Monte Carlo simulation of the experiment MAMBO I and possible correction of neutron lifetime result

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Introduction

1. W.Mampe et al., Phys. Rev. Lett. 63, 593 (1989)
2. W.Mampe et al., Nucl. Instr. and Meth. A 284, 111 (1989)

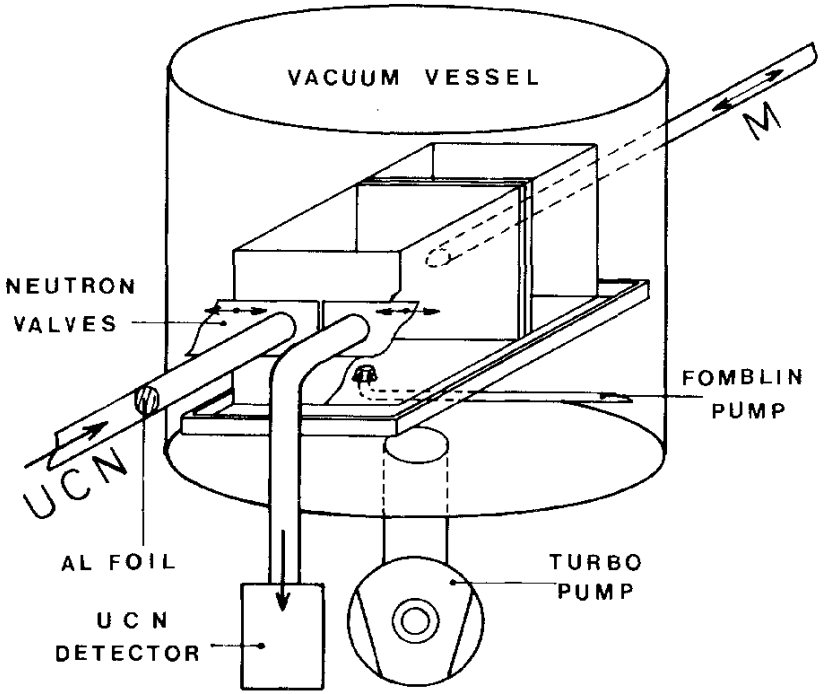
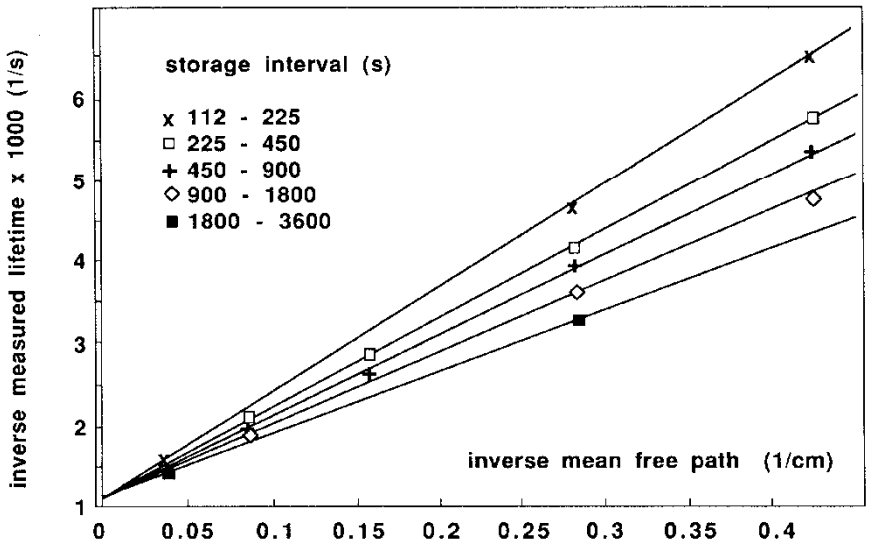


FIG. 1. Sketch of the apparatus.



Results of the experiment

TABLE I. Results of τ_β for different storage intervals.

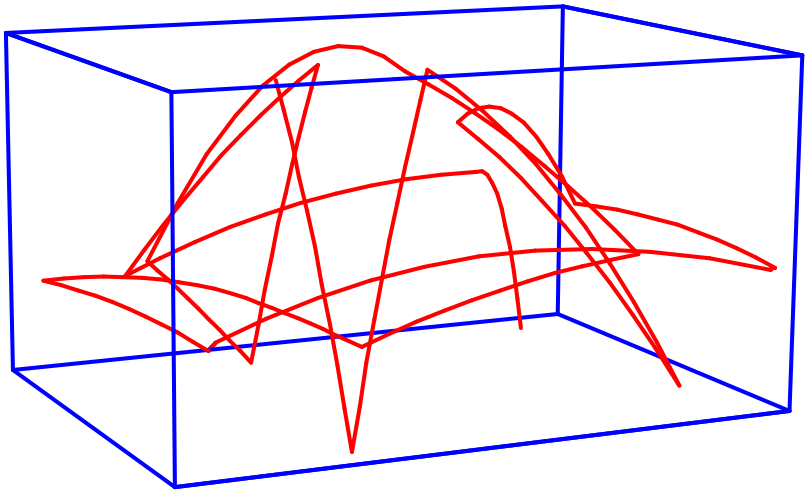
Storage interval (s)	τ_β uncorrected (s)	$\Delta\tau$ correction (s)	τ_β corrected (s)
112–225	893(10)	~ -2	891(10)
225–450	885.0(4)	+3.5	888.5(4)
450–900	881.2(2.5)	+8	889.2(2.5)
900–1800	878.0(1.5)	+9	887.0(1.5)
1800–3600	878.5(2.6)	+8.6	887.1(2.6)

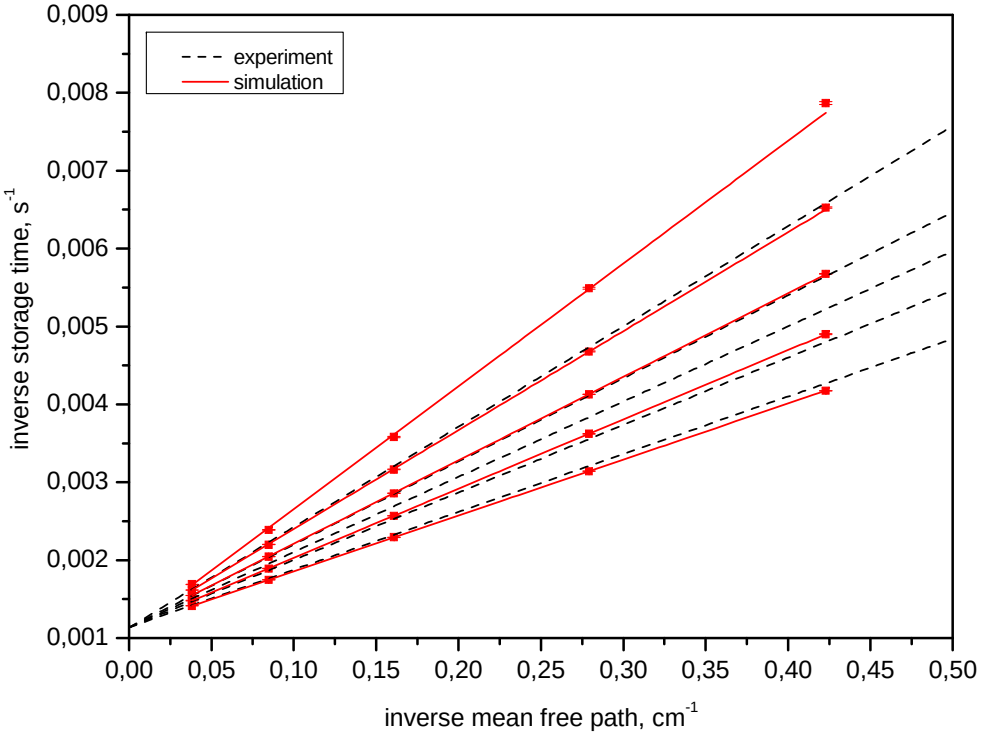
887.6(1.1)

$\tau_n = 887.6 \pm 3$ s

2 corrections made:
1. gravitational correction ~+0.6%
2. filling correction ~+0.3%

MC simulation





MC simulation was performed at the following computing clusters:

1. PNPI ITAD cluster
2. PNPI PC Farm

Quasi-elastic scattering of UCN

S.K.Lamoreaux et al., Phys. Rev. C 66, 044309 (2002)
S.K.Lamoreaux et al., nucl-ex/0612004v3

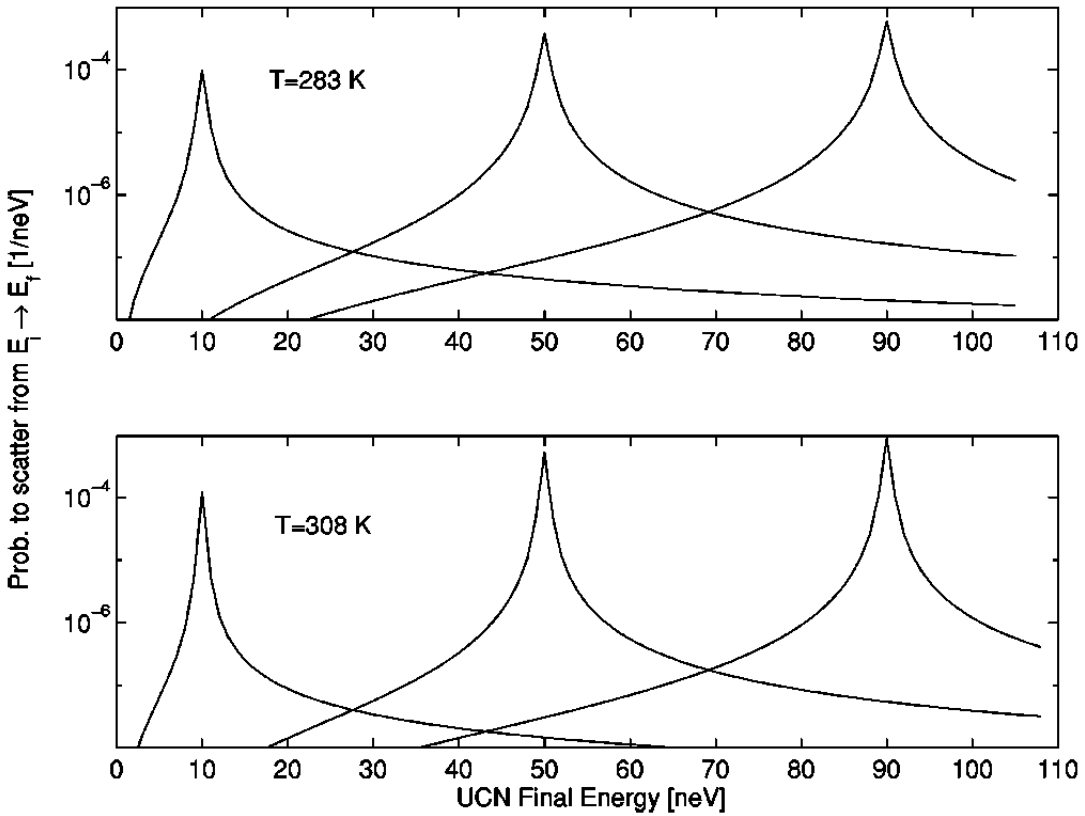


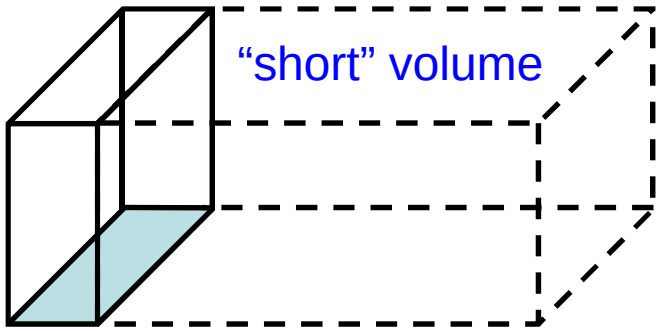
FIG. 13. The probability for UCN to upscatter or downscatter, per neV final energy, for three different UCN initial energies. These results are similar to those presented in [9,10].

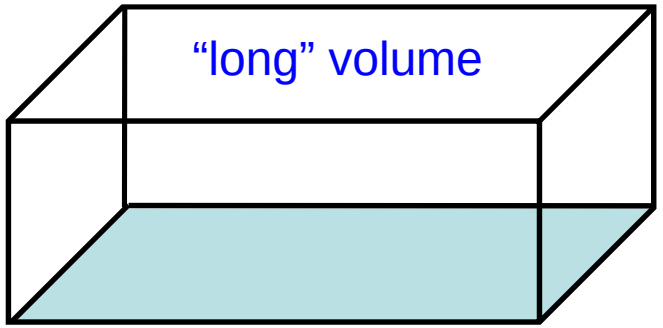
$$P(E_i \to E_f)\delta E_f = E_i(\alpha_1 e^{-\beta_1|E_i-E_f|} + \alpha_2 e^{-\beta_2\sqrt{|E_i-E_f|}})\delta E_f$$

$$\alpha_1 = 10^{-8}\ \text{cm}^{-1},\ \beta_1 = 0.065\ \text{cm}^{-1},\ \alpha_2 = 10^{-5}\ \text{cm}^{-5},\ \beta_2 = 2\ \text{cm}^{-0.5}\ \text{(T=283 K)}$$

Features of storage in different volumes

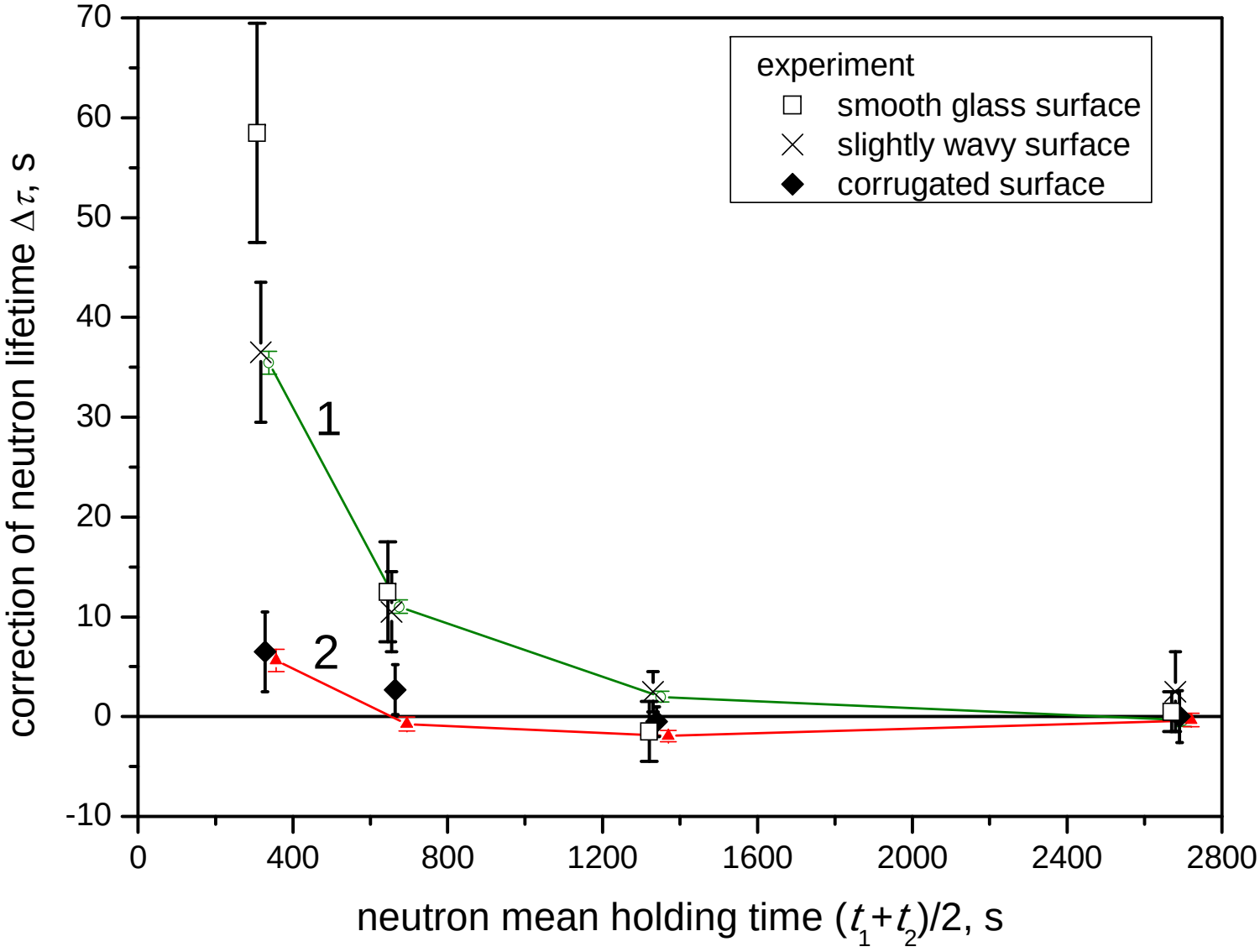
scaling: $\frac{t_2(i)}{t_2(j)} = \frac{t_1(i)}{t_1(j)} = \frac{\lambda(i)}{\lambda(j)} = \frac{t_2(i) - t_1(i)}{t_2(j) - t_1(j)}$



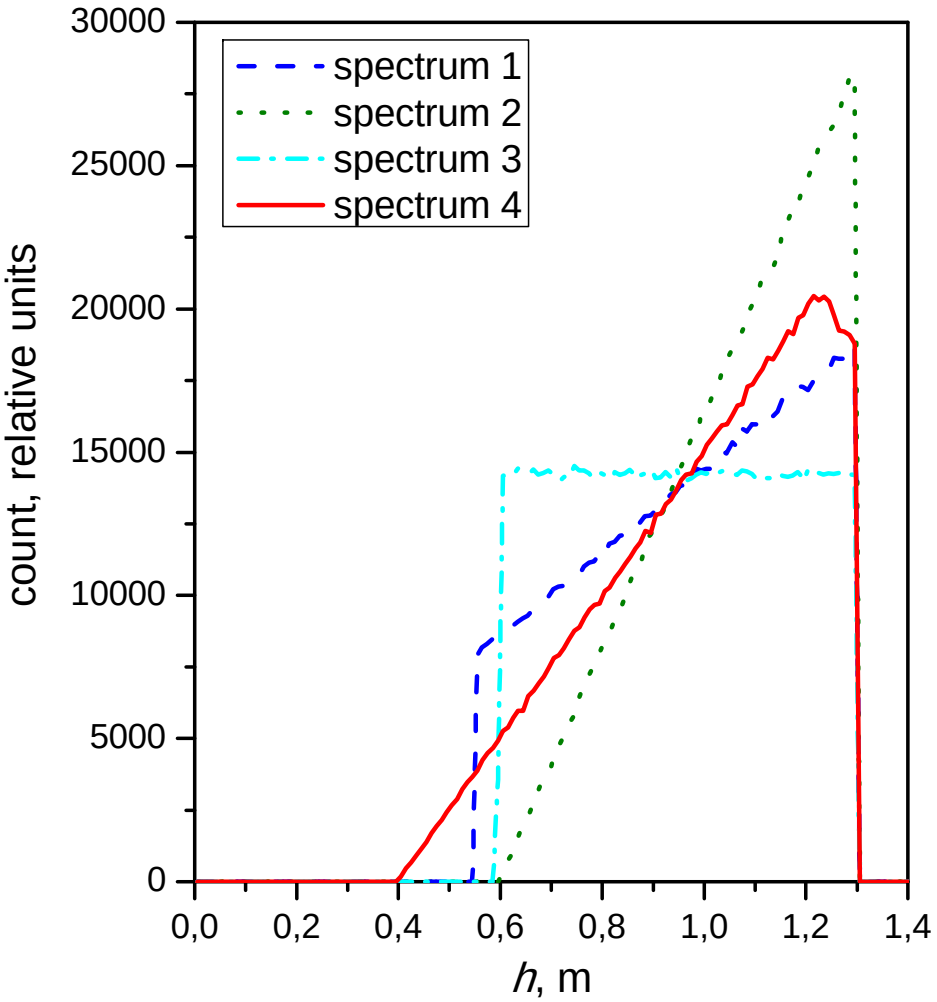


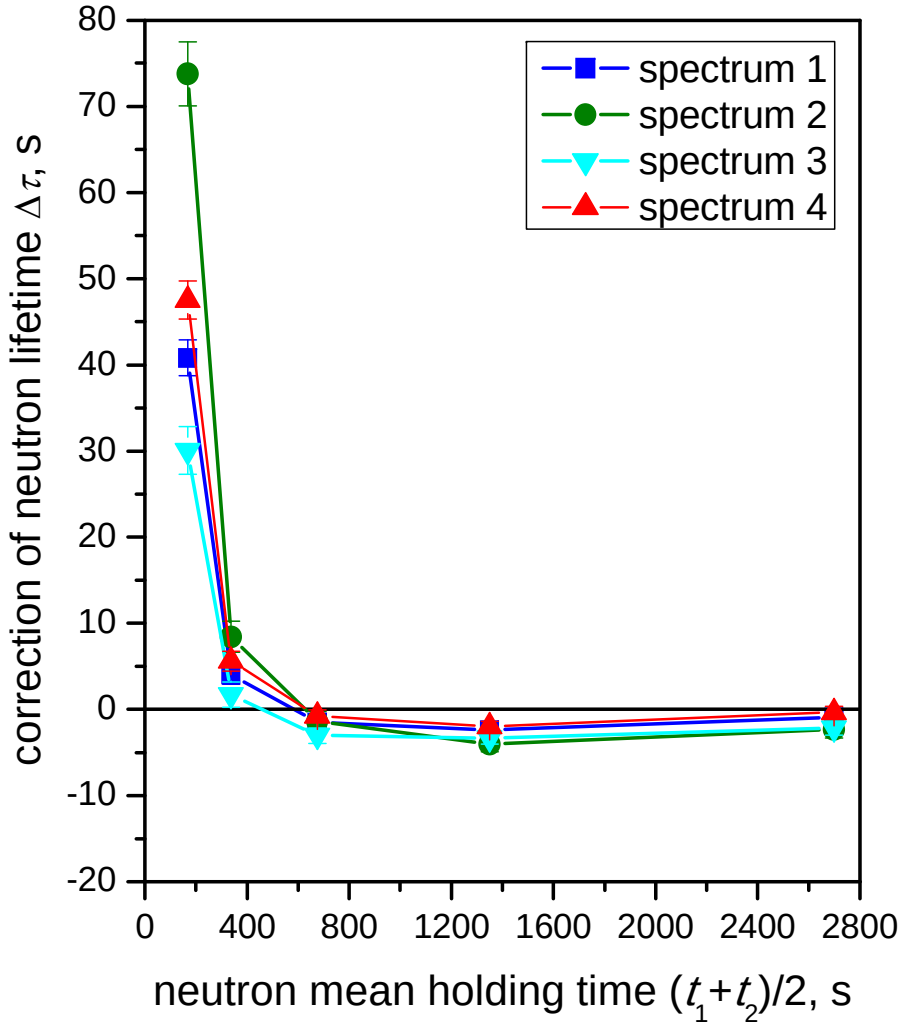
1) losses are more in “long” volume
2) cleaning is slower in “short” volume

Comparison with the experiment

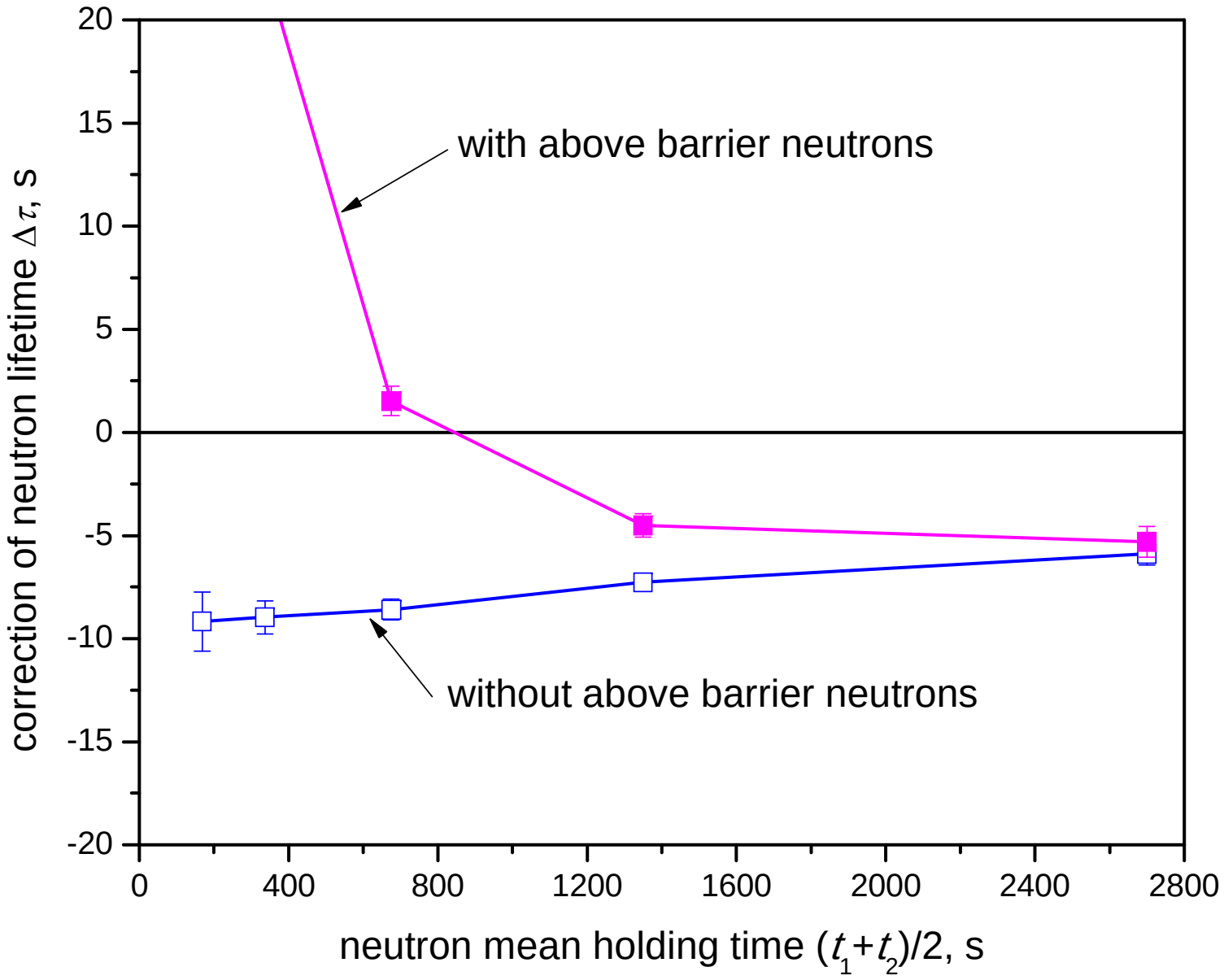


Results of the simulations with different initial UCN spectrums in the trap

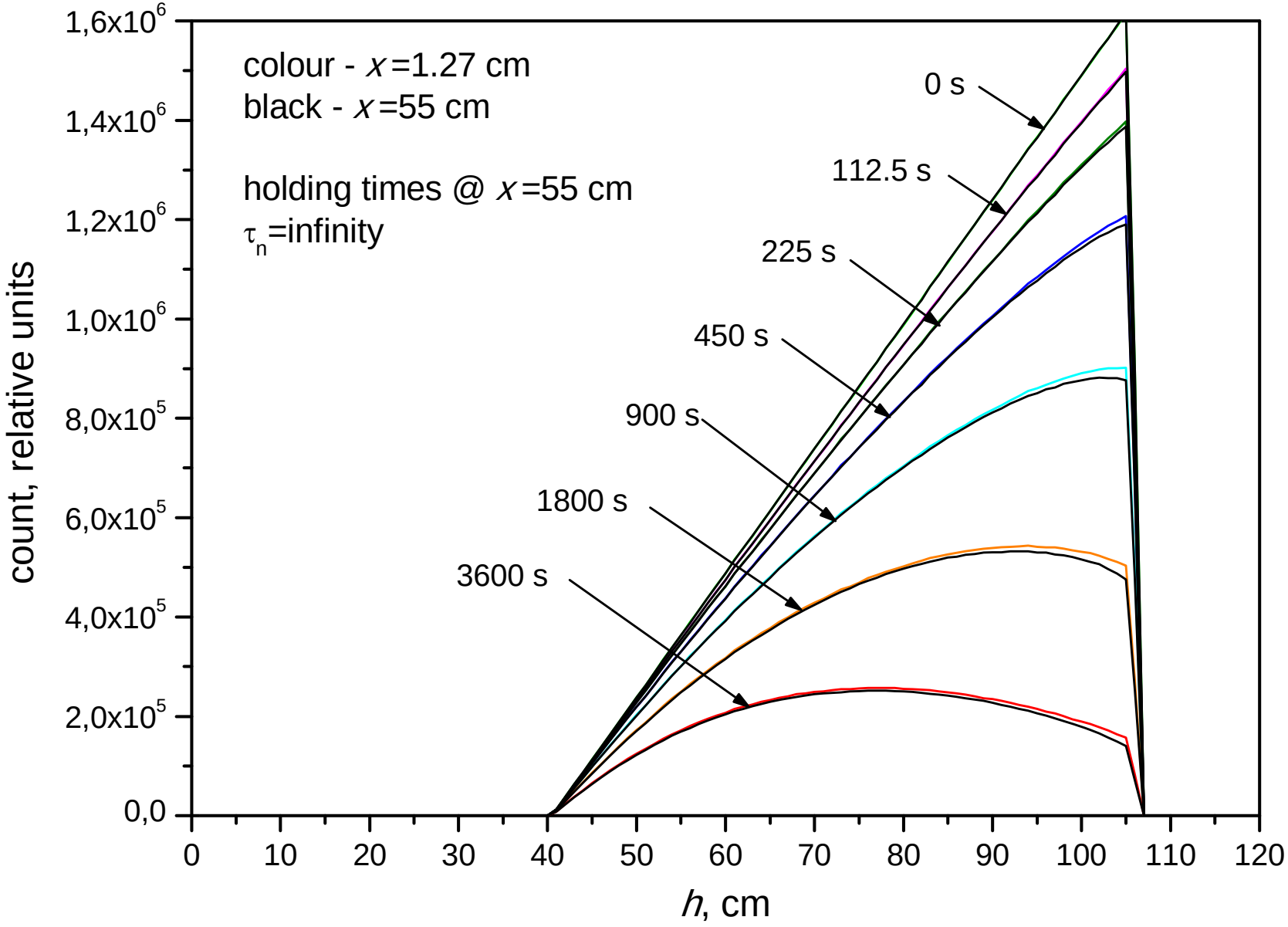




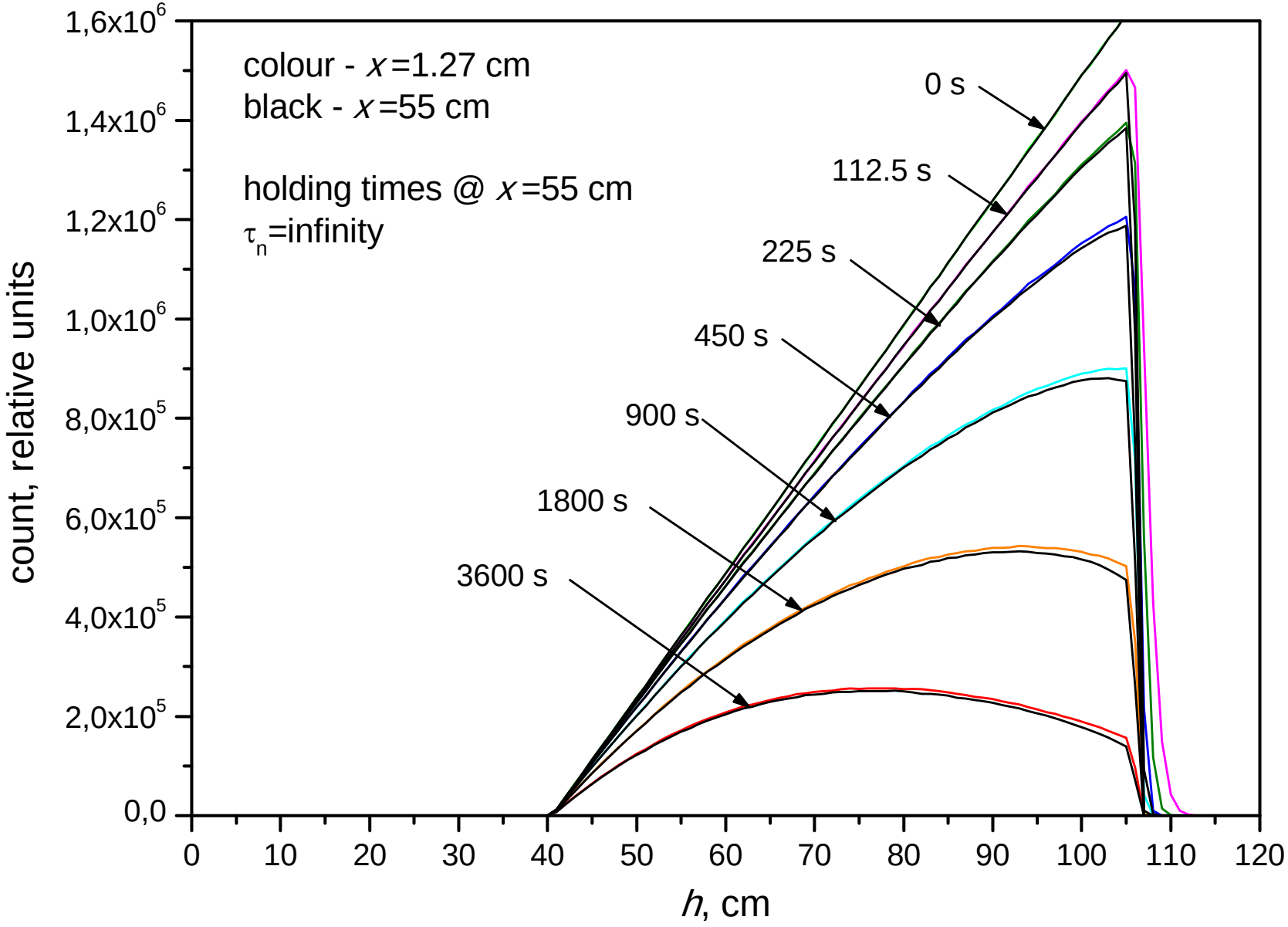
Δτ for the case without quasi-elastic scattering



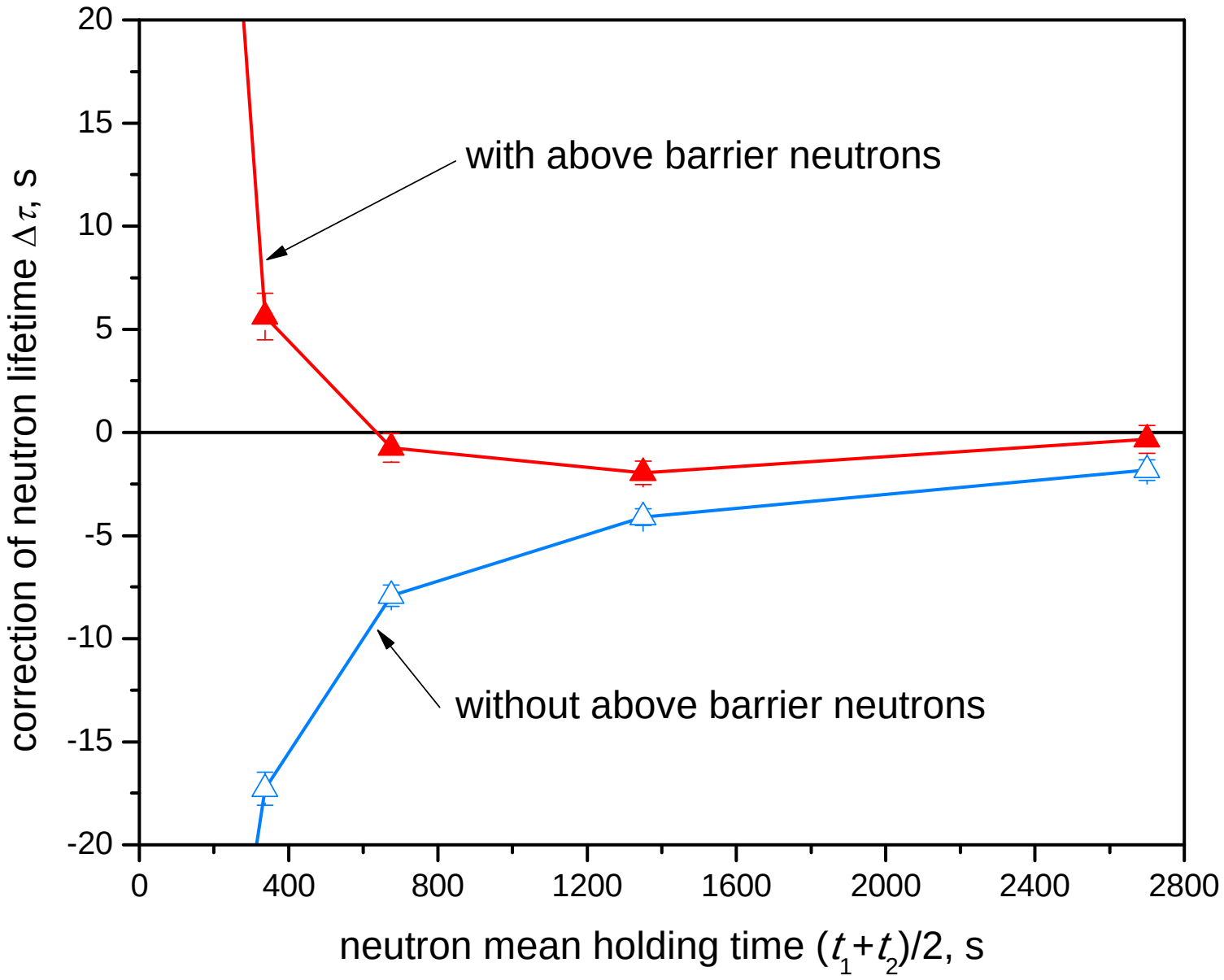
Spectrum for the case without quasi-elastic scattering and without above barrier neutrons



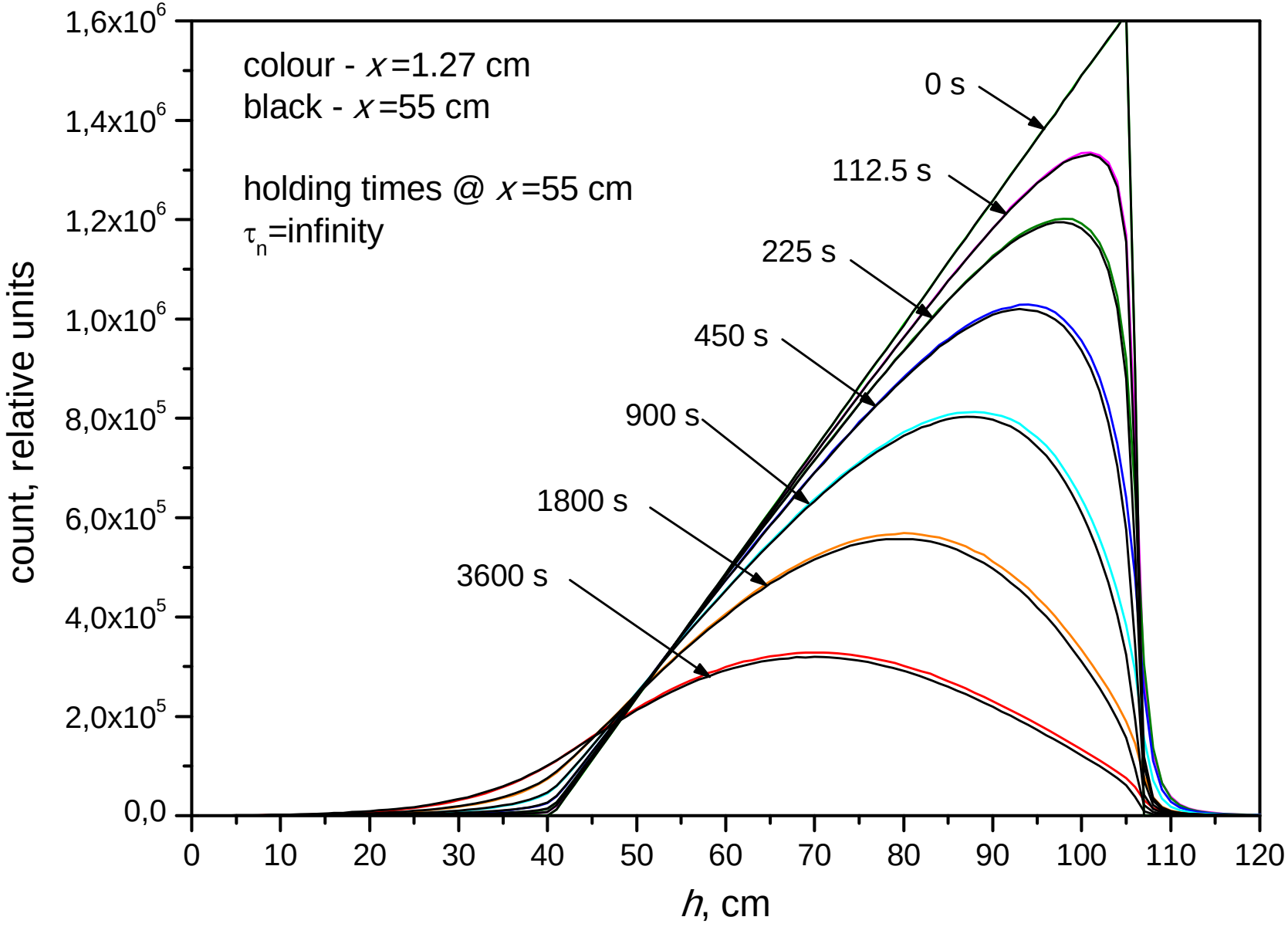
Spectrum for the case without quasi-elastic scattering and with above barrier neutrons



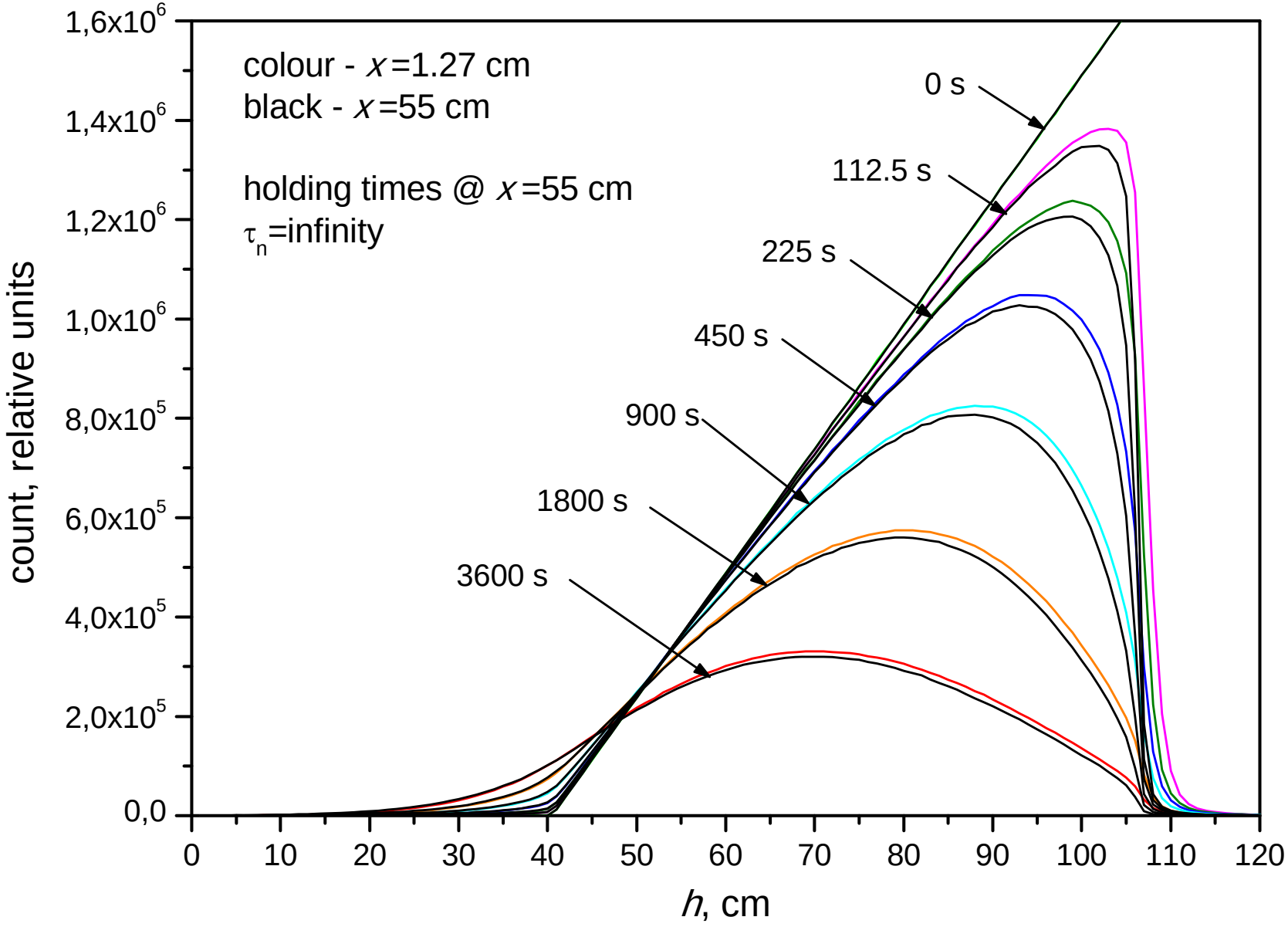
$\Delta\tau$ for the case with quasi-elastic scattering



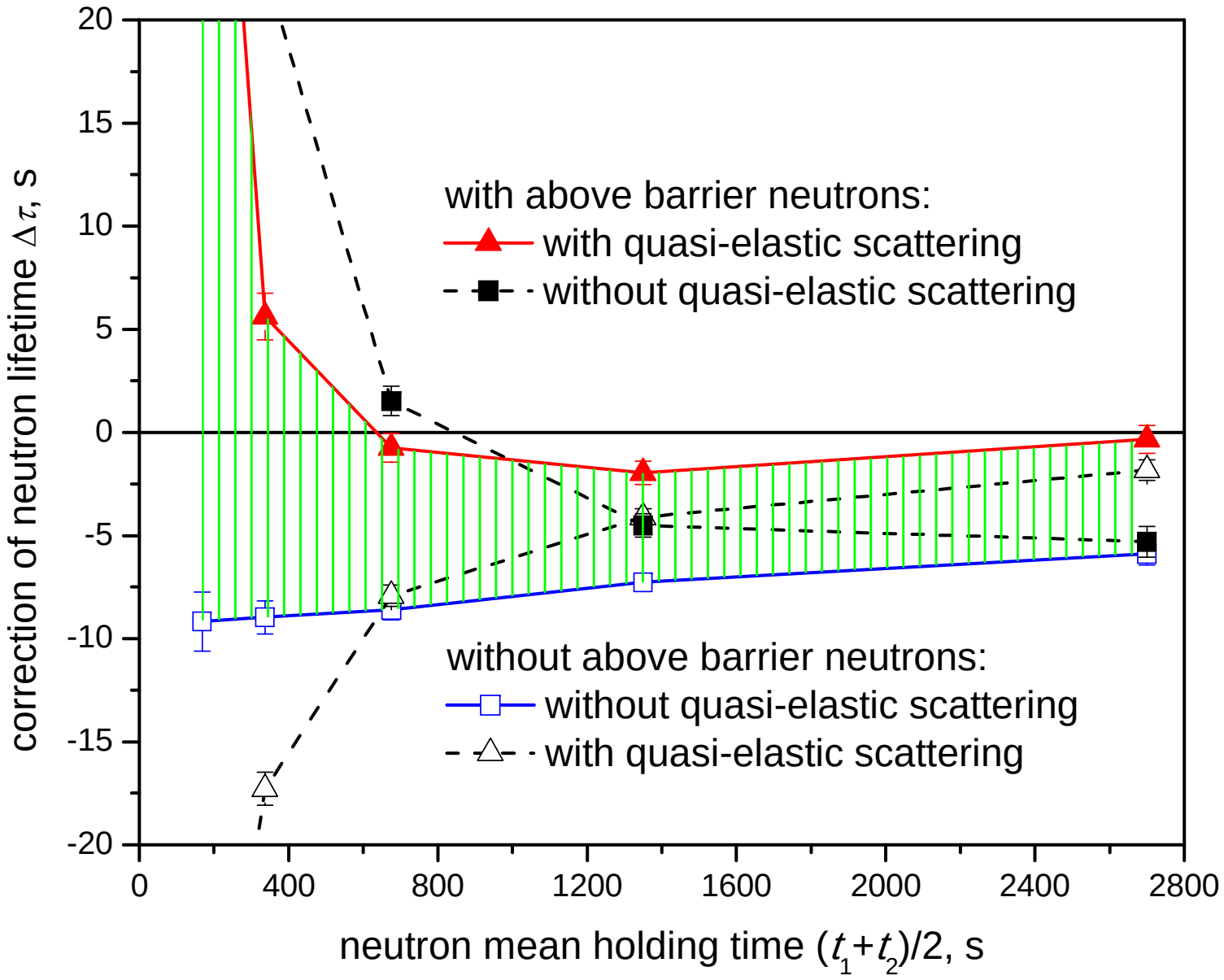
Spectrum for the case with quasi-elastic scattering and without above barrier neutrons



Spectrum for the case with quasi-elastic scattering and with above barrier neutrons



New corrections for experiment MAMBO I due to above barrier neutrons and quasi-elastic scattering



New corrections for experiment MAMBO I due to above barrier neutrons and quasi-elastic scattering

storage interval, s	τ_n, s	$\Delta\tau_n$, s	τ_n', s
112.5-225	891(10)	-56.68 (2.63)	834.32 (10.34)
225-450	888.5(4)	-14.58 (1.39)	873.92 (4.23)
450-900	889.2(2.5)	-7.84 (0.87)	881.36 (2.65)
900-1800	887.0(1.5)	-5.29 (0.70)	881.71 (1.65)
1800-3600	887.1(2.6)	-5.54 (0.87)	881.56 (2.74)

887.6(1.1) ⟹ 880.4(1.2)

τ_n=880.4 ± 3.0 s

Correction of result by -7.2±1.6 s

Conclusion

The Monte Carlo simulation of the experiment MAMBO I shows that the result of this experiment can be corrected and instead of the previous result 887.6 ± 3 s the new result 880.4 ± 3 s could be claimed.