IMAGING-PAM
Chlorophyll Fluorometer

for measuring images of photosynthesis

Pulse-amplitude modulation

Compact, battery-powered, portable device

LED-ring-array providing blue Measuring Light, Actinic Light and Saturation Pulses, as well as red and near-infrared light

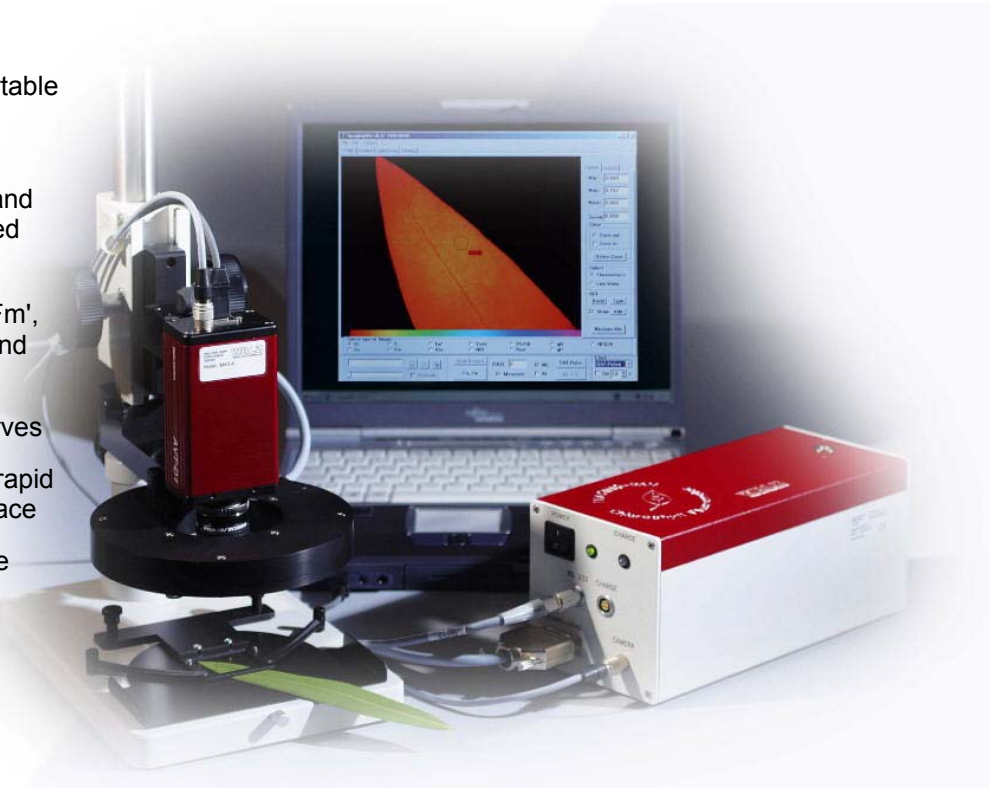
Images of Fo, Fm, Fv/Fm, ΔF/Fm', qP, qN, NPQ, absorbed PAR and relative rate of photosynthesis

Induction Curves and Light Curves

Digitization within camera and rapid data transfer via firewire interface

Dedicated ImagingWin software

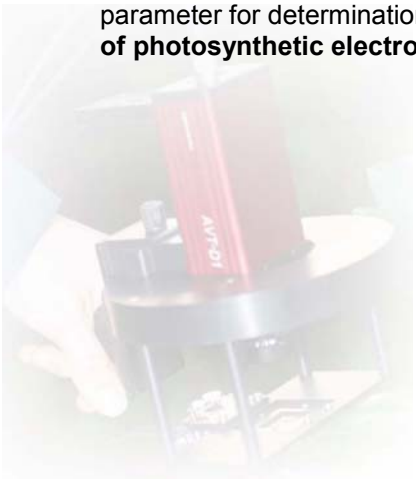
High flexibility with respect to different sample geometries



Standard set-up of IMAGING-PAM for laboratory applications featuring Mounting Stand IMAG-S

The **IMAGING-PAM Chlorophyll Fluorometer** is a highly compact device for measuring images of photosynthetic activity of leaves and other photosynthetically active samples. Like all PAM fluorometers it specifically measures **pulse-amplitude-modulated fluorescence,** thus tolerating ambient daylight. The same LED-ring-array not only provides blue pulse-modulated Measuring Light, Actinic Light and Saturation Pulses, but also pulse-modulated red and near-infrared measuring light. The latter serve for assessment of **PAR absorptivity**, which is an important parameter for determination of the **relative rate of photosynthetic electron transport.**

The IMAGING-PAM is particularly well suited for the study of objects displaying **heterogeneities in photosynthetic activity** (so-called patchiness), which may be due to metabolic regulation, tissue differentiation, mutation, virus infection and biotic or abiotic stress. Important **fields of application** are phytopathology, molecular biology, stress physiology, agriculture, horticulture and toxicology.



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The IMAGING-PAM displays exceptional flexibility with respect to various sample geometries in different applications. For standard laboratory work a robust stand with rack-and-pinion drive is provided. While the distance between LED-ring-array and sample is kept constant the working distance between camera and sample may vary between 35 and 70 mm, corresponding to imaged areas of 17x22 mm and 26x34 mm, respectively. The Measuring Head (camera plus LED-ring-array) can be also mounted on a tripod.

IMAGING-PAM measuring head featuring Universal Sample Holder IMAG-USH mounted on tripod

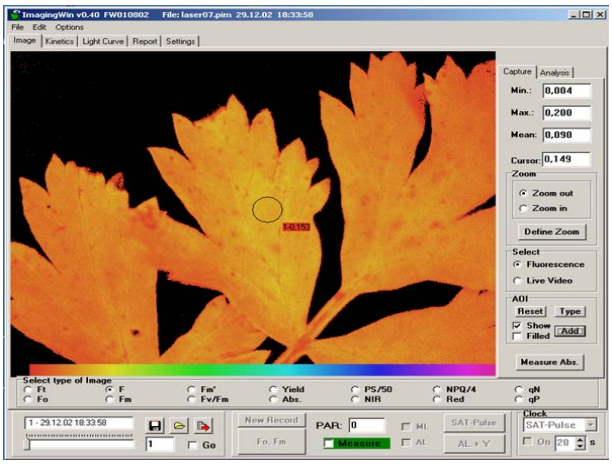
Alternatively, the **Universal Sample Holder IMAG-USH** may equipped with a robust handle which in field applications enables the user to hold the Measuring Head and at the same time to fix a leaf in the holder, all with one hand. The Measuring Head can be also mounted on the Control Unit IMAG-C, a particularly compact set-up for field work. The instrument contains a Li-ion battery providing enough power for at least 6 hours. Also a standard 12V battery may be connected.

Combination of Mounting Stand IMAG-S and Universal Sample Holder IMAG-USH

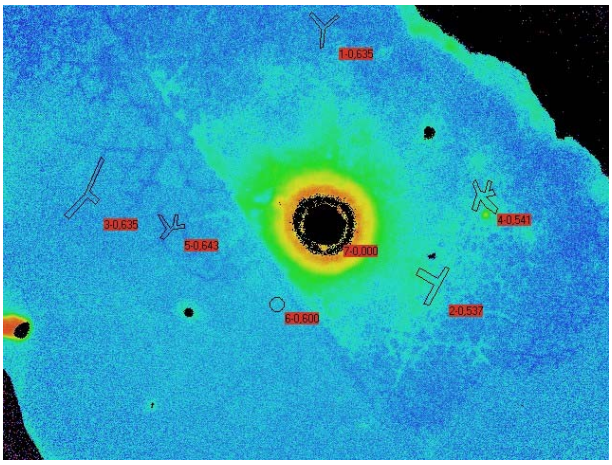
Hand-held operation unsing Universal Sample Holder IMAG-USH

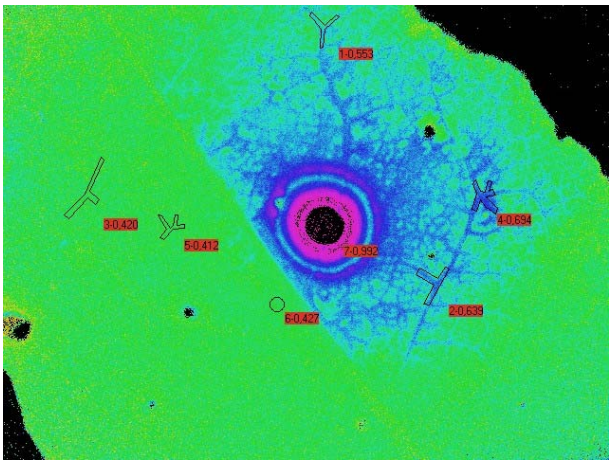
Universal Sample Holder IMAG-USH mounted on Control Unit

The windows software **ImagingWin** was developed for operation of the IMAGING-PAM and analysis of the obtained data. The user surface of ImagingWin is illustrated in the figures below.

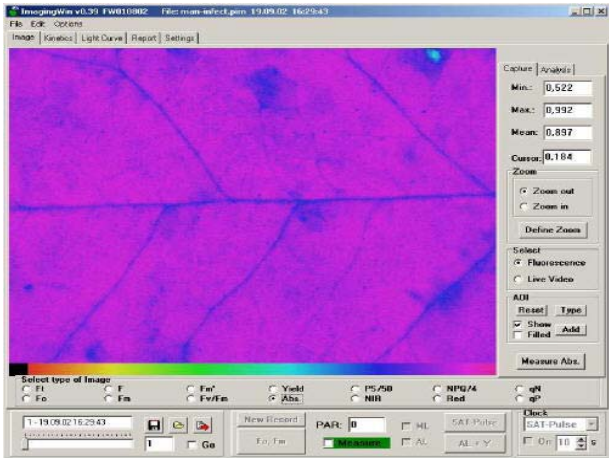


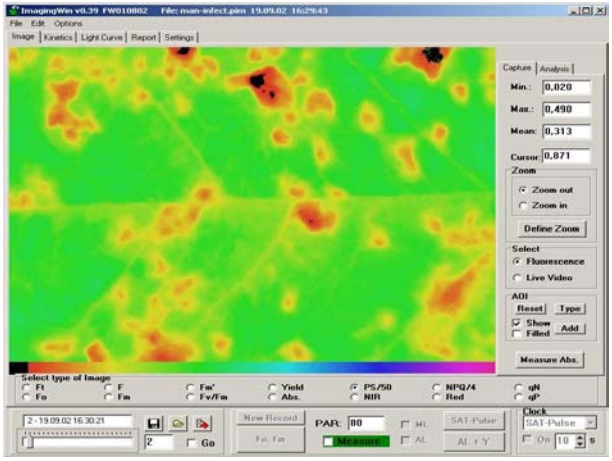
User surface of ImagingWin software: Display of Image-window which is one out of 5 different windows. The F-image is displayed which is one out of 14 different images. One Area of Interest (AOI) is selected. The instrument is operated via cursor/mouse click and the PC keyboard.



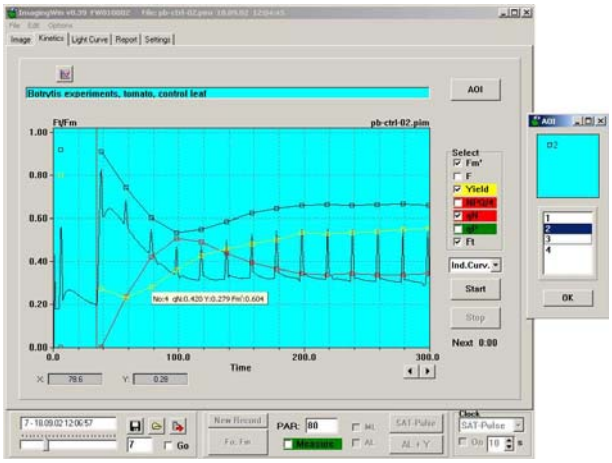


Images of the effective PS II quantum yield, ΔF/Fm' (left) and the coefficient of nonphoto chemical quenching, qN (right) measured 70s after laser spot heating of a dandelion leaf.

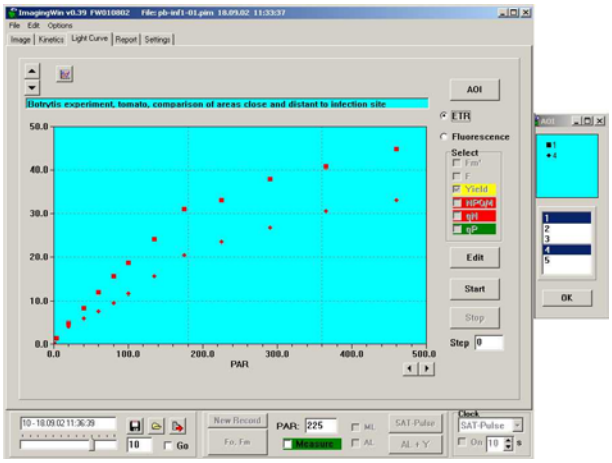




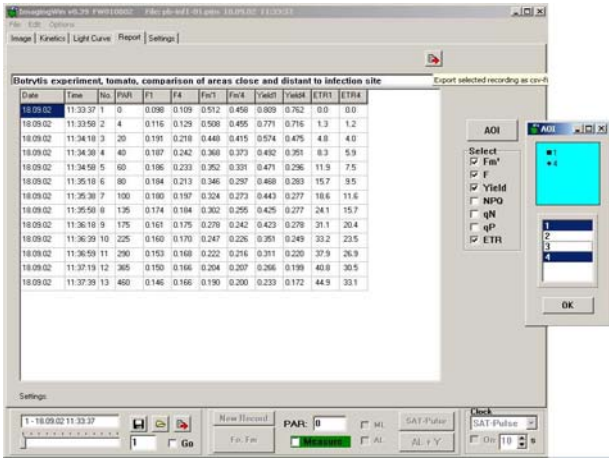
Images of PAR-absorptivity (left) and the relative rate of photosynthesis (right) of a pathogen infected leave showing patchiness in pigment distribution and photosynthetic activity.



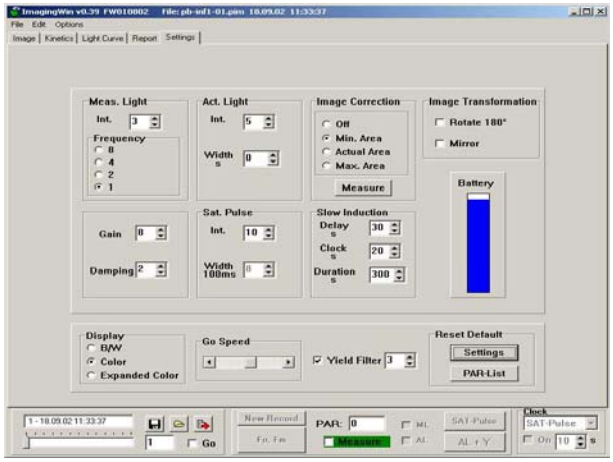
Kinetics-window showing dark-light induction curve of one selected AOI



Light Curve window with light response curves for two selected AOIs



Report-window showing numerical lists of fluorescence parameters of two selected AOIs



Settings-window serving for definition of instrument settings

Technical specifications

Basic System

Control Unit IMAG-C

Design: Aluminum housing featuring large size built-in Li-ion battery, sockets for cable connections with CCD Camera IMAG-K, LED-Ring-Array IMAG-L, PC (RS 232) and Battery Charger 2120-N or external battery

Microcontroller: RISC processor

User interface: Pentium PC with Imaging Win Software; connection via RS 232; keyboard operation; monitor screen display

Power supply: Internal rechargeable Li-Ion battery 14.4 V/6 Ah, providing power for at least 6 hours; external 12 V battery

Power consumption: Basic operation 350 mA, with all LED light sources turned on max.1.5 A

Recharging time: approx. 4 hours (IMAGING-PAM turned off) via Battery Charger 2120-N

Operating temperature: -5 to +45 °C

Dimensions: 25 cm x 10.5 cm x 11 cm (L x W x H)

Weight: 2.2 kg (incl. battery)

Windows Software ImagingWin

Minimum PC requirements: processor 1 GHz, memory 256 MB, built-in DVD or DVD/CD-RW drive, built-in serial interface (RS 232), built-in Firewire interface (IEEE1394), operating system Windows XP Home or Professional

Features: Data display and instrument settings on 5 different windows

- Image : display of 14 different parameters
- Kinetics: time dependent changes of fluorescence parameters
- Light Curve: registration of preprogrammed light response curves
- Report: numerical lists of parameter values for selected areas of interest
- Settings: instrument settings

Battery Charger 2120-N

Input: 90 to 264 V AC, 47 to 63 Hz

Output: 19 V DC, 3.7 A

Operating temperature: 0 to 40 °C

Dimensions: 15 cm x 6 cm x 3 cm (L x W x H)

Weight: 300 g

Transport Box IMAG-T

Design: Aluminum box with custom foam packing for IMAGING-PAM and accessories

Dimensions: 60 cm x 40 cm x 25 cm (L x W x H)

Weight: 5 kg

LED-Ring Array IMAG-L

Design: LEDs on heat-conducting printed-circuit board; aluminum housing with adapter to Mounting Stand IMAG-S

Light source for fluorescence excitation and actinic illumination: 96 blue LEDs (470 nm) standard excitation intensity 0.5 µmol quanta m^{-2} s^{-1} PAR, modulation frequency 1-8 Hz; max. actinic intensity 1200 µmol quanta m^{-2} s^{-1} PAR; max. saturation pulse intensity 2400 µmol quanta m^{-2} s^{-1} PAR

Light sources for assessment of absorbed PAR: 8 red LEDs (650 nm); 8 NIR LEDs (780 nm)

Dimensions: Outer Ø 15 cm, inner Ø 7 cm, height 4 cm

Weight: 570 g (incl. cable 1 m long)

CCD Camera IMAG-K

Design: Black and white C-mount camera operated in 10-bit-mode at 30 frames/sec

CCD Chip size: 1/3" (640 x 480 pixel)

Interface: Firewire (IEEE1394)

Dimensions: 11.5 cm x 5.8 cm x 3.9 cm (L x W x H)

Weight: 400 g

Camera Accessory LED-Ring-Array IMAG-K/STD

CCTV camera lens: Cosmicar/Pentax F1.2, f = 12 mm; weight: 67 g; diameter 30 mm; length 35.5 mm

Detector filter: long pass 640 nm, short pass 780 nm

Extension ring: 5 mm C-mount

Mounting Stand IMAG-S

Design: Metal stand featuring high performance rack-and-pinion drive for adjustment of working distance

Platform base: 25 cm x 17 cm

Central hole for optional sample holder: Ø 9.3 cm

Height: 34 cm

Weight: 3.3 kg

Accessories (optional)

Leaf Holder IMAG-S/B

Design: Consisting of black anodized aluminum plate to be mounted on Stand IMAG-S, with XY sliding properties; exchangeable sample frames for different sample areas; optional mounting of nylon thread for sample flattening

Sample areas: 17 mm x 22 mm and 26 mm x 34 mm

Universal Sample Holder IMAG-USH

Design: Consisting of black anodized aluminum plate featuring exchangeable sample frames, to be mounted with four aluminum rods on LED-Ring-Array IMAG-L; optional mounting of leaf clip and carrying handle

Sample areas: 17 mm x 22 mm and 26 mm x 34 mm

Reference

Schreiber U, Walz H and Kolbowski J (2003): Propagation of spatial variations of chlorophyll fluorescence parameters in dandelion leaves induced by laser spot heating. PAM News 01: 1-18

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