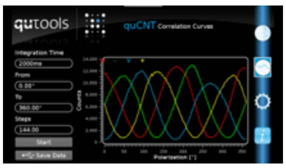
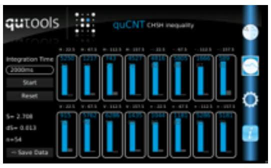
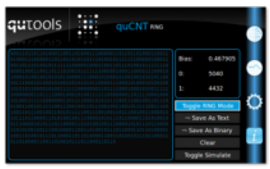
A Science Kit for Quantum Physics

Quantum physics is deeply rooted in the heart of modern physics, but is not easy to teach. Corresponding experiments are often difficult to use and maintain.

The quED is an entanglement demonstrator that fits on any lab desk and can be set up in minutes. Its design combines recent achievements of quantum optics technology into an easy-to-use system for academic, research and applied purposes with precise accuracy. Advanced models for scientific purposes are available as well, with a high performance meeting the requirements of state-of-the-art physics experiments. The software with touch screen interface is easy-to-use and intuitive.

Easy-to-use software interface



Two versions are available

The manual version of the quED is best suited for student lab courses, where the students have to measure for themselves. Thus, they get a feeling what “measuring” really means and that you need a bit of patience in the natural sciences.

The motorized version is a complete one-click solution suitable for demonstrating quantum effects in lectures or presentations. You don’t have to worry about the measurement itself, you can just view the results as they build up automatically.

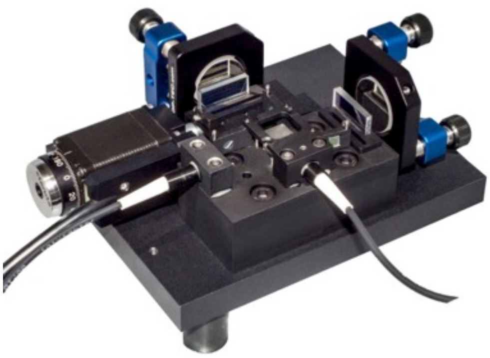
Everything included to start the experiments immediately

The system includes the source of polarization-entangled photon pairs, two silicon avalanche photodiodes, a four-channel counter with integrated coincidence unit, two polarizers (either in a manual rotation mount or in a motorized mount) and a control unit with a touchscreen interface.

For maintenance, alignment utilities including auxiliary visible laser module are included as well.

The functionality of the quED system can easily be extended with (currently) three add-ons:

Michelson Interferometry Add-On for quED



Interference is generally considered to be a wave phenomenon. Curiously it also works with single quantum objects. Use the quED-MI Michelson Interferometer add-on together with the quED to show that this is the case.

This Add-On is available as a manual version (for student labs) and (for demonstration/lectures) as a motorized version.

Hanbury Brown-Twiss effect Add-On for quED

Explore the particle nature of single photons with the quED-HBT add-on for the quED. You can perform the "Grangier-experiment" with this Hanbury Brown & Twiss setup or build your own quantum random bit generator.

In connection with the quED-MI Michelson Interferometer add-on, it is even possible to show wave and particle nature of photons at the same time!

Hong-Ou-Mandel effect Add-On for quED

Experience the purely quantum 2-photon interference effect by revealing the Hong-Ou-Mandel dip.

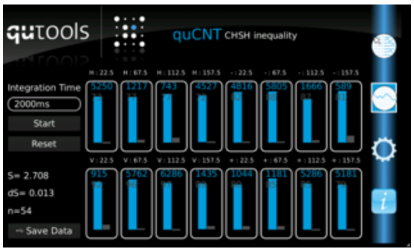
This Add-On is available as a manual version (for student labs) and (for demonstration/lectures) as a motorized version.

quED website

Please visit the quED website at http://www.qutools.com/qued/ for more information about the quED, its add-ons and sample experiments.

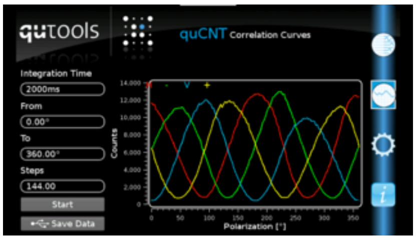
Sample experiments

Violation of Bell's inequality (CHSH)



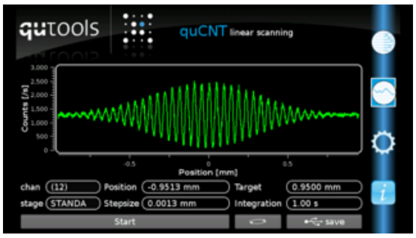
The definition of an entangled state in quantum physics can be rather simple: Two quantum objects cannot be described separately, only together. To show that a quantum system is entangled, the value of the Bell inequality (here, the CHSH equation) is determined by measuring the coincidence rate at 16 different polarizer settings. If the value is above 2, the state is entangled.

"Non-classical" polarization correlations



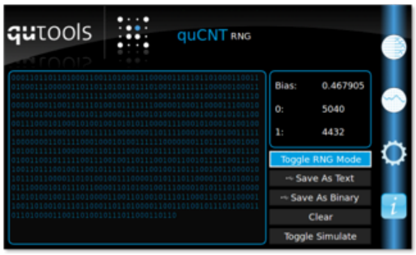
Polarization entangled states show correlations for all different combinations of the polarizer settings. You can fix one polarizer at 0° (horizontal, in the screenshot red), 45° (yellow), 90° (vertical, blue), 135° (green). The other polarizer is rotated. This shows the "non-classical" correlations of entangled photons.

Michelson-Interferometer



In a Michelson interferometer, the light is split up at a beam splitters into two arms and combined again and it will show interference. You can show that this is also possible with single photons. Perform this experiment with the quED and its add-on for the Michelson interferometer.

Quantum randon number generation



Photons behave completely random which can be used to generate real random numbers. You can build your one random number generator with the Hanbury Brown-Twiss add-on. The photon is detected after the beam splitter either at detector 1 (equals a "0" in a bit) or detector 2 (equals "1" in a bit) (and never on both because of the particle nature of photons).

There are a lot more experiments that can be performed using the entanglement demonstrator (and its add-ons). Please visit the website http://www.qutools.com/quED/ for more information.

What do you need for which experiment?

Experiment	quED	quED-MI	quED-HBT	quED-HOM	other parts
Single Photon Experiments without Interference					
Particle Nature of Photons	●	-	●	-	-
Quantum Cryptography / QKD: BB84 Protocol	●	-	-	-	●
Tomographic Single Photon State Reconstruction	●	-	-	-	●
Quantum Zeno Effect	●	-	-	-	●
Quantum Random Number Generation	●	-	●	-	-
Single Photon Experiments with Interference					
Wave Nature of Photons: Single Photon Michelson Interferometer	●	●	-	-	-
Quantum Eraser	●	●	-	-	-
Wave-Particle Dualism: Michelson + HBT	●	●	●	-	-
Double Michelson Interferometer	●	●●	-	-	-
Visible (White) Light Interference (Observable by Eye)	●	●	-	-	●
Measurement of Central Wavelength of Single Photons	●	●	-	-	-
Measurement of Coherence Length of Single Photons	●	●	-	-	-
Interaction-Free Measurement (Bomb Test)	●	●	-	-	●
Photon Pair Experiments with Polarisation Entanglement					
Violation of Bell's Inequality (CHSH)	●	-	-	-	-
"Non-Classical" Polarisation Correlations	●	-	-	-	-
Tomographic State Reconstruction of an Entangled Photon State	●	-	-	-	●
Quantum Cryptography / QKD: BBM Protocol	●	-	-	-	●
Quantum Cryptography: Ekert Protocol	●	-	-	-	●
Photon Pair Experiments without Polarisation Entanglement					
Hong-Ou-Mandel 2-Photon Interference	●	-	-	●	-
Hong-Ou-Mandel Interference + Hanbury Brown & Twiss	●	-	●	●	-
Franson Interference	●	●●	-	-	-

- ● AddOn / part needed
- ●● 2 AddOns needed
- \- not needed