Calorimetry with THGEM

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

Summary

- Focus on detector technology
  - Large-scale single-stage & stable

- 2012 - focus on SRWELL (see slide 4) based configurations
  - High efficiency at low pad multiplicity
  - But also some problems
- 2014 - focus on RPWELL - very promising results
  - Single-stage discharge free THGEM based configuration
  - High efficiency at low pad multiplicity
  - Need to study the long term properties of the resistive material
  - Fully industrially produced

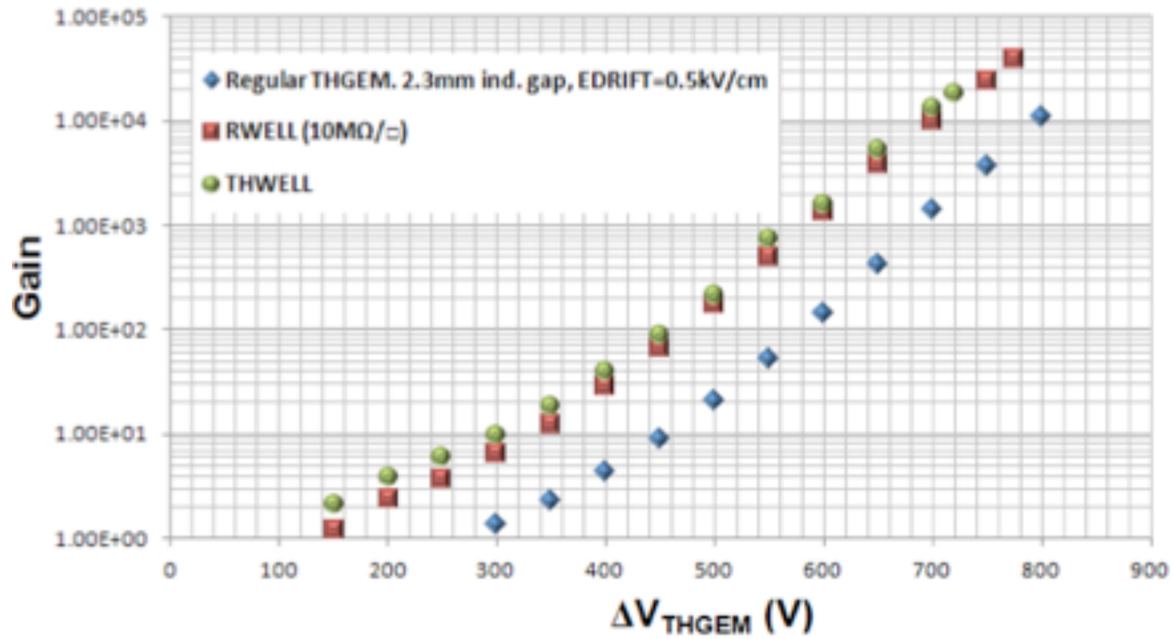
Past results - SRWELL

- We have shown that SRWELL-based sampling element can meet the DHCAL requirements in terms of efficiency and pad multiplicity
  - Using single-stage and double-stage configurations
  - We achieved in the beam efficiency > 98% at pad multiplicity < 1.2

THGEM structures -RWELL & SRWELL

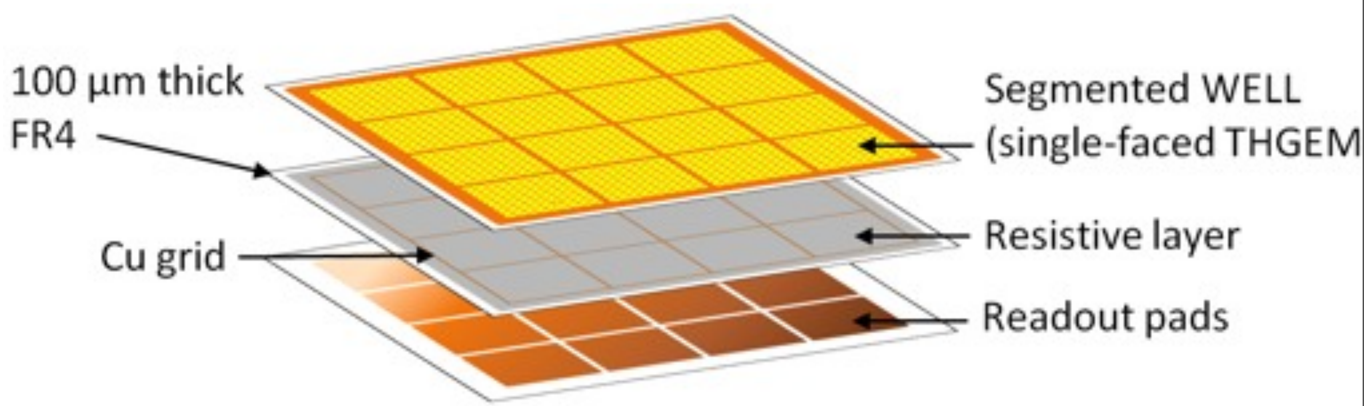
Resistive WELL:

- **WELL** coupled to a **resistive** layer (RL 10-20MΩ/square)
- Pads separated from the RL by a thin insulating sheet
- Charge induced on the readout pads
- RL quenches the energy of occasional discharges



Segmented RWELL:

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

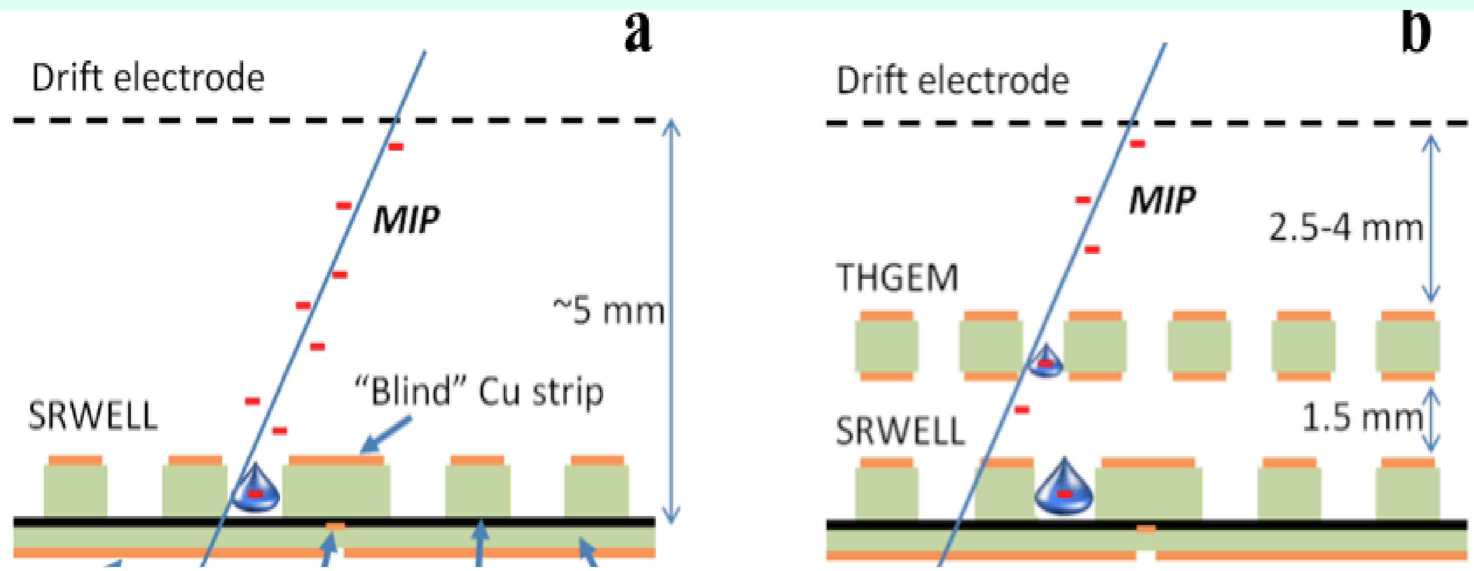


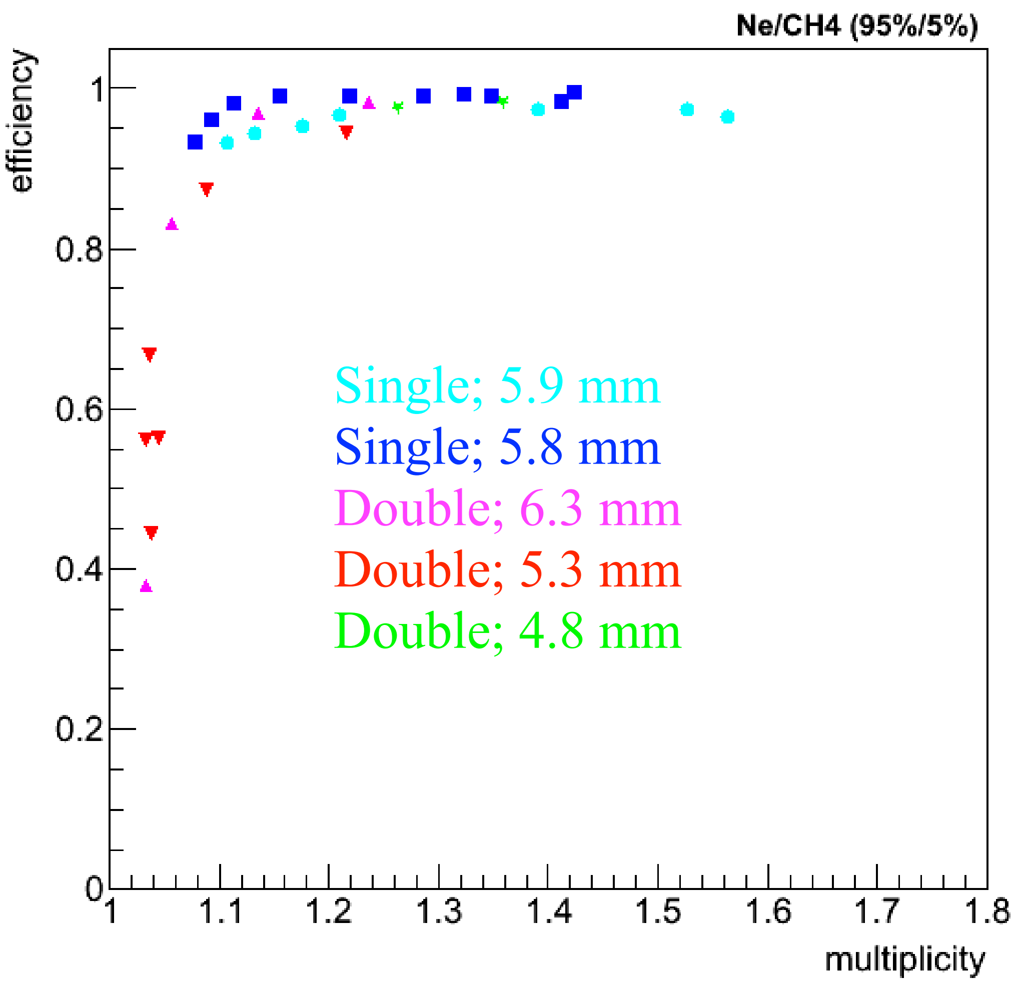
L. Arazi et. al, JINST 9 P04011 2014

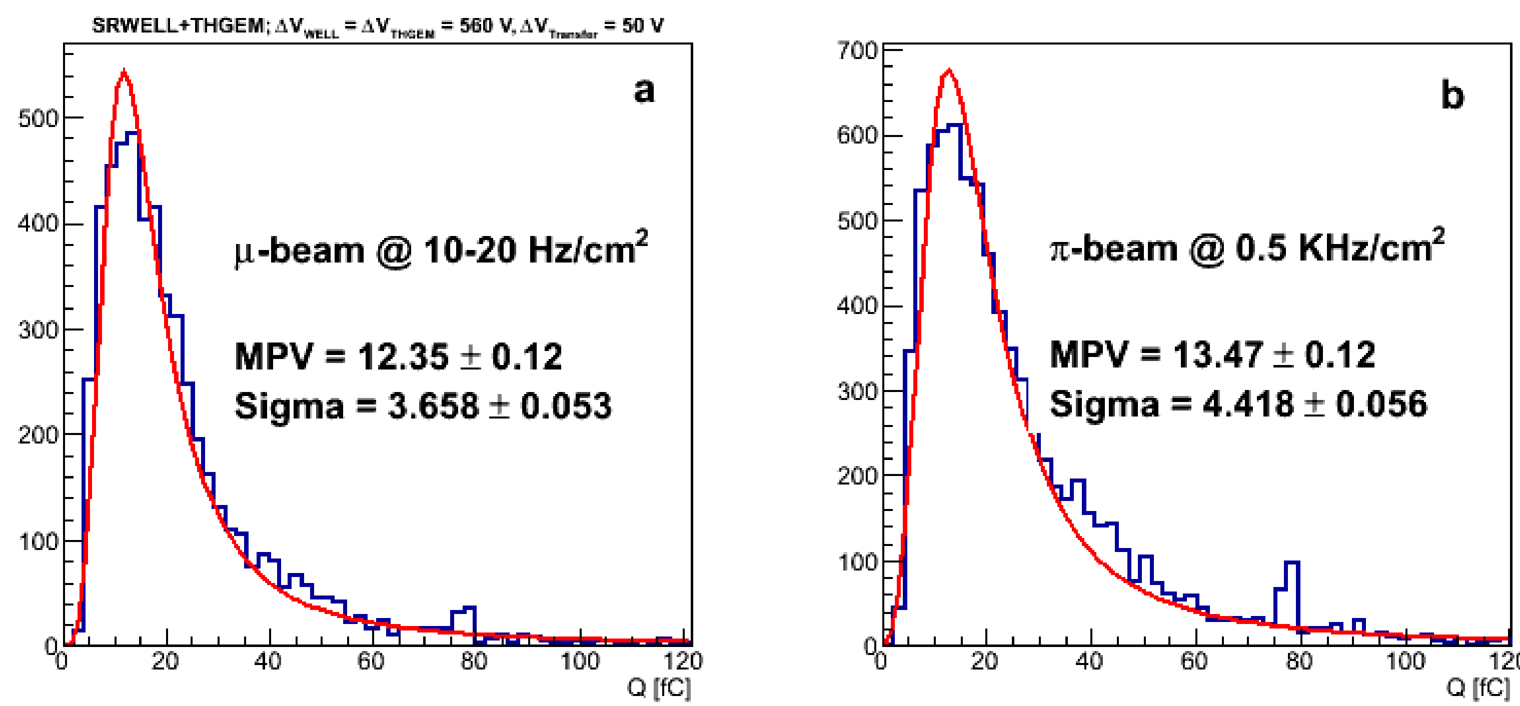
Test beam results - SRWELL for (S)DHCAL

Beam test evaluation: SRS/APV readout

- 4.8 - 6.3 mm thick single- and double-stage configurations
- Gains 1000-8000
- Detection efficiency > 95% @ pad multiplicity ≲ 1.2







S. Bressler et. al, JINST 8 P07017 2013

Studies with MICROROC

- **THGEM**/MICROROC: successful operation in μ-beam and π-beam, inc. showers
- **SRWELL**/MICROROC: promising preliminary lab R&D

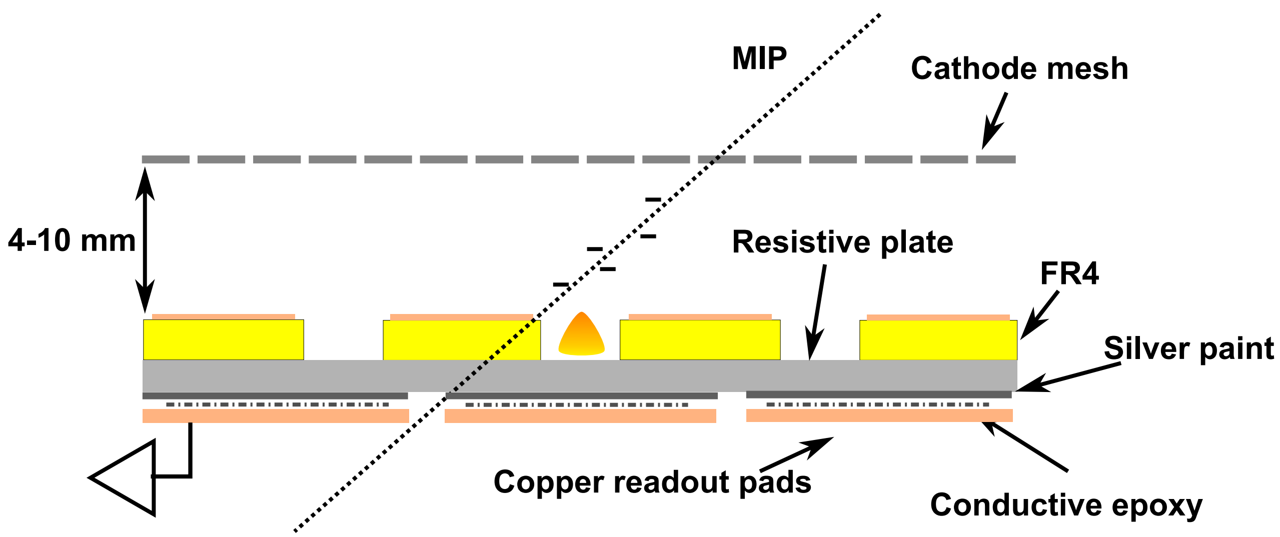
SRWELL - main problems

- Single stage: discharge probability at the level of 10^{-6} in high rate pion beam
  - Too high for DHCAL application
- Double stage: not cost effective
  - Price scale like the number of drilled holes

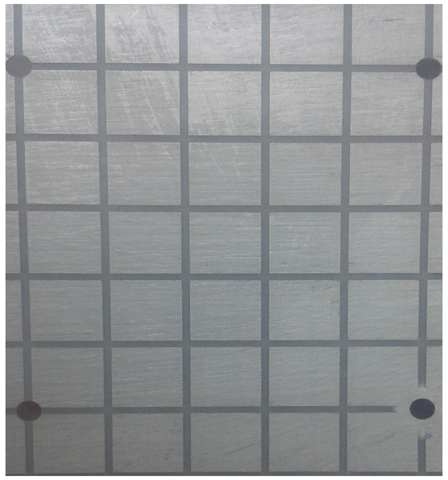
Recent results - RPWELL (Dec. 2014)

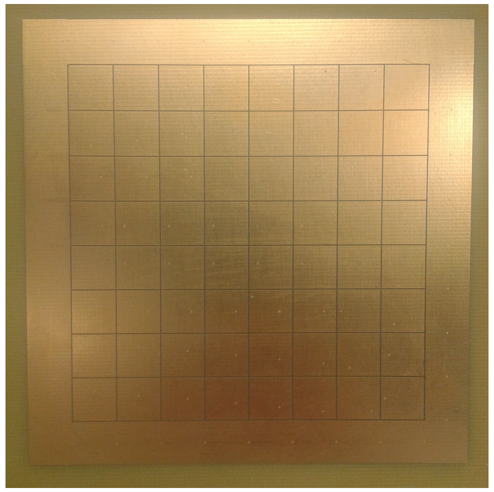
Resistive ***P***late ***WELL***:

- 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



A. Rubin et. al, JINST 8 P11004 2013





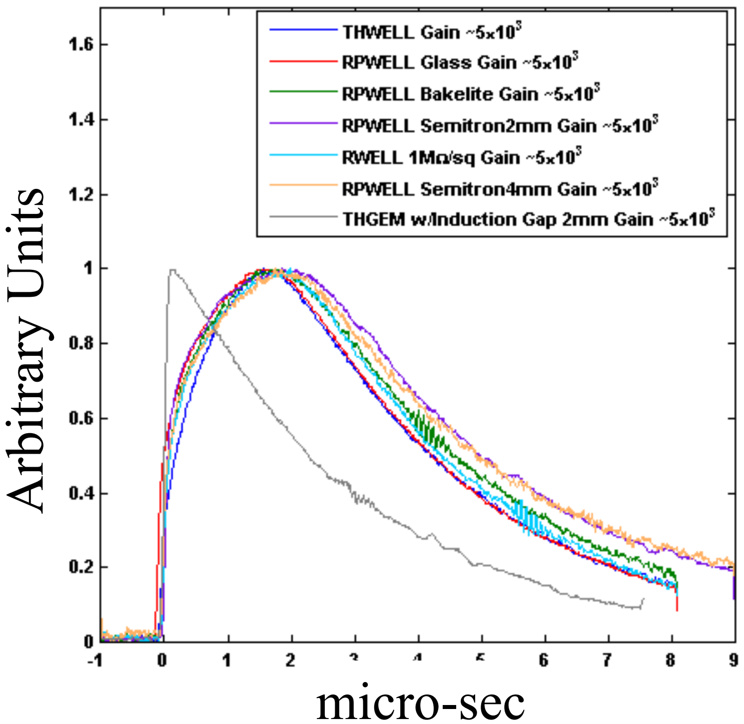
Tested materials

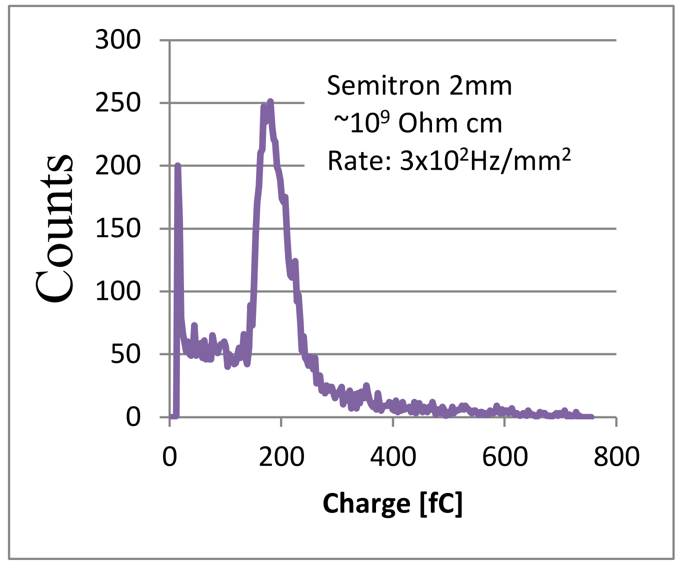
Material	Dimensions [mm]	Bulk resistivity [Ωcm]
VERTEC 400 glass	36×31×0.4	8×10^{12}
HPL Bakelite	29×29×2	2×10^{10}
Semitron ESD 225	30×30×2	2×10^{9}
Semitron ESD 225	30×30×4	3×10^{9}

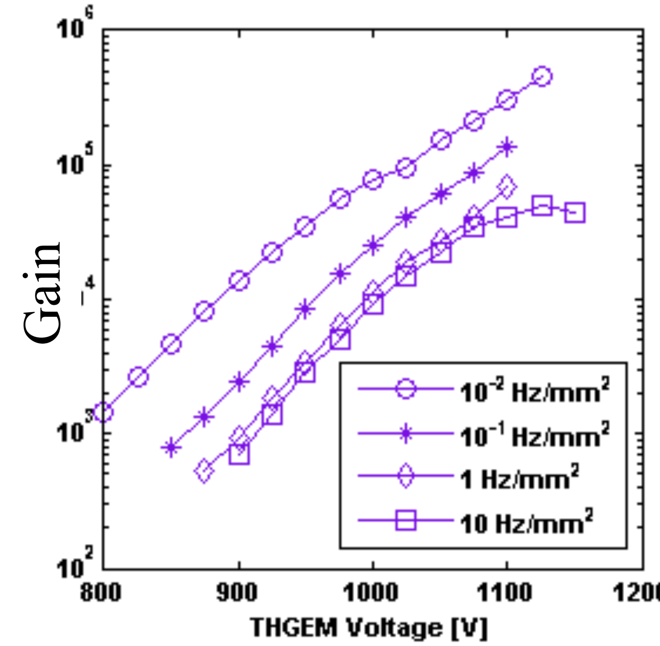
Focus on thin Semitron ESD 225 layers

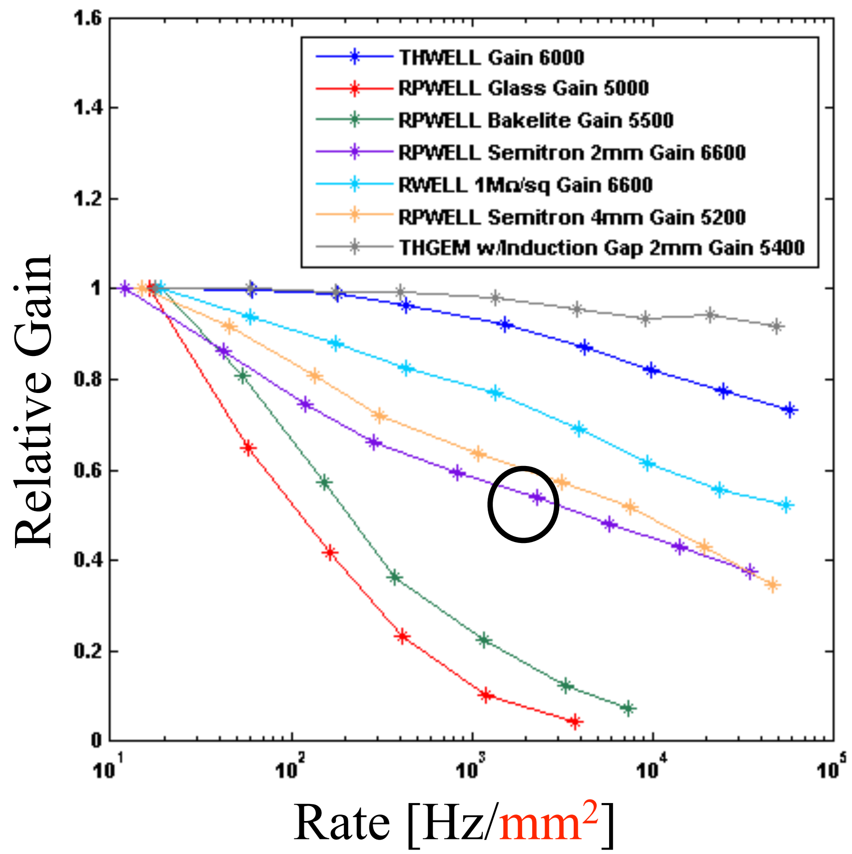
A. Rubin et. al, JINST 8 P11004 2013

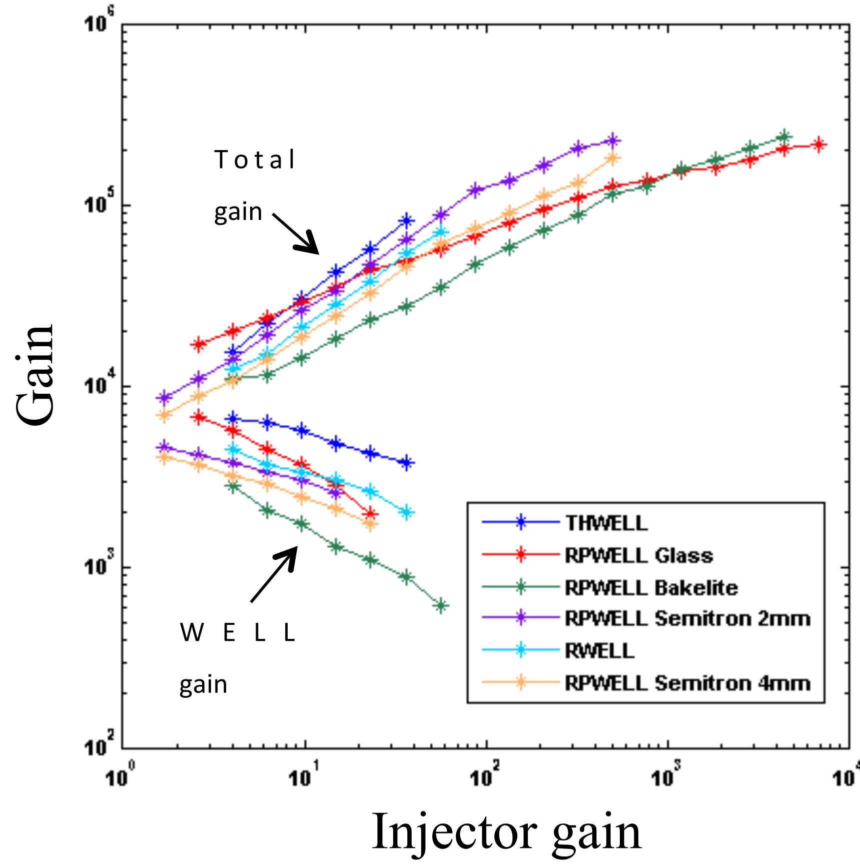
RPWELL 10^9 Ωcm - 2 mm layer







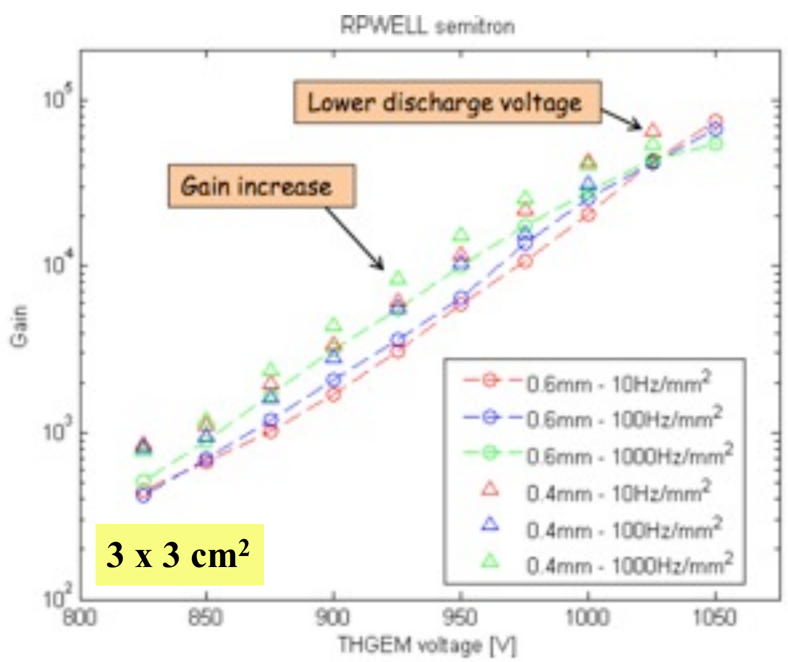




- Same pulse shape as standard well
- ~20% Energy resolution
- Gain saturation at high irradiation rate
- < 50% gain drop over 4 orders of rate magnitudes
- **No discharges at high rate of HIPs**

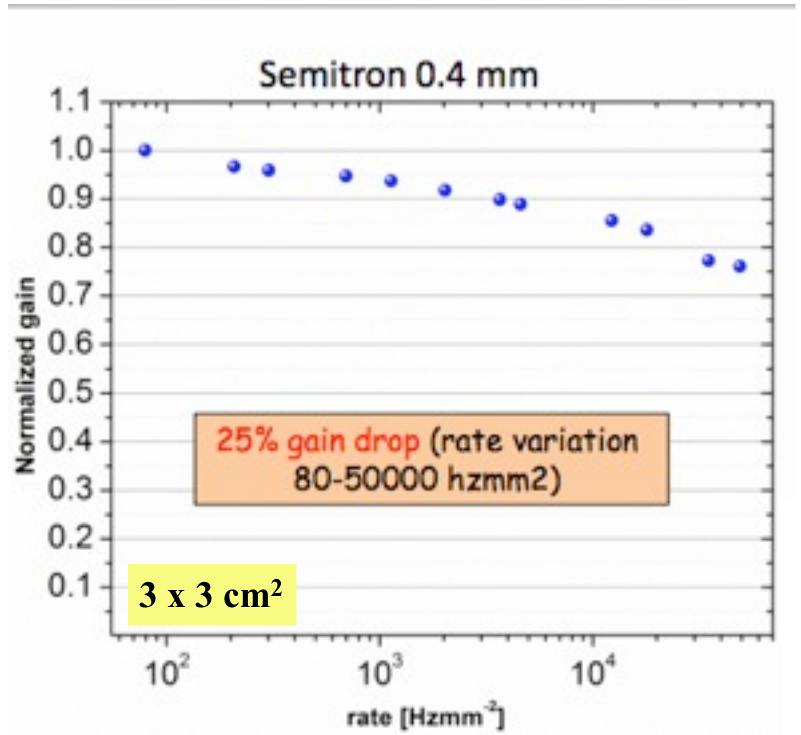
Focus on thin Semitron ESD 225 layers

Improved performance with thinner (0.4 & 0.6 mm) layers - **R~#10^8 Ωcm**



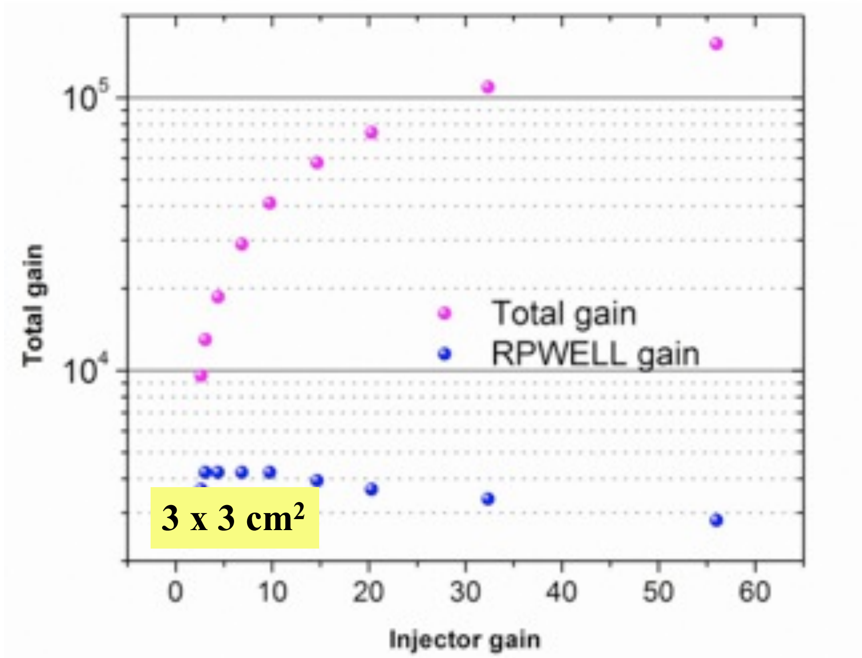
Higher gain for the same voltage

- Smaller anode-cathode gap



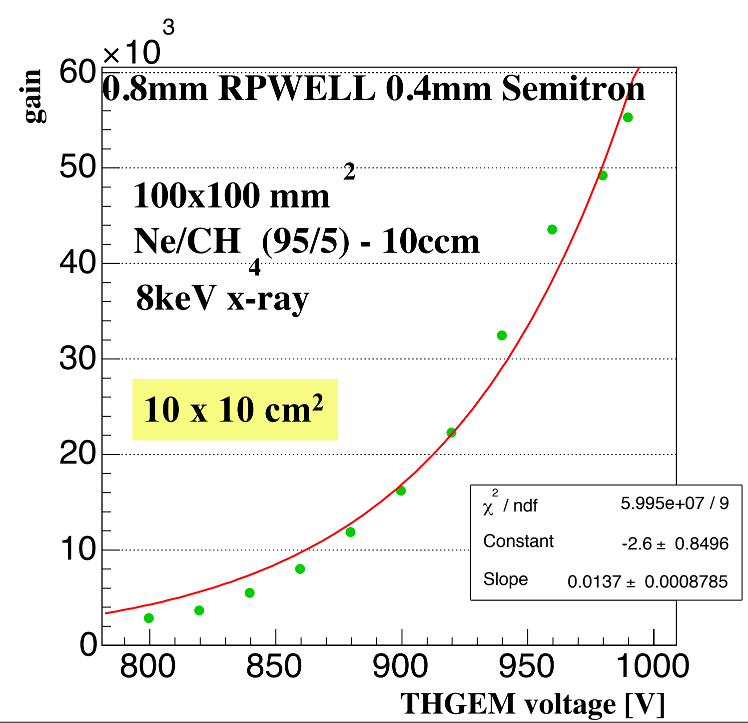
Gain drops slower with rate

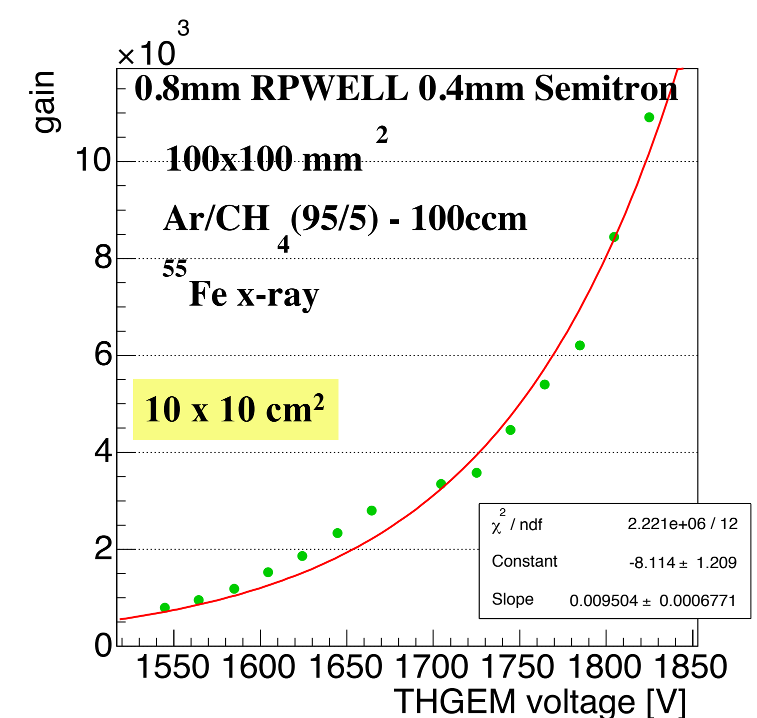
- Lower resistivity



Stable with HIPs

- Observe gain saturation



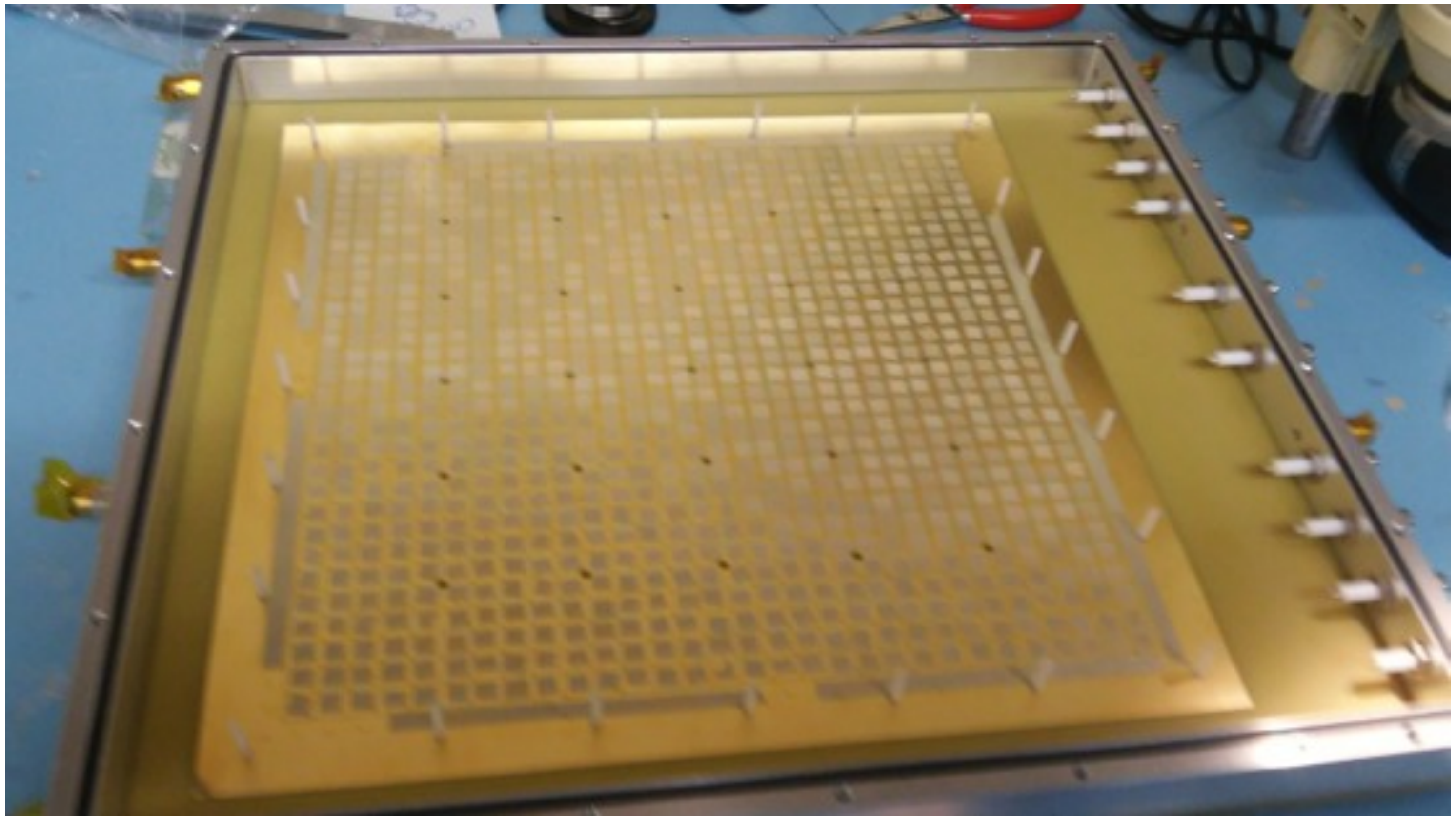


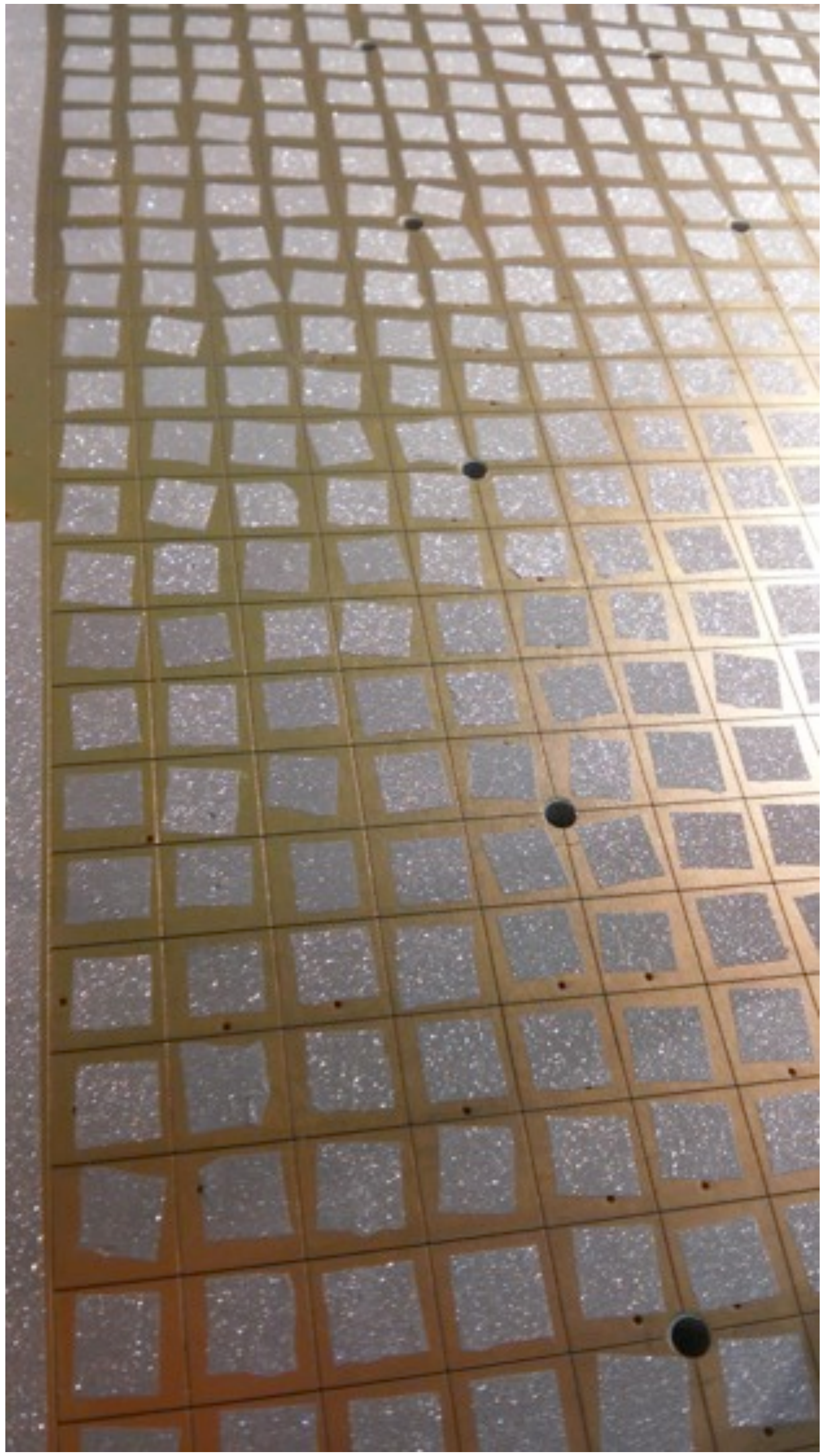
Hand made 30 x 30 cm^2 RPWELL

Two RPWELL 0.4 mm Semitron configurations:

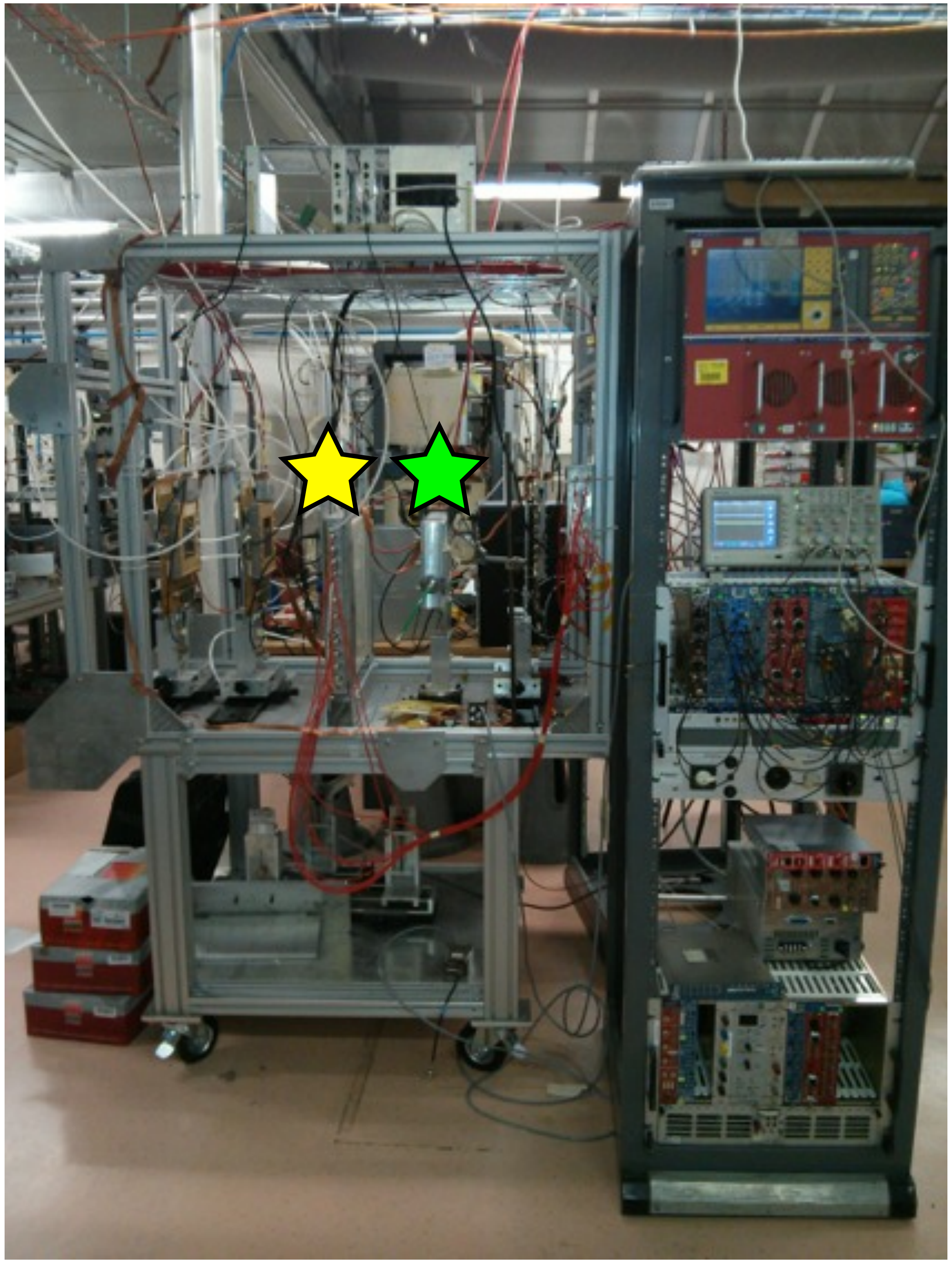
- 10 x 10 cm^2 - 0.8 mm electrode; 3 mm drift
  - Operation in Ne/CH4 and maybe also Ar/Co2
- 30 x 30 cm2 - 0.4 mm electrode; 5 mm drift
  - Electrode of bad quality (not intentionally)

30 x 30 cm^2





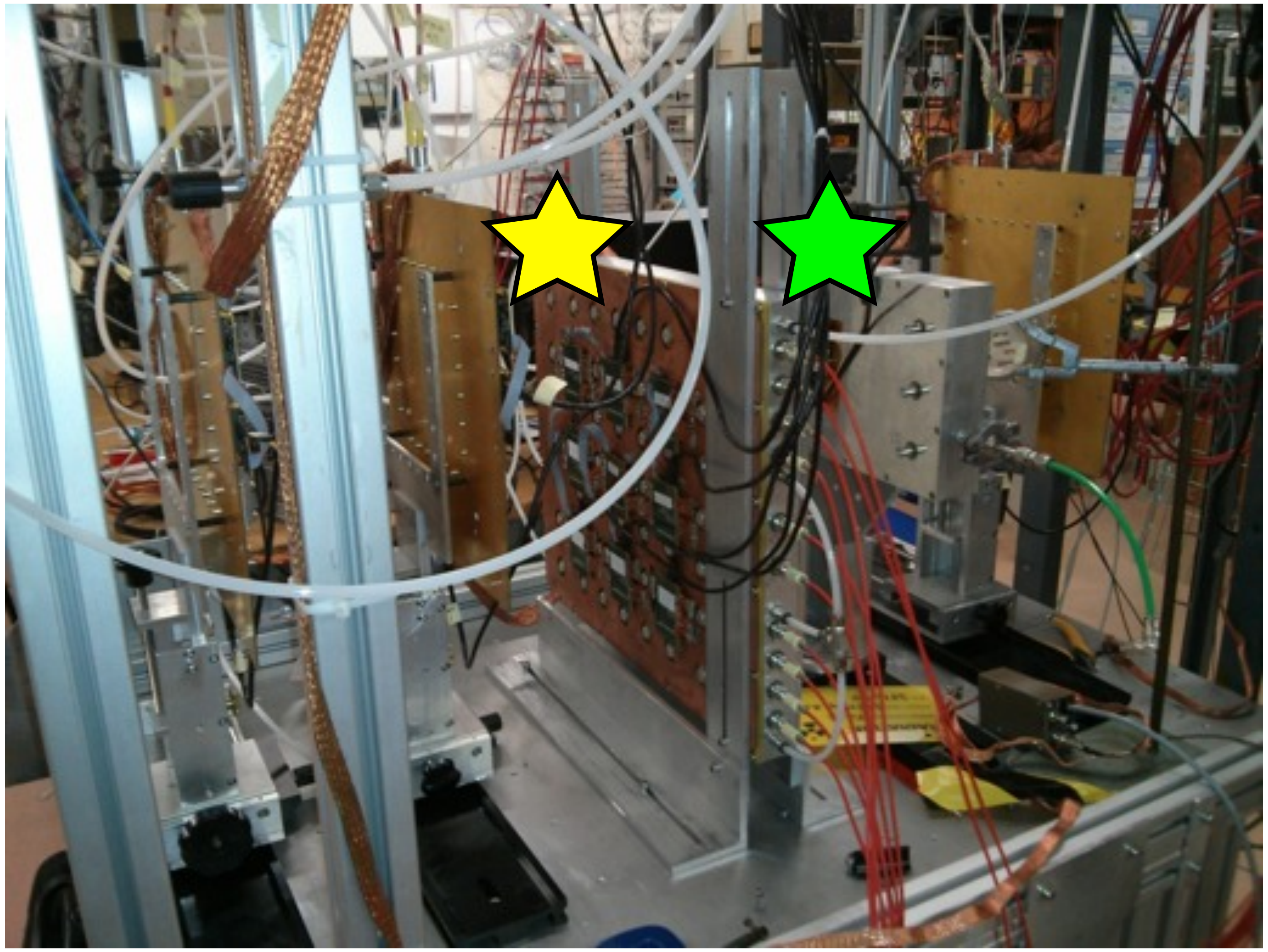
Test beam setup



2 detectors setup + telescope installed in SPS/H4 beam area:

★ 30 x 30 cm^2 configuration with induction gap

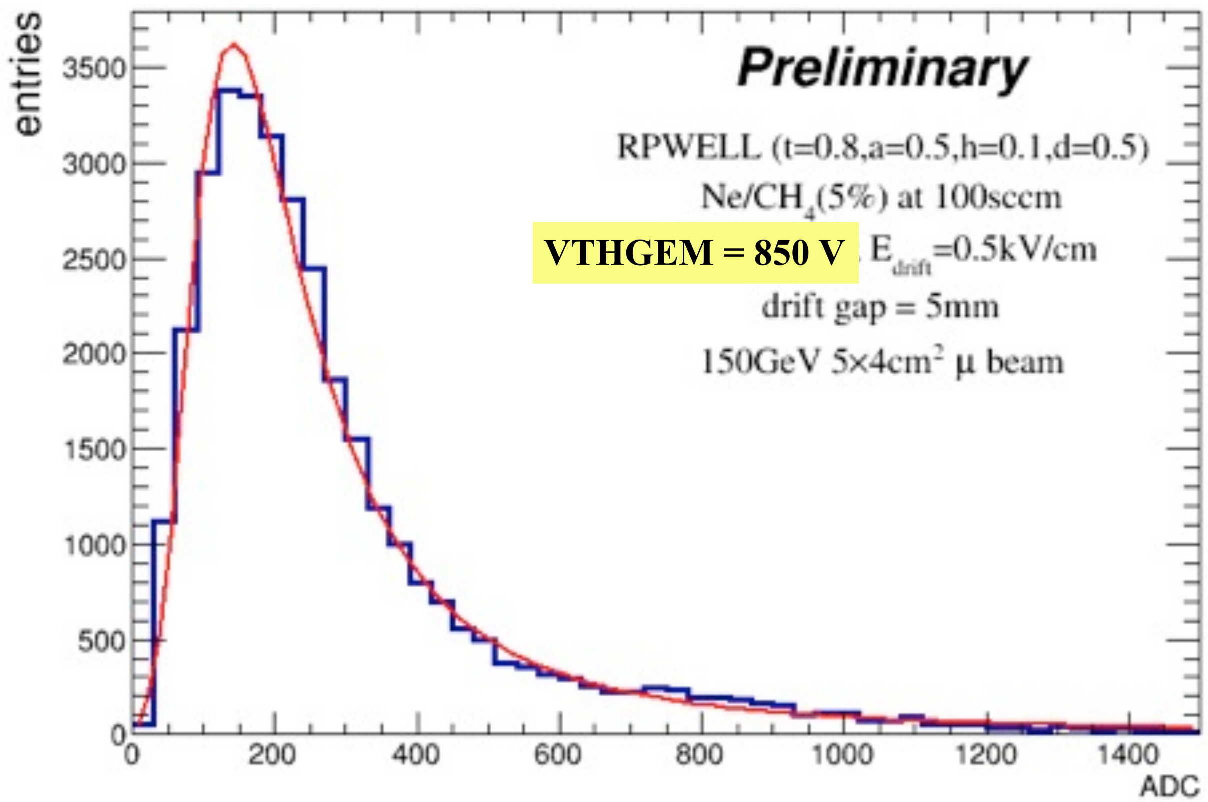
★ 10 x 10 cm^2 RPWELL 0.4 mm Semitron layer

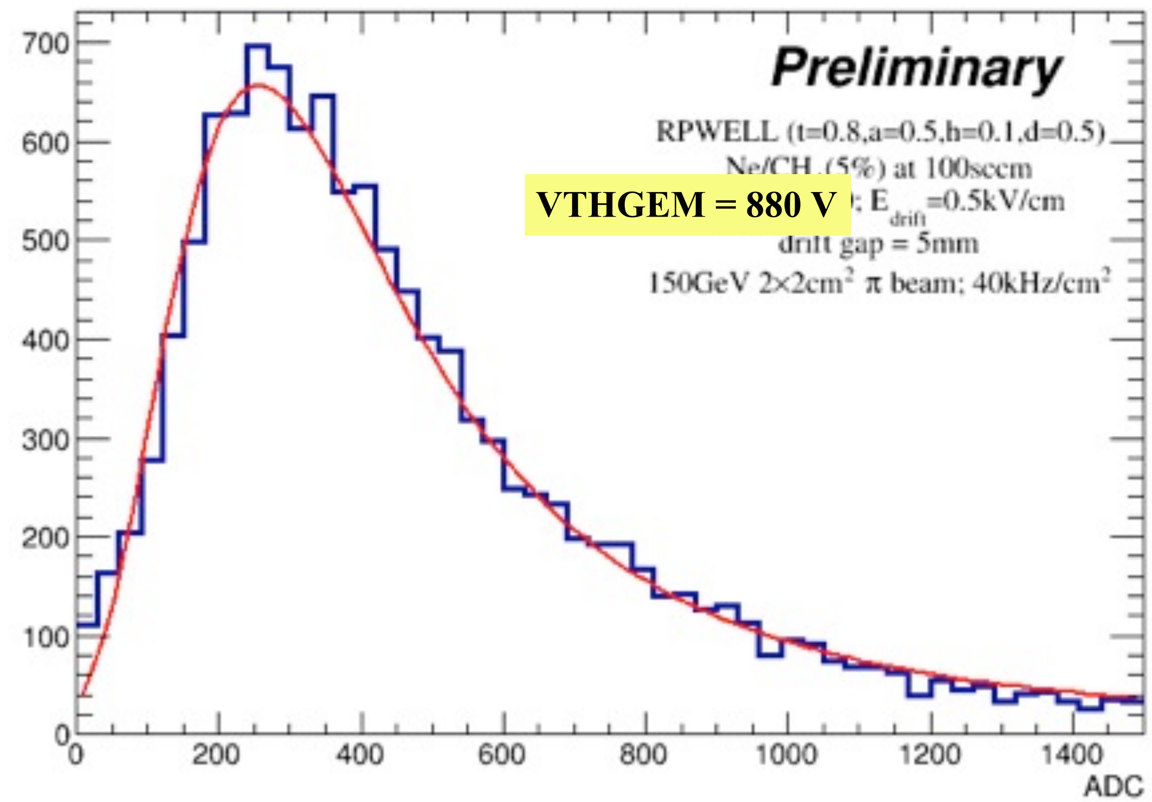


Results - 10 x 10 cm² 0.8 mm RPWELL

Clear Landau distribution

Excellent signal to noise separation in low and high rate beams

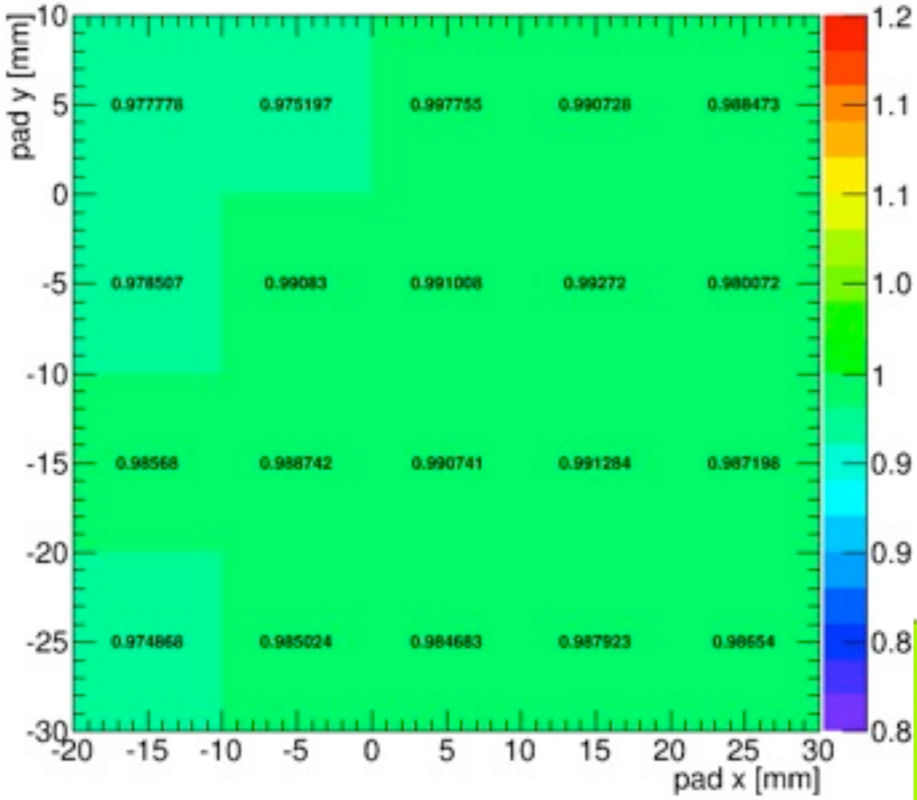


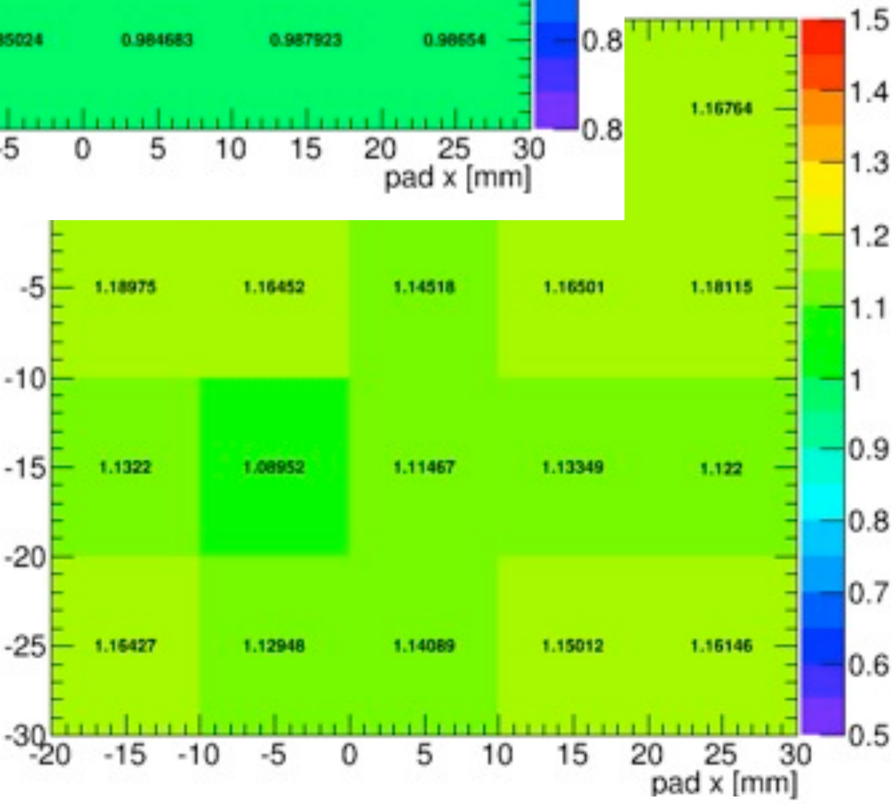


200 ADC counts ~ Q = 4 fC ~ Effective gain = 3000

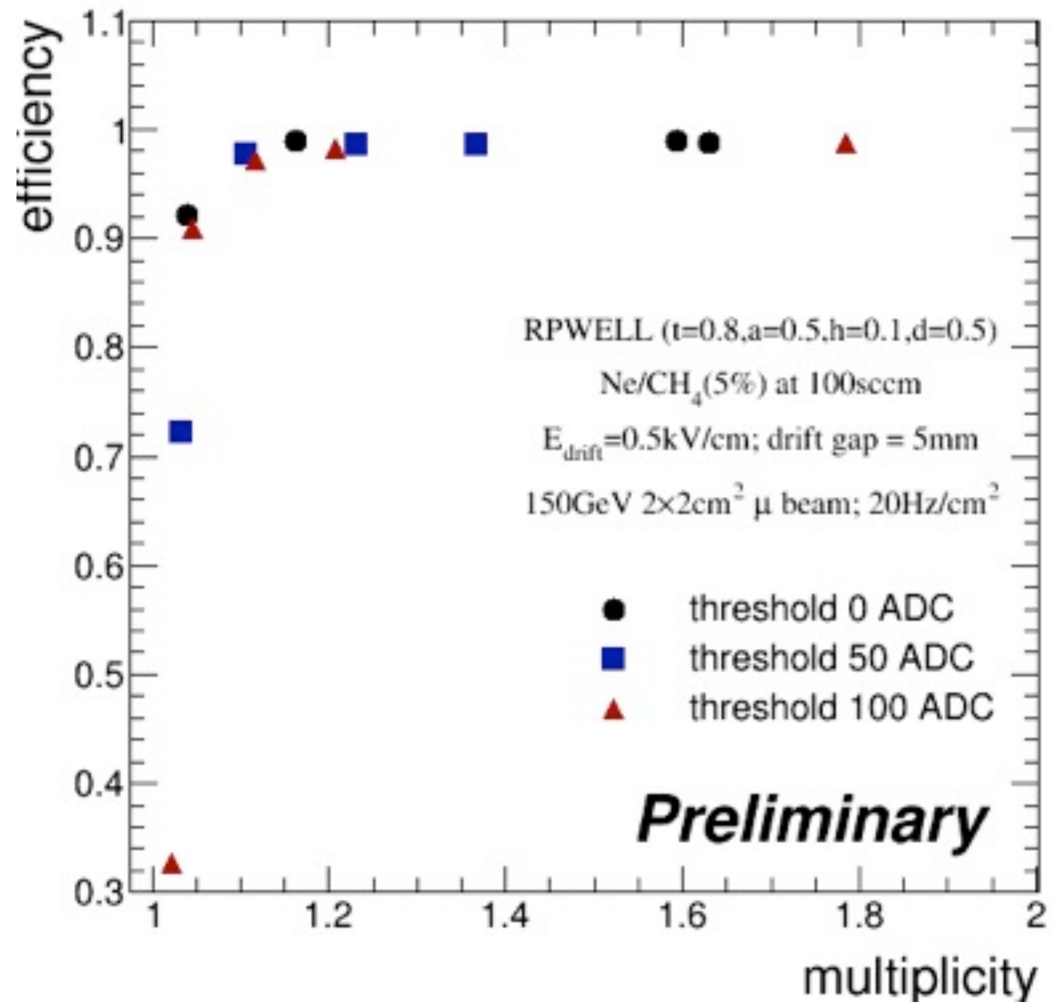
Results - 10 x 10 cm^2 0.8 mm RPWELL

Pad efficiency





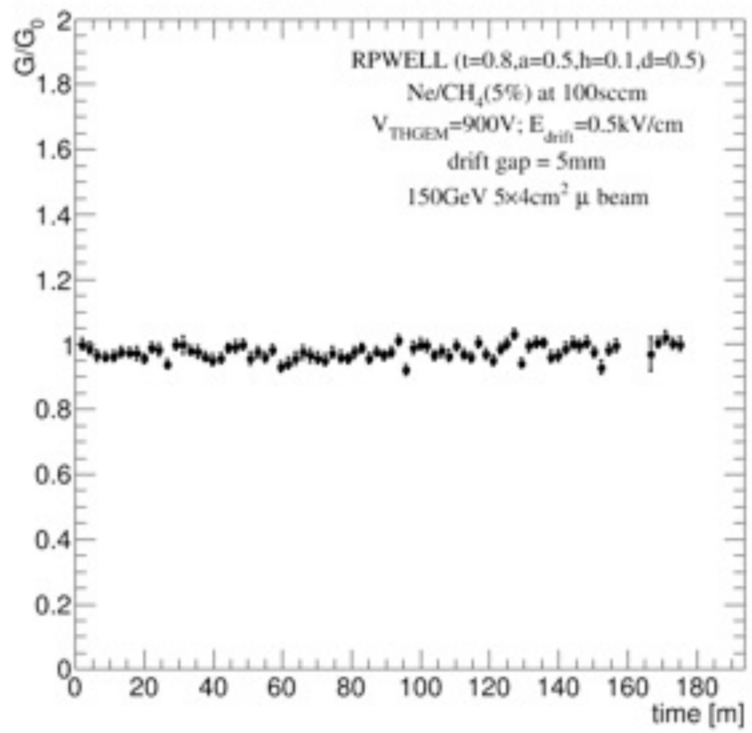
Average pad multiplicity

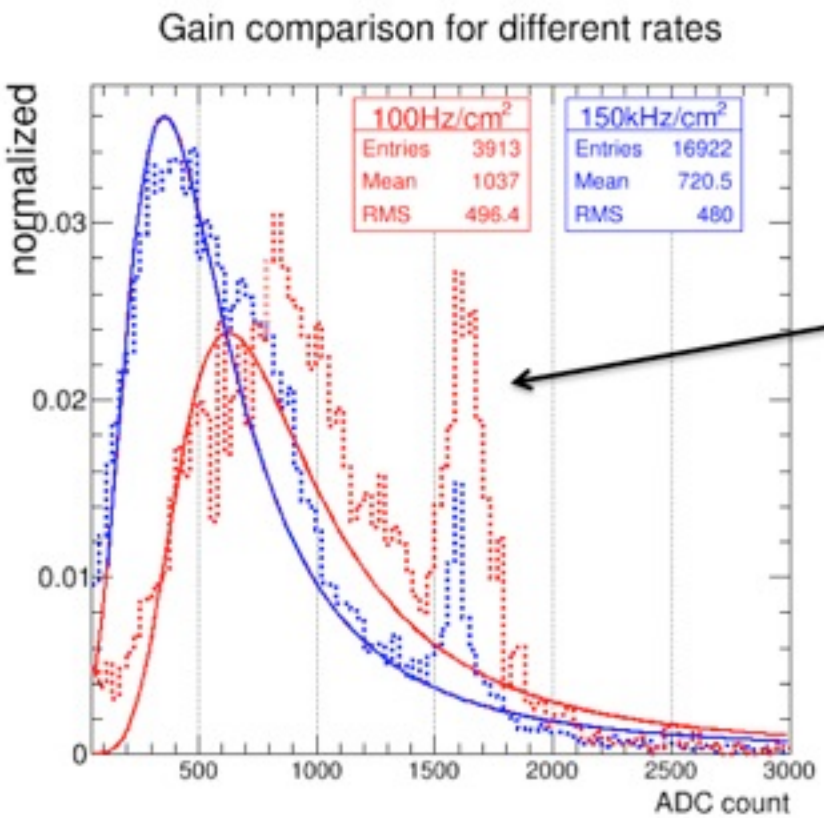


High efficiency (>98%) at reasonably low multiplicity (1.1) - **More details in Luca's talk.**

Uniform response

Results - 10 x 10 cm^2 0.8 mm RPWELL

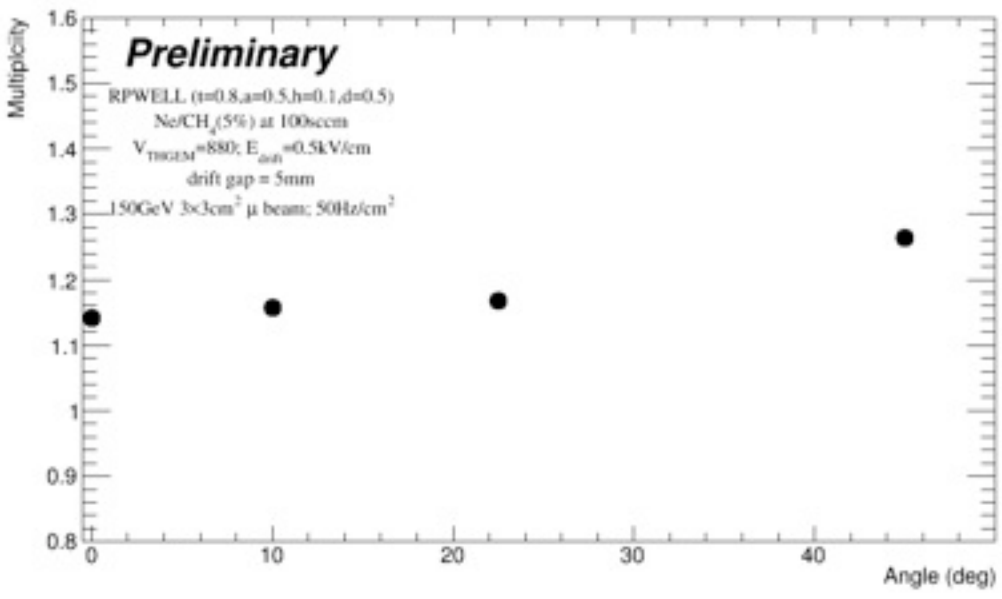




10% variation in gain over time - **More details in Luca's talk.**

Gain drop of order 30-40% over 4 orders of magnitude of rate - **More details in Luca's talk.**

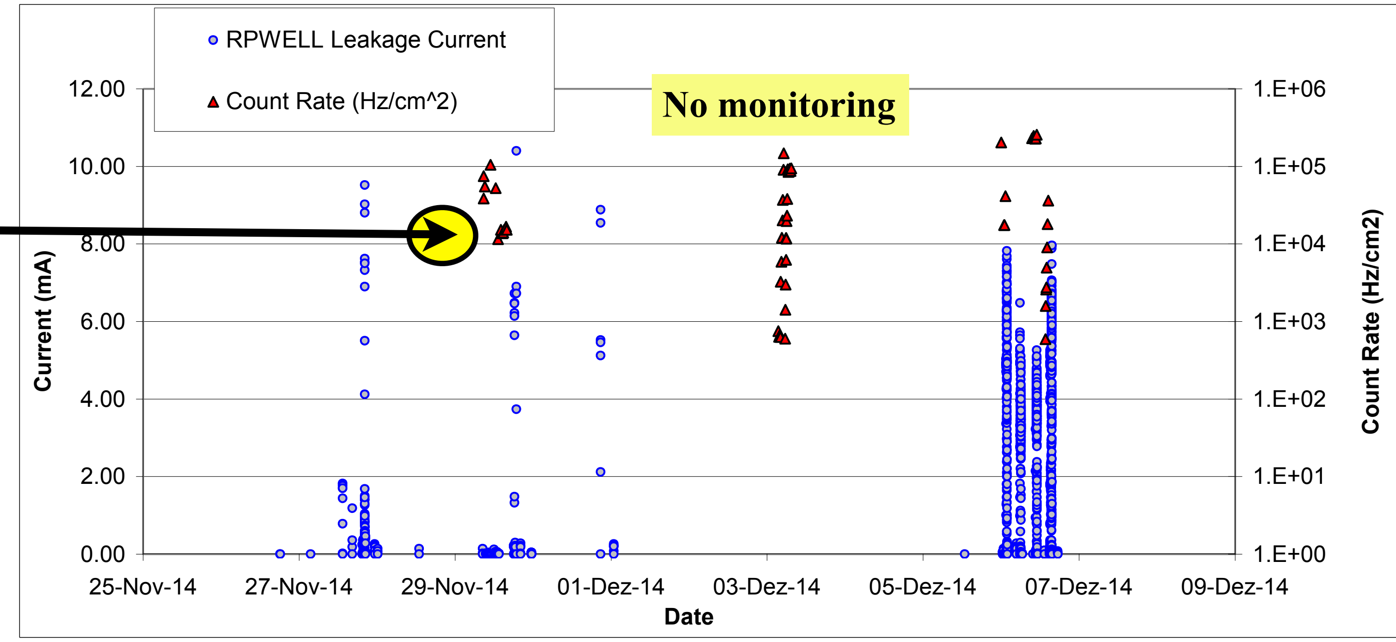
~10% increase in multiplicity for particle incoming angle of 45 degrees - **More details in Luca's talk.**



Results - 10 x 10 cm^2 0.8 mm RPWELL

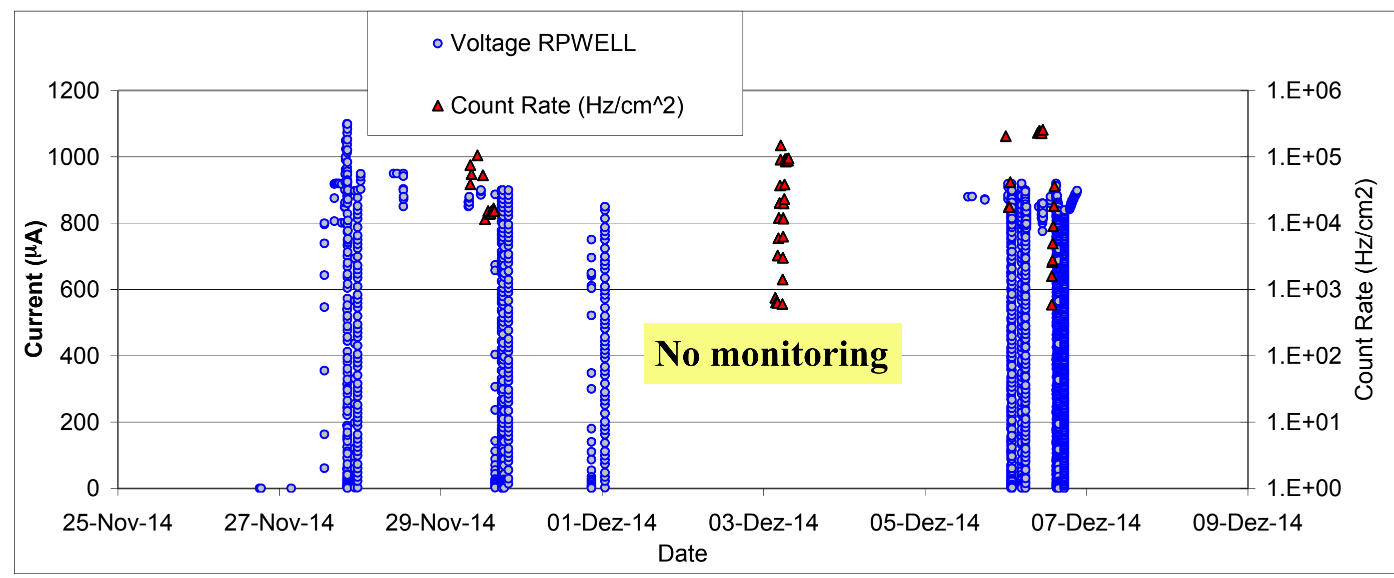
Discharge free*!! Discharge prob < 10^{-10}

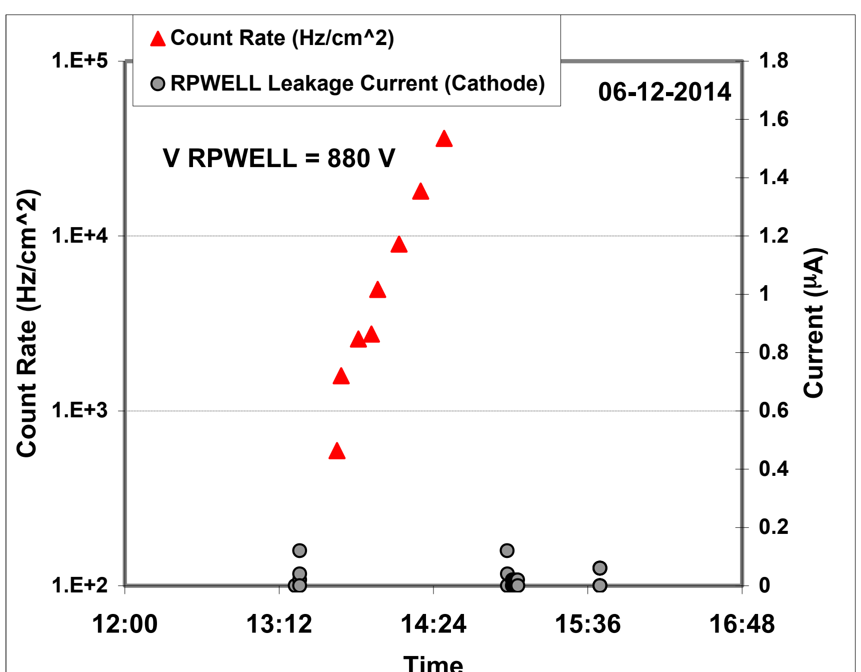
Long Pi run. No current activity



Trips - long term high current - occur rarely

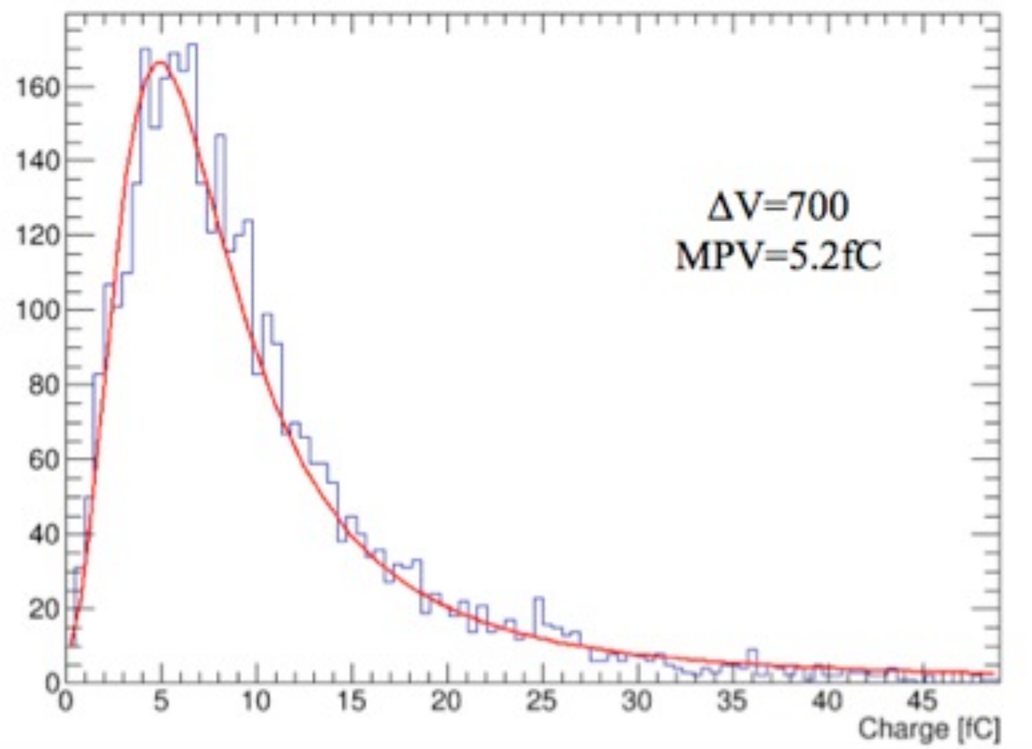
- At very high rates and high gains (at the same time)
- Recovery takes time
- Cause has to be understood



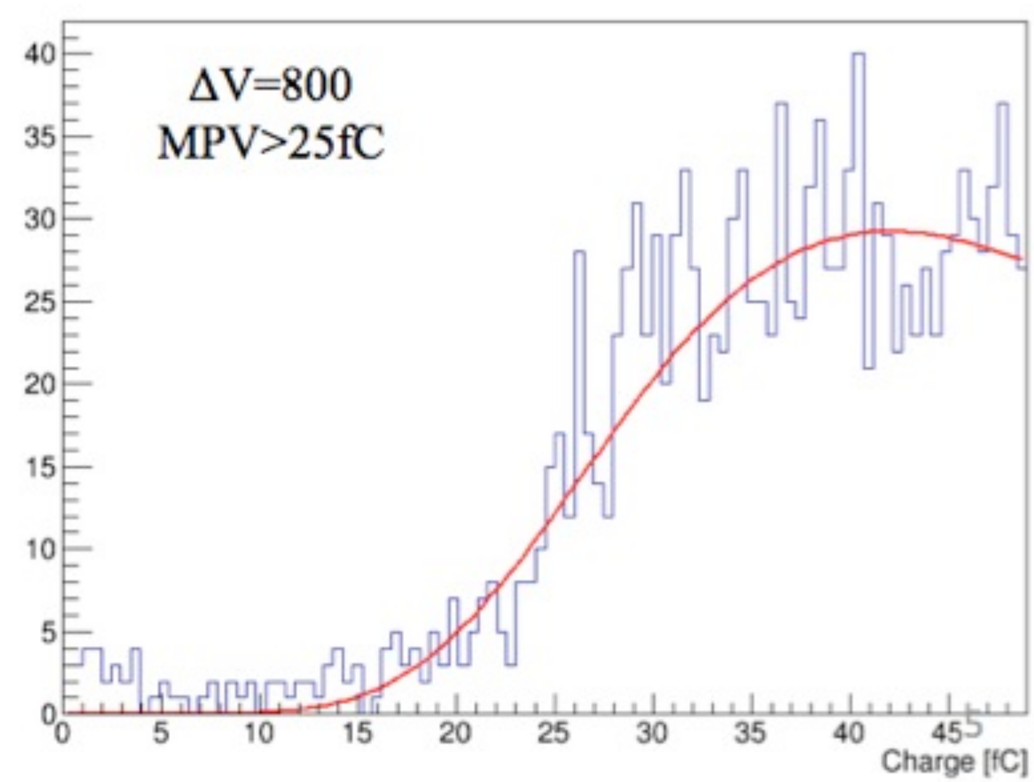


More details in Luca's talk

Results - 30 x 30 cm^2 0.4 mm RPWELL



Landau for clusters that matched to a track within 1.0cm



Stable operation despite of defects
- also at high gains

High efficiency (>95%) @ Lower operation voltages
(Thinner electrode)

More details in Luca's talk.