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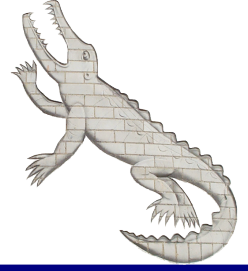

Coherent photon emission from quantum dots

Atomic, Mesoscopic and Optical Physics Group
Quantum Information and Nanoscale Metrology Subgroup

Outline

- Motivation: high quality single photons for the interfacing of distributed spins.
- State of the art
- Main experimental results:
  - Highly coherent single photons
  - Tailored photon wavepackets
  - Indistinguishability of photon emission
  - Raman transitions in X- emission spectrum
- Conclusions and outlook

Why resonance fluorescence?

- Need high coherence single photons
- Non-resonant excitation:
  - Induces dephasing
  - Coherence with laser is lost
  - Spectral wandering
- RF allows transition selectivity
- Two regimes of RF:
  - High power: Mollow triplet
  - Low power: Coherent scattering

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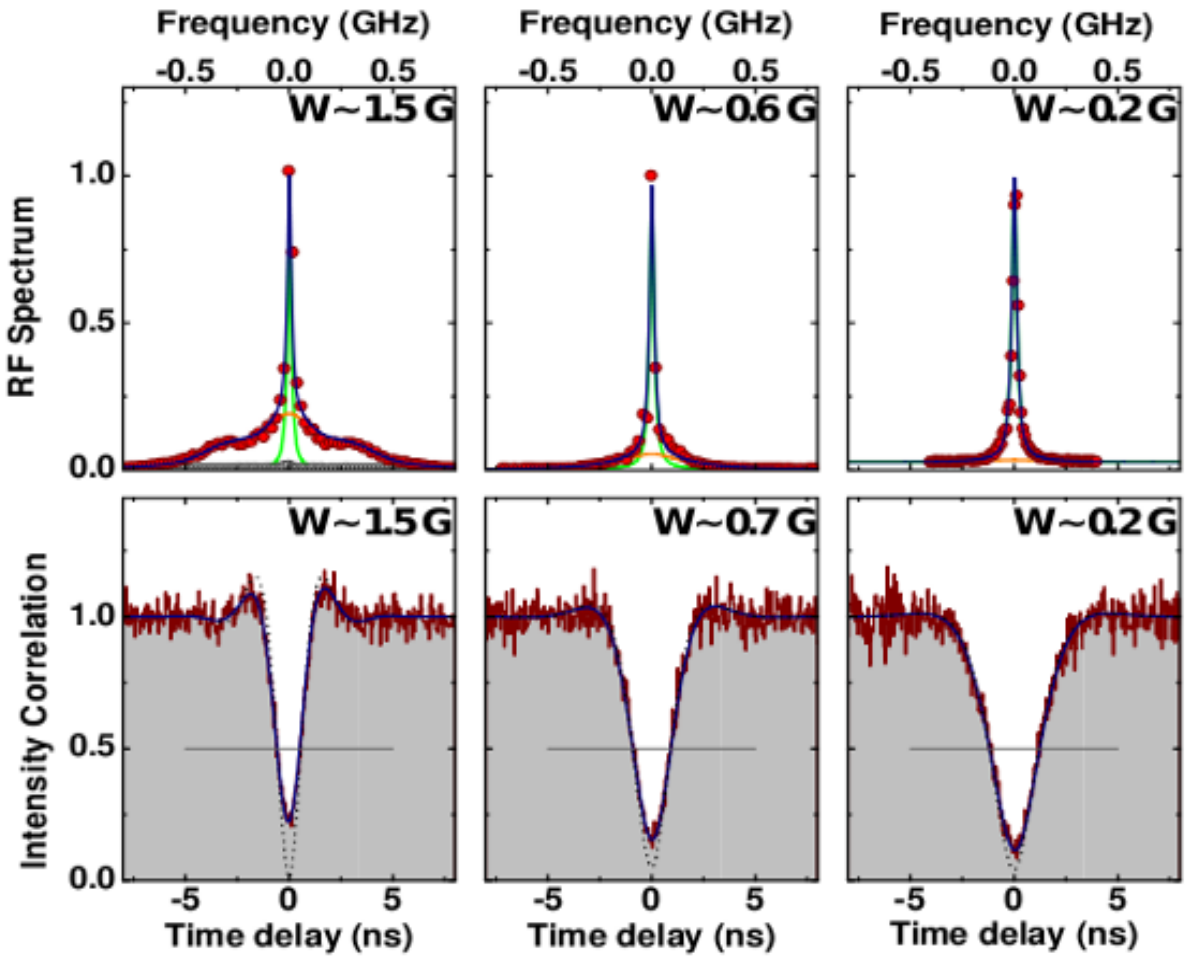
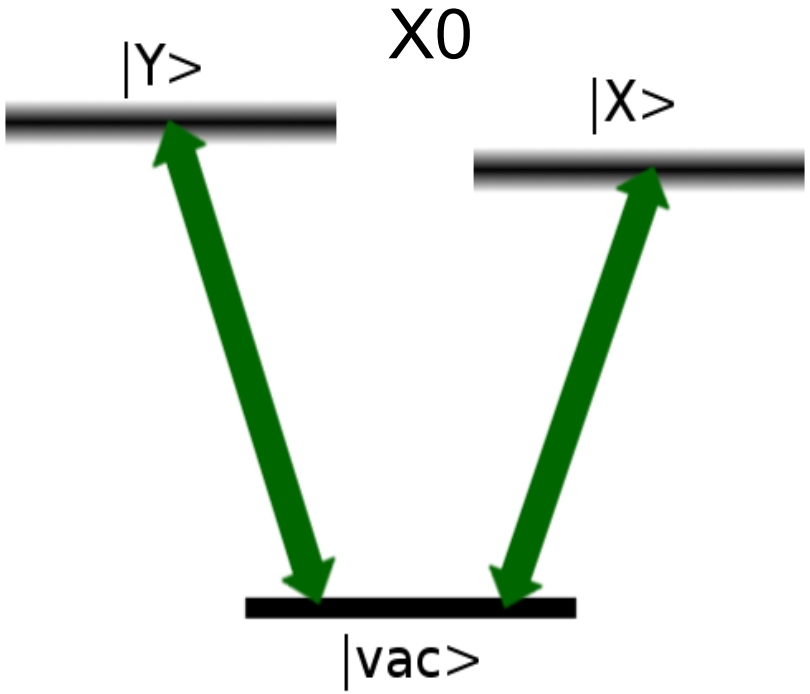
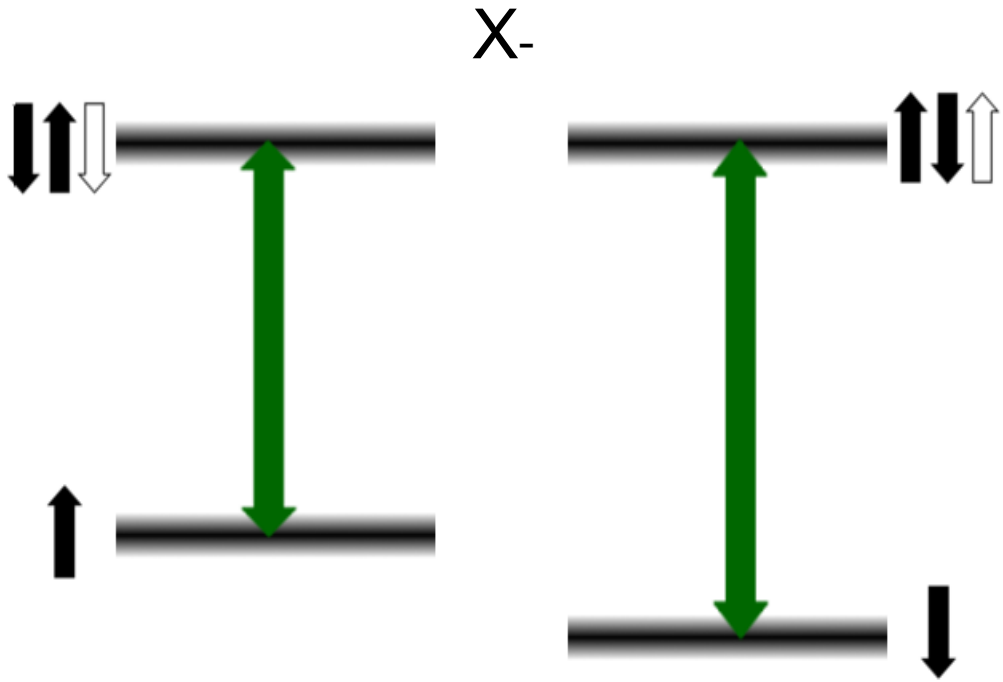


C.Matthiesen et al, PRL108, 093602 (2012)

Level structures in QDs

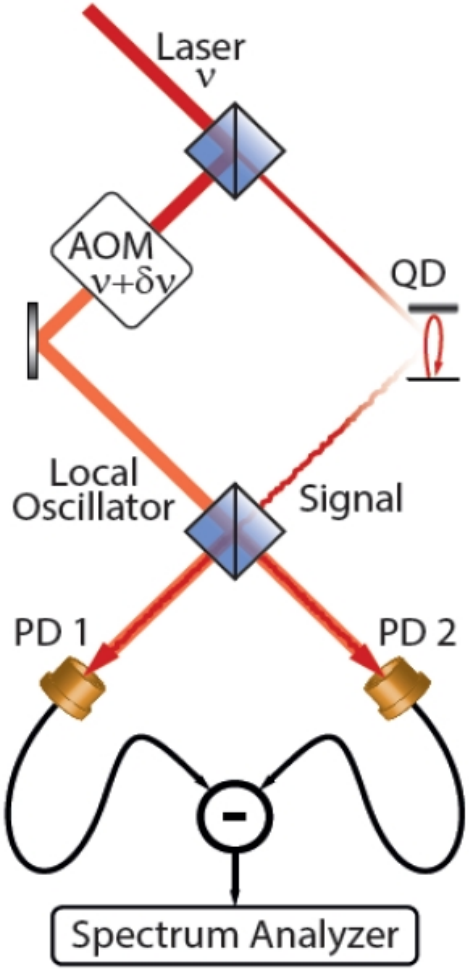




- Easy to isolate 2 level system
- Environment fluctuations don't affect ground state

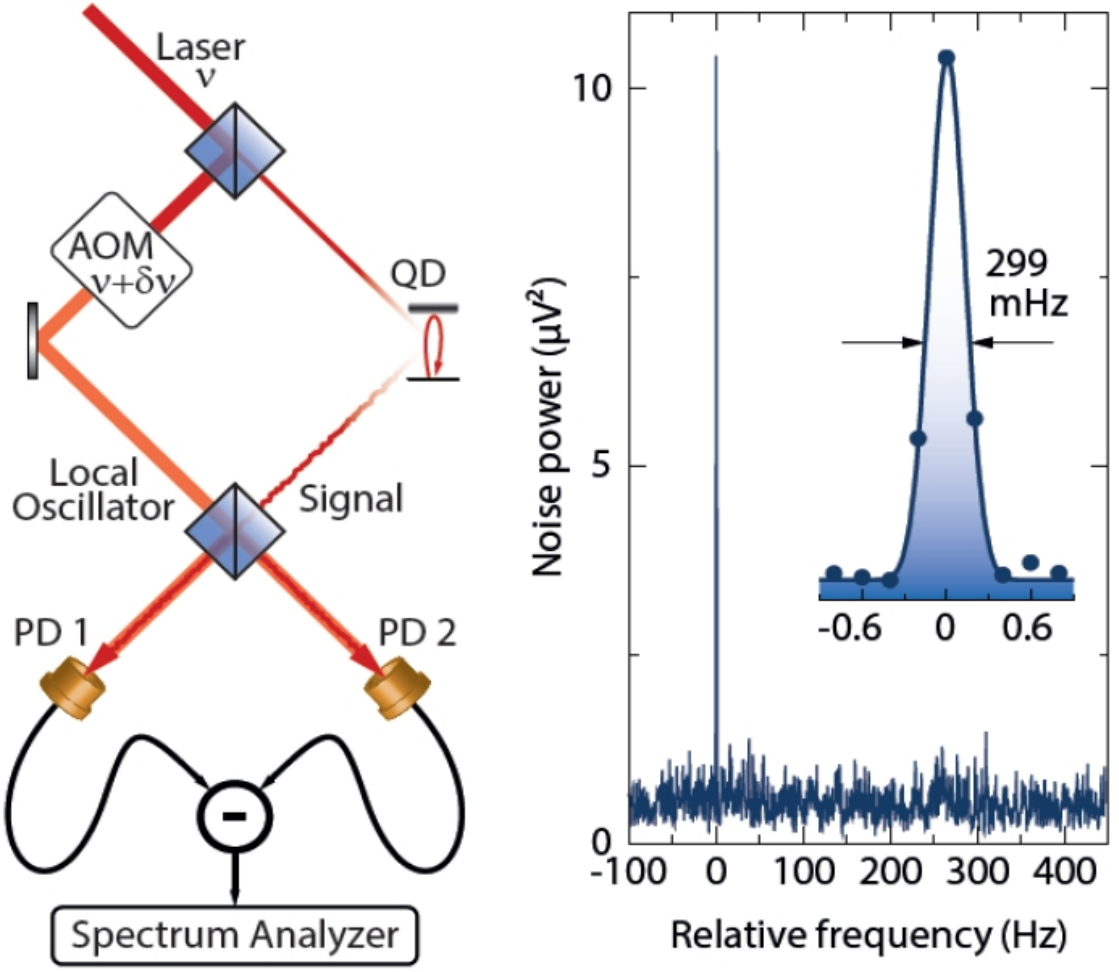
- Can use spin ground states as a qubit
- Electron susceptible to nuclear spin fluctuations

Highly coherent photons



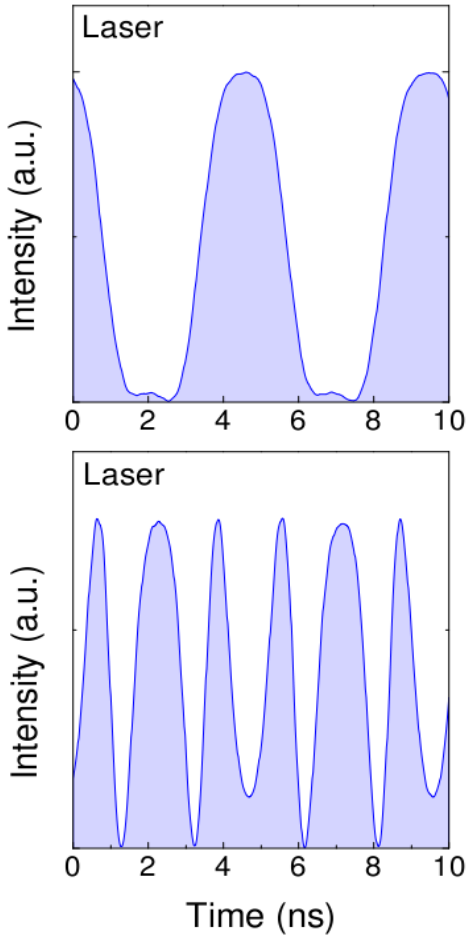
C.Matthiesen, et al, Arxiv/1208.1689 (2012)

Highly coherent photons



C.Matthiesen, et al, Arxiv/1208.1689 (2012)

Tailoring wavepackets



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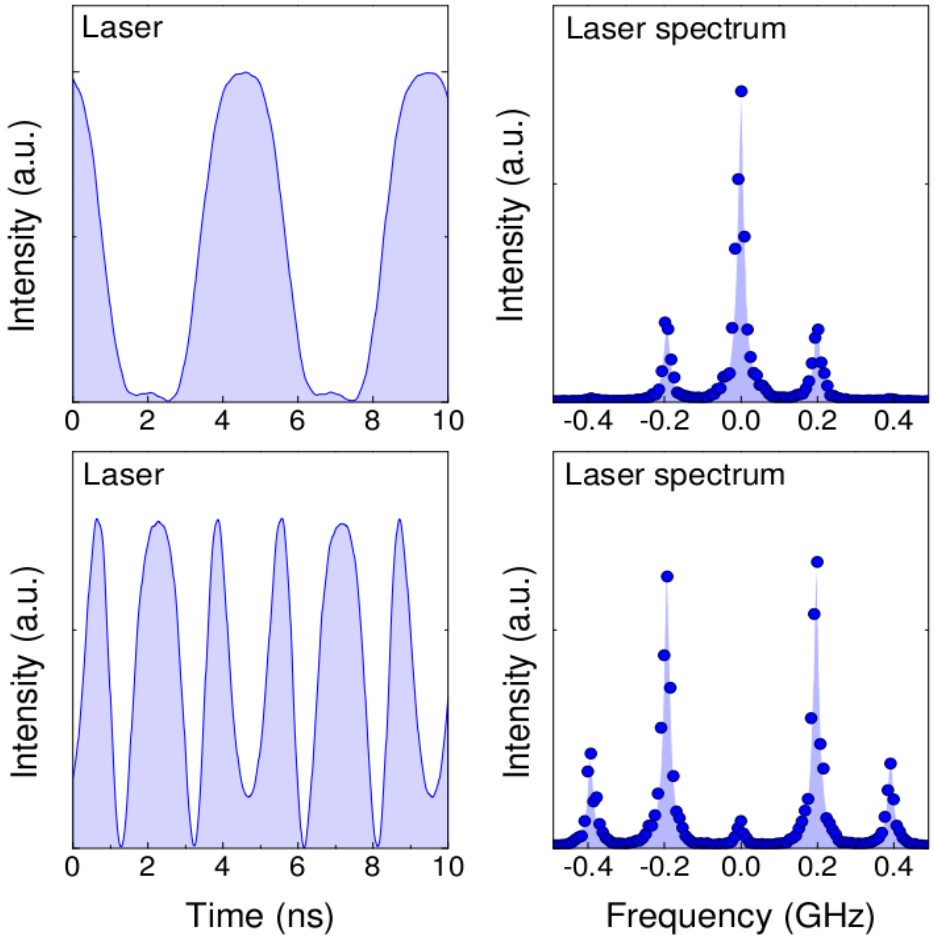

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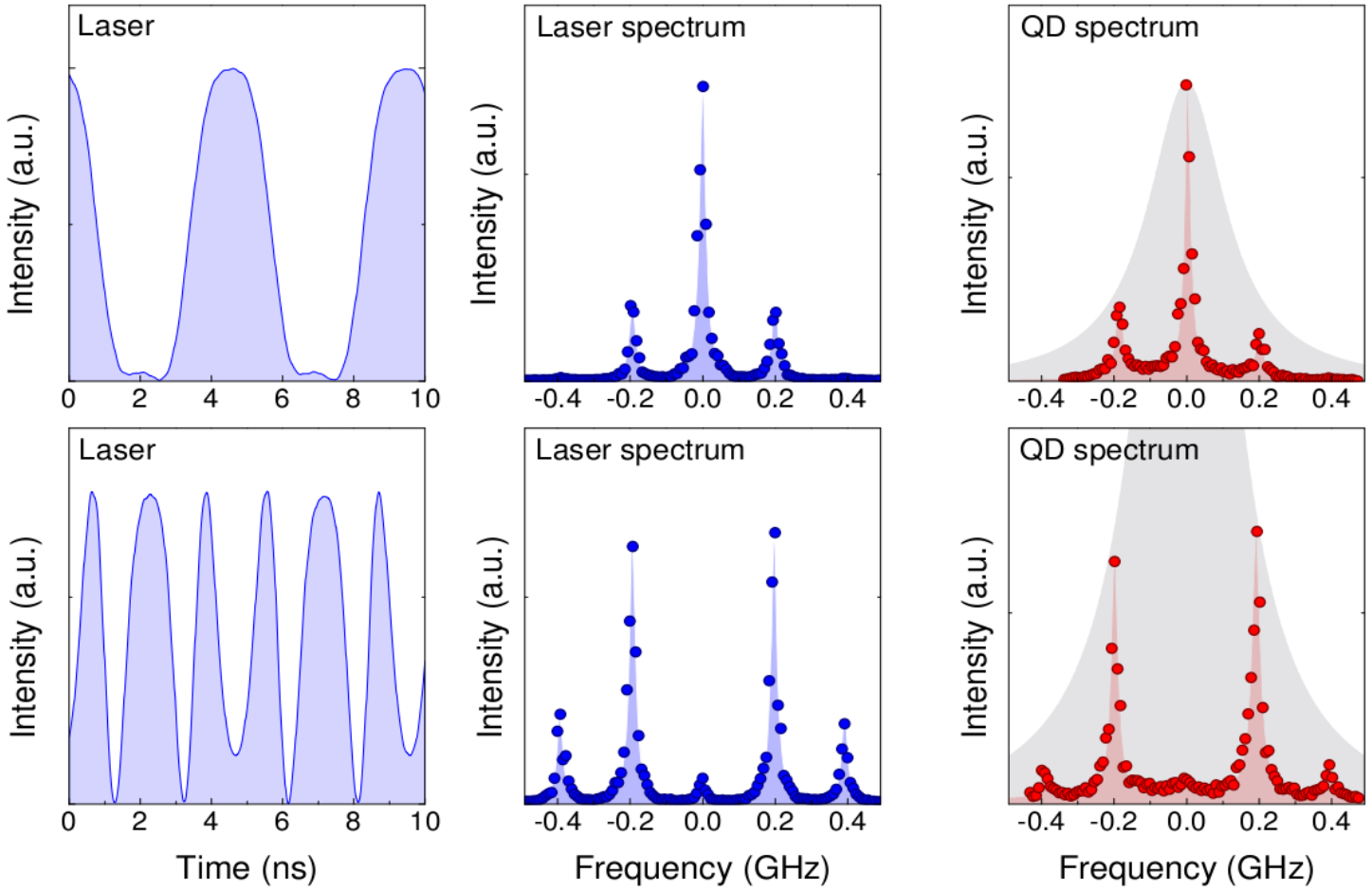
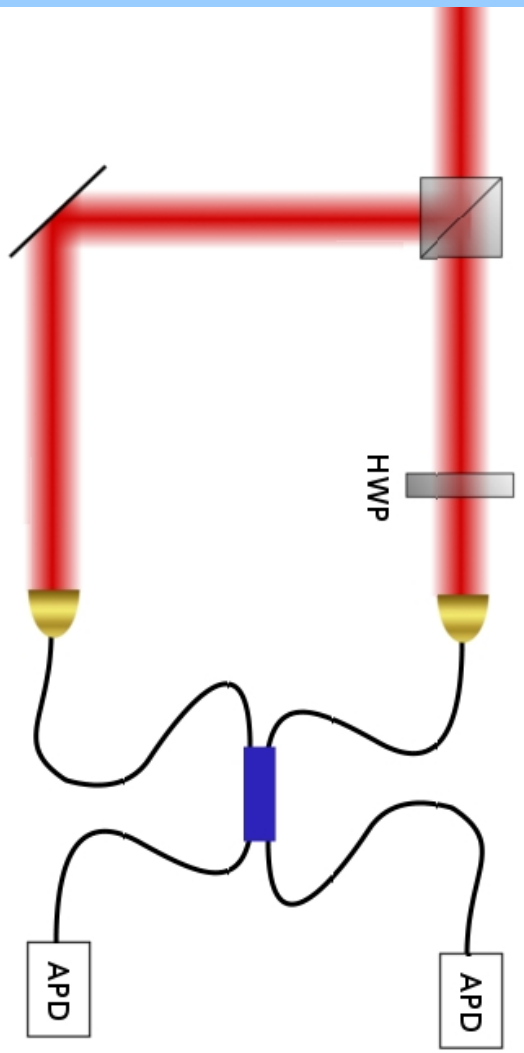
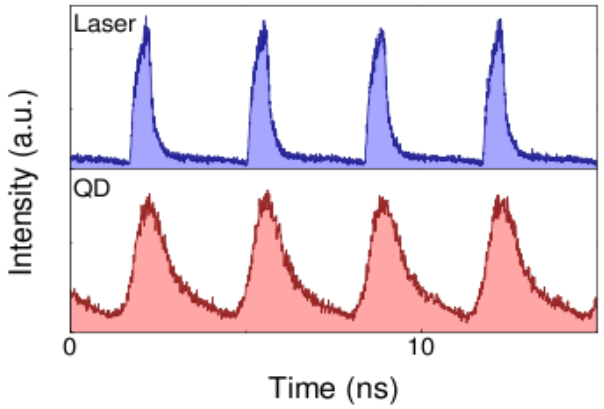


C.Matthiesen, et al, Arxiv/1208.1689 (2012)

Photon indistinguishability





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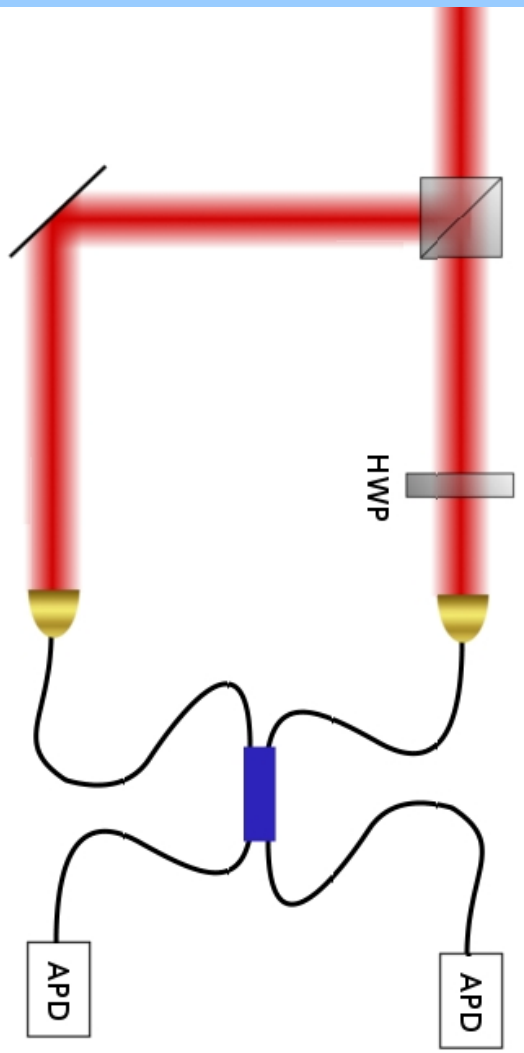

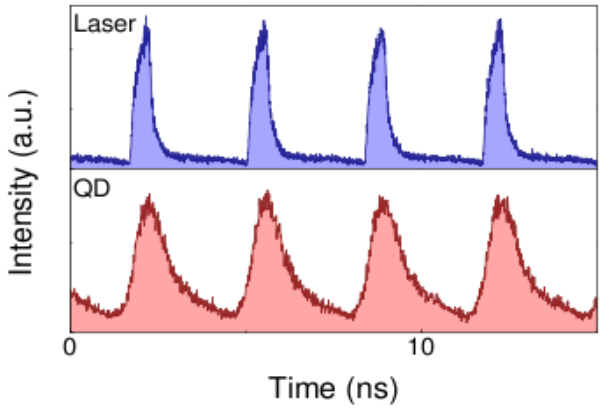

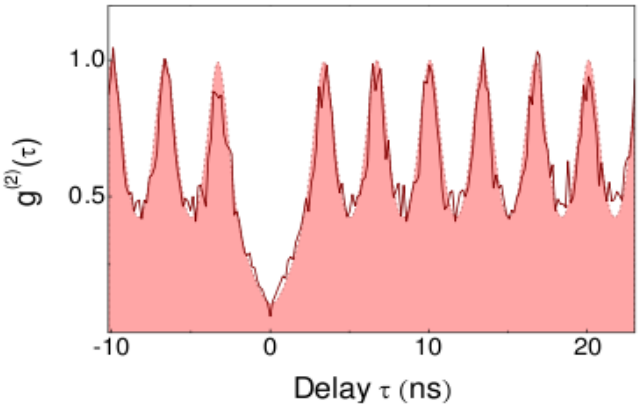

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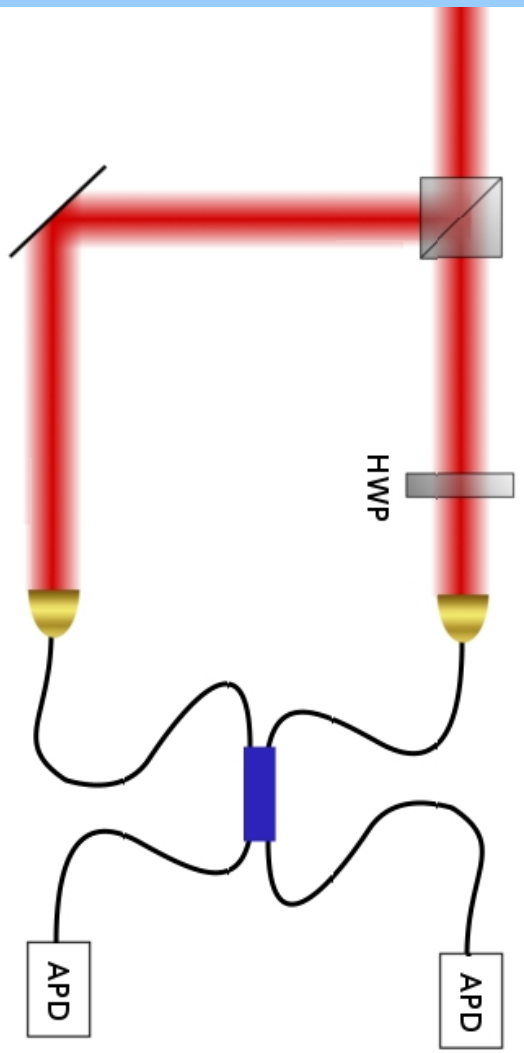

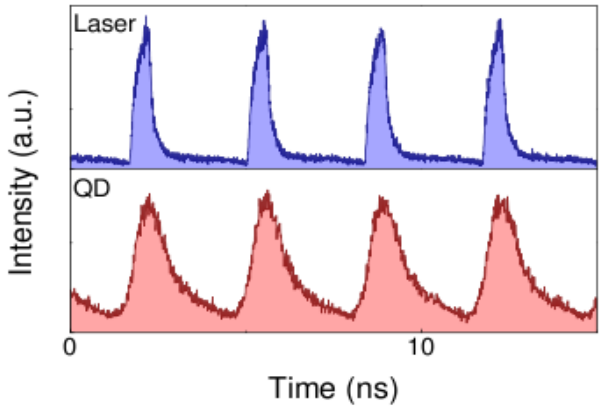

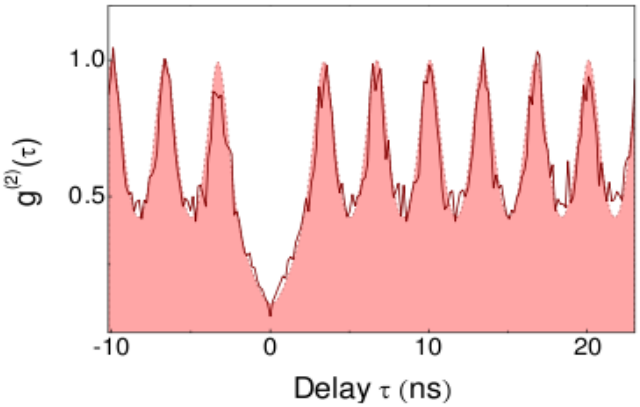

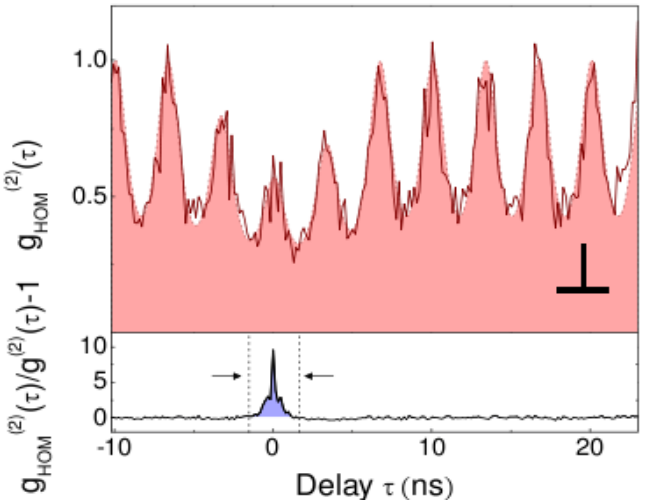

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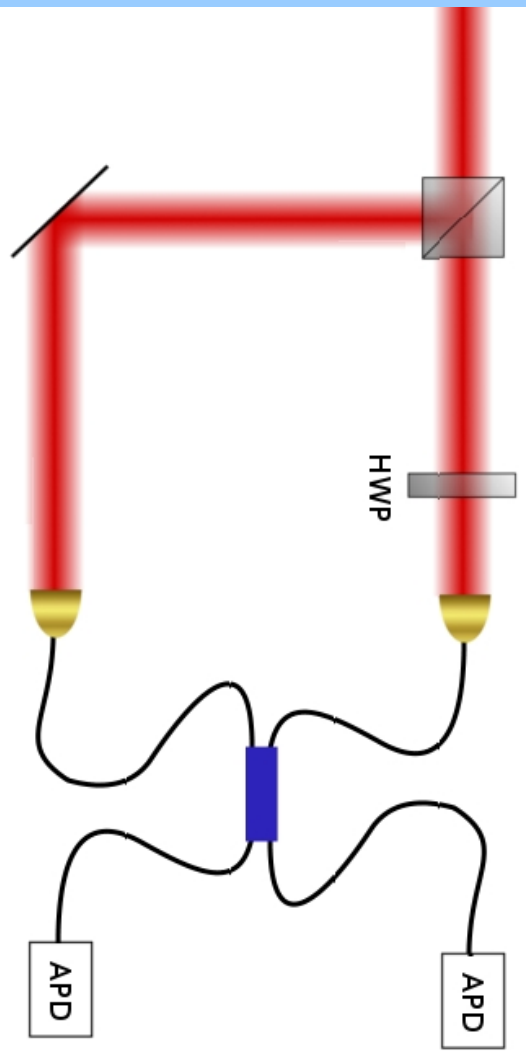
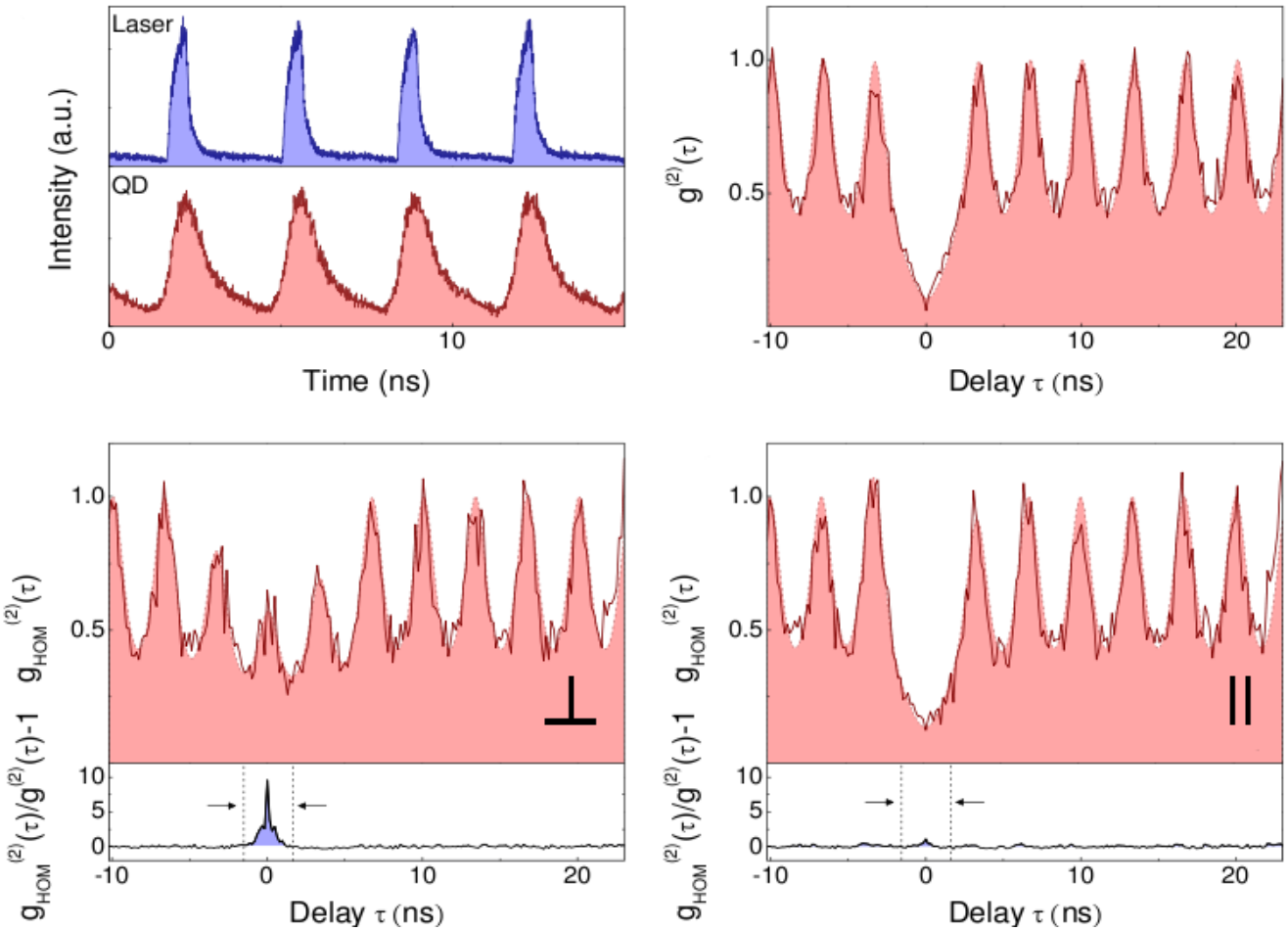




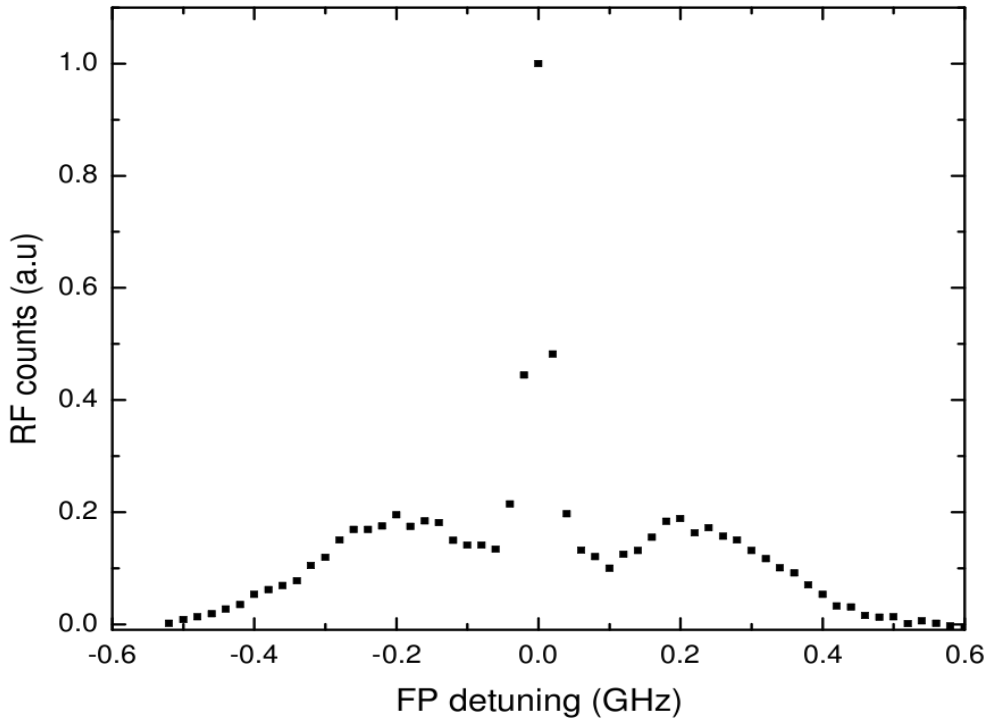
C.Matthiesen, et al, Arxiv/1208.1689 (2012)

X- spectrum

- Sidebands appear

  → not a simple 2 level system
- Splitting independent of:
  - Excitation power
  - Laser detuning

→ Suggests a coherent Raman process



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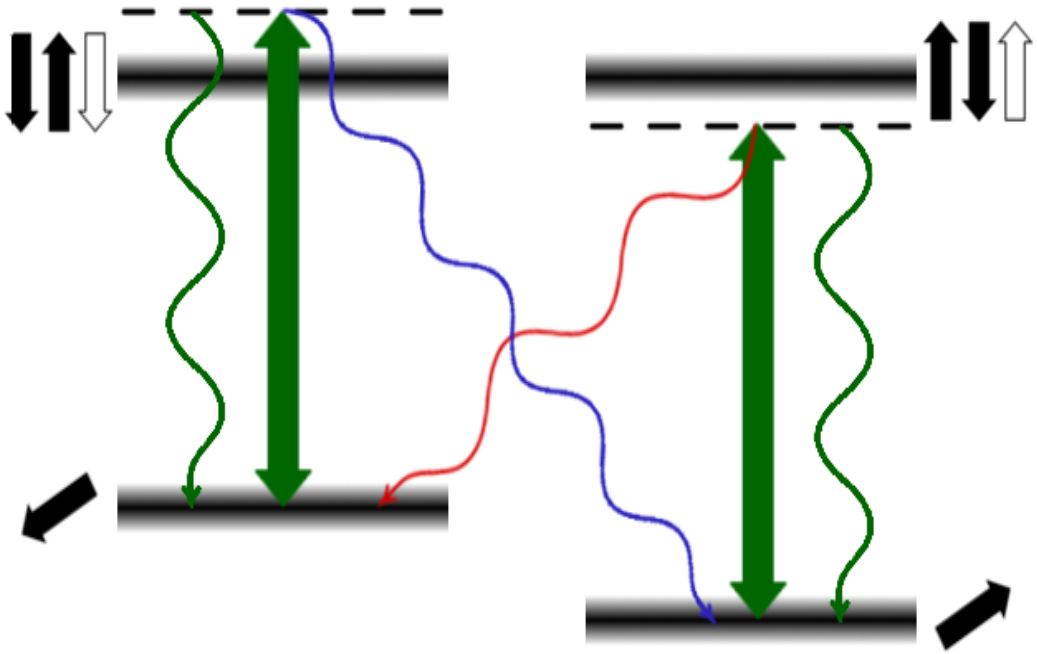
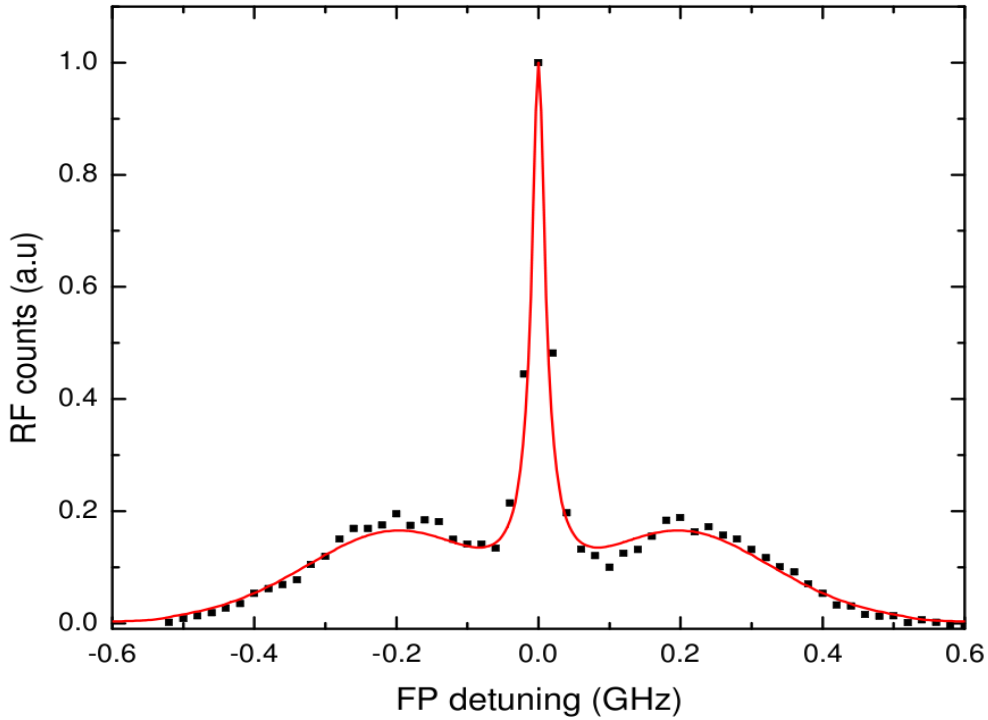
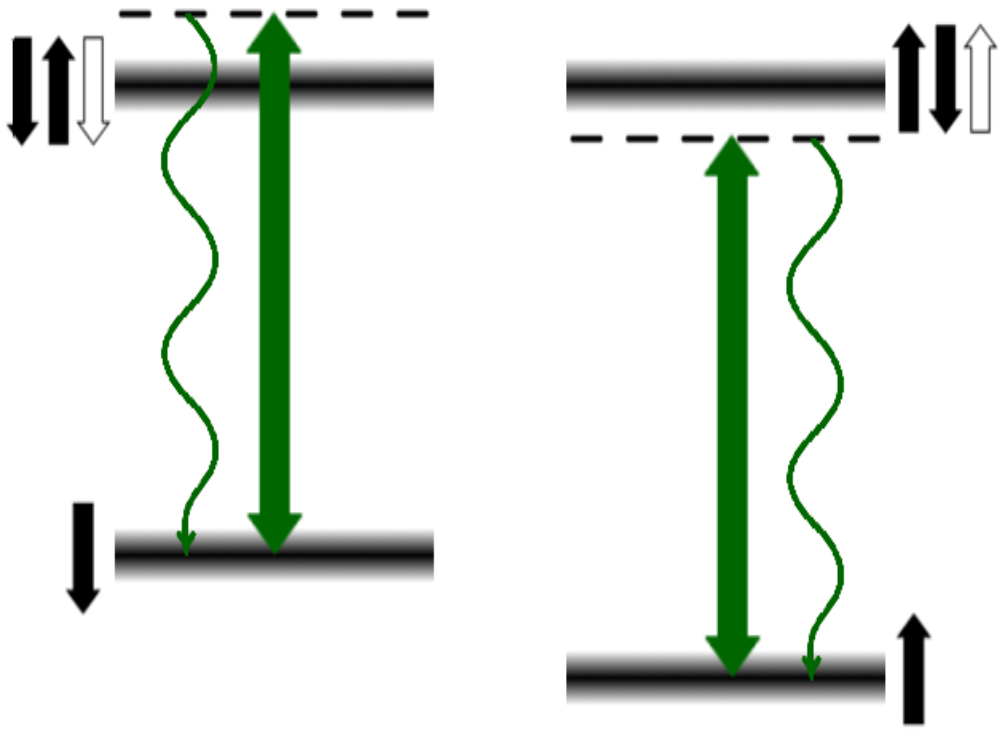
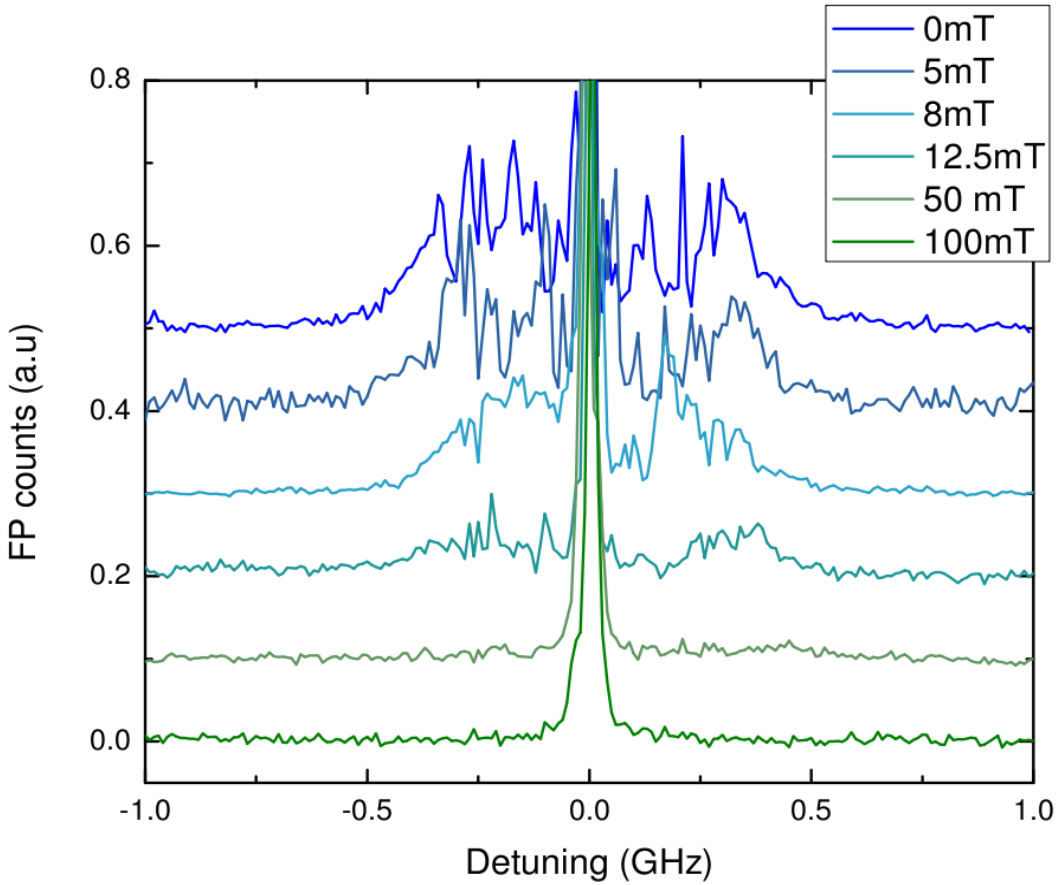




Data are consistent with coherent Raman transitions due to in-plane nuclear magnetic field

B-field dependence





Applying an external B-field redefines the quantisation axis → Selection rules apply

Conclusion and outlook

- We have shown that:
  - High quality single photon generation is feasible in a solid-state source
  - X- spectra shows interesting features attributed to hyperfine interactions
- Outlook:
  - Coherent control of electron spin after narrowing of the nuclear spin distribution
  - Spin photon entanglement

Quantum Dot Team

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