

# Laser calibration & electron drift property analysis for NEWS-G

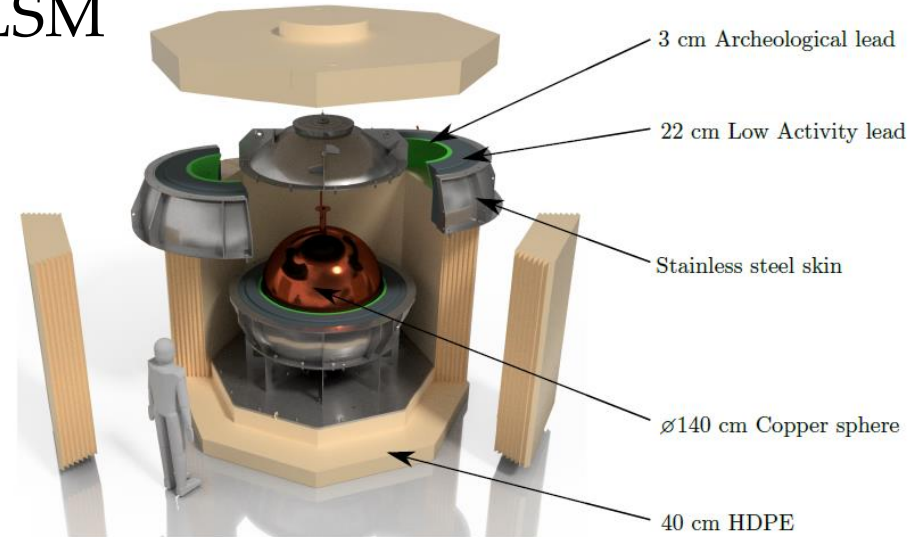
Jean-Marie Coquillat

CAP-ACP 2020

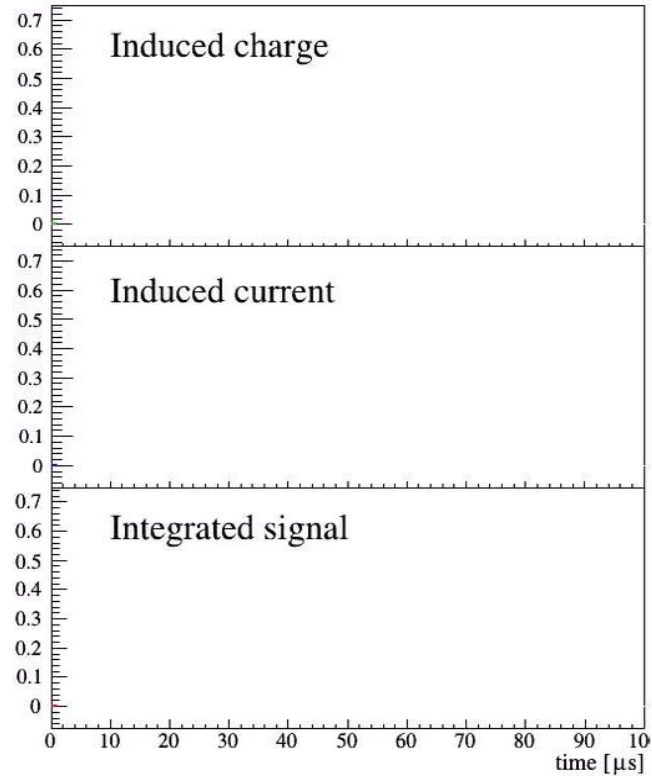
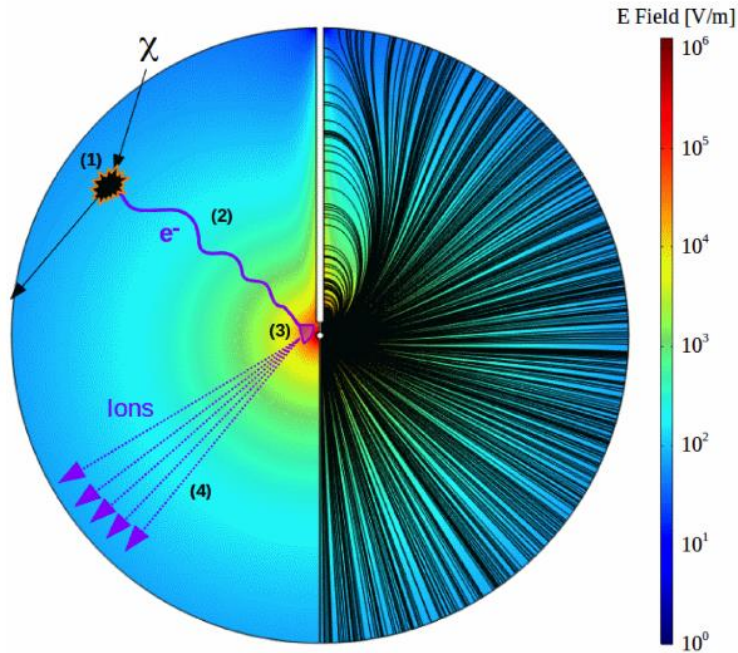


# NEWS-G detector summary

- Spherical proportional counter filled with gas
- Trying to detect low mass WIMPs
- Current data analysis from LSM runs of Ne and  $\text{CH}_4$
- Installation ongoing in SNOLAB on covid break



# Event detection

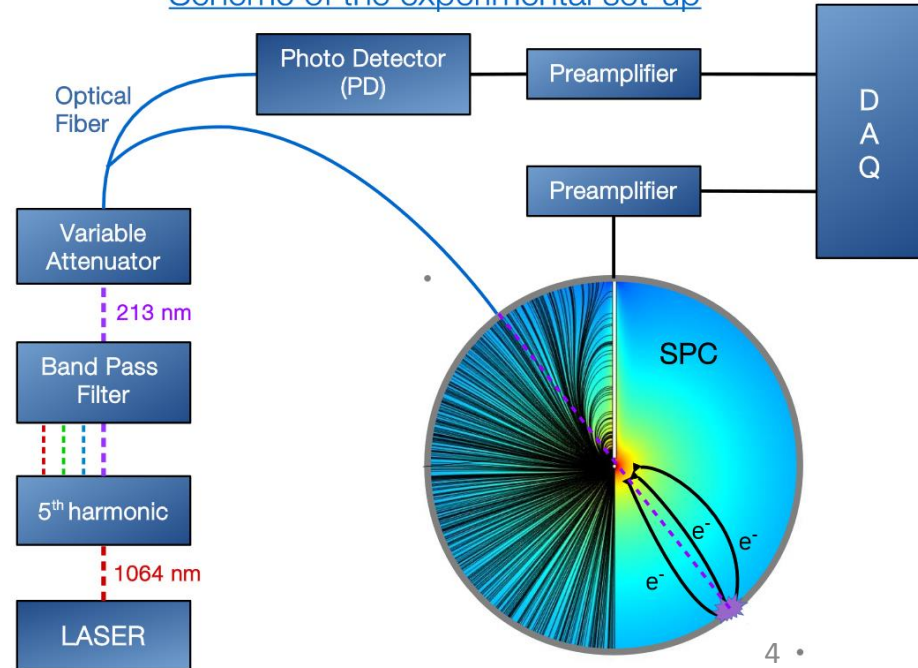


Animation by  
Philippe Gros

# Drift time

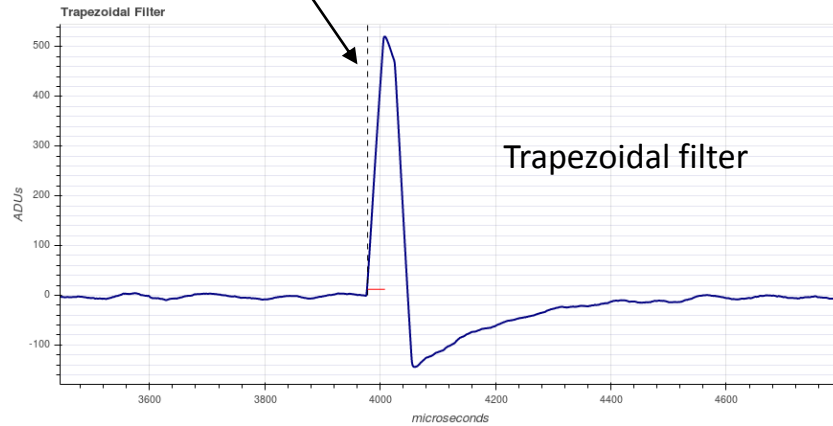
- Drift time: Mean time for  $e^-$  to travel from surface of the sphere to the central anode
- Allows characterization of the detector, e.g. for simulations
- Measured with a laser using a photodetector and the photoelectric effect
- Laser used at 5 or 10Hz in all runs for more consistency

Scheme of the experimental set-up

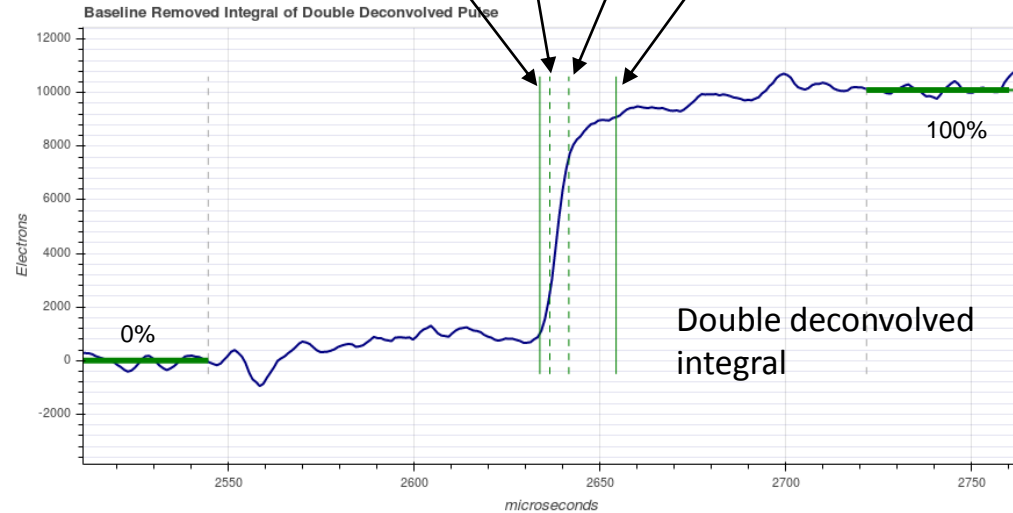


# Calculation of Drift Time

Start of photodetector pulse [channel 2]



Rise 10%   Rise 25%   Rise 75%   Rise 90%   South [channel 1]

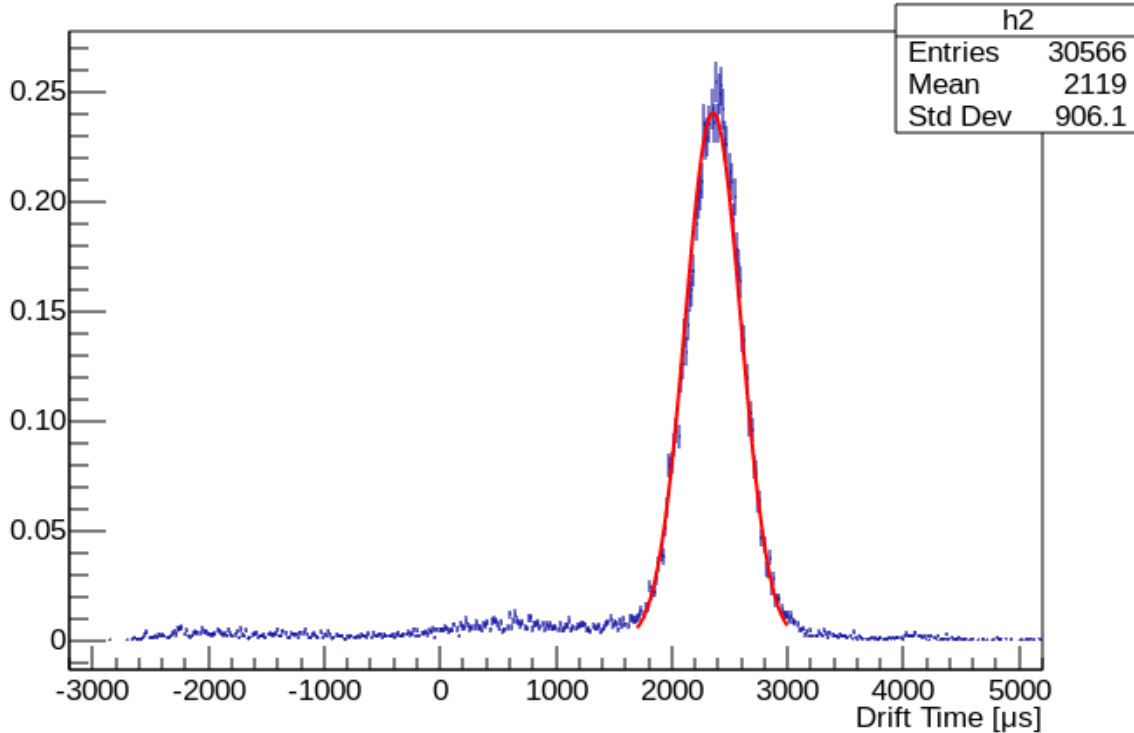


$$\text{Drift time} = \frac{(\text{Rise 10\%} + \text{Rise 25\%} + \text{Rise 75\%} + \text{Rise 90\%})}{4} - \text{Start of photodetector pulse} + \Delta t$$

Where  $\Delta t$  is the time shift between the two channels (Time[ch. 2] – Time[ch. 1])

# Calculation of Drift Time

ti19s002 / 1b Ne / 1500 V / 130 A laser

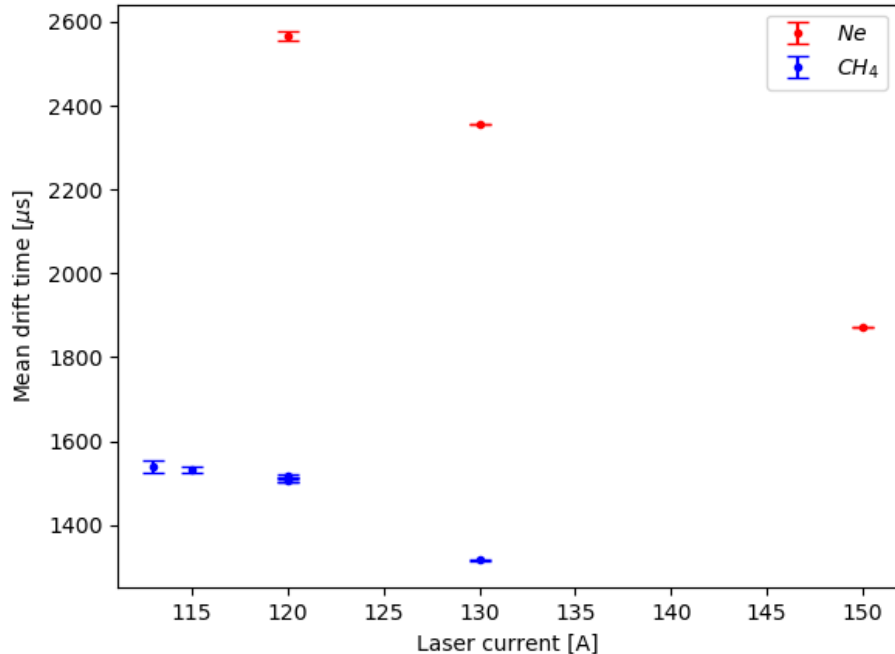


Gaussian fit applied to the distribution to find the mean drift time and its uncertainty

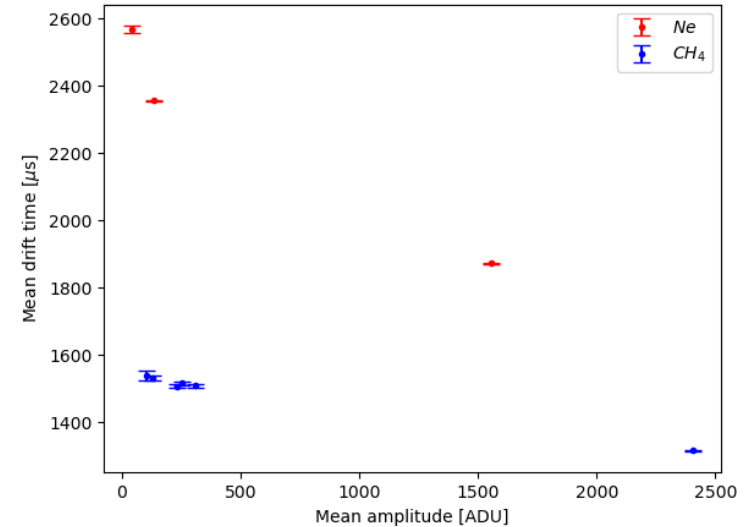
# Drift time results – Gas and laser current

- The drift time is longer with neon than methane.
- Higher laser current produces higher energy events resulting in a shorter drift time.

Mean drift time laser runs results



Mean drift time laser runs results



Neon:  $V = 1500 \text{ V}$ ,  $P = 1 \text{ bar}$

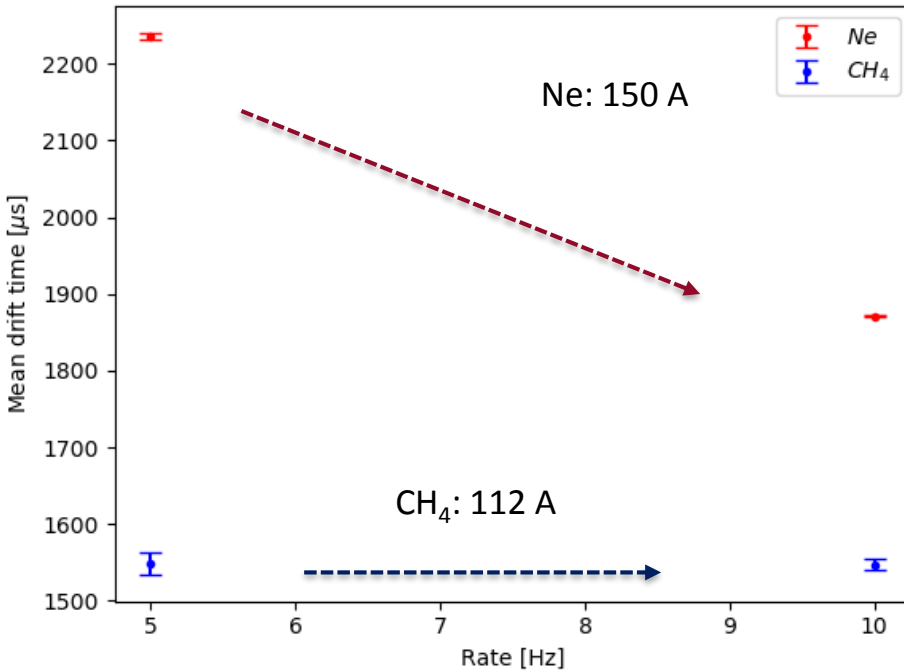
Methane:  $V = 2030 \text{ V}$ ,  $P = 0.135 \text{ bar}$

# Drift time results – Rate and radioactive source

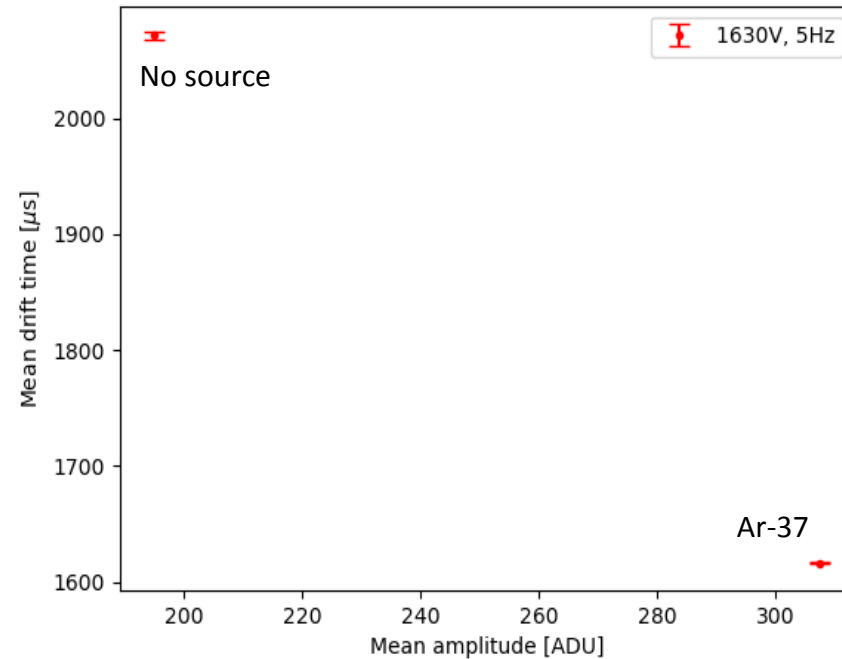
- The rate of laser events can also reduce the mean drift time.

- So does adding traces of radioactive argon to the gas mixture.

Mean drift time laser runs results



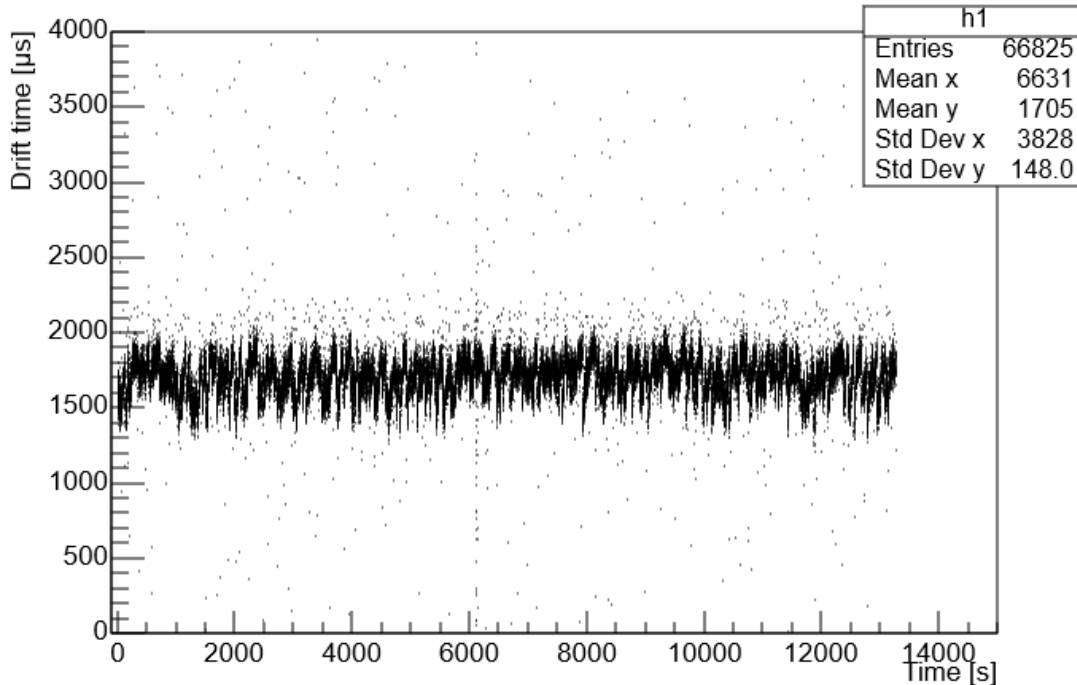
Mean drift time laser runs results - 1b Ne





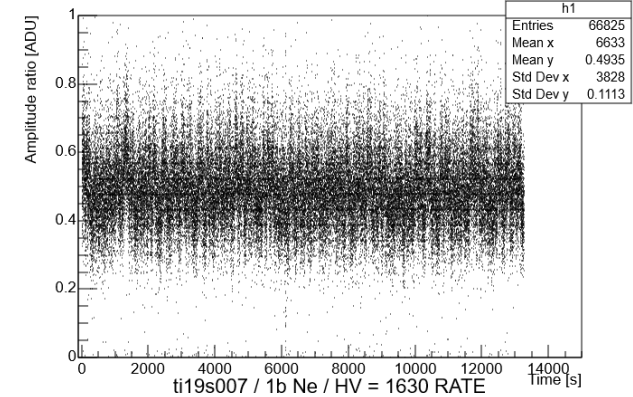
# Fluctuations in the drift time

ti19s007 / 1b Ne / HV = 1630 DRIFT

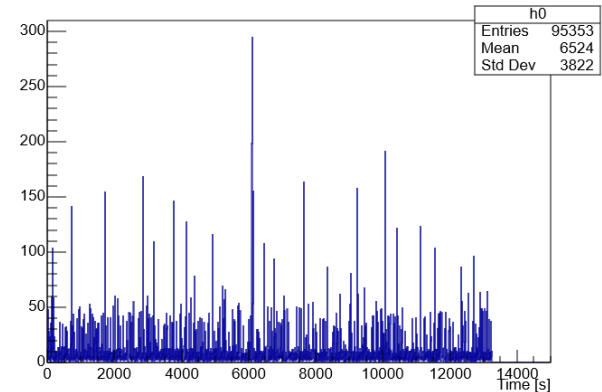


- The drift time fluctuates a lot. Similar fluctuations are observed on the gain and total rate of events.

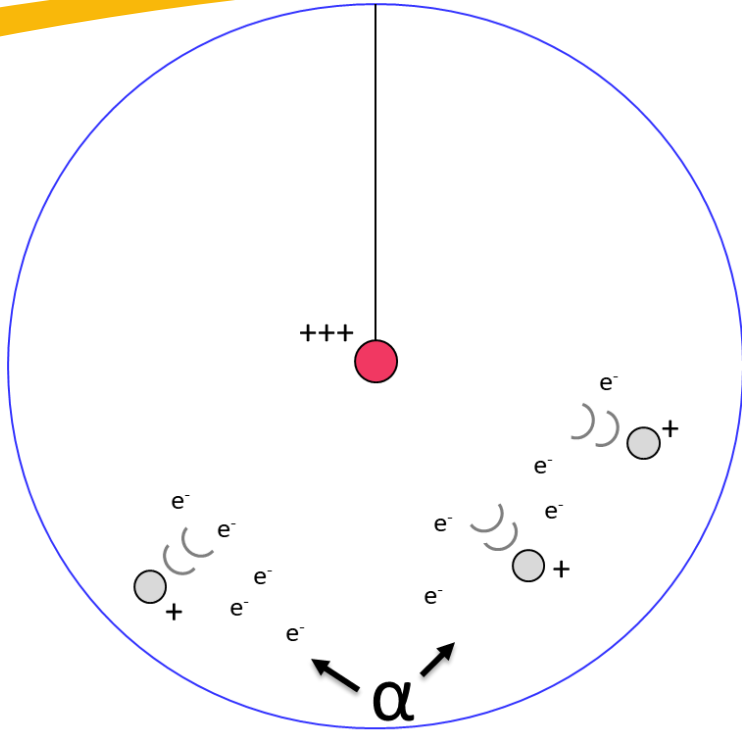
ti19s007 / 1b Ne / HV = 1630 GAIN



ti19s007 / 1b Ne / HV = 1630 RATE

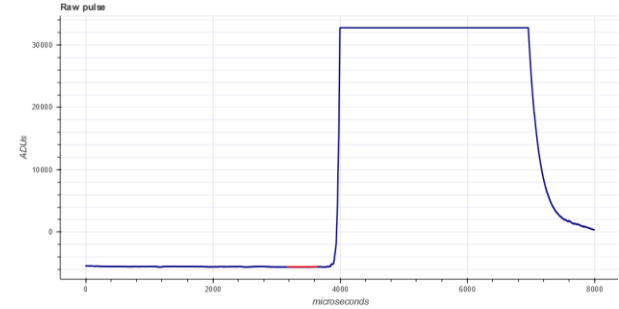


# Alphas in the detector

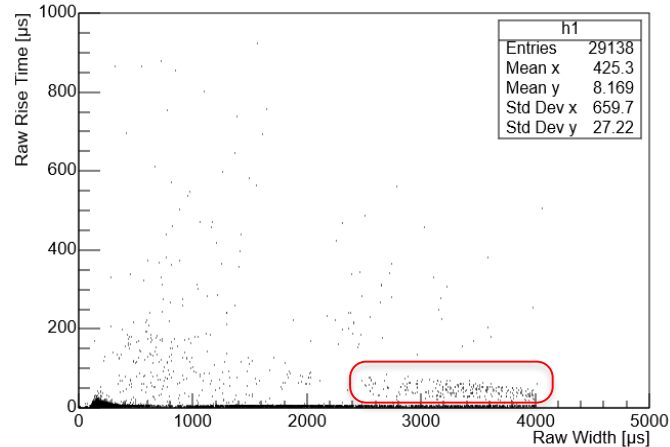


“Space charge effect”: Drift of ions slowly perturbate the electric field

Alpha event signal



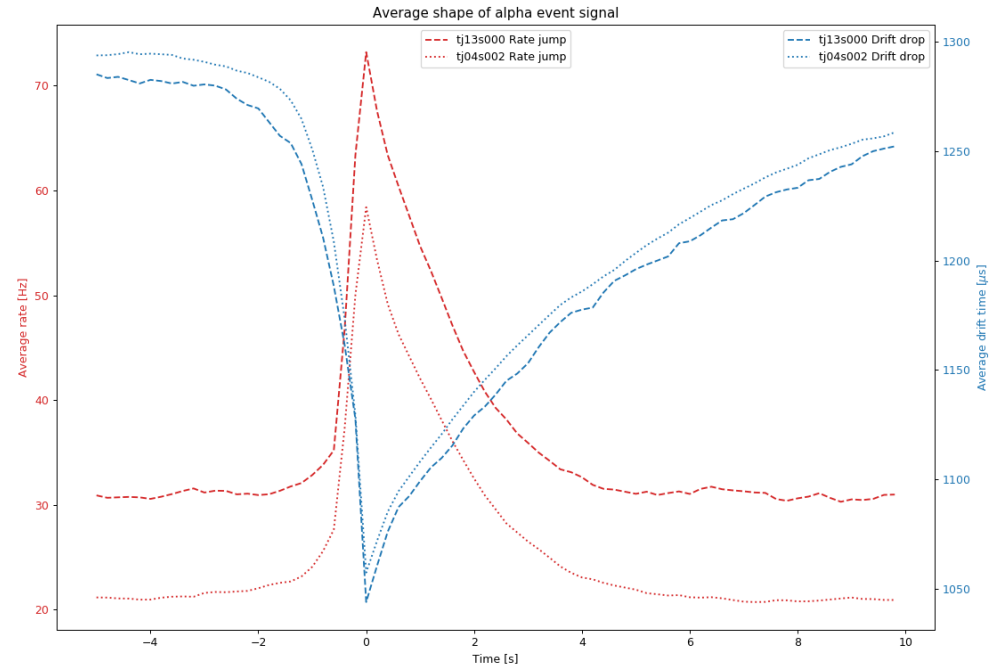
tj04s001 / 135 mb CH4 / HV = 2030 / Saturated only



These alphas cause the fluctuations observed on drift time, gain and rate.

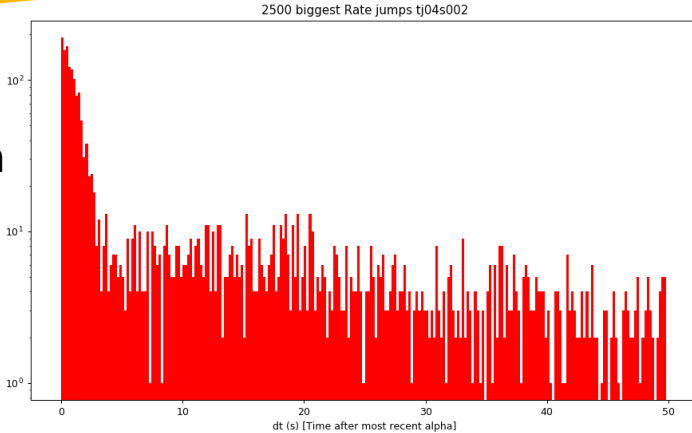
# Fluctuation shape

- Sudden drop of the **drift time** after an alpha, followed by a slow (>10s) exponential return to baseline
- Similar effect with the **rate of events**, but with a much faster return to baseline

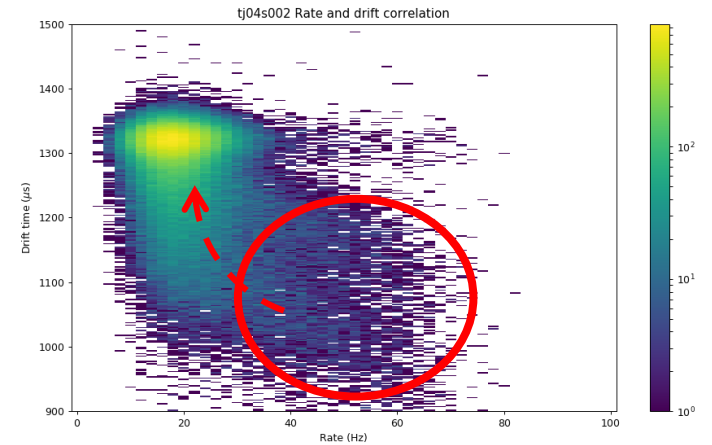
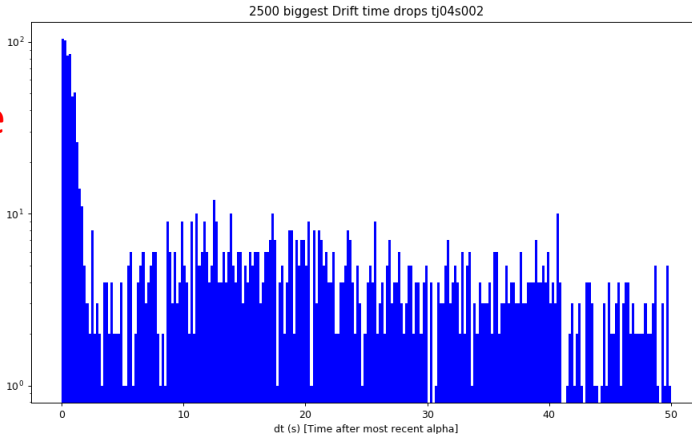


# Fluctuations effects

Clear correlation  
between the  
different  
fluctuations



Here is the time  
difference  
between big **rate  
jumps** / **drift  
time drops** and  
the most recent  
preceding alpha.



Problem:

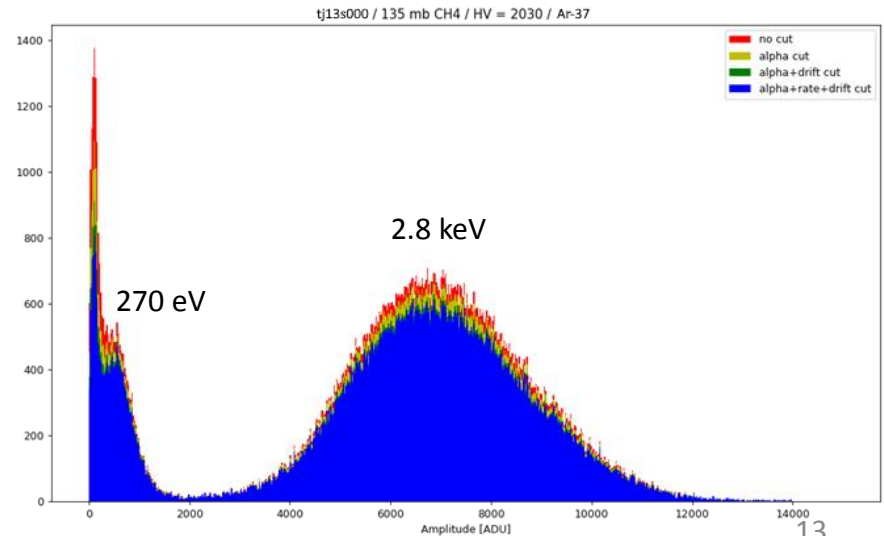
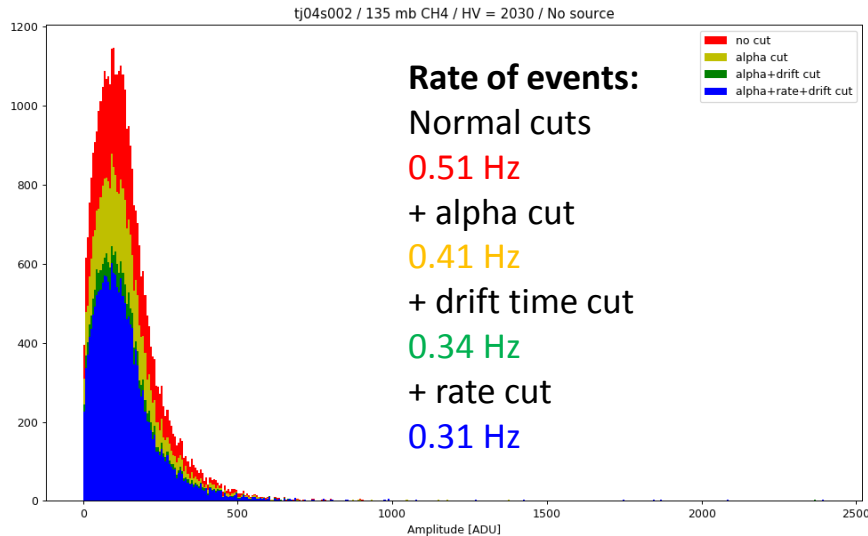
A lot of seemingly “good events”  
created because of this phenomenon,  
similar to a WIMP single-electron event.

# Solution: Cuts on alphas

- 5-second dead time cut
- Around 85% of the total time kept with all cuts

Proportion of kept events with alpha cut function for Argon-37 run

	Ampl<300	300<Ampl<2000	Ampl>2000
Alpha only	0.788	0.932	0.951
Alpha+Drift	0.664	0.868	0.895
Alpha+Rate+Drift	0.597	0.842	0.873



*Thank you!*

- Q. Arnaud et al., First results from the NEWS-G direct dark matter search experiment at the LSM, *Astroparticle Physics*97(2018) 54-52.
- Q. Arnaud et al., Precision laser-based measurements of the single electron response of SPCs for the NEWS-G light dark matter search experiment, arXiv:1902.08960
- A. Dastgheibi-Fard & G. Gerbier, Development of Spherical Proportional Counter for light WIMP search within NEWS-G collaboration, arXiv:1904.01944