H8 Test Beam Data Analysis

Updates & Plans

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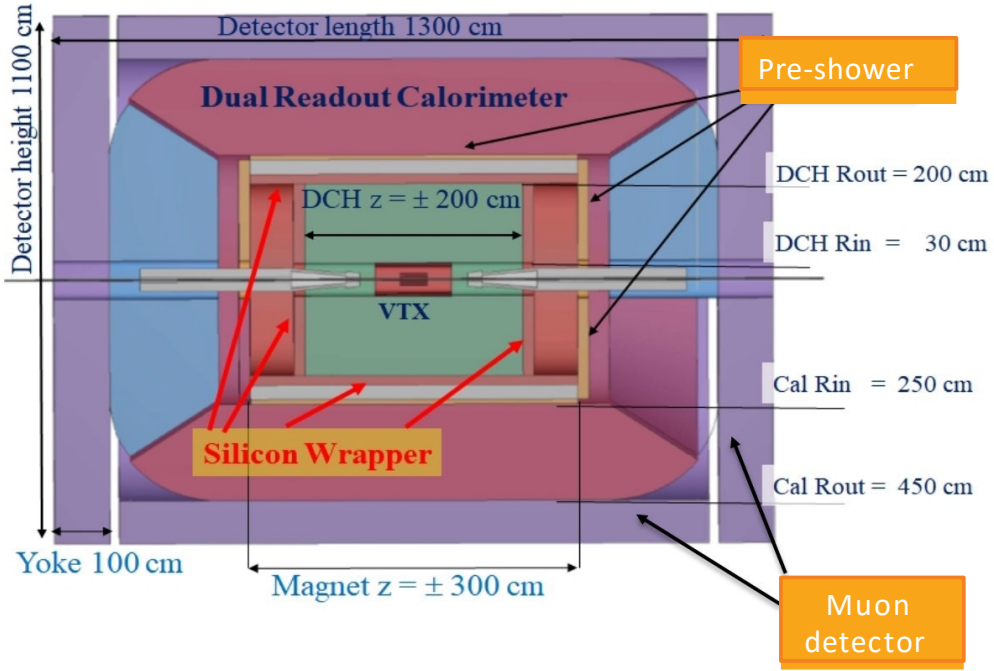
1 – INFN Torino
2 – INFN Ferrara
3 – LNF-INFN
4 – INFN Bologna

RD-FCC → µ-RWELL for tracking and muon system

The IDEA detector is a general purpose detector designed for experiments at future e^+e^- colliders (FCCee and CepC).
Pre-shower detector and the Muon system are designed to be instrumented with µ-RWELL technology.



Pre-shower — Oct.'21 TB

Tiles: 50x50 cm^2 with X-Y readout
Strip length: 50cm
Strip pitch: 0.4mm
Input FEE capacity ~ 70 pF

TOT: 330 m^2, 1.5×10^6 channels

Muon detector — TO BE DONE

Tiles: 50x50 cm^2 with X-Y readout
Strip length: 50cm
Strip pitch: 1.5mm
Input FEE capacity ~ 270 pF

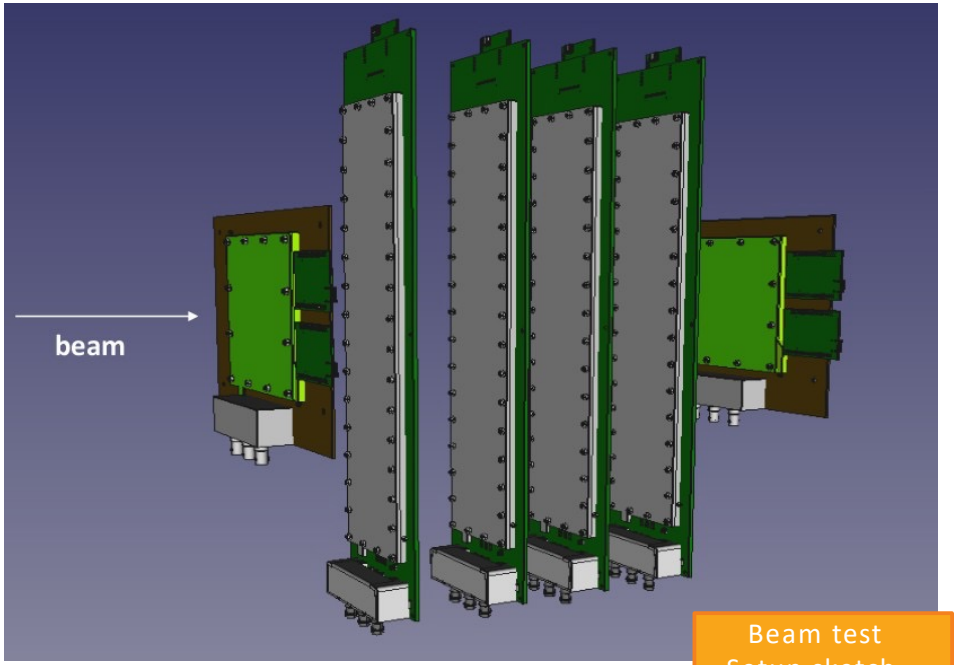
TOT: 4000 m^2, 5×10^6 channels

TB GOALS:

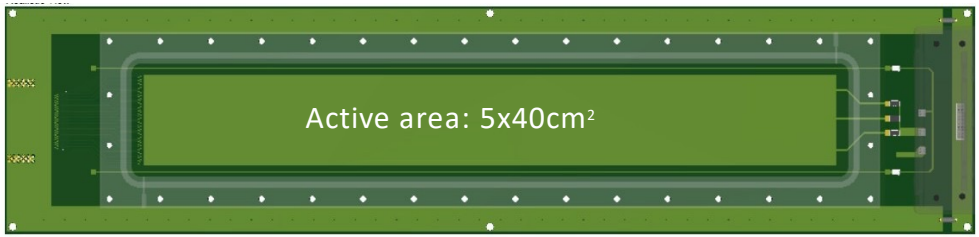
- Charge spread measurement to optimize readout geometry (strip pitch/width/lenght vs DLC surface resistivity).
- Tuning of µ-RWELL resistive stage simulations.

Experimental Setup

TB plan: measurement of the space resolution as a function of the detector surface resistivity for 0.4mm pitch strip (1-D readout).
All the measurement done with Ar/CO2/CF4 45:15:40.

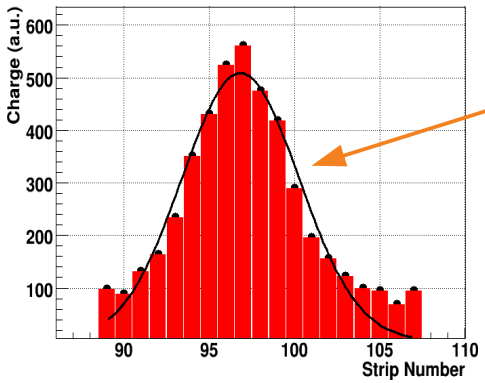


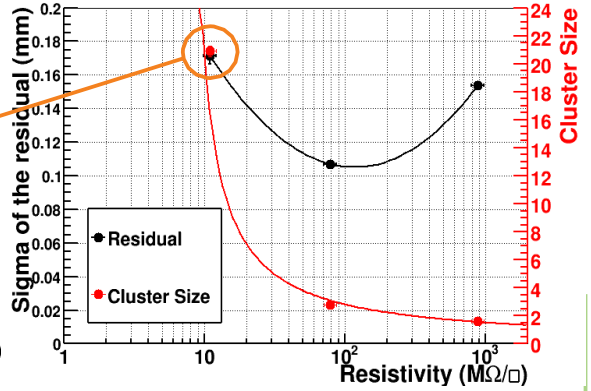
Beam test Setup sketch



Charge collected by the APV25 on the Strip readout (resistivity ~ 10 MΩ/□)

APV25 & 400 µm strip pitch →capacity = 15 pF





G. Bencivenni et al., NIM A 886 (2018) 36

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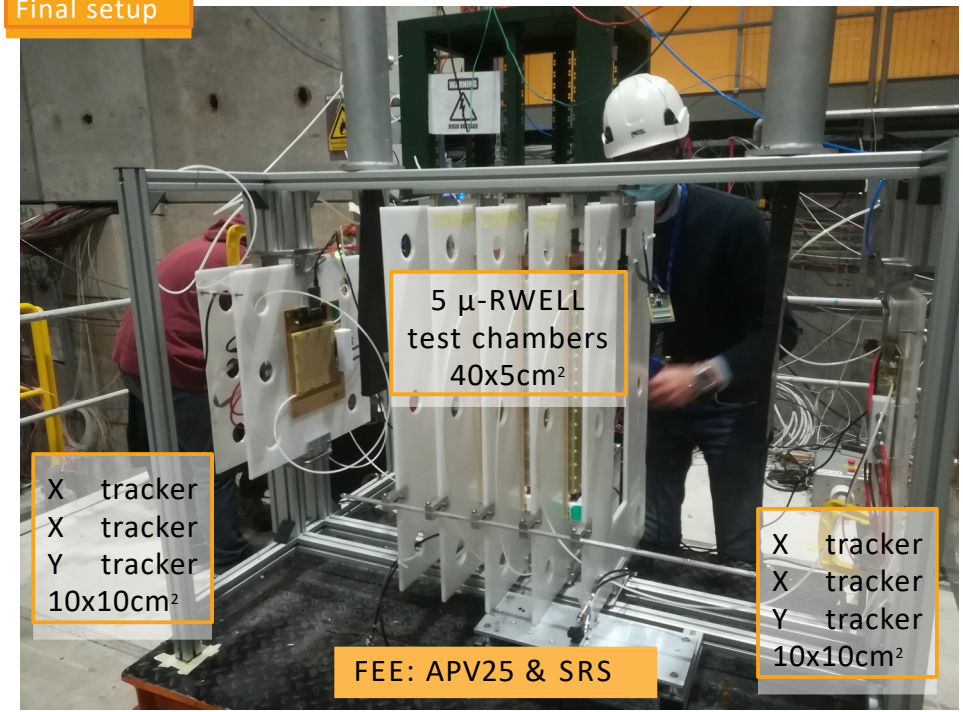
Final setup



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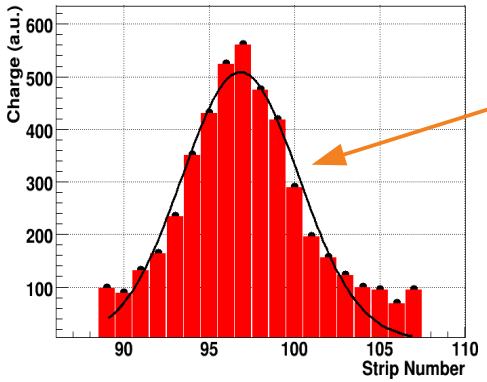

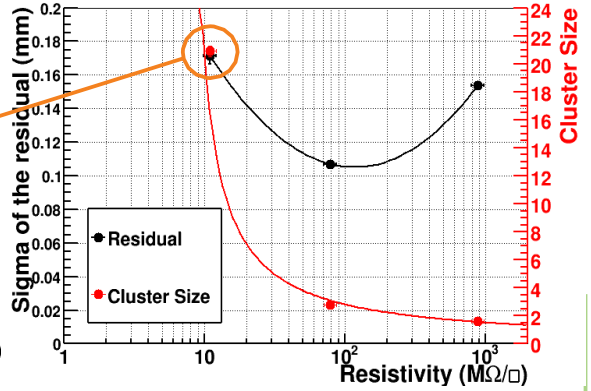

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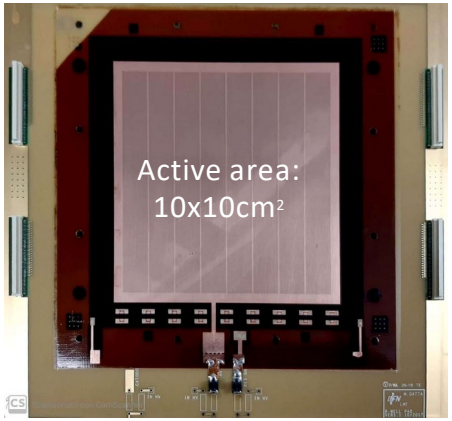
Detector Comparison



μ-RWELL trackers		μ-RWELL test	FEE signal
10x10cm²	Active area	5x40cm²	
300μm / 400μm / 10cm	Strip width/pitch/lenght	150μm / 400μm / 40cm	÷ 2
100μm (updates?)	Strip distance from DLC	50μm	× 2
Standard (70μm)	Amplification WELL diameter	Larger (to be measured)	÷ ?
30÷40MΩ/□	DLC surface resistivity	10÷80MΩ/□	

Data set

HV Scan:

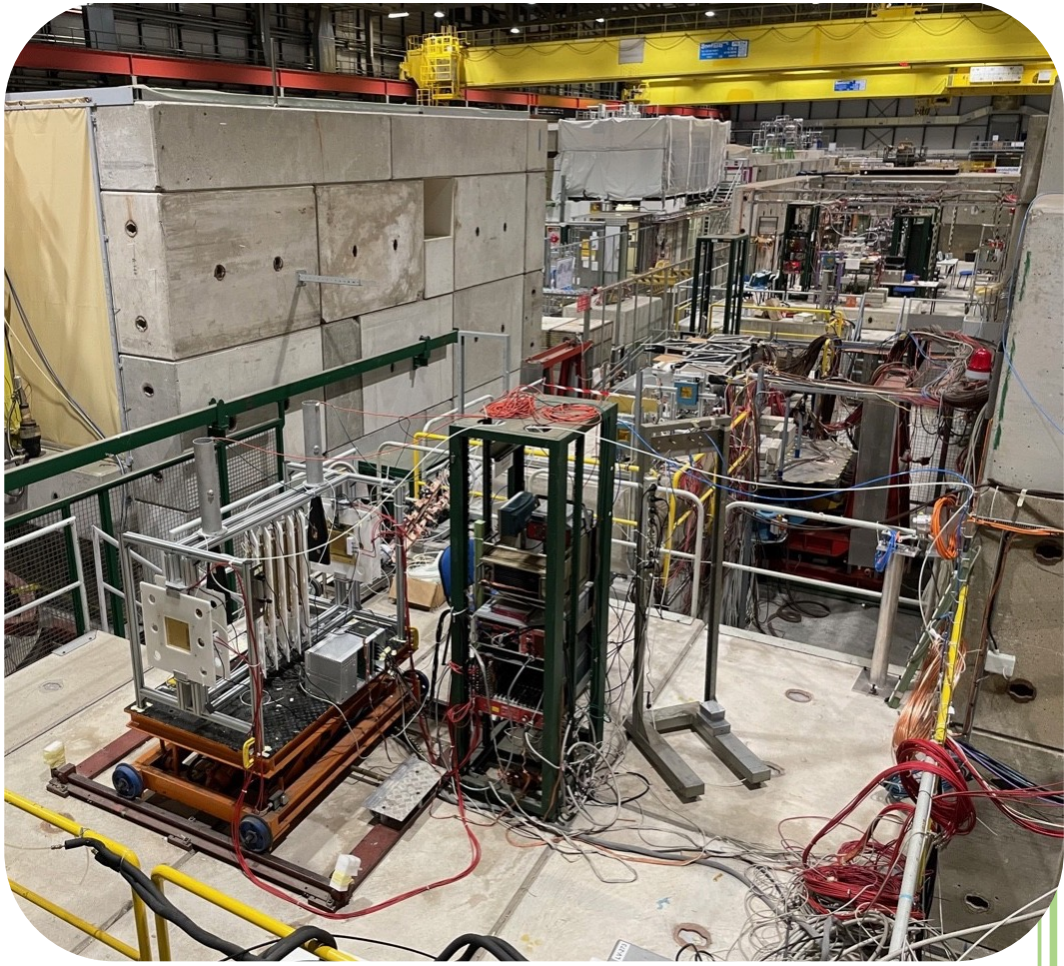
- @ 0° for trackers & test chambers (muons & pions)
  Test chambers resistivity:
  [10,15,20,40,60,80,80] MΩ/□

- @ 40° for test chambers (with muons)

Angle Scan [0,10,20,30,40]° for test chambers

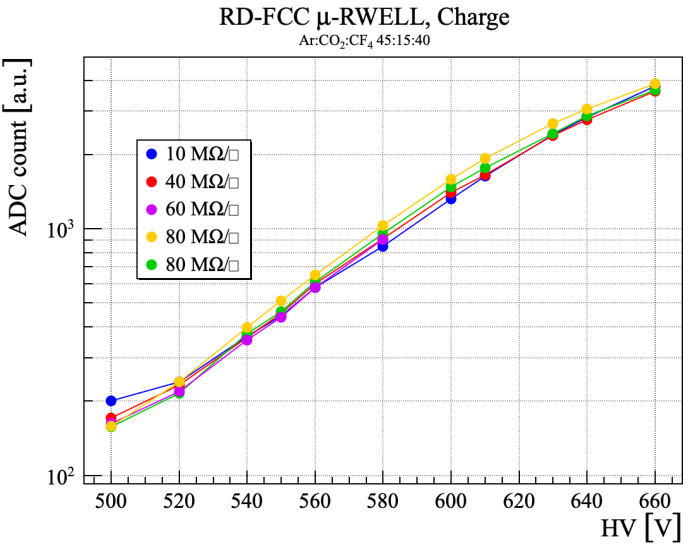
- Drift field 0.5 kV/cm with muons
- HV [640/660/680] V for each angle

Drift field scan @0°
[0.01,0.05,0.1,0.5,1,2,3,3.5,4,5] kV/cm

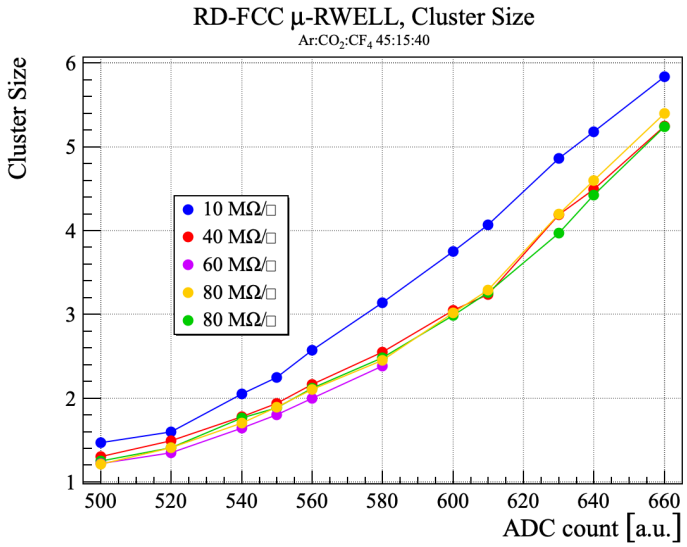


Preliminary results @ VCI '22

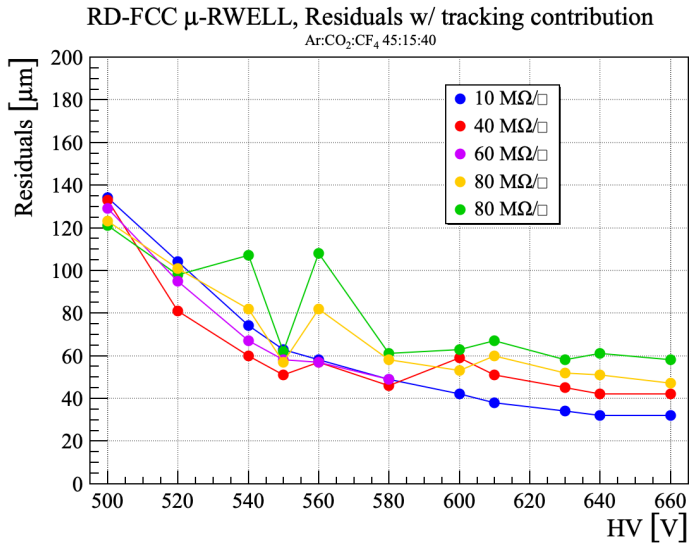
All the measurement with Ar/CO2/CF4 45:15:40,
Drift Field 3.5 kV/cm and ortogonal incidence.
Software Threshold = 200 a.u. applied



Good gain uniformity among prototypes.
Lower than 10x10 µ-RWELL (due to larger amplification holes).



Cluster Size:
higher for 10MΩ/□ proto
Flat for the other resistivity values.
Compatible with the 2018 published plot.



Residuals of test chambers w.r.t. all chambers.
No tracker contribution subtracted.
Next step: back to back analysis.

Data Analysis selection & definitions

All the measurement with Ar/CO2/CF4 45:15:40, Drift Field 3.5 kV/cm and ortogonal incidence.

Trackers requirements:

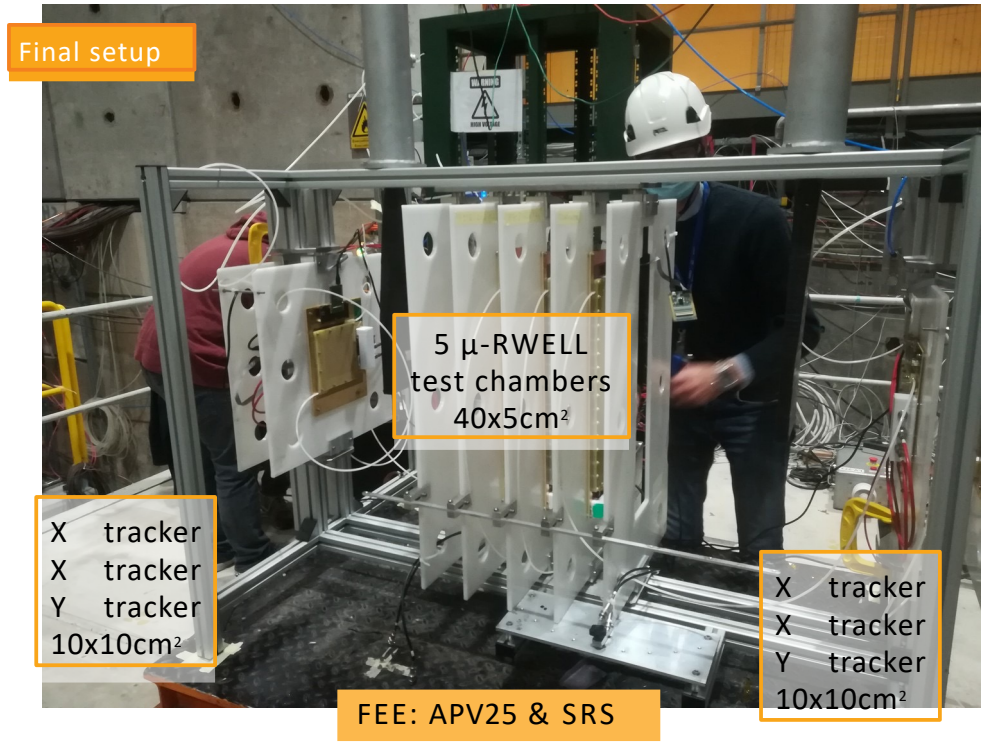
- Hits in all 3 front and back trackers with enemy residuals in X coordinate within 2 sigmas of the double-gaussian fit
- Hits in 1st and last X trackers in [-8 ,8] cm to avoid sector's dead zones
- Tracking successfully in both front and back trackers

Test Chamber selection:

- All hits in the chamber within 10 sigmas of the residuals double-gaussian fit wrt trackers are retained.

Test Chamber measurements:

- Measure_Res_All: referred to the cluster's expect position evaluated using all trackers and chambers but the one under evaluation.
- Measure_Res_Trk: referred to the cluster's expect position evaluated using all trackers. Same hits selection
- Measure_Res_enemy

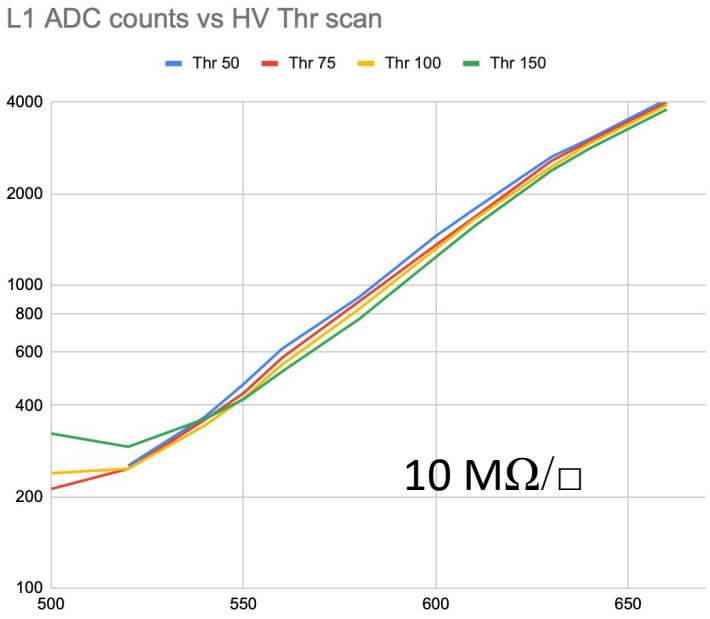


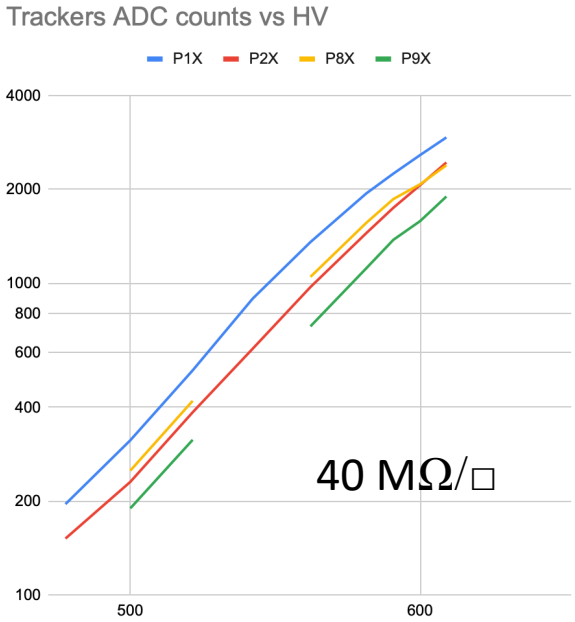
- Measure_Eff: Test Chamber sele / Trackers sele
- Measure_Charge
- Measure_Size

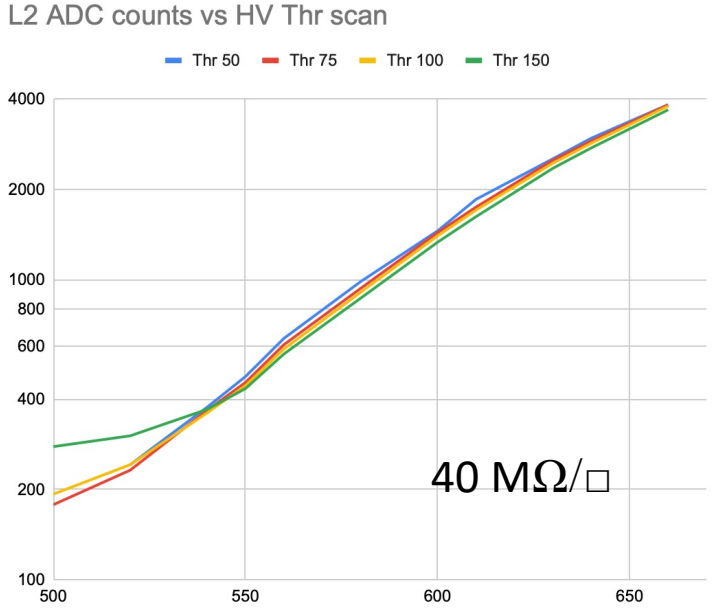
Today's updates w Threshold Scan: ADC counts

All the measurement with Ar/CO2/CF4 45:15:40, Drift Field 3.5 kV/cm and ortogonal incidence.
Software Threshold scan performed (*):

- Study efficiency vs HV and residuals vs HV
- Study tails in the residual distributions vs HV







(*) runs with Thr = 200 to be redone

Today's updates w Threshold Scan: Cluster Size

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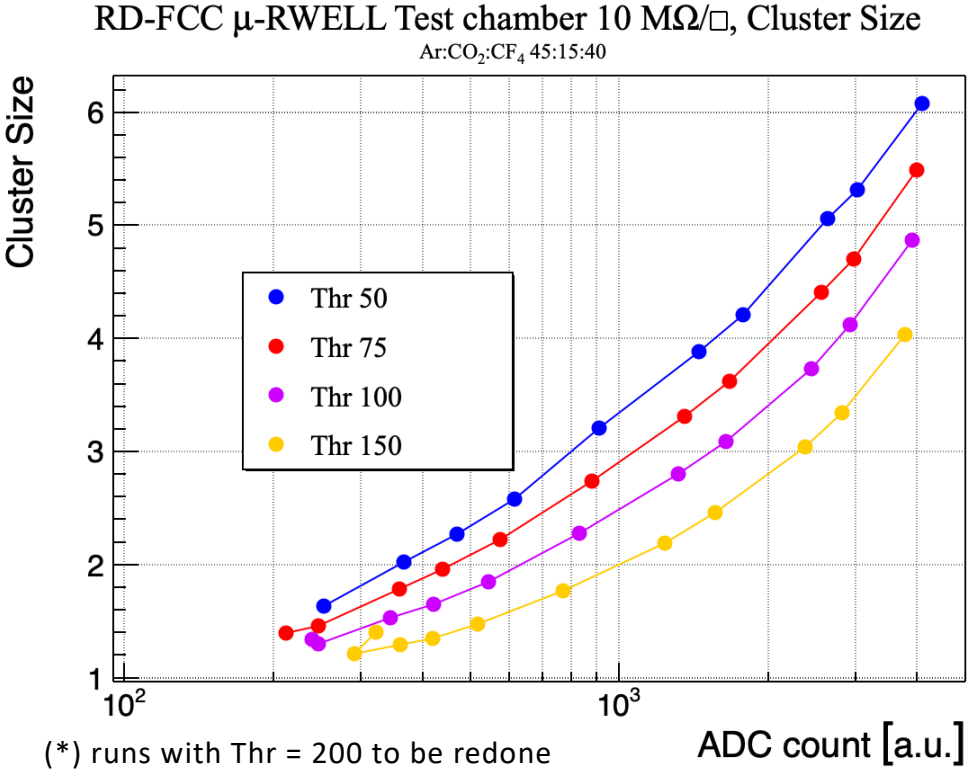

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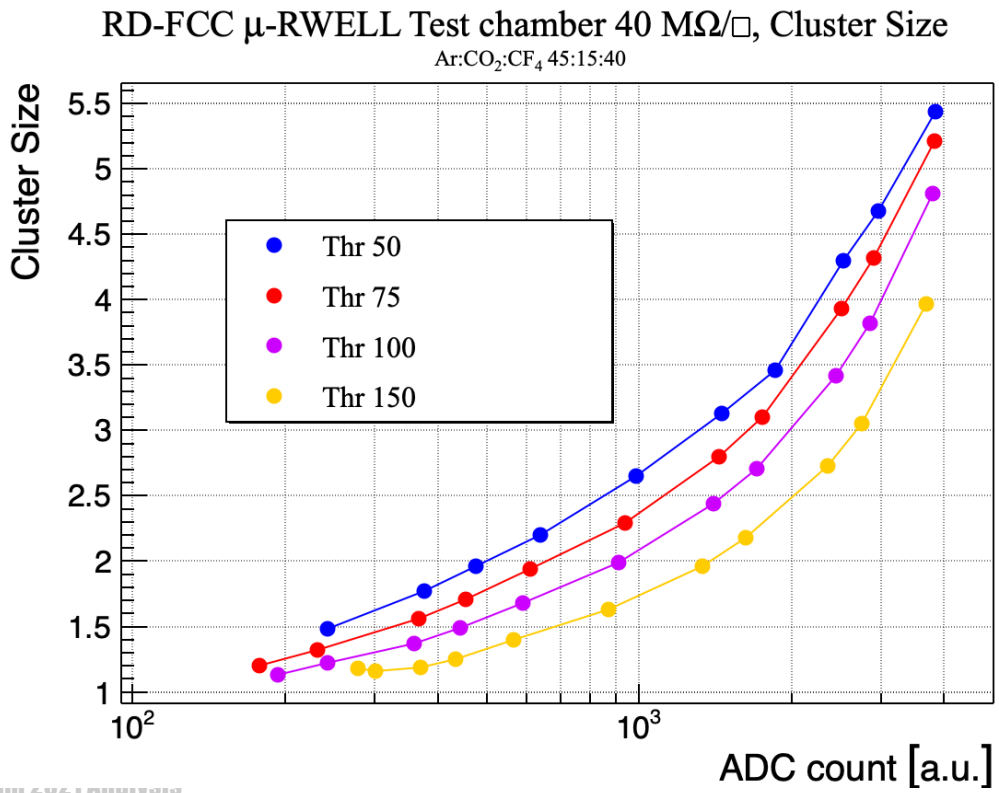

Today's updates w Threshold Scan: Cluster Size wrt Trackers

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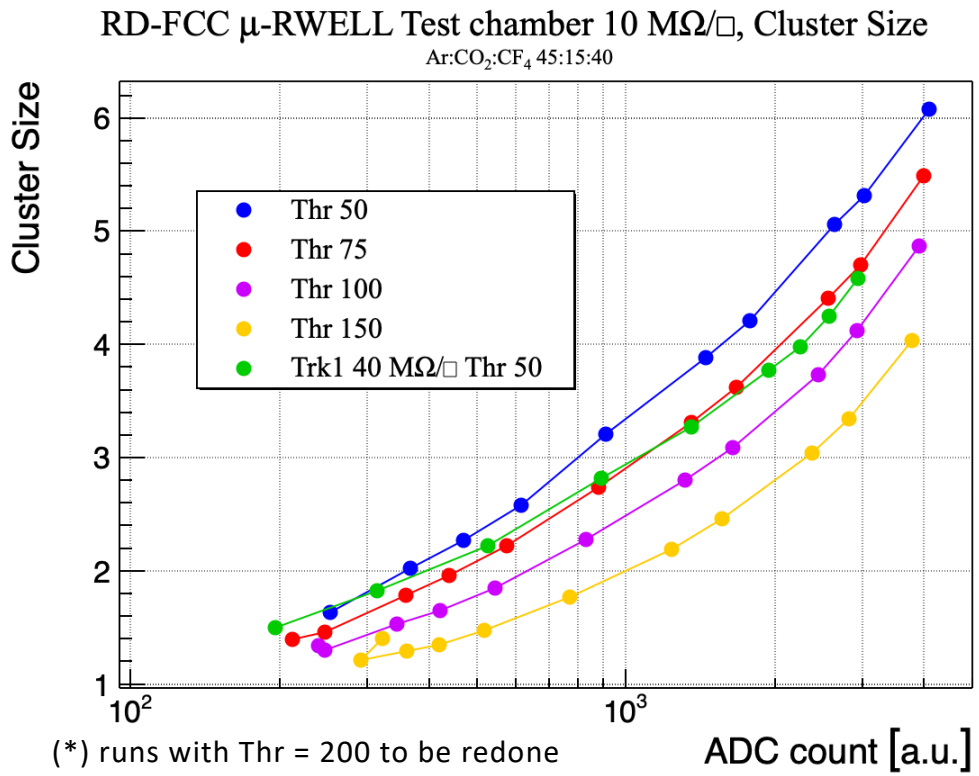

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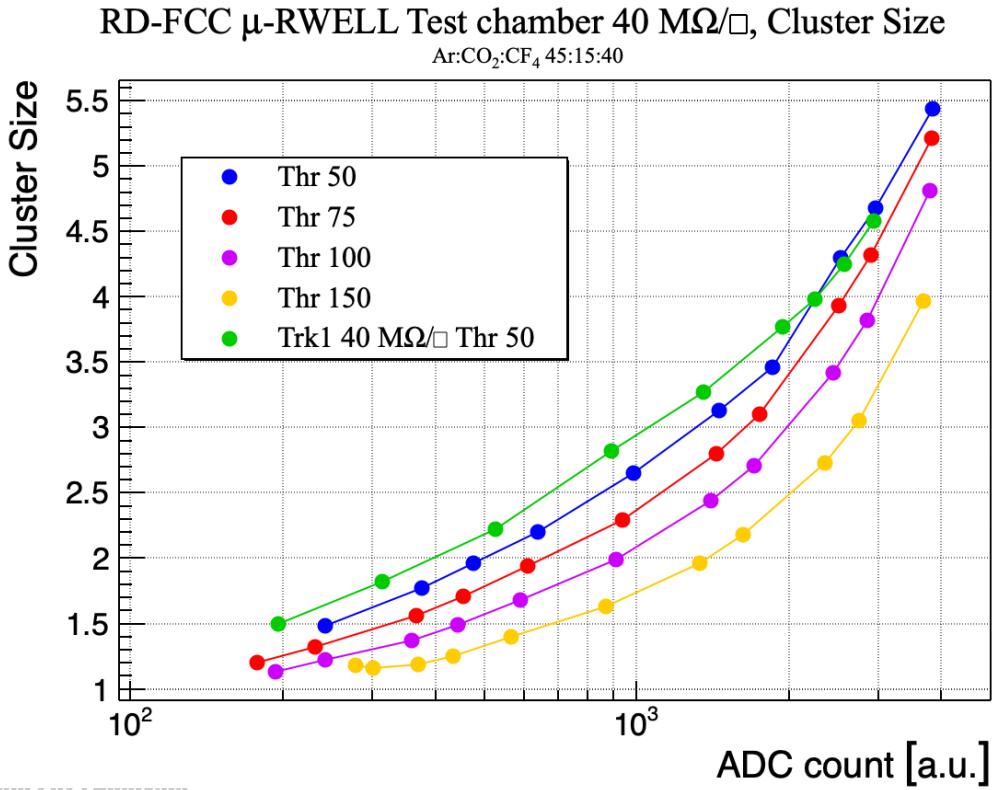

Today's updates w Threshold Scan: Efficiency

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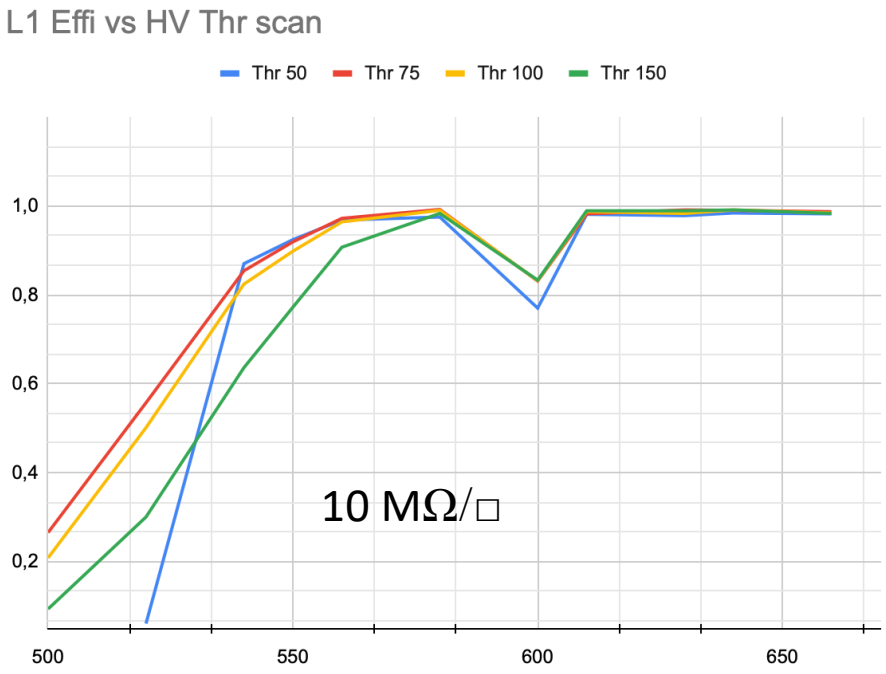

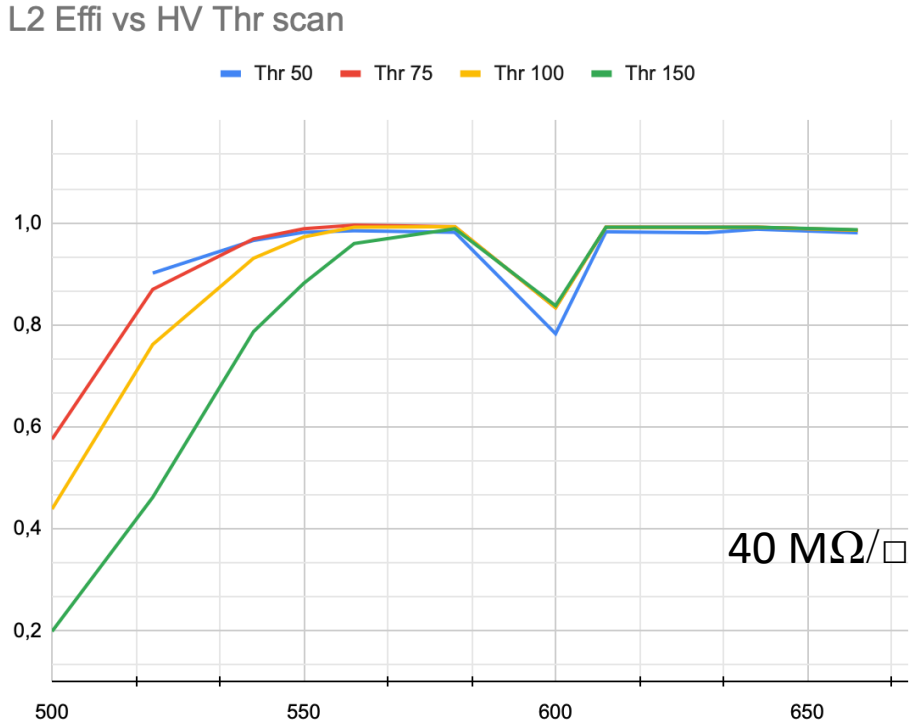

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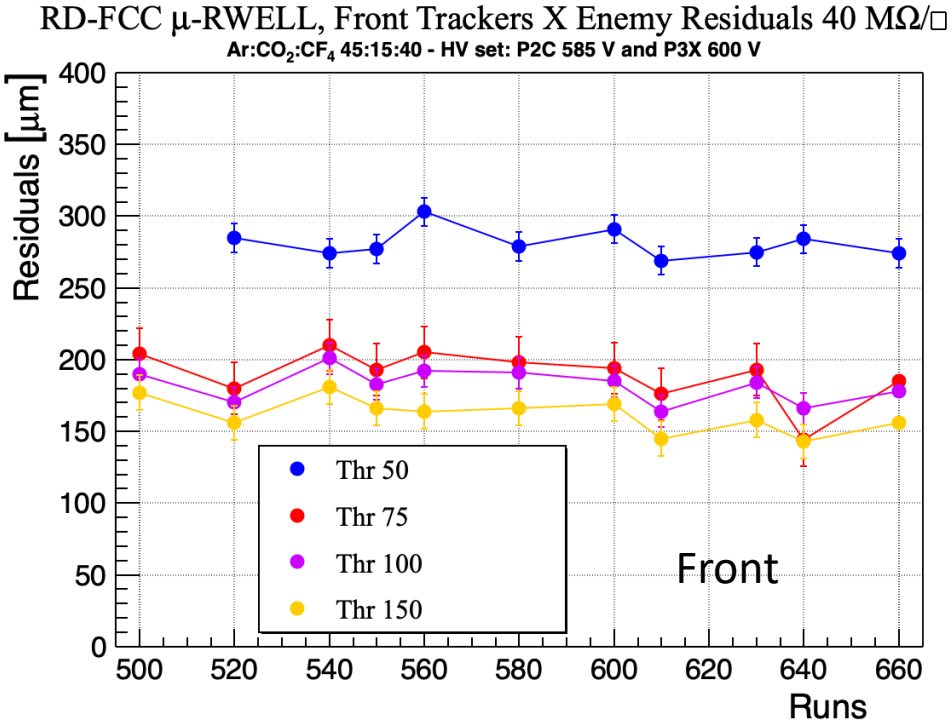
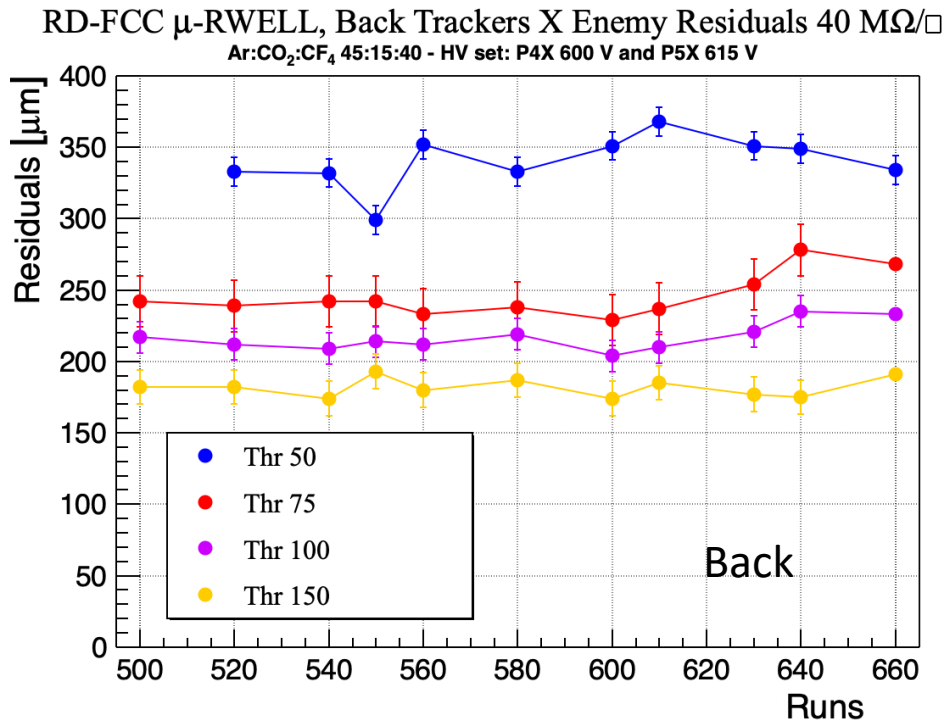
Today's updates: Enemy Residuals for Trackers

- Software update with double gaussian fit for residual distributions
- **Statistical fluctuations from external trackers residual standard deviation**
- Some effect visible for runs with test chambers HV above 620 V





Today's updates: Enemy Residuals for Test Chamber

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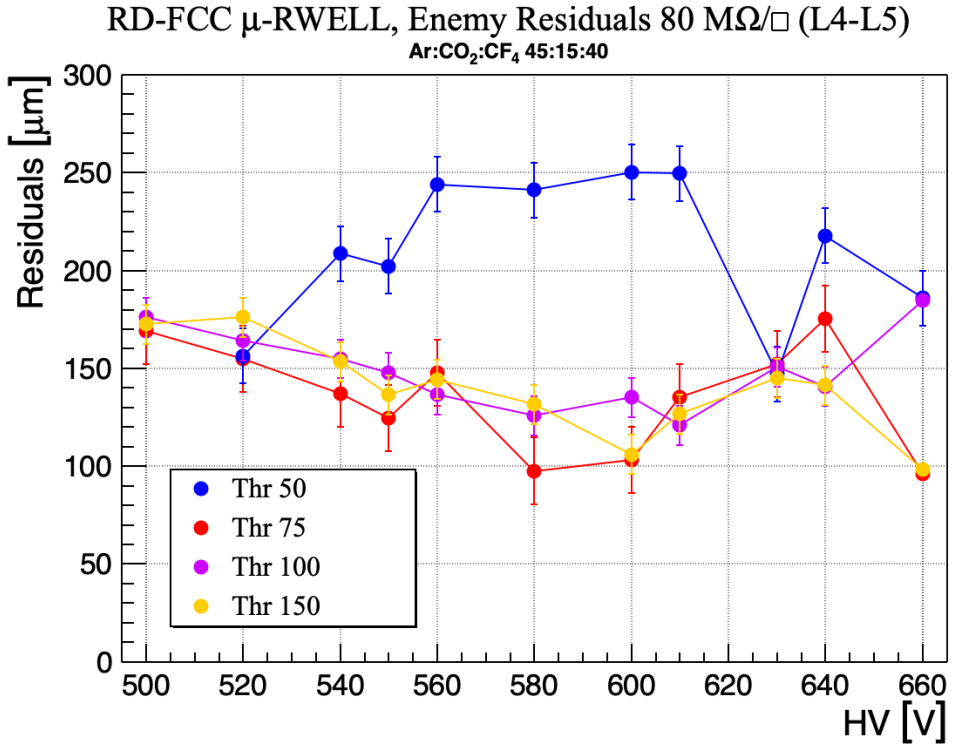
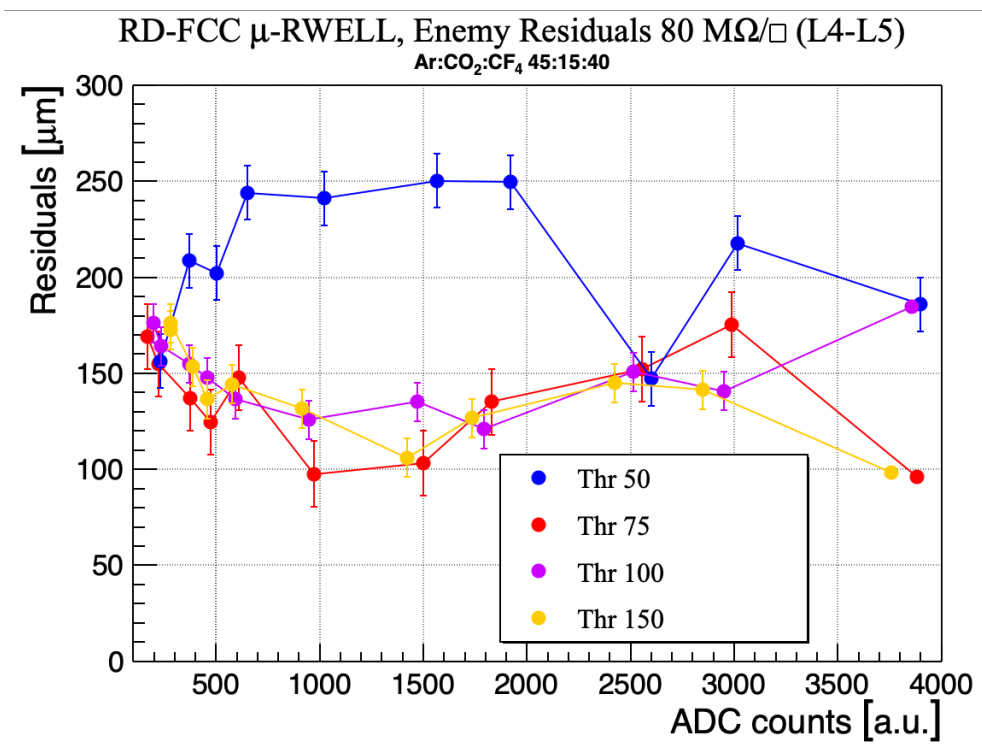
To do: study the tails in the residuals distribution





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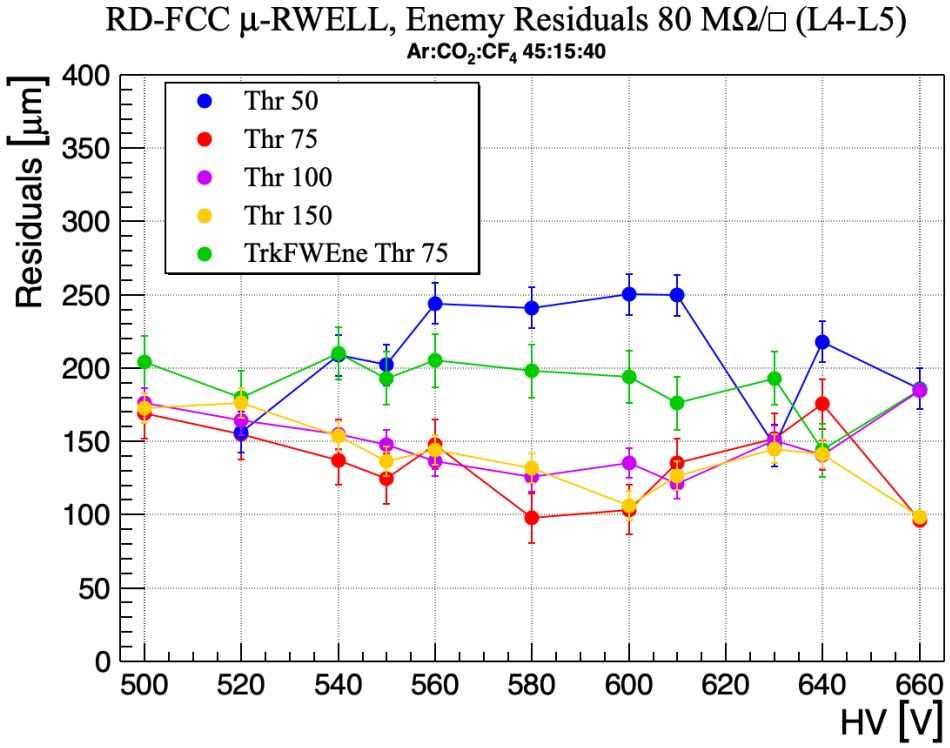

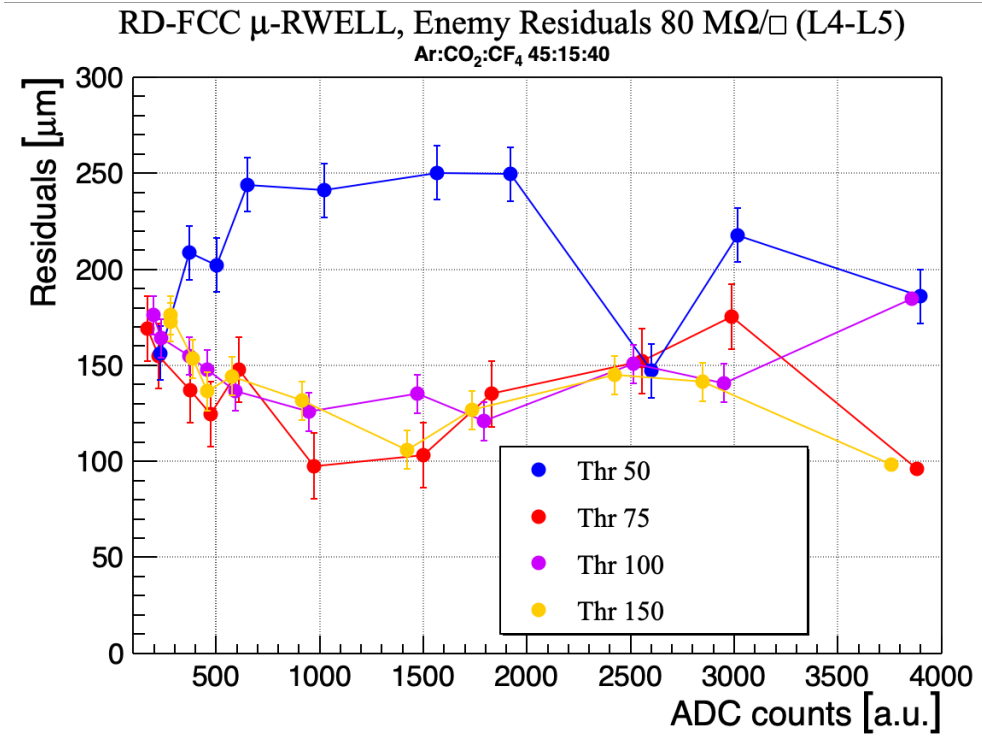

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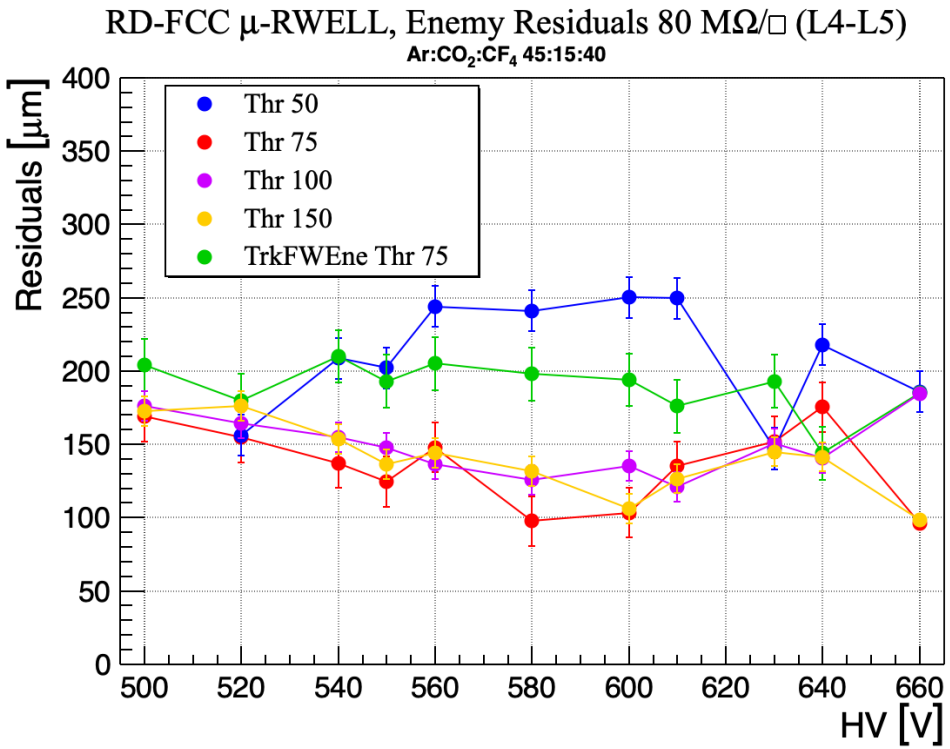
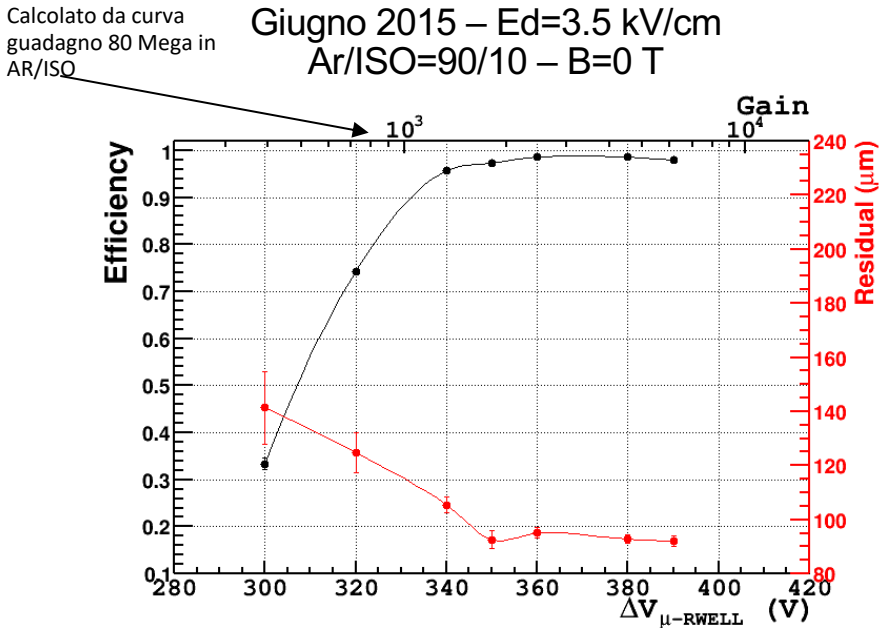




Compared with results from June 2015, looks like the residuals are almost flat because we are very close to the efficiency plateau region

Conclusions and Plans

Measurement with Ar/CO2/CF4 45:15:40, Drift Field 3.5 kV/cm and ortogonal incidence

New version of Reconstuction Software: double-gaussian fit and user-friendly selections & algorithms

Started some comparision between Test Chambers and Trackers performance:

- Cluster Size
- Enemy Residuals

Software Threshold scan performed and the following studies re ongoing:

- Efficiency vs HV and residuals vs HV
- Enemy Residual distribution

Next:

1. Concentrate on the study of the tails in the residual distributions vs HV. Compare residuals measured with all trackers and test chambers with those measured with trackers only (Erika)

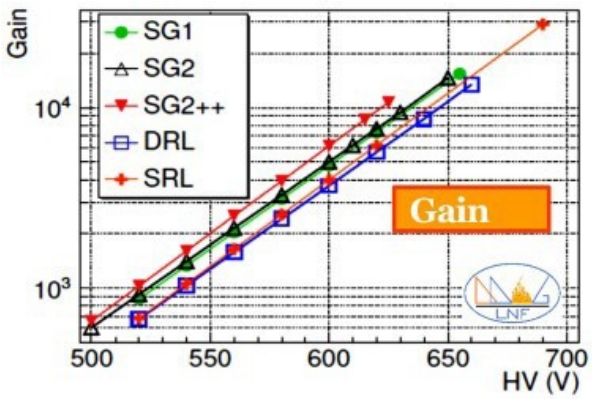
2. External tracking subtraction from test chamber residuals: use Riccardo's ToyMC. Multiple scattering contribution in the setup (Lia)

3. Compare Enemy Residuals with Residuals from external tracking (Erika)

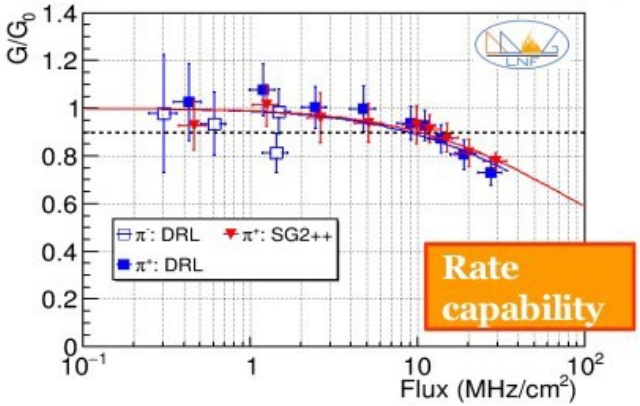
Spare

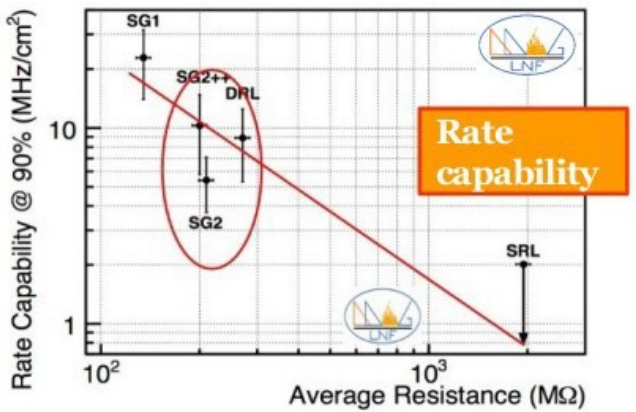
μ-RWELL performance overview

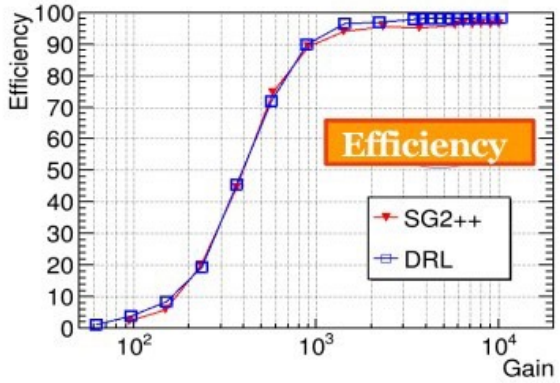
Gain up to 10^4



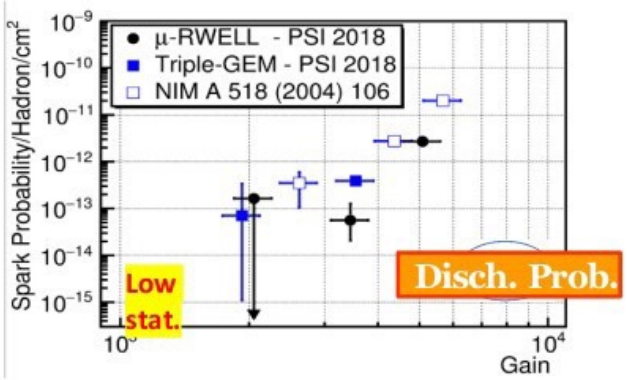
Rate Capability (@ G= 5000) ~ 5-10 MHz/cm^2



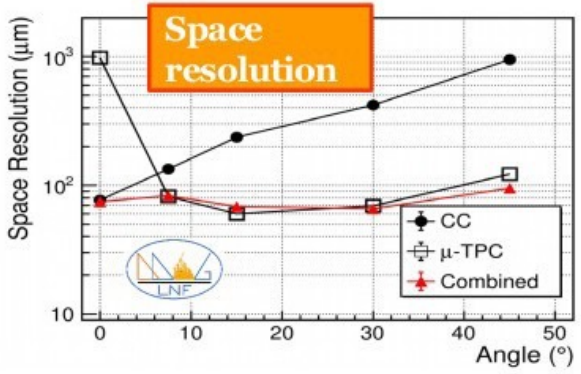




Efficiency ~ 98%



Discharge probability ~ 10^{-13} @ 4000



Space resolution ~ 100 μm

Preliminary results @ November '21

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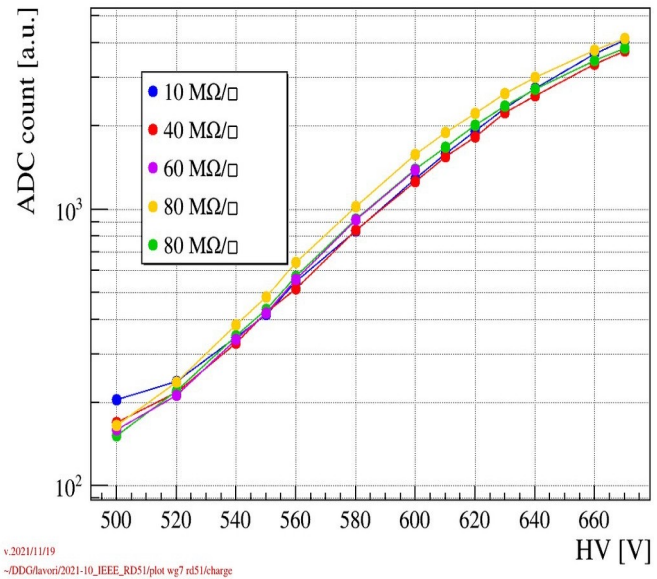

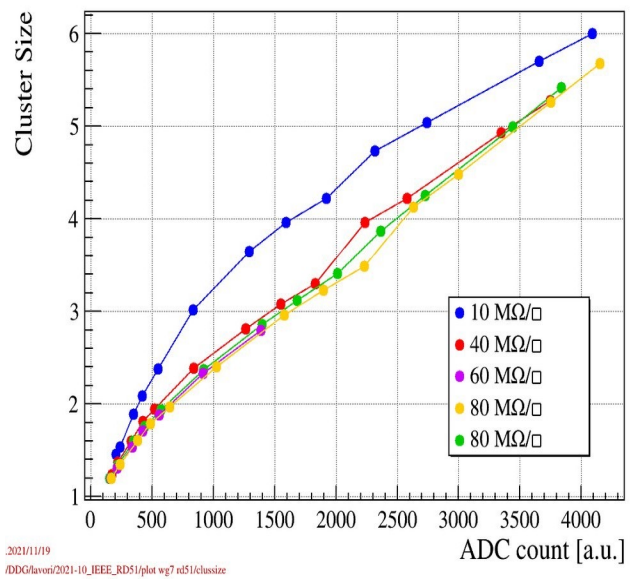

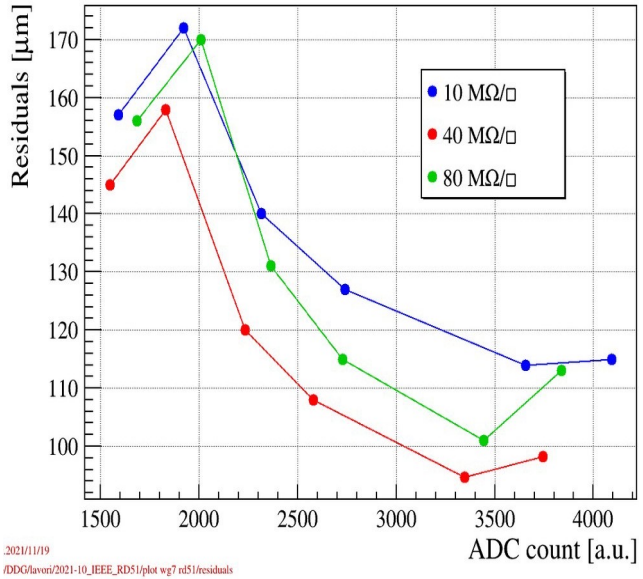

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Lower than 10x10 μ-RWELL (due to larger amplification holes).

Cluster Size:
higher for 10MΩ/□ proto
Flat for the other resistivity values.
Compatible with the 2018 published plot.

Residuals of test chambers w.r.t. the trackers.
No tracker contribution subtracted.
Next step: back to back analysis.

Confronto Test Beam Dic 2014 vs Giu 2015
WELL 80 MegaOhm/square

Analizzati solo run con traccie ortogonali &
fit Lineare (curvilineo sembra non funzionare)

Codice Analisi Versione 1

TEST BEAM DICEMBRE 2014

CASO DI TUTTI I PIANI INCLUSI (TRACCIATORI)
--> Risoluzione spaziale 53.88
--> Risoluzione spaziale 45.62
--> Risoluzione spaziale 0.00
--> Risoluzione spaziale 2.66

Numero di Piani di TRACCIAMENTO: 3
--> Sigma Fit 40.79
--> Risoluzione WELL 51.89

CASO DI UN PIANO ESCLUSO (WELL DETECTOR)
--> Risoluzione spaziale 56.99

(3 GEM-TRK interni al Campo B)

Codice Analisi Completamente cambiato

TEST BEAM GIUGNO 2015

CASO DI TUTTI I PIANI INCLUSI (TRACCIATORI)
--> Risoluzione spaziale 62.56
--> Risoluzione spaziale 58.24
--> Risoluzione spaziale 47.63
--> Risoluzione spaziale 46.53
--> Risoluzione spaziale 0.00
--> Risoluzione spaziale 52.00

Numero di Piani di TRACCIAMENTO: 5
--> Sigma Fit 53.75
--> Risoluzione WELL 72.19

CASO DI UN PIANO ESCLUSO (WELL DETECTOR)
--> Risoluzione spaziale 80.39

(3 GEM-TRK esterni al Campo B + 2 GEM interni al campo B)

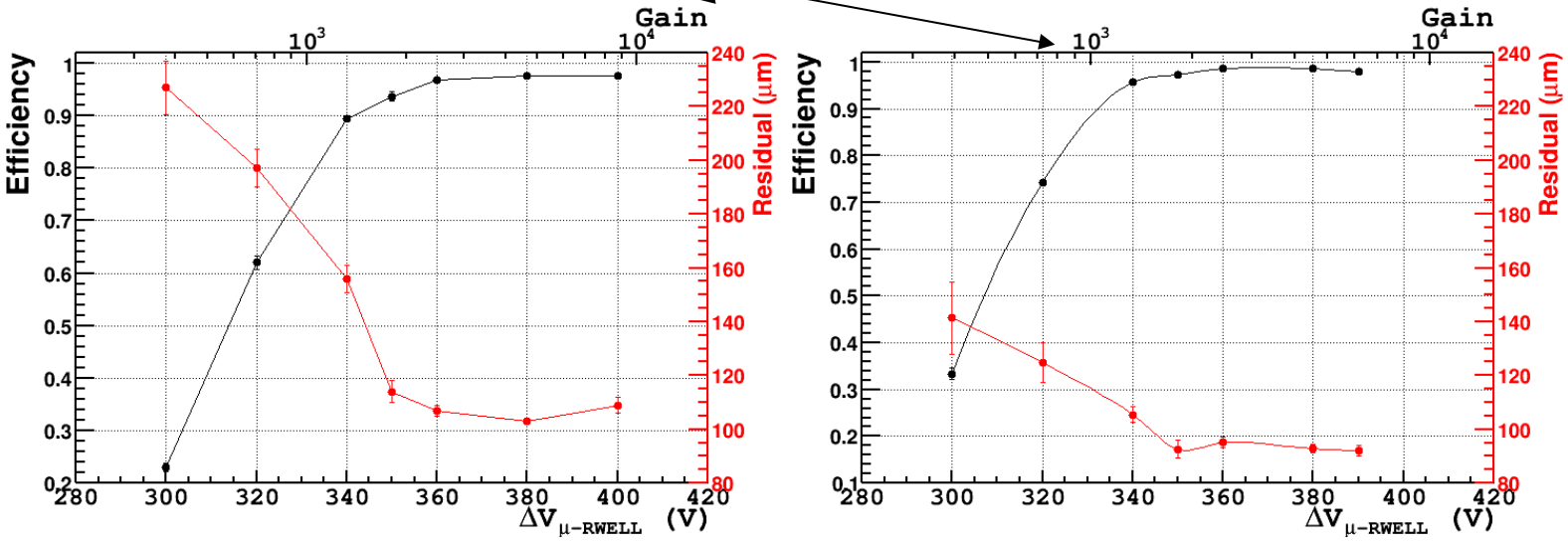
Confronto
Test Beam Dic 2014 vs Giu 2015
in
AR/ISO=90/10

Efficienza & residui vs HV

Dicembre 2014 – Ed=3.5 kV/cm
Ar/ISO=90/10 – B=0.5 T

Calcolato da curva guadagno 80 Mega in AR/ISO

Giugno 2015 – Ed=3.5 kV/cm
Ar/ISO=90/10 – B=0 T

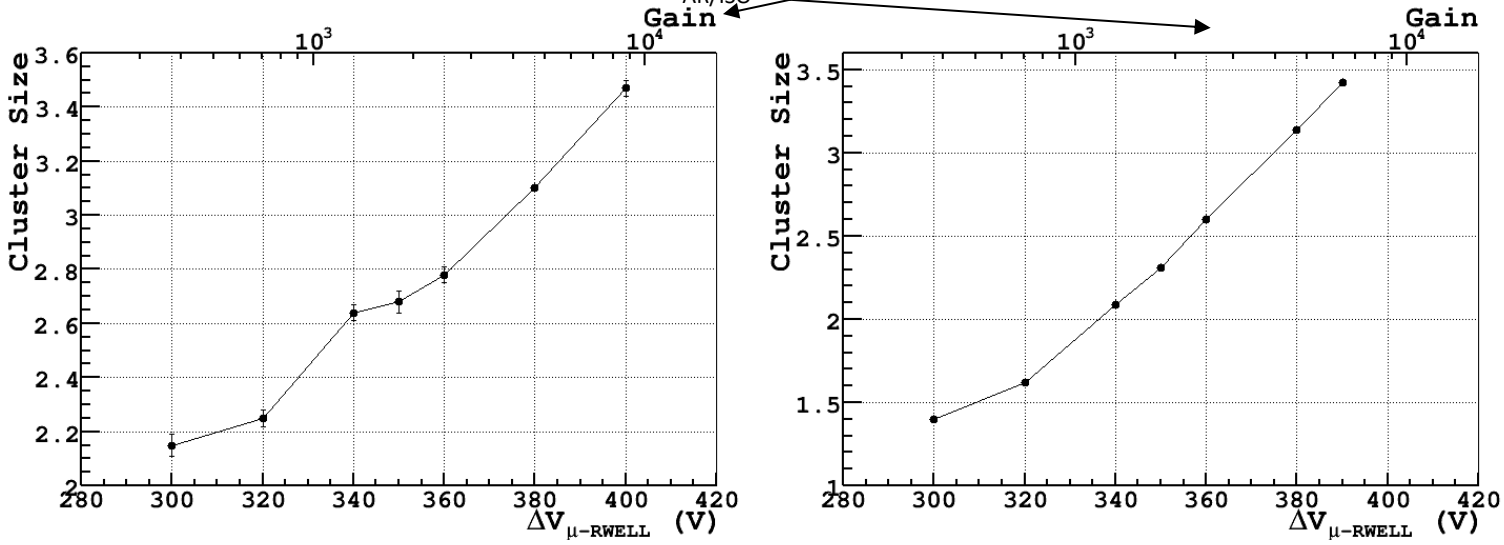


Cluster Size vs HV

Dicembre 2014 – Ed=3.5 kV/cm
Ar/ISO=90/10 – B=0.5 T

Calcolato da curva guadagno 80 Mega in AR/ISO

Giugno 2015 – Ed=3.5 kV/cm
Ar/ISO=90/10 – B=0. T



Non stessa scala Y