Test of resistive Kapton LEM in double phase LAr TPC

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on behalf of

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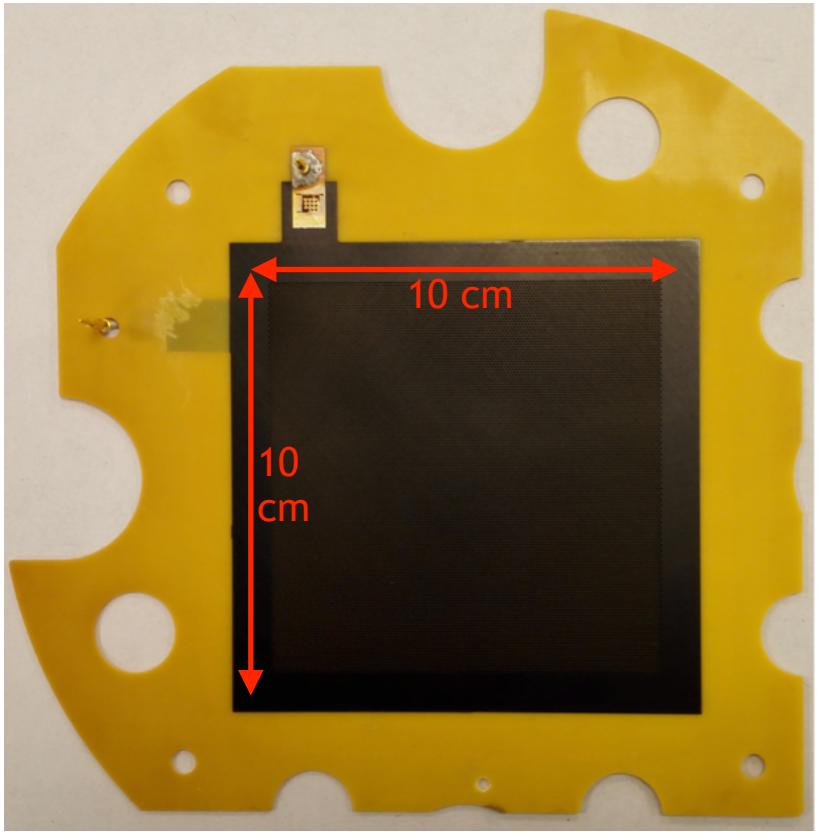
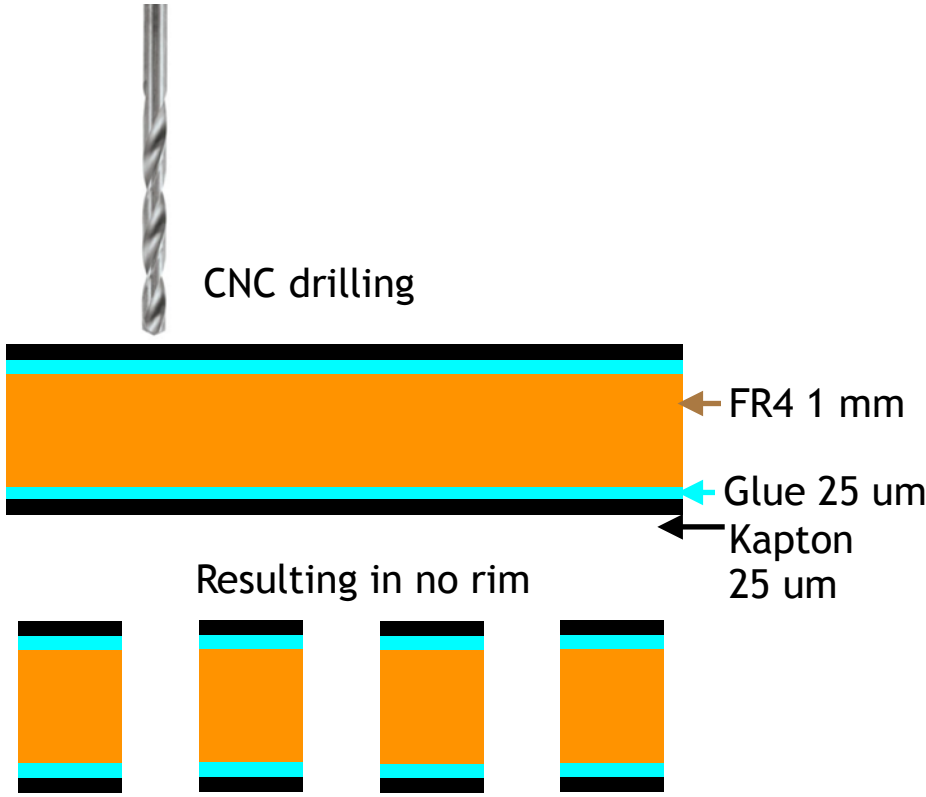
Outline

- Resistive Kapton LEM tests in room temperature gases.
- Resistive Kapton LEM test in double phase LAr TPC.
- Conclusion.

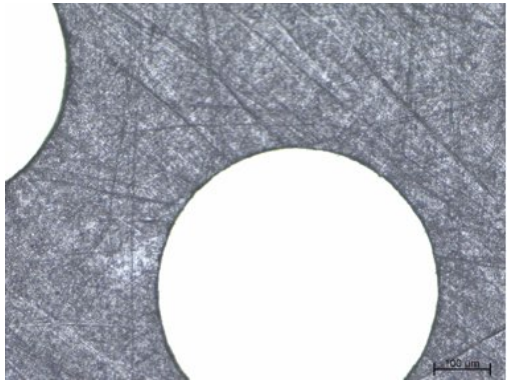
Resistive Kapton LEM/THGEM (RKLEM/RETHGEM)

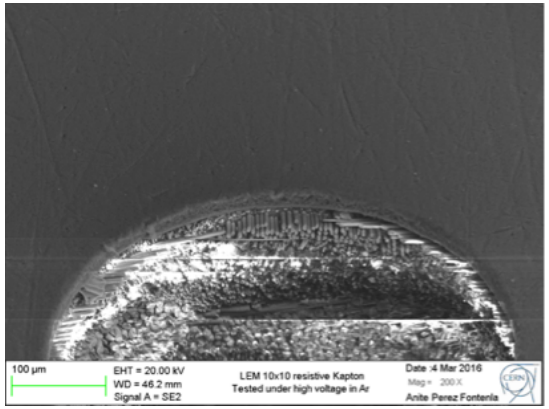
5 MΩ/sq Resistive Kapton LEM





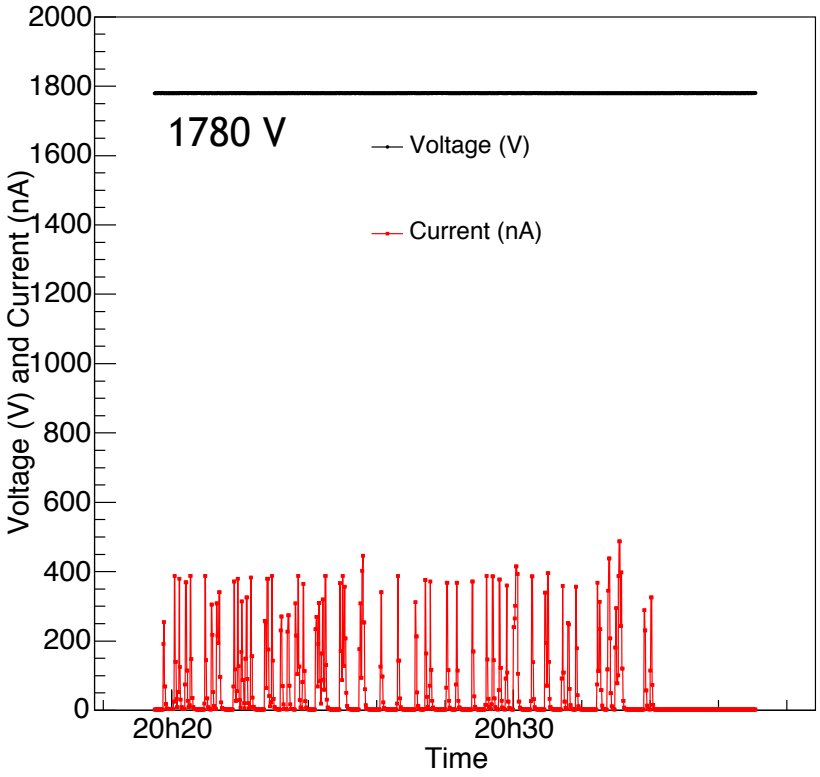
Microscope pictures



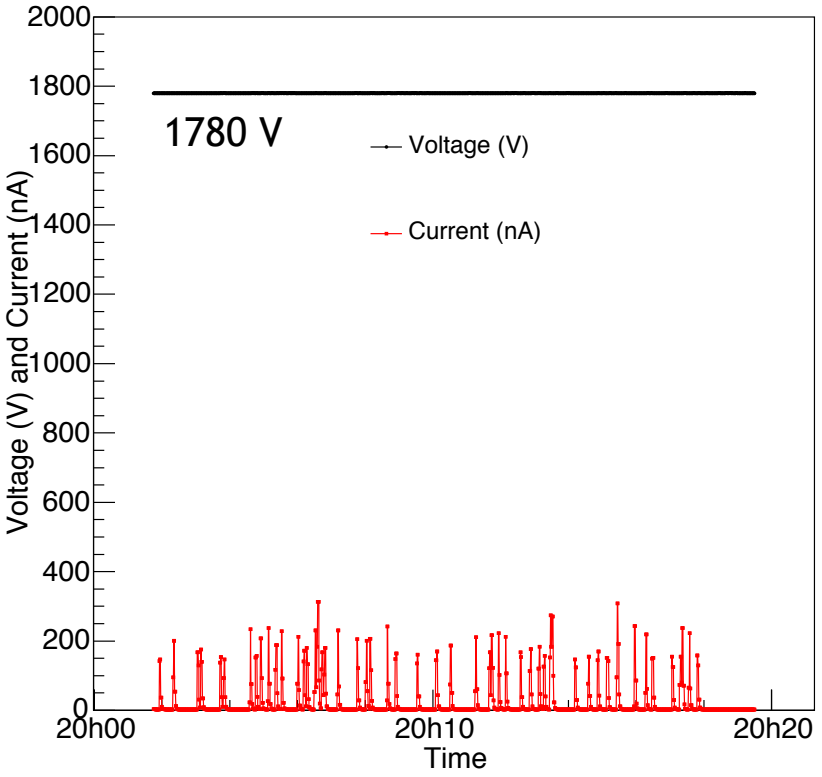


Discharge quenching capability with 1 GOhm series current limiting resistor

Copper LEM with 1 GOhm current limiting resistor in series



RKLEM with 1 GOhm current limiting resistor in series



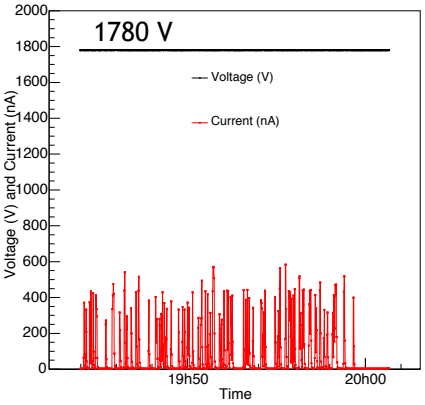
Condition: pure argon at room temperature

pure argon = Ar with 1 ppm impurity flushing gas box for > 20 volume changes

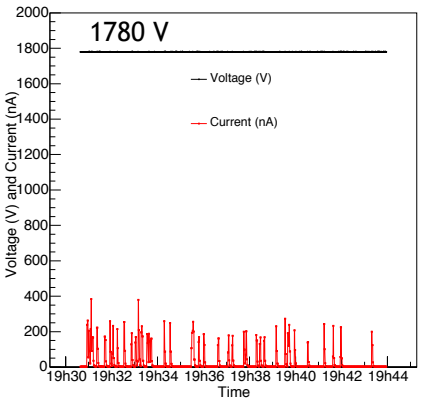
Is it possible to power the RKLEM w/o a current limiting resistor?

500 MOhm current limiting resistor

Copper LEM

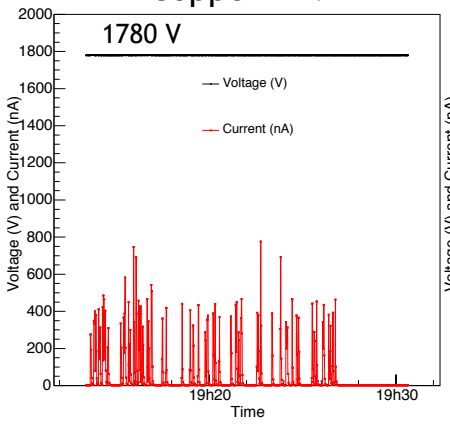


RKLEM

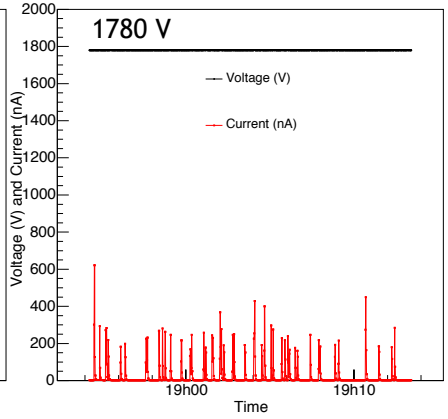


100 MOhm current limiting resistor

Copper LEM

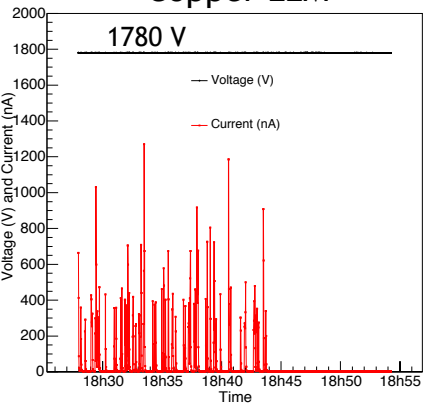


RKLEM

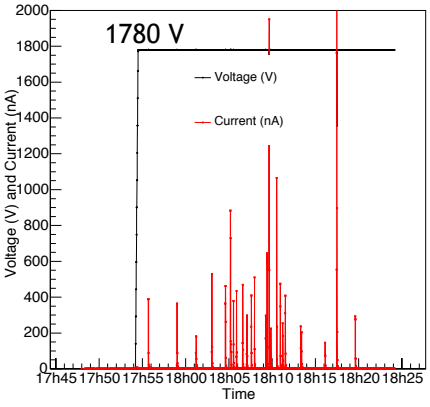


10 MOhm current limiting resistor

Copper LEM

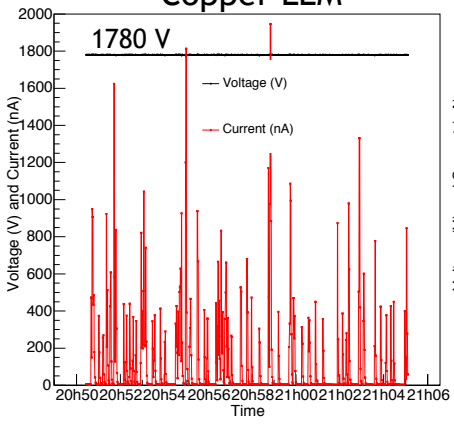


RKLEM

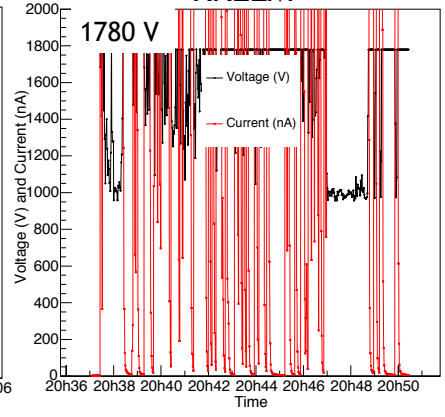


1 MOhm current limiting resistor

Copper LEM

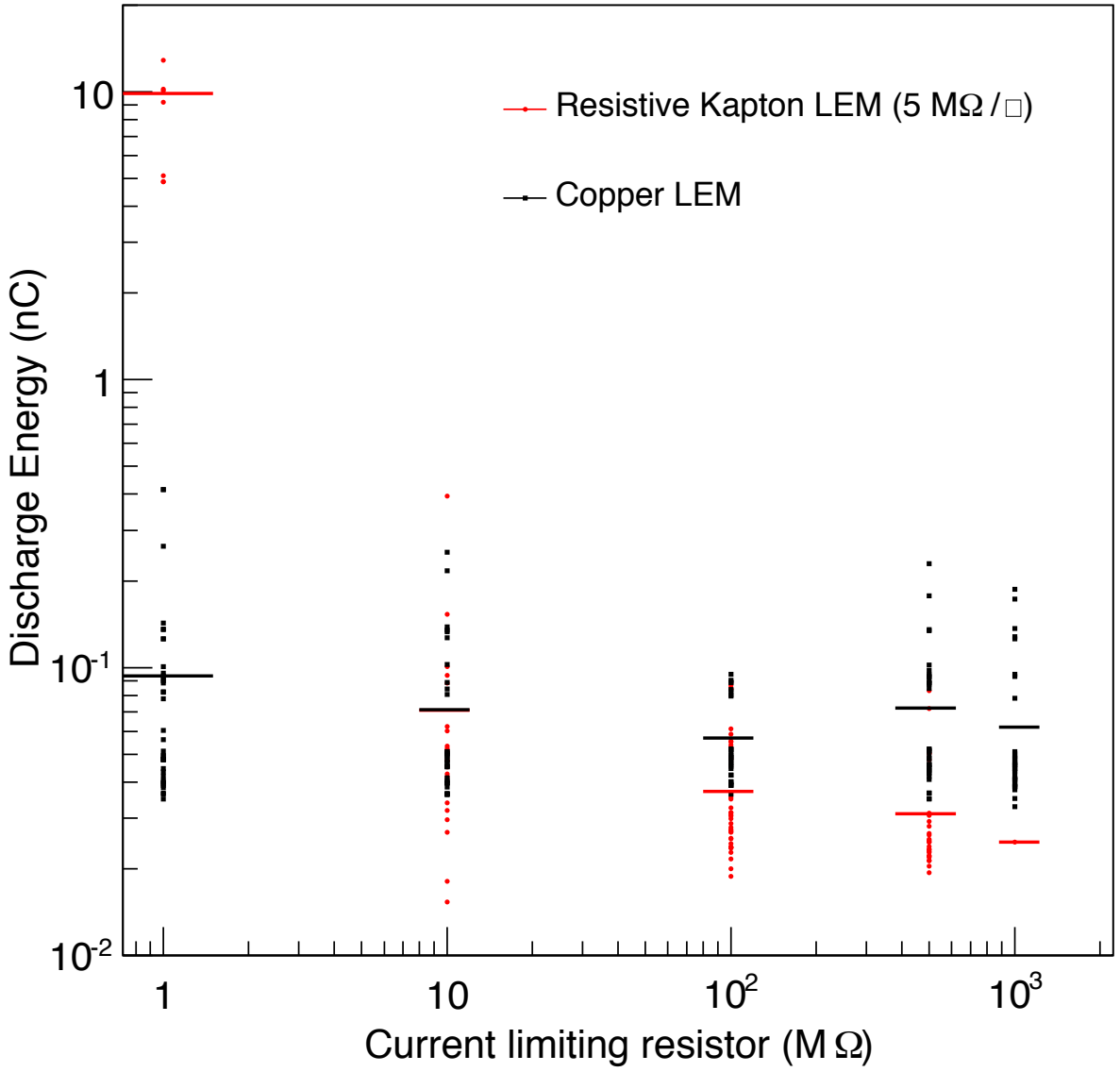


RKLEM



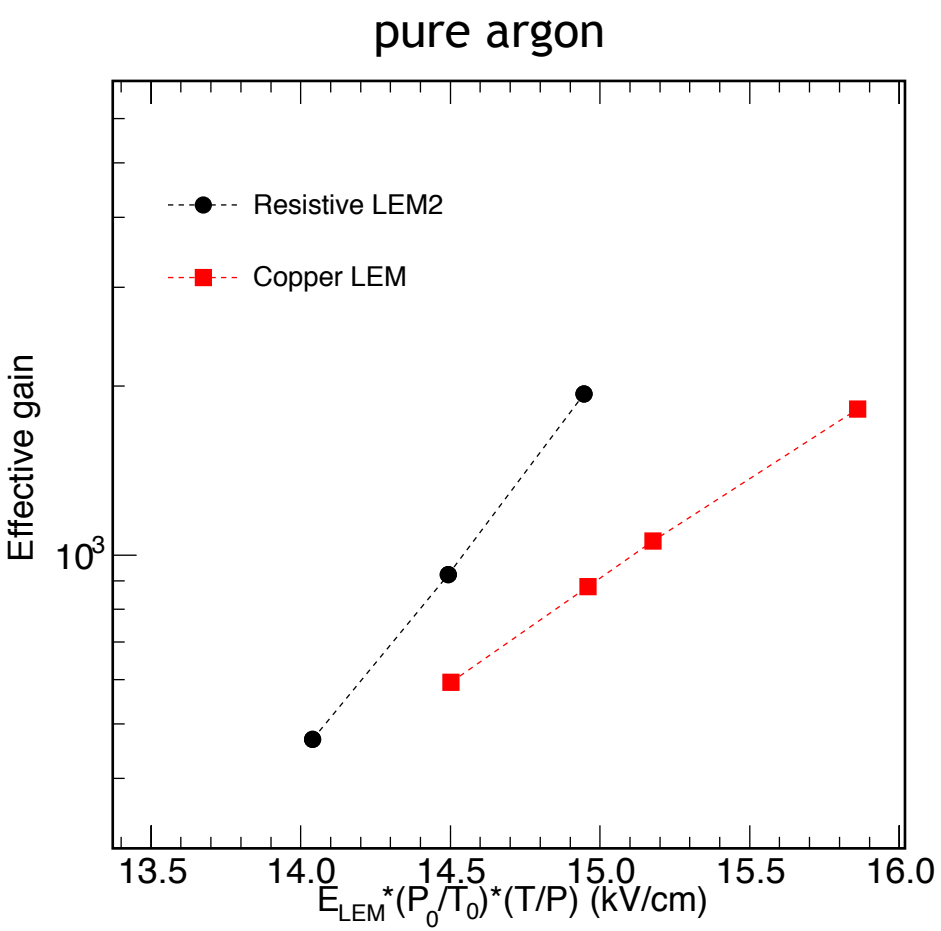
Condition: pure argon at room temperature

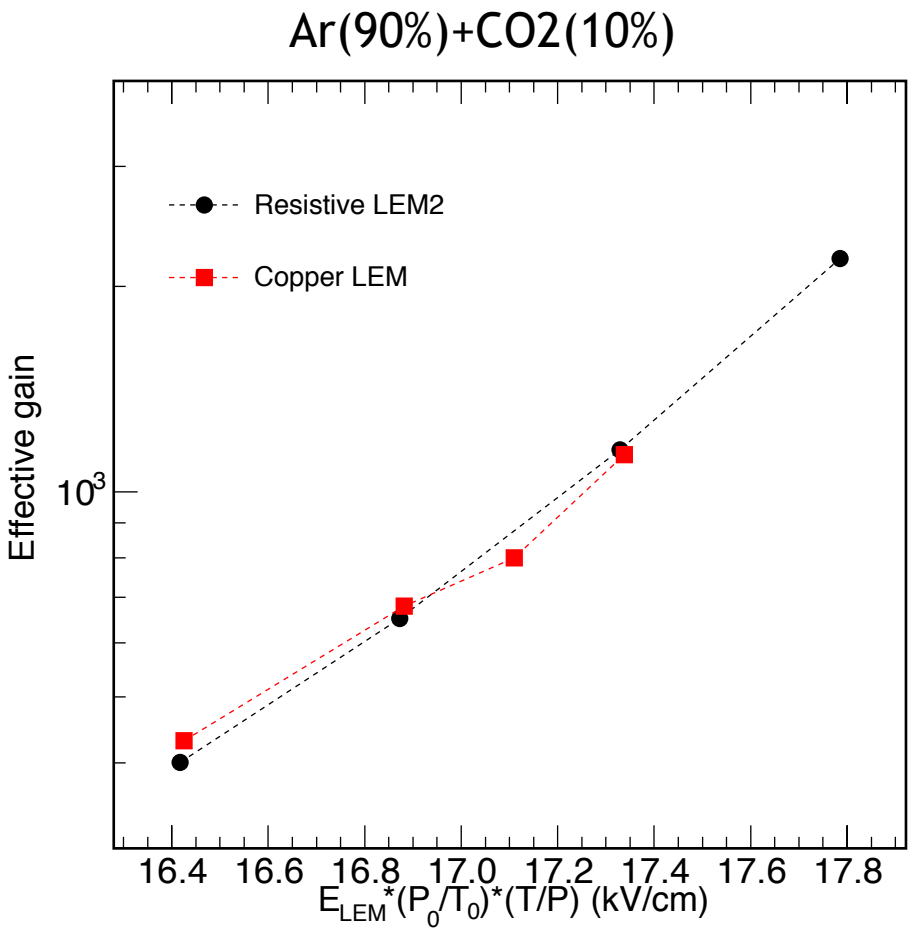
Discharge quenching performance as a function of current limiting resistor



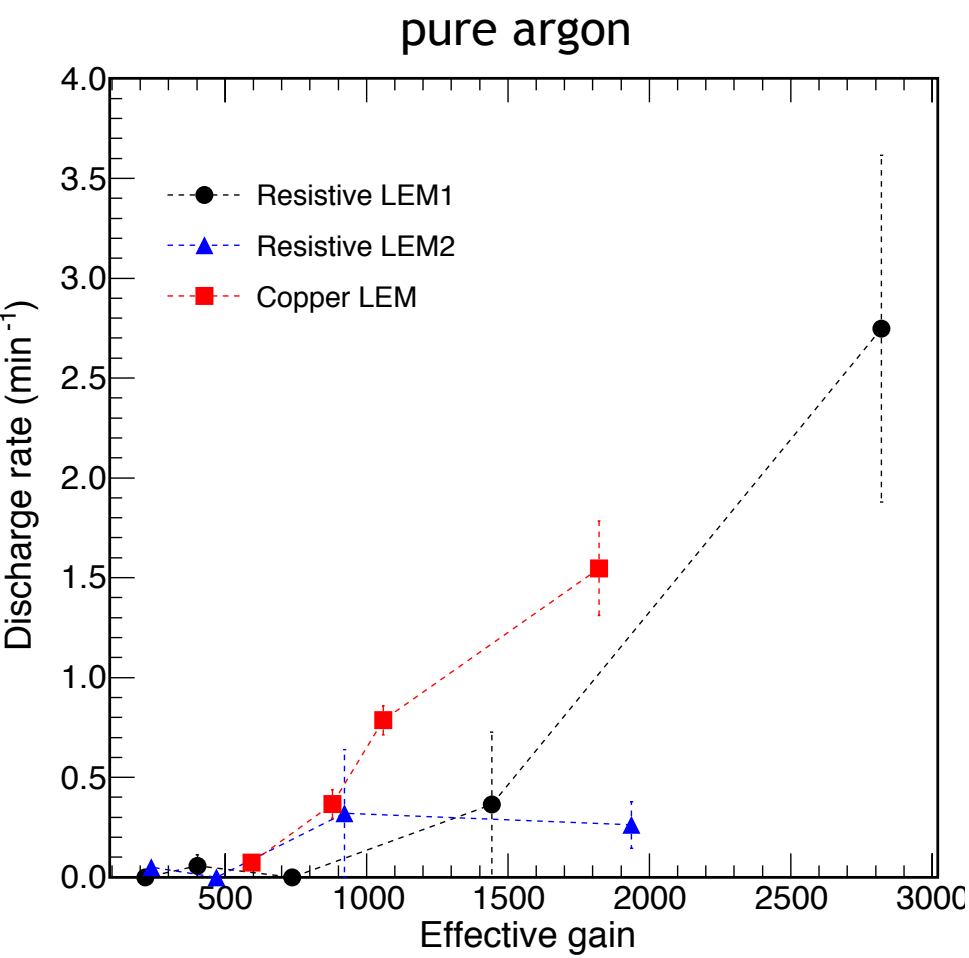
Condition: pure argon at room temperature

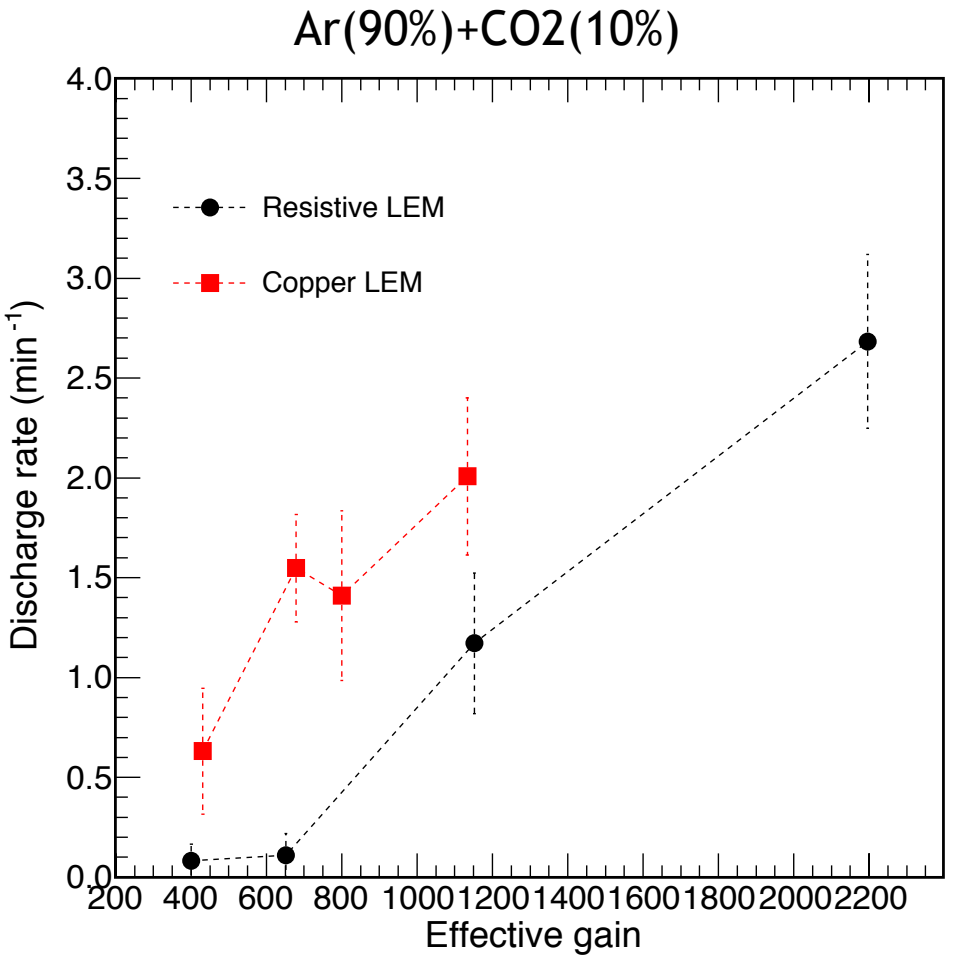
Effective gain of RKLEM and copper LEM (40um rim) in pure argon and Ar(90%)+CO2(10%)





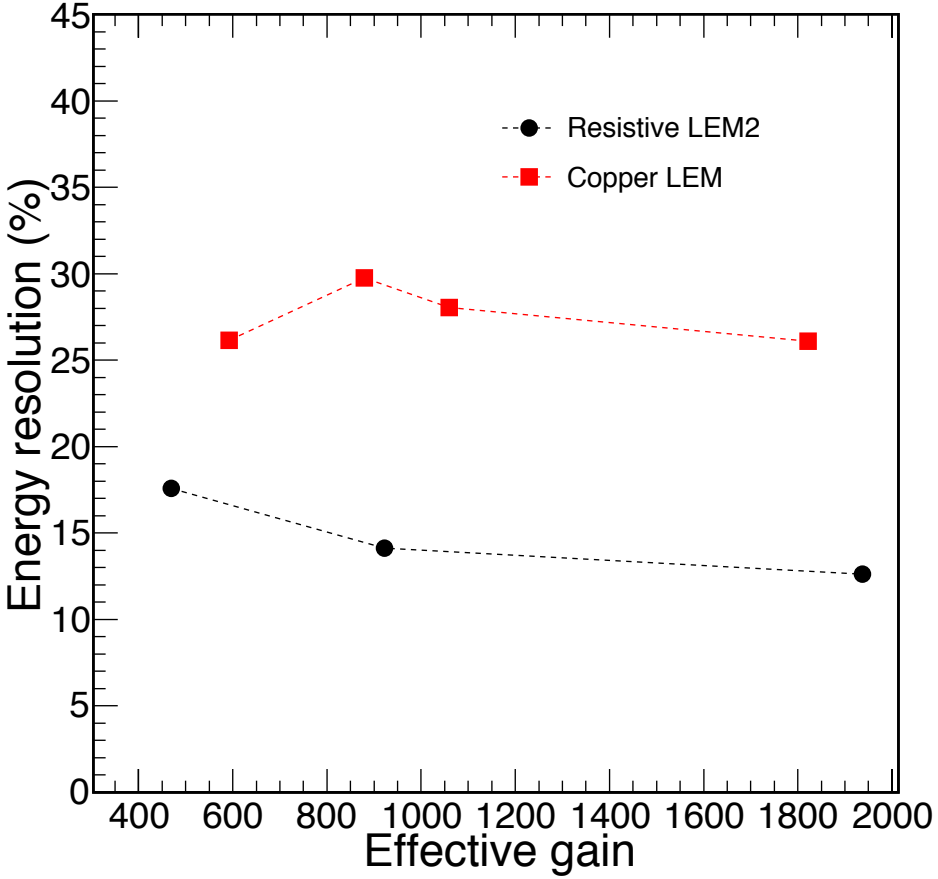
RKLEM has a lower discharge rate than copper LEM under ^{55}Fe (~1 kHz)



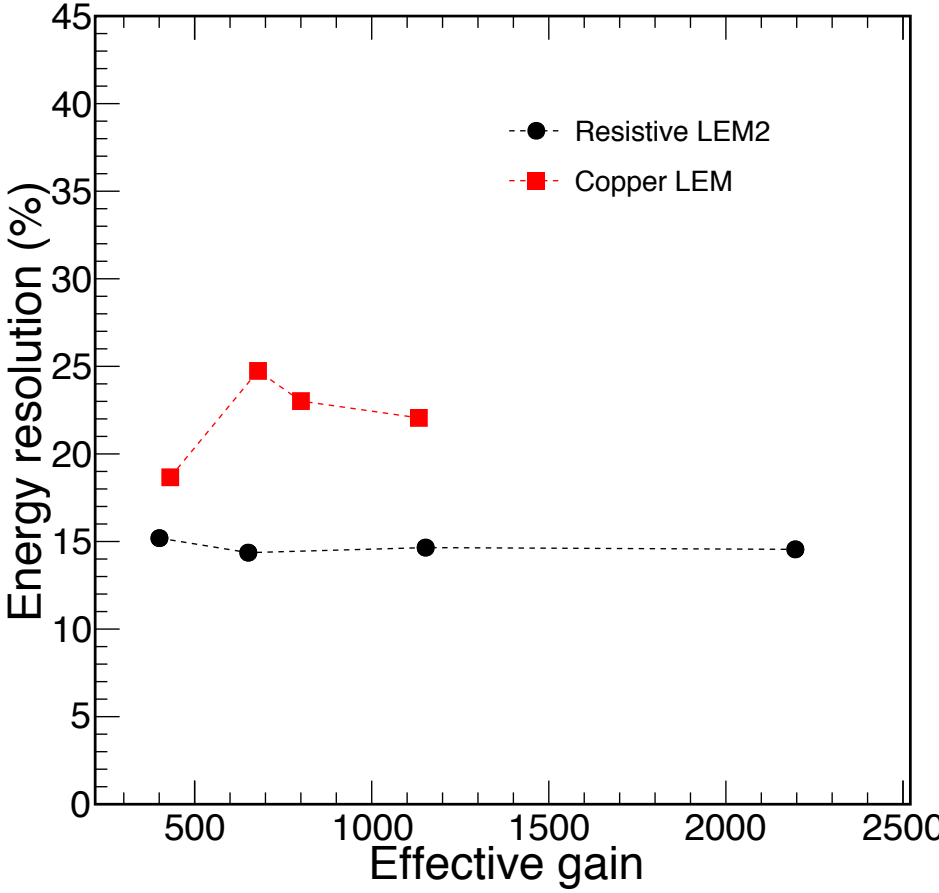


RKLEM has a better energy resolution

pure argon



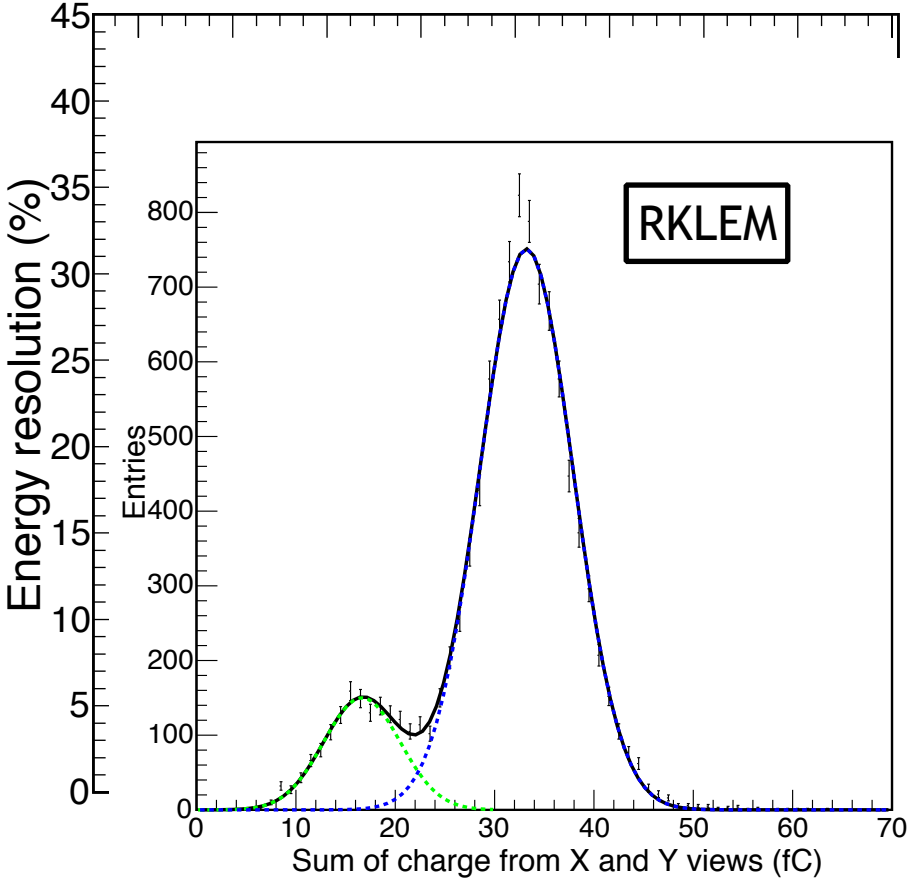
Ar(90%)+CO2(10%)



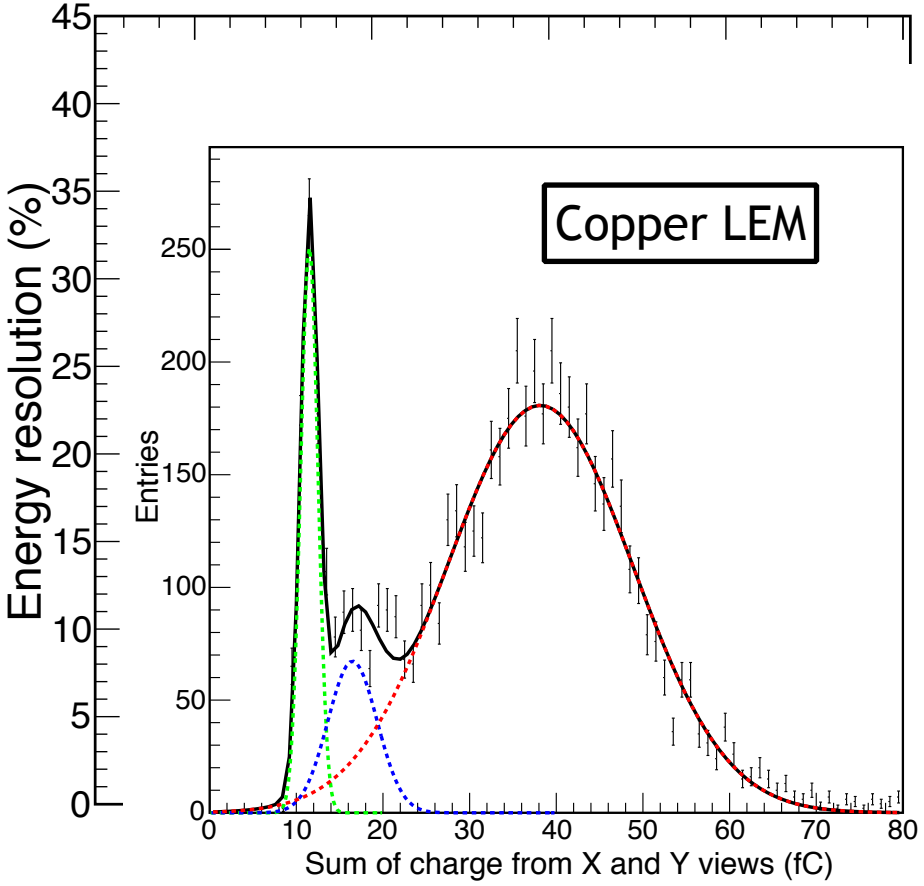
Possible due to 0 rim size? (rim size precision ~5 um for CU LEM)

RKLEM has a better energy resolution

pure argon



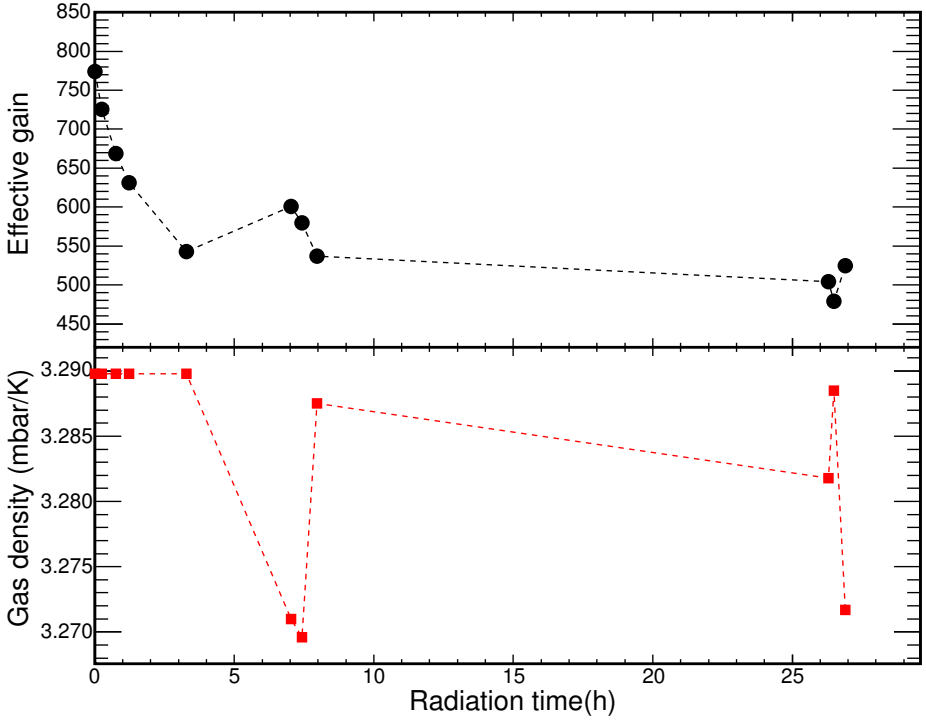
Ar(90%)+CO2(10%)



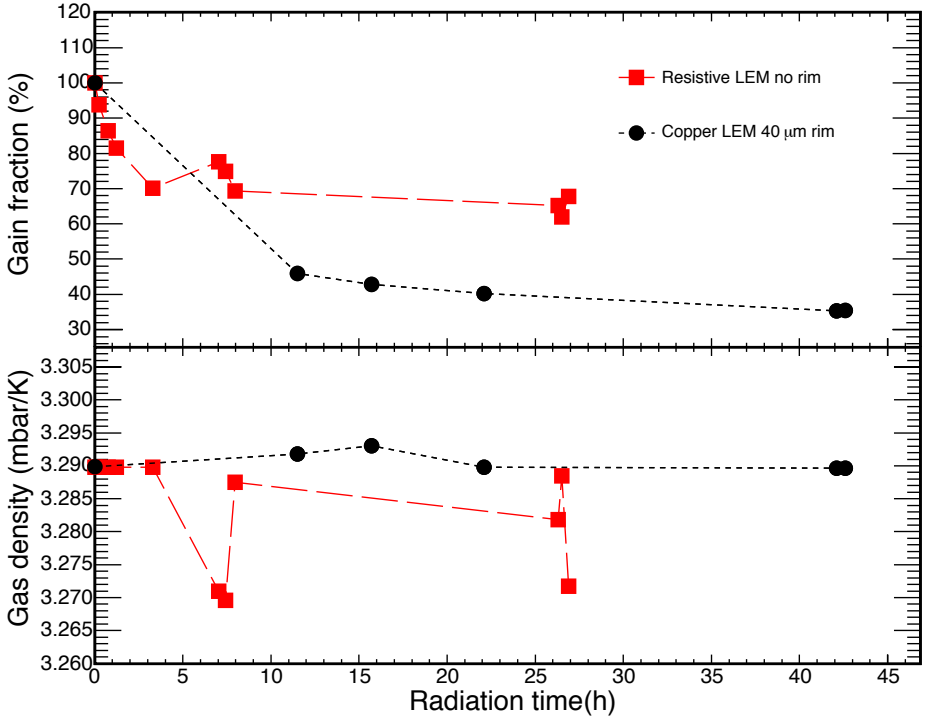
Possible due to 0 rim size? (rim size precision ~5 um for CU LEM)

RKLEM gain stability under ^{55}Fe irradiation

RKLEM

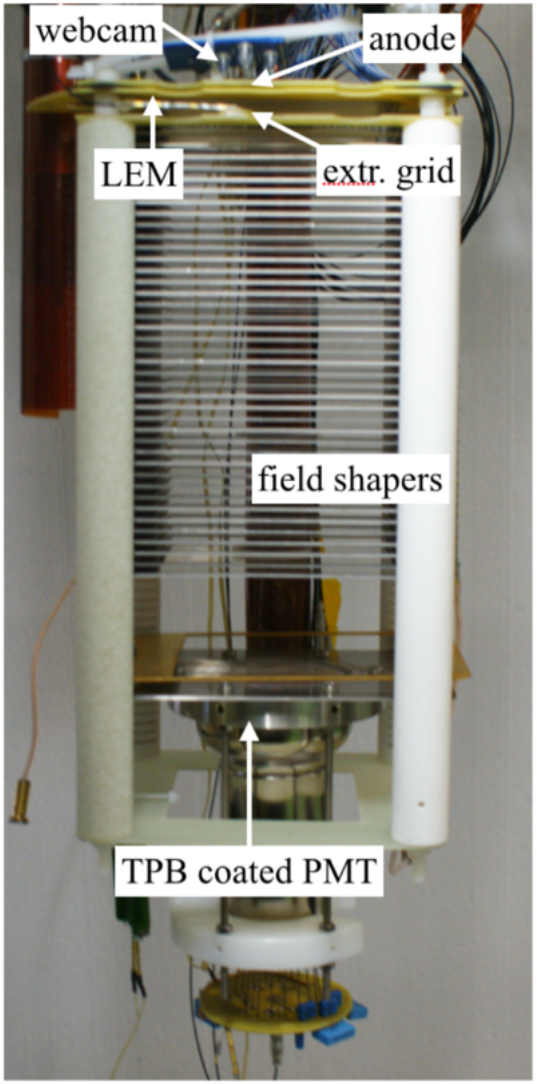


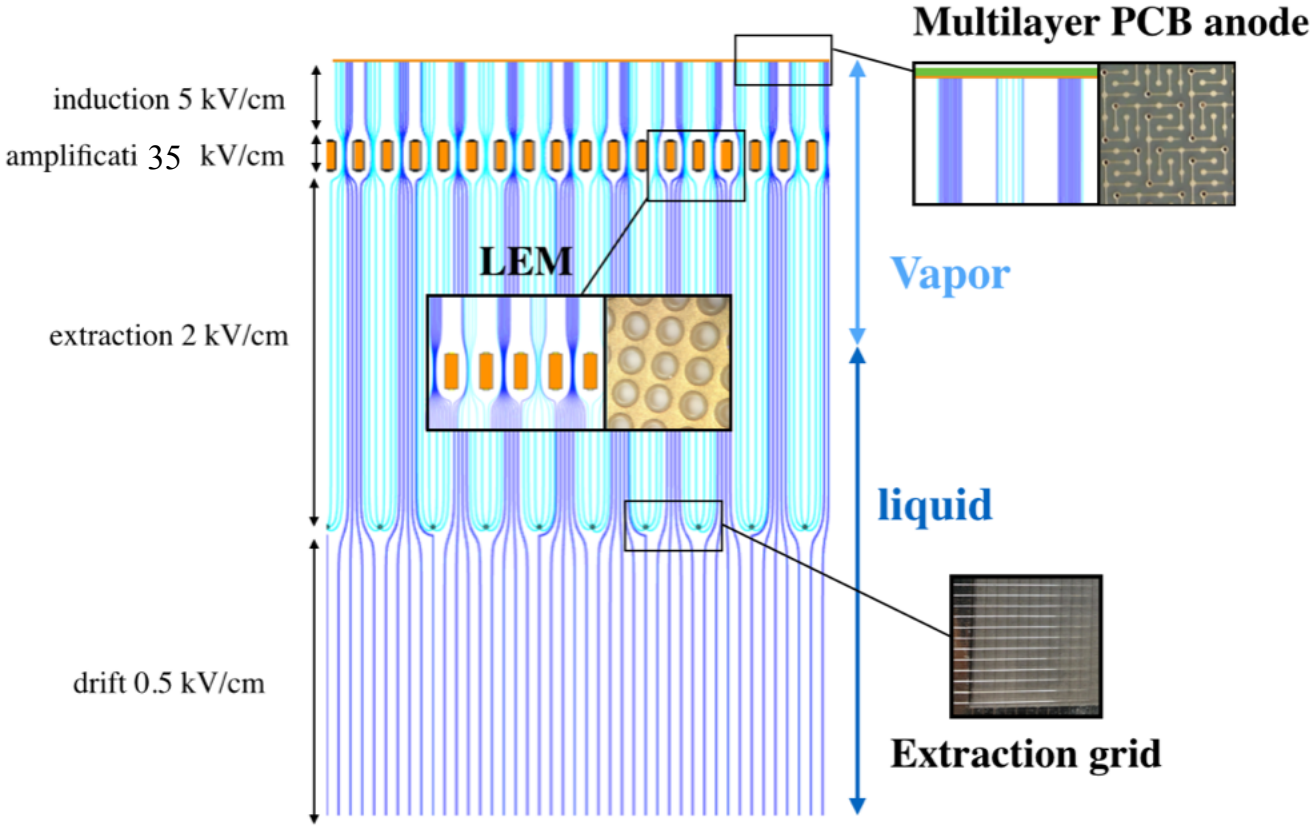
RKLEM and copper LEM



Higher (60%) gain fraction compared to copper LEM (30%) possibly due to zero rim size

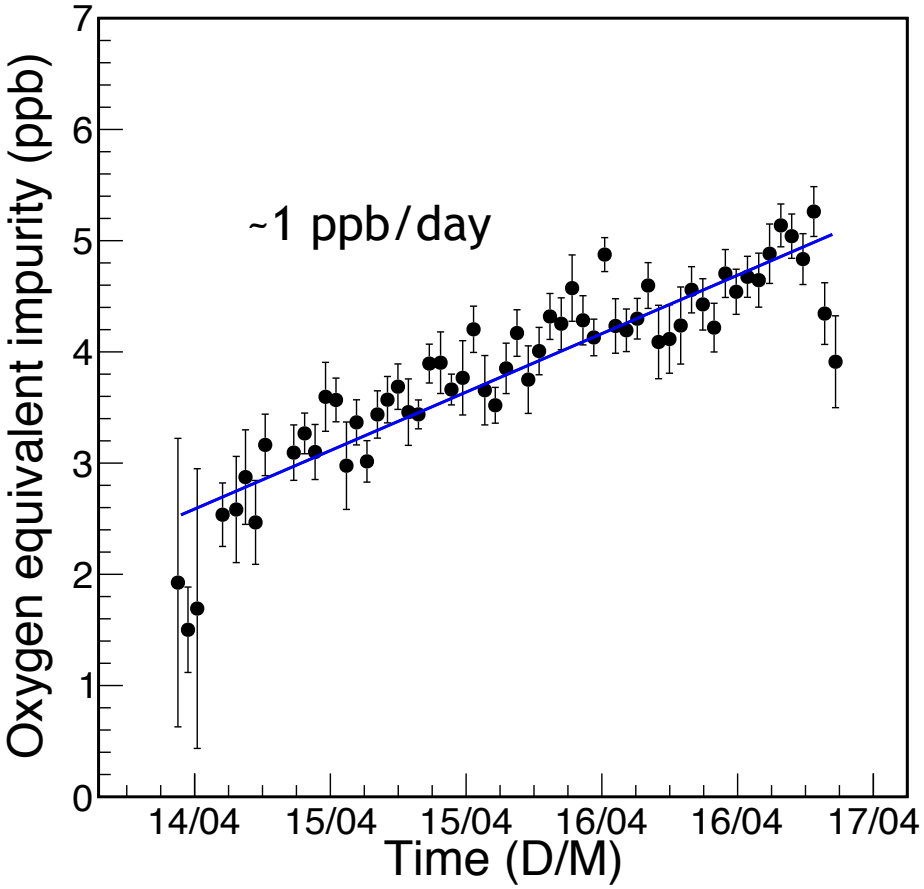
The “3 liter” double phase LAr TPC setup



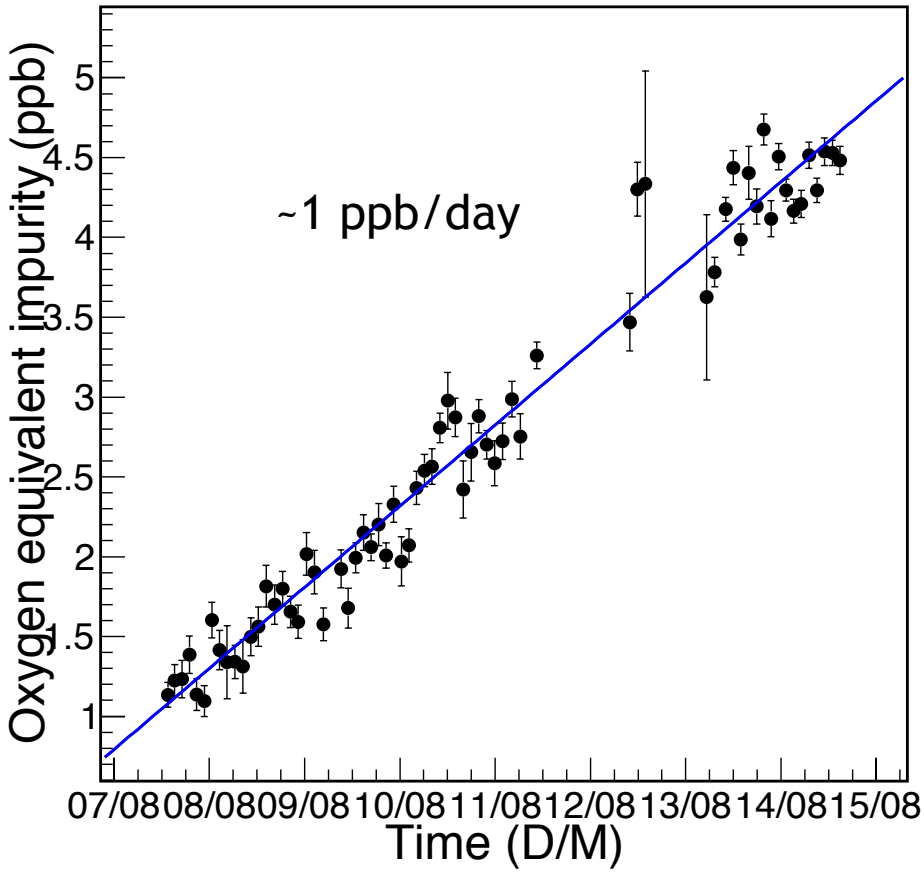


Kapton does not bring any issue to LAr purity

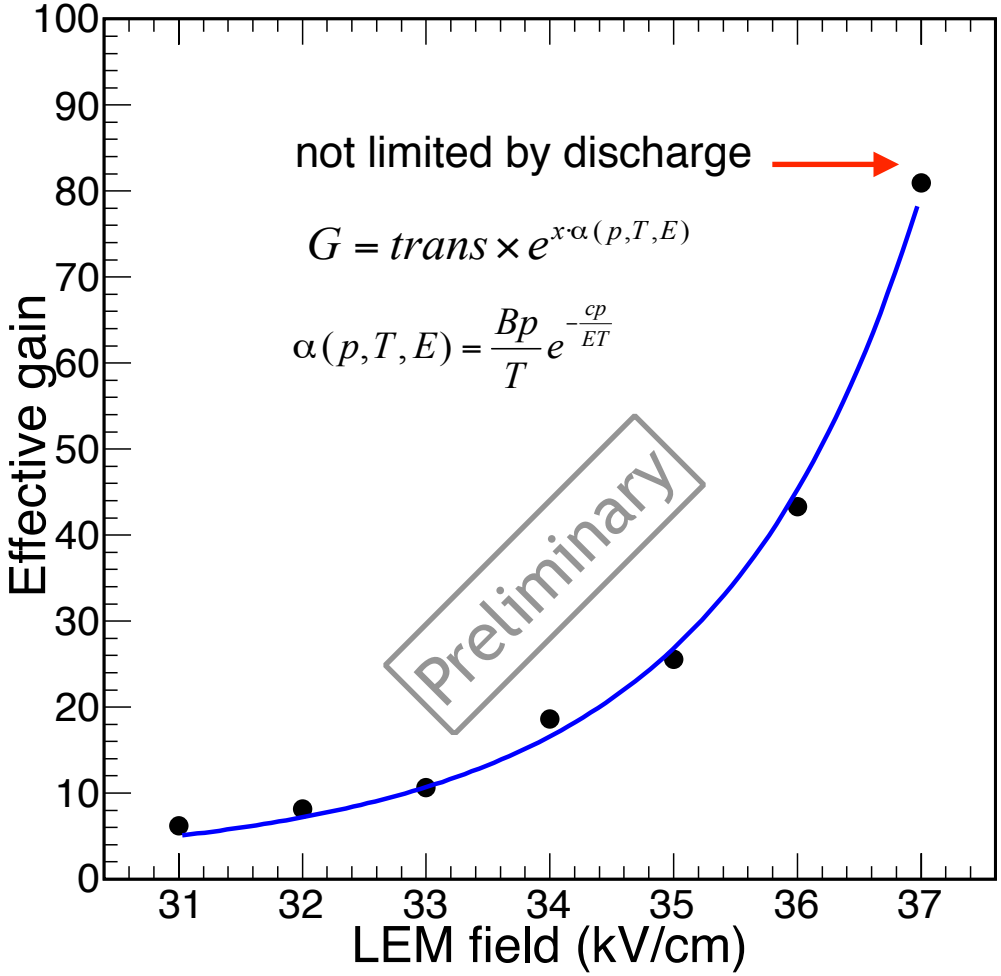
Kapton LEM



Copper LEM

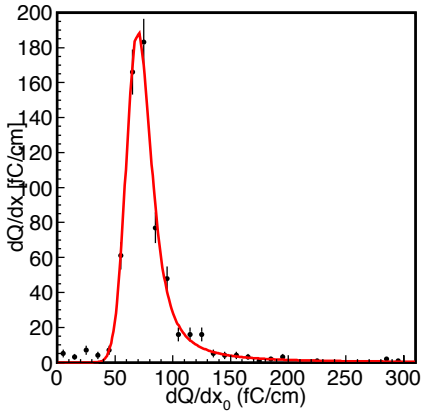


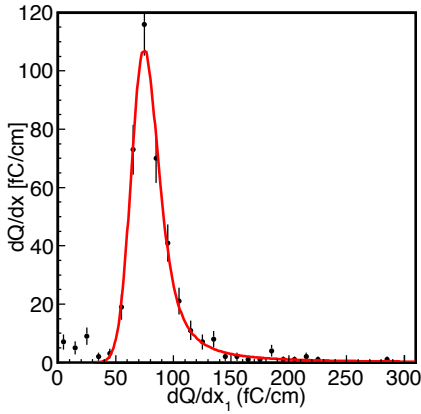
Effective gain as a function of LEM field



Effective gain= $\frac{< dQ/dx_0 > + < dQ/dx_1 >}{dQ/dx_{mip}}$

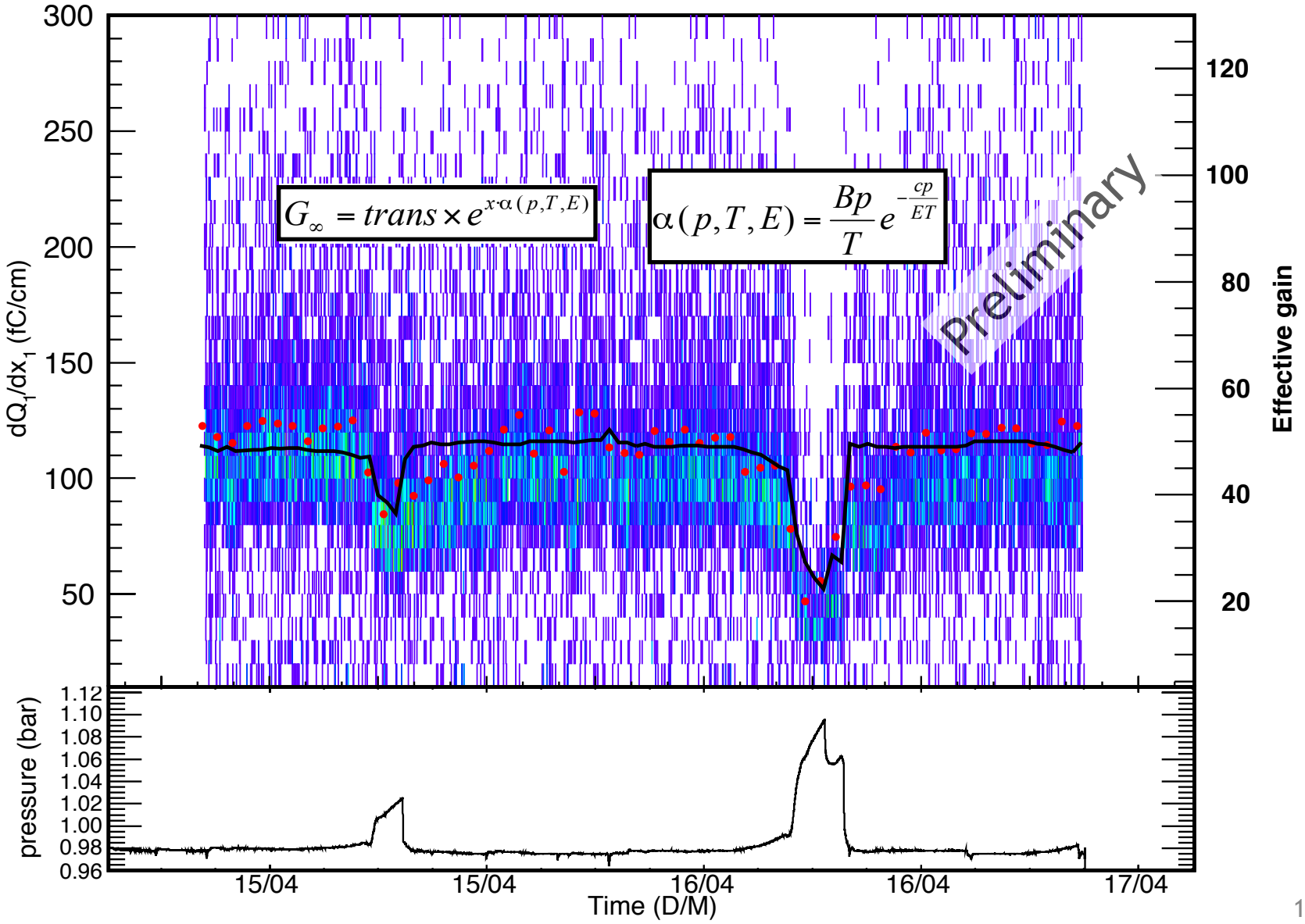
Landau distribution of MIP dQ/dx



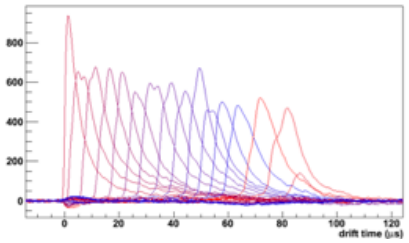


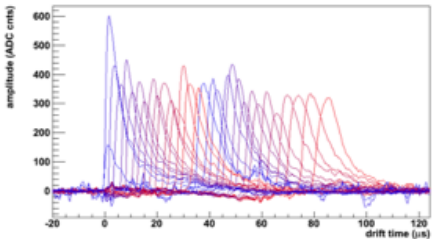
our goal: gain of 20 (SNR>100)

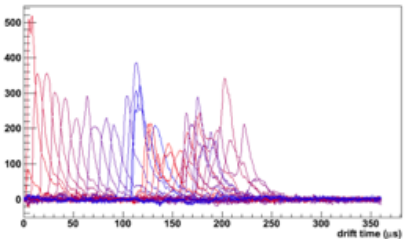
Stable operation at gain 50 for 2 days w/o discharge

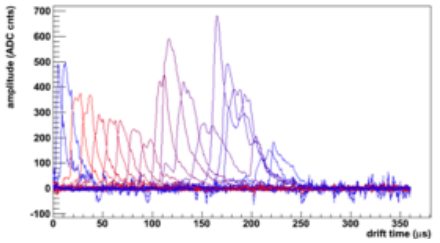


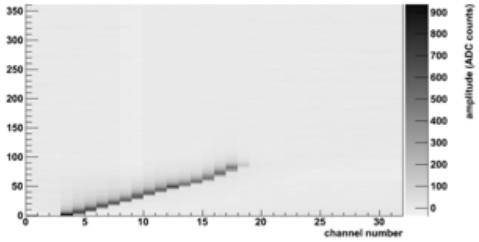
Event gallery

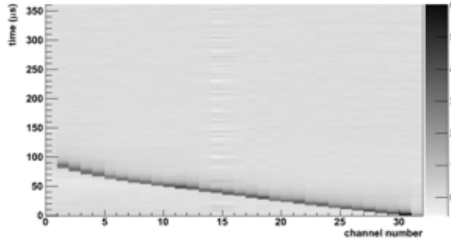


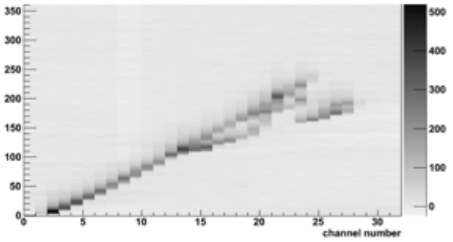


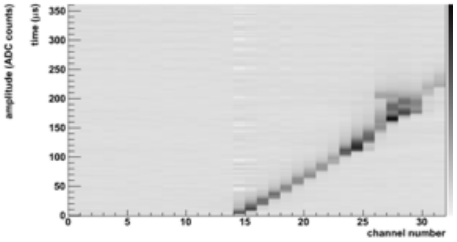


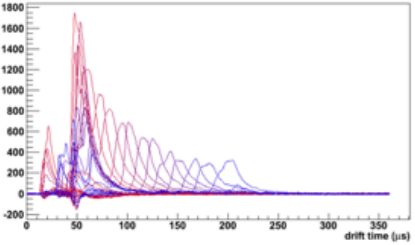


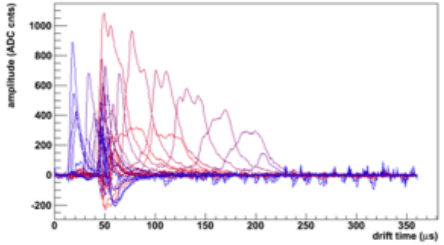


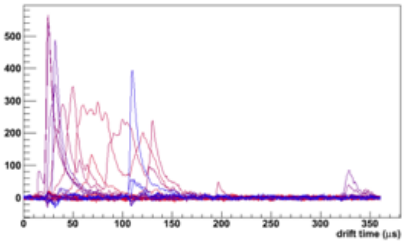


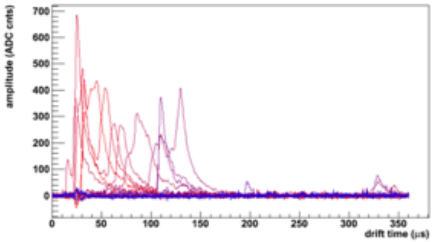


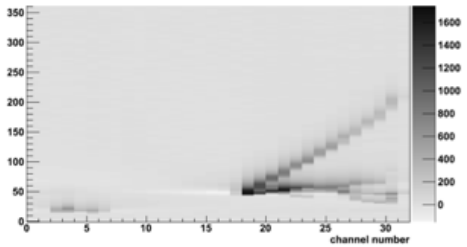


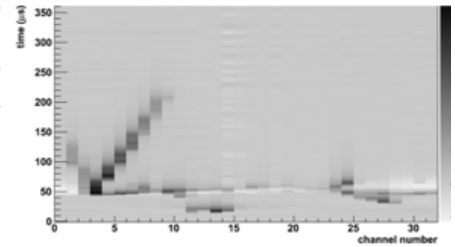


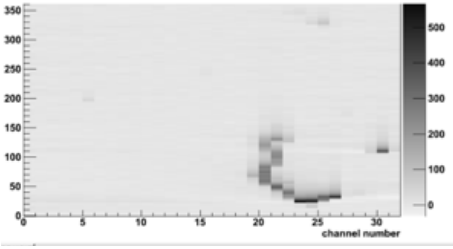


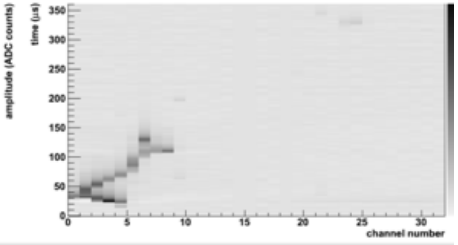






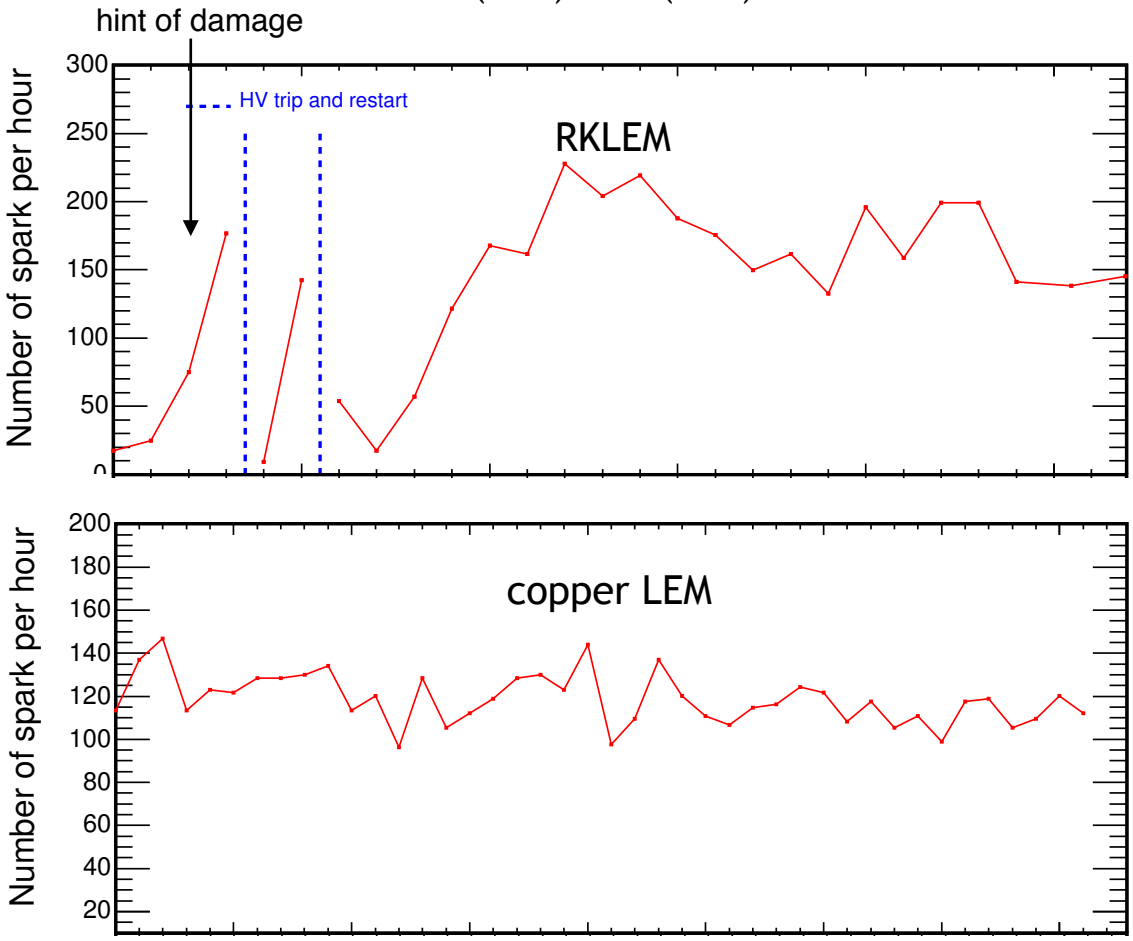




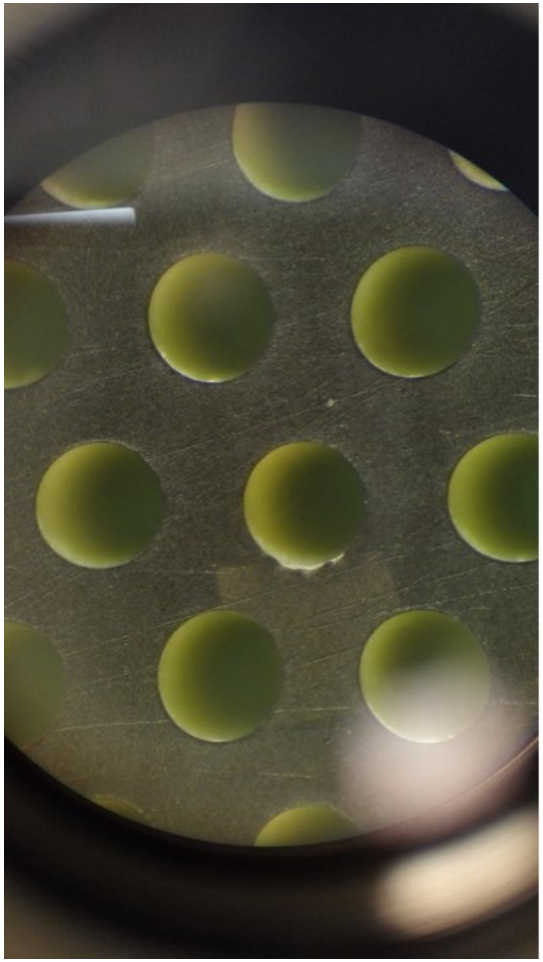


Yet, Kapton LEM seems to be fragile

Discharge rate during the ^{55}Fe irradiation in room T Ar(90%)+CO2(10%)



The burned hole



- The “damaged” RKLEM did not perform in double phase: gain<10
- The copper LEM performed well in double phase (gain~100) after discharges in warm gas
- The RKLEM performed well in double phase sparked limited times (<10) in gas first.

Summary

- The resistive Kapton (5 MOhm/sq) LEM has better energy resolution, lower discharge rate, near half the discharge energy and compatible gain compared to copper LEM with 40um rim in warm pure argon and ar(90%)+co2(10%).
- 5 MOhm/sq surface resistivity seems not high enough, thus a big resistor in series is needed — this brings dead time during discharges.
- The resistive Kapton LEM has similar performance as the copper LEM in double phase LAr TPC — maximal gain around 100 and stable operation at a gain of 50 over several days.
- However, the Kapton LEM seems less discharge resistant than copper LEM.
- A possible solution to remove the big series resistor and have better discharge resistance will be the DLC (Diamond Like Carbon) with ~1-10 GOhm/sq?

Thank you for your attention!