

Status of Solar ^8B CE ν NS and Light Dark Matter Search in PandaX

Speaker : Qing Lin (qinglin@ustc.edu.cn)

(On behalf of PandaX collaboration)

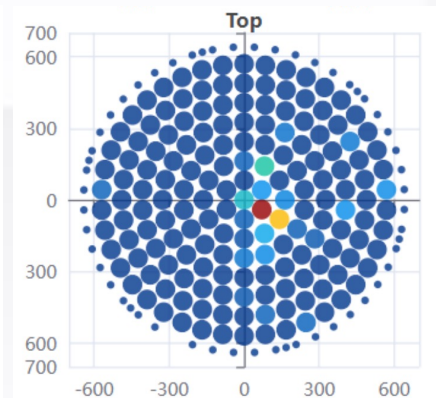
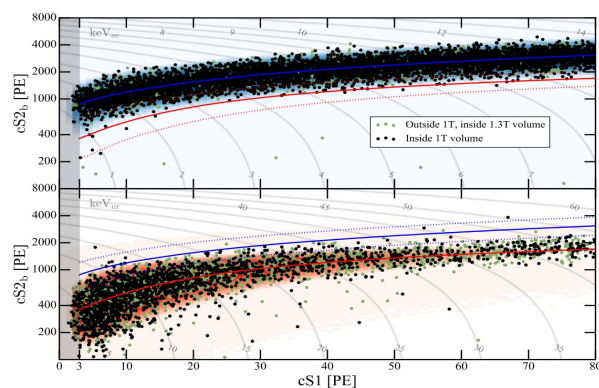
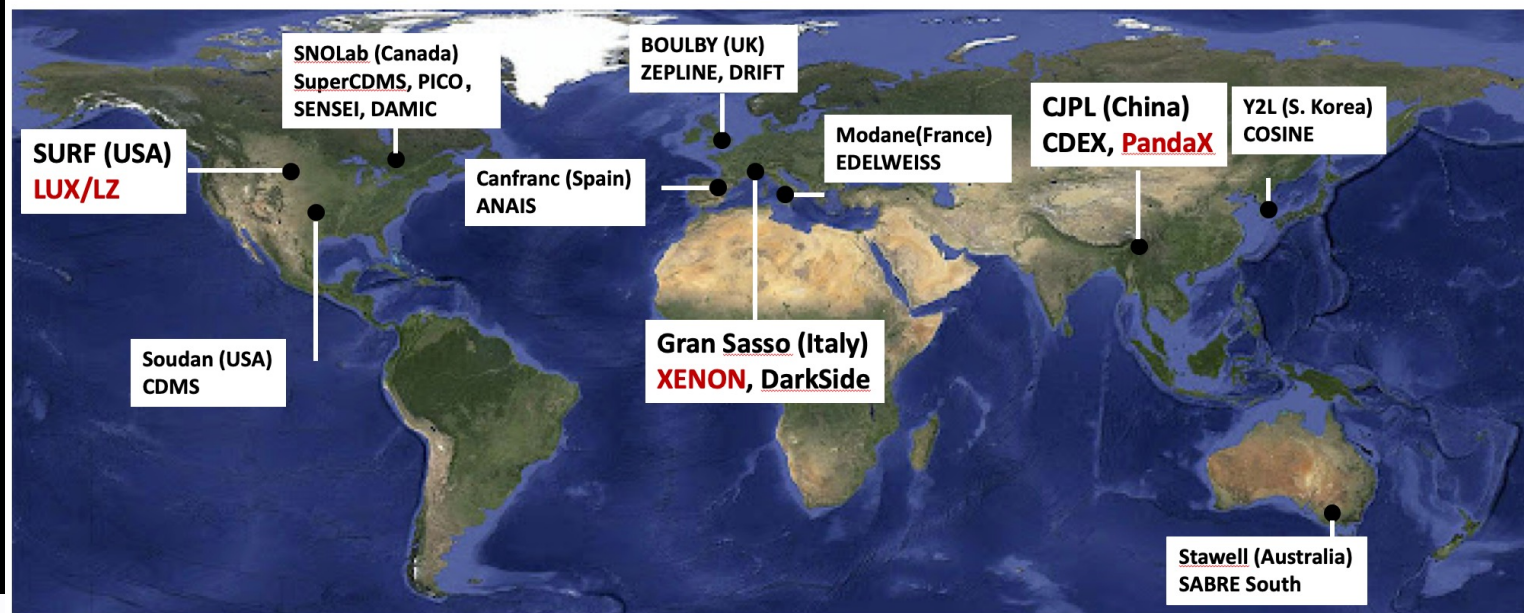
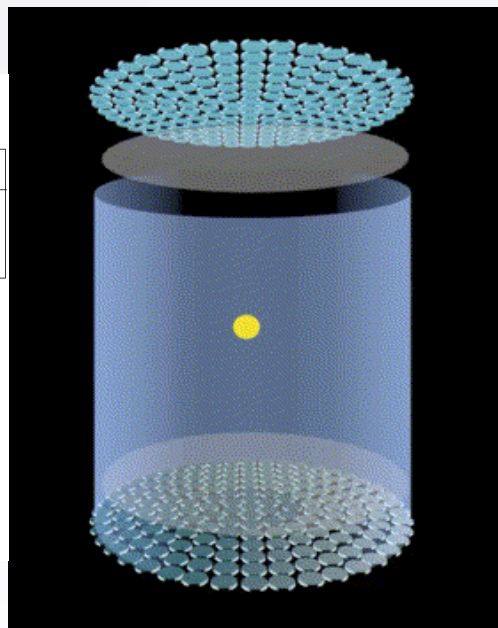
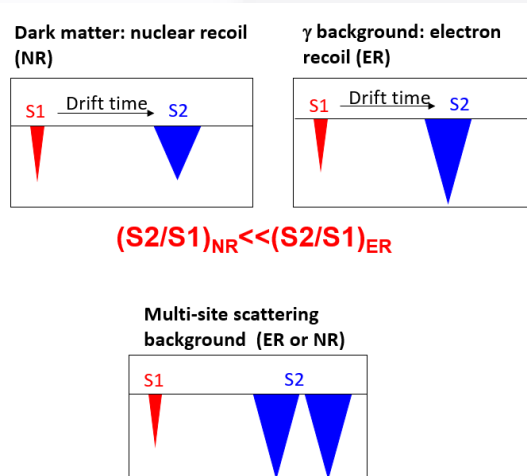
University of Science and Technology of China

TeVPA2026 @ Tendo, 2026.08.31

Dual phase xenon TPC

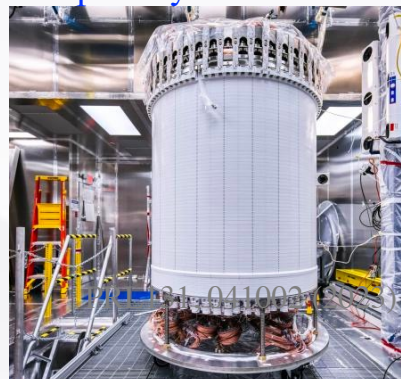


Global efforts for dark matter direct searches



LZ

See plenary and next talk



XENONnT



PandaX-4T

See last talk by Yong



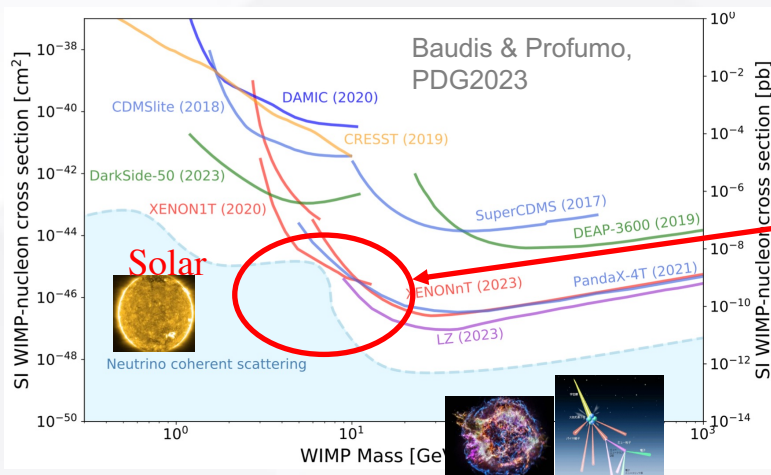
Timeline of PandaX-4T Experiment



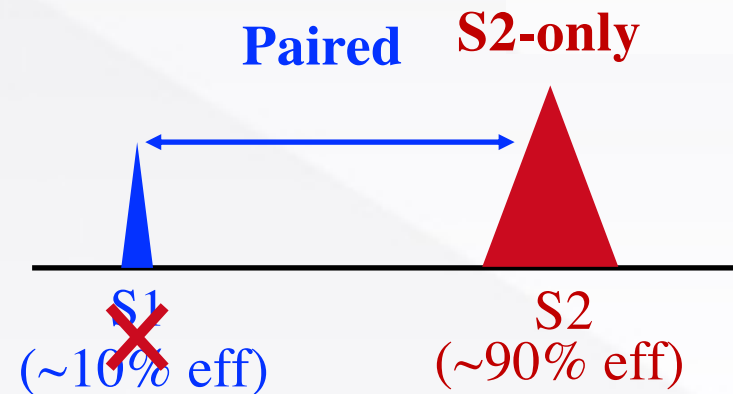
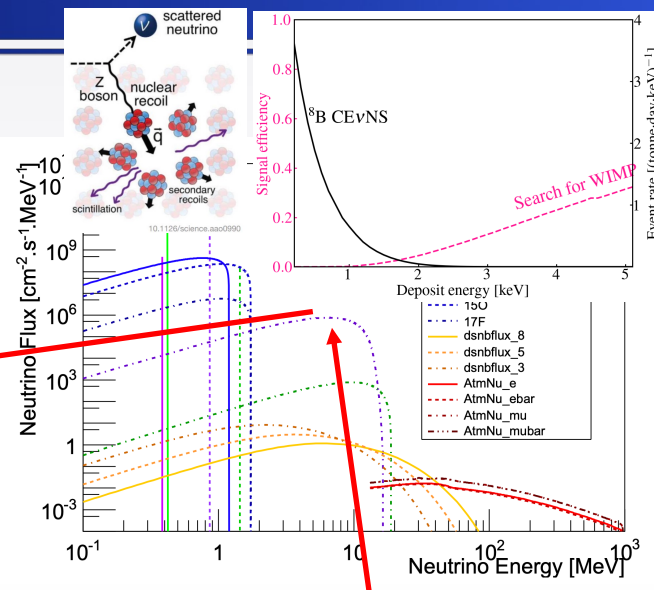
2020/11 – 2021/04	Commissioning (Run0) 95 days
2021/07 – 2021/10	Tritium removal xenon distillation, gas flushing, etc
2021/11 – 2022/05	Physics run (Run1) 164 days
2022/09 – 2023/12	CJPL B2 hall construction xenon recuperation, detector upgrade
2024/01- 2026/04	Physics run (Run2)
2026/04/15	PandaX-4T decommission



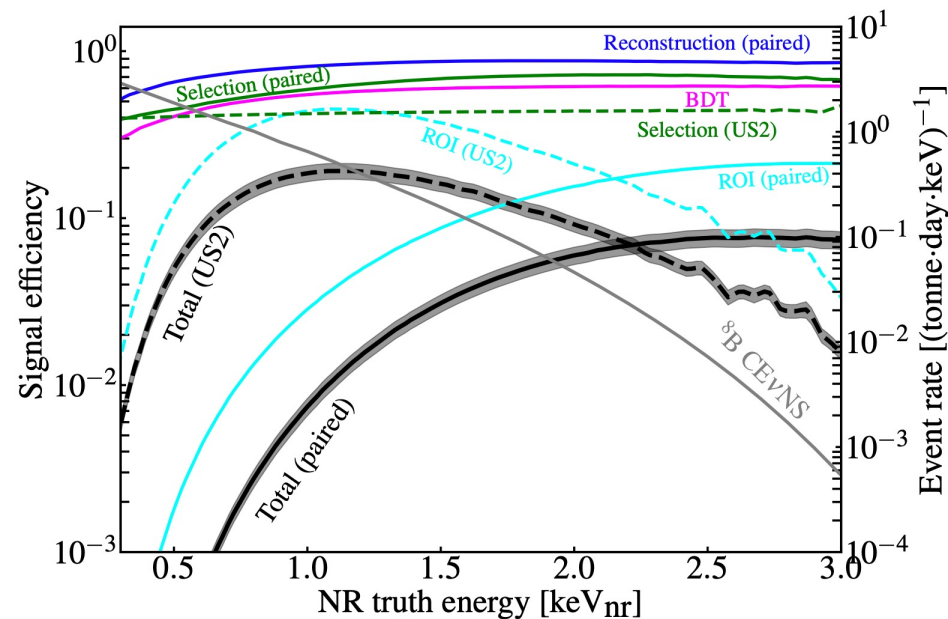
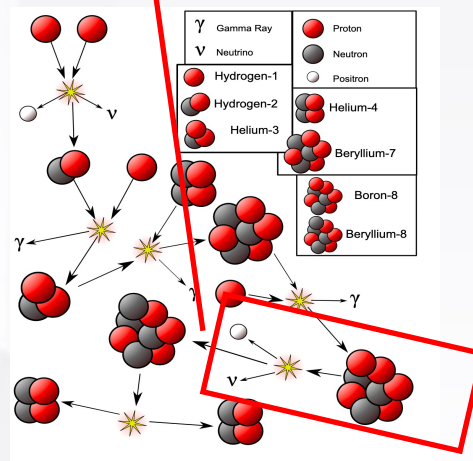
Search for solar neutrinos



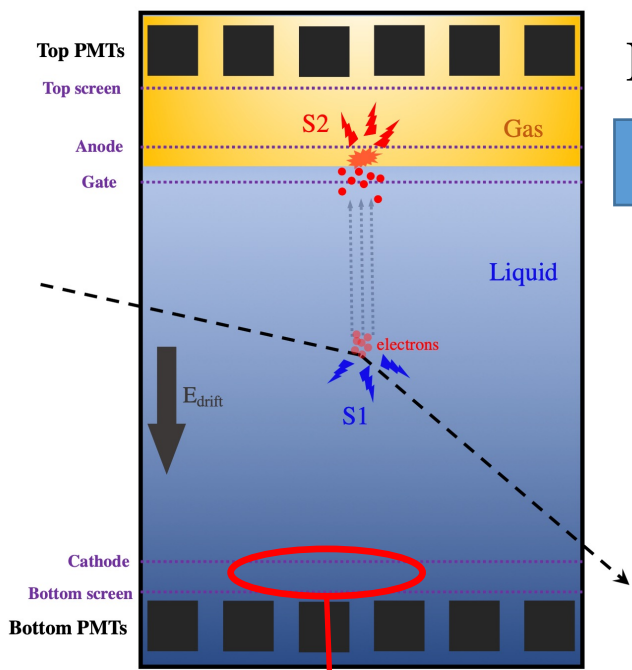
SN Atomspheric



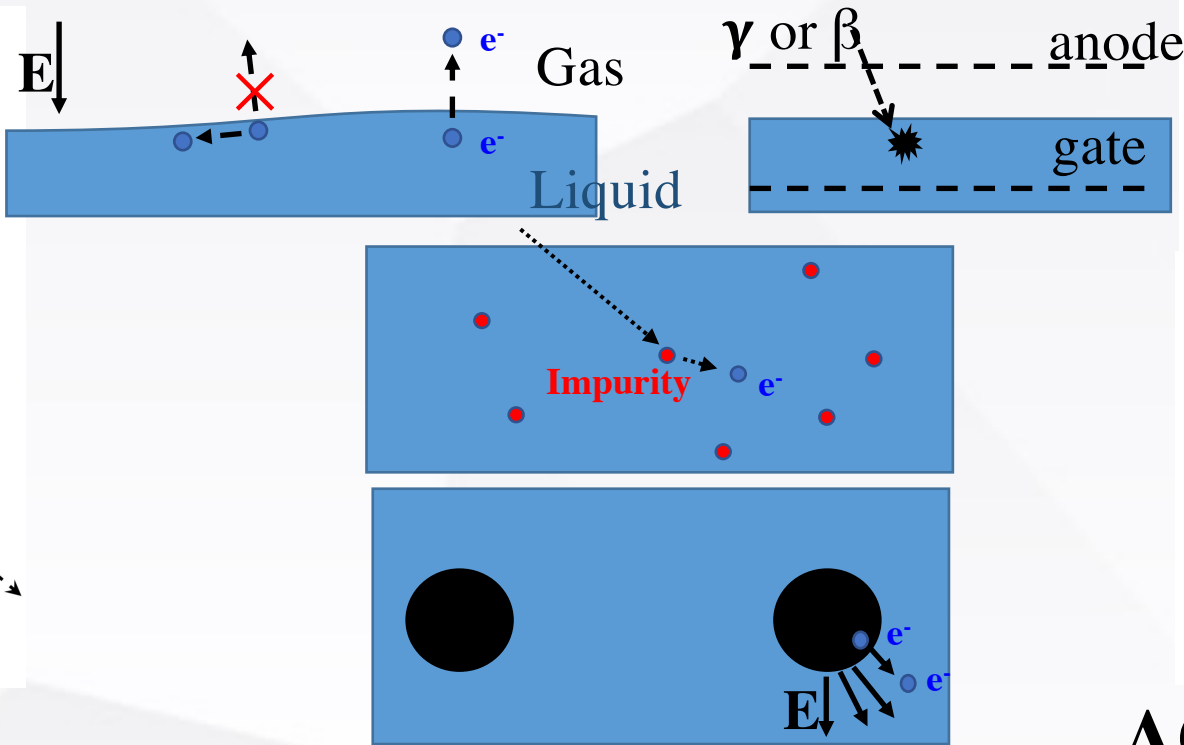
- PandaX-4T searches for solar B8 CEvNS with lowered threshold;
- Large amount of background emerged with lowered threshold;
- Two data regions used: **Paired** and **S2-only**;



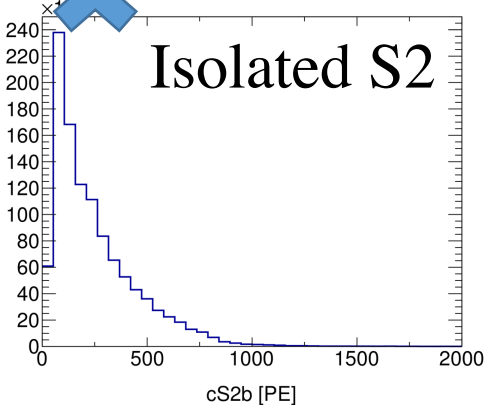
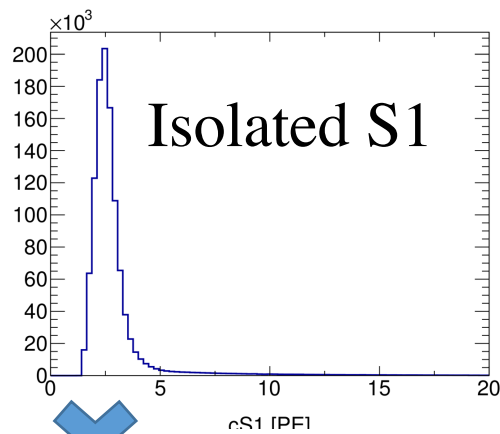
Major AC background for paired data



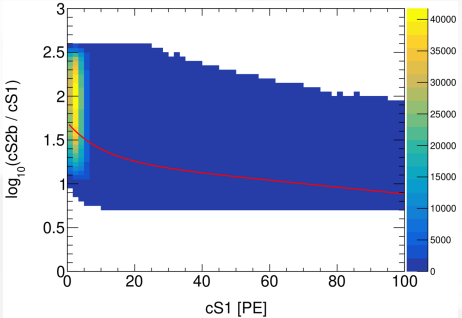
Isolated S1



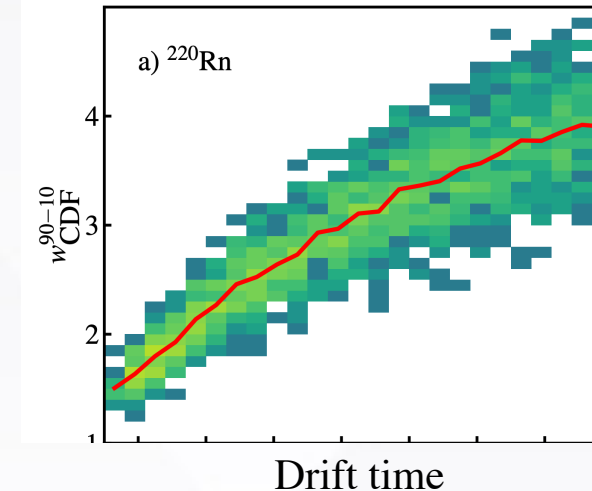
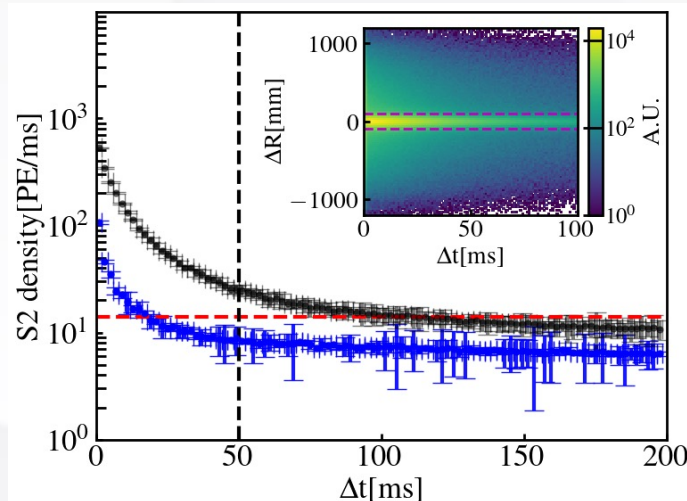
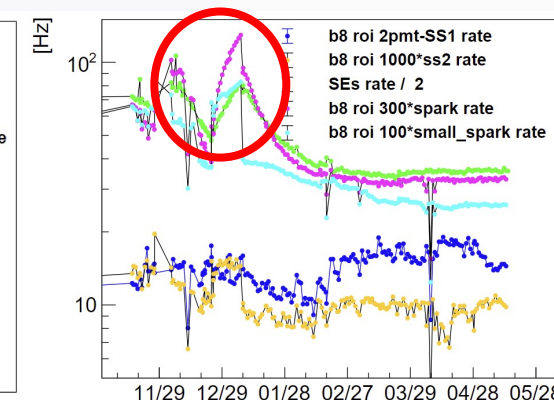
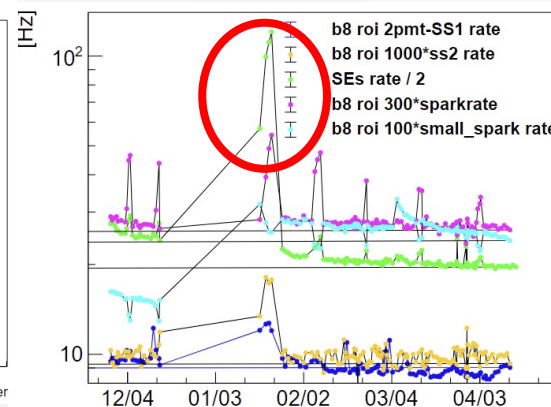
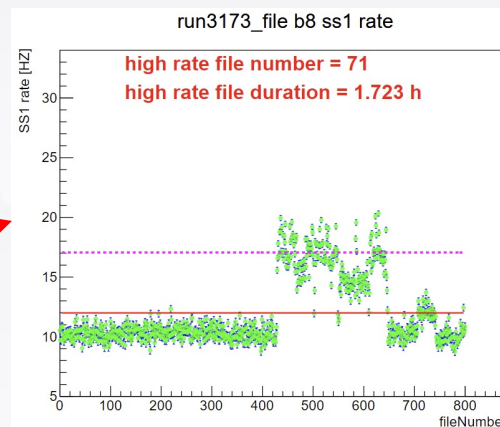
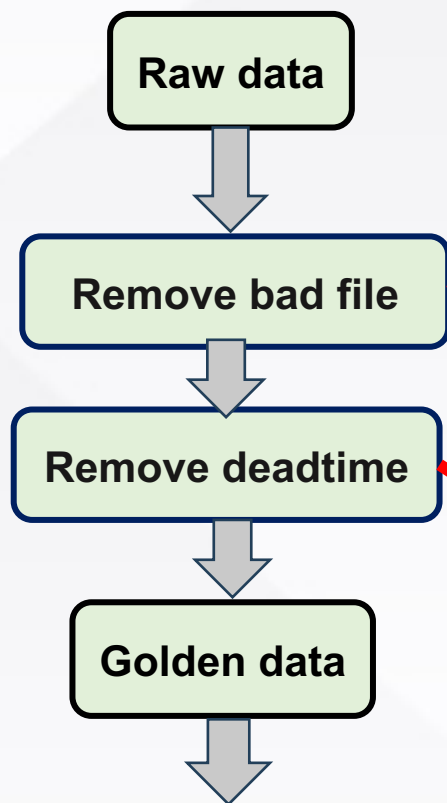
Isolated S2



AC
=
=



Data Selection in paired data



Paired

US2

Exposure
[tonne.year]

1.20

1.04

- Tag abnormal data as bad file through detector parameters
- Remove the period after the large signal and the volume near the large S2

BDT suppression of paired AC

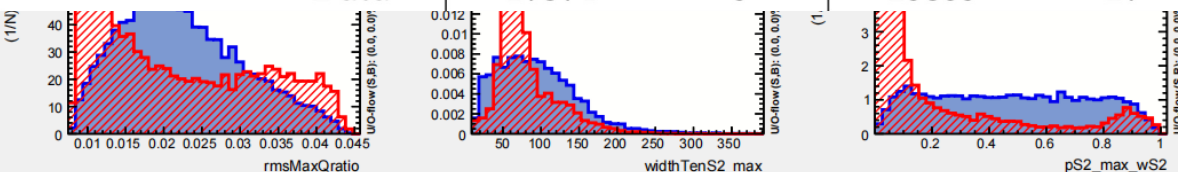


- 23 BDT variables
- Variables developed for the **shape and pattern** features of S1 and S2;

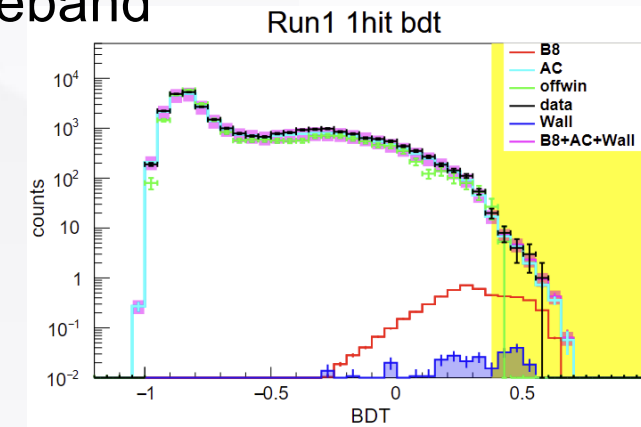
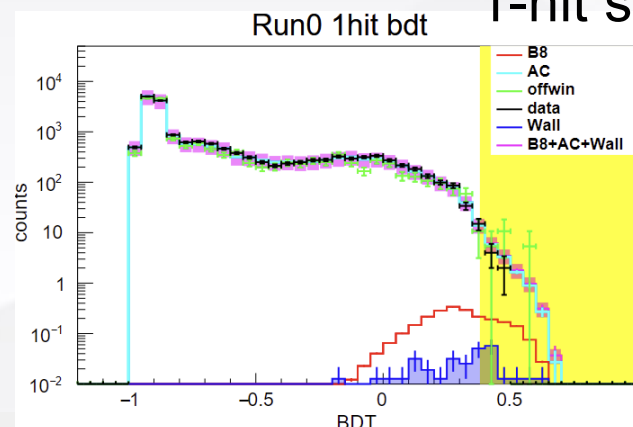
Some BDT variables



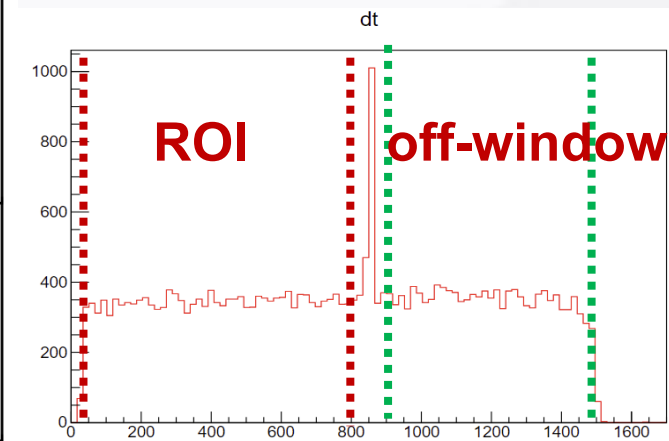
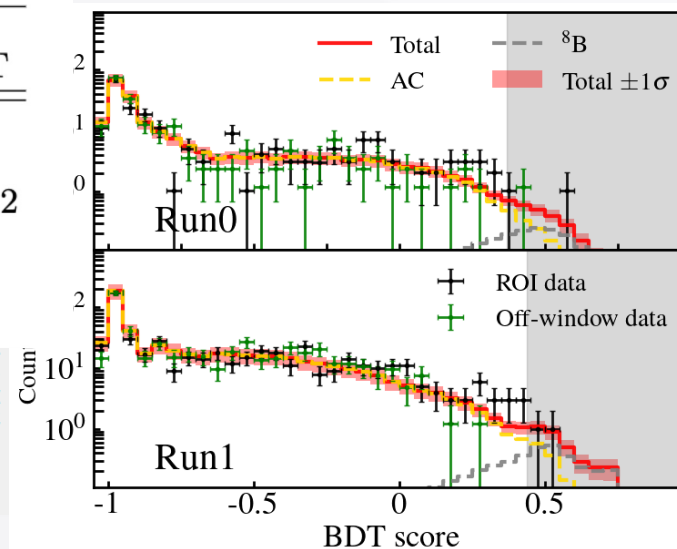
		Run0		Run1	
		WO BDT	W. BDT	WO BDT	W. BDT
Off-window	Model	209±25	1.2±0.4	485±43	0
	Data	209	1	495	2
OD	Model	26±6	0.12±0.04	34±7	0.06±0.02
	Data	18	0	29	0
1-hit side-band	Model	17095±2564	14±4	27567±4135	15±5
	Data	17374	9	29359	17



1-hit sideband



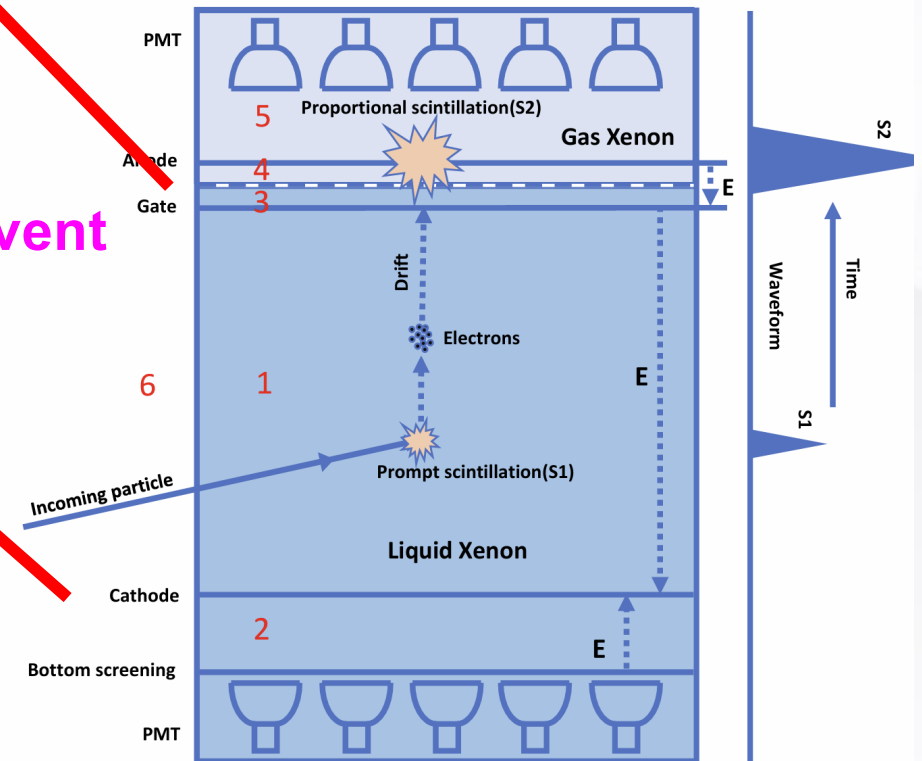
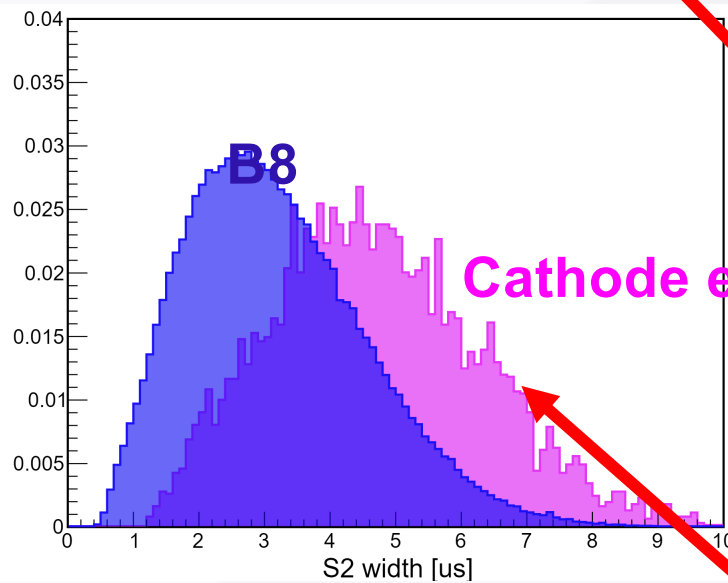
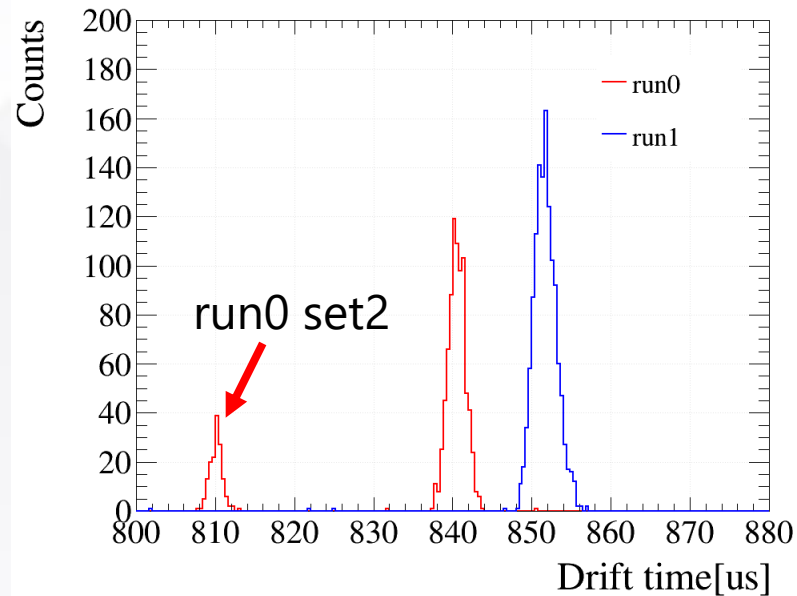
ROI & Off-window



Cathode Background in S2-only data

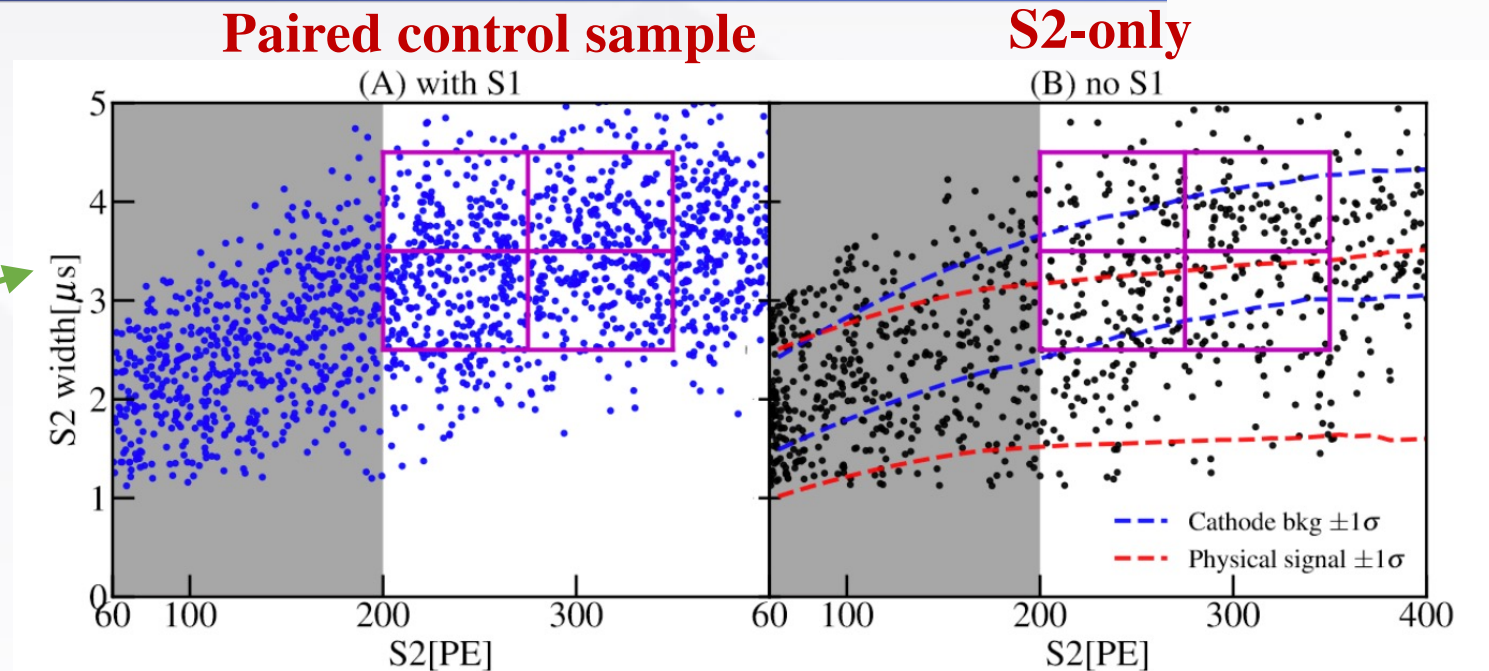
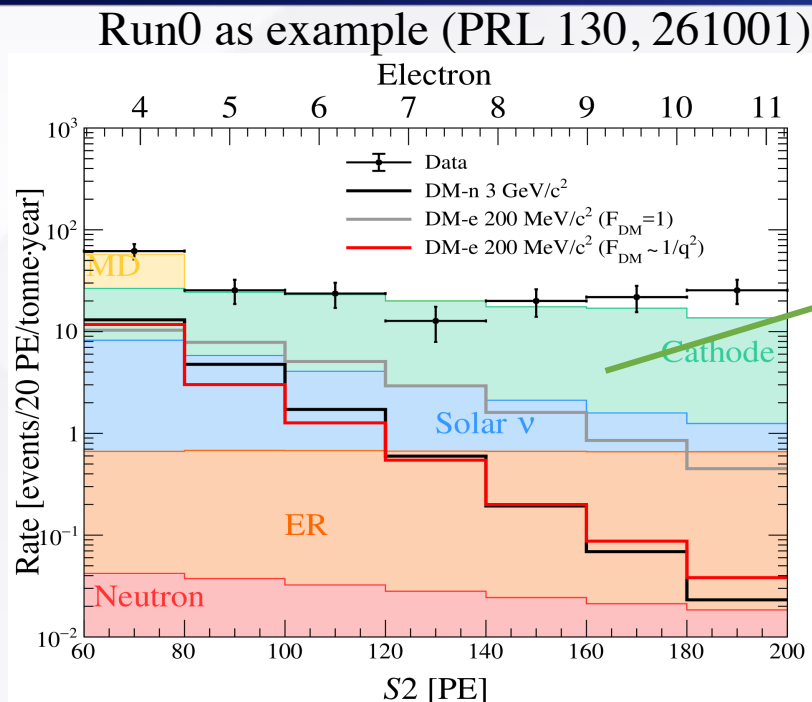
- Gate events can easily be removed by width cut

Cathode drift time distribution

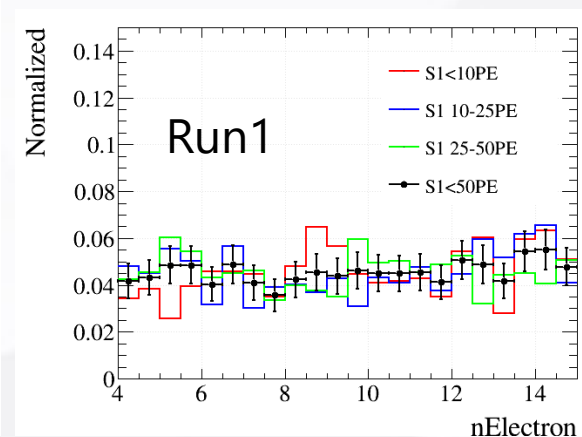
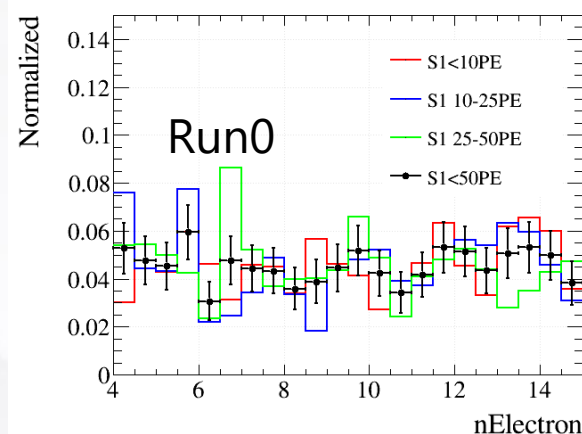


- Cathode control samples are selected with characteristic drift time;
- Cathode background has larger width due to its larger mean drift length.

Cathode Background in S2-only data



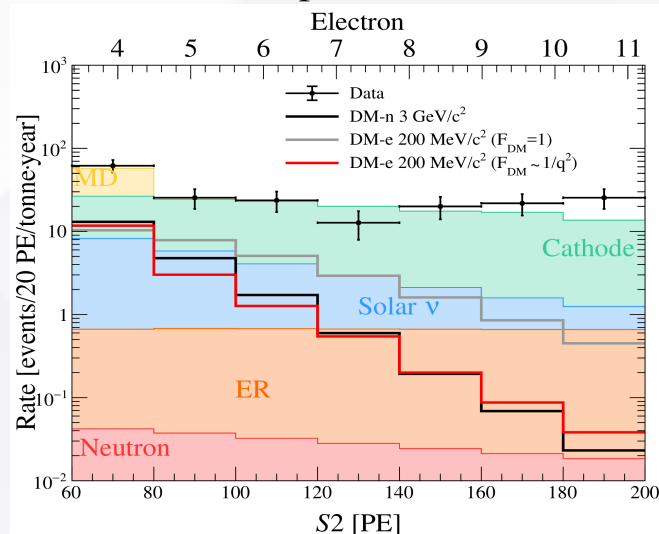
- Cathode bkg spectral shape in ROI is using cathode control samples;
- The rate normalization is done using high-S2 sideband;
- No S1 dependence is observed for the cathode background spectral shape.



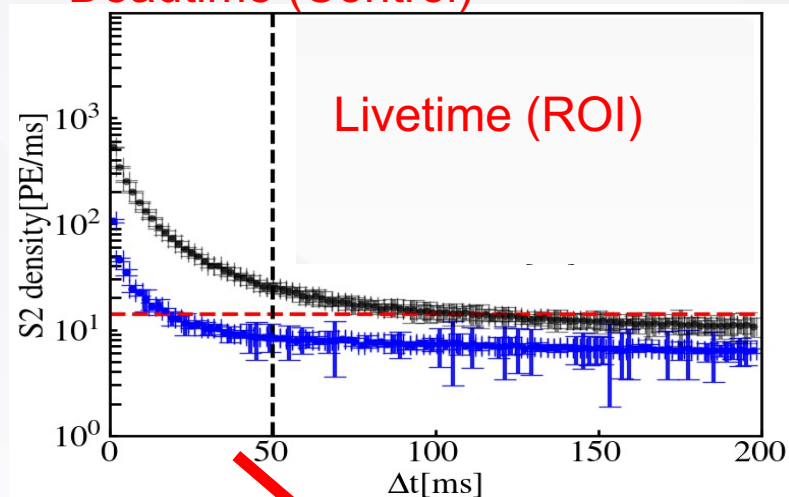
Delay electron (DE) background in S2-only data



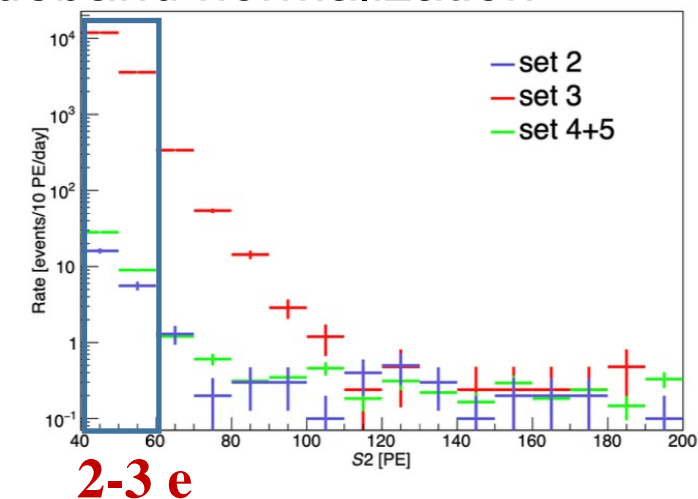
Run0 as example (PRL 130, 261001)



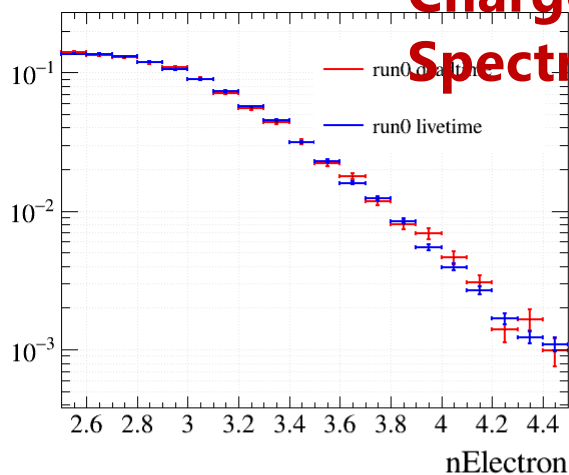
Deadtime (Control)



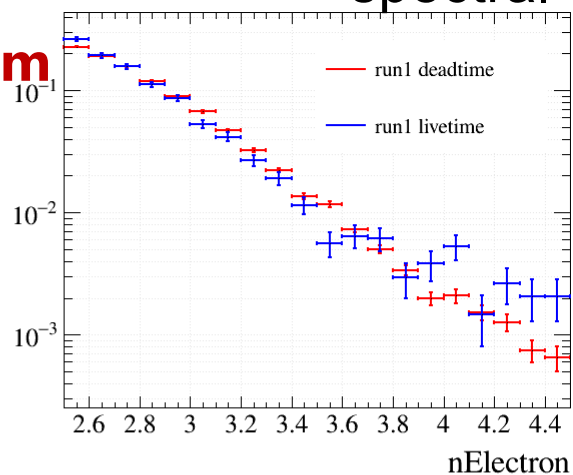
Sideband normalization



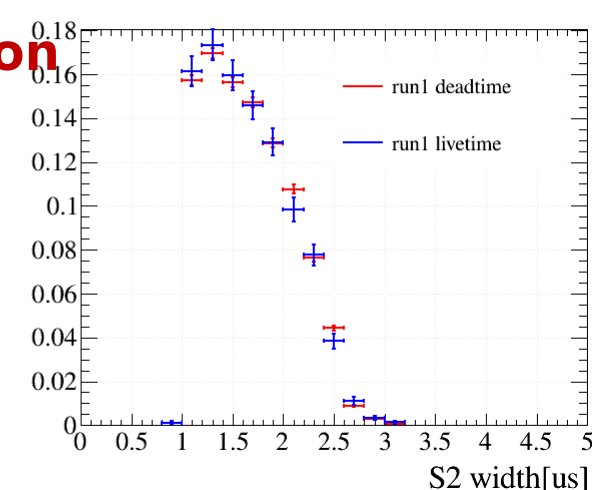
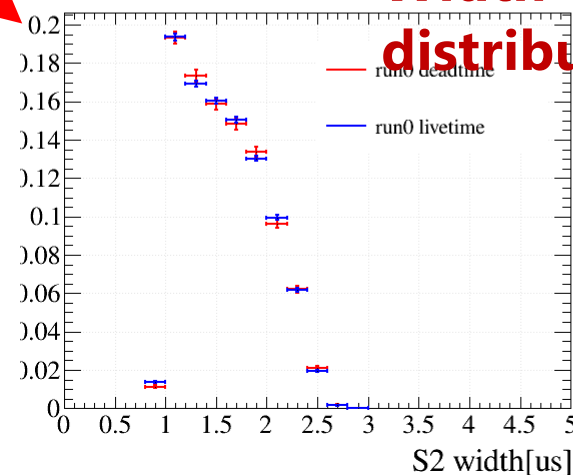
Charge Spectrum



spectral



Width distribution



Data Unblinded



➤ **Run0+Run1 seem to see an excess in US2 data**

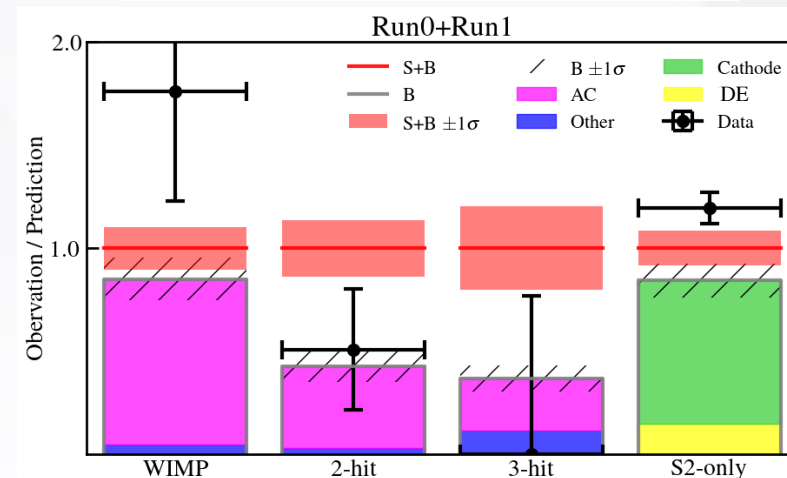
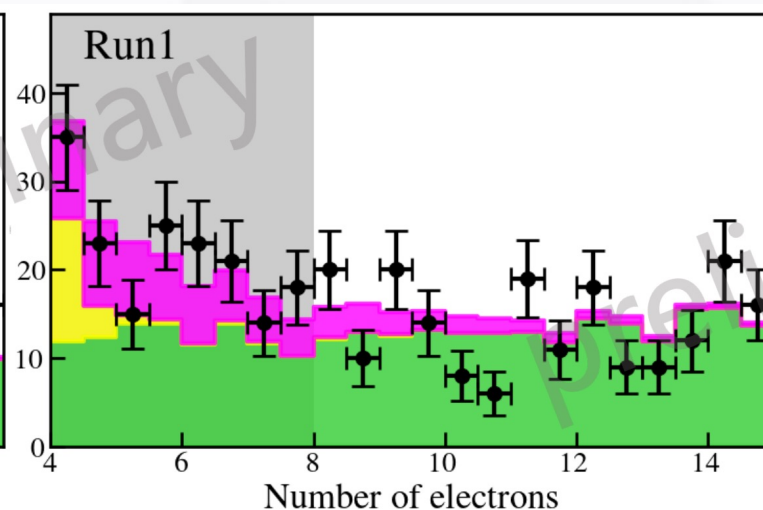
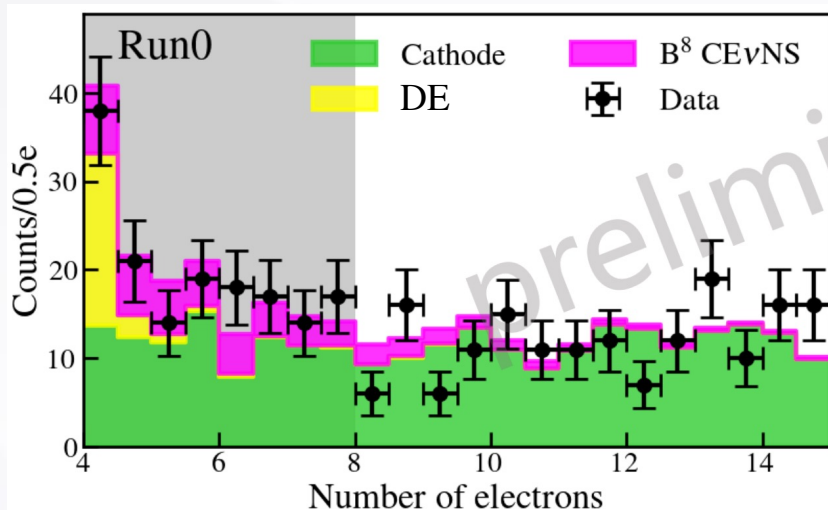
➤ **Paired data has a downward fluctuation**

Paired data

paired ROI	Run0		Run1	
	2-hit	3-hit	2-hit	3-hit
Surface	0.06 ± 0.01	0.06 ± 0.01	0.01 ± 0.01	0.02 ± 0.02
ER	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.01 ± 0.01
Neutron	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.01	0.03 ± 0.01
AC	1.08 ± 0.28	0.07 ± 0.02	1.15 ± 0.35	0.24 ± 0.08
Total bkg.	1.16 ± 0.28	0.15 ± 0.02	1.21 ± 0.35	0.30 ± 0.08
$^8\text{B CE}\nu\text{NS}$	1.00 ± 0.24	0.24 ± 0.09	1.76 ± 0.50	0.40 ± 0.18
Observed	1	0	2	0

S2-only data

US2 ROI	Run0	Run1
Cathode	100 ± 24	104 ± 21
DE	25 ± 3	20 ± 4
ERs	1.3 ± 0.1	0.9 ± 0.2
Total bkg.	126 ± 24	125 ± 21
$^8\text{B CE}\nu\text{NS}$	18 ± 4	25 ± 6
Observed	158	174

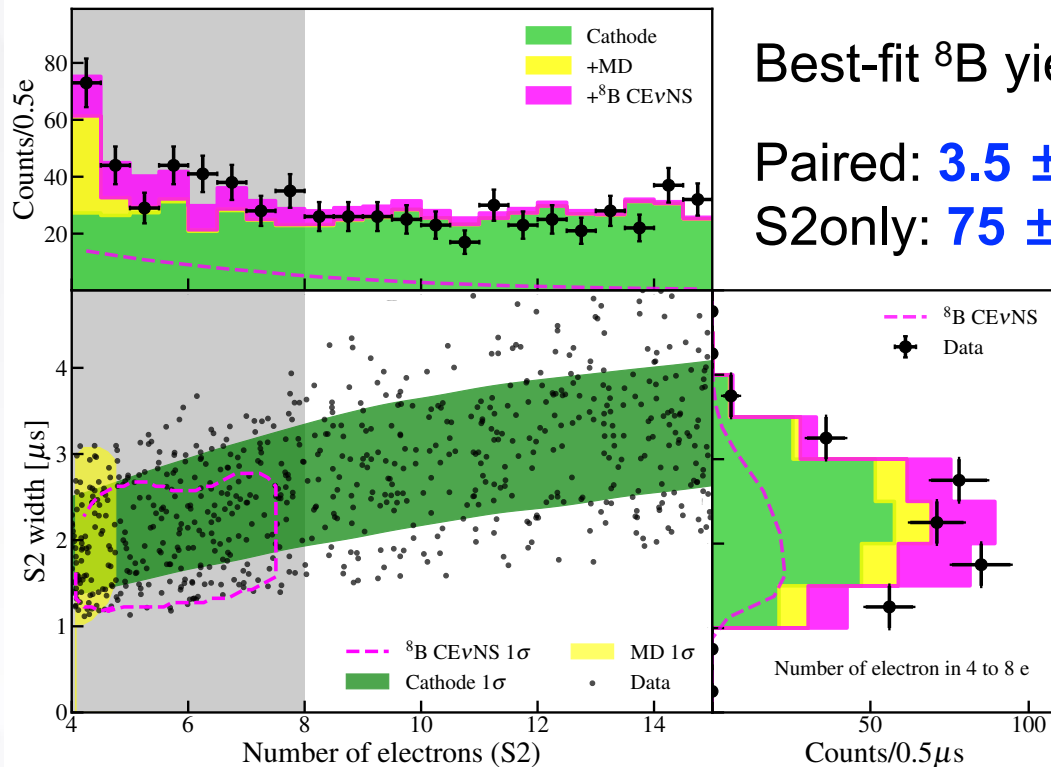


Indication of B8 CEvNS

- First indication of solar B8 CEvNS signal
 - Significance: 2.64σ
 - Fitted flux $(8.4 \pm 3.1) \times 10^6 \text{ cm}^{-2} \text{ s}^{-1}$

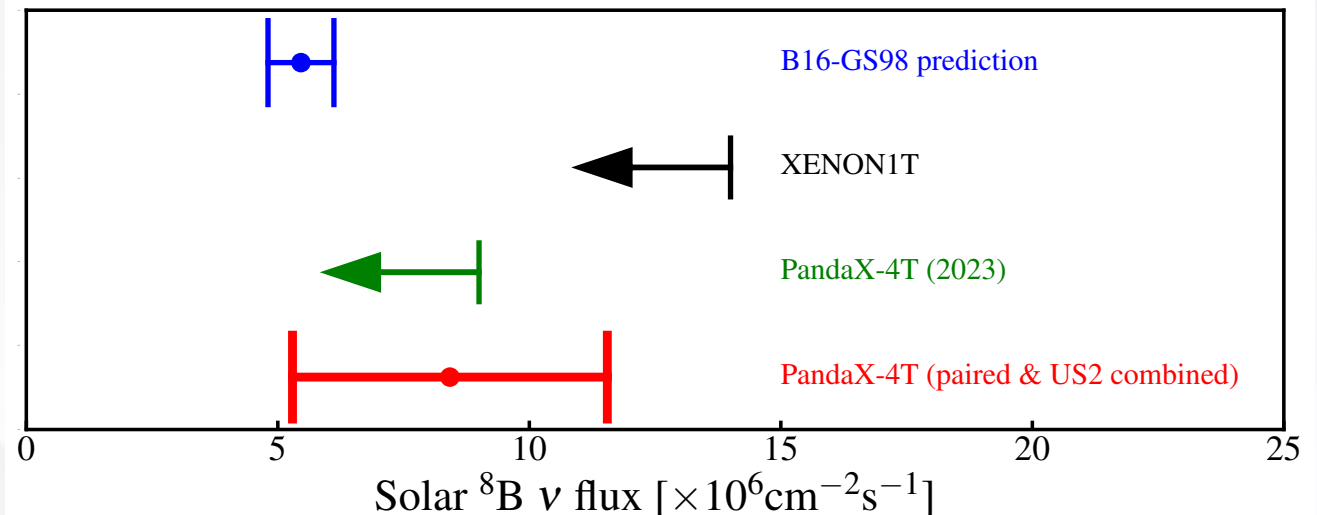
Best-fit ^8B yield

Paired: 3.5 ± 1.3 evts
S2only: 75 ± 28 evts



PRL 133, 191001 (2024)

PRL editor suggestion

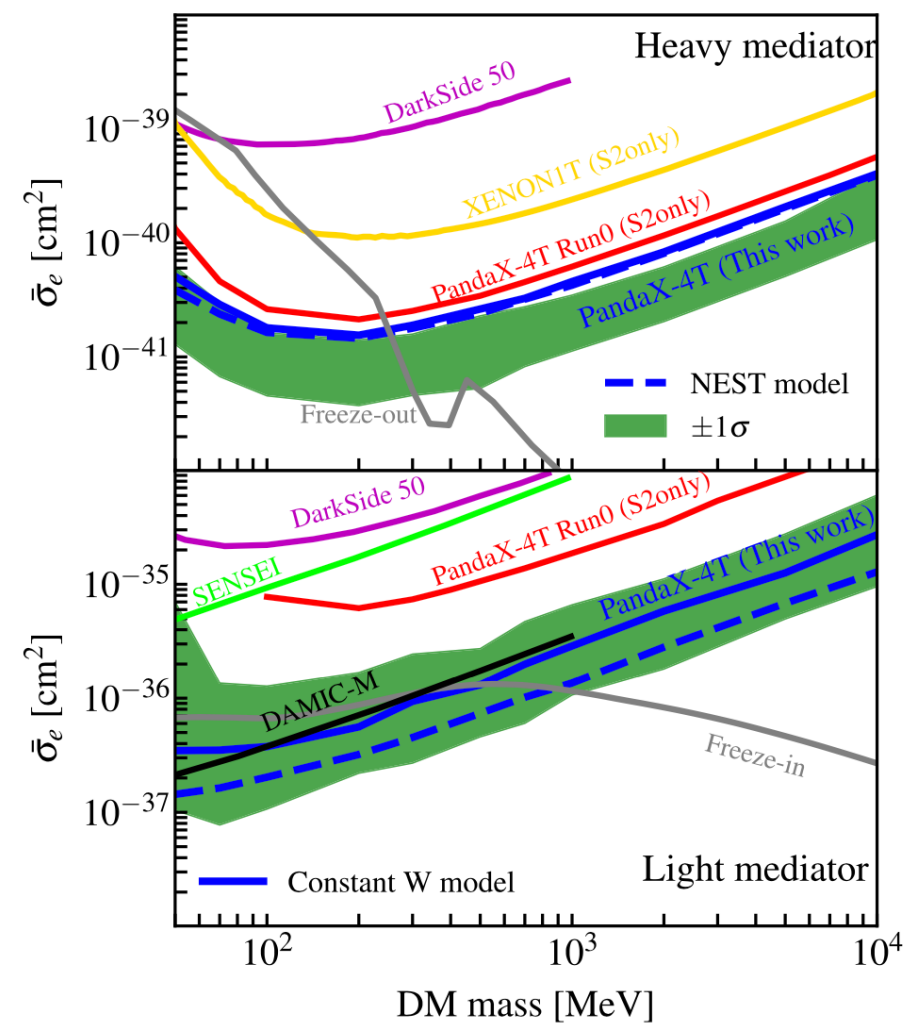
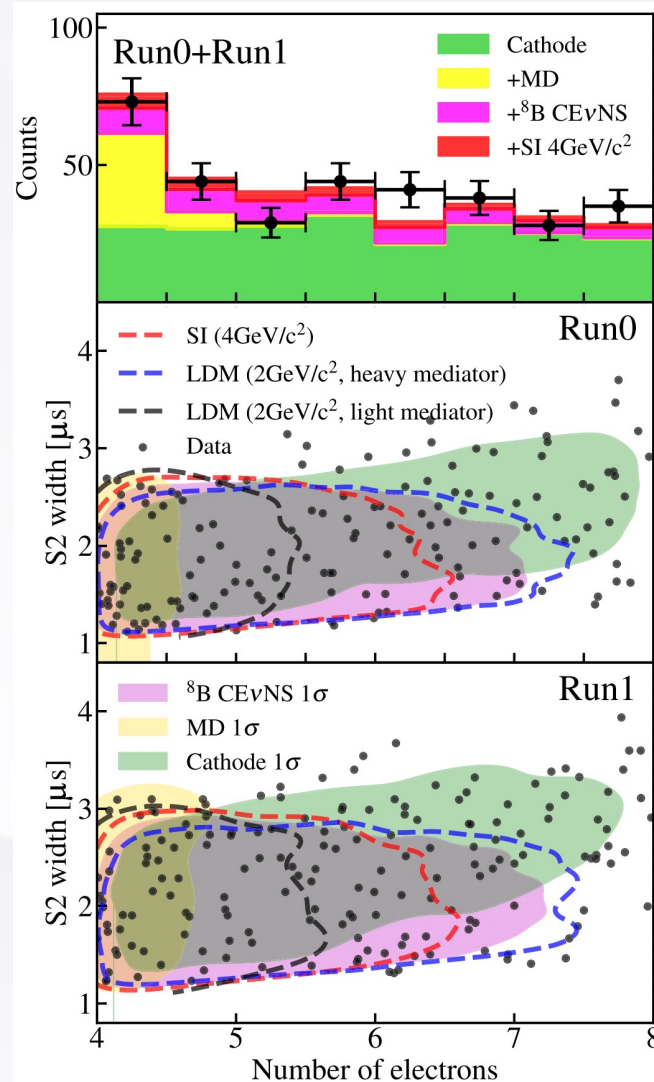


Extend to Light Dark Matter Search



- Greatly lower the threshold for Noble Liquid TPCs;
- Combine with large exposures, can reach good sensitivities for **~ 100 MeV** LDM (LDM-e scattering);

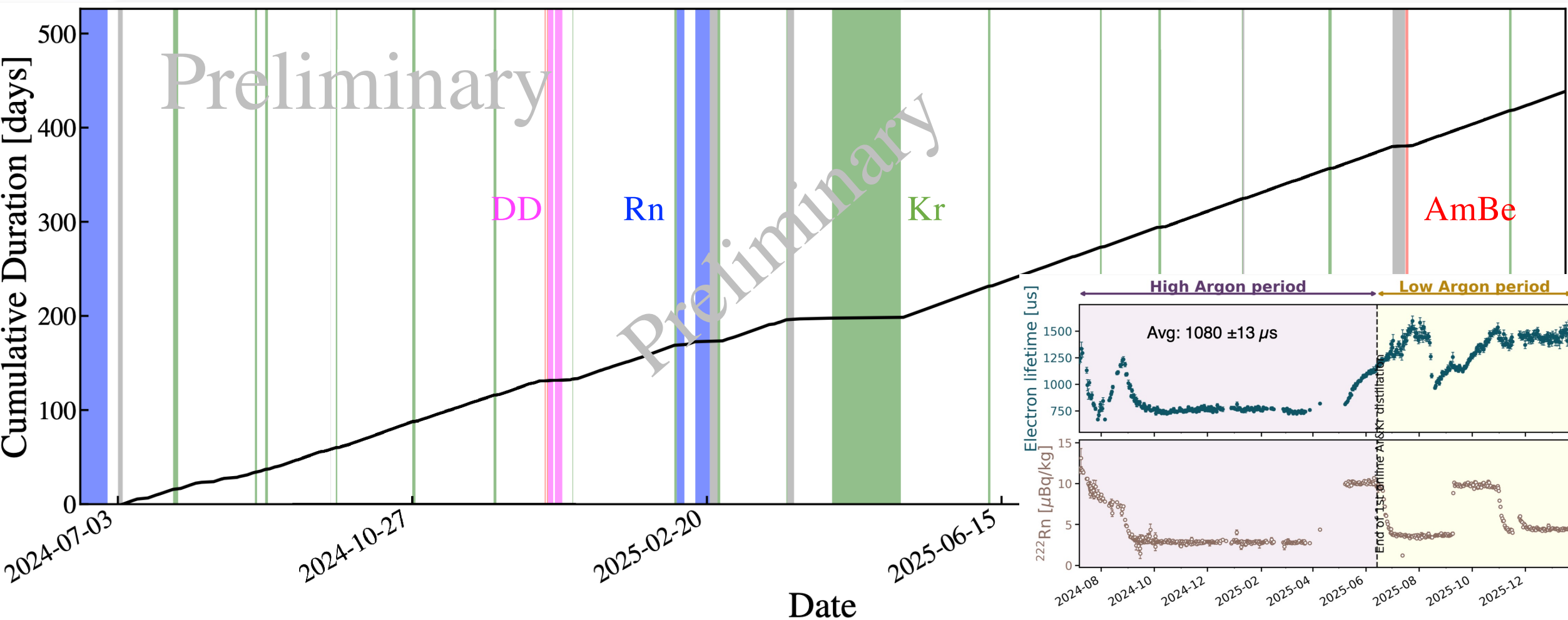
PandaX-4T, PRL 135, 211001 (2025)



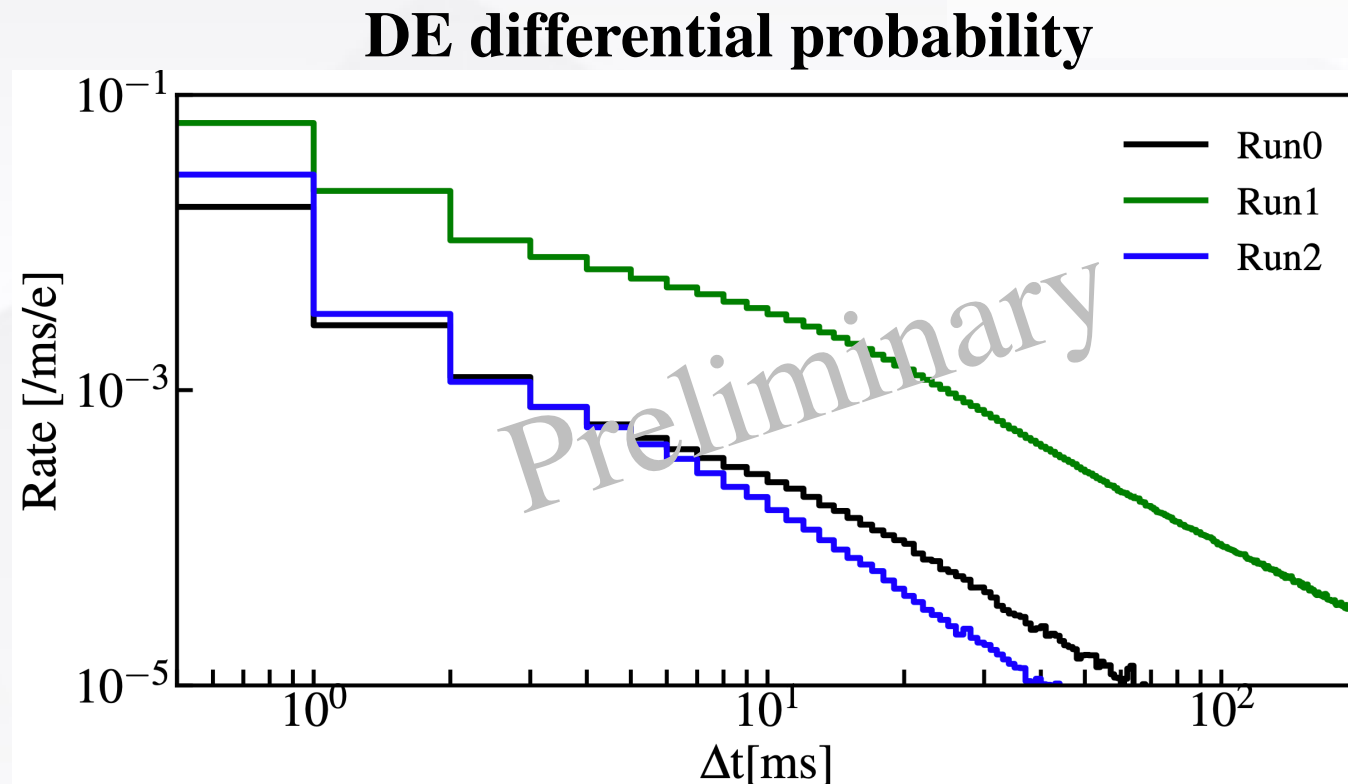
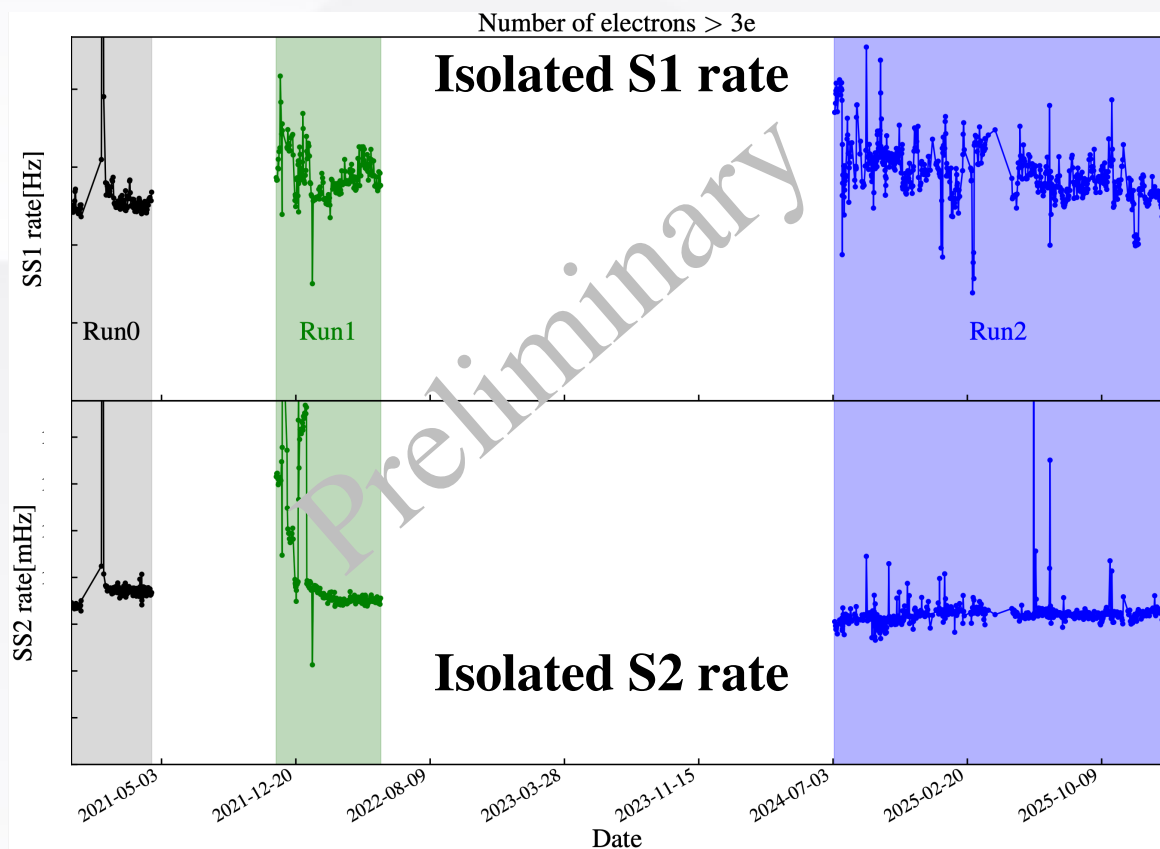
Run2 data



Total 438 calendar days in Run2!



Run2 data quality

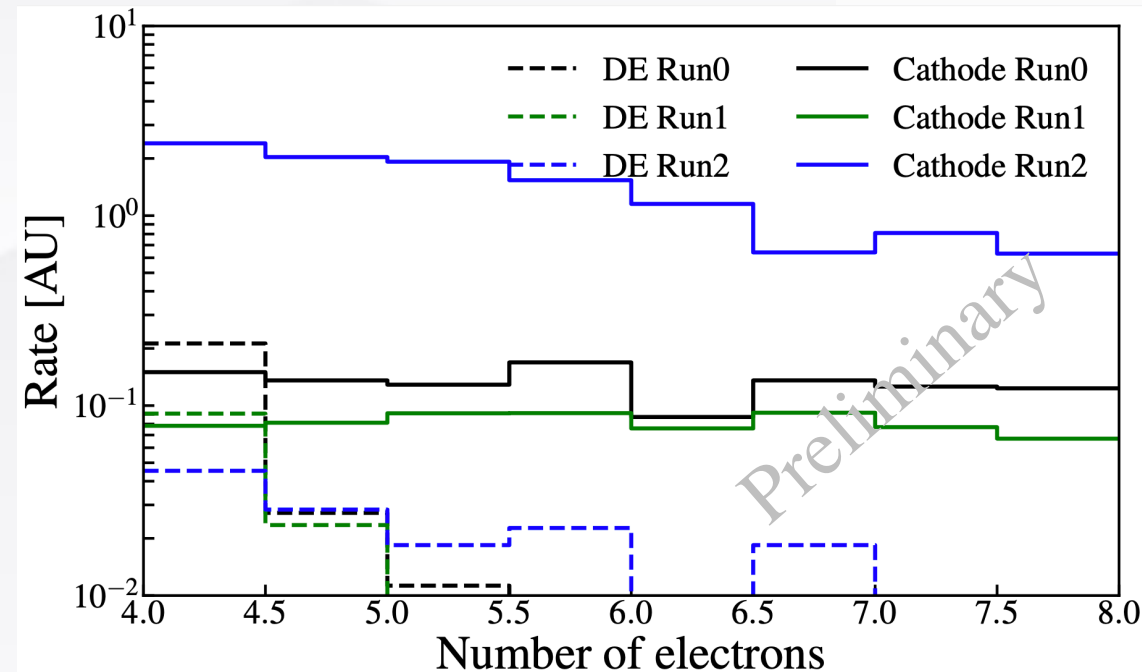
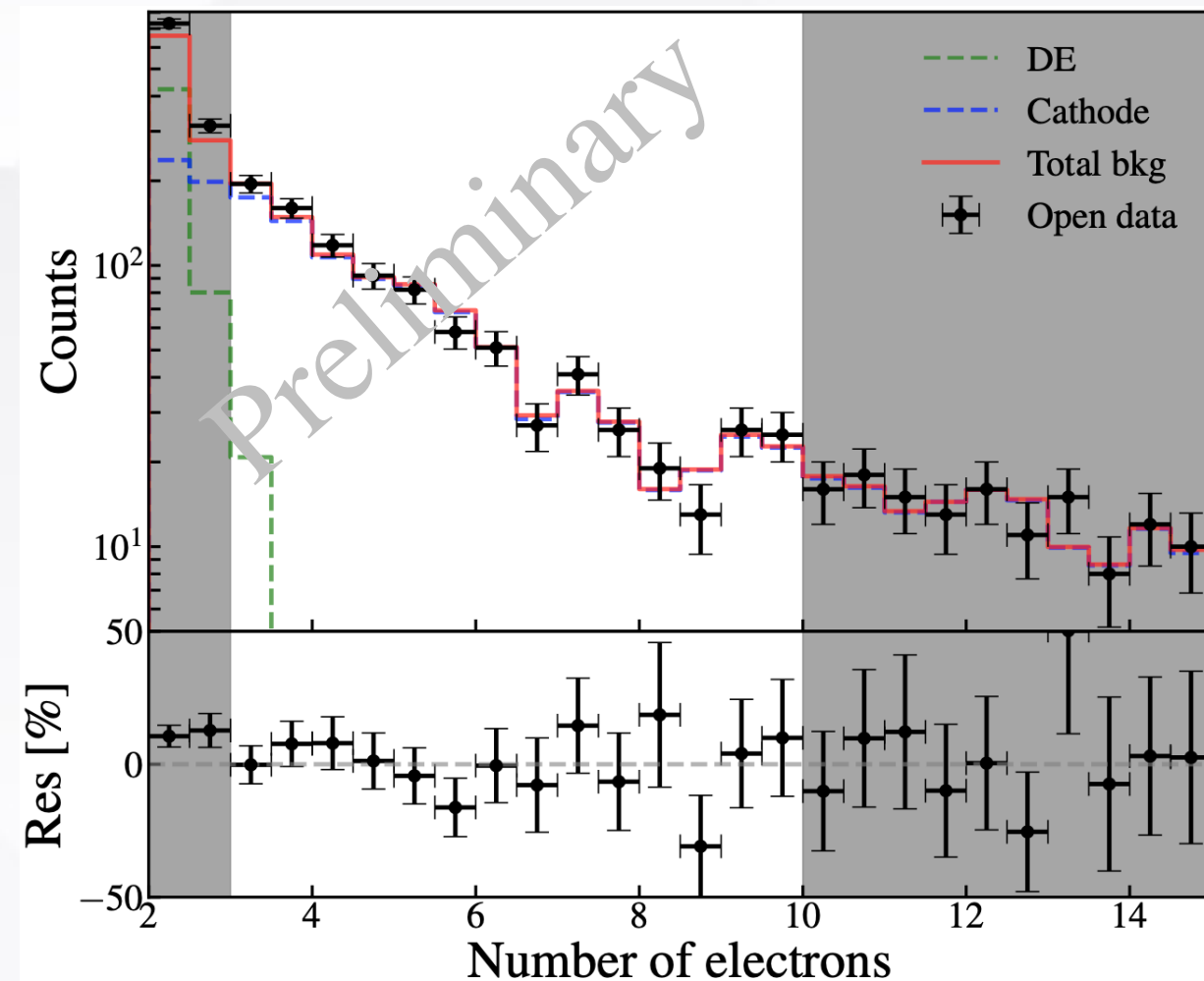


- SS1 and SS2 rates are compatible with Run0 and Run1 before quality cuts applied;
- The delay electron occurring probability after large S2 is getting smaller in Run2;

DE and cathode background in Run2

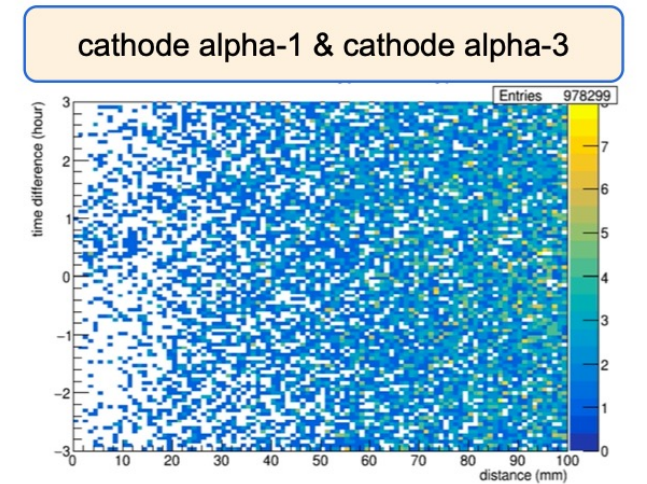
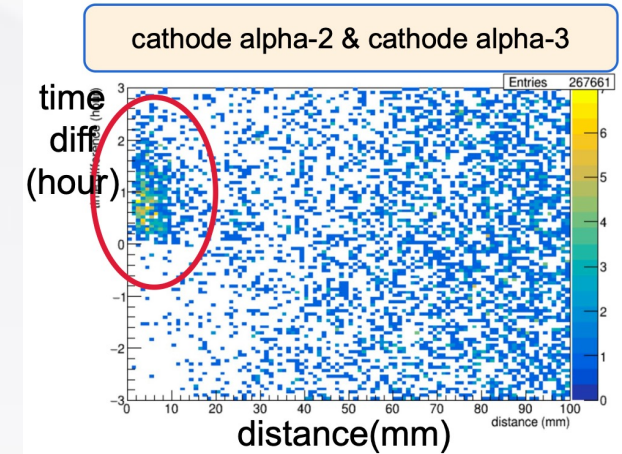
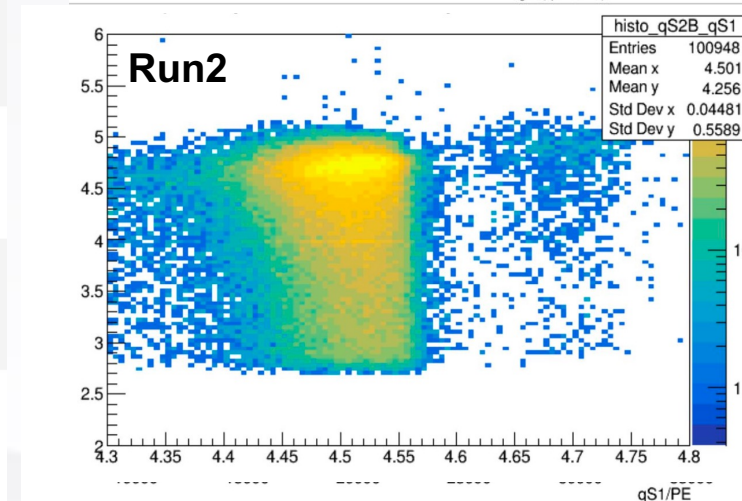
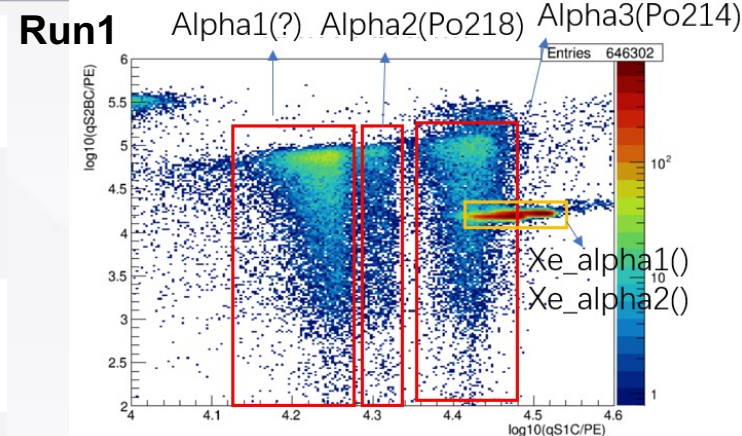
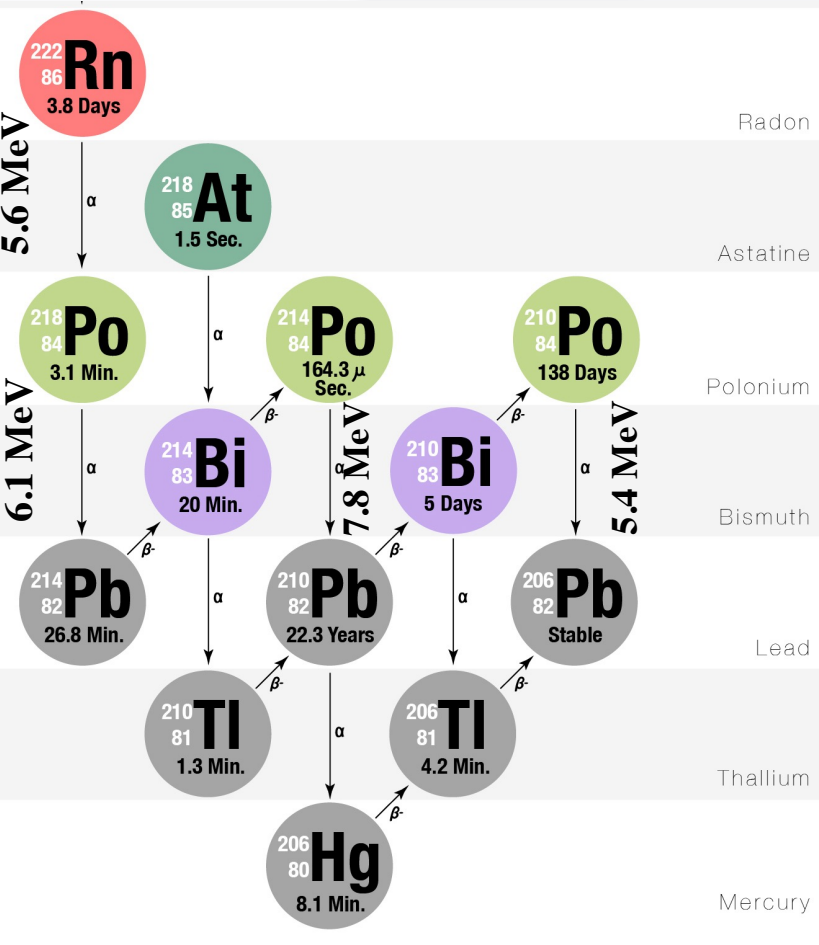


Compare with 10% open data



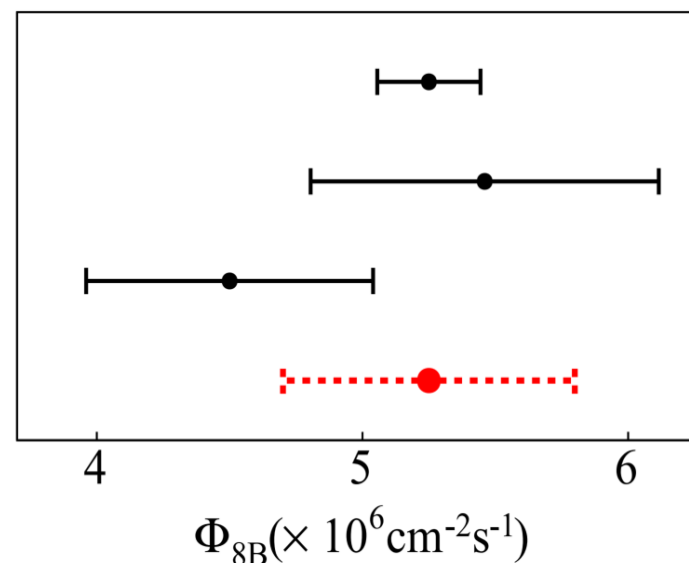
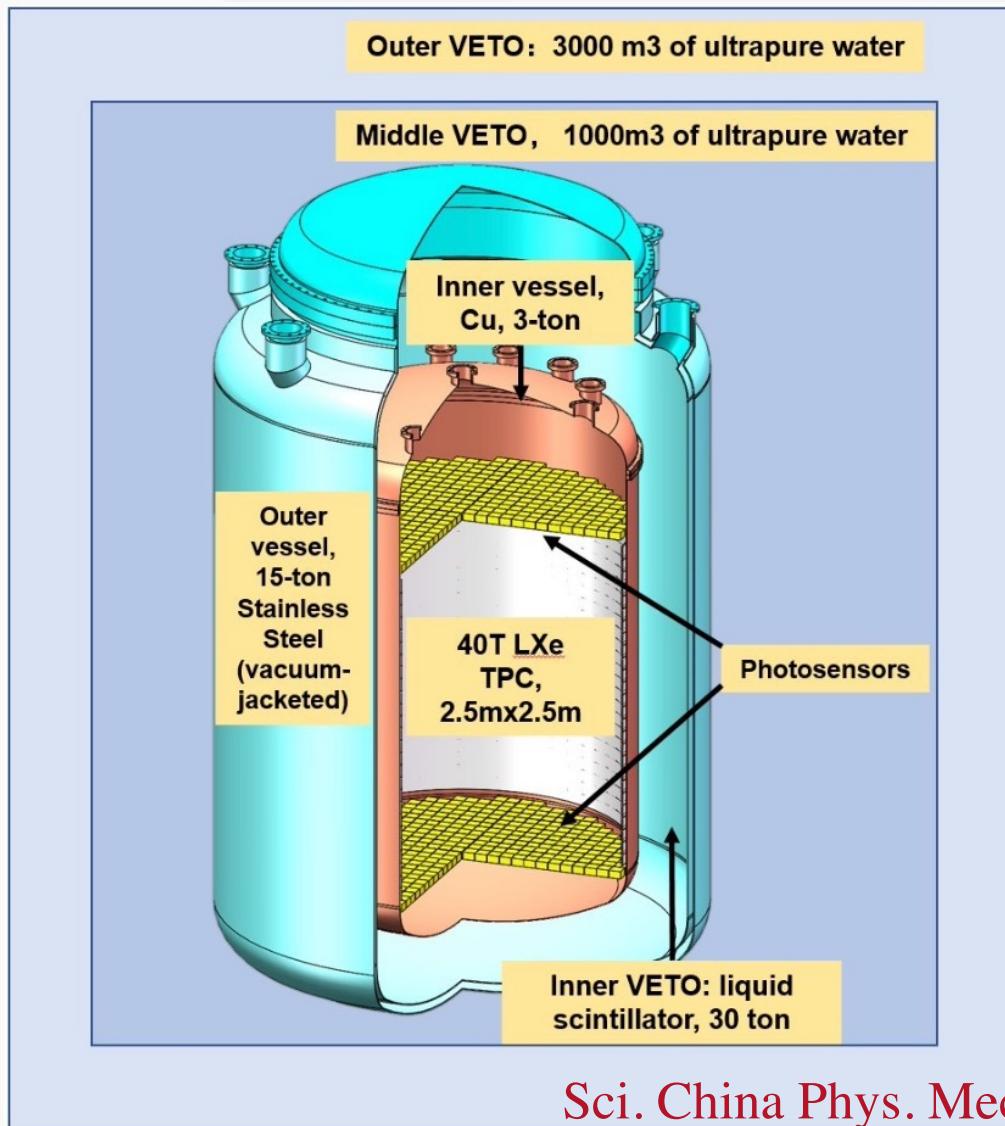
- DE model = control region (spatially and temporally close to large S2) scaled based on sideband (2-3e); Not much different from Run01;
- Cathode model = pre-cut spec * efficiency, which is obtained by control region, **20** times larger than Run01;
- Match well with 10% open data.

Cathode increase in Run2



- Run2 saw a significant increase of ²¹⁰Po alphas (~20 times increase in rate), indicating ²¹⁰Pb could be the reason of increased cathode events (betas);
- This is likely due to the contamination during installation;

Future experiment: PandaX-xT



SNO 2013

B16-GS98 (HZ)

B16-AGSS09met (LZ)

PandaX-20T 80 tonne-year

First stage: PandaX-20T
(TPC with 2m in diameter and 2.6m in height)✓

Summary



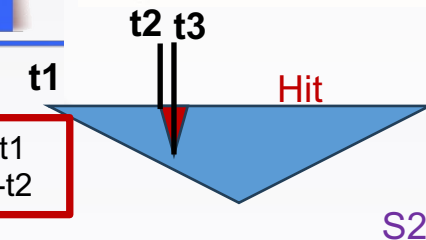
- B8 CEvNS search using Run0 and Run1 data sees indication of B8 signal with a significance of 2.6σ ;
- We saw an increase of cathode background in Run2 likely due to Pb210 attachment during installation;
- Mitigation method using DNN and transformer is under-development!
- Next stage of PandaX (PandaX-20T) is expected to be online in 2027, further improving the CEvNS search sensitivity!



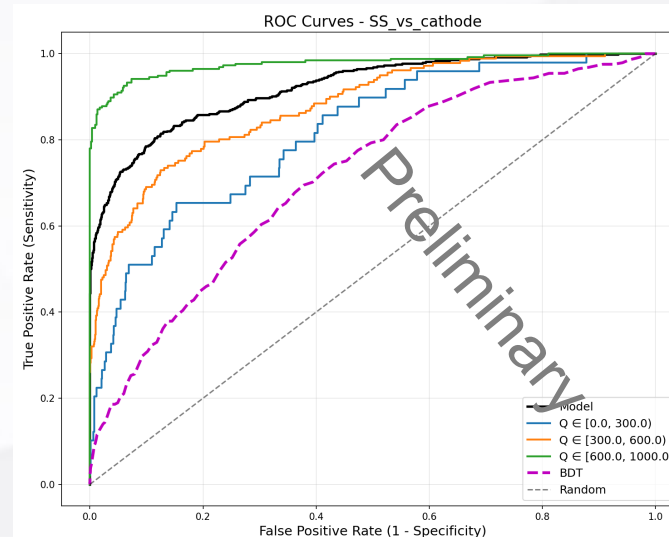
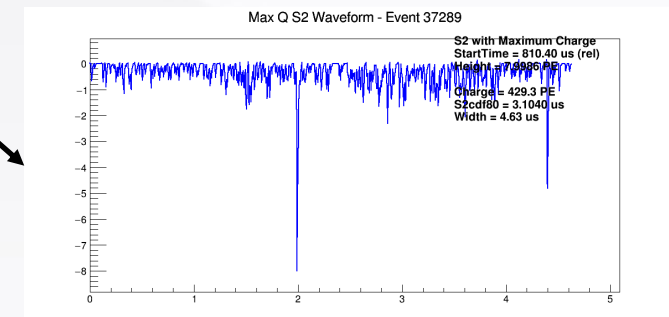
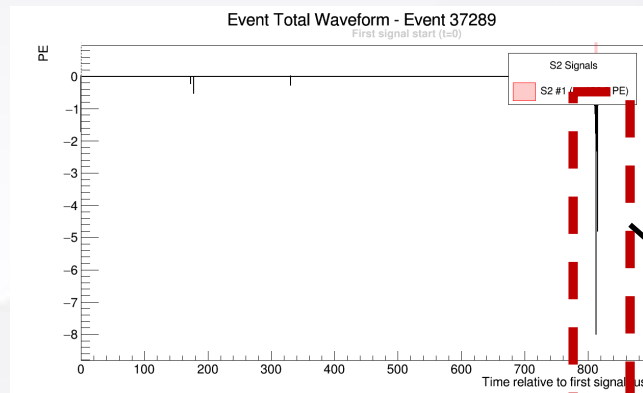
Backup



Transformer-based Discriminator



startTimeHit=t2-t1
peakTimeHit=t3-t2



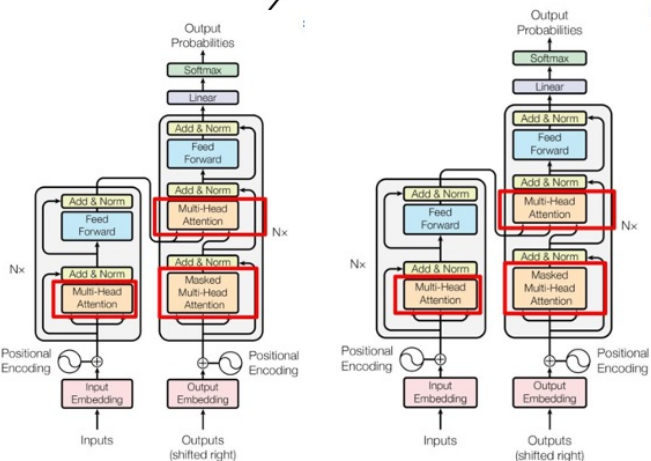
- Transformer to extract waveform information;
- MLP to extract higher signal-level features;
- Simulated B8 neutrino waveforms as “signal”;
- Data-driven cathode S2s as “background”;

Regressor layer/
Classification layer

Concat

[Batch size,256]

MLP



Top Hits info
[batch size,100,5]

Bottom Hits info
[batch size,100,5]

Signal Level info
[Batch size,8]