DRD1 VMM3a/SRS Beam Telescope

Test Beam September 2024
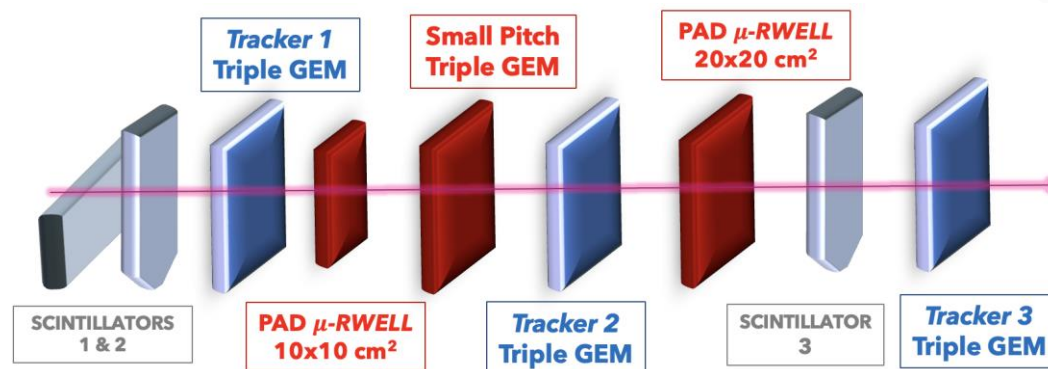
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16/01/2025

PAD μ-RWELL 20X20 CM^2
TB September 2024

Tracking With Corryvreckan

1 [EventLoaderMPGD]

(Thanks to Maryna for sharing the code and providing support)

Loads :
- Trigger timestamps as event reference
- Clusters (reconstructed with vmm-stdat) of TRACKER 1, 2 & 3 and DUT 20x20 uRwell

2
```
[Tracking4D]
min_hits_on_track = 3
time_cut_abs = 600ns
spatial_cut_rel = 4
exclude_dut = true
```

- The 20x20 uRwell is excluded
- Fits all cluster combinations on the 3 Tracker planes with a straight line (at least one cluster per plane)
- Associates clusters to the track if the residuals are < 4 x spatial resolution of the detector

3
```
[DUTAssociation]
use_cluster_centre = true
time_cut_abs = 600ns
spatial_cut_abs = 20mm,20mm
elliptic_cut = true
```
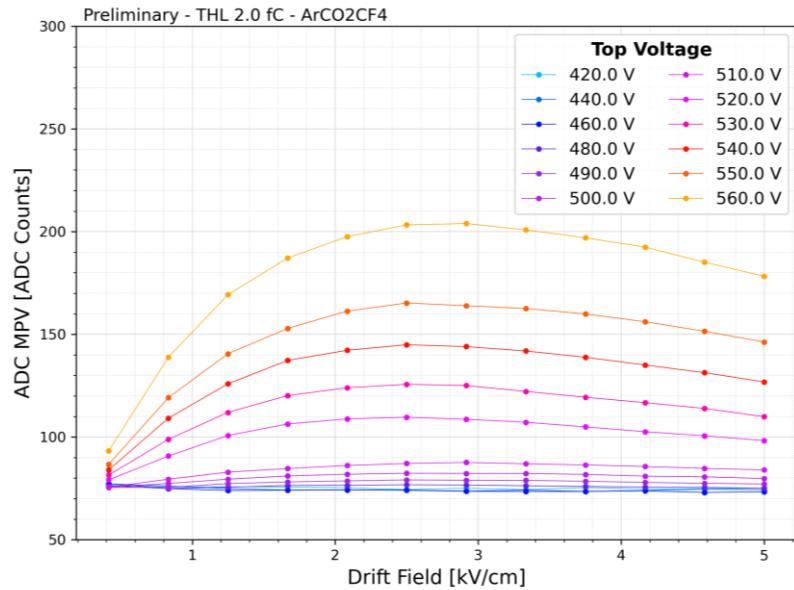
- Associates clusters of the 20x20 uRwell with the track if the residuals from the cluster centre to the track intercept on the DUT plane are along x and y are < 20 mm

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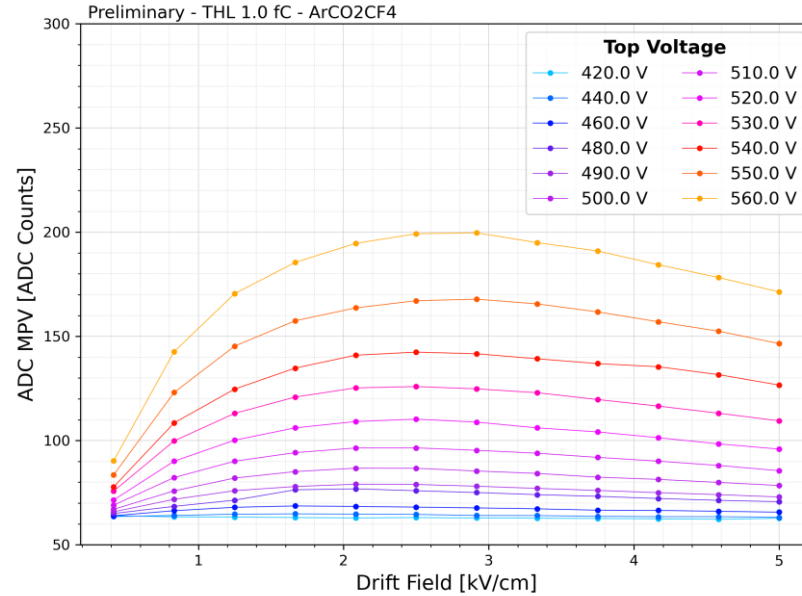# PAD μ-RWELL 20X20 CM^2

ADC MPV

- Results in agreement with measurements on a light-cathode uRwell with a picoammeter carried out by Silvia (*presented at the Common Project Meeting on 4/09/2024*)
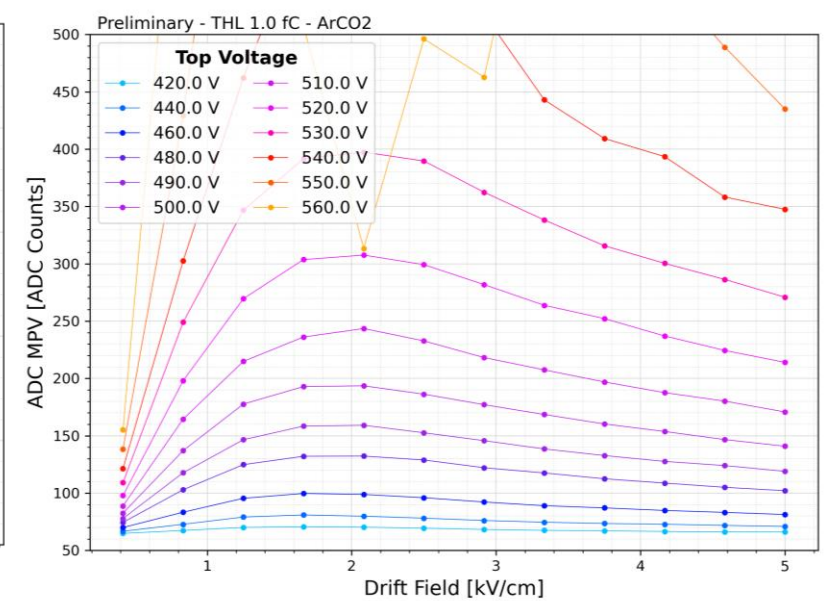
Preliminary – ArCO$_2$CF$_4$: - THL 2 fC   **Preliminary - ArCO$_2$CF$_4$ - THL 1 fC**   **Preliminary – ArCO$_2$ - THL 1 fC**


- Maximum ADC at ~ 2.5 kV/cm, then decreasing at larger values of the drift field (independent of the top voltage)
- **Increasing ADC at increasing Top Voltages for the whole drift range**
- Same behavior with **ArCO$_2$CF$_4$** and **ArCO$_2$** : independent of the gas mixture, only dependent on the detector technology

PAD μ-RWELL 20X20 CM²

EFFICIENCY BASED ON TRACKING

- Ratio between :
  - Number of tracks with associated cluster on the uRwell, with **dy** & **dy < 20 mm**
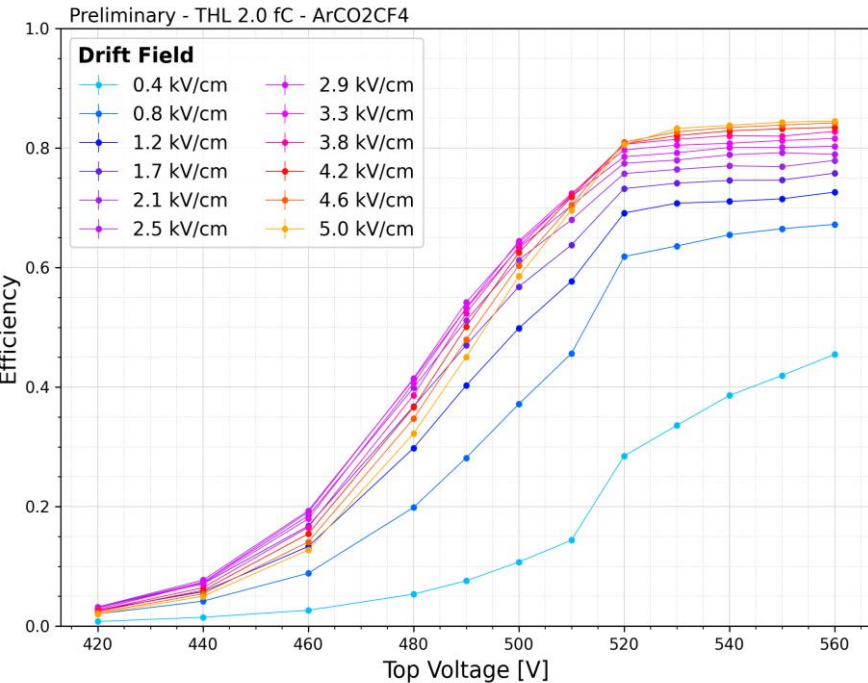 - Total number of reconstructed tracks

16/01/2025
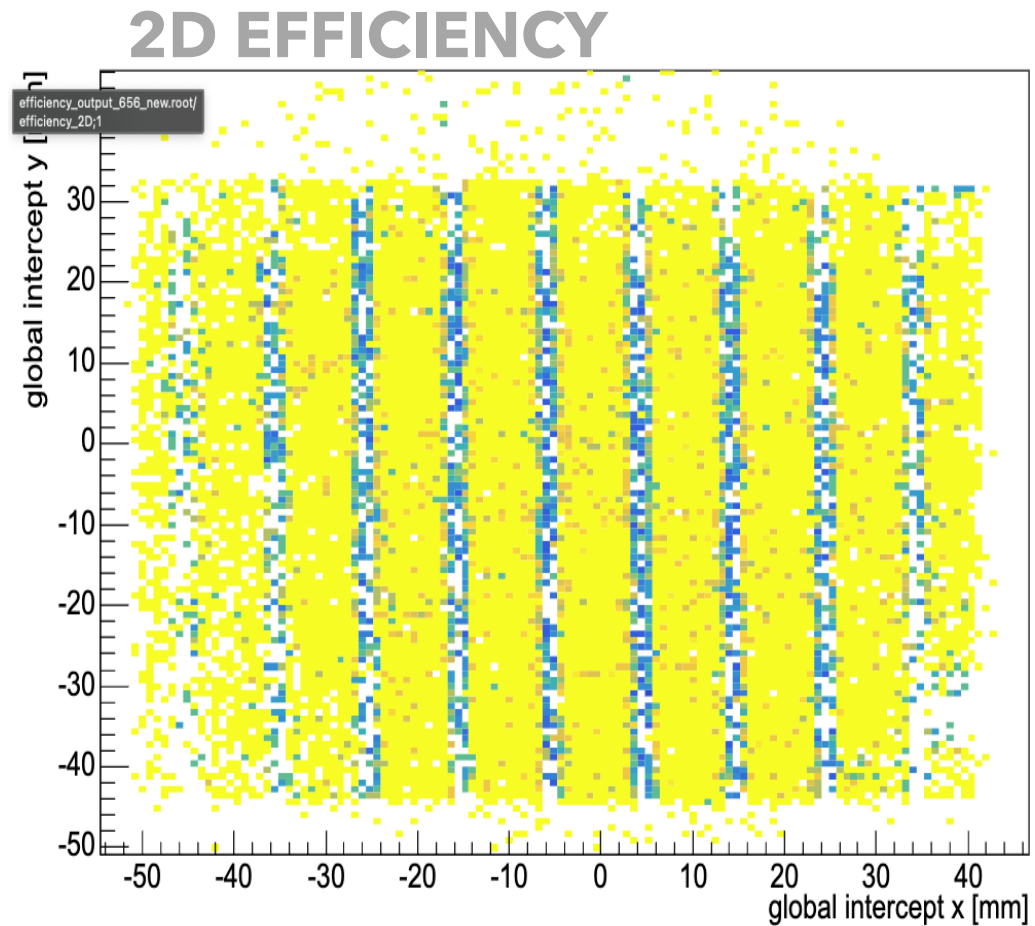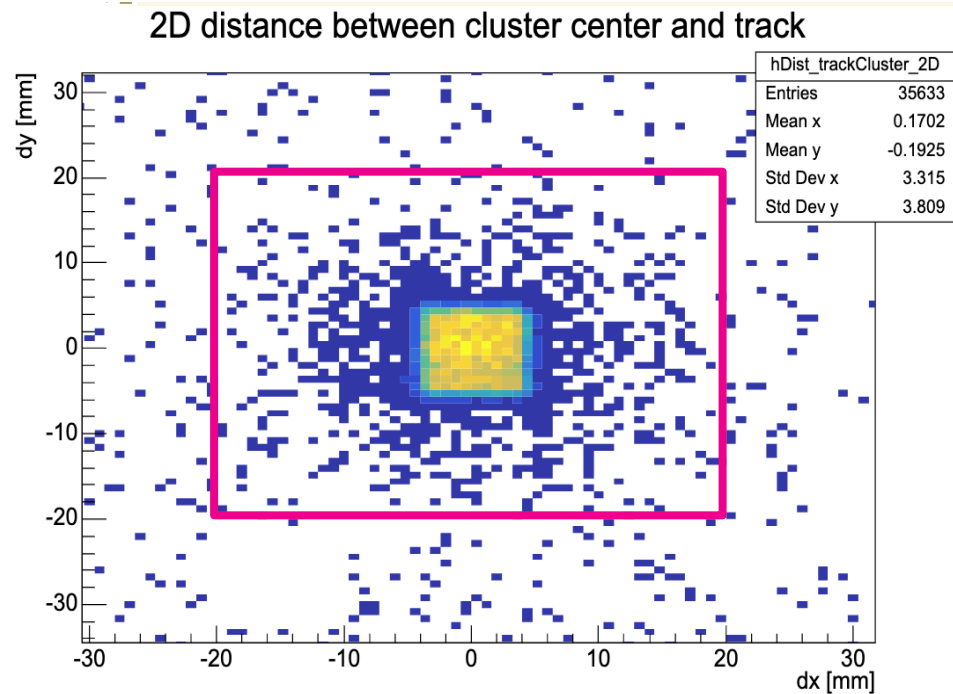
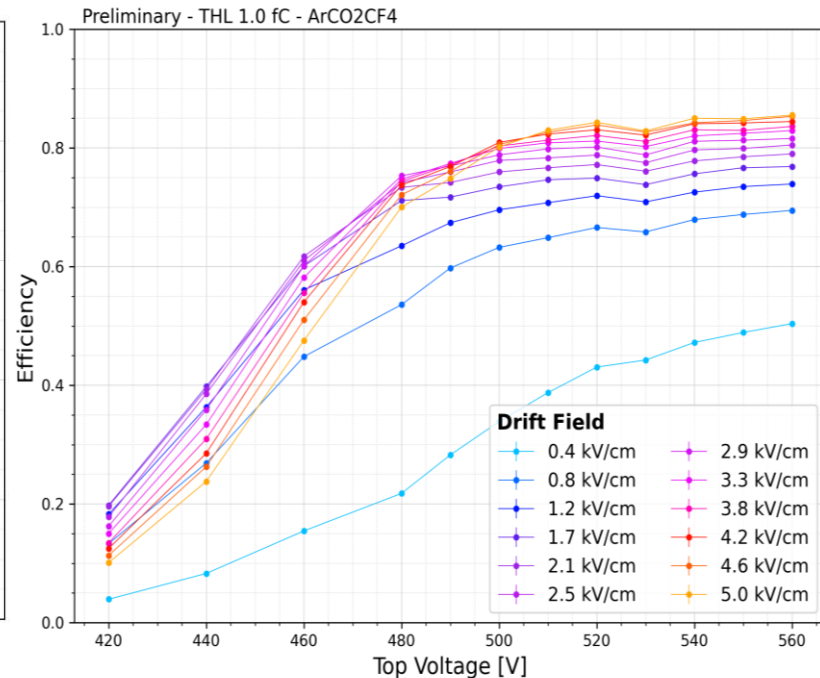# PAD μ-RWELL 20X20 CM^2

Efficiency vs Top Voltage

- Plateau @ ~ 520 V for $ArCO_2CF_4$ and @ ~ 480 V for $ArCO_2$
- The larger the drift field the higher the plateau level: ~ 85% @ 5 kV/cm for $ArCO_2CF_4$ ~ 88% @ 5 kV/cm for $ArCO_2$

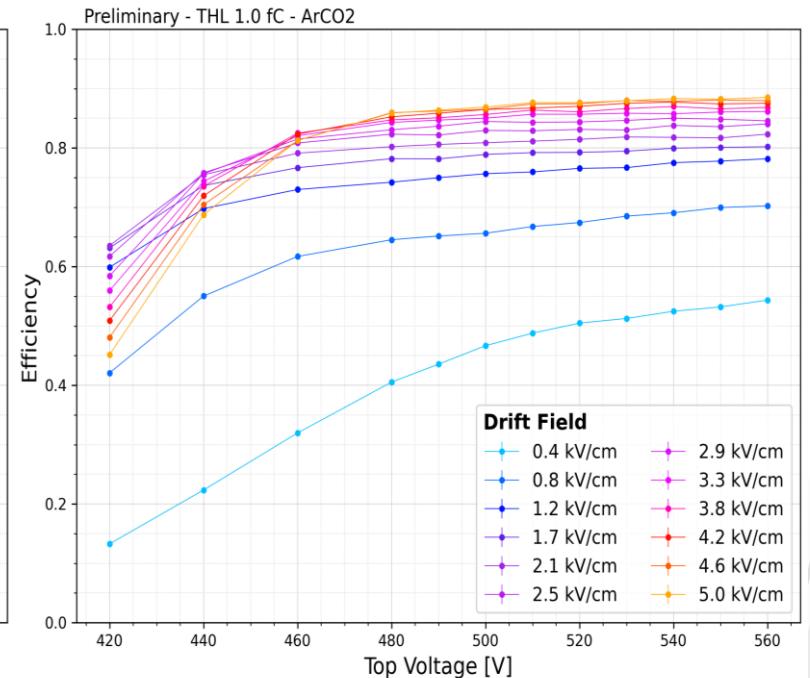(expected : 10 % intrinsic detector inefficiency due to the groove structure)

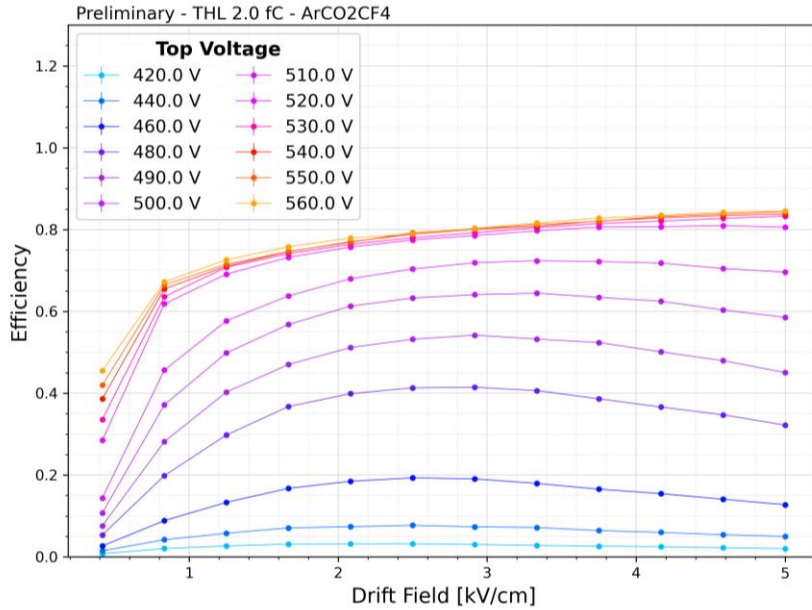**Preliminary – $ArCO_2CF_4$: - THL 2 fC**   **Preliminary - $ArCO_2CF_4$ - THL 1 fC**   **Preliminary – $ArCO_2$ - THL 1 fC**

PAD μ-RWELL 20X20 CM^2

Efficiency vs Drift Field

Preliminary – ArCO$_2$CF$_4$: - THL 2 fC

Preliminary - ArCO$_2$CF$_4$ - THL 1 fC
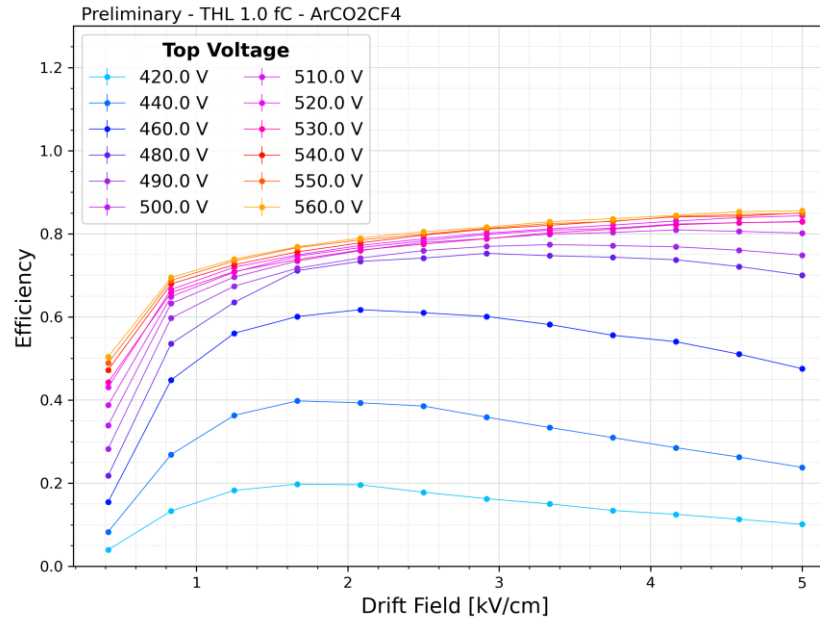
Preliminary – ArCO$_2$ - THL 1 fC
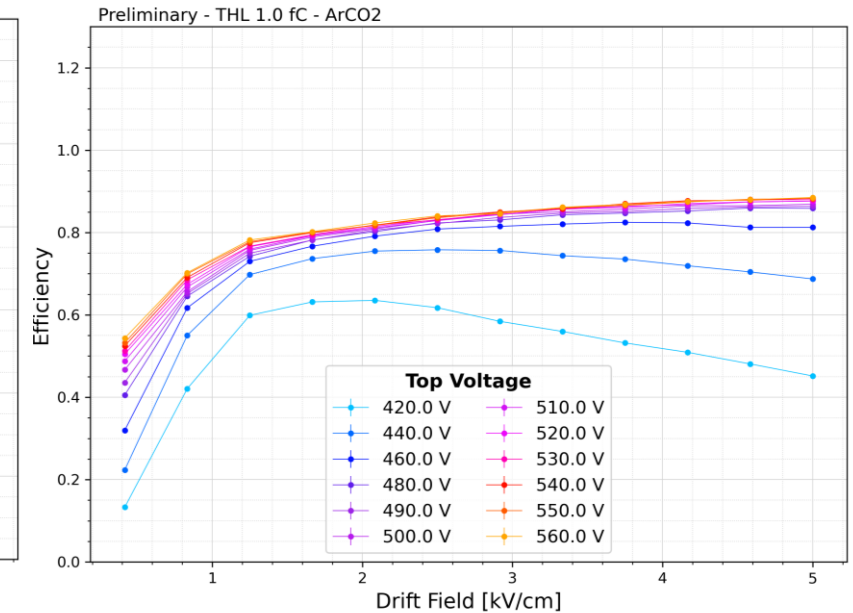
Low Top Voltage (~ low gain) :

- Maximum efficiency at ~ 2-3 kV/cm, then decreasing at larger values of the drift field

High Top Voltage (~ high gain) :

- Increasing trend in the whole drift range - **Inconsistent with the pulse height of the signal**

- ➔ some "compensation" mechanism must be responsible for the efficiency increase despite the lower gain
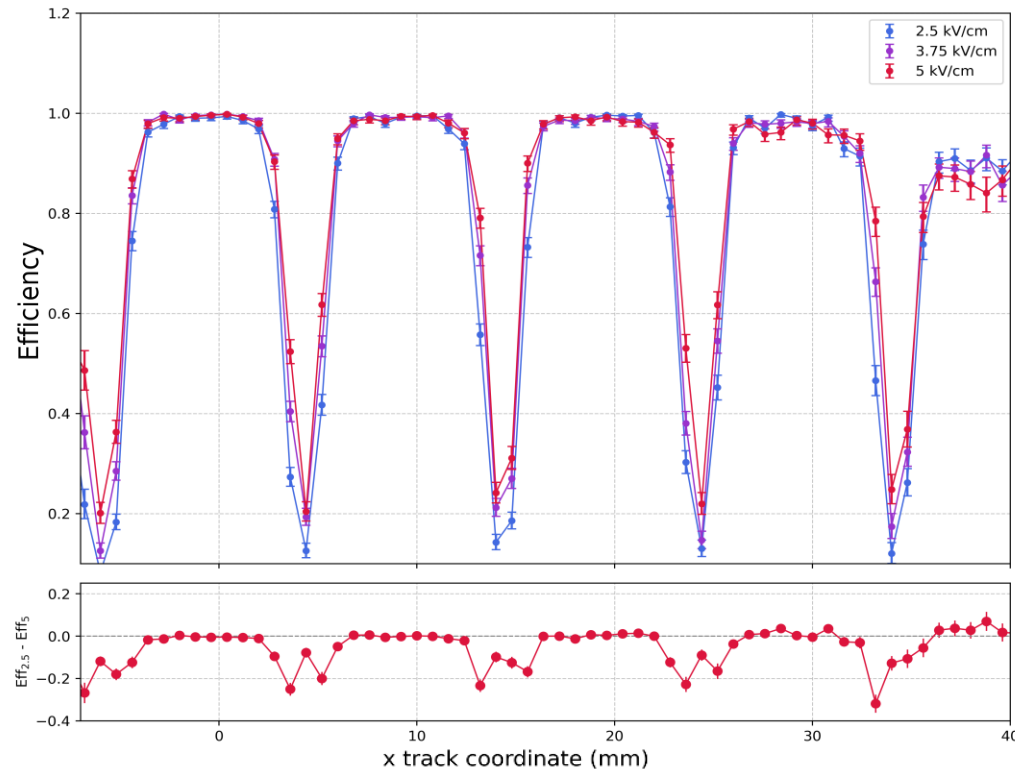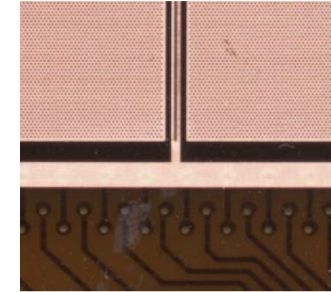
PAD μ-RWELL 20X20 CM²

HYPOTHESIS

Expected increase of the efficiency in zones close to the pep lines (along y) at increasing Drift Fields due to a possible straightening of the field lines
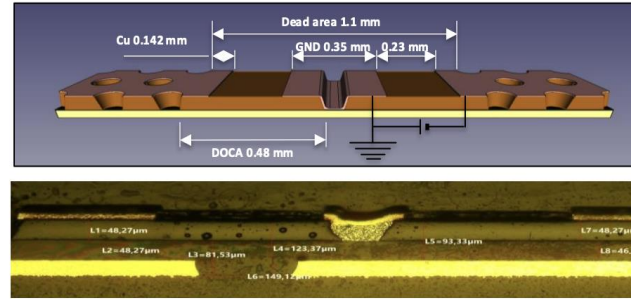
2022

PEP-Groove:
DLC grounding through conductive groove to ground line
Pad R/O = 9×9mm²
Grounding:
- Groove pitch = 9mm
- width = 1.1mm
→ 84% geometric acceptance

EFFICIENCY ALONG THE X-AXIS AT DIFFERENT DF

- Observable dips of the efficiency with a modular pattern (corresponding to the 1 cm spacing of subsequent pep lines)

- The efficiency dips are "less deep" at larger Drift Fields

- They compensate for the systematic decrease in efficiency given by smaller amplification at large Drift Field

Electronics
VMMs Vs APVs

- **APV** data at 1.8 kV/cm form TB 07-2024
- **VMM** data with Ar:CO2 :CF4
- Saturation efficiency of APVs compatible to VMM 1&2 fC @ 1.7 kV/cm
- APVs turn on rise similar to that of VMMs @ 1 fC
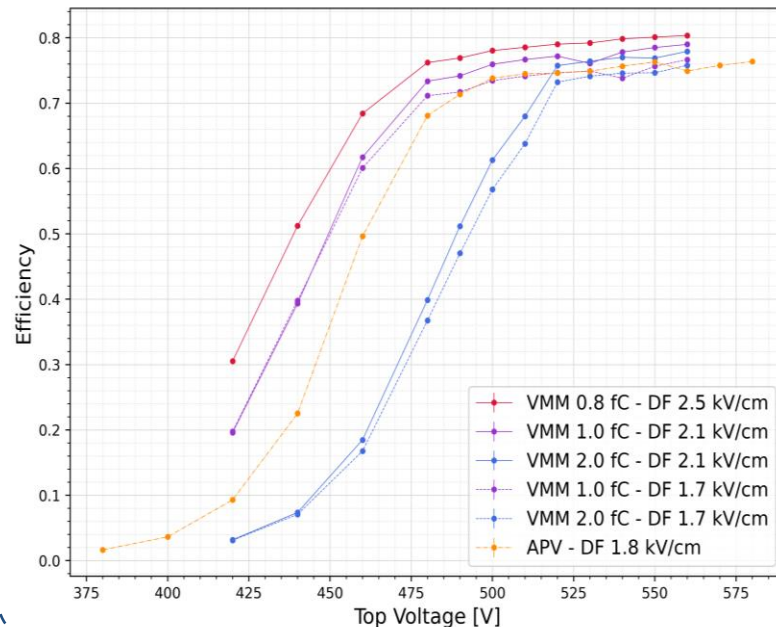
# Gas Mixture
ArCO$_2$CF$_4$ Vs ArCO$_2$

Ar:CO$_2$ 70:30 higher charge multiplication → extended gain-range inspected
- Overlapping of the turn-on curves at low charge values (below 100 ADC)
- Saturation value of the efficiency is about few % **larger** in **Ar:CO$_2$ than** in **Ar:CO$_2$:CF$_4$**
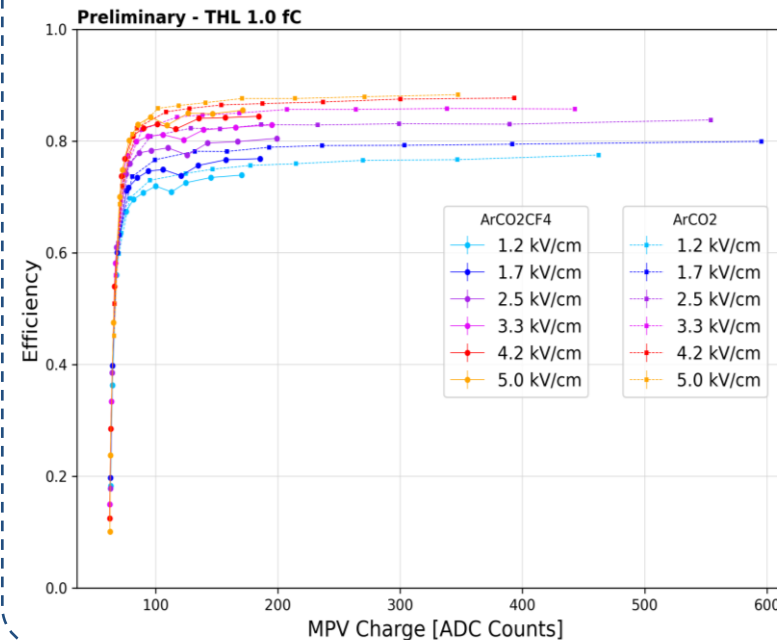
Analog Threshold
THL 1 fC Vs 2 fC

- Plateau reached almost for the same charge value, independently of the drift field :

    THL 1 fC @ ~80 ADC counts
    THL 2 fC @ ~100 ADC counts

- The lower the THL the larger the saturating efficiency
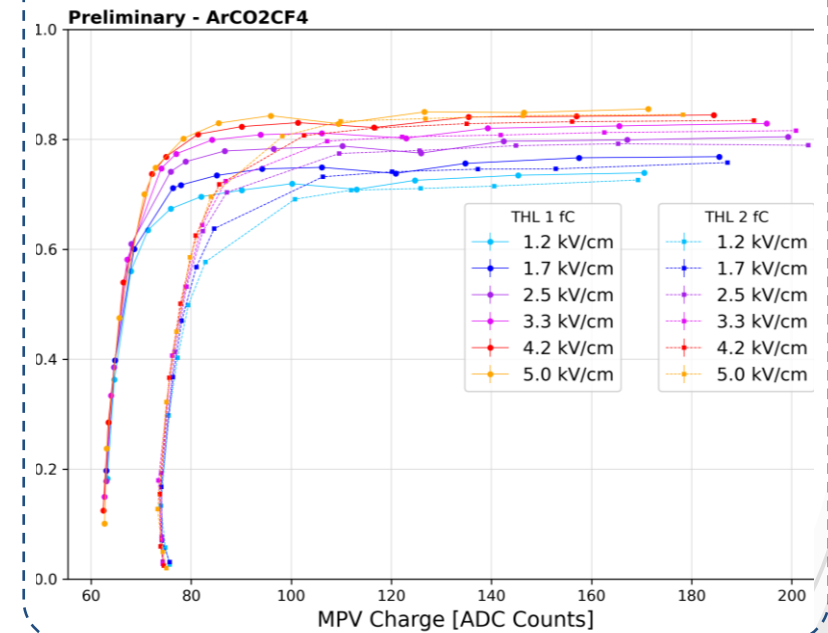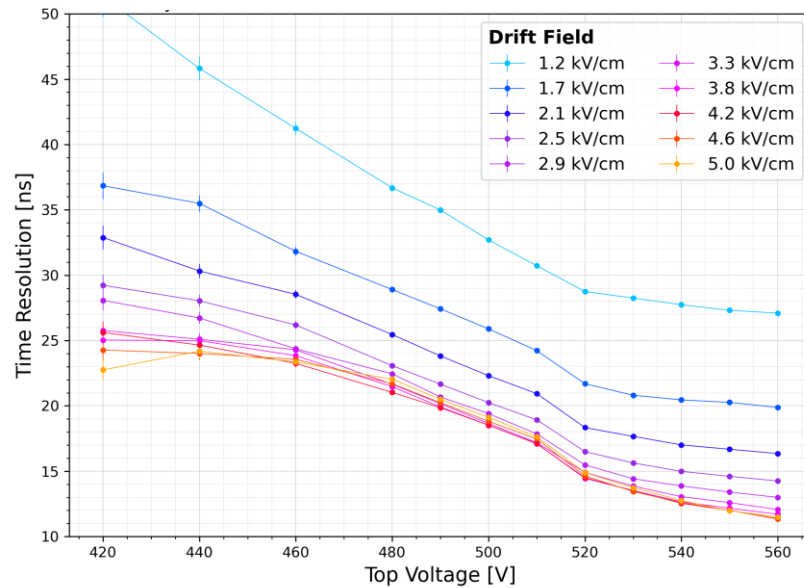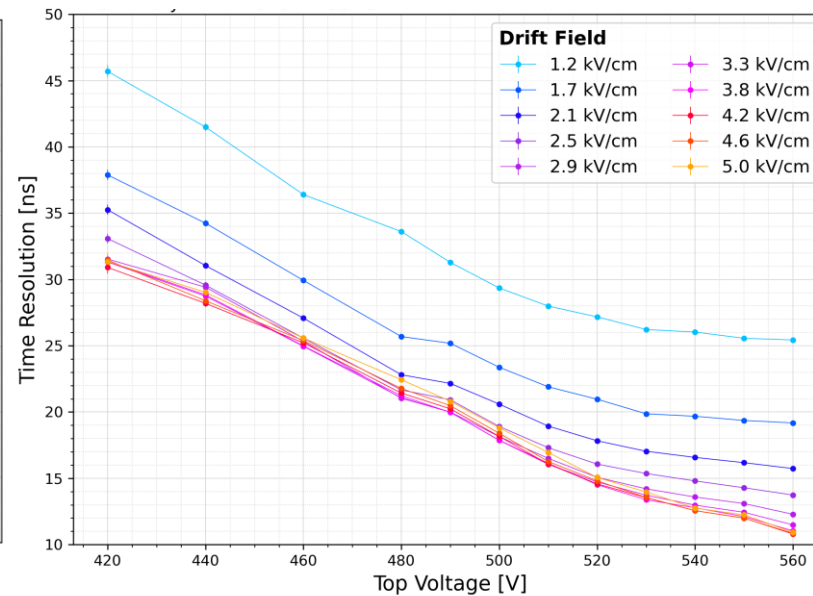
PAD μ-RWELL 20X20 CM^2
TIME RESOLUTION

- Gaussian fit of the time difference distributions between trigger each cluster associated with a track
- The **sigma** provides an estimate of the convolution of the time resolution of the uRwell, electronics and trigger

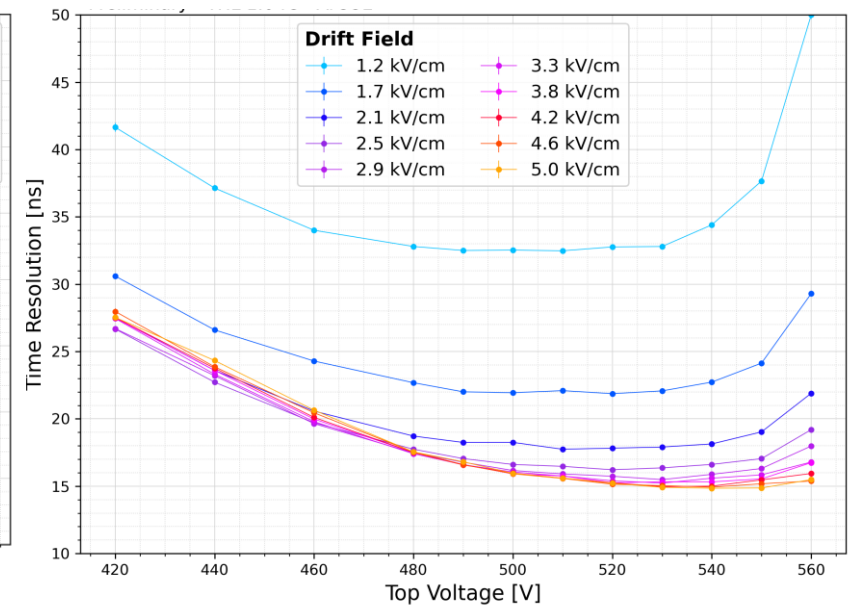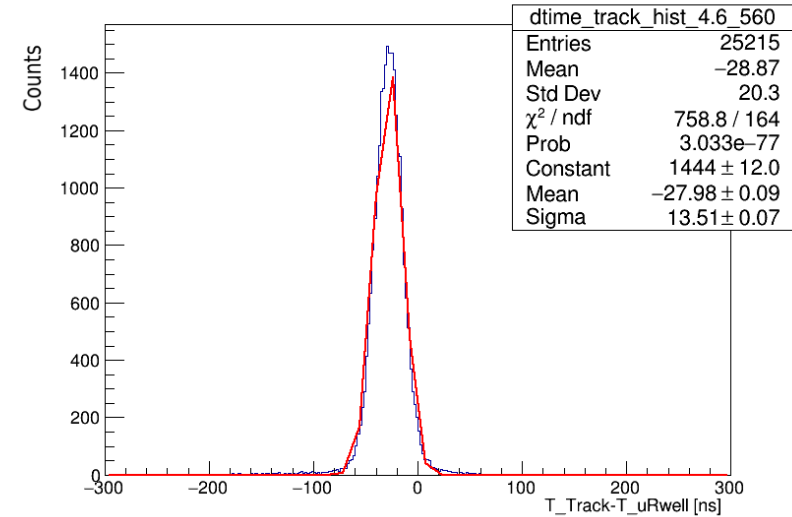- Best **time resolution** of **10.5-11 ns** @ DF :5 kV/cm and TV : 560 V
- The measured values must be corrected by subtracting the trigger time resolution (difficult to estimate)
    → easier to consider the **Δt** wrt the timestamp of the track
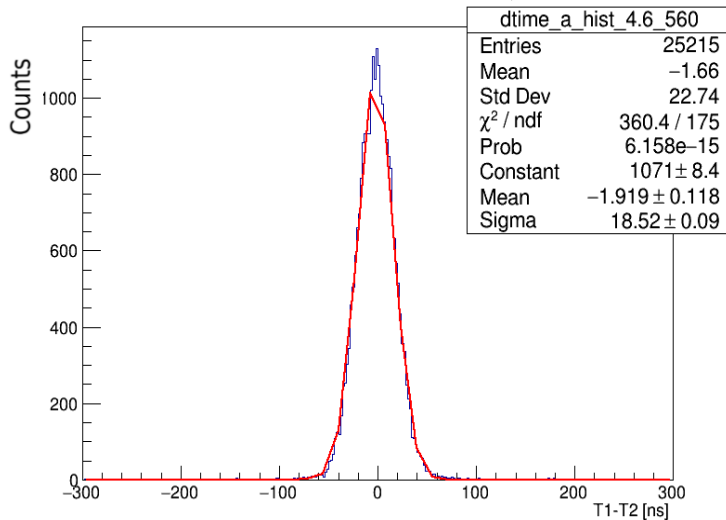
PAD μ-RWELL 20X20 CM²
CORRECTED TIME RESOLUTION

- Gaussian fit of $\Delta t = t_{track} - t_{uRwell} \rightarrow \sigma = \sqrt{\sigma_{uRwell} + \sigma_{track}}$

  - The t_{track} is the mean time of the t_{max} of the trackers clusters associated with the track (t_1, t_2, t_3)

  - The σ_{track} can be estimated from the fit of the distributions $t_1 - t_2$, $t_2 - t_3$ and $t_3 - t_1 \rightarrow$ get σ_{uRwell}

  - Errors computed by propagating the uncertainties of the fits on the sigmas of each Gaussian
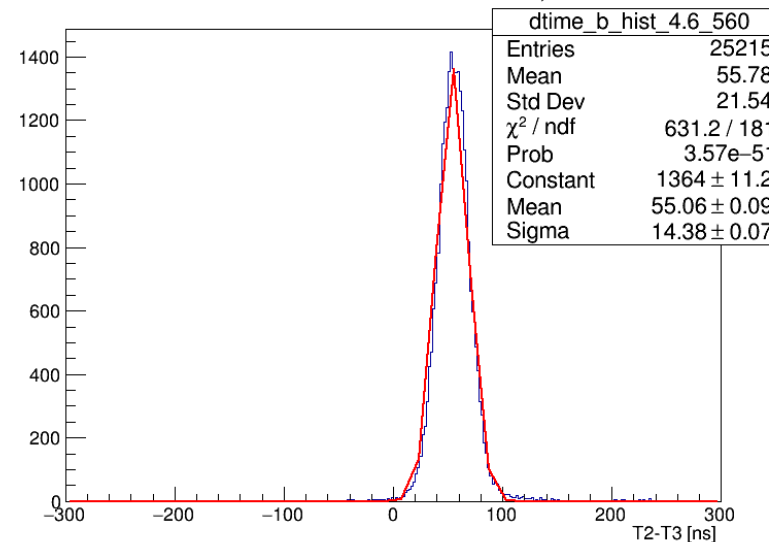

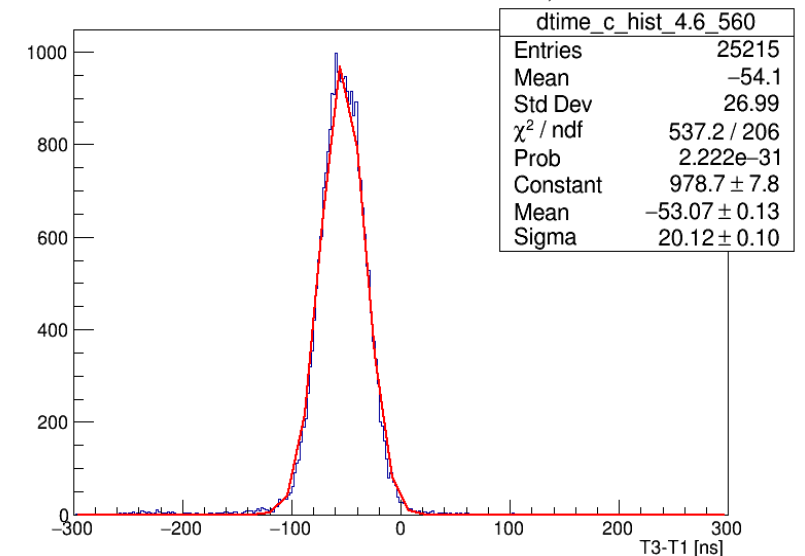Delta time distribution for DF 4.6 kV/cm, TV 560 V

dtime_track_hist_4.6_560	
Entries	25215
Mean	−28.87
Std Dev	20.3
χ^2 / ndf	758.8 / 164
Prob	3.033e−77
Constant	1444 ± 12.0
Mean	−27.98 ± 0.09
Sigma	13.51 ± 0.07

Delta time distribution for DF 4.6 kV/cm, TV 560 V

dtime_a_hist_4.6_560	
Entries	25215
Mean	−1.66
Std Dev	22.74
χ^2 / ndf	360.4 / 175
Prob	6.158e−15
Constant	1071 ± 8.4
Mean	−1.919 ± 0.118
Sigma	18.52 ± 0.09

Delta time distribution for DF 4.6 kV/cm, TV 560 V

dtime_b_hist_4.6_560	
Entries	25215
Mean	55.78
Std Dev	21.54
χ^2 / ndf	631.2 / 181
Prob	3.57e−51
Constant	1364 ± 11.2
Mean	55.06 ± 0.09
Sigma	14.38 ± 0.07

Delta time distribution for DF 4.6 kV/cm, TV 560 V

| dtime_c_hist_4.6_560	
Entries	25215
Mean	−54.1
Std Dev	26.99
χ^2 / ndf	537.2 / 206
Prob	2.222e−31
Constant	978.7 ± 7.8
Mean	−53.07 ± 0.13
Sigma	20.12 ± 0.10

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PAD μ-RWELL 20X20 CM^2
CORRECTED TIME RESOLUTION

- Gaussian fit of $\Delta t = t_{track} - t_{uRwell} \rightarrow \sigma = \sqrt{\sigma_{uRwell} + \sigma_{track}}$

- Represent the $\sigma_{uRwell} = \sqrt{\sigma - \sigma_{track}}$ wrt DF and TV

  - The errors on σ_{uRwell} are also represented, though they are small

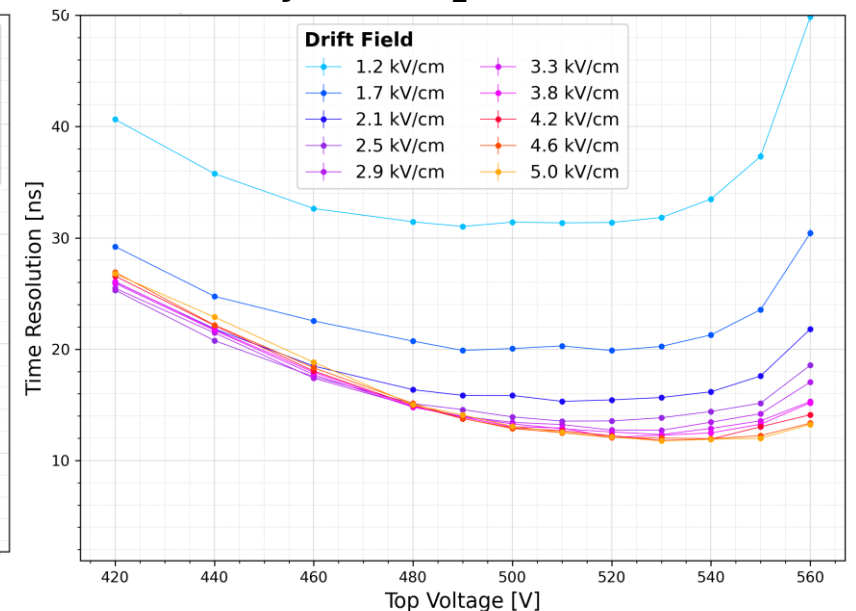Preliminary – ArCO$_2$CF$_4$: - THL 2 fC
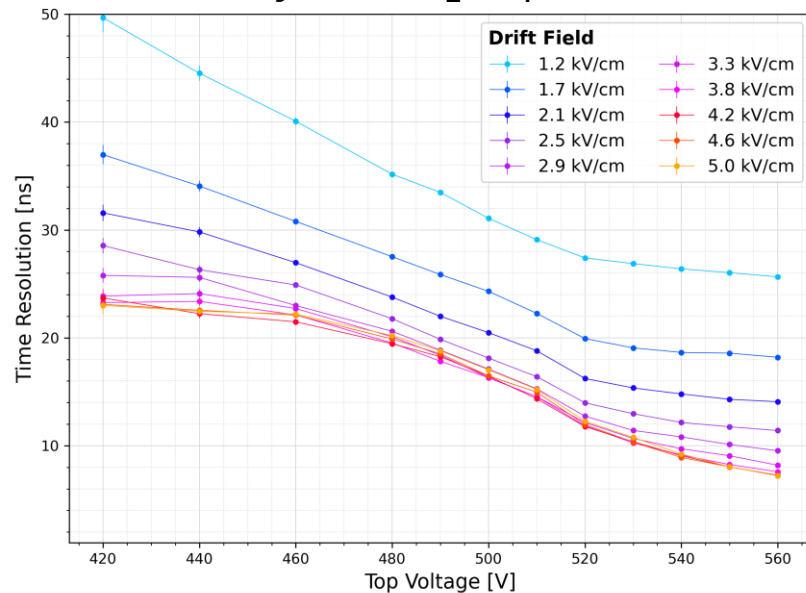
Preliminary - ArCO$_2$CF$_4$ - THL 1 fC
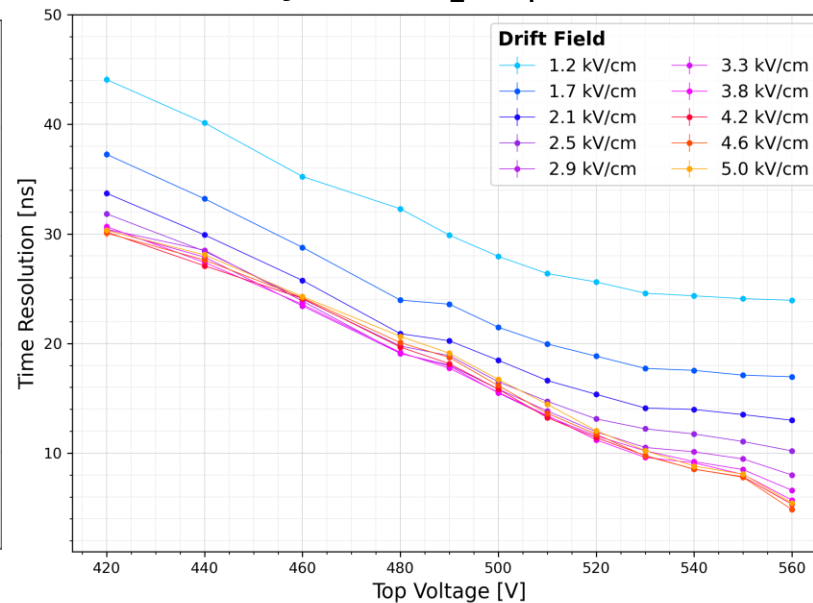
Preliminary – ArCO$_2$ - THL 1 fC

- Corrected **time resolution** for a **6 mm uRwell** is **below 10 ns** for TV > 530 V in **ArCO$_2$CF$_4$**
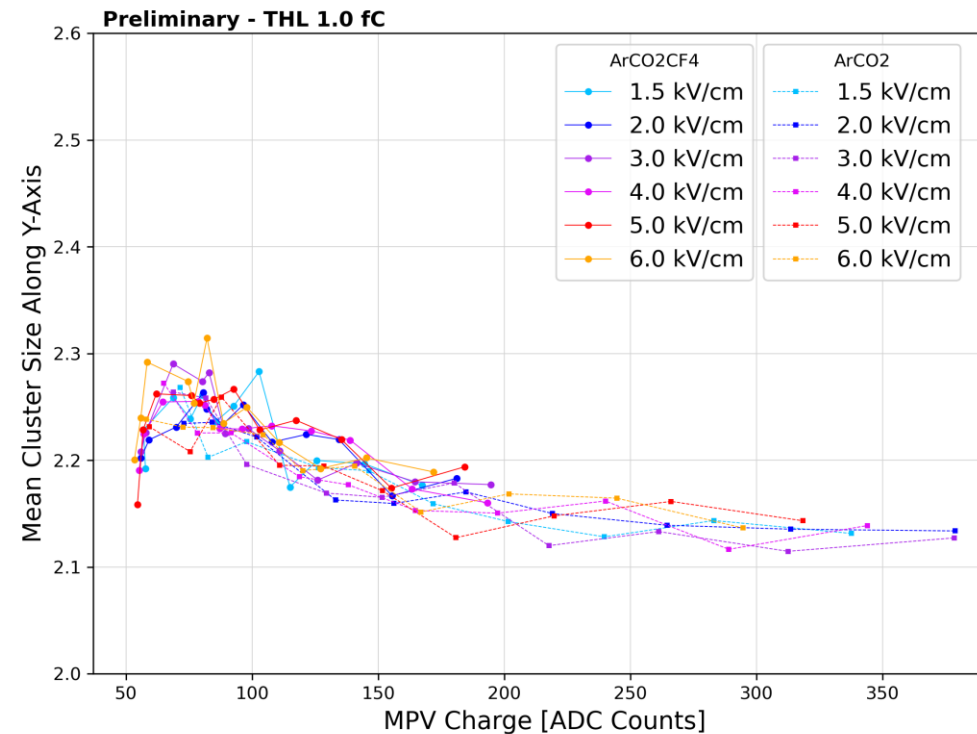
16/01/2025

INSPECT FOR CROSS TALK

Cluster Size vs Pulse Height

- Average cluster size along x (y) for cluster sizes along x (y) > 1

- Different trends along the two axis

  → **along x :** increase and saturation above 200 ADC (possible **x-talk?**)

  → **along y :** (anomalous) **peak at ~ 70 ADC**, then decrease and saturation
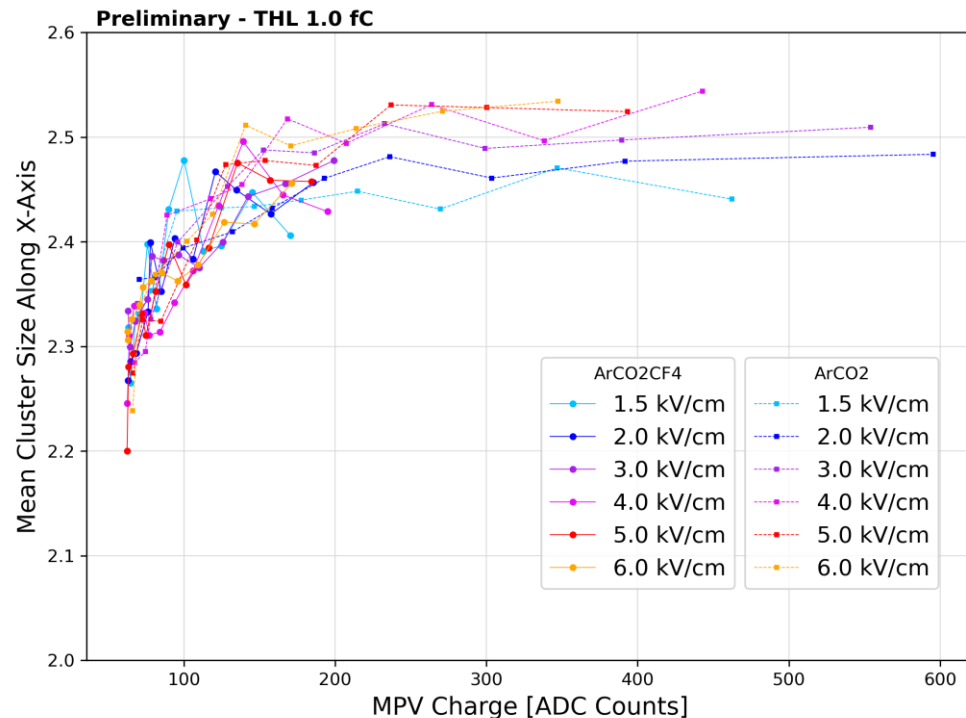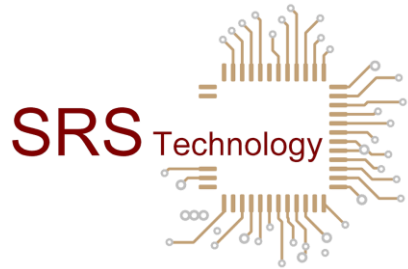
THANK YOU

FOR THE ATTENTION

BACKUP SLIDES

EXPERIMENTAL SETUP
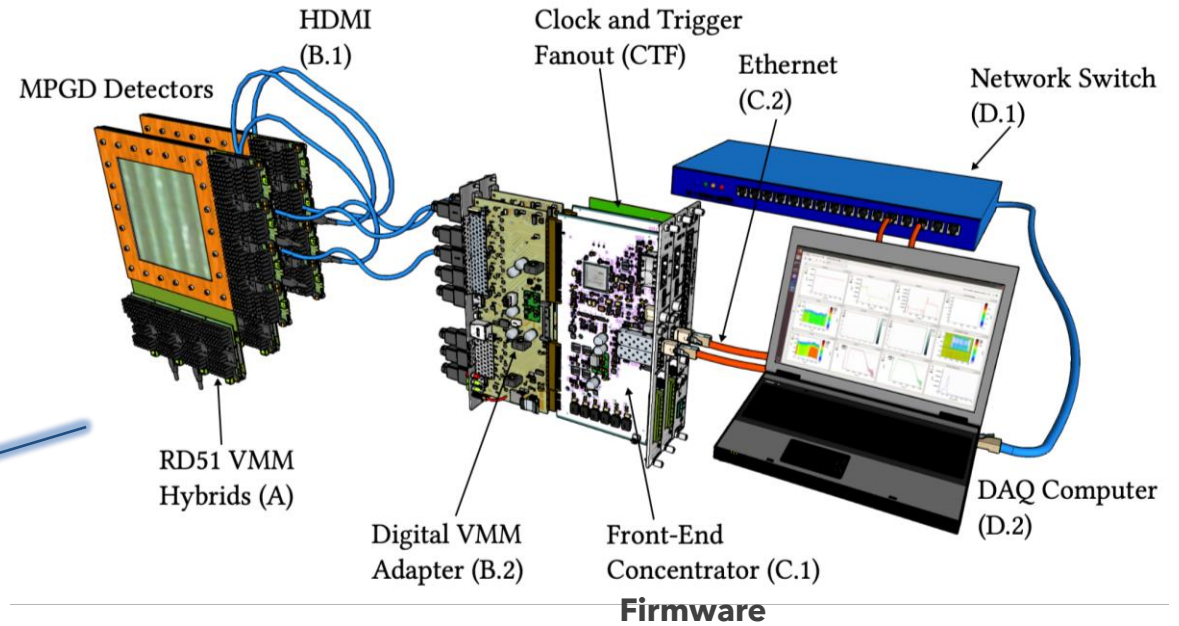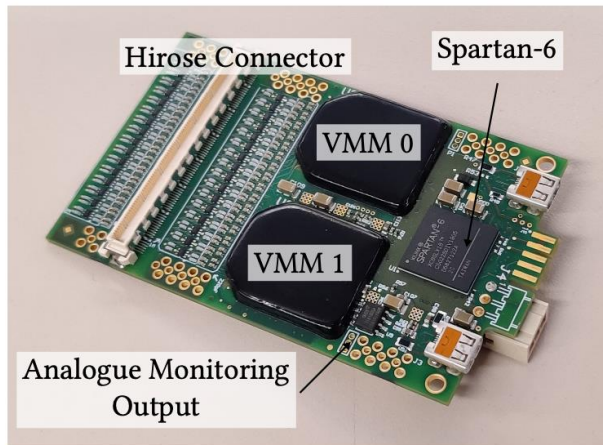
VMM3a / Scalable Readout System (SRS)
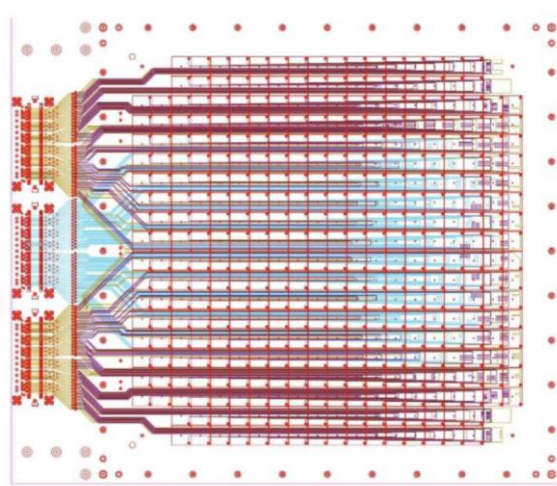
SRS Technology

Modular readout structure,
consisting of a read-out chain :

VMM HYBRID

- 2 VMM chips each
- 64 channels per VMM
- All hybrids powered by an external power supply
- Except for those of the 20x20 cm^2 uRwell : internal HDMI powering in use
- Additional hybrid used to store trigger information

PAD μ-RWELL 20X20 CM²

- **1×1 cm² pad area**
- 384 pads → 3 hybrids
- Drift Gap: **6 mm**
- DLC grounded, TOP and DRIFT connected to HV
- Horizontal connecting vias
- Gas Mixture **Ar CO_2 CF_4 45:15:40** and **Ar CO_2 70:30**

- Electronic Gain : 12 mV/fC
- Analog Threshold Levels: 0.8 fC, 1 fC, 2 fC
- Reconstruction of the beam profile
- Active area of the detector limited to the overlap of the triggering scintillators

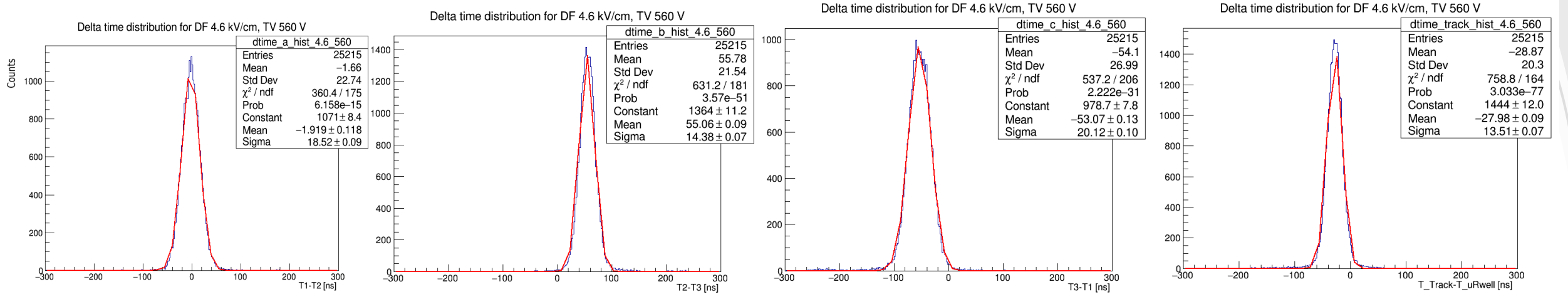16/01/2025
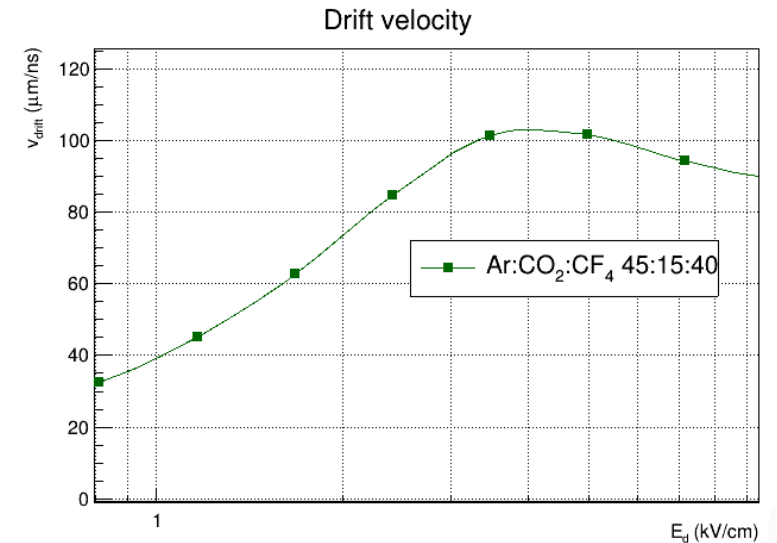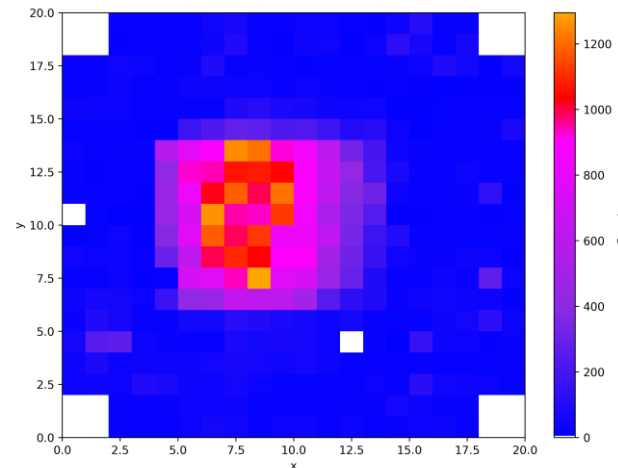
PAD μ-RWELL 20X20 CM²

TB September 2024

Cluster Reconstruction with vmm-sdat

```
args = ['/eos/project/r/rd51/SRSVMMAnalysis/vmm-sdat/build/convertFile',
        '-f', '/eos/project/r/rd51/SRSVMMData/tb202409/rawdata/run' + str(item) + '.pcapng',
        '-geo', '/eos/project/r/rd51/SRSVMMAnalysis/tb202409/mappings/mapping_tb202409_beam_coordinates.json',
        '-bc', '44.4444', '-tac', '60',
        '-th', '-1',
        '-cs', '[1,1,1,1,1,1,1]', '-ccs', '[1,2,2,2,2,1,1]', '-mst', '[0,1,1,1,2,2,2]',
        '-dt', '[150,150,150,150,150,350,350]', '-spc', '[150,500,500,500,500,700,700]', '-dp', '[150,250,250,250,500,700,700]',
        '-crl', '[0.5,0.25,0.25,0.25,0.1,0.1,0.1]', '-cru', '[2.0,4.0,4.0,4.0,10.0,10.0,10.0]',
        '-save', '[[],[],[0,1,2,3,4,5,6]]',
        '-algo', '4',
        '-info', 'corry',
        '-cal', '/eos/project/r/rd51/SRSVMMAnalysis/tb202409/calibs/tb202409_calib_completly_full.json',
        '-df', 'SRS']
```

PAD μ-RWELL 20X20 CM^2

ArCO2CF4 THL 1

ArCO2 THL 1

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