Single photon synchronization with a room-temperature atomic quantum memory

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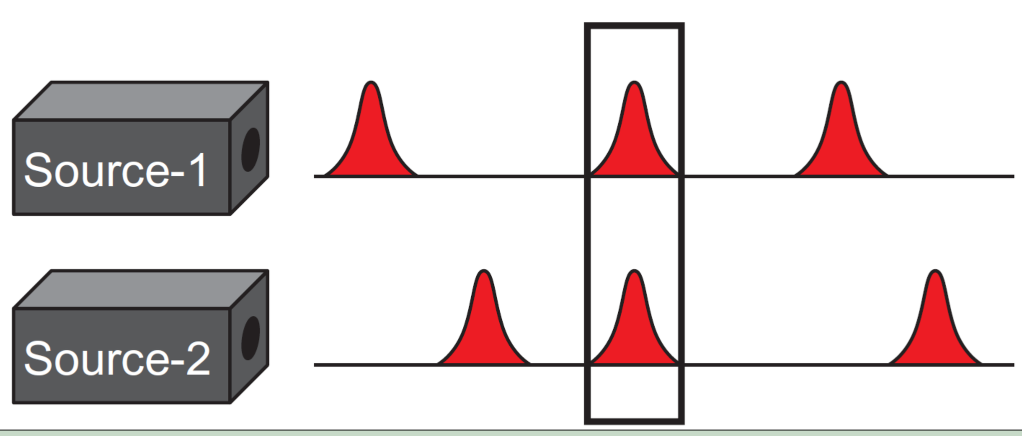
AMOs Atomic Molecular Optical Sciences

Problem: probabilistic photon sources

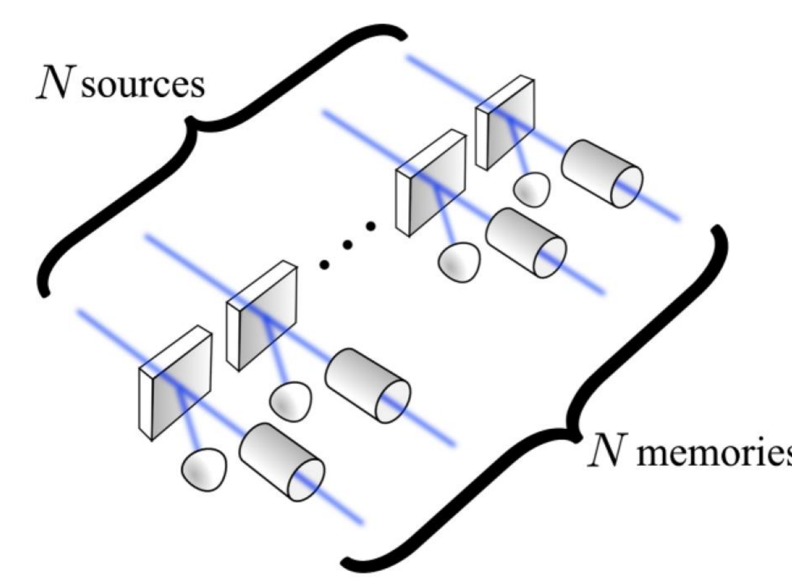
Probabilistic generation of single photons renders the construction of multi-photon states exponentially slow.



Makino *et al.* Sci. Adv. **2**, e1501772 (2016)

Solution: quantum memories

Using quantum memories can exponentially enhance the multi-photon rates.



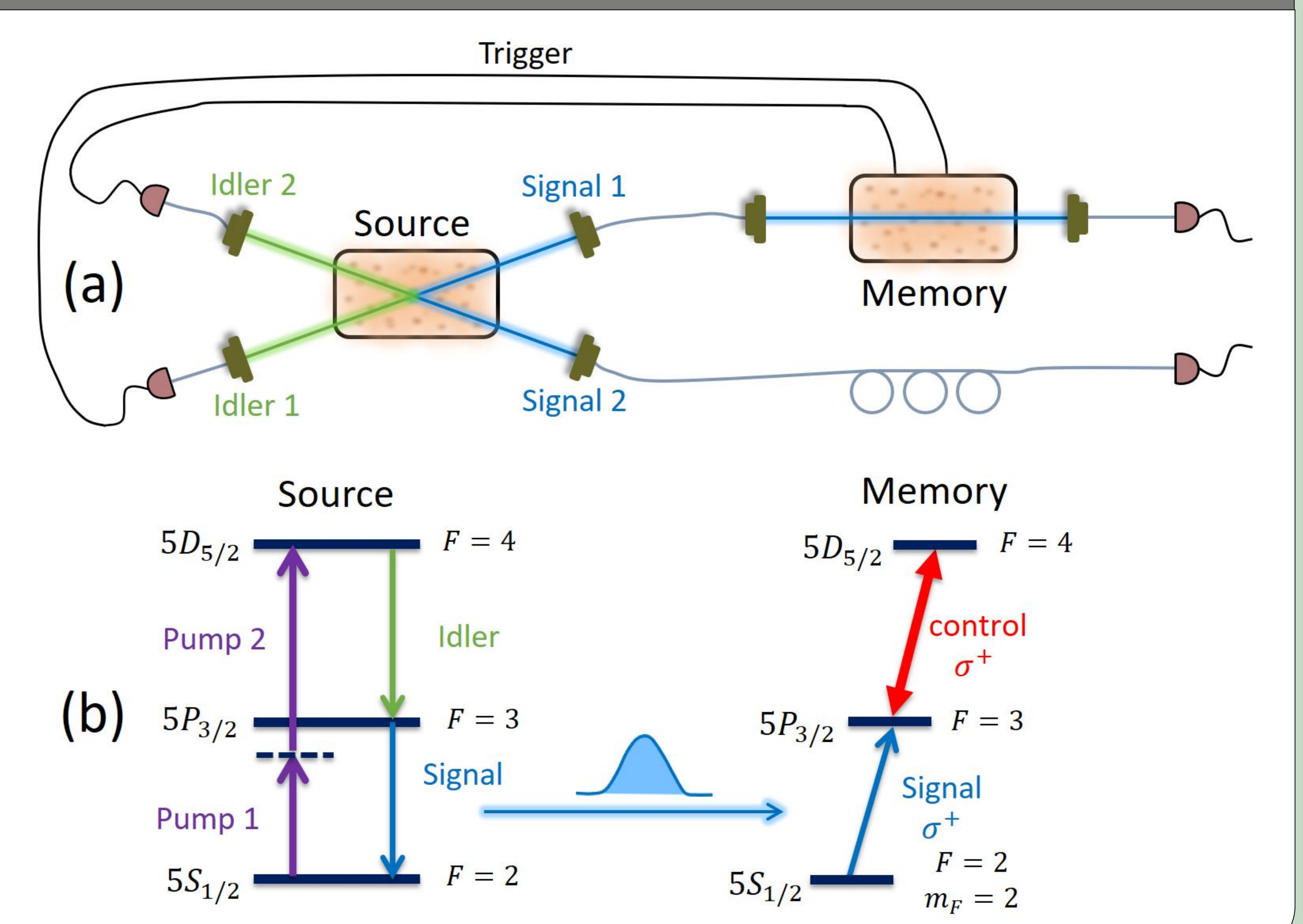
Nunn *et al.* PRL **110**, 133601 (2013)

Synchronization scheme

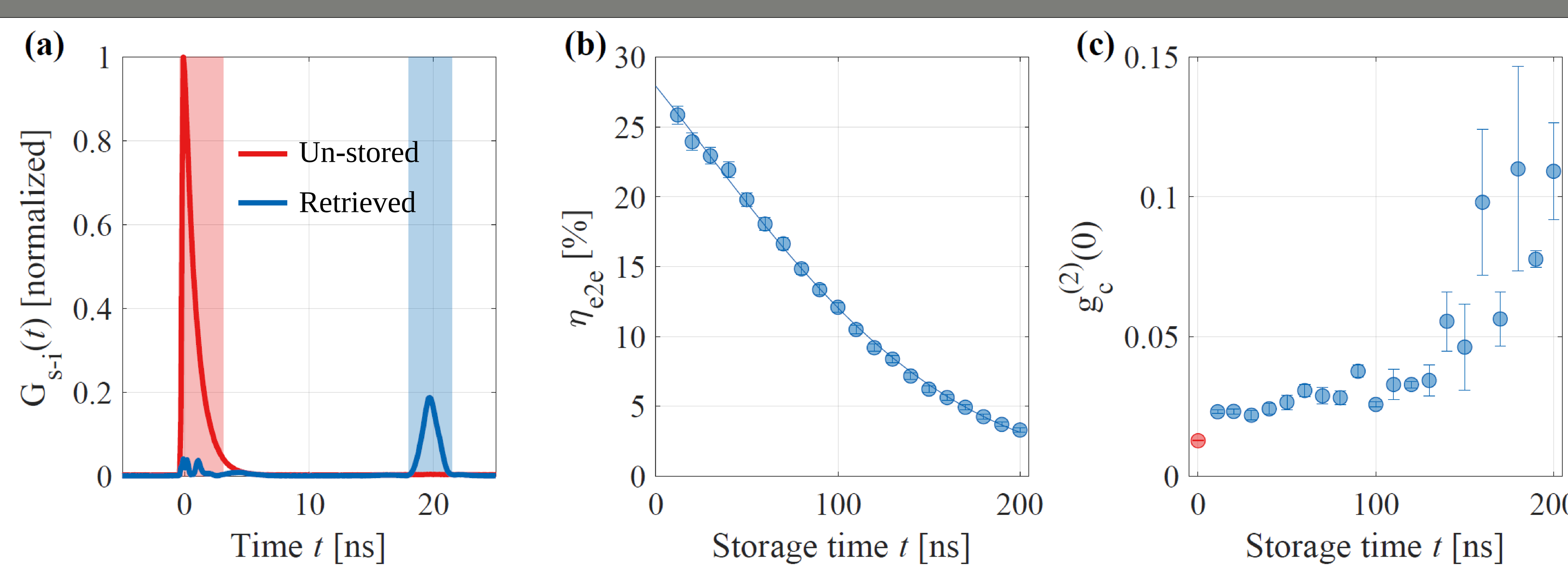
Our spatially multiplexed heralded single photon source is based on four-wave-mixing in rubidium vapor [1]. Two pump lasers doubly excite the atoms to the $5D_{5/2}$ state, which is followed by a cascaded emission of the signal and idler photons into the phase-matched direction.

Our fast ladder memory (FLAME) is based on the same atomic level scheme as the photon source [2]. An input photon is stored by applying a first control pulse, and retrieved on-demand by applying a second control pulse.

Detection of idler 1 (idler 2) photon heralds the generation of signal 1 (signal 2) photon and triggers the control storage (retrieval) pulses in the memory. Thus, the stored photon is emitted synchronously with the second photon.

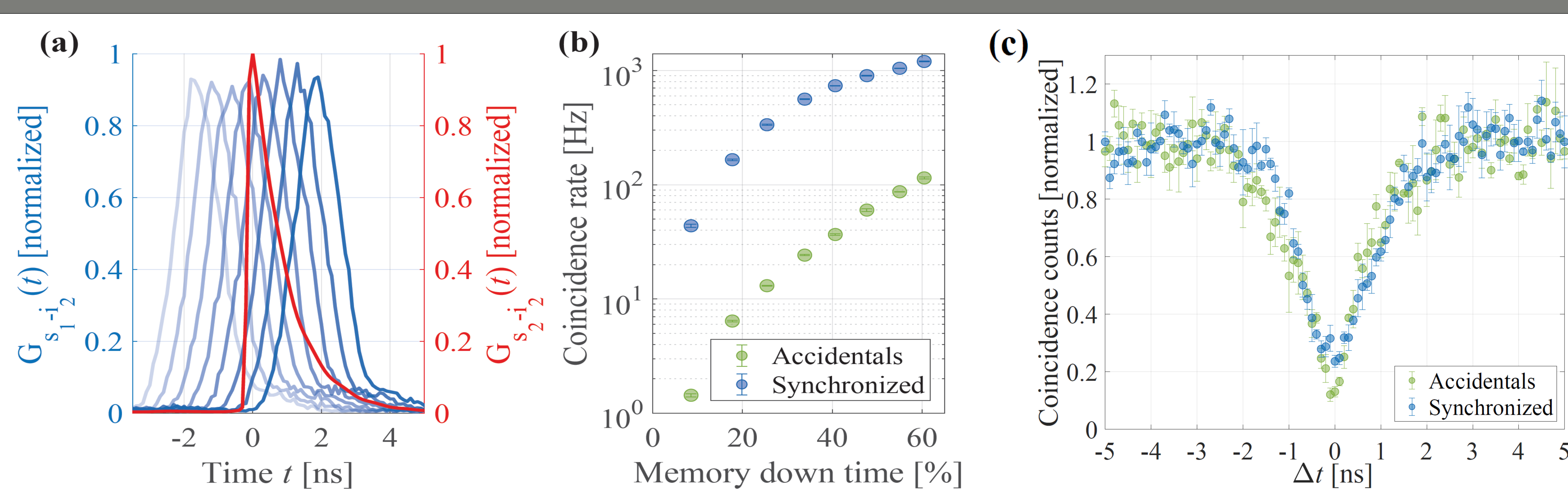


Storage and retrieval of heralded single photons



(**a**) Single photon histogram (signal-idler cross-correlation) before and after storage in the memory.
(**b**) Memory end-to-end storage and retrieval efficiency η_{e2e}.
(**c**) Conditional autocorrelation $g_c^{(2)}(0)$ of the heralded single photons before and after the memory.

Single photon synchronization



(**a**) Cross-correlation histogram between idler 2 and signal 1 photons after synchronization with controlled retrieval time.
(**b**) The heralded single photons coincidence count rate with and without the memory.
(**c**) Hong-Ou-Mandel interference of the photons before and after the memory.

[1] O. Davidson, R. Finkelstein, E. Poem, and O. Firstenberg. Bright multiplexed source of indistinguishable single photons with tunable GHz-bandwidth at room temperature. *New J. Phys.*, 23, 073050 (2021)
[2] R. Finkelstein, E. Poem, O. Michel, O. Lahad, and O. Firstenberg. Fast, noise-free memory for photon synchronization at room temperature. *Science Advances*, 4(1), (2018)