Full experimental verifications towards practical deployment of measurement-device-independent quantum key distribution

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Outline

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- **Previous experimental MDIQKD**

2

- **Long distance MDIQKD over 200 km spooled fiber**
- **Field test of MDIQKD over 30 km deployed fiber**

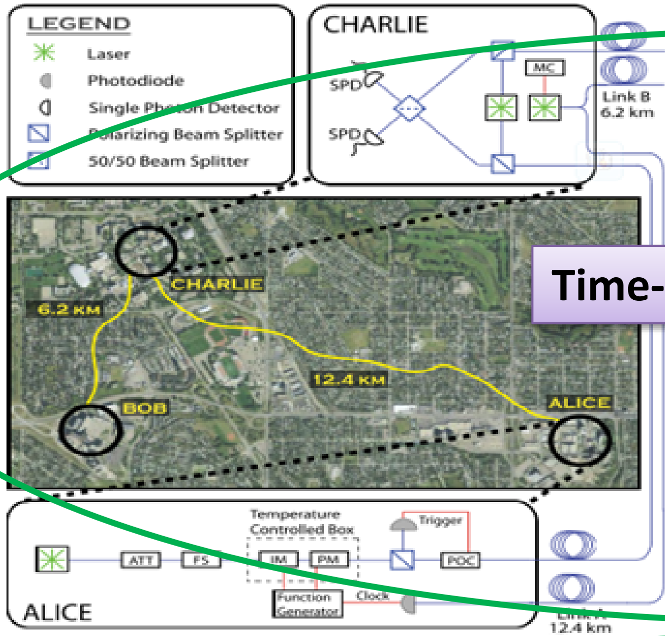
3

- **Conclusion and discussion**

1. Previous MDIQKD demonstrations

Time-bin phase encoding

1



A. Rubenok, et al., "Real-world two-photon interference and proof-of-principle quantum key distribution immune to detector attacks", Phys. Rev. Lett.111, 130501 (2013).

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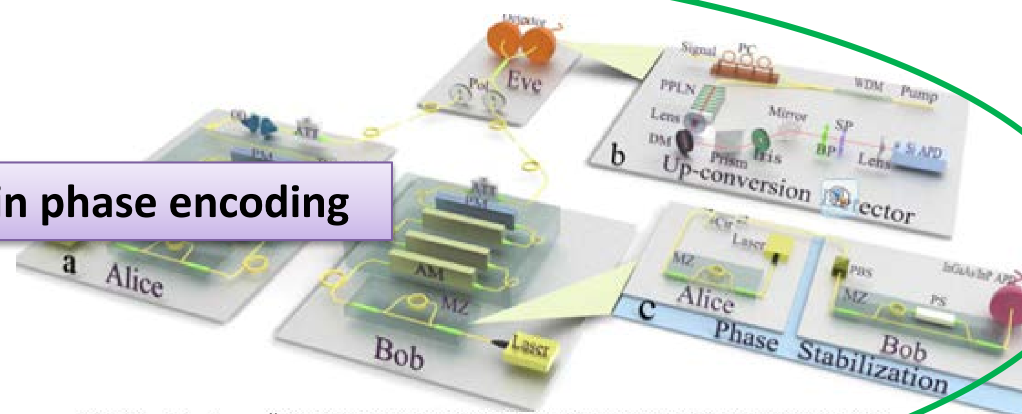
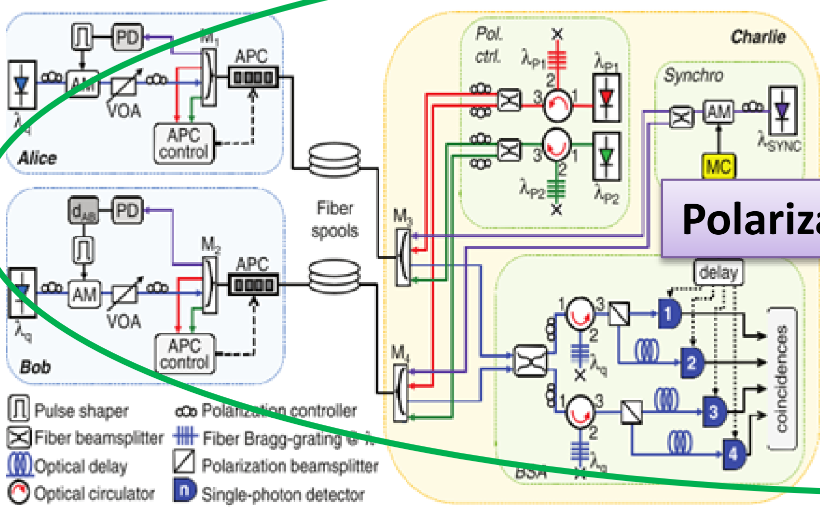


Y. Liu, et al., "Experimental measurement-device-independent quantum key distribution". Phys. Rev. Lett.111, 130502 (2013).

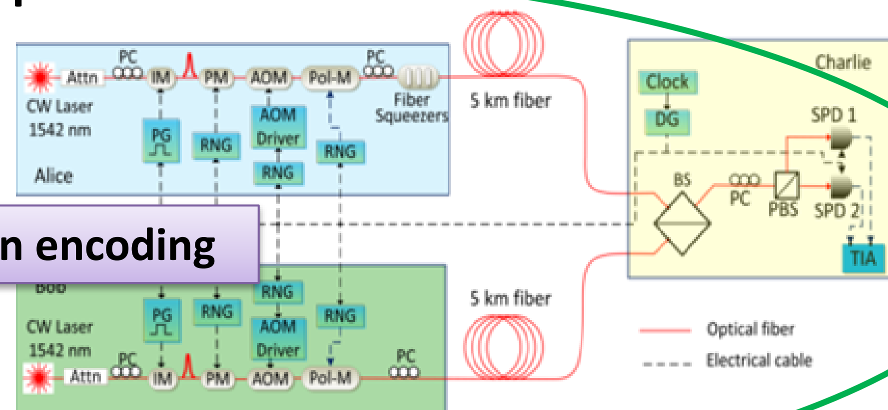
Polarization encoding

3



] T. Ferreira da Silva, et al., "Proof-of-principle demonstration of measurement-device-independent quantum key distribution using polarization qubits", Phys. Rev. A88, 052303 (2013).

4



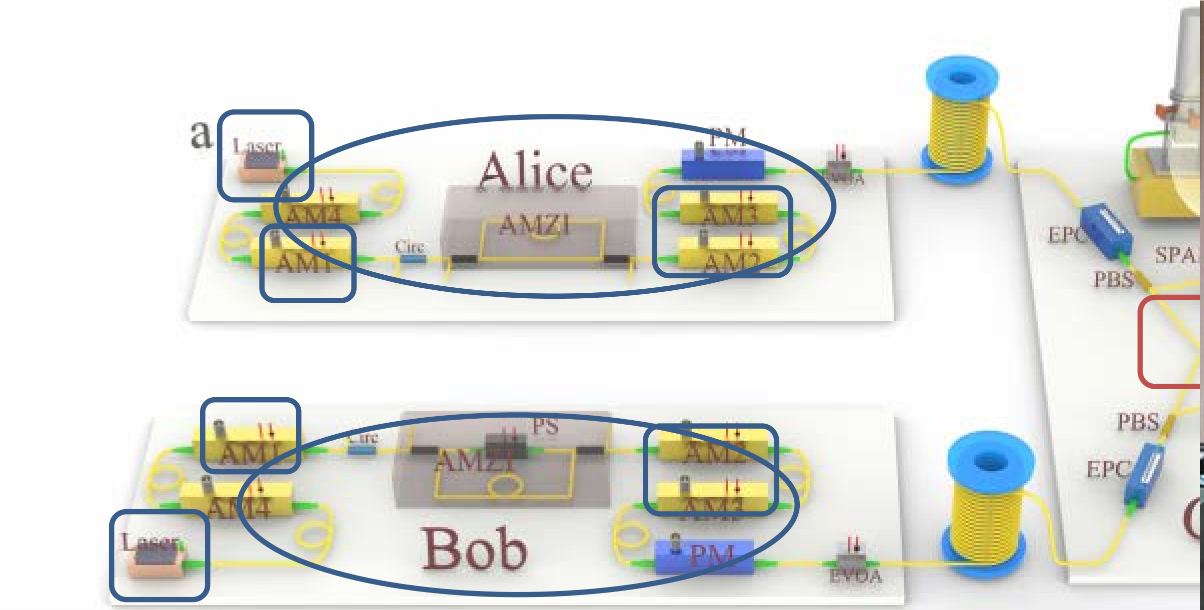
Z. Tang, et al., "Experimental demonstration of polarization encoding measurement-device-independent quantum key distribution", Phys. Rev. Lett.112, 190503 (2014).

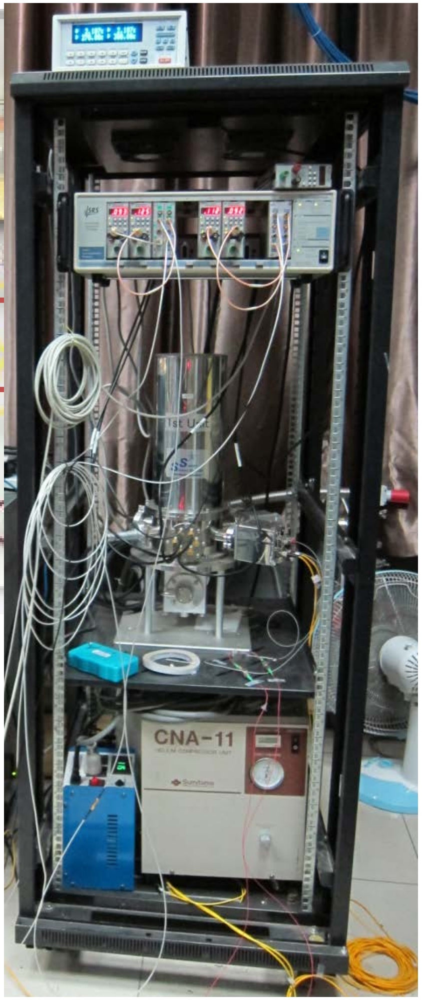
1. Previous MDIQKD demonstrations

	1	2	3	4
	Tittel's group	Pan's group	Weid's group	Lo's group
Encoding method	Time-bin phase	Time-bin phase	Polarization	Polarization
Arrangement	Field test	In lab	In lab	In lab
Maximum distance	18.6 km	50 km	17 km	10 km
System Frequency	2 Mhz	1 MHz	1 MHz	500 KHz
Total Time	Not reported	59.5 hours	Not reported	94 hours
Key rate	Not reported	0.12 bps	Not reported	0.0047 bps

Goal:
long-distance, high-key-rate, practical MDIQKD system & field test

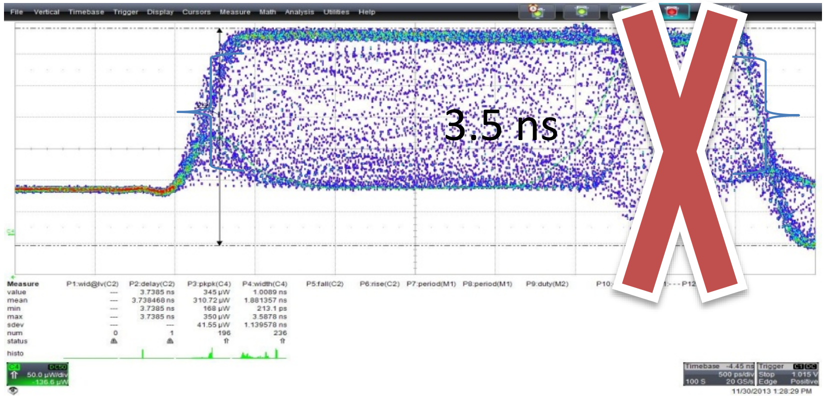
2. 200 km MDIQKD

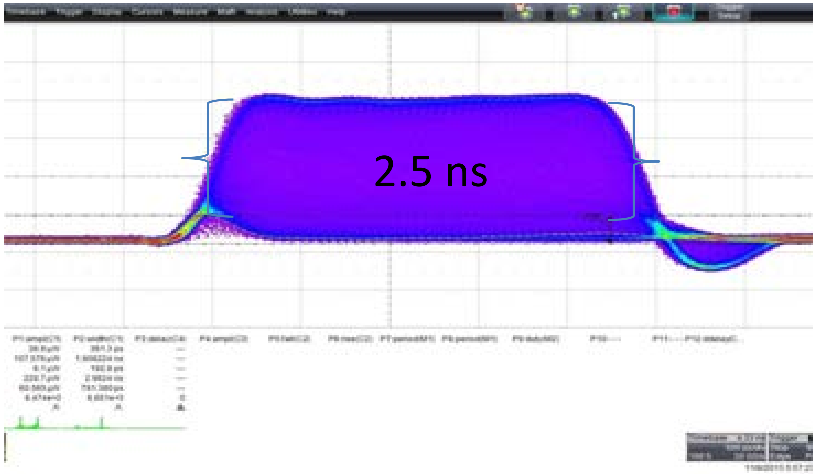




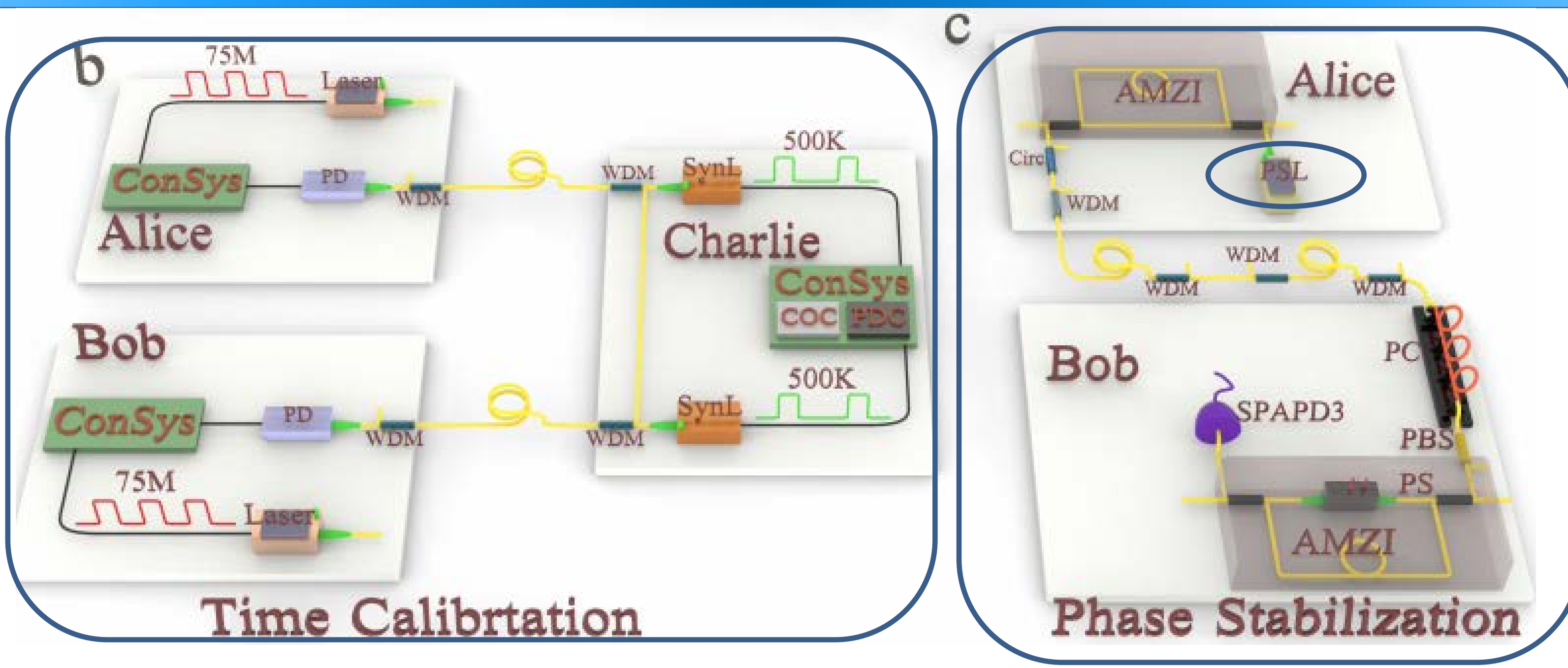
- System clock rate: 75 MHz
- Source :Internally modulated laser source, 1550 nm
- Decoy-state scheme: vacuum+weak decoy-state scheme
- Encoding scheme: time-bin phase-encoding
- Detector: superconducting nanowire single photon detector (SNSPD), >40% @ 10Hz

2. 200 km MDIQKD





2. 200 km MDIQKD



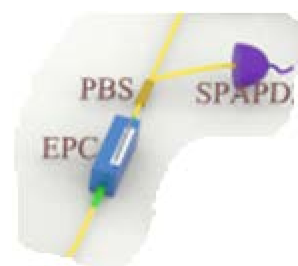
- **Automatic feedback systems:**
  - Time calibration system

    (Synchronization laser, SNSPD, programmable delay chip)
  - Spectrum calibration system

    (optical spectrum analyzer, temperature controlled circuit)
  - Polarization stabilization system

    (EPC. PBS, APD)
  - Phase stabilization system

    (phase-stabilization laser (1550 nm), APD, PS)



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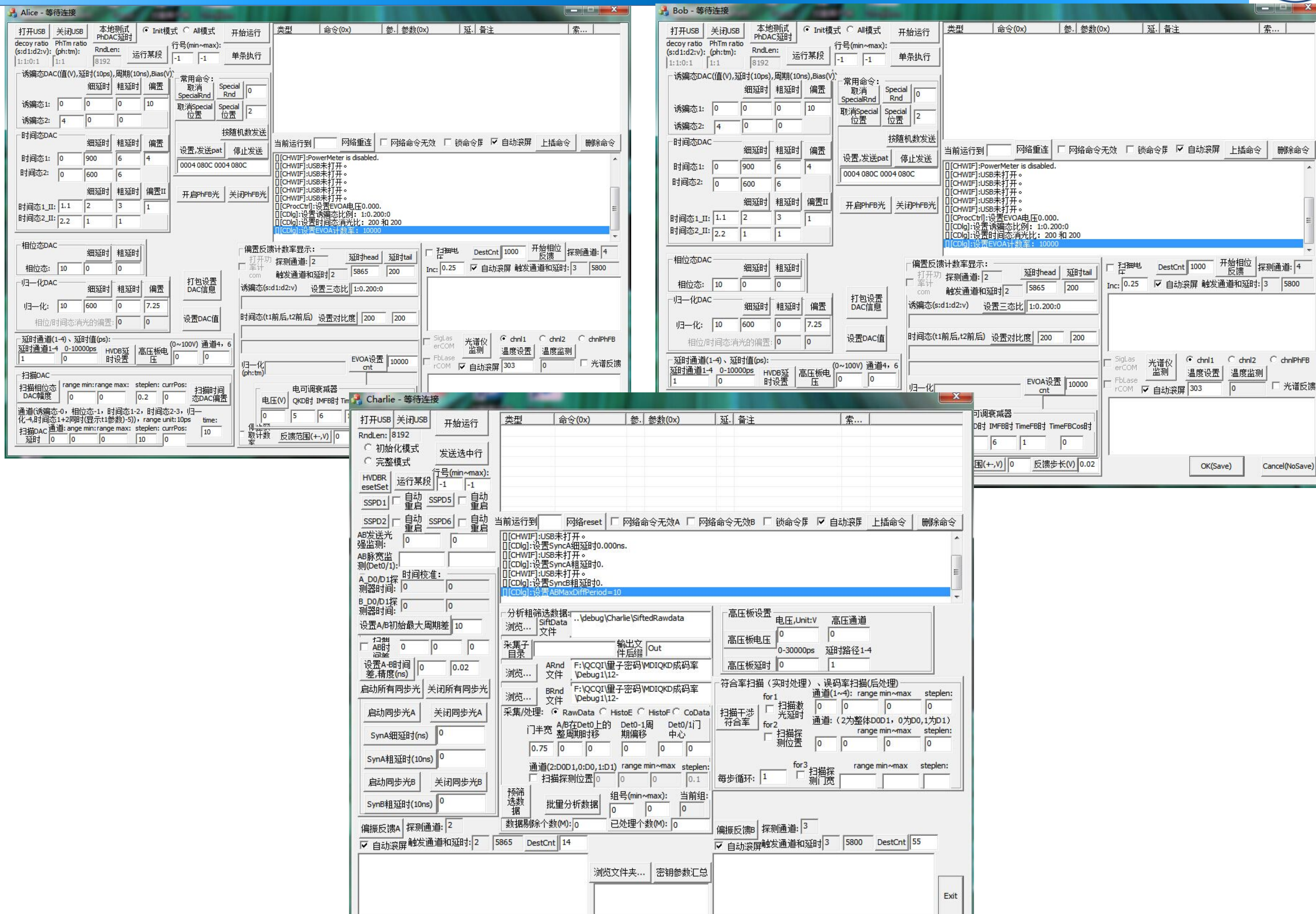
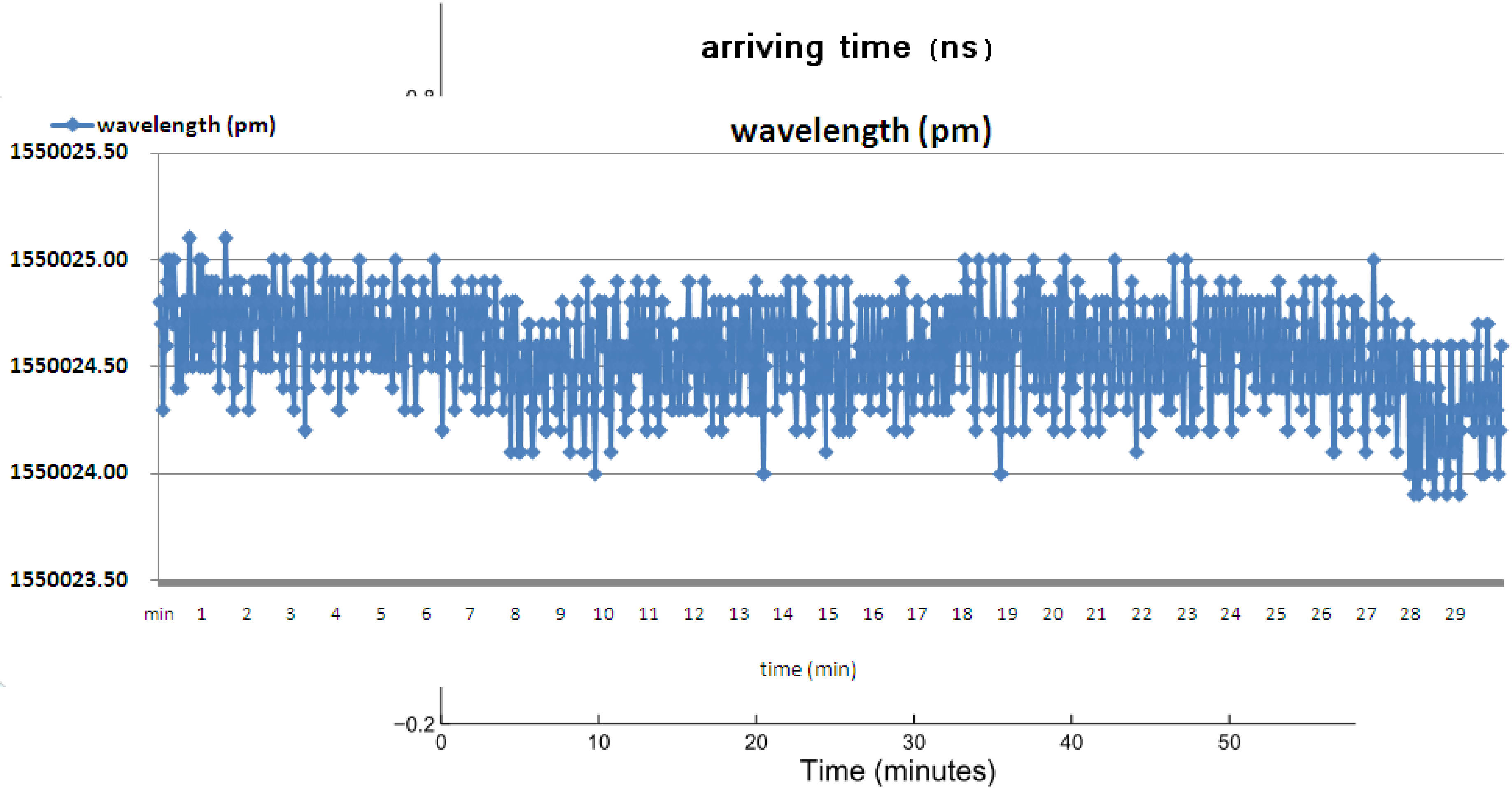


3. Field test of MDIQKD

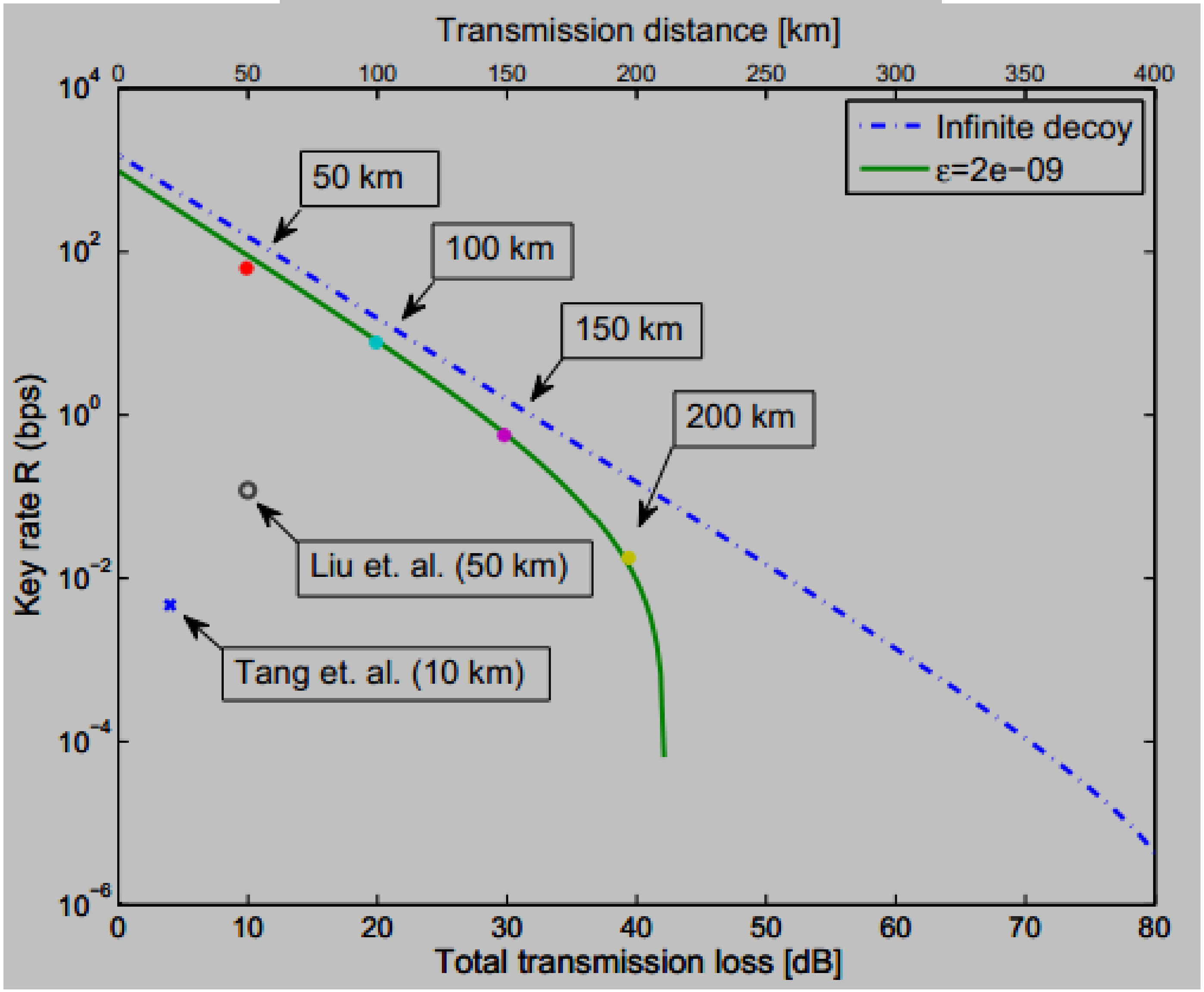


2. 200 km MDIQKD

timing calibration precision	~20 ps
Time shift	< 200 ps /15 min
Spectrum calibration precision	0.5 pm
Spectrum shift	<1 pm / 15 min
Polarization shift	<3% (real time)
Phase shift	<1% (real time)

2. 200 km MDIQKD

$$R \geq Q_{11}^{\mu\mu}[1 - H(e_{11}^{\mu\mu})] - Q^{\mu\mu} f H(E^{\mu\mu})$$



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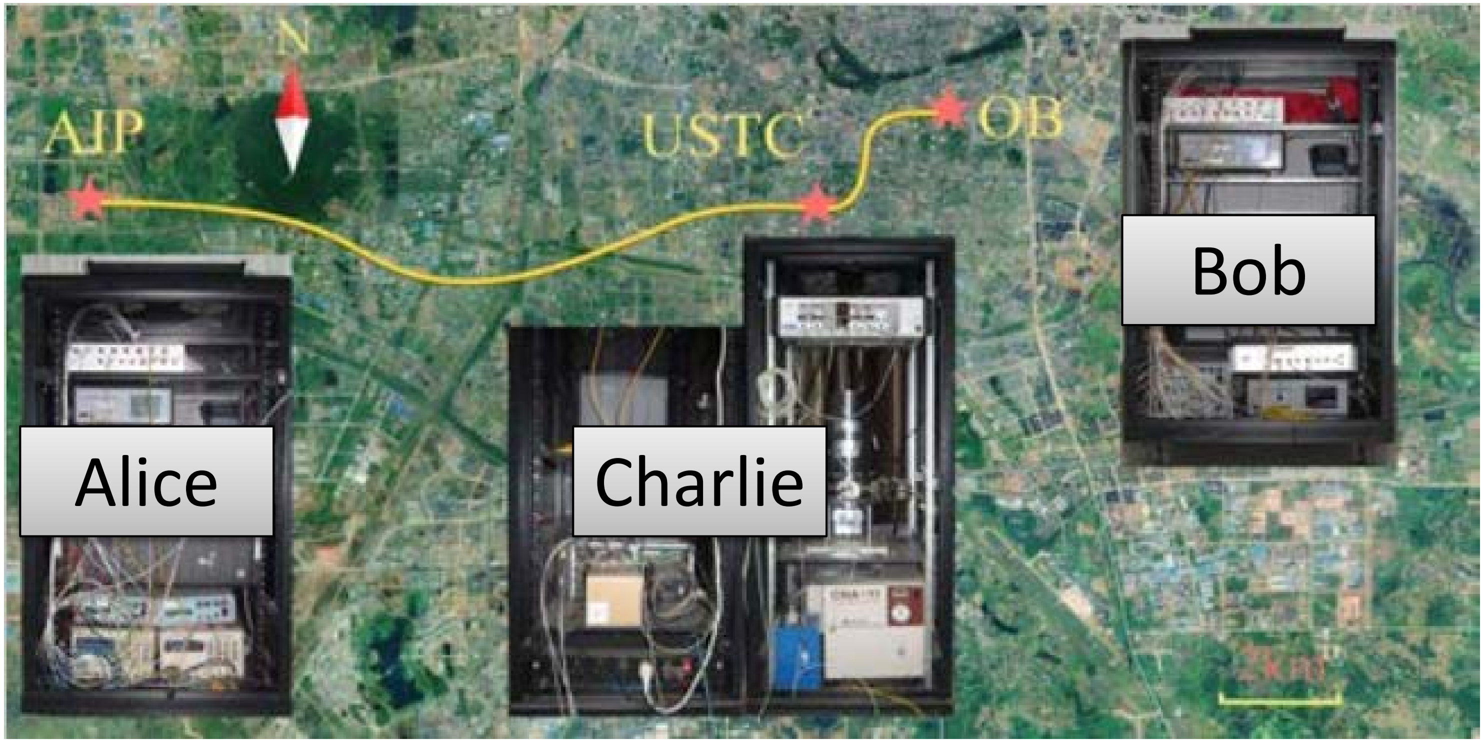


Alice-Charlie link: 25 km (7.9 dB)

Bob-Charlie link: 5 km (1.3 dB)

Total distance: 30 km (9.2 dB)

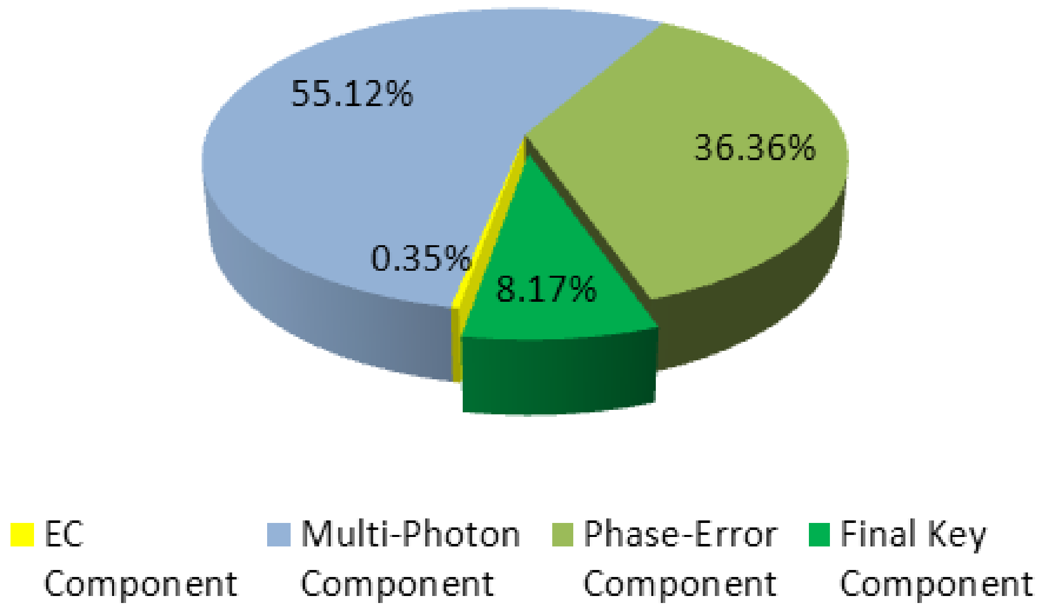
2. Field test of MDIQKD

TABLE I
LIST OF THE TOTAL COINCIDENCE EVENT COUNTS OF BELL STATE $|\psi^-\rangle$ IN THE 30 KM FIELD TEST FOR 18.2 HOURS.

	μ_a/μ_b	0	ν	μ
$M_z^{\mu_a\mu_b}$	0	0.00×10^0	1.93×10^2	2.64×10^3
	ν	3.60×10^1	8.12×10^5	3.36×10^6
	μ	1.46×10^2	3.49×10^6	1.35×10^7
$M_x^{\mu_a\mu_b}$	0	0.00×10^0	8.58×10^5	2.03×10^7
	ν	4.30×10^4	2.72×10^6	4.42×10^7
	μ	9.94×10^5	6.55×10^6	4.48×10^7

TABLE II
LIST OF THE QBERS IN THE 30 KM FIELD TEST FOR 18.2 HOURS.

	μ_a/μ_b	0	ν	μ
$E_z^{\mu_a\mu_b}$	0	0.00%	52.33%	49.26%
	ν	52.78%	0.04%	0.10%
	μ	47.26%	0.01%	0.02%
$E_x^{\mu_a\mu_b}$	0	0.00%	51.49%	49.90%
	ν	52.10%	38.12%	46.85%
	μ	49.92%	27.72%	36.82%



Secure key rate: 16.9 bps

3. Conclusion

- Summary:
  - In lab: 50 km →200 km
  - Field test: 30 km, robustness
  - Secure key rate: 16.9 bps (field test), 2~3 orders higher than previous experiments
- Outlook:
  - increase the system clock : (1 ~10) GHz
  - Higher detection efficiency and lower dark count rate
  - Optimization of Decoy-state parameters and basis choice

（Arxiv: 1407.8012 and Arxiv: 1408.2330）

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Thank you!