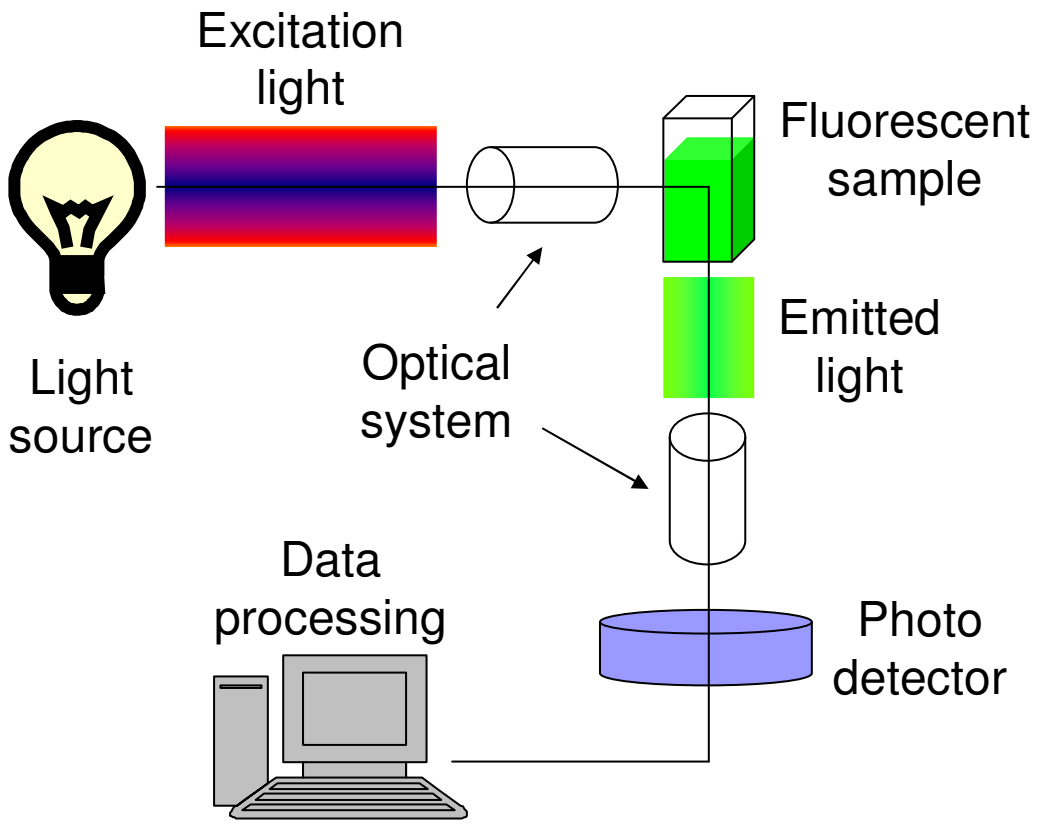
Simulation modelling for the analysis and the optimal design of SPAD detectors for time-resolved fluorescence measurements

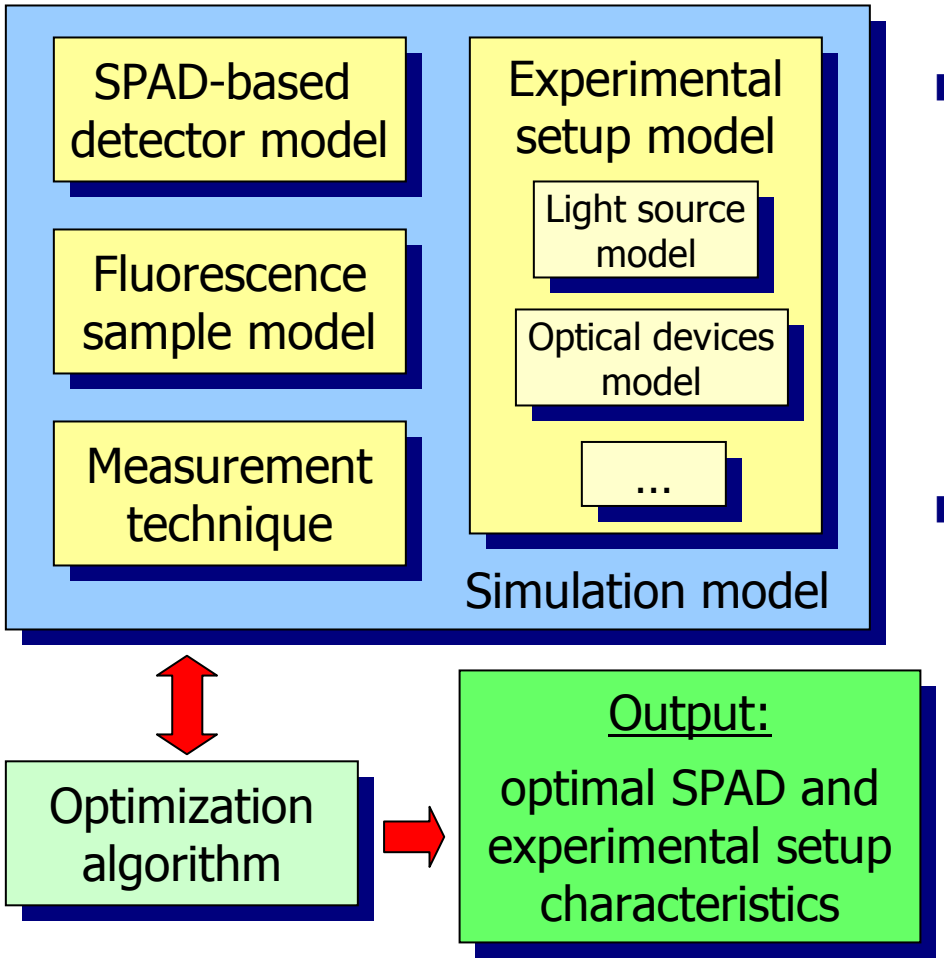
Marina Repich, David Stoppa,
Lucio Pancheri,
Gian-Franco Dalla Betta

Typical fluorescence measurement setup

- The photodetector determines the accuracy of the measurements.
- General performance of measurement setup are defined by all part: from light source to software.

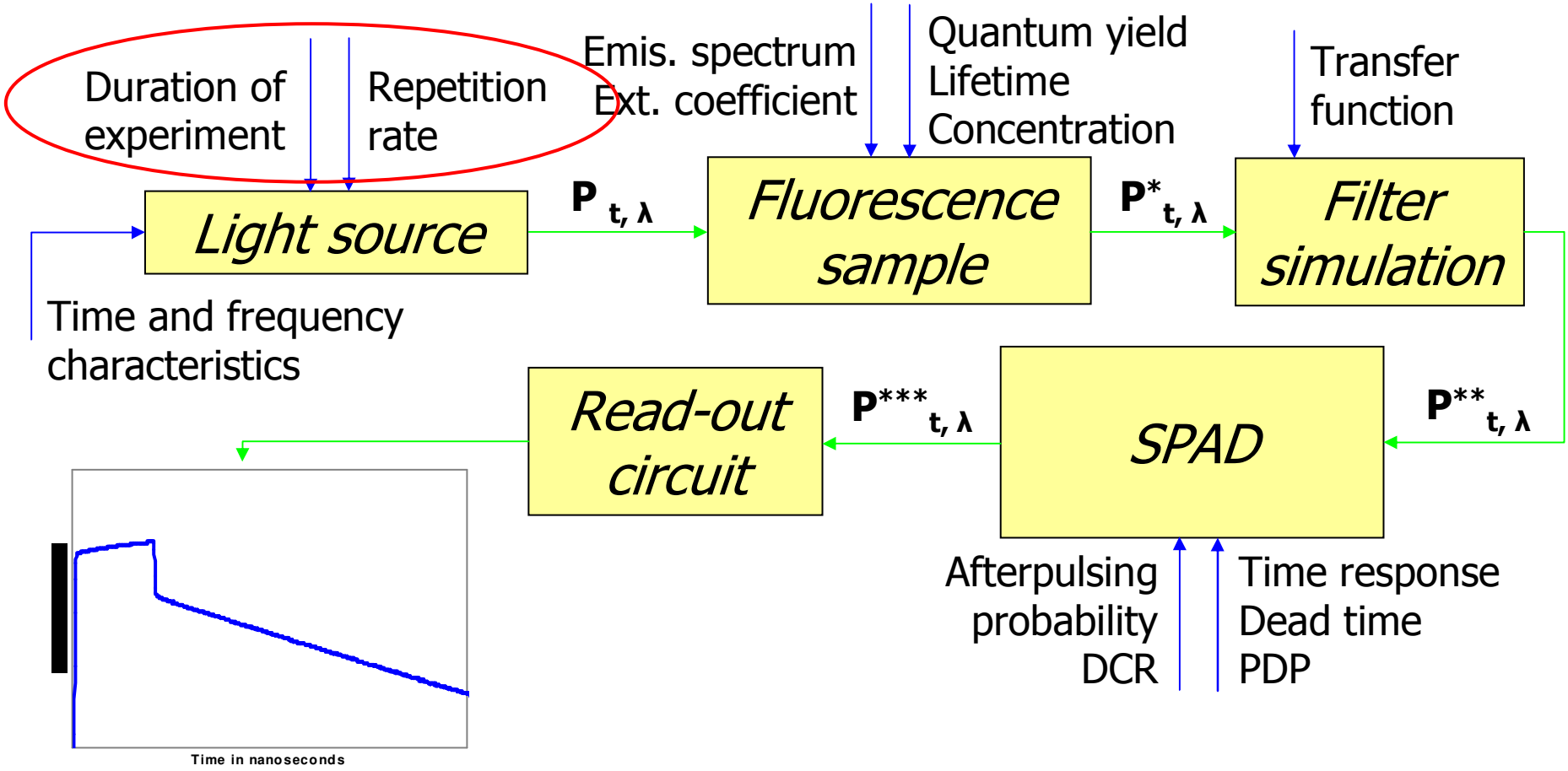


System structure

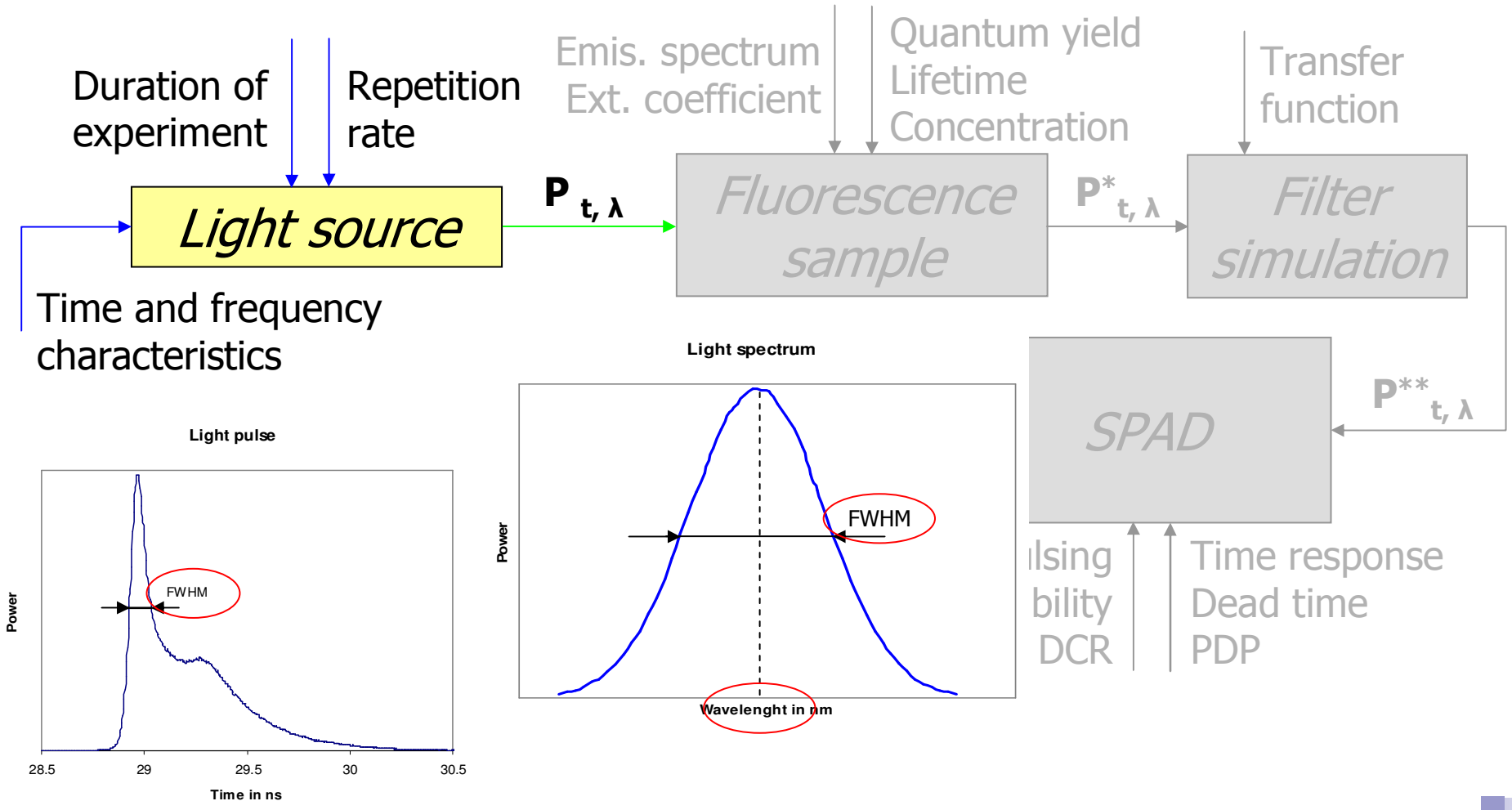


- The simulation model consists of a set of independent blocks each of them simulates an appropriate part of the experiment
- Optimization algorithm provide an opportunity to fit SPAD and experimental setup parameters to achieve the optimal system performance

Simulation workflow

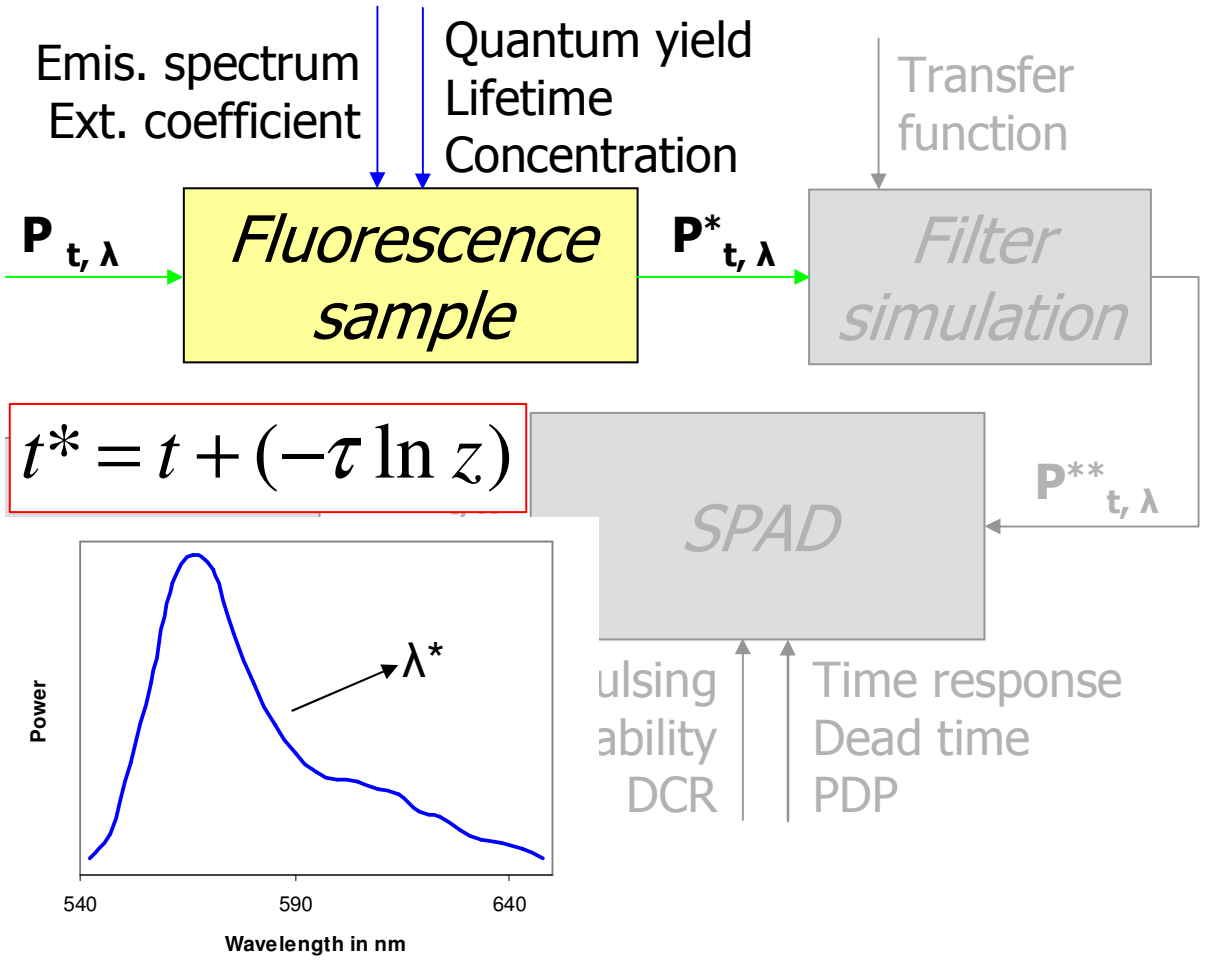


Simulation workflow

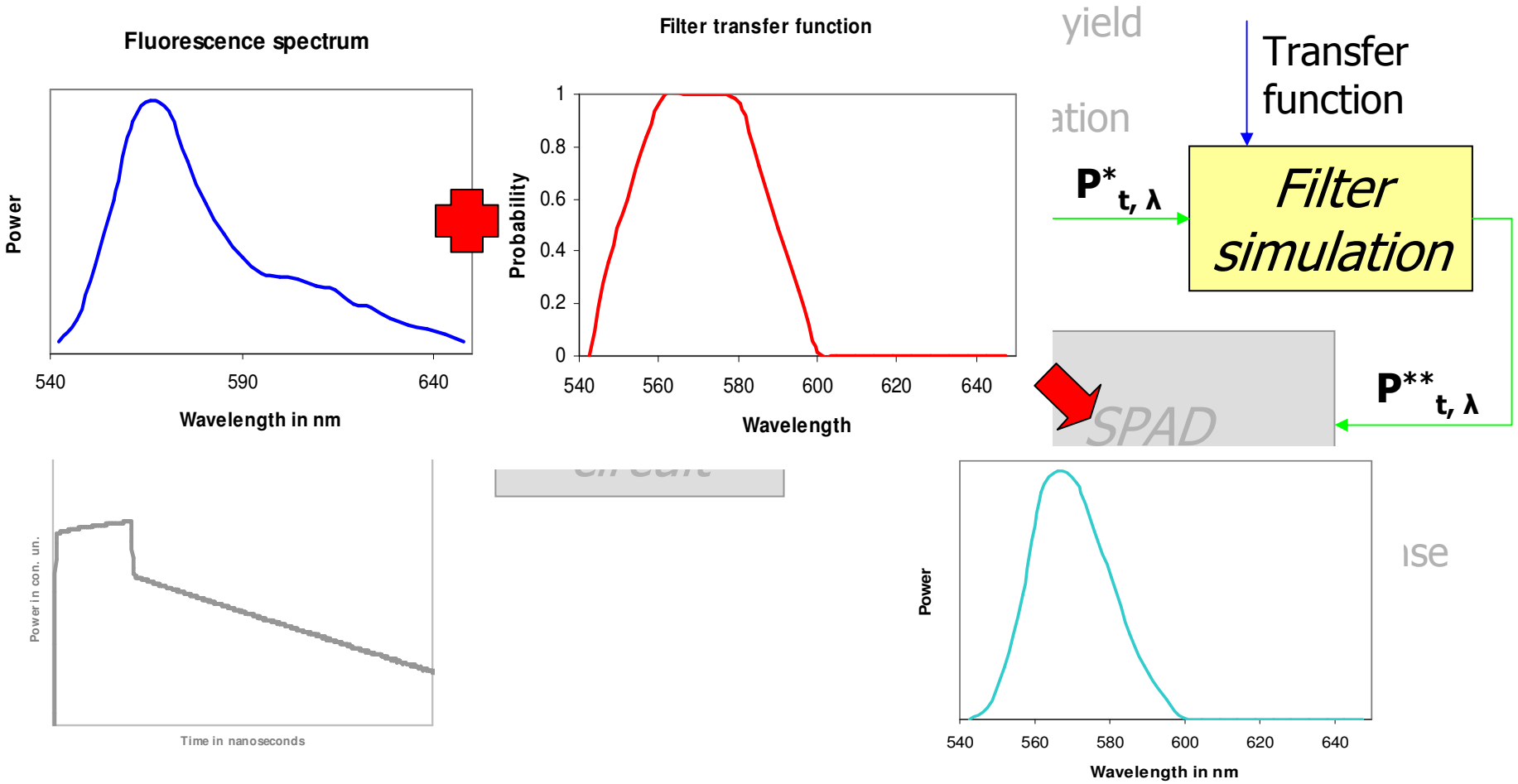


Simulation workflow

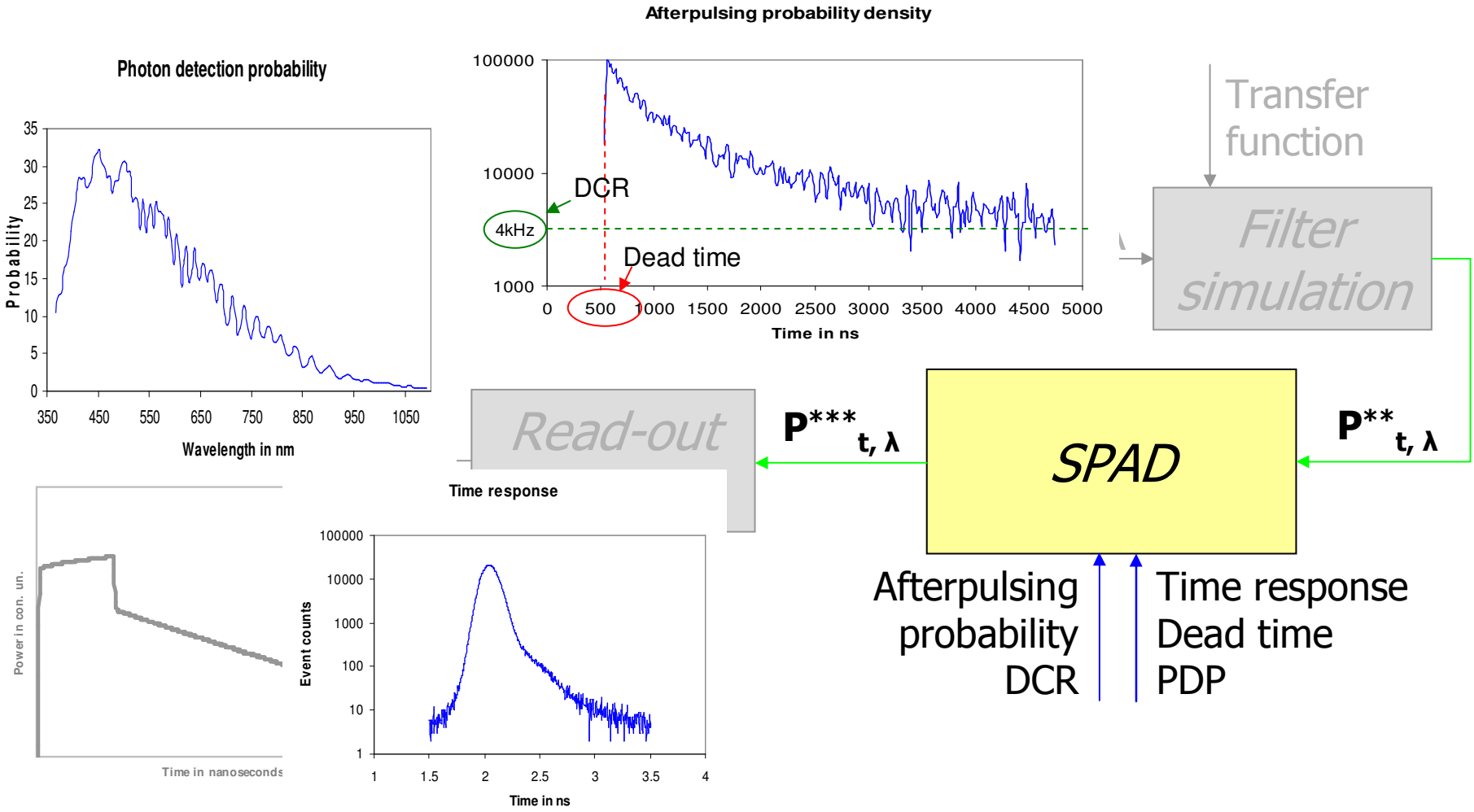
- Assumptions:
  - the light absorption obeys the Beer-Lambert law;
  - fluorophores have uniform distribution;
  - the optical density of the fluorescent sample is negligible;
  - fluorescence decay is monoexponential;
  - there are no other processes influencing light emission except fluorescence.



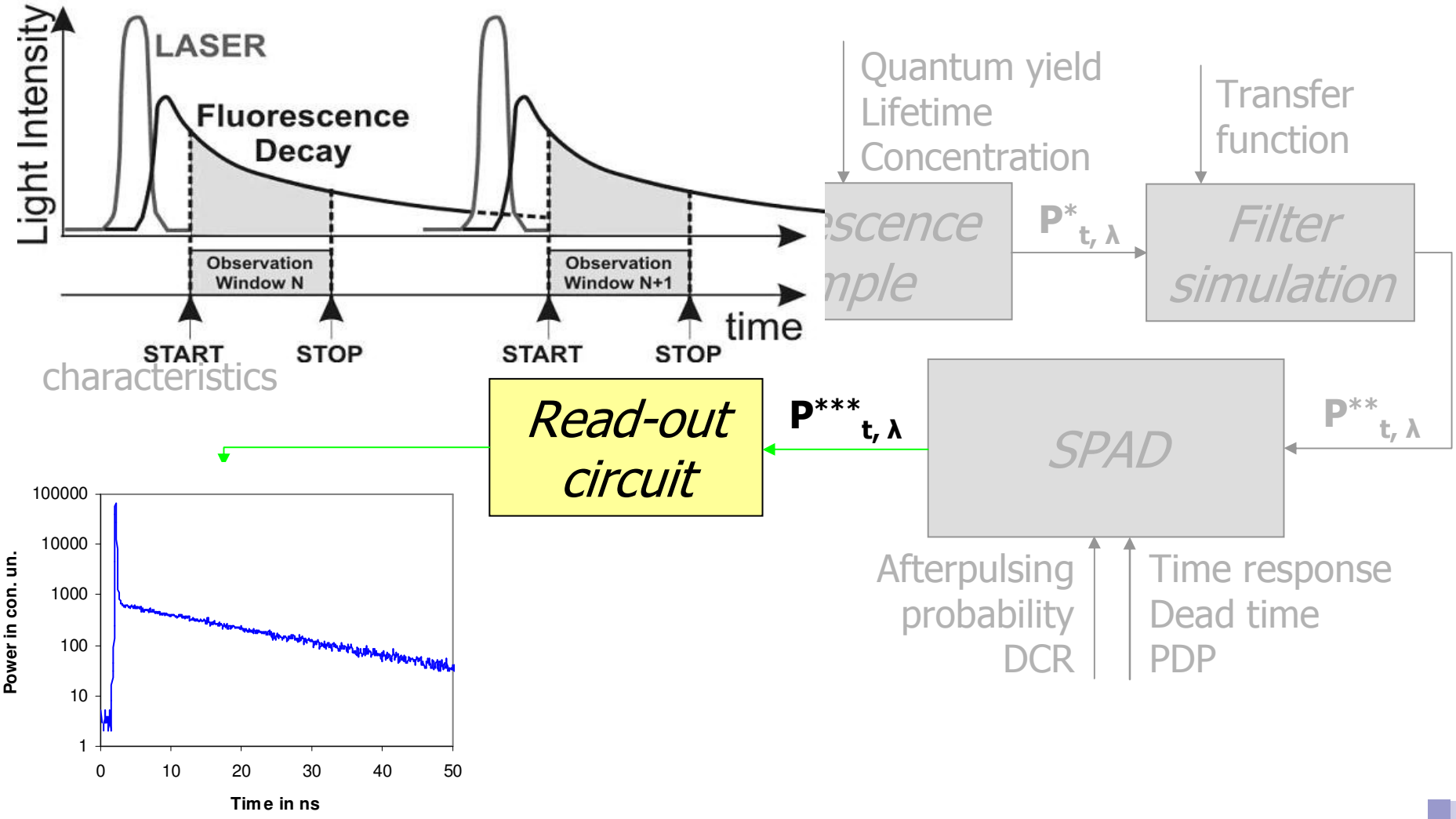
Simulation workflow



Simulation workflow

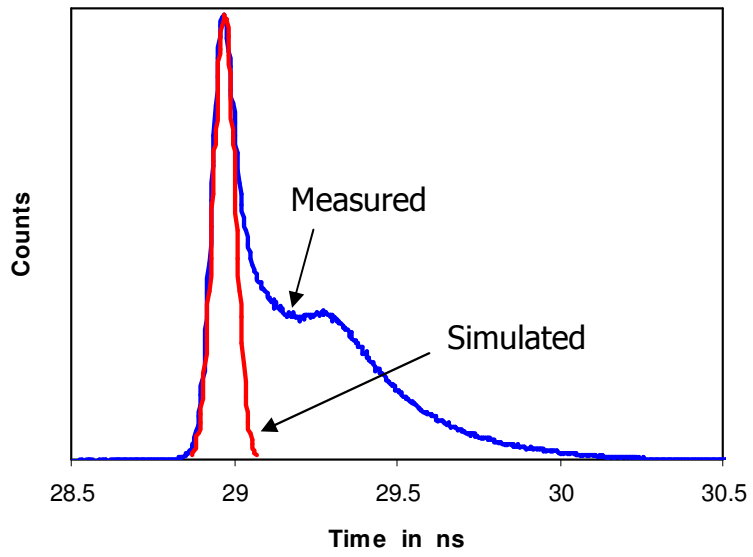


Simulation workflow

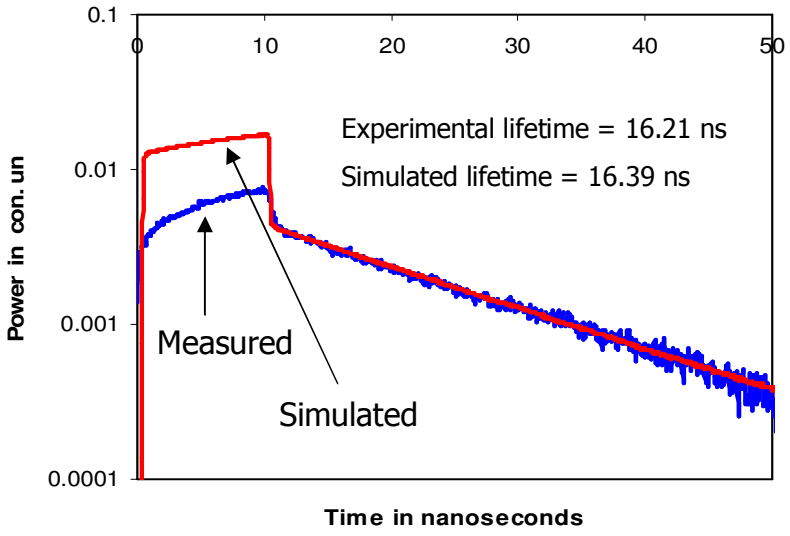


Simulation results

- The practical and simulated laser pulses (Picoquant LDH-P-C-470 pulsed diode laser with 80-ps FWHM)



- Fluorescence decay simulated and measured with SPAD (time-gated technique with 10ns observation window and 60ps shift)



Future work

- Further improvement of SPAD simulation
  - Geometry
  - Effects related to passive quenching
  - Temperature dependence
- Including additional setup characteristics
  - Light source intensity
  - Optical lenses
- Implementation of optimization algorithm

Thank you
Questions?