Dark matter search results from the PandaX-II experiment
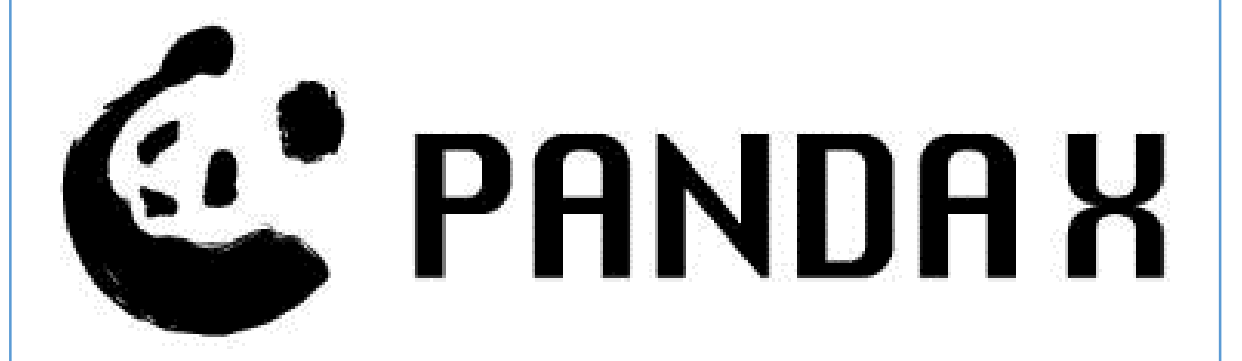
Mengjiao XIAO
University of Maryland, College Park
On behalf of PandaX-II Collaboration

1. Introduction to PandaX-II experiment

➢ PandaX = **P**article **AND A**strophysical **X**enon experiment.

➢ Located at **C**hina **J**in-**P**ing Underground **L**aboratory with ~2400 m or 6800 m.w.e depth (deepest one in the world).
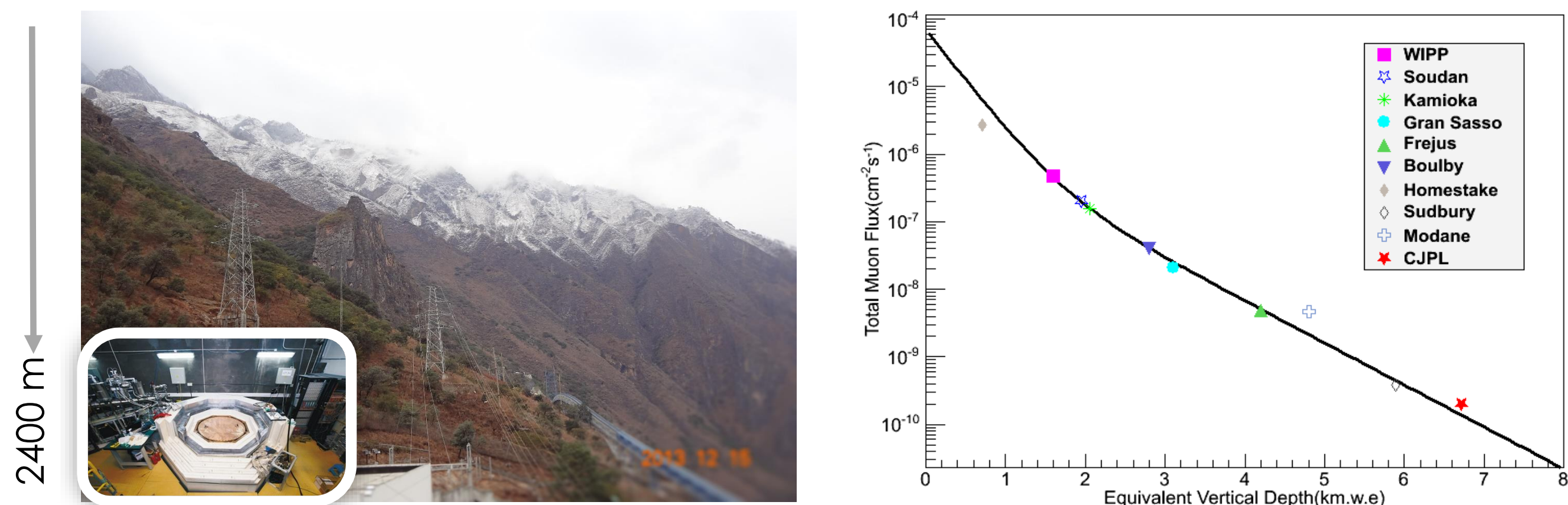
Fig.1. China Jin-Ping Underground Laboratory

➢ PandaX-II: 2nd phase of PandaX serial experiments

- use the dual-phase xenon time projection chamber for WIMP dark matter direct detection.
- a half-ton scale LXe sensitive target in the detector.
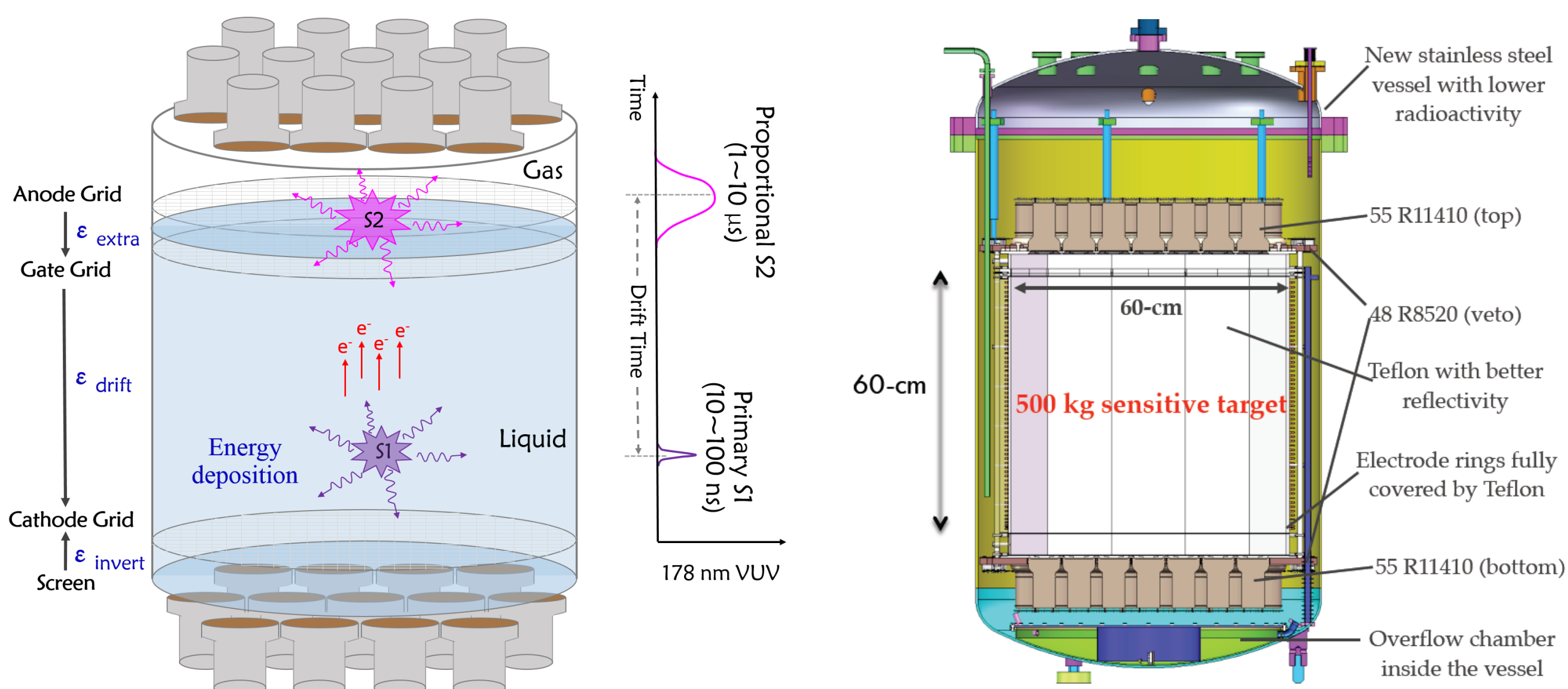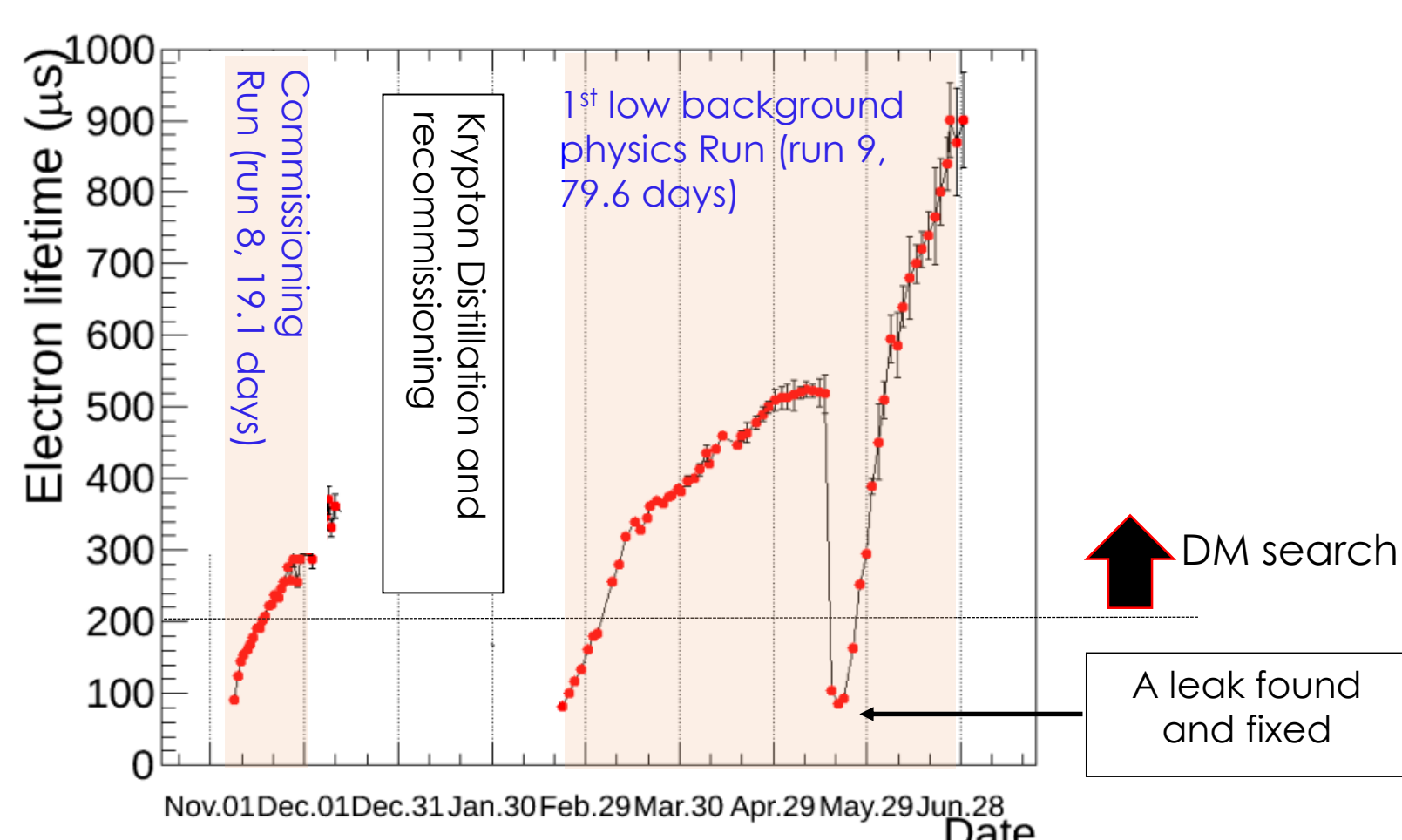- commissioning in 2015 and started data taking in 2016.

FIG.2. Work principle of TPC (left) and PandaX-II detector design (right)

2. Detector performance

➢ Electron lifetime evolution:

- The max electron drift time in the TPC is 350 μs

➢ Detector parameters:

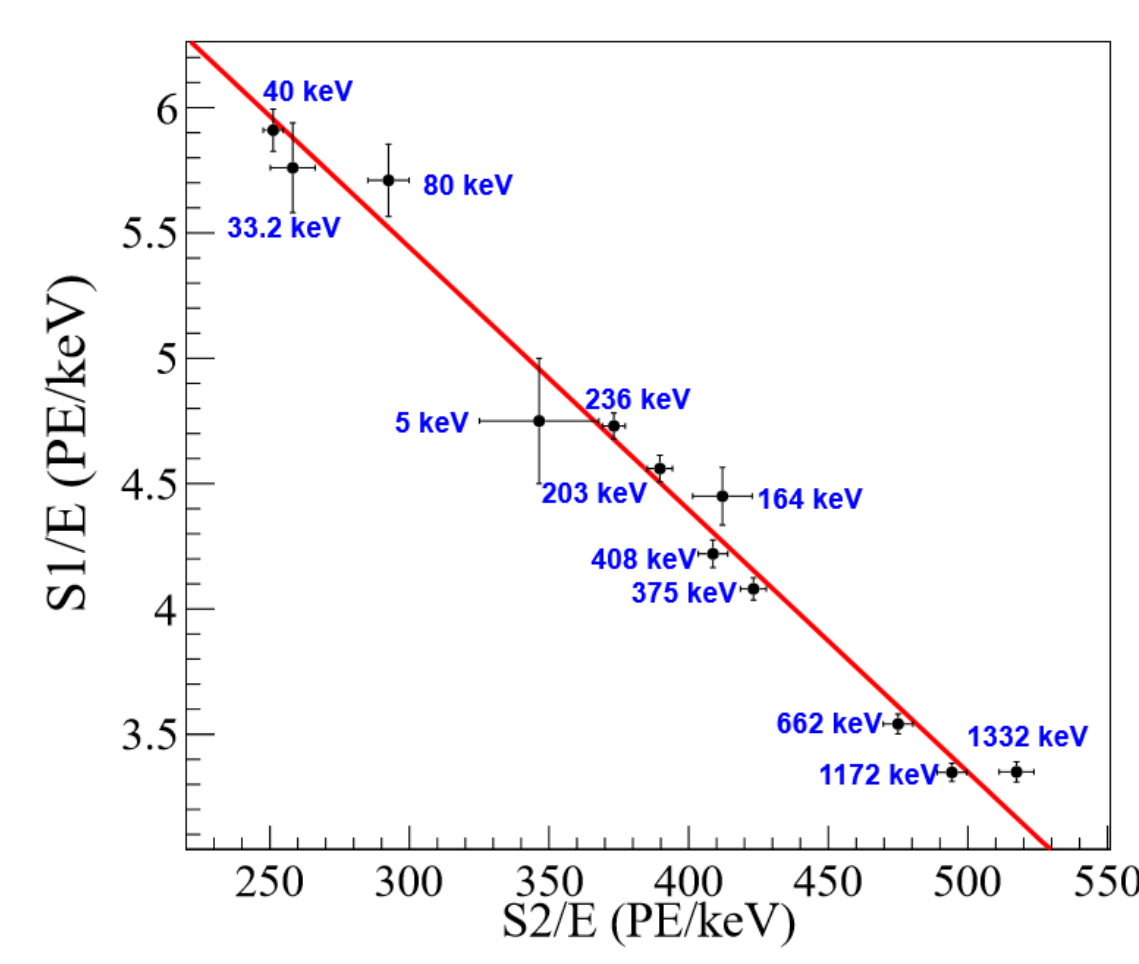$$E_{ee} = W \times \left(\frac{S1}{PDE} + \frac{S2}{EEE \times SEG} \right)$$

FIG.3. Electron lifetime evolution (left) and linear fit for all γ peaks to determine PDE&EEE (right)

➢ Summary of detector parameters in Run9:

- E_{drift}, $E_{extract}$: drift and extract field setting in TPC
- PDE: photon detection eff.
- EEE: electron extraction eff.
- SEG: single electron gas gain
- τ_e: average electron drift time

Setting	Live time (day)	E_{drift} (V/cm)	$E_{extract}$ (kV/cm)	PDE (%)	EEE (%)	SEG PE/e	τ_e (μs)
1	7.76	397.3	4.56	11.76	46.04	24.4	348.2
2	6.82	394.3	4.86	11.76	54.43	26.9	393.1
3	1.17	391.9	5.01	11.76	59.78	26.7	409.0
4	63.85	399.3	4.56	11.76	46.04	24.4	679.6

Reference:

[1] PandaX-II Collaboration: "Dark Matter Search Results from the Commissioning Run of PandaX-II". *Phys. Rev. D 93, 122009 (2016)*.

[2] PandaX-II Collaboration: "Dark Matter Results from First 98.7 Days of Data from the PandaX-II Experiment". *Phys. Rev. Lett. 117, 121303 (2016)*.

[3] PandaX-II Collaboration: "Spin-Dependent Weakly-Interacting-Massive-Particle–Nucleon Cross Section Limits from First Data of PandaX-II Experiment". *Phys. Rev. Lett. 118, 071301 (2017)*

3. Detector calibration

➢ Nuclear recoil (NR) calibration with AmBe source.

- 162.4-hour data, ~3400 low energy single scatter NR events
- NR median curve in agreement with NEST prediction, detection efficiency was derived through comparing data to MC
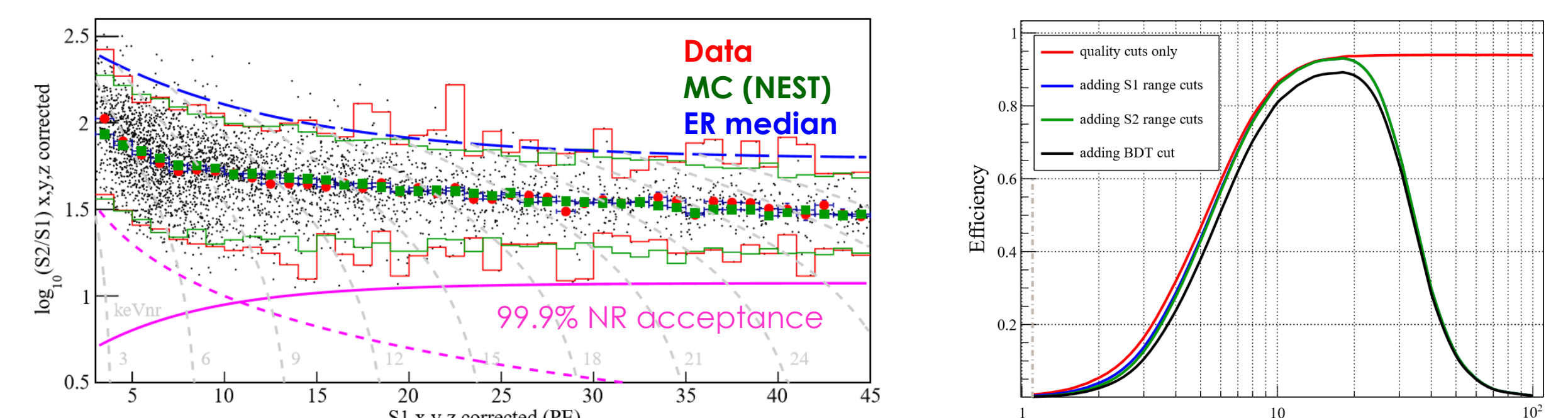
Fig.4. NR band (left) and NR detection efficiency (right)

➢ Electron recoil (ER) calibration with tritiated methane.

- 18.0-hour data, ~2800 low energy ER events in fiducial volume.
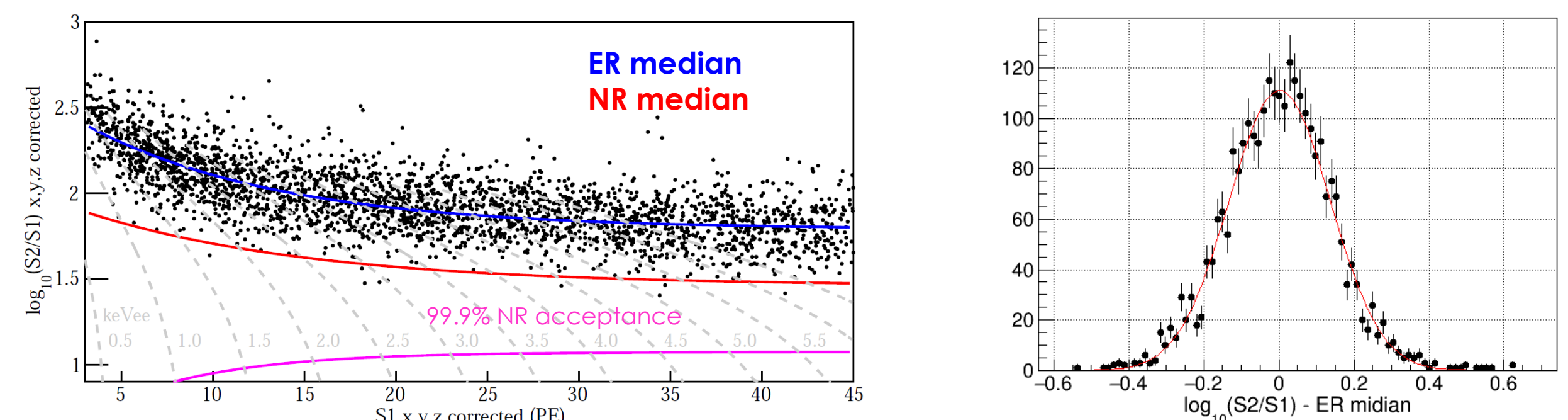- 9 events below NR median, leakage fraction (0.32±0.11)%

Fig.5. ER band (left) and projection (right)

4. Background for dark matter search

➢ Low–energy ER background:

- ~2 mDRU on average, world lowest reported background level.

Item	Run 8 (mDRU)	Run 9 (mDRU)
^{85}Kr	11.7	1.19
^{127}Xe	0	0.42
^{222}Rn	0.06	0.13
^{220}Rn	0.02	0.01
Detector material ER	0.20	0.20
Total	12.0	1.95

➢ Accidental background:

- random pair of isolated S1 and S2 events formed the accidental background (toy MC based on data)
- boosted decision tree (BDT) cut was developed to suppress them

➢ Neutron background: estimated with MC simulation.

5. Dark matter search results

➢ A total exposure of **3.3×10^4 kg·day**.

➢ No dark matter candidate is found above background.

	ER	Accidental	Neutron	Total Expected	Total observed
Run 8	622.8	5.20	0.25	628±106	734
Below NR median	2.0	0.33	0.09	2.4±0.8	2
Run 9	377.9	14.0	0.91	393±46	389
Below NR median	1.2	0.84	0.35	2.4±0.7	1

➢ Set 90% C.L. cross section upper limits with CLs approach.

➢ Lowest exclusion: **2.5×10^{-46} cm^2** @ 40 GeV/c^2 (SI) and **4.1×10^{-41} cm^2**@40 GeV/c^2 (SD neutron)