On-line Supplementary

Superradiant MeV γ scattered by a room-temperature spinor quantum fluid

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Evaluation of the fluctuations in Fig. 5

Fluctuations of the ^{182}Ta decay and three broad-band γs, i.e., BBL ranging from 275 keV to 660 keV, BBM ranging from 663 keV to 1120 keV and BBH ranging from 1130 keV to 1400 keV as presented in Figures S2(F), S2(G) and S2(H), are calculated in the following way. The calibrated baselines $Baseline(i,j) = C_j exp(-t_i \times ln2/T)$, *where* t_i *is the time span between the calibration time of day -2 and the* i^{th} *measuring time,* C_j *are the calibrated counts at day -2, and j=1 for Ta, j=2 for BBL, j=3 for BBM, j=4 for BBH. T = 118.3 $\pm$ 0.3 d is the calibrated half-life of ^{182}Ta superradiance without applying the M4 γ @662 keV between day -2 and day 106, which is slower than normal by 4%. Figure 5 shows the time sequences of* $Ta(i) - Base(i,1)$, $BBL(i) - Base(i,2)$, $BBM(i) - Base(i,3)$, *and* $BBH(i) - Base(i,4)$, *the background decay of ^{182}Ta in which is then removed.*

Supplementary Figures

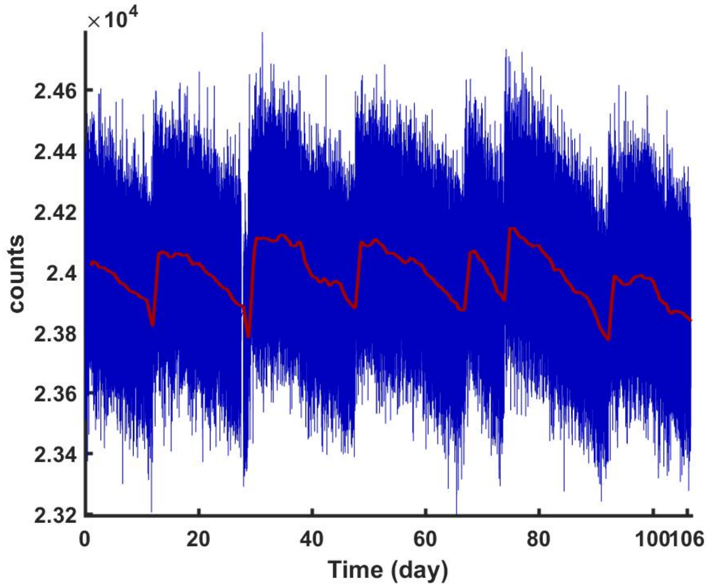

Figure S1: Raw data (blue) of superradiance with 2.5-mCi ^{137}Cs at the position of (0.3 cm, 90°), which is the first monitoring experiment. Data were obtained every 60 s, while the storing of data took ~0.25 s. The red line incorporates daily smoothing of the raw data.

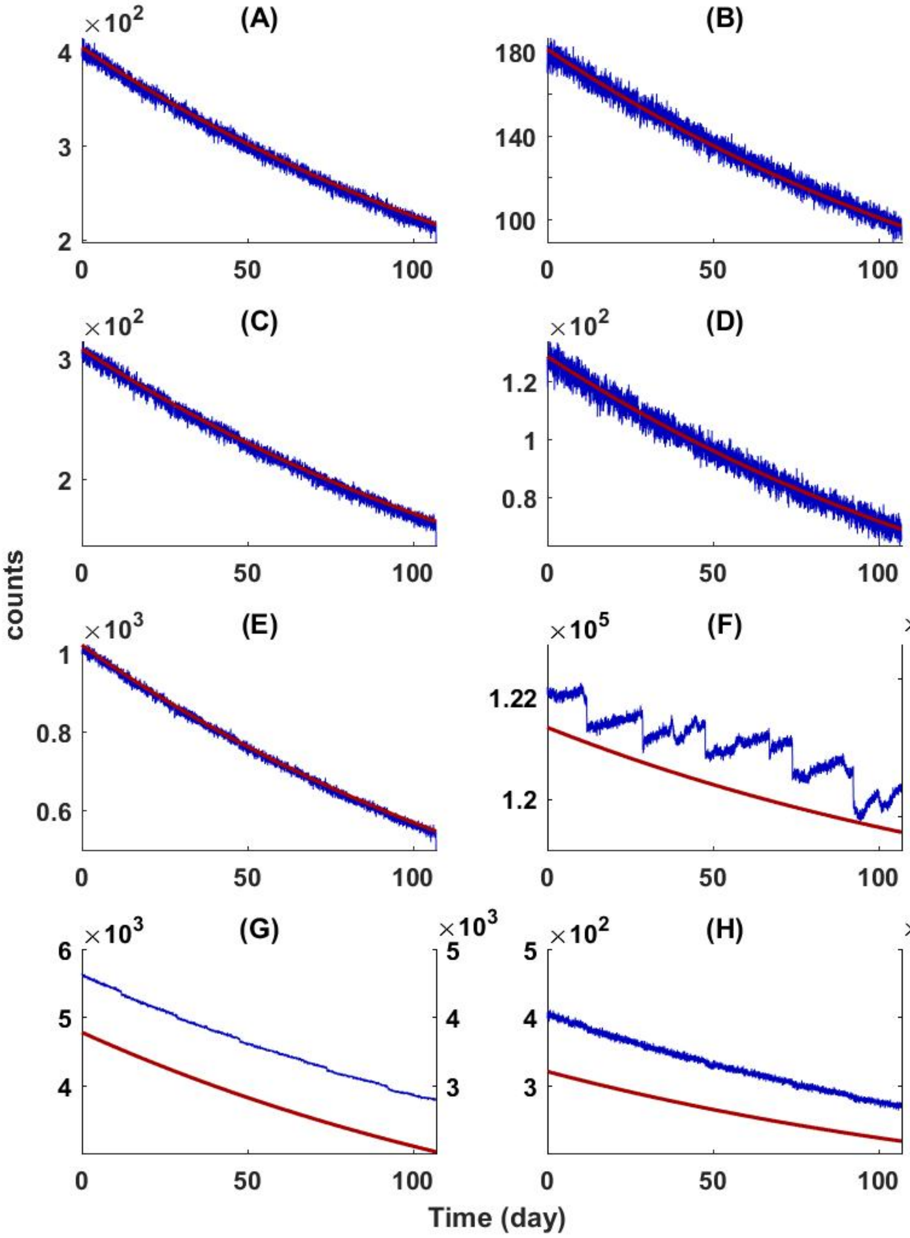

Figure S2: γ counts of the first monitoring experiment in Fig. S1 (using left axis). (A) M1+E2 γ counts @1121keV (34.9%) emitted from the ^{182}Ta decay; (B) E1+M2+E3 γ counts @1189keV (16.2%) emitted from the ^{182}Ta decay; (C) E2 γ counts @ 1221keV (27.0%) emitted from the ^{182}Ta decay; (D) M1+E2 γ counts @1231keV (11.4%) emitted from the ^{182}Ta decay; (E) The summation of 4 former γ counts to present the decay of ^{182}Ta; (F): Broad-band γ counts BBL collected between 275 keV and 660 keV; (G): Broad-band γ counts BBM collected between 663 keV and 1120 keV; (H) Broad-band γ counts BBH collected between 1.12 MeV and 1.4 MeV. The time sequence of data was γ counts per minute from day 0 to day 106, while the presentation incorporates hourly smoothing (61 data), as for Fig 4. Calibrated baselines to be removed in Fig. 5 are also shown in red, which use the right axis except (A)-(E).

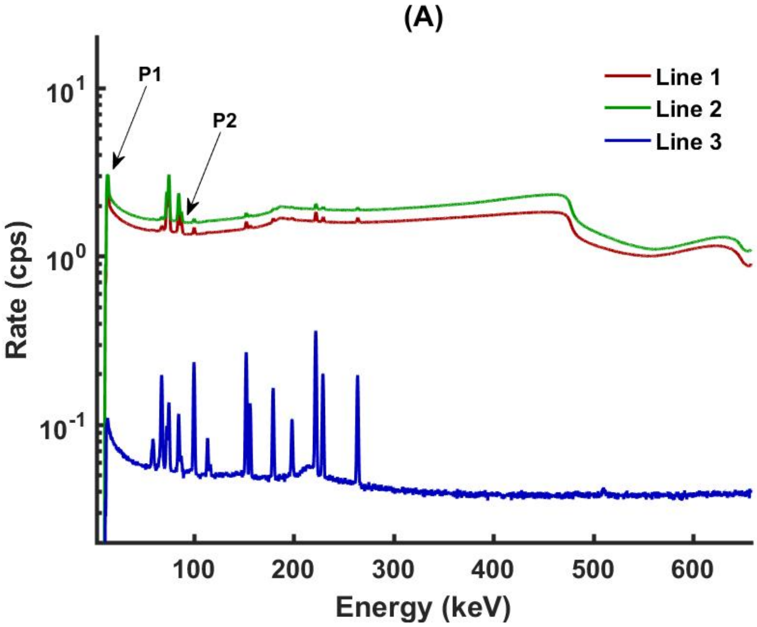

Figure S3 (A): Three spectra below the energy of 662 keV in counts per second (cps). Line 1: spectrum accumulated from the whole of the data in Fig. S1; Line 2: spectrum accumulated from the whole of the data in Fig. S5; Line 3: spectrum of calibration at day -2. There are two bumps located at 630 keV and 470 keV, the intensities of which depend on the intensity of 662 keV. P1 peaks are Pb L-lines and P2 peaks are Pb K-lines.

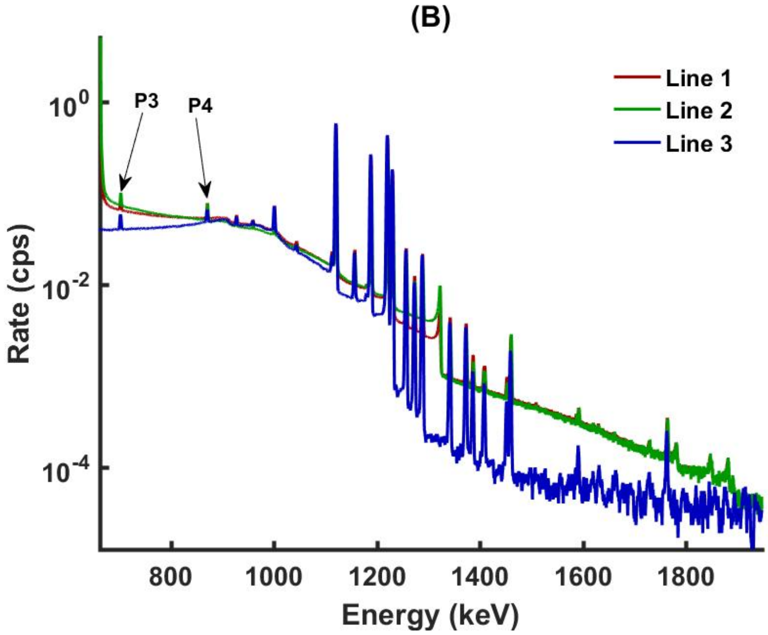

Figure S3: (B) Three spectra above the energy of 662 keV. Line 1: spectrum accumulated from the whole of the data in Fig. S1; Line 2: spectrum accumulated from the whole of the data in Fig. S5; Line 3: spectrum of calibration at day -2. We found that the high-energy γ peaks of the ^{182}Ta decay moved several keV to the high-energy side depending on the 662-keV intensity, as next shown. The dead time of line 1 and line 2 were 6% and 7%, respectively. For example, the location of 1121-keV peak increased $\sim$ 0.5 keV at line 1 and $\sim$ 1 keV at line 2, as shown in Fig. S3D. P3 and P4 peaks are γs from the ^{94}Nb decay.

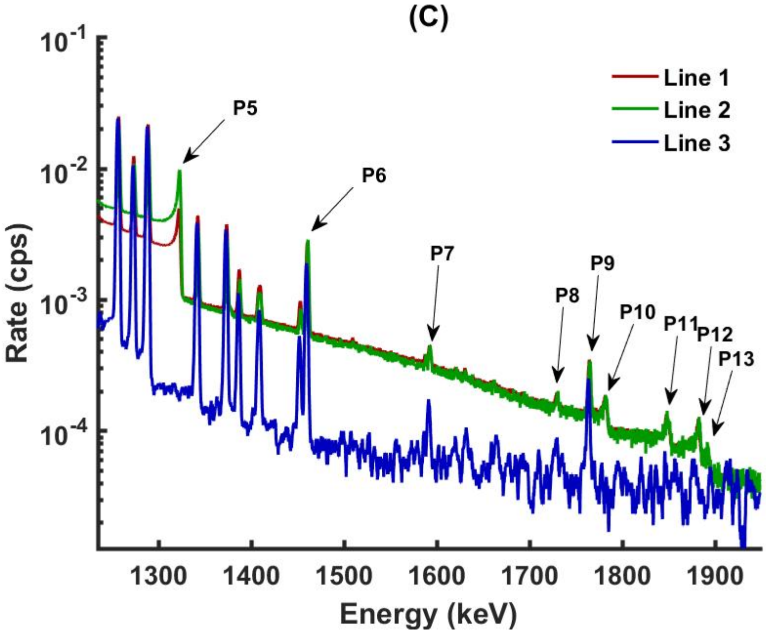

Figure S3(C): Three spectra above the energy of 1.2 MeV. Line 1: spectrum accumulated from the whole of the data in Fig. S1; Line 2: spectrum accumulated from the whole of the data in Fig. S5; Line 3: spectrum of calibration at day -2. Line 3 incorporates smoothing of 11 data points. P5 peak @ 1324 keV is the coincident arrival of two 662-keV γs, while P10-P13 peaks are the coincident arrivals of one 662-keV γ and one ^{182}Ta γ, i.e., 1121, 1189, 1221, 1231 keV. P7 @1592 keV and P9 @1766 keV are emitted from two ^{94}Mo states of $J^{\pi} = 6^{+}$ @3166 keV and 3340 keV, the β transitions to which from a virtual ^{94}Nb state of $J^{\pi} = 6^{+}$ with a Q_{β} of 2045 keV by a Raman pumping energy > 1295 keV is allowed. However, the pumping energy must be much higher than 1295 keV in order to increase the transition probability. Therefore, it must be a hyper-Raman process to provide the sufficient energy without exchanging the l-quantum. Two unknown peaks are P6 @1460 keV and P8 @1730 keV.

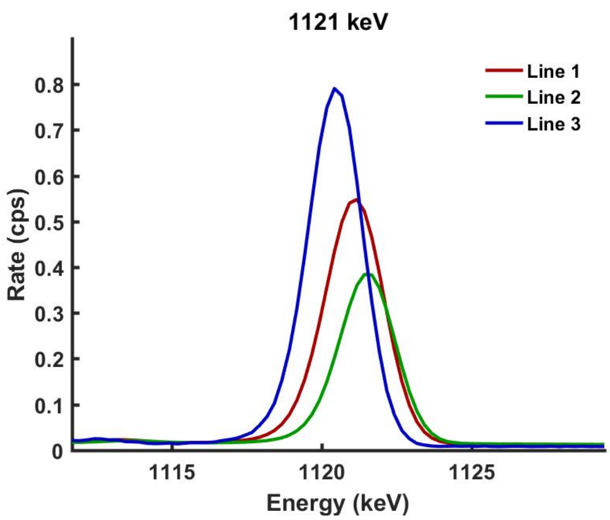

Figure S3(D): Shifts of the ^{182}Ta γ @1121 keV regarding the impinging 662-keV γ. Line 1: peak accumulated from the whole of the data in Fig. S1; Line 2: peak accumulated from the whole of the data in Fig. S5; Line 3: peak of calibration at day -2.

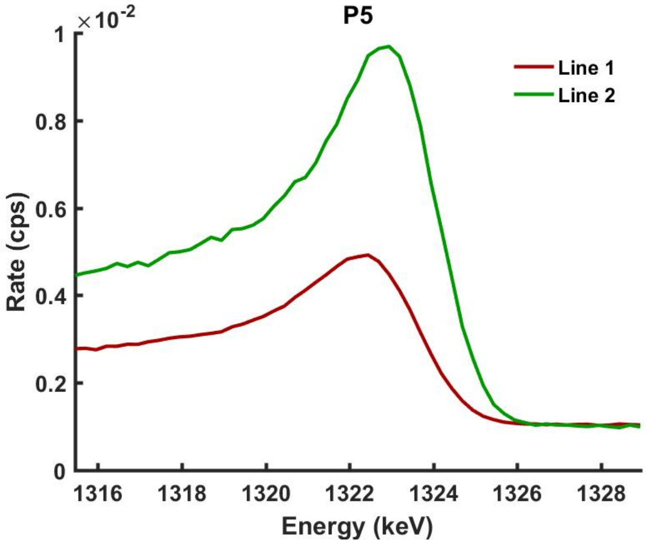

Figure S3(E): Shifts of the P5 @1324 keV, which is coincident arrival of two 662-keV γs. Line 1: peak accumulated from the whole of the data in Fig. S1; Line 2: peak accumulated from the whole of the data in Fig. S5.

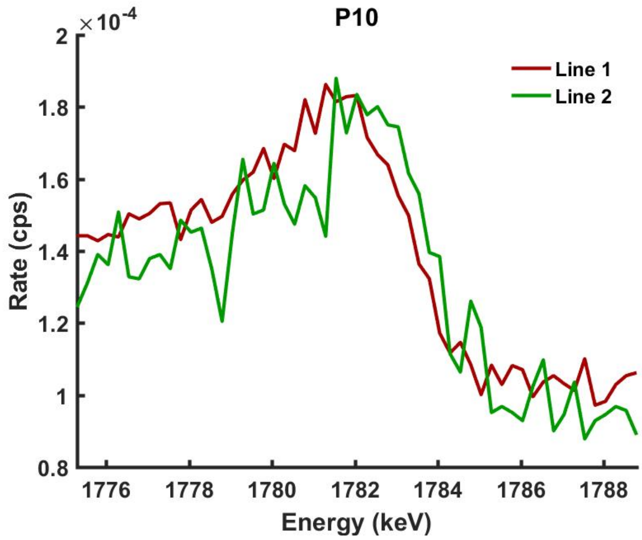

Figure S3(F): Shifts of the P10 @1783 keV, which is coincident arrival of 662-keV and 1121-keV γs. Line 1: peak accumulated from the whole of the data in Fig. 4; Line 2: peak accumulated from the whole of the data in Fig. S5.

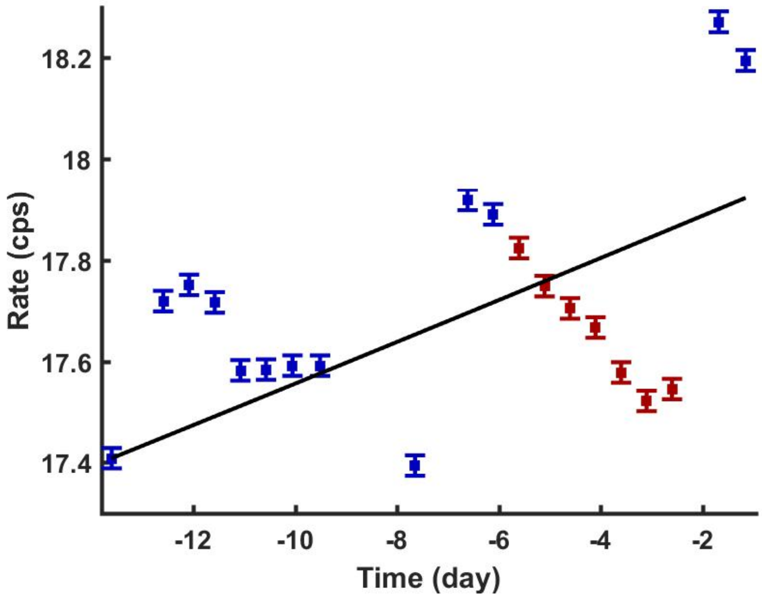

Figure S4: ^{182} Ta γ count rates of two θ-dependence measurements taken for half sidereal day using two disk sources of 10-μCi ^{137}Cs with r = 2.7 cm from day -13 to day -2. Their normal vectors of two disk sources were in the z direction (red) and in the θ direction (blue) directions. The growth gave a negative half-life of 296 $\pm$ 1 d.

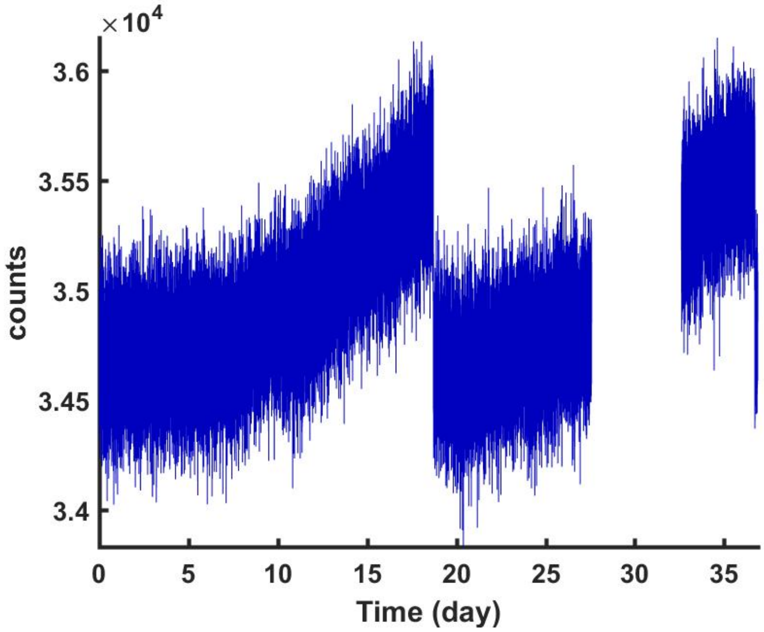

Figure S5: Raw data of superradiance with 2.5-mCi ^{137}Cs at the position of (0.3 cm, 270°), which is the second monitoring experiment. Data were obtained every 60 s, while the storing of data took ~ 0.25 s.

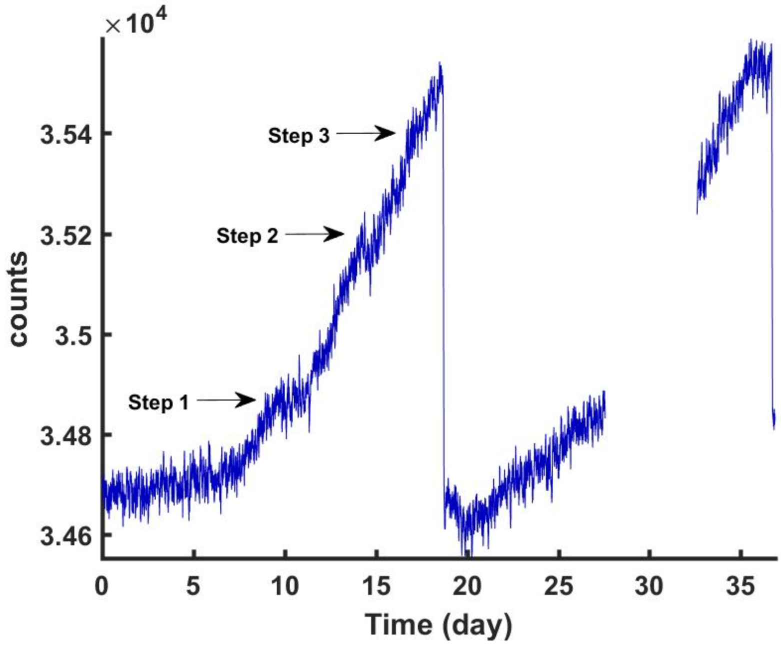

Figure S6: Data in Fig. S5 incorporating the hourly smoothing (61 data). Three quantized hopping steps before the Sisyphus fall at day 18 are highlighted.

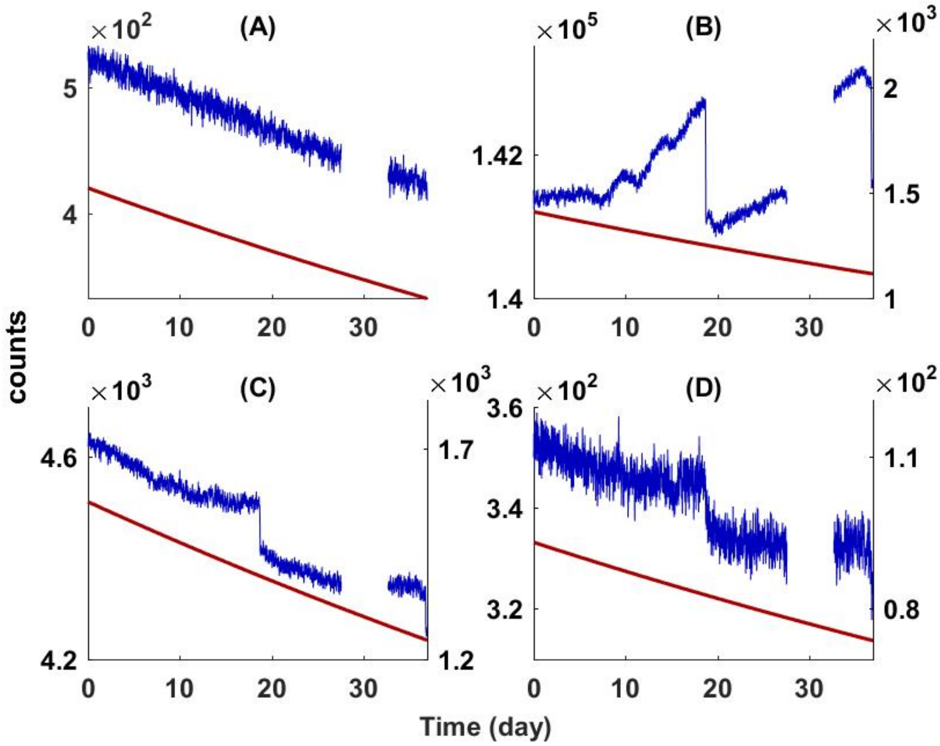

Figure S7: γ counts of the second monitoring experiment (using the left axis). (A) Ta γ counts, as presented in Fig. S2(E); (B) BBL γ counts, as presented in Fig. S2(F); (C) BBM γ counts, as presented in Fig. S2(G) (D) BBH γ counts, as presented in Fig. S2(H). Baselines in red use the right axis, except (A).