

# FL-3500 – Overview of Single Models

## What Does It Measure?

FL3500 measures various Chl fluorescence parameters, ratios, and quenching coefficients that provide information on the functionality of the photosynthetic apparatus. These are five basic fluorescence parameters  $F_0$ ,  $F_m$ ,  $F_0'$ ,  $F_m'$ ,  $F_s$  and a number of differences and fluorescence ratios. Such as, for instance,

- Maximum quantum yield of Photosystem II  $\Phi_m = F_v/F_m$
- Non-photochemical quenching  $NPQ = (F_m - F_m')/F_m'$
- Effective quantum yield of Photosystem II  $\Phi_{II} = (F_m' - F_s)/F_m'$
- Non-photochemical quenching of variable Chl fluorescence  $q_n = (F_v - F_v')/F_v$
- Photochemical quenching of variable Chl fluorescence  $q_p = (F_m' - F_s')/(F_m' - F_0')$

## Other Supported Protocols

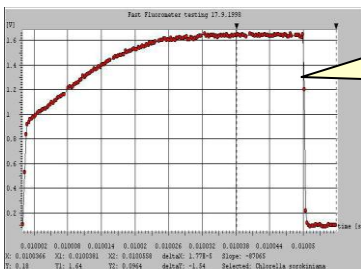
- Flash fluorescence induction (one flash)
- Fast OJIP transients
- Rapid  $Q_A$ -reoxidation kinetics
- S-states
- Effective antenna size
- PSII connectivity (J parameter)

## How Does It Measure?

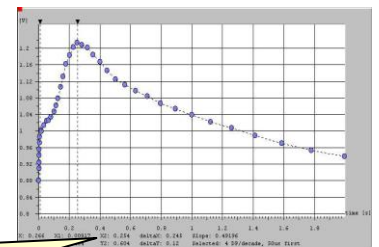
Measured fluorescence emission is excited by a set of light emitting diodes that generate measuring flashes. The photochemistry is driven by single-turnover flashes or by continuous actinic irradiance. The FL3500 has two input channels. One channel is used for a PIN photodiode with 1 MHz A/D converter and 16-bit resolution. The second channel can be configured according to a customer's request.

## What Is the Typical Experimental Material?

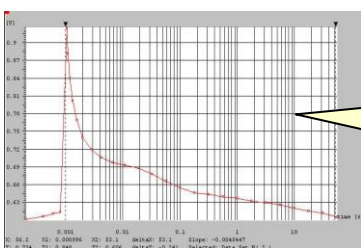
- **Suspensions** of photosynthetically active samples in a cuvette (e.g., thylakoids, chloroplasts, algae, cyanobacteria)
- **Leaves, leaf segments**



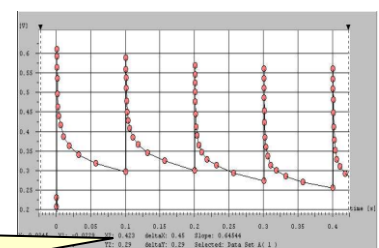
**Flash fluorescence induction:** DCMU-like induction measured without herbicide on 50  $\mu$ s time scale.



**Kautsky effect:** OJIP kinetics, logarithmic timing of measuring flashes up to 1  $\mu$ s resolution



**$Q_A^-$  reoxidation kinetics:** logarithmic timing of measuring flashes with 4 measurements per decade.



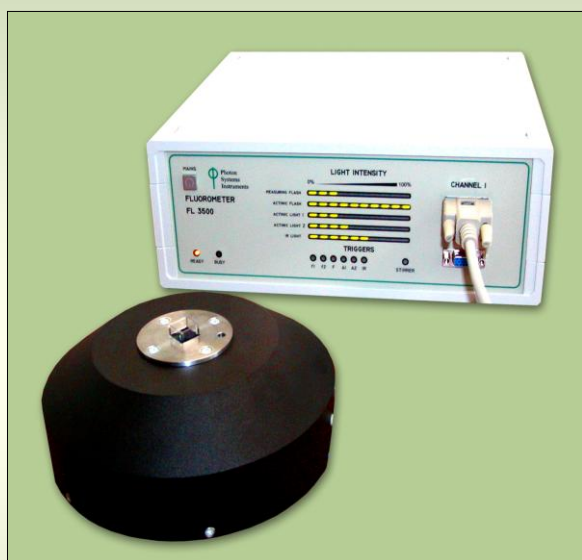
**S-state dependent fluorescence transients:** repetitive single-turnover flashes

## General Description

**Double-Modulation Fluorometer FL3500/X** measures Chl-fluorescence signal with a time resolution of up to 1  $\mu$ s in the Fast FL3500/F version or up to 4  $\mu$ s in the Standard FL3500/S version. Measured fluorescence emission is excited by a set of light-emitting diodes that generate short measuring flashes; the photochemistry is driven by single-turnover flashes or by continuous actinic irradiance. Chlorophyll fluorescence is detected by a PIN photodiode and digitized by a 16-bit A/D converter. The instrument supports Pulse Amplitude Modulation measurements and, at the same time, can capture **fast OJIP transients** or perform **rapid measurements of  $Q_A$ - reoxidation kinetics, S-states**, or of the **effective antenna size**. The major novel feature of this fluorometer is the capacity of the instrument to generate rectangular actinic flashes of extremely high power. Full reduction of  $Q_A$  acceptor can be achieved within 25  $\mu$ s and the instrument can measure fluorescence induction during such a single-turnover saturating flash. This technique is used to determine the effective antenna size of the Photosystem II as well as its heterogeneity and connectivity without disturbing the measured system by DCMU or other herbicides (Nedbal et al., 1999, J. Photochem. Photobiol. B: 48, 154-157, Koblizek et al., 2001, Photosynth.Res., 68 (2): 141-152). Photosynthetically active samples, either suspensions, leaves, or even corals, can be investigated for their photochemical yields, quenching parameters, state transitions, or for the kinetics of photosynthetic redox reactions. The Double-Modulation Fluorometer is manufactured in several custom-made versions: Standard, Fast, Leaf-Clip, High-Sensitivity, Submersible, or the pocket-sized FluorPen.

**FL3500 is manufactured in several custom-made versions:**

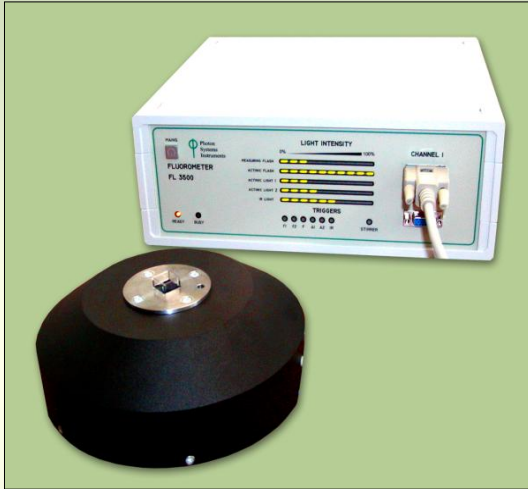
### FL3500 STANDARD



- Sophisticated system for fast kinetic measurement of **OJIP** and PAM measurements in liquid samples
- Suitable to measure **suspensions** of chloroplasts, thylakoids, algae, or cyanobacteria, **small leaves** or **leaf segments**
- **Four integrated light sources** with user definable intensities and timing
- **Far-red light** for preferential photosystem I excitation
- Dedicated **FluorWin software** for data analysis and instrument control

**Options:** Far-red LED unit  
Optional light source colors  
Magnetic Stirrer for uniform sample mixing  
Thermoregulator for precise temperature regulation

## FL3500 FAST



control and automated recordings of light response curves and chart recordings of induction curves

- Unique system for measurement of **flash fluorescence induction, PAM and OJIP** in liquid samples
- Time resolution of **1 $\mu$ s**
- Suitable to measure **suspensions** of chloroplasts, thylakoids, algae, or cyanobacteria, **small leaves** or **leaf segments**
- **Four integrated light sources** with user definable intensities and timing
- **Far-red light** for preferential photosystem I excitation
- Custom Windows® software for **instrument**

**Options:** Far-red LED unit  
Optional light source colors  
Magnetic Stirrer for uniform sample mixing  
Thermoregulator for precise temperature regulation

## FL3500 SUBMERSIBLE



- Water-resistant system for measurement of **flash fluorescence induction, PAM and OJIP** for underwater studies down to 1 m
- Suitable for studying photosynthesis in underwater organisms, **plants, corals, or seaweed**, under natural conditions
- Compact design allows **easy manipulation** under the water
- Dedicated **FluorWin software** for instrument control, sophisticated data analysis, visualization and data export routines

**Options:** Submersible head  
Far-red LED unit  
Optional light source colors

## FL3500 LEAF-CLIP



- Convenient system for measurement of **all standard experiments, such as PAM and OJIP**, in leaves and their segments
- Comes with **2 measuring sources** (blue and red), **1 actinic light** (red, 2000  $\mu\text{E}$ ) and **1 single turnover saturating light** (red) in default configuration
- **No damaging or removing the target leaf** from its habitat during experiment
- **Compact design and practical holder** for easy manipulation
- **FluorWin software** for instrument control, sophisticated data analysis and visualization.

**Options:** Far-red LED unit  
Optional light source colors

## FL3500 HIGH-SENSITIVITY



- **Ultra-high sensitivity: detection limit below 1 ng Chl/l**
- Suitable to measure **fluorescence induction** and  **$Q_A$  reoxidation kinetics** with **pico-molar chlorophyll concentrations**.
- Perfect tool for measuring **natural water with phytoplankton**
- Equipped with an **avalanche photodiode detector**, alternatively with a second detector to capture fluorescence transients in different spectral band
- **FluorWin software** for instrument control and sophisticated data analysis

**Options:** Far-red LED unit  
Optional light source colors  
Second detector