Case study for standardization - The Modular Quantum Computer

Delft, 14 February 2023
dr. ir. Rob F.M. van den Brink

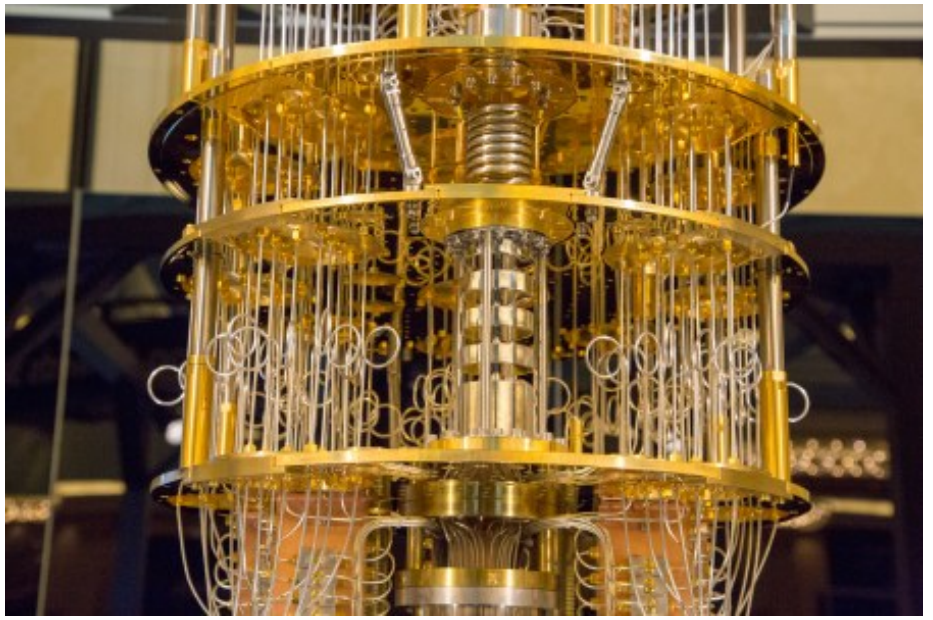
Delft Circuits
Hardware for quantum engineers

1. About Delft Circuits - Our company

Rapid growing start-up company (founded 2017)
Based in the Netherlands (Delft)
Supplier of hardware for quantum computers







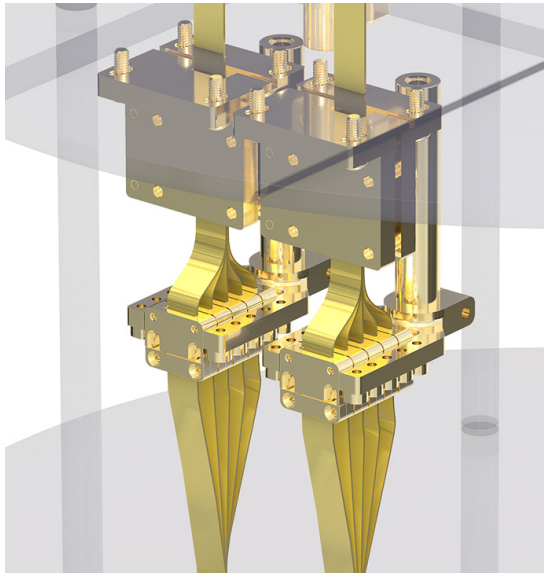
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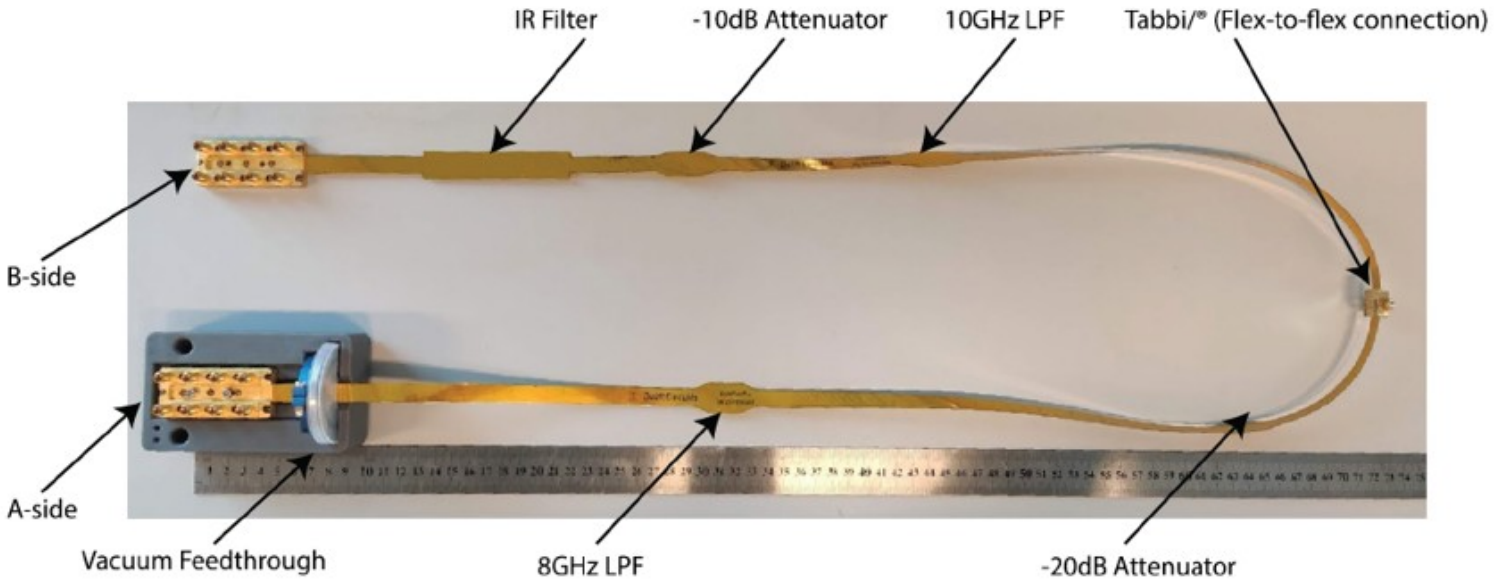
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1. About Delft Circuits – Our products:

Product: Solutions to prevent this wiring problem

- Enable >1000 qubits by make the “wiring” much smaller
- Integrate microwave products in flexible wiring
- Cryogenic environment!







1. About Delft Circuits – Our goals:

Goal: Become biggest player on a global market

Needs 1: a global Market

- Simple *exchange* (for customers) of products by other ones
- Modules (from different vendors) that can *interwork*
- Through well-defined *interfaces*
- *Requirements* supporting customer needs
- *Supply chain* of all kinds of components / modules
- A mature concept, called ***Modular Quantum Computer***



Needs 2: consensus on modularity

- How to subdivide a quantum computer in smaller pieces?
- What requirements / interfaces / functionality / …

- How to get consensus about it? → **Standards**

To be solved for *creating* a global market!

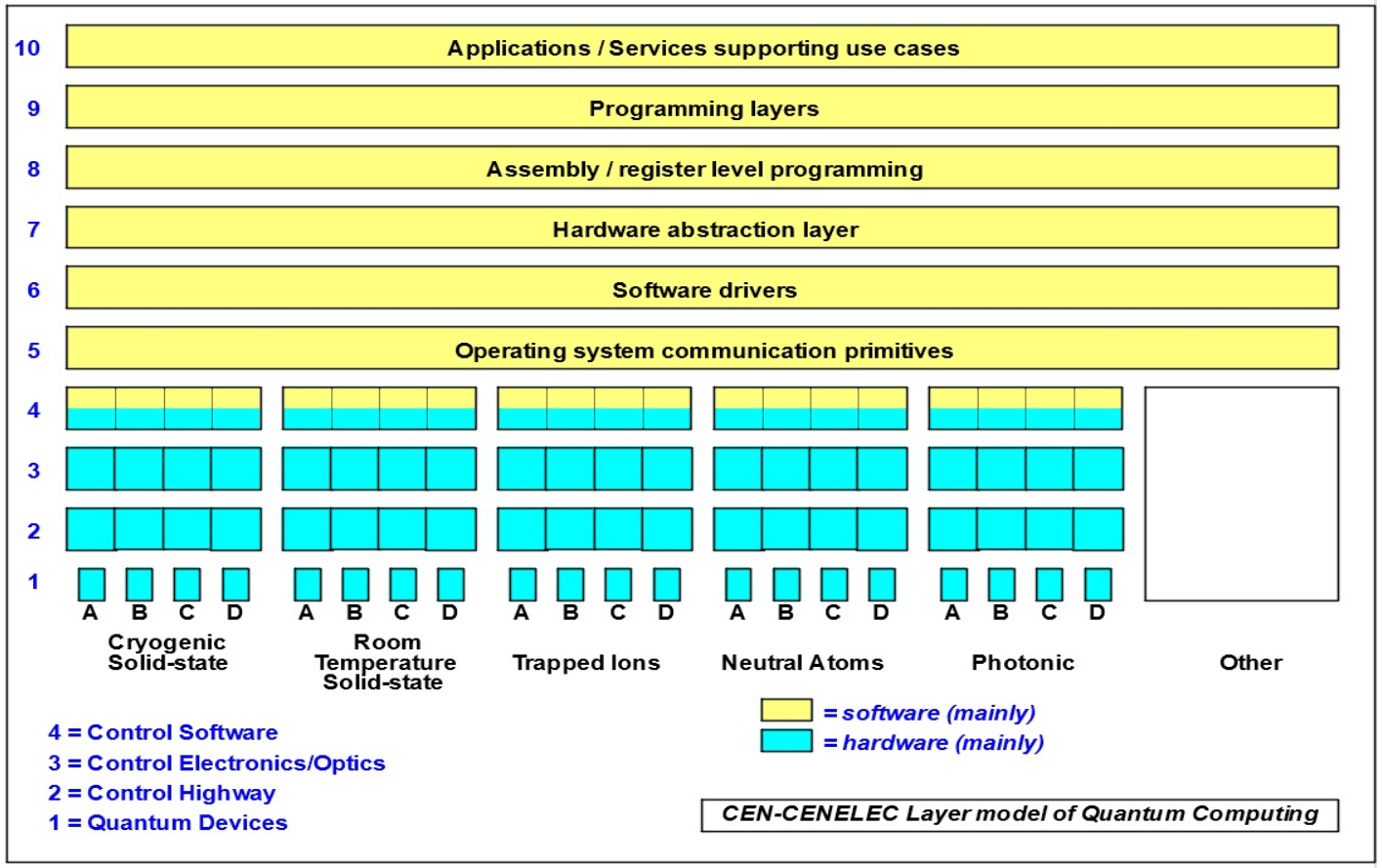
2. CEN-CENELEC Focus Group QT (2021-2023):

1. Main deliverables:

- *A roadmap document*
- *Use case document ("bright ideas")*
- *Start of official std.-group: "JTC-22"*

2. Layer model of Quantum Computing

- A *European* consensus view how to sub divide a quantum computer into smaller chunks
- Comparable with ISO-Model for telecommunication Networks



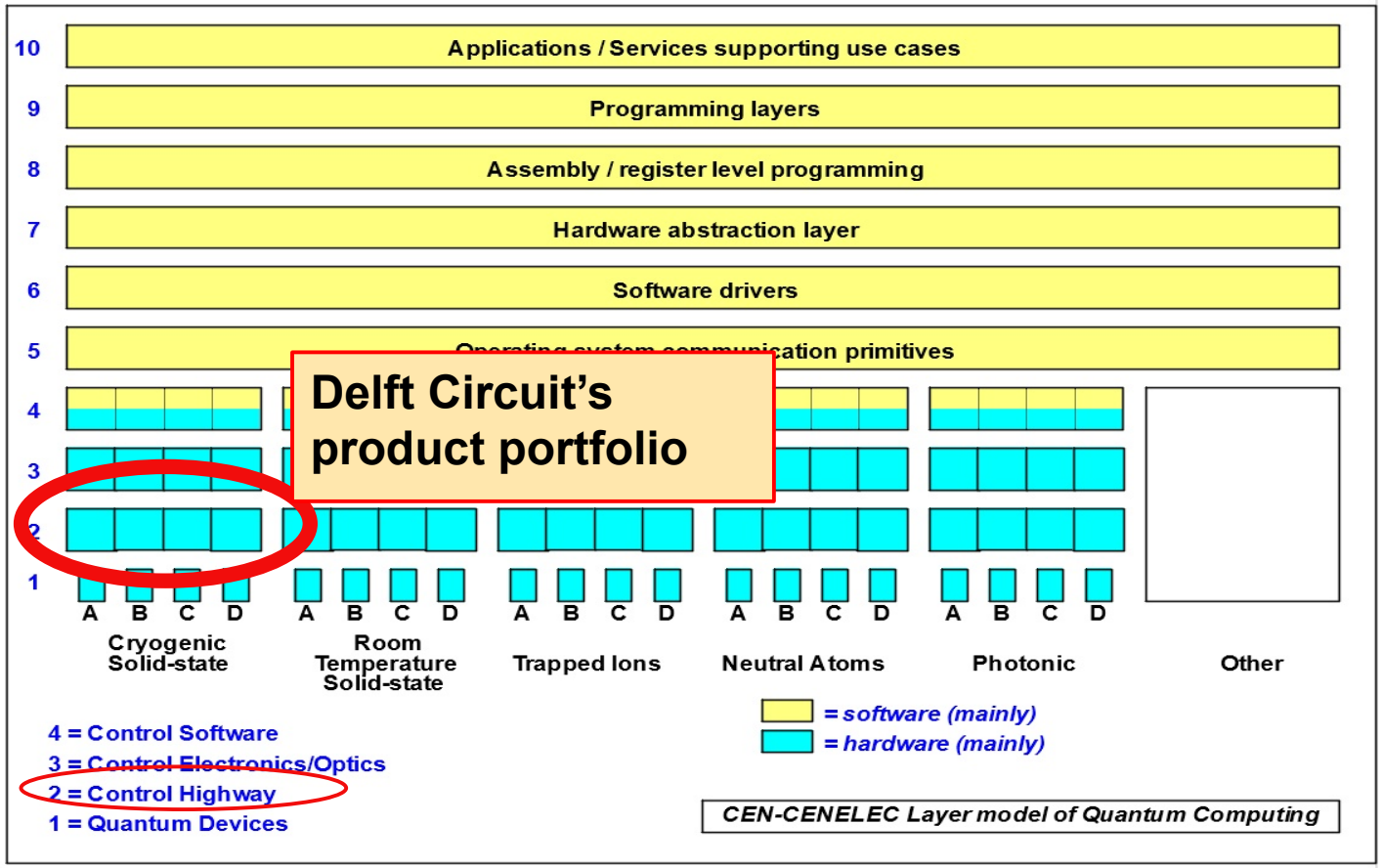
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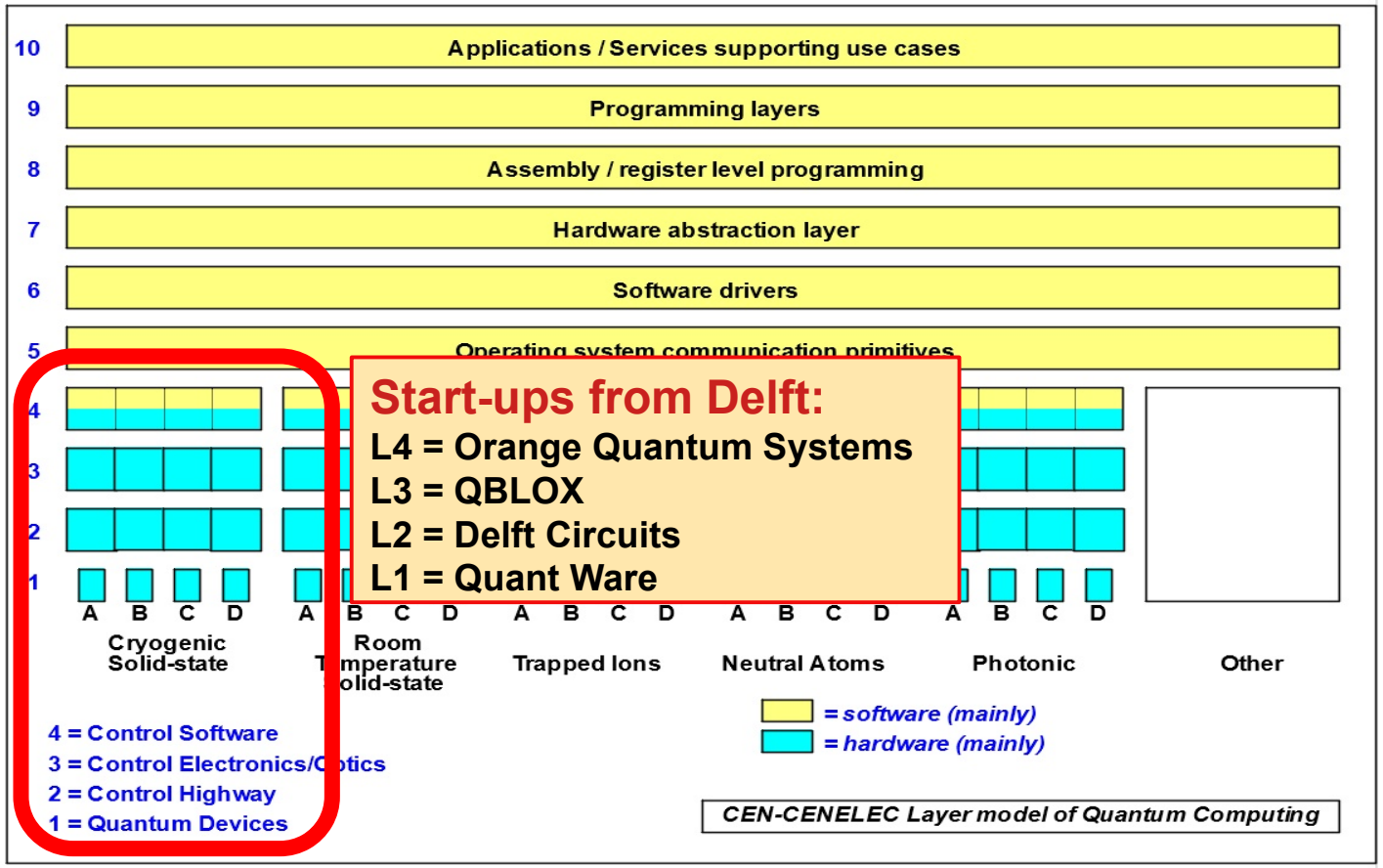
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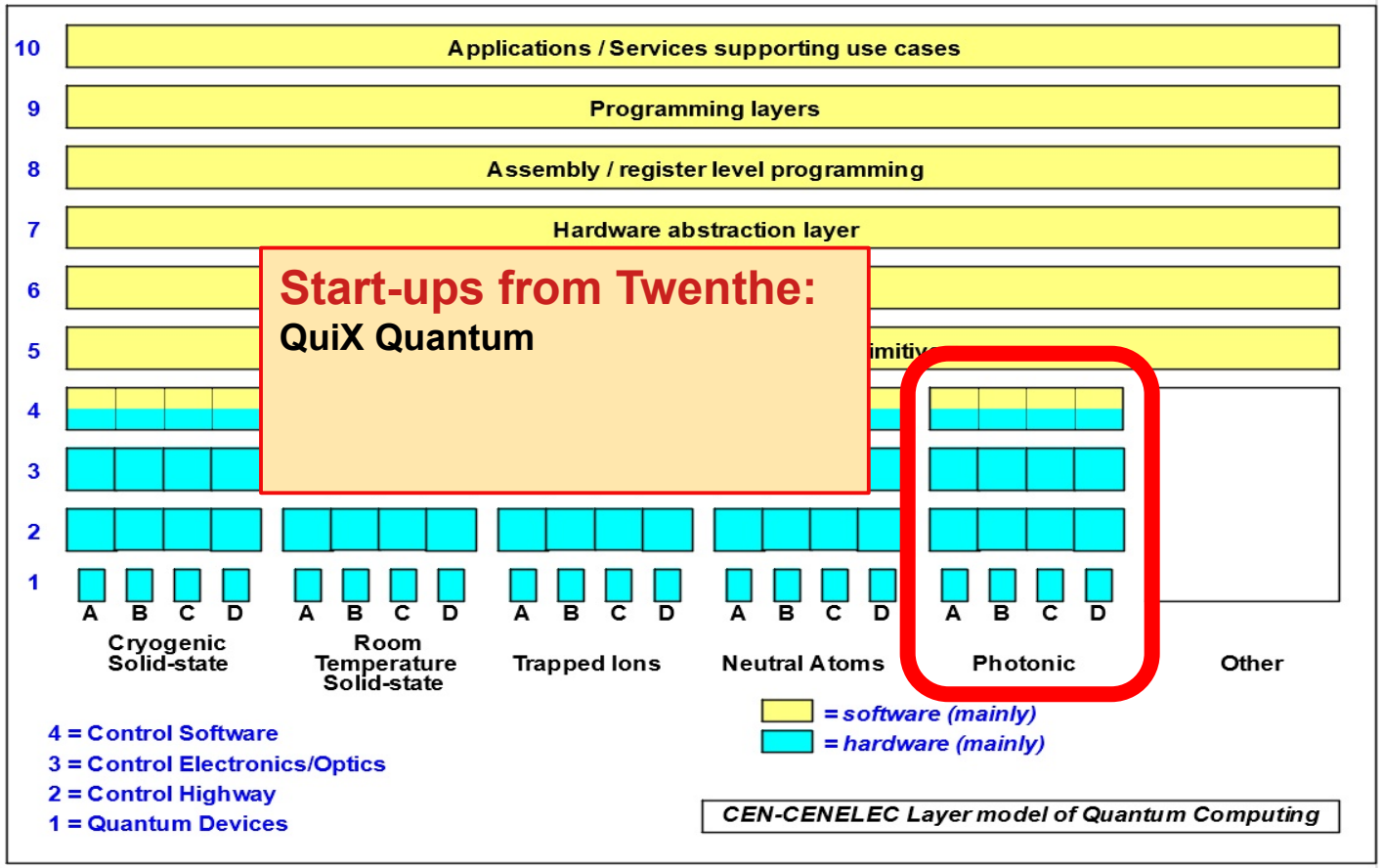
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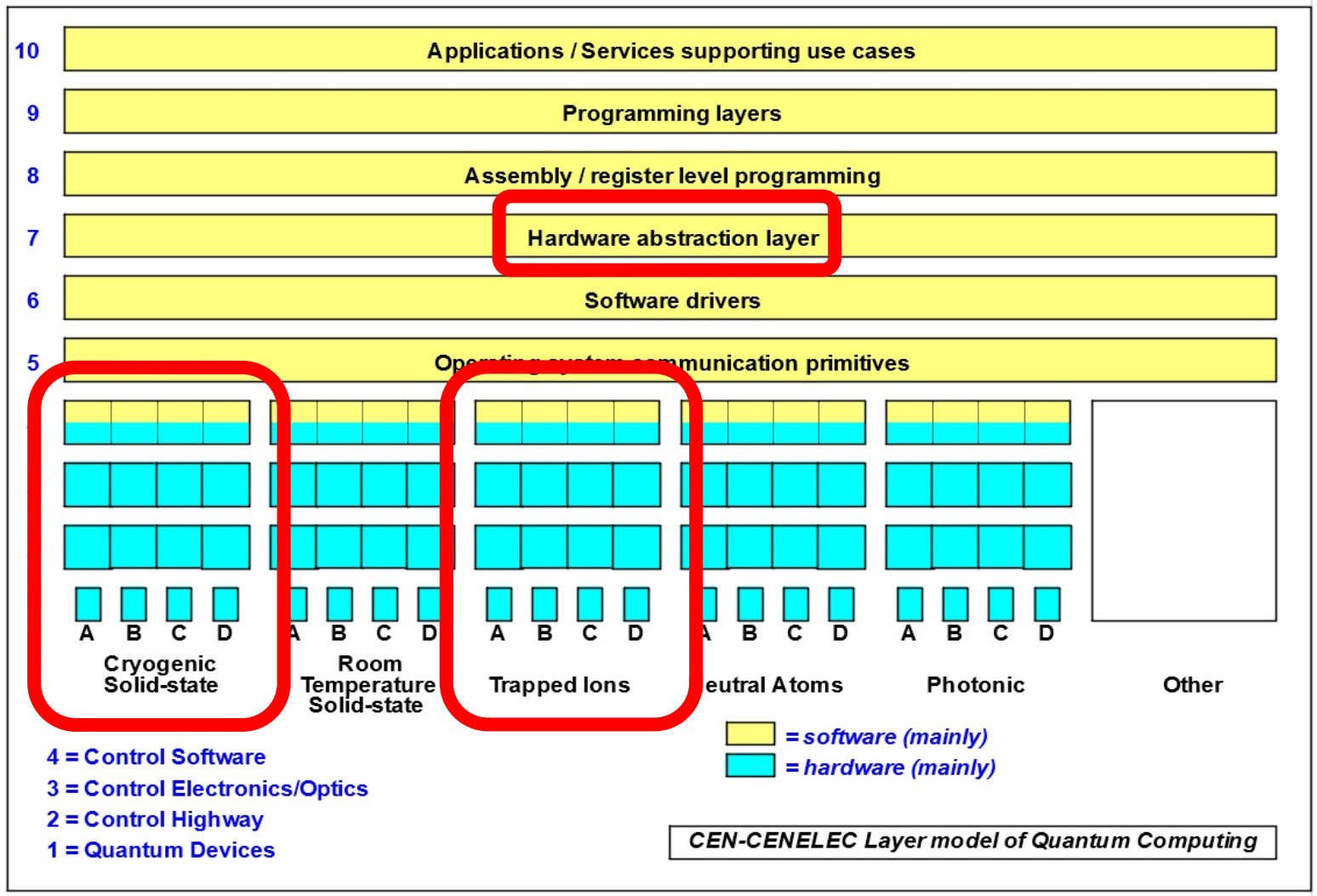
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2. CEN-CENELEC Follow up (JTC-22, 2023-20xx):



Next steps

Consolidate layer model

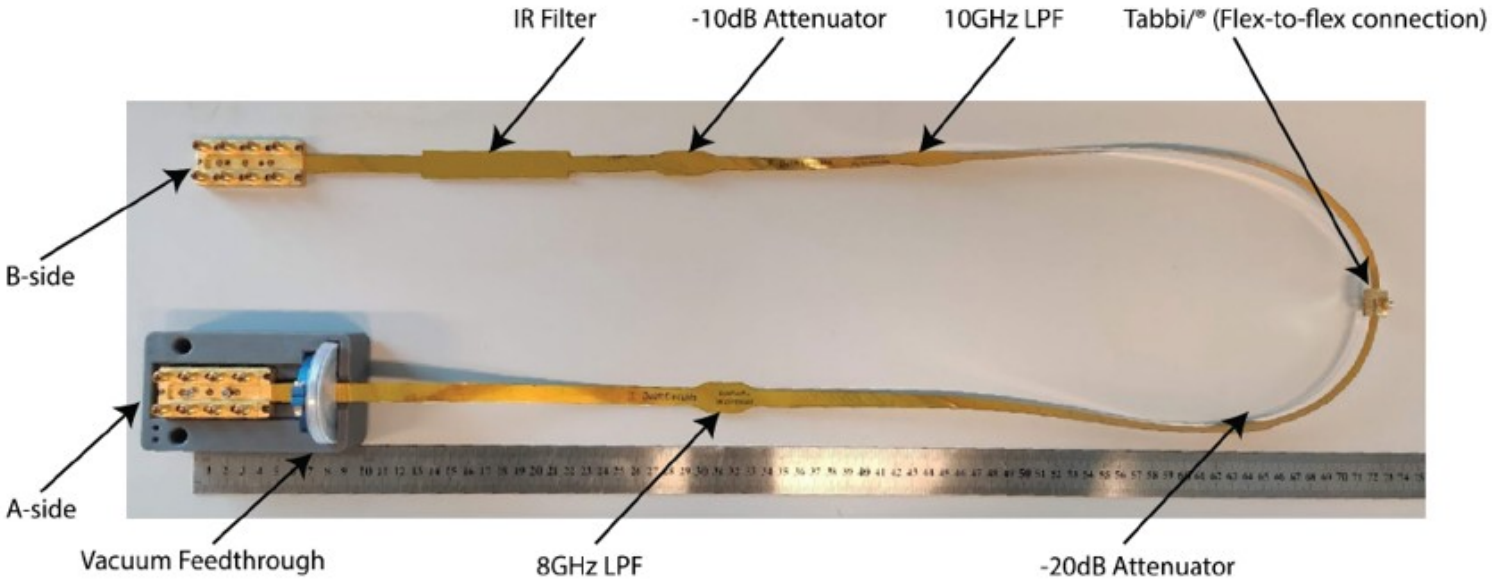
Functional description

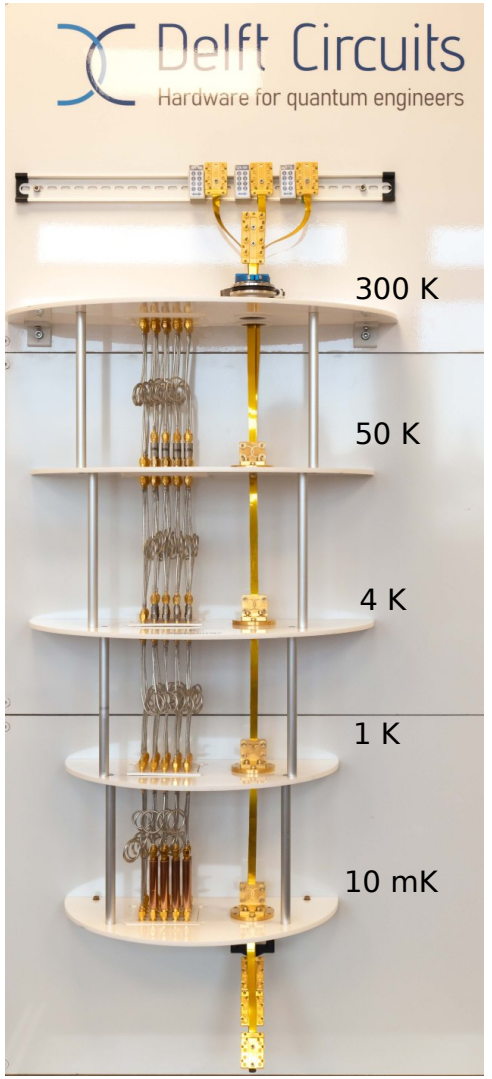
Functional requirements

No Values yet !!!!

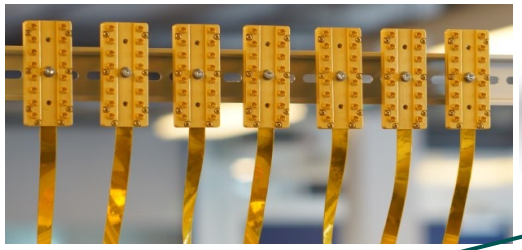
close cooperation
Vendors – customers
(Research teams)

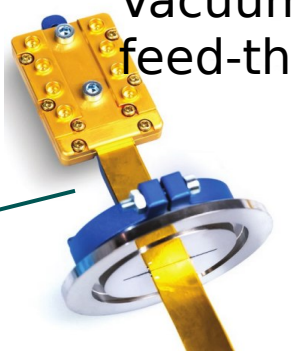
3. Example functional requirements – cabling in fridge



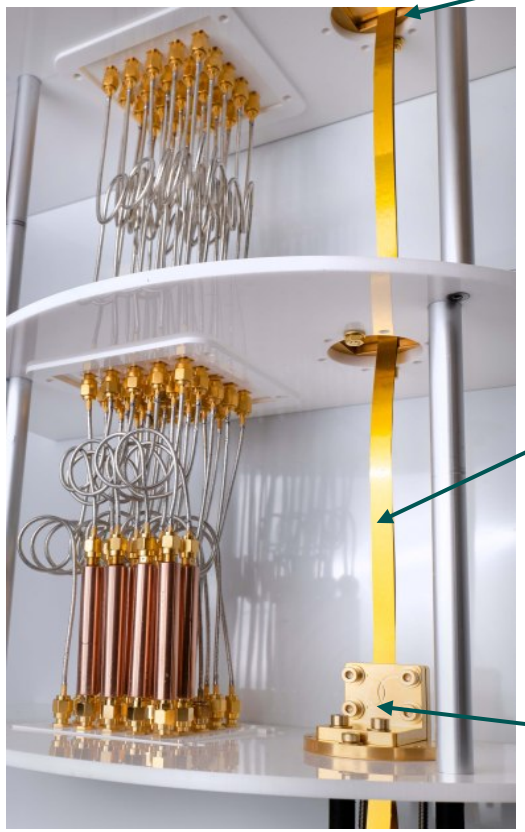


3. Example functional requirements – cabling in fridge





Vacuum feed-through



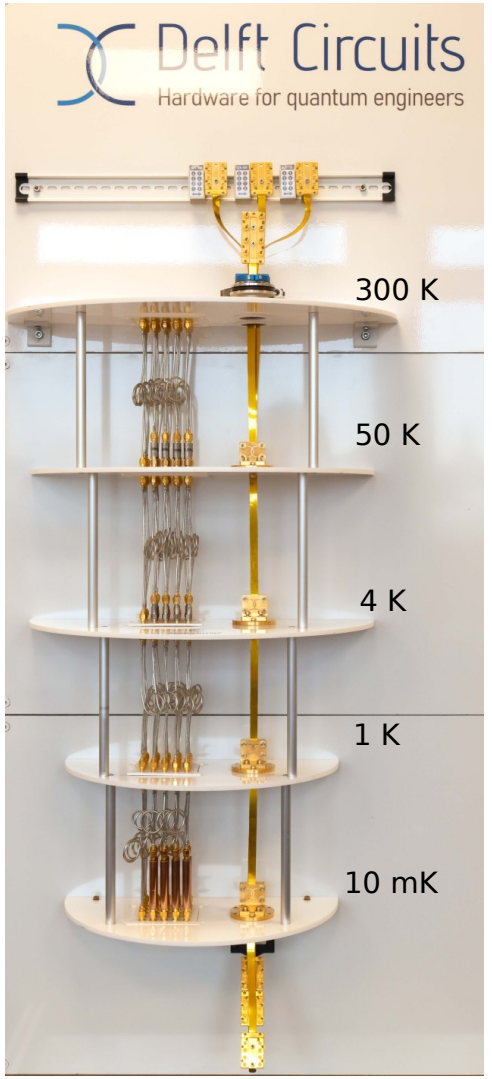
Integrated Filters & attenuators

Thermal clamp

Requirements on "Control Highway":

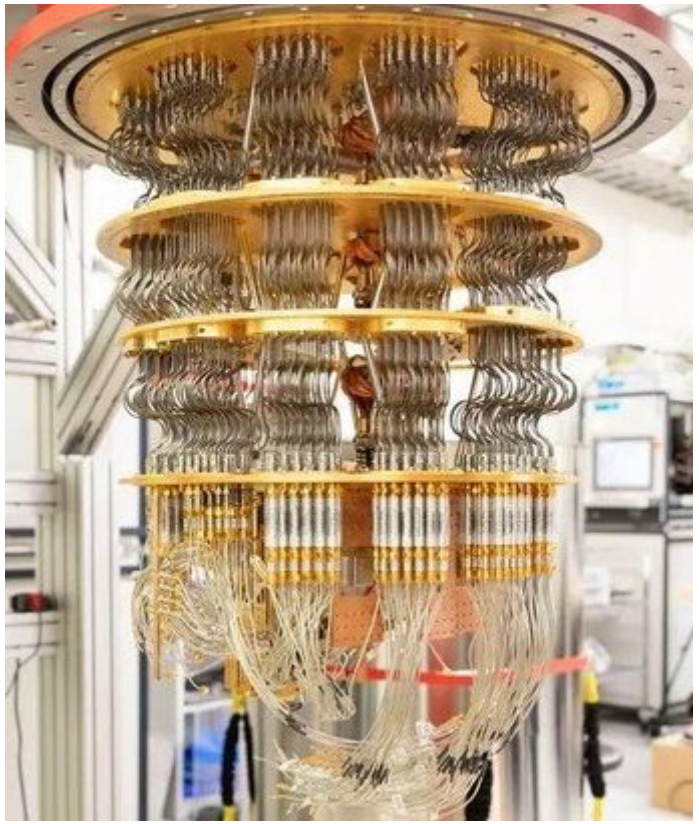
- Vacuum leakage
- Outgassing
- Thermal conductance
- Superconducting sections
- Filtering & bandwidth
- Attenuation (signal levels)
- Thermal clamping
  ("Heat" dissipation in attenuators)
- Bulk interconnection at top
- Interconnection with Q device
- Footprint

- Noise levels, amplifiers
- Functional descriptions



3. Example functional requirements – other

More examples … towards >1000Qubit computers



L4: Control Software

- Functionality to allow for calibration
- Interfacing with control electronics
  - Software commands to shape and fire pulses
  - What to read-out
- Functionality to allow for error-correction

L1: Quantum devices

- Interconnection for >1000 qubits
- Magnetic / shielding / cryogenic requirements
- Signal requirements (shape, stability, …)

L7: Hardware abstraction layer

- Definition, commands, functionality, ..
- Common names for gates
  - not only well known X, Y, H,cNOT , Rx(fi)
  - Also for entangled gates (Ising, Molmer-Sorensen, ..)
- ……

4. Wrap up

Motivation & achievements so far

- Modular Quantum Computer can boost Dutch / European quantum industry
- It won't happen automatically
- First milestone: consensus on "CEN-CENELEC Layer model



Early involvement → easy to shape standardisation

- Vendors (Start-up's) : → will enlarge your market
- Customers (Research teams): → access to products meeting ***your*** requirements

Next Step in standardisation: setting *functional* requirements

- National-level: → "NEN" group, for preparing views & co-signed contributions
- European-level: → "CEN-CENELEC", formal standardisation

If we want to shape the quantum future,

then we need a strong involvement of Dutch stake holders

Thanks for your attention

Delft Circuits

Hardware for quantum engineers