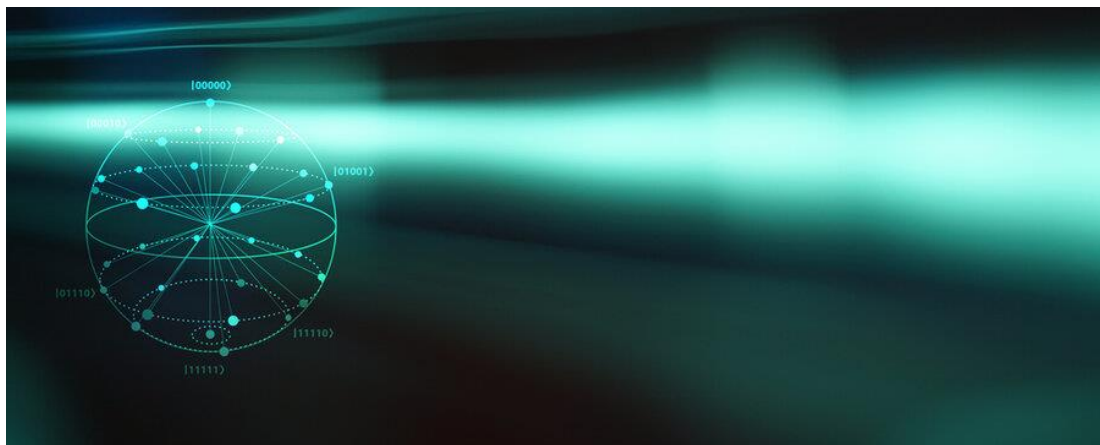


OpenQASM Debugger Visual Studio Extension Documentation

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Installation

Extension can be downloaded and installed from Microsoft Visual Studio Marketplace

<https://marketplace.visualstudio.com/items?itemName=QuantagITSolutionsGmbH.openqasm-debug>

Description

This VS Code extension connects to QSCore (Quantag Studio Core) component which runs instance of Quantum Virtual Machine (QVM) using DAP (Microsoft Adapter Debugger) protocol and allows:

- debug Quantum circuits written on OpenQASM or Python using [Qiskit](#) or [PyTKET](#) frameworks.
- perform step debugging on remote Quantum Virtual Machine
- see quantum state on every step
- see compiled OpenQASM code for python circuits in Disassembly View
- see visualized Quantum Circuits directly in VS Code and on web frontend.

The main idea is to establish a quantum development environment in a way like a classic software development environment with sources, assembler code, and direct hardware execution possibility.

How does it work?

After installing extension from Marketplace, it registers itself for .py and .qasm files. *There can be other extensions also installed and registered for same file types. They can work together; just be sure you choose the right menu items and command for every extension.*

Before any action sources from local workplace must be submitted to cloud server where QVM working. To do it we do not use SSH Tunnels which is common way of working with remote file system from VS code, instead we submit all workplace files to server using own microservice. All files submitted after opening new Workplace to avoid delays when browsing files. So be careful with private data, do not open private data with activated extension.

When a user chooses '**Debug circuit**' with python file – source is analyzed on server and *updated* to add OpenQASM-export and rendering circuit commands depends on detected framework.

When choosing '**Debug circuit**' on OpenQASM file – this file imported to Qiskit on server using import-qasm commands and rendered to circuit image which later can be opened using command palette with command 'Render OpenQASM/Qiskit circuit'.

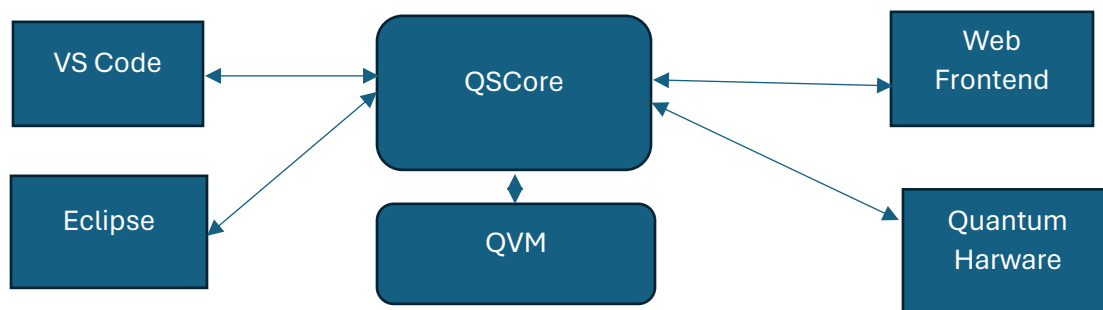
For TKET python sources – circuit generated to HTML and opened in external browser using 'Render TKET circuit.'

Rendered circuits and compiled OpenQASM files transferred from server to VS code using dedicated microservice.

Launching circuit on remote hardware implemented using adding commands to 'Command Palette'.

Hardware configuration for launching taken from workplace root file '*config.json*' which contains all information required for launch.

QSCore uses DAP protocol to communicate with VS Code, so it can work with any IDE which supports DAP, for example Microsoft Visual Studio, Eclipse or Emacs. Full list of supported IDEs can be found here: <https://microsoft.github.io/debug-adapter-protocol/implementors/tools/>



QSCore

QSCore (Quantag Studio Core) is key component which launch instance of QVM and communicates with IDE and web frontend.

It is written in C++ and uses CMake. It is tested on Windows and Linux. It can be run locally or in the cloud.

By default extension connects to QSCore instance deployed in development servers of Quantag IT Solutions. Endpoint configured in file **src/extension.ts** in line 123:

```
return new vscode.DebugAdapterServer(5555, "cryspprod3.quantag-it.com");
```

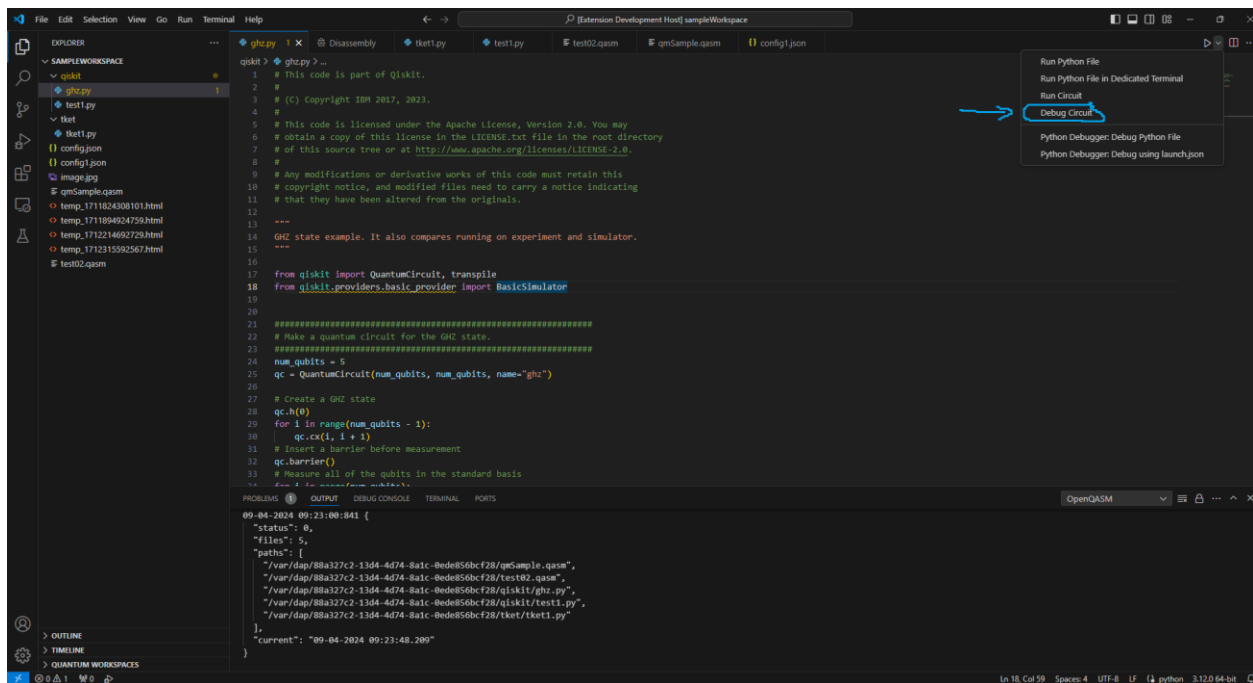
To use local QSCore this line should be changed to

```
return new vscode.DebugAdapterServer(5555);
```

where 5555 is port of QSCore for incoming DAP websocket TCP connections.

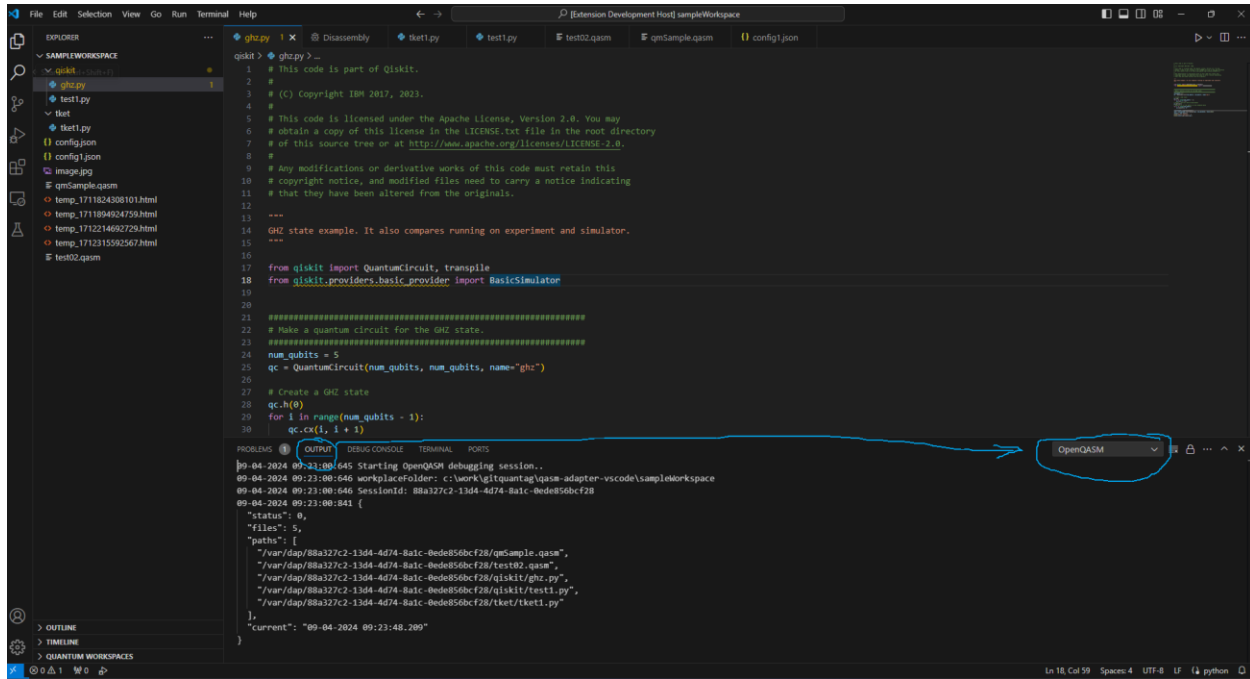
Activation and starting

Extension activated on .qasm and .py files and can be started by choosing 'Debug Circuit' command from 'Run' menu



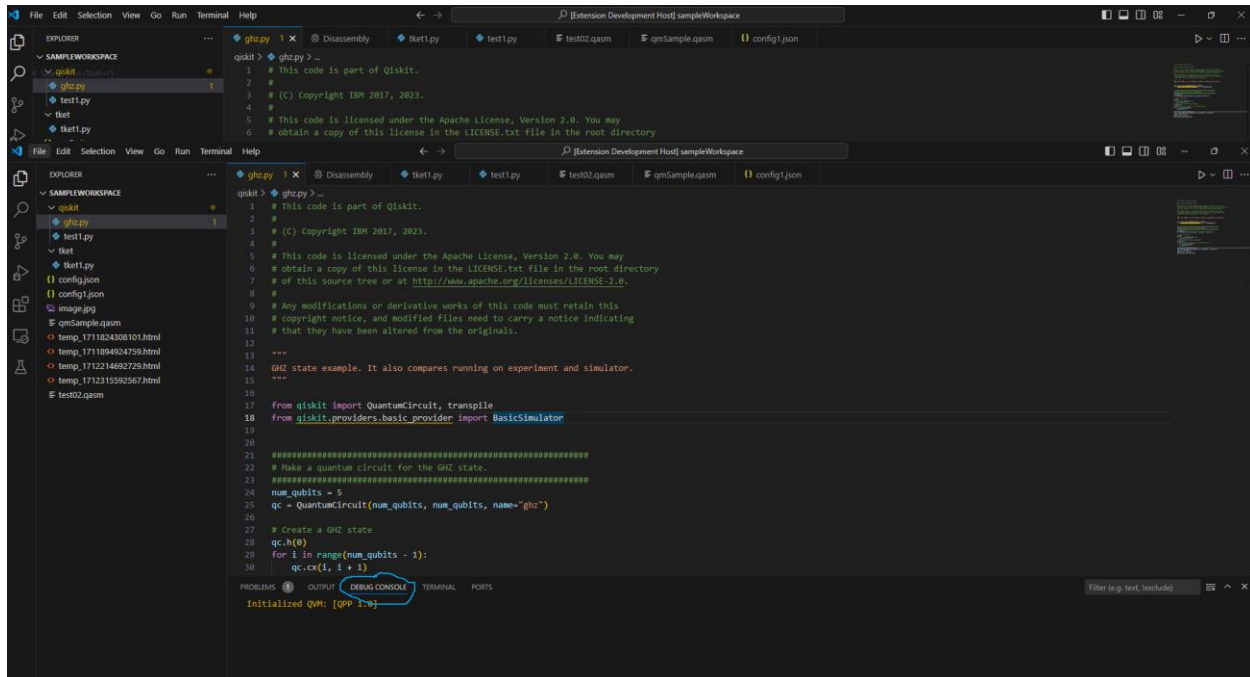
Output and debug messages.

After starting debugging session Extension debugging information can be seen in 'Output' View after choosing 'OpenQASM' output channel. *These messages are needed to debug the extension itself, not python or OpenQASM program.*



Debug console.

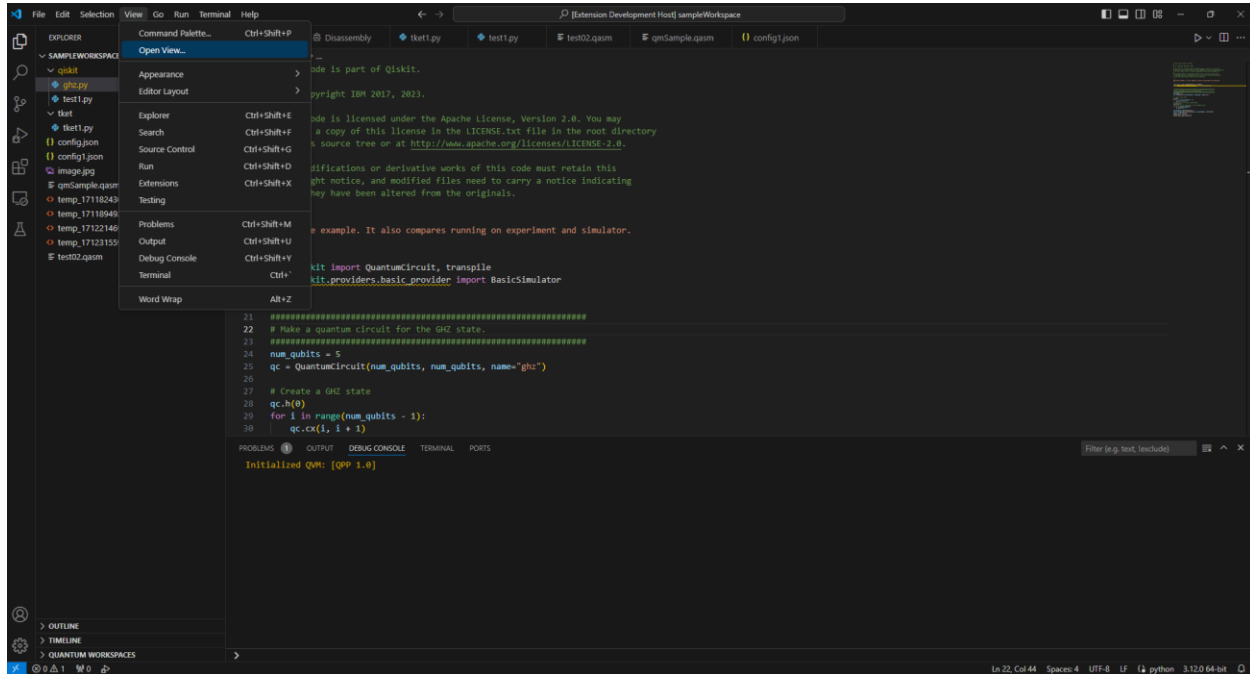
In Debug Console view you can see messages sent from *remote* Quantum Virtual Machine. For example, OpenQASM parsing errors. These messages sent using [OutputEvent](#) DAP command.



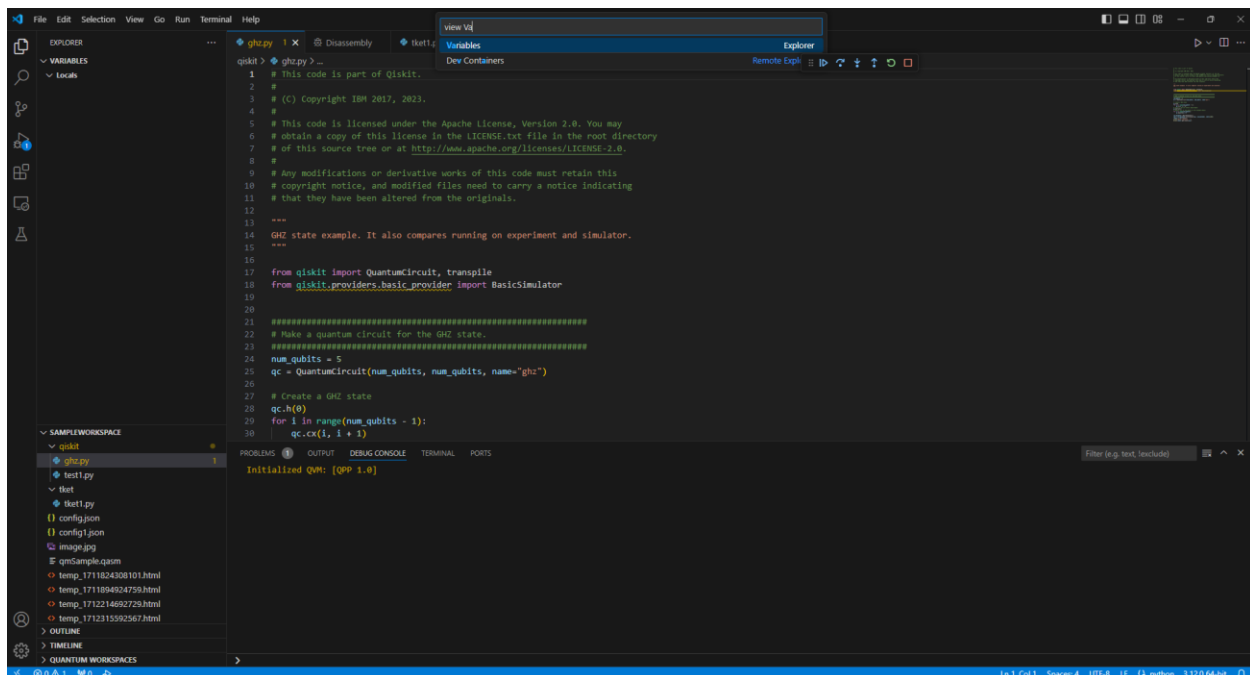
Quantum state

Quantum state of the QVM can be seen in view 'Variables'.

After starting debugging session go to 'View' menu and choose 'Open View..' item.



Then type 'Variables' in opened prompt



Quantum state can be seen in Variables View after parsing circuit after first ‘Step’ command of debugger.

The screenshot displays a VS Code interface with a quantum circuit simulation. The left sidebar shows the 'VARIABLES' view, which lists the quantum state for each qubit. The main editor shows a Python script for a GHZ state example. The bottom panel shows the 'DEBUG CONSOLE' with the output 'Initialized QM: [QM 1.0]'.

VARIABLES View:

- Locals:**
 - `[00000]: 0.707107 + 10.000000i`
 - `[00010]: 0.000000 + 10.000000i`
 - `[00011]: 0.000000 + 10.000000i`
 - `[00100]: 0.000000 + 10.000000i`
 - `[00101]: 0.000000 + 10.000000i`
 - `[00110]: 0.000000 + 10.000000i`
 - `[00111]: 0.000000 + 10.000000i`
 - `[01000]: 0.000000 + 10.000000i`
 - `[01001]: 0.000000 + 10.000000i`
 - `[01010]: 0.000000 + 10.000000i`
 - `[01011]: 0.000000 + 10.000000i`
 - `[01100]: 0.000000 + 10.000000i`
 - `[01101]: 0.000000 + 10.000000i`
 - `[01110]: 0.000000 + 10.000000i`
 - `[01111]: 0.000000 + 10.000000i`
 - `[10000]: 0.707107 + 10.000000i`
 - `[10001]: 0.000000 + 10.000000i`
 - `[10010]: 0.000000 + 10.000000i`
 - `[10011]: 0.000000 + 10.000000i`
 - `[10100]: 0.000000 + 10.000000i`
 - `[10101]: 0.000000 + 10.000000i`
 - `[10110]: 0.000000 + 10.000000i`
 - `[10111]: 0.000000 + 10.000000i`

Main Editor (ghz.py):

```

14 ghz state example. It also compares running on experiment and simulator.
15 ---
16
17 from qiskit import QuantumCircuit, transpile
18 from qiskit.providers.basic_provider import BasicSimulator
19
20
21 #####
22 # Make a quantum circuit for the GHZ state.
23 #####
24 num_qubits = 5
25 qc = QuantumCircuit(num_qubits, num_qubits, name="ghz")
26
27 # Create a GHZ state
28 qc.h(0)
29 for i in range(num_qubits - 1):
30     qc.cx(i, i + 1)
31 # Insert a barrier before measurement
32 qc.barrier()
33 # Measure all of the qubits in the standard basis
34 for i in range(num_qubits):
35     qc.measure(i, i)
36
37 sim_backend = BasicSimulator()
38 job = sim_backend.run(transpile(qc, sim_backend), shots=1024)
39 result = job.result()
40 print("Basic simulator : ")
41 print(result.get_counts(qc))
42

```

DEBUG CONSOLE:

```

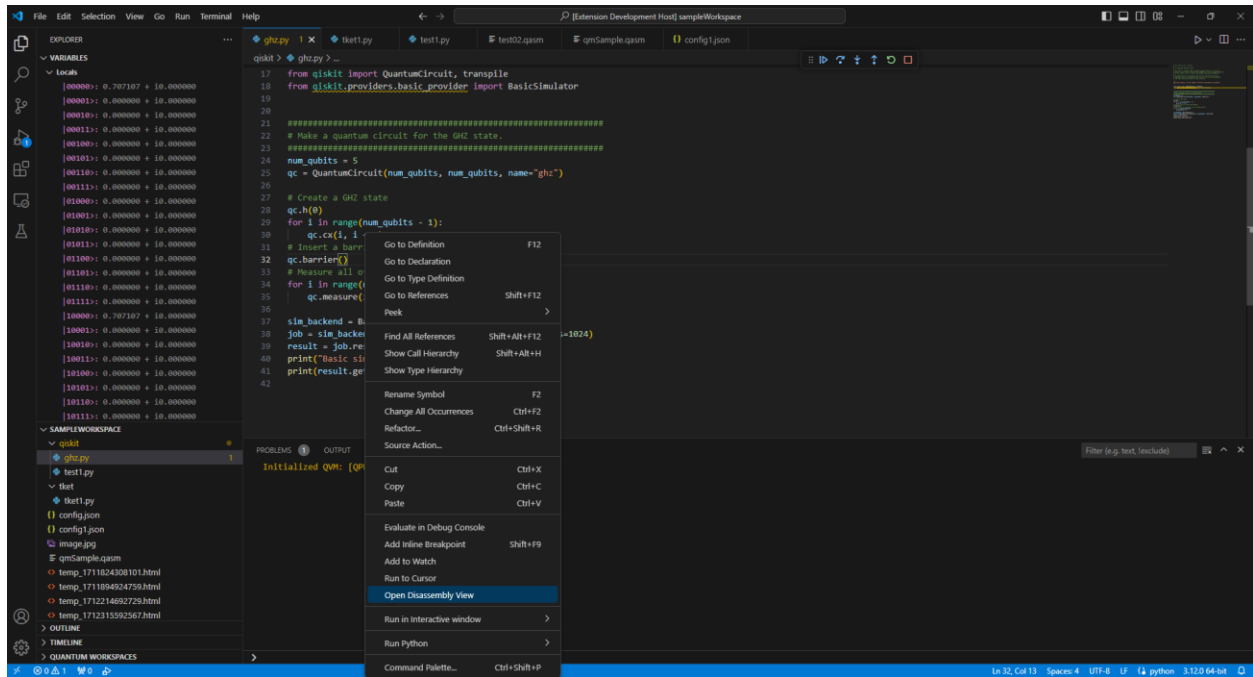
Initialized QM: [QM 1.0]

```

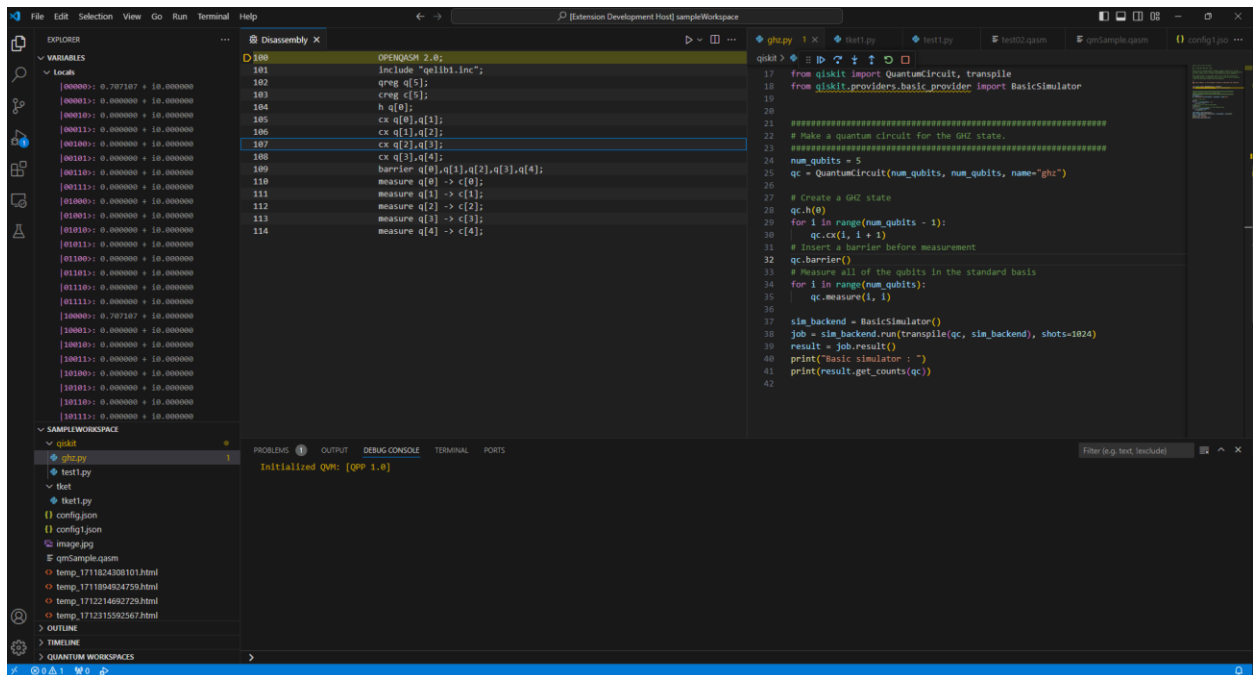
For example, line `|10000> = 0.707107 + i0.0` means that during measurement probability to get qubit #0 in state ‘1’ and qubits #1-#4 in state ‘0’ equals ½. (0.707107^2). More about state of quantum system of N qubits can be found [here](#).

Compiled OpenQASM code

After the first 'Step debug' command of python script you can see OpenQASM code in 'Disassembly View' if python code was compiled correctly to OpenQASM in QVM.

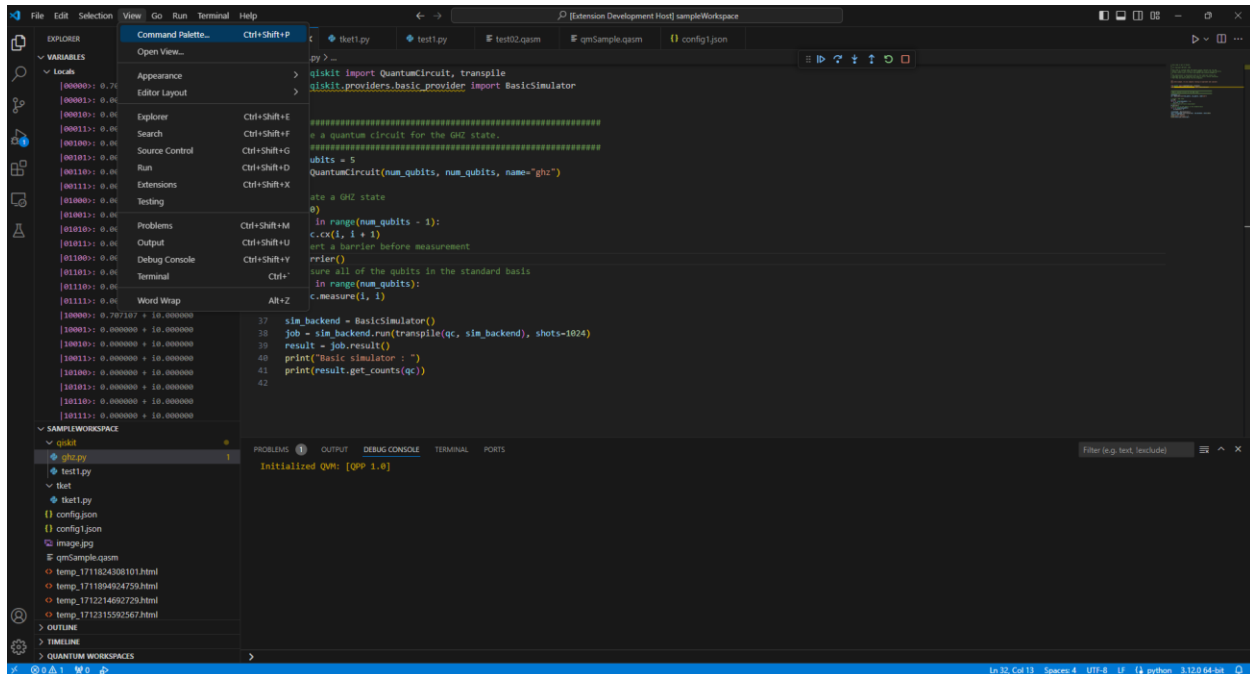


Disassembly View can be moved as any other View in VS code for convenience.



Command Palette

Extension exposes few commands which are available in Command Palette. To open Command Palette press 'Ctrl+Shift+P' in Windows or open menu 'View' and then 'Command Palette..' item

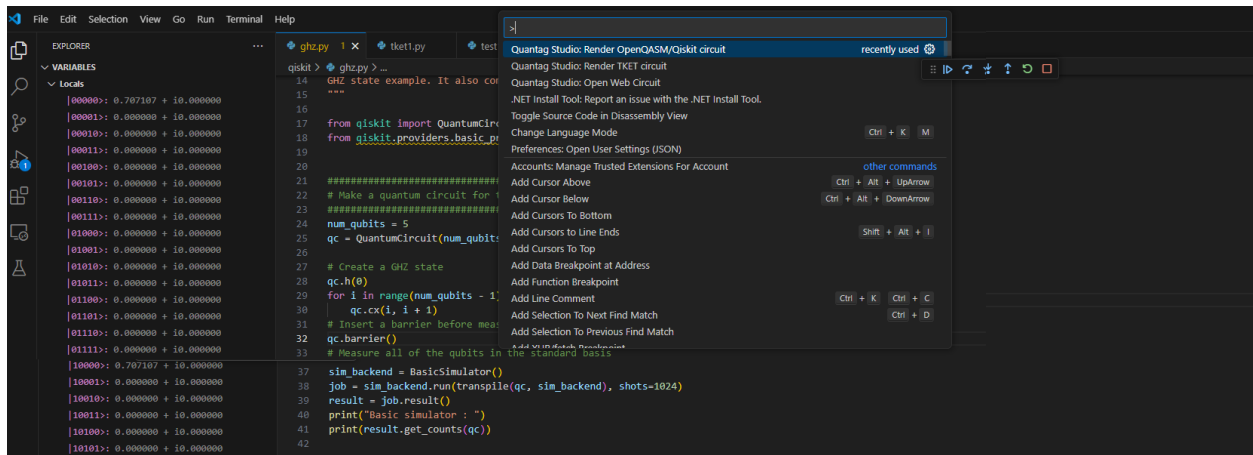


Some commands are available only during debugging sessions, some only for '.py' files or only for '.qasm' files. If you can not find some command check that you are in the right mode and correct file is opened.

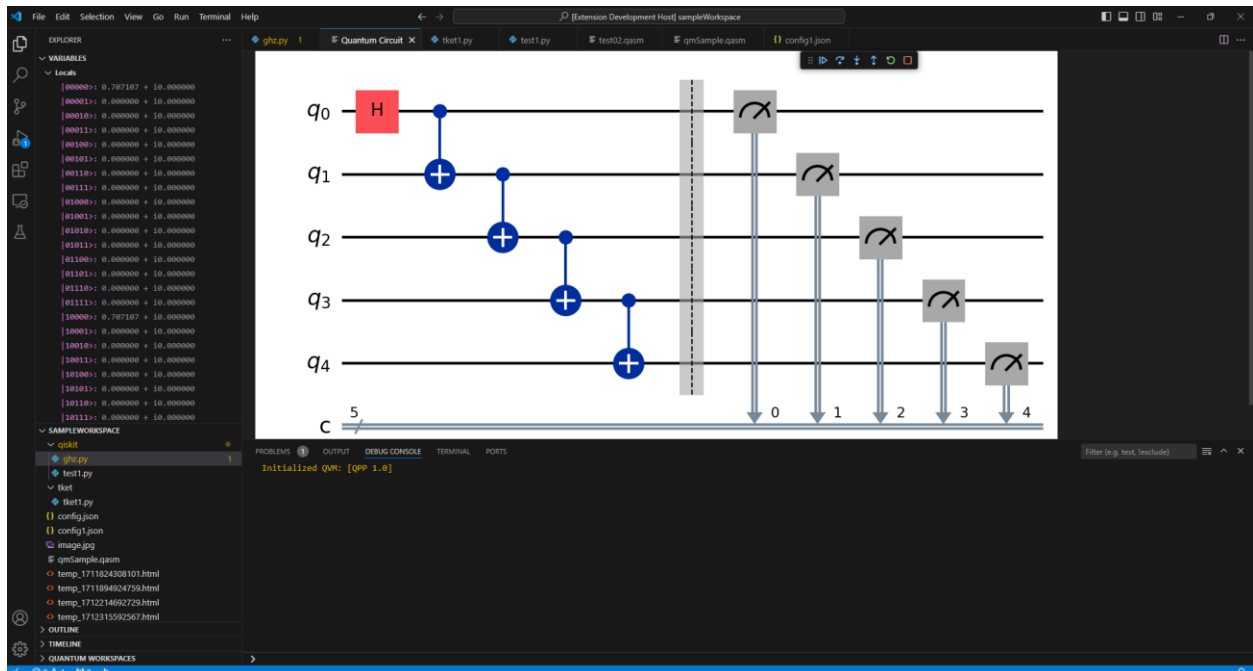
Render OpenQASM/Qiskit circuit command

This command can be used during debugging session to render OpenQASM or Qiskit circuit within VS Code.

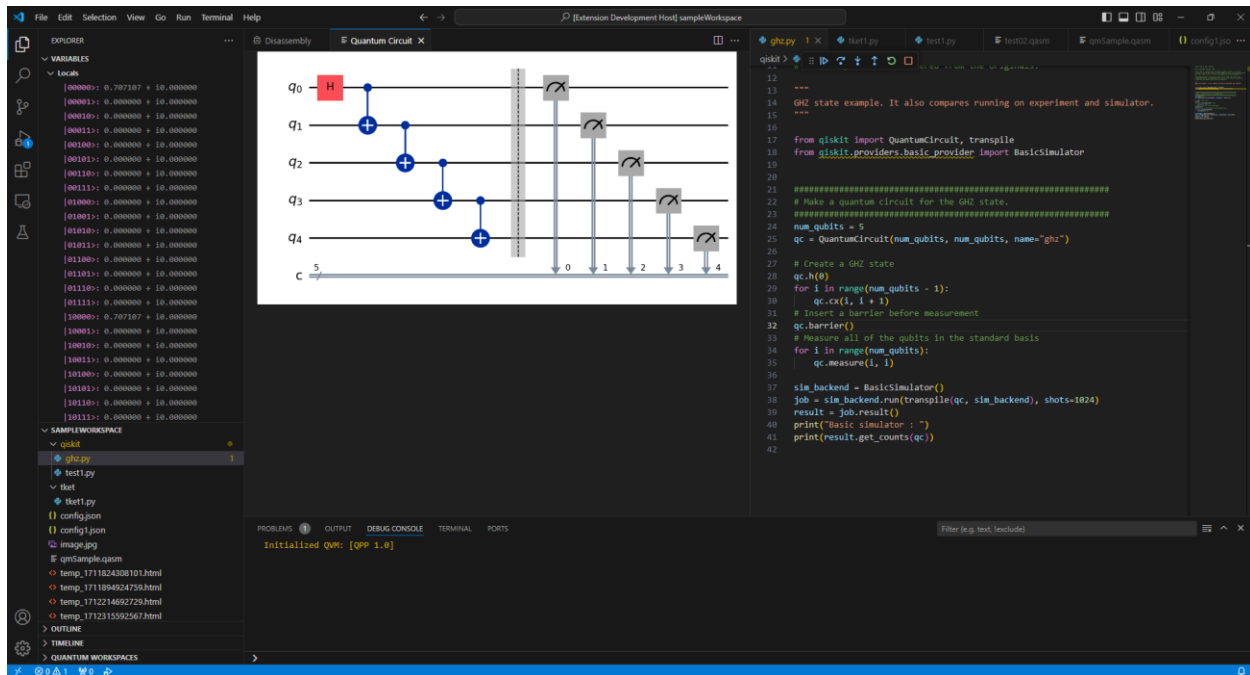
Open 'Commands Palette' and choose 'Quantag Studio: Render OpenQASM/Qiskit circuit'



If circuit correctly parsed in QVM you will see rendered circuit in new View in VS Code.



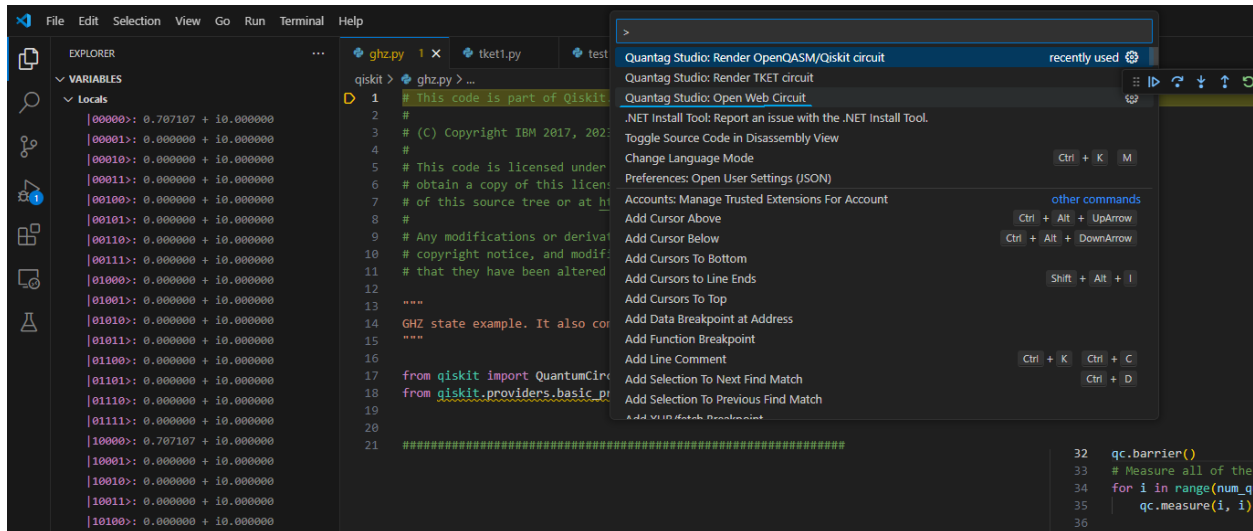
You can rearrange visualized circuit like any other View in VS Code to see source code and circuit at same time:



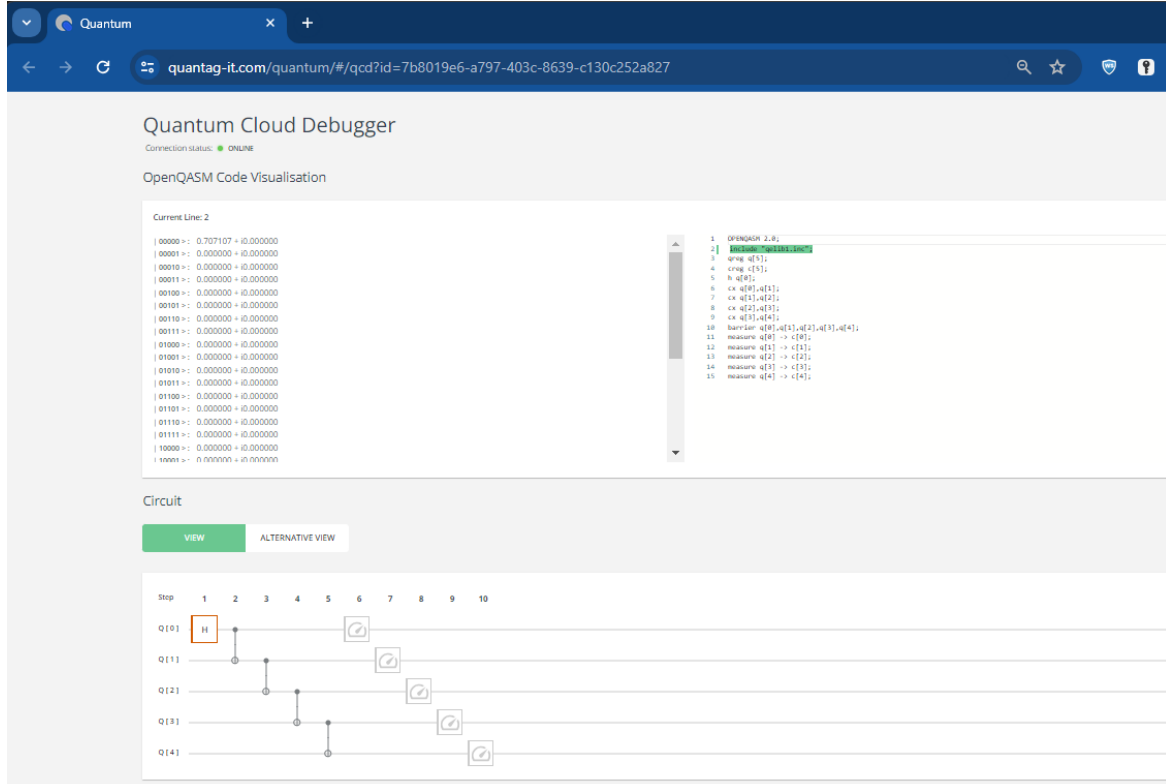
Web frontend

Additionally, QVM has its own web frontend which opens in external browser *after starting debugging session* and can render circuits, show quantum state and source. It is implemented on angular.js and communicates with QSCore using web-socket connection.

To open web frontend use command ‘Open Web Circuit’.



It can render circuits using own renderer in View or Qiskit renderer in ‘Alternative View’ is available.



Alternative Web View

Quantum Cloud Debugger

Connection status: ● ONLINE

OpenQASM Code Visualisation

Current Line: 2

```
00000 >: 0.707107 + i0.000000
00001 >: 0.000000 + i0.000000
00010 >: 0.000000 + i0.000000
00011 >: 0.000000 + i0.000000
00100 >: 0.000000 + i0.000000
00101 >: 0.000000 + i0.000000
00110 >: 0.000000 + i0.000000
00111 >: 0.000000 + i0.000000
01000 >: 0.000000 + i0.000000
01001 >: 0.000000 + i0.000000
01010 >: 0.000000 + i0.000000
01011 >: 0.000000 + i0.000000
01100 >: 0.000000 + i0.000000
01101 >: 0.000000 + i0.000000
01110 >: 0.000000 + i0.000000
01111 >: 0.000000 + i0.000000
10000 >: 0.000000 + i0.000000
10001 >: 0.000000 + i0.000000
10010 >: 0.000000 + i0.000000
10011 >: 0.000000 + i0.000000
10100 >: 0.000000 + i0.000000
10101 >: 0.000000 + i0.000000
10110 >: 0.000000 + i0.000000
10111 >: 0.000000 + i0.000000
11000 >: 0.000000 + i0.000000
11001 >: 0.000000 + i0.000000
11010 >: 0.000000 + i0.000000
11011 >: 0.000000 + i0.000000
11100 >: 0.000000 + i0.000000
11101 >: 0.000000 + i0.000000
11110 >: 0.000000 + i0.000000
11111 >: 0.000000 + i0.000000
```

```
1 OPENQASM 2.0;
2 include "qelib1.inc";
3 qreg q[5];
4 creg c[5];
5 h q[0];
6 cx q[0],q[1];
7 cx q[1],q[2];
8 cx q[2],q[3];
9 cx q[3],q[4];
10 barrier q[0],q[1],q[2],q[3],q[4];
11 measure q[0] -> c[0];
12 measure q[1] -> c[1];
13 measure q[2] -> c[2];
14 measure q[3] -> c[3];
15 measure q[4] -> c[4];
```

Circuit

Web frontend can be used to integrate QSCore in existing web cloud services.

Limitations and future plans

QSCore component and extension currently under active development. Not all features are fully implemented and stable.

Here is list of main limitations:

- not all circuits are working and supported. QSCore analyzes python sources and modifies them on the fly to add rendering and OpenQASM exporting. If circuit is complex with mixed functions and modules – it might fail, and errors will be shown in ‘Debug output’ view
- For big workplaces file transfer might take some time, and there can be delay at the beginning of session.
- QVM initialization can be slow for big number of qubits in circuit.
- There is no mapping yet between python and compiled OpenQASM sources.

Future plans are:

- Adding commands for Circuit Compression and Qubit-to-Qudits circuit conversions
- Adding support of new hardware for direct execution
- Adding support of cloud-based execution of circuits
- Adding different types of QVM with hardware acceleration (Nvidia cuQuantum <https://developer.nvidia.com/cuquantum-sdk>) currently we use <https://github.com/softwareQinc/qpp> as QVM.
- Adding support of hybrid programs (classic + quantum)
- Adding visualization of measurement results in VS code
- Adding circuit step animation of debugging session in VS Code.

Please report found bugs to support@quantag-it.com