CLAIMS

We claim:

1. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected.

2. The method of claim 1, wherein step (1) comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin, then defining a new signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin then defining a new signal spectral bin to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(ii) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

3. The method of claim 1, wherein step (1) comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin;

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin having:

(a) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(b) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin, defining a new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated

with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(a) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(b) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps,

defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energies associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy widths associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more

not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

4. The method of claim 1, wherein step (1) comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having an upper bound and a lower bound based on the central energy and energy width associated with the chosen photopeak;

(B) ordering the signal spectral bins from lowest lower bound to highest lower bound;

(C) choosing a signal spectral bin that has a lowest lower bound of all non-yet chosen signal spectral bins;

(D) if the chosen signal spectral bin overlaps with any other signal spectral bins:

(i) redefining the chosen signal spectral bin to have a lower bound equal to the lower bound of the chosen spectral bin and an upper bound equal to the highest upper bound of all the signal spectral bins that overlap the chosen bin;

(ii) deleting the signal spectral bins that overlap the chosen bin;

(iii) repeating step (D) based on the redefined chosen signal spectral bin; and

(E) repeating steps (C) and (D) until all signal spectral bins have been chosen.

5. The method of claim 1, wherein step (1) comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak;

(B) choosing a not-yet-chosen defined signal spectral bin;

(C) if the chosen defined signal spectral bin does not overlap with another defined signal spectral bin, then leaving the chosen defined signal spectral bin unchanged;

(D) if the chosen defined signal spectral bin does overlap with one or more other defined signal spectral bins then replacing both the chosen signal spectral bin and the overlapping other defined signal spectral bins with a new defined signal spectral bin having:

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen defined signal spectral bin and the one or more overlapping defined signal spectral bins; and

(ii) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen defined signal spectral bin and the one or more overlapping other defined signal spectral bins; and

and classifying the new defined signal spectral bin as chosen; and

(E) repeating steps (B) through (D) until each signal spectral bin on the predetermined list has been chosen.

6. The method of claim 1 further comprising:

if a plurality of signal spectral bins exists, that are associated only with a set of photopeaks all of which originate from a same single isotope, then replacing the plurality of signal spectral bins with a single non-contiguous signal spectral bin associated with all of the set of photopeaks.

7. The method of claim 1 wherein the associated energy width for a photopeak on the predetermined list is the full width at a predetermined fraction of the maximum of the spectrum of the photopeak.

8. The method of claim 1 wherein the associated energy width for a photopeak on the predetermined list is the calculated second moment of the spectrum of the photopeak.

9. The method of either of claims 2 or 3 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have any energy in common.

10. The method of either of claims 2 or 3 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have at least a predetermined fraction of the photopeak's included energies in common.

11. The method of claim 10 wherein the predetermined fraction is at least 10%.

12. The method of claim 10 wherein the predetermined fraction is at least 25%.

13. The method of claim 10 wherein the predetermined fraction is at least 50%.
14. The method of either of claims 4 or 5 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have any energy in common.
15. The method of either of claims 4 or 5 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have at least a predetermined fraction of the chosen signal spectral bin's included energies in common.
16. The method of claim 15 wherein the predetermined fraction is at least 10%.
17. The method of claim 15 wherein the predetermined fraction is at least 25%.
18. The method of claim 15 wherein the predetermined fraction is at least 50%.
19. The method of claim 1 wherein:

    step (2) includes collecting in the memory from the network of at least one detector background data associated with energies lying within three background spectral bins, one of which includes a 1461 keV photopeak of ^{40}K.
20. The method of claim 1 wherein:

    step (4) includes estimating an expected number of background counts in at least one defined signal spectral bin by fitting a multi-component, linear model to the collected background data and evaluating the linear model at the at least one defined signal spectral bin energies.
21. The method of claim 1 further comprising:

    (6) repeating steps (2), (3), (4) and (5) for a plurality of predetermined time intervals.
22. The method of claim 21 further comprising collecting in steps (2) and (3) each detector's location and velocity.
23. The method of claim 22 wherein step (4) includes a particle filter process for detecting at least one radiation source, the particle filter process comprising:

    if no ensemble exists, creating an ensemble of virtual particles, each virtual particle having at least an associated location, velocity and activity level; then

    for each virtual particle in the ensemble, computing a weight associated with the virtual particle, the weight being based on an estimate of a likelihood that the data collected in steps (2) and (3) originated from a radiation source having the location, velocity and activity level of the virtual particle; and then

determining whether the computed weights collectively meet a predetermined detection criterion.

24. The method of claim 23 further comprising collecting in steps (2) and (3) each detector's orientation, and angular velocity.

25. The method of either of claims 23 or 24 further comprising:

modifying the ensemble of virtual particles by deleting from the ensemble any virtual particles having an associated weight below a predetermined threshold; and

adding to the ensemble new virtual particles that are based on virtual particles having an associated weight above a predetermined threshold;

thereby creating a new ensemble of virtual particles.

26. The method of claim 25 wherein the new virtual particles are copies of randomly selected virtual particles having an associated weight above a predetermined threshold.

27. The method of any of claims 22-26 wherein step (4) further comprises determining a direction for at least one detector to move in during a subsequent predetermined time interval.

28. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including:

a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates; and

a predetermined list of a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list of photopeaks is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the

predetermined energy range with which no photopeak on the predetermined list of photopeaks is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list of photopeaks is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list of photopeaks is associated is referred to as a signal spectral bin;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(2) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(3) combining, in the processor, the collected background data and signal data, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(4) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected.

29. The method of claim 28, wherein the predetermined list of energy bins has been determined from the predetermined list of photopeaks by at least:

(A) choosing a not-yet-chosen photopeak from the predetermined list of photopeaks;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin, then defining a new signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin then defining a new signal spectral bin to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(ii) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak;

(D) repeating steps (A) through (C) until each photopeak on the predetermined list of photopeaks has been chosen; and

(E) listing the defined signal spectral bins along with at least one background spectral bin, thereby forming the predetermined list of energy bins.

30. The method of claim 28, wherein the predetermined list of energy bins has been determined from the predetermined list of photopeaks by at least:

(A) choosing a not-yet-chosen photopeak from the predetermined list of photopeaks;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin;

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin having:

(a) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(b) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin, defining a new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(a) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(b) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energies associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with

the defined signal spectral bins which the chosen photopeak overlaps, and the energy widths associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen;

(D) repeating steps (A) through (C) until each photopeak on the predetermined list of photopeaks has been chosen; and

(E) listing the defined signal spectral bins along with at least one background spectral bin, thereby forming the predetermined list of energy bins.

31. The method of claim 28, wherein the predetermined list of energy bins has been determined from the predetermined list of photopeaks by at least:

(A) for each photopeak on the predetermined list of photopeaks, defining a signal spectral bin having an upper bound and a lower bound based on the central energy and energy width associated with the chosen photopeak;

(B) ordering the signal spectral bins from lowest lower bound to highest lower bound;

(C) choosing a signal spectral bin that has a lowest lower bound of all non-yet chosen signal spectral bins;

(D) if the chosen signal spectral bin overlaps with any other signal spectral bins:

(i) redefining the chosen signal spectral bin to have a lower bound equal to the lower bound of the chosen spectral bin and an upper bound equal to the highest upper bound of all the signal spectral bins that overlap the chosen bin;

(ii) deleting the signal spectral bins that overlap the chosen bin;

(iii) repeating step (D) based on the redefined chosen signal spectral bin;

(E) repeating steps (C) and (D) until all signal spectral bins have been chosen; and

(F) listing the defined signal spectral bins along with at least one background spectral bin, thereby forming the predetermined list of energy bins.

32. The method of claim 28, wherein the predetermined list of energy bins has been determined from the predetermined list of photopeaks by at least:

(A) for each photopeak on the predetermined list of photopeaks, defining a signal spectral bin having:

(ia) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak;

(B) choosing a not-yet-chosen defined signal spectral bin;

(C) if the chosen defined signal spectral bin does not overlap with another defined signal spectral bin, then leaving the chosen defined signal spectral bin unchanged;

(D) if the chosen defined signal spectral bin does overlap with one or more other defined signal spectral bins then replacing both the chosen signal spectral bin and the overlapping other defined signal spectral bins with a new defined signal spectral bin having:

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen defined signal spectral bin and the one or more overlapping defined signal spectral bins; and

(ii) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen defined signal spectral bin and the one or more overlapping other defined signal spectral bins; and

and classifying the new defined signal spectral bin as chosen; and

(E) repeating steps (B) through (D) until each signal spectral bin on the predetermined list of photopeaks has been chosen; and

(F) listing the defined signal spectral bins along with at least one background spectral bin, thereby forming the predetermined list of energy bins.

33. The method of claim 28 further comprising:

if a plurality of signal spectral bins exists, that are associated only with a set of photopeaks all of which originate from a same single isotope, then replacing the plurality of signal spectral bins with a single non-contiguous signal spectral bin associated with all of the set of photopeaks.

34. The method of claim 28 wherein the associated energy width for a photopeak on the predetermined list is the full width at a predetermined fraction of the maximum of the spectrum of the photopeak.

35. The method of claim 28 wherein the associated energy width for a photopeak on the predetermined list is the calculated second moment of the spectrum of the photopeak.

36. The method of either of claims 29 or 30 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have any energy in common.

37. The method of either of claims 29 or 30 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have at least a predetermined fraction of the photopeak's included energies in common.

38. The method of claim 37 wherein the predetermined fraction is at least 10%.

39. The method of claim 37 wherein the predetermined fraction is at least 25%.

40. The method of claim 37 wherein the predetermined fraction is at least 50%.

41. The method of either of claims 31 or 32 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have any energy in common.

42. The method of either of claims 31 or 32 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have at least a predetermined fraction of the chosen signal spectral bin's included energies in common.

43. The method of claim 42 wherein the predetermined fraction is at least 10%.

44. The method of claim 42 wherein the predetermined fraction is at least 25%.

45. The method of claim 42 wherein the predetermined fraction is at least 50%.

46. The method of claim 28 wherein:

step (1) includes collecting in the memory from the network of at least one detector background data associated with energies lying within three background spectral bins, one of which includes a 1461 keV photopeak of ^{40}K.

47. The method of claim 28 wherein:

step (3) includes estimating an expected number of background counts in at least one defined signal spectral bin by fitting a multi-component, linear model to the collected background data and evaluating the linear model at the at least one defined signal spectral bin energies.

48. The method of claim 28 further comprising:

(5) repeating steps (1), (2), (3) and (4) for a plurality of predetermined time intervals.

49. The method of claim 48 further comprising collecting in steps (1) and (2) each detector's location and velocity.

50. The method of claim 49 wherein step (3) includes a particle filter process for detecting at least one radiation source, the particle filter process comprising:

if no ensemble exists, creating an ensemble of virtual particles, each virtual particle having at least an associated location, velocity and activity level; then

for each virtual particle in the ensemble, computing a weight associated with the virtual particle, the weight being based on an estimate of a likelihood that the data collected in steps (2) and (3) originated from a radiation source having the location, velocity and activity level of the virtual particle; and then

determining whether the computed weights collectively meet a predetermined detection criterion.

51. The method of claim 50 further comprising collecting in steps (1) and (2) each detector's orientation, and angular velocity.

52. The method of either of claims 50 or 51 further comprising:

modifying the ensemble of virtual particles by deleting from the ensemble any virtual particles having an associated weight below a predetermined threshold; and

adding to the ensemble new virtual particles that are based on virtual particles having an associated weight above a predetermined threshold;

thereby creating a new ensemble of virtual particles.

53. The method of claim 52 wherein the new virtual particles are copies of randomly selected virtual particles having an associated weight above a predetermined threshold.

54. The method of any of claims 49-53 wherein step (3) further comprises determining a direction for at least one detector to move in during a subsequent predetermined time interval.

55. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin.

56. The method of claim 55, wherein defining a plurality of energy bins comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin, then defining a new signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin then defining a new signal spectral bin to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(ii) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

57. The method of claim 55, wherein defining a plurality of energy bins comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin;

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin having:

(a) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(b) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin, defining a new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(a) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(b) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energies associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy widths associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

58. The method of claim 55, wherein defining a plurality of energy bins comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having an upper bound and a lower bound based on the central energy and energy width associated with the chosen photopeak;

(B) ordering the signal spectral bins from lowest lower bound to highest lower bound;

(C) choosing a signal spectral bin that has a lowest lower bound of all non-yet chosen signal spectral bins;

(D) if the chosen signal spectral bin overlaps with any other signal spectral bins:

(i) redefining the chosen signal spectral bin to have a lower bound equal to the lower bound of the chosen spectral bin and an upper bound equal to the highest upper bound of all the signal spectral bins that overlap the chosen bin;

(ii) deleting the signal spectral bins that overlap the chosen bin;

(iii) repeating step (D) based on the redefined chosen signal spectral bin; and

(E) repeating steps (C) and (D) until all signal spectral bins have been chosen.

59. The method of claim 55, wherein defining a plurality of energy bins comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak;

(B) choosing a not-yet-chosen defined signal spectral bin;

(C) if the chosen defined signal spectral bin does not overlap with another defined signal spectral bin, then leaving the chosen defined signal spectral bin unchanged;

(D) if the chosen defined signal spectral bin does overlap with one or more other defined signal spectral bins then replacing both the chosen signal spectral

bin and the overlapping other defined signal spectral bins with a new defined signal spectral bin having:

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen defined signal spectral bin and the one or more overlapping defined signal spectral bins; and

(ii) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen defined signal spectral bin and the one or more overlapping other defined signal spectral bins; and

and classifying the new defined signal spectral bin as chosen; and

(E) repeating steps (B) through (D) until each signal spectral bin on the predetermined list has been chosen.

60. The method of claim 55 further comprising:

if a plurality of signal spectral bins exists, that are associated only with a set of photopeaks all of which originate from a same single isotope, then replacing the plurality of signal spectral bins with a single non-contiguous signal spectral bin associated with all of the set of photopeaks.

61. The method of claim 55 wherein the associated energy width for a photopeak on the predetermined list is the full width at a predetermined fraction of the maximum of the spectrum of the photopeak.

62. The method of claim 55 wherein the associated energy width for a photopeak on the predetermined list is the calculated second moment of the spectrum of the photopeak.

63. The method of either of claims 56 or 57 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have any energy in common.

64. The method of either of claims 56 or 57 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have at least a predetermined fraction of the photopeak's included energies in common.

65. The method of claim 64 wherein the predetermined fraction is at least 10%.

66. The method of claim 64 wherein the predetermined fraction is at least 25%.

67. The method of claim 64 wherein the predetermined fraction is at least 50%.

68. The method of either of claims 58 or 59 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have any energy in common.

69. The method of either of claims 58 or 59 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have at least a predetermined fraction of the chosen signal spectral bin's included energies in common.

70. The method of claim 69 wherein the predetermined fraction is at least 10%.

71. The method of claim 69 wherein the predetermined fraction is at least 25%.

72. The method of claim 69 wherein the predetermined fraction is at least 50%.

73. 1. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin;

wherein an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(3) combining, in the processor, collected signal data from at least one signal spectral bin, and an estimate of the background radiation in the at least one signal spectral bin, and thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(4) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected.

74. The method of claim 73 wherein:

step (1) further comprises defining at least one energy bin associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

the method further comprises collecting, in the memory, from the network of at least one detector, during the predetermined time interval, background data associated with energies lying within the one or more background spectral bins; and

the estimate of the background radiation is based on collected background data from at least one background spectral bin.

75. The method of claim 73 wherein the estimate of the background radiation is based on guard bands defined on other side of each of the at least one signal spectral bin.

76. The method of claim 73 wherein the estimate of the background radiation is based on erosion.

CLAIMS

1. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected,

wherein step (1) comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin, then defining a new signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin then defining a new signal spectral bin to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(ii) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

2. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected,

wherein step (1) comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin;

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin having:

(a) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(b) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin, defining a new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, defining a new signal spectral bin, to replace the at least one

overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(a) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(b) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal

spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energies associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy widths associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen

photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

3. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected,

wherein step (1) comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having an upper bound and a lower bound based on the central energy and energy width associated with the chosen photopeak;

(B) ordering the signal spectral bins from lowest lower bound to highest lower bound;

(C) choosing a signal spectral bin that has a lowest lower bound of all non-yet chosen signal spectral bins;

(D) if the chosen signal spectral bin overlaps with any other signal spectral bins:

(i) redefining the chosen signal spectral bin to have a lower bound equal to the lower bound of the chosen spectral bin and an upper bound equal to the highest upper bound of all the signal spectral bins that overlap the chosen bin;

(ii) deleting the signal spectral bins that overlap the chosen bin;

(iii) repeating step (D) based on the redefined chosen signal spectral bin; and

(E) repeating steps (C) and (D) until all signal spectral bins have been chosen.

4. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected,

wherein step (1) comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak;

(B) choosing a not-yet-chosen defined signal spectral bin;

(C) if the chosen defined signal spectral bin does not overlap with another defined signal spectral bin, then leaving the chosen defined signal spectral bin unchanged;

(D) if the chosen defined signal spectral bin does overlap with one or more other defined signal spectral bins then replacing both the chosen signal spectral bin and the overlapping other defined signal spectral bins with a new defined signal spectral bin having:

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen defined signal spectral bin and the one or more overlapping defined signal spectral bins; and

(ii) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen defined signal spectral bin and the one or more overlapping other defined signal spectral bins; and

and classifying the new defined signal spectral bin as chosen; and

(E) repeating steps (B) through (D) until each signal spectral bin on the predetermined list has been chosen.

5. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

(1) defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin;

(2) collecting, in the memory, from the network of at least one detector, during a predetermined time interval, background data associated with energies lying within the one or more background spectral bins;

(3) collecting, in the memory, from the network of at least one detector, during the predetermined time interval, signal data associated with energies lying within at least one signal spectral bin;

(4) combining, in the processor, at least collected background data from at least one background spectral bin and collected signal data from at least one signal

spectral bin, thereby determining whether at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval; and

(5) if at least one radiation source has been detected in at least one signal spectral bin in the predetermined time interval, outputting through the output device an indication that at least one radiation source has been detected;

if a plurality of signal spectral bins exists, that are associated only with a set of photopeaks all of which originate from a same single isotope, then replacing the plurality of signal spectral bins with a single non-contiguous signal spectral bin associated with all of the set of photopeaks.

6. The method of claim 1 wherein the associated energy width for a photopeak on the predetermined list is the full width at a predetermined fraction of the maximum of the spectrum of the photopeak.

7. The method of claim 1 wherein the associated energy width for a photopeak on the predetermined list is the calculated second moment of the spectrum of the photopeak.

8. The method of either of claims 1 or 2 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have any energy in common.

9. The method of either of claims 1 or 2 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have at least a predetermined fraction of the photopeak's included energies in common.

10. The method of claim 9 wherein the predetermined fraction is at least 10%.

11. The method of claim 9 wherein the predetermined fraction is at least 25%.

12. The method of claim 9 wherein the predetermined fraction is at least 50%.

13. The method of either of claims 3 or 4 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have any energy in common.

14. The method of either of claims 3 or 4 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have at least a predetermined fraction of the chosen signal spectral bin's included energies in common.

15. The method of claim 14 wherein the predetermined fraction is at least 10%.

16. The method of claim 14 wherein the predetermined fraction is at least 25%.

17. The method of claim 14 wherein the predetermined fraction is at least 50%.

18. The method of claim 1 wherein:

step (2) includes collecting in the memory from the network of at least one detector background data associated with energies lying within three background spectral bins, one of which includes a 1461 keV photopeak of ^{40}K.

19. The method of claim 1 wherein:

step (4) includes estimating an expected number of background counts in at least one defined signal spectral bin by fitting a multi-component, linear model to the collected background data and evaluating the linear model at the at least one defined signal spectral bin energies.

20. The method of claim 1 further comprising:

(6) repeating steps (2), (3), (4) and (5) for a plurality of predetermined time intervals.

21. The method of claim 20 further comprising collecting in steps (2) and (3) each detector's location and velocity.

22. The method of claim 21 wherein step (4) includes a particle filter process for detecting at least one radiation source, the particle filter process comprising:

if no ensemble exists, creating an ensemble of virtual particles, each virtual particle having at least an associated location, velocity and activity level; then

for each virtual particle in the ensemble, computing a weight associated with the virtual particle, the weight being based on an estimate of a likelihood that the data collected in steps (2) and (3) originated from a radiation source having the location, velocity and activity level of the virtual particle; and then

determining whether the computed weights collectively meet a predetermined detection criterion.

23. The method of claim 22 further comprising collecting in steps (2) and (3) each detector's orientation, and angular velocity.

24. The method of either of claims 22 or 23 further comprising:

modifying the ensemble of virtual particles by deleting from the ensemble any virtual particles having an associated weight below a predetermined threshold; and

adding to the ensemble new virtual particles that are based on virtual particles having an associated weight above a predetermined threshold;

thereby creating a new ensemble of virtual particles.

25. The method of claim 24 wherein the new virtual particles are copies of randomly selected virtual particles having an associated weight above a predetermined threshold.

26. The method of any of claims 21-25 wherein step (4) further comprises determining a direction for at least one detector to move in during a subsequent predetermined time interval.

27. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin,

wherein defining a plurality of energy bins comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin, then defining a new signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin then defining a new signal spectral bin to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(ii) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

28. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin,

wherein defining a plurality of energy bins comprises:

(A) choosing a not-yet-chosen photopeak from the predetermined list;

(B) if the chosen photopeak does not overlap with a defined signal spectral bin;

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin having:

(a) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(b) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin, defining a new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with

the chosen photopeak and the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(C) if the chosen photopeak overlaps with at least one defined signal spectral bin

(i) then if the chosen photopeak does not overlap with any not-yet-chosen photopeak, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, the new signal spectral bin having

(a) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energy associated with the chosen photopeak, and

(b) a new signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy width associated with the chosen photopeak; and

(ii) then if the chosen photopeak overlaps with one or more not-yet-chosen photopeaks, determining whether any of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, and

(a) if none of the overlapping not-yet-chosen photopeaks overlaps with a defined signal spectral bin in addition to the defined signal spectral bins which the chosen photopeak overlaps, defining a new signal spectral bin, to replace the at least one defined signal spectral bin which the chosen photopeak overlaps, having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the defined signal spectral bins which the chosen photopeak overlaps, and the central energies associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the defined signal spectral bins which the chosen photopeak overlaps, and the energy widths associated with the chosen photopeak and with the one or more not-yet-chosen photopeaks overlapping the chosen photopeak; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(b) if at least one of the overlapping not-yet-chosen photopeaks overlaps with at least one defined signal spectral bin in addition to the defined signal spectral bins which the chosen

photopeak overlaps, defining a new signal spectral bin, to replace the at least one overlapping defined signal spectral bin, the new signal spectral bin having

(I) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

(II) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen photopeak, the one or more not-yet-chosen photopeaks overlapping the chosen photopeak, and the at least one overlapping defined signal spectral bin; and

classifying the not-yet-chosen photopeaks overlapping the chosen photopeak as chosen; and

(D) repeating steps (A) through (C) until each photopeak on the predetermined list has been chosen.

29. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin,

wherein defining a plurality of energy bins comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having an upper bound and a lower bound based on the central energy and energy width associated with the chosen photopeak;

(B) ordering the signal spectral bins from lowest lower bound to highest lower bound;

(C) choosing a signal spectral bin that has a lowest lower bound of all non-yet chosen signal spectral bins;

(D) if the chosen signal spectral bin overlaps with any other signal spectral bins:

(i) redefining the chosen signal spectral bin to have a lower bound equal to the lower bound of the chosen spectral bin and an upper bound equal to the highest upper bound of all the signal spectral bins that overlap the chosen bin;

(ii) deleting the signal spectral bins that overlap the chosen bin;

(iii) repeating step (D) based on the redefined chosen signal spectral bin; and

(E) repeating steps (C) and (D) until all signal spectral bins have been chosen.

30. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin,

wherein defining a plurality of energy bins comprises:

(A) for each photopeak on the predetermined list, defining a signal spectral bin having:

(i) an associated signal spectral bin central energy equal to the central energy associated with the chosen photopeak; and

(ii) an associated signal spectral bin energy width equal to the energy width associated with the chosen photopeak;

(B) choosing a not-yet-chosen defined signal spectral bin;

(C) if the chosen defined signal spectral bin does not overlap with another defined signal spectral bin, then leaving the chosen defined signal spectral bin unchanged;

(D) if the chosen defined signal spectral bin does overlap with one or more other defined signal spectral bins then replacing both the chosen signal spectral bin and the overlapping other defined signal spectral bins with a new defined signal spectral bin having:

(i) an associated signal spectral bin central energy based on a combination of the central energies associated with the chosen defined signal spectral bin and the one or more overlapping defined signal spectral bins; and

(ii) an associated signal spectral bin energy width based on a combination of the energy widths associated with the chosen defined signal spectral bin and the one or more overlapping other defined signal spectral bins; and

and classifying the new defined signal spectral bin as chosen; and

(E) repeating steps (B) through (D) until each signal spectral bin on the predetermined list has been chosen.

31. A method of detecting a radiation source using:

a network of at least one detector, each detector being capable of detecting photons in a predetermined energy range; and

a computer including:

a processor;

an input device;

an output device; and

a memory, the memory including a predetermined list of a plurality of photopeaks, the list including for each photopeak an associated central energy, an associated energy width, and an associated isotope from which the photopeak originates;

the computer being capable of receiving by the input device and storing in the memory data collected at each of the detectors;

the method comprising:

defining a plurality of energy bins within the predetermined energy range, such that each of the plurality of photopeaks on the predetermined list is associated with exactly one energy bin, and at least one energy bin is associated with an energy range within the predetermined energy range with which no photopeak on the predetermined list is associated;

wherein:

an energy bin associated with an energy range with which no photopeak on the predetermined list is associated is referred to as a background spectral bin; and

an energy bin with which at least one photopeak on the predetermined list is associated is referred to as a signal spectral bin,

if a plurality of signal spectral bins exists, that are associated only with a set of photopeaks all of which originate from a same single isotope, then replacing the plurality of signal spectral bins with a single non-contiguous signal spectral bin associated with all of the set of photopeaks.

32. The method of claim 27 wherein the associated energy width for a photopeak on the predetermined list is the full width at a predetermined fraction of the maximum of the spectrum of the photopeak.

33. The method of claim 27 wherein the associated energy width for a photopeak on the predetermined list is the calculated second moment of the spectrum of the photopeak.

34. The method of either of claims 27 or 28 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have any energy in common.

35. The method of either of claims 27 or 28 wherein a photopeak and a defined signal spectral bin are determined to overlap if the photopeak and defined signal spectral bin have at least a predetermined fraction of the photopeak's included energies in common.

36. The method of claim 35 wherein the predetermined fraction is at least 10%.

37. The method of claim 35 wherein the predetermined fraction is at least 25%.

38. The method of claim 35 wherein the predetermined fraction is at least 50%.

39. The method of either of claims 29 or 30 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have any energy in common.

40. The method of either of claims 29 or 30 wherein the chosen signal spectral bin and a defined signal spectral bin are determined to overlap if the chosen signal spectral bin and the defined signal spectral bin have at least a predetermined fraction of the chosen signal spectral bin's included energies in common.

41. The method of claim 40 wherein the predetermined fraction is at least 10%.

42. The method of claim 40 wherein the predetermined fraction is at least 25%.

43. The method of claim 40 wherein the predetermined fraction is at least 50%.