First Operation of an ACHINOS-equipped Spherical Proportional Counter with Individual Anode Read-out
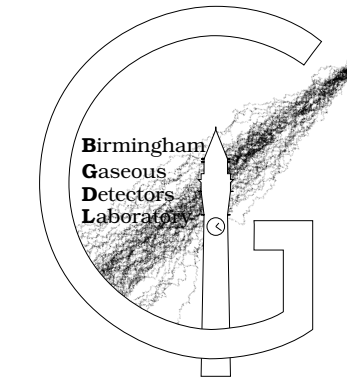
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Spherical Proportional Counters

- The spherical proportional counter [1, 2] is a simple and robust gaseous detector, well suited to various applications ranging from fast neutron spectroscopy [3] to direct Dark Matter (DM) searches [4, 5]
- For larger volumes and higher pressures, ACHINOS was developed [6, 7], to decouple the drift and avalanche field
- Previously, ACHINOS read-out in two channels - Near and Far
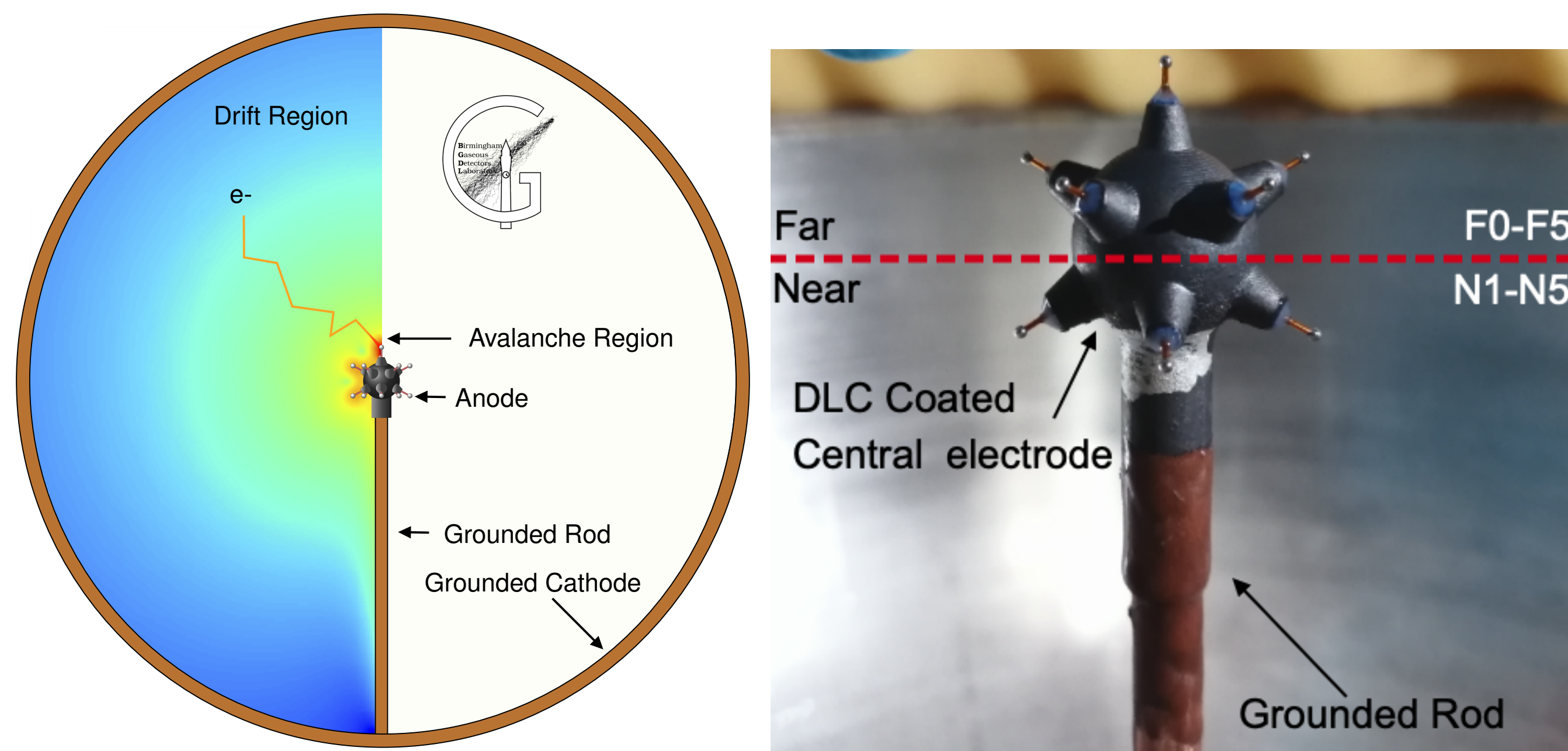
Individual Anode Read-Out

- Individually read-out ACHINOS: 11 $\varnothing$1 mm anodes in a $\varnothing$30 cm sphere [8]
- Detector operated with 500 mbar of Ar:CH_4 (98%:2%)
- Anodes biased (800 V) and read-out individually through a purpose built preamplifier board
- A ^{210}Po source decays via a 5.3 MeV α-particle, the position of which could be manipulated for calibration
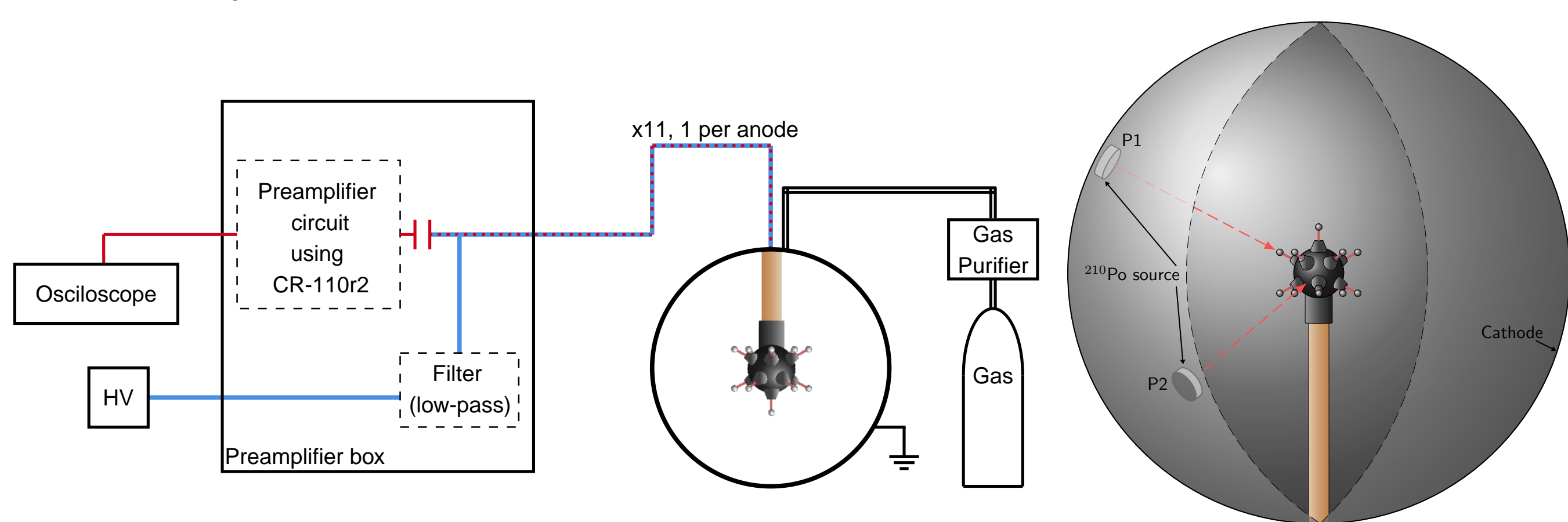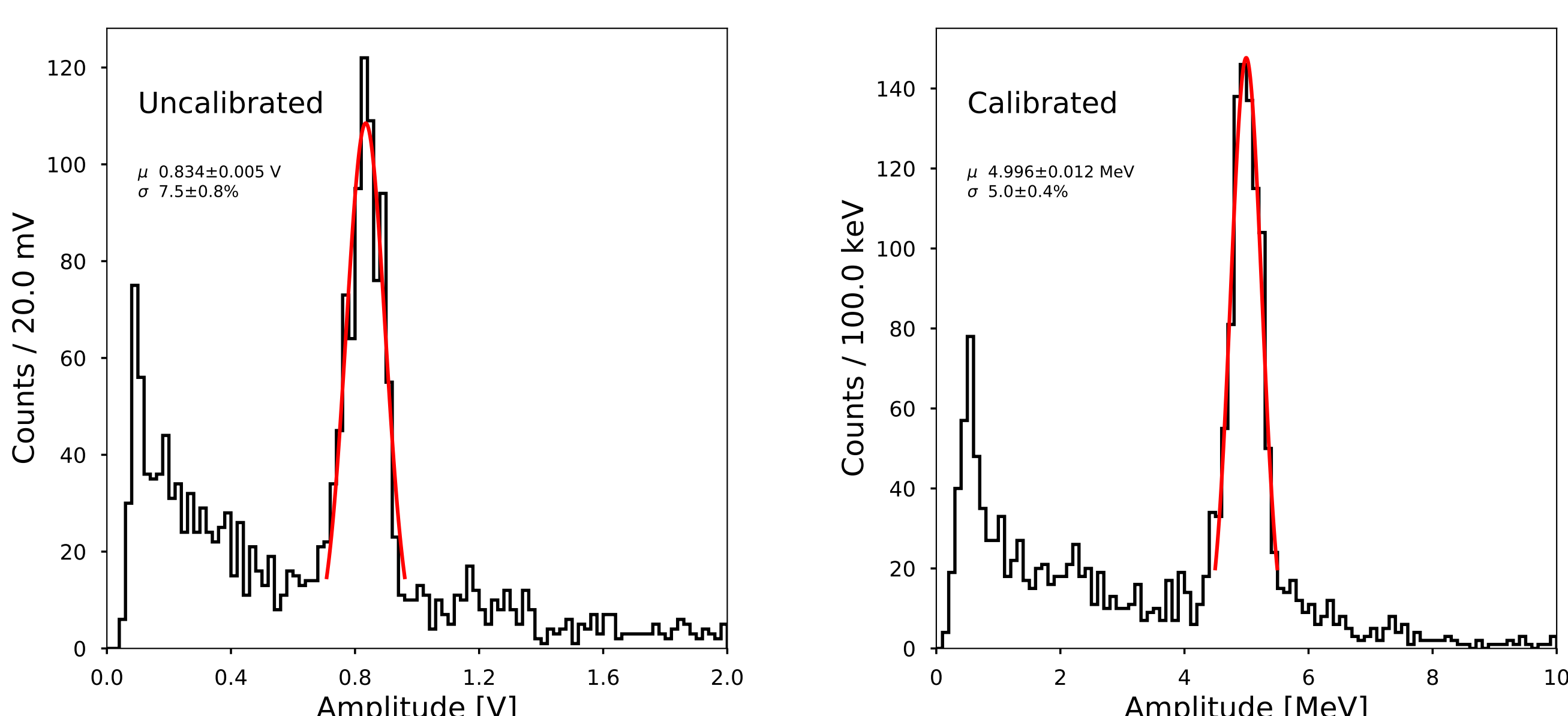

Experimental Results

- After individual calibration, energy resolution of 2.7%
- Similar to approximate local energy resolution of a single anode
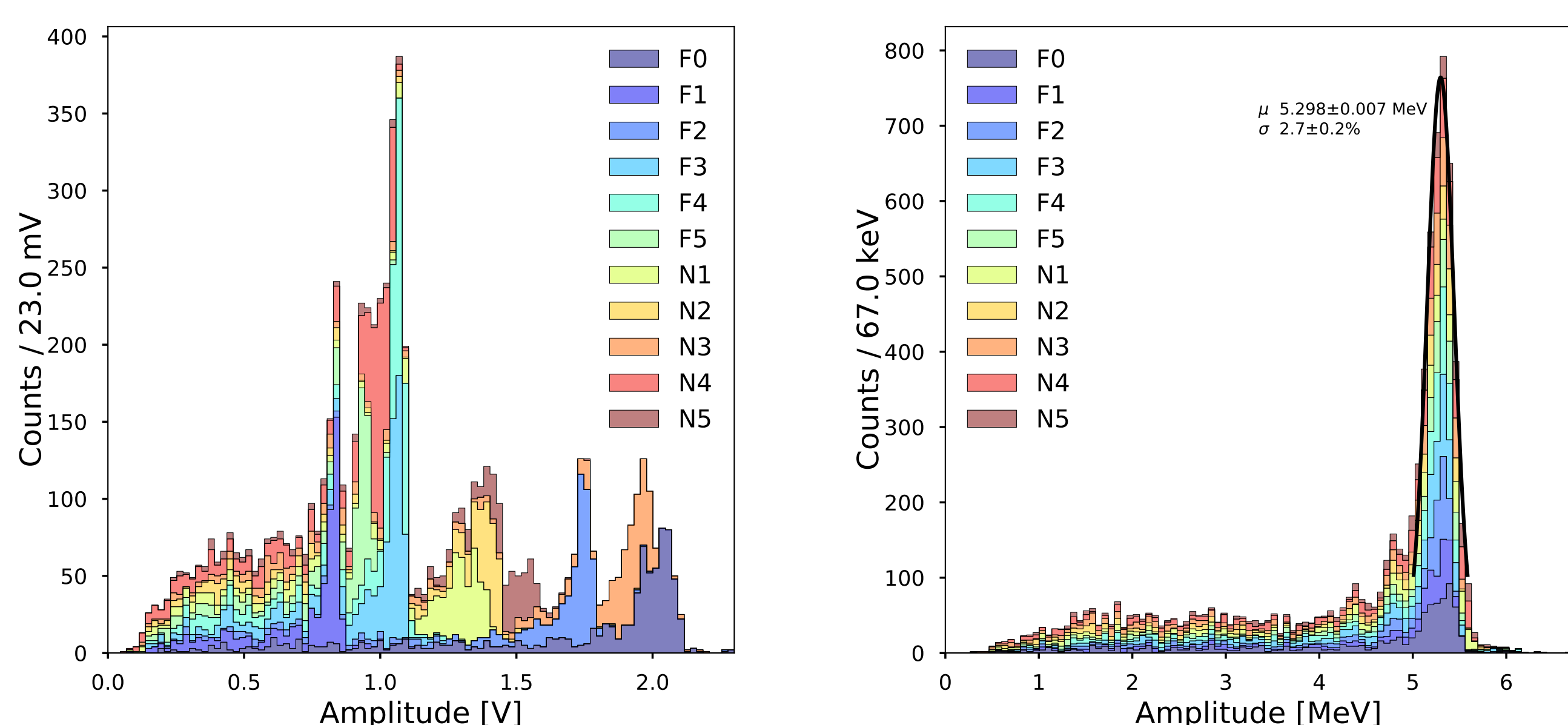
- Source directed between anodes, ionisation charge is shared
- 2.5% energy resolution improvement for individually calibrated anodes


Simulation Study

- Main anode to anode variation in gain caused by grounded rod → can be corrected [7]
- Other anode to anode variations simulated
- Sensor modelled using Gmsh/Elmer
- Dedicated simulation framework utilises Geant4 and Garfield++ [9]
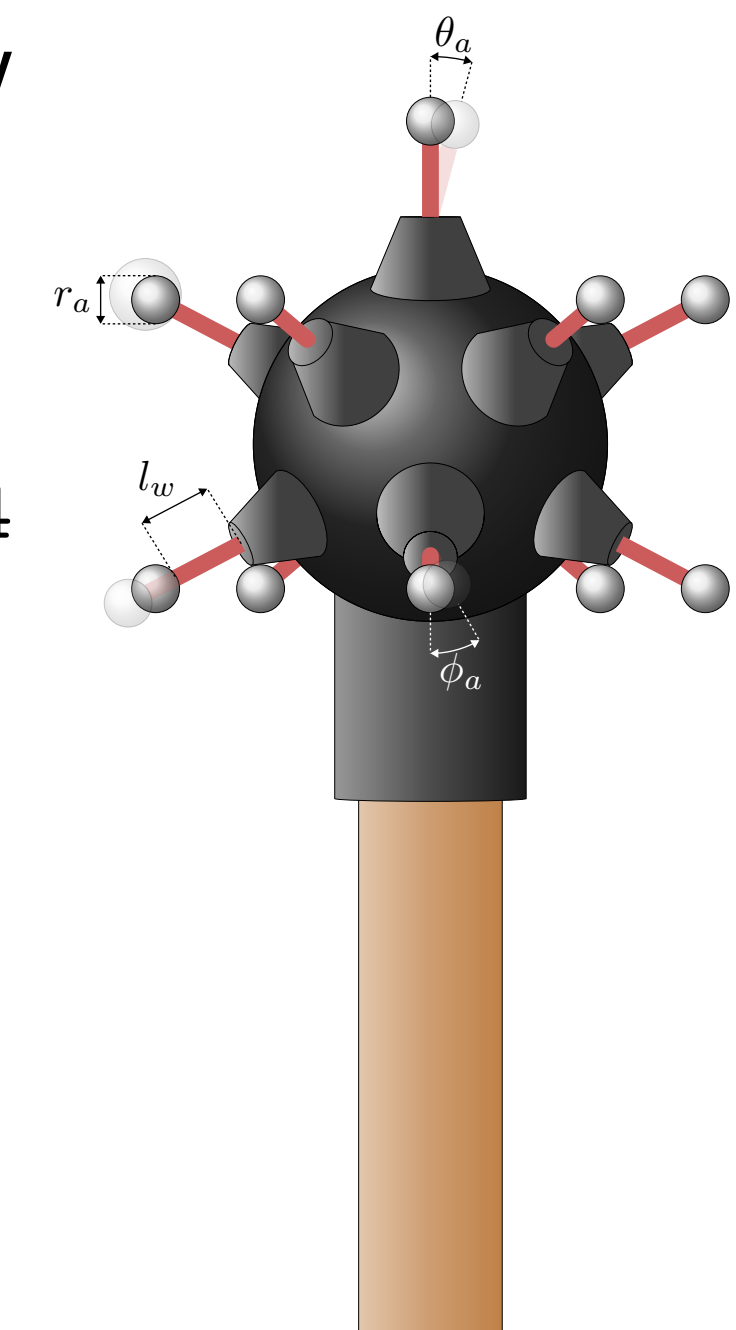
Parameter	Nominal Value	Deformation Magnitude
r_a	0.5 mm	$\pm$0.0125 mm
l_w	2.5 mm	$\pm$0.05 mm
θ_a	0 rad	$\pm$0.5 rad
ϕ_a	0 rad	$\pm$0.5 rad

Construction Imperfections

- For each deformation, average gas gain compared to nominal
- Gain difference correction either by individual calibration or by adjusting the voltage applied to the affected anode
- For l_w and r_a it is possible to recover the energy resolution by adjusting voltage
- Example: for $+r_a$, correction voltage needed to optimise relative difference in gain on the deformed anode is demonstrated
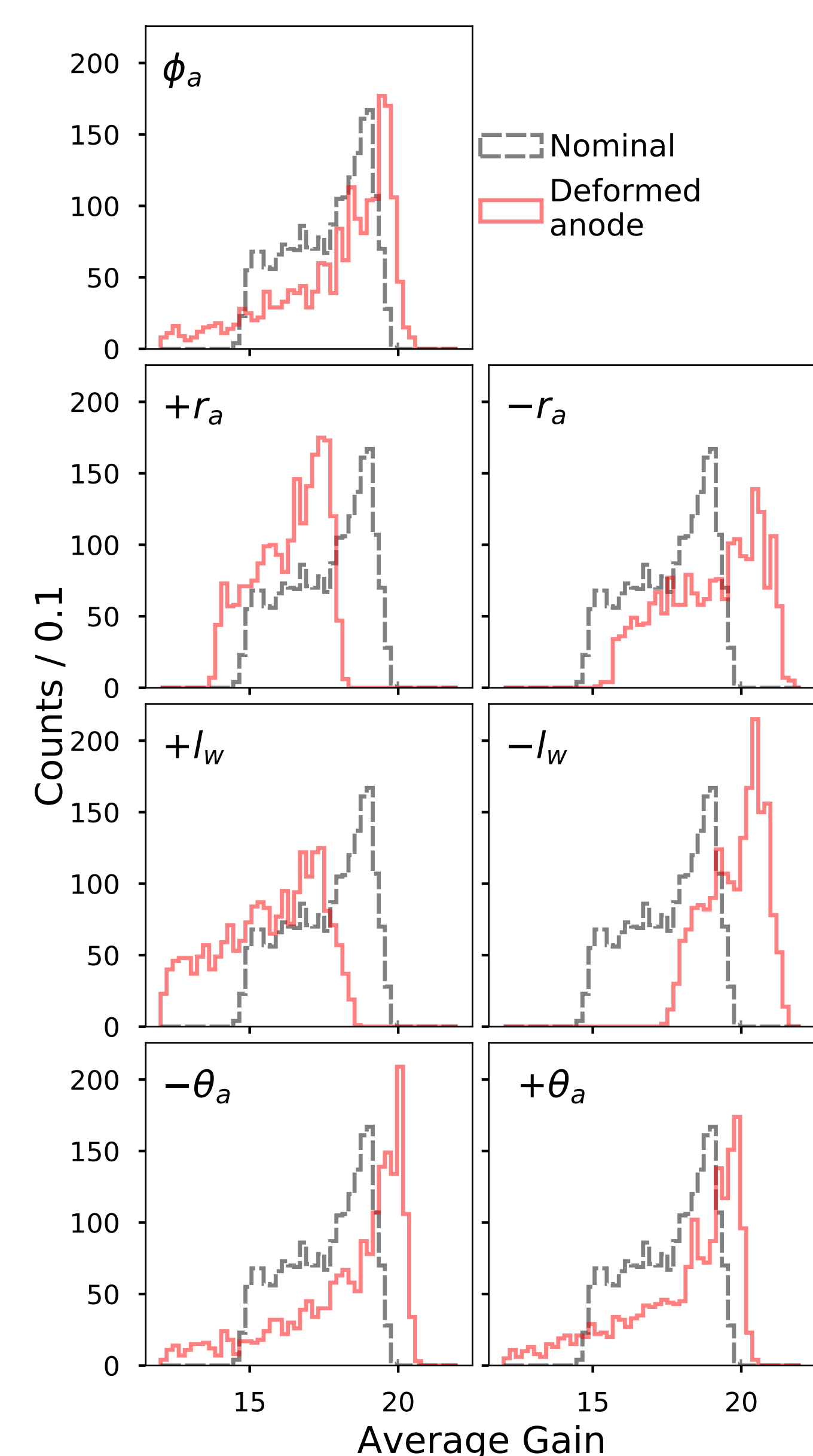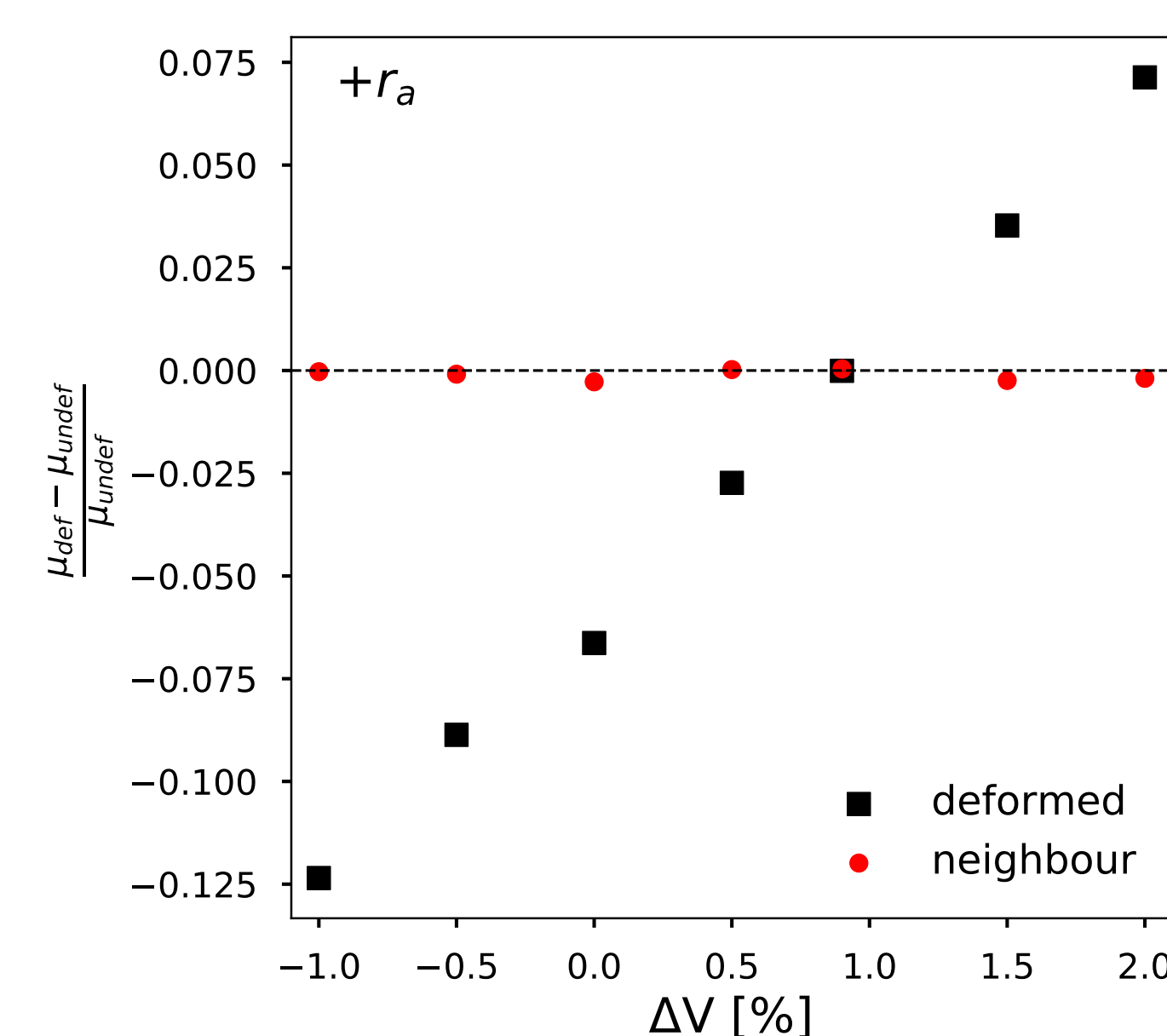
Summary

- SPC instrumentation developments ongoing for future applications
- Individual anode read-out has been developed for ACHINOS
- Energy resolution improvement with individual anode read-out
- Unlocks spherical proportional counter's potential, e.g. by allowing for 3D reconstruction of events and event localisation, important for applications such as direct DM searches and neutron spectroscopy
- Sources of gain difference between anodes studied extensively in simulation, and correction voltages to recover energy resolution computed

References

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cm