Erratum to: Sensitivity of multi-PMT optical modules in Antarctic ice to supernova neutrinos of MeV energy

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We found an error in the code for calculating the CCSN detection range that led to double counting of signal events and thus to ranges that were too large by a factor of about 1.3. This results in the following corrections (old value → new value):

• The values for the detection ranges decrease as shown in the corrected Table 4. Figures 8, 9, 10 change accordingly. Correspondingly, the numbers change in:
  – Abstract: We find that exploiting temporal coincidences between signals in different photocathode segments, a 27 M⊙ progenitor mass CCSN can be detected up to a distance of (341 kpc → 269 kpc) with a false detection rate of 0.01 year−1 with a detector consisting of 10,000 sensors.
  – Section 4.2: The trigger condition (m ≥ 7, Nν ≥ 7) can be used to send supernova alerts with very high confidence (about one false detection per century), and identify CCSN at a distance of (341 kpc → 269 kpc) with 50% probability.
  – Section 4.2: With a relaxed set of conditions of (m ≥ 7, Nν ≥ 6), SNe up to (370 kpc → 291 kpc) can be detected with less than one false CCSN detection per year.
  – Section 4.2: For example, for a number of detected events Nν = 5 a background origin can be excluded at 3.2 σ, while at least a corresponding number of events will be detected in 50% of cases from a 27 M⊙ CCSNe at a distance of (407 kpc → 322 kpc).

– Section 4.2: If Nν = 7 events with m ≥ 7 are detected we obtain a 4.9 σ confidence that such signal was not produced by background with a 50% detection probability at (341 kpc → 269 kpc) distance.
– Conclusions: For a detector equipped with 10,000 sensors consisting of 24 3-inch photomultipliers, we find that CCSNe up to a distance of (341 kpc → 269 kpc) can be identified with 50% probability with 0.01 false SN detection per year.
– Conclusions: If the arrival time of CCSN neutrinos is known from an independent observation with δt = 1 h, a 27 M⊙ CCSN at ([407, 341] kpc → [322, 269] kpc) can be detected in 50% of cases and with a [3.2, 4.9] σ certainty that the signal was not produced by background.

• Change in the 5σ detection horizons, in case the arrival time of the burst is known exactly:
  – Section 4.2: The 5σ discovery horizon in this scenario reaches (400 kpc → 315 kpc) for a 27 M⊙ CCSN using m ≥ 7, and (300 kpc → 234 kpc) for the 9.6 M⊙ model.

• To reach a detection of one CCSN about every decade doubling the number of modules, the necessary noise reduction changes from a factor ∼ 70 to a factor ∼ 140:
  – Section 4.2: Increasing the number of sensors to 20,000 and reducing the optical background by a factor of (∼ 70 → ∼ 140) expands the range such that a CCSN detection rate of (0.1 → 0.08) per year is achieved, while keeping the false detection rate at 0.01 year−1.
  – Section 4.2: In contrast, doubling the number of modules installed would allow the false SN detection rate to be kept below 0.01 year−1 while expecting (1 → 0.8) CCSN detection per decade if the radioactive noise within the glass vessel can be reduced by a factor of about (70 → 140).

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Table 4: False CCSN detection rate and range of supernova detection (50% probability) for different values of $m$ and $N_{\nu}$ (see trigger conditions in Section 4; $\Delta t_{\text{coin}} = 20$ ns, $\Delta T_{\text{SN}} = 10$ s).

| Trigger | False CCSN rate ($\text{year}^{-1}$) | Range (kpc) |
|---------|-------------------------------------|-------------|
| $m \geq 5$ | $N_{\nu} \geq 104$ | 0.7 | 135 (101) |
| $m \geq 6$ | $N_{\nu} \geq 107$ | < 0.01 | 133 (99) |
| $m \geq 7$ | $N_{\nu} \geq 17$ | 0.9 | 245 (182) |
| $m \geq 8$ | $N_{\nu} \geq 20$ | < 0.01 | 225 (167) |
| $m \geq 9$ | $N_{\nu} \geq 7$ | 0.01 | 269 (200) |
| $m \geq 10$ | $N_{\nu} \geq 3$ | 0.2 | 275 (204) |
| $m \geq 11$ | $N_{\nu} \geq 4$ | < 0.01 | 235 (174) |

Fig. 8 Probability for the detection of a CCSN of 27 M$_{\odot}$ progenitor mass as a function of distance using the trigger conditions presented in Table 4.

Conclusions: Increasing the number of installed modules to 20,000 and using pressure vessels with significantly reduced optical background could extend the range such that one CCSN (per decade $\rightarrow$ every $\sim$ 12 years) can be observed.

The conclusion from this work remains unchanged despite the reduced detection range: exploiting coincidences between detected photons within a segmented photosensor will significantly increase the sensitivity of sparsely instrumented neutrino telescopes to distant CCSNe.

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