Modulation of Single Photons

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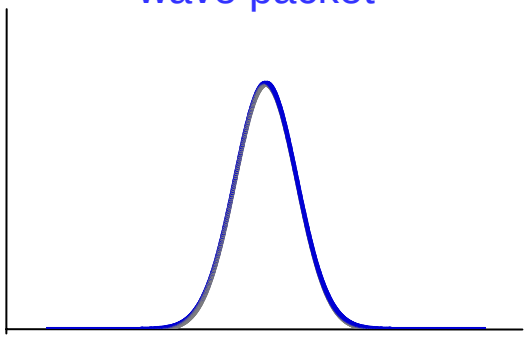
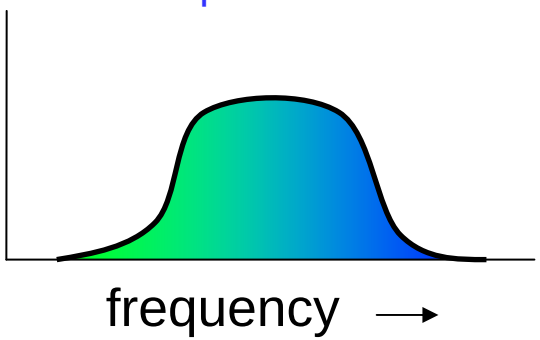
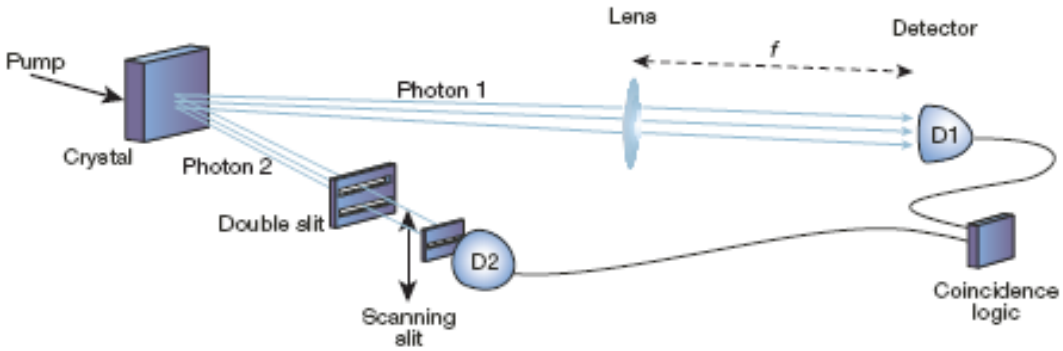
Modulation of Single Photons?

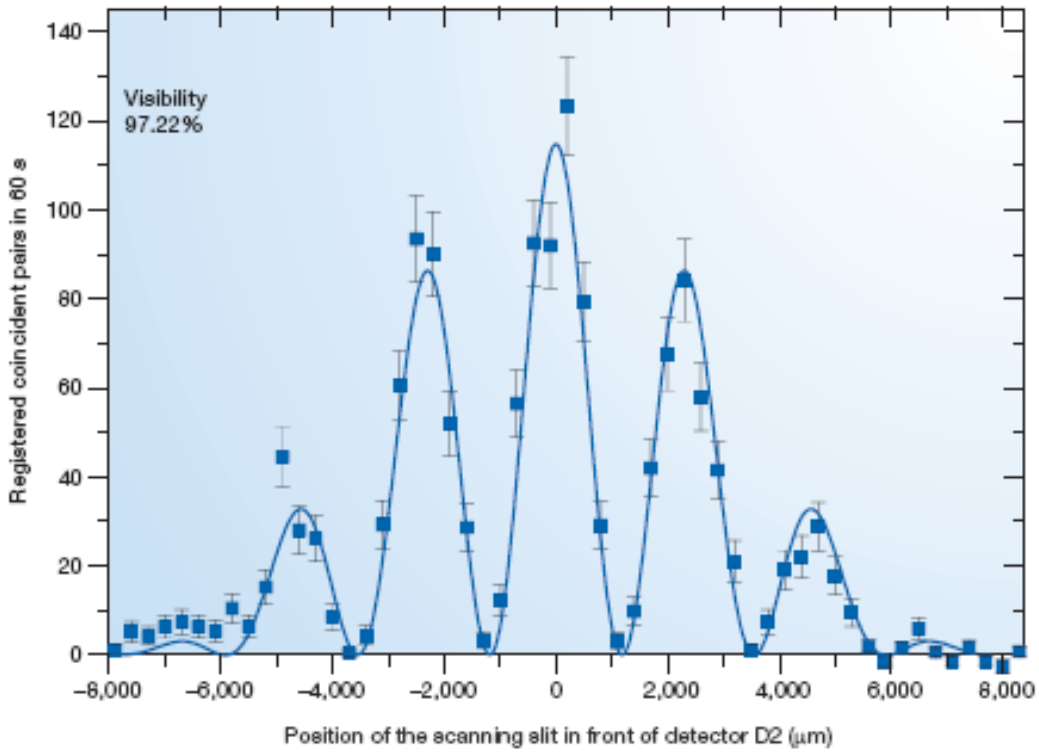
wave packet



spectrum







Zeilinger et al., Nature 433 230 (2005)

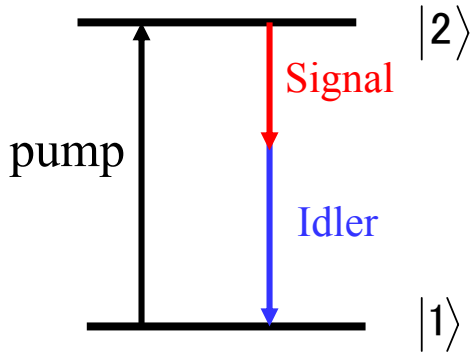
Modulation of Electromagnetic Wave

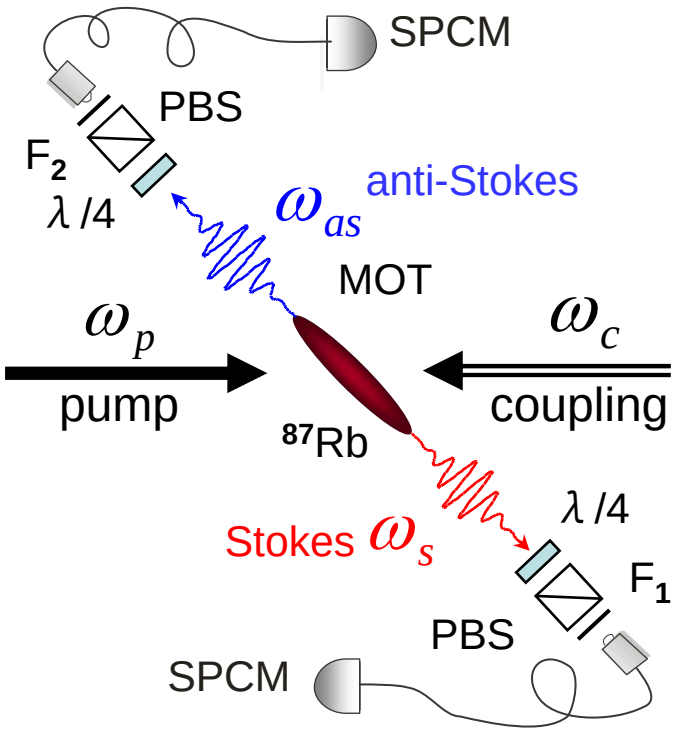
Outline

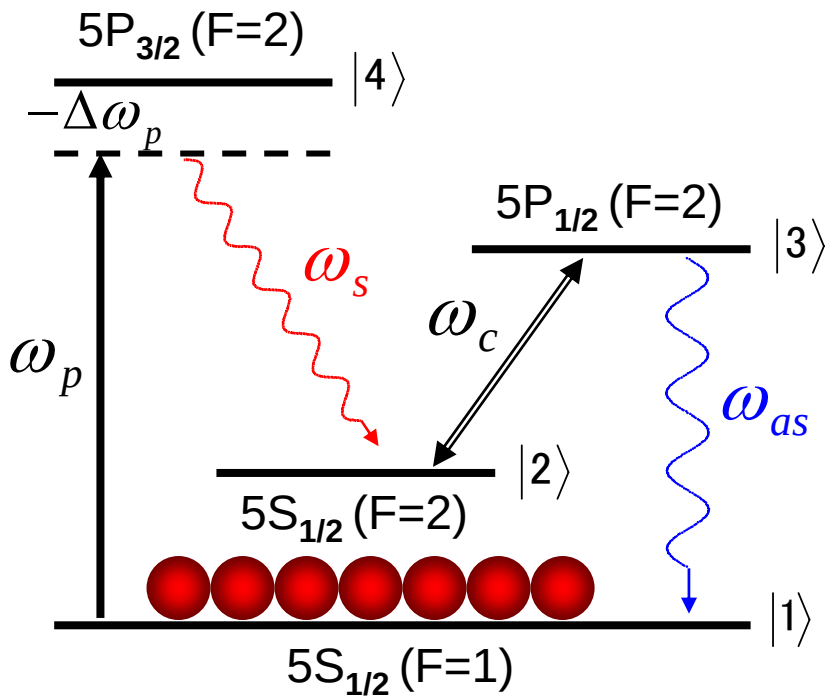
1. **Generation of long single photons**
2. **Amplitude modulation of single photons**
3. **Phase modulation of single photons**
4. **Outlooks**

Generation of Long Single Photons

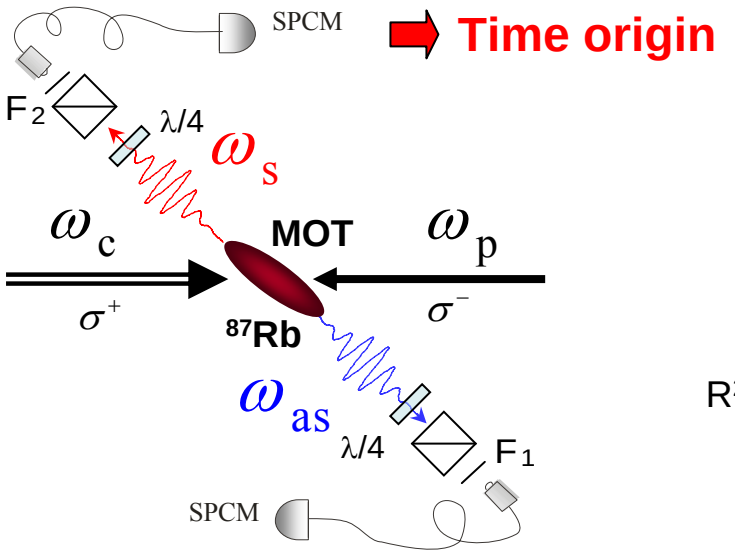
Photon Pair Generation

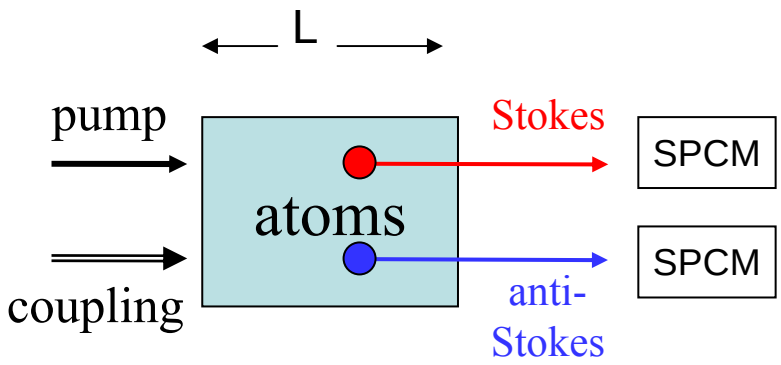


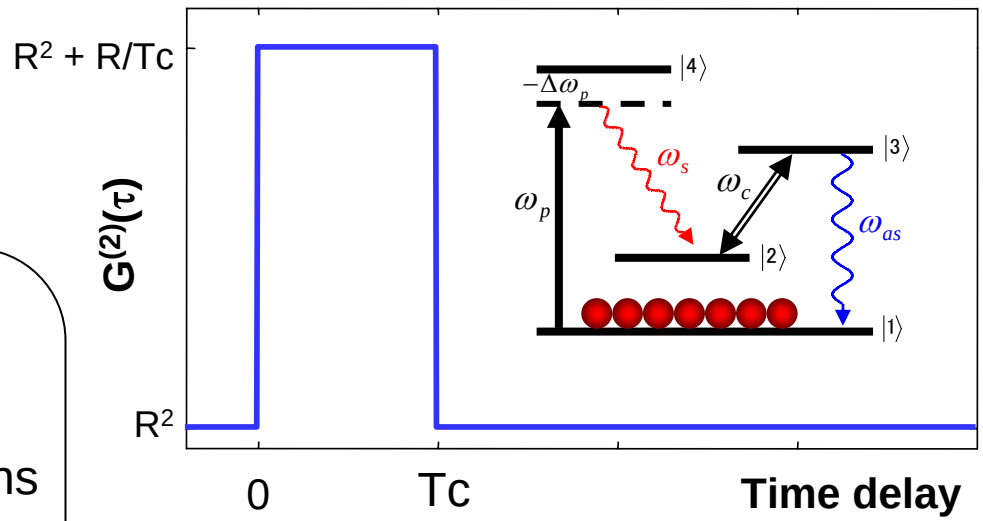




Single-photon Wave Packet



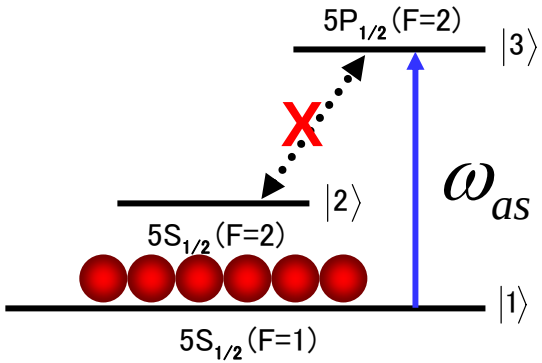


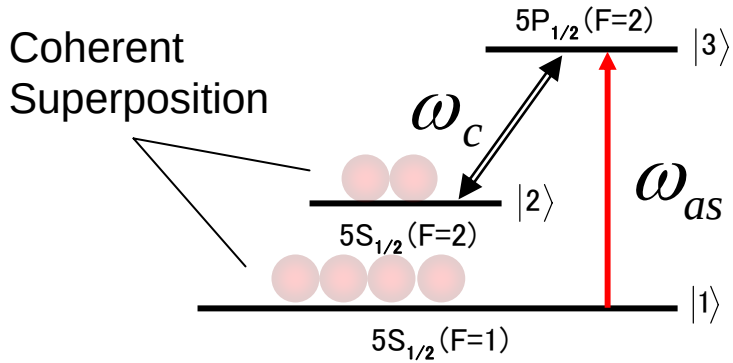


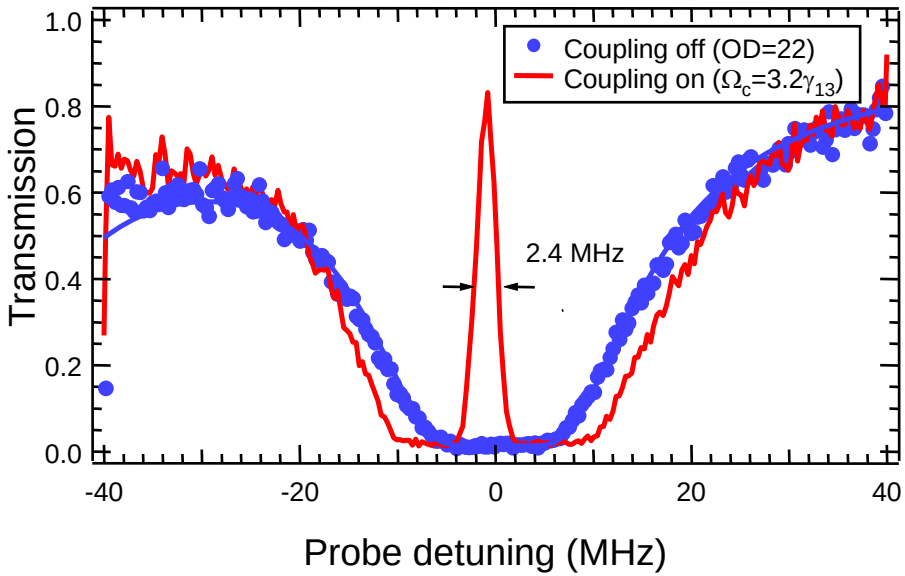
- Tc= Coherence time of conditional single-photon wavepacket
- R = Rate of emission of paired photons
- $G^{(2)}(\tau)$ = Glauber intensity correlation function
- Contrast ratio scales as 1/ RT

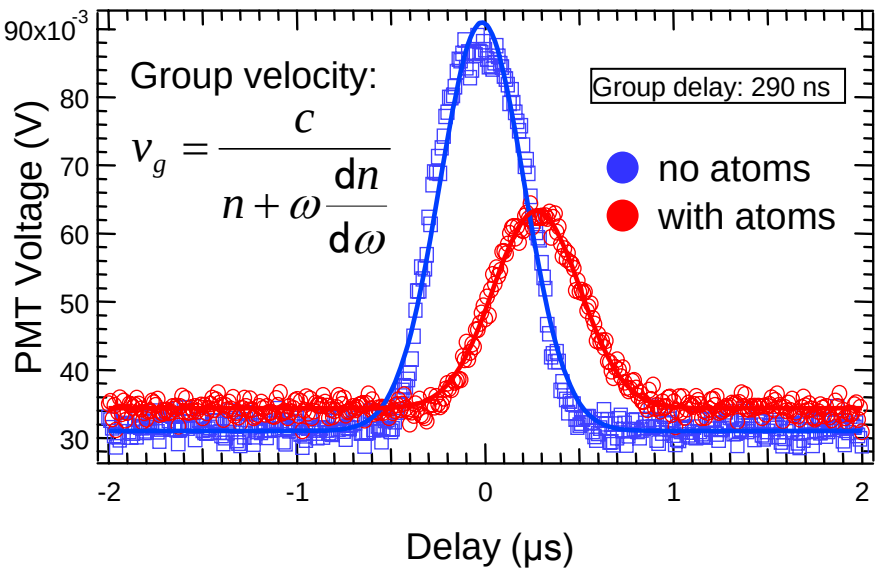
$$Tc = T_{as} - T_s$$
$$= L / V_{as} - L / V_s$$

EIT and Slow light

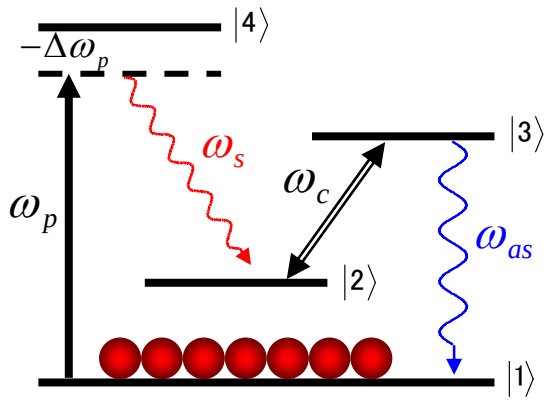


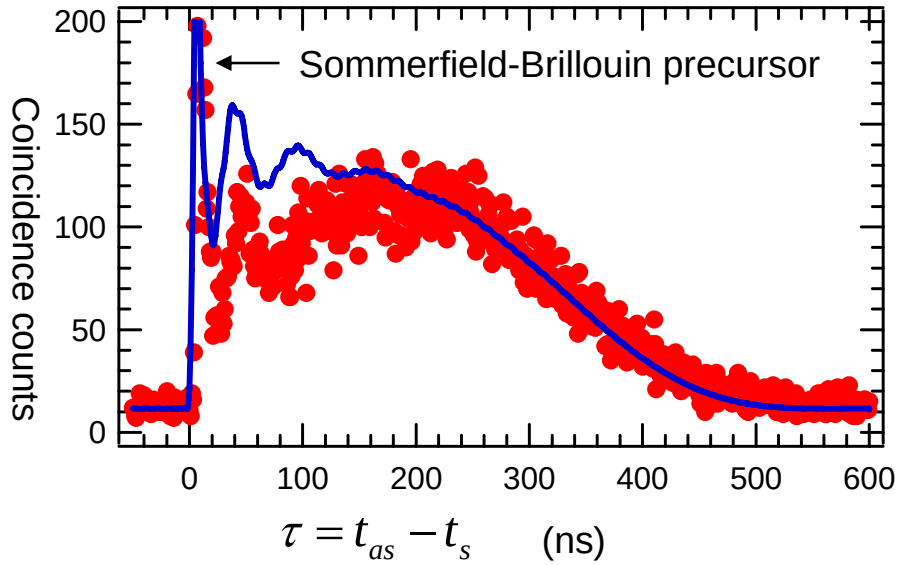






Measurement of Single-photon Wave Packet





OD=62

Ω_c = 4.2 γ_{13}, Ω_p = 1.16 γ_{13}, Δ_p= 48.67 γ_{13}

Run time = 800 s

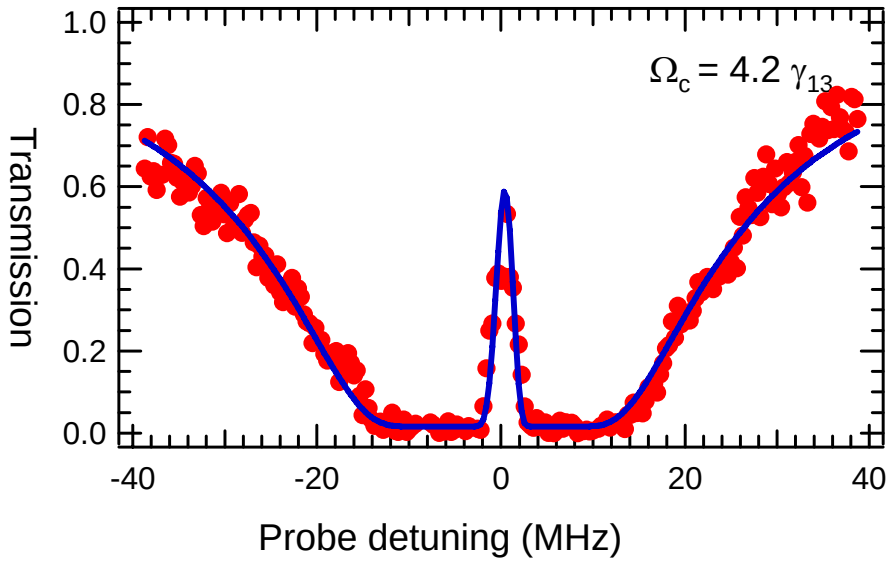
Pair generation rate= 13250 pairs/sec

$g^{(2)}_{max}$= 20

Coherence time = 363 ns

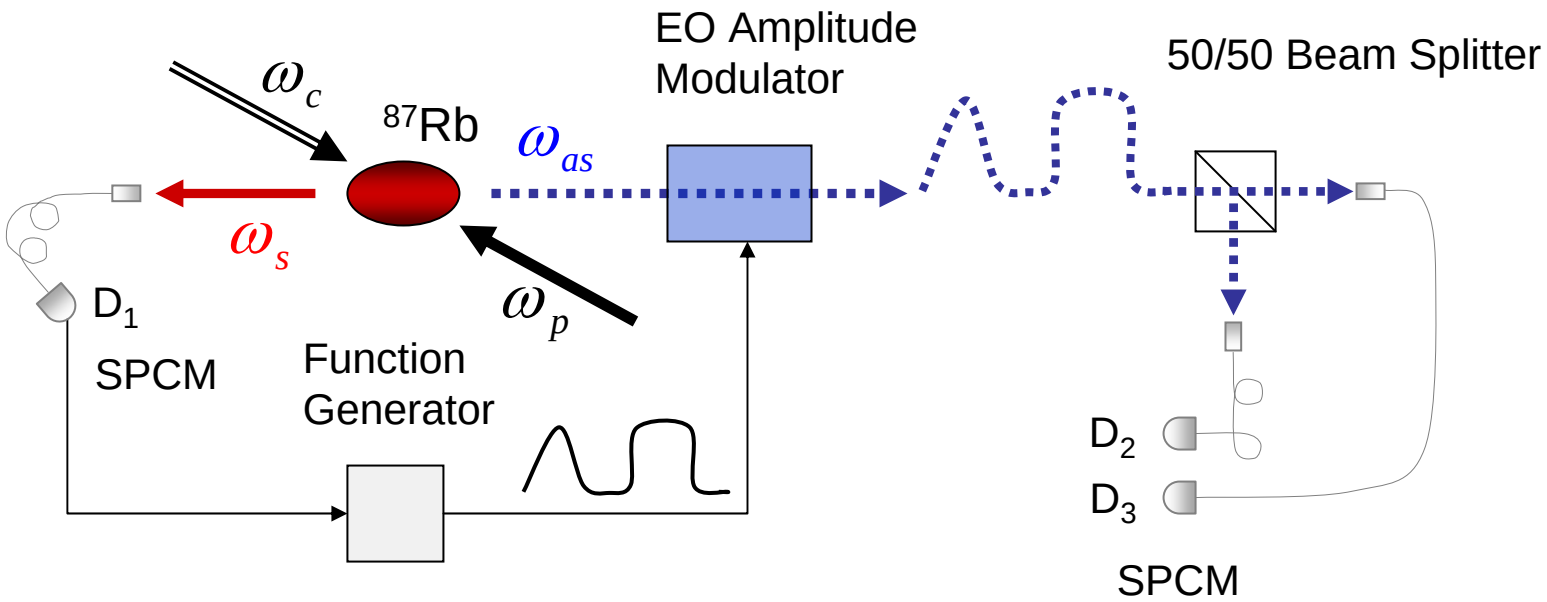
Linewidth = 2.06 MHz

BW_{EIT} = 2.35 MHz



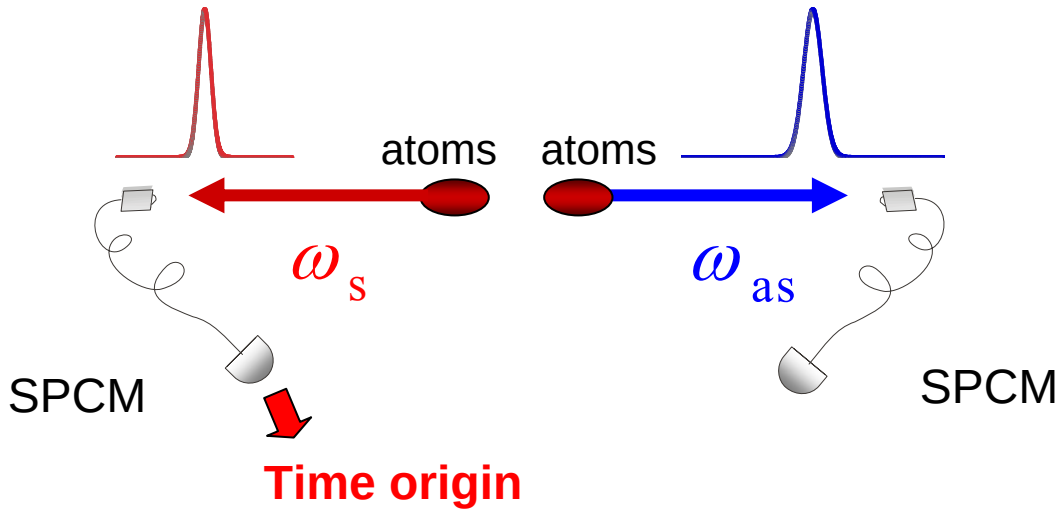
Amplitude Modulation of Single Photons

Conditional Modulation of Single Photons



- The anti-Stokes photon is modulated conditionally on the detection of a Stokes photon.
- Establishing a time origin allows both phase and amplitude modulation of the single photon wavefunction.

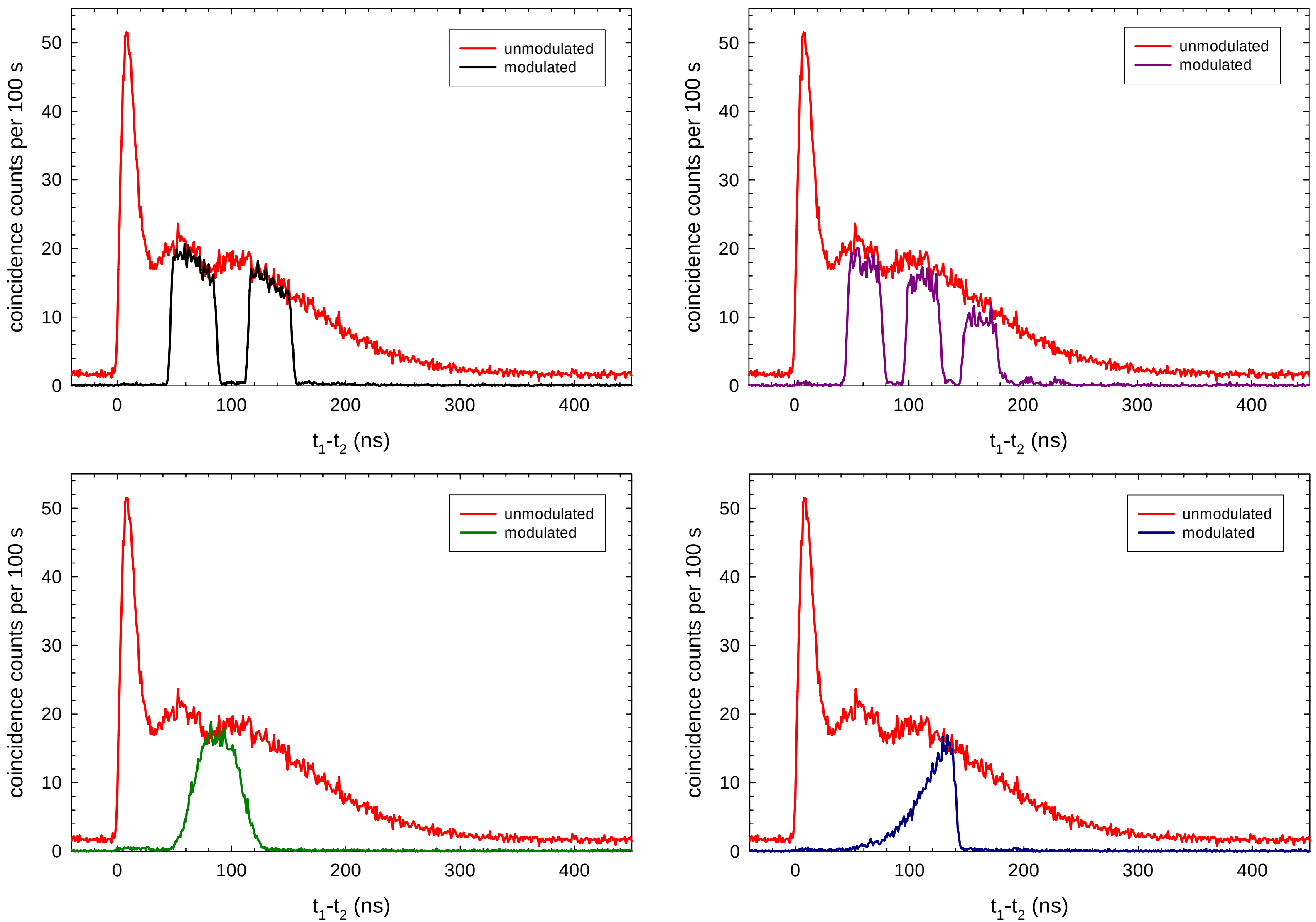
Quantum Versus Classical Timing



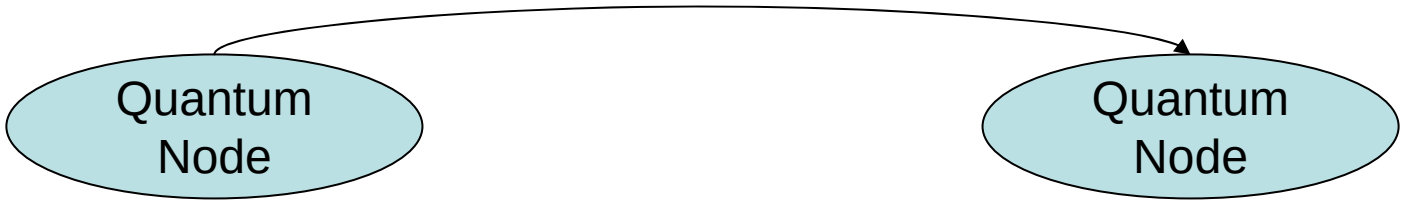
- The detection of a Stokes photon establishes the time origin for the anti-Stokes wave packet.

- Classically, with the SPCM's replaced by photomultipliers, the time origin of the anti-Stokes packet is uncertain to within the width of the Stokes wave packet.

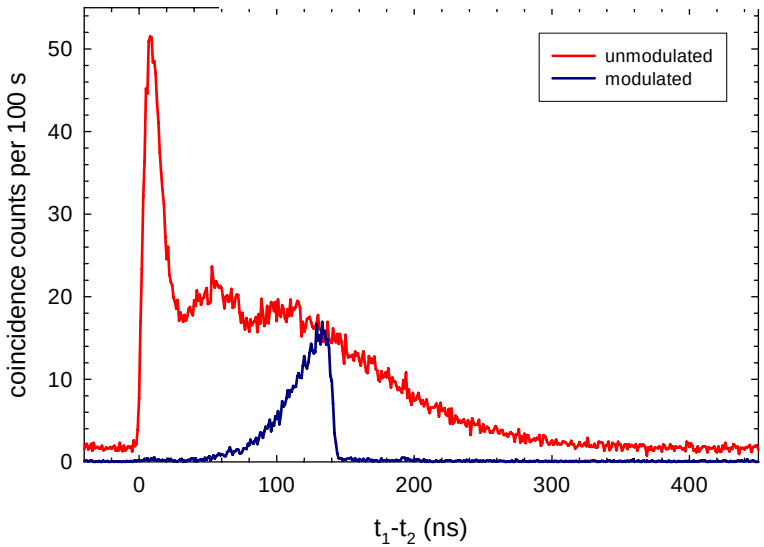
Single Photons with Controlled Waveforms

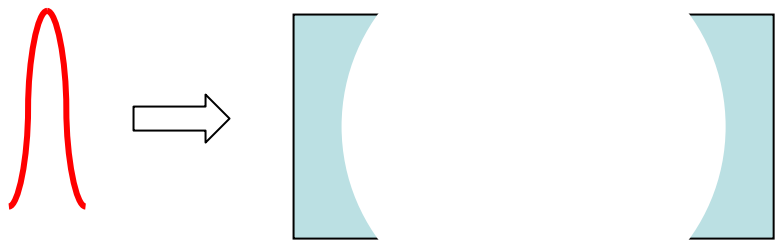


Outlooks



Atomic ensemble,
Cavity, ….





Acknowledgements

PI
Prof. Stephen Harris

Research Associate
Guan-Yu Yin

Graduate Student
Chinmay Belthangady

Collaborator
Prof. Joeseph Kahn

Visiting Professor
Prof. Ite Yu