Discharge quenching in Thick-GEM based WELL detectors

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THGEM-based WELL detectors

- A single-sided THGEM foil (0.1 mm Cu on 0.4 mm FR4) placed on top of a metallic plate (anode) forms a WELL structure (**THWELL**). Another plate at 3 mm above THGEM acts as cathode.
- Anode at 0 V, THGEM top at $-V_{WELL}$, cathode at $-(V_{WELL}+\Delta V_{drift})$. Electric field in the drift region = 0.5 kV/cm, inside WELL holes ~ 15-35 kV/cm.
- Primary ionization produced electrons are directed towards the WELL holes where avalanche multiplication occurs. Movement of all the charges induces currents on the readouts.
- For avalanche size > $10^7 – 10^8$ electrons (Raether limit), gas breakdown occurs.
- **RPWELL**: a resistive plate (silicate glass, $\rho=2\times10^{10}$ Ω-cm) in between the anode and THGEM. Slow charge evacuation through the resistive plate should quench discharges.

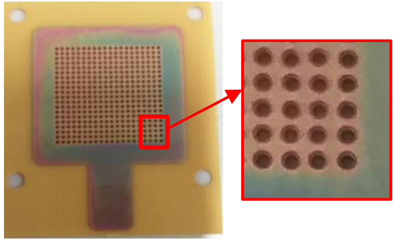

Fig: a 2 cm × 2 cm THGEM foil

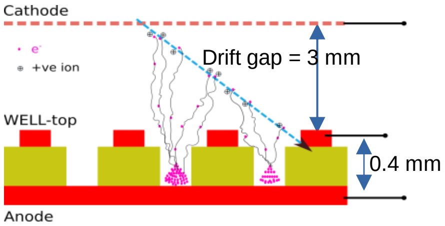

Fig: Schematic of a THWELL operation.

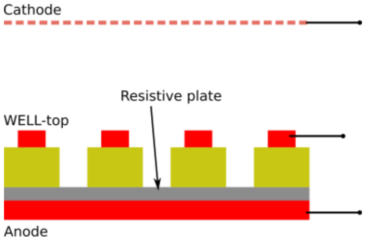

Fig: Schematic of a RPWELL detector.

Discharges in THWELL

- Production of discharges in THWELL creates sudden change in the power supply currents to the electrodes participating in discharge production.
- **No discharge** was seen in RPWELL following this method (sensitivity = 5 nA). Much higher maximum achievable gain in RPWELL.
  - G = 9×10^{3} at 745 V in THWELL. Strong discharges does not allow application of higher voltage.
  - G = 5×10^{4} in RPWELL at 1000 V. Distorted spectrum above this voltage.

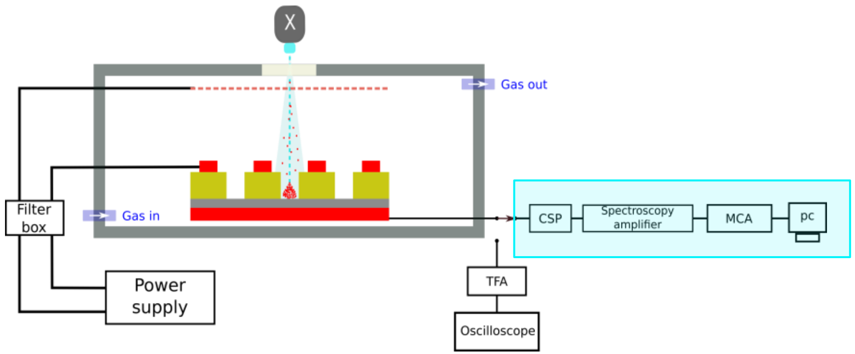

Fig: Experimental setup for basic characterization.

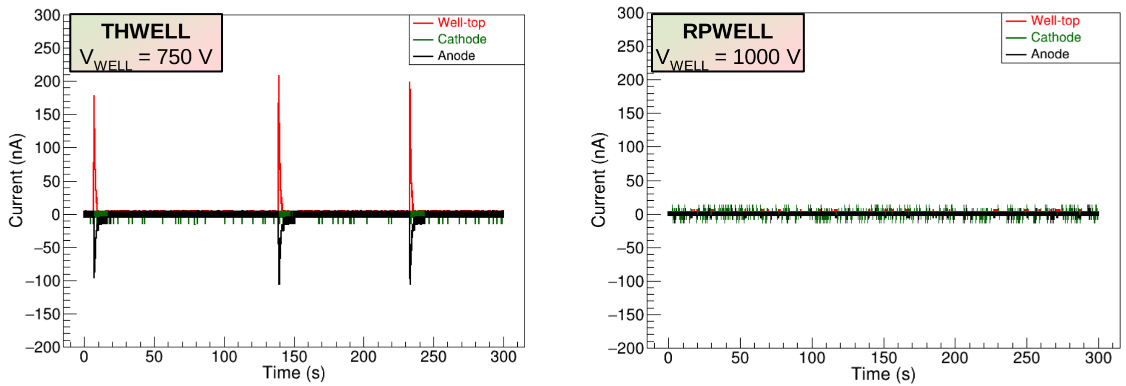

Fig: Current supplied by power supply to the electrodes of THWELL and RPWELL around their maximum allowed voltages.

Discharges in RPWELL

- **New method:** monitor anode pulses using a timing-filter amplifier.
  - Standard pulses with hundreds of fC charge in both the detectors. Maximum charge of this population corresponds to ~10^7 electrons → **avalanche mode**.
  - Large-amplitude pulses (a few hundred times than avalanche mode) in RPWELL accompanied by sub-nA current fluctuation in power supply→ **discharge mode**.
  - Clear separation between charge content of pulses in the 2 modes.
- Discharges in RPWELL are about **100 times quenched** than THWELL.

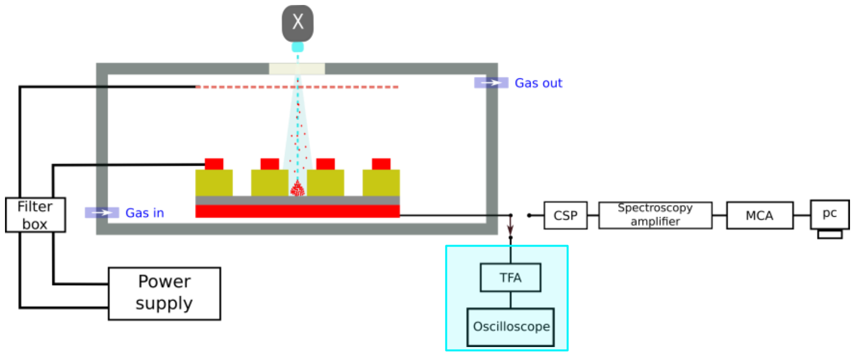

Fig: Experimental setup for pulse acquisition.

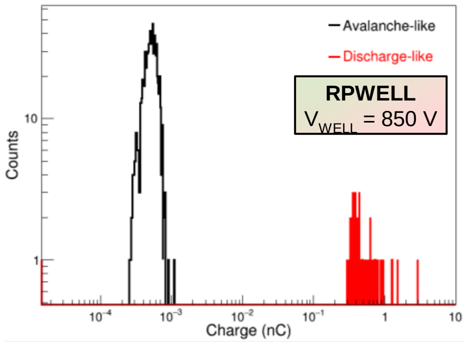

Fig: Distribution of charge content of pulses in RPWELL.

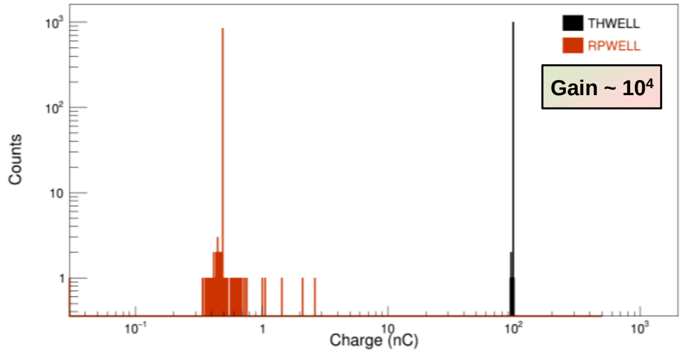

Fig: Distribution of charge content in discharges in THWELL and RPWELL.

Effect of discharges in RPWELL

Experimental setup

- Controlled production of localized discharges at a known position inside RPWELL (R_D strip) using a charge injector with a shutter controlled low rate X-ray source ($X_{injector}$). Proof of principle in a THWELL (discharge production rate ≤ 1 Hz).
- A 500 Hz X-ray source (X_{WELL}) irradiates RPWELL directly at the position of R_m readout strip.
- Continuous spectra acquisition (duration = 2 s) from R_m. Peak of each spectrum gives the detector gain.
- Find difference in gain in absence and presence of discharges.

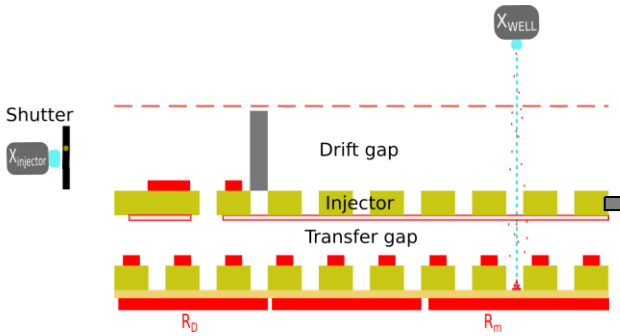

Fig: Setup – acquire R_m spectrum in absence of discharge.

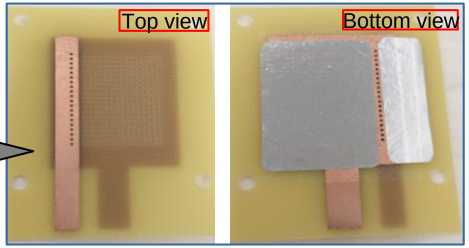

Fig: The localized charge injector.

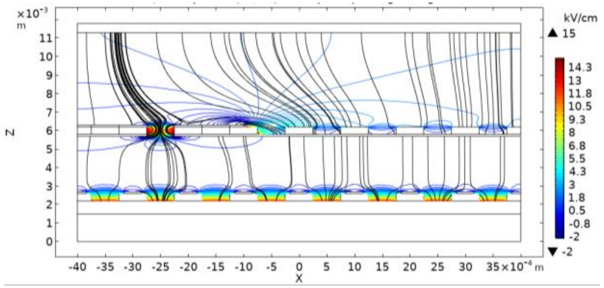

Fig: Electric field map and charge propagation lines in the setup, simulated in COMSOL.

Results

- RPWELL gain drops in presence of multiple discharges. Amount of gain drop increases with the number of discharges and their intensity.
- Gain drop decreases with distance from discharge production point, increases with resistance.
- Recovery time ~ 1 minute, irrespective of distance.
- No effect due to single discharge was seen using the present method.
- The effect can be avoided using a segmented resistive plate (observed).

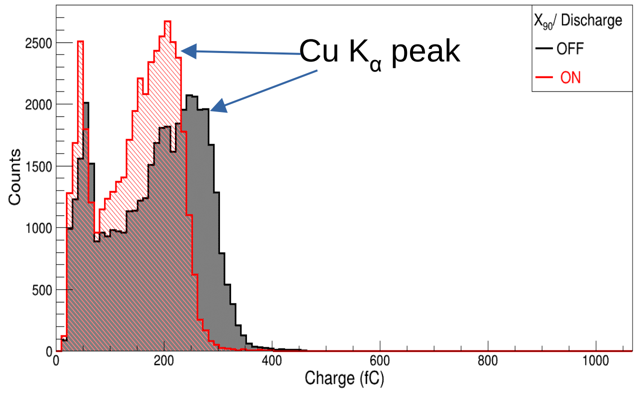

Fig: RPWELL gain variation (peak position) in absence and presence of discharges.

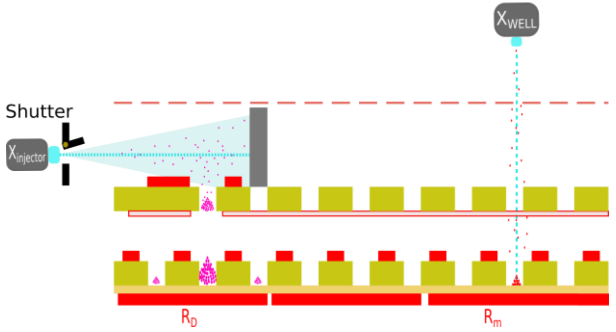

Fig: Setup – acquire R_m spectrum in presence of discharge.

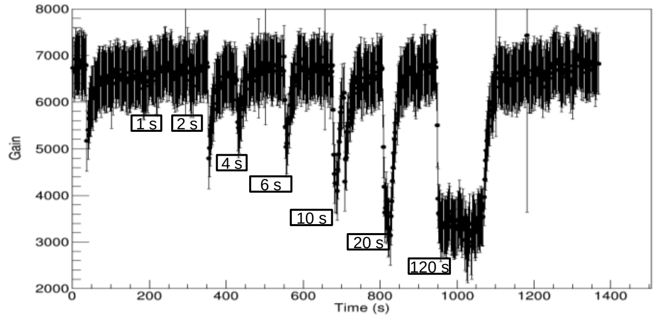

Fig: RPWELL gain drop for different duration of discharge production.

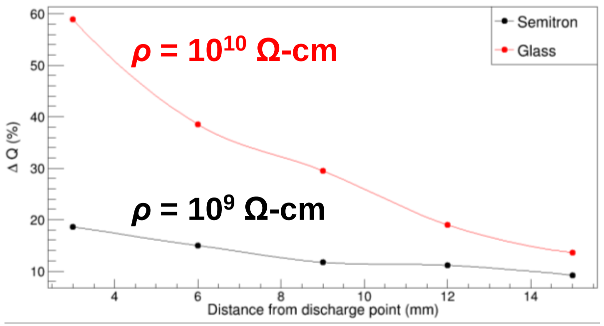

Fig: RPWELL gain drop as a function of distance from discharge production point.

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We will be happy to answer your queries.

Thank you

BACKUP

Pulses in RPWELL

- The discharge-like pulses in RPWELL are a few hundred times larger than the avalanche like pulses.

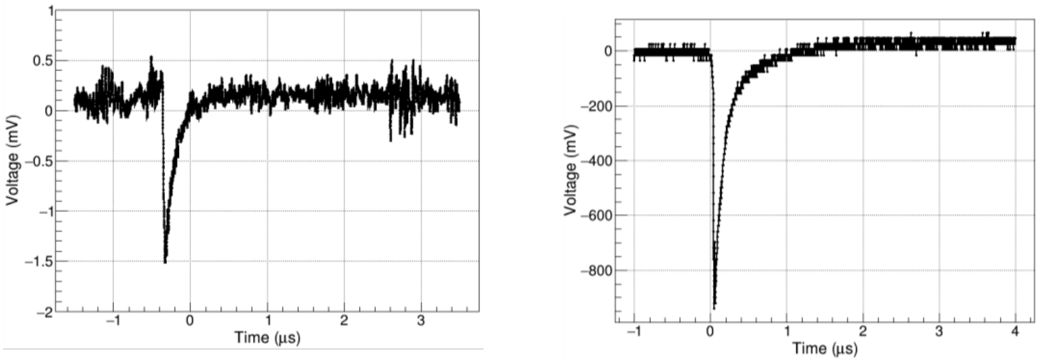


Fig: Avalanche (left) and discharge (right) like pulses from RPWELL anode.

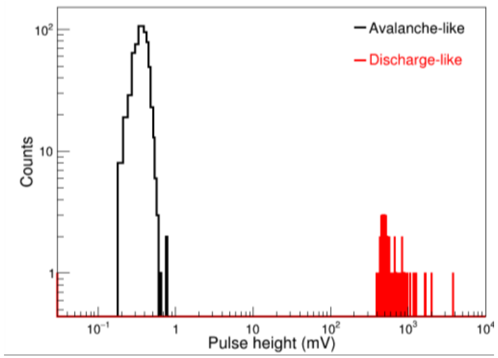
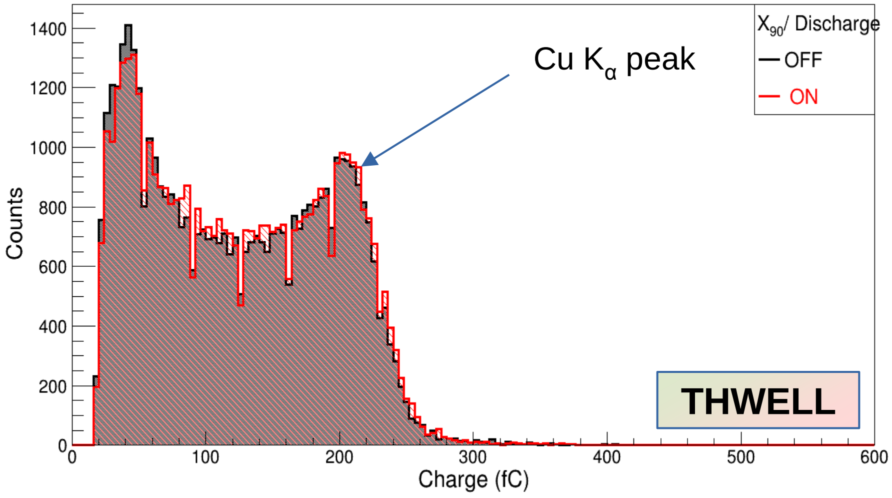


Fig: Pulse height distribution of RPWELL pulses.

Observed effect

- THWELL: discharge at R_D **does not influence** the R_1 (3 mm from R_D) spectrum.
- RPWELL: discharge at R_D **reduces the gain** at R_m .
- The second peak at the lower channel number and the bad resolution of spectrum is due to the presence of the charge injector in front of the detectors.



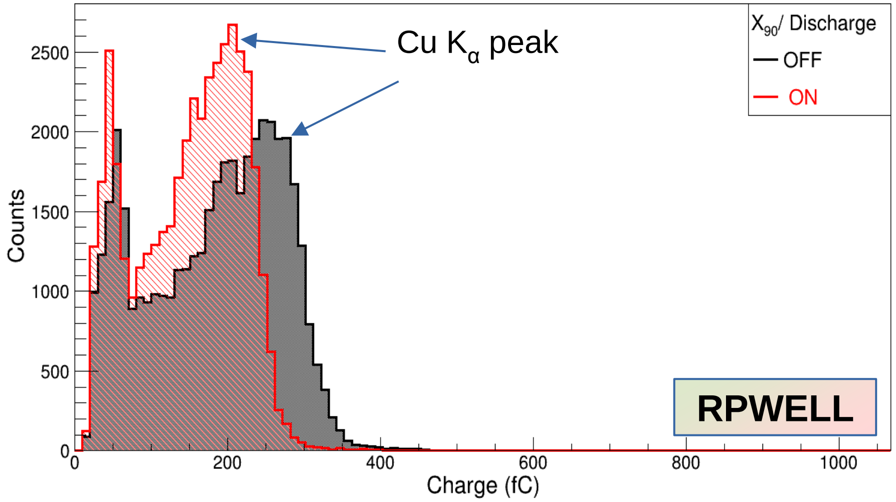


Fig: MCA spectra from R_m with and without discharge at R_D in THWELL (left), RPWELL (right).

Observed effect

- Repeated spectra acquisition (each for 5 seconds) in a cycle of discharge (or X_{90}) OFF and ON for different exposure times.

- Error bars are from the Gaussian fit.

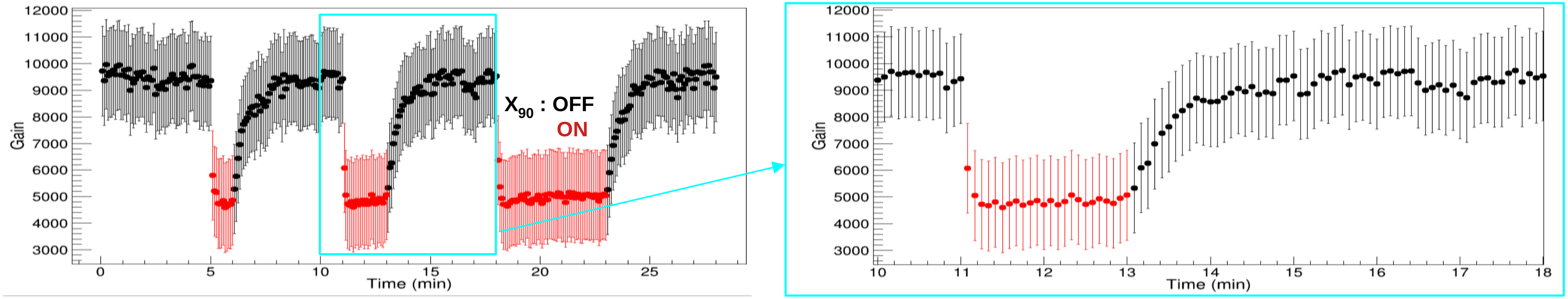


Fig: Variation of RPWELL gain as a function of time in a cycle of discharge (X_{90}) off and on.

- Discharge production reduces the gain very fast (≤ 5 seconds). The **recovery time is about 1 minute**.