Quantum Position Verification in the Plane

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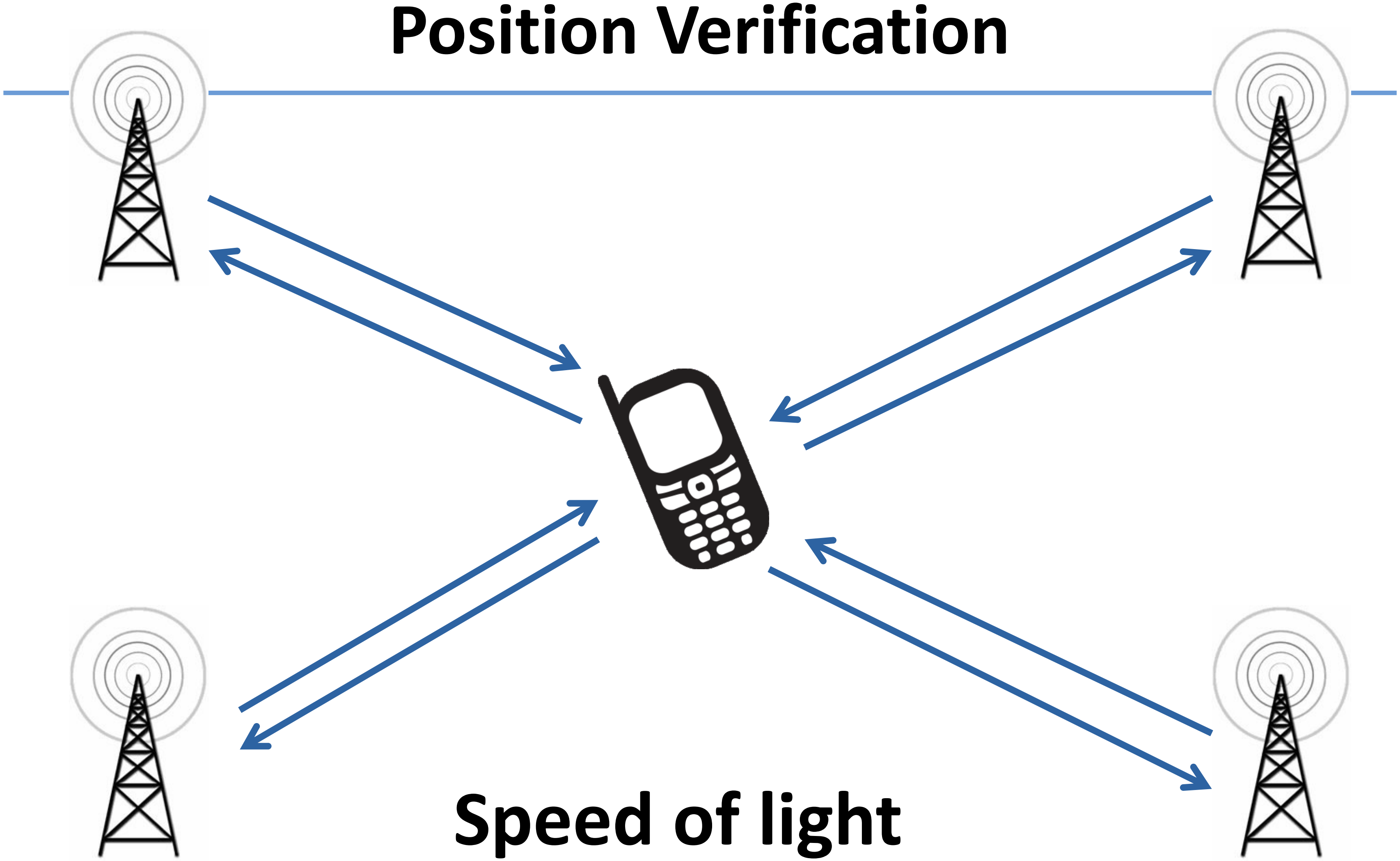
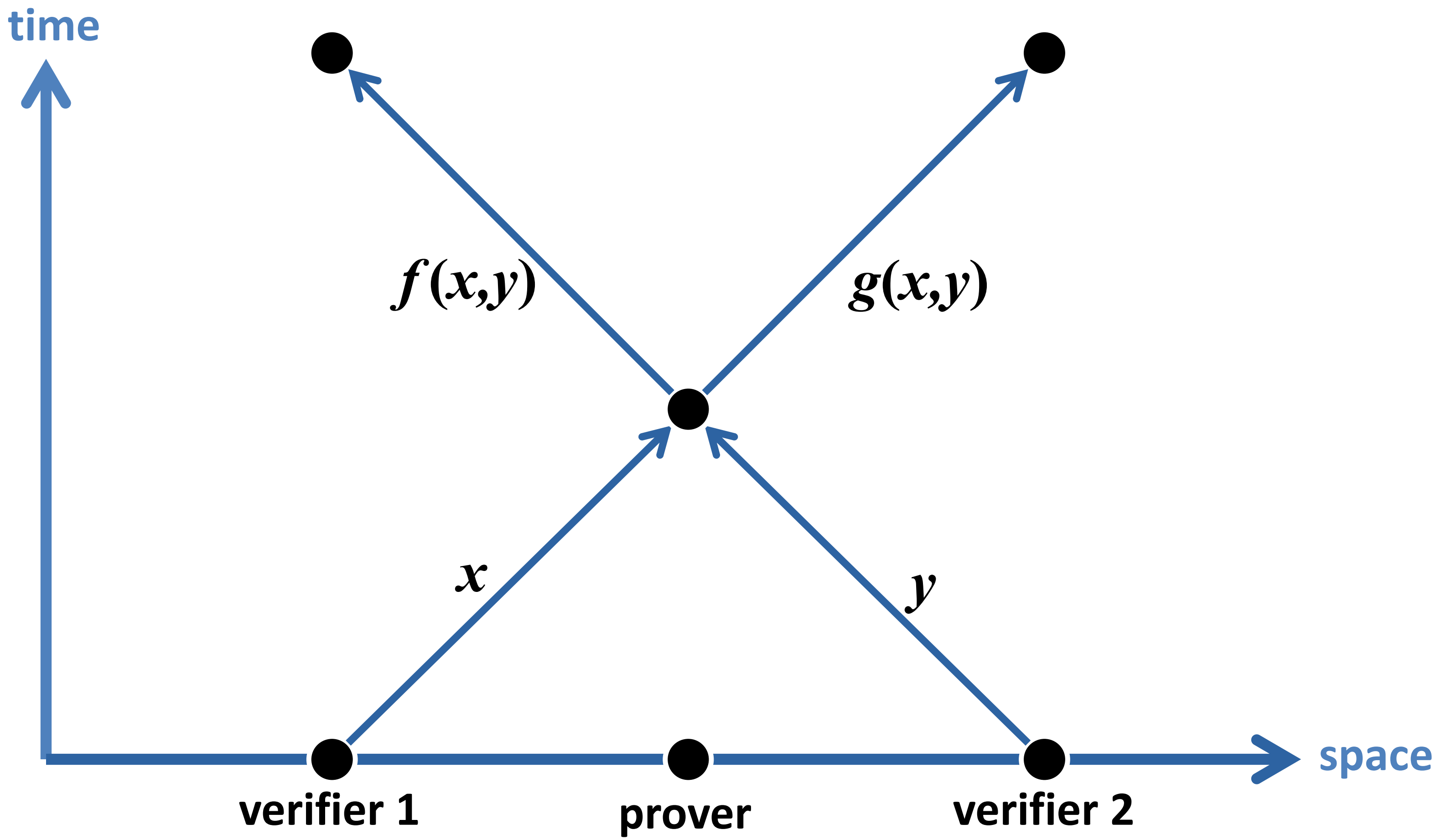
Position Verification

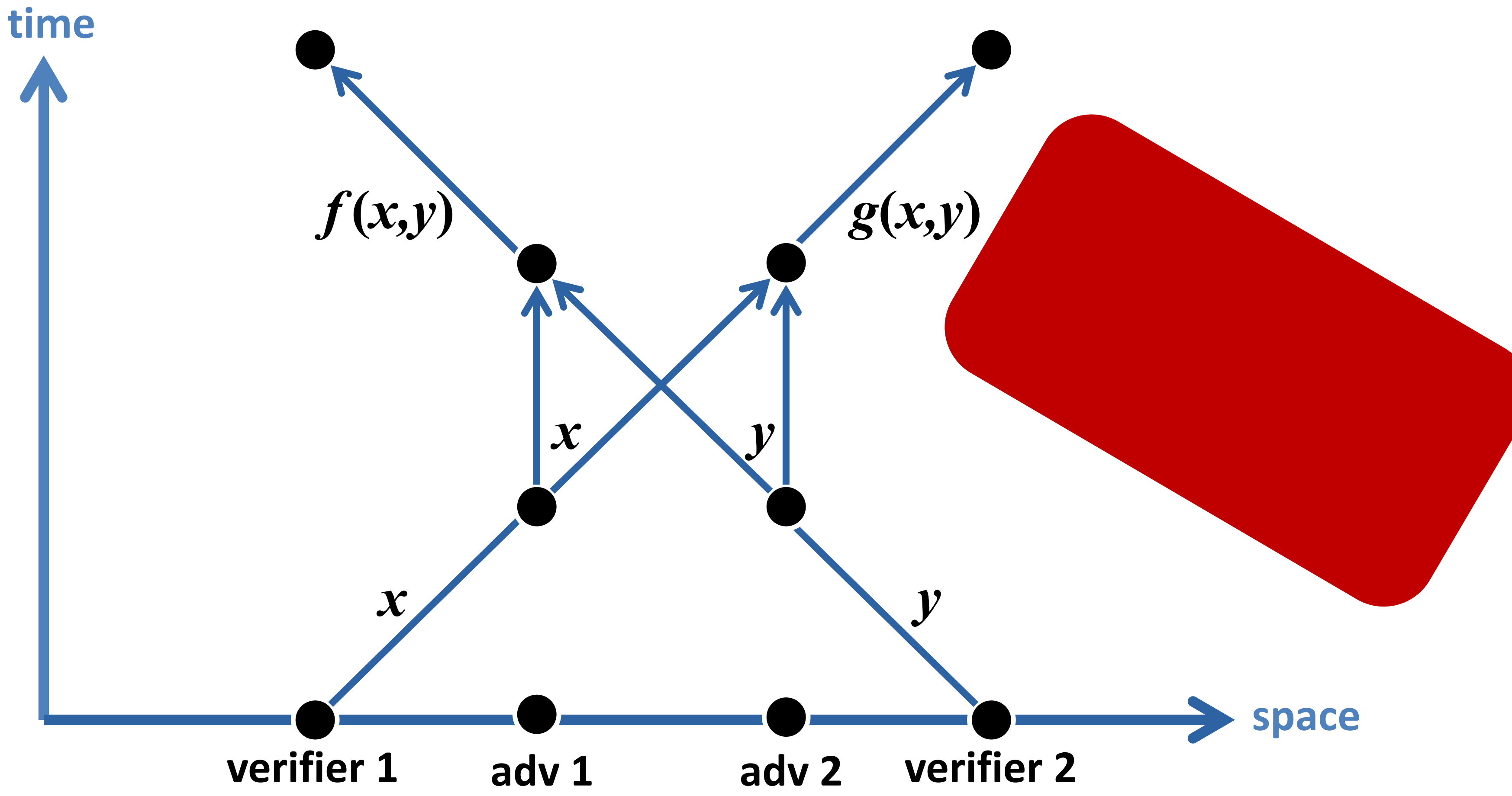


Speed of light
→ Position verified

A generic protocol



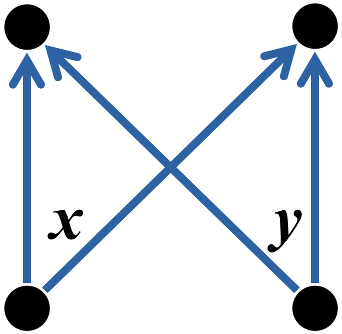
A generic attack



[CGMO09] Chandran, Goyal, Moriarty, Ostrovsky, *Position Based Cryptography*, Crypto 2009

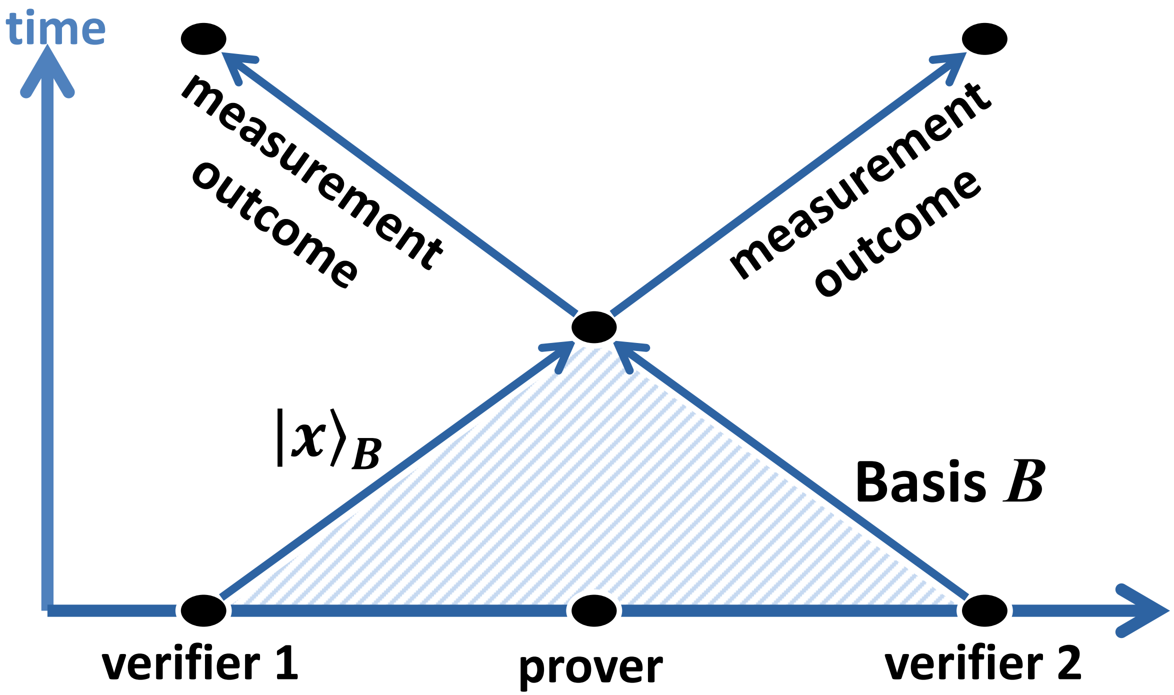
Way out: quantum crypto

- In attack: adversary copies x,y
- If x or y quantum: No cloning!
- Attack does not work
- Other attacks?
  - Without extra assumptions:
    Generic attack (exponential entanglement)



[BCF⁺11] Buhrman, Chandran, Fehr, Gelles, Goyal, Ostrovsky, Schaffner: *Position-Based Quantum Crypto*, Crypto 2011

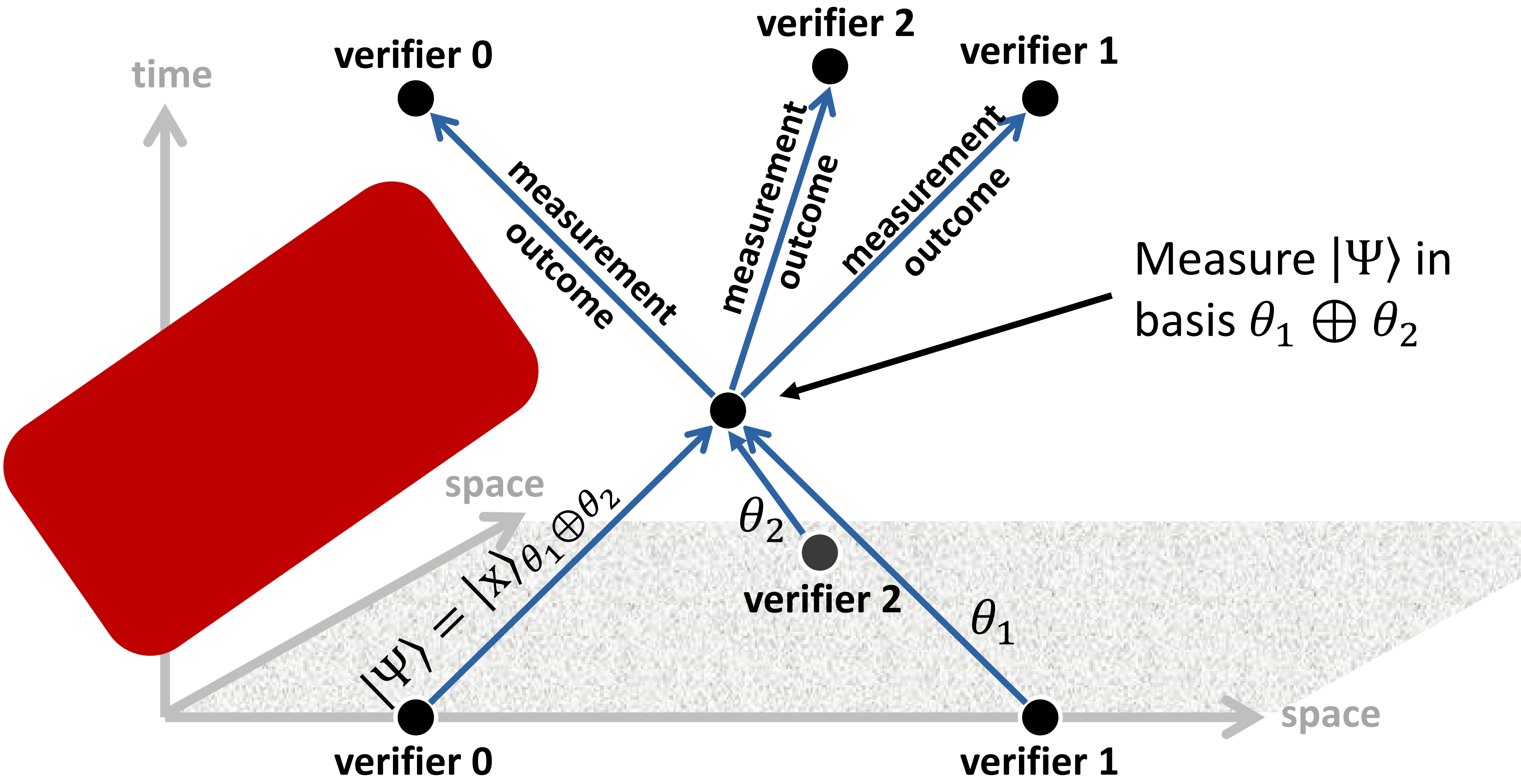
Quantum crypto: A secure protocol



Assumption:
No entangled photons in ▨

[TFKW13] Tomamichel, Fehr, Kaniewski, Wehner: *One-Sided Device-Independent QKD and Position-Based Cryptography from Monogamy Games*, Eurocrypt 2013 (and [BCF+11])

2D/3D case



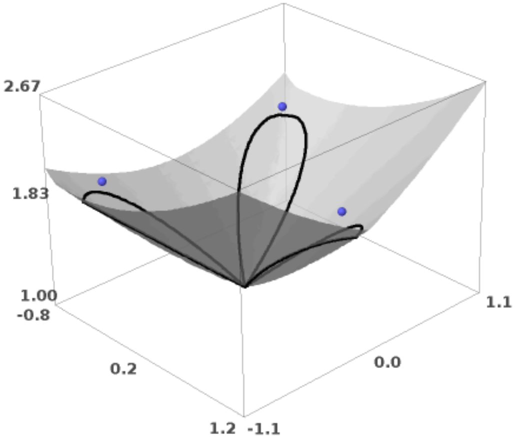
(There is a secure 3D protocol in the random oracle model, though [Unr14])

Our result

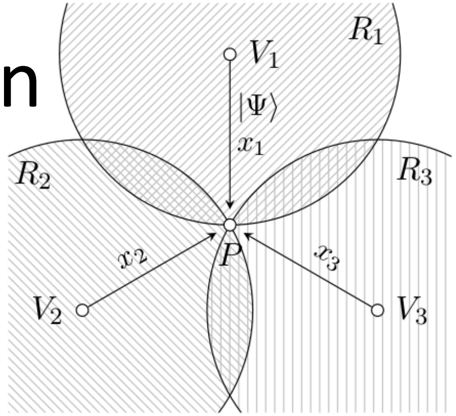
- Security proof in **2D-case**
- Sufficient for position verification “on earth”
- 3D-case: open problem

Why is 2D/3D tricky?

- Events (like getting all three messages) along complicated space-time surfaces



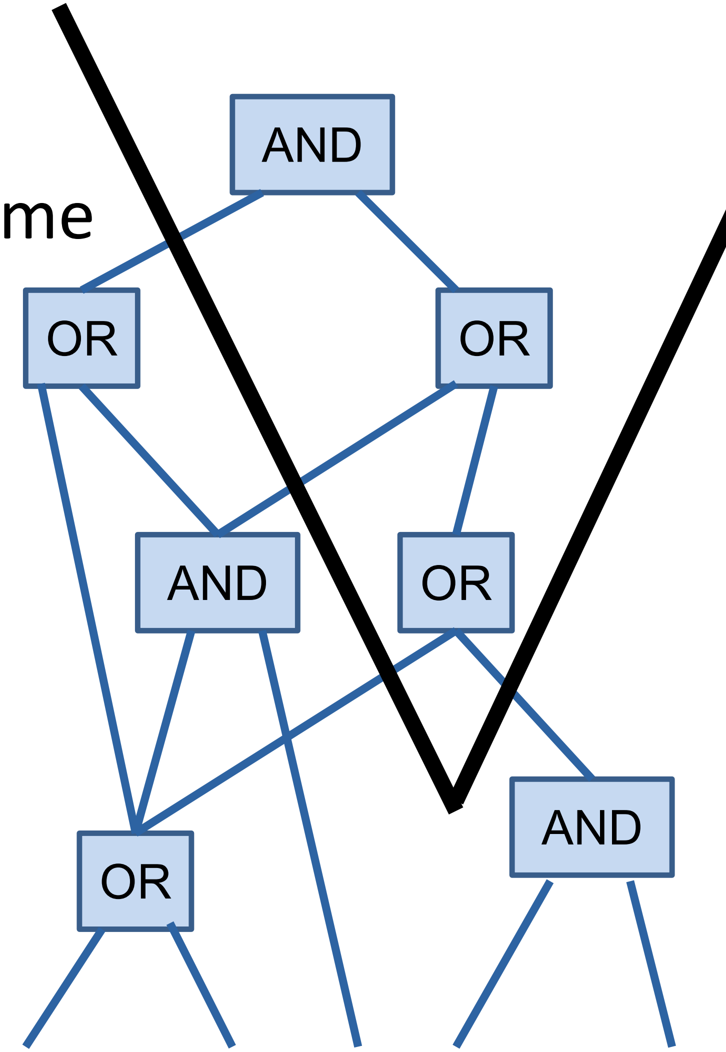
- In some space-time areas, some but not all messages known



- Complicated mix geometry + quantum

Proof technique: Space-time circuits

- Tool: Space-time circuits
  - Gates have positions in space-time
  - No wire leaves light cone
- Derive connectivity from geometry
- Then forget about geometry, only use connectivity
  - Normal game-based proof



[Unruh, *Quantum Pos. Verif. in the RO model*, Crypto 14]

Proof – analyzing space-time regions

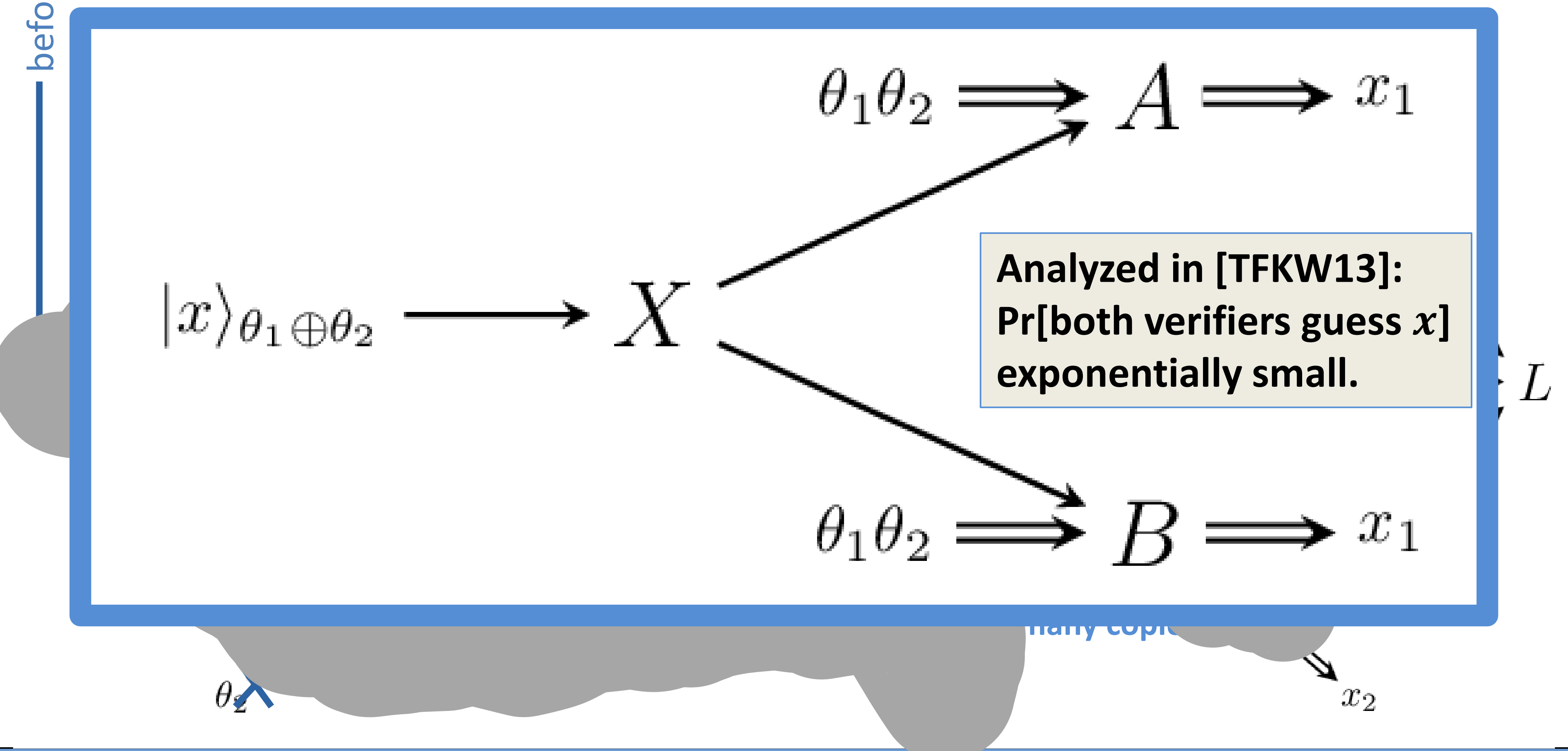
before protocol

reachable by one verifier

reachable by two verifiers

reaches two verifiers

reaches one verifier



Analyzed in [TFKW13]: Pr[both verifiers guess x] exponentially small.

Conclusion

- 2D case solved
- Lesson learned:
  Relativistic protocols complicated in 2D/3D
  - [BCF$^+$11] got it wrong.
- Use space-time circuits!
  (Also for relativistic commitments)
- 3D case: open problem

Thank you for your attention

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Postdoc Positions (also phd)

Verification of Quantum Crypto

Formal verification of quantum crypto protocols
(“QuEasyCrypt” tool)

http://tinyurl.com/postdoc-vqc