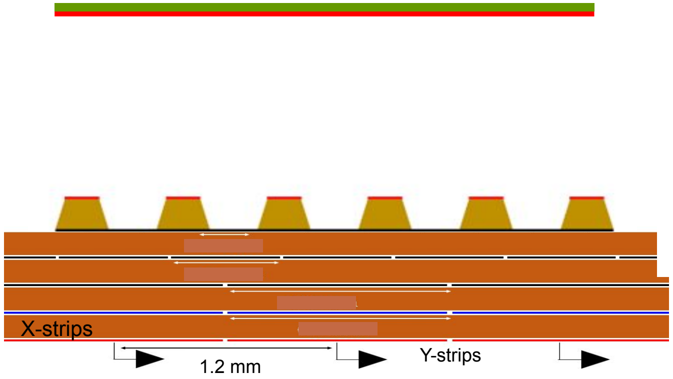
Experimental measurements - 2D readout

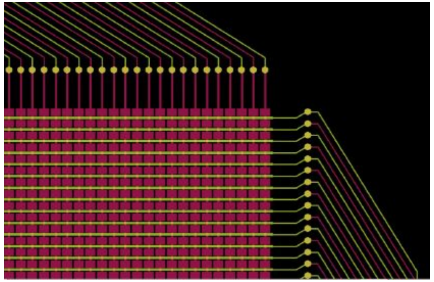
µ-RWELL 2x1D



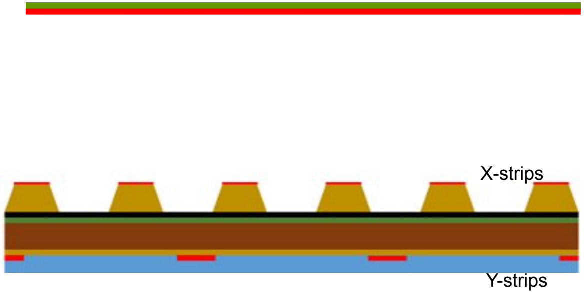
µ-RWELL 2D (Charge Sharing r/o)



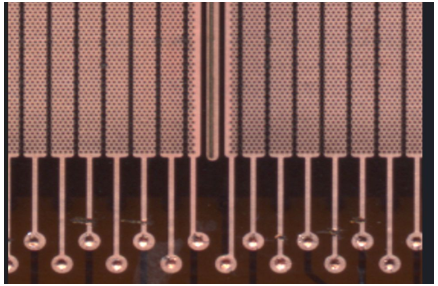
CS Readout board



µ-RWELL 2D (TOP r/o)



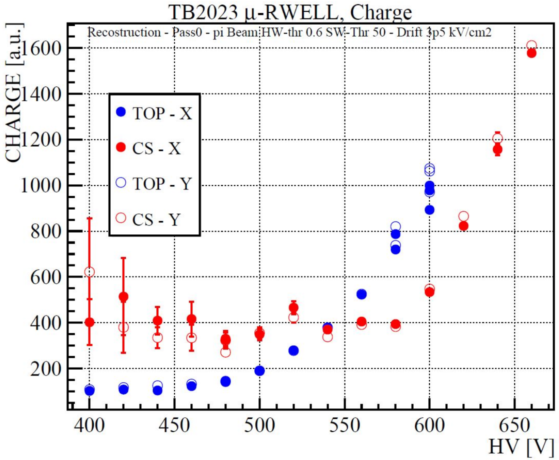
X coordinate on the TOP of the amplification stage

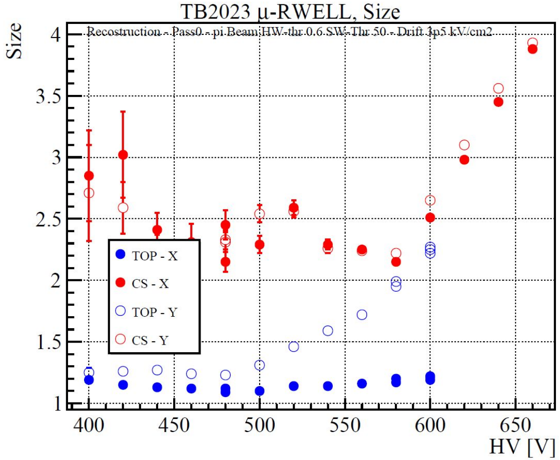


Scan results - 2D readout

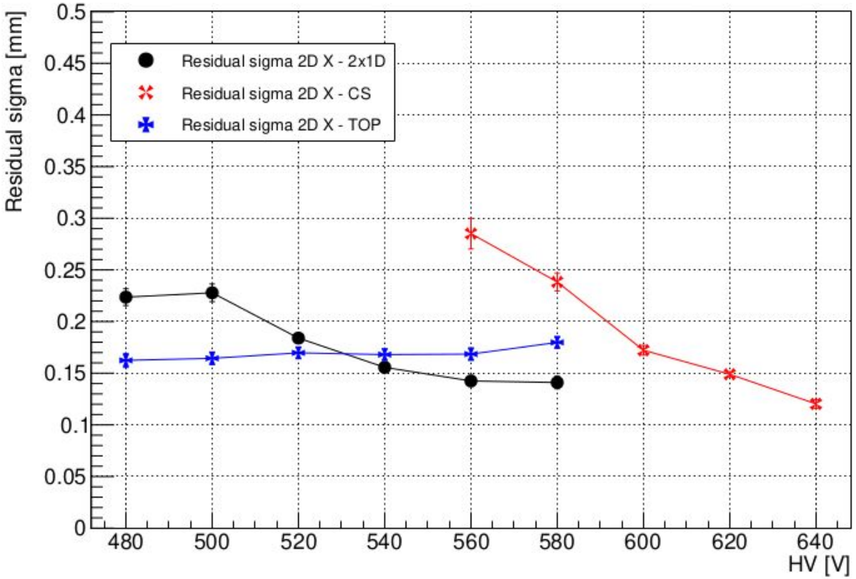
TOP r/o does not share the signal charge between X and Y. On the X (TOP) its cluster size is fixed and the spatial resolution is digital; while on the Y it has a standard behavior and thanks to the charge diffusion (DLC) the spatial resolution improves with the gain.

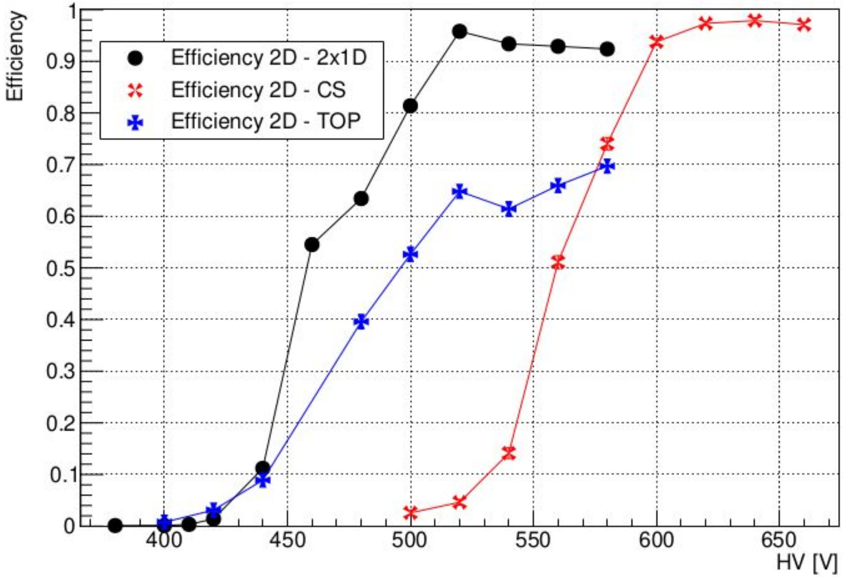
CS r/o shares the signal charge between X and Y. The charge sharing mechanics works properly and it increases the cluster size up to 4; this improves the spatial resolution.





Final results





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Setup

Tracking system:

2 x triple-GEM XY strips

Detector under test:

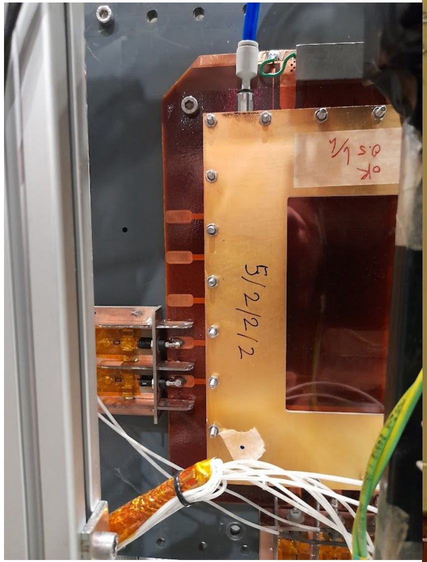
4 x µRWELL 1D strip

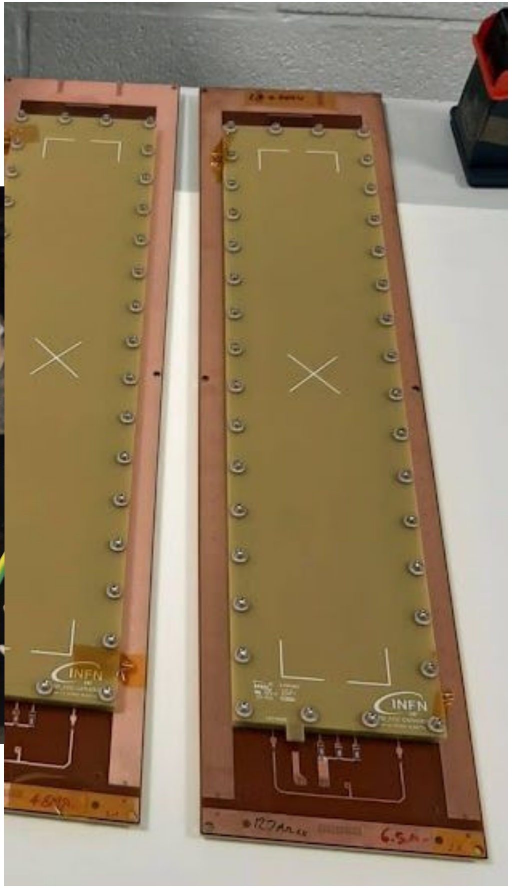
DUT setting:

active area: 400x50 mm^2
prepreg thickness: 50 µm
resistivity range: 10-80 MΩ/□
strip pitch: 400 µm
strip width: 150 µm

Gas mixtures:

Ar:CO_2 (70/30)
Ar:CO_2:CF_4 (45:15:40)



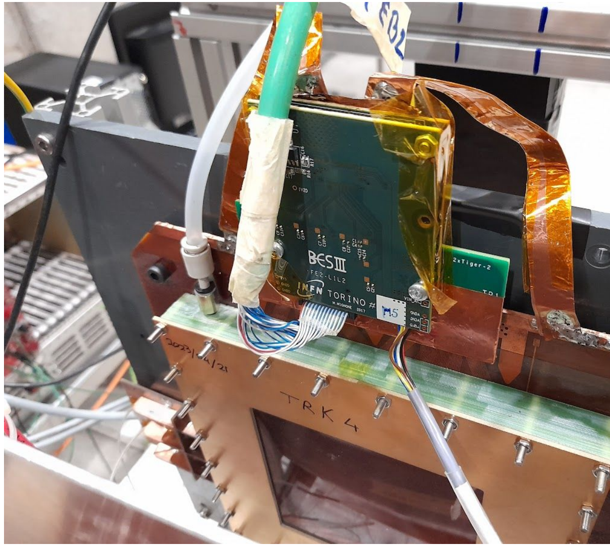


Electronics

8 TIGER electronics
2 GEMROC FPGA
1 FANOUT

TIGER:
110 nm CMOS fabrication technology
Analog input - digital output S/H or ToT for energy measurement
Simultaneous time and charge measurement ; Triggerless operation capability; Suitable for capacitances up to 100 pF and charges up to 50 fC

GEMROC :
Distribute digital and analog voltage levels;
Configure the TIGERs; Monitor currents and temperatures during operation; Collect and organize output data from the TIGERs;
Receive trigger signal for trigger-matched operation



Goals

Evaluate the µRWELL performance with TIGER+GEMROC readout system.

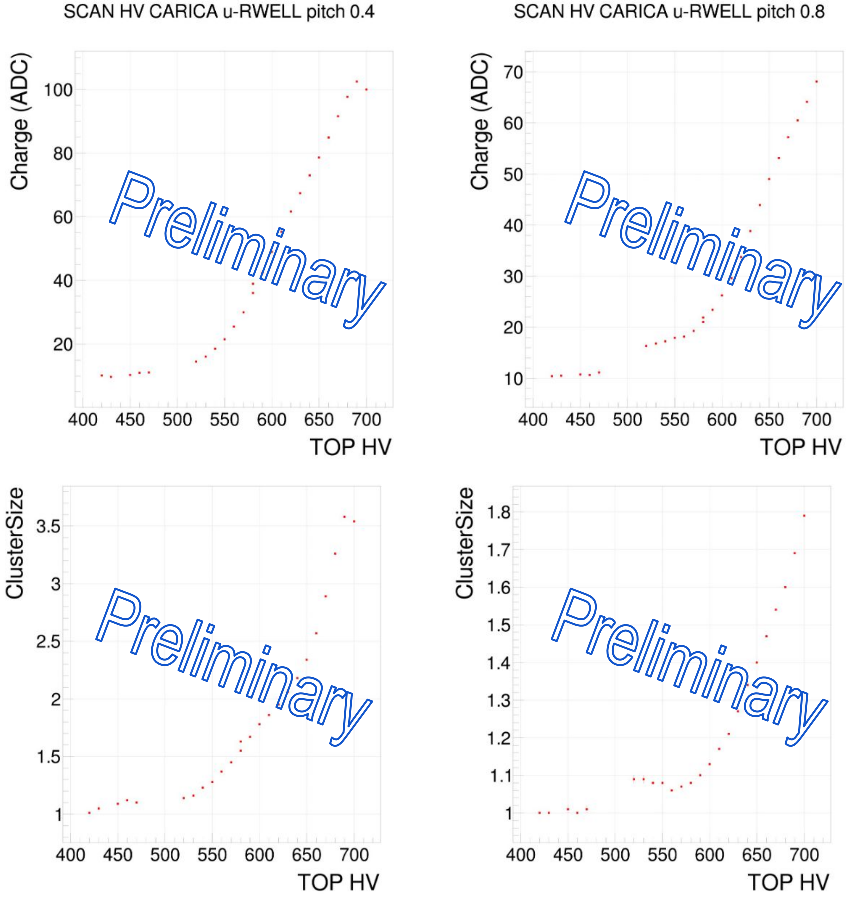
Minimize the noise, expected at 0.5-1 fC

2 x HV scan
with Ar:CO_2 (70/30) and Ar:CO_2:CF_4 (45:15:40) gas mixtures

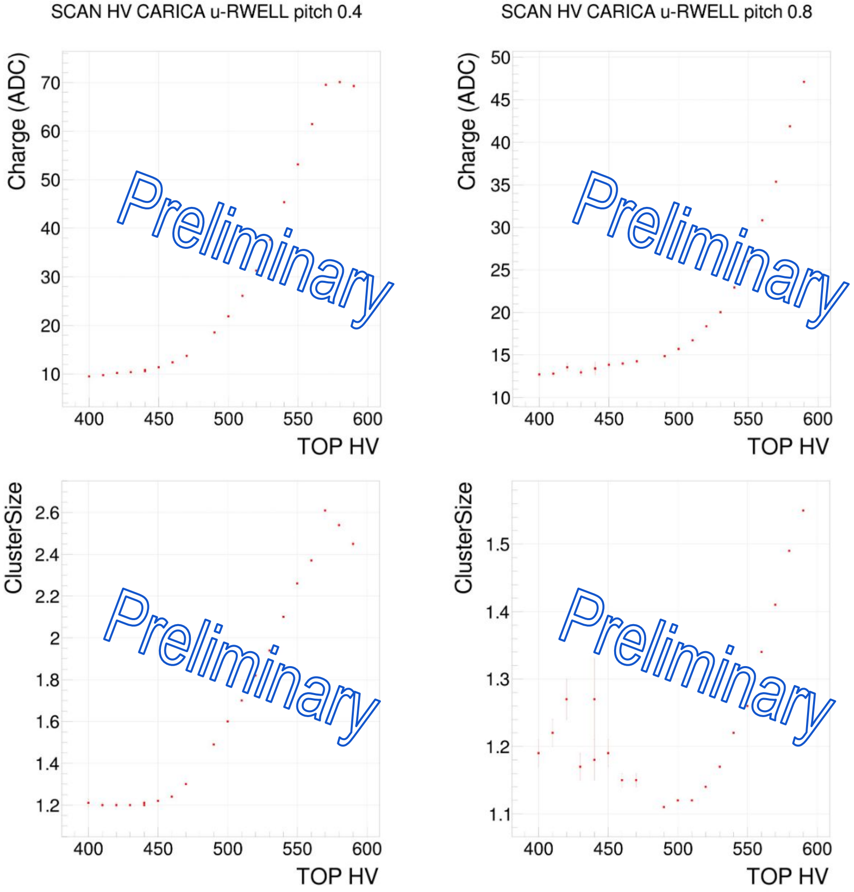
Compare the results collected with APV25

Collect data to tune the simulation (µRWELL+TIGER)

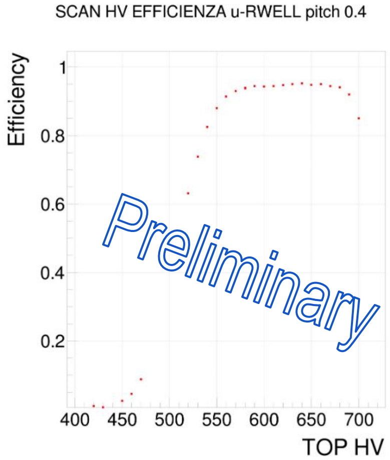
ArCO2CF4 soglie 5-5

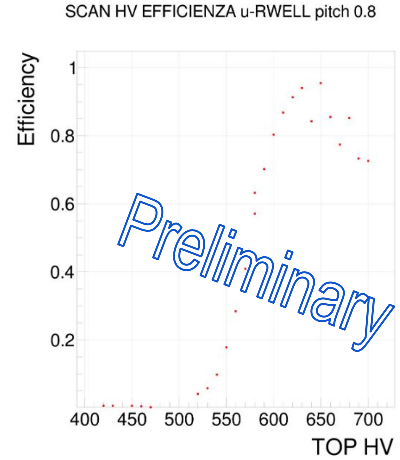


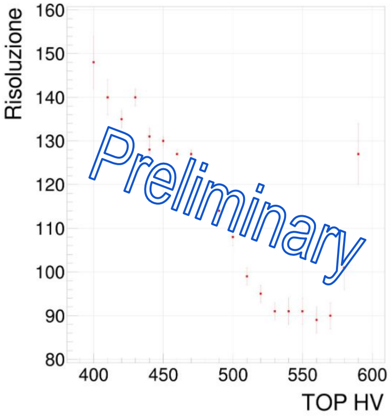
ArCO2 soglie 5-5

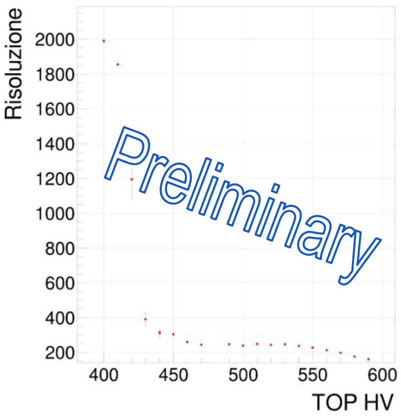


ArCO2CF4 soglie 5-5

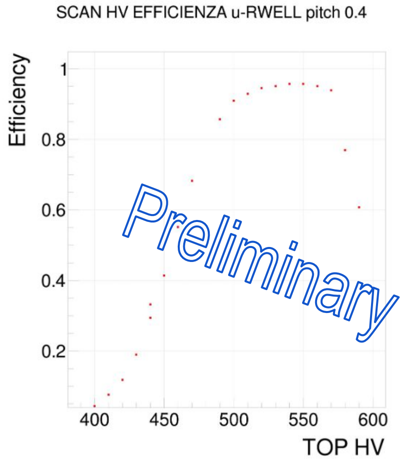


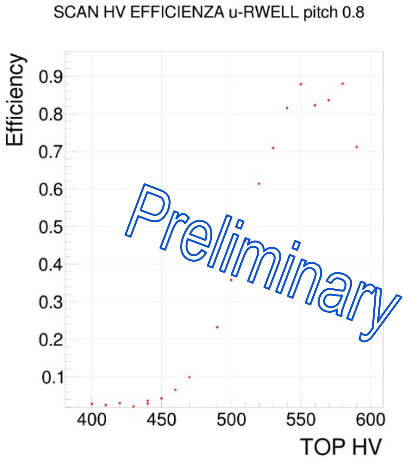


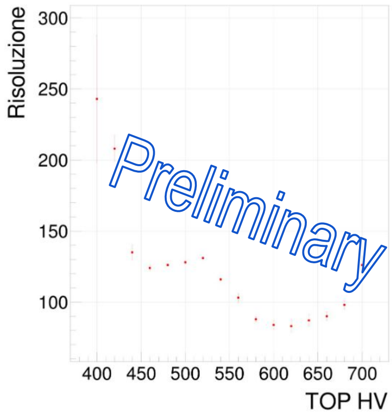


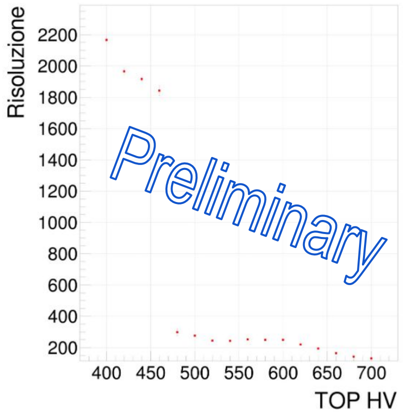


ArCO2 soglie 5-5









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μRWELL+TIGER parametrized simulation and new FEE proposal

Ionization

Electron drift

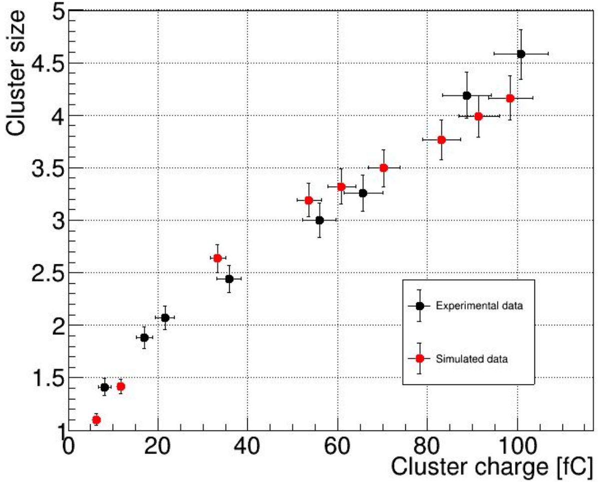
Amplification

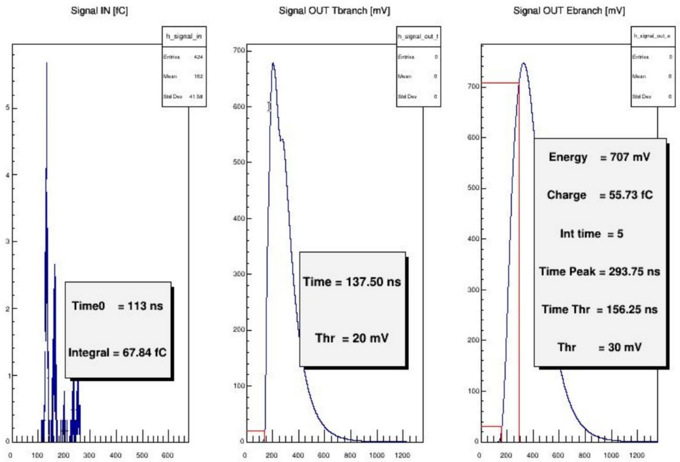
Resistive

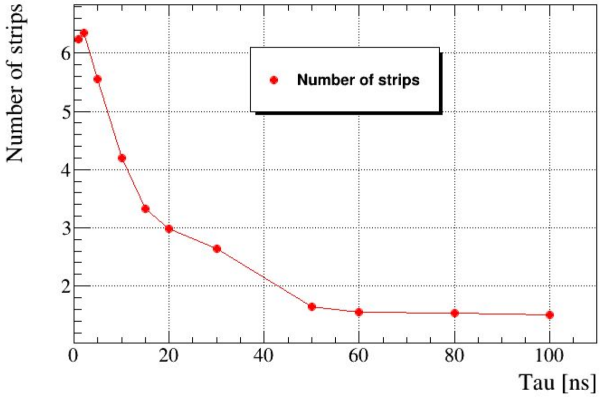
Induction

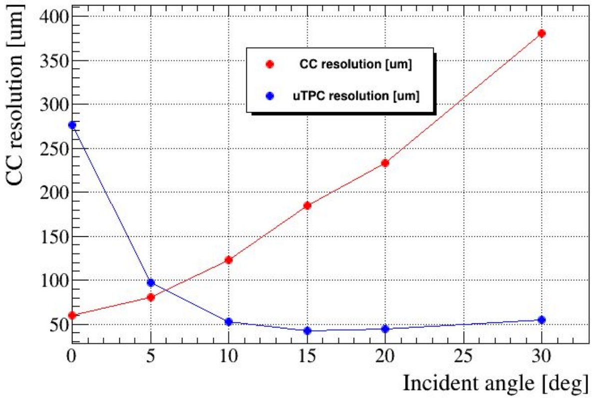
Readout

Reconstruction









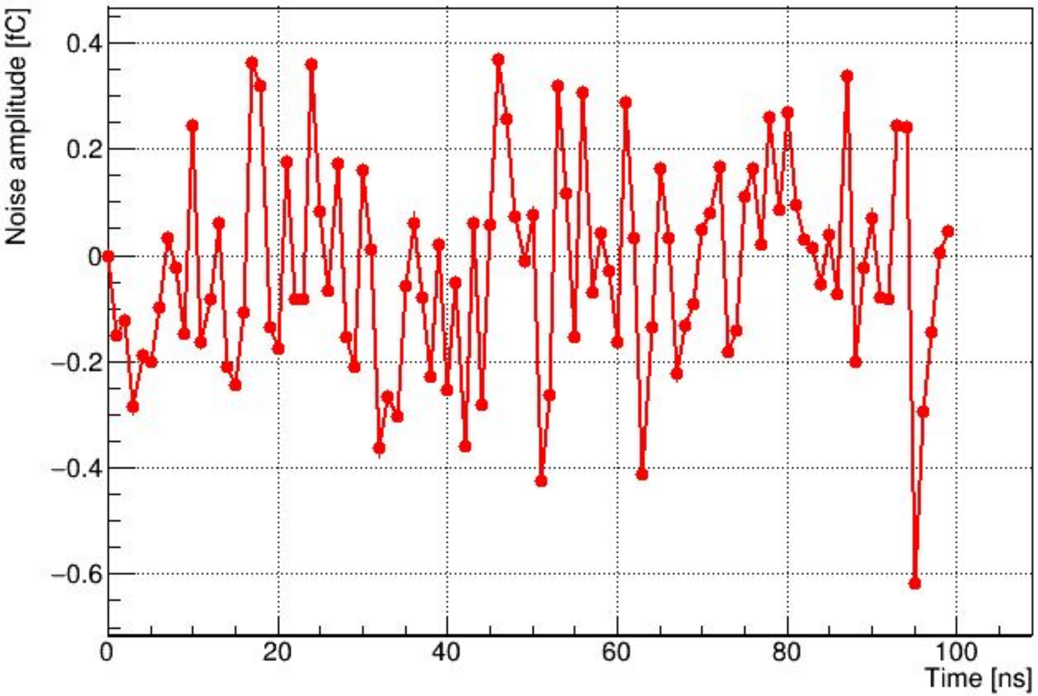
White noise implementation

```
const int max_freq = 1e6;
float white_noise(int itime){
  float output=0;
  for(int ifreq=1;ifreq<max_freq;ifreq*=10){
    output+=r->Gaus()*max_amplitude*sin(itime*ifreq);
  }
  return output;
}
```

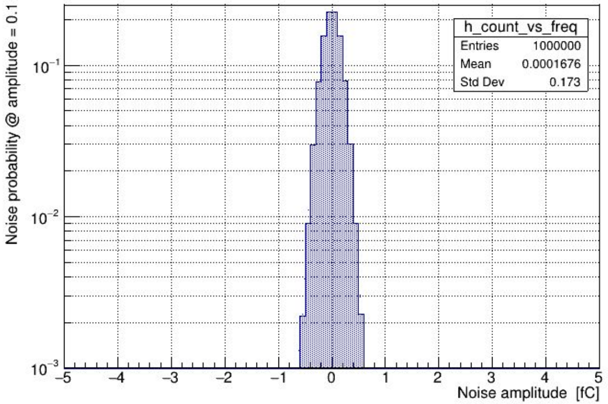
itime = 1 ns bin
For each frequency [1,10,100,1000,10000,10000] a sinusoidal function with the same amplitude is considered.

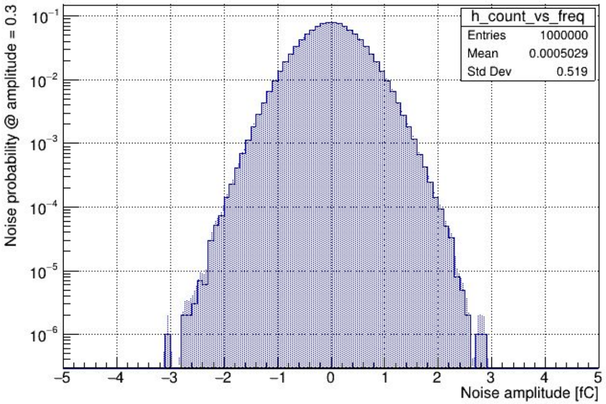
White noise = flat amplitude vs frequency

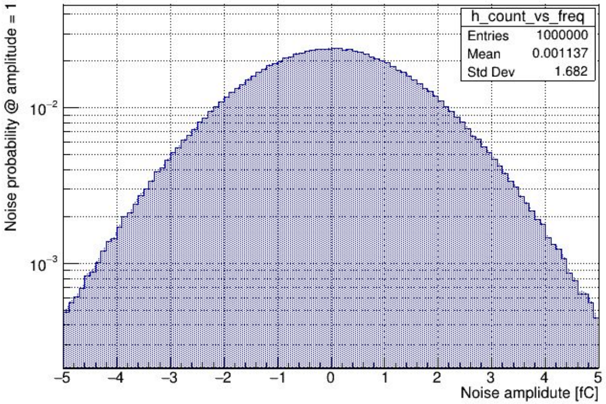
Simulation time ~ 1e7 time bin -> 10s



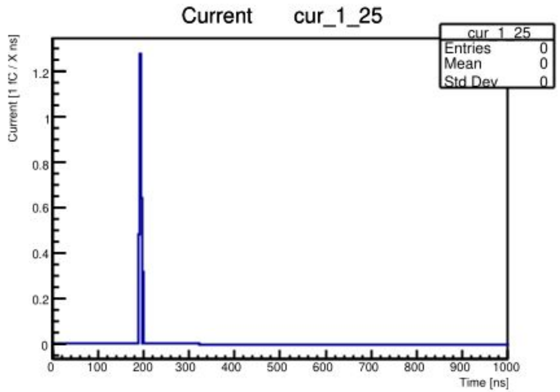
White noise implementation

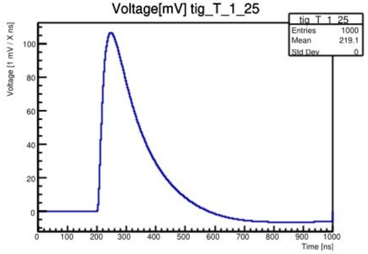


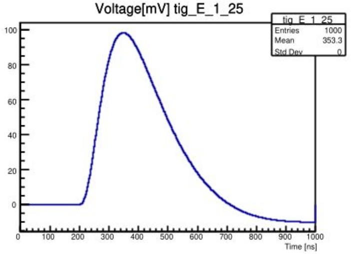


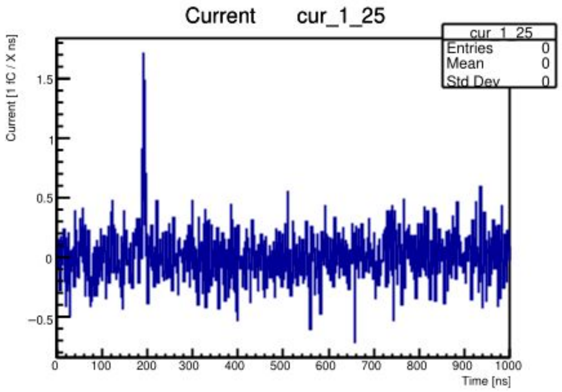


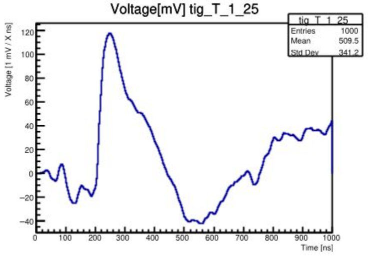
Delta current and the noise

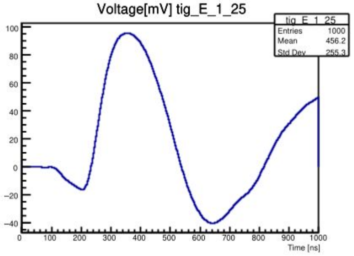








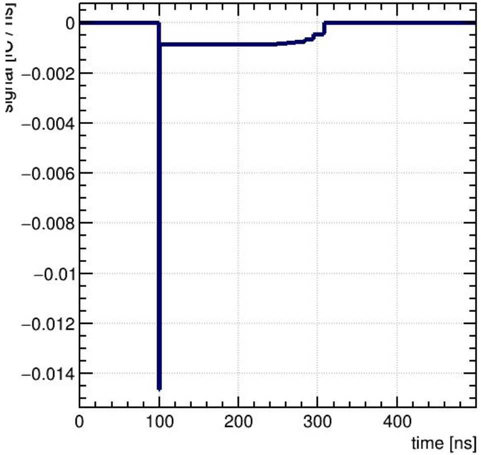




Single electron/ion induction

Ground model for the induction is to inject a pulse of 1ns and 1.6e-4fC once the electron reach the readout plane of the µRWELL.

To improve the reliability of the induction, the ion tails needs to be considered.
A simulation of 1 e- and 1 Ar+ drift along +60µm and -60µm together the relative induction of a plane is reported.



Ion tail included in the simulation