

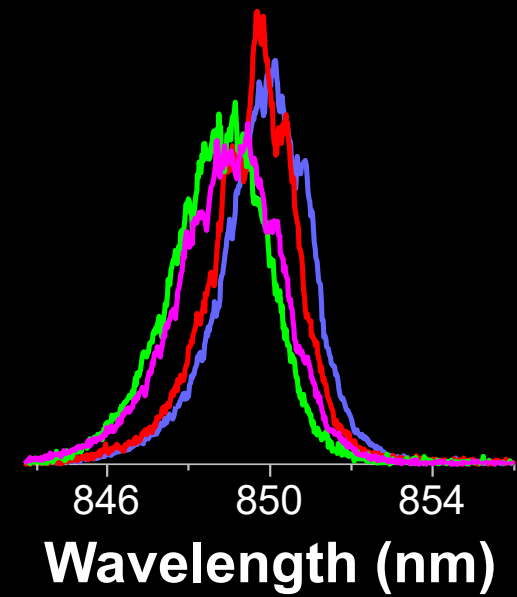
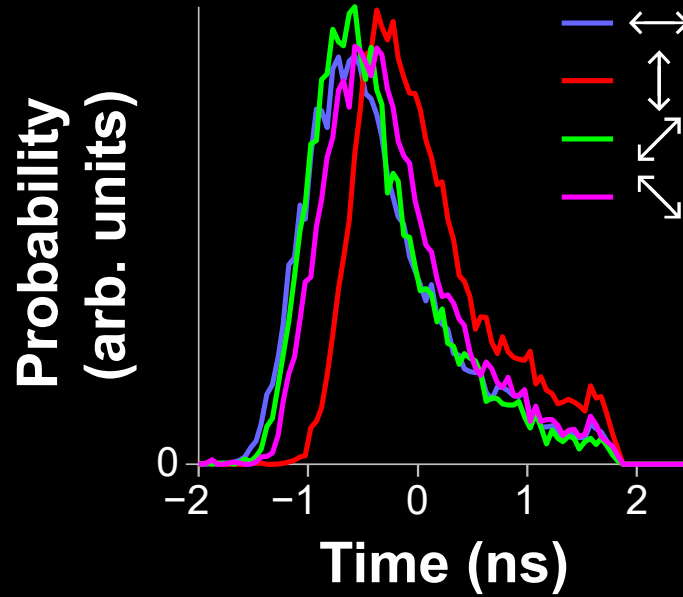
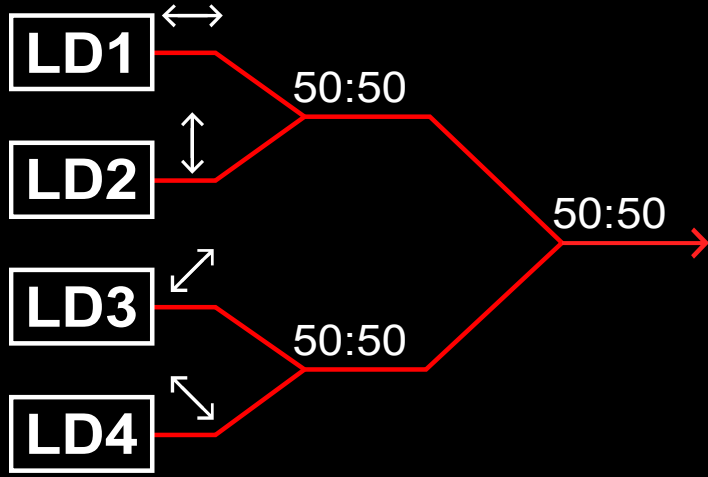
# Source distinguishability; Certification and audit

| <b>Attack</b>   | <b>Target component</b>      | <b>Tested system</b>                     |
|---|------------------------------|--|
| <b>Distinguishability of decoy states</b><br><i>A. Huang et al., Phys. Rev. A</i> <b>98</b> , 012330 (2018)   | laser in Alice               | 3 research systems                       |
| <b>Intersymbol interference</b><br><i>K. Yoshino et al., poster at QCrypt</i> (2016)  | intensity modulator in Alice | research system                          |
| <b>Laser damage</b><br><i>V. Makarov et al., Phys. Rev. A</i> <b>94</b> , 030302 (2016); <i>A. Huang et al., poster at QCrypt</i> (2018)  | any                          | 5 commercial &<br>1 research systems     |
| <b>Spatial efficiency mismatch</b><br><i>M. Rau et al., IEEE J. Sel. Top. Quantum Electron.</i> <b>21</b> , 6600905 (2015); <i>S. Sajeed et al., Phys. Rev. A</i> <b>91</b> , 062301 (2015) | receiver optics              | 2 research systems                       |
| <b>Pulse energy calibration</b><br><i>S. Sajeed et al., Phys. Rev. A</i> <b>91</b> , 032326 (2015)  | classical watchdog detector  | ID Quantique                             |
| <b>Trojan-horse</b><br><i>I. Khan et al., presentation at QCrypt</i> (2014)   | phase modulator in Alice     | SeQureNet                                |
| <b>Trojan-horse</b><br><i>N. Jain et al., New J. Phys.</i> <b>16</b> , 123030 (2014); <i>S. Sajeed et al., Sci. Rep.</i> <b>7</b> , 8403 (2017)   | phase modulator in Bob       | ID Quantique                             |
| <b>Detector saturation</b><br><i>H. Qin, R. Kumar, R. Alleaume, Proc. SPIE</i> 88990N (2013)  | homodyne detector            | SeQureNet                                |
| <b>Shot-noise calibration</b><br><i>P. Jouguet, S. Kunz-Jacques, E. Diamanti, Phys. Rev. A</i> <b>87</b> , 062313 (2013)  | classical sync detector      | SeQureNet                                |
| <b>Wavelength-selected PNS</b><br><i>M.-S. Jiang, S.-H. Sun, C.-Y. Li, L.-M. Liang, Phys. Rev. A</i> <b>86</b> , 032310 (2012)  | intensity modulator          | (theory)                                 |
| <b>Multi-wavelength</b><br><i>H.-W. Li et al., Phys. Rev. A</i> <b>84</b> , 062308 (2011)   | beamsplitter                 | research system                          |
| <b>Deadtime</b><br><i>H. Weier et al., New J. Phys.</i> <b>13</b> , 073024 (2011)   | single-photon detector       | research system                          |
| <b>Channel calibration</b><br><i>N. Jain et al., Phys. Rev. Lett.</i> <b>107</b> , 110501 (2011)  | single-photon detector       | ID Quantique                             |
| <b>Faraday-mirror</b><br><i>S.-H. Sun, M.-S. Jiang, L.-M. Liang, Phys. Rev. A</i> <b>83</b> , 062331 (2011)   | Faraday mirror               | (theory)                                 |
| <b>Detector control</b><br><i>I. Gerhardt et al., Nat. Commun.</i> <b>2</b> , 349 (2011); <i>L. Lydersen et al., Nat. Photonics</i> <b>4</b> , 686 (2010)                                   | single-photon detector       | ID Quantique, MagiQ,<br>research systems |

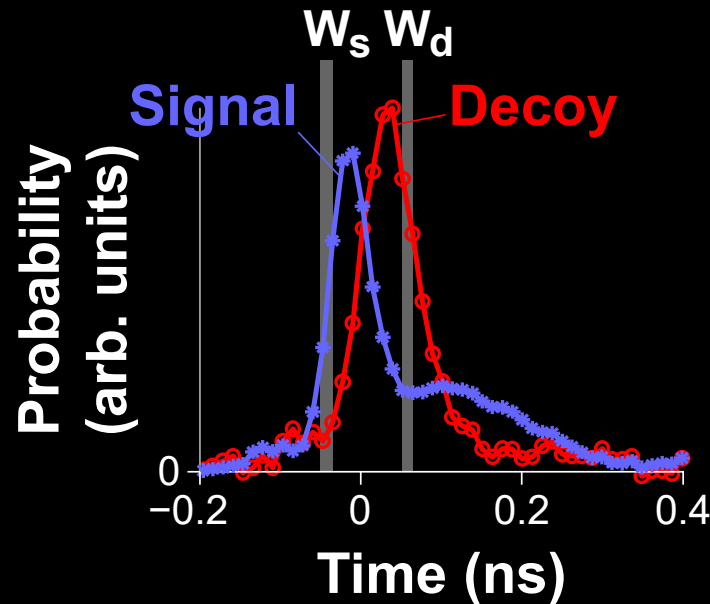
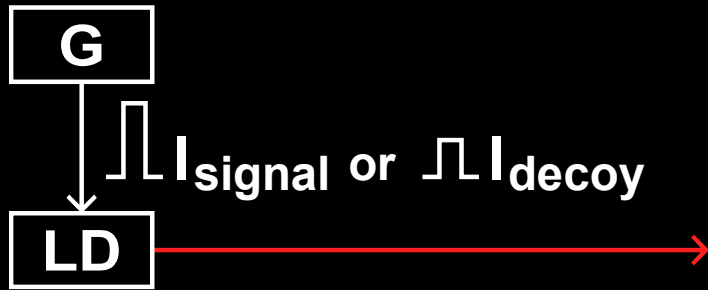
## 3 ways to deal with an imperfection

- ★ Technical countermeasure that attempts to stop the attack
- ★ Make a scheme intrinsically insensitive to imperfection
- ★ Characterise imperfection, upper-bound *partial* information leakage, eliminate it by privacy amplification

# Distinguishability of source states

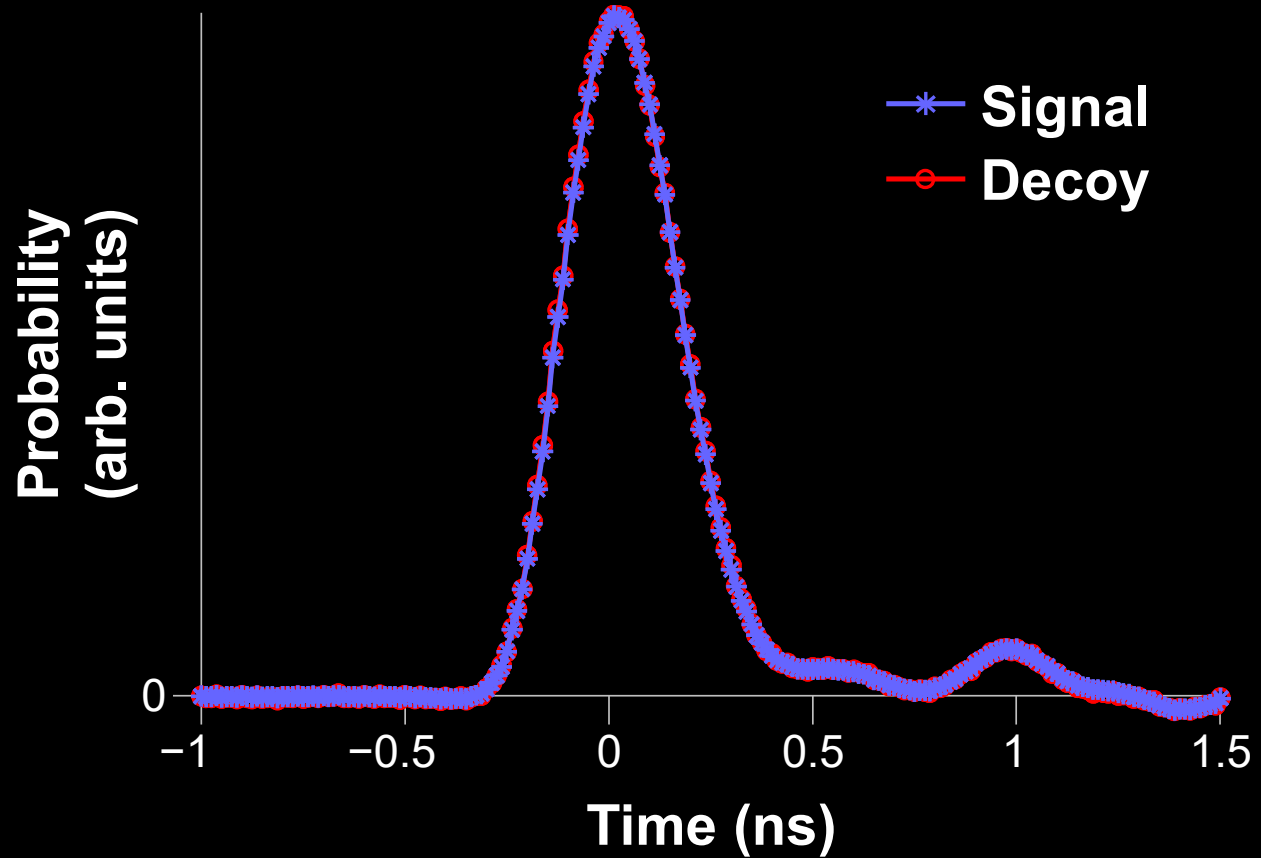
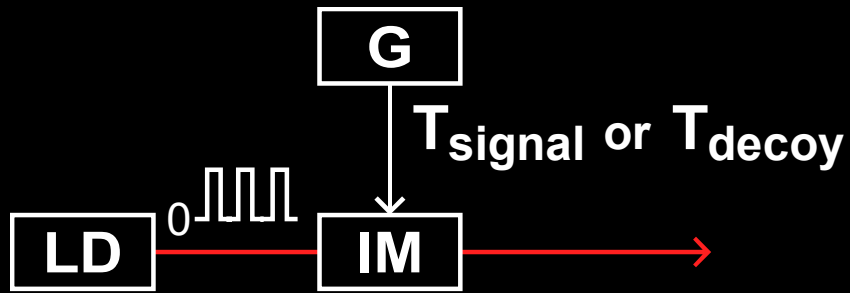


S. Nauerth *et al.*, New J. Phys. **11**, 065001 (2009)

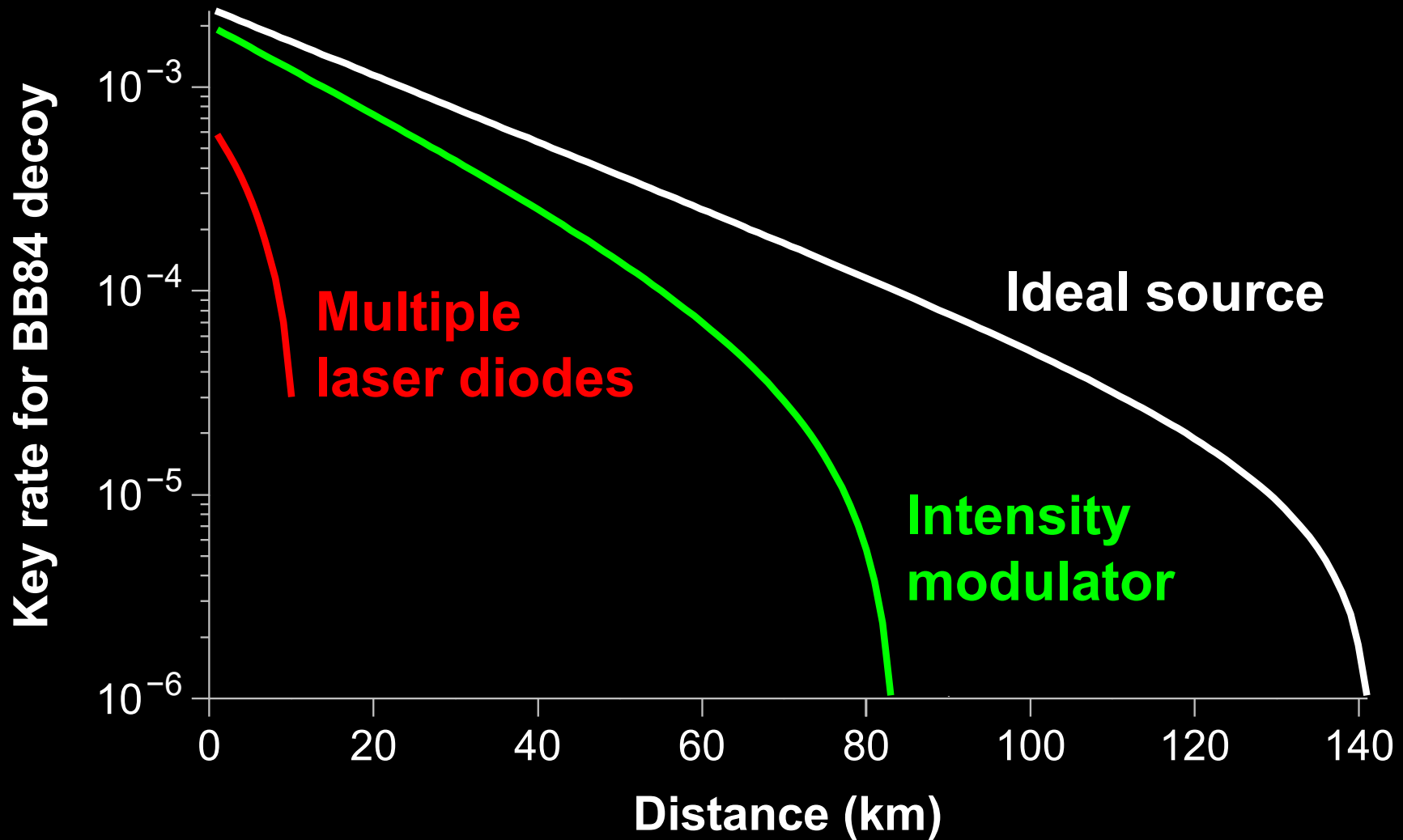


A. Huang, S.-H. Sun, Z. Liu, V. Makarov, Phys. Rev. A **98**, 012330 (2018)

# Distinguishability of source states



# Distinguishability of source states



**Pump-current modulation: zero key rate**

# Certification of cryptographic tools



Legal requirements



Approval

**Accredited lab**

System



Engineering documentation



**Certificate**



**Manufacturer**

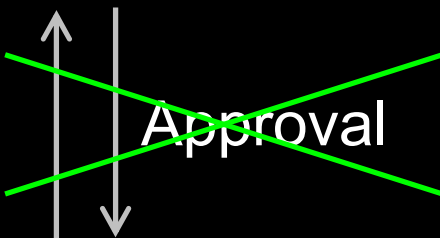
Sale

**Customer**

# Certification of cryptographic tools



Legal requirements



**Accredited lab**

System



Engineering documentation



Certificate

**Russia:  
optional for  
commercial  
uses**



**Manufacturer**

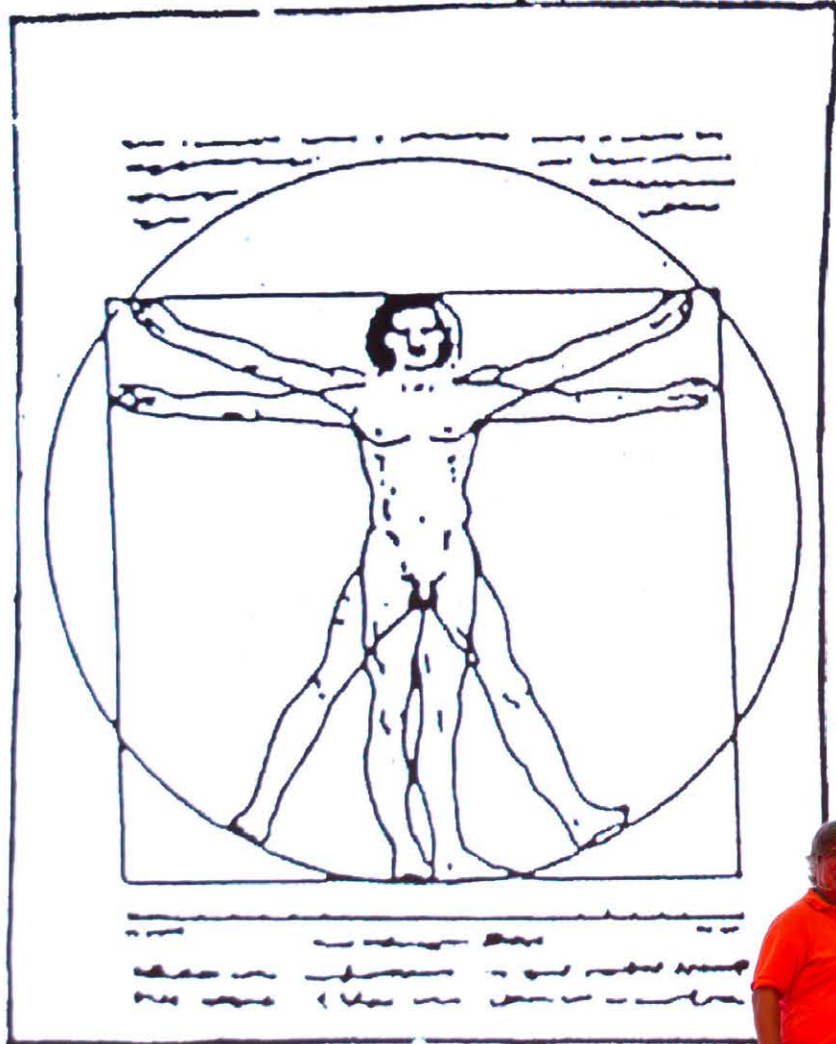
Sale

**Customer**





# THEORY



# EXPERIMENT



MSTEVENS

# Security audit

# System

# Report

# Tests



2016

-2018  
interrupted



国盾量子  
QuantumCTek



40 MHz

2016,  
2018-19

ongoing



ITMO UNIVERSITY

(ООО Квантовые коммуникации)

Subcarrier scheme

2018

ongoing

S. Sajeed *et al.*, arXiv:1909.07898



New 312.5 MHz system (2020) ongoing

Certification standards are being drafted since 2019 in



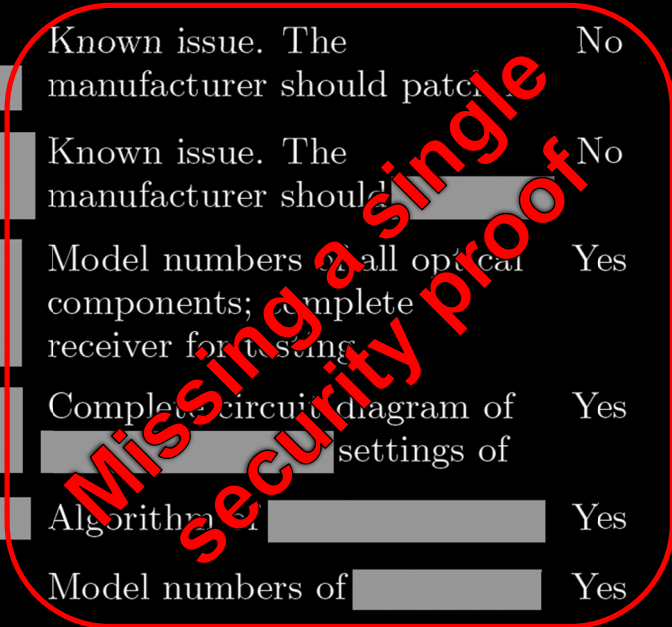
Industry standards  
group in QKD



# Example of initial analysis report

TABLE I: Summary of potential security issues in [redacted] system.

| Potential security issue | C  | Q      | Target component | Brief description                          | Requirements for complete analysis  | Lab testing needed? | Risk evaluation          |
|--------------------------|----|--------|------------------|--|---|---------------------|--------------------------|
| [redacted]               | CX | Q1–5,7 | [redacted]       | [redacted]                                 | Complete circuit diagram of [redacted]  | Yes                 | High                     |
| [redacted]               | CX | Q1–3   | [redacted]       | See Ref. [3].                              | Complete circuit diagram of [redacted]  | Yes                 | High                     |
| [redacted]               | CX | Q1,2   | [redacted]       | See Ref. [4].                              | Complete circuit diagram of [redacted]  | Yes                 | High                     |
| [redacted]               | C0 | Q2,3   | [redacted]       | Manufacturer needs to implement [redacted] | Known issue. The manufacturer should patch [redacted]                             | No                  | High                     |
| [redacted]               | CX | Q3–5,7 | [redacted]       | [redacted]                                 | Known issue. The manufacturer should [redacted]                                   | No                  | Medium                   |
| [redacted]               | CX | Q1     | [redacted]       | [redacted]                                 | Model numbers of all optical components; complete receiver for testing [redacted] | Yes                 | High                     |
| [redacted]               | CX | Q1–5   | [redacted]       | [redacted]                                 | Complete circuit diagram of [redacted] settings of [redacted]                     | Yes                 | Insufficient information |
| [redacted]               | CX | Q1–3   | [redacted]       | [redacted]                                 | Algorithm for [redacted]  | Yes                 | Low                      |
| [redacted]               | CX | Q1,2   | [redacted]       | See Ref. [13].                             | Model numbers of [redacted]   | Yes                 | Medium                   |
| [redacted]               | CX | Q4,5   | [redacted]       | [redacted]                                 | Full system algorithms; complete system if decided to test.                       | Maybe               | Low                      |
| [redacted]               | CX | Q1,3–5 | [redacted]       | Eve can [redacted]                         | Algorithm for [redacted]  | Maybe               | Low                      |



~~COMINT~~

Declassified and approved for  
release by NSA on 12-10-2008  
pursuant to E.O. 12958, as  
amended. MDR 54498

~~VII~~-26-X

**A HISTORY OF U.S. COMMUNICATIONS SECURITY (U)**  
**(The David G. Boak Lectures)**

**NATIONAL SECURITY AGENCY**  
**FORT GEORGE G. MEADE, MARYLAND 20755**

Revised July 1973

**TENTH LECTURE:**

**TEMPEST**

In 1962, an officer assigned to a very small intelligence detachment in Japan was performing the routine duty of inspecting the area around his little cryptocenter. As required he was examining a zone 200 ft. in radius to see if there was any "clandestine technical surveillance". Across the street, perhaps a hundred feet away, was a hospital controlled by the Japanese government. He sauntered past a kind of carport jutting out from one side of the building and, up under the eaves, noticed a peculiar thing—a carefully concealed dipole antenna, horizontally polarized, with wires leading through the solid cinderblock wall to which the carport abutted. He moseyed back to his headquarters, then quickly notified the counter-intelligence people and fired off a report of this "find" to Army Security Agency, who, in turn, notified NSA. He was directed to examine this antenna in detail and perhaps recover it, but although the CIC had attempted to keep the carport under surveillance that night, the antenna had mysteriously disappeared when they checked the next day. Up on the roof of the hospital was a forest of Yagi's, TV-antennas, all pointing towards Tokyo in the normal fashion, except *one*. That one was aimed right at the U.S. cryptocenter.



able impact on most of our cryptosystems, and because we view it as the most serious technical security problem we currently face in the COMSEC world.

First, let me state the general nature of the problem as briefly as I can, then I will attempt something of a chronology for you. In brief: any time a machine is used to process classified information electrically, the various switches, contacts, relays, and other components in that machine may emit radio frequency or acoustic energy. These emissions, like tiny radio broadcasts, may radiate through free space for considerable distances—a half mile or more in some cases. Or they may be induced on nearby conductors like signal lines, power lines, telephones lines, or water pipes and be conducted along those paths for some distance—and here we may be talking of a mile or more.

When these emissions can be intercepted and recorded, it is frequently possible to analyze them and recover the intelligence that was being processed by the source equipment. The phenomenon affects not only cipher machines but any information-processing equipment—teleprinters, duplicating equipment, intercomms, facsimile, computers—you name it. But it has special significance for cryptomachines because it may reveal not only the plain text of individual messages being processed, but also that carefully guarded information about the internal machine processes being governed by those precious keys of ours. Thus, conceivably, the machine could be radiating information which could lead to the reconstruction of our key lists—and that is absolutely the worst thing that can happen to us.

Now, let's go back to the beginning. During WW II, the backbone systems for Army and Navy secure TTY communications were one-time tapes and the primitive rotor key generator then called SIGTOT. Bell Telephone rented and sold the military a mixing device called a 131-B2 and this combined with tape or SIGTOT key with plain text to effect encryption. They had one of these mixers working in one of their laboratories and, quite by accident, noted that each time the machine stepped, a spike would appear on an oscilloscope in a distant part of the lab. They examined these spikes more carefully and found, to their real dismay, that they could read the plain text of the message being enciphered by the machine. Bell Telephone was kind enough to give us some of their records of those days, and the memoranda and reports of conferences that ensued after this discovery are fascinating. They had sold the equipment to the military with the assurance that it was secure, but it wasn't. The only thing they could do was to tell the Signal Corps about it, which they did. There they met the charter members of a club of skeptics (still flourishing!) which could not believe that these tiny pips could really be exploited under practical field conditions. They are alleged to have said something like: "Don't you realize there's a war on? We can't bring our cryptographic operations to a screeching halt based on a dubious and esoteric laboratory phenomenon. If this is really dangerous, prove it." The Bell engineers were placed in a building on Varick Street in New York. Across the street and about 80 feet away was Signal Corps' Varick Street cryptocenter. The Engineers recorded signals for about an hour. Three or four hours later, they produced about 75% of the plain text that was being processed—a fast performance, by the way, that has rarely been equalled. (Although, to get ahead of the story for a moment, in some circumstances now-a-days, either radiated or conducted signals can be picked up, amplified, and used to drive a tele-

# Today's digital

**Crypto module** - Bus - Memory - Software - Bus - **Signal proc.** - DAC - Amplifier —

## vs. quantum

**Crypto module** — **Optical line**

## [vs. future quantum]

**Crypto module** — **Quantum bus, computer, memory...** —





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