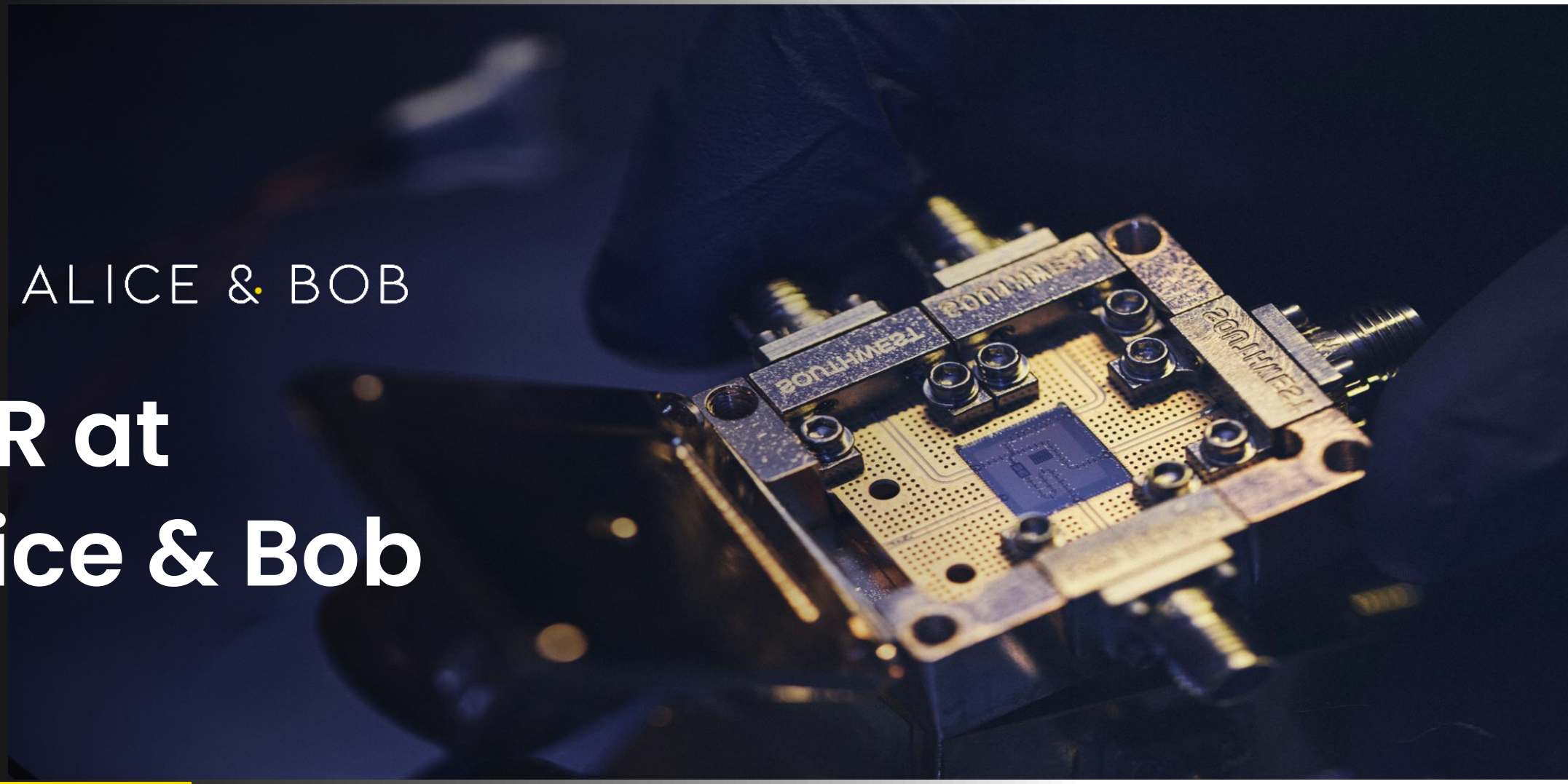
ALICE & BOB

# QIR at Alice & Bob



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# Alice & Bob: building a fault-tolerant quantum computer

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Co-inventor of the cat qubit technology

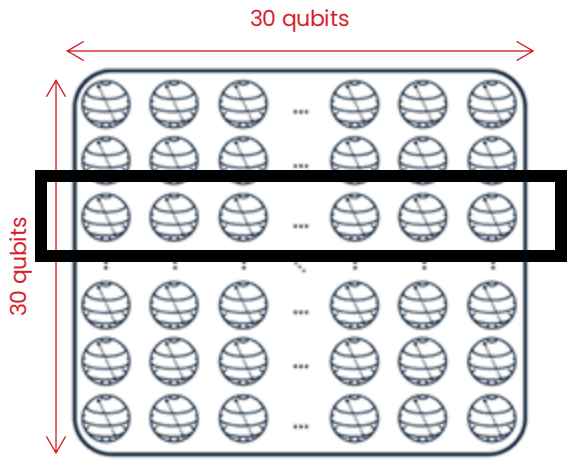
| | | | | |
|---|---|---|---|---|
| 65 employees at the end of 2022 (incl. 50 R&D) | 15 patents filed at the end of 2022 | 30M€ raised in VC capital | 6 academic partnerships | Created in 2020 EU leader in 2022 |

ENS · MINES ParisTech · Inria · Sorbonne Université · bpifrance SERVIR L'AVENIR · cea · European Innovation Council · Agoranov · La FRENCH TECH DEEPNUM20

# Cat qubits

The perfect basis for logical qubits

**QUANTITATIVE APPROACH**
**STANDARD QUBITS + SURFACE CODE**

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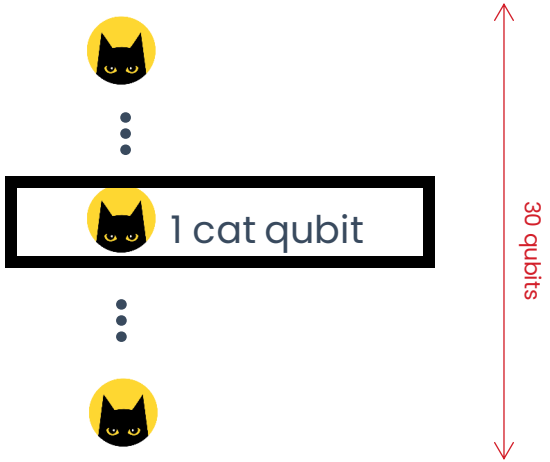
**QUALITATIVE APPROACH**
**CAT QUBITS + REPETITION CODE**




Shor to break RSA

**22M**
physical qubits

C. Gidney et al. 2019

vs

**350k**
cat qubits

E. Gouzien et al. 2022

vs Google

1 ≈ 49

A&B cat qubit — Google physical qubits

vs amazon

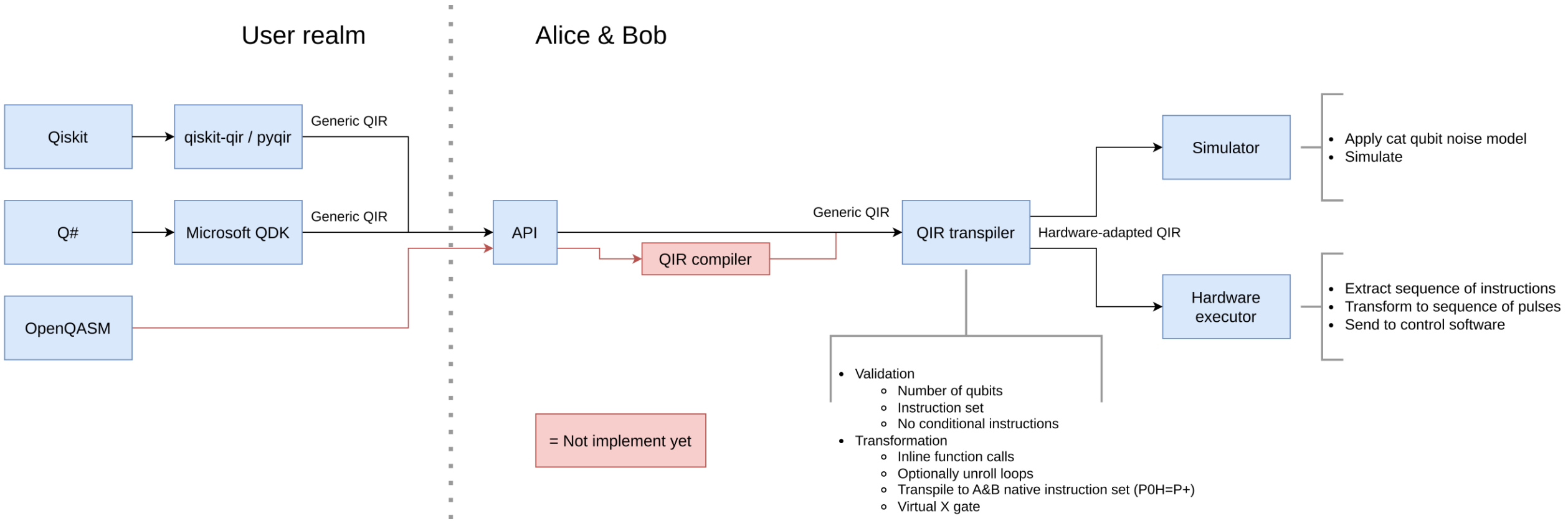
**100%** of the scientific articles cited are from A&B

**151x** mentions of A&B technology

# Specificities of cat qubits affecting the end user

- "Measure in the x-basis" or Mx is a native operation
- Preparation of states |1>, |-> and |+> are native operations
- Some gates (like Hadamard) are not available (not bias preserving)
- The number of photons is a global program parameter that the user can tweak

# System logical architecture



# How Alice & Bob uses QIR

## How do we use QIR today?

- QIR is the language accepted by our REST API
- QIR is used internally for transpilation passes. Nothing fancy for now. User intent is almost executed as-is on the QPU.

## What's the value of QIR to us?

Short-term

- Interoperability: frontend compilers to QIR make us compatible with many languages

Long-term

- Classical/quantum hybrid logic management
- Express hardware-aware optimizations, cat qubit specific error correction codes
- Benefit from the open-source ecosystem around LLVM/QIR

# What QIR developments would help us

- Increase interoperability
  - Harmonize the output of frontend compilers (standard QIS)
  - Offer a community-backed OpenQASM --> QIR compiler (qcor?)
  - Make the Qiskit -> QIR compiler more flexible (qiskit-qir)
- Make it easy to write QIR transpilation passes
  - Prototype QIR transpilation passes in Python (right now pyqir makes it difficult)
  - Make QAT a standard by accepting LLVM passes
  - Ease writing QIS-related transpilation passes (in QAT)