Further laboratory investigation of the RPWELL

RD51 mini-week, June 2016, CERN
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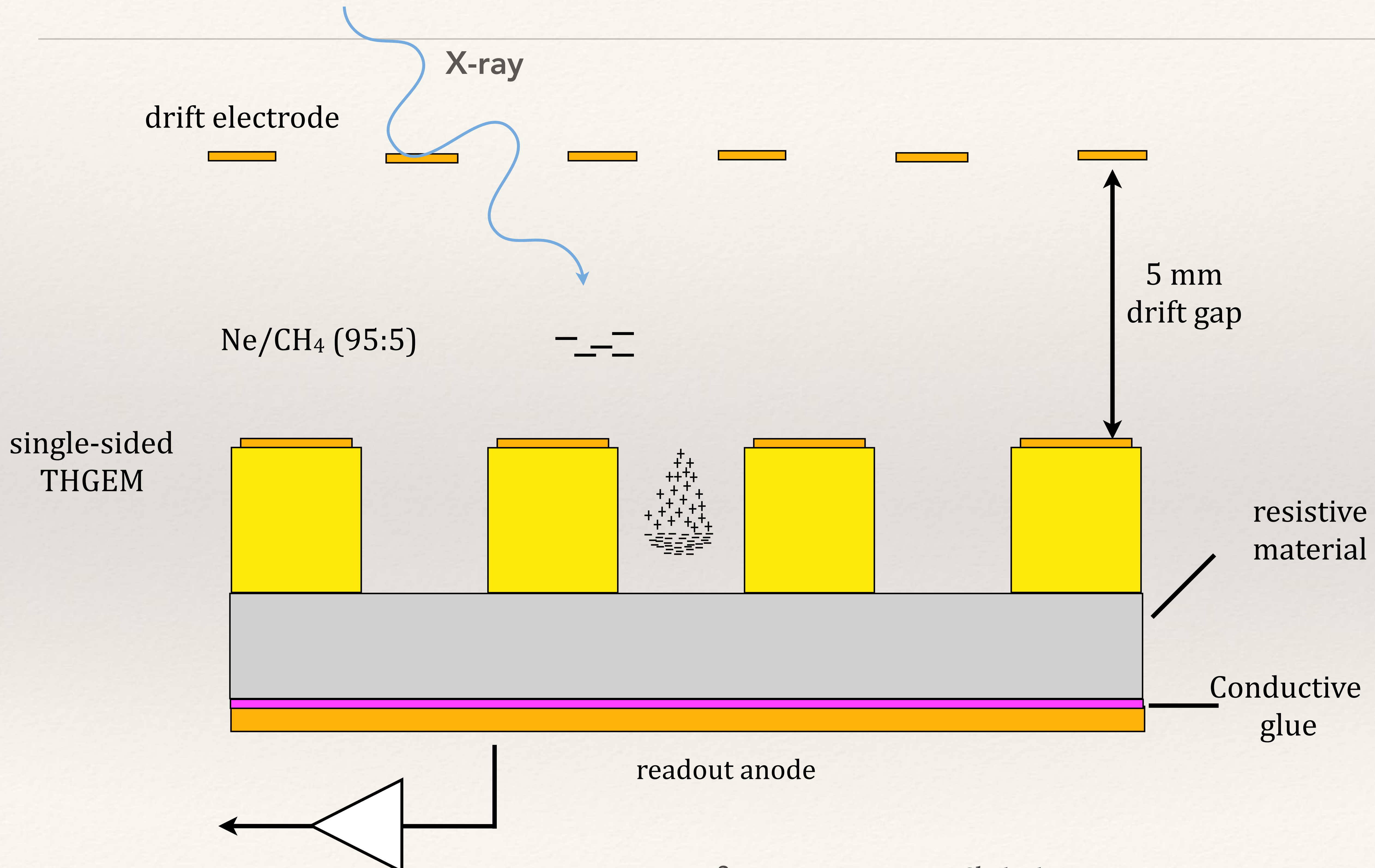
on the behalf of the Weizmann group

A reminder: the RPWELL



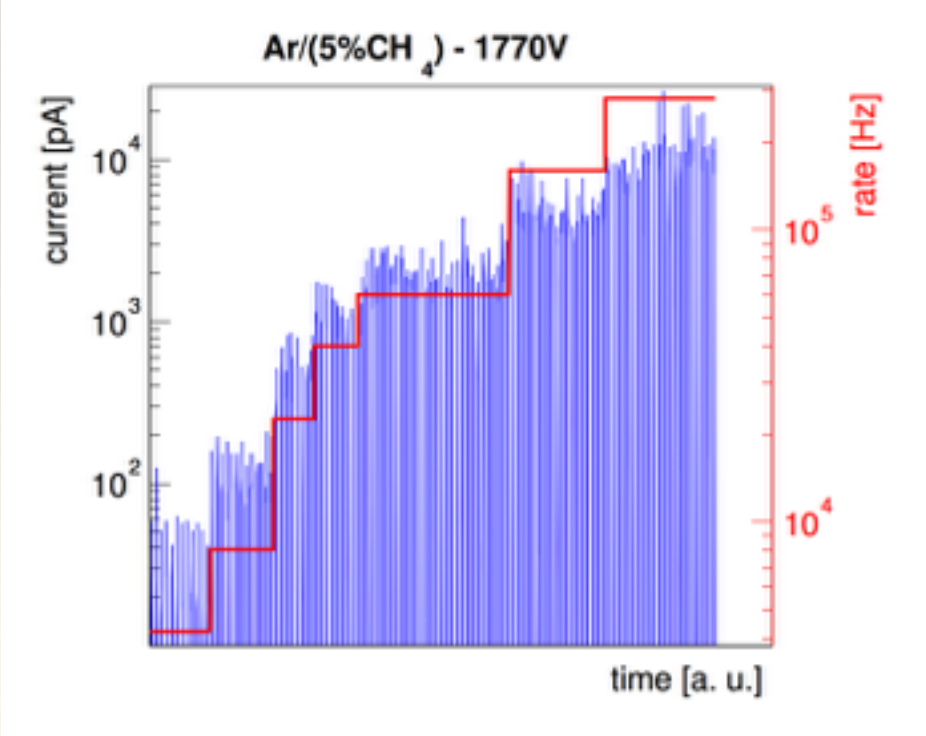
Outline

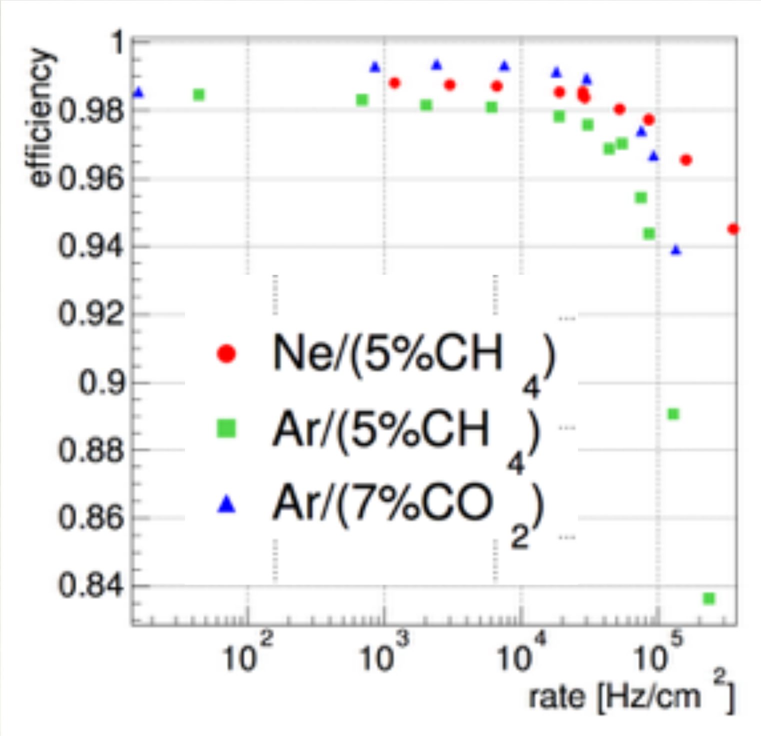
- Motivation: Promising results with the RPWELL
- Current efforts:
  - scaling up - aiming $1m^2$ prototype
    - Scalable production techniques
    - Better materials
    - Scalable detector design & assembly procedure
  - general characterization
    - Position resolution (preliminary)

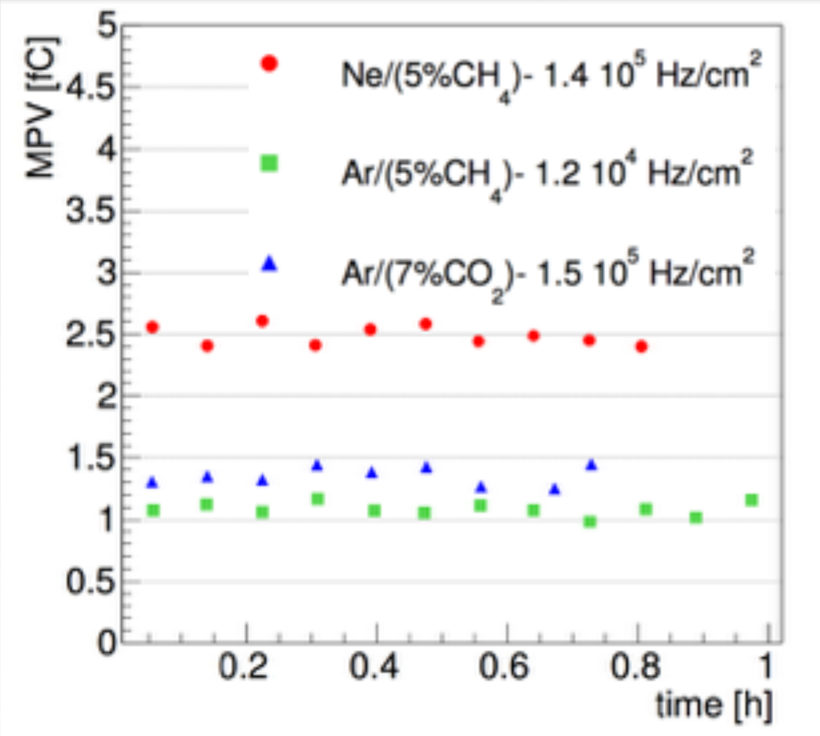
Recent test beam results

- Stable operation
  - With Ar- and Ne-based gas mixtures
  - Under high rate pion beam
- Discharges free
- Stable gain over long time
- High detection Efficiency at broad range of incoming particle fluxes

Meets the DHCAL requirements
in terms of efficiency
and pad multiplicity







New Production Techniques and Materials

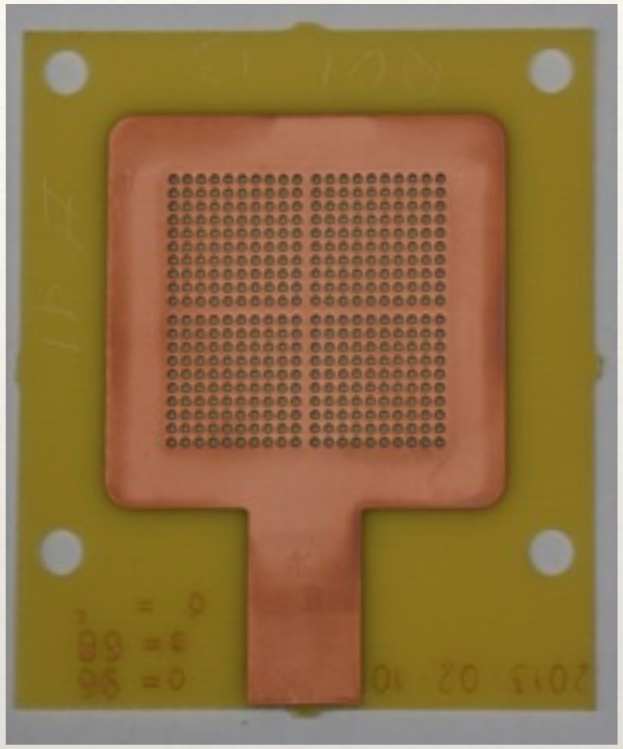
- FR4 drilling
  - Time consuming
  - Requires expensive post treatment
  - Could be problematic for very large area coverage
- New technologies and materials are available
- New companies on the market

geometry	electrode material	resistive material	bulk resistivity
0.8mm*	FR4 - Cu	0.4mm semitron	$10^9\Omega$cm
0.4mm*	FR4 - Cu	None	-
0.4mm	FR4 - Cu	0.4mm semitron	$10^9\Omega$cm
0.4mm	FR4 - Cu	0.7mm glass**	$10^{10}\Omega$cm
0.4mm step	Epoxy - Ni	0.4mm semitron	$10^9\Omega$cm
0.4mm	Alumina - Cu	0.4mm semitron	$10^9\Omega$cm

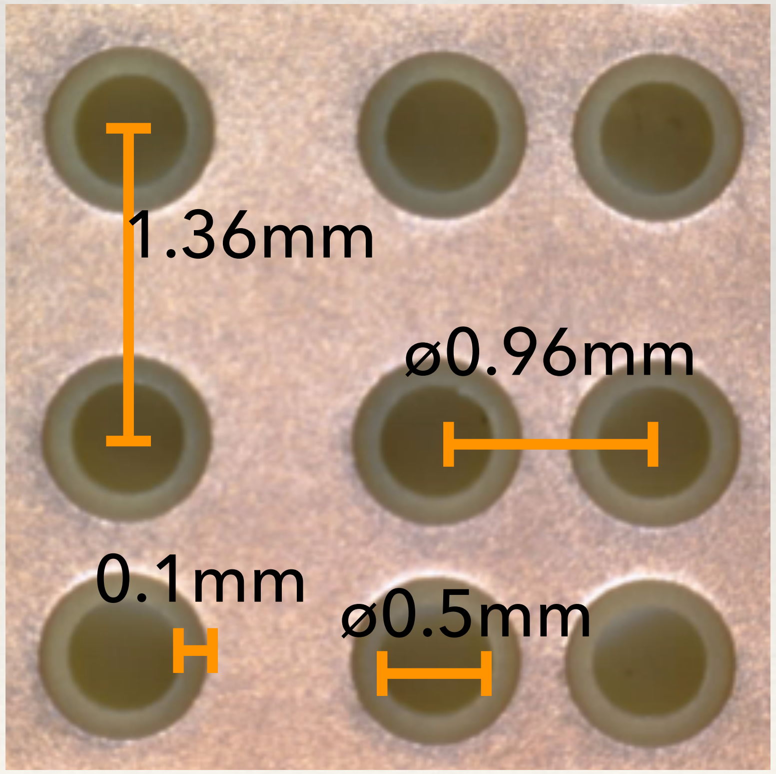
* Reference measurements **Yi Wang of Tsinghua University

Reference: 0.8 & 0.4mm thick FR4

- Copper coated
- Mechanically drilled
- Produced by ELTOS
- Post-treatment at CERN workshop

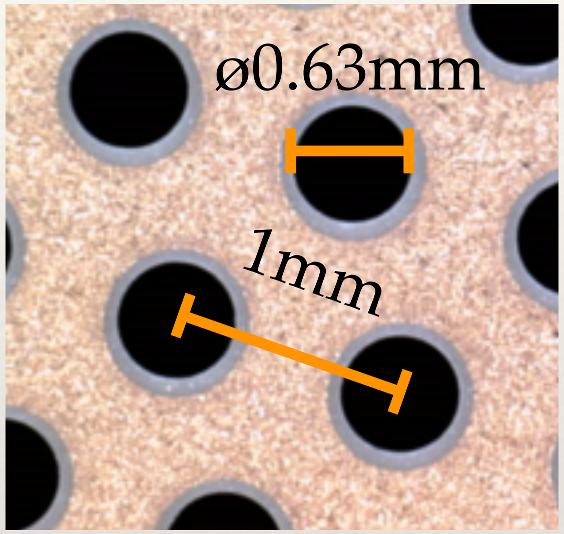


Dielectric constant:	4.34 (1GHz)
Dielectric strength:	~20 V/μm
Resistivity:	~$10^{14}\Omega$cm

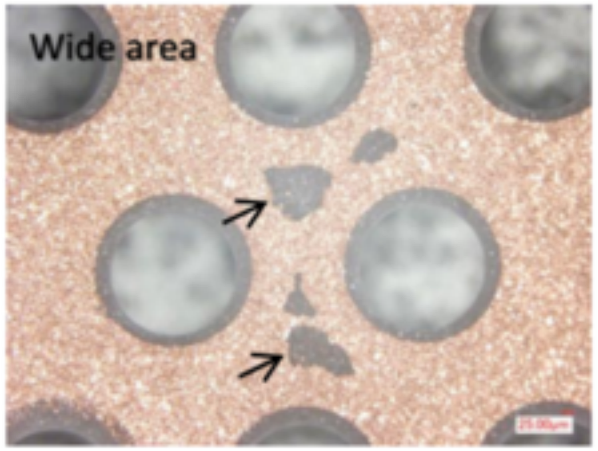


0.4mm Alumina

- Laser cut
  - Sharp edges seen from time to time
  - Can be mitigated with post treatment
- Copper mesh screen printed
  - Procedure not yet optimized

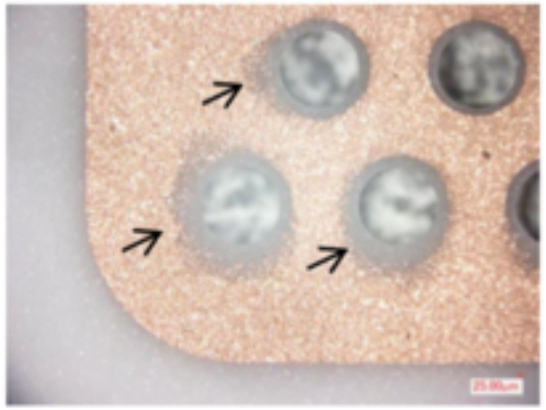


Dielectric constant:	9.5 (1MHz)
Dielectric strength:	23.6 V / μm
Resistivity:	>10^{14} Ωcm (@25˚C)



Irregular electrode holes distributed

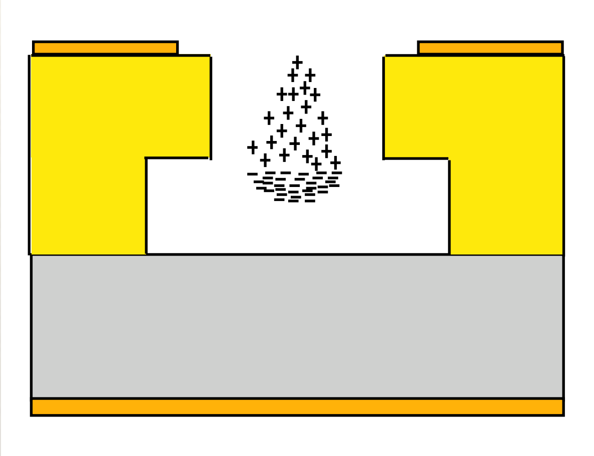
1A (outer corner and mesh edge)

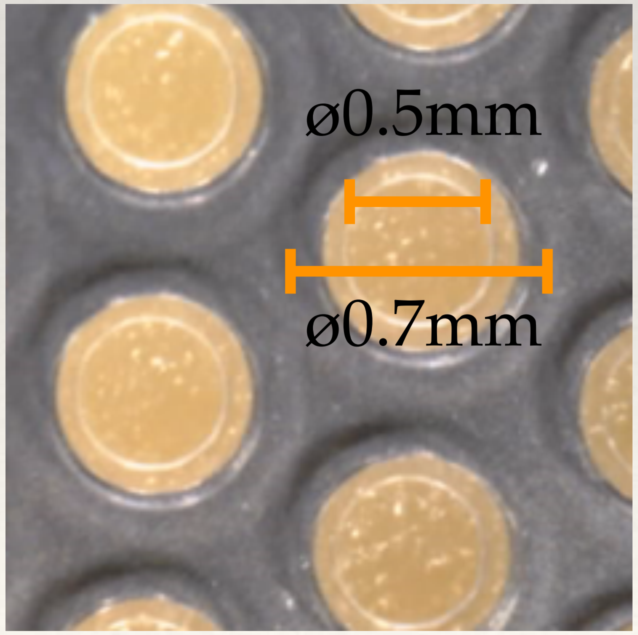

Unshapen Cu electrode hole edges

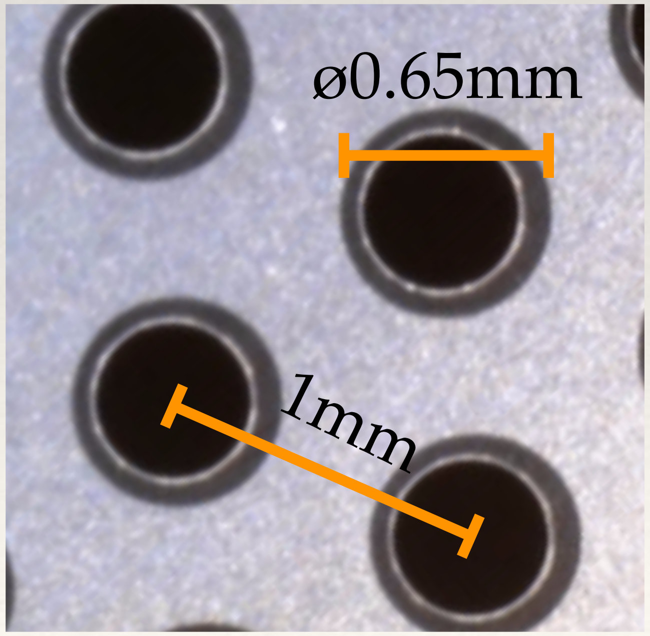
0.4mm thick Step-EPOXY

- Photo-lithography
- Step-well geometry: holes of 2 different diameters
  - Longer path between the top and bottom electrodes → potentially more stable
  - Wider hole at the region of maximum charge → possibly less charging up of the hole walls
- Nickel coated
- Very precise machining.

Dielectric constant:	3~4 (1GHz, 50%RH)
Dielectric strength:	110~120 V/µm
Resistivity:	2~3x10^{16} Ωcm

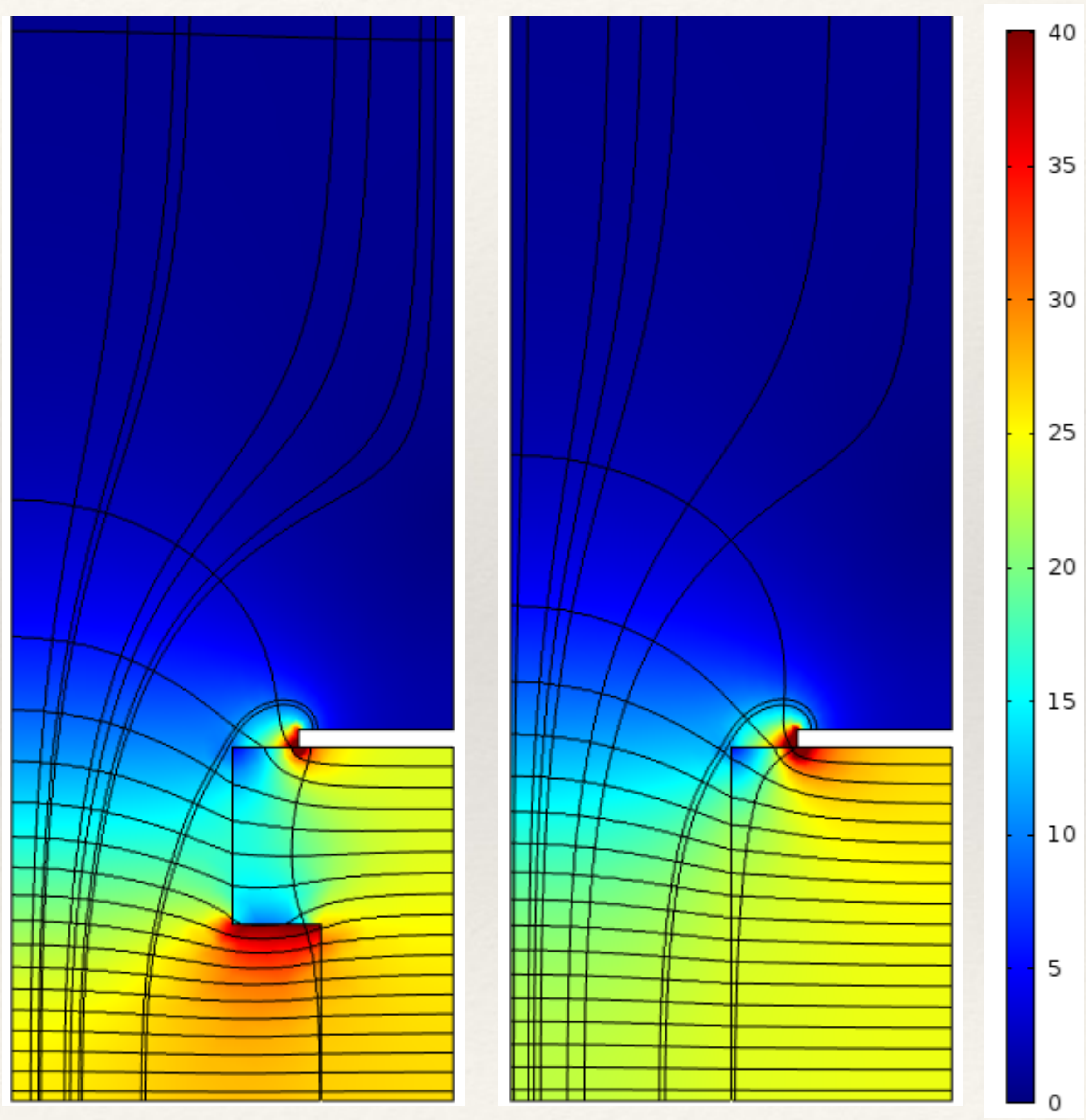






step-RPWELL field simulation

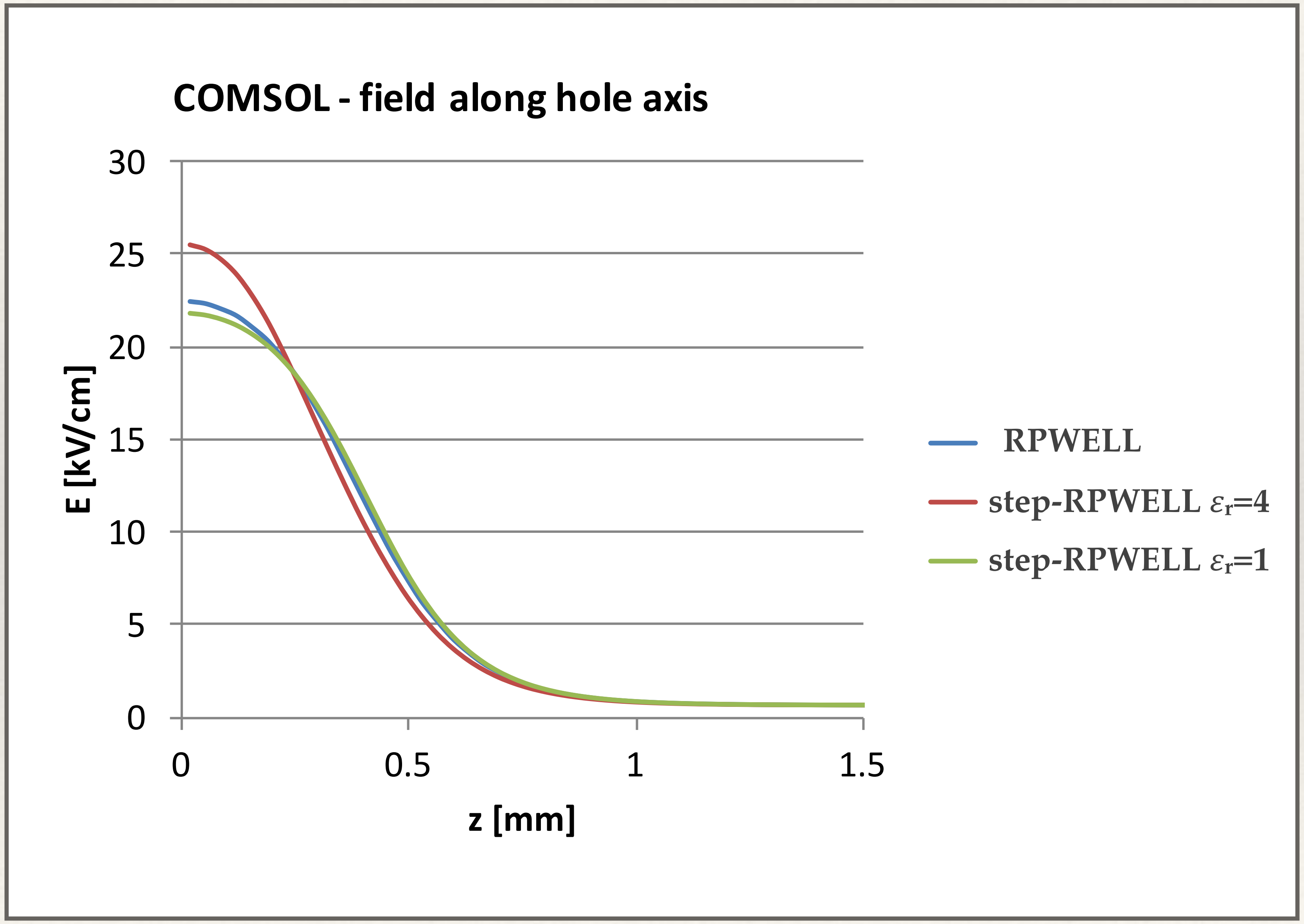
- Field similar to that of a standard WELL
- Avalanche charge is far from the walls



d_{top}=0.5 mm, d_{bot}=0.7 mm, t=0.4 mm, a=1 mm, h=75 μm, ΔV_{THGEM}=1000V, E_d=0.5 kV/cm

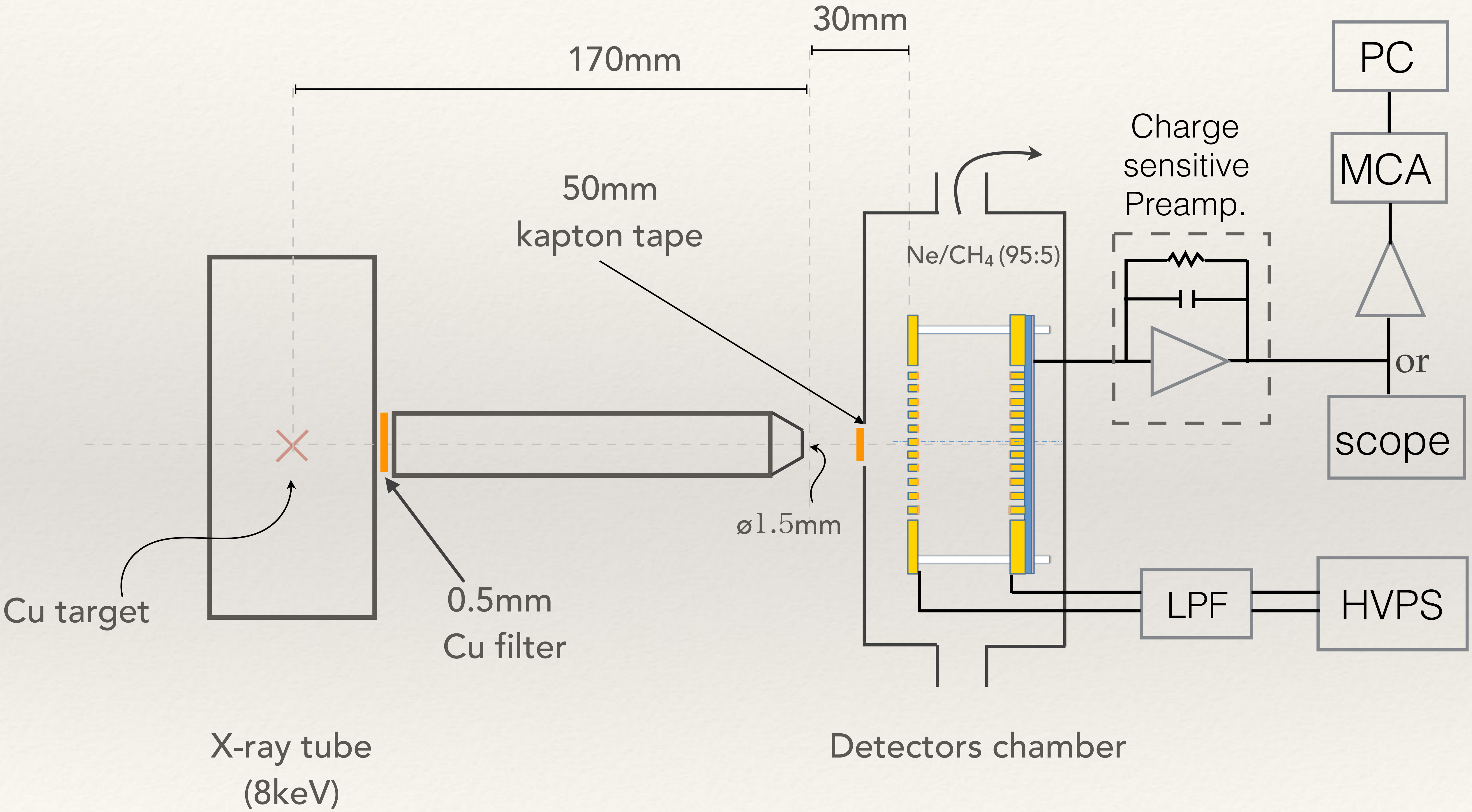
step-RPWELL field simulation

- Field similar to that of a standard WELL
- Avalanche charge is far from the walls
- <u>Next step</u>: multiplication & charging up simulation



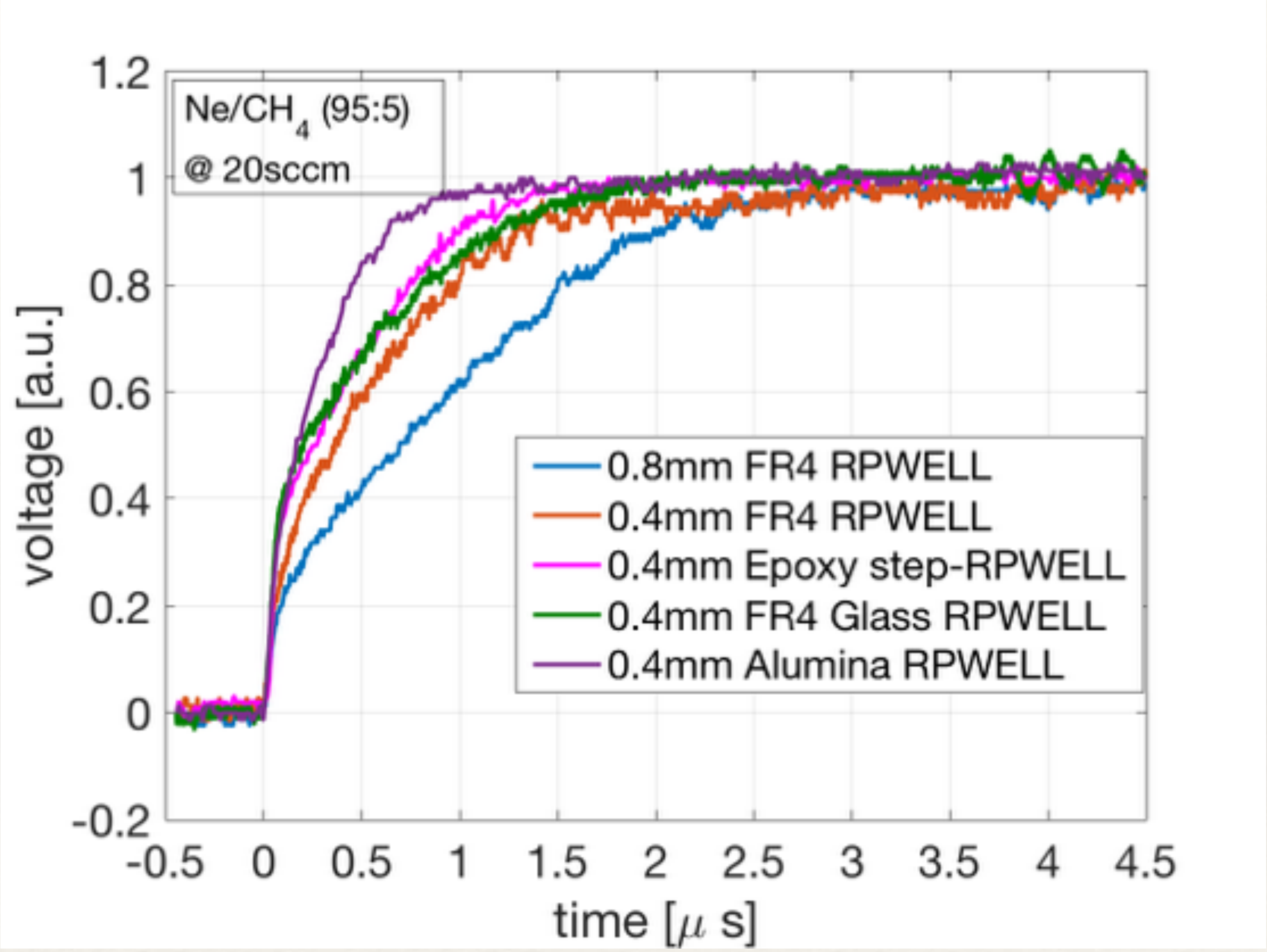
d_{top}=0.5 mm, d_{bot}=0.7 mm, t=0.4 mm, a=1 mm, h=75 μm, ΔV_{THGEM}=1000V, E_d=0.5 kV/cm

Experimental Setup

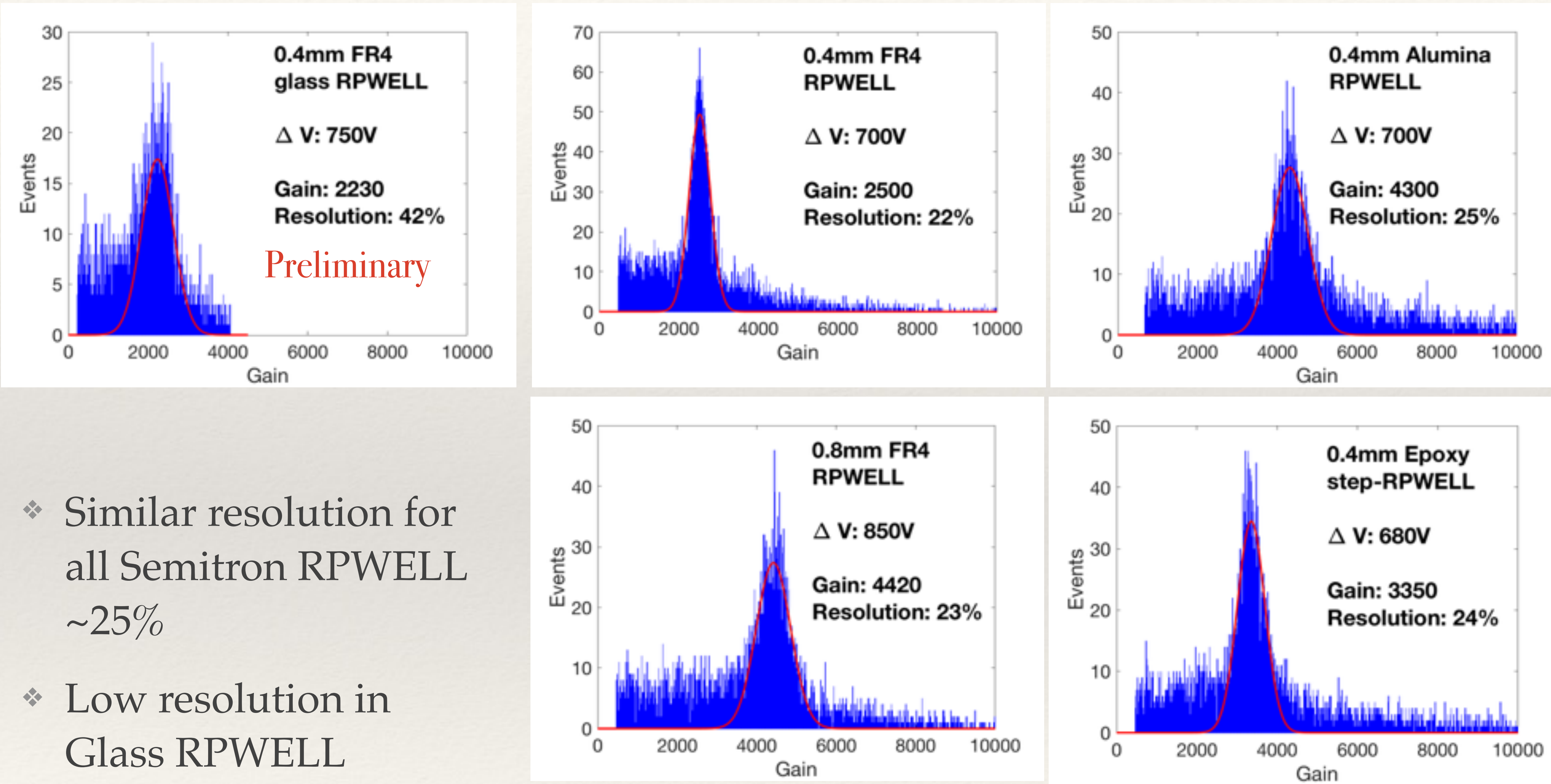


Signal Shape

- 0.4 mm thick RPWELLs have shorter rise due to the sorter ion drift time
- Fraction of charge in the fast component differs between configurations
  - Also when comparing only the 0.4 mm thick configurations.
  - Largest for the alumina
  - Under investigation



Spectra



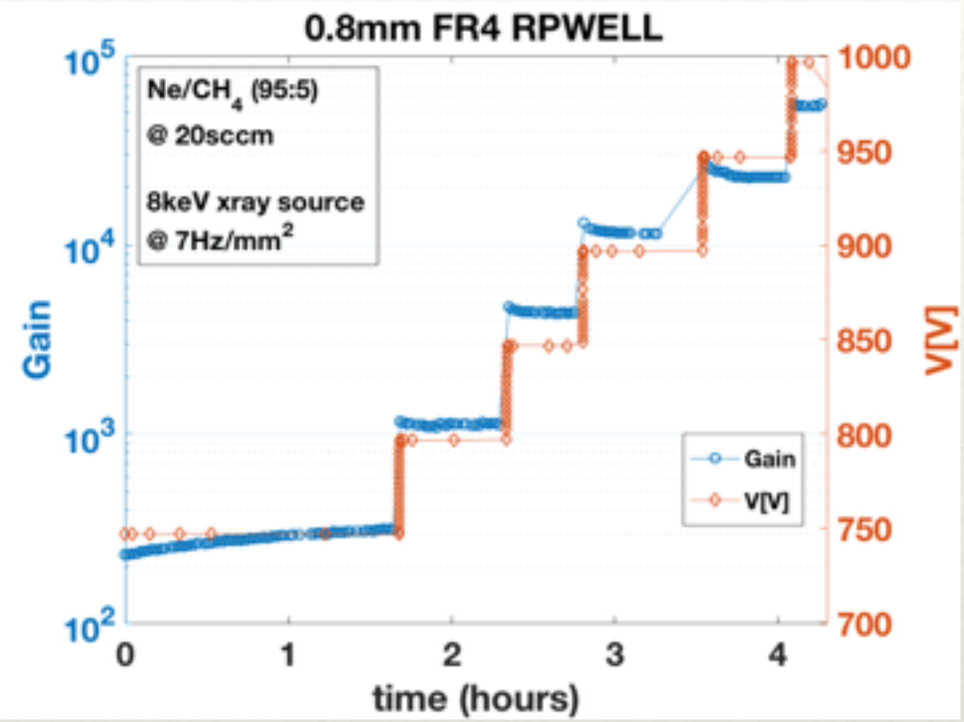
- Similar resolution for all Semitron RPWELL ~25%
- Low resolution in Glass RPWELL
  - Under investigation

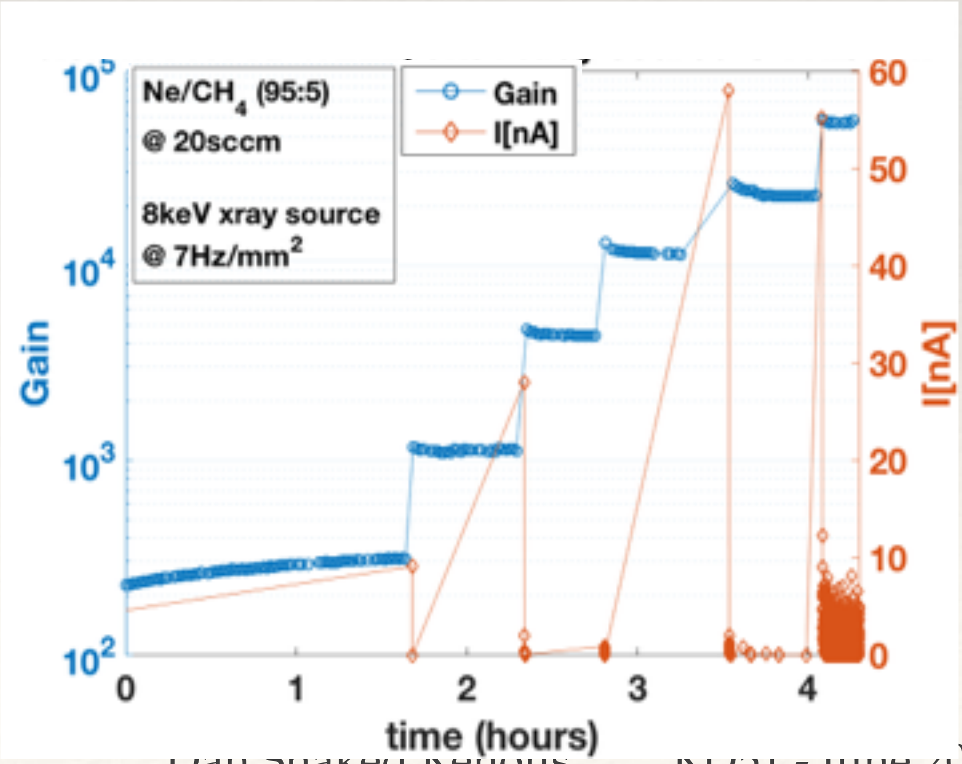
Ne/CH_4 (95:5) @ 20sccm

8keV xray tube @ 7Hz/mm^2

Gain Measurement: methodology

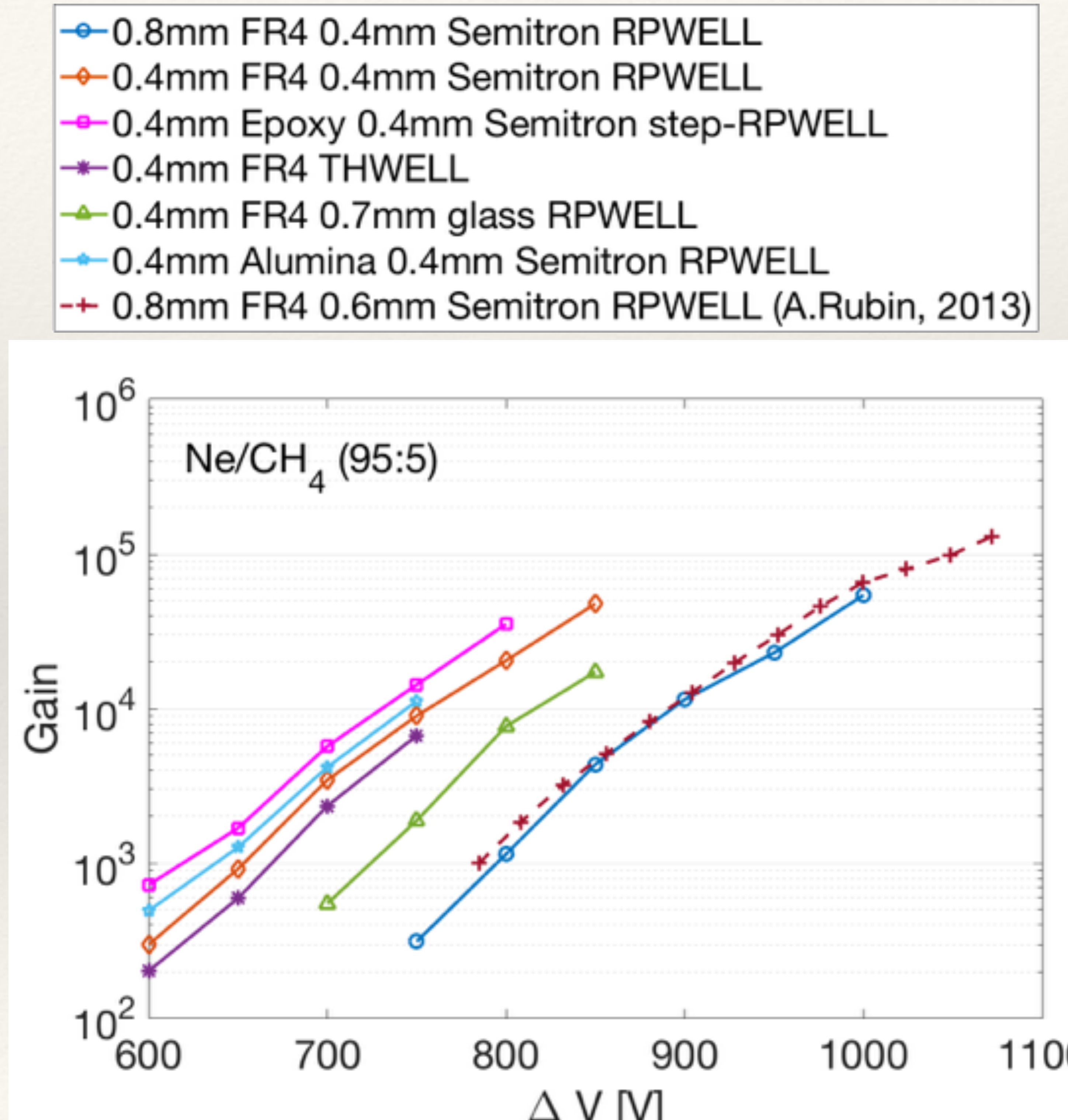
- Wait for the relatively fast stabilization
- No discharges.
- Stable current.
- End of gain curve @ onset of current spikes.
- No voltage drop





Gain Measurement: results

- 0.8 & 0.4mm thick FR4-RPWELLs reach a gain of #10^4
- Epoxy step-WELL reaches similar gain
  - Despite sharp edges and smaller rims
- Alumina-WELL yields lower gain
  - Likely due to unperfected production of the prototype
- Glass RPWELL lower gain is under investigation.



Conclusions

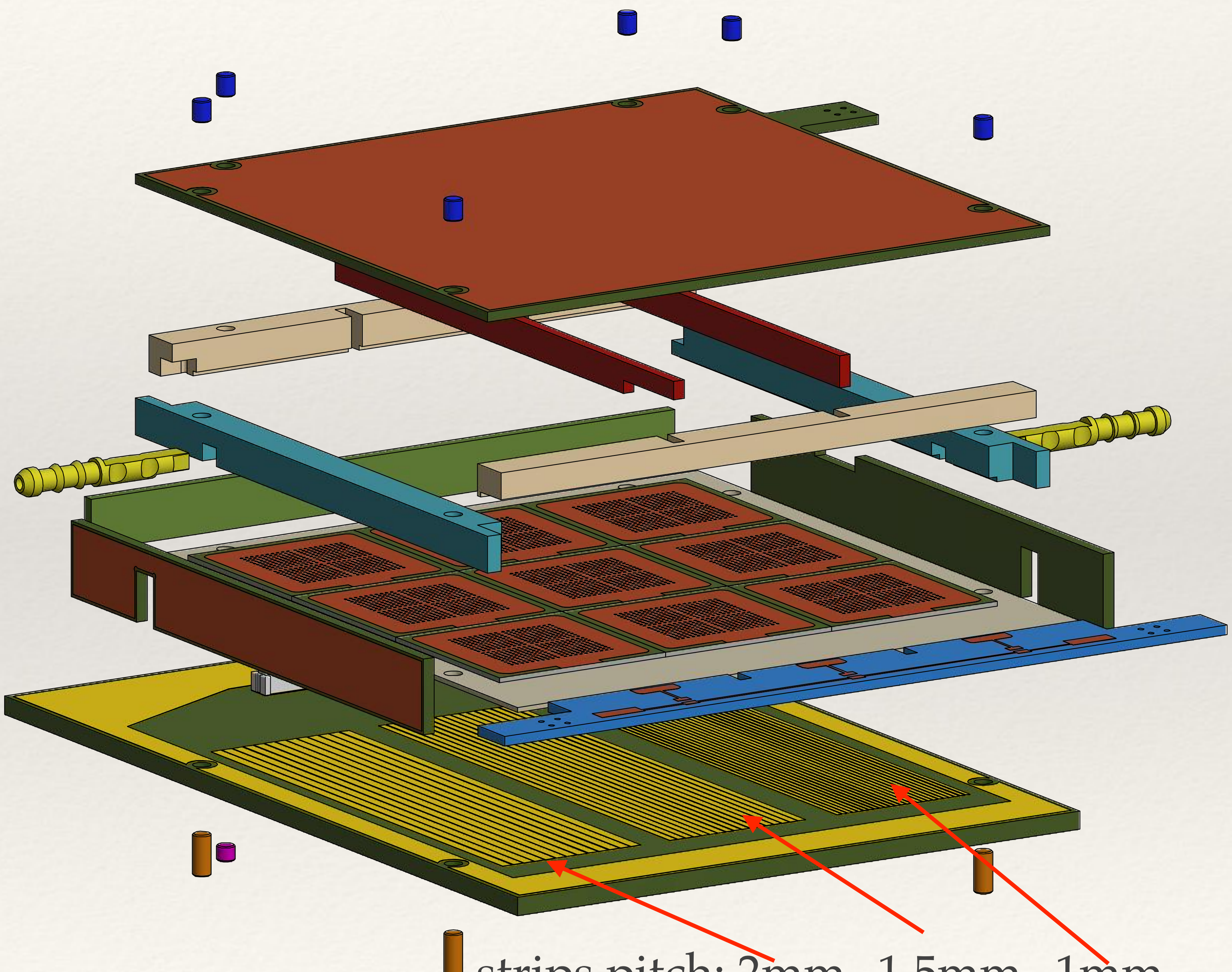
- Revisit different production techniques
- FR4 still an excellent solution
- Epoxy provides with interesting possibility
  - Allows testing complicated geometries
  - Provides with possibility to investigate charge up effects
- Alumina - production has to improve
  - Laser drilling is promising but imperfect at this point
- Looking for resistive materials to replace the Semitron polymer
  - To meet environmental criteria in high energy experiments.

Upscaling :
targeting 1m^2 detector

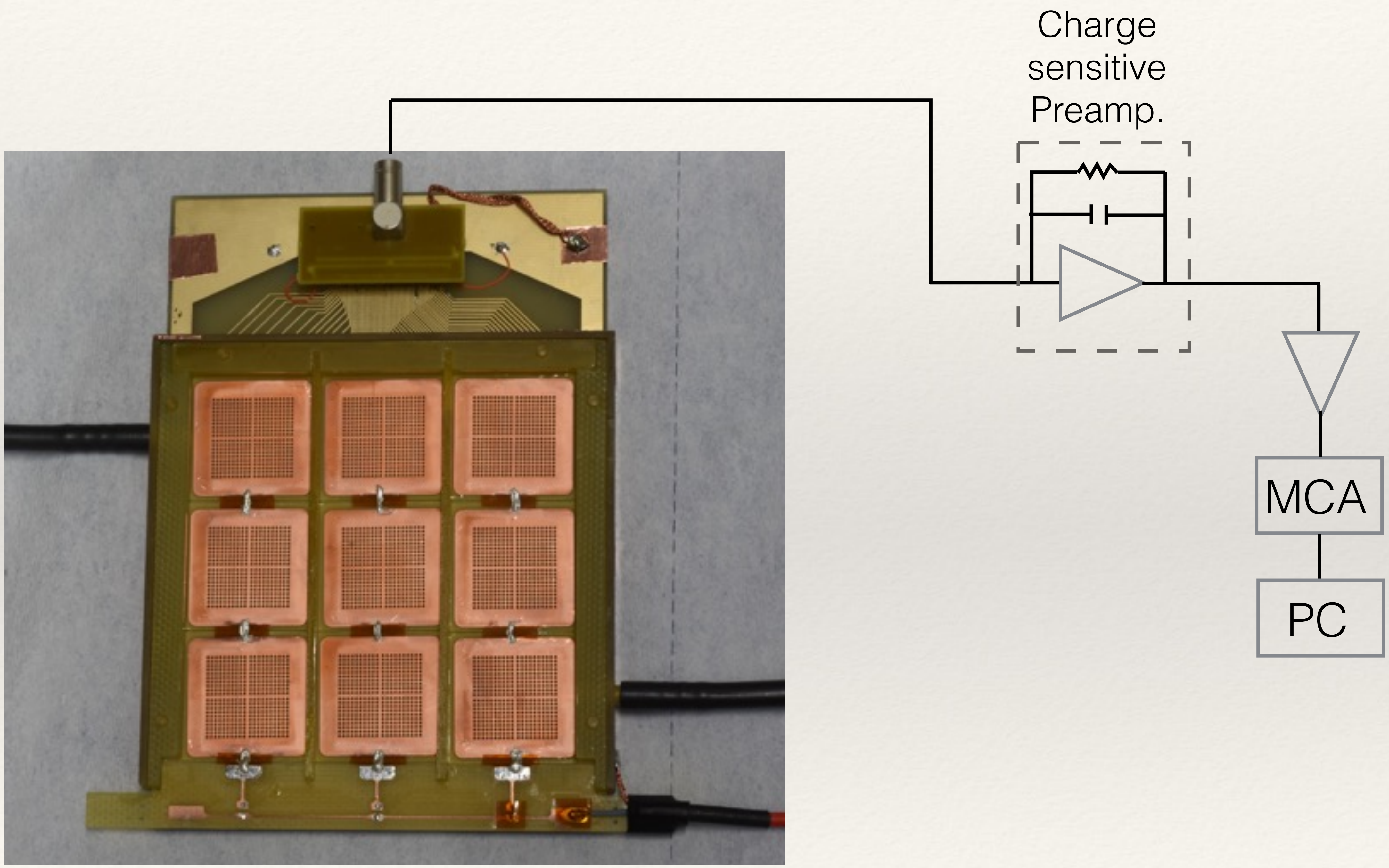
Exercise: Tiled 10×10cm^2 detector

Goals:

- use design and assembly that can be scaled up.
- Assess position resolution - from pad readout to strips.



First test readout setup



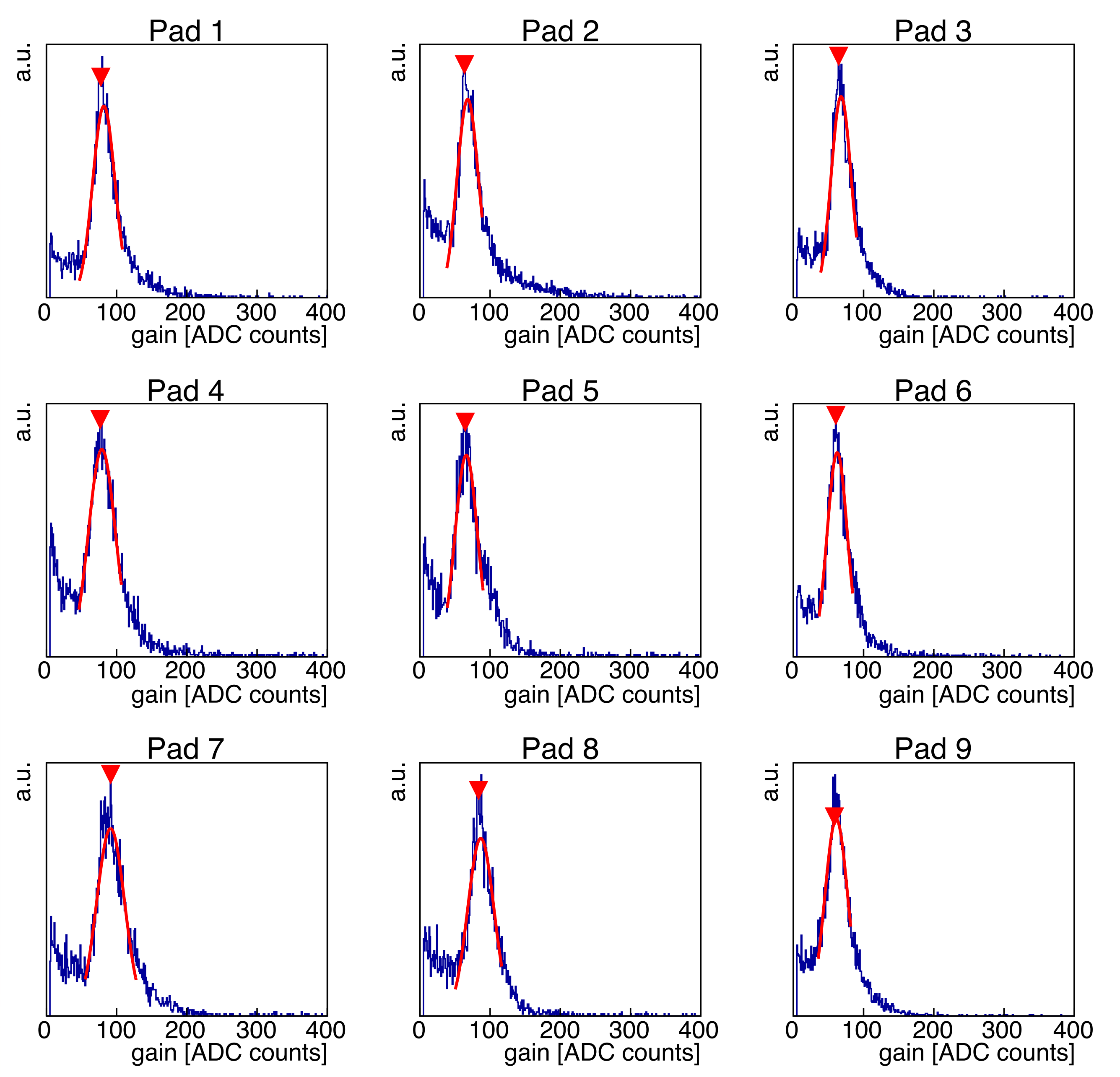
Preliminary results

First tests after assembly with uncollimated Fe^{55} source

- gas: Ne/(5%CH_4)
- ΔV_{RPWELL}= 880V

~10Hz - 5.9keV x-rays

all strips are shorted and the source was moved in front of each THGEM (pad)



- Clear signal on all the tiles

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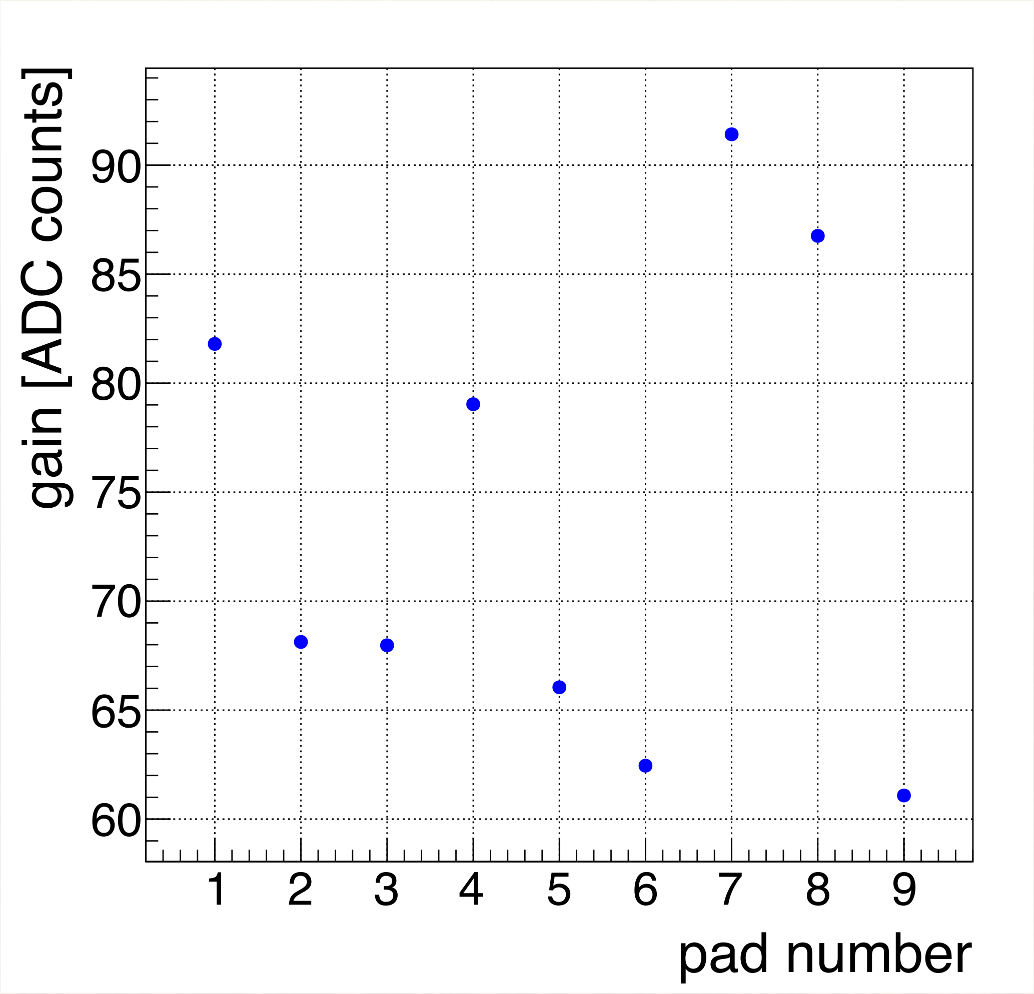
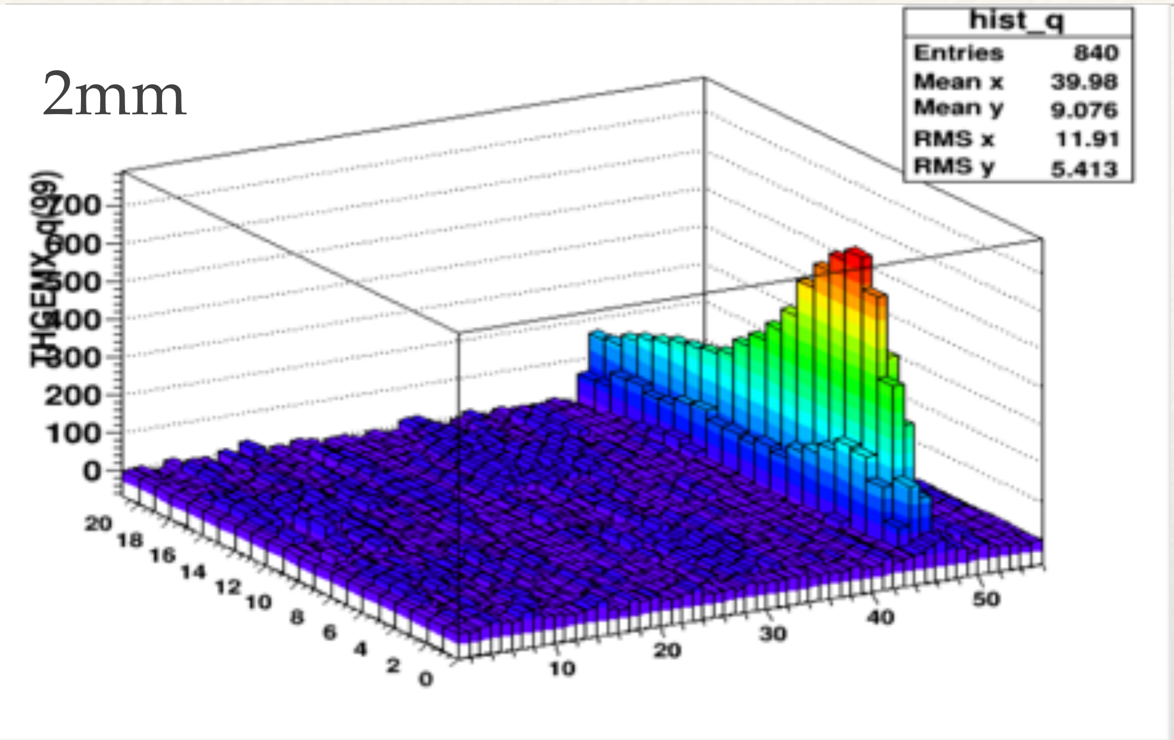


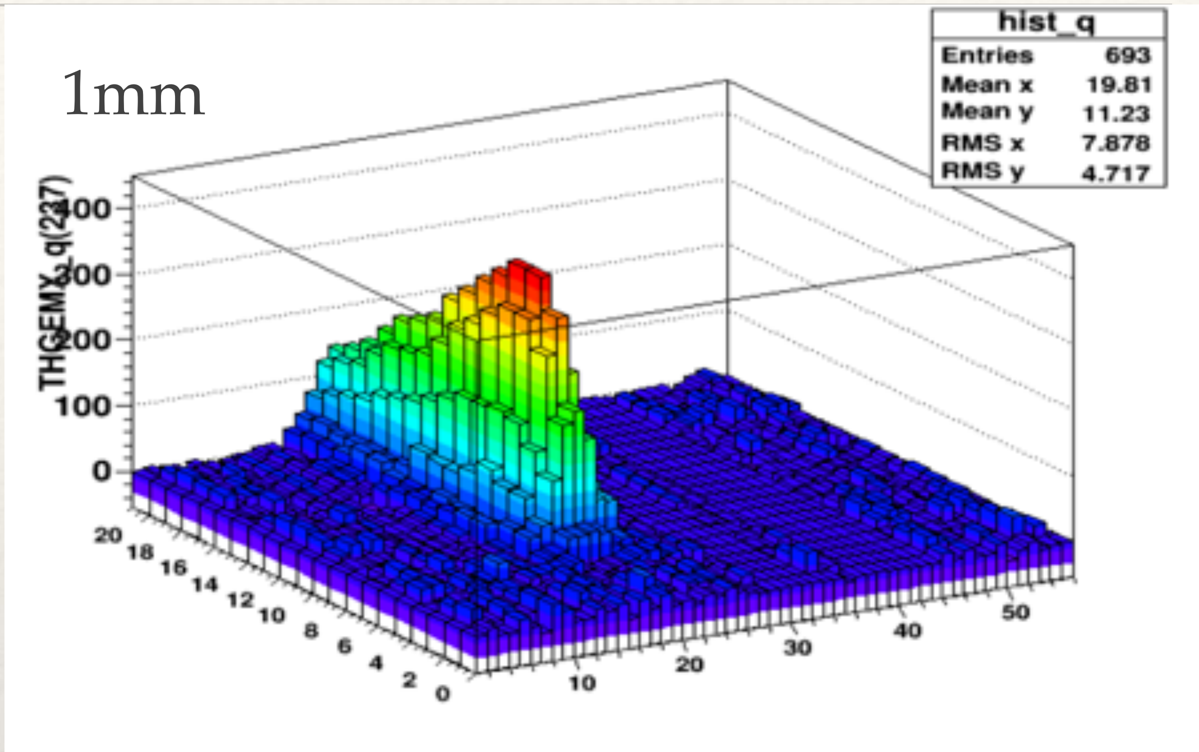
~20% gain variations likely due to non uniform electrode thickness

Strip by strip readout - APV/SRS

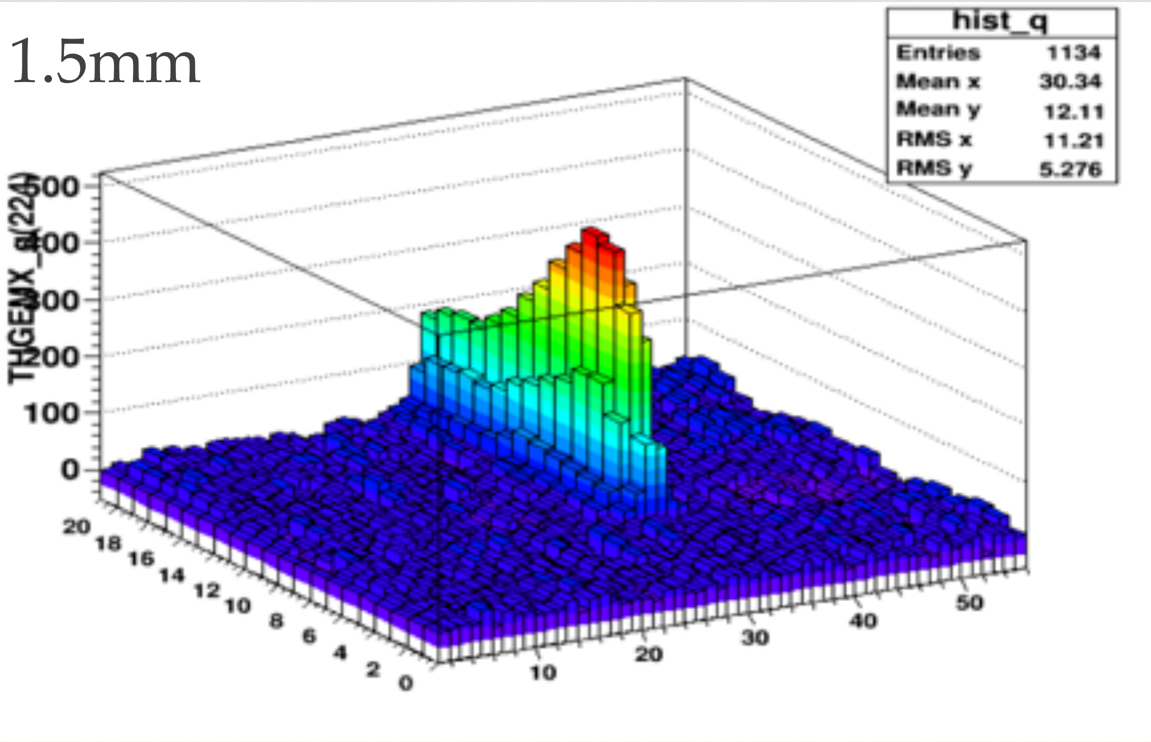
2mm



1mm



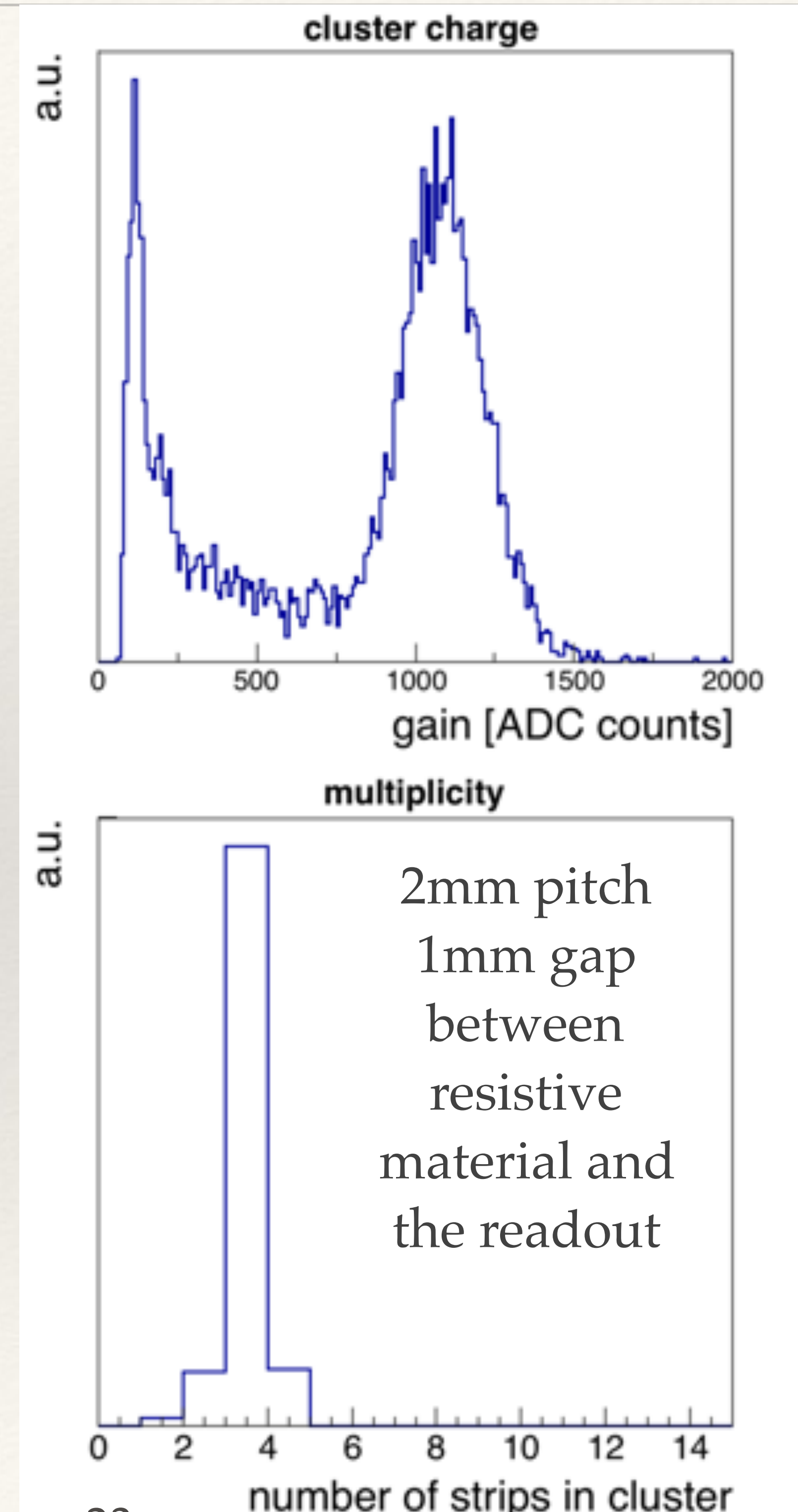
1.5mm



Preliminary results

Tests with SRS/APV25

- gas: Ne/(5%CH_4)
- ΔV_{RPWELL}= 880V
- ~10Hz - 8keV x-rays
- 0.5mm collimation
- readout: SRS/APV25 in self-trigger mode (from THGEM)
- strips pitch 2mm



~20% energy resolution

3 strips in cluster: localized signal and position resolution better than the pitch

Summary and Outlook

- Tiled detector is a viable solution
  - allows pre-selection of elements
  - dead areas can be optimize
- 0.5 x0.5 m^2 detector design is evolving
- Further characterization is on going
  - spatial resolution
  - UV detection

Thank you