Poster ID: 173

# Solar $^8$B neutrino and light dark matter search in the PandaX-4T experiment

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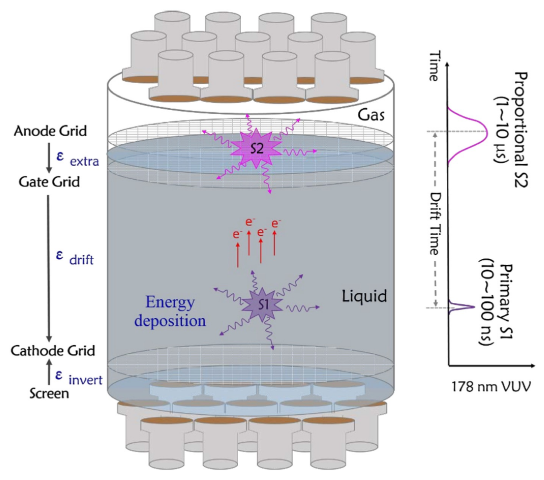
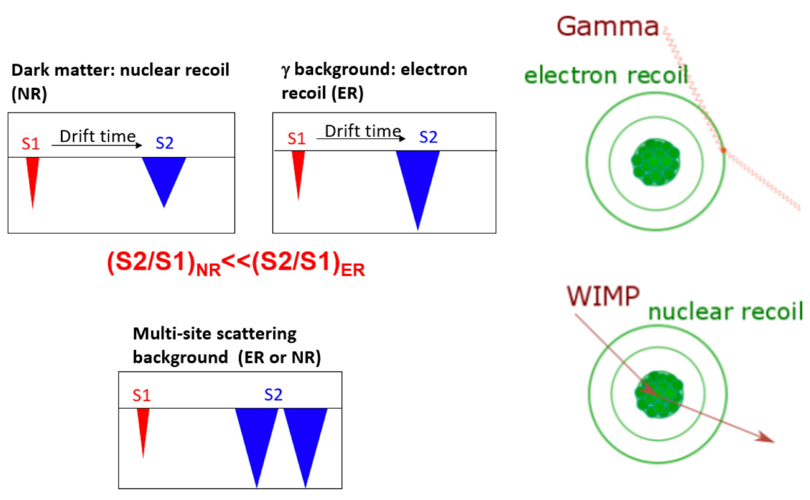
## PandaX-4T introduction

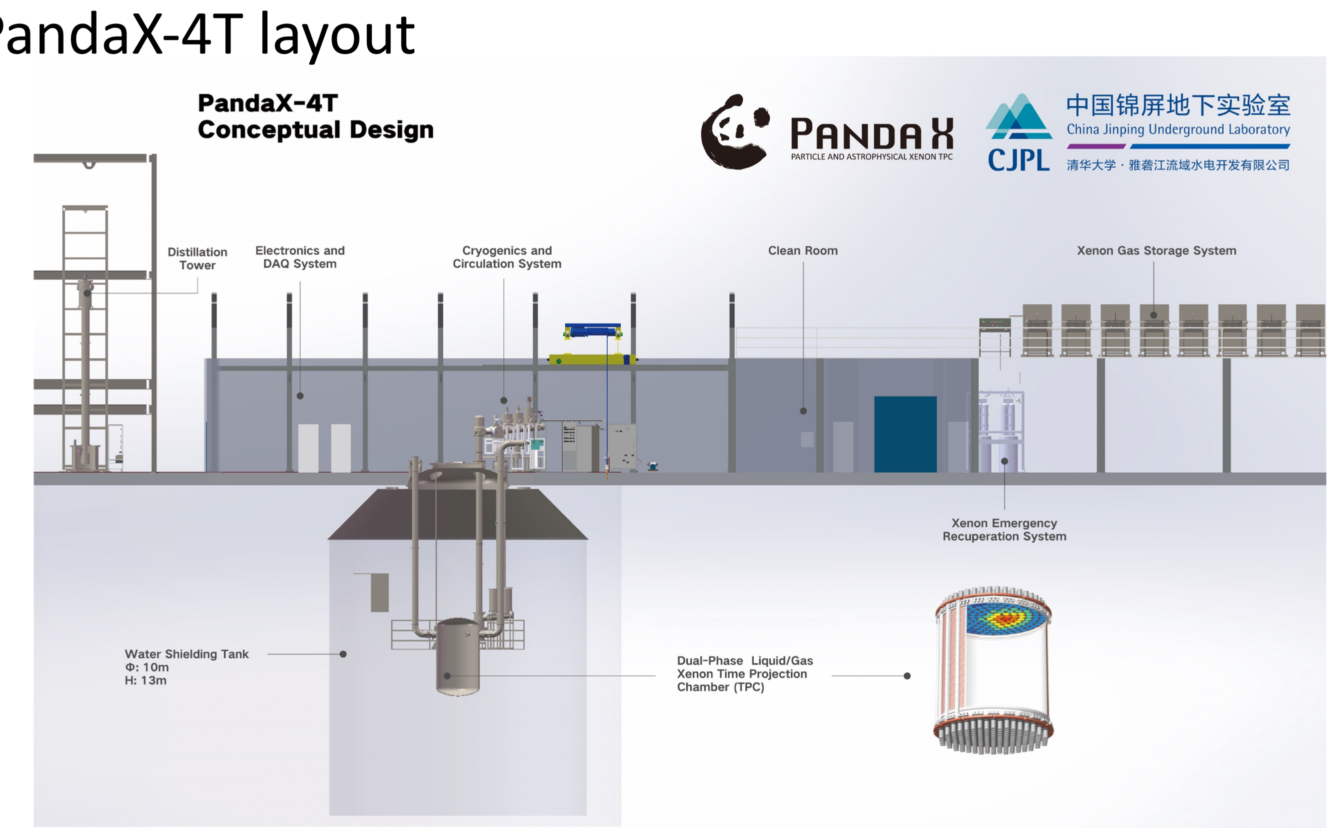
- Dual-phase xenon time projection chamber (TPC) technique to detect neutrino and dark matter






- 3D reconstruction and fiducialization
- Good electron recoil/nuclear recoil rejection
- Calorimeter capable of seeing a couple of photons/electrons

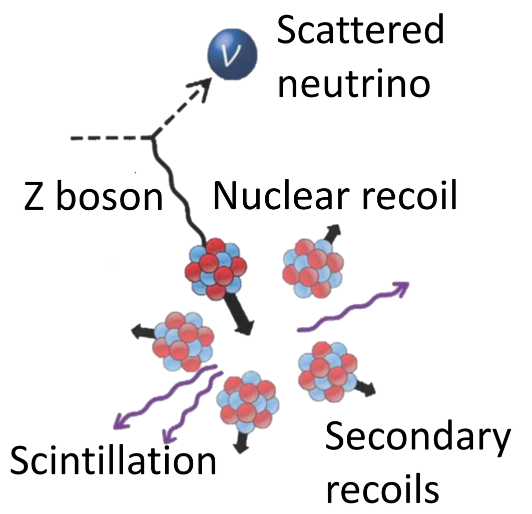
- Locate in Jinping Underground laboratory in China with 2400m overburden
- PandaX-4T layout



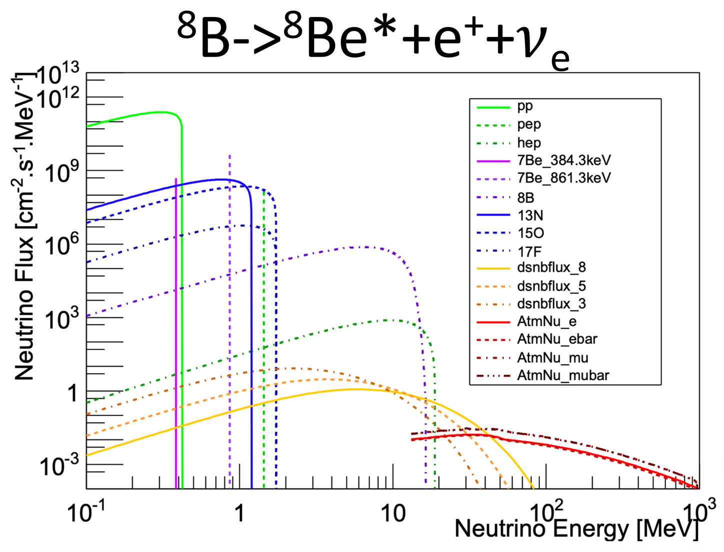

- Commissioning run: 2020/11 – 2021/04

## $^8$B neutrino detection

- Solar $^8$B neutrino can be detected by Coherent Elastic $\nu_e$-Nuclear Scatting channel and deposit few $keV_{nr}$ energy in the detector



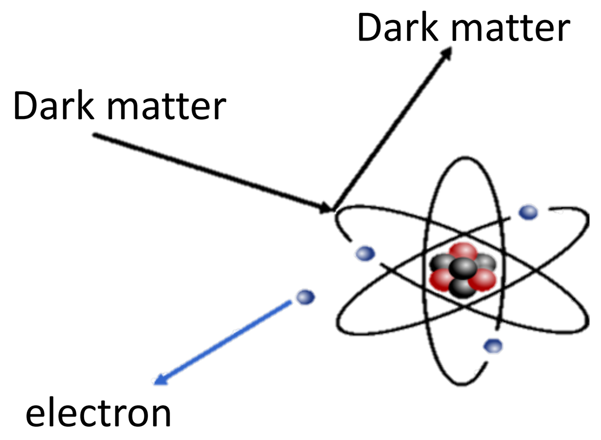

10.1126/science.aao0990



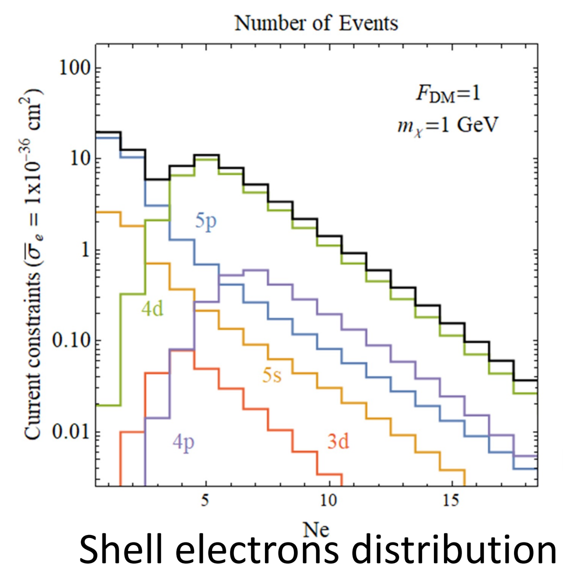

PRD 89, 023524 (2014)

## Light dark matter detection

- Shell electrons and light dark matter scatterings to produce the observable signal in the detector




Electron and light dark matter interaction

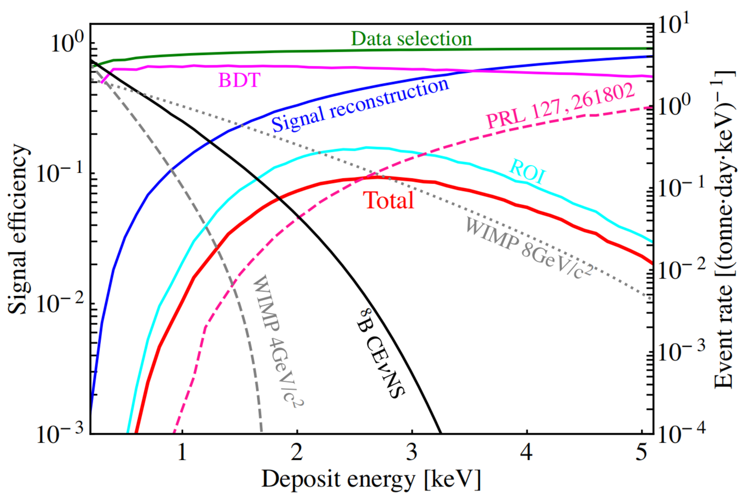



PRD 85, 076007 (2012)

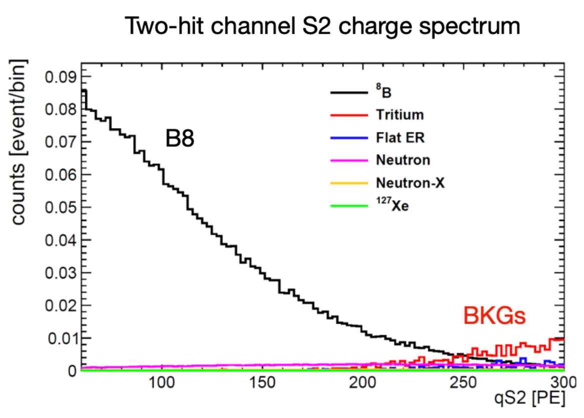
Shell electrons distribution

## S1+S2 analysis

- **lower the threshold for the paired S1+S2 signals:**
  - –S1: 2 or 3 hits among the entire PMT array
  - –S2: 65 PE of S2 (~3 electrons)
  - –Improvement on deadtime monitoring, signal reconstruction, and quality cuts




- **Waveform simulation**
  - –Data-driven simulation for S1, S2, delay ionization, dark noise, and so on
  - –Estimate the detection efficiency
- **Higher accidental background, dominant background**
  - –Boosted Decision Tree is applied
  - –Sideband check on data with drift length > max drift




| $N_{hit}$ | $S2$ range [PE] | BDT | ER | NR | Surf | AC | Total BKG | $^8$B | **Obs** |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 65-230 | pre | 0.04 | 0.10 | 0.14 | 62.43 | 62.71 | 2.32 | **59** |
| | | post | 0.02 | 0.04 | 0.03 | 1.41 | 1.50 | 1.42 | **1** |
| 3 | 65-190 | pre | 0.01 | 0.05 | 0.08 | 0.79 | 0.93 | 0.42 | **2** |
| | | post | 0.00 | 0.02 | 0.03 | 0.02 | 0.07 | 0.29 | **0** |

- **Unblind data**
  - –Statistically consistent with our expectation

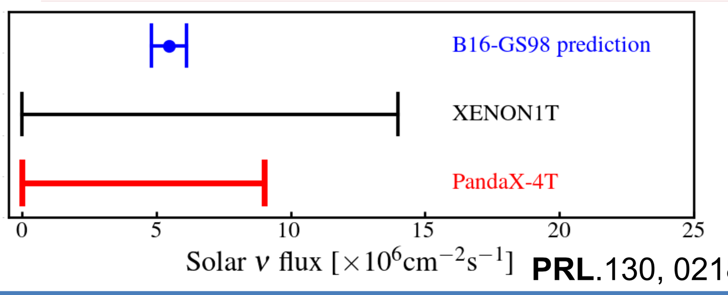
Apply-BDT result

| N-hit | Total bkg | B8 | Data |
|---|---|---|---|
| 2 | 1.50 | 1.42 | 1 |
| 3 | 0.07 | 0.29 | 0 |

- **Statistical interpretation**
  - –Profile Likelihood Ratio method

$$\mathcal{L} = G(\delta_e)G(\delta_s)G(\delta_b)G(\delta_\Phi) \times \left[\prod_i G(\delta^i_{\mathrm{BDT},s})G(\delta^i_{\mathrm{BDT},b})\frac{\lambda_i^{N_i}}{N_i!}e^{-\lambda_i}\right]$$

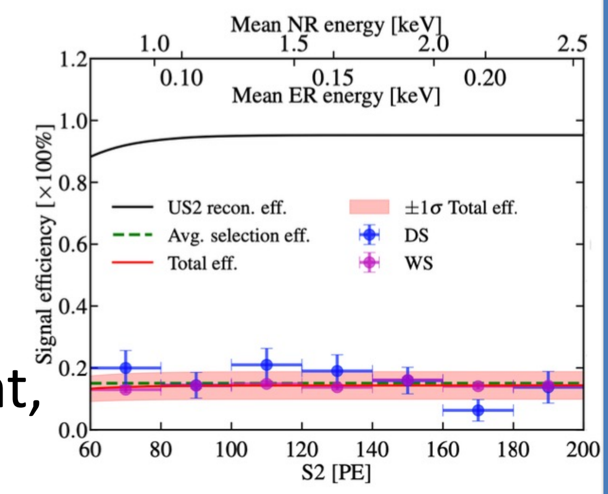
- Most stringent limit to solar neutrino flux using CEvNS channel with the xenon detector




PRL.130, 021802

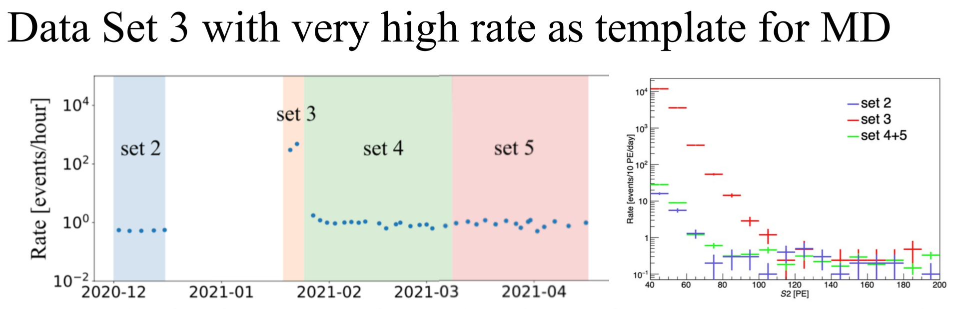
## S2-only analysis

- **Ionization-only signal to lower the threshold:**
  - –no scintillation signal requirement
  - –ROI S2 [60, 200]PE: threshold down to ~100 eV (from 1 keV)
  - –Tight cuts on the ionization signal to remove the background (Cathode event, gas event and electron burst event)

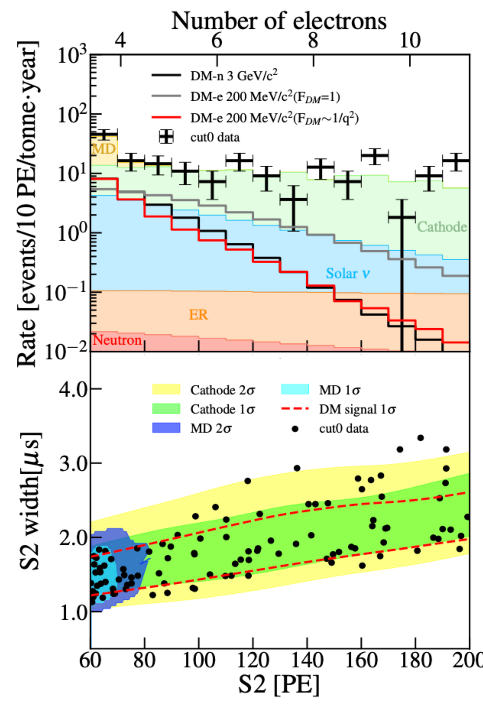


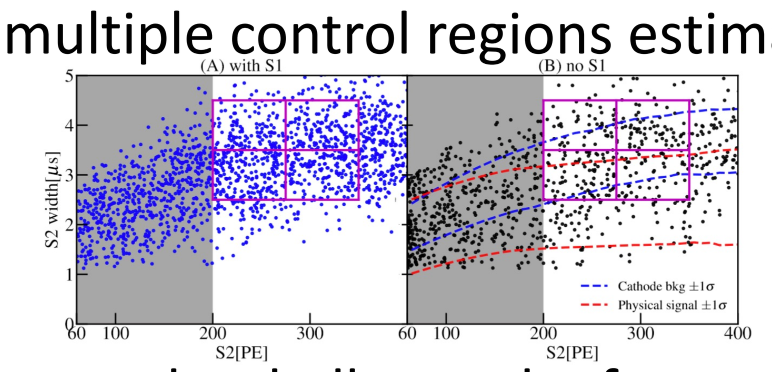

- **Key challenge: background components**
  - –No full picture in previous xenon-based experiments
  - –Data-driven modelling of micro-discharging background

Data Set 3 with very high rate as template for MD

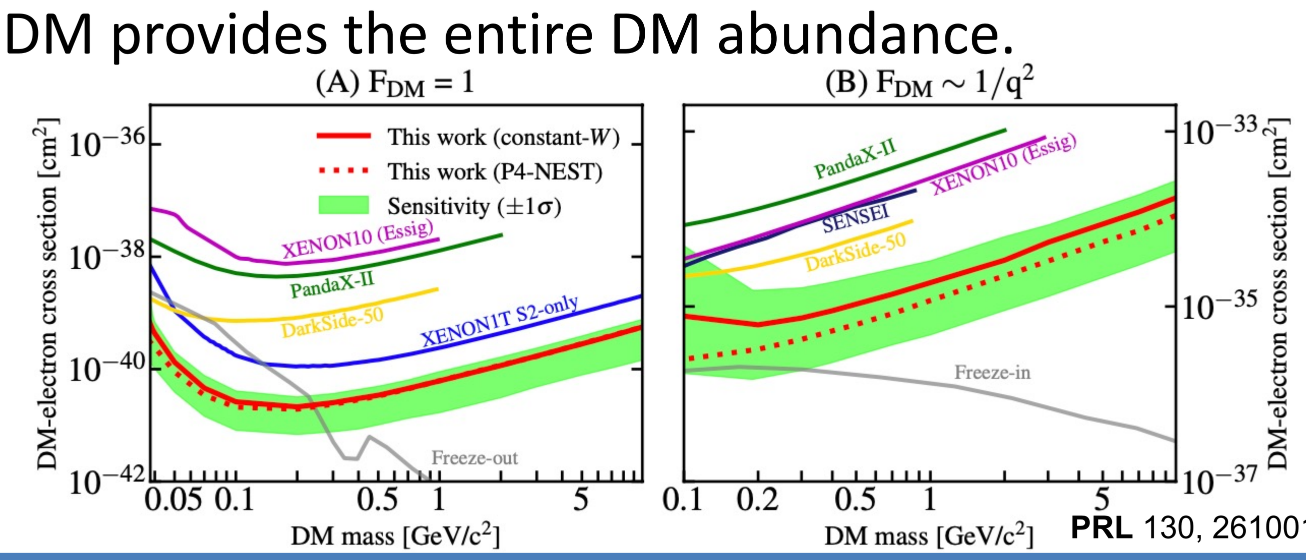



  - –Model the cathode background with multiple control regions estimation




- Our results challenge the freeze-out mechanism for DM mass range from 0.04 to 0.25 GeV/c$^2$ with $F_{DM}$=1, and are closing in on the freeze-in prediction with $F_{DM} \sim 1/q^2$, assuming such light DM provides the entire DM abundance.

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