Eur. Phys. J. C (2022) 82:660
https://doi.org/10.1140/epjc/s10052-022-10602-8

THE EUROPEAN PHYSICAL JOURNAL C

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Erratum

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

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Received: 2 May 2022 / Accepted: 11 July 2022 / Published online: 1 August 2022
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Erratum to: Eur. Phys. J. C (2021) 81:1058
https://doi.org/10.1140/epjc/s10052-021-09809-y

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 $M_\odot$ 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 ($m \geq 7, N_\nu \geq 7$) 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 ($m \geq 7, N_\nu \geq 6$), 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 $N_\nu = 5$ 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 $M_\odot$ CCSNe at a distance of (407 kpc → 322 kpc).
  - Section 4.2: If $N_\nu = 7$ events with $m \geq 7$ 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 $\delta t = 1$ h, a 27 $M_\odot$ 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 $M_\odot$ CCSN using $m \geq 7$, and (300 kpc → 234 kpc) for the 9.6 $M_\odot$ 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:
  - Abstract: 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).

The original article can be found online at https://doi.org/10.1140/epjc/s10052-021-09809-y.

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

Trigger		False CCSN rate	Range (kpc)
m	N_ν	(year^{-1})	$27\,\text{M}_\odot$ ($9.6\,\text{M}_\odot$)
≥ 5	≥ 104	0.7	135 (101)
	≥ 107	< 0.01	133 (99)
≥ 6	≥ 17	0.9	245 (182)
	≥ 20	< 0.01	225 (167)
≥ 7	≥ 6	0.4	291 (216)
	≥ 7	0.01	269 (200)
≥ 8	≥ 3	0.2	275 (204)
	≥ 4	< 0.01	235 (174)

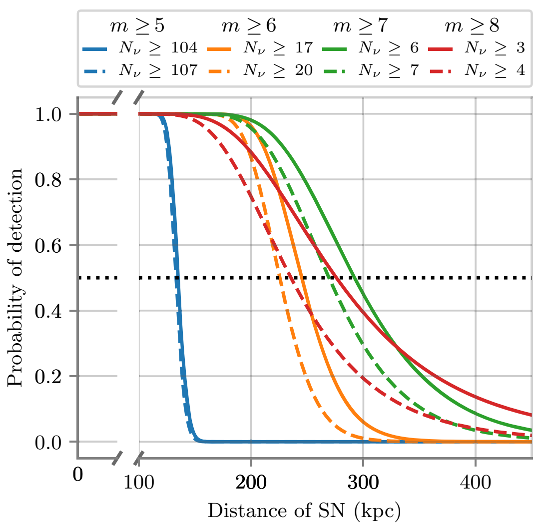

Fig. 8 Probability for the detection of a CCSN of $27\,\text{M}_\odot$ progenitor mass as a function of distance using the trigger conditions presented in Table 4

– 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 → every ∼ 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.

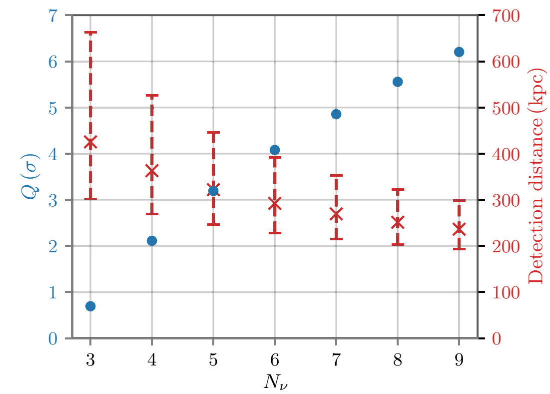

Fig. 9 Detection prospects for a CCSN whose time is known to within 1 h ($m \geq 7, \Delta t_{\text{coin}} = 20\,\text{ns}, \Delta T_{\text{SN}} = 10\,\text{s}$). Left axis: Probability in σ that the signal is not produced by background fluctuations. Right axis: Distance at which a $27\,\text{M}_\odot$ progenitor mass CCSN is detected with 10% (upper boundary), 50% (middle mark) and 90% probability (lower boundary), when at least N_ν detected events are required

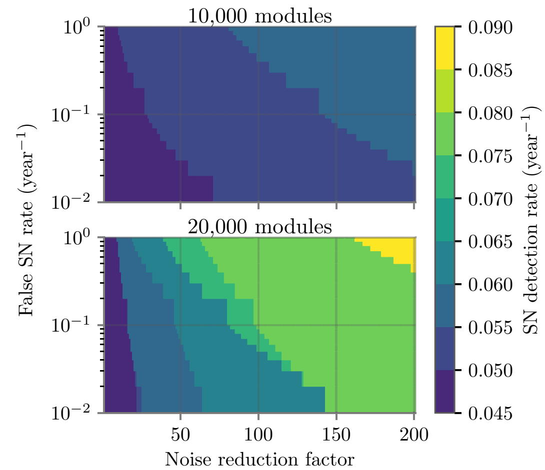

Fig. 10 CCSN detection rate for hypothetical detectors with 10,000 (upper) and 20,000 (lower) mDOMs as a function of the false SN detection rate and a reduction in radioactive noise compared to standard mDOMs. The CCSN detection rates have been calculated using the estimated CCSNe population from [16] based on actual observations and scaled to the star formation rate

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Funded by SCOAP^3. SCOAP^3 supports the goals of the International Year of Basic Sciences for Sustainable Development.