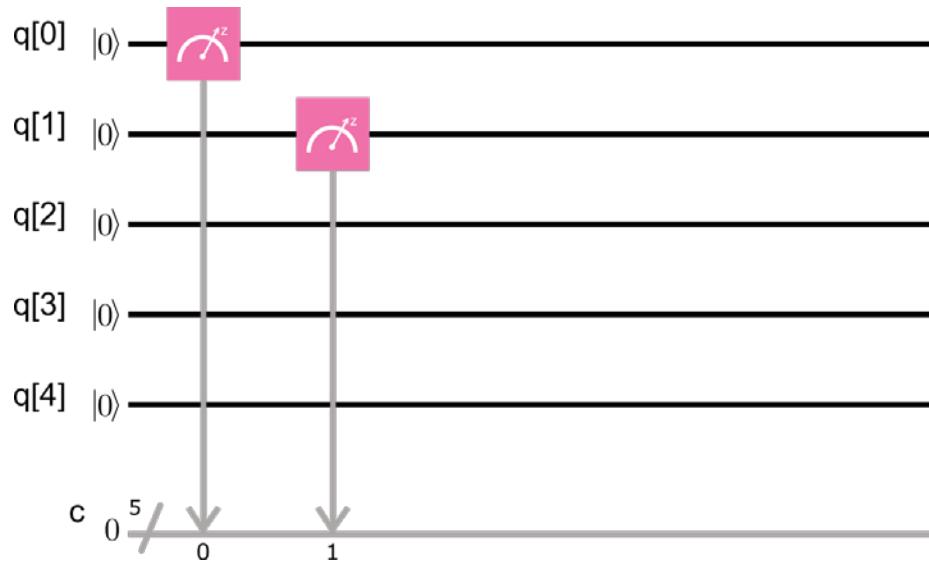




## Measurement: Part 2

To better understand how the measurement results are stored in the classical register, let's consider the quantum circuit below



The QASM code that generates this circuit is

```
1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[0];
5 measure q[1] -> c[1];
```

Similar to the previous example, the analytical probabilities of projecting qubits  $q[0]$  and  $q[1]$  onto states  $|0\rangle$  and  $|1\rangle$  are respectively given by  $p(q[0],|0\rangle)=|\langle 0|0\rangle|^2=1$ ,  $p(q[0],|1\rangle)=|\langle 0|1\rangle|^2=0$ , and  $p(q[1],|0\rangle)=|\langle 0|0\rangle|^2=1$ ,  $p(q[1],|1\rangle)=|\langle 0|1\rangle|^2=0$ .

The following figure shows the result of simulating the previous code with 10 shots. Qubits  $q[0]$  and  $q[1]$  were projected 10 times into state  $|0\rangle|0\rangle$ . **Note that the label in the left column is "00", this is because two qubits are being measured.**

$c[5]$	$n$
00	10

The figure below shows the result of running the previous code in a real quantum computer 1024 times. Since the qubit  $q[0]$  measurement was stored in  $c[0]$ , and  $q[1]$  in  $c[1]$ , the labels are given in the order  $c[1]c[0]$ . The number  $n=1014$  at the right of label "00" indicates that qubits  $q[0]$  and  $q[1]$  where projected onto state  $|00\rangle$  1014 times. The number  $n=1$  at the right of label "01" indicates that qubits  $q[0]$  and  $q[1]$  where projected onto state  $|01\rangle$  1 time. The number  $n=9$  at the right of label "10" indicates that qubits  $q[0]$  and  $q[1]$  where projected onto state  $|10\rangle$  9 times. **Note that there is no label "11"; this is because the qubits where never projected on to state  $|11\rangle$ .**

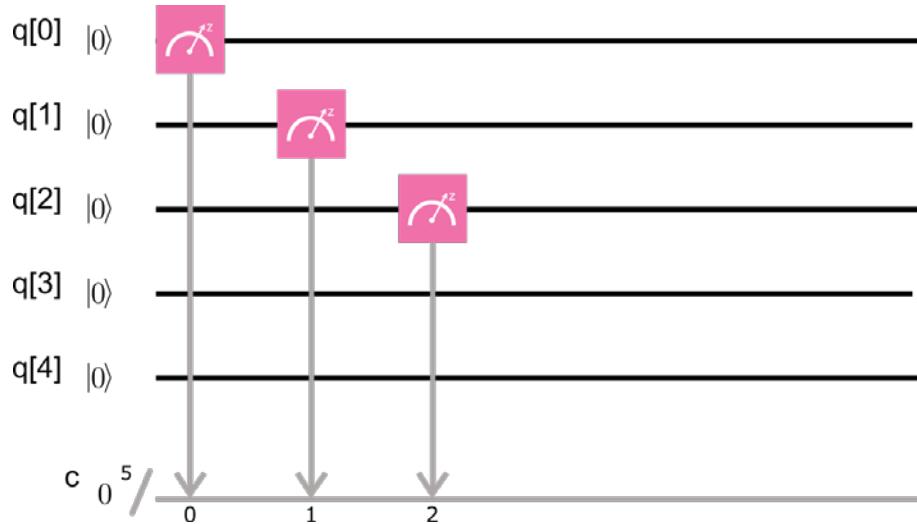
$c[5]$	$n$
00	1014
01	1
10	9

The following table shows a summary of the previous results. You can see that the measurement results are in general -- but not perfect -- agreement with the analytical probabilities.

Table 1

Analytical Probabilities	Quantum state $ q[0]q[1]\rangle$	Result Label $c[1]c[0]$	Projection Frequency $n$
1	$ 00\rangle$	00	1014
0	$ 01\rangle$	10	9
0	$ 10\rangle$	01	1
0	$ 11\rangle$	11	0

To understand how the labeling of the results works can be complicated, so let's analyze the following example



The code that generates this quantum circuit is

```

1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[0];
5 measure q[1] -> c[1];
6 measure q[2] -> c[2];

```

Since the q[0], q[1] and q[2] measurements are stored in c[0], c[1] and c[2] respectively, the projection results will be stored as in Table 2. If instead the measurements are stored in the following way,

```

1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[2];
5 measure q[1] -> c[1];
6 measure q[2] -> c[0];

```

then the projection results will be stored as shown in Table 3

Table 2:  $q[0] \rightarrow c[0]$ ;  $q[1] \rightarrow c[1]$ ;  $q[2] \rightarrow c[2]$ ;

<b>Label</b> $c[2]c[1]c[0]$	<b>Quantum state</b> $ q[0]q[1]q[2]\rangle$
000	$ 000\rangle$
001	$ 100\rangle$
010	$ 010\rangle$
011	$ 110\rangle$
100	$ 001\rangle$
101	$ 101\rangle$
110	$ 011\rangle$
111	$ 111\rangle$

Table 3:  $q[0] \rightarrow c[2]$ ;  $q[1] \rightarrow c[1]$ ;  $q[2] \rightarrow c[0]$ ;

<b>Label</b> $c[2]c[1]c[0]$	<b>Quantum state</b> $ q[0]q[1]q[2]\rangle$
000	$ 000\rangle$
100	$ 100\rangle$
010	$ 010\rangle$
110	$ 110\rangle$
001	$ 001\rangle$
101	$ 101\rangle$
011	$ 011\rangle$
111	$ 111\rangle$