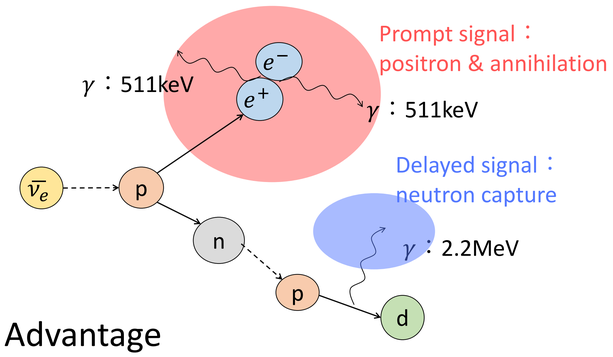
Supernova neutrino burst search at KamLAND

Minori Eizuka and KamLAND collaboration, RCNS, Tohoku Univ. (minori@awa.tohoku.ac.jp)

Introduction

- Supernova neutrino (SNν) search in KamLAND data set
- KamLAND
  - ➢ 1000 m under the top of Mt. Ikenoyama
  - ➢ 1 kt liquid scintillator ($r = 6.5$ m)
  - ➢ Anti-electron neutrino detector
- $\bar{\nu}_e$ search via Inverse Beta Decay (IBD) using delayed coincidence method



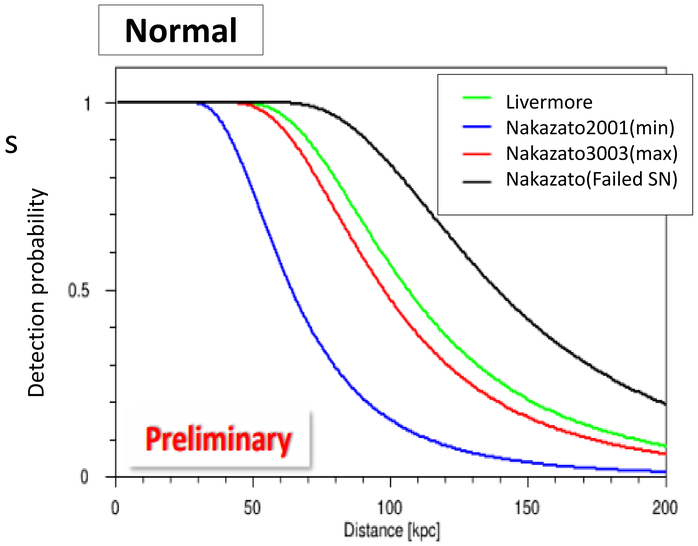
- Advantage
  - ➢ Low energy threshold
  - ➢ Long stable data set

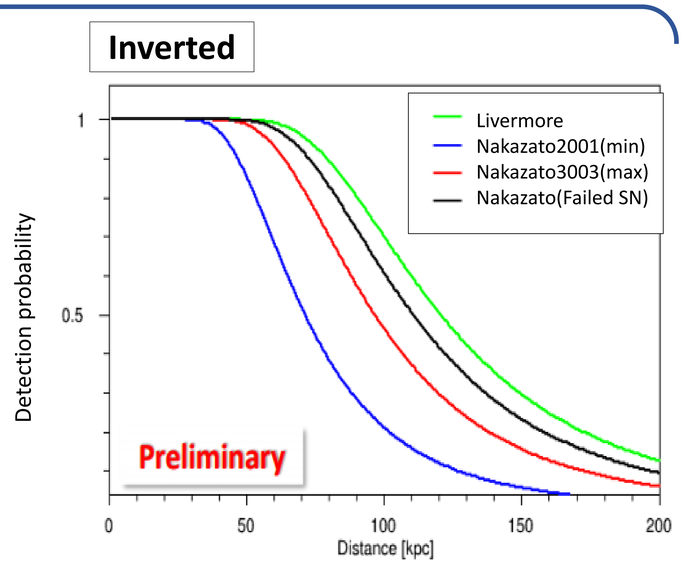
Selection criteria

- ✓ $0.9 \leq E_p \leq 100$ MeV ($1.8 \leq E_{\bar{\nu}_e} \leq 111$ MeV)
- ✓ $1.8 \leq E_d \leq 2.6$, $4.4 \leq E_d \leq 5.5$ MeV
- ✓ $r_p \leq 600$ cm, $r_d \leq 600$ cm
- ✓ $dR \leq 160$ cm, $0.5 \leq dT \leq 1000$ μsec
- ✓ Data period : 2002/3/9 ~ 2020/7/17
- ✓ Muon and spallation vetos

Sensitivity

- Calculation of detectable range
- Models Time scale ~ 10 s
  - ➢ Livermore [1][2]
  - ➢ Nakazato [3]
  - ➢ Nakazato (Failed SN) [3]
- Poisson distribution
  - ➢ Expected value = Observed events in KamLAND
  - ➢ Detection probability = Ratio more than 2 events





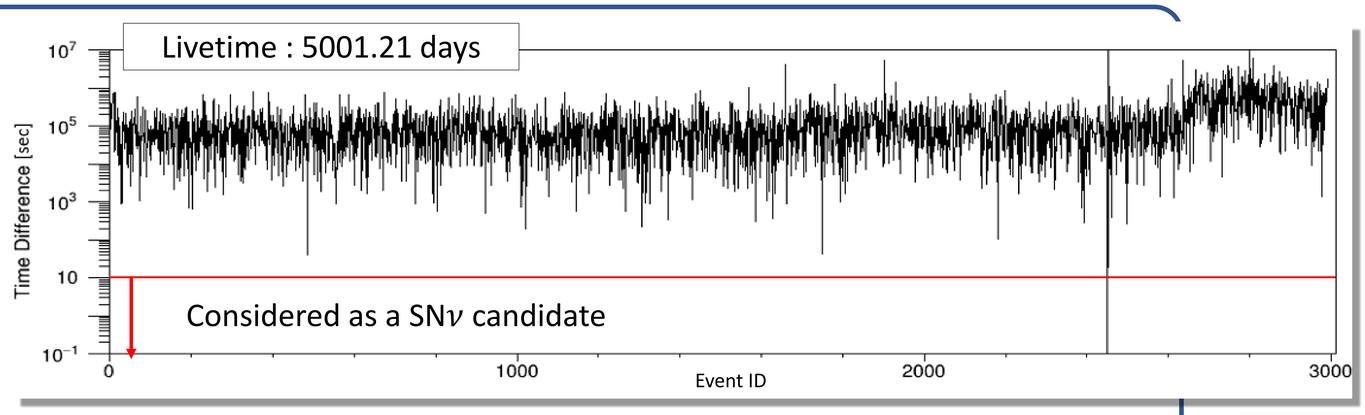
- **Our galaxy ~25 kpc → detection probability ~100 %**
- Detectable range : (detection probability ≥ 95%)
  - **≤ 38 kpc Normal Mass Hierarchy**
  - **≤ 42 kpc Inverted Mass Hierarchy**

Preliminary

Analysis and Result

- SNν
  - → More than 2 IBD events within 10 s
  - → Check time difference b/w prompt events
- One SNν candidate → GPS error
- Estimated IBD background (within 10 s more than 2 events) ~ 0

No SNν candidate : $N_{obs} = 0$, $N_{BG} \sim 0$



- 90% upper limit on SN burst rate in our galaxy

Rate ≤ 0.178 [evt/yr] (Feldman-Cousins) **Preliminary**

Conclusion

- No significant SNν events
- Upper limit on SN burst rate
- KamLAND covers our galaxy (~25 kpc)

References

[1] K. Kotake, et al. 2006, Rep. Prog. Phys, 69, 971
[2] T. Totani, et al. 1998, Apj, 496, 216
[3] K. Nakazato, et al. 2013, Astrophys. J. Supp. 205, 2