

**Cost of Single Photon Experiments**  
**Kiko Galvez**  
**December 2016**

Attached are current prices for all the components needed for single-photon experiments. I have divided them in three categories:

1. Basic down-conversion: All you need to get photon pairs via parametric down-conversion. This includes a laser, down-conversion crystal, necessary optics, detectors and electronics.
2. Single-photon interference: Additional components to do interference and the quantum eraser. It also includes a measurement that photons exists-the Hanbury-Brown-Twiss test. This involves only additional optics components and their mounts.
3. Entanglement and Bell: Additional components to obtain polarization entangled photons, measure correlations and violations of Clauser-Horne-Shimony-Hold version of Bell inequalities. This entails an additional crystal and some polarization optics. One expensive item is a good polarizer (Glan Thompson). It is good to have, but it is not absolutely necessary.

The grand totals are given in the table below:

<b>Apparatus</b>	<b>Total</b>
Basic	\$10.6k
Single photon int.	\$3.2k
Entanglement	\$3.6k
Totals	\$17.4k

The details are in the spreadsheets that are enclosed. Implementing the experiments will require some planning. The costs can be reduced, so in the next table we present the costs under a different rubric. What components do we absolutely need to purchase and which components we can get used from in-house or elsewhere? The next table makes this breakdown. (There may be some round-off errors.)

<b>Apparatus</b>	<b>Total</b>	<b>New</b>	<b>Used</b>
Basic	\$10.6k	\$6.9k	\$3.7k
Single photon int.	\$3.2k	\$1.0k	\$2.1k
Entanglement	\$3.6k	\$3.4k	\$0.1
Totals	\$17.2k	\$11.3k	\$5.8k




Notice that the price tag of the “must buy” goes down. Those under “new” are components such as down-conversion crystal, detectors, laser, etc., and those under “used” are mirrors, mounts, the breadboard, laser goggles, etc. Some more sacrifices can be made, but those must be informed decisions. Often being stubborn does not work out (we say this by own experience...). For example, there is no way to compromise on the detectors. Photomultipliers will not work (yet). In the next table we list the type of components, so you get an idea. I have divided them into three categories: “single items” (breadboard, crystals, detectors, etc.), “optics” (mirrors, waveplates) and “mounts” (hardware).

<b>Apparatus</b>	<b>Single items</b>	<b>Optics</b>	<b>Mounts</b>
Basic	\$7.4k	\$1.3k	\$1.6k
Single photon int.	\$0.1k	\$1.4k	\$1.8k
Entanglement		\$2.8k	\$0.8k
Totals	\$7.5k	\$5.5k	\$4.2k

Suppose we have some money this year and some more next year, what are the most expensive items? That is in the next table. Amazingly, the most expensive item is a breadboard. Listed is the range of prices. For example, in optics, the least expensive is a \$70 mirror, and the most expensive is a Glan-Thompson polarizer (\$550). At the high end of mounts we have the beam splitter mounts. I note that one can mount hardware with anything at hand, but for the interferometer I highly recommend the “pedestal mounts” because they are rigid and stable.



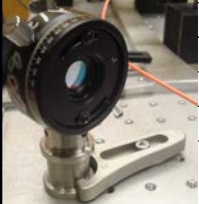
<b>Item</b>	<b>Cost</b>
Optical breadboard	\$1.9k
Detectors	\$1.4k (each; need 2-3)
Crystal	\$500-1000
Laser	\$20-500
Optics	\$70-550
Mounts	<\$350

Finally, in a separate spreadsheet I give the individual prices, part numbers and photos of the components..

Price list for photon experiments KG last update: 12/17							
Basic down-conversion							totals
		vendor	model	price	#	total	
mirror for blue laser	1" dielectric mirror	Thorlabs	BB1-E02	75	1	75	It is important to have a mirror that does not absorb the blue laser - Al absorbs!
	mirror mount	Thorlabs	KM100	40	1	40	
	2" pedestal	Newport		9954	26	26	
	regular fork clamp	Newport		9909	14	14	
Down conversion crystal	BBO 5x5x3mm 29deg	Newlight Photonics Inc.		549	1	549	
	type-I						
	Rotational/tilt mount	Thorlabs	KS1RS	232	1	232	NEW- provides most convenient adjustments.
	1.5" pedestal	Newport		9953	26	26	
	regular fork clamp	Newport		9909	14		
Helpful	iris	Thorlabs	ID25SS	56	2	112	
	Magnetic mount	Thorlabs	MB175	48	2	96	
	3" post	Thorlabs	TR3	5	4	20	
	Post holder	Thorlabs	RA90	10	2	20	
	Thumbscrews	Thorlabs	TS25H	2	4	8	256
HeNe laser (surplus)							

Blue laser options (NEW)	(1) GaN diode laser	Power technology		7000	1	7000	Current and temp control	
	(2) GaN diode laser	Crystal laser	DL-405-50	4000	1	4000	Current and temp control, 50 mW	
(1)	(3) GaN diode laser	Power technology	GPD405-50	400	1	400	Current control, 50 mW	
	(4) GaN diode laser	Axiz	AIX-405-150T	64	1	64	Rugged, but with current and temp control, 150 mW	
	(5) GaN laser pointer	Laser pointer pro	HK-E03143	41	1	41	free running	
	1.5" pedestal	Newport		9953	26	2	52	for all but (3)
(5)	regular fork clamp	Newport		9909	14	2	28	for all but (3)
	Holder	Thorlabs	KM100V	89	1	89	for (5)	
	Safety goggles	Thorlabs	LG1, LG2 or LG9	196	2	392	as many as needed!	
								872
mirrors for HeNe	20mm mirror mounted	Edmund	M33-502	85	3	255		
	2.5" pedestal	Newport		9955	23	3	69	
	Thread adapter	Thorlabs	AP8E25E	1.7	3	5.1	These are to connect mirror	
	Spacers	Thorlabs	SD1	7	3	21	to pedestal.	
	regular fork clamp	Newport		9909	14	3	42	
	flipper mirror	Newport		9891	149	1	149	
	1.5" pedestal	Newport		9953	26	1	26	
	dielectric mirror	Thorlabs	BB1-E02	75	1	75		642.1
Band-pass filters	1" 800nm, 40nm	Thorlabs	FB800-40	99	3	297		



Electronics	(1) Coincidence unit software	Altera DE2 Labview	DE2	250	1	250		250
								
Optical breadboard	2'x5'x4"	Thorlabs	B3060G	1900	1	1900		1900
			Total basic downconversion					10633
Single Photon interference setup								
Mach-Zehnder	Non-polarizing beam splitters near IR 20mm	Thorlabs	BS017	190	2	380	buy together	
	Beam splitter mount	Newport		9481	336	2	672	
	1.5" pedestal	Newport		9953	26	3	78	
	mounted mirror	Edmund	M33-502		85	3	255	
	2.5" pedestal	Newport		9955	30	2	60	
	Thread adapter	Thorlabs	AP8E25E		7	2	14	
	short fork holder	Newport		9916	13	4	52	
	piezo electric linear stage	Thorlabs	AE0505D08F MT1	131 286	1 1	131 286	6.6x6.5x10mm w/o amplifier	1928
Eraser additions	Zero-order waveplates	NewLight Photonics	WPA03-H-810	249	2	498		
	polarizer holder	Optosigma	114-0240	125	2	250		
	holder adapter	Optosigma	114-0420		35	2	70	
	1.5" pedestal	Newport		9953	26	2	52	
	short fork holder	Newport		9916	13	2	26	
	polarizing beam splitter	Thorlabs	PBS102	183	1	183		

	Rotary mount	Thorlabs	RSP1x15	128	1	128	
	1" adapter for PBS	custom					
	Magnetic mount	Thorlabs	MB175	48	1	48	
	3" post	Thorlabs	TR3	6	2	12	
	Post holder	Thorlabs	RA90	10	1	10	
	Thumbscrews	Thorlabs	TS25H	2	2	4	1281
Additional electronics	(1) D/A interface	Arduino	custom	50	1	50	
	(2) Voltage amplifier	Emco	Q02-24	81	1	81	131
 (1)							
 (2)			Additional interference				3209
Entanglement/Bell setup							
	Half-wave plate 405nm	NewLight Photonics	WPA03-H-405	249	1	249	
	Rotational mount	Thorlabs	RSP1x15	128	1	128	
	Compensating crystal	Newlight	QAR25550-A-AR405	429	1	429	
	Crystal pair	Newlight	PABBO5050-405(I)-HA3	1000	1	1000	
	Rotational/tilt mount	Thorlabs	KS1RS	232	1	232	NEW
	1.5" pedestal	Newport	9953	20	1	20	
	Glan-Thompson prism	Thorlabs	GTH10M	555	2	1110	
	prism rotary holder	Optosigma	114-0240	125	2	250	
	holder adapter	Optosigma	114-0420	35	2	70	
	1.5" pedestal	Newport	9953	20	2	40	
	regular fork clamp	Newport	9909	14	2	28	
			Additional Entanglement				3556
			All				17398