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(54) **DETECTOR ARRAY FOR IMAGING** (56) **MODALITY**

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(21) Appl. No.: $15/307,938$ (Continued)

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(57) ABSTRACT

A detector array such as for use in a radiation imaging modality is provided . The detector array includes a first pixel $(302a)$ having a first scintillator (402) . The first scintillator has a first detection surface (408) and a first light emission surface (412). The first detection surface extends along a first detection surface plane and the first light emission The detector array includes a second pixel $(302b)$ having a second scintillator (420). The second scintillator has a second detection surface (426) and a second light emission surface (430). The second detection surface extends along a second detection surface plane and the second light emission surface extends along a second light emission surface plane. At least one of the first detection surface plane is not coplanar with the second detection surface plane or the first light emission surface plane is not coplanar with the second light emission surface plane.

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FIG. 1

 $106 -$

FIG. 2

FIG. 3

FIG. 8b

$$
^{800}\sim
$$

 $1000 -$

 \mathbf{z} -→

FIG. 10b

 \mathbf{z} –

FIG. 11b

FIG. 12b

 $z \rightarrow$

 $FIG. 13$

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BRIEF SUMMARY

TECHNICAL FIELD

array with pixels having varying thicknesses or defining a non-planar surface. It finds particular application in the field array comprises a first pixel comprising a first scintillator of computed tomography (CT) imaging utilized in medical, configured to convert a first radiatio of computed tomography (CT) imaging utilized in medical, configured to convert a first radiation photon into first light
security, and/or industrial applications, for example. How-
energy. The first scintillator comprises ever, it also relates to other radiation modalities where a 20 detector array is used.

mation, or images, of interior aspects of an object under
examination photon into second light energy.
examination. Generally, the object is exposed to radiation
the second scintillator comprises a second detection surface based upon the radiation absorbed and/or attenuated by the 30 scintillator and a second light emission surface through interior aspects of the object, or rather an amount of radia-
which the second light energy exits the s interior aspects of the object, or rather an amount of radia-
tion photons that is able to pass through the object. Typi-
The second detection surface extends along a second detec-
cally, highly dense aspects of the object cally, highly dense aspects of the object (or aspects of the tion surface plane and the second light emission surface object having a composition comprised of higher atomic extends along a second light emission surface pla number elements in the case of dual-energy) absorb and/or 35 attenuate more radiation than less dense aspects, and thus an the second detection surface plane or the first light emission aspect having a higher density (and/or high atomic number surface plane is not coplanar with the aspect having a higher density (and/or high atomic number surface plane is not coplanar with the second light emission elements), such as a bone or metal, for example, will be surface plane. apparent when surrounded by less dense aspects, such as
According to another aspect, a detector array for detecting
muscle or clothing.
40 radiation photons comprises a first scintillator configured to

other things, one or more radiation sources (e.g., an X-ray first scintillator comprises a first detection surface through source, Gamma-ray source, etc.) and a detector array com-
which the first radiation photon enters t source, Gamma-ray source, etc.) and a detector array com-
prised of a plurality of pixels that are respectively configured and a first light emission surface through which the first light to convert radiation that has traversed the object into signals 45 energy exits the first scintillator. The first light emission that may be processed to produce the image(s). As an object surface extends along a first lig is passed through an examination region defined between the The detector array comprises a second scintillator configration source(s) and the detector array, radiation is ured to convert a second radiation photon into seco

amount/energy of radiation detected by the detector array. 50 It is desired to detect most, if not all, of the radiation that It is desired to detect most, if not all, of the radiation that second scintillator and a second light emission surface
passes through the object (e.g., to produce a higher fidelity through which the second light energy ex image). However, only a portion of the X-ray dose passing scintillator. The second detection surface extends along a through the object is detected or measured by the detector second detection surface plane. The first ligh array due to the presence of cross-talk inhibiting reflective 55 material located between adjacent scintillators of the detecmaterial located between adjacent scintillators of the detec-
the second detection surface plane does not intersect the first
tor array, where radiation that impinges upon the reflective
scintillator. material goes undetected or unmeasured. It is not uncom-
 $\frac{1}{25\%}$ are reflective scintillator configured to
 $\frac{1}{25\%}$ of the radiation that passes through the
 $\frac{1}{25\%}$ another aspect, a detector array for det object to impinge upon the reflective material (e.g., instead 60 convert a first radiation photon into first light energy. The of the active/scintillator material) and thus go undetected. first scintillator comprises a fir of the active/scintillator material) and thus go undetected.

objects scanned by a radiation system. Z_{eff} is a material energy exits the first scintillator. The first scintillator has a property that allows threat materials to be distinguished 65 first scintillator thickness betwe property that allows threat materials to be distinguished 65 first scintillator thickness between the first detection surface from benign materials (e.g., by providing a metric to dif- and the first light emission surface.

DETECTOR ARRAY FOR IMAGING X-rays having more than one distinct X-ray spectra (e.g., \blacksquare MODALITY corresponding to more than one distinct photon energy) are used to measure Z_{eff} (e.g., where photons of different ener-CROSS-REFERENCE TO RELATED gies are attenuated differently by the same material to yield
APPLICATIONS 5 an indication of a characteristic of the material). While some an indication of a characteristic of the material). While some detector arrays are configured to detect two distinct photon This application is a national phase entry under 35 U.S.C. energies, such as detector arrays that implement photon § 371 of International Patent Application PCT/US2014/ counting technologies and/or sandwich technologies (e

Aspects of the present application address the above The present application relates to a radiation detector 15 matters, and others. According to one aspect, a detector array ray with pixels having varying thicknesses or defining a is provided for detecting radiation photons first scintillator and a first light emission surface through which the first light energy exits the first scintillator. The first BACKGROUND detection surface extends along a first detection surface plane and the first light emission surface extends along a first Today, CT and other imaging modalities (e.g., mammog- 25 light emission surface plane. The detector array comprises a raphy, digital radiography, etc.) are useful to provide infor-second pixel comprising a second scintilla second pixel comprising a second scintillator configured to through which the second radiation photon enters the second
scintillator and a second light emission surface through extends along a second light emission surface plane. At least
one of the first detection surface plane is not coplanar with

uscle or clothing.

Radiation imaging modalities generally comprise, among a convert a first radiation photon into first light energy. The Radiation imaging modalities generally comprise, among convert a first radiation photon into first light energy. The other things, one or more radiation sources (e.g., an X-ray first scintillator comprises a first detectio and a first light emission surface through which the first light emergy exits the first scintillator. The first light emission absorbed/attenuated by the object, causing changes in the energy. The second scintillator comprises a second detection amount/energy of radiation detected by the detector array. 50 surface through which the second radiatio through which the second light energy exits the second second detection surface plane. The first light emission surface plane does not intersect the second scintillator and

radiation photons comprises a first scintillator configured to convert a first radiation photon into first light energy. The Moreover, in some applications (e.g., security) it is also which the first radiation photon enters the first scintillator beneficial to obtain an effective atomic number (Z_{eff}) of and a first light emission surface t ferentiate objects having similar density characteristics). comprises a second scintillator configured to convert a

second radiation photon into second light energy. The sec-

FIG. $9a$ illustrates a perspective view of a portion of an

ond scintillator comprises a second detection surface

example detector array. ond scintillator comprises a second detection surface through which the second radiation photon enters the second
scintillator and a second light emission surface through
which the second light emergy exits the second scintillator.
The second scintillator has a second scintil The second scintillator has a second scintillator thickness example detector array.

between the second detection surface and the second light $FIG. 10b$ illustrates a side view of a portion of an example emission surface.

According to another aspect, a detector array configured $\frac{10 \text{ example}}{\text{FIG. 11b}$ illustrates a side view of a portion of an example to detect radiation photons comprises a first pixel comprision and example

ing a first direct conversion material configured to convert a

first radiation photon into a first electrical charge. The first

direct conversio detection surface plane and the first emission surface 20 DETAILED DESCRIPTION extends along a first emission surface plane. The detector array also comprises a second pixel comprising a second The claimed subject matter is now described with refer-
direct conversion material configured to convert a second ence to the drawings, wherein like reference numeral direct conversion material configured to convert a second ence to the drawings, wherein like reference numerals are radiation photon into a second electrical charge. The second generally used to refer to like elements thro radiation photon into a second electrical charge. The second generally used to refer to like elements throughout. In the direct conversion material comprises a second detection 25 following description, for purposes of exp direct conversion material comprises a second detection 25 following description, for purposes of explanation, numer-
surface through which the second radiation photon enters the ous specific details are set forth in order surface through which the second radiation photon enters the second direct conversion material and a second emission thorough understanding of the claimed subject matter. It surface through which the second electrical charge exits the may be evident, however, that the claimed subjec surface through which the second electrical charge exits the may be evident, however, that the claimed subject matter second direct conversion material. The second detection may be practiced without these specific details. second direct conversion material. The second detection may be practiced without these specific details. In other
surface extends along a second detection surface plane and 30 instances, structures and devices are illustra surface extends along a second detection surface plane and 30 instances, structures and devices are illustrated in block
the second emission surface extends along a second emis-
diagram form in order to facilitate describi the second emission surface extends along a second emis-
sion surface plane. At least one of the first detection surface subject matter. sion surface plane. At least one of the first detection surface subject matter.

plane is not coplanar with the second detection surface plane FIG. 1 is an illustration of an example environment 100

or the first emission or the first emission surface plane is not coplanar with the second emission surface plane.

FIG. 1 illustrates an example environment of an imaging modality.

imaging modality. The functional contrates a functional CT of a helical CT of an example environment 100, an examination unit

FIG. 4a illustrates a perspective view of a portion of an example detector array.

ent than the first scintillator thickness.

According to another array configured 10 example detector array.

be configured to generate data (e.g., images) representative of an object 102 or aspect(s) thereof under examination. It Those of ordinary skill in the art will appreciate still other of an object 102 or aspect(s) thereof under examination. It needs of the present application upon reading and under- will be appreciated that the features d aspects of the present application upon reading and under-
standing the appended description the standing the appended description.
 $\frac{1}{2}$ find applicability to other imaging modality besides the example computed tomography (CT) scanner illustrated in BRIEF DESCRIPTION OF THE DRAWINGS 40 FIG. 1. For example, pixels may find applicability to other types of imaging modalities, such as line scanners and/or The application is illustrated by way of example and not other systems comprising an indirect conversation detector limitation in the figures of the accompanying drawings, in array. Moreover, the arrangement of components array. Moreover, the arrangement of components and/or the which like references generally indicate similar elements types of components included in the example environment and in which: $\frac{45}{100}$ are for illustrative purposes only. For example, as will 100 are for illustrative purposes only. For example, as will be described in more detail below, at least a portion of a data odality.
FIG. 2 illustrates a functional diagram of a helical CT of a detector array 106.

FIG. 3 illustrates a top down view of a portion of an 50 of the imaging modality is configured to examine one or example detector array. more objects 102 . The examination unit 108 can comprise a rotating gantry 104 and a (stationary) support structure 110 ample detector array.

FIG. 4b illustrates a side view of a portion of an example the rotating gantry 104 (e.g., as illustrated with an outer, detector array.

FIG. 5a illustrates a perspective view of a portion of an

example detector array.

EVG. 5b illustrates a side view of a portion of an example

FIG. 5b illustrates a side view of a portion of an example

e as a bed or conveyor belt, for example, that is selectively detector array.
FIG. 6 illustrates a side view of a portion of an example ω in the rotating gantry 104), and the rotating gantry 104 can FIG. 6 illustrates a side view of a portion of an example ω in the rotating gantry 104), and the rotating gantry 104 can detector array. detector array.
FIG. 7 illustrates a top down view of a portion of an rotator 116, such as a motor, drive shaft, chain, roller truck,

example detector array.

FIG. 8a illustrates a perspective view of a portion of an

examination region 114 and may comprise one or more

example detector array. ample detector array.
FIG. 8b illustrates a side view of a portion of an example radiation sources 118 (e.g., an ionizing X-ray source, gamma FIG. 8b illustrates a side view of a portion of an example radiation sources 118 (e.g., an ionizing X-ray source, gamma detector array. radiation source, etc.) and a detector array 106, comprised of that is mounted on a substantially diametrically opposite can inspect the image(s) to identify areas of interest within side of the rotating gantry 104 relative to the radiation the object(s) 102. The terminal 126 can a side of the rotating gantry 104 relative to the radiation the object(s) 102. The terminal 126 can also be configured source(s) 118.

radiation 120 configurations from a focal spot(s) of the In the example environment 100, a controller 132 is radiation source(s) 118 (e.g., a point within the radiation operably coupled to the terminal 126. In an example, source(s) 118 from which radiation 120 emanates) into the controller 132 is configured to receive user input from the examination region 114. It will be appreciated that such 10 terminal 126 and generate instructions for examination region 114. It will be appreciated that such 10 terminal 126 and generate instructions for the examination 120 may be emitted substantially continuously unit 108 indicative of operations to be performed. and/or may be emitted intermittently (e.g., a brief pulse of It will be appreciated that the example component diaradiation is emitted followed by a resting period during gram is merely intended to illustrate one embodiment of one which the radiation source 118 is not activated). type of imaging modality and is not intended to be inte

As the emitted radiation 120 traverses the object($\frac{s}{s}$) 102, 15 the radiation 120 may be attenuated differently by different the radiation 120 may be attenuated differently by different one or more components described herein may be separated aspects of the object(s) 102. Because different aspects into a plurality of components and/or the functi attenuate different percentages of the radiation 120 , an more components described herein may be consolidated into image(s) may be generated based upon the attenuation, or merely a single component. Moreover, the imagin variations in the number of photons that are detected by the 20 may comprise additional components to perform additional detector array 106. For example, more dense aspects of the features, functions, etc. (e.g., such as a detector array 106. For example, more dense aspects of the features, functions, etc. (e.g., such as automatic threat detec-
object(s) 102, such as a bone or metal plate, may attenuate tion). more of the radiation 120 (e.g., causing fewer photons to FIG. 2 is a functional diagram 200 of a helical CT imaging strike the detector array 106) than less dense aspects, such modality. In such an imaging modality, the o as skin or clothing. 25 examination is translated 204 (typically at a constant speed)

a single row/column or multiple rows/columns. The pixels more radiation sources 118 and/or the detector array 106 are (and corresponding channels) may directly and/or indirectly rotated about the object 102 (in an x and/or convert detected radiation into analog signals. For example, $\frac{30}{106}$ causing the radiation source(s) 118 and/or the detector array respective pixels may comprise a direct conversion material $\frac{106}{102}$ to follow a configured to convert radiation energy directly into electrical to the object 102 (e.g., where the source and detector array energy. As another example, respective pixels may comprise do not move in the z direction, and th energy. As another example, respective pixels may comprise do not move in the z direction, and thus the helical trajectory a scintillator material configured to convert radiation energy is established by the combination of into light energy and an array of photodetectors configured 35

to convert the light energy into electrical energy.
Signals that are produced by the detector array 106 may FIG. 3 illustrates a top down view of a portion of the
be transmitted to a data acquisition component 122 that is be transmitted to a data acquisition component 122 that is in detector array 106. The detector array 106 comprises a operable communication with the detector array 106 (e.g., plurality of pixels 302, typically arranged in and at least portions of which may be coupled to and/or 40 extending in the z-direction) and rows (e.g., extending in the comprised within at least some of the pixels of the detector x-direction). For example, the detector comprised within at least some of the pixels of the detector x-direction). For example, the detector array 106 may array 106. Typically, the data acquisition component 122 is include a first column 306 of pixels 302, which array 106). Typically, the data acquisition component 122 is include a first column 306 of pixels 302, which includes a configured to convert the electrical signals output by respections in the state in a second between (configured to convert the electrical signals output by respec-
tive pixel $302a$ positioned between (e.g., adjacent) a second
tive pixels of the detector array into digital data and/or to
pixel $302b$ and a third pixel 3 combine the digital data acquired during a measuring inter-45 is rotated in an x, y plane, columns of the detector array thus val. The collection of digital output signals for a measuring extend perpendicular to the x, y plane. In some embodi-
interval may be referred to as a "projection" or a "view." ments, a pitch between pixels 302 (e.g., meas interval may be referred to as a "projection" or a "view." ments, a pitch between pixels 302 (e.g., measured from a Moreover, an angular orientation of the rotating gantry 104 center of a first pixel to the center of an ad (e.g., and the corresponding angular orientations of the be approximately 1 millimeter, although the pitch may vary radiation source(s) 118 and the detector array 106) relative 50 by application. to the object(s) 102 and/or support article 112, for example,
during generation of a projection may be referred to as the pixels 302 comprise a conversion material configured to
"projection angle." directly and/or indirect

The example environment 100 also illustrates an image energy. For example, where the pixels 302 are configured for reconstructor 124 that is operably coupled to the data 55 direct conversion, respective pixels may comprise reconstructor 124 that is operably coupled to the data 55 direct conversion, respective pixels may comprise a direct acquisition component 122 and is configured to generate one conversion material configured to convert rad acquisition component 122 and is configured to generate one conversion material configured to convert radiation energy or more images representative of the object 102 under into electrical energy. As another example, where examination based at least in part upon signals output from 302 are configured for indirect conversion, respective pixels the data acquisition component 122 using suitable analytimative may comprise an indirect conversion material configured to cal, iterative, and/or other reconstruction technique (e.g., 60 convert radiation energy into light cal, iterative, and/or other reconstruction technique (e.g., 60 tomosynthesis reconstruction, back-projection, iterative tomosynthesis reconstruction, back-projection, iterative photodetector configured to convert the light energy into reconstruction, etc.). Such images may be 3D images and/or electrical energy. reconstruction, etc.). Such images may be 3D images and/or electrical energy.
2D images. Turning to FIGS. $4a$ and $4b$, a portion 400 of the detector
The example environment 100 also includes a terminal array 106 is il

126, or workstation (e.g., a computer), configured to receive 65 image(s) from the image reconstructor 124, which can be image(s) from the image reconstructor 124, which can be indicated by lines $4b-4b$ in FIG. $4a$. As illustrated, the displayed on a monitor 128 to a user 130 (e.g., security portion 400 comprises of a plurality of pixels

a plurality of pixels (e.g., also referred to as detector cells), personnel, medical personnel, etc.). In this way, the user 130 that is mounted on a substantially diametrically opposite can inspect the image(s) to identif $s = \frac{118}{2}$ is to receive user input which can direct operations of the During an examination of the object(s) 102, the radiation $\frac{108}{2}$ examination unit 108 (e.g., a speed of gantry rotation, an During an examination of the object(s) 102 , the radiation 5 examination unit $\overline{108}$ (e.g., a speed of gantry rotation, an source(s) 118 emits fan, cone, wedge, and/or other shaped energy level of the radiation, et

operably coupled to the terminal 126. In an example, the

aspects of the object(s) 102 . Because different aspects into a plurality of components and/or the functions of two or type of imaging modality and is not intended to be inter-
preted in a limiting manner. For example, the functions of

The detector array 106 can comprise a linear (e.g., one-
dimensional) or two-dimensional array of pixels disposed as
a single row/column or multiple rows/columns. The pixels more radiation sources 118 and/or the detector a is established by the combination of the x/y rotation of the source and detector array and the z-axis translation of the

center of a first pixel to the center of an adjacent pixel) may

rojection angle." directly and/or indirectly convert the radiation into electrical
The example environment 100 also illustrates an image energy. For example, where the pixels 302 are configured for

array 106 is illustrated where FIG. $4a$ is a perspective view and FIG. $4b$ is a side view as seen from a perspective portion 400 comprises of a plurality of pixels $302a-302c$,

In an example, the first pixel $302a$ comprises a first 5 face an opposite direction from the second detection surface scintillator 402. The first scintillator 402 can detect a radia-426 and away from the radiation source scintillator 402. The first scintillator 402 can detect a radia $-$ 426 and away from the radiation source(s) 118 (illustrated in tion photon (e.g., a first radiation photon 404) and convert FIGS. 1 and 2). the first radiation photon 404 into first light energy 406. In The second scintillator 420 may be at least partially the illustrated example, the first scintillator 402 comprises a surrounded by a second reflective materia the illustrated example, the first scintillator 402 comprises a surrounded by a second reflective material 434. In the first detection surface 408 through which the first radiation 10 illustrated example of FIG. 4b, the se first detection surface 408 through which the first radiation 10 photon 404 enters the first scintillator 402 . The first detecphoton 404 enters the first scintillator 402. The first detec-
tion surface 408 may, in some examples, be generally flat lator 420 between the second detection surface 426 and tion surface 408 may, in some examples, be generally flat lator 420 between the second detection surface 426 and and/or planar, such that the first detection surface 408 second light emission surface 430. The second reflec extends along a first detection surface plane 410. In an material $\overline{434}$ is not so limited however, and in other example, the first detection surface $\overline{408}$ may face the radia- 15 examples, may also be disposed, a example, the first detection surface 408 may face the radia- 15 tion source(s) 118 (illustrated in FIGS. 1 and 2).

surface 412 through which the first light energy 406 can exit lator 420. In such an example, the second reflective material the first scintillator 402. The first light emission surface 412 434 may be disposed on all walls/ may, in some examples, be generally flat and/or planar, such 20 that the first light emission surface 412 extends along a first light emission surface plane 414. In an example, the first second scintillator 420.

light emission surface 412 may face an opposite direction Turning to the third pixel 302c, the third pixel 302c may

from the first dete

rounded by a first reflective material 416. The first reflective pixel $302a$ is not coplanar with the second pixel $302b$ or the material 416 can reduce/limit cross-talk between adjacent third pixel $302c$. The third pix material 416 can reduce/limit cross-talk between adjacent third pixel 302c. The third pixel 302c comprises the third scintillators. For example, the first reflective material 416 scintillator 440 configured to convert a t can reduce/limit light energy generated within the first 30 ton 442 into third light energy 444. In the illustrated scintillator 402 from entering another scintillator of the example, the third scintillator 440 comprises a third detec-
detector array 106, such as a second scintillator 420 and/or tion surface 446 through which the third detector array 106, such as a second scintillator 420 and/or tion surface 446 through which the third radiation photon a third scintillator 440. The third detection a third scintillator 440. The first reflective material 416 can
also increase detector efficiency by reducing/limiting the surface 446 may, in some examples, be generally flat and/or loss of light energy associated with optical photons escaping 35 the first scintillator 402 (e.g., escaping a lateral wall of the along a third detection surface plane 448. In an example, the first scintillator 402 and not being detected by a first pho-
third detection surface 446 may to detector 460 positioned below the first scintillator 402). In 118 (illustrated in FIGS. 1 and 2).
the illustrated example of FIG. 4b, the first reflective mate-
rial 416 may be disposed on lateral walls of the first 40 rial 416 may be disposed on lateral walls of the first 40 scintillator 402 between the first detection surface 408 and scintillator 402 between the first detection surface 408 and the third scintillator 440. The third light emission surface the first light emission surface 412. The first reflective 450 may, in some examples, be generally f material 416 is not so limited however, and in other such that the third light emission surface 450 extends along examples, may also be disposed, at least partially, on the first a third light emission surface plane 452. I detection surface 408 while still allowing for the first 45 radiation photon(s) 404 to enter the first scintillator 402 . In radiation photon(s) 404 to enter the first scintillator 402. In direction from the third detection surface 446 and away from such an example, the first reflective material 416 may be the radiation source(s) 118 (illustrat disposed on all walls/surfaces of the first scintillator 402 The third scintillator 440 may be at least partially sur-
except for the first light emission surface 412 through which rounded by a third reflective material 45 the first light energy 406 exits the first scintillator 402 , for 50 example.

Turning to the second pixel 302b, the second pixel 302b the third detection surface 446 and third light emission may be adjacent (e.g., next to) the first pixel 302a. The surface 450. The third reflective material 454 is may be adjacent (e.g., next to) the first pixel 302*a*. The surface 450. The third reflective material 454 is not so second pixel 302*b* comprises the second scintillator 420 limited however, and in other examples, may als configured to convert a second radiation photon 422 into 55 posed, at least partially, on the third detection surface 446 second light energy 424. In the illustrated example, the while still allowing for the third radiatio second light energy 424. In the illustrated example, the second scintillator 420 comprises a second detection surface second scintillator 420 comprises a second detection surface enter the third scintillator 440. In such an example, the third 426 through which the second radiation photon 422 enters reflective material 454 may be disposed 426 through which the second radiation photon 422 enters reflective material 454 may be disposed on all walls/surfaces the second scintillator 420. The second detection surface 426 of the third scintillator 440 except for may, in some examples, be generally flat and/or planar, such ω surface 450 through which that the second detection surface 426 extends along a second the third scintillator 440.

emission surface 430 through which the second light energy from the first light energy 406 into electrical energy, the 424 can exit the second scintillator 420. The second light electrical energy from the first photodetect

including the first pixel 302*a*, the second pixel 302*b*, and the emission surface 430 may, in some examples, be generally third pixel 302*c*. The pixels $302a - 302c$ can be supported in that and/or planar, such that the bracket and/or to a rotating gantry, for example. In an example, the second light emission surface 430 may
In an example, the first pixel 302a comprises a first 5 face an opposite direction from the second detection surfac

second light emission surface 430. The second reflective material 434 is not so limited however, and in other It is source (s) 118 (illustrated in FIGS. 1 and 2). second detection surface 426 while still allowing for the The first scintillator 402 comprises a first light emission second radiation photon(s) 422 to enter the second The first scintillator 402 comprises a first light emission second radiation photon(s) 422 to enter the second scintil-
surface 412 through which the first light energy 406 can exit lator 420. In such an example, the secon 434 may be disposed on all walls/surfaces of the second scintillator 420 except for the second light emission surface 430 through which the second light energy 424 exits the

diation source(s) 118 (illustrated in FIGS. 1 and 2). 25 second pixel 302b. In an example, the third pixel 302c is
The first scintillator 402 may be at least partially sur-
generally coplanar with the second pixel 302b, w generally coplanar with the second pixel $302b$, while the first scintillator 440 configured to convert a third radiation phosurface 446 may, in some examples, be generally flat and/or planar, such that the third detection surface 446 extends

a third light emission surface plane 452. In an example, the third light emission surface 450 may face an opposite

rounded by a third reflective material 454. In the illustrated example of FIG. 4*b*, the third reflective material 454 may be ample.

Turning to the second pixel $302b$, the second pixel $302b$ the third detection surface 446 and third light emission limited however, and in other examples, may also be disposed, at least partially, on the third detection surface 446 of the third scintillator 440 except for the third light emission surface 450 through which the third light energy 444 exits

detection surface plane 428. In an example, the second
detection surface plane 428. In an example, the second
detection surface plane 428. In an example, the second
(illustrated in FIGS. 1 and 2).
406 from the first scinti electrical energy from the first photodetector 460 can be

The second pixel $302b$ may include a second photodetector 470. The second photodetector 470 can receive the second light energy 424 from the second scintillator 420 and convert the second light energy 424 into electrical energy. Upon being converted from the second light energy 424 into 10 electrical energy, the electrical energy from the second electrical energy, the electrical energy from the second millimeter, for example). Pixels on a detector array are photodetector 470 can be transmitted to the data acquisition generally the same size and thus all three of t photodetector 470 can be transmitted to the data acquisition generally the same size and thus all three of the pixels may component 122 (illustrated in FIG. 1) for conversion into be increased in size in the z-direction by component 122 (illustrated in FIG. 1) for conversion into be increased in size in the z-direction by an equal amount digital data. In this example, the second photodetector 470 (e.g., instead of merely increasing the si is adjacent the second light emission surface 430 , such as by 15 being located under/below and in close proximity to the

energy 444 from the third scintillator 440 and convert the 20 material 416, the second reflective material 434 or the third third light energy 444 into electrical energy. Upon being reflective material 454 may be reduced i converted from the third light energy 444 into electrical thus allowing for the scintillator material of the pixels to be energy, the electrical energy from the third photodetector enlarged further. Similarly, where the si energy, the electrical energy from the third photodetector enlarged further. Similarly, where the size of the pixels is not **480** can be transmitted to the data acquisition component increased in the z-direction, but at le 480 can be transmitted to the data acquisition component 122 (illustrated in FIG. 1) for conversion into digital data. In 25 reflective material 416, the second reflective material 434 or this example, the third photodetector 480 is adjacent the third reflective material 454 is third light emission surface 450, such as by being located the size of at least one of the first scintillator 402, the second under/below and in close proximity to the third light emis-
scintillator 420 or the third scinti under/below and in close proximity to the third light emission surface 450 . The first photodetector 460 , second photodetector 470 and third photodetector 480 may comprise 30 surface 426 and/or the third detection surface 446, may be photodiodes, though other light converting electronic com-
ponents are also contemplated, for example. Given that the first pixel $302a$, the second pixel $302b$ and
In some examples, as illustrated in FIGS. $4a$ and $4b$

second detection surface plane 428 and/or the third detection 35 surface plane 448 . In this example, the first detection surface surface plane 448. In this example, the first detection surface achieved in the x-direction. For example, pixels can be 408 is positioned in closer proximity to the radiation brought closer together in the x-direction allo 408 is positioned in closer proximity to the radiation brought closer together in the x-direction allowing more source(s) 118 (illustrated in FIGS. 1 and 2) than the second pixels to be on the detector array (e.g., such th source(s) 118 (illustrated in FIGS. 1 and 2) than the second pixels to be on the detector array (e.g., such that more detection surface 446. $\frac{1}{8}$ radiation is detected by the detector array and/or such that detection surface 426 and/or the third detection surface 446. radiation is detected by the detector array and/or such that In some examples, the first light emission surface plane 414 40 higher fidelity images are produced In some examples, the first light emission surface plane 414 40 higher fidelity images are produced from radiation detected is not coplanar with the second light emission surface plane by the detector array (e.g., more is not coplanar with the second light emission surface plane by the detector array ($e.g.,$ more pixels or channels per unit 432 and/or the third light emission surface plane 452 . In this area on the detector array)). A example, the first light emission surface 412 may be posi-
tioned in the x-direction but where
tioned in closer proximity to the radiation source(s) 118 reflective material is decreased in size in the x-direction (illustrated in FIGS. 1 and 2) than the second light emission 45 while scintillator size (e.g., and thus detection surface) is surface 430 and/or the third light emission surface 450 . The increased in the x-directio first light emission surface plane 414 of FIGS. $4a$ and $4b$ pixel size may be increased where scintillator size (e.g., and may not intersect the second scintillator 420 and/or the third thus detection surface) is incr scintillator 440. In an example, the second detection surface reflective material size may plane 428 and/or the third detection surface plane 448 may $\frac{1}{20}$ decreased in the x-direction.

reduces or inhibits light energy from escaping scintillators, increased pursuant to the staggered or non-planar imple-
the reflective material has little to no effect on radiation mentation presented in FIGS. 4*a* and 4*b* the reflective material has little to no effect on radiation mentation presented in FIGS. $4a$ and $4b$. For example, a photons (e.g., reflective material is substantially transparent 55 detection surface of a 1 mm² pix photons (e.g., reflective material is substantially transparent 55 detection surface of a 1 mm² pixel may be on the order of to radiation photons). Accordingly, as illustrated in FIG. $4b$, 0.95 mm in the x and y dire to radiation photons). Accordingly, as illustrated in FIG. $4b$, 0.95 mm in the x and y directions, for an effective detection the first reflective material 416 is able to overlap some of the area of around 0.9 mm² with the first reflective material 416 is able to overlap some of the area of around 0.9 mm² with the staggered or non-uniform second scintillator $\frac{1}{20}$ and/or some of the third scintillator pixel configuration. In cont second scintillator 420 and/or some of the third scintillator pixel configuration. In contrast, in the absence of the non-
440 while still allowing the second radiation photons 422 to uniform arrangement, a detection surf 440 while still allowing the second radiation photons 422 to uniform arrangement, a detection surface of a 1 mm² pixel enter the second scintillator 420 and/or allowing the third 60 may be on the order of 0.8 mm in the radiation photon 442 to enter the third scintillator 440. At due to the amount of reflective material needed between
least one of the second pixel $302b$ or the third pixel $302c$ adjacent pixels to sufficiently reduce cr least one of the second pixel 302b or the third pixel 302c adjacent pixels to sufficiently reduce cross talk), for an may be shifted (e.g., to bring the second pixel 302b and the effective detection area of around 0.64 mm may be shifted (e.g., to bring the second pixel $302b$ and the effective detection area of around 0.64 mm². Thus, the third pixel $302c$ closer to one anther) to achieve this reflection arrangement allows more radiation tive material to scintillator overlap (e.g., thus allowing more 65 pixels to be included on the detector array). Alternatively, or pixels to be included on the detector array). Alternatively, or effective detection area of pixels on the detector array and/or in addition, at least one of the first pixel 302a, the second by allowing more pixels to be in

10

transmitted to the data acquisition component 122 (illus-
transmitted in FIG. 1) for conversion into digital data. In this z-direction to achieve this reflective material to scintillator trated in FIG. 1) for conversion into digital data. In this z-direction to achieve this reflective material to scintillator example, the first photodetector 460 is adjacent the first light overlap. For example, where the s overlap. For example, where the size of the first reflective emission surface 412, such as by being located under/below material 416 is maintained in the z-direction, the size of at and in close proximity to the first light emission surface 412. 5 least one of the first scintillator and in close proximity to the first light emission surface 412. \bar{s} least one of the first scintillator 402, the second scintillator
The second pixel 302b may include a second photode-420 or the third scintillator 440, detection surface 408 , the second detection surface 426 and/or the third detection surface 446 , may be increased in the z-direction (e.g., to increase an active area of one or more pixels without increasing the pitch of such pixels beyond 1 (e.g., instead of merely increasing the size of the first pixel $302a$). Moreover, given that the space 491 between the second pixel 302b and the third pixel 302c serves to mitigate second light emission surface 430. cross talk (e.g., between the first pixel 302*a* and the second
The third pixel 302*c* may include a third photodetector pixel 302*b* and/or between the first pixel 302*a* and the third The third pixel 302c may include a third photodetector pixel 302b and/or between the first pixel 302a and the third 480. The third photodetector 480 can receive the third light pixel 302c), the size of at least one of the pixel $302c$), the size of at least one of the first reflective reflective material 454 may be reduced in the z-direction thus allowing for the scintillator material of the pixels to be of the first detection surface 408, the second detection

In some examples, as illustrated in FIGS. $4a$ and $4b$, the third pixel $302c$ are arranged in a column (as illustrated first detection surface plane 410 is not coplanar with the in FIG. 3) and thus are adjacent pixels in FIG. 3) and thus are adjacent pixels in other columns, the staggered arrangement also allows the same results to be reflective material is decreased in size in the x-direction while scintillator size (e.g., and thus detection surface) is thus detection surface) is increased in the x-direction and reflective material size may or may not be increased or

not intersect the first scintillator 402.
It will be appreciated that the effective detection area of
It will be appreciated that while the reflective material a pixel (e.g., detection surface) may be substantially It will be appreciated that while the reflective material a pixel $(e.g.,$ detection surface) may be substantially reduces or inhibits light energy from escaping scintillators, increased pursuant to the staggered or non-plan non-uniform arrangement allows more radiation to be detected with a same size detector array by increasing the by allowing more pixels to be included on the detector array.

tive view and FIG. 5b is a side view as seen from a fourth pixel 702b in a second column and a third pixel 702c perspective indicated by lines 5b-5b in FIG. 5a. In this in a third column may have a configuration similar t example, the second pixel $302b$ and third pixel $302c$ are 5 generally identical to the second pixel $302b$ and third pixel generally identical to the second pixel $302b$ and third pixel having a configuration similar to the configuration of the $302c$ described above with respect to FIGS. $4a$ and $4b$. A first pixel $702a$ may be (e.g., spar 302c described above with respect to FIGS. 4a and 4b. A first pixel 702a may be (e.g., sparsely) scattered through the first pixel 500 is provided in FIGS. 5a and 5b. The first pixel detector array in a patterned (e.g., c 500 may include the first scintillator 402, first reflective pillared pattern (e.g., where an entire column or row of the material 416, etc.

first photodetector 502 and an optical carrier 510. The first 702*a* can be provided as part of the second detector array photodetector 502 may be generally identical in structure, 700.

shape, etc. as the first photodete In this example, the optical carrier 510 may be situated 15 between the first light emission surface 412 and the first between the first light emission surface 412 and the first tive view and FIG. 8b is a side view as seen from a photodetector 502. The optical carrier 510 can carry the first perspective indicated by lines 8b-8b in FIG. 8a. photodetector 502. The optical carrier 510 can carry the first perspective indicated by lines $8b-8b$ in FIG. $8a$. In this light energy 406 between the first scintillator 402 and the example, the portion 800 comprises first photodetector 502. It will be appreciated that the optical including the first pixel 702*a*, the second pixel 302*b*, and the carrier 510 may include, for example, a gap, space, opening, 20 third pixel 302*c*. The p carrier 510 may include, for example, a gap, space, opening, 20 third pixel $302c$. The pixels $302b$, $302c$, and $702a$ can be or the like. The optical carrier 510 may be filled with air, or, supported in any number of in other examples, may be filled with gas and/or an optical to a mounting bracket and/or rotating gantry, for example.
fiber, for example so as to allow for the first light energy 406 In an example, the first pixel 702*a*

first distance 520 from the first scintillator 402. While the to FIGS. 4a and 4b. Indeed, the first scintillator 802 can first distance 520 comprises any number of distances, in detect the first radiation photon 404 and co first distance 520 comprises any number of distances, in detect the first radiation photon 404 and convert the first some possible examples, the first distance 520 is between radiation photon 404 into first light energy 40 some possible examples, the first distance 520 is between radiation photon 404 into first light energy 406. The first about 0.5 mm to about 1.5 mm. In an example, the second scintillator 802 comprises a first detection sur photodetector 470 is spaced a second distance 522 from the 30 second scintillator 420 while the third photodetector 480 is scintillator 802. The first detection surface 808 may be spaced a third distance 524 from the third scintillator 440. In generally flat and/or planar, such that spaced a third distance 524 from the third scintillator 440. In generally flat and/or planar, such that the first detection some examples, the first distance 520 is different than the surface 808 extends along a first dete second distance 522 and/or the third distance 524. In the The first detection surface 808 may face the radiation illustrated example, the first distance 520 may be greater/ 35 source(s) 118 (illustrated in FIGS. 1 and 2). larger than the second distance 522 and/or the third distance
524. In some examples, the second photodetector 470 may surface 812 through which the first light energy 406 can exit 524. In some examples, the second photodetector 470 may surface 812 through which the first light energy 406 can exit be in contact with the second scintillator 420 and/or the third the first scintillator 802. The first l be in contact with the second scintillator 420 and/or the third the first scintillator 802. The first light emission surface 812 photodetector 480 may be in contact with the third scintil- may, in some examples, be general lator 440, such that the second distance 522 and/or the third 40 distance 524 may be zero or about zero. However, the illustrated distances (e.g., first distance 520, second distance light emission surface 812 may face 522 and third distance 524) of FIGS. 5*a* and 5*b* are not from the first detection surface 808.

Turning now to FIG. 6, the portion 400 of the detector array 106 of FIGS. $5a$ and $5b$ is illustrated. In this example. array 106 of FIGS. 5a and 5b is illustrated. In this example, example, the first light emission surface plane 814 is not a support structure 600 may be provided for supporting the coplanar with the second light emission first scintillator 402. The support structure 600 can extend and/or the third light emission surface plane 452. For partially or completely across the first pixel 500, the second 50 example, the first scintillator 802 has partially or completely across the first pixel 500, the second $\overline{50}$ example, the first scintillator 802 has a first scintillator pixel 302*b* and/or the third pixel 302*c*. The support structure thickness 820 between pixel 302*b* and/or the third pixel 302*c*. The support structure 600 can be positioned adjacent and/or in contact with the 600 can be positioned adjacent and/or in contact with the first light emission surface 812. The second scintillator 420 first light emission surface 412 of the first scintillator 402. has a second scintillator thickness 83 first light emission surface 412 of the first scintillator 402. has a second scintillator thickness 830 between the second As such, the first scintillator 402 can rest upon the support detection surface 426 and the second structure 600. The support structure 600 comprises any 55 number of materials that allow for the light energy (e.g., the number of materials that allow for the light energy (e.g., the ness 832 between the third detection surface 446 and the first light energy 406), as well as for the second radiation third light emission surface 450. In this photons 422 and/or the third radiation photons 442, to pass scintillator thickness 830 and/or the third scintillator thick-
through (e.g., such that the support structure 600 is substan-
ness 832 are different than the fir tially transparent to radiation and to light). In operation, the 60 For example, the first scintillator thickness 820 may be first light energy 406 can pass from the first scintillator 402, smaller/less than the second sci first light energy 406 can pass from the first scintillator 402, smaller/less than the second scintillator thickness 830 and/or through the support structure 600 and to the first photode-
the third scintillator thickness 8

detector array 700. As illustrated, the second detector array 65 thickness 830 and/or the third scintillator thickness 832 , the 700 may include a column 306 of pixels that include a first scintillator 802 can measur pixel 702a, the second pixel 302b, and the third pixel 302c.

Turning to FIGS. $5a$ and $5b$, the portion 400 of the It may be appreciated that any number of pixels may be detector array 106 is illustrated where FIG. $5a$ is a perspec-
configured similar to the first pixel 702a. For configured similar to the first pixel $702a$. For example, a in a third column may have a configuration similar to the configuration of the first pixel $702a$. Accordingly, pixels aterial 416, etc.
In the illustrated example, the first pixel 500 comprises a tion), etc.) or a random fashion. Any number of first pixels

pass therethrough.
In this example, the first photodetector 502 is spaced a 25 tical to the first scintillator 402 described above with respect
In this example, the first photodetector 502 is spaced a 25 tical to the first tical to the first scintillator 402 described above with respect scintillator 802 comprises a first detection surface 808 through which the first radiation photon 404 enters the first

> may, in some examples, be generally flat and/or planar, such that the first light emission surface 812 extends along a first light emission surface plane 814 . In an example, the first light emission surface 812 may face an opposite direction

intended to be limiting, as any number of distances are
envisioned. 45 810 may be coplanar with the second detection surface plane
Turning now to FIG. 6, the portion 400 of the detector 428 and/or the third detection surf coplanar with the second light emission surface plane 432 detection surface 426 and the second light emission surface 430 . The third scintillator 440 has a third scintillator thickthird light emission surface 450. In this example, the second

tector 502.
FIG. 7 illustrates a top down view of a portion of a second tillator thickness 820 that is less than the second scintillator thickness 820 that is less than the second scintillator FIG. 7 illustrates a top down view of a portion of a second tillator thickness 820 that is less than the second scintillator detector array 700. As illustrated, the second detector array 65 thickness 830 and/or the third first scintillator 802 can measure radiation photons having a different energy spectrum than the second scintillator 420 radiation photons 404) having a first energy spectrum. The an example, the filters 1002 can filter out radiation photons second scintillator 420 can measure radiation photons (e.g., having the first energy spectrum (e.g., low energy) from second radiation photons 422) having a second energy \bar{s} reaching the second scintillator 420 and/or second radiation photons 422) having a second energy 5 reaching the second scintillator 420 and/or the third scintil-
spectrum different than the first energy spectrum. Likewise, lator 440. the third scintillator 440 can measure radiation photons (e.g., Turning to FIGS. $11a$ and $11b$, the portion 800 of the third radiation photons 442) having a third energy spectrum second detector array 700 is illustrated

lower energy radiation photons while the second energy spectrum and/or third energy spectrum may comprise high spectrum and/or third energy spectrum may comprise high gered" with respect to the second scintillator 420 and/or the energy radiation photons and/or a full energy spectrum (e.g., third scintillator 440. For example, the energy radiation photons and/or a full energy spectrum (e.g., third scintillator 440. For example, the first detection surface high and low energy radiation photons). In operation, data plane 810 is not coplanar with the s high and low energy radiation photons). In operation, data plane 810 is not coplanar with the second detection surface yielded from the first pixel $702a$ and indicative of the lower 15 plane 428 and/or the third detectio yielded from the first pixel 702*a* and indicative of the lower 15 plane 428 and/or the third detection surface plane 448. In energy radiation photons (e.g., as measured by the first this example, the first detection surf scintillator 802) can be combined with data yielded from the closer proximity to the radiation source(s) 118 (illustrated in second pixel 302b and/or the third pixel 302c and indicative FIGS. 1 and 2) than the second dete of the higher energy radiation photons (e.g., as measured by the third detection surface 446. In some examples, the first the second scintillator 420 and/or the third scintillator 440) 20 light emission surface plane 814 the second scintillator 420 and/or the third scintillator 440) 20 light emission surface plane 814 is not coplanar with the to calculate an effective atomic number (Z_{α}) of objects second light emission surface plane 43 to calculate an effective atomic number (Z_{eff}) of objects second light emission surface plane 452. second detector array 700 (e.g., such as through interpola-
tion the first light emission surface 812 is
tion techniques that interpolate the total radiation that would
positioned in closer proximity to the radiation have been detected by the first pixel 702*a* had the first pixel 25 (illustrated in FIGS. 1 and 2) than the second light emission been configured to detect both high and low energy pho-
surface 430 and/or the third light been configured to detect both high and low energy pho-
tons). It may be appreciated that by sparsely placing pixels first light emission surface plane 814 of FIGS. 11*a* and 11*b* having a first configuration (e.g., the first scintillator thick-may not intersect the second scintillator 420 and/or the third ness) among other pixels having a second configuration scintillator 440. In an example, the se ness) among other pixels having a second configuration (e.g., the second scintillator thickness and/or the third scin-30 plane 428 and/or the third detection surface plane 448 may tillator thickness) a dual energy detector array may be not intersect the first scintillator 80 tillator thickness) a dual energy detector array may be created that is less costly than other forms of dual energy of this non-planar, "staggered" layout, the respective sizes of detector arrays, such as a detector array constructed using the first pixel $702a$, second pixel photon counting technologies and/or sandwich technologies.
Turning now to FIGS. $9a$ and $9b$, the portion 800 of the 35

second detector array 700 is illustrated where FIG. $9a$ is a FIGS. $4a$ and $4b$.
perspective view and FIG. $9b$ is a side view as seen from a Turning to FIG. 12a, a portion 1200 of the second detector
perspective indica perspective indicated by lines $9b-9b$ in FIG. $9a$. The portion 800 can include a first pixel 900 comprising the first scintillator 802 and the first photodetector 460 (e.g., the detector 40 array 700 has the first pixel 900 instead of the first pixel 702*a*). In this example, the first detection surface plane 810 is not coplanar with the second detection surface plane 428 is not coplanar with the second detection surface plane 428 first photodetector 460. The optical carrier 510 can carry the and/or the third detection surface plane 448. In this example, first light energy 406 between the f the first light emission surface plane 814 is coplanar with the 45 second light emission surface plane 432 and/or the third Turning to FIG. 12b, a portion 1250 of the second detector light emission surface plane 452. As with the previous array 700 is illustrated. In this example, the por light emission surface plane 452. As with the previous array 700 is illustrated. In this example, the portion 1250 example illustrated in FIGS. $8a$ and $8b$, the first scintillator may include the first pixel 702a, the s example illustrated in FIGS. $8a$ and $8b$, the first scintillator may include the first pixel 702a, the second pixel 302b, and 802 can measure radiation photons (e.g., first radiation the third pixel 302c. The support photons 404) having a first energy spectrum that is different 50 for supporting the first scintillator 802. The support structure (e.g., lower) than the second energy spectrum of the second 600 can extend partially or comp scintillator 420 and/or the third energy spectrum of the third $\frac{702a}{102a}$, the second pixel 302b and/or the third pixel 302c. The scintillator 440.

second detector array 700 is illustrated where FIG. $10a$ is a 55 perspective view and FIG. $10b$ is a side view as seen from a perspective indicated by lines $10b-10b$ in FIG. $10a$. As energy 406 can pass from the first scintillator 802, through illustrated, the portion 1000 may include the first pixel 702a, the support structure 600, through filter 1002 may be provided covering portions of the pixels 60 In some possible examples, such as the examples illus-
302 (e.g., first pixel 702a, second pixel 302b, and/or third trated in FIGS. 7 to 11, the first scintill 302 (e.g., first pixel 702a, second pixel 302b, and/or third pixel $302c$). For example, as illustrated, two filters 1002 may pixel $302c$). For example, as illustrated, two filters 1002 may scintillator 420 and/or third scintillator 440 may have dif-
be provided, with one of the filters 1002 provided over the ferent compositions. In one be provided, with one of the filters 1002 provided over the ferent compositions. In one possible example, the first second scintillator 420 and third scinsecond scintillator 420 and the other of the filters 1002 scintillator 402, 802, second scintillator 420 and third scin-
provided over the third scintillator 440. In this example, the 65 tillator 440 may have the same c second pixel 302b and third pixel 302c comprise the filters the same material(s)). In another example, the first scintil-
1002 while the first pixel 702a does not comprise the filter lator 402, 802 may have a first compos

and/or the third scintillator 440. For example, the first 1002 . In an example, the filters 1002 can filter out radiation scintillator 802 can measure radiation photons (e.g., first photons having a certain energy spectr photons having a certain energy spectrum. For instance, in

second detector array 700 is illustrated where FIG. $11a$ is a different than the first energy spectrum.
In this example, the first energy spectrum may comprise 10 a perspective indicated by lines 11b-11b in FIG. 11a. In this a perspective indicated by lines $11b-11b$ in FIG. 11a. In this example, the first scintillator 802 is non-planar and/or "stagthis example, the first detection surface 808 is positioned in FIGS. 1 and 2) than the second detection surface 426 and/or the third detection surface 446 . In some examples, the first

> positioned in closer proximity to the radiation sources first light emission surface plane 814 of FIGS. $11a$ and $11b$ may not intersect the second scintillator 420 and/or the third the first pixel 702a, second pixel 302b and third pixel 302c may be increased and/or more pixels may be included on the detector array, such as previously described with respect to

> may include the first pixel 702*a*, the second pixel 302*b*, and the third pixel 302*c*. In this example, the first pixel 702*a* comprises the optical carrier 510 situated between the first light emission surface 812 of the first scintillator 802 and the first light energy 406 between the first scintillator 802 and the first photodetector 460 .

the third pixel $302c$. The support structure 600 is provided intillator 440.
Turning now to FIGS. 10*a* and 10*b*, a portion 1000 of the contact with the first light emission surface 812 of the first contact with the first light emission surface 812 of the first scintillator 802 . As such, the first scintillator 802 can rest upon the support structure 600. In operation, the first light

lator 402, 802 may have a first composition while the second

440 may have the first composition, the second composition,
or a third composition, with the third composition being second emission surface 1330 through which the second
or a third composition, with the third composition different than the first composition and/or the second com-
position. In these examples, by providing different compoposition. In these examples, by providing different compo-
sitions, the first scintillator 402, 802, second scintillator 420 some examples, be generally flat and/or planar, such that the sitions, the first scintillator 402, 802, second scintillator 420 some examples, be generally flat and/or planar, such that the and/or third scintillator 440 may be able to better detect second emission surface 1330 extend and/or third scintillator 440 may be able to better detect second emission surface 1330 extends along a second emis-
certain energy spectrums (e.g., low energy, high energy, sion surface plane 1332. In an example, the seco

It may be appreciated that while the foregoing examples detection surface 1326 and away from the radiation described configurations for pixels configured to indirectly source(s) 118 (illustrated in FIGS. 1 and 2). convert radiation into electrical energy, such configurations Turning to the third pixel $1301c$, the third pixel $1301c$ may find applicability to pixels configured to directly con-
may be adjacent (e.g., next to) the fi may find applicability to pixels configured to directly con-
vert radiation into electrical energy. By way of example, the 15 the second pixel 1301b. In an example, the third pixel 1301c vert radiation into electrical energy. By way of example, the 15 scintillator and/or photodetector of a pixel may be substiscintillator and/or photodetector of a pixel may be substi-
tis generally coplanar with the second pixel 1301*b*, while the
tuted with a direct conversion material to convert the pixel $\frac{1301a}{1301a}$ is not coplanar wi tuted with a direct conversion material to convert the pixel first pixel $1301a$ is not coplanar with the second pixel $1301b$
from indirect conversion to direct conversion. $\frac{1301a}{201a}$ or the third pixel $1301c$. Th

1301*a*-1301*c* configured for direct conversion is illustrated. 20 Such pixels 1301*a*-1301*c* can be supported in any number of

direct conversion material 1302. The first direct conversion 25 material 1302 can detect a radiation photon (e.g., a first material 1302 can detect a radiation photon (e.g., a first material 1340. The third detection surface 1346 may, in radiation photon 1304) and convert the first radiation photon some examples, be generally flat and/or plana 1304 into a first electrical charge 1306. In the illustrated example, the first direct conversion material 1302 comprises a first detection surface 1308 through which the first radia- 30 surface 1346 may face the radiation source(s) 118 (illustion photon 1304 enters the first direct conversion material trated in FIGS. 1 and 2). 1302. The first detection surface 1308 may, in some The third direct conversion material 1340 comprises a examples, be generally flat and/or planar, such that the first third emission surface 1350 through which the third e examples, be generally flat and/or planar, such that the first third emission surface 1350 through which the third electrician surface detection surface trical charge 1344 can exit the third direct conversion plane 1310. In an example, the first detection surface 1308 35 may face the radiation source(s) 118 (illustrated in FIGS. 1 may face the radiation source(s) 118 (illustrated in FIGS. 1 examples, be generally flat and/or planar, such that the third and 2).

charge 1306 can exit the first direct conversion material 40 surface 1346 and away from 1302. The first emission surface 1312 may, in some (illustrated in FIGS. 1 and 2). examples, be generally flat and/or planar, such that the first The first pixel 1301*a* may include a first detection layer emission surface a 1312 extends along a first emission surface 1360. The first detection layer 1360 emission surface 1312 extends along a first emission surface 1360. The first detection layer 1360 may comprise a thin-
plane 1314. In an example, the first emission surface 1312 film transistor (TFT) or other readout compo may face an opposite direction from the first detection 45 surface 1308 and away from the radiation source(s) 118 surface 1308 and away from the radiation source(s) 118 direct conversion material 1302. This information can be (illustrated in FIGS. 1 and 2).

of direct conversion material layers that are configured to version into digital data. In this example, the first detection generate electrical charge in response to radiation energy so layer 1360 is adjacent the first emi generate electrical charge in response to radiation energy 50 impinging thereon. Such direct conversion materials may comprise amorphous selenium, cadmium zinc telluride (CdZnTe), and/or silicon, for example.

1301b may be adjacent (e.g., next to) the first pixel 1301*a*. 55 detect the second electrical charge 1324 from the second The second pixel 1301*b* comprises a second direct conver-
direct conversion material 1320. This i The second pixel $1301b$ comprises a second direct conversion material 1320. The second direct conversion material 1320 can detect a radiation photon (e.g., a second radiation photon 1322) and convert the second radiation photon 1322 into a second electrical charge 1324 . In the illustrated 60 example, the second direct conversion material 1320 comexample, the second direct conversion material 1320 com-
prises a second detection surface 1326 through which the proximity to the second emission surface 1330. second radiation photon 1322 enters the second direct con-
The third pixel $1301c$ may include a third detection layer
version material 1320. The second detection surface 1326
may, in some examples, be generally flat and/ may, in some examples, be generally flat and/or planar, such that the second detection surface 1326 extends along a

scintillator 420 has a second composition that is different second detection surface 1326 may face the radiation source than the first composition. Likewise, the third scintillator (s) 118 (illustrated in FIGS. 1 and 2).

second emission surface 1330 through which the second electrical charge 1324 can exit the second direct conversion sion surface plane 1332. In an example, the second emission etc.).
It may be appreciated that while the foregoing examples detection surface 1326 and away from the radiation

from indirect conversion to direct conversion. or the third pixel $1301c$. The third pixel $1301c$ comprises a Referring to FIG. 13, an example configuration of pixels third direct conversion material 1340. The third dire third direct conversion material 1340. The third direct conversion material 1340 can detect a radiation photon (e.g., a third radiation photon 1342 and convert the third radiation ways, such as by being coupled to a mounting bracket and/or photon 1342 into third electrical charge 1344. In the illustrated and the interval property, for example. a rotating gantry, for example.
In an example, the first pixel $1301a$ comprises a first comprises a third detection surface 1346 through which the comprises a third detection surface 1346 through which the third radiation photon 1342 enters the third direct conversion some examples, be generally flat and/or planar, such that the third detection surface 1346 extends along a third detection surface plane 1348 . In an example, the third detection

trical charge 1344 can exit the third direct conversion material 1340 . The third emission surface 1350 may, in some d 2).
The first direct conversion material 1302 comprises a first face plane 1352. In an example, the third emission surface The first direct conversion material 1302 comprises a first face plane 1352. In an example, the third emission surface emission surface 1312 through which the first electrical 1350 may face an opposite direction from the t 1350 may face an opposite direction from the third detection surface 1346 and away from the radiation source(s) 118

film transistor (TFT) or other readout component and can receive/detect the first electrical charge 1306 from the first (lustrated in FIGS. 1 and 2). transmitted from the first detection layer 1360 to the data
The direct conversion material may comprise any number acquisition component 122 (illustrated in FIG. 1) for conacquisition component 122 (illustrated in FIG. 1) for conversion into digital data. In this example, the first detection as by being located under/below and in close proximity to the first emission surface 1312.

 $dZnTe$), and/or silicon, for example.
Turning to the second pixel 1301*b*, the second pixel layer 1370. The second detection layer 1370 can receive/ layer 1370. The second detection layer 1370 can receive/
detect the second electrical charge 1324 from the second transmitted from the second detection layer 1370 to the data acquisition component 122 (illustrated in FIG. 1) for conversion into digital data. In this example, the second detection layer 1370 is adjacent the second emission surface

that the second detection surface 1326 extends along a material 1340. This information can be transmitted from the second detection surface plane 1328. In an example, the third detection layer 1380 to the data acquisition third detection layer 1380 to the data acquisition component

this example, the third detection layer 1380 is adjacent the ments, items, etc. For example, a first set of information and third emission surface 1350, such as by being located a second set of information generally corres third emission surface 1350, such as by being located a second set of information generally correspond to set of under/below and in close proximity to the third emission information A and set of information B or two differ under/below and in close proximity to the third emission information A and set of information B or two different or surface 1350 .

In some examples, as illustrated in FIG. 13, the first
detection surface plane 1310 is not coplanar with the second
detection surface plane 1328 and/or the third detection
surface plane 1348. In this example, the first det second detection surface 1326 and/or the third detection this specification and the annexed drawings. The disclosure second detection surface 1326 and/or the third detection surface includes all such modifications and alt surface 1346. In some examples, the first emission surface includes an such modifications and alterations and is infinited surface $\frac{1344 \text{ m}}{2}$ is not container with the second emission surface only by the scope of th plane 1314 is not coplanar with the second emission surface
plane 1332 and/or the third emission surface plane 1352. In 15 regard to the various functions performed by the above plane 1332 and/or the third emission surface plane 1352. In 15 regard to the various functions performed by the above
this example, the first emission surface 1312 may be nosi-
described components (e.g., elements, resour this example, the first emission surface 1312 may be posi-
tioned in closer proximity to the radiation sources source(s) terms used to describe such components are intended to tioned in closer proximity to the radiation sources source(s) terms used to describe such components are intended to $(i\text{llustrated}$ in FIGS, 1 and 2) than the second emission correspond, unless otherwise indicated, to any com (illustrated in FIGS. 1 and 2) than the second emission correspond, unless otherwise indicated, to any component surface 1330 and/or the third emission surface 1350. The which performs the specified function of the describ surface 1330 and/or the third emission surface 1350. The which performs the specified function of the described first emission surface plane 1314 of FIG. 13 may not $_{20}$ component (e.g., that is functionally equivalent) first emission surface plane 1314 of FIG. 13 may not $_{20}$ component (e.g., that is functionally equivalent), even intersect the second direct conversion material 1320 and/or though not structurally equivalent to the dis the third direct conversion material 1340. In an example, the Theorem and Material method detection surface plane 1328 and/or the third detec-
the material method of the spectra conduction surface plane 1348 may not inters tion surface plane 1348 may not intersect the first direct implementations, such feature may be combined with one or
conversion material 1302. Accordingly as a result of this 25 more other features of the other implementat conversion material 1302. Accordingly, as a result of this 25 more other features of the other implementations as may be non-planar "staggered" layout the respective sizes of the desired and advantageous for any given o non-planar, "staggered" layout, the respective sizes of the desired first nixel 1301a, the second nixel 1301b and the third nixel cation. first pixel 1301*a*, the second pixel 1301*b* and the third pixel cation.

1301*c* may be increased and/or more pixels may be included

on the detector array, such as previously described with What is claimed is: on the detector array, such as previously described with What is claimed is:
respect to the examples of FIGS. 4 to 11. That is, although 30 1. A detector array configured to detect radiation photons, not illustrated, a reflective material may be disposed on at the detector array comprising: least some surfaces of one or more pixels (e.g., akin to 416 a first pixel comprising: least some surfaces of one or more pixels (e.g., akin to **416** a first pixel comprising discussed above) to inhibit electrical charge (e.g., as a first photodetector; discussed above) to inhibit electrical charge (e.g., as a first photodetector;
opposed to light energy) from migrating from one pixel to a first scintillator overlying the first photodetector and opposed to light energy) from migrating from one pixel to a first scintillator overlying the first photodetector and another. The staggered arrangement may provide benefits 35 another. The staggered arrangement may provide benefits 35 configured to convith regard to the charge reflective material that are similar first light energy; with regard to the charge reflective material that are similar first light energy;
to the aforementioned benefits realized with regard to the an optical carrier intervening between the first scintilto the aforementioned benefits realized with regard to the light reflective material.

As used in this application, the terms "component," first reflective material beginning and en nodule," "system," "interface," and the like are generally 40 a sidewall of the first scintillator; and " module," " system," " interface," and the like are generally 40 a sidewall of the first scintillator; and intended to refer to a computer-related entity, either hard- a second pixel partially underlying the first pixel a intended to refer to a computer-related entity, either hard a second pixel ware, a combination of hardware and software, software, or ware, a combination of hardware and software, software, or comprising:
software in execution. For example, a component includes a second photodetector; software in execution. For example, a component includes a a second photodetector;
process running on a processor, a processor, an object, an a second scintillator directly on the second photodeexecutable, a thread of execution, a program, or a computer. 45 tector and configured to convert a second radiation
By way of illustration, both an application running on a photon into second light energy; and By way of illustration, both an application running on a controller and the controller can be a component. One or controller and the controller can be a component. One or second reflective material beginning and ending adja-
more components residing within a process or thread of cent a sidewall of the second scintillator.

an example, instance, illustration, etc., and not necessarily as 3. The detector array of claim 1, wherein the first reflecadvantageous. As used in this application, "or" is intended to tive material at least partially overlies the second scintillator.
mean an inclusive "or" rather than an exclusive "or." In 4. The detector array of claim 1, w addition, "a" and "an" as used in this application are 55 tillator has a first width and the first photodetector has a generally be construed to mean "one or more" unless second width less than the first width. specified otherwise or clear from context to be directed to a 5. The detector array of claim 1, wherein the second singular form. Also, at least one of A and B and/or the like reflective material underlies the first scinti generally means A or B and/or both A and B. Furthermore, **6.** The detector array of claim 1, further comprising a to the extent that "includes," "having," "has," "with," or 60 support structure disposed over a top surface to the extent that "includes," "having," "has," "with," or 60 variants thereof are used, such terms are intended to be variants thereof are used, such terms are intended to be scintillator of the second pixel and under a bottom surface of inclusive in a manner similar to the term "comprising." the first scintillator of the first pixel.

Many modifications may be made to the instant disclosure 7. The detector array of claim 6, wherein the support without departing from the scope or spirit of the claimed structure is disposed between the first scintillator subject matter. Unless specified otherwise, "first," "second," 65 optical carrier of the first pixel.

or the like are not intended to imply a temporal aspect, a **8**. The detector array of claim 1, wherein the first scin-
 spatial aspect, an ordering, etc. Rather, such terms are

122 (illustrated in FIG. 1) for conversion into digital data. In merely used as identifiers, names, etc., for features, eletis example, the third detection layer 1380 is adjacent the ments, items, etc. For example, a first rtace 1350.
In some examples, as illustrated in FIG. 13, the first $\frac{5}{\text{mation}}$ is the same set of infor-

-
-
-
- lator and the first photodetector; and
first reflective material beginning and ending adjacent
-
- -
	-
	-

execution and a component may be localized on one com-

2. The detector array of claim 1, wherein the first reflec-

puter or distributed between two or more computers.

50 tive material at least partially overlies the sec ter or distributed between two or more computers. $\frac{50}{20}$ tive material at least partially overlies the second reflective Moreover, "exemplary" is used herein to mean serving as material.

scintillator has a second scintillator thickness, the second a second pixel adjacent the first pixel and comprising:
scintillator thickness different than the first scintillator thick-
a second photodetector;

9. The detector array of claim 1, wherein the first scin-
later is configured to measure radiation photons having a $\frac{5}{2}$ radiation photon into second light energy; and tillator is configured to measure radiation photons having a ⁵ radiation photon into second light energy; and first energy spectrum and the second scintillator is config-
first energy spectrum and the second scintillator First energy spectrum and the second scintillator is config-

ured to measure radiation photons having a second energy

a sidewall of the second scintillator; and

a support structure disposed under the first scintillator

scintillator has a first composition and the second scintillator $\frac{18. A$ detector array configured to detect radiation pho-
has a second composition different than the first composihas a second composition different than the first composi-
 $\frac{15}{4}$ in tons, the detector array comprising:

third pixel partially underlying the first pixel and compris - 20 an optical carrier extending from and between the first ing: scintillator and the first photodetector; and

-
- a third scintillator directly on the third photodetector and a sidewall of the first scontinue of the first scintillator $\frac{a \text{ second pixel}}{a \text{ second pixel}}$, comprising: configured to convert a third radiation photon into third $\frac{a \text{ second pixel, comprising}}{25}$ is second photodetector; light energy; and
interval botation and ordinal property of a second photodetector;
a second scintillator on the second photodetector and
- third reflective material beginning and ending adjacent a a second scintillator on the second photodetector and
configured to convert a second radiation photon into
itidewall of the third scintillator.

External of converting to convert a second radiation photon into second radiation photon into second radiation into second reflective material beginning and ending adja-

The detector array of claim 13, wherein the first p

15. The detector array of claim 14, wherein the optical 30 cent a sidewall of the second scintillator; and a support structure disposed under the first scintillator and structure disposed under the first scintillator and carrier of the first pixel extends from and between the second
reflective potential of the second pixel and the third reflective
over each of the optical carrier and the second scintilreflective material of the second pixel and the third reflective over haterial of the third pixel.

tons, the detector array comprising:
a first pixel, comprising:

-
- first reflective material that begins and ends adjacent a sidewall of the first scintillator; and
-
- ness. a second scintillator directly contacting the second
 a The detector array of claim 1 wherein the first scintillator directly contacting the second
 a The detector array of claim 1 wherein the first scintillator
	-
	-

a filter.
 a filter the first pixel and the second scintillator of the **11**. The detector array of claim 1, wherein the first second pixel each directly contact the support structure.

- 12. The detector array of claim 1, wherein a width of first a first pixel, comprising:

12. The detector array of claim 1, wherein a width of first a first photodetector;

13. The detector array of claim 1, further compris
	-
	- a third photodetector;
a third scintillator directly on the third photodetector and
a sidewall of the first scintillator; and
		-
		- -
- intervenes between the second pixel and the third pixel.
15 The detective numerical and the third pixel is continued beginning and ending cent a sidewall of the second scintillator; and
	-

19. The detector array of claim 18, wherein the first $\frac{19}{15}$ scintillator has a first composition and the second scintillator a first pixel, comprising:

has a second composition different than the first composi-

a first photodetector:

a first photodetector, **20**. The detector array of claim **18**, wherein the first photodetector $\frac{1}{2}$ scintillator has a first scintillator thickness and the second a first scintillator over the optical carrier and configured
the scintillator has a second scintillator thickness, the second
the second scintillator thickness, the second to convert a first radiation photon into first light 40 scintillator has a second scintillator thickness, the second scintillator thick energy; and ress.