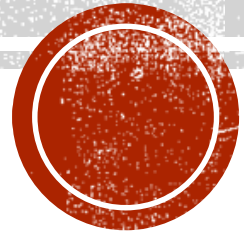
# SUPERCONDUCTING QC DESIGN WITH QISKIT METAL

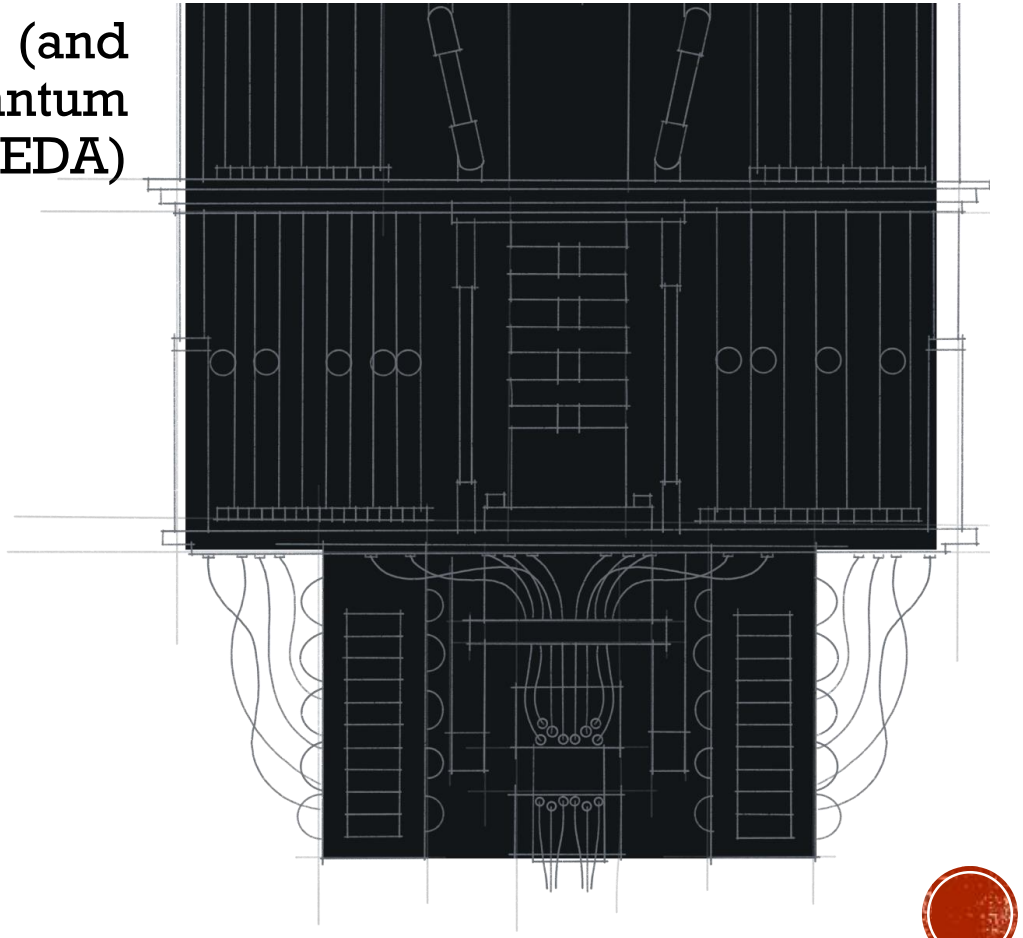
A QHardware Tutorial Series

Part-5



# QISKIT METAL

- Qiskit metal is an open-source framework (and library) for the design of superconducting quantum chips and devices. It is called quantum EDA (Q-EDA) and analysis.



# FOUNDATION MODULES

**Qiskit Metal consists of four foundational elements:**

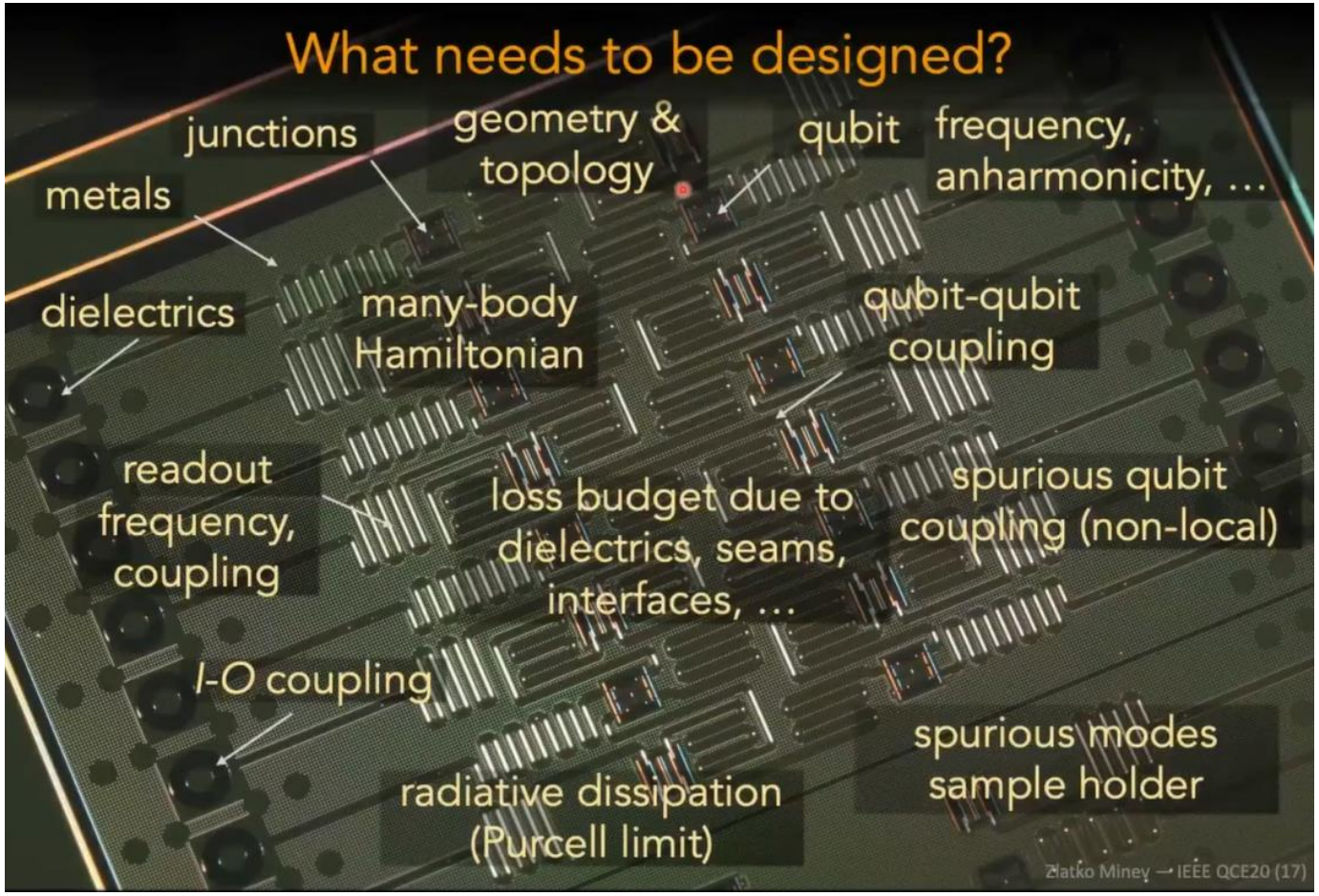
- Quantum Device Design (QDesign): QDesign
- Quantum Device Components (QComponent): Core Classes
- Quantum Renderer (QRenderer): Renderer Base
- Quantum Analysis (QAnalysis): Analysis Core

# HOW QUANTUM CHIPS ARE DESIGNED?

Quantum Device Design with Superconducting Circuits Steps

- Physical Layout
- Electromagnetic Analysis
- Quantum Hamiltonian Analysis
- Qubit Hilbert Space

# WHAT NEEDS TO DESIGN QUANTUM CHIP



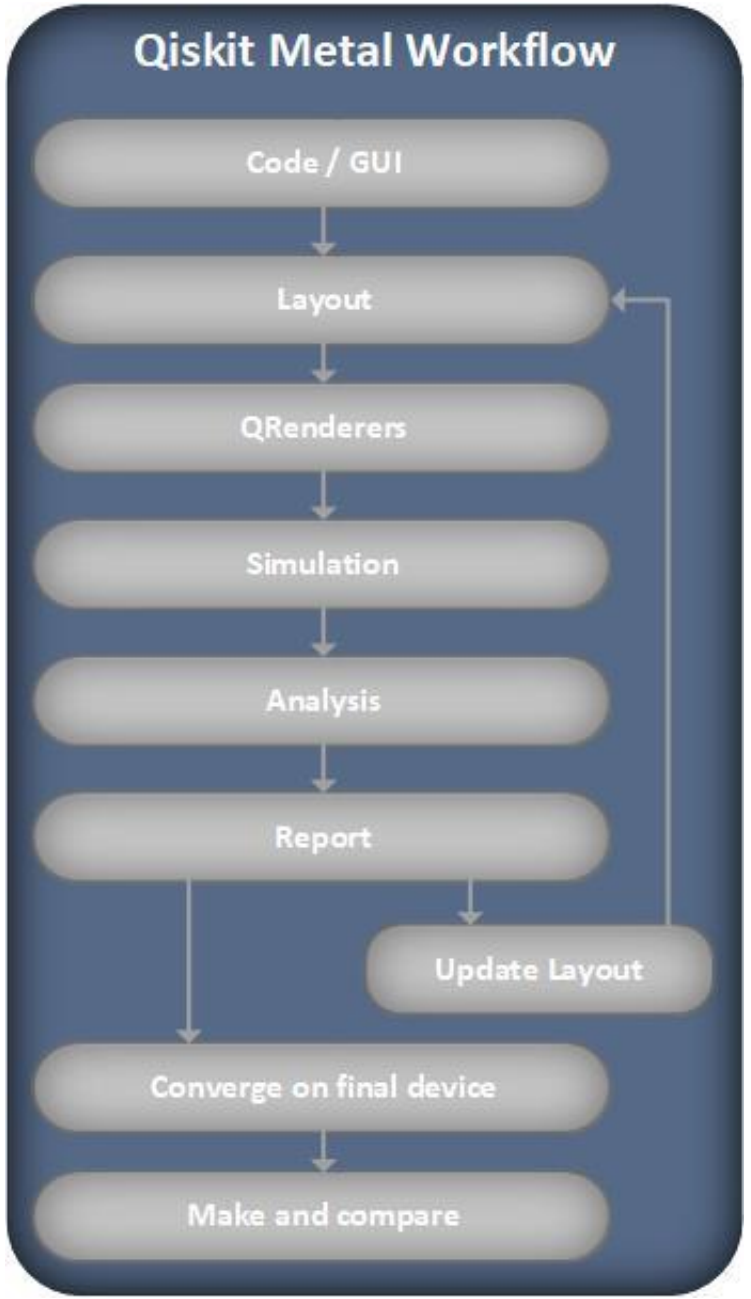
# HARDWARE FABRICATION PROCESS

- For the circuit design and fabrication system, numerous steps are followed for processing to go from a lumped circuit description of an electronic design to the full layout of a circuit.
- The first step that is generally followed in fabrication is BOM (Bill of Materials) confirmation (components of design).
- A bill of materials or product structure is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, and parts, and the quantities of each needed to manufacture an end product.
- The second step is the coordination of data files from the bill of materials.
- Then another significant step comes, which is called gerber file generation and processing.

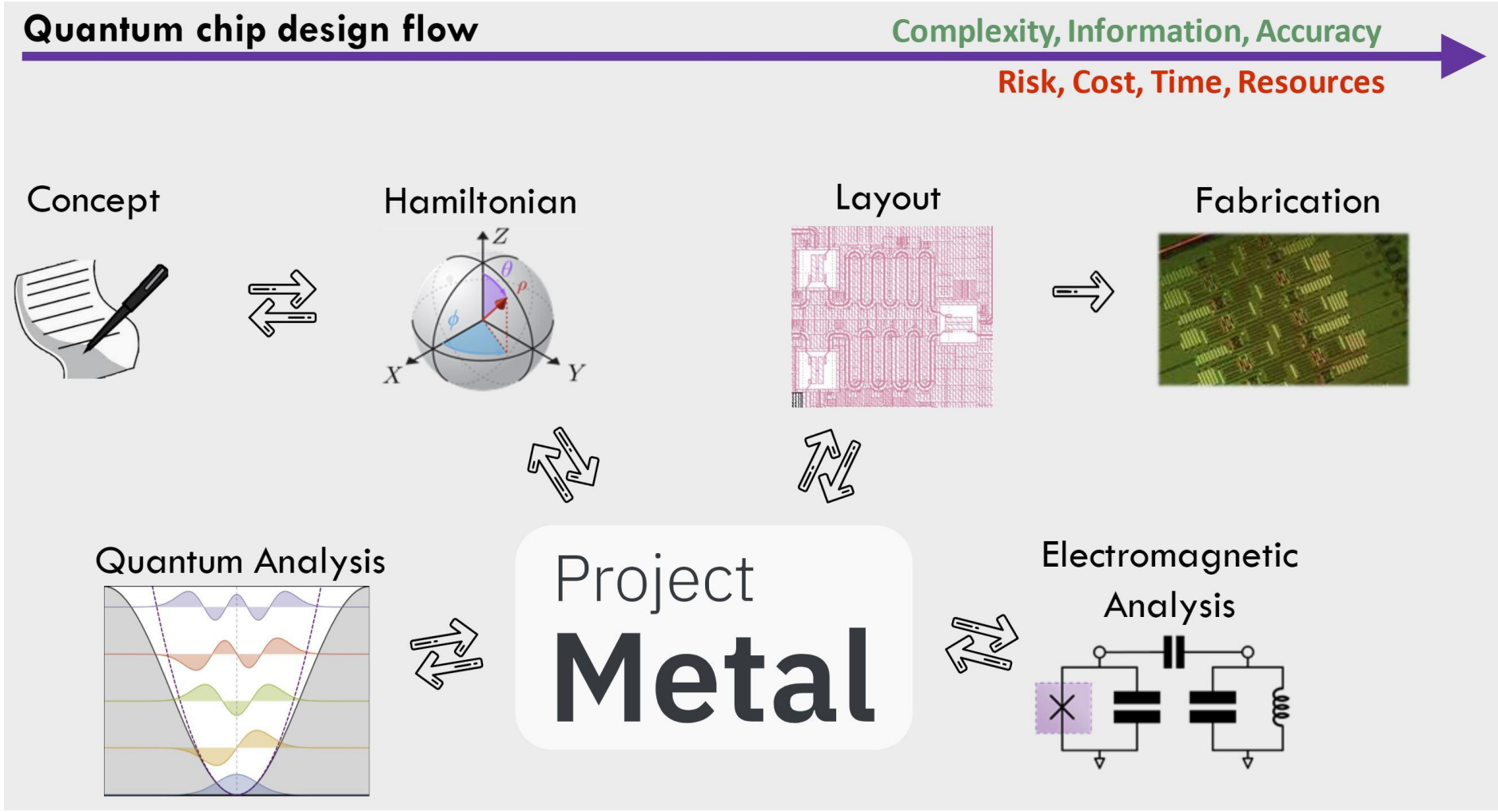
# HARDWARE FABRICATION PROCESS

- The Gerber format is an open ASCII vector format for printed circuit board (PCB) designs.
- It is a standard used by PCB industry software to describe printed circuit board images.
- The next process is making a design of the circuit as per the standard.
- The subsequent important step is the optimization of the entire program.
- For instance, Fuji flexa is a software that is used for optimisation steps.
- After positive results from the Quality Assurance (SA) side, the model will be ready for PP (pilot production).

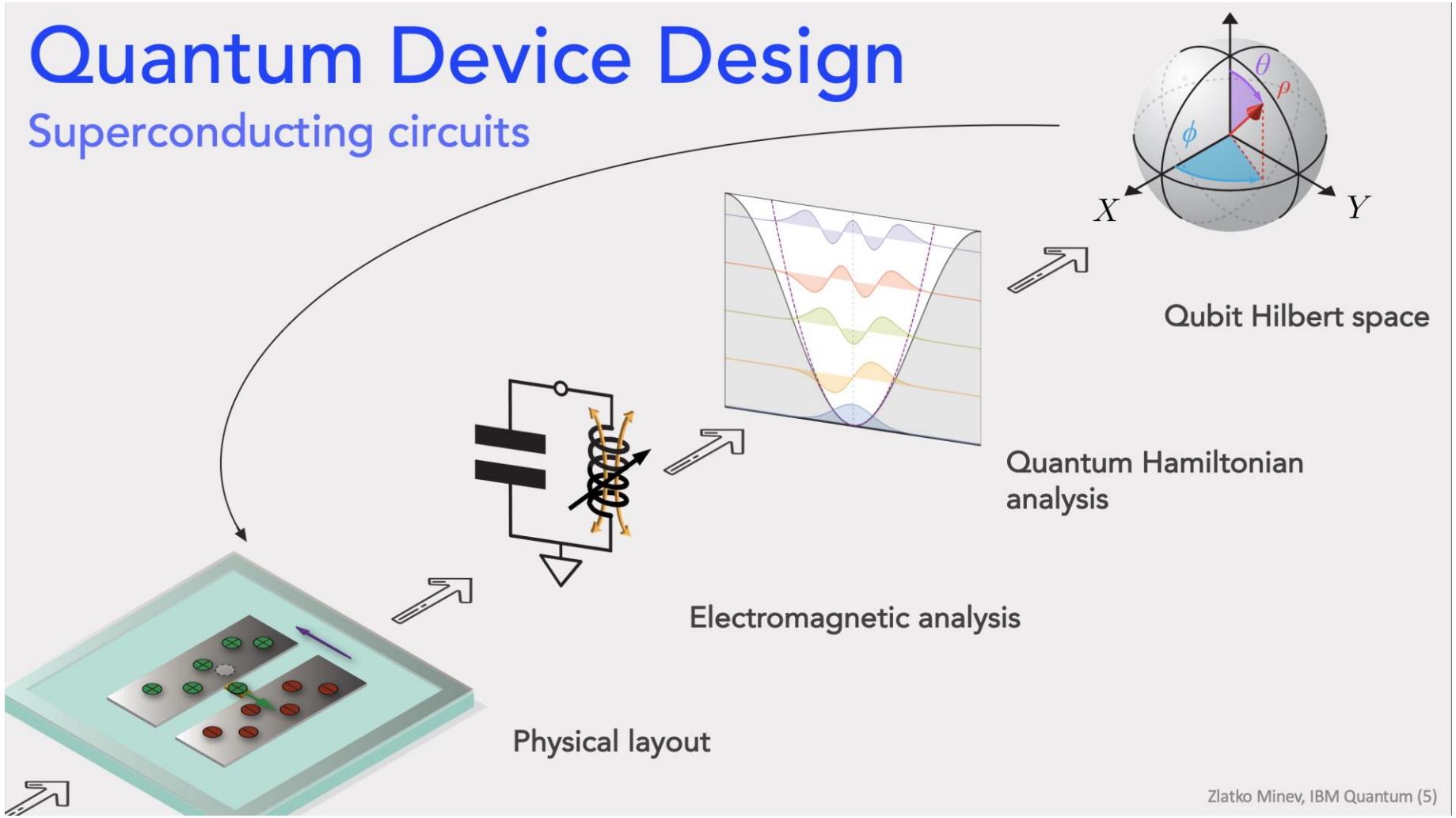
# QISKIT METAL WORKFLOW



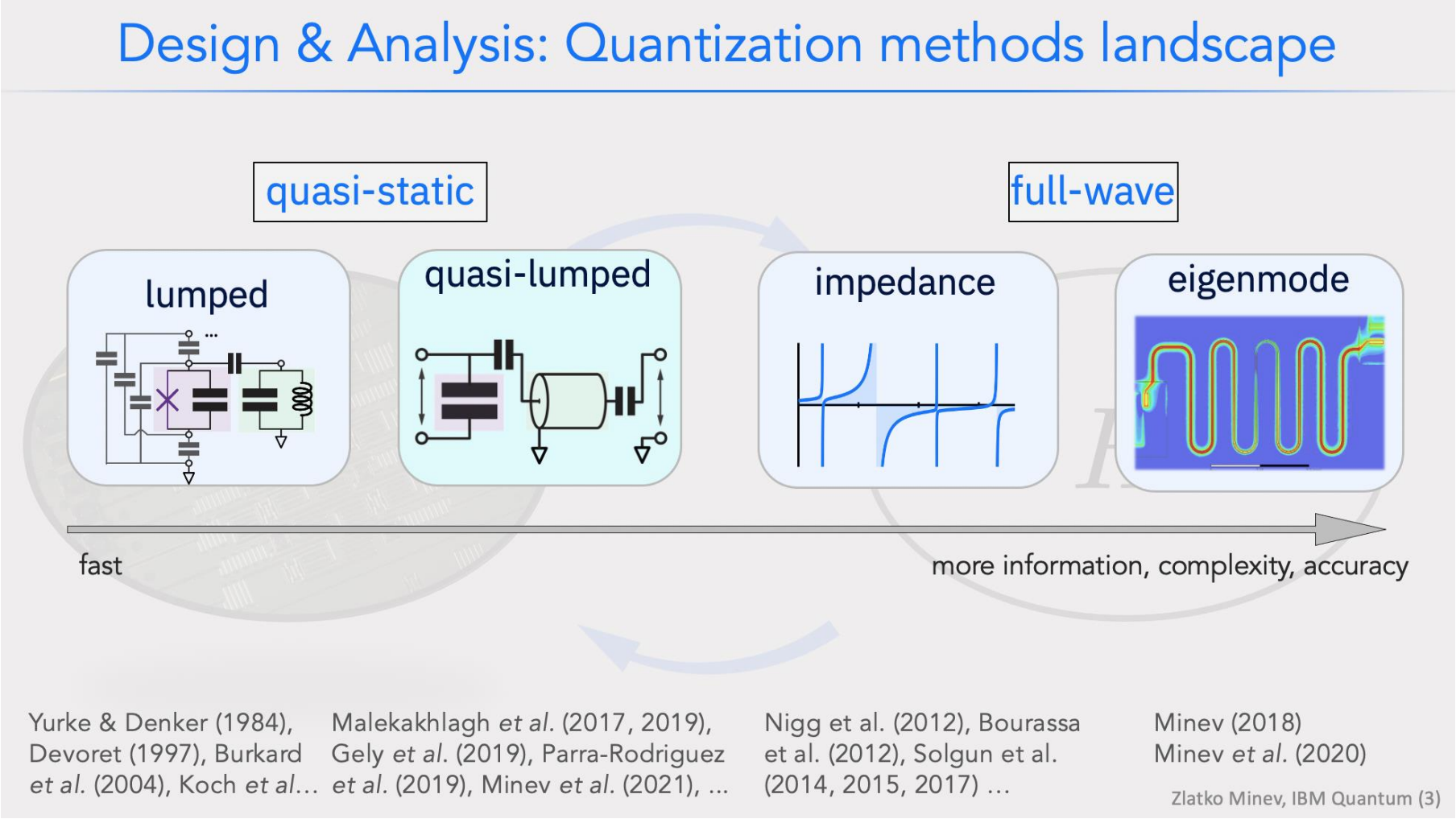
# QUANTUM CHIP DESIGN FLOW



# QUANTUM DEVICE DESIGN



# QUANTIZATION METHODS



# QISKIT METAL USING PROCESS

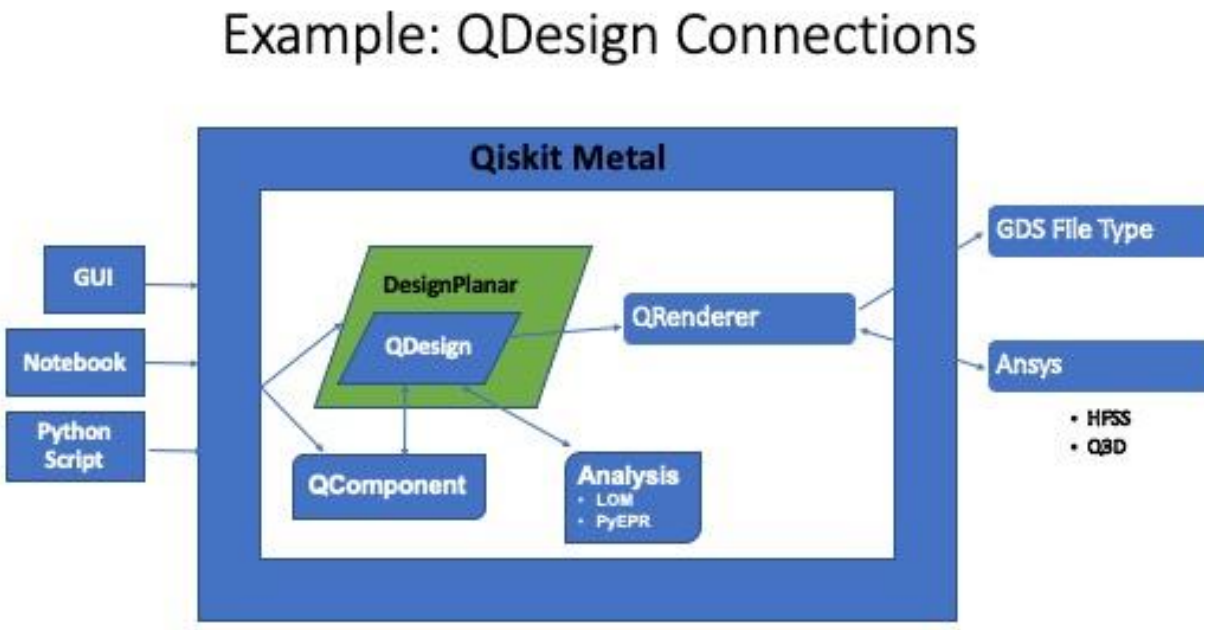
1. Choose a design class to instantiate.

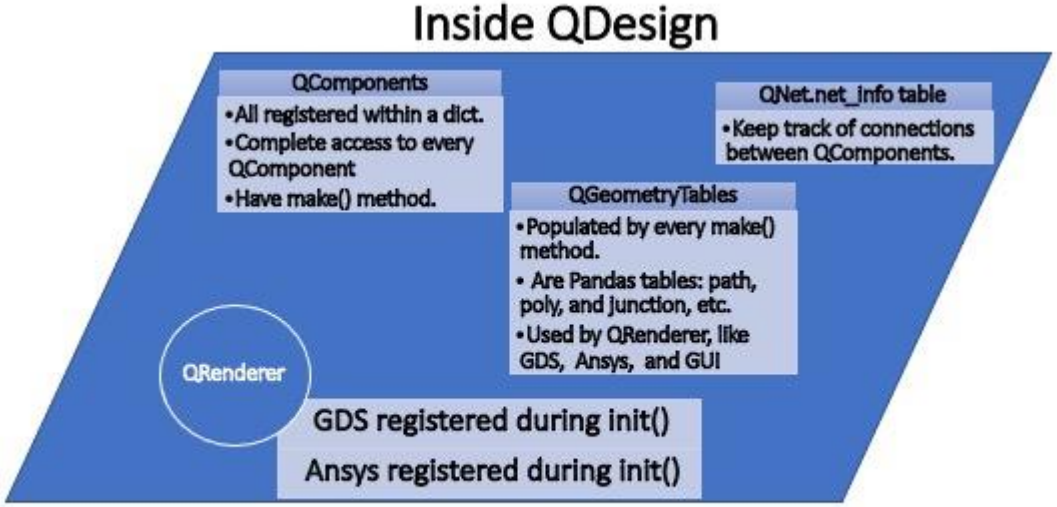
2. Add and modify pre-built components (qubits, coplanar wave guides, etc.) from the QComponent library to your design.

3. Render to Simulate & Analyze
   - Current Rendering Options:
     - Ansys
       - HFSS Renderer - for high frequency simulations (eigenmode, modal, terminal)
         - EPR Analysis - Uses eigenmode simulation to perform energy participation ratio analysis
       - Q3D Renderer - for extracting equivalent circuit values of a layout, such as capacitance
         - LOM Analysis - Uses the capacitance matrix from Q3D to determine the parameters of a transmon qubit

4. Render for Fabrication
   - Current Rendering Options:
     - GDS

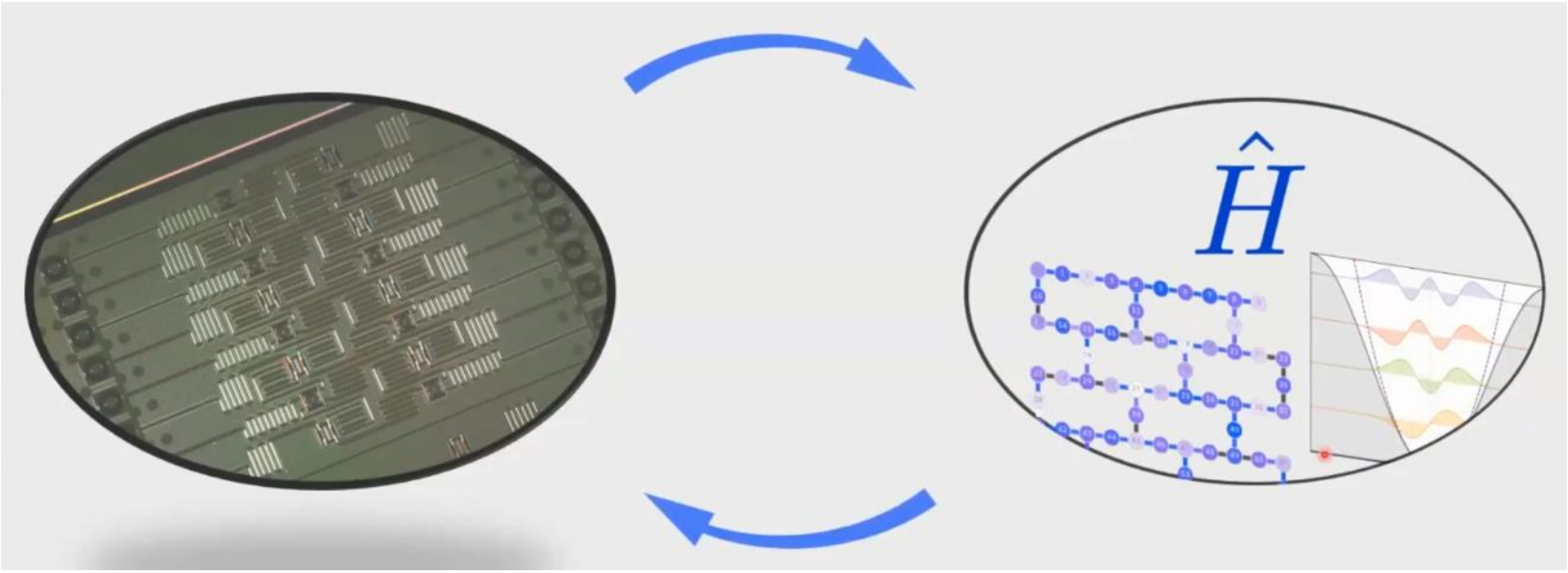
# QDESIGN MODULE



# QC CHIP DESIGN

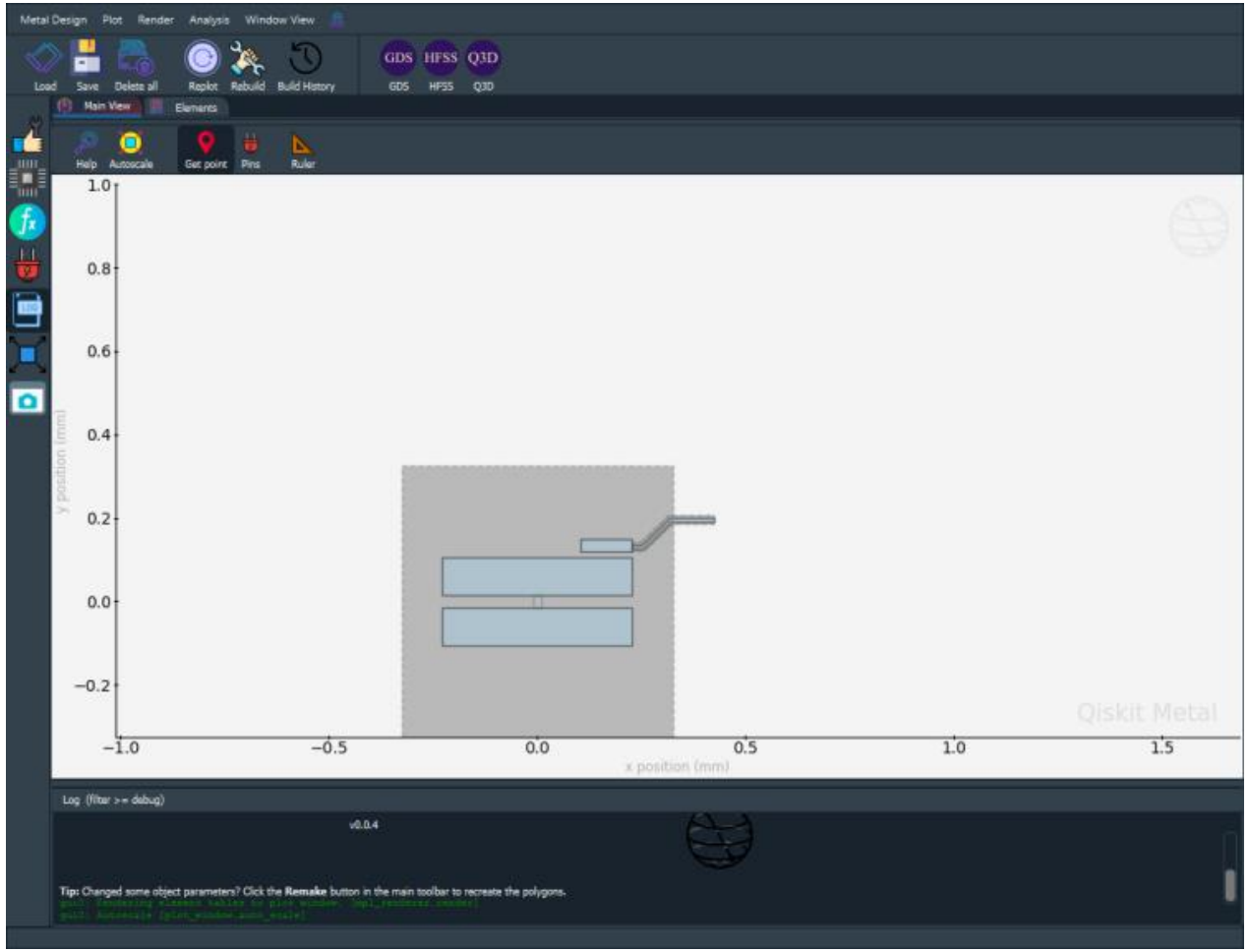
- Layout, analyze and optimize a four qubit quantum chip.



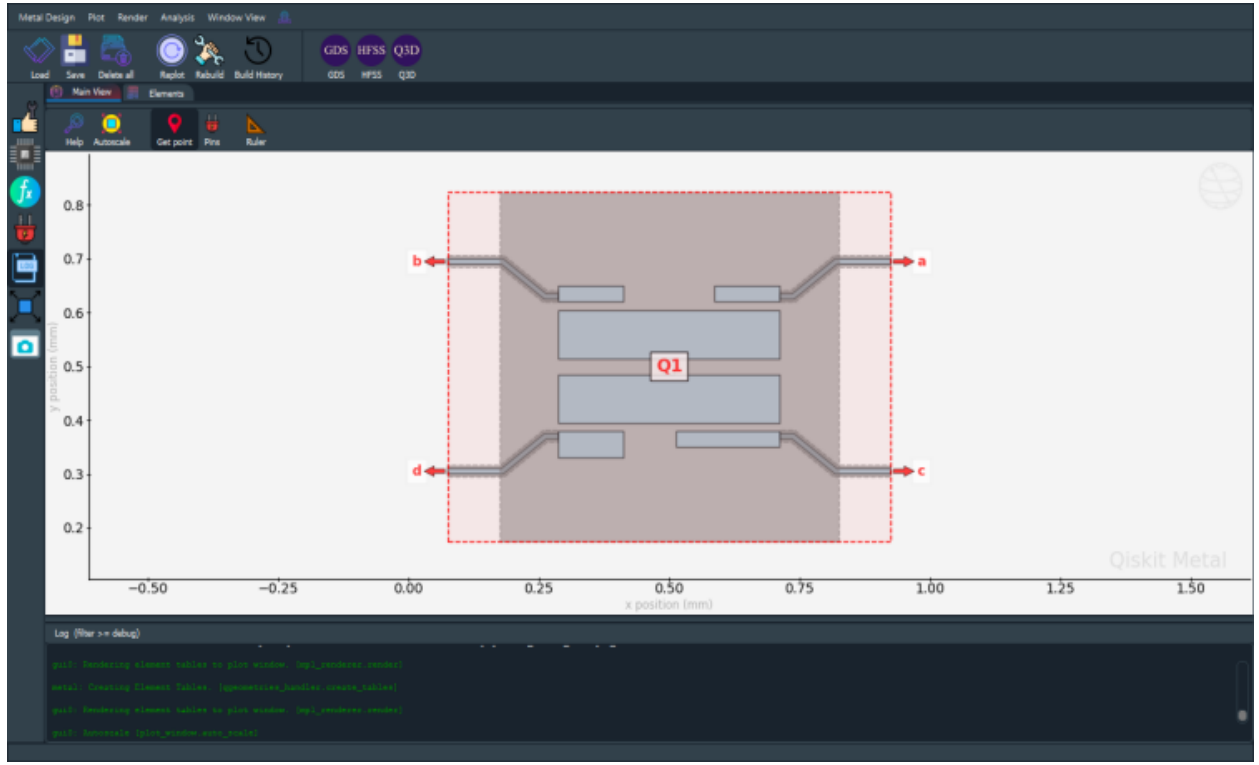
# FIRST QISKIT METAL PROGRAM

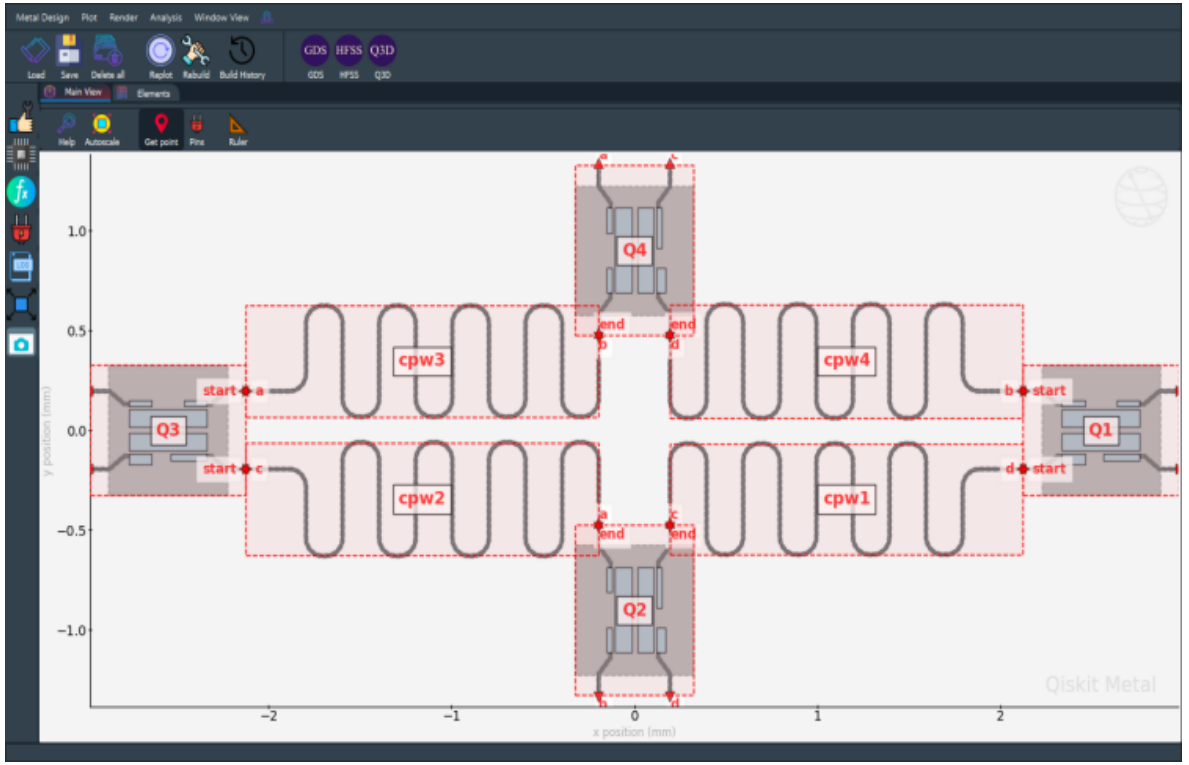
- First code to start qiskit_metal

```
import qiskit_metal as metal from qiskit_metal
import designs, draw
```



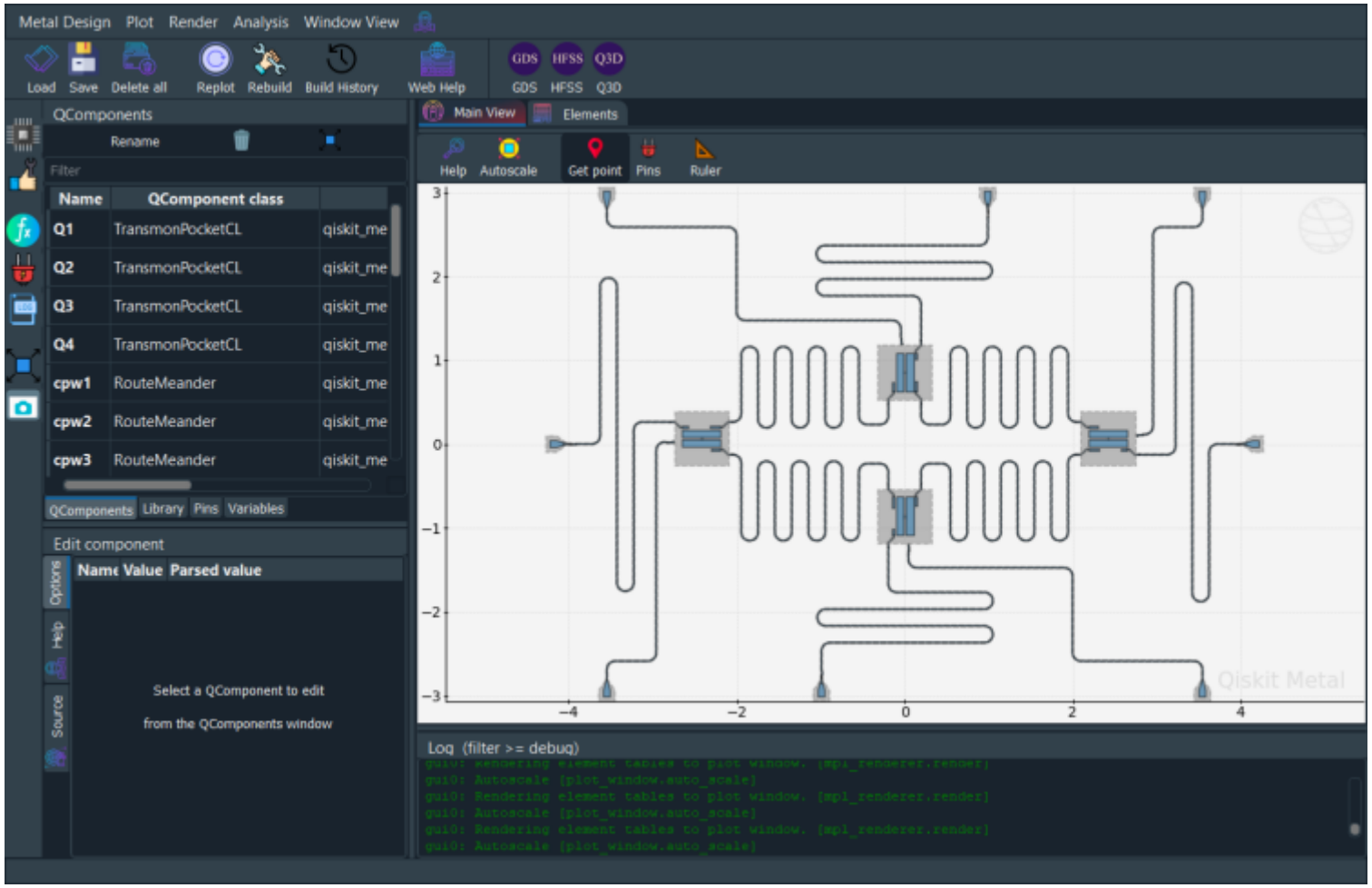
# FIRST QUANTUM CHIP WITH METAL



# 4-QUBIT CHIP DESIGN

**Purpose: to create a complete quantum chip and to export it to GDS**



# REFERENCES


- 1. Qiskit Metal Documentation- https://qiskit.org/documentation/metal/
- 2. Qiskit Textbook- https://qiskit.org/learn/
- 3. A Quantum Engineer's Guide to Superconducting Qubits (https://arxiv.org/abs/1904.06560)
- 4. Quantum Computation and Quantum Information by Michael A. Nielsen and Isaac Chuang
- 5. Principles of Superconducting Quantum Computers by Daniel D. Stancil and Gregory T. Byrd
- 6. National Academies of Sciences, Engineering, and Medicine. 2019. Quantum Computing: Progress and Prospects. Washington, DC: The National Academies Press. https://doi.org/10.17226/25196.