Three-node timing network with compact optical clocks

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We will present results on our spring 2024 measurement campaign, in which we combine a free-space three node time and frequency transfer network [1] with compact atomic clocks [2]. Compared to [1], we will replace optical cavity 'clocks' with optical atomic clocks [2] with an Allan deviation below 10^{-13} for averaging times ranging from minutes to days. We will also use a quantum-limited frequency-comb based free-space time transfer protocol [3] that allows operation for link losses up to around 90 dB reducing our detection threshold to 100's of femtowatts from the 10's of nW of [1]. Both the high clock performance and the ability of the frequency-comb based time transfer to recover the clock phase difference for untracked drifts of up to 5 ns mean that the proposed three-node setup can bridge holdover periods of many days, which is essential for operation in adverse atmospheric conditions or with sporadic line-of-sights such as ground to low-earth orbiting satellites.

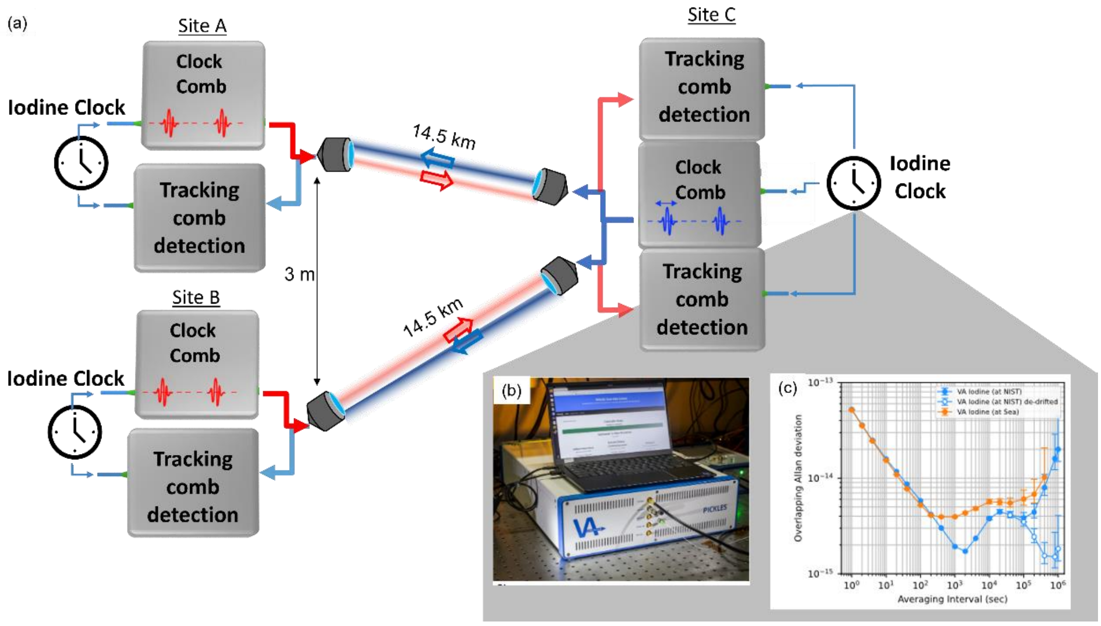

Fig. 1: a) Schematic of planned three-node timing network in Boulder, CO. Sites A and B are collocated on the NIST campus with site C located 14.5 km distant at the Table Mountain Antenna Facility. b) photograph of a compact iodine optical atomic clock from Ref. [2]. c) corresponding Allan deviation for compact iodine clocks from Ref. [2]

1. M. I. Bodine *et al.*, APL Photonics **5**, 076113 (2020).
2. J. D. Roslund *et al.*, arXiv:2308.12457 (2023).
3. E. D. Caldwell *et al.*, Nature **618**, 721–726 (2023).