Supporting Information

Quantum Efficiency of PSII Turnover at 1.7 K. PSII was shown to photoconvert at 1.7 K as a result of monochromatic light emanating from the spectrometer. The quantum efficiency of PSII photoconversion can be estimated at this temperature if we know the photon flux at the sample and the absorption of the sample.

The incident light flux (I_L+I_R) can be determined as follows. The absorption and CD are determined simultaneously in our apparatus, via parallel measurement of (I_L+I_R) and (I_L-I_R), respectively. These two signals intrinsically have the same noise level, as the noise arises purely from the statistics of photons arriving at the detector. A simple determination of the noise level in the CD, where the noise has been determined to be shot-noise limited at the frequency of the photoelastic modulator (57kHz), immediately provides the detected light flux.

Light intensity inherently follows a Poisson distribution: if on average n photons are detected during one second, the variance in light intensity during that time is $\sqrt{n}$. The signal-to-noise ratio will then be $n/\sqrt{n} = \sqrt{n}$. The light level we detect is close to 100 times greater when using 500-μm slit widths compared with 50-μm slit widths. This improves the signal-to-noise ratio by a factor of 10, confirming that the noise in the CD arises from Poisson statistics, and is indeed determined by this so called 'shot noise'. We can use the detected signal-to-noise ratio to determine n. With narrow slits, (I_L+I_R) is 0.5-0.7×10^4 times greater than the noise on (I_L-I_R). This translates to 0.2-0.5×10^8 photons arriving at the detector during the acquisition time of 0.3 s.

The detector used (Hamamatsu PM R669) has a quantum efficiency of 7-8% in the visible region, so the number of photons incident on the detector over this period of time is 2-7×10^{8}. For wide slits, the corresponding number is 2-7×10^{10}. A spectral scan takes on the order of 1000 seconds, resulting in 0.6-2×10^{14} incident photons in total.

The light from the spectrometer is focused at the sample to a slit image 1 cm high and close to 0.5 mm wide. For the case of wide slits and a typical PSII core sample with a peak absorbance of 1, there are ≈10^{-10} moles, i.e. ≈6×10^{13} PSII reaction centers, in the interrogated volume. From the absorption spectrum, we estimate that on average 10-20% of the incident photons are absorbed by the sample, and 20-30% of the core complexes are photoconverted during the scan. This allows us to estimate a quantum efficiency range for 1.7-K photoinduced conversion of PSII to the order of 0.1-1.

Our illumination of a sample at 260 K by 2 mW/cm^2 of green light for 3 seconds corresponds to total flux of ≈10^{16} photons. The beam illuminates the entire 1-cm diameter of our sample, which contains ≈10^{15} PSII reaction centers. Close to complete conversion is achieved by this brief illumination. The fraction of green light absorbed by our samples is around 10-15%. This again proscribes a quantum efficiency of photoconversion close to unity for the 260-K illumination.