Influence of long-wavelength antenna chlorophyll forms on the photochemical quantum efficiency of PSII in *Chromera velia* and *Pheodactylum tricornutum*

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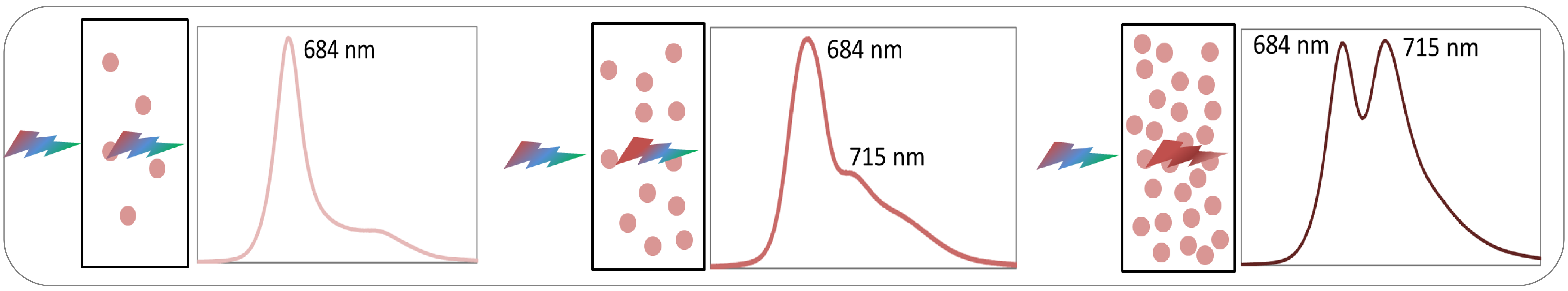
BACKGROUND

Grown under limiting light regimes (~20 µE m^{-2} sec^{-1}) and/or shading conditions, often associated to increasing cellular densities, the red algae *C. velia* and *P. tricornutum* show an intriguing adaptive strategy related to the synthesis of specific antenna isoforms. These harbour moderately red-shifted Chlorophyll forms having maximal emission at ~710-715 nm at room temperature, clearly discernible from the principal emission form of cells grown under unshaded conditions, peaked at ~684 nm (**Caron, L. et al, *Photosynth Res* 1983; Brown, J. S., *BBA* 1967**). In order to investigate whether or not these forms are associated to PSII, as some authors suggested (**Herbstová, M. et al, *BBA* 2015; Belgio, E. et al, *Photosynth Res* 2018**), comparative studies of the steady-state fluorescence emission and dynamics in the ps time domain have been undertaken on cells grown in different light regimes.



RESULTS AND PERSPECTIVES

***Excited state relaxation dynamics in C. Velia* cells.** When grown under un-shaded conditions show a clear emission peak at ~684 nm and an almost flat value of the average lifetime τ_{av} ($\tau av=\Sigma aiti/Ai$) across the whole emission band. When grown with lights filtered by other cultures, or with increasing cell density, a second emission peak, centred at ~715 nm, is obvious in the steady state emission at room temperature. The average lifetime value display a pronounced variation with maximal values corresponding to the ~715 nm emission.

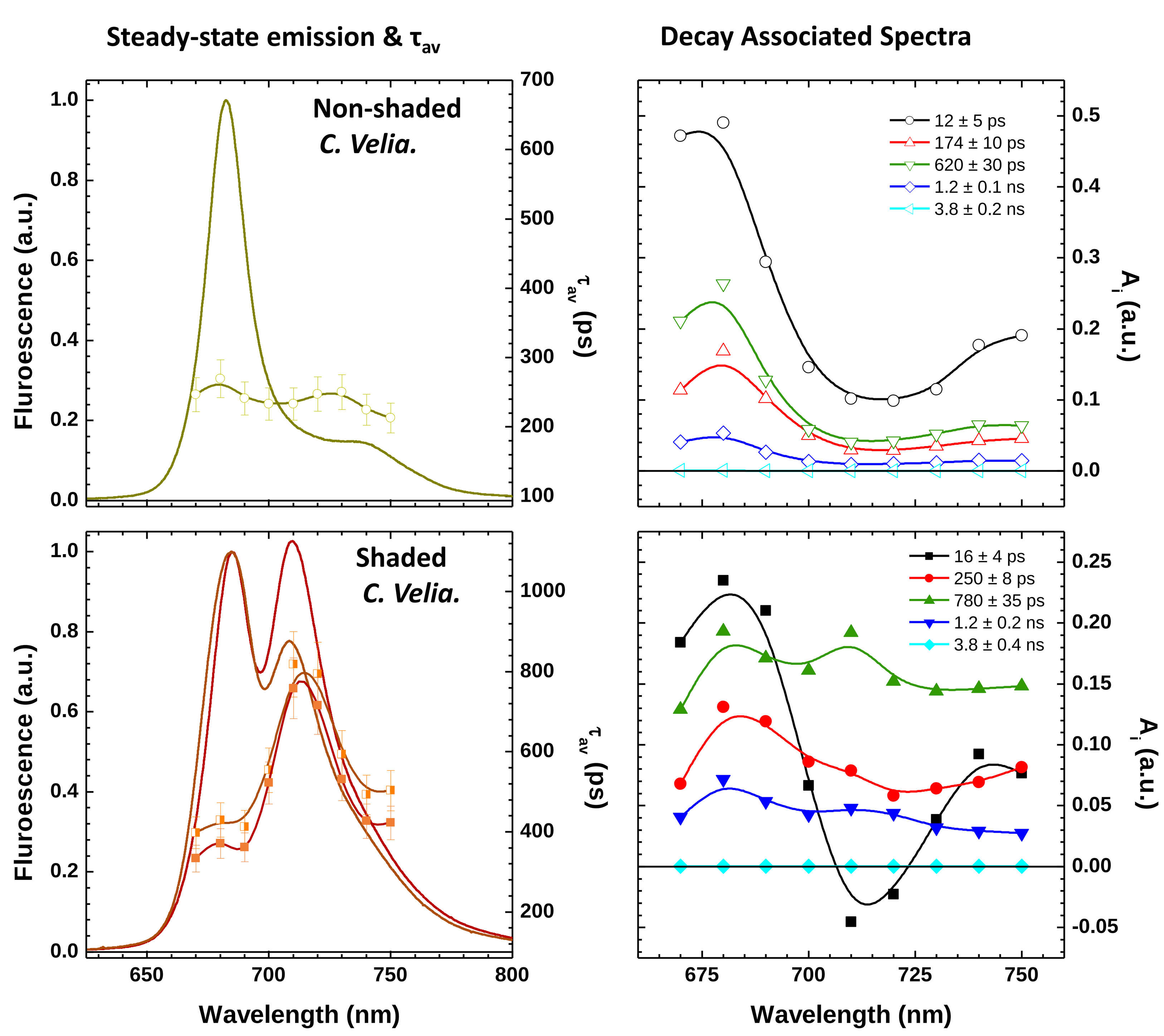


Figure 1. Left Hand Side: room temperature emission of *C. velia* cells grown in un-shaded , i.e. directly exposed to growth light (dark yellow, top panel) and shaded, i.e. filtered by other *C. velia* cultures (orange and dark red lines, bottom panel) , conditions; also shown are the corresponding t_{av} recorded in un-shaded (open symbols, top panel) and shaded (solid symbols) conditions. The decay associated spectra (DAS) resulting from the global analysis of excited state relaxation kinetics are presented in right hand panels, for un-shade (to) and for the largest fraction of 715 nm emission (bottom) .

***Excited state relaxation dynamics in P. tricornutum* cells** grown under shaded conditions also show an increasing emission in the long wavelength range, characterised by a maximum at ~715 nm. It is clearly observed at room temperature and further highlighted upon cooling at 80 K. Under conditions approaching PSII open centres (F_0), the τ_{av} increases towards the long wavelength emission edge, as observed in *C. velia*. A similar increase is, however, also observed under PSII closed trap conditions (F_M).

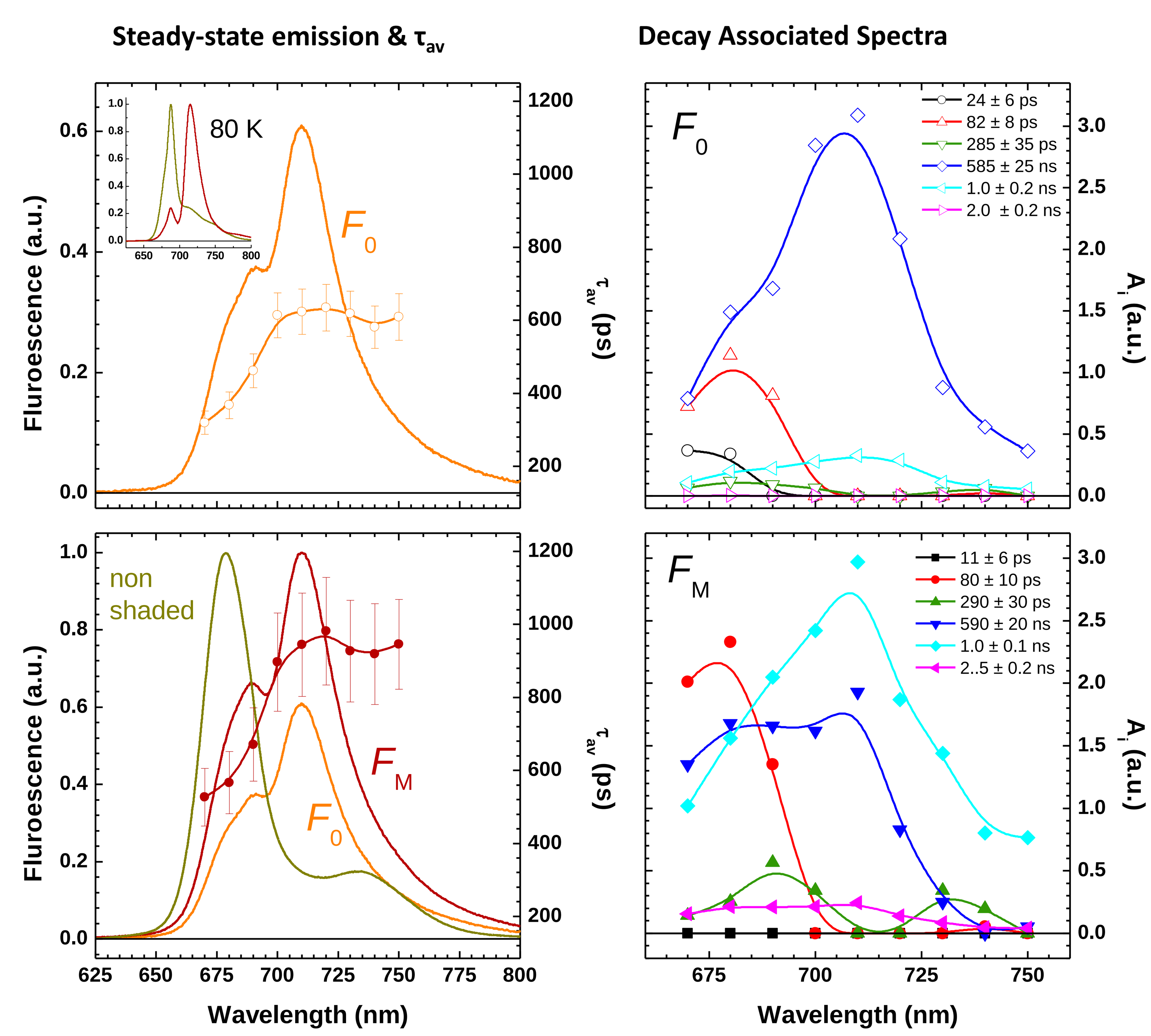


Figure2. Right hand side. room temperature emission spectra of *P. tricornutum* cells grown in shaded conditions, i.e. filtered by other *P. triccornutum* cultures at F0 (orange line, top panel) and *FM* (dark red line, bottom panel); also shown are the corresponding τav . The insert in the upper panel shows the spectra recorded at 80 K. The bottom panel presents a comparison also between un-shaded and shaded emission at F0. Right Hand panels: DAS for shaded cultures at F0 and FM.

Our present results demonstrates that red forms primarily associated to PSII antenna of both *C. velia* and *P. Tricornutum* can be observed when the cells are grown in shaded conditions by either other culture of the same organism or when cell cultures become sufficiently dense. The presence of PSII antenna forms having a maximal emission at 715 nm, imposes a slowing down of excited state dynamics in the long wavelength emission trail, as indicated by the emission-wavelength dependency of t_{av} . The lengthening depends on the extent of the red forms accumulation, in agreement with previous findings in the PSI. This can be interpreted in terms of a partial kinetic bottleneck for energy diffusion, due to up-hill energy distribution, which also leads to a decrease of the maximal PSII quantum conversion efficiency.

Acknowledgments

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