Spallation Backgrounds in water-Cherenkov detectors

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Neutrino signals

★ Solar neutrinos, DSNB   ★ SN burst

What are spallation backgrounds?

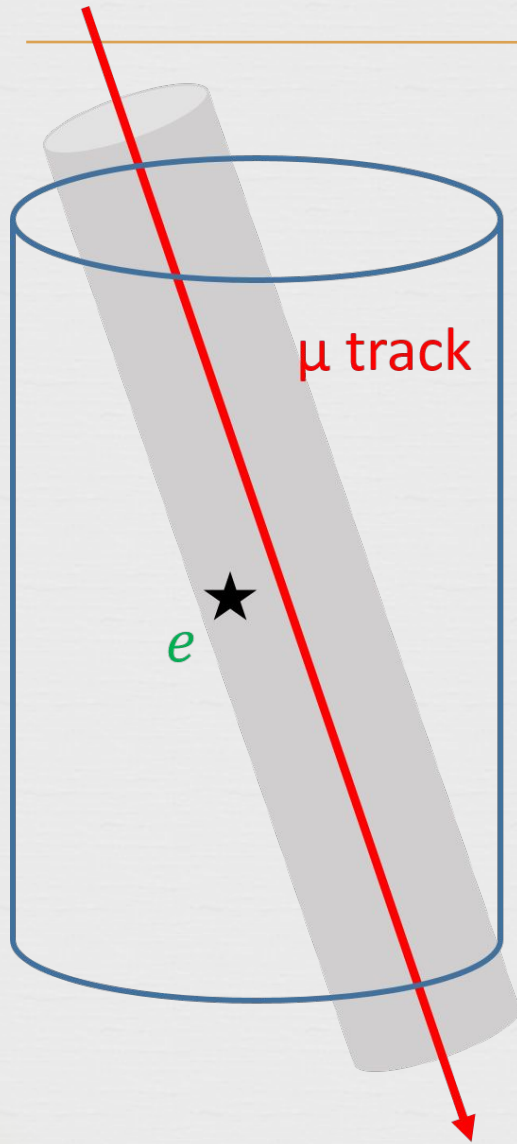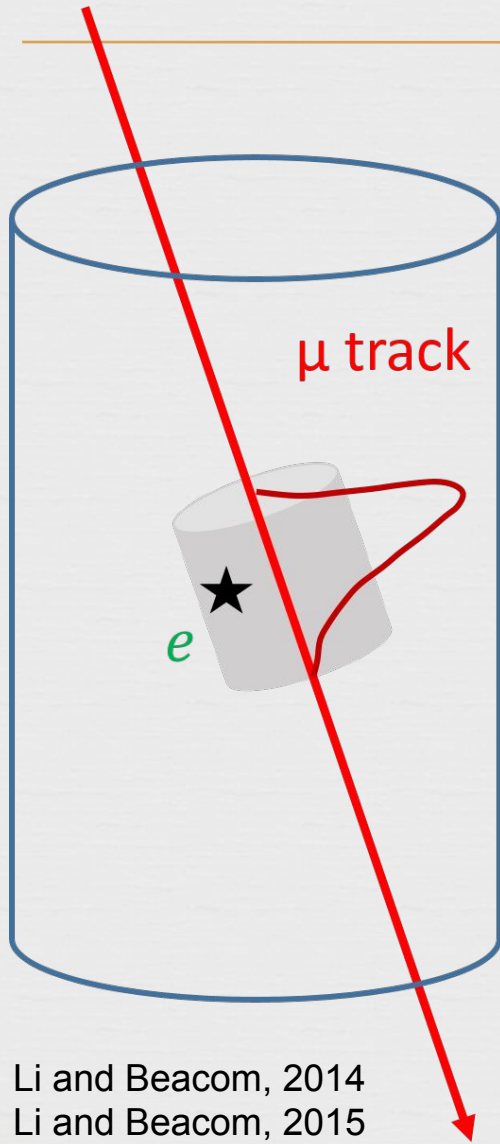|	all flavor	$\overline{\nu}_e$
Signal	$\nu + e \rightarrow \nu + e$	$\overline{\nu}_e + p \rightarrow e + n$
Background	$\mu + X \rightarrow \mu + X'$	$\mu + X \rightarrow \mu + X'$
	$X' \rightarrow e + \text{others}$	$X' \rightarrow e + n + others$
	e.g., $X' = {}^{16}\text{N}$	e.g., $X' = {}^{9}\text{Li}$

Basic properties of spallations

★ Rate per muon is low

★ Total rate ∝ muon rate, detector height
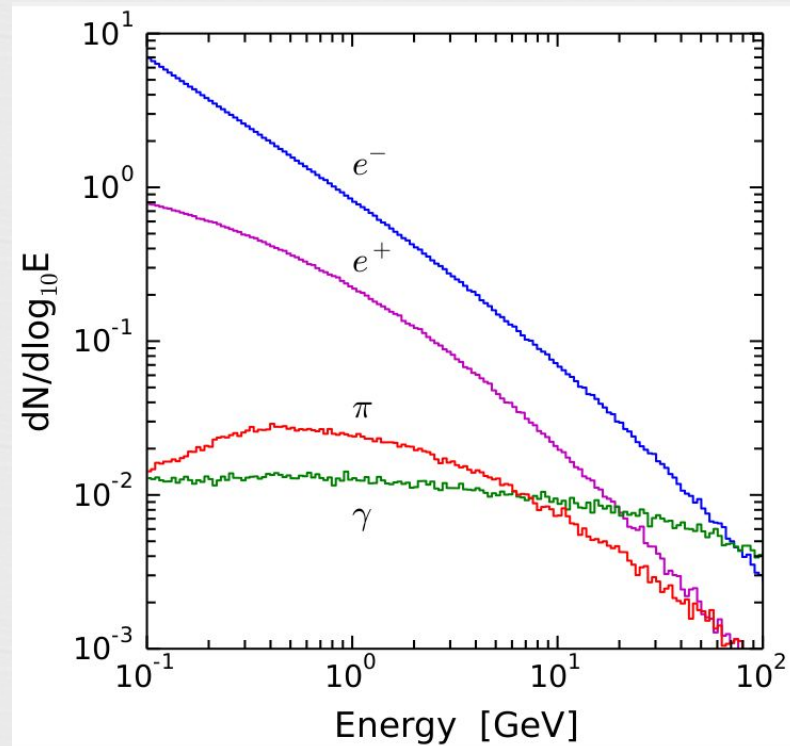
★ Large fluctuations among muons

The story: before

μ track

e

★ Isotope lifetime vs. muon rate

★ Lifetime: ms -- s -- min

The story: now

★ Isotopes are produced in showers

★ Showers are rare

μ track

e

Li and Beacom, 2014
Li and Beacom, 2015

Spallation for SN
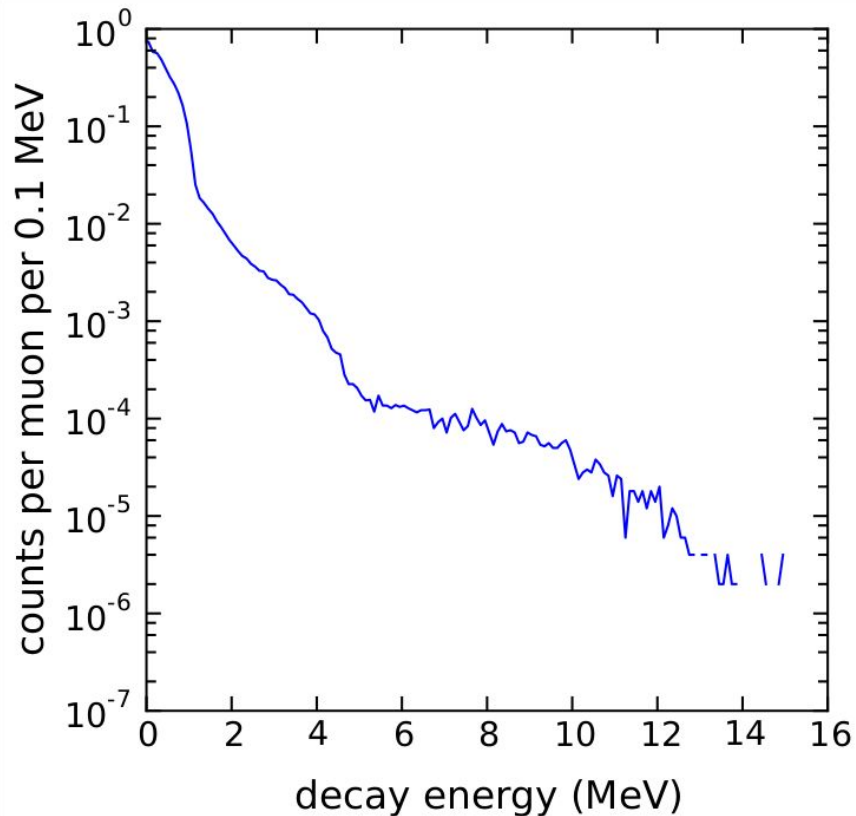
★ Average: ~ 30e-7 / muon / cm $\rightarrow$ 0.1 event / 10 s

★ Bad: one huge muon (energy loss) event,

producing up to a few isotopes

    ○ Afterpulsing
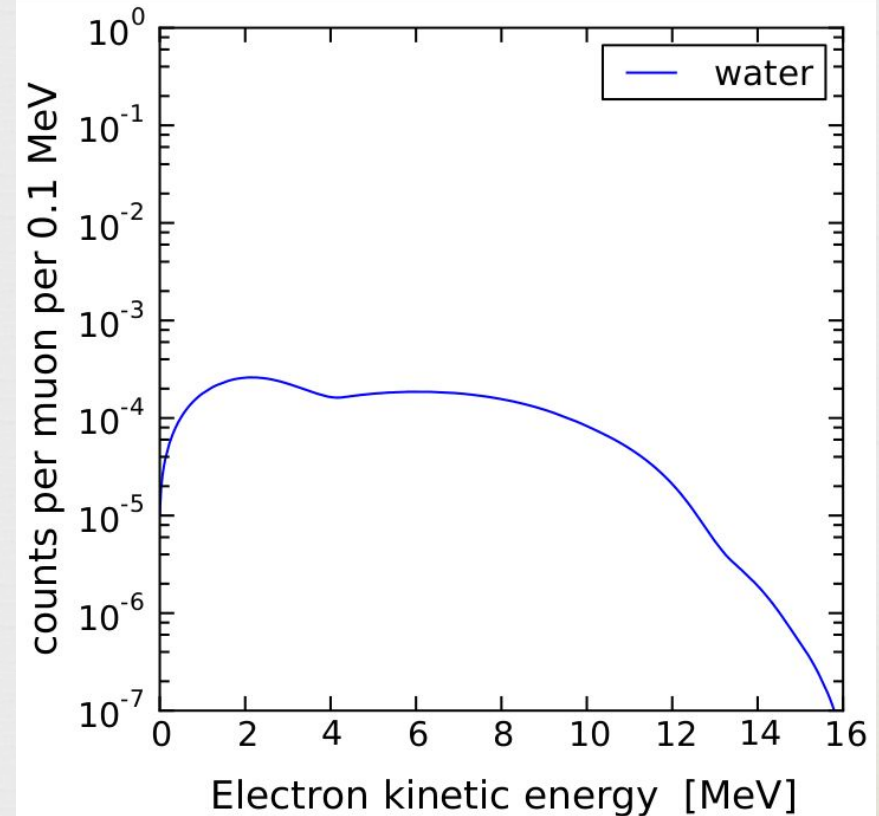
    ○ Muon track reconstruction
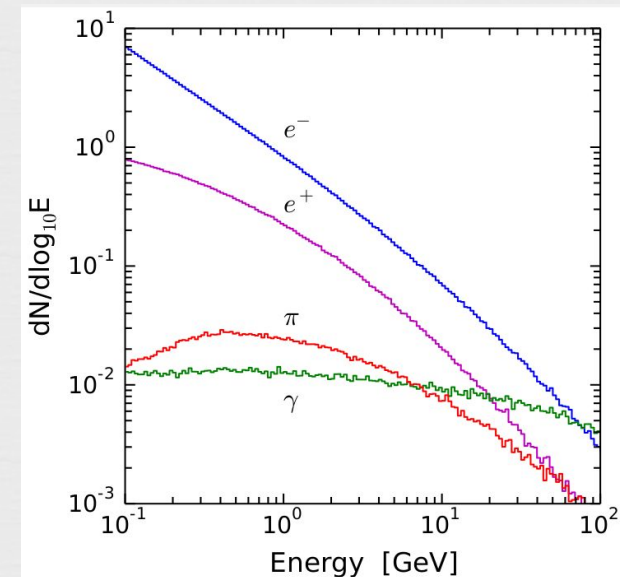
Liquid Ar

Rate in Ar
Muon 0.15 Hz

Rate in water
Muon 2 Hz

Conclusions

★ Spallations are produced in showers

★ Better rejection for solar neutrino in Super-K is underway

★ Rate in argon is even lower (solar, DSNB)

★ Unlikely to be a problem for SN burst