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# Supplementary Information - Heralded generation of entangled photon pairs

Stefanie Barz[1,2,†], Gunther Cronenberg[1,2†], Anton Zeilinger[1,2], Philip Walther[1,2]
[1] *Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria*
[2] *Institute for Quantum Optics and Quantum Information (IQOQI), Austrian Academy of Sciences, Boltzmanngasse 3, A-1090 Vienna, Austria*
[†] *These authors contributed equally to this work*

The analysis of the polarization-dependent photon-number distribution using the Fock basis is shown in Table I. This data represents the diagonal elements of the density matrix, i.e. the probabilities of having $n$ photons in each mode, starting from the vacuum contribution up to the case with one photon in each mode.

| | 17/83 | 30/70 | 50/50 | 70/30 |
|---|---|---|---|---|
| $P_{0,0;0,0}$ | $(9.74 \pm 0.002) \cdot 10^{-1}$ | $(9.63 \pm 0.003) \cdot 10^{-1}$ | $(9.14 \pm 0.006) \cdot 10^{-1}$ | $(8.68 \pm 0.023) \cdot 10^{-1}$ |
| $P_{1,0;0,0}$ | $(7.19 \pm 0.08) \cdot 10^{-3}$ | $(10.8 \pm 0.15) \cdot 10^{-3}$ | $(2.42 \pm 0.04) \cdot 10^{-2}$ | $(2.70 \pm 0.12) \cdot 10^{-2}$ |
| $P_{0,1;0,0}$ | $(8.32 \pm 0.09) \cdot 10^{-3}$ | $(10.2 \pm 0.14) \cdot 10^{-3}$ | $(2.26 \pm 0.03) \cdot 10^{-2}$ | $(3.25 \pm 0.13) \cdot 10^{-2}$ |
| $P_{0,0;1,0}$ | $(5.77 \pm 0.07) \cdot 10^{-3}$ | $(8.41 \pm 0.13) \cdot 10^{-3}$ | $(1.58 \pm 0.03) \cdot 10^{-2}$ | $(2.72 \pm 0.12) \cdot 10^{-2}$ |
| $P_{0,0;0,1}$ | $(4.47 \pm 0.65) \cdot 10^{-3}$ | $(7.20 \pm 0.12) \cdot 10^{-3}$ | $(1.93 \pm 0.03) \cdot 10^{-2}$ | $(3.62 \pm 0.14) \cdot 10^{-2}$ |
| $P_{1,1;0,0}$ | $(2.08 \pm 0.44) \cdot 10^{-5}$ | $(2.38 \pm 0.69) \cdot 10^{-5}$ | $(2.41 \pm 0.35) \cdot 10^{-4}$ | $(3.75 \pm 1.42) \cdot 10^{-4}$ |
| $P_{1,0;1,0}$ | $(12.05 \pm 0.85) \cdot 10^{-5}$ | $(32.3 \pm 2.02) \cdot 10^{-5}$ | $(10.26 \pm 0.68) \cdot 10^{-4}$ | $(2.22 \pm 0.32) \cdot 10^{-3}$ |
| $P_{1,0;0,1}$ | $(2.56 \pm 0.73) \cdot 10^{-5}$ | $(0.718 \pm 1.63) \cdot 10^{-5}$ | $(5.94 \pm 0.64) \cdot 10^{-4}$ | $(1.01 \pm 0.33) \cdot 10^{-3}$ |
| $P_{0,1;1,0}$ | $(4.88 \pm 0.87) \cdot 10^{-5}$ | $(6.84 \pm 1.76) \cdot 10^{-5}$ | $(5.22 \pm 0.56) \cdot 10^{-4}$ | $(1.83 \pm 0.32) \cdot 10^{-3}$ |
| $P_{0,1;0,1}$ | $(6.28 \pm 0.66) \cdot 10^{-5}$ | $(21.5 \pm 1.52) \cdot 10^{-5}$ | $(9.20 \pm 0.65) \cdot 10^{-4}$ | $(2.96 \pm 0.34) \cdot 10^{-3}$ |
| $P_{0,0;1,1}$ | $(6.63 \pm 0.25) \cdot 10^{-6}$ | $(1.19 \pm 0.49) \cdot 10^{-5}$ | $(1.31 \pm 0.26) \cdot 10^{-4}$ | $(3.75 \pm 1.42) \cdot 10^{-4}$ |
| $P_{1,1;1,0}$ | 0 | $(1.98 \pm 1.98) \cdot 10^{-6}$ | $(2.6 \pm 1.17) \cdot 10^{-5}$ | 0 |
| $P_{1,1;0,1}$ | 0 | $(3.96 \pm 2.80) \cdot 10^{-6}$ | 0 | $(1.07 \pm 0.76) \cdot 10^{-4}$ |
| $P_{1,0;1,1}$ | 0 | 0 | $(1.05 \pm 0.74) \cdot 10^{-5}$ | 0 |
| $P_{0,1;1,1}$ | 0 | 0 | 0 | 0 |
| $P_{1,1;1,1}$ | 0 | 0 | 0 | 0 |

TABLE I: The Table lists the measured probabilities $P_{n_{1H},n_{1V};n_{2H},n_{2V}}$ of finding $n_{1H}$, $n_{1V}$, $n_{2H}$ and $n_{2V}$ photons numbers in the output modes $t_{1H}$,$t_{1V}$,$t_{2H}$ and $t_{2V}$ with orthogonal polarizations H and V for the different beam splitter transmissions using our standard photo-avalanche diodes. The error for each probability is following a Poissonian distribution of the measured counts.

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For each beam splitter transmission ratio we used a (overcomplete) tomographic set of measurements for each basis $\sigma_x$, $\sigma_y$, $\sigma_z$ to reconstruct the polarization correlations of the (high-power) output state. In Table II we list the measured detection events that were triggered by a four-fold coincidence of the ancilla photons.

| 17/83 | $\sigma_x^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_z^{(2)}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\|0,0;0,0\rangle$ | 124009 | 116831 | 120881 | 118334 | 109941 | 113054 | 93318 | 119896 | 111629 |
| $\|1,0;0,0\rangle$ | 990 | 811 | 776 | 995 | 925 | 716 | 636 | 906 | 831 |
| $\|0,1;0,0\rangle$ | 871 | 946 | 1114 | 909 | 785 | 1048 | 969 | 1122 | 1014 |
| $\|0,0;1,0\rangle$ | 665 | 661 | 668 | 733 | 659 | 610 | 587 | 779 | 727 |
| $\|0,0;0,1\rangle$ | 545 | 447 | 531 | 568 | 528 | 481 | 436 | 595 | 591 |
| $\|1,1;0,0\rangle$ | 1 | 0 | 2 | 5 | 2 | 5 | 2 | 1 | 4 |
| $\|1,0;1,0\rangle$ | 11 | 3 | 8 | 7 | 8 | 10 | 14 | 6 | 13 |
| $\|1,0;0,1\rangle$ | 3 | 8 | 7 | 10 | 11 | 2 | 5 | 11 | 2 |
| $\|0,1;1,0\rangle$ | 9 | 13 | 4 | 15 | 11 | 7 | 5 | 11 | 9 |
| $\|0,1;0,1\rangle$ | 5 | 2 | 6 | 6 | 2 | 9 | 5 | 4 | 10 |
| $\|0,0;1,1\rangle$ | 1 | 0 | 1 | 1 | 0 | 0 | 2 | 1 | 1 |
| $\|1,1;1,0\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;0,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,0;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|0,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30/70 | $\sigma_x^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_z^{(2)}$ |
| $\|0,0;0,0\rangle$ | 53770 | 59081 | 61607 | 54745 | 55060 | 57606 | 26923 | 57227 | 59855 |
| $\|1,0;0,0\rangle$ | 568 | 683 | 677 | 579 | 584 | 644 | 257 | 708 | 752 |
| $\|0,1;0,0\rangle$ | 610 | 571 | 674 | 605 | 600 | 587 | 327 | 587 | 605 |
| $\|0,0;1,0\rangle$ | 506 | 491 | 551 | 486 | 450 | 457 | 220 | 516 | 570 |
| $\|0,0;0,1\rangle$ | 374 | 463 | 399 | 380 | 499 | 442 | 222 | 408 | 449 |
| $\|1,1;0,0\rangle$ | 0 | 0 | 1 | 3 | 2 | 1 | 3 | 2 | 0 |
| $\|1,0;1,0\rangle$ | 19 | 4 | 17 | 11 | 11 | 7 | 5 | 17 | 13 |
| $\|1,0;0,1\rangle$ | 6 | 10 | 3 | 5 | 6 | 14 | 6 | 10 | 8 |
| $\|0,1;1,0\rangle$ | 10 | 21 | 4 | 13 | 6 | 9 | 3 | 8 | 5 |
| $\|0,1;0,1\rangle$ | 14 | 3 | 8 | 2 | 4 | 8 | 5 | 7 | 8 |
| $\|0,0;1,1\rangle$ | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 2 |
| $\|1,1;1,0\rangle$ | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;0,1\rangle$ | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| $\|1,0;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|0,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 50/50 | $\sigma_x^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_z^{(2)}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\|0,0;0,0\rangle$ | 32429 | 15769 | 16779 | 14303 | 14002 | 16309 | 31535 | 17756 | 15859 |
| $\|1,0;0,0\rangle$ | 956 | 443 | 390 | 377 | 387 | 376 | 838 | 446 | 405 |
| $\|0,1;0,0\rangle$ | 749 | 394 | 482 | 304 | 292 | 443 | 884 | 398 | 374 |
| $\|0,0;1,0\rangle$ | 576 | 277 | 208 | 204 | 253 | 314 | 623 | 338 | 224 |
| $\|0,0;0,1\rangle$ | 627 | 319 | 433 | 302 | 292 | 308 | 720 | 312 | 381 |
| $\|1,1;0,0\rangle$ | 6 | 1 | 9 | 5 | 4 | 5 | 15 | 1 | 0 |
| $\|1,0;1,0\rangle$ | 47 | 3 | 15 | 13 | 13 | 16 | 29 | 20 | 14 |
| $\|1,0;0,1\rangle$ | 25 | 38 | 9 | 5 | 14 | 15 | 22 | 12 | 8 |
| $\|0,1;1,0\rangle$ | 19 | 18 | 8 | 14 | 4 | 8 | 21 | 14 | 7 |
| $\|0,1;0,1\rangle$ | 33 | 2 | 11 | 17 | 9 | 11 | 48 | 12 | 11 |
| $\|0,0;1,1\rangle$ | 4 | 1 | 4 | 3 | 0 | 0 | 10 | 2 | 1 |
| $\|1,1;1,0\rangle$ | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| $\|1,1;0,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,0;1,1\rangle$ | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| $\|0,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 70/30 | $\sigma_x^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_z^{(2)}$ | $\sigma_x^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_y^{(2)}$ | $\sigma_z^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_x^{(2)}$ | $\sigma_y^{(1)}\sigma_z^{(2)}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\|0,0;0,0\rangle$ | 833 | 1371 | 1480 | 1478 | 1402 | 3360 | 3630 | 1692 | 972 |
| $\|1,0;0,0\rangle$ | 23 | 55 | 36 | 56 | 52 | 94 | 102 | 64 | 22 |
| $\|0,1;0,0\rangle$ | 27 | 43 | 79 | 55 | 38 | 136 | 140 | 57 | 33 |
| $\|0,0;1,0\rangle$ | 26 | 42 | 48 | 31 | 45 | 110 | 121 | 61 | 25 |
| $\|0,0;0,1\rangle$ | 34 | 47 | 66 | 52 | 44 | 147 | 170 | 76 | 41 |
| $\|1,1;0,0\rangle$ | 0 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 |
| $\|1,0;1,0\rangle$ | 4 | 1 | 3 | 3 | 4 | 6 | 6 | 4 | 4 |
| $\|1,0;0,1\rangle$ | 2 | 5 | 4 | 8 | 4 | 10 | 3 | 3 | 0 |
| $\|0,1;1,0\rangle$ | 2 | 4 | 2 | 1 | 2 | 11 | 7 | 3 | 4 |
| $\|0,1;0,1\rangle$ | 4 | 0 | 7 | 1 | 4 | 12 | 6 | 4 | 2 |
| $\|0,0;1,1\rangle$ | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 0 |
| $\|1,1;1,0\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;0,1\rangle$ | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| $\|1,0;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|0,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $\|1,1;1,1\rangle$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE II: We show the measured photon-numbers for each polarization and spatial mode, $|n_{1H}, n_{1V}, n_{2H}, n_{2V}\rangle$, where $n_{1H}$, $n_{1V}$ denote the photon number for the orthogonal polarization states in output mode 1 and $n_{2H}$, $n_{2V}$ denote the orthogonal polarization states in output mode 2. The settings for the different measurement bases $\sigma_i^{(1)}\sigma_j^{(2)}$ with $i, j = x, y, z$ are adjusted by phase retarders in front of the polarizing beam splitters.