Comparative study of resistive MPGD technologies

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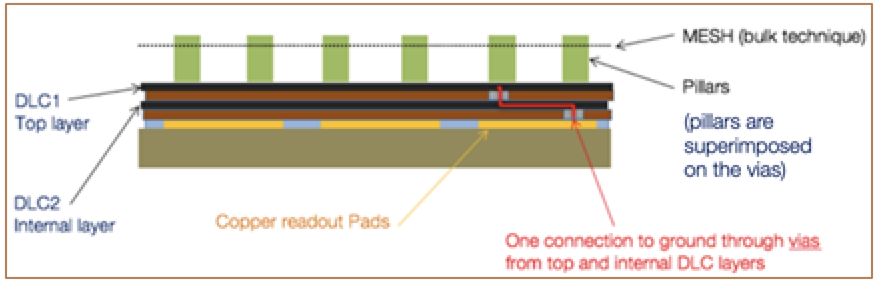
Reminder

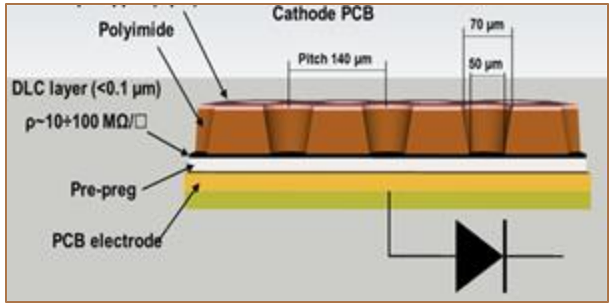
Motivation: to characterize three technologies in similar conditions systematically

Micromegas, MM



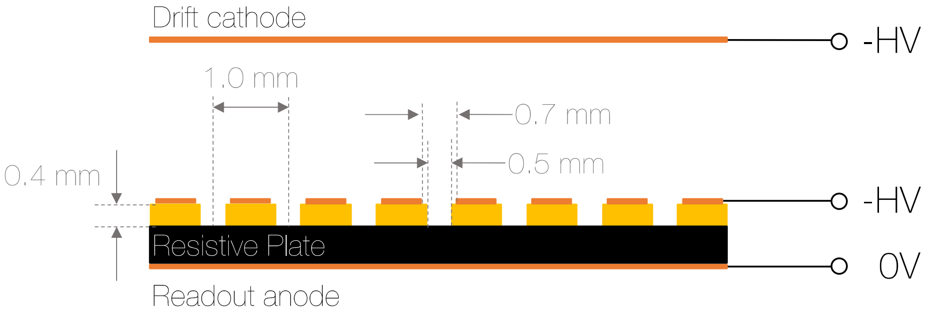
- Double DLC layer
- ~ 50 MΩ/□
- Grounding points through vias under the pillars
- $ArCO_2iC_4H_{10}$ 93:5:2

uRWELL



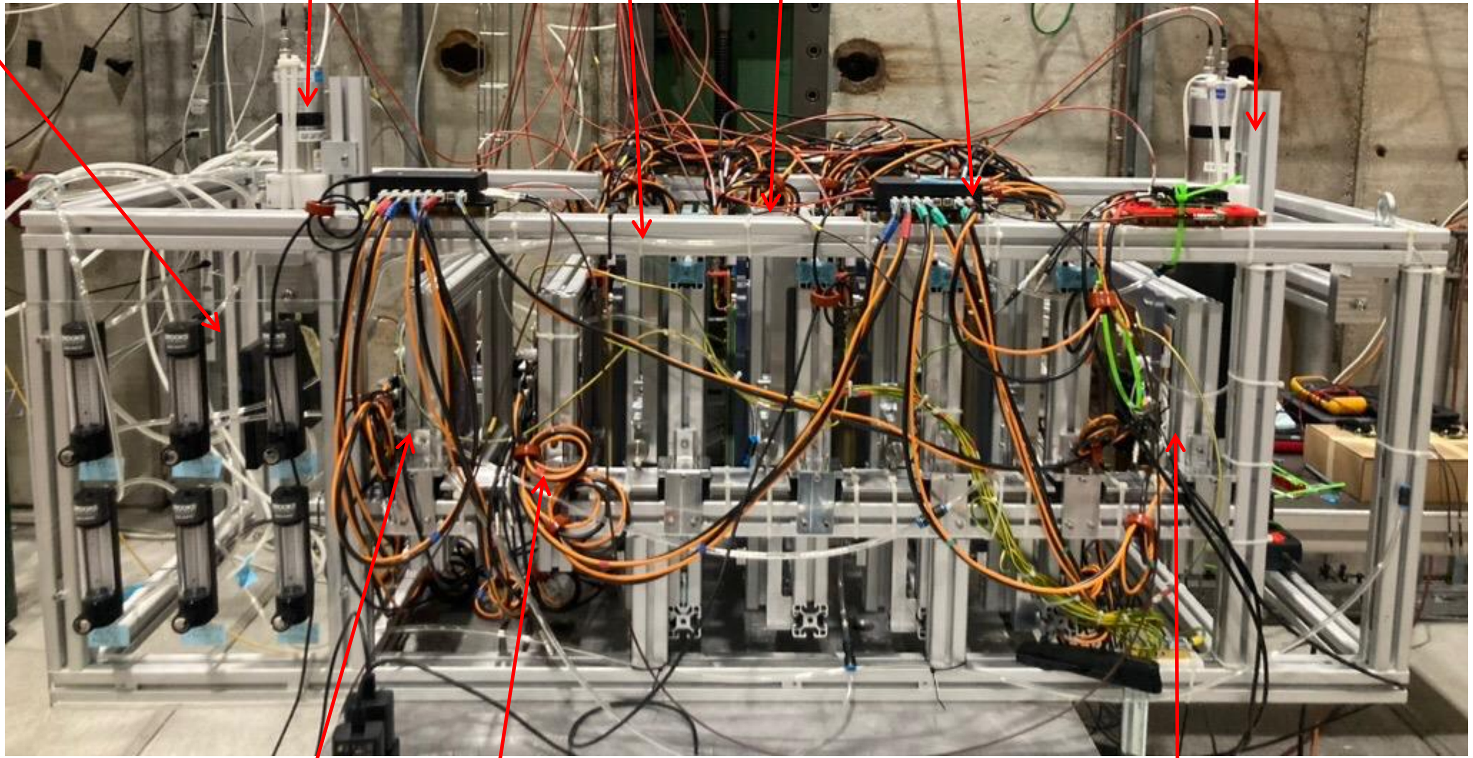
- Single DLC layer
- ~ 100 MΩ/□
- Gounding lines between GEM HV sectors
- $ArCO_2iCF_4$ 45:15:40

RPWELL



- Fe-dopped glass
- 2 GΩ·cm
- Grounding through pads with epoxy-graphite mixture
- $ArCO_2iC_4H_{10}$ 93:5:2

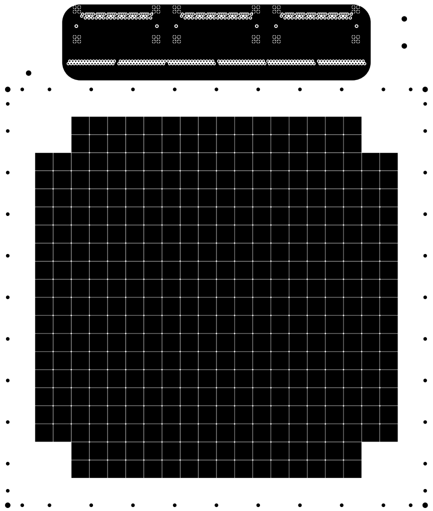
Reminder

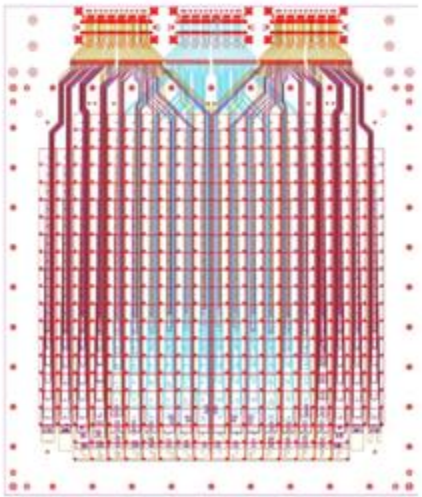


- Common readout scheme
- Common DAQ – VMM3a-based SRS
- Setup within a telescope

- Muon & pion beams at CERN SPS NA

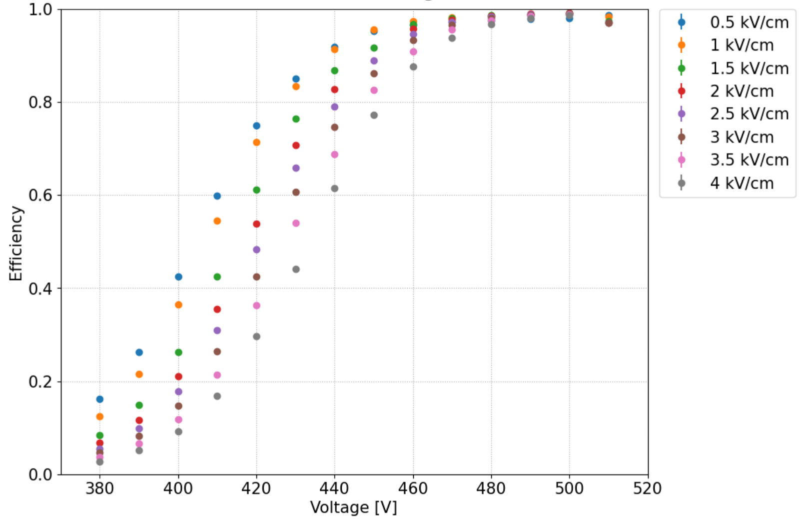
- vmm-sdat cluster reconstruction
- Tracking based on Hough transform seeded with clusters
- Tracker efficiency ~70%
- Matching cluster to a track within 1cm





Reminder - efficiency

Micromegas



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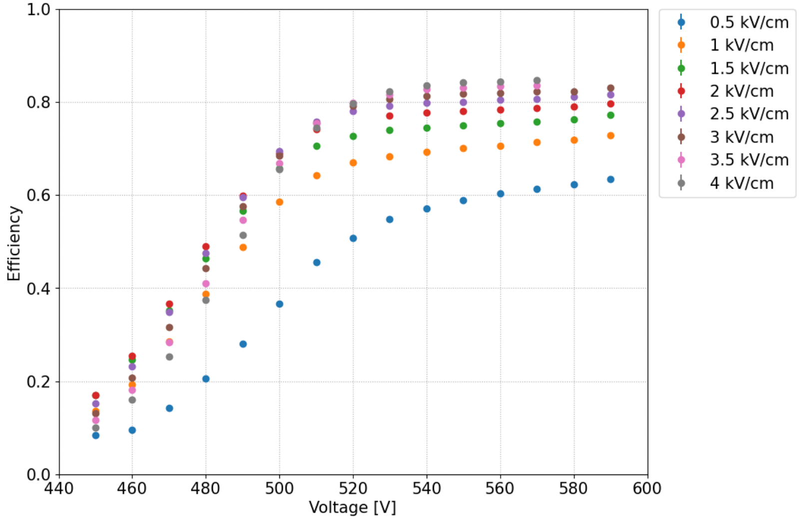
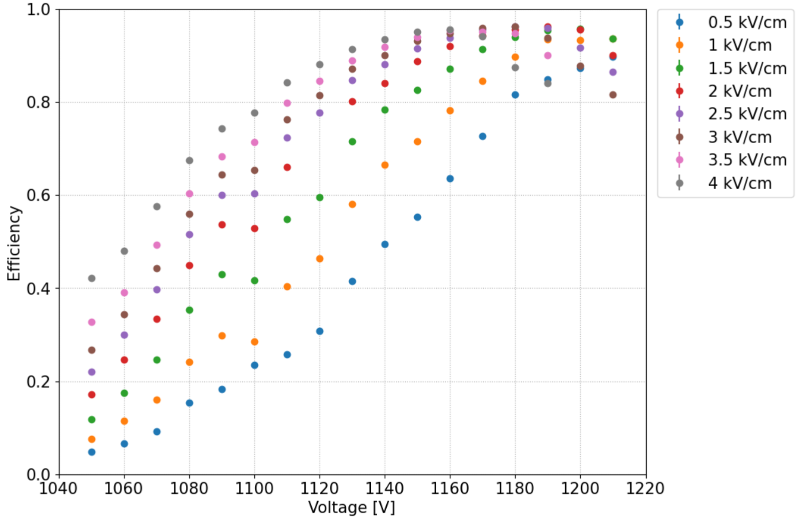
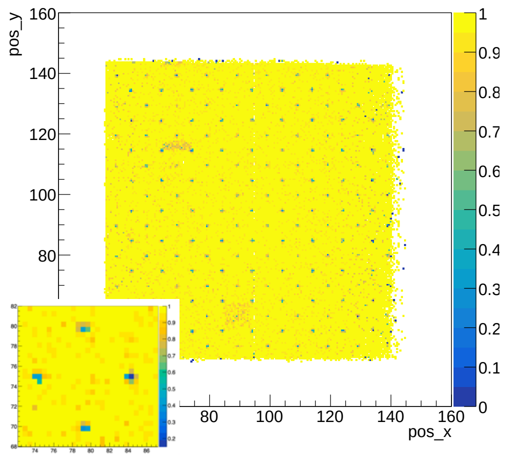
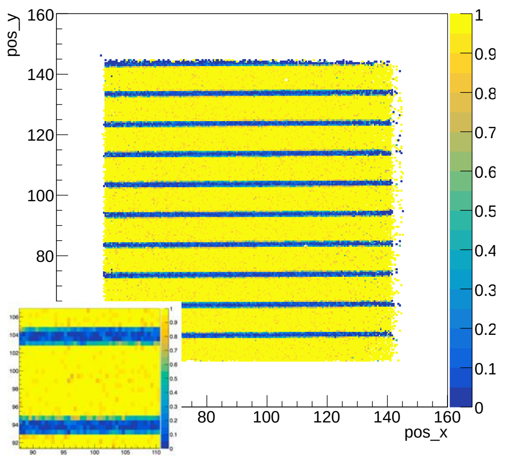
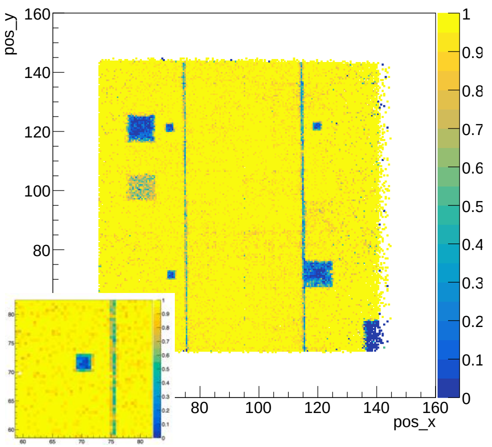


RPWELL





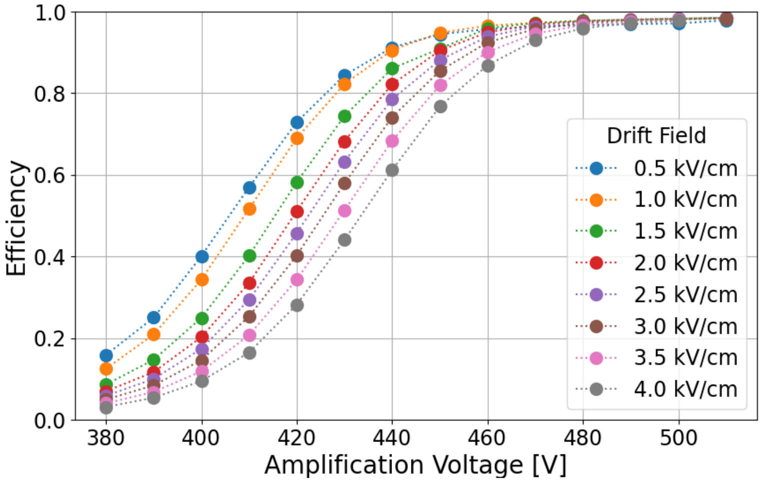




Efficiency excluding the dead areas

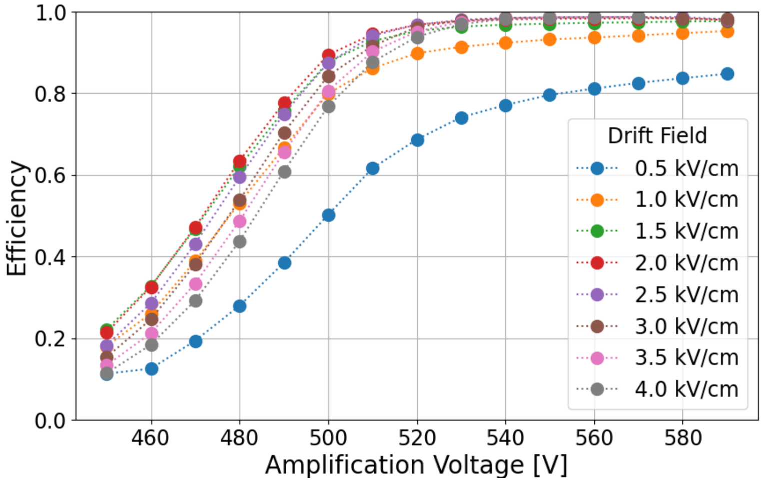
Micromegas

- No dead areas
- Pillars are an integral part
- Plateau of 98% starts @470V



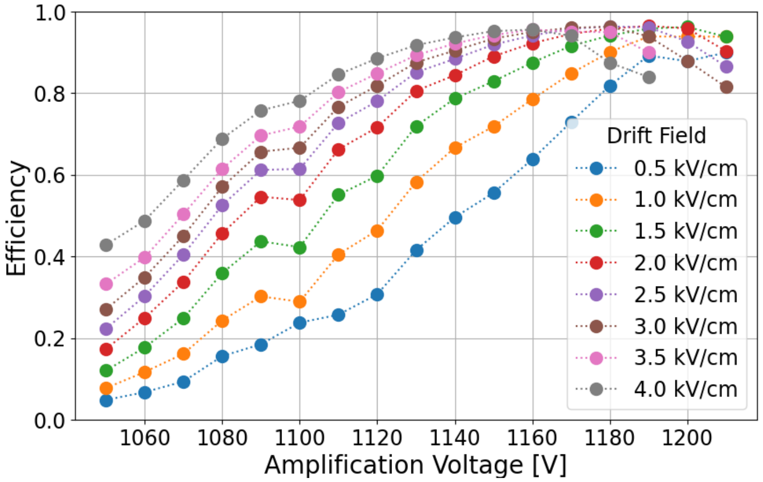
uRWELL

- Excluding PEP lines – 3mm – 30% of the tested area
- Lines be replaced by PEP dots
- Plateau of 98% starts @540V



RPWELL

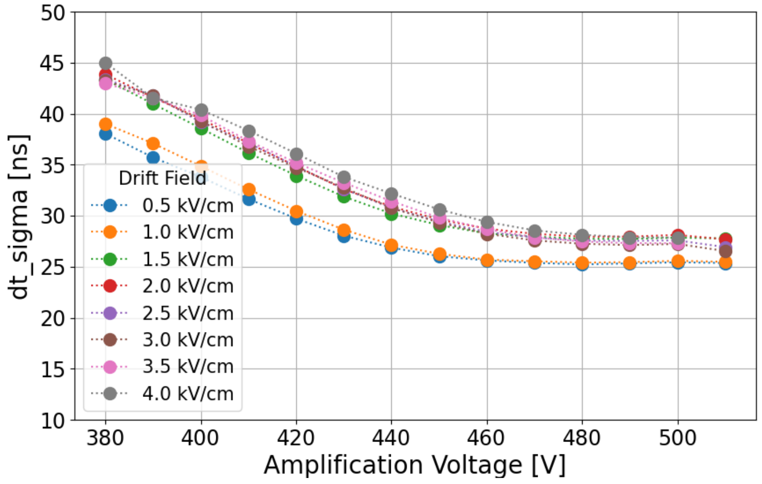
- Excluding dead channels
- Keeping the gluing points and HV sectors separating lines
- Plateau of 96% starts @1170V, dependent strongly on the drift – simulations in progress



Timing – width of dt = $t_{trigger} - t_{DUT}$

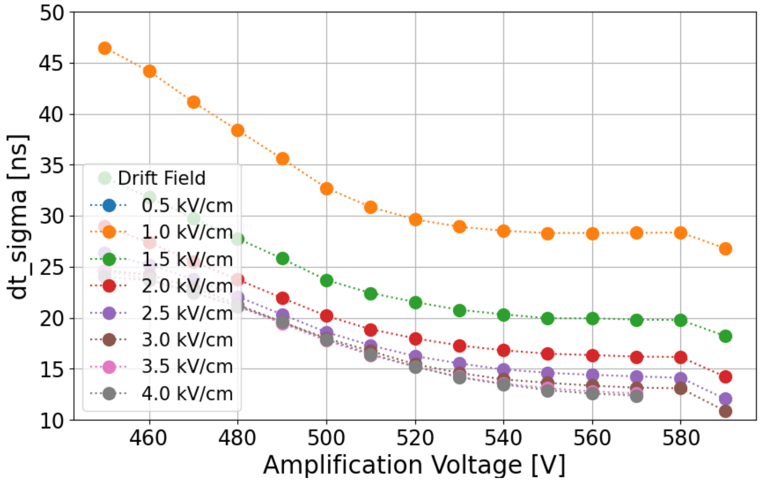
Micromegas

- Optimal at 0.5 kV/cm



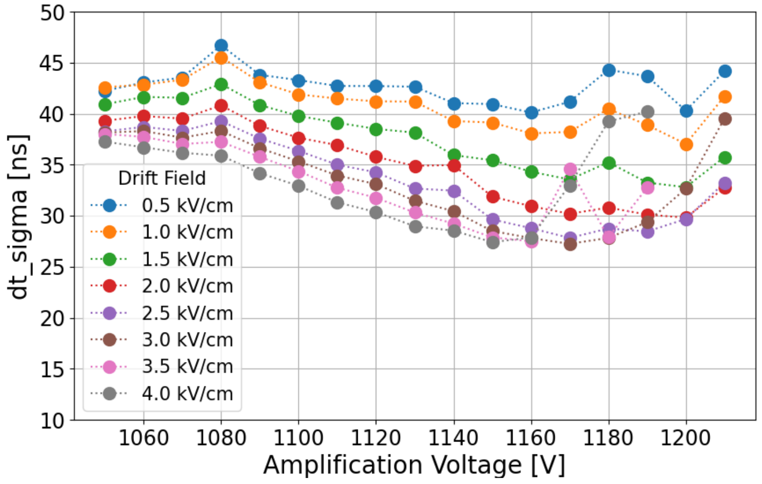
uRWELL

- Better resolution with higher drift field – to be understood



RPWELL

- Higher values due to the thicker amplification gap
- Better resolution with higher drift field – to be understood



Charge

Micromegas

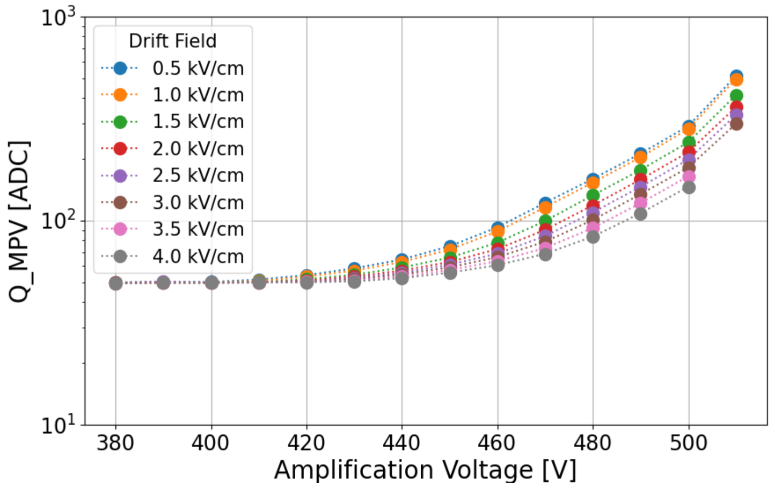
- Highest gain @0.5 kV/cm

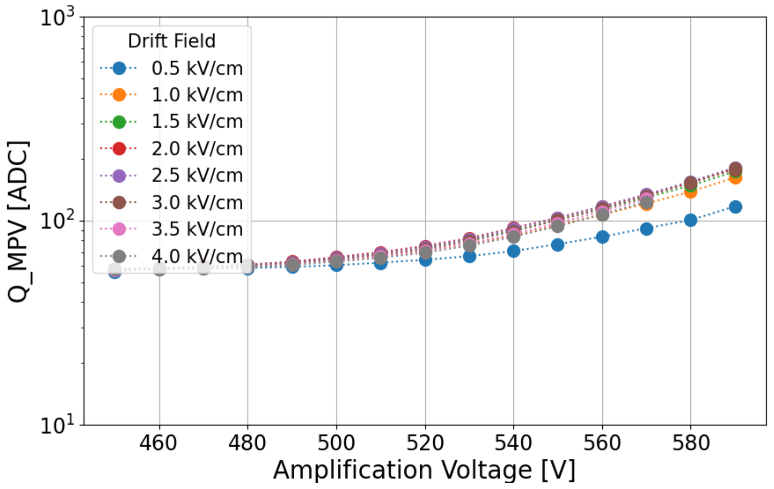
uRWELL

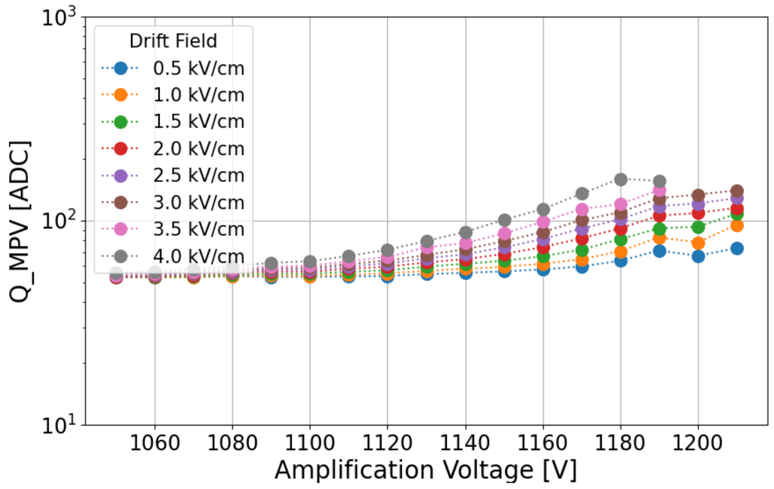
- Highest gain @2.0 kV/cm
- Overall lower gain than MM

RPWELL

- Higher charge with higher drift field
- Partial charge measurement

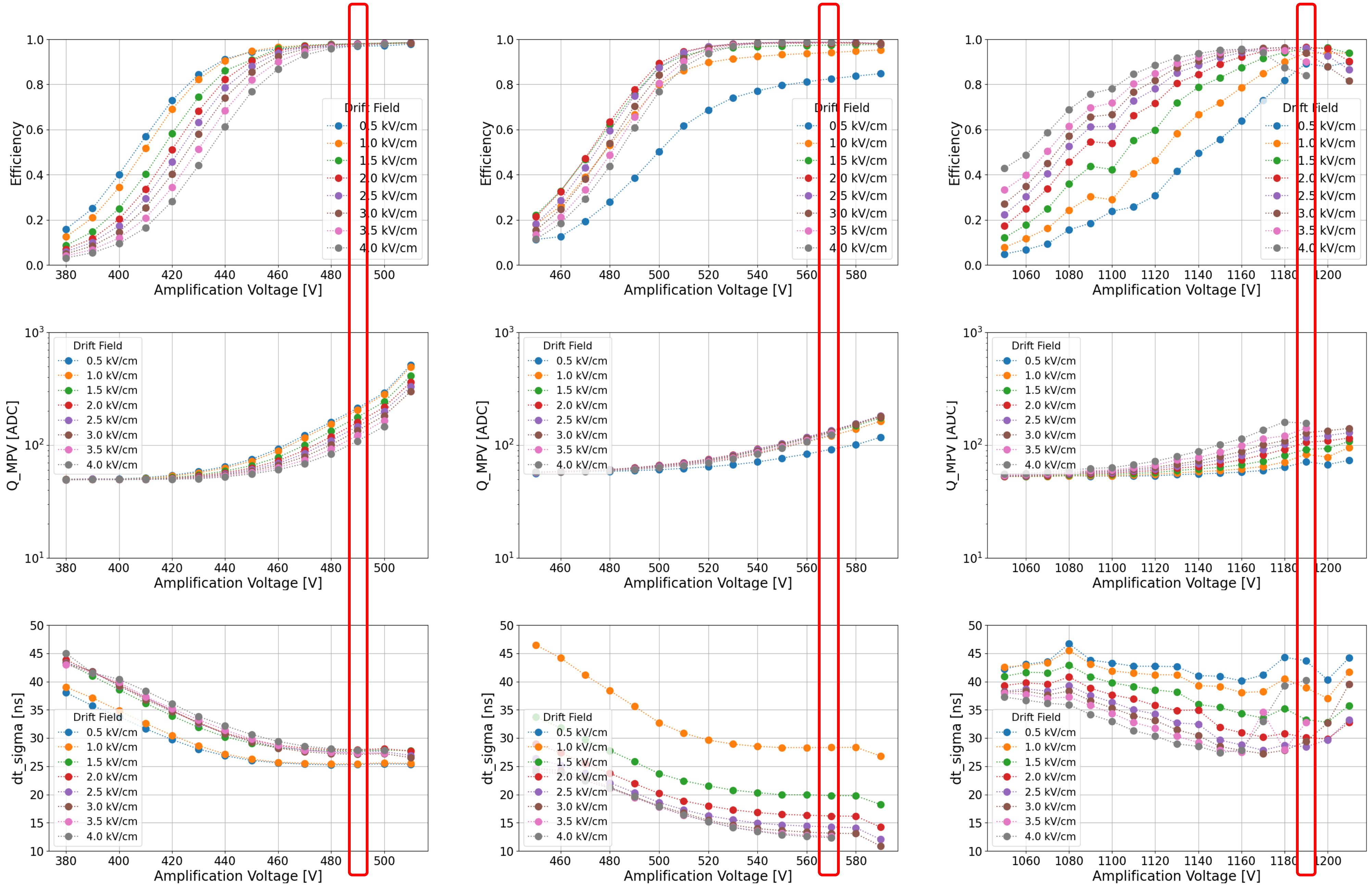




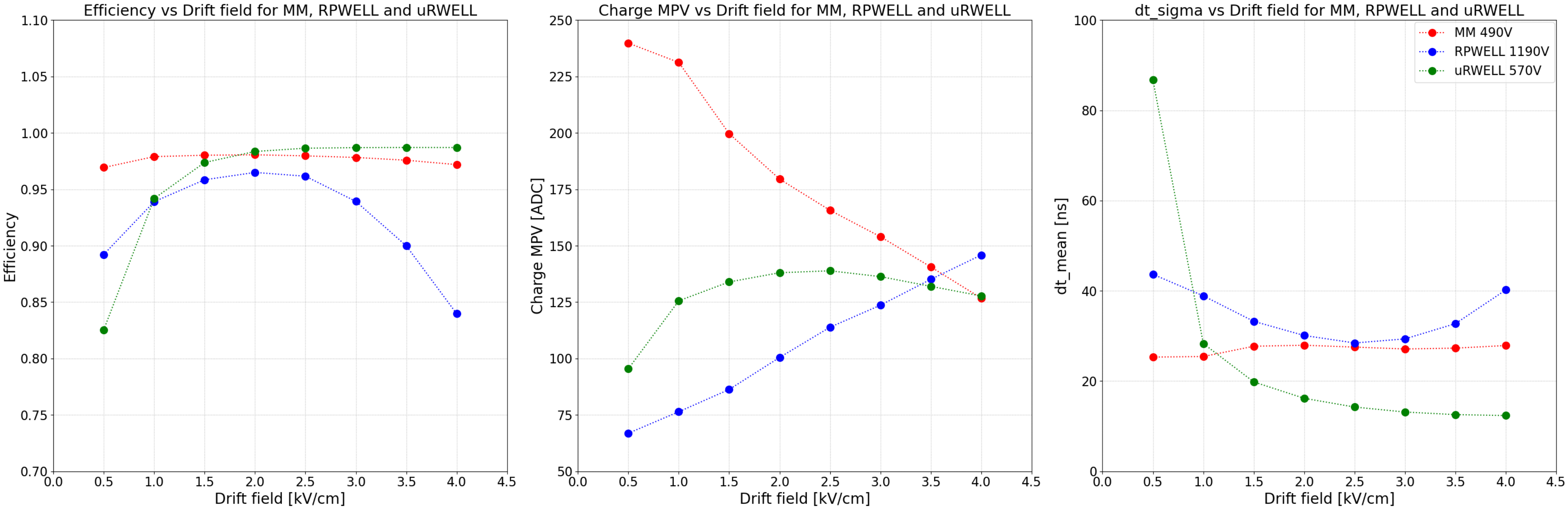


*First points are not to believe – due to the threshold cutting the Q distribution - not a real gain of the detector

Micromegas | uRWELL | RPWELL

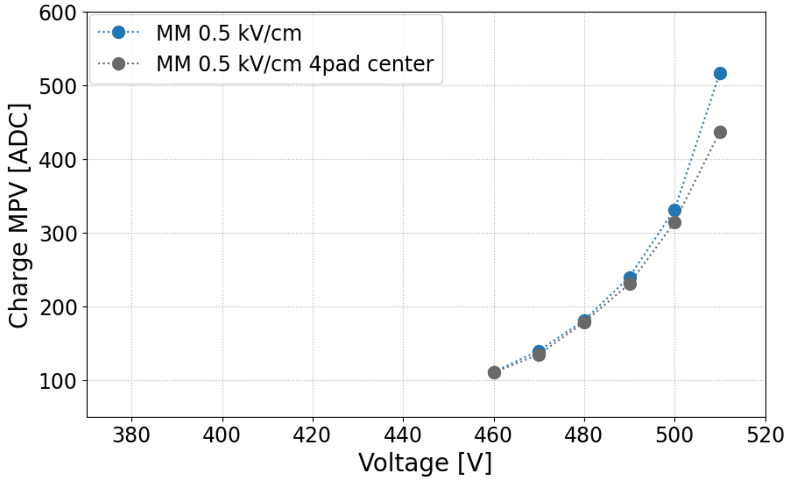


Performance dependency on the drift field – to be understood

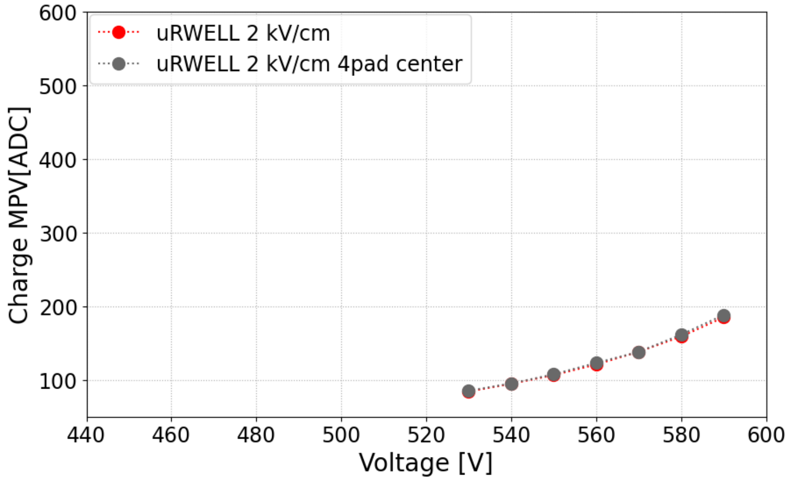


Charge measurements – at the efficiency plateau, at optimal drift field

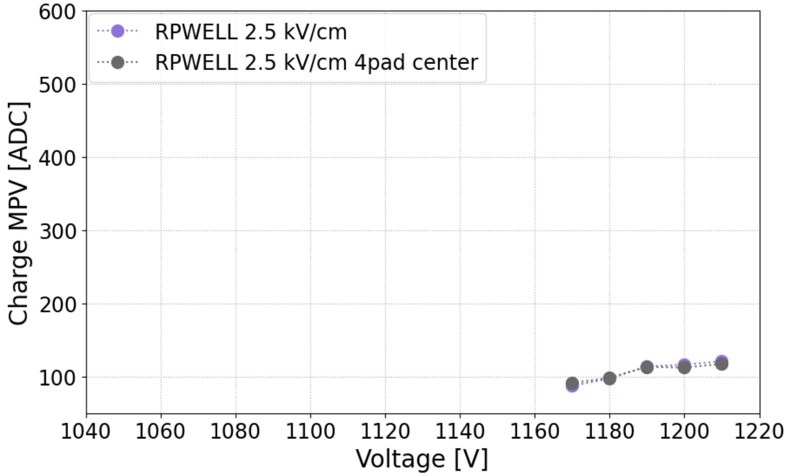
Micromegas



uRWELL



RPWELL



Main questions:

1. Why uRWELL gain is lower than MM?

   Gas mixture? 45% argon instead of 93? → Garfield simulations

2. How much of the total charge we measure with VMM3a 200ns shaping time?

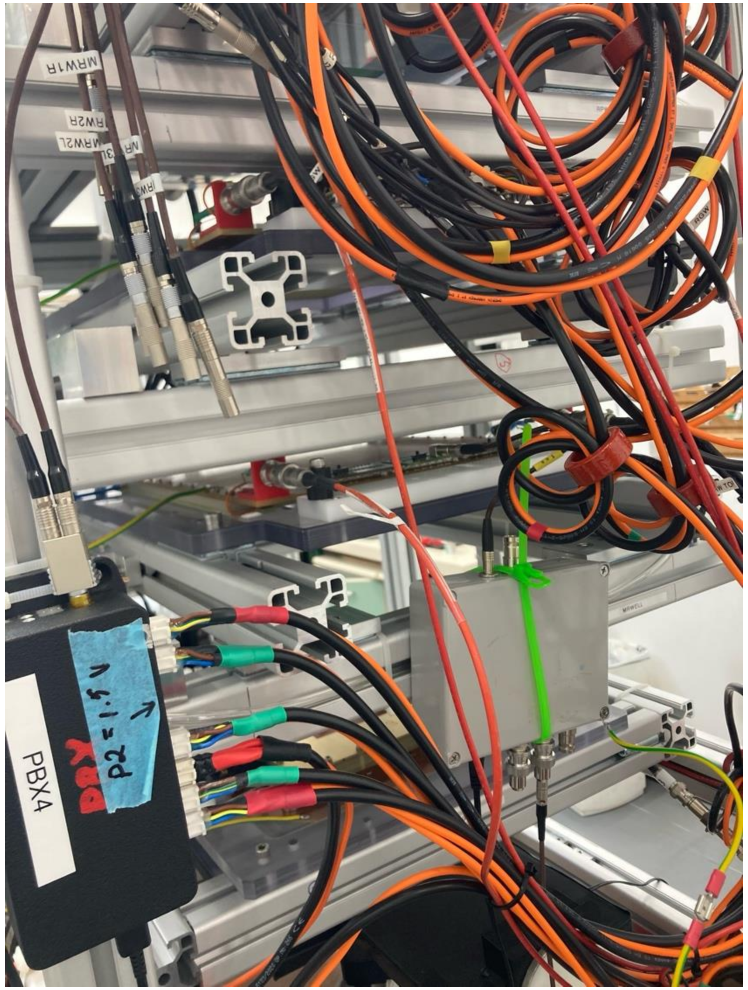
   Signal is order of magnitude longer in RPWELL → Signal shape measurement

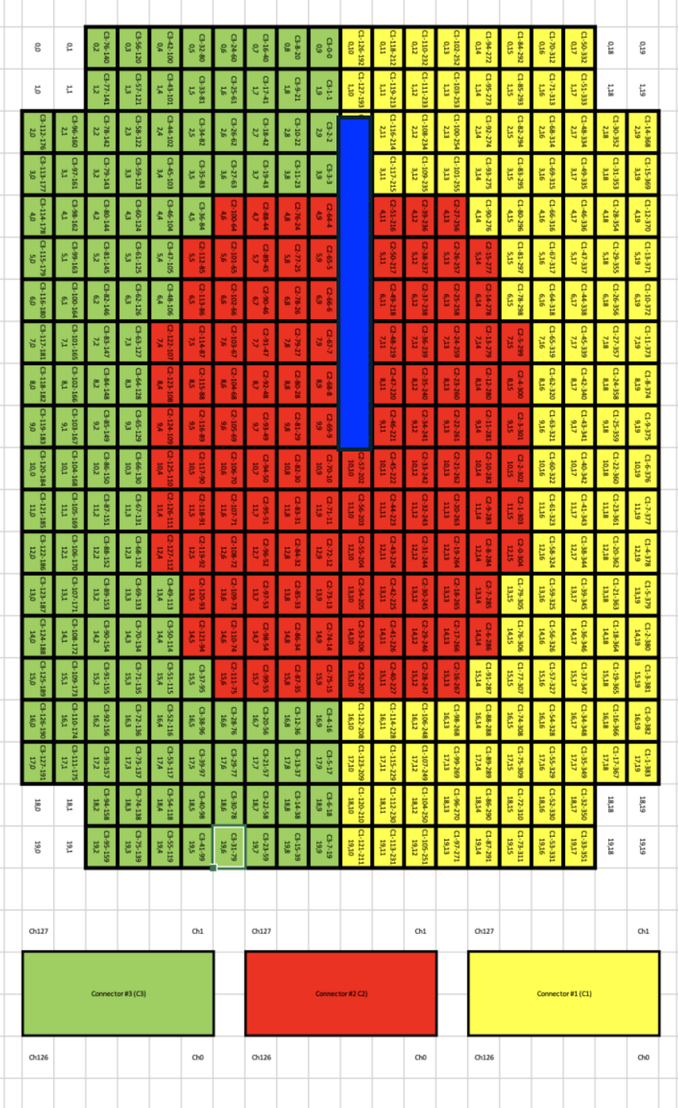
Signal shape measurements

Cremat110 preamp:
- 1.4 V/pC
- 7 ns rise time with 0 input capacitance

HRS terminator
- Cluster of 8 channels

Triggering with cosmic muons

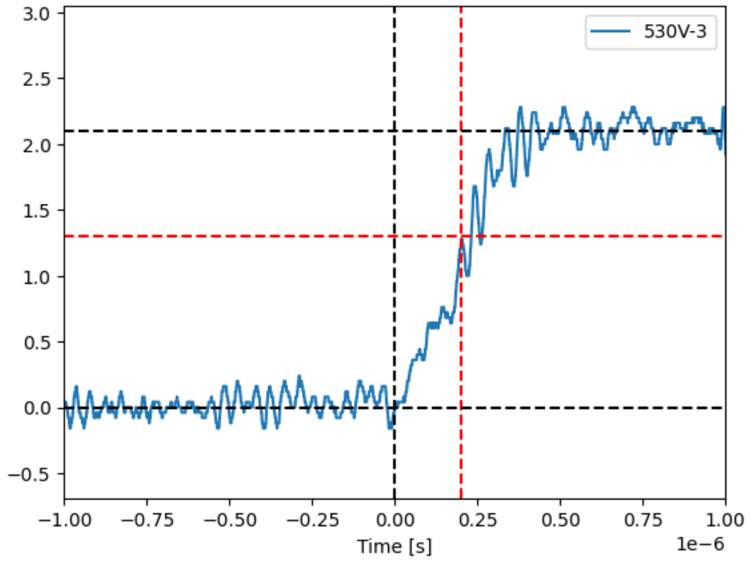




Signal shape in thee detectors

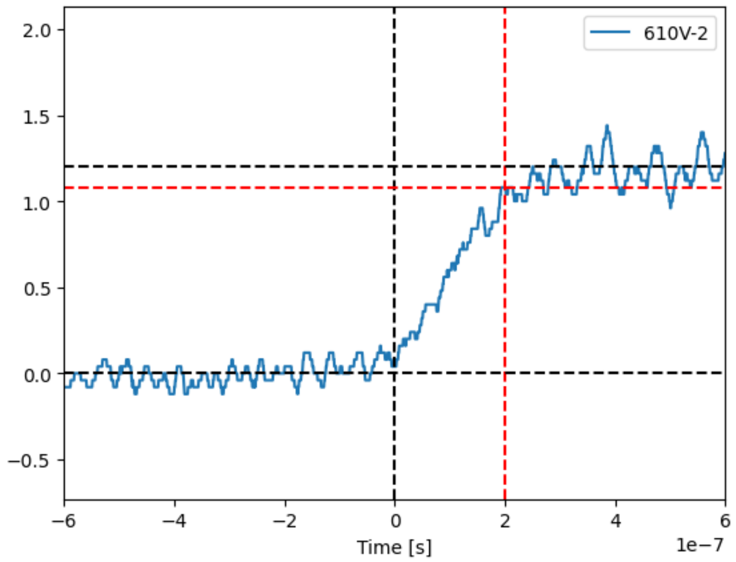
Micromegas

- Rise time ~ 300ns
- At 200 ns, 63.6 ± 1.3 % of the total amplitude is measured



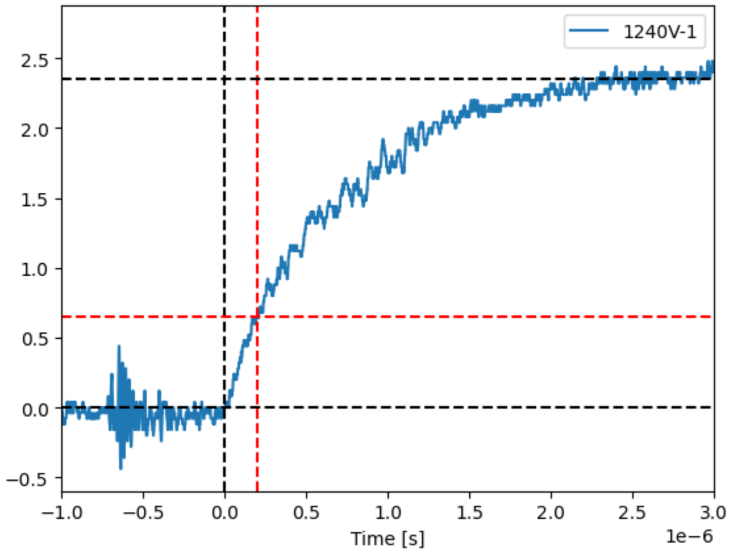
uRWELL

- Rise time ~ 200ns
- At 200 ns, 89.9 + 1.1 % of the total amplitude is measured



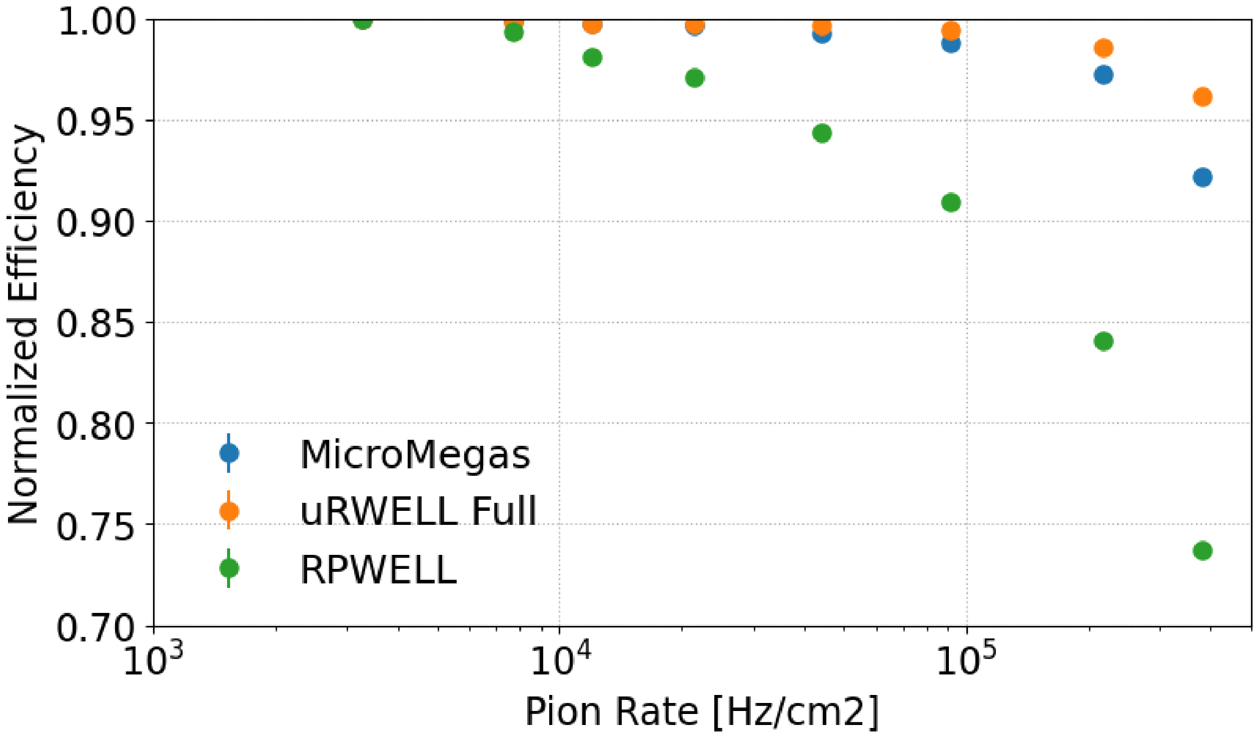
RPWELL

- Rise time ~ 2000ns
- At 200 ns, 32.1 + 1.3 % of the total amplitude is measured



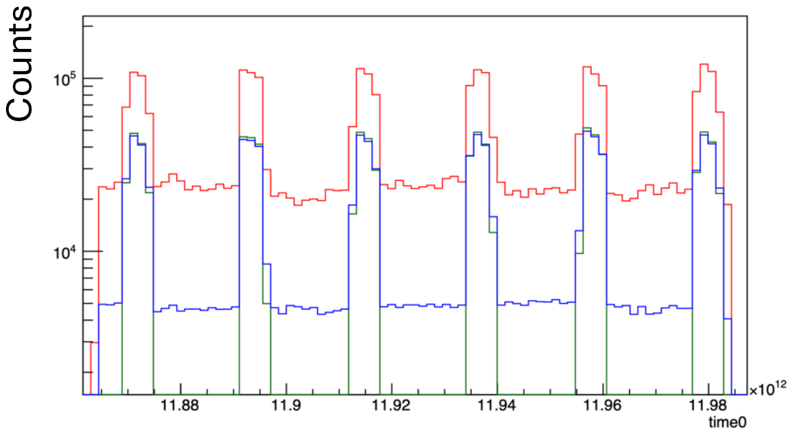
This has to be taken into account for gain estimation.

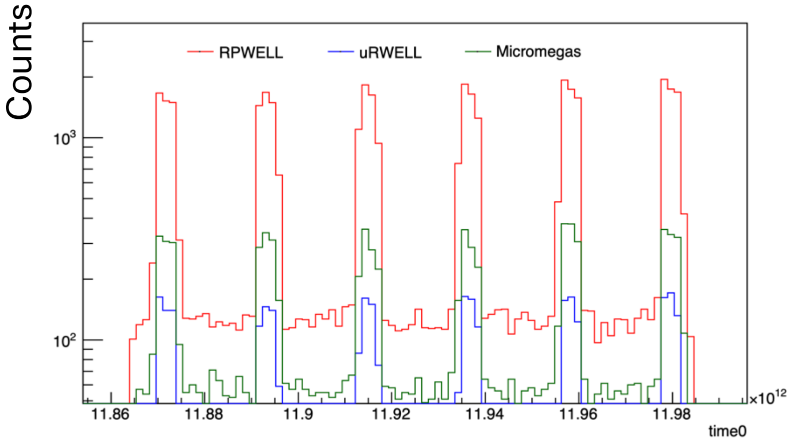
Rate capability with pion beam



- Detectors operated at the efficiency plateau with ~optimal drift field
- Efficiency normalized to the first point
- RPWELL drop ~26% due to higher resistivity
- MM and uRWELL drop by 8 and 4% respectively

Off-beam activity – stability



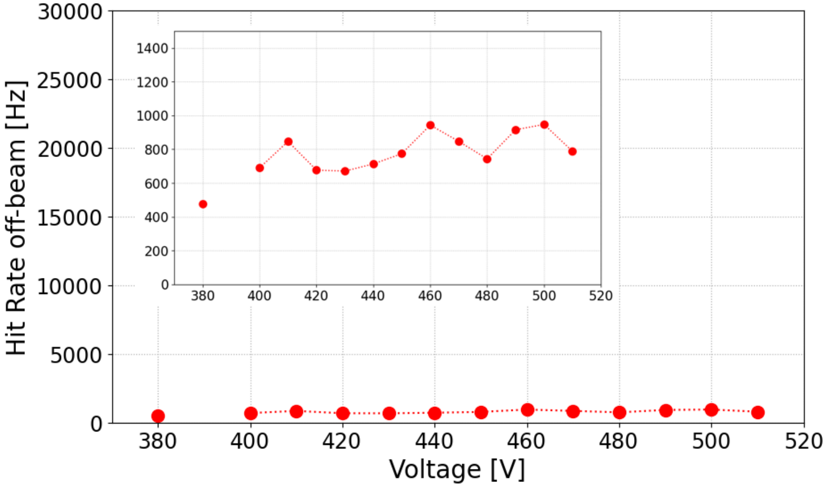


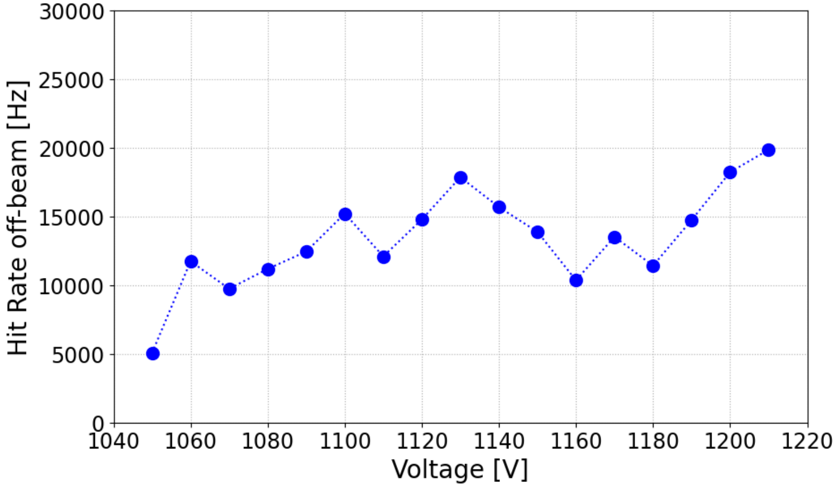
← Reported in MPGD2024

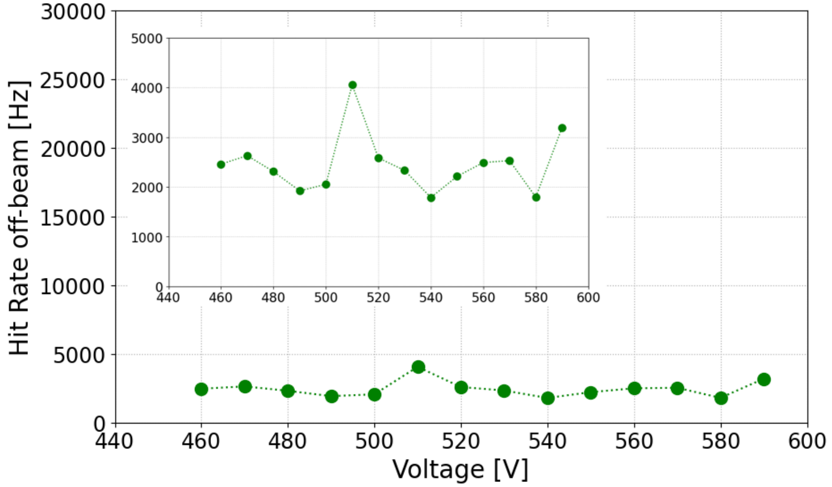
Off-beam activity

Micromegas | RPWELL | uRWELL

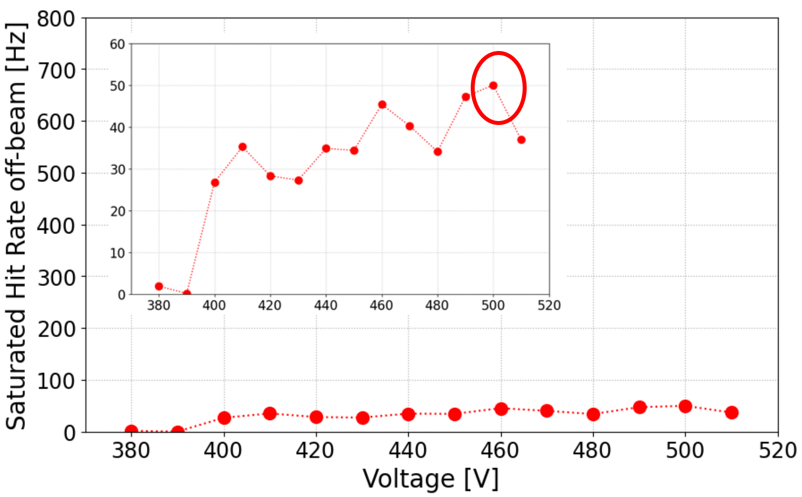
1. All hits rate in off-beam

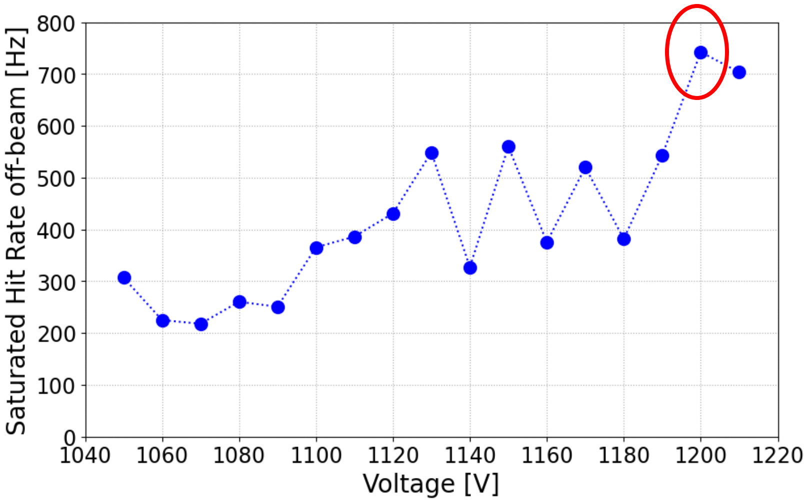


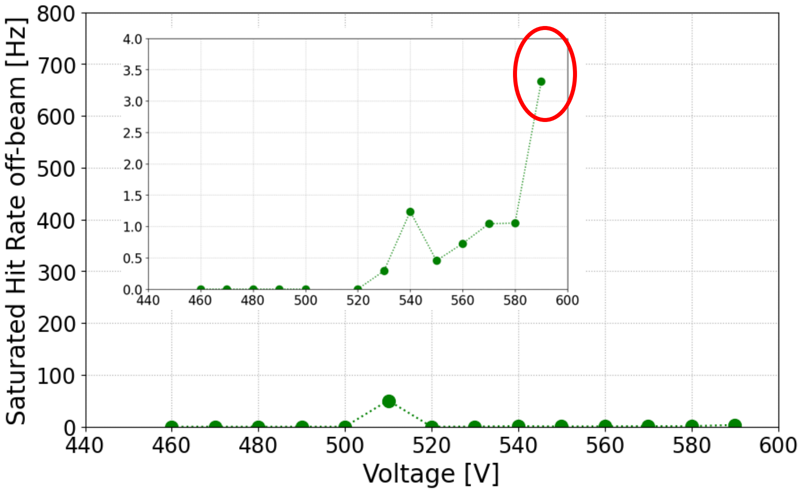




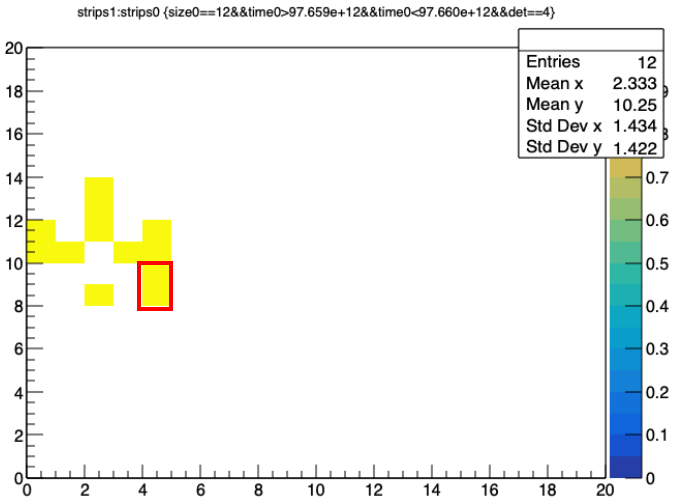
2. Saturated hits rate in off-beam



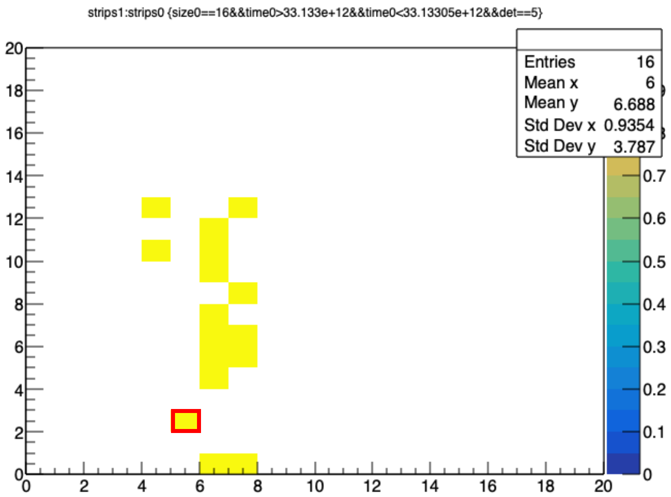




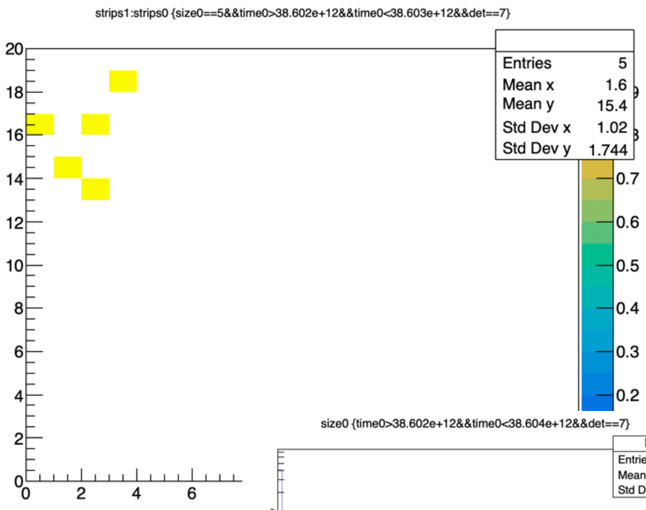
Micromegas

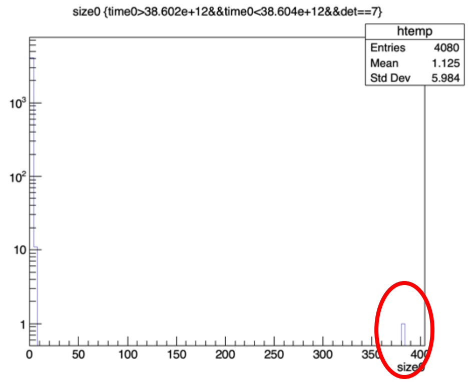


RPWELL



uRWELL





1. Saturated clusters (with saturated single hits) are present in MM and RPWELL
2. Size of saturated clusters in RPWELL is higher than in MM
3. No saturated clusters in uRWELL, but huge size non-saturated clusters are present

→ Further analysis needed and ongoing