GENERAL
MICROTECHNOLOGY
& PHOTONICS

LifeSpec II Spectrometer

Fluorescence lifetimes with ultimate temporal resolution

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Photonics Division

The LifeSpec II is a compact, fully integrated, high performance fluorescence lifetime spectrometer designed for use with high-repetition rate pulsed femtosecond and picosecond lasers. The system is a fully automated solution, combining hardware and software in a single package for fundamental research and routine laboratory applications. Its zero temporal dispersion optics set the standards for technical performance in measuring ultra-fast decays.

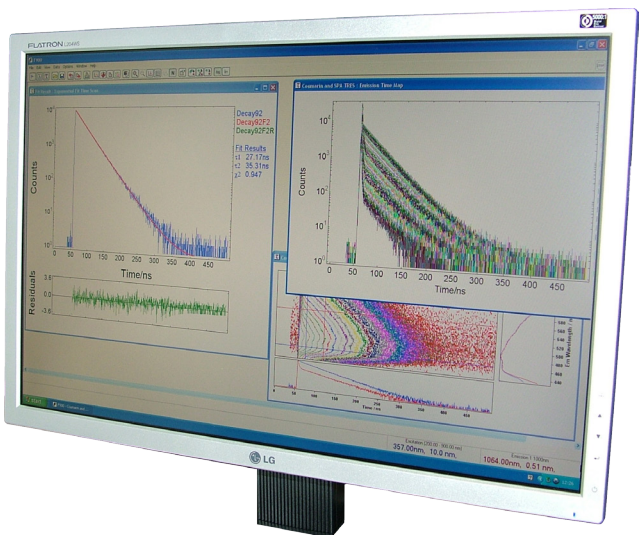
The LifeSpec II utilises the technique of Time Correlated Single Photon Counting (TCSPC) for accurate measurements of fluorescence lifetimes.

The LifeSpec II features a subtractive double monochromator, giving the spectrometer zero temporal dispersion and allowing the instrument to measure fluorescence lifetimes down to 5 ps – 10 ps.

Advanced software controls all the hardware and also analyses the raw data. With reconvolution, the software can reliably measure fluorescence lifetimes down to a tenth of the instrument response function.

Data acquisition modes range from fluorescence lifetime decay acquisitions and time-resolved spectra to automated time-resolved anisotropy measurements and automated temperature maps.

The LifeSpec II in the standard configuration is supplied with one detector. Additional detectors can be added. The LifeSpec II requires at least one picosecond pulsed diode laser, pulsed LED, supercontinuum laser or Ti:Sapphire laser (with suitable pulse picker) for operation.



Sample chamber

The LifeSpec II has a large sample chamber that enables a variety of sample holder options to be fitted easily. These include single cuvette holders, multiple sample holders, front face film/bulk/powder holders, fibre attachments, thermostated sample holders and cryostats.

Subtractive double monochromator

Zero temporal dispersion in the optical path is a necessity for precise measurements in the lower picosecond time scale. Conventional monochromators introduce temporal shifts and pulse broadening originating from propagation delays caused by the dimensions of the grating. The new design of the LifeSpec II uses two coupled monochromators with opposite pulse broadening characteristics. This eliminates temporal delays and temporal dispersion and enhances the stray light rejection. In this manner sources of errors in the response of the instrument are reduced and lifetime measurements can be performed and analysed more accurately.

Computer controlled polarisers

Computer Controlled Polarisers Motorised mounts are used both in the excitation beam path and in the emission path to operate the optional Glan Thompson polarisers. An excitation polariser may not be needed if the laser's emission is naturally polarised, which is the case for Ti:Sapphire and picosecond-pulsed diode lasers. Linearly polarised excitation and emission is a necessity for fluorescence anisotropy measurements. However, even for precise fluorescence decays (energy relaxation), polarisers may be required to eliminate rotational artifacts that are superimposed on the fluorescence decay ("magic angle" measurements).

Measurement and analysis capabilities

Data Acquisition Modes

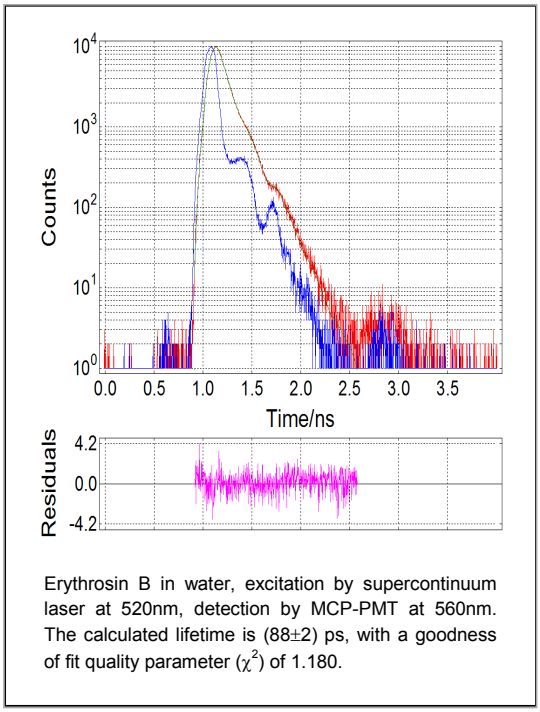
- Fluorescence Decay Acquisition.
- Time Resolved Fluorescence Spectra.
- Quasi-Steady State Spectra (with spectral correction).
- Automated Time-Resolved Anisotropy Measurements (with optional polarisers).
- Automated Temperature Maps (with optional cryostat or Peltier cooled sample holder).

Data Analysis Modes

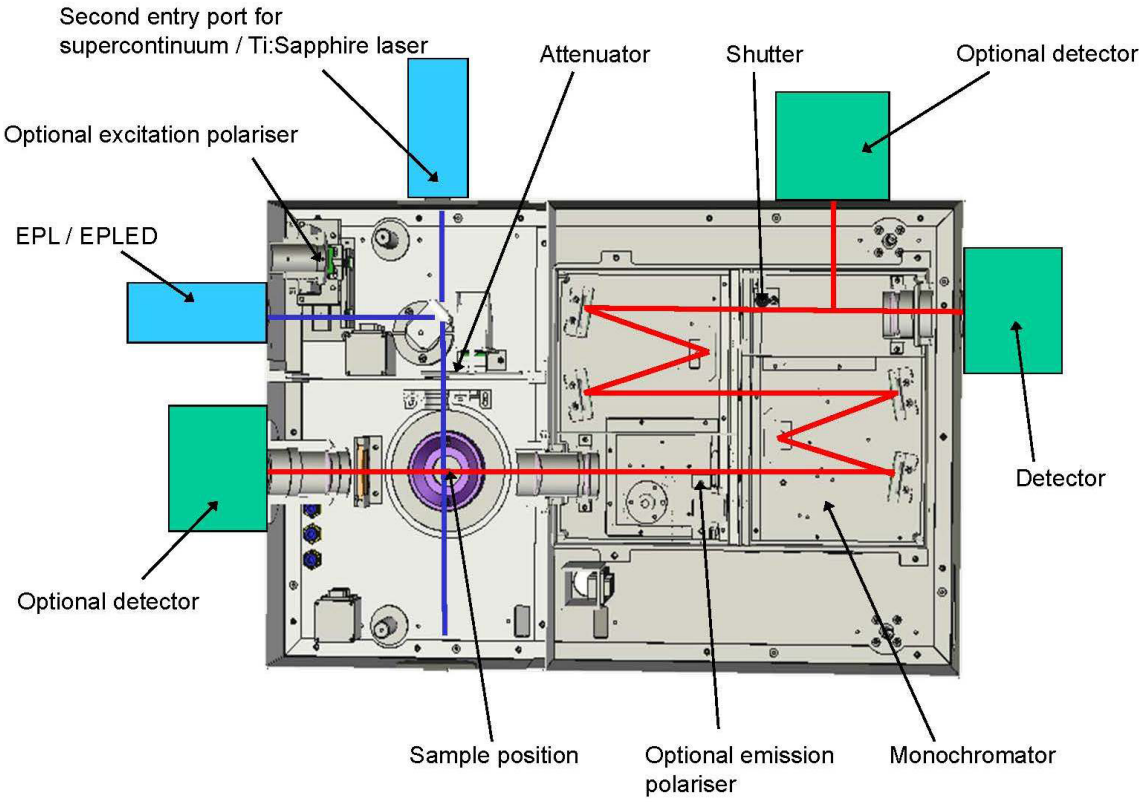
- 4-exponential fit with background, shift, reconvolution (based on Marquardt Levenberg algorithm).
- Multi-exponential fluorescence anisotropy fits (tail fits only).

Advanced Data Analysis (optional)

- 4-exponential fit with background, shift, reconvolution, no initial guesses required (based on propriety algorithm).
- Lifetime Distribution Analysis with a grid of 200 lifetimes and no a priori shapes of the distribution.
- Batch Analysis.
- Global Analysis.
- Förster Kinetics.
- Micellar Quenching Fits.
- Extended Expotential Components Analysis.
- Advanced Fluorescence Anisotropy kinetics with reconvolution.



Erythrosin B in water, excitation by supercontinuum laser at 520nm, detection by MCP-PMT at 560nm. The calculated lifetime is (88±2) ps, with a goodness of fit quality parameter (χ^2) of 1.180.



Principal Layout

The complete LifeSpec II spectrometer comprises of the optical spectrometer, a power supply module and a computer fitted with a data acquisition card, the TCC900. In the standard configuration, the LifeSpec II is fitted with one selected light source and one detector. The system can be upgraded with additional sources, detectors, polarisers, sample cooling stages, and fiber optics. Note that some of these upgrades need to be factory fitted. The LifeSpec II main unit is height adjustable, so that the optical plane can be set to between 130 mm to 180 mm from the table top. This simplifies beam steering and coupling of complex external laser systems to the LifeSpec II.

Light Sources and Detectors

The LifeSpec II spectrometer can be used with all modern high repetition rate pulsed sources, such as picosecond pulsed diode lasers and LEDs, supercontinuum "white" picosecond pulsed lasers, and femtosecond Ti:Sapphire lasers.

The standard LifeSpec II comes with an adjustable receptor flange for picosecond pulsed diode lasers (EPL Series) and UV-LEDs (EPLED Series).

A supercontinuum laser can be fitted with a special wavelength selection package that allows computer controlled wavelength and spectral bandwidth selection. This package also has an integrated and optimised laser synchronisation trigger pick-up.

Alternatively, radiation of Ti:Sapphire lasers with frequency doubling / tripling and pulse picker can be used for sample excitation. A trigger pick-up accessory is available.

The shortest measurable lifetime is dependent on the speed of the detector and on the pulse width of the picosecond pulsed light source. By applying numerical reconvolution, lifetimes as short as 1/10th of the system's instrumental response function can be extracted from the data. The table shown is a guide for the time resolution that can be achieved with the LifeSpec-II using different light source – detector combinations. The figures given in the table represent the width (FWHM) of the response function of the overall system, in units of ps. The shortest possible lifetime that can be measured is estimated by dividing the figure by ten.

Detectors

	Wavelength Coverage	Detector Response Width	Dark Count Rate
High Speed Blue PMT	230 – 650 nm	250 ps	<100 cps
High Speed Red PMT	230 – 850 nm	250 ps	<100 cps
MCP-PMT	230 – 850 nm	<25 ps	<10 cps
NIR-PMT-1700 (LN_2)	300 – 1700 nm	800 ps	<100,000 cps
NIR-PMT-1700 (TE)*	950 – 1700 nm	400 ps	<100,000 cps

Instrument Response Function (IRF)

	Ti:Sapphire laser	Picosecond Pulsed Diode Laser (EPL)	Picosecond Pulsed LED (EPLED)	SuperContinuum White Light Laser
High Speed Blue PMT	<250 ps	<300 ps	<1 ns	<300 ps
High Speed Red PMT	<250 ps	<300 ps	<1 ns	<300 ps
MCP-PMT	<50 ps	<130 ps	<1 ns	<300 ps
NIR-PMT-1700 (LN_2)	<800 ps	<800 ps	<1.5 ns	<800 ps
NIR-PMT-1700 (TE)*	<400 ps	450 ps	<1 ns	<450 ps

* The TE cooled version of the NIR-PMT cannot directly measure an Instrument Response Function below 950nm.

The shortest recoverable lifetime (lifetime resolution) is approximately 1/10th of the Instrument Response Function after numerical reconvolution.

Technical Specifications

Optical Configuration

90° between excitation and emission beam path

Mode of Operation

Time Correlated Single Photon Counting

Lifetime Range

5 ps – 50 µs (depending on source and detector choice)

Mechanical Spectral Range

200nm – 900 nm (standard)
800 nm – 2000 nm (optional for infrared photomultipliers)

Spectral Band Pass

0 nm – 60 nm (computer controlled)

Temporal Dispersion

Zero (negligible)

Laser Beam Attenuation

4 order of magnitude, continuously adjustable (computer controlled)

Spectrometer Software

F900 for Windows® complete software package for data acquisition and lifetime data analysis