1. Introduction

The macroscopic receptor current in the photoreceptor of *Limulus* ventral nerve consists of three distinct components [1]. The current-time integral of the first component (C_1) is a linear, but that of the second component (C_2) is a supralinear function of the light intensity [2,3]. Two types of single photon evoked currents (so called quantum “bumps“, c_1 and c_2) have been identified, which form the corresponding C_1 and C_2 macroscopic current components [4].

These results would imply that the number of c_1- and c_2-bumps increases as a linear and a supralinear function of light intensity, respectively. We studied this property by measuring the light-intensity dependence of the number of the two bump types separately at low intensities.

2. Methods

Voltage-clamp experiments were performed with *Limulus* ventral nerve photoreceptors. Short flashes, evoking one bump per flash on average at the lowest intensity, were applied every 40 s (1-20 $\cdot 10^6$ photons/cm^2; λ=538nm). Separation of the bump types could be achieved by setting a threshold for the normalized rise time t_r* (**Fig. 1**).

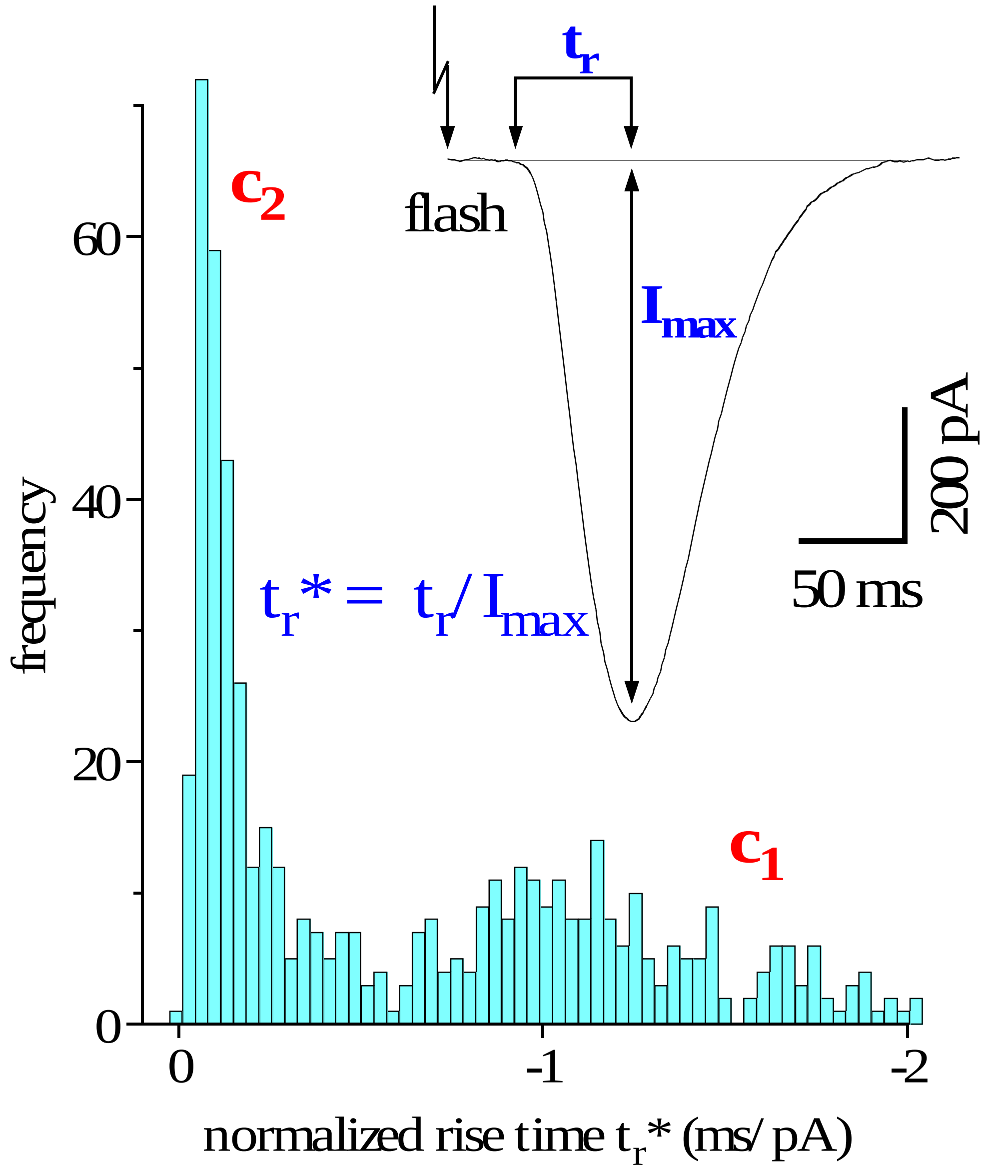

Figure 1: Separation of distinct bump-types. **Inset:** Demonstration of some bump parameters on an original bump.

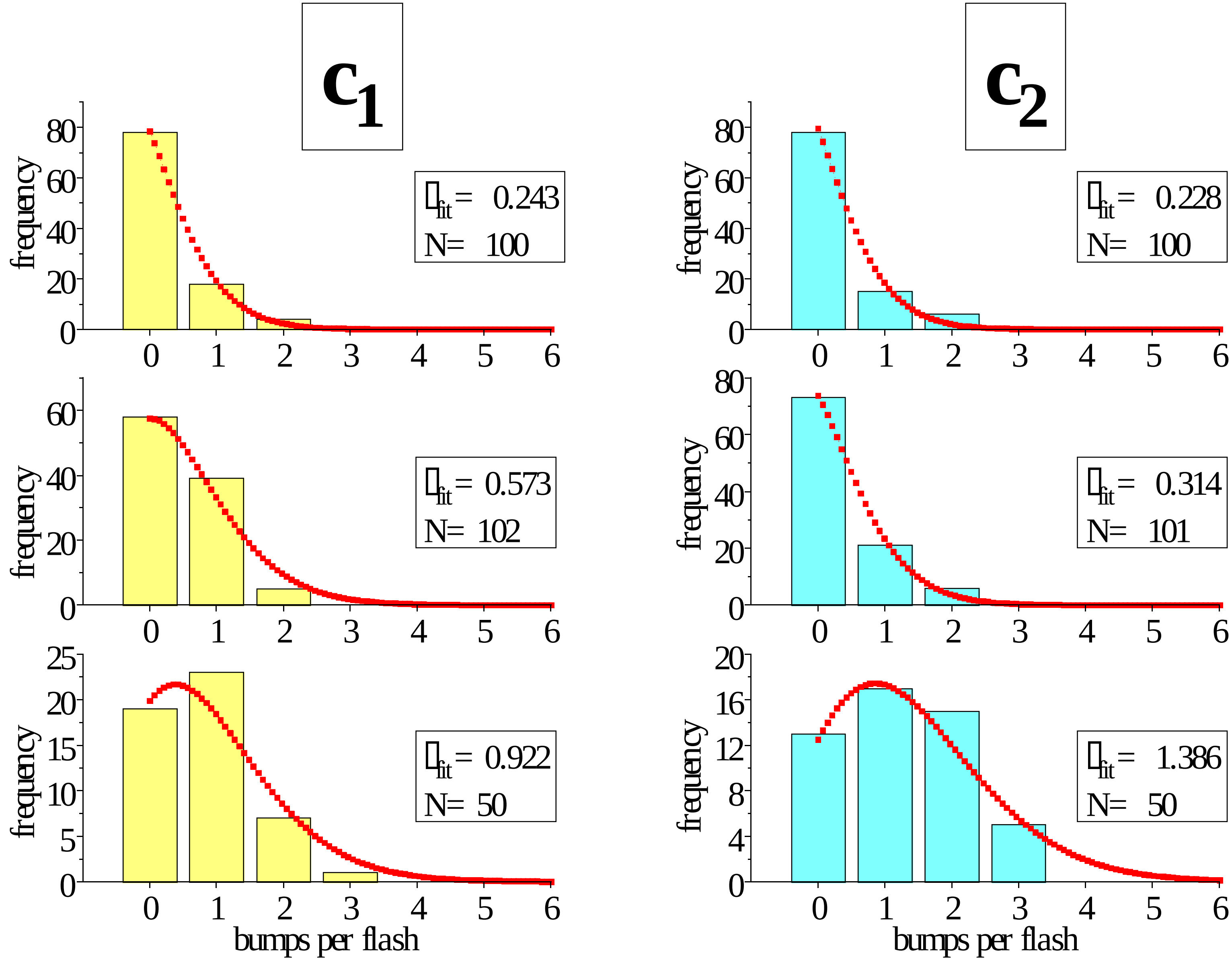

Figure 2. The number of bumps per flash obeys a Poisson distribution.

3. Results

Fig. 2 shows histograms for the two bump-types, giving the number of bumps per flash for three light-intensities. The light intensity for the lower histograms was 10-fold of that of used for the upper ones (red arrow shows the intensity increase). Least-square-fits to the data (red squares) resulted in good agreement with a Poisson distribution (χ^2-test, 5% level of significance).

From the Poisson distribution one can conclude that c_1-bumps as well as c_2-bumps are independent of each other.

4. LIGHT INTENSITYDEPENDENCE OF BUMPS

The average number of c_1- and c_2-bumps evoked by flashes of different light intensities were calculated after separation. The numbers were corrected for spontaneously occurring bumps. The apparent number of bumps for overlapping multiple bumps were analysed by dividing the total current-time integral of overlapped bumps by the mean current-time integral of single bumps.

Fig. 3 demonstrates that the average number of bumps per flash was proportional to the applied light intensity for both types of bumps. Plots on log-log scale (**Fig. 4**) revealed linear correlations with slopes close to one.

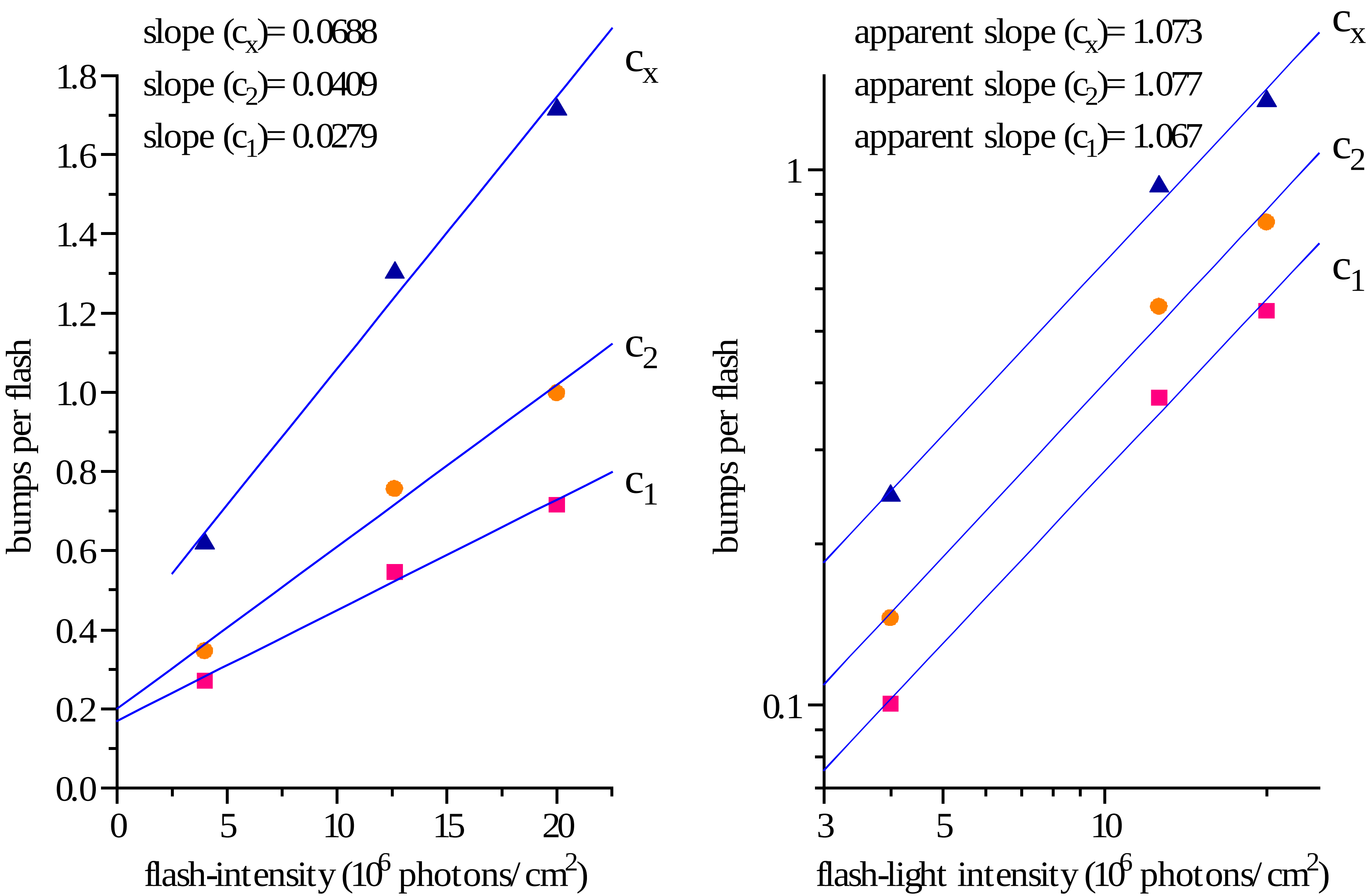

Figure 3: The light intensity dependencies of both types of bumps are linear.

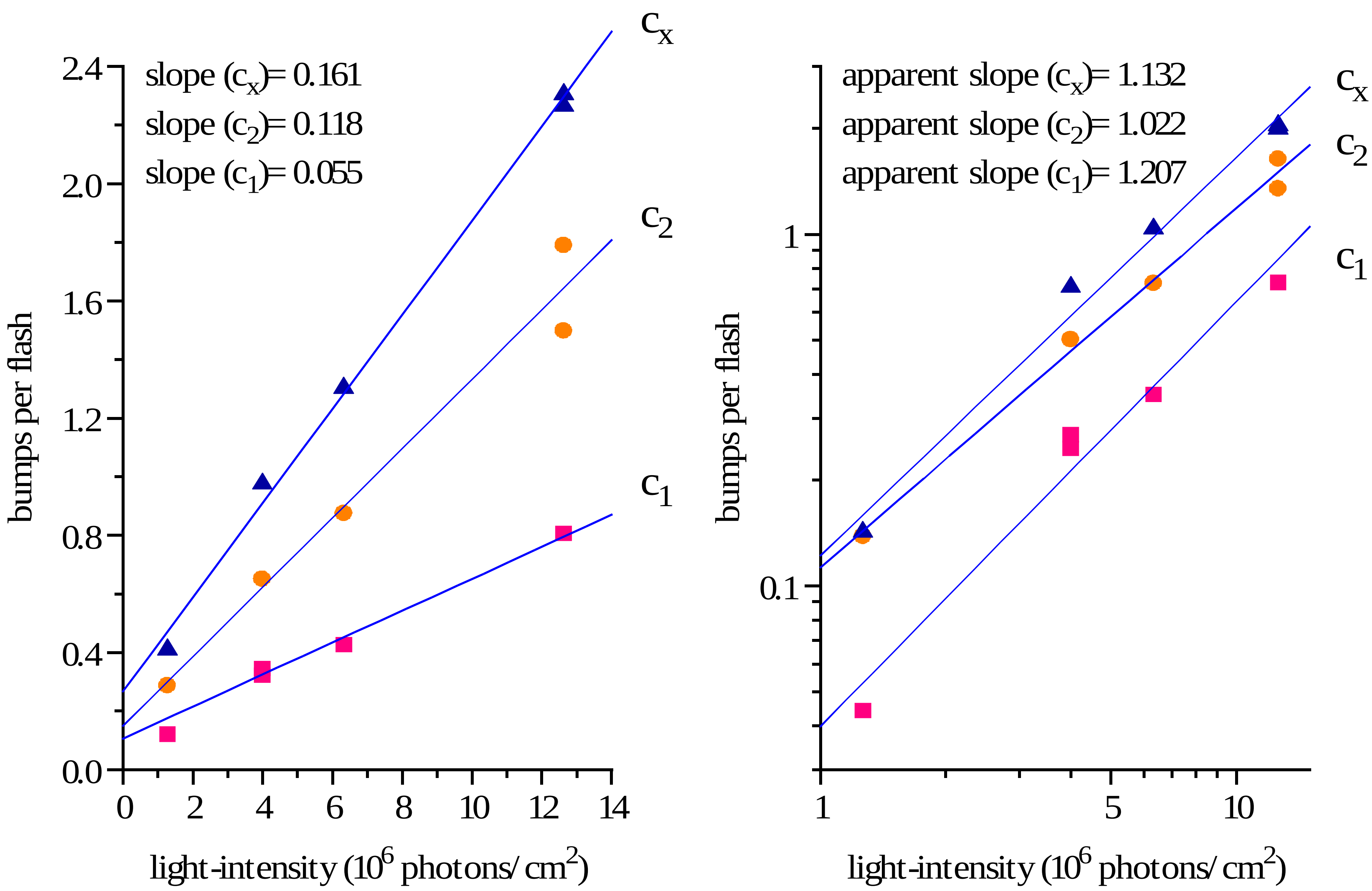

Figure 4: The light intensity dependencies of both types of bumps are linear.

5. CONCLUSIONS

One possible explanation for a supralinearity of the C_2-component beyond the light-intensity range described here, may be a mechanism of "facilitation", i.e. bumps, which occur first may improve the condition for subsequent bumps. In terms of the "bump-speck model" [2] it is assumed that adjacent bump-specks spacially overlap within a certain light-intensity range. According to the model, the finding of a slope ≤ 2 in the log-log-plot of the supralinear range may be interpreted as due to a cooperative binding of (two) terminal transmitters (from adjacent sources) to the membrane channels. Since the C_1-component does not reveal a supra-linear behaviour, its specific membrane channel may have only one binding site for terminal transmitters (e.g. cGMP).

6. QUANTIZED CURRENT-TIME INTEGRAL?

In one experiment we found a discrete distribution of the bump`s current-time integral (**figure 5**).

The peaks in the histogram were nearly equidistant and could easily be detected by a Fast Fourier Transformation routine (not shown).

This finding suggests the current-time integral of a bump being the n-fold of a "quantum" *q*. In this cell *q* was 565pAms (565fC). Since the amount of charge transported through one light-activated membrane channel is in the range of 1fC [5], about 600 channels should be involved in the transport of 1 quantum.

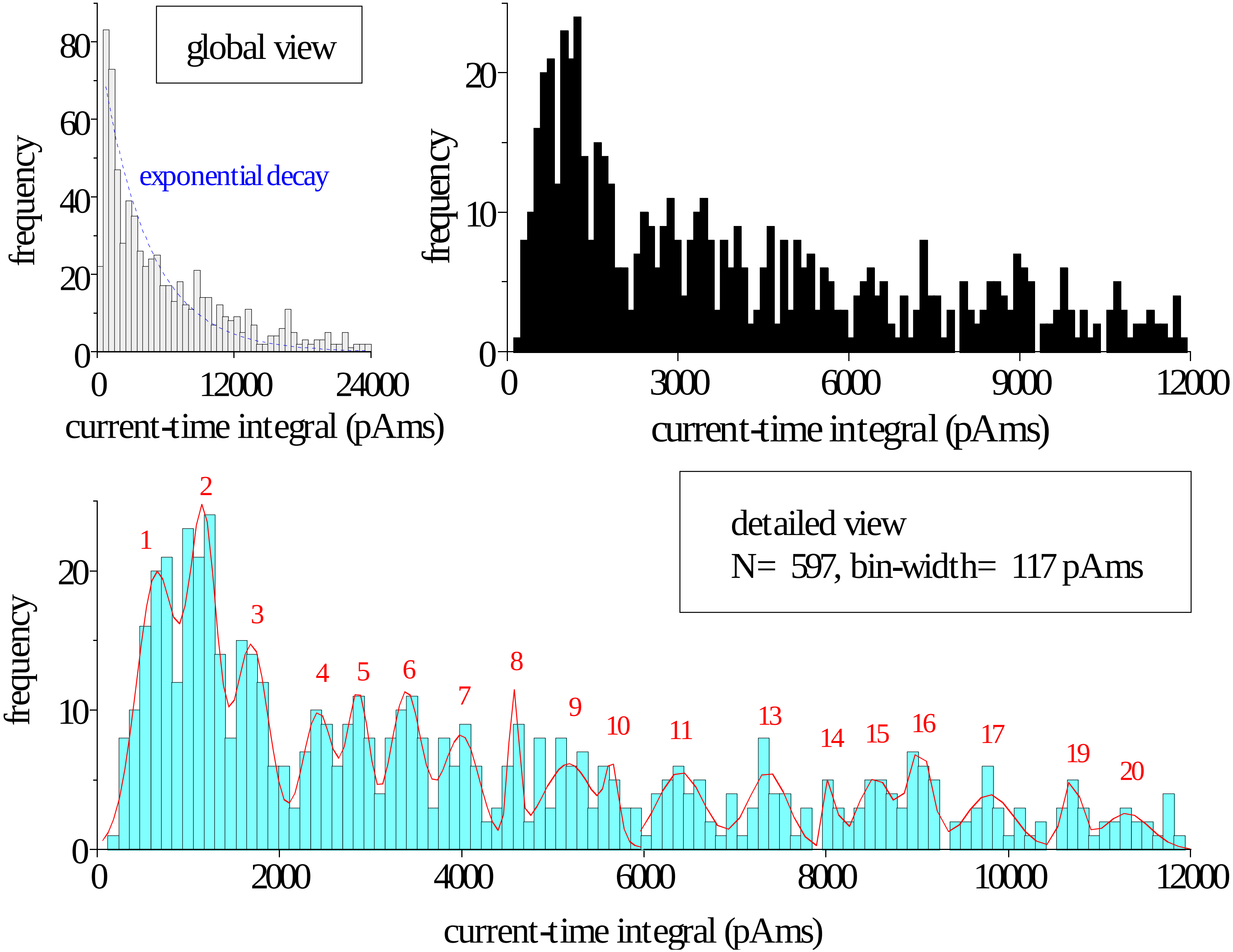

Figure 5: Demonstration of the quantisation of the bumps`s current-time integral.

7. Summary

1. The number of bumps per flash shows a Poisson distribution for both bump-types and at different light intensities. Therefore c_1- bumps as well as c_2-bumps can be regarded as statistically independent events. In contrast to other publications we were able to show this for separated bump-types.
2. The number of flash-evoked c_1- and c_2-bumps is proportional to the light-intensity of the stimulus, i.e. the number of the applied photons.
3. In one experiment, the current-time integral of bumps revealed a "humpy" substructure. This quantisation could not easily be explained in terms of artifacts. Therefore it may reflect an underlying principle of phototransduction!

[1] Deckert et al. (1992) J. Physiol. 453: 69-96

[2] Stieve et al. (1989) Z. Naturf. **44c** : 999-1014

[3] Reuß (1991) Thesis, RWTH-Aachen

[4] Nagy (1991) Rev. Biophysics **24,2** : 165-226

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