The low-energy ionization signal and backgrounds in PandaX-4T experiment

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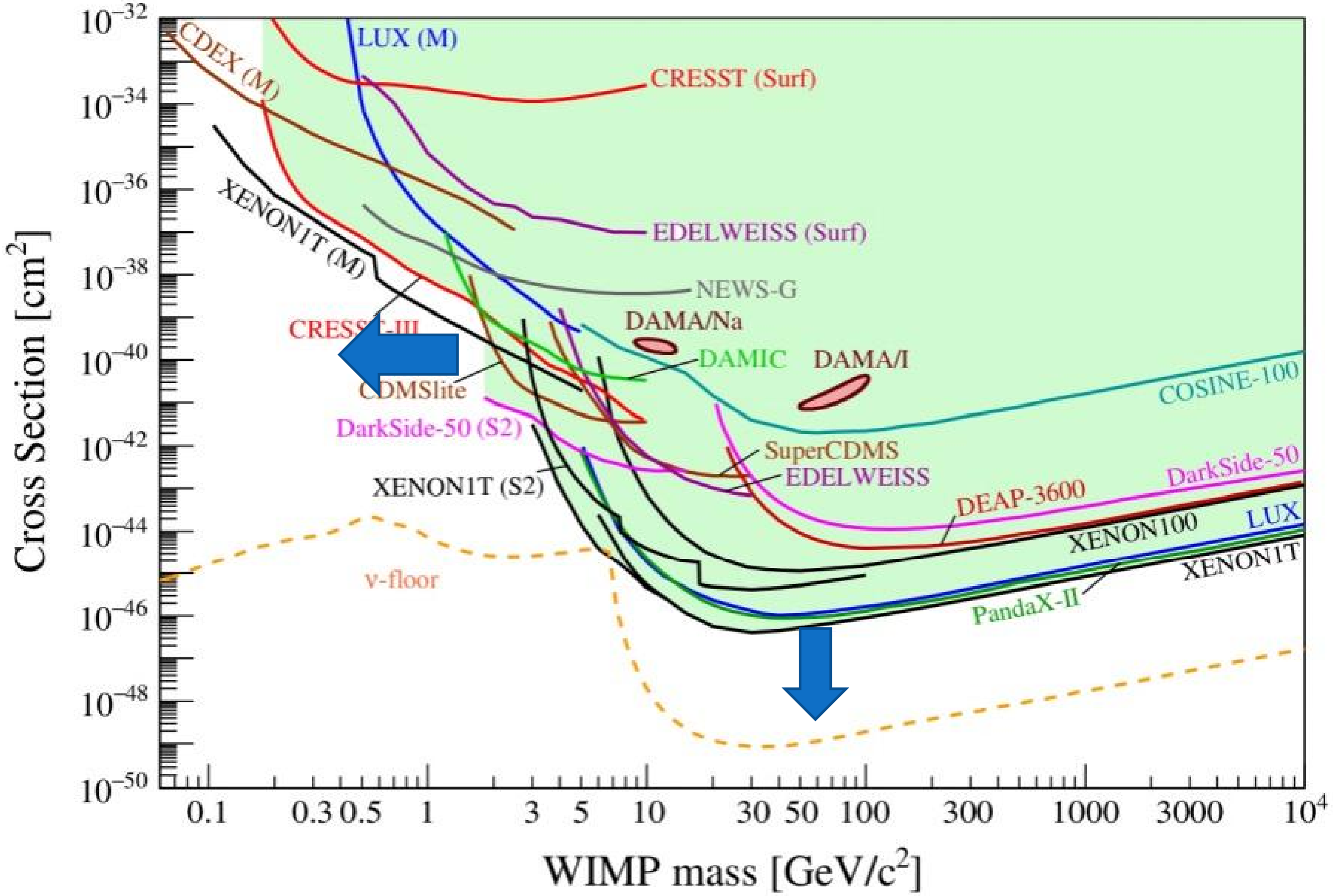
WIMP dark matter detection

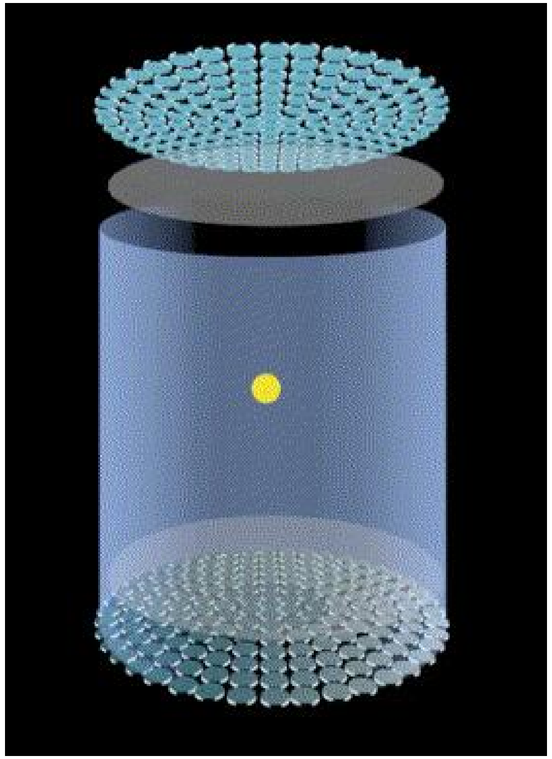
- light dark matter, boron 8 ...

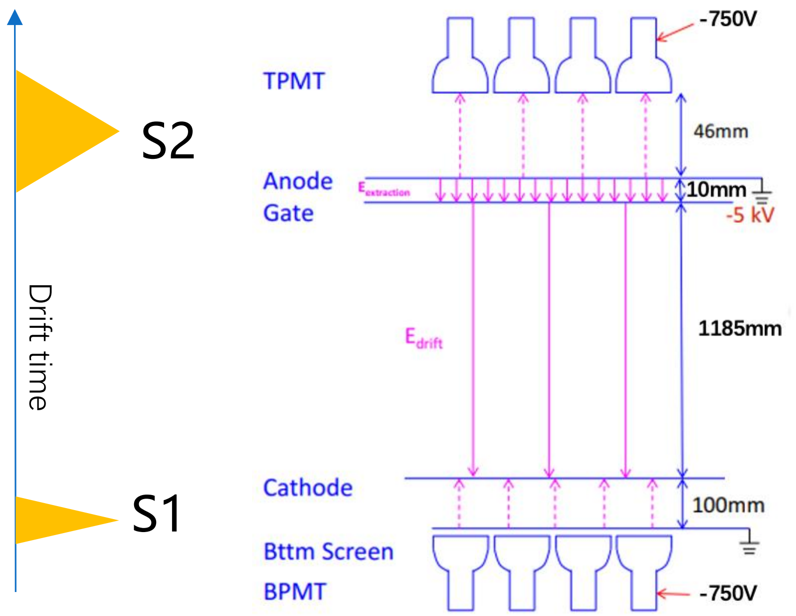


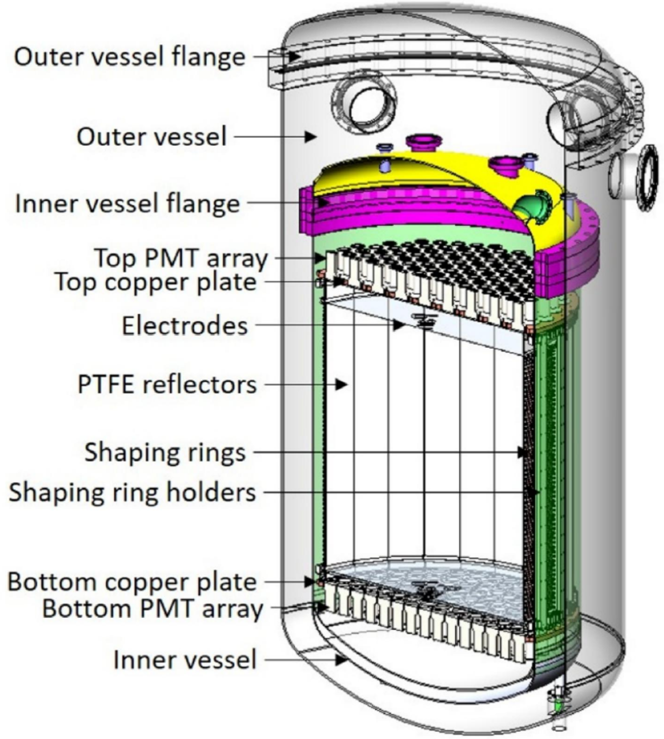
to lower energy, higher sensitivity

PandaX-4T Time Project Chamber (TPC)

- Physical events produce S1 (scintillation) and delayed S2 (ionization) signals.
- TPC uses S1-S2 paired information to reconstruct events.



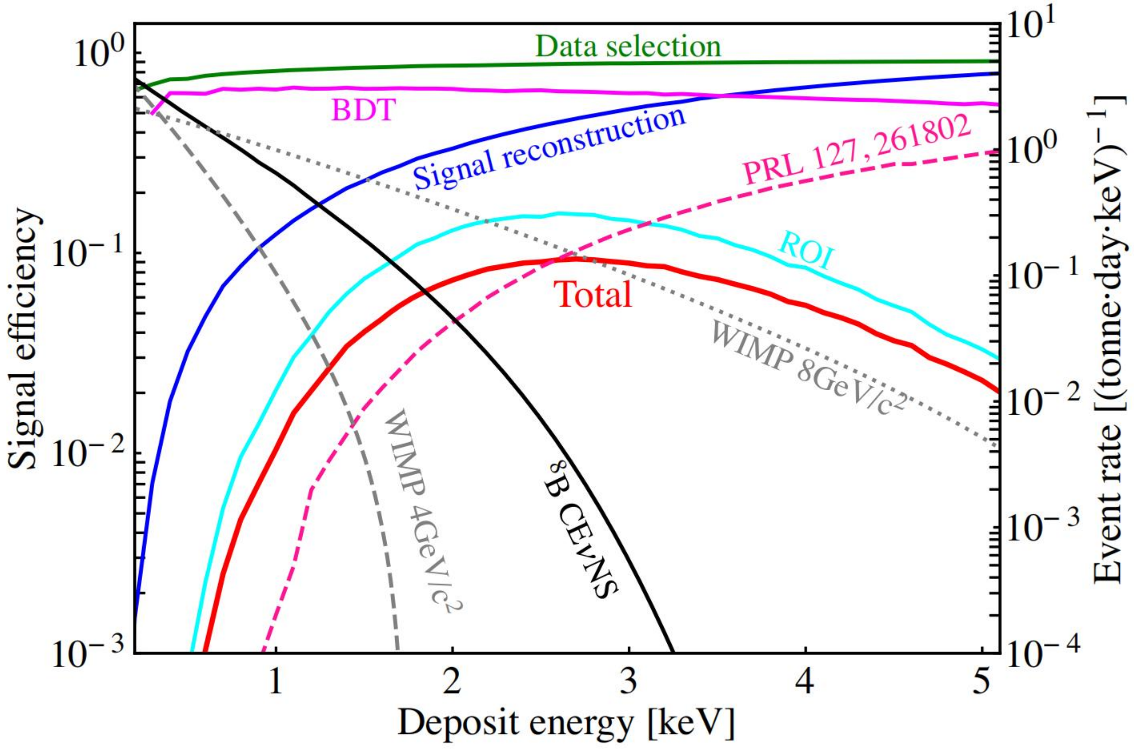


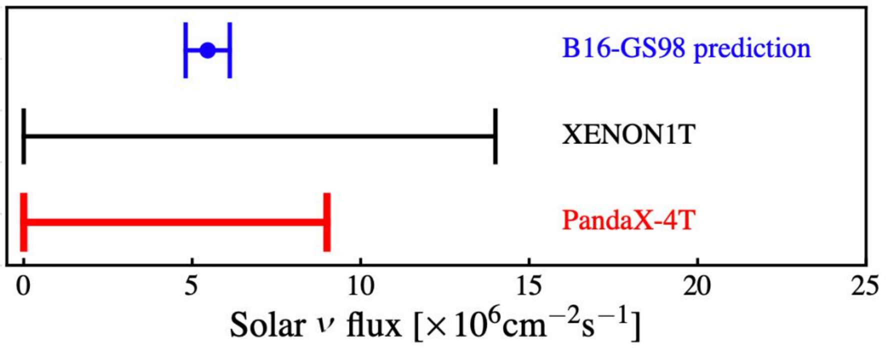


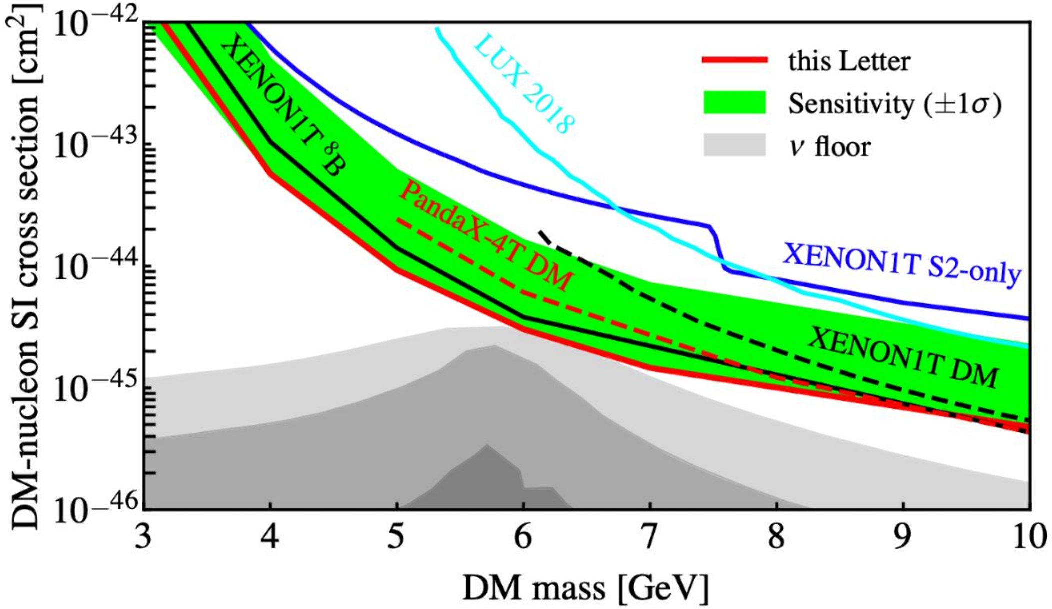
Detection efficiency of S1 << S2

lower energy threshold- lower S1 threshold

- adjust S1 threshold from 2 PE to 0.3 PE





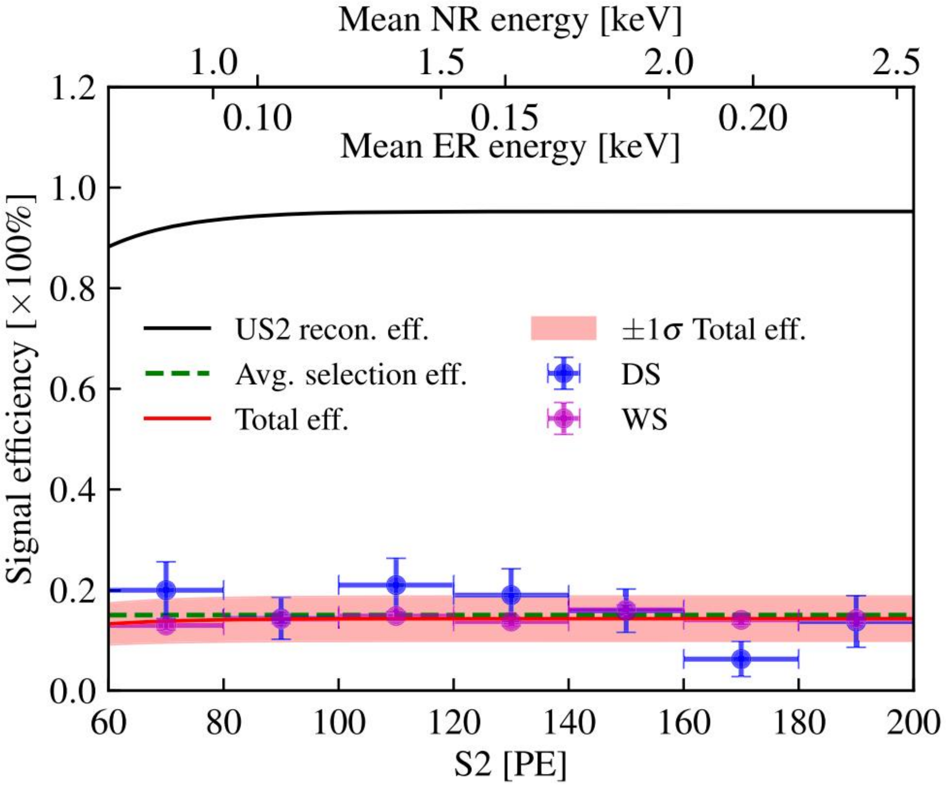


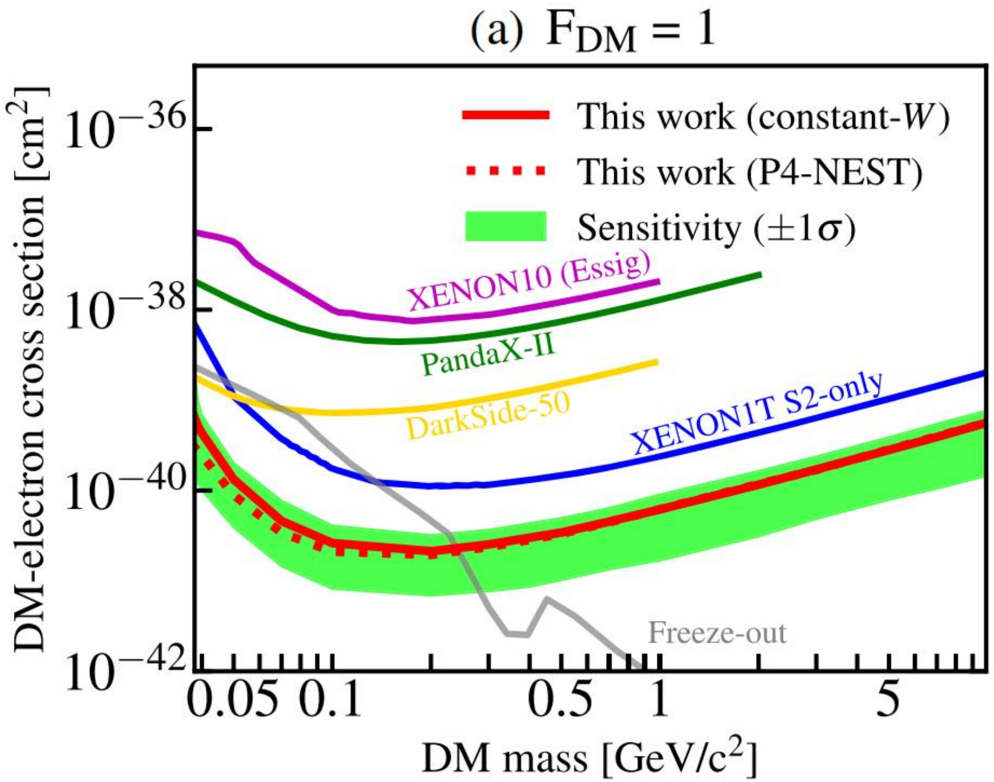
W. Ma et al. PhysRevLett.130.021802

PandaX-4T used the lower S1-S2 detect solar v

lower energy threshold-S2 only

- abandon the dependence of S1

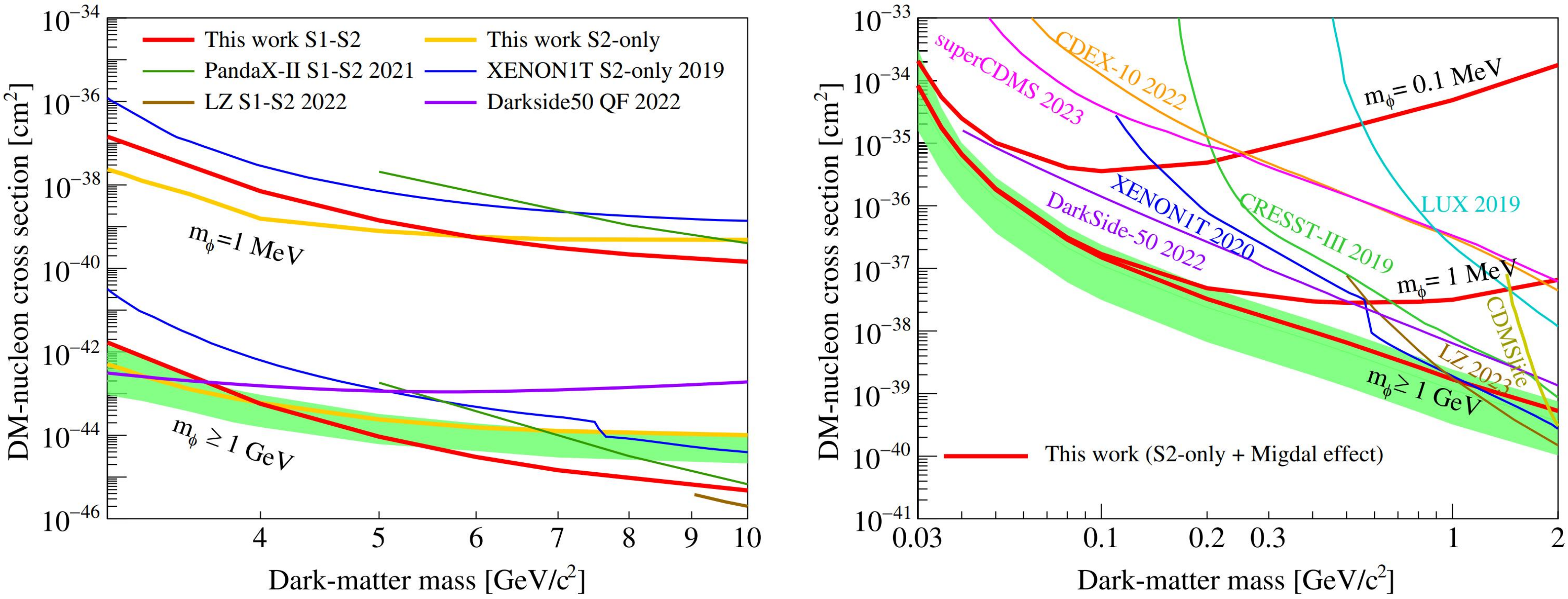




Shuijie Li. et al. PhysRevLett.130.261001

PandaX-4T used S2 only data to detect light DM

Also the DM–nucleon Interactions



Di Huang et al. PhysRevLett.131.191002

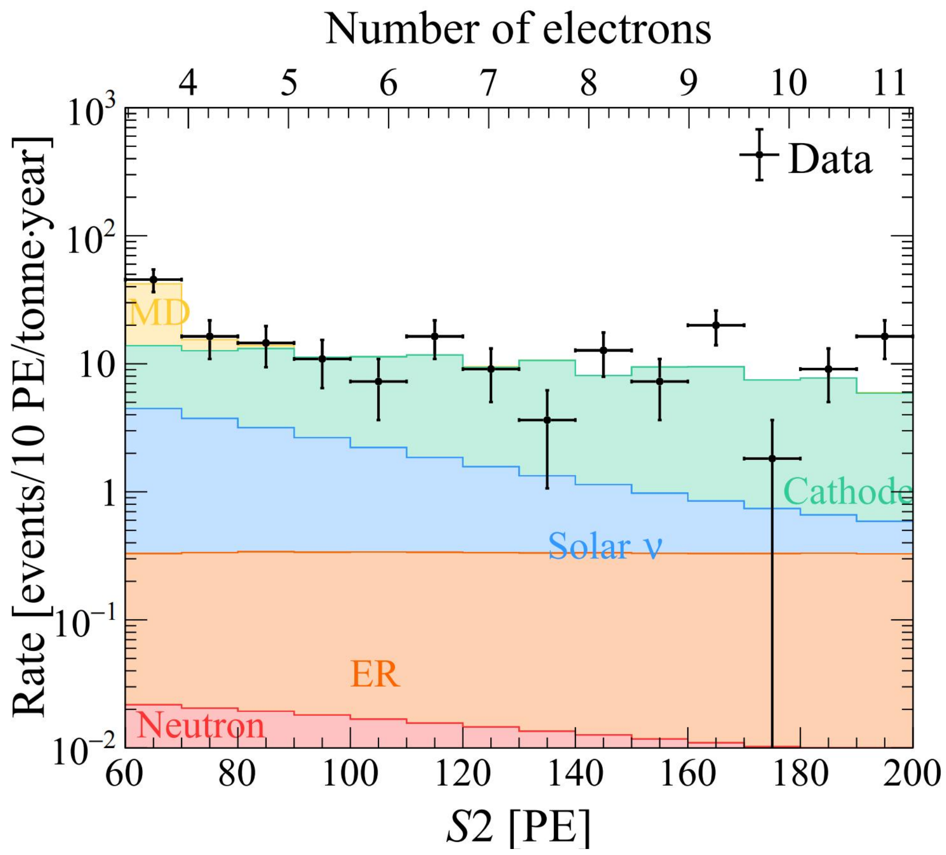
The potential of S1-S2 and S2 only analysis

Backgrounds limit the sensitivity

- lower S1-S2 data: accidental backgrounds (S2-only)
- S2-only data: micro-discharge and cathode events

TABLE I. Nominals and background-only best-fits of the background components in the US2 candidates.

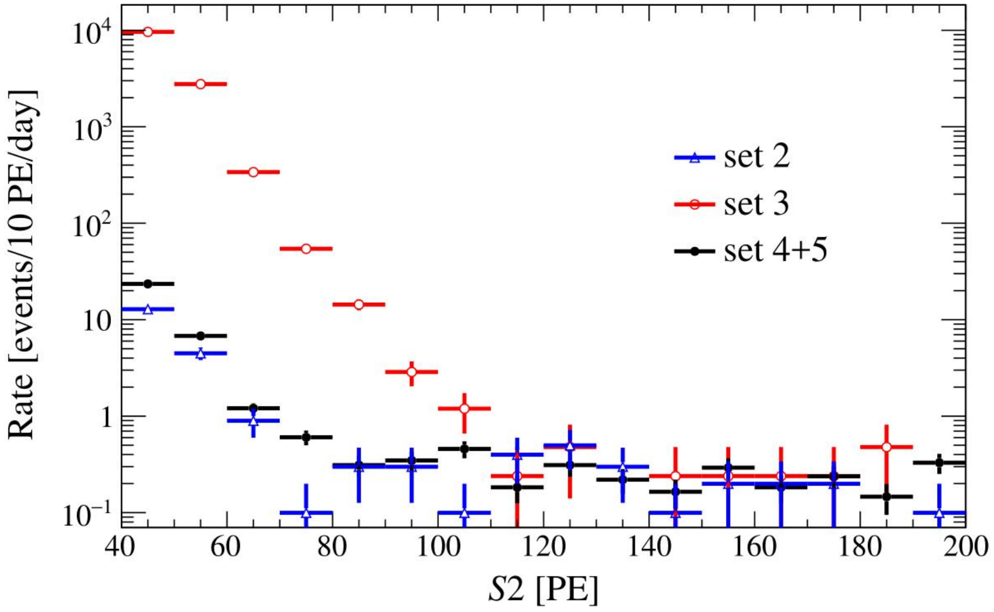
	Nominal	Best-fit
Cathode	41.6 ± 10.6	63.9 ± 9.1
MD	$6.9^{+9.0}$	17.7 ± 5.3
Solar ν	10.8 ± 3.7	11.7 ± 3.6
ER	2.3 ± 0.6	2.5 ± 0.5
Neutron	0.1 ± 0.1	0.1 ± 0.1
Total	$61.7^{+14.4}_{-11.2}$	95.8 ± 11.3



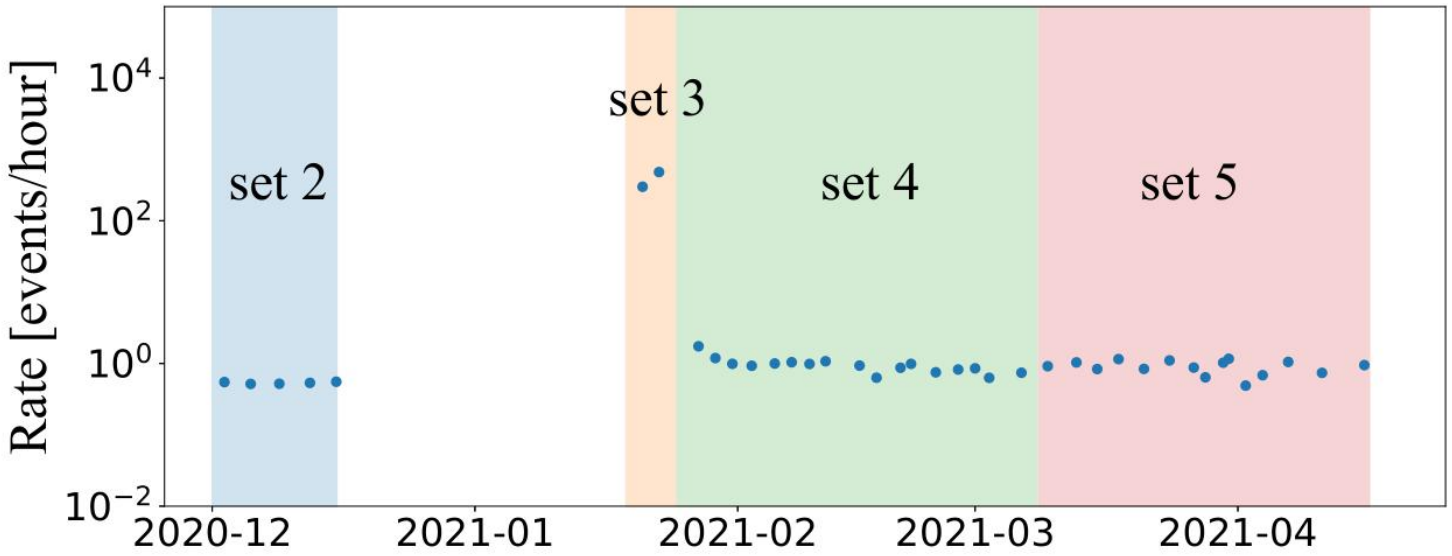
How to understand MD and cathode events

md estimation by sideband

- In run0 data, set3 is a typical MD dataset



S2 rate comparison of run0 Set 2, 3, 4+5

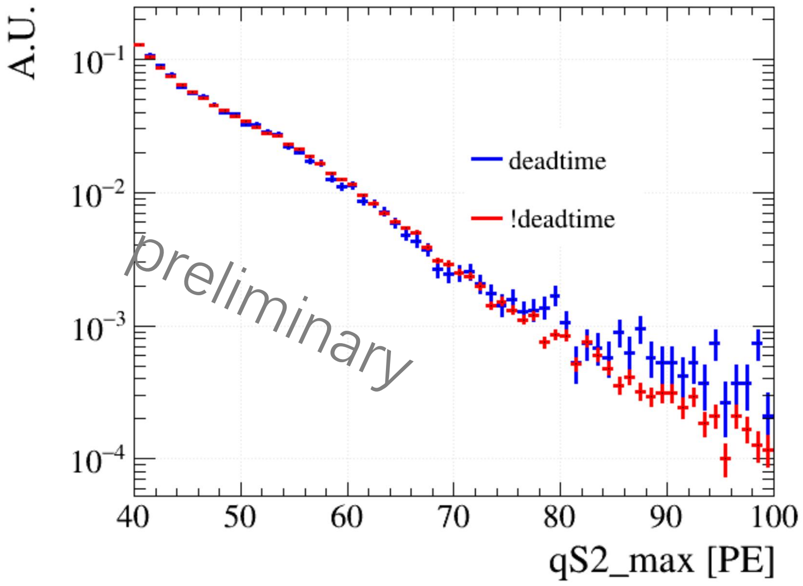


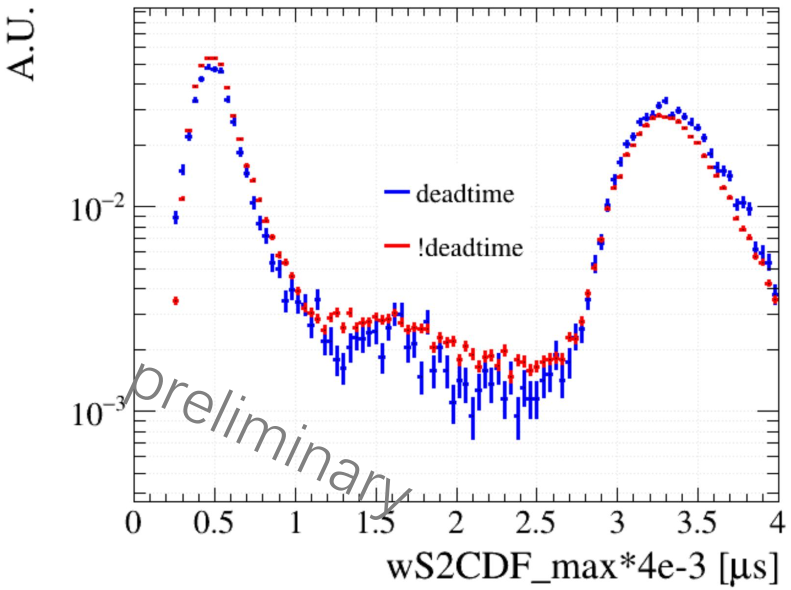
S2 rate time evolution

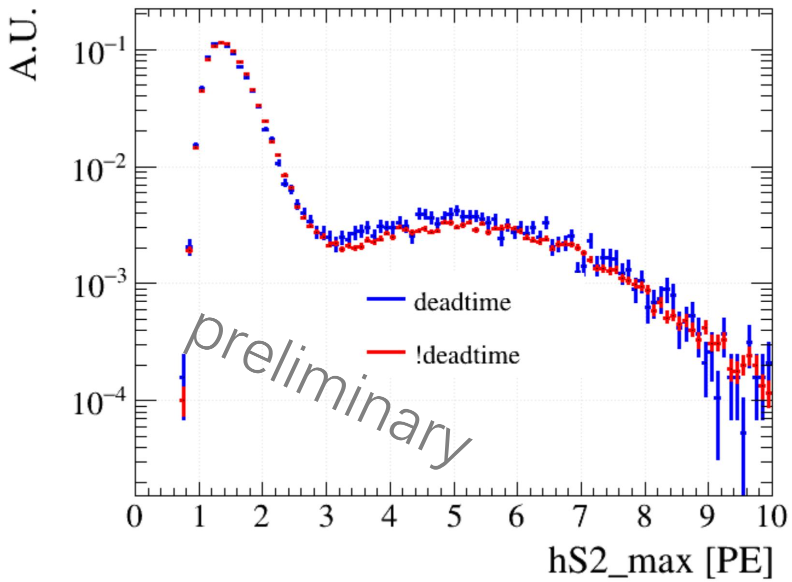
data-driven estimation has large error

what is md events

- very high SE rate in MD sample: tail of single electron spectrum?
- compare delayed signals after large S2 and high MD dataset
- deadtime cut： dominant by delayed signals after large S2



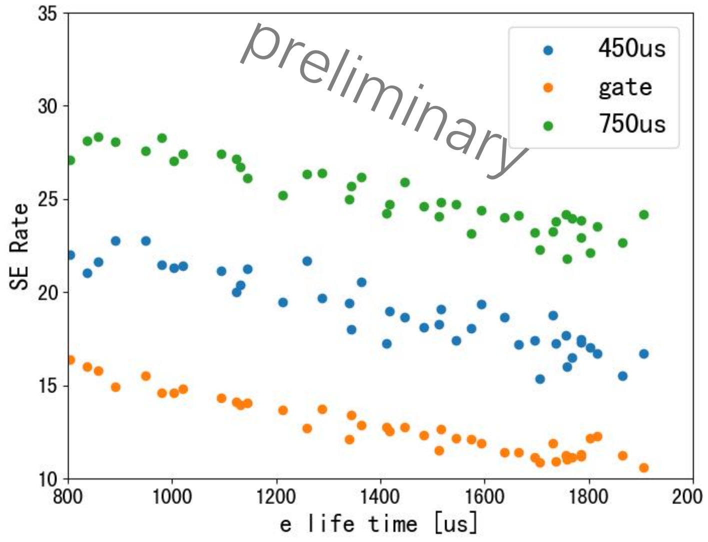


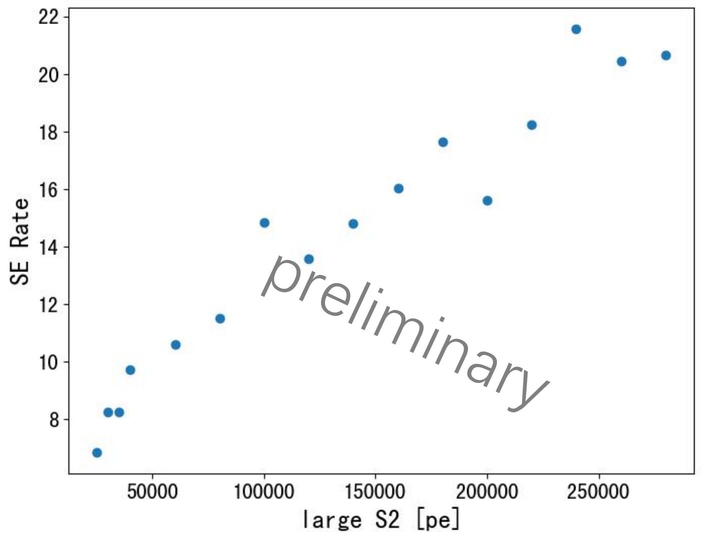


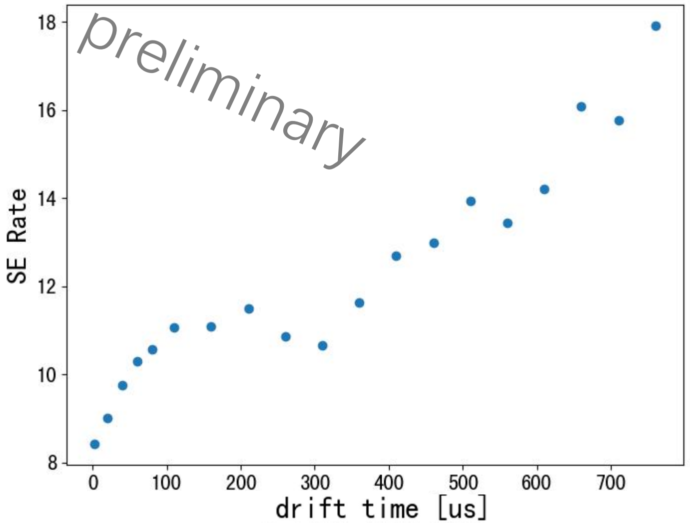
how to produce delayed SE

delay SE

- SE vs. elife/largeS2/dt
  - impurity capture and release
  - photoionization



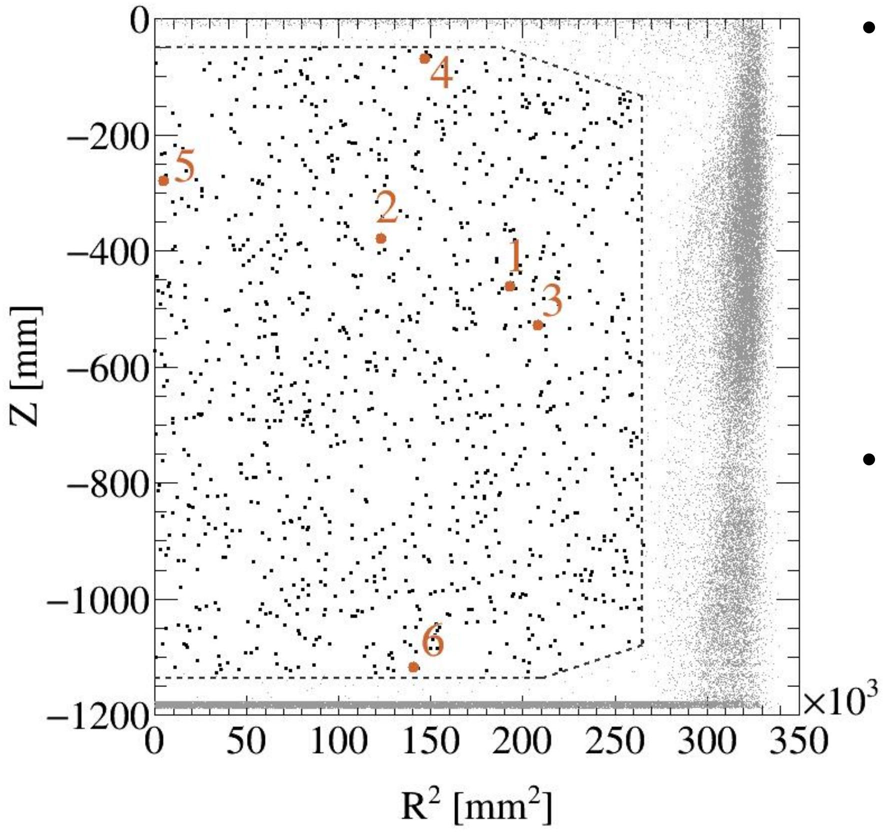




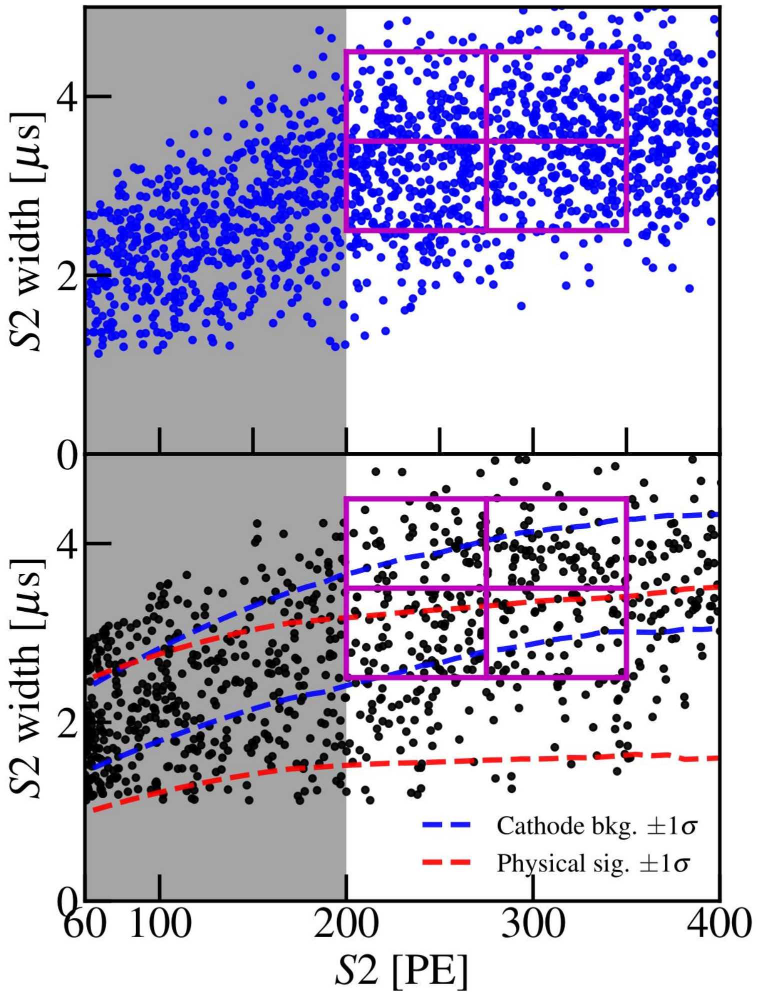
The features support the impurity capture and release hypothesis

cathode enents estimation by sideband

- cathode events are real and many



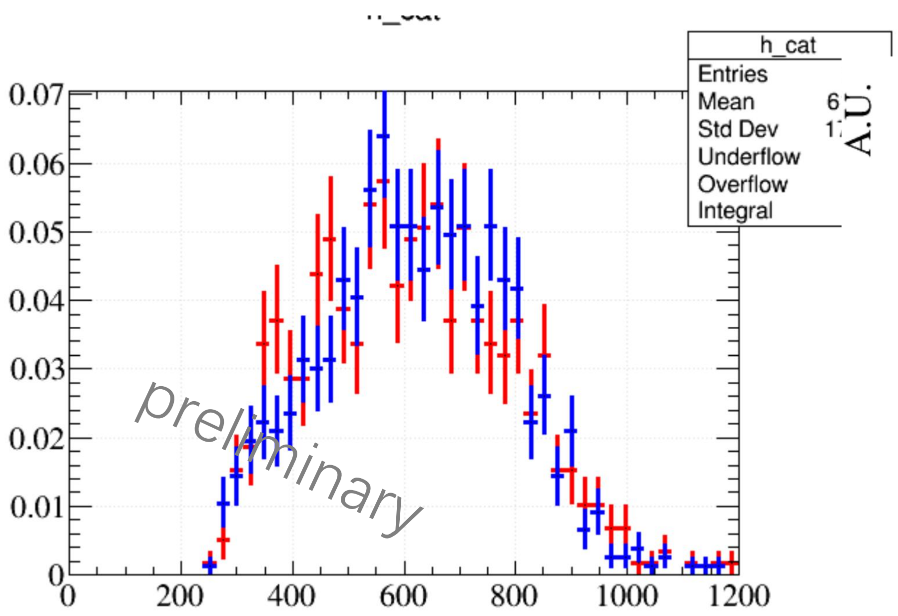
- Suppose the side band S2 only signals are only from cathode and physical backgrounds.
- Choose 200-350 PE as side band and divide into 12 control regions to estimate the system uncertainty.

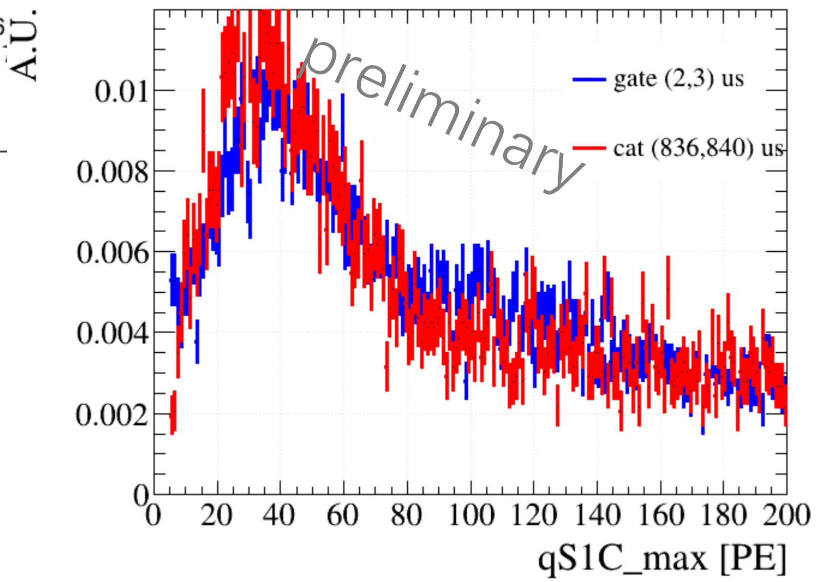


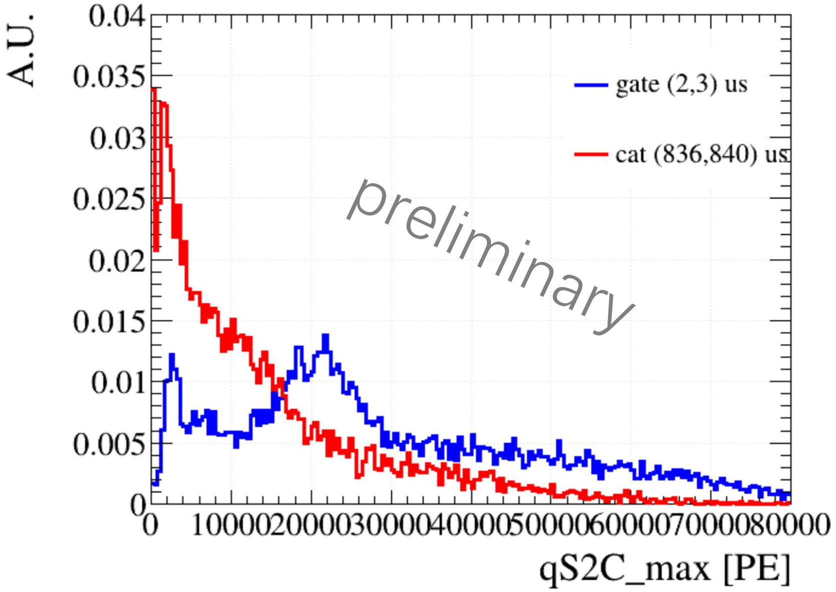
data-driven estimation has large error

What are cathode events

- compare cathode(s1-s2) with simulation (fig1)
- compare cathode and gate (fig2&fig3)



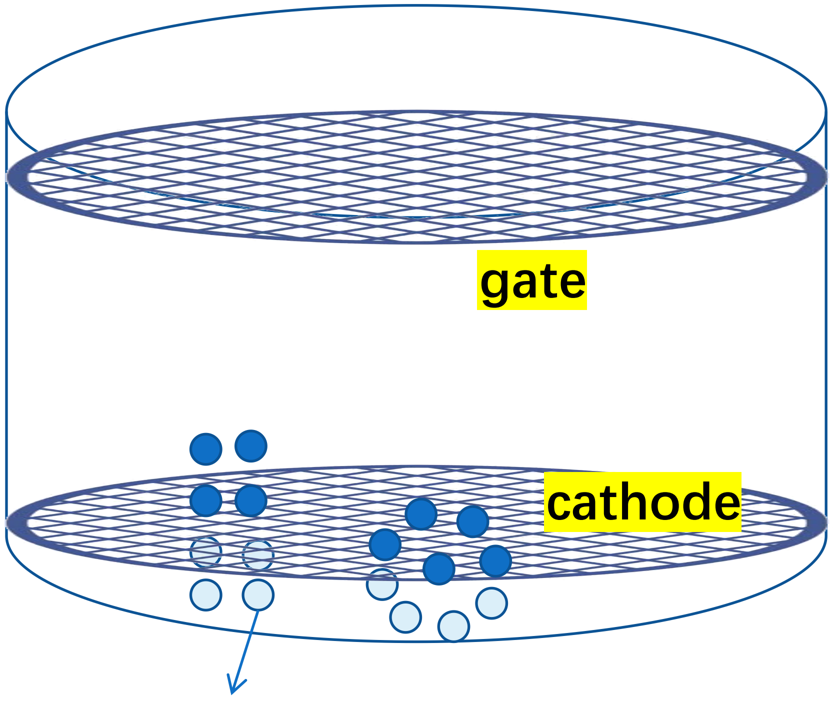


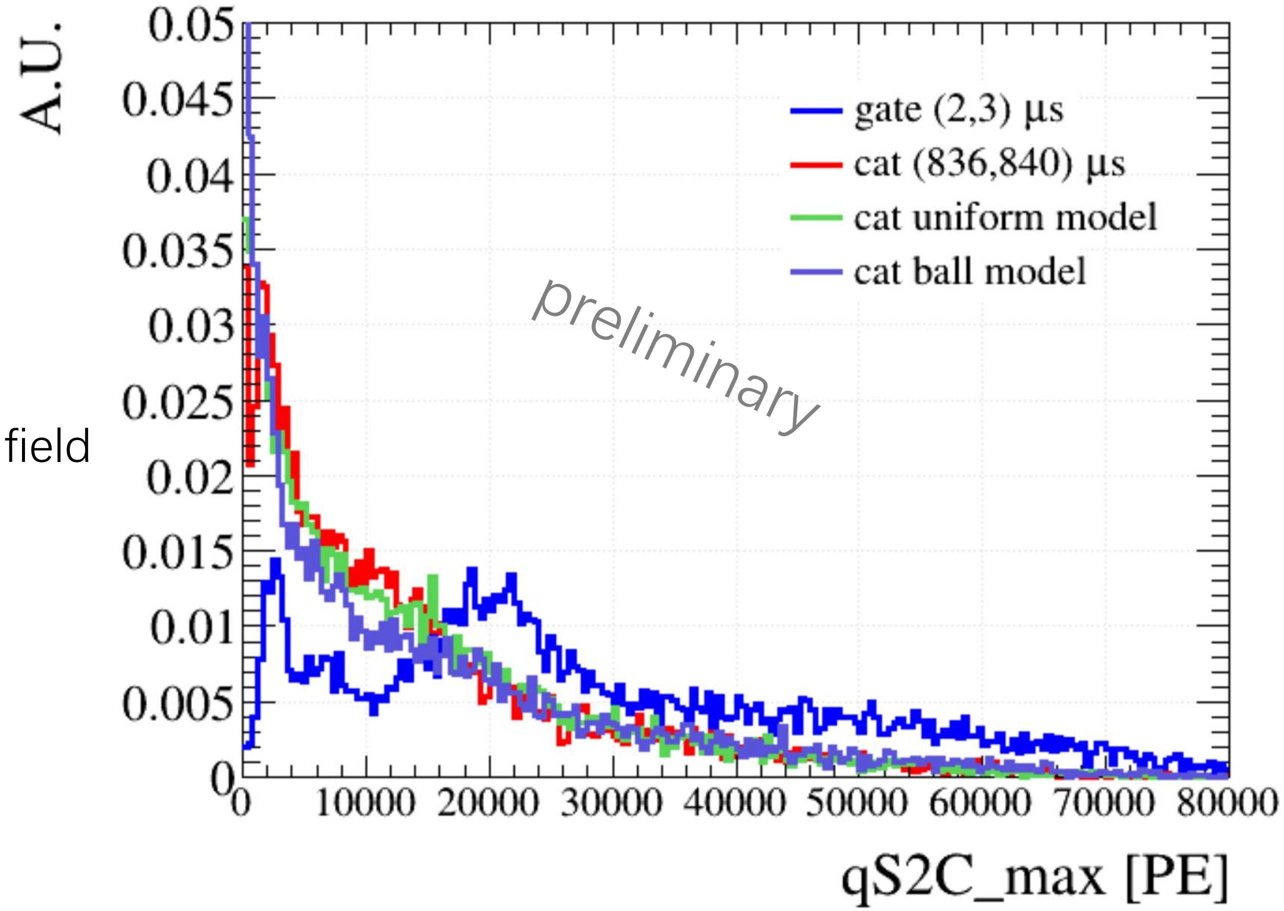


physical and smaller S2

smaller S2 mechanism

- electron cluster is divided by cathode electrode





depends on the electron cluster shape

Summary

- S2 only analysis have potential to detect light dark matter, solar B8 neutrino…
- The MD and cathode backgrounds limit the sensitivity
- Need model the produce mechanism of MD and cathode

On progress …

Thanks!