Recent progress with the RPWELL detector

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

THGEM-based detectors

Wish list

Random order

- Simple
- Robust
- Cost-effective
  - Production
  - Operation (etc. gas mixtures)
- Large-area
- Efficient
- Resolution: spatial, time, energy
- Broad dynamic range
- Rate capabilities
- Discharge free
- Industrially produced

Applications

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- RICH devices
  M. Alexeev et al. 2012 JINST 7 C02014
- Cryogenic detectors for TPC in neutrino physics and rare-event searches
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- Thin sampling elements for DHCAL
  S. Bressler et al. 2013 JINST 8 P07017

- And more...

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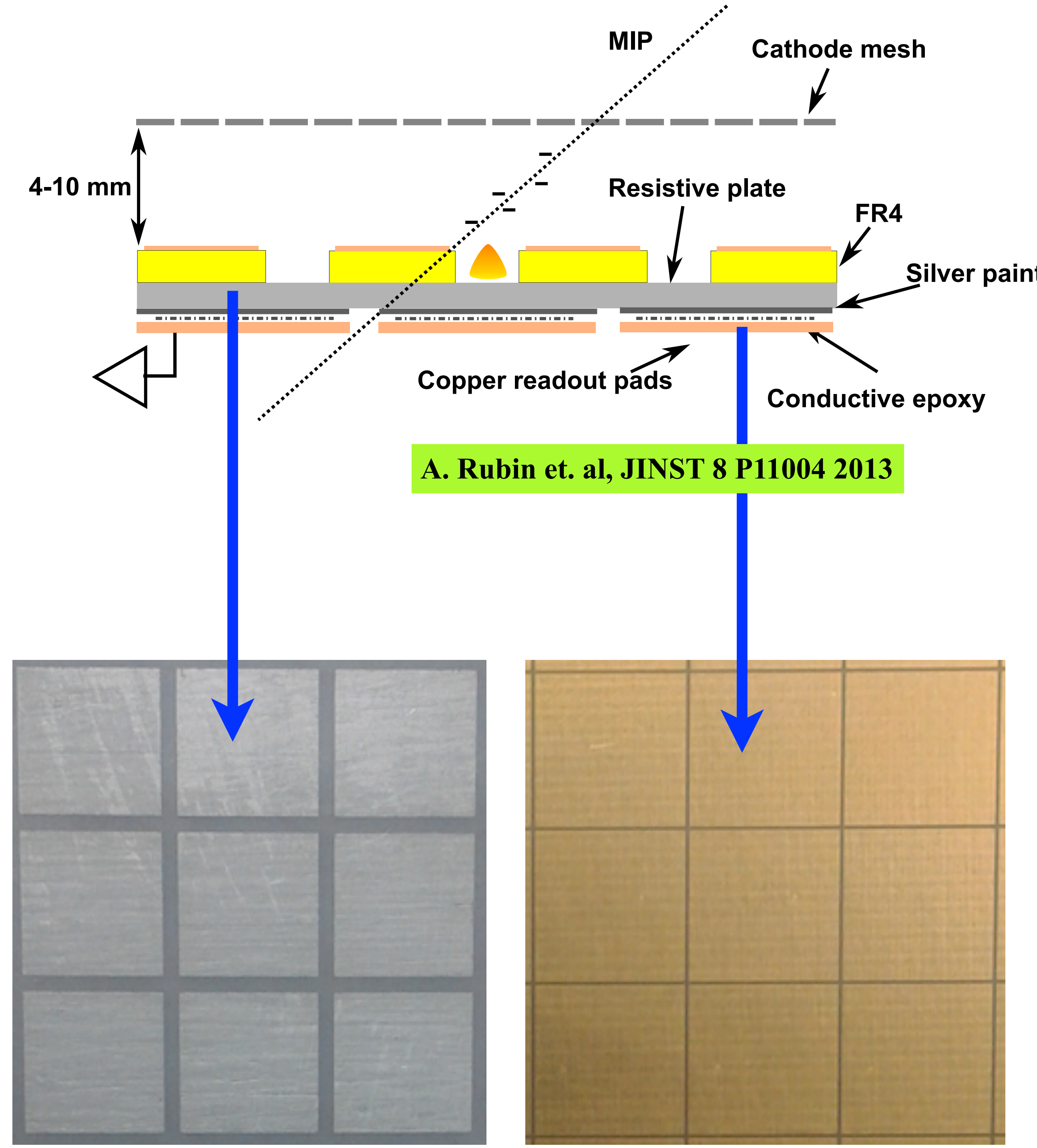
The RPWELL - boosts the items on the wish list

The RPWELL detector

Resistive Plate 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



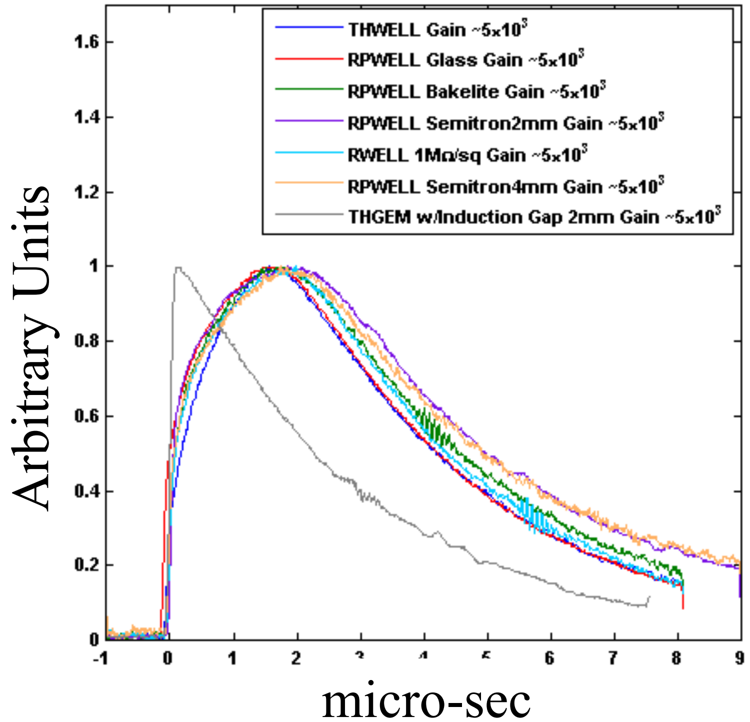
Tested materials

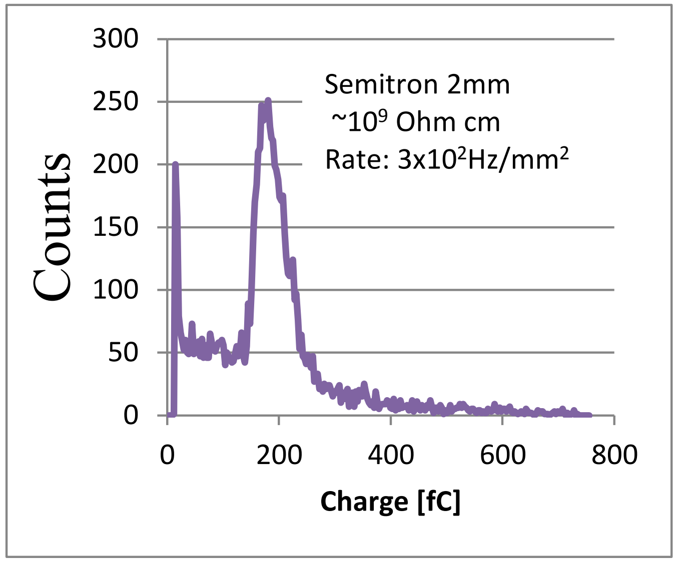
Material	Dimensions [mm]	Bulk resistivity [Ωcm]
VERTEC 400 glass	36×31×0.4	8×10^{12}
HPL Bakelite	29×29×2	2×10^{10}
Semitron ESD 225	30×30×2	2×10^{9}

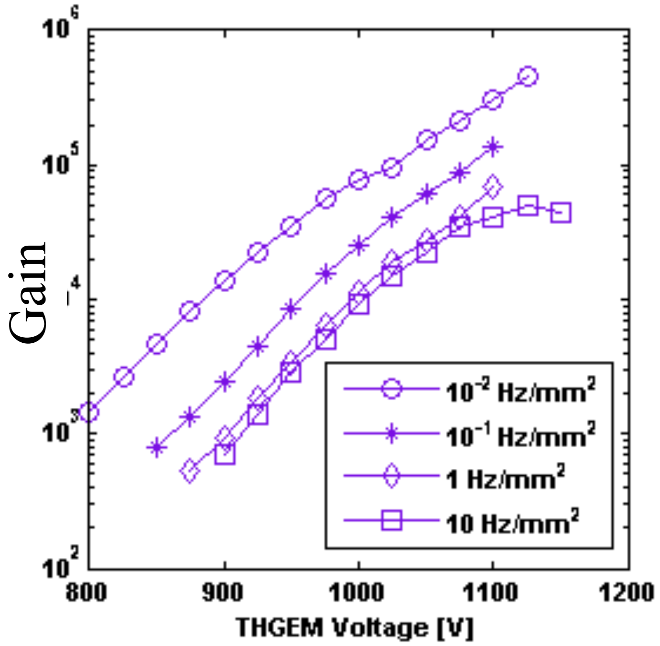
Lab. studies — Characterization in Ne\(5%)CH_4

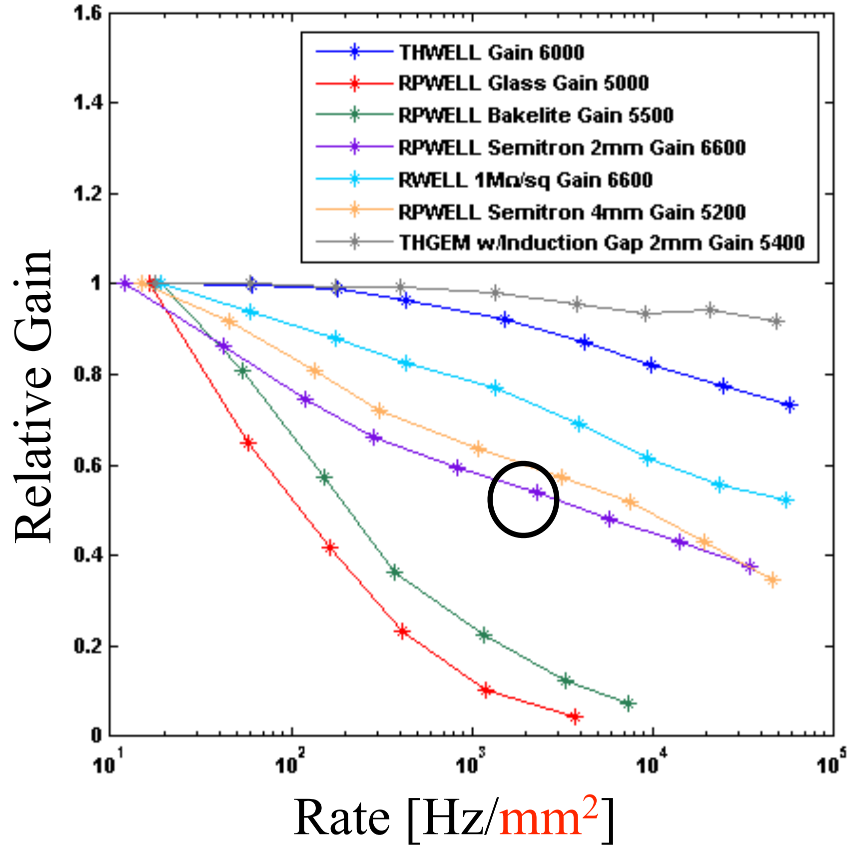
A. Rubin et. al, JINST 8 P11004 2013

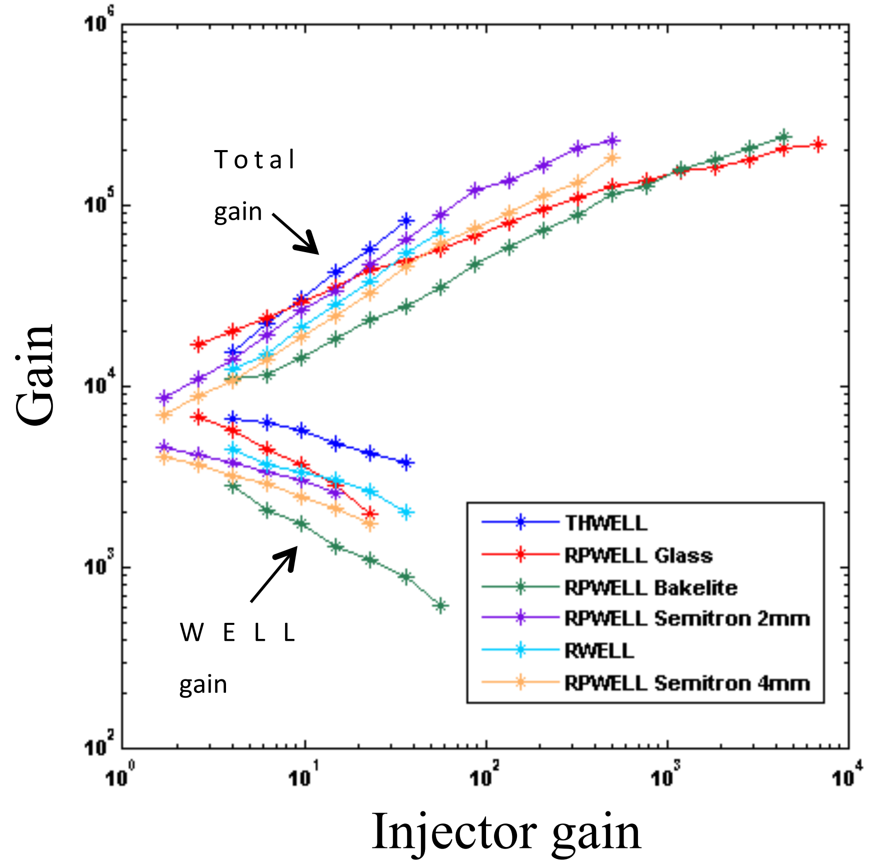
RPWELL 10^9 Ωcm - 2 mm layer









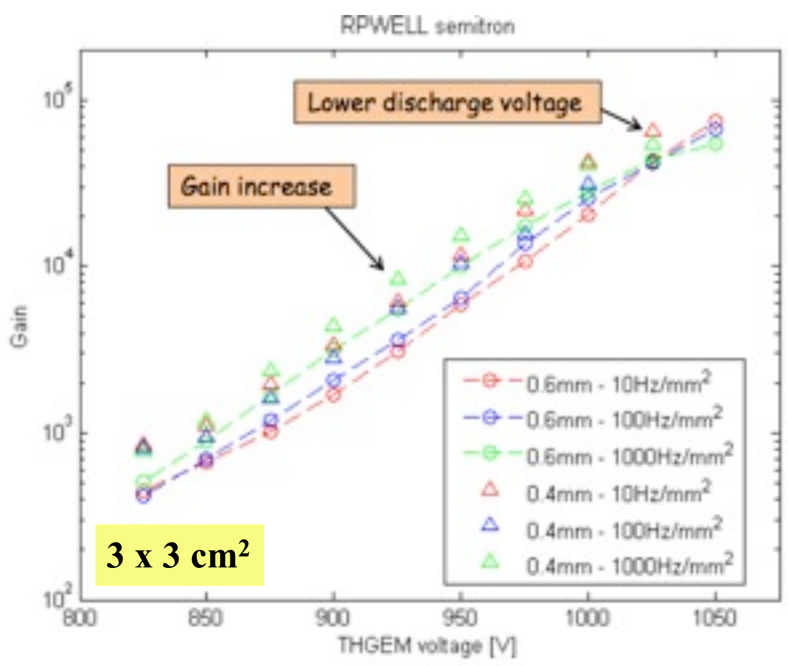


- Same pulse shape as standard well
- ~20% Energy resolution
- Gain saturation at high irradiation rate
- < 50% gain drop over 4 orders of rate magnitudes
- **No discharges at high rate of HIPs**

Focus on thin Semitron ESD 225 layers

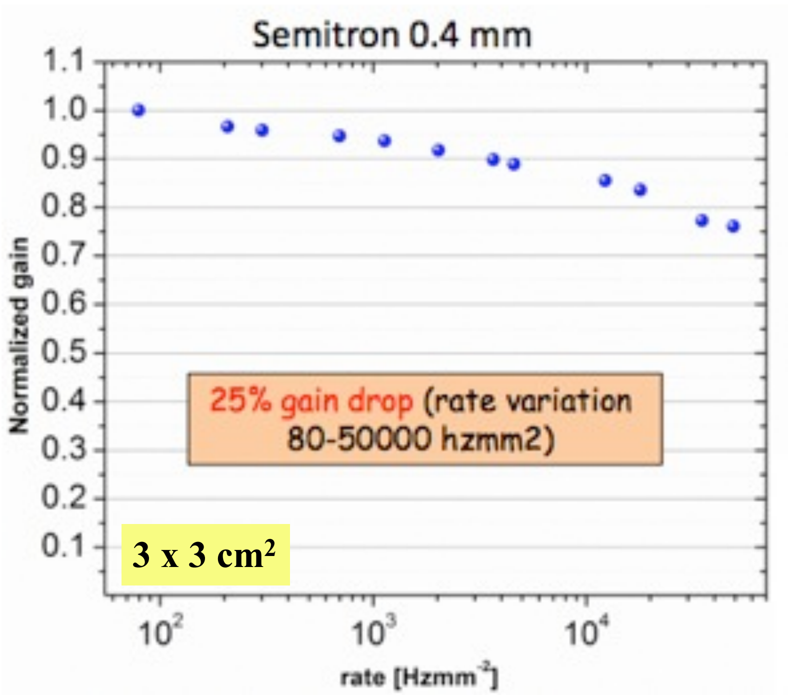
Lab. studies — Characterization in Ne\(5%)CH_4

Improved performance with thinner (0.4 & 0.6 mm) layers



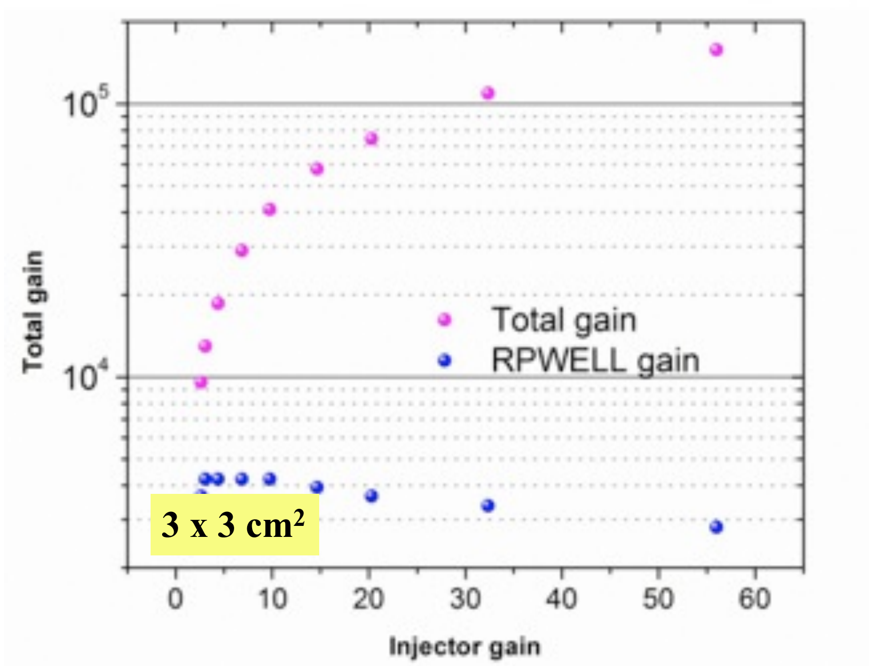
Higher gain for the same voltage

- Smaller anode-cathode gap



Gain drops slower with rate

- Lower resistivity



Stable with HIPs

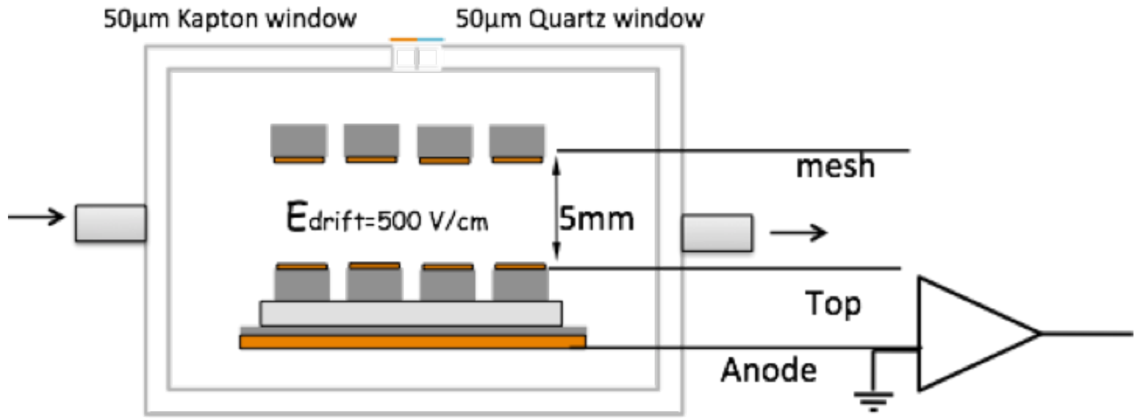
- Observe gain saturation

Focus on thin Semitron ESD 225 layers

Lab. studies

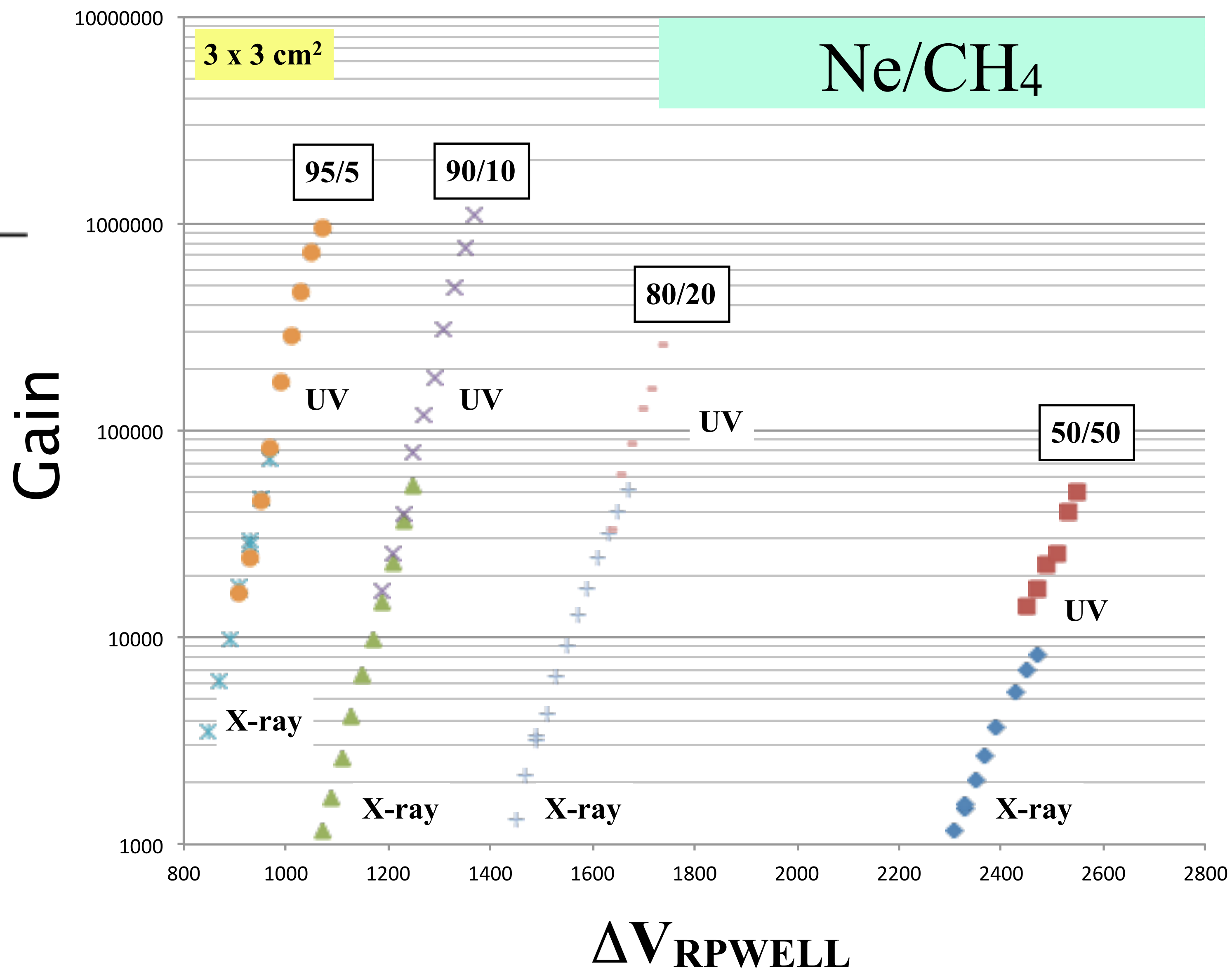
Operation in different gas mixtures

UV & X-ray



- Very high gains > 10^6
  - Also with X-ray

- High gain with high CH_4 concentration
  - Potential advantage in photo-electron extraction efficiency



S. Bressler

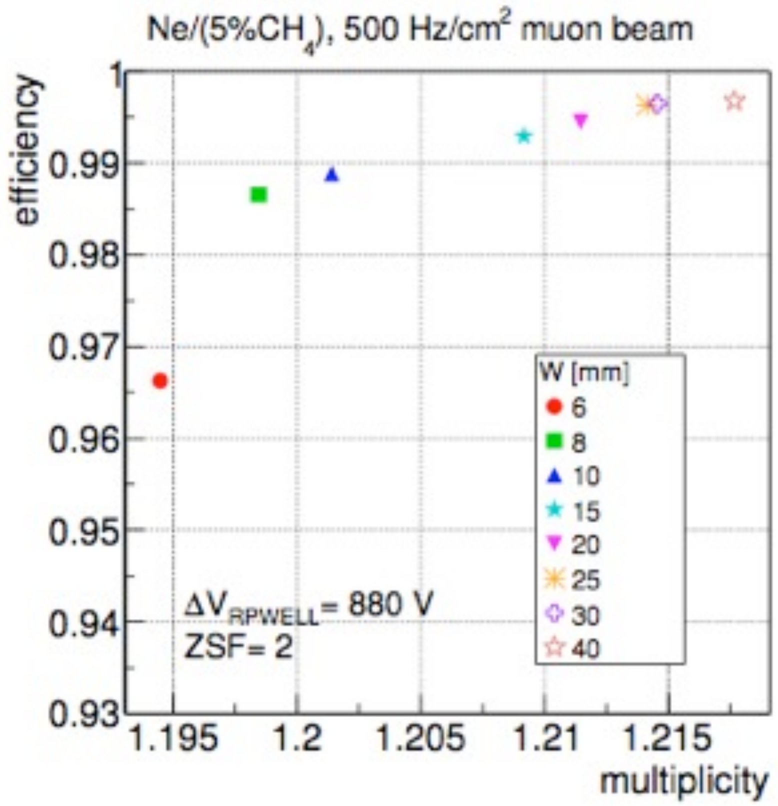
Beam studies — $10\times10\ cm^2$ detector - $Ne/(5\%CH_4)$

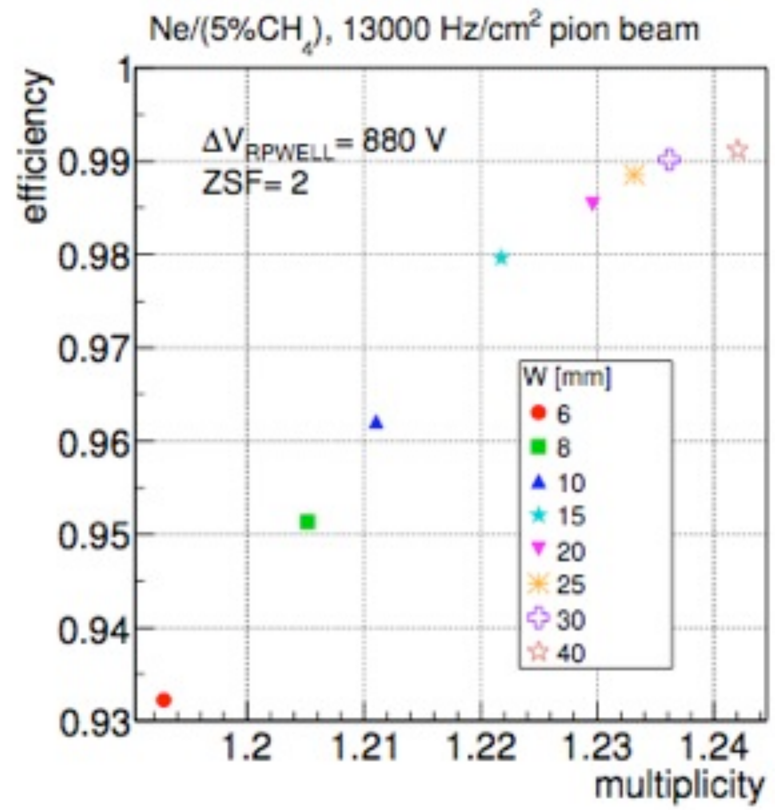
150 GeV μ & π beams — Global detector response

μ-beam
- Efficiency ≥ 99%
- Pad multiplicity ≤ 1.2

π-beam
- Efficiency ≥ 98%
- Pad multiplicity ≤ 1.25

- Small difference attributed to secondary particles emitted in π interactions





S. Bressler et. al, arxiv:1510.03116

Gas gain $\sim10^4$; effective gain $\sim10^3$

Discharge-free operation also at high rate π-beam

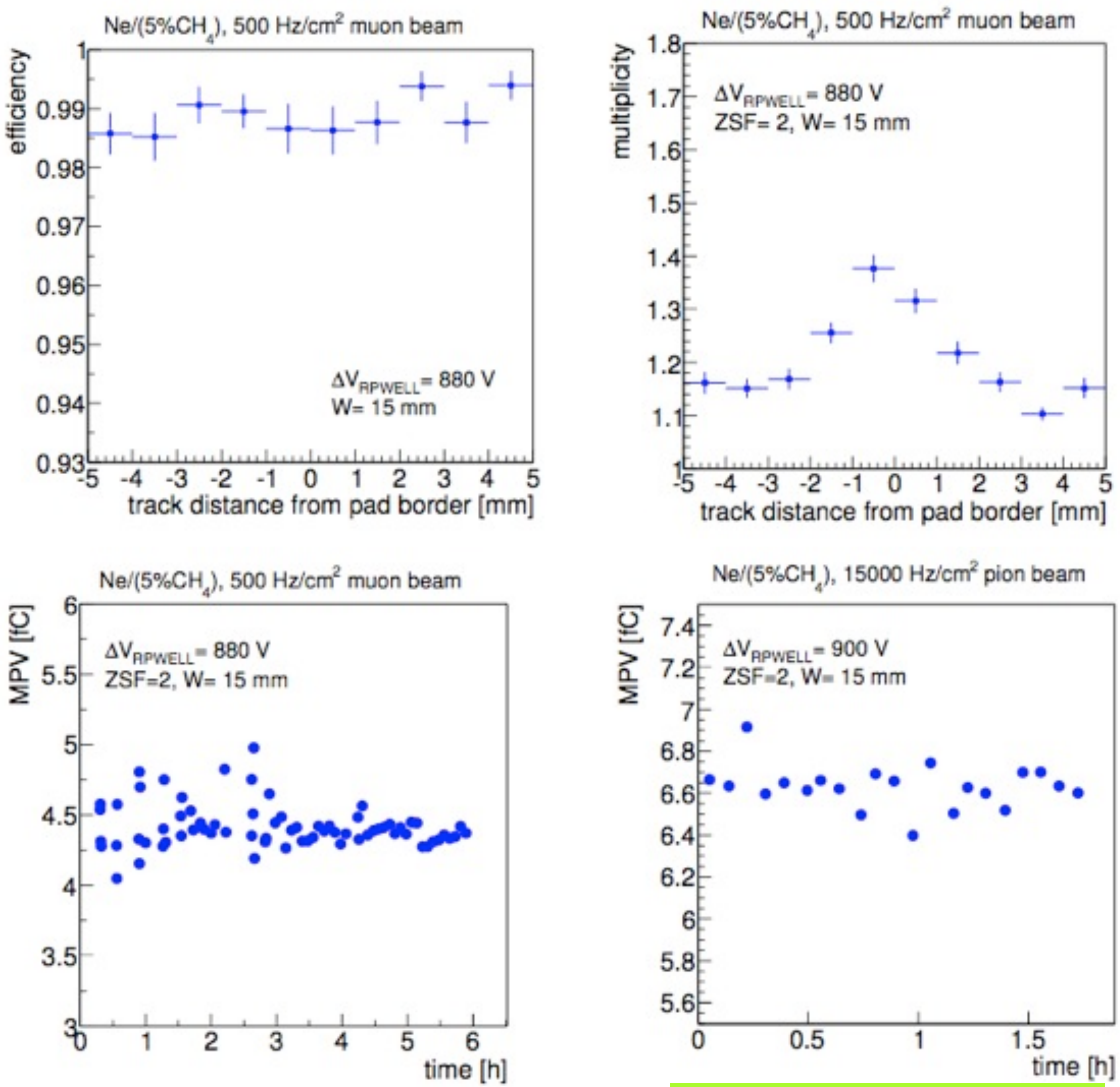
Beam studies — 10×10 cm^2 detector - Ne/(5%CH_4)

150 GeV μ & π beams — Local detector response

Local performance
- Uniform efficiency
- Larger multiplicity close to pad boundaries

Stability in time
- μ-beam: RMS 0.2 fC (5%)
- π-beam: RMS 0.1 fC (2%)

Gas gain ~10^4; effective gain ~10^3



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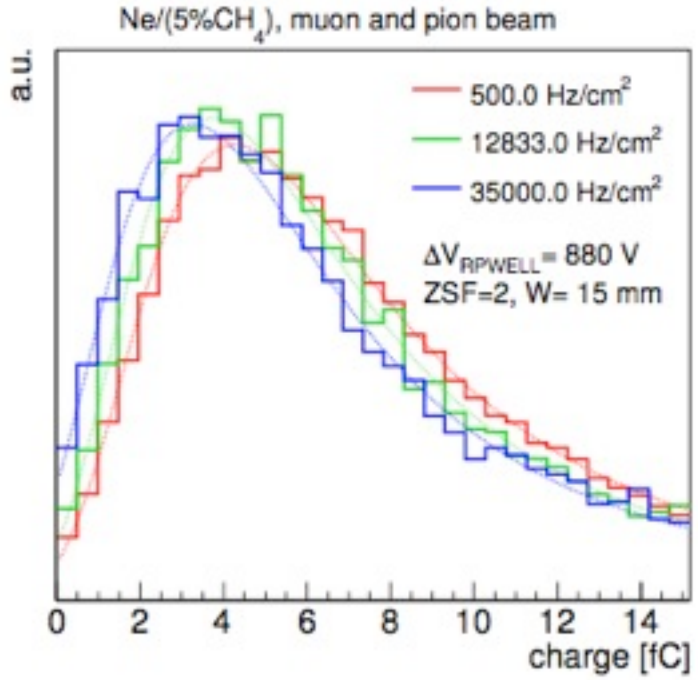
Discharge-free operation also at high rate π-beam

Beam studies — 10×10 cm^2 detector - Ne/(5%CH_4)

150 GeV μ & π beams — Rate capabilities

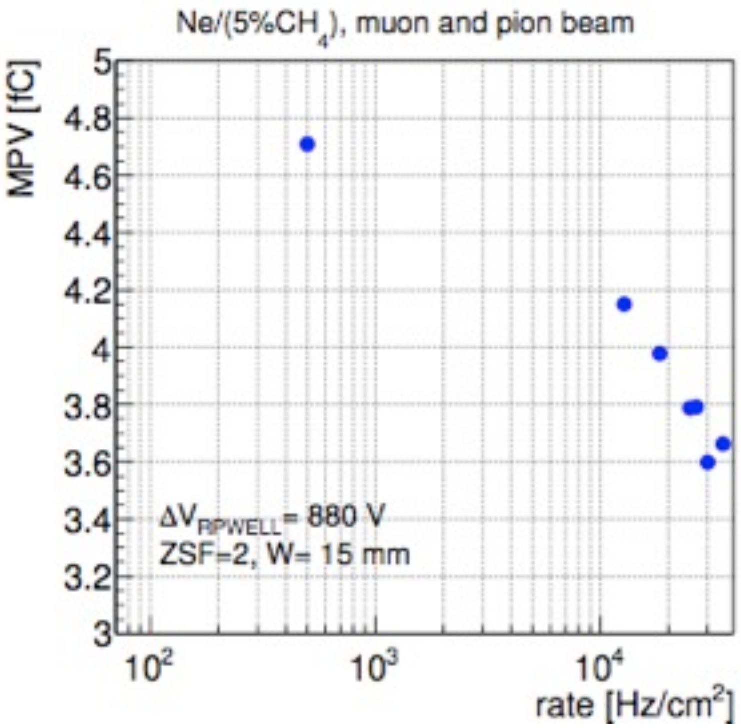
S. Bressler et. al, arxiv:1510.03116

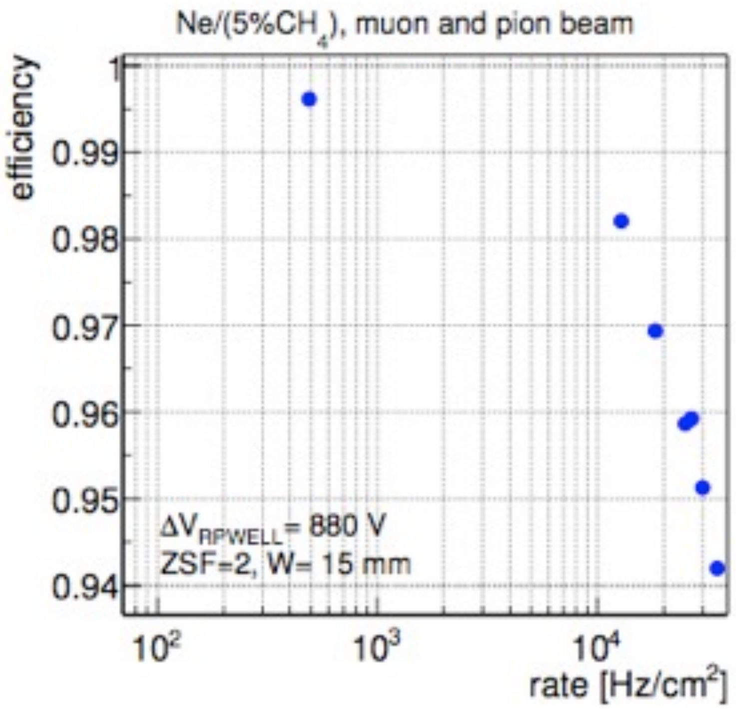


- ~20% gain drop over 2 orders of rate magnitudes

  ⇒

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





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Discharge-free operation also at high rate π-beam

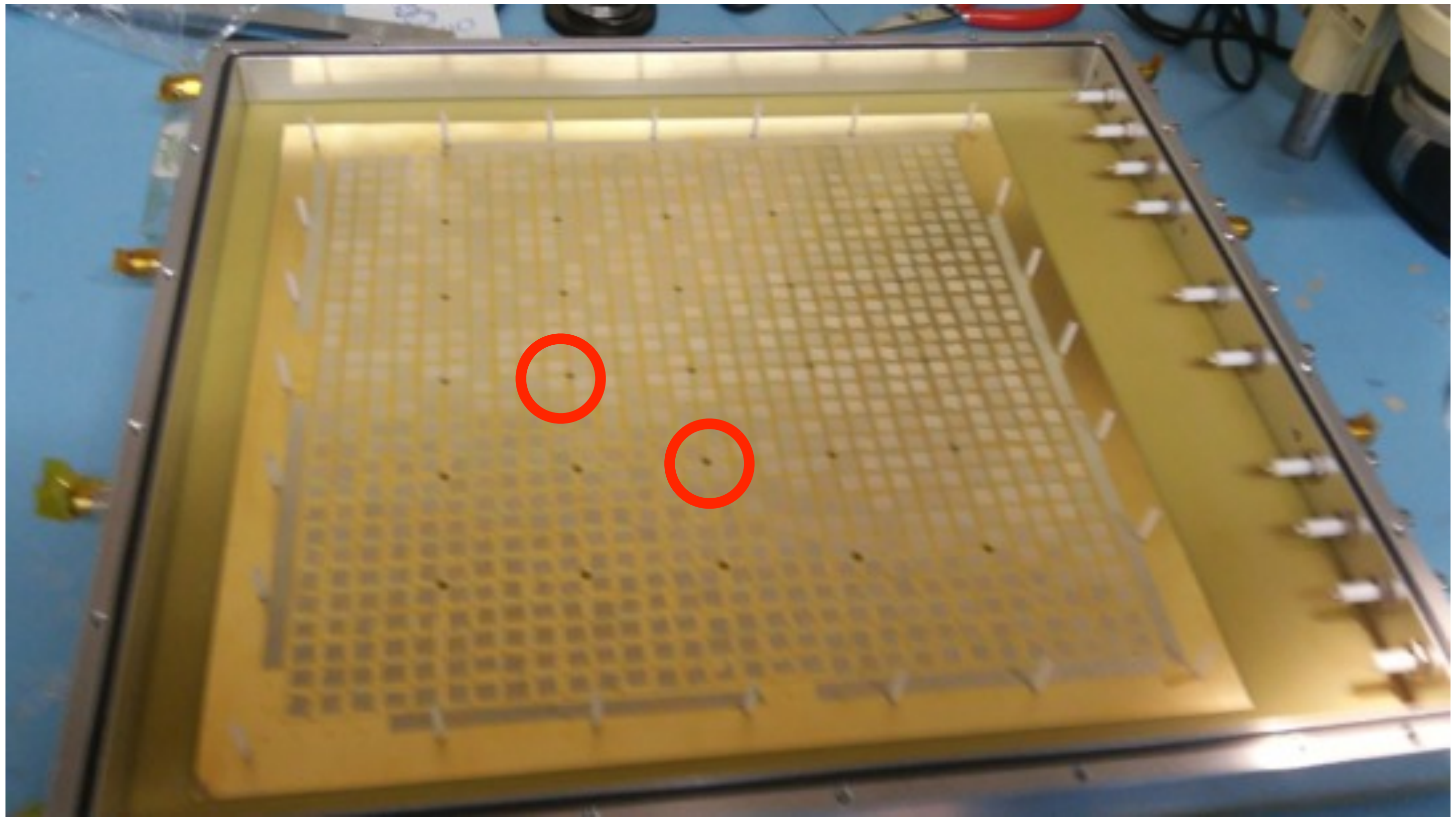
Beam studies

30×30 cm^2 detector

150 GeV μ & π beams

Present detector

- Discharges from the holes in the resistive sheet ⇒ direct link between the RPWELL electrode and the cathode



Beam studies

30×30 cm^2 detector

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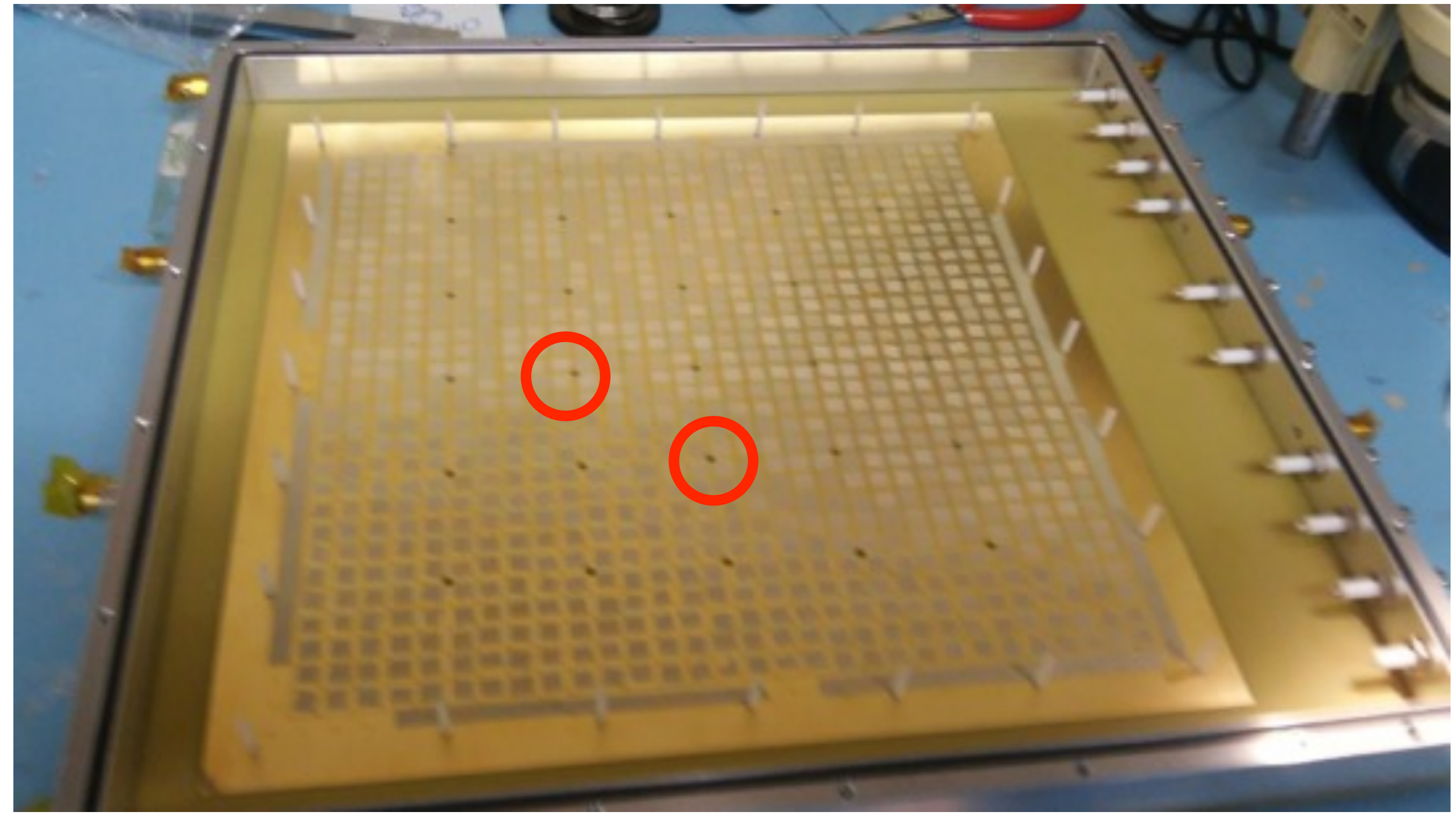
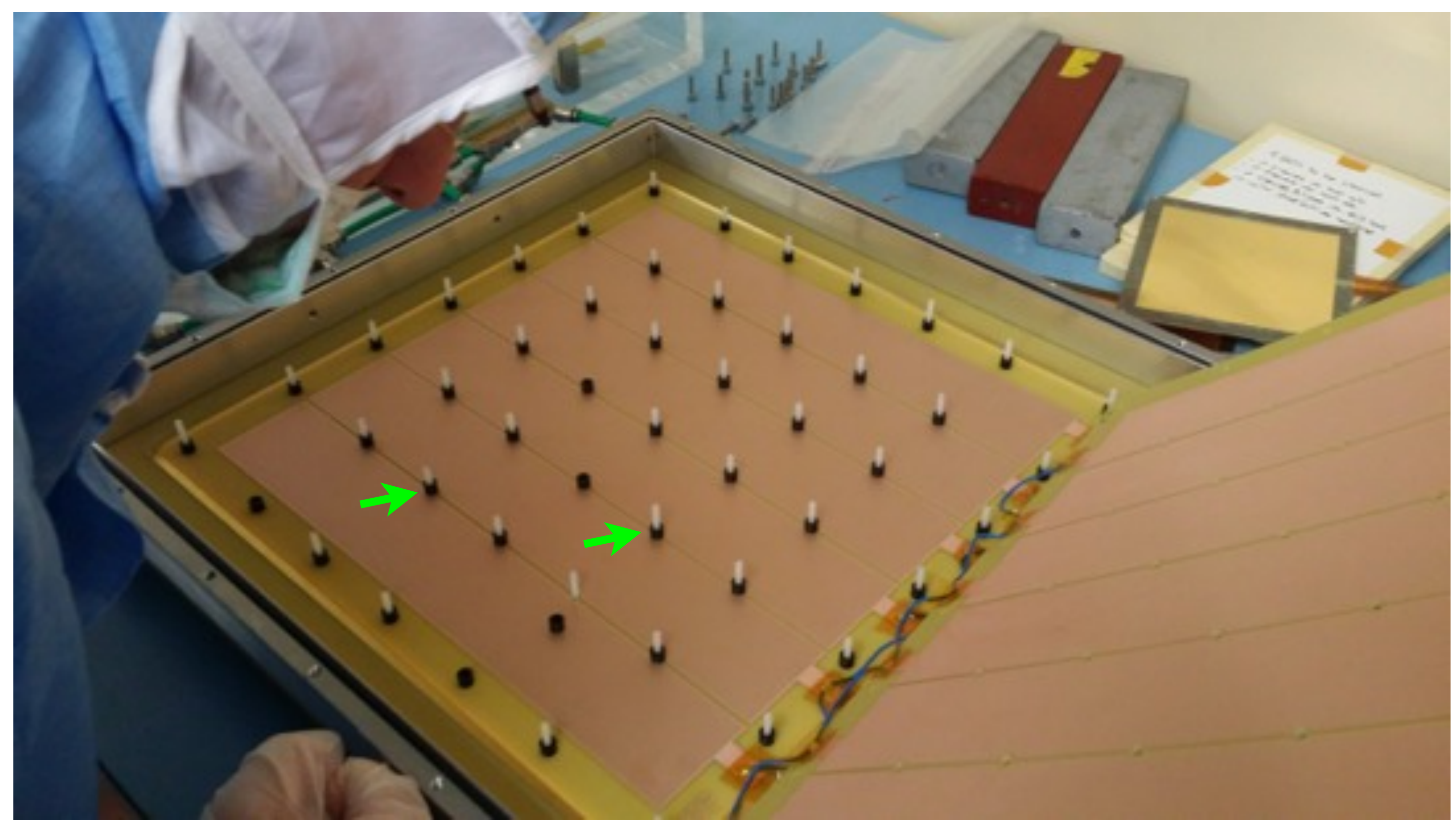
Present detector

- Discharges from the holes in the resistive sheet ⇒ direct link between the RPWELL electrode and the cathode
- Improves with additional isolation around the holes





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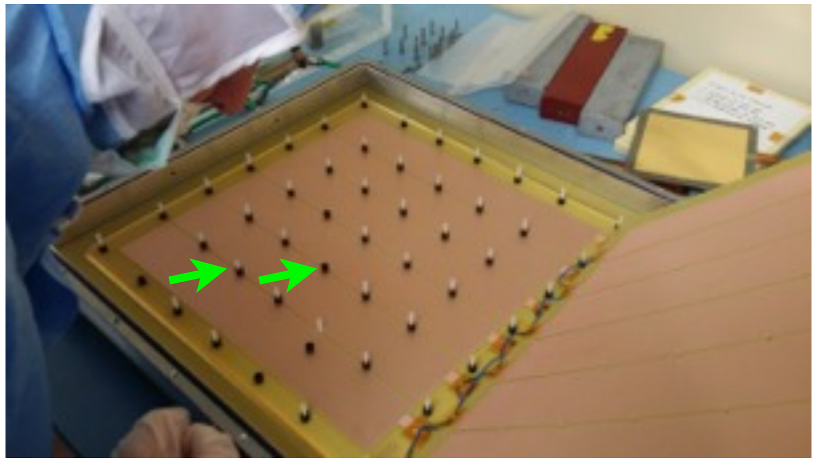
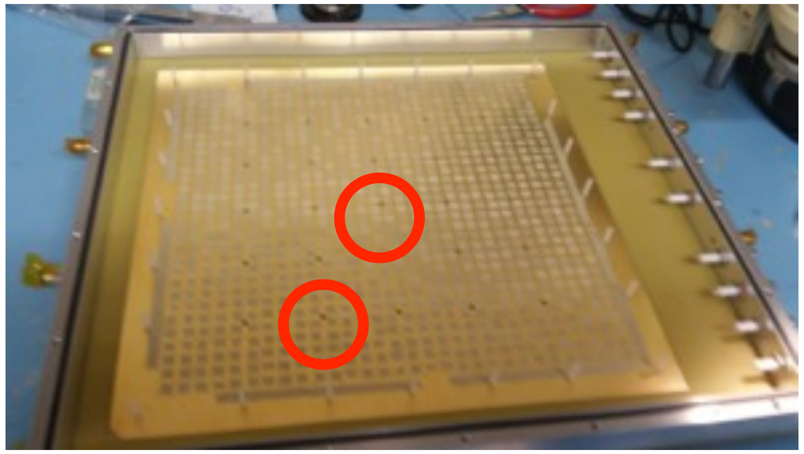


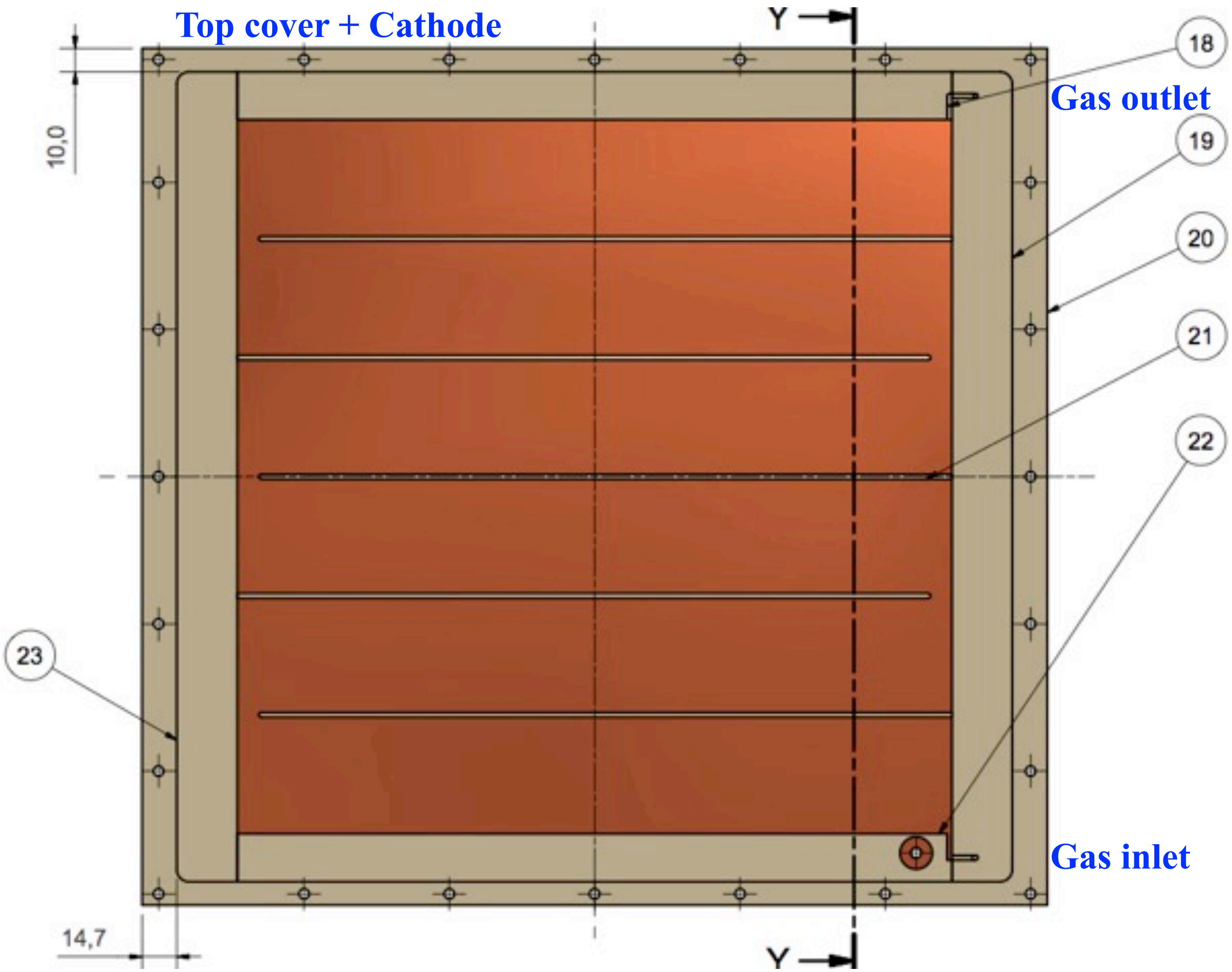


Present detector

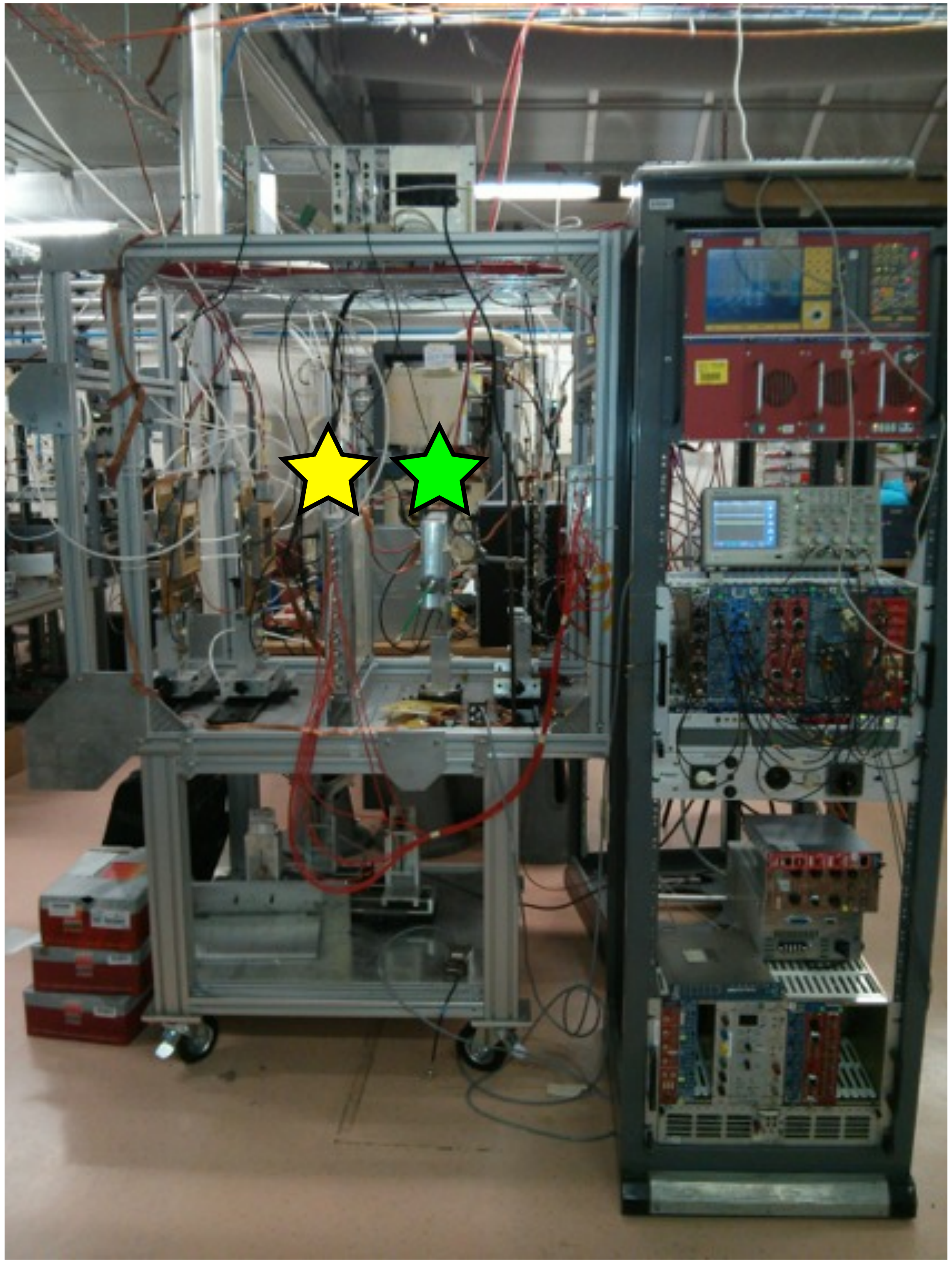
- Discharges from the holes in the resistive sheet ⇒ direct link between the RPWELL electrode and the cathode
- Improves with additional isolation around the holes

Future detector
(design is in progress)

- Large area built from smaller tiles
- Single uniform resistive sheet
- No holes
- Snake-shaped support also force uniform gas flow across the detector (a la ATLAS TGC)

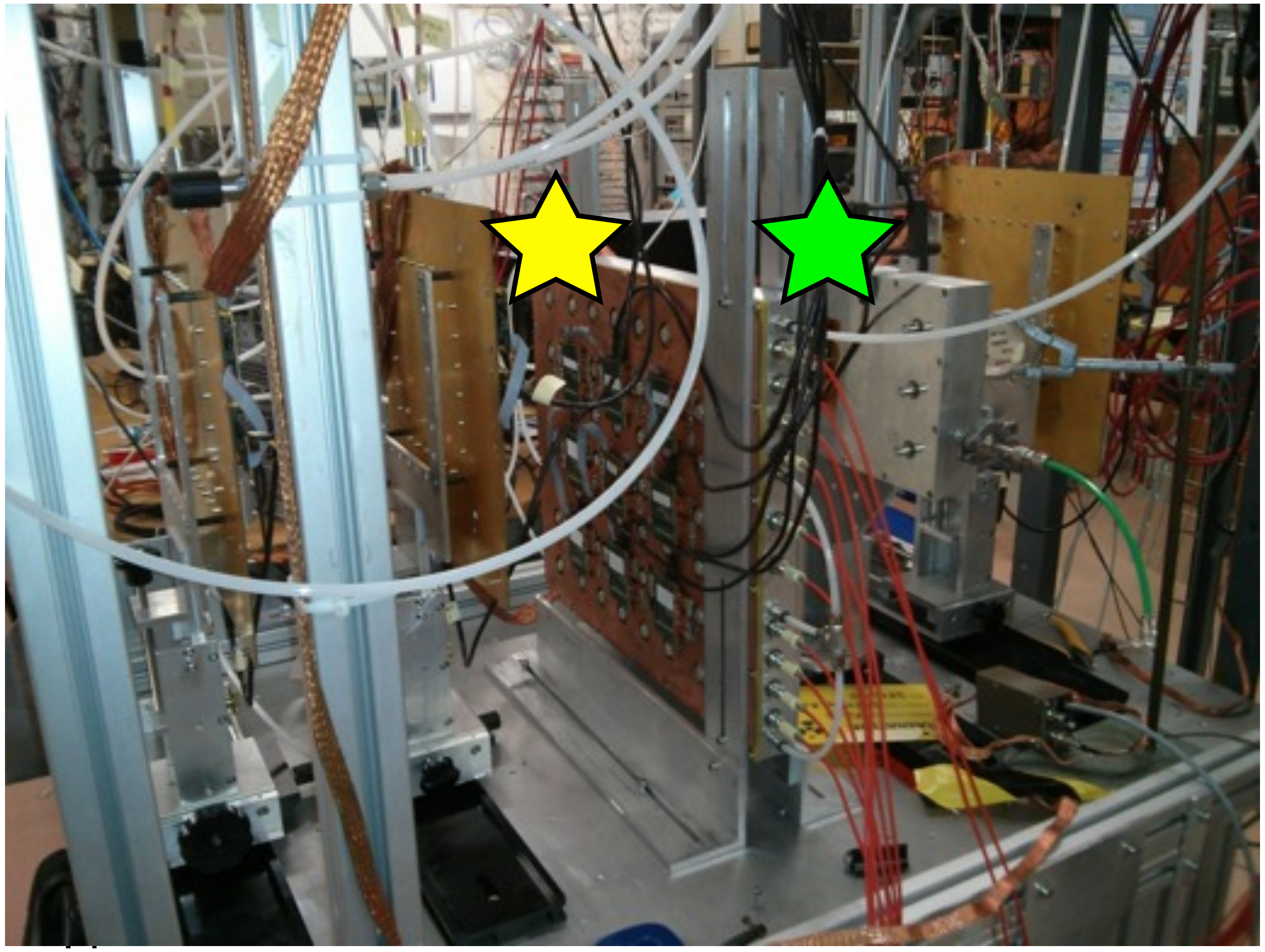


Beam studies	**$Ne/(5\%CH_4)$ - $Ar/(5\%CH_4)$ - $Ar/(20\%CO_2)$**
150 GeV μ & π beams	10×10 cm^2 & 30×30 cm^2



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



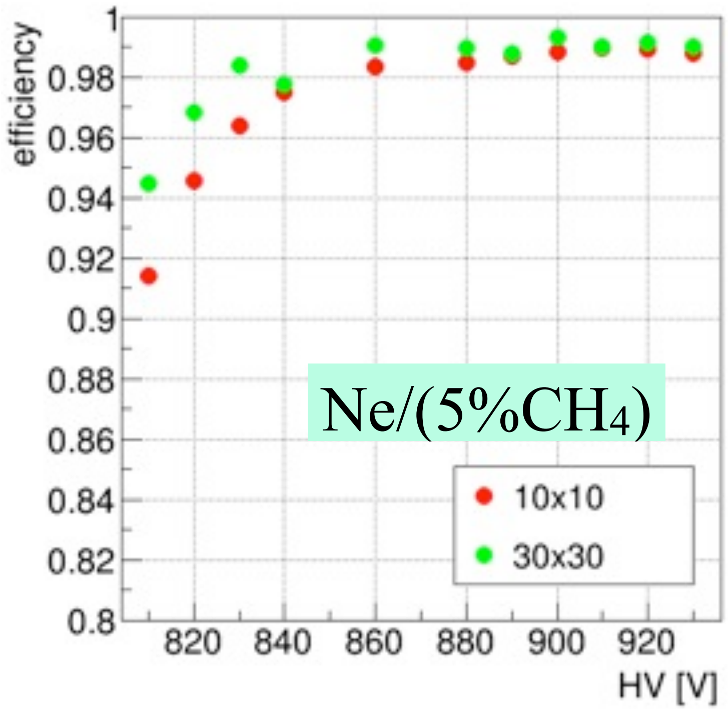
Beam studies

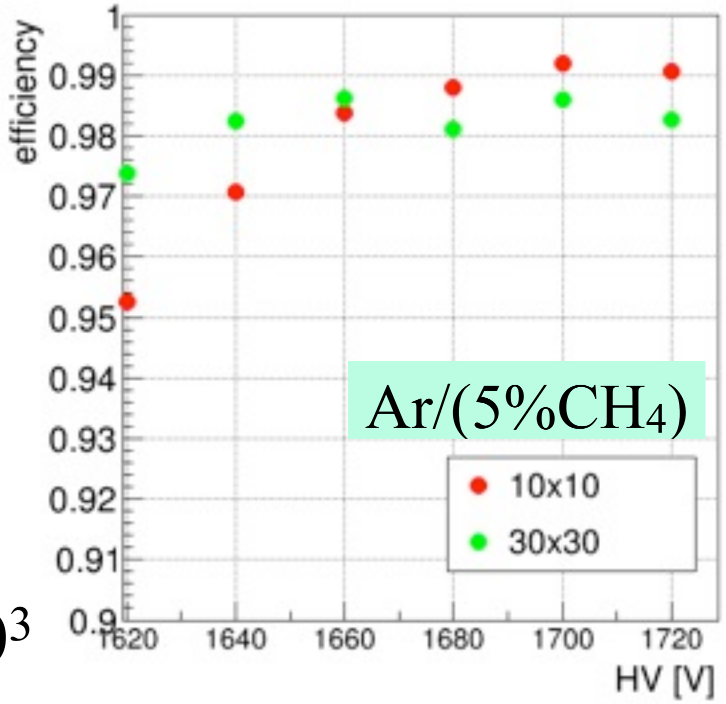
$Ne/(5\%CH_4)$ - $Ar/(5\%CH_4)$ - $Ar/(7\%CO_2)$

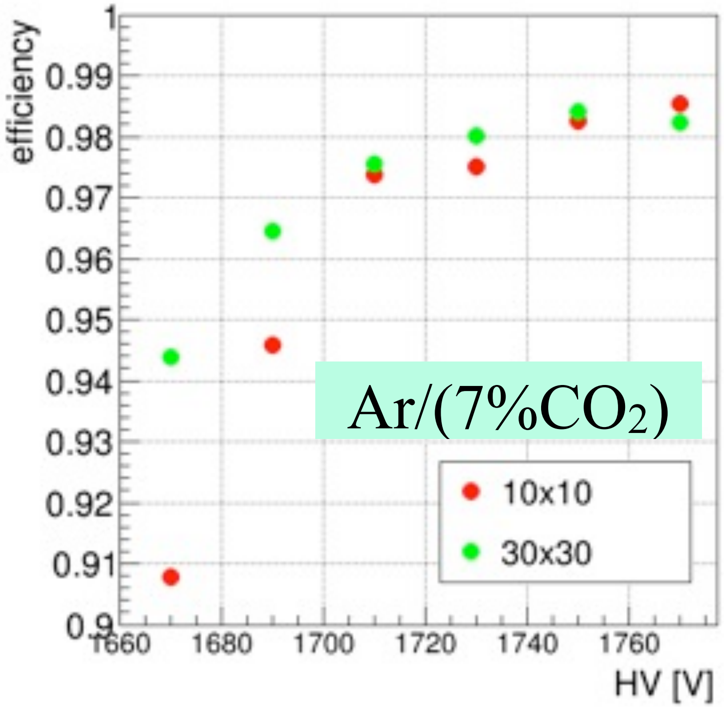
150 GeV μ & π beams

Efficiency

- Similar efficiency for 10×10 cm^2 & 30×30 cm^2 detectors
  - Small difference in the electrode thickness
  - Analysis not final
- High efficiency with all gas mixtures







Gas gain ~10^4; effective gain ~10^3

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

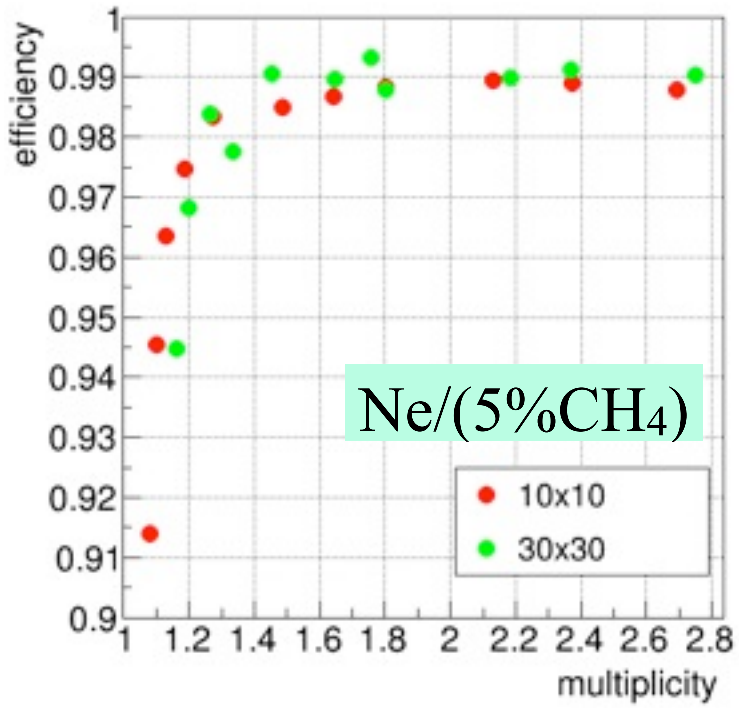
Beam studies

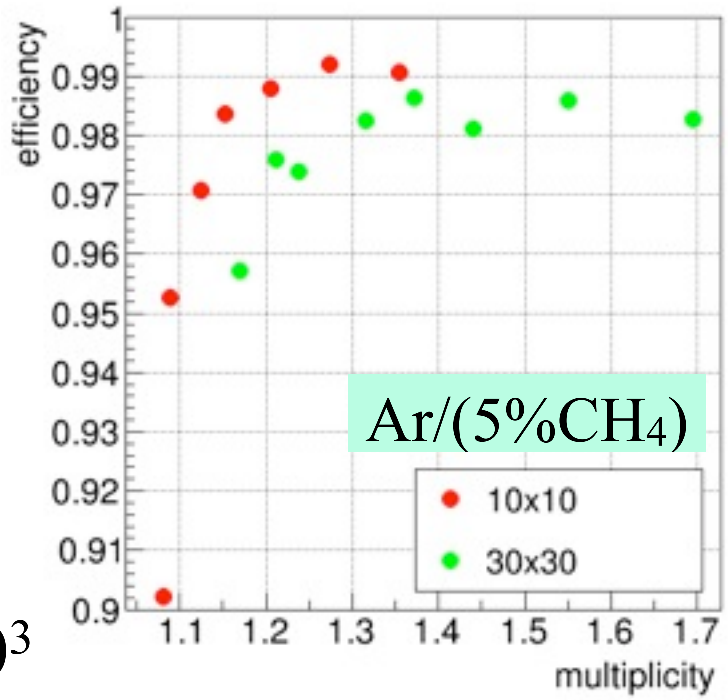
$Ne/(5\%CH_4)$ - $Ar/(5\%CH_4)$ - $Ar/(7\%CO_2)$

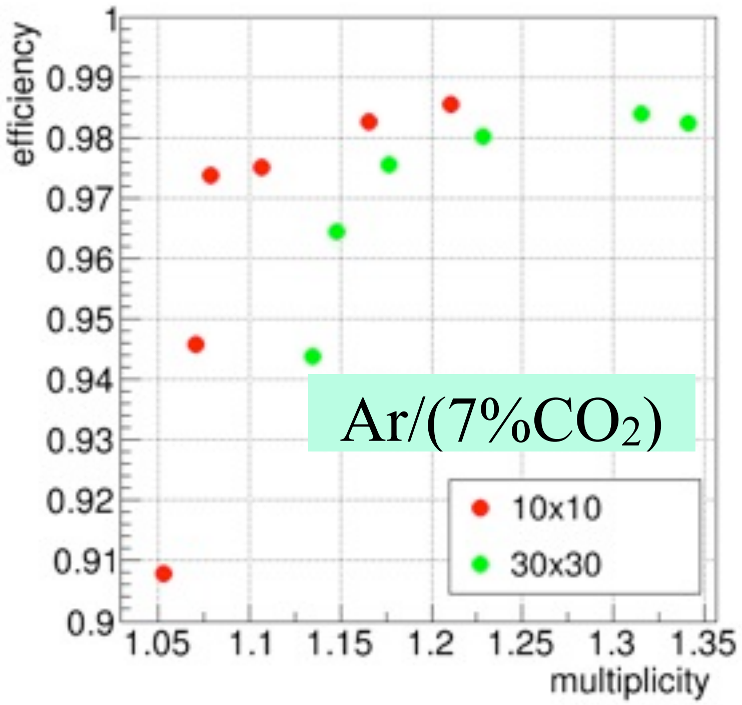
150 GeV μ & π beams

Efficiency & Multiplicity

- Higher multiplicity for 30×30 cm^2 compared to that of 10×10 cm^2 detectors
  - Analysis not final
- Also related to the naive production used
  - Misalignment between the readout pads and painted pads on the resistive sheet
- Will be done more carefully in the new detector







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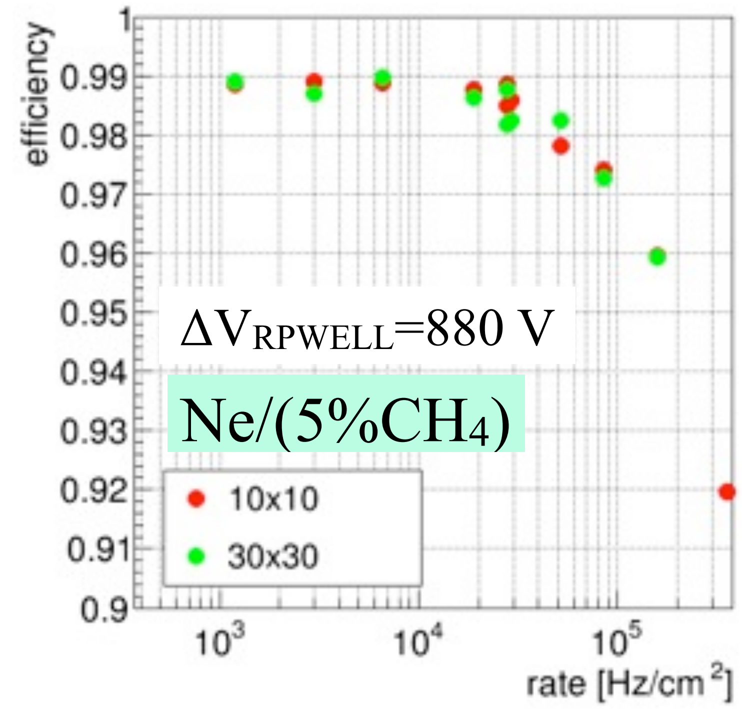
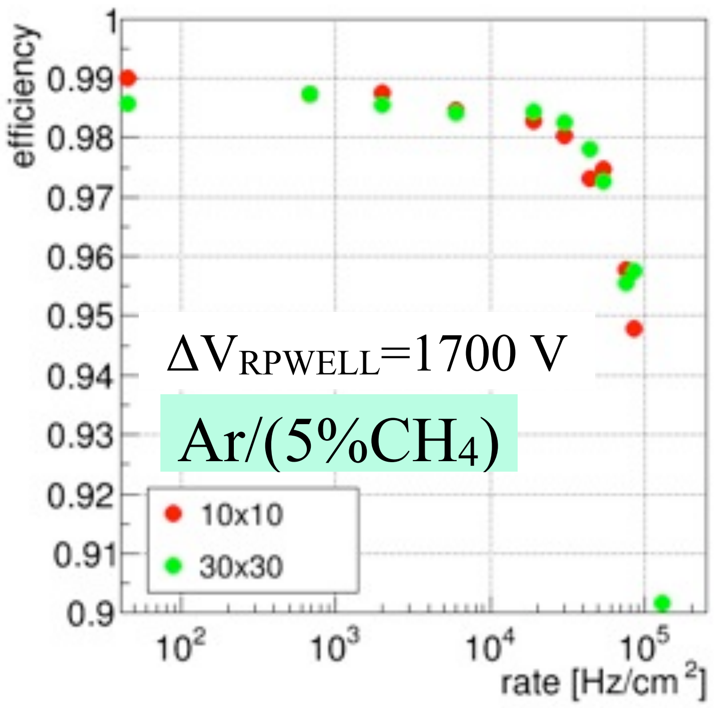
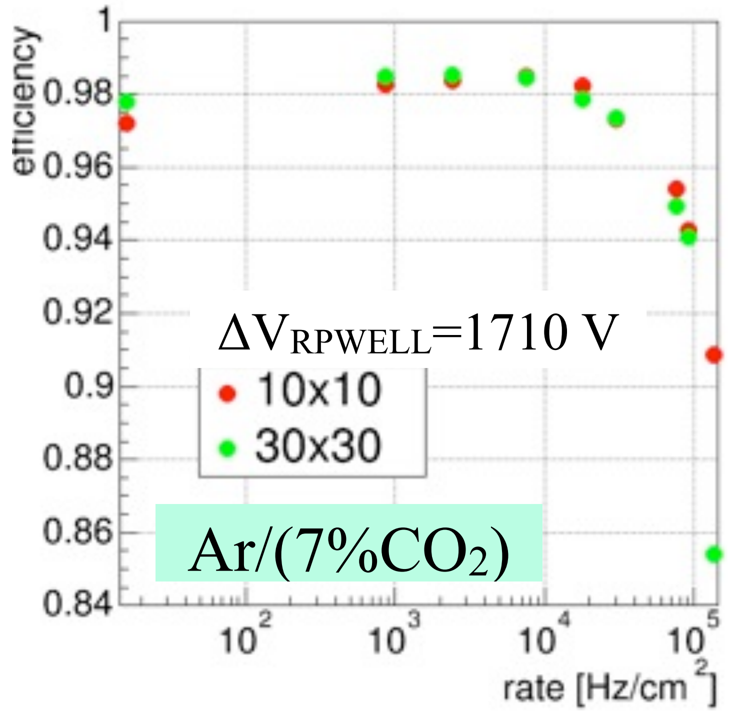
150 GeV μ & π beams

Rate capabilities

- 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

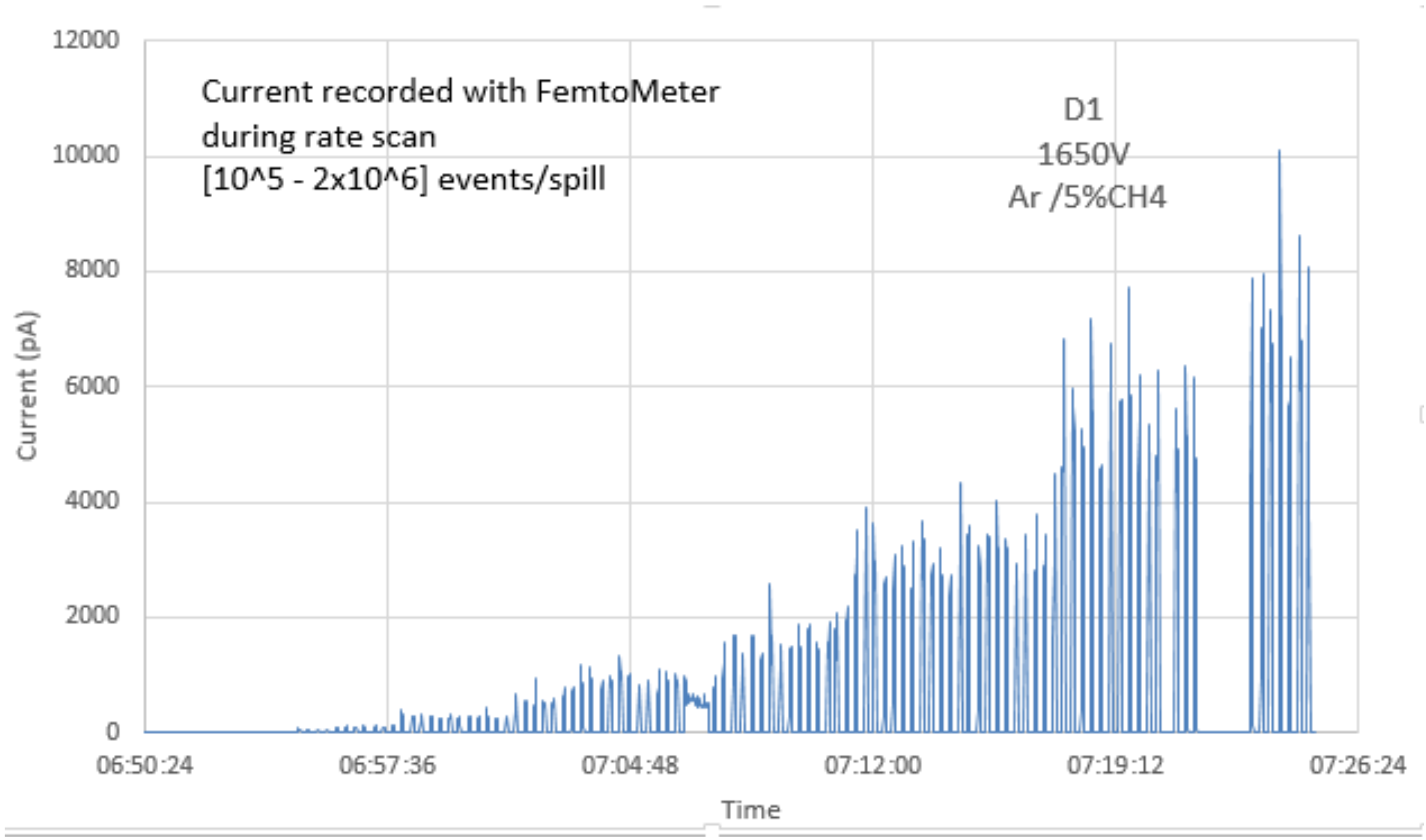
Beam studies

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

150 GeV μ & π beams

Rate capabilities

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



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- Additional characterization is on-going

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