CLAIMS

1. A method of converting position or momentum correlation of correlated photon pairs to a polarization entangled photon pair, the method comprising:

generating the correlated photon pairs in a crystal using a single pump beam;

a conversion step of separating the correlated photon pairs into first and second groups based on their generated position in first and second portions of a photon generation distribution of the single pump beam in~~at~~ the crystal ~~(position correlation)~~ or based on their direction about the propagation axis ~~(momentum correlation)~~ and rotating a polarization of the first correlated photon pair group such that the polarization of the first correlated pair group is at 90 degrees relative to the polarization of the second correlated photon pair group; and

a combining step of combining the first and second correlated photon pairs such that at least respective portions of respective spatial distributions of the first and second photon pair groups overlap with negligible wavelength dependent phase difference.

2. The method of claim 1, wherein the conversion step comprises imaging a generation plane of the correlated photon pairs onto a wedge mirror for splitting the first and second correlated photon pair groups onto first and second paths, respectively.

3. The method of claim 2, wherein the first and second paths comprise different respective sets of mirrors in an interferometer configuration or wherein the first and second paths comprise a same set of mirrors in a folded interferometer configuration, or

wherein the conversion step comprises using a half wave plate at 45 degrees in the first path, using a half wave plate at 0 degrees in the second path to equalize respective path lengths of the first and second paths, or using both of the half wave plates.

~~4. The method of claim 2, wherein the first and second paths comprise a same set of mirrors in a folded interferometer configuration.~~

~~5. The method of any one of claims 2 to 4, wherein the conversion step comprises using a half wave plate at 45 degrees in the first path.~~

~~6. The method of claim 5, wherein the conversion step comprises using a half wave plate at 0 degrees in the second path to equalize respective path lengths of the first and second paths.~~

~~7. The method of any one of claims 1 to 6, wherein the combining step comprises using a polarization beam splitter, PBS.~~

4~~8~~. The method of ~~any one of~~ claim~~s~~ 1~~ to 7~~, wherein the combining step comprises flipping the spatial distribution of the first or second correlated photon pair groups such that substantially the entire respective spatial distributions of the first and second correlated

photon pair groups overlap and the conversion step comprises equalizing the path lengths of the first or second correlated photon pair groups.

~~9. The method of claim 8, wherein the flipping comprises using a dove prism.~~

~~10. The method of claims 8 or 9, further comprising compensating an additional path length caused by the flipping.~~

~~11. The method of claim 10, wherein the compensating the additional path length caused by the flipping comprises using a glass block.~~

5~~12~~. The method of ~~any one of~~ claim~~s~~ 1 ~~to 11~~, wherein the combining step comprises spatially filtering the first and second correlated photon pair groups to erase spatial information such that the respective portions of the respective spatial distributions of the first and second correlated photon pair groups overlap.

~~13. The method of claim 12, wherein the spatially filtering comprises using a pinhole or collecting into a single mode fiber.~~

6~~14~~. The method of claim 1, wherein pairs of the first and second correlated photon pair groups are each position correlated, and the conversion step comprises rotating the polarization of the first correlated photon pair group generated in a first portion of a photon generation distribution and within a Rayleigh range of the first and second correlated photon pair groups.

~~15. The method of claim 14, wherein the first portion is substantially one half of the photon distribution.~~

7~~16~~. The method of claim 1, wherein pairs of the first and second correlated photon pair groups are each momentum correlated, and the conversion step comprises rotating the polarization of the first correlated photon pair group generated in a first portion of a photon generation distribution and outside a Rayleigh range of the first and second correlated photon pair groups.

~~17. The method of claim 16, wherein the first portion is substantially one half of the photon generation distribution.~~

8~~18~~. The method of ~~any one of~~ claim~~s~~ 1~~4 to 17~~, wherein the combining step comprises spatially filtering the first and second correlated photon pair groups to erase spatial information such that the respective portions of the respective spatial distributions of the first and second correlated photon pair groups overlap.

~~19. The method of claim 18, wherein the spatially filtering comprises collecting into a single mode fiber.~~

9~~20~~. The method of claim~~s~~ 8~~18 or 19~~, wherein the combining step comprises using a birefringent crystal to introduce a displacement for overlapping the respective spatial distributions of the first and second correlated photon pairs.

~~21. The method of any one of claims 1 to 20, comprising the step of generating the correlated photon pairs.~~

10~~22~~. A module for converting position or momentum correlation of correlated photon pairs to a polarization entangled photon pair, the module comprising:

a polarization optics for rotating the polarization of a first group of the correlated photon pairs such that a polarization of the first correlated photon pair group is at 90 degrees relative to a second group of the correlated photon pairs; and

a combiner for combining the first and second correlated photon pair groups such that at least respective portions of respective spatial distributions of the first and second photon pair groups overlap with negligible wavelength dependent phase difference.

wherein the first and second correlated photon pair groups are generated in first and second portions a photon generation distribution of a single pump beam in a crystal or have different directions about the propagation axis.

11~~23~~. The module of claim 10~~22~~, wherein the module comprises ~~a~~an imaging optic and a wedge mirror, the focusing optic configured for focusing a generation plane of the first and second correlated photon pair groups onto a wedge mirror for splitting the first and second correlated photon pair groups onto first and second paths, respectively.

12~~24~~. The module of claim 11~~23~~, wherein the first and second paths comprise different respective sets of mirrors in an interferometer configuration or wherein the first and second paths comprise a same set of mirrors in a folded interferometer configuration, or

wherein the polarization optics comprises a half wave plate at 45 degrees in the first path, a half wave plate at 0 degrees in the second path to equalize respective path lengths of the first and second paths, or both the half wave plates.

~~25. The module of claim 23, wherein the first and second paths comprise a same set of mirrors in a folded interferometer configuration.~~

~~26. The module of any one of claims 23 to 25, wherein the polarization optics comprises a half wave plate at 45 degrees in the first path.~~

~~27. The module of claim 26, wherein the polarization optics comprises a half wave plate at 0 degrees in the second path to equalize respective path lengths of the first and second paths.~~

~~28. The module of any one of claims 22 to 27, wherein the combiner comprises a polarization beam splitter, PBS.~~

13~~29~~. The module of ~~any one of~~ claim~~s~~ 10~~22 to 28~~, wherein the combiner comprises an optical element for flipping the spatial distribution of the first or second correlated photon pair groups such that substantially the entire respective spatial distributions of the first and second correlated photon pair groups overlap, and a compensator for equlizing respective path lengths of the first and second correlated photon pair group.

~~30. The module of claim 29, wherein the optical element for flipping comprises a dove prism.~~

~~31. The module of claims 29 or 30, further comprising a compensator for compensating an additional path length caused by the flipping.~~

~~32. The module of claim 31, wherein the compensator comprises a glass block.~~

14~~33~~. The module of ~~any one of~~ claim~~s~~ 10~~22 to 32~~, wherein the combiner comprises a filter for spatially filtering the first and second correlated photon pair groups to erase spatial information such that the respective portions of the respective spatial distributions of the first and second correlated photon pair groups overlap.

~~34. The method of claim 33, wherein the filter comprises a pinhole or a single mode fiber.~~

15~~35~~. The module of claim 10~~22~~, wherein pairs of the first and second correlated photon pair groups are each position correlated, and the polarization optics are configured for rotating the polarization of the first correlated photon pair generated in a first portion of a photon generation distribution and within a Rayleigh range of the first and second correlated photon pair groups.

~~36. The module of claim 35, wherein the first portion is substantially one half of the photon generation distribution.~~

16~~37~~. The module of claim 10~~22~~, wherein pairs of the first and second correlated photon pair groups are each momentum correlated, and the polarization optics are configured for rotating the polarization of the first correlated photon pair generated in a first portion of a photon generation distribution and outside a Rayleigh range of the first and second correlated photon pair groups.

~~38. The module of claim 37, wherein the first portion is substantially one half of the photon generation distribution.~~

~~39. The module of any one of claims 35 to 38, wherein the polarization optics comprise a segmented half wave plate.~~

17~~40~~. The module of ~~any one of claims 35 to 39~~claim 22, wherein the combiner comprises a filter for spatially filtering the first and second correlated photon pair groups to erase spatial information such that the respective portions of the respective spatial distributions of the first and second correlated photon pair groups overlap, a birefringent crystal to introduce a

displacement for overlapping the respective spatial distributions of the first and second correlated photon pair groups, or both the filter and the birefringent crystal.

~~41. The module of claim 40, wherein the filter comprises a single mode fiber.~~

~~42. The module of claims 40 or 41, wherein the combiner comprises a birefringent crystal to introduce a displacement for overlapping the respective spatial distributions of the first and second correlated photon pair groups.~~

~~43. The method of any one of claims 22 to 42, comprising a source for generating the correlated photon pairs.~~

18~~44~~. A source for generating polarization entangled photon pairs, comprising the module of ~~any one of~~ claim~~s~~ 10~~22 to 43~~.

19. A method of converting position or momentum correlation of correlated photon pairs to a polarization entangled photon pair, the method comprising:

a conversion step of separating the correlated photon pairs into first and second groups based on their generated position at the crystal or based on their direction about the propagation axis and rotating a polarization of the first correlated photon pair group such that the polarization of the first correlated pair group is at 90 degrees relative to the polarization of the second correlated photon pair group; and

a combining step of combining the first and second correlated photon pairs such that at least respective portions of respective spatial distributions of the first and second photon pair groups overlap with negligible wavelength dependent phase difference;

wherein the conversion step comprises imaging a generation plane of the correlated photon pairs onto a wedge mirror for splitting the first and second correlated photon pair groups onto first and second paths, respectively.

20. A module for converting position or momentum correlation of correlated photon pairs to a polarization entangled photon pair, the module comprising:

a polarization optics for rotating the polarization of a first group of the correlated photon pairs such that a polarization of the first correlated photon pair group is at 90 degrees relative to a second group of the correlated photon pairs;

a combiner for combining the first and second correlated photon pair groups such that at least respective portions of respective spatial distributions of the first and second photon pair groups overlap with negligible wavelength dependent phase difference; and

an imaging optic and a wedge mirror, the focusing optic configured for focusing a generation plane of the first and second correlated photon pair groups onto a wedge mirror for splitting the first and second correlated photon pair groups onto first and second paths, respectively.