

## 1. Introduction

First/only observation of supernova (SN) neutrinos from SN1987A



Core-collapse supernova (CCSN) explosion:

- The occurrence rate is only  $\leq 3$  per century in the Milky Way [1]
- Lasts only a few or a few tens of seconds
- Total energy  $\sim 10^{53}$  erg

Fig. 1. Before (right) and after (left) SN1987A explosion. Credit: David Malin / Australian Astronomical Observatory.

**Start of neutrino astronomy !**

- Neutrinos arrive on earth much earlier than electromagnetic radiation.
- Supernova early warnings can be provided for the astronomical community.

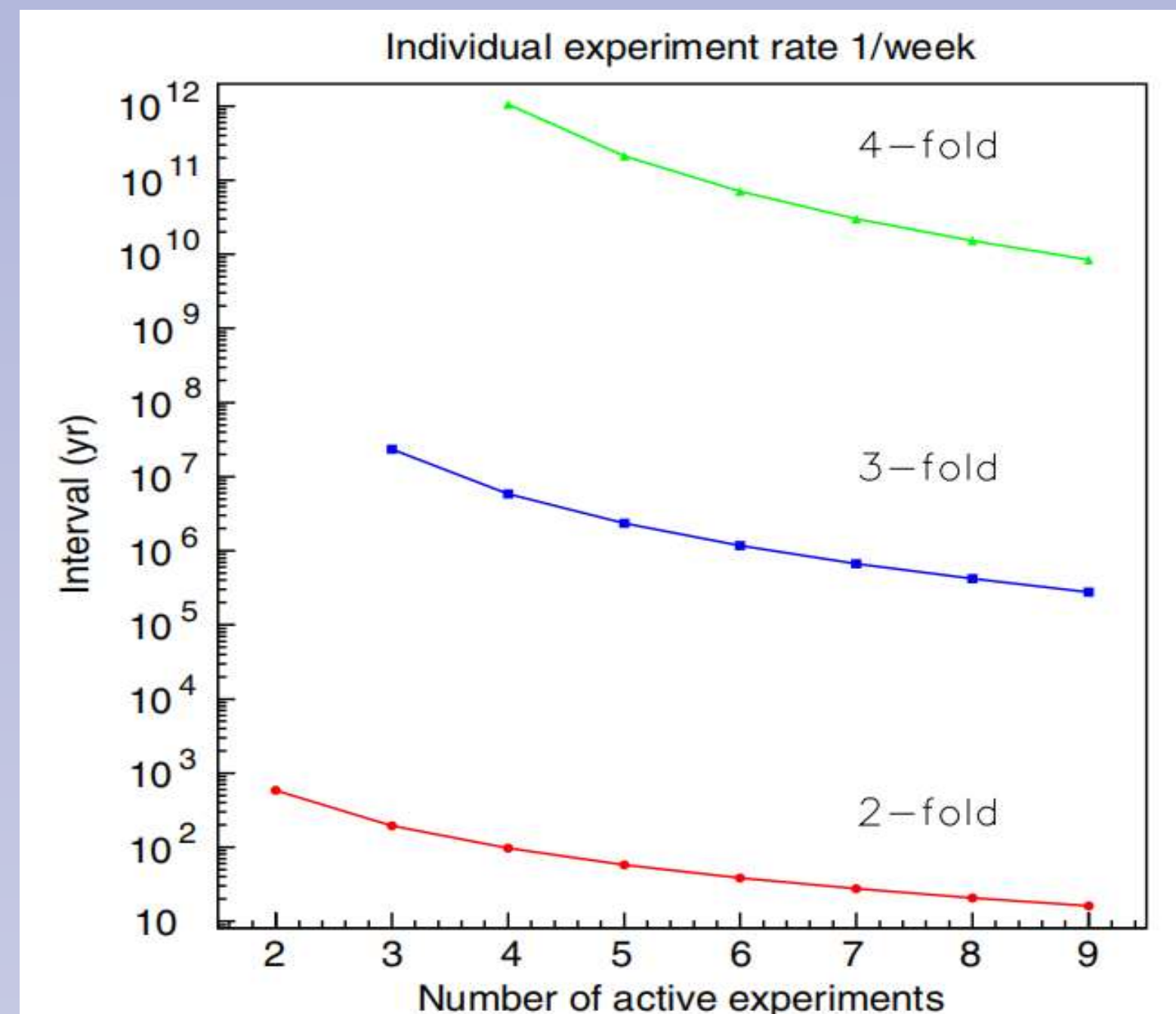


Fig. 2. Global supernova neutrino early warning system (left, Credit: SNEWS) and average interval between accidental alerts for an n-fold coincidence of N experiments [2] (right).

## 2. PandaX-4T experiment

- Located in the China Jinping Underground Laboratory (CJPL), with 2400 m overburden.
- Dual-phase xenon time projection chamber (TPC) technique to detect dark matter and neutrinos.

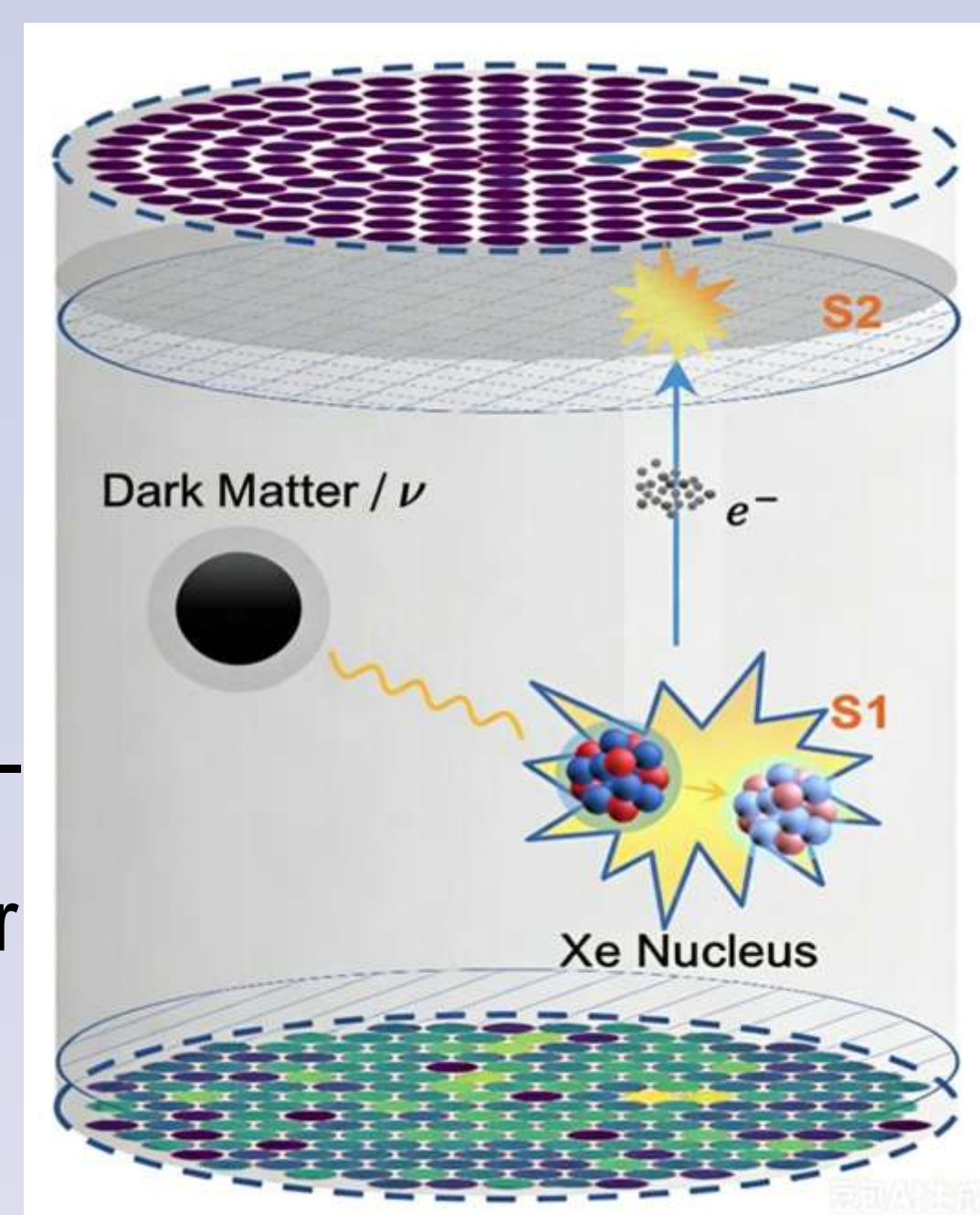


Fig. 3. Schematic diagram of the PandaX-4T detector.

## 3. GPS module in PandaX-4T

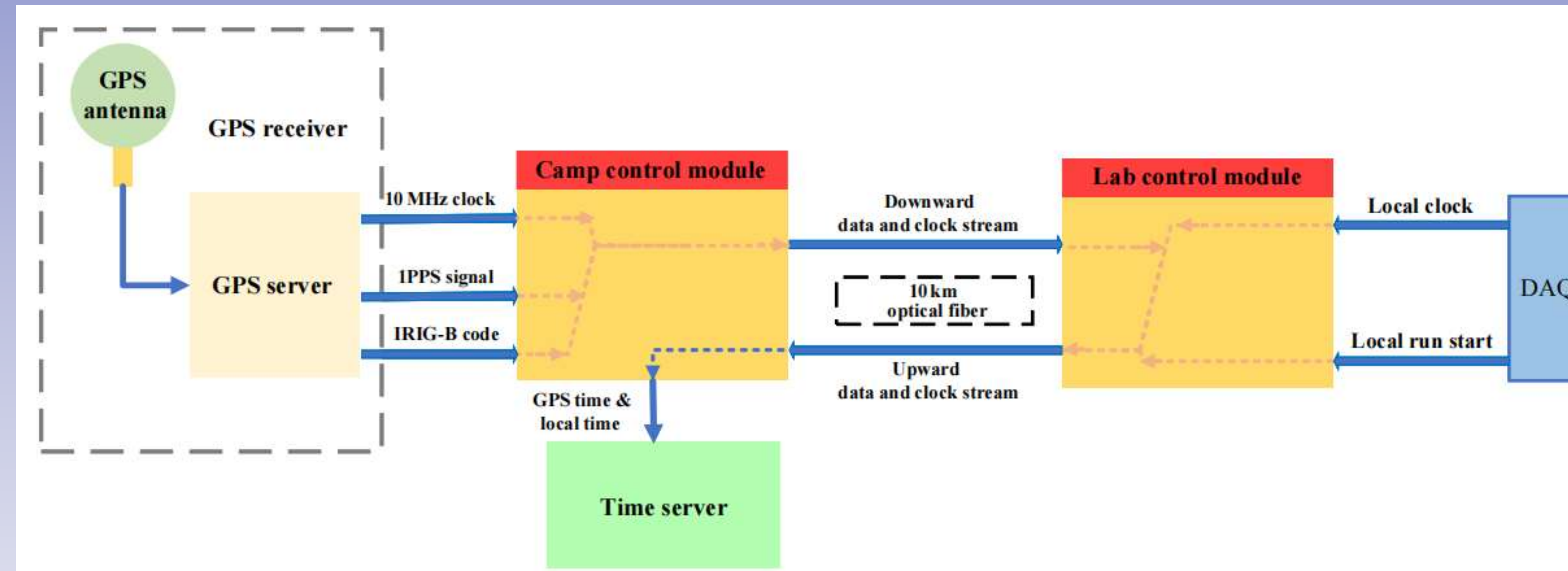


Fig. 4. Schematic diagram of the PandaX-4T's GPS-based timing system[3].

- The system comprises a GPS receiver, a camp control module, a lab control module and a time server.
- The GPS module provides millisecond-level time precision.

## 4. SN online monitoring system

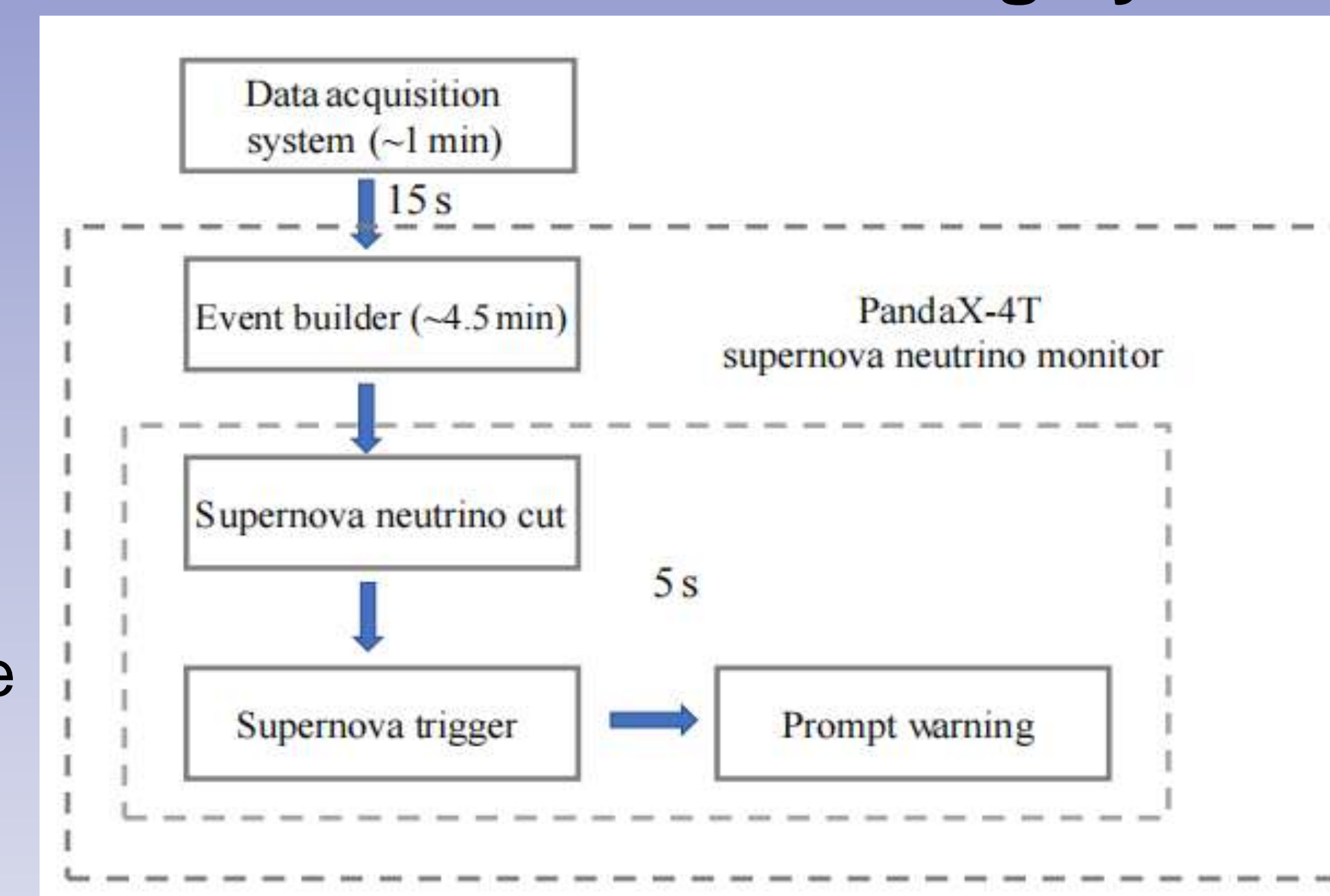


Fig. 5. Schematic diagram of SN online monitoring system.

- S1–S2-paired CE $\nu$ NS-like events:
  - S1  $\in [2.1, 100]$  PE, S2  $\in [80, 4000]$  PE
  - Cuts applied: Fiducial volume, accidental coincidence (AC), S1/S2 quality etc.
- S2-only method as an alternative (to be performed).

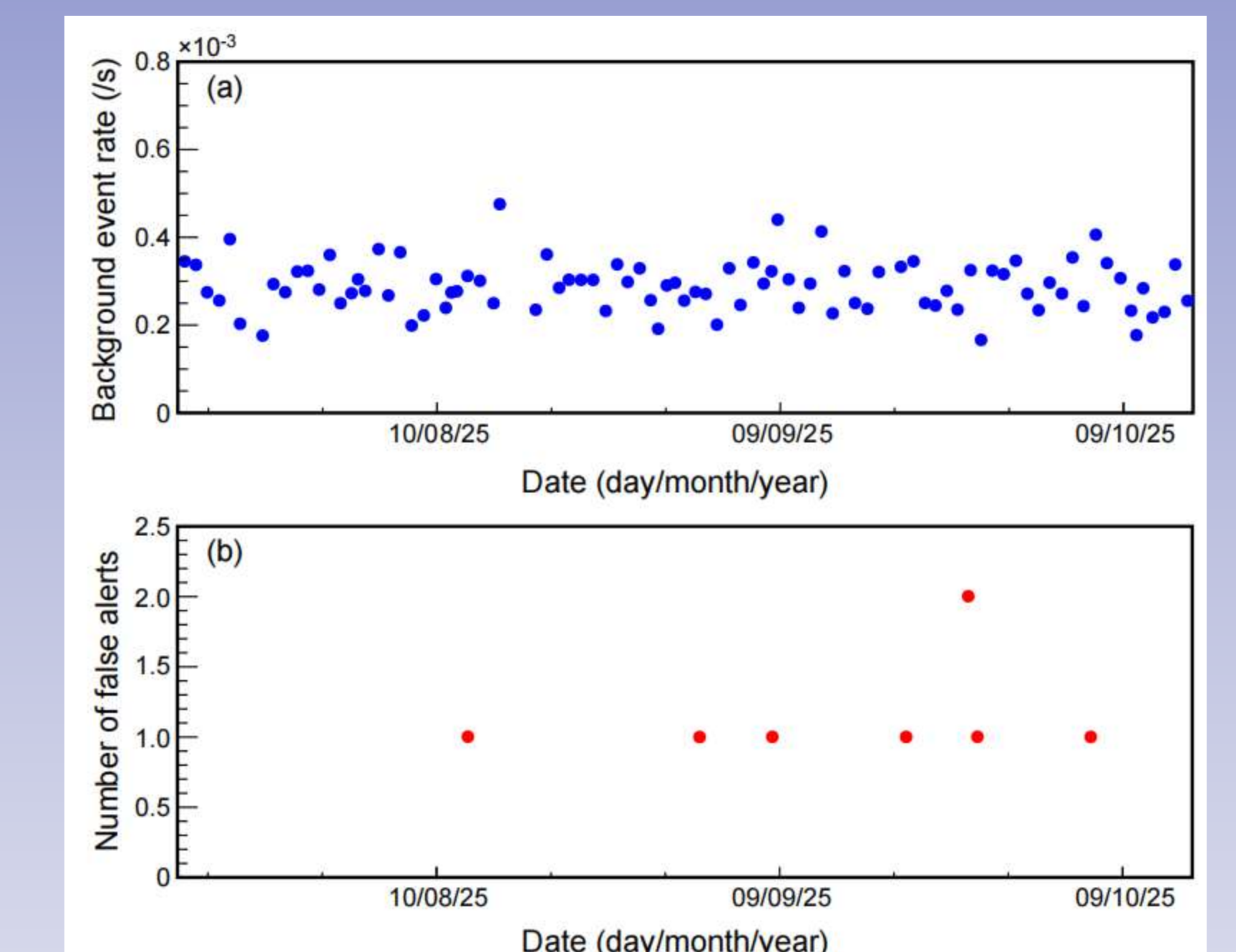


Fig. 6. (a) The background event rate and (b) the false alert as a function of time.

## 5. Estimation of false alert rate and detection probability

Data type	Rate [/s]	Calendar time	Observed	Expected
DD	$2.2 \times 10^{-2}$	2.8 days	886	870.6
AmBe	$9.7 \times 10^{-3}$	3.7 days	288	265.3
Physical	$2.9 \times 10^{-4}$	83 days	8	6.1

Table 1. The observed and expected false alerts are compared using datasets from DD, AmBe, and physical data.

SN model	d = 10 kpc	d = 168 pc	Duration (s)
$11.2 M_{\odot}$	3.7	$1.3 \times 10^4$	7.60
$27 M_{\odot}$	8.1	$2.9 \times 10^4$	8.35

Table 2. The number of expected SN neutrinos for source distances of 10 kpc and 168 pc in PandaX-4T.

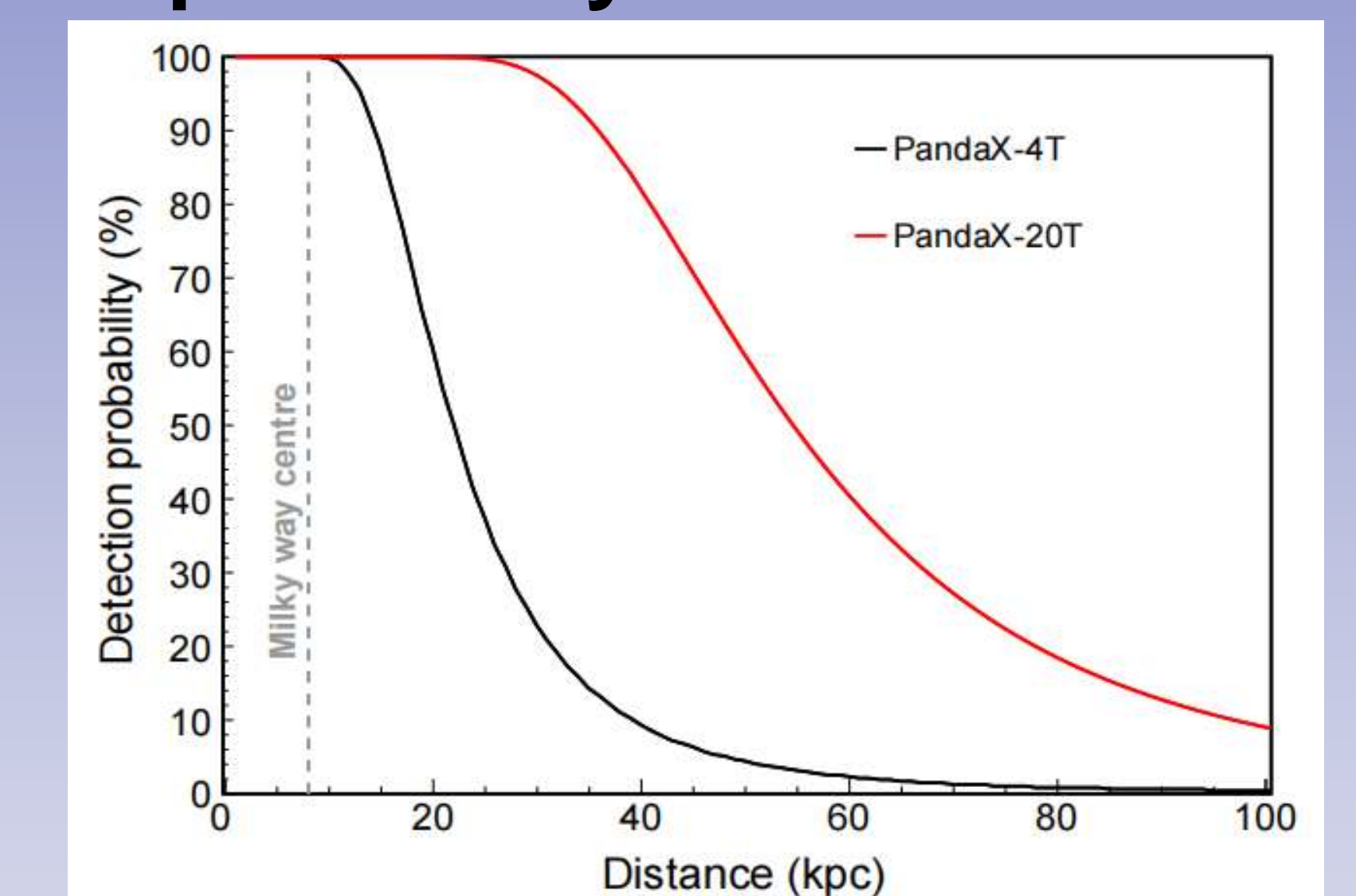


Fig. 7. Detection probability of the CCSN explosions as a function of distance using the Garching model with  $27 M_{\odot}$ .

## 6. Summary and prospects

- A robust online SN monitoring system with GPS time synchronization has been implemented in PandaX-4T to detect galactic SN explosions.
- **The next-generation PandaX-20T experiment is under construction.**

## References

- [1] Horiuchi S, Beacom J F, and Dwek E 2009 Phys. Rev. D 79 083013
- [2] Antoniolli P, Fienberg R T, Fleurot F et al. 2004 New J. Phys. 6 114
- [3] Pang B Y, Abdukerim A, Bo Z H et al. 2026 Chin. Phys. L 43 021103