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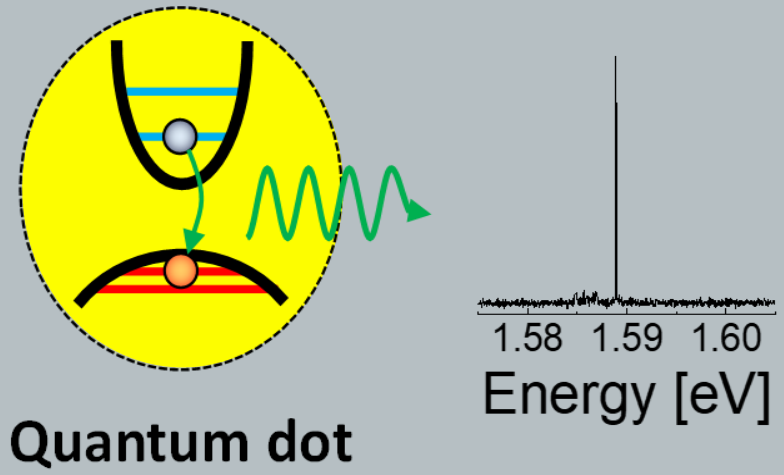
CHyN

INF18 - Photolumineszenz von Halbleiter-Quantenpunkten

Christian Heyn, Center for Hybrid Nanostructures (CHyN), University of Hamburg



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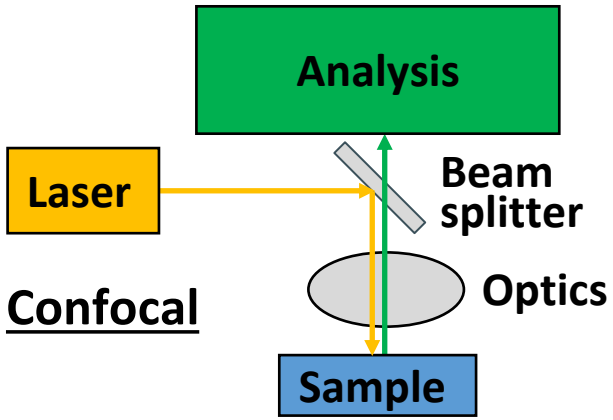
Luminescence: „cold light“
Photoluminescence: inelastic light scattering

Photoluminescence (PL) spectroscopy:

- Excitation by laser
- Confocal geometry for high resolution: excitation / emission through one objective
- Spectral analysis of the reflected emission
- Information: energy of states inside the sample
- Here: PL on semiconductor quantum dots (QDs)



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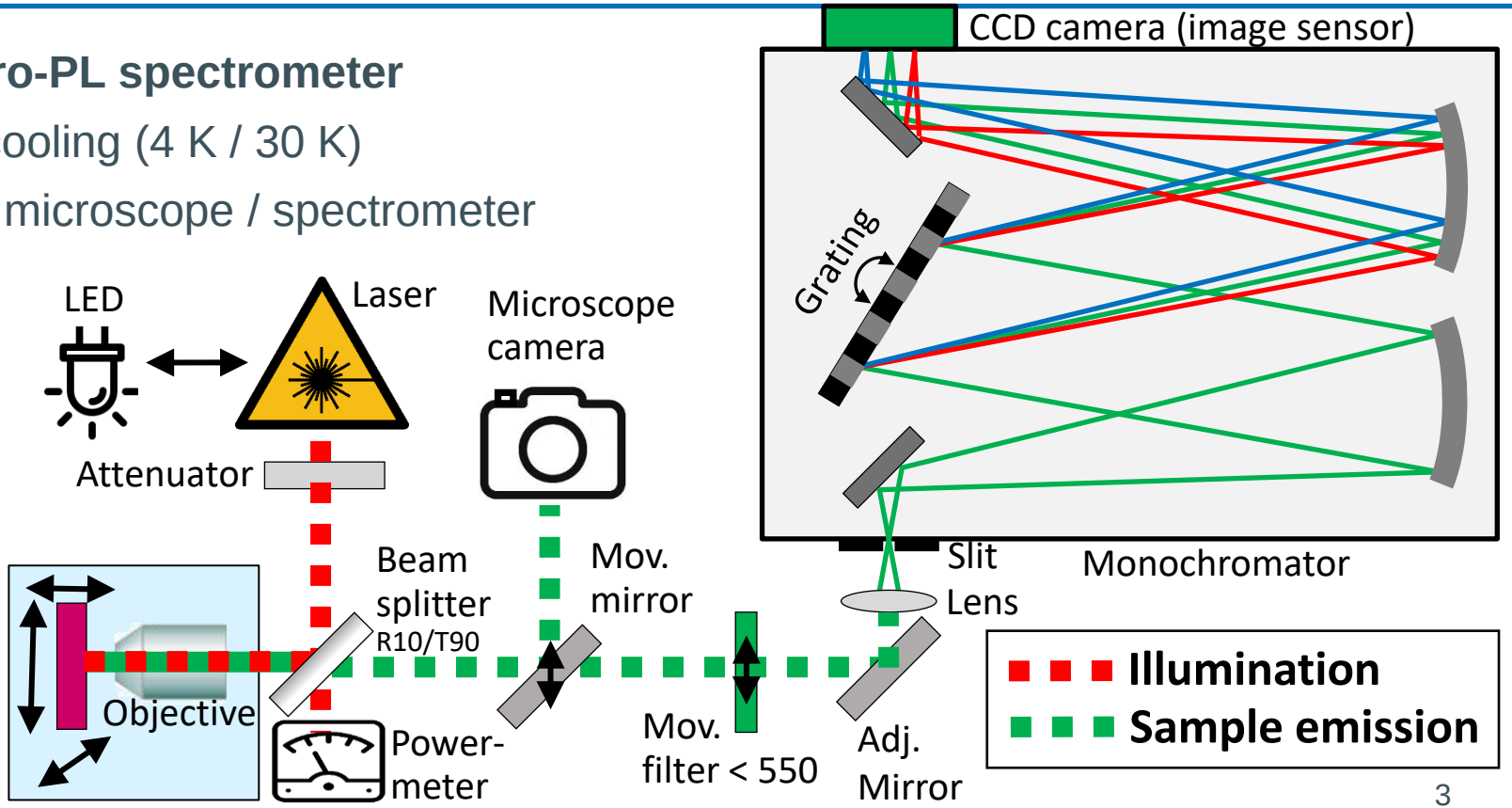
Basic micro-PL spectrometer

- Sample cooling (4 K / 30 K)
- Confocal microscope / spectrometer



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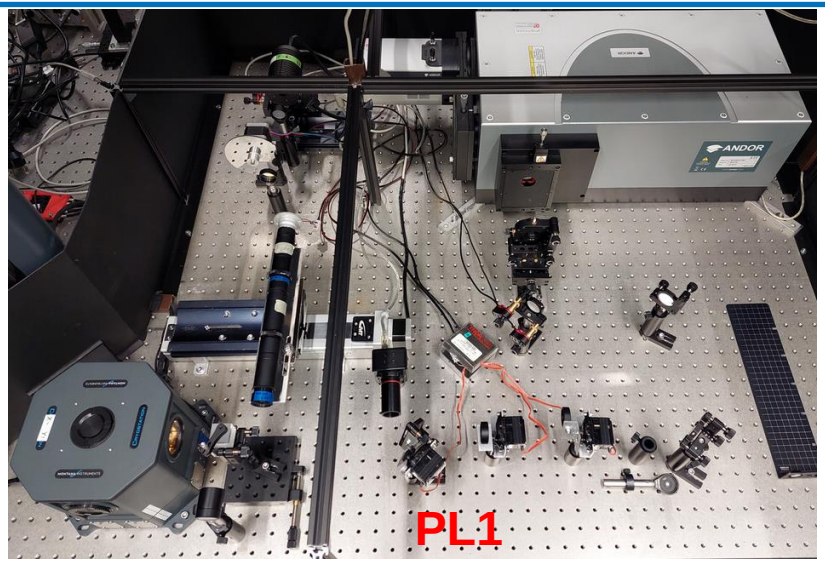

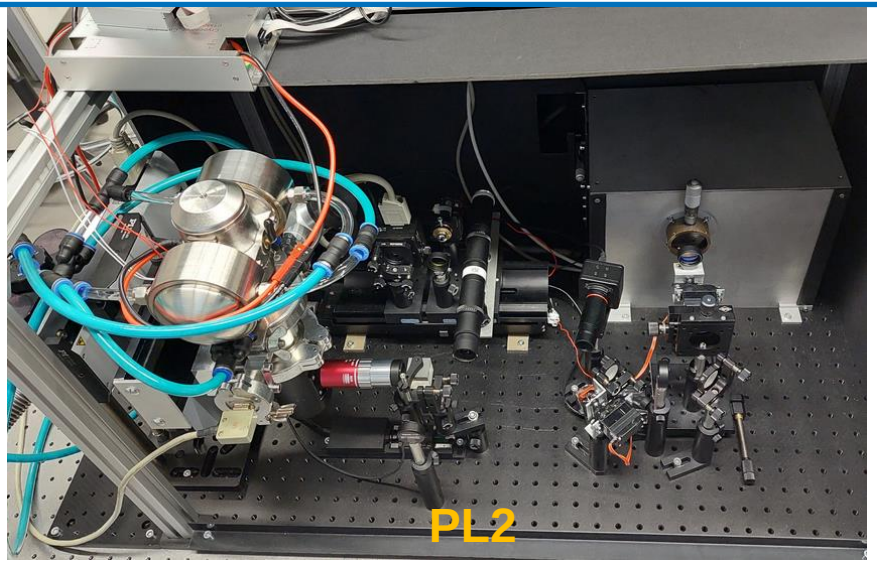

PL1 (state of the art setup)

- Sample cooling down to 3 K
- Ultra-low vibrations (< 1 nm)
- Extensions: high resolution, lifetime, …

PL2 (simplified setup)

- Sample cooling down to 30 K
- Vibrations ≈ 10 µm

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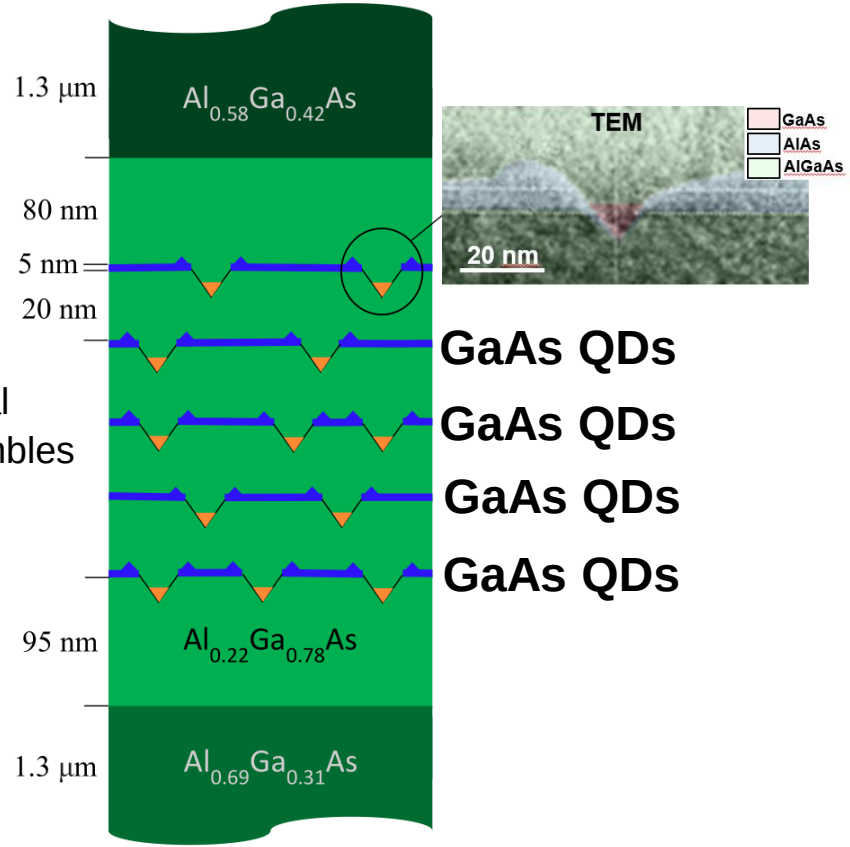
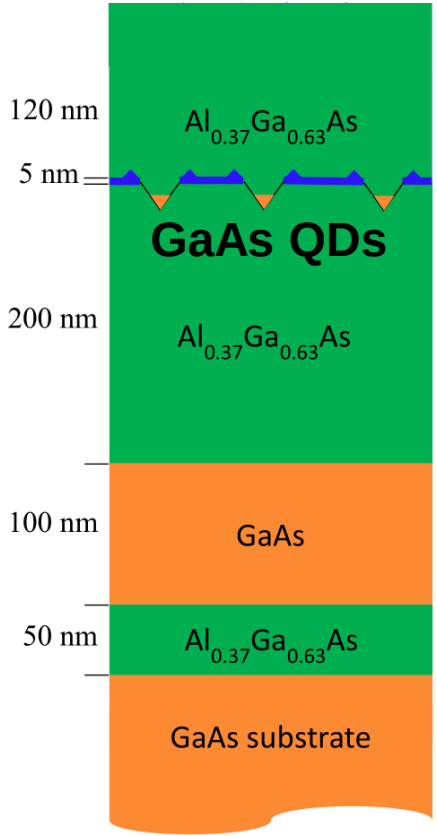
Samples A
(special)
5 QD layers
thick AlGaAs

+ High intensity
+ No GaAs signal
- Only QD ensembles



Samples B
(standard)
1 QD layer
thin AlGaAs

- Low intensity
- GaAs signal
+ Single QD PL



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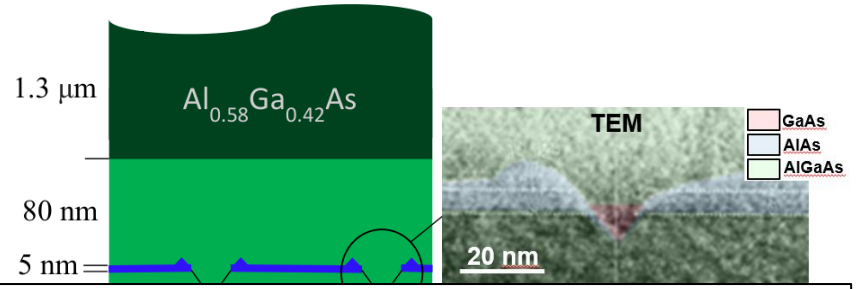
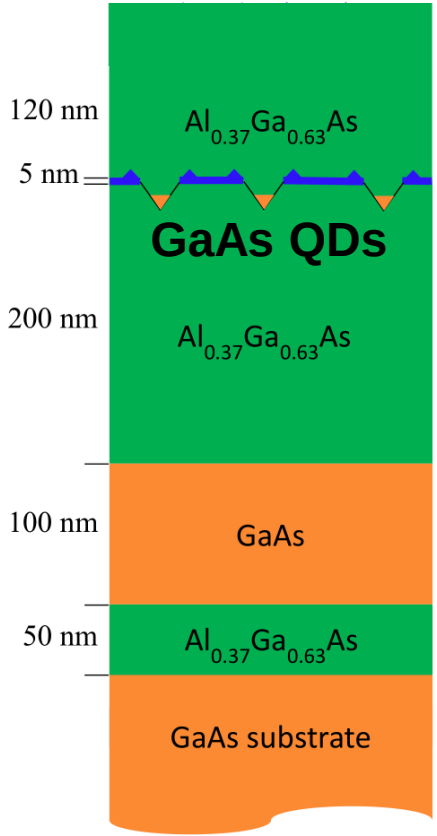
Samples A
(special)
5 QD layers
thick AlGaAs

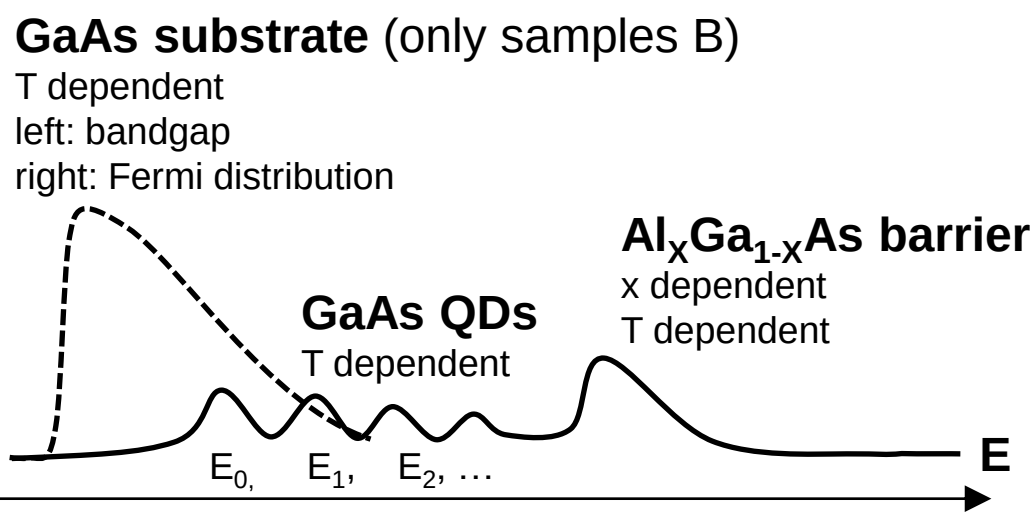


Samples B
(standard)
1 QD layer
thin AlGaAs

- Low intensity
- GaAs signal
+ Single QD PL



Intensity



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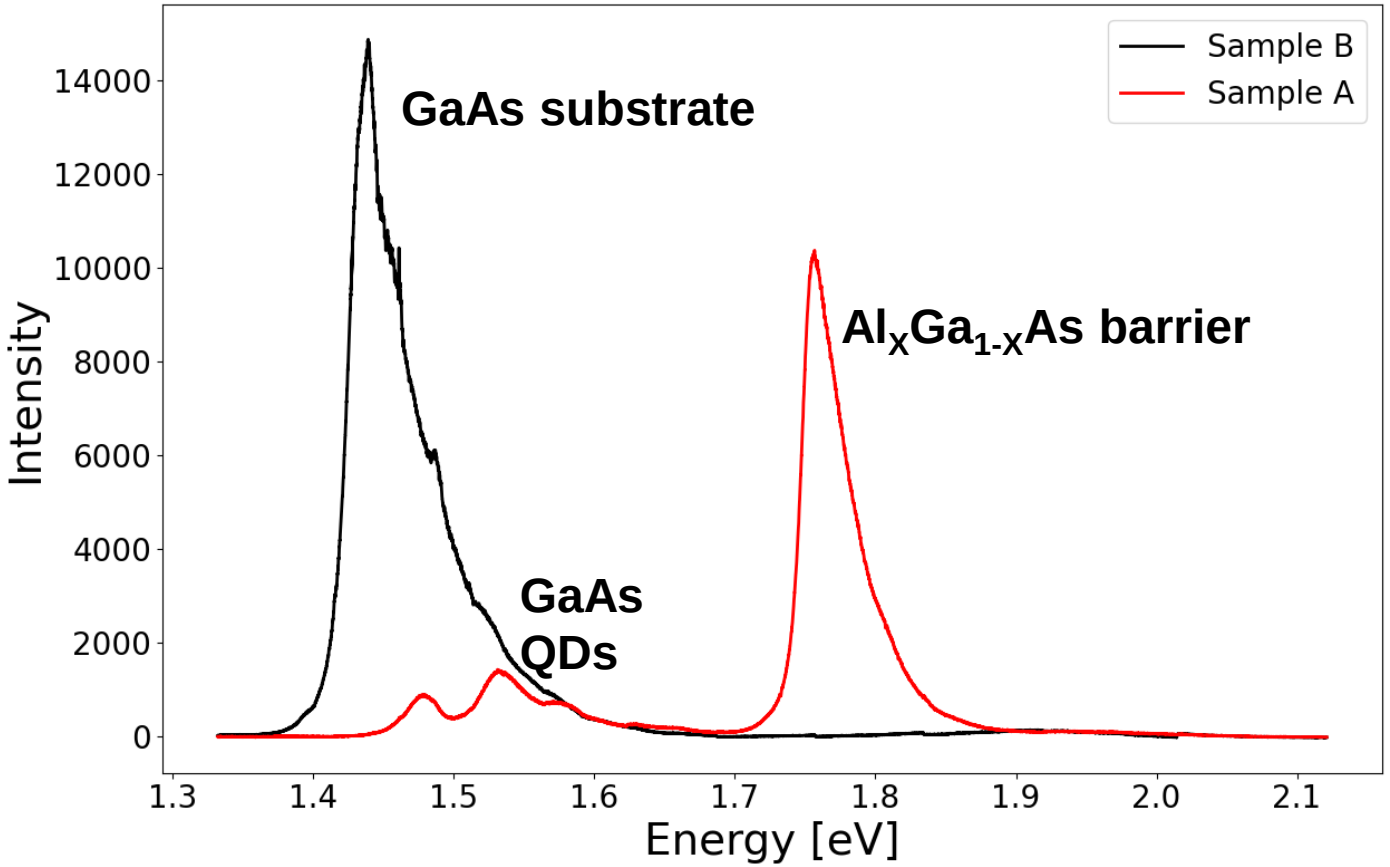
T = 300 K

Setup PL2

→ **Sample design**
QD shell structure



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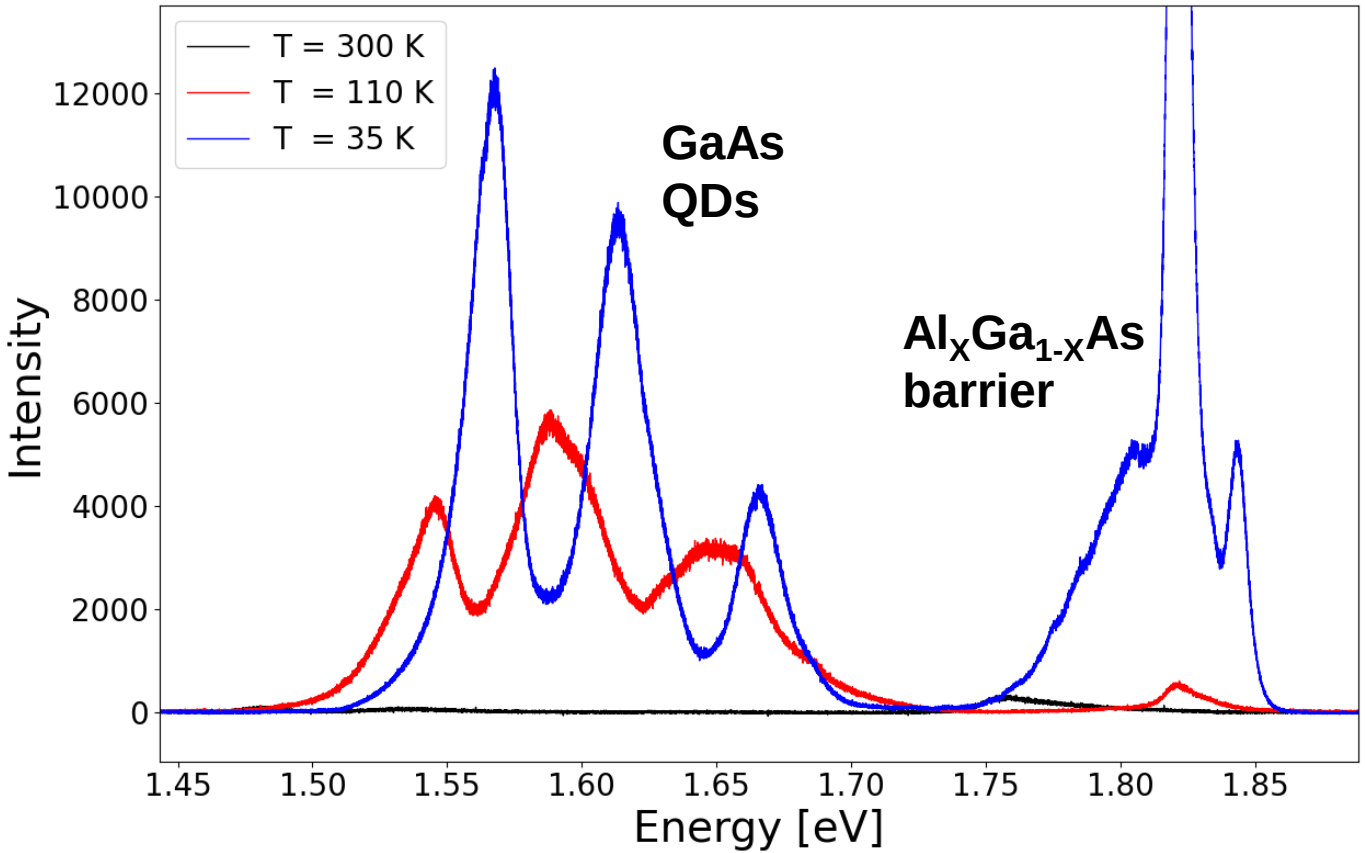
T varied

Sample A

Setup PL2

→ **T dependence of energy and intensity**



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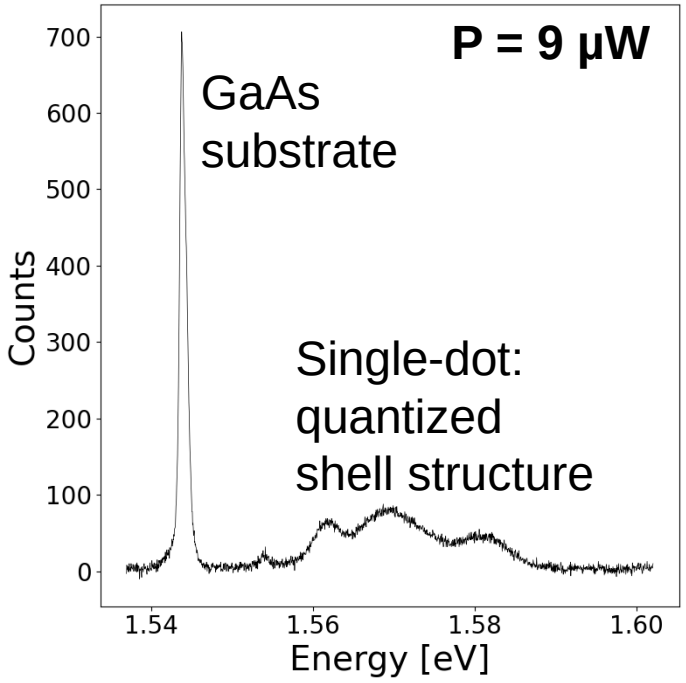
T = 4 K

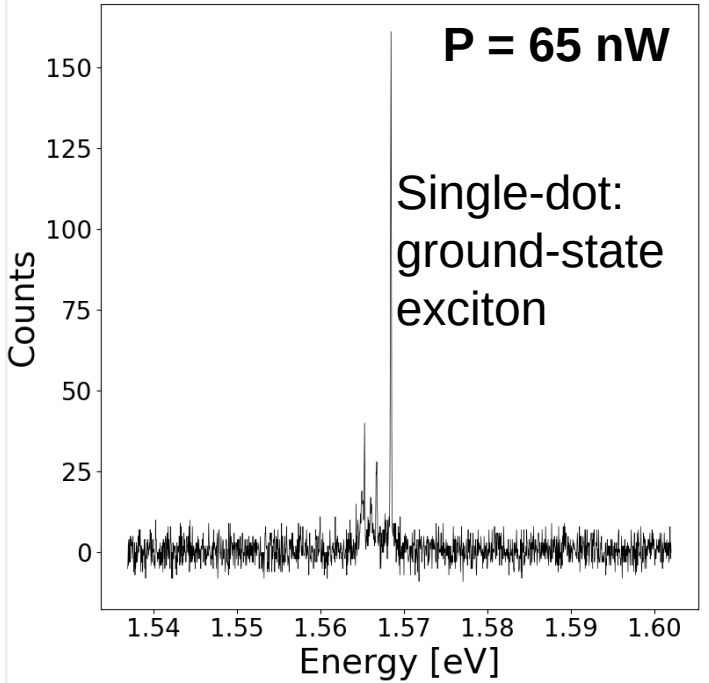
Laser power P varied

Sample B

Setup PL1

→ **GaAs PL small**
Single-dot PL
Single photons





Applications:
in quantum information technology QDs as deterministic source for single photons e.g. for quantum cryptography or photonic integrated circuits

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Aim of the experiment, experimental part:

- Basics of optical spectroscopy: optical components, spectrometer, cryo-cooler
- Practical training on optical spectroscopy: adjustment, measurement of: single nanometer-sized objects, at cryogenic T, with single photon sensitivity
- Data acquisition: sensitivity, noise, parameter optimization strategies, errors

Data analysis:

- Basic understanding of semiconductors optics and semiconductor quantum dots
- Data interpretation from QDs as 3D quantum harmonic oscillator: electron and hole quantization energies, Coulomb-interaction, QD size
- Influence of sample design, temperature, excitation power, …