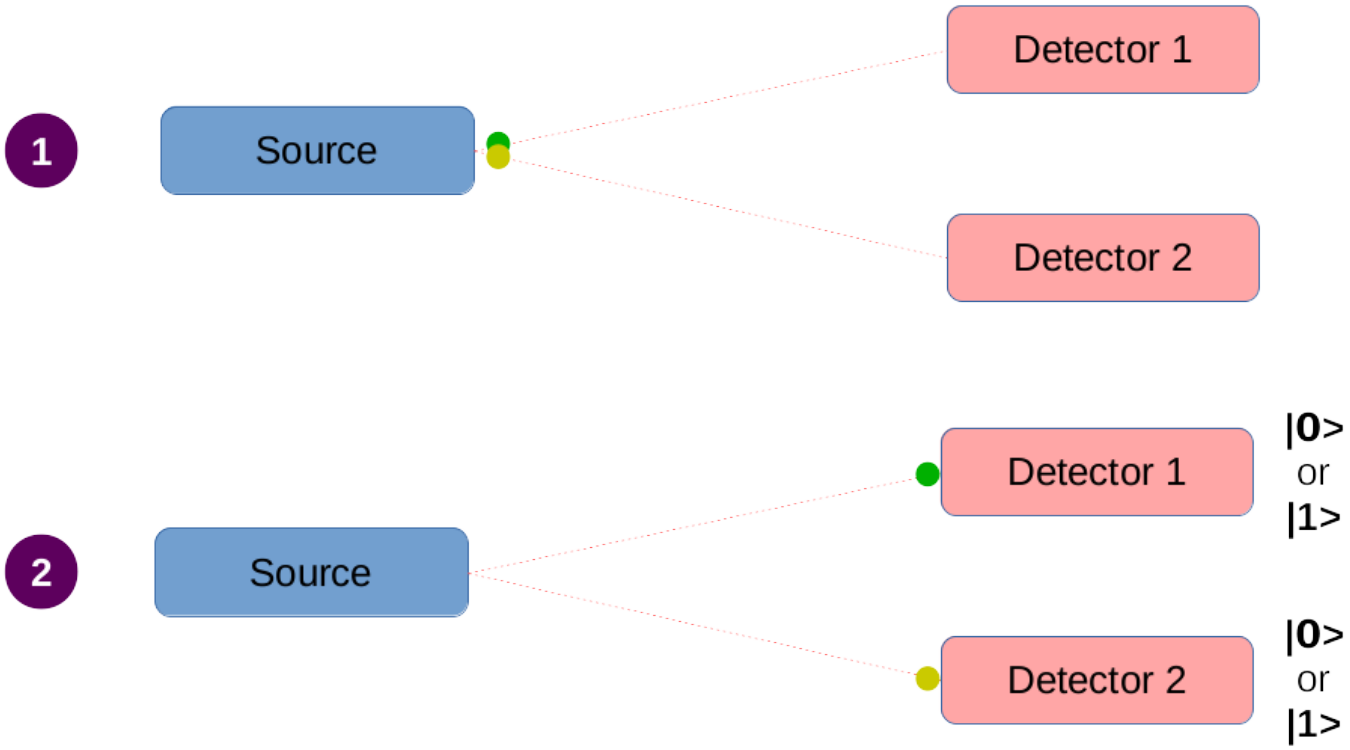
Quantum registers

Playing with one qubit is fun, but not sufficient to run algorithms. You we'll see that later: we need many more than 1 qubit for interesting purposes.
When more than one qubit are in the game, we use quantum registers containing several.

Let's considers the following experiment:



(1) At the left we have a source of qbits (or quantum particles) emitted by a single source in two separate direction. At the right we have two detectors facing the trajectory of qbits.
(2) Each qbit is traveling from the source to the detector in a superposed state between |0> and |1> before being read |0> or |1>.

We could imagine that the behavior with two qbits is the same than one qbit separated from the another. But we have two qbits emitted by the same source, and it changes everything because in this case they are **entangled**.
That means that the result of the top qbit is linked to the result of the bottom qbit. Their probabilities are linked one to the other.

If we would have two sources with two detectors, each qbit would be in the state seen in the previous chapter:

$$|\psi> = \alpha |0> + \beta |1>$$

But since we have a single source emitting two entangled qbits we have amplitudes on all possible result:

$$|\psi> = \alpha |00> + \beta |01> + \gamma |10> + \delta |11>$$

And because Greek letters does not help to know the corresponding state we use only alpha with the

state in little for amplitudes:

$$|\psi>=\alpha_{00}|00>+\alpha_{01}|01>+\alpha_{10}|10>+\alpha_{11}|11>$$

And the associated matrix is:

$$XXX$$

This is crazy isn't it? When they are detected, qbits are in different places in space, yet there is a link between the result read by detectors. However during their travel from source to detectors (at the speed of light) each of them are in a superposed states:all states at the time or |0> and |1> at the same time - you choose.

This is one of the great mystery of quantum mechanics: do particles communicates or do they share information when leaving the source?
It has been demonstrated that the two particles does not share the information at their start. Therefore they must exchange the information when measured by detectors. But that would mean that the information is transmitted faster than light. What is impossible according to Einstein's special relativity.

This mystery has not been solved and we still don't know how particles can interact to share amplitudes of probabilities. We will come back on this mystery later because it is fascinating.

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