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A loophole-free Bell test with spin qubits in diamond[1] ANAIS DREAU, BAS HENSEN, HANNES BERNIEN, ANDREAS REISERER, JUST RUITENBERG, MACHIEL BLOK, Kavli Institute of Nanoscience Delft, Delft University of Technology, MATTHEW MARKHAM, DANIEL TWITCHEN, Element Six, Ltd., Kings Ride Park, Ascot, Berkshire SL5 8BP, UK, STEPHANIE WEHNER, RONALD HANSON, Kavli Institute of Nanoscience Delft, Delft University of Technology, QUANTUM TRANSPORT GROUP TEAM[2], ELEMENT 6 TEAM — One of the most intriguing phenomena in quantum physics is the entanglement of spatially separated objects. The benchmark to prove the fundamental non-locality of remote entanglement is provided by the famous Bell's theorem. Nevertheless, all its experimental implementations to date open the door to loopholes that restrict the practical validity of this theorem., we present our latest experimental results towards the realization of a Bell test, aimed to close the detection loophole and address the locality and free-will loopholes in a single experiment. Our qubits consist of the electronic spin associated with single NV center defects in diamond. An efficient remote entanglement protocol allows us to generate entangled qubit pairs between two labs separated by 1.3 km on the TU Delft campus. The moderate time (<3.5 us) required for high fidelity (>99%) qubit rotations and efficient (>97%) readout make our setup a good candidate to allow the experimental violation of Bell's inequalities between two space-like separated entangled spins without relying on the fair sampling assumption.

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