Measurement of two-neutrino double electron capture half-life of ^{124}Xe with the PandaX-4T detector

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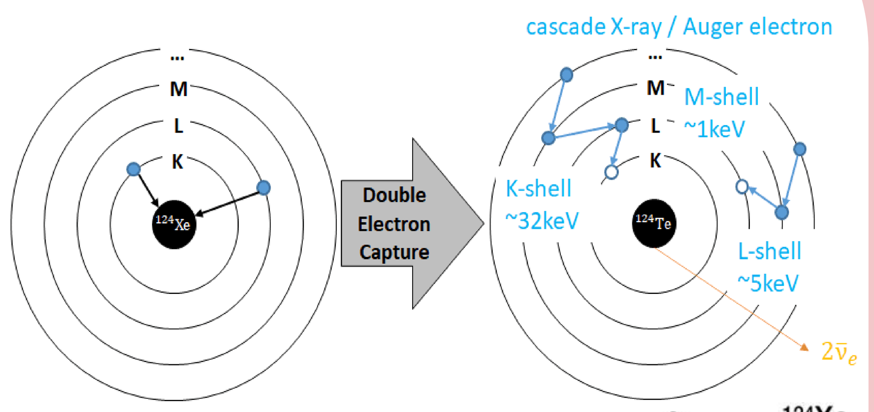
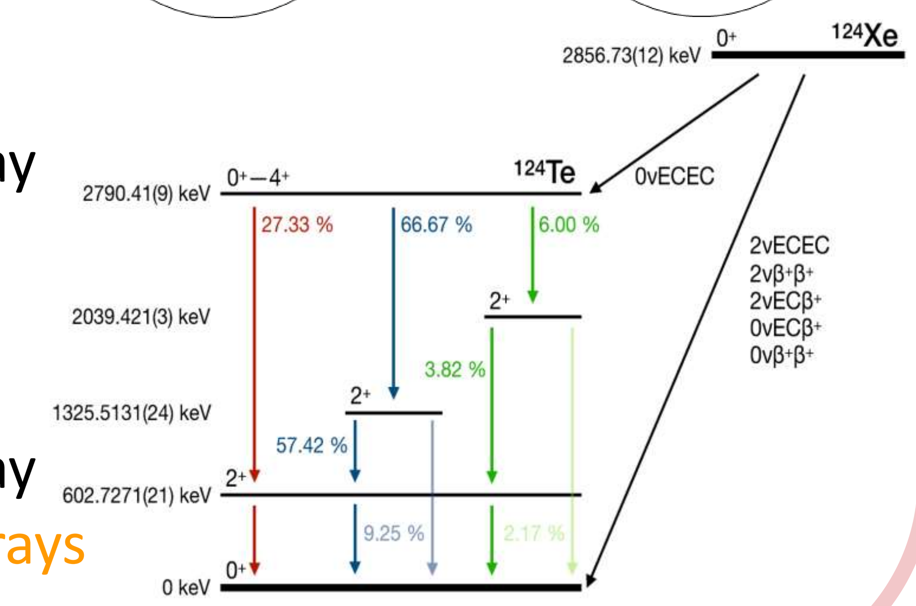
Double Electron Capture

$$^{124}\text{Xe} + 2e^- \rightarrow {}^{124}\text{Te} + (2\nu_e)$$



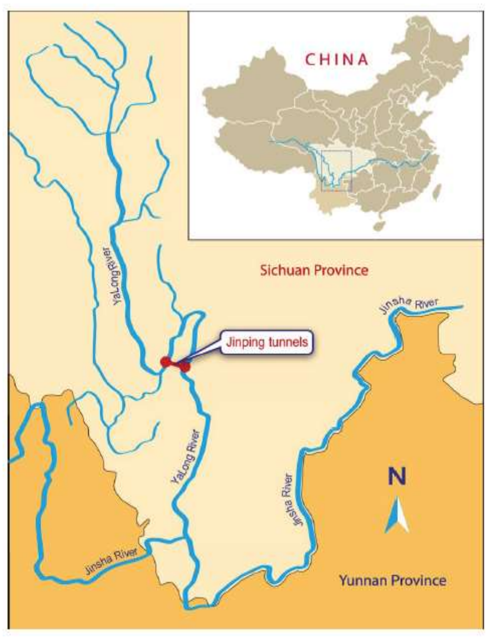
- 2ν ECEC
  - Auger electron & X-ray cascades
- 0ν ECEC
  - Auger electron & X-ray cascades + several γ-rays

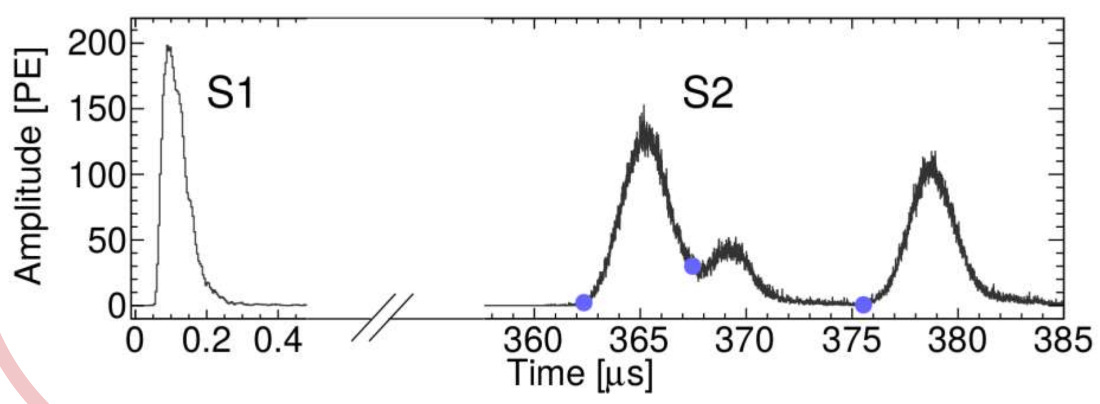


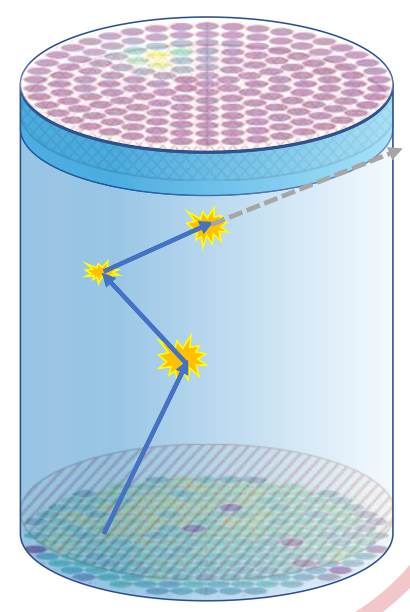
PandaX-4T Detector

Dual phase xenon detector capability:

- ✓ 4 tonne natural Xe in sensitive volume, ~0.1% ^{124}Xe abundance.
- ✓ Single / multi-site identification
- ✓ 3D reconstruction and fiducialization
- ✓ Calorimeter from sub keV to MeV

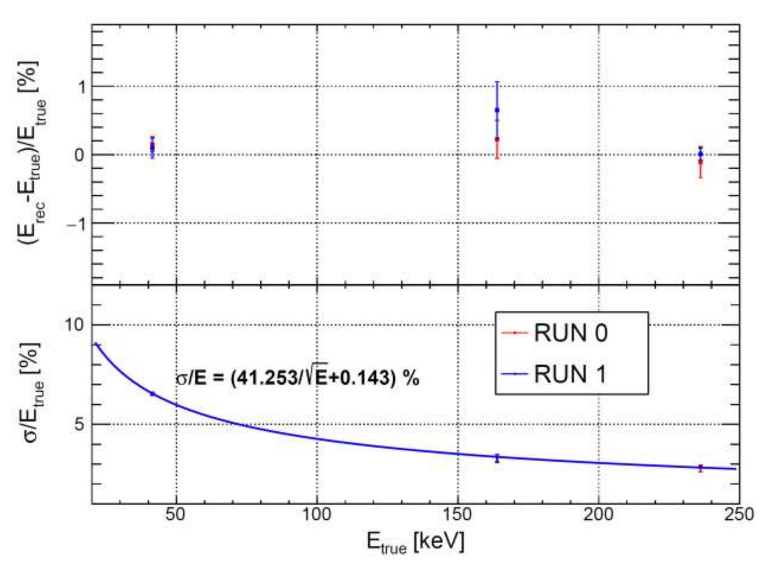


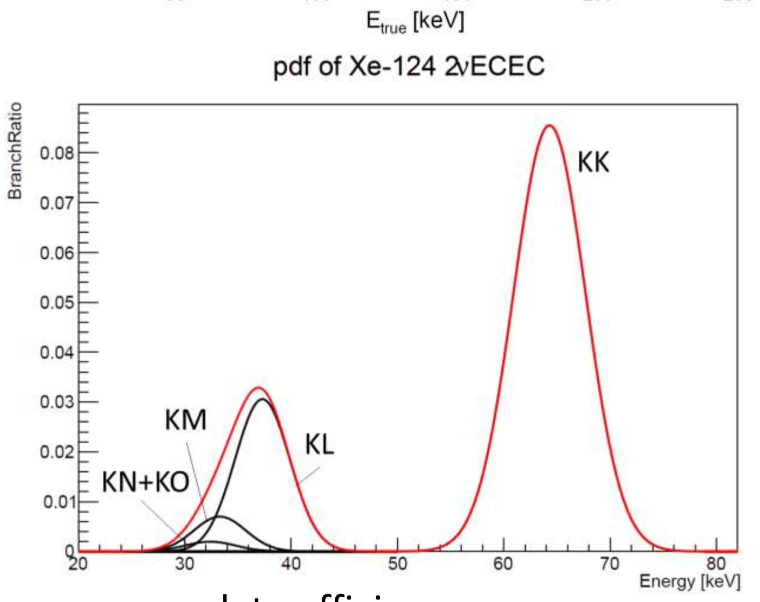




Methodology

- Precise energy reconstruction performed by calibration.
- **Un-binned 2D-profile likelihood fit to Run0 + Run1 data in the parameter space of (energy, time)**
- Find the number of count of ^{124}Xe during the data exposure.

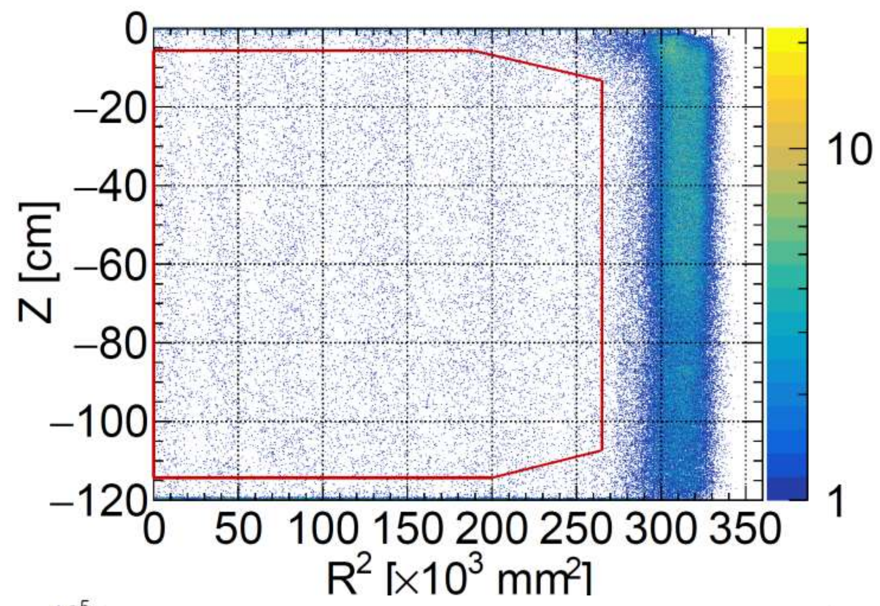


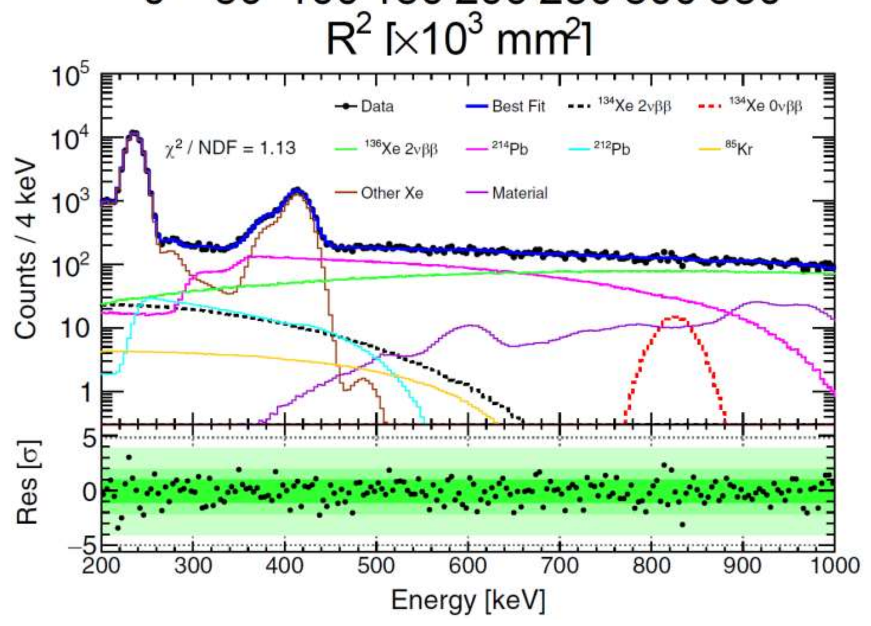


$$T_{1/2} = \ln 2 \frac{N_A \times \epsilon \times \eta \times mt}{M \times N}$$

ε: data efficiency,
η: abundance,
mt: total exposure,
M: mole mass,
N: number of counts of ^{124}Xe.

Background Model of ^{124}Xe 2vECEC

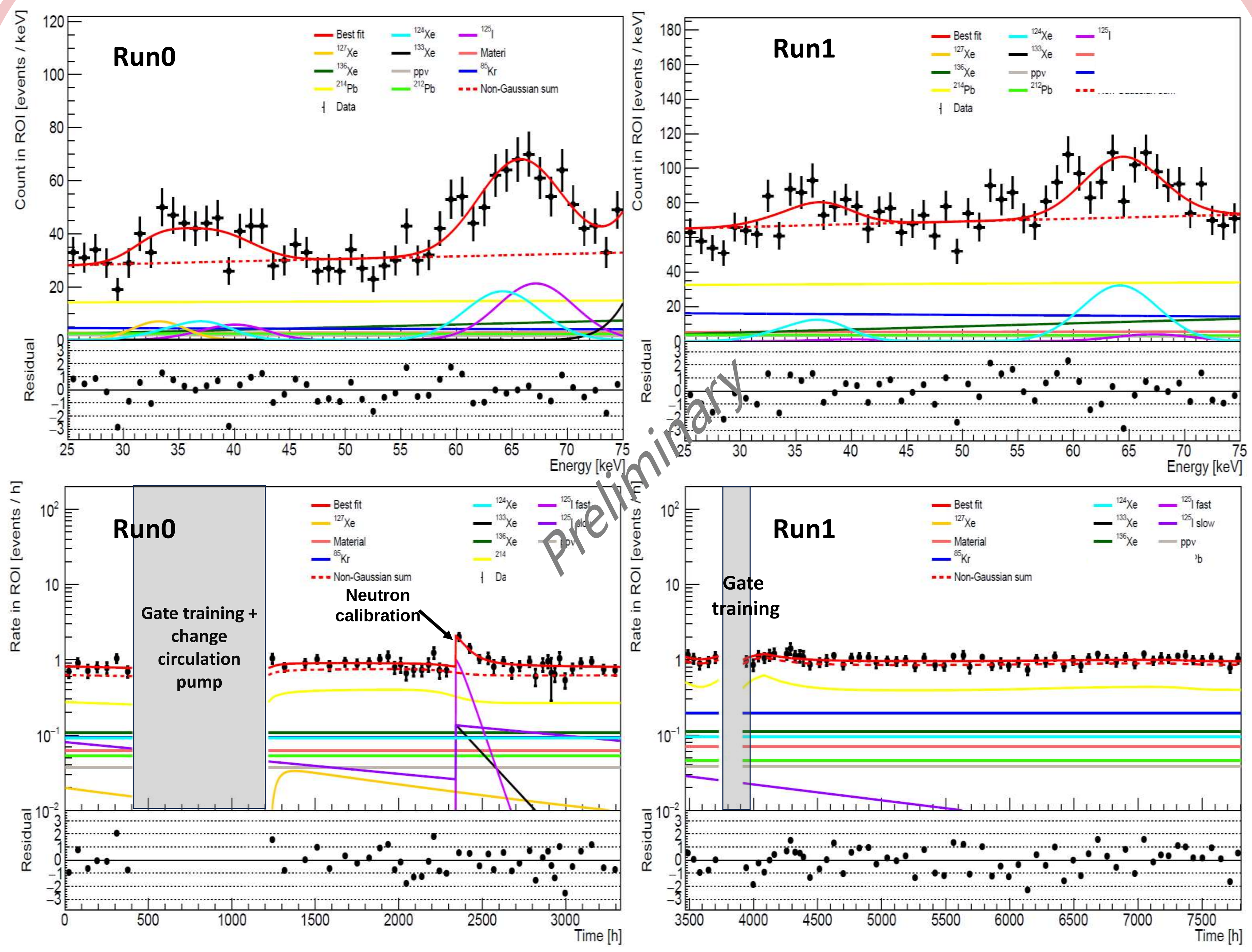




Source	Spectrum	Evolution
^{124}Xe	Multi-Gaussian	Constant in time
^{125}I	Multi-Gaussian	Exponential decay
^{133}Xe	From simulation, Tail extending below 75keV	
^{127}Xe	Gaussian	by ^{127}Xe at ~408keV
^{214}Pb	From simulation, ~Flat	by ^{222}Rn α
^{212}Pb		Constant in time
^{85}Kr		
Material ER		
^{136}Xe 2νββ	From simulation, ~Slope	
Solar ν		

- ROI: 25~75keV
- ~2.4kg ^{124}Xe in the fiducial volume.
- The estimation of background content comes from other analyses of hundred keV to MeV spectrum of PandaX-4T.

Preliminary Result



✓Preliminary measurement on ^{124}Xe 2νECEC half-life: $9.5 \pm 0.9(stat.) \pm 1.5(syst.) \times 10^{21}$yr, with the exposure of 1.7 kg · yr of ^{124}Xe

✓Self-consistent within data, and consistent with other experiments.

✓Analysis of ^{124}Xe 0νECEC is processing.

Reference:

10.1103/PhysRevLett.132.152502

10.1140/epjc/s10052-020-08726-w