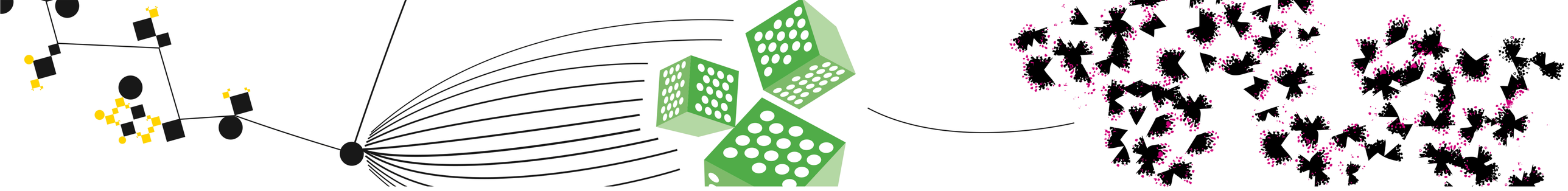

# Retention of a Double Slit Single Photon Interference Demonstration of Particle-Wave Duality

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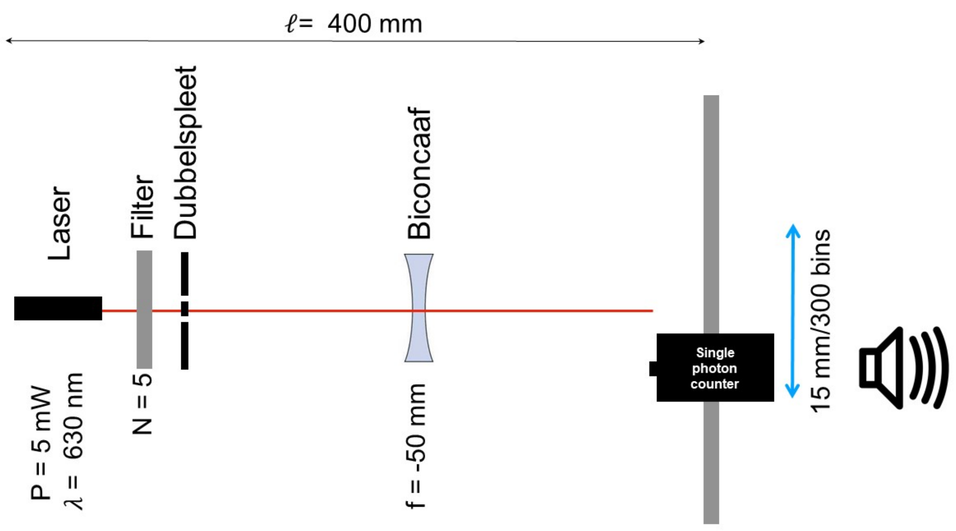
**Introduction**
Demonstrations and lab experiments need to be carefully piloted, evaluated and fine-tuned in order to realise their potential benefits. We presented experiences and research with a demonstration of wave-particle duality at GIREP 2018. In this poster we present new data on retention.

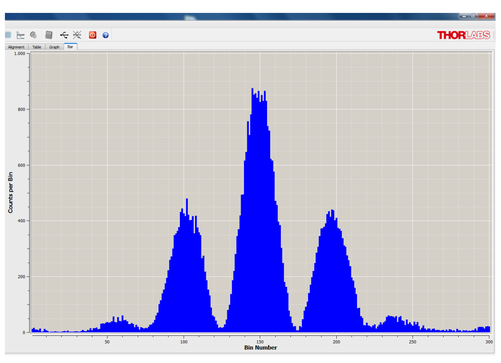
Secondary school students were interviewed a few weeks (27 students), 3 months (5 students), and 9 months (5 students) after a single photon interference demonstration. Most students remembered essentials, that single particles produce interference instead of the expected two stripes. Most also remembered the crucial details of the set-up.

Example statements of students are (**after 3 months**): *With particles you would expect two stripes and with waves interference, we saw waves. With single photons, there should be no interference, but we saw interference.*
PhET applet, can you tell which slit the photon went through? *No*
**After 9 months**:
Correct recall of most details of set-up. *With quantum you either see two stripes or an interference pattern, two stripes if you try to look* [which slit the photon passes].
De Broglie formula: *what is the h?*
Do you know where the photon is? *I think the photon is everywhere, the wave is everywhere.*

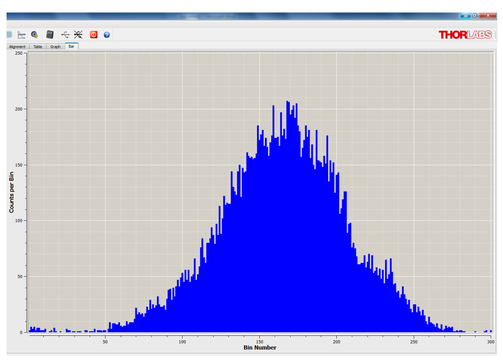



**Experimental Set-up**
In a closed suitcase, light of a laser diode is filtered to 1/1,000,000 of its original intensity and then passes through a double slit and a divergent Bi-Concave lens. At any time there will be only 1 or 2 photons between slit and detector. A linear actuator moves a single photon counter module (SPCM) from Thorlabs in steps across the light beam. The SPCM is connected via USB to a laptop running the Thorlabs SPCM software, displaying the real-time photon count (per second and per location).

The linear actuator, the laser diode, the loudspeaker, and the SPCM module are controlled by an Arduino-based system with an electronic shield to provide interfaces with the various subsystems. This Arduino module is connected to a laptop via USB and controlled by software on the laptop. The SPCM produces an electric pulse with every photon that is being detected. This pulse is electronically amplified to produce a clicking sound on an attached loudspeaker.



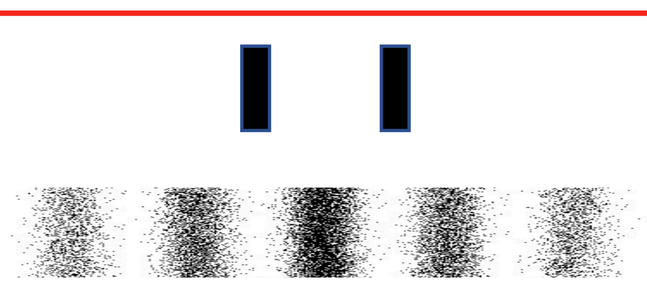

Double slit interference pattern. Horizontal the x-location (arbitrary units) and vertical the number of photons counted during 100 ms.

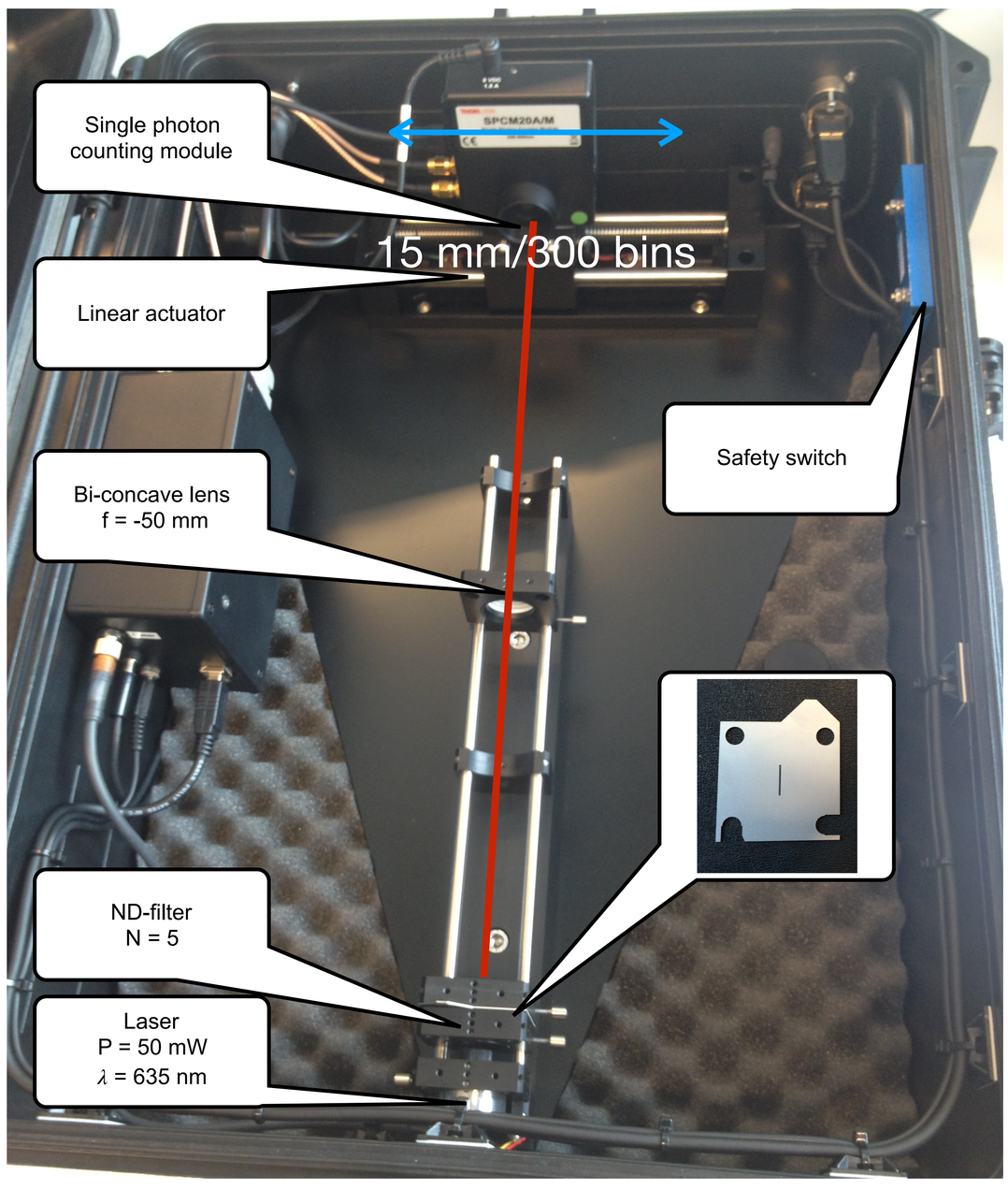



Single slit diagram.

**Educational set-up**
Based on research with 112 students of 5 schools we developed the following series of demonstrations. In each demo students are asked to predict results individually on paper.

1. Spray paint through a double slit (use plant sprayer), What will we see at the screen? (opening ±0,5 cm)
2. Shine a parallel beam of light through a wide double slit (same is in 1).
3. Show a YouTube video of water waves passing a double slit.
4. Show and discuss photos with normal lighting and severely under exposed (grainy!).
5. Shine a laser through a narrow slit (opening ±0.2 mm).
6. Demonstrate the suitcase experiment with single photon interference. Let students compute the distance between photons + predict.
7. Demonstrate and discuss the PhET applet for quantum wave interference.



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