Combined Stationary Fluorescence Spectroscopy and Nanosecond Time-Resolved Laser Flash Photolysis Setup

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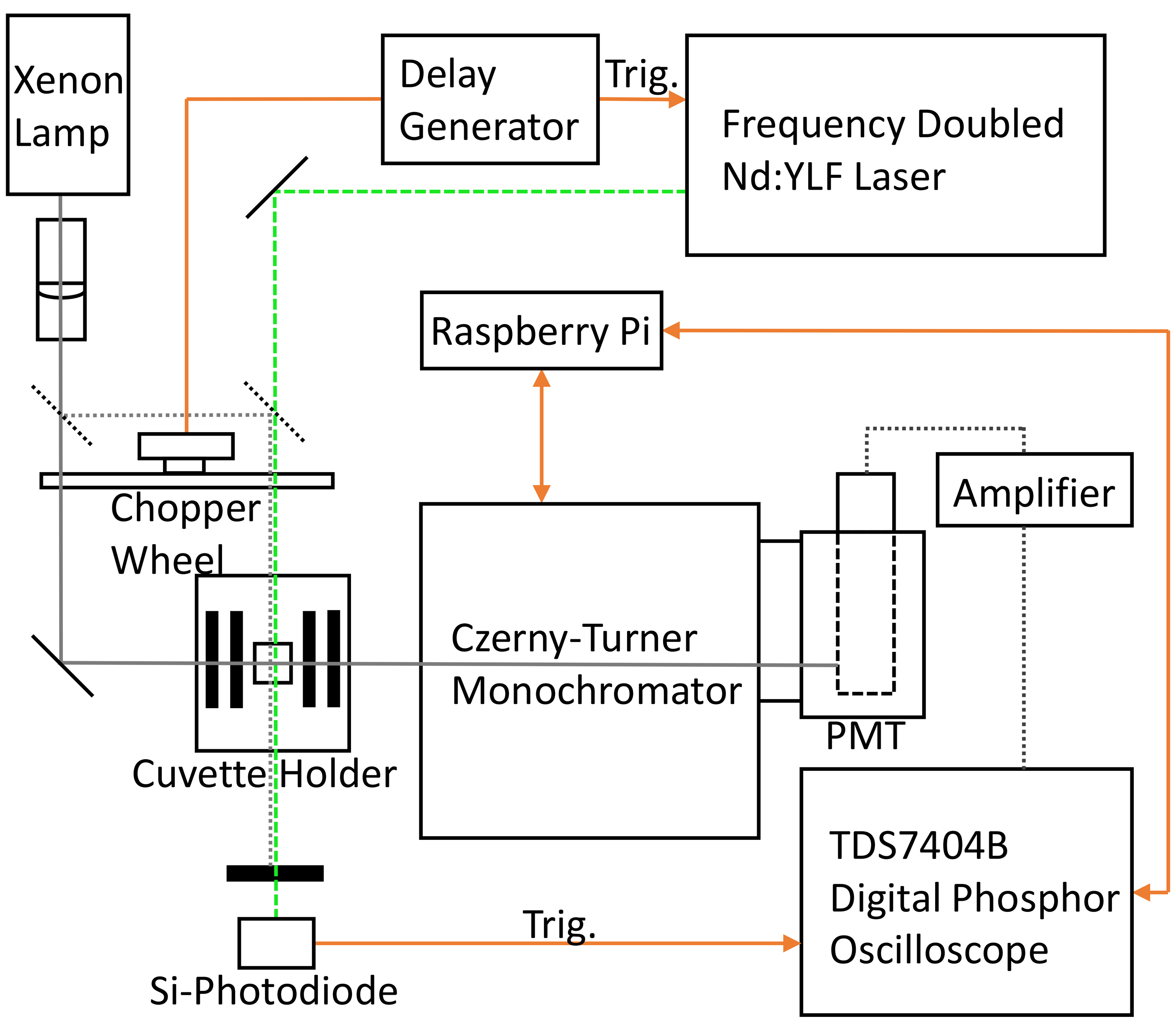
Motivation

Excited states in organic molecules occur when photons are absorbed, promoting the molecule to a higher energy level. Studying their properties and lifetimes can help the development of novel photoactive compounds used in solar cells, volumetric 3D printing and other light-driven technologies. Fluorescence spectroscopy can provide spectral information about the emission spectrum, quantum yield and intensity change factors, while laser flash photolysis reveals the dynamics and lifetimes of non-radiative excited states such as triplet-states.

Experimental Setup



Excitation Sources

Pump laser wavelength	527 nm
Laser repetition rate	444 Hz - 10 kHz
Laser pulse energy	0.1 - 9.6 mJ
Laser pulse width	232 ns
Fluorescence excitation / Probe beam	Xenon arc lamp (75 W / 6000 K)

Detection System

Radiometric sensitivity	380 - 780 nm
Spectral resolution	0.79 nm
Wavelength accuracy	± 1 nm
Linearity deviation	< 2.5 %
Temporal resolution	2-5 ns
Time window	2.3 ms

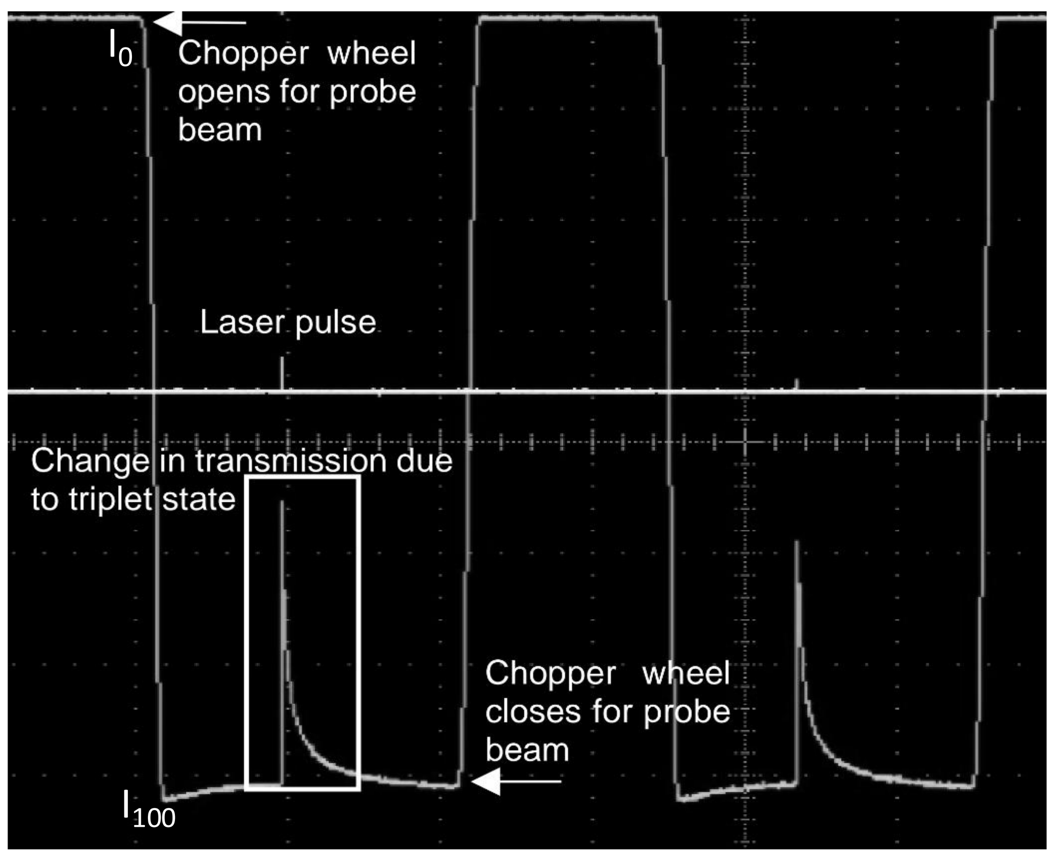
System Control for Pump-Probe Measurements

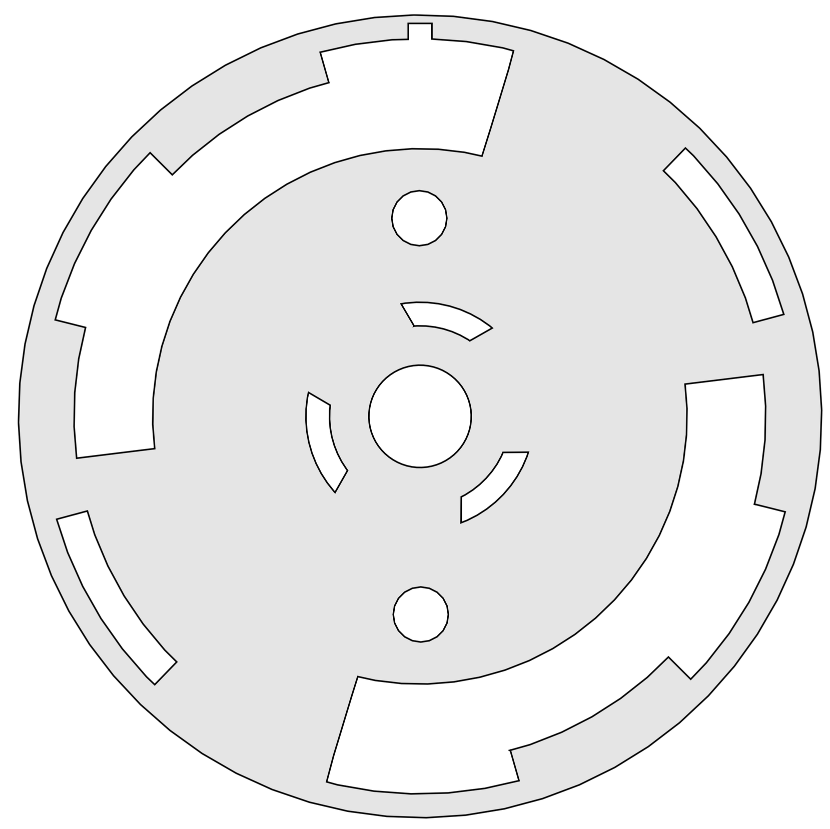
Chopper wheel design:

- Inner holes for pump beam passage and pulse picking
- Outer slots for probe beam transmission
- Slots on perimeter used by chopper controller to detect rotations

Timing behavior:

- Six laser pulses per rotation
- A delay generator ensures synchronization of laser pulses with the open segments in the chopper wheel
- Two pulses pass through designated holes
- Effective laser frequency drops down to 148 Hz
- Pulses hit the Si-photodiode and trigger the oscilloscope
- Control and data acquisition via Python scripts on Raspberry Pi





Measured Parameters

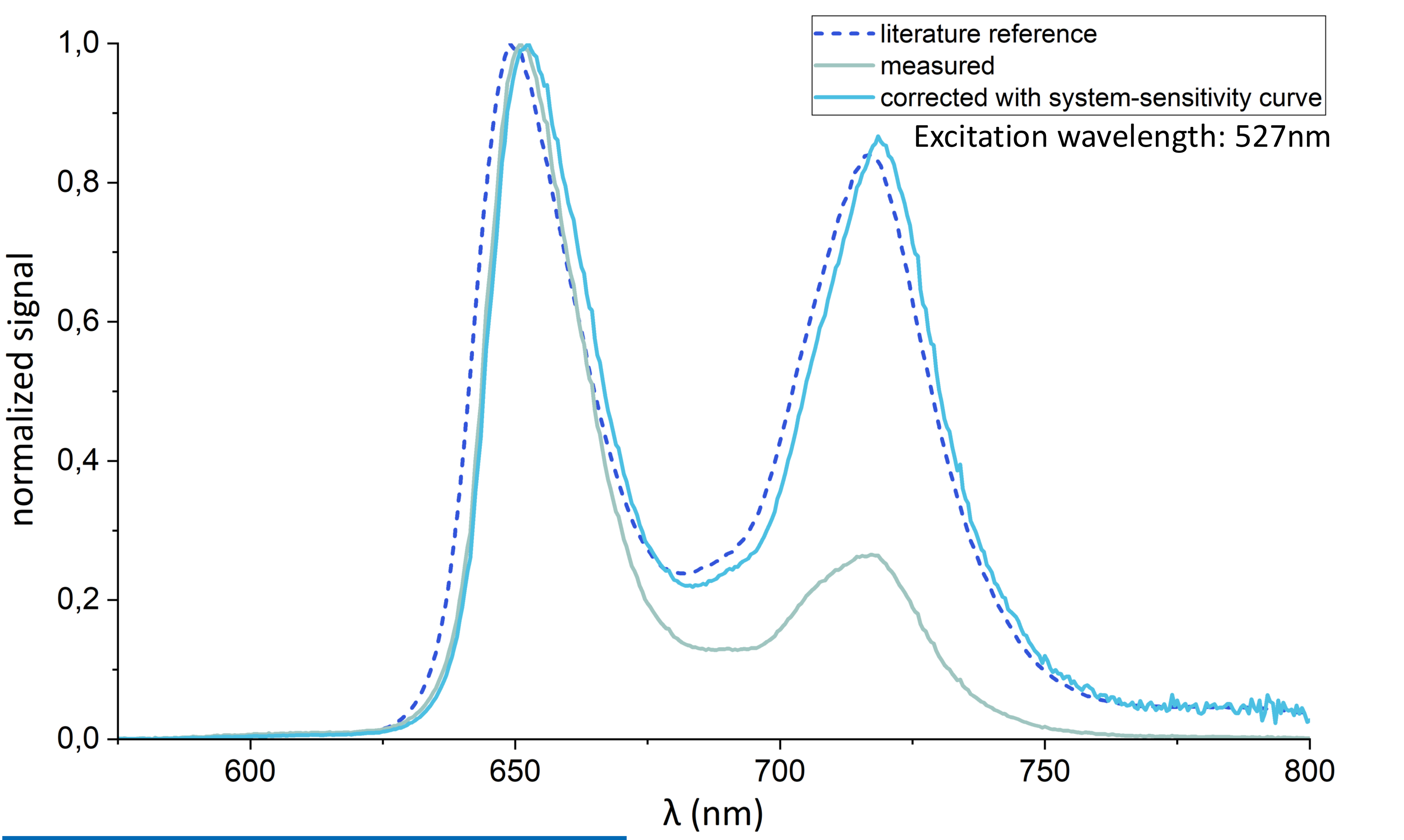
Steady-State Fluorescence Spectroscopy:

- Fluorescence emission spectra
- Emission maxima
- Stokes shift
- Quantum yield
- Intensity changes in response to external conditions

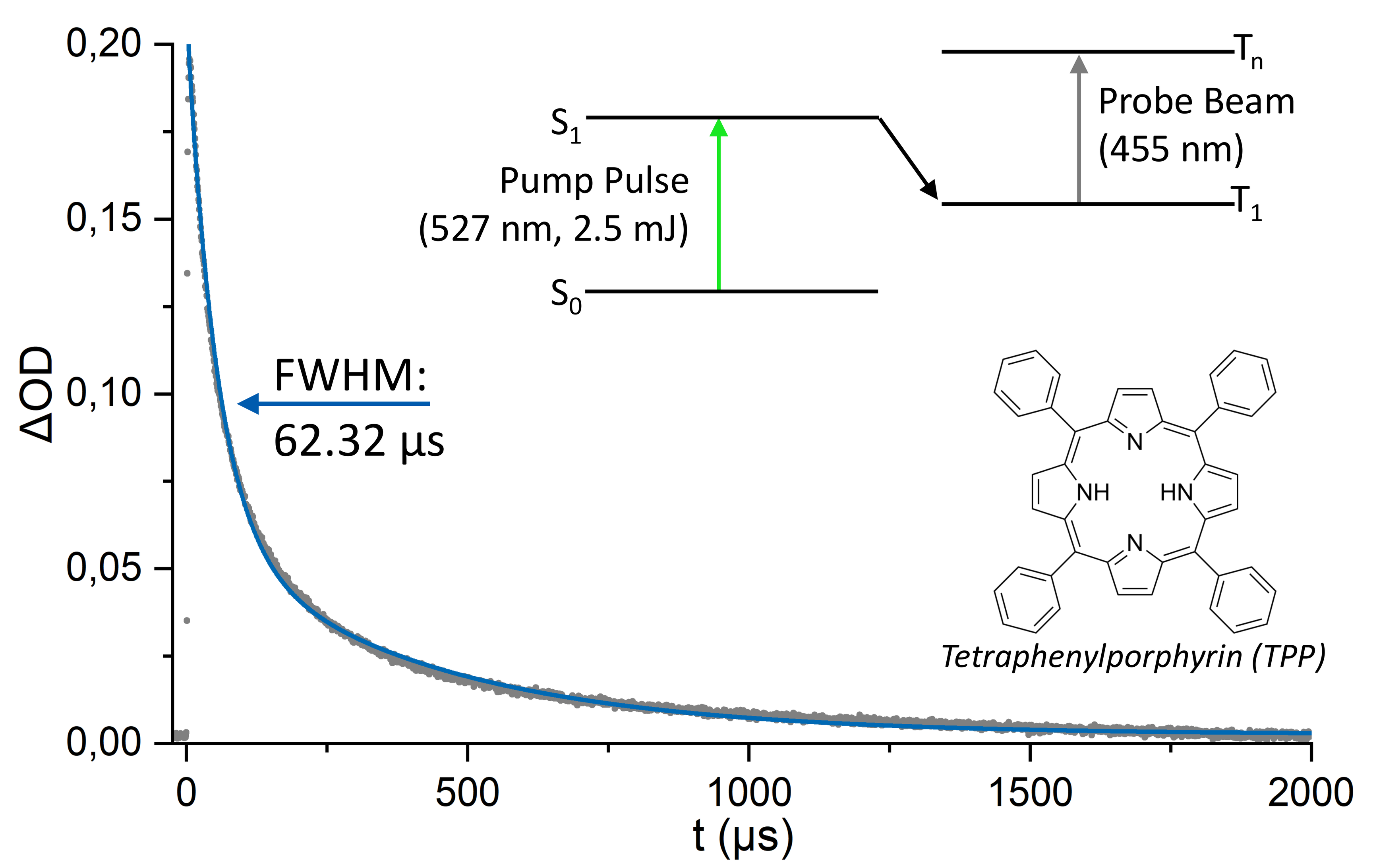
Nanosecond Time-Resolved Laser Flash Photolysis:

- Excited-state lifetimes
- Transient absorption spectra (ΔOD)
- Kinetics of photophysical processes
- Effect of quenchers on triplet-state decay

Fluorescence Emission Spectrum



Triplet State Lifetime



Conclusion

This setup combines steady-state fluorescence spectroscopy with nanosecond time-resolved laser flash photolysis in a compact system. All components can be easily replaced or adapted for specific experimental requirements. A custom-designed chopper wheel eliminates the need for complex time control electronics. Initial measurements with *tetraphenylporphyrin* demonstrated reliable results for fluorescence emission and triplet-state lifetime.

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