Resistive WELL
THGEM-based resistive concepts

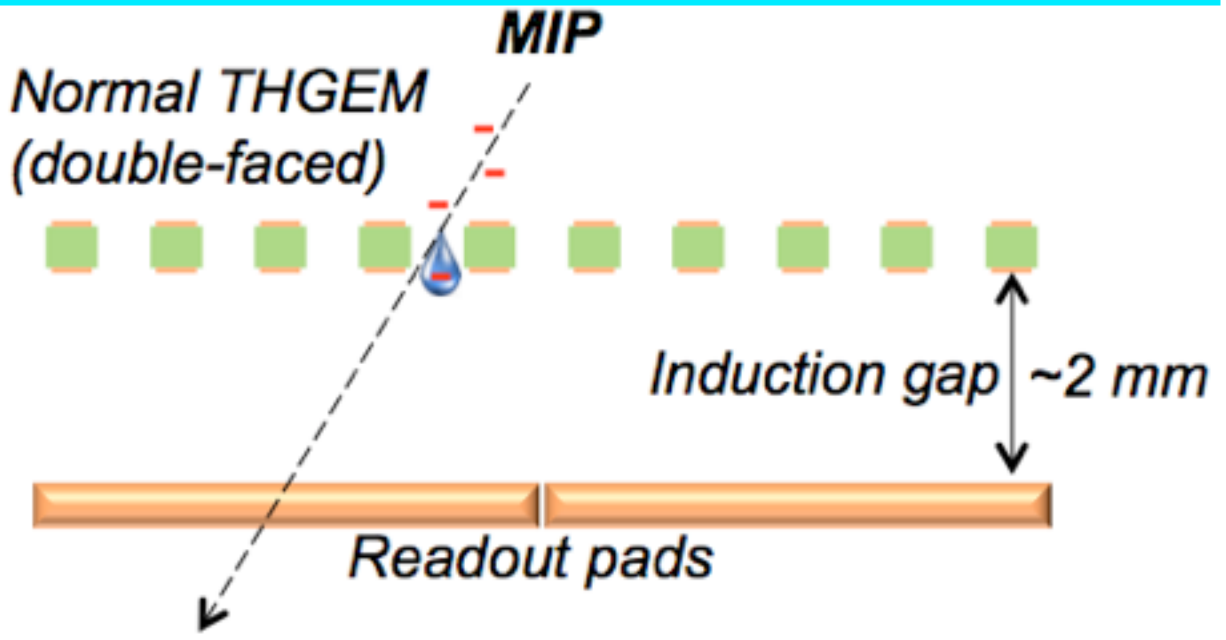
S. Bressler on behalf of the
WIS/Coimbra/Aveiro groups

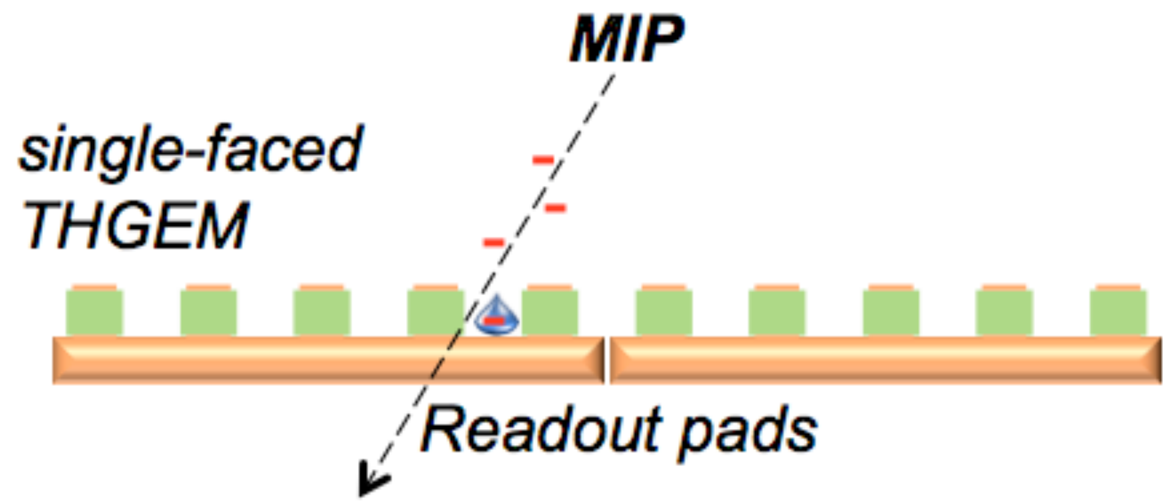
Points for consideration

- Performance of resistive detector is characterized in terms of
  - Efficiency & spatial resolution
    - **Pad multiplicity in ‘our’ case**
  - Discharge probability
  - Discharge energy
  - Rate capabilities
    - Gain at different rates (linear current response)
    - Gain at different primary ionization
  - Aging
    - Also of resistive material
    - Not yet studied by us

THGEM Vs. WELL

THGEM	WELL





THGEM

- Discharge - often between the top and bottom THGEM electrodes
  - Energy reaches also the anode - fraction depends on the size and field in the induction gap
- In presence of resistive THGEM/anode separation - charge accumulating on the anode is assumed to have small effect on the field inside the THGEM hole ⇒ resistive concepts more suitable to the WELL configuration

WELL

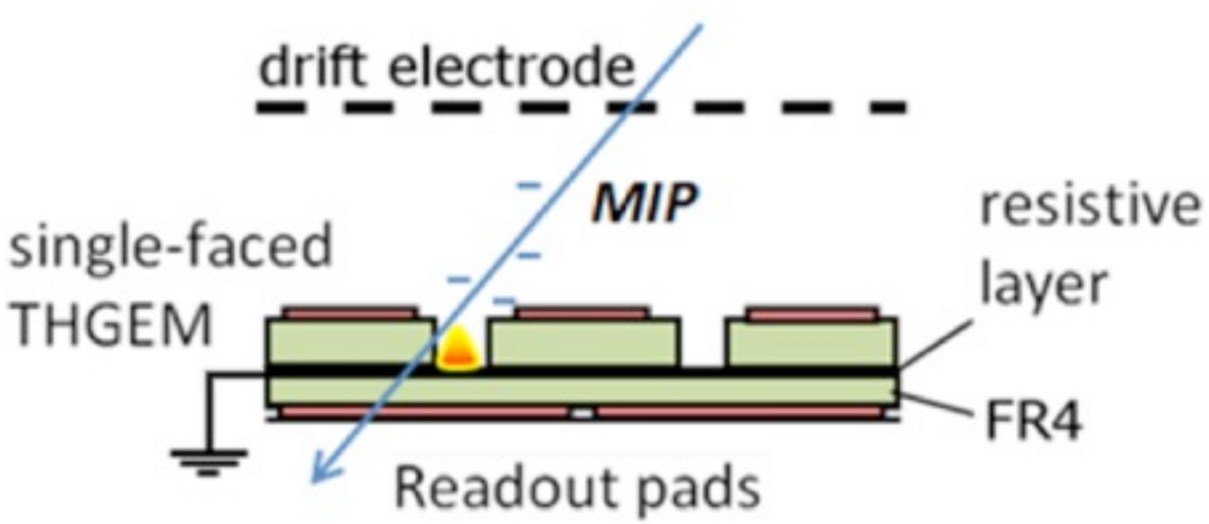
- Discharge - between the top electrode and anode
- All the energy reaches the anode
- In presence of resistive WELL/anode separation - charge accumulating on the anode reduces the field in the bottom of the hole ⇒ quenching the discharge energy

RWELL & SRWELL

L. Arazi et. al. JINST 9 (2014) P04011
L. Arazi et. al. JINST 7 (2012) C05011

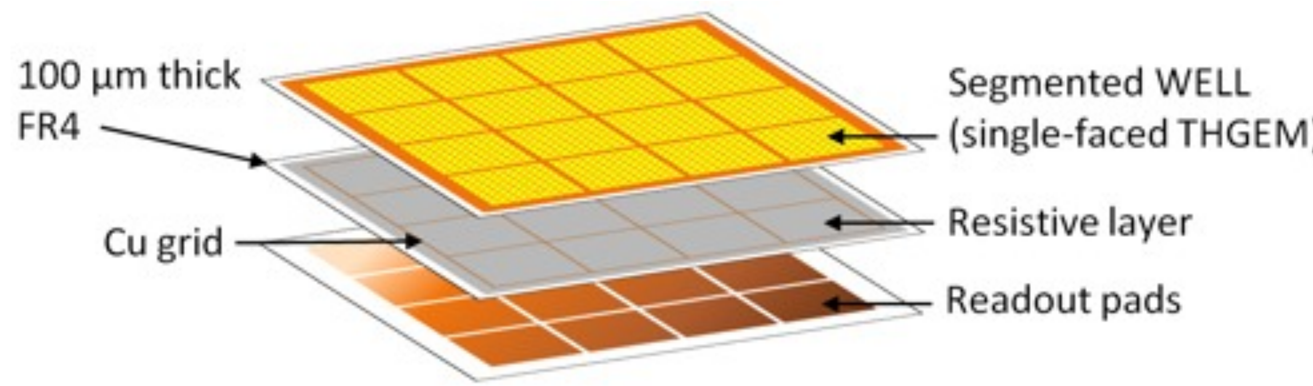
Resistive WELL

- Exploits technologies developed at WIS for the Thin Gap Chambers
- Well coupled to a resistive layer (1-20MΩ/square) - *graphite epoxy mixture*
- Pads separated from the RL by thin insulating sheet
- Charge induced in the readout pads
- RL quenches discharge energy
  - Not reducing their rate (?)



Segmented Resistive WELL

- Cross talk due to charge propagation across the RL is avoided by adding a Cu greed underneath
- The electrode is segmented accordingly to prevent discharge in holes residing directly above grid lines



- Reintroducing direct path between conductive areas on the electrode and the anode
- Conceptually, degrades uniformity

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RWELL & SRWELL

L. Arazi et. al. JINST 9 (2014) P04011
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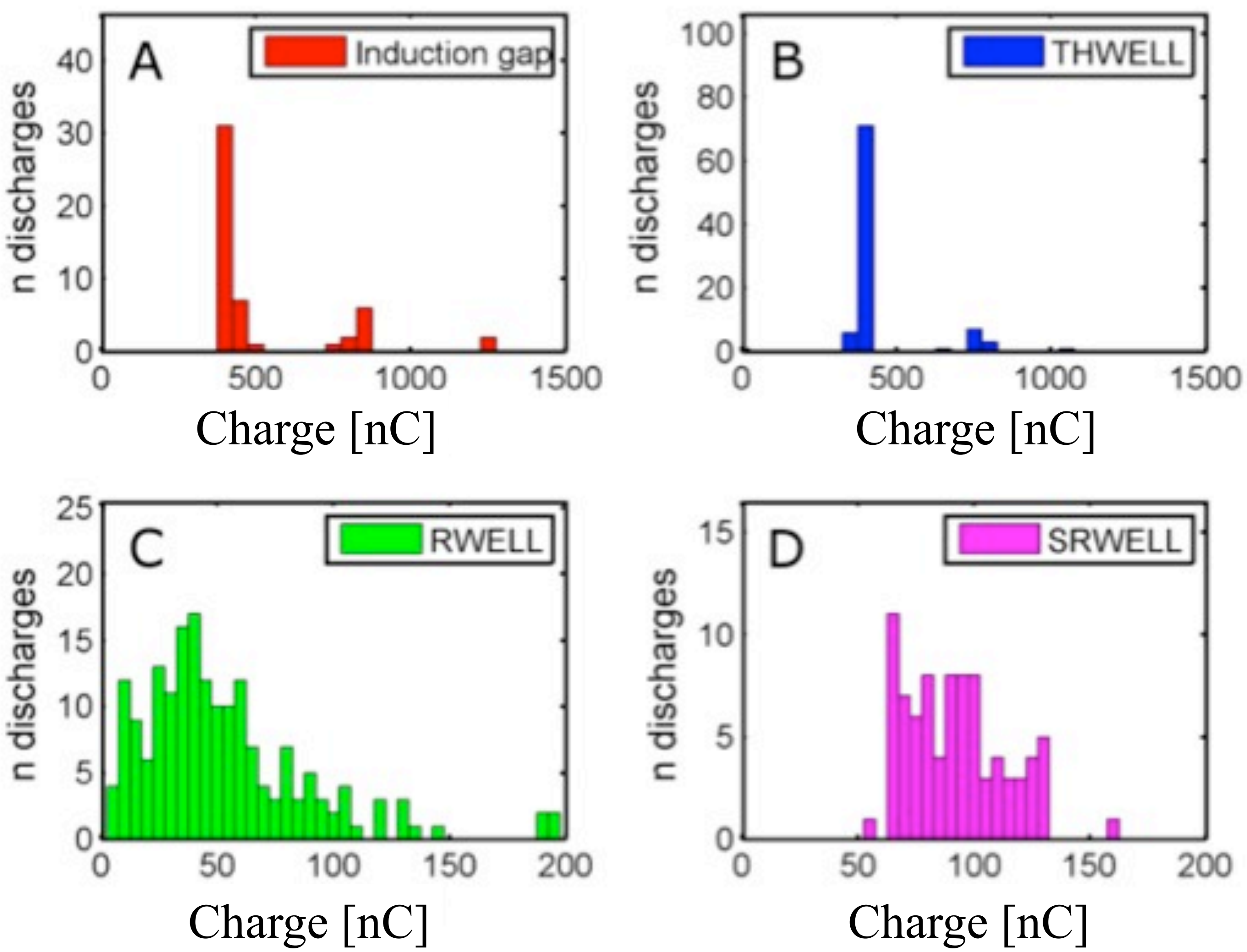
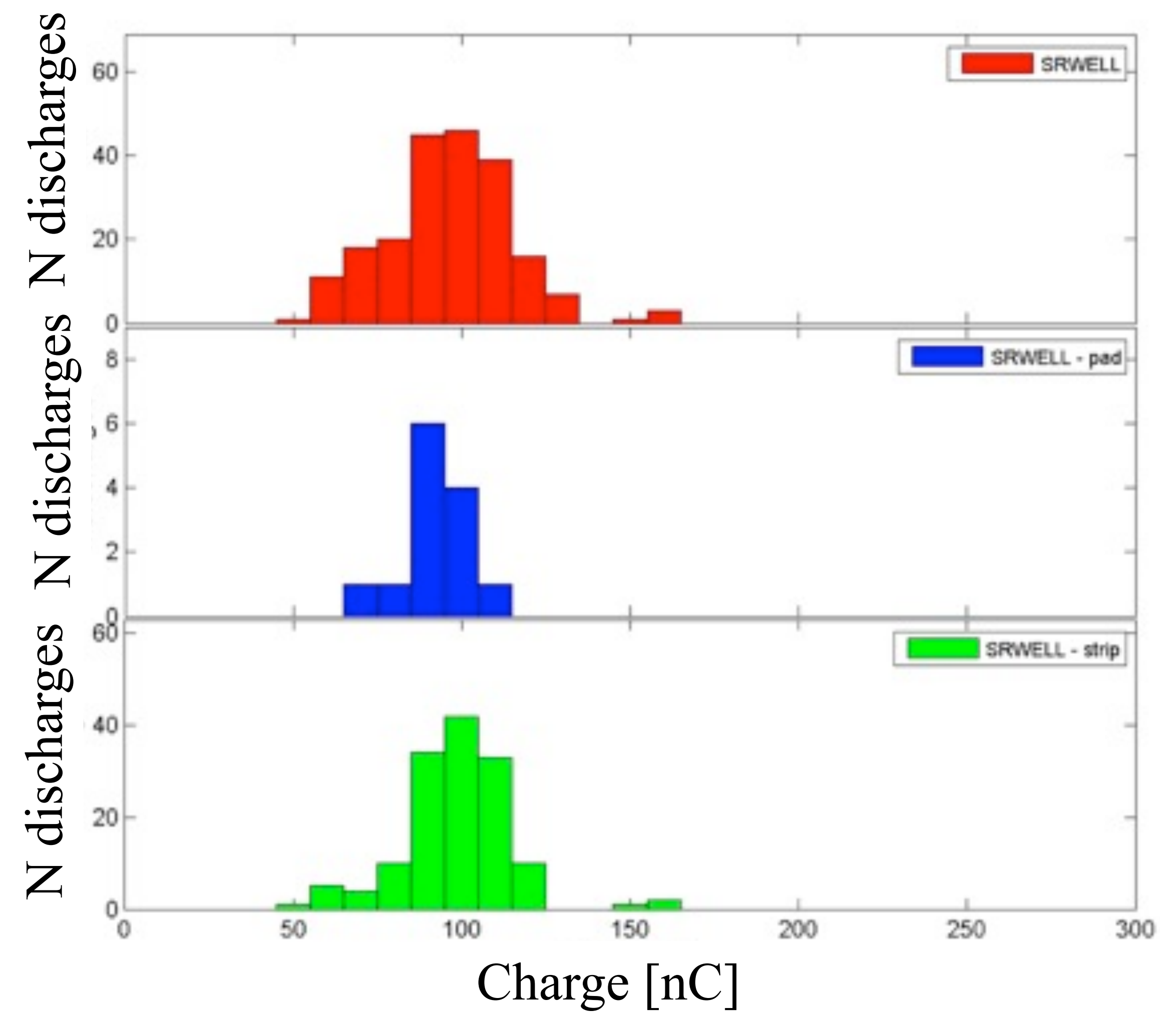
- Spark energy magnitude quenched by a factor of 20/5 in SRWELL/RWELL
- Cu strip reduces the quenching
- Spark magnitude not affected by the distance from the strips





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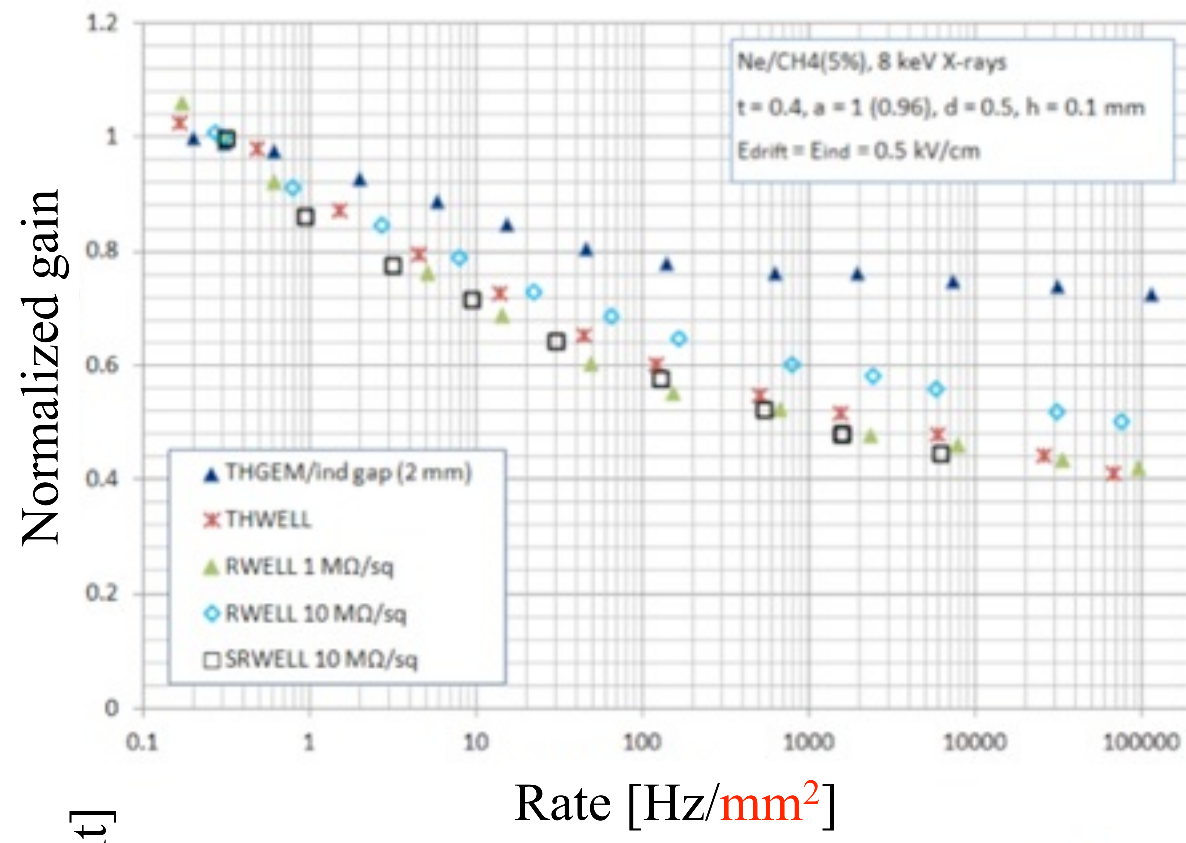
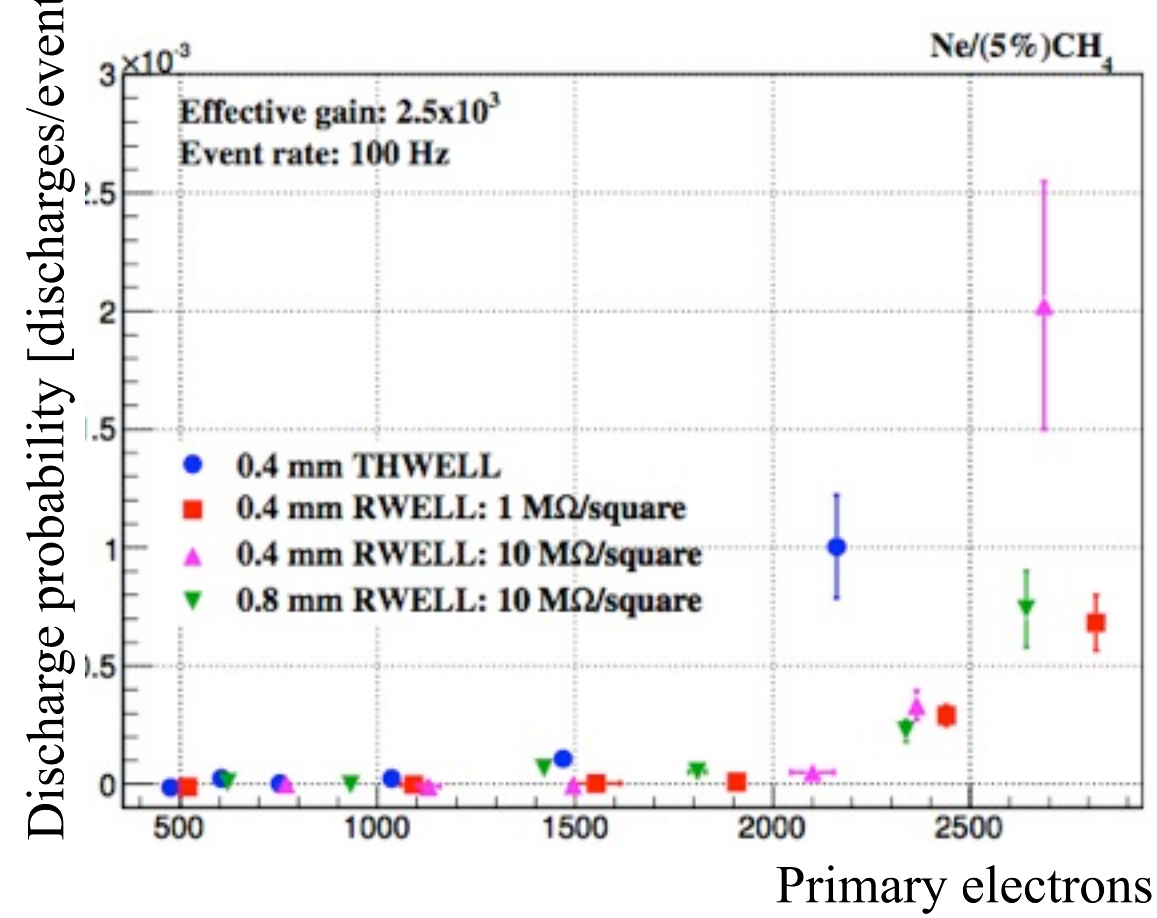
RWELL & SRWELL

L. Arazi et. al. JINST 9 (2014) P04011
L. Arazi et. al. JINST 7 (2012) C05011
S. Bressler et. al. JINST 9 (2014) P030051

- Gain loss at high rate
    - Similar regardless of the resistivity value ⇒ at least part of the effect is not related to the resistive layer
- Narrow dynamic range ⇒ with this resistivity values discharges are not avoided
    - Their energy is quenched



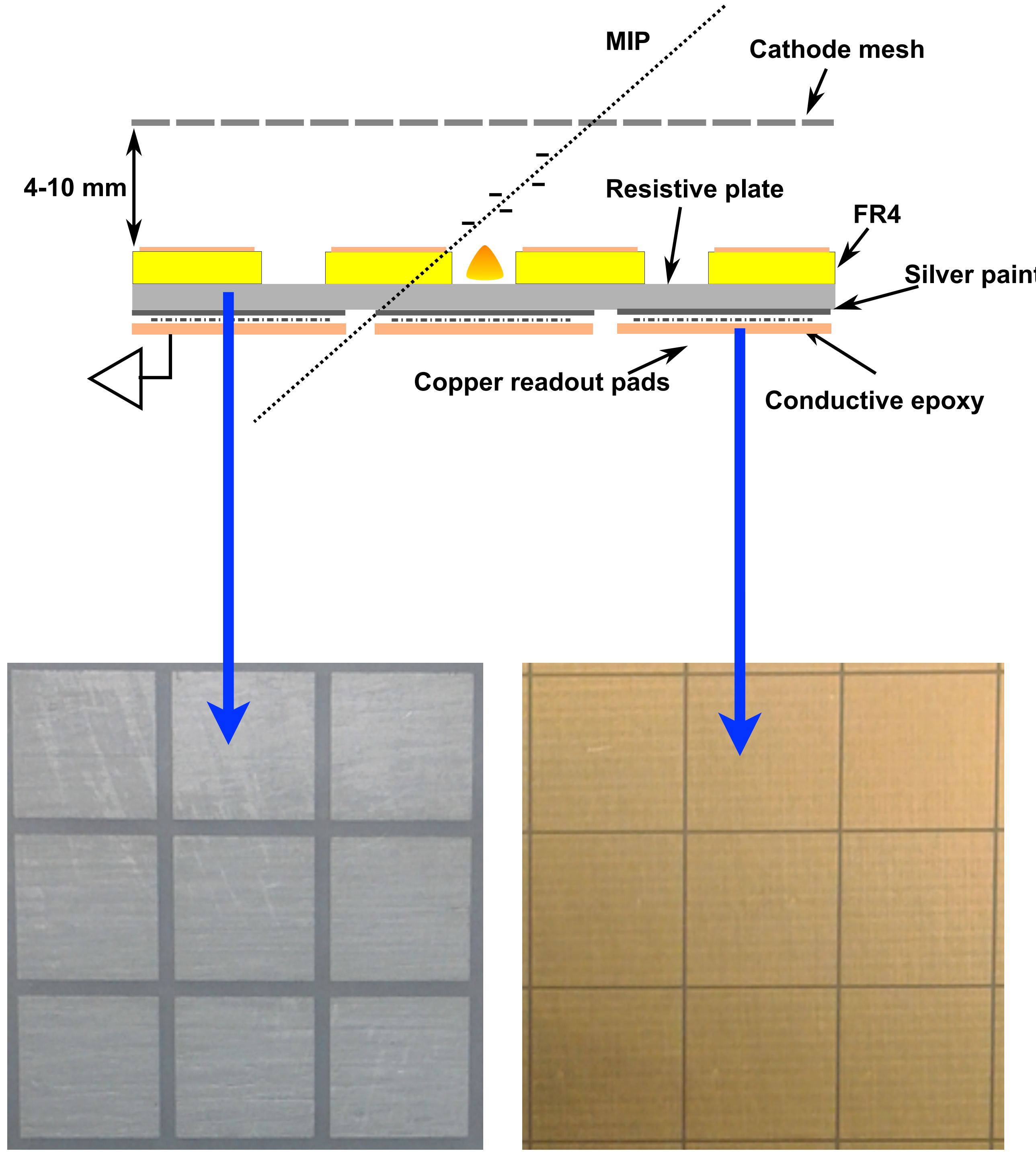


The RPWELL detector

A. Rubin et. al, JINST 8 P11004 2013

Resistive **P**late **WELL**:

- WELL coupled to materials with large bulk resistivity
- The charge is induced on the readout pads
- The avalanche charge flows through the plate to the anode
- Uniform detector
  - Up to RP uniformity



Tested materials

Material	Dimensions [mm]	Bulk resistivity [Ωcm]
VERTEC 400 glass	36×31×0.4	8×10^{12}
HPL Bakelite	29×29×2	2×10^{10}
Semitron ESD 225	30×30×2	2×10^{9}

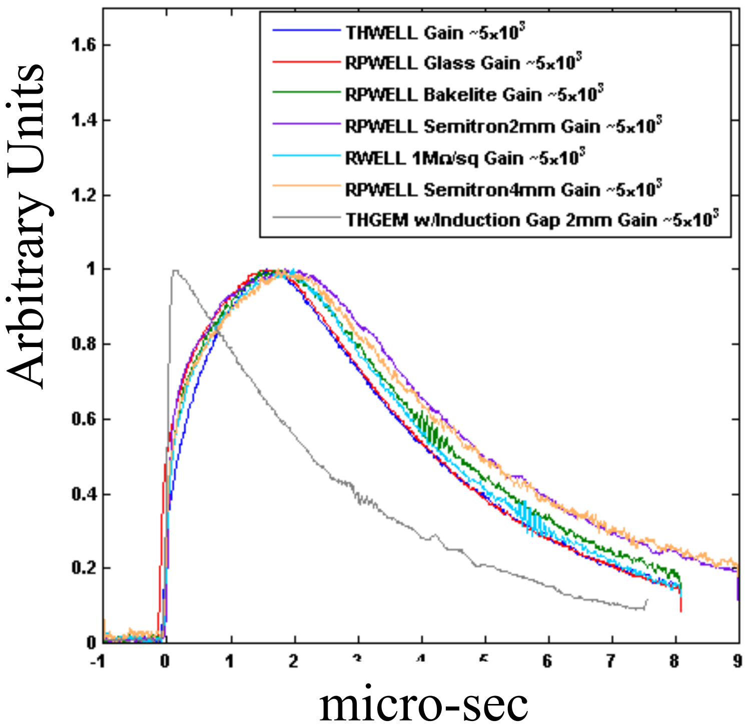
The RPWELL detector

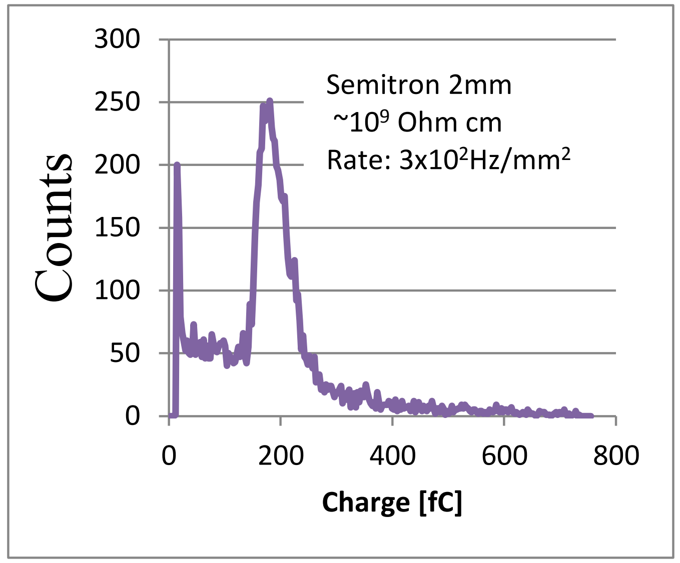
A. Rubin et. al, JINST 8 P11004 2013

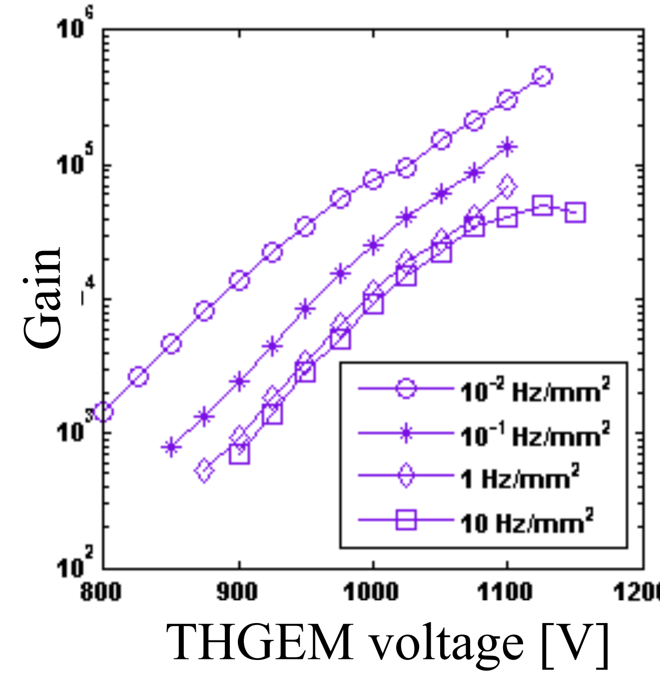
Lab. studies

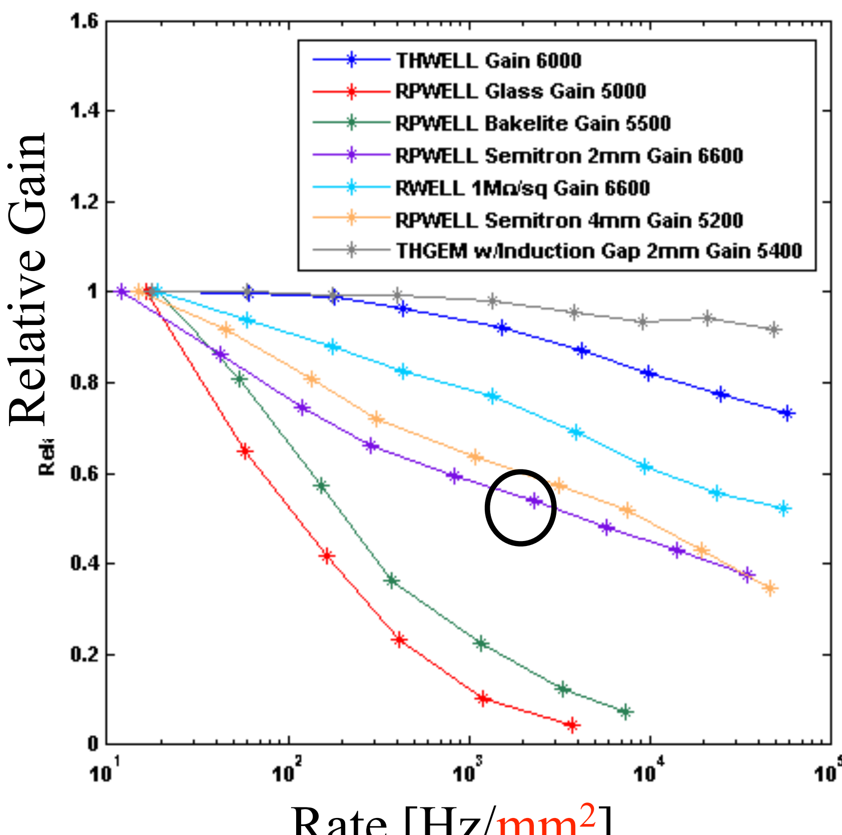
Characterization in Ne/5%CH_4

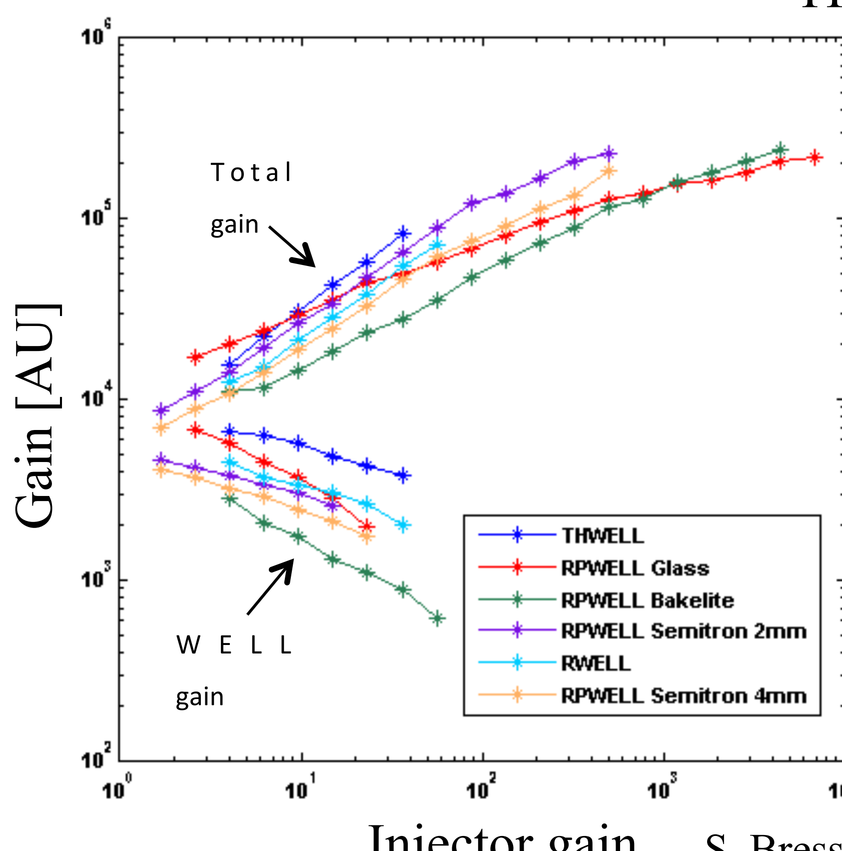
RPWELL 10^9 Ωcm - 2 mm layer











- Same pulse shape as standard well
- ~20% Energy resolution
- Gain saturation at high irradiation rate
- < 50% gain drop over 4 orders of rate magnitudes
- **No discharges at high rate of HIPs**

S. Bressler et. al. JINST 9 (2014) P030051

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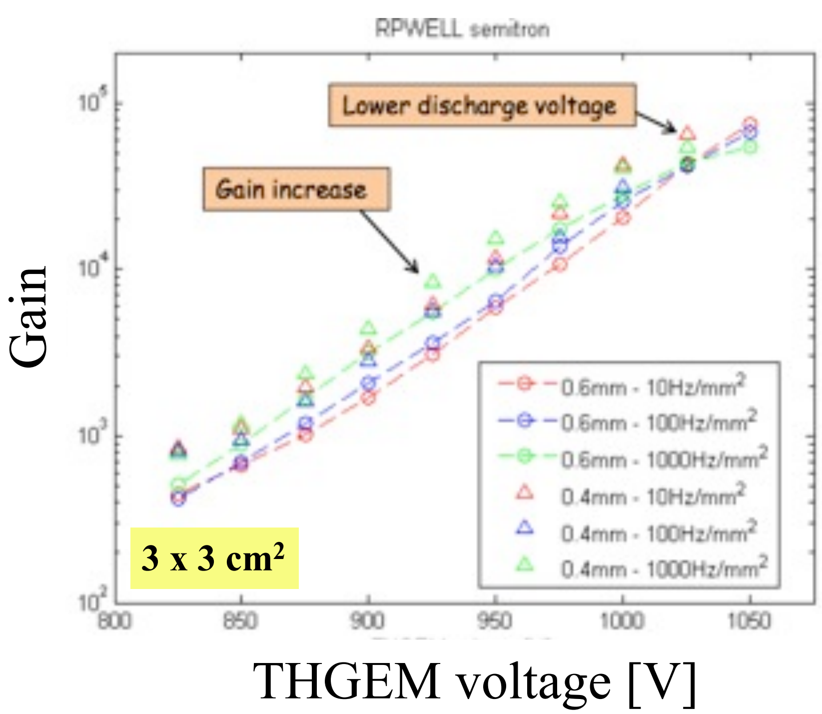
The RPWELL detector

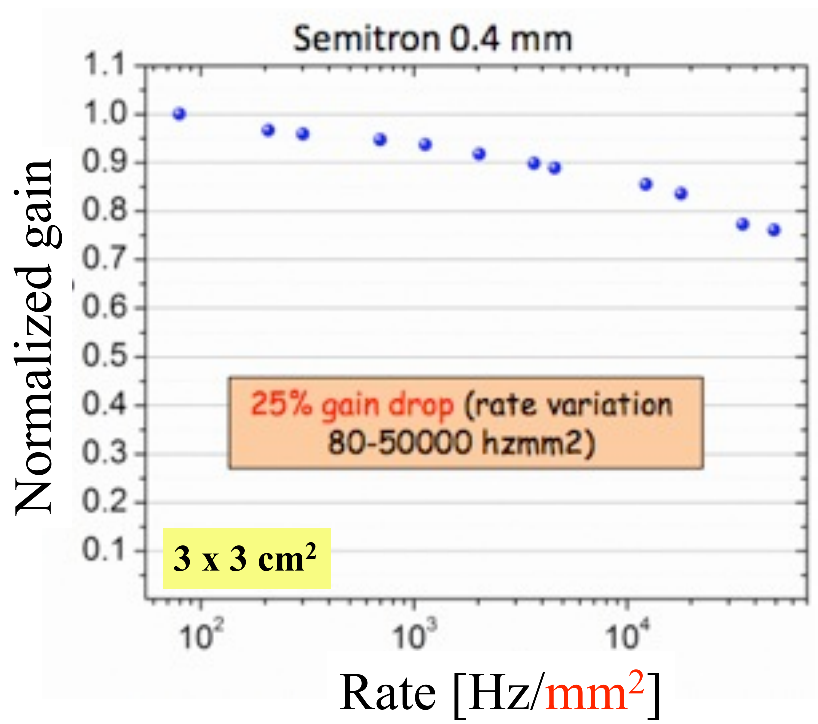
Lab. studies | Characterization in Ne/5%CH_4

Improved performance with thinner (0.4 & 0.6 mm) layers



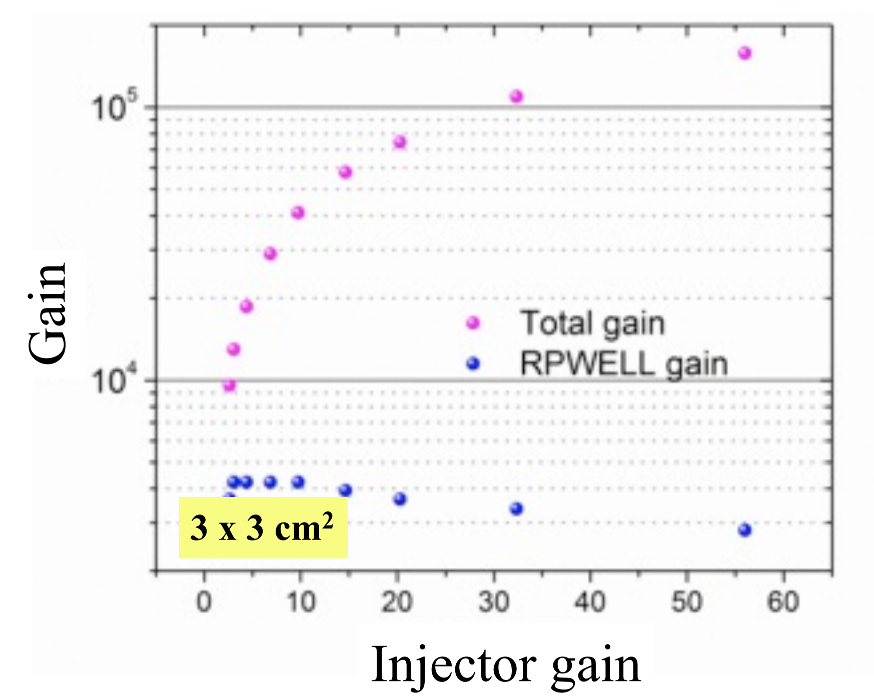
Higher gain for the same voltage

- Smaller anode-cathode gap



Gain drops slower with rate

- Lower resistivity



Stable with HIPs

- Observe gain saturation

Focus on thin Semitron ESD 225 layers

The RPWELL detector

S. Bressler et. al, arxiv:1510.03116

Beam studies

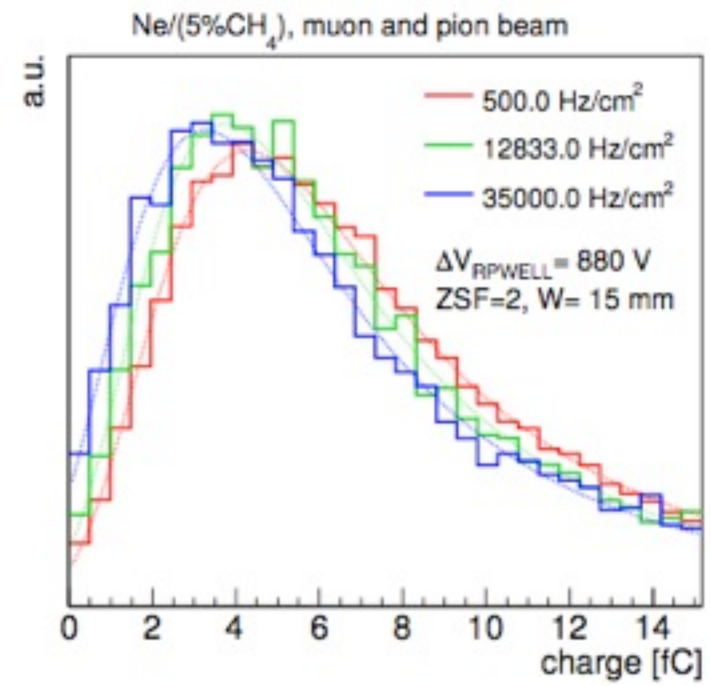
150 GeV μ & π beams

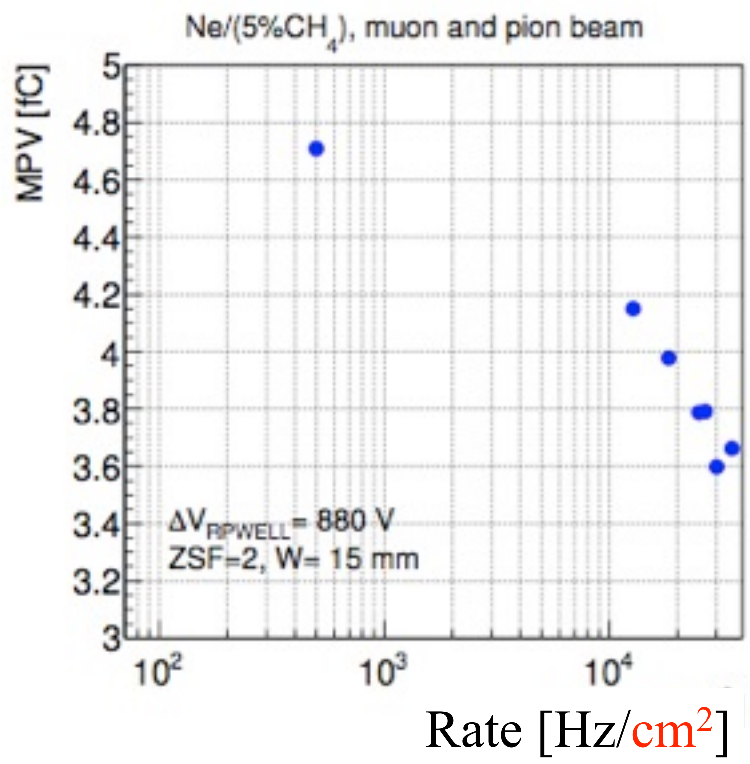
- ~20% gain drop over 2 orders of rate magnitudes

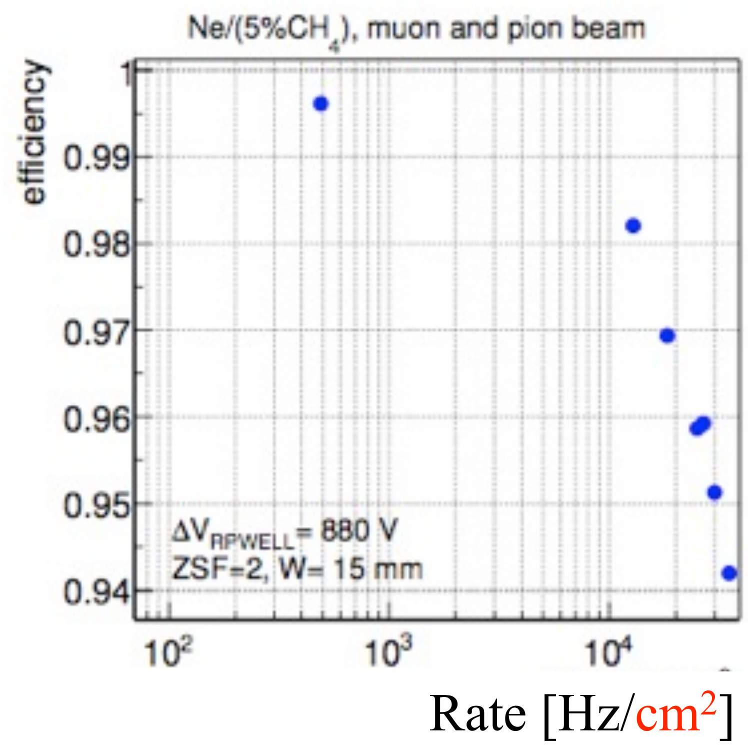
  ⇒

- ~5% efficiency loss
  - Can be avoided with slightly higher nominal operation voltage (still in discharge-free) mode

10×10 cm^2 detector in $Ne/5\%CH_4$







Discharge-free operation also at high rate π-beam

The RPWELL detector

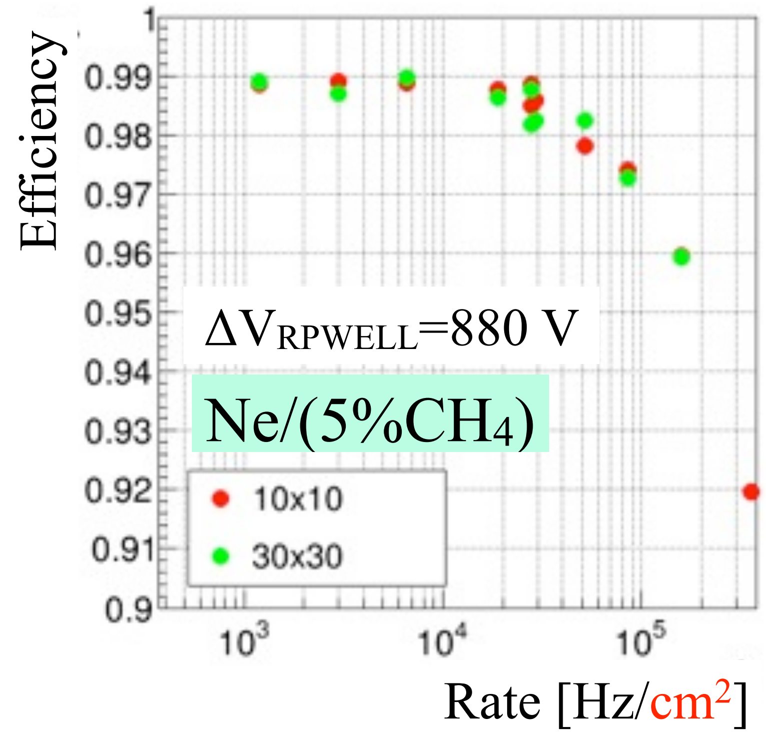
Beam studies

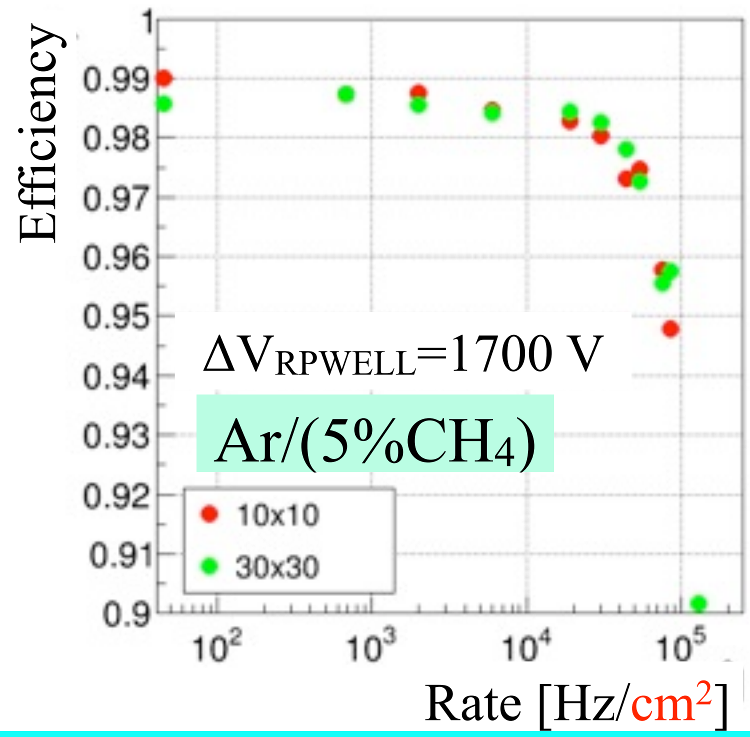
Ne/5%CH_4 - Ar/5%CH_4 - Ar/7%CO_2

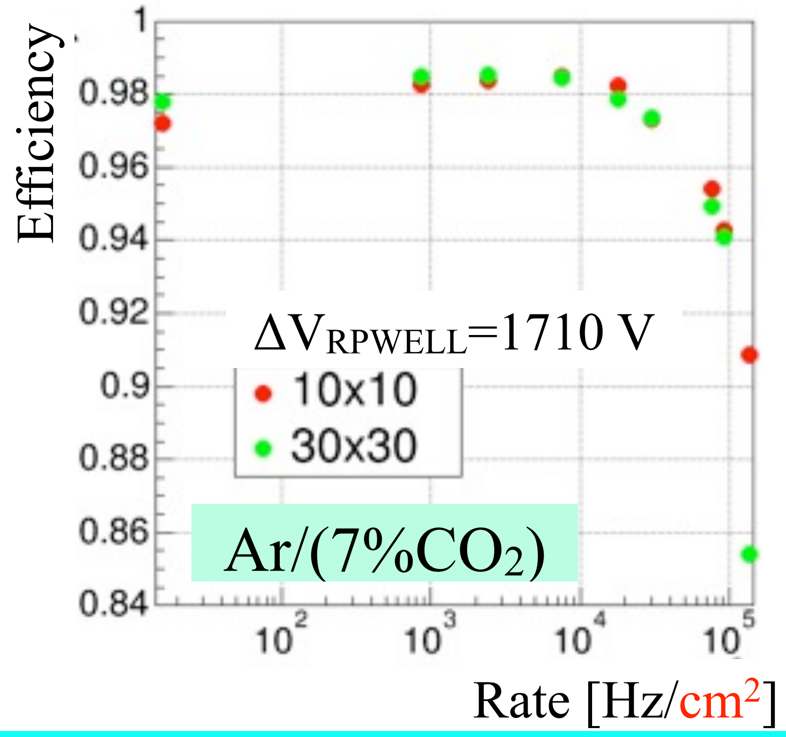
150 GeV μ & π beams

- Similar rate dependence for both 10×10 cm^2 & 30×30 cm^2 detectors

- ~5% efficiency loss over 3 orders of rate magnitudes
  - Can be avoided by defining higher nominal operation voltage
  - Still maintain discharge-free operation







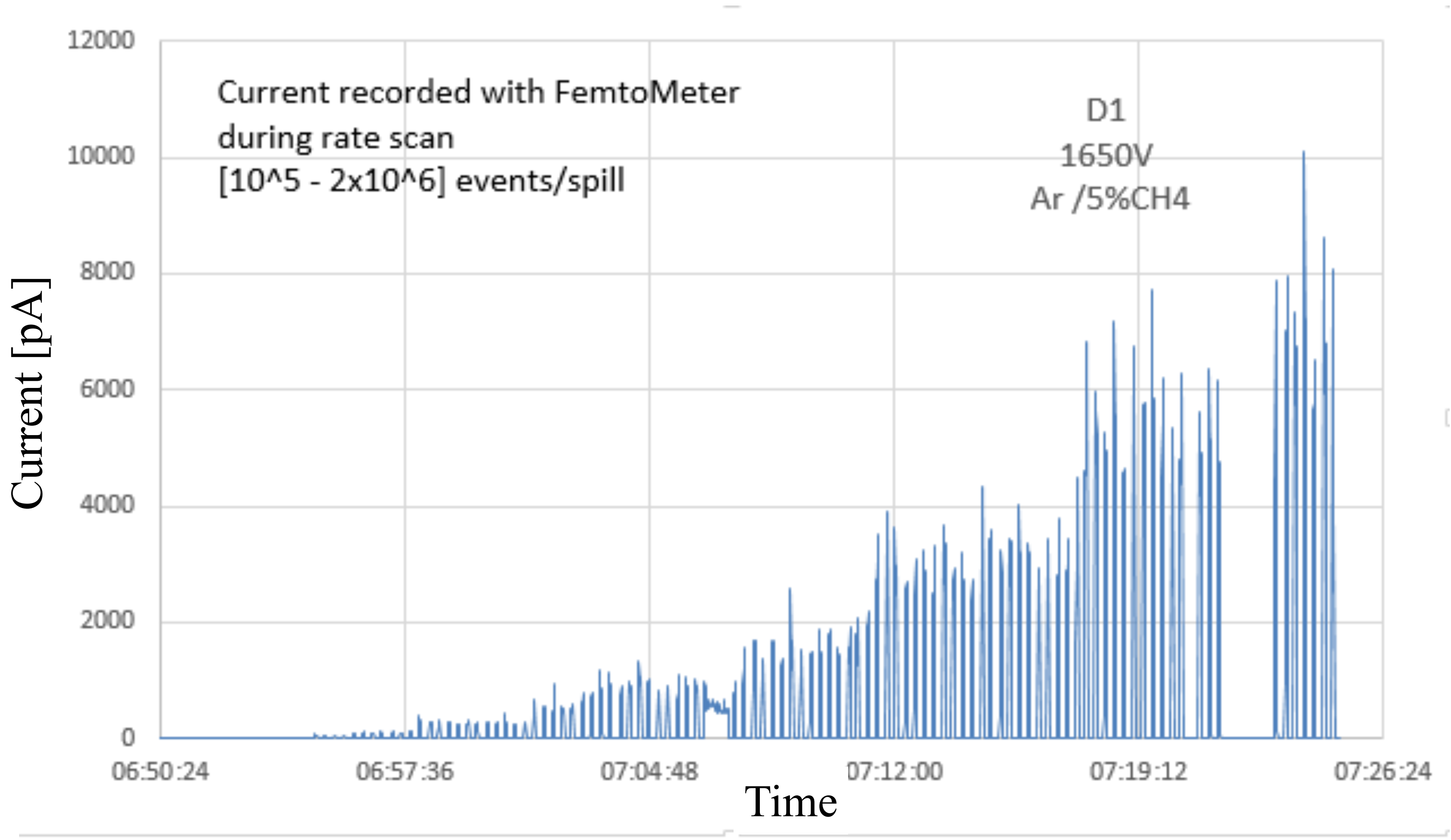
10×10 cm^2 - Discharge-free operation also at high rate π-beam

The RPWELL detector

Beam studies

$Ne/5\%CH_4$ - $Ar/5\%CH_4$ - $Ar/7\%CO_2$

- The current increases with the rate
- ‘Ohmic’ behavior is observed



$10\times10\ cm^2$ - Discharge-free operation also at high rate π-beam

Points for consideration

- Performance of resistive detector is characterized in terms of
  - Efficiency & spatial resolution
    - Pad multiplicity in ‘our’ case
  - Discharge probability
  - Discharge energy
  - *Rate capabilities*
    - Gain at different rates (linear current response)
    - Gain at different primary ionization
  - Aging
    - Also of resistive material
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Rate capabilities

- A priorly affected by
  - The resistive concept
  - The R & C (or RC) values
  - Charging up of the THGEM itself
    - Rims, wall of the holes
  - Hard to decouple the different effects

Available ‘tools’

- Measurement under different irradiation rates ⇒ fixed number of primary electrons at variable rates
- The injector method ⇒ fixed rate at variable number of primary electrons
- Different structures ⇒ mitigating the effect of charging up
  - For example - Small rims