



The ACHINOS sensor in the NEWS-G Experiment

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CAP conference 2020



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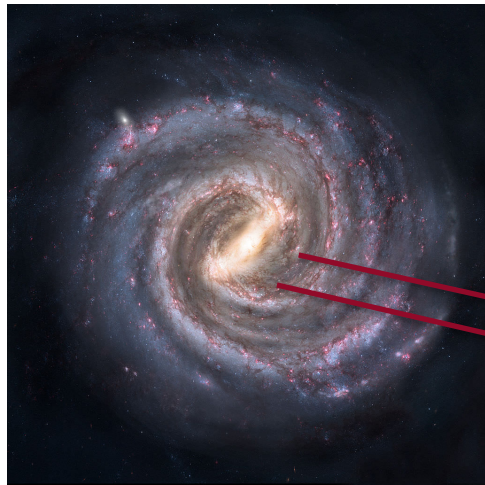
laboratoire Souterrain de Modane

Low-Mass Dark Matter detection



Queen's UNIVERSITY

Spherical Proportional Counter



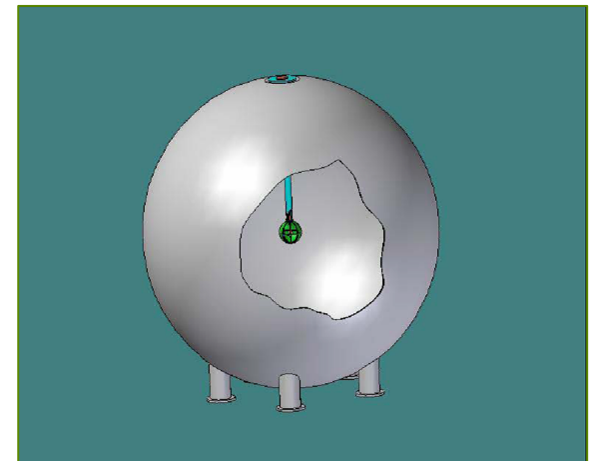
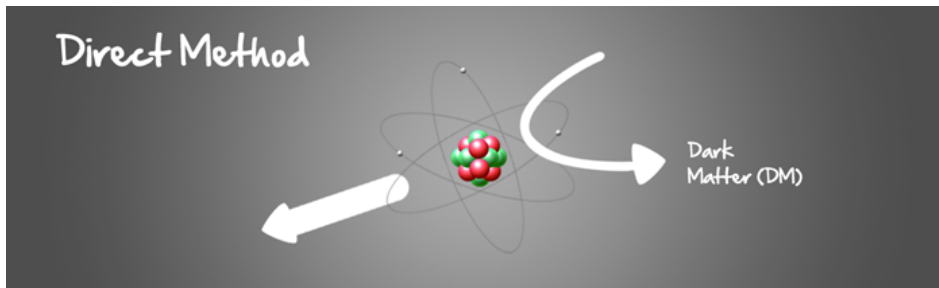
WIMPS



140 cm low activity copper sphere

Direct Method: WIMP interacts with the gas nuclei through scattering

Measure the recoil energy of the scattered nuclei



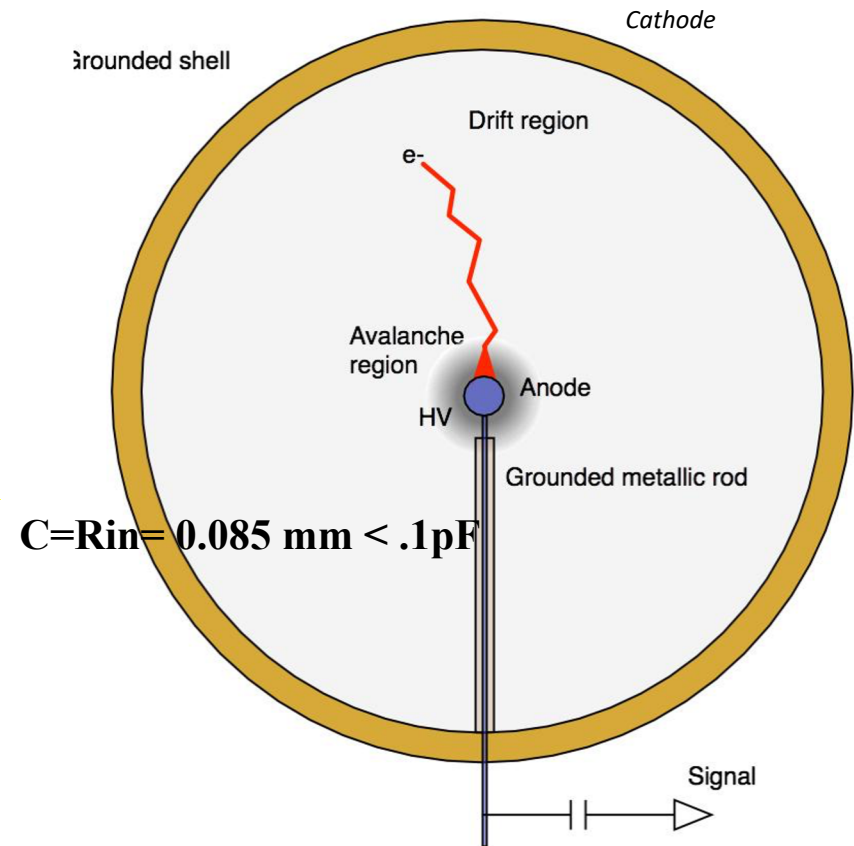
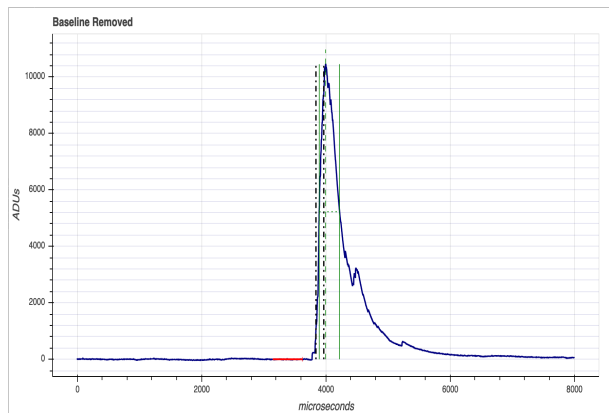
SPC Principle of Operation

- Incoming particle ionizes the gas – Primary Ionization
- e- drift towards the anode at the center along the \vec{E} field lines
- Avalanche occurs – Secondary Ionization
- Signal is produced and measured

$$E(r) = \frac{V_0}{r^2} \frac{r_A r_C}{r_C - r_A} \approx \frac{V_0}{r^2} r_A$$

$r_A = \text{anode radius}$

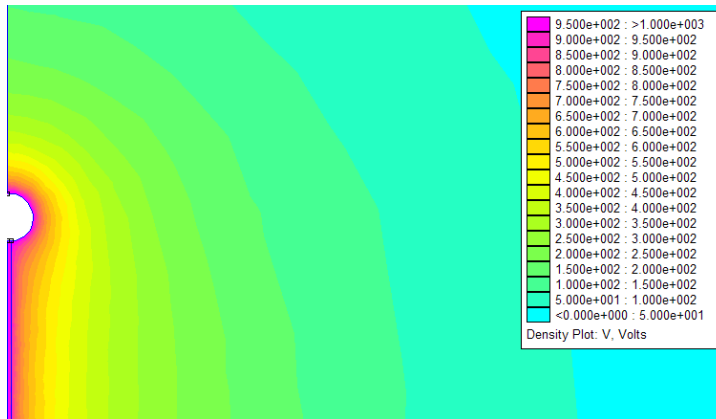
$r_C = \text{cathode radius}$



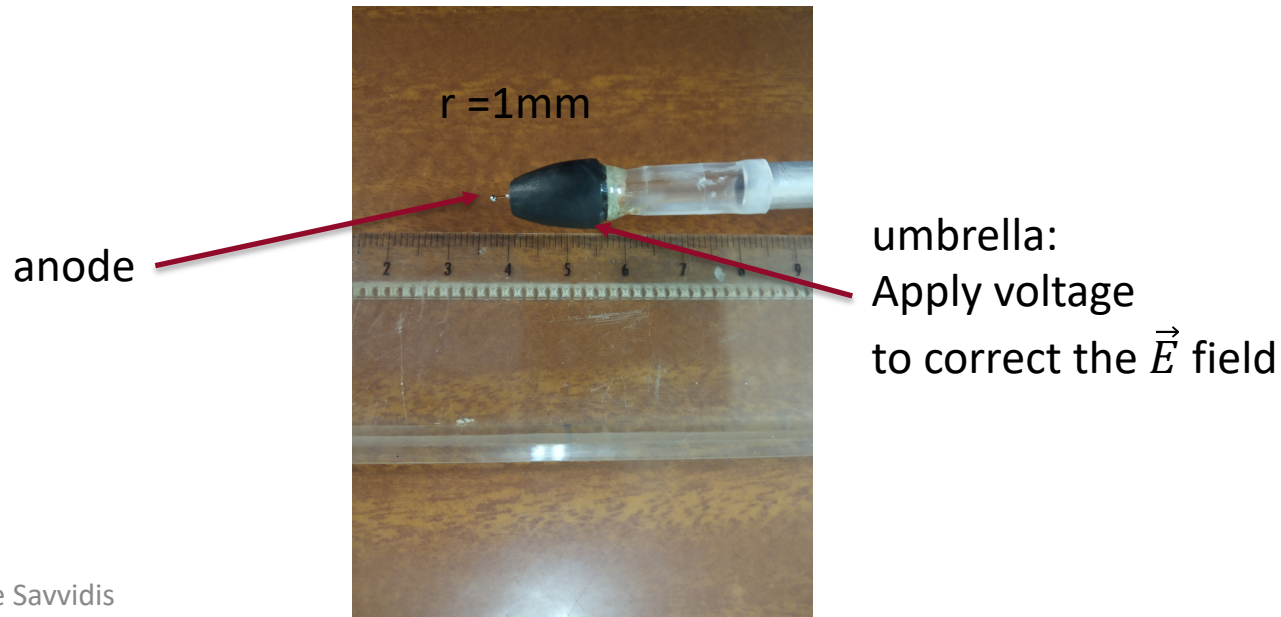
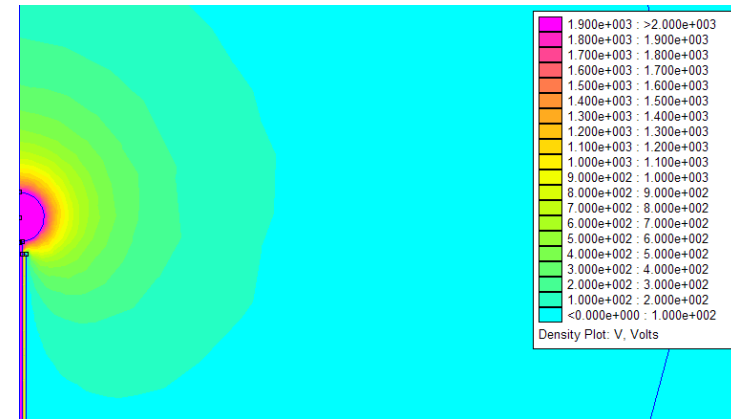
Goal: WIMP detection at SNOLAB!

The \vec{E} field

\vec{E} field before correction



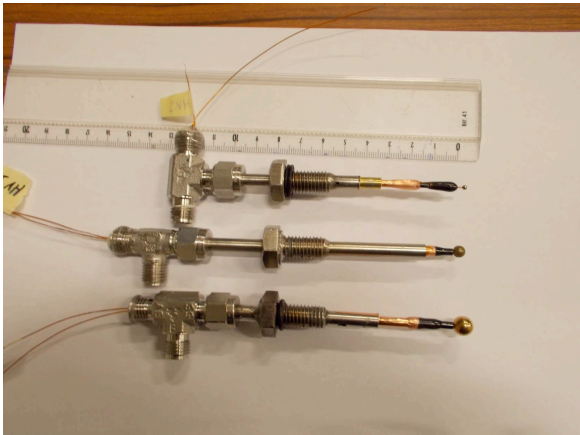
\vec{E} field after correction (umbrella)



The ACHINOS sensor

Multi-Anode ACHINOS Sensor

Single Anode Sensors



Sea Urchin = achinos in greek



\vec{E} field vs Gain

$$E(r) = \frac{V_0}{r^2} \frac{r_A r_C}{r_C - r_A} \approx \frac{V_0}{r^2} r_A$$

if $r_A \downarrow \Rightarrow \text{gain} \uparrow$ but $\vec{E} \downarrow$ at distance r from the center

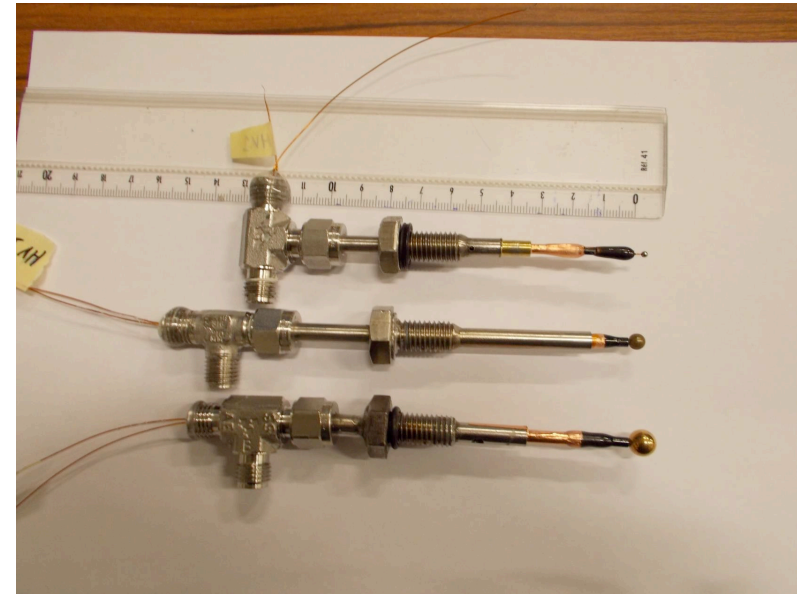
Why do we need high gain?

Because for low-mass WIMP detection we have to go down up to single-electron detection $\sim 30 \text{ eV}$

Use anode with very small radius and for high gain. But how to compensate for the weakening of the \vec{E} field?

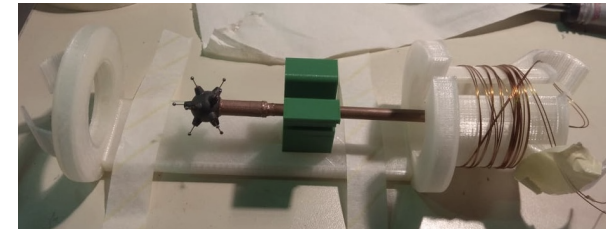
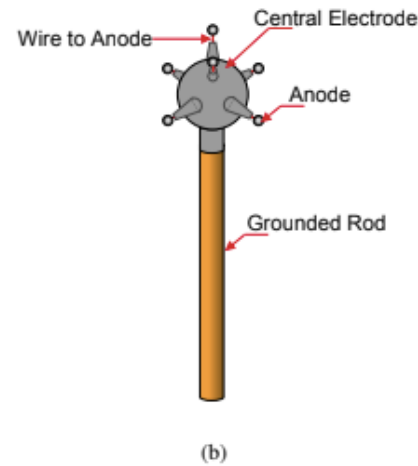
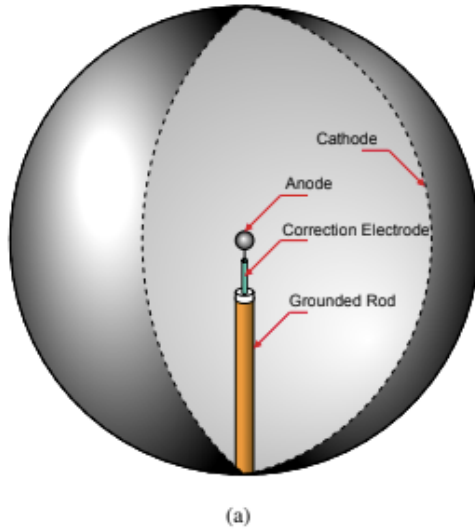
Solution: multi-anode sensor “ACHINOS”

Single Anode Sensors with different radii



ACHINOS

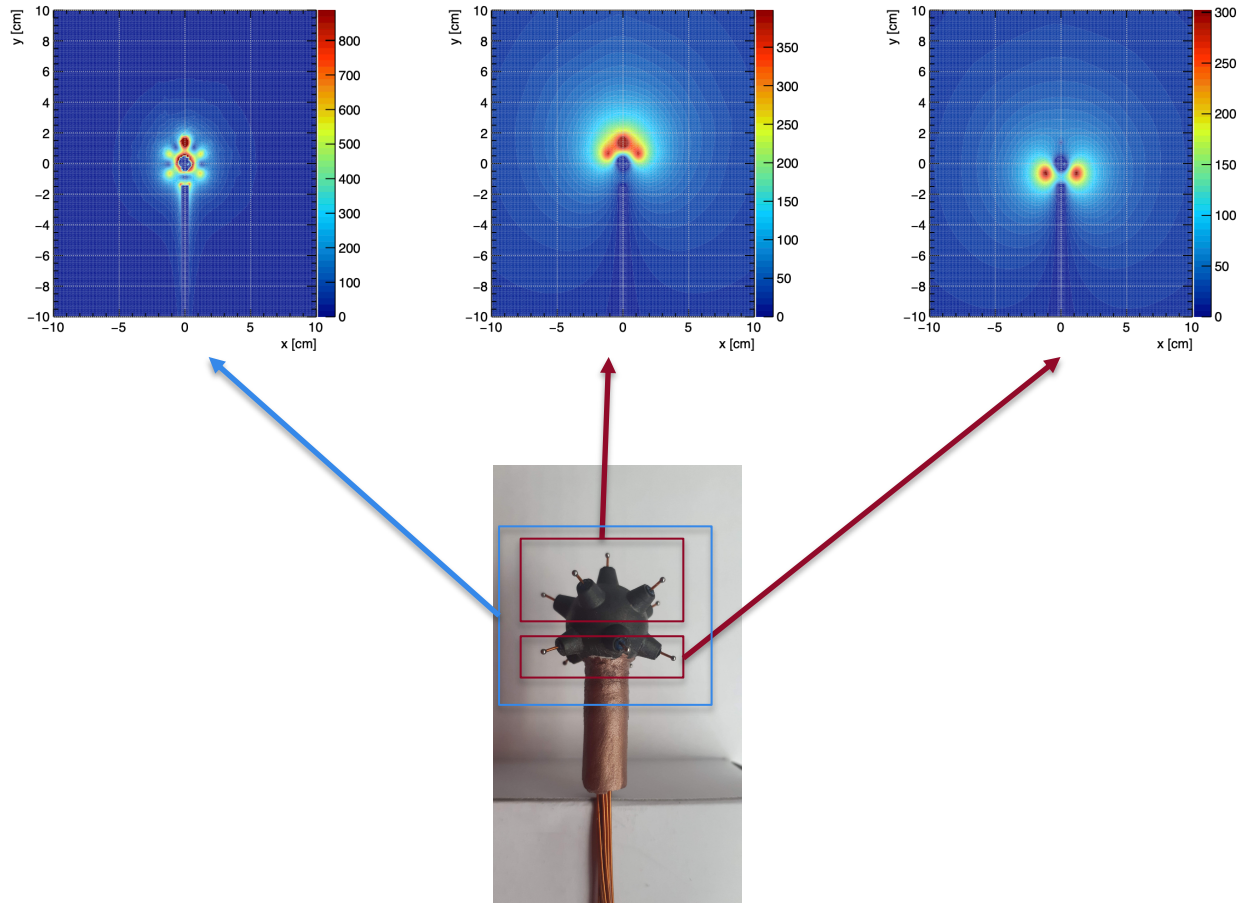
I. Giomataris et al. arXiv:2003.01068



- 11-ball ACHINOS sensor
- 1.7 mm diameter silicon balls
- High gain, capable to go up to single electron detection
- Strong \vec{E} field to collect primary e- far from the center

Simulation of \vec{E} field for the ACHINOS sensor

Preliminary



Simulation: Tom Neep et al., University of Birmingham, UK, NEWS-G Collaboration

2-channel ACHINOS for NEWS-G Experiment

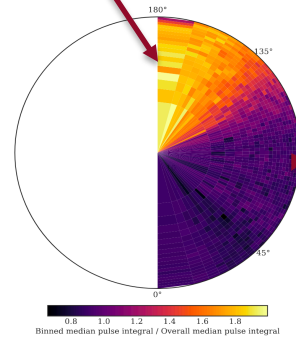
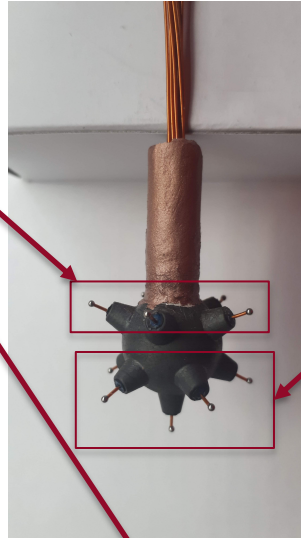


- Implementation of a 2-channel ACHINOS for NEWS-G at LSM summer 2019 – first test
- The 2 channels are obtained by grouping the wires of the 5 and 6 balls together at sensor location (next slide)
- The 2-channel sensor allows for volume analysis of the events between the two hemispheres of the detector
- Implementation at SNOLAB in Spring 2020 – Postponed due to COVID-19

2-channel ACHINOS for NEWS-G Experiment

Channel 0 "North"

Channel 1 "South"

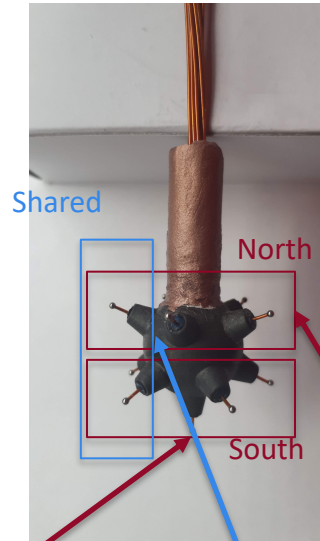


Preliminary

2-channel ACHINOS for NEWS-G Experiment: Cross Talk

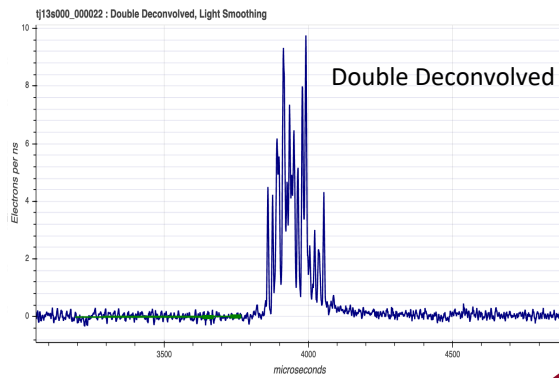


- Cross talk between the 2 channels
- Indications it is not electronic cross talk but an effect happening inside the detector

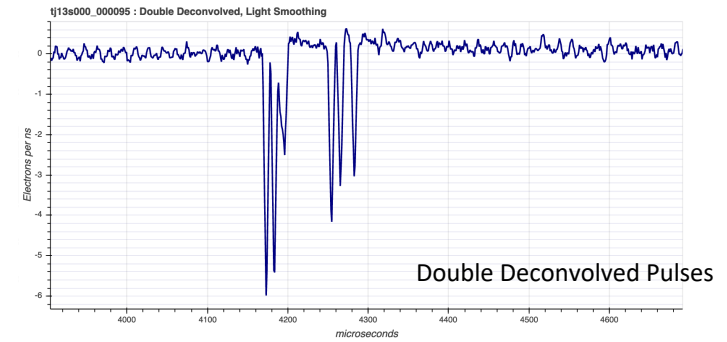


South → North

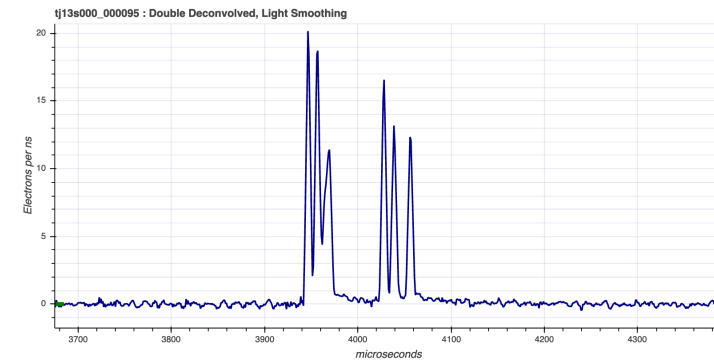
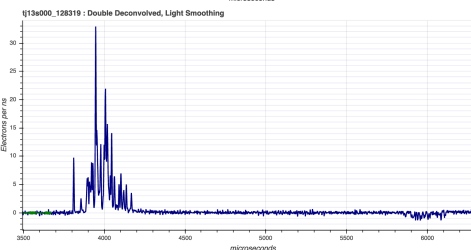
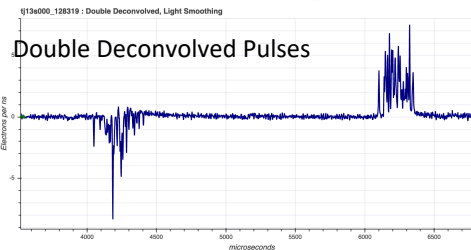
Double Deconvolved Pulses



North → South



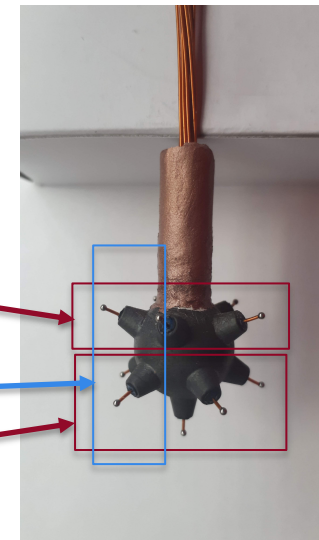
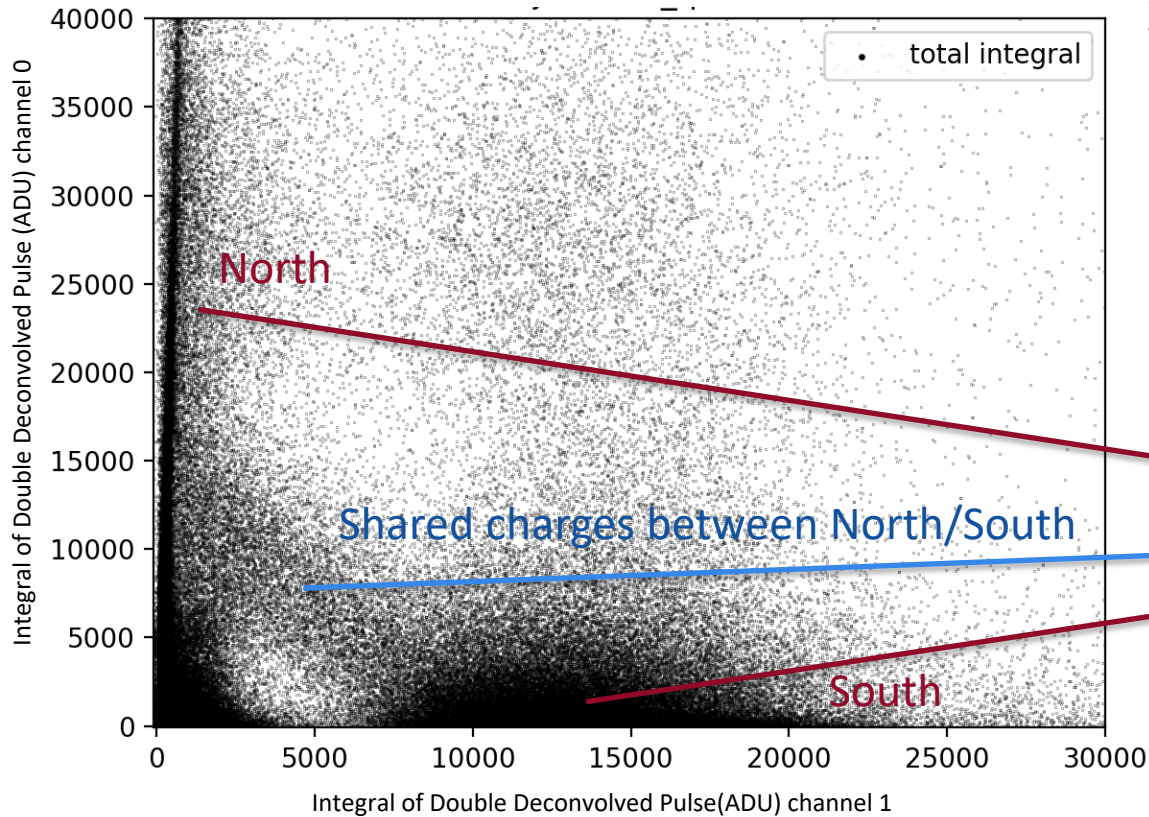
South ↔ North



2-channel ACHINOS for NEWS-G Experiment

Preliminary experimental data from LSM

135 mbar pure CH₄
Ar37 source: 2.8keV photon
2-channel ACHINOS sensor



Future



- Disentangling various effects to extract relevant information for WIMP search and fiducial volume is object of current studies
- Develop 11-channel ACHINOS sensor
- Could allow for directional measurement of Dark Matter in large and low-pressure Spherical Proportional Counter



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Thank you