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Experimental violation of a Bell-Leggett-Garg inequality using weak measurements, Part I: Avoiding loopholes J. DRESSEL, UC Riverside, T. WHITE, UC Santa Barbara, J. MUTUS, R. BARENDS, Google, Santa Barbara, A. MEGRANT, UC Santa Barbara, E. JEFFREY, D. SANK, Google, Santa Barbara, J. KELLY, B. CAMPBELL, UC Santa Barbara, Y. CHEN, Google, Santa Barbara, Z. CHEN, B. CHIARO, A. DUNSWORTH, I.-C. HOI, C. NEILL, P.J.J. O'MALLEY, UC Santa Barbara, P. ROUSHAN, Google, Santa Barbara, C. QUINTANA, A. VAINSENCHER, J. WENNER, UC Santa Barbara, A. FOWLER, Google, Santa Barbara, A.N. KOROTKOV, UC Riverside, A.N. CLELAND, UC Santa Barbara, J.M. MARTINIS, University of California and Google, Santa Barbara — We demonstrate the violation of a hybrid Bell-Leggett-Garg inequality that avoids both the disjoint sampling and fair sampling loopholes that are common to traditional Bell inequalities. Our algorithm uses sequential weak measurements of a Bell state that are implemented with four superconducting Xmon qubits. In this first of two talks, we detail the high-fidelity partial projections that are needed for this violation, which are realized by entangling an ancilla qubit to each data qubit using a controlled-Z two-qubit gate. After calibration of the ancilla readout, these partial projections indirectly measure qubit expectation values with a tunable amount of state disturbance. For sufficiently weak disturbance, the inequality can be violated using all the data collected in a single configuration.

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